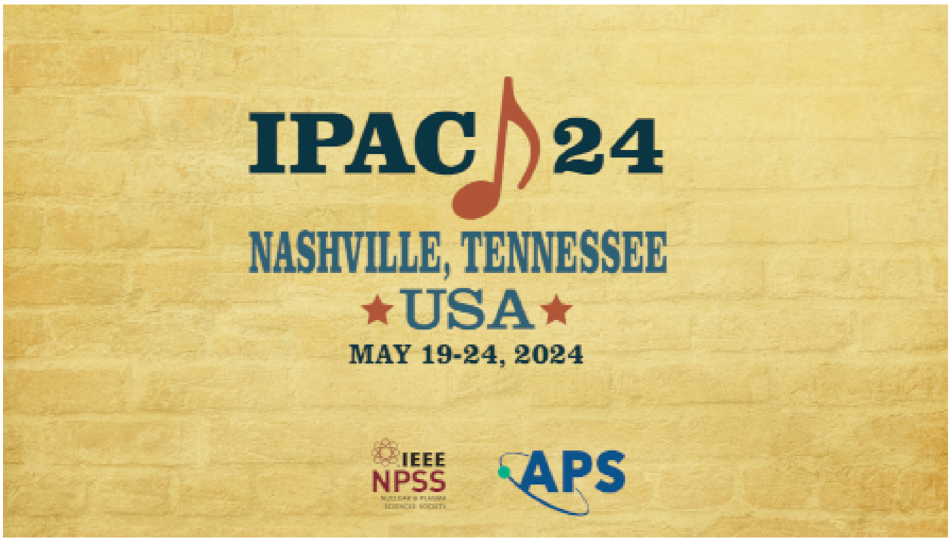
IPAC'24 - 15th International Particle Accelerator Conference

Sunday, 19 May 2024 - Friday, 24 May 2024

Music City Center



Book of Abstracts

Contents

TUZN: Photon Sources and Electron Accelerators (Invited) / 15

Shanghai hard X-ray FEL facility (SHINE) progress status

Author: Zhentang Zhao[1]

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SHINE (Shanghai Hard X-ray FEL Facility) is a high repetition rate X-FEL facility under construction in Shanghai, China. The facility is based on an 8 GeV CW superconducting linac and plans to have 3 undulator lines and 10 experimental stations in phase-I, covering the photon energy range of 0.4 –25 keV. Mass production of the components and installation of the machine are in course. User experiments are expected to start in 2025. This presentation summarizes the proposed configuration and the status of R&D and production for the critical components and systems, discussing the key technologies. The current status of the project and the plans leading to the completion will be presented, outlining the major scientific goals of the facility.

Footnotes:

Funding Agency:

Paper preparation format:

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Asia

WEZN: Accelerator Technology and Sustainability (Invited) / 23

The path to high beam power targets

Author: Drew Winder[1]

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This talk will outline the challenges ahead in high power targetry and the material R&D plan for achieving 2.4 MW and beyond, windows and targets.

Footnotes:

Funding Agency:

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North America

FRXD: Applications of Accelerators, Technology Transfer and Industrial Relations and Outreach (Invited) / 55

Application of superconducting cavities as ultra-sensitive RF photon detectors

Author: Bianca Giaccone[1]

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Superconducting radio frequency (SRF) cavities are the world's most efficient engineered oscillators, and they have long been employed for extremely high efficiency transfer of energy to beams of charged particles. Decades of R&D for particle accelerators have led to modern treatments for SRF cavities that achieve higher performance than was previously possible. Advanced SRF cavities using particle accelerator technology are now being used to search for new physics, including dark matter and gravitational waves. The extremely high Q makes it possible to search for very small signals from photons in the radio frequency range, and the extremely high electric fields makes it possible to perform experiments that involve pumping one mode of a cavity in order to search for power transfer mediated by new physics. This talk will present novel experiments that employ SRF cavities, including searches for axions and dark photons dark matter, light-shining-through-walls, and high frequency gravitational waves. Results to be presented include searches with world record sensitivity.

Footnotes:

Funding Agency:

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Region represented:

North America

THYN: Accelerator Technology and Sustainability (Invited) / 56

First results of AUP Nb3Sn quadrupole horizontal tests

Author: Maria Baldini[1]

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The Large Hadron Collider will soon undergo an upgrade to increase its luminosity by a factor of ˜10. A crucial part of this upgrade will be replacement of the NbTi final focus magnets with Nb3Sn magnets that achieve a ˜50% increase in the field strength. This will be the first ever large scale implementation of Nb3Sn magnets in a particle accelerator. This talk will present the program to fabricate these components and first results from horizontal tests of fully assembled cryoassemblies.

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North America

MOZD: Beam Dynamics and Electromagnetic Fields (Invited) / 67

New advances in optical stochastic cooling

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Co-authors: Abhishek Mondal [1]; Alexander Romanov [1]; Jinhao Ruan [1]; Michael Wallbank [1]; Valeri Lebedev [2]

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Recently, Optical Stochastic Cooling (OSC) became the first demonstrated method for ultra-high-bandwidth stochastic cooling. The initial experiments at Fermilab's IOTA ring explored the essential physics of the method and demonstrated cooling, heating and manipulation of beams and single particles. Having been validated in practice, with continued development, OSC carries the potential for dramatic advances in the state-of-the-art performance and flexibility for beam cooling and control. The ongoing program at Fermilab is now focused on the development of an OSC system that includes high-gain optical amplification, which promises a two-order-of-magnitude increase in the strength of the OSC force. In this talk, we briefly review the results of the initial experimental campaign, describe the status of the conceptual and hardware designs for the amplified OSC system, report initial experimental results of our high-gain amplifier development, and explore near-term operational plans and use cases.

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TUYN: Novel Particle Sources and Acceleration Techniques (Invited) / 75

The latest results on plasma wakefield experiments on the FACET-II facility / plasma-based acceleration at FACET-II

Author: Chan Joshi[1]

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FACET-II is the recently completed 10 GeV electron beam facility at SLAC National Accelerator Laboratory. The latest results on the flagship E300 experiment on Plasma Wakefield experiment will be presented.

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North America

FRXN: Novel Particle Sources and Acceleration Techniques (Invited) / 82

20 years since the first laser plasma accelerated dream beams and a look forward

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Overview on laser plasma accelerators since the dream beam results.

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North America

MOZN: Photon Sources and Electron Accelerators (Invited) / 84

Next 10 years of light sources

Author: Timur Shaftan[1]

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Synchrotron light sources and free electron lasers (FELs) have established as powerful research tools in various disciplines, as physics, chemistry, biology, materials science, and medicine. During the last decade new developments and advancements, leading to construction of new facilities and upgrades to existing ones, have allowed to further extend their capabilities to drive scientific progress. This paper explores the emerging and future trends and perspectives in synchrotron light sources and FELs, including novel accelerator and component designs and advances in technology, with a perspective over the next decade. The scientific and technological challenges needed for the design and construction are discussed together with the strategies and innovation necessary, also considering how key societal challenges, such as sustainable energy management and advanced manufacturing, are addressed.

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North America

WEXN: Applications of Accelerators, Technology Transfer and Industrial Relations and Outreach (Invited) / 91

Superconducting magnets technology for heavy ion gantry for hadron therapy

Author: Marco Prioli[1]

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Various initiatives in Europe have been launched to study superconducting magnets for a rotatable gantry suitable for delivery up to 440 MeV/A carbon ions for hadron therapy. Various technologies and layouts are being considered: strongly curved cos-theta dipole (R_bending = 1.6 m) rated for 4 T central field and a ramp rate of 0.15 –0.4 T/s. or novel Canted Cosine Theta (CCT) dipoles in combined functions layout. Beside classical NbTi superconductors also HTS is being explored with CCT layout. The concept and the progress in the construction of three first prototypes to validate the various concepts is discussed.

Footnotes:

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Paper preparation format:

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Europe

Friday Plenary / 95

High-efficiency klystrons from a dream to a reality

Author: Nuria Catalan-Lasheras[1]

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During last year a comprehensive R&D program on high-efficiency klystrons has been carried out in collaboration with industry. The first prototypes are being tested and experimental results are promising. The talk will describe the main results of this R&D focusing in the experimental ones.

Footnotes:

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Europe

TUYD: Colliders and other Particle and Nuclear Physics Accelerators (Invited) / 109

Monochromatization a new operation mode for e+e- circular colliders

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Monochromatization of the beams is presented as a technique to reduce the energy spread and thus improve the CM energy resolution in colliding-beam experiments. Monochromatization consists of generating opposite correlations between a spatial position and the energy deviation in the colliding beams. In beam-optics terms, this can be achieved by generating a nonzero dispersion function of opposite signs for the two beams at the Interaction Points. For the FCC-ee collider monochomatization could enable measurement of the electron Yukawa coupling. This talk will describe the different possible implementation schemes in FCC-ee, its interaction with a modified large-acceptance lattice, and possible experimental tests at the Daphne or SuperKEKB colliders.

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Europe

THYD: Beam Dynamics and Electromagnetic Fields (Invited) / 128

Coherent electron cooling physics for the EIC

Author: William Bergan[1]

Co-authors: Christopher Mayes [2]; Colwyn Gulliford [3]; Erdong Wang [1]; Gang Wang [1]; Ji Qiang [4]; Joseph Conway [3]; Jun Ma [1]; Kirsten Deitrick [5]; Michael Blaskiewicz [1]; Nicholas Taylor [3]; Ningdong Wang [6]; Panagiotis Baxevanis [7]; Stephen Benson [5]

[1] *Brookhaven National Laboratory*

[2] *SLAC National Accelerator Laboratory*

[3] *Xelera Research LLC*

[4] *Lawrence Berkeley National Laboratory*

[5] *Thomas Jefferson National Accelerator Facility*

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In order to prevent emittance growth during long stores of the proton beam at the future Electron-Ion Collider (EIC), we need to have some mechanism to provide fast cooling of the dense proton beams. One promising method is coherent electron cooling (CeC), which uses an electron beam to both "measure" the positions of protons within the bunch and then apply energy kicks which tend to reduce their longitudinal and transverse actions. In this talk, we discuss the underlying physics of this process. We then discuss simulations which constrain the electrons to move only longitudinally in order to perform fast optimizations and long-term tracking of the bunch evolution, and benchmark these results against fully 3D codes. Finally, we will discuss practical challenges, including the necessity of a high-quality electron beam and sub-micron alignment of the electrons and protons.

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MOZN: Photon Sources and Electron Accelerators (Invited) / 136

On the production of short X-ray pulses at diffraction-limited light sources, an update and recent developments

Author: Simone Di Mitri[1]

[1] *Elettra-Sincrotrone Trieste S.C.p.A.*

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The last decade has seen a renaissance of machine physics studies and technological advancements worldwide which aim at upgrading storage ring light sources to the diffraction limit up to few hundreds of keV photon energy. This is expected to improve the spectral brightness and the transversally coherent fraction of photons by several orders of magnitude in the X-ray wavelength range. This is done, however, at the expense of pulse durations typically longer than 80 ps FWHM. We discuss the compatibility of proposed and established schemes for the generation of (sub-)picosecond photon pulses durations with standard multi-bunch operation and, in particular, with diffraction-limited electron optics design. We then focus on the scheme of radio-frequency deflecting cavities generating a steady-state vertical deflection of selected electron bunches for the production of short pulses. The study demonstrates the feasibility of (sub-)picosecond long X-ray pulses at MHz repetition rate, provided simultaneously to several beamlines. The scheme provides flexibility in pulse duration, is transparent to standard multi-bunch operation, and is capable of largely preserving the transverse coherence of the emitted radiation. Ultimate performance, limits and operational aspects of the scheme are analyzed in an integrated accelerator-plus-beamlines perspective.

Footnotes:

[1] S. Di Mitri, One Way Only to Synchrotron Light Sources Upgrade, J. Synchr. Rad., 25 (2018).
[2] S. Di Mitri et al., Laser-slicing at a low-emittance storage ring, J. Synchr. Rad., 26 (2019) 1523–1538.
[3] A. Zholents, New possibility for production of sub-picosecond x-ray pulses using a time dependent radio frequency orbit deflection, Nucl. Instrum. Methods Phys. Res. A, 798 (2015) 111–116.

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Paper preparation format:

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Europe

THXD: Beam Instrumentation, Controls, Feedback and Operational Aspects (Invited) / 152

Machine learning for improved accelerator and target reliability

Author: Willem Blokland[1]

Co-author: Malachi Schram [2]

[1] *Oak Ridge National Laboratory*

[2] *Thomas Jefferson National Accelerator Facility*

Corresponding Author: blokland@ornl.gov

The Spallation Neutron Source uses a high-power accelerator and target to produce neutrons to explore the nature of materials and energy. Running the facility at the cutting edge of technology does lead to occasional interruptions in the scientific program. We present results from a three year project aimed at exploring Machine Learning methods to improve accelerator and target reliability. Various application areas ranging from reducing beam trips, surrogate modeling of high-power targets, to improving on cryogenic system behavior will be discussed as well as lessons learned. Finally, we present our plans for the continuation of the project, including a continual learning framework necessary to integrate Machine Learning with Operations.

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North America

Plenary after coffee / 166

Photocathodes: a fundamental tool for enabling new accelerator-based science

Author: Matt Poelker[1]

[1] *Thomas Jefferson National Accelerator Facility*

Corresponding Author: poelker@jlab.org

We will review of the current state of the advanced photocathode material development and structures necessary for production of electron beams with high brightness, high charge, and electron spin polarization.

Footnotes:

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North America

FRXD: Accelerator Technology and Sustainability (Invited) / 169

Nb3Sn SRF cavities: from R&D to real accelerator –overview of recent developments

Author: Uttar Pudasaini[1]

[1] *Thomas Jefferson National Accelerator Facility*

Corresponding Author: uttar@jlab.org

The superior superconducting properties of Nb3Sn promise enhanced RF performance (Q and Eacc) compared to Nb at any given temperature. The potential deployment of Nb3Sn-coated superconducting radiofrequency (SRF) cavities at 4 K, achieving performance comparable to Nb cavities at 2 K, signifies a transformative technology poised to enable innovative classes of SRF accelerators and improve the efficiency and cost-effectiveness of future accelerators. State-of-the-art Nb3Sn-coated single-cell Nb cavities have achieved accelerating gradients of ˜20 MV/m with quality factors of ˜1E10 at 4 K. Comparable performance has been demonstrated in cavities of different frequencies and multi-cell accelerator cavities currently in use. With these achievements, several ongoing projects are adopting Nb3Sn cavity technology to develop practical particle accelerators for industrial, environmental, and nuclear physics applications. This presentation provides an overview of recent developments in Nb3Sn cavity technology, transitioning from research and development to real-world accelerators while discussing the current challenges in the field.

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THXN: Novel Particle Sources and Acceleration Techniques (Invited) / 177

High gradient RF photoinjector at LANL

Author: Anna Alexander[1]

Co-authors: Chengkun Huang [1]; Dimitre Dimitrov [1]; Evgenya Simakov [1]; Gaoxue Wang [1]; Haoran Xu [1]; James Rosenzweig [2]; Jinlin Zhang [1]; Petr Anisimov [1]; Ryo Shinohara [1]; Soumendu Bagchi [1]; Torben Grumstrup [1]; Walter Barkley [1]

[1] *Los Alamos National Laboratory*

[2] *University of California, Los Angeles*

Corresponding Author: aalexander@lanl.gov

High frequency RF guns cryogenically cooled to liquid nitrogen temperatures or lower offer potential for extreme accelerating electric fields exceeding 250 MV/m at the cathode. This can result in enormous increase in the brightness of electron beams obtained from RF guns but can be challenging to integrate high QE photocathodes. This talk will detail the efforts at LANL towards the realization of such a gun and possibly the first field and beam results from a C band room temperature gun.

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North America

WEYN: Beam Instrumentation, Controls, Feedback and Operational Aspects (Invited) / 183

Prospects of transverse deflecting structures as diagnostic tools for linacs

Author: Paolo Craievich[1]

[1] *Paul Scherrer Institut*

Corresponding Author: paolo.craievich@psi.ch

Transverse deflection structures (TDS) are used as diagnostic tools for linac-based accelerators. Since their reintroduction in the early 2000s, their development has been continued in several laboratories, in particular to improve temporal resolution given the ongoing tendency of getting shorter and shorter electron bunches. Furthermore, the development of a new TDS with variable streaking direction has opened up new possibilities to diagnose, using tomographic techniques, multidimensional phase space to investigate complex beam dynamics. In recent years, in parallel with the development of TDS based on RF structures, TDS based on self-induced fields in corrugated or dielectric structures, the so-called passive streaking, have also been used as diagnostics to retrieve the temporal properties of particle beams. In this contribution, these devices will also be discussed by comparing advantages and disadvantages with TDS based on RF structures.

Footnotes:

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Europe

WEXD: Photon Sources and Electron Accelerators (Invited) / 197

Review of advanced schemes for free electron lasers

Author: Zhirong Huang[1]

[1] *SLAC National Accelerator Laboratory*

Corresponding Author: zrh@slac.stanford.edu

Free electron lasers (FEL) have made significant progress in the last decade, offering unique opportunities of high brightness radiation to the users'community. Various advanced schemes aiming at achieving fully coherent, stable X-ray pulses are proposed and are actively being investigated and developed. Self-amplified spontaneous emission (SASE) can be used to generate intense coherent radiation starting from electron shot noise and is the most common approach for X-ray FELs. SASE has limited temporal coherence and pulse stability due to its noisy startup, but it allows generating ultrashort X-ray pulses from hundreds of femtosecond down to hundreds of attosecond in duration. Alternatively, external seeding schemes, like HGHG and EEHG, and self-seeding are being applied or proposed to allow for the generation of fully coherent FEL pulses in many laboratories. After a review of the present state of the art, the presentation will concentrate on perspectives of the new advanced schemes being proposed and developed at various facilities worldwide.

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North America

WEZN: Accelerator Technology and Sustainability (Invited) / 215

Towards a green accelerator: implementing energy-saving practices at NSRRC

Author: Wen Shuo Chan[1]

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Taiwan heavily relies on imported fuel for power generation, making the country susceptible to energy market risks. To mitigate this issue, the government is actively promoting the adoption of renewable energy sources, such as solar and wind power, while also encouraging companies to enhance their energy-saving efforts. At NSRRC, five major energy-saving practices were implemented, including (1) optimizing chiller services, (2) energy-saving operation of accelerator booster magnetic power supplies,(3) heat recovery by heat pumps, (4) fouling remove from heat exchangers and (5) replacement of compressed air compressors from 2020 to 2022. These practices resulted in an annual energy saving of 3.59 GWh, representing a 4.9% reduction in electricity consumption at NSRRC compared to 2019. The implementation of these practices also led to a reduction in energy costs, saving approximately 11 million New Taiwan dollars, and yielding a payback period of 4.3 years. Moreover, a regression model was developed to forecast energy consumption at NSRRC with an r-square value of 0.926. NSRRC obtained the energy management certification of ISO 50001 in 2019, which has facilitated the continuous improvement of energy efficiency. Going forward, NSRRC plans to utilize machine learning methods to establish the optimal operating mode for its air conditioning system.

Footnotes:

Funding Agency:

Paper preparation format:

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Asia

TUXN: Beam Dynamics and Electromagnetic Fields (Invited) / 229

Metamaterials for impedance optimization and sustainability

Author: Carlo Zannini[1]

Co-author: Leonardo Sito [2]

[1] *European Organization for Nuclear Research*

[2] *University of Napoli Federico II*

Corresponding Author: carlo.zannini@cern.ch

Metamaterials could allow developing superconductive-like materials at ambient temperature, with consequent drastic reduction in energy consumption. They are therefore promising materials for future accelerators of small and big scale. Here, electromagnetic metamaterials to synthesize an equivalent structure that approaches superconductive-like properties, i.e. extremely high electrical conductivity, are investigated. The underlying electromagnetic model is formalized analytically using transmission line theory and supported by electromagnetic simulations and experimental measurements.

Footnotes:

Funding Agency:

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LaTeX

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Europe

FRXN: Hadron Accelerators (Invited) / 232

Crystal collimation of heavy ion beams

Author: Stefano Redaelli[1]

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An important upgrade programme is planned for the collimation system of Large Hadron Collider (LHC) for lead–ion beams that will already reach their high-luminosity target intensity upgrade in the LHC Run 3 (2022-2025). While certain effects like e-cloud, beam-beam, impedance, inject and dump protection are relaxed with ion beams, halo collimation becomes a challenge, as the conventional multi-stage collimation system is about two orders of magnitude less efficient than for proton beams. Ion fragments scattered out of the collimators in the betatron cleaning insertion risk to quench cold dipole magnets downstream and may represent performance limitations. Planar channeling in bent crystals has been proven effective for high energy heavy ions and is now considered as baseline solution for collimation at High-Luminosity LHC (HL-LHC). In this paper, simulation and measurement results, demonstrating the observation of channeling of heavy-ion beams and improvement of collimation cleaning in the multi-TeV energy regime, and the efficiency of the collimation scheme foreseen for HL-LHC are presented.

Footnotes:

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Europe

MOZD: Beam Dynamics and Electromagnetic Fields (Invited) / 235

A novel Vlasov approach for modeling electron cloud instabilities

Author: Sofia Johannesson[1]

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This presentation discusses the generalization of the two-dimensional impedance model in the presence of an electron cloud. It will be discussed the implementation of a linear model of the e-cloud forces including both dipolar and quadrupolar forces to improve the modeling of the electron cloud instabilities. The linear model is included in the Vlasov equation, which allows for finding unstable modes. Benchmarking with conventional macro-particle tracking codes by also implementing the same linear model is discussed for negative, low, as well as large chromaticity. It is found that the instability modes by Vlasov agree well with those of the macro-particle simulations, using the same linear model for negative and low chromaticity. For large-chromaticity, the mode visible in the macro-particle simulations is among the unstable Vlasov modes. The present status of the checks with impedance-driven instabilities is being discussed also including recent benchmarking against tracking simulations and measurements.

Footnotes:

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Europe

Friday Plenary / 240

US high-energy physics collider proposals for the future

Author: Vladimir Shiltsev[1]

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In the US high energy planning process more than 30 colliders were considered. This talk gives an overview of these colliders and emphasized the strength of the various approaches.

Footnotes:

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North America

WEZD: Colliders and other Particle and Nuclear Physics Acclerators (Invited) / 247

Status of SuperKEKB and experience with nonlinear collimation

Author: Makoto Tobiyama[1]

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An update on SuperKEKB status will be presented including an overview of performance limitations and experience with nonlinear collimation.

Footnotes:

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Region represented:

Asia

Plenary after coffee / 271

Novel undulators: the long and winding road to brightness

Author: Sara Casalbuoni[1]

[1] *European XFEL GmbH*

Corresponding Author: sara.casalbuoni@xfel.eu

Storage rings and free electron lasers use undulators to produce high-brilliant X-ray photon beams. In order to increase brilliance and photon energy tunability it is necessary to enhance the undulator magnetic peak field on axis by reducing its period without decreasing the electron beam stay clear. Undulator technologies aiming to reach this goal are presented.

Footnotes:

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WEZD: Colliders and other Particle and Nuclear Physics Acclerators (Invited) / 282

The electron cloud and its impact on LHC and future colliders

Author: Lotta Mether[1]

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Corresponding Author: lotta.mether@cern.ch

The secondary emission of electrons and their interaction with the electromagnetic fields of charged particle beams can lead to the build-up of electron clouds in accelerator beam chambers. The interaction of the electrons with both the beam and the chamber walls leads to detrimental effects, such as transverse instabilities and emittance growth, beam loss, pressure rise and heat load. Such effects are systematically observed in the Large Hadron Collider (LHC) during operation with proton beams with the nominal bunch spacing of 25 ns. Furthermore, the severity of electron cloud effects has increased after each long shutdown period of the machine, due to a degradation of the beam screen surfaces with air-exposure. Consequently, electron cloud is already limiting the total intensity in the collider and is one of the main concerns for the performance of the HL-LHC upgrade. In this contribution, the present understanding of electron cloud in hadron accelerators is reviewed. Measurements and observations at the LHC are presented, the impact on performance is evaluated and mitigation measures are discussed along with lessons for future machines.

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Europe

FRXN: Beam Instrumentation, Controls, Feedback and Operational Aspects (Invited) / 283

Beam instrumentation for advancing accelerators

Author: Lorraine Bobb[1]

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Beam instrumentation is of critical importance for the operation and optimization of modern particle accelerators. With advancing accelerator technology and the increasing requirements for higher quality beams, it is an ever-present challenge that beam diagnostics must similarly progress. In this talk the instrumentation considered most impactful for the progress of 4th generation storage ring light sources is presented with reference to possible lessons learned, applicability to other accelerators and potential future directions.

Footnotes:

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Europe

WEYD: Hadron Accelerators (Invited) / 318

Status and outlook on slow extraction operation at J-PARC main ring

Author: Ryotaro Muto[1]

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The Main Ring (MR) at J-PARC (Japan Proton Accelerator Research Complex) is a proton synchrotron that accelerates protons from 3 GeV to 30 GeV. One of the two MR's extraction modes is slow extraction using third-order resonance toward the Hadron Experimental Facility, where various particle and nuclear physics experiments are conducted. There are two major points in the slow extraction: beam loss reduction and flat spill structure of the extracted beam. In the beam operation of 2021, we achieved a beam power of 65 kW with a high extraction efficiency of 99.5% and a spill duty factor of 60%, but requirements for further improvements from physics experiments have never stopped. From 2021 to 2022, various devices in the MR were upgraded. The primary purpose of this upgrade was to increase the beam power by shortening the acceleration time and increasing the repetition rate. To achieve this goal, we rebuilt most parts of the main magnet power supplies. The new power supplies are also expected to be significantly improved in the current ripple. Thus the time structure of the slow extracted beam is also expected to be greatly improved. In addition, plans are underway for further reduction of the beam loss through the use of beam diffusers and bent silicon crystals and for improvement of the spill structure by feedback algorithms reconstruction. This talk presents the status of the MR and the prospects of the slow extraction after the MR upgrade.

Footnotes:

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Asia

TUZN: Photon Sources and Electron Accelerators (Invited) / 322

Status and first results of the APS-U, the high-brightness upgrade of the Advanced Photon Source at the Argonne National Laboratory

Author: Elmie Peoples-Evans[1]

[1] *Argonne National Laboratory*

Corresponding Author: epeoplesevans@anl.gov

The Advanced Photon Source Upgrade (APS-U) is a 4th generation 6-GeV synchrotron light source based on a hybrid seven-bend achromat lattice with a record emittance goal of ˜40 pm-rad. It is the first storage ring light source that implements full-charge bunch injection in a scheme known as swap-out. APS-U completely replaces the APS storage ring while largely keeping the original injectors and increases the photon brightness by a factor of 500. Complete removal of the old APS storage ring, installation of the new APS-U, integration with existing infrastructure, and commissioning was scheduled to be completed in one year, by Apr 2024. The talk will describe both challenges and successes in the pre-installation assembly, equipment removal and installation process, commissioning status, and early results.

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DOE Basic Energy Sciences

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TUXD: Hadron Accelerators (Invited) / 328

FRIB one year user operation

Author: Andreas Stolz[1]

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FRIB is in user operation more than one year. Statistics and lessons learned will be presented.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

North America

Plenary before coffee / 331

The journey to highest power proton beams at the SNS

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The Spallation Neutron Source accelerator is the highest power proton accelerator in the world, operating with over 1.4 MW with high reliability. Commissioned in 2006, it took thirteen years to achieve the 1.4 MW design goal of the facility and required overcoming tremendous technological challenges. The SNS path to high power has significantly influenced the outlook for future of high-power accelerators. This talk will describe the innovative journey to high power and the lessons learned along the way, and will close with a preview of SNS's future beyond 1.4 MW.

Footnotes:

Funding Agency:

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North America

FRXD: Applications of Accelerators, Technology Transfer and Industrial Relations and Outreach (Invited) / 338

Commissioning of carbon ion treatment accelerator with a superconducting rotating gantry

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The world's smallest carbon ion treatment facility has been commissioned at Yamagata University. The treatment system consists of an ECR ion source, a linac cascade of 0.6 MeV/u RFQ and 4 MeV/u IH-DTL, a 430 MeV/u slow extraction synchrotron, and irradiation systems of a fixed horizontal beamline and a compact rotating gantry using superconducting combined function magnets. The size of the building is 45 x 45 m, realized by placing the irradiation rooms not on the same level as the synchrotron, but above it, connected by a vertical beam transport.
The most advanced accelerator technology of this machine is to control the beam range up to 300 mm in 0.5 mm steps without any physical block range shifter. To achieve this range step, 600 beam energies were provided in the synchrotron and in the beam transport and tuned to control the beam size in the treatment room. Initial commissioning and daily/monthly quality assurance were carried out by interpolation of beam energy and gantry angle.
After tuning the beam size and correcting the beam axis in the treatment rooms, precise dose measurement was performed for clinical irradiation. After the clinical commissioning, the facility started treatment irradiation in February 2021 with a fixed beam port and in March 2022 with a gantry beam port. After March 2023, the gantry angle was operated with a 15-degree step. By November 2023, 1330 patients had been treated.

Footnotes:

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Region represented:

Asia

Friday Plenary / 371

Recent development and future direction of ring-type synchrotron light sources in Japan

Author: Nobuyuki Nishimori[1]

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The 4th generation synchrotron light sources and energy recovery linacs progress greatly in Japan. The first 4th generation synchrotron light source in Asia, NanoTerasu, has been constructed through a public-private regional partnership, whereas soon SPring-8 is to be upgraded. The energy recovery linac, which features not only high brightness but also sustainability as the cERL, and its related technology such as DC gun injectors have been developed, also. The talk will present an overview and future direction of synchrotron radiation light sources in Japan, with a particular focus on recent advances in NanoTerasu.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Plenary after coffee / 372

Sustainable accelerator concepts and technologies

Author: Thomas Roser[1]

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Sustainability of accelerators construction and operation is becoming a driver for new accelerators at the high-energy and beam power frontier. The ICFA Panel on Sustainable Accelerators and Colliders assesses and promotes developments on energy efficient and sustainable accelerator concepts, technologies, and strategies for operation, and assess and promote the use of accelerators for the development of Carbon-neutral energy sources. This talk gives an overview of the world-wide efforts, notable accomplishments to date, and trends that will shape the construction and operation of future large accelerators.

Footnotes:

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North America

Plenary before coffee / 373

Accelerator-based isotope production

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The World-wide accelerator-based isotope production for research as well as medical and industrial applications is growing. Aside the use of isotopes in fundamental research, their medical use is widely known, and isotopes enjoy growing importance in many fields. Isotopes are used in inter disciplinary research as tracers to examine the trace flow of nutrients and pollutants in the environment for instance. Isotopes are also used to characterize newly designed materials and the behavior of nano-structured materials that play a key role in modern electronics devices.
The production and investigation of short lived isotopes, also known as rare-isotopes, is mainly based on accelerators using different nuclear reactions. This talk gives an overview of the accelerators used for isotope production, the relevant performance parameters, and new trends that drive the technology development and physics understanding of these accelerators.

Footnotes:

Funding Agency:

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North America

Tuesday Poster Session / 374

A preliminary feasibility study on dual cavity cryomodule integration for the Electron Ion Collider energy recovery linac cooler

Author: Sadiq Setiniyaz[1]

Co-authors: Christopher Mayes [2]; Colwyn Gulliford [3]; Jiquan Guo [1]; Kirsten Deitrick [1]; Nicholas Taylor [3]; Stephen Benson [1]

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The Electron-Ion Collider (EIC) is a cutting-edge accelerator designed to collide highly polarized electrons and ions. For enhanced luminosity, the ion beam is cooled via an electron beam sourced from an energy recovery linac (ERL). The current ERL design accommodates one RF cavity per cryomodule, presenting both beam transport and cost-related challenges. This study investigates the feasibility of reducing the cavity size to accommodate two cavities within a single cryomodule. We analyze two compact cavity design options through frequency scaling, assuming constant loaded quality factor Q and R/Q scaling proportional to the square of the frequency ratio. Our analytical and tracking Beam BreakUp (BBU) model predicts the threshold current for each option. While a smaller cavity footprint is advantageous, maintaining sufficient damping of Higher Order Modes (HOMs) is crucial. We compare the HOM damping effectiveness of the proposed compact design to the existing configuration, which achieves sufficient damping within a slightly larger footprint.

Footnotes:

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North America

Tuesday Poster Session / 375

Development of test bench for 324 MHz superconducting cavity power couplers

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The power coupler is one of the most important components for superconducting cavities. Different from the normal conducting cavity, the superconducting cavity has to keep an ultra-high cleanliness environment for operation. As the vacuum barrier, power couplers are welded by many different materials and maybe the gas source since they are installed to the cavities after vertical test, therefore, they should be high power conditioned before operation. Generally speaking, test bench equipment with two power couplers is often designed to improve the high conditioning efficiency. In this paper, different types of test benches are compared according to simulation and the cylindrical quarter-wavelength cavity is chosen. Besides, the detailed electromagnetic and mechanical design of the test bench is presented; to verify machining accuracy, two test pieces are also designed to measure the transmission of the test bench. In addition, to meet the high power conditioning of different power couplers, the test bench is optimized to have a capacity of 300 kW CW forward power. Finally, limited by the output power of klystron, the test bench with a pair of couplers is high power conditioned to a standing power level of 500 kW with a repetition rate of 25 Hz and a pulse width of 1.2 ms.

Footnotes:

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Asia

Thursday Poster Session / 376

Quasi-isochronous conditions and high order terms of momentum compaction factor at the compact storage ring

Author: Alexander Papash[1]

Co-authors: Matthias Fuchs [1]; Anke-Susanne Mueller [1]; Robert Ruprecht [1]

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The compact storage ring project for accelerator research and technology (cSTART) is realized at the Institute for Beam Physics and Technology (IBPT) of the Karlsruhe Institute of Technology (KIT). Flexible lattice of a ring benefits variety of operation modes. Different physical experiments are planned at cSTART. In particular, deep variation of momentum compaction factor with simultaneous control of high order terms of alpha would demonstrate the capture and storage of ultra-short bunches of electrons in a circular accelerator. Computer studies of linear and non-linear beam dynamics were performed with an objective to estimate arrangement and performance of dedicated three pole chicane magnets to provide quasi-isochronous conditions for electrons. Additional families of so called "longitudinal"sextupoles and octupoles were added in a ring model to control slope and curvature of momentum compaction factor as function of energy offset of particles in a bunch.

Footnotes:

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Europe

Thursday Poster Session / 377

Development of linear power operational amplifier for TPS correction magnet power supply

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This paper investigates the design and implementation of a TPS correction magnet power supply using a combination of a linear power operational amplifier (PA05) and a pre-regulator voltage controller. The PA05 linear power operational amplifier features bipolar output, high internal power dissipation, and wide bandwidth. Utilizing a DCCT sensor as a current feedback element integrated with the pre-regulator voltage controller, a closed-loop current modulation circuit is formed, providing the variable voltage required by the linear power operational amplifier. Through these measures, we have successfully developed a prototype of a linear power operational amplifier power supply with a pre-regulator voltage controller for TPS correction magnets. Design validation is achieved through control loops, resulting in fast and stable output current performance. The output current ripple is maintained below 100 μA, and the rise time during the step response is 75 μs. During the frequency response test using a 0.1 V interference signal, the gain margin remains within -3 dB at an 11.2 kHz bandwidth, and the phase margin is within -45° over a range of 5.1 kHz. The long-term stability of the output current is maintained within 10 ppm. Finally, a hardware prototype circuit is assembled in the power laboratory with input voltage ranging from ±24 V, an output current of ±20 A, and a maximum rated power of 240 W.

Footnotes:

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Asia

Thursday Poster Session / 378

Effects of implantation temperature and annealing on structural evolution and migration of ruthenium in glassy carbon

Author: Tasabeeh Alabid Jafer[1]

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The use of glassy carbon (GC) as a future nuclear waste storage material depends on its capability to retain all radioactive fission products found in spent nuclear fuels. Ruthenium (Ru) is one of the most important fission products in nuclear reactors. This work investigates the effects of implantation temperature and annealing on the structural evolution and migration of Ru implanted in GC. To achieve these objectives, 150 keV Ru+ was implanted into GC samples separately at room temperature (RT) and 200℃ to a fluence of 1×10ˆ16 cmˆ−2. Some of the as-implanted samples were annealed at two temperature regimes (from 500 to 1000℃ and from 1000 to 1300℃–in steps of 100℃) for 5 h and characterized by Raman spectroscopy, X-ray diffraction (XRD), atomic force microscopy (AFM), and Rutherford backscattering spectrometry (RBS). Both Raman spectroscopy and XRD showed that implantation caused defects in the GC structures, with more defects in the RT as-implanted sample. Annealing caused the healing of both sample types but retained some radiation damage. No migration of Ru atoms was observed after annealing the as-implanted samples up to 800℃. However, a different migration behavior was seen after annealing the RT and 200℃ samples from 900 to 1300℃, attributed to the aggregation, trapping and de-trapping of Ru atoms in different amounts of defect induced by implantation.

Footnotes:

Implantation, Aggregation, Migration, Stress, Glassy Carbon

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Paper preparation format:

Region represented:

Asia

Tuesday Poster Session / 379

An electron beam modulation laser for steady-state microbunching

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Steady-state microbunching (SSMB) represents an innovative scheme for generating high-power coherent radiation. This approach is expected to generate kilowatt-scale extreme ultraviolet (EUV) radiation for lithography in the semiconductor industry. During the second phase of the SSMB proof-of-principle experiment (SSMB PoP II), the creation of quasi-steady-state microbunches requires specific modulation of the electron beam. This modulation is achieved through a phase-locked laser with a high repetition rate, which enables the detection of continuous coherent radiation over multiple turns. To meet the requirements of SSMB PoP II, a high-power, high-repetition-rate, phase-stabilized pulsed laser has been developed. The single-frequency pulsed laser has been achieved using an electro-optic modulator stage, three amplification stages, and a phase-locked feedback system. Here we report on the development and test results of the electron beam modulation laser.

Footnotes:

Funding Agency:

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Region represented:

Asia

Thursday Poster Session / 381

Using octupoles to create uniform electron beam produced by irradiation accelerators

Author: Weihang Gu[1]

Co-authors: Hao Zha [1]; Jiaru Shi [1]; Huaibi Chen [1]; An Li [1]

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In contemporary radiotherapy, most accelerators employ the scatter technique to achieve a relatively uniform dose distribution of electron beams. However, this method often results in the loss of a substantial number of particles, leading to suboptimal efficiency. This paper proposes a method utilizing permanent magnet components to homogenize the beam, achieving both beam spreading and uniformity within a short distance without particle loss. The proposed homogenization beamline comprises two quadrupole magnets and two octupole magnets, ultimately yielding a square field with a side length of approximately 20 cm. The manuscript includes theoretical derivations and simulation validations, with the physical prototype currently under fabrication. Experimental results will be provided in future work.

Footnotes:

Funding Agency:

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Region represented:

Asia

Thursday Poster Session / 382

Design of the SILF accelerator control system

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The Shenzhen Innovation Light-source Facility (SILF) is a 3 GeV 4th synchrotron radiation light source. It is planned to be built in Shenzhen, Guangdong Province, South China. This paper will introduce the latest design of the SILF accelerator system. As an EPICS-based system, it will be powered by industry-leading technology such as MicroTCA.

Footnotes:

Funding Agency:

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Region represented:

Asia

Monday Poster Session / 383

Fabrication and high-gradient testing of an X-band phase shifter for VIGAS

Author: Fangjun Hu[1]

Co-authors: Qiang Gao [1]; Jiaru Shi [1]; Qingzhu Li [1]; Hao Zha [1]; Boyuan Feng [1]; Hongyu Li [1]; Huaibi Chen [1]

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A new X-band phase shifter for the Very Compact Inverse Compton Scattering Gamma-ray Source (VIGAS) program in Tsinghua University has been fabricated and conducted high-gradient testing. After 10 h of conditioning in the Tsinghua X-band high-power test stand (TPOT), the phase shifter reached a peak power of 72 MW at 230 ns pulse width, and peak power of 82 MW at 130 ns pulse width.

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Asia

Tuesday Poster Session / 384

The online undulator magnetic field measurement system at SSRF

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The undulator is the core device for producing high energy synchrotron radiation light in Synchrotron Radiation and Free Electron Laser facilities. The long-term operation of the undulator is bound to be damaged by radiation. Furthermore, this radiation damage leads to the reduction or even demagnetization of the magnetic field, directly affecting the electron beam's operating state and the light's performance and stability. This magnetic measurement system aims to monitor the magnetic flux change to obtain the undulator's local magnetic field disturbance or decay. Moreover, it provides insights into phase errors and electron trajectories by estimating the half period magnetic field integrals for each magnetic pole. The measurement results on the undulator at SSRF are detailed.

Footnotes:

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Asia

Wednesday Poster Session / 385

Terahertz diagnoses bunch-to-bunch spacing for ultrafast electron bunch trains

Author: Yang Xu[1]

Co-authors: Yifang Song [1]; Jian Wang [1]; Zhengzheng Liu [1]; Cheng-Ying Tsai [1]; Kuanjun Fan [1]

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Ultrafast micro-bunched electron beams have broad applications, including wakefield-based acceleration and coherent Terahertz sources, where precise diagnosis of individual bunch-to-bunch spacing is critical. However, high-precision direct measurements of these spacings remain challenging. This paper introduces a novel method capable of measuring these spacings with femtosecond temporal

resolution using a THz-driven resonator. Simulations on a 3 MeV electron bunch train demonstrate a temporal resolution better than 10 fs for the bunch-to-bunch spacings. This method facilitates in-depth investigation of the longitudinal characteristics of the bunch train, promising significant advancement in narrow-band Terahertz sources and compact accelerators.

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Asia

Wednesday Poster Session / 386

Using CT algorithm to reconstruct electron beams transverse phase space in HUST-UED

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Accurate beam emittance and transverse phase space measurement are crucial for obtaining high-quality sample information in ultrafast electron diffraction (UED). Traditional methods rely on general initial assumptions about the electron beam's phase space and lack specific distributions. The transverse phase space reconstruction technique based on the CT (computerized tomography) algorithm eliminates the need for prior assumptions, resulting in more precise measurements. In this paper, we developed an Algebraic Reconstruction Technique (ART) algorithm for HUST-UED, enabling the reconstruction of the beam transverse phase space distribution at the sample location and facilitating the system optimization further.

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Asia

Thursday Poster Session / 393

Cold plate upgrade at the SNS

Author: Yugang Tan[1]

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The Spallation Neutron Source (SNS) employed over 200 cold plates in its Injection Kicker and quadrupole power supplies for semiconductor cooling. Each cold plate consisted of an aluminum base with interconnected copper tubes that were brazed together. Unfortunately, the durability of these plates was compromised over time due to corrosion of the copper tubes by de-ionized water. This corrosion led to the formation of small pinhole leaks, which became increasingly problematic in recent years, causing more frequent leaks and subsequent operational downtime for the SNS system. To tackle this issue, a novel solution was pursued involving the incorporation of stainless-steel tubes in the redesign. Two types of cold plates underwent rigorous simulations and extensive testing. One of the redesigned cold plates demonstrated competitive performance and was identified as a feasible replacement option. Consequently, a comprehensive initiative was executed to replace all cold plates.

Footnotes:

Funding Agency:

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Word

Region represented:

North America

Thursday Poster Session / 394

Towards Unlocking Insights from Logbooks Using AI

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Co-authors: Annika Eichler [1]; Gregor Hartmann [2]; Tim Wilksen [1]; Jason St. John [3]; Frank Mayet [1]; Jennefer Maldonado [4]; Daniel Ratner [5]; Jan Kaiser [1]; Verena Kain [6]; Thorsten Hellert [7]; Hayden Hoschouer [3]

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[3] *Fermi National Accelerator Laboratory*

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Electronic logbooks contain valuable information about activities and events concerning their associated particle accelerator facilities. However, the highly technical nature of logbook entries can hinder their usability and automation. As natural language processing (NLP) continues advancing, it presents opportunities to address various challenges that logbooks present. This work explores jointly testing a tailored Retrieval Augmented Generation (RAG) model for enhancing the usability of particle accelerator logbooks at institutes like DESY, BESSY, Fermilab, BNL, SLAC, and LBNL. The RAG model is using a corpus built on logbook contributions, and aims to unlock insights from logbooks by leveraging retrieval over facility datasets, including potential multimodal sources. Our goals are to increase the FAIR-ness (findability, accessibility, interoperability, and reusability) of logbooks by exploiting their information content to streamline everyday use, enable macro-analysis for root cause analysis, and facilitate problem-solving automation.

Footnotes:

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Europe

Wednesday Poster Session / 396

SRF cryomodule R&D for SHINE project

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Superconducting cryomodule prototypes and series have been developing for SHINE project. Up to now, several sets of high-Q cryomodules have been assembled and tested. This talk will present the development of cryomodule components, the assembly and performance test.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Wednesday Poster Session / 397

Design, construction and operation of a surface-treatment platform for SHINE superconducting cavities

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The SHINE project requires more than 600 cavities for the superconducting Linac. These cavities are fabricated from both domestic and foreign companies. The cavities fabricated in domestic companies requires corresponding capacity of surface-treatment. In order to guarantee the production capacity, we are constructing a new surface-treatment platform near Shanghai for SHINE project. In this paper, the design, construction, commissioning and operation of this platform will be reported.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Wednesday Poster Session / 398

Monte Carlo modeling of spin-polarized photoemission from NEA GaAs with low-temperature and strained-lattice effects

Author: John Callahan[1]

Co-authors: Ambar Rodriguez Alicea [2]; Luca Cultrera [3]; Oksana Chubenko [4]; Siddharth Karkare [4]

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GaAs-based photocathodes activated to negative electron affinity (NEA) is the only existing technology that can deliver intense and highly spin-polarized electron beams for the forthcoming Electron-Ion Collider as well as enable spin-polarized scanning tunneling microscopy, ultrafast spin-polarized low-energy electron diffraction, and other cutting-edge experiments. The degree of spin-polarization of electrons photoemitted from unstrained GaAs is usually considerably less than the theoretical maximum of 50%. However, it has been experimentally observed that the degree of electron spin polarization can be increased and even exceed the theoretical maximum when the sample is cooled to low temperatures. Additionally, in strained lattice samples, the theoretical maximum of spin polarization increases to 100%. The previously developed Monte Carlo approach to spin-polarized photoemission from unstrained, room temperature NEA GaAs provides excellent agreement with experimental data in a wide range of doping densities and photoexcitation energies. This study aims to extend the model's capabilities by incorporating both low-temperature and strained-lattice effects into the band structure and exploring their impact on spin and momentum relaxation mechanisms. Modeling of both low-temperature and strained NEA GaAs will provide a foundation for modeling photoemission from novel spin-polarized materials and complex layered structures.

Footnotes:

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North America

Wednesday Poster Session / 399

The study of single bunch instability at the Taiwan Photon Source

Author: Chih-Hsien Huang[1]

Co-authors: Demi Lee [1]; Jenny Chen [1]; Jin-Kun Liao [1]; Kuo-Tung Hsu [1]; Yung-Sen Cheng [1]

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A bunch-by-bunch (BbB) monitoring system has been developed, incorporating a high-speed analog-to-digital converter meticulously synchronized with the accelerator's radio frequency at the Taiwan Photon Source. This system is employed to investigate transverse beam motion resulting from instability in both single and multiple bunches, along with the subsequent oscillation damping following injection. Through independent component analysis, discrete sources of beam oscillation can be extracted for further analysis. This report will also address the current threshold with and without BbB feedback.

Footnotes:

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Asia

Monday Poster Session / 400

BAGELS: a general method for spin matching electron storage rings

Author: Matthew Signorelli[1]

Co-authors: Yunhai Cai [2]; Georg Hoffstaetter [1]

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[2] *SLAC National Accelerator Laboratory*

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We present a novel method for minimizing the effects of radiative depolarization in electron storage rings by use of vertical orbit bumps in the arcs. Depolarization is directly characterized by the RMS of the spin-orbit coupling function in the bends. In the Electron Storage Ring (ESR) of the Electron-Ion Collider (EIC), as was the case in HERA, this coupling function is excited by the spin rotators. Individual vertical corrector coils in the arcs can have varying impacts on the spin-orbit coupling function globally. In this method, we use a singular value decomposition of the response matrix of this coupling function for each corrector coil to define a minimal number of most effective groups of corrector coils, motivating the name "Best Adjustment Groups for ELectron Spin"(BAGELS) method. The BAGELS method can be used for obtaining the best knobs to minimize the depolarizing effects in the design lattice, and for obtaining fine-tuning knobs to perform this minimization in rings with realistic closed orbit distortions during operation. Its application has significantly increased the asymptotic polarization in simulations of the planned 18 GeV ESR, beyond achievable with conventional methods.

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North America

Wednesday Poster Session / 401

Mass production of 3.9 GHz 9-cell cavities at SHINE

Author: Xiaowei Wu[1]

Co-authors: Jiani Wu [2]; Jinfang Chen [2]; Lijun Lu [2]; Runzhi Xia [3]; Sen Sun [4]; ShenJie Zhao [4]; Shengwang Xiang [2]; Shuai Xing [2]; Yawei Huang [3]; Yue Zong [4]; Yuefeng Liu [5]; Zheng Wang [4]; pengcheng dong [2]

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Two 3.9~GHz cryomodules of sixteen cavities are required in the Shanghai high-repetition-rate XFEL and extreme light facility (SHINE) linac. They are placed before the first bunch compressor to linearize energy distribution. A total of twenty-one 3.9~GHz 9-cell cavities including two prototypes were fabricated and tested. The first two prototypes reached a Q0 of 2.9x10^9 at 13.1 MV/m and a maximum accelerating gradient of 20.0 MV/m during the vertical test, with a large margin with respect to the SHINE specification. The first prototype was integrated into a small cryostat and horizontal tested. Batch fabrication of nineteen cavities started after the prototype qualification. The 3.9 GHz cryomodules are under assembling after the vertical tests. Horizontal tests are planned to start from mid of 2024. This paper will introduce the experience of the prototype development and mass production of the 3.9 GHz cavities.

Footnotes:

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Paper preparation format:

Region represented:

Asia

Monday Poster Session / 402

Benchmark of AT vs MADX-PTC with exact integrators

Author: Simone Liuzzo[1]

Co-authors: Laurent Farvacque [1]; Nicola Carmignani [1]; Simon White [1]

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Recently exact Hamiltonian integrators have been added for drift, multipoles and dipoles in Accelerator Toolbox. This paper reports the tracking simulations benchmarks performed to compare with the results provided by MADX-PTC for four lattices: FODO, DBA, H7BA and FCC-HFD@Z. Tracking times are also reported for completeness. The agreement in 4D is complete while small discrepancies persist for 6D tracking. Fringe fields models were not included in the comparison and are known to be different for the two codes.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Europe

Tuesday Poster Session / 405

Parallel BBA for the EBS storage ring

Author: Simone Liuzzo[1]

Co-authors: Lee Carver [1]; Lina Hoummi [1]; Nicola Carmignani [1]; Simon White [1]; Thomas Perron [1]

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The parallel beam based alignment technique developped at SLAC is applied for the EBS storage ring. The results are compared with the standard beam based alignment technique used for operation.

Footnotes:

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Region represented:

Europe

Monday Poster Session / 406

High-efficiency traveling-wave accelerating structure with ceramic insertion

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In a radiofrequency accelerating structure with ceramic insertion, high shunt impedance (162 megaohm/m) and high group velocity (3.1% of the speed of light) are achieved simultaneously. The ceramic insertion is in the form of a cylinder, sandwiched between copper endplates with the beam aperture opened at the center. We report our theoretical study on this novel type of traveling wave accelerating structure that operates with a 2pi/3-mode at 5.7 GHz. The high shunt impedance is realized by the low-loss, highly reflective ceramic insertion confining the accelerating mode at the center. The high group velocity, or fast filling time of the radiofrequency wave, is made possible by the side coupling slots designed with large dimensions. As a result, this novel traveling wave accelerating structure enhances the power efficiency significantly, by two means. The high shunt impedance allows providing a greater accelerating gradient with a given amount of radiofrequency power. The fast filling time allows an earlier start of the beam acceleration within each radiofrequency power pulse, thus leading to a higher duty factor of the accelerator beam production. This type of the structure design allows using metallic iris features, which minimizes the electric field magnitude witnessed by the ceramic component. We also discuss the scheme of using periodic permanent magnets to focus an electron beam in the accelerating structure. The unique radiofrequency coupler design is also addressed.

Footnotes:

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North America

Tuesday Poster Session / 407

Vacuum acceptance test of vacuum chambers for early science FAIR

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A new accelerator facility (FAIR) is currently being built at GSI Helmholtz Centre for Heavy Ion Research in Darmstadt, Germany. The FAIR accelerator facility will consist of various beam lines, which provide different functions and experiments using various particle beams (ions, proton and anti-protons). Due to unprecedented circumstances, the FAIR project is currently divided into several design phases. The first priority of the design phase (referred to as "Early Science") is focused on the high energy beam transfer (HEBT) and Super Fragment Separator (SRFS) beamlines.
To ensure the vacuum compatibility of these beam lines, vacuum acceptance tests of various prototypes and first of series of vacuum components are carried out before installation to the accelerator. This work will present some of the latest results of the vacuum acceptance tests for HEBT vacuum tubes produced in-house at GSI, the first of series of SFRS Slit vacuum parts and SFRS multiplet vacuum tubes.

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Wednesday Poster Session / 408

Comparison of WarpX and GUINEA-PIG for electron positron collisions

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As part of the Snowmass'21 planning exercise, the Advanced Accelerator Concepts community proposed developing multi-TeV linear colliders and considered beam-beam effects for these machines [1]. Such colliders operate under a high disruption regime with an enormous number of electron-positron pairs produced from QED effects. Thus, it requires a self-consistent treatment of the fields produced by the pairs, which is not implemented in state-of-the-art beam-beam codes such as GUINEA-PIG. WarpX is a parallel, open-source, and portable particle-in-cell code with an active developer community that models QED processes with photon and pair generation in relativistic laser-beam interactions [2]. However, its application to beam-beam collisions has yet to be fully explored. In this work, we benchmark the luminosity spectra, photon spectra, and the recently implemented pair production processes from WarpX against GUINEA-PIG in ultra-tight collisions, ILC,

and C^3 scenarios. This is followed by a run-time comparison to demonstrate the speed-up advantage of WarpX. Ultimately, this work ensures a more robust modeling approach to electron-positron collisions, with the goal of scaling up to 15 TeV.

Footnotes:

[1] T. Barklow et al. Journal of Instrumentation 18, P09022 (2023).
[2] L. Fedeli et al. 2022 SC22: International Conference for High Performance Computing, Networking, Storage and Analysis (SC). IEEE Computer Society 2022.

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Monday Poster Session / **409**

Formulas of coherent synchrotron radiation induced microbunching instability in an arbitrary four-dipole chicane bunch compressor

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Almost all linac-based free-electron laser (FEL) facilities have employed a symmetric three- or four-dipole chicane to compress the electron beam in order to achieve a kA-level bunch current. The achromatic C-type chicane has been widely used in present linac-FEL facilities. Coherent synchrotron radiation (CSR) induced microbunching instability (MBI) can be an issue in the chicane design. Recently a novel design of non-symmetric four-dipole chicane has been proposed to effectively mitigate the CSR-induced emittance growth. In this work we derive an analytical formula of the CSR-induced microbunching gain in a generic four-dipole chicane based on the iterative approach. The formulas have been benchmarked against semi-analytical Vlasov calculation, applied for a quick estimate of CSR-induced MBI for a generic four-dipole achromatic chicane beamline, and can be used to verify the effectiveness of suppressing MBI in a non-symmetric S-type four-dipole bunch compressor chicane.

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Monday Poster Session / 410

Particle tracking simulation and semi-analytical Vlasov calculation of CSR induced microbunching instability in a non-symmetric S-type four-dipole bunch compressor chicane

Author: Bingxi Liu[1]

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Corresponding Author: lbx@hust.edu.cn

Coherent synchrotron radiation (CSR) induced microbunching instability (MBI) has been an issue in the multi-bend design for a single-pass high-brightness electron beam transport. Recently a novel design of a non-symmetric four-dipole bunch compressor chicane has been proposed to effectively mitigate the CSR-induced emittance growth, compared with the symmetric C-type chicane widely used in present linac-FEL facilities. In this paper we perform a particle tracking simulation of the CSR-induced microbunching instability in a generic four-dipole chicane using ELEGANT. The results are compared and found consistent with the semi-analytical Vlasov calculation. The results provide a solid support for effectiveness of suppressing MBI in a non-symmetric S-type four-dipole bunch compressor chicane.

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Tuesday Poster Session / 411

The status of X-ray beam position monitor in TPS front end

Author: Chia-Mu Cheng[1]

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The X-ray beam position monitor (XBPM) with APS blade type has been installed on TPS front end system. Most XBPMs in the insertion device beamline front end have been calibrated and functioning. The stability and resolution of XBPM will be introduced and discussed in the article. The problems encountered will also be mentioned.

Footnotes:

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Asia

THBN: Accelerator Technology and Sustainability (Contributed) / 412

Advancements in superconducting undulator technology: deployment of the first Nb3Sn-based SCU at the Advanced Photon Source

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Co-authors: Stephen MacDonald [1]; Matthew Kasa [1]; Joel Fuerst [1]; Jeffrey Dooling [1]; Louis Emery [1]; Maofei Qian [1]; Daniele Turrioni [2]; Emanuela Barzi [2]; Sarvjit Shastri [1]; Vadim Sajaev [1]; Alexander Zlobin [2]; Yury Ivanyushenkov [1]; Joseph Xu [1]; Efim Gluskin [1]

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A state-of-the-art Nb3Sn-based Superconducting Undulator (SCU) has been designed and built at the Advanced Photon Source (APS) of Argonne National Laboratory in collaboration with Fermi and Berkeley National labs. Following the successful completion of its commissioning phase, this SCU in February 2023 began delivering high energy x-ray beam to APS users. The successful realization of the Nb3Sn-based SCU paves the way for short-period, high-field undulators that greatly benefit current and future light sources. The presentation will provide details on the fabrication, magnetic characterization, installation and commissioning of the APS Nb3Sn SCU.

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North America

Thursday Poster Session / 414

EPICS communication structure based on a SoC FPGA board

Author: ChongYue Li[1]

Co-authors: Fu-Yu Chang [1]; Zong-Kai Liu [1]

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In the radio frequency system of a synchrotron accelerator, precise modulation of signals in the radio frequency cavity is crucial for achieving a stable acceleration electric field. The National Synchrotron Radiation Research Center's (NSRRC) Taiwan Photon Source (TPS) underwent a significant upgrade in 2019, transitioning from analog to digital control for the low-level radio frequency system. This upgrade enhances noise resistance and enables more precise control. Within the NSRRC's digital low-level radio frequency control system, a Field-Programmable Gate Array (FPGA) serves as the core, interfacing with a Raspberry Pi through GPIO to connect to the Experimental Physics and Industrial Control System (EPICS). This article outlines the implementation of a SoC FPGA, constructing a Linux OS within the Hardware Process Structure (HPS), and establishing direct communication with EPICS.

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Asia

Thursday Poster Session / 415

Enhanced harmonic stability in magnet resonant power supplies via multi-harmonic closed-loop control and current feedforward

Author: Ran Li[1]

Co-authors: Jun Li [2]; Guodong Zhao [1]; Xin Qi [3]; Wenqing Zhang [3]; Yuntao Liu [1]; Yuan Huang [2]

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As the China Spallation Neutron Source (CSNS) Phase II project upgrades beam power to 500 kW, maintaining horizontal beam orbit stability necessitates more precise output current from the main magnet power supplies. The existing control strategy, suited for 100 kW extraction power, falls short of the higher precision requirements for the output current, characterized by a quasi-sinusoidal waveform with 25 Hz and its higher-order harmonics. Moreover, this strategy is highly sensitive to environmental temperature, causing significant fluctuations in the amplitude and phase of the high-order harmonics, thereby adversely affecting the power supplies' performance.
This paper proposes a new control scheme that merges high-order harmonic current compensation

with double PI closed-loop control, enabling up to sixth harmonic control in the main magnet power supplies. Leveraging the existing Digital Power Supply Control Module (DPSCM) controller in the power supply system, this approach achieves precise and efficient control of the 50 Hz harmonic current output which was previously the source of the largest ripple error.
The study confirms that the new control scheme effectively mitigates temperature drift issues and reduces the output ripple of the entire 50 Hz reference current waveform. As a result, the performance of the main magnet resonant power supplies in Rapid Cycle Synchrotron is significantly enhanced, leading to a marked reduction in the variation of beam orbit deviation.

Footnotes:

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Asia

Monday Poster Session / **416**

Polarization preservation methods for the electron storage ring of the EIC

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Co-authors: Yunhai Cai [2]; Anna Elizabeth Connelly [3]; Eliana Gianfelice-Wendt [4]; Georg Hoffstaetter [1]; Jorg Kewisch [5]; Daniel Marx [5]; Christoph Montag [5]; Vadim Ptitsyn [6]; Steven Tepikian [5]

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The Electron Storage Ring (ESR) of the Electron-Ion Collider (EIC) to be built at Brookhaven National Laboratory will provide spin-polarized electron beams at 5, 10, and 18 GeV for collisions with polarized hadrons. Electron bunches with polarization parallel and anti-parallel to the arc dipole fields will co-circulate in the ring at the same time, and each bunch must be replaced once it is sufficiently depolarized by synchrotron radiation. In this work, we detail the unique challenges posed by designing such a collider ring to operate at different energies, and their solutions. This includes satisfying spin matching conditions, calculating optimal energies for polarization, determining best figures-of-merit, and correcting the spin match with optimized closed orbit distortions even where a longitudinal spin match is not feasible. Finally, we show that polarization requirements are exceeded in nonlinear tracking results of the ESR including magnet errors, beam-beam effects, crab cavities, and vertical emittance creation for beam size matching at the interaction point.

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North America

Wednesday Poster Session / 418

Monte Carlo study of electron energy losses and stoichiometry effects in thin cesium antimonide photocathodes

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Cesium antimonide photocathodes are known for their ability to generate bright electron beams for various accelerator applications. Lab-grown polycrystalline cesium antimonides as well as Cs1Sb and Cs3Sb crystals are distinguishable; however, it remains unclear how the crystalline and other material properties of each govern the main photocathode properties such as quantum efficiency and mean transverse energy. Furthermore, photoexcited electrons undergo significant energy losses before being emitted from thin cesium antimonide films. This process is not well understood since there is very little room for scattering events within thin films. The generation of ultra-bright electron beams, capable of substantially enhancing the scientific potential of advanced accelerator applications, requires deep understanding of these and other fundamental mechanisms, which constrain photocathode performance and simultaneously determine the maximum attainable beam brightness. The purpose of this work is to use the Monte Carlo approach in a combination with Density Functional Theory to shed light on these mechanisms and provide the guidance for effective photocathode optimization.

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North America

Wednesday Poster Session / 419

The first FCC-ee final focus quadrupole prototype

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A first FCC final focus quadrupole prototype has been designed, constructed and tested. The prototype is of a Canted Cosine Theta type using a NbTi conductor with novel features like edge compensation and wax impregnated. It has an aperture of 40 mm and a field gradient of 100 T/m. In this paper we recall the main design features and report on the test results on field quality and the powering campaign.

Footnotes:

Funding Agency:

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Europe

Monday Poster Session / 420

Fabrication and low-power testing of an X-band mode convertor for VIGAS

Author: Fangjun Hu[1]

Co-authors: Jiaru Shi [1]; An Li [1]; Hao Zha [1]; Boyuan Feng [1]; Hongyu Li [1]; Jian Gao [1]; Huaibi Chen [1]

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A new X-band mode convertor for the Very Compact Inverse Compton Scattering Gamma-ray Source (VIGAS) program in Tsinghua University has been fabricated and conducted low-power testing. S11 is under -30dB with -0.05dB of S21 at the operating frequency of 11.424GHz according to the low-power test using the vector network analyzer, which is consistent with simulation results.

Footnotes:

Funding Agency:

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Asia

Tuesday Poster Session / 421

A pole design optimization method for permanent quadrupole magnet

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Permanent quadrupole magnet (PQM) has good physical properties and extremely high economic performance, which can be used in proper physical design to adjust the central magnetic field gradient and at the same time greatly reduce the operating cost of modern gas pedals, but the design and optimization of the PQM's pole is still a difficult problem that needs to be solved at present. We hope to expand the range of the permanent magnet quadrupole's good field area, lower its high harmonic order of magnitude, and create a permanent magnet quadrupole magnet with a better magnetic field quality by applying new optimization algorithms.

Footnotes:

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Asia

Tuesday Poster Session / 422

Modern electron beam diagnostic techniques based on LOCO and feed forward artificial neural networks.

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National Synchrotron Radiation Center SOLARIS operates a third-generation synchrotron light source located in Krakow, Poland. It is the only operator of synchrotron light source in Poland. SOLARIS accelerator complex consists of a linear accelerator, 1.5 GeV storage ring with 96 m circumference, six operating beamlines and three more under construction. The storage ring accelerates the electron beam from injection (approx. 550 MeV) to its final 1.5 GeV energy and stores the circulating electron beam for approximately 13 hours on a stable orbit providing beamlines access to the synchrotron radiation used for research around the world for low to tender gamma energy range.
The beam stability and reproducibility are of great interest for the light source facilities. Beam stability is characterized in 6-D phase space: (x, x′, y, y′, E, t), where x, x′, y, y′ are the transverse position and divergence of the beam whereas the E, t is related with the longitudinal coordinates beam energy and time. In the first part of this presentation results of diagnostic measurement methods based on loco runs for various beam conditions will be discussed. In the second part concepts and implementations of anomaly detection techniques, neural network forecasting based on Long short-term memory (LSTM) and Bayesian integrated in Tango will be presented with emphasis on the usage of GPU for computation speed up.

Footnotes:

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Europe

Wednesday Poster Session / 423

A life cycle assessment of the ISIS-II neutron and muon source

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The ISIS-II Neutron and Muon source is the proposed next generation of, and successor to, the ISIS Neutron and Muon Source based at the Rutherford Appleton Laboratory in the United Kingdom. Anticipated to start construction in 2031, the ISIS-II project presents a unique opportunity to incorporate environmental sustainability practices from its inception.
A Life Cycle Assessment (LCA) will examine the environmental impacts associated with each of the ISIS-II design options across the stages of the ISIS-II lifecycle, encompassing construction, operation, and eventual decommissioning. This proactive approach will assess all potential areas of environmental impact and seek to identify strategies for minimizing and mitigating negative impacts, wherever feasible. This presentation will provide insights into the process and first results of the LCA of the entirety of the ISIS-II project.

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Europe

Monday Poster Session / 424

Empirical modeling of the photocurrent time-dependence in co-deposition activation procedures for GaAs photocathodes

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GaAs-based photocathodes can provide electron beams with high spin-polarization. In order to be used in a photo-gun for high-current applications such as energy-recovery linacs and colliders, the quantum efficiency as well as the lifetime of the photocathode needs to be as high as possible. Both

parameters depend on the quality of the thin layer that is applied to the photocathode surface during the so-called activation process in order to create negative electron-affinity conditions for optimal photoemission. Hence, it is of great interest to optimize and standardize this procedure in order to provide the best possible photocathode performance for accelerator applications.
For an automatization of the activation process it is necessary to model the photocurrent as a function of time during the process. To this end, activations of bulk-GaAs using Cs and O, conducted at the Photo-CATCH test stand, were analyzed using an empirical model function. This contribution presents the results of the analysis and its implications regarding the influence of the activation process on the performance of the activated photocathode.

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Wednesday Poster Session / 426

Gas jet dosimeter measurements at DCF for medical accelerator applications

Author: Narender Kumar[1]

Co-authors: William Butcher [1]; Milaan Patel [2]; Oliver Stringer [1]; Alexander Webber-Date [1]; Joseph Wolfenden [1]; Hao Zhang [1]; Carsten Welsch [2]

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Achieving non-invasive in-vivo dosimetry is a critical objective in the field of ion beam therapy. The comprehensive real-time characterization of the ion beam is highly desirable to ensure the safety of patients, treatment precision, and the efficiency of the treatment facility. However, current methods have limitations in terms of the information they provide and can be invasive to the beam.
This contribution focuses on the development of a non-invasive, gas jet-based in-vivo dosimeter for use in treatment facilities. This technique relies on a non-disruptive interaction of a low-density supersonic gas jet curtain with the primary treatment beam. An existing gas jet monitor-based ionization profile monitor was modified and coupled with the accelerator beamline at the Dalton Cumbrian Facility (DCF), UK (United Kingdom). The aim of the test was to conduct proof-of-concept measurements for the profile and dosimetry of beams having characteristics similar to the medical treatment facilities. Measurements were carried out for proton and carbon beams of varied sizes, energies, and currents. The results obtained from these measurements demonstrated the feasibility of such a dosimeter and are instrumental for its improvement.
This contribution introduces the design of the adapted gas jet dosimeter, discusses the findings from the measurements, highlights the dosimetry challenges addressed and outlines the scope of improvement for an online non-invasive gas jet in-vivo dosimeter.

Footnotes:

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Thursday Poster Session / 427

Dimensional and thermal design of the electrostatic chopper for the new ISIS MEBT

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Co-authors: Jonathan Speed [1]; Scott Lawrie [1]

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The electrostatic chopper for the new ISIS MEBT is a fast deflecting device to create gaps in the beam coming out of the RFQ, which will improve the trapping efficiency when injecting the beam into the ISIS synchrotron. The electromagnetic design of the chopper was initially developed to define its functional specifications, shape and dimensions, and it was presented elsewhere. A dimensional sensitivity study was developed to estimate the maximum acceptable thermal loads due to the beam loss (used later in the thermal model) and to ensure that the electric field shape and strength were still valid. Dimensional tolerances were defined based on the sensitivity study. Thermal calculations and models were required to ensure that the electrodes were properly cooled for the expected beam loss in the diverse working and failure situations, and to ensure that the hot beam dump inside the chopper was not indirectly overheating the electrodes. The mechanical design and manufacturing were carried out according to the results from the previous analyses, and the details are presented elsewhere.

Footnotes:

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Europe

Thursday Poster Session / 428

Design of a spin rotator for the ISIS Super-MuSR beamline

Author: Iker Rodriguez[1]

Co-authors: Davide Reggiani [2]; James Lord [1]; Jonathan Cawley [1]; Thomas Rauber [2]

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The spin rotators (SR) are DC electromagnetic devices that produce a homogeneous magnetic field to rotate the spin of the muons in flight, which is counterbalanced by a matched perpendicular electric field to avoid the bending of the muon beam trajectory. Two identical SR will be used in the new Super-MuSR beamline to rotate the muon spin by up to 34° per device relative to the beam direction, enabling higher transverse field muon measurements and other experiments not currently possible in the ISIS MuSR beamline. The fundamental design of the SR is shown in this paper, both for the magnet and the high voltage vessel. The optimization of the electric and magnetic fields shape and strength is presented including fundamental hand calculations, 2D/3D models and beam tracking simulations. The high voltage feedthroughs and the electrode insulating supports were thoroughly designed to reduce the breakdown probability. A sensitivity study was also developed to estimate the manufacturing tolerances, but it is not presented in this paper.

Footnotes:

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Europe

Thursday Poster Session / 429

Towards mitigation of challenges in development of high power ISOL targets

Author: Sundeep Ghosh[1]

Co-authors: Alexander Gottberg [1]; Carla Babcock [1]; Luca Egoriti [1]; Tobias Junginger [1]

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Worldwide Isotope Separation On-Line (ISOL) facilities face growing demand for producing and extracting high-purity exotic radioactive ion beams to serve nuclear physics, astrophysics and medical applications. In this technique, a particle beam interacts with a suitable target material to produce the desired isotopes through a combination of mechanisms like spallation, fragmentation and fission. TRIUMF has the world's highest-power ISOL facility—ISAC, handling 50 kW of proton beam power. The formidable challenge is to suitably handle the power deposited within the target material and maintain it at 2000℃ to optimize the diffusion and effusion of the radioactive products. The intricacy of this design requires precise knowledge of the thermal properties of the target material. Typically, a blend of metallic carbide and graphite, these targets exhibit varying porosity and morphology and have effective thermal properties differing from individual constituent elements. To investigate these properties, a combined numerical-experimental approach is employed. This contribution discusses the optimization of target material sample size using numerical tools and outlines the exploration of thermal properties using an experimental apparatus, the Chamber for Heating Investigations (CHI), developed at TRIUMF.

Footnotes:

Funding Agency:

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Region represented:

North America

Tuesday Poster Session / **430**

Influence of reduced baking time of Taiwan photon source front-end system on dynamic pressure

Author: Chin Shueh[1]

Co-authors: Yuan-Ming Hsiao [1]; Bo-Ying Chen [1]; Yu Tsun Cheng [1]; Chia-Mu Cheng [1]; Yan-Hong Guo [1]; Yi-Chen Yang [1]; Che-Kai Chan [1]; Chin-Chun Chang [1]

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The Taiwan photon source (TPS), a synchrotron accelerator at the National Synchrotron Radiation Research Center in Taiwan, is a third-generation accelerator operating at 3 GeV that was designed to create a high energy photon source. The TPS front-end (FE) systems are located between the storage ring and beamline, which was designed to protect the safety of users as well as control experimental requirements. As the FE vacuum pressure influences the storage ring and beamline vacuum pressures, the FE vacuum systems must maintain a low dynamic pressure. Therefore, at the beginning of FE system construction, each FE vacuum system is baked at 200℃ for 24 hours. Next, when the FE systems need to be upgraded or maintained lead to vacuum interventions, it must also be baked for 24 hours to recover a low dynamic pressure. However, the 24 hour baking process requires manpower support on-site owing to facility safety in the TPS tunnel. The maintenance of the FE systems takes two duty days. Therefore, reducing baking time is necessary in the TPS facility. The beam cleaning efficiency after reduced baking time has been described in this paper.

Footnotes:

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Asia

Tuesday Poster Session / **431**

Pumping characteristics of Zr and TiZrV getter films

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Co-authors: Yuan-Ming Hsiao [1]; Bo-Ying Chen [1]; Che-Kai Chan [1]; Chin-Chun Chang [1]

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NEG coatings is widely used in many accelerators due to its provide sufficiently low pressure in the beam pipe during machine operation. The single zirconium wire target is easy to apply for small diameter pipe coating compare to TiZrV twist wire target. In this study, Single metal Zr thin film and TiZrV were deposits on stainless steel pipe with inner diameter of 20mm and a length of 500mm using pulsed DC and DC mode. The Test Particle Monte-Carlo (TPMC) models were used to check Zr and TiZrV thin film pumping properties for interpreting the results of the measurements in the experimental setup.

Footnotes:

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Asia

Tuesday Poster Session / 432

Optical cavity status for SSMB at Tsinghua

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A novel mechanism, known as steady-state microbunching (SSMB), is anticipated to produce light with high peak brilliance and a high repetition rate by integrating the characteristics of free electron lasers and synchrotron radiation facilities. This paper presents the status of a high-finesse prototype optical enhancement cavity designed for SSMB, achieving an average power of 55 kW. The cavity finesse, measured through both the decay-time method and the EOM-based frequency modulation method, is approximately 16,000. The phenomenon of thermal-induced modal degeneracy is observed, and the mitigation of modal instability is successfully achieved through the implementation of a pair of D-shaped mirrors. The average absorption coefficient of the cavity mirrors is estimated to be 12 ppm by fitting the size of the thermal-induced evolution of the cavity fundamental mode in experiments. The intra-cavity average power reaches 55 kW, limited by the high absorption coefficient.

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Monday Poster Session / 433

Numerical methods for emittance computation from luminosity

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The beam transverse emittances play a critical role in high-energy colliders. Various measurement techniques are employed to measure them. In particular, the so-called luminosity emittance scans (or Van der Meer scans) are used in order to evaluate the convoluted beam emittances. This method assumes different emittances in the two planes but identical emittances in the two beams. In this paper, we propose an approach to remove this constraint. After having presented the new measurement protocol, we will discuss its potential and limits, including the statistical measurement error of the luminosity value as obtained from numerical studies.

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Wednesday Poster Session / 434

Bmad-julia: a julia environment for accelerator simulations including machine learning

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Bmad-Julia is a new, open-source software project for modern accelerator simulations with an emphasis on Machine Learning. As compared to existing accelerator codes, reverse differentiability, e.g. for the optimization of neural networks, will be embedded. Multiple standalone Julia packages are being developed that provide fundamental tools and methods commonly needed in accelerator simulations, it is envisaged that Bmad-Julia will be able to serve as the basis for developing new programs to meet the ever changing simulation requirements of high energy machines. By avoiding the necessity of "reinventing the wheel", programs that make use of Bmad-Julia packages can be developed in less time and with fewer bugs than programs developed from scratch.

Included will be a package for accelerator lattice instantiation and bookkeeping, a package for handling physical and atomic constants, and a package for truncated Power Series Algebra (TPSA) with routines for manipulations and analysis including map inversion, partial map inversion, normal form decomposition, Poisson bracket, etc. Ultimately, all features of today's versatile Bmad toolkit will be transferred, including polarized beams, radiation effects, beam scattering, symplectic tracking, and long-term dynamics. Discussed is the present state of the project as well as plans for the future.

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Wednesday Poster Session / 435

High power conditioning of the prototype power coupler for CSNS-II spoke cavity

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The prototype fundamental power coupler (FPC) and superconducting spoke cavity for the China Spallation Neutron Source upgrade project (CSNS-II) were manufactured before January 2023. To validate functionality, the FPC must undergo high power conditioning process prior to its assembly with the cavity. However, the high power conditioning process is quite complicated, it involves aspects like clean processing and assembly in the clean room, ultra-high vacuum acquisition, S parameter measurement and adjustment, cooling and monitoring conditions arrangement, test platform integration, and so on. In this paper, we will describe the complete process from receipt to test completion, and some problems encountered are also outlined. Finally, the FPC is high power conditioned to a peak power of 400 kW with a 3% duty factor in traveling wave mode and 75 kW with a pulse length of 1.2 ms (25 Hz repetition rate) in standing wave mode with 16 different reflection wave phases, it fully satisfies the requirement of spoke cavities for CSNS-II —200 kW peak power with 3% duty factor.

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Asia

Monday Poster Session / 436

Machine interlock system for accelerator section in PAL-XFEL

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Laser, MPS, Modulator, Vacuum, LLRF, etc. are installed at the Pohang Accelerator Laboratory-XFEL linac section. Each device must be protected against emergency situations. When an interlock signal occurs in the XFEL linac section of Pohang Accelerator Research Institute, the beam shutter is closed using the PLC and the operation of each device is blocked. We used an Emerson PLC and connected the interlock signal to each device with a cable to the terminal block.
The operating status of devices required for accelerator operation is displayed on the driver's cabin HMI, providing the driver with the information necessary for accelerator operation, and storing changed status data in real time. If the MIS is abnormal, beam operation is impossible, so the CPU and communication are each configured as redundant.

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Tuesday Poster Session / 437

Fundamental power couplers development at CSNS campus

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The China Spallation Neutron Source (CSNS) project is now operating stable at the CSNS campus and the upgrade work (CSNS-II) has already started in 2023, meanwhile, the preliminary research work on the south advance photon source (SAPS) project is in progress. More than six types of accelerator cavities: radio frequency quadrupole (RFQ), drift tube linac (DTL), double spoke superconducting cavities, elliptical superconducting cavities, Debuncher and C band traveling wave structure, and so on in these projects, requiring corresponding different fundamental power couplers (FPCs). These FPCs are divided into waveguide and coaxial types. Different coaxial FPCs are chosen for the superconducting cavities and RFQ, while waveguide FPCs are chosen for the DTL, Debuncher, and traveling wave structure as they need a high peak power. In this paper, we will review the FPCs development at the CSNS campus. The basis for selection, design considerations, operating or testing results, etc. will be all detail described in this paper.

Footnotes:

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Asia

Monday Poster Session / 439

An open-source Python tool for the Maxwell eigenvalue problem and multipacting analysis in axisymmetric elliptical cavity structures

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Multipacting is a phenomenon arising from the emission and subsequent multiplication of charged particles in accelerating radiofrequency (RF) cavities, which can limit the achievable RF power. Predicting field levels at which multipacting occurs is crucial for optimizing cavity geometries. This paper presents a new open-source Python code for analyzing multipacting in 2D axisymmetric cavity structures.
The code leverages the NGSolve framework to solve the Maxwell Eigenvalue Problem (MEVP) to obtain the cavity's resonant modes' electromagnetic fields. The relativistic Lorentz force equation governing the motion of charged particles is then integrated using the fields within the cavity. Benchmarking against existing multipacting analysis tools is performed to validate the code's accuracy and efficiency. The open-source nature of the code fosters further development and customization for specific applications.

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Thursday Poster Session / 440

An experimental study on plasma cleaning of room temperature copper cavity: design and analysis

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The development and standardization of in-situ plasma cleaning for superconducting radio frequency (SRF) cavities have a well-established history. This technique has demonstrated efficacy in reducing dark current and electron multiplication, thereby enhancing the acceleration gradient and stability of SRF devices. However, applying in-situ plasma cleaning to normal-temperature copper (NTC) cavities presents a unique challenge due to the absence of defined parameters, processes, and experimental data. Unlike SRF cavities, NTC cavities face difficulty removing surface oxide to increase the work function. Addressing this challenge, Tsinghua University conducted a study to investigate the application of argon-oxygen plasma for the removal of organic matter, gas, and burrs, and argon-hydrogen plasma to reduce copper oxide on NTC cavities specifically. The findings from this research contribute valuable insights that can serve as a guide for the effective implementation of in-situ plasma cleaning in NTC cavities.
This paper is only for experimental results and data analysis. The related plasma physics formulas and COMSOL calculation results will be presented in future papers.

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Wednesday Poster Session / 441

Fermilab Booster beam emittances from quadrupole modes measured by BPMs

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The measurement of beam emittances by extracting the quadrupole mode signal from a 4 plate BPM was published at least 40 years ago. Unfortunately, in practice, this method suffers from poor signal to noise ratio and requires a lot of tuning to extract out the emittances. In this paper, an improved method where multiple BPMs are used together with better mathematical analysis is described. The BPM derived emittances are then compared with those measured by the Ion Profile Monitor (IPM). Surprisingly, the BPM measured emittances behave very well and are more realistic than those measured by the IPM.

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Thursday Poster Session / 442

Design and commissioning of a high-level control system for a medical isochronous cyclotron

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MEDICYC (MEDical CYClotron) is an isochronous cyclotron dedicated to radiotherapy which was built and commissioned in Nice, France, in 1990 by a local team aided by experts from CERN. The cyclotron accelerates H- to a maximum energy of 65 MeV and uses stripping to extract a proton beam. Its primary purpose is treating ocular melanoma by protontherapy but a significant research activity is also present on beam-lines dedicated for this purpose.
An extensive refurbishment program of the cyclotron has been started to cope with the end-of-life and/or the obsolescence of several sub-systems. In this context, a new high-level cyclotron control system has been developed and implemented in 2021-2023. The primary responsibility of the system is the high-level coordination of the H- source, the RF system and the beam-line and cyclotron magnets to produce and deliver a beam with a given set of characteristics. A secondary responsibility is the collection, visualization and analysis of sub-system and beam data for monitoring and pre-emptive fault detection.
In this contribution, the control system software architecture is presented and the infrastructure on which the systems are deployed is laid out.

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Monday Poster Session / 443

Transfer learning for field emission mitigation in CEBAF SRF cavities

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The Continuous Electron Beam Accelerator Facility (CEBAF) operates hundreds of superconducting radio frequency (SRF) cavities in its two linear accelerators (linacs). Field emission (FE) is an ongoing operational challenge in higher gradient SRF cavities. FE generates high levels of neutron and gamma radiation leading to damaged accelerator hardware and a radiation hazard environment. During machine development periods, we performed invasive gradient scans to record data capturing the relationship between cavity gradients and radiation levels measured throughout the linacs. However, the field emission environment at CEBAF varies considerably over time as the configuration of the radio-frequency (RF) gradients changes or due to the strengthening of existing field emitters or the abrupt appearance of new field emitters. To mitigate FE and lower the radiation levels, an artificial intelligence/machine learning (AI/ML) approach with transfer learning is needed. In this work, we mainly focus on leveraging the RF trip data gathered during CEBAF normal operation. We develop a transfer learning based surrogate model for radiation detector readings given RF cavity gradients to track the CEBAF's changing configuration and environment. Then, we could use the developed model as an optimization process for redistributing the RF gradients within a linac to mitigate field emission.

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North America

Wednesday Poster Session / 444

Characterization and optimization of a C-band photoinjector for inverse Compton scattering radiation sources

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We performed an optimization study of a C-band photoinjector for high brightness electron beams. Such a device is capable of producing high quality electron beams, with low energy spread and small transverse emittance, which are properties required by Inverse Compton Scattering radiation sources and compact light sources in general. This work aimed to carry out, via numerical simulations, an optimization of the beam generated by such photoinjector, in the pursuit of its real application in the context of current projects, namely EuPRAXIA@SPARC_LAB*, and proposals such as BoCXS** at the University of Bologna.

Footnotes:

- M. Ferrario et al., Design study towards a compact FEL facility at LNF EuPRAXIA@SPARC_LAB, arXiv, (2018). ** M. Placidi, et al., BoCXS: A compact multidisciplinary X-ray source, Physics Open, (2020).

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Tuesday Poster Session / 446

Magnetic field simulation of a planar superconducting undulator for the FEL demonstrator

Author: Yuko Shiroyanagi[1]

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An Argonne-SLAC collaboration is working on the design of a superconducting undulator (SCU) demonstrator for a free-electron laser (FEL)*. A SCU magnetic structure consisting of a 1.5-m-long planar SCU magnet, and a superconducting phase shifter have been designed. A novel three-groove correction scheme has been implemented for the SCU magnet. A compact four-pole phase shifter with magnetic shields was also designed. This paper presents the calculations of the magnetic performance of the phase shifter and a planar SCU magnet, which include magnetic field and field integrals with end corrections.

Footnotes:

- D. C. Nguyen et al., "Superconducting Undulators and Cryomodules for X-ray Free-Electron Lasers"in Proc. 5th North American Particle Accelerator Conf. (NAPAC2022), Albuquerque, NM, USA, August 2022, pp. 870 –873. doi:10.18429/JACoW-NAPAC2022-THYE3

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Thursday Poster Session / 447

Development of a special power supply for the injector of compact X-ray source

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Development of a special power supply for the injector of compact X-ray source.

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Monday Poster Session / 448

Construction progress of THz-FEL for NFTHZ

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Superconductors, multiferroic materials, and giant magnetoresistance are the key to the information, energy, and optoelectronic industries. In the terahertz band, their common characteristics are related to the terahertz complex optical constant, and they also strongly interact with ultrafast terahertz waves, resulting in many fascinating physical phenomena. This paper will introduce an accelerator-based terahertz radiation source for a high-throughput material physical property measurement system. The method of a laser-modulated electron beam is adopted in this accelerator to generate tunable terahertz light in the frequency range of 0.5-5 THz.

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Monday Poster Session / 449

Design and development of array multipoint accelerator tube

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Linear accelerators with multiple ray sources are widely used in detection imaging technology. In this paper, an S-band multipoint source traveling wave accelerator tube is designed and developed. The accelerator tube consists of 8 parallel-arranged accelerator cavity units and uses a power source to output 8 X-ray beams alternating from different positions. The acceleration tube operates at S-band 2998 MHz. In this paper, the physical design of the accelerator tube is introduced, the dynamic design of the accelerator tube is completed by numerical calculation, and the verification calculation is carried out by PARMELA. After machining, the cold test tuning and high power beam test are carried out. The beam energy range is between 0.5 and 1 MeV, and 8 beams can be switched arbitrarily.

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Tuesday Poster Session / 450

A data science and machine learning platform supporting large particle accelerator control and diagnostics applications

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Osprey DCS is developing the Machine Learning Data Platform (MLDP) supporting data science applications specific to large particle accelerator facilities and other large experimental physics facilities. It represents a "data-science ready"host platform providing integrated support for advanced data science applications used for diagnosis, modeling, control, and optimization of these facilities. There are three primary functions of the platform: 1) high-speed data acquisition, 2) archiving and management of time-correlated, heterogeneous data, and 3) comprehensive access and interaction with archived data. The objective is to provide full-stack support, from low-level hardware acquisition to broad data accessibility within a portable, standardized platform offering a data-centric interface for accelerator physicists and data scientists. Osprey DCS has developed a working prototype MLDP* and is now pursuing full-scale development. We present an overview of the MLDP including use cases, architecture, and deployment, along with the current development status. The MLDP is deployable at any facility, however, the low-level acquisition component is EPICS based.

Footnotes:

- C. K. Allen, B. Dalesio, G. McIntyre, C. McChesney and M. Davidsaver, "Machine Learning Data Platform", Report TM-01-2032 Osprey DCS, January 10, 2023.

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Thursday Poster Session / 451

Numerical analysis on a modified air conditioning system of the experimental hall at TPS

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It has been seven years since the Taiwan Photon Source (TPS) started to serve users in 2016. Sixteen beamlines had been installed in the first and second phases of TPS beamline project. The third phase project was also launched in 2021. Considering the experimental hall is more compact and power saving issue, our research aimed to analyze a modified air conditioning system with better cooling efficiency through Computational Fluid Dynamic (CFD) simulation. One twelfth of the TPS experimental hall and two beamlines are modeled.

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Thursday Poster Session / 452

Improved beam loss accounting with fast data acquisition (DAQ) chassis

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Identifying the source of beam loss events in the CEBAF accelerator can be a challenging task. Determining whether an RF cavity with an unannounced gradient or phase transient is the culprit would be a valuable tool for operations staff in addressing recurring beam loss incidents. A prototype offline system was developed in the fall of 2022, utilizing a dispersive beam position monitor (BPM) and the existing switched electrode electronics BPM hardware. A commercial off-the-shelf data acquisition (DAQ) system was employed to capture BPM wire signals at a sample rate of 20 kS/s. The system was triggered by the fast shutdown signal, which disables the beam at the injector. Analysis of beam position and energy variation before a beam loss event was used to determine if the beam loss event was associated with an energy transient. The prototype system, implemented using National Instruments hardware and LabVIEW software, relied on a software trigger. Manual post-processing was required to ascertain whether the fault was due to an un-tripped cavity with a gradient or phase transient. This work presents a production-quality system that utilizes the same data acquisition hardware developed and installed in CEBAF to monitor the time domain RF control signals in the legacy analog RF systems. As the new system employs a hardware trigger, developing tools to automatically identify faults linked to energy transients unrelated to cavity faults will be straightforward.

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North America

Wednesday Poster Session / 453

Developing nested auto-differentiation tracking code for beam dynamics optimization

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An innovative particle tracking code is in development using the Julia programming language, utilizing the power of auto-differentiation (AD). With the aid of specifically designed truncated power series algebra (TPSA) methods and built-in Julia AD packages, this code enables automatic calculation of derivatives with respect to selected parameters of interest. This tracking code provides a flexible and powerful solution for accelerator physicists applicable across various research topics, especially for beam dynamics optimization works.

Footnotes:

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North America

Tuesday Poster Session / 454

Machine learning enabled model predictive control of the FRIB RFQ

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Efficient control of frequency detuning for the radio-frequency quadrupole (RFQ) at the Facility for Rare Isotope Beams (FRIB) is still challenging. The transport delay and the complicated heat transfer process in the cooling water control system convolute the control problem. In this work, a long-short term memory (LSTM)-based Koopman model is proposed to deal with this time-delayed control problem. By learning the time-delayed correlations hidden in the historical data, this model can predict the behavior of RFQ frequency detuning with given control actions. With this model, a model predictive control (MPC) strategy is developed to pursue better control performance.

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North America

Thursday Poster Session / 455

Impedance model for the Fermilab Recycler ring

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We present an impedance model of the Fermilab Recycler ring using PyHEADTAIL. The model is constructed by incorporating analytical expressions for the wakefields of beamline components that contribute significantly to impedance. The effects of indirect space charge are included as an inductive impedance. Benchmarking against measured coherent Betatron tune shifts, the impedance model is found to capture 73.4% of observed tune shifts. Our findings serve as a stepping stone for the development of a realistic impedance model crucial for studying impedance-driven instabilities at higher intensity.

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Europe

Monday Poster Session / 456

Generation of attosecond electron bunches through terahertz regulation

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Co-authors: Renkai Li [1]; Yingchao Du [1]; Zhichao Dong [1]; Han Chen [1]

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Obtaining ultrashort electron bunches is the key to the studies of ultrafast science, yet second and higher order nonlinearities limits the bunch length to a few femtoseconds after compression. Traditional regulation methods using rf higher order harmonics have already optimized the bunch length to sub-fs scale, yet the energy loss and rf jitter are not negligible. In this paper we demonstrate the second order regulation with THz pulses through a dielectric-loaded wave-guide. Simulations suggest that with higher order correction, the MeV electron bunches with tens of fC charges can be compressed to a 679 attoseconds rms and the second order distortion can be compensated. The transverse beam size is also optimized to 16.8 um rms. This scheme is feasible for a wide range of electron charges. The relatively short bunch length is expected to find a better time resolution in UED, UEM and other ultrafast, time-resolved studies.

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Asia

Monday Poster Session / **457**

Beam dynamics study of the bimodal RF cavity for advanced light source

Author: Dinghui Su[1]

Co-authors: Wencheng Fang [2]; Jianhao Tan [3]; Cheng Wang [2]; Yixing Lu [2]; Hanyu Gong [1]; Yusen Guo [4]; Zihe Gao [1]

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Beam lengthening is significant for improving the beamlife of storage rings. Based on the previously proposed design of a room temperature conducting bimodal RF cavity, we conducted relevant dynamic simulations. The results showed that in a simulated storage ring lattice with the beam energy of 2 GeV and the synchronous radiation energy of 0.0356 MeV, the bimodal cavity realizes a same bunch-lengthening performance that is comparable to the double RF system composed of a main high-frequency cavity and a third harmonic cavity. This works provides reference materials for the design of bimodal cavities and provides strong support for application.

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Monday Poster Session / **458**

Investigation of the superconducting cavity from performance test to beam experiment

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RAON SCL3 superconducting cavities have been developed. The design, fabrication, vertical test, and beam commissioning processes are investigated for RAON SCL3 superconducting cavities such as quarter-wave resonator (QWR) and half-wave resonator (HWR) cavities. The design parameters for QWRs and HWRs are shown, and the fabrication processes for the QWR and HWR are introduced. A schematic of the vertical test is presented. Calibration and cavity preparations are shown to test the superconducting cavities. Performance for the QWRs and HWRs was successfully tested through the vertical test. Cryomodules for QWR and HWR are assembled and tested. The beam commissioning is successful for the superconducting cavities.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Thursday Poster Session / 459

Design and measurement of the septum magnet for Hefei Advanced Light Facility

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The septum magnet with shorter drive pulse has a smaller leakage field and stray field time tail. The examination is performed experimentally and theoretically.

Footnotes:

septum, leakage field, Hefei Advanced Light Facility (HALF)

Funding Agency:

Hefei Advanced Light Facility Pre-research Project

Paper preparation format:

Region represented:

Asia

Thursday Poster Session / 460

The pre-alignment strategy of Hefei Advanced Light Facility storage ring magnet unit

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As a fourth-generation diffraction-limited light source, Hefei Advanced Light facility has high requirements on the alignment accuracy and installation efficiency of key components of the storage ring. We plan to use four laser trackers to build a high-precision pre-alignment system based on the principle of polygonal to achieve a pre-alignment accuracy of 30μm within the magnet unit (generally composed of eight quadrupole and sextupole). In order to ensure reliable accuracy, the position of the quadrupole magnet is checked using a vibrating wire pre-alignment system. According to relevant engineering experience, in the early stage of the project, it will take about 5 working days to complete the pre-alignment work of an eight-magnet unit. After the operation is proficient, it can be shortened to 3 working days. This schedule can meet the progress requirements of the project construction.

Footnotes:

Funding Agency:

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Region represented:

Asia

Wednesday Poster Session / 461

Status of the RUEDI UK national facility design

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RUEDI (Relativistic Ultrafast Electron Diffraction & Imaging) is a proposed facility which will deliver single-shot, time-resolved, imaging with MeV electrons, and ultrafast electron diffraction down to 10 fs timescales. RUEDI is being designed to enable the following science themes: dynamics of chemical change; materials in extreme conditions; quantum materials; energy generation, storage, and conversion; and in vivo biosciences. RUEDI is proposed to be built at STFC's Daresbury Laboratory in the UK.

Footnotes:

Funding Agency:

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Region represented:

Europe

Thursday Poster Session / 464

Development of a multi-angle ultrahigh dose rate MV-level X-ray radiation system for FLASH radiotherapy clinical transformation

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Co-authors: Liang Zhang [2]; Xiaotong Zhang [2]; Yinuo Zhu [1]; Fusheng Zhang [1]; Qiang Gao [1]; An Li [1]; Hao Zha [1]; Jiaru Shi [1]; Yaohong Liu [1]; Wenhui Huang [1]; Chuanxiang Tang [1]; Huaibi Chen [1]

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In this work, MAX FLASH system (Multi-Angle ultrahigh dose rate megavolt-level X-ray radiation system for FLASH radiotherapy) is presented. This system consists of a rapid RF power distribution network and five linacs vertically installed at different coplanar angles. The distribution network can switch all power to one terminal linac between pulses. Electron beams are accelerated to 10 MeV with more than 400 mA peak currents in the high-performance linac and then convert into X-ray at a compact rotating target. The system aims for a compact FLASH radiotherapy clinical facility with a gantry 3 meter in diameter and 2.5 meter in length, which can be installed in most of hospital radiotherapy treatment rooms. There is reserved space in the gantry for a coplanar CBCT to implement for image guidance. The gantry can rotate to an optimized angle for a better conformality before radiation while the system remains stationary and switches the operating linac during radiation. Construction of the first system prototype, with 40 Gy/s dose rate at 80 cm source-axis-distance, is supposed to be finished in the summer of 2024.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Tuesday Poster Session / 465

New design techniques on matching couplers for travelling wave accelerating structures

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Numerical optimizations on couplers of the traveling wave accelerating structures usually require lots of calculation resources. This paper proposes a new technique for matching couplers to an accelerating structure in a more efficient way. It combines conventional Kroll method with improved Kyhl method, thereby simplifying the tuning and simulation process. We will present the detailed design of a constant-gradient C-band accelerating structure based on this new method.

Footnotes:

Funding Agency:

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Paper preparation format:

Region represented:

Asia

Thursday Poster Session / 467

A study on the application of photoconductive switches for kicker excitation pulse power supply

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Pulse power supply for kicker needs high di/dt. In old way, the thyristor, IGBT, SCR are chosen as the switch. We have found the photoconductive switches has nice parameters.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Monday Poster Session / 468

Experimental characterization of the timing-jitter effects on a beam-driven plasma wakefield accelerator

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Plasma wakefield acceleration is nowadays very attractive in terms of accelerating gradient, able to overcome conventional accelerators by orders of magnitude. However, this poses very demanding requirements on the accelerator stability to avoid large instabilities on the final beam energy. In this study we analyze the correlation between the driver-witness distance jitter (due to the RF timing jitter) and the witness energy gain in a plasma wakefield accelerator stage. Experimental measurements are reported by using an electro-optical sampling diagnostics with which we correlate the distance between the driver and witness beams prior to the plasma accelerator stage. The results show a clear correlation due to such a distance jitter highlighting the contribution coming from the RF compression.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Europe

TUBD: Colliders and other Particle and Nuclear Physics Accelerators (Contributed) / 469

Analyzing sudden beam loss in the SuperKEKB/Belle-II experiment with RFSoC technology

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In the SuperKEKB/Belle-II experiment, a multitude of elementary particle reactions is initiated through the collision of 4 GeV positrons with 7 GeV electrons, paving the way for the exploration of new physics. The experiment includes plans for the substantial enhancement of luminosity in the future, aiming to achieve an integrated luminosity approximately 100 times the current level. However, the

realization of this goal is impeded by a recurrent occurrence of a phenomenon known as "Sudden Beam Loss," which entails the abrupt disappearance of the beam within tens of microseconds. The cause and location of these occurrences have not yet been identified.
To provide the tools to diagnose and debug these sudden beam loss events, a new Bunch Oscillation Recorder (BOR) has been developed to analyze this phenomenon, utilizing the Radio Frequency System on Chip (RFSoC) from AMD/Xilinx. The beam position of each individual bunch is measured and recorded by the BOR just prior to the onset of sudden beam loss. We will present how the signal from the button beam position monitor of the beam pipe is processed by RFSoC, along with the results obtained from observing the actual SuperKEKB beam using RFSoC.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Thursday Poster Session / 470

Design study of a compact superconducting undulator based on laser-structured HTS tapes

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Undulators are X-ray sources which are widely used in synchrotron storage rings or in future light sources such as free-electron lasers. Due to sustainability and energy efficiency the development envisages small-scale high-field and compact undulators with short period lengths (<10 mm) and narrow magnetic gaps (<4 mm). Therefore, high-temperature superconducting (HTS) tapes, which can provide both large critical current densities and high critical magnetic fields, are widely used and investigated at KIT. A new concept of superconducting undulators (SCUs) was introduced and further developed by laser-scribing a meander pattern into the superconducting layer to achieve quasi-sinusoidal current path through the tape.
In this contribution, we present our results from the design study in respect of the cooling concept for a compact SCU. The foreseen cooling is based on the one hand on calculations of the different heat loads through synchrotron radiation, impedance, and current supplies and on the other hand on the design of the liner including the tapering.

Footnotes:

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Region represented:

Europe

Tuesday Poster Session / 471

LSTMs for anomaly detection in the magnet power supply temperatures of APS-U

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We present an approach for detection of anomalies in the temperatures of magnet power supplies (PSs) in storage rings. We train a Long Short-Term Memory (LSTM) neural network to predict the temperatures of several components of a PS (heatsinks, capacitors, resistors) based on the PS current, PS voltage, and room temperature. An anomaly is detected when the observed PS temperature starts to deviate significantly from the LSTM prediction. A dedicated test stand has been built with a PS and a PS controller of the same kind that will be used in the Advanced Photon Source Upgrade (APS-U). The PS was modified to be able to programmatically create artificial anomalies in the PS temperature, so that the proposed method can be tested. Additionally, we use this test stand to experiment with more advanced PS temperature monitoring techniques employing infrared cameras, which could be used for all APS-U PSs in the future.

Footnotes:

Funding Agency:

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North America

Wednesday Poster Session / 473

Beam diagnostics status for the Korea 4GSR project

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The Korean 4GSR project is currently under construction in Ochang, South Korea, with the aim of first beam commissioning in 2027. Designed to achieve an emittance approximately 100 times

smaller than that of third-generation synchrotron radiation storage rings, the project requires the development of several high-precision beam diagnostic devices. In particular, the beam position monitor is designed to reduce longitudinal wake impedance, thereby suppressing heating and beam instability. The electronics component has also been developed using RFSOC to enable Turn by Turn data acquisition and Bunch by Bunch beam position monitoring.
Additionally, a Beam Loss Monitor utilizing 100 Hz operating-rate scintillating optical fibers has been developed, and an enhanced beam profile monitor utilizing GAGG has also been created. Furthermore, the development progress of a multi-bunch energy measurement beam position monitor system for linear accelerator energy feedback will be introduced. This presentation aims to provide an overview of the current status of beam diagnostic devices developed for the 4GSR project, including details on the overall system configuration.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Thursday Poster Session / **474**

Testing aspects of the CERN beam interlock system prior to installation in the accelerator

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The Beam Interlock System (BIS) is the backbone of the machine protection system throughout the accelerator complex at CERN, from LINAC4 to the LHC. After 15 years of flawless operation, a new version of the BIS is currently being produced and will be installed in the LHC, SPS and North Area during CERN's Long Shutdown 3, planned to start in 2026. Overall, more than 3,000 Printed Circuit Boards will be produced and assembled outside CERN. In addition, more than 120,000 lines of firmware and supporting scripts are written to implement the critical and monitoring functionalities of the BIS. Both hardware and firmware need to be thoroughly tested before installation and operation to guarantee the high levels of reliability and availability required by the operation of the accelerators. In this paper we present the testing methodology including the development of dedicated testbeds for hardware validation, the use of comprehensive simulation and continuous integration for firmware development, and the implementation of automated tests for system-level functional validation.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Europe

Tuesday Poster Session / 475

Crystal collimation for the HL-LHC upgrade using MERLIN++

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This paper details the implementation and benchmarking of crystal collimation within MERLIN++ accelerator physics library and demonstrates its application in simulating crystal collimation process for the High Luminosity upgrade of LHC at CERN. Crystal collimation is one of the key technologies suggested to enhance the current collimation system according to the requirements of HL-LHC upgrade due to its increased beam energy and luminosity. This paper outlines the proposed methodology for this study which includes implementing the demonstrated physics of particle crystal interaction in MERLIN++, benchmarking it with the existing experimental data and simulating the HL-LHC operational scenarios with the crystals as primary collimators. MERLIN++ has already been efficiently used for multiple LHC collimation studies which highlights its importance , making it an essential simulation tool for comparative analysis with other simulation tools, as relying on a single tool for concluding the HL-LHC collimation system is often insufficient. As collimation systems are fundamental for machine protection , accurately predicting the crystal collimation performance is of utmost importance to know how they will perform in HL-LHC to guarantee that the HL-LHC meets its intended objectives with crystal collimators.

Footnotes:

Funding Agency:

Paper preparation format:

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Europe

WEBN: Beam Instrumentation, Controls, Feedback and Operational Aspects (Contributed) / 476

The availability challenge in the FCC-ee: targets, shortfalls and game-changing opportunities

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The FCC-ee*is CERN's leading proposal for the next generation of energy-frontier particle accelerators. To reach integrated luminosity goals, it must be operational for minimum 80% of the scheduled 185 physics days each year. For comparison, the LHCachieved 77% in Run 2, 2016-2018. There are additional challenges in operation and maintenance of the FCC-ee due to its scale, complexity and ambitious technical objectives. Availability is therefore a significant risk to physics deliverables. This paper deconstructs the availability challenge in the FCC-ee according to its top-level systems. Contributions are in three parts: (I) For the first time, availability requirements are defined by system, scaled according to complexity of delivery. (II) A blueprint for each system is constructed, where availability of the RF***
is projected in Monte Carlo simulation from existing colliders to the FCC-ee. Forecasts for Z and W modes are highly inadequate, suggesting radical change in operation and maintenance paradigm is required. (III) Solutions to the availability challenge are proposed and exploratory simulations analyzed for several potentially game-changing R&D opportunities.

Footnotes:

- FCC-ee: the Electron-positron Future Circular Collider ** LHC: the Large Hadron Collider *** RF: Radio Frequency

Funding Agency:

Paper preparation format:

Region represented:

Europe

Monday Poster Session / **477**

Investigation of plasma stability of the prototype plasma lens for optical matching at the ILC e+ source

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The quest for novel technologies in the ever-evolving landscape of scientific exploration has led to the investigation of plasma lensing as a potential solution for optical matching devices at the International Linear Collider (ILC) positron source. This research becomes increasingly significant as the need for higher data output demands innovative concepts to increase positron yield and therefore luminosity. Our initial experiments revealed instabilities within the plasma. This talk will delve into these instabilities, explore their potential causes and the challenges they would pose. We'll discuss strategies for stabilizing the plasma to enhance the development of an efficient optical matching device. Overcoming these challenges is pivotal for a future application of plasma lenses as an integral part of a high performance ILC positron source.

Footnotes:

plasma lens, optical matching, ILC positron source, plasma stability

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Federal Ministry of Education and Research in Germany

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Europe

Monday Poster Session / 478

Axially symmetric McMillan map based on e-lens

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In this work, we investigate the transverse dynamics of a single particle in a model integrable accelerator lattice, based on a McMillan axially symmetric electron lens. Although the McMillan e-lens has been considered as a device potentially capable of mitigating collective space charge forces, some of its fundamental properties have not been described yet. The main goal of our work is to close this gap and understand the limitations and potential of this device. It is worth mentioning that the McMillan axially symmetric map provides the first-order approximations of dynamics for a general linear lattice plus an arbitrary thin lens with motion separable in polar coordinates. Therefore, advancements in its understanding should give us a better picture of more generic and not necessarily integrable round beams. We classify all possible regimes with stable trajectories and provide set of canonical action-angle variables, along with an evaluation of the dynamical aperture, Poincare rotation numbers as functions of amplitudes, and spread in nonlinear tunes. We show that there are three fundamentally different configurations of the accelerator optics causing different modes of nonlinear oscillations. Each regime is considered in great detail, including the limiting cases of large and small amplitudes. In addition, we analyze the dynamics in Cartesian coordinates and provide a description of observable variables and corresponding spectra.

Footnotes:

Funding Agency:

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Region represented:

North America

Thursday Poster Session / 479

Machine-assisted discovery of integrable symplectic mappings

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Integrable systems possess a hidden symmetry associated with the existence of conserved quantities known as integrals of motion. These systems play an important role in understanding general dynamics in accelerators and have potential for future designs. This work will cover two automated methods for finding integrable symplectic maps of the plane.
The first algorithm is based on the observation that the evolution of an integrable system in phase space is confined to a lower-dimensional submanifold of a specific type. The second algorithm relies on an analysis of dynamical variables. Both methods rediscover some of the famous McMillan-Suris integrable mappings and ultra-discrete Painlevé equations.
Over 100 new integrable families are presented and analyzed, some of which are isolated in the space of parameters, while others are families with one parameter (or the ratio of parameters) being either continuous or discrete.
In addition, the newly discovered maps are related to a general 2D symplectic map through the use of discrete perturbation theory. A method is proposed for constructing smooth near-integrable dynamical systems based on mappings with polygon invariants.

Footnotes:

Funding Agency:

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Region represented:

North America

Monday Poster Session / 480

Understanding sextupole

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In this study, we reassess the dynamics within a simple accelerator lattice featuring a single degree of freedom and incorporating a sextupole magnet. In the initial segment, we revisit the Henon quadratic map, a representation of a general transformation with quadratic nonlinearity. Through a stability diagram, we offer a precise description of dynamic aperture, tune spreads, and nonlinear resonances. In the subsequent section, we unveil that a conventional sextupole is essentially a composite structure, comprising an integrable McMillan sextupole and octupole, along with non-integrable corrections of higher orders. This fresh perspective sheds light on the fundamental nature of the sextupole magnet, providing a more nuanced understanding of its far-from-trivial chaotic dynamics. Importantly, it enables the description of driving terms of the second and third orders and introduces associated nonlinear Courant-Snyder invariant.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

North America

Monday Poster Session / **481**

Design and development of array multipoint accelerator tube

Author: Liang Zhang[1]

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Linear accelerators with multiple ray sources are widely used in detection imaging technology. An S-band multi-point light source standing wave Linac is designed and developed in this paper. The tube consists of 7 parallel-arranged acceleration cavity units, and adopts a power source to output 7 X-ray beams alternating from different positions. The accelerating tube operates at S-band 2998 MHz. In this paper, the physical design of the accelerating tube is introduced, and the dynamic design of the accelerating tube is completed by numerical calculation. PARMELA is used to verify the calculation, and the result is in accord with the expected result. According to the theoretical design results, machining and testing have been carried out.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Monday Poster Session / **482**

R&D of X-band deflecting structure applied on SHINE

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For the development of X-band deflecting structure at Shanghai Synchrotron Radiation Facility (SSRF), two units of X-band deflecting structures totally including six RF structures have been used on SXFEL successfully for ultra-fast beam diagnostics. The construction of another new FEL facility has started from 2018, which is named Shanghai high repetition rate XFEL and extreme light facility (SHINE). Four units of X-band deflectors will be installed on SHINE. The design and measurement of the first prototype has been finished, and the high power test will be carried out soon, in this paper, the design and measurement results will be presented.

Footnotes:

Funding Agency:

Paper preparation format:

Word

Region represented:

Asia

Tuesday Poster Session / 483

Conceptual Design for a Future Australian Light Source

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Conceptual design work is under way for a fourth generation light source in Australia.This new light source is being designed as a completely new facility, intended to come into operation around 2037 as the current Third generation Australian Synchrotron reaches its end of life. This paper will outline the main design parameters, initial lattice design and technology choices currently under consideration.

Footnotes:

Funding Agency:

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Region represented:

Asia

Tuesday Poster Session / 484

Network status for PAL-XFEL

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The accelerator network of the Pohang Accelerator Laboratory (PAL) was initially designed and installed in 2015. It consists of three types of networks: a Public Network for external internet access, an Operation Network for accelerator operation and overall control, and a Control Network for device control and monitoring.
From a hardware perspective, it comprises 2 firewalls, 1 intrusion prevention system, 4 backbones, 36 office network switches, and 77 switches for gallery and tunnel networks. Each network is physically or logically separated, and the backbone, serving as the main equipment, is configured in a redundant manner to prepare for failures

Footnotes:

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Word

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Asia

Tuesday Poster Session / 485

The laser system of very compact inverse Compton scattering γ-ray source

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We present the design and experiment of a laser system for the very compact inverse Compton scattering (ICS) γ-ray source (VIGAS). The laser system comprises a photo injector drive laser and a scattering laser system. The photocathode drive laser system produces ultraviolet (UV) pulses with 575 μJ energy, 9.4 ps FWHM pulse width, and 10 Hz repetition at 267 nm central wavelength, which illuminates a photo injector to generate a high-quality electron beam. The ICS laser system produces two alternative intense ultrashort laser pulses with 800 nm (3 J) and 400 nm (0.8 J) central wavelengths for interacting with the electron beam, respectively. The two laser systems are phase-locked to a 2856 MHz master clock signal with a time jitter of 47 fs and 55 fs, respectively.

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Asia

Tuesday Poster Session / 486

Magnetic compression method for macro pulses of relativistic electron beam

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We developed a magnetic compression method for relativistic electron beam macro-pulses. Our device, with a significantly larger transfer function R56 compared to the classical chicane structure, enables nanosecond-scale compression of relativistic electron pulses using a compact apparatus measuring just a few meters. This paper introduces the principles of this compression method and presents the results of dynamic simulations.

Footnotes:

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Asia

Tuesday Poster Session / 488

SIS18 Operation with U28+

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In SIS18 U28+ is used to reach highest heavy ion beam intensities for FAIR-operation. The medium charge state avoids losses during stripping processes and shifts the space charge limit to higher number of particles. Nevertheless, these ions are subjected to ionization loss in collisions with residual gas particles. Via ion impact induced gas desorption a feedback between vacuum quality and beam emerges, yielding in a beam intensity limitation. The installation of a charge exchange collimator is one of the several upgrade measures which have been performed to shift this limit. They are equipped with a current measurement system to detect charge exchanged ions, which is routinely used during machine experiments.
In this proceeding we present different beam based measurements showing dynamic vacuum effects. The non-linear dependence of the extraction intensity on the number of injected particles, ramp rate, and brake-time for vacuum relaxation will be shown. Stored heavy ion beams were used for charge exchange current measurements. They allow conclusions on the vacuum conditions and are presented as well.

Footnotes:

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Region represented:

Europe

Thursday Poster Session / 489

Impedance analysis of the septum in Hefei Advanced Light Facility

Author: Wenbin Song[1]

Co-authors: Chunyu Xu [1]; Feng-lei Shang [1]; Lei Shang [1]; Xiao Ding [1]

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An eddy-current design is used for the septum in HALF (Hefei Advanced Light Facility), with the whole cores located in a vacuum chamber. The stored beam passes through a copper vacuum pipe which set in the vacuum chamber. Two types of connections between the copper pipe and the flanges at both ends of the chamber were considered. The impedance calculations were done, and the wake-field, heat have also been analyzed. A flexible connection using a beryllium bronze casing was finally selected.

Footnotes:

Funding Agency:

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Paper preparation format:

Region represented:

Asia

MOCD: Accelerator Technology and Sustainability (Contributed) / 490

X-band high gradient accelerating structure for VIGAS project at Tsinghua university

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Co-authors: Jiaru Shi [1]; Hao Zha [1]; Xiancai Lin [1]; Fangjun Hu [1]; Boyuan Feng [1]; Hongyu Li [1]; Weihang Gu [1]; Qingzhu Li [1]; An Li [1]; Wenhui Huang [1]; Chuanxiang Tang [1]; Huaibi Chen [1]; Yingchao Du [1]

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A light source project named Very Compact Inverse Compton Gamma-ray Source (VIGAS) is under development at Tsinghua University. VIGAS aims to generate monochromatic high-energy gamma rays by colliding a 350 MeV electron beam with a 400-nm laser. To produce a high-energy electron beam in a compact accelerator with a length shorter than 12 meters, the system consists of an S-band high-brightness injector and six X-band high-gradient accelerating structures. The X-band structure' s frequency is 11.424 GHz, and it adopts a constant gradient traveling wave approach; thus, the iris from the first cell to the end cell is tapered. The total cell number is 72, so we named it XT72. In the last two years, we conducted the design, fabrication, and tuning of the first prototype of XT72. Recently, we finished the high-power test, and the result demonstrates that it has the ability to work at an 80 MV/m gradient. In this paper, we present the latest update on this structure.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Tuesday Poster Session / 491

The mechanical behavior of the EIC beam screen during a magnet quench

Author: Marco Morrone[1]

Co-authors: Cedric Garion [1]; Charles Hetzel [2]; Paolo Chiggiato [1]

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As part of the Electron-Ion Collide (EIC) upgrade at Brookhaven National Laboratory (BNL), the development of new beam screens for the vacuum system is underway. The mechanical design of the beam screens received support from CERN, particularly in addressing the mechanical response during a magnet quench, i.e. a resistive transitions in the superconducting magnets. Maintaining an overall elastic behavior in this component is crucial for the efficient functioning of the collider. The mechanical behavior of the EIC beam screen during a quench was initially analyzed using analytical methods and subsequently validated through a Multiphysics FEM model developed for the High-Luminosity LHC (HL-LHC) beam screen. The FEM model underwent an initial verification against analytical formulations in its simpler 2D magnetic-based version. Following this, thermal and mechanical physics were fully coupled with the magnetic model in a 3D framework. Various features, including partial weld penetration, pumping holes, and guiding rings, were then taken into consideration. Additionally, the plastic behavior of the beam screen materials was considered too. The assessment included an analysis of the maximum deformation and stress experienced by the EIC beam screen during a magnet quench, resulting in an overall elastic response for the proposed design.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Europe

Wednesday Poster Session / 492

Optimization studies on accelerator sample components for energy management purposes

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Co-authors: Andreas Grau [1]; Anke-Susanne Mueller [1]; Bennet Krasch [1]; David Saez de Jauregui [1]; Erik Bruendermann [1]; Giovanni De Carne [1]

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The large amount of energy required to operate large-scale facilities with particle accelerators within has been considered as one of the important research topics over the past years. This sheds light on the importance of the research field of energy management that entitles, with a view to long-term operations, the implementation of smart and sustainable technologies.
One of the key technologies in accelerators are superconductor (SC)-based designs. The vanishing electrical resistance together with the ability to provide field values well above those from conventional conductors is the main motivation behind exploiting superconducting wires in building coils and magnets for large-scale accelerators. However, these superconductors can also quench under certain conditions, driving the wires into the normal state and potentially allowing for overheating and destruction of the conductor material and/or the whole design.
This work will present the results of optimization-based analyses performed on accelerator SC-sample components aiming at goal designs that are more energy efficient at a reference operational field or current. A compromise between getting the best performance for excellent science from a design (with superconductivity preserved and safe operation maintained) and reducing its power consumption (and eventually its effective cost) will be addressed too.

Footnotes:

Funding Agency:

Paper preparation format:

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Europe

Monday Poster Session / 493

Expansions of the integrability program for novel accelerators

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The physical realization of integrable Hamiltonian dynamics provides promising avenues for investigations of new particle accelerators, best demonstrated by the Integrable Optics Test Accelerator (IOTA) at Fermilab. The core concept of IOTA centers around the results of the Danilov-Nagaitsev paper, where taking the paraxial approximation of the Hamiltonian for a charged particle can lead to a completely integrable system for a charged particle in the transverse plane. However, certain generalizations of that paper fail to provide similar results. We provide insights into some reasons for failure, as well as discuss a set-up for establishing a 6D integrable Hamiltonian system, in order to include the possibility of acceleration.

Footnotes:

While I would like to present this in the Sunday Students Poster Session, I will be unable to due to conflicts with military service requirements and will not be present until the following day.

Funding Agency:

Paper preparation format:

Region represented:

North America

Tuesday Poster Session / 495

Future upgrades for GANIL

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Co-author: Stephane Grevy [2]

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We will present the plans and ideas for the next upgrades as discussed for the GANIL-SPIRAL2 installation in France. Recently, a report "French roadmap for Nuclear, Particle, and Astroparticle physics, along with associated technical developments and applications." were produced. It particularly focused to "The future of GANIL". This was further enriched through extensive discussions by an international expert committee led by Michel SPIRO. These endeavors aim to push the boundaries of research capabilities at GANIL-SPIRAL2 during the next decades.
Since the starting up in 1983, 40 years ago, successful exploitation with stable beams at the cyclotrons of GANIL, the laboratory has continuously evaluated and enhanced its capabilities. The latest evolution was the starting up of the SPIRAL2 facility. Today GANIL, with its state-of-the-art installations, including cyclotrons, a linear accelerator, and experimental areas, presents unique opportunities for cutting-edge research.
The next upgrades under discussion are to be presented. Involving increasing beam intensities, exploring new exotic nuclei. Endeavors that aim to push the boundaries of research capabilities at GANIL-SPIRAL2 for the next decades.

Footnotes:

Funding Agency:

Paper preparation format:

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Europe

TUBN: Novel Particle Sources and Acceleration Techniques (Contributed) / 496

High power experimental results of a multicell dielectric disk accelerating structure

Author: Sarah Weatherly[1]

Co-authors: Ben Freemire [2]; Chunguang Jing [3]; Eric Wisniewski [1]; Gongxiaohui Chen [3]; John Power [3]

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A Dielectric Disk Accelerator (DDA) is a metallic accelerating structure loaded with dielectric disks to increase its shunt impedance. These structures use short RF pulses of 9 ns to achieve accelerating gradients of more than 100 MV/m. Single cell and multicell clamped structures have been designed and high power tested at the Argonne Wakefield Accelerator. During testing, the single cell clamped DDA structure achieved an accelerating gradient of 102 MV/m with no visible damage in the RF volume region. The minimal damage that was seen outside the RF volume was likely due to RF leakage from uneven clamping during assembly. Based on the success of that experiment, a clamped multicell DDA structure has been designed and tested at high power. Simulation results for this new structure show a 108 MV/m accelerating gradient with 400 MW of input power with high shunt impedance and group velocity. Engineering designs were improved from the single cell structure for a more consistent clamping over the entire structure. Up to this point in the high power experiments, the results show a peak input power of 222 MW correlating to an accelerating gradient of 80 MV/m. Testing of this structure will continue January 2024.

Footnotes:

Funding Agency:

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North America

Monday Poster Session / 497

Particle beam-driven wakefield in carbon nanotubes: hydrodynamic model vs PIC simulations

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[2] *Universidade Federal de Ciências da Saúde de Porto Alegre*

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The interactions of charged particles with carbon nanotubes (CNTs) may excite electromagnetic modes in the electron gas that makes up the nanotube surface. This novel effect has recently been proposed as an alternative method to achieve ultra-high gradients for particle acceleration. In this contribution, the excitations produced by a localized point-like charge propagating in a single wall nanotube are described by means of the linearized hydrodynamic model. In this model, the electron gas is treated as a plasma with specific solid-state properties. The governing set of differential equations consists of the continuity and momentum equations for the electron fluid, in conjunction with Poisson's equation. Through numerical simulations, we investigate the influence of key factors, including the driving velocity, CNT radius, surface density and the friction (between the electron fluid and the ionic lattice) parameter, on the excited wakefields, comparing the results with Particle-in-Cell (PIC) simulations. A comprehensive discussion is presented to analyze similarities, differences and limitations of both methods. This research provides a valuable perspective on the potential use of CNTs to enhance particle acceleration techniques, paving the way for further advancements in high-energy physics and related fields.

Footnotes:

Funding Agency:

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Paper preparation format:

Region represented:

Europe

Thursday Poster Session / 500

Practical design and manufacturing of the new ISIS MEBT chopper

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The electrostatic chopper for the new ISIS MEBT is a fast deflecting device which will create gaps in the beam coming out of the RFQ, which will improve the trapping efficiency when injecting the beam into the ISIS synchrotron. The fundamental design (including electromagnetic and thermal calculations, and sensitivity studies) are presented elsewhere. The practical aspects of the mechanical design and the assembly of the prototype chopper are presented here. This includes how challenges were resolved, such as insufficient transmission from the fiber thermocouples through the feedthroughs, ease of life design features, such as the use of o-ring screws, tests performed to feed into the analytical design and the promising progress made to date.

Footnotes:

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Europe

Wednesday Poster Session / 502

In situ plasma processing of superconducting cavities at JLab, 2024 update

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Jefferson Lab has an ongoing R&D program in plasma processing. The experimental program investigated processing using argon/oxygen and helium/oxygen gas mixtures. Plasma processing is a common technique where the free oxygen produced by the plasma breaks down and removes hydrocarbons from surfaces. This increases the work function and reduces the secondary emission coefficient. The initial focus of the effort was processing C100 cavities by injecting RF power into the HOM coupler ports. We also developed the methods for establishing a plasma in C75 cryomodules where the RF power is injected via the fundamental power-coupler. Four C100 cryomodules were in-situ processed in the CEBAF accelerator in May 2023 with the cryomodules returning to an operational status in Sept. 2023. The overall operational energy gain for the four cryomodules was 49 MeV. Methods, systems and results from processing cryomodules in the CEBAF accelerator and vertical test results will be presented. Current status and future plans will also be presented.

Footnotes:

Funding Agency:

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Paper preparation format:

Region represented:

North America

Thursday Poster Session / 503

A large momentum acceptance gantry for light-weight proton therapy facility: its beam lattice, magnets design and clinical advantages

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As one of the state-of-the-art radiotherapy approaches, proton therapy possesses conformal dose profiles yet expensive cost. Designing a facility with a small footprint and a high treatment efficiency is the main goal for researchers to fulfill the potential of proton therapy and make it more affordable both for vendors and patients. In this contribution, the design of a light-weight proton therapy gantry based on the alternating-gradient canted-cosine-theta (AG-CCT) super-conducting (SC) magnet is presented. The AG-CCT magnets adopt large bores and combined function design. With fine field harmonic control and fringe field shape optimization of the magnets, the multi-particle tracking results prove that the gantry achieves a momentum acceptance of ±8%. So that the full energy range from 70 to 230 MeV can be covered with merely 3 field switch points. Combined with a fast degrader component, whose switch time is below 50 ms, the energy modulation speed can be greatly fastened. To fully utilize the advantages of the large momentum acceptance gantry, the energy spread of the proton beam is expanded and a reduced treatment plan is proposed. Compared with the standard treatment plan, the energy layers number of a prostate case is reduced by 61.3% with comparable plan quality. In summary, the proposed gantry has significant superiority both in manufacture and clinical aspects.

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Funding Agency:

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Paper preparation format:

Region represented:

Asia

Thursday Poster Session / 504

Cryogenic permanent magnet undulator at high beam currents

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[2] *The Institute of Physical and Chemical Research*

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A PrFeB-based cryogenic permanent-magnet undulator (CPMU) of period length 15 mm has been constructed to provide hard X-rays of energy 10-40 keV at the Taiwan photon source (TPS). Two cryocoolers with total cooling capacity nearly 300 watts and special designed components are dedicated for TPS-CU15 to ensure its stable magnetic and cryogenic performance. The CU15 can generate an effective magnetic field of 1.32 T at gap 4 mm when the temperature of magnet is 80 K. At beam current of 500 mA with bunch length of 16 ps, the measured beam-induced heat load is 112 W at a vacuum gap 4.8 mm. The broadband impedance, include geometrical impedance and resistive wall heating, was found to contribute the most in the beam heating mechanism.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Thursday Poster Session / 505

HPSim as an online beam model for LANSCE operation

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We present our recent results on the calibration of the GPU-powered High-Performance Simulator (HPSim) with the LANSCE operation history and the implementation of HPSim as an online beam model that can provide minute-by-minute multiparticle distributions. During LANSCE's operation, several key diagnostics, like the loss monitors and the beam position & phase monitors, are helpful tools for the operators to optimize the performance continuously under an ever-drifting system. However, the real-time 6-D beam distributions from HPSim for energy, phase, positions, and momentums can provide valuable information which are not available through these measurements. The beam distributions could potentially help operators understand the source of beam losses coming from the tails and halos and provide the energy distributions of beam on target for the user facilities.

Footnotes:

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LANL LDRD

Paper preparation format:

Region represented:

North America

Thursday Poster Session / 506

First implementation of KO extraction at COSY

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Radio Frequency Knock Out (RF KO) resonant slow extraction is commissioned at the Cooler Synchrotron (COSY) Jülich for the first time to extract the stored beam and deliver spills with constant particle rates to the experiments. Therefore, transverse RF excitation generated with a software-defined radio is applied to control the extraction rate. A built-in feedback system adjusts the excitation amplitude to maintain the desired extraction rate. To suppress fluctuations of the particle rate on timescales of milliseconds and below, an optimization algorithm is used to tune the RF signals used for excitation. The method was used extensively during the final run of COSY in 2023, delivering stable beams to the various users.

Footnotes:

Funding Agency:

Paper preparation format:

LaTeX

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Europe

Monday Poster Session / 507

Studies of space-charge compensation of positive ions by creating time-dependent secondary electrons in low-energy beam transport line

Author: Emre Cosgun[1]

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The space-charge neutralization of an ion beam by created electrons when the beam ionizes the gas is investigated using a three-dimensional electrostatic particle-in-cell code. Different kinds of injected gases are considered, and their space-charge compensation transient times are compared. The created secondary electrons by the beam collision with neutral gas along the beam trajectories are loaded in the simulation by a Monte Carlo generator, and their space charge contribution is added to the primary beam space charge densities. The injection and accumulation of secondaries are time-dependent and this process is continued until total space charge densities reach a steady state. In this study, a 2.4-meter LEBT line with two solenoid magnets is considered. Usually, the proton beam energy is 25 keV and the current level is around 10-15 mA. Additionally, beam extraction studies are conducted, and the extracted beam is used in both IBSIMU and Tracewin codes for LEBT lines to validate the results.

Footnotes:

Funding Agency:

Paper preparation format:

LaTeX

Region represented:

Asia

Tuesday Poster Session / 508

Integrated Hall probe and stretched wire measurement system for an in-vacuum undulator

Author: Chih-Wei Chen[1]

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Taiwan Photon Source (TPS) is a 3 GeV synchrotron light source at the National Synchrotron Radiation Research Center (NSRRC) in Taiwan. Several in-vacuum undulators are expected to be installed before the end of 2024. Before installation in the storage ring, an in-vacuum undulator's magnetic field has been measured at operational gaps. In order to assess the performance of the in-vacuum undulator, we integrated two measurement methods in the vacuum chamber: one is the SAFALI (Self Aligned Field Analyzer with Laser Instrumentation) system to measure the magnetic field, and the other is the stretched wire system to measure the magnetic field integral. In this work, we designed a stretched wire measurement system integrated with the SAFALI system inside the vacuum chamber. This measurement system was applied to the in-vacuum undulator with a period of 22mm and a magnetic length of 2 m.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Monday Poster Session / 509

Design of X-band distributed-coupling accelerating structure

Author: Weihang Gu[1]

Co-authors: Hao Zha [1]; Huaibi Chen [1]; Jiaru Shi [1]; Qingzhu Li [1]

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Distributed-coupling structures has been proposed as an advanced type of high-gradient accelerators, RF power flow independently into each cavity.This method has few advantages such as high shunt impedance, superior power efficiency, and low costs. And the most distributed-coupling structures typically set 0° or 180° as the phase advance which can simplify the design.In this study we introduces a new-designed distributed-coupling structures with phase advance greater than 180°. This choice of angle will significantly reduce costs without affecting the shunt impedance.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Thursday Poster Session / 510

Automated Anomaly Detection on European XFEL Klystrons

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High-power multi-beam klystrons represent a key component to amplify the acceleration field of the radio frequency superconducting (SRF) cavities at European XFEL. Exchanging these high-power components takes time and effort, thus it is necessary to minimize maintenance and down times and at the same time maximize the device operation. In an attempt to explore the behavior of klystrons using machine learning, we completed a series of experiments on our klystrons to determine various operational modes and conduct feature extraction and dimensionality reduction to extract the most valuable information about a normal operation. To analyze recorded data we used state-of-the-art data-driven learning techniques and recognized the most promising components that might help us better understand klystron operational states and identify early on possible faults or anomalies.

Footnotes:

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Europe

Thursday Poster Session / 511

Lifetime studies of superconducting magnet protection systems for the Large Hadron Collider at CERN

Author: Enrique de Nicolás Lumbreras[1]

Co-authors: David Carrillo [1]; Edward Nowak [1]; Mirko Pojer [1]; Thorbjørn Nielsen [1]

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In the architecture of the protection of the superconducting magnets of the Large Hadron Collider (LHC), systems such as Quench Heater Discharge Power Supplies (HDS), Local Protection Interface Module (LIM), Linear Redundant Power Supplies (LPR), and Power Packs (LPUS) are crucial. Thousands of these devices, some in operation since 2007, directly impact LHC's availability and reliability.
This paper delves into comprehensive lifetime studies on these critical systems. The methodology involves estimating their remaining operational lifespan through detailed analyses of failure modes, assessing electronic component criticality, accelerated aging of electrolytic capacitors, inspections, and irradiation tests at both component and system levels. The study concludes by presenting essential findings, including the estimated remaining lifetime of each equipment. Additionally, the paper recommends future developments to enhance system robustness, offering valuable insights for maximizing the longevity of these critical devices. This research significantly contributes to ensuring the sustained reliability and performance of the LHC's magnet protection systems.

Footnotes:

Funding Agency:

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Region represented:

Europe

Wednesday Poster Session / 512

Impact of octupoles on the Schottky spectra of bunched beams

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Co-authors: Diogo Alves [1]; Kacper Lasocha [1]; Nicolas Mounet [1]; Tatiana Pieloni [2]

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Schottky monitors serve as non-invasive tools for beam diagnostics, providing insights into crucial bunch characteristics such as tune, chromaticity, bunch profile, or synchrotron frequency distribution. However, octupole magnets commonly used in circular storage rings to mitigate instabilities through the Landau damping mechanism, can significantly affect the Schottky spectrum. Due to the amplitude-dependent incoherent tune shift of individual particles, the satellites of the Schottky spectrum are smeared out as the octupolar field increases. This study investigates the impact of octupoles and their incorporation into theory, with the goal of improving beam and machine parameter evaluation from measured spectra. Theoretical findings are validated through macro-particle simulations conducted across a range of octupole strengths, encompassing typical operational conditions at the Large Hadron Collider.

Footnotes:

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Europe

Wednesday Poster Session / 513

Experimental and simulated LHC Schottky spectra

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Schottky monitors are valuable non-invasive tools used for beam diagnostics, providing insights into crucial bunch characteristics such as tune, chromaticity, bunch profile, or synchrotron frequency distribution. This study investigates Schottky spectra at the Large Hadron Collider (LHC) through a combination of simulations and measurements. Experimental data from lead ion bunches are compared with simulated spectra derived from time-domain, macro-particle simulations.
In particular, amplitude detuning due to the octupole magnets, known to influence the Schottky spectra, is incorporated into the simulations. These simulations are performed for various octupoles currents with the goal of better understanding the interplay between octupoles and the Schottky spectrum. Finally, measured spectra are compared to simulations performed using the best available knowledge of the parameters impacting the spectra.

Footnotes:

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Paper preparation format:

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Europe

Tuesday Poster Session / 514

RF design of a C-band spherical pulse compressor for Super Tau-Charm linac

Author: Zexin Cao[1]

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Pulse compressors have been widely used to generate very high peak RF power in exchange for the reduction in the RF pulse length for linear accelerators. As compared to a traditional SLAC Energy Doubler(SLED), a spherical pulse compressor is more compact while maintaining a high energy gain. A C-band spherical pulse compressor is studied in this paper, which consists of a dual-mode polarized coupler for producing two orthogonal TE11 modes simultaneously, as well as a resonant cavity working at TE113 mode for storing energy. Through optimizations, an average energy gain of 4.7 with a coupling factor of 6.6 can be achieved for such a spherical pulse compressor. The RF design of this pulse compressor has been finalized, the fabrication and measurement of prototype can be expected in the next step.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Monday Poster Session / 515

Intrabunch motion in the presence of mode coupling

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The intrabunch motion for independent longitudinal or transverse beam oscillation modes has been explained analytically for impedance driven bunched-beam coherent instabilities already several decades ago by Laclare and they have been observed in many measurements and simulations. These oscillation patterns do not depend on the bunch intensity, they are head/tail symmetric and they exhibit a number of nodes equal to the radial mode number. However, in many measurements and simulations of transverse beam instabilities (due to impedance only, impedance and beam-beam, impedance and space charge, or electron cloud), asymmetric patterns are observed depending on the bunch intensity. The latter can be described theoretically considering the interaction between several modes, i.e. mode coupling, which explains why and how different kinds of asymmetric intrabunch signals can be observed. In this paper, the intrabunch motion in the presence of mode coupling is explained first without maths and then with maths, considering the case of a bunch interacting with a transverse impedance, using the GALACTIC Vlasov solver.

Footnotes:

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Region represented:

Europe

Monday Poster Session / 516

Comparison between self-consistent and non self-consistent space charge analysis for the evolution of the coherent direct space charge modes

Author: Elias Métral[1]

Co-authors: David Amorim [1]; Xavier Buffat [1]

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The question of the mitigation of the Transverse Mode Coupling Instability (TMCI) by space charge has been discussed for more than two decades. Since few years, it has become clear that the ABS model, which has been often used in the past and which assumes an air-bag bunch in a square well, is not sufficient to properly describe the complexity of the interaction between impedance and space charge. Considering a more realistic longitudinal Gaussian distribution, a fully self-consistent treatment of space charge was performed few years ago using the circulant matrix model, which revealed the usual TMCI mechanism but with oscillation modes shifted both by impedance and space charge. In this paper, a non self-consistent treatment of space charge is analyzed, still using a Gaussian distribution, to look at the evolution of the coherent direct space charge modes. It is shown in particular that it leads to exactly the same result as the self-consistent treatment for space charge parameters below 1 and that it is a much better approximation than the ABS model for space charge parameters above 1, as it reveals clearly how the positive modes lead to negative tune shifts.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Europe

Thursday Poster Session / 520

LCLS-II dc magnet power supplies –an overview

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Co-authors: Briant Lam [1]; Chang Herr [1]; Jerico Tagle [1]; John Hugyik [1]; Marc Larrus [1]

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The Linac Coherent Light Source II (LCLS-II) at the SLAC National Accelerator Laboratory represents a groundbreaking advancement in the realm of free electron x-ray laser (XFEL) science. This 1.3 GHz continuous-wave superconducting RF LINAC is designed to generate 4 GeV electron bunches up to one MHz, propelling the capabilities of XFEL sources. Achieving a significant milestone, the LCLS-II successfully reached its 2K operating temperature with first electrons in October 2022, culminating in the generation of the first x-rays in September 2023.
This paper offers an overview of the diverse array of DC magnet power supplies employed in LCLS-II, which can be categorized into two sections: warm and superconducting. The warm section comprises of two crucial types of power supplies—intermediate and trim. Notably, these power supplies are subjected to tight stability requirement as low as 20 PPM. The warm section has close to 600 power supplies. In the superconducting section, an extra level of complexity is added by including a quench protection circuit to protect the magnets in case of a sudden loss of superconductivity.

Power supplies in this section also have a stability requirement of 0.02%. The superconducting section has 105 power supplies. This paper also discusses the system design and testing of these power supplies.

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Tuesday Poster Session / 521

Status of machine learning based beam size control during user operation at the Advanced Light Source

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The Advanced Light Source (ALS) storage ring employs various feedback and feedforward systems to stabilize the circulating electron beam thus ensuring delivery of steady synchrotron radiation to the users. In particular, active correction is essential to compensate for the significant perturbations to the transverse beam size induced by user-controlled tuning of the insertion devices, which occurs continuously during normal operation. Past work at the ALS already offered a proof-of-principle demonstration that Machine Learning (ML) methods could be used successfully for this purpose. Recent work has led to the development of a more robust ML-algorithm capable of continuous re-training and its routine deployment into day-to-day machine operation. In this contribution we focus on technical aspects of gathering the training data and model analysis based on archived data from 2 years of user operation as well as on the model implementation including the interface of an EPICS Input/Output Controller (IOC) into a Phoebus Panel, enabling operator-level supervision of the Beam Size Control (BSC) tool during regular user operation.

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Thursday Poster Session / 522

RF and multipactor analysis for the CARIE RF photoinjector with a photocathode insert

Author: Haoran Xu[1]

Co-authors: Anna Alexander [1]; Evgenya Simakov [1]; Petr Anisimov [1]; Torben Grumstrup [1]; Walter Barkley [1]

[1] *Los Alamos National Laboratory*

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At Los Alamos National Laboratory (LANL), we developed a 1.6-cell C-band RF photoinjector for the Cathodes And Radiofrequency Interactions in Extremes (CARIE) project. The injector will be used to study the behavior of advanced photocathode materials under very high RF gradients. The photocathodes will be prepared with an INFN-style photocathode plug, compatible with the plugs used by other institutions. This presentation will report the RF design of the photoinjector with distributed coupling and RF field symmetrization. Beam physics simulations show that symmetrized RF fields in the vicinity of the beam axis are essential for achieving normalized emittances below 100 nm for a 250-pC electron bunch. We will also present the design for the photocathode insertion and the analysis of the challenges related to reducing the peak electric fields, multipactor suppression, and resonant frequency tuning by fine adjustment of the plug position.

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Tuesday Poster Session / 523

Design of a two-cell C-band accelerator cavity with higher-order mode damping

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Higher-order mode (HOM) damping is essential for building large-scale facility linear accelerators, such as a linear collider, because of the need to reduce the wakefield strength inside the accelerating structure. We designed a C-band accelerator cavity with distributed coupling and thin HOM-damping waveguides oriented in the radial direction. It was proposed that nickel-chrome (NiCr) coating deposited on the surface of the thin waveguides will be used to increase the surface resistivity and to damp the HOMs. Recently, we designed a two-cell cavity to conduct a concise high power test that will help us understand the fabrication challenges for the cavity with NiCr HOM

absorbers, and examine the performance of the NiCr coating under high-power conditioning. This presentation will report the detailed electromagnetic and engineering design of the cavity, the theoretical prediction of the cavity high-gradient performance, the status of fabrication, and plans for high-gradient testing.

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Wednesday Poster Session / 524

Experimental testing of a ceramic enhanced accelerator cavity

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Co-authors: Leanne Duffy [1]; Ryan Hemphill [1]; John Lewellen [1]; Quinn Marksteiner [1]; Doug Patrick [1]; Marvyn Raya [2]; Janardan Upadhyay [1]; Haoran Xu [1]

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It is desirable to decrease the dimensions and power loss of accelerator components as much as possible when using accelerated charged particle beams on a rocket or satellite for ionospheric and magnetospheric research applications. We present the experimental results of a radiofrequency (RF) pillbox cavity loaded with a low-loss, high-permittivity ceramic placed concentrically within the cavity. We use high-electron mobility transistors (HEMTs) to power the RF at a frequency of 5.712 GHz. At this frequency, the cavity operates at a TM020 mode. The ceramic enhances the cavity's accelerating field confined within the scope of the ceramic insertion, increasing the shunt impedance, and improving the power coupling from the RF to the electron beam with the same gradient as a conventional TM010 mode cavity. Moreover, because the power coupling to the beam is improved, we were able to reduce the longitudinal dimension of the cavity compared to the conventional cavity. We show that the cavity accelerated the beam by approximately 12 keV. We also show that the cavity and ceramic can survive a flight to space by conducting vibration and shock tests that replicate the rocket launch environment.

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Wednesday Poster Session / **525**

A High-Energy Muon Collider at Fermilab

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The High-Energy Physics community has established that a multi-TeV Muon Collider should be included in plans for future high energy facilities. We consider the possibility of siting the future high energy muon collider at Fermilab. Using magnet and RF system capabilities that are expected to be readily available in the near future a complete muon collider facility with up to ~10 TeV center of mass energy could fit on the Fermilab site. This facility would include a proton source based on PIP-II, muon production and cooling systems, and accelerators reaching up to ~5 TeV/beam, and a fixed-field collider ring. The largest accelerator would be a two-stage hybrid rapid cycling synchrotron with ~16.5 km circumference. The facility will reuse Fermilab infrastructure whenever possible. Parameters and layouts of possible colliders will be presented as well as a discussion of required R&D.

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Wednesday Poster Session / **526**

Plasma processing on C75 cavities in Jefferson Lab

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Plasma processing has shown to be an effective tool for removing hydrocarbons built up during the operation of the superconducting cavities. Motivated by the 49 MeV operational energy gain of the four C100 cryomodules at Jefferson Lab, there is an ongoing experimental and simulation study of plasma processing on the C75 cavities. The simulation work is focused on the dynamics of

the gas, plasma ignition, and control. In parallel, a program to plasma process C75 cavity pairs and cryomodules is in progress. The recent progress report will be presented in this proceedings.

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Monday Poster Session / 527

Magnetic focusing architecture for a compact electron beam buncher

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Co-authors: Doug Patrick [1]; Maria Sanchez Barrueta [1]; Quinn Marksteiner [1]; Ryan Hemphill [1]; Haoran Xu [1]

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We present a beam-focusing architecture using electro- and permanent magnets for a novel compact electron beam buncher under development for space-borne electron accelerators. Developing compact and efficient accelerator components has become desirable with renewed interest in using space-borne electron beams for ionospheric aurora research and very low frequency wave generation for particle removal from the magnetosphere. An electron gun injects a direct current electron beam, and the buncher modulates the DC beam into periodic bunches at a frequency of 5.7 GHz. A 5.7 GHz linear accelerator in the downstream will capture the bunched beam with minimal acceptance mismatch. The beam modulation is done by three radiofrequency pillbox cavities. The buncher uses the electrostatic potential depression (EPD) method to shorten the structure length remarkably. The electron gun and a tunable solenoid provide the initial focusing of the beam. We then use a series of permanent magnets surrounding the buncher cavities clamped together by ferromagnetic steel plates to focus the beam through the buncher. Permanent magnets do not consume any power and weigh less than solenoid magnets, which provide equivalent focusing, making them ideal for use on a satellite or sounding rocket. We use the three-dimensional (3D) particle tracking solver from CST Studio Suite to simulate the beam-focusing.

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Wednesday Poster Session / 528

Status of the power coupler for the half wave resonator in IRIS

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The Institute of Rare Isotope Science(IRIS) has a heavy-ion accelerator facility in Daejeon, Korea. The cryomodule with quarter-wave resonators (QWR) and half-wave resonators (HWR) were also installed in the SCL3 tunnel and a beam operation test (Beam energy = 17.6 MeV/u) was performed. However, the frequency drift of the HWR is one of the failures of the beam control. Therefore, the multi-physics analysis, which includes electromagnetic, thermal, and mechanical analysis, is performed to evaluate the deformation of the outer conductor and the antenna of the power coupler. The required power of the power coupler for HWR is 4 kW in CW mode at 162.5 MHz. The geometry of the power coupler is a coaxial capacitive type based on a conventional 1-5/8 inch electronic industries alliance (EIA) 50 Ω coaxial transmission line with a single ceramic window. In this paper, we present the status and analysis results of the power coupler for HWR.

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Monday Poster Session / 529

NuMI beam muon monitor data analysis and simulation for improved beam monitoring

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Following the decommissioning of the Main Injector Neutrino Oscillation Search (MINOS) experiment, muon and hadron monitors have emerged as essential diagnostic tools for the NuMI Off-axis nu_mu Appearance (NOvA) experiment at Fermilab. For this study, we use a combination of muon monitor simulation and measurement data to study the monitor responses to variations in proton

beam and lattice parameters. We also apply pattern-recognition algorithms to develop machine-learning-based models to establish correlations between muon monitor signals, primary beam parameters, and neutrino flux at the detectors.

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Wednesday Poster Session / 530

Study of generalized electron emission theory in a superconducting cavity

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Generalized electron emission theories consisting of field emission and thermionic emission are investigated. Electrons in metal are emitted due to a strong local electric field for field emission. For thermionic emission, the electrons in metal are emitted due to the local high temperature. Field emission is studied in terms of dimensions, and thermionic emission is also studied as a function of dimensions. Generalized electron emission theory, which comes from field emission and thermionic emission, is developed. This generalized electron theory is applied to superconducting cavities.

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Thursday Poster Session / 531

Support structures and their removal improve performance of additively manufactured RF cavities

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The enormous potential of additive manufacturing (AM), in particular laser powder bed fusion (L-PBF), for the manufacturing of normal-conducting radio frequency cavities (cavities) has already been demonstrated. However, the required geometrical accuracy for GHz TM010 cavities is currently only achieved using: a) co-printed support structures, which are however difficult to remove for small GHz cavities. b) Avoidance of downskin angles alpha<40°, which in turn leads to a cavity geometry with reduced shunt impedance. We have developed an L-PBF-based manufacturing approach to overcome these limitations. To enable arbitrary geometries, co-printed support structures are used that are designed in such a way that they can be removed after printing by electrochemical post-processing. At the same time, the surface roughness is reduced, and thus the quality factor maximized. The fabrication approach is evaluated on a 3 GHz TM010 single-cavity geometry printed entirely from high-purity copper.

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Thursday Poster Session / 532

Design, manufacturing and validation of the new quench heater discharge power supplies for the protection of superconducting magnets for the High-Luminosity LHC Project at CERN

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Co-authors: Raphael Berberat [1]; Spyridon Georgakakis [1]; Josep Guasch-Martinez [1]; Enrique de Nicolás Lumbreras [1]; Edward Nowak [1]; Maria Papamichali [1]; Mirko Pojer [1]; Felix Rodriguez Mateos [1]; Miguel Leon Lopez [2]

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The Quench Heater Discharge Power Supplies (HDS) are magnet protection devices installed in the Large Hadron Collider (LHC) that, upon detection of a magnet quench, release energy into the copper-plated stainless-steel strip heaters, inducing a resistive transition all along the superconducting coils. Such a distributed internal heating ensures an even energy dissipation across the entire volume, preventing local overheating and magnet damage. Over 6000 HDS units have been operational in the LHC tunnel since 2007. The new HDS design for protection of the High Luminosity LHC (HL-LHC) Inner Triplet magnets, to be installed in the Long Shutdown starting in 2026, calls for a more advanced design with up-to-date components resulting in a higher reliability of the HDS units.
Several HDS prototypes were produced at CERN, eventually culminating in the development of the HL-LHC HDS version to be installed in the accelerator. This paper describes the design of the upgraded HDS units and the comprehensive safety and electromagnetic compatibility (EMC) tests, coupled with extensive operational tests, including irradiation tests, that have been conducted.

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Thursday Poster Session / 533

Design, manufacturing and validation of the CLIQ units for the protection of superconducting magnets for the High-Luminosity LHC project at CERN

Author: David Carrillo[1]

Co-authors: Raphael Berberat [1]; Mathieu Favre [1]; Spyridon Georgakakis [1]; Josep Guasch-Martinez [1]; Enrique de Nicolás Lumbreras [1]; Edward Nowak [1]; Mirko Pojer [1]; Felix Rodriguez Mateos [1]; Miguel Leon Lopez [2]

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The novel Coupling-Loss-Induced-Quench (CLIQ) concept will be part of the quench protection system of the High Luminosity Large Hadron Collider (HL-LHC) Inner Triplet superconducting magnets at CERN. Several units of two distinct CLIQ prototype variants were produced to validate the CLIQ novel protection concept and define the system parameters for the required performance. Subsequently, these units were further enhanced by introducing additional redundancy, advanced monitoring systems, and improved safety features. These improvements culminated in the development of the third and final version. This paper provides insights into the evolution from prototypes to the final version to be installed in the machine, shedding light on the outcomes of comprehensive safety and electromagnetic compatibility (EMC) tests, coupled with extensive operational assessments.

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Thursday Poster Session / 534

Design automation of pre-separator wedges for FRIB advanced rare isotope separator

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At the Facility for Rare Isotope Beams (FRIB) unique pre-separator wedges are required for each experiment. As the number of experiments and wedges needed increases every year, reduction in design time and increase in accuracy is critical (FY23 utilized 40 unique wedges, FY24 approx. 60 are planned, and eventually 100 annually).
Design automation is achieved by DriveWorksXpress, which reduced design/drafting time by 60%. A form was created with parameters (inputs) listed for each component of the wedge assembly (e.g., wedge height, wedge on axis thickness, wedge angle, etc.). The dimensions and file properties of each component are then able to reference the input values for each parameter from the form and automatically adjust the model and assembly accordingly. Automation on drawing drafting is achieved at the same time.
The reduction in design time resulted in completing the design task more efficiently. A reduction in design error and human error was also observed, reducing manufacturing down time and effort required during the release process. These benefits have streamlined the mechanical design process for the pre-separator wedges.

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Tuesday Poster Session / 535

SRF cavity instability detection with machine learning at CEBAF

Author: Hal Ferguson[1]

Co-authors: Adam Carpenter [2]; Chris Tennant [2]; Dennis Turner [2]; Dillon Thomas [2]; James Latshaw [2]; Ramakrishna Bachimanchi [2]

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During the operation of the Continuous Electron Beam Accelerator Facility (CEBAF), one or more unstable superconducting radio-frequency (SRF) cavities often cause beam loss trips while the unstable cavities themselves do not necessarily trip off. The present RF controls for the legacy cavities report at only 1 Hz, which is too slow to detect fast transient instabilities during these trip events. These challenges make the identification of an unstable cavity out of the hundreds installed at CEBAF a difficult and time-consuming task. To tackle these issues, a fast data acquisition system (DAQ) for the legacy SRF cavities has been developed, which records the sample at 5 kHz. A Principal Component Analysis (PCA) approach is being developed to identify anomalous SRF cavity behavior. We will discuss the present status of the DAQ system and PCA model, along with initial performance metrics. Overall, our method offers a practical solution for identifying unstable SRF cavities, contributing to increased beam availability and facility reliability.

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Tuesday Poster Session / 536

Simulations of coherent electron cooling with varied beam parameters

Author: Jun Ma[1]

Co-authors: Gang Wang [1]; Vladimir Litvinenko [2]; Yichao Jing [1]

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Coherent electron cooling (CeC) is a novel technique for rapidly cooling high-energy, high-intensity hadron beam. Plasma cascade amplifier (PCA) has been proposed for the CeC experiment in the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL). Cooling performance of PCA based CeC has been predicted in 3D start-to-end CeC simulations using code SPACE. The dependence of the cooling rate on the electron beam parameters has been explored in the simulation studies.

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Wednesday Poster Session / 537

Simulations of incoherent effects driven by electron clouds forming in the inner triplets of the Large Hadron Collider

Author: Konstantinos Paraschou[1]

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During Run 2 and Run 3 of the Large Hadron Collider (LHC), slow losses from electron cloud (e-cloud) effects have been systematically observed during the full duration of fills with closely-spaced proton bunches. In particular, these effects had been found to depend strongly on the crossing angle of the two beams and the value of the betatron functions in the interaction points. Due to this observation, the main cause of this effect was attributed to the non-linear forces induced by electron clouds forming in the vacuum chamber of the LHC Inner Triplet quadrupole magnets. In this contribution, electron cloud buildup simulations reveal that the induced forces depend strongly on the transverse coordinates of the beam particles, on time, as well as on the longitudinal coordinate within the Inner Triplet. Finally, non-linear maps are generated based on the buildup simulations, and the effect of these forces on the motion of the protons is simulated.

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Monday Poster Session / 538

Fringe field maps for transverse gradient bending magnets with curved poles

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We present second-order fringe maps for gradient dipoles whose poles are curved to follow the reference orbit. While some of the results have been previously found, we find new contributions including soft-edge linear terms that can be significant for gradient dipoles. In addition, we depart from previous works by writing all soft-edge corrections in terms of integrals along the particle trajectory; this appears to be required for dipoles with strong transverse gradients. We have added the fringe model to the CSBEND element in the tracking code ELEGANT*, and we compare the fringe map predictions to those of field-map tracking for several transverse gradient dipoles used in the APS-Upgrade.

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Wednesday Poster Session / 541

A parallel variable population multi-objective optimization software package for accelerator design optimization

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The simultaneous optimization of multiple objective functions is needed in many particle accelerator applications. In this paper, we report on the development of an open source parallel evolution based multi-objective optimization package that uses a variable population from generation to generation and an external storage to save good solutions. Two heuristic optimization methods, one uses the unified differential evolution and the other uses the real-coded genetic algorithm, are included in the optimizer to generate next generation candidate solutions. We will present the usage of the package, tests, and application examples.

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Thursday Poster Session / 542

Field characterization of axially and radially magnetized neodymium rings

Author: Tianzhe Xu[1]

Co-authors: Robert England [1]; Scott Anderson [1]

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Permanent magnets are attractive options for nano focusing and q-magnification in MeV ultrafast electron diffraction (MeV-UED) due to their high field strengths and compact footprints. In this work, we present field characterization of axially and radially magnetized neodymium rings. Such rings can produce strong axisymmetric focusing and naturally fulfill the requirement of stigmatic imaging

for post-sample optical systems. Field qualities of the rings and their application in MeV-UED are studied and presented.

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Thursday Poster Session / 543

Advanced modeling and optimization of nuclear physics colliders

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Co-authors: William Fung [2]; Xiaofeng Gu [3]; Yi-Kai Kan [1]; Yue Hao [2]

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High energy colliders provide a critical tool in nuclear physics study by probing the fundamental structure and dynamics of matter. Optimizing the collider's machine parameters is both computationally and experimentally expensive. A fast and robust optimization framework that includes both beam-beam and the detailed machine lattice will be crucial to attaining the best performance of the collider. In this paper, we report on the development of an integrated framework that includes an advanced Bayesian optimization software GPTune, a self-consistent beam-beam simulation code BeamBeam3D, and the detailed lattice model from MAD-X. Some application results to the RHIC facility optimization will also be presented.

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Thursday Poster Session / 544

Combined wakefield and beam-beam effects in the EIC design

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Collective wakefield and beam-beam effects play an important role in accelerator design and operation. These effects can cause beam instability, emittance growth, and luminosity degradation, and warrant careful study during accelerator design. In this paper, we report on the development of a computational capability that combines both short and long range wakefield models and a strong-strong beam-beam simulation model. Applications to the EIC will be discussed.

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Wednesday Poster Session / 545

High brightness electron source development in Tsinghua university

Author: Peng-Wei Huang[1]

Co-authors: Chuanxiang Tang [1]; Lianmin Zheng [1]; Renkai Li [1]; Wenhui Huang [1]; Xiao-Yang Zhang [1]; Yingchao Du [1]

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High brightness electron source is a key component for accelerator based scientific instruments. The beam brightness can be further improved with the combination of high electric field and low thermal emittance cathode. We develop an ultrahigh vacuum S-band electron gun to accommodate advanced semiconductor photocathodes, which are easily degraded in poor vacuum condition. The high power test of ultrahigh vacuum S-band gun has finished and the axial electric field has reached over 100 MV/m with dark current around 500 pC. The vacuum under operation is 2.08e-8 Pa, which is one of the best vacuum condition with regards to such high gradient operation. The gun has been operated with Cs_2Te cathode for 3 months without quantum efficiency (QE) degradation. Advanced photocathode deposition system has been setup in a clean room and the deposited photocathodes are transferred through suitcase to load lock system in ultrahigh vacuum environment. We have deposited K_2CsSb cathode in the deposition system. The QE is between 1% and 4.5% with driven laser wavelength of 532 nm. The QE and thermal emittance of the K_2CsSb have been measured under high gradient in the gun and results are presented in the paper.

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Wednesday Poster Session / **547**

The European Spallation Source neutrino super beam

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The discovery of neutrino Charge-Parity Violation (CPV) became an important candidate to explain the matter dominance in the Universe. The goal of the ESSnuSB project is to discover and measure neutrino CPV with unprecedented sensitivity. *The construction of the European Spallation Source, ESS, the world's most intense proton source, represents an outstanding opportunity for such project to take place. ESSnuSB has been granted from EU in the framework of H2020 (2018-2022) and Horizon Europe (2023-2026) to make Design Studies. The aim of the first Design Study was to demonstrate that the ESS linac can be used to generate an intense neutrino beam by doubling its average beam power and that a megaton water Cherenkov detector can be constructed in a mine 360 km from ESS providing detection of neutrinos at the 2nd neutrino oscillation maximum. A CDR** has been published in which it is shown the high physics performance to discover CPV and precisely measure the violating parameter δCP. For this, the modification for neutrino generation to compress the proton pulse length from 2.86 ms, to 1.3 μs has been studied.
The second, ongoing, Design Study, ESSnuSB+, is devoted to neutrino cross-section measurements relevant to the CPV discovery. Two facilities are proposed, a low energy nuSTORM (muons decaying to neutrinos in a race-track storage ring) and low energy ENUBET (pions decaying to a muon and a neutrino, allowing the neutrino beam to be monitored by detection of the decay muon).

Footnotes:

- A Very Intense Neutrino Super Beam Experiment for Leptonic CP Violation Discovery based on the European Spallation Source Linac, Nuclear Physics B, Vol 885, Aug 2014, 127-149, doi:10.1016/j.nuclphysbps.2015.09.278
  ** The European Spallation Source neutrino Super Beam conceptual design report. Eur. Phys. J. Spec. Top. 231, 3779–3955 (2022), doi:10.1140/epjs/s11734-022-00664-w

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Wednesday Poster Session / **548**

Picometer scale emittance from plasmonic spiral photocathode for particle accelerator applications

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In this work we demonstrate the generation of a record low root mean square normalized transverse electron emittance of less than 30 pm-rad from a flat metal photocathode –more than an order of magnitude lower than the best the emittance that has been achieved from a flat photocathode. This was achieved by using plasmonic focusing of light to a sub-diffraction regime using plasmonic Archimedean spiral structures resulting in a ˜40 nm root mean square electron emission spot. Such nanostructured electron sources exhibiting simultaneous spatio-temporal confinement to nanometer and femtosecond level along with a low mean transverse energy can be used for developing advanced electron sources to generate unprecedented electron beam brightness for various accelerator applications.

Footnotes:

Funding Agency:

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North America

Tuesday Poster Session / 549

Thermal and vibrational studies of a new germanium detector for X-ray spectroscopy applications at synchrotron facilities

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The European LEAPS-INNOV project has launched a Research and Development program dedicated to the design of a new generation of germanium detectors for X-ray spectroscopy applications. The present article shows the results of the thermomechanical simulations of this design, based on finite element analysis (FEA) studies, under vacuum and cryogenic conditions. The first results of these simulations were published at IPAC'23*. In this new work, the final results are presented, which includes the thermal optimization of the detector with respect to the previous study, as well as new numerical simulations to investigate the effects of vibration transmission from the cryocooler to the head detector.

Footnotes:

- M. Quispe, "Thermal Mechanical Simulations of a New Germanium Detector Developed in the European Project LEAPS-INNOV for X-Ray Spectroscopy Applications at Synchrotron Facilities" , Proceedings of IPAC2023. Venezia, Italy May 11, 2023

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Europe

Monday Poster Session / 550

Status update of the SASE3 variable polarization project at the European XFEL

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The SASE3 Variable Polarization project was intended to offer the possibility of setting any polarization of the soft X-ray laser emission. The project was completed in early 2022. During the winter shutdown 2021-2022, all four APPLE-X helical undulators were placed in the tunnel and the first lasing was achieved in April 2022. Unfortunately, further use of the helical afterburner proved impossible, as the encoders used to position the magnetic structures of the undulator and thus set the K parameter and polarization mode were damaged by radiation. To carry out the repair work, all undulators were removed from the tunnel in the summer of 2022. Meanwhile, studies were carried out to determine the causes of the radiation damage, as presented in this article. This article also

presents measures taken to minimize further radiation damage that will allow the continued operation of the helical afterburner. An overview of the magnetic measurements carried out and the current status of the project are also presented.

Footnotes:

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Europe

Wednesday Poster Session / 551

Near-Infrared noise in intense electron beams

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Requirements for the noise in electron beams (NEB) have recently approached the Shot-noise level in some new applications. The density fluctuations of intense beams in the near-infrared (NIR) region are being measured at the Fermilab Accelerator Science and Technology (FAST) facility. The main goal of the experiment is to accurately compare the Shot-noise model with the observations of optical transition radiation (OTR) generated by the gamma=63 electron beam transiting an Al metal surface. In addition, evidence for longitudinal-space-charge-induced microbunching for the chicane-compressed beam was obtained with coherent enhancements up to 100 in the various bandwidth-filtered NIR OTR photodiode signals. With micropulse charges up to 1 nC, the beam parameters are close to those proposed for a stage in an Electron-Ion Collider (EIC) with coherent electron cooling (CEC). In this paper we present the current progress of the NEB project and compare the low electron energy measurements with ImpactX simulations.

Footnotes:

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North America

Monday Poster Session / 552

Calculation of focal spot of secondary X-rays generated by high-energy electron beam bombarding of heavy metal targets

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One of the main methods to generate X-rays is to bombard metal targets with electron beams. However, this process introduces uncertainty in the electron transport, which leads to uncertainty in the position and momentum of the secondary X-rays. As a result, the focal spot of the X-rays is larger than the electron beam. In this paper, we use the Monte Carlo software Geant4 to investigate the conditions for minimizing the X-ray focal spot size. We assign different weights to the X-rays according to their energy components, based on the actual application parameters. We calculate the focal spot size for three target materials: lead, copper, and tungsten, finding that when the incident electron energy is in the MeV range and the electron source radius is 1 um, the mass thickness of the target of 1.935×10e-3 g/cmˆ2 is the limit for achieving the smallest equivalent focal spot size.

Footnotes:

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Asia

Monday Poster Session / 554

Establishing a new class of high-current accelerator-driven neutron sources with the HBS project

Co-authors: Alexander Schwab [1]; Andreas Lehrach [2]; Eric Mauerhofer [1]; Holger Podlech [3]; Jingjing Li [2]; Johannes Baggemann [1]; Julius Storch [3]; Jörg Voigt [1]; Klaus Kümpel [3]; Olaf Felden [2]; Oliver Meusel [3]; Paul Zakalek [1]; Ralf Gebel [4]; Romuald Hanslik [5]; Thomas Brückel [1]; Thomas Gutberlet [1]; Ulrich Rücker [1]; Winfried Barth [4]; Yannick Bessler [5]

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Accelerator-driven high brilliance neutron sources are an attractive alternative to the classical neutron sources of fission reactors and spallation sources to provide scientists with neutrons. A new class of such neutron facilities has been established referred to as High-Current Accelerator-driven

Neutron Sources (HiCANS). The basic features of HiCANS are a medium-energy proton accelerator with of tens of MeV and up to 100 mA beam current, a compact neutron production and moderator unit and an optimized neutron transport system to provide a full suite of high performance, fast, epithermal, thermal and cold neutron instruments.
The Jülich Centre for Neutron Science (JCNS) has established a project to develop, design and demonstrate such a novel accelerator-driven facility termed High Brilliance neutron Source (HBS). The aim of the project is to build a versatile neutron source as a user facility. Embedded in an international collaboration, the HBS project offers the best flexible solutions for scientific and industrial users. The overall conceptual and technical design of the HBS as a blueprint for the HiCANS facility has been published in a series of recent reports.
The status and next steps of the project will be presented, focusing on the high-current linear accelerator and the proton beamline, including a novel multiplexer to distribute the proton beam to three different neutron target stations while adapting a flexible pulse structure.

Footnotes:

Technical Design Report HBS Volume 1 –Accelerator 2023, Forschungszentrum Jülich GmbH Zentralbibliothek, Verlag Jülich, ISBN: 978-3-95806-709-7, https://juser.fz-juelich.de/record/1016730

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Europe

Tuesday Poster Session / 555

The P3 experiment: a proof-of-principle e+ source for future colliders

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The PSI Positron Production (P3 or P-cubed) experiment is a e+ source and capture system with potential to increase by an order of magnitude the state-of-the-art e+ yield normalized to the drive linac energy, a long-desired goal for future lepton colliders. The experiment is framed in the FCC-ee injector study and will be hosted at SwissFEL, located at the Paul Scherrer Institute in Switzerland. This paper paper presents the P3 project at an advanced stage, with an emphasis on a capture system featuring a novel e+ matching device based on high-temperature superconducting solenoids, followed by 2 large aperture RF cavities surrounded by normal-conducting solenoids. The diagnostics design is also introduced, including monitors of charge, energy spectrum and bunch by bunch longitudinal profile simultaneously for secondary e+ and e-. The last chapter of the text overviews the currently ongoing installation at SwissFEL, including the beam transfer line, RF network, radiation protection and other relevant activities towards the operation with e+ in the coming years.

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Thursday Poster Session / 558

Studies and mitigation of TMCI in FCC-ee

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The previous studies have shown that the turbulent mode coupling instability (TMCI) is expected to be one of the most severe single bunch instabilities in FCC-ee that can limit performance of the collider. The instability threshold depends on both the transverse and longitudinal wake fields created due to the vacuum chamber discontinuities and the beam-beam interaction that, in turn, can be considered as the transverse cross wake force. In this paper the TMCI is studied by using the latest collider parameter list and the updated impedance model. Different mitigation techniques aimed at the instability threshold increase such as positive chromaticity, feedback systems, unequal tunes etc. are also discussed.

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Tuesday Poster Session / 559

Wakefield analysis of the FCC-ee collimation system

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The paper focuses on calculating the longitudinal and transverse wake-fields and impedances of the FCC-ee collimators through electromagnetic simulations using CST, ECHO3D and IW2D codes. The conducted studies have revealed that the collimation system can significantly contribute to the overall collider impedance/wake budget, both broad-band and narrow-band. The single bunch dynamics simulations with PyHEADTAIL have shown that the wake-fields of the collimators are expected to play a crucial role in reducing the TMCI threshold. In addition, the higher order modes (HOM) trapped in collimator's structures can affect the multi-bunch stability. In this paper some design solutions are proposed to suppress the HOMs. However, further studies are still required to mitigate the impact of this wake-field source on beam quality and stability.

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Monday Poster Session / 562

Extraction of Coulomb crystals with limited emittance growth

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Laser Doppler cooled ion traps can produce stationary bunches of ions with extremely low velocity spread (0.6 m/s RMS) and emittance (10e-13 m normalized). This corresponds to temperatures of a few milli-Kelvin and allows the ions to settle into a fixed lattice analogous to a solid crystal, but with the Coulomb repulsion balanced by the trapping force, rather than a chemical bond. Extraction of such a bunch into a beamline could provide a new regime of ultra-low emittance beams if the emittance is preserved through the extraction operation. This paper shows that extraction from the ion trap and initial acceleration does not cause drastic growth, thus preserving the ultra-low emittance nature of the bunch. Techniques for compensating coherent 'emittance growth' effects such as nonlinear bunch distortion are also investigated.

Footnotes:

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Brookhaven National Laboratory / Department of Energy

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North America

Tuesday Poster Session / 563

Optimization of a permanent magnet multi-energy FFA arc for the CEBAF energy upgrade

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It is currently planned to increase the energy of the CEBAF recirculating linear accelerator to 20 GeV or more by adding two new recirculating arcs that contain multiple new energy passes. The beam is continuous (CW), so no field ramping is desired, making this a fixed-field accelerator (FFA). The wide energy range requires a low dispersion lattice that can be created with high-gradient permanent magnets. One constraint is the existing tunnel radius in relation to the fields achievable by practically-sized permanent magnets. Thus, searching for the most efficient implementation in terms of magnet material volume is important. In this paper, a lattice cell search and optimization is conducted that evaluates cells by the magnet volume per unit length, with the permanent magnet designs also produced via an automated code. The new lattice cells are compared to the previous manually designed cell.

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Brookhaven National Laboratory / Department of Energy

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North America

Monday Poster Session / 564

Simulated impact of the HL-LHC beam on a graphite target

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In the High Luminosity Large Hadron Collider (HL-LHC) era, the intensity of the circulating bunches will increase to 2.2e+11 protons per bunch, almost twice the nominal LHC value. Besides detailed studies of known and new failure cases for HL-LHC, *it is also required to investigate failures beyond nominal design. The consequence of such failures can be the impact of a large number of high-energy particles in one location, resulting in a significantly increased damage range due to an effect called hydrodynamic tunneling.The phenomena is studied by coupling FLUKA, an energy deposition code, and Autodyn, a hydrodynamic code. This paper presents the simulated evolution of the deposited energy, density, temperature and pressure for the impact of the HL-LHC beam on a graphite target. It then computes the resulting tunneling range and finally compares the outcome with previous studies using LHC intensities.***

Footnotes:

- B. Lindstrom et al., "Fast failures in the LHC and the future high luminosity LHC,"Phys. Rev. Accel. Beams, vol. 23, no. 8, p. 81001, Aug. 2020 ** N. A. Tahir et al., NIM B, 427 (2018), 70–86 *** C. Wiesner et al., J.Phys.Conf.Ser. 2420 (2023) 1, 012004, JACoW IPAC2022 1870-1873

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Europe

Thursday Poster Session / 565

ELISA: a compact linear accelerator for societal applications

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ELISA (Experimental LInac for Surface Analysis) is a linear proton accelerator installed in the Science Gateway exhibition at CERN since October 2023. Its development is built upon the experience gained at CERN from the R&D for LINAC4, with an innovative design of the Radio Frequency Quadrupole (RFQ). With a footprint of only 2x1 square meters, ELISA has the potential of full portability and requires manufacturing capabilities already established in industries involved in medical and societal applications of accelerators. ELISA consists of an ion source, a one-meter-long RFQ working at 750 MHz and an analyzing line dedicated to Particle Induced X-ray Emission (PIXE). The system can accelerate a proton beam (extracted from the source at 20 keV) up to an energy of 2 MeV. In this paper we present the ELISA source commissioning and the optimization process that allowed to achieve the required brilliance. High energy beam commissioning will be also discussed, including beam current measurements at 2 MeV, investigation of the beam quality after acceleration and RFQ power scans to characterize the ELISA RFQ.

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Europe

Thursday Poster Session / 566

Operation status of FRIB wedge systems and plan for power ramping up

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At the Facility for Rare Isotope Beams (FRIB) Advanced Rare Isotope Separator (ARIS), wedges are critical devices to achieve rare isotope beam production. Different ions experience a different amount of slowing down by the wedges, which leads to a spatial separation of ion species and enables separation/purification of the secondary isotope beam.
As of December 2023, wedge systems have successfully supported FRIB commissioning for over 4,000 hours. Nearly 60 unique wedges were utilized which were implemented during 15 wedge maintenance periods. Material selection, unique wedge designs for beam tuning, secondary wedge design, and diagnostic wedge design developments will be discussed in this paper.
The current wedge devices will support primary beam operations to a power level of 65 kW, as evaluated by analysis. Development is underway to achieve a higher power wedge system, capable of 400 kW with full remote handling capacity. Further development plans include a variable wedge system to reduce maintenance time and increase ARIS tuning flexibility.

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North America

Thursday Poster Session / 567

Pressure spike in the LBNF absorber core's gun drilled cooling channel from an accident beam pulse

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The LBNF Absorber consists of thirteen 6061-T6 aluminum core blocks. The core blocks are water cooled with de-ionized (DI) water which becomes radioactive during beam operations. The cooling water flows through gun-drilled channels in the core blocks. The cooling water is supplied by the LBNF Absorber Radioactive Water (RAW) cooling system which is designed as per ASME B31.3 Normal Fluid Service. An uninhibited beam accident pulse striking the water channels was identified as a credible accident scenario. In this study, it is assumed that the beam pulse hits the Absorber directly without interacting with any of the other upstream beamline components. The beam parameters used for the LBNF beam are 120 GeV, 2.4 MW with a 1.2 s cycle time. The accident pulse lasts for 10 µs. The maximum energy is deposited in the 3rd aluminum core block. For the sake of simplicity, it is assumed that the accident pulse strikes the 1"ID water channel directly. The analysis here simulates the pressure rise in the water during and after the beam pulse and its effects on the aluminum piping components that deliver water to the core blocks. The weld strengths as determined by the Load and Resistance Factor Design (LRDF) and the Allowable Strength Design (ASD) are compared to the forces generated in the weld owing to the pressure spike. A transient structural analysis was used to determine the equivalent membrane, peak, and bending stresses and they were compared to allowable limits.

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North America

Tuesday Poster Session / 568

Optimization of a welding procedure for making critical aluminum welds on the LBNF absorber core block

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The LBNF Absorber consists of thirteen 6061-T6 aluminum core blocks. The core blocks are water cooled with de-ionized (DI) water which becomes radioactive during beam operations. The cooling water flows through gun-drilled channels in the core blocks. A weld quality optimization was performed to produce National Aeronautical Standard (NAS) 1514 Class I quality welds on the aluminum core blocks. An existing Gas Tungsten Arc Welding (GTAW) Welding Procedure Specification (WPS) was fine tuned to minimize, in most cases, and eliminate detectable tungsten inclusions in the welds. All the weld coupons passed welding inspection as per ASME B31.3 Normal Fluid Service inspection criteria. Tungsten electrode diameter, type, and manufacturer were varied. Some of the samples were pre-heated and others were not. It was observed that larger diameter electrodes, 5/32", with pre-heated joints resulted in welds with the least number of tungsten inclusions. It is hypothesized that thinner electrodes breakdown easily and get lodged into the weld pool during the welding process. This breakdown is further enhanced by the large temperature differential between the un-preheated sample and the hot electrode.

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North America

Wednesday Poster Session / **572**

The design and electromagnetic analyses of the new elements in the FCC-ee IR beam pipe

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High currents of bunched electron and positron beams plan to be used in the proposed FCC-ee collider to achieve a high luminosity. Naturally, the impedance of the interaction region of the FCC must be as small as possible. Previously, a very smooth beam pipe in the interaction region was designed, and now we add necessary elements important for the beam operation, reduced backgrounds, and assembly. Among these elements are BPMs, expansion bellows, extension of the common beam pipe, and an elliptical synchrotron radiation mask. These new elements will be analyzed to see if they increase the impedance and, then, followed by discussions how to mitigate any issue.

Footnotes:

Funding Agency:

Paper preparation format:

Word

Region represented:

North America

Wednesday Poster Session / **573**

LCLS-II MHz-rate photoinjector performance

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LCLS-II 1-MeV CW electron source commissioning was successfully completed 2018-2020. Full 100 MeV injector system has been commissioned since summer 2022. CW RF gun and buncher operations are routinely established and e-beam is being ramped to 33 kHz now and eventually up to 1 MHz. About 0.5 μm of emittance has been achieved for 50 pC at desired bunch length. Dark current from the CW gun is systematically characterized and has been effectively mitigated with circular collimators after the gun at <1MeV of beam energy. In this contribution, we will present commissioning and operational experience for CW RF gun/buncher, dark current and high rate e-beam performance. Challenges for operating such CW NC gun based photoinjector and plans for future improvement of emittance and further mitigations of dark current are discussed.

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Tuesday Poster Session / 574

The magnetic error correction of SAPS storage ring based on ELEGANT script in AT code

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The correction of storage ring magnetic errors typically requires the use of multiple programs. However, there are generally differences in the correction results between different programs. We may perform error correction in one program and then continue with other tasks in another program, which requires us to accurately achieve the conversion of the lattice between different programs after correction. Based on the elegant script, we have successfully performed the error correction for the SAPS storage ring using the AT code to address this issue.

Footnotes:

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Asia

Tuesday Poster Session / **575**

Preliminary study of HALF lattice utilizing superconducting longitudinal gradient bend

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Co-authors: Guangyao Feng [1]; Lin Wang [1]; Penghui Yang [1]; Weimin Li [1]

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The Hefei Advanced Light Facility (HALF) is a diffraction-limited storage ring with a 2.2 GeV energy and modified 6BA lattice that is currently under construction. To meet the requirement for high-brightness hard X-rays, it is being considered that superconducting longitudinal gradient bend will replace ordinary longitudinal gradient bend in some cells in the future. Based on the measured magnetic field of a prototype, a preliminary study was conducted to explore modifying the storage ring lattice and optimizing the field shape of the superconducting longitudinal gradient bend to enhance the performance of HALF.

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LaTeX

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Asia

Thursday Poster Session / **576**

Electrical fire safety assessment of the synchrotron accelerator experimental station in NSRRC

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The synchrotron facility and experimental station in the National Synchrotron Radiation Research Center (NSRRC) uses many electrical appliances, the improper use of which can cause fires, resulting in property damage and personal injury. Therefore, the usage of these electri-cal appliances must be assessed.
This study conducted a comprehensive inspection and evaluation of the electrical appliances used in

NSRRC, including extension cords and electrical connections; this was done to not only reduce the risk of fire but also emphasize the importance of electrical safety habits. We connected an extension cord reel in the NSRRC to a pump or a dehumidifier and used a thermal imaging cam-era to measure the temperature of the cord and these two appliances. We tested the extension cord reel when it was coiled up in the reel and straightened to determine which electrical appliances or extension cord states were prone to high temperatures and fires.
The results showed that the extension cord was 18–20°C hotter when it was coiled than when it was straight. Therefore, we recommend that at least two-thirds of the length of the extension cord should be extended out of the reel when it is used.

Footnotes:

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Asia

Monday Poster Session / 577

Beam dynamics research for high-repetition-rate infrared FEL linac

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Compared to conventional free-electron lasers (FELs), high-repetition-rate FEL has the ability to generate laser pulses at a higher frequency, thereby significantly enhancing the laser's mean power. The high-repetition-rate infrared FEL (IR-FEL) device aims to incorporate optical resonator-based FEL technology, powered by a photocathode RF gun and a superconducting RF accelerator. This paper outlines the design layout and optimization of the primary parameters of the high-repetition-rate IR-FEL device. Beam dynamics simulations of the injector, accelerator, and bunch compressor are performed using the codes ASTRA and CSRTrack. Code Genesis 1.3 is used to simulate the physics in the undulator sections. During the simulation, the collective effects like space charge, coherent synchrotron radiation (CSR), and longitudinal cavity wake field effects are taken into consideration.

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Thursday Poster Session / 578

Impact of insertion devices on SSRF-U lattice

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The Shanghai Synchrotron Radiation Facility upgrade (SSRF-U) lattice is a 4th generation, 3 GeV, upgrade plan for SSRF. It aims to reach the diffraction limit while keeping the existing beam lines and spaces. The majority of insertion devices (IDs) in operation of current SSRF will be considered as the ID scheme in SSRF-U. The kick-map method has been used to build ID models, including the EPUs and SCW. Optical distortion caused by IDs was compensated using both local and global corrections. Then, frequency map analysis (FMA) method was used to identify potentially dangerous resonance lines. After considering high-order magnetic field errors, the dynamic aperture, energy acceptance, and Touschek lifetime were examined.

Footnotes:

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Asia

Thursday Poster Session / 579

Continuous position estimation for the full remote alignment system of the High Luminosity LHC upgrade

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The Full Remote Alignment System (FRAS) is an alignment system remotely controlled and monitored that comprises almost one thousand permanent sensors distributed along the 200 meters of equipment that will be installed in the frame of the High Luminosity LHC (HL-LHC) project on either side of the ATLAS and CMS detectors. The sensors, along with their electronics and a system of motorized actuators, will be used to adjust the relative positions of the components remotely, in real time, with no human intervention needed in the irradiated environment of the tunnel. In this contribution we describe the design and the implementation of the position estimation algorithm which is a core-component of the FRAS. This algorithm will process the data provided by all the sensors to determine exact positions and orientations of the associated components in real-time. The position estimation module is designed as a reusable C++ library and builds on the existing CERN LGC, a modular least-square software. It will be fully integrated into the FRAS software stack and

is entirely file-less during operation. In this paper we will demonstrate its performance in a realistic case study and showcase its ability to provide position updates on a much higher frequency than the required 1 Hz.

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Tuesday Poster Session / 580

Widely tunable laser pulses enable the generation of femtosecond electron beams with controllable lengths

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The length of the ultrafast electron bunch is crucial for ultrafast electron diffraction, serving as the timescale for observing ultrafast dynamic changes. Achieving continuous control over the length of these bunches within a certain range is crucial. This control ensures the accuracy of diffraction images, precise measurement of electron bunch length, and efficient terahertz radiation generation. Current devices often employ radio frequency (RF) cavity compression for electron bunch length compression. Still, this approach introduces time jitter and faces limitations in continuously adjusting the bunch length due to structural constraints. This paper focuses on compressing femtosecond laser pulses to obtain laser pulses with continuously adjustable pulse widths. It further analyzes the distribution of photocathode bunches and combines it with the bunch compression process to enhance the time resolution of ultrafast electron diffraction devices. Simultaneously, the use of continuously adjustable laser pulses can improve the precision of terahertz pulse generation.

Footnotes:

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Asia

Tuesday Poster Session / 581

Applications of horizontal field damping wigglers in the diffraction limited storage ring

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In this study, we present a lattice design for the diffraction limited storage ring (DLSR), that achieves an ultra-low natural emittance of 25.6 pm·rad (N-IBS). To address the significant intrabeam scattering (IBS) effect resulting from the ultra-low emittance and long damping times, Horizontal Field Damping Wigglers (HFDWs) were adopted. These components decrease damping times and beam horizontal emittance while generating vertical emittance, thereby achieving a "round beam" in the 864mDLSR. The optimal peak field, period length, and overall length of the HFDWs for the 864mDLSR have been determined using theoretical analysis and accelerator toolbox simulations. In addition, the linear optical corrections were performed on both the front and rear units of the HFDWs using six quadrupoles. A comparison of spectral brightness and flux was conducted on the 864mDLSRs with and without HFDWs.

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Asia

Wednesday Poster Session / 583

Unconventional high-voltage insulator in DC photoemission sources

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Especially when a high average current of 1 mA and more is required, it is important to protect photocathodes from overheating due to the absorbed laser power. Heat must be dissipated via the surrounding components and materials. This is largely limited by the low heat conductivity of usual high-voltage insulators, e.g. made of aluminum oxide. At the Johannes Gutenberg University in Mainz, we have successfully tested an insulating structure from boron nitride. Due to its physical properties, boron nitride fulfills both requirements: good heat conduction and high-voltage resistance. The results of high voltage tests and of the heat transfer capabilities will be presented.

Footnotes:

Funding Agency:

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Europe

Monday Poster Session / 584

A study for emittance growth compensation by space charge effects at the injector of KEK-STF after dry ice cleaning of the RF gun

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The International Linear collider (ILC) is an electron-positron linear collider with a center-of-mass energy up to 1 TeV. At the interaction point, the beam shape must be flat in the transverse space to maximize the luminosity and minimize the energy spread by Beamstrahlung. The flat beam is obtained by asymmetric emittance in x and y made up by radiation damping with a 3 km damping ring. We propose a new method to make asymmetric emittance based on emittance exchange techniques known as Round to Flat beam transformation (RFBT) and Transverse to Longitudinal Emittance Exchange (TLEX). We use ASTRA simulations to understand the transverse motion along the beamline of KEK Superconducting Test Facility (STF) with the goal of minimizing the emittance growth due to space charge effects. In the KEK STF facility the RFBT experiment was performed. In December 2023, to investigate the cause of unexpected emittance growth in previous experimental runs, we performed a detailed study of the STF injector with the cryomodules detuned. Here we report the results of this study and plans to achieve emittance compensation.

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Asia

Wednesday Poster Session / 585

Commissioning simulation for the Hefei advanced light facility storage ring

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Hefei advanced light facility (HALF) is a fourth-generation light source under building. The lattice contains 20 super-periods with modified hybrid 6-bend achromat (MH6BA). The circumference is 479.86 m, and the natural emittance is 85.8 pm·rad at 2.2 GeV. In reality, the real storage ring is different from the ideal lattice due to different kinds of errors. The errors come from many sources, like misalignment of components, imperfect magnetic field, etc. Due to strong nonlinear effect and small dynamic aperture of the HALF storage ring, the errors degrade the performance of the lattice seriously. The closed orbit may not exist without any correction. To figure out the practical performance of the lattice with errors, a start to end commission simulation is performed in this study, which also helps to build correction scheme for effective commissioning.

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Asia

Thursday Poster Session / 586

Status of the development of the new digital LLRF for ALBA synchrotron light facility

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One of the crucial control systems of any synchrotron is the Low-Level Radio Frequency (LLRF). The main purpose of an LLRF is to generate and maintain a stable electric field within the accelerator cavities by controlling its amplitude and phase. SAFRAN Electronic & Defense Spain S.L.U. is currently developing the new digital LLRF to update the system in the ALBA Synchrotron Light facility located in Barcelona. The design, implementation and tests are based on ALBA technical specifications. It is expected that the system will be tested on site, in its 500 MHz version, by summer 2024 while the 1.5 GHz (third harmonic version) will be tested on site by the first quarter of 2025. The architecture, design, and development as well as the performance of the LLRF system will be presented in this work.

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Europe

Tuesday Poster Session / 587

White Rabbit based picosecond timing system for scientific facilities

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The timing system is a critical element in scientific facilities such as particle accelerators or laser ignition installations. The different subsystems that integrate these scientific facilities need to have a common notion of time. This common time reference is provided by the timing system. Thanks to that, it is possible to operate the machine in a time coherent manner and to properly track the different events that occur during the operation of the machine. The timing system also provides the discrete triggering events and periodic signals requested for the different subsystems. Furthermore, it can be used also for radiofrequency distribution across the facility. In this work it is presented the timing system architecture, based on the White Rabbit technology and currently under development by Safran Electronic & Defense Spain SLU, for the distribution of synchronized triggers. The hardware, based on FPGA, will be detailed. The timing system allows total triggering configuration in terms of direction, number of pulses, pulse rate, pulse period and delay offering a resolution in the order of 5 ps. The White Rabbit technology provides sub-nanosecond accuracy and picosecond precision in addition to important characteristics such as automatic link calibration. The performance achieved will be shown in this work.

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Europe

Tuesday Poster Session / 588

Exploring convective heat transfer coefficients in fully developed flows: a combined CFD analysis and experimental validation for common geometries in particle accelerators

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Within the field of Particle Accelerators engineering, the design of cooling channels for its components has heavily relied on experimental correlations to compute convective heat transfer coefficients. These coefficients are believed to have a conservative factor which end up in oversized designs. The following study assesses this conservative factor for fully developed flows, in the laminar, turbulent and transition regimes. It will also focus on different geometries to do so. With this objective in mind, simulation models have been developed and correlated with experiments carried out at ALBA synchrotron. In the course of this research, various turbulence models and meshes have been examined for the development of the simulations. Heat transfer coefficients were derived from the Computational Fluid Dynamics (CFD) simulations and juxtaposed with empirical correlations. The specific geometries under investigation encompass a circular channel with a 10mm inner diameter, a rectangular section channel, and a pinhole geometry, the latter being frequently employed in accelerator technology.

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Thursday Poster Session / 589

Status of ABC production line at Varex Imaging Corporation

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During past 7 years at Varex Imaging Corporation, we have created a pilot production line for Accelerator Beam Centerlines (ABC), replacing supply of Beam Centerlines (BCL) by Varian after the Component Division separated from Varian in 2017, becoming an independent public company. Our ABC production growth rate seems to double every year, and in last quarter of 2023 Fiscal Year, we delivered 35 ABCs, satisfying Industrial group full demand in such ABCs.
In this 2024 Fiscal Year started on 1 October 2023, our goal is to deliver 12 units per month, but the

stretch goal is to produce anywhere between 160 and 200 ABCs, which will include ABCs for 3, 6, and 9 MeV Linacs mostly for security screening, for Non-Destructive Testing (NDT), also a few units for our customers in radiation therapy business. We drive to complete the transition away from Varian to 100% in-house ABC production in 2025,

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North America

Thursday Poster Session / 590

Study of the beam-beam interaction in an electron-positron collider with large Piwinski angle and crabbed waist

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To achieve very high luminosity, the next generation circular colliders adopt the crab waist collision scheme with a large Piwinski angle. In this scheme, beams collide with high current, low emittances, and small beta functions at the interaction point (IP). However, several effects arising from these extreme parameters, especially the coherent X-Z instability, will significantly impact the collider's performance, necessitating dynamic processing of longitudinal motion in a three-dimensional self-consistent treatment. The transverse vibration becomes coupled with the longitudinal motion, as well as the increase in horizontal beam size alters the interaction between beams and corresponding beam-induced effects. These instabilities limit the stable high luminosity area for the selected working point of the original design. Therefore, it is necessary to optimize the safe area of the working point by readjusting the parameters of the IP.In this paper, based on the Super Tau-Charm Facility (STCF) project in China, the instability caused by beam interactions is studied through numerical simulation. The relationship between the parameters at the IP and the stable selection area of the working point is systematically explored. The regularities found from simulations can assist future high luminosity electron-positron colliders in selecting the corresponding parameters. Additionally, some methods, such as adding adjustable devices to achieve stable high luminosity, are also proposed.

Footnotes:

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Asia

Tuesday Poster Session / 591

SRF cavity fault prediction using deep learning at Jefferson Lab

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In this study, we present a deep learning-based pipeline for predicting superconducting radio-frequency (SRF) cavity faults in the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab. We leverage pre-fault RF signals from C100-type cavities and employ deep learning to predict faults in advance of their onset. We train a binary classifier model to distinguish between stable and impending fault signals, where each cryomodule has a uniquely trained model. Test results show accuracies exceeding 99% in each of the six models for distinguishing between normal signals and pre-fault signals from a class of more slowly developing fault types, such as microphonics-induced faults. We describe results from a proof-of-principle demonstration on a realistic, imbalanced data set and report performance metrics. Encouraging results suggest that future SRF systems could leverage this framework and implement measures to mitigate the onset in more slowly developing fault types.

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North America

Tuesday Poster Session / 592

Collimator study for the Diamond-II storage ring

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Horizontal and vertical collimators will be installed in the Diamond-II storage ring to protect the ring components against undesired losses and radiation showers. Different loss mechanisms have been studied, including lifetime effects, RF trips, injection losses and kicker misfire. In this paper, we present the latest collimator layout and collimation efficiency. In addition, the risk of damage to the collimator blades has been studied for different materials using BDSIM.

Footnotes:

[1] H. Ghasem et al., in Proc. IPAC'22, TUPOMS032, (2022)
[2] BDSIM, https://www.pp.rhul.ac.uk/bdsim

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Europe

Tuesday Poster Session / 593

Application of generalized gradient expansion for magnet modelling in the Diamond-II storage ring

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To accurately represent fringe-field and cross-talk effects between the magnet pairs, a generalized gradient expansion method has been applied for modelling the magnets in the Diamond-II storage ring. These studies identified significant perturbations to the closed orbit and linear optics as well as the introduction of unwanted multipole errors. In this paper we summarize the impact these effects have on beam dynamics and present compensation measures that restore the design optics.

Footnotes:

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Europe

Thursday Poster Session / 594

Field shaping techniques in a spectrometer magnet in the presence of ferromagnetic obstructions

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The Targeted Alpha Tumor Therapy and Other Oncological Solutions (TATTOOS) project at the Paul Scherrer Institute aims to produce large quantities of radioisotopes (in the range of GBq), mainly Terbium-149, for the promising Targeted Alpha-particle Therapy (TAT) against metastasized cancer. To facilitate this, a new electromagnetic separator is currently being designed. Comprising two spectrometer magnets, the design of the separator is crucial, with magnetic properties and fringe fields strongly influencing beam characteristics and purity of the collected radioisotopes. The first of these magnets is exposed to high radiation and has strong requirements on surrounding shielding materials. The required steel for effective fast-neutron shielding introduces distortions to the field in the spectrometers. In this paper, we explore techniques to mitigate the sensitivity of the magnet to nearby shielding materials. The investigation begins with simulating a dipole magnet, assessing produced fringe fields, and understanding the influence of surrounding steel walls. Various methods, including Rogowski-profile ends, mirror plates, field clamps, and end shunts, are investigated to correct the aberrations in the generated field. The evaluation of produced field maps is quantified using harmonics, and the potential for tuning fringe fields with a sequence of end shunts is explored. Ultimately, the paper identifies the most suitable method for implementation in the TATTOOS project.

Footnotes:

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Europe

Monday Poster Session / 595

New high power linear accelerator ABC and platform

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At Varex Imaging Corporation, we have started a transition to our in-house supply of Accelerator Beam Centerlines (ABC), replacing Varian as a supplier. As part of this program we are considering changing design of our K-15, the only standard production unit capable of delivering Bremsstrahlung at 12000 R/min@1m by striking a copper target with high energy electron beam at 15 MeV. We plan on changing the RF source from frequency of 2856 MHz, used by Varian to 2998 MHz, establishing one common frequency for all our S-Band linear accelerator supply. We may be using a two-section design of the new 15 MeV ABC and yet various designs are being investigated, including, but not limited to two collinear standing wave (SW) sections and a patented combination of SW and Traveling Wave (TW) Sections with reverse feed. We have analyzed both concepts and present the preliminary analysis results. The platform can be used for running guides at various energy levels from 2 to 20 MeV, continuously changing energy or doing that selectively, various combinations of energy levels will be possible, also, upgrading the platform to higher average beam power levels. Indeed, operating at high average beam power above 1-2 kW level may require new advanced target development, and in case of e-beam applications, a scan horn will be required for extracting e-beam from vacuum to air.

Footnotes:

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North America

WEAN: Applications of Accelerators, Technology Transfer and Industrial Relations and Outreach (Contributed) / 596

Particle accelerator spin-transparent storage rings for beyond state-of-the-art science

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We will describe spin-transparent storage rings that exhibit spin-coherence times of several hours and store a large number of particles and their use in novel applications. For example, these rings can be used to directly measure the electric dipole moment of the electron, relevant to CP violation and matter-antimatter asymmetry in the universe, and to search for dark energy and ultra-light dark matter*. These rings can also serve as a compelling platform for quantum computing. In this presentation, we will describe how spin-transparent rings can be used in conjunction with ion traps to enhance scalability and increase quantum coherence times of ion quantum computing.

Footnotes:

- High precision fundamental physics experiments using compact spin-transparent storage rings of low energy polarized electron beams, Riad Suleiman, Vasiliy S. Morozov and Yaroslav S. Derbenev, Physics Letters B 843, 138058 (2023).

Funding Agency:

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Monday Poster Session / 597

Single-bunch instabilities and their mitigation in Diamond-II

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Diamond-II is a future 4-th generation synchrotron light source with a significantly narrower vacuum chamber compared to the existing Diamond storage ring. The strength of wake fields will increase, and, consequently, the risk of single-bunch instabilities also rises. We consider chromaticity adjustment and a passive harmonic cavity as mitigation measures, including for cases with impedance strength larger than the design value. This work presents single-bunch thresholds obtained in particle tracking simulations for the latest lattice and impedance database, including the case of non-equal bunch lengthening in realistic filling patterns due to beam loading in the RF cavities. The impedance database includes accurate computations of asymmetric vessels causing non-zero monopole and quadrupole components of the wake. Resulting emittance dilution due to impedance is found to be tolerable.

Footnotes:

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Tuesday Poster Session / 598

The MESA high power 1.3 GHz CW solid state power amplifier systems

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The Mainz Energy recovering Superconducting Accelerator MESA is a multi-turn energy recovery linac with beam energies in the 100 MeV regime currently under construction at Institut für Kernphysik (KPH) of Johannes Gutenberg-Universität Mainz. The main accelerator consists of two superconducting Rossendorf type modules, while the injector MAMBO (MilliAMpere BOoster) relies on normal conducting technology. The high power RF system is relying completely an solid state technology. After some in-depth testing of a 15 kW prototype amplifier in 2017-2019 a modified version of the amplifier modules was developed.
In 2020 series production has begun at JEMA France and first amplifiers, a 74 kW, a 56 kW and two 15 kW have been delivered to KPH lately. In this paper we will present the results of the performance measurements of the amplifiers.

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Europe

Tuesday Poster Session / 599

The Data Platform: an independent system for management of heterogeneous, time-series data to enable data science applications

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The Data Platform is a fully independent system for management and retrieval of heterogeneous, time-series data required for machine learning and general data science applications deployed at large particle accelerator facilities. It is an independent subsystem within the larger Machine Learning Data Platform (MLDP) which provides full-stack support for such facilities and applications [1]. The Data Platform maintains the heterogeneous data archive along with all associated metadata and post-acquisition user annotations. It also facilitates all interactions between data scientists and the data archive, thus it directly supports all back-end data science use cases. Accelerator facilities include thousands of data sources sampled at high frequencies, so ingestion performance is a key requirement and the current challenge. We describe the operation, architecture, performance, and development status of the Data Platform.

Footnotes:

[1] C.K. Allen, C. McChesney, et. al., "The Machine Learning Data Platform: Full Stack Support for Data Science Based Modeling, Control, and Optimization in Particle Accelerator and Large Experimental Physics Systems", IPAC24.

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Wednesday Poster Session / 600

Decoupling of nitrogen and oxygen impurities in nitrogen doped SRF cavities

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The performance of superconducting radiofrequency (SRF) cavities is critical to enabling the next generation of efficient, high-energy particle accelerators. Recent developments have focused on altering the surface impurity profile through in-situ baking, furnace baking, and doping to introduce and diffuse beneficial impurities such as nitrogen, oxygen, and carbon. However, the precise role and properties of each impurity are not well understood. In this work, we attempt to disentangle the role of oxygen and nitrogen impurities through time-of-flight secondary ion mass spectrometry of niobium samples baked at temperatures varying from 75-800℃ with and without nitrogen injection. From these results, we developed treatments recipe that decouple the effects of oxygen and nitrogen in doping treatments. Understanding how these impurities and their underlying mechanisms drive further optimization in the tailoring of impurity profiles for high performing SRF cavities.

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Monday Poster Session / 601

Incoherent and coherent tune shifts for Elettra 2.0

Author: Sara Dastan[1]

Co-authors: Emanuel Karantzoulis [1]; Koryun Manukyan [1]; Simone Di Mitri [1]; Stefano Krecic [1]

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Elettra 2.0, will be a 4th generation synchrotron radiation source that will replace Elettra, the 3rd generation light source that has been in operation since 1993 at Trieste. In this paper, the effects of the quadrupolar wake fields are investigated, and the transverse mode coupling threshold is presented. Also, the incoherent tune shift for multi-bunch operation is examined considering the rhomboidal vacuum chamber of Elettra 2.0.

Footnotes:

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Paper preparation format:

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Europe

Tuesday Poster Session / 602

Eight-piece quadrupole magnet allows precise pole tip positioning

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Quadrupole magnets are used extensively in particle accelerators, synchrotrons, and storage rings around the world. High field quality specifications are required for the quadrupole magnets at these facilities. Precise positioning of pole tips is needed to obtain high-quality fields in a quadrupole magnet. Typically, solid quadrupole magnet cores are machined with very high precision to obtain precise positional accuracy of the pole tips after assembly. High-precision machining of cores is costly, difficult, and time consuming. An assembly method that allows core pieces to be machined to standard machining tolerances but allows precise positioning of the pole tips on a quadrupole magnet is presented. An eight-piece yoke, with four quarter cores and four pole tips, is used to achieve this. All eight yoke pieces are machined using standard machining tolerances, while the assembly method allows for precise accurate pole tip positioning. This paper discusses the patented eight-piece quadrupole assembly method and assembly technique.

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North America

Tuesday Poster Session / 603

Beam correction for multi-pass arcs in FFA@CEBAF: status update

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Co-authors: Jay Benesch [2]; Katheryne Price [2]; Kirsten Deitrick [2]; Ryan Bodenstein [2]; Todd Satogata [2]

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This work examines the multi-pass steering of six electron beams in an FFA arc ranging from approximately 10.5 GeV to 22 GeV. Shown here is an algorithm based on singular value decomposition (SVD) to successfully steer all six beams through the arc given precise knowledge of all beam positions at each of one hundred and one diagnostic locations with one hundred individual corrector magnets: that is successive application of SVD to different 100 × 101 response matrices—one for each beam energy. Further, a machine learning scheme is developed which only requires knowledge of the energy-averaged beam position at each location to provide equivalent steering. Extension of this scheme to other beam optics quantities as well as transverse and longitudinal coupling is explored.

Footnotes:

I would like to present my poster at the student session if and only if I'm able to personally attend: if one of my colleagues ends up presenting the poster it should not be in the student session.

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North America

Tuesday Poster Session / 604

Development of a flux-concentrator-based 2-Tesla solenoid as a round lens for ultrafast microscopy

Author: Chunguang Jing[1]

Co-authors: Eric Montgomery [2]; Pavel Avrakhov [3]

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[2] *Euclid Beamlabs, LLC*

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Ultrafast Microscopy using MeV beam has made significant progress in the past 5 years. However, in order to push to atomic level resolution, other than the requirements of beam source, there are also high demands in high strength focusing elements. In comparison of commercial 100s KeV level electron microscopes, an MeV imaging beamline requires Tesla level lenses, preferably round solenoid lens. Tesla class DC solenoids are prohibitively bulky and heavy, and superconducting solenoids are not cost effective. We have developed a novel miniature flux concentrator based solenoid lens system for MeV UED/UEM applications. It can reach 2-Tesla with 1e-5 level stability (depending on the pulsed current source). Here we will present detailed development process and experimental results.

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North America

Wednesday Poster Session / 605

Beam Tomography using Markov Chain Monte Carlo

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Beam tomography is a method to reconstruct the higher dimensional beam from its lower dimensional projections. Previous methods to reconstruct the beam required large computer memory for high resolution; others needed differential simulations, and others did not consider beam elements' coupling. This work develops a 4D reconstruction using Markov Chain Monte Carlo.

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North America

Monday Poster Session / 606

EUV FEL light source based on energy recovery linac with on-orbit laser plasma injection

Author: Ganesh Tiwari[1]

Co-authors: Andrei Seryi [2]; Bryan Belcher [3]; Charles Rohde [4]; David Garcia [5]; Eiad Hamwi [6]; Erel Milshtein [7]; Hyojeong Lee [8]; James Maslow [4]; Jared De Chant [9]; Marlene Turner [9]; Parker Landon [10]; Spencer Kelham [11]; Sridhar Tripathy [12]; William Fung [13]

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[6] *Cornell University (CLASSE)*

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[9] *Lawrence Berkeley National Laboratory*

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We report on a week-long study of a conceptual design of EUV FEL light source based on an energy recovery linac with on-orbit laser plasma accelerator injection scheme. We carried out this study during USPAS Summer 2023 session of Unifying Physics of Accelerators, Lasers and Plasma applying the art of inventiveness TRIZ. An ultrashort Ti-sapphire laser accelerates electron beams from a gas target with mean energy of 20 MeV, which are then ramped up to 1 GeV in a five-turn scheme with a series of fixed field alternating magnets and two superconducting RF cavities (100 MeV per cavity per turn). The electron beam is then bypassed to an undulator line optimized to generate EUV light of 13.5 nm at kW level in a single pass.

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North America

Wednesday Poster Session / 607

Measurements and computer simulation of the effect of magnet vibrations on the electron beam orbit in the NSLS-II storage ring

Author: Aamna Khan[1]

Co-authors: Jonathan Gomprecht [1]; Chenghao Yu [1]; Sushil Sharma [1]; Victor Smaluk [1]; Guimei Wang [1]

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One major factor contributing to electron beam stability in a storage ring is the mechanical vibrations of magnets. At NSLS-II, we employ electromagnetic actuators to induce controlled vibrations in the support girders of the magnets. Beam position monitors distributed around the ring measure the spatial and frequency distribution of beam oscillations. The collected data is used to create and validate a computer model through a simulated commissioning tool, simulating beam motion caused by magnet vibrations. This computational model is useful for establishing mechanical stability specifications for the low-emittance upgrade of NSLS-II.

Footnotes:

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North America

Thursday Poster Session / 608

Crossing transition in the EIC HSR with a resonance island jump scheme

Author: Steve Peggs[1]

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The Resonance Island Jump (RIJ) scheme for transition crossing in the Hadron Storage Ring of the Electron-Ion Collider is radically new, and untested. Beam experiments in RHIC will be necessary if it becomes necessary to consider the RIJ scheme as a serious alternative to upgrading the first order linear jump scheme currently implemented in RHIC. This paper outlines the theoretical foundations of the RIJ scheme, and considers how a beam experiment in RHIC could be performed.

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North America

Thursday Poster Session / 609

Beam based measurements of Ti coated ceramic chamber at NSLS-II

Author: Aamna Khan[1]

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We summarize recent experimental studies of the impedance and beam-induced heating of titanium-coated ceramic vacuum chambers used in the NSLS-II injection kickers. We installed a spare chamber (SN003) in test section C01, demonstrating that beam-induced power is effectively dissipated in the titanium coating. Equipped with 12 temperature detectors, we measured temperatures and beam

currents during operational fill patterns. The results, highlighting the heating of chamber, will be thoroughly presented.

Footnotes:

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North America

Thursday Poster Session / 610

Comparison of simulation and measurement of an in-vacuum undulator coupling impedance at NSLS-II

Author: Aamna Khan[1]

Co-authors: Michael Seegitz [1]; Robert Todd [1]; Victor Smaluk [1]; Xi Yang [1]

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The impedance of in-vacuum undulators (IVU) is a significant part of the total broadband impedance determining collective effects of beam dynamics in synchrotrons. It is computationally difficult to simulate the full few-meter-long 3D structure, which includes bellows, flanges, and taper transitions with a variable gap. So, the impedance is usually calculated separately for a simplified geometry of every component and the resistive-wall impedance is calculated using analytical formulas. The ECHO3D code based on a low-dispersive numerical technique provides an opportunity to compute the wakefield induced by a very short bunch in the full 3D model of the NSLS-II IVU. Here, we discuss the numerical simulations in comparison with beam-based measurements.

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North America

Wednesday Poster Session / 611

Preliminary tests of NaKSb photocathodes in high gradient S-band photoinjector

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We report on initial characterization of NaKSb photocathodes in the Pegasus high gradient S-band RF photoinjector. These cathodes were grown at Cornell and transported by air to UCLA. Preliminary characterization was done in the UV and yielded a quantum efficiency of 1.5% and a mean transverse energy of 0.7±0.2 eV measured by solenoid scan. Photocathode response at different wavelengths as well as measurements of other important parameters such as cathode life-time, dark current levels and the time response are being planned.

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North America

Monday Poster Session / 612

Optimizing the beam parameters for plasma wakefield acceleration at FACET-II

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At the FACET-II accelerator, a pair of 10 GeV high-current electron beams can be used to study a method called Plasma Wakefield Acceleration (PWFA) in a few-cm short laser-ionized gas jet. While PWFAs allow for astonishingly high accelerating gradients of 10s of GeV/m, matching the electron beam into the plasma wake with micrometer precision to maintain beam quality requires precise tuning of linac parameters. The purpose of this study was to explore how start-to-end simulations could be used to optimize two important measures of beam quality, namely maximizing energy gain and minimizing transverse emittance growth. These two beam characteristics were investigated with an in-depth model of the FACET-II accelerator using two simulation techniques: i) varying experimental parameters, including plasma density and the strengths of focusing quadrupole magnets, within predefined ranges and examining their impact on beam quality. ii) Numerical optimization of quadrupole magnet strengths to transverse emittance growth. These results demonstrate the importance of simulating beam-transport simulations in tandem with particle-in-cell simulations to get insight into optimizing these two important beam characteristics without the need to devote significant accelerator physics time tuning the FACET-II accelerator.

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North America

Tuesday Poster Session / 613

On the possibility of resistive-wall wake field losses reduction

Author: Alexander Novokhatski[1]

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We discuss a possible method to reduce the resistive-wall wake fields losses in some special cases. We present results of computer simulations, which confirm the practical possibility of the method.

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North America

Wednesday Poster Session / 616

Towards operating low mean transverse energy alkali antimonide photocathodes at Argonne Cathode Test-stand

Author: Tariqul Hasan[1]

Co-authors: Eric Wisniewski [2]; John Power [3]; Oksana Chubenko [4]; Philippe Piot [1]; Gongxiaohui Chen [3]

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The performance and scientific reach of advanced electron accelerator applications, such as particle colliders, x-ray free electron lasers, and ultrafast electron diffraction, are determined by beam brightness. The beam brightness is constrained by the quality of photocathodes and is associated with low Mean Transverse Energy (MTE) of photoemitted electrons. To meet the requirements for applications demanding a bright electron beam, photocathodes must exhibit ultrasmooth physical and chemical roughness, a long operational lifetime, and robustness under high applied electric fields and laser fluences. In this work, we present the development of an experimental setup for the growth and in-situ characterization of high-quality, low-MTE alkali antimonide photocathodes. Additionally, we describe the modifications made to the Argonne Cathode Test-stand (ACT) at the Argonne Wakefield Accelerator (AWA) Facility, necessary for studying the performance of alkali antimonide photocathodes under real photoinjector conditions.

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North America

Tuesday Poster Session / 617

Beam optics modelling for the LAMP proton storage ring upgrade using pyORBIT

Author: Joshua Yoskowitz[1]

Co-authors: En-Chuan Huang [1]; Enrique Henestroza [1]; Haoran Xu [1]; Janardan Upadhyay [1]; Salvador Sosa Guitron [1]

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The proton storage ring (PSR) upgrade for the LANSCE Modernization Project aims to minimize the yearly maintenance outage by minimizing beam loss. Several improvements could potentially impact the beam dynamics in the PSR, including a larger coated beam pipe and new buncher, injection, and extraction systems. The larger diameter, from 4"to 6", will directly impact the beam dynamics due to an increased pole-to-pole gap height within the dipoles and quadrupoles, which would in turn increase their effective length and alter their fringe field profiles. In this work, a simulation model of the PSR ring was developed using the particle tracking code pyORBIT to study the effect of different beam pipe diameters on the beam optics. The parameters of the injected beam are derived from an existing model of the PSR injection system, and the resulting beam parameters will be used in a simulation model of the extraction system, to be presented separately at the conference. The pyORBIT results were benchmarked against beam optics simulations created using accelerator codes including MAD-X, etc. The pyORBIT simulation model of the PSR ring will be described, and the results will be presented at the conference.

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Wednesday Poster Session / 619

Developments of beam loss monitors for FETS-FFA test ring

Author: Emi Yamakawa[1]

Co-authors: Alan Letchford [1]; David Posthuma de Boer [1]; James FitzGibbon [1]; Shinji Machida [1]

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ISIS-II is UK's proposed next-generation pulsed, spallation neutron source, and is expected to be driven by a MW-class proton accelerator. A Fixed Field Alternating gradient (FFA) machine is one accelerator configuration being considered. A demonstrator machine, called FETS-FFA, is now being actively developed. Beam Loss Monitors (BLMs) for this demonstrator are presented with the unique challenge of low-energy (3-12 MeV) and low intensity (1e+11 ppp) beams, and should provide turn-by-turn measurements during commissioning as well as form a vital component of the Machine Protection System (MPS). The final BLM systems will operate in stray magnetic fields from the main magnets, and need to fit in the limited available space. This paper presents a feasibility study of using a combination of Ionisation Chambers (IC) and Scintillation Detectors (SD). The ideal geometry of both BLM types will be discussed, and comparisons made between Monte Carlo simulations and beam tests on the FETS linac at the Rutherford Appleton Laboratory.

Footnotes:

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Europe

Wednesday Poster Session / 620

Measurement of stability diagrams in the IOTA ring at Fermilab

Author: Mary Bossard[1]

Co-authors: Nathan Eddy [2]; Osama Mohsen [3]; Robert Ainsworth [2]; Young-Kee Kim [1]

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Nonlinear focusing elements can enhance the stability of particle beams in high-energy colliders through Landau Damping, by means of the tune spread which is introduced. Here we discuss an experiment at Fermilab's Integrable Optics Test Accelerator (IOTA) which investigates the influence of nonlinear focusing elements, such as octupoles, on the beam's transverse stability. In this experiment, we employ an anti-damper, an active transverse feedback system, as a controlled mechanism to induce coherent beam instability. By utilizing the anti-damper we can examine the impact of a nonlinear focusing element on the beam's transverse stability. The stability diagram, a tool used to determine the system's stability, is measured using a recently demonstrated method at the LHC. The experiment at IOTA adds insight towards this stability diagram measurement method by supplying a reduced machine impedance to investigate the machine impedance's effect on the stability diagram, as well as by aiming to map out the full stability diagram by using a large phase range of the anti-damper. From this experiment in IOTA, we present the first results of stability diagram analysis with varying octupole currents.

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North America

Thursday Poster Session / 621

FLASHlab@PITZ beamline upgrade towards full functionality – status and plans

Author: Matthias Gross[1]

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At the Photo Injector Test facility at DESY in Zeuthen (PITZ), an R&D platform for electron FLASH cancer radiation therapy and radiation biology is being prepared: FLASHlab@PITZ. The design of the full beamline with optimized beam properties was finished; the setup is currently being finalized and the mechanical design and manufacturing is underway. The beamline runs in parallel to the SASE THz beamline at PITZ and is connected to it with a dogleg. Beam dynamics simulations were conducted to assure excellent beam quality at the experimental area. A fast kicker system will be installed which is capable of distributing electron bunches from a single bunch train freely over an area of 25mm x 25mm within one microsecond. When the full FLASHlab@PITZ beamline is ready in 2024, the accelerator will deliver 22 MeV electrons to generate dose rates from 0.01 Gy/s up to 10e+14 Gy/s to an experimental area, which can accommodate a variety of setups for irradiation studies. The

flexible arrangement of the experimental area will make it possible for external users to collaborate with PITZ and conduct experiments with existing or newly designed irradiation setups.

Footnotes:

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Europe

Tuesday Poster Session / 622

Preliminary design of the normal conducting RF cavities for EIC hadron storage ring

Author: Binping Xiao[1]

Co-author: Douglas Holmes [1]

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The RF systems of EIC hadron storage ring (HSR) consist of 4 normal conducting RF (NCRF) cavities and 1 superconducting RF (SRF) cavity, including 24.6 MHz, 49.2 MHz, and 98.4 MHz NCRF Quarter Wave Resonators (QWRs), 197 MHz normal conducting reentrant cavity and 591 MHz SRF cavity. 24.6 MHz is used to accelerate and capture the beam, 49.2 MHz and 98.4 MHz are mainly used for bunch splitting, and 197 MHz are used as storage cavities. In this paper, preliminary design of these NCRF cavities will be presented.

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THBD: Beam Dynamics and Electromagnetic Fields (Contributed) / 625

Commissioning optics: larger dynamic aperture and Touschek lifetime at the (temporary) cost of larger horizontal emittance in 4th generation light sources

Author: Tessa Charles[1]

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Reduction of dynamic aperture encountered in 4th generation light sources presents a challenge for injection efficiency and commissioning. It's possible that only after BBA and optics corrections are applied, will the dynamic aperture be sufficient for reasonable injection efficiency. Furthermore, it' s only after a circulating beam is established that BBA, BPM calibration, and other optics corrections can be applied. Limited dynamic aperture not only makes standard top-up operation more challenging; during commissioning this challenge is even greater. To address this problem, we have developed a lattice design that allows for both low emittance optics (for standard user beam operation) and what we have called "commissioning optics"which is a set of lattice parameters that allows for larger dynamic aperture and Touschek Lifetime at the (temporary) cost of larger horizontal emittance.

Footnotes:

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Asia

Thursday Poster Session / 626

Design study of a compact IH-DTL-based injector for proton therapy facilities

Author: Yixing Lu[1]

Co-authors: Wencheng Fang [1]; Yusen Guo [2]; Chengcheng Xiao [1]; Zhentang Zhao [1]

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A new proton injector based on the 425-MHz radio frequency quadrupole (RFQ) and interdigital H-mode drift tube linac (IH-DTL) has been designed. The injector is ~7 m long and comprises an electron-cyclotron-resonance (ECR) ion source, a low-energy beam transport, an RFQ, an IH-DTL, two triplets, a medium-energy beam transport, and a debuncher. The IH-DTL is specially designed with two tanks with different bunching phases, which can contribute to excellent transverse and longitudinal beam quality. The ion source produces an 18-mA proton beam with the energy of 30 keV. The output energy of the injector is 7 MeV with the transmission efficiency of 86.2%. A three-dimensional electromagnetic simulation was conducted, and the results agreed with the design. A systematic and mechanical design of the entire proton injector was also performed for the following research and development. The injector has great performance and is planned to be utilized in Shanghai APACTRON Proton Therapy facility (SAPT). In the future, it can also promote advanced proton accelerators for medical applications.

Footnotes:

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Asia

Wednesday Poster Session / 627

Design of a Ku-band 3MeV on-axis coupled standing-wave accelerator

Author: Qingzhu Li[1]

Co-authors: Jiaru Shi [1]; Hao Zha [1]; Jian Gao [1]; Fangjun Hu [1]; Boyuan Feng [1]; Hongyu Li [1]; Huaibi Chen [1]

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The compact accelerator assumes a pivotal role within the medical domain, necessitating higher frequencies to attain smaller size. Presently, the most condensed medical accelerators predominantly operate in the X-band, with dimensions typically akin to platform sizes. To achieve further refinement in accelerator system design compactness, elevated operating frequencies become imperative. We delineates the design of a pi/2 mode accelerator tube based on the Ku-band (15 GHz), incorporating standing-wave axis coupling. Through meticulous simulation and analysis utilizing ANSYS HFSS, the proposed design achieves notable results: an input power of 0.8 MW, an output electron energy of 3 MeV, and an electron capture efficiency of 28%. The ultimate optimization of the longitudinal length of the accelerator tube to 10 cm signifies the realization of a more compact design paradigm for medical accelerators.

Footnotes:

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Asia

TUAN: Beam Dynamics and Electromagnetic Fields (Contributed) / 629

Beam loss and beam emittance minimization at J-PARC RCS for simultaneous operation to the MLF and MR

Author: Pranab Saha[1]

Co-authors: Hiroyuki Harada [1]; Yoshihiro Shobuda [1]; Kunihiro Kojima [2]; Fumihiko Tamura [3]; Hidefumi Okita [3]; Masahiro Yoshimoto [3]; Kota Okabe [1]; Takamitsu Nakanoya [1]; Shuichiro Hatakeyama [3]; Katsuhiro Moriya [1]; Kazami Yamamoto [1]; Tomohiro Takayanagi [3]; Hideaki Hotchi [4]

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The 3-GeV RCS (Rapid Cycling Synchrotron) at J-PARC (Japan Proton Accelerator Research Complex) simultaneously delivers high-intensity proton beam to the muon and neutron production targets at the MLF (Material and Life Science Experimental Facility) as well as to the MR (Main Ring). Beam loss mitigation is highly essential not only to keep the machine activation lower for maintaining a stable operation with high availability, but also to ensure a high-quality beam having a lower beam emittance and minimum beam halos. We have performed systematic numerical simulations and beam studies and implemented several measures, such as resonance corrections, optimization of the longitudinal and transverse paintings and also optimization of the betatron tune. We have obtained significant beam loss mitigation as well as beam emittance improvement for the beam delivered to both MLF and the MR. Recently, a transverse painting area of 50π mm·mrad has been increased to 100π mm·mrad implemented for the MR beam. This gives a half reduction of the average foil hitting of the circulating beam. As a result, not only the uncontrolled foil scattering beam losses but also the beam loss at the collimator have been reduced to half. Such improvements in the RCS have also been well recognized at both MLF and the MR by reducing the beam losses at the beam transport as well as each facility. The RCS has been continued a sustainable operation with record high of nearly 99% availability.

Footnotes:

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Asia

Tuesday Poster Session / 630

A wide open waveguide cavity for the International Linear Collider crabbing system

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The International Linear Collider (ILC) requires crabbing system to compensate 14 mrad crossing angle. The crabbing system at 1.3 GHz needs to provide 1.845 MV crabbing voltage for 250 GeV case and 7.4 MV for 1 TeV case and needs to be fitted within 3.8 m allocated space. In this paper, a Wide-Open-Waveguide (WOW) type cavity is proposed as one of the candidates due to its simple structure and reasonable High Order Mode (HOM) damping.

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Wednesday Poster Session / 631

HOM power in the EIC crab cavity system

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Two types of crab cavities, one at 197 MHz and the other at 394 MHz, are designed to compensate the loss of luminosity due to a 25 mrad crossing angle at the interaction point (IR) in the Electron Ion Collider (EIC). The Higher Order Mode (HOM) damper designs of the EIC differs from the LHC designs since in the EIC the impedance budget is tighter, especially longitudinally, and in the EIC the HOM power is much higher due to the short and high intensity electron and ion beam. In this paper, HOM power in these two cavities is evaluated and optimized.

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Thursday Poster Session / 632

EMI measurement for SXFEL klystron-modulator system

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The purpose of this paper is to estimate the conducted and radiated Electromagnetic Interference (EMI) for subsystems in the SXFEL LINAC. A spectrum analyzer system with a wide frequency range of 9 kHz to 3 GHz was conducted to measure the EMI spectrum of pulse modulator and klystron system. The radiated EMI was tested by electric and magnetic field probe. A stray current was tested by wide frequency current transformer in order to measure the conducted current for kicker and septum systems. According to the experiment results, the stray current could flow through the other subsystems, and it might be affected the stability of other subsystems. Therefore reducing and eliminating the interference of EM waves will be a very important issue. At the end, measures to improve EMI performance are given.

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Wednesday Poster Session / 633

Development of an active beam-stabilization system for electrofission experiments at the S-DALINAC

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Co-authors: Michaela Arnold [1]; Jonny Birkhan [1]; Uwe Bonnes [1]; Adrian Brauch [1]; Manuel Dutine [1]; Ruben Grewe [1]; Lars Juergensen [1]; Norbert Pietralla [1]; Felix Schliessmann [1]; Gerhart Steinhilber [1]

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The r-process fission cycle terminates the synthesis of heavy elements in binary neutron-star mergers. Fission processes of transuranium nuclides will be studied in electrofission reactions at the thrice-recirculating electron accelerator S-DALINAC*. Due to the minuscule fissile target, the experimental setup requires an active beam-stabilization system with high accuracy and a beam position resolution in the sub-millimeter range. Requirements and concepts for this system regarding beam diagnostics elements, feedback control and readout electronics will be presented. The usage of a cavity beam position monitor and optical transition radiation screens to monitor the required beam parameters will be discussed in detail. Additionally, various measurements including a study of beam stability performed in the injector section of the S-DALINAC to assess requirements and limits for the beam-stabilization system will be presented. Finally, the application of advanced machine learning methods, such as neural networks and agent-based reinforcement learning, will be discussed.

Footnotes:

- N. Pietralla, Nuclear Physics News, Vol. 28, No. 2, 4 (2018).

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Monday Poster Session / 634

Enhancing CERN-SPS slow extraction efficiency: meta bayesian optimization in crystal shadowing

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The Super Proton Synchrotron at CERN serves the fixed-target experiments of the North Area, providing protons and ions via slow extraction, and employs the crystal shadowing technique to significantly minimize losses. Over the past three operational years, the use of a crystal, positioned upstream of the electrostatic septum to shadow its blade, has allowed to achieve a 25% reduction in losses. Additionally, a novel non-local shadowing technique, utilizing a different crystal location, has successfully halved these losses. While using a single crystal in this location resulted in a temporary 50% reduction in slow extraction losses at nominal intensity, this effect was not sustainable beyond a few hours. This limitation is primarily attributed to the magnetic non-reproducibility and hysteresis inherent to the SPS main dipoles and quadrupoles. In this paper, we introduce the application of the Rank-Weighted Gaussian Process Ensemble to the setup of shadowing. We demonstrate its superior efficiency and effectiveness in comparison to traditional Bayesian optimization and other numerical methods, particularly in managing the complex dynamics of local and non-local shadowing.

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Thursday Poster Session / 635

Control system of injection and extraction for synchrotron-based proton therapy facility

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This control system had been designed for the injection and extraction system of Shanghai Advanced Proton Therapy(SAPT). Interface of the SPELLMAN 100 kV high voltage power supply for septum magnets and Capacitor Charing Power Supply(CCPS) of the pulser for bumper magnets are including in the control design based on Programable Logic Contrllor (PLC) s7-1200. The control system realizes the precise digital setting and states reading of the high power supplys and focuses on the remote anti-interference information transmission through the designing of a multi-channel frequency and voltage converter.The system is already stable and reliable working for years in the proton accelerator facility hall.

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Monday Poster Session / 636

Demonstrations of the 4D phase space reconstruction of flat and magnetized beams using neural-networks and differentiable simulations

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Phase space reconstruction using Neural-Networks and differentiable simulation* is a robust beam diagnostic method to obtain complete 4D phase space including the coupling terms such as (x-y') and (y-x'). In the first experimental demonstration, it was verified that the RMS beam envelope and normalized emittance from the reconstructed phase space are quantitatively similar to those from the conventional beam diagnostics such as quadrupole scan. In addition, here we show the demonstration of the phase space for the i) flat and ii) magnetized beam where the beam has i) very large ratio in between horizontal and vertical emittances (e.g., enx/eny »1) and ii) transverse coupling induced by non-zero solenoid magnetic field at the cathode (known-as canonical momentum-dominated beam). Through the demonstrations using the experimental data achieved at the Argonne Wakefield Accelerator Facility (AWA), we successfully obtained the information such that the measured flat beam indeed has the emittance ratio larger than 70 with minimized transverse coupling. In addition, we were

able to obtain the magnetization from the reconstructed phase space. Moreover, we will compare the beam parameters obtained from the phase space reconstruction and conventional diagnostics and discuss the uncertainty of the parameters.

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- R. Roussel et al., Phys. Rev. Lett. 130, 145001, 2023

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Thursday Poster Session / 637

A double multiturn injection scheme for mixed helium and carbon ion beams

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With a very low relative charge-to-mass ratio offset of approximately 6e-4, helium (4He-2+) and carbon ions (12C-6+) are interesting candidates for being simultaneously accelerated in hadron therapy accelerators. At the same energy per nucleon, helium ions exhibit a stopping range approximately three times greater than that of carbon ions and can therefore be exploited for online range verification in a detector downstream of the patient during carbon ion radio therapy.
The synchrotron-based MedAustron Ion Therapy Center provides the opportunity to study the feasibility of such a mixed beam based in-vivo range verification system due to the availability of 120-402 MeV/u carbon beams and the ongoing commissioning of 39-402 MeV/u helium beams. One possibility for creating this mixed beam is accelerating 4He-2+ and 12C-6+ sequentially through the LINAC and subsequently "mixing"the ion species at injection energy in the synchrotron with a double injection scheme. This contribution introduces this newly proposed injection scheme, outlines challenges and presents first feasibility estimates obtained through measurements and particle tracking simulations.

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Thursday Poster Session / 638

Investigation of onset field variations in diversely fabricated samples through field emission scanning microscopy

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Current superconducting radio frequency (SRF) cavities are predominantly constructed from high purity niobium which is pushed to its theoretical limit. To enhance future cavity performance by minimizing operational power losses and increasing accelerating field strength, the focus of research must shift to alternative cavity materials. An effective strategy involves depositing superconducting thin films like NbTiN or Nb3Sn on the cavity inner walls. Heat treating NbTiN may further optimize film properties, while modifying the grain size of bulk niobium using fine grained niobium could also improve cavity characteristics.
In this study various samples, including as deposited NbTiN, annealed NbTiN and fine grained Nb are analyzed via a Field Emission Scanning Microscopy (FESM). Current voltage curves allow the determination of onset fields for parasitic field emission. Mapping these fields, at e.g. 1 nA, reveals lateral variations due to thin film inhomogeneities defects or surface contaminations. Additionally, assessing long term surface stability through constant current measurements over an extended period is crucial for practical cavity applications.

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Thursday Poster Session / 639

Mechanical design and cryo-module of a C-band cryogenic bi-periodic accelerating structure

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The energy upgrade of the Shanghai Soft X-ray Free Electron Laser(SXFEL) requires a higher gradient accelerating structure. The performance of oxygen-free copper is significantly improved in many aspects at low temperatures, so it can withstand higher surface fields, so that the accelerator can achieve a higher accelerating gradient. Therefore, a stable and uniform low temperature environment is extremely necessary. For this purpose, the mechanical model of the accelerating structure at normal temperature is designed, and the design of the cryo-module is completed. This is a standing wave bi-periodic structure, with a total length of 1m, divided into four independent parts, which feed power separately. The special RF design of the structure makes it possible to set tuning screws outside the accelerating cavity, as well as the coupling cavity. There is a cooling belt outside the structure, which transmits heat to four coolers. In the future, the manufacturing of the structure and the cryo-module will be completed, and they will be tested.

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Wednesday Poster Session / 640

High-resolution bunch profile measurements for enhanced longitudinal beam diagnostics

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Efficient operation of the Large Hadron Collider (LHC) relies on accurate longitudinal beam measurements to diagnose beam instabilities and verify the correctness of bunch-shaping techniques. To achieve this goal, a diagnostic system was developed to perform high-resolution measurements of longitudinal bunch profiles. High-performance oscilloscopes, synchronized to precise accelerator events, are employed to carry out the measurements, acquiring data from wideband wall-current monitors installed in the machine. This paper provides details on the implementation of the system, highlighting its current and future applications that will play a key role in increasing beam intensity in the LHC.

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Thursday Poster Session / 641

Fabrication and tuning of a 325 MHz ion-injector for particle therapy facility

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In order to miniaturize ion injectors for particle therapy, a design of ion injectors based on a 325 MHz operating frequency was completed. The LINAC was consist of a 2.0 m length RFQ and a 3.8 m length IH-DTL, which was designed to accelerate 12C4+, 3H+, 3He+ and 18O6+ beams to 7 MeV/u. The RFQ cavity and the first DTL tank was been manufactured using aluminum. This paper gives an overview of the fabrication and tuning procedure of the prototype. The quadrupole electric field of the RFQ is adjusted flat by the tuner while reducing the dipole field components in both directions. The measured DTL electric field distribution after tuning is in good agreement with the simulation results.

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Tuesday Poster Session / 642

Study of an upgraded lattice for Taiwan photon source

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To maximize the performance of the current Taiwan Photon Source (TPS) while minimizing costs, a feasibility study was conducted to reassess the lattice scheme within the existing tunnel. The current TPS configuration exhibits a considerable difference in length between the long (12 m) and short (7 m) straight section. In an effort to minimize the source points displacement for insertion devices and enhance overall beam performance, we propose an upgrade lattice design based on the 5BA scheme. The report discusses the challenges and preliminary results of this 5BA lattice design, showcasing its potential for enhancing TPS capabilities.

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Tuesday Poster Session / 643

HL-LHC series collimators: production challenges

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In view of HL-LHC project, an upgraded collimation system has been developed to accommodate a rise of ten times of the integrated luminosity compared to the LHC. A new series of collimators will be produced and installed in the machine during the Long Shutdown 3 (LS3) to take place during 2026-2028. The updated design incorporates cutting-edge technologies to meet the demanding operating requirements.
Multiple production activities are recognized as critical to ensure the quality of the supply. Among others, the vacuum brazing of the jaw's cooling system shall maximize the contact surface to ensure an efficient heat exchange. Each sub-component of the mobile tables shall be high precision machined and assembled to obtain an accurate and reliable movements in a radioactive environment. The absorber blocks shall be assembled fulfilling tight flatness tolerances to precisely interact with the beam. The RF fingers shall be correctly shaped to preserve the structural integrity and the contact with vessel during lifetime. Comprehensive qualification checks of the production procedures are planned and functional tests will be conducted to validate the performance of each unit produced.

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Wednesday Poster Session / 645

Conceptual RF design and modelling of a 704 MHz pillbox cavity for the Muon Cooling Complex

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The Muon Cooling Complex (MCC) is a prospective facility to develop technology essential for ionization cooling for a future high-energy Muon Collider at CERN. This cooling technique necessitates the utilization of normal conducting, RF accelerating cavities operating within a multi-Tesla magnetic field.
This study illustrates the conceptual RF design of a 704 MHz cavity equipped with beryllium windows for the muon cooling demonstrator. Based on the specifications from the beam dynamics, frequency-domain eigenmode simulations have been conducted to calculate the primary RF figure of merits for the cavity. Several materials were simulated for the cavity walls, including copper, beryllium, and aluminum. In selected cases, more advanced engineering analyses, including thermo-mechanical simulations and design of the cooling channels, have been performed to enable operation at gradients up to 44 MV/m within strong solenoidal magnetic fields up to 13 T. Furthermore, the impact of the beam loading on the muon energy spread is investigated, and appropriate mitigation techniques are proposed.

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Wednesday Poster Session / 646

Design of a non-invasive bunch length monitor using coherent synchrotron radiation simulations

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Synchrotron radiation (SR) is a phenomena found in most accelerator facilities. Whilst many look to reduce the amount of SR produced to minimize beam losses, its existence allows for several types of novel non-invasive beam instrumentation. The aim of this study is to use SR in the development of a non-invasive, high resolution, longitudinal bunch length monitor. The monitor will be capable of sub 100 fs bunch measurements, which are becoming more common in novel acceleration and free electron laser facilities. This contribution details the simulation work carried out in Synchrotron Radiation Workshop (SRW), which allows for complex studies into the production and features of coherent synchrotron radiation (CSR). The design of the monitor has also been discussed, alongside simulations of the planned optical setup performed in Zemax OpticStudio (ZOS).

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Tuesday Poster Session / 647

Initial operational experience of an LHC injection kicker magnet upgraded for HL-LHC

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The intensity of the HL-LHC beam will be twice that of LHC. Hence, an upgrade of the LHC injection kickers (MKIs) is necessary for HL-LHC to avoid excessive beam induced heating of the MKIs. In addition, any newly installed MKI magnet would limit HL-LHC operation for a few hundred hours due to dynamic vacuum activity. Extensive studies have been carried out to identify solutions to address these problems and they have been implemented in an upgraded LHC injection kicker magnet (MKI Cool): the MKI Cool was installed in the LHC during the 2022-23 Year End Technical Stop. Magnet heating has been reduced by redistributing a significant portion of the beam induced power deposition from the ferrite yoke to a ferrite loaded RF Damper, which is not at pulsed high voltage, and by water cooling of the damper. Furthermore, a surface coating, to mitigate dynamic vacuum activity, has been applied. This paper discusses the upgrades, presents results from the initial operational experience, and compares the predicted and 'measured'beam induced power deposition.

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Tuesday Poster Session / 648

Beam-based girder alignment to reduce corrector strengths: conceptual simulations for PETRA IV

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DESY is planning to upgrade PETRA III to a 4th generation light source. The magnetic lattice components are pre-installed and aligned on long girders before being installed in the tunnel. These long girders and the misalignment of the magnets pose a challenge for the PETRA IV lattice, including the storage of the beam in the ring. Commissioning simulations have been performed which showed that relatively high corrector strengths are required for the orbit correction system. A simulation study was performed to demonstrate the possibility of beam-based girder alignment correction to relax the corrector strengths during machine operation. The simulation results are presented and then discussed for later implementation.

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Thursday Poster Session / 650

Mechanical design of a QWR cavity for the new ISIS MEBT

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The Quarter Wave Resonator (QWR) is a longitudinal bunching cavity for the MEBT section of the Pre-injector Upgrade project at ISIS. Four cavities are required with at least one functional spare. The production of a full scale prototype is discussed here. Three main manufacturing challenges were encountered as follows: the tight manufacturing tolerances of the stainless steel tank, most noticeably the 80 µm tolerance along the length of the 370 mm bore; the 50 µm ± 10 µm copper plating layer on the inside of the complex geometry cavity; and the brazing of the copper lid to a long (280 mm) stem with the use of a jig, to achieve a tight precision in the length inside the cavity. Trials for all these have been conducted before being accurately assembled with a CMM, with lessons learnt and the final solutions presented.

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Tuesday Poster Session / 651

A review of the 2023 antiproton physics run in the CERN antimatter factory

Author: Lajos Bojtar[1]

Co-authors: Bertrand Lefort [1]; Bruno Dupuy [1]; Davide Gamba [1]; Lars Joergensen [1]; Laurette Ponce [1]; Pierre Freyermuth [1]; Sergio Pasinelli [1]; Yann Dutheil [1]

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Despite a shorter than scheduled physics run due to a hardware problem, the AD/ELENA antiproton complex delivered record beam intensities to the experiments during the 2023 run. This paper reviews the performance of both the CERN Antiproton Decelerator (AD) and the Extra Low ENergy Antiproton (ELENA) decelerator and their associated transfer lines. It presents the main improvements that allowed these record beam intensities to be delivered to the experiments. Emphasis is put on the optimization of the injection line, progress made on the stochastic and electron cooling performance, increased deceleration efficiency and the stability, and the software tools used. Remaining issues and potential future improvements will also be presented.

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Wednesday Poster Session / 653

H- source characterization and transfer line studies with realistic EM fields in the Extra Low Energy Antiproton Decelerator (ELENA) at CERN

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A local H−/p source is operated at the CERN Extra Low Energy Antiproton (ELENA) decelerator for commissioning the ring and subsequent electrostatic transfer lines towards the experiments. For proper optics characterization it is important to have a detailed knowledge of the H- beam parameters at the source. Phase space tomography techniques were applied to reconstruct the beam distribution at the measurement point, which was then tracked backward to the H- source using symplectic realistic field maps to calculate the beam matrix. Due to the presence of an ion switch a highly non-linear behavior with significant deviation from the linear model was observed. The SIMPA tracking code allows EM fields in the transfer line to be treated continuously and as a whole. This feature was exploited to perform extraction line matching studies, including the propagation of perturbations from the apparatus of the ELENA experiments through all the beam lines.

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Wednesday Poster Session / 657

Magnetron diagnostics with a novel optical fibre-Cherenkov detector

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Co-authors: Carsten Welsch [2]; Hao Zhang [1]; Joseph Wolfenden [1]; Lauryn Eley [1]

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Development of an optical fiber-based beam loss monitor (OBLM) is in progress at the Cockcroft Institute (CI), UK. The novel sensor utilizes the Cherenkov radiation (CR) emitted in optical fibers by relativistic particle showers generated in beam loss or RF breakdown events.
RF breakdowns are a problem for high-power magnetrons, such as those in medical accelerator facilities, as damage to the magnetron cathode reduces the device efficiency and lifetime. These events can be detected by emitted CR channeled along the fibers to photomultiplier detectors, and a time-of-flight method can be used to calculate the RF breakdown location from the CR arrival time. This has previously been demonstrated with the OBLM system on RF cavities (at CLARA, Daresbury Laboratory, and CTF3, CERN); and allows for rapid and reliable breakdown detection which is important for damage mitigation.
This contribution presents proof-of-concept measurements from OBLM studies into magnetrons at Teledyne e2v, Chelmsford. It also discusses design adjustments made to improve the detector sensitivity and how the performance can be enhanced using the sensor (or similar).

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Wednesday Poster Session / 660

Development of a hybrid thermionic and photoemission electron gun and dedicated test stand for ELSA

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Co-authors: Dennis Proft [1]; Klaus Desch [1]; P. Haenisch [1]

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A new electron gun is currently being designed for the S-band Linac injector for ELSA. The objective of this development is to realize a new single bunch injection mode in addition to the standard long pulse (multi bunch) mode along with an improvement of the current beam parameters (e.g. emission current & transverse emittance) achieved by the existing gun. A dual mode design is being developed that utilizes a cesium dispenser cathode both as a thermionic and a photo-cathode using thermally assisted photoemission. In addition to the novel electron gun, a dedicated test stand is currently being designed to allow detailed characterization of both operating modes. The refined design of the gun and the current status of the test stand including beam parameter simulations are presented.

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Wednesday Poster Session / 662

Impedance and thermal studies of the CERN SPS Wirescanners and mitigation of wire heating

Authors: Elena de la Fuente[1]; Leonardo Sito[2]

Co-authors: Benoit Salvant [1]; Carlo Zannini [1]; Chiara Antuono [1]; Christine Vollinger [1]; Federico Carra [1]; Giovanni Rumolo [1]; Giulia Papotti [1]; Ioannis Papazoglou [1]; Ivan Karpov [1]; Jonathan Emery [1]; Kevin Li [1]; Michael Sullivan [1]; Rama Calaga [1]; Raymond Veness [1]; William Andreazza [1]

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All wires of the four CERN SPS rotational wirescanners broke when increasing the beam intensity towards the target for the LHC Injector Upgrade in 2023. Impedance and thermal studies were immediately launched, with simulations and measurements indicating that beam induced heating from resonant modes on the thin wire could be sufficient to cause these breakages. Mitigation measures to displace electromagnetic losses away from the wire were proposed and implemented. This allowed a much higher beam intensity to be reached, close to the LIU target. Simulations now predict that the modified wirescanners can sustain the LIU beam parameters.

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Wednesday Poster Session / 663

V3Si: an alternative thin film material for superconducting RF cavities

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Superconducting materials, like V3Si, NbN, NbTiN and Nb3Sn, are potential alternatives to Nb for next generation thin film SRF cavities. In comparison to the Nb, their relatively high Tc could allow for operation at higher temperatures (≥ 4 K) and the higher critical field could lead to for higher accelerating gradients. We investigate optimum deposition parameters and substrates for V3Si, using single target physical vapor deposition (PVD). We report on the superconducting properties such as Tc and surface resistance using RRR and low power RF, stoichiometry using RBS, SIMS, XPS and EDX and surface quality using AFM and white light interferometry.

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Wednesday Poster Session / 666

Rubidium telluride photocathodes for high quantum efficiency and low mean transverse energy accelerator applications

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High brightness electron beams are required to drive next generation light sources. This will only be achieved by photocathodes with high quantum efficiency (QE) and low intrinsic emittance, whilst also having long operational lifetimes and minimal dark current. Cesium telluride (CsTe) photocathodes are currently the favored material for many accelerators around the globe, typically chosen for its relatively high QE and its significant operational lifetime compared to other alkali-based alternatives. Rubidium telluride (RbTe) has the potential to have a similar peak QE to CsTe with a higher work function. This would lead to a lower mean transverse energy and reduced susceptibility to field emission, improving brightness and reducing dark current.
In this paper, thin film RbTe photocathodes were grown and are characterized using X-ray photoelectron spectroscopy, QE measurements and the Transverse Energy Spread Spectrometer (TESS) at Daresbury Laboratory.

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Monday Poster Session / 667

Simulations and lattice optimization of RF electron linac designed for VEGA LCS gamma-ray source

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The Variable Energy Gamma (VEGA) System is under implementation in Bucharest-Magurele Romania as one of the major components in the project of Extreme Light Infrastructure Nuclear Physics. The VEGA System is designed as an advanced Laser Compton Scattering gamma-ray source with unique parameters in terms of high spectral density, monochromaticity, high polarizability, and energy tunability. It brings new opportunities and is dedicated for photonuclear research in both applied and fundamental physics, and will be open for worldwide users. Optimization of spectral density and guaranty of monochromaticity of the gamma-rays impose the necessity to control both, transverse emittance and energy spread, putting strong requirements on electron beam dynamics. We present results from computer simulations carried out for the injector of the LCS gamma-ray source based on a room-temperature RF linac, and we investigate the lattice configuration to optimize the electron beam parameters at the virtual interaction point located at the end of the linac.

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Wednesday Poster Session / 668

Generation of high brightness electron beams by the 2.4-cell photocathode RF gun

Author: Hong Qi[1]

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Modern accelerator facilities, including free electron lasers and ultrafast electron diffraction, are constantly demanding electron beams with improved characteristics such as lower emittance and higher brightness. This study proposes a 2.4-cell photocathode electron gun to produce such high-quality beams by enhancing the electric field gradient at the photocathode. This enhanced gradient effectively suppresses space charge effects in the low-energy region, leading to superior beam quality. This paper provides a comprehensive overview of the electron gun's structure and specifications, including essential parameters such as the quality factor, operation frequency, and shunt impedance. Furthermore, we present dynamics simulation results that showcase the performance of the gun. Notably, our simulations indicate that with a charge of 1 pC, the bunch length measures less than 50 fs, while achieving a remarkable normalized emittance of 0.1π mm·mrad.

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Asia

Thursday Poster Session / 669

Development progress of high-level applications for the HEPS

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To meet the beam commissioning requirements of the High Energy Photon Source (HEPS), a brand-new framework called Pyapas has been developed based on pure Python. All high-level applications (HLAs) for the HEPS will be developed using Pyapas. The beam commissioning of the Linac started on March 9, 2023, and the HLAs performed excellently, helping the Linac meet its design specifications successfully and pass acceptance testing. By June 2023, the development of the HLAs for the transport line and the booster was completed, and several multi-system integration tests were performed to ensure normal operation after the HLAs went online. Beam commissioning of the booster began in late July and successfully met design specifications in late November. The storage ring HLAs are currently under development, and expected to be completed by mid-2024. This paper provides a detailed overview of the recent development progress of the HEPS HLAs and the upcoming development roadmap.

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Thursday Poster Session / 671

Modernizing of magnet power supplies at KARA and a transition to EPICS-based control system

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This paper presents a study on the upgrade and modernization of the magnet power supplies of the KARA (Karlsruhe Research Accelerator) storage ring. The existing power supplies, which have been in operation for more than two decades, were facing obsolescence and operational limitations. To ensure the continued availability and reliability of the facility for the next decade and beyond, a comprehensive refurbishment was required.
The project involved the replacement and upgrade of the power supplies for the dipole and sextupole magnets at KARA, as well as for the dipole and quadrupole magnets in the booster. A key aspect of this modernization effort beside an improvement in efficiency and stability is the migration from a custom control system to EPICS running embedded on the power supplies.
This paper provides an in-depth analysis of the motivations, goals, and technical aspects of the power supply modernization project as well as first measurements with the new power supplies and the project status.

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Europe

Tuesday Poster Session / 672

Studies of single bunch and multi-bunch beam instabilities in the Diamond-II booster

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To reduce filling times and enable advanced injection schemes, it is desirable for the Diamond-II booster to provide high charge in both single and multi-bunch modes. The single bunch charge will be limited by short range wakefields in the booster, and long-range wakefields limit the charge for the multi-bunch trains. Due to the relatively low 100 MeV injection energy into the booster, the injected beam is susceptible to instabilities due to the very weak synchrotron radiation damping. In this paper, we present the simulation results carried out to estimate the single and multi-bunch charge thresholds in the Diamond-II booster including short and long range wakefields, RF cavity HOMs, and with physical apertures applied. Simulations results will also be presented that demonstrate the extracted multi-bunch charge could be increased by installing a transverse multi-bunch feedback (TMBF).

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Tuesday Poster Session / 673

Exploring high gradient limit with cryogenic experiments at FREIA laboratory

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Field emission (FE) and vacuum arcs limit the maximum achievable accelerating field of both normal and superconducting cavities. The performance of accelerating cavities can be improved after a long conditioning process. Understanding this process and the formation of vacuum arcs is important for all technologies where vacuum arcs cause device failure. The understanding could be more complete with novel diagnostic tools and tests in variable environments.
The cryogenic HV system in FREIA laboratory is used to study different aspects of conditioning using DC pulses at a wide range of temperatures, down to 4K. We are currently measuring FE currents during conditioning for Cu, Nb and Ti electrodes in function of temperature and breakdown rate. We are also developing a new characterization method, evaluating the surface resistivity of the electrodes during conditioning. Changes in the surface resistivity could indicate the formation of dislocations below the surface, which has been speculated to be a very important process behind conditioning.
We will present the results of conditioning with the FE measurements and the surface resistivity measurements.

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Europe

Monday Poster Session / 674

Design, fabrication, and testing of a W-band corrugated waveguide for Wakefield acceleration

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In the field of structure wakefield acceleration there is considerable interest in radiofrequency (RF) structures capable of producing high gradients. Structures in the sub-terahertz (sub-THz) regime are of note due to their high gradient and high efficiency, allowing for a low physical footprint. In the pursuit of this goal we have designed a metallic corrugated W-band structure using the CST Studio Suite. After optimizing for the maximum achievable gradient from a nominal Argonne Wakefield Accelerator (AWA) electron bunch at 65 MeV with a Gaussian distribution we attempted to achieve a higher transformer ratio using a shaped bunch. Shaped bunches such as these are achievable at the AWA emittance exchange (EEX) beamline. Preliminary results from the structure testing at AWA using shaped electron bunches will be presented. Further tests are planned, involving a comprehensive optimization of the beamline at AWA.

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Monday Poster Session / 675

Lattice design of a pulsed synchrotron for a muon collider fitting within the Fermilab site boundary

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A muon collider allows one to have a high energy reach for physics studies while having a relatively compact footprint. Ideally such a machine would accelerate muon beams to about 5 TeV. We present a preliminary lattice design for a pulsed synchrotron that will accelerate muon beams to their maximum collision energy and having a circumference of 16.5 km, which would allow it to fit just within the Fermilab site boundary. We wish to estimate the maximum energy that muons can be accelerated to on the Fermilab site based on a realistic lattice layout. To achieve a high average bend field, superconducting fixed field dipoles are interleaved with iron-dominated dipoles whose field is rapidly ramped from negative to positive field. Multiple RF stations are required to ensure that the beam energy and the dipole fields are reasonably well synchronized and to avoid longitudinal losses due to the large synchrotron tune. We use FODO arc cells with dispersion suppressed into the RF straights. We will discuss tradeoffs between maximum energy, energy range, and muon decays. We will consider whether to mix superconducting and iron quadrupoles like the dipoles.

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Thursday Poster Session / 676

Preparations of the Elettra booster for Elettra 2.0

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The low emittance (4th generation) light source Elettra 2.0, that will replace Elettra the 3rd generation light source in Trieste Italy, will be commissioned in 2026. However the injector complex will be conserved but improvements will be done in order to be ready before of the storage ring commissioning. Optics modification, hardware upgrade and software development will be undertaken to improve the performance, stability and reliability of the Injector complex

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Wednesday Poster Session / 678

Dark current studies for a SW C-band electron gun with a deflector

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To generate the very high brightness beams in light sources, injectors based on radiofrequency photoguns with very high peak electric fields on the cathode are used. However, this very high surface electric field on the surface of a radio frequency cavity leads to the generation of dark current due to the field emission effect which can damage the instrumentation and radio-activate components. Consequently, it is important to reduce the emission of these electrons and evaluate the subsequent transportation. In this paper, the deflector has been innovatively positioned at the exit of the photogun so as to reduce the dark current as much as possible. The dark current emission and spectrum of the dark current of the C-band electron gun have been evaluated by Particle-In-Cell simulations. The dark current before the accelerating sections has been captured and observed both with and without the deflector.

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Wednesday Poster Session / 679

Passive longitudinal bunch diagnostics with a dielectric Wakefield streaker at CLARA

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Passive streaking devices have been proposed and developed at several facilities worldwide, providing a flexible and cost-effective longitudinal bunch profile diagnostic. A passive streaker, using wakefields excited in dielectric lined waveguides, is planned to be installed in the FEBE experimental chamber at CLARA Phase-2. We present experimental tests of bunch reconstruction performed during dielectric wakefield acceleration experiments at Phase-1 of CLARA, with 100 pC, 35 MeV electron beams. These profiles have been compared to simulated beam profiles, produced using S2E simulation codes Elegant and ASTRA. Conclusions have been drawn on the operation of passive streakers, applicable to the design and operation of the future streaker at CLARA.

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Europe

Monday Poster Session / 680

Challenges and mitigation measures for synchrotron radiation impact on the FCC-ee arcs

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In a high-energy circular electron-positron collider like the Future Circular Collider (FCC-ee) at CERN, synchrotron radiation (SR) presents a significant challenge due to the radiation load on collider magnets and equipment in the tunnel like cables, optical fibers, and electronics. The efficiency of the anticipated photon absorbers in the vacuum chambers depends on the operational beam energy, ranging from 45.6 GeV to 182.5 GeV. Radiation load studies using FLUKA are conducted for the four operation modes to assess the SR impact on various systems and equipment. Particularly at higher energies (120 GeV and 182.5 GeV), the radiation levels in the tunnel environment would likely not be sustainable. The objective is to implement a mitigation strategy that enables the placement of essential components, such as electronics, power converters, and beam instrumentation, in the tunnel, while enduring both instantaneous and long-term radiation effects over multiple years.

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Monday Poster Session / 681

Quadrupole field instability in cylindrical dielectric wakefield accelerators

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Dielectric Wakefield Acceleration is a technology under active research, providing the potential to accelerate charged particle bunches with gradients much greater than conventional RF-based metallic cavities. The stability of driving bunches needs to be solved before practical applications are seen. Strong transverse fields are known to be excited in DWAs, with previous research focusing on mitigating single-beam breakup instability (BBU) induced when a beam propagates off-center due to orbit-jitter or misalignment. It is also known that quadrupole-like fields are excited in planar/slab DWA structures and research has been conducted on mitigating this effect. We present simulation results that demonstrate quadrupole-like fields are also excited in circular DLWs, induced by beam astigmatism. We have shown that this in an extra source of instability within circular DWA structures and calculate the size of the fields excited as a function of beam astigmatism.

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Thursday Poster Session / 682

Radiation levels from a beam gas curtain instrument at the LHC at CERN

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A prototype Beam Gas Curtain (BGC) monitor was installed at the Large Hadron Collider (LHC) at CERN to provide 2D images of the transverse beam profile during the ongoing Run 3 (2022 to date) and in view of the High Luminosity LHC upgrade (HL-LHC). By design, the BGC operation generates collisions between the beam particles and an injected gas jet proportionally to the beam intensity and the gas density, possibly causing radiation-induced issues to the downstream LHC equipment. In this work, the radiation showers from the BGC are characterized using measured data from different LHC radiation monitors during the Run 3 BGC operation, along with Monte Carlo simulations with the FLUKA code. Finally, predictions of the expected radiation showers during the operation of the BGC in the HL-LHC era are discussed.

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Monday Poster Session / 683

High bunch charge linacs design for the FCC-ee project

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The international e-e FCC study group aims to design an accelerator complex capable of injecting tunable and high charge electron-positron bunches into a collider with center-of-mass energy between 90 and 365 GeV. The injector complex will boost the initial energy of the electron-positron bunches using multiple linacs accelerating only electrons, only positrons, and both species up to the booster injection energy of 20 GeV. The requirements on the charge poses several challenges for the injector chain due to the important role played by the wakefield both in the longitudinal and in the transverse planes. We optimized the bunch length, the RF aperture of the accelerating cavities and the linacs'layout to match the target parameters at the booster injection. In the longitudinal space we studied the impact of the wakefield on the final beam energy spread. In the transverse plane we minimized the emittance growth due to static errors along the different sections using several orbit steering algorithms, and we verified the impact of dynamic errors for the most promising designs. Furthermore, we designed an energy compressor to add flexibility to our design, and to widely scan the beam charge without strongly modifying the final bunch parameters. In this work we present a summary of these studies, which led to the linac design satisfying all the present requests for the injection to the booster. This current design is the basis for the injector complex cost estimation.

Footnotes:

- H. Pommerenke and Z. Vostrel presently working not at CERN anymore.

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Europe

Tuesday Poster Session / 684

Advancements in X-band technology at the TEX facility at INFN-LNF

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In anticipation of the Eupraxia@SPARC_LAB project at the INFN Frascati National Laboratories, an intensive testing and validation activity for the X-band RF system has commenced at the TEX test facility. The Eupraxia@SPARC_LAB project entails the development of a Free-Electron Laser (FEL) radiation source with a 1 GeV Linac based on plasma acceleration and an X-band radiofrequency (RF) booster. The booster is composed of 16 high-gradient accelerating structures working at 11.994GHz. All radiofrequency components comprising the basic module of the booster, from the power source to the structure, must undergo testing at nominal parameters and power levels to verify their reliability. For this reason, since 2021, several experimental runs have been conducted to test various components in X-band technology at the TEX facility. This paper presents the results obtained thus far from the different experimental runs, and it also outlines the future upgrade of the facility, which will enhance testing capabilities and the future prospects of the facility itself.

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Tuesday Poster Session / 685

Optimization of nanostructured plasmas for laser wakefield acceleration using a Bayesian algorithm

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Nanostructures are currently attracting attention as a medium for obtaining ultra-high-density plasmas for beam-driven or laser-driven acceleration. This study investigates Bayesian optimization in Laser Wakefield Acceleration (LWFA) to enhance solid-state plasma parameters towards achieving extremely high gradients on the order of TV/m or beyond, specifically focusing on nanostructured plasmas based on arrays of carbon nanotubes. Through Particle-In-Cell (PIC) simulations via EPOCH and custom Python scripts, we conducted a parameter analysis for various configurations of carbon nanotube arrays. Utilizing the open-source machine learning library BoTorch for optimization, our work resulted in a detailed database of simulation results. This enabled us to pinpoint optimal parameters for generating effective wakefields in these specialized plasmas. Ultimately, the results demonstrate that Bayesian optimization is an excellent tool for significantly refining parameter selection for nanostructures like carbon nanotube arrays, thus enabling the design of promising nanostructures for LWFA.

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TUCN: Photon Sources and Electron Accelerators (Contributed) / 686

Machine learning for orbit steering in synchrotrons

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Co-authors: Jonas Kallestrup [1]; Michael Böge [1]; Romana Boiger [1]

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In the latest years Machine Learning (ML) has seen an unprecedented diffusion in the most different fields in simulations and real life as well. Probably two of the first and most used ML applications in accelerators are the optimization of the final performance of the machines, and the so called virtual diagnostics. In the latest years ML was successfully applied to improve the machine safety performing fault detection or to prevent interlocks. In this work we explored the possibility to use a ML approach to efficiently steer the beam in case the lattice contains high order magnets (sextupolar order and higher). We applied this scheme to SLS 2.0, the synchrotron upgrading at the Paul Scherrer Institut.

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Tuesday Poster Session / 687

Preliminary results on X-Band structures for the Eupraxia@SPARC_LAB project

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Co-authors: Andrea Iungo [1]; Andrea Liedl [1]; Beatrice Serenellini [1]; David Alesini [1]; Enrico Di Pasquale [1]; Gianluca Di Raddo [1]; Giulia Latini [1]; Luca Piersanti [1]; Lucia Giuliano [2]; Luigi Faillace [1]; Marco Bellaveglia [1]; Roberto Di Raddo [1]; Stefano Pioli [1]; Valerio Lollo [1]

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The Eupraxia@SPARC_LAB project involves the development of a 1 GeV normal conducting Linac with an S-band injector followed by an X-band booster. To achieve the final energy, the booster consists of 16 traveling wave accelerating structures operating at 11.994 GHz with a minimum working gradient of 60 MV/m. An intensive design activity, prototyping, and testing of these structures is underway at INFN-LNF. This paper comprehensively presents all the work conducted in the design and prototyping, along with preliminary test results obtained from the first RF prototype of the Eupraxia@SPARC_LAB X-band accelerating structure.

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Wednesday Poster Session / 688

Overview of beam intensity issues and mitigations in the CERN-SPS fast wire scanners

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A new design of fast wire scanner was installed in the CERN injector complex as part of the upgrades linked to the High-Luminosity LHC Project. Initial operations with these beams were good, but during the planned intensity ramp-up one early 2023, all four SPS scanners failed at the same

time. An urgent program was put in place to understand and address this failure with experts from across the accelerator fields. Many measurements and simulations were performed and solutions implemented. This paper gives an overview of the issues seen, understanding and mitigations put in place to allow the instrument to perform at the maximum planned operational intensities.

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Thursday Poster Session / 689

Update on automated RF-conditioning utilizing machine learning

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The conditioning of room temperature cavities is an exhausting process. To prevent damage to the cavity and auxiliary equipment, this potentially long process needs constant supervision or extensive safety precautions. Additionally, the unpredictability of every new conditioning makes the development of effective classical algorithms difficult. To reduce the workload for everyone involved and to increase the efficiency of the conditioning process, it was decided to develop a machine learning algorithm with the goal of fully automated conditioning in mind. To reach this goal, it is planned to train the model on the data of already conducted conditionings of room temperature cavities, a virtual cavity and several more conditionings to be conducted soon. In this paper, the status of development, problems and challenges as well as the planned future progression shall be summarized.

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Monday Poster Session / 690

Explore higher order transverse resonance island buckets at the Cornell electron storage ring

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Transverse resonance island buckets (TRIBs) near a third-order resonance are observed at the Cornell Electron Storage Ring with a newly-designed lattice. Hamiltonian perturbation theory and map-based PTC method have been successfully implemented to design the TRIBs lattice and find the fixed points near the third-order resonance. For higher order resonances (fourth order and higher) which are intrinsically weaker, the effects of radiation damping and excitation may not be negligible in the lepton machine such that the Hamiltonian approach could break down. In this paper, we study TRIBs near the fourth-order and fifth-order resonances with tracking simulations, which predict the existence of islands in both orders. Then experimental observations confirmed the existence of islands near the fourth-order resonance. The positions of the fixed points extracted from experimental results agree reasonably well with those predictions from both tracking and PTC calculations. Experimental exploration of the fifth-order resonance will also be briefly discussed.

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Wednesday Poster Session / 691

Impact of second-order chromaticity on the Schottky spectra of bunched beams

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Observation of Schottky signals provides information on important beam and machine parameters, such as transverse emittance, betatron tune, and first-order chromaticity. However, the so-far developed theory of Schottky spectra does not include the impact of the higher-order chromaticity, known to be non-negligible in the case of the Large Hadron Collider (LHC). In this contribution, we expand the theory of Schottky spectra to also take into account second-order chromaticity. Analytical results are compared with macro-particle simulations and the errors resulting from neglecting second-order chromaticity are assessed for the case of the LHC.

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Wednesday Poster Session / 692

Measurement, tuning and test for the two-mode TDS

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SSRF/SXFEL has develop the advanced transverse deflecting structure TTDS (two-mode transverse deflecting structure) to perform variable polarization based on the design of a dual-mode RF structure. The 15-cell prototype of the TTDS was fabricated at SSRF/SXFEL. Perturbing object measurement was also performed at SSRF/SXFEL, and a new method for tuning two modes simultaneously were designed and applied. The low power test was perform and all the results are summarized in this paper.

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Monday Poster Session / 694

Resonance compensation at the CERN PS booster aided by Bayesian optimization and BOBYQA

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The CERN Proton Synchrotron Booster (PSB) operation involves the crossing of multiple resonance lines in the tune diagram. Loss maps from dynamic tune scans are a helpful way to visualize and quantify the strength of such resonances. Sextupole and octupole correctors can be used in order to partially or fully compensate multiple resonance lines, i.e., third and fourth order lines. The following work explores the application of advanced optimization algorithms such as Bayesian Optimization and Bound Optimization By Quadratic Approximation (BOBYQA) in order to compensate these resonance lines with available correctors.

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Monday Poster Session / 697

Implementing betatron radiation for beam diagnostics studies

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Betatron radiation is a form of synchrotron radiation emitted by moving or accelerated electron or positron-like charged particles. As a valuable tool it can provide useful information about their trajectories, momentum and acceleration. It has good potential as a novel non-destructive diagnostic for laser-driven plasma wakefield acceleration (LWFA) and beam-driven plasma wakefield acceleration (PWFA).
Since information about the properties of the beam is encoded in the betatron radiation, measurements using the Maximum Likelihood Estimation (MLE) method, rich information about the beam parameters (beam spot size, emittance, charge, energy etc.) can be extracted. Machine learning (ML) techniques can then be applied to improve the accuracy of these measurements. It has already been observed that betatron radiation can give an insight into the change in plasma density.
The QUASAR Group, based at the Cockcroft Institute on Daresbury Sci-Tech campus, is planning to build on and expand an existing collaboration with UCLA and also to apply the technique for the AWAKE experiment at CERN. In this work, a hybrid ML-MLE approach is attempted to optimize the use of these diagnostics and obtain a deep insight into the beam's parameters e.g. beam spot sizes where ML and MLE individually have their limitations.

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Wednesday Poster Session / 698

Understanding of the new horizontal instability at the PS Booster after LIU

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Following the LHC Injectors Upgrade (LIU) project at CERN, the Proton Synchrotron Booster (PSB) has been upgraded to operate with a new injection kinetic energy of 160 MeV and an extraction energy of 2 GeV. To understand the performance of the accelerator in this new energy range, a series of measurements have been conducted, especially devoted to the beam stability to ensure the optimal operation of the machine. A horizontal instability, firstly observed in 2021 at about 1.6 GeV (between the old and the new extraction energy of the Proton Synchrotron Booster), has undergone in-depth investigation in measurements. Despite the identification of a mitigation strategy to cure the horizontal instability, efforts have also been focused to understand its source. The results have once again drawn the attention to the termination of the extraction kicker. As happened in 2018, a dedicated MD performed at the end of 2023 run with matched kicker termination confirmed the impact of the extraction kicker in this instability.

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Thursday Poster Session / 699

A wireless method for beam coupling impedance bench measurement of resonant structures

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The Beam Coupling Impedance (BCI) is a crucial aspect in the realm of accelerator physics, as it describes the electromagnetic interactions between charged particle beams and the accelerator structure. The measurement and quantification of BCI is an essential requirement to assess and mitigate its impact, particularly when introducing new components or addressing problems within existing devices. The stretched Wire Method (WM) is a well-established technique for BCI evaluations, although with well-known limitations. These are particularly prominent when dealing with cavity-like structures. In that case, the estimates obtained below the cut-off frequency of the beam pipe can be inaccurate. It is worth noting that this frequency range is particularly relevant for many accelerator applications. To overcome these well-recognized limitations, a different bench measurement technique has been identified and thoroughly examined. This novel approach has been subjected to comprehensive testing in both virtual and real measurements, with a particular focus on a pillbox cavity.

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Wednesday Poster Session / 700

Superconducting dipole for Elettra 2.0

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Elettra 2.0 is the 4th generation synchrotron light source that is going to replace Elettra, the 3rd generation light source operating for 30 years in Trieste Italy. The new ring will be giving light to the users in 2026 at 2.4 GeV. Three beam lines require very hard-x-rays i.e. photon energies at 50 keV or more with a flux of 1013 ph/sec and this can be achieved with a superconducting magnet at 6 T peak field.
A new superconducting magnet is developed with an innovative compact design integrated with quadrupole side magnets. A new cryogenic solution will combine the benefits of a liquid-helium cooled inner magnet with a liquid-helium-free upper cooling stage. A C-shaped design will allow to slip in and slip out the magnet from its position on the storage ring vacuum chamber. A prototype of a new 6T superconducting magnet will be constructed and installed in the storage ring to replace

a normal 1.4 T magnet allowing a full characterization of its performance. The NbTi superconducting magnet will work at 3.5K conduction cooled, using a system of heat exchanger connected to a subcooled Helium bath.

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Thursday Poster Session / 701

Impedance reduction of the beam gas ionization monitors for the CERN SPS

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The beam gas ionization monitors (BGIs) are non-destructive instruments to measure the transverse beam profiles. With the goal to double the beam intensity in the injector chain for the High-Luminosity Large Hadron Collider (HL-LHC), any element contributing to the overall beam coupling impedance requires an in-depth impedance evaluation from the design stage. This paper presents the beam coupling impedance optimization and mitigation study of the beam gas ionization monitors for the Super Proton Synchrotron (SPS) at CERN. Detailed electromagnetic simulations of the 3D model were carried out already before the construction of the prototype. Consequently, geometrical modifications required for impedance mitigation were still possible and were investigated while keeping the functionality of the device. We present different mitigation measures as coatings, RF-fingers and the introduction of additional loss mechanisms to dampen resonances of the geometry. At last, a comparison of the instrument design before and after impedance reduction is shown.

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Wednesday Poster Session / 702

Design of a constant-gradient backward-traveling-wave accelerating structure for irradiation application

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We have presented a novel design of a constant-gradient backward-wave accelerating structure. This structure employs a tapered group velocity, enhancing the efficiency of the accelerating structure. This accelerating tube will be integrated into the system of high-power irradiation accelerators. The paper provides a detailed overview of the design process and parameters involved.

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Wednesday Poster Session / 703

Status of the CARIE high gradient photocathode test facility at LANL

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This presentation will report on the status of assembling and commissioning of the Cathodes And Radio-frequency Interactions in Extremes (CARIE) C-band high gradient photoinjector test facility at Los Alamos National Laboratory (LANL). The construction of CARIE began in October of 2022. CARIE will house a high gradient copper RF photoinjector with a high quantum-efficiency cathode and produce an ultra-bright 250 pC electron beam accelerated to the energy of 7 MeV. The 50 MW 5.712 GHz Canon klystron will power the facility. The klystron was received and installed in fall of 2023. The WR187 waveguide line brings the power from the klystron into a concrete vault that is rated to provide radiation protection for an electron beam powers up to 20 kW. The first RF injector that was fabricated is made of copper and does not have cathode plugs. This injector will be commissioned to validate operation of the CARIE facility. The second injector that will accommodate cathode plugs and novel photocathodes was designed and will be fabricated. The status of the facility, the designs of the photoinjector and the beamline, and plans for photocathode testing will be presented.

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Wednesday Poster Session / 704

MENT-Flow: maximum entropy tomography using normalizing flows

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Generative models can be trained to reproduce low-dimensional projections of high-dimensional phase space distributions. Normalizing flows are generative models that parameterize invertible transformations, allowing exact probability density evaluation and sampling. Consequently, flows are unbiased entropy estimators and could be used to solve the high-dimensional maximum-entropy tomography (MENT) problem. In this work, we evaluate a flow-based MENT solver (MENT-Flow) against exact maximum-entropy solutions and Minerbo's iterative MENT algorithm in two dimensions.

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Thursday Poster Session / 705

An overview of the LAMP front-end upgrade at LANSCE

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The Los Alamos Neutron Science Center (LANSCE) is one of the oldest operating high-average-power accelerators in the United States, having recently celebrated its 50th anniversary of operation. LANSCE is comprised of an 800-MeV linac capable of concurrently accelerating both H+ and H- ions,

and can presently provide beam to six separate user stations. The LANSCE accelerator operates with much of its original equipment, including the Cockcroft-Walton injectors and drift-tube linacs.
As part of the proposed LANSCE Modernization Project (LAMP), a refurbishment and upgrade effort would replace the initial portion of the LANSCE accelerator, from ion sources to the end of the 100-MeV drift-tube linac. This paper describes the overall approach taken to establish performance goals, downselect a preferred technology approach, and identify viable pathways towards implementation.

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Tuesday Poster Session / 706

An overview of the proton storage ring upgrade at LANSCE

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The Los Alamos Neutron Science Center (LANSCE) is one of the oldest operating high-average-power accelerators in the United States, having recently celebrated its 50th anniversary of operation. LANSCE is comprised of an 800-MeV linac capable of concurrently accelerating both H+ and H- ions, and can presently provide beam to six separate user stations.
The Proton Storage Ring (PSR) at LANSCE acts as a pulse-stacker, providing intense bunches of protons to the Lujan neutron scattering center target. Critical subsystems have become increasingly difficult to maintain due to spare parts availability; more generally, the PSR contributes significantly to our annual maintenance duration due to beam spill and component activation. The proposed LAMP project would extend the operating lifetime and improve the operational characteristics of the PSR via increasing the physical aperture by 50%; modernizing and improving the performance of the RF buncher system, extraction kickers and impedance inserts; and updating the injection line and stripper foil system for reduced injection losses and improved maintainability. This paper provides an overview of the PSR portion of LAMP.

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TUAD: Hadron Accelerators (Contributed) / 708

LAMP: the LANSCE modernization project

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Co-authors: Dimitre Dimitrov [1]; Eric Brown [1]; Gregory Dale [1]; John Lewellen [1]; Juan Barraza [1]; Kip Bishofberger [1]

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The Los Alamos Neutron Science Center (LANSCE) is one of the oldest operating high-power accelerators in the United States, having recently celebrated its 50th anniversary of operation. LANSCE is comprised of an 800-MeV linac capable of concurrently accelerating both H+ and H- ions, and can presently provide beam to six separate user stations.
The proposed LANSCE Modernization Project (LAMP) is intended to revitalize and enhance the performance of two key areas in the LANSCE accelerator complex: the front end of the accelerator, from the sources to the end of the drift tube linac at 100 MeV; and the 800-MeV proton storage ring, or PSR. This paper provides a high-level overview of the proposed LAMP scope of work, timeline and performance goals.

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Tuesday Poster Session / 709

Update and improvement planning at the Los Alamos Neutron Science Center (LANSCE)

Author: Bruce Carlsten[1]

Co-authors: Eric Brown [1]; John Tapia [1]; Mark Gulley [1]; Shea Mosby [1]

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The Los Alamos Neutron Science Center (LANSCE) is one of the oldest operating accelerators in the United States, having recently celebrated its 50th anniversary of operation. LANSCE is comprised of an 800-MeV linac capable of concurrently accelerating both H+ and H- ions, and can presently provide beam to six separate user stations.
We present an overview of proposed and underway upgrade and enhancement efforts at LANSCE. These include both near- and far-term efforts, encompassing lifetime extension and performance enhancement of the LANSCE linac; the potential for addition of new end stations and user facilities; and ancillary projects to provide additional materials characterization methods via ultrafast electron diffraction and inverse Compton scattering.

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Wednesday Poster Session / 710

This is a poster tile: semiconductor photocathodes fabrication at ACERT

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Co-authors: Anna Alexander [1]; Evgenya Simakov [1]

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Photocathodes play key roles in supplying electron beams for diverse research facilities. Among them, semiconductor photocathodes stand out for their high quantum efficiency (QE). Typically, a high QE, long operation time, low thermal emittance and fast response time are desired for the accelerator community. However, the performance of semiconductor photocathodes is extremely sensitive to growth conditions. In this presentation, I will delve into recent advancements in semiconductor photocathodes fabrication at Applied Cathode Enhancement and Robustness Technologies (ACERT) of Los Alamos National Laboratory (LANL). These updates allow us to fine tune growth parameters and fabricate photocathodes with high QE and low emittance at high gradient to meet the requirements of photocathodes for Cathodes and Radiofrequency Interactions in Extremes (CARIE) project at LANL. Specifically, I will highlight our progress in developing a control system that enables to accurately control growth parameters. Furthermore, I will show our preliminary results focusing on the fabrication of CsSb and CsTe photocathodes using both sequential and co-deposition methods.

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Tuesday Poster Session / 711

Upgrade and expansion options for the LANSCE user facility complex

Author: Shea Mosby[1]

Co-authors: Bruce Carlsten [1]; Dimitre Dimitrov [1]; Eric Brown [1]; John Lewellen [1]; John Tapia [1]; Mark Gulley [1]; Robert Garnett [1]; Steven Russell [1]

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The Los Alamos Neutron Science Center (LANSCE) is one of the oldest operating high-power accelerators in the United States, having recently celebrated its 50th anniversary of operation. LANSCE is comprised of an 800-MeV linac capable of concurrently accelerating both H+ and H- ions, and can presently provide beam to six separate user stations.
The Area A end-station at LANSCE is the site of the original MW-class meson target, now in the final stages of remediation and cleanup. The LANSCE accelerator has not delivered beam to Area A since its transition to a multi-user facility. This paper discusses the potential for reestablishing both low- and high-power beam delivery to new end stations and user facilities to be located within Area A.

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Wednesday Poster Session / 714

Summary of the LANL mini-workshop on source region options for LAMP

Author: John Lewellen[1]

Co-authors: Anna Alexander [1]; Charles Taylor [1]; Dmitry Gorelov [1]; Enrique Henestroza [1]; Gregory Dale [1]; John Tapia [1]; Nathan Moody [1]; Remington Thornton [1]; Sergey Kurennoy [1]

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The core components of the LANSCE accelerator complex –the beam source area, drift-tube and cavity-coupled linear accelerators –are more than 50 years old; a critical subsystem for beam delivery to the Lujan Center, the proton storage ring (PSR), is more than 20 years old. The proposed LAMP project is intended to begin a revitalization and update of the LANSCE accelerator complex, starting with the beam source region, drift-tube linac, and PSR.
To help assure we have selected an optimal candidate design for the source region, an internal workshop was held in August 2023 to consider options for providing two beam species at the peak and average currents, and beam macropulse formats, required by the various LANSCE user stations. This document describes the workshop goals and processes, presents the various configurations considered, and lists the results of the downselect process and potential paths forward.

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Wednesday Poster Session / 715

Concepts for more flexible UED/UEM operation

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Ultrafast electron diffraction and microscopy (UED/UEM) has advanced beyond proof-of-concept stage into the realm of instrumentation. To date, most UED/UEMs have been constructed around high-gradient RF-driven electron guns designed as X-FEL beam sources.
A UED/UEM system driven by a CW beam, either normal- or superconducting, offers several potential performance benefits over high-gradient pulsed beam sources. These include the ability to operate at much higher average repetition rates, and the ability to extend measurement times beyond O(1 μs). If a quarterwave-type beam source is used, there is an additional possibility to vary the time between probe pulses by other than an RF period. In this paper we present the basis for this claim, discuss implications for detectors, and consider also utilization of probe electron beams at different beam energies.

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Monday Poster Session / 716

First results from the EuPRAXIA doctoral network: paving the way for next-generation particle accelerators

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This contribution presents the inaugural findings from the 3.2M€ EuPRAXIA Doctoral Network. The European Plasma Research Accelerator with eXcellence In Applications (EuPRAXIA) initiative is at the forefront of advanced particle accelerator research, focusing on the development of plasma-based accelerator technologies.
The EuPRAXIA Doctoral Network, a collaborative effort among leading research institutions, has been dedicated to exploring and advancing the frontiers of plasma-based particle acceleration.
The network's research encompasses a wide range of topics, from beam diagnostics and optimization techniques to new applications. We will highlight the innovative approaches and methodologies employed to achieve unprecedented acceleration gradients, improving both energy sharpness and beam quality. This contribution will discuss the early results of this new network, showcasing the progress made across its three scientific work packages in harnessing the potential of plasma wakefield acceleration.

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Tuesday Poster Session / 717

Breaking new ground in data-intensive science: first insights from the LIV.INNO center for doctoral training

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LIV.INNO is a new initiative which will train around 40 PhD students over three cohorts. It fosters innovation in data-intensive science, serves as a dynamic platform for collaboration between leading research organizations and the next generation of scientists. Within this context, several projects focus on research that intersects between data science and particle accelerator research.
This contribution will showcase the early results from experimental studies and Monte Carlo simulations into novel 3D X-ray imaging techniques; the application of machine learning techniques to reconstruct a beam's profile; the use of optical transition radiation-based diagnostics for low energy ion beams. These early insights highlight the many benefits from collaborative R&D in data-rich accelerator environments. A summary of the training events offered by the center will also be given.

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MOCD: Accelerator Technology and Sustainability (Contributed) / 719

Multi-mode cavity design and characterization

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We present the design and initial characterization of a multi-mode cavity, a novel electromagnetic structure with potential benefits such as compactness, efficiency, and cost reduction. The 2nd Harmonic mode was chosen to linearize the fundamental mode for use as an accelerating and bunching cavity. The reduction in the number of cavities required to bunch and accelerate promises cost and space savings over conventional approaches. Superfish and COMSOL simulations were used to optimize the cavity's geometry with the goal of balancing various design parameters, such as quality factor (Q-factor), harmonic modes, and mode coupling. A 3D-printed copper-plated cavity was used to validate code predictions.
The cavity's multi-mode nature positions it for use with other harmonic modes with small deviations in design. For example, a 3rd Harmonic can be used to decrease energy spread by widening the peak of the fundamental. This research lays the foundation for further exploration of the cavity's applications and optimization for specific use cases, with potential implications for a wide range of accelerator fields.

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Thursday Poster Session / 720

Bunch-by-bunch simulations of beam-beam driven particle losses in the LHC

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Recent experimental measurements in the Large Hadron Collider (LHC) have shown a clear correlation between beam-beam resonance driving terms and beam losses, with a characteristic bunch-by-bunch signature. Due to the encounter schedule of the different bunches as they cross the interaction points, it is known that different bunches experience different long-range interactions with bunches of the other beam. This creates interesting conditions to study particle stability. Over the past few decades, early chaos indicators, frequency map analysis and dynamic aperture studies have been commonly used to study particle stability in circular machines. However, the underlying mechanisms driving particles to large amplitudes in the presence of high order resonances is still an open question. In preparation for the High-Luminosity upgrade of the LHC and other future circular colliders, a better understanding of slow particle losses is needed, alongside possible compensation schemes to reduce strong nonlinearities. Leveraging on years of development on particle tracking tools, this paper presents full-fledged bunch-by-bunch beam loss simulations in the LHC and shows the evolution of macroscopic observables for the beam over a time scale of 30 minutes (2e+7 turns). The experimental observations from LHC Run 3 are reproduced and compensation schemes are proposed.

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Monday Poster Session / 721

Recycling magnets for the EIC electron storage ring

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The Electron Storage Ring (ESR) of the Electron-Ion Collider requires some 400 quadrupoles and 200 sextupoles, plus dipole magnets and correctors. In an effort to reduce cost and relax the demand on the magnet vendor pool, used quadrupoles and sextupoles of the Advanced Photon Source at Argonne National Laboratory will be refurbished and installed in the ESR.

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Wednesday Poster Session / 722

Study of single bunch effect in PETRA-IV storage ring

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Co-authors: Sergey Antipov [1]; Yong-Chul Chae [1]

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This paper analyzes the single bunch effect due to impedance in PETRA-IV storage ring. With an established impedance element database, the geometrical impedance is generated accordingly. The resistive wall impedance is obtained through the ImpedanceWake2d simulation. The H6BA lattice is now considered as the baseline design and applied for the simulation study. It is required that the ring can be operated with and without damping wigglers, which results in two sets of natural equilibrium beam parameters. In this paper, we will show the influence of the impedance on the electron beam in both scenarios. We conclude that with the help of a 3rd-order harmonic cavity and chromaticity equal to 6, the single bunch current threshold is above 2 mA. At the nominal emittance ratio kappa=0.1, the Touschek lifetime is around 10 hours

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Wednesday Poster Session / **723**

CETASim: A numerical tool for beam collective effect study in storage rings

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We developed a 6D multi-particle tracking program CETASim in C++ programming language to simulate intensity-dependent effects in electron storage rings. The program can simulate the collective effects due to short-range and long-range wakefields for single and coupled-bunch instability studies. It also features to simulate the ion interactions with the trains of electron bunches, including both fast ion and ion trapping effects. As an accelerator design tool, the bunch-by-bunch feedback is also included so that the user can simulate the damping of the unstable motion when its growth rate is faster than the radiation damping rate. The particle dynamics is based on the one-turn map, including the nonlinear effects of amplitude-dependent tune shift, high-order chromaticity, and second-order momentum compaction factor. When required, a skew quadrupole can also be introduced, which is very useful for the emittance sharing and the emittance exchange studies. This paper describes the code structure, the physics models, and the algorithms used in CETASim. We also present the results of its application to the PETRA-IV storage ring.

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Monday Poster Session / **727**

The EIC accelerator –design highlights and project status

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Wang [1]; Gennady Stupakov [7]; Georg Hoffstaetter [4]; George Mahler [1]; Guillaume Robert-Demolaize [1]; Haixin Huang [1]; Henry Lovelace III [1]; Holger Witte [1]; Igor Pinayev [1]; J. Berg [1]; James Jamilkowski [2]; Ji Qiang [8]; Jonathan Unger [4]; Jorg Kewisch [1]; Joseph Tuozzolo [1]; Kevin Smith [1]; Kirsten Deitrick [3]; Kirsten Drees [1]; Matthew Signorelli [4]; Medani Sangroula [1]; Michael Blaskiewicz [1]; Michael Sullivan [9]; Michiko Minty [1]; Nicholaos Tsoupas [2]; Panagiotis Baxevanis [2]; Qiong Wu [10]; Ramesh Gupta [1]; Robert Rimmer [3]; Roberto Than [1]; Sarin Philip [3]; Sergei Nagaitsev [2]; Sergei Seletskiy [1]; Silvia Verdu-Andres [2]; Stephen Benson [3]; Steve Peggs [1]; Steven Tepikian [1]; Sumanta Nayak [1]; Tim Michalski [3]; Todd Satogata [3]; Vadim Ptitsyn [2]; Vahid Ranjbar [2]; Vasiliy Morozov [6]; Wencan Xu [1]; William Bergan [1]; Wolfram Fischer [1]; Xiaofeng Gu [1]; Yongjun Li [1]; Yue Hao [11]; Yun Luo [1]; Yunhai Cai [9]; Yuri Nosochkov [9]; Zachary Conway [1]

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The design of the electron-ion collider (EIC) at Brookhaven National Laboratory is well underway, aiming at a peak electron-proton luminosity of 10e+34 cmˆ-1·secˆ-1. This high luminosity, the wide center-of-mass energy range from 29 to 141 GeV (e-p) and the high level of polarization require innovative solutions to maximize the performance of the machine, which makes the EIC one of the most challenging accelerator projects to date. The complexity of the EIC will be discussed, and the project status and plans will be presented.

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Tuesday Poster Session / 729

Recent progress in laser wire based H- beam diagnostics at the SNS linac

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Laser wire has been used for nonintrusive profile and emittance measurements of operational hydrogen ion (H-) beam at the SNS linac. In this talk, we will describe the following recent developments in the laser wire system. 1) An upgraded light source and laser transport line which enables novel measurement capabilities including longitudinal profile measurement and high-energy proton beam extraction over potentially an entire macropulse. 2) A dual-detector emittance measurement scheme that boosted the dynamic range by an order of magnitude. 3) Design and implementation laser-wire-based nonintrusive longitudinal phase space measurement system.

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Tuesday Poster Session / **730**

Design and construction progress of ALS-U

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The ALS-U project to upgrade the Advanced Light Source to a multi bend achromat lattice received CD-3 approval in 2022 marking the start of the construction phase for the Storage Ring. Construction of the accumulator under a prior CD-3A authorization is already well advanced. ALS-U promises to deliver diffraction limited performance in the soft x-ray range by lowering the horizontal emittance to about 70 pm rad resulting in two orders of magnitude brightness increase for soft x-rays compared to the current ALS. The design utilizes a nine bend achromat lattice, with reverse bending magnets and on-axis swap-out injection utilizing an accumulator ring. It is optimized to produce intense beams of soft x-rays, which offer spectroscopic contrast, nanometer-scale resolution, and broad temporal sensitivity. This paper presents the final design, prototype results as well as construction progress.

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Thursday Poster Session / 731

Status of the Spallation Neutron Source beam test facility and progress of beam dynamics studies

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The Spallation Neutron Source (SNS) Beam Test Facility (BTF) supports the study of beam dynamics in the front end of a high power LINAC. The BTF combines a replica of the SNS front end, including nearly-identical ion source, RFQ and MEBT, with extensive phase space diagnostics and a FODO transport line. Diagnostic capabilities include direct measurement of 6D phase space distribution and detection of halo distributions to a sensitivity of greater than one part-per-million. The goal of ongoing BTF studies is to demonstrate accurate particle-in-cell modeling of halo growth and evolution by leveraging unprecedented accuracy in the description of the initial beam distribution. This work is motivated by operational experience at the SNS, which currently operates with beam loss that cannot be described by any model. This paper summarizes progress in the BTF beam study program as well as diagnostics development and recent upgrades to the beamline configuration.

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Monday Poster Session / 732

Thermoelastic response of Bragg crystals under MHz thermal loading

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An x-ray free-electron laser oscillator (XFELO) is a promising candidate for producing fully coherent x-rays beyond the fourth-generation light sources. An R&D XFELO experiment (ANL-SLAC-Spring-8 collaboration) to demonstrate the basic principles and measure the two-pass FEL gain is expected to be accomplished by 2024. Beyond this R&D experiment, an XFELO user facility will be eventually needed to produce stable x-ray pulses with saturated pulse energy at MHz repetition rate. However, one of the outstanding issues for realizing an MHz XFELO is the possible Bragg crystal degradation due to the high-repetition-rate thermal loading of the high-pulse-energy x-rays. The deposited energy by one x-ray pulse induces temperature gradients and elastic waves in the crystal, where the deformed crystal lattice impacts the Bragg performance for subsequent x-ray pulses. Here, we report on the numerical study of the crystal thermoelastic response under thermal loading of x-ray pulse trains. The long-term decoupled thermoelastic behavior of the crystal and the possible mitigation of the thermal loading such as crystal cryogenical cooling will be discussed.

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Thursday Poster Session / 733

Simultaneous acceleration of multiple beams in novel LANSCE front end

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We present the 100 MeV injector design for the LANSCE Accelerator Facility, which is designed to replace the existing 750-keV Cockcroft-Walton-columns-based injector. This new Front End includes two independent low-energy transports for H+ and H- beams merging at the entrance of a single RFQ, with the subsequent acceleration of particles in the new Drift Tube Linac. The challenge of this design is associated with the necessity of simultaneous acceleration of protons and H- ions with multiple beam flavors in a single RFQ and DTL. The LANSCE operation regime provides simultaneous delivery of beams to five experimental areas, with a forecasted increase in the number of targets in the future. Each beam is characterized by a unique time structure, pulse length, emittance, and charge per bunch. The paper presents the details of this design and injector parameters.

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Wednesday Poster Session / 734

HOM suppression study for the C-band accelerating structure

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The C-band (5.712 GHz) accelerating structure with distributed coupling and four waveguide manifolds for HOM damping has been studied at Los Alamos National Laboratory to evaluate suppression of the higher-order-modes (HOMs). The HOM damping manifolds were covered by Nickel Chrome (NiCr) and had rounded edges at the interface of the waveguide with accelerating cavities. In this design study, we modeled a 20-cell accelerating structures and calculated the Q-factors and the transverse kick factors for the wakefields in the frequency range up to 40 GHz. Simulations were performed with the Omega3p code. The goal of the study was to bring all Q-factors below 10000 and kick-factors x Q-factors below 1000 V/pC/mm/m for all major HOMs. This presentation will summarize the results of the study.

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Thursday Poster Session / 735

Design and testing of compact C-band RF prototype for a VHEE flash radiotherapy linac

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FLASH Therapy, a novel cancer treatment technique, aims to control the tumor-grown sparing the healthy tissue from radiation damage increasing the therapeutic index. The translation of FLASH therapy into clinical practice, especially for treating deep-seated tumors, necessitates achieving Very High Electron Energy (VHEE) levels within the 50-150 MeV range.
In collaboration with INFN, Sapienza is actively developing a compact C-band high-gradient VHEE

FLASH linac. This paper provides insights into the design strategy and electromagnetic characteristics, with a particular focus on prototype testing and tuning conducted at the Sapienza Accelerator Laboratory. The progress of this innovative linac represents a step toward realizing the SAFEST project, an advanced FLASH VHEE source in cancer treatment

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Wednesday Poster Session / 738

Design of the L-band photocathode RF gun

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In this paper, we presented the design of an L-band photocathode RF gun for the particle-driven wakefield accelerator proof-of-principle project at IHEP. The gun is a critical component, tasked with generating both the driving beam and potentially the witness beam. It is specifically engineered to deliver a beam with a bunch charge of 5 nC. Key aspects of the design, including RF optimization and the focusing solenoid arrangement, are discussed in detail.

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Monday Poster Session / 739

Vertical emittance creation compatible with high polarization in the electron storage ring of the EIC

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The Electron-Ion Collider (EIC) to be built at Brookhaven National Laboratory will provide spin-polarized collisions of electrons and protons/light-ions for a wide range of center-of-mass energies. The Electron Storage Ring (ESR) of the EIC must be designed so that the depolarizing effects of synchrotron radiation are kept sufficiently low, while still satisfying all beam requirements, e.g. a sufficiently large vertical beam size at the interaction point. The insertion of a vertical emittance creation scheme in the ESR will have detrimental effects on polarization unless carefully implemented. In this work, various methods of creating vertical emittance are analyzed in-depth and iteratively implemented in the preliminary ESR lattices. This includes using the Best Adjustment Groups for ELectron Spin (BAGELS) method to determine which groupings of vertical emittance creation magnets have the least impact on polarization. The polarization robustness of all methods in the presence of realistic misalignments and the beam-beam effects is also analyzed. Taking into consideration spin matching, effects on the optics, and physical feasibility, optimal methods for creating vertical emittance in the ESR are determined.

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Monday Poster Session / 740

Electromagnetic and beam dynamics modeling of LANSCE front-end elements with CST studio

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The front end of the 800-MeV proton linac at the Los Alamos Neutron Science Center (LANSCE) is still based on Cockcroft-Walton voltage generators that bring proton and H- beams of various flavors to 750 keV. We have developed 3D CST models of the LANSCE front-end elements including low-frequency and main bunchers. The fields in these elements are calculated with MicroWave and ElectroMagnetic Studio. Beam dynamics is modeled with Particle Studio for beams with realistic charge distributions using the CST calculated fields. The modeling results provide insight into linac operations and a guidance for designing a modern, RFQ-based front end for the LANSCE linac.

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Wednesday Poster Session / 741

Measurement of the spatial distribution of inverse Thomson scattered gamma rays generated by an axially symmetric polarized laser

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Inverse Thomson (Compton) scattering is a well-known radiation process that produces high energy and highly polarized gamma rays using a high energy electron accelerator. Linearly polarized gamma rays are generated by the interaction of a linearly polarized laser and an electron beam, while circularly polarized gamma rays are generated by a circularly polarized laser*. On the other hand, it is also possible to generate radially or azimuthally polarized lasers whose polarization direction is radially or azimuthally distributed. These are called axially symmetric polarized beams because the polarization distribution is symmetric about the optical axis. A space variant waveplate, s-waveplate, was used to convert a linearly polarized laser into an axially symmetric polarized laser. The polarized lasers were collided with a 750 MeV electron beam of the UVSOR synchrotron facility, and the spatial distribution of the generated 6.6 MeV gamma rays was measured using a radiation imaging detector with a 1-mm-thick CdTe sensor (AdvaPIX TPX3). It was found that the spatial distribution of gamma rays generated from axially symmetric polarized lasers is different from that of linearly and circularly polarized gamma rays. In order to clarify the polarization state of these gamma rays, the spatial polarization distribution of the gamma rays will be measured in the near future. In this conference, the detail of the experiment will be presented.

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- Y. Taira et al., "Measurement of the spatial polarization distribution of circularly polarized gamma rays produced by inverse Compton scattering", Phys. Rev. A 107 063503 (2023).

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Tuesday Poster Session / 742

Generative deep learning for 6D phase space diagnostics via physics-constrained neural networks, physics models, and adaptive feedback

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We present a unifying approach to generative deep learning-based 6D phase space diagnostics which combines neural networks, physics models, and adaptive feedback. Our approach includes a physics-constrained neural network (PCNN) for calculating the electromagnetic fields of intense relativistic charged particle beams via 3D convolutional neural networks. Unlike the popular physics-informed neural networks (PINNs) approach, in which soft physics constraints are added as part of the network training cost function, our PCNNs respect hard physics constraints, such as ▿·B=0, by construction. Our 3D convolutional PCNNs map entire large (256×256×256 pixel) 3D volumes of time-varying current and charge densities to their associated electromagnetic fields. We demonstrate the method on space charge dominated, relativistic (5 MeV), short (hundreds of fs), high charge (2 nC) electron beams, such as those in the injector sections of modern free electron laser and plasma wakefield accelerators. We show that the method is accurate, respects physics constraints, and that the trained 3D convolutional PCNNs perform electromagnetic calculations orders of magnitude faster than traditional solvers which require a O(N^2) process for calculating the space charge fields of intense charged particle beams. We show how we combine this with an online physics model, adaptive feedback, and automatic differentiation for real-time predictions of the 2D projections of the 6D phase space of charged particle beams.

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WECD: Colliders and other Particle and Nuclear Physics Acclerators (Contributed) / 743

Measures to mitigate the coherent beam-beam instability at CEPC

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Both horizontal and vertical coherent beam-beam instability are important issues at CEPC. The horizontal instability (X-Z instability) could be induced by beam-beam itself. The main method to suppress the X-Z instability is the optimization of machine parameters. In this paper we try to study the effect of chromaticity, local vacuum impedance and resistive feedback by analysis and simulation. The vertical instability may be induced due to the combined effect of beam-beam interaction and vacuum impedance. Finite chromaticity and asymmetrical tunes have been proposed to suppress

the vertical instability. Due to the further increase of impedance budget, we need to find more measures to mitigate the instability. The effect of resistive feedback and hourglass effect are evaluated by analysis and/or simulation.

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Thursday Poster Session / 744

Linear optics correction of an asymmetric storage ring lattice

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The SSRF storage ring has been upgraded to an asymmetric lattice containing two super-bend cells, two double-mini-βy optics (DMB) cells and a superconducting wiggler (SCW) in 2019. Due to the destruction in structural symmetry, the restoration of linear optics becomes an essential issue in commissioning and routine beam dynamics maintenance. During the initial commissioning, the linear optics were well corrected with the LOCO method even though the SCW had not yet been installed. Recently, it has been found that the setups of some quadrupole power supplies tend to exceed the limits and deviate significantly from the intrinsic theoretical values, and the beta-functions and the tunes cannot be commendably recovered, leading to degradation of the storage ring performance. In this paper, the linear optics correction of the SSRF storage ring is introduced, the difficulties of the linear optics correction in asymmetric lattice are investigated, and the improved correction method and related application results are introduced.

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Tuesday Poster Session / 745

Force-neutral adjustable phase undulator

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A Force-Neutral Adjustable Phase Undulator (FNAPU) has been constructed at the Advanced Photon Source. The FNAPU is a 2.4-meter-long planar hybrid permanent magnet undulator with a 27-mm period length and a fixed gap of 8.5 mm. It consists of two magnetic assemblies with matching periods: one featuring an undulator magnetic structure and the other a simpler magnet structure to compensate the force of the undulator. The magnetic field measurement results of the undulator will be presented.

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Thursday Poster Session / 746

Power ramp up and minimization of beam losses at the facility for Rare Isotope Beams

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The Facility for Rare Isotopes Beams started operation nearly two years ago and ramped up beam power by a factor of 10 from 1 kW to 10 kW. The main contributions to the beam losses are due to the beam halo generated in the ion source and low energy beam transport, the effect of the stripper, and multiple charge state acceleration. The linac tuning procedure includes setting both RF cavity fields, phases, and beam optical devices based on pre-calculated values followed by Courant-Snyder parameters matching based on profile measurements in several linac sections. The simultaneous acceleration of multiple charge states of heavy ion beams is routinely used to minimize the beam power deposition on the charge selector slits after the stripper and provide higher power on the target for the heaviest ions with limited intensity from the ion source. Recently, we added acceleration of dual charge state beams, which is a significant challenge due to the absence of the central charge state but highly desirable for light ions (Z<50) to reduce controlled beam losses on the charge selector. The optics at the Beam Delivery System are optimized to simultaneously focus all charge states into the required phase space on the target. The transverse and longitudinal envelop mapping is applied for each charge state to confirm low-loss linac tuning. The uncontrolled beam losses for any ion species from neon to platinum at the entire linac are well below 1e-4.

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THBD: Beam Dynamics and Electromagnetic Fields (Contributed) / 747

Preparation for experimental demonstration of arbitrary correlation generation

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A method using transverse wigglers has been proposed for imparting arbitrary correlation on the transverse phase space. This concept employs transverse wigglers to introduce cosine-like modulations on the phase space. Similar to the approximation of periodic function by Fourier series, the series of properly designed cosine modulations approximates arbitrary correlations. Currently, preparation is underway for the experimental demonstration of the concept. The planned demonstration includes three simple examples: profile shaping, linearization, and saw-tooth correlation. We present the status of the experimental preparation.

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North America

Monday Poster Session / 748

Imparting arbitrary correlation on longitudinal phase space using transverse wigglers and deflecting cavities

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Imparting designed nonlinear correlation on the longitudinal phase space is nontrivial task. While RF cavities operating at different frequencies can generate arbitrary correlation in principle, it is hard to realize such system due to the lack of RF power sources and their costs. We present a new method that may overcome such practical limitation by adopting transverse wigglers and transverse deflecting cavities. Deflecting cavities introduce and eliminate linear correlation between longitudinal and transverse coordinates. We located transverse wigglers, which impart arbitrary correlation on the transverse phase space, where the longitudinal-to-transverse correlation is maximized. In principle, this system only requires deflecting cavities operating in the same frequency and several magnets such as transverse wigglers and quadrupoles.

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North America

Monday Poster Session / 749

Microbunching instability test for emittance exchange-based photoinjector

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Previous start-to-end simulations of an emittance exchange (EEX)-based photoinjector have demonstrated highly attractive beam properties. The EEX-based photoinjector can provide another interesting opportunity that potentially eliminate the microbunching instability issue. The space-charge and/or CSR-induced amplification occurs during density-to-energy and energy-to-density modulation conversion process. This amplification becomes particularly pronounced when multiple compressors are implemented. In contrast, the proposed EEX-based photoinjector doesn't require additional compression process. Moreover, the initial longitudinal phase space becomes the transverse phase space, resulting in a significant reduction of space-charge and CSR's longitudinal interaction. We present preliminary simulation results of microbunching instability in EEX-based photoinjector.

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North America

Monday Poster Session / 750

Start-to-end simulation of high-gradient, high-transformer ratio structure wakefield acceleration with TDC-based shaping

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In collinear wakefield acceleration, two figures of merits, gradient and transformer ratio, play pivotal roles. A high-gradient acceleration requires a high-charge beam. However, shaping current profile of such high-charge beam is challenging, due to the degradation by CSR. Recently proposed method, utilizing transverse deflecting cavities (TDC) for shaping, has shown promising simulation results for accurate shaping of high-charge beams. This is attributed to its dispersion-less feature. We plan to experimentally demonstrate high-gradient (>100 MV/m) and high-transformer ratio (>5) collinear structure wakefield acceleration. The experiment is planned at Argonne Wakefield Accelerator Facility. We present results from start-to-end simulations for the experiment.

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North America

Tuesday Poster Session / 752

A new design of the S-band acceleration unit

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The performance of a photoinjector relies on the brightness preservation. For acceleration structures used for emittance compensation, it will lead to a smaller additional emittance growth with fewer nonlinearities. To compensate for the possible asymmetry on both sides of the installation, an S-band acceleration structure with a novel coupler was designed. The beam test results show a significant improvement in the higher-order fields for the beam of the photoinjector.

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Asia

Thursday Poster Session / 755

New insertion devices for BRIGHT beamlines at the Australian Synchrotron

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In 2016 the Australian Synchrotron embarked on the BRIGHT program to build four new insertion device beamlines: Biological Small Angle X-ray Scattering (BioSAX), High Performance Macromolecular Crystallography, Advanced Diffraction and Scattering and Nanoprobe beamlines. To maximize the flux for these very demanding beamlines, cryogenic and short period devices have been selected. In particular a 1.6 m long 16 mm period superconducting undulator, a 3 m long 18 mm period cryogenic undulator (CPMU), 3 m long 17 mm in-vacuum undulator and a 2 m long 48 mm period superconducting wiggler. This report will discuss some of the design considerations and overall parameters of the new insertion devices.

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Monday Poster Session / 756

RPI LINAC refurbishment control system engineering plan

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The RPI LINAC refurbishment control system engineering plan outlines Cosylab's and RPI's approach to initiating and managing the control system architecture for an accelerator refurbishment project at RPI. One of the goals was to achieve a low total cost of ownership, which encompasses the direct price, the cost of maintenance, the upgrade potential, and the quality and cost of support services. To create the technical part RPI provided valuable knowledge and experience from running the RPI LINAC and Cosylab used prior experience and industry best practices to deliver high-level project documentation, which includes the control system architecture, strategies for device integration, and clearly defined scope descriptions. The documentation also covers specific content, such as detailed subsystem descriptions, device interface descriptions, subsystem operation descriptions and recommended implementation methods for specific device types. Several technical solutions, lead time comparisons, and the quality of support services were thoroughly evaluated. In terms of project management, a concrete upgrade plan was developed. A standard project management process was proposed. The work was divided into independent work packages, and included a recommended sequence within the project. The outcome of the study is a comprehensive document, which provides all the necessary information required to initiate the control software portion of the project.

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Europe

Thursday Poster Session / 757

Particle radiation in multilayer waveguides taking into account the frequency dependence of the electromagnetic parameters of the layers.

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The features of particle radiation in two-layer and three-layer cylindrical waveguides are studied in the presence of a frequency dependence of conductivity in metal layers and dielectric and magnetic permeability in dielectric layers. A comparison is made with the results obtained at constant values of the electromagnetic parameters of the layers.

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Asia

Thursday Poster Session / 759

Stability monitoring of TPS booster ring power supply units

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The TPS is a latest generation of high brightness synchrotron light source and scheduled to be commissioning in 2014. Its booster is designed to ramp electron beams from 150 MeV to 3 GeV in 3 Hz. Within this, there are 54 power supply units for the dipole magnets and 84 for the quadrupole magnets. During routine user beam time, a top-up injection occurs every 4 minutes, where the stability of numerous power supply units within the booster becomes pivotal for the seamless execution of injections. This paper discusses how fluctuations in the booster power output waveform impact injections and elucidates the monitoring programs developed to address these variations.

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Asia

Thursday Poster Session / 760

Commissioning of the digital LLRF system at the KEK Photon Factory 2.5 GeV ring

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In 2023, the KEK-PF 2.5 GeV ring LLRF system was replaced from a conventional analog to an FPGA-based digital system. The hardware and software of our digital LLRF system were developed by customizing the LLRF technologies established at the SPring-8 and J-PARC. In our system, we adopted the non-IQ direct sampling method for RF detection. We set the sampling frequency at 8/13 (307.75 MHz) of the RF frequency, where the denominator (13) is the divisor of the harmonic number (312) of the storage ring. This allows us to detect the transient variation of the cavity voltage that is synchronized with the beam revolution. To compensate this voltage variation, we plan to implement a feedforward technique. These functions will be useful to improve the bunch lengthening performance in a double RF system for KEK future synchrotron light source. The new digital LLRF system has been already installed and used for the user operation. At the nominal beam current of 450 mA, the variation of the cavity voltage amplitude and phase were within ±0.06% and ±0.06°, respectively. In this presentation, we introduce the details of our new system and report on the commissioning results.

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Wednesday Poster Session / 761

Numerical investigation of beam loss scenarios and top-up safety for Elettra 2.0

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Elettra 2.0 is the 4th generation synchrotron light source that is going to replace Elettra, the 3rd generation light source operating since 30 years in Trieste Italy, giving light to the users in 2026. In this paper we present simulation results of the beam losses. Two different way of beam losses are studied namely beam decay, which mainly concentrates on the losses due to Touschek scattering and losses due to equipment such as RF and magnets failures. Based on this study the preliminary location of the scrapers has been defined. In addition the possibility for the injected beam to enter a front-end of a beam-line is investigated since this study is important for the top-up permission according to the radio-protection rules in Italy.

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Thursday Poster Session / 762

A new approach to solving the problem of an extended helical undulator.

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An exact solution for the radiation field of a particle in a helical undulator, valid for an arbitrary point in space and an arbitrary particle energy, was obtained by the partial domain method, generalized for the case of spiral motion of a particle. The interface between the regions is a cylindrical surface containing the spiral trajectory of the particle. A comparison is made with the existing solution, which is valid in the far zone at high particle energies.

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Thursday Poster Session / 763

Energy selection of synchrotron booster for SLRI beam test facility

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The SLRI Beam Test Facility (SLRI-BTF) is able to produce electron test beam with maximum energy of 1.2 GeV and various intensities from a few to millions of electrons per repetition. The main components of the SLRI-BTF are the Siam Photon Source (SPS) injector consisting of a 40-MeV linear accelerator, a low-energy transport beamline, a synchrotron booster increasing electron energy to 1.2 GeV, and a high-energy transport beamline. As the SLRI-BTF has successfully utilized the electron test beam to characterize pixel sensors for high-energy particle detectors and to perform high-energy electron irradiation, the test beam with lower energy ranges has also been requested by users. In

this work, the test beam with lower energy can be obtained by changing the acceleration pattern of the SPS booster and adjusting high-energy transport beamline to match the extracted beam energy. Production of test beam with lower energy can be confirmed by test beam measurement at the SLRI-BTF experimental station.

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Wednesday Poster Session / 764

Data processing for profile monitor of HEPS linac

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Profile Monitor (PR) is used to observe and measure the beam profile in the Linac and transport line of the High Energy Phone Source (HEPS). To obtain more precise results, we implemented several widely used fitting algorithms in the framework Pyapas. We carried out detailed testing and comparison of these fitting methods based on simulated results and actual measurement data, respectively, and found the most suitable method under different beam conditions. These methods have been used in various applications for HEPS commissioning, including emittance measurement, energy and energy spread measurement, and RF phase scan. This paper provides an introduction to these algorithms. Subsequently, taking the emittance measurement application as an example, the results of error analyses are presented.

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Monday Poster Session / 765

Study on high energy coupling efficiency of laser-electron interaction via vortex beam

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Manipulation electron beam phase space technology by laser-electron interaction has been widely used in accelerator-based light sources. The energy of the electron beam can be modulated effectively under resonant conditions by using an intense external laser beam incident into the undulator together with the electron beam. It is of great significance to improve the modulation efficiency for seeded free electron laser (FEL) and other devices. In this paper, we propose a new scheme to improve the efficiency of laser-electron interaction by using the interaction of vortex beam and electron beam in a helical undulator. Three-dimensional time-dependent simulation results show that the modulation repetition rate of laser-electron interaction by vortex beam can be improved by one order of magnitude compared with the Gaussian beam at the same input power.

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Asia

Tuesday Poster Session / 766

Advancements in the development of beam dynamics software for CEPC

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The design and study of the Circular Electron Positron Collider (CEPC) present a significant challenge, requiring the proper modeling of various physical phenomena such as the crab-waist collision scheme with a large Piwinski angle, strong nonlinear effects, energy sawtooth, beam-beam interactions, and machine impedances. In response to this challenge, the APES software project was proposed in 2021 and received support from the IHEP Innovative Fund in 2022. This paper provides an overview of the progress made in the APES project, encompassing modeling for special cases, orbital and spin tracking with synchrotron radiation, optics and emittance calculation, particle tracking, and more. Additionally, the paper discusses future developments.

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Asia

Wednesday Poster Session / 767

Digital processing of electron beam images for glass plate irradiation: analysis of electron beam profiles and absorbed dose distribution

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In recent years, materials irradiation processing experiments have gained significant attention due to their critical role in science and various industries, including life science, material science and electronics. Efficient and accurate dose distribution determination is essential to optimize the irradiation process. This research explores the integration of glass plate irradiation and electron beam image digital processing to enhance the characterization of electron beam profiles and absorbed dose in materials irradiation experiments. The proposed method aims to overcome challenges associated with conventional irradiation techniques, such as lack of real-time feedback and inadequate spatial resolution. The integration of glass plate irradiation and advanced digital processing techniques offers the potential for high-resolution dose distribution mapping, ensuring precise and controlled irradiation for enhanced materials processing.

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Wednesday Poster Session / 768

AIRIX reconfiguration for the synchronization of the two EPURE LINACs and control of the high current functioning point by reducing the consequences of BBU instabilities

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In 2023, a significant reconfiguration has been undertaken on the first radiographic axis AIRIX to assure its synchronization with the second LINAC of EPURE facility. On AIRIX, the high current functioning point in progress since 2016 (2.6 kA / 19.2 MeV) has been maintained. A number of experimental tests has been performed to further understand the BBU beam instability phenomenon, mainly in the final acceleration and drift space of the machine. Some studies have been conducted to find the origin of this phenomenon and to improve our electronic performances. After calculating differing beam initial conditions at the cathode, variations of constraints on the electron beam have been applied to learn about the consequences of these transport strategies on the envelop beam stability. Finally, by keeping our historical transport global trend and by locally adjusting magnetic fields just downstream the injector module, we noted a significant decrease of instabilities from the middle of accelerator up to the X-ray conversion target. A more robust configuration seems to be reached. It will be tested again on AIRIX at the beginning of 2024 to confirm our works, and then on our second accelerator hoping to reduce time dedicated to EPURE LINACs preparation.

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Wednesday Poster Session / 770

Towards Elettra 2.0 –R&I preparation activities

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The "Dark Period"(DP), that is the final shutdown for the Elettra Storage Ring (SR) with its ancillary equipment and most of its beamlines, is scheduled to start on July 2nd, 2025. During the DP we will remove the complete SR lattice structure with annexed cabling, piping, and supports; the Service Area, where most of the equipment to operate the SR is installed, will be completely renovated; the majority of the photon beamlines will be removed, moved, updated or "brand-new"installed, causing the reconfiguration of a large part of the outer wall of the SR tunnel.
Several activities are running in order to reduce the Removal and Installation (R&I) workload –already quite significant –during the DP. These activities are mostly related to the beamlines in the Experimental Hall and some shielding wall reconfiguration.
The paper summarizes the most relevant activities done in preparation to the DP, with focus also on the logistics aspects related to the installation of a new machine while removing the old one (Elettra) being very closed to another operating one (FERMI).

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Europe

Tuesday Poster Session / 771

Instability issue of rapid cycling synchrotron of CSNS-II

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The Rapid Cycling Synchrotron (RCS) at the China Spallation Neutron Source phase II (CSNS-II) is a high intensity proton accelerator, which accumulates a 300 MeV proton beam and accelerates it to 1.6 GeV with a repetition rate of 25 Hz. The CSNS-II is designed to have a beam power of 500 kW. A circulated beam intensity current in the RCS is 15 A, making it the highest of its kind in the world. The beam power may be limited by the impedance and its beam effects Using impedance model, the beam instabilities in the RCS are systematically estimated, and the threshold and growth time of conventional instability are determined. Furthermore, a mitigation scheme for addressing key instabilities is proposed to achieve the desired design beam power.

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Thursday Poster Session / 772

The LOEWE-3 RFQ project

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After the first two CHs as well as the two QWR rebunchers were successfully conditioned at the IAP Frankfurt, the following CH cavities are also to be conditioned in Frankfurt, whereby both the number of cavities to be tested and the planned time frame pose enormous challenges. In this paper, the concept of the conditioning setup in the experimental hall of the IAP Frankfurt as well as the planned time frame will be presented.

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Wednesday Poster Session / 774

Simulation studies for the confinement of antiprotons for the AEgIS experiment classification: beam dynamics

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The AEgIS (Antimatter Experiment on Gravity, Interferometry and Spectroscopy) project, based at CERN's Antiproton Decelerator (AD) facility, has undergone significant enhancements, capitalizing on the increased quantity of colder antiprotons made available by the new Extra Low Energy Antiproton Ring (ELENA) decelerator. These improvements aim to create a horizontal beam and enable a direct investigation into the impact of gravity on antihydrogen atoms. This exploration seeks to probe the Weak Equivalence Principle for antimatter.
In AEgIS a series of circular ring electrodes and an axial magnetic field of 1T are utilized for the trapping of antiprotons. This contribution describes the design and optimization of the electrodes to generate a parabolic potential well to effectively trap the antiprotons. The behavior of the trapped antiprotons is reproduced by simulating a spherical source under different bias voltage settings applied to the electrodes. The general layout of the AEgIS trap is shown, alongside suitable electrode configurations, and results from electrostatic particle-in-cell code simulations carried out to optimize the confinement time of the antiprotons.

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Thursday Poster Session / 775

Beam-cavity interaction in the CERN PS 80 MHz RF systems

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The 40 MHz and 80 MHz Radio Frequency (RF) systems in the CERN Proton Synchrotron (PS) are required to perform non-adiabatic bunch shortening before beam ejection. This manipulation allows to fit the bunches into the short RF buckets of the 200 MHz Super Proton Synchrotron (SPS). Although the impedance of the cavities is strongly reduced by feedback, the detailed understanding of the beam-cavity interaction is essential to evaluate their impact on the beam. This contribution focuses on the impedance characterization of the 80 MHz RF systems to describe how the RF amplification chain behaves as a function of beam current changes. Complementary measurement techniques, both beam and RF-based, were adopted. The results of the different measurements show good agreement. The aim is to study and predict possible beam quality degradation at beam intensities required by the High Luminosity LHC (HL-LHC), as well as to propose future consolidation to the high-frequency RF systems in the PS.

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Thursday Poster Session / 776

Assessment of the ratios of radiation sources and total electron loss at the injection section of the Taiwan Photon Source facility and total electron loss by using neutron measurements

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Radiation in the injection section of a synchrotron radiation facility is primarily the result of injection beam loss, which occurs each time the current is replenished, and storage beam loss, which accounts for the lifetime during routine operations. This study conducted neutron measurements by using high-sensitivity neutron detectors and obtained the total electron loss during the unfolding process. With the known lifetime, the ratio of injection beam loss to storage beam loss and the total loss in the injection section of the Taiwan Photon Source facility during routine operations were determined. The total electron loss at the measurement site was approximately five millionths of the full load current. The ratio of injection beam loss to storage beam loss was 1.64. The total electron loss was 0.44 pC, with 0.27 pC being attributed to injection beam loss and 0.17 pC being attributed to storage beam loss.

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Asia

Monday Poster Session / **777**

Cooling demonstrator target and pion capture study

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The muon collider has great potential to facilitate multi-TeV lepton-antilepton collisions. Reaching a suitably high luminosity requires low-emittance high-intensity muon beams. Ionization cooling is the technique proposed to reduce the emittance of muon beams. The Muon Ionization Cooling Experiment (MICE) has demonstrated transverse emittance reduction through ionization cooling by passing the beams with relatively large emittance through a single absorber, without acceleration. The international Muon Collider Collaboration aims to demonstrate 6-D ionization cooling at low emittance using beam acceleration. Two siting options are currently considered for a Cooling Demonstrator facility at CERN, with proton-driven pion production facilitated by the Proton Synchrotron or the Super Proton Synchrotron. In this work, we use FLUKA-based Monte Carlo simulations to optimize the number of pions produced in the proton-target interactions and subsequently captured by a magnetic horn or solenoid-based system. We explore the feasibility of different target and capture system designs for 14, 26 and 100 GeV proton beam energies.

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Tuesday Poster Session / **778**

Secondary beam line efficiency studies at the CERN PS East Area

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The East Area at the Proton Synchrotron has undergone extensive renovations, marking a significant milestone in its more than 55-year history as one of CERN's enduring facilities for experiments, beam tests, and irradiation. This facility, which serves over 20 user teams for about 200 days annually, now boasts an enhanced infrastructure to cater to future beam test and physics requirements. It also features new beam optics that ensure a better transmission and purity of the secondary beams, with the addition of pure electron, hadron, and muon beams. With this contribution, we present the ongoing performance studies underway following the implementation of the East Area secondary beamlines in the BDSIM (Beam Delivery Simulation) Monte Carlo simulation software. Using BDSIM, the impact on the transmission, purity, and overall efficiency of the secondary beams is assessed to the measured performance, paving the way for possible additional modifications and/or further upgrades.

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Thursday Poster Session / 779

Magnetic field study for air-cored HTS skeleton cyclotron

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Skeleton cyclotron is a compact size air-cored cyclotron with a high temperature superconducting (HTS) coil system. HTS coils'high critical current density and high heat stability allow magnetic

field induction without using any iron core. With this advantage, the magnetic field configuration can be adjusted quickly without consideration for the hysteresis from iron. The purpose of skeleton cyclotron is to change the beam type quickly between proton, deuteron and alpha particle for the needs of various RI production. In order to achieve this goal, the coil system has to be designed with superconductors'properties taken into account, such as critical current density under strong external magnetic field etc. In this work, the coil system and magnetic field designed for the skeleton cyclotron will be presented. The capability of accelerating various beam type will also be discussed.

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Asia

Wednesday Poster Session / 782

A design for very short superconducting quadrupoles

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Powered optics magnets which could be stacked in a very dense alternating pattern could enable a higher density of focusing in beamlines, with potential use for e.g. muon beams or high-current hadron beams at low energy. Here, we investigate such a design of quadrupole, where the yoke is energised by straight conductors running parallel to the beam, and does not require conductor to pass within the gap between yokes of adjacent magnets of opposite polarity. Suitable shaping and design of the steel yokes allows alternating focusing and defocusing quadrupoles, of arbitrary thickness, to be positioned with only the spacing required for constraining fringe fields. We investigate multiple thicknesses/sizes, and the use of thin field clamps to further reduce the required spacing between quadrupoles.

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Wednesday Poster Session / 783

Effects of delta ray electrons on the measurement uncertainties of multi-wire beam profile monitoring system

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Multi-wire beam profile monitoring (MWPM) system is foreseen upstream of the spallation target to make in situ calibration of beam current density configuration on the target along with beam imaging from luminescent coating on the beam entrance window at the Second Target Station (STS) of the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory (ORNL). This beam interception-based beam diagnostics system on the target will be used to ensure that the maximum beam loads on the target is within the design range during neutron production. Current design of the MWPM consists of three layers of measurement wires each of which is sandwiched between voltage biasing wire planes. The signal obtained from each measurement wire layer is disturbed by secondary electrons (SE) and delta rays produced by beam-matter interactions in neighboring wires and ionization of residual gases in accelerator vacuum. While the backgrounds from SE can be suppressed by voltage biasing, the delta-ray electrons with kinetic energies above keV ranges overcome the electric potential bias. In this paper, we study the effects of delta-rays on the measurement uncertainties of MWPM using the particle transport simulation code FLUKA. Furthermore, the cases where MWPM is installed in the proximity of a large delta ray sources such as proton beam window or in the core vessel filled with sub-atmospheric helium have been studied.

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North America

Wednesday Poster Session / 784

Update in the optics design of monochromatization interaction region for direct Higgs s-channel production at FCC-ee

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The FCC-ee could allow the measurement of the electron Yukawa coupling via direct Higgs s-channel production at ˜125 GeV center-of-mass energy, provided that the center-of-mass energy spread of this channel, can be reduced to about 5–10 MeV to be comparable to the width of the standard model Higgs boson. The natural collision-energy spread at 125 GeV, due to synchrotron radiation, is about 50 MeV. Its reduction to the desired level can be accomplished by means of monochromatization, e.g., through introducing non-zero dispersion of opposite sign at the Interaction Point (IP), for the two colliding beams. This nonzero dispersion in the IP (horizontal or vertical) could be generated by different methods, requiring or not modifications of the Final Focus System (FFS) Local Chromaticity (LOC) dipole system. In this paper we report and compare the different recent Interaction Region (IR) optics design of this new possible collision mode.

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Tuesday Poster Session / 786

ATF2-3 harwdware upgrade and new experimental results to maximize the luminosity potential of linear colliders

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The ATF2-3 beamline is the only facility in the world for testing the Final Focus Beamline of linear colliders and is essential for the ILC and the CLIC projects. A vertical electron beam size of 41 nm (within 10% of the target), a closed-loop intra-bunch feedback of latency 133 ns, and direct stabilization of the beam position at the Interaction Point to 41 nm (limited by IP BPM resolution) have all been achieved at ATF2. These results fulfilled the two main ATF2 design goals, but were obtained with reduced aberration optics and a bunch population of approximately 10% of the nominal value of 10ˆ10 electrons. Recent studies indicate that the beam degradation with the beam intensity is due to the effects of wakefields. To overcome this intensity limitation, hardware upgrades including new vacuum chambers, magnets, IP-Beam Size Monitor laser, cavity BPMs, wakefield mitigation station, as well as a comprehensive R&D program to maximize the luminosity potential are being pursued in the framework of the ILC Technology Network. This new R&D program focuses on the study of wakefield mitigation techniques, correction of higher-order aberrations, tuning strategies, including AI techniques, as well as beam instrumentation issues, such as the BPMs, advanced Cherenkov Diffractive Radiation monitors, and fast feedback systems, among others. This paper summarizes the hardware upgrades, the R&D program and the results of the Fall 2023-Winter 2024 experimental campaign performed in ATF2-3.

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Europe

Monday Poster Session / 788

Advancing electron injection dynamics and mitigation approaches in the Electron-Ion Collider's swap-out injection scheme

Author: Derong Xu[1]

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The Electron-Ion Collider (EIC) will use swap-out injection scheme for the Electron Storage Ring (ESR) to overcome limitations in polarization lifetime. However, the pursuit of highest luminosity with the required 28 nC electron bunches encounters stability challenges in the Rapid Cycling Synchrotron (RCS). Consequently, multiple RCS bunches will be accumulated in the ESR.
A pivotal aspect lies in optimizing the injected and stored bunch separation for efficient injection. However, maximizing this separation introduces intricate challenges, notably electron emittance blowup and proton emittance growth because of beam-beam interaction. This delicate balance between injection facilitation and mitigating electron emittance blowup is further constrained within a small dynamic aperture.
This paper conducts simulation studies investigating proton emittance growth and electron emittance blowup in transverse and longitudinal injection schemes. Mitigation strategies are explored, including: (1) Employing a secondary kicker to manipulate beam separation at the injection point by offsetting the stored beam negatively and the injected beam positively; (2) Exploring electron working point optimization, etc.
These findings promise enhanced EIC stability and performance, shaping potential future operational improvements.

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North America

Monday Poster Session / 789

Assessing global crabbing scheme feasibility for Electron-Ion Collider

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The Electron-Ion Collider (EIC) plans to utilize the local crabbing crossing scheme. This paper explores the feasibility of adopting a single crab cavity with adjusted voltage, inspired by the successful global crabbing scheme in KEKB, to restore effective head-on collisions. Using weak-strong simulations, the study assesses the potential of this global crabbing scheme for the EIC while emphasizing the need for adiabatic cavity ramping to prevent luminosity loss. Additionally, the research outlines potential risks associated with beam dynamics in implementing this scheme.

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Monday Poster Session / 794

ZDC effective cross section for Run 16 gold-gold collisions in RHIC

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The 2016 RHIC Au-Au run took place from February 8 to June 27, 2016. Four so-called vernier scans were performed at 100 GeV per beam, with γ=107.396 at flattop at one of the interaction points, IP6. During this type of procedure, one beam is swept across the other, first horizontally and then vertically, recording the interaction rate as a function of the beam to beam distance. From that data, the effective cross section of the ZDC can be derived. This note discusses the results as well as the systematic uncertainties of the effective cross section.

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North America

Tuesday Poster Session / 795

Shower simulations for the CERN proton synchrotron internal dump and possible shielding options

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During the Long Shutdown 2, the two internal dumps were replaced and successfully integrated into the CERN Proton Synchrotron operation to withstand the intense and bright beams for the High-Luminosity LHC. They function as safety devices, designed to swiftly intersect the beam's trajectory and effectively stop the beam over multiple turns. A significant challenge arises from their limited energy absorption capacity. Previous studies indicate that at the maximum PS beam energy of 26 GeV, only about 7% of the energy is absorbed by the dumps upon their insertion. This study, employing a combination of the FLUKA and SixTrack simulation code chain, evaluates the absorbed dose in downstream elements in view of the projected increase of beam intensities, according to the LHC injector upgrade parameters, and explores the feasibility and potential benefits of implementing shielding as a mitigation measure.

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Europe

Tuesday Poster Session / 796

Energy deposition in the new SPS scrapers

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The successful injection of proton beams into the Large Hadron Collider (LHC) depends on an efficient scraping mechanism in the Super Proton Synchrotron (SPS). The beams accelerated in the SPS contain a significant non-Gaussian tail population. If not removed, this transverse tail population can cause high losses in the transfer lines and in the LHC injection elements. Subsequently, the Beam Loss Monitor (BLM) system may trigger a beam dump reducing the machine availability. As beam intensities increase to meet the parameters set by the LHC Injector Upgrade (LIU), the efficiency of the scraping operation becomes increasingly crucial.
To fully cope with higher beam intensities in the framework of the High-Luminosity LHC (HL-LHC) project, an upgrade of the scraper system, consisting of two movable graphite blades, is being developed and scheduled for installation in January 2025. This article presents the results of a comprehensive simulation study that employs the FLUKA code coupled with SixTrack to assess energy deposition in the scrapers.

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Monday Poster Session / 797

Design and construction of the photocathode vacuum suitcase for CARIE test facility

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This poster will discuss the design of the photocathode vacuum suitcase that we currently design and construct for the Cathodes And Radiofrequency Interactions in Extremes (CARIE) test stand. The CARIE test stand is built to test behavior of the high quantum efficiency photocathodes at strong fields. The semiconductor photocathodes must be grown and delivered to the photoinjector under ultra-high-vacuum (UHV) conditions in order to maintain their properties. This is typically done using portable UHV vacuum systems called vacuum suitcases. We will discuss the vacuum and photocathode handling design of the CARIE vacuum suitcase and the status of the suitcase construction and testing.

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Thursday Poster Session / 798

Comparative study of decay heat calculations with FLUKA and MCNP

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In designing a high-power solid spallation target, decay heat driven temperature rise in the spallation volume is a safety concern during maintenance and in loss of coolant accidents. As tungsten above 800℃ hydrates and becomes volatile in steam, it is important to keep the target temperature below this threshold when active cooling is unavailable. Decay heat in a target is calculated with particle transport simulation codes combined with transmutation codes. The calculated decay heat usually differs depending on the nuclear cross sections and the decay particle transport models built in the code architecture. In this paper, we present the results of a decay heat calculation benchmark study using two popular particle transport codes, FLUKA and MCNP6 Version 6.2.0, coupled with the built-in transmutation solver within FLUKA and CINDER2008 paired with MCNP6. The effect of decay particle transport options on calculated decay heat values is included. The calculation is based on a simple water-cooled solid tungsten target model with water premoderators, liquid hydrogen cold moderators and beryllium reflectors. Heavy stainless-steel shielding is modeled around this target-moderator-reflector system. The tungsten volume is clad with a thin layer of erosion/corrosion resistant material. This study also informs uncertainty estimation in decay heat values in high-power spallation targets used in hazard analysis.

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Thursday Poster Session / 799

Diffusion bonding of zircaloy-vanadium and vanadium-tungsten using vacuum hot pressing for the development of a low decay heat cladding solution for solid tungsten spallation targets

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Tantalum has been used as cladding material for water-cooled solid tungsten targets at many leading spallation neutron production facilities thanks to its high neutron yield, manageable radiation damage behavior, and excellent corrosion/erosion resistance in radiation environments. However, thermal neutron capture of tantalum in spallation environment causes a high specific decay heat in the target volume, which often becomes a limiting factor in increasing the beam power on the target from a safety hazard perspective. In this paper, we have developed vacuum hot processing (VHP) parameters to diffusion bond zircaloy to tungsten to explore the feasibility of using zircaloy as an alternative cladding material to tantalum. Zircaloy has long been used as cladding material for non-tungsten solid targets, and nuclear fuel rods. It causes significantly lower decay heat with shorter decay time in the target compared to tantalum in spallation environments. The hot isostatic pressing (HIP) of zirconium and tungsten is known to produce limited bonding quality due to the formation of brittle ZrW2 intermetallic layer. To overcome this problem, placing vanadium interlayer between tungsten and zircaloy has been proposed. The zircaloy-vanadium and vanadium-tungsten under the same VHP conditions, 850℃ at 120 MPa for 4 hours showed good diffusion bonding qualities, which demonstrates the feasibility of a single step HIP process to make the zircaloy clad tungsten spallation volume.

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Thursday Poster Session / 800

Proton beam power limits for stationary water-cooled tungsten target with different cladding material options

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The proton beam power limit on a spallation target is largely determined by beam induced thermo-mechanical structural loads and decay heat generation within the target, and its lifetime is limited by radiation damage and fatigue behavior of the spallation materials. In this paper, we present the power limits for a stationary water-cooled solid tungsten target concept with different tungsten cladding material options that include tantalum, zircaloy or stainless steel. These cladding materials have proven operations records in spallation target and nuclear fission environments, supported by materials data gathered from post irradiation examinations. Particle transport simulations code FLUKA was used to calculate energy deposition and decay heat in the target, based on beam parameters technically feasible at the Second Target Station of the Spallation Neutron Source at Oak Ridge National Laboratory. The energy deposition data were used for coupled flow, thermal, and structural analyses of the target to determine its beam intensity limit. The decay heat data were used to calculate the transient temperature evolution in the tungsten volume in a loss of coolant accident scenario to determine its beam power limit. The beam power limit on the target was determined by the maximum surface temperature of tungsten, which is limited by 800℃ due to risk of safety hazards caused by volatilization of tungsten oxides in steam environment above this threshold temperature.

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Tuesday Poster Session / 801

A power amplifier based on rad-hard gallium nitride FETs for the 10 MHz cavities of the CERN proton synchrotron

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The upcoming High-Luminosity Large Hadron Collider (HL-LHC) program requires a beam performance in the CERN Proton Synchrotron (PS) that is at the limits of the current RF systems. Following the discontinuation of the RF tube production of the driver amplifiers a new solid-state design has been developed using radiation-hard amplifier technology. In view that the current system architecture has reached its maximum achievable gain, the goal was to reduce the cavity impedance encountered by high-intensity circulating beams. This reduction is achieved by increasing the fast feedback gain around the 10 MHz cavities. A 400W modular driver amplifier based on GaN technology and its control system have been prototyped and are currently in the testing phase. The FETs have been qualified for radiation in J-PARC and they will undergo additional irradiation time in the PS tunnel at CERN to additionally qualify the amplifier in its entirety. The paper outlines the modeling phase, the challenges encountered during prototyping, and the achieved results.

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Tuesday Poster Session / 802

Further investigations into the impact of insertion devices on the Diamond-II lattice

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As part of the Diamond-II upgrade project*, the Diamond storage ring will be replaced with a new modified hybrid 6 bend achromat (M-H6BA) lattice, in which each existing arc sections will be split in two to provide additional mid-straights and thereby increase the ring capacity. The majority of insertion devices currently in operation will be either retained or upgraded, and the new mid-straights allow the total number of ID beamlines to be increased from 28 to 36. Therefore, it is important to investigate how the IDs will affect the equilibrium emittance and energy spread, along with their impact on the linear and nonlinear beam dynamics. Methods to compensate for their effects have been established, including a re-optimization of the octupole settings and identification of alternative working points. A kickmap approach has been used to model all IDs, including the APPLE-II IDs and APPLE-II-Knot with active shim wires. In this paper, the outcome of these investigations will be presented and discussed.

Footnotes:

- R.P. Walker, et al., Diamond-II Technical Design Report, Aug. 2022, https://www.diamond.ac.uk/Diamond-II.html

Funding Agency:

Diamond Light Source Ltd, Harwell Science and Innovation Campus, Didcot, OX11 0DE, Oxfordshire, United Kingdom

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Europe

Thursday Poster Session / 803

Monte Carlo estimation of emittance growth during injection into the LANSCE PSR

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The Los Alamos Neutron Science Center (LANSCE) accelerator uses charge exchange injection to accumulate a high-intensity proton beam in the Proton Storage Ring (PSR). H- ions are accelerated to 800 MeV and then stripped of their electrons when they pass through a thin foil at the ring injection site. Various parameters, such as foil thickness, density and chemical composition, effect the performance of stripper foils, and foils are engineered to maximize charge exchange efficiency and foil lifetime while minimizing beam loss and emittance growth during injection. A model of the stripper foil has been created using a Monte Carlo radiation transport code as part of the conceptual design for a PSR upgrade. The model will be used to optimize the foil and estimate parameters of the ion beam after injection. Preliminary results for the emittance growth of the injected beam are presented for a range of foil parameters.

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North America

Monday Poster Session / 804

Beam commissioning of the EIC with detector

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The high-luminosity, 10e+33 —10e+34 cm-2s-1 (e-p), Electron-Ion Collider is presently being developed at Brookhaven National Laboratory in partnership with the Jefferson Laboratory. Beam commissioning is planned right after the installation is complete and after passing all necessary reviews, including the Accelerator Readiness Reviews. Initially, the detector performance testing and commissioning, conducted without a beam utilizing cosmic radiation, will occur in the assembly hall area of IP-6. Subsequently, after demonstrating beam collisions at low electron and proton beam intensities and fine-tuning the lattice and beam parameters, the detector will be integrated into the collider for beam commissioning. Our focus encompasses commissioning sequences, optimization of collimators in response to background conditions, and machine parameter adjustments to achieve optimal luminosity and polarization, all aimed at optimizing the detector's performance in response to the beam.

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North America

Tuesday Poster Session / 805

Deeper phase-space distribution analysis to enhance beam loss control

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As beam intensity and power continue to increase, and installations become larger, it becomes increasingly important to reduce and control losses and costs. This can be achieved by controlling the beam transmission through the measurement of phase-space distributions, including the emittance growth down to the smallest details. This requires the detection of very low intensities of the halo and the rejection of signal from background noise. In this paper, we present a review of existing techniques for image processing and analysis (semantic aspect) applied to data cleaning, contour recognition, and emittance figure reconstruction, as well as promising AI techniques.

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Thursday Poster Session / 806

EIC impedance and beam dynamics

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A new high-luminosity Electron-Ion Collider (EIC) is being developed at BNL. Beam collisions occur at IP-6, involving two rings: the Electron Storage Ring (ESR) and the Hadron Storage Ring (HSR). The vacuum system of both rings is newly developed and impedance optimization is progressing. Beam-induced heating and thermal analysis are performed for both rings to manage and control thermal distribution. The study explores collective effects across the Rapid Cycling Synchrotron (RCS), ESR, and HSR using simulated single bunch wakefields. Discussions encompass impedance analysis, collective effects and beam interactions, and the impact of ion and electron clouds on beam dynamics.

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Wednesday Poster Session / 807

A new beam-based method to calibrate the relative gains of the beam position monitor pick-up electrodes at the Cornell Electron Storage Ring

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The Cornell Electron Storage Ring (CESR) beam position monitors (BPM) consists of four button-shaped pick-up electrodes, each individually instrumented with readout electronics that allow acquisition of turn-by-turn data. The beam position is reconstructed using the measured signal amplitude from the four electrodes. Systematic effects such as physical differences between the electrodes (displacement, tilt) and gain differences between the readout electronics bias the measured amplitudes, thus the measured beam position. A novel beam-based method to measure the relative gains has been developed and validated using Monte Carlo simulations, and has been successfully deployed at CESR. It relies on solving a system of equations for different beam positions and simultaneously for the relative gains, knowing the response map of the pick-up electrodes as a function of beam position. The typical implementation uses 9 beam positions at one BPM with horizontal and vertical spatial separation greater than 500 microns. The main limitation of the method is time; it takes about 15 minutes to collect data for a single/few BPMs, making it impractical to calibrate all the 100 BPMs. We are planning on using a transverse resonance island buckets (TRIBs) lattice demonstrated at CESR to allow collecting 9 beam positions at all BPMs at once in a matter of minutes. This paper will present the new method, its use, and how its performance compares to the previous technique developed in 2010.

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Tuesday Poster Session / 809

Radiation to electronics studies for CERN gamma factory-proof of principle experiment in SPS

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The Physics Beyond Colliders is a CERN exploratory study aimed to fully exploit the scientific potential of its accelerator complex. In this initiative, the Gamma Factory experiment aims to produce in the Large Hadron Collider (GF@LHC) high-intensity photon beams in the energy domain up to 400 MeV. The production scheme is based on the collisions of a laser with ultra-relativistic atomic beam of Partially Stripped Ions (PSI) circulating in a storage ring. The collision results in a resonant excitation of the atoms, followed by the spontaneous emission of high-energy photons. A Proof of Principle (PoP) experiment is being planned to study the GF scheme generating X-rays, in the range of keV, from lithium-like lead PSI stored at the CERN Super Proton Synchrotron (SPS). GF-PoP has undergone a series of exhaustive radiation effect studies in view of Radiation to Electronics (R2E) risks. With the use of FLUKA Monte Carlo code, the radiation environment in the laser room and its premises has been estimated during proton and PSI runs. Recorded data from beam instruments has been used to appropriately scale the computed results and to verify the compliance with general R2E limits.

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Thursday Poster Session / 810

Current status of MINIBEE –minibeam beamline for preclinical experiments on spatial fractionation in the FLASH regime

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In vivo studies support that the combination of protons and spatial fractionation, the so-called proton minibeam radiotherapy (pMBT), enhances the protection of normal tissue for a given tumor dose. A preclinical pMBT facility for small animal irradiation at the 68 MeV cyclotron of Helmholtz-Zentrum Berlin (HZB) will improve the understanding of this method. A two-step energy-degrading system will first define the maximum energy of the beam and further degrading will occur before the target forming a spread-out Bragg peak (SOBP), if necessary. Beam size and divergence will be adjusted by slit systems before a 90-degree magnet bending the beam into the experimental room. At the current stage, a magnetic quadrupole triplet placed close to the target demagnifies the beam by a factor of ˜5. The goal is to generate a magnetically focused minibeam of 50 micrometer sigma. Scanning magnets will enable a raster-scan application in the tumor. Conventional dose rate delivery will be allowed while FLASH applications can be achieved with the possible use of a ridge filter. The results of beamline simulations by TRACE-3D and BDSIM will be presented.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Europe

Thursday Poster Session / 811

Impact of passive harmonic cavities on resistive wall-driven instability in the ILSF storage ring

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In low-emittance machines, where the resistive wall is the primary impedance contributor, passive higher harmonic cavities are frequently employed to extend bunch lengths and enhance Touschek lifetimes. This study explores single-bunch and multi-bunch instabilities in the MBTRACK2 and ELEGANT tracking codes by tuning harmonic cavities to a near-flat potential condition. We investigate the threshold current at various chromaticities in the presence of a passive higher harmonic cavity for the specific machine parameters of the ILSF light source.

Footnotes:

Funding Agency:

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MOCD: Accelerator Technology and Sustainability (Contributed) / 813

LCLS-II-HE cavity acceptance testing progress

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LCLS-II-HE is an ongoing project to upgrade SLAC's superconducting linac. The upgrade will add 23 cryomodules with a total of 192 nine-cell 1.3 GHz nitrogen-doped niobium cavities. The production and qualification testing of these cavities is nearly complete. To date, they have achieved an average maximum gradient of 27.0±3.5 MV/m and an average Q0 of 3.24±0.38e+10 at the nominal operating gradient (21 MV/m). Here we present an update of the performance statistics and an outlook on the final stages of cavity qualification. We also report on issues and lessons learned during the industrial production process.

Footnotes:

Funding Agency:

Paper preparation format:

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North America

Tuesday Poster Session / 814

High temperature superconducting RF cavity

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High Q cavities are an essential component for RF pulse compression. We are interested in developing compact superconducting cavities that operate at high temperature (liquid nitrogen, 80 K). We are designing an RF cavity at 11.424 GHz operating in the TM011 mode using eight facets with flat inner faces. These flat faces will be covered with High Temperature Superconductor (HTS) tapes. The cavity fill time (one exponential step) must be 1 microsecond. That sets loaded Q at 143,558. The external Q was selected to provide this loaded Q given the high ohmic Q. Cavity beta is 39.6. The cavity is fed by a TE10 to TM01 mode converter. Wall current is completely axial, so wall current does not cross the gaps between HTS tapes. Cavity tuning is accomplished by changing the separation between cavity facets using wedges.

Footnotes:

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North America

Wednesday Poster Session / 815

APS storage ring waveguide layout study for solid state amplifier upgrade

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Co-authors: Aditya Goel [1]; Ali Nassiri [1]; Douglas Horan [1]; Geoff Waldschmidt [1]; Gianfranco Trento [1]; Joseph Schultz [1]; Kamlesh Suthar [1]

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Currently, radiofrequency (RF) power to the Argonne Advanced Photon Source (APS) storage ring and Booster cavities is provided by several klystrons. APS is in the process of replacing the storage ring klystrons with clusters of 160 kW solid state amplifier (SSA) gradually. It is required to keep most of the existing equipment racks, klystrons and cable trays for smooth operation and transition until the SSA upgrade commissioning. The replaced klystrons may be kept for future RF power backup to the sectors waiting for SSA upgrade. The following post challenges to the waveguide installation: confined space of the waveguide lines removal and installation, finding space for additional new equipment racks, SSA racks, power combiners, AC power distribution, water cooling systems and new cable trays. The goal of this study is to generate a new waveguide layout design with enough space clearance for installation, operation, repairing of SSA plus AC distribution, water

cooling system and all safety requirements. This work presents the study of waveguide lines layout modification for storage ring cavities and the result of this study will be a guideline of waveguide construction for APS storage ring SSA upgrade as well as the installation of the system. A discussion of waveguide combiner vs. coax combiner is also presented.

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North America

Tuesday Poster Session / 816

Rotor-based multileaf collimator for beam shaping

Author: Nathan Majernik[1]

Co-authors: Darrell Doran [2]; Eric Wisniewski [3]; Gerard Andonian [4]; James Rosenzweig [4]; John Power [2]; Walter Lynn [4]

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Multileaf collimators (MLC) are versatile tools for beam shaping, both transversely or, when used in conjunction with an emittance exchange (EEX) beamline, longitudinally. The requirement for ultra-high vacuum compatibility introduces significant constraints on the design of a MLC. Here, we present a novel design for a MLC based on stacks of rotors with angularly dependent radii. The use of tabs and slots allow dozens of these rotors to be positioned using a single vacuum feedthrough, dramatically reducing complexity over independently positioned leaves. We discuss other design elements and also the considerations arising from having a volumetric rather than planar beam mask.

Footnotes:

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North America

Monday Poster Session / 817

The Reconfiggler: a uniquely versatile wiggler

Author: Nathan Majernik[1]

Co-authors: Darrell Doran [2]; Eric Wisniewski [3]; Gerard Andonian [4]; Gwanghui Ha [5]; James Rosenzweig [4]; John Power [2]; Wanming Liu [2]

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Wigglers are periodic arrays of magnets with myriad applications in accelerator physics. Generally though, they are only tunable by adjusting the gap between jaws. Here, we present a wiggler based on diametrically magnetized cylindrical magnets with independently adjustable angle. This allows the realization of arbitrary (bandwidth constrained) magnetic configurations. We illustrate its application to the recently proposed "transverse wiggler"concept for transverse phase space control.

Footnotes:

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North America

Wednesday Poster Session / 818

Resolution enhancement of double-differential spectrometer images

Author: Nathan Majernik[1]

Co-authors: Auralee Edelen [1]; Brendan O'Shea [1]; Claudio Emma [1]; Douglas Storey [1]; Mark Hogan [1]; Ryan Roussel [1]

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By pairing the effects of a transverse deflecting cavity and dipole magnet, a beam's longitudinal phase space (LPS) can be imaged on a screen. However, the emittance of the beam, chromatic focusing, and other effects are convolved into the resulting screen image, functionally blurring it, reducing the fidelity of the LPS measurement. Here, we explore the use of both conventional, space-variant deconvolution as well as machine-learning approaches to better resolve the LPS.

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North America

Monday Poster Session / 819

Simulating dielectric wakefield acceleration of positrons from a solid target converter

Author: Nathan Majernik[1]

Co-authors: Brendan O'Shea [1]; Gerard Andonian [2]; James Rosenzweig [2]; Mark Hogan [1]; Spencer Gessner [1]

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Positrons and electrons can be generated by impinging a relativistic electron beam onto a solid converter, sometimes referred to as a non-neutral fireball beam. Depending on the scenario, a substantial fraction of the incoming driver bunch may still have sufficient quality to drive high gradient (˜GV/m) accelerating wakefields in a dielectric structure. Here we consider the design of a dielectric loaded waveguide, positron converter, and electron driver bunch structure to realize capture and GV/m dielectric wakefield acceleration of positrons at SLAC FACET-II.

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North America

Monday Poster Session / 820

Particle motion in spatio-spectrally iso-diffracting ultrabroadband pulsed beams

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An analytical form is derived using the Faddeeva function to represent terahertz-frequency pulses generated by optical rectification of ultrashort laser pulses. Spectra of these pulses can be described by a Gaussian fall-off at high frequencies and a power-law as DC is approached. A set of pulsed beams based on this form is also derived for the special case of propagation-invariant spatio-temporal coupling (iso-diffracting). Motion of charged particles in these pulsed beams is considered analytically and numerically and energy gain is computed and compared with ponderomotive force laws. Particle motion in more complex pulsed-beam fields is also considered.

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North America

Thursday Poster Session / 821

Parallel quadrupole modulation for fast beam-based determination of magnet centers

Author: Xiaobiao Huang[1]

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A method to simultaneously determine the magnetic centers of multiple magnets with beam-based measurements is proposed. Similar to the quadrupole modulation system (QMS) method that is widely used for beam-based alignment measurement, the strengths of the group of selected magnets are modulated. The orbit shifts induced by the modulation are used to deduce the kicks applied at the magnet locations with the help of orbit response matrix calculated with the lattice model. By varying the beam orbit at the magnets, with a pair of corrector of magnets or local orbit bumps, and repeating the modulation measurement at each orbit, the magnet centers can be determined through fitting the calculated kicks versus the beam orbit. Demonstration of the method on a storage ring is presented. The method can also been applied to nonlinear magnets.

Footnotes:

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North America

Monday Poster Session / 822

Beam-based alignment simulations for FCC-ee

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Corresponding Author: xiahuang@slac.stanford.edu

Beam-based alignment (BBA) studies are done for the FCC-ee baseline lattice, using two parallel BBA methods. The results will be presented.

Footnotes:

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North America

Monday Poster Session / 823

Generation of sawtooth correlation for bunching factor enhancement

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Co-author: Nathan Majernik [2]

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[2] *SLAC National Accelerator Laboratory*

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Bunch trains have been considered as a promising means of generating intense, coherent radiation in compact accelerator facilities. However, conventional methods, which impart a sinusoidal modulation on the beam's longitudinal phase space, are inefficient for generating a high bunching factor density modulation. Only a small fraction of a sinusoidal modulation, which has linearity, primarily forms density spikes while other particles under nonlinear correlation have limited contribution to these spikes. One way to improve such bunching efficiency is imparting a saw-tooth correlation, which has piecewise-linearities. This correlation maximizes the peaks of density spikes as more than 90% of particles will contribute to the spikes. While such correlation can be generated by a series of transverse wigglers, a single transverse wiggler with shaped poles to introduce higher harmonics can generate saw-tooth or saw-tooth-like correlations. We present a recent study on this new approach, employing a shaped-pole transverse wiggler.

Footnotes:

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Wednesday Poster Session / 825

A laser-heated thermionic cathode

Author: Heather Andrews[1]

Co-authors: Anna Alexander [1]; Darrel Beckman [1]; Angus Guider [1]; Michael Holloway [2]; John Lewellen [1]; Juan Moreno [1]; Gabriel Santana [1]

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[2] *University of Maryland*

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There is increasing interest in developing accelerator technologies for space missions, particularly for fundamental science. In order to meet these mission needs, key accelerator technologies must be redesigned to be able to function more reliably and efficiently in a remote and harsh environment. In this work we focus on a modest electron injector system, specifically the traditional thermionic cathode. Typically such cathodes are resistively heated by a power supply that is floated at the cathode accelerating negative high voltage. This can increase engineering complexity and add a significant load to the accelerating voltage supply. We pursue laser heating a thermionic cathode in order to remove the heater power supply from the injector system, allowing for reduced engineering complexity and power requirements for the injector. To date we have shown that a simple tantalum disk cathode can be heated by a laser with similar emission performance to the same disk resistively heated.

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North America

Thursday Poster Session / 826

Correction of nonlinear lattice with closed orbit modulation

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We propose to correct nonlinear lattice optics with the closed-orbit modulation technique. Closed orbit modulation with large amplitude samples the nonlinear optics. Fitting such data measured on the machine to the lattice model with appropriate lattice variables can reveal the nonlinear errors and provide means for correction. We demonstrate the technique in both simulation and experiments.

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North America

Tuesday Poster Session / 827

Design of an 805 MHz cavity with thin beryllium windows and distributed coupling for muon ionization cooling

Author: Tianhuan Luo[1]

Co-author: Dillon Merenich [2]

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[2] *Northern Illinois University*

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For the future multi-TeV muon collider, ionization cooling is a critical step to achieve the required beam emittance for a proton-driven muon beam. Ionization cooling of intense muon beams requires the operation of high-gradient, normal-conducting RF structures in the presence of strong magnetic fields. The MAP modular cavity study at Fermilab has demonstrated the RF breakdown threshold at 13 MV/m for copper surface and 50 MV/m for beryllium surface in a 3 T solenoid B field. Based on these surface E field limits, we design a new 805 MHz copper cavity with thin curved beryllium windows that can achieve a gradient (without the transit time factor) of ˜27 MV/m, which is comparable to the current 6D cooling lattice design. We also explore the distributed coupling for feeding the RF power to multiple cavities in the cooling lattice to accommodate the tight space in the superconducting solenoids. This cavity design study can be applied to the muon collider demonstrator program to experimentally evaluate the 6D muon emittance cooling.

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North America

Wednesday Poster Session / 828

Electromagnetic bench testing of ALS-U BPM buttons and assemblies

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Co-authors: Angel Jurado [1]; Changchun Sun [1]; Dan Wang [1]; Paul Centeno [1]; Stefano De Santis [1]

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Corresponding Author: tluo@lbl.gov

The ALS Upgrade Project (ALS-U) consists in the replacement of the existing ALS storage ring and the addition of a new accumulator ring in order to decrease the horizontal beam emittance to about 70 pm·rad, resulting in an increase of two orders of magnitude in the soft X-Ray brightness. The vacuum chambers of two new rings, and of the transfer lines connecting them, will include 327 new beam position monitors (BPM). The design of these BPM is now largely completed and relies on the procurement of about 1,500 BPM buttons (including spares and prototypes) from commercial suppliers and their installation on the BPM chamber enclosures. Our design includes more than a dozen different BPM designs and almost as many different buttons. All the buttons, as well as the assembled BPM, have to undergo vacuum and RF testing to characterize them and detect defective units before their installation. In this paper, we describe our electromagnetic testing plan and report on the results covering the entire button production for the accumulator ring and the prototypes for the storage ring, as well as the electromagnetic measurement for the assembled ALS-U Accumulator Ring (AR) BPMs.

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North America

Monday Poster Session / 829

Fabrication and testing of mode couplers for a 180 GHz colinear wakefield accelerator

Author: Branko Popovic[1]

Co-authors: Alexander Siy [2]; Alexander Zholents [1]; Ali Nassiri [1]; Emil Trakhtenberg [1]; Geoff Waldschmidt [1]; Kamlesh Suthar [1]; Karl Kusche [3]; Mikhail Fedurin [3]; Semyon Sorsher [1]; Soonhong Lee [1]; William Li [3]

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[2] *University of Wisconsin-Madison*

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A corrugated waveguide based collinear wakefield accelerator is under development at Argonne National Laboratory. The accelerating mode is operating at 180 GHz with a high average power level up to 600 W compounding at the end of the 0.5 m long accelerator module. It is extracted by a dedicated coupler to prevent excessive heating of the corrugated structure of the next accelerator module downstream. Also, it is necessary to monitor beam offsets from the center of the corrugated structure. It is done by utilizing the offset beam's induced wakefield dipole mode at 190 GHz and extracting it to diagnostic electronics via the second dedicated coupler. Both are contained in the transition section between the accelerator modules*. This paper presents the mechanical design, fabrication, and performance testing of the transition section. Testing included mmWave measurements at ANL and electron beam measurements at Brookhaven National Lab's Accelerator Test Facility. Both tests involved characterizations of the wakefield modes and coupler's performances.

Footnotes:

- A. Siy, N. Behdad, J. Booske, G. Waldschmidt, and A. Zholents, "Electromagnetic design of the transition section between modules of a wakefield accelerator", Phys. Rev. Accel. Beams 26, 012802(2023), https://journals.aps.org/prab/pdf/10.1103/PhysRevAccelBeams.26.012802

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North America

Thursday Poster Session / 830

Design and instrumentation for permanent magnet samples exposed to a radiation environment

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Co-authors: Bamunuvita Gamage [1]; Kirsten Deitrick [1]; Ryan Bodenstein [1]

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This work is part of a larger program to study the effects of radiation on permanent magnets in an accelerator environment. In order to be sure that the permanent magnet samples are accurately placed, measured, and catalogued we have developed a system of sample racks, holders and measuring apparatuses. We have combined these holders and measurement racks with electronics to allow a single computer to catalogue the position and intensity of the magnet measurements. We outline the design of the apparatus, the collection software, and the methodology we will use to collect the data.

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North America

Thursday Poster Session / 831

Simple estimate, detailed computer simulation and measurement of the transverse kick in the SLAC accelerating structure

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Co-authors: Aliaksei Halavanau [1]; Franz-Josef Decker [1]

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We discuss the result of calculation and measurement of the transverse kick in the SLAC accelerating section in a single bunch and multi-bunch regimes. We present a simple estimate, which can be used in practical situations.

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North America

Tuesday Poster Session / 833

Various methods for computing dominant spin-orbit resonance strengths in storage rings

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Co-author: Georg Hoffstaetter [1]

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The strength of a first-order spin-orbit resonance is defined as the amplitude of the corresponding Fourier component of the spin precession vector. However, obtaining this Fourier spectrum is often infeasible in practice. If a resonance is sufficiently strong, then to a good approximation, one can neglect all other depolarizing effects when near the resonance. Such an approximation leads to the single resonance model (SRM), for which many aspects of spin motion are analytically solvable. In this paper, we calculate the strength of first-order resonances using various formulae derived from the SRM, utilizing spin tracking data, the direction of the invariant spin field, and amplitude-dependent spin tune jumps.

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North America

Thursday Poster Session / 834

AGS Booster model calibration and digital-twin development

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Co-authors: Bohong Huang [2]; David Sagan [1]; Georg Hoffstaetter [1]; Kevin Brown [3]; Kiel Hock [3]; Natalie Isenberg [3]; Nathan Urban [3]; Vincent Schoefer [3]; Yinan Wang [4]

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An accurate physics simulation model is key to accelerator operation because all beam control and optimization algorithms require good understanding of the accelerator and its elements. For the AGS Booster, major discrepancy between the real physical system and online simulation model mainly comes from magnet misalignments, which also lead to beam degradation and prevent the beam from reaching the desired specifications (e.g., polarization). In this work, we propose a Bayesian optimal experimental design (BOED)-based approach for identifying the magnet misalignments using a Bmad model of the AGS Booster. This approach can find magnet control variables (i.e., currents) which are expected to lead to beam position data that most reduces uncertainty in the magnet misalignment parameters. The misalignment values can then be used to calibrate the physical model of the Booster, leading to a more accurate simulation model for future polarization optimizations, and to the development of a fully functional digital-twin.

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North America

Tuesday Poster Session / 835

Path to high current 500 mA at NSLS-II

Author: Guimei Wang[1]

Co-authors: Danny Padrazo Jr [1]; James Rose [1]; Robert Todd [1]; Timur Shaftan [1]; Toshiya Tanabe [1]; Victor Smaluk [1]

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NSLS-II is a 3 GeV third generation synchrotron light source at BNL. The storage ring was commissioned in 2014 and began its routine operations in the December of the same year. Since then, we have progressed steadily upwards in beam current and reached 500 mA in five years while continue to install and commission new insertion devices. Along this path, we met various challenges. In this paper, we report our experience and the improvements to reach high current.

Footnotes:

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North America

Tuesday Poster Session / 836

Complex bend prototype beamline commissioning result

Author: Guimei Wang[1]

Co-authors: Jinhyuk Choi [1]; Minghao Song [1]; Timur Shaftan [1]; Xi Yang [1]; Yoshiteru Hidaka [1]

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Corresponding Author: gwang@bnl.gov

Modern synchrotron light sources are competing intensively to increase X-ray brightness and, eventually, approach the diffraction limit, which sets the final goal of lattice emittance. Recently, we propose a new optics solution aimed at reaching low emittance, using a lattice element "Complex Bend". The Complex Bend is a sequence of dipole poles interleaved with strong alternate focusing so as to maintain the beta-function and dispersion oscillating at low values. By integrating this element at low emittance lattice, the designed emittance is around 30 pm-rad. To prove the feasibility of this new design, we designed and fabricated the key element, prototype complex bend, with gradient at 140 T/m. It was installed in the beam line with 100-200 MeV beam energy at NSLS-II linac beamline and beam commissioned started in Jan. 2023. In this paper, we report the beam commissioning result.

Footnotes:

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North America

Thursday Poster Session / 837

Design of the linear optics of a complex bend lattice

Author: Minghao Song[1]

Co-author: Timur Shaftan [1]

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The demands of a higher brightness photon beam push the electron beam emittance of storage rings towards a diffraction-limited level. The concept of multi-bend achromat (MBA) structure, which contains multiple dipoles in a cell, has been widely employed in the fourth-generation storage ring light sources. Recently, a novel concept of lattice structure, called complex bend lattice, extends the option for low emittance ring lattice design [1,2]. In this paper, the linear optics of a developed complex bend lattice is presented [3]. It demonstrates the benefits of using complex bends, including ultra-low emittance, long straight sections for IDs, more drift space for accelerator equipment, and reduction of power consumption for magnets.

Footnotes:

[1] G. Wang, T. Shaftan, et al. PHYS. REV. ACCEL. BEAMS 21, 100703 (2018)
[2] G. Wang, T. Shaftan, et al. PHYS. REV. ACCEL. BEAMS 22, 110703 (2019)
[3] M. Song and T. Shaftan, Design study of a low emittance complex bend achromat lattice (2023), arXiv:2310.20010v2 [physics.acc-ph].

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LaTeX

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North America

Monday Poster Session / 838

Design of prototype magnet for FETS-FFA

Author: Ta-Jen Kuo[1]

Co-authors: Alan Letchford [2]; Chris Rogers [2]; David Kelliher [2]; Iker Rodriguez [2]; Jaroslaw Pasternak [2]; Jean-Baptiste Lagrange [2]; Jonathan Speed [2]; Shinji Machida [2]; Stephen Brooks [3]

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Capable of achieving a high repetition rate with strong focusing, Fixed Field Alternating gradient (FFA) accelerators have the potential to be used for pulsed high intensity operations. With no pulsed high intensity FFA ever built so far, a prototype machine called FETS-FFA has been proposed to study the FFA option for the next generation spallation neutron source (ISIS-II). One of the essential components of this machine will be the main magnets which must satisfy the following conditions: zero chromaticity during acceleration, flexibility in operating tune point to test dynamics for high beam intensity and a large dynamic aperture to avoid uncontrolled loss. The chosen lattice design utilizes

spiral magnets to provide edge focusing to focus in the vertical direction while also introducing a reverse bending magnet to better control the vertical tune. A three-dimensional study is being carried out in OPERA 3D software to investigate the parameters of the magnets to achieve the required field. The details on the design will be presented in this paper.

Footnotes:

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Europe

Thursday Poster Session / 840

Test of parallel beam-based alignment at NSLS-II

Author: Minghao Song[1]

Co-authors: Xi Yang [1]; Guimei Wang [1]; Xiaobiao Huang [2]; Yoshiteru Hidaka [1]; Jinhyuk Choi [1]

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Misalignment of magnets in the storage rings causes trajectory deviation when the beam traverses through magnets, resulting in the degraded performance of linear optics and nonlinear dynamics. The beam-based alignment (BBA) technique is commonly used to steer the beam passing through the centers of magnets. Recently, a new method has been developed to determine the centers of multiple quadrupole magnets simultaneously [1]. In this paper, the test of this fast BBA method at NSLS-II is presented and compared with the traditional BBA method.

Footnotes:

[1] Xiaobiao Huang, 'Simultaneous beam-based alignment measurement for multiple magnets by correcting induced orbit shift', PHYS. REV. ACCEL. BEAMS 25, 052802 (2022).

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North America

Tuesday Poster Session / 841

Characterization of meter-scale Bessel beams for plasma formation in a plasma wakefield accelerator

Author: Travis Nichols[1]

Co-authors: Michael Litos [2]; Robert Ariniello [2]; Robert Holtzapple [1]; Spencer Gessner [3]; Valentina Lee [2]

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A large challenge with plasma wakefield acceleration (PWFA) lies in creation of a uniform-density plasma with profile and length that properly match the electron beam. Using a laser-ionized plasma source provides control in creating an appropriate plasma density ramp. Additionally, using a laser ionized plasma instead of ionization from the electron beam, allows for the accelerator to run at a higher repetition rate. At the Facility for Advanced Accelerator Experimental Tests (FACET-II), located at SLAC National Accelerator Laboratory, we ionize hydrogen gas with a 10 TW ultrashort laser pulse that passes through an axicon lens, imparting a conical phase on the pulse that produces a focal spot with an intensity distribution described by a two-dimensional Bessel function. This presentation will provide an overview of the diagnostic tests used to characterize and optimize the focal spot along the meter-long focus. In particular, we observe how wavefront aberrations in the laser pulse impact the plasma formation. Furthermore, I will discuss measurements of the nonlinear plasma defocusing effect that broadens the laser focus within the plasma.

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Tuesday Poster Session / 842

Single bunch tracking on the ten-pass ER@CEBAF energy recovery beamline

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The proposed ten-pass energy recovery linac (ERL) demonstration (five accelerating, five decelerating) at the CEBAF accelerator, ER@CEBAF, involves a multi-GeV energy range of a continuous electron beam. New CEBAF transverse optics were designed for this ERL demonstration. This redesign incorporates additional components in Arc A, including a path length chicane and new quadrupoles to ensure proper dispersion localization. The additional five energy recovery passes with a shared arc transport scheme posed challenge in the overall beamline optics design, including large beta functions in the CEBAF spreaders and recombiners. In this paper, we discuss results of bunch tracking performed using the elegant tracking code for this full ER@CEBAF beamline.

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Tuesday Poster Session / 844

Bayesian optimization scheme for the design of a nanofibrous high power target

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High Power Targetry (HPT) R&D is critical in the context of increasing beam intensity and energy for next generation accelerators. Many target concepts and novel materials are being developed and tested for their ability to withstand extreme beam environments; the HPT R&D Group at Fermilab is developing an electrospun nanofiber material for this purpose.
The performance of these nanofiber targets is sensitive to their construction parameters, such as the packing density of the fibers. Lowering the density improves the survival of the target, but reduces the secondary particle yield. Optimizing the lifetime, production efficiency, and length of the target poses an interesting design problem, and in this paper we study the applicability of Bayesian optimization to its solution.
We first describe our architecture for the simulation of the in-beam operations of a nanofiber target with prescribed construction parameters, which requires a heat transfer model specialized for nanofibrous media. We then explain the optimization loop setup. Thereafter, we present the optimal design parameters suggested by the algorithm, and close with discussions of limitations and future refinements.

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Thursday Poster Session / 845

Progress on pulsed electron beams for radiation effects characterization of electronics

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Ultrafast high-energy pulsed electron beams can provide deep penetration and variable linear energy transfers by controlling the characteristics of the electron bunch, both of which currently oversubscribed heavy ion facilities cannot provide. Early experiments at the UCLA PEGASUS beamline (~3 MeV) with ~1 ps electron bunches and a 50 µm spot size yielded charge collection transients that were not correlated well with standard heavy-ion data. Sub-micron focusing of the beam would allow for the electron bunch to mimic ion tracks by saturating the charge collection in a small cross-sectional area while simultaneously providing high spatial resolution to allow for the targeted testing of microelectronic components. Using a 10 µm collimator and strong lens, current experiments are planned at UCLA to characterize standard photodiodes with smaller spot sizes to achieve stronger correlations with the heavy-ion data.

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Tuesday Poster Session / 846

Multiphysics simulation of thermal shock testing of nanofibrous high power targets

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Limitations on primary beam power for neutrino beamlines originate from the reduced survival of targets at higher intensities. The field of High Power Targetry (HPT) is generating new target concepts to meet this need. One idea being investigated by the HPT Research and Development Group at Fermilab is that of an electrospun nanofiber target.
As part of their evaluation, samples with different fiber packing densities were prepared and sent

to the HiRADMat facility at CERN for thermal shock tests. The samples with the higher density were destroyed whereas those with the lower density were completely intact. The exact cause of this failure was unclear at the time. In this paper, we present the results of multiphysics simulations of the thermal shock experienced by the nanofiber targets that suggest the failure originates from the reduced permeability of the high density sample to airflow. The air present in the porous target expands due to heating from the beam, but is unable to flow freely in the high density sample, resulting in a larger back pressure that blows apart the mat. We close with a discussion on how to further validate this hypothesis.

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Monday Poster Session / 847

The hadron storage ring lattice of the Electron-Ion Collider

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The hadron storage ring (HSR) of the Electron-Ion Collider (EIC) is a modification of the RHIC for acceleration and collision of protons and ions. The 6 straights in RHIC will be modified, and the 6 arcs will be left in place. There are four geometric configurations, switching one arc depending upon the energy of the hadrons or ions, and with two different configurations for one straight, where ultimately there will be a second detector, but initially the detector will be absent. For a given configuration, there are multiple sets of magnet strengths different ion species and different states (collision modes, injection, transition, pre-squeeze, etc.). We will describe important characteristics of the configurations and states we have studied. We explain the functions of the individual straights and describe recent modifications to their designs. We discuss the choice for the integer part of the tunes and the process by which the tune is set. We will also indicate how limitations on existing power supplies in RHIC constrain the design.

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Thursday Poster Session / 848

Alternative gamma-ray source based on 2.2 MeV linear accelerator with field emission cathode

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High energy gamma-ray generators have the potential to be used in place of radioisotope sources, thus eliminating the security risk posed by radioisotopic sources. Euclid Techlabs design of non-radioisotopic gamma-ray source is based on ultra-compact linear accelerator with affordable magnetron RF power feeding. Wide aperture 15 cell X-band linac with embedded field emission cathode operates without expensive high voltage electron gun and bulky magnetic focusing system. 2.2 MeV output electron energy and 1 μA average accelerated beam current on composite target can provide gamma-ray spectrum similar to 2nd category Cs-137 radioisotope source.

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Thursday Poster Session / 849

Importance of quadrupole magnet fringing fields in low energy beam transport: example in the LIPAc 5 MeV D+ beamline

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The hard-edge model for a quad field distribution is widely assumed in particle simulations at the early design phase of beam transport lines or circular accelerator rings to quickly evaluate their beam optics. However, the model assuming a rectangular field distribution even with an effective length is not an appropriate approximation for low-energy beams (<50 MeV). This approximation is known not to necessarily lead to the correct beam optics. The evaluated beam size based on this hard-edge model has tended to be different from measured ones and simulation results employing the exact field distribution fully implementing fringing fields. We try to study the magnetic field gradients of single quads installed in the Linear IFMIF Prototype Accelerator beamline. We define a characteristic magnetic field gradient gc [T/m] of the quad, which is determined only by the distance relations for the target quad, steerer, and BPM. Simulation results, where the hard-edge and file-map models are assumed, are compared with those measured using a 5 MeV deuteron beam. The details of the comparison of the results and the effect of the fringe fields on the beam optics are discussed in this paper.

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Tuesday Poster Session / 850

Waveguide system for SRF cryomodule in KEK

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A superconducting radio frequency (SRF) cryomodule (CM) for the International Linear Collider (ILC) Technology Network (ITN) is being developed at KEK. In the scope of this, a waveguide system is being designed. Its main features are a low center of gravity, a reduced number of corners and waveguide elements, and a compact bellow for connecting it to the input power coupler. Furthermore, the waveguide layout was designed to stay within the CM. This will avoid interference between components in the case of a multi-CM assembly. It is planned to adapt both the waveguide system and the installation process for the ITN.
Analytical calculations and simulations have shown that most of the reflected power is dissipated in the load of the variable hybrid on removing the circulator. Thus, in the initial layout of the waveguide, the circulator is strategically installed to allow a future replacement with an H-corner integrated with a directional coupler, without disrupting the other waveguide components. Furthermore, a low-power test on a similar waveguide system showed that analytical calculations and simulation matched the measured values well.

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Wednesday Poster Session / 851

Optimizing the magnetic circuit of HTSU through REBCO tape selection

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The National Synchrotron Radiation Research Center (NSRRC) has conducted a study on the magnetic circuit design of a high-temperature superconducting undulator (HTSU). This study explores the potential use of second-generation high-temperature superconducting (2G-HTS) materials in undulator magnet, which offer advantages such as higher current density and operating temperature. To evaluate the feasibility of HTSU design, a preliminary magnetic circuit analysis has been conducted. The simulation of the HTSU involved the use of several commercial 2G-HTS tapes with different widths. Insulating and non-insulating HTS tapes were compared to evaluate their effects on current density and magnetic field. Additionally, the maximum field strength on the surface of the tape was determined to establish the optimal operating temperature and current density for the HTSU. These simulation results provide valuable insights for optimizing the design and performance of the HTSU, ultimately contributing to advancements in particle accelerator technologies.

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Wednesday Poster Session / 852

Nonlinear dynamic optimization for HLS

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Hefei Light Source (HLS) is a dedicated synchrotron light source with an electron beam energy of 800 MeV. Due to the limited circumference of 66.13 m, the current lattice adopts Double-Bend Achromat (DBA) with 4 super periods. The natural emittance is 38 nm·rad . To improve the light source performance, we reselect the work point, based on the new work point, we optimize the beam nonlinear dynamic, including dynamic
aperture(DA),momentum aperutre(MA), which strongly connect beam lifetime and injection efficiency.The optimization only changes the strength of quadrupoles and sextupoles, while remaining the same drift length and magnet length, after the optimization, we have produced lattice with larger dynamic aperture and momentum aperture for new working point with positive chromaticities. The detail optimization is reported in this paper.

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Thursday Poster Session / 853

The preliminary design and fabrication of LLRF system in proton CT

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A new proton CT(pCT) facility will be built in Shanghai Ruijin Hospital. The main structure of the proton CT includes a high gradient proton LINAC, a compact 360-degree gantry, and a proton imaging platform. In the proton LINAC, a 16 S-band proton accelerating tube increased the energy from 230 MeV to 350 MeV. To provide a more accurate and stable Radio-Frequency(RF) control, a CPCI-based Level Radio- Frequency(LLRF) control system was developed. In this paper, we introduce the LLRF control system both in firmware and software, which contains the front frequency conversion board with vector modulation RF output, the acquisition and digital processing board with 10 Channels 125 MSPS ADC, the clock and Local-Oscillator(LO) generator board, the RF distributions, and the feedback control.

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Tuesday Poster Session / 854

Design of side-coupled proton accelerating structure

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In the paper, we simulate and calculate a side-coupled proton accelerating structure with high shunt impedance and Q factor by optimizing the key parameters of the nose cone. The accelerating structure consists of accelerating cell and coupling cell and operates on bi-period mode.

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Thursday Poster Session / 855

Implementation of EPU56 control system at the Taiwan Photon Source

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The elliptically polarized undulator with a period length of 56 mm, called EPU56, is part of the Taiwan Photon Source (TPS) phase-III beamline project. Its control system is built within the EPICS framework using motion controllers and EtherCAT. The control systems of EPU56 include a safety interlock system, which automatically stops movement based on limit switches, torque limit switches,emergency stop button, and readings from the enclosed linear optical encoder. In addition, the control system offers settings for adjusting the correction magnets' power supply and employs optical absolute encoder motors to control the movement of the Gap and Phase. In order to maintain stability during movement, PID control is applied to the motion process by the motion controller. To further enhance precision, the system also employs an integrator limit within the motion controller for additional adjustments. This paper describes the development of the control system and the enhancements made to the insertion device movement process.

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Monday Poster Session / 856

Start-to-end simulation of second hard X-ray beamline at the PAL-XFEL and plans of R&D activities on high-brightness XFEL generation

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A second hard X-ray beamline (HX2) at the PAL-XFEL (Pohang Accelerator Laboratory, X-ray Free Electron Laser) has been proposed to meet the increased demands of XFEL science. A photon energy ranging between 1.5 to 10 keV was determined to cover low photon energy with enhanced FEL pulse energy of about 3.0 mJ, and to cover mostly used range between 8 to 10 keV simultaneously. Accordingly, baseline design of the electron beamline was completed using MAD-X code. Here, to avoid physical overlap of the beamline elements, a dog-leg transport line is installed. In addition to first-order optics design, complete start-to-end simulation is performed to understand the evolution of the 6D electron beam phase space and to optimize the beam parameters such as energy chirp, energy spread, and emittance at the entrance of the undulator. In this study, we will show the start-to-end simulation by using Impact-T for injector section and ELEGANT for the remaining sections from linac modules to the end of the HX2 undulator line. Particularly, we will discuss whether coherent synchrotron radiation effects along the dog-leg section is suppressed so that the beam phase space distortion is minimized. Plus, we will introduce planned R&D activities such as AI/ML-based injector operation (virtual machine) and various studies on the XFEL modes such as multi-bunch operation, enhanced SASE (ESASE), and THz FEL.

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Thursday Poster Session / 858

Evaluation of top-up injection by a single nonlinear kicker in Taiwan Photon Source

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The existing conventional bump-based injection scheme at the Taiwan Photon Source (TPS) causes considerable disruption to the stored beam, which proves to be unacceptable for certain synchrotron radiation beamlines and the future upgraded TPS with a small dynamic aperture. This article focuses on the evaluation of the nonlinear injection scheme, considered as one of the candidates for transparent top-up injection at the TPS, across three distinct phases. During the initial two phases, the configuration of the booster-to-storage-ring transfer line remains unchanged. Consequently, the coexistence of the current bump-based injection and the nonlinear injection methods within the system is maintained, with the former serving as a backup scheme. Notably, in the second phase, a crucial modification involves replacing the existing septum with a movable septum, providing increased flexibility in selecting the location of the kicker. Finally, in the third phase, a new booster-to-storage-ring transfer line is introduced. This redesigned layout situates the injection point near the end of straight section, facilitating the potential installation of at least one insertion device. This strategic placement aims to enhance the availability of radiation sources, catering to the diverse needs of users.

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Thursday Poster Session / 859

Validation of the slice model used in the beam-beam simulation

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The slice model is the theoretical foundation for various beam-beam simulation methods. In the formulation of the slice model, some approximations have been made based on the assumption of particle beams with an extremely high Lorentz factor. However, this assumption might not always be valid for the particle colliders applied in the nuclear physics study because of the usage of heavy-ion beams. It is thus worthwhile to verify the slice model in that parameter region. In this study, we investigate the theoretical formulations of the slice model and a full 3D model. Besides, we perform weak-strong simulations based on these two theoretical models. Results and their implications will be presented.

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Tuesday Poster Session / 860

Design of permanent dipole magnet in transport line for TPS

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Co-authors: Jyh-Chyuan Jan [1]; Yang-Yang Hsu [1]; Hsiung Chen [1]; Chin-Kang Yang [1]; Chih-Wei Chen [1]; Chih-Sheng Yang [1]; Jui-Che Huang [1]

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To reduce the electric power consumption and advance the magnetic stability, a prototype of BTS dipole magnet in TPS transfer line between booster and storage ring came into sight. An 1 m long, high current dipole will be replaced by a permanent magnet with Sm2Co17. The new permanent dipole magnet will decrease total volume compared with original electric one, and the homogeneity of integral field is promoted as well. With simulation, the assembly deviation was also discussed. This article presents the magnet circuit design status of prototype to upgrade the transport line in TPS.

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Thursday Poster Session / 862

Novel clock and trigger solutions with ultra-high precision delay to support time-resolved experiments at TPS

Author: Jin-Kun Liao[1]

Co-authors: Chunyi Wu [1]; Demi Lee [1]; Kuo Hwa Hu [1]; Kuo-Tung Hsu [1]; Yung-Sen Cheng [1]

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The TPS (Taiwan Photon Source) is a third generation 3 GeV synchrotron light source. Some beamlines use synchrotron pulses in conjunction with laser pulses for pump-probe experiments, which is a time-resolved experiment method for capturing the temporal evolution of the pumped process. Periodic X-ray pulses are provided by the synchrotron light source as detecting light (Probe), and laser pulses can be used as a pump to excite a target, which changes a certain property when excited. Pump-probe experiments re-quire a synchronized laser system to alter the delay time between X-ray pulses and laser pulses. It has been built a laser synchronizer and timing support system. One direct digital synthesizer (DDS) with fine delay adjustment can change the laser pump pulse relative to the X-ray pulse. The clock fanout buffer with output dividers provides the synchronized clocks required by the laser oscillator and laser source. An SBC (single-board computer) is employed as a control interface The software architecture is created using the EPICS framework, which is compatible with the TPS control system, and a GUI with the ability to adjust the time delay is created. The efforts will be described in this report.

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Thursday Poster Session / 863

Topology optimization of a dipole magnet using normalized gaussian network

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The precision of the proton therapy beam depends on maintaining high field quality in the magnet' s good field region. Iron yoke is employed in magnets to increase the magnetic field and reduce the fringe field. However, when providing a high magnetic field for transporting relatively high-energy particles, the saturation effect of the yoke can distort the field quality. To mitigate this effect, tuning holes and pole shape optimization are adopted in the iron yoke to adjust the magnetic flux, which helps in maintaining a higher field quality for particles with different energies. Optimizations are often limited by human expertise. In this paper, we use a topology optimization method that employs a non-dominated sorting genetic algorithm for the prototype design of an iron yoke in a dipole magnet. To achieve a smooth distribution of material, we represent the shape of the iron yoke using a normalized Gaussian network. This method effectively mitigates the field error at different energy levels. Shape optimization is performed to compare it with topology optimization. It is suitable for the application of topology optimization in the beam line system for the proton therapy system.

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Thursday Poster Session / 864

Design of cyclotron-based in-vacuum material irradiation beamline at TINT

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A new cyclotron facility has been constructed at Thailand Institute of Nuclear Technology to provide proton beams with energy of 15-30 MeV for radioisotope production and material analysis. Due to requirements of particle induced X-ray emission (PIXE) and particle induced gamma-ray emission (PIGE) techniques that need a low-energy and low-intensity proton beam in range of 2-15 MeV and picoamperes as well as high detection sensitivity, the additional setup including an energy degrader, a collimator, a 30-degree separator magnet, and a slit, is employed for an in-vacuum irradiation beamline. In this work, we study the proton beam trajectory and beamline elements. The energy degrader made of aluminum has shown promising results in decreasing the beam energy while the energy spread of a secondary beam is significantly reduced by the following 30-degree separator magnet. Furthermore, the combination of the collimator and the slit lessens the beam current to proper values. To measure the proton beam current downstream, a copper Faraday cup will be used.

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Monday Poster Session / 865

X-ray optics and diagnostics for the cavity-based X-ray free-electron laser project

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Co-authors: Paresh Pradhan [1]; Lahsen Assoufid [1]; XianRong Huang [1]; Keshab Kauchha [1]; Kwang-Je Kim [1]; Keenan Lang [1]; Antonino Miceli [1]; Zhi Qiao [1]; Xianbo Shi [1]; Deming Shu [1]; Joseph Sullivan [1]; Donald Walko [1]; Marion White [1]; Yuri Shvyd'ko [1]; Mark Rivers [2]; Taito Osaka [3]; Kenji Tamasaku [3]; Aliaksei Halavanau [4]; James MacArthur [4]; Takahiro Sato [3]; Diling Zhu [4]

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The cavity-based x-ray free-electron laser (CBXFEL) R&D project utilizes a low-loss x-ray cavity (65.5 m long) to provide circulating monochromatized x-ray seeding for electrons from the Cu-linac at SLAC. The project aims to demonstrate the two-pass gain in x-ray regenerative amplifier and XFELO modes by 2024. Here, we report on the design, manufacture, and characterization of x-ray optical and diagnostic components for this project. The low-loss wavefront-preserving x-ray optical components include high-reflectivity C(400) diamond crystal mirrors, drumhead diamond crystal with thin membranes, beryllium refractive lenses, channel-cut Si monochromators, and exact-Backscattering C(440) diamond crystal. The x-ray diagnostics are designed to ensure the accuracy of beam alignment and to characterize and optimize CBXFEL performance. These include different types of x-ray beam position and profile monitors and x-ray beam intensity monitors, and a meV-resolution x-ray spectrograph. All x-ray optical and diagnostic components have been fully characterized with x-rays, and the mechanical installation of these components is expected to be finished soon.

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Thursday Poster Session / 866

Construction and installation of a 320 kW solid state power amplifier for Taiwan Photo Source.

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It took a decade to develop the 500-MHz module for the Solid State Power Amplifier (SSPA) in NSRRC. Performance of a single module was gradually improved to reach a steady output power of 960 W by using the RF chip IC-BLF578XR. Heat dissipation unit and high-efficiency power supply are key issues in improving integral performance (49.5% RF power) of the single module. A 110-module SSPA tower was first constructed to generate 80 kW CW RF power. Next this 80-kW tower was successfully combined with a 100-kW klystron-type RF source to generate 140 kW RF power

to finish the conditioning of power couplers (CPL) and off-line high-power test of a KEKB-type SRF module in the RF laboratory. Based on these operation experience, four towers of modified SSPA were then constructed and successfully combined to generate 320 kW RF power, in which the RF chip in each module is upgraded to IC-BLF578. This 320-kW SSPA station is applied to the on-line high-power test and CPL aging of a KEKB-type SRF module in 2021-2022. However, reduction on module damage rate during CPL aging, higher operation stability, greater energy efficiency, and suppression on acoustic noise are the challenges foreseen.

Footnotes:

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Asia

Tuesday Poster Session / 867

Error analysis and commissioning simulations for the SSRF-U lattice

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SSRF-U, a 3.0 GeV diffraction limited storage ring lattice with emittance of 53.2 pm·rad, is an alternative to SSRF for future upgrades. A large number of high-field intensity and multi-function magnets are used in this compact lattice, which greatly increases the error sensitivity to the beam. To quickly complete beam commissioning and achieve stable operation in the future, error analysis and commissioning simulations were studied during the design phase. In this paper, we present commissioning simulations for the SSRF-U and analyze the lattice error acceptance depending on the simulation results at each stage.

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Tuesday Poster Session / 868

BESSY III overview and its bending sources

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The BESSY III project evolves from a pre-CDR phase into the CDR phase. And for lattice design, it means, that one of the different Higher-Order-Achromat MBA lattice candidates has to be chosen as the baseline lattice for the iterations with the construction department. Therefore it is essential that the design of the main and most important components, the bending magnets, will be defined as early as possible. At BESSY III, it is requested, that the bends be used as bending sources in different regimes, the soft-X-ray (<2 keV), in the tender (2-12 keV), and hard X-rays (>10 keV). In this contribution, we will give an overview of the BESSY III project and its bending sources and discuss briefly the baseline lattice.

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Tuesday Poster Session / 870

The low charge linac injector for the SAPS

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The SAPS is a fourth-generation light source which is planned to be built at the Guangdong Province, the south of China. On injection option for the SAPS is a booster ring with a low energy linac. The linac initially provides full charge bunches to booster and then the boosted beams are injected to the storage ring via swap-out injection. When the brightness of the storage ring become lower, the linac can provide low charge bunches to booster and those beams will be injected via longitudinal injection to the storage ring. In the paper, the low charge linac injector is described, which is well adapted the booster ring for the longitudinal injection.

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Tuesday Poster Session / 871

Findings of simulation studies for the fast corrector magnets of PETRA IV

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Fourth-generation synchrotron radiation sources, which are currently being planned in several accelerator laboratories, require fast orbit feedback systems to correct distortions in the particle orbit and thus meet stringent stability requirements. Such feedback systems feature corrector magnets powered at frequencies up to the kilo-hertz range, giving rise to strong eddy currents. To understand the eddy current effects and the characteristics of these fast corrector magnets, elaborate finite element simulations must be conducted. This paper gives an overview of the most important findings of our simulation studies for the fast corrector magnets of the future synchrotron radiation source PETRA IV at DESY, Hamburg, Germany. Using a homogenization technique for the laminated yokes, we simulate the magnets over a wide frequency range. We investigate the integrated transfer function of the magnets and the phase shift between the field in the aperture and the current in the coils.We show the impact of different material choices for the yoke, of various beam pipe layouts, and of the cross-talk with the neighboring quadrupoles. By presenting a concise summary of our findings, we aim to bring valuable insights to researchers working on fast orbit feedback systems for the next generation of synchrotron light sources.

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Tuesday Poster Session / 872

Single-shot meV-resolution hard X-ray spectrograph for CBXFEL diagnostics

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A cavity-based x-ray free-electron laser (CBXFEL) is a possible future direction in the development of fully coherent hard x-ray sources of high spectral brilliance, a narrow spectral bandwidth of ˜1-100 meV, and a high repetition rate of ˜1 MHz. A diagnostic tool is required to measure CBXFEL spectra with a meV resolution on the shot-to-shot bases. Here we present test results of a single shot hard x-ray angular-dispersive spectrograph designed for this purpose.
Angular-dispersive x-ray spectrographs are composed of a dispersive element —Bragg reflecting crystals arranged in an asymmetric scattering geometry, a focusing element, and a pixel detector [1]. The CBXFEL spectrograph was designed to image 9.8 keV x-rays in a ˜200 meV spectral window with a spectral resolution of a few meV. Two Ge asymmetrically cut crystals in the dispersive 220 Bragg reflection geometry were used as the dispersive element. A compound refractive Be lens was used as the focusing element.
The spectrograph was built and tested at the Advanced Photon Source beamline 1-BM-B. The spectrograph operates close to design specification featuring a 185 meV (FWHM) spectral window of imaging, a 1.4 μm/meV linear dispersion rate, and a spectral resolution of 15 meV estimated with a 40 meV width of the spectral reference benchmark available in the test measurements.

Footnotes:

[1] Yu. Shvyd'ko. Theory of angular-dispersive, imaging hard-x-ray spectrographs. Phys. Rev. A, 91 (2015) 053817.

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Tuesday Poster Session / 873

Transient finite-element simulations of fast-ramping muon-collider magnets

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Conceptual studies for a muon collider identify fast-ramping magnets as a major design challenge. Rise rates of more than 1 T/ms are attainable with normal-conducting magnets, incorporating iron yokes to make sure that stored magnetic energies and inductances stay below reasonable thresholds. Moreover, for energy efficiency, the magnets need to exchange energy with capacitors, such that the electric grid only needs to compensate for the losses. The design of such magnet systems is based on two- and three-dimensional finite-element models of the magnets coupled to circuit models of

the power-electronics equipment. The occurring phenomena necessitate nonlinear and transient simulation schemes. This contribution presents the analysis of a two dimensional, non linear and time transient analysis of a bending magnet, energized by a switched resonance capacitor-based circuit which generates a symmetrical current pulse of few ms. The magnet's yoke is represented by a homogenized material refraining from the spatial discretization of the individual laminates, but nevertheless representing the true eddy-current losses. The hysteresis losses are estimated in a post-processing step.

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Thursday Poster Session / 874

Development and Testing of High Precision and Stability Power Supply for High Energy Photon Source

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The High Energy Photon Source (HEPS) is the fourth-generation synchrotron photon source. Compared with the third-generation synchrotron photon source, the brightness is 100-1000 times higher, and the electron emittance of the storage ring is low to the diffraction limit of light. Through physical calculations, it is required that the stability of the storage ring quadrupole magnet power supply be better than 10ppm, and the accuracy of output current be better than 80ppm. This high demand for technical parameter poses a challenge to the development of high precision and stability power supplies. The main circuit topology of the power supply adopts a phase shifted full bridge soft switching scheme, which avoids interference caused by switching noise and improves power stability and efficiency. The high-precision digital power supply controller based on FPGA improves the sampling speed and control accuracy of the power supply, and the constant temperature control circuit ensures that the output current of the power supply meets the requirements of HEPS for power supply performance. In the batch testing section, a testing facility was built to test the stability, accuracy, repeatability, voltage ripple, and other parameter of high precision and stability power supplies. After a year and a half of testing, the performance tests of 1066 power supplies, including linear accelerators power supplies, booster power supplies, storage rings power supplies, dipole and quadrupole combined power supplies, dipole and quadrupole power supplies, were completed. The results all met and exceeded the design specifications. The HEPS high precision and stability power supply meets the design requirements in terms of current stability, accuracy, repeatability, voltage ripple, and other aspects. The batch test results show that the power supply performance using the full bridge phase shifting soft switching technology combined with high-precision digital controller scheme is excellent, and the power supply consistency is good, providing a guarantee for the successful operation of HEPS in the future.

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Asia

Monday Poster Session / 875

A compact water window X-ray source based on inverse Compton scattering

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X-rays in the water window (2.33 nm to 4.40 nm wavelength) can be used to provide high quality images of wet biological samples. Given the limited availability of current generation light sources in this energy range, table-top water window X-ray sources have been proposed as alternatives. We present start-to-end simulations in RF-Track of a water window X-ray source based on inverse Compton scattering. A brazing-free electron gun with a maximum beam energy of 7 MeV is considered, providing photon energies covering the full water window range. Performance estimates for the gun operating with copper and cesium telluride cathodes are presented. The cesium telluride cathode, combined with a burst mode Fabry-Perot cavity, allows for an increase in flux by orders of magnitude compared to single bunch copper cathode operation. A beamline of 1 m was determined to be sufficient to produce a high photon flux.

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Monday Poster Session / 876

Status of the commissioning of the X-band injector prototype for AWAKE Run 2c

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The status of commissioning of the electron injector intended for the next phase of the proton driven wakefield experiment (AWAKE) is presented, showing first experimental results from operating the brazing-free electron gun. To provide a high-quality electron beam, the UV laser was centered on the copper cathode, and a novel simplex and beam-based alignment of the focusing solenoid was performed. Measurements of the beam parameters and working points are addressed. The electron gun is shown to provide a high quality, stable and reproducible beam.

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TUAD: Hadron Accelerators (Contributed) / 877

Correcting asymmetry of closed-orbit distortion in J-PARC main ring by reducing current ripples of main magnet power supplies

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The main ring (MR) of the Japan proton accelerator research complex (J-PARC) delivers the high-intensity proton beams to the T2K long-baseline neutrino experiment. To observe charge-conjugation and parity-transformation violation in the lepton sector with high accuracy, the upgrade of the MR toward the beam power of 1.3 MW is mandatory. The magnet power supply system of MR was upgraded for this purpose during the long-term shutdown period in FY2021. However, the asymmetry of the closed-orbit distortion (COD) was observed after the upgrade. The cause of the asymmetry was attributed to the large ripples of the excitation currents for the bending magnets. The measures to reduce the ripples were applied to six identical power supplies for the bending magnets, and then the asymmetry was successfully corrected. This result suggests the tune region of the stable beam operation is expected to be improved since the effect of the non-structure resonance should be suppressed. This presentation reports the scheme of the ripple reduction for the excitation currents of the bending magnets and the measurement results of the COD in the MR.

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Thursday Poster Session / 878

Emittance growth studies due to Crab Cavity induced amplitude noise in the SPS

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In the context of the HL-LHC upgrade, RF Crab Cavities (CCs) are one of the key components. Due to the increased intensity, the collider will operate with a large crossing angle scheme and these CCs will be used to counteract the geometrical reduction factor coming from the crossing angle. Amplitude and phase noise injected from the Low-Level RF, are known to induce transverse bunch emittance growth. This contribution presents the latest measurements of emittance growth induced by amplitude noise. The measurement was performed thanks to the SPS Beam Synchrotron Radiation Telescope (BSRT), that has been used to characterize the evolution of the transverse distributions. The measured emittance growth was found to be dependent on the amplitude detuning induced by the SPS octupoles, although no dependence was predicted by the available theories and models. In this paper, the measurement results will be presented and discussed.

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Wednesday Poster Session / 879

Dark current reduction for NSRRC photoinjector system by collimation

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NSRRC THz facility provides MW-level superradiant radiation with wavelengths ranging from 100–500 μm from a U100 planar undulator. An S-band laser-driven photocathode radio-frequency (RF) gun has been used in its 25 MeV linac system to generate a sub-picosecond high brightness relativistic electron beam for coherent emission of undulator radiation. However, the high accelerating field in the gun cavity is found to be the main cause of electron field emission that generates the non-negligible background current (dark current) in the system. A portion of the field-emitted electrons with launching conditions close to that of the main beam can be accelerated to high energies in the booster linac structure located downstream. Collision of these unwanted high energy electrons with the vacuum vessel in the system becomes the main source of excessive radiation dosage. In order to limit the transportation of these unwanted electrons to the booster linac, a collimation system will be implemented upstream of the linac. In this work, a model of the drive linac system has been setup with 3D space charge tracking code –IMPACT-T for main beam and dark current simulation. Particle trajectories under various launching conditions are also analyzed. Best location of the collimator has been chosen for dark current reduction.

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Asia

Monday Poster Session / 881

GENAC: a compact LINAC integrated with microwave generator

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In this paper, we propose a novel linear accelerator (LINAC) integrated with a microwave source (generator) based on a modified klystron. Particle-In-Cell (PIC) simulations has been conducted for principle demonstration. The device works at X-band, under the input DC voltage of 50 keV and the driver current of 120 A. The microwave generation region in the annular channel reaches the peak average output power of 3 MW at 10.0 GHz when unloaded. At the accelerator region, after hundreds-mm-long bunching and acceleration, the witness beam energy gains from 50 keV to 3 MeV. The proposed scheme is expected to further reduce the footprint of accelerators and promotes the development of medical accelerators.

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Asia

Tuesday Poster Session / 882

Intra-beam scattering and Touschek scattering optimizations for the upgraded SSRF

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In this study, we present the design of a candidate lattice for the Shanghai Synchrotron Radiation Facility Upgrade (SSRF-U) storage ring, reaching the soft X-ray diffraction limit. Due to its ultra-low emittance, intra-beam and Touschek scattering are significant and require attention. We conducted particle simulations to examine the emittance growth and beam lifetime of different machine configurations in the SSRF-U storage ring. Equilibrium beam emittance variations due to beam coupling, bunch lengthening and damping wigglers were identified through simulations. Additionally, Touschek scattering and beam lifetime were calculated.

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Asia

Wednesday Poster Session / 883

Application of a novel high brightness photogun for MeV ultrafast electron diffraction

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MeV ultrafast electron diffraction has become a new frontier for the study of molecular dynamics. With the temporal resolution of MeV-UED being limited by the electron bunch length at the target, electron sources used for this technique are becoming ever more intricate in the the push for shorter bunches length. However, moving to these complex setups makes them less feasible in a small-scale setting, such as universities, where keV-UED setups have become common place. In this paper, we use a novel travelling-wave RF photogun without any additional bunch compressor to generate ultra-short electron pulses whose lengths rival that of the most intricate magnetic or ballistic compression schemes. The broadband nature of the TW device allows for unique operation schemes that combines significant acceleration and compression all within the TW photogun. Such a device, when combined with state-of-the-art synchronization systems and lasers will be demonstrated to cross the so-called '50-fs time-resolution barrier'and push towards the femtosecond regime.

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Tuesday Poster Session / 884

Study on beam injection and ramping efficiency for Korea-4GSR booster

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The Korea fourth-generation storage ring (Korea-4GSR) project was launched in 2021 to generate high-brightness photon beams as a diffraction-limited light source. The 200 MeV beam is injected into the booster synchrotron. The beam parameters and transmission efficiency fluctuate with initial beam conditions such as beam Twiss parameters and centroid offsets during the injection and energy ramping process. Therefore, the study on the initial conditions of the incident beam to the booster synchrotron needs to be carried out to gain high beam quality and efficiency. This paper presents the energy ramping results of the beams injected into the booster synchrotron with various initial beam conditions.

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Asia

Thursday Poster Session / **885**

Summary of the operation of CSNS accelerator since its official opening in past five years

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China Spallation Neutron Source (CSNS) is a large-scale scientific research facility located in Dongguan, China. It is a pulsed neutron source that uses a proton accelerator to produce neutrons, which are then used to study the structure and properties of materials at the atomic and molecular level. Since its opening, CSNS has steadily improved its operation efficiency and beam power year by year. In particular, during the 2021-2022 operating year, the beam supply time and efficiency reached their highest levels， and was also the advanced level of similar facilities. This poster will present the operational status of the CSNS accelerator over the past five years, as well as the issues encountered and some of the measures taken to improve beam supply efficiency and reliability.

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Asia

Tuesday Poster Session / **886**

Energy deposition and radiation level studies for the FCC-ee experimental insertions

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Co-authors: Andrea Ciarma [2]; Anton Lechner [1]; Antonio Perillo Marcone [1]; Barbara Humann [1]; Carl Järmyr Eriksson [1]; Carsten Welsch [3]; Daniele Calzolari [1]; Giuseppe Lerner [1]; Manuela Boscolo [2]; Marco Calviani [1]; Narender Kumar [4]

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The Future Circular Collider (FCC) study foresees the construction of a 90.6 km underground ring where, as a first stage, a high-luminosity electron-positron collider (FCC-ee) is envisaged, operating at beam energies from 45.6 GeV (Z pole) to 182.5 GeV (ttbar). In the FCC-ee experimental interaction regions, various physical processes give rise to particle showers that can be detrimental to machine components as well as equipment in the tunnel, such as cables and electronics. In this work, we evaluate the impact of the synchrotron radiation emitted in the dipoles and the beamstrahlung radiation from the interaction point (IP). The Monte Carlo code FLUKA is used to quantify the power deposited in key machine elements, such as the beamstrahlung dump and the dipole and quadrupole magnets, as well as the cumulative radiation levels in the tunnel. We also examine the effect of synchrotron radiation absorbers in the vacuum chamber, in combination with additional shielding. The results are presented for the different operation modes, namely Z pole and ttbar.

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Europe

Tuesday Poster Session / 888

Status of beam commissioning at NanoTerasu

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NanoTerasu is a new 3 GeV compact soft X-ray (SX) light source having a circumference of 349 m constructed in Japan. The lattice structure is a type of multi-bend achromat with design emittance values of 1.14 nm·rad and 10 pm·rad, respectively. A target stored current is set to 400 mA to provide a high coherence and highly brilliant light from extreme ultraviolet to SX range. The injector LINAC commissioning was started in April 2023. After first 10 days, the beam energy successfully reached 3 GeV with the designed emittance. The 3 GeV C-band full-energy injector LINAC enables

the extension to the SX free electron laser in the future. The storage ring beam commissioning was started on June 8th. We achieved the off-axis beam injection just adjusting beam injection trajectory from the beginning of the beam commissioning. As a result of the precise alignment of the magnets, the injected beam turned around 300 turns without the supply of RF power and the adjustment of the steering magnets on the first day of the commissioning. The stored current was reached 300 mA with top-up beam injection in November. The user operation will be started in April 2024. The creation of COD and tune correction tables for the insertion device is also in progress including non-linear magnetic field correction. We try to start the user operation with designed 400 mA top-up beam injection. The status of beam commissioning will be presented.

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Monday Poster Session / 889

Comparison of multi-objective Bayesian optimization and the reduction of resonance driving terms in the optimization of the dynamic aperture of the BESSY III MBA lattice

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HZB is currently designing the lattice for BESSY III, the successor of the 1.7 GeV electron storage ring running in Berlin since 1998. HZB follows a deterministic lattice design strategy, where the natural substructures of a non-hybrid MBA lattice are optimized separately. The substructures consist of only a few parameters, that can be derived from the strategic goals of the project. In the next step, the focusing and de-focusing sextupole families are split up, to optimize the longitudinal and the transverse apertures. The paper compares two approaches to select the optimal sextupole strengths. The first one is multi-objective Bayesian optimization, where the dynamic aperture volume from tracking simulations is used as an objective to be maximized. The second approach does not involve tracking and minimizes the geometric and chromatic resonance driving terms. The comparison of the two results includes their quality in terms of the size of the achievable 3D dynamic aperture and the computational effort involved.

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Wednesday Poster Session / 890

Status of the time-dependent FEL code Genesis 1.3

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Version 4 of the widely used time-dependent FEL code Genesis 1.3 has been released. The C++ code keeps the entire bunch in memory and thus allows for self-consistent effects such as wakefields or long-range space charge fields. With sufficiently allocated distributed memory, Genesis 1.3 can represent each individual electron. This solves the problem of the shot noise statistics at any arbitrary frequency in the simplest way and allows for sorting and redistribution of particles among the computer cores for advanced FEL applications such as the Echo-Enabled Harmonic Generation schemes. This presentation reports on the new physics added to the code as well as features which simplify the setup of the simulations as well and the ability to link user-made libraries to adapt to the specific needs of each user.

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Wednesday Poster Session / 891

Ion sources for FAIR - Facility for Antiproton and Ion Research at Darmstadt, Germany

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FAIR (Facility for antiproton and ion research) is a new accelerator complex in Darmstadt, Germany which will come into operation 2027. The existing GSI accelerator will serve as an injector for the

FAIR facility. GSI comprises three main injector lines equipped with different kinds of ion sources producing ion beams of a large number of gaseous and metallic elements according to the various requirements of different experiments. The south injector is equipped with Penning type ion sources (PIG) for metallic and gaseous ion production delivering ion currents up to 100 µA and charge states of up to 8+. The north injector is equipped with high current ion sources of the multicusp type (MUCIS, CHORDIS) and the vacuum arc type ion source VARIS. With this kind of ion source we are able to deliver ion beam currents of up to several mA of up to 5+ charged ions. The third injector is the high charge state injector equipped with a 14.5 GHz ECR ion source delivering ion beam currents of up to 100 µA and charge state of up to 20+ of gaseous and metallic ions. This paper gives an overview of all the ion beams produced by these ion sources and the most important operational parameters

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Thursday Poster Session / 892

Equipment protection system against unexpected abnormalities during high-intensity proton beam operation at J-PARC MR

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The J-PARC MR synchrotron began high repetition operation with shortened accelerator cycles in 2022. So far, FX has been supplying a 2x10e+14 proton per pulse (ppp) beam to the Neutrino Experimental Facility with a repetition rate of 1.36 seconds, and SX has been supplying a 0.6x10e+14 ppp beam to the Hadron Experimental Facility with a 5.20 seconds repetition. The amount of heat per accelerated proton beam pulse exceeds 1 MJ, and it is an important issue to avoid damage to the equipment caused by high-intense beam due to abnormalities during beam acceleration. Since the MR is operated in different extraction modes, i.e. FX and SX, the countermeasures are also different, and the adequate protection system also needs to be considered, respectively. Therefore, the countermeasures have been put in place, including a high-speed beam abort system and/or a fast sequential interlock between devices. This report summarizes the systems to protect equipment from abnormalities that unexpectedly occur during high-intensity proton beam acceleration.

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Wednesday Poster Session / 894

Modelling intra-beam scattering in the LHC for longitudinal beam loss studies

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In the Large Hadron Collider (LHC), intra-beam scattering (IBS) is one of the main drivers of longitudinal emittance growth during the extended injection plateau. With the halo of the longitudinal bunch distribution being close to the separatrix, IBS consequently drives beam losses by pushing particles outside the RF bucket at the flat-bottom. Because IBS and beam losses impose a requirement on the minimum RF bucket size, this mechanism has an important impact on the RF power requirements for the High Luminosity (HL-) LHC. In this contribution, the effect of IBS is introduced in the Beam Longitudinal Dynamics (BLonD) tracking code in the form of an energy kick. This numerical model is then benchmarked against analytical estimates, as well as beam measurements performed in the LHC. The impact of IBS-driven losses on the RF power requirements is investigated through observed flat-bottom and start-of-ramp losses, as well as the bunch length evolution.

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Tuesday Poster Session / 895

Simulating a rectilinear cooling channel using BDSIM for the 6D muon cooling demonstrator

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Muon colliders hold promise for high luminosity multi-TeV collisions, without synchrotron radiation challenges. However, this involves investigation into novel methods of muon production, acceleration, cooling, storage, and detection. Thus, a cooling demonstrator has been proposed to investigate 6D muon ionization cooling. The MICE experiment validated ionization cooling to reduce transverse emittance. The demonstrator will extend this to also cool longitudinal emittance. It would also use bunched beams instead of single particles from a muon source. The 6D cooling lattice comprises successive cells which consist of: solenoids for tight focusing, dipoles to introduce dispersion in the beam, wedge-shaped absorbers for differential beam absorption, and RF cavities for reacceleration. In this paper, the simulation and further optimization of the rectilinear cooling channel is discussed. This analysis extends existing theoretical and numerical work using BDSIM, a Geant4-based accelerator framework built to simulate the transport and interaction of particles. The study also incorporates beams from existing proton drivers, using output from targetry and capture designs for the same.

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Thursday Poster Session / 896

Real-time digital controller design based on SoC FPGA for general usage in J-PARC MR magnet power supplies

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Nowadays, the real-time control is more and more popular in the particle accelerator field because it is a powerful tool for stable operation and beam loss suppression in the particle accelerator. However, in the Japan Proton Accelerator Research Complex (J-PARC) Main Ring (MR), real-time control has not been widely used in magnet power supplies yet. Magnet power supplies are very easily affected by disturbances from external factors, such as environmental temperature, device aging, power grid voltage and current fluctuations, and so on. Therefore, it is worth developing a real-time digital controller with general functions for the magnet power supplies to observe and suppress these disturbances. In this paper, we propose the design of a general-purpose intelligence controller for the magnet power supply realized by a System-on-Chip (SoC) Field Programmable Gate Array (FPGA). This digital controller can also be used as a high-resolution data acquisition system, a pattern generator, and a high-precision current control system for magnet power supplies.

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Thursday Poster Session / 897

The 3.5 MeV MAMI injector linac as a versatile experimental area

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The 3.5 MeV Injector Linac of the Mainz Microtron accelerator (MAMI) at the Campus of the Johannes Gutenberg-University in Mainz has proven great reliability and flexibility during the last three decades of MAMI operation. We present the versatile usage of the first part of the accelerator complex ranging from routine spin-polarization measurements for fundamental research towards irradiation for different material science studies. In addition, the 3.5 MeV beam line is regularly used for experiments within the advanced lab course of the MSc. Curriculum in physics.

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Thursday Poster Session / 898

A kick-and-cancel injection scheme for Diamond-II

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The Diamond-II storage ring upgrade will provide users with 1-2 orders of magnitude brightness increase over the existing Diamond facility, for which a quasi-transparent top-up injection scheme will be a key performance requirement [1]. The ring was originally designed to use a single-bunch aperture sharing injection scheme [2], in which short stripline kickers are used to kick the injected bunch into the storage ring's dynamic aperture but remaining weak enough to avoid kicking the stored bunch outside the acceptance. A modification to this scheme which implements a kick-and-cancel method [3] shows promise for the stored bunch. The kicker power supplies are thus required to provide a double-pulse with few-microsecond pulse spacing. This new method is expected to significantly improve the transparency and reduce the recovery time for the targeted bunch, along with minimizing transverse wakefield effects and any interactions with the transverse multibunch feedback.

Footnotes:

[1] R.P. Walker, et al., Diamond-II Technical Design Report, Aug 2022.
[2] J. Kallestrup et al. In proc. IPAC'22, THPOPT018, May 2022.
[3] C. Sun et al., Phys. Rev. Lett. 109, 264801, Dec 2012.

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Monday Poster Session / 899

Automated optimization of accelerator settings at GSI

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The complexity of the GSI/FAIR accelerator facility demands a high level of automation in order to maximize time for physics experiments. Accelerator laboratories world-wide are exploring a large variety of techniques to achieve this, from classical optimization to reinforcement learning. This paper reports on the first results of using Geoff at GSI for automatic optimization of various beam manipulations. Geoff (Generic Optimization Framework & Frontend) is an open-source framework that harmonizes access to the above automation techniques and simplifies the transition towards and between them. It is maintained as part of the EURO-LABS project in cooperation between CERN and GSI. In dedicated beam experiments, the beam loss of the multi-turn injection into the SIS18 synchrotron has been reduced from 40% to 10% in about 15 minutes, where manual adjustment can take up to 2 hours. Geoff has also been used successfully at the GSI Fragment Separator (FRS) for beam steering. Further experimental activities include closed orbit correction for specific broken-symmetry high-transition-energy SIS18 optics with Bayesian optimization in comparison to traditional SVD-based correction.

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Wednesday Poster Session / 901

Real-time processing of longitudinal Schottky signals in CERN's antiproton chain

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A low-latency, real-time diagnostic system for the analysis of longitudinal Schottky signals in CERN's antiproton chain has been developed. The system, installed in CERN's AD (Antiproton Decelerator), processes the combined output of two low-noise, wideband AC beam transformers. It uses a GPU and the NVIDIA® CUDA® Toolkit, exploiting the directly sampled turn-by-turn data and hardware features provided by the LLRF VXS (VMEBus Switched Serial) system and its companion ObsBox server, to implement the FFT-based multi-harmonic spectral analysis needed to set up and monitor the stochastic and electron cooling processes. Longitudinal beam properties, such as mean momentum and momentum spread, are also derived to evaluate and log the machine performance. This paper describes the implementation of the system and its integration within the CERN control system, achieved using the FESA (Front-End Software Architecture) framework and a graphics co-processor directly installed in the Front-End computer, running an RTOS environment. Preliminary results of its usage in the ELENA (Extra Low ENergy Antiproton) ring and next steps to process bunched beam spectra are also presented.

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Wednesday Poster Session / 902

Measurements of the time-structure of the current to a single injection kicker module and simulation of its effect on the transverse beam dynamics in SIS100

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Distortions in the SIS100 injection kicker's pulse time-form gives rise to beam emittance blow-up in the horizontal plane. Beam particle tracking simulations were carried out to try to predict the emittance at the end of the injection process for pbar and RIB operation. The RIB cycle's beam grew to just beyond the acceptance of the slow extraction separatrix at 27 Tm. During pbar operation with the longitudinal RF cavities set to bunch the beam at the 5th harmonic of the beam revolution frequency instead of the originally planned 10th harmonic, the beam ended up exceeding the halo collimator's acceptance resulting in a small loss.

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Monday Poster Session / 903

Expanding the CERN ion injector chain beyond Pb ions: beam-dynamics and lifetimes studies of novel ion candidates

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The present ion physics program in the CERN accelerator complex is mainly based on Pb ion beams. The ALICE3 detector upgrade proposal at the Large Hadron Collider (LHC) requests significantly higher integrated nucleon-nucleon luminosity compared to the present Pb beams, which can potentially be achieved with lighter ion species. These lighter ion species have also been requested by the fixed-target experiment NA61/SHINE in the CERN North Area (NA). To assess the performance capabilities of the CERN Ion Injector chain (consisting of Linac3, LEIR, PS and SPS) for light ions, for which there is little or no operational experience at CERN, beam-brightness and intensity limitations need to be studied. This contribution presents tracking simulation results for the PS and SPS, compared against recent experimental beam data for Pb in the Ion Injectors. These simulations include limiting beam-dynamics effects such as space charge and intra-beam scattering, and their impact on the intensity and emittance evolution is discussed. These simulation models are used to predict the optimal ion species for maximum performance out of the Ion Injector Chain.

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THAN: Novel Particle Sources and Acceleration Techniques (Contributed) / 904

Design, realization and high power RF test of the new brazed free C band photo-gun

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RF photo-gun are the electron beam sources of FELs or Compton facilities. They are key components and, presently, the RF technology mostly used for these devices is the S band (3 GHz) with typical cathode peak fields of 80-120 MV/m and repetition rates lower than 100-120 Hz. An innovative C-Band (5.712 GHz) RF gun aiming at reaching cathode peak field larger than 160 MV/m, with repetition rates exceeding the 400 Hz, has been designed, realized and high power tested in the context of the European I.FAST and INFN Commission V projects. It is a 2.5 cell standing wave cavity with a four-port mode launcher, designed to operate with short RF pulses (300 ns). Its realization is based on the new brazed-free technology developed and successfully tested at INFN. In the paper, after a short overview of the design and RF gun capabilities, we illustrate the realization procedure and the results of the high power RF tests that have been done at the high power C band test facility at PSI (Switzerland).

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Wednesday Poster Session / 905

Synchrotron radiation studies for the FCC-ee interaction region

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The FCC-ee is a proposed high-luminosity circular electron-positron collider that will operate with beam energies spanning from 45.6 to 182.5 GeV, yielding a total of 50 MW of synchrotron radiation power per beam. The lattice design upstream of the interaction point is based on weak dipoles and long straight sections combined with a 30 mrad crossing angle. The optics design provides a flat beam at the IP while integrating an anti-solenoid and detector solenoid.
The paper summarizes the design principle and performance of the FCC-ee synchrotron radiation collimation scheme and provides insights into the synchrotron radiation simulations within the interaction region, conducted using the GEANT4 toolkit BDSIM. Special attention is given to the complexity of the transverse beam tails, including their width and particle density, providing valuable perspectives for the design of an effective synchrotron radiation collimation system.

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Wednesday Poster Session / 906

Impact of synchrotron radiation on FCC-ee top-up injections

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The FCC-ee is a proposed high-luminosity circular electron-positron collider that will have beam energies spanning from 45.6 to 182.5 GeV, yielding a total of 50 MW of synchrotron radiation power per beam. To sustain this high luminosity alternating top-up injection, constituting 10% of the nominal electron or positron intensity, is employed. Injection strategies involving off-axis/on-energy and on-axis/off-energy schemes are considered. This paper focuses on evaluating the synchrotron radiation contribution from the injected beam in the interaction region.
An overview of the FCC-ee synchrotron radiation collimation scheme is given, specifically focusing on its performance during top-up injection. GEANT4 simulations are realized to investigate the various injection schemes. This additional heat load impacts the synchrotron radiation collimation

and the hardware within the interaction region. The results presented offer valuable insights for optimizing the collimation scheme.

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Thursday Poster Session / 907

Integration of LHC-type beam loss monitors into the protection system for the SIS100 synchrotron at FAIR

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The SIS100 heavy ion synchrotron is the central machine of the FAIR (Facility for Antiprotons and Ions Research) project at GSI. It presents complex challenges due to its features handling high-intensity ion beams from protons up to uranium. It demands sensitive beam diagnostics with robust Machine Protection Systems (MPS). Due to anticipated extreme conditions, one safety subsystem includes LHC-type Beam-Loss Monitors (BLMs). These BLMs play a critical role in beam diagnostics and machine safety, strengthening protection measures by enhancing monitoring capabilities for severe beam losses and triggering safe beam dump requests. These BLMs are gas chamber detectors which aim to prevent beam-induced quenching superconducting magnets and protect other machine components from damage.

This document outlines a conceptual study of a Machine Protection System, integrating 168 LHC-type BLMs to safeguard the SIS100 synchrotron. The integration involves upgrading the readout electronic chain and adopting FPGA-based logic firmware to handle intricate rate counting requirements over specified time windows. Additionally, hardware sanity checks are carried out to prevent non-conformities and ensure reliability alongside beam loss rate counting. Overall, the focus on beam loss monitoring for the SIS100 within the FAIR project underscores the necessity for sophisticated diagnostic tools and protective measures to ensure the safe and efficient operation of this state-of-the-art synchrotron.

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Wednesday Poster Session / 909

Simulations of simultaneous measurement of GHz bunches using a fast kicker

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High quality electron bunch trains enable investigations in scientific frontiers with high resolution and efficiency and are earnestly desired by various accelerator facilities, including inverse Compton scattering (ICS), high energy computed tomography, and free electron lasers. An average beam flux can be greatly increased by using the bunch train mode. A bunch train with an average current of 1 A is required in the future steady-state microbunching light source with a bunch spacing of 350 ps (2856 MHz). It is essential to measure each bunch in a bunch train and ensure that each bunch has roughly the same quality. Thus, we proposed utilizing a fast kicker to measure different bunches simultaneously. Different bunches get varying deflection angles by utilizing the kicker's rapidly rising edge, and eventually, different bunches can be measured simultaneously. The measuring methods of real space bunches profile, bunch energy, longitudinal phase space, and its corresponding simulation results are presented.

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Thursday Poster Session / 910

Research on ultra-high energy electron beams for FLASH radiotherapy @ ELSA

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Ultra-high energy electrons (UHEE) are used to investigate their effect on tumor cells and healthy tissue in short pulses of microseconds at the electron accelerator facility ELSA. This may enable highly efficient treatment of deep-seated tumors due to the FLASH effect. In a preliminary setting electrons with an energy of 1.2 GeV are used to irradiate cell samples which are located inside a water volume, representing the human body. Irradiation occurs with dose rates of up to 10 MGy/s due to the short pulse lengths of 250 ns. The relative biological effectiveness (RBE) can be determined by assessing the cell survival of healthy and tumor tissues. For a precise dose determination, dose measurements via radiochromic films are utilized and compared to simulations with Geant4, that reproduce the electromagnetic shower process.

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Tuesday Poster Session / 911

Summary of Jefferson Lab LDRD on FFA@CEBAF beam dynamics simulations

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As Thomas Jefferson National Accelerator Facility (Jefferson Lab) looks toward the future, we are considering expanding our energy reach by using Fixed-Field Alternating Gradient (FFA) technology. Significant efforts have been made to design a hybrid accelerator which combines conventional recirculating electron LINAC design with permanent magnet-based FFA technology to increase the number of beam recirculations, and thus the energy. In an effort to further this progress, Jefferson Lab awarded a Laboratory Directed Research and Development (LDRD) grant to focus not on the design, but on detailed simulations of the designs created by the larger collaboration. This document will summarize the work performed during this LDRD, and direct the reader to other proceedings which describe elements of the work in greater detail.

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Monday Poster Session / 912

Conceptual facility design of the Dresden Advanced Light Infrastructure

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The ELBE radiation source at HZDR has a long success story of delivering bright and powerful infrared and THz beams to a broad user community. Following the science driven user requests we have written a conceptual design report for the Dresden Advanced Light Infrastructure (DALI) as a successor to ELBE.
The proposed DALI facility aims to increase the spectral brightness and pulse energy by orders of magnitude while providing two decades of tunability over the whole THz spectrum. It utilizes different radiation production schemes adapted to the wavelength range - super-radiant undulator sources for the long-wavelength THz range and an optical klystron driven by an oscillator FEL for the far-IR range. All sources are driven by superconducting linear accelerators allowing CW operation. The facility layout is chosen such that parallel operation of all sources is possible and great versatility is available to provide users with pulse repetition rates from single-shot to 1 MHz with flexible timing and the ability to combine sources.
A positron source and a UED setup are planned to complete the facility.

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Thursday Poster Session / 913

Design of local control system for injection of fast pulse power supply for HEPS

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The high-energy photon source (HEPS) under construction in Beijing is an excellent photon source with an emissivity better than 60pm rad. HEPS adopts on axis injection. The fast pulse power supply for booster injection adopts a topology structure of LC resonant discharge based on heavy hydrogen thyristor. The energy storage scheme of pulse capacitors adopts a design scheme of DC charging. The local control station of the fast pulse power supply for the enhancer is mainly responsible for the timing control, charging control, interlock control, protection of the kicker, and remote control. Fast pulse power supplies have high reliability, which poses challenges to the development of local control stations for fast pulse power supplies. The local control station adopts a high-performance programmable logic controller (PLC) as the control core, and applies standard modbus and ethernet for communication protocol to control equipment. A local control station prototype has been built. Through system joint testing, the designed local control station can achieve power control and protection, remote control of the local station, and interlocking protection of the magnet power supply.

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Thursday Poster Session / 914

Development of a second-generation system for the reliable distribution of machine protection parameters

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The Safe Machine Parameter (SMP) system is an electronic hardware-based system which has been an integral part of the LHC's machine protection strategy since it started operation. Its primary objective is to provide several parameters and interlock signals to critical machine protection users across the LHC and SPS accelerators, whilst prioritizing high reliability and availability. After almost two decades of operation, there is a need to upgrade the SMP hardware electronics. In the High Luminosity LHC era the requirements of connected systems have changed, leading to new system functions and operational requirements which must be integrated into the new design. This paper details the electronic design considerations of developing the second-generation SMP. The general distribution of parameters relies on the CERN WhiteRabbit timing network renovation, for which dedicated high-precision clock components were selected and tested on a prototype board. Details of the hardware design and validation are discussed, along with the comprehensive upgrades aimed at delivering an SMP system with expanded monitoring and diagnostic features.

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Thursday Poster Session / 915

Permanent magnet resiliency in Jefferson Lab's radiation environment: LDRD grant status and plans

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As the FFA@CEBAF energy upgrade study progresses, it is important to investigate the impact of radiation exposure on the permanent magnet materials to be used in the upgraded fixed field alternating gradient (FFA) arcs. To address this, Jefferson Lab has awarded a Laboratory Directed Research and Development (LDRD) grant to study the resiliency of several permanent magnet materials placed in a radiation environment similar to that in which they are expected to operate. Samples of NeFeB and SmCo are to be placed alongside appropriate dosimetry in a variety of radiation environments in the beam enclosure and experimental halls at CEBAF. The magnet degradation will be measured, and extrapolated to the higher energies expected during operations after the energy upgrade. This document will describe the current status of the LDRD study, as well as describe the upcoming plans. It will also direct the readers to other proceedings which further detail the work thus far.

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Thursday Poster Session / 916

Horizontal splitter design for FFA@CEBAF energy upgrade: current status

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Thomas Jefferson National Accelerator Facility (Jefferson Lab) is currently studying the feasibility of an energy upgrade based upon Fixed-Field Alternating Gradient (FFA) permanent magnet technology. The current plan is to replace the highest-energy recirculation arcs with FFA arcs, increasing the total number of beam recirculations, thus the energy. In order to accommodate multiple passes in the FFA arcs, horizontal splitters are being designed to control the beam parameters entering the FFA arcs, as well as the time of flight and R56. In the current design, six passes will recirculate through the FFA arcs, necessitating the design of six independent beamlines to control the optics and beam dynamics matching into the arcs. These beamlines must fit into the current CEBAF tunnel, while allowing for personnel and equipment access. They must also be flexible enough to accommodate the beam under realistic operational conditions and fluctuations. The constraints on the system are highly restrictive, complicating the design. This document will describe the current state of the design, and indicate the work remaining for a complete conceptual design.

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Wednesday Poster Session / 917

Longitudinal Phase space density tomography constrained by the Vlasov-Fokker-Planck equation

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Understanding the evolution of complex systems with numerous interacting particles requires advanced analytical tools capable of capturing the intricate dynamics of the phase space. This study introduces a novel approach to longitudinal phase space density tomography in an electron storage ring, leveraging constraints imposed by the Vlasov-Fokker-Planck equation. The Vlasov-Fokker-Planck equation provides a comprehensive description of the evolution of density functions in phase space, accounting for both deterministic and stochastic processes. Measurements of the turn-by-turn

bunch profile offer a time-dependent projection of the phase space. Observing the bunch profile evolution of charged particles in regimes characterized by a rich phase space dynamics presents a challenging inverse problem for reconstructing the phase space densities.
In this work, we present a tomographic framework for reconstructing the longitudinal phase space density of an electron bunch at the Karlsruhe Research Accelerator (KARA). This framework utilizes simulated data and applies the Vlasov-Fokker-Planck equation to drive the reconstruction process.

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Thursday Poster Session / 918

Focusing of high-energy electron beam using silicon crystals for application in radiotherapy

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By using a high-energy electron beam (beam energy of several hundred MeV) strongly focused on the tumor lesion area, radiotherapy can be performed with a relatively simple beam generation and handling system while resulting in a suitable shape of the deposition energy curve in a tissue-like material. Quadrupole magnets are typically used for beam focusing, which makes the beam delivery system complex and challenging from an engineering point of view. In the Geant4 simulation toolkit, we performed a feasibility study of an alternative solution, in which focusing is achieved by using a bent silicon crystal with an appropriately shaped exit surface. However, the focusing strength is still not high enough. Research to find the optimal crystal shape to achieve the ideal focusing strength is ongoing. Such a crystal lens can be a very light object (mass in the order of grams), allowing for a much simpler beam delivery system for radiotherapy facilities.

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Thursday Poster Session / 919

Development of high-current correction magnet power supply for TPS facilities

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This technical report focuses on the future development of the Taiwan Photon Source (TPS), with a specific emphasis on the power supply system required for the TPS-II permanent magnet corrector coil. The prototype of this power supply system features a maximum output current of 20 A and a working voltage of 48 V. To enhance the flexibility of the correction magnetic field; the Danisense DP50-IP-B DCCT is employed as the current feedback component, while MOSFETs serve as power switches in a full-bridge configuration with a driving frequency of 40 kHz. Analog modulation and protective circuits ensure precise current control in the modulation control loop. The hardware prototype circuit is assembled in the laboratory with a 48 V input voltage, 20 A output current, a maximum power of 960W, and a ripple current component maintained within 400 µA. The prototype demonstrates the control loop design's effectiveness, achieving rapid output current stability. Further small-signal bandwidth testing reveals a -3 dB bandwidth of 8.51 kHz. Long-term current stability is maintained within ±10 ppm, and the interface is compatible with the existing TPS corrector magnet power source interface, enabling direct operation within the current system. These results reinforce the feasibility and superior performance of the power supply system, providing valuable insights for the future upgrade and improvement of the TPS.

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Wednesday Poster Session / 920

Detailed simulation study of wakefield induced beam dynamics in the dielectric dechirper at CLARA

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Minimizing the energy spread within the electron bunch is essential for an optimal performance of free electron lasers. Wakefields from corrugated and dielectric structures have been demonstrated to be effective in bunch dechirping. However, the repercussions in beam quality are not yet well

understood. Here, a dielectric wakefield structure, manufactured to be included in CLARA facility, has been studied by simulations. It consists of two planar and orthogonally oriented dielectric waveguides with adjustable dielectric gaps. This geometry allows the longitudinal wakefield to compensate the energy spread while controlling the undesirable effect of the transverse wakefields in the beam quality. Simulations have been performed using the in-house developed code called DiWaCAT. These simulations included different bunch lengths, beam energies and dielectric gaps to allow a better understanding of longitudinal and transverse wakefields beam effects within the dechirper.

Footnotes:

- Gong, YW. et al (2021). Beam performance of the SHINE dechirper. doi:10.1007/s41365-021-00860-8 ** Antipov, S. et al (2014). Experimental demonstration of energy-chirp compensation by a tunable dielectric-based structure. doi:10.1103/PhysRevLett.112.114801 *** Pacey, T. H. et al (2018). Simulation studies for dielectric wakefield programme at CLARA facility. doi:10.1016/j.nima.2017.12.038.

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Thursday Poster Session / 921

Simulation of the simple feedback system for the mitigation of the cavity RF noise effects in EIC HSR

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Crab crossing in the Electron-Ion Collider (EIC) is planned to provide head-on beam collisions and maximize luminosity for beams with a 25 mrad crossing angle. This crab crossing requires superconducting RF crab cavities for both EIC electron and hadron beams. Phase and amplitude errors of these transverse crab cavities can cause emittance growth, of particular concern for hadron beams and the project hadron cooling requirements. Low-noise low-level RF control and feedback systems are being considered to address the hadron beam noise-driven emittance growth. Here we discuss simulations to investigate this emittance growth, and evaluate performance and requirements of potential beam-based feedback.

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North America

Monday Poster Session / 922

Design of the electron storage ring of the Electron-Ion Collider

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The Electron-Ion Collider (EIC) at Brookhaven National Laboratory will feature a 3.8-kilometer electron storage ring that will circulate polarized beams with energies ranging from 5 GeV to 18 GeV for collision with hadrons from a separate ring at luminosities up to 10e+34 cmˆ-2 sˆ-1. Designing this ring is very challenging due to the geometric constraints of the existing tunnel and other beamlines; the wide energy range of both electrons and hadrons, which must be synchronized and matched; the high spin-polarization (>70%) required; the complex and asymmetrical interaction region, which includes solenoid-based spin rotators and crab cavities; the large synchrotron radiation produced at top energy; the large natural chromaticity that needs to be corrected; and many other features that make this a highly complex and unique accelerator. Over the past few years the design has evolved and matured to satisfy the plethora of constraints and challenging design requirements, which are driven by a combination of beam-physics studies and technical considerations. In this contribution the latest design of the electron storage ring lattice is presented and discussed with a summary of major design decisions, including among others the super-bend dipoles in the arcs and the spin-rotator sections around the interaction point.

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Wednesday Poster Session / 923

Tailoring the production of Nb superconducting films for SRF cavities: mass/energy spectroscopy and film characterization

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SRF cavities are commonly coated with superconducting materials (e.g., niobium) using magnetron sputtering. In this process, various power supplies are employed such as DC, pulsed DC or HiPIMS. The sputtered ions are ejected from the target to the cavity or sample surface with an energy dependent on the power conditions and pressure range. In this study, we investigated the efficiency of such deposition by tracking the mass and energy of the main ions produced (e.g., Kr+, Kr2+, Nb+, Nb2+) using mass spectroscopy with time resolved measurement when applicable.
Additionally, a retarding field analyzer was also used to measure the ions energy (peak and mean) with information on the IV-characteristics of the plasma formed. We report the optimal conditions suitable to enhance both ions energy and film growth for different power supplies and pressure conditions ranging from 1e-3 mbar to 1e-1 mbar. To support the gas phase analysis, the produced film surfaces were analyzed and characterized by XPS and SEM.

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Monday Poster Session / 924

Simulations of dielectric-lined waveguide seeding option for THz FEL at PITZ

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The first operational high peak and average power THz SASE FEL at the Photo Injector Test facility at DESY in Zeuthen (PITZ) has demonstrated up to 100 uj single pulse energy at a center frequency of 3 THz from electron bunches of 2-3 nC. The measured shot-to-shot radiation pulse energy has a fluctuation of ˜10\%. Shot-to-shot stability and temporal coherence in FELs can be greatly enhanced by the seeding method. In this paper, we propose the use of dielectric-lined waveguides (DLW) to obtain the initial seeding signal. Simulations of using electromagnetic wakefield in DLW to get energy modulation, control the transformation between energy modulation and density modulation, space charge dominated beam matching with chicane will be presented.

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Wednesday Poster Session / 926

Comparison on the superconducting properties of Nb and NbTiN thin films produced by both HiPIMS and bipolar HiPIMS

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Most superconducting thin films found on SRF cavity are generally produced through magnetron sputtering using niobium (Nb) as target. Yet, this technique can still be improved as the resulting film lack in efficiency. Alternative materials such as NbTiN could potentially be used with significant improvement compared to pure Nb films. Here, we report the use of both high-power impulse magnetron (HiPIMS) and bipolar HiPIMS to produce superconducting thin film, with a particular attention on the optimal conditions to enhance the film growth highly dependent on the pressure and power conditions. We used both mass spectroscopy and a retarding field analyzer to analyze the plasma chemistry providing information on the mass/energy of the ions formed. The surface of the resulting films was analyzed by XPS and SEM and their superconducting properties were characterized by measuring the Tc, RRR and low RF.

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Tuesday Poster Session / 927

Real time monitoring of the crystal collimation system at the CERN Large Hadron Collider

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At the CERN Large Hadron Collider (LHC), bent crystals play a crucial role in efficiently redirecting beam halo particles toward secondary collimators used for absorption. This innovative crystal collimation method leverages millimeter-sized crystals to achieve deflection equivalent to a magnetic field of hundreds of Tesla, significantly enhancing the machine's cleaning performance particularly when running with heavy ion beams. Nevertheless, ensuring the continuous effectiveness of this process requires the optimal channeling angle with respect to the beam to be constantly maintained. The primary goal of this study is to improve the monitoring of crystal collimation by providing a tool that detects any deviations from the optimal channeling orientation. These deviations can arise from both crystal movement and fluctuations in beam dynamics. The ability to adapt and compensate for these changes is crucial for ensuring stable performance of crystal collimation during LHC operation. To achieve this, a feedforward neural network (FNN) was trained using data collected during the 2023 lead ion physics run at the LHC. The results demonstrate the network's capability to supervise these crystal devices, accurately classifying when the crystal is optimally aligned with respect to the circulating beam. Furthermore, the model provides valuable insights into how to adjust the crystal's position to restore optimal channeling conditions when required.

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Wednesday Poster Session / 928

Beam studies using a Cherenkov diffraction based beam position monitor for AWAKE

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A beam position monitor based on Cherenkov diffraction radiation (ChDR) is being investigated as a way to disentangle the signals generated by the electromagnetic fields of a short-pulse electron bunch from a long proton bunch co-propagating in the AWAKE plasma acceleration experiment at CERN. These ChDR BPMs have undergone renewed testing under a variety of beam conditions with proton and electron bunches in the AWAKE common beamline, at 3 different frequency ranges between 20-110 GHz to quantify the effectiveness of discriminating the electron beam position with and without proton bunches present. These results indicate an increased sensitivity to the electron beam position in the highest frequency bands. Furthermore, high frequency studies investigating the proton bunch spectrum show that a much higher frequency regime is needed to exclude the proton signal than previously expected.

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Monday Poster Session / 929

Development of numerical tools for intra-beam scattering modelling

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Intra-beam Scattering (IBS) is one of the main mechanisms of emittance blowup and performance deterioration in the Large Hadron Collider (LHC) accelerator complex. It is particularly relevant since the recent upgrades across the injector complex to reach the high brightness beams of the High Luminosity LHC (HL-LHC) era have been implemented. Several studies have focused on developing an accurate formalism to describe IBS, and the integration of IBS in codes such as, e.g. MAD-X, is widely used in the accelerator physics community. This study presents the latest developments of a Python package for IBS simulations, recently developed at CERN, meant for integration with the Xsuite ecosystem. The new capabilities of the Python code are detailed and a thorough benchmark against existing codes is presented, for various machines of the CERN accelerator complex in different configurations.

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Thursday Poster Session / 930

Mini-beta optics commissioning at the ESRF-EBS

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Co-authors: Gaël Le Bec [1]; Nicola Carmignani [1]; Reine Versteegen [1]; Simone Liuzzo [1]

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The European Synchrotron Radiation Facility (ESRF) presently operates with the Hybrid Multi-Bend Achromat (HMBA) lattice that features ⍰-functions of 6.9 m and 2.7 m in the horizontal and vertical planes at the center of the straight sections. New optics were designed to increase the brilliance of beam lines with a single undulator placed at the center of the straight section. The reduction of the in-vacuum undulator gap and of the beta-functions both contribute to this increase. This paper reports on the optics beam commissioning results and experimental observation with the reduced in-vacuum undulator gap.

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Tuesday Poster Session / 931

Slow extracted spill ripple control in the CERN SPS using adaptive Bayesian optimization

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The CERN Super Proton Synchrotron (SPS) offers slow-extracted, high-intensity proton beams at 400 GeV/c for 3 fixed targets in the CERN North Experimental Area (NA) with a spill length of about 5 seconds. Since first commissioning in the late seventies, the NA has seen a steady increase in users, many of which requiring improved spill quality control. Slow extraction is sensitive to small perturbations with the effect of reduced spill quality. While some of these effects have been addressed in recent years, continuous compensation of intensity fluctuations at 50 Hz harmonics originating from power converter ripple has been particularly difficult to achieve. In 2023, the deployment of two techniques - "Empty-Bucket Channeling" and active control with Adaptive Bayesian Optimization –resulted in a significant suppression of these intensity modulations. This paper focuses on using Adaptive Bayesian Optimization for 50 Hz harmonic control. The chosen algorithm is described, together with details of integration in the CERN control system. The 2023 results are presented and complemented with an overview of the next steps.

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Thursday Poster Session / 932

Hardware Commissioning of the HL-LHC Inner Triplet String Facility at CERN: Individual System and Short Circuit Tests

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The goal of the High Luminosity-Large Hadron Collider (HL-LHC) Inner Triplet (IT) String test, is to validate the assembly and connection procedures and tools required for its construction, to assess the collective behavior of the superconducting magnet chain in conditions as close as possible to those of their operation in the HL-LHC and to provide a training opportunity for the equipment teams for their work in the LHC tunnel. The IT String includes the systems required for operation at nominal conditions, such as the cryogenics, powering and quench protection systems. This contribution describes the individual system and short circuit tests performed at the IT String as part of the hardware commissioning and preparation for the full exploitation of the facility.
After describing the IT String infrastructure, the individual system tests performed on the cryogenic and the associated vacuum systems are detailed. Moreover, the individual system and short circuit tests executed on the warm powering systems part of the magnet circuit including power converters, energy extraction systems and the DC connections are described. The powering interlock controller used for the global interlocking of the magnet circuits is also validated during this phase. The tests described involve the same steps as those planned for the LHC collider. Therefore, they validate the systems to be installed and ensure the time-efficient execution of activities for the HL-LHC project.

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Tuesday Poster Session / 933

Emittance blow-up with a magnetic shaker at different chromaticities

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The ESRF-EBS storage ring is operated with constant vertical emittance at 10 pm. The emittance blow-up is obtained with a magnetic shaker exciting the beam with a noise in a range of frequencies including the betatron tunes. The amplitude of the shaker is tuned by a feedback depending on the measured emittance. The coherent oscillations given to the beam by the shaker at each turn become incoherent thanks to the chromaticity and the amplitude detuning. Simulations and measurements have been performed to assess the efficiency of the emittance blow-up as a function of the chromaticities.

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Tuesday Poster Session / 934

Dynamic aperture in a wiggler dominated ring electron cooler of the EIC

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The Ring Electron Cooler (REC) is currently under design for use in the Electron Ion Collider (EIC) for hadron cooling. In this device the hadrons are cooled by the electrons and the electrons are cooled through radiation damping, which is enhanced by a number of 4 meter-long wigglers with 2.4 T field. When optimizing the beam envelope, intra beam scattering and Touschek scattering are also considered. Using a field configuration with additional focusing to keep the emittance at an acceptable value, these wigglers make up a substantial portion of the ring, with the wiggler section contributing the majority of the ring's chromaticity. In this paper, the effects of the REC's unusual properties on dynamic aperture are analyzed and a correction scheme is proposed.

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Optimization of a longitudinal bunch merge gymnastic with reinforcement learning

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Co-authors: Auralee Edelen [2]; David Sagan [3]; Georg Hoffstaetter [3]; John Morris [1]; Keith Zeno [1]; Kevin Brown [1]; Linh Nguyen [1]; Malachi Schram [4]; Natalie Isenberg [1]; Vincent Schoefer [1]; Weijian Lin [3]; Yinan Wang [5]

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The RHIC heavy ion program relies on a series of RF bunch merge gymnastics to combine individual source pulses into bunches of suitable intensity. Intensity and emittance preservation during these gymnastics require careful setup of the voltages and phases of RF cavities operating at several different harmonic numbers. The optimum setting tends to drift over time, degrading performance and requiring operator attention to correct. We describe a reinforcement learning approach to learning and maintaining an optimum configuration, accounting for the relevant RF parameters and external perturbations (e.g., a changing main dipole field) using a physics-based simulator at BNL Booster.

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TUCN: Photon Sources and Electron Accelerators (Contributed) / 937

Vertical beam halo characterisation at the ESRF EBS for operation with reduced in vacuum undulator gap

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The vertical beam halo is the main limitation for very low gap operation of in-vacuum undulators at the ESRF EBS. The vertical halo is due to Touschek electrons with large energy deviation crossing some betatron resonances. The crossing of the resonances can transfer horizontal momentum to vertical momentum. The beam halo has been characterized and measured and different low halo optics have been studied and tested to allow the operation of the machine with lower in-vacuum undulator gaps.

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TUAD: Hadron Accelerators (Contributed) / 938

Simulation and study of the nuSTORM (neutrinos from Stored Muons) experiment

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The nuSTORM experiment aims to create neutrino beams through muon decay in a storage ring, targeting %-level precision in flux determination. With access to two neutrino flavors, it enables precise measurement of nu-A cross sections and exhibits sensitivity to Beyond Standard Model (BSM) physics. With muons in the 1-6 GeV/c momentum range, it covers neutrino energy regimes relevant to experiments like DUNE and T2HK. Additionally, nuSTORM serves as a step towards a muon collider, a proof of concept for storage rings, and a test for beam monitoring and magnet technologies. The lattice structure consists of a pion transport line and a racetrack storage ring based on a hybrid FFA design, with conventional FODO cells in the production straight combined with FFA cells in the return straight and arcs. Using the nuSIM framework and BDSIM, this study simulates and optimizes the nuSTORM lattice, using beams from existing proton drivers. Using GENIE, neutrino events and their rates at the detector at different energies are also presented. The creation of synthetic neutrino beams like nuPRISM, allowing for >65% narrower neutrino beams than the natural muon decay spectrum is also discussed.

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Thursday Poster Session / 939

3D integration methodologies of the accelerators at CERN

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The 3D design of large accelerators like the Large Hadron Collider (LHC) requires coordination among equipment, services, and infrastructures. As numerous systems are designed, procured, and installed, 3D integration studies are important steps at any stages of a project, starting from the conceptual phase with space reservations, envelopes and interfaces, followed by the technical design phase managing the detailed and simplified 3D models, and finishing by the installation phase with follow-up of discrepancies. While the first phases serve to validate the accelerator configuration and design, the installation phase is followed by a reverse engineering process to verify the 'as-built'configuration, representing the final actual setup of the accelerator. At CERN, the 3D integration office for the accelerators assumes responsibility for collecting, aggregating, centralizing, and checking the 3D models provided by CERN design offices such as equipment owners, electrical, civil engineering, metallic structure, transport, handling, cooling, and ventilation services. This office manages 3D space, avoiding mechanical interferences before and during the installation phase. This paper describes the CAD, PDM and PLM methodologies used for 3D integration of the accelerators at CERN, highlighting their critical aspects and specificities.

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THBN: Accelerator Technology and Sustainability (Contributed) / 940

Lifetime of non-evaporable getter thin films over repeated activation

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Non-evaporable getter (NEG) coatings are used in accelerator beamlines to create an area of distributed pumping, allowing less external pumps to be installed, and smaller diameter tubes to be used. Both giving way to greater space for magnet arrays to better control the beam within, allowing more efficient accelerators to be produced. To work, NEG coatings must be activated by heating to a set temperature for 24 hours. This temperature depends on the properties of the NEG coating, and requirements of the system. The coating is then able to pump residual gasses out of the vacuum system, until it becomes saturated and will once again need activating. Over its a lifetime, a NEG coating will be activated and saturated numerous times, each time reducing the available sites for molecules to diffuse to during activation. Thus, eventually, the NEG coating will lose its capability, and will no longer be able to reach the same pumping capacity from the same activation regime. This study investigates the limits of NEG lifetimes, looking at the effect of multiple activations on the same coating. Samples of diameter 35 mm and length 50 cm were characterized by CO and H2 injections, from which the sticking probabilities and NEG coating capacity could be obtained. The samples were activated numerous times to see any degradation of the NEG coating. The results will be presented and discussed at IPAC 2024.

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Thursday Poster Session / 943

3D integration of FCC-ee RF systems targets and challenges

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Following the study progress on the FCC-ee radiofrequency systems (i.e. length of the cryomodules), general services infrastructure (i.e. electrical, cooling, ventilation), transport and handling volumes, and alignment requirements, the 3D integration evolved with a new configuration scenario. This paper describes the new proposal to locate the collider RF elements (400 MHz and 800 MHz cryomodules) at point H, and the booster RF elements (800 MHz cryomodules) at point L, without changing the 5.5 m inner diameter tunnel.

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Tuesday Poster Session / 945

Sub-picosecond long-wave infrared laser for advanced accelerators

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Ultra-intense, ultra-fast, near-infrared (NIR) solid-state lasers based on chirped pulse amplification (CPA) are main radiation sources to support strong-field scientific research. At the same time, the wavelength scaling of fundamental physical processes calls for extending the spectral coverage into the long-wave infrared (LWIR) domain (8–14 µm). Using optical transitions between vibrational energy levels of molecular gases offers a direct way to access laser wavelengths an order of magnitude beyond those of typical NIR lasers which are based on electronic transitions. CO2 laser operating at 10 µm stands out among molecular gas lasers for its energy efficiency. Our recent breakthroughs in CO2 laser technology, including the first ever implementation of the CPA technique for molecular gas lasers, have made it possible to generate single 2-ps pulses with the peak power of 5 TW. Based on the example of Brookhaven's multi-terawatt, picosecond CO2 laser system, we discuss ongoing R&D aimed at advancing ultra-intense LWIR lasers into the sub-picosecond regime. In our recent experiment, several-joule, 700 fs pulses have been demonstrated at 9.2 µm opening the way to potentially achieving tens of terawatt peak powers in few optical cycles. The use of such lasers might benefit a variety of applications including laser wake field electron acceleration and electrostatic shock wave ion acceleration briefly reviewed here.

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Thursday Poster Session / 947

IMPACT-T simulation for the latest coherent electron cooling pop experiment

Author: Kai Shih[1]

Co-authors: Gang Wang [1]; Igor Pinayev [1]; Irina Petrushina [2]; Jun Ma [1]; Vladimir Litvinenko [3]; Yichao Jing [1]

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This paper presents the results of the IMPACT-T simulation conducted for the latest iteration of the Coherent Electron Cooling (CeC) Pop Experiment at Brookhaven National Laboratory (BNL). The CeC experiment aims to demonstrate the principles of CeC, a rapid cooling technique designed for high-energy hadron beams. In addition to presenting simulation results for the current lattice parameters, this paper includes a discussion of previous benchmarking results obtained from IMPACT-T simulations and real CeC experiments. These comprehensive simulations not only facilitate the fine-tuning of CeC lattice parameters but also offer insights into the ongoing performance enhancements, all aimed at achieving exceptional beam quality.

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Thursday Poster Session / 949

Preparation for the conditioning of the MYRRHA CH-Cavities and testing of a new coupling loop design

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At the Institute of Applied Physics (IAP) at the University of Frankfurt, a new type of coupling loop has been designed in cooperation with the company Kress. The prototype of the 175 MHz FRANZ-RFQ and the developed coupling loop are currently in the low-power measurement phase, including vacuum tests. At the same time, a permanently installed station will be established in the experimental hall, which will enable simultaneous conditioning in up to three different power ranges with a maximum output of 50 kilowatts. This facility will enable the conditioning of CH-Cavities as part of the MYRRHA project in the future.

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Thursday Poster Session / 950

The high level software of the beam position limits detector system for APS upgrade accelerator storage ring

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A new Machine Protection System (MPS) and the Beam Position Limits Detector (BPLD) system are being developed for APS Upgrade (APS-U) accelerator storage ring. The MPS/BPLD system consists of one main MPS and 20 local MPS/BPLD controllers distributed around the ring, each local controller is located on every odd double sector. Each LMPS handles one double sector. Each double sector can be equipped up to seven Libera BPM electronics units. Each Libera unit processes up to four BPMs at Turn-by-Turn (TbT) rate. The Beam Position Limits Detector (BPLD) provides two types of protections: BPLD-ID and BPLD-BM for insertion device (ID) front-end (FE) and bending magnet (BM) incident radiation protection respectively. We select bumps using orbit feedback in a machine simulation to test the position limits of the system consistent with accelerator physics requirements for stable beam. This paper introduces the high level software implementation of APS-U BPLD-ID and BPLD-BM validation.

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Thursday Poster Session / 952

Experimental measurement of the second-order transit time factor in a single-cell RF cavity for relativistic electron beams

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In this paper, we present a concise measurement of the Second-Order Transit Time Factor(TTF) of the relativistic electron beams within the bunching cavity of the Coherent Electron Cooling (CeC) Pop Experiment. Our study outlines a specialized measurement methodology that tackles the unique challenges posed by the CeC accelerator environment. The results not only provide significant insights into controlling CeC beam dynamics but also critically validate the theoretical prediction of the Second-Order TTF for relativistic electron beams. This work advances our understanding of beam dynamics and enhances the efficiency and control of CeC-based systems.

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Wednesday Poster Session / 953

Demonstration of time-resolved diagnostic in coherent electron cooling pop experiment

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We present a demonstration of time-resolved diagnostics within the Coherent Electron Cooling (CeC) Pop Experiment. This technique utilizes a combination of a focusing lattice, transverse deflecting cavity, and YAG screen, along with unique analytical techniques, to precisely measure and analyze the longitudinal profile information of the CeC electron beams. Additionally, our measurement of slice quantities contains slice emittance, slice current, and slice Twiss parameters. Through comprehensive analysis of these key parameters, we acquire essential information that aids in the detailed control of the beam instability of the CeC electron beams. This ultimately enhances our understanding of beam dynamics and contributes to the optimization of performance within the Coherent Electron Cooling system.

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Tuesday Poster Session / 955

Energy chirp control using transverse deflecting cavities at the Argonne Wakefield Accelerator

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A very high electron peak current is needed in many applications of modern electron accelerators. To achieve this high current, a large energy chirp must be imposed on the bunch so that the electrons will compress when they pass through a chicane. In existing linear accelerators (LINACs), this energy chirp is imposed by accelerating the beam off-crest from the peak fields of the RF cavities, which increases the total length and power requirements of the LINAC. A novel concept known as the Transverse Deflecting Cavity Based Chirper (TCBC) [1] can be used to actively impose a large energy chirp onto an electron beam in an accelerator, without the need for off-crest acceleration. The TCBC consists of 3 transverse deflecting cavities, which together impose an energy chirp while cancelling out the transverse deflection. An experiment is being developed to demonstrate this concept at the Argonne Wakefield Accelerator (AWA) facility. Here we explain the concept, show preliminary simulations of the experiment, and report on progress related to implementation of the experiment at AWA.

Footnotes:

[1] N. Yampolsky, E. I. Simakov, and A. Malyzhenkov, "Imposing strong correlated energy spread on relativistic bunches with transverse deflecting cavities,"Phys. Rev. Accel. Beams 23, 054403 (2020).

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Wednesday Poster Session / 956

Proposed muon collider proton driver R&D at SNS

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Generation of a muon beam at a Muon Collider requires relatively short, high-charge proton bunches. They are produced in a high-average-power proton driver by first accumulating a proton beam from a super-conducting linac, then bunching the beam and finally compressing and combining the bunches into a single high-intensity proton pulse. All of these beam formation stages involve handling of unprecedentedly high beam charges. Validation of these intricate beam manipulations requires better understanding of extreme space-charge effects and experimental demonstration. A facility perhaps most closely matching the proton driver configuration and beam parameters is the SNS accelerator complex at ONRL. Considering the energy scaling of the space-charge parameters, many of the beam formation steps planned for the proton driver can be experimentally checked at the SNS at the relevant space-charge interaction levels. This paper discusses potential proton driver R&D at the SNS.

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Thursday Poster Session / 957

Generation of symmetrical optical caustic beams for precise alignment

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Generating layers of symmetrical optical caustic beams using a specific configuration of cylindrical lenses is an innovative idea with potential application in precision alignment and other fields. The technique allows the generation of layers of non-diffracting beams with opposite accelerating directions. This approach can be extended in two dimensions or to create rotationally symmetric beams. Prior methods have produced similar beams using spatial light modulators, but the presented approach with cylindrical lenses reduces setup complexity and cost, thereby opening the possibility for new applications. In the context of particle accelerators, these include particle acceleration using high-power lasers and alignment of accelerator components. The presented research emphasizes the possibility for this technique to be used as a reference line for precise alignment. It allows the generation of reference lines with a thickness in the order of millimeters for distances of tens to hundreds of meters, which is advantageous for large accelerator facilities. A brief description of the sensors used to detect misalignment is also presented.

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Tuesday Poster Session / 958

PIP-II laser beam profile monitor laser system

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Fermilab is currently engaged in the development of an 800 MeV superconducting RF linac, aiming to replace its existing 400 MeV normal conducting linac. PIP-II is a warm front-end producing 2 mA of 2.1 MeV H-, followed by a sequence of superconducting RF cryomodules leading to 800 MeV. To mitigate potential damage to the superconducting RF cavities, PIP-II uses laser-based monitors for beam profiling via photoionization. This abstract provides an update on the project's beam profiling, focusing on advancements made since the initial prototype. The prototype profile monitor featured a high-repetition-rate, low-power fiber laser and fiber optic transport that was tested with a 2.1 MeV H- beam at the PIP-II Injector Test (PIP2IT) accelerator. Since then, the fiber laser and fiber transport have been upgraded to a diode laser based system and free-space optical transport. This highlights a significant evolution in the laser system, enhancing its efficiency and adaptability. This talk will focus on a variable pulse width drive laser system via gain-switching, and the stability of a free-space propagated optical beam. In addition, this presentation will also share findings related to transverse and longitudinal beam profile measurements given different laser profiles.

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Monday Poster Session / 959

Correction of the detector solenoid effect in the hadron storage ring of the Electron-Ion Collider

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The Electron Ion Collider design strategy for reaching unprecedented luminosities and detection capabilities involves collision of flat bunches at a relatively large crossing angle. The collision geometry is further complicated by a tilt of the Electron Storage Ring plane with respect to that of the Hadron Storage ring. In addition, the interaction point is placed inside the field of a detector solenoid. Reaching the design luminosity requires a precise control of the 6D bunch distribution at the IP accounting for all of the aforementioned design features. Effective head-on collisions are restored using crab cavities, which introduce a correlation of the particles' transverse coordinates with their longitudinal positions in the bunch, or crab dispersion. This paper describes local correction of the detector solenoid effect on the collision dynamics in the Hadron Storage Ring. The closed orbit distortion of the hadron beam by the solenoid is compensated at the interaction point and is localized to its nearby region by a set of dipole correctors. The solenoid effect on the bunch distribution parameters is corrected at the interaction point and localized to the interaction region using a set of skew quadrupoles in the adjacent sections of the ring. The Electron Ion Collider case is unique in that, in addition to the usual correction of transverse coupling and momentum dispersion, we also consider control of the interaction plane orientation and of the crab dispersion.

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THBD: Beam Dynamics and Electromagnetic Fields (Contributed) / 960

Bunch lengthening induced by a combination of higher-harmonic cavities of different order in low-emittance rings

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The next generation of light sources aim to provide bunch beams with small transverse emittances. A common feature in the design of light sources with small emittance lattices is the small value of the momentum compaction, which implies a short nominal equilibrium bunch length. Combined with the small transverse emittances, a short bunch length can pose severe limitations on the beam lifetime caused by collective effects such as intra-beam and Touschek scattering. To improve the beam lifetime of the bunches, an efficient way is to use a Higher-Harmonic Cavity (HHC) system, which leads to an increase of the equilibrium bunch length without an increase of the energy spread. Besides the improvement of beam lifetime, the HHC system plays an important role to cure beam instabilities and mitigate possible beam induced heating issues of the storage ring vacuum components. Present HHC systems are based on HHCs of the same order. To increase the bunch lengthening factor induced by the HHC system, we investigate a novel scheme based on the combination of HHCs of different order. The feasibility and performance of the novel scheme will be studied with the beam dynamics codes SPACE and Elegant, with parameters of the NSLS-II upgrade.

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Monday Poster Session / 962

Luminosity maximization in a small vertex region at RHIC

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Co-authors: Chuyu Liu [1]; Deepak Raparia [1]; Grigor Atoian [1]; Guillaume Robert-Demolaize [1]; Haixin Huang [1]; Joanne Beebe-Wang [1]; Keith Zeno [1]; Kirsten Drees [1]; Michiko Minty [1]; Vincent Schoefer [1]; Wolfram Fischer [1]; Xiaofeng Gu [1]; Yun Luo [1]

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For the 2024 100 GeV proton run at RHIC, the new sPHENIX detector will require a maximum amount of collisions within ±10 cm of its central Interaction Point (IP), and preferably few or no collisions outside this range. To maximize the collisions within the vertex, a large crossing angle of up to 2 mrad will be used, operating the Large Piwinski Angle (LPA) scheme. To compensate for the reduction in luminosity from the large Piwinski angle, a β=50 cm lattice has been designed and supported with dynamic aperture simulations. To further compensate the luminosity reduction, injector studies have been performed to support up to a 45% increase in the injected intensity relative to the previous 100 GeV run in 2015.1

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Wednesday Poster Session / 963

Single unified model of a CCT dipole using 3DEXPERIENCE platform

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The concept of a single unified model for designing accelerator magnets has long been sought. Any meaningful virtual twin model must embody the ability to simulate the electromagnetic, thermal and structural performance of the device, as well as retaining the full geometric, materials and manufacturing information. Not only this, but the virtual twin must be able to respond to a design change and identify that either some of the simulations need to be repeated to capture the effect of the design change or to reliably identify that the last simulation results available were from a previous virtual prototype. As the fields of interest in these magnets are particularly sensitive to small geometric perturbations, accurate simulation capabilities are required to capture both electromagnetic and mechanical effects. Finally, the ability to optimize the design accounting for input from multiple areas of physics is paramount.
In this paper, the authors report how the Dassault Systemes 3DEXPERIENCE Platform has been used to create a robust and efficient virtual twin model of a canted cosine theta dipole structure, leveraging the electromagnetic simulation tools CST Studio Suite® and Opera®, the structural solvers available on the 3DEXPERIENCE Platform, and the embedded optimization functionalities. All of the physics simulation and optimization processes share a single parametrized CAD geometry, which provides the flexibility for model design variation and rapid prototyping.

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Monday Poster Session / 964

Development of FFA RLA design concept

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A single wide-momentum-acceptance FFA beam line allows for recirculating a beam several times through a linac. Such a scheme provides an efficient path towards high-energy, high-power continuous beams. This paper describes the development of a conceptual design of an FFA RLA focusing on but not limited to a high-power hadron beam case. We present a complete optics design including arc, linac, and matching sections. The matching sections are implemented following the adiabatic approach whereby matching of all beam passes occurs simultaneously within a single beam line. Harmonic correction is applied for precise orbit and optics control of the individual passes. We discuss approaches to optimization of the linac timing and control of the longitudinal beam dynamics.

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Tuesday Poster Session / 965

Progress in the design of the future circular collider FCC-ee interaction region

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In this paper we discuss the latest developments for the FCC-ee interaction region layout, which represents one of the key ingredients to establish the feasibility of the FCC-ee. The collider has to achieve extremely high luminosities over a wide range of center-of-mass energies with two or four interaction points. The complex final focus hosted in the detector region has to be carefully designed, and the impact of beam losses and of any type of synchrotron radiation generated in the interaction region, including beamstrahlung, have to be evaluated in detail with simulations.
We give an overview of the progress of the whole machine-detector-interface-related studies, among which are the updated mechanical model of the interaction region, the plans for a novel R&D activity of a IR mockup which is just starting, the collimation scheme and evaluation of beam induced backgrounds in the detectors, evaluation of radiation dose in the experimental area, and MDI integration with the detector.

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Tuesday Poster Session / **966**

Upgrade specifications for the booster main magnet power supply

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The current Booster Main Magnet Power Supply (MMPS) has a maximum power draw of 18 MW drawn directly from the AC power line. To support this high power draw, the Booster has a dedicated 69 kV substation. The Rapid Cycling Synchrotron for the Electron Ion Collider will also require a 69 kV substation. To free the existing 69 kV substation, the Booster MMPS will be upgraded to a capacitor style power supply. This paper documents the power supply requirements.

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Tuesday Poster Session / **967**

Simulations of polarized helions in the hadron storage ring

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The Electron Ion Collider calls for collisions of helion beam on polarized electron beams. Polarized helions will be injected into the Hadron Storage Ring at $|G\gamma| = 49.5$ and have a maximum energy corresponding to $|G\gamma| = 820$. Simulations of helions in this energy range have been performed using zgoubi. These studies quantify the polarization transmission with six snakes and also categorize the lattice constraints.

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Monday Poster Session / 969

The UK XFEL conceptual design and options analysis - mid-term update

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The UK XFEL project is now mid-way through its three-year Conceptual Design and Options Analysis (CDOA) phase. The purpose of this phase is to develop concepts to meet the required 'next-generation'XFEL capabilities identified in the project's comprehensive, peer-reviewed, Science Case, which was developed by UK academia. The envisaged next-generation features are a step-change in both the number of simultaneous experiments and in their capability –through multiple, combinable FEL sources delivering transform limited pulses across a wide range of photon energies and pulse durations, together with a comprehensive array of synchronized sources including high power lasers and particle beams. The project is assessing options to achieve this either via a new UK-based facility or by investment at existing XFELs, based on criteria including performance, cost, and environmental sustainability. The project is holding a series of Townhalls and other workshops around the UK (see https://xfel.ac.uk) and is building collaborations nationally and internationally. This talk will give an overview of progress to date and future plans.

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Wednesday Poster Session / 970

Resonator design optimization for a compact transverse-deflecting system

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Various design options have been studied and simulated using CST MICROWAVE STUDIO for a compact transverse-deflecting system proposed for diagnostics of extremely short electron bunches. The idea of the method is to use terahertz radiation, produced from optical rectification of the facility' s electron gun laser pulse. The proposed system is to be checked experimentally at the test facility FLUTE (Ferninfrarot Linac- und Test-Experiment) at Karlsruhe Institute of Technology (KIT).
The present paper is focused on the simulations of the resonator providing interaction between the electron bunch and the terahertz pulse. Two types of resonators and their arrays have been studied for this purpose: inverse split-ring resonator and tilted slit resonator. Different types of terahertz pulse structure have been studied, including plane wave and transversely focused (Gaussian) beam. Useful analytical models have been proposed to systematize the results of the simulations.

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Tuesday Poster Session / 971

A left-handed helical snakes for the HSR

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The Electron Ion Collider calls for polarized proton and helion beams on polarized electron beam collisions. To preserve polarization of polarized hadron beams, six full helical snakes will be installed. As there are currently 4 snakes in RHIC, the remaining two snakes will be made from existing rotator magnet coils. The rotator magnets are made from both right handed and left handed helicities. In order for a sufficient stock of spare coils, one snake will be made of left handed coils. Simulations using zgoubi show the left handed snake has sufficient range to provide the desired snake precession axes for helions and protons with the existing power supplies.

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Wednesday Poster Session / 972

Update of the PLACET2 code for the low-energy acceleration stages of the muon collider

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This work describes improvements made to the tracking code PLACET2 to make it possible to simulate the acceleration from 250 MeV to 63 GeV in a future muon collider. This software was selected because of its unique ability to optimally simulate recirculating linacs, which are part of the proposed layout for this initial muon acceleration stage. PLACET2 has been updated to simulate non-relativistic particles and to consider particle beams of different species, charges and masses. The main changes were introduced in the longitudinal dynamics, synchrotron radiation and wakefield descriptions. In addition, the decay of particles has been added as a new feature. The changes were benchmarked in different tests against RF-Track, a code able to simulate low energy muon beams and their decay. Finally, the lattice of the 16.6 GeV arc in the initial acceleration stage of the muon collider was simulated with both PLACET2 and RF-Track, providing another test. All the results showed excellent agreement between both codes, verifying the implementation in PLACET2.

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Tuesday Poster Session / 973

Solder cryogenic fatigue of the RHIC 12x150A current leads and mitigation for future operation

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A recent failure of the RHIC powering system has led to the discovery of cracked solder joint on the 12x150A current leads used to trim the superconducting magnet current in the interaction regions. These cracked joints are thought to have led to an electrical breakdown, first within the joint, and eventually across adjacent conductors of the same lead. An experiment has been set up to study the behavior of Sn96Ag4 solder joints under cryogenic temperature cycling in relevant conditions. Mitigation measures to minimize further crack propagation have been studied for the next RHIC run and will be discussed. This paper aims to describe our understanding of the solder cryogenic cracking issue encountered and present the mitigation measures for future RHIC operation.

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Thursday Poster Session / 974

Recent updates in the impedance characterization of the CERN PS Booster Finemet® RF system

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During the last long shutdown of the accelerators at CERN (LS2), the main radio frequency system of the Proton Synchrotron Booster (PSB) was upgraded. A wideband system with Finemet® magnetic alloy cavities driven by solid-state amplifiers replaced several different ferrite-loaded cavities. In measurements post-LS2, the longitudinal beam stability did not match predictions, which triggered a survey of the PSB impedance model. This started with the Finemet® RF system, which are expected to be the dominant impedance contribution. Single stretched wire measurements were carried out on a 6-cell Finemet® cavity test stand with different amplifier configurations. Measurement results and electromagnetic simulations are presented in this paper and compared to the previous impedance model. The total impedance of the cavity and amplifier system is discussed and analyzed with a combined CST studio and PSpice simulation. The electromagnetic characterization presented in this contribution will complement the beam-based impedance and low-level RF measurements as an input for the simulations of beam stability.

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Wednesday Poster Session / 976

Implementing NOECO at NSLS-II

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With the recently implemented lattice tool LOCOM, which combines the precision of LOCO as well as the speed of multi-frequency AC-LOCO, it takes only a few minutes for the NSLS-II lattice measurement and correction of both linear optics and coupling. Besides, LOCOM can be applied to characterize linear optics at the extremely high chromaticity condition, thus, greatly speeding up the development of a new operational mode with x/y chromaticity of +10/+10. The high chromaticity lattice could potentially enable a reliable operation of the storage ring with high single-bunch current. Moreover, to characterize the errors of chromatic sextupoles with high precision, we are in the process of implementing the NOECO based on the LOCOM method. Preliminary simulation study indicates that 1-2% precision can be achieved for the calibration of chromatic sextupole errors. If such high accuracy can be achieved, it could potentially help in resolving some long-standing challenges of NSLS-II, e.g., the discrepancy between the designed and measured tune shift with amplitude. Finally, to have an independent crosscheck, we have implemented the TBT based ICA NOECO method with a confirmed 2% accuracy.

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TUBD: Colliders and other Particle and Nuclear Physics Accelerators (Contributed) / 977

From RHIC to EIC hadron storage ring –overview of the engineering challenges

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The Electron Ion Collider (EIC) Hadron Storage Ring (HSR) will reuse most of the existing hardware from the RHIC rings. However, extensive modifications will have to be performed in preparation for the new accelerator parameters and performance required by EIC. The beam vacuum chamber will have to be upgraded and new beam position monitors (BPM) implemented to account for the higher beam intensity and shorter EIC hadron bunches. The RF system will also need to be upgraded and include new cavities to drive the new bunch parameters. In some straight sections, existing superconducting magnets will have to be reshuffled and their cold powering scheme modified to accommodate the new accelerator lattice. The hadron injection scheme will also be modified to accommodate three time more bunches and the machine protection system will need to include new collimators. This paper aims to give an overview of the engineering modifications required to turn RHIC into the EIC HSR.

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Monday Poster Session / 978

FLASH status –FEL user facility between two upgrade shutdowns

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FLASH, the XUV and soft X-ray free-electron laser user facility at DESY, is in the transitional period between two substantial upgrade shutdowns within the FLASH2020+ upgrade project. FLASH consists of a common part FLASH0 (injector & superconducting linac), two FEL beamlines (FLASH1/2) and an experimental beamline FLASH3, accommodating the plasma wakefield experiment FLASHForward. The first (2021/22) shutdown was aimed at upgrading FLASH0 and install an APPLE-III undulator in the otherwise unchanged beamline FLASH2, enhancing the third harmonic at flexible output polarization. The next (2024/25) shutdown will focus on the complete exchange of the FLASH1 beamline to allow for externally seeded operation in the range from 60 nm down to 4 nm at 1 MHz bunch repetition rate (600 µs trains at 10 Hz train repetition rate). We report on the operation

between the two shutdowns which was, to a large extend, dedicated to FEL operation for users and on the commissioning of the new features implemented in the last shutdown.

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Thursday Poster Session / 979

High fidelity numerical modelling and condition monitoring applied to septum magnets at CERN

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The CERN Accelerator Beam Transfer group has recently launched a study to investigate the life cycles of pulsed septum magnets. The development is aiming to enhance the prediction of anomalies, leading to reduced life cycles of these beam transfer equipment. For this reason, the standard vacuum operated, direct drive septa magnet has been chosen to investigate critical design features. In the initial project phase, a so called High-Fidelity (HF) numerical simulation has been carried out, providing insight on critical components, like brazed joints, reducing the fatigue life. In parallel a dedicated test setup with state-of-the-art instrumentation has been developed, allowing to confirm the predicted system response. The novel approach for the beam transfer equipment will allow to review presently established design criteria. In a further iteration, the project is now aiming to demonstrate an anomaly detection and their prediction based on novel machine learning techniques. This paper presents the initial phase of developing the HF model, as well as the results of the instrumented magnet tests which will be compared to results from the numerical simulations.

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Wednesday Poster Session / 980

Exploring the impact of surface roughness on optical transition radiation characteristics of a 10 keV electron beam

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This paper investigates the influence of surface roughness on the optical transition radiation (OTR) characteristics of a 10 keV electron beam incident on carbon steel targets. While OTR is well-established as a profile monitoring tool for relativistic charge beams, its viability for low-energy beams is still under scrutiny, primarily due to issues such as low yield and a wide angle of the radiation cone. This study explores the potential of exploiting the anomalously high intensity of OTR observed on rough surfaces for precise profile measurements of low-energy charge beams. A systematic examination of the dependence of OTR yield and polarization on surface roughness characteristics, beam current, and the incidence angle of the beam is presented. The results are discussed qualitatively, shedding light on the nuanced interactions between these parameters and OTR characteristics. Furthermore, OTR beam profile measurements are compared with those obtained using a scintillator, providing a comprehensive understanding of the effectiveness of OTR in capturing the beam profile at 10 keV. This research gives valuable insight into the use of OTR as a tool for diagnostics of low energy beams.

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Tuesday Poster Session / 981

Beam centroid studies at the Canadian Light Source

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The Canadian Light Source (CLS) storage ring RF frequency varies on timescales of seconds to days. Over approximately 20 years it has drifted from its design value. We outline and discuss our efforts to identify, disentangle and mitigate the potential sources of variations in the RF frequency on various timescales. These sources include the building temperature regulation, the orbit correction algorithm and the dipole power supply. Further, orbit correction generates an undesirable amount of beam

noise through the dispersion correction. We have ongoing efforts to understand and improve orbit correction and remove the noise it propagates into the RF frequency.

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Monday Poster Session / 982

Klystron HOMs in the 805 MHz SCCL at LANSCE

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The 805 MHz RF power plant at LANSCE has been in operation over 50 years. The RF amplifier system consists of 44 klystrons, which power each of the SCCL modules, currently running the H- beam. There exist several possible sources of instabilities in the beam-line. In this paper we examine the measurements performed in terms of the distribution of the RF power spectrum and its relation to the beam stability. The higher order mode (HOM) content of the 805 MHz klystrons at LANSCE was measured to locate the peaks in the output frequency spectrum. This spectrum allowed us to perform system calibrations at specific frequency locations and were used to calibrate the HOM content measurement. The Side Coupled Cavity Linac (SCCL) S-parameters were measured at the accelerator tank window, and the HOMs coupling to the linac were calculated using these measurements. These calculations of the acceptance of HOM in in the SCCL were used to model the HOMs, these were modeled with CST Microwave Studio to investigate the modes being excited and the intensity of these modes. We conclude with a discussion of the possible disturbances introduced to the H- beam by the presence of HOMs coupling from the klystron amplifier to the accelerator cavity structure.

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WEAN: Beam Dynamics and Electromagnetic Fields (Contributed) / 983

Latest progress on ACE3P modeling capabilities

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SLAC developed ACE3P is a parallel multi-physics electromagnetics (EM) simulation toolkit aiming for virtual prototyping of accelerator and RF component design, optimization and analysis. In this paper, we will present the latest progress on ACE3P modeling capabilities. First, for the time domain solver T3P, modeling of nonlinear materials with higher-order electric susceptibilities has been developed. It can be used to design the devices for THz accelerators and quantum information science. Second, for the particle tracking module Track3P, external DC fields calculated by the electrostatic solver embedded in the DC gun module Gun3P can be read in to model the use of DC bias in mitigating multipacting in accelerator structures. Third, a surface impedance boundary condition to treat a thin layer of lossy materials has been implemented in the frequency domain S-parameter module S3P. This enables calculation without explicitly building an extremely fine mesh in the layer and substantially reduces the computational cost when a much larger mesh would have been needed to resolve the field in the layer. Fourth, a code integration effort has been embarked to integrate Track3P with the radiation transport code Geant4 for modeling radiation effects for dark current in accelerator structures. The applications using these new model capabilities will be presented in the paper as well.

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Wednesday Poster Session / 984

Electron cloud simulations in the Fermilab booster using PyECLOUD

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As part of Fermilab's Proton Improvement Plan-II (PIP-II), the Fermilab Booster synchrotron will operate at a higher intensity, increasing from 4.5×1012 to 6.7×1012 protons per pulse. A potential challenge for achieving high-intensity performance arises from rapid transverse instabilities induced by electron clouds (EC). This research presents electron cloud simulations using PyECLOUD, which is an advanced computational tool that incorporates measurements of the secondary electron yield (SEY) from the Booster's combined function magnet material. By systematically varying beam parameters in PyECLOUD, such as bunch structure, bunch length, and intensity, the EC effects on beam stability and overall performance of Booster can be predicted.

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Tuesday Poster Session / 985

Final cooling with thick wedges for a muon collider

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In the final cooling stages for a muon collider, the transverse emittances are reduced while the longitudinal emittance is allowed to increase. In previous studies, Final 4-D cooling used absorbers within very high field solenoids to cool low-momentum muons. Simulations of the systems did not reach the desired cooling design goals. In this study, we develop and optimize a different conceptual design for the final 4D cooling channel, which is based on using dense wedge absorbers. We used G4Beamline to simulate the channel and Python to generate and analyze particle distributions. We optimized the design parameters of the cooling channel and produced conceptual designs (corresponding to possible starting points for the input beam) which achieve transverse cooling in both x and y by a factor of ˜3.5. These channels achieve a lower transverse and longitudinal emittance than the best design previously published.

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TUBN: Novel Particle Sources and Acceleration Techniques (Contributed) / 986

Staging of high-efficiency and high-quality laser-plasma accelerators for collider applications

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The viability of next generation, compact, TeV-class electron-positron colliders based on staging of independently-powered plasma-based accelerators relies on the possibility of accelerating high-charge bunches to high energy with high efficiency and high accelerating gradient, while maintaining a small energy spread and emittance. Achieving a small energy spread with high-efficiency requires employing witness bunches with optimally tailored current profiles (optimal beamloading). Such profiles are analytically known in the case of plasma-wakefield accelerators operating in the blowout regime, while in the case of laser-plasma accelerators (LPAs) can only by computed numerically, and their determination requires, among other things, taking into account the laser driver evolution. A small bunch energy spread is a necessary condition to enable staging and minimize emittance degradation from chromaticity when bunches are transported from one plasma accelerator stage to the following one. In this contribution we will discuss examples of LPA stages operating in different regimes, namely a self-guided stage in the nonlinear regime and a quasi-linear stage in a hollow plasma channel, providing high-gradient, high-efficiency, and quality-preserving acceleration of bunches for collider applications. We will present, for each example, the current profile distribution for optimal beamloading, and we will analyze bunch emittance degradation when staging of such LPAs is considered.

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Thursday Poster Session / 987

Generation femtosecond proton beam for laser plasma acceleration

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Laser plasma accelerators have a great potential to accelerate a charged particle beam to high energy within a short distance due to their extraordinarily high accelerating gradient. However, in order to effectively use the laser plasma accelerator, the input beam has to be moving at relativistic velocities, with a duration 100 femtoseconds or less. In this study, we propose a scheme to generate a femtosecond proton beam for the laser plasma acceleration. The self-consistent simulation including the three-dimensional space-charge effects was used to verify this concept in a simplified version.

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Thursday Poster Session / 988

Study of the performance and beam loss limitations during injection of high-intensity LHC proton beams

Author: Belen Salvachua[1]

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The LHC Injectors Upgrade project at CERN optimized the injection accelerator chain to deliver proton intensities per bunch of 2.3e+11 ppb. Throughout 2023, the LHC was filled with up to 2464 bunches per beam using a hybrid injection scheme, involving up to 236 bunches per injection, with a maximum intensity per bunch of 1.6e+11 ppb. These beam parameters already revealed significant beam losses at the primary collimator in Point 7 during injection, with large fluctuations from fill to fill, limiting in several cases the machine performance. This contribution analyses the performance of the LHC during injection and discusses possible improvements.

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Wednesday Poster Session / 990

Optimizing current density measurements for intense low beta electron beams

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The cathode test stand at LANL is utilized to test velvet emitters over pulse durations of up to 2.5 µs. Diode voltages range from 120 kV to 275 kV and extracted currents exceed 25 A and depend on cathode size and pulse duration. Current density measurements taken with scintillators or Cherenkov emitters produce inconsistent patterns that disagree with the anticipated beam profile. Several factors contribute to the measured beam distribution, such as electron scatter, X-ray scatter, and Snell's law. Here, we present a range of experiments designed to evaluate both electron scatter and Cherenkov emission limits in efforts to optimize current density measurements. For electron ranging studies, metal foils of different densities and thicknesses are coupled with a scintillator, which is then imaged with an ICCD. Similarly, Cherenkov emission and Snell's law are investigated through imaging materials with differing indices of refraction over a range of beam energies. MCNP6® modeling is utilized to further guide and evaluate these experimental measurements.

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Monday Poster Session / 991

Towards large phase space beams at the CEBAF injector

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We report on the status of a degrader device to generate large phase space beams for machine acceptance studies in the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab. The degrader device consists of thin, low-Z targets to degrade the electron beam phase space through multiple scattering, two apertures to define the maximum transverse emittance, and a solenoid to aid in matching to the rest of the injector beamline. The engineering design of the degrader device and projected degraded beam phase space parameters are presented.

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Low RF loss DC conductive ceramic for RF windows

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Charging of RF windows has historically been problematic, frequently resulting in damage to the window severe enough that the window needs to be replaced. Many attempts have been made to prevent charging and therefore improve window lifetime, the most successful and common of which is coating the window with titanium nitride (TiN). Surface coatings such as TiN rely on the secondary electron yield of the coating material being lower than that of the ceramic window material, reducing the number of electrons emitted from a variety of mechanisms. An alternative approach is to introduce a small amount of DC conductivity to the ceramic itself, turning the traditionally insulating window into a mildly conductive one. This allows any charge on the surface of the window to drain rather than build until a discharge happens. A magnesium titanate ceramic has been developed with a small DC conductivity and used to make RF windows. Several window assemblies have been produced and tested, including 1.3 GHz waveguide and 650 MHz coaxial designs. The results of the conductive ceramic window test program will be presented.

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Monday Poster Session / 993

Modeling and optimization of the FACET-II injector with machine learning algorithms

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Linear particle accelerators are elaborate machines that demand a thorough comprehension of their beam physics interactions to enhance performance. Traditionally, physics simulations model the physics interactions inside a machine but they are computationally intensive. A novel solution to the long runtimes of physics simulations is replacing the intensive computations with a machine learning model that predicts the results instead of simulating them. Simple neural networks take milliseconds to compute the results. The ability to make physics predictions in almost real time opens a world of online models that can predict diagnostics which typically are destructive to the beam when measured.
This research entailed the incorporation of an innovative simulation infrastructure for the SLAC FACET-II group, aimed at optimizing existing physics simulations through advanced algorithms. The new infrastructure saves the simulation data at each step in optimization and then improves the input parameters to achieve a more desired result. The data generated by the simulation was then used to create a machine learning model to predict the parameters generated in the simulation. The machine learning model was a simple feedforward neural network and showed success in accurately predicting parameters such as beam emittance and bunch length from varied inputs.

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Thursday Poster Session / 994

Electronic brachytherapy replacement of iridium-192

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The replacement of radionuclides used for cancer therapy with accelerators offers several advantages for both patients and medical staff. These include the elimination of: unwanted dose, specialized storage and transportation, and isotope production/replacement. Several electronic brachytherapy devices exist, and typically utilize an x-ray tube around 50 keV. These have primarily been used for skin cancer, though intraoperative applications are becoming possible. For several types of cancer, Iridium-192 has been the only brachytherapy treatment option, due to its high dose rate and 380 keV average energy. An accelerator-based alternative to Ir-192 has been developed, comprised of a 9.4 GHz, 1 MeV compact brazeless accelerator, narrow drift tube, and target. The accelerator is supported and positioned through the use of a robotic arm, allowing for remote delivery of radiation for internal cancer treatment. Preliminary results including dose rate and profile and plans for complete system demonstration will be presented.

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Thursday Poster Session / 995

The design of the proton-EDM injection line, from BNL AGS booster

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The proton Electric Dipole Moment (pEDM) storage ring to measure the electric dipole moment of the proton [1] is proposed to be built in the tunnel of the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory (BNL) by storage ring EDM (srEDM) Collaboration. We proposed that the AGS Booster to pEDM ring transfer and injection line (BtP) would use the partial portions of the existing BtA (AGS Booster to AGS) transfer line optics. In this practice, both of BtP Clockwise orientation (CW) and Counter-clockwise orientation (CCW) injection line are designed and matched in the hypothesis of a single turn injection scheme. The injecting beam-properties are matched to pEDM ring Twiss functions.

Footnotes:

[1] Zhanibek Omarov et al. Phys. Rev. D 105, 032001 (2022)

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Tuesday Poster Session / 996

ALS-U accumulator ring raft and dipole installation

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The ALS-U project is an upgrade to the Advanced Light Source (ALS) at the Lawrence Berkeley National Laboratory that aims to deliver diffraction-limited x-ray beams with an increased beam brightness of two orders of magnitude for soft x-rays compared to the current ALS facility. A nine-bend achromat lattice Storage Ring (SR) and a three-bend achromat Accumulator Ring (AR) will be installed in the facility in two phases. The AR is currently being installed in the ALS facility during its regularly planned shutdowns while the SR upgrade will follow during a 12 months shutdown. AR rafts and dipoles are being installed with ground based tooling and overhead crane lifting methods. This paper focuses on the AR installation. In particular we will describe the engineering design, prototyping and testing of the customized ground based installation tooling, which led to a successful installation of the first AR production rafts and dipoles in the ALS tunnel.

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Wednesday Poster Session / 997

Analog APS linac phase detector and digital phase detector test comparison

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Maintaining beam-accelerating structure RF phasing of a linac is crucial for maintaining optimal beam transport performance. At the Advanced Photon Soure (APS), in 2008 we implemented an analog phase detector system using the Analog Devices AD8302 phase detector chip. The APS phase detectors use as an S-Band RF phase reference an out-coupled signal from the waveguide supplying the accelerating structures with RF and an S-Band filtered RF signal from a bpm for the beam-RF system phase measurement. The phase detectors are used throughout the length of the linac in a control law to automatically maintain the beam on-crest phase condition during operations. We have obtained from Instrumentation Technologies two phase detection systems we evaluated as a possible upgrade path for the legacy APS phase detector system. The systems are the Libera LLRF and Libera cavity BPM products available from Instrumentation Technologies. We compare the performance of each system to induced phase changes using the APS Linac RF thermionic gun electron source.

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Wednesday Poster Session / 998

Non-invasive beam diagnostics using differentiable simulations and computer vision methods

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The direction of particle accelerator development is ever increasing beam quality, currents, and repetition rates. Advanced control techniques using machine learning are required for the optimization and operation of such accelerators. These techniques greatly benefit from having single-shot beam measurements. However, high intensity beams poses a challenge for traditional interceptive diagnostics due to the mutual destruction of both the beam and the diagnostic.
An alternative approach is to infer beam parameters non-invasively from the synchrotron radiation emitted in bending magnets. In this talk, we will discuss the development of such a diagnostic at FACET-II. Inferring the beam distribution from a measured radiation pattern is a complex and computationally expensive task. To address these challenges we use differential simulations and computer vision techniques. This enables both fast inference and uncertainty quantification of the beam parameters.

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Tuesday Poster Session / 999

Calculating the channelling efficiency of bent silicon crystals using two particle simulation programs: SixTrack and Xsuite

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A novel double-crystal experiment is being considered for installation in CERN's Large Hadron Collider (LHC) to measure precession properties of short-lived baryons such as Λc+. The experiment utilizes a first bent silicon crystal to deflect halo particles away from the circulating proton beam by 50 μrad. Further downstream, a second crystal is installed, which produces a significantly greater bending angle of 7 mrad. While the former is well established for operations in the LHC, the latter presents a new challenge for existing simulation tools. Using particle tracking programs, SixTrack and the newly developed Xsuite, we simulate a single pass experiment to calculate the expected channelling efficiency of these crystals. The results serve as a prediction for the performance of prototype crystals recently tested in CERN's North Area at 180 GeV/c, that are planned to be installed in the LHC in 2025 for use in the multi-TeV energy range.

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Tuesday Poster Session / 1000

Space charge simulation of proton beams in the AGS booster

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During RHIC Run24, the new sPHENIX detector will require a maximum number of collisions within ±10 cm of its central Interaction Point (IP) and using a large crossing angle of up to 2 mrad for 100 GeV protons. One of the proposed ways to compensate for the luminosity reduction due to the crossing angle is to increase the proton beam intensity injected into the AGS Booster by up to 45% relative to the previous 100 GeV run in 2015.
Space charge could well become a dominant effect in limiting the intensity of the beam that can be delivered to RHIC, and is a concern particularly in the lower energy stages of acceleration such as during injection of AGS Booster. To investigate the dynamics of proton beams with a higher intensity in the AGS Booster, a range of simulations including space charge have been performed. The studies are allied to known parameters and features of the machine. Optimizations have been carried out at various stages of the AGS Booster cycle covering features such as injection, beam bunching, and tune ramping, using simulations that take into account space charge effects. Full cycle simulations with space charge were carried out using the optimized tunes and timings for a range of beam properties, including intensity, emittance, and momentum spread.

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North America

Thursday Poster Session / 1001

Mechanical design, structural requirements and optimization of the FCC e+e- interaction region components

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This paper describes the mechanical design of the Future Circular Collider e+e- interaction region. The Future Circular Collider, as a forefront particle accelerator project, demands meticulous attention to the mechanical integrity and performance of its components, to the integration of the different systems and to the respect of the spatial constraint. The vacuum chamber design, the support tube and the bellows design are reported, highlighting the solutions adopted. The structural optimization method of the support structure is also presented, as well as the results obtained.

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Tuesday Poster Session / 1002

LANSCE 805 MHz klystron performance analysis

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Los Alamos Neutron Science Center (LANSCE) relies on 44 klystron modulator systems to feed the accelerating cavities and produce proton beam of 800 MeV. This paper focuses on the new VA-862A1 86kV 1.25 MW klystron units and aims to compare their performance with previously purchased units. Service hours for each klystron unit was used as the primary metric in the analysis and records from various sources cross-corroborated to confirm recorded information. Factors such as prior repair/rebuilds, factory acceptance tests and runtime notes were carefully inspected to provide a comprehensive view of the klystron performance during analysis. Klystron units currently being used in the LINAC were surveyed along with failed units and analysis performed to predict the next failure. The frequency and cause of failure was also compared with historical performance and failure data and results utilized for LANSCE SCCL performance optimization.

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Wednesday Poster Session / 1003

Ionization profile monitor for in-vivo dosimetry in medical accelerators

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In-vivo dosimetry is essential to deliver precise doses to patients in ion beam therapy. Real-time dose monitoring without disturbing the beam improves patient safety and treatment efficiency. It is critical for emerging treatment modalities like FLASH therapy due to the narrow dose tolerance. Existing real-time dosimetry devices are invasive to beam, necessitating a non-invasive dosimetry solution.
The gas-jet based beam profile monitor developed at the Cockcroft Institute (CI), UK is being studied for application in medical accelerator facilities. Recent measurements at the Dalton Cumbrian Facility, UK yielded promising results for beam monitoring at energies equivalent to medical beam. These studies have indicated the need to improve the gas-jet based Ionization Profile Monitor (IPM) to monitor dose in real time.
A new IPM detector system is under development at CI to reduce the monitor size and complexity and increase its sensitivity, resulting in fast acquisition, paving the way for real-time in-vivo dose monitoring. This contribution presents the design of the optimized IPM and its working principle based on electrostatic field and particle trajectory simulations.

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Tuesday Poster Session / 1004

Improve the injection with high energy for CAMD light source

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With Insertion devices adapted to Center of Advanced Microstructures and Devices (CAMD) light source. Injection has more difficulties at low energy. We have proposed some upgrade to the facility, but we would like to look for other choices. In the paper, we will mention the CAMD operation status, discuss raising electron energy method for injection, and simulate the transfer line. The practical upgrade will be proposed. The injection lattice at high electron energy will be available. The kicker parameter will be given.

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Wednesday Poster Session / 1005

Impact of medium temperature heat treatment on flux trapping sensitivity in SRF cavities

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Recently, the medium temperature alloying of SRF cavities at temperature of 200-400℃ in UHV resulted in an increase of the quality factor for increasing accelerating gradient. Studies suggest that medium temperature heat treatment dissolves the surface oxide within the RF penetration depth, therefore tuning the electronic mean free path to an optimal value to enhance the performance. Here, we present the results of measurement on several 1.3 GHz single cell cavity which were heat treated at different temperature between 200-400℃ to measure the effect of heat treatment on flux trapping sensitivity. The results show the correlation between the treatment temperature, quality factor, and flux trapping sensitivity.

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Wednesday Poster Session / 1006

Novel materials for beam acceleration

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Bulk niobium is currently the standard material for constructing superconducting radio frequency (SRF) cavities for acceleration in particle accelerators. However, bulk niobium is limited, and new materials and surface treatments may allow greater performance to be reached. We present progress on novel materials and treatments for SRF cavity fabrication.

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Tuesday Poster Session / 1008

Predicting the multi-turn channelling efficiency of a 7 mrad-bending silicon crystal in the Large Hadron Collider for TeV-range proton energies

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A double-crystal fixed-target machine experiment is planned for installation in CERN's Large Hadron Collider (LHC). This experiment features a 7 cm-long bent silicon crystal, with 7 mrad bend-angle to deflect particles produced by proton interactions with a target. As this crystal is more than an order of magnitude longer than any other installed in the LHC, it requires specific characterization, alignment and testing. Testing will begin using the LHC's proton beam at different beam energies, before considering studies of interactions with particles out scattered from a target. Using particle tracking programs, we simulate the expected signals from the angular alignment of this unique crystal with multi-turn halo particles of the circulating LHC proton beam. A range of beam energies is considered to evaluate the performance, as particles with a spread of energies are anticipated downstream of the target following their interaction with the 7 TeV beams in the final experiment. The simulation results provide a prediction of the crystal's multi turn efficiency as a function of energy and serve as a benchmark for the commissioning process to integrate this long crystal into the LHC.

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Thursday Poster Session / 1009

A multi-variable approach to mid-ranging control for unified operation of fast and slow correctors in fast orbit feedback system

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Advanced Photon Source Upgrade (APS-U) Fast Orbit Feedback (FOFB) system uses 160 fast and 160 slow corrector magnets to stabilize orbit measured at 560 Beam Position Monitors (BPM). We plan to operate both fast and slow correctors in a unified feedback algorithm at 22 kHz correction rate. Mid-ranging control is a proven approach for feedback systems with two manipulated inputs each exerting distinct dynamic effects to regulate a single output. This method resets the fast input to its chosen DC setpoint and proves beneficial when cost of fast input is more than the slower one. Unified operation of fast and slow correctors is a fitting application to mid-ranging concept which is well founded for two input one output systems. In this work, based on the cross-directional nature of the FOFB system we developed a multi-variable approach to mid-ranging control. It can be applied to FOFB with multiple fast and slow correctors, and multiple BPMs. Performance of proposed scheme is tested in simulations with APS-U FOFB prototype model in MATLAB. The feedback loop with fast and slow correctors is stable with mid-ranging algorithm, and the fast corrector drives effectively tracked setpoints.

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Wednesday Poster Session / 1013

Ionization profile monitors for the IOTA proton beam

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We present the design details and outline the construction progress of the Ionization Profile Monitors (IPMs). Two IPMs, designed for transverse beam size measurements of 70 MeV/c protons, are slated for installation—one horizontal and one vertical—in the IOTA ring. These IPMs are fast (1.8 microsecond, one turn), accurate (to better than 10%) and non-destructive diagnostics. They will play a pivotal role in facilitating comprehensive beam studies, particularly in investigating the dynamics of space-charge dominated proton beams in IOTA.

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Monday Poster Session / 1017

Initial results from 35 keV H+ beam at the LANL RFQ test stand

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The Los Alamos Neutron Science Center (LASNCE) is over 50 years old. Currently, Cockroft-Waltons are being used to accelerate H+ and H- beams to 750 keV. The LANSCE Modernization Project (LAMP) is proposing to replace the font-end of LANSCE with a Radio-Frequency Quadrupole (RFQ). A RFQ Test Stand is being commissioned at LANL for technical demonstration of simultaneous dual-beam species acceleration through a RFQ under the timing constraints required by the LANSCE users facilities. We will describe the status and present initial results of the 35keV H+ line on the RFQ Test Stand.

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Wednesday Poster Session / 1018

X-ray measurements in a prototype superconducting radiofrequency electron gun for LCLS-II-HE project

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Argonne National Laboratory is collaborating with MSU, HZDR, and SLAC on the design, fabrication, and testing of a prototype superconducting radiofrequency (SRF) gun for the LCLS-II-HE upgrade at SLAC. The gun cavity is a quarter-wave resonator with a frequency of 185.7 MHz. Despite careful calibration of the cavity field probe, there are still uncertainties in the RF measurements taken to determine quality factor and field level in the cavity. One way to independently check the RF measurements is to calculate the field level from the x-ray energy spectrum generated by field emission during testing. X-ray measurements were done with a sodium iodide detector. This paper presents results of x-ray energy spectrum measurements and compares it to the RF measurements of cavity field level at 18 MV/m and 21 MV/m. Numerical simulations are also presented to understand the acceleration and dynamics of field-emitted electrons.

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Wednesday Poster Session / 1019

Quantitative description and correction of longitudinal drifts in the Fermilab linac

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The Fermilab Linac accepts the 0.75 MeV H- ions from the front end and accelerates them to 400 MeV for injection into the Booster. Day-to-day drifts of the longitudinal trajectory in the Linac, reconstructed from phase readings of Beam Position Monitors, are at the level of several degrees. They are believed to cause additional losses both in the Linac and Booster, and are addressed by empirically adjusting the phases of Linac cavities. This work explores the option of expressing these drifts in terms of phase shifts in two cavities at the low-energy part of the Linac. Such description allows for a simplified visual representation of the drifts, suggest a clear algorithm for their compensation, and provides a tool for estimating efficiency of such compensation.

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Thursday Poster Session / 1021

Proton beam dynamics in bare IOTA with intense space-charge

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We are currently commissioning the Integrable Optics Test Accelerator at Fermilab to conduct beam dynamics experiments with 2.5 MeV protons, for transverse space-charge tune shifts approaching 0.5. In this study, we assess the anticipated emittance growth and beam loss as intensity varies, considering configurations where only the dipoles and quadrupoles are activated. Our analysis involves a comparison of results obtained from various simulation codes, including XSuite, PyORBIT, IMPACT-X, and MAD-X.

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Monday Poster Session / 1023

Differentiable modeling of Siberian Snakes in BNL's AGS: nonlinear maps, symplectic tracking, and optical compensation

Author: Eiad Hamwi[1]

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Meaningful prediction and enhancement of spin-polarization in the RHIC and EIC accelerators relies on accurate modeling of each sub-component. While nonlinear beam propagation and symplectic tracking is well established for common accelerator components, it has hitherto not been established for Siberian Snakes, which are essential for the acceleration of polarized protons in storage rings. Here we describe the first differentiable model, applied to both snakes of the AGS, which injects polarized beam into RHIC and the HSR of the EIC. This enables the full power of nonlinear maps to be applied to the AGS, including normal form theory and symplectic tracking. We show how important this is for long-term beam motion in the AGS: without the symplectic representations, simulated particle motion destabilizes during about 1000 turns spent close to injection energy. Including the new snake representations, the Bmad toolkit was used to optimize the closed orbit and the optics between injection and extraction, including corrections to the coupling and to the vertical dispersion

that the snakes currently create. Finally, we use simulation results to compare randomly generated lattice misalignments with surveying data measurements.

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Thursday Poster Session / 1024

Prototype control system for the Low Energy Branch ion beamline

Author: Matevz Skobe[1]

Co-authors: Ziga Brencic [1]; Mitja Kelemen [1]; Primoz Pelicon [1]; Klemen Bucar [1]; Matjaz Vencelj [1]; Jure Simcic [1]; Ziga Barba [2]; Anton Biasizzo [1]; Andrej Trost [2]

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We are developing a prototype control system for the Low Energy Branch (LEB) ion beamline at the Microanalytical Infrastructure Centre (MIC) of the Jozef Stefan Institute (JSI) in Ljubljana, Slovenia. This activity is ongoing simultaneously with the hardware construction of the ion beamline branch dedicated to the research with low-energy ion beams with energies from 1 to 30 keV.
The LEB instrumentation is categorized into: a) Ion sources, b) Ion beam transport optics, and c) Accessories, including specialized detector systems and devices, used to prepare and maintain optimal experimental conditions. Therefore, key functionalities of the control system include the control of devices like vacuum pumps, power supplies, etc., data acquisition from sensors and detector systems, and ensuring reliable autonomous operation for high-precision physics experiments [1]. The control system will be implemented within the Experimental Physics and Industrial Control System (EPICS) environment [2], providing us with the tools required to develop a comprehensive and scalable control system.
In this work, we present a block scheme, a device list, the control system architecture with its development layers, a minimal control system prototype currently operational in our laboratory, and a 3D visualization of the complete LEB experiment.

Footnotes:

[1] Ž. Brenčič, M. Skobe et al, Development of Low Energy Branch at MIC, Ljubljana, 14th IPAC, 2023.
[2] P. Weigel et. all, The EPICS control system for IsoDAR, Nucl. Instrum. Methods Phys. Res. Section A, 1056 (2023) 168590.

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Tuesday Poster Session / 1025

Impedance evaluation, mitigation, and measurement of ALS-U vacuum components.

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The Advanced Light Source Upgrade (ALS-U) is a 4th generation diffraction-limited soft x-ray radiation source. Coupling-impedance-driven instabilities have been carefully evaluated to ensure meeting the machine's high-performance goals during the design stage. At present, the focus of impedance modeling efforts primarily revolves around supporting beam tests of key components at ALS beamlines and the fabrication of various components. This paper presents impedance measurements of the main RF bellows with the Goubau-Line, as well as thermal evaluations on beam-induced heating on the RF bellows and the booster-to-accumulator ferrite (BTA) kicker on the ALS beamline. One challenge in the impedance modeling of the BTA kicker arises from a 4-micrometer-thick TiN coating, rendering direct modeling in CST challenging. To address this, we employed the ImpedanceWake2D (IW2D) code as an initial step to validate the efficacy of RF shielding. Subsequently, an equivalent model was constructed in CST to calculate the total impedance. We also show the impedance evaluation results and reduction strategies for the keyhole bellows and photon absorbers, incorporating thermal expansion considerations. Notably, the work is essential for successfully commissioning the ALS-U project.

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North America

Monday Poster Session / 1026

Proton polarization in RHIC with partial Siberian Snakes

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Co-author: Georg Hoffstaetter [1]

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In December 2021, damage to RHIC helical magnets forced one of two Siberian Snakes in the Blue ring to operate as a partial Siberian Snake and with a different snake axis of rotation. Quite surprisingly, the time-averaged polarization for that run actually ended higher than in the Yellow ring, after casting the undamaged snake as a partial snake as well to optimize polarization parameters. In this work, we simulate polarization transmission through a series of increasingly realistic models of the Blue ring in the "dangerous region"of polarization loss. At first the bare lattice has a perfect closed-orbit and ideal magnet strengths. Then the measured magnet-to-magnet field strength variations were added to the lattice. Finally, the six Interaction Region 5 mm closed-orbit bumps were implemented. Each of these model lattices compared the use of a pair of partial snakes against a pair of a full snakes. In simulations with realistic emittances, realistic polarization losses were only reproducible with nonzero RMS lattice misalignments. Even in the most realistic models, a clearly verifiable reason for better performance of partial snakes in RHIC could not be established. It therefore is reasonable to continue HSR designs with full Siberian Snakes. Using the realistic RHIC model with misalignments, we show scans for maximum polarization transmission over a set of allowed snake axes, known as snake matching, to demonstrate benefits of this technique for the HSR design.

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Monday Poster Session / 1027

The achievement of independently-tunable two-color lasing at the FHI FEL

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The Fritz-Haber-Institut (FHI) der Max-Planck-Gesellschaft Free Electron Laser (FEL) achieved first light from its Mid-IR beamline at 18 microns on February 14, 2012. In the subsequent years, the 3 to

60 micron light has been supplied to users resulting in 96 refereed publications in Chemical Physics. In 2019, the FEL Group initiated an upgrade to add a Far-IR beamline to the system. On June 8, 2023, first light was achieved at 8 microns from this beamline which spans 4.5 to 165 microns in tunable radiation. A unique feature of this upgrade is the inclusion of a 500 MHz kicker cavity that can send the 1 GHz electron pulses alternatively into the MIR and FIR beamlines. On December 8, 2023, first light was obtained simultaneously at 18 and 55 microns respectively, thereby achieving the project goal of independently-tunable two-color lasing. We will discuss the physics and engineering design of the new FIR beamline and provide details of the radiation spectrum and parameters. We will also outline planned user experiments using this new radiation tool.

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Monday Poster Session / 1028

Machine learning polarization transfer through the double resonance model with two Siberian Snakes

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The isolated resonances model of spin depolarization hinges on a closed-form solution of energy ramping through the Single Resonance Model by Froissart and Stora. However, depolarization by single-resonance crossing is impossible in the SRM with pairs of Siberian Snakes for appropriately chosen orbital tunes, since the amplitude-dependent spin tune is fixed to one-half. This demonstrates that the isolated resonances model is not a good approximation of polarization dynamics with Siberian Snakes. We therefore develop an extended model in which pairs of resonances in close proximity push the amplitude-dependent spin tune away from one-half in the presence of Siberian Snakes, allowing the crossing of higher-order spin resonances associated with depolarization. Here we present results from applying Machine Learning methods that establish spin transport models with two overlapping resonances from tracking data. These can then be used to predict spin tune deviations from ½ over a large parameter space, allowing us to find conditions for the presence or avoidance of higher-order resonances, and to compute the effective strengths of such higher-order resonances.

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Wednesday Poster Session / 1029

Summary of the workshop on "UED opportunities for dynamical imaging of materials"

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In late 2023 (6-8 November), Los Alamos National Laboratory hosted the "UED Opportunities for Dynamical Imaging of Materials"workshop in Santa Fe, New Mexico. The workshop was divided into two sections. The first part (1.5 days) was dedicated to material science and needs for UED imaging, and the second part (1 day) to discuss accelerator science driving next generation ultra-fast diffraction systems. In this workshop, emphasis was placed on identifying current and future scientific problems that will utilize compact MeV-UED machines, discussing state-of-the-art technological advances, and exploring future opportunities for MeV-UED machine developments. This paper will present an overview of the workshop's goals and summarize discussions and conclusions.

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Thursday Poster Session / 1030

Accelerator control system software at LANSCE: vision and strategy for improvement and modernization

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The LANSCE accelerator is an 800 MeV linear accelerator delivering beams for more than fifty years. As it has aged, maintenance and upgrades to its control system software components have become challenging and often deferred due to operational and schedule constraints. As a result, we have a wide variety of new and old software, difficult to re-use, with a large staff burden. Data is stored in redundant sources, inconsistent formats, and outdated technology. Multiple tools exist for the same tasks. Some production software is updated without proper processes. We describe our approach to modernizing LANSCE control system software with proper development processes. We consider reduction of diversity, redundancies, data sources. Migration to modern technologies is also discussed. We explore the possibility of language standardization, and describe our database implementation and other future plans. Lifecycle management is also considered. This years-long effort will utilize a risk-based strategy to address the most urgent issues while also ensuring steady progress, ultimately resulting in a coherent and maintainable suite of control system software.

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Wednesday Poster Session / 1031

Temperature, density of states, and thin film optical effects on electron emission from semiconductor photocathodes

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Increasing the brightness of electron beams emitted from photocathodes will allow X-ray Free Electron Lasers (XFELs) to lase at larger photon energies with higher pulse energies. This will enable the development of key new accelerator capabilities. Higher electron beam brightness can be achieved by creating photocathodes with high quantum efficiency (QE) and/or low intrinsic emittance. Results from recent experiments demonstrated that QE can be increased 2 to 5 times by optical interference absorption effects in specifically layered materials compared to conventionally grown photocathodes. We have developed models for electron emission from thin film semiconductor photocathodes that include optical interference effects and show similar increase in QE for alkali-antimonide and cesium-telluride photocathodes. Here, we extend these models to include temperature and density of states effects on electron emission. We present results from these models on both QE and intrinsic emittance and discuss possible ways to increase the brightness of electron beams emitted from thin film semiconductor photocathodes.

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Tuesday Poster Session / 1033

Status of the Advanced Light Source

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The LBNL Advanced Light Source, a pioneering third-generation soft x-ray synchrotron radiation source operating at 1.89 GeV with a 2˜nm beam emittance, stands as one of the earliest facilities in its class, continually evolving to maintain its status at the forefront of soft x-ray sources. This paper reviews the most significant advancements in the accelerator's hardware and software infrastructures and presents the machine operational statistics over the last 15 years.

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Monday Poster Session / 1034

Proposal for a proton-bunch compression experiment at IOTA in the strong space-charge regime

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The longitudinal compression of intense proton bunches with strong space-charge force is an essential component of a proton-based muon source for a muon collider. This paper discusses a proton-bunch compression experiment at the Integrable Optics Test Accelerator (IOTA) storage ring at Fermilab to explore optimal radio frequency (RF) cavity and lattice configurations. IOTA is a compact fixed-energy storage ring that can circulate a 2.5-MeV proton beam with varying beam parameters and lattice configurations. The study will aim to demonstrate a bunch-compression factor of 2 to 10 in the IOTA ring while examining the impact of intense space-charge effects on the compression process.

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Thursday Poster Session / 1035

Status of tune feedback system in Taiwan Photon Source

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Taiwan Photon Source (TPS) is a 3-GeV dedicated synchrotron light source, consisting 24 double bend achromat that provide six 12-m long straights and eighteen 7-m short straights to accommodate insertion devices including in-vacuum undulators (IU) and elliptical polarization undulators. The gap/phase moving will cause tune shift, lattice function distortion, closed-orbit distortion, variation of emittance and energy spread. These effects deteriorate the quality of the synchrotron light source. Many actions are taken to cure these undesired effects, among which a tune feedback system has been implemented to compensate the tune shifts.

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Monday Poster Session / 1036

Symplectic modeling of the ALS-U bending dipoles using 3D magnetic field data

Author: Chad Mitchell[1]

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The Advanced Light Source Upgrade (ALS-U) is a 2 GeV high-brightness, nine-bend achromat storage ring, designed to reduce the natural emittance relative to the existing ALS by a factor of 20 for improved x-ray coherent flux and brightness. The upgrade includes the installation of an accumulator ring of the same energy as, and slightly smaller circumference than, the storage ring. The bending dipoles provide special challenges for accurate symplectic modeling, such as the combination of large sagitta and magnet narrow vertical aperture (in the accumulator ring) and overlapping fringe fields (in the main ring). We describe a procedure for the calculation of symplectic maps for the ALS-U dipoles using robust surface-fitting methods based on 3D finite-element field data, including a discussion of vector potential gauge choice and model-dependent effects on the lattice chromaticity.

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Wednesday Poster Session / 1038

NSLS-II bunch-by-bunch BPM development and beam operation

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The Radio Frequency System-on-Chip (RFSoC) FPGA-based high-performance bunch-by-bunch beam position monitor (BxB BPM) was developed and commissioned at NSLS-II. The new BxB BPM features a 14-bit 5 Gsps ADC, directly sampling 2 ns four-button signals, and digital signal processing with a synchronized 500 MHz RF reference clock. The BxB BPM provides 32 K points of ADC raw data, 5 K turns for up to 1320 bunch amplitude and position data, 2.6 million turn-by-turn (TxT) data points, 10 K turns of circular buffer, and 10 Hz streaming data. The potential applications include, but are not limited to measuring injection transient, efficiency, ion instability detection, and single/multi-bunch motion analysis. A ~15 μm single-bunch resolution was confirmed with the beam test. This paper will present the beam test results, hardware FPGA firmware architecture, and control system interface for operation.

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Thursday Poster Session / 1040

Design and magnetic field measurement of type c nonlinear magnet

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By designing a C-type nonlinear magnet, low emittance beam injection is realized on HALF

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Wednesday Poster Session / 1041

ImpactX space charge modeling of high intensity linacs with mesh refinement

Author: Chad Mitchell[1]

Co-authors: Axel Huebl [1]; Jean-Luc Vay [1]; Ji Qiang [1]; Marco Garten [1]; Remi Lehe [1]; Ryan Sandberg [1]

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The code ImpactX represents the next generation of the particle-in-cell code IMPACT-Z, featuring s-based symplectic tracking with 3D space charge, parallelism with GPU acceleration, adaptive mesh-refinement, modernized language features, and automated testing. While the code contains features that support the modeling of both linear and circular accelerators, we describe recent code development relevant to the modeling of high-intensity linacs (such as beam transport for the Fermilab PIP-II upgrade), with a focus on space charge benchmarking and the impact of novel code capabilities such as adaptive mesh refinement.

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Wednesday Poster Session / 1042

Review of MeV energy scale accelerators, their capabilities, and common applications

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High Energy Density Physics (HEDP) is mostly related to charged particle beams, lasers, and plasma systems. Most of the available charged particle beam systems are either of low energies (keV scale, for example, medical x-rays) or of very high energies (>GeV, for example, SLAC accelerators, CERN for fundamental research). We need MeV energy scale accelerators to study the Bragg peaks of materials and for many other reasons, such as x-ray imaging of materials, medical isotopic production, dynamic structure analysis, plasma behavior studies, plasticity tests for drinking and ocean water, and more. To generate high-energy primary e-beams, an RF accelerator or induction accelerator is first to be considered, which are well known to the accelerator and beam physics communities. But RF accelerators have the limitation of acceleration in the range of several hundred micro-ampere-level currents. The induction accelerator can transport kA-level current, but the pulse duration is compressed to a nanosecond scale. We will review the performance of known medium-energy accelerators in search of their applications, high current (mA), and long pulse (ms) capability.

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Monday Poster Session / 1043

Fabrication of THz corrugated structure using X-ray based lithography

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In a preceding study, the wakefield accelerator, which is being actively researched worldwide, was successfully developed by the die stamping method. In order to realize smaller and more precise structure for future wakefield accelerators, X-ray based lithography is successfully implemented to fabricate micro-meter scale wakefield structure. The fabricated structure is half mm radius and 400 GHz wakefield structure. As a result, compared with currently demonstrated structure, higher power generation and extension of RF pulse duration can be possible by help of X-ray lithography scheme. In this paper, novel fabrication scheme based on X-ray lithography will be described.

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Tuesday Poster Session / 1044

Dynamic aperture of the RCS during bunch merges

Author: Daria Kuzovkova[1]

Co-authors: Georg Hoffstaetter [1]; Jonathan Unger [1]

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The Rapid Cycling Synchrotron (RCS) of the Electron Ion Collider (EIC) will be used to accelerate polarized electrons from 400 MeV to a top energy of 5, 10, or 18 GeV before injecting into the Electron Storage Ring. At 1 GeV, the RCS will perform a merge of two bunches into one, adding longitudinal dynamics that effects the dynamic aperture, depending on the merge parameters. In this paper, results for different merge models will be compared, as well as finding the relationship between the merge parameters of the RCS and its dynamic aperture.

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Monday Poster Session / **1045**

Progress on high-power generation using sub-THz corrugated waveguide

Author: Gwanghui Ha[1]

Co-authors: Eric Wisniewski [2]; Gongxiaohui Chen [3]; Ho Jae Kwak [4]; Hyung-sup Kong [4]; Jina Kim [4]; Jinjoo Ko [5]; John Power [3]; Jong Hyun Kim [4]; Min Kyu Seo [5]; Seung-hwan Kim [4]; Seunghwan Shin [5]; Wanming Liu [3]

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Previously we had developed a new method to fabricate corrugated waveguides (CW) operating in sub-THz frequency regime. As the next step, collaborative effort is underway to demonstrate GW-level high-power sub-THz pulse generation using a CW. We plan to fabricate a CW operating at around 400 GHz. This waveguide will be driven by a bunch train including 16 bunches with nanocoulomb-level charges per bunch. We present an overview of project's current status.

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Monday Poster Session / **1046**

Simulation study for nanometer-scale modulation transfer in emittance exchange beamlines

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Generating nanometer-scale density modulation has been pursued due to its potential for compact X-ray source applications. Realization of this nanometer modulation involves two key challenges: development of sub-micron-scale momentum modulation method and conversion method to density modulation without quality degradation. Addressing the first challenge, emittance exchange (EEX) beamline is a promising candidate. Its unique capability of transverse-to-longitudinal phase space exchange makes it compatible with various modulators imparting either transverse or longitudinal modulations. This versatility allows us to find optimal radiators, addressing the second challenge. Study on degradation sources and their effects on the beam are underway to realize nanometer-scale modulation using EEX beamline. We present most recent results from our simulation study.

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Tuesday Poster Session / 1047

Machine learning based response matrix correction

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The response matrix is the closed orbit distortion at each BPM responses to the change in every corrector. For a large ring, the response matrix has tens of thousands of data points which can fully include the linear optics of the ring. LOCO use response matrix for lattice calibration and error correction. For 4 th generation diffraction limitation ring which uses many strong sextupoles and octupoles, the response matrix will influence by the nonlinearity and can only be driven from closed orbit distortion tracking not from linear matrix. The strong nonlinearity will make it difficult for LOCO to match lattice parameters and also need more time to get Jacobi matrix. Machine learning may help bypass the time assuming Jacobi matrix and avoid local optima. This work try to improve the speed and accuracy of LOCO by machine learning method.

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Wednesday Poster Session / **1048**

Initial design of a proton complex for the Muon Collider

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The proton complex is the first piece in the Muon Collider, it comprises a high power acceleration section, a compressor and a target delivery system. For the International Muon Collider Collaboration we are investigating the possibility of having a full energy 5-GeV linac followed by an accumulator and a compressor ring and finally a target delivery system. In this paper we present the initial studies for the complex and derived initial beam parameters at each interface.

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Europe

Wednesday Poster Session / **1049**

Developments and first results from a test stand for high brightness C-band photoguns at PSI

Author: Thomas Lucas[1]

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An international collaboration between PSI and INFN-LNF has been undertaken with the aim of developing the next generation of high brightness electron sources. Through this collaboration, two unique high gradient RF photoguns that operate in the C-band frequency regime have been designed and realized. Concurrent to this, a new high power test stand at the Paul Scherrer Institut has been commissioned to test these novel devices. Here we report on the new test stand and the first results from the high-power testing of these devices.

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Monday Poster Session / 1050

Fabrication study of corrugated structure for sub-THz by stacking disks

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We have fabricated corrugated structures for sub-THz regime by stacking disks. By sending electron beams into the structure, the wakefield of 200 GHz was successfully measured. The frequency and power levels of wakefield were very similar to our design. For the our next target of gigawatts power, we have newly designed a structure of 400 GHz. More precise fabrication is required compared to the 200 GHz structure. The die stamping method was changed to the LIGA process for the production of each disk. And we improved the assembly method as well. In the previous fabrication, the maximum error was around 10 micrometers. The errors may be reduced to one-tenth of the previous one. In this paper, we will introduce the new design.

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Wednesday Poster Session / 1051

Benchmarking equilibrium emittance simulation tools for the Future Circular Collider

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The determination of equilibrium emittance stands as a critical factor in optimizing the luminosity of the Future Circular Collider (FCC). In order to have accurate simulations and understanding of the emittance, multiple effects have to be taken into consideration including errors in the machine, solenoid effects, synchrotron radiation and beam-beam effects. The novel X-Suite software aims to encompass many of these effects. In this paper we present benchmark studies and first results for determining equilibrium emittances using X-Suite and other simulation codes.

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Wednesday Poster Session / 1052

Relaxed insertion region optics and linear tuning knobs for the Future Circular Collider

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This paper provides updates on two essential toolsets designed to facilitate the tuning and commissioning processes of the Future Circular Collider (FCC): relaxed optics and linear tuning knobs specifically for the experimental insertion regions. Motivated by the imperative need for efficient tuning strategies, we outline the construction methodology for both toolsets and present initial studies demonstrating their efficacy. The paper discusses the significance of these tools in enhancing the operational capabilities of the FCC and presents early results showcasing their potential impact on the collider's performance during tuning and commissioning phase.

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Wednesday Poster Session / 1053

The status of the FCC-ee optics tuning

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With a circumference of approximately 91 km, the electron-positron Future Circular Collider, FCC-ee, aims to achieving unprecedented luminosities at beam energies from 45.6 to 182.5 GeV. One of the most profound challenges is to reach its design performance in the presence of various alignment and field errors. The FCC-ee optics tuning working group studies all aspects of this wide topic, applying state-of-the art techniques for beam-based alignment, commissioning simulations, beam threading and optics measurements and corrections, probed at numerous world-leading accelerator physics facilities. Recently, long-range misalignments models have been developed to probe tuning simulations, including IP tuning, progress has been made with magnetic tolerances and a new optics is being thoroughly studied. The current status of tuning simulations for different FCC-ee lattices is presented here.

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Thursday Poster Session / 1054

Upgrade of the PSB to ISOLDE beam transfer line to facilitate an increase in proton driver energy

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Following the successful completion of the LHC Injectors Upgrade project, since 2021 the Proton Synchrotron Booster (PSB) has served the LHC injector chain with protons at an increased kinetic energy of over 2 GeV. An upgrade of the ISOLDE facility has long been considered to produce radioactive ion beams with a higher energy proton driver beam. A Consolidation and Improvements program is presently underway to maintain ISOLDE's position as a world-leading ISOL facility in the decades to come, with activities planned during the upcoming Long Shutdown 3 (2026 - 28) and beyond. This contribution details a study to upgrade the beam line to operate between 1.4 and 2 GeV, and to increase the power of the proton driver in the future, assuming the replacement of the two beam dumps behind the facility's production targets.

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Tuesday Poster Session / 1055

Estimation and control of particle accelerators in simulation using latent space tuning

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In this work we explore the estimation and control of a particle accelerator simulation of the 800 MeV linac at Los Alamos National Lab. We use a convolution neural network model with a low dimensional latent space to predict the phase space projections of the beam and beam loss, which are mapped from RF and initial condition parameters. In deploying the model, we assume phase space predictions cannot be measured but beam loss can, and we apply a feedback using the error in beam loss prediction to tune the latent space. With beam loss and phase space predictions well correlated, we apply constrained optimization techniques, simultaneous with phase space prediction, to control the beam phase space while keeping beam loss from reaching unsafe levels.

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Study of the corrector systems for the new lattice of the CERN hadron-hadron Future Circular Collider

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A new layout for the energy-frontier hadron collider (FCC-hh) under study at CERN has been designed, following the constraints imposed by the outcome of recent tunnel placement studies. The new lattice and the need to maximize the dipole filling factor triggered a deep revision of the corrector systems located in the regular arcs, such as orbit, tune, linear coupling, and chromaticity correctors. The system of octupoles aimed at providing Landau damping has also been reviewed. Furthermore, the corrector package in the experimental insertion aimed at compensating the field quality of the triplet quadrupoles has been reconsidered in view of the experience gained with the design of the corresponding system developed for the CERN HL-LHC. In this paper, an account of this review is presented and discussed in detail. These estimates will need confirmation when the magnet design of the various correctors will be studied.

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Monday Poster Session / 1057

A new baseline layout for the FCC-hh ring

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The Future Circular Collider (FCC) study includes two accelerators, a high-energy lepton collider (FCC-ee) and an energy-frontier hadron collider (FCC-hh). Both machines share the same tunnel infrastructure. We present the current design status of FCC-hh, highlighting the most recent changes, including a new layout following updated tunnel dimensions, a change from 12 to 16 dipoles per cell increasing the dipole filling factor, implementation of the beam crossing scheme at experimental interaction points, and the optical solutions found for the eight experimental and technical insertions.

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Thursday Poster Session / 1058

Beam optics modelling of slow-extracted very high-energy heavy ions from the CERN Proton Synchrotron for radiation effects testing

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Testing of space-bound microelectronics plays a crucial role in ensuring the reliability of electronics exposed to the challenging radiation environment of outer space. This contribution describes the beam optics studies carried out for the run held in November 2023 in the context of the CERN High-Energy Accelerators for Radiation Testing and Shielding (HEARTS) experiment. It also delves into an investigation of the initial conditions at the start of the transfer line from the CERN Proton Synchrotron (PS) to the CERN High Energy Accelerator Mixed-field (CHARM) facility. Comprehensive optics measurement and simulation campaigns were carried out for this purpose and are presented here. Using a validated optics model of the transfer line, the impact of air scattering on the beam size was quantified with MAD-X and FLUKA, providing valuable insights into the current performance and limitations for Single Event Effects (SEE) testing at CHARM.

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Tuesday Poster Session / 1059

Feed-down effects during injection into the CERN proton synchrotron

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Single-turn injection in the CERN Proton Synchrotron (PS) takes place in a deformed orbit in the injection region. A closed-orbit bump is created at injection by means of dipole correctors (BSW) pulsed over hundreds of turns. The pulsing of the BSWs and the related fast field changes generate sextupole eddy currents. The beam, injected off-center, is affected by feed-down. The quadrupolar field component related to the eddy currents-induced-sextupole can result in a significant tune-shift during injection. Beam-based measurements were carried out to characterize this effect. Subsequently, measurements were benchmarked with simulated tune-shifts in MAD-X.

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Tuesday Poster Session / 1060

Energy dependence of PS main unit harmonics

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CERN Proton Synchrotron (PS) is featured with 100 C-shaped combined-function Main Units (MUs) magnets with a complicated pole shape. The operation and the modelling of the PS-MUs has been historically carried out with empirical beam-based studies. However, it would be interesting to understand whether, starting from a proper magnetic model and using the predicted harmonics as input to optics simulations, it is possible to accurately predict the beam dynamics behavior in the PS, and assess the model accuracy with respect to beam-based measurements. To evaluate the magnetic model quality and its predictions, bare-machine configurations at different energies were prepared, where only the Main Coil is powered and the additional circuits are off. In this paper, a comparison of tunes and chromaticity measurements with the predicted optics is reported, showing the saturation of the quadrupolar and sextupolar components at high energy, which affect these quantities.

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Monday Poster Session / 1061

LHC ion commissioning

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In 2023, about 2 months of the LHC operation were devoted to the Heavy Ions physics, after more than 5 years since the last ion run. In this paper, the results of the 2023 Ion optics commissioning are reported. Local corrections in Interaction Point (IP) 1 and 5 were reused from the regular proton commissioning, but the optics measurement showed the need for new local corrections in IP2. We observed that an energy trim of the level of 10e-4 helped to reduce the optics errors at top energy. The dedicated measurements during the energy ramp revealed a larger than expected beta-beat, which is consistent with an energy mismatch. Furthermore, global corrections were performed to reach a β-beating of about 5% for the collision optics.

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Simulated performance of FCC-ee IP tuning knobs

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The Future Circular electron-positron Collider (FCC-ee) is a proposed accelerator with 91 kilometers circumference that should serve as a Higgs and electroweak factory, with unprecedented luminosity. Unavoidable misalignments and field errors will generate optics errors at the interaction point (IP), whose effect would be amplified by the beam-beam collisions, which would make it challenging for the collider to reach its intended luminosity goals. Hence, there is a need for correction tools that will enable the precise correction of the optics at the IP, such as linear coupling parameters and spurious dispersion, which will be essential both for FCC-ee commissioning and during routine operation. This paper describes the construction, simulated effectiveness, and constraints of such tools.

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Thursday Poster Session / 1063

Performance optimization design of photocathode injector based on multi-objective genetic algorithm

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Generating beam with nC-level charge is of great significance for particle colliders. In order to achieve lower emittance and length of bunch, based on the photocathode injector, we designed a L-band gun and L-band accelerating tube. However, with many coupled parameters, it is difficult to optimize its performance to the limit when optimizing them separately. Therefore, we employed a multi-objective genetic algorithm for searching in the multi-dimensional parameter space and utilized a deep Gaussian process as a surrogate model to solve the high-dimensional parameter optimization problem. Through optimization, we successfully obtained the normalized transverse emittance of 3.4 π mm·mrad and the bunch length of 1.0 mm for a fixed charge of 5 nC. This indicates that our method can effectively improve the performance of the photocathode injector.

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Wednesday Poster Session / 1064

Development of novel beam instrumentation for in vivo and in vitro end stations for Laser-hybrid Accelerator for Radiobiological Applications

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Radiotherapy is an effective, non-invasive, widely used treatment for cancerous tumors that uses x-ray photon, electron and ion beam sources. The Laser-hybrid Accelerator for Radiobiological Applications (LhARA) is a proposed novel laser-driven accelerator system under development that aims to deliver a multi-ion Particle Beam Therapy (PBT) technique. This study aims to develop a novel technique to deliver different light ion minibeams to the in vivo and in vitro end stations. A novel technique will produce the desired beams and minibeams by magnetically focusing the incoming proton and light ion beams, without collimation. This solution focuses the beam magnetically to the required 1 mm spot distribution with an energy of 15 MeV, for the low energy in vitro end station's experimental requirements. A novel spot-scanning beam delivery modality simulation is also being developed. This simulation allows the beam delivery system to deliver the beam to spots in the treatment field, through a dynamic rotational motion.

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Wednesday Poster Session / 1065

Optimization of a 2.6-cell normal-conducting S-band photocathode RF gun

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A new S-band photocathode RF gun proposed for ultrafast electron diffraction (UED) has been designed and optimized. The 2.6 cell electron gun works at π-mode and the operating frequency is 2.856 GHz. The peak electric field on the cathode is 56 MV/m and the field in the following cells are optimized to reduce transverse emittance. The pulsed RF power loss is 2.5 MW and the final kinetic energy of the electron beam is 3.5 MeV. The RF gun works at high duty factor and the average power loss reaches 5 kW. The cooling channel has been carefully designed to minimize the temperature rise inside the cavity.

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Wednesday Poster Session / 1066

The design of a 2.3-cell X-band photocathode RF electron gun

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Recent advancements in electron beam compression methods have enabled the production of ultrashort electron beams at the sub-femtosecond scale, significantly expanding their applications. However, the temporal resolution of these beams is primarily limited by the flight time jitter, especially during their generation in photocathode RF electron guns. This paper explores the dynamics of electron beams within different cell structures of the photocathode RF electron gun and introduces a novel RF cavity design. This design enables the electron beam's output energy and the flight time within the gun to remain unaffected by microwave phase jitter simultaneously. Moreover, the power coupler of this RF cavity has been optimized for high efficiency. Our results indicate that this design not only stabilizes ultrashort electron beams but also paves the way for novel advancements in ultrafast science.

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Improvements to 4-rod RFQs with additive manufacturing processes

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The institute of applied physics (IAP), university of Frankfurt, has been working for years on the development of increasingly powerful 4-Rod RFQ accelerators for hadron acceleration. The need for such accelerators has increased significantly in the recent past, as accelerator-driven neutron sources are becoming increasingly important following the closure of various test reactors. High beam currents, particle energies and operational stability are often required from those LINACs. In order to meet these requirements, the copper structure of the RFQ is to be manufactured using a new type of pure copper 3D printing in order to be able to introduce optimized cooling channels inside the copper parts. Comprehensive multiphysics simulations with ansys, cst and autodesk CFD will first be carried out to evaluate the operational stability and performance. In addition, it will be clarified whether the printed copper fulfills the necessary vacuum and conductivity requirements after CNC processing, or whether galvanic copper plating should be carried out.

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Monday Poster Session / 1068

Development of normal conducting heavy ion linac in China

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Research on heavy ion linac was began more than ten years ago to improve the HIRFL operation. In China, the first continuous wave (CW) heavy ion linac, SSC Linac, working at 53.667 MHz was designed and constructed as the SSC injector. The ion particle can be accelerated to 1.48 MeV/u with the designed A/q=5.17. At present stage, this CW linac has been put into operation and the Uranium has been accelerated to 1.48 MeV/u successfully in the end of 2023. To meet the rising requirements of the applications, a compacter 162.5 MHz heavy ion linac operating in pulse mode was developed with A/q≤3. The "KONUS"beam dynamics was adopted in the IH-DTL design and the heavy ions can be accelerated to 4 MeV/u in 9 m length. The 108.48 MHz SESRI linac was another pulse machine which was built at Harbin. Both of the heavy ions and proton beam can be accelerated by this linac to 2 MeV/u and 5.6 MeV,respectively. In this paper, the status of these three heavy ion linacs and their beam commissioning results were reported.

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Monday Poster Session / 1069

A faster algorithm to compute lowest order longitudinal and transverse resistive wall wake for non-ultrarelativistic case

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With the development of the steady state micro bunching (SSMB) storage ring, its parameters reveal that the ultra relativistic assumption which is wildly used is not valid for the electron beam bunch train, which has length in the 100 nm range, spacing of 1 μm and energy in hundreds MeV range. The strength of the interaction between such bunches and the potential instability may need careful evaluation. At the same time, the effect of the space charge inside a single bunch due to space charge effect also needs to be considered. In this article, we reorganized the lowest-order longitudinal wakefield under non-ultra relativistic conditions, and modified the inconsistent part in the theoretical derivation in some essays of the lowest-order transverse wakefield. We present the modified theoretical results and analysis. Then based on the result we have derived, we give a algorithm which is thousands time faster than direct calculation. It lays foundation in future research.

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Tuesday Poster Session / 1070

Operation of TPS 300 kW solid-state amplifier

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The National Synchrotron Radiation Research Center (NSRRC) has developed a 300 kW solid-state amplifier. This 300 kW solid-state amplifier RF transmitter has been operating continuously since August 2023, consistently delivering an output of 250 kW RF power during user beam time at 500 mA. This report describes the performance of the solid-state amplifier RF transmitter during this period, module failure rates, and specific instances of malfunction.

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Superradiant cooling and dynamics of ultrashort electron beams

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Accelerator-based light source can produce extremely high brightness radiation and has been an indispensable tool in various fields. By exploiting the collective dynamics of electrons in external fields, high-gain free electron lasers can generate radiation with powers several orders of magnitude higher than typical synchrotron radiation. This collective enhancement, could also be realized in future synchrotrons with ultrashort electron beams stored. The classical theory of storage ring cannot be extended to describe such devices since it assumes the emission of radiation is independent for each electron. To incorporate this collective radiation effect, a fundamentally different theory of storage ring physics has to be developed. In this paper, we consider a quantum electrodynamics treatment of the collective radiation of electrons in storage rings. We find that the ultimate limit on beam brightness in classical theory will break down due to the failure of the independence assumption and electrons will be cooled superradiantly. Moreover, we give a complete analysis of the intricate beam dynamics under the coherent synchrotron radiation effect and superradiant cooling effect.

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Thursday Poster Session / **1072**

An automated quad sweep based emittance profile monitor

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Beam emittance plays the crucial role in a beam transportation system. At the NASA Space Radiation Laboratory (NSRL), beam emittance is determined through measuring the beam width via a segmented wire ion chamber (SWIC) and varying quadrupole strength. In this paper, we briefly describe the quadrupole scan technique to calculate the beam emittance and describe an automated system developed to carry out this measurement expeditiously. A dedicated manager has been developed to set up measurements, acquire data, paired with a python-based software package to perform analysis to calculate the emittance along the beam line.

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Monday Poster Session / 1073

Nonlinear optimization of generalized longitudinal strong focusing steady-state microbunching storage ring

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Steady-state microbunching (SSMB) storage rings are promising candidates for coherent-EUV-radiation light sources. In a generalized longitudinal strong focusing (GLSF) approach, the concept is to achieve perfect cancellation of modulations by ensuring that a particle's coordinate remains identical after passing through both modulators. This requires effective control over the deviation in the longitudinal position, contributed from the lattice nonlinearity. Additionally, since GLSF involves both vertical and longitudinal dimensions, it is crucial to limit the growth of the apparent vertical emittance as well, which is induced by the distortion of the lattice nonlinearity. This paper derives the expressions for these indicators in terms of beam parameters and lattice map elements. It aims to provide valuable insights into the system's behavior and improve the performance of the GLSF unit.

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Tuesday Poster Session / 1074

Improved modelling and characterization of the LANSCE PSR stripper foils

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This paper will describe efforts to simulate and test materials for the LANSCE PSR stripper foils. Stripper foils convert H- beams to H+ as part of the charge-exchange injection process in the LANSCE PSR that produces high intensity proton beams. The foil properties directly affect the total current and activation in the ring, and their overall robustness also determines the types of experiments that can be done, as the number of available foils is limited and some modes are particularly destructive to the foils. We will describe a preliminary approach to modelling, characterizing, testing and optimizing PSR foils performance and lifetime given the extreme heat and radiation conditions which can heavily constrain both characterization and testing, and note potential opportunities for a PSR upgrade as part of LAMP.

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Tuesday Poster Session / 1075

Bmad based particle tracking simulation for slow resonant extraction

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Co-authors: David Sagan [2]; Eiad Hamwi [2]; Georg Hoffstaetter [2]; Kevin Brown [1]; Weijian Lin [2]

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Slow resonant extraction plays a crucial role in delivering a high-quality continuous beam to experiments. Simulating extraction and transport of charged particle beams require a process of careful modeling and experimentation. There are various particle tracking simulation tools available to use. Each has its merits and deficiencies. In this work we have used long-term tracking based on the Bmad toolkit to run third integer resonant extraction simulations of beams of various ion species in the booster synchrotron at Brookhaven National Laboratory. In this paper, we will present results of detailed slow extraction, multi-particle tracking simulations, and we will describe the features that make Bmad a useful tool for this work. We will show comparisons to other simulation tools of our results.

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Tuesday Poster Session / 1076

Radio frequency design and analysis of quasi-waveguide multi-cell deflecting cavities for the production of picosecond-long x-ray pulses for Elettra 2.0

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Picosecond-long x-ray pulses of moderate intensity and high repetition rate are highly sought after by the light source community, especially for time-resolved fine spectroscope analysis of matter in the linear response regime. As part of the upgrade of the Elettra 2.0, two radio frequency deflecting cavities will be installed to produce time-dependent orbit deflection to a few dedicated electron bunches with no effect on the regular bunches. This paper reports the radio frequency design of super-conducting deflecting crab cavities operating at 3.0 and 3.25 GHz. The design is based on a Quasi-waveguide Multicell Resonator (QMiR), firstly developed for Advanced Photon Source, which uses a trapped dipole mode for the crabbing of the bunches. QMiR has heavily loaded Higher Order Modes (HOMs) resulting in a sparse HOMs spectrum thus eliminating the need for HOMs couplers simplifying the cavity mechanical design. The detailed EM analysis, including HOM damping, particle tracking through the field, thermal & mechanical simulations are presented. This article reports both static and dynamic thermal loads and the conceptual design for "0 boil off" cavity cool down at 4.2 K or lower.

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Thursday Poster Session / 1077

Beam Trajectory influence on dispersion and uniform beams at NASA Space Radiation Laboratory's beam line

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The Booster synchrotron at Brookhaven National Laboratory delivers slowly extracted beams to the NASA Space Radiation Laboratory (NSRL). Experimenters at NSRL require uniformly distributed radiation dose to simulate the space radiation environment. The NSRL facility generates uniform beam distribution of various ion species at the location of the target using a pair of octupole magnets in the beam-transport line. The beamline is designed to be achromatic through the octupoles and to the target. However, the dispersion function depends on the trajectory of the beam as it is transported out of the booster and into the beamline. The dependence on this trajectory has not been previously studied. In this report we describe a new model we have developed to study this effect and show measurements to compare to our simulations.

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Tuesday Poster Session / 1078

Distributed coupling linac for efficient acceleration of high charge electron bunches

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Co-authors: Emilio Nanni [1]; Glen White [1]; Mei Bai [1]; Mohamed Othman [1]; Sami Tantawi [1]; Zenghai Li [1]

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Future colliders will require injector linacs to accelerate large electron bunches over a wide range of energies. For example the Electron Ion Collider requires a pre-injector linac from 4 MeV up to 400 MeV over 35 m. *Currently this linac is being designed with 3 m long traveling wave structures, which provide a gradient of 16 MV/m. We propose the use of a 1 m distributed coupling design as a potential alternative and future upgrade path to this design. Distributed coupling allows power to be fed into each cavity directly via a waveguide manifold, avoiding on-axis coupling**. A distributed coupling structure at S-band was designed to optimize for shunt impedance and large aperture size. This design provides greater efficiency, thereby lowering the number of klystrons required to power the full linac. In addition, particle tracking analysis shows that this linac maintains lower emittance as bunch charge increases to 14 nC and wakefields become more prevalent. We present the design and fabrication of this distributed coupling structure, as well as cold test data and plans for higher power tests to verify on the structure's real world performance.

Footnotes:

- F. Willeke, "Electron ion collider conceptual design report 2021," tech. rep., United States, 2021. ** S. Tantawi et al., Phys. Rev. Accel. Beams, vol. 23, p. 092001, Sep 2020.

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Thursday Poster Session / 1079

Solid-state driven X-band linac for electron microscopy

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Current transmission electron microscopes (TEM) accelerate electrons to 200-300 keV using DC electron guns with a nanoamp of current and very low emittance. However at higher voltages these DC sources rapidly grow in size, oftentimes several meters tall for 1 MeV microscopes. Replacing these electron guns with a compact linac powered by solid-state sources could dramatically lower cost while maintaining beam quality, thereby increasing accessibility. Utilizing compact high shunt impedance X-band structures ensures that each RF cycle contains at most a few electrons, preserving beam coherence. CW operation of the RF linac is possible with distributed solid-state architectures* which power each cavity directly with solid-state amplifiers which can now provide up to 100W of power at X-band frequencies. We present a demonstrator design for a prototype low-cost CW RF linac for high-throughput electron diffraction producing 200 keV electrons with a standing-wave architecture where each cell is individually powered by a solid-state transistor. This design also provides an upgrade path for future compact MeV-scale sources on the order of 1 meter in size.

Footnotes:

- O. Heid and T. Hughes. Proc. 25th International Linear Accelerator Conference, page THP068, 2011. D. Nguyen et al. Proc. 9th International Particle Accelerator Conference (IPAC18), pp. 520-523 M. A. K. Othman, E. A. Nanni, V. A. Dolgashev, S. Tantawi, and J. Neilson. Solid-state powered x-band accelerator. Technical report, SLAC National Accelerator Laboratory, 2016.

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North America

Monday Poster Session / 1080

Toward a long-lifetime polarized photoelectron gun for the Ce+BAF positron source

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The addition of spin-polarized, continuous-wave (c.w.) positron beams to the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) would provide a significant capability to the experimental nuclear physics program at Jefferson Lab. Based on bremsstrahlung and pair-production in a high-Z target, a 120 MeV spin-polarized c.w. electron beam of several milliamperes is required. While the beam dynamics of the high-current electron beam are tenable, sustaining this current for weeks of user operations requires an unprecedented charge lifetime from a high-polarization GaAs-based photocathode. A promising approach to exceed the kilocoulomb charge lifetime barrier is reducing the ion back-bombardment fluence at the photocathode. By increasing the laser size and managing the emittance growth with an adequate cathode/anode design, significantly enhanced charge lifetime may be achieved. Based upon a new simulation model that qualitatively explains the lifetime data previously measured at different spot sizes, we describe the practical implications on the parameter space available for a kilocoulomb-lifetime polarized photogun design.

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Tuesday Poster Session / 1081

Magnetic characterization and phase error tuning of a 1.5 m-long NbTi SCU for the Advanced Photon Source

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Prior to assembly into the operational cryostat each superconducting undulator (SCU) at the Advanced Photon Source undergoes testing in a LHe bath cryostat where coil training and magnetic measurements are performed. If necessary, the baseline magnetic measurements are used for phase error tuning which is achieved by adjusting the magnetic gap of the SCU at prescribed locations. An optimization routine using a genetic algorithm is used to determine the magnitude of the gap change. Once complete, the SCUs are incorporated into the production cryostat and magnetic measurements of the final assembly are performed. Details of the process during phase error tuning and LHe bath testing of a 1.5 m-long SCU magnet are presented.

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Wednesday Poster Session / 1082

Beam dynamics study for SLS 100 MeV pre-injector upgrade

Author: Helena Alamprese[1]

Co-authors: Thomas Lucas [2]; Paolo Craievich [3]; Riccardo Zennaro [3]; Maarten Turenhout [2]

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The storage ring from the SLS is currently in the process of a significant upgrade to a new multi-bend achromat that aims to improve the performance of the machine by allowing it to deliver even brighter beams to the beamlines. The linear accelerator of the SLS is an ageing piece of infrastructure that need to continue to run for the few decades to continue to feed SLS 2.0 reliably. In this work, we investigate potential upgrades to the linac with the aim of reducing the overall complexity of the system.

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Monday Poster Session / 1083

Compton gamma-ray production enabled by VUV FEL operating around 170 nm

Author: Ying Wu[1]

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The linac-based single-pass FEL has been successfully operated
in the EUV and x-ray regions for about two decades. However, the oscillator FEL has been limited to operating in the longer wavelength region. This limitation arises from the challenge of obtaining short-wavelength FEL mirrors with high reflectivity, thermal stability, and radiation resistance. With the Duke storage ring FEL, we have demonstrated VUV FEL lasing from 168.6 to 179.7 nm with excellent beam stability. This progress has been made possible by developing a new FEL configuration with substantially reduced undulator harmonic radiation on the FEL mirror, a thermally stable FEL optical cavity, and a new type of high-reflectivity fluoride-based multilayer coating with a protective capping layer. Employing this VUV FEL in Compton scattering, we have also produced a high-flux, circularly polarized gamma-ray beam up to 120 MeV at the High-Intensity Gamma-ray Source (HIGS). The high-energy gamma rays will open up new opportunities for experimental study of the nucleon's structure through the lens of Chiral Perturbation Theory.

Footnotes:

- Y.K. Wu et al., J. Appl. Phys. 130, 183101 (2021); doi: 10.1063/5.0064942

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Wednesday Poster Session / 1084

Tolerance calculations for 197 MHz prototype crab cavity for EIC

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We will calculate tolerances for fabrication for the 197 MHz prototype crab cavity for EIC.

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Wednesday Poster Session / 1085

Testing of two-cell RF-dipole crab cavity

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We will report on the test results of the first ever built 2-cell RF-dipole type crab cavity.

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North America

Thursday Poster Session / 1086

Ultrafast high voltage kicker system hardware for ion clearing gaps

Author: Alexander Smirnov[1]

Co-authors: Alexei Smirnov [2]; Evgenii Ivanov [2]; Gunn-Tae Park [3]; Haipeng Wang [3]; Ronald Agustsson [1]; Sergey Kutsaev [1]; Shukui Zhang [3]; Stephen Benson [3]

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Ionization scattering of electron beams with residual gas molecules causes ion trapping in electron rings, both in a collider and electron cooling system. These trapped ions may cause emittance growth, tune shift, halo formation, and coherent coupled bunch instabilities. In order to clear the ions and prevent them from accumulating turn after turn, the gaps in a temporal structure of the beam are typically used. Typically, the gap in the bunch train has a length of a few percent of the ring circumference. In those regions, the extraction electrodes with high pulsed voltages are introduced. In this paper, we present the design consideration and initial test results of the high-voltage pulsed kicker hardware that includes vacuum device and pulsed voltage driver, capable of achieving over 3 kV of deflecting voltage amplitude, rise and fall times of less than 10 ns, 100 ns flat-top duration at 1.4 MHz repetition rate.

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North America

Tuesday Poster Session / 1087

Investigations in turn-by-turn optics measurements at KARA

Author: Johannes Steinmann[1]

Co-authors: Anke-Susanne Mueller [1]; Bastian Haerer [1]; Edmund Blomley [1]; Erhard Huttel [2]; Frank Zimmermann [3]; Jacqueline Keintzel [3]; Julian Gethmann [1]; Rogelio Tomas [3]

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The Karlsruhe Research Accelerator (KARA) is a synchrotron light source user and test facility, operating at an electron beam energy ranging from 0.5 to 2.5 GeV. Performing optics measurements and comparing with the machine model promises an improved understanding of the lattice and the underlying beam dynamics. Horizontal and vertical turn-by-turn Beam Position Monitor data are acquired and used for performing optics measurements in this storage ring. The results of these studies are presented in this paper.

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Thursday Poster Session / 1088

A 50 kV pulse generator for fast kickers

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Brookhaven National Laboratory has recently been selected as the site for the Electron-Ion Collider (EIC). The EIC will consist of two intersecting accelerators, one producing an intense beam of electrons, the other a high-energy beam of protons or heavier atomic nuclei, which are steered into head-on collisions. One of the sections of the EIC beamline will require a hadron injection fast kicker system. RadiaBeam is developing GaN-based pulser with ±50 kV voltage amplitude, <4 ns rise and fall times, 40 ns pulse width. In this paper, we discuss the development progress.

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Wednesday Poster Session / 1089

Advances in the accelerator design of the Future Circular Electron-Positron Collider

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Co-authors: Antoine Chance [2]; Barbara Dalena [2]; Katsunobu Oide [1]; Mauro Migliorati [3]; Michael Benedikt [1]; Olivier Brunner [1]; Paolo Craievich [4]; Roberto Kersevan [1]; Tor Raubenheimer [5]; Yann Dutheil [1]

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In autumn 2023, the FCC Feasibility Study underwent a crucial "mid-term review". We describe the accelerator performance risks for the proposed future circular electron-positron collider, FCC-ee, identified for, and during, the mid-term review. For the collider rings, these are the collective effects when running on the Z resonance –especially resistive wall, beam-beam, and electron cloud, –the

beam lifetime, dynamic aperture, top-up operation, beam losses, collimation, and machine protection, alignment tolerances, beam-based alignment versus mechanical alignment, and the configurations of the radiofrequency (RF) system. For the booster, the issues of concern are collective effects at Z and ttbar energies, with a stainless-steel vacuum chamber, definition of a baseline optics, injection from the high-energy linac, extraction into the main ring, and again the RF configuration. For the pre-injector, the layout and the linac repetition rate are primary considerations. We discuss the various issues and report the planned mitigations.

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Wednesday Poster Session / 1090

Probing FCC-ee energy calibration through resonant depolarization at KARA

Author: Johannes Steinmann[1]

Co-authors: Anke-Susanne Mueller [1]; Bastian Haerer [1]; Edmund Blomley [1]; Erhard Huttel [2]; Frank Zimmermann [3]; Jacqueline Keintzel [3]; Robert Ruprecht [1]; Tatiana Pieloni [4]; Yi Wu [4]

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The FCC-ee collider physics program requires a precise determination of the center-of-mass energy. The average energies of the two colliding beams can be measured by resonant depolarization (RDP) of polarized electron and positron bunches. The depolarization is achieved by an electromagnetic device, e.g., a strip line, excited at a sweeping frequency. Once the excitation frequency is equal to the spin precession frequency, which is directly proportional to the beam energy, the polarization is lost or reduced. At KARA the resonant frequency is routinely measured via the change of the Touschek lifetime. We report on an RDP beam measurement campaign at the Karlsruhe Research Accelerator (KARA), exploring how this technique could be applied at the FCC-ee. In particular, we examine the sensitivity of the inferred value of beam energy to various parameters, such as the depolarize scan speed, the scan direction, and the beam operation energy.

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Monday Poster Session / 1091

Advanced accelerator concepts for dark sector searches and fast muon acceleration

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Dielectric laser acceleration (DLA) is a promising approach to accelerator single electrons at a high repetition rate to GeV energies, for indirect dark matter searches. Relevant concepts include the integration of the dielectric structure inside the laser oscillator, deflecting DLAs combined with a segmented detector, high-rate source of single electrons, DLA structure alignment, and diagnostics. To efficiently use muons for high energy physics applications they need to be accelerated rapidly, before they decay. Plasma acceleration achieves GV/m accelerating fields and could be ideal for accelerating to muon-collider energies. Amongst the challenges are the injection and preservation of the muons inside a plasma "bubble". Single muons could also be accelerated in DLAs for dark matter searches. They could be injected from existing low-intensity muon sources, such as the one at PSI. A workshop organized in the frame of the EU project "Innovation Fostering in Accelerator Science and Technology" (I.FAST) focused on GHz Rate & Rapid Muon Acceleration for Particle Physics to address these topics. We report workshop highlights and future research directions.

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Tuesday Poster Session / 1092

Dark current simulations in accelerating structures operating with short RF pulses

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The attainable acceleration gradient in normal conducting RF accelerating structure is limited by RF breakdown, a major challenge in high gradient operation. Some of the recent experiments at the Argonne Wakefield Accelerator (AWA) facility suggest the possibility of breakdown mitigation by using short RF pulses (on the order of a few nanoseconds) to drive the accelerating structures. To understand the physics of RF breakdown on a nanosecond time scale, we simulated the dark current in few accelerating structures in both long-pulse and short-pulse regimes comparatively, and studied multiple potential breakdown initiators, including field emission and multipacting. Our simulations suggest the potential of a class of accelerators designed to work in the short-pulse regime.

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Wednesday Poster Session / 1095

Progress & developments of the Beam Delivery Simulation (BDSIM)

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Beam Delivery Simulation (BDSIM), is a C++ program that seamlessly models particle beam transport within an accelerator model that can encompass the beam line, the accelerator's environment, and any accompanying detectors. Based on a suite of high-energy physics software including Geant4, CLHEP, and ROOT, BDSIM transforms the optical design of an accelerator into a detailed 3D model. This facilitates the simulation of particle interactions with matter and the subsequent production of secondary particles. Widely utilized across diverse accelerators worldwide, BDSIM is ideal for simulating energy deposition and assessing charged particle backgrounds. Here, the latest BDSIM developments are shown, including python bindings & interfacing with external tracking tools such as Xsuite.

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Wednesday Poster Session / 1096

A review of the Beam Delivery Simulation (BDSIM) user community

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Beam Delivery Simulation (BDSIM) is a Monte Carlo particle tracking simulation tool for modelling energy deposition in 3D models of particle accelerators. Initially conceived in 2001 to model the collimation system in the International Linear Collider (ILC), in recent years BDSIM has undergone a significant transformation across virtually its entire code base. As a result of its newer features, functionality, and performance, BDSIM is becoming increasingly adopted throughout the particle accelerator community for a wide variety of applications. Here, we review recent BDSIM studies by members of the BDSIM user community, including but not limited to linear and circular High Energy Physics (HEP) colliders, HEP fixed target experiments, diagnostics and collimation at light sources, and medical accelerators including start-to-end proton therapy machines and radiobiology research beam line design projects.

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Thursday Poster Session / 1098

The Laser-hybrid Accelerator for Radiobiological Applications (LhARA): an update towards the conceptual design

Author: William Shields[1]

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LhARA, the Laser-hybrid Accelerator for Radiobiological Applications, is a proposed facility designed to advance radiobiological research by delivering high-intensity beams of protons and ions in unprecedented ways. Designed to serve the Ion Therapy Research Facility (ITRF), LhARA will be a two-stage facility that will employ laser-target acceleration in the first stage, generating proton bunches with energies around 15 MeV via the TNSA mechanism. A series of Gabor plasma lenses will efficiently capture the beam, directing it to an in-vitro end station. In the second stage, protons will be accelerated in a fixed-field alternating gradient ring, reaching up to 127 MeV, while ions can achieve up to 33.4 MeV/u. The resulting beams will be directed to either an in-vivo end station or a second in-vitro end station. The demonstrated technologies have the potential to shape the future of hadron therapy accelerators, offering versatility in time structures and spatial configurations, with instantaneous dose rates surpassing the ultra-high dose rates required for studies into the FLASH effect. Here, we present a status update of the LhARA accelerator as we approach a full conceptual design.

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Thursday Poster Session / 1100

Sorting strategies for the new superconducting magnets for the CERN HL-LHC

Author: Thomas Pugnat[1]

Co-authors: Andreas Wegscheider [1]; Ezio Todesco [1]; Massimo Giovannozzi [1]; Rogelio Tomas [1]

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In a circular collider, precise control of the linear optics in the vicinity of the interaction points plays a crucial role in ensuring optimal operational performance and satisfying the machine protection constraints. Superconducting magnets are affected by unavoidable field errors that impact machine performance, and mitigation strategies are usually put in place to improve the situation. Past studies performed on the LHC have shown the benefit of magnet sorting on both initial beta-beating, through compensation of magnetic field errors, and overall correction quality of the machine optics. This work aims at extending those studies in the context of the luminosity upgrade of the LHC by considering the possible impact on performance from various sorting strategies applied to the new triplet quadrupoles for the ATLAS and CMS high-luminosity insertions.

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Thursday Poster Session / 1102

Direct measurements of RHIC BPM data at the IP using linear regression

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Many mature methods to study the betatron function of a lattice rely on beam position monitor (BPM) data and the model of the whole machine. In this study, we focused on analyzing specific parts of the lattice of the Relativistic Heavy Ion Collider (RHIC), taking advantage of BPMs separated by drift space near interaction points (IPs) of RHIC. This (local) approach would provide a alternative measure of beta*and s* at specific regions which can be compared to previous (global) methods. This process utilizes the phase transfer matrix built from existing BPM data from RHIC using Linear Regression techniques. Results at the IPs were compared to B3/B4 magnet sections. These were then compared to previous methods. It was found that this local method does just as well as existing global methods in certain regions (around IP10 and 12) while doing subpar in other regions (around IP6). However, we propose that AC dipole data will perform better than the previous set of BPM data, though results are currently pending. This method of considering specific regions with special conditions could be extended to experiments at NSLS-II and the upcoming EIC for further luminosity optimization.

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North America

Wednesday Poster Session / 1104

Conceptual designs of a 20 T dipole based on hybrid HTS/LTS cos-theta coils

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20 T dipole magnets are being considered for the next generation of particle accelerators. The nominal operation field of 20 T is above the practical limit of Nb3Sn accelerator magnets and, thus, it requires using superconductors with higher critical parameters such as High Temperature Superconductors (HTS). The high cost of HTS and the more complicated technology of HTS coils makes attractive a hybrid approach, which uses both superconductors and technologies. This paper presents a design concept of an HTS/LTS hybrid dipole with 50 mm aperture and 20 T nominal field based on the cos-theta (CT) coil and cold iron yoke. The HTS part of magnet coil uses the REBCO Twisted Stacked-Tape cable. The LTS part is graded and made of Nb3Sn Rutherford cables with two different cross-sections. Due to high sensitivity of REBCO and Nb3Sn superconductors to large stresses and strains in the coil at high field, a Stress Management (SM) concept combined with the CT coil geometry is used. The results of magnet magnetic analysis are presented and discussed. The parameters of this design are compared with the parameters of similar LTS/HTS hybrid magnets based on block-type and canted cos-theta coils.

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Wednesday Poster Session / 1105

Development and test of a large-aperture Nb3Sn cos-theta dipole coil with stress management

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The stress-managed cos-theta (SMCT) coil is a new concept which was proposed and is being developed at Fermilab in the framework of US Magnet Development Program (US-MDP) for high-field and/or large-aperture accelerator magnets based on low-temperature and high-temperature superconductors. A 120-mm aperture two-layer Nb3Sn SMCT dipole coil has been developed at Fermilab to demonstrate and test the SMCT concept including coil design, fabrication technology and performance. The first SMCT demo coil was fabricated and assembled with 60-mm aperture Nb3Sn coil inside a dipole mirror configuration and tested separately and in series with the insert coil. This paper summarizes the design, parameters, and quench performance of the 120-mm aperture SMCT coil in a dipole mirror configuration.

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Wednesday Poster Session / 1106

Development and test of a small-aperture dipole coil made of REBCO stacked-tape cable

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This paper describes the magnetic and mechanical design, and the main parameters of a small-aperture two-layer dipole coil made of REBCO twisted stacked-tape cable. The coil has 36-mm diameter aperture and 59-mm outer diameter. The coil turns are wound into groves in a special structure that ensures the appropriate turn location and control the level of strain and stress in the brittle REBCO tapes throughout the magnet assembly and operation. The coil structure is produced using a 3D printing technology. The twist of the stacked-tape cable is introduced in the coil straight section during coil winding. The structure geometry and the coil winding procedure were tested and optimized using 3D printed plastic parts and "dummy"cable made of stainless-steel tapes. The REBCO coil was fabricated and tested in liquid Nitrogen and Helium. The details of the coil design, fabrication and tests will be reported and discussed.

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Tuesday Poster Session / 1107

ML-enhanced online commissioning and optimization of the APS-U accelerator complex

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The Advanced Photon Source (APS) facility has just completed an upgrade to become one of the world's brightest storage-ring light sources. For the first time, multiple machine learning (ML) methods have been developed and used as part of the baseline commissioning plan. One such method is Bayesian optimization (BO) –a tool for efficient online high-dimensional single and multi-objective tuning. In this paper we will present our BO development work, including novel augmentations motivated by experimental needs - fast multi-fidelity measurement techniques, simulation-based uncertainty-aware priors, and time-aware adaptive drift compensation. These techniques were successfully applied to tuning linac and booster transmission efficiency, injection stabilization, enlarging storage ring dynamic and momentum apertures, and many other tasks - results of each will be shown, as well as validation tests at external facilities. Given the success of BO methods at APS, we are planning and will outline future work on tighter ML method integration into the standard control room procedures and software.

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Wednesday Poster Session / 1108

DBR-SL-GaAs surface charge limit observation and suppressing for EIC high charge polarized source

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The research and development (R&D) of the polarized electron source for the EIC has made significant progress this year. We achieved an 11 nC bunch charge of the polarized electron beam. One challenge we faced was the surface charge limit of the Distributed Bragg Reflector (DBR) GaAs/GaAsP Super Lattice (SL) photocathode. We suppressed this effect by optimizing the surface doping and heating procedures. We also tested increasing the charge by expanding the emission area but found it could not be linearly scalable. In this report, we will discuss the surface charge limit mechanism and model the surface charge limit using the diffusing equations, one for diffusing the excited electrons to the surface and another for surface-trapped electrons diffusing to the ground.

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Monday Poster Session / 1109

The design progress of a high charge, low energy spread polarized pre injector for Electron Ion Collider

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The polarized pre-injector for the Electron-Ion Collider is intended to produce four bunches every second, each containing 7 nC, with 85% polarization along the longitudinal axis, for injection into the Rapid Cycling Synchrotron. The pre-injector consists of a polarized electron source, bunching section, longitudinal phase space manipulation, and SLC-Type LINAC. To reduce energy spread and increase bunch length, a compact zig-zag chicane and dechirp cavity rotate the bunch in longitudinal phase space. In this paper, we will discuss the progress of recent pre-injection design and RF frequency selection. Additionally, we will examine the effects of wakefield, as well as coherent and incoherent synchrotron radiation on beam quality.

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Monday Poster Session / 1110

Generating super-Gaussian distribution and uniform sliced energy spread bunch for EIC strong hadron cooling

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Strong Hadron Cooling (SHC), utilizing the coherent electron cooling scheme, has been extensively investigated for the Electron Ion Collider (EIC). Throughout our cooling optimization studies, we realized that a Super-Gaussian electron bunch offers enhanced performance in comparison to a Gaussian bunch. Our approach involves initiating the electron beam distribution in a double peak form, transitioning them into a Super-Gaussian distribution due to the longitudinal space charge. Subsequently, a chicane within the linac section compresses the bunch to meet the required bunch length. We tuned a third harmonic cavity amplitude to reduce the nonlinear term of the chicane. Moreover, given the low initial current leading to a small but non-uniform slice energy spread, we evaluated utilizing laser heating techniques to achieve a uniformly distributed slice energy spread. In this report, we discuss the concepts and simulation results.

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Wednesday Poster Session / 1111

Design of a 3-cell rectangular deflecting cavity for a compact THz-FEL

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In this paper, we present the design of a multipurpose 3-cell deflecting RF cavity for a compact terahertz (THz) free electron laser (FEL) facility. The 3-cell deflecting RF cavity is mainly used for longitudinal bunch length measurement and a chopper system to cut off the bunch tail caused by the thermionic gun. Single-cell cavities suffer from orbit offset, while a 3-cell cavity is possible to eliminate the offset effect. In addition, rectangular deflector is decided for its superiority in fabrication and mode separation when compared to a cylindrical deflector. We used CST for cavity design and placed the results of the analysis of the cavity in this paper. Particle tracking is performed with the Astra code, and space charge effect is taken into account. It is shown that the time resolution are 500fs when used as a longitudinal bunch length measurement. When used as a beam chopper, the beam orbits are free of offset while cutting off the tail particles, which has less impact on the subsequent beam transport.

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Orbital angular momentum beams research using a free-electron laser oscillator

Authors: Peifan Liu[1]; Jun Yan[2]; Andrei Afanasev[3]; Stephen Benson[4]; Hao Hao[5]; Stepan Mikhailov[2]; Victor Popov[2]; Ying Wu[2]

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Orbital angular momentum (OAM) photon beams are excellent tools for non-contact optical manipulation of matter in a broad photon energy range. A free-electron laser (FEL) oscillator is well-suited for studying OAM beams with various features including a wide spectral coverage, wavelength tunability, two-color lasing, etc. Here, we report the first experimental demonstration of superposed OAM beams from an oscillator FEL. Lasing at around 458 nm, we have generated superposed OAM beams up to the fourth order as a superposition of two pure OAM modes with opposite helicities. These generated beams have a high beam quality, a high degree of circular polarization, and high power. Using external rf modulation with frequencies from 1 to 30 Hz, we also developed a pulsed mode operation of the OAM beams with a highly reproducible temporal structure. FEL operation showcased in this work can be extended to higher photon energies, e.g. using a future x-ray FEL oscillator. The operation of such an OAM FEL also paves the way for the generation of OAM gamma-ray beams via Compton scattering.

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Monday Poster Session / 1114

Haissinski distribution of electron beam in Electron-Ion Collider and its impact on the hadron beam

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The longitudinal distribution of the electron beam in the electron storage ring of the Electron-Ion Collider will be modified by the machine impedance. The modified distribution, combined with crab cavities may have an impact on the quality of the hadron beam during the collision. In this paper, we will explore the possible impact on the hadron beam quality with strong-strong and weak-strong beam-beam simulations.

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North America

Thursday Poster Session / 1115

Prototype design of a digital low-level RF system for S-band deflectors

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S-band deflectors are generally operated on pulsed mode for beam diagnosis. We plan to deploy 5 S-band (2997 MHz) deflectors to accurately measure the longitudinal time distribution of ultra-short electron beam pulses in Shenzhen Superconducting Soft X-ray Free Electron Laser (S3FEL). A microwave system of one deflector consists of a low-level RF system (LLRF), a solid-state amplifier, waveguide couplers, and a klystron, operated in pulse mode with a maximum repetition frequency of 50 Hz. Its microwave amplitude and phase stability must be better than 0.06%/0.08° (RMS). This article will introduce the prototype design of the hardware, firmware, and software of the digital LLRF system. We use homemade Local Oscillators (LOs) and commercial cards based on the MicroTCA standard in hardware design. The firmware design will use a Non-IQ demodulation and a pulse feedforward algorithm to suppress noise from high voltage of klystron. The software design is based on the EPICS control system architecture, achieving slow control and interface display functions. This report will also show some preliminary test results.

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Monday Poster Session / **1116**

An ultimate single-ion source using a Coulomb crystal in a Paul trap

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An ion cloud confined in a Paul trap eventually reaches a Coulomb crystalline state when strongly cooled toward absolute zero. The normalized emittance of the Coulomb crystal can be in the sub-femtometer range. The trap is thus usable as a unique ion source for nano-beam production, though the available beam intensity is limited. This new concept was first discussed nearly 20 years ago*and later experimentally demonstrated by several research groups (,***). In this paper, we report on the result of a recent experiment where an attempt was made to extract Ca+ or N2+ ions one by one from a compact linear Paul trap. In addition to the regular extraction scheme based on a string Coulomb crystal, the possibility of using a multi-shell crystalline structure is explored in detail.

Footnotes:

- M. Kano et al., J. Phys. Soc. Jpn. 73, 760(2004). ** W. Schnitzler et al., Phys. Rev. Lett. 102, 070501 (2009). *** K. Izawa et al., J. Phys. Soc. Jpn. 79, 124502 (2010).

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Monday Poster Session / **1117**

Undulator radiation of single electrons: coherence length and quantum-optical properties

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The aims of the CLARA experiment at the Fermilab Integrable Optics Test Accelerator (IOTA) were to directly measure the coherence length of undulator radiation emitted by a single electron and to test whether the radiation is in a pure classical Glauber coherent state or in a quantum mixture of coherent and Fock states. We used a Mach-Zehnder interferometer (MZI) to study visible radiation generated by 150-MeV electrons circulating in the ring. The relative delay between the two arms of the MZI was adjusted by varying the length of one of them with a resolution of 10 nm. The intensity of the circulating beam spanned several orders of magnitude, down to single electrons. A pair of single-photon avalanche diodes (SPADs) was placed at the output of the MZI arms to detect photocounts with high efficiency and timing resolution. We describe the observed interference patterns and photocount rates as a function of interferometer delay and discuss their implications.

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Monday Poster Session / 1118

An experimental proposal for the strong-filed Terahertz generation at SXFEL facility

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Strong field Terahertz (THz) light source has been in-creasingly important for many scientific frontiers, while it is still a challenge to obtain THz radiation with high pulse energy at wide-tunable frequency. In this paper, we introduce an accelerator-based strong filed THz light source to obtain coherent THz radiation with high pulse energy and tunable frequency and X-ray pulse at the same time, which adopts a frequency beating laser pulse modulated electron beam. Here, we present the experimental preparation for the strong filed THz radiation at shanghai soft X-ray free-electron laser (SXFEL) facility and show its simulated radiation performance.

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Wednesday Poster Session / 1119

Improving the dynamic range of a wire scanner up to 1e+7

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Diagnostics and control of beam halo along the beamline are of utmost importance for a high-intensity proton accelerator. To guide halo collimation and mitigate beam loss, halo diagnostics at different betatron phases have been proposed for the CSNS hydrogen linac accelerator. Instead of a scintillating detector, a wire scanner with a neutron-sensitive BF3 detector has been suggested, achieving a dynamic range of 1e+5. To further enhance the bottom limit of halo diagnotics, a novel wire scanner equipped with a fluorescence strip has been proposed and demonstrated at CSNS linac. This design has a high light yield and blooming-free design, enabling a dynamic range of over 1e+7 using a CMOS camera during the initial commissioning phase. This paper reports on the optimizations of the dynamic ranges of the aforementioned two schemes and the sequence observations of beam-halo dynamics.

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Wednesday Poster Session / 1120

Simulations of an X-band transverse deflection structure with variable polarization

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Transverse deflection structures (TDS) have been widely used as diagnostic devices to characterize longitudinal properties of electron bunches in a linear accelerator. However, the conventional TDS can only measure either the horizontal or the vertical slice envelopes of electron bunches. In order to give full control of the angles of the transverse streaking field inside of the TDS to characterize the projections of the beam distribution on different transverse axes, we numerically investigate an X-band TDS with variable polarization in this paper. Through variable streaking direction, the orientation of the streaking field of the TDS is adjusted to an arbitrary azimuthal angle. This helps facilitate the development of next-generation TDS for the characterization of electron bunches, such as slice emittance measurement on different planes.

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Thursday Poster Session / 1121

High-voltage nanosecond power supply simulation

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The high-voltage nanosecond power supply is required to power the kicker in the injection system of the Hefei Advanced Light Facility (HALF). The amplitude of this power supply is ≥ ±10 kV and its pulse width is about 2 ns. The feasibility of the actual project is theoretically verified by simulation in this paper.

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Tuesday Poster Session / 1122

Optics rematching between TT24 and P42 primary beam lines within the HI-ECN3 study project at CERN

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The High Intensity ECN3 (HI-ECN3) study project aims to increase the intensity of the proton beam delivered to a new experimental facility housed in the ECN3 underground cavern in CERN's North Area up to the ˜4e+13 ppp (protons per pulse) and up to ˜4e+19 POT (protons on target) per year. The increase necessitates upgrades of the primary beam transfer lines coming from SPS directly to the new Target Complex upstream of ECN3. In this work we describe the modifications to the primary beam line optics that allow the transfer of the beam to the HI-ECN3 facility in two scenarios: shared (beam is split between the three existing production targets) and dedicated (beam goes directly to the target serving ECN3). An optimization study is presented to reduce the sensitivity of the beam optics to errors and minimize the effects of the beam's interaction with material when transiting the existing target area between TT24 and P42, whilst respecting the different constraints needed to share the beam between ECN3 and the rest of the North Area and permit a vertical trajectory bump around the target serving EHN1.

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Thursday Poster Session / 1123

Development of RF reference distribution system for Hefei Advanced Light Facility

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Hefei Advanced Light Facility (HALF) is a diffraction-limited storage ring-based light source consists of a 180 m linear accelerator and a 480 m storage ring. The RF reference signal included 499.8 MHz and 2856 MHz are generated from two phase-locked master oscillators and transmitted to the RF system, beam position monitor system, timing system and beamline station by the phase stabled coaxial cables which are installed in the ±0.5 ℃ thermostatic bath. The RF Reference Distribution System (RF-RDS) are developed to realize the phase synchronization and transmission with low phase noise for long distance. The continues wave amplifier are manufactured to generate enough

RF power, with the added phase noise being less than 1 fs (10 Hz˜10 MHz). The phase noise of each receiving terminal is estimated be less than 30 fs (10 Hz˜10 MHz). The design of RF-RDS and experimental result are discussed in this paper.

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Monday Poster Session / 1125

Optimization design of photoneutron source for detecting dissolved substances in aqueous solutions

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Measuring the composition and content of dissolved substances in aqueous solutions is in demand in fields such as biomedicine, and industrial production. The material analysis technique based on thermal neutron capture reaction is one of the commonly used methods for analyzing the composition and content of dissolved substances in aqueous solutions. The material analysis technology based on thermal neutron capture reaction requires the selection of appropriate neutron sources. Due to its mobility, high neutron yield, moderate cost, controllable beam output, and being a pulse type neutron source, photoneutron sources are suitable for detecting dissolved substances in aqueous solutions. In this article, design and optimization of a photoneutron source based on a 7 MeV electron accelerator was done using the Monte Carlo simulation. At 1 μA current, the photoneutron sources can yield 1.6e+8 neutrons per second. The detection of gadolinium concentration in aqueous solution was carried out using this photoneutron source. The results showed that in 5-minute, the measurement error did not exceed 15% when the gadolinium concentration was between 0.6 g/L and 1.0 g/L.

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Tuesday Poster Session / 1126

Application of common points selection method based on uniformity dividing space in HALF

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The alignment installation work of Hefei Advanced Light Facility (HALF) is usually carried out in tunnels. We convert the coordinates of the landmark points to the global coordinate system through coordinate transformation, and accurately adjust them to the corresponding coordinate values for alignment and installation. However, tunnels are often long and narrow, which can easily lead to ill-conditioned normal equations and loss of accuracy when solving coordinate transformation parameters. Therefore, to quickly and accurately obtain the coordinate transformation parameters, this paper proposes a common point selection method based on uniformity division space, which divides the coordinate transformation space according to the uniformity in different directions to select the optimal common points combination, and uses simulation and measured data to verify the method in this article. The results show that the conversion parameters solved by this method are more accurate and more stable, avoiding accuracy loss due to aggregation in a certain direction, and are suitable for narrow and long layout scenarios.

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Tuesday Poster Session / 1127

Progress of physics studies and beam commissioning of the High Energy Photon Source

Author: Yi Jiao[1]

Co-authors: Bin Wang [1]; Cai Meng [2]; Chenghui Yu [1]; Chongchong Du [1]; Daheng Ji [1]; Dongbing Li [1]; Fang Yan [1]; Gang Xu [1]; Haisheng Xu [1]; Hongfei Ji [1]; Huamin Qu [2]; Jing Zhang [2]; Jingyi Li [2]; Jintao Li [1]; Jiuqing Wang [1]; Na Wang [3]; Nan Li [1]; Ping He [1]; Saike Tian [1]; Sen Yue [1]; Suying Chen [1]; Wei Li [1]; Weimin Pan [2]; Xiang Zhang [2]; Xiao Yu Li [2]; Xiaohan Lu [1]; Xiaohao Cui [1]; Xiuqian Shi [2]; Xiyang Huang [2]; Xu Hang [2]; Yaliang Zhao [1]; Yao Gao [2]; Yuan Guo [1]; Yuanli Luo [1]; Yuanyuan Wei [4]; Yuemei Peng [2]; Yuting Wang [2]; Zhe Duan [1]; Zuyue Hao [1]

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The High Energy Photon Source (HEPS) is a 34-pm, 1360-m storage ring light source being built in the suburb of Beijing, China. The HEPS construction started in 2019, with the main civil construction finished at the end of 2021. In the past year, the beam commissioning of the HEPS injector (both Linac and booster) was started and had been finished, and the equipment installation was underway

for the storage ring simultaneously. In this paper, we will briefly introduce system conditioning and commissioning of the HEPS Linac and booster, and also simulation studies and high-level applications'development for the commissioning of the storage ring.

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Monday Poster Session / 1129

Research on spatial alignment of laser and electron beam in the generation of ultra-short electron pulses by laser modulation

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Co-authors: Biaobin Li [1]; Haoran Zhang [1]; Xiazhen Xu [1]; Zhigang He [1]; Zixin Guo [1]

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The utilization of laser modulation techniques shows potential in producing sub-femtosecond electron beams within photoinjector electron guns. The precise spatial alignment between the modulated laser and electron beam is crucial for the stable emission of sub-femtosecond electron beams. In practical applications, inevitable lateral positional fluctuations are present in both the modulated laser and electron beam pulses, resulting in uneven and suboptimal modulation effects of the laser on the electron beam. Photocathode electron guns commonly utilize solenoid focusing for transverse electron beam concentration, inducing transverse phase space coupling and causing the laser-induced transverse jitter in the electron gun to not accurately reflect the transverse jitter of the electron beam. This study seeks to employ coherent lasers and devise a solenoid coil to disentangle the transverse phase space of the electron beam, ensuring that the transverse jitter of the electron beam aligns with the jitter of the modulated laser at the focal point.

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Thursday Poster Session / 1130

Narrowband impedance studies in the HEPS storage ring

Author: Na Wang[1]

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The High Energy Photon Source (HEPS) is a fourth-generation synchrotron radiation facility with design beam emittance of less than 60 pm. Impedance modelling is an important subject due to the adopted small beam pipe as well as the tight requirements from beam collective effects. Narrowband impedances can be generated by the discontinuity of the vacuum chamber or the finite conductivity of the beam pipe. The coupled bunch instabilities caused by the narrowband impedances could restrict the beam current or perturb the synchrotron radiations. In this paper, the narrowband impedances in the HEPS storage ring are investigated element by element.

Footnotes:

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Thursday Poster Session / 1132

Study of band gap alteration in CVD-grown few-layer MoS_2 under swift-heavy ion irradiation

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The distinctive electronic band structure characteristics of 2D materials enable various advanced applications in electrical and optoelectronic devices. The present work reports on a simple CVD technique that employs alkali halide to synthesize high-quality few-layer MoS2 by reducing growth temperature from 850℃ to 650℃ and its ion-irradiation study for band gap modification. The Raman peak position difference of A_1g to E1_2g is ≈24.5 cmˆ-1 for the synthesized MoS2, which corresponds to a few layers (< 5 monolayers) of MoS2 on the substrate, as also confirmed by the AFM. The optical image shows the continuous distribution of flakes throughout the substrate; the average area of flakes is ≈0.2 μmˆ2, as confirmed by SEM and TEM analysis. SHI irradiation at 100 MeV ion energy of 1e+11 to 1e+13 ions/cmˆ2 ion fluences have been used to modify the band gap in MoS2. UV-vis spectroscopy shows the absorption peak shifts from 680 nm to 674 nm for the A-peak and 630 nm to 624 nm for the B-peak. As a result, 100 MeV Ni ions with an (S_e) of 11.3 keV/nm have modified the band gap of a MoS2 (20 meV), due to ion irradiation-induced strain.

Footnotes:

two-dimensional (2D), Chemical vapor deposition (CVD), Swift heavy-ion (SHI), electronic energy loss (S_e)

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Tuesday Poster Session / 1133

A prototype storage ring for the precision frontier

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Two of the major scientific drivers of particle physics and cosmology are the faith of antimatter after the Big Bang and the origin of Dark Matter. The answers to these questions can be addressed by investigating permanent and oscillating Electric Dipole Moments (EDM) of fundamental particles. The experiments can be performed with polarized beams in a dedicated storage ring.
Important milestones have been achieved by the JEDI Collaboration, using the magnetic storage ring COSY at Forschungszentrum Juelich (Germany). The next measure is to design a Prototype Storage Ring (PSR), comprising two steps: (i) an all-electric version and (ii) a hybrid ring, complementing the electric fields with magnetic ones. The layout of the PSR with a beam energy of about 30-45 MeV and a circumference of around 100 m will serve as enabler for the final EDM facility facility operated at a magic energy of 233 MeV, with a circumference of about 500 m.
Once built, the first phase of the PSR will demonstrate the remaining ambiguities and technologies, and in the second stage provide a first direct measurement of the EDM of the proton with a sensitivity comparable to EDM measurements of neutrons.

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Wednesday Poster Session / 1134

ESS WS scintillator system design and test results

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The WS superconducting systems are based on scintillator detectors and wavelength shifting fibers are mounted on the beam pipe. The detectors are coupled to long haul optical fibers, which carry the signals to custom front end electronics sitting in controls racks at the surface. The acquisition chain have been characterized at IHEP (Protvino), CERN PSB, COSY Juelich and SNS before installation in the ESS tunnel. The beam test results of this system design, differing from the standard approach where photomultipliers are coupled to the scintillator will be presented.

Footnotes:

wire scanner, scintillator

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Europe

Wednesday Poster Session / 1135

Gamma beam modulation in Shanghai Laser Electron Gamma Source

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The Shanghai Laser Electron Gamma Source (SLEGS) is one of the beamlines of the Shanghai Synchrotron Radiation Facility, which dedicate to producing gamma beams in the slant-scattering for the first time. After produced in the interaction area, gamma rays pass through a carefully designed Gamma Modulation System (GMS), which consists of a double collimator system, attenuator system, and X/gamma imaging system.
The quasi-monochromatic gamma beams with an energy spread of 4.2-4.6% are produced at the target position by using an aperture of 2 mm of the double collimator system*. The flux of gamma beams is regulated by the gamma attenuator system.
X/gamma imaging system is equipped with two beam-spot monitors, an X-ray camera MiniPIX and the gamma spot monitor. MiniPIX is used for imaging electron-induced bremsstrahlung to reflect the position of gamma beam indirectly. The gamma spot monitor is used to reflect the gamma spatial distribution directly.
With the GMS the gamma beam have been successfully implemented on SLEGS, the obtained high-quality gamma beam has been applied to photoneutron validation experiments. The expected results confirm the reliability of SLEGS gamma quality.

Footnotes:

- Hao Z R, Fan G T, Wang H W, et al. Collimator system of SLEGS beamline at Shanghai Light Source[J]. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 2021, 1013: 165638.

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Monday Poster Session / 1136

Generating tunable X-ray optical frequency combs using a free-electron laser

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As an important experimental tool, the Optical Frequency Combs (OFCs) has had a profound impact on research in various fields, whereas, generating high power high repetition frequency OFCs at tunable frequencies is still a limitation for most of the existing methods. In this study, free-electron laser (FEL) is proposed to generate coherent X-ray OFC with a tunable repetition frequency and high pulse energy. The approach involves using a proper seed laser with frequency modulation, followed by amplification in the Echo-Enabled Harmonic Generation (EEHG) mode to generate X-ray OFCs. Numerical simulations using the realistic beam parameters of the Shanghai soft X-ray free-electron laser facility have demonstrated the feasibility of generating X-ray OFCs. These OFCs have a peak power of about 1.5 GW and repetition frequencies ranging from 6 THz to 12 THz at Centre energies carbon K edge (~284 eV). The proposed technique presents new possibilities for resonant inelastic x-ray scattering (RIXS) spectroscopy and Terabit-level coherent optical communication, etc.

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Tuesday Poster Session / 1137

Effects of dipole power-converter ripple during empty-bucket channelling

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In 2023, an RF technique known as empty-bucket channelling was implemented operationally at the CERN Super Proton Synchrotron (SPS) to improve the quality of the spill provided to the North Area experiments. Empty-bucket channelling suppresses particle-flux variations during resonant slow extraction by accelerating particles between empty RF buckets and rapidly displacing particles into the tune resonance via chromatic coupling. The flux variations are often caused by the power-converter ripple present in the synchrotron's magnets, which modulates the beam dynamics during the extraction process. In a chromatic extraction, the quadrupole ripple is the main contribution to the modulation as it directly perturbs the transverse tune. When empty-bucket channelling is applied, however, dipole ripple additionally modulates the size of the empty RF bucket. In this contribution, the phenomenon is explored and the consequences for empty bucket channelling in the SPS are outlined.

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Wednesday Poster Session / 1138

Simulations of an electro-optical in-vacuum bunch profile monitor and measurements at KARA for use in the FCC-ee

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The Karlsruhe Research Accelerator (KARA) is an electron storage ring and synchrotron light source for accelerator research at the Karlsruhe Institute of Technology (KIT). It features an electro-optical (EO) in-vacuum bunch profile monitor to measure the longitudinal bunch profile in single shot on a turn-by-turn basis using electro-optical spectral decoding (EOSD). A simulation procedure has been set up to evaluate its suitability as a beam instrumentation for the operation of the future electron-position collider FCC-ee. In order to assess the simulations, this contribution focuses on a comparison to EO sampling (EOS) measurements at KARA and a study on the heat load of the EO crystal due to the expected high bunch repetition rate envisioned for FCC-ee.

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THAN: Novel Particle Sources and Acceleration Techniques (Contributed) / 1139

Beam profile measurement of the ultra-slow muon for the transmission muon microscope

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Co-authors: Akira Goto [2]; Jun-ichi Ohnishi [1]; Koichiro Shimomura [3]; Kosuke Umeda [4]; Natsuki Teshima [3]; Patrick Strasser [5]; Shinki Nakamura [4]; Sohtaro Kanda [3]; Taihei Adachi [2]; Takahiro Yuasa [3]; Takayuki Yamazaki [3]; Takuya Umezawa [4]; Toshikazu Adachi [3]; Yasuhiro Miyake [3]; Yu Oishi [3]; Yukinori Nagatani [3]; Yutaka Ikedo [3]

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We have performed a beam profile measurement of the ultra-slow muon for the transmission muon microscope, which is being developed at the Japan Proton Accelerator Research Complex (J-PARC). A laser ionization of thermal muonium generates the ultra-slow muon. The generated ultra-slow muon is extracted by an electrostatic lens and transported to the beam profile monitor, which consists of a micro-channel plate and delay-line anode. In this paper, the results of profile measurements and the beam commissioning status of the ultra-slow muon beamline are reported.

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Thursday Poster Session / 1140

Optimizing the layout for a highly efficient multi-room particle therapy facility with a minimal footprint

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Proton therapy has a significant advantage over conventional radiation therapy. Yet most hospitals do not offer it because of the significant cost associated with it. In this work, we developed the most compact, low-cost, expandable, and high-performance beamline for multi-room particle therapy. The accelerator is located at a lower level (underground) and the beamline guides the particles to treatment rooms located on the upper level of the floor. The treatment delivery rooms are then designed in a circular arrangement such that the rotating beamline can deliver a beam to each treatment room where the patient is treated in an upright position and rotated in front of a static treatment beam. The compact beamline can rotate 360o about the vertical axis. For this beamline, the beam characteristics for treatment are calculated with the BDSIM Monte Carlo simulations code. With this invention, we can fit a single-room proton facility within an existing LINAC vault and 4 room facility could fit within a tennis court. We believe that the high throughput and minimum investment cost will allow treating the patients with protons the same as the conventional radiation therapy treatment cost.

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Tuesday Poster Session / 1141

Novel positron beam generation based on Shanghai Laser Electron Gamma Source

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The Shanghai Light Source has been operated since 2009 to provide synchrotron radiation to 40 beamlines of the electron storage ring at a fixed electron energy of 3.5 GeV. The Shanghai Laser Electron Gamma Source (SLEGS) is approved to produce energy-tunable gamma rays in the inverse Compton slant-scattering of 100 W CO2 laser on the 3.5 GeV electrons as well as in the back-scattering. SLEGS can produce gamma rays in the energy range of 0.66 –21.7 MeV with flux of 1e+5 –1e+7 photons/s*. A positron source based on SLEGS is designed to produce positron beams in the energy range of 3 – 16 MeV with a flux of 1e+5 /s and energy resolution of ˜7% with an aperture of 10 mm collimator. The positron generated has been simulated by GEANT4, uses a SLEGS gamma injected into a single-layer target, and a dipole magnet deflect positrons. Based on the energy-tunable SLEGS gamma rays, the

optimized parameters at each gamma energy were simulated to obtain an energy-tunable positron source.
We have confirmed positron generation in the commissioning. We plan to construct the positron source in the summer of 2024. We present the positron source based on results of simulation and test measurements.

Footnotes:

- H. H. Xu, G. T. Fan, H. W. Wang, H. Utsunomiya, L. X. Liu, Z. R. Hao, et al. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 2022 Vol. 1033 Pages 166742. &. Wang, HW., Fan, GT., Liu, LX. et al. Commissioning of laser electron gamma beamline SLEGS at SSRF. NUCL SCI TECH 33, 87 (2022).

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Asia

Tuesday Poster Session / 1142

Setup of Goubau Line system for impedance-measurement of vacuum components at the NSRRC

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A setup of in-house made Goubau (G-) Line system for measuring the broadband impedance of vacuum components has been developed at the NSRRC for improving the beam-stability of the Taiwan Photon Source (TPS). A thin copper wire of 0.287 mm in diameter with polyimide-coating ~0.02 mm in thickness connects two horn-shape aluminum launchers face-to-face at a distance ~1.2 m far in between via two impedance-matching copper tapers welded on both ends of the wire that transports the surface waves through the vacuum duct under test (DUT) allocated at the middle of wire. Measurement of time domain reflection (TDR) for the G-Line has verified the systematic performance of matching the impedance of 50 ohms. A vector network analyzer measures the transmission parameters of S21 of the DUT from the G-Line that the longitudinal impedance of DUT can be obtained. Various DUTs of vacuum components e.g. flanges without gasket were measured for inspecting the G-Line performance, besides, the special designed aluminum gaskets with rf-shielding property sealed flanges were also inspected that must feature with ultra-low impedance. The detail design and the test results of the G-Line will be described.

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Asia

Monday Poster Session / 1143

Characterization of a single-pass high-gain THz FEL at PITZ

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A single-pass THz free-electron laser (FEL) at the Photo Injector Test facility at DESY in Zeuthen (PITZ) was designed and implemented for a proof-of-principle experiment on a tunable high-power THz source for pump-probe experiments at the European XFEL. THz pulses are generated at a radiation wavelength of 100 µm within a 3.5 m long, strongly focusing planar LCLS-I undulator. High gain is achieved by driving the FEL with high brightness beams from the PITZ photoinjector at 17 MeV and a bunch charge of up to several nC. In addition to the mechanisms of self-amplified spontaneous emission (SASE), seeding of the THz-FEL by electron bunch modulation at the photocathode is also being investigated. The experimental results, including the gain curves and spectral properties of the THz-FEL radiation, are presented in comparison with theoretical predictions and numerical simulations.

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Europe

Wednesday Poster Session / 1144

Introducing a semi-Gaussian mixture model for simulating multiple coulomb scattering in RF-Track

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Co-authors: Rudolf Frühwirth [2]; Andrea Latina [1]; Daniel Schulte [1]; Jochen Schieck [2]

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The deflection of charged particles in matter can be characterized by multiple-Coulomb scattering. Simulating the interaction of each particle with the Coulomb forces of the material is prohibitively time-consuming from a computational perspective. To address this, scientists have developed a scattering probability models, such as the Moliere model, which have seen refinements and contributions from various researchers over the past decades. In the context of a design study of a LINAC for ionization cooling, RF-Track has recently incorporated particle interactions with matter. This inclusion enables simulations for applications like ionization cooling channels for muon colliders and the design of machines for medical purposes. Within RF-Track, a novel Semi-Gaussian mixture model has been introduced to describe the deflection of charged particles. This innovative model comprises a Gaussian core and a non-Gaussian tail function to account for the effects of hard scattering. To validate the accuracy of our results, we conducted a benchmarking against other particle tracking codes, with the outcomes demonstrating a high level of agreement.

Footnotes:

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Europe

Wednesday Poster Session / 1145

Optimizing initial beam parameters for efficient muon ionization cooling

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Co-authors: Elena Fol [1]; Chris Rogers [2]; Jochen Schieck [3]; Daniel Schulte [1]

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Ionization cooling is only cooling technique capable of efficiently reducing the phase space of a muon beam within a short timeframe. The ultimate cooling phase of a muon collider aims to minimize transverse emittance while simultaneously curbing longitudinal emittance growth, to achieve optimal luminosities within the collider ring. This study shows that achieving efficient cooling performance requires selecting the best initial muon beam parameters. We present a technique that enables the determination of these optimal initial parameters through simulations and compare them with analytical models.

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Europe

Thursday Poster Session / 1146

Non-linear optimization of Iranian Light Source Facility storage ring using MOGA

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Nonlinearities pose several challenges for accelerator physicists. In order to optimize nonlinearities in the lattice and improve the dynamic aperture (DA) and lifetime of the lattice, the designer utilized a variety of algorithms and trial and error methods. The Multi Objective Genetic Algorithm (MOGA) is a commonly used method for optimizing lattice nonlinearities. This technique involves tracking particles to select the working tuning points and the multipole strength to improve DA and Momentum Acceptance (MA). This paper briefly summarizes the preliminary optimization study on nonlinearities utilizing MOGA in the ELEGANT accelerator simulation code. We used the Turin System at the Iranian Light Source Facility (ILSF). Our primary objective was to determine the optimal strength for three families of employed octupoles in the ILSF lattice. The last DA and lifetime of the beam are studied, and the RDTs are estimated.

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Asia

Tuesday Poster Session / 1148

Research of plasma discharge process of magnetron sputtering coating for NEG film in the IAU vacuum chamber

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The non-evaporable getter (NEG) film deposited on the inner wall of the vacuum chamber using magnetron sputtering has been widely used in the fourth-generation synchrotron radiation light source to obtain and maintenance ultra-high vacuum in narrow vacuum chambers. The IAU vacuum chamber has a small cross-sectional size and a long length . It also needs to deposit a NEG film to meet the needs of ultra-high vacuum. Due to the limitation of cross-sectional size, it is difficult to obtain magnetron sputtering discharge and optimal coating parameters through experiments. In order to obtain clear discharge boundaries and optimal discharge parameters, the PIC-MCC method is used to conduct numerical simulations to determine the boundaries of discharge parameters. Taking a reasonable shell thickness and a lower discharge voltage as optimization goals, the optimal discharge parameters are determined and an experimental device is established. The spectral changes of Kr I and Kr II are measured with a spectrometer to verify the reliability of the numerical simulation and provide theoretical and data support for the next step of engineering coating implementation.

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Asia

Tuesday Poster Session / 1150

Injection magnet system for Korea-4GSR facility

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A 4th generation storage ring based light source is being developed in Korea since 2021. It features <100 pm rad emittance, about 800 m circumference, 4 GeV e-beam energy, full energy booster injection, and more than 40 beamlines which includes more than 24 insertion device (ID) beamlines. For extraction/injection to the booster and storage ring, it needs 4 septums, and 6 kickers. Particularly, for SR injection needs an eddy current septum with 1 mm septum thickness for 10 mrad bending, and a thick septum with 5 degree direct current driven septum. In this report, the design of the injection magnets (kickers, septums) for Korea-4GSR will be discussed.

Footnotes:

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Asia

Wednesday Poster Session / 1151

T-Mapping diagnostic system for vertical test of SHINE superconducting cavity

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T-mapping diagnostic system is an indirect method to detect the internal surface of superconducting cavity during vertical testing. When superconducting cavity is powered, T-Mapping can detect the thermal instability and thermal collapse caused by defects. The goal of the project is to develop temperature detection devices that are highly accurate and easy to install. The development of the equipment plays a supporting role in the production of superconducting cavity, and can intuitive feedback the defects in the machining assembly, which is conducive to the improvement of the processing technology.

Footnotes:

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Asia

Tuesday Poster Session / 1152

Modification of TPS arc-cell vacuum system for installation of EPU66

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Modification of an arc-cell vacuum system (length 14 m) for the cell SR18 in the TPS storage ring is described, which includes (a) replacement of a new bending chamber (B1) with an increased vertical aperture from 9 to 18 mm to prevent the B1 chamber from being exposed to synchronous radiation from the upstream elliptically polarized undulator (EPU), and (b) incensement of three pairs of flanges to separate the old arc-cell vacuum system into four subsystems (S3, B1, S4, B2). In this paper, we will report the manufacturing processes, measurement data and vacuum tests of these vacuum chambers.

Footnotes:

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Asia

Thursday Poster Session / 1153

High-reliability and high-performance machine protection system for a demanding electron linac

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LightHouse was a project utilizing a 3 MW electron linac to produce medical isotopes, requiring a very fast and reliable machine protection system to protect key accelerator components. RI Research Instruments GmbH designed the linac and conducted the risk analysis. This led to specifications to which Cosylab engineered a machine protection system (MPS). The MPS exhibits rapid responsiveness, with short reaction times on the order of 350 nanoseconds, while actively monitoring and reacting to approximately 700 inputs from crucial accelerator components. To enhance reliability and upgradeability, an FPGA solution based on the National Instruments platform was implemented. Additionally, the project envisions the integration of high availability storage and tertiary subsystems, with the overarching goal of achieving elevated uptime and ensuring the trustworthiness of all device elements.

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Europe

Tuesday Poster Session / 1154

Enhancing e+ sources for future colliders through conical converter targets

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Co-authors: Andrea Latina [2]; Anton Lechner [2]; Barbara Humann [2]; Paolo Craievich [3]; Ramiro Mena Andrade [2]; Yongke Zhao [4]

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This paper proposes a concept for a e+ source based on high energy e- beams incident on conical converter targets, in pursuit of its implementation in future lepton colliders such as FCC-ee. We developed 2 conical target solutions optimized for a state-of-the-art capture system based on an high temperature superconducting solenoid, allowing for a full immersion of the target in a 12.7 T peak field. According to simulation studies, conical targets would increase by up to 70% the e+ yield accepted by the FCC-ee damping ring, including the detrimental impact of their mechanical interface and cooling pipes. A thermo-mechanical study of 2 conical targets and their supports is also presented, using the baseline parameters of the FCC-ee injector linac, as well as a fully developed mechanical integration design for P3, a future e+ source demonstration facility.

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Thursday Poster Session / 1155

Measurement of ozone concentration at the BL-02A beamline hutch in the Taiwan photon source for ensuring personnel safety

Author: Po-Jiun Wen[1]

Co-authors: Yu-Chi Lin [1]; Sy-Yu Lin [1]; Miao-Hua Chang [1]

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The Taiwan Photon Source (TPS) BL-02A beamline at the National Synchrotron Radiation Research Center is a curved magnet beamline designed for white light mi-crotomography experiments, wherein biological samples are irradiated with high-energy white light for structural analysis. Experimenters frequently complain of odors when entering the end-station Hutch to change samples, which may be attributed to high concentrations of ozone. Ozone is a toxic gas that is produced when white light radiation reacts with oxygen in the air. Therefore, analyz-ing the ozone concentration distribution within the Hutch is necessary to evaluate safe windows of time for personnel to enter and the type of personal protective equipment that should be used.
The TPS operates at a stored energy and current of 3.0 GeV and 500 mA, respectively, with ventilation air condi-tioning turned off in the beamline Hutch. We measured ozone concentrations in regions of white light exposure at the front end (15 cm) and rear end (13.5 cm) of the Hutch, with the light source turned on for 300 s and off for 300 s. We placed the detector at different distances above, below, and to the right of the beam center. Our results demonstrated that more ozone was produced when white light was exposed for a longer duration. At any given distance, the highest amount of ozone was generat-ed above the beam center, followed by to the right side and below the beam center. These findings can serve as a reference for evaluating the health and safety of research-ers exposed to ozone in their work environments.

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Wednesday Poster Session / 1156

Shanghai Laser Electron Gamma Source in Shanghai Synchrotron Radiation Facility

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Quasi-monochromatic gamma-ray beams are produced in the laser Compton slant-scattering at the Shanghai Laser Electron Gamma Source (SLEGS) of the Shanghai Synchrotron Radiation Facility(SSRF) [1,2]. The laser Compton slant-scattering was pioneered to produce X rays as early as in 1996 [3] and has more recently been used to produced gamma rays in the MeV region at UVSOR [4]. The slant-scattering makes the usage of energy-tunable gamma-ray beams compatible with that of the synchrotron radiation in synchrotron radiation facilities operated at a fixed electron beam energy worldwide.
The SLEGS is designed to produce gamma rays in the energy range of 0.66 –21.7 MeV with a flux of 1e+5 - 1e+7 photons/s [2]. We have conducted test runs of the slant-scattering in the commissioning of the beamline to confirm the designed energy tunability and flux [5]. After a more careful measurement and data processing of the γ ray energy spectra in 2023, the newest experiment results of the quality of gamma-ray beams in flux and bandwidth is obtained and will be present in this report. The gamma-ray flux is in a range of 1e+4 - 3e+5 cps in 60° - 120° and the energy-resolution is in the range of 6 - 18%.

Footnotes:

[1] H.H. Xu et al., submitted to Nuclear Inst. and Methods, Physics Research A.
[2] Z.R. Hao et al., Nuclear Inst. and Methods, Physics Research A 1013, 165638 (2021).
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[5] H.W. Wang, et al., Nuclear Science and Techniques 33(2022)

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Asia

Thursday Poster Session / 1157

Upgrade of LLRF control systems for infrared free-electron laser

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Hefei Infrared Free-Electron Laser device (IR-FEL) is a user experimental device dedicated to energy chemistry research that can generate high brightness mid/far infrared lasers. It is driven by an S-band linear accelerator with a maximum electron energy of 60 MeV. The stability of the final output laser is determined by the energy of the electron beam, and optimizing the Low-Level RF control system (LLRF) can improve the energy stability of the electron beam. There are two klystrons in the linear accelerator of IR-FEL, and the power output of the klytrons exhibits periodic oscillation. This leads to fluctuation of the microwave field in the accelerator tube (approximately ±5%). In this optimization, we exchanged the filament power supplies of two klystrons to change the oscillation period. We used pulse-to-pulse feedforward method to compensate for the periodic fluctuations of the microwave signal, and changed IQ demodulation to Non-IQ demodulation. After optimization, the 3rd harmonic noise of the klystron is reduced to -50 dBc. The in-pulse feedback stability of LLRF has improved from 0.3%/0.3°(rms) to 0.12%/0.12°(rms).

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Monday Poster Session / 1158

Design and test of a S band TW buncher for the injector linac of HEPS

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The bunching system of injector Linac in High Energy Photon Source (HEPS) includes two sub-harmonic bunchers, a prebuncher and a traveling wave S band buncher. In this paper, the design and test of the traveling wave buncher are presented The buncher is a 6-cell constant impedance traveling wave structure operating in 2π/3 mode at 2998.8 MHz. The phase velocity is 0.75 times the velocity of light. First, the characteristic parameters are optimized in CST. The shunt impedance is 33.2 MV/m. The maximum bunching voltage is 1.2 MV with input power of about 5 MW. Then the buncher is precisely tuned and cold tested with a vector network analyzer after fabrication. Finally, the high power test was finished before installation in Linac. The buncher can operate stably with input power of 10 MW after a week of conditioning. So far the buncher has been applied successfully in Linac of HEPS

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Wednesday Poster Session / 1159

Devices and preparation methods for niobium coupon samples used to investigate high-Q mechanism

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A surface treatment device has been established at the Wuxi Platform, enabling chemical polishing treatment on coupon samples. Currently, several samples treated with buffered chemical polishing (BCP) have been utilized in the investigation of nitrogen doping and medium-temperature baking mechanisms. This paper presents the development process of this device along with the experimental outcomes. In the future, we plan to enhance the device to facilitate electropolishing (EP) treatment on coupon samples.

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Monday Poster Session / 1160

First operational experience with data-driven hysteresis compensation for the main dipole magnets of the CERN SPS

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Magnetic hysteresis, eddy currents, and manufacturing imperfections pose significant challenges for beam operation in multi-cycling synchrotrons. Addressing the dynamic dependency of magnetic fields on cycling history is a current limitation for control room tools using existing models. This paper outlines recent advancements to address this, presenting the outcome of operational tests utilizing data-driven approaches and an overview of the next steps. Notably, artificial neural networks, including LSTMs and transformers, are employed to model static and dynamic effects in the main dipole magnets of the CERN SPS. Cycle-by-cycle feed-forward corrections are implemented through the CERN accelerator controls infrastructure. Utilizing physics-bound loss functions, these networks capture hysteresis and eddy currents based on measured magnetic field and current data from the B-Train, the real-time magnetic measurement system of the SPS main dipoles. The developed models interface with the CERN accelerator settings management system, propagating computed corrections of magnetic fields to corresponding adjustments in the current of the power converters feeding the magnets.

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Tuesday Poster Session / 1162

Preliminary results on the reinforcement learning-based control of the microbunching instability

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Reinforcement Learning (RL) has demonstrated its effectiveness in solving control problems in particle accelerators. A challenging application is the control of the microbunching instability (MBI)

in synchrotron light sources. Here the interaction of an electron bunch with its emitted coherent synchrotron radiation leads to complex non-linear dynamics and pronounced fluctuations.
Addressing the control of intricate dynamics necessitates meeting stringent microsecond-level real-time constraints. To achieve this, RL algorithms must be deployed on a high-performance electronics platform. The KINGFISHER system, utilizing the AMD-Xilinx Versal family of heterogeneous computing devices, has been specifically designed at KIT to tackle these demanding conditions. The system implements an experience accumulator architecture to perform online learning purely through interaction with the accelerator while still satisfying strong real-time constraints.
The preliminary results of this innovative control paradigm at the Karlsruhe Research Accelerator (KARA) will be presented. Notably, this represents the first experimental attempt to control the MBI with RL using online training only.

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Thursday Poster Session / 1163

The on-line radiation monitoring system for Hefei Advanced Light Facility

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An advanced online monitoring system with dual systems is being developing for Hefei Advanced Light Facility (HALF). One is based on the C language, which integrates data acquisition, storage and interface display. The other is based on EPICS system, which developed Input/Output Controller (IOC) and Operator Interface (OPI) for data acquisition and display. The two systems are based on Ethernet TCP / IP protocol for data communication, but they are independent. The on-line radiation monitoring system of Hefei Advanced Light Source (ORMSH) have the function of neutron and gamma dose monitoring and alarming. The ORMSH contains 160 monitors for workplace monitoring and environmental monitoring. Each monitor combines data collection, storage, automatic upload. two alarm methods will be adopted for dose interlocking in ORMSH: instantaneous dose rate alarming and cumulative dose alarming. This paper describes in detail the implementation of the system infrastructure and functions.

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Thursday Poster Session / 1164

Perspectives and recent achievements on additive manufacturing technologies for accelerators

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This paper reports the exploratory studies on advanced accelerator technologies performed within the I.FAST (Innovation Fostering in Accelerator Science and Technology) EU project, and in particular the impressive results of the additive manufacturing Tasks. This includes results of two surveys targeted to the accelerator community: a) on current additive manufacturing applications in accelerators and expected new developments, b) on current additive manufacturing repair technologies for accelerator and list of possible applications. Additive-manufactured SRF cavities and performance results of the superconducting cavities made by additive manufacturing technology by Nb or Cu with Nb thin spattered film on the internal surface are discussed. Results of prototyping of Cu-made complex linear accelerator structures (RFQ) are reported and discussed. The paper is outlining potential additive manufacturing applications in accelerators and strategies applicable to accelerator components repairs benefiting from additive manufacturing technology.

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Monday Poster Session / 1166

Optimization of beam emittance under the influence of geomagnetic field

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The injector section of the SHINE device is currently in the debugging phase. The electron beam energy in the injector section is low and is significantly affected by the geomagnetic field, with an intensity of approximately 250 milligauss. Through theoretical optimization, adjustments to the positions and intensity parameters of helical coils and corrector magnets are being made to significantly reduce the growth of beam emittance under the influence of the geomagnetic field. The aim is to optimize the beam quality of the injector section of the SHINE device based on this model.

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Wednesday Poster Session / 1170

Particles and photon attenuating behavior of lead free Eu^{3+} doped barium phosphate glass system

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The study investigates the radiation attenuation performance of five ternary glass systems with varying chemical compositions: $50P_2O_5$-(50-x)BaO-xEu_2O_3, where x = 0, 1, 2, 4, and 6 mol%. It utilizes theoretical and Monte Carlo methods to determine shielding parameters such as attenuation coefficients, mean free path, value layers, electron densities, conductivity and neutron removal cross-sections across an energy range from 1 keV to 100 GeV. In addition to these analyses, the study explores kinetic energy stopping potentials and projected ranges of ions (H^+, He^+, and C^+) through the Stopping and Range of Ions in Matter database. Furthermore, research evaluates the dose rate attenuation behaviour and trajectories of photons bombarded from ^{137}Cs and ^{60}Co sources using Particle and Heavy Ion Transport code System. Obtained results show that sample: $50P_2O_5$-44BaO-6Eu_2O_3 with higher Eu^{3+}-doped glass has a potential for radiation shielding application among selected samples and is comparable with previously recommended, tested polymer and glass samples.

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Wednesday Poster Session / 1171

3D beam tracking studies including intrabeam scattering

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Particle tracking serves as a computational technique for determining the mean field of dynamically tracked charged macroparticles of a particle beam within an accelerator. Conventional solver tend to neglect collisionality, resulting in loss of relevant information (particle and momentum redistribution). In this study, macro-particle collisions are incorporated into a 3D Poisson solver. In the previous studies, identifying close particles have been performed in a static condition (IPAC23-Macroparticle collisionality in PIC solver). The requirement to uphold energy momentum within a dynamic tracking is initiated in simple lattices and the results are presented. A comparison with analytic model of the Bjorken-Mtingwa or Conte-Martini is included to verify.

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Thursday Poster Session / 1172

Diffusion and acoustic properties of Nb thin films studied by time-domain thermoreflectance

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The thermal diffusion and acoustic properties of Nb impacts the thermal management of devices incorporating Nb thin films such as superconducting radiofrequency (SRF) cavities and superconducting high-speed electronic devices. The diffusion and acoustic properties of 200-800 nm thick Nb films deposited on Cu substrates were investigated using time-domain thermoreflectance (TDTR). The films were examined by X-ray diffraction, scanning electron microscopy, and atomic force microscopy. The grain size and thermal diffusivity increase with film thickness. The thermal diffusivity increased from 0.100± 0.002 cm2s-1 to 0.237± 0.002 cm2s-1 with the increase in film thickness from 200 nm (grain size 20±6 nm) to 800 nm (grain size 65±16 nm). Damped periodic photoacoustic signals are detected due to laser heating generated stress in the Nb film, which results in an acoustic pulse bouncing from the Nb/Cu and the Nb/vacuum interfaces. The period of the acoustic oscillation gives a longitudinal sound velocity of 3637.3 ms-1 inside the Nb films, which is in good agreement with the values reported in the literature.

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Monday Poster Session / 1173

Experimental verification of integrability in a Danilov-Nagaitsev lattice using machine learning

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In non-linear optics, achieving integrability can enhance the dynamic aperture in storage rings. We analyze turn-by-turn phase-space data from our Danilov-Nagaitsev lattice implementation at Fermilab's Integrable Optics Test Accelerator using machine learning. AI Poincare estimates conserved quantities from experimental data without prior knowledge of the invariant structure, showing qualitative agreement with theoretical predictions. Additionally, one of the two learned invariants exhibits superior conservation compared to known theoretical expressions.

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WEBD: Colliders and other Particle and Nuclear Physics Accelerators / 1174

Technologies and concepts for the next generation of heavy ion synchrotrons

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New technical approaches are under investigation to further push the intensity frontier of the next generation heavy ion synchrotrons. Residual gas dynamics and corresponding charge exchange processes are key issues which need to be overcome by means of advanced UHV system technologies, but also by a focused design of the synchrotron as a whole. Cryogenics and superconductivity enable high field operation but in synergy also enable technologies for stabilizing the dynamic vacuum. Beam loss usually implicated as driver for activation and damages is as well an important initiator for residual gas pressure dynamics. Advanced superconducting cables promise lower energy consumption, fast ramping and higher average beam intensities. The cryo-pumping properties of specially developed cryogenic inserts, can also be used to upgrade existing synchrotrons and enable operation with lower charge states and higher intensities. The advancement of laser technologies may be applied as new devices in heavy ion synchrotrons for advanced manipulations, e.g. non-liouville injection or laser cooling. With FAIR, GSI has expanded its competence for the design of novel high intensity heavy ion synchrotrons.

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Wednesday Poster Session / 1177

Design of an ion-acoustics proof-of-principle experiment for LhARA

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LhARA, the Laser-hybrid Accelerator for Radiobiological Applications, is a proposed facility for the study of radiation biology. The accelerator will deliver ions at ultra-high dose rates and requires real-time measurement of the dose distribution. We have developed an ion-acoustic dose mapping system that exploits the acoustic waves generated by the beam's energy deposition. A proposed proof-of-principle experiment is presented.
A water-based phantom features a beam entry window sealed with Kapton. Three ports located on three orthogonal sides mount transducer arrays for detecting the acoustic waves. To calibrate their acoustic response, a liquid scintillator will be added to the water and its luminescence arising from the energy deposited by the beam is imaged by two cameras, positioned perpendicularly to each other. The acoustic wave generation and detection have been simulated in Geant4 and k-Wave, and the optical system in OpticStudio.
The simulation shows precise reconstruction of the 3D deposited energy distribution using the acoustic and optical systems should be obtained in the proposed design. Combining these will yield a real-time calibrated dose map in the experiment.

Footnotes:

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Tuesday Poster Session / 1178

Superconducting magnet string test for the SIS100 accelerator of FAIR

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The SIS100 accelerator, currently under construction in Darmstadt (Germany), consists of six arc and straight sections. Each of the six cryogenic arc sections comprises fourteen regularly repeating

optical cells (lattice). Each standard cell includes two dipole magnets and two quadrupole units integrated in a quadrupole doublet module. The SIS100 String Test technically represents one standard cell of the arc section of the SIS100, terminated by and End Cap and a Bypass Line as a representation of the end of the arc section. The purpose of the SIS100 String Test is to validate all technical systems such as cryogenics, vacuum, interlock and quench detection and investigate their collective behavior. A wide spectrum of tests will be performed during cool down, powering at operational conditions and warm up. Additionally, the experience gained during the SIS100 String Test will be crucial for the installation, commissioning and operation of the SIS100. The planning, installation process and first experimental results of the String Test will be presented.

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Monday Poster Session / 1179

Feasibility study of the Alice fixed-target experiment with HL-LHC lead ion beams based on crystal-assisted beam Halo splitting

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The Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN) is the world's largest and most powerful particle accelerator, colliding beams of protons and lead ions at energies up to 7 ZTeV. ALICE is one of the detector experiments optimized for heavy-ion collisions. A fixed-target experiment in ALICE is considered to collide a portion of the beam halo, split using a bent crystal, with an internal target placed a few meters upstream of the detector. For proton beams, we have already demonstrated that such a setup provides satisfactory performance in terms of particle flux on target and that it can be safely operated in parallel to regular beam-beam collisions. On the other hand, in the case of lead ion beams, a beam halo is populated with nuclei of many species that may differ in charge, mass and magnetic rigidity, making such a scenario more challenging to operate. This paper summarizes our first considerations of the feasibility of a fixed-target layout at ALICE to be operated with lead ion beams in the LHC.

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Wednesday Poster Session / 1180

Development of new method of NEA Activation with Cs-Sb-O

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Negative Electron Affinity (NEA) activated GaAs photocathodes are the only one capable of generating spin-polarized electron beam larger than 90%. However, the NEA layer currently made from mainstream cesium (Cs) and oxygen (O) is chemically unstable, the NEA-GaAs photocathode has a rapid QE degradation over time or electron beam. As a result, it requires an operating vacuum pressure of 1e-9 Pa and has a short lifetime. Recently, a new NEA layer using heterojunctions with semiconductor thin film of alkali metals and antimony or tellurium has been proposed. The latest research shows that the NEA activation method using Cs-Sb-O is made by co-evaporation of Cs, O2 and Sb. However, the co-evaporation method has high demands on equipment. Therefore, in this work, we attempted to fabricate a Cs-Sb-O NEA layer using a separation evaporation method. Specifically, we attempted four recipes and successfully fabricated the NEA layer by Cs-Sb-O. We also evaluated the dependence of QE on Sb thickness and found that it is easy to form a NEA layer with 0.2 nm of Sb.

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Monday Poster Session / 1181

First commissioning of the corrector quadrupoles in the 2nd bunch compression chicane at FLASH

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FLASH, the superconducting XUV and soft X-ray FEL is undergoing a substantial upgrade (FLASH2020+) with two long shutdowns 2021/22 and 2024/25. In the 1st shutdown, FLASH's 2nd bunch compression chicane (BC2) has been completely redesigned for the FLASH2020+ upgrade project. The redesign allowed the installation of two quad/skew-quad packs in each of the arms of the 4-dipole (C-type) chicane. With these corrector quadrupoles it should be possible to partially compensate linear correlations between the transverse centroids and the longitudinal position inside the bunch, so called bunch-tilts. During the limited commissioning/development shifts in a year of operation devoted to maximizing user hours we started measuring the impact of the quads on the bunch tilts and the unavoidable effects on dispersion closure and beam optics. In this contribution we report first results.

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Thursday Poster Session / 1182

Design of the H- beam line for the LANL RFQ test stand

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The Los Alamos Neutron Science Center (LANSCE) accelerator produces high intensity H+ and H- beams for multiple experiments in fundamental and national security science. The proposed LANSCE Modernization Project (LAMP) is evaluating necessary upgrades to enable continuous LANSCE operations in years to come. LAMP seeks to upgrade the H+ and H- 750 kV Cockcroft-Walton (CW) generators with a dual-beam, 3-MeV Radiofrequency Quadrupole (RFQ). For technology maturation and know-how associated with this concept, an RFQ test stand with LAMP-like layout is being set-up to demonstrate dual-beam operation in an RFQ with all beam patterns required by experiments. The RFQ test stand will have 35-keV H+ and H- beamlines that simultaneously inject into a 750 keV RFQ. Assembly and initial characterization of the H+ beam is under way. The H- beamline has stringent requirements and will also demonstrate systems like a beam chopper and a low frequency buncher to produce required beam patterns. We describe the design of the H- beamline based on accelerator codes Warp and Impact.

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Thursday Poster Session / 1184

Start-to-end simulations of the LAMP accelerator front-end

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Co-authors: Dimitre Dimitrov [1]; Dmitry Gorelov [1]; Enrique Henestroza [1]; Gregory Dale [1]; Janardan Upadhyay [1]; John Lewellen [1]; Juan Barraza [1]; Kip Bishofberger [1]; Sergey Kurennoy [1]

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The Los Alamos Neutron Science Center (LANSCE) accelerator delivers high intensity proton beams for fundamental science and national security applications since 1972. LANSCE is capable of simultaneous H+ and H- beam operations to multiple experiments requiring different time structures. This is achieved upstream in the facility with a combination of two 750 kV Cockcroft-Walton (CW) generators, a chopper and radiofrequency cavities, before going into the 800-MeV linac.
The proposed LANSCE Modernization Project (LAMP) is evaluating critical machine upgrades necessary to continuous beam operations in decades to come. A significant component of LAMP is replacing the two CW with a dual-species 3-MeV Radiofrequency Quadrupole (RFQ). This change requires a full re-design of the LAMP front-end accelerator to deliver the existing and expanded capabilities of the facility. This contribution will discuss the LAMP front-end accelerator layout based on the general beam requirements and on standard accelerator codes, showcasing the start-to-end propagation of H+ and H- beams from the source to the linac entrance.

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Thursday Poster Session / 1185

Simulation of the LANSCE PSR injection and extraction beam lines

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The Los Alamos Neutron Science Center (LANSCE) accelerator delivers high intensity proton beams for fundamental science and national security experiments since 1972. The Proton Storage Ring (PSR) accumulates a full 625-us macro-pulse of proton beam and compresses it into a 290-ns long pulse, delivering an intense beam pulse to the Lujan Neutron Science target. The proposed LANSCE Modernization Project (LAMP) is evaluating necessary upgrades to the accelerator that will guarantee continuous beam operations in the next decades. Upgrades to the PSR and its high-energy injection and extraction beamlines are being considered to handle the higher beam intensity enabled by the LAMP upgrades in the front-end. For the PSR upgrades studies, we are building models of the PSR injection and extraction lines in codes which include space charge calculations like Elegant and Impact. These better illustrate the beam dispersion and the beam halo in the high-energy transport. This work describes the LANSCE PSR injection and extraction lines and the corresponding simulation models. The models are compared to available beam diagnostics data where available.

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Wednesday Poster Session / 1186

MELODY –the first muon facility in China

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A Muon station for sciEnce, technoLOgy and inDustrY (MELODY) is under construction based on China Spallation Neutron Source. Up to 5Hz of proton pulses will be extracted from the RCS ring to a stand-alone target station. One surface muon and one decay muon beamline are designed to provide multi-terminals for various applications. In this report, we describe the design of MELODY and prospect for future applications.

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Monday Poster Session / 1187

Quest for an optimal spin-polarized electron source for the Electron Ion Collider

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Superlattice GaAs photocathodes play a crucial role as the primary source of polarized electrons in various accelerator facilities, including CEBAF at Jefferson National Laboratory and the Electron Ion Collider (EIC) at Brookhaven National Laboratory. To increase the quantum efficiency (QE) of GaAs/GaAsP superlattice photocathodes, a Distributed Bragg Reflector (DBR) is grown underneath using metal organic chemical vapor deposition (MOCVD). There are several challenges associated with DBR photocathodes: the resonance peak may not align with the emission threshold of around 780 nm, non-uniform doping density in the top 5 nm may significantly impact QE and spin polarization, high-temperature heat treatment may lead to interlayer material diffusion, and the number of DBR pairs may not be optimal, affecting both QE and spin polarization. In this paper, we will report our progress of addressing these challenges to hunt for suitable photocathodes for the EIC.

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Tuesday Poster Session / 1188

Intensity reach in the CERN PSB with the high-current LINAC4 source

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The CERN Proton Synchrotron Booster (PSB) was upgraded within the LHC Injectors Upgrade (LIU) project and delivers a large variety of high-intensity beams for fixed target experiments and high-brightness beams for collisions at the LHC. In the context of the Physics Beyond Colliders (PBC) study and of a possible upgrade of the ISOLDE experimental area, intensities up to 1500×1e+10 particles per ring are considered. High-intensity tests have thus been performed during machine development studies in 2023 injecting the nominal or higher beam current from Linac4. In this contribution, the intensity reach and the main performance limitations for the production of high-intensity beams in the PSB are presented. The results are compared to numerical simulations.

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Thursday Poster Session / 1189

Performance improvement studies of the fixed target beams along the CERN injector chain

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Within the LHC Injectors Upgrade (LIU) project, the LHC injectors received major upgrades that resulted in an unprecedented brightness performance. In the framework of the Physics Beyond Colliders (PBC) study, the full potential of the upgraded injectors is being explored for the improvement of the Fixed Target (FT) beams as well. This contribution details the recent studies on the beam transmission and beam quality along the injectors of the SPS Fixed Target PROton (SFTPRO) beams that reach the North Area (NA) experiments. In particular, the possibilities for tailoring the transverse emittances out of the PSB and the impact on the beam transmission in the SPS are shown. Furthermore, the impact of the transverse damper excitation on the efficiency of the Multi-Turn-Extraction in the PS are discussed. Finally, the main factors that limit the intensity reach of the injectors are also discussed.

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Wednesday Poster Session / 1190

Monte-Carlo photoemission model for thin film semiconductors under high fields

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Monte-Carlo models have been successfully used to model bulk semiconductor photocathodes, such as GaAs and others. Here we present a Monte-Carlo model under development for the photoemission from semiconductor thin films, such as Cs2Te, under high acceleration field gradient. Thin films and heterostructures, as well as high photocathode gun operating gradient and cyro-cooling, are both beneficial to high brightness electron sources. Our model employs electronic, phonon, dielectric and optical properties directly from Density Functional Theory (DFT) calculation. Furthermore, a photo excitation model based on the light interference effect in thin films is also being implemented, where our previous work indicates that such effect plays an important role in the photoemission from semiconductor thin films. Effects of the high field gradient on the semiconductor photocathode on the quality of the emitted electron beams will be discussed and used to inform a theoretical transport model based on the moment method and the cathode development for the CARIE project at LANL.

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Wednesday Poster Session / 1191

Review of MAD-X for FCC-ee studies

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The design of the electron-positron Future Circular Collider (FCC-ee) challenges the requirements on optics codes (like MAD-X) in terms of accuracy, consistency, and performance. Traditionally, MAD-X uses a transport formalism by expanding the transfer map about the origin up to second order to compute optics functions and synchrotron radiation integrals in the TWISS and EMIT modules. Conversely, particle tracking uses symplectic maps to propagate particles. These approaches solve the same problem using different approximations, resulting in a mismatch between the models used for tracking and for optics. While in a machine like LHC these differences are not relevant, for FCC-ee, given the size and the sensitivity to phase advance, the different approaches lead to important differences in the models. For instance, a tapering strategy that matches the tunes for optics needs to apply approximations that would mismatch the tune in tracking and vice versa. In this paper, we show the effectiveness of advanced methods that bring the maps used for optics and tracking closer and that will be used to reduce the gap between optics and tracking models to an acceptable level for FCC-ee studies.

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Tuesday Poster Session / 1193

Operation, development and sustainability at the ESRF-EBS light source

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The European Synchrotron Radiation Facility - Extremely Brilliant Source (ESRF-EBS) is a facility upgrade allowing its scientific users to take advantage of the first high-energy 4th generation storage ring light source. In December 2018, after 30 years of operation, the beam stopped for a 12-month shutdown to dismantle the old storage ring and to install the new X-ray source. On 25th August 2020, the user program restarted with beam parameters very close to nominal values. Since then beam is back for the users at full operation performance and with an excellent reliability. This paper reports on the present operation performance of the source, highlighting the ongoing and planned developments and the sustainability efforts.

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WEAN: Applications of Accelerators, Technology Transfer and Industrial Relations and Outreach (Contributed) / 1195

First dual isotope beam production for simultaneous heavy ion radiotherapy and radiography

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Co-authors: Christian Graeff [1]; David Ondreka [1]; Dmitry Varentsov [1]; Fabio Maimone [1]; Jens Stadlmann [1]; Lennart Volz [1]; Martin Schanz [2]; Peter Spiller [1]; Ralph Hollinger [1]; Stephan Reimann [3]; Winfried Barth [1]

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In the context of research on simultaneous heavy ion radiotherapy and radiography, a mixed carbon/helium ion beam has been successfully established and investigated at GSI for the first time to serve fundamental experiments on this new mode of image guidance. A beam with an adjustable ratio of 12C3+/4He+ was provided by the 14.5 GHz Caprice ECR ion source for subsequent acceleration in the linear accelerator UNILAC and the synchrotron SIS18. Despite the mass difference between the 4He+ and 12C3+ ions, both could be slowly extracted simultaneously at 225 MeV/u using the transverse knock-out extraction scheme. The ion beam has been finally characterized in the biophysics cave in terms of beam composition (particularly inter- and intra-spill He fraction), depth-dose-profiles, beam size, position and other parameters, all related to combined ion beam treatment and online monitoring. Utilizing high-speed particle radiography techniques, a fast extracted mixed ion beam has also been characterized in the plasma physics cave under conditions favorable to FLASH therapy.

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Monday Poster Session / 1196

Simulations of positron sapture at Ce+BAF

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We present an initial capture concept for the continuous wave (CW) polarized positron beam at the Continuous Electron Beam Accelerator Facility (CEBAF) upgrade at Jefferson Lab. This two-step concept is based on (1) the generation of bremsstrahlung radiation by a longitudinally polarized electron beam (1 mA, 120 MeV, >90% polarization), passing through a tungsten target, and (2) the production of e+e- pairs by these bremsstrahlung photons in the same target. To provide highly-polarized positron beams (>60% polarization) or high-current positron beams (>1 µA) with low polarization for nuclear physics experiments, the positron source requires a flexible capture system with an adjustable energy selection band. The results of beam dynamics simulations and calculations of the power deposited in the positron capture section are presented.

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Monday Poster Session / 1197

Macro-particle simulations of longitudinal peak detected Schottky signals

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The peak detected Schottky system is a powerful diagnostic tool for determining longitudinal beam parameters. According to the theoretical model, the peak value of the signal from a wideband pick-up contains information on particle distribution as a function of the synchrotron frequency. Due to intrinsic assumptions for modelling the acquisition set-up and uncertainties of beam parameters, a one-to-one comparison of predictions and measurements remains a challenge. This work presents the peak detected Schottky spectra obtained in idealized macro-particle simulations. Following refinement of the theoretical model, a direct comparison was performed under controlled conditions. Agreement with the numerical results was improved by introducing a form factor, which describes the probability of a particle being present in the observation window. Modifications due to collective effects are discussed as well. Finally, the corresponding peak detected spectra for various intensities, assuming a simplified impedance model, are presented.

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Tuesday Poster Session / 1198

Studies of beams with non-factorizable transverse beam distributions at the CERN PSB

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Co-authors: Foteini Asvesta [2]; Giuliano Franchetti [3]; Guido Sterbini [2]; Hannes Bartosik [2]; Mike Seidel [4]; Tirsi Prebibaj [2]

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Beam profile measurements in the LHC injector complex show heavy tails in both transverse planes. From these profile measurements, it is not possible to determine if the underlying 4D phase space distribution is statistically independent. A measurement campaign in the CERN PSB was carried out to introduce cross plane dependence in bunched beams in controlled conditions, in view of characterizing the operational beam distributions. The results of the measurement campaign demonstrate how heavy tails can be created via coupled resonance excitation of the lattice in the presence of space charge in accordance with predictions from the fixed line theory. The coupled resonance introduces dependence between the transverse planes of the 4D particle distribution, as demonstrated by beam profile measurements for different levels of scraping in one transverse plane.

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Monday Poster Session / 1199

Luminosity effects of heavy tailed beams with transverse x-y correlation

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The luminosity of particle colliders depends, among other parameters, on the transverse profiles of the colliding beams. At the LHC at CERN, heavy-tailed transverse beam distributions are often observed, and the luminosity is modeled with the assumption that the x-y planes are independent in each beam. Analytical calculations show that the solution of inverting 1D heavy-tailed beam profiles to transverse 4D phase-space distributions is not unique. For the same transverse profile, the distributions can be dependent or independent in the transverse planes in absence of machine coupling. In this work, the effect of transverse x-y dependence of the 4D phase space distribution on the luminosity of a particle collider is evaluated for heavy-tailed q-Gaussian beams.

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Tuesday Poster Session / 1200

Initial status report on BNL ATF AE131 experiment harmonic nonlinear inverse Compton scattering

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Recent progress of basic study on Harmonic nonlinear Compton scattering in Brookhaven National Laboratory Accelerator Test Facility (BNL ATF) will be reported. Experiment is conducted by counter collision of a multi TW CO2 laser and 60-70 MeV electron beam having 300-600 pC of charge per pulse. Experiment AE131 is intended for two aspects of experimental demonstrations. A: Nonlinear bi harmonic effect seen in external lasers having shorter wavelength such as Nd:YAG laser induced by a long wavelength intense CO2 laser at scattered photon energy of 100 keV range. B: Detailed study on the harmonic radiation induced by circularly polarized multi TW CO2 laser which potentially contain the Orbital Angular Momentum at photon energy of 10 keV range.

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Wednesday Poster Session / 1201

Low-cost button BPM signal processing electronics for the AWA electron linac

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Single-pulse, high dynamic range BPM signal detection has been at the top of the Argonne Wakefield Accelerator (AWA) Test Facility's most-wanted list for many years. The AWA beamline's unique capabilities require BPM instrumentation with an unprecedented dynamic range, making it challenging to design and prototype a cost-effective solution. We have prototyped many different approaches over the years. Finally, a recent prototype shows the long-sought solution for AWA's low-cost button BPM signal detection is becoming feasible. This paper shares the design and test results of this prototype.

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TUBD: Colliders and other Particle and Nuclear Physics Accelerators (Contributed) / 1204

Analysis of beam performance in the 2023 LHC Pb-Pb run

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The 2023 Pb-Pb run in the Large Hadron Collider (LHC) took place at a record beam energy of 6.8 □ TeV and it marked the first heavy-ion physics period of Run 3. Higher beam intensities than in the previous runs and several machine upgrades have enabled higher peak luminosities in the ALICE experiment, dedicated to heavy-ion physics. This paper compares the achieved operational

performance for different beam configurations that were used, addressing in particular the impact of luminosity leveling and the length of the trains injected. In addition, the evolution of the measured luminosity in various fills is compared against predictions from the Collider Time Evolution tracking code.

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THAD: Beam Instrumentation, Controls, Feedback and Operational Aspects (Contributed) / 1205

First measurement of the proton beam and lead ion beam in the LHC using beam gas curtain monitor

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Co-authors: Alexander Webber-Date [1]; Ashley Churchman [2]; Carsten Welsch [3]; Cristina Sequeiro [2]; Gerhard Schneider [2]; Krystian Sidorowski [2]; Marton Ady [2]; Muhammed Sameed [4]; Oliver Stringer [1]; Ondrej Sedlacek [3]; Peter Forck [5]; Raymond Veness [2]; Serban Udrea [5]; Stefano Mazzoni [2]; Thibaut Lefevre [2]

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A novel beam gas curtain (BGC) monitor was installed in the LHC as part of CERN's High Luminosity LHC upgrade during the 2022 year-end technical stop and started to measure the profile of the proton and lead ion beams during the 2023 run. The monitor utilizes a supersonic neon beam shaped into a curtain that crosses the primary LHC beam with an angle of 45 degrees. By observing the fluorescence generated due to this interaction, one can measure the 2-dimensional profile of the circulating beam minimum-invasively. This contribution presents the first profile measurement of the LHC's proton and lead ion beams using the BGC monitor. It also summarizes the experiences gained from operating this novel device in the LHC, particularly its minimal impact on the vacuum and radiation levels.

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Monday Poster Session / 1206

Study of interfering spin resonances in multi-snake lattice

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Using a simplified multi spin resonances model we study the how the interference of spin resonances near a strong intrinsic spin resonance crossing effect the polarization transmission as a function of emittance for a lattice with more than two snakes.

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Monday Poster Session / 1207

Polarization performance of a 3 GeV electron booster

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We Study the design and spin performance of a polarized electron Booster. This booster will accelerate polarized electrons from 200 MeV to 3 GeV. We examine the polarization transmission of the existing the NSLS-II Booster design as well as modifying the design from its existing 4-fold symmetric design to a 7-fold one and increasing the betatron tune from 3.41 to 6.85 to avoid all intrinsic spin resonances.

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Monday Poster Session / 1208

Results and plans for Run 2 of the Advanced Proton Driven Plasma Wakefield Acceleration Experiment

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This talk summarizes the plans, challenges and key components of the four phases in the AWAKE roadmap. In addition, an overview of the rich measurement program of the second phase, AWAKE Run 2b, during 2023 and 2024 is given. Results from a unique 3-week measurement opportunity with a 10m discharge plasma source prototype are shown, including the effects of different gases, plasma densities, bunch charges and plasma lengths on the proton bunch self-modulation, ion-motion, current filamentation instabilities and plasma light. A new 10 m long rubidium vapor source was installed in the summer of 2023 with the possibility to generate a density step (0-10%) every 50 cm along the first 4 m. First measurement results with this plasma cell are also presented, showing the positive effect of the density step on the plasma light as well as an increased energy gain for externally injected electrons.

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Monday Poster Session / 1209

Realization of external electron injection for AWAKE Run 2b

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Co-authors: Marlene Turner [2]; Fern Pannell [3]; Vittorio Bencini [1]; Alexander Gerbershagen [4]; Edda Gschwendtner [1]; Patric Muggli [5]; Giovanni Zevi Della Porta [1]

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The Advanced Wakefield Experiment (AWAKE) aims to drive GV/m wakefields over tens or hundreds of meters using a proton driver. The experiment uses 400 GeV drive bunches from the CERN SPS that undergo self-modulation over the first few meters of plasma. Numerical simulations predict that the use of a density step early in the plasma increases the average accelerating gradient over long distances. AWAKE is now in Run 2b (2023-2024), where the plasma cell used is a novel rubidium vapor source that allows for a plasma density step. To demonstrate that the density step can stabilize the wakefield amplitude and to probe the longitudinal fields, ˜19 MeV electron bunches produced by a photo-injector will be externally injected and accelerated. We summarize the experimental setup and challenges of this injection process, and present results from first measurements.

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Monday Poster Session / 1211

Simulations of CXFEL with the MITHRA code

Author: Elena Ros[1]

Co-authors: Lucas Malin [1]; Ross DeMott [1]; Samuel Teitelbaum [1]; Sean Tilton [1]; William Graves [1]

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The CXFEL project at ASU will produce coherent soft x-ray radiation at a university-scale facility. Unlike conventional XFELs, the CXFEL will use an optical undulator in addition to nanobunching the electron beam instead of a static magnetic undulator. This reduces the undulator period from cm-scale to micron scale and lowers the requirements on the electron beam energy. CXFEL's overtaking geometry design reduces the effective undulator period to 7.86 μm to produce 1 keV photons. This is accomplished by crossing the laser and electron beam at a 30 degree overtaking angle, and using a tilted laser pulse front to maintain temporal overlap between the electron beam and laser pulse. The inverse Compton scattering interaction between a microbunched electron beam and an optical undulator falls out of the range of most accelerator codes. We employ MITHRA, a FEL full-wave FDTD solver software package which includes inverse Compton scattering to simulate the FEL lasing process. We have adapted the code to the CXFEL instrument design to simulate the radiation/electron beam interactions and report results of studies including scaling of key parameters.

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North America

Tuesday Poster Session / 1213

Optimizations and updates of the FCC-ee collimation system

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The Future Circular electron-positron Collider, FCC-ee, is a design study for a 90 km circumference luminosity-frontier and highest-energy e+e- collider. It foresees four operation modes optimized for producing different particles by colliding high-brightness lepton beams. Operating such a machine presents unique challenges, including stored beam energies up to 17.5 MJ, a value about two orders of magnitude higher than any lepton collider to date. Given the high stored beam energy, unavoidable beam losses pose a serious risk of damage. Thus, an adequate protection system has to be implemented. To address this challenge, a beam collimation system to protect the sensitive equipment of this machine is indispensable. This paper presents the studies that led to a new collimation system baseline and a collimation performance evaluation under selected beam loss scenarios.

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Monday Poster Session / 1214

Studies of photoemission in the high-field regime in an X-band photoemission RF gun

Author: Gongxiaohui Chen[1]

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A program is underway at the Argonne Wakefield Accelerator (AWA) facility, in collaboration with Euclid Techlabs and Northern Illinois University (NIU), to develop a GV/m-scale photocathode gun, to produce bright electron bunches. The novel X-band (11.7 GHz) photoemission gun (Xgun) is powered by high-power, short RF pulses (9 ns) generated by the AWA drive beam in a wakefield structure. In the first series of experiments, the Xgun demonstrated peak fields of ˜400 MV/m on the photocathode surface. As a first step towards achieving a complete understanding of the Xgun' s performance in the high-field regime, we studied the photoemission mechanism by measuring the quantum efficiency (QE) and thermal emittance across a large range of operating fields on the photocathode surface from 60 MV/m to values exceeding 300 MV/m. In this work, we will present the results of our experimental measurements and simulation studies on examining photoemission at high fields on the photocathode surface.

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Wednesday Poster Session / 1215

First year of data taking with the electricity meter network for sustainable operation of the KIT accelerator facilities for the KIT-TEN project

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In times of climate change and with increasing challenges of the power grid stability due to unstable renewable energy sources, it is not sufficient to know the electric energy consumption of accelerator facilities. In order to optimize the operation of the research infrastructure in terms of stability, reliability and sustainability, the knowledge of the dynamics of energy consumers, and generators is mandatory.
Since a few years, KIT's accelerator teams collaborate with its EnergyLab 2.0, Europe's largest research infrastructure for renewable energies, within the KIT test field for energy efficiency and grid stability of large-scale research infrastructures (KITTEN). At the research accelerators KARA and FLUTE a dense network of power meters, more than 100 sensors of different kind, operate to observe from individual components to infrastructural components and the central electricity distribution. With more than one year of data taking for most of the sensors, we are already able to quantify implemented energy-savings measures. In this contribution the findings of the installation and the first analysis and savings within the more than one year data taking will be presented.

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Monday Poster Session / 1216

Solving the Orszag-Tang vortex magnetohydrodynamics problem with physics-constrained convolutional neural networks

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The 2D Orszag-Tang vortex magnetohydrodynamics (MHD) problem is studied through the use of physics-constrained convolutional neural networks (PCNNs). The density and the magnetic field are forecasted, and we also predict magnetic field given the velocity field of the fluid. We examined the incorporation of various physics constraints into the PCNNs: absence of magnetic monopoles, non-negativity of density and use of only relevant variables. Translation equivariance was present from the convolutional architecture. The use of a residual architecture and data augmentation was found to increase performance greatly. The most accurate models were incorporated into the simulation, with reasonably accurate results. For the prediction task, the PCNNs were evaluated against a physics-informed neural network (PINN), which had the ideal MHD induction equation as a soft constraint. The use of PCNNs for MHD has the potential to produce physically consistent real-time simulations to serve as virtual diagnostics in cases where inferences must be made with limited observables.

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Monday Poster Session / 1217

Mastering longitudinal losses for HL-LHC

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Power limitations are expected at injection for the main Radio Frequency (RF) system due to the doubled bunch intensity in the High Luminosity (HL-) Large Hadron Collider (LHC). One way to overcome these power limitations is to reduce the capture voltage. The smaller RF bucket, however, increases both capture and flat-bottom beam losses. In practice, the start of the ramp losses, which is the sum of capture and flat-bottom losses, cause beam dumps if the capture voltage is reduced too much. In this contribution, we analyze start-of-ramp losses as recorded during operation, and model capture losses as a function of RF voltage, as well as phase and energy errors at injection. The correlation between start-of-ramp and flat-bottom losses is investigate by mapping the abort gap population to the Beam Loss Monitor (BLM) threshold. The aim is to understand the proportions of different beam loss contributions and optimize the future RF parameters such that the main RF system can capture and retain the HL-LHC beam intensities within acceptable loss limits.

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Monday Poster Session / 1218

Utilizing neural networks to speed up coherent synchrotron radiation computations

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Coherent synchrotron radiation has a significant impact on electron storage rings and bunch compressors, inducing energy spread and emittance growth in a bunch. While the physics of the phenomenon is well-understood, numerical calculations are computationally expensive, severally limiting their usage. Here, we explore utilizing neural networks (NNs) to model the 3D wakefields of electrons in circular orbit in the steady state condition. We demonstrate that NNs can achieve a significant speed-up, while also accurately reproducing the 3D wakefields. NN models were developed for both Gaussian and general bunch distributions. These models can potentially aid in the design and optimization of accelerator apparatuses by enabling rapid searches through parameter space.

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Monday Poster Session / 1220

Ultrafast electron diffraction with adjustable camera length at high energies

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Ultrafast Electron Diffraction (UED) is a pioneering method for real-time observation of atomic-level structures. Recent advancements leverage relativistic electrons from radiofrequency (RF) guns to overcome space charge limitations, enhancing resolution. While perspectives may differ, an ongoing debate surrounds the optimal energy for a UED instrument. Our study contributes to this discussion by employing an 8.2 MeV electron beam and a compact post-sample magnetic optical system with small-gap Halbach permanent magnet quadrupoles. This system allows tunable magnification and improved reciprocal space resolution in a compact footprint, as demonstrated in simulations and experiments with a single crystal Au sample.

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Tuesday Poster Session / 1221

Correction of horizontal partial snake resonances with pulsed skew quadrupoles at the Brookhaven AGS

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Proton polarization is preserved in the AGS by using helical dipoles partial snakes to avoid depolarizing vertical resonances. These same helical dipoles also drive numerous (82) weak horizontal resonances that result in polarization loss. These horizontal resonances occur at the same energy (and therefore frequency) as depolarizing resonances driven by linear betatron coupling. A new scheme has therefore been implemented to correct the snake-driven resonances with the placement of skew quadrupoles in the AGS ring powered to cancel the resonance driving term at each horizontal resonance crossing. The skew quadrupoles are required to pulse independently for each resonance to account for the variation of drive term phasing with energy. Fifteen thin skew quadrupoles have been installed in the AGS ring to implement this correction. We describe the correction principle, the magnet design and commissioning results from RHIC Run 24.

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Thursday Poster Session / 1222

Minimizing space charge tune spread and increasing beam quality parameters with circular modes

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Space charge has been a limiting effect for low energy accelerators inducing emittance growth and tune spread. Tune shift and tune spread parameters are important for avoiding resonances, which limits intensity of the beam. Circular modes are round beams with intrinsic flatness that are generated through strong coupling, where intrinsic flatness can be transformed to real plane flatness through decoupling. It is understood that flat beams increase the quality parameters of a beam due to one of the plane emittances being smaller than the other plane since luminosity and beam brightness depend inversely on the beam emittances. We show that circular mode beams manifest smaller space charge tune spread compared to uncorrelated round beams, which allows better systematic control of operating point of the beam. Minimized tune spread allows flexible operating points on the tune map. We also dedicate current and intrinsic flatness ratio limits on circular modes, which increase quality parameters without detrimental effects on the emittance increase.

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Tuesday Poster Session / **1223**

Test magnet for the EIC Rapid Cycling Synchrotron

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Brookhaven National Laboratory (BNL) was recently chosen to host the Electron Ion Collider (EIC), which will collide high energy and highly polarized hadron and electron beams with a center of mass energy up to 140 GeV and a luminosity of up to 1e+34 1/cm^2/s. Part of the accelerator complex is a Rapid Cycling Synchrotron (RCS), which is planned to accelerate electrons from 400 MeV to 18 GeV. Due to the large energy range and the given circumference of the ring, the magnetic fields of the RCS magnets at injection are very low (~mT). A test dipole magnet was constructed to study differences in field quality from 5-50 mT. The paper discusses the design of the test magnet and first measurement results.

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Thursday Poster Session / **1224**

Design of IH-DTL with PMQ focusing for medical RI production

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In recent years, plans for cancer treatment using medical RI have been progressing worldwide. The stable supply is difficult due to the aging of small nuclear reactors and dependence on imports from abroad. Manufacturing using accelerators could realize a stable supply in Japan. To give an example of Astatine-211, the production of an alpha-ray drug requires helium nuclei of 7 MeV/u or more. This time, we are designing an accelerator system with the aim of accelerating helium ions with a peak current value of 30mA and a duty cycle of 5%. As an accelerator following the radio-frequency quadrupole linac (RFQ), which accelerates up to 0.6 MeV/u, we are considering the design of an interdigital H-mode drift tube linac (IH-DTL) with permanent magnet quadrupoles (PMQ) in the drift tubes. This accelerator is designed to operate at 200 MHz to use the commercially available semiconductor power supply for saving space and electricity and improving maintainability. In this presentation, we report on the basic design of the IH-DTL with PMQ.

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Thursday Poster Session / 1225

Relationship between anisotropy and cross rolling process for high purity niobium sheets

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The standard fabrication method for superconducting cavities is to press high RRR niobium sheets to form half cells, which are then joined by EBW (electron beam welding) to form cavities. If the anisotropy of the niobium sheet is too large, gaps will form when the half-cells are joined, so a sheet with low anisotropy is required. To reduce the anisotropy of the sheet, it is essential to apply cross-rolling during fabrication. In this experiment, three types of sheets were produced with different reduction rates during TSCR (Two Sep Cross Rolling). Then, the average anisotropy coefficient $\bar{r}$ and planar anisotropy Δr, the evaluation criteria of anisotropy, were compared to find a relationship between anisotropy and cross rolling condition. As a result, it was found that the Δr value was the smallest and the in-plane anisotropy was the smallest when the reduction ratio before and after cross rolling was the same. In addition, half cells of superconducting cavities were press formed using three types of niobium sheets, and the roundness of the equatorial part was measured. There was no difference among the three types.

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Thursday Poster Session / 1226

Study on the strength of large grain sliced niobium discs

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Large grain niobium has a higher production yield than fine grain niobium, the price can be lowered. On the other hand, it has a significant reduction in mechanical strength. In this study, tensile tests were conducted on different RRR (RRR185 and RRR495) of large grain sliced discs and two tensile speeds (5 mm/min, 2 mm/min) with more than 50 samples under each condition. In general quality control, three times the mean plus or minus the standard deviation is set as the control value. Using this method, the mean minus 3 standard deviations was reported as the minimum strength of large grain niobium. Since the mechanical strength of large grain niobium is highly dependent on crystal orientation, single crystal round bar tensile test samples were prepared and each crystal orientation was measured before tensile testing. We were able to show that there is a strong correlation between the crystal orientation and the yield stress of niobium single crystals. The purpose of this study is to present the minimum strength of large grain niobium and to provide information to cavity researchers.

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Tuesday Poster Session / 1227

Numerical simulation study on the mechanism of emittance growth and beam loss arising from magnetic field ripples in J-PARC MR

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This paper discusses the mechanism of emittance growth and beam loss arising from magnetic field ripples in J-PARC MR, based on numerical simulations supported by beam experiments.

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Thursday Poster Session / 1228

Statistical evaluation of mechanical properties of RRR300 niobium sheets for SRF cavities

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Tokyo Denkai has been producing niobium for superconducting cavities since 1985. We have also produced niobium for L-band cavities since the beginning of their development, and have a large number of production records. In particular, more than 20,000 pieces have been delivered to TESLA based on the XFEL-007 specifications for the European XFEL, LCLS-II, LCLS-II HE, and SHINE projects. In this report, we present a statistical evaluation of measured data on the actual mechanical properties of niobium sheets in a mass production of niobium sheets based on nearly identical specifications. Specifically, histograms of hardness, RRR, and tensile testing (rolling and transverse direction) of niobium sheets were drawn to evaluate the data variability. The data for all items were normally distributed, indicating that quality was controlled. In addition, the relationship between rolling direction and all tensile test items (yield stress, maximum stress, and elongation) were examined. Positive correlations were observed for yield stress and maximum stress. I report on the quality data and statistical results of the same product over a period of more than 10 years.

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Thursday Poster Session / 1230

Revised error sensitivity study for the ESS proton linac

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The normal-conducting injector of the superconducting proton linac of the European Spallation Source (ESS) was commissioned in 2023. Commissioning of the superconducting linac is planned by end of 2024, followed by first beam on the spallation target in 2025. One of the prominent challenges in commissioning and operation of high power accelerators, such as the linac of the ESS, is to minimize beam loss to protect its components from excessive activation and potential damage. Sensitivity studies looking at various types of errors were conducted in the past during the design phase for defining requirements and tolerances. With the commissioning of the full linac approaching, a revised error sensitivity study was carried out, and the result is presented in this paper. The aim of the revised study is to better understand the relation between potential error sources and loss patterns.

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Wednesday Poster Session / 1231

Slice energy spread measurements of a 20 MeV electron beam at PITZ

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Due to improvements of the performance of FELs, the measurements of the beam's slice energy spread is becoming increasingly important for optimization of the brightness. Of particular interest are measurements of the uncorrelated energy spread near the gun as this determines the lower limit of the energy spread for the rest of the machine. At the Photo Injector Test facility at DESY in Zeuthen (PITZ), the uncorrelated energy spread is measured of an electron beam generated from an L-band electron gun and accelerated to 20 MeV with a booster cavity. The energy spread of the central time slice is measured using a transverse deflecting structure (TDS) and a dispersive arm to image the longitudinal phase space. Scans of the TDS voltage and quadrupole strengths are used to remove the contributions from the TDS, transverse emittance, and imaging resolution. Presented is an overview of the measurement procedure, resolution, and results of measurements over a range of parameters including bunch charge, laser spot size, and focusing strength at the gun.

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Wednesday Poster Session / 1232

GaAs cathode activation by deposition of Cs-K-Sb thin film

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GaAs cathodes are unique devices which generate a spin-polarized electron beam by the photoelectric effect when illuminated with a circularly polarized laser. Thin-film Negative Electron Affinity (NEA) surfaces have an essential role in spin polarized beam production, but they have limited lifetimes. In this study, we activate GaAs as an NEA cathode by evaporating Cs, K, and Sb metal on its cleaned surface. Here we present the latest experimental results of quantum efficiency measurements taken after evaporative deposition of multi-alkali thin-film surfaces.

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Thursday Poster Session / 1233

Selected beam measurements at PIP-II injector test facility

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The Proton Improvement Plan-II Injector Test (PIP2IT) Facility had been fully constructed and commissioned at Fermilab during 2020-21. The PIP2IT beamline includes a H- ion source capable of delivering 15 mA, 30 keV DC or pulsed beam, a Low Energy Beam Transport (LEBT), a 162.5 MHz,continuous wave (CW) Radio Frequency Quadrupole (RFQ) that accelerates the beam to 2.1 MeV, a 10-m Medium Energy Beam Transport (MEBT) and a SRF section that comprises one cryomodule of each family of Half Wave Resonator (HWR) and Single Spoke Resonator (SSR). The beam is accelerated up to 16 MeV through the SRF section and transported to the beam dump via a High Energy Beam Transport (HEBT) line. This paper describes current understanding of the PIP2IT beamline optics and details selective beam measurements including beam trajectories along the beamline, variation in trajectories due to hysteresis in superconducting solenoids, and characterization of transverse kick exerted by beam chopping system on bunches. The paper also presents a comparison between the model-based and measured beam trajectories. This comparison enabled diagnosis of polarity swap of HWR solenoid and BPMs in the beamline.

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Monday Poster Session / 1234

Progress on the design of the interaction region of the Electron-Ion Collider EIC

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Co-authors: Alexander Jentsch [1]; Alexander Novokhatski [2]; Alexei Blednykh [3]; Bamunuvita Gamage [4]; Brett Parker [1]; Charles Hetzel [3]; Christoph Montag [1]; David Gassner [3]; Douglas Holmes [1]; Elke Aschenauer [1]; Ferdinand Willeke [1]; George Mahler [1]; GianLuca Sabbi [5]; Giorgio Ambrosio [6]; Guillaume Robert-Demolaize [1]; Henry Hocker [1]; Henry Lovelace III [1]; J. Berg [1]; James Rochford [1]; John Cozzolino [1]; Joseph Tuozzolo [1]; Karim Hamdi [1]; Kevin Smith [1]; Kirsten Drees [1]; Lucas Brouwer [5]; Marcy Stutzman [4]; Michael Anerella [1]; Michael Blaskiewicz [1]; Michael

Sullivan [2]; Paolo Ferracin [5]; Qiong Wu [7]; Soren Prestemon [5]; Steve Peggs [1]; Steven Tepikian [1]; Tim Michalski [4]; Vadim Ptitsyn [3]; Vasiliy Morozov [8]; Yun Luo [1]; Yuri Nosochkov [2]; Zhengqiao Zhang [1]

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We present an update on the design of the Interaction Region (IR) for the the Electron Ion Collider (EIC) being built at Brookhaven National Laboratory (BNL). The EIC will collide high energy and highly polarized hadron and electron beams with a center of mass energy up to 140 GeV with luminosities of up to 10ˆ34 /cmˆ2/s. The IR, located at RHIC's IR6, is designed to meet the requirements of the nuclear physics community as outlined in [1]. A second IR is technically feasible but not part of the project.

The magnet apertures are sufficiently large to allow desired collision products to reach the far-forward detectors; the electron magnet apertures in the rear direction are chosen to be large enough to pass the synchrotron radiation fan. In the forward direction the electron apertures are large enough for non-Gaussian tails.

The paper discusses a number of recent recent changes to the design. The machine free region was recently increased from 9 to 9.5 m to allow for more space in the forward direction for the detector. The superconducting magnets on the forward side now operate at 1.9 K, which helps crosstalk and space issues.

Footnotes:

[1] An Assessment of U.S.-Based Electron-Ion Collider Science. (2018). Washington, D.C.: National Academies Press. https://doi.org/10.17226/25171

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Thursday Poster Session / 1235

Research on Monte Carlo model of radiation source in HLS storage ring

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Hefei Light Source (HLS) is the first dedicated synchrotron radiation facility in China. HLS-II operates in the TOP-OFF constant-current mode. For the safety of personnel, it is crucial to analyze the radiation fields applying Monte Carlo. The radiation source directly affects the results. The paper discusses the impact of three radiation source models on the radiation field results. In the first model, beam averaged losses over eight bend magnets. The second model assuming that there is a uniform loss at all beam pipes and bend magnets. The third model assumes that beam losses uniformly in a torus pipe. The radiation field during TOP-OFF constant-current of HLS-II storage ring was simulated applying FLUKA. The position and direction sampling equations were constructed for different radiation sources. Simulation results indicated that the dose rates of the second model was consistent to the torus uniform loss model. The calculation results of two models are in accord with the actual situation. As for the simulations on the radiation fields and radiation shield design in the storage ring, the torus radiation source with uniform loss is more convenient to operate.

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Wednesday Poster Session / 1236

Development and applications of CW normal conductivity VHF gun at Tsinghua university

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A 217 MHz VHF gun operating in CW mode is being developed at Tsinghua University, which will be served as the beam source of the high repetition XFEL facilities and high repetition MeV UED. The cavity profile has been optimized to minimize input power, peak surface electric field, peak wall power density, and multipacting. The fabrication of the gun has been completed, and the frequency and quality factor measured in cold test are in good agreement with simulation expectations. During high power conditioning, 75 kW cw RF power was successfully fed into the gun, corresponding to a cathode gradient of 27 MV/m and a gun voltage of 780 keV.Under this condition, the maximum dark current collected by the Faraday cup at the gun exit was 376 nA. To measure and optimize the beam quality, a test beamline was constructed. After preliminary optimization, the 95% projected transverse emittance was 0.161 µrad for 10 pC, 0.429 µrad for 50 pC, and 0.853 µrad for 100 pC. Now one of the guns has been delivered to Shanghai and installed in the SHINE tunnel. Recently, it was operated in CW mode with ˜70 kW input power and generated the first beam successfully.

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Wednesday Poster Session / 1238

Precise measurements of mean transverse energy of photocathodes

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Single crystal photocathode films promise to lower the mean transverse energy (MTE) of emitted electrons by tens of millielectronvolts, offering significant benefits for advanced light sources and electron microscopes. Traditional methods for assessing the surface quality involve accelerating electrons in a DC gap and inferring their angular distribution from the beam spot size. However, the accuracy of this approach is limited by the finite spot size of the photon beam at the cathode. To overcome this limitation, we capture a series of electron distributions on a screen at varying accelerating voltages. Each distribution corresponds to a convolution of the electron momentum distribution and the intensity distribution of light at the cathode. The relative contributions of these factors depend on the applied voltage, enabling us to reconstruct both the momentum distribution of electrons and the intensity of light to best match the observations. We conclude that it enables the measurement of the momentum distribution of photoemitted electrons with a resolution of about 5 meV in a reasonable momentatron geometry.

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Monday Poster Session / 1239

High-resolution X-ray topography characterization of diamond self-seeding monochromator for the SHINE

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In this paper, the results of high-resolution X-ray topography characterization of monocrystal diamond plate with (100) crystal surface orientation used for high-quality monochromators of high-heat-load self-seeding free electron lasers are reported. The plate was fabricated by laser-cutting of the (100) facet of monocrystal diamond grown using high-pressure high-temperature method. The intrinsic crystal quality of the diamond surface was studied using sequential X-ray diffraction topography in weak-dispersive and non-dispersive configuration and data analysis using rocking-curve topography. The variations of the rocking-curve width and peak position measured with 7.4 µm spatial resolution and ˜10-7 energy resolution over a 0.5 mm×0.5 mm selected region were found to be less than 0.15 µrad, which was suitable for applications in wavefront-preserving high-heat-load crystal optics.

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Monday Poster Session / 1240

Multi-FELOs driven by a common electron beam

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It requires a linac-driven, high-brightness electron beam to produce a FEL. To make multi FELs, the electron beam must be shared to enable one beam driving one undulator. This leads to a reduced average current and compromised performance. Recently, a concept of production of multi FELs driven by one common electron beam was proposed which enables substantial reduction of required equipment and improvement of productivity. We present here a study based on an 1D FELO model to demonstrate this innovative concept. The system consists of FELOs arranged side-by-side along the beamline and one electron beam passing through them. As such, the second, downstream FELO is driven by bunches already been used once, while the first FELOs always receives fresh bunches from the linac. The study shows that lasing could be achieved for both FELOs, their radiation intensities at saturation are comparable. The concept also enables a potential application using a circulator ring such that a FELO can be driven alternately by fresh bunches from the linac and used bunches in the ring. Cases of more than two FELOs driven by one electron beam is also explored.

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Initial beam commissioning results of RAON linac

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The institute of rare isotope science (IRIS) developed a superconducting linac facility (called RAON, Rare isotope Accelerator complex for ON-line experiments) through the rare isotope science project (RISP). The superconducting linac (SCL) consists of two different type of cavities, QWR and HWR. It is designed to accelerate a variety of ions, from protons to uranium. Uranium beams can be accelerated to energies of up to 18.5 MeV/u. The input beams to the superconducting accelerator are generated by a 14.5 GHz ECR ion source and accelerated to the energy of 500 keV/u through RFQ. The linac installation was completed in December 2021 and a series of beam commissioning are in progress. The injector beam commissioning started from August 2020 with argon beams. The first SCL beam commissioning using argon beams began in October 2022 and was finished in May 2023. Afterwards, the beam commissioning has been expanded to include various ion beams such as neon, oxygen, and protons. This work summarizes the beam commissioning results.

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Tuesday Poster Session / 1242

Design of an X-Undulator

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The Advanced Photon Source Upgrade (APS-U) will deliver a new storage ring based on a Multi-Bend Achromat (MBA) lattice featuring swap-out on-axis injection, enabling the use of small diameter insertion device vacuum chambers. To leverage this advantage, we designed an X-undulator similar to the APPLE-X undulator but with a fixed gap and additional simpler magnet arrays for force compensation. The X-undulator is a pure permanent-magnet-based polarization variable undulator with a 30 mm period length and an 8.5 mm diameter bore in the beam center. The gaps between neighboring undulator magnetic arrays are 3 mm. Variation of the radiation wavelength and polarization is achieved using the longitudinal motion of the undulator magnetic arrays. This contribution covers the magnetic and mechanical design, as well as the optimization of this X-undulator.

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Thursday Poster Session / 1244

Improving the uniformity of magnetron sputtering titanium film for nonlinear injection kicker

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The design and manufacturing of the Nonlinear Injection Kicker is one of the upgrade project for the Taiwan Photon Source (TPS). In accordance with the requirements of the developed ceramic vacuum chamber, it is necessary to apply a uniform titanium coating on the inner surface of the ceramic substrate to reduce the impedance and image current observed by the stored electron beam. Therefore, titanium films must be sputtered onto a 30 cm × 4 cm ceramic substrate, and these films must exhibit excellent uniformity. Based on our tests of sputtering titanium films on a 300 mm × 60 mm ceramic substrate, the uniformity of the titanium film can be controlled within 5%. The adhesion between the ceramic substrate and the titanium films meets the highest level of ASTM-D3359 5B standard, with an adhesive strength reaching 40 MPa. This paper describes the detailed manufacturing processes and testing results.

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Tuesday Poster Session / 1245

Design fabrication and measurements of a quadrupole wiggler prototype

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A quadruple wiggler consisting of a row of alternating polarity quadrupoles is used in a collinear wakefield accelerator under development at Argonne National Laboratory. We designed such a wiggler and fabricated a prototype consisting of four quadrupoles. The permanent magnet-excited quadrupole has a bore diameter of 3 mm, a length of 25 mm, and a peak magnetic field gradient of 0.94 T/mm. Fine translational and angular adjustment mechanisms were implemented in all quadrupoles to obtain better than one-micrometer alignment of the quadrupole wiggler assembly. The quadrupole wiggler prototype was measured and aligned employing the pulsed wire technique. We describe the design, fabrication, and alignment of this quadrupole wiggler prototype and describe the influence of the ambient temperature on the quadrupole wiggler alignment.

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Thursday Poster Session / 1246

Design and fabrication of the automation system in TLS BL07A end station

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Co-authors: Chia-Jui Lin [1]; Chun-Shien Huang [1]; Din-Gao Huang [1]; Huai-San Wang [1]; Keng-Hao Hsu [1]; Tse-Chuan Tseng [1]; Chien-Kuang Kuan [1]

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The end station for TLS beamline 07A (BL07A) primarily serves industrial applications, catering to various sample inspection requirements within the industry in multiple modes. In the past, manual switching of modes for different experiments was time-consuming, requiring the re-installment a lot components and taking long time to readjust the gas proportion for different samples. To enhance the efficiency of the BL07A experimental station, an automated design has been implemented, utilizing multiple self-made motorized platforms. Another crucial aspect for improved experimental efficiency is the use of a combination of vacuum pumps, flow meters, and electromagnetic valves for gas replacement system, significantly reducing the time needed for this process. The automated system is currently operational, reducing the operation time for experimental equipment switching from several hours to two minutes. The execution time for the gas replacement process has also been drastically reduced from 100 minutes to 5 minutes.

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Wednesday Poster Session / 1247

Status of coil-dominated discrete-cosine-theta quadrupole prototype for high rigidity isotope beams

Author: David Greene[1]

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Iron-dominated superconducting magnets are one of the most popular and used design choices for superconducting magnetic quadrupoles for accelerator systems. While the iron yoke and pole tips are economic and effective in shaping the field, the large amount of iron also leads to certain drawbacks, namely, unwanted harmonics from the sextupole correctors nested inside of quadrupole iron pole tips. Additional problems include the nonlinear field profile present in the high-field regime caused by the presence of steel, the cryogenic design challenges of the iron yoke being part of the cold mass, and the mechanical challenges of mounting the sextupole and octupole, which will generate significant forces for apertures of the size being proposed. The Facility for Rare Isotope Beams is developing a coil dominated quadrupole as a future upgrade, and the presented work discusses the advantages of using an iron-free quadrupole, along with the methods and choices of the design and the current status of prototype fabrication. The methods and work presented will include the model results and the aspects of the model that have been verified up to the current status of prototype fabrication.

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Monday Poster Session / 1248

Physics design of CEPC linac

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Circular Electron-Positron Collider (CEPC) is a 100 km ring collider as a Higgs factory. It consists of a double ring collider, a full energy booster, a Linac and transport lines. The Linac is a normal conducting S-band and C-band linear accelerator and provide electron and positron beam at an energy up to 30 GeV with repetition frequency of 100 Hz. A conventional positron source scheme, including a tungsten target and an adiabatic matching device (AMD), is adopted and the energy of electron beam for positron production is 4 GeV. There is a 1.1 GeV electron bypass transport line in vertical plane to bypass the positron source and a 1.1 GeV damping ring to reduce the positron beam emittance. The C-band accelerating structures are adopted to accelerate electron and positron beam from 1.1 GeV to 30 GeV. The physics design and dynamic simulation results of the Linac will be detailed presented in this paper.

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Tuesday Poster Session / 1249

Beam commissioning and upgrade considerations for the CSNS RCS

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Co-authors: Huachang Liu [2]; Xiao Li [1]; Yuliang Zhang [3]; Xin Qi [3]; Shouyan Xu [2]; Xiaohan Lu [1]; Liangsheng Huang [1]; Yong Li [2]; Yaoshuo Yuan [1]; Hanyang Liu [1]; Jun Peng [1]; Zhiping Li [2]; Yuwen An [1]; Jianliang Chen [3]; Yanliang Han [1]; Kai Zhou [1]; Sheng Wang [4]

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For the China Spallation Neutron Source (CSNS), the rapid cycling synchrotron (RCS) accumulates and accelerates the injection beam to the design energy of 1.6 GeV and then extracts the high energy beam to the target. In this paper, firstly, the beam commissioning of the RCS have been comprehensively studied. In order to meet the requirements of beam power increase and stable operation of the CSNS accelerator, the RCS beam losses from different sources are studied and optimized. With the aid of weekly radiation dose measurement, the hot spots of the RCS are studied in depth to explore the causes and find the solutions. Secondly, for the CSNS-II, the upgrade of the RCS will be introduced and studied in detail. Based on the detailed simulation results, the upgrade scheme of the RCS will be given.

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Wednesday Poster Session / 1250

Beam dynamics and injection condition in a ring-type dipole of a laser-accelerated electron beam for compact light sources

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We are developing a compact synchrotron light source using laser electron acceleration, focusing on creating a tabletop accelerator-based radiation system. Our approach involves a small ring-type dipole with block-shaped permanent magnets, prioritizing cost and weight reduction. Simple beam dynamic calculations revealed that a smaller electron beam divergence angle results in a more stable orbit and the field modulation of peak magnetic strength improves the stability without the additional quadrupoles. CST simulations shows that the magnetic field of the ring-type dipole includes the field modulation of peak magnetic strength along the orbit due to shape changes. The injection to the ring-type dipole is the one of the issues to be solved for a compact light source. In this paper, we present the studies on designing and optimizing the ring-type dipole including the injection of electron beam and the extraction of dipole radiation.

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Monday Poster Session / 1252

Microbunching instability for beam swithyard transport

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Microbunching instability (MBI) has been an important issue in the design of advanced x-ray free-electron lasers. We have performed theoretical and simulation analyses of MBI for the transport in the beam switchyard system, including the effects of different initial beam parameters. In addition, a comparison is given for different beam switchyard section designs.

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Wednesday Poster Session / 1253

The status of beam instrument at CSNS

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Beam instrumentation is of critical importance for the operation and optimization of modern particle accelerators. The upgrading work of CSNS has led to higher requirements for beam measurement equipment in increasing beam current research. Existing equipment, including current intensity measurement systems, emissivity measurement systems, and position measurement systems, cannot meet these requirements。 In this paper, Phenomena and improvement plans of beam diagnostics system will be discussed.

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Monday Poster Session / 1254

Capture cavities for the CW polarized positron source Ce+BAF

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The initial design of the capture cavities for a continuous wave (CW) polarized positron beam for the Continuous Electron Beam Accelerator Facility (CEBAF) upgrade at Jefferson Lab is presented. A chain of standing wave multi-cell copper cavities inside a solenoid tunnel are selected to bunch/capture positrons in CW mode. The capture efficiency is studied with varying cavity gradients and phases. The heating load from the incoming particle radiation shower and RF field will limit the achievable gradients, especially the first cavity. The cooling method and results are shown. The beam loading cancellation from positrons and electrons are investigated.

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Monday Poster Session / 1255

Compact high peak power THz source driven by thermionic RF gun

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This work unveils the design of a compact high-power terahertz source, a collaborative effort between UCLA and RadiaBeam Technologies. The system, driven by a thermionic RF gun, features an alpha-magnet beamline that effectively compresses the beam, resulting in short bunch lengths and an additional S-band linac that elevates the beam energy to 10 MeV. The key to achieving high-efficiency radiation in the 1–1.5 THz range lies in using the tapered undulator equipped with a waveguide. This innovative approach serves a dual purpose: compensating for diffraction effects and ensuring optimal matching between the group velocity of the beam and the radiation field. The synergistic combination of these elements results in a compact terahertz source with high peak power, promising advancements in various scientific and technological applications.

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Monday Poster Session / 1257

Towards attosecond x-ray sources driven by infrared free-electron laser oscillators

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We have launched a research program on attosecond X-ray sources utilizing high-harmonic generation (HHG) driven by an infrared free-electron laser (FEL) oscillator. As the results of the first six years of the program, we have improved the FEL performance at KU-FEL and LEBRA-FEL to achieve FEL intensity high enough for HHG. We observed HHG from a solid target and tunnel-ionizing electrons in gas, both of which indicate high-field photon reactions. In the present paper, we report on the recent status and future perspectives of the program.

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Monday Poster Session / **1260**

Electron bunch spacing for the FEL generation with a laser heater and collimators at PAL-XFEL

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High current electron bunches with lower emittance and slice energy spread are required to generate the intense XFEL. However, it is difficult to maintain the emittance and slice energy spread during the bunch compression at magnetic bunch compressors (BC). The higher current peaks in the head and tail of compressed bunches spoil the core slices by the wakefield and coherent synchrotron radiation. We suppress these collective effects by the bunch spacing with a laser heater (LH) and collimators. Head and tail slices can be eliminated by collimators in the BCs. The effects from the head and tail slices are strongly suppressed to dilute them by the intense laser heating in the LH. In this paper, we present the bunch spacing with the LH and collimators in simulations and experiments. Also, we present the FEL improvement by these bunch spacing.

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Monday Poster Session / **1262**

Inference and use of uncertainty-aware Bayesian models

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Use of uncertainties is key to improving the efficiency and interpretability of ML algorithms. One interesting uncertainty-aware technique is Bayesian parameter inference, whereby posterior distributions are determined from experimental data though gradient-enabled methods like Hamiltonian Monte Carlo. Key to this idea is implementation of standard linear optics and tracking in a differentiable framework like Jax, which we previously demonstrated. In this paper we explore the usefulness of Bayesian inference methods by estimating Twiss parameters, magnet strengths, and response matrices of APS beamlines. Results show accuracy comparable to standard tools like LOCO but using fewer measurements. Moreover, this analysis does not require specific corrector patterns and can run non-destructively alongside orbit and trajectory feedback. The inferred parameter posteriors can be used to create uncertainty-aware surrogate models using Gaussian processes or neural networks, to be used as priors for Bayesian optimization (presented in our other papers). Overall, this work demonstrates a complete uncertainty-aware pipeline usable in any scenario where differentiable models are available.

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Tuesday Poster Session / 1266

Enhancing beam current in compact cyclotrons for diverse applications

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Compact cyclotrons, with their ability to deliver high-intensity beams, hold immense potential for advancements in radioisotope production, cancer therapy, and materials research. However, achieving this potential has been limited by inherent challenges and technological constraints. This work presents a comprehensive approach to boosting beam current in compact cyclotrons, paving the way for unlocking their full potential. By combining innovative strategies in axial injection optimization, beam loss mitigation, and novel beam extraction technologies, significant increases in beam intensity can be achieved.

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Wednesday Poster Session / 1268

Detailed characterization of coherent synchrotron radiation effects using generative phase space reconstruction

Author: Juan Pablo Gonzalez-Aguilera[1]

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Coherent synchrotron radiation (CSR) effects in linear accelerators, such as projected emittance growth and microbunching, have been well studied. However, traditional measurement techniques lack the precision to fully comprehend the intricate multi-dimensional aspects of CSR, particularly the varying rotation of transverse phase space slices along the longitudinal coordinate of the bunch. This study explores the effectiveness of our generative-model-based high-dimensional phase space reconstruction method in characterizing CSR effects at the Argonne Wakefield Accelerator Facility. Additionally, we assess the current limitations in resolution of the phase space reconstruction method and conduct an analysis of its accuracy and precision through simulated scenarios. Finally, the reconstruction algorithm is tested using synthetic beams that emulate distributions affected by CSR.

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THAD: Beam Instrumentation, Controls, Feedback and Operational Aspects (Contributed) / 1269

Spatio-temporal measurements of stripper foil temperatures at 1.7 MW H− beam power at the SNS

Author: Abdurahim Oguz[1]

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We propose and demonstrate a time-resolved, two-dimensional temperature monitoring technique for nanocrystalline diamond stripper foils exposed to high-intensity hydrogen ion (H-) beams at the Spallation Neutron Source (SNS) accumulator ring which is independent of foil emissivity. The technique utilizes a two-color imaging pyrometer in the shortwave infrared (SWIR) spectral band to measure thermal radiation from stripper foils located 40 meters away from the measurement site. This work presents a unique optical design, optical calibration of the system using a high-temperature blackbody source, preliminary temperature measurement results from two stripper foils (new and used) under various H− production beam conditions with average powers up to 1.7 MW and energy of 1.0 GeV. This technique can be utilized to understand the thermal behavior of charge

strippers under high-intensity particle beams, providing crucial feedback to operations to control foil temperature and ensure foil lifetime.

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THBN: Accelerator Technology and Sustainability (Contributed) / 1270

Progress in the design of the magnets for a Muon Collider

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Magnets have been identified as one of the critical technologies for a proton-driven Muon Collider. Within the scope of the International Muon Collider Collaboration we have progressed in the review of requirements, and the development of concepts towards the initial engineering of several of the most critical magnets identified from our previous work. In this paper we present an update of the accelerator magnet configuration for all the parts of the Muon Collider complex, from muon production to collision. We then give details on the specific technologies that have been selected as baseline. Overall, it is clear that a Muon Collider requires very significant innovation in accelerator magnet technology, mostly relying on the success of HTS magnet development. We include in our description a list of options and development staging steps intended to mitigate technical, cost and schedule risk.

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Tuesday Poster Session / 1273

A high-power positron converter based on a recirculated liquid metal in-vacuum target

Author: Nicholas Taylor[1]

Co-authors: Bruce Dunham [2]; Christopher Mayes [2]; Colwyn Gulliford [1]; Joseph Conway [1]; Karl Smolenski [1]; Vaclav Kostroun [3]

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An effective high-power positron converter for electron linear accelerators is not currently available from industry. A commercial source would allow research institutes to have ready access to high-brightness positrons for a wealth of material science, nuclear, particle, and accelerator physics projects. Xelera Research LLC has designed, built, and tested a prototype free-surface liquid-metal (GaInSn) jet converter. Free-surface liquid-metal jets allow for significantly greater electron beam power densities than are possible with solid targets. Higher power densities lead to greater positron production and, importantly, allow continuous wave (CW) operation. A modified version of the GaInSn converter prototype is planned to be constructed and tested at the Thomas Jefferson National Accelerator Facility.

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Monday Poster Session / 1274

Thermal emission measurement and research of cesium telluride photocathodes

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The thermal emission of photoelectric cathodes significantly influences the emittance of electron beams. Employing cesium telluride as the cathode material, the hard X-ray free-electron laser device utilizes thermal evaporation deposition for fabrication. The typical thermal emission value for cesium telluride cathode materials is ˜0.7 mm-mrad/mm. Poor processes and formulations lead to decreased cathode quality and increased thermal emission. Therefore, a measurement device is required to assess the thermal emission of cathodes produced under different processes, optimizing fabrication methods and maintaining emission within specified ranges. Traditional emittance measurement methods rely on large accelerator installations, incurring high construction costs, complexity, and environmental demands. We have chosen a pore-anode-based thermal emission measurement scheme that operates within laboratory settings. This approach is independent of large

accelerator installations, compact in structure, compatible with cathode fabrication setups, allowing for offline rapid measurement of cathode thermal emission.

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Monday Poster Session / 1275

Study of the radiation field from multiple out-coupling holes in an infrared free electron laser oscillator

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A new infrared Free-Electron Laser (FEL) facility FELiChEM has been established as an experimental facility at the University of Science and Technology of China. It consists of two FEL oscillators driven by a normal-conducting S-band linac, covering the spectral ranges of 2.5-50 μm and 40-200 μm, respectively. This coverage is achieved by adjusting the beam energy from 12 to 65 MeV. The facility is dedicated to energy chemistry research, and output power is one of the most crucial parameters concerned by users. The output power is typically achieved by an out-coupling hole located in the center of a cavity mirror. Nevertheless, the spectral gap phenomenon has been observed in FEL oscillators with partial waveguides, which means that output powers are drastically reduced at certain wavelengths. Such power gaps have an adverse effect on experimental results since numerous experiments require continuous spectral scanning. In this paper, we propose the utilization of multiple out-coupling holes on the cavity mirror, instead of relying solely on a central out-coupling hole, to reduce the adverse impact of the spectral gap phenomenon.

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Thursday Poster Session / 1276

Transmission characteristics of dark current in a 1.4-cell RF photocathode gun

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One effective method to improve the brightness of an RF electron gun is to increase the acceleration gradient of the photocathode to suppress space charge effects. However, this increases the risk of field emission from the metal surface, which becomes a significant factor limiting the further improvement of the electron gun performance. The dark current formed by field emission electrons leaving the electron gun can affect downstream accelerator structures. This paper thoroughly analyzes the critical characteristics of dark currents from various possible emission positions. By constructing a transmission matrix from the cathode to the fluorescent screen, we simulate the image of dark currents on the fluorescent screen and obtain the magnification factor. Based on this, we determine the position of the field emission source. Additionally, we consider the manipulation of the dark currents by the electron gun and solenoid and construct a 4×4 transmission matrix to track the behavior of dark current imaging on the fluorescent screen and analyze their distribution characteristics. The results show a good agreement between the calculated and simulated results.

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Thursday Poster Session / 1277

Estimation of impedances and corresponding instabilities in Korea-4th generation storage ring

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Due to the small vacuum apertures, impedance serves as a significant cause of beam instabilities in the 4th generation storage ring. These instabilities are directly affected by the bunch charge, thereby placing a limit on the maximum achievable beam current within the storage ring. The Korea-4th generation storage ring (Korea-4GSR) is currently under construction with the aim of reaching a maximum beam current of 400 mA. To meet this goal, we've conducted estimations and optimizations of the current storage ring's impedance. In this presentation, we show the impedance of Korea-4GSR and the corresponding instabilities.

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Monday Poster Session / 1278

Towards latent space evolution of spatiotemporal dynamics of six-dimensional phase space of charged particle beams

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Addressing the charged particle beam diagnostics in accelerators poses a formidable challenge, demanding high-fidelity simulations in limited computational time. Machine learning (ML) based surrogate models have emerged as a promising tool for non-invasive charged particle beam diagnostics. Trained ML models can make predictions much faster than computationally expensive physics simulations. In this work, we have proposed a temporally structured variational autoencoder model to autoregressively forecast the spatiotemporal dynamics of the 15 unique 2D projections of 6D phase space of charged particle beam as it travels through the LANSCE linear accelerator. In the model, VAE embeds the phase space projections into a lower dimensional latent space. A long-short-term memory network then learns the temporal correlations in the latent space. The trained network can evolve the phase space projections across further modules provided the first few modules as inputs. The model predicts all the projections across different modules with low mean squared error and high structural similarity index.

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Monday Poster Session / 1279

Mode-locked soft x-ray FEL generation based on HHG seed

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High Harmonic Generation (HHG) has been a brilliant and successful technique for the generation of natural mode-locked attosecond laser pulses in the VUV regime. It's promising to employ the HHG laser as an external seed in a harmonic-generation FEL facility for the generation of high power short wavelength mode-locked FEL pulses. In this paper we propose a method to try to make this happen. And we will address some critical problems. The possible performance will also be given through numerical simulations.

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Monday Poster Session / 1280

Accelerator system parameter estimation using variational autoencoded latent regression

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A particle accelerator is a time-varying complex system whose various components are regularly perturbed by external disturbances. The tuning of the accelerator can be a time-consuming process involving manual adjustment of multiple components, such as RF cavities, to minimize beam loss due to time-varying drifts. The high dimensionality of the system (˜100 amplitude and phase RF settings in the LANSCE accelerator) makes it difficult to achieve optimal operation. The time-varying drifts and the dimensionality make system parameter estimation a challenging optimization problem. In this work, we propose a variational autoencoded latent regression (VAELR) model for robust estimation of system parameters using 2D unique projections of a charged particle beam's 6D phase space. In VAELR, VAE projects the phase space projections into a lower-dimensional latent space, and a dense neural network maps the latent space onto the space of system parameters. The trained network can predict system parameters for unseen phase space projections. Furthermore, VAELR can generate new projections by randomly sampling the latent space of VAE and also estimate the corresponding system parameters.

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Monday Poster Session / 1281

Electron acceleration by Laguerre-Gaussian pulse in relativistic-ponderomotive regime of magnetoplasma

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In present paper, the coupled effect of spatio-temporal variation of the laser pulse propagating inside magnetoplasma on electron acceleration have been investigated theoretically. The variation in the dielectric properties under the combined effect of relativistic and ponderomotive non-linearity have been taken into account. Two coupled second order non-linear differential equations determining variation in both spatial and temporal widths have been obtained using moment theory approach. The propagation of laser pulse excites an electron plasma wave, which behaves as a wakefield and accelerates the trapped electrons to high energy values. The laser dynamics and electron acceleration have been investigated for different laser and plasma parameters. Furthermore, the effect of externally applied axial magnetic field has also been observed. The results are interesting and are useful for scientists and researchers working in the the field of wakefield acceleration.

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Thursday Poster Session / 1282

Radiation dose simulations for Jefferson Lab's permanent magnet resiliency LDRD study

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In late 2023, Thomas Jefferson National Accelerator Facility (Jefferson Lab) funded a Laboratory Directed Research and Development (LDRD) grant dedicated to investigating the impact of radiation

on permanent magnet materials. This research initiative is specifically geared towards assessing materials slated for use in the CEBAF energy upgrade. The experimental approach involves strategically placing permanent magnet samples throughout the accelerator, exposing them to varying radiation doses. The simulation code BDSIM is used to first validate the data and then to simulate the effects on future higher energy passes to study the degradation effects on the permanent magnets. In this paper we present the progress of that work.

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Monday Poster Session / 1283

Emittance growth due to coupler wake kick of SHINE injector

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The acceleration unit of the SHINE injector consists of a single-cavity superconducting cryomodule with an 8-cavity superconducting cryomodule. When the beam passes through the superconducting cryomodule of the SHINE injector, the presence of the coupler leads to an asymmetry in the superconducting cavity structure, which induces coupler wake kick. Coupler wake kick due to the asymmetric structure caused by the coupler, is more likely to lead to emittance growth in the SHINE injector with low beam energy. In this paper, the emittance growth due to coupler wake kick is estimated and compared to the coupler RF kick, and optimized to derive the optimal emittance for the superconducting cryomodule of SHINE injector.

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Thursday Poster Session / 1284

Resonant matching section for CEBAF energy upgrade

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Co-authors: Alex Bogacz [1]; Alexander Coxe [2]; Andrei Seryi [1]; Dejan Trbojevic [3]; Dennis Turner [1]; Donish Khan [1]; Francois Meot [3]; Geoffrey Krafft [1]; Georg Hoffstaetter [4]; J. Berg [3]; Katheryne Price [1]; Kirsten Deitrick [1]; Reza Kazimi [1]; Ryan Bodenstein [1]; Stephen Brooks [3]; Todd Satogata [1]; Vasiliy Morozov [5]; Yves Roblin [1]

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The ongoing study Thomas Jefferson National Accelerator Facility (Jefferson Lab) energy upgrade to 22 GeV involves the addition of two new Arcs based on Fixed-Field Alternating Gradient (FFA) permanent magnet technology. The six highest energy passes will share the FFA Arc and will be connected to the rest of the machine through a transition section that will match the Twiss functions of all six passes to that of the linac entrance. With the high number of constraints and the limited space available, we are investigating a parametric resonance technique to match the Twiss parameters by using the Panofsky corrector magnets placed throughout the FFA arcs. This paper presents the current progress of that transition section.

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Monday Poster Session / 1285

Status of the second interaction region for Electron Ion Collider

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Provisions are being made in the Electron Ion Collider (EIC) design for future installation of a second Interaction Region (IR), in addition to the day-one primary IR. The envisioned location for the second IR is the existing experimental hall at RHIC IP8. It is designed to work with the same beam energy combinations as the first IR, covering a full range of the center-of-mass energy of ~20 GeV to ~140 GeV. The goal of the second IR is to complement the first IR, and to improve the detection of scattered particles with magnetic rigidities similar to those of the ion beam. To achieve this, the second IR hadron beamline features a secondary focus in the forward ion direction. The design of

the second IR is still evolving. This paper reports the current status of its parameters, magnet layout, and beam dynamics and discusses the ongoing improvements being made to ensure its optimal performance

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Wednesday Poster Session / 1286

A new superconducting harmonic cavity for HALF storage ring

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A superconducting (SC) 1.5 GHz (3rd harmonic) cavity is being developed for lengthening bunch and improving beam lifetime in the Hefei Advanced Light Facility (HALF) storage ring. This SC cavity is excited by an electron beam with 350 mA current, 1 nC charge, and ˜6.7 ps length. This contribution presents optimizations on such a SC harmonic cavity in detail. It has a RF coupler to adjust the loaded quality factor and extract RF power out of the cavity from the beam. In combination with a frequency tuner, this permits adjustment of both the amplitude and phase of the harmonic voltage such that the cavity is able to operate at various beam currents. Higher-order-modes are strongly damped using a pair of room-temperature silicon carbide (SiC) rings to meet the requirement of beam instabilities. In addition, preliminary engineering design for the SiC rings is also described in this contribution.

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Thursday Poster Session / 1288

Design and Installation of the Liquid Nitrogen Transfer Line for TPS 15A Beamline Endstation

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At Taiwan Photon Source (TPS), the main liquid-nitrogen (LN2) transfer line of length 600 m for beamline endstations was installed in 2015. It formerly supplied LN2 to maximum 24 beamline endstations. Beamline endstation 15A (TPS 15A), of which the aim is to determine 3D crystal structures from micro-scale single crystals and non-ambient conditions. We designed and self-manufactured one LN2 transfer line according to the requirement of TPS 15A, to supply LN2 into the both end station and 50L phase separator. The 50L phase separator was constructed to provide high quality of LN2 and pressure stability to the chiller of double-crystal monochromator (DCM), to prevent the thermal deformation of the crystal. In this paper, we present the design and manufacturing of LN2 pipeline, 50L phase separator and pressure regulator. The heat-load measurement and performance test was also presented and discussed.

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Monday Poster Session / 1289

Instability of asymmetric electron drive beams in hollow plasma channels

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Using hollow plasma channels is one approach to compact positron acceleration, potentially reducing the cost and footprint of future linear colliders. However, it is prone to transverse instabilities since beams misaligned from the channel axis tend to get deflected into the channel boundary. In contrast, asymmetric electron drive beams can tolerate misalignment and propagate stably after the initial evolution, but this has only been reported for short distances. In this work, we use quasi-static particle-in-cell simulations to demonstrate the instability of asymmetric drivers even after splitting into two beamlets and reaching equilibrium. As the driver decelerates, its particles gradually return into the channel, making the driver susceptible to deflection by the transverse dipole mode. To understand this behavior, the transverse motion of an individual beam particle is modeled. Strategies to mitigate this instability are also proposed.

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Monday Poster Session / 1291

Ultrafast free-electron laser generation with optical beat note

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As one of the most important frontiers of international science and technology, the development of ultrafast science has provided important research tools for many disciplines. Free-electron laser (FEL) has the unique advantages of high power and short wavelength in generating ultrafast pulses. In this paper, the theoretical simulations were performed to produce the ultrafast pulses, utilizing an electron beam compressed by an optical beat note. The main parameters used in the simulation are from Shanghai Soft X-ray Free Electron Laser Facility (SXFEL). The results show that an isolated FEL pulse with the peak power of 700 MW and the pulse duration of ~1 femtoseconds can be generated. In addition, we discuss the effect of the relative delay jitter of optical beating laser on ultrafast radiation. The result shows that the scheme is very sensitive to time delay jitter.

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Tuesday Poster Session / 1292

The energy spread measurement for the CSNS linac

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The accelerator of CSNS is composed by a 80 MeV H- linac and a RCS ring. The H- beam from the linac is stripped and injected to RCS where the stripped proton beam will be accumulated and boosted to 1.6 GeV. In order to improve the injection efficiency, it is a must to know and control the linac beam parameters. In this paper, the energy spread of H- beam at the LRBT of CSNS linac is measured.

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Wednesday Poster Session / 1293

Experimentally verified reduction of local reflection of traveling-wave accelerating structure by output coupler undercoupling

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Hefei Advanced Light Facility (HALF) injector comprises 40 S-band 3-meter traveling wave accelerating structures, capable of delivering electrons of full energy 2.2 GeV into the storage ring. To mitigate the emission degradation caused by dipole and quadrupole fields in the coupler cavity, the coupler design incorporates a racetrack and a short-circuit waveguide to eliminate this impact. This article presents an introduction to design of the traveling wave structure and the results of cold and high-power testing. We performed tuning and preliminary measurements on accelerating structure, resulting in meeting the single-cell phase deviation and accumulated phase deviation requirements of the project objectives while maintaining good measurement consistency.

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Monday Poster Session / 1294

Different scenarios for generating coherent THz radiation based on a compact electron accelerator

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Terahertz radiation sources have significant applications in non-invasive detection fields, including medical imaging, drug design, and the quantification of specific biochemical substances. Currently, accelerator-based terahertz sources play a crucial role in producing high-power terahertz radiation. To achieve high-power Terahertz output, beam manipulation is necessary. This paper presents various beam manipulation methods to generate a prebunched electron beam and achieve coherent Terahertz radiation. The proposed methods are based on a compact electron accelerator, and performances under different scenarios are discussed.

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Tuesday Poster Session / 1295

Comparison of BBA methods for commissioning of fourth generation light sources

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Beam based alignment (BBA) plays an important role in the commissioning of the fourth generation light source but it takes a lot of time with several hundreds of BPMs. To speed up BBA, a method using AC excitation, called fast BBA, has been proposed and is tested in several 3rd generation light sources. We have recently also proposed and tested a new BBA based on the neural network machine learning. In this paper, we will compare these new BBAs with conventional BBA in term of error, speed and some other aspects such as the betatron coupling.

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Wednesday Poster Session / 1296

Recent studies on high current operation at the compact ERL

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The compact ERL (cERL) is operated at mid-energy region around 17 MeV for beam studies on industrial applications since 2017. Toward the future high power FEL source for EUV lithography, high current beam operation was demonstrated at low bunch charge after install of undulators as a first step. It is critical to reduce beam loss not to exceed 20 uSv/h outside the shield wall of the cERL acceleration room, however, it can increase especially at the arc sections, the undulators, and superconducting cavities for decelerating. Therefore, 16 high-speed loss monitors are located along the whole beam line as the machine protection system. Recently, machine learning is applied for beam tuning to reduce all loss monitor signal. In addition, we tried the energy recovery operation while undulator light is amplified at a high bunch charge around 60 pC.

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Wednesday Poster Session / 1297

Gas sheet ionization based monitor for electron beams

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The gas sheet ionization based diagnostic is a minimally invasive profile monitor for electron beams. In the ionization based monitor, the electron beam ionizes a neutral gas that is spatially tailored. The newly ionized particles form a footprint of the electron beam, and are imaged using an array of electrostatic lenses. The gas sheet diagnostic was conceptually tested using a 7 MeV electron beam and has shown strong correlations for use as a transverse profile. The concept is extendible, and proposed, for use with electron beams with energy greater than 10 GeV. Although different ionization mechanisms are dominant for each regime, the gas sheet diagnostic imaging scheme is viable when novel algorithms are employed to reconstruct the beam profile.

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Tuesday Poster Session / 1300

Simulation study of a 300 keV positive ion linac for D and T fusion

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An 870 mA CW positive ion source and linac is being developed to produce Mo-99 using neutrons from a fusion of deuterium and tritium. The project will be situated at the ENEA Sorgentina Laboratory at Brasimone, Italy. The beam line consists of an ion source, multi-aperture extraction system and a 300 keV electrostatic accelerator. The multi-aperture extraction system is designed with each aperture oriented so that each beamlet meets at a common focal point. The beam distribution at the target should be wide with a reasonably high degree of uniformity. A particle tracking simulation study using the G4beamline program with electric field distributions in the extractor and accelerator that are calculated in COMSOL is being performed to optimize the beam line components to produce the desired ion distribution at the target.

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Monday Poster Session / 1301

Unusual electron emission characteristics of CeB6 cathodes

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Thermionic electron guns that use borides of lanthanum or cerium as the electron emission surface are widely adopted for electron microscopes due to their high brightness. CeB6 cathodes are known for their high environmental durability and can be used up to a vacuum pressure of 1e-6 Pa. At MHI-MS, our company, we also adopt CeB6 cathodes in the C-band compact accelerating structure units we manufacture, and we have shipped dozens of units so far.
As for the cathode assembly, we purchase Vogel-type cathodes and incorporate them into the thermionic electron guns. Before shipping, we bake the entire accelerating structure, including the electron gun, and confirm the electron emission characteristics. Recently, some of the procured cathodes have exhibited abnormal behavior, such as a decrease in electron emission as the vacuum pressure of the electron gun decreases. Analysis of the CeB6 crystal shows no significant differences between the normal and abnormal batches, and the cause is still unknown.

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Tuesday Poster Session / 1302

Design of 500 MHz HOM-damped normal conducting RF cavity

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Jinhua Light Source, which is a industrial light source, will be built in Jinghua City, Zhejiang Province, China. Its energy is 2.6 GeV and beam current is 500 mA. 4 sets of normal-conducting RF systems are likely to be chosen. A kind of 500 MHz HOM-damped normal conducting RF cavity has been designed for the Jinhua Light Source. The KEK-PF main cavity type was selected and three rectangular waveguides equally spaced by 120°. One of the rectangular waveguides is longitudinally separated from the other two rectangular waveguides. The main mode is TM010 mode and the effective shunt impedance is greater than 7.5 MΩ. The simulation results show that longitudinal HOM impedance is no more than 1 kΩ and transverse HOM impedance is no more than 50 kΩ/m.

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Thursday Poster Session / 1303

An accumulator ring lattice design for swap-out injection scheme

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The on-axis swap-out scheme is a potential injection scheme to be adopted in the diffraction-limited storage ring light source, since it only need a rather small dynamic aperture. An accumulator is added between the booster and storage ring to allow for off-axis injection from the booster and extracting low emittance beam into the storage ring. In this paper, an accumulator ring is designed through modifying the storage ring lattice of NSLS-II for swap-out injection scheme. It provides a possible injection scheme for the upgrade of Shanghai Synchrotron Radiation Facility.

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Asia

Thursday Poster Session / 1304

Investigation for the applicability of a Hall probe measurement in B-field control for synchrotron duty cycle optimization

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MedAustron is a state-of-the-art synchrotron-based accelerator complex that provides irradiation with proton and carbon ion beams. The implemented DCCT feedback based control of the current provides good results for magnets of the accelerator in terms of precision and accuracy. However, since the B-Field of the main ring dipoles is not directly controlled, parasitic, time consuming effects cannot be compensated. Hence, the implementation of a B-Field control system offers a major improvement opportunity for the operation. This contribution presents the measurement chain of the proposed solution which is centered around a Hall probe located in the so-called B-train magnet. This approach requires an assessment of the applicability of local Hall probe measurements for this purpose, including the development of a model for relating the respective local measurement to the integral field. Ultimately, the Hall probe has shown characteristics of high accuracy and a measurement uncertainty that is below the overall field error target of 2 units. The model was tested under laboratory conditions and an accurate estimation of the integral field has been observed in the scope of simulations.

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Wednesday Poster Session / 1305

GEANT4 simulations on wire scanners and Faraday cup design for PIP-II

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The PIP-II accelerator upgrade at Fermilab represents a groundbreaking leap forward in high-energy physics research. This ambitious initiative involves enhancing Fermilab's accelerator complex by replacing the current linear accelerator with a warm front end (WFE) capable of accelerating H- beams up to 2.1 MeV. Subsequently, a superconducting linac further accelerates these beams up to 800 MeV. To precisely measure the transverse beam profile, a combination of traditional wire scanners at the WFE section and Laser wire scanners along the superconducting linac section are planned for implementation. This investigation centers on studies of H- beam interactions with wire scanners and refining the Faraday cup design for the PIP-II Laser wire scanners by utilizing GEANT4, a Monte Carlo simulation toolkit. Leveraging this method enables a comprehensive analysis of particle trajectories, energy deposition, secondary electron emission, backscattering, etc., facilitating optimization through adjustments to cup geometries, materials, and placement to maximize its efficacy in beam diagnostics.

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Thursday Poster Session / 1307

Treatment of the residual particles after foil stripping for the CSNS-II

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During the injection process, after the foil stripping, the remaining particles are H−, H0, p and e−. The injection system must promise that most of the H− particles are stripped to protons and enter the RCS. Although the residual particles H−, H0 and e− are relatively small, they can cause beam instability and large beam losses if left untreated. In this paper, for the CSNS-II, the treatment of the residual particles after foil stripping will be studied in detail. The little H0 particles, stripped by the secondary stripping foil, enter the beam dump. The very small amount of un-stripped H− particles are deflected by the magnet BCH3 and enter another beam dump. The stripped electrons will be collected by an electron catcher.

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Tuesday Poster Session / 1308

Final preparation of accelerated and polarised protons at COSY Jülich

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2023 was the last year of operation for the Cooler Synchrotron (COSY) in Jülich, Germany. To prepare for the extraction of polarized protons at a momentum of 1950 MeV/c to an external target, full advantage of the most recent developments of the COSY control system was taken along with the established hardware of COSY.
Challenges in beam development included the operation close to transition energy as well as seven depolarizing resonances (4 intrinsic and 3 imperfection resonances) which have to be crossed during the acceleration. To overcome the intrinsic resonances tune jumps were carried out with the Q-jump quadrupole system of COSY. *To identify the correct time window for the jump, the precise measurement of the tune** during the acceleration ramp was used.
We present how the recent developments in the control system, along with the established techniques, enabled us to successfully accelerate and extract the polarized beam.

Footnotes:

- A. Lehrach et al., "Acceleation of the Polarized Proton Beam in the Cooler Synchrotron COSY", Proc. PAC 1999 ** P.J. Niedermayer et al., "Development of a Fast Betatron Tune and Chromaticity Measurement System for COSY", Proc. IPAC'21

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Wednesday Poster Session / 1309

Development and performance evaluation of the Cavity BPM system for SHINE

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The Shanghai high repetition rate XFEL and extreme light facility (SHINE) under construction is designed as one of the most advanced FEL facilities in the world, which will produce coherent x-rays with wavelengths from 0.05 to 3 nm and maximum repetition rate of 1 MHz. To achieve precise beam trajectory measurement and stable alignment of the electron and photo beams in the undulator, the cavity beam position monitors (CBPM) including beam diameters of 35 mm in LINAC and Bunch distribution section and 8mm in undulator have been designed and developed for the SHINE. The requirement of the transverse position resolution is better than 1 μm and 200 nm for a single bunch of 100 pC, respectively. In this paper, we present the design of the cavity BPM system and the processing of the key equipment. The beam test bench has been established at the Shanghai Soft X-ray FEL facility (SXFEL), and preliminary beam experiments indicate that, with the bunch charge about 100 pC, the position resolution of CBPM-35mm and CBPM-8mm is better than 330 nm and 70 nm, respectively.

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Wednesday Poster Session / 1311

Algorithmic access to beam control and beam diagnostics at COSY Jülich

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During the last years of operation of the COSY facility, significant improvements were made in beam control and diagnostics. Many systems have been upgraded from a Tcl/Tk based control system to EPICS. One of the advantages of EPICS is the coherent communication via Process Variables (PVs). This allowed us not only to control the synchrotron and its injection beam line (IBL) through GUIs but also allowed us to control the beam with algorithms. In our case, these algorithms covered a range of applications from variation of the currents of the electromagnets up to more advanced techniques of AI/ML such as Bayesian Optimization or beam control with Reinforcement Learning. Due to the unified nature of the PVs, the algorithms can be fed with a plethora of input parameters such as beam positions, beam current, or even live images of a camera. Depending on the algorithm, it is also possible to switch the target quantity (e.g. from measured current at the beam cups to the intensity of the injected beam at COSY). The algorithms can also trigger model calculations and access their results, if desired. We present an overview of different applications and our efforts to prepare COSY for them.

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Thursday Poster Session / 1312

Beam emittance growth caused by longitudinal mismatch in the CSNS linac

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The beam emittance growth at the end of the CSNS linac was measured to be larger than the simulation,though transverse matching was performed. We find that the longitudinal mismatch is responsible for the emittance growth because of the lack of longitudinal diagnostics. A matching technique based on the emittance measurement at the end of the linac was performed on the CSNS linac. Modifying the quadrupole gradients and RF fields of two bunchers in the MEBT improves the matching, and the beam loss along the linac is also reduced.

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Wednesday Poster Session / 1313

R&D of EOTD bunch length monitor for SXFEL

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As one of online single-shot and non-destructive absolute measure methods with high resolution, Electro-Optical (EO) techniques have been widely utilized in Free Electron Laser to measure the longitudinal bunch profile. A bunch length monitor with 100 fs resolution is required for Shanghai Soft X-ray FEL (SXFEL) facility. The solution based on Electro-Optical Temporal Decoding (EOTD) method has been developed and tested during the past year. This paper will present the whole design according to SXFEL condition and its test results.

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WECN: Accelerator Technology and Sustainability (Contributed) / 1314

Muon production target at J-PARC

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A pulsed muon beam has been generated by a 3-GeV 333-microA proton beam on a muon target made of graphite at J-PARC, Materials and Life Science Experimental Facility. The first muon beam was successfully generated in 2008, and 300-kW proton beam has been operated by a fixed target till 2014. To extend the lifetime, a muon rotating target, in which the radiation damage is distributed to a wider area, had been developed. The muon rotating target #1 was installed in 2014 and had operated for five years until 2019. The rotating target #2 has stably operated at 830 kW until now in 2023. 1-MW operation was also completed for 32hours in 2020. Simultaneously, in the COMET experiment to explore the muon-electron conversion process, 8 GeV proton beam with an intensity of 3.2 kW in Phase 1 and 56 kW in Phase 2 will irradiate targets in a superconducting solenoid magnet. The MLF 2nd target station is a future project where 3 GeV protons will irradiate a tungsten target to produce high-brightness neutrons and muons. In this presentation, the status and future prospect of the muon target at J-PARC MLF MUSE, the COMET target, and MLF 2nd target station will be introduced.

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Thursday Poster Session / 1316

Study on the H- stripping injection for the CSNS-II

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For the high intensity spallation neutron sources, the foil stripping injection is an effective method to accumulate proton beam. For different injection beam parameters and stripping foil parameters, the foil temperature rising due to the energy deposition have been simulated in detail by using the codes COMSOL and ANSYS. With the increasing of the beam power, there are many difficulties by using the foil stripping, such as short foil lifetime, extremely high peak temperature, large radiation dose, etc. Laser-assisted H− stripping can be an alternative to the foil stripping to overcome the above difficulties. Based on the phase II of China Spallation Neutron Source (CSNS-II), the physical principle of laser-stripping injection has been explored theoretically. The laser-stripping injection process have been simulated by the code Py-ORBIT.

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Tuesday Poster Session / 1317

Superconducting undulator mock-up coils with 18 mm period length –design and first cryogenic tests

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In advanced light sources such as 4th generation synchrotrons and Free Electron Lasers (FELs), undulators are important devices to produce photons with high brilliance. This necessitates to reach highest possible magnetic fields. For a given magnetic gap and period length this demand can only be accomplished by using the superconducting undulator (SCU) technology.
At the Institute for Beam Physics and Technology (IBPT) of the Karlsruhe Institute of Technology (KIT) there is an ongoing R&D collaboration on SCUs together with Bilfinger Noell GmbH (BNG). Within the latest project a SCU mock-up was designed and manufactured by BNG. This device is suitable for testing applications in liquid helium and conduction cooled environments at the IBPT measurement setups. Additionally, it aims for higher field applications as needed for implementation e.g., at the European XFEL.
In this contribution we describe the general layout of a ˜400 mm long mock-up coil package with 18 mm period length and present result of first cryogenic tests in liquid helium.

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Tuesday Poster Session / 1318

Design of an X-band parallel-coupled travelling-wave accelerating structure for future linacs

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As compared to conventional travelling-wave (TW) structures, parallel-coupled accelerating structures eliminate the requirement for the coupling between cells, providing greater flexibility in optimizing the shape of cells. Each cell is independently fed by a periodic feeding network for this structure. In this case, it has a significantly short filling time which allows for ultrashort pulse length, thereby increasing the achievable gradient. In this paper, a design of an X-band parallel-coupled TW structure is presented in detail.

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Thursday Poster Session / 1319

Linear optics correction at CSNS/RCS

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The China Spallation Neutron Source (CSNS) is a high-intensity pulse facility with a repetition rate of 25 Hz. The Rapid Cycling Synchrotron (RCS) is a crucial component responsible for accumulating and accelerating the proton beam from 80 MeV to 1.6 GeV. To address instability and reduce the space charge effect, the RCS lattice must be highly flexible to allow for precise tuning of the working point. In this paper, we have implemented and extended the LOCO algorithm to effectively restore the RCS lattice at each stage of the acceleration process. This work holds significant importance for the operation and scientific research at CSNS/RCS.of the acceleration process.

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Monday Poster Session / 1320

Study of orbit correction by machine learning in TPS storage ring

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Machine learning has been applied in many fields in recent decades. Many research articles also presented remarkable achievements in either operation or designing of the particle accelerator. This paper present orbit correction by neural networks, a subset of machine learning, in Taiwan Photon Source.

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THAD: Beam Instrumentation, Controls, Feedback and Operational Aspects (Contributed) / 1321

Beam storage monitor to achieve 3-D spiral injection in muon g-2/EDM experiment at J-PARC

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Anomalous magnetic moment (g-2) of a muon has been precisely measured by the BNL and FNAL experiments, and there is a discrepancy from the Standard Model prediction. A new measurement of muon g-2 is planned at J-PARC based on a different strategy. In the J-PARC experiment, a low emittance 300 MeV muon beam is injected into a compact storage orbit by newly developed 3-D spiral injection scheme*. Injected muons follow a vertical betatron oscillation around the storage orbit. A reduction of betatron oscillation amplitude is a key to achieve the physics goal of this experiment. This paper presents a new beam profile monitor which measures vertical distribution of stored muons to realize the 3-D spiral injection and to minimize vertical oscillation amplitude. There is a stringent requirement on the effective material budget in order to suppress multiple scattering of muon beam which passes through this monitor for hundred times on every cyclotron period. To achieve this, the monitor utilizes thin scintillating fibers of 0.2 mm diameter are placed with an interval of 10 mm. Reconstruction procedure of vertical beam motion from measured hit distribution will also be discussed.

Footnotes:

- H. Iinuma et al., "Three-dimensional spiral injection scheme for g-2/EDM experiment at J-PARC" , Nucl. Instrum. Methods Phys. Res. A, vol. 832, pp. 51–62, 2016.

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Tuesday Poster Session / 1323

Candidate lattice design for SAPS storage ring with emittance approaching the diffraction limit of hard X-rays

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The Southern Advanced Photon Source (SAPS) is a 3.5 GeV, kilometer-scale, ultra-low emittance storage ring to be built next to the CSNS (China Spallation Neutron Source) in Guangdong Dongguan, China. A lattice design of storage ring was proposed, consisting of 32 modified hybrid 7BAs, and having a natural emittance of 26.3 pm·rad and a circumference of ˜810 m. In this paper, we discuss the possibility of further reducing the emittance to approaching the diffraction limit of hard X-ray with 'typical'wavelength of 1 Å. We introduce the considerations on the choice of lattice structure and circumference, and concrete lattice designs.

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Wednesday Poster Session / 1324

Testing electron polarization at SuperKEKB using Touschek lifetimes

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The Chiral Belle project is a proposed project which aims to expand the capabilities of SuperKEKB and the physics goals of Belle II by injection polarized electrons into the High Energy Ring. Before the full implementation of spin rotator magnets near the interaction point, we propose to demonstrate the injection and transport of polarized electrons in the SuperKEKB Main Ring. By measuring the effect of differing polarization states on the Touschek lifetime, we aim to show the preservation of polarized spin vectors around the main ring without the need for the full apparatus of Compton polarimetry and spin rotator magnets which will be required for the full Chiral Belle project.

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Thursday Poster Session / 1325

Assembly process and inspection results for W100

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The 100 mm periodic permanent magnet Wiggler (W100) was installed in the 31st straight section of the TPS storage ring in September 2020, during a prolonged shutdown of the TPS. It provides photon energy ranging from 5 to 50 keV for user experimental applications. The mechanical structure of this facility involves assembling and connecting it to the upper and lower magnetic arrays, each approximately 500 mm in length. Precise control of the gap between the magnetic arrays and accurate adjustments are required. This report primarily describes the assembly process of various components of W100 and the inspection items along with the results.

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Thursday Poster Session / 1326

Status of the ALBA-II lattice studies

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Due to the constrains imposed by the tight geometry of the ALBA storage ring the initial 6BA lattice envisioned for the ALBA2 upgrade was reconsidered in favor of a more relaxed 5BA configuration. The first engineering studies of magnets and vacuum chambers made evident many short comings of the 6BA optics. The here proposed 5BA optics allows for an easier integration at cost of a small increase of the natural emittance. The employed linear and non-linear optics optimization process is here described along with the first studies about dynamic aperture and lifetime.

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Thursday Poster Session / 1327

Simulations of beam loading compensation scenarios with RF-Track

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The beam loading effect results in a gradient reduction of the accelerating structures due to the excitation of the fundamental mode when the beam travels through the cavity. A recent implementation of this process in the tracking code RF-Track allows the simulation of realistic scenarios, thus revealing the impact of this phenomenon in start-to-end accelerator designs. In this paper, we present the latest update of the beam loading module which allows the simulation of the compensation of this effect and we explore the potential of the developed tool in heavy-loaded scenarios.

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Wednesday Poster Session / 1328

Single-shot determination of the Munich Compact Light Source's two-dimensional X-ray source profile based on a backprojection approach

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The Munich Compact Light Source (MuCLS)*is a compact synchrotron source based on inverse Compton X-ray scattering. This effect produces brilliant quasi-monochromatic hard X-ray radiation with rather low electron energy (tens of MeV) by colliding these electrons head-on with a laser beam. Such sources are sufficiently compact to fit into a laboratory or industrial environment enabling a more widespread use of synchrotron techniques.
Many of these techniques are affected detrimentally by a larger (projected) source size, e.g. X-ray phase contrast imaging. The more precisely the exact shape of the source is determined, the better can its effects be corrected for in the recorded data.
We experimentally evaluate a novel approach to obtain an accurate 2D X-ray source profile***. A hole in a strongly absorbing structure is used to record the edge-spread function azimuthally resolved in a single shot. The 2D source spot is retrieved from this data by taking the derivative of the edge-spread function and applying the filtered-backprojection algorithm of computed tomography. We discuss results obtained for the source shape and relate them to general performance parameters of the MuCLS.

Footnotes:

- Eggl et al. Journal of Synchrotron Radiation 23, 1137 (2016) ** Guenther et al. Journal of Synchrotron Radiation 27, 1395 (2020) *** Di Domenico et al, Medical Physics 43, 294 (2016)

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Monday Poster Session / 1329

Neutron production using compact linear electron accelerators

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Many reactor-based neutron sources are planned to shut down in the near future, and this is despite the increasing demand for neutron beamlines for a wide range of scientific and industrial applications. Consequently, compact accelerator-based neutron sources arise as a competitive alternative that could meet the need for medium-flux fission or spallation sources. In this work, we explore the performance of compact electron accelerators as neutron drivers and propose a preliminary target design for an X-band electron-linac-based neutron source.

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Monday Poster Session / 1330

Harnessing machine learning for the optimal design of ILC e-driven positron source

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The International Linear Collider (ILC) is a next-generation electron-positron collider designed to operate at center-of-mass energies ranging from 250 GeV to 1 TeV, opening up a wide range of possibilities for exploring physics beyond the Standard Model. Being the first of its kind, the ILC requires sophisticated technology to produce large quantities of positrons. The ILC electron-driven positron source is currently being designed and optimized using software tools such as Geant4, GPT, and SAD. However, this approach has traditionally involved sequential optimization, requiring human intervention, resulting in inefficiency and making global optimization challenging. To address this issue, we are incorporating machine learning techniques into the simulation of the entire positron source accelerator system, aiming for efficient and comprehensive optimization. By integrating machine learning methods from the design stage of the accelerator, we expect to efficiently create an accelerator of high precision. Herein, we present the efforts we are undertaking to achieve this goal.

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Tuesday Poster Session / 1331

Multi-dimensional pulse shaping of the PITZ photocathode laser

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Fine control of the electron bunch properties in the photoinjector is a key aspect for optimization of free-electron lasers (FELs) such as the Free-Electron Laser in Hamburg (FLASH) and the European XFEL. With the installation of a new fiber-based photocathode laser frontend with in-line spectral shaping capabilities at the Photo Injector Test facility at DESY in Zeuthen (PITZ) new longitudinal electron bunch properties can be manipulated.
This new 4.5 MHz repetition rate photocathode laser system can be optionally coupled with a transverse spatial light modulator (SLM) to apply arbitrary transverse masking of the laser pulse effectively becoming a programmable, "virtual"beam shaping aperture (BSA). This permits many fascinating possibilities from simple homogenization of the laser spot on the cathode, elliptical truncated Gaussian distributions, and more. All with the aim of providing μJ UV laser pulses at the photocathode.
The on-table layout, experimental results, and preliminary electron beam results are presented alongside future planned optical diagnostic capabilities and feedback systems.

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Tuesday Poster Session / 1332

Full simulations of the Diamond-II storage ring commissioning and possible improvements of procedures

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To provide confidence in the future commissioning of the Diamond-II storage ring, realistic specifications for the error tolerances have been established. Based on these values, commissioning simulations have been conducted starting from on-axis injection through to stored beam and finally the alleviation of beta-beating caused by insertion devices. The goal of these studies is to develop a robust commissioning procedure that stays within the magnet strength limits using the statistics of many random machines simulated. In this paper we summarize these studies and present the results at each stage. Other topics such as testing on Diamond and comparisons of alternative commissioning methods are also discussed.

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Wednesday Poster Session / 1333

Mechanical design of the 12 T superconducting dipole - an accelerator-fit, NB3Sn double aperture magnet

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In the context of the High Field Magnet project, the 12 T program aims to design and manufacture a 2-meter, 12 T, cosθ, double aperture dipole. To reach magnetic fields higher than 10 T in accelerator magnets, brittle epoxy-impregnated Nb3Sn Rutherford cables are employed, which makes it difficult to predict the coil's mechanical limit and, in extenso, the magnet's performance. To tackle this challenge, expensive procedures are often implemented.
The 12 T mechanical design aims to prioritize intrinsically safe structures and minimize the number of components. This approach is intended to counteract issues stemming from fabrication tolerances and assembly tool misalignment. To prevent coil over-compression, mechanical stoppers are integrated within the magnet structure. The design is committed to eliminating the need to employ solutions that work well on a short demonstrator but are difficult to scale to long magnets that need to be produced in series.

This paper reports on the results of finite element calculations for the proposed design, with an emphasis on stress management and an investigation into the correlation between component tolerances and the stresses on the coil.

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Thursday Poster Session / 1334

Information display board system to enhance safety management at the National Synchrotron Radiation Research Center

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The National Synchrotron Radiation Research Center houses two accelerators, namely the Taiwan Light Source and the Taiwan Photon Source. It also includes approxi-mately 40 end stations.
The center has an information display board system that integrates information from the Instrumentation and Control Group, Experimental Facilities Division, Scien-tific Research Division, Radiation and Operation Safety Division, and User Administration and Promotion Office in the form of interactive display pages. It provides cru-cial information, such as source status, beamline details, and user sign-in data, as well as useful resources, such as end-station training courses and experimental safety approval forms.
The system offers diverse use cases tailored to the spe-cific needs of different users. This paper describes how we use the information display board system to improve safety management at the center.

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Thursday Poster Session / 1335

Tail population studies in the CERN PS

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The beam quality in terms of the transverse beam profiles from the CERN injectors plays a crucial role for the luminosity production at the LHC. Transverse tails beyond a Gaussian distribution have been observed in all the LHC injectors and efforts to optimize them are ongoing, as they can perturb operations due to large losses at LHC injection. At the CERN Proton Synchrotron (PS), measurements with various beam parameters and at different points along the cycle have been conducted to identify the source of the additional tails'population. Transition crossing was identified as the most critical point in the shaping of the profiles. Consequently, measurements of the optics perturbations during the gamma jump have been conducted. Simulations of the full transition crossing process including space charge effects have also been performed to fully characterize the effects.

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Monday Poster Session / 1336

Measurements and simulations of the e-cooling performance in ELENA

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Understanding and optimizing the electron cooling performance is essential to ensure high-brightness antiproton beams at the Extra Low Energy Antiproton (ELENA) ring at CERN. This paper presents measurements and simulations of the electron cooling performance in ELENA. The simulations are obtained using the Parkhomchuk model for electron cooling recently implemented in the Xsuite simulation framework. The studies focus on the impact of the electron-beam current, electron-beam size, magnetic field quality, and electron-/pbar-beam trajectory overlap on cooling performance. Notably, the results indicate the maximum magnetic field imperfection that would still provide adequate cooling in ELENA.

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Monday Poster Session / 1337

Simulation studies of laser cooling for the Gamma Factory proof-of-principle experiment at the CERN SPS

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The proof-of-principle (PoP) experiment at the Super Proton Synchrotron (SPS) at CERN aims at demonstrating laser cooling of high energy Li-like Pb79+ in a synchrotron. First laser cooling simulations with realistic laser and beam parameters of the Gamma Factory proof-of-principle experiment (PoP) in the Super Proton Synchrotron (SPS) at CERN are presented. Furthermore, we investigate the expected cooling performance for various laser-pulse types, such as Fourier-limited and continuous wave lasers, and compare their performance metrics such as emittance reduction and the required laser power.

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Tuesday Poster Session / 1338

Development of prototype magnets for the ultralow emittance storage ring ALBA II

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The ALBA synchrotron light source is in the process of a significant upgrade, aiming to become a fourth-generation facility by reducing its emittance by at least 20 times. The initial phase of this project involves a comprehensive prototyping program designed to validate various critical technologies, such as magnets, vacuum systems, girders, etc., essential for facilitating the impending upgrade. This paper focuses on the development of the prototype magnets to implement the MBA lattice designed by our Beam Dynamics group. The lattice presents unique challenges, notably a remarkable degree of compactness necessitating magnet-to-magnet distances of just a few centimeters. Additionally, stringent strength requirements are imposed on both the quadrupolar (up to 110 T/m) and the sextupolar (up to 5000 T/m²) magnets. In this paper we will describe the design details of the initial set of resistive-type prototypes, as well as the preliminary efforts to develop alternative designs making use of permanent magnets. This dual-track approach reflects our dedication to both conventional methods and innovative solutions for the upgraded storage ring.

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Wednesday Poster Session / 1339

Overview of the superconducting accelerator magnet system developments at the Karlsruhe Institute of Technology

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A key strategic approach to making accelerator-driven light sources more energy-efficient and sustainable is to employ superconductivity. At Karlsruhe Institute of Technology (KIT) there is a successful experience in developing and enhancing superconducting magnet systems for accelerators. That includes the design and fabrication of low and high-temperature superconducting technologies, high-field undulators with long/short periodic lengths as well as novel miniature high-strength magnets. This contribution gives an overview of the previous achievements and ongoing projects at KIT related to superconducting undulators and magnets.

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Thursday Poster Session / **1340**

Cost-effective asset management for accelerator control systems: design and implementation for the ALS-U controls system

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This paper presents a cost-effective asset management system (AMS) designed to optimize the workflow of the accelerator control system for the Advanced Light Source Upgrade (ALS-U) project at LBNL. The AMS stores all essential information about equipment, including location, owner, hardware details, and firmware versions. Its user-friendly interface provides consistent access throughout the equipment lifecycle, from quality assurance to installation, through label printing, QR codes, and the Web application. By streamlining workflows and improving data consistency, the AMS contributes significantly to the efficiency and success of the ALS-U project.

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Tuesday Poster Session / **1341**

Design of a 500 MHz normal-conducting cavity for Super Tau-Charm main rings

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A 500 MHz normal-conducting (NC) cavity is being developed to suppress multi-bunch instabilities induced by both fundamental and higher order modes (HOMs) for Super Tau-Charm Main Rings which has a current of 2 A. This NC cavity consists of a storage cavity, a coupling cavity and an accelerating cavity. The storage cavity is used to reduce the required detuning frequency so that the coupled bunch instabilities (CBIs) driven by the accelerating mode are greatly suppressed. These three coupled cavities are operated in the π/2 mode so that HOMs can be strongly damped. This paper presents RF design of this NC cavity in detail.

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Wednesday Poster Session / 1342

Measurements of the transverse beam emittance at the AREAL linac

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One of the main tasks for advanced experiments in modern accelerators is the generation of low-energy and high-brightness beams. The Advanced Research Electron Accelerator Laboratory (AREAL) is a linear electron accelerator based on a photocathode RF gun. The basic aim of this facility is to generate electron bunches of sub-picosecond duration with an extremely small beam emittance for ultrafast processes in advanced experimental studies in the fields of accelerator technology and dynamics, material and life sciences. In this paper, the current status and plans for further upgrades of the diagnostic system, along with the techniques used for transverse beam emittance measurements, are presented.

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Wednesday Poster Session / 1343

Superconducting thin films on higher order mode antennas for increase the CW performance of SRF cavities at MESA

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The Mainz Energy-Recovering Superconducting Accelerator (MESA), an energy-recovering (ER) LINAC, is currently under construction at the Institute for Nuclear physics at the Johannes Gutenberg-Universität Mainz, Germany. In the ER mode continues wave (CW) beam is accelerated from 5 MeV up to 105 MeV. The energy gain of the beam is provided through 2 enhanced ELBE-type cryomodules containing two 1.3 GHz 9-cell TESLA cavities each. By pushing the limits of the beam current up to 10 mA, a quench can occur at the HOM Antennas. The quench is caused through the increased power deposition induced by the electron beam in ER mode. Calculation shown that an upgrade from 1 mA to 10 mA is increasing the deposited power in the HOMs up to 3080 mW. 30% of this power will be out coupled with the HOM couplers and can be used as a thermal input. Simulations show a power limit of 95 mW which includes the power for 1 mA but is exceeded at 10 mA. A solution to increase the power limit are superconducting thin films which provides higher critical fields, temperature and currents. As candidates are Nb3Sn and NbTiN are chosen. First simulations of the power limit for coated HOM antennas are shown.

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Monday Poster Session / 1345

Microbunching threshold manipulation by a corrugated structure impedance at KARA

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Two parallel corrugated plates will be installed at the KIT storage ring KARA (KArlsruhe Research Accelerator). This impedance manipulation structure will be used to study and eventually control the electron beam dynamics and the emitted coherent synchrotron radiation (CSR). In this contribution, we present the impedance that is most effective to manipulate the threshold of the microbunching instability for different machine settings. Furthermore, it will be shown, how the resonance frequency of this impedance is related to the spectrum of the substructures in the electron bunches.

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Tuesday Poster Session / 1346

A machine-learing application for orbit stabilization in Taiwan Photon Source

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Machine learning has been arisen to resolve a variety and diversity of scientific and engineering problems. In the last decade, it has been also applied to the particle accelerators. In this report, we investigate the application of machine learning for orbit stabilization in TPS.

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Monday Poster Session / 1347

Dust-induced beam losses in the Large Hadron Collider

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Since the start of the Large Hadron Collider (LHC), dust-induced beam loss events resulted in more than hundred premature beam aborts and more than ten dipole quenches during proton physics operation. The events are presumably caused by micrometer-sized dust grains, which are attracted by the proton beams and consequently give rise to beam losses due to inelastic proton-nucleus collisions. Besides the events which trigger dumps or quenches, a large number of smaller dust events has been detected by the beam loss monitors every year. Although these events are not detrimental for physics operation, they are still carefully scrutinized as they give a better understanding about the correlation with beam parameters, about the long-term evolution of event rates, and about possible correlations with shutdown activities and the installation of new equipment. In this contribution, we present a summary of observations from the first three runs of the LHC.

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Tuesday Poster Session / 1348

LHC abort gap monitor electronics upgrade

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The LHC Abort Gap Monitor (AGM) is part of the LHC machine protection system (MPS) and is designed to measure the particle population in a 3us wide region known as the "abort gap." This region needs to be kept empty to ensure safe beam dumps. The AGM captures the synchrotron light generated in the visible part of the spectra and converts it into an electric signal. This signal is then processed by an acquisition system and can trigger the 'abort gap cleaning'process.
The current AGM, which has been in operation since 2010, uses an analogue integrator ASIC and a 40 MHz analogue-to-digital (ADC) converter to provide the particle population information. However, this solution is now considered obsolete and is being replaced by a digital signal processing approach. Working directly in the digital domain not only offers more scalability but also better determinism and reliability.
This work presents the new technical solution for the acquisition chain, compares the characteristics of both implementations, and showcases recent measurements conducted on the LHC ion and proton beams.

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Wednesday Poster Session / 1349

CERN accelerates sustainability

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CERN is pursuing several initiatives to reduce its impact on the environment through an integrated approach to address all the objectives set by the relevant United Nations (UN) Sustainable Development Goals (SDG). In particular CERN is committed to respect the net-zero paradigm for future machines and has established a Sustainable Accelerators Panel to harmonize the approach to sustainability of the various studies for future accelerators. In this paper we will describe the efforts taken in managing responsibly our technical installations and the process we are setting up to perform the lifecycle assessment of the different future projects to better understand the main drivers of CO2 emissions in order to minimize them by design.

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Monday Poster Session / 1351

Simulations and experiments for dynamic aperture studies in the LHC ion operation

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Dynamic Aperture (DA) studies, based on single-particle tracking simulations including important non-linear fields such as beam-beam effects, have played a crucial role in guiding the operation

of the Large Hadron Collider (LHC) in proton-proton collisions. The correspondence between DA computed through simulations and the actual beam lifetime during operation has been established for proton beams through dedicated experiments at the LHC. However, such an approach has not yet been applied to the Pb ion operation of the accelerator, as the simulation tools have not been rigorously benchmarked against experimental data yet. The present paper presents the simulation studies and experimental tests performed to establish the correlation between DA and beam lifetime for ions. The main focus lies on exploring the beam-beam limit when the crossing angle is significantly reduced in all LHC experiments as compared to the nominal configuration. This approach opens the possibility to operate with reduced crossing angles or reduced β^* within the beam-beam limit, potentially leading to an enhanced performance of the accelerator with ions.

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Monday Poster Session / 1352

Design and optimization of structured metal plasma targets using a CFD code for laser wakefield acceleration

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Laser Wakefield Acceleration (LWFA) can generate a high-energetic electron beam in a short accelerating distance of several cm, which is advantageous for the development of an compact accelerator. The LWFA using metal targets is highly influenced by the field ionization process of metal atoms (or ions) due to the high intensity of main laser. Titanium produces a large amount of ionized electrons near the optical axis due to localized peak intensity followed by breaking the wake cavity. However, this nature of ionization process of titanium can apply to the intense ionization injection into the wake cavity formed by the aluminum plasma. Our group suggested a structured metal plasma target using aluminum with a thin titanium layer and investigated the performance of the controlled injection depending on the location and thickness of titanium layer in the aluminum plasma [1].
In this paper, a structured plasma target is designed and optimized using a CFD code to realize the desired profile of metal plasma ablated by a laser. The performance of laser electron acceleration obtained by PIC simulation was presented for different profile of metal plasma targets designed using a CFD code.

Footnotes:

[1] H. W. Lee et. al., "Control of Electron Injection in LWFA with a Laser-ablated Aluminum Plasma by inserting a thin-layer of different metal", presented in IPAC 2023.

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Tuesday Poster Session / 1355

Improvements of the SPS slow extraction electrostatic septum

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The impact of high-flux protons on the inherent beam loss in the slow extraction from SPS towards the North Area has been recently discussed and potential improvements have been proposed. These solutions are mainly aiming to reduce the high component activation and related reduction of lifetime, as well as observed non straightness in the anode body. Recent studies have allowed to demonstrate feasibility of replacing the currently installed stainless steel tank, flanges, and anode body by lowZ materials. The design iteration and material choice has led to the fabrication of a reduced length prototype, demonstrating mechanical, electrical, as well as the vacuum related performance. The mass reduction of the anode body has been optimized using numerical simulation, considering mechanical and thermal constraints. The paper presents the development of the vacuum vessel, including numerical analysis. The results from the design and prototype tank fabrication will be compared to the existing system. Furthermore, the optimization of the anode body and potential fabrication based on additive manufacturing including 3d optical straightness metrology will be discussed.

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Wednesday Poster Session / 1356

Radiation shielding studies for superconducting magnets in multi-TeV muon colliders

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Circular muon colliders provide the potential to explore center-of-mass energies at the multi-TeV scale within a relatively compact footprint. Because of the short muon lifetime, only a small fraction of stored beam particles will contribute to the physics output, while most of the muons will decay in the collider ring. The resulting power carried by decay electrons and positrons can amount to hundreds of Watt per meter. Dedicated shielding configurations are needed for protecting the superconducting magnets against the decay-induced heat and radiation damage. In this paper, we present generic shielding studies for two different collider options (3 TeV and 10 TeV), which are presently being explored by the International Muon Collider Collaboration. We show that the key parameter for the shielding design is the heat deposition in the magnet cold mass, which will be an important cost factor for facility operation due to the associated power consumption.

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Thursday Poster Session / 1357

ALS-U accelerator motion design and realization

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Transitioning from the aging ALS Geo MACRO motor controller, this paper details the meticulous selection process for a new, cost-effective standard to fulfill the diverse motion requirements of the upcoming ALS-U project. Targeting primarily simple stepper motors with varying current demands, the chosen solution seamlessly integrates into the existing ALS-U EPICS environment while preserving the established ALS motion architecture and EPICS IOC support. Notably, the solution maintains independence from Delta-Tau technology while comprehensively accommodating the project's required range of servo/stepper motor types and offering dedicated support for critical subsystems like Beam Scraper and Cold Finger motion. This document delves into the exhaustive selection process, from comprehensively summarizing the current architecture and ALS-U requirements to meticulously analyzing the results of a year-long evaluation of diverse vendor offerings.

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Tuesday Poster Session / 1361

Networking activities of the I.FAST project in the high brightness accelerator for light sources

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The Innovation Fostering in Accelerator Science and Technology (I.FAST) project aims to enhance innovation in the particle accelerator community, mapping out and facilitating the development of breakthrough technologies common to multiple accelerator platforms. Task 7.2 of the I.FAST project, Enabling Technologies for Ultra Low Emittance Rings, focuses on networking in the area of low emittance rings dominated by the recent X-ray storage ring upgrades and exploiting synergies with existing and future e+/e- colliders. Strengthening networking activities in essential technologies ranging from magnet design, RF systems, vacuum, injection systems to feedback systems and beam instrumentation leads to a state where technological difficulties are shared, so that the R&D path is strongly linked to other facilities and scientific fields. Such a state also stimulates joint organizations to collaborate on projects with organic links worldwide. To facilitate networking, Task 7.2 has so far organized several thematic workshops, and is planning further workshops to prepare opportunities to strengthen networking. In this contribution we present our activities in the past and for the future.

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Wednesday Poster Session / 1362

Pulsed-optical timing distribution using hollow core optical fibers

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New generation X-ray free electron lasers require reliable and precise synchronization of pulsed laser sources across various locations. This demands stable timing distribution to preserve ultra-low timing jitter, ultrashort pulse duration, and high peak power. *Fiber optic delivery, compared to free-space optics, offers advantages in flexibility, laser safety, ease of deployment and superior output beam quality. However, standard fibers with silica glass core face challenges like high dispersion, nonlinear pulse shaping and environmental sensitivity, causing excess timing jitter. Emerging anti-resonant hollow core fibers that guide light though a central hole have significantly lower environmental sensitivity, high nonlinearity threshold and low dispersion, while achieving attenuation similar to glass-core fibers*. This makes them an improved medium for low-noise transmission of fs pulses with high peak powers. Here, we experimentally demonstrate passively stable timing distribution of fs pulses using sealed hollow core fibers without vacuum components. We achieve a timing precision of 10 fs RMS over several hours with a fiber length of 300 m without requiring any stabilization.

Footnotes:

- M. Xin, K. Şafak, and F. X. Kärtner, Optica, vol. 5, no. 12, pp. 1564-1578, 2018. ** G. T. Jasion et al., 2022 Optical Fiber Communications Conference and Exhibition (OFC), San Diego, CA, USA, pp. 1-3, 2022.

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Thursday Poster Session / 1363

Development of a non-linear injection kicker for the TPS storage ring

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The TPS storage ring adopts a standard four kickers bump off-axis injection. This scheme is known to disturb stored beam during injections. The non-linear kicker injection concept provides a possible solution to facilitate top off injection with minimizing the oscillation of the stored beam. This non-linear kicker has zero Bx and By field in the center and an off-axis By displaced by 15 mm for TPS case. In this paper, we present the magnetic circuit design, consideration, fabrication, and first field measurement results of the TPS non-linear injection kicker.

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Thursday Poster Session / 1365

Simulation of longitudinal phase space measurements for the RUEDI ultrafast electron diffraction beamline

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The RUEDI (Relativistic Ultrafast Electron Diffraction & Imaging) ultrafast electron diffraction (UED) beamline aims to provide electron bunches to diffraction samples with an at-sample temporal resolution of sub-10 fs. Electron bunches of such short duration prove non-trivial to measure at electron beam kinetic energies of 4 MeV. A diagnostic beamline design is presented to enable simultaneous longitudinal phase space measurements (bunch duration, momentum and momentum spread) with a streaker and spectrometer. Several methods of measuring sub-10 fs bunch durations using both RF transverse deflecting cavities and THz streakers are outlined here with their limitations. Measurements are replicated in simulation to demonstrate the diagnostic beamline is capable of the high-resolution required for the longitudinal phase space measurements within the RUEDI UED beamline.

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Thursday Poster Session / 1366

Investigating transverse noise excitation for improving slow extracted spill quality at the CERN PS

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One of the most fundamental aspects of the slow extraction process is the uniformity of the spill. In this contribution, the application of transverse radio-frequency (RF) noise excitation is investigated to mitigate the low-frequency ripple (~100 Hz), which is caused by imperfections in the power converters supplying current to the CERN Proton Synchrotron's (PS) main magnets. A transverse RF exciter and a realistic power converter ripple are incorporated into an Xsuite simulation model of the CERN PS to simulate the slow extraction process and benchmarked with beam measurements.

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Tuesday Poster Session / 1367

Tracking error analysis on the power supply currents of J-PARC main ring main magnets

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The bending, quadrupole, and sextupole power supplies in the J-PARC Main Ring (MR) have been upgraded ramping up the average beam power for fast extraction (FX) operation for the neutrino oscillation experiment and slow extraction (SX) operation for the experiments in the hadron facility. The repetition cycles have been shortened from 2.48 sec. to 1.36 sec. for the FX operation and will be soon shortened from 5.2 to 4.24 sec. for the SX operation. The current ripples in the power supply generate the electric current errors of the main magnets. A tracking error can also generate the electric current deviation for the main magnets. A rather large tracking error has been observed after the power supply upgrade. An equivalent circuit analysis for the output load has been conducted to

examine the cause. The impact on the beam optics for the longitudinal and transverse beam motions will be discussed. A manipulation of the power supply to improve the tracking errors is tried in the equivalent circuit analysis.

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Tuesday Poster Session / 1368

The reinforcement learning for autonomous accelerators collaboration

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Reinforcement Learning (RL) is a unique learning paradigm that is particularly well-suited to tackle complex control tasks, can deal with delayed consequences, and can learn from experience without an explicit model of the dynamics of the problem. These properties make RL methods extremely promising for applications in particle accelerators, where the dynamically evolving conditions of both the particle beam and the accelerator systems must be constantly considered. While the time to work on RL is now particularly favorable thanks to the availability of high-level programming libraries and resources, its implementation in particle accelerators is not trivial and requires further consideration. In this context, the Reinforcement Learning for Autonomous Accelerators (RL4AA) international collaboration was established to consolidate existing knowledge, share experiences and ideas, and collaborate on accelerator-specific solutions that leverage recent advances in RL. Here we report on two collaboration workshops, RL4AA'23 and RL4AA'24, which took place in February 2023 at the Karlsruhe Institute of Technology and in February 2024 at the Paris-Lodron Universität Salzburg.

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Wednesday Poster Session / 1369

Buffered chemical polishing process of 3.9 GHz cavities for SHINE

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The linear acceleration part of the SHINE project consists of two 3rd harmonic cryogenic modules which are operating at 3.9 GHz. Each of the cryomodules consists of eight 3.9 GHz 9-cell superconducting cavities. The SHINE specifications of the 3.9 GHz cavities are Qo >2.0e+9@13.1 MV/m and maximum accelerating gradient >15 MV/m. The 3.9 GHz cavities were treated with buffered chemical polishing (BCP) baseline combined with 2-step low-temperature baking surface treatment process to meet the specifications. In order to achieve the required performance, the BCP process had been optimized at the SHINE Wuxi surface treatment platform, especially the acid ratio. Vertical tests of all 3.9 GHz bare cavities treated with the optimized BCP process showed Qo up to 3.0e+9@13.1 MV/m and maximum accelerating gradient over 20 MV/m. The optimized BCP process applied to the 3.9 GHz cavities and related vertical test results were presented in this paper.

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Monday Poster Session / 1370

High gradient operation of cryogenic C-band RF photogun at UCLA

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Future electron accelerator applications such as x-ray free electron lasers and ultrafast electron diffraction are dependent on significantly increasing beam brightness. We have designed and produced a new CrYogenic Brightness-Optimized Radiofrequency Gun (CYBORG) for use in a new beamline at UCLA to study the brightness improvements achievable in this novel low temperature high gradient accelerating environment. We are currently in the process of commissioning the photogun for operation with peak cathode fields in excess of 120 MV/m. We report here on the status of conditioning the photogun and report on dark current measurements and maximum field achieved thus far.

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Wednesday Poster Session / 1371

Field emission experience, statistics and challenges with ESS elliptical cryomodule

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ESS elliptical cryomodules, CEA-INFN-STFC in-kind contribution, undergo site acceptance test at ESS Lund Test Stand (TS2). Here the Field Emission operation experience, modules performances statistics and limiting mechanism, diagnostics equipment and analysis tool are described. High energy field emission and dose rate operational challenges and long-term superconducting LINAC operational strategy are described.

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Tuesday Poster Session / 1372

More general formula of minimum emittance

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In the storage rings, the electron beams go to the equilibrium state. One of the equilibrium parameters is the natural emittance which is determined by the radiation damping and quantum excitation effects. In other words, the equilibrium emittance is determined by the magnet lattice regardless of the initial beam. Theoretically the minimum emittance and its optimal conditions for uniform bending magnet have been well demonstrated. However, the minimum condition doesn't include the damping partition number. In this paper, we tried to calculate the minimum emittance including the damping partition number. The results shows that the minimum emittance condition and the minimum emittance value is slightly changed by including the damping partition number.

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Wednesday Poster Session / 1374

Resonant spin depolarization at the test facility KARA: overview of recent efforts

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The Karlsruhe research accelerator KARA offers a setup to measure the beam energy with resonant spin depolarization. The depolarization is excited by the stripline kickers of the bunch-by-bunch feedback system and the resonant frequency is measured via change in Touschek lifetime. Energy measurements with resonant spin depolarization are implemented as a standard routine in the control system and are used regularly to measure both the beam energy and the momentum compaction factor for different energies and optics regimes.
Long-time experience with the setup, short polarization time, and variation options of beam energy in combination with much available beam time qualify KARA as a test facility for systematic studies. Such studies are of particular interest for future colliders designed for precision studies like FCC-ee, as resonant spin depolarization is known for its high accuracy. This contribution presents the resonant spin depolarization setup at KARA and selected results of recent measurement campaigns.

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Tuesday Poster Session / 1376

Design of a single mode 3rd harmonic cavity for PETRA IV

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The upgrade of PETRA III to PETRA IV at DESY is currently in its design phase. To achieve the desired beam parameters a 3rd harmonic cavity is necessary for the accelerating system. An investigation of three types of cavity structures thus is conducted to find the most cost effective and environmentally sustainable option.
A high focus in this investigation is placed on the damping of higher order modes. Therefore, two of the investigated structures are so called single mode structures. Such structures have its cavity directly coupled to an RF-absorber, allowing for damping of all resonant modes but the desired ground mode. The design considered in this paper is from a conceptual test of Helmut Herminghaus (MAMI, Mainz, DE). Taking the requirements of PETRA IV into account, the design is adapted, numerically simulated and optimized.

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Monday Poster Session / 1377

LHC optics commissioning in 2023 and 2024

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The LHC machine configuration was changed in 2023 compared to previous years, requiring a new set of optics configurations to be measured and corrected. A telescopic optics was deployed in energy the ramp for the first time, which gave rise to a beta-beating of up to 25%. This was corrected using a global correction approach which reduced the beta-beat down to 10%. A change in the phase advance at injection was also applied to mitigate the negative effect of the main octupoles used to stabilize the beam. These measurements and corrections, coupled with the results from the 2024 commissioning, will be presented in this paper

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Wednesday Poster Session / 1378

Simulation optimization of electrom beams from the ELBE superconducting RF gun for ultrafast electron diffraction

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Moving towards beam energies around 2-6 MeV in ultrafast electron diffraction (UED) experiments allows achievement of larger coherence length for better k-space resolution, while the temporal resolution is improved when shorter electron bunches are generated and the velocity mismatch between the optical pump and UED probe is reduced.
At Helmholtz-Zentrum Dresden-Rossendorf (HZDR), a series of superconducting cw RF (SRF) guns has been designed, build, and tested, with the latest version currently in routine operation as one of the electron sources for the ELBE Center for High Power Radiation. This SRF photoinjector produces bunches with a few-MeV energies at up to MHz repetition rates, making it a suitable electron source also for MeV-UED experiments. The high repetition rate provides a significant advantage for the characterization of samples with low scattering cross-sections such as liquids and gases.
In this paper, we outline the conceptual MeV-UED instrument program under development at HZDR. We also showcase the beam quality achieved in first simulations of the ELBE SRF gun operating at low bunch charge as an electron source for diffraction experiments.

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Wednesday Poster Session / 1379

Lattice correction and polarization estimation for Future Circular Collider e+e-

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Precise determination of the center-of-mass energy in the Future Circular Collider e+e- (FCC-ee) at Z and W energies can be achieved by employing resonant spin depolarization techniques, for which a sufficient level of transverse beam polarization is demanded under the presence of machine imperfections. In this study, the FCC-ee lattice has been modeled and simulated with a variety of lattice imperfections, including misalignments, angular deviations, BPM errors, long range errors, etc., along with orbit correction, tune matching, and dispersion correction procedures. The equilibrium polarization is calculated within the context of realistic machine models. A more profound examination has been conducted on the association between imperfections and polarization, aiming to understand the underlying reason for polarization loss and potentially improve polarization by lattice manipulation.

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Monday Poster Session / 1380

High level software for operating an EEHG FEL

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Reliable operation of a seeded Free Electron Laser requires the simultaneous control of several electron-beam, laser and accelerator parameters. With EEHG the complexity increases due to the second seed laser and the strong dependence of EEHG bunching to seeding parameters. With the recent upgrade of the FEL-1 line, FERMI is the first FEL facility to be operated in EEHG mode for users. This required a major work for developing software tools that could be used to easily set the FEL at the desired wavelength. We report here on the recent software developments at FERMI for the operations of the new FEL-1.
An important prerequisite for EEHG is to determine both the electron beam energy spread and seed laser induced energy modulation. This is done by using HGHG time dependent bunching equations to match experimental parameters scans. With these data, optimal EEHG settings of the machine parameters are then calculated to reach the desired FEL wavelength. The requested parameters are then sent to interface tools that accurately control laser, undulator, chicane and electron beam.

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Monday Poster Session / 1384

Sensitivity jitter studies of the EuPRAXIA@SPARC_LAB RF injector

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The objective of the EuPRAXIA@SPARC_LAB European user facility is to operate a stable, reliable, and reproducible machine. This study delves into a comprehensive analysis of injector jitter to assess the machine's stability concerning RF and laser jitters. The stability and reproducibility of the beam are significantly influenced by RF generation. As such, a portion of the work concentrates on studying sensitivity jitter across all RF injector components. The investigation begins with the assessment of cathode beam parameters' jitters, such as variations in charge, spot size, and bunch separation. The impact of these variations on beam stability is scrutinized. To enhance beam stability, an X-band High Harmonic Cavity (HHC) is employed to pre-correct the longitudinal phase space of the bunch. This correction serves to shorten and flatten the charge distribution, allowing for manipulation of the beams to achieve proper longitudinal and transverse parameters at the photoinjector exit.

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Wednesday Poster Session / 1386

Enhanced position resolution of L-band cavity BPM via matching its resonance frequencies

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Three L-Band cavity BPMs were tested at the Accelerator Test Facility (ATF) for raising beam position resolution. In the previous study, we found each BPM has a different resonant frequency due to manufacturing tolerance. From the earlier experiment, the position resolution was around 324 nm, while data incoherence problems occurred. Recently, we developed a Local oscillator (LO) to compensate for different BPM resonance frequencies during the L-Band BPM test at ATF2. The LO generates three channels corresponding to each BPM to yield intermediate frequencies, 80 MHz in the L-Band down-convertor. We achieved around 200 nm position resolution by using the developed LO. In this paper, we will explain the differences between the former beam test and the present beam test, its configuration, and the experiment method.

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European Laboratories for Advanced Sciences –an EC funded transnational access project for nuclear, high-energy physics and accelerator experiments and R&D support

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European Laboratories for Accelerator Based Sciences (EURO-LABS), a program for research infrastructures services advancing the frontiers of knowledge, aims to provide unified transnational access (TNA) to leading Research Infrastructures (RI) across Europe. Taking over from previously running independent TNA programs, the new program brings the nuclear physics, the high-energy accelerator, and the high-energy detector R&D communities together to foster collaborations and to stimulate synergies. With 33 partners from European countries, EURO-LABS forms a large network of RIs. These RIs offer TNAs ranging from a modest size test infrastructure to large scale ESFRI facilities. The offered access will enable research at the technological frontiers in accelerator and detector development to explore new physics ideas and will open wider avenues in both basic and applied research in diverse topics ranging from optimal running of reactors to mimicking reactions in the stars. Within this large network, EURO-LABS will ensure diversity, and actively support researchers from different nationalities, gender, age, grade, and variety of professional expertise.

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Monday Poster Session / 1388

FERMI plans for a 2 nm seeded FEL

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Most FELs employ the mechanism of self-amplified spontaneous emission (SASE) from a relativistic electron beam to generate intense femtosecond pulses in the x-ray spectral region. Such SASE FELs are characterized by a broad bandwidth and relatively poor longitudinal coherence, and offer a rather limited control over the spectro-temporal properties. The limitations of a SASE FEL can be overcome by using an external laser to trigger the amplification process. Echo-enabled harmonic generation (EEHG), alone or in combination with the high-gain harmonic generation scheme (HGHG) is currently the most promising candidate to extend the operation of externally-seeded FELs into the soft

x-ray region. Here, we discuss the plan at FERMI for the upgrade of the second FEL line in order to reach ~2 nm at the fundamental emission wavelength. In the first step, coherent radiation at ~10 nm will be generated with an EEHG layout and used as a seed in an HGHG stage on a fresh part of the electron beam. The experience with EEHG at the FEL-1 line will be an important step towards the final realization of the FERMI FEL as a reliable source of highly coherent radiation at ~2 nm and below.

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Wednesday Poster Session / 1389

Sub-femtosecond resolution electro-optical arrival-time measurement of relativistic electron bunches in a free-electron laser

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SwissFEL is a normal conducting linear accelerator driving two separate free-electron laser (FEL) lines –one for soft and one for hard x-rays. We report jitter and correlation measurements of two electro-optical Bunch Arrival-Time Monitors (BAMs), which use directly the pulses from a mode-locked laser oscillator. The arrival-time is encoded in the amplitude of one single reference laser pulse in a fiber coupled Mach-Zehnder modulator driven by a fast RF-transient from a button pick-up. Using the modulation slope and the laser amplitude jitter, we demonstrate <1 femtosecond resolution at 200 pC bunch charges for the BAM with a 16 mm pick-up beam pipe diameter and <10 fs at 10 pC for the BAM with 8 mm pick-up beam pipe diameter. We also report a jitter correlation measurement of two independent BAMs over 1 min at 100 Hz machine repetition rate as well as a similar correlation measurement of one single BAM station with 8 mm pick-up beam pipe diameter and having two identical high resolution channels. The measured correlations are as low as 1.3 fs rms resulting in sub-femtosecond resolution of the optical detection scheme.

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Wednesday Poster Session / 1390

Possible harmonic spin matching schemes using orbit bumps for the Future Circular Collider e+e-

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There is a notable prospect of attaining high precision measurement of the center-of-mass energy in the Future Circular Collider e+e- (FCC-ee) at Z and W energies using resonant spin depolarization, the realization of which is based on a sufficient transverse beam polarization level. The application of harmonic spin matching schemes using closed orbit bumps holds promise for improving the equilibrium polarization under the presence of large machine errors. In this study, the potential optimization schemes that can be applied in the FCC-ee have been explored and compared. A comprehensive scheme has been proposed to fulfill the FCC specifications, the effectiveness of which has been testified in Z, W and even ttbar lattices.

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Tuesday Poster Session / 1391

Development of a spill-structure manipulation cavity and first experiment with beam in SIS18

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For several years, significant effort has been spent at GSI to improve the time structure of the spill during slow extraction in SIS18. This led to the requirement to extend the possibilities to experimentally improve the micro-spill structure by partially or fully capturing the beam with an RF of more than 40 MHz. Therefore, a so-called spill-structure manipulation cavity was designed, realized and optimized which allows the mentioned experiments. In this contribution, the design of the cavity and the challenges of its realization are described, and measurement results concerning the first experimental operation in the SIS18 synchrotron are presented.

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Thursday Poster Session / 1392

Bead-pull measurement procedure for AREAL linear accelerator accelerating structure

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In this paper, the widely used RF measurement bead-pull technique for the S-band accelerating structure pre-tuning of the AREAL linear accelerator is presented. Bead-pull measurements were conducted before brazing with various group sets of accelerating cells to evaluate the effectiveness of "smart combinations"for AREAL accelerating structures. The "smart combination"technique represents the grouping of cells with corresponding lengths to achieve the same length sets (triplets for $2\pi/3$ mode) as it is possible. Cell lengths were measured in advance based on TM resonance frequencies measurement. This procedure will significantly reduce the tuning routine required after brazing.

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Monday Poster Session / 1393

Evolution of special LHC optics configurations: Run 3 update

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The Large Hadron Collider (LHC) employs special optics and configurations, alongside low-beta*collision optics, to address specific experimental requirements. These include calibrating luminosity monitors (vdM) and facilitating forward physics measurements in TOTEM and ALFA experiments (high-beta). The special optics have been in use since Run 1, and for Run 3, they have been updated for compatibility with standard low-beta collision optics to ensure streamlined commissioning and reduced setup time. For vdM optics in Run 3, beam de-squeezing yields beta* values of 19 to 24 m, while in the high-beta optics, beams are de-squeezed to round beams with beta*of 120 m, followed by a second step to asymmetric optics with beta* of 3 km and 6 km in the horizontal and vertical planes. The 2023 high-beta optics run with the km beta* optics, incorporates tight collimation settings and the use of crystals at top energy for the first time, aiming to substantially reduce backgrounds in the experiments. This publication introduces and discusses the updated optics for Run 3, covering their validation, optics measurement results, and operational insights.

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Monday Poster Session / 1394

A full C-band high brightness RF injector for future EuPRAXIA@SPARC_LAB upgrade

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C-band technology holds the potential to generate a high-energy, high-brightness electron beam by elevating the peak field of both the cathode and cavity within the machine. This proposed injector offers a promising avenue for achieving a high repetition rate, facilitating kHz operation. The conceptualization of this injector draws inspiration from the EuPRAXIA@SPARC_LAB S-band injector,

wherein the original gun is replaced with a 2.6-cell C-band RF gun. The entire beamline is proportionally scaled, reducing longitudinal lengths by a factor of 2 while doubling electric and magnetic fields. Operating with brief RF pulses, the 2.6-cell C-band RF gun effectively mitigates breakdown rates and power dissipation. By capitalizing on higher peak fields and applying established scaling laws to reduce laser spot size and duration, it becomes feasible to minimize both cathode and space charge emittance. The incorporation of a complete C-band injector is anticipated within the framework of the X-band Linacs for the EuPRAXIA@SPARC_LAB design study, aiming to produce ultra-high-quality beams primed for applications such as light production or plasma acceleration.

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Wednesday Poster Session / 1395

Emittance and luminosity monitoring and modelling for LHC Run 3

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A comprehensive model accurately depicts and tracks emittance and luminosity evolution in the Large Hadron Collider (LHC), considering known effects like IBS, synchrotron radiation damping, coupling and incorporating data-driven factors on emittance growth and intensity losses. Used extensively in LHC Run 2, the model is updated for compatibility with new optics and operational schemes in Run 3, featuring luminosity leveling. This paper discusses the analysis of 2022 and 2023 LHC data, exploring emittance evolution and identifying extra blow-up at injection and collision energies compared to model predictions. Examining the model's agreement with collision data provides insights into the impact of degradation mechanisms, configuration options, filling schemes, and beam types on delivered luminosity. These studies offer valuable insights into potential gains in integrated luminosity for subsequent Run 3 years.

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Tuesday Poster Session / 1396

DONES-ConP1 project: consolidating the start of the IFMIF-DONES construction phase

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IFMIF-DONES is an ESFRI facility based on a 5 MW deuteron accelerator currently under construction in Granada (Spain) as part of the European roadmap to fusion electricity. Its main goal is to characterize and qualify materials under a neutron field with an induced damage like the one faced in a fusion reactor, developing a material database for the future fusion nuclear reactors. Moreover, a list of medium neutron flux experiments in other irradiation areas for fusion and non-fusion applications have been identified previously and are under analysis.
The construction phase was officially launched from March 2023, after setting up the steering committee for the DONES Program composed of several countries. To support the preparation of the key documentation and consolidate contributions from parties, a set of tasks is being developed within the framework of the new DONES Consolidation Phase project (DONES-ConP1). In this contribution, the main objectives of the project such as the drafting of the acceptance tests for the procurement, the first version of the irradiation plan for fusion and non-fusion applications, or the update of key project documentation will be discussed.

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Thursday Poster Session / 1397

PLAN analytics for enhanced understanding of RUN3 and LS3 activities

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Designed as an internal tool at CERN, PLAN has a pivotal role in the centralization and macroscopic aggregation of technical intervention and enhancement activities planned within the accelerator complex. As part of a broader strategy to enhance tool utilization and extract valuable insights, a substantial endeavor during RUN3 aimed to develop and disseminate analytics derived from tool-generated data. These analytics are seamlessly accessible via a FLASK application, crafted primarily using Python and the Bokeh library, JavaScript, HTML, and CSS. Hosted internally at CERN through OpenShift, it is containerized through Docker, and subject to continuous integration via GitLab.
These analytics serve versatile purposes, encompassing the quantification of activities, identification of resource constraints across departments and groups, and the provision of insights into various facilities, projects, and more. Moreover, they play an instrumental role in identifying bottlenecks and critical milestones in planning timelines. These analytics are designed to furnish management and other stakeholders with essential insights, ultimately contributing to wide-ranging improvements across CERN.

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Wednesday Poster Session / 1398

First FCC-ee lattice design with combined function magnets

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The Future Circular Electron-Positron Collider (FCC-ee) represents a cutting-edge particle physics facility designed to further investigate the Z0, W± and Higgs boson in addition to the top quark. The implementation of Combined Function Magnets (CFMs) in the FCC-ee arc cells would maintain high luminosity and reduce its energy consumption. The use of these special magnets induces changes in the damping partition numbers. To mitigate this the dipole fields in focusing and defocusing quadrupoles have to be different. This solution gives rise to incompatibility problems for the machine layout between the different energy configurations as the optics is also changed. This problem is tackled by defining different bending and geometric angles for the combined function magnets. The beam dynamics and performance aspects of the new lattice are studied in this paper.

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WEAD: Photon Sources and Electron Accelerators (Contributed) / 1399

Echo-enabled harmonic generation at FERMI FEL-1: commissioning and initial user experience

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The FERMI free-electron laser (FEL) facility has recently achieved a significant milestone with the successful implementation of the echo-enabled harmonic generation (EEHG) scheme in the FEL-1 amplifier line. This advancement is part of a broader upgrade strategy aiming at expanding the covered spectral range of the facility to the entire water window and beyond. Through this upgrade, the maximum photon energy of FEL-1 has been doubled and spectral quality has been enhanced. The updated FERMI FEL-1 is the first user facility operating in the spectral range 20-10 nm utilizing the EEHG scheme. It will serve also as the ideal test bench for conducting new machine studies in the perspective of future developments. In this contribution, we present the results obtained during the commissioning phase and the first user experiments.

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Thursday Poster Session / 1401

First studies on error mitigation by interaction point fast feedback systems for FCC-ee

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During operation, the Future Circular electron-positron Collider (FCC-ee) will be subject to vibrations from mechanical sources and ground motion, resulting in errors with respect to the closed orbit. To achieve physics performance, luminosity and beam lifetime must be kept to design specifications. To correct for errors at the IPs, a fast feedback system is required. In this paper, we present the tolerances for the allowable beam offsets at the interaction points (IPs) and propose a fast feedback system to address these errors, with the methods of detecting and correcting errors discussed.

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Monday Poster Session / 1402

Transverse instabilities in SOLEIL II storage ring in the presence of a harmonic cavity

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SOLEIL II is an upgrade project of the existing Synchrotron SOLEIL facility. It aims to reach fourth-generation light source parameters. This includes reductions of the transverse beam emittance, vacuum chamber dimensions and momentum compaction factor. A new impedance model of the SOLEIL II storage ring was developed. This paper demonstrates the evaluation of transverse single- and coupled-bunch instabilities with an up-to-date impedance model. Storage ring operation with a harmonic cavity is an essential component of the project. A harmonic cavity provides bunch lengthening and perturbs synchrotron motion. Its effects on transverse instabilities in SOLEIL II are reported in this contribution.

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Tuesday Poster Session / 1404

Beam loss studies for the P42 beam line at the CERN SPS north area

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The P42 beamline transports 400 GeV protons from the CERN SPS between the T4 and T10 targets. A secondary particle beam is produced at the T10 target and transported along the K12 beamline to the experimental cavern ECN3, presently housing the NA62 experiment. In the context of the Physics Beyond Colliders (PBC) study, an increase of the beam intensity in P42 has been considered to provide protons to a future high-intensity fixed-target experiment in ECN3. For both its present usage and especially for the intensity upgrade, it is important to reduce beam losses to a minimum to decrease environmental radiation levels and protect equipment. In this study, simulations of P42 with the Monte Carlo software BDSIM, are used to demonstrate that beam losses in P42 are primarily driven by particle-matter interactions in material intercepted by the beam. The distribution of the simulated losses is compared to doses measured along the beamline in radioprotection surveys and beam loss monitors. Future mitigation strategies to reduce beam losses are then discussed and evaluated.

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Wednesday Poster Session / 1405

Parameter space for the magnetic design of combined function magnets in the FCC-ee arc cell

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The Future Circular Collider (FCC-ee) is designed to explore the Z0 and W± bosons, along with the Higgs boson and top quark, achieving exceptionally high luminosity and energy efficiency. In order to minimize the energy lost per turn due to Synchrotron Radiation (SR) we explore the use of Combined Function Magnets into the arcs cell. For this, it is necessary to explore the possible combinations of the different magnet types in the cell, namely: dipoles, quadrupoles and sextupoles. Specifications in terms of strength and alignment tolerances are reviewed in this paper.

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Tuesday Poster Session / 1406

Magnetic design of non linear kicker for ESRF-EBS

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The ESRF-EBS injection is performed with a standard off-axis injection scheme consisting of two in-air septa S1/2, one in vacuum septum S3 and four kicker magnets K1 to K4 to generate the injection bump. We can achieve 80% efficiency with this scheme. Despite many modifications and adjustments which allow the reduction of the perturbation, some beamlines are still affected. The Non-Linear Kicker could be a solution to this problem because it acts only on the injected beam. This paper reports on the magnetic design of the Non-Linear Kicker, including the octupole like Magnetic field simulations, magnetic forces calculations and mechanical tolerance optimizations.

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TUBN: Novel Particle Sources and Acceleration Techniques (Contributed) / 1407

Next-generation laser-plasma acceleration

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Most current laser-plasma accelerators (LPAs) require driver lasers with relativistic intensities and pulse durations that are significantly shorter than the plasma wavelengths. This severely limits the laser technology that can be used to drive LPAs and with that their wide spread and the currently achievable LPA parameters, such as repetition rate and accelerating gradient. Here, we report a widely unexplored regime of laser-plasma electron acceleration that is based on the direct parametric excitation of plasma waves. This method markedly relaxes the driver laser requirements in terms of peak power and pulse duration. We show experimental data that demonstrates the generation of high-charge mildly relativistic electron bunches with laser-to-electron conversion efficiency that is unprecedented in gas-phase targets. The accelerating field gradient in this regime reach 3 TV/m.
The experimental results demonstrate a novel regime that opens LPA electron acceleration for a wide range of driver laser technologies and holds the promise for a path to ultracompact high-repetition rate LPAs with extreme field gradients for future compact particle accelerators and secondary sources.

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Tuesday Poster Session / 1408

Magnetic measurement bench for a pulsed non-linear kicker based on vibrating wire

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Transparent off-axis injection in a storage ring by means of a non-linear kicker requires tight field tolerances at the limit of modern technique. To characterize the field profile of the non-linear kicker under development for the ALBA-II storage ring, a dedicated measurement bench based on a variant of the vibrating wire technique was developed. The small size and limited weight of the kicker magnet under study allows for some unusual solution which substantially simplify the set-up. Field mapping is obtained by scanning the magnet aperture, while keeping the wire steady, simplifying considerably the wire tensioning system. The wire is suspended vertically in a pendulum configuration eliminating the wire sagging problem and resulting in an inherently stable wire tension. Furthermore we investigate the possibility to characterize time dependent phenomena, such as the effect of eddy currents induced in the titanium coating of the magnet vacuum chamber, by using using an etherodyne approach where the magnet and the wire are excited by a continuous wave signal with period close to the characteristic kicker pulse period and differing in frequency by the wire resonance frequency

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Tuesday Poster Session / 1409

Characterization of the optics of the TT24 and P42 beam lines in the CERN SPS north area

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400 GeV protons extracted from the CERN SPS are transported to the T4 target via the TT20 transfer line. The P42 beamline then transports the protons that did not interact in the T4 target to the T10 target. During operation in 2021 and 2022, higher than expected beam losses were measured, in addition to an increased beam spot size that had previously been observed. It was suspected that the optics between TT24 and P42 might not be well matched but due to a lack of instrumentation this was not confirmed. The recent installation of additional beam profile monitors (BSG) in the P42 beamline has allowed the present optics to be evaluated for the first time. In addition, magnet response functions have been measured and updated. A kick response study was performed using corrector dipoles to kick the beam with the subsequent displacement measured on the BSGs. The dependence between the kick and the beam position was used to fit a MADX optics model of TT24 and P42. Quadrupole scans were then performed to determine the initial conditions of the model. These results are presented in this paper.

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Thursday Poster Session / 1410

Beam-based alignment of magnetic system in AREAL linear accelerator

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In this paper the beam-based alignment for solenoid and quadrupole magnets in the AREAL linear accelerator is presented. The AREAL accelerator, at this stage, operates with one solenoid, one quadrupole, corrector, and dipole magnets. The adjustment of solenoid and quadrupole magnets is crucial for the stable operation of the accelerator and for forming the desired beam required for the AREAL upgrade program. This work also takes into account the influence of the RF field radial component on the off-axis beam parameters and trajectory due to laser spot misalignment on the cathode. The study involves theoretical, simulation, and experimental comparisons.

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Monday Poster Session / 1413

Resistive wall heating and thermal analysis of the EIC HSR beam screen

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The Electron-Ion Collider (EIC) utilizes the existing Relativistic Heavy Ion Collider (RHIC) rings as a Hadron Storage Ring (HSR) with some modifications. However, this presents significant challenges, primarily due to beam-induced Resistive Wall (RW) heating resulting from a larger radial offset and shorter EIC bunches (up to 10 times shorter than RHIC). Additionally, the formation of an electron cloud further complicates matters. To address these issues and operate the HSR effectively, this paper focuses on the RW heating and thermal analysis of the EIC HSR beam screen. Our approach involves the insertion of a copper-coated stainless steel beam screen with cooling channels and longitudinal slots. We conducted a detailed thermal analysis, assessing piecewise RW losses around the beam screen's profile due to an offset beam, employing the 3D commercial code CST. These losses, along with realistic boundary conditions, were then integrated into another code, ANSYS, to determine the thermal distribution.

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PulseOne, first FLASH-ready LINAC timing/trigger system

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The system offers a single-card solution with optional IO extensions cards, enabling synchronization of electron gun, RF modulator, dosimetry, and other diagnostic devices. Noteworthy features include the ability to generate multiple, preconfigured pulse trains on synchronous channels, each with individual configuration settings. With real-time control of pulse width modulation or sheer number of pulses (pulse increment/decrement) it can enable fast and precise control over output channels. Such control comes as necessary in all future FLASH applications.

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Tuesday Poster Session / 1415

Present status and future project of synchrotron light sources at KEK

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Two synchrotron radiation sources, the 2.5 GeV Photon Factory Storage Ring (PF ring) and the 6.5 GeV Photon Factory Advanced Ring (PF-AR), have been in stable operation at the High Energy Accelerator Research Organization (KEK) for over 40 years. This paper first describes the current operational status and recent developments at PF. Next, a new concept of hybrid light source (PF-HLS) combining the advantages of a superconducting linac and a low-emittance storage ring is described. In the preliminary design, the energy range is from 2.5 GeV to 5.0 GeV, and the storage ring will be constructed in a green field with a circumference of 750 m. The design baseline for superconducting linac uses the International Linear Collider (ILC) specifications.

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Thursday Poster Session / 1416

Linac optics optimization of CSR-induced projected emittance growth for the PWFA experiment FLASHForward

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For linacs generating high-current bunches, matching of the beam optics can be a challenge due to the presence of microbunch-induced Coherent Optical Transition Radiation (COTR) that can spoil the measured beam profile on OTR-based diagnostics. Furthermore, strong kicks due to Coherent Synchrotron Radiation (CSR) in the bunch compressors can result in an increased projected emittance in the dispersion direction. In this contribution, we present results from the soft X-ray FEL user facility FLASH at DESY, Hamburg, where a recently installed laser heater was used to suppress the effects of microbunching, enabling the proper measurement and matching of the beam optics at nominal bunch compression. Equipped with this capability, we then explore the possibility of optimizing the optics for minimal CSR-induced emittance growth with the help of Bayesian Optimization. The importance of these techniques to the beam-driven plasma-wakefield acceleration (PWFA) experiment FLASHForward is then discussed.

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Wednesday Poster Session / 1417

Collimation for SOLEIL II

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The storage ring of the SOLEIL II project will be based on a low-emittance multi-bend achromat 7BA-4BA lattice resulting in very compact lattice (1500 magnets for a 354 m long ring), very high quadrupole gradient (120 T/m), strong sextupole (8000 T/m2), and moderate octupole (50 000 T/m3) with a beam circulating in a tiny vacuum chamber of 12 mm diameter. The project makes extensive use of permanent magnets (dipole, reverse bend, and all quadrupole magnets). This paper presents the main challenges of collimating the high electron density of the storage ring beam. The absence of "Loss Stay Clear" makes the loss profile to be fully distributed along the storage ring: the aperture itself acts as a global collimator with very short-ranged losses (80% during the first turns, majority of losses in the 7BA arcs). The absence of dispersion in the straight sections leads to strong difficulties in finding an efficient collimation scheme for Touschek scattered particles. The collimation scheme, lattice modification options, radiation damage, and radiation safety aspects are also discussed.

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Tuesday Poster Session / 1419

SOLEIL II Project

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SOLEIL II is the French upgrade project to build the science of tomorrow with synchrotron light radiation. Providing the highest brilliance in its class while maintaining the radiation range from IR to hard X-rays, the project is an ambitious triple upgrade of the SOLEIL facility: accelerators (new booster and storage ring), 29 beamlines and 3 laboratories, and an information technology transformation plan. High-order Achromat based on multi-bend achromat lattices will be used to replace both the storage (SR) and booster rings of the Synchrotron SOLEIL. The achieved equilibrium emittance of the SR (below 100 pm·rad, 354 m, 2.75 GeV) is about 50 times smaller than that of the existing Storage Ring (4000 pm·rad). To ensure the technical feasibility, an intensive R&D phase based on extensive numerical simulations, prototyping, and measurements has been carried out. This paper presents the latest status of the project, and the updated timeline, and describes the main results obtained so far in terms of performance and the prototypes launched in many technical domains (lattice, magnets, insertion device, vacuum, alignment…).

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Europe

Tuesday Poster Session / 1420

Operational status of synchrotron SOLEIL

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The synchrotron SOLEIL is the French third-generation 2.75 GeV synchrotron light source, a research laboratory at the forefront of experimental techniques for the analysis of matter down to the atomic level, and a service platform open to all scientific and industrial communities. We present the performance of the accelerators, which deliver extremely stable photon beams to 29 beamlines. We report on last year's overall performance figures and the operation of the brand-new cooling station. As the optimization of the energy and carbon footprint becomes more and more prevalent in France and Europe, actions for a more sustainable operation are given. Several incidents are also presented, together with the lessons learned to avoid recurrence. Major research and development activities related to component obsolescence and the SOLEIL II project will also be presented.

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Monday Poster Session / 1421

Beam induced heating analysis update for the EIC vacuum chamber components

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Co-authors: Alexei Blednykh [2]; Charles Hetzel [2]; Chuyu Liu [1]; David Gassner [2]; Douglas Holmes [1]; Frederic Micolon [2]; Jonathan Bellon [2]; Karim Hamdi [1]; Michael Blaskiewicz [1]; Peter Braunius [2]; Silvia Verdu-Andres [2]

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One of the challenges in designing the Electron-Ion Collider (EIC) is mitigating beam-induced heating caused by the intense electron and hadron beams. Heating of the ESR vacuum chamber components is primarily due to beam-induced resistive wall (RW) losses and synchrotron radiation. For the HSR, heating results mainly from large radial offsets and heat conduction from room temperature to cryogenic temperatures for cryo-components. In this paper, we provide an update on the beam-induced heating and thermal analysis of critical ESR vacuum chamber components, such as the ESR

Large Angle Bremsstrahlung Monitor (LABM). We also offer a similar update for crucial HSR vacuum components, including the cryo-cooled BPM button assembly, abort kicker, and polarimeter. To perform the thermal analyses, we calculate the resistive wall loss on individual components using CST, and we evaluate the synchrotron radiation (if it exists) using SynRad. These losses, along with realistic boundary conditions, are then fed into ANSYS to determine the temperature distribution.

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Tuesday Poster Session / 1422

Stress-strain state analysis of the first-grade titanium foil of the accelerator output window in a static state

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The stress-strain state of the titanium foils of the accelerator output windows at various thicknesses was studied with the choice of first-grade titanium foil as a brand. The latter is more affordable and accessible compared to a second-grade titanium foil. The deformation diagram, density, Young's modulus, and Poisson's ratio of the first-grade titanium were selected as initial data. Atmospheric pressure was used as an external pressure, and the pressure from the vacuum side was taken as zero. The latter is acceptable in simulations of ultrahigh vacuum assemblies since it does not affect the overall picture of the stress-strain state. In addition to studying the central nodes of the metal foil, the sealing nodes were also considered as an object of research, with the study of stress intensity, meridional and circumferential stresses, and maximum displacements of the center. Based on the results, a function was obtained that allows us to accurately calculate the displacements of the center of the first-grade titanium foil depending on its thickness. The analysis of the received data was carried out.

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Wednesday Poster Session / 1423

Development of a TE-mode sample host cavity

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In order to study the radio-frequency performance of superconducting materials at cryogenic temperature, we developed a TE-mode 3.9 GHz sample host cavity with a spherical bottom shape. A 11.5 cm diameter flat sample plate is enabled to attach to the cavity, with 9 cm diameter central area exposed to the RF field. In this paper, the design, fabrication and vertical test results of the sample host cavity will be presented.

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Asia

Wednesday Poster Session / 1424

Longitudinal phase space measurement using a corrugated metallic dechirper at PAL-XFEL

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We present the experimental results of the longitudinal phase space measurement using the wakefields driven by the dechirper wall. In the soft X-ray line of the PAL-XFEL (Pohang Accelerator Laboratory, X-ray Free Electron Laser), the dechirper composed of 1-meter-long corrugated metallic walls is located at the upstream of the undulator section. When the electron bunch travels through the corrugated plate, a strong transverse wakefield can be generated, resulting in a transverse kick to the trailing electrons in the bunch. The horizontally deflected bunches were monitored on the screen monitor at the undulator downstream and we also observed bunch images through a vertically bending magnet at the beam dump. In this way we measured the XY beam profile, in which the X and Y axis represent the time structure and the energy spread of the bunch, respectively. Finally

we will also discuss the use of passive deflector to measure the longitudinal phase space of electron beams influenced by FEL generation.

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Wednesday Poster Session / 1426

DAFNE operation strategy for the observation of the kaonic deuterium

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DAFNE, the Frascati F-factory the collider where the Crab-Waist collision scheme has been implemented and successfully tested, is presently working for a physics program in the field of exotic atoms. The present scientific program foresees the study and the characterization of the never observed before kaonic deuterium. Providing a suitable data sample for such measurement requires the collider to provide the highest flux of k- meson and the lowest possible background shower on the detector. The operation strategy, and the collider setup in terms of collisions and beam dynamics are presented and discussed.

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Tuesday Poster Session / 1428

Irradiation damage characterization of positron source materials

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The secondary beam production target at future positron sources at the Continuous Electron Beam Accelerator Facility (CEBAF), the International Linear Collider (ILC) or the Future Circular Collider (FCC), features unprecedented mechanical and thermal stresses which may compromise sustainable and reliable operation. Candidate materials are required to possess high melting temperature together with excellent thermal conductivity, elasticity and radiation hardness properties. In order to substantiate the material choice for the CEBAF and ILC positron sources, the response of candidate materials such as titanium alloys, tungsten, and tantalum to electron beam irradiation was experimentally investigated. CEBAF and ILC expected operating conditions were mimicked using the 3.5 MeV electron beam of the MAMI facility injector. The material degradations were precisely analyzed via high energy X-ray diffraction at the HEMS beamline operated by the Helmholtz-Zentrum Hereon at the PETRA III synchrotron facility. This work reports the results of these measurements and their interpretation.

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Wednesday Poster Session / 1432

Time decay effect of the superconducting final focus quadrupole fields on SuperKEKB beam operation

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SuperKEKB is the particle collider of electrons at 7 GeV and positrons at 4 GeV, and it is the cutting-edge collider in the luminosity frontier using the "Nano-beam scheme". The beam colliding operation of SuperKEKB started from 2018 May, and the peak luminosity reached at 4.678×1e-34 1/cm² 1/s with quite expert beam operation. In beam operation, the vertical tune of the positron beam was measured to decline exponentially with time just after exciting the final focus quadrupole magnets. To identify the source of the tune change, we performed the magnetic field measurements of the prototype final focus quadrupole magnets, and the exponential field change with time after exciting the magnets was measured and the measured field decay rates were found to be of equal size of the measured tune change during beam operation. Because the field change is due to the magnetization decay in the superconductor, NbTi, filament, we modified the excitation pattern of the magnets and canceled the field decay. We will report the measured beam tune changes, the prototype field measurement results and the condition of beam operation with the modified excitation patterns of the quadrupole magnets.

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Asia

Thursday Poster Session / 1433

Injectors de-cabling project

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During the LHC Intensity Upgrade (LIU) implementation, it became evident that an injector de-cabling project was needed to increase infrastructure resilience. Several difficulties in the setup of the project, originating from the 50 years history of some of the machines concerned, enforced the need of a meticulous and careful step-by-step approach to structure the project and defined its roadmap, before the start of the work in the field. Despite the limited intervention windows constrained by the CERN accelerator complex operation, 1300 km of obsolete cables were removed from the injectors within six years, effectively meeting the LIU requirements. The increased infrastructure resilience observed, prompted CERN management to support a project phase 2 to globally increase resilience in the injectors and improve safety. The phase 2 benefited from some phase 1 processes but faced other challenges. 400 km of cables were removed during 2 programmed stops and thanks to a structured approach, the project reached a continuous operation mode, being not limited to the programmed stops, hence allowing to target new areas. Phase 3 is now starting with a new roadmap covering the next 6 years.

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Europe

Wednesday Poster Session / 1434

Thermal studies of the magnet quenches of the SuperKEKB beam final focus system

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The beam final focus system of SuperKEKB consists of 55 superconducting magnets. They are 8 main quadrupole magnets, 43 corrector magnets and 4 compensation solenoids. During beam operation from 2018 to 2022, the superconducting magnets quenched 40 times induced by the electron or positron beam hitting the superconducting coils or the other disturbances. The temperatures of the quenched superconducting coils are being studied with the accumulated magnet quench data and the conditions of beam operation. The temperatures of the coils are evaluated with the critical temperature defined by the operation magnetic field and the transport current. The authors will report the temperature range of the superconducting coil shortly after the coil quench.

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Asia

Thursday Poster Session / 1435

Status of the Bonn Isochronous Cyclotron

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The Bonn Isochronous Cyclotron provides proton, deuteron, alpha and other light ion beams with a charge-to-mass ratio Q/A >= 1/2 and kinetic energies ranging from 7 to 14 MeV per nucleon. The beam is guided via a high-energy beam line (HEBL) to one of five experimental sites.
The installation of a modern irradiation site for high-uniformity radiation hardness tests of Si detectors has been finalized in 2021. Additionally, a neutron irradiation site will be commissioned soon. Here, a collimated neutron beam, generated by a stripping reaction of the deuteron beam in a carbon target, can be used for irradiation.
To provide stable beam with constant optics for these experiments, the power supplies (PS) of all magnets in the HEBL will be replaced. The replacement candidates must meet strict criteria regarding output current's short and long-term stability. The criteria were derived from current measurements of the existing PS. Each PS will be PLC-controlled, enabling its bipolar operation, magnet-degaussing, PS and magnet operation safety/health and power consumption monitoring. The PLCs will be operated as OPC UA servers and integrate each PS into the future cyclotron control system.

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Wednesday Poster Session / 1436

FLUKA simulations of neutrino-induced effective dose at a Muon Collider

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The International Muon Collider Collaboration (IMCC) is in charge of assessing the performance and feasibility of an underground circular accelerator colliding TeV-scale muons. During the operation of a muon collider, the decay of circulating muons produces a narrow disk of high-energy neutrinos emitted radially in the collider plane and emerging on the Earth's surface at several km. The goal is to ensure that neutrino interactions do not entail any noticeable addition to natural radioactivity, such that the environmental impact of the muon collider is negligible. To do so, dedicated studies of the expected neutrino and secondary-particle fluxes are performed. This work presents a set of FLUKA Monte Carlo simulations that characterize the radiation showers generated by the interaction in soil of high-energy neutrinos from muon decays. The results are presented as the effective dose in soil at different distances from the muon decay, quantifying the peak dose and the width of the radiation cone, for beam energies of 1.5 TeV and 5 TeV. The implications of the results for realistic muon collider scenarios are discussed, along with possible methods to mitigate the local neutrino flux.

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Thursday Poster Session / 1437

Simulation study of nanosecond pulse power based on gyromagnetic nonlinear transmission line

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On-axis injection mode is planned to use in the Southern Advanced Photon Source (SAPS), which requires high quality to injection pulsed power supply. Gyromagnetic nonlinear transmission line (GNLTL) is introduced as a pulse compressor to meet the needs for pulse width. In this paper, 3-D finite element model is established based on Landau-Lifshitz-Gilbert equation and Maxwell's equations. The influence of geometrical sizes and bias magnetic field to output pulse is analyzed for better design of NLTL. A prototype was built with nanosecond pulse width and sub-nanosecond rise time to verify the simulation.

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Asia

Wednesday Poster Session / 1438

Preliminary design for the JHLS storage ring

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Co-authors: Masahito Hosaka [1]; Wei Xu [1]

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Jinhua light source (JHLS) is a synchrotron radiation facility with the aim of the increasing requirement of user demands for industrial applications. The lattice contains 16 super-periods in order to accommodate different end users for experiments. The circumference is less than 240 m, and the natural emittance is less than 10 nm·rad at 2.6 GeV. In this paper, we present a modified Triple Bend Achromat (TBA) lattice as the preliminary design for the JHLS storage ring. The 'sandwich'longitudinal gradient bends and horizontal defocusing bends are introduced into lattice in order to decrease the natural emittance. The detail design is reported in this paper.

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Thursday Poster Session / 1439

SOLEIL II booster robustness and emittance exchange

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For the injection into the SOLEIL II storage ring a beam with small transverse and longitudinal sizes is necessary, which requires the booster synchrotron to be upgraded. The new booster is designed as a multi-bend 16BA Higher-Order Achromat lattice with a small emittance of 5 nm·rad at 2.75 GeV. Robustness of the lattice has been studied with realistic errors in magnet alignment and calibration, but also taking into account specific errors as mismatch in the RF frequency and circumference error, as RF frequency is driven by the main storage ring. Also, power supply tracking errors have been considered and their reduction will be discussed. On top of these error studies an emittance exchange is performed to allow more flexibility in the injection parameters into the storage ring. Different methods are compared within the framework of a very realistic machine.

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Monday Poster Session / 1441

Experimental characterization of the sensitivity of echo-enabled harmonic generation to operating parameters

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Echo-enabled harmonic generation (EEHG), a free-electron laser (FEL) scheme relying on two modulating sections, each consisting of an optical seed laser, an undulator and a magnetic chicane, has recently been implemented on the FEL-1 radiator line at the FERMI FEL user facility in Trieste, Italy. This setup imprints a density modulation onto a relativistic electron beam at a high harmonic of the seed frequency before injecting the electrons into the radiator, where they emit coherent soft x-rays. We have experimentally studied EEHG performance as a function of the properties of both seeds (modulation amplitude, frequency chirp) and the electron beam (slice energy spread, energy profile). We measured a relatively low output sensitivity to the properties of the first and a high sensitivity to the properties of the second seed, and simultaneously a high tolerance both to slice energy spread and to non-linear terms in the electron-beam energy profile. All of these observations are consistent with theoretical predictions. The emission of coherent, shot-to-shot stable radiation at harmonics of the second seed frequency as high as 50 sets the stage for a future upgrade of the FEL-2 line.

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Thursday Poster Session / 1442

A novel pulse compressor with dielectric assistance

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A compact pulse compressor with dielectric loaded structure is proposed and simulated. The novel pulse compressor adopts a spherical resonant cavity design with dual-mode polarization mode. A dielectric sphere added in the center of the spherical cavity can reduce the volume and weight of the pulse compressor and improve the quality factor of the cavity. A C-band compact storage cavity model is designed and simulated on ANSYS HFSS using dielectric with permittivity of 9. The simulation of the dielectric-assist resonant cavity with an inner diameter of 34 mm indicates an unloaded quality factor about 200000.

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Wednesday Poster Session / 1443

Design of the cryogenic BPM pick-ups for the EIC Hadron Storage Ring

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Designing cryogenic BPM pick-ups for the Hadron Storage Ring (HSR) of the Electron-Ion Collider is challenging due to the need for reliable beam position measurements across diverse beam species, operating modes, and with various energies. The existing RHIC BPM stripline pick-ups are incompatible with the planned EIC HSR beam parameters, as it will have a 10-times shorter bunch length (6 cm rms, shortest hadron bunch anywhere), a factor of 3 more currents, compared to RHIC, and will have a large radial offset (±20 mm) to adjust the path length for different beam energies. The BPM pick-up design takes into consideration the potential elevated heating concerns caused by resistive wall loss due to radial beam offset and heat conduction through cryogenic BPM signal cables from room temperature feedthrough to the cryogenic temperature BPM housing. Minimizing geometric impedance in the button configuration and housing transition to the adjacent HSR beam screen is crucial. This paper focuses on the evolution of the button BPM design and describes simulation results of the position-related voltage signals, and beam-induced losses on the metallic BPM buttons due to the radial offsets.

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Tuesday Poster Session / 1444

Commissioning of the new ps timing system at ELBE

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The CW electron accelerator ELBE is in operation for more than two decades. The timing system has been patched several times in order to meet changing requirements. In 2019 the development of a new timing system based on Micro Research Finland Hardware has been started which is designed to unify the heterogeneous structure and to replace obsolete components. In spring 2024 the system has been put in user operation. The contribution will discuss the commissioning process and first experiences from the routine operation.

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Tuesday Poster Session / 1445

ALBA II accelerator upgrade project status

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ALBA is working on the upgrade project that shall transform the actual storage ring, in operation since 2012, into a 4th generation light source, in which the soft X-rays part of the spectrum shall be diffraction limited. The project was launched in 2021 with an R&D budget to build prototypes of the more critical components. The storage ring upgrade is based on a MBA lattice which has to comply with several constraints imposed by the decision of maintaining the same circumference (269 m), the same number of cells (16), the same beam energy (3 GeV), and as many of the source points as possible unperturbed. At present, the lattice optimization, iterating with the technical constraints of space and performance, is ongoing. This paper presents the status of the project, with the present proposed lattice, the proposed design for magnets, vacuum chambers and girders, the proposed RF system with fundamental and harmonics cavities, and the general context of the upgrade.

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Wednesday Poster Session / 1446

Status of the new bunch length measurement system downstream the injector of the S-DALINAC

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Energy-recovery linacs provide high beam currents with lower RF power requirements compared to conventional machines while maintaining the high beam quality of a linac. The S-DALINAC is a thrice-recirculating accelerator operating at a frequency of 3 GHz that is capable of being operated as a multi-turn superconducting energy-recovery linac. Its efficiency is currently limited by the bunch length, which by now is measured using the RF zero-crossing method. In order to improve both accuracy and measurement time a new setup using a streak camera is developed. Optical transition radiation from electron bunches passing an aluminum-coated Kapton screen is used to produce light pulses that can be measured with the streak camera. An imaging system consisting of multiple mirrors is used to maintain a high temporal resolution for the measurement and to support in shielding the streak camera from harmful radiation. The device will be used at two different measurement setups downstream of the injector. The design and current status of the measurement setup will be presented.

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Wednesday Poster Session / 1447

Comparison studies in dynamic aperture for combined function magnets and baseline lattice in the FCC-ee

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A significant project such as the FCC-ee (with 91.17 km of circumference) entails numerous challenges to ensure the stability and performance of the machine. In pursuit of contributing to the improvement of energy consumption during its operation, the exploration of Combined Function Magnets as a means to reduce synchrotron radiation has been undertaken. This paper focuses on studying the Dynamic Aperture (DA) concerning the nominal lattice to understand how the luminosity can be achieved with this novel design.

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Wednesday Poster Session / 1448

Bubble-beam accelerators: breaking the paradigm

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Most particle accelerators utilize beams with a charge density concentrated in the center of the bunch in real 3-dimensional space and the 6-dimensional phase space. In this work, by enhancing the space-charge forces in the photo-cathode injector of the Compact Linear Electron Accelerator for Research (CLEAR) at CERN, we produce electron bunches with a "bubble-like"shape, with a charge density mostly concentrated on the outside shell. We demonstrate that the dynamics of such beams can be tailored to achieve stable uniformity in the coordinate and momentum transverse planes simultaneously. This would allow reaching a uniform dose distribution without a severe loss of particles which is of the great interest in the irradiation community. Additionally, we investigate the potential benefits of bubble-beams across several accelerator pillars: for driving light sources, for advanced acceleration technologies, and for particle colliders.

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Thursday Poster Session / 1449

Discussion of space charge effects of a beam train containing infinitely many bunches

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Using an algorithm capable of calculating the space charge effects of a beam train containing infinitely many bunches with uniform spacing, we compare results of different beams with different energy, either longitudinal or transversal distribution, bunches' spacing and so on.

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Thursday Poster Session / 1451

The gamma activation measurements at Shanghai Laser Electron Gamma Source

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SLEGS is a Laser Compton Scattering gamma source. The gamma energy is 0.66 to 21.7 MeV, and the gamma flux is approximately 4.8e+5 to 1.5e+7 phs/s. Gamma activation method is used in beam flux monitor, medical isotpoe production and nuclear astrophysics in SLEGS. *Gamma beam flux under different collimated apertures has been checked by gamma activation method by using various half-life nuclide targets with an online activation and offline measurement platform. It is consistent with the flux measured with direct method by the LaBr3 detector. The activation method will be uniquely advantageous for monitoring gamma beam with short-life nuclide in a short time.A series of potential medical isotopes giant resonance production cross sections are measured by gamma activation method, which will provide key data for medical isotopes production by photonuclear reactions. The p-nuclei's photonuclear cross sections**, for example Ru, are measured by photoneutron and gamma activation, which can provide favorable data on the much larger abundance of 98Ru, 96Ru. The activation experiment of SLEGS provides a reliable option for different experimental research objectives in photonuclear physics.

Footnotes:

- Wang H W, Fan G T, Liu L X, et al., Commissioning of Laser Electron Gamma Beamline SLEGS at SSRF[J], Nuclear Science and Techniques, 2022, 33, 87. **Gy. Gyürky, Zs. Fülöp, F. Käppeler, G. G. Kiss, and A. Wallner, The Activation Method for Cross Section Measurements in Nuclear Astrophysics[J], Eur. Phys. J. A 55, 41 (2019).

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Thursday Poster Session / 1452

Impedance database for the Diamond-II booster

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Boosters in synchrotron injector systems have traditionally had more relaxed designs than storage rings, and consequently impedance has not been considered an important factor in their designs. In 4th generation light sources like Diamond-II, it is desirable to increase the extracted charge per shot to reduce filling times and enable advanced injection schemes. As such, the vacuum chamber impedance becomes a significant design parameter. An impedance database has been created for the Diamond-II booster, using the same AT-style lattice concept as for the storage ring, to be used as input into particle tracking and other simulations. We present here an overview of the database, including details of significant components and current progress on engineering designs.

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Thursday Poster Session / 1453

Updates to the impedance database for the Diamond-II storage ring

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Impedance is a significant concern in modern storage rings like Diamond-II, due to instabilities limiting maximum bunch charge and other potential effects such as emittance dilution. Significant changes have been made to the Diamond-II impedance database, partly driven by progress in engineering design work, and partly by the requirements of particle tracking simulations and increase in available computing resources. We present an overview of the current state of the Diamond-II impedance database, focusing on the most significant updates and additions.

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Wednesday Poster Session / 1454

Online diagnostics of electron beam irradiation with minimally invasive screens and beam charge monitors

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In 2019, the annual number of cancer cases exceeded 100 million, resulting in 10 million deaths worldwide. Radiation therapy stands out as one of the most effective methods for cancer treatment. Electron beams in the 100 MeV range can reach even deep-seated tumors without the need for surgical intervention. Thanks to novel, high-gradient acceleration technologies, clinical facilities for high-energy electron-based irradiation are actively under development. However, the online dosimetry of the delivered dose remains a challenge. In this work, we present a simple and effective solution. We demonstrate that thin YAG screens permanently integrated into the layout of the beamline can be used to characterize the transverse beam distribution shot-to-shot during irradiation. When combined with beam charge monitors, it allows for the prediction of the dose delivered to the target. We benchmark this method against the standard dosimetry technique based on the irradiation of radiochromic films calibrated with an ion chamber.

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Wednesday Poster Session / 1455

Variable polarization self-locked streaking of electrons in time with a pair of corrugated structures

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Corrugated structures have recently been utilized for the time-resolved diagnostics of electron bunches and free-electron-laser (FEL) pulses in several FEL facilities: SwissFEL at PSI and European XFEL at DESY. This approach is simple and cost-effective, based on the self-streaking of electrons with a transverse wakefield enhanced in such structures. In this work, we optimize the design of a corrugated streaker for the wide range of beam parameters of the Compact Linear Electron Accelerator for Research (CLEAR) at CERN. We present the first results of the commissioning of a pair of orthogonally oriented streakers at CLEAR and demonstrate that in such a configuration, variable polarization streaking can be achieved. Additionally, we validate that while streaking in the vertical (or horizontal) direction with one structure, the undesired quadrupole wakefield can be compensated by the second streaker. This allows for a significant improvement in the resolution of the method.

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Tuesday Poster Session / 1457

Dismantle, assembly and installation plans for the ALBA II upgrade

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The 3.0 GeV ALBA Synchrotron Light Source, in operation with users since 2012, is looking forward an upgrade aimed at enhancing the brightness and coherence fraction of the delivered X-ray beam. The Storage Ring (SR) will be completely renewed but we plan on keeping the same orbit length and the position of the ID source points. The energy of the electrons will be preserved and the same injector will be used. Major part of the Insertion Devices and Front Ends will be kept; new ones will feed additional long Beamlines (230m-275m), included on the project.
The "dark period"is foreseen for 2030-2031. This paper presents the strategic plans being developed to test and assemble the new SR components, the dismantling of the present SR and the seamless installation of the upgraded SR. Emphasizing a cost-effective and time-efficient approach, we have started the planning by focusing on optimizing spaces and equipment movements necessary for the upgrade process.

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Wednesday Poster Session / 1458

Time-interleaved-sampling for high bandwidth BPM signals

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BPM signal processing uses digital or analog down-conversion to report phase and magnitude at a single frequency, however the digitized BPM signal may contain many more harmonics and a larger bandwidth of information which may be useful. An FPGA implementation is described which captures the full bandwidth BPM signal with minimal processing and resources. This approach can be scaled to captures as many beam harmonics as needed, limited only by the bandwidth of the ADC used. The periodic nature of the BPM signal is utilized to use time-interleaved sampling to effectively multiply the sampling rate of the ADC.

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Wednesday Poster Session / 1459

Optimization of bunch charge distribution for space charge emittance growth compensation in the PERLE injector

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Low energy electron bunches experience emittance growth due to space charge. This effect can lead to large emittances which are unacceptable for a facility like PERLE at IJCLab. PERLE will be an ERL test facility circulating a high current electron beam. The traditional method to reduce emittance due to this effect is already planned for the PERLE injector, this has a limit of how small the emittance can be reduced to. This limit is defined by the quality of the bunch as it is upon production at the cathode. The transverse and longitudinal properties of the laser pulse incident on the cathode defines some characteristics of the bunch, to which the space charge effect is related. In addition, the complex evolution of the bunch along the injector could result in optimal laser parameters which are different from the simple flattop distribution currently simulated. Presented here are simulation-based studies of the bunch charge distribution at the cathode and its subsequent evolution along the injector. An optimization of the laser parameters which create the bunch is also performed. We find that there is an optimal bunch charge shape which corresponds to minimal emittance growth.

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Wednesday Poster Session / 1460

Electro-optical spectral decoding of THz pulses at MHz repetition rates

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A far-field electro-optical (EO) setup based on a balanced detection scheme has been set up to measure the coherent synchrotron radiation (CSR) at the Karlsruhe Research Accelerator (KARA). To enable the readout with a spectrally decoded scheme (EOSD), a KALYPSO based line array camera sensitive to NIR operating at a readout rate of 2.7 MHz has been included in the set-up. In this contribution, measurement results with the KALYPSO based spectrometer in combination with a commercial THz emitter are presented.

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Wednesday Poster Session / 1461

Performance evaluation of InGaAs and silicon based micro-strip detector systems for electro-optic based electron bunch diagnostics

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At the KIT storage ring KARA (Karlsruhe Research Accelerator), electro-optical (EO) methods are used for studying electron bunch dynamics. A near-field EO experiment allows measurements of the longitudinal electron bunch dynamics and a far-field EO experiment is currently under commission to detect the temporal profile of the coherent synchrotron radiation (CSR) in the terahertz spectral domain. Both experiments employ the electro-optical spectral decoding (EOSD) technique with the ultra-fast line camera KALYPSO as a detector. Thereby, KALYPSO with different sensors (InGaAs and Si) is used to enable measurements with lasers at different wavelength ranges for EOSD and further applications.
In this contribution, the two systems are evaluated for their noise, spectral sensitivity and performance for EOSD based on fs/ps-laser pulses with central wavelengths at 1060 nm and at 1550 nm.

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Tuesday Poster Session / 1462

Intensity reach of the barrier-bucket multi-turn transfer for fixed-target proton beam from PS to SPS

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Fixed target beams are extracted in five turns from the Proton Synchrotron (PS) at CERN to fill almost half the circumference of the Super Proton Synchrotron (SPS) with each transfer. To avoid beam loss during the risetime of the extraction kickers a longitudinal gap is generated with an RF barrier-bucket scheme. However, the synchronization of the gap with the PS extraction and SPS injection kickers requires the RF system to operate without any beam feedback during the transverse splitting process at the flat-top. Low RF voltage is moreover required during the process to keep a small momentum spread. Both conditions are unfavorable for longitudinal stability and a campaign of beam measurements has been performed to explore potential intensity limitations. Up to 3.3e+13 protons have been accelerated and remained longitudinally stable at high energy. Longitudinal coupled-bunch instabilities occurring at the intermediate plateau below transition energy are moreover cured by a dipole-mode feedback system initially developed for LHC-type beams. The contribution summarizes the results of the beam tests, probing the limits of the fixed-target proton beam production.

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Monday Poster Session / 1463

A compact electron accelerator for muon production

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Muon is a unique particle. The muon is the elementary particle same as the electron, but the mass is much heavier than the electron. The muon collider can reach much higher energy than the electron-positron circular collider. Muon is useful for imaging. Recently, the anomalous magnetic moment of Muon is one of the hottest topics. In this article, a compact electron linac for muon production based on the latest super-conducting accelerator technology is considered.

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Tuesday Poster Session / 1464

3rd harmonic active EU-HOM damped cavity commissioning results

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A collaboration agreement between the ALBA, DESY and HZB institutions was signed on 2021 in order to commission the 3rd harmonic normal conducting, HOM damped, active cavity designed and prototyped by ALBA. The cavity prototype arrived to ALBA in December 2021, and successfully passed the low power RF and vacuum tests. Afterwards, in January 2022 it was sent to HZB and mounted in the SUPRALAB@HZB, in the HoBiCat bunker for bead-pull measurements and high-power conditioning. Finally, in May 2022 the cavity was installed in the BESSY-II ring for test with beam. In this contribution we summarize and highlight the major results after two years of commissioning with beam including the lengthening capability of the cavity for single bunch and homogeneous filling pattern, lifetime increase measurements, HOM damping capability and transient beam loading effects due to the presence of a gap in the filling pattern.

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Thursday Poster Session / 1465

An approachable beam loss monitor configuration and operation tool for FRIB

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The folded LINAC beamline at FRIB presents many challenges to effectively utilizing beam loss monitors (BLMs) for machine protection. Several dozens of ion chambers and neutron detectors are installed at various locations, and must have machine protection thresholds configured to meet requirements for an array of beam destinations, ion species, energies, and beam power. This presents a large number of variables to account for, and each detector needs to be handled differently given its unique position in the beamline. A tool is presented which approaches the management of these variables and sets BLM thresholds in a largely automated way that requires very little operational time or training to set up.

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Thursday Poster Session / 1466

Using a particle-in-cell model for accelerator control room applications

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Many accelerator control rooms rely on envelope models to simulate beam dynamics because they are fast and accurate at tracking the beam core. Particle-in-Cell models, however, can track particles inside and outside the core and, with the improvements of computers, are now fast enough to be used in control rooms. The Spallation Neutron Source at Oak Ridge National Laboratory is currently developing a tool to use a Particle-in-Cell model for control room applications. This report covers the progress so far and the future goals of using PyORBIT, a Particle-in-Cell simulation model, in the SNS control room.

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Wednesday Poster Session / 1468

Digital direct feedback at ALBA for beam loading mitigation

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A digital direct RF feedback (DDRF) has been implemented in the DLLRF of the ALBA synchrotron light source in order to mitigate the beam loading effects of the beam. Specifically, with the DDRF implemented in the main cavities, the tune shift due to beam loading can be minimized and therefore the DC-Robinson instability can be mitigated. It can also be used to minimize voltage drops in case of transients after a cavity loss during the operation. Also, for the next generation machine ALBA-II and applied to the active 3rd harmonic system, it can be used to fight against AC-Robinson instability induced by the harmonic cavities, increasing the damping rate of the fundamental CBI mode, and reducing the transient beam loading effects. In this contribution we present measurements with beam of the DDRF applied to ALBA main cavities, demonstrating a reduction of a factor two in the effective impedance of the cavity as seen by the beam.

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Thursday Poster Session / 1469

FRIB target thermal image processing for accurate temperature maps

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The FRIB target receives the primary beam at high power and produces fragments. The carbon disc target is rotating at 500 RPM, and is water cooled, but if one of these heat management strategies fails, local temperatures on the target can increase to the point of material damage. A thermal imaging camera was temperature was calibrated and installed for the purpose of monitoring the target temperature map in real time. Various image processing strategies were deployed to improve the accuracy and usefulness of the resulting image. Processing stages include intensity to temperature conversion, median filter to remove dead pixels, and flat field correction to compensate for vignetting and edge effects.

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Tuesday Poster Session / 1471

Investigation of longitudinal phase space distribution at MedAustron

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MedAustron is an ion therapy facility located in Wiener Neustadt, Austria, which uses third order resonant slow extraction to deliver protons and carbon ions for clinical irradiation. The beam dynamics during the slow extraction and the consequent spill characteristics depend on the longitudinal phase space distribution. Motivated by the continuously ongoing development of alternative slow extraction mechanisms, this proceeding presents investigations into the longitudinal dynamics in the MedAustron synchrotron. In particular, measurements from the orbit pick-ups and Schottky monitor signals will be compared against BLonD simulations to evaluate the longitudinal phase space distributions from injection to the end of the acceleration process.

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Wednesday Poster Session / 1472

Simulation of coupled space charge and wakefield effects in a proposed electron source upgrade to the SwissFEL

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In the injector section of electron linacs, both internal space charge forces and wakefield effects influence the beam dynamics. So far, existing simulation approaches can not account for both effects simultaneously. To fill this gap, we have developed a computational method to account for both effects self-consistently*. It couples a space charge solver in the rest frame of the bunch with a wakefield solver by means of a scattered field formulation. The novelty of this approach is that it enables us to simulate the creation of wakefields throughout the emission and acceleration process. In our contribution, we present extensive studies of the coupled wakefield and space charge effects in

a traveling wave electron gun under development at the Paul Scherrer Institute. Wakefields created by the multi-cell design and the transition to the beam pipe are accounted for. Hence, the respective influences of these causes for geometric wakefields on particle dynamics are compared, providing detailed insights into the coupling of wakefields on bunches at low energies. Specifically, uncorrelated energy spread and emittance are investigated which are of key interest for FEL operation.

Footnotes:

- J. Christ and E. Gjonaj, "Scattered field formulation for wakefield and space charge calculations" , presented at the IPAC'23, Venice, Italy, May 2023, paper WEPA088, unpublished.

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Tuesday Poster Session / **1473**

Slow extraction of a dual-isotope beam from SIS18

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Recently, the heavy ion synchrotron SIS18 at GSI was for the first time operated with a dual-isotope beam, made up of 12C3+ and 4He+. Such a beam can be used to improve carbon radiotherapy by providing online information on dose deposition, where the helium ions serve as a probe beam traversing the patient while depositing a negligible dose. For this, the accelerator has to deliver a slowly extracted beam with a fixed fraction of helium over the spill. The difference in mass-to-charge ratio of 4He compared to 12C is small enough to permit simultaneous acceleration and to make the two isotopes practically indistinguishable for the accelerator instrumentation. Yet, it may cause a temporal shift between the two components in the spill owing to the sensitivity of slow extraction to tiny tune variations. We investigated different extraction methods, and examined the time-wise stability of the dual-isotope beam with a beam monitoring setup installed in the GSI biophysics experiment room. A constant helium fraction was obtained using transverse knock-out extraction with adjusted chromaticity.

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Wednesday Poster Session / 1474

Optimization of the PERLE injector using a multi-objective genetic algorithm

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The PERLE (Powerful Energy Recovery Linac for Experiments) project requires an injector capable of delivering a beam current of 20 mA at a total beam energy of 7 MeV with 500 pC bunches. These requirements present challenges for achieving the high quality beam required for the main ERL loop. At low energy and high bunch charge, the electron bunches will predominantly experience emittance growth due to the space charge effects. The compensation of this emittance growth will be performed with the traditional method of two solenoids a single bunching cavity and a linac to reach the intended injection energy. Additionally, the control of longitudinal and transverse bunch size must be performed to meet the requirements at the end of the injector. For stable operation of PERLE a rms bunch length of < 3 mm is required, with transverse emittances < 6 mm·mrad and acceptable transverse size. Presented here is the re-optimization of the injector settings used during commissioning for two alternative DC photoguns. It is found that the former cathode does not perform to the standard of previous optimizations. However, a newly procured cathode when optimized can meet the requirements for PERLE.

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Tuesday Poster Session / 1475

Status and plans for the upgrade of the PETRA IV RF system

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In the framework of the planned upgrade of PETRA III to the fourth-generation light source PETRA IV at DESY, it is necessary to replace the more than forty-year-old RF system with state-of-the-art components to suppress coupled-bunch instabilities caused by parasitic higher-order modes (HOM). The plan is to install single-cell normal-conducting HOM-damped cavities, each driven by a high-power solid-state amplifier (SSA) at the fundamental frequency of 500 MHz. In order to suppress the negative effects of Touschek and intrabeam scattering, a third harmonic system is foreseen which lengthens the bunches and reduces their charge density. The RF system will be controlled by a low-level RF system based on the microTCA platform. In 2023, a prototype of the fundamental RF system was installed in PETRA III, which contains a HOM-damped cavity driven by a 120 kW SSA that can be operated in parallel with the existing RF system. This paper describes the planned design of the PETRA IV RF system and reports on the first results of the performance of the fundamental prototype system with beam.

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Thursday Poster Session / 1477

Updated analysis of beam halo measurements in LHC Run 2 and 3

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Measurements of the transverse beam halos in the LHC deliver crucial input for the evaluation of the performance of collimation configuration at the HL-LHC. Such measurements are carried out in various phases of the LHC operational cycle by scraping the beam with movable LHC collimators. Understanding the halo-population and halo formation mechanisms is crucial for the accelerator performance. The analysis of collimation scan data allows the evaluation of the future needs for active halo depletion mechanisms at the HL-LHC, or other ways of mitigating halo-related risks to machine availability and protection. In this contribution, LHC Run 2 and Run 3 measurements are analysed using measured bunch-by-bunch beam intensity data. Different beam parameters are explored by profiting from the availability of upgraded beam parameters in the LHC injection complex.

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Wednesday Poster Session / **1478**

Design of an isochronous achromat using transverse gradient undulators

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In a typical storage ring, the beam quality, especially the energy spread, is always relatively large for the radiation of free electron lasers.To mitigate the relatively high energy spread in the storage ring and generate FEL radiation with superior performance, we have proposed an isochronous achromat using transverse gradient undulators. In this paper, we will give a detailed theoretical analysis and parameters of stable optics in which the first-order longitudinal dispersion (i.e., R56) can be eliminated.

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Tuesday Poster Session / **1479**

Influence of deposition parameters on structures and vacuum properties of NEG coated vacuum chamber

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The non-evaporable getter (NEG) coatings provide not only conductance-free evenly distributed pumping and low thermal outgassing rates but also photon-and electron-stimulated desorption and second electron yield. NEG coatings are considered pivotal for attain-ing ultrahigh vacuum in fourth-generation diffraction storage ring vacuum systems. TiZrV thin films were deposited onto elongated CuCrZr pipes for this inves-tigation. The influence of various deposition parame-ters on the NEG

coatings was investigated. The micro-structure, surface topography, roughness, and phase composition were evaluated using Scanning Electron Microscopy, Energy Dispersive Spectroscopy, X-ray Diffraction, and Atomic Force Microscope, respective-ly. Additionally, the activation performance of the TiZrV films was investigated in relation to deposition parameters.

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WECD: Colliders and other Particle and Nuclear Physics Acclerators (Contributed) / 1480

The US effort towards making a Muon Collider

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A multi-TeV muon collider has the unique potential to provide both precision measurements and the highest energy reach in one machine that cannot be paralleled by any currently available technology. There has been significant physics interest on Muon Colliders recently as indicated by the number of publications, relevant workshops, Snowmass activities but also the P5 report. This study describes a possible set of R&D and deliverables of the muon collider accelerator R&D program in the U.S. We describe high-priority studies to be performed in the first phase that will address critical questions for deciding the future plan for a muon collider design. The goal of these studies is to firm up choices for the most challenging components of a muon collider design, and to propose and begin testing and prototyping of components and systems that are needed to have confidence in and inform our specification choices. Key areas wherein the US can provide critical contributions to the newly formed international muon collider collaboration will be discussed as well.

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Monday Poster Session / 1481

Research and application of chromatic effect in laser-driven proton therapy

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CLAPA-II, a novel proton therapy accelerator under development at Peking University and supported by the Ministry of Science and Technology of China, utilizes chromatic aberration and dispersion effects for energy selection of the laser proton beam driven by the radiation pressure acceleration (RPA). Through comprehensive research of the energy selection system using TraceWin, CLAPA-II can achieve a 3 MeV energy spread in proton beam transport. Take a deep research and prospect of chromatic effect in laser-driven proton therapy, enabling the transmission of a 6 MeV spread proton beam and enhancing beam transmission efficiency by 6.8 times based on the CLAPA-II design with a 3.8-meter beamline. Moreover, a corresponding treatment plan for beam delivery is provided, utilizing a 30-120 MeV proton beam for the treatment of head and neck tumors, with a single treatment time controlled within 20 minutes. Additionally, a lightweight gantry scheme is proposed to enhance its applicability in commercial settings for FLASH.

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Thursday Poster Session / 1482

SAFEST project, a compact C-band RF linac for VHEE FLASH radiotherapy

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FLASH Therapy, an innovative cancer treatment, minimizes radiation damage to healthy tissue while maintaining the same efficacy in tumor cure as conventional radiotherapy. Successful integration of FLASH therapy into clinical practice, specifically for treating deep-seated tumors with electrons, relies on achieving Very High Electron Energy (VHEE) within the 50-150 MeV range.
In collaboration with INFN, Sapienza University actively develops a compact C-band high-gradient VHEE FLASH linac called SAFEST. This paper presents the general layout and the main characteristics of the machine and the first prototype set for deployment at Sapienza University of Rome. This endeavor is a significant step towards the clinical implementation of FLASH Therapy.

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Wednesday Poster Session / 1483

Development of spin polarized electron sources based on III-V semiconductors at BNL

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Photocathodes capable of producing spin polarized electrons beams are required for both high energy and nuclear physics experiments. In this work, we describe in detail the commissioning of a new apparatus for photocathode characterization which includes a retarding field Mott polarimeter for the measure of photoelectron spin polarization. We will illustrate the design of superlattice structures equipped with Distributed Bragg Reflector and present the measurements of spin polarization and quantum efficiency of emitted electrons from these structures.

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Monday Poster Session / 1484

Classification of potentials for self consistent symplectic space charge

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A general theory of symplectic tracking under the influence of space charge force is not yet available, even if some specific solution was proposed [1, 2]. In this paper we will first review how the pull-back of the Lie transform can be used to self-transport the beam distribution and its associated electromagnetic potential under the effect of the space-charge. We will then classify the functions suitable for an iterative algorithm with the Lie transform. Those functions will be used to describe the electromagnetic potential of the space charge.

Footnotes:

[1] J. Qiang, "Symplectic multiparticle tracking model for self-consistent space-charge simulation,"Physical Review Accelerators and Beams, vol. 20, no. 1, p. 014203, 2017.
[2] E. Laface and J. Esteban Müller, "Self-consistent space charge tracking method based on lie transform,"in 8th Int. Particle Accelerator Conf., Copenhagen, Denmark, 2017, pp. 4454–4457.

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Monday Poster Session / 1485

Optical matching procedure employing multi-objective optimization in the transfer line of the Muon Collider

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The conceptual design of the Muon Collider aims to achieve muon beam collisions at approximately 10 TeV. Challenges, such as the imperative for a short pulse and an intense beam to prevent muon decay, necessitate an investigation into crucial design parameters. This study specifically addresses the transfer line lattice, which includes FODO-cells and a triplet, situated between the muon-proton compressor and the target. The aim is to determine the optimal lattice design for effective matching. In addressing this goal, we introduce multi-objective optimization techniques for obtaining design variables tailored to the requirements of the final focusing parameters in the presence of space charge. Additionally, we present an optimized numerical computing technique enabling parallelization and GPU acceleration, specialized for simulating the beam dynamics in the transfer line.
By comparing its performance and accuracy trade-off with a physics-constrained neural network surrogate model, our goal is to establish a time-effective tool for optimizing the muon transfer-line lattice across various input beam parameters.

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Wednesday Poster Session / 1487

Mapping the stray magnetic field at the Relativistic Heavy Ion Collider tunnel

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A new Rapid Cycling Synchrotron (RCS) [1] is designed to accelerate the electron bunches from 400 MeV up to 18 GeV for the Electron Ion Collider (EIC) [2] being built at Brookhaven National Laboratory (BNL). One of the two Relativistic Heavy Ion Collider (RHIC) rings will serve as the Hadron Storage Ring (HSR) of the EIC. Beam physics simulations for the RCS demonstrate that the electron beam is sensitive to the outside magnetic field in the tunnel. Significant magnetic fields are expected due to the HSR and the Electron Storage Ring (ESR) being at full energy during the RCS operation. The earth magnetic field at the location of the RCS center was measured throughout the circumference of 3870 m tunnel without RHIC operation. In addition, the fringe magnetic field from RHIC magnets at several locations during RHIC operation was measured and compared with simulation at different ramping currents. A robotic technology is being developed to automatically measure the stray magnetic field at any location during the RHIC (or future EIC) operation.

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Thursday Poster Session / 1489

Implementation and experience with the pilot CMDS (Cryomodule and Distribution System) control system at TS2, in view of operating the ESS superconducting LINAC cryogenics

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Co-authors: Adalberto Fontoura [1]; Emilio Asensi Conejero [1]; Jianqin Zhang [1]; Kristine Arada [1]; Marek Skiba [2]; Pawel Halczynski [2]; Per Nilsson [1]; Philipp Arnold [1]; Wawrzyniec Gaj [2]; Wojciech Blinczyk [1]

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This paper introduces the strategy for operating the cryogenic system of the ESS superconducting LINAC, emphasizing the integration of individual cryomodules and valve boxes within an unified system. The study focuses on the practical implementation of this strategy at Test Stand 2 (TS2) as a pilot project, validating the proposed control system in a real-world setting. The paper evaluates the primary goals which include performing functional tests, successful implementation, identifying control system shortcomings, and collecting valuable operator feedback for continuous improvement.

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Thursday Poster Session / 1490

Nozzle design optimization for proton FLASH therapy

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An increasing number of accelerators are pursuing FLASH radiotherapy, which promises to mitigate unwanted damage to healthy tissues by applying ultra-high dose rates. To reach this extreme intensity regime, it is necessary to maximize the transmission through the exit nozzle, apart from increasing the accelerator's output beam current. Simultaneously, the delivered beam properties must satisfy certain quality criteria that clinical applications require, such as transverse homogeneity.
For this reason, a Python-based software has been developed to optimize the design of double-scattering beam nozzles. For a user-defined set of incoming beam parameters, output field requirements and available materials, the tool searches for the most efficient scattering conditions utilizing a graphical interface. These conditions are then translated into distances and shaping of the scatterers, involving a combination of high and low-density elements in a multiple-ring arrangement. A solution for the treatment of eye tumors has been successfully calculated, implemented, and tested with beam, in order to demonstrate the capabilities of this approach.

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Thursday Poster Session / 1491

Medical irradiation studies at IBPT accelerators

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Radiation therapy is an important oncological treatment method in which the tumor is irradiated with ionizing radiation. In recent years, the study of the beneficial effects of short intense radiation pulses (FLASH effect) or spatially fractionated radiation (MicroBeam/MiniBeam) have become an important research field. Systematic studies of this type often require non-medical accelerators that are capable of generating the desired short intense pulses and, in general, possess a large and flexible parameter space for investigating a wide variety of irradiation methods.
At KIT, the accelerators of IBPT (Institute for Beam Physics and Technology) give access to complementary high-energy and time-resolved radiation sources. While the linear electron accelerator FLUTE (Ferninfrarot Linac- und Testexperiment) can generate ultrashort electron bunches, the electron storage ring KARA (Karlsruhe Research Accelerator) provides a source of pulsed X-rays.
In this contribution, first dose measurements and simulations for FLUTE and KARA using the Monte Carlo simulation program FLUKA are presented.

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Thursday Poster Session / 1492

Optics corrections and performance improvements in the Bessy II Booster

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The Bessy II Booster is a fast-ramping synchrotron which has been reliably delivering beam to the BII storage ring for several decades. As part of an effort to improve understanding and control of beam dynamics in the Booster, new instrumentation, including a turn-by-turn beam position measurement system, has recently been installed and commissioned. These instrumentation upgrades have allowed for measurement and correction of optics parameters throughout the acceleration ramp, and an understanding of mechanisms of beam loss and instabilities, which was not previously possible. Here we describe the beam position measurement system and present the results of corrections to the orbit, tune, and chromaticity throughout the acceleration ramp, and the resulting improvements to the top-up operation of Bessy II.

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Wednesday Poster Session / 1493

Progress on high power FPC development for EIC

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The Electron-Ion Collider (EIC) requires 34, 500 kW continuous-wave (cw), 591 MHz Fundamental Power Couplers (FPCs) to compensate the Electron Storage Ring's (ESR) 10 MW of synchrotron radiation and other beam driven losses. This paper will describe the FPC design and fabrication status, particularly the technical challenges associated with 500 kW cw operation and the innovative design addressing this. Of important note, the RF window based on 99.5% purity alumina window was designed to be wide operating bandwidth, which makes it applicable to FPCs for the EIC's RF systems outside of the ESR with frequencies ranging from 197 MHz-591 MHz. This results in significant savings by eliminating the need to design multiple different RF windows for the different RF systems. This paper will describe the design and prototype progress of the High Power FPC for EIC.

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Wednesday Poster Session / 1494

An engineering prototype of a late stage ionization cooling cell for a muon collider

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Achieving the low emittances required for a muon collider requires ionization cooling. Much of that cooling occurs in compact cooling cells where superconducting coils and conventional RF cavities are closely interleaved [1]. The MICE experiment demonstrated the ionization cooling principle [2]. The real challenges for these cooling cells reside in their engineering challenges: high field solenoids, RF cavities, and absorbers, often designed near technological limits, placed in close proximity to each other. We thus propose to build a 1.5 cell prototype ionization cooling cell to demonstrate the capability of constructing an ionization cooling and to provide engineering input for the design of such beamlines. The cell will contain RF cavities for one cell, and magnets for two cells, the latter to ensure we have addressed the full range of interactions between the magnets. Essentially we will build the most challenging design from [1] or a similar study that can be constructed with currently available technology to ensure we are exploring technological limits.

Footnotes:

[1] D. Stratakis and R. B. Palmer, "Rectilinear six-dimensional ionization cooling channel for a muon collider: A theoretical and numerical study", Phys. Rev. ST Accel. Beams 83, 031003 (2015).
[2] MICE Collaboration, "Demonstration of cooling by the Muon Ionization Cooling Experiment," Nature 578, 53–59 (2020).

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TUCN: Photon Sources and Electron Accelerators (Contributed) / 1495

Results from CXLS commissioning

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The Compact X-ray Light Source (CXLS) is a compact source of femtosecond pulses of x-rays that is now commissioning in the hard x-ray energy range 4-20 keV. It collides the beams from recently developed X-band distributed-coupling, room-temperature, standing-wave linacs and photoinjectors operating at 1 kHz repetition rates and 9300 MHz RF frequency, and recently developed Yb-based lasers operating at high peak and average power to produce fs pulses of 1030 nm light at 1 kHz repetition rate with pulse energy up to 200 mJ. These instruments are designed to drive a user program in time-resolved x-ray studies such as SAXS/WAXS, XES and XAS, femtosecond crystallography as well as imaging. The different technical systems also act as prototypes for the more advanced CXFEL discussed elsewhere in these proceedings. We present the performance of the CXLS technical components and initial x-ray results.

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Wednesday Poster Session / 1496

Implementing bunch-by-bunch diagnostics at the KARA booster synchrotron

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In the upcoming compact STorage ring for Accelerator Research and Technology (cSTART), LPA-like electron bunches are only stored for about 100 ms, in which the equilibrium emittance will not be reached. Therefore, to measure parameters such as bunch profiles, arrival times and bunch current losses, bunch-resolved diagnostics are needed.
The booster synchrotron of the KARA accelerator accepts pre-accelerated bunches from a racetrack microtron and accelerates them further over a 500 ms long energy ramp. As the KARA booster synchrotron has a similar circumference and injection energy as the cSTART storage ring, new bunch-by-bunch diagnostics developed there can be transferred to the cSTART project with minimal effort.

Currently the diagnostic system of the booster is not designed for bunch-by-bunch diagnostics, thus after using the booster as a testbed for cSTART, such a system could be used permanently.
At the booster synchrotron we use the picosecond sampling system KAPTURE-II to read-out a button beam position monitor and an avalanche photo diode at the synchrotron light port and compare the results with a commercial bunch-by-bunch system.

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Wednesday Poster Session / 1497

Upgraded multiprobe sample inserts for thin film SRF cavity development

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Optimization of thin film (TF) coating parameters for producing SRF cavities requires rapid testing of superconducting properties. A dedicated multiprobe facility built at Daresbury Lab, based on a liquid He free cryocooler, allows us to perform such measurements. The facility has vacuum tubular inserts where the sample probe is loaded and cooled with He gas. The experimental inserts were either newly built or upgraded: (1) A DC resistance experiment allows measurements of critical temperature (Tc) and residual resistance ratio (RRR) on nonconductive substrates (e.g. sapphire). A newly designed insert allows better temperature control and easier sample change. (2) A new insert for magnetic field measurements of Tc on both conductive and nonconductive substrates. (3) An existing insert for planar magnetic field penetration experiments was significantly redesigned. It operates at lower temperatures (>5.5 K), parallel magnetic fields <600 mT, increased sensitivity and enables measurements of field of full flux penetration (Bfp) and Tc on various substrates: copper and sapphire, the latter of which was impossible to measure with an older design.

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Tuesday Poster Session / 1498

Modeling of single-beam and multiple-beam klystrons by the TESLA-family of large-signal codes

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Klystrons and Multiple-Beam Klystrons (MBKs) are widely used or proposed to be used in accelerators as high-power RF sources. Development and optimization of klystron and MBK's designs is aided by the use of different simulation tools, including highly efficient large-signal codes. We present an overview of capabilities of the TESLA-family of 2.5D large-signal codes, which have been developed at the Naval Research Laboratory (NRL) and which are suitable for the accurate modeling of single-beam and multiple beam klystrons. TESLA algorithm does support proper treatment of 'slow'and 'reflected'particles, what enables accurate modeling of high-efficiency klystrons. Recently developed more general TESLA-Z algorithm is based on the impedance matrix approach and enabled accurate, geometry-driven large-signal modeling of devices with such challenging elements as multiple-gap cavities, filter-loading, couplers and windows. Finally, recent introduction of the reduced-order, 1.5D versions of the TESLA algorithms enabled much faster, but limited modeling options. Examples of applications of TESLA-family of codes to the modeling of advanced single-beam and MBKs will be presented.

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Prototype and high power test of SiC HOM absorber for EIC

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The Electron Ion Collider (EIC), to be built at BNL, is a unique high-energy, high-luminosity, polarized electron-proton/ion collider. High-Order-Mode (HOM) damping is a big challenge for EIC electron accelerators, especially for 17 single-cell 591 MHz SRF cavities in EIC Electron Storage Ring (ESR) because of its high electron beam current (up to 2.6 A). Room temperature SiC Beamline HOM absorbers (BLA) were chosen as the baseline of the HOM absorber, due to its broadband and high power capability. A SiC HOM absorber was prototyped to test a preparing process and high power handling capability. The high power test demonstrates 0.3 W/mmˆ2 of power handing capability by far, and we are going higher power to test its limit. This paper will present the preparing process (shrink fit, cleaning and outgassing test) and high power test results of the SIC HOM absorber prototype.

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Thursday Poster Session / 1500

STAR High-Energy Linac status: complete installation acceptance tests.

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The installation of the STAR High-Energy Linac, the energy upgrade of the Southern European Thomson Back-Scattering Source for Applied Research (STAR) project at the University of Calabria, was conducted by INFN by the end of 2023. This paper presents the testing procedures aimed at confirming the consistency, completeness, and quality of the STAR accelerator upgrade installation (electron beam energy boost from 65 MeV up to 150 MeV). We illustrate the installation and testing of the electrical, hydraulic and related automation and auxiliary systems. We will discuss the high-power commissioning of the two C-band RF power stations and testing of the low-level C-band RF system and control system configuration based on EPICS. Finally, we will describe the layout and testing of the vacuum system, the characterization and commissioning of the magnets with related power supplies and the assessment of the installed diagnostics devices. The linac commissioning as well as electron beam measurements are planned for Summer 2024, due to pending radioprotection authorizations.

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Wednesday Poster Session / 1501

Characterizing optical synchrotron radiation in the geometric optical phase space and optimizing the energy transport to a photo detector

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At the Karlsruhe Research Accelerator (KARA) facility, an electron beam is generated by a thermionic electron gun, pre-accelerated to 53 MeV by a microtron and then ramped up to 500 MeV in a booster synchrotron before being injected into the storage ring, where a final electron energy of 2.5 GeV is reached. Compared to a 2D camera, when using 1D photodetectors either directly at the synchrotron light port or after a fiber optics segment, the optic design goal is to maximize the optical intensity at the photo detector, rather than to keep spacial coherence. In this field of non-imaging optics the emitter, optical setup and sink can be modeled in the optical phase space, with the etendue being the conserved quantity and position and angle the independent variables. In this contribution we describe the synchrotron radiation emitted at a dipole in the KARA booster synchrotron and the imaging setup into an optical multimode fiber with this formalism and compare the results with measurements at the synchrotron light port of the booster synchrotron.

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Tuesday Poster Session / 1503

Injection Optimization via Reinforcement Learning: From Simulation to Real-World Application

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This research presents a framework for the application of Reinforcement Learning (RL) to optimize the injection process at particle accelerator facilities. By utilizing a tailored and enhanced RL agent, we demonstrate its capability to dynamically optimize the beam's cross-section to meet predefined targets effectively at the Cooler Synchrotron COSY facility in Jülich, Germany. The agent, trained exclusively in a simulated environment, successfully applied its learned strategies during live operations, achieving optimization accuracy comparable to that of a human operator but in a notable less time. An empirical analysis of the architecture components—dense layers, observation noise, history, and domain randomization—demonstrates their individual and collective importance in preparing the agent for real-world applications. The findings highlight the potential of RL to enhance the efficiency of operations in particle accelerators.

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Monday Poster Session / 1504

Start-to-end simulations of microbunching instability based on optimized velocity bunching in linac-driven FELs

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The microbunching instability (MBI) driven by beam collective effects can cause significant electron beam quality degradation in advanced X-ray free electron lasers. Typically, multiple stage magnetic bunch compressors used to generate high peak current electron beam will dramatically amplify the microbunching instability. In this paper, by redesigning the solenoid elaborately and adopting a dual-mode buncher cavity with the third harmonic mode used to correct the RF curvature, in combination with the evolutionary many-objective beam dynamics optimization, it is potential for the electron beam to be further compressed in velocity bunching (VB) process. Therefore, a VB plus one bunch compressor could be a promising alternative scheme to achieve moderate peak current beam for X-ray FELs. Start-to-end simulations based on the Shanghai high-repetition-rate XFEL and extreme light facility proves the feasibility of the scheme in suppressing the additional MBI gain due to multi-stage magnetic bunch compressors.

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Monday Poster Session / 1505

Bunch compression with a beam energy control unit consisting of DBA structures

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The bunch-to-bunch energy control of the electron beam is crucial in the continuous wave XFEL facility. Recently, a delay system based on Double Bend Achromat (DBA) was proposed for the SHINE linear accelerator to achieve this goal. On this basis, we further optimize this structure to realize the bunch compression/decompression while maintaining the electron beam qualities. Here, we will discuss the related lattice design and strat-to-end simulations.

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Tuesday Poster Session / 1506

Control system for insertion devices at the APS-U

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The insertion devices serve as the primary x-ray sources at the Advanced Photon Source (APS). In the context of the APS-Upgrade project, new Hybrid Permanent Magnet Undulators (HPMUs) have been designed and manufactured, utilizing servo motors as the drivers to amplify power for more precise control. At the same time, existing HPMUs equipped with legacy stepper motors are systematically re-fabricated, with the goal of replacing the stepper motors with servo motors. In tandem with these mechanical modifications, a comprehensive upgrade is implemented for both the control hardware and software. This upgrade involves the integration of industrial standard devices, with a particular focus on the replacement of motor controllers and drivers. In this regard, the Kollmorgen PCMM and AKG servo drives are introduced. The soft IOCs are developed and deployed to replace the VME IOC across 24 sectors for revolver and planar devices. In this paper, we will present our work on the new insertion device control system, covering aspects such as the architecture, control mechanisms, interlock protocols, and development and implementation of tools for diagnostics and troubleshooting.

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Radiation load studies for the proton target area of a multi-TeV muon collider

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Muon production in the multi-TeV muon collider studied by the International Muon Collider Collaboration is planned to be performed with a high-power proton beam interacting with a fixed target. The design of the target area comes with a set of challenges related to the radiation load to front-end equipment. The confinement of the emerging pions and muons requires very strong magnetic fields achievable only by superconducting solenoids, which are sensitive to heat load and long-term radiation damage. The latter concerns the ionizing dose in insulation, as well as the displacement damage in the superconductor. The magnet shielding design has to limit the heat deposition and ensure that

the induced radiation damage is compatible with the operational lifetime of the muon production complex. Finally, the fraction of the primary beam passing through the target unimpeded poses a need for an extraction channel. In this study, we use the FLUKA Monte Carlo code to assess the radiation load to the solenoids, and we explore the possible spent proton beam extraction scenarios taking into account the constraints stemming from the beam characteristics and the required magnetic field strength.

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Monday Poster Session / 1508

Effects of the ALBA slab movement on ALBA-II

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ALBA, the Spanish third generation synchrotron light source, is studying the future construction in the same location of a fourth generation light source called ALBA-II. Since the construction of ALBA in 2008, its critical slab has moved significantly, changing with it the accelerator elements positions. In this study, the effects on closed orbit and beam optics errors are simulated from data of the survey campaigns on the ALBA storage ring and compared to measurements in terms of orbit, linear optics, and orbit correctors budget. The results of this study on ALBA are used to infer the effect of the slab movement on the future machine through simulations, predicting yearly and seasonal changes. Plausible correction methods are discussed.

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Performance of a longitudinal bunch by bunch feedback in a system with a passive harmonic cavity

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While designed to be inherently stable, the accelerator upgrade SLS 2.0 will have a longitudinal multi-bunch feedback system, to be used as a diagnostics device and as a fallback against unexpected problems. Modelling the performance of the system is complicated by the presence of a passive harmonic cavity introduced for longer bunch lengths and correspondingly higher stability thresholds, which has the following effects: the voltage of the harmonic cavity varies with the beam current leading to a variation of the synchronous frequency, specially pronounced in the initial injection at very low currents. Even at full current, the presence of the ion clearing gap provokes transients in the main and harmonic system leading to a transient variation of the synchronous frequency over the bunch train. Another effect of the RF transients is a variation in the synchronous phase over the bunch train, which leads to cross talk effects, the open loop gain starts to vary with the order of the coupled bunch oscillation. The feedback filter needs to take account of all these effects for a satisfactory performance.

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Wednesday Poster Session / 1510

Measurement of the field quality and repeatability on the first Q2 magnets for HL-LHC

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The Q2 insertion quadrupoles for the HL-LHC upgrade of the LHC are currently being produced and tested. The test of the first units provides valuable information about the static and dynamic field quality of superconducting accelerator magnets built from Nb3Sn coils. This paper presents the results of the magnetic measurements performed on the prototype and series magnets from the point of view of field quality and field repeatability, effects from flux-jumps and persistent currents, magnetic axis, and alignment. It also gives an outlook on the possible impact on the beam dynamics and on the field description for operation.

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Wednesday Poster Session / 1512

Design of the low-energy acceleration stages of the muon collider

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The Muon Collider aims to produce collision of μ- and μ+ beams at a center-of-mass energy of 10 TeV by using various stages of acceleration and cooling. In order to bring the muon beams to the relevant energy before injection into the collider ring, both μ- and μ+ beams are proposed to be accelerated on same beamline by a series of fast acceleration stages including Recirculating Linac Accelerators (RLA) and a Rapid Cycling Synchrotron (RCS). One of the multi-pass RLAs is used to accelerate the beam from 5 GeV to 62 GeV. The need for fast acceleration, a wide range of operating energies, a large longitudinal and transverse emittance, and a high-bunch charge bring many challenges in the design. In this study, we present a cost-effective lattice for the linac and arcs of the RLA and discuss instabilities in the proposed lattice.

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Monday Poster Session / 1513

Optimization of ELSA electron beam transport for its inverse Compton scattering X-ray source

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ELSA LINCS (ELSA Linac INverse Compton Source) at CEA DAM DIF is an Inverse Compton Scattering X-ray source in the 5-40 keV range, through interaction between 10-30 MeV electrons with a Nd:YAG laser. The source was upgraded to increase the X-ray flux produced in the 5-40 keV range. The new experimental setup and imaging systems have been modified for compatibility with fundamental emission at 1064 nm and for better mechanical stability. The upgrade also includes installation of a new RF linearizing cavity before magnetic compression, to improve bunch compression. Experimental optimization of the beam transport has been achieved, relying on recent detailed simulation work. Results taking advantage of this optimization are presented: achieved bunch duration, emittance, dimension at interaction point, for several electron energies and several bunch charges between 50 pC up to 1 nC. Comparisons with simulations provide an insight about major contributions to emittance growth. Achievable X-ray flux through Inverse Compton Scattering and applications are discussed.

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Beam tomography and emittance measurement at the CERN Linear Electron Accelerator for Research

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The CERN Linear Electron Accelerator for Research (CLEAR) has been operating since 2017 as a user facility providing beams for a large variety of experiments. Its photocathode-based linear accelerator can accelerate electrons up to 220 MeV with a bunch charge of 0.1-1.5 nC, from single bunches up to 150 bunches per train. Its wide range of applications require different beam parameters, requiring the operators to be able to perform a fast measurement of the Twiss parameters at any location of beamline. To this end, we have developed a quadruple scan tool that can compute Twiss parameters at a dedicated location of the CLEAR beamline using single and multiple quadrupoles. In this paper, we present measurement results based on different fitting algorithm and tomographic reconstruction of the phase space with the results in excellent agreement.

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Tuesday Poster Session / 1515

Design optimization of a dual energy electron storage ring cooler for improved cooling performance

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A dual energy electron storage ring cooler was proposed to maintain a good hadron beam quality against intra-beam scattering and all heating sources in a collider. This configuration has two energy loops. Electron beam in the low energy loop extracts heat away from the hadron beam through Coulomb interaction, while electron beam in the high energy loop loses heat through its intrinsic synchrotron radiation damping. Early studies of this concept show promising results and demonstrate its validity. This paper presented further optimization of optics design and parameters, and evaluation of improved cooling performance.

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Enhancing beam intensity in RHIC EBIS beam line via GPTune machine learning-driven optimization

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The utilization of machine learning techniques in accelerator research has yielded remarkable advancements in optimization strategies. This paper presents a pioneering study employing a machine learning algorithm, GPTune, to optimize beam intensity by adjusting parameters within the EBIS injection and extraction beam lines. Demonstrating significant enhancements, our research showcases a remarkable 22% and 70% improvements in beam intensity at two different measurement locations.

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Monday Poster Session / 1517

RHIC Au-Au operation at 100 GeV in Run 23

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The Relativistic Heavy Ion Collider (RHIC) Run 23 program consisted of collisions of 100 GeV gold beams at two collision points for the first time since 2016; the sPHENIX collaboration used the beam to commission their new detector systems while STAR took physics data. Completion of sPHENIX construction pushed the start of the run to May, forcing the collider complex to operate over the summer months and incurring lower than normal availability due to heat and power dip related problems. Issues with dynamic pressure rise during acceleration through transition resulted in a slower ramp up of intensity compared to prior years. Finally, a failure of a warm-to-cold current lead interface in the valve box for the Main Magnet power supply forced the run to end. This paper will discuss the progress made by each experiment and the failure mode, repair and mitigation efforts in preparation for Run 24.

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Design and optimization of an ERL-based X-ray FEL

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An energy-recovery-linac (ERL)-based X-ray free-electron laser (FEL) is proposed considering its three main advantages: i) shortening the linac by recirculating the electron beam by high-gradient SRF cavities, ii) saving the klystron power and reducing the beam dump power through the energy recovery in the SRFs, iii) producing a high average photon brightness with high average beam current. Such a concept has the capability of optimized high-brightness CW X-ray FEL performance at different energies with simultaneous multipole sources. In this paper, we will present the preliminary results on the optics design, parameter optimization, beam dynamics study and identification of potential R&D aspects.

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Monday Poster Session / 1519

The CXFEL project at Arizona State University

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The CXFEL is designed to produce attosecond-femtosecond pulses of soft X-rays in the range 300-2500 eV using nanobunched electron beams and a very high power laser undulator. The project includes 5 X-ray endstations with applications in biology, quantum materials, and AMO science. The CXFEL Project overall includes both the CXFEL and the nonlasing hard X-ray CXLS that is described elsewhere in these proceedings. The CXFEL has recently completed a 3-year design phase and received NSF funding in March 2023 for construction over the next 5 years. Both CXFEL and CXLS instruments use recently developed X-band distributed-coupling, room-temperature, standing-wave linacs and photoinjectors operating at 1 kHz repetition rates and 9300 MHz RF frequency. They rely on recently developed Yb-based lasers operating at high peak and average power to produce fs pulses of 1030 nm light at 1 kHz repetition rate with pulse energy up to 400 mJ. We present the design and initial construction activities of the large collaborative effort to develop the fully coherent CXFEL.

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high current DC gun for low energy RHIC cooler project

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Electron cooling of ion beams employing RF-accelerated electron bunches was successfully used for the RHIC physics program in 2020 and 2021. Electron cooler LEReC uses a high-voltage photoemission electron gun with stringent requirements for beam current, beam quality, and stability. The electron gun has a photocathode with a high-power fiber laser, and a novel cathode production, transport, and exchange system. It has been demonstrated that the high-voltage photoemission gun can continually produce a high-current electron beam with a beam quality suitable for electron cooling. We describe the operational experience with the LEReC dc photoemission gun in RHIC and discuss the important aspects needed to achieve the required beam current, beam quality, and stability. We also present recent gun tests in which stable operation at 50 mA CW beam current was established, as well as future plans.

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Thursday Poster Session / 1523

Investigating X-ray detector systems using Monte Carlo techniques

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Digital Tomosynthesis (DT) is a 3D mode of x-ray imaging. Adaptix Ltd have developed a novel mobile DT device enabled by implementing an array of R-ray emission points and a flat-panel detector.

This device gives access to human and animal 3D imaging, as well as to non-destructive material evaluation. DT is not as clinically popular as Computed Tomography (CT) or radiography, and flat-panel source DT even less so, thus creating scope to investigate the optimal flat-panel detector technology for this modality. Geant4, a Monte Carlo Particle Transport code, has been used to simulate the Adaptix Ltd system to do this. Parameters such as the material composition of the detectors, the exact detection method and the inclusion vs exclusion of a scintillation layer are tested in this simulation environment. This work aims to find the optimal flat-panel detector design by comparing different scintillator compositions and structures for this DT method. Therefore, the ideal detector that preserves the advantages of this low-cost, low-dose scanning approach is determined.

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Novel materials for next-generation accelerator target facilities

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As beam power continues to increase in next-generation accelerator facilities, high-power target systems face crucial challenges. Components like beam windows and particle-production targets must endure significantly higher levels of particle fluence. The primary beam's energy deposition causes rapid heating (thermal shock) and induces microstructural changes (radiation damage) within the target material. These effects ultimately deteriorate the components'properties and lifespan. With conventional materials already stretched to their limits, we are exploring novel materials including High-Entropy Alloys and Electrospun Nanofibers that offer a fresh approach to enhancing tolerance against thermal shock and radiation damage. Following an introduction to the challenges facing high-power target systems, we will give an overview of the promising advancements we have made so far in customizing the compositions and microstructures of these pioneering materials. Our focus is on optimizing their in-beam thermomechanical and physics performance. Additionally, we will outline our imminent plans for in-beam irradiation experiments and advanced material characterizations.

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Tuesday Poster Session / 1525

Production and validation of the RF cooling damper for the LHC injection kickers

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Fast single-turn injection kicker systems deflect incoming beam onto the orbit of the LHC. The higher intensities of High Luminosity (HL) LHC beams are predicted to cause the ferrite yokes of the LHC injection kicker magnets (MKI), in their current configuration, to heat up to their Curie temperature. Studies to reduce the beam induced heating have been carried out over the past years and resulted in a design featuring a water-cooled RF damper. A significant portion of the beam induced power has been relocated from the yoke to a ferrite in the RF damper. The ferrite damper is cooled via a copper sleeve, brazed to the ferrite, via a set of water pipes. The manufacturing of this RF damper system is challenging since different materials are brazed together to form a complex and fragile assembly, optimized for heat transfer, installed in an ultra-high vacuum environment. This paper outlines fabrication methods and their reproducibility, compares the results of measurements of the thermal interface between the ferrite and copper sleeve, and concludes on the challenges of assuring a production technique that results in a reliable and suitable thermal interface.

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Thursday Poster Session / 1526

Accelerator beam kicker review

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The following paper embarks on an in-depth exploration of extraction kickers employed at some of the most renowned particle physics and neutron science facilities worldwide. Specifically, we delve into the extraction kickers utilized at the Spallation Neutron Source, Fermi National Accelerator Laboratory, Los Alamos Neutron Science Center, and delve into the novel inductive adder structures. These facilities represent the forefront of scientific research, housing state-of-the-art technologies and extraction kicker systems that play a fundamental role in advancing our understanding of particle physics, neutron science, and related domains. Throughout the paper, we will investigate the design principles, operational intricacies, and technological innovations associated with these extraction kickers. By analyzing existing research and scholarly works, we aim to provide a comprehensive overview of the unique challenges and advancements encountered at each facility.

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Monday Poster Session / 1527

Design and status of the SHINE injector

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Shanghai HIgh repetitioN rate XFEL and Extreme light facility (SHINE) is an x-ray FEL facility, consisting of an 8 GeV CW superconducting linac and 3 FEL undulator lines, covering the spectral ranges 0.4-25 keV. Photoinjector using VHF gun is one of the key part of the facility. The installation of the electron gun section of the SHINE injector has been completed in August 2023. RF conditioning and commissioning were carried out from September to December. In this paper, we will introduce the installation progress of the injector and show some commissioning results of the electron gun section.

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Wednesday Poster Session / 1528

The RF BPM pickup and feedthrough testing results in the lab and SR for APS-U

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The BPM feedthroughs were manufactured and tested at the vendor and the APS lab. All feedthroughs were sorted in groups of four according to their capacitance. Four feedthroughs with close capacitance were welded to the housing in an assembly. The assemblies were measured in the APS lab to confirm their electrical performance acceptable and their x/y offsets were calculated according to VNA data. After the BPM assemblies were installed in the SR, they were measured again to verify their connections. The x/y offsets including the cables were compared with the previous data and will be used as the reference in beam commissioning. The testing results at the vendor, APS lab and APS-U SR were analyzed.

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Wednesday Poster Session / 1529

Laser-based cleaning of phocoathode at SXFEL

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The Shanghai soft X-ray Free-Electron Laser user facility has open to users since 2023. The electron beam is generated by Cu photocathode, integrated in an S-band electron gun. As the photocathode

quantum efficiency drops to less than 1e-5, photocathode cleaning technology based on drive laser is used to improve the performance of the photocathode.

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Monday Poster Session / 1530

High gradient C-band cryogenic copper silver structures

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C-band accelerators have been of particular interest in recent years due to their ability to provide high gradients and transport high charge beams for applications such as colliders and medical technologies. New Advancements in high gradient technologies that can suppress the breakdown rate in a particular structure by using distributed coupling, cryogenic cooling, and copper alloys. Previous work has shown each of these separately to significantly improve the maximum gradient. In this work, for the first time, we will combine all three methods in an ultra-high gradient structure and benchmark the difference between Cu and CuAg. The exact same structures were previously tested at room temperature and showed gradients in excess of 200 MeV/m and a 20% improvement in the CuAg version over its pure Cu counterpart [1]. These structures are now tested at 77K simultaneously. They were found to perform similarly due to the presence of significant beam loading. Taking beam loading into account, a maximum achievable gradient of 200 MeV/m achieved for a 1 µs pulse at an input power of 5 MW into each cavity with a breakdown rate of 1e-1 breakdown/pulse/m.

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Wednesday Poster Session / 1531

ESS installation progresses

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The ESS Linac on-going installation and technical commissioning are progressing towards the first operation at 870 MeV on the beam dump in fall 2024. Four out of five DTL tanks were commissioned with beam in the normal conducting section (NCL) and a pilot installation of 1 spoke and 1 elliptical cryomodule was conducted in the superconducting (SCL) part of the ESS tunnel in spring 2023. Regarding the latter, the goal was both to demonstrate the installation sequence as well as the completion of the cryogenic distribution system (CDS) commissioning. A total of 13 spoke and 14 elliptical cryomodules (9MB + 5HB) are being installed. Overall, 30 elliptical cryomodules will be necessary to allow the 5 MW potential power after the target commissioning. The CM test plan along with the installation of the necessary RF power stations up to the 2 MW stage for the first project phase is advancing well. This contribution will report on the deliveries from the In-kind partners, SRF activities at the ESS test stands including the resolution of non-conformities and focus on the installation and technical commissioning of the linac components.

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Tuesday Poster Session / 1532

Single-electron experiments at the DELTA storage ring

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Scraping the beam in an electron storage ring while counting photons of synchrotron radiation is a well-known technique to produce a beam of a single or a few electrons which enables new experimental opportunities compared to standard accelerator physics. Synchrotron radiation is usually described as an electromagnetic wave in the frame of classical electrodynamics. The emission of photons by a single electron, on the other hand, reveals the quantum nature of synchrotron light. The statistical properties of photons contain additional information, which can be used for beam diagnostics purposes. The paper describes the experimental setup and first single-electron measurements at the 1.5-GeV synchrotron radiation source DELTA at TU Dortmund University.

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Tuesday Poster Session / 1533

Vertical quadrupole electric field systematics and its mitigation in the proton-EDM ring

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With the present proton electric dipole moment (pEDM) storage ring design [1], the counter rotating (CR) beam closed orbits will separate vertically if there is a nonzero radial magnetic field Bx. If a quadrupole electric field Ey is also present, then its direction would be opposite for the CR beams hence it becomes a potential source for a false EDM signal. In this work, we model this non-zero stray radial magnetic field Bx as a field perturbation source and it would cause the closed orbit distortion around the pEDM ring. This EDM-like background is due to the product of the electric quad multipole and the closed orbit distortion. We found the difference of the precession rates for CR beams and quadrupole magnet polarity would be a cure to this systematics.

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[1] Zhanibek Omarov et al., Phys. Rev. D 105, 032001 (2022).

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Wednesday Poster Session / 1535

REBCO sample testing at high power X-band

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SRF materials such as niobium have been extremely useful for accelerator technology but require low temperatures operation < 9 K. The development of high temperature superconductors (HTS) is promising due to their to their high critical temperature 89.5 K. This work intends to determine the high-power RF performance of such materials at X-band (11.424 GHz). Two kinds of REBCO coatings (thin film deposition and soldered tapes) on a copper substrate were tested. Testing was done in a hemispherical TE mode cavity due to its ability to maximize the magnetic field on the sample and minimize the electric field. We will report conductivity vs temperature at low and high power. We determine the quench field in the REBCO sample and explain the evidence which shows that the quenching is most likely due to reaching the critical current and not due to average applied heat load for powers up to 1.6 kW.

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Monday Poster Session / 1536

Microbunching gain evaluation of bunch compressor designs

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The Electron-Ion Collider (EIC) is currently under development to be built at Brookhaven National Lab and requires cooling during collisions in order to preserve the quality of the hadron beam; an Energy Recovery Linac (ERL) operated at either 150 or 55 MeV is being designed to provide cooling through the mechanism of Coherent electron Cooling (CeC). This requires that the electron beam delivered to the cooling section be minimally perturbed by the bunch compressor located between

the injector and the main linac. This paper evaluates the microbunching gain of the compressor design for the optics of both energies and considers the performance of alternate designs.

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Tuesday Poster Session / 1538

Echo-enabled harmonic generation at the DELTA storage ring

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Echo-enabled harmonic generation (EEHG) has been proposed as a seeding method for free-electron lasers but can also be employed to generate ultrashort radiation pulses at electron storage rings. With a twofold laser-electron interaction in two undulators, each followed by a magnetic chicane, an electron density pattern with a high harmonic content is produced, which gives rise to coherent emission of radiation at short wavelengths. The duration of the coherently emitted pulse is given by the laser pulse lengths. Thus, the EEHG pulse can be three orders of magnitude shorter and still more intense than conventional synchrotron radiation. At the 1.5-GeV synchrotron light source DELTA at TU Dortmund University, the worldwide first implementation of EEHG at a storage ring was achieved by reconfiguring an electromagnetic undulator. The paper reviews the experimental setup and describes the present status of the project.

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Monday Poster Session / 1539

Towards short-pulse generation at FLASH via laser-assisted electron bunch manipulation

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The FLARE project aims to investigate special operation modes of the laser heater at the free-electron laser FLASH in Hamburg that enable the generation of few- or possibly sub-femtosecond soft X-ray pulses. To this end, laser pulses of the laser heater are split and then recombined after one pulse has been delayed. By controlling the interference of both pulses via their temporal overlap, a longitudinally non-uniform heating of the electron bunches can be achieved. Utilizing this, two short-pulse generation schemes are to be implemented as part of the FLARE project. In the first scheme, the energy spread of the bunch is increased to a degree that inhibits lasing, leaving only a small unheated region which emits a short FEL pulse. The second scheme works by imprinting an energy modulation with a linearly increasing amplitude onto the longitudinal phase-space distribution of the bunch. In subsequent magnetic chicanes, this phase-space structure results in a localized compression of the bunch, creating an extremely short current spike, which might be used to produce an X-ray pulse on the same time scale. The FLARE setup as well as first experimental results are presented.

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Wednesday Poster Session / 1540

Single shot THz spectrometer for FEBE experimental facility

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The CLARA facility at Daresbury Laboratory (UK) is capable of producing femtosecond-scale electron bunches, which will be used in the Full Energy Beam Exploitation (FEBE) beamline. CLARA will employ multiple techniques to manipulate the longitudinal beam profile, including a variable bunch compressor and velocity bunching. Existing longitudinal THz diagnostics on CLARA are multi-shot methods, but for user experiments a single-shot diagnostic operating at the machine repetition rate of 100 Hz is needed. Here, we present a single-shot, 4-channel calorimeter system for use in FEBE to measure the spectrum of THz Coherent Transition Radiation (CTR), which can then be used to estimate longitudinal bunch length. In the device, a set of frequency selective elements designed at STFC RAL Space (UK) distribute specific bandwidths between calorimeters, which use a single-shot detector based on earlier wideband single-shot THz diagnostics developed for CLARA. Characterization of the frequency selective elements has been done using both simulations and Time-domain spectroscopy. The instrument is currently being assembled and tested, and commissioning with beam is planned for early 2024.

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Monday Poster Session / 1541

Laser-plasma injector for an electron storage ring

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Laser-plasma accelerators (LPAs) are compact accelerators with field gradients that are approximately 3 orders of magnitude higher than RF-based machines, which allows for very compact accelerators. LPAs have matured from proof-of principle experiments to accelerators that can reproducibly generate ultrashort high-brightness electron bunches. Here we will discuss a first combination of LPAs with an electron storage ring, namely an LPA-based injector for the cSTART ring at the Karlsruher Institute of Technology (KIT). The cSTART ring is currently in the final design phase. It will accept electron bunches with an energy of 50 MeV and will have a large energy acceptance to accommodate the comparably large energy spread of LPA-generated electron beams. The LPA will be required to reproducibly and reliably generate 50 MeV electron bunches with few percent energy spread. To that end, different controlled electron injection methods into the plasma accelerating structure, tailored plasma densities are explored and beam transfer lines to tailor the beam properties are designed.

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Tuesday Poster Session / 1543

Numerical optimization of the Diamond-II storage ring optics

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The design performance of the 3.5 GeV Diamond-II low-emittance electron storage ring has been studied as a function of the linear and nonlinear lattice tuning parameters. An alternative working point has been identified which optimizes the beam lifetime and the injection efficiency for off-axis injection. The simulations include misalignment and field strength errors, with the number of machine seeds tuned to achieve converging results whilst minimizing computational time. The optimization takes care to preserve the design beam emittance, energy spread, Twiss parameters and cell tunes. The results are presented for 2D parameter scans and multi-objective optimization techniques such as the Multi-Objective Genetic Algorithm (MOGA).

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Monday Poster Session / 1545

Global betatron coupling compensation for the hadron storage ring of the Electron-Ion Collider

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The Electron Ion Collider (EIC), to be constructed at Brookhaven National Laboratory, will collide polarized high-energy electron beams with hadron beams, achieving luminosities up to 1e+34 cmˆ−2 sˆ−1 in the center-mass energy range of 20-140 GeV. The Hadron Storage Ring (HSR) of the EIC will utilize the arcs of the Relativistic Heavy Ion Collider (RHIC) and construct new straight sections connecting the arcs. In this article, we will examine all available skew quadrupoles currently in the HSR lattice and explore possible schemes for future global betatron coupling correction with RHIC-like decoupling feedback system. The effects of detector solenoids and quadrupole rolls are estimated

at injection and stored energies. We also studied the decoupling requirements for generating and maintaining large transverse emittance ratio beams in the HSR.

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Wednesday Poster Session / 1546

Real-time measurements of the RF-path of an electro-optical bunch arrival-time monitor with integrated planar pickup-structure with low-charge electron beams at ELBE

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Co-authors: Andreas Penirschke [1]; Herbert De Gersem [2]; Holger Schlarb [3]; Marie Kristin Czwalinna [3]; Michael Kuntzsch [4]; Nisamol Nazer [3]; Wolfgang Ackermann [2]

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Ultra-low-charge operation of free-electron lasers down to 1 pC or even lower, requires adequate diagnostics for both, the users and the operators. For the electro-optical bunch-arrival time monitor a fundamental design update is necessary to yield single-digit fs precision with such low charges. In 2023 a vacuum sealed demonstrator for a novel pickup structure with integrated combination network on a printed circuit board was built for operation of the free-electron laser ELBE at HZDR. Together with a new low-pi-voltage ultra-wideband traveling wave electro-optical modulator, this concept reaches an estimated theoretical jitter charge product of 9 fs pC. As a proof-of-concept measurements done at ELBE with the pickup demonstrator were carried out: In this contribution we analyze the effects of the variation of different beam properties, e.g., charge and position.

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Development status of laser arrival time measurement at SXFEL

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X-ray Free Electron Lasers (XFELs) are transformative across multiple disciplines, offering high power and tunable wavelengths. Facilities like FLASH, LCLS, and SwissFEL, including China's SXFEL and SHINE, provide ultra-bright femtosecond X-ray pulses. Their operation hinges on the precise synchronization of RF and laser sources, typically using femtosecond lasers as the master clock generator.
Environmental factors such as temperature, pressure, and vibrations induce timing jitter, impacting the laser chain and experimental outcomes. Laser Arrival-time Measurement (LAM) technology precisely tracks and compensates for these variations, ensuring stability and accuracy. LAM's precision is vital for XFEL performance enhancement and future facility development.
The paper reviews the current state of LAM technology at SXFEL, analyzes the impact of environmental factors on stability, and looks forward to future developments, emphasizing the importance of LAM technology in advancing XFEL facility performance and scientific research.

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Asia

Monday Poster Session / 1548

Status of the seeding upgrade for FLASH2020+ project

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In the framework of the FLASH2020+ project, the FLASH1 beamline will be upgraded to deliver seeded FEL pulses for users. This upgrade will be achieved by combining high gain harmonic generation and echo-enabled harmonic generation with a wide-range wavelength-tunable seed laser,

to efficiently cover the 60-4 nm wavelength range. The undulator chain will also be refurbished entirely using new radiators based on the APPLE-III design, allowing for polarization control of the generated light beams. With the superconducting linac of FLASH delivering electron beams at MHz repetition rate in burst mode, laser systems are being developed to seed at full repetition rates. In the contribution, we will report about the progress of the project.

Footnotes:

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Wednesday Poster Session / 1549

Preparation, transport, and operation of high quantum efficiency semiconductor Cs-Te photocathode for SHINE

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According to the high repetition rate, high brightness and other operating characteristics of SHINE, the photocathode with high quantum efficiency, low emittance, and long operating lifetime is required to produce high-quality electron beam. After solving the problems of ultra-high vacuum acquisition, photocathode plug in vacuum transmission, and photocathode preparation process, the Cs-Te photocathode prepared on SHINE's photocathode preparation device based on Te intermittent and Cs continuous deposition method has a quantum efficiency greater than 10% under 265 nm light irradiation, and the quantum efficiency remains almost unchanged in the photocathode preparation device, photocathode suitcase, photocathode load lock system, and electron gun.

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Monday Poster Session / 1550

Exploiting optical interference effects to enhance the quantum efficiency of photocathodes

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We present measurements of quantum efficiency (QE) modulations in CsSb and Cs3Sb photocathodes that arise from optical interference of reflections from the underlying substrate that has multiple semi-transparent layers. The photocathode films are grown on a cubic silicon carbide layer (3C-SiC) which itself is grown epitaxially on Si(100) during fabrication. We find that the QE modulates by up to a factor of two over a laser wavelength range of 30 nm, and that a modulation peak can be tuned to coincide with a desired laser wavelength by changing the thicknesses of both the photocathode and the silicon carbide layer in the substrate. A model for the QE modulations is derived and fitted to QE measurements of CsSb and Cs3Sb films, which have different indices of refraction, in addition to QE measurements of Cs3Sb films grown on 3C-SiC substrates with two different silicon carbide layer thicknesses. Good agreement is found between the model and measurements, confirming the optical interference effect can be exploited to enhance quantum efficiency at desired visible wavelengths.

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Tuesday Poster Session / 1551

Background mitigation concepts for Super-NaNu

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Super-NaNu is a proposed neutrino experiment as part of the SHADOWS proposal for the high intensity facility ECN3 in CERN's North Area. It aims to detect neutrino interactions downstream of a beam-dump that is penetrated with a 400 GeV high intensity proton beam from the SPS. The experiment would run in parallel to the HIKE and SHADOWS experiments, taking data with an emulsion detector. Simulations show that various combinations of muon backgrounds pose the major limiting component for NaNu operation. As muons will leave tracks in the emulsion detector, their flux at the detector location is directly correlated to the frequency of emulation exchange and therefore with the cost of the experiment. Finding ways of mitigating the muon background as much as possible is therefore essential. In this paper, we present a possible mitigation strategy for muon backgrounds.

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TUAN: Beam Dynamics and Electromagnetic Fields (Contributed) / 1552

Limitations from LHC RF fingers

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During the third run of the Large Hadron Collider in 2023, which had the highest intensity bunch population compared to previous runs, a beam dump incident occurred due to increased losses attributed to pressure spikes within a warm vacuum sector. Subsequent inspections revealed localized annealing and plasticization of the tension spring in the sliding contact radio-frequency finger module, alongside traces of vapor deposition on the various module components with the stainless-steel spring material. A comprehensive analysis involving vacuum and beam impedance studies was conducted to investigate the triggering mechanisms behind the radio-frequency finger module failure. The findings indicate localized beam-induced heating, which could lead to the annealing of the spring

with a consequent cascade of effects. Additionally, investigations of potential mitigation measures were performed.

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Thursday Poster Session / 1553

Development of an ERL for coherent electron cooling at the Electron-Ion Collider

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The Electron-Ion Collider (EIC) is currently under development to be built at Brookhaven National Lab and requires cooling during collisions in order to preserve the quality of the hadron beam despite degradation due to intra-beam scattering and beam-beam effect. An Energy Recovery Linac (ERL) is being designed to deliver the necessary electron beam for Coherent electron Cooling (CeC) of the hadron beam, with an electron bunch charge of 1 nC and an average current of 100 mA; two modes of operation are being developed for 150 and 55 MeV electrons, corresponding to 275 and 100 GeV protons. The injector of this Strong Hadron Cooler ERL (SHC-ERL) is shared with the Precooler ERL, which cools lower energy proton beams via bunched beam cooling, as used in the Low Energy RHIC electron Cooling (LEReC). This paper reviews the current state of the design.

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Thursday Poster Session / 1554

Upgrade of the SPARC_LAB low level radiofrequency system

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SPARC_LAB facility was born in 2004 as an R&D activity to develop a high brightness electron photoinjector dedicated to FEL experiments and exploration of advanced acceleration techniques. The electron source consists in a brazefree 1.6-cell S-band RF gun with a peak electric field of 120 MV/m and a metallic copper photocathode. The gun injects particles into two S-band sections, the initial section acting as an RF compressor using the velocity bunching technique, with built-in solenoid coils that enhance magnetic focusing and control emittance. A subsequent C-band acceleration section acts as a booster to achieve the desired kinetic energy. The Lazio Regional government recently funded the SABINA project for the consolidation of SPARC_LAB facility. The reference and the distribution systems and the Low Level radiofrequency (LLRF) system will also undergo a significant upgrade, involving the replacement of the original analogue S-band and digital C-band radiofrequency systems with commercial, temperature-stabilized, FPGA-controlled LLRF digital systems provided by Instrumentation Technologies in order to improve performance in terms of amplitude, phase resolution, and stability.

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Thursday Poster Session / 1555

Exploring varied slow extraction schemes in SIS100

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The synchrotron SIS100 at FAIR, currently under construction in Darmstadt, Germany, will deliver slow extracted proton and ion beams up to 100 Tm employing resonant extraction. The baseline scheme for slow extraction is transverse knock-out (KO) extraction, but recently the COSE (Constant Optics Slow Extraction) scheme has been studied as an interesting alternative. One advantage is the possibility of compensating the influence of systematic magnetic field errors on slow extraction. Higher order multipoles of the fast ramping compact super-ferric dipole and quadrupole magnets deform the separatrix, leading to an increase in angular spread for particles with different momenta at the electrostatic septum, which results in higher losses. The effect is especially pronounced for the smaller separatrices associated with KO extraction at high energies and for quadrupole driven

extraction in general. With COSE, the angular spread can be reduced by adapting chromaticity, decreasing losses at the electrostatic septum to an acceptable level. In this contribution, we report on the status of simulations of slow extraction in SIS100 for different extraction schemes, including COSE.

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Wednesday Poster Session / 1557

Preliminary design consideration for CEPC fast luminosity feedback system

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With very small beam sizes at IP (several tens of nanometers in the vertical direction) and the presence of strong FFS quadrupoles in the CEPC, the luminosity is very sensitive to the mechanical vibrations, requiring excellent control over the two colliding beams to ensure an optimum geometrical overlap between them and thereby maximize the luminosity. Fast luminosity measurements and an IP orbit feedback system are therefore essential. In this paper, we will show the preliminary design consideration for a fast luminosity feedback system at CEPC.

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Wednesday Poster Session / 1558

Microscopic understanding of the effects of impurities in low RRR SRF cavities

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The SRF community has shown that introducing certain impurities into high-purity niobium can improve quality factors and accelerating gradients. We question why some impurities improve RF performance while others hinder it. The purpose of this study is to characterize the impurities of niobium coupons with a low residual resistance ratio (RRR) and correlate these impurities with the RF performance of low RRR cavities so that the mechanism of impurity-based improvements can be better understood and improved upon. The combination of RF testing, temperature mapping, frequency vs temperature analysis, and materials studies reveals a microscopic picture of why low RRR cavities experience low BCS resistance behavior more prominently than their high RRR counterparts. We performed surface treatments on low RRR cavities to evaluate how the intentional addition of oxygen and nitrogen to the RF layer further improves performance through changes in the mean free path, grain structure, and impurity profile. The results of this study have the potential to unlock a new understanding on SRF materials and enable the next generation of high Q/high gradient surface treatments.

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Monday Poster Session / 1559

FFA@CEBAF beam transport error and tolerance simulation studies

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The Continuous Electron Beam Accelerator Facility (CEBAF) is a 12 GeV recirculating electron accelerator at the Thomas Jefferson National Accelerator Facility (JLAB). Major upgrades to the accelerator are being investigated which include a new 650 MeV injection beamline and state-of-the-art fixed-field alternating (FFA) gradient recirculation arcs. The upgrade will extend the energy of the electron beam to over 20 GeV. In this paper, we provide an error and tolerance simulation study of the amended beam optics transport of the existing accelerator tuned for 22 GeV operation. The study is conducted with the particle tracking codes elegant and Bmad in two parts. In the first part, we treat each section of the accelerator (electromagnetic arcs and linacs) modularly with ideal conditions at the beginning. The second part is a pseudo start-to-end (S2E) simulation with accumulated errors propagating from one beamline to the next.

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Thursday Poster Session / 1560

Towards the slow extraction of mixed He-2+ and C-6+ beams for online range verification

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In recent years, mixed helium (He-2+) and carbon ion (C-6+) irradiation schemes have been proposed to facilitate in-vivo range verification in ion beam therapy. Such a scheme proposes to accelerate and extract both ion species simultaneously, with the idea of using C-6+ for tumor treatment, while performing real-time dosimetry with He-2+ in a detector downstream of the patient.
The MedAustron center for ion beam therapy and research, which supplies protons and carbon ions for clinical treatment, is currently being commissioned to additionally provide helium ions for non-clinical research. The availability of both He-2+ and C-6+ beams opens the opportunity for studying the feasibility of the described mixed beam irradiation scheme. A key aspect in this context is the slow extraction of the ion mix, which is affected by both the relative charge-to-mass ratio offset of approximately 6e-4 and potential differences in the transverse phase space distributions. This contribution discusses requirements for maintaining a specified ion ratio throughout the spill, presents first simulation results and summarizes preliminary assessments on the applicability of different extraction mechanisms.

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Monday Poster Session / 1561

Plasma accelerator based free electron laser program at ELI-beamlines

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The plasma accelerator-based Free Electron Laser research program at ELI-ERIC (ELI-Beamlines, Czech Republic) intends to utilize the unique qualities of plasma accelerators to build FELs with remarkable brightness, coherence, and pulse length. The program is based on the novel high-power, high-repetition-rate laser system, which is under preparation at ELI-Beamlines. The program entails expanding the LUIS experimental setup to test and validate the performance of the laser-plasma accelerator-based extreme ultra-violet (EUV) FEL, integrating a high-power laser, plasma source, and electron beam transport line with relevant diagnostics to create a comprehensive test bed for the development of the EuPRAXIA LPA-based FEL. The plasma accelerator-based FEL development program at ELI-Beamlines represents an innovative effort to expand the capabilities of FEL technology and open new possibilities for scientific research and industrial applications. In the frame of this report, we provide an overview of the relevant developments at ELI-ERIC (ELI-Beamlines) as well as the main challenges of this program.

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Tuesday Poster Session / 1563

RF power station stabilization techniques and measurements at LNF

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In the framework of EuPRAXIA@SPARC_LAB project, we are studying possible solutions to upgrade and measure the amplitude and phase stability of the RF accelerating fields generated by a klystron. These studies concern the C- and X- band klystrons installed in the LNF infrastructures. In particular, we will present our work on a fast phase feedback around the C-band power station (50 MW klystron and solid state modulator) installed at SPARC_LAB. We are trying to push the timing jitter below the standard limit of such systems (few tens of fs RMS). A second topic is the study of the jitter of the X-band power station (50 MW klystron and solid state modulator) installed in the TEX facility. Precise measurements on amplitude and phase of this system will be reported at different positions both upstream (LLRF and pre-amp) and downstream (waveguides and prototype structure) the klystron.

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Monday Poster Session / 1564

Weak-strong beam-beam simulation with crab cavity noises for the hadron storage ring of the Electron-Ion Collider

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The Electron Ion Collider (EIC), to be constructed at Brookhaven National Laboratory, will collide polarized high-energy electron beams with hadron beams, achieving luminosities of up to 1e+34 cmˆ−2 sˆ−1 in the center-mass energy range of 20-140 GeV. Crab cavities are employed to compensate for the geometric luminosity loss caused by a large crossing angle of 25 mrad in the interaction region. The phase noise in crab cavities will induce a significant emittance growth for the hadron beams in the Hadron Storage Ring (HSR). Various models have been utilized to study the effects of crab cavity phase noise. In this article, we present our numerical simulation results using a weak-strong beam-beam model. In addition to horizontal emittance growth, we also observed vertical emittance growth resulting from both crab cavity noises and beam-beam interaction. The tolerance for crab cavity phase noise was determined and compared with analytical predictions.

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Thursday Poster Session / 1565

Exploratory splitter bend system designs for FFA@CEBAF

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An upgrade to the Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (JLAB) is anticipated to provide an electron beam of over 20 GeV using the existing superconducting-RF linear accelerator and new fixed-field alternating (FFA) gradient recirculation arcs made up of Halbach-style permanent magnets. In the current design, the FFA arcs will carry six beams with energies of approximately 11, 13, 16, 18, 20, and 22 GeV which will require horizontal splitter lines to match the beam from the preceding linac. In this paper, we describe two alternative splitter beamline designs that are tuned to match the beam's Twiss parameters, R56, time-of-flight, bend-plane offset, and dispersion into the FFA cells.

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Tuesday Poster Session / 1566

Design of dipole magnets for luminosity pair spectrometer subsystem at the detectors of Electron Ion Collider

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The EIC will collide high energy and highly polarized hadron and electron beams with luminosities up to 1e+34 /cm^2/s. Bremsstrahlung photons from the Bethe-Heitler process at the interaction point (IP) need to be counted to determine the delivered luminosities. The pair spectrometer luminosity detector utilizes photon conversions (e+ and e- pairs) in the far-backward region. A sweeper dipole magnet was designed to sweep away the photon conversions that occur at the thick exit window. An analyzer dipole magnet was designed with an integrated field of 1.13 T*m to deflect the electrons and positrons that will be analyzed by the tracker and calorimeter detectors. Both magnets were designed and simulated using the 3-dimensional (3D) finite element method (FEM). The effects of notch size and locations on the iron yoke to the magnetic field quality were studied. The tracker

performance, including tracker position resolutions and tracker energy resolutions, were analyzed based on the field map of the designed dipole magnets.

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Wednesday Poster Session / 1567

Observation of a synchro-betatron instability in Fermilab booster

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In preparation for PIP2, there has been interest in running the Fermilab Booster at a higher current more indicative of the PIP2 era operation. In July 2023 an experiment was performed to study collective instabilities over the transition crossing at the Fermilab Booster. Over the transition crossing, the synchrotron tune becomes small and synchro-betatron instabilities become possible. During the experiment, an intensity threshold was observed, above which a dipole instability with losses concentrated in the tail of the bunch. These losses are consistent with the Convective Instability*.

Footnotes:

*Burov, Alexey. "Convective instabilities of bunched beams with space charge", PHYSICAL REVIEW ACCELERATORS AND BEAMS 22, 034202 (2019); doi: 10.1103/PhysRevAccelBeams.22.034202

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Thursday Poster Session / 1568

Assessment of the real part of the impedance of the LHC collimators with instability growth rate measurements

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The impedance of the Large Hadron Collider (LHC) is a source of instabilities and has to be monitored closely. It is usually assessed by measuring the tune-shift vs intensity, in particular at top energy where it is the most critical, as the collimators are the closest to the beam. However, to get information on the real part of the impedance, growth rate measurements are required. These are difficult to perform at flat-top because triggering the instability in a sharp and fast manner remains a challenge. Moreover, the length of the full cycle, including an energy ramp, prevents the measurement repetition. Instead, measuring growth rates at injection is more natural and allows rapid cycling, with the downside that the impedance at injection is not dominated by collimators but rather by fixed-gap devices. Here, we present measurements at injection energy, placing the collimators in tighter positions than the nominal ones, in an attempt to obtain a similar configuration as the flat top situation. The measurements are performed at several negative chromaticities to study the evolution of the growth rate of the rigid bunch mode instability. Results are finally compared to simulations.

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Wednesday Poster Session / 1569

Electron cloud build-up studies for DAΦNE collider and FCCee damping ring

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DAΦNE is a a medium energy electron-positron collider operating in the National Laboratory of INFN at Frascati, Italy. The accelerator complex consists of two rings with an approximate circumference of 97 m. High-intensity electron and positron beams circulate and collide with the center of mass energy of around 1.02 GeV. The FCCee is an ongoing lepton collider project and its current injector design includes a damping ring for emittance cooling of positron beams. The electron cloud is one the most important collective effects and can represent a bottleneck for the performances of accelerators storing particles with positive charge. Several undesired effects such as transverse instabilities, beam losses, emittance growth, energy deposition, vacuum degradation may arise due to interaction of the circulating beam with the e-cloud. The aim of this presentation is to provide e-cloud buildup simulations for the DAΦNE positron ring and the Damping Ring of FCCee. This study

will also include experimental studies concerning the instabilities induced by the e-cloud exploiting the opportunity offered by the positron beam at DAΦNE.

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Monday Poster Session / 1570

Conceptual design of the laser-plasma based soft X-ray Free Electron laser

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The conceptual design of the laser-plasma-based soft X-ray Free Electron Laser at ELI-Beamlines involves the integration of a novel high-power, high-repetition-rate laser, plasma source, compact LPA-based electron beam accelerator, dedicated electron beam line with relevant diagnostics, undulator beam line, photon beam line with required diagnostics, as well as a photon beam distribution system. The proposed concept of the whole setup is optimized to produce high-quality, coherent X-ray pulses with femtosecond duration in the 'water-window'wavelength of the photon radiation, which will be used by the photon user community for expiring research in the field of biology to study biological structures and processes at the cellular and molecular level at high resolution. In addition, the laser-plasma-based soft X-ray FEL will extend the abilities of users in material science to study nanostructures and thin films. In the frame of this report, we present the conceptual design for the full setup, which will be incorporated into the existing infrastructure of ELI-Beamlines. Furthermore, we discuss the key obstacles and the role of this project in the EuPRAXIA joint activity.

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Monday Poster Session / 1571

Current status of the FFA@CEBAF energy upgrade

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An upgrade to the Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (JLAB) to extend its energy reach from 12 GeV to 22 GeV is being explored. The upgrade pushes the boundaries of the current CEBAF facilities and will require several state-of-the-art beamline components. The first of which is nonscaling Fixed Field Alternating (FFA) Gradient recirculation arcs, using novel Halbach-style permanent magnets. These new arcs would replace the current highest-energy recirculating arcs and allow up to six new beam passes spanning approximately a factor of two in energy. Matching into these arcs will require the design of splitter bend systems proceeding the north and south linac sections. Matching from these arcs into the proceeding linac section will be achieved using a novel transition section. Additionally, several major changes to the existing CEBAF accelerator will be implemented including a 650 MeV recirculating injector, a new multi-pass linac optics design based on a triplet focusing lattice, and a newly designed spreader/recombiner bend systems to accommodate the higher energy requirement.

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Monday Poster Session / **1572**

Wide range tune scan for the hadron storage ring of the Electron-Ion Collider

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The Electron Ion Collider (EIC), to be constructed at Brookhaven National Laboratory, will collide polarized high-energy electron beams with hadron beams, achieving luminosities up to 1e+34 cmˆ−2 sˆ−1 in the center-mass energy range of 20-140 GeV. The current fractional design tunes for the Hadron Storage Ring (HSR) are (0.228, 0.210) to mitigate the effects of synchro-betatron resonances. In this article, based on a strong-strong beam-beam simulation model, we carried out a wide range tune scan for the HSR to search for optimum working points. We found a good tune space around (0.735, 0.710), which is close to the working point (0.695, 0.685) of the polarized proton operation of the Relativistic Heavy Ion Collider (RHIC). We plan to further estimate the dynamic aperture and polarization with this working point.

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Wednesday Poster Session / 1573

Innovative bulge test setup to characterize thin beam vacuum windows

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As part of the International Muon Collider study, a beam vacuum window is being developed at CERN. It is required for the final cooling, where the charged particles travel from the vacuum chamber to the absorber; here, the beam loses momentum to cross a second window entering in a RF cavity that increases the longitudinal momentum. The best absorber for the final cooling is hydrogen. As the absorber should be installed inside a high field focusing solenoid, the hydrogen density should be as high as possible, ideally liquid or high pressure gas, to have a reasonable solenoid length. To evaluate the performance of the window, it is necessary to study the tightness at cryogenic temperatures, resistance to burst, high temperature and beam-induced damage. The main objective of the proposed work is to design and validate a versatile bulge test setup for the mechanical characterization of thin windows at different pressures and temperatures to cover all operating conditions, from 77 K to 293.15 K and ideally above. Due to the low thicknesses, a non-contact measuring technique based on a confocal chromatic sensor is proposed.

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Wednesday Poster Session / 1574

Real-time 100 MeV proton beam monitoring system for radioisotope production at KOMAC

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In Korea Multi-purpose Accelerator Complex (KOMAC) of Korea Atomic Energy Research Institute (KAERI), a 100 MeV proton LINAC is in operation and provides the proton beam for various applications since 2013. A radioisotope (RI) production beam line has developed in 2015 and the commissioning started in 2016. Recently, a beam diagnostics system for high proton beam currents of 100 μA was designed to produce the Cu-67 radioisotope, which is considered the next generation of radiopharmaceuticals.
The beam diagnostic system includes a multi-wire scanner and Faraday cup to measure the position and current of the proton beam. It also utilizes an AC current transformer and 4-sector collimators for real-time position and current monitoring, respectively. Considering the long beam irradiation time for RI production, the system was designed to be moved up and down using cylinders so that it can only be used for beam QA. The control system was designed to be integrated with the EPICS IOC operating in other target rooms. In this paper, we would like to present the details of the beam diagnostic system and preliminary experimental results of real-time monitoring for 100 MeV RI production.

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Wednesday Poster Session / 1576

FORTRESS: a facility for relativistic time-resolved electron sources and scattering in Tsinghua University

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High-energy electrons generated from photocathode RF gun driven by ultrafast laser can be used as probes to observe the microstructure of matter with atomic level spatiotemporal resolution, which is the key that determines whether the electron beams could be used to study structure and dynamics on the femtosecond timescale, and for existing devices, there is still considerable room for development in terms of the resolution. In this paper, we report on a newly constructed high brightness electron beamline with 1 femtosecond-level spatial resolution and high stability at Tsinghua University. This beamline can generate ultrashort electron bunches with several MeV energy at a maximum repetition frequency of 800 Hz, specially designed for relativistic electron beams manipulation or diagnosis, and applications including ultrafast electron diffraction and imaging. We have separately constructed sample chambers capable of introducing solid and liquid materials. The layout, dynamic simulation and measurement results of electron beams, stability performance monitored, sample delivery and pump laser systems will be discussed in detail.

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Wednesday Poster Session / 1577

Commissioning and experiments with a compact transverse deflecting system at FLUTE

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A Compact Transverse Deflecting System (Compact-TDS) designed for longitudinal electron bunch diagnostics in the femtosecond regime is presently undergoing commissioning at the Karlsruhe Institute of Technology (KIT). This technique, based on THz streaking with a Split-Ring Resonator (SRR), demands a high level of electron beam controllability and stability at the micrometer scale. To meet these requirements, the Ferninfrarot Linac- Und Test-Experiment (FLUTE) has undergone an upgrade in 2023, incorporating a new RF system equipped with a state-of-the-art modulator, RF photoinjector and solenoid magnet. In this contribution, we present first experiments conducted with the Compact-TDS at FLUTE, utilizing the enhanced RF setup.

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Thursday Poster Session / 1579

Status of beam-beam studies for the high-luminosity LHC

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Optimizing the configuration of an operational cycle of a collider such as the LHC is a complex process, requiring various simulation studies. In particular, Dynamic Aperture (DA) simulations, based on particle tracking, serve as indispensable tools for achieving this goal. In the framework of the high-luminosity LHC (HL-LHC) studies, our primary focus lies in performing parametric beam-beam DA simulations for the critical phases of the collision process, which includes the collapse of the beam separation bump, as well as the start, and the end of the luminosity leveling. In this paper, we present the status of our ongoing studies for different optics and filling schemes, and we comment on how they could guide the orchestration of the operational settings along the luminosity leveling phase of the HL-LHC cycle.

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Thursday Poster Session / 1580

Novel method for transverse narrow-band impedance calculation by coupled-bunch instability measurements in circular accelerators

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In the research and development phase of accelerators, impedance and instability analysis of the storage ring are typically conducted in advance for performance evaluation. However, the pre-calculated impedance often deviates from the actual measurement results. For built accelerators, the impedance of individual components can be measured with various methods such as the coaxial wire method. However, modern accelerators are typically composed of a large number of complex components, such as cavities, magnets, and solenoids, each with unique geometric shapes and structures. Measuring the impedance of each component individually is therefore a challenging and time-consuming task. This paper proposes a novel method to estimate the overall impedance parameters of the storage ring by analyzing the change in the growth rate of beam instability modes with beam current. This method provides an effective impedance measurement solution for built accelerators, furthering our understanding and optimization of accelerator performance. This novel method is also applied in BEPCII.

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Thursday Poster Session / 1581

Estimates of cross-talk effects for magnets of the Advanced Photon Source upgrade lattice

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The Advanced Photon Source (APS) has recently installed and begun commissioning of a hybrid seven-bend-achromat design*to replace the original storage ring. As in many recent storage ring designs, the APS Upgrade** (APS-U) magnets are closely spaced compared to those in third-generation storage rings. Calculation of "cross-talk" effects for such closely-spaced magnets can be time-consuming if performed using magnetic modeling codes. For APS-U, the effects are modest, so we used an approximate method of field-clamping at adjacent iron boundaries. This paper presents details on the methods and results of applying that method.

Footnotes:

- L. Farvacque et al., IPAC13, 79 (2013). ** M. Borland et al., IPAC18, 2872 (2018).

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Wednesday Poster Session / 1582

Gas jet-based beam profile monitor for the electron beam test stand at CERN

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A non-invasive bidirectional beam profile monitor using beam-induced fluorescence upon a thin sheet of gas has been developed at the Cockcroft Institute in collaboration with CERN and GSI. This device is particularly suited to the Electron Beam Test Stand, and as such, a bespoke gas injection has been optimized for this specific use-case to provide diagnostics unavailable to conventional scintillator screens. The bidirectionality allows for the observation of beam reflections back along the beam path as a result of a beam dump with non-optimized repeller electrode potential. Furthermore, the heating effects of a high current DC beam are negated by the self-replenishing gas sheet. These benefits make this device ideal for use in the Electron Beam Test Stand.
This contribution summarizes the optimization study of the gas jet generation performed with a multi-objective genetic algorithm to meet required screen dimensions whilst maintaining acceptable vacuum levels.

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Monday Poster Session / 1584

New opportunities for excellent FEL experiments at FLASH

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The FLASH facility is currently undergoing a transformation to generate FEL radiation suitable for next generation user experiments. Here, the transition of FLASH1 from a SASE to an externally seeded FEL beamline is in main focus and will significantly expand the facilities capabilities. Near transform limited pulses at superior spectral and energy stability at full FLASH repetition rate of 1 MHz burst, together with variable polarization, will continue to broaden the facilities user community.
As a prerequisite the superconducting linear accelerator has been upgraded in a recent shutdown to improve stability and control of the electron bunches while also increasing the maximal electron beam energy to 1.35 GeV. For testing of the future undulator concept for the seeded beamline a shorter period prototype device employing also APPLE III configuration has been installed in the FLASH2 beamline as an afterburner to boost the third harmonic at variable polarization.
The increased wavelength range down to 1.33 nm along with before mentioned improvements already benefit current user experiments and preparatory seeding experiments undertaken within the Xseed environment.

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Tuesday Poster Session / 1585

Optimization of spin-coherence time for electric dipole moment measurements in a storage ring

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Electric dipole moments are very sensitive probes of physics beyond the Standard Model. The JEDI collaboration is dedicated to the search for the electric dipole moment (EDM) of charged particles making use of polarized beams in a storage ring. In order to reach the highest possible sensitivity, a fundamental parameter to be optimized is the Spin Coherence Time (SCT), i.e., the time interval within which the particles of the stored beam maintain a net polarization greater than 1/e. To

identify the working conditions that maximize SCT, accurate spin-dynamics simulations have been performed using BMAD. In this study, lattices of a "prototype" storage ring, which uses combined electric and magnetic fields for bending, and a "hybrid" storage ring using only electric bending fields with magnets for focusing, are investigated. This talk presents a model of spin behavior in frozen-spin lattices that has been verified in both situations, as well as a technique to optimize the second-order beam optics for maximum SCT at any given working point.

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Wednesday Poster Session / 1586

Commissioning of the first H^- beam through the LEBT from the RF ion source at ISIS

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A high power RF driven negative hydrogen ion source is currently in development as part of the Pre-Injector Test Stand at the ISIS pulsed spallation neutron and muon facility, UKRI-STFC Rutherford Appleton Laboratory. The source is now operating reliably with an extracted H^- beam current of 17 mA at RF power up to 60 kW and pulse lengths up to 400 µs. This paper will detail both the re-commissioning of the ion source after upgrades were made to the RF and high voltage systems and the commissioning of H^- beam transport through the LEBT to the RFQ mask Faraday cup. The latest up-to-date commissioning results and challenges will be presented.

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Thursday Poster Session / 1587

Machine protection system for TEX facility

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In the context of LATINO (Laboratory in Advanced Technologies for INnOvation) and Rome Technopole Projects founded by Regione Lazio and NextGenerationEu, and directly involved in the EuPRAXIA@SPARC_Lab flagship project, a testing facility for X-band (TEX) has been established at the Frascati National Laboratories of INFN. TEX is dedicated to the examination of radiofrequency X/C-band, aiming to develop and test the technologies and systems of a particle accelerator operating under such conditions. Given the complex nature of such a system and the advancement of technology to the forefront of the state of the art, it is imperative to have an advanced Machine Protection System (MPS) characterized by high reliability, availability, and safety, in accordance with IEC-61508 standards. Currently in development is a prototype MPS designed to autonomously initiate procedures to control operations and avert anomalies. An EPICS supervisor oversees the management of all devices and monitoring connected subsystems. Additionally, a real-time interlock system, based on distributed FPGA, is employed to swiftly respond to vacuum and RF systems during the next RF pulse.

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Tuesday Poster Session / 1588

Machine-learning based extraction of longitudinal beam parameters in the LHC

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Accurate knowledge of beam parameters is essential for optimizing the performance of particle accelerators like the Large Hadron Collider (LHC). An initial machine-learning (ML) model for the reconstruction of the longitudinal distribution has been extended to extract the main parameters of multiple bunches at LHC injection. The extended model utilizes an encoder-decoder architecture to analyze sets of longitudinal profile measurements. Its development was partially driven by the need of a real-time beam energy error estimate, which was not directly available in the past. The derived beam parameters moreover include injection phase error, bunch length and intensity in the LHC, as well as the RF voltages at extraction from the Super Proton Synchrotron (SPS) and at capture in the LHC. In this paper, we compare the results of the ML model with conventional measurements of bunch length and energy error, from the beam quality monitor (BQM) and the orbit acquisition

system, respectively. These benchmarks demonstrate the potential of applying the ML model for operational exploitation in LHC.

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Thursday Poster Session / 1589

3D printed beam correctors

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Starting from 2018 we have designed and created 3D printed beam correctors using two different types of FDM materials, Ultem and ASA. The design was defined based on the ergonomics of the existing machine parts, avoiding radial and longitudinal mechanical interference, and the magnetic performances to be produced. The size and configuration of the resulting windings influenced the choice of the most suitable FDM material for the purpose. In total we present 3 different prototype models which, in addition to demonstrating the ability to produce the design performances, are currently used on the SPARC-Lab Experiment in our INFN National Laboratories in Frascati.

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Tuesday Poster Session / 1590

Concluding the operation and development of COSY

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The operation of the COler SYnchrotron COSY and its further development ended in October 2023. We briefly review the operation of the accelerator facility and continuous development of its subsystems. Additionally, this work is put in context of the transformation process that COSY operation and the Institute of Nuclear Physics (IKP) of the Research Center Jülich went through starting 2015. Furthermore, the decommissioning strategy along with the possible further use of COSY components are discussed.

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Thursday Poster Session / 1591

Use of two- and three-dimensional magnetic measurement data to refine the APS upgrade model

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The Advanced Photon Source (APS) has recently installed and begun commissioning of a hybrid seven-bend-achromat design*to replace the original storage ring. The APS Upgradelattice includes two types of longitudinal-gradient dipoles, five types of transverse-gradient dipoles, and five types of high-strength quadrupoles. All of these magnets were designed*** using three-dimensional magnetic models, the results of which were used in lattice development. After construction of the magnets, various types of two- and three-dimensional field maps were measured. We describe the uses and limitations of these measurements to refine the model prior to commissioning, and indicate what, if anything, commissioning experience tells us about the success of our efforts.

Footnotes:

- L. Farvacque et al., IPAC13, 79 (2013). ** M. Borland et al., IPAC 18, 2872 (2018). *** M. S. Jaski et al., IPAC 15, 3260 (2015).

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Monday Poster Session / 1593

Investigation of beam generation in laser back-illumination mode using metal cathodes of varying thickness in a photocathode DC electron gun

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This study focuses on beam generation in the laser back-illumination mode using metal cathodes of varying thicknesses in a 200-kV photocathode DC electron gun. The aim is to investigate the quality and characteristics of beam production in this mode and provide valuable insights for the application of the electron gun in electron microscopy and related fields. Experimental preparations involved the fabrication of metal cathode samples with different thicknesses. The 200-kV photocathode DC electron gun was then utilized to generate beams under various settings, specifically in the laser back-illumination mode. Beam quality and characteristics, including beam emittance, space charge effects, and energy spread, were measured and analyzed. The results indicate a significant influence of metal cathode thickness on beam quality in the laser back-illumination mode. These findings contribute to the understanding of beam production characteristics and provide guidance for optimizing electron gun design, particularly for applications in electron microscopy.

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Asia

Monday Poster Session / 1594

Field emission of nanotip cathode in RF gun

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Nowadays, DC gun field emission currents have become common applications as electron sources for electron microscopy, while we focus on the research of field emission of sharp tips in microwave fields, which promises low emittance currents for high energy electron imaging. The tungsten rods are fabricated into tips by electrochemical etching with the radius of curvature of apex within one hundred nanometers, and the field emission experiments are expected to be performed in RF gun. Simulation results show that if the gradient of RF gun is set to 30 MV/m, the corresponding emission current is expected to reach nano scale, and the field enhancement factor can be up to 100 according to the Fowler-Nordheim formula. The instantaneous current density per cycle is approximately as a Gaussian distribution of which the rms width below 20° in general. The magnitude of the field enhancement can be controlled by fine-tuning the protruding length from the cathode plug to protect the tip itself. We anticipate that the combination of nanotip cathode and RF gun is expected to yield stable, low-emittance and high-energy electron beams as high-quality electron sources in electron microscopy.

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Wednesday Poster Session / 1596

Second generation Cherenkov diffraction radiation studies at Diamond Light Source

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Diamond Light Source (DLS) is a 3 GeV synchrotron facility in the UK, which has been a part of the Cherenkov diffraction radiation (ChDR) collaboration since 2017 and is now in its second phase of experiments. The current experiment aims to produce and test a one-dimensional beam position monitor (BPM) that utilizes ChDR at visible and near-infrared (NIR) wavelengths. This paper will cover the characterization of the ChDR setup, including: the changes observed to the ChDR signal due to both beam specific and target specific variations.

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Thursday Poster Session / 1597

Updates on the wake potential calculation for the Electron-Ion Collider with ECHO3D

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ECHO3D has been used for calculating the geometric impedance and short-range wake-fields for several EIC (Electron-Ion Collider) beamline vacuum components in the past few years. For the HSR, calculations have been carried out for the polarimeter, the beam screen with pump slots, and the bellows with pump ports. For the ESR, the short-range wake potential for the flange weld as well as various designs of the storage ring cavity have been calculated. In this work, we present the wake potential calculations conducted in the past two years with ECHO3D and discuss some findings while cross-checking the calculation results from multiple codes.

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Tuesday Poster Session / 1598

Advanced charge selector for stripped heavy ion beams

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A new charge selector is currently under development at FRIB to intercept unwanted charge states of higher-power 17 - 20 MeV/u stripped heavy ion beams. The charge selector is located in the first bending segment of the FRIB linac, where high dispersion separates charge states to allow for their selection. The design concept is based on rotating graphite cylinders that act as an intermediate heat transfer medium, efficiently absorbing beam power and radiating it to a water-cooled heat exchanger. The power in the beam spot of up to 5 kW and the rms spot width as small as 0.7 mm present

significant design challenges. Beyond thermal stress, the proposed design addresses the effects of radiation damage and implantation of the intercepted ions. The challenges of the engineering design associated with high temperatures, thermal expansion, rotation and linear actuation feedthrough into vacuum, as well as radiation shielding and remote handling, will be discussed. A comprehensive exploration of these challenges aims to contribute to the broader field of beam interception technology.

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Monday Poster Session / 1599

Python FLUKA BeamLine (pyflubl), a python library to create FLUKA simulations of accelerators

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FLUKA simulations of beamlines are important for understanding numerous different aspects of accelerators, including beam losses, particle backgrounds, activation and shielding. Creating a beamline simulation using FLUKA is a time consuming and potentially error prone process. This paper describes a set of python tools called pyflubl (Python FLUKA beamline) which can create a FLUKA simulation using input from MAD-X, MAD8, Transport or BDSIM. pyflubl is based on multiple stable and advanced python packages created to make BDSIM (Geant4) beamline simulations as simple as possible, these are pymadx (an interface to MAD-X output), pymad8 (an interface to MAD8 output), pybdsim (interface to BDSIM) and most importantly pyg4ometry (a geometry engine for Monte Carlo geometry creation). The magnetic fields required for FLUKA are implemented in C++ via BDSIM, thus keeping fields consistent between Geant4 and FLUKA beamline simulations. This paper describes pyflubl design and implementation and example results for a idealized electron beamline. Particular attention is given to geometry, fields and scoring.

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Tuesday Poster Session / 1600

Schedule management for large scale project: the example of HL-LHC at CERN

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The High Luminosity Large Hadron Collider (HL-LHC) project seeks to significantly enhance the performance of the LHC to deliver ten times more data to the LHC Experiments. The project relies on cutting-edge systems and technologies deployed in the new facilities constructed to the HL-LHC requisites and replacing large existing equipment and systems in the LHC tunnel. The project complexity lies in the production and installation of innovative systems with strong interdependencies. A methodological schedule management approach is essential to ensure timely equipment delivery, anticipate potential risks and implement mitigation actions. This paper describes the schedule management aspects of the HL-LHC project, providing a robust framework adaptable to any large-scale project. It encompasses the management of the baseline changes, the monitoring of milestones, the planning and coordination of the new facilities installation, and the integration of the HL-LHC installations within the regular LHC maintenance program. Emphasizing the significance of key performance indicators (KPIs), the paper highlights the critical role of metrics as indicators of schedule robustness.

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Sextupole RDTs in the LHC at injection and in the ramp

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During 2023, examination of the action dependence of sextupolar resonance driving terms (RDT) in the LHC at injection, as measured with an AC-dipole, demonstrated that a robust measurement of the RDTs could still be achieved even with very small amplitude kicks, typically used for linear optics studies. Consequently, analysis of optics measurements from 2022 and 2023 during the LHC energy ramp allowed a first measurement of the sextupole resonance evolution. A large asymmetry was observed between the two LHC beams, with the clockwise circulating beam (LHCB1) significantly worse than the counter-clockwise circulating beam (LHCB2), and a clear increase in the RDT strength during the ramp was observed. Results are presented and compared to MAD-X simulations, in this report.

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Estimates of the recombination rate for the strong hadron cooling system in the EIC

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The strong hadron cooling system (SHC) for the electron-ion collider (EIC) consists of the modulator, the microbunching amplifier and the kicker section. In the modulator and the kicker section, the electrons are co-moving with the protons. If the relative velocity of an electron with respect to a proton is small enough, it can be captured by the proton and the resulting neutral particle, i.e. a hydrogen atom, will deviate from the designed trajectory and get lost around the cooling section. Since the probability of a proton capturing an electron depends on the relative velocity between them, one can align the energy of the two beams based on the number of hydrogen atoms detected by a recombination monitor. In this work, we estimate the rate at which the hydrogen atoms produced by the recombination process for the SHC in EIC.

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PYG4OMETRY update: a tool to create geometries for Geant4, BDSIM, G4Beamline and FLUKA.

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Studying the energy deposition in accelerator components, mechanical supports, services, ancillary equipment and shielding requires a detailed computer readable description of the component geometry. The creation of geometries is a significant bottleneck in producing complete simulation models and reducing the effort required will allow non-experts to simulate the effects of beam losses on realistic accelerators. This paper describes a flexible and easy to use Python package to create geometries usable by either Geant4 (and so BDSIM or G4Beamline) or FLUKA either from scratch or by conversion from common engineering formats, such as STEP or IGES created by industry standard CAD/CAM packages. This paper describes the updates to pyg4ometry since IPAC19. These updates include ROOT geometry loading, refactored geometry processing using CGAL, direct CAD file loading using OpenCASCADE, geometrical feature extraction and geometry comparison algorithms. The paper includes small examples of the new features with explanations.

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Thursday Poster Session / 1605

Magnetic measurements for Halbach-type permanent quadrupoles using a single-stretched wire system

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In the framework of the acceleration techniques, the Plasma Wake Field Acceleration (PWFA) is one of the most promising in terms of high machine compactness. For this purpose, a crucial role is played by the particle beam focusing upward and downward the plasma-beam interaction, performed by high gradient Permanent Magnet Quadrupoles (PMQs). In the framework of the INFN-LNF SPARC_LAB (Sources for Plasma Accelerators and Radiation Compton with Laser And Beam) six Halbach-type PMQs have been tested before installing them into the machine. This paper presents the outcomes of magnetic measurements conducted using a Single-Stretched Wire (SSW) system. The results include comprehensive details on integrated gradients, magnetic multipole components, and roll angles of the magnets. By considering the operational parameters of the machine, the results show that the tested magnets can be feasibly installed only within limited triplets configurations.

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FCC-ee large scale project installation planning: challenges & proposals

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CERN is contemplating further advancements in the energy frontier through the Future Circular Collider (FCC) study, envisioning a 90.7 km underground accelerator with multiple energy stages over time. Following the European Strategy for Particle Physics recommendation in 2020, CERN initiated a feasibility study to scrutinize all aspects of the FCC project.
A crucial component of this study involves developing a timeline from project approval to the operational commencement of FCC-ee, the initial energy stage of the machine. Since the last planning iteration in 2018, modifications in the machine layout and shaft configuration necessitated a re-evaluation of the planning.
This paper focuses on the updated planning for FCC-ee, spanning from civil engineering premises acceptance to beam operation. It compiles pertinent elements, including the civil engineering release date, layout data, and human resources regulations and limitations. These elements were analyzed systematically to derive a sector sequence. Employing a bottom-up approach in conjunction with

resource constraints, an overarching plan for the FCC-ee machine until the start of operations was formulated.

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Monday Poster Session / 1607

Electron-emitted THz radiation optimized with a model-less algorithm

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The FERMI free-electron laser makes use of electron bunches in the 50 fs to 1 ps range. After the FEL process, the spent electron bunches are sent through a thin metallic foil placed in the main beam dump, where coherent transition radiation with THz frequencies is generated and transported to the TeraFERMI beamline. Intensity and spectral properties of those THz pulses strongly depends upon the transverse spot size and the temporal charge distribution of the electron bunch. As simulations revealed, the quadrupole setting in the dispersive region of the main beam dump impacts on the electron temporal distribution and consequently on the THz radiation. MIMOFB optimizers have been routinely used for fine tuning these quadrupoles and properly steering the beam trajectory to improve the TeraFERMI THz-intensity and minimize radiation doses in the dump region. A large campaign of measurements has been carried on during different machine configurations and user beamtimes, and the main results are presented in this paper.

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Impedance calculation for large accelerator structures using a domain decomposition method

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The beam coupling impedance is a key design parameter for all accelerator structures. Recently, we have introduced a novel simulation approach for impedance calculations in 3D-geometry. Unlike conventional methods, this approach is based on the solution of Maxwell's equations in the frequency domain using a high-order finite element technique. The main challenge for all impedance simulations, however, is the huge amount of computational resources that is required for the numerical discretization of electromagnetically large accelerator structures.
In this contribution, we introduce a specialized domain decomposition technique for impedance simulations. The technique allows to handle large accelerator structures by decomposing the computational domain into subdomains that interact by means of suitably chosen boundary conditions. We describe a class of such boundary conditions that accurately take into account the modal wave contributions traveling through domain interfaces in the presence of a particle beam. An application of the method considered in the paper is the full impedance characterization of a large in-vacuum undulator for the PETRA IV synchrotron source.

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Thursday Poster Session / 1609

Measured dynamic aperture and detuning of nonlinear integrable optics

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One of the most promising advantages of nonlinear integrable optics is strong amplitude dependent tune shift without degrading the dynamic aperture. The integrable optics test accelerator (IOTA) at Fermilab is constructed around nonlinear lattice elements of the elliptical type as described by Danilov and Nagaitsev. Detuning and dynamic aperture scans in IOTA were performed using a fast dipole kicker and a low emittance electron beam. The evolution of the dynamic aperture and detuning for different configurations of the integrable optics lattice are presented.

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Tuesday Poster Session / 1610

Chromaticity and Landau damping effects in the SLS 2.0 transverse coupled bunch instability threshold

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Bunches excited by a transverse kick out of the closed orbit develop betatron oscillations, whose dynamics is affected by the chromaticity used in the accelerator or storage ring. Specifically, decoherence and recoherence effects caused by chromaticity can be modified by introducing Landau damping in the synchrotron phase space, when using a harmonic cavity to stretch the bunch length in order to improve the beam stability. Chromaticity will convert any oscillation in the longitudinal phase space into a frequency modulation of the betatron tune, changing the pattern of the echos of the kick in the beam offset. Focusing on the SLS 2.0 storage ring, we present a study about the damping of single bunch transverse oscillations with non zero chromaticity, including the harmonic cavity and the broadband impedance. These damping times are used to predict the threshold of the transverse coupled bunch instability in SLS 2.0.

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Optimization of cooling distribution of the EIC cooler ERL

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The Electron-Ion Collider (EIC) Hadron Storage Ring (HSR) will use strong hadron cooling to maintain the beam brightness and high luminosity during long collision experiments. An Energy Recovery Linac is used to deliver the high-current high-brightness electron beam for cooling. For the best cooling effect, the electron beam requires low emittance, small energy spread, and uniform longitudinal distribution. In this work, we simulate and optimize the longitudinal laser-beam distribution shaping at the photo-cathode, modeling space charge forces accurately. Machine parameters such as RF cavity phases are optimized in conjunction with the beam distribution using a genetic optimizer. We demonstrate the improvement to the cooling distribution in key parameters.

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Tuesday Poster Session / 1613

Intra-undulator magnets for the SABINA THz FEL line: magnets design, manufacturing and measurements

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In the framework of the SABINA project (Source of Advanced Beam Imaging for Novel Applications), a new Free Electron Laser line will be realized at the Laboratori Nazionali di Frascati (LNF). It will be based in the SPARC_LAB laboratory with the purpose to supply radiation in the Thz/MIR range to external user. The line layout foresees two correctors between the three APPLE-X undulators devoted to providing angular and position offset correction to the beam aiming to maximize the efficiency of the FEL process. They will steer the electron beam both in the X and Y axis at the mrad level, and they will be integrated with Beam Position Monitors to perform the trajectory correction and the position monitoring at the same point. This paper presents the magnetic design of the two correctors performed by OPERA 3D software, the mechanical design, the manufacturing together with the magnetic measurement performed at the magnetic laboratory facility in LNF using a Hall probe system.

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Tuesday Poster Session / 1614

HL-LHC magnets production: building a complex planning to identify bottlenecks

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The High-Luminosity LHC project aims to enhance the integrated luminosity of the LHC machine by a factor of 10, by upgrading various components located in the LHC tunnel just before the collision point, with cutting-edge technologies. Among these innovations are the new superconducting magnets equipped with a combination of Nb-Ti and Nb3Sn. Over 100 magnets are being produced, each undergoing multiple production and test stages across different facilities worldwide, including labs outside CERN. Various technology systems are integrated into the magnets, involving collaboration with different groups for assembly work.
Recognizing the complexity of this production process, a decision was made to establish a comprehensive production and test schedule at CERN. This paper elucidates the schedule tools implemented to oversee the entire resource loaded process. The compiled data serves to identify strategic or technical bottlenecks in the production flow. By adopting such an approach and simulating various production scenarios, the aim is to proactively address potential conflicts, ensure the optimal allocation of resources and the readiness for installation during the Long Shutdown 3.

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Wednesday Poster Session / 1616

Effects of defects on the electronic and optical properties of cesium antimonide: insights from first-principles calculations

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Cesium antimonide (Cs3Sb) photocathodes are prime candidates to replace the metallic ones currently used to generate high brightness electron beam in X-ray free electron laser and X-ray energy-recovery linacs. Their appeal stems from their outstanding photo-emissive properties, such as low work function, that give them a high quantum yield. Whereas typical computational analyses of these materials have focused on the defect-free crystal structure, the crystals grown in the laboratory are bound to have intrinsic defects that can alter their photo-emissive properties. Therefore, understanding the effect of such defects on the photo-emissive properties from first principles is essential. In this work, we started by computationally studying the effect of Cs vacancies of varying concentration on the electronic and optical properties of Cs3Sb. Our calculations reveal that such vacancies induce mid gap states in the electronic band structure. These mid-gap states lead to changes in the absorption coefficient. Such changes in the absorption coefficient suggest changes in the quantum yield of Cs3Sb, affecting its photo-emissive response.

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Investigation of hot-spot and quench location due to trapped flux in niobium superconducting radiofrequency cavities

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One of the significant sources of residual losses in superconducting radio-frequency cavities is magnetic flux trapped during the cool-down due to the incomplete Messier effect. If the trapped vortices are non-uniformly distributed on the cavity surface, the temperature mapping revealed the "hot-spots"at the location of high density of pinned vortices. In this contribution, we present the results of combined temperature and magnetic mapping measurements on a single cell 3.0 GHz and 1.3

GHz niobium single-cell cavities. The results show the direct evidence of pinned vortices induced "hot-spots".

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Orbital alignment of electron beam in the CeC experiment

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During the coherent electron cooling (CeC) experiment at RHIC, we have encountered various challenges to align the electron beam both in the low energy beam transfer line and in the cooling section. For example, the electrons exit the SRF gun with an orbital angle of tens of milli-radian, which is likely caused by the misalignment of the cavity inside the cryostat and the tilted cathode. The significant orbital angle leads to transversely asymmetric beam with deteriorated emittance. In run 23, we have demonstrated that such orbital angle can be minimized by adjusting the position of the laser spot at the cathode. Another challenge is to align the orbit of the electron beam with the ion beam in the cooling section, which plays a critical role in demonstrating CeC. Over the past few years, we have developed a procedure to ensure the transverse alignment to the precision of 0.1 mm. The proper alignment has been confirmed by significant growth of the ion beam's longitudinal emittance due to its interaction with the electrons and increased signal from the recombination monitor. In this paper, we will present the techniques developed for beam alignment with experimental results.

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Study of flat-to-round-to-flat transformation at high space charge

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We describe experimental, theoretical, and simulation activities testing Derbenev's 1998 proposal for using flat-to-round-to-flat (FTRTF) transformations to enable electron synchrotrons for ion beam cooling. FTRTF systems have also been proposed for storage-ring and single-pass light sources (FELs), beam sources, and microwave tubes. The experiment—based on a low-energy (5–10 keV) linear electron transport system—includes an electron source, beam-shaping aperture plate, quadrupole matching section, Derbenev skew-quadrupole vortex sections, and a long solenoid. Our theoretical efforts explore the optical conditions required to optimize the canceling of angular momenta at the core of the Derbenev system. The complexity of the beam dynamics requires the use of simulation codes—here WARP and OPAL—to model the system for comparison with experiment. To reduce the computational effort required for optimization, we introduce the use of the adjoint technique, well-known in plasma physics but not beam physics. Using 5–10 keV beams allows us to study beam dynamics over a broad range of space charge in an environment readily accessible to students.

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Applications of machine learning in ultrafast laser control

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In our pursuit to tailor a precise electron bunch with a photoinjector, fine-tuning laser parameters, especially those influencing the photocathode pulse, is pivotal. Our ongoing research integrates

machine learning, training neural networks with experimental data from ATF. The first approach involves generating a downstream photocurrent image to replicate the emission profile, serving as a fitness function for neural network training. The second approach employs an emittance scan during each iteration of the neural network-controlled laser profile, using magnetic optics and beam profile monitors, with calculated beam emittance as an additional fitness function. Our research aims to demonstrate the potential superiority of the neural network in achieving precise laser shaping for electron beam optimization. Leveraging real data, our goal is to reduce electron beam emittance through optimized laser profiles, underscoring the impactful applications of machine learning in advancing photoinjector technology.

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I am working with Professor Sandra Gail Biedron and working with Marcus Babzian at BNL. I could not add them as a co-author but will figure out later and add them as well.

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A seeded THz free electron laser with an overmoded waveguide to reduce diffraction

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THz (1e+12 Hz) radiation is very attractive for its non-ionizing penetrative nature and unique absorption in water, metals, and other chemicals. While THz has great potential for imaging and for diagnosing chemical traces, it has not been utilized extensively due to scarcity of high-power THz sources. Currently, compact THz sources deliver power in the range of 50 μW —0.5 W, insufficient for most imaging and sensing applications. A compact THz sources is proposed to mitigate this gap of technology. FELs have been used for THz generation but have not been compact enough for most applications. The recent demonstration of waveguide THz FELs [1] has opened the door to more compact THz FELs. We propose a design of a seeded THz FEL with an overmoded waveguide. In addition, an efficient use of compact photoinjector to drive particles in energy of 2-4 MeV greatly reduces the overall footprint by 20%. We plan to use high-power GUNN diodes provides to efficiently seed THz power to the electron bunches, reducing the overall length of the device by 200%. An overmoded waveguide will allow for a larger waveguide to be used. The design has the potential to unleash full potential of THz spectrum.

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HPR and Plasma Processing of a Superconducting 360 MHz CH Cavity

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Goethe University (GU), Gesellschaft für Schwerionenforschung (GSI) and Helmholtz Institut Mainz (HIM) work in collaboration on the Helmholtz Linear Accelerator (HELIAC). A new superconducting (SC) continuous wave (CW) high-intensity heavy ion linear accelerator (Linac) will provide ion beams with a maximum duty factor up to beam energies of 7.3 MeV/u. The acceleration voltage will be provided by SC Crossbar H-mode (CH) cavities, developed by the Institute for Applied Physics (IAP) at GU. Preparation methods were investigated to increase their performance. High-pressure rinsing (HPR) with ultra-pure water was performed at HIM and recovered the maximum electric field of a 360 MHz 19-cell CH cavity from Ea = 1.6 MV/m to Ea = 8.4 MV/m. This result exceeds the prior highest electric field observed of Ea = 7 MV/m by 20%. The effect of helium processing has been subsequently investigated. The cavity has been processed for a total of 2 hours at a cavity pressure of 5e-5 mBar. The performance measurement showed promising results, with an increase in maximum gradient and a change in Q-slope behavior. Further tests of helium processing concerning the reproducibility, longevity, and optimization of the observed effects are scheduled at IAP.

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Tuesday Poster Session / 1623

Simulation of the secondary beams in the CERN north and east areas using FLUKA

Author: Laurence Nevay[1]

Co-authors: Alice Goillot [1]; Anna Baratto Roldan [1]; Bastien Rae [1]; Dipanwita Banerjee [1]; Elisabetta Parozzi [2]; Emily Andersen [1]; Fabian Metzger [1]; Florian Stummer [1]; Johannes Bernhard [1]; Laurent Gatignon [3]; Luke Dyks [1]; Maarten Van Dijk [1]; Marc Jebramcik [4]; Markus Brugger [1]; Nikolaos Charitonidis [1]; Robert Murphy [1]; Silvia Schuh-Erhard [1]

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The CERN North and East Experimental Areas provide a wide variety of secondary beams for fixed-target experiments and test beam set-ups. These secondary beams are exploited by the many users of these facilities, requiring a large diversity of different particle species at different momenta. Magnetic selection as well as optional converters and absorbers are used to create the beams according to user and experiment requirements. Presented here are start-to-end Monte Carlo simulations of complete secondary beam lines using FLUKA, which demonstrate beam composition, spectra and beam size. Custom geometry and accurate magnetic field maps are composed automatically into detailed models. A comparison with measured beam composition in select cases is presented along with a description of the automated beam line modelling.

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Wednesday Poster Session / 1624

A fast simulation tool for multi-species secondary beam optics

Author: Laurence Nevay[1]

Co-authors: Alice Goillot [1]; Anna Baratto Roldan [1]; Bastien Rae [1]; Dipanwita Banerjee [1]; Elisabetta Parozzi [2]; Emily Andersen [1]; Fabian Metzger [1]; Florian Stummer [1]; Johannes Bernhard [1]; Laurent Gatignon [3]; Luke Dyks [1]; Marc Jebramcik [4]; Markus Brugger [1]; Nikolaos Charitonidis [1]; Robert Murphy [1]; Silvia Schuh-Erhard [1]

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The secondary beam lines in the CERN North and East Experimental Areas are heavily subscribed, with the beams requested by users spanning a huge range of momenta and particle types. With the highly dynamic nature of test beam requirements, traditional optics tools do not always provide suitable feedback for rapid beam line tuning. Presented here is a tool to provide optics solutions and beam distributions for multi-species beams including those with unstable particles such as muons that stem from decays. The tool is written in Python and uses cpymad and BDSIM underneath. A

demonstration is shown for the M2 beamline at CERN where the muon distribution is predicted from an initial pion beam with rapid tracking that includes tracking in yokes with particle-matter interaction.

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Tuesday Poster Session / 1625

Coherent radiation of a microbunched beam in a short undulator

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We calculate the coherent radiation of a modulated beam in a short resonantly tuned undulator taking into account the finite transverse size and the angular spread of the beam. The result allows to optimize the radiation by controlling the Twiss parameters in the undulator.

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Wednesday Poster Session / 1626

Charge measurement systems on CLARA at Daresbury laboratory

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CLARA is a 250 MeV electron facility at Daresbury Laboratory, which will provide short bunches between 1 and 250 pC for a variety of experiments, including novel acceleration experiments. As part of the Phase 2 upgrade new charge measurement systems have been installed. This paper presents the charge measurement systems that will be used on CLARA, as well as commissioning results without beam for some of those systems. CLARA will include a Wall Current Monitor (WCM), 3 Integrating Current Transformers (ICTs) and five Faraday cups. The ICTs are commercial systems by Bergoz, while a custom front-end has been designed for the WCM and Faraday cups, which includes calibration circuitry and switchable gain. Calibration results, including measurements of resolution, are presented for the in-house front-end design.

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Wednesday Poster Session / 1627

Measuring transverse momentum space of alkali-antimonide photocathodes with the Cornell cryo-MTE-meter

Author: Charles Zhang[1]

Co-authors: Adam Bartnik [1]; Elena Echeverria [1]; Chad Pennington [1]; Alice Galdi [2]; Christopher Pierce [1]; Jared Maxson [3]

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The brightness of the beam in any linear accelerator can be no greater than at its source. Thus characterization of source initial conditions, including spatial and momentum distributions, is then critical to understand brightness evolution in a linac. Often measurement of the initial momentum distribution and closely related quantities such as the mean transverse energy (MTE) is hampered by imperfect knowledge of either the spatial source distribution or the downstream particle optics. Here, we experimentally demonstrate a method* that reconstructs the initial transverse momentum space without the aforementioned limitations, only assuming the beam transport is linear. This method entails scanning the excitation laser across the photocathode and simultaneously measuring the 4D phase space of the beam via aperture scans. We also measure the transverse momentum space and MTE with other methods, including solenoid scans and m11=0 imaging, and compare the results. Lastly, we will discuss the measurements of initial transverse momentum spaces across a spectrum of photocathode temperatures and excitation energies for an alkali-antimonide photocathode.

Footnotes:

- C. Zhang et al., "Reconstructing 4D source momentum space via aperture scans", in Proc. IPAC'23, Venice, Italy, May 2023, pp. 4595-4597. doi:10.18429/JACoW-IPAC2023-THPL071

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Wednesday Poster Session / 1628

Novel high-intensity X and Gamma-rays sources using crystals

Author: Riccardo Negrello[1]

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The research is focused on finding new ways to generate high-intensity, monochromatic X and gamma-rays, surpassing the capabilities of existing methods. While Free-Electron Lasers (FEL) have limitations on photon energy, and Inverse Compton Scattering relies on powerful lasers, the search for alternatives continues. TECHNO-CLS, a PATHFINDER project funded by the European Innovation Council, is dedicated to crafting innovative gamma-ray Light Sources (LSs), utilizing linear, bent, or periodically bent crystals. Similar to magnetic undulators, crystals leverage a strong interplanar electrostatic field to prompt particle oscillation, resulting in electromagnetic radiation. By reducing the oscillation period to sub-mm dimensions, these undulators can produce tens of MeV in photon energy when exposed to GeV electron beams*. As a passive and sustainable element, CLSs show great promise. In the initial phase of the project, we identified techniques to realize CLSs, using alternated pattern deposition on silicon, using simulation to optimize the pattern and conducted experiments at CERN PS with Tungsten and Iridium crystals.

Footnotes:

- A.V. Korol, A.V. Solov'yov, Novel Lights Sources Beyond Free Electron Lasers, Particle Acceleration and Detection series, Springer Nature Switzerland, Cham (2022), 214 p., ISBN: 978-3-031-04281-2

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Tuesday Poster Session / 1629

PSI's open-source FPGA DSP libraries

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Paul Scherrer Institute (PSI) has led significant advancements in accelerator electronics development, leveraging FPGA-based Digital Signal Processing (DSP) across various critical systems, including LLRF, LLM, ICT, Timing, FPM, BPM and other essential beam instruments. Over the past decade, PSI's approach to develop in-house control system platform (e.g. CPCI-S), has encouraged innovation. The strategic reorganization within PSI, fostering collaboration among FPGA firmware engineers, led to the inception of Open-Source FPGA DSP libraries hosted on GitHub. Serving as a comprehensive repository, these libraries empower developers by providing common FPGA IPs, fundamental DSP algorithms and fixed-point arithmetic units. Their presence advances prototype development by enabling rapid assembly of several measurement and or control concepts. In this contribution, we present the feature and the transformative impact of the PSI Open-Source FPGA libraries with a focus on LLRF. This initiative has not only empowered our team to provide valuable insights, but has also streamlined the integration of new recruits and students, enabling the seamless continuation of FPGA design frameworks.

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Tuesday Poster Session / 1632

Harmonic EU cavity pransdamper improvements

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ALBA has designed and prototyped the Harmonic EU Cavity, a normal conducting active 1.5 GHz HOM damped cavity for the active third harmonic RF system for the ALBA Storage Ring (SR), which also will serve for the upgraded ALBA II. The HOM dampers incorporate a custom-made transition to coaxial line that allows to dissipate the HOM power in external loads, avoiding the use of in-vacuum soldered ferrite absorbers. The performance of the prototype transitions, although enough to grant stable operation of the cavity installed in BESSY II, can be further improved to achieve the performance predicted by simulations. This paper presents the measurements and improvements made with the prototype Transdampers in order to achieve the expected performance.

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Tuesday Poster Session / 1633

Adjoint approach to the design of vacuum RF sources

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Efficient calculation of multi-dimensional derivatives of various performance metrics of RF sources with respect to different design parameters is a critical element of their optimization and sensitivity analysis. The direct approach is to change slightly the value of a design parameter of interest and compute the resulting change in the metric of interest; an example is a calculation of how a small change in klystron cavity spacing affect output power. The major problem with this approach is a number of required runs of a simulation code. For example, when there are many (N) design parameters of interest then (N+1) runs are required. N can be very large for detailed design of RF sources for accelerators [,*]. By computing the solution of the adjoint of the perturbed equations for the beam-wave interaction, we have shown [*]* that all N partial derivatives may be computed with only three runs of the simulation code, no matter how large (N) is. Once calculated, these partial derivatives may be used to specify manufacturing tolerances and/or used in a design optimization calculation. We will also present examples of applications of adjoint approach to klystron and TWT design.

Footnotes:

[*] G. Cariotakis, IEEE Trans. on P.S, 22, 693-691, 1994*
[] A.Y. Baykov, et al., IEEE Trans. on ED, 62, 3406-3412, 2015
*[**] A.N. Vlasov, et al., IEEE Trans. PS, 50, 2568-2577, 2022

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Monday Poster Session / 1634

Optimizing the sextupole configuration for simultaneous correction of third order resonances at the recycler ring

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For the Recycler Ring at Fermilab, space charge tune shifts of almost 0.1 will have to be dealt with under the Proton Improvement Plan (PIP-II) framework. This will lead to the excitation of third order resonances. The minimization of Resonance Driving Terms (RDTs) allows to mitigate the harmful effect of these betatron resonances. Past work has shown that previously-installed sextupoles can compensate the RDTs of individual third order resonance lines, thus reducing particle losses in these operational regimes. Nevertheless, trying to compensate multiple resonances of the same order simultaneously with these existing sextupoles is limited due to current constraints in the magnets. The following study showcases the procedure to install additional sextupoles in order to aid the compensation of multiple resonances. This includes the optimization of the new sextupoles' locations in order to cancel out multiple RDTs while minimizing the currents needed. This is followed by a verification of their effectiveness by means of the RDT response matrix.

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Monday Poster Session / 1635

An update on EIC rapid cycling synchrotron optics

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The Electron-Ion Collider (EIC) requires continuous replacement of the stored electron bunches to facilitate arbitrary spin patterns in the Electron Storage Ring (ESR). This is accomplished by a dedicated, spin transparent Rapid Cycling Synchrotron (RCS). The dynamic range of the accelerator is from 400 MeV to 18 GeV. To maintain stability throughout the acceleration ramp, the linear and nonlinear optics must be tuned accordingly. In this paper, we will discuss the updated linear optics, chromaticities, and dynamic aperture of the RCS.

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Thursday Poster Session / 1636

Container stripping: enhanced classification of materials within cargo containers

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For cargo and vehicle inspection, where high energy linear accelerators are used, materials within radio-graphic images can be classified using their atomic number (Z). The identification and classification of materials and objects within cargo containers can be difficult, due to the nature of energy spectra and their impact on the discrimination of materials. This can also be impacted by system-level factors, such as the stability of the linear accelerator and the alignment of the system. By removing the container from images of cargo, materials inside can be classified with higher confidence. When a low-Z, low density organic material is obscured by a 5 mm thick steel container, its effective-Z value changes and it can colorise as green rather than orange. This could lead to mis-classification of materials by an operator, potentially leading to the mis-identification of threatening materials. Further to the container removal, extra layers can be 'stripped'away to better reveal certain areas of interest. In future, this could be tied in with operator-assisting algorithms, as part of an enhanced image quality analysis package.

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Wednesday Poster Session / **1637**

Cavity and cryomodule test stands in SHINE

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The SC Linac of SHINE (Shanghai HIgh repetition rate XFEL aNd Extreme light facility) comprises 79 cryomodules housing 609 1.3 GHz TESLA type superconducting cavities (SCCs), and 16 3.9 GHz SCCs. These SCCs and cryomodules should be tested in ATH (cryomodule Assembly and Test Hall) at SSRF (Shanghai Synchrotron Radiation Facility) campus. Four VTFs (SCC Vertical Test Facility) and four HTFs (Cryomodule Horizontal Test Facility) will undertake the vertical test of these SCCS and horizontal test of cryomodules. The status and future plan of these test stands will be shown.

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Tuesday Poster Session / **1638**

Impact of beam screen eddy currents on transition crossing in the EIC HSR

Author: Henry Lovelace III[1]

Co-authors: Guillaume Robert-Demolaize [1]; Kirsten Drees [1]; Silvia Verdu-Andres [2]; Steve Peggs [1]; Vadim Ptitsyn [2]

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The Electron Ion Collider (EIC) hadron storage ring (HSR) requires a beam screen made of 75 μm copper layer on top of a 1 mm thick 316LN stainless steel sheet. The eddy currents produced by the dynamic fields at the beam screens of the transition jump quadrupoles will increase the field response delay. The field response curve depends on the thickness and Residual Resistivity Ratio (RRR) value of the copper layer. Manufacturing variances of thickness and RRR in the beam screens of the gamma transition quadrupole will result in different field response delays. This paper summarizes the effects from the beam screens on transition crossing. From the varying delays, the beta-wave and eta-wave may exceed typical RHIC values. The effectiveness of the jump will be estimated using simulations of the existing RHIC lattice.

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Wednesday Poster Session / 1640

Experimental study into the invasiveness of a gas jet beam profile monitor for charged particle beams

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Co-authors: Carsten Welsch [2]; Hao Zhang [1]; Milaan Patel [2]; Narender Kumar [1]; Oliver Stringer [1]

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A non-invasive gas jet in-vivo dosimeter for medical treatment facilities is being developed at the Cockcroft Institute, (UK) to provide full online (real time) monitoring with less frequent calibration. The monitor functions via a thin, low-density, gas jet curtain, intersecting with the beam. Online monitoring is crucial for hadron beams where acceptable dose tolerances are narrow, hence the beam should be perturbed only by the minimum amount necessary to acquire a signal. An experiment to determine the level of invasiveness of supersonic gas jet beam profile monitors was undertaken to quantify how much the gas jet perturbs the beam. This was accomplished using a 10 keV electron gun with a maximum current of ~100 nA, available in the DITAlab of the Cockcroft Institute. A scintillator screen and Faraday cup were placed in path of the beam to measure the change in beam size and current respectively. In the future, a simulation study using GEANT4 will be completed with the experimental beam parameters to verify the results. This contribution examines the perturbation experienced by a particle beam from a gas jet beam profile monitor, and quantifies the effect the jet has on the beam size and current.

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Monday Poster Session / 1641

Photocathode epitaxy and beam experiments laboratory at Cornell: current status and future work

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Co-authors: Abigail Flint [2]; Adam Bartnik [2]; Chad Pennington [2]; Charles Zhang [2]; Christopher Pierce [2]; Elena Echeverria [2]; Ivan Bazarov [2]; Jared Maxson [3]; William Li [4]

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High-efficiency alkali antimonide photocathodes degrade with little oxidation, making them hard to characterize and test outside their growth chamber. In this proceeding, we report on the design and performance of the PHOtocathode Epitaxy and BeamExperiments (PHOEBE) laboratory at Cornell University, where the growth, characterization, and testing of photocathodes in vacuum has been successfully integrated. The growth of photocathodes is characterized in-situ by measuring the QE and by looking at the photocathode's reflection high energy electron diffraction (RHEED) pattern. Once the desired photocathode is obtained, it is moved to a storage chamber to collect complete spectral response data, after which it is moved to the Cryo-MTE-Meter DC gun and characterization beamline via a vacuum suitcase. Utilizing a rapid cathode exchange system in the Cryo-MTE-Meter, alkali-antimonide photocathodes can be efficiently transferred to beamline operation with little QE loss. Using the Cryo-MTE-Meter, the mean transverse energy of the photocathode can be continuously measured across photoexcitation wavelengths in the visible-UV spectrum and sample temperatures between 20 and 300 K.

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Tuesday Poster Session / 1642

TDR baseline lattice for Soleil II upgrade project

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Co-authors: Alexis Gamelin [1]; Amor Nadji [1]; Laurent Nadolski [1]; Marie-Agnès Tordeux [1]; Pascale Brunelle [1]; Vadim Gubaidulin [1]; Watanyu Foosang [1]

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Previous TDR (Technical Design Report) studies for the SOLEIL upgrade project (SOLEIL II) have converged towards a lattice alternating 7BA and 4BA HOA (High Order Achromat) type cells providing an ultra low natural horizontal emittance value in the 85 pm·rad range at an energy of 2.75 GeV. The new TDR lattice is an evolution that keep the insertion devices photon source points at their present location, allows a better relative magnet positioning and more space for accommodating photon absorbers, BPMs (Beam Position Monitor) and other mandatory diagnostics. This last evolution includes a better modeling of all the bend magnets based on their realistic field profiles and the accommodation of height super-bends for beam-lines as well as for beam size diagnostics. In addition an exhaustive investigation of the systematic and especially the cross-talk multipoles as well as the phase 1 portfolio of insertion devices impacts has been carried out. This paper reports the linear and the non-linear beam dynamic optimizations as well as future directions for performance improvement.

Footnotes:

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Thursday Poster Session / 1643

Dynamics study of laser stripping injection of H- beam in the SNS

Author: Fanglei Lin[1]

Co-authors: Abdurahim Oguz [1]; Alexander Aleksandrov [1]; Nicholas Evans [1]; Sarah Cousineau [1]; Timofey Gorlov [1]; Yun Liu [1]

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A Laser Assisted Charge Exchange (LACE) injection in the Spallation Neutron Source (SNS) is under development. By utilizing powerful lasers and magnetic fields, electrons are stripped out of the H- beam without foils. Such a process avoids any foil-based charge exchange injection problems, such as foil degradation and beam loss, especially for future multi-megawatt power beams. Proof-of-principle of LACE has been experimentally demonstrated in the SNS in a transport line. Integration of the LACE injection into the SNS accumulator ring is in progress. In this paper, we present preliminary results of optics design and beam dynamics study.

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Monday Poster Session / 1644

An LWFA injector for AWAKE Run 2 expertiment

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Co-authors: Laury Batista [1]; Vittorio Bencini [2]; Antoine Chance [1]; Nicolas Chauvin [1]; Brigitte Cros [3]; Steffen Doebert [2]; John Farmer [4]; Edda Gschwendtner [2]; Francesco Massimo [5]; Ioaquin Moulanier [3]; Patric Muggli [4]; Didier Uriot [1]; Damien Minenna [1]; Phu Anh Phi Nghiem [1]

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A beam physics design has been carried out for a 200 MeV-LWFA injector to the AWAKE Run 2 experiment as an alternative to the reference RF injector. It is composed of a laser-plasma acceleration stage and a transport line. In addition to specific environment constraints that impose a dogleg configuration, the electron beam must feature unprecedented performances for a plasma-based accelerator: 100 pC charge, a few mm·mrad emittance, and a few % energy spread. Thanks to an integrated beam physics study assigning specific roles to each section of the accelerator, all the requirements are successfully met in numerical simulations, paving the way for plasma-based accelerators to be competitive with conventional accelerators.

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Monday Poster Session / 1645

Compact, quality-preserving energy booster for intense laser-plasma ion sources

Author: Axel Huebl[1]

Co-authors: Stepan Bulanov [1]; Sahel Hakimi [1]; Lieselotte Obst-Huebl [1]; Chad Mitchell [1]; Carl Schroeder [1]; Eric Esarey [1]; Cameron Geddes [1]; Jean-Luc Vay [1]; Marco Garten [1]

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Ion beams from laser-driven plasma sources can provide ultra-short (10s of fs for 10s of MeV), ultra-low slice emittance (10s of nm), and high-charge (100s of pC) properties. Demonstrated maximum energies for laser-ion sources are just short of those needed for pivotal applications, such as proton tumor therapy. Here, a robust and energy-scalable concept is presented that could boost the energy of an ultra-intense ion bunch through multiple stages to 100s of MeV/u and even towards the relativistic regime, using identical plasma booster stages based on magnetic vortex acceleration. Electromagnetic, full-3D particle-in-cell simulations are used to demonstrate the capability to capture, accelerate, and preserve the quality of a high-charge (200 pC), 20 nm emittance proton bunch, where both source and booster stages could be realized with capabilities of existing laser facilities.

Footnotes:

Preprint:
Marco Garten, Stepan S. Bulanov, Sahel Hakimi, Lieselotte Obst-Huebl, Chad E. Mitchell, Carl Schroeder, Eric Esarey, Cameron G. R. Geddes, Jean-Luc Vay, and Axel Huebl. "A Laser-Plasma Ion Beam Booster Based on Hollow-Channel Magnetic Vortex Acceleration", submitted (2023) https://arxiv.org/abs/2308.04745

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Thursday Poster Session / 1646

Computational fluid dynamics design of a very high-power rotating positron target

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Computational Fluid Dynamics (CFD) has been used to design a very high-power rotating tungsten target to produce a positron beam. The positrons will be produced by a primary 1 mA electron beam with energy 120 MeV impinging on a rotating tungsten wheel through bremsstrahlung. The W target will be instrumented with water cooling to remove the estimated 17 kW of heat deposited by the primary electron beam in it [1]. The target will be central to accomplishing a rich experimental program using a positron beam at Jefferson Lab. In this contribution, I will present the status of the CFD-driven design of the target and the path towards a production positron target.

Footnotes:

[1] J. Grames et al., "Positron beams at Ce+BAF", in Proc. IPAC'23, Venice, Italy, May 2023, pp. 896-899. doi:10.18429/JACoW-IPAC2023-MOPL152

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Tuesday Poster Session / 1647

Development of high-power electron gun and collector for the new antiproton decelerator electron cooler

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The electron cooler of the Antiproton Decelerator (AD) at CERN was initially developed for the Initial Cooling Experiment in 1979. It was subsequently adapted for use at LEAR and is currently employed in the AD. However, certain components of the cooler are now more than 40 years old and lack spare parts. To ensure the reliable operation of the AD, a new electron cooler is under development.
This presentation focuses on the development of the new electron gun and collector that will provide the 2.4 A / 27 keV electron beam. The process involves choosing the gun/collector design, informed by electron-beam simulations, which aim to achieve the lowest transverse temperature of the electron beam within the cooling section and the highest collection efficiency of the collector. Subsequently, the gun and collector undergo meticulous testing and characterization on a dedicated test bench. The design undergoes iterative refinement to address issues related to high voltage sparks, vacuum pressure, and electron losses.
Distinguishing features of the new cooler that make it more reliable compared to its predecessor will also be discussed.

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Tuesday Poster Session / 1648

First injection and lattice commissioning of APS upgrade storage ring

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APS Upgrade is a 6 GeV fourth-generation light source that has been recently assembled at Argonne National Laboratory. APS-U storage ring utilizes hybrid seven-bend achromat with reverse bends and promises a design natural emittance of 42 pm·rad. Due to very strong focusing and highly nonlinear lattice, the first-turn trajectory correction and establishing first stored beam rely heavily on automated correction algorithms. We will describe the automated correction process and present the results of the APS-U lattice commissioning which covers commissioning steps from first injection to orbit correction to lattice correction.

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Thursday Poster Session / 1649

A new cryogenic permanent magnet undulator at BESSY-II: The CPMU-20

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We discuss the design and properties of a proposed planar cryogenic permanent magnet undulator with 20 mm period length called CPMU-20. The undulator is set to use (Pr,Nd)2Fe14B as permanent magnet material and Permendur poles and is set to be part of the planned SoTeXS beamline at the BESSY-II upgrade which will offer a unique working environment for research into energy-materials –especially energy-storage materials. The CPMU-20 is designed to produce high photon fluxes in the energy range of 0.5 to 5 keV with a maximum K-value of 2.2 which permits research into a wide range of materials used in state of the art batteries. The optimization process that led to the specific device properties like the period length, the width of the poles and the end-magnet configuration – which ensures an aligned electron beam through the device for the whole gap-range from 6 to 22

mm - will be presented in detail. This includes a discussion of the usage of the UNDUMAG and WAVE software written by Michael Scheer for the optimization and simulations.

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Tuesday Poster Session / 1650

Review of the complex baseband RF cavity model and its applications

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Recently the need has arisen to examine the effects of a variable coupling factor in the complex baseband RF cavity model. This paper briefly reviews the dynamic baseband model, then augments the model to include variable coupling. Power balance, asymptotic behavior and model simplifications are explored. Finally, applications of high-power RF pulse compression and transient heating in high-gradient RF cavity structures planned for use in the CXFEL project are modeled.

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Tuesday Poster Session / 1652

Theoretical derivation of figures of merit for a dielectric disk accelerating structure

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A Dielectric Disk Accelerator (DDA) is a high gradient, metallic accelerating structure loaded with dielectric disks to increase its shunt impedance. So far, multiple of these structures have been fabricated and high power tested, reaching accelerating gradients higher than 100 MV/m with no significant damage. After the success of these experiments, derivations are being carried out to calculate the figures of merit of the geometry, such as accelerating gradient, shunt impedance, Q, etc. This work will be used to optimize the geometry of a structure for future design work. Results of these derivations as well as optimized geometries will be presented and discussed.

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Tuesday Poster Session / 1654

Transistor load imbalances within a 6:1 smart combining structure during an output short condition

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For achieving sufficient RF power from a solid state amplifier for accelerate particles applications usually many transistor stages need to be combined. Power levels of more than one kilowatt (kW) per transistor are state of the art for a variety of frequencies. Depending on the required total output power for multi ten kW systems a combining structure is needed. The approach of a sequential multi stage combining bears some advantages. As reflected power also plays a crucial role for the amplifies when used for particle acceleration in a cavity, we investigated the effect of a controlled short within a 6:1 smart combining structure and how it affects the reflected power into the loads in this design. The design we consider is a non-isolating combining with a circulator and load in each single transistor module so that no external customized circulators are needed for this system. Our findings illustrate that strong imbalances can occur, depending on the position of the different modules to each other. We will share experimental and simulation results on findings of a controlled short and the imbalances that can occur.

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Wednesday Poster Session / **1657**

Niobium-tin films grown on copper by low-temperature co-sputtering for SRF cavity application

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In this contribution the low-temperature synthesis of Nb3Sn, a promising material for superconducting radio frequency (SRF) application is presented. Theoretically Nb3Sn is superior to Nb in surface resistivity, critical temperature and critical field, but in practice the performance is lacking behind due to early quenching at low fields. Co-sputtering at low sample temperature could overcome the microstructure-related limitations due to the high kinetic energy of the sputtered particles.
We show by X-ray photoelectron spectroscopy that copper diffusion during low-temperature growth is limited to an interface region of about 100 nm. Furthermore, we show that the deposition time has a critical influence on phase formation. The deposited Nb3Sn films have low surface roughness, high scratch resistance and they show excellent adhesion before and after thermal cycling.

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Tuesday Poster Session / **1658**

A crystal-based positron source for FCC-ee

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Positron source yield is a key factor for reaching the luminosity needed in future lepton colliders. Conventional scheme relies on a few GeV e-beam impacting on a high-density solid target to initiate an e.m. shower and collect the positrons after the target. This scheme is limited by the maximum heat load on the target before its structural failure.
An innovative approach to overcome such limitations exploits the large photon emission in axial channeling in a crystal radiator, to increase the positron yield and/or decrease the target thickness and therefore the Peak Energy Deposited Density in it. *Together with the conventional scheme, our crystal-based one is under study for the FCC-ee injector design. We carried out experiments at DESY and CERN PS with high-Z crystals (W and Ir) and tuned e-beam parameters useful for FCC-ee to validate a new simulation model implemented in Geant4***. This model includes the modified photon production in channeling condition and oriented crystals in general. Capable of designing the full FCC-ee source. This new model was employed to simulate the positron source showing reduced energy deposition compared to conventional sources.

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Tuesday Poster Session / 1659

Optics design of the solenoid compensation scheme at FCC-ee

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We present the optics design of the solenoid compensation scheme at the FCC-ee. The 2T solenoids from the experiments induce coupling on the beams, generating an increase on vertical emittance. This compensation scheme minimizes emittance growth, with a final value of approximately 5% of

the nominal. A screening solenoid is placed around the Final Focus Quadrupoles to protect them from the experiment's field. A skew quadrupole component is added to the Final Doublet, aligning the magnet axis to the rotated reference frame of the beam. Two anti-solenoids placed approximately ±20 m from the IP are used to cancel the field integral. The vertical orbit generated by the horizontal crossing angle in the detector field is compensated by vertical correctors placed right after the beam pipe separation and next to the final focus quadrupoles. We describe the IR optics in this scheme, including the detector solenoid and the magnetic elements used for compensation.

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Tuesday Poster Session / 1660

Anodically bonded bent crystals: an advanced tool for channeling applications in particle beams steering

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In accelerator physics, channeling is a well-established phenomenon. By carefully selecting crystal orientation, particle's trajectories can be controlled and guided along desired paths. Bent crystals have been used at worldwide particle accelerators as optical elements to steer charged particle beams, with an elective application related to the collimation of the lead ion beam circulating in the large hadron collider (LHC) at CERN. This result opens new possibilities for innovative experimental setups, allowing for example to realize fixed target experiments at the TeV scale energy. Such experiments require compact, and light bent crystals with a length along the beam in the range of few cm and extremely uniform radius of curvature. An innovative method of crafting bent crystal for this class of experiments relies on anodic bonding of silicon to pre-figured glass. The presented methodology has potential to open new possibilities for optimizing beam quality and beam extraction in particle accelerators, leading to innovative physics experiments.

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Thursday Poster Session / 1661

Full-cycle 6D simulations of the FNAL booster

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The PIP-II project currently under construction at FNAL will replace the existing 400 MeV normal conducting linac with a 800 MeV superconducting linac. The beam power in the downstream rapid-cycling Booster synchrotron will be doubled by raising the machine cycle frequency from 15 to 20 Hz and by increasing the injected beam intensity by a factor 1.5. This has to be accomplished without raising uncontrolled losses beyond the administrative limit of 1 W/m. In addition, slip-stacking efficiency in the Recycler —the next machine in the accelerator chain- sets an upper limit on the longitudinal emittance of the beam delivered by the Booster. As part of an effort to better understand potential losses and emittance blow-up in the Booster, we have been conducting full cycle 6D simulations using the code pyORBIT. The simulations include space charge, wall impedance effects and transition crossing. In this paper, we discuss our experience with the code and present representative results for possible operational scenarios.

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Monday Poster Session / 1662

Electron probing of laser wakefield at the Accelerator Test Facility

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Laser wakefield accelerators (LWFAs) have been experimentally shown to produce sustained gradients of tens of GeV/m over tens of centimeters. While the strength of these fields has been demonstrated, a direct measurement of the field configurations inside an LWFA represents an emerging research topic. Here, we report on the results of transverse probing of the fields inside an LWFA at densities of 1e+15 —1e+17 1/cm3, corresponding to plasma wavelengths in the range of several hundred microns. The LWFA is driven by BNL Accelerator Test Facility's unique long-wave-infrared CO2 laser (9.2 μm) pulse, which currently generates 2 ps long pulses at 2-3 TW. The linac-produced electron beam has an energy of 50-60 MeV and about a 200 fs long bunch length. A YAG:Ce scintillator placed on a translation stage records the electron beam density profile at distances of up to 10 cm from the plasma. Particle-In-Cell Simulations using OSIRIS are used to corroborate the results of the experiment.

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Monday Poster Session / 1663

Characterization of FEL mirrors with long ROCs

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FEL oscillators typically employ a two-mirror cavity with spherical mirrors. For storage ring FELs, a long, nearly concentric FEL cavity is utilized to achieve a reasonably small Rayleigh range, optimizing the FEL gain. A challenge for the Duke storage ring, with a 53.73 m long cavity, is the characterization of FEL mirrors with a long radius of curvature (ROC). The Duke FEL serves as the laser drive for the High Intensity Gamma-ray Source (HIGS). As we extend the energy coverage of the gamma-ray beam from 1 to 120 MeV, the FEL operation wavelength has expanded from infrared to VUV (1 micron to 170 nm). To optimize Compton gamma-ray production, the optimal value for the mirror's ROC needs to vary from 27.5 m to about 28.5 m. Measuring long mirror ROCs (> 10 m) with tight tolerances remains a challenge. We have developed two different techniques, one based on light diffraction and the other on geometric imaging, to measure the long ROCs. In this work, we present both techniques and compare their strengths and weaknesses when applied to measure mirror substrates with low reflectivity and FEL mirrors with high reflectivity.

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Wednesday Poster Session / 1665

Design and operation of a commercial molecular beam reactor for alkali antimonide growth

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Alkali antimonide epitaxy and the demonstration of very high quantum efficiencies (QEs) from ultrathin films has been an exciting development of the last few years. With goals of superb film uniformity, physical/chemical roughness, and control of stoichiometry and defect densities, comes an increased emphasis on highly capable growth systems. We report on the design and performance of a new molecular beam reactor system for alkali antimonide photocathode preparation. Calibration of effusion cell flux, low temperature effusion cell stability, and routine operation is described. Photoemissive performance is presented for the most recent thin films grown, using a new rapid spectral QE profiler which enables real-time feedback for stoichiometric control during co-evaporation.

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Monday Poster Session / 1666

Progress towards high quality, high-repetition-rate plasma acceleration at FLASHForward

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Plasma-wakefield acceleration represents an exciting route towards reducing the footprint of future high-energy electron accelerators by accelerating bunches in fields exceeding 1 GV/m. One such technique employs a double-bunch structure where the trailing bunch is accelerated in the fields of a high-amplitude plasma-density wake driven by the leading bunch. A future particle collider or photon science facility incorporating plasma accelerators will be required to have high overall energy efficiency and to accelerate up to millions of bunches per second, all while preserving the brightness, emittance and energy spread of the accelerating bunch. This contribution presents the latest progress towards these goals at FLASHForward (DESY).

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Wednesday Poster Session / **1667**

Superconducting magnets for SIS100 and Super-FRS at FAIR – overview and progress

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Co-authors: Alexander Bleile [1]; Andreas Waldt [1]; Anna Szwangruber [1]; Eun Jung Cho [1]; Florian Kaether [1]; Haik Simon [1]; Hans Mueller [1]; Jan Meier [1]; Jochen Ketter [1]; Kei Sugita [1]; Martin Winkler [1]; Matthias Janke [1]; Niels Pyka [1]; Patricia Aguar Bartolome [1]; Pawel Kosek [1]; Peter Spiller [1]; Piotr Szwangruber [1]; Tiemo Winkler [1]; Vasileios Velonas [1]; Walter Freisleben [1]

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At the FAIR project in Darmstadt, Germany, superconducting magnets will be utilized for the main accelerator, the SIS100 heavy ion synchrotron, and for the fragment separator Super-FRS. For SIS100, the magnets are fast ramped with a rate of up to 4 T/s while large apertures are required for Super-FRS. In total, several hundred magnets need to be produced, qualified and characterized for the operation at FAIR. For both machines, series production is ongoing and testing programs at operational conditions have been established for quality assurance of the high demanding magnet modules.
In the presentation, an overview is given on the design and operation principles of the various magnet types and module combinations. The complex project landscape involving several sites for production, module integration, and cold testing is pictured. The project progress and key testing results are highlighted and an outlook for the installation and commissioning plans at FAIR is given.

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Thursday Poster Session / 1668

Updating the RF system model in beam-cavity interactions under heavy beam loading effects

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This study presents a refined model of radio frequency (RF) systems by the transfer function perspective of the Pedersen model on the basis of microwave RLC circuit model. While the former concentrates on the signal variation or error analysis, focusing on the cavity-beam interaction. the latter emphasizes the signal's properties within the system, allowing for seamless integration with components like controllers. Recognizing the limitations of the Schilcher model under certain conditions, such as the uncontrolled synchronous oscillation caused by the change in cavity voltage under heavy beam loading, a problem that has been overlooked. Therefore, it combines Pedersen model frequency-domain analysis results with the time-domain analysis conclusions of the new model, providing recommendations for system parameter and controller settings. The resulting model not only offers a more accurate representation of real RF systems but also facilitates digitalization, thus contributing to the innovation of Low-Level RF (LLRF) control systems.

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Wednesday Poster Session / 1669

Overview of inverse Compton scattering feasibility studies at MESA

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Johannes Gutenberg University Mainz is currently constructing a new electron accelerator that employs an energy recovery scheme. The Mainz Energy Recovery Superconducting Accelerator (MESA) will provide two modes of operation: the Energy Recovery (ER) mode, which will supply an internal gas target experiment, and the Extraction Beam (EB) mode, primarily used in the P2 experiment where MESA's spin-polarized electrons will be directed towards a target.
As an Energy Recovery Linac (ERL), MESA shows potential as an accelerator for an Inverse Compton Scattering (ICS)-based gamma source. To anticipate the impact of the scattering on electron beam parameters, significant for energy recovery, a novel quasi-analytical simulation code, "COMPARSE", has been developed and used for the feasibility studies. The investigations examine various applications of ICS sources at MESA. This paper gives an overview of the results as well as the limitations and possibilities of the underlying mathematical approach.

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Tuesday Poster Session / 1670

Extended Jiles-Atherton hysteresis model to accurately predict fields in a Rapid Cycling Synchrotron dipole magnet

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Particle accelerators use high field quality magnets to steer and focus beams. Normal conducting magnets commonly use soft iron for the yoke, which is subject to hysteresis effects. It is common practice to use an initialization procedure to accomplish a defined state of the magnet for which its hysteresis behavior must be known. In this article, a variation of the scalar Jiles-Atherton model with an improved physical basis called the Extended Jiles-Atherton (EJA) model is employed to predict the B-H trajectories in a Rapid Cycling Synchrotron (RCS) magnet. Simulations are conducted using COMSOL Multiphysics using the external material feature to integrate EJA model with the Finite Element Method (FEM). Results from the experimental studies conducted on a magnet prototype are also presented. Finally, potential improvements in the model and extension to the case of a two-dimensional anisotropic material are discussed.

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Monday Poster Session / 1671

Discovering transient models of emittance growth via mode interaction of phase space nonuniformities

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One of the Grand Challenges in beam physics is development of virtual particle accelerators for beam prediction. Virtual accelerators rely on efficient and effective methodologies grounded in theory, simulation, and experiment. We will address one sample methodology, extending the understanding and the control of deleterious effects, for example, emittance growth. We employ the application of the Sparse Identification of Nonlinear Dynamical systems algorithm–previously presented at NAPAC'22 and IPAC'23–to identify emittance growth dynamics caused by nonuniform, empirical distributions in phase space in a linear, hard-edge, periodic FODO lattice. To gain further understanding of the evolution of emittance growth as the beam's distribution approaches steady state, we compare our results to theoretical predictions describing the final state emittance growth due to collective and N-body mode interaction of space charge nonuniformities as a function of free-energy and space-charge intensity. Finally, we extend our methodology to a broader range of virtual and real experiments to identify the growth(decay) of (un)desired beam parameters.

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Thursday Poster Session / 1672

Early prediction of system failures at LANSCE

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Particle accelerators are among the largest and most expensive scientific facilities. Constant monitoring of data from a diverse array of diagnostics is imperative to ensure proper operational parameters —such as beam parameters, power sources, cooling systems, etc. Detecting equipment failure within this data stream is challenging due to the accelerator parameters gradually shifting over time due to diverse user demands, environmental factors, and the feedback control system's operation. At LANSCE, identifying anomalies stemming from deteriorating equipment is a significant issue. To address this, we propose implementing an anomaly detection system based on existing machine learning algorithms. This system will monitor all available data for each accelerator subsystem, establish typical parameter ranges, and determine whether the measured parameters fall beyond those thresholds. This anomaly detection system aims to factor in intrinsic internal correlations among various parameters, which the current Data Watcher warning system fails to consider. We anticipate that this developed warning system will effectively identify ongoing equipment degradation and predict upcoming failures.

Footnotes:

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Wednesday Poster Session / **1673**

Emittance and energy distribution reduction in the positron injector of FCC-e+e-

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The FCC-e+e- project foresees the realization of the most intense ever realized source of positrons providing a bunch charge of the order of 5 nC. This big number of positrons (≈3.12e+10) is produced by pair conversion following a 6 GeV electron beam bremsstrahlung on a target, and as a consequence has large divergence and energy spread. The actual design of the positron injector includes a damping ring and a bunch compressor to reduce the beam particle distributions in the longitudinal and transverse phase spaces to values appropriate for the injection in the common LINAC, which accelerates both electron and positron beams from 1.54 to 6 GeV. An energy compressor installed after the positron LINAC improves the positron acceptance in the damping ring. This contribution presents relevant aspects related to the damping of the positron beam including the evaluation of the damping ring transmission efficiency through the whole transfer line from the positron source to the common LINAC, the energy compressor, and the bunch compressor in the injection and extraction branches of the Damping Ring.

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Monday Poster Session / 1674

Experimental investigation of zero transverse force modes in sub-THz dielectric lined waveguide

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Dielectric-lined waveguides have been extensively studied for high-gradient acceleration in beam-driven dielectric wakefield acceleration (DWFA) and for beam manipulations, including the application of zero transverse force modes in the waveguides. In this paper, we investigate the zero transverse force modes excited by a relativistic electron bunch passing through a dielectric waveguide with a rectangular transverse cross section. Numerical simulations were performed to optimize the start-to-end beamline using Opal-t, ELEGANT, and WARPX. A Longitudinal Phase Space (LPS) measurement system is used to understand the interaction of the beam with the waveguide modes, and analysis of the resolution of the LPS system was conducted. We will discuss preliminary experimental data collected at the Argonne Wakefield Accelerator (AWA) benchmarked with the simulation results.

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Wednesday Poster Session / 1675

Upgrading of the INFN-LNF magnetic measurements laboratory

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The magnetic measurements laboratory of the Frascati National Laboratories of INFN is one of the pole of the Innovative Research Infrastructure for applied Superconductivity (IRIS). This infrastructure aims at upgrading laboratories to carry out basic research on magnetism and superconducting materials, test of superconducting magnets, wires, tapes, cables. The LNF pole will be devoted to testing SC coils and magnets at room temperature. These measurements are recommended during the manufacturing phase, since they allow the validation of the assembly and the detection of defects at early stages of production, before the cryogenic tests are carried out. Part of the equipment is already available, including a stretched wire bench, a rotating coil system, a NMR probe, gaussmeters, instruments for high precision electrical measurements. The IRIS upgrade will include a 3D Hall probe mole system, a pulsed wire bench, a 5-axes coordinatometer, high-stability power supplies of various sizes, a calibration system. The flexibility of the instruments will allow to cover a large range of magnetic measurements, from point maps to integrated fields, from multipolar analysis to fiducialization.

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Thursday Poster Session / 1676

A pulsed Wien filter as a low-energy kicker

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In order for the new ATLAS Materials Irradiation Station (AMIS) to take advantage of the future multi-user capabilities at ATLAS, a pulsed kicker is needed to switch 1 MeV/u heavy-ion beams. At this energy and due to space limitations, a pulsed electric kicker is very challenging due to very high voltage requirement, and a magnetic kicker is also very challenging due to the high magnetic field and fast switching requirements. A solution that satisfies the beam switching requirements is a pulsed Wien filter that combines a DC magnetic field with a pulsed electric field, where each provide only half of the kick angle. During the kicked beam pulse, the two fields combine to provide the full kick angle, while the electric field switches sign to cancel the magnetic field during the unkicked beam pulse. The electromagnetic and beam design for this novel device will be presented and

discussed. The device is now under construction and will be tested in the coming year, first offline then online with beam.

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Thursday Poster Session / 1678

Mitigation of beam coupling impedance for the wire scanners in the CERN Super Proton Synchrotron

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The beam wire scanners of the CERN Super Proton Synchrotron (SPS) experienced multiple failures of their carbon wires caused by the high-intensity beam during a very short period in April 2023. Different modifications of the existing instrument were therefore studied to reduce the beam-induced power without compromising its functionality nor negatively affecting the beam coupling impedance. Amongst these options were the implementation of ferrite absorbers, a change of the scanner mechanism and the installation of an RF coupler in the vacuum tank. In this paper, we introduce the electromagnetic simulation results for the installed ferrite loads and the RF coupler, as well as their impact on the on-axis beam impedance. The final improvement for the configuration to be installed during the end-of-year stop of the accelerator will be summarized.

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Tuesday Poster Session / 1680

Beam dynamics studies for the C3 main linac

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The Cool Copper Collider (C3) is a novel accelerator concept for a linear collider utilizing a cryogenically-cooled copper linear accelerator (linac) with a distributed coupling architecture. The C3 main linac is designed to accelerate electron/positron from 10 GeV to 125 GeV while preserving the beam's emittance. Here we present the analysis of the beam dynamics for the C3 main linac. We shows the beam dynamics simulation results of the C3 main linac to investigate the alignment and vibration tolerance of beamline elements. Results presented will be used to guide the future design of the main linac and the accelerating structure.

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Thursday Poster Session / 1681

Investigation of pulsed slow extraction schemes at the MedAustron synchrotron

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MedAustron, a synchrotron-based center for ion beam therapy and research located in Wiener Neustadt, Austria, extracts proton and carbon ion beams with third-order resonant slow extraction. In addition to clinical operation, the center hosts a diverse user community for non-clinical research studies, which may require experimental, non-clinical beam parameters. Within this context, different extraction mechanisms are investigated concerning their suitability for delivering the beam not in a continuous spill but rather in a series of short pulses (sub-millisecond to millisecond length) with customizable separation and intensity. Such a beam may offer new opportunities for non-clinical research users, for example, studying the impact of different time structures when delivering beams with FLASH-compatible dose rates.

This contribution explores the suitability of phase displacement and radio frequency knockout extraction for such an application based on Xsuite simulations and measurements. The measurement setup employs a silicon carbide detector in conjunction with a 20MHz bandwidth amplifier, enabling intensity measurements with a resolution exceeding the revolution time.

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Thursday Poster Session / 1682

Selective laser peening of copper for high gradient NCRF applications

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The largest barrier to achieving >100MV/m gradients in normal conducting accelerators is breakdown, believed to be caused by atomic defects motion associated with the pulsed heating and high fields. While recent tests show that high strength, high conductivity materials can improve structure performance; new design and manufacturing strategies which retain the hardened surface state after joining are needed. We aim to improve the performance of NCRF structures through a combination of laser peening (LP), copper alloying and electron beam welding (EBW). LP performed by CWST introduces deep residual compressive stress into the surface and is a proven method to improve the fatigue properties of highly stressed mechanical components. This presentation will outline recent work at RadiaBeam concerning mechanical, vacuum and RF characterization of various laser peened copper alloys (C101, C107, C145, C182). We are specifically focused on the relationship between laser peening, microwave surface resistance and mechanical deformation. We will also present work on high-voltage copper EBW as well as a novel manufacturing strategy for precise, clean structure alignment and assembly.

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Thursday Poster Session / 1683

FLASH proton therapy facility design with permanent magnets

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We present a design of the proton FLASH radiation therapy facility using the Brag peak to be built at Stony Brook University Hospital at the Radiation Oncology Department. It includes an injector using a commercially available injector cyclotron (10-30 MeV), fixed field alternating (FFA) gradient beam lines, permanent magnet Fixed Field Alternating Gradient non-scaling variable transverse field fast-cycling synchrotron accelerator with unprecedented kinetic energy range between 10-250 MeV, and a permanent magnet delivery system the FFA gantry. This facility removes limitations of the present proton cancer therapy facilities allowing FLASH radiation to be performed with 40 Gy/s in 100 ms. This allows treatment with the FLASH therapy without magnet adjustments for any proton kinetic energy between 70-250 MeV. The proposal is based on already experimentally proven FFA concept at the Energy Recovery linac 'CBETA' built and commissioned at Cornell University.

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Thursday Poster Session / 1684

The design of a rocket based RF electron accelerator for space applications

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Beam Plasma Interactions Experiment (Beam-PIE) is a NASA sounding rocket experiment that successfully ran in November 2023. Beam-PIE used space as a laboratory to explore wave generation from a modulated electron beam in the ionosphere. Beam-PIE electron accelerator used a 10keV

electron gun and a 5-GHz RF cavity, enabling the acceleration of the electron beam to a total energy of ~25–60 keV. The experiment was pulsed at VLF frequencies ranging from 5 to 500 kHz. The third parameter was duty cycle which ranged from 2.5% to 10%. In total, 32 different combinations of beam parameters were used and repeated every 32 seconds through the flight at various altitudes and background plasma conditions. Each of these different beam parameters ran for a ½-second beam pulse, separated by ½-second intervals when the beam was off. Beam-PIE was successful at generating plasma waves. We present an outline of the accelerator design, theoretical predictions, and experimental results of generated plasma waves. Results will be used to quantitatively test our understanding of beam-plasma-wave interactions in the space environment with applications to space communication and radiation belt remediation.

Footnotes:

[1] Reeves, Geoffrey D., et al. "The beam plasma interactions experiment: An active experiment using pulsed electron beams." Frontiers in Astronomy and Space Sciences 7 (2020): 23.
[2] Marksteiner, Quinn, et al. "Beam dynamics and radiation modeling for the Beam Plasma Interaction Experiment." AGU Fall Meeting Abstracts. Vol. 2021. 2021.
[3] Yakymenko, Kateryna, et al. "Beam physics in support of active experiments in space." APS Division of Plasma Physics Meeting Abstracts. Vol. 2019. 2019.

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Thursday Poster Session / 1685

Recovery of Neptunium-236g from photon and deuteron-irradiated actinide targets

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Neptunium-236g is a rare radionuclide used for nuclear material analyses. The availability of 236gNp is limited and the viable production routes are costly, time consuming, and only produce trace quantities of the desired product. For this work, two known production methods were tested to determine product recovery, purity, and viability for use as a tracer. The first method utilizes a photon-irradiated 237Np target to produce 236gNp by the 237Np(γ, n) → 236Np reaction. The second method utilizes the 238U(d, 4n) → 236Np reaction. These production routes were evaluated previously, and the former was considered ineffective without isotope separation and the latter was not well-characterized for the 236mNp/236gNp production ratio. Recent resurgence of electromagnetic isotope separation technology has enabled at least partial recovery of 236gNp from part-per-million abundance feeds produced by the photonuclear reaction. To address the lack of production data for the second method, a deuteron-irradiated depleted uranium target was chemically processed to recover and purify the Np for abundance and ratio analyses. The status and analytical results for each production method are presented.

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Tuesday Poster Session / 1686

Towards few-shot reinforcement learning in particle accelerator control

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This paper addresses the automation of particle accelerator control through reinforcement learning (RL). It highlights the potential to increase reliable performance, especially in light of new diagnostic tools and the increasingly complex variable schedules of specific accelerators. We focus on the physics simulation of the AWAKE electron line, an ideal platform for performing in-depth studies that allow a clear distinction between the problem and the performance of different algorithmic approaches for accurate analysis. The main challenges are the lack of realistic simulations and partially observable environments. We show how effective results can be achieved through meta-reinforcement learning, where an agent is trained to quickly adapt to specific real-world scenarios based on prior training in a simulated environment with variable unknowns. When suitable simulations are lacking or too costly, a model-based method using Gaussian processes is used for direct training in a few shots only. The work opens new avenues for implementing control automation in particle accelerators, significantly increasing their efficiency and adaptability.

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Tuesday Poster Session / 1687

Data-driven model predictive control for automated optimization of injection into the SIS18 synchrotron

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In accelerator labs like GSI/FAIR, automating complex systems is key for maximizing physics experiment time. This study explores the application of a data-driven model predictive control (MPC) to refine the multi-turn injection (MTI) process into the SIS18 synchrotron, departing from conventional numerical optimization methods. MPC is distinguished by its reduced number of optimization steps and superior ability to control performance criteria, effectively addressing issues like delayed outcomes and safety concerns, including septum protection.
The study focuses on a highly sample-efficient MPC approach based on Gaussian processes, which lies at the intersection of model-based reinforcement learning and control theory. This approach merges the strengths of both fields, offering a unified and optimized solution and yielding a safe and fast state-based optimization approach beyond classical reinforcement learning and Bayesian optimization.
Our study lays the groundwork for enabling safe online training for the SS18 MTI issue, showing great potential for applying data-driven control in similar scenarios.

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Monday Poster Session / 1688

Harmonic generation from hard X-ray self-seeded free-electron laser

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Hard X-ray self-seeded (HXRSS) free-electron lasers (FEL) provide high intensity radiation pulses with both transverse and longitudinal coherence in the hard X-ray regime. These sources are important for experiments requiring high spectral density and high photon energies like nuclear resonance scattering. However, as the photon energy increases, HXRSS efficiency may decrease in a typical HXRSS system with limited undulator length. Harmonic generation can be a relatively cheap and efficient way to extend the photon energy range for the existing FEL beamlines. Here we

present experimental results about harmonic generation from the HXRSS system at the European XFEL. We first tune the HXRSS system targeting at the subharmonic of the high photon energy, and split the last undulator section into two parts with undulator strength resonant at subharmonic and high photon energies separately. This method is a combination of HXRSS, harmonic bunching, post-saturation tapering techniques without hardware change to the existing HXRSS system. With optimized taper the final amplification is close to saturation and hundreds of micro-Joule pulse energy is obtained for the high photon energy.

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Tuesday Poster Session / 1689

Analysis of laser engineered surface structures' roughness and surface impedance

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This study examines Laser Engineered Surface Structures (LESS) in the context of their potential application within particle accelerators. These structures are investigated due to their efficient reduction of secondary electron yield to counteract the formation of electron clouds, a phenomenon detrimental to accelerator performance. A critical aspect of their evaluation involves understanding their radio-frequency characteristics to determine their influence on beam impedance.
LESS involves intricate surface modifications, integrating etched grooves and deposited particulates, resulting in a complex surface topology. Measurements are conducted on two distinct surface patterns, from which particulates are then removed with incremental cleaning. Acquired data form the basis for mathematical models elucidating observed results.
Novel approaches are investigated in addition to several established surface roughness models, including analysis of geometrical attributes of the surface topology and the associated electric currents. The aim is to develop a framework that describes roughness's influence across varying scales to assist in selecting appropriate treatment parameters.

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Tuesday Poster Session / 1691

Overview of the new beam physics research at the IOTA/FAST facility

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Co-authors: Alexander Valishev [1]; Dean Edstrom [1]; Giulio Stancari [1]; James Santucci [1]; Jinhao Ruan [1]; John Wieland [1]; Jonathan Jarvis [1]; Michael Wallbank [1]; Nathan Eddy [1]; Nikita Kuklev [2]; Nilanjan Banerjee [1]; Vladimir Shiltsev [3]

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The Fermilab Accelerator Science and Technology (FAST) facility is dedicated to the exploration of novel concepts in accelerator and beam physics, and the development of a robust workforce, in order to enable and enhance next-generation particle accelerators. FAST comprises a high-brightness superconducting electron linac, and a storage ring, the Integrable Optics Test Accelerator (IOTA). Experiments in the most recent operational run include studies of nonlinear integrable lattices; tracking of single electrons; precise characterization of undulator radiation; studies with low-momentum-compaction lattices; and ultra-wide range beam diagnostics based on Photomultiplier tubes. In the linac, experiments on noise in intense electron bunches were conducted. The IOTA proton injector, currently being commissioned, will enable a diverse program on space-charge-dominated beams. Research areas include non-invasive beam profile monitoring for proton beams; beam dynamics with electron lenses; halo suppression, feedback systems, and electron cooling. In this presentation, we provide an overview of the recent results and highlight future plans together with opportunities for collaboration.

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Tuesday Poster Session / 1692

Status of undulators for the APS upgrade

Author: Roger Dejus[1]

Co-authors: Grace Avellar [1]; Aric Donnelly [1]; Wei Li [2]; Elizabeth Moog [1]; Yinghu Piao [1]; Maofei Qian [1]; John TerHAAR [1]; Isaac Vasserman [1]; Joseph Xu [1]; Mohan Ramanathan [1]

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The Advanced Photon Source Upgrade (APS-U) project is developing a multi-bend achromat (MBA) lattice at 6.0-GeV beam energy to replace the existing APS storage ring lattice operating at 7.0 GeV. A major part of the project is to design, fabricate, and install 59 hybrid permanent magnet undulators (HPMUs) in 35 straight sections. We have developed four new period lengths for 37 new HPMUs, including Revolver undulators, and plan to reuse 22 existing undulators with four more different period lengths. Large challenges were anticipated at the start of the project to be able to meet tight mechanical fabrication tolerances for many new components and to tune undulators to tight magnetic field requirements on schedule in order to be ready for storage ring installation prior to beam commissioning. We will provide a status update, including measurement results to date, and report on tools and techniques used to meet those demands.

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Tuesday Poster Session / 1693

Particle injection and acceleration in laser wakefield generated via propagation of two laser pulses

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Interaction of intense laser pulses with plasma finds one of the important applications in acceleration of charged particles. The pioneering work of Tajima and Dawson [1] has given great impetus to the idea of electron acceleration using wakefield generated by intense laser pulses. Acceleration of electrons by enhanced wakefield generated by chirped laser pulse propagating together in plasma has been studied [3].
Present work deals with the comparative study of acceleration of particle via wakefield generated by two co- and counter propagating laser pulses in homogeneous plasma. This study reveals that the maximum energy gained by test electrons is enhanced and depends on the relative polarization and frequency difference. Phase space analysis shows that a test electron of lower energy, injected behind the wakefield, can be trapped and accelerated to higher energy.

Footnotes:

[1] T. Tajima and J. M. Dawson, Phys. Rev. Lett. 43, 267 (1979).
[2] E. Esarey, P. Sprangle, J. Krall and A. Ting, IEEE Trans. Plasma Sci., 24, 252 (1996).
[3] S Singh, D. Mishra, B. Kumar and P. Jha, Phys. Scr. 98 075504 (2023).

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Asia

Monday Poster Session / 1694

Tunable laser Doppler spectroscopy of LANSCE H- ion source plasma

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Plasma temperature dynamics provide significant insight when evaluating ion source performance. Quantities such as beam emittance, or mean transverse energy, are strongly correlated with the source plasma temperature. At LANSCE there is currently no method implemented for measuring initial source emittance or implementing tunability of mean transverse energy through ion source control parameters. In this work we will discuss our demonstration of a new laser diagnostic tool for measuring H- beam emittance on the LANSCE H- ion source laser diagnostic stand. Our investigated method will be an extension of systems outlined for NIFS, and will be optimized for rapid response times, scanning the Doppler broadened Hydrogen-alpha emission line at a rate 10x faster than the plasma ignition time window (800 microseconds). We will show that our real-time, non-intrusive measurement approach will enable characterization and study of source control parameter effects on source plasma temperature for future emittance optimization.

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Monday Poster Session / 1695

Development of low temperature oven and high temperature oven for the production of heavy ion beams at Facility for Rare Isotope Beams

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Many of ion beams generated by the Electron Cyclotron Resonance Ion Source (ECRIS) originate from solid-state materials and undergo a conversion process to transition from a solid to a gaseous state before being introduced into the plasma. Established techniques for thermal evaporation encompass ovens and others. The primary objective is to advance oven technology targeting increased reliability, durability, efficiency, and an expanded temperature range. At FRIB, specialized low and high temperature ovens have been developed to ensure the consistent and reliable production of heavy metal ion beams. The LTO has demonstrated its capability at temperature close to 600℃ and was successfully used to generate continuous and stable 48Ca beams at an intensity sufficient to support operation of the FRIB accelerator at 10 kW on target. The HTO operates durably at temperatures close to 2000℃, which helps the ECRIS to accommodate intense heavy metal ion beams, such as uranium. Testing of the HTO is ongoing but it already demonstrated beam intensity as high as 20 euA of 238U33+ and 15 euA of 238U35+. The detailed design, testing and simulation results will be presented and discussed.

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Monday Poster Session / 1696

Electron beam shaping by laser heater for attosecond pulse duration X-ray free electron laser

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We experimentally and numerically demonstrate that electron beam energy spread produced by laser heating can be used for shaping electron beam current profile. In particular, we introduce this method for generating attosecond pulse duration X-ray free electron laser. Electron beam scattering material (slotted foil) is additionally used for final selection of the effective current profile. This study is based on the beamline design of the hard x-ray free electron laser at Pohang Accelerator Laboratory (PAL).

Footnotes:

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Tuesday Poster Session / 1698

An update on the transition crossing schemes for the EIC hadron storage ring

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The Electron Ion Collider (EIC) Hadron Storage RIng (HSR) requires the crossing of transition for all species except for protons. The current scheme for the Relativistic Heavy Ion Collider (RHIC) utilizes the gamma transition quadrupoles will be adopted for the scheme of the HSR. With rebuilt straight sections, the jump quadrupoles responsible for tune compensation will need to be placed at the proper phase advance to mitigate the beta and dispersion waves generated. As an alternative method, the beam may be nonadiabatically kicked into a stable resonance island to place the beam above transition. This paper discusses transition crossing using the matched first order method and resonance island jump schemes applied to the latest HSR lattice.

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Monday Poster Session / 1699

Optical pump generation for long-wave infrared lasers for advanced acceleration

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The favorable wavelength scaling of ponderomotive interactions indicates that long-wave infrared (LWIR) lasers are well suited for applications such as laser wakefield acceleration and high harmonic generation. CO2 amplifiers are the primary source of such wavelengths, able to generate TW peak powers with sub-ps pulse lengths. However, a limiting factor for these amplifiers is the necessity of using electrical discharges to pump the gain medium, reducing the maximum repetition rate and energy stability. This can be mitigated by instead optically pumping the CO2 at 4.5 μm. We demonstrate a proof of principle of the generation of this wavelength by utilizing stimulated Raman scattering, a process where photons inelastically scatter from a material. For this wavelength, we employ a novel class of material known as ionic liquids as the Raman medium. We demonstrate efficient conversion from a 532 nm frequency doubled Nd:YAG laser to 603 nm in the ionic liquid EMIM DCA, followed by performing difference frequency generation to produce the 4.5 μm pump.

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Monday Poster Session / 1700

Linac-driven beam physics at Eupraxia@SPARC_LAB

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EuPRAXIA@SPARC_LAB is a multi-disciplinary user facility currently under construction at the Laboratori Nazionali di Frascati of the INFN as part of the EuPRAXIA collaboration. This facility features a multi-GeV plasma-based accelerator with high-quality electron beams, intended for piloting two Free Electron Laser (FEL) beamlines for experiments —one in the VUV and the other in the XUV-soft X-rays spectral region. The paper discusses the machine beam physics of EuPRAXIA@SPARC_LAB, which has been investigated by means of start-to-end simulations, and its stability and reliability, important factors for a successful and consistent FEL emission. Additionally, the paper includes experimental results obtained at SPARC_LAB, a test facility that is currently operational at Laboratori Nazionali di Frascati. This facility is specifically oriented towards research in plasma acceleration physics. The combination of numerical simulations and experimental results

provides a comprehensive overview of the EuPRAXIA@SPARC_LAB facility, its capabilities and its performance.

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Wednesday Poster Session / 1701

Superconducting energy savings devices by IRIS

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IRIS (Innovative Research Infrastructure on applied Superconductivity) is a major project to build a research infrastructure in applied superconductivity, recently approved in Italy and led by INFN Milano. In this framework, we are developing two superconducting energy savings devices, both working at 20 K either in helium gas flow or by cold-heads: An HTS dipole (Energy Saving Superconducting Magnet) and a 1 GW rated superconducting line (Green SuperConducting Line). ESMA is an HTS ReBCO metal insulated racetrack dipole, this magnet will be 1 m long with a medium-sized round bore of 70 mm diameter and a maximum central field of 10 T. The paper reports the design updates, presenting and discussing the main technological choices (coil layout, ramping time, etc.). An R&D plan is supporting the technology choices and the construction that will be carried out in Industry will also be included. We are also developing a 130 m long MgB2 Superconducting Line (GSCL), capable of carrying 40 kA at 25 kV, an almost zero-dissipation DC transmission line. The paper will present the up-to-date status of the IRIS energy-saving devices, ESMA and GSCL: design, tests, and production.

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Europe

Monday Poster Session / 1702

Commissioning of spectral diagnostics and future concepts for the PAX experiment at FACET-II

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The ongoing Plasma-driven Attosecond X-ray source experiment (PAX) at FACET-II aims to produce coherent soft X-ray pulses of attosecond duration using a Plasma Wakefield Accelerator [1]. These kinds of X-ray pulses can be used to study chemical processes where attosecond-scale electron motion is important. For this first stage of the experiment, PAX plans to demonstrate that <100 nm bunch length electron beams can be generated using the 10 GeV beam accelerated in the FACET-II linac and using the plasma cell to give it a percent-per-micron chirp. The strongly chirped beam is then compressed in a weak chicane to sub-100 nm length, producing CSR in the final chicane magnet at wavelengths as low as 10s of nm. In this contribution we describe the commissioning of the spectral diagnostics as well as the results expected of this experiment.
Additionally, we describe a future iteration of the experiment in which short undulators are used to drive coherent harmonic generation to produce attosecond gigawatt X-ray pulses at 2 and 0.4 nm, with lengths comparable to the shortest attosecond pulses ever measured at 2 nm using HHG.

Footnotes:

[1] C. Emma, X.Xu et al APL Photonics 6, 076107 (2021)

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Monday Poster Session / 1703

Final physics design of proton improvement Plan-II at Fermilab

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This paper presents the final physics design of the Proton Improvement Plan-II (PIP-II) at Fermilab, focusing on the linear accelerator (Linac) and its beam transfer line. We address the challenges in longitudinal and transverse lattice design, specifically targeting collective effects, parametric resonances, and space charge nonlinearities that impact beam stability and emittance control. The strategies implemented effectively mitigate space charge complexities, resulting in significant improvements in beam quality—evidenced by reduced emittance growth, lower beam halo, decreased loss, and better

energy spread management. This comprehensive study is pivotal for the PIP-II project's success, providing valuable insights and approaches for future accelerator designs, especially in managing nonlinearities and enhancing beam dynamics.

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Monday Poster Session / 1705

A compact source of positron beams with small thermal emittance

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In this contribution, we investigate electrostatic traps as a novel source of positron beams for accelerator physics applications. Penning-Malmberg (PM) traps are commonly employed in low-energy antimatter experiments. Positrons contained in the trap are cooled to room temperature or below. We calculate the thermal emittance of the positrons in the trap and show that it is comparable to or better than the performance of state-of-the-art photocathode guns. We propose a compact positron source comprised of a PM trap, electrostatic compressor, and RF accelerator that can be built and operated at a fraction of the cost and size of traditional target-based positron sources, albeit at reduced repetition rate and with intrinsic angular momentum. We model the acceleration of a positron bunch up to an energy of 17.6 MeV with a final thermal emittance of 0.60 micron-rad and bunch length of 190 microns. This system may be useful for accelerator physics studies, such as investigations of flat-beam sources for linear colliders and positron plasma wakefield acceleration.

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Monday Poster Session / 1706

Beam dynamics of twin-bunch generation in the LCLS-II

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The LCLS-II is a high repetition rate upgrade to the Linac Coherent Light Source (LCLS) and will offer photon science users an unprecedented million pulses per second. However, the accelerating gradient on the cathode of the Very-High-Frequency photoinjector is relatively lower compared to traditional electron guns, the longitudinal beam dynamics become more complicated as required to achieve bunch current high of kA. This paper presents the simulation study of twin-bunch generation in the LCLS-II and analyzes the feasibility of corresponding experimental demonstration in the LCLS-II.

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North America

Wednesday Poster Session / 1707

Beam alignment strategy at the beam transport line for J-PARC muon g-2/EDM experiment

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To realize very precise measurement of the muon spin precession frequency in the level of sub-ppm, a muon beam is injected into a precisely adjusted storage magnet of sub-ppm uniformity via "Three-dimensional spiral beam injection scheme [1]"at J-PARC muon g-2/EDM experiment. This injection scheme requires a strongly X-Y coupled beam which is applied by eight rotating quadrupoles on the 10m of beam transport line [2]. Currently we have two scenarios of set of rotation angles (1) 45 or 60 degrees fixed, (2) any angles.
In this presentation, strategy to precise control of the X-Y coupling at the beam transport line is discussed: how to control/monitor X-Y coupled phase space with eight rotatable quadrupole magnets including its alignment requirements for the case of (1) and (2). Results of alignment of the newly developed mount system for the rotating quad is also introduced. A pair of dedicated magnets called

active shield multipole magnet (ASXM) will be set at the entrance and the exit of the beam channel of the storage magnet yoke. These devices will guarantee how well the beam phase space is matched with requirements at the reference point inside the storage magnet [3].

Footnotes:

[1] H. Iinuma et al., Nucl. Instrum. Meth. Phys. Res. Sect. A, vol. 832, pp. 51–62, 2016. doi:10.1016/j.nima.2016.05.126
[2] H. Iinuma, H. Nakayama, M. Abe, K. Sasaki, and T. Mibe, IEEE Trans. Appl. Supercond., vol. 32, no. 6, pp. 1–5, Sep. 2022. doi:10.1109/TASC.2022.3161889
[3] H. Iinuma et al., in Proc. IPAC'23, Venice, Italy, May 2023, pp. 304-307. doi:10.18429/JACoW-IPAC2023-MOPA110

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Thursday Poster Session / 1708

Thermal analysis of rotating single slice graphite target system for FRIB

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The Facility for Rare Isotope Beams (FRIB) is a high power heavy ion accelerator facility at Michigan State University completed in 2022. Its driver linac is designed to accelerate all stable ions to energies above 200 MeV/u with beam power of up to 400 kW. Currently FRIB is operating at 10 kW delivering various primary beams. The target absorbs roughly 25% of the primary beam power and the rest is dissipated in the beam dump. This paper presents a brief overview of the current production target system and details the thermal analysis ANSYS simulations utilized for temperature and stress prediction. The existing single-slice rotating graphite target can accommodate up to 40 kW for lighter beams, with a planned transition to a multi-slice concept.

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Tuesday Poster Session / 1709

Linac_Gen: integrating machine learning and particle-in-cell methods for enhanced beam dynamics at Fermilab

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Here, we introduce Linac_Gen, a tool developed at Fermilab, which combines machine learning algorithms with Particle-in-Cell methods to advance beam dynamics in linacs. Linac_Gen employs techniques such as Random Forest, Genetic Algorithms, Support Vector Machines, and Neural Networks, achieving a tenfold increase in speed for phase-space matching in Linacs over traditional methods, through the use of genetic algorithms. Crucially, Linac_Gen's adept handling of 3D field maps elevates the precision and realism in simulating beam instabilities and resonances, marking a key advancement in the field. Benchmarked against established codes, Linac_Gen demonstrates not only improved efficiency and precision in beam dynamics studies but also in the design and optimization of Linac systems, as evidenced in its application to Fermilab's PIP-II Linac project. This work represents a notable advancement in accelerator physics, marrying ML with PIC methods to set new standards for efficiency and accuracy in accelerator design and research. Linac_Gen exemplifies a novel approach in accelerator technology, offering substantial improvements in both theoretical and practical aspects of beam dynamics.

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Wednesday Poster Session / 1710

Hybrid plasma generator for high intensity fast pulsed ion sources

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The main challenge in the development of high intensity ion sources is, besides the space charge limited extraction, the available plasma density. Conventional plasma generators use e.g. arc discharge plasmas or RF generated plasmas. Preliminary tests are carried out on both types of plasma generators and plasma parameters are determined to create a basis for evaluation. A concept is being developed that combines the advantages of both types. This hybrid plasma generator will also be investigated in terms of plasma parameters in order to test a possible application for high intensity ion sources. Further the proposed plasma generator has the property that due to a permanently available

low-density RF plasma a faster build-up of the highly dense arc discharge plasma may be achieved. The properties of the concept with regard to a fast plasma build-up time are being investigated in order to test a possible application for the fast pulsing of high intensity ion sources.

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Thursday Poster Session / 1711

Space charge dominated momentum spread and compensation strategies in the post-linac section of Proton Improvement Plan-II at Fermilab

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The upcoming Proton Improvement Plan-II (PIP-II), designated for enhancements to the Fermilab accelerator complex, features a Beam Transfer Line (BTL) that channels the beam from the linac exit to the booster. In the absence of longitudinal focusing beyond the superconducting linac, the beam experiences an elevated momentum spread, primarily due to nonlinear space-charge forces, surpassing the allowable limit of 2.1e-4. This study presents a detailed examination of the space-charge-induced momentum spread and outlines mitigative strategies. The investigation includes the fine-tuning of a de-buncher cavity, analyzed in terms of operating frequency, longitudinal location, and gap voltage, under both standard and perturbed beam conditions—specifically accounting for momentum jitter and energy variation. The impact of buncher cavity misalignments on the beam's longitudinal phase space is also assessed. The paper concludes by recommending an optimized cavity configuration to effectively mitigate the observed increase in momentum spread along the BTL.

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Tuesday Poster Session / 1713

Bayesian optimization at ISAC: a machine learning algorithm for efficient and reliable tuning of radioactive beams

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Tuning of radioactive beams in a post-accelerator facility such as TRIUMF's ISAC involves a considerable amount of overhead and often leads to tunes which diverge from the theoretical optimum for the system, introducing undesirable effects such as aberrations or chromatic couplings. We hereby present the development and application of a Bayesian Optimization algorithm for corrective transverse steering of the low-energy electrostatic beam transport optics; specifically through the polarizer beamline, which contains a 2-metre section where beam can be electrically neutralized, to the beta-NMR experiment. This work holds promise for enhancing the efficiency and reliability of beam delivery at ISAC, supporting TRIUMF's scientific mission. Current developments involve multi-objective Bayesian Optimization using beam profile monitors and eventual integration of other diagnostic devices, such as CCD cameras. The developments presented herein aim to enable autonomous tuning methods, facilitating user-friendly operation by operators.

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Wednesday Poster Session / 1714

Development of superconducting RF cavity in traveling-wave regime at Fermilab

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Niobium Superconducting RF (SRF) cavities have a theoretical peak magnetic field which limits the accelerating field to 50-60 MV/m. Presently, all SRF cavities operate in a Standing Wave (SW) resonance field in which particles experience an accelerating force alternating from zero to peak. In

contrast, a resonance field in Traveling Wave (TW) mode propagates along with a structure, so particles in such field can experience a constant acceleration force and could have higher energy gain than that of SW mode. This phenomenon is defined by the cavity's transit time factor, T. A TW structure proposed in an early study achieves T ˜0.9, suggesting an increase in acceleration per structure by more than 20% compared to a SW structure (T ˜0.7). The early stages of developments had been funded by several SBIR grants to Euclid Techlabs and completed in collaboration with Fermilab through a 1-cell prototype and a proof-of-principle 3-cell TW cavity. It demonstrated the TW resonance excitation at room temperature in the "as-fabricated"3-cell structure. Here we report recent progresses and the first cryogenic testing of the 3-cell TW cavity in 2 K liquid helium at Fermilab.

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Monday Poster Session / 1715

Injection of collider-quality e-beams in plasma accelerators

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The plasma accelerator community has made significant progress in advancing particle beams, bringing us closer to realizing the dream of replacing the radio frequency (RF) cavities' MV/m fields with the plasma-sustained GV/m fields for collider applications. The beam requirements for realizing this vision emphasize a collider-quality beam featuring hundreds of pC of charge, energy spread less than 1%, and a normalized emittance in the tens of nanometers range. Achieving the low-energy-spread of the beam during acceleration involves flattening the accelerating field within the wakefield region occupied by the beam, which can be accomplished if the charge per unit length of the injected electron beam to exhibit a trapezoidal profile. In this study, we demonstrate how novel techniques for controlling the spatiotemporal properties of a focusing laser pulse enable the optical injection of an electron bunch inside a plasma wakefield that meets all the beam requirements for collider applications. Quasi-3D particle-in-cell simulations demonstrate the feasibility of this method for producing beams exceeding 200 pC of charge with emittance and energy spread well within collider requirements.

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Monday Poster Session / 1716

UV-Soft X-ray betatron radiation characterization from laser-plasma wakefield acceleration

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The spontaneous emission of radiation from relativistic electrons within a plasma channel is called betatron radiation and has great potential to become a compact x-ray source in the future. We present an analysis of the performance of a broad secondary radiation source based on a high-gradient laser-plasma wakefield electron accelerator. The purpose of this study is to assess the possibility of having a new source for a non-destructive X-ray phase contrast imaging and tomography of heterogeneous materials. We report studies of compact and UV-soft X ray generation via betatron oscillations in plasma channel and in particular measurement of the radiation spectrum emitted from electron beam is analyzed from a grazing incident monochromator at Centro de Laseres Pulsados Ultraintensos (CLPU).

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Europe

Thursday Poster Session / 1717

Optimizations for ultrafast electron diffraction with a cryogenic C-band gun

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Co-authors: Adam Bartnik [1]; Fabio Bosco [2]; Gerard Lawler [2]; James Rosenzweig [2]; Jared Maxson [3]

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Ultrafast electron diffraction (UED) is a growing accelerator application that enables the study of transient material processes at sub-picosecond timescales with nanometer spatial resolution. In this proceeding, we present simulations of the Cryogenic Brightness-Optimized Radiofrequency Gun (CYBORG) beamline using the General Particle Tracer (GPT) code that are optimized for the application of UED. We explore advantages of performing UED with a beamline equipped with a low intrinsic emittance photocathode, extraction fields approaching 200 MV/m, and a cathode temperature below 77 K. The electron beam bunch length and the 4D transverse emittance are critical metrics for achieving high spatial and temporal resolution in UED, and are minimized at the sample location in our optimization using a Non-Dominated Sorting Genetic Algorithm II (NSGA II).

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Tuesday Poster Session / 1718

Four-dimensional phase space control with a strongly X-Y coupled beam for the three-dimensional spiral trajectory with a validation experiment with 0.12 m radius of compact storage ring

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Co-authors: Hisayoshi Nakayama [2]; Kazuro Furukawa [2]; Ryota Matsushita [3]; Satoshi Ohsawa [2]; Shinji Ogawa [2]; Tsutomu Mibe [2]

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"Three-dimensional spiral beam injection scheme"[1] is a key to realize J-PARC muon g-2/EDM experiment exploring the beyond standard model of elementary physics. Muon is stored in a compact orbit of 0.33 m radius in the super conducting solenoid storage magnet. Appropriate X-Y coupled beam phase space, which strongly coupled radial and solenoid axes, is crucial to inject the beam passing through the static solenoid fringe field. Vertical kicker [2] is also crucial to stabilize beam motion in the storage ring.
In this report, results from the validation experiment [3] which utilize 80 keV electron beam and super compact storage ring with 0.12 m radius orbit are discussed: how well we do with (1) extended

Twiss parameters for X-Y coupled beam in accordance with parameter weighting priority, (2) evaluate four-dimensional sigma-matrix of such strongly X-Y coupled beam phase space, (3) control the beam size during the injection, especially along the solenoid-axis. Utilizing several beam diagnostic methods in the storage volume (beam visualization monitor, wire-scan system), we discuss comparison between design and real data, and judge strategic robustness.

Footnotes:

[1] H. Iinuma et al., Nucl. Instrum. Meth. Phys. Res. Sect. A, vol. 832, pp. 51–62, 2016. doi:10.1016/j.nima.2016.05.126
[2] H. Iinuma et al., in Proc. IPAC'23, Venice, Italy, May 2023, pp. 304-307. doi:10.18429/JACoW-IPAC2023-MOPA110
[3] R. Matsushita et al., in Proc. IPAC'23, Venice, Italy, May 2023, pp. 327-330. doi:10.18429/JACoW-IPAC2023-MOPA118

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Asia

Thursday Poster Session / 1719

Improvements of longitudinal stability with LLRF optimization at SIRIUS

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SIRIUS is a 4th generation synchrotron light source built and operated by the Brazilian Synchrotron Light Laboratory (LNLS). Recently, investigations of noise sources and the storage ring RF plant identification enabled a fine-tuning of digital low-level radio frequency (DLLRF) parameters. This paper presents the main improvements implemented, which include the mitigation of 60Hz noise from the LLRF Front End and the optimization of the control system parameters. Optimizations in the machine were made based on an adjusted model of the SIRIUS storage ring RF plant. Tests with the model's parameters showed that the system's stability was strongly dependent on the system phase, which is affected by the output power due to the system's non-linearity. The new parameters significantly improved the control performance, increasing the bandwidth of the system and reducing longitudinal oscillations. BPM and BbB systems were employed to quantify longitudinal beam stability improvements.

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Monday Poster Session / 1720

Numerical simulations of harmonic lasing at SASE2 beamline of European XFEL

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In high-gain free-electron lasers (FELs) with planar undulators it is possible (in the linear regime) to independently amplify at the fundamental and at odd harmonics, a process referred to as Harmonic Lasing (HL). For the HL process preservation of the quality of the incoming high-brightness electron beam is essential. This requires suppression of the lasing at the fundamental, which can be achieved using several methods such as special phase shifter set points and attenuation of the fundamental radiation using intra-undulator optical high-pass filters. The European XFEL variable-gap undulator beamline SASE2 features two intra-undulator stations combining a magnetic chicane and the possibility to insert a thin diamond crystal onto the optical axis of the beamline. While installed for the operation in hard x-ray self seeding (HXRSS) mode, this hardware is well-suited for HL experiments at a low electron beam energy corresponding to a fundamental photon energy of about 2keV. In this contribution we present numerical simulations of third-harmonic lasing at this working point.

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Wednesday Poster Session / 1721

Progress on the autonomous event detection system for the laser particulate counter

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Field emission is one of the most important issues that limits the performance of the superconducting radio frequency (SRF) systems and leads to SRF cavity trips at the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab. Studies have confirmed that particulates are the dominant source of field emitters and the particulates can be transported into a cavity from other parts of the accelerator. To monitor the transportation of the particulates, a prototype of a novel, non-invasive laser particulate counter (LPC) is being developed and tested at Jefferson Lab. Experiments have been done to validate the capability of the LPC, in which precisely-created defects with various sizes on rotating disks were used to mimic the motion of the particulates in a tabletop system, and the readout from the LPC was saved as the response to the "particulates". We are developing a machine learning model that will be used to continuously monitor the readout from the LPC and to recognize real events generated by particulates from noises. In this report, we will present how the data are prepared and how the model is trained. We will also discuss the performance of the model.

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Wednesday Poster Session / 1722

Experimental evidence of the effect of transverse Landau damping on the microbunching instability

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The mechanisms that drive short-range modulations in the longitudinal phase space of accelerated electron bunches, otherwise known as the microbunching instability, have undergone intensive study. The various collective interactions between charged particles within the bunch, and their environment, can degrade the quality of these bunches, eventually making them unsuitable to drive light sources such as free-electron lasers (FELs). Although the most common method for removing this instability at X-ray FELs –namely, the laser heater –has proven to be very useful in improving the performance of these facilities, alternative methods to achieve this goal are active areas of research. In this contribution, we present experimental evidence of the influence of transverse Landau damping on mitigating the microbunching instability.

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Tuesday Poster Session / 1723

Machine learning assisted control and data analysis for an MeV ultrafast electron diffraction beamline and photocathode laser system

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An MeV ultrafast electron diffraction (MUED) instrument system is a unique characterization technique used to study ultrafast processes in a variety of materials by a pump-probe method. This technology can be advanced further into a turnkey instrument by using data science and artificial intelligence (AI) mechanisms in conjunction with high-performance computing. This can facilitate automated operation, data acquisition, and real-time or near-real-time data processing with minimal intervention by a beamline scientist. Real-time optimization and virtual beamline diagnostics combined with deep learning can be applied to the MUED diffraction patterns to recover valuable information on subtle lattice variations that can lead to a greater understanding of a wide range of material systems. Additionally, understanding the laser beam that drives photocathode electron production helps to further optimize the system. A data-science-enabled MUED facility will open this technique to a wider user base and provide a state-of-the-art instrument. Updates on research and development efforts for the MUED instrument in the Accelerator Test Facility of Brookhaven National Laboratory are presented.

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Wednesday Poster Session / 1724

High-gradient C-band accelerating structure simulations for XFEL facilities using high performance computing

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Linacs are an integral part of high-gradient accelerating structures for X-ray Free Electron Laser (XFEL) facilities. For high energy (42+ keV) x-rays, this translates into a longer linac (linear accelerator), which in turn translates into increased cost due to the larger footprint. One such case is the DMMSC (Dynamic Mesoscale Material Science Capability) at Los Alamos National Laboratory. C-band devices are an attractive option, as they offer suitable electron beam properties and are significantly smaller than conventional L- or S- band structures. This need for state-of-art designs dictates increasingly complex structures such that CPU-intensive simulations are now a key part of accelerator component design. As that happens, high performance computing (HPC) becomes a necessary component of the design process. The Argonne Leadership Computing Facility offers a route to rapid design evaluation through successive simulations while varying, for example, geometric features and particle beam properties.

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Wednesday Poster Session / 1725

Molecular beam epitaxial growth of potassium antimonide and cesium potassium antimonide photocathodes

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Molecular-beam epitaxy (MBE) growth with lattice matched substrates can lead to the synthesis of single-crystal alkali antimonide photocathodes*. Single-crystal photocathodes are expected to have not only high quantum efficiencies (QE) but also low mean transverse energy dispersion since they are usually grown as thin films. In this proceeding, we report the synthesis of potassium antimonide and cesium potassium antimonide photocathodes at the PHotocathode Epitaxy Beam Experiments (PHOEBE) laboratory at Cornell via MBE by using a sequence of shuttered growth of different unit cells. These cathodes are characterized in terms of spectral response and crystalline structure. Reflection high energy electron diffraction RHEED pattern simulations using PyRHEED are also presented and compared to the RHEED patterns obtained during the synthesis of these photocathodes. Oxidation studies were also performed to better understand the performance of these materials under not ideal ultra-high vacuum (UHV) conditions.

Footnotes:

- C. T. Parzyck, et. Al., "Single-Crystal Alkali Antimonide Photocathodes: High Efficiency in the Ultrathin Limit", Physical Review Letters, 128, 114801 (2022)

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Thursday Poster Session / 1726

Experimental measurements for extracting nonlinear invariants

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Nonlinear integrable optics are a promising alternative approach to lattice design. The integrable optics test accelerator (IOTA) at Fermilab has been constructed for dedicated studies of magnetostatic elliptical elements as described by Danilov and Nagaitsev. The most compelling verification of correct implementation of the NIO lattice is direct observation of the analytically expected invariants. This report outlines the experimental and analytical methods for extracting the nonlinear invariants of motion from data gathered in the last IOTA run.

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Tuesday Poster Session / 1727

Machine learning tools for heavy-ion linacs

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At a heavy ion linac facility, such as ATLAS at Argonne National Laboratory, a new ion beam is tuned once or twice a week. The use of machine learning can be leveraged to streamline the tuning process, reducing the time needed to tune a given beam and allowing more beam time for the experimental program. After establishing automatic data collection and two-way communication with the control system, we have developed machine learning models to tune and control the machine. We have successfully trained different Bayesian Optimization (BO)-based models online for different sections of the linac, including the commissioning of a new beamline. We have demonstrated transfer learning from one ion beam to another allowing fast switching between ion beams, and also transfer learning from a simulation-based model to an online machine model using Neural Networks as the prior-mean for BO. We have also trained a Reinforcement Learning (RL) model online for one beam and deploy it for the tuning of other beams. These models are now being generalized to other sections of the ATLAS linac and can, in principle, be adapted to control other ion linacs and accelerators with modern control systems.

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Wednesday Poster Session / 1728

Pulsed laser deposition assisted growth of alkali-based photocathodes

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Alkali-based semiconductor photocathodes are widely used as electron sources and photon detectors. The properties of alkali-based semiconductor materials such as crystallinity and surface roughness fundamentally determine the performance merits like quantum efficiency and thermal emittance. Epitaxial growth of alkali-based photocathodes can be achieved on lattice-matched substrates with controlled growth techniques like molecular-beam epitaxy (MBE). [1] In BNL, pulsed laser deposition (PLD) was used to assist the growth of alkali-based photocathode materials, providing precise control of film thickness, improving film adhesion and quality. PLD-assisted growth of K2CsSb, Cs3Sb and Cs2Te were performed on various lattice matched substrates. High quantum efficiency, ultrasmooth, and epitaxial thin film photocathodes are achieved with this growth technique.

Footnotes:

[1] C. T. Parzyck, A. Galdi, J. K. Nangoi, W. J. I. DeBenedetti, J. Balajka, B. D. Faeth, H. Paik, C. Hu, T. A. Arias, M. A. Hines, D. G. Schlom, K. M. Shen, and J. M. Maxson, Phys. Rev. Lett. 128, 114801 –Published 18 March 2022

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Tuesday Poster Session / 1729

Study of longitudinal effects during transition crossing of the EIC hadron storage ring

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The Electron Ion Collider (EIC) Hadron Storage Ring (HSR) will accelerate all species except protons through transition to the desired storage energy. The effects at transition may cause unwanted emittance blowup beam loss due to bunch area mismatch and negative mass instability. In this paper, we will show the longitudinal dynamics of transition crossing in the HSR with current parameters using the accelerator code Beam Longitudinal Dynamics (BLonD).

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Monday Poster Session / 1731

Development of a de-focusing space charge lens for positive ion beams

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Space charge lenses are ion-optical devices that focus an ion beam by the intrinsic electric field of confined non-neutral plasmas, for example electron clouds. This was first proposed by Dennis Gabor in the year 1947 and is therefore also known as Gabor-lenses. Previous studies have shown the strong linear focusing forces of a confined electron plasma. In this paper, the first confinement of a pure proton plasma in a Gabor-lens will be discussed. The confinement of a positive space charge column provides either a linear de-focusing force for positively charged ion beams or a linear focusing force for negatively charged heavy ion beams. Very first results of proton confinements and their diagnostics will be presented. A special focus lies on the diagnosis of the proton density distribution, as well as the comparison between the behavior of the proton and electron clouds.

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Tuesday Poster Session / 1732

Sextupole misalignment and defect identification and remediation in IOTA

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The nonlinear integrable optics studies at the integrable optics test accelerator (IOTA) demand fine control of the chromaticity using sextupole magnets. During the last experimental run undesirable misalignments and multipole composition in some sextupole magnets impacted operations. This report outlines the beam-based methods used to identify the nature of the misalignments and defects, and the subsequent magnetic measurements and remediation of the magnets for future runs.

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Wednesday Poster Session / 1733

On-line helium mass flow monitoring system for SRF cavities at 2 K

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The Helium Flow Monitor System developed by Jefferson Lab and Hyperboloid LLC is designed to measure the health of cavities in a Cryomodule in real-time. It addresses the problem of unhealthy cavities with low Q0, which generate excess heat and evaporation from the 2 K super-fluid helium bath used to cool the cavities. The system utilizes a unique meter that incorporates superconducting elements for high-resolution measurements of increased evaporation from the Cryomodule while the accelerator is operating. It can also measure individual Cavity Q0s when the beam is turned off. The Linux-based control system is an integral part of this device, providing the necessary control and data processing capabilities. The system was integrated with a LabJack A/D (analog-to-digital)and D/A (digital-to-analog) converter, which provides the necessary input and output capabilities for the system.

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Thursday Poster Session / 1734

Thermal-fluid analysis and operation of a low power water-cooled tilted beam dump at Facility for Rare Isotope Beams

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The Facility for Rare Isotope Beams is a high power heavy ion accelerator completed in April 2022. The FRIB accelerator was commissioned with acceleration of heavy ions to energies above 200 MeV/nucleon (MeV/u) that collide onto a rotating single-disk graphite target. The remaining beam is absorbed by a water-cooled static beam dump that is oriented at a 6 degrees angle with respect to the beam. The beam dump consists of the beam stopper made of machined Aluminum 2219 block, and 3D-printed inlet and outlet parts made of Aluminum 6061 that delivers the cooling water from utilities to the beam stopper and its return. This low power beam dump is designed for up to 10 kW beam power. This paper presents a discussion on the thermal-fluid behavior of the beam dump for various beam species and beam power.

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Wednesday Poster Session / 1736

Field emission assisted heating of Cs2Te photocathode: implication toward RF breakdown

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The occurrence of breakdown events are a primary limiting factor for future accelerator applications aiming to operate under high field-gradient environments. Experimental evidence often leads to a hypothesis that breakdown events are associated with temperature and dark current spikes on the surface of RF devices. In the past decade, there has been increased interest in unveiling the mechanism behind breakdown in metal copper and copper alloys; however, there has been a limited effort regarding breakdown phenomenon in photocathode relevant semiconductors.
In this work, we explore field emission assisted localized heating via Nottingham and Joule processes. Field emission from intrinsic cesium telluride ultra thin film coated on top of a copper substrate was modeled within Stratton–Baskin–Lvov–Fursey formalism, describing the processes and effects in the bulk and at the surface of a semiconductor exposed to a high applied electric field. These heating effects were incorporated into the surface diffusion model, where the surface gradient of the chemical potential defines the time evolution and resulting reorganization of the surface.

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Thursday Poster Session / 1738

Precision current measurement and calibration system for the APS-U unipolar magnet power supplies

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The APS Upgrade (APS-U) multi-bend acromat storage ring requires 1000 high-stability unipolar magnet power supplies. A precision current measurement and calibration system has been developed to independently measure the power supply output current to ensure the accuracy and repeatability of the supplies. The measurement system uses custom commercial DCCT current transducers along with APS-U-designed electronics. The calibration system is designed to perform on-demand calibration of all 1000 DC measurement channels simultaneously using a single current reference source instrument. The calibration system includes a precision current multiplier and impedance buffer based on a novel use of DCCT technology that provides a local precision calibration current for up to 6 DCCTs in series through multi-turn low impedance calibration windings. All system components have been received and passed acceptance testing; the full system is currently being installed in the new storage ring and full-scale evaluation will begin in early 2024. This paper describes the system design and presents preliminary test results.

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Tuesday Poster Session / 1740

Status of helium ion beams commissioning at MedAustron ion therapy center

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MedAustron is a synchrotron-based cancer therapy center located in Lower Austria. Patients are treated with proton and carbon ion beams in an energy range of 62-252 MeV/u and of 120-400 MeV/u respectively. The facility features three clinical irradiation rooms, among which horizontal and vertical beam lines as well as a proton gantry are available for treatment. A fourth irradiation room (IR1) is dedicated to non-clinical research activities among which helium ion beams are currently under commissioning. Helium ions are also promising future candidates for clinical treatment due their favorable physical and biological properties. At MedAustron the beam commissioning up to IR1 is near completion. A large energy range (i.e. 39-402 MeV/u) has been commissioned with the support of Monte Carlo simulations performed by the future users. The beam properties in terms of spot size and beam roundness obtained at the isocenter fulfill the user requirements. In this work we present the helium commissioning status with the main focus on the recent results obtained from the commissioning of the synchrotron and transfer line up to the isocenter in IR1.

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Thursday Poster Session / 1741

BPM feedback for LLRF energy and phase regulation in charge stripping beamlines

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Charge stripping is inherent for high power ion accelerators such as the FRIB LINAC. However, at high power, strippers require motion to prolong the operational life of the stripping media, or by flowing a liquid Lithium film. The charge stripping process introduces energy losses that vary

with the actual Lithium film thickness, which can result in observable beam losses along the tuned beamline at high on-target beam power, above ~100 kW, if not adequately mitigated. BPM phase feedback is used in real-time to compensate for these effects, controlling upstream RF cavities in order to maintain a constant beam energy and phase post-stripper, which significantly reduces beam energy fluctuations.

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Wednesday Poster Session / 1742

Hybrid RF photoinjector beam characterization with FET detectors

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RadiaBeam has recently built and commissioned a novel C-band photo injector for high brightness Inverse Compton Source. This photoinjector is capable of producing ultra-short femtoseconds electron 250 pC bunches producing up to 300 A of beam current while maintaining the transverse emittance at a submicron level. In this paper, we describe the beam characterization of this photoinjector using novel field effect transistors (FET) sub-THz detectors. FET detectors based on nanoscale semiconductor wires are passive devices and capable of detecting a very short and weak signal in THz and sub-THz reneges and suit well for beam characterization. By detecting the signal from the coherent transition radiation produced by the electron bunch passing through a thin aluminum foil we were able to characterize the longitudinal beam parameters. This work describes the system layout, experiment procedure, and test results of bunch length measurements.

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Wednesday Poster Session / **1743**

Calibration of the Mu2e momentum scale using π+ ⟶ e+nu_e decays

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The Mu2e experiment at Fermilab will search for neutrinoless muon-to-electron conversion in the nuclear field using an Al target to stop μ^-. Muons are produced by a resonantly extracted 8 GeV proton beam from the Fermilab delivery ring. The experimental signature of $\mu^- \rightarrow e^-$ conversion on Al is mono-energetic conversion electrons with 104.97 MeV energy*. Rejection of one of the most important experimental backgrounds coming from muon Decays-In-Orbit (DIO) requires a momentum resolution of <1% FWHM and a momentum scale calibrated to an accuracy of better than 0.1% or 0.1 MeV. Among other momentum scale calibration techniques, the collaboration is considering using 68.9 MeV e+ from π+ ⟶ e+nu_e decays of stopped π+. This momentum calibration measurement has a significant background dominated by the muon decays in flight affecting the calibration accuracy. The background can be reduced by placing a thin Ti degrader in front of the stopping target and properly choosing the timing of the measurement. We discuss optimization of the π+ ⟶ e+nu_e momentum calibration measurement and present the results.

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Monday Poster Session / **1744**

Thermomechanical and nonlinear plasmonic modeling of laser-field emission from extended nanostructured cathodes

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Laser-field emission is a process that can produce electron beams with high charge density and high brightness with ultrafast response times. Using an extended nanostructure, such as a nanoblade, permits plasmonic field enhancement up to 80 V/nm with an incident ultrafast laser wavelength of 800 nm. Stronger ionizing fields lead to higher current densities, so understanding how this field is attained will aid in further increasing brightness. In this analysis we study the nanoblade system thermomechanically and plasmonically. The structure is a silicon wedge with a 20-40 nm thick gold coating. We model the constituent materials as temperature-dependent, nonlinear dielectrics. The bulk geometry is well-represented in the finite element framework. We first perform a modal analysis of the surface plasmon polaritons using a 2-D slice of the blade. Next, we perform a 3-D steady-state calculation of the electromagnetic fields, the electron temperature, and the lattice temperature within a frame following the perturbing laser pulse. With these tools we study the peak fields and temperatures achieved as functions of the blade geometry and laser parameters.

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Monday Poster Session / 1746

Integrating Sustainable Computational Strategies in Light Source Accelerator Upgrades

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The operation of light source accelerators is a complex process that involves a combination of empirical and theoretical physics, simulations, and data-intensive methodologies. For example, the FLASH1 beamline at DESY is upgrading to an external seeding FEL light source*. We utilize special diagnostics, machine learning algorithms, and comprehensive simulations to achieve this. To optimize resources, we constantly look to improve our approach, allowing us to robustly control the acceptor and meet the desired stability of our users. Machine learning and GPU-based algorithms have become crucial, enabling us to employ advanced optimization techniques and possibly AI. However, in many cases, it is imperative to establish a robust mechanism for simulations involving large particle numbers to ensure that future upgrades and experiments can effectively and sustainably leverage these computational strategies.

Footnotes:

- New opportunities for excellent FEL experiments at FLASH (another contribution to the IPAC 2024 conference)

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Thursday Poster Session / 1747

Strain measurements of the Apple X SABINA undulator with fiber Bragg grating

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Co-authors: Alberto Petralia [2]; Alessandro Vannozzi [1]; Andrea Polimadei [2]; Andrea Selce [1]; Enrico Di Pasquale [1]; Federico Nguyen [2]; Luca Giannessi [1]; Lucia Sabbatini [1]; Mario Del Franco [1]; Michele Arturo Caponero [2]

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The SABINA project will add a user facility to SPARC_LAB at INFN in Frascati (Rome). For the THz line, an electron beam is transported to the APPLE-X undulators to produce photon pulses in the ps range, with energy of tens of μJ, with linear or elliptical polarization. Each undulator has four magnetic arrays that can be moved radially simultaneously to set the operating gap. Two arrays can also move longitudinally for phase displacement. A structural analysis of this unique mechanical structure has been performed by the production company (KYMA S.p.a) to ensure good field quality and beam trajectory. To support those, a set of tests has been performed with FBG acting as strain sensors in Frascati. An FBG is a phase grating inscribed in the core of a single-mode fiber, whose Bragg-diffracted light propagates back along the fiber. Any deformation of the grating affects its pitch, which changes the diffracted Bragg wavelength thus giving information about the occurred deformation. Application of the technique at the state-of-the-art level allows to perform strain measurements with 1 μStrain resolution. Such analysis and results will be presented in this contribution.

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Thursday Poster Session / 1748

Environmental sustainability in basic research: a perspective from HECAP+

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The High Energy Physics, Cosmology, Astroparticle Physics, and Hadron and Nuclear Physics (HECAP+) communities make use of common and similar experimental infrastructure, such as accelerators and observatories, and rely similarly on the processing of big data. Our communities therefore face immense challenges to improving the sustainability of our research. This poster presents the grassroots initiative which reflects on environmental sustainability in the context of High Energy Physics, Cosmology, Astroparticle Physics, and Hadron and Nuclear Physics (HECAP+). The document this poster is based on can be accessed at https://sustainable-hecap-plus.github.io.

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Monday Poster Session / 1749

VUV diagnostics for oscillator FEL operation from 200 nm to 155 nm

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Powered by a storage ring with energies ranging from 240 MeV to 1.2 GeV, the Duke Free-Electron Laser (FEL) has demonstrated operation across a broad wavelength spectrum from infrared (IR) to vacuum ultraviolet (VUV): 1100 nm to 170 nm. This FEL serves as a photon source for the High Intensity Gamma-ray Source (HIGS), producing polarized, near-monochromatic, and high-flux Compton gamma-ray beams in an extensive energy range from 1 MeV to 120 MeV, with the highest flux recorded at 3.5e+10 ph/s (total) around 10 MeV. To generate high-energy gamma-ray beams above 80 MeV, the FEL must operate in the VUV region from 195 nm to 155 nm. This work describes the development and operation of VUV beam diagnostics within a nitrogen-purged enclosure, with increased difficulty as the wavelength shortens towards 155 nm. We will discuss the challenges encountered and the solutions found for VUV beam diagnostics, leading to the successful FEL lasing in the VUV region.

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Wednesday Poster Session / 1750

Optimization of the ASU CXLS beamline in simulation via Bayesian methods

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Single objective Bayesian optimization is used in the simulation of the compact X-ray light source (CXLS) at Arizona State University, an inverse Compton based X-ray source, to optimize the 6D electron distribution prior to final focusing at the interaction point. For inverse Compton X-ray sources, a small 6D emittance as well as a small pulse (both transversely and longitudinally) are essential for producing bright X-ray pulses. Using IMPACT-T on a 200 pC initial charge with an RF photoinjector operating in blow-out mode, we vary parameters, such as transverse laser diameter on the cathode, RF gun phase, solenoid strength, as well as linac amplitude and phase, to balance minimizing the 6D emittance and spatial profiles. We test objective functions that are combinations of beam parameters, such as energy spread before final focus, pulse duration, and normalized emittance.

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Tuesday Poster Session / 1751

Adaptation of the Fermilab proton souce to support new muon facilities

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The PIP-II proton accelerator will provide the intensity sufficient to power a new generation of high energy facilities at Fermilab. Extension of that linac to higher energy with following acceleration and bunching rings could provide the intensity needed to feed a muon production target for a high-energy μ+-μ- collider. Scenarios using a rapid-cycling synchrotron or an ˜8 GeV Linac are presented and discussed. Use of the existing Fermilab accelerators is also discussed. Support for other high-intensity experiments such as muon-ion collisions, neutrino sources and lepton flavor conservation is also considered.

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Wednesday Poster Session / 1754

Intrinsic emittance measurements of alkali-based photocathodes

Author: Yilin Yang[1]

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Intrinsic emittance is one important figure of merit to determine the photocathode performance in accelerators fields. We present and measure the intrinsic emittance of alkali-based photocathodes with a concise design using MCP-YAG detector. Simulations for electric fields are also performed by Possion/Superfish software. The final emittance results are compared with a simple photoemission model and show good results. It is possible to connect this design to photocathode growth systems making it easy to characterize photocathodes and study photoemission physics under high electric fields.

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Tuesday Poster Session / 1755

Studies of operation and control of CW magnetrons for HEP and ADS accelerators

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CW magnetrons designed and optimized for industrial heaters, driven by an injection-locking signal, were suggested to power Superconducting RF (SRF) cavities. However, CW magnetrons are regenerative devices that apply some of their output back to its input to add to the input signal, increasing the gain/amplification. to avoid large regenerative instability in operation, we propose a new approach to operation and control of CW magnetrons considering non-stationary processes during start-up and operation that makes it possible to find a mode of almost coherent RF generation of tubes with a significant reduction in regenerative instability and noise and increased efficiency.

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North America

Wednesday Poster Session / 1756

Integration of the beam dynamics and neutronics simulation tools for the IFMIF-DONES accelerator design

Author: Marta Ternero Gutierrez[1]

Co-authors: Concepcion Oliver [2]; Fernando Mota [2]; Irene Álvarez Castro [1]; Ivan Podadera [3]; Javier Díaz [1]; Jin Hun Park [4]; Marta Anguiano [1]; Yuefeng Qiu [4]

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In this work we present the coupling of the simulation processes of two different physical phenomena. These being the Beam Dynamics at the high energy line of an accelerator, and the Neutron flux transport produced by beam-target nuclear interactions. This work is held within the framework of the IFMIF-DONES project (International Fusion Irradiation Facility-DEMO Oriented NEutron Source), whose main goal is to test materials capable of withstand the extreme irradiation conditions that future fusion reactors will have to manage. In order to recreate these conditions, a Deuteron beam is accelerated until it reaches a 40 MeV energy, 125 mA and it is shaped to have an specific profile by the end of the High Energy Beam Transport line. Colliding with a Lithium target afterwards, it will produce a neutron flux whose irradiation effects are upon study. In this contribution we focus on how the BD of the HEBT, i.e. the profile shaping, affects this neutron flux by developing a coupling tool that runs sequentially both softwares (TraceWin for BD and MCNP6.2 for Neutron transport) and that serves multiple purposes since it allows to determine the impact of the HEBT on neutron configuration.

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Wednesday Poster Session / 1757

High average current DC electron gun for strong hadron cooling

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Co-authors: Donald Bruno [1]; Erdong Wang [1]; John Skaritka [1]; Jyoti Biswas [1]; Matthew Paniccia [1]; Mengjia Gaowei [1]; Patrick Inacker [1]; Robert Lambiase [1]; Wei Liu [1]

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The Strong Hadron Cooling (SHC) for electron ion collider project requires a state of the art high brightness DC electron gun. The gun is required to deliver high average current (100 mA), 1 mm·mrad normalized transverse emittance and 1-2.5 nC bunch charge. In this paper, we describe the high voltage design of a DC gun with an operating voltage of 550 KV, conditioned up to 600 KV. The gun design includes design of the electrode, active cooling for the cathode electrostatic design of the triple point shield, a novel high voltage power supply (HVPS) and HVPS power transfer mechanism. We also discuss the beam dynamics simulation to quantify the ultimate performance of the gun.

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Thursday Poster Session / 1758

Experimental results on longitudinal RF beam phase feedback in the heavy-ion synchrotron SIS18

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In the SIS18 heavy-ion synchrotron at GSI, RF beam phase feedback systems are developed and tested with beam for the damping of coherent longitudinal bunch oscillations. In particular, a beam phase control system is currently commissioned for the damping of longitudinal dipole oscillations. The feedback system has to cope with both, a large RF frequency span (400 kHz to 5.4 MHz) and synchrotron frequencies of up to 6 kHz. It has to be compatible with several beam manipulation schemes such as dual-harmonic, bunch merging, and bunch compression. The system relies on recent upgrades of the SIS18 LLRF topology including a newly developed multi-purpose DSP system that is used for the RF cavity synchronization as well as for RF beam feedback. This paper describes the LLRF concept of the RF beam phase feedback at SIS18 and presents results from machine experiments with beam where an adaptive feedback filter for damping longitudinal dipole oscillations during the whole SIS18 machine cycle was realized and successfully applied. Finally, an outlook will be given towards the full integration into the central control system and towards the SIS100 bunch-by-bunch longitudinal feedback system.

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Wednesday Poster Session / 1759

An upgrade for the CeC cathode deposition system: co-deposition of K2CsSb and CsTe/GaAs for CeC use

Author: Kali Prasanna Mondal[1]

Co-authors: Jyoti Biswas [1]; John Walsh [1]; Rudy Begay [1]; Luca Cultrera [1]; Mengjia Gaowei [1]

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Semiconductor photocathodes are key for the fast development of electron accelerators with high current electron beams and photon detectors, to fulfill these requirements one looks for photocathodes that should have merits like high QE, low thermal emittance, long lifetime,etc. Compared to the traditional sequential deposition, the co-evaporation method is reported to yield better surface roughness, film crystallinity and high quantum efficiency for photocathode materials*. Here we present the effort in upgrading the CeC photocathode deposition system to adapt the co-evaporation growth method, the development of the co-evaporation recipe and the preparation of K-Cs-Sb photocathode using the developed system. QE of about 6.3% at wavelength 532 nm was obtained for co-deposited K2CsSb photocathode, where stoichiometry was determined by the deposition rate of each element. The system upgrade also enables the preparation of GaAs photocathodes activating with Cs-Te. In our study, both CsTe and CsTe/CsO activated GaAs are prepared using the "yo-yo" method. QE of about 3.6% and 5.8% at wavelength 532 nm are obtained respectively. Lifetime measurements are performed and results are reported.

Footnotes:

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Tuesday Poster Session / 1760

Hydrodynamic simulations of an argon-filled tapered plasma lens for optical matching at the ILC E+ source

Author: Manuel Formela[1]

Co-authors: Gregor Loisch [2]; Gregory Boyle [2]; Gudrid Moortgat-Pick [2]; Jens Osterhoff [2]; Maxence Thévenet [2]; Niclas Hamann [1]; Steven Mewes [2]

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The beam produced in the target of the ILC positron source is highly divergent and therefore requires immediate optical matching, conventionally performed by some kind of solenoid arrangement. Recently, the use of a plasma lens has been considered as an alternative with hopes to increase number of positrons available for the downstream acceleration. Previous simulations have indicated that a plasma lens design with linear tapering is optimal for the ILC positron source. In the latest hydrodynamic simulations, argon is studied as the plasma medium for the aforementioned plasma lens design. During these studies, argon's various reaction paths are systematically examined to understand their impact on the discharge process. This is followed by a comparison with hydrogen.

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Thursday Poster Session / 1761

Time-of-flight beam loss monitor for the Advanced Photon Source upgrade booster to storage-ring transport line

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Co-authors: Adam Brill [1]; Jie Liu [1]; Steven Shoaf [1]; Suyin Wang [1]

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We present initial results from the booster-to-storage-ring beam-loss monitor (BTSBLM) employing time-of-fight analysis to localize and minimize losses along the BTS line. The BTSBLM utilizes a pair of high-purity, fused silica fiber optic cables running in parallel along the 65-m BTS transport line. Photomultipliers located at both upstream and downsteam ends of each fiber monitor Cherenkov radiation generated by lost electrons. The downstream detectors receive temporally-compressed, higher-intensity, spatially-inverted signals, while the upstream waveforms are temporally expanded with lower intensity allowing finer time resolution; both upstream and downstream effects owing to the refractive index in the fiber glass. Each radiation-hard optical fiber is composed of 600, 660, and 710-micron-diameter core, cladding, and buffer and is similar to those used in the newly commissioned LCLS-II superconducting linac BLM system. Realtime waveforms are recorded on a fast oscilloscope and available for diagnostic observation through EPICS waveform records. Remote controlled high-voltage power supplies provide gain adjustment. Data from booster and storage-ring commissioning are presented.

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North America

Monday Poster Session / 1762

Matching and guiding of an laser plasma accelerated electron beam in a undulator with FODO lattice

Author: Samuel Barber[1]

Co-authors: Finn Kohrell [1]; Curtis Berger [1]; Christopher Doss [1]; Sarah Schroeder [2]; Guillaume Plateau [3]; Stephen Milton [3]; Carl Schroeder [1]; Eric Esarey [1]; Jeroen van Tilborg [1]

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Compact free electron laser (FEL) technology enabled by plasma-based accelerators is rapidly maturing with several milestone demonstrations in the last 2-3 years. Still, critical work is needed to bridge the gap from proof of concept experiments to reliable operation of plasma-based FELs. At the BELLA Center, we have a laser plasma accelerator (LPA) beamline equipped with an electron beam transport section that culminates in a 4m long, strong focusing undulator. This undulator system with 16 embedded FODO cells, represents a comparable proxy to many undulator systems used at XFEL beamlines. Notably, the presence of distributed focusing imposes tight requirements on both transverse matching and alignment of the beam through the undulator in order to enable FEL lasing. Recent efforts have demonstrated quasi matched propagation of the LPA beam in the undulator. Additionally, through control of the launch trajectory into the undulator coherent enhancement of the undulator radiation can be triggered, a strong indication of FEL gain. Recent results and future plans are discussed.

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North America

Tuesday Poster Session / 1763

An input port for a high-power magnetron

Author: Michael Neubauer[1]

Co-authors: Jerry Wessel [2]; Milorad Popovic [1]; Ronald Lentz [1]; Thomas Blassick [2]; Tony Wynn [1]

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An input port for the magnetron uses the helix of the filament as an antenna into the resonant structure of the magnetron. Analytical results indicate the coupling variables in pitch and radius of the filament. High voltage standoff includes a combination of DC blocks and capacitive coupling techniques in either waveguide or coax. The importance of this novel innovation in magnetron development is discussed.

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North America

Wednesday Poster Session / 1764

Epitaxial growth of cesium potassium antimonide photocathode

Author: Kali Prasanna Mondal[1]

Co-authors: John Smedley [2]; Chad Pennington [3]; Elena Echeverria [3]; Jared Maxson [4]; Priyadarshini Bhattacharyya [5]; Siddharth Karkare [5]; Kenneth Evans-Lutterodt [1]; Mengjia Gaowei [1]

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Photocathodes play an integral role in the development of electron accelerators and photon detectors. The emitted beam brightness can be limited by the surface and bulk disorder of the polycrystalline photocathode material. Epitaxial growth of photocathodes has the potential to overcome this problem and achieve high brightness electron beam. This work demonstrates the epitaxial growth of K2CsSb photocathode on varied single crystal substrates. In our study, streaky pattern aligned with latticed matched substrates from reflection high energy electron diffraction (RHEED) were observed from the K2CsSb thin film. Further, azimuthal angular dependence of the crystalline structure of the K2CsSb thin film was also observed for RHEED, which confirms the growth of the epitaxial layer with flat surface and high crystallinity. We obtained quantum efficiency (QE) of about 4.5 % at wavelength 530 nm light from the ˜ 20 nm film with a roughness of ˜ 0.8 nm. The stoichiometry and crystallinity of the K2CsSb thin films are confirmed by X-ray diffraction (XRD) and X-ray fluorescence (XRF). High QE over 9 % at 530 nm has been achieved for epitaxial K2CsSb photocathode thin films.

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Tuesday Poster Session / 1767

Progress on combining digital twins and machine learning based control for accelerators at SLAC

Author: Auralee Edelen[1]

Co-authors: Christopher Mayes [1]; Claudio Emma [1]; Kathryn Baker [2]; Ryan Roussel [1]; Tobias Boltz [3]; Juan Pablo Gonzalez-Aguilera [4]

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Advances in high-performance computing have enabled detailed physics simulations, including those with nonlinear collective effects such as space charge, to be deployed online in a control room setting to aid operator intuition and be used directly in automatic tuning. Simultaneously, machine learning (ML) has enabled deployment of detailed models online with sub-second execution time, opened up new avenues for adapting simulation models to more closely match real accelerator behavior, and enabled novel ways to combine detailed physics simulations and ML-based tuning. This contribution will provide an overview of how these tools are being developed and successfully applied at SLAC, with an emphasis on experimental demonstrations. This includes improvements in adaptive calibration methods, novel approaches to simulation (e.g. differentiable physics combined with ML), and the use of system models in ML-based tuning (e.g. Bayesian optimization with system model priors, iterative simulation and ML tuning to aid LCLS-II injector commissioning). Discussion of the software infrastructure required to achieve this and deploy these solutions into regular operation will also be discussed.

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Monday Poster Session / 1768

Development of liquid lithium target in crucible for laser ion source

Author: Shunsuke Ikeda[1]

Co-authors: Antonino Cannavó [1]; Masahiro Okamura [1]; Takeshi Kanesue [1]

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A liquid lithium target system is being developed for laser ion sources. Existing laser ion sources are operated at the repetition rate of the order of 1 Hz. The limitation stems from the use of solid laser targets because of the craters created and the need to provide a fresh surface by either repositioning the laser beam or the target. In addition, an enormously large surface area is needed for long-term operation. This limits the total yield of lithium ions and the application of laser ion sources. To dramatically increase the repetition rate, we propose the use of a liquid lithium target in a crucible because a liquid surface shape is recovered by itself after laser irradiation. The establishment of a liquid target system is an important objective for the development of the intense lithium beam driver for a clean compact source of a directional neutron beam. In the conference, the concept and design of experimental apparatus for the development will be presented.

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Tuesday Poster Session / **1769**

Simulation study on an electron cloud and plasma waves confined in GL2000 device

Author: Martin Droba[1]

Co-authors: Julian Rausch [1]; Katrin Thoma [1]; Oliver Meusel [1]; Thomas Dönges [1]

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GL2000 Gabor-lens (GL)[1, 2] is a 2-m long device constructed and successfully operated at Goethe University. The confined electron column is much longer compared to previous constructed lenses and offers unique opportunity for investigation of electron cloud dynamics. Especially, kind of fingertip stopband structures were precisely measured in production diagram (operation function) in the year 2023 [2]. This fully reproducible behavior and dependence on a rest gas pressure left unexplained. For this purpose, a large scale multi-particles simulation PIC(particle-in-cell)-code was written in C++ and implemented on FUCHS-Cluster of the Goethe University. The main objective is to find an optimal operation parameter set for a stable operation of GLs, which is crucial for high energy hadron beam transport and focusing. Further topic will be investigation of possible longitudinal handling of bunched ion beams. The first simulation result will be presented and discussed.

Footnotes:

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[2] K.Thoma et al. IPAC2023-TUPM101

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Tuesday Poster Session / **1770**

SoC based time-resolved scaler DAQ and amplifier-discriminator upgrade for BECOLA

Author: Shriraj Kunjir[1]

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The BEam COoler and LAser spectroscopy (BECOLA) is a collinear laser spectroscopy facility at Facility for Rare Isotope Beams (FRIB) at Michigan State University. Time resolved laser spectroscopy experiments are performed to study the nuclear structure of radioactive isotopes. The current data acquisition (DAQ) system being used is based on Xilinx Spartan 6 field programmable gate array (FPGA) and supports time resolution of 8 ns. There was a need to upgrade existing hardware to meet the requirements for higher time resolution of fast ion detectors. A new DAQ system with Xilinx Zynq System on Chip (SoC) FPGA based time-resolved scaler was designed, developed and fabricated; and is achieving a time resolution of 2 ns. The current amplifier-discriminator (AD) has an output pulse resolution of 10 ns. To address this constraint and fully leverage the 2 ns time resolution provided by the new SoC FPGA, a new AD with an output pulse resolution of 1 ns was designed. A brief overview of the upgraded DAQ system will be discussed in this poster, including its features, improvements, Experimental Physics and Industrial Control System (EPICS) Input / Output Controller (IOC), and future updates.

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Tuesday Poster Session / 1771

Novel injection locked coaxial magnetrons

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Co-authors: Jerry Wessel [2]; Michael Neubauer [1]; Ronald Lentz [1]; Thomas Blassick [2]; Tony Wynn [1]

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To meet phase stability requirements, a high peak power coaxial magnetron-based RF system with >70% efficiency would normally be injection locked to an RF source by using a circulator to send the locking signal into the magnetron through the antenna. This added requirement of a high-power circulator pushes the inherently low coaxial magnetron's cost-per-watt to a high overall RF Power Source system cost-per- watt. For this project, the injected phase locking signal for the magnetron will use a novel input port that does not require a high- power circulator. The new input port uses the cathode stalk assembly to turn the filament-cathode into an antenna that couples to the resonant circuit of the magnetron. The coupling system between the cathode stalk, which runs at high voltage, and the RF input includes isolation for high voltage.

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Thursday Poster Session / **1772**

The X-ray imaging laboratory: a radiation test facility for validating industrial linacs

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The X-ray Imaging Laboratory is a radiation test facility developed by Rapiscan systems at their facility in Stoke-On-Trent, UK. The X-ray Imaging Laboratory comprises two areas: the Test Facility and the Linac Development Area. The Test Facility is a state-of-the-art facility designed for subsystem and system level testing of x-ray imaging hardware utilizing normal conducting electron linacs with energies of up to 6MeV. The Test Facility is primarily focused on utilizing mature industrial linacs to produce x-rays for imaging validation. The Linac Development Area is a new facility focused on testing linear accelerator components and subsystems for a new generation of industrial electron linacs. The Linac Development Area includes a high voltage test area and a radiation test bunker. This allows for testing of critical components, such as modulators, in isolation in the high voltage test area and then as part of an industrial linac in the radiation test bunker.

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Tuesday Poster Session / **1773**

ROCK-IT –a demonstrator for automation and remote-access to synchrotron beamlines

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ROCK-IT aims to develop a demonstrator for automation and remote-access to beamlines of synchrotron radiation facilities. The four participating Helmholtz centers DESY, HZB, HZDR, and KIT have identified catalysis operando experiments as a pilot development. So far, no automation exists for such experiments and since the optimization of catalysts requires to evaluate a large parameter space of experimental and material conditions, it is a perfect demonstrator case for a prototype. For the research community, a suitable automation of such experiments will allow for a more effective development workflow. For KIT's catalyze beamline CAT at the Karlsruhe Research Accelerator KARA a prototype of the setup is currently in development.

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Tuesday Poster Session / 1774

Measurements of hysteretic effects and eddy currents on a FeCo magnet for the design of a novel ion gantry

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Hadron therapy uses scanning magnets to precisely deliver therapeutic beams, minimizing the damage to healthy tissues and reducing side effects. A collaboration between CNAO, CERN, INFN and MedAustron is developing an innovative gantry design with superconducting magnets and a downstream scanning system. The project features two compact scanning dipoles, each with a central field of 1 T –about three times higher than current magnets used in clinical practice. The heightened magnetic field, together with the large rate of varying currents required for operation during treatments, prompts an investigation into non-linearities, necessitating a careful study of their impact on the performances of the system. This contribution provides insights into the dynamic behavior of a prototype scanning magnet with a FeCo yoke, with measurements of saturation, hysteretic effects, and eddy currents performed at Frascati National Laboratories, elucidating the feasibility of the proposed model. Additionally, in view of clinical implementation, the study explores methods of fast degaussing.

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Wednesday Poster Session / 1775

High-intensity polarized H- source development and operation at BNL

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The AGS-RHIC injector complex includes H- ion sources at 35 keV, 750 keV RFQ and 200 MeV Linac. This report will focus on the recent upgrade of the 35 KeV Low Energy Beam Transport (LEBT) with three sources: two high-intensity magnetron H- sources and an Optically Pumped Polarized Ion Source (OPPIS) polarized H- source. There were still significant beam intensity losses in the 8 m long OPPIS transport line due to H- stripping, therefore, to meet the demand for the higher beam intensity in the 2024 polarized run, the OPPIS LEBT length was reduced by about two meters. Another possibility for increasing beam intensity is to increase the beam pulse width. The OPPIS performance and operation in Run-2024 will be presented.

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Thursday Poster Session / 1776

Overview on the Sirius Delta undulator

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A new Delta type undulator has recently been installed in Sirius, the 3 GeV, 4th generation Brazilian synchrotron light source in Campinas city. It is the first Delta undulator to be installed on a synchrotron storage ring, thanks to the low horizontal emittance and related low horizontal beam-stay-clear. The 1.2 m length device has a pure permanent magnet structure comprised of 21 periods of 52.5 mm and a 13.6 mm fixed gap between its four magnetic array cassettes achieving a 0.1 - 1.6 keV energy range, addressing the needs of the soft X-ray beamline Sabiá, aimed at carrying out X-ray absorption spectroscopy and electron photoemission microscopy experiments. The radiation polarization and energy can be fully controlled by moving the magnetic arrays in the longitudinal direction, providing the capability of generating left-handed and right-handed circular polarization, which is essential for X-ray circular dichroism experiments, as well as horizontal and vertical linear polarizations. The design, construction, field measurements and correction, as well as the initial impact on the electron beam will be discussed in this paper.

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North America

Monday Poster Session / 1777

Change of Hamiltonian during longitudinal separatrix crossing

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Near-adiabatic capture into an RF bucket with rising voltage has been used since 1946 or earlier. But until the present work, there is no analytic and deterministic description of the process capable of predicting the final phase space distribution (for arbitrary voltage ramps). Recently, we have developed formulae for trajectories that cross the instantaneous separatrix, and the corresponding change of Hamiltonian. Previous attempts at this calculation were unsatisfactory: either plagued by singularities, or limited to probabilistic results for linear variation of the confining potential. Previously*, we presented formulae for the changes in Hamiltonian (due to modulation and bunching) before and after separatrix crossing; and those contributions to emittance growth are equally or more important. Together, the three results provide a complete, analytic description of near-adiabatic capture into an RF bucket.

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WECN: Accelerator Technology and Sustainability (Contributed) / 1778

The testing experience of the cryomodules for the ESS beam on target phase at 2 MW capability

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Co-authors: Anders Svensson [1]; Artur Gevorgyan [1]; Cecilia Maiano [1]; Cedric Lombard [1]; Filip Skalka [2]; Henry Przybilski [1]; Marcin Wartak [2]; Marek Skiba [2]; Morten Jensen [1]; Muyuan Wang [1]; Paolo Pierini [1]; Pawel Halczynski [2]; Philippe Goudket [1]; Piotr Rutowski [2]

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ESS is completing the installation of the first phase of operation, which will start in fall 2024 on the partial beam dump and proceed with operation on the target in 2025, after receiving the intentional neutron production license from the authorities. All modules for this operation phase, with an energy reach of 870 MW and a power capability of 2 MW, will be tested by spring 2024. The CM performance, associated statistics and the resulting linac composition is discussed here. Testing activities for the remaining CM for the full ESS 5 MW scope will continue until mid 2026.

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Europe

Monday Poster Session / 1779

Mechanical analysis and design for the LCLS-II-HE soft X-ray undulator reconfiguration

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As a part of the High Energy upgrade to the Linac Coherent Light Source II at SLAC, LBNL is responsible for the update of the undulators of the Soft X-Ray (SXR) line. In order to span the required photon energy range, the SXR undulators require longer magnetic period. This increased magnetic period leads to higher magnetic force, requiring updates to certain elements of the design. In contrast, many elements can safely remain unchanged. This presentation details the updates

and analyses performed to support the adaptation to HE-SXR, as well as pre-production undulator results.

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Monday Poster Session / 1781

Alternative negative electron affinity activation studies at HERA-CLES

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A new growth chamber at the High ElectRon Average Current for Lifetime ExperimentS (HERA-CLES) beamline at Cornell has been installed enabling Negative Electron Affinity (NEA) activations of GaAs using Cs-Sb-O and Cs-Te-O recipes. These activation recipes have been shown to be more robust against vacuum poisoning when measured at low voltages and currents. In this proceeding we present charge lifetime measurements of these recipes when operated in a high voltage, high current electron gun.

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Monday Poster Session / 1782

Beam dynamics simulations for "witness"and "driver"beam generation using a C-band hybrid photoinjector

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This paper reports on beam dynamics simulation studies made to validate the feasibility of manipulating "witness" and "driver" beams through a C-Band hybrid photoinjector, aiming to use it for plasma acceleration. The hybrid photoinjector combines the characteristic features of traveling wave and standing wave structures within a single device. Among the numerous RF advantages of the hybrid photoinjector, the phase shift of 90 degrees introduced between the two structures enables operation within the velocity bunching regime. The collaborative efforts within the DARPA-GRIT collaboration have yielded an accurately designed and realized hybrid structure. Beam dynamics simulations demonstrate capabilities in producing high-brilliance beams. The use of such device as a beam source in plasma accelerator allows to obtain high brightness ultra-short beam necessary in the plasma acceleration process. This research presents simulation outcomes, showing parameters for witness and driver beams such as bunch length, spot size, and the optimal time distance between the "witness" and "driver" beams.

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Thursday Poster Session / 1783

Adjoint computation of lattice sensitivities using particle simulation codes

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The design of accelerator lattices involves evaluating and optimizing Figures of Merit (FoMs) that characterize a beam's properties. These properties (hence the FoMs) depend on the many parameters that describe a lattice, including the strengths, locations, and possible misalignments of focusing elements. We have developed efficient algorithms to determine the multi-parameter dependence of an FoM, taking advantage of recent developments in adjoint techniques that facilitate the efficient computation of FoM derivatives with respect to the many parameters that describe a lattice. One algorithm applies to lattices and beams for which the paraxial approximation holds and particle motion is described as 4D in transverse phase space with distance along the beam path as the independent variable. Another algorithm—appropriate for implementation in a code such as OPAL—applies to beams in which particle trajectories are calculated in 6D phase space with time as the independent variable. We describe both the underlying adjoint theory and the numerical implementation of these algorithms.

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Tuesday Poster Session / 1784

Longitudinal beam profile monitoring in ILSF based on Smith-Purcell, transition, and diffraction radiation

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Seeking non-invasive beam profile monitoring for the Iranian Light Source Facility (ILSF), we propose a novel approach based on the utilization of Smith-Purcell, transition, and diffraction radiation. The ILSF is a synchrotron radiation facility with a storage ring capable of providing electron bunches up to 3 GeV. The Smith-Purcell radiation is generated when a charged particle passes over a periodic structure, while transition radiation is generated when a charged particle passes through a boundary between two media. Diffraction radiation is generated when a charged particle passes through a slit or grating. To analyze the radiation spectra, we use the Martin-Puplett interferometer, which provides valuable information about the bunch duration. The proposed method is aimed at identifying the key parameters that affect the performance of ILSF. By using this approach, we can monitor the electron bunches and observe any deviation from their trajectory. This can provide a powerful tool for optimizing ILSF performance.

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Thursday Poster Session / 1785

Automation upgrade of the CXLS photoinjector

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The automation upgrade of the photoinjector for the Compact X-Ray Light Source (CXLS) at Arizona State University is described. As the accelerator vault of the CXLS is only 10 meters long, the photoinjector drive laser is located in an enclosure inside the vault. Since ionizing radiation is present in this room during operations, it necessitates remote control of all devices used to optimize the laser spot. This includes multiple shutters, Galil motors, picomotors, a mirror flipper, LEDs, and remote lens controllers. To actuate these devices, a GUI was created with the use of MATLAB AppDesigner which communicates with the hardware through EPICS (Experimental Physics and Industrial Control System). Challenges with this GUI are described, along with the team's efforts to finalize the control software. After these upgrades, the photoinjector laser characteristics can be adjusted remotely during operation and changes to the drive laser's position, shape, and intensity can be made without interrupting beam time.

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Thursday Poster Session / 1786

Fabrication of 1.3 GHz Nb cavities at RadiaBeam

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Niobium cavities are key elements in superconducting radiofrequency (SRF) accelerators. Despite increasing worldwide demand, global commercial production capacity is limited to a small number of vendors with virtually no US-based turn-key suppliers. As SRF technology expands across scientific research, industry, and technology sectors, the demand for their production is expected to rise even more in the coming years. Due to the limited supply base and very long delivery times, the US accelerator community is seeking to promote new vendors to enter SRF business capable of rapid iteration of low-volume/high mix R&D cavities. RadiaBeam has been involved in developing niobium fabrication capabilities for several years now, with the objective of understanding the technological challenges and commercial opportunities. In this paper, we present the progress in fabrication process of a single 1.3 GHz TESLA-style niobium cavity at RadiaBeam. This process involves the deep drawing of half cells, machining of weld joints, chemical cleaning, and electron beam welding capabilities.

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Wednesday Poster Session / 1787

Low-energy muon and muonium beam source at Fermilab

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We describe a high-efficiency source of muonium that can be transported as a beam in vacuum provides opportunities for fundamental muon and precision physics measurements such as sensitive searches for symmetry violation. Although PSI is currently the world leader, the intense 800-MeV PIP-II linac beam at Fermilab could provide world-class low-energy muon and muonium beams, with unparalleled intensity, driving the next generation of precision muon-based physics experiments at the intensity frontier. However, it is critical to initiate the prerequisite R&D now to prepare for the PIP-II era. A low-energy secondary muon line recently installed in an operating facility (the MeV Test Area, which utilizes the intense 400-MeV Fermilab Linac beam) could support the required R&D, and potentially compete for new physics in the immediate term, if approved. This beamline was developed for μ–and will need to be re-optimized for surface μ+ production and transport, making it also suitable for muon spin rotation physics—a unique research and industrial application for which no U.S. facility exists, and whose facilities are oversubscribed worldwide.

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Monday Poster Session / 1788

Chemical robustness enhancement of negative electron affinity photocathodes through cesium-iodide deposition

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Photocathodes at Negative Electron Affinity (NEA), like GaAs and GaN, allow for efficient production of spin-polarized electrons. When activated to NEA with cesium and an oxidant, they are characterized by an extreme sensitivity to chemical poisoning, resulting in a short operational lifetime. In this work, we demonstrate that deposition of a cesium iodide (CsI) layer can be used to enhance the dark lifetime of both GaN and GaAs photocathodes activated with cesium. The mechanism behind this improvement is investigated using X-ray Photoelectron Spectroscopy (XPS) and Atomic Force Microscopy (AFM) techniques.

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Monday Poster Session / 1790

Surface oscillations and multipole dynamics in charged particle distributions

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This study explores surface oscillations and multipole dynamics within distributions of charged particles, both cylindrical and spherical, analyzing their deviations from equilibrium. It reveals the emergence of surface plasmonic oscillations, derived from electric fields induced by charge density on the particles' surfaces. Commencing from the analysis of monopole oscillations and extending it to dipole and quadrupole variations, this work outlines self consistent equations of motion. An in-depth analysis of emittance evolution highlights distinct behaviors associated with specific multipole modes, emphasizing a significant connection with surface plasmonic oscillations. This research underscores the intriguing relationship between surface oscillations and beam emittance dynamics, offering important insights into the microscopic behavior within perturbed distributions. The approach demonstrates the versatility of analyses of surface oscillations for both equilibrium and non-equilibrium charged particle distributions.

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Monday Poster Session / 1791

Coherent spectrotemporal shaping of fresh slice attosecond X-ray free-electron lasers

Author: River Robles[1]

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X-ray free-electron lasers (XFELs) have emerged as a promising counterpart to high harmonic generation sources for scientific applications requiring high power attosecond X-ray pulses. To date, attosecond XFELs have specialized in producing isolated pulses enabling the study of nonlinear ultrafast science in the impulse regime. We present a method to coherently shape the spectrotemporal characteristics of attosecond X-ray free-electron laser pulses, offering a path towards broader coherent bandwidths and more versatile control of pulse amplitude and phase. We show that with undulator tapering in a fresh slice reamplification scheme, it is possible to produce phase-stable pulse pairs with tunability in color and temporal separation, phase-stable pulse trains, and flexibly

chirped pulses. Our method enables bandwidth broadening for attosecond X-ray FELs and offers a path towards sub-100 as pulse duration at soft X-ray wavelengths.

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Tuesday Poster Session / 1792

Progress on the magnetron R&Ds for industrial particle accelerators

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The magnetron as an efficient RF source for a compact industrial SRF accelerator has been proposed [1]. The performance of injection phase lock on two independent magnetron transmitters operated at 915 MHz, in CW mode with maximum power of 75 kW each has been demonstrated to satisfy for this application [2]. This industrial type magnetron has transformer and SCR rectifier on the DC anode power supply. Output power spectrum with phase locking can achieve noise reduction of -21 dBc at the 1st 60 Hz, -29 dBc at 1st 120 Hz with only -22.6 dBc injection power. Solenoid current increase of 16% can increase the magnetron relative natural frequency by 4e-4. Further solenoid current modulation with feedback control and the 2x75 kW power combining scheme with the WR975 magic-tee are to be further studied. We intend to use one 75 kW power station with InnoSys' switching DC power supplies to drive normal conducting and superconducting RF cavities for an industrial compact linac. We are also going to report on the 4x1.2 kW power combining experiment on the 2450 MHz magnetron system carried out at GA, including the control algorithm with modified magnetron heads with trim-coils and characterized at JLab.

Footnotes:

[1] G. Ciovati, et al, Development of a prototype superconducting radio-frequency cavity for conduction-cooled accelerators, Physical Review Accelerators and Beams 26, 044701 (2023)
[2] H. Wang, et al, Demonstration of Magnetron as an Alternative RF Source for SRF Accelerators, Proceedings of 21st International Conference on RF Superconductivity, SRF2023, Grand Rapids, MI, USA, doi:10.18429/JACow-SRF2023-WEPWB131

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Monday Poster Session / 1793

Pulsed Compton Gamma-ray beam generation using pulsed FEL beam

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For certain photonuclear experiments utilizing Compton gamma-ray beams, beam-uncorrelated background poses a significant challenge. At the High Intensity Gamma-ray Source (HIGS), we have developed methods to generate pulsed free-electron laser (FEL) beams by transversely or longitudinally modulating the storage ring FEL. Both methods enable periods of FEL interaction: one by transversely manipulating the electron beam orbit, the other by de-synchronizing the electron and FEL beams. The recently-developed longitudinal method has proven superior: it avoids beam loss and is applicable across a wide range of electron beam energies. In this work, we describe the operational principle of pulsed FEL beam generation using longitudinal modulation, and we present measurements of the macro- and micro-temporal structure of the FEL beam. Furthermore, we present experimental results demonstrating the effectiveness of using a pulsed gamma-ray beam to reduce beam background.

Footnotes:

M.W. Ahmed et al. https://doi.org/10.1016/j.nima.2003.08.166.
S.F. Mikhailov et al. https://accelconf.web.cern.ch/IPAC2015/papers/tupma012.pdf

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Monday Poster Session / 1794

Development of X-ray laser oscillator

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The X-ray Laser Oscillator (XLO) uses LCLS pulses to pump population inversion in solid copper and lase on the K alpha line, producing fully coherent, transform limit X-ray pulses, opening new avenues for experiments in fields such as inelastic X-ray scattering, parametric down-conversion, quantum science, X-ray interferometry, and coherent imaging. An important component of XLO is a bow-tie cavity to recirculate the X-ray pulses, using Si or diamond crystals as mirrors in a Bragg configuration. In this proceeding, we report on the XLO optical cavity design and initial measurements, including intracavity focusing, mirrors and lenses alignment. We present and discuss a comparison between the numerical simulations and experimental data.

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Wednesday Poster Session / 1795

Commissioning an S-band hybrid photocathode gun in Mithra laboratory at UCLA

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Co-authors: Brian Naranjo [1]; Fabio Bosco [1]; Gerard Andonian [1]; Gerard Lawler [1]; James Rosenzweig [1]; Monika Yadav [1]; Oliver Williams [1]; Pratik Manwani [1]; Yusuke Sakai [1]

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In Mithra Laboratory at UCLA, we are commissioning an S-band Hybrid gun which has a photocathode RF gun and a traveling-wave velocity buncher section contained in one integrated structure. To analyze its performance, we have measured the beam energy at various launch phases and the cavity temperatures. The beam charge was observed up to 200 pC, and emittance and bunch length measurements are now underway. We will report the detailed results of this experimental campaign, and plans for the near future.

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Monday Poster Session / 1796

Terawatt-scale attosecond soft X-ray pulses from a superradiant free-electron laser cascade

Author: Paris Franz[1]

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High-power attosecond X-ray pulses are ideal probes of ultrafast nonlinear interactions in quantum systems. We demonstrate the production of soft X-ray pulses with terawatt-scale peak powers and few hundred attosecond pulse durations in a two-stage cascaded X-ray free-electron laser. We diagnose the pulse properties in the time domain with angular streaking. Our results exceed the peak power of previous state-of-the-art attosecond XFELs by an order of magnitude. Furthermore, our data provides strong evidence of operation in the soliton-like superradiant regime of the free-electron laser at X-ray wavelengths.

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Monday Poster Session / 1798

An overview of spin-polarized photocathode research at cornell university

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The development of a robust spin-polarized electron source capable of sustaining mA scale average beam currents in a photoinjector is critical for many future accelerator facilities such as the International Linear Collider (ILC). In this proceeding we overview the several efforts being carried out at Cornell towards this end, including: high current (>1 mA) gun tests of robust activation recipes of GaAs at the HERACLES beamline, the development and demonstration of GaN as a robust spin polarized source and Density Functional Theory (DFT) ab initio studies of alkali-antimonide photocathodes as potential spin polarized electron sources.

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Tuesday Poster Session / 1800

Geometry-based design of high power RF sources with the Neptune 3D EM-PIC code

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We present new capabilities in the Neptune electromagnetic particle-in-cell (EM-PIC) simulation code and design environment created to support geometry-based design of high power RF sources. Neptune's time-domain EM-PIC model to simulate high-voltage, high-current electron beam/RF interactions is a key component of the first-principles design codes created by NRL and Leidos, which provide a comprehensive, geometry-based approach to RF source design*. Neptune allows importing multi-part device geometry created by conventional CAD tools, which can simplify the design process for complex 3D devices. Imported CAD parts can be manipulated, modified and combined with other geometric elements as needed using a constructive solid geometry (CSG) model to create the device geometry to be used for simulation. New features of the EM-PIC model include an improved waveguide port model, with time-resolved waveguide mode diagnostics, and support for customized electron beam models. We will summarize the new capabilities and present examples of applications to high power RF sources.

Footnotes:

- J. J. Petillo et al., "First Principles Codes and Analysis Environments for Vacuum Electronics Simulation," IEEE Trans. Electron Devices, vol. 70, no. 6, pp. 2666-2679, June 2023, doi: 10.1109/TED.2023.3236910

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Wednesday Poster Session / 1801

Update on the MEDUSA ultrafast electron diffraction beamline at Cornell

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The Micro Electron Diffraction for Ultrafast Structural Analysis (MEDUSA) beamline is an ultrafast electron diffraction (UED) beamline currently operational at Cornell. The MEDUSA beamline specializes in the study of small samples, with electron beam probe sizes down to the single micron scale. These samples can be pumped by lasers with wavelengths ranging from IR to UV. In this proceeding, we discuss the upgrades made to MEDUSA, with a focus on the cryogenic compatibility changes made to allow the study of samples down to liquid nitrogen temperatures. We report on preliminary pump-probe experiments preformed at cryogenic temperatures. Additionally, we detail results on aberrations in foil-wound solenoids being used for post-sample magnification of the resulting diffraction patterns.

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Monday Poster Session / 1802

High-energy and narrow-bandwidth X-ray regenerative amplifier FEL design for LCLS-II-HE

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LCLS-II-HE is an energy upgrade of the LCLS-II linac from 4 GeV to 8 GeV. The X-ray FEL photon energy (Self-Amplified Spontaneous Emission mode) will extend towards 12 keV (from the present 5 keV) based on the current beam emittance. To reach higher photon energy range towards 20 keV, a new injector with a much brighter electron beam will be required. Here we study an X-ray regenerative amplifier FEL (XRAFEL) configuration that enables reaching 20 keV photon energy with the current LCLS-II injector parameters, by reamplifying the cavity-returned X-rays in the LCLS-II undulator over multiple passes. At 20 keV, the Bragg mirrors have very narrow angular and wavelength acceptances. In this paper, we discuss how to layout the cavity optics in combination with the electron-beam based Q-switching method to generate fully coherent bright high-energy X-rays with 20 meV spectral bandwidth.

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First testing results of an improved multi-dimensional bunch shape monitor

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Measuring longitudinal beam parameters is key for the operation and development of high-intensity linear accelerators but is notoriously difficult for ion beams at non-relativistic energies. The Bunch Shape Monitor (BSM) is a device used for measuring the longitudinal bunch distribution in a hadron linac. RadiaBeam has developed a BSM prototype with enhanced performance, integrating several key innovations. Firstly, to improve the collection efficiency, we introduced a focusing field between the target wire and the entrance slit. Secondly, we implemented a novel design of the RF deflector to enhance beam linearity. Finally, the design was enriched by incorporating a mechanism that allows moving both the wire and deflector cavity enabling the functionality of transverse profile measurements. In this paper, we present the process of fabricating, assembling, and beam tests of the BSM prototype at the SNS facility.

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Tuesday Poster Session / 1808

Advanced laser-driven betatron X-ray generation

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Ultrafast high-brightness X-ray pulses have proven invaluable for a broad range of research. Such pulses are typically generated via synchrotron emission from relativistic electron bunches. Recently, compact X-ray sources based on laser-wakefield accelerated (LWFA) electron beams have been demonstrated, where the radiation is generated by transverse betatron oscillations of electrons within the plasma accelerator structure.
Here, we present a novel method for enhancement of and control over the parameters of LWFA-driven betatron X-ray emission. We realize this through specific manipulation of the electron bunch phase-space using our novel Transverse Oscillating Bubble Enhanced Betatron Radiation (TOBER) scheme. The phase space is controlled through the orchestrated evolution of the temporal laser pulse shape and the accelerating plasma structure, which leads to off-axis electron injection and large-amplitude transverse betatron oscillation, resulting in enhanced X-ray emission. TOBER holds the promise of compact sources that can generate X-rays with optimized parameters for specific applications using the same setup beams with even higher peak and average brilliance.

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Monday Poster Session / 1809

Status of cavity-based X-ray free electron laser project at SLAC

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Margraf [3]; Ryan Lindberg [2]; S. Joshua Stein [2]; Sheikh Mashrafi [2]; Shweta Saraf [1]; Steven Kearney [2]; Taito Osaka [4]; Takahiro Sato [4]; Xavier Permanyer [1]; Xianbo Shi [2]; Yuri Shvyd'ko [2]; Zhirong Huang [1]

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Cavity-based X-ray free electron laser (CBXFEL) is the proposed scheme to dramatically improve stability and coherence of the existing XFELs. A project to demonstrate proof-or-principle CBXFEL is underway at SLAC National Accelerator Laboratory, in collaboration with Argonne National Lab (ANL, USA) and RIKEN Research Institute (Japan). CBXFEL is expected to operate at 9.831 keV photon energy, using synthetic diamonds as cavity Bragg mirrors. LCLS copper linac will deliver two electron bunches 624 RF buckets apart, resulting in the total X-ray cavity size of about 65500.87 mm. In this proceeding, we present the final design of the X-ray cavity, including photon and electron beam subsystems, and report on projected performance and current installation status.

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Monday Poster Session / 1811

Koopman operator method for nonlinear dynamics analysis using symplectic neural networks

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Data driven methods have proved to be a useful tool for analyzing Hamiltonian systems. The symplectic condition is a strong constraint on Hamiltonian systems and it is therefore useful to implement this constraint into neural networks to ensure the accuracy of long term predictions about the system. One such method is the use of SympNets*, linear, activation, and gradient layers that guarantee the symplectic condition is met without the use of symplectic integration or extra gradient calculations. Data driven methods are also useful for calculating Koopman operators which aim to simplify nonlinear dynamical systems into linear ones. By using SympNets, one can ensure that the transformation described by the Koopman operator is symplectic, reversible, and more easily trained.

Footnotes:

- Jin, P., Zhu, A., Karniadakis, G. E., & Tang, Y. (2020). Symplectic networks: Intrinsic structure-preserving networks for identifying Hamiltonian systems. CoRR, abs/2001.03750

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Monday Poster Session / 1812

LCLS multi-bunch improvement plan: recent progress and future work

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Linac Coherent Light Source (LCLS) copper linac typically functions in a single bunch mode, having a repetition rate of 120 Hertz. Numerous internal projects and external user experiments at the LCLS necessitate X-ray pulse trains consisting of two or multiple pulses. Previously we have reported on implementing a system of two ultra-fast stripline kickers, aimed at correcting pulse train machine trajectory differences. In this proceeding we report on the installation of the second pair of kickers, and discuss other improvements that were made. Our work is particularly focused on long pulse separation, greater than 200 ns.

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Monday Poster Session / 1813

Dynamics study of the crab crossing at the electron ion collider using square matrix and iterative methods

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Crab crossings are designed to increase the luminosity of accelerators by ensuring beam interactions are closer to a head on collision. One will be implemented at the Electron Ion Collider (EIC) at Brookhaven National Laboratory. It is then important to examine how the crab cavity will affect beam dynamics at the EIC. Methods such as Frequency Map Analysis (FMA) have been shown to be helpful in examining the phase space of accelerators in order to find properties such as resonances and the dynamic aperture. An alternative to such methods is an iterative method based on square matrix method that has been shown to reveal similar properties as FMA while reducing the computational power needed,*. This method has been applied to the crab crossing scheme in order to find and explain effects of the higher order mode of crab cavities on the particle dynamics of the EIC.

Footnotes:

- K.J. Anderson, Y. Hao, and L.H. Yu, "Study of Nonlinear Dynamics in the 4-D Hénon Map Using the Square Matrix Method and Iterative Methods", in Proc. NAPAC'22, Albuquerque, NM, USA, Aug. 2022, pp. 232-235. doi:10.18429/JACoW-NAPAC2022-MOPA81 ** L.H. Yu, Y. Hao, Y. Hidaka, F. Plassard, and V.V. Smaluk, "Progress on Convergence Map Based on Square Matrix for Nonlinear Lattice Optimization", in Proc. NAPAC'22, Albuquerque, NM, USA, Aug. 2022, pp. 823-825. doi:10.18429/JACoW-NAPAC2022-WEPA80

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Monday Poster Session / 1814

Commissioning results of third C75 cryomodule for CEBAF

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The program to upgrade CEBAF cryomodules has been implemented to enhance the energy gain of refurbished cryomodules up to 75 MeV. This strategy involves reusing the waveguide end-groups from original CEBAF cavities produced in the 1990s, and existing five elliptical cell cavities are replaced with a new optimized cell shape cavity constructed from large-grain, ingot Nb material. Following fabrication, each cavity undergoes electropolishing and is tested at 2.07 K. Eight cavities are then assembled into "cavity pairs" and tested at 2.07 K before integration into the cryomodule. This paper presents the outcomes of the cavity qualification for the third C75 module, providing a detailed account of the assessment in both a vertical cryostat and the commissioning results of the cryomodule. Furthermore, efforts have been made to address performance limitations arising from field emission and multipacting.

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Monday Poster Session / 1815

3D theory of short-wavelength instabilities driven by space-charge

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Microbunching - or short-wavelength –instabilities are well-known for drastic reduction of the beam quality, its filamentation and strong amplification of the noise in a beam. Space charge and coherent synchrotron radiation (CSR) are the leading causes for such instability. In this paper we present rigorous 3D theory of such instabilities driven by the space-charge forces. We define the condition when our theory is applicable for an arbitrary accelerator system with 3D coupling. Finally, we derive a linear integral equation describing such instability and identify conditions it can be reduced to an ordinary second order differential equation

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Tuesday Poster Session / 1816

Fast 6-dimensional phase space reconstructions using generative beam distribution models and differentiable beam dynamics

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Next-generation accelerator concepts, which hinge on the precise shaping of beam distributions, demand precise diagnostic methods capable of reconstructing beam distributions with 6-D phase spaces. However, the characterization of 6-D beam distributions using conventional techniques necessitates hundreds of measurements, using hours of valuable beam time. Novel diagnostic techniques are needed to reduce the number of measurements required to reconstruct detailed, high dimensional beam features for precision beam shaping applications. In this study, we present a novel approach to analyzing experimental measurements using generative machine learning models of 6-D beam distributions and differentiable beam dynamics simulations. We demonstrate in simulation that using our analysis technique, conventional beam manipulations and diagnostics can be used to reconstruct detailed 6-D phase spaces using as few as 20 beam measurements with no prior training or data collection. These developments enable detailed, high dimensional phase space information to be obtained for precision control and improved understanding of complex accelerator beam dynamics.

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Monday Poster Session / 1817

Early lasing at LCLS and its implications for future cavity-based XFELs

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Cavity-based XFEL, or CBXFEL, is a future photon source concept under intense development at SLAC. It is considered a path towards full 3D coherence at angstrom wavelength, delivering another 2-3 orders of magnitude leap in source brightness compared to current XFELs configurations. In a first phase of the project, one of the goals is to demonstrate the regenerative amplification by returning and amplifying the seed pulse from 7 LCLS Hard X-ray Undulators (HXUs) with a rectangular crystal cavity. In this paper, we report on the recent measurement of early stage XFEL lasing characteristics at 9.831 keV photon energy by using 7 LCLS HXUs under e-beam conditions close to those chosen for the first phase of CBXFEL gain demonstration.

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Tuesday Poster Session / 1818

Future colliders using recycling energy-recovery linacs

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I plan to discuss potential offered by Energy-Recovery Linacs (ERLs) and particle recycling for boosting luminosity in high-energy electron-positions and lepton-hadron colliders. ERL-based colliders have promise not only of significantly higher luminosity, but also of higher energy efficiency measured in units of luminosity divided by the consumed AC power. Addition of recycling collided particles and their recuperations in damping ring removes insane ILC/CLIC appetite for fresh positions and offers high degrees of polarization in colliding beams.
Presentation will cover similarities and distinctions between linear and re-circulating ERL concepts with focus on their costs, energy efficiency and energy reach. Two examples of HIGS ERL-based factory located in LHC and FCC tunnels will be compared with two concepts of linear ERL colliders. Status of ERLs worldwide will be briefly review and technical challenges facing this promising accelerator technology will be discussed. I will finish talk with discussion of possible technical breakthroughs which can make ERL technology more affordable and more attractive.

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Tuesday Poster Session / 1819

Novel radiation durable composite materials

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NanoSonic has demonstrated advanced high radiation durable composite and polymeric materials for applications in radio frequency devices, cryomodule gate valves, and seals for beam dumps. Through additive and scalable manufacturing techniques, the novel radiation tolerant polymers for use within accelerator components and subsystems have shown potential to replace current state of the art materials which degrade through radiation induced brittle failure and other failure mechanisms. NanoSonic's composites have undergone both shielding and exposure radiation testing at low doses of proton, iron, and electron irradiation (up to 27 Gy) and are currently being tested for ultra-high radiation exposure (up to 20.0 MGy). No remarkable mechanical changes have been observed after low dose testing for NanoSonic's materials. These novel composite materials will reduce maintenance and replacement frequency offering the potential for significant cost reductions and operational downtime.

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Tuesday Poster Session / 1820

Studying the properties of particle accelerator cavity materials

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Stuctural Health Monitoring (SHM) program at European Spallation Source (ESS) aims to perform preventive studies on machine structure through the development and implementation of non-destructive techniques. The goal of this program is to: 1. Understand cavity material-ion beam interaction mechanisms 2. Quantify material damage at nominal operational parameters and abnormal scenarios, 3. Study the factors that affect cavity lifetime. This study will outline the need for such techniques in the field of particle accelerators and their implementation at ESS in an effort to assess high power/intensity Radio-Frequency Quadrupole (RFQ) lifetime.

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Thursday Poster Session / 1821

Real-time data acquisition with CompactPCI serial platform at PSI.

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Data acquisition (DAQ) is an ubiquitous feature in modern particle accelerator measurement and control systems. At the Paul Scherrer Institut (PSI), a next generation of electronic devices is being designed to meet the demands of upcoming renewal of facilities. The new developments utilize the CompactPCI Serial platform, and will cover a diverse set of applications, including LLRF, LLM, ICT and FPM systems. Careful design considerations and selection of an optimal architecture are crucial to fulfill a variety of DAQ requirements such as maximum frequency of acquisition, size of the data and different modes of triggering. In this contribution, we focus on the real-time DAQ implementations utilizing a multiprocessor system on a chip (MPSoC) technology. We review the IP components developed in-house at the PSI that provide the DAQ functionality. We demonstrate, that by reusing the IP components development, prototyping and testing of applications requiring the DAQ are accelerated.

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Thursday Poster Session / 1822

Reduction of radiotoxic lifetime of spent nuclear fuel to produce energy

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We describe how the Mu*STAR system uses a superconducting proton accelerator produces a proton beam powerful enough to drive several subcritical small modular reactors (SMRs). Each SMR is a graphite-moderated molten salt (MS) fueled reactor with an internal spallation target to generate source neutrons. These source neutrons initiate fission chains that die out, producing energy in a subcritical core. The MS core remains far enough below criticality (which depends on materials and geometry but not the beam), to be incapable of self-generated critical operation, and is thus immune to criticality accidents. The MS fuel in the core is continuously purged of volatile fission products

such that the potential offsite doses associated with the core volatile source term can be reduced by at least three orders of magnitude. The combination of subcriticality, the small source term, and additional safety innovations will deliver deployment flexibility and should simplify regulatory approval.

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Tuesday Poster Session / 1823

Status coherent electron cooling experiment at RHIC

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Coherent electron Cooling (CeC) experiment aims on demonstrating cooling if 26.5 GeV/u ion beam circulating in RHIC. We will present results of the CeC experiment with special focus won the use and the control of the broad-band micro-bunching Plasma Cascade Amplifier with bandwidth of 15 THz. We will also discuss connection of this experiment with the developing the CeC cooler for future

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Wednesday Poster Session / 1824

Horizontal cryostat testing of the ORNL Spallation Neutron Source proton power upgrade cryomodules at Jefferson Lab

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Co-authors: Ashley Lynn Mitchell [1]; David Savransky [2]; Edward Daly [1]; John Fischer [1]; Michael Drury [1]; Naeem Huque [1]

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Oak Ridge National Laboratory (ORNL) is in the process of upgrading its Spallation Neutron Source (SNS) Linear Accelerator in order to double the total machine power from 1.4 to 2.8 MW. This Proton Power Upgrade (PPU) makes use of an added seven additional four-cavity cryomodules to its Superconducting Radio-Frequency (SRF) Linac to raise the machine energy to a total 1.3 GeV (with one additional module produced as a ready spare). Jefferson Lab was contracted to produce these modules with vertical testing, manufacturing, and limited horizontal testing of the cryomodules executed at Jefferson Lab and final high-power testing occurring locally at ORNL. This paper will detail ensemble cool downs/warm ups, tuner testing results, passbands, and loaded Q results obtained for the 8 modules which have been manufactured.

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Wednesday Poster Session / 1826

Investigations of a potential 5D detector system for a laserwire instrument on the front end test stand

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A laserwire diagnostic capable of measuring 5D phase space is to be installed on the Front End Test Stand (FETS) at the Rutherford Appleton Laboratory. The FETS beamline is a hydrogen ion source and the laserwire operates on the principle of photodetachment. A conventional tranverse laserwire is capable of 4D transverse profiling and emittance reconstruction. The FETS laserwire has a pulse duration shorter than the bunch temporal length enabling longitudinal profiling. A detector capable of measuring the laserwire signal is under development. One scheme being considered is a modular detector system. The initial section of the detector would consist of a scintillator to absorb the incoming beam, emitting photons. Following this an optical system will direct the signal to a CCD. Simulations for the photon production for a range of scintillators are compared. A configuration to remove the CCD from the direct line of the accelerator using an optical transport system is considered along with the impact on potential measurements. The expected signal to the CCD and reconstruction of beam size, temporal distribution, and transverse emittance are presented.

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Monday Poster Session / 1827

High gradient C-band photoinjector performance utilizing sacrificial charge to enhance brightness

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Co-authors: Adam Bartnik [1]; Evgenya Simakov [2]; Haoran Xu [2]; James Rosenzweig [3]; Jared Maxson [4]; Matthew Gordon [5]; Petr Anisimov [2]

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We report simulation results showing the use of sacrificial bunch charge to achieve high brightness in photoinjector beamlines designed for Ultrafast Electron Diffraction (UED) and Inverse Compton Scattering (ICS). The beam undergoes nonlaminar focusing during which the tails dynamically linearize the core's transverse phase space. An aperture then removes the resulting diffuse tails, leaving a beam with high brightness. We employ this scheme in C-band photoinjector guns, whose high gradients are attractive for both low (UED) and high charge (ICS) applications. In our simulations we use a 1.6 cell gun with a peak field at the cathode of 240 MV/m. We start with negligible intrinsic emittance and use a multi-objective genetic algorithm to obtain a Pareto front minimizing bunch length and emittance. For ICS applications, we obtain an extremely small minimum emittance of 80 nm at a final charge of 250 pC per bunch and 1.44 ps rms bunch length. For a final bunch charge of 1e+5 electrons, typical for UED experiments, we obtain an emittance of 1.2 nm at an rms bunch length of 50 fs. Both results far exceed the brightness state of the art for these applications.

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Wednesday Poster Session / 1828

Evaluation of plasma cascade amplifier at frequency of 15 THz

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We present results of experimental demonstration of Plasma Cascade Amplifier with 10 THz bandwidth of Coherent electron Cooling experiment at BNL. We present results our simulation, experimental set-up and analysis of our measurements.

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Thursday Poster Session / 1829

Design and characterization of adjustable-length pulse generator for beam kicker system

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The contemporary advancement in particle accelerator technology necessitates precise control over beam manipulation for various experimental and industrial applications. One pivotal aspect of this control resides in the generation and modulation of high-voltage pulse to manipulate the trajectory and behavior of particle beams within the accelerator systems. This extensive study delves into the design, development, and characterization of an adjustable-length pulse generator specifically tailored for a beam extraction kicker system, which is employed to navigate the beam out of the photon storage ring. The primary aim of this research is to engineer a versatile and reliable pulse-length modulation mechanism for a high-voltage pulse generation, which is capable of producing adjustable pulses with ultra-fine precision to meet the demanding requirements of beam manipulation within the accelerator setup. The system's design encompasses a meticulous integration of electronic components, waveform shaping modules, and control mechanisms to achieve the desired output.

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Wednesday Poster Session / 1831

Development of plasma processing for coaxial cavity cryomodules

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Several groups have demonstrated that plasma processing can help to mitigate degradation of the performance of superconducting radio-frequency cavities. Plasma processing provides an alternative to removal of cryomodules from the accelerator for refurbishment. Studies of plasma processing for quarter-wave resonators (QWRs) and half-wave resonators (HWRs) are underway at FRIB, where a total of 324 such resonators are presently in operation. Plasma processing tests were done on several QWRs using the fundamental power coupler (FPC) to drive the plasma. Driving the plasma with a higher-order mode (HOM) shows promise, as it allows for less mismatch at the FPC. Before-and-after cold tests showed a significant reduction in field emission X-rays with judicious application of plasma processing. The first attempt at plasma processing of FRIB QWRs in a cryomodule is planned for December 2023/January 2024. A repeat bunker test of the cryomodule is planned to assess the results.

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Thursday Poster Session / 1832

GSI electron lens for space charge compensation

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The electron lens for space charge compensation is an R&D project to increase the primary beam intensity and thus the accelerator efficiency of SIS18 and eventually SIS100 for FAIR operation. As a first step, the principle of space charge compensation will be demonstrated in SIS18 with a single lens, aiming at a tune shift of 0.1. However, the design should also be compatible with the SIS100. Following the conceptual design studies, a technical design of the electron lens has been prepared and the main components of the electron lens are currently under development. This contribution gives an overview of the development of the electron lens, with particular emphasis on the main lens components and the studies carried out on the dynamics of the ion beam.

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Wednesday Poster Session / 1833

CEBAF 2023 linac plasma processing gradient and Qo results

Author: Michael McCaughan[1]

Co-authors: Dakota Christian [1]; Gary Croke [1]; George Biallas [2]; Kevin Jordan [1]; Kyle Hesse [1]; Michael Drury [1]; Ramakrishna Bachimanchi [1]; Tom Powers [1]

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Firmware for the Low-level Radiofrequency (LLRF) systems used in JLAB C100 & C75 cryomodules was upgraded to allowing a variable duty factor pulsed mode operation with triggered waveforms through EPICS. A new type of gaseous Helium flow meter has been in development for the past 2 years and was opportunistically installed in cryogenic return U-tubes of 14 cryomodules that were thermally cycled in Spring 2023. These flow meters were developed under an SBIR project* with Hyperboloid LLC. Stub tuners were also adjusted to improve the loaded-Q of the cavities for better klystron operation range. The combination of these activities allowed for re-commissioning of recently plasma processed cavities with pulsed and continuous wave (CW) Self-Excited Loop with Amplitude and Phase locked (SELAP) gradients measured via the LLRF system. Newly developed software also allowed us to measure Qos with the installed flow meters. The new methodologies were benchmarked against an SRF commissioning cart with on-board RF power meters and a calorimetric Qo measurement method which has been long employed at Jefferson Lab with good results and agreed to within error bars. Results will be presented herein.

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WEBN: Beam Instrumentation, Controls, Feedback and Operational Aspects (Contributed) / 1834

Higher order mode detection as a beam offset monitor for LCLS-II

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LCLS-II commissioning is well under way. As an indirect diagnostic, electron beam-induced higher order mode (HOM) signals from the RF cavities in the first LCLS-II cryomodule are routed outside the accelerator and filtered to select dipole modes. The signals are amplified and detected using a Schottky diode, following a design tested at Fermilab. The detected signal magnitude is proportional to the bunch charge and the transverse offset magnitude of the electron beam in the cavity. This hardware was initially tested at the Fermilab Accelerator Science and Technology (FAST) facility, and has been adapted to LCLS-II. In this paper, we describe commissioning tests of the system in LCLS-II at SLAC. This includes a description of the associated hardware, and the code under development for live monitoring and beam offset display, as well as the calibration of the signal magnitudes using magnet and beam position monitor data.

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Monday Poster Session / 1835

Fixed tunes fast cycling permanent magnet proton FFA synchrotron

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We present a novel concept of the Fixed-Field-Alternating (FFA) permanent magnet small racetrack proton accelerator with kinetic energy range between 10-250 MeV. The horizontal and vertical tunes are fixed within the energy range providing very fast cycling with a frequency of 400 Hz to 1.3 KHz. The injector is commercially available cyclotron with RF frequency of 65 MHz. The permanent magnet synchrotron has a shape of a racetrack where the two arcs are made of combined function permanent non-linear fields magnets to provide fixed betatron tunes for the extraordinary kinetic energy range between 10 and 250 MeV.

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Wednesday Poster Session / 1836

Quench detection and protection measures of superconducting cavities at ESS

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This paper describes the aspects of quench detection and protective mitigation measures strategy for superconducting cavities at the European Spallation Source (ESS). A series of tests conducted at TS2 on elliptical cavities, where various methods for quench detection and mitigation measures are implemented, are described.

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Thursday Poster Session / 1837

Autofocusing accelerator beams

Author: Alexander Katrusiak[1]

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A novel tuning approach, Model Coupled Accelerator Tuning (MCAT), has been applied to the separated function DTL at TRIUMF's Isotope Separator and Accelerator (ISAC). A digital twin of the rare-isotope postaccelerator is used for transverse and longitudinal tune optimizations, which are then loaded directly into the control system. Beam-based testing produced accelerated beam with a 0.26% error in output energy, with a 1.6% energy spread. This method significantly reduces the operational complexity of tuning interventions, rendering them more efficient. An analysis of the high energy beam lines (HEBT) is also presented, including analysis of dispersive couplings in certain sections of the beamline. A mitigation strategy involving buncher cavities is discussed.

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Monday Poster Session / 1838

Transversely driven coherent beam oscillations in the EIC electron storage ring

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We study coherent transverse beam oscillations in the EIC electron storage ring (ESR), to specify the tolerance for high-frequency ripple of the magnet power supplies. To avoid unacceptable proton emittance growth from the oscillating beam-beam kick from the electrons, the amplitude of these oscillations at the proton betatron frequency needs to be limited to about 1e-4 fraction of the beam size at the interaction point. We show that the oscillations potentially caused by the ESR magnet dipole power supply ripple could be substantial, but still tolerable, if we account for the eddy current shielding in the vacuum chamber. Beam size oscillations, potentially caused by the rippling quadrupole magnet power supplies are also studied and appear manageable.

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Monday Poster Session / 1839

Extreme pulse compression for impulsive ionization of valence wavepackets

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We show how a chicane with anomalous dispersion can be used to compress an electron beam into a narrow, high-current, spike by exploiting the intrinsic chirp created by collective effects. We explore the limits of compression in a linearized model and then apply these beams to impulsively pump valence electrons. In the limit of an ultrashort electron beam, the valence electron wave-packet is accelerated so rapidly that the excited state forms an image of the bound state, allowing for unique insight into the structure of the electronic states of a molecule.

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Thursday Poster Session / 1840

Optimizing non linear kicker injection parameters using machine learning

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Synchrotron light source storage rings aim to maintain a continuous beam current without observable beam motion during injection. One element that paves the way to this target is the non-linear kicker (NLK). The field distribution it generates poses challenges for optimizing the topping-up operation. Within this study, a reinforcement learning agent was developed and trained to optimize the NLK operation parameters. We present the models employed, the optimization process, and the achieved results.

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Thursday Poster Session / 1841

Ernest Courant traineeship in accelerator sciences

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Ernest Courant Traineeship is a consortium of Stony Brook University, Brookhaven National Laboratory and Fermi National Accelerator Laboratory with goal of workforce development in Accelerator Science and Engineering at the Center for Accelerator Science and Education (CASE, SBU). We present the curriculum of the traineeship and advantages provided by access to large and medium accelerators, superconducting RF accelerators and related research, high power RF system engineering and large liquid helium cryogenic systems at SBU, BNL and FNAL.

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Monday Poster Session / 1842

Single line ERL permanent magnet electron FFA accelerator for LHeC

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[3] *Cornell University (CLASSE)*

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We present a Fixed-Field-Alternating (FFA) permanent magnet racetrack electron accelerator with energy range between 10-60 GeV for the future LHeC. Electron beam is brought back to the linac by the single beam line without requiring electric power REDUCING estimated wall power of 100 MW in the present LHeC design to a negligible power for arcs as the permanent magnets are used. The design is based on experience from the very successful commissioning of the Cornell University and Brookhaven National Laboratory Energy Recovery Test Accelerator –'CBETA'. The proposal supports sustainability efforts for LHeC by making a 'green' accelerator. It is an energy recovery linac with 99.9% energy efficiency and reduces the power consumption by using small permanent magnets. The FFA non-linear gradient design is a racetrack shape, where, as in the CBETA, the arcs are matched by adiabatic transition to the two (LHeC) or multiple straight sections. Two 10 GeV superconducting linacs are placed on both sides of the Interaction Region (IR) significantly reducing the power of synchrotron radiation loss.

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Thursday Poster Session / 1843

Uranium spallation target chemistry for subcritical reactors

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Over the last 13 years, Muons has also worked with other companies (ADNA, Niowave) and institutions (Virginia Tech, Jefferson Lab, ORNL, INL, SRNL) on accelerator-driven subcritical reactors (ADSR), to take advantage of large advances in superconducting RF (SRF) accelerators. In the last decade, SRF proton accelerators have been demonstrated to have the power and efficiency to produce copious spallation neutrons needed to enable a Molten Salt (MS) fueled subcritical nuclear reactor. Our Mu*STAR is the ADSR concept that is best matched to new accelerator capabilities, allowing subcritical operation with unenriched fuels or used nuclear fuel (UNF). We believe that reduced regulatory burdens from large subcritical safety margins and the continuous removal of volatile radiotoxic isotopes from an operating MSR will make Mu*STAR the cost competitive choice for nuclear energy.

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Thursday Poster Session / 1846

Coupling of codes for modeling high-energy-density conditions in fourth generation light sources

Author: Austin Dick[1]

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We present a method for coupling particle dynamics, particle-matter interaction, and hydrodynamics codes to model the effects of high-intensity electron beams in Fourth Generation Storage Rings for the purpose of machine protection. The coupled codes determine if high-energy-density conditions (>100 J/mmˆ3) are present in beam-intercepting components. Elegant is used to simulate the dynamics of a whole-beam abort by muting the high-power cavity RF. Within the APS-U, the impacting beam begins interacting with a horizontal collimator, at which point elegant is interrupted and the beam impact process is modeled using MARS and FLASH. MARS simulates the interaction of the beam with the collimator, passes the energy density to FLASH, and returns the transmitted particle distribution to elegant. FLASH uses the energy deposition to determine the density of the collimator material. The surviving beam is propagated again through the APS-U lattice and the process is repeated until the beam is fully lost. The input MARS geometry is updated each step to reflect the changing material properties. The coupled codes also examine the effects of synchrotron radiation within the vacuum beam chambers.

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Monday Poster Session / 1847

Eddy current shielding of the magnetic field ripple in the EIC electron storage ring vacuum chambers

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The EIC electron storage ring has very tight tolerances for the amplitude of electron beam position and size oscillations at the interaction point. The oscillations at the proton betatron frequency and its harmonics are the most dangerous because they could lead to unacceptable proton emittance growth from the oscillating beam-beam kick from the electrons. To estimate the amplitude of these oscillations coming from the magnet power supply current ripple we need to accurately account for the eddy current shielding by the copper vacuum chamber with 4-mm thick wall. At the frequencies of interest, the skin depth is a small fraction of the wall thickness, so the commonly used single-pole expressions for eddy current shielding transfer function do not apply. In this paper we present new (to the best of our knowledge) analytical formulas that adequately describe the shielding for this frequency range and chamber geometry and discuss the implications for the power supply ripple specifications at high frequency.

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Tuesday Poster Session / 1848

Benchmarking power deposition from fast losses of heavy-ion beams at the onset of LHC Run 3

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In 2023, the LHC started its Run 3 operation with 208Pb82+ beams at 6.8 ZTeV, with a substantially higher number of bunches compared to past runs. Several new hardware systems were used operationally for the first time with high-intensity beams, including bent crystal collimators in the betatron cleaning insertion. Crystal-assisted collimation reduces the leakage of secondary ion fragments to the downstream dispersion suppressors, therefore decreasing the risk of quenching superconducting magnets. Nevertheless, one of the limitations encountered during the 2023 run were events with fast beam losses impacting the collimation system, which triggered multiple premature beam aborts on Beam Loss Monitors (BLMs). In this contribution, we present energy deposition simulations for these events, performed with the FLUKA tool, aiming to quantify the quench margin for the fast loss regime (~30 ms). To assess the predictive ability of the model, benchmarks against 2023 measurements are presented. The studies provide an important input for fine-tuning BLM thresholds in future heavy-ion runs, therefore increasing the tolerance to beam losses and hence the LHC availability.

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Thursday Poster Session / 1849

Image based reconstruction of the Danilov-Nagaitsev integrable potential

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The integrable optics test accelerator (IOTA) at Fermilab was designed to operate a nonlinear magnet satisfying the Danilov-Nagaitsev integrable potential. At large excitations of this nonlinear magnet the small amplitude vertical tune crosses the integer resonance. At this point the beam splits vertically into two separate beamlets whose separation distance depends on the nonlinear strength. This phenomenon is difficult to study with traditional beam position monitors, so studies of this regime relied on the IOTA synchrotron light imaging system. The 2-D transverse profile of the beam was measured for large excitations of the nonlinear magnet. Using these profiles and accurate knowledge of the rest of the accelerator lattice, the potential could be reconstructed from these profiles and compared to the analytical expectations.

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Wednesday Poster Session / 1850

Emittance growth and transport of an intense relativistic electron beam after foil scattering

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Intense relativistic electron beams such as those produced by the DARHT accelerators, consist of large total currents of 1.6-2 kA at modest energies in the range of 16-20 MeV. Beam envelope codes are generally used to predict the evolution of the first moment of the radial distribution (i.e. beam 2-RMS radius) assuming a constant emittance. Upon passing through a thin metal foil, such as may be used in a vacuum window, the beam experiences multiple Coulomb scattering and foil focusing effects which modify downstream transport. We measure the 4-RMS emittance of the beam with and without a material scattering foil using the solenoid sweep method with a downstream magnet. A 50 µm Ti foil is found to increase the emittance from about 0.09 cm-rad to 2.9 cm-rad after 1.5 m of transport. We also make measurements with aluminum scattering foils 1.5 m upstream and 3 cm upstream of the imaging foil to examine the beam dynamics after scattering. We find envelope codes are able to describe the 2-RMS radius of the beam after foil interaction taking into account appropriate weights on the scattering angle after 1.5 m of transport.

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Thursday Poster Session / 1852

High-power RF conditioning and 700 keV beam commissioning of the revised RFQ for the Frankfurt neutron source

Author: Hendrik Hähnel[1]

Co-authors: Adem Ates [1]; Benjamin Dedic [1]; Christopher Wagner [1]; Chuan Zhang [2]; Holger Podlech [1]; Ulrich Ratzinger [1]

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We report the successful high power RF conditioning of the revised 175 MHz FRANZ RFQ up to 80 kW CW, as well as successful beam commissioning up to 700 keV in pulsed operation. After a revision of the RFQ electrodes, the RFQ accelerates protons from 60 keV to 700 keV. The Frankfurt Neutron Source FRANZ will be a compact accelerator driven neutron source utilizing the 7Li(p,n)7Be reaction with a 2 MeV proton beam.

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Thursday Poster Session / 1853

Multi-physics and multi-objective design optimization of quadrupole resonators under geometric uncertainties

Author: Piotr Putek[1]

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Exploring the fundamental properties of materials such as niobium, NbTiN, multilayers or Nb3Sn, in high-precision surface resistance measurements is highly relevant to superconducting radio-frequency (RF) technology. Typically, for a precise determination of the RF properties of superconducting samples, the calorimetric measurement is carried out with a quadrupole resonator (QPR). Still, one of the main challenges in the QPR design and operations is to mitigate the impact of microphonics and Lorentz force (LF) detuning, on the one hand, and the RF losses on the adapter flange with the fabrication tolerances, on the other hand, into QPR functioning. For this reason, we address the electro-stress-heat coupled problem under geometric uncertainties to study a significant measurement bias of the surface resistance, observed mainly for the third operating mode of the given QPR. We then use a multi-objective and multi-physics shape optimization method to compensate for its influence and find the optimal QPR design in the Pareto sense. Finally, the optimization results and their implications for QPR operating conditions are discussed to demonstrate the proposed approach.

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Monday Poster Session / 1854

Active stabilization in high-power laser plasma accelerators

Author: Jeroen van Tilborg[1]

Co-authors: Samuel Barber [1]; Ben Greenwood [1]; Curtis Berger [1]; Finn Kohrell [1]; Fumika Isono [1]; Kyle Jensen [1]; Qiang Chen [1]; Robert Jacob [1]; Christopher Doss [1]; Anthony Gonsalves [1]

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Owing to strong 10-100 GV/m accelerator gradients, Laser Plasma Accelerators (LPAs) have the capability to generate high-brightness and high-energy electron beams in compact facilities. The (sub)PW laser systems that drive LPAs are currently operating at 1-10 Hz repetition rates, while the next generation of multi-kHz technologies are being aggressively pursued at various R&D facilities worldwide. The robustness and stability of LPAs can largely be traced back to the laser performance. Fluctuations in laser pointing and other laser parameters directly translate to variations in electron beam parameters. Here we present results from recent techniques that mitigate laser fluctuations in a two-fold approach: (1) develop on-line and non-perturbative high-power laser diagnostics, both for the high-power laser as well as for a correlated background laser [1], and (2) implementation of active feedback systems to stabilize the high-power laser. Experimental results [2] show that through execution of these efforts at the BELLA Center LPA facilities, we have made significant improvements to the LPA electron beam and light source stability.

Footnotes:

[1] F. Isono et al, High Power Laser Sci. Eng. 9, e24 (2021),
[2] C. Berger et al, Phys. Rev. AB 26, 032801 (2023)

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Thursday Poster Session / 1855

A compact, ultrafast high-voltage pulser for transverse electromagnetic kickers

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A compact, high-voltage (HV) pulser in the nanosecond regime for transverse electromagnetic (TEM) kickers is presented. TEM kickers are electromagnetic deflectors used in particle accelerators to redirect bunches of particles out of their original trajectory into a new path, such as alternate beam paths, detectors, or other instrumentation devices. The circuit proposed in this design consists of two main portions: a gate driver and a HV switch. The gate driver consists of an isolated and high-speed gate driver, powered by an isolated DC/DC converter with dual output voltages. The HV switch portion was simulated in Ansys HFSS and is composed of a SiC MOSFET, LC resonance

components, and specialized diodes. When switched, the MOSFET is used to pump a high voltage into the LC circuit and diode stack, and the ultrafast diode turnoff delivers the final HV pulse to the resistor load. Careful layout techniques were implemented for the MOSFET driver to reduce pulse to pulse instability. A 1 MHz repetition rate was the target of our design.

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Monday Poster Session / 1856

PolFEL –polish free electron laser under construction

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PolFEL, the Polish Free Electron Laser facility, after recent configuration adjustments, will feature a dual superconducting electron linac fed in the first stage by pulse-operating, made of copper photoinjectors. In the second stage, both Cu injectors will be replaced by superconducting injectors enabling the cw operation. The first linac line equipped with two Rossendorf-RI type cryomodules will supply up to 80 MeV electrons to a superradiant undulator generating experimentally useful THz FEL radiation. The second linac will be dedicated to the experiments with electron beams, most notably for ultrafast electron diffraction (UED). Here, the linac line will form very low emittance electron bunches of few fs duration and charge up to 100 fC. Particular care will be paid to provide a minimal jitter of the fs laser pulses for high resolution pump-probe UED experiments. Additionally, another cryomodule will be installed behind the UED station, serving as a source for VHEE experiments. The basic facility will be supplemented with a VUV/EUV HHG source and a rich optical laser setup which together will allow to run photon research in a full THz –EUV spectral range.

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Thursday Poster Session / 1857

Channeling performance of bent crystals developed at CERN

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Bent crystals are a mature technology used in several applications at CERN, such as the crystal-assisted collimation system for LHC ion operation and reduction of losses during the slow extraction from the SPS by shadowing the electrostatic septum. In the future, it is planned to measure electric and magnetic dipole moments of short-lived particles with a double-crystal experiment in the LHC. To consolidate their strategic use, CERN has been equipped to produce in-house bent crystals. Each crystal is required to be fully validated before its installation by different techniques, such as metrology, X-ray diffractometry and characterization with beams. The latter can measure the bending angle, the torsion, and the channeling efficiency, which is related to crystal imperfections. In this contribution, we present the performance with beams of the first prototype bent crystals manufactured at CERN and tested during a measurement campaign in the North Area.

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Monday Poster Session / 1858

Impact of the crab cavities on polarization in EIC

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The Electron Ion Collider (EIC) represents a cutting-edge facility designed to explore the internal structure of protons and atomic nuclei at unprecedented levels. In this study, we focus on the investigation of the influence of crab cavities within the EIC setup on the polarization. Crab cavities play a crucial role in achieving head-on collisions between particle bunches, enhancing luminosity. However, their influence on polarization spread remains an aspect yet to be understood. Through computational simulations and theoretical analysis, this study aims to analyze the effect of crab cavities on the polarization in the EIC. The findings will contribute to understanding beam dynamics and refining experimental methods, thereby optimizing collider performance.

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Monday Poster Session / 1859

Optically-generated plasma lens for focusing relativistic electron beams

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To maintain beam emittance and quality, particle beams in plasma wakefield accelerators (PWFAs) need to be focused to extremely small sizes upon entering the accelerator. Conventional methods that achieve this involve large quadrupole electromagnets, which can occupy a considerable amount of space, often spanning several meters. The plasma lens, however, represents a compact, strong alternative means of focusing high-energy electron beams.
We present an experimental infrastructure designed to generate this plasma lens. The plasma lens is formed by the laser-ionization of gas in the outflow of a gas jet positioned along the electron beam line. By using cylindrical lenses to focus an ultrashort, 10 mJ, Ti:sapphire laser pulse, a pancake-like region of plasma is created prior to the arrival of the electron beam. To avoid undesired ionization from the Coulomb field of the electron beam, a high ionization threshold gas, like helium, is used. Simulations and results of experiments testing the optical setup at the University of Colorado Boulder will be presented, demonstrating the feasibility and tolerance of the system.

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Thursday Poster Session / 1860

RF conditioning of an IH-DTL cavity made using additive manufacturing

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Additive manufacturing ("AM") has become a powerful tool for rapid prototyping and manufacturing of complex geometries. A 433 MHz IH-DTL cavity has been constructed to act as a proof of concept for direct additive manufacturing of linac components. In this case, the internal drift tube structure has been produced from 1.4404 stainless steel, as well as pure copper using AM. We present the most recent results of vacuum, low level RF, as well as RF conditioning of the cavity.

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Tuesday Poster Session / 1861

Self-correction coil for RCS dipole in Electron Ion Collider

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The Rapid Cyclotron Synchrotron (RCS) is an acceleration ring designed for boosting the electron energy from 400 MeV after the LINAC to 1 GeV prepared for injection into the Electron Storage Ring (ESR). Operating in a pulsed mode at 1 Hz, the RCS accelerates four consecutive bunches with dipole magnet ramping rapidly at each injection. Rapid ramping of the magnetic field induces eddy currents, causing delays and high harmonic effects which are detrimental to low-energy electron bunches. To mitigate this, cost-effective multi-turn coils with specific patterns are proposed. These coils, powered by eddy currents from main dipole field ramping, generate counter fields to cancel selected high harmonic components. This paper explores the coil pattern selection process.

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Wednesday Poster Session / 1862

First high-Q treatments for FCC 800 MHz 5-cell elliptical cavities

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Development towards the FCC-ee "Z" machine requires optimization of sub-GHz elliptical cavities for high-gradient and high-Q operation, both in pulsed and CW mode, for application in the booster and collider portions. Previous development work validated the proposed 800 MHz 5-cell elliptical RF design, showing reasonable performance after EP treatment. However, the stringent high-Q (3.8e+10) and high-gradient (24 MV/m) goals of the FCC machine cavities will require further development, relying on advanced surface processing techniques developed at 1.3 GHz such as N-doping or medium-temperature furnace baking. We report the results of the first applications of these techniques to the 5-cell prototype 800 MHz elliptical cavity.

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Monday Poster Session / 1863

Multi-objective genetic optimization of high charge TopGun photoinjector

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TopGun photoinjector is a 1.6 cell C-band gun developed by UCLA team. Their low emittance design has been optimized for 100 pC operation. However, Los Alamos National Lab needs to operate with 250 pC bunch charge and emittance below 100 nm. Initial optimization of High Charge TopGun Photoinjector design to be built at Los Alamos National Lab has been previously reported. That design had a single objective of the lowest possible emittance, which was achieved at significantly longer bunch length and thus limited improvement in beam brightness. Here, we report multi-objective genetic optimization of High Charge TopGun Potoinjector design to obtain a Pareto front minimizing bunch length and emittance. We have been able to reduce the bunch length by a factor of two while maintaining similar emittance values.

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Wednesday Poster Session / 1864

Next-generation SRF cavities with energetic condensation

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The development of energetic condensation techniques has resulted in exceptional Nb film quality and improved Nb/Cu RF performance. Progress is continuously made in exploiting film forming and energetic processes to tailor the final film RF response. Convergence of parameters is emerging across techniques such as electron cyclotron resonance (ECR) and high power impulse magnetron sputtering (HiPIMS). The lessons learned also enable the development of NbTiN and Nb3Sn in single and multilayer structures.
The resulting RF performance is studied with large quadrupole resonator samples and 1.3 GHz cavities at different temperatures, along with the cooldown effect and sensitivity to external applied magnetic fields. In conjunction, material and superconducting properties of the films and structures are evaluated with microscopy and magnetometry techniques to gain insight into various processes influence on the residual and flux induced surface resistances.
This contribution presents the latest progress in exploiting processes involved in energetic condensation towards RF Q-slope mitigation for Nb/Cu films and the development of alternative superconductors and layered structures.

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White X-ray beam position monitor for coherent soft X-ray beamlines

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A novel soft X-ray BPM (sXBPM) for high-power white beams of synchrotron undulator radiation has been developed through a joint effort of BNL/NSLS-II and Stony Brook University. In our approach, custom-made multi-pixel GaAs detector arrays are placed into the outer portions of the X-ray beam, and the beam position is inferred from the pixel photocurrents. Our goal is to achieve micron-scale positional resolution without interfering with user experiments, especially the most sensitive ones exploiting coherent properties of the beam. An elaborate mechanical system, which provisions for possible intercepts of kW-level beam in abnormal conditions, has been designed, fabricated, and installed in the 23-ID canted undulator beamline first optical enclosure. Separately, GaAs detectors with specially tailored spectral response have been designed, fabricated, and tested in the soft and hard X-ray regions at two NSLS-II beamlines. The paper gives an overview of the sXBPM system, presents the first results from the high-power white X-ray beam, and explains why our approach can be beneficial for XBPMs in future light sources with highly coherent beams.

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Wednesday Poster Session / 1866

Dark current in the LCLS-II Injector: characterization and mitigation strategies

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In addition to the desired electron beam, RF photoinjectors such as the one in LCLS-II produce dark current via field emission. Left unchecked, the dark current can cause various operational issues in the accelerator, such as increased radiation, damage to accelerator components and diagnostics, and desorption of gases from vacuum chamber surfaces. In this contribution, we present measurements of the dark current in the LCLS-II injector, including imaging, current, and energy distributions of the observed dark current emitters. These measurements allow us to characterize each emitter in terms of the Fowler-Nordheim model of field emission, which in turn enables us to more accurately model the behavior of the dark current in the accelerator. Taking these results into account, we also present potential active and passive mitigation strategies.

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Thursday Poster Session / 1868

CXLS ionizing and laser radiation safety interlock systems

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The Compact X-ray Light Source (CXLS) requires the acceleration of electron bunches to relativistic energies, which collide with focused IR laser pulses to produce X-rays which are then transported to the experiment hutch. A class 4 UV laser is used at the photocathode to liberate the electrons that are generated via the photoelectric effect. During electron acceleration bremsstrahlung radiation (gamma and neutron) is generated through electron interactions with solid matter. In the experiment hutch the X-rays then interact with the sample under test in pump-probe configuration where the pump laser is another class 4 laser with a wide spectral range from deep UV to THz. Interlock systems have been designed and deployed to protect users of the facility from exposure to these ionizing and laser radiation hazards. We present the design architecture of CXLS interlock systems. In this description we make clear what systems are independent, and which are interdependent and what administrative override modes are made available and why. We also provide an overview of our monthly interlock system testing protocols and conclude with comments on overall system performance.

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THAN: Photon Sources and Electron Accelerators (Contributed) / 1869

Numerical simulations of an integrated X-band high-field photoinjector

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Particle accelerators based on a two-beam acceleration scheme offer a path to high-accelerating fields by powering the accelerating structures using short (nanosecond) radiofrequency pulses. At the Argonne Wakefield Accelerator (AWA) facility, this approach was recently applied to an X-band radiofrequency gun and demonstrated an unprecedented electric field on the photocathode of ˜400 MV/m. In the next phase, a short X-band linac will be added to boost the beam energy up to ˜10 MeV. This paper examines the linac optimization and beam dynamics in this integrated system over a wide range of operating parameters. Planned experiments will also be discussed along with possible applications of the setup to compact light sources (e.g. inverse Compton scattering) or electron scattering experiments (e.g. microscopy or diffraction).

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Wednesday Poster Session / 1870

Conceptual design of the HTS split coil test facility for the Muon Collider cooling section

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The cooling section of the Muon Collider requires a number of solenoidal coils of various diameters (0.05-2 m) and fields (2-60 T). An unusual feature of the cooling section is that the RF cavities operates under the large magnetic fields and field gradients generated by the focusing elements. Here we present the design of a test facility based on split coils, wound with HTS, to study the performance of RF cavities under magnetic field. The main characteristics are: 330 mm free room temperature bore, uniform 7 T field along 300 mm on axis, coils energized with parallel or antiparallel field: this last configuration provides a gradient field of about 40 T/m. The use of HTS in form of REBCO tape enables magnet operation at 20 K and cooling via solid conduction by cryocoolers. This facility will be a first prototype of the cooling cell magnets that are being designed in cryogen-free layout at 20 K for energy saving and will allow to anticipate system integration concepts. The conceptual design of the facility is almost frozen and the engineering design is well under way. If we get financial support by 2025 we can commission the facility in 2027.

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Tuesday Poster Session / 1871

Enhancing plasma wakefield accelerator analysis through machine learning

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In this groundbreaking study, an advanced particle-in-cell (PIC) simulation code,QuickPIC, is used to explore beam physics within Plasma Wakefield Accelerators (PWFA). The primary aim is to comprehensively analyze beam distributions, particularly those exhibiting perturbations with significant instabilities. To connect simulated beam distributions to physical observables, the study uses cutting-edge neural networks. This research underscores the transformative potential of machine learning (ML) in unraveling PWFA complexities and enhancing our capabilities in the development of advanced accelerators.

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FPGA design of FRIB chopper monitor system

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In FRIB we use chopper in the low energy beam line for beam power controls. As appropriate functioning of chopper is critical for both beam operation and machine protection, an FPGA-based chopper monitoring system was developed to monitor its operation for fixed duty cycle operation and has been in use to support operation. The chopper monitor shuts off beam promptly at detection of a deviation of duty cycle outside tolerance. For future higher beam power operation, automatic beam power ramp modes will be required where beam duty factor is dynamically ramped up following a predetermined sequence. Recently FPGA prototype is developed to enhance the chopper monitor to accommodate one of such dynamic modes, cold start beam mode. It is a design challenge to integrate all the beam modes in one FPGA while synchronizing with external timing system pulse generator and recording the process data and failure information. Detailed FPGA design for this enhancement of chopper monitor will be discussed in this paper, followed by the test result of integrated system of chopper monitor, global timing system pulse generator, high voltage switch of chopper control and EPICS control software.

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Tuesday Poster Session / 1873

Realizing high average power temporal laser shaping for photocathode emittance reduction

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Generating low emittance electron bunches from the photocathodes backing free-electron lasers (FEL) is a potential source of significant improvement in achievable X-ray peak powers. Temporally shaping the photoexcitation lasers with intensity profiles that are perfectly flattop or ellipsoidal has been demonstrated to improve the emittance of the emitted electron bunch. However, experimental techniques to achieve these profiles have not been demonstrated at the high-energy, high-repetition rate conditions required by next-generation XFELs, such as LCLS-II(HE). We present an experimental demonstration of the dispersion controlled nonlinear synthesis (DCNS) technique* which has been shown in theory to produce emittance-reducing laser profiles under these conditions. Our implementation generates 20 picosecond pulses in the ultraviolet with a flattop intensity profile. We compare the simulated emission of electron bunches to the currently implemented Gaussian temporal profiles and the performance of LCLS-II XFEL with electrons generated from both laser profiles. Finally, we suggest methods to adapt DCNS to non-uniform shaping and for lasers using other nonlinear conversion processes.

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Low-emittance beam generation at Argonne Wakefield Accelerator's upgraded drive-beam photoinjector

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The Argonne Wakefield Accelerator (AWA) facility's main beamline – the drive-beam linac – can produce electron bunches over a wide range of charges (100 pC up to 100 nC). A planned upgrade of the beamline includes the installation of a symmetrized RF gun and linac cavities with the ultimate goal of improving beam brightness. Simulations were done to explore the performance of the upgraded photoinjector to produce very low-emittance beams in conjunction with low mean-transverse-energy photocathodes. Additionally, selective collimation is also explored to further increase the beam brightness. An experiment to validate the devised operational modes will be discussed along with preliminary results on diagnostics tests.

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Thursday Poster Session / 1876

Pulsed correctors for the beam vertical stability during injection in CESR

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Beam motion during injections could be a serious problem to x-ray users and jeopardize their experiments. In the Cornell Electron Storage Ring (CESR) the particles are injected with pulsed elements such as pulsed bumpers and septum which could cause transient motion of the stored beam. By analyzing the turn-by-turn position data of the stored beam acquired during injection, we identify the source of beam motion in different time scales.
A new corrector coil is then designed to compensate the beam motion with 0.1 msec duration at a 60 Hz repetition rate in the vertical plane. In addition to the new corrector we also use one of the existing magnet coils to correct 60 Hz kicks and DC offsets. Although, during the last summer down the 60 Hz source was identified and suppressed by an order of magnitude, this corrector is still in use to minimize the injection transient. The waveforms, used to drive the correctors, are extracted based on the beam turn-by-turn coordinates and orbit kick analyses using the 110 CESR Beam Position Monitors data.
In this paper we discuss the requirements and parameters of the new corrector, as well as the correction technique, which is proven to be effective.

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Ion-ion collisions in plasma wakefield accelerators: nonlinear focusing and emittance growth in high-energy linear colliders

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The plasma wakefield accelerator, with acceleration gradients ranging from GeV/m to TeV/m, holds promise for propelling particles to high energies in linear colliders. This results in exceptionally bright beams characterized by intense ion-derived focusing, leading to the collapse of plasma ions. The non-uniform ion density triggers robust nonlinear focusing, potentially resulting in undesirable beam emittance growth. Our study extends prior research focused on electron acceleration by investigating ion-ion collisions, studying different collision models emphasizing the near-equilibrium state post-ion collapse utilizing the OSIRIS PIC code. Notably, our findings reveal that parametric excitations arising from plasma non-uniformity have an insignificant impact on phase space diffusion, a crucial insight for optimizing linear colliders.

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Tuesday Poster Session / 1878

High-quality dislocation-free diffraction grade HPHT diamond substrates for next-generation of synchrotron and FEL X-ray sources

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Next-generation of synchrotron and FEL X-ray sources will increase the peak power by several orders of magnitude. In these conditions, X-ray intensity will become too severe for the existing materials. Large, single-crystal diamond is one of the few materials suitable for X-ray optical applications due to its unique combination of physical properties. We developed the modified High-Pressure High-Temperature (HPHT) temperature gradient growth technology that allows the growth of the highest crystalline quality large diamond crystals with a dislocation density of less than 10 cm-2. This near-equilibrium process is carried out under extreme conditions, where diamond single crystals are grown from a molten metal solvent under 5 GPa pressures and temperatures of 1,600 K. We present results from a collaboration that includes experimental growth carried out at the Euclid Beamlabs, modeling efforts by the University of Minnesota and Fraunhofer IISB, and X-ray crystals characterization conducted by APS/ANL. This three-fold approach provides rigorous tools to both understand growth in this system and to perform subsequent optimization of growth conditions of diffraction-grade diamonds.

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Wednesday Poster Session / 1879

Ferroelectric fast reactive tuner –technology progress and applications

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In a world's first, CERN recently tested Euclid's prototype ferroelectric tuner with a superconducting cavity, and successfully demonstrated its microphonics compensation*. This Ferroelectric Reactive Tuner (FRT) stands out as the swiftest RF cavity tuner utilizing a ferroelectric ceramic tuning element, boasting an impressive response time below 100 ns. The implications of this advancement are substantial, potentially leading to a significant reduction in the RF power consumption of accelerators across various applications. During this presentation, we will discuss various aspects of this novel tuning technology. Topics to be covered include the development and characterization of ferroelectric materials, metallization techniques, biasing voltage supply, and the FRT designs tailored for SRF microphonic compensations. Specifically, we will introduce a magic-T configuration designed for CEBAF C100, enabling its utilization with a single RF port connected to the cavity. Additionally, we will explore potential applications for other projects such as EIC, LHC, BERLinPro, and beyond.

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Monday Poster Session / 1880

Measurement of the beam-beam effects on luminosity

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At the Large Hadron Collider (LHC), the accuracy of absolute luminosity calibrations with the van der Meer (vdM) method is affected by the electromagnetic interaction between colliding beams, commonly known as beam-beam effects. These effects introduce relative orbit shifts, optical distortions, and deviations in the transverse distribution from Gaussian profiles within the colliding bunches. Understanding and addressing these complexities is crucial when establishing the absolute luminosity scale and also for monitoring the performance of detectors during physics runs.
The dedicated experiment was performed at the LHC to measure the beam-beam interaction effects directly on the luminosity. Modified optics configuration was used to enhance the distortions. The first observation of the beam-beam effects on the luminosity was made, including the dependence on the multiple collisions. The comparison between simulation studies and experimental data showcases a remarkable agreement at a precision level of 1%, underscoring the consistency between theoretical projections and empirical observations.

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Monday Poster Session / 1881

First experimental demonstration of fully structured light in an EUV FEL

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Co-authors: Alberto Simoncig [2]; Alexander Brynes [2]; Carlo Spezzani [2]; Emanuele Pedersoli [3]; Erik Hemsing [1]; Flavio Capotondi [2]; Giovanni De Ninno [2]; Luka Novinec [2]; Marco Zangrando [2]; Matteo Pancaldi [2]; Michele Manfredda [2]; Primoz Rebernik Ribic [2]; William Fawley [1]

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Light with polarization structure is called Fully Structured Light (FSL). We present an experimental demonstration of coherent FSL EUV light with spatially varying states of polarization generated at the FERMI free electron laser (FEL) in Trieste, Italy. Control of the polarization is obtained through the overlap of radiation emitted in orthogonally polarized helical undulators with different transverse phase distributions. The spatial polarization structure was mapped by imaging the light downstream of a polarizer, and two classes of FSL were observed and characterized: cylindrical vector and Poincare beams.

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Thursday Poster Session / 1882

Modernization of DARHT axis-I spinning wheel debris blocker

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The Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT) uses a spinning wheel debris blocker as a crucial machine protection system to prevent target debris from the electron to X-ray conversion process from traveling upstream and damaging the accelerator. The spinning wheel in use on DARHT Axis-I consists of two spinning disks normal to the beamline, each with an open slit that crosses the beamline at frequencies of 50 Hz and 40 Hz, creating an opening at a beat frequency of 8 Hz allowing the electron beam to pass through and shut behind it. In this poster, we present steps taken to improve the reliability and performance of the spinning wheel, which include replacing legacy and custom diagnostic components with off-the-shelf hardware. We also present the challenges and solutions in testing and deploying these upgrades without disrupting operation of the accelerator.

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Tuesday Poster Session / 1883

Identifying Downtime Sources in CEBAF SRF Linac Systems for Improving Its Reliability

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In this work, we will present some recent analysis of the reliability of the CEBAF SRF Linac systems. Based on the data collected by the existing Down Time Manager (DTM), the year-to-year downtime evolution trend of linac zones over the last nine years (FY2015-FY2023) is established. An in-depth downtime tracking at resolution higher than the zone level of the SRF linac system was demonstrated by introducing a system hierarchy consisting of sub-systems and components. This new paradigm was implemented in a pilot downtime study over the two-month period of CEBAF operation from 9/13/23 to 11/13/23, enabling localization of the responsible sub-systems (SRF, HPRF, LLRF, Beamline vacuum, Cryogenics, etc.) and hardware components (cavity, tuner, RF coupler, etc.) in the CEBAF SRF linac systems. Pinpointing downtime sources over long operation periods at the sub-systems and component levels holds the key to improving the CEBAF SRF systems reliability and helps identify areas of SRF technology development for future high-power CW SRF Linacs.

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Thursday Poster Session / 1884

Optimizing beam-matching optics for MITHRA plasma injection studies: simulation and experimental alignment

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This study focuses on developing beam-matching optics for the transport of the MITHRA beam into plasma to study long range plasma effects. To ensure successful injection into the plasma chamber, matching conditions are crucial at the entrance. A dedicated focusing system, comprising beam-matching optics, is designed to transport the beam from the 1.5-meter linear accelerator (linac) and align the necessary parameters at the plasma entrance. Optimization simulations employing Elegant and General Particle Tracer (GPT) codes, based on MITHRA gun data, have been conducted with promising results that align with our expectations. Further investigations involve simulating the PWFA interaction using advanced, fully relativistic, three-dimensional Particle-in-Cell (PIC) codes, namely OSIRIS and QuickPIC.

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Tuesday Poster Session / 1886

Novel ion cyclotron auto-resonance accelerator

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A novel deuteron accelerator concept, the deuteron cyclotron auto-resonance accelerator (dCARA) is presented here, with (a) an analytical theory to characterize a simplified model for dCARA, (b) simulated tracks of deuteron orbits in a more realistic model for dCARA, and (c) CST-Studio particle-in-cell simulations for high-current deuteron beams in a realistic dCARA. These predict that dCARA will produce a high-current multi-MeV beam of accelerated deuterons along an axis parallel to, but displaced from, the center conductor of a coaxial resonator immersed in a uniform static magnetic field. The example presented, where the magnetic field strength is 7.0 T (for cyclotron auto-resonance at 53.0 MHz), acceleration of a 100 mA deuteron beam from 60 keV to 35 MeV is predicted to occur along a 2.8 m long half-wave resonant cavity, with an efficiency of 88%. Such a beam could be highly competitive with that produced either with linacs or cyclotrons for an application to produce, via deuteron stripping, a high flux of neutrons with an energy spectrum centered near 14.1 MeV, as needed for testing inner-wall materials for a future deuterium-tritium fusion power reactor.

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Tuesday Poster Session / 1887

Dielectric wakefield accelerators: tuning THz radiation via coherent Cerenkov radiation for biomedical applications

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The THz spectrum reveals distinctive vibrational and rotational modes, and when charged particle beams produce THz radiation, it becomes a promising source for generating narrowband, high-energy radiation. Particularly in dielectric wakefield accelerators, where a dielectric-lined channel is traversed by a relativistic electron beam, coherent Cerenkov radiation (CCR) is generated. The frequency and amplitude of CCR are dependent on structural geometry and drive beam parameters. Simulating a µm, pC driver beam in a dielectric wakefield structure yields longitudinal fields of MV/m, with a fundamental mode associated with a resonant peak corresponding to the process of demethylation in DNA. Achieving higher frequencies requires a thin dielectric layer or Bragg-like boundaries in the structure to constructively reinforce the fundamental frequency.

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Monday Poster Session / 1888

Simulation study for GeV electron beam generation in LWFA using laser-ablated metal plasma

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Laser wakefield acceleration (LWFA) has been highlighted in the development of table-top accelerators and compact light sources. However, the stability issues on beam quality and pointing remain unsolved problems. Many groups apply the technique of ionization injection for higher charge with the narrower energy spread into a supersonic gas jet target or a capillary discharge system. The LWFA using a laser-ablated metallic plasma target also involves the ionization effects, not only the ionization injection but also ionization diffraction. The ionization injection may increase the bunch charge at the expense of its peak energy. The strong ionization diffraction generally keeps the optical guiding from being steady at long distances, resulting in a decrease in the accelerating length. At a certain condition, it causes the sudden break of the wake cavity, resulting in a nearly zero-accelerating wakefield. In this condition, the electron bunch may keep its property in the steady state, resulting in lower energy spread. In this paper, we present the simulation study to optimize the generation of a near-GeV electron beam using the metal plasma targets.

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Monday Poster Session / 1889

Linking edge-ML X-ray diagnostics and adaptable photoinjector laser shaping for leveraging the capabilities of LCLS-II

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SLAC's LCLS-II is rapidly advancing towards MHz repetition rate attosecond X-ray pulses, opening new opportunities to leverage the abundance of data in combination with advances in machine learning (ML) to better align the x-ray source with specific experimental goals. We approach the challenge from both ends of the facility. Starting at the X-ray output, we showcase our low latency, high throughput ML algorithms implemented at-the-edge for X-ray detection and reconstruction in the Multi-Resolution 'Cookiebox' (MRCO) angle resolved electron spectrometer with its 16 electron time-of-flight detectors. MRCO performs spectro-temporal characterization of X-ray profiles with a resolution that allows single shot identification of well-seeded shots versus SASE background at MHz rate. MRCO enables fast feedback, so we also tackle the problem as a control issue, focusing on programmable photoinjector laser shaping to adjust the initial electron bunch. Towards this end of using advances in ML to explore the parameter space for optimizing X-ray production, we present our progress towards a digital twin linking the photoinjector laser all the way through MRCO in the endstation diagnostics.

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Tuesday Poster Session / 1890

Virtual diagnostics and ML-based longitudinal stability corrections at the Fermilab linac

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The Fermilab Linac delivers 400 MeV H- beam to the Booster rapid cycling synchrotron. A major source of Booster losses at injection, especially in an injection painting scheme as will be employed at PIP-II, is Linac centroid energy (momentum) drift and energy spread. Factors like ambient temperature and humidity variations affect cavity resonant frequencies. This, combined with fluctuations in the energy and phase of particles emerging from the Front End causes perturbations in the longitudinal motion of beam in the Linac, resulting in longitudinal emittance blowup and central momentum drift. To improve longitudinal stability, we have developed several machine learning (ML)-based correction schemes using beam position monitor (BPM) and beam shape monitor (BSM) data. The BSM is a longitudinal profile monitor and is particularly useful in the drift tube section of the Linac where BPMs are sparse. However the BSM is a destructive diagnostic thus taking data is expensive. To mitigate these limitations, work is on-going on developing ML-based modeling of the beam longitudinal phase space, to be used as virtual BSM for tuning.

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Wednesday Poster Session / 1891

CXLS inverse Compton scattering interaction point chamber

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The Inverse Compton Scattering Interaction Point (ICS-IP) vacuum chamber provides a UHV environment where the electron and IR laser beams are overlapped in space and time to generate hard X-rays between 4 and 20 keV. The chamber has over two dozen motorized stages that position YAG screens with ˜10 nm precision utilizing the EPICS framework for instrumentation interface. Using agile programming methods, MATLAB GUIs were created to control all the motors inside the chamber. Each YAG screen has a linear array of holes ranging between 10 microns and 2 mm that are imaged by cameras mounted on top of the chamber. Programmable focus lenses and IR mirrors are positioned to focus the IR laser at the interaction point. An X-ray optic is mounted onto a six degree of freedom nano-positioner enabling capture and collimation of X-rays coming from the IP. The X-ray optic can also be extracted from the beam path to transport the freely diverging X-rays to the experiment hutch for imaging experiments. We present the systems integration of the chamber, diagnostics elements, and control software and comment on its performance during instrument commissioning.

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Wednesday Poster Session / 1892

Wire scanner assessment of transverse beam coupling in the Fermilab side-coupled linac

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The Fermilab Side-Coupled Linac contains seven 805 MHz modules accelerating H- beam from 116 MeV to 400 MeV. Each module contains at least one wire scanner, yielding beam intensity at positions along a transverse direction. These wire scanners each contain three wires, mounted at different angles: "X", "Y", and 45° between "X" and "Y" to analyze coupling. Recently, a significant amount of transverse coupling was identified within wire scanner data from the Side-Coupled Linac, which has been present in data from the past decade. This realization has prompted an investigation into the wire scanner's utility as a diagnostic tool in the Fermilab Linac. This work presents efforts to better characterize the wire scanners' limitations and the phenomenon occurring in the Side-Coupled Linac.

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Thursday Poster Session / 1893

Development of a cryogen free MgB2 high temperature superconducting undulator

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RadiaBeam is designing and manufacturing a 15-mm period, 1.15 T field superconducting undulator. Realizing these parameters require a small gap, on the order of 5 mm. This small gap imparts a thermal management challenge due to heating from resistive walls, wakefields, upstream dipoles, and particle losses which is challenging to overcome with NbTi or NbSn3 wires without the use of liquid helium. Further, to reduce operating costs and reliance on liquid helium infrastructure, this undulator is designed to run off cryocoolers. In order to provide sufficient thermal overhead for cryocooling capacities, we will utilize Magnesium Diboride (MgB2), a metallic superconductor with a transition temperature at around 39 K. Thermo-mechanical engineering design studies and production plans of our prototype will be presented.

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Monday Poster Session / 1894

Ion optics test stand: generating ML training data sets for ion optics optimization

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Transfer maps of different ion optical elements are usually obtained via ray tracing methods without taking into account the imperfections and misalignments of the optics. Normally beam profile monitors do not measure the full 6D phase-space, but only a portion of it. To verify the beam phase-space, we have constructed an Ion Optics Test Stand (IOTS) that is located at the Low Energy Branch (LEB) of the Jozef Stefan Institute in Ljubljana, Slovenia [1]. The IOTS consists of two Allison emittance scanners (AES) [2] with an electrode sandwiched between them, and is supplied by the LEB with a variety of ion beams with energies up to 20 keV. This allows us to automatically measure the 6D beam phase-space before and after the electrode and determine the electrodes transfer map. We will discuss the status of the IOTS, the emittance scanners, electrode transfer map measurements with them, and describe an example of AES–Einzel lens–AES test configuration. We will also show how the phase-space measurements performed with the IOTS can be used as a training ground of Machine Learning (ML) tools designed for ion optics optimization with respect to a preferred transport metric.

Footnotes:

[1] Z. Brencic et. all, Development of Low Energy Branch at Micro Analytical Centre, Ljubljana, IPAC 23

[2] P. Allison et. all, An Emittance scanner for intense Low-Energy Ion beams, IEEE Trans. On Nuc. Sci. 30, 2204 (1983)

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Wednesday Poster Session / 1898

Measuring uniformity and gas density of gas sheet profile monitor for use with heavy-ion accelerators

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We report updates on design work* and ongoing development of a fluorescence-based molecular gas curtain which will be used to observe the 2D transverse profile of multi-charge state heavy ion beams at the Facility for Rare Isotope Beams (FRIB). The device will produce an ultra-thin, rarefied nitrogen gas sheet and requires that the gas curtain be uniform and thin to prevent distortion of the collected signal in operation. To determine the characteristics of the generated curtain, we evaluate the design using a combination of bench-testing with a Bayard-Alpert gauge and molecular dynamics simulations using MolFlow+. This paper details the design and bench testing of the sheet generator, gas removal system, and interaction chamber of the device, as well as expected photon generation from these parameters.

Footnotes:

- A. Lokey and S.M. Lidia, "Status of Gas Sheet Monitor for Profile Measurements at FRIB", in Proc. 12th Int. Beam Instrum. Conf. (IBIC'23), Saskatoon, Canada, Sep. 2023, pp. 415-417. doi:10.18429/JACoW-IBIC2023-WEP027

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Stability and scalability of superradiant amplification in attosecond X-ray free-electron lasers

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In free-electron lasers seeded by a coherent pulse, the term superradiance refers to a regime in which the seed pulse is consistently shortened by a slippage-dominated interaction with the electron beam. This regime is extremely promising for attosecond X-ray free-electron lasers in particular, as it offers a potential path towards shorter, higher power pulses. We study the practical limits of this regime in two directions. First, we study numerically and analytically the conditions under which superradiant behavior is observed. Second, we study the limits of superradiant amplification, in particular how long this nonlinear interaction can be prolonged for realistic beam conditions.

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Monday Poster Session / 1900

Slow longitudinal mode-1 instability in electron storage rings with harmonic cavities

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Recent studies have revealed an intriguing longitudinal instability that may develop in electron storage rings featuring higher-harmonic cavities. The instability, also referred to as periodic transient beam loading, manifests as a slow oscillation of bunch longitudinal profiles following a coupled-bunch mode-1 pattern. In this contribution, we applied the well-established theory of longitudinal mode-coupling to assess the thresholds and oscillation frequency for this instability. Results obtained through this semi-analytical approach, considering different storage ring and harmonic cavity parameters, were validated using macroparticle tracking and compared against other methods proposed in previous investigations.

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Thursday Poster Session / 1901

Status of the transverse bunch-by-bunch feedback system at APS-U storage ring

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Transverse bunch-by-bunch (BxB) feedback system has been designed, fabricated, installed, and tested with beam at the Advanced Photon Source Upgrade (APS-U) storage ring. The transverse feedback system (TFB) is designed to suppress coupled bunch instabilities and single bunch instabilities. It adapted a stripline kicker design which has the same profile as the APS-U injection/extraction kickers. The system uses digital controllers which provide powerful diagnostics, in addition to its major functionality for feedback control. This paper presents the status of the TFB system including early beam commissioning results.

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Evaluation of ultrafast terahertz near-fields for electron streaking

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Co-authors: Carlos Peqeuno [1]; Emilio Nanni [1]; Emma Snively [1]; Matthias Hoffmann [1]; Mohamed Othman [1]; Wei Hou Tan [1]

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THz-frequency accelerating structures could provide the accelerating gradients needed for compact next generation particle accelerators. One of the most promising THz generation techniques for accelerator applications is optical rectification in lithium niobate using the tilted pulse front method. However, accelerator applications are limited by losses during transport and coupling of THz radiation to the acceleration structure. Applying the near-field of the lithium niobate source directly to the electron bunch removes losses due to transport and coupling, yielding a simplified and efficient system. Using electro-optic sampling we have reconstructed the full temporal 3D THz near-field close to the lithium niobate emission face and shown that it can be controlled by manipulating the generation setup. Analysis of the results of this measurement shows an estimated peak field strength of 86 MV/m. A future THz near-field electron streaking experiment is currently planned as a first test of manipulating an electron bunch with the THz near field. Analysis for this planned experiment has yielded an estimated THz near-field kick strength of 23 keV.

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Wednesday Poster Session / 1905

Beam position monitoring system and beam commissioning at APS-U Storage ring

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Advanced Photon Source Upgrade (APS-U) storage ring, currently in installation and testing, is set for beam commissioning in early 2024. In the APS-U storage ring, there are 560 Beam Position Monitor (BPM) pickups, each equipped with high resolution electronics. This paper presents outcomes from pre-beam testing and beam commissioning of the APS-U BPM system. We discuss tailored features for advanced beam measurements, testing methodologies, challenges, and successful integration into the storage ring. Our findings demonstrate the robustness of the BPM system, emphasizing its crucial role in achieving the first beam and optimizing the APS-U storage ring's performance.

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Wednesday Poster Session / 1906

Coupler HV bias studies on ESS elliptical cavities

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We study the effects of high voltage DC bias on the fundamental power couplers of the ESS elliptical SRF cavities. These tests were carried out at the TS2 facility, where cryomodule acceptance and characterization tests are carried out. We present the observed effects of positive and negative bias field on multipacting in the RF couplers, as well as the implications for operation in the ESS linac.

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Monday Poster Session / 1907

Simulating the transverse probing of laser-driven plasma wakefields using ultrarelativistic electrons

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Laser wakefield accelerators (LWFAs) are capable of supporting accelerating and focusing forces on the order of 10–100 GeV/m, about three orders of magnitude greater than conventional RF accelerators. While theoretical solutions for the electromagnetic (EM) focusing fields have been developed, the field structures have yet to be verified experimentally. In this poster, we present simulation results for transverse probing of laser wakefields using ultrarelativistic electrons. We study the behavior of the probing electrons by implementing filtering masks to investigate focusing characteristics of thin electron "bands". The deflection of these bands after propagating through the wakefield is then used to characterize the EM forces. The simulated focusing behavior of these electron bands is in reasonable agreement with a theoretical model developed based on a thin lens model of the wakefield. Simulation results show the focusing of the bands to be an effective experimental diagnostic for verifying the EM field structure. This provides an analytic framework needed for the first direct measurements of focusing forces in an LWFA at the Accelerator Test Facility at Brookhaven National Lab.

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Reinforcement learning enabled fast optimization in lasers and accelerator control: with experimental demonstration on laser combining

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Semi-deterministic optimization problems are common in operating complex lasers and accelerator facilities. In these problems, a few optimal solutions exist that can achieve satisfactory system performance for a specific system state. Typically, online optimizations are performed to find these optimal solutions, which can be time-consuming and must be repeated when the system state changes. In this paper, we propose a high-efficient optimization method called method, which can directly map any given system state to the optimal solution based on the optimization criterion. We demonstrate the effectiveness of our method in several real-life optimization scenarios, including simulations

and experiments conducted at SLAC and LBNL. Our proposed method can significantly reduce the optimization time and cost and provide a more efficient solution for accelerator facility operations. Moreover, an 8-beam, diffractive coherent beam combiner is phase-controlled by the method, from random states, showing fast optimization of the complex laser system without labeling target patterns as demonstrated in previous publications.

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Wednesday Poster Session / 1909

Optimizing Touschek lifetime at MAX-IV 1.5 GeV ring with overstretched bunch profiles

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Synchrotron light sources often use higher-harmonic RF cavities for bunch lengthening to enhance Touschek lifetime. By adjusting the harmonic voltage, a flat-potential condition for the longitudinal voltage can be achieved, typically improving Touschek lifetime by 4 to 5 times. It is known that exceeding the flat-potential voltage results in double-peaked bunch profiles, referred to as overstretched conditions. Simulations suggest overstretched profiles can surpass flat-potential improvements on lifetime. In this paper we report on experimental results from MAX-IV 1.5 GeV storage ring, demonstrating a longer beam lifetime with a stable beam in overstretched conditions compared to the flat-potential case. Additionally, a remarkable agreement between measured bunch profiles using a streak camera and predictions from a semi-analytical equilibrium solver was obtained for all tested harmonic voltages.

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Monday Poster Session / 1910

Transport and dosimetry of laser-driven proton beams for radiobiology at the BELLA center

Author: Jared De Chant[1]

Co-authors: Kei Nakamura [1]; Lieselotte Obst-Huebl [1]; Sahel Hakimi [1]; Morgan Cole [1]; Laura Geulig [2]; Samuel Barber [1]; Jamie Inman [1]; Antoine Snijders [1]; Anthony Gonsalves [1]; Jeroen van Tilborg [1]; Cameron Geddes [1]; Carl Schroeder [1]; Eric Esarey [1]

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Laser-driven ion accelerators (LDIAs) are well-suited for radiobiological research on ultra-high dose rate effects due to their high intensity. For this application, a transport system is required to deliver the desired beam intensity and dose distribution while online dosimetry is required due to the inherent shot-to-shot variability of LDIAs. At the BELLA Center's iP2 beamline, we implemented two compact, permanent magnet-based beam transport configurations for delivering 10 or 30 MeV protons to a biological sample, along with a suite of diagnostics used for dosimetry. These diagnostics include multiple integrating current transformers (ICTs) for indirect online dose measurements and calibrated radiochromic films (RCFs) to measure the dose profile and calibrate the ICT dosimetry. Benchmarked Monte-Carlo (MC) simulations of the beamline allow us to predict the dose received by the sample and correct the linear energy transfer (LET)-dependent response of the RCFs. This work not only further establishes the practicality of utilizing LDIAs for radiobiological research but also highlights the BELLA Center's capacity to accommodate further experiments in this domain.

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Thursday Poster Session / 1911

Conditioning of rod-style RFQ in support of LANSCE front-end upgrade

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The Los Alamos Neutron Science Center (LANSCE) front-end injection scheme requires an upgrade to a Radio-Frequency Quadrupole (RFQ) in order to replace the obsolete Cockroft-Waltons used in present operation. A test stand using a rod-style RFQ is under development in support of this upgrade, and conditioning of the RFQ to the expected peak and average power levels was completed to ensure its feasibility. The RFQ conditioning also revealed thermal issues with the RF power coupler and issues in managing the power reflected from the RFQ. These issues and their mitigation will be discussed in light of the capability of the test stand, and future plans will also be discussed.

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Wednesday Poster Session / **1912**

Design, prototyping and testing of the Electron Ion Collider electron storage ring SRF cavity

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The electron storage ring (ESR) in the Electron Ion Collider (EIC) requires a challenging 591 MHz fundamental 17-cavity RF system to provide up to 10 MW CW power to the beam with up to 2.5 A beam current and a wide range of voltage. In this paper, we will report the latest RF and mechanical design status, as well as the prototyping and testing results.

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Tuesday Poster Session / **1913**

A novel two stage collimation unit for Fermilab booster

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A new two-stage collimation unit (2SC) for Fermilab Booster will be installed during 2024 summer shutdown. It is a supplementary collimator for existing single stage Booster collimators. Unique operational principles of this new 2SC adapted to Booster conditions are described. Results of beam dynamics simulations on collimation efficiency of the new 2SC are presented. Evaluation of collimator shielding has been performed with MARS code. The analysis on prompt and residual activation was found to meet Fermilab Radiological Control limits. We will also present the results from analysis on shielding as well as residual activation.

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WEBD: Hadron Accelerators (Contributed) / 1914

Commissioning of extended electron beam ion source for Relativistic Heavy Ion Collider

Author: Benjamin Coe[1]

Co-authors: Edward Beebe [1]; Sergey Kondrashev [1]; Shunsuke Ikeda [1]; Takeshi Kanesue [1]; Trevor Rodowicz [1]

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The Extended Electron Beam Ion Source (EEBIS) was installed and commissioned for the Relativistic Heavy Ion Collider (RHIC), NASA Space Radiation Laboratory (NSRL), and future Electron Ion Collider (EIC) at Brookhaven National Laboratory (BNL). Within one month of completed installation, daily operation of multiple ion beams for Galactic Cosmic Ray (GCR) simulation for NSRL science was achieved. Concurrently, gold ion beam was developed at higher intensities and pulse rates in anticipation of RHIC operation. After demonstrating simultaneous operation of beams for both the RHIC and NSRL programs, machine learning algorithms were implemented to tune both the electrostatic beam transport lines and the dynamic voltages of the drift tube structure inside of EEBIS. The methods and results are presented and discussed.

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Tuesday Poster Session / 1915

Light source top-up through direct generation of electron beam based on LPA technology

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Laser plasma acceleration (LPA) technology is advancing day by day, getting ready for user facility applications. LPA might be applicable to a generation of electron beams directly within the light-source storage-ring vacuum chamber. Typical injector of the light source facility consists of linac and synchrotron booster (or simply a full energy linac). It can be replaced by a laser plasma cell and a driving laser system that can generate multi-GeV electron beams through so-called self injection. The electron beam out of plasma cell has typically a large energy spread. In this application, however, we do not require small energy spread since the storage ring can accept off-energy electrons of up to ±5% or so. It can also have a transverse angular acceptance of a few hundred micro radian. Therefore, a large fraction of generated electrons can be eventually accepted by the storage ring. LPA system, which replaces the conventional injector, may contribute to significant energy saving.

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Tuesday Poster Session / 1916

High vacuum measurements at a linear inductive accelerator module

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[2] *Los Alamos National Laboratory*

[3] *National Security Technologies, LLC*

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We are going to present recent high vacuum pressure measurements recorded at new Prototype Accelerator Module (PAM) of the Advance Sources and Detectors (ASD) –Scorpius project [1]. To avoid the ion-hose instability [2] in our linear inductive accelerator with 2 kA, 20 MeV electron multi-pulse beams during radiographic scans, an advance high vacuum system and accelerator components were being developed. The Scorpius PAM vacuum chamber consists of three induction voltage adder beam lines, vacuum plenums with three different vacuum pumps: turbo-molecular pump (TMP; 1000 l/s), NEG pump (2100 l/s for H2) and ion pump (500 l/s). An ultimate vacuum pressure of 4.0 to 5.0 1e-8 Torr along single PAM vacuum chamber was achieved. Dominant residual gases (H2, H2O, O2, N2, CO, Ar, CO2) were recorded to understand different vacuum pumping speed configurations (NEG-ION configuration or production setup, NEG-ION-TMP pumps ON for vacuum roughing from atmosphere to high vacuum pressure, influences of each pump on different residual gas species in PAM, etc.). Measured results will be discussed and compared with the vacuum pressure simulations.

Footnotes:

[1] M. Crawford, and J. Barraza, "Scorpius: The Development of a New Multi-Pulse Radiographic Systems", IEEE 21st International Conference on Pulsed Power, Brighton, UK 18-22 June 2017, IAN 17563191.
[2] C. Ekdahl, "The Ion-Hose Instability in a High-Current Multi-Pulse Linear Induction Accelerator" IEEE Transactions on Plasma Sciences, Vol 47, No 1, January 2019, page 300-306.

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Wednesday Poster Session / 1917

Results from extended range SRF cavity tuners tests for LCLS-II HE

Author: Crispin Contreras-Martinez[1]

Co-authors: Andrew Cravatta [1]; Brian Hartsell [1]; Gennady Romanov [1]; Joshua Kaluzny [1]; Sam Posen [1]; Timergali Khabiboulline [1]; Tug Arkan [1]; Yuriy Pischalnikov [1]

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Corresponding Author: ccontrer@fnal.gov

The LCLS-II HE superconducting linac can produce multi-energy beams by supporting multiple undulator lines simultaneously. This could be achieved by using the cavity SRF tuner in the off-frequency detune mode. This off-frequency operation method was tested in 8 cryomodules at Fermilab at 2 K. In all the tests the tuners successfully achieved a frequency shift of -565±80 kHz from the 1.3 GHz value. This study discusses the cavity frequency during each stage of assembly from the cryomodule string to when they are finally tested at 2 K. Monitoring the cavity frequency from this initial stage contributed in reaching this large frequency shift. The specific procedures of tuner setting during assembly will be presented.

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Thursday Poster Session / 1918

Impact of Delta undulator on SIRIUS beam dynamics

Author: Gabriel Ascenção[1]

Co-authors: Fernando de Sá [1]; Matheus Velloso [1]; Murilo Alves [1]; Ximenes Resende [1]

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SIRIUS is the Brazilian 4th generation synchrotron light source. Currently, SIRIUS is in its Phase 1 stage of the project and is already operating with external users, for this project phase 14 beamlines were proposed, with the majority of them already being used by users. Recently, the SABIÁ beamline had its commissioning insertion device (ID) changed to the beamline titular ID, a Delta undulator. This device can generate different polarizations for light depending on the relative positions of the ID cassettes, these degrees of freedom, however, generate perturbations in beam dynamics, especially on the beam orbit and on linear and non-linear optics. This paper reports the effects of the Delta on the beam dynamics for its different configurations, as well as the correction schemes adopted to neutralize those effects.

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Tuesday Poster Session / 1919

Electron stimulated desorption using a Compton electron beam on PHIL facility

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The understanding of the dynamic pressure during accelerator operation is fundamental to provide solutions to mitigate pressure rises induced by multiple-effects occurring in the vacuum chambers and leading to beam instabilities. These effects induced by pressure increase have to be well understood to reach high performances for future machines as HL-LHC or FCC-ee. To get a better understanding of the global dynamic pressure phenomena, a new experimental setup dedicated to electron stimulated desorption (ESD) measurement, i.e. molecules released from the surface of a solid by the impact of an incoming electron, was developed. The experimental setup is located at IJCLab-Orsay, France, on PHIL photo-injector beam line. This setup is composed of an experimental vessel in the low 1e-10 mbar (N2 eq.) range and a pumping system. The total pressure and the partial pressure are monitored. A second vessel is dedicated to the electron beam characterization. Qualification and commissioning of the setup were performed. The electron-stimulated desorption by Compton electron on copper beam screen at room temperature for various primary electron energy, (MeV range) have been carried out.

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Thursday Poster Session / 1920

Implementation of workstation-based slow-orbit feedback for the upgrade of the Advanced Photon Source

Author: Louis Emery[1]

Co-author: Hairong Shang [1]

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Until the 22-kHz sampled fast orbit feedback is ready for the upgrade of the Advanced Photon Source, the light source will use a 1-Hz workstation- and EPICS-based orbit feedback using all of the features of the previous APS slower orbit correction. All 560 beam position monitors will be available in a 1-second time constant filter mode, and 320 and 400 dipole correctors will be available in the horizontal and vertical plane respectively. GUIs and other software will be presented, such as: configuration GUI where bpm and correctors are selected, which singular vectors to remove, and Tikhonov filtering for controlling the speed or noise suppression of spatial orbit error modes; GUI for launching workstation loop process, setting operations and alarm limits, and launching orbit/corrector displays; beamline-based light source point steering server and client system.

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Wednesday Poster Session / 1921

SuperKEKB IR upgrade idea with Nb3Sn quadrupole magnets

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The SuperKEKB IR is designed to achieve extremely small vertical and horizontal beta functions at the IP. Superconducting magnets provide the focusing magnetic field required to squeeze down the beta functions. The Belle II detector solenoid field is fully compensated with the superconducting anti-solenoids on each side of the IP. For further luminosity improvement, an upgrade of the superconducting final focus quadrupole magnets is required; a new canceling scheme for the Belle-II solenoid field, based on new anti-solenoids, is to be implemented.
The design concept of the new IR is to make the beam trajectory as parallel to the QC1 magnet axis as possible to cancel the X-Y coupling and chromaticity between the IP and QC1s and minimize vertical emittance by redesigning the anti-solenoid profile. Moving QC1P closer to the IP results in an increase in the required field strength and current density. Nb3Sn is selected as the cable material instead of the present NbTi. While superconducting properties are better, Nb3Sn magnet fabrication is quite difficult because of the brittleness of the material. New IR design idea and the technical challenges of the new IR magnets are described.

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MOCN: Beam Instrumentation, Controls, Feedback and Operational Aspects (Contributed) / 1922

Direct RF sampling based LLRF control system for C band linear accelerator

Author: Chao Liu[1]

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Low Level RF (LLRF) control systems of linear accelerators (LINACs) are typically implemented with heterodyne based architectures, which have complex analog RF mixers for up and down conversion.

The Gen 3 RF System-on-Chip (RFSoC) device from AMD Xilinx integrates data converters with maximum RF frequency of 6 GHz. That enables direct RF sampling of C band LLRF signal typically operated at 5.712 GHz without RF mixers, which can significantly simplify the system architecture. The data converters sample RF signals in higher order Nyquist zones and then up or down converted digitally by the integrated data path. The closed-loop feedback control firmware implemented in FPGA integrated in RFSoC can process the baseband signal from the ADC data path and calculate the updated phase and amplitude to be up-mixed by the DAC data path. We have developed an LLRF control RFSoC platform, which targets Cool Copper Collider (C3) and other C or S band LINAC research and development projects. In this paper, the architecture of the platform and the test results for some of the key performance parameters, such as phase and amplitude stability with our custom solid-state amplifier, will be described.

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Wednesday Poster Session / 1924

Investigation of longitudinal multi-bunch instabilities in the upgraded Advanced Photon Source

Author: Louis Emery[1]

Co-authors: Pavana Kallakuri [1]; Ulrich Wienands [1]; Weixing Cheng [1]

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The strongest five higher-order-modes (HOM) of each of the 12 single-cell RF cavities of the upgraded Advanced Photon Source (APS) are the main contributors to driving multi-bunch instabilities. The resonant frequencies of these HOMs are controlled by the cooling water temperature of the cavities, settings for which were partially determined in the last years of operation of the APS. With the change of the fundamental RF frequency of about +115 kHz (0.4 of the revolution frequency) for the upgraded APS storage ring, the optimum temperature tuning will change and the new optimum be verified. We report on: measurement of HOM frequencies as a function of cooling temperature and RF cavity wall power; measurement of HOM impedance using the bunch-by-bunch feedback system; running the feedback to suppress any instability; contributions from other sources, such as impedance of insertion device chambers and other shape transitions in the vacuum chamber.

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Wednesday Poster Session / 1925

Investigation of transverse instabilities in the upgrade of the Advanced Photon Source

Author: Louis Emery[1]

Co-authors: Pavana Kallakuri [1]; Ryan Lindberg [1]; Weixing Cheng [1]

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A Dimtel feedback system was installed in the Advanced Photon Source to suppress transverse single-bunch and multi-bunch instabilities. We report on the tune shift, decoherence, and any observed instabilities as a function of both chromaticity and stored current, and furthermore characterize the action of the feedback system. We compare observations with simulations that were done previously.

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Tuesday Poster Session / 1926

DYVACS code: calculation of gas density profiles for dynamic conditions in FCCee accelerator.

Author: Suheyla Bilgen[1]

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The computation of residual gas density profiles in particle accelerators is an essential task to optimize beam pipes and vacuum system design. In a hadron collider such as the LHC, the beam induces dynamic effects due to ion, electron and photon-stimulated gas desorption. The well-known VASCO was already used to estimate pressure profiles in steady state conditions. Nevertheless, some phenomena are not considered such as the ionization of residual gas by the electron clouds (EC) and the evolution of the electronic density related to the EC build up. Therefore, we proposed an upgrade by introducing EC maps to estimate the electron density and the ionization of gas by electrons. Results obtained with DYVACS reproduces with a good accuracy the experimental dynamic pressure recorded in the VPS beam pipes sector of the LHC from the proton beam injection to the stable beam

period, for several materials of vacuum chamber. Additionally, DYVACS was used as a predictive tool to compute the pressure evolution for the Future Circular Collider e- e+. New experimental measurements on electron-stimulated desorption by Compton electron have been carried out and implemented in DYVACS inputs.

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Monday Poster Session / 1927

Update on ion instability simulations for the APS-U

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Co-author: Michael Borland [1]

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Interaction between the beam and residual gas ions can lead to a variety of undesirable effects, such as instability and emittance growth. This ion instability is a serious concern for high-brightness electron storage rings, such as the APS-Upgrade. To study ion instability in detail, an IONEFFECTS element was added to the particle tracking code ELEGANT. Recently the IONEFFECTS code was updated to include a Poisson solver for calculating the ion-beam kicks, which is faster and more robust than previous methods. Using the Poisson solver method, IONEFFECTS has been used to model ion instability experiments done using a gas injection system at the APS. It has also been employed to make predictions and give guidance for APS-U storage ring operation. In particular, the effect of different bunch patterns has been studied, from initial APS-U commissioning through operation at full current. The simulations show that a compensated gap method should be effective at preventing ion instability during APS-U operation.

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WEAD: Photon Sources and Electron Accelerators (Contributed) / 1928

Two-color FEL pulse generation at PAL-XFEL

Author: Chi Hyun Shim[1]

Co-authors: Chang-Ki Min [1]; Chang-Kyu Sung [1]; Changbum Kim [1]; Gyujin Kim [1]; Haeryong Yang [1]; Heung-Sik Kang [1]; Hoon Heo [1]; Inhyuk Nam [1]; Kookjin Moon [1]; MyungHoon Cho [1]; Seong-Hoon Kwon [1]; Teyoun Kang [1]

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PAL-XFEL has achieved successful operation with both SASE and self-seeding modes. In an effort to broaden the capabilities of PAL-XFEL, research has been conducted on the generation of two-color XFEL pulses, leading to the development of two additional modes: two-color XFEL with time delay and pulse duration control, and time-synchronized two-color XFEL. In the first mode, a dipole magnet at the self-seeding section and a slotted foil at the bunch compressor are utilized. The pump and probe XFEL pulses are generated from undulators before and after the self-seeding section, respectively. The time delay between the pulses can be controlled using the dipole magnet, and the pulse duration can be manipulated using the triangular slotted foil. For the second mode, phase shifters are employed. Typically, phase shifters are used to optimize FEL intensity by matching the phase between the FEL pulse and the electron beam. However, by adjusting the phase shifter setting away from the matched condition, sideband spectra can be introduced, resulting in the generation of time-synchronized two-color XFEL pulses. The experimental results of these two additional modes will be presented.

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Wednesday Poster Session / 1929

First conduction cooled photoinjector status

Author: Roman Kostin[1]

Co-authors: Chunguang Jing [2]; Ernest Knight [3]; Yubin Zhao [3]; Mauricio Camarena [2]

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SRF photoguns become a promising candidate to produce highly stable electrons for UEM/UED applications because of the ultrahigh shot-to-shot stability compared to room temperature RF photoguns. SRF technology was prohibitively expensive for industrial use until two recent advancements: Nb3Sn and conduction cooling. SRF gun can provide a CW operation capability while consuming only 2W of RF power which eliminates the need of an expensive high power RF system and saves a facility footprint. Euclid is developing a continuous wave (CW), 1.5-cell, MeV-scale SRF conduction cooled photogun operating at 1.3 GHz. We aim for generation of the first beam in 2024. In this paper, we present the most up-to-date progress including results of the first cool down of the gun-cavity in the newly developed conduction cooled cryomodule and LLRF system development.

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Wednesday Poster Session / 1930

A faster initial cesium transfer for the LANSCE H- ion source

Author: David Kleinjan[1]

Co-authors: Anna Alexander [1]; Charles Rohde [1]; Gary Rouleau [1]; Levi Neukirch [1]

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The LANSCE H- Ion Source utilizes a cesium coated converter to induce H- surface conversion. To achieve an optimal cesium coating, a heated cesium reservoir and transfer tube vaporizes cesium onto the converter surface. An initial coating of cesium is done via an initial cesium transfer. During this process, the cesium heater is brought to a high initial temperature (250℃) and is slowly lowered to the operational temperature (˜190℃) over six hours, followed by a static conditioning for another 18 hours to get the cesium converter coating optimal for H- surface conversion. Any reduction in the 24-hour cesium transfer process would allow more for experimental time for LANSCE experiments. Thus, there is high value in seeking to reduce the initial Cs transfer time. The LANSCE H- Ion Source Laser Diagnostic Stand was recently utilized to take cesium density measurements inside the H- Ion Source as a function of cesium reservoir temperature. A comparison of the measured cesium densities to the theoretical cesium vapor pressure values will be presented. Also, results using the measured cesium densities to calculate and run a faster cesium transfer process will be discussed.

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Tuesday Poster Session / 1931

Snake matching in the EIC's hadron storage ring

Author: Eiad Hamwi[1]

Co-authors: Georg Hoffstaetter [1]; Haixin Huang [2]; Kiel Hock [2]; Vadim Ptitsyn [3]

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Pairs of Siberian Snakes allow the avoidance of first-order spin resonances during energy ramping in storage rings. Nevertheless, different combinations of multiple snakes lead to different higher-order resonances for the same bare ring. Finding an optimal combination of snakes is referred to as snake matching. Symmetries of the ring can be used to find optimal snake combinations that minimize first-order spin-orbit coupling integrals. In particular, for a 3-fold symmetric ring such as the HSR, 12 snakes are sufficient and their axes can be specified analytically. For a smaller number of snakes, the best snake combinations must be found by numerical optimization. While a 3-fold symmetric model is appropriate for RHIC and the HSR, 12 snakes seem excessive and numerical snake matching has therefore been performed with 6 snakes. We show the suppression of the strongest first-order resonances by varying the orientation of the snake axes in the horizontal plane and by optimizing the betatron phase advance in the arcs. Our 7-dimensional optimization leads to the weakest resonance structure using a variety of metrics and optimizes the polarization transmission.

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Monday Poster Session / 1932

Compact, all-optical positron production and collection scheme

Author: Davide Terzani[1]

Co-authors: Carl Schroeder [1]; Carlo Benedetti [1]; Eric Esarey [1]; Stepan Bulanov [1]

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We discuss a compact, laser-plasma-based scheme for the generation of positron beams suitable to be implemented in an all-optical setup. A laser-plasma-accelerated electron beam hits a solid target producing electron-positron pairs via bremsstrahlung. The back of the target serves as a plasma mirror to in-couple a laser pulse into a plasma stage located right after the mirror where the laser drives a plasma wave (or wakefield). By properly choosing the delay between the laser and the electron beam the positrons produced in the target can be trapped in the wakefield, where they are focused and accelerated during the transport, resulting in a collimated beam. This approach minimizes the

ballistic propagation time and enhances the trapping efficiency. The system can be used as an injector of positron beams and has potential applications in the development of a future, compact, plasma-based electron-positron linear collider. After injection, positrons can be accelerated to high energies in a plasma (e.g., using a plasma column) for applications to plasma-based colliders.

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Monday Poster Session / 1933

Highly charged magnesium ion production using laser ablation ion source at Brookhaven National Laboratory

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We are researching the development of an ultra-high intensity heavy ion source based on laser ablation ion source (LIS) technology coupled with a unique beam injection technique called Direct Plasma Injection Scheme (DPIS). A metallic target is ablated using a Q-switched Nd:YAG laser to generate a pulsed high-density plasma, which is then injected and accelerated by a radio-frequency quadrupole (RFQ) linear accelerator. The ion source enables the production of rare isotopes, the use of particle beams in cancer treatment, and nuclear physics experiments. The exploration of multiple charge states for Mg production is currently underway. The measurement of beam current is conducted using a Faraday cup positioned at the end of the beam line. Following the RFQ acceleration, the beam is transported by multiple quadrupole magnets and a steerer, and a dipole magnet then directs the beamline into the Faraday cup. Notably, we have accomplished an ion beam current of about 20 mA for Mg10+ ions and a current exceeding 10 mA for fully stripped Mg12+ ions. In this presentation, I will discuss the operation of the LIS at Brookhaven National Laboratory (BNL) and the outcomes of Mg ion production.

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Tuesday Poster Session / 1934

Test results of compact double-lever tuner for ILC SRF cavities

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A compact double-lever tuner for 1.3 GHz SRF cavity has been considered as baseline option for future SRF linacs like ILC in Japan and 8-GeV linac at Fermilab. In the framework of LCLS-II/LCLS-II-HE and PIP II projects, significant R&D efforts led to design of inexpensive and reliable tuners operating in CW mode. As part of US-Japan collaboration, FNAL/KEK team is working on further improving the double-lever tuner design. In this paper we present results of testing a tuner for 1.3 GHz cavities operating in pulsed mode.

Footnotes:

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North America

Thursday Poster Session / 1935

ALS-U AR RF equipment protection system

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This paper presents the design and development of the Radio-Frequency (RF) Equipment Protection System (EPS) for the Accumulator Ring (AR) of Advanced Light Source Upgrade (ALS-U) project at LBNL. The key components of AR RF EPS include an FPGA-based LLRF controller managing fast interlocks, RF Drive Control acting as primary RF mitigation device and a PLC-based Master Interlock subsystem handling slow interlocks and supervisory control of the AR RF System. The design of AR RF EPS components is presented along with their interaction with internal and external subsystems.

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North America

Wednesday Poster Session / 1936

Experience with the higher-harmonic cavity for the upgrade of the Advanced Photon Source

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In the upgrade of the Advanced Photon Source Upgrade ring a passive fourth-harmonic cavity (HHC), tuned at 1408 MHz, is used to lengthen the bunch to increase by a large factor the lifetime of the stored beam. We report on: the tuning of the cavity and the gap voltage generated by the beam, and an estimate of the bunch lengthening from the lifetime increase observed.

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North America

Thursday Poster Session / 1937

Online model fine-tuning using multi-fidelity simulations

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Modern accelerator design requires extensive simulation to find the best configurations. During accelerator commissioning, the lattice model is rapidly changing due to beam-based measurements, and it is desirable to update simulations to guide further tuning. However, continuous reevaluation is computationally infeasible. We propose a new approach of online multi-fidelity modelling, whereby lattice simulation data is used as a guide to be fine-tuned with sparse sampling of new simulations. Our implementation employs a multi-task Gaussian Process (GP) model to learn the correlation between old and new data as part of the fitting process and quantify prediction confidence. We then run new variable fidelity simulations (i.e. changing number of turns, grid size, etc.) using multi-fidelity Bayesian optimization with objective being to achieve desired accuracy at lowest compute time cost. This method optimally uses both coarse and fine simulations to bring overall model in agreement, saving enormous amounts of compute time and making online retuning feasible. It has proven useful during APS-U commissioning for nonlinear beam dynamics tuning, instability control, and other purposes.

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Monday Poster Session / 1938

Computational simulations and beamline optimizations for an electron beam degrader at CEBAF

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An electron beam degrader is under development with the objective of measuring the transverse and longitudinal acceptance of the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab. This project is in support of the CE+BAF positron capability. Computational simulations of beam-target interactions and particle tracking were performed integrating the GEANT4 and Elegant toolkits. A solenoid was added to the setup to control the beam's divergence. Parameter optimization of the solenoid field and magnetic quadrupoles gradient was also performed to further reduce particle loss through the rest of the injector beamline.

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North America

Monday Poster Session / 1940

Optimizing plasma-downramp profiles and beam transport for emittance preservation in multi-stage plasma accelerators

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Co-authors: Remi Lehe [1]; Carlo Benedetti [1]; Ryan Sandberg [1]; Olga Shapoval [1]; Axel Huebl [1]; Jean-Luc Vay [1]

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Plasma-based particle accelerators maintain accelerating fields that are several orders of magnitude higher than conventional accelerators. This allows for more compact accelerator footprints that can deliver particle beams of very high charge (> 100 pC) and large current (> kA) for various applications. Plasma-wakefield accelerators are promising candidates for next-generation TeV-class electron-positron colliders for high-energy physics and secondary light sources. However, to reach the desired TeV energy regime, a staging approach of independent laser-driven plasma accelerators that each preserve low energy spread and beam emittance is required. Maintaining beam emittance over tens and hundreds of stages is a serious challenge but is crucial to achieve a high luminosity in future collider experiments. We present results for the optimization of plasma-stage downramp profiles and inter-stage beam transport in simulations of multi-stage plasma accelerators, carried out with codes from the Beam pLasma & Accelerator Simulation Toolkit (BLAST) and steered by optimas, a Python library for optimization at scale, powered by libEnsemble.

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Monday Poster Session / 1941

Engineering of interaction region for a 200 keV inverse Compton scattering light source

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RadiaBeam is building an Inverse Compton Scattering (ICS) source with a complex Interaction Region to increase interaction efficiency. By colliding an infrared laser head-on with a tunable 60-100 MeV electron beam, up to 200 KeV photons are produced. This is done with a setup consisting of the final focus and re-capture system, an interaction chamber, an infrared (IR) laser beam delivery system, and a dump dipole. The vacuum chambers are constructed with a central cube at the interaction point (IP) flanked by symmetric laser-injection cubes. The IR interaction laser is injected downstream of the IP and exits the vacuum envelope upstream of the IP. Multiple optical transition radiation (OTR) foils allow for tuning the electron beam for the 10-micron beam size. Alignment at the IP relies on OTR radiators and scraping pinholes.

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Thursday Poster Session / 1942

Broadband impedance induced heating proxy for operation at higher total current at SIRIUS

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SIRIUS is a 4th generation synchrotron light source built and operated by the Brazilian Synchrotron Light Laboratory (LNLS), in Campinas, Brazil. Currently, SIRIUS storage ring operates in top-up mode at 100 mA in uniform fill. The main limiting factor for reaching higher currents is the temporary RF system in use. It is comprised of one PETRA VII-Cell cavity and two solid state amplifier towers that, combined, provide at most 120kW of power. By mid 2024, two superconducting RF cavities will replace the current cavity and two amplifier towers will be added to the system, allowing operation at higher currents. The design current of SIRIUS storage ring is 350 mA, which can only be achieved once a third harmonic cavity is installed to lengthen the bunches to avoid excessive wake-induced heating of sensitive components. However, the installation of such cavity is not foreseen in the near future, which raises the question of which is maximum current in uniform fill SIRIUS can be operated. This work will present some theoretical and experimental studies carried out to answer this question.

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North America

Thursday Poster Session / 1943

CXFEL labs

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The Compact X-ray Free-Electron Laser Labs (CXFEL Labs) encompass facility infrastructure that supports the operation of two beamlines, the Compact X-ray Light Source (CXLS) beamline (6-10 keV, <500 fs X-ray pulses @ 1 kHz), and the Compact X ray Free-Electron Laser (CXFEL) beamline (0.25-2.5 keV, <10 fs X-ray pulses @ 1 kHz). We present an overview of the science instrumentation and its requirements for CXLS and CXFEL and how these physics requirements translate to engineering specifications that drive the facility design. The facility design includes many interdependent systems including: network; on-lab and off-lab data processing and storage; fast and slow controls; air and water systems; health and safety systems; power distribution; vibration isolation; electron, laser, and x-ray beam transport, for example. We articulate specific challenges associated with beam transport where sub-10-fs timing requirements exist across multiple rooms, and network requirements for large data flow from 1 kHz source in a compact footprint with reasonable cost. We conclude with an overview of implementation status for the CXLS and CXFEL beamlines.

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Tuesday Poster Session / 1944

APS upgrade booster commissioning

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After a long shutdown, the Advanced Photon Source (APS) booster synchrotron was recently re-commissioned for the APS Upgrade (APS-U) project. The APS-U requirements for the booster are more demanding than the old APS: much higher bunch charge, reduced beam emittance, and improved charge stability of better than 5% shot to shot. The booster accelerates electron bunches of 1-12 nC from 425 MeV to 6 GeV at a 1 Hz rep rate. While the booster ring hardware was largely kept the same, it is now run on a separate RF source, which allows for frequency manipulation during the booster ramp. Photon diagnostics have recently been upgraded for reduced thermal drift. This paper will report on the booster re-commissioning process, including checkout of various systems, tests of the new RF source, and tuning for improved performance. It will also detail plans for further improvements, in particular for achieving even higher bunch charge.

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North America

Tuesday Poster Session / 1945

Preserving, restoring and conditioning the RF cavities of the storage ring for the Advanced Photon Source upgrade

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The RF cavities for the Storage ring RF systems were not changed or removed for APS-U. The paper discusses the process of preparing the cavities at the start of the upgrade, preservation through the upgrade installation process, challenges associated when restoring the cavities at the end of the installation period and finally the conditioning process of the RF cavities to operating power levels to allow for beam commissioning.

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Thursday Poster Session / 1946

Reducing background/noise in stretched wire alignment technique measurements

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The stretched-wire alignment technique is one method of magnet alignment for linear induction accelerators. The applications of the Stretched-Wire Alignment Technique (SWAT) have been implemented for aligning magnets/solenoids on the Scorpius linear induction accelerator which will be sited at the Nevada National Security Site and the Flash X-Ray (FXR) linear induction accelerator at Lawrence Livermore National Laboratory's Contained Firing Facility.
This article describes both systematic (repeatable) and random sources of background/noise as well as practical ways to either eliminate or mitigate them to acceptable levels. Systematic sources include reflections from wire ends, rapid sag due to ohmic heating of the wire, magnetic materials, and shot rate. Random sources include air currents, vibration of nearby equipment, mechanical stability of test equipment, and the instruments used to measure the wire motion. Mitigations include curve fitting and adaptive noise signal cancellation, and mechanical damping. Finite Element Analysis (FEA) was used to interpret results.

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Monday Poster Session / 1948

Wakefield studies for an ultra compact X-rays free electron laser

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Co-authors: Andrea Mostacci [2]; Atsushi Fukasawa [1]; Bruno Spataro [3]; Enrica Chiadroni [2]; Gerard Lawler [1]; James Rosenzweig [1]; Luigi Palumbo [2]; Martina Carillo [2]; Mauro Migliorati [4]; Monika Yadav [1]

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High flux, coherent hard X-rays constitute an efficient tool for applications in high resolution (sub nm) chip metrology which offers notable advantages to the modern semiconductor industry. A candidate source for such photons is represented by a recently proposed compact X-rays free electron laser (XFEL) based on high gradient cryogenic accelerating structures and short period cryogenic undulators. Moreover, such a design can be upgraded with the introduction of a regenerative amplifier scheme, known as XRAFEL, for increasing both the flux and the coherence of the Xray pulses. Unfortunately, the high performance obtained in the compact accelerating structures and undulator magnets are also accompanied by strong wakefields that can potentially introduce emittance dilution, large energy spread or even instabilities. In this paper we utilize a custom tracking code, MILES, to perform wakefield studies for the high brightness beam propagating in this machine. In particular, our analysis emphasizes the short-range and long-range beam break up interaction in the main linac as well as the energy spread introduced in the undulator system.

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Tuesday Poster Session / 1949

Models for power combining magnetrons in a magic tee

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Industrial accelerator applications require efficient, scalable, continuous wave (CW) microwave power systems. Magnetrons are inexpensive and efficient devices for converting electrical energy into microwave power; however, their power output is limited to approximately 100 kW. Cost effective power combining magnetron systems would serve the accelerator industry by providing practical and affordable RF power to accelerator applications.
In a magic tee configuration, two oscillators can be power combined and locked to a common frequency. Researchers at General Atomics, in collaboration with Thomas Jefferson National Accelerator Facility, have constructed an experiment to demonstrate the power combining of magnetrons in a such a configuration. An analytic model is presented describing the power combining efficiency of a 4-port magic tee, accounting for two magnetron output signals, an injection signal, and a reactive load. The Adler-Chen model is solved numerically using robust computational geometry

techniques*. These complete solutions provide insight to the phenomena of magnetron frequency locking and optimal combining efficiency, which are compared to experiment.

Footnotes:

- S. C. Chen, "Growth and frequency pushing effects in relativistic magnetron phase-locking,"IEEE Trans. Plasma Sci., vol. 18, no. 3, pp. 570–576, Jun. 1990, doi: 10.1109/27.55928.

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Thursday Poster Session / 1950

Generation of bunched beam for SRF industrial cryomodules

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Compact SRF industrial linacs can provide unique parameters of the beam (>1 MW and >1-10 MeV) hardly achievable by normal conducting linacs within limited space. SRF technology was prohibitively expensive until the development of conduction cooling which opened the way for compact stand alone SRF systems suitable for industrial and research applications. Limited cooling capacity puts strict requirements on the beam parameters with zero losses of the beam on the SRF cavity walls. This implies strict requirements on the beam energy to be accepted by the cryomodule and most importantly the beam bunching with zero particles in between. We present one possible solution for this problem based on velocity bunching and tails annihilation by a dipole. A group of bunchers provide beam bunching and energy boost from 20 keV up to 300 keV to be acceptable by the cryomodule.

Footnotes:

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North America

Tuesday Poster Session / 1951

Design and test plans for a 1.3-GHz, 100-kW high-efficiency IOT amplifier

Author: Mohamed Othman[1]

Co-authors: Michael Boyle [2]; Carlos Peqeuno [1]; Ann Sy [1]; Holger Schult [2]; Brandon Weatherford [1]

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Recent efforts at SLAC aim at developing high-power accelerators powered by compact, high-efficiency RF sources such as klystrons and Inductive output tubes (IOT). Stellant Systems (formerly L3Harris Electron Devices) has long pioneered the IOT design and recently leveraged its power toward various accelerator applications. In this talk, we show the progress of developing a 1.3 GHz HEIOT in terms of design, and manufacturing. We also show results of 3D space-charge beam dynamics simulation of an L-Band inductive output tube (IOT) RF electron gun using the accelerator code ACE3P as a transformative approach to HEIOT design. Based on the beam optics simulation we have designed an efficient output structure that results in >100 kW of average power with an upward of 80% power efficiency. We have designed the amplifier with special attention to cooling requirement at 100 kW including extensive thermal analysis of the anode, output structure and windows. We also commissioned a solid state driver for testing purposes. In this presentation we will discuss the progress of the amplifier build and the testing plans.

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Monday Poster Session / 1953

Progress of the nonlinear time-domain finite element solver implementation in the electromagnetic code ACE3P

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SLAC has developed the parallel finite element electromagnetics simulation suite ACE3P which employs the parallel high-order finite element (FE) method to solve Maxwell's equations at the macroscopic level. Under the support of an SLAC LDRD, optical nonlinearities in the transient regime have been incorporated into the ACE3P time-domain solver for the investigation of nonlinear physical processes such as harmonic generation, parametric processes and electro-optic effects. This nonlinearity will be applied to provide high fidelity modeling capability to quantum frequency converters employing nonlinear materials in quantum information science applications. The new solver has been benchmarked against the commercial solver ANSYS Lumerical. Furthermore, we have

completed the first prototype of the new nonlinear solver employing PETSc, a powerful suite of data-structure-neutral scalable numerical routines for large-scale linear and nonlinear problems. The PETSc library and the Scalable Nonlinear Equations Solvers (SNES) components include back-end CPU/GPU implementations thus offering the needed numerical methods for solving Maxwell's equations with nonlinearities.

Footnotes:

Funding Agency:

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North America

Wednesday Poster Session / 1954

Report on an international accelerator school - ISBA23

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The sixth International School on Beam dynamics and Accelerator technology (ISBA23) was held for 10 days from August 3rd to 12th, 2023 at Pohang in Korea. ISBA23 was jointly hosted by Korea Atomic Energy Re search Institute (KAERI) and Korea Accelerator and Plasma Research Association (KAPRA). After screening 83 registrant's resumes and letters of recommendation, 70 students from Korea, Japan, China, Taiwan, India, and Thailand were finally admitted to the school. For 10 days, 20 professional scientists from Korea, Japan, China, Taiwan, Thailand, Germany, and the USA gave 30 valuable lectures and 14 hands-on training sessions with ASTRA and ELEGANT accelerator codes. Thanks to the generous financial support from 14 sponsors, the school was successfully completed. This is the first time that ISBA has been held outside of Japan, and it is a big step toward becoming a truly international accelerator school. We report on ISBA23, which is the biggest international accelerator school in Asia.

Footnotes:

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Asia

Tuesday Poster Session / 1955

Status of SIRIUS top-up operation with users

Author: Liu Lin[1]

Co-authors: Fernando de Sá [1]; Gabriel Ascenção [1]; Murilo Alves [1]; Ximenes Resende [1]

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We report on the upgrades implemented in the SIRIUS storage ring during the first year of operations for users, aiming to improve the performance and reliability of its operation for users in top-up mode. SIRIUS is now preparing to start Phase 2, with the installation of the final RF system and new insertion devices.

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North America

Monday Poster Session / 1956

Attosecond research at the Linac Coherent Light Source

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Attosecond X-ray free-electron lasers can deliver isolated sub-fs pulses with a peak power that surpasses conventional table-top sources by more than six orders of magnitude in the soft X-ray region [1]. The intensity at the focus is sufficient for non-linear X-ray spectroscopy methods, and two-color configurations enable applications such as attosecond pump/attosecond probe experiments.
I will discuss the development of attosecond XFELs at the Linac Coherent Light Source: from the demonstration of isolated soft X-ray pulses with the XLEAP project, to the recent development of terawatt-scale pulses and attosecond pump/probe capabilities. I will also present our plans for attosecond science with the LCLS-II linac, which will enhance the available repetition rate by up to four orders of magnitude (up to 1 MHz [2]).

Footnotes:

[1] J. Duris et al. Nat. Photonics 14.1 (2020): 30-36.
[2] P. Abbamonte et al. SLAC-R-1053. 2015.

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Wednesday Poster Session / 1957

Lessons learned from hardware failure during AUP cabling

Author: Elizabeth Lee[1]

Co-authors: Algirdas Baskys [2]; Andy Lin [1]; Carlos Perez [1]; Elaine Buron [1]; Ian Pong [1]; Jean-Francois Croteau [1]; Michael Naus [1]; Thomas Lipton [1]

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The cabling facility at Lawrence Berkeley National Laboratory has experienced a heavy increase in workload during the US-HiLumi Accelerator Upgrade Project (AUP). Several critical components have experienced unexpected failure over the project's lifetime for reasons at least partly attributable due to increased wear and tear on the hardware subsystems. This work presents three case studies of varying severity and lessons learned from each failure. Suggested strategies to ensure operational readiness and uptime for legacy systems are also discussed.

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Tuesday Poster Session / 1958

Performance Improvement of LTS Undulators for synchrotron light sources

Author: Akihiro Kikuchi[1]

Co-authors: Alexander Zlobin [2]; Daniele Turrioni [2]; Emanuela Barzi [2]; Ibrahim Kesgin [3]

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The expertise of ANL and FNAL has led to the production of Nb3Sn undulator magnets for the ANL Advanced Photon Source (APS). These magnets showed performance reproducibility ˜100% of the short sample limit, and a design field increase of 20% at 820 A. However, the long training did not allow obtaining the expected 50% increase of the on-axis magnetic field with respect to the 1.1 T produced at 450 A current in the ANL NbTi undulator. To address this, 10-pole long prototypes were fabricated, and CTD-101K® was replaced as impregnation material with TELENE®, an organic olefin-based thermosetting dicyclopentadiene resin produced by RIMTEC Corporation, Japan. Training and magnet retraining after a thermal cycle were nearly eliminated, with only a couple of quenches needed before reaching short sample limit at over 1,100 A. TELENE will enable operation of Nb3Sn undulators much closer to their short sample limit, expanding the energy range and brightness intensity of light sources. TELENE is Co-60 gamma radiation resistant up to 7-8 MGy, and therefore already applicable to impregnate planar, helical and universal devices operating in lower radiation environments than high energy colliders.

Footnotes:

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Monday Poster Session / 1959

Cryogenic testing of CuAg alloys for high gradient cavities

Author: Gerard Lawler[1]

Co-authors: Bruno Spataro [2]; Evgenya Simakov [3]; Fabio Bosco [1]; James Rosenzweig [1]; Paul Carriere [4]

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Increasing accelerating gradients in normal conducting cavities is a major focus in the development of future lepton linacs in applications like light sources and medical devices. To this end, improved understanding of material and surface physics of cavities is of paramount importance especially in the context of reducing breakdown rates. We are here interesting in considering the use of CuAg silver alloys to improve material properties such as hardness. We present on the preparation and measurements of CuAg pillbox cavities. Unloaded quality factor measurements are compared with existing C101 measurements in a significant range of temperatures from room temperature to below 77 K.

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North America

Wednesday Poster Session / 1960

Design and implementation of an instrumentation & control system for cathodes and radio-frequency interactions in extremes project

Co-authors: Brian Haynes [1]; Evgenya Simakov [1]; Tyagi Ramakrishnan [1]; Walter Barkley [1]

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The Accelerator Operations and Technology division at Los Alamos Neutron Science Center (LANSCE) is working on designing and implementing an Instrumentation and Controls System (ICS) for the Cathodes and Radio-frequency Interactions in Extremes (CARIE) project. The system will utilize open-source Experimental Physics and Industrial Control System (EPICS) developed for scientific facilities for control, monitoring, and data acquisition. The hardware form factors will include National Instrument's (NI) cRIO automation controller for industrial-like slow inputs/outputs and NI's PXIe for high-speed data acquisition for diagnostic signals featuring masked and event-based time window capture. In this paper, we will discuss the reasons that led to the design, the hardware and software design specifics, the challenges that we faced during implementation, including the EPICS device support for NI PXIe, as well as the advantages and drawbacks of our system given the experimental nature of the CARIE project.

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Tuesday Poster Session / 1962

Future directions for RF buncher at LANSCE proton storage ring

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Co-authors: Janardan Upadhyay [1]; Wesley Hall [1]; Maria Sanchez Barrueta [1]

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Los Alamos Neutron Science Center (LANSCE) is designing a Proton Storage Ring (PSR) refurbishment as part of the proposed LAMP project. An important component of this is the ring RF bunching system at h=1 for one circulating bunch. It has operated with high availability since an upgrade was installed in 1999 to raise the gap voltage*. A second RF system at h=2 is planned to improve the bunching factor, reducing the peak beam current at the center of the bunch resulting from space charge forces, helping mitigate effects of electron cloud and leaving an avenue for circulating two bunches in the future. The unique low output impedance RF system for h=1 is based on a cathode follower configuration using push-pull triode vacuum tubes. This feature provides automatic beam loading compensation without active feedback or feedforward systems. The triodes are no longer produced, and suitable replacements are unavailable. The ferrite rings of the h=1 system are also obsolete. Our goals include determining a suitable replacement amplifier configuration that can work on either frequency, and developing a replacement resonator for each harmonic that uses current production ferrite material.

Footnotes:

- J. Lyles, J. Davis, "Improvements to the Cathode-Follower RF Amplifier System for the LANSCE PSR Buncher", Proc. PAC'99, New York, pp. 1001-3.

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Thursday Poster Session / 1963

Development of a compact electron cyclotron resonance accelerator for industrial and security applications

Author: Mark Palmer[1]

Co-authors: Jay Hirshfield [2]; Mikhail Fedurin [1]; Xiangyun Chang [3]; Yong Jiang [4]

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[2] *Omega-P, Inc.*

[3] *Yale University*

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We describe the development of a novel accelerator, an electron Cyclotron Resonance Accelerator (eCRA) [1], to produce high power electron beams and X-ray beams for medical, research, sterilization, and national security applications. The several attractive features of eCRA include: a compact robust room-temperature single-cell RF cavity as the accelerating structure; continuous ampere-level high current output; and production of a self-rastering electron beam, thus eliminating the need for a separate beam scanner. Progress on the eCRA development, including numerical simulation, engineering design, and on-going experimental efforts will be reported here.

Footnotes:

[1] Shchelkunov, S. V. and Chang, X. and Hirshfield, J. L., 2022, Compact cyclotron resonance high-power accelerator for electrons, Phys. Rev. Accel. Beams, 25, 021301.

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Monday Poster Session / 1964

Superradiance in X-ray free-electron lasers

Author: Agostino Marinelli[1]

Co-authors: Paris Franz [2]; River Robles [2]

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The soliton-like superradiant regime in a free-electron laser is a fully non-linear phenomenon in which the bandwidth of a short pulse can be coherently broadened as the pulse is amplified. As such, superradiance has long been considered a promising route towards high-power ultrashort pulses exceeding the natural bandwidth of high-gain FELs. This regime has now been observed in several experiments from the infrared to the X-ray energy range. These experiments have confirmed intriguing effects such as the generation of self-similar pulses and coherent bandwidth broadening beyond the linear amplification bandwidth. I will review the existing experimental evidence for soliton-like superradiant behavior and compare these results with theoretical predictions.

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North America

Monday Poster Session / 1965

Test of a metamaterial structure for structure-based wakefield acceleration

Author: Dillon Merenich[1]

Co-authors: Brendan Leung [1]; Charles Whiteford [2]; Darrell Doran [2]; Eric Wisniewski [3]; Gaurab Rijal [1]; Gongxiaohui Chen [2]; John Power [2]; Wanming Liu [2]; Xueying Lu [2]

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[2] *Argonne National Laboratory*

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Metamaterial accelerators driven by nanosecond-long RF pulses show promise to mitigate RF breakdown. Recent high-power tests at the Argonne Wakefield Accelerator (AWA) with an X-band metamaterial structure have demonstrated to achieve a gradient of 190 MV/m, while we also observed a new acceleration regime, the breakdown-insensitive acceleration regime (BIAR), where the RF breakdown may not interrupt acceleration of a main beam. Statistical analysis between different breakdown types reveals that the characteristics of the BIAR breakdown are beneficial to high-gradient acceleration at short pulse lengths.

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North America

Monday Poster Session / 1966

Recent developments and future plans for Brookhaven's Accelerator Test Facility

Author: Mark Palmer[1]

Co-authors: Igor Pogorelsky [1]; Marcus Babzien [1]; Mikhail Fedurin [1]; Mikhail Polyanskiy [1]; William Li [1]

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The Accelerator Test Facility (ATF) at Brookhaven National Laboratory is a DOE Office of Science User Facility supported by the DOE Office of Accelerator R&D and Production. It provides its users with 3 major beam capabilities: 75 MeV high brightness electron beams, multi-terawatt long-wave infrared (LWIR) laser beams, and near infrared (NIR) laser beams. These capabilities can be used individually or in any combination by users. Over 20 active experimental efforts in advanced accelerator and laser research are presently underway. Recent progress and future plans for the ATF are described.

Footnotes:

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North America

Monday Poster Session / **1967**

Enabling access to research capabilities through Brookhaven's accelerator science & technology initiative

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Brookhaven National Laboratory is presently implementing dedicated accelerator research space to support development of accelerator technology for industrial, security, and medical applications. The need for such research capacity was identified through interactions with non-DOE organizations needing support in the development of accelerator technology as part of outreach events supported by DOE's Accelerator Stewardship Program in 2018. 3 research areas form the basis for the new Low Energy Accelerator Development (LEAD) Facility which aims to support partnerships in accelerator R&D and technology development.

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North America

Thursday Poster Session / **1968**

Machine learning for the LCLS-II injector online modeling and optimization

Author: Zihan Zhu[1]

Co-author: Auralee Edelen [1]

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The LCLS-II is a high repetition rate upgrade to the Linac Coherent Light Source (LCLS). The emittance and dark current are both critical parameters to optimize for ideal system performance. Here

we summarize the role these tools played in the commissioning period and are playing in the current operational stage of the LCLS-II injector, which provides an example of how other accelerator facilities may benefit from combining online modeling and optimization infrastructure. We also describe current progress on creating a fully deployed digital twin of the LCLS-II injector based on a combination of ML modeling and physics modeling, using the LUME software suite and various ML-based characterization tools. Finally, we will describe current efforts and plans to leverage the online LCLS-II injector model in fast optimization and control schemes.

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North America

Tuesday Poster Session / 1969

Advanced utilization of a single laser source for an inverse Compton scattering system

Author: Loic Amoudry[1]

Co-authors: Adam Moro [1]; Alex Murokh [1]; Amirari Diego [2]; Dmitriy Gavryushkin [1]; Maksim Kravchenko [2]; Maximilian Lenz [3]; Nanda Matavalan [1]; Nathan Burger [2]; Pietro Musumeci [4]; Robert Berry [1]; Robert Foster [2]; Tara Hodgetts [2]

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An Yb:YAG laser has been used to generate both the electron emission from a photocathode and act as the interaction laser on a 100 MeV inverse Compton scattering experiment. The laser generates 25 mJ pulses at 1030 nm, 1.5 ps long, up to 120 Hz. 10 % of the energy is sent into a Fourth Harmonic Generation (FHG) module where frequency doubling happens twice. Up to 200 µJ of adjustable Ultra-Violet (UV) laser can be exploited and sent towards the photocathode. The rest of the energy, 90 % of the initial IR beam, is propagated to the interaction region. The goal is to match 1mm beam on the photocathode and 40 µm at the interaction region with high stability. To reach it, significant effort was put into optimization using state of the art laser propagation software. We used a set of tools like low aberrations lenses, truncated Gaussian beam, vacuum transport, relay of images, and closed loop stabilization system. In the end, this project pairs strong optical and mechanical constraints. A large part of it was built and tested, showing exciting results.

Footnotes:

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Tuesday Poster Session / 1970

A reformulated accelerator R&D program as envisioned by the 2023 Particle Physics Project Prioritization Panel

Author: Mark Palmer[1]

Co-authors: Amalia Ballarino [2]; Cameron Geddes [3]; Robert Zwaska [4]; Tor Raubenheimer [5]

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[2] *European Organization for Nuclear Research*

[3] *Lawrence Berkeley National Laboratory*

[4] *Fermi National Accelerator Laboratory*

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Corresponding Author: mpalmer@bnl.gov

The 2023 Particle Physics Project Prioritization Panel recommends an updated approach for accelerator R&D activities in the US research program. Key recommendations for the DOE-HEP General Accelerator R&D Program, a new targeted Collider R&D program, and the potential for increased engagement with the NSF are described.

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North America

Thursday Poster Session / 1971

Interplay of space charge, emittance, and angular momentum in a flat-to-round transformer

Author: Liam Pocher[1]

Co-authors: Brian Beaudoin [1]; David Sutter [1]; Irving Haber [1]; Kevin Hermstein [1]; Patrick O'Shea [2]; Santiago Bernal [1]; Tom Antonsen [1]

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We present simulations compared to an experiment based on Derbenev's flat-to-round (FTR) transformation designed to match an electron beam from a high energy storage ring into a solenoidal cooling channel. Our experiment transports a large-aspect-ratio electron beam through a skew quadrupole system and a long solenoid. We focus on examining the complex dynamics of FTR systems in low-energy electron beams where space charge is a major factor. We explore the interplay of angular momentum imparted by the skew quadruples with emittance and space charge in the transport system. We have found that while the envelope equations accurately predict averaged beam parameters, beam evolution details depend on the initial beam distribution. We present simulation results that illuminate the complex interplay of emittance, space charge, and angular momentum in non-ideal beam distributions, and we test our understanding against experimental results described elsewhere in these proceedings.

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Monday Poster Session / 1972

Dispersion orbit detection by orbit harmonic analysis and potential applications

Author: Fernando Sannibale[1]

Co-author: Thorsten Hellert [1]

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Electron storage rings in synchrotron light sources are typically composed of N identical sectors that repeat over the ring. Transverse plane betatron frequencies are not an integer harmonic of the beam revolution frequency to avoid that accelerator imperfection effects are turn-by-turn amplified causing beam losses. Consequently, orbit variations induced by ring parameters not affecting beam energy, do not show periodicity equal to N, while variations affecting energy do generate dispersion orbits with N periodicity. In the relativistic case, the beam energy in a ring is set by its closed orbit length (set by the RF) jointly with the field in bend magnets. Ring thermal expansion/compression, undulator gaps variations, etc. cause energy variations and periodic dispersion orbits. In the frequency domain, the real-time amplitude of these orbits can be determined from their N spectral line magnitude and phase. This info can be used in orbit feedbacks to adjust the RF to remove orbit dispersion components avoiding conflict with the corrector magnet action. Measurements performed at the ALS in Berkeley to validate the technique are presented. Application possibilities are also discussed

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North America

Tuesday Poster Session / 1973

Multiphysics design of a high heat-load superconducting undulator

Author: Yung-Chuan Chen[1]

Co-authors: Alessandro Schillaci [2]; Osvaldo Chimalpopoca [1]; Ronald Agustsson [2]

[1] *RadiaBeam Technologies*

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RadiaBeam is developing and manufacturing a 15-mm period, 1.15 T high temperature superconductor undulator using Magnesium Diboride (MgB2) wire to operate in a temperature range of 10 K - 15 K. This temperature range can be achieved by a cryocooler, a simpler and less expensive cryogenic solution compared to a liquid helium approach. As the supported current density, and ultimately the quench behavior of MgB2 wire, is a combined problem of magnetic field, tensile stress, tensile strain and temperature, a multiphysics approach is required. We will present the details of this multiphysics design addressing the magnetic, mechanical and thermal engineering challenges, along with the devices anticipated performance characteristics.

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Tuesday Poster Session / 1974

Higher order modes characteristic of the capacitive type RF cavity at the Siam Photon Source

Author: Nawin Juntong[1]

Co-authors: Chatchabhumi Dhammatong [1]; Keerati Manasatitpong [2]; Kritsada Kittimanapun [1]; Sarawut Bootiew [1]; Somjai Chunjarean [1]; Thakonwat Chanwattana [1]

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The present storage ring of the Siam Photon Source is equipped with the new 118 MHz capacitive type RF cavity, adapted from MAX-IV laboratory. This cavity has been installed in the ring since 2016. The cavity is operated with the digital low level RF controller and the solid-state RF amplifier. The system is running fine with less downtime and maintenance. After the full four insertion devices were added in the ring, there are instabilities detected in the beam signals. Investigation on the cavity were carried out with the simulation and measurement to characterize the higher order modes that may causes beam instabilities, especially the longitudinal modes. Simulation of the higher order modes will be presented. The modes properties from the measurements with various temperatures will also be presented. The cavity has two ports on its body reserved for the higher order modes damping mechanism. This study will be served as the baseline of the modes for the future designing of the damping mechanism.

Footnotes:

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Asia

Monday Poster Session / 1975

Crossing angle implementation for luminosity maximization in a narrow vertex region in RHIC operation

Author: Chuyu Liu[1]

Co-authors: Kiel Hock [1]; Kirsten Drees [1]; Michael Blaskiewicz [1]; Severino Binello [1]; Travis Shrey [1]; Wolfram Fischer [1]

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The Relativistic Heavy Ion Collider (RHIC) was designed for head-on collisions in the Interaction Regions. However, RHIC operation in recent years necessitated crossing angles to limit collisions to a narrow longitudinal vertex region, which created operating conditions with a large Piwinski angle (LPA). The angles were implemented by adjusting the shunt currents of four dipoles, the D0 and DX magnets, near the IP. The longitudinal bunch profile often deviates from Gaussian due to the utilization of high-order RF cavities, adding complexity to calculating luminosity reduction with crossing angle. This paper introduces two methods for implementing crossing angles, discusses resultant aperture concerns, conducts numerical calculations of luminosity reduction, and compares these findings with experimental observations.

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North America

Monday Poster Session / 1976

Study of orbital effects on EIC detector synchrotron radiation background

Author: Chuyu Liu[1]

Co-authors: Charles Hetzel [2]; Christoph Montag [1]; Kirsten Drees [1]; Michael Sullivan [3]; Vera Shmakova [2]

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Synchrotron radiation could contribute to detector background significantly, especially when the electron beam deviates from the design orbit. Without effective control, synchrotron radiation could impede physics data taking or even damage detector components. One of the key contributors to suppress synchrotron radiation in the Electron-Ion Collider IR is to control the electron orbit upstream the detectors. Therefore, it is imperative to define the tolerance of orbit errors in the IR which requires studying the orbital effects on synchrotron radiation. In this report, we will present the studies of orbital effects on synchrotron radiation background in EIC IR, including beam offsets introduced by upstream dipole, correctors, and quadrupole offsets.

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North America

Monday Poster Session / 1978

Local and global betatron coupling correction based on beam position measurements in RHIC

Author: Chuyu Liu[1]

Co-authors: Brendan Lepore [1]; Derong Xu [1]; Henry Lovelace III [1]; Kirsten Drees [1]; Michiko Minty [1]; Yun Luo [1]

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Local coupling correction in Interaction Regions (IRs) and global coupling correction based on Base-Band Tune (BBQ) measurement have been performed routinely for RHIC operation. However, one still observes significant residual local coupling measured by beam position data. For the Electron-Ion Collider (EIC) project, betatron decoupling for the hadron beam needs to be improved to maintain a large horizontal to vertical beam emittance ratio (12:1). In this paper, we will analyze the cause for noticeable residual coupling in RHIC and propose an integrated local and global betatron coupling correction based on beam position measurements and verify the new scheme with simulation and measurements.

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Tuesday Poster Session / 1979

Solid state amplifier project at the Advanced Photon Source

Author: Douglas Horan[1]

Co-authors: Aditya Goel [1]; Ali Nassiri [1]; Branko Popovic [1]; David Meyer [1]; Geoff Waldschmidt [1]; Gianfranco Trento [1]; Nicholas DiMonte [1]; Timothy Madden [1]; William Yoder [1]

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Argonne National Laboratory is in the process of acquiring solid state amplifiers from R&K to replace four 1 MW klystrons due primarily to obsolescence issues. Based on present needs for the APS-Upgrade, twelve 160 kW SSA RF amplifier systems will be required to replace the legacy klystrons. Each of the 352 MHz SSA systems consist of control racks, two 85 kW amplifier racks, four 48-way coaxial combiners, and a single 4-way waveguide combiner. The system is designed with particular attention to reliability and redundancy to help ensure high reliability metrics for the APS-U RF system.

Footnotes:

Funding Agency:

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North America

Wednesday Poster Session / 1980

Mechanical mesign of the thermal imaging system for the FRIB target

Author: Sergio Rodriguez Esparza[1]

Co-authors: Aftab Hussain [1]; Frederique Pellemoine [2]; Igor Nesterenko [1]; Marc Hausmann [1]; Mikhail Avilov [3]; Mohit Patil [1]; Steven Lidia [1]; Tracy Xu [1]

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As the Facility for Rare Isotope Beams (FRIB) ramps up to 400 kW, a thermal imaging system (TIS) is essential to monitor the beam spot on the production target. The TIS is an array of mirrors and a telescope in the target vacuum chamber; this relays the image through a window to the optics module outside the chamber. The design presented many challenges from alignment, to remote installation of the TIS and integrated shielding, and repeatable re-installation of the mirror array and optics module. The target TIS has been in operation since 2021 and supports FRIB operations for secondary beam production, with incident power up to 10 kW. The temperatures seen validate the expected temperatures from analysis. The mechanical design of the FRIB target TIS is presented here as well as initial performance.

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Monday Poster Session / 1981

Low-alpha operation of the IOTA storage ring

Author: Michael Wallbank[1]

Co-authors: Alexander Romanov [1]; Giulio Stancari [1]; Jonathan Jarvis [1]; Nathan Eddy [1]

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Corresponding Authors: jjarvis@fnal.gov, wallbank@fnal.gov

Operation with ultra-low momentum-compaction factor (alpha) is a desirable capability for many storage rings and synchrotron radiation sources. For example, low-alpha lattices are commonly used to produce picosecond bunches for the generation of coherent THz radiation and are the basis of a number of conceptual designs for EUV generation via steady-state microbunching (SSMB). Achieving ultra-low alpha requires not only a high-level of stability in the linear optics but also flexible control of higher-order compaction terms. Operation with lower momentum-compaction lattices has recently been investigated at the IOTA storage ring at Fermilab. Experimental results from some

initial feasibility studies will be discussed in the context of ensuring an improved understanding of the IOTA optics for future research programs.

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Monday Poster Session / 1982

Fast-ramping alpha magnet for interleaved operation at ANL APS

Author: Yung-Chuan Chen[1]

Co-authors: Animesh Jain [2]; Davide Bianculli [3]; Geoff Waldschmidt [4]; Kent Wootton [4]; Mark Jaski [4]; Ronald Agustsson [5]; Tara Hodgetts [5]; William Berg [4]

[1] *RadiaBeam Technologies*

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RadiaBeam is designing and manufacturing a fast-ramping alpha magnet is developed for interleaved operation at the Argonne APS. This interleaving operation requires the alpha magnet to stably complete a 5 s long cycle with a 100 ms ramp-up, 1000 ms nominal field output and a 100 ms ramp-down. A laminated yoke is used to minimize eddy currents, ensure fast field response times and reduce core-loss during operation. The magnetic and mechanical design demonstrating the performance of this 2.75 T/m maximum field gradient alpha magnet within a 10 cm x 14 cm good field region will be presented along with the current fabrication status.

Footnotes:

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North America

Tuesday Poster Session / 1983

Progress on the normal conducting magnets for the Electron-Ion Collider

Author: Racquel Lovelace[1]

Co-authors: Holger Witte [2]; Christoph Montag [2]; Vahid Ranjbar [1]; J. Berg [2]; Steven Tepikian [2]; Daniel Marx [2]; Sara Notaro [2]; George Mahler [2]; Sarin Philip [3]; Chase Dubbe [3]; Mark Jaski [4]; Joseph Xu [4]

[1] *Brookhaven National Laboratory (BNL)*

[2] *Brookhaven National Laboratory*

[3] *Thomas Jefferson National Accelerator Facility*

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The electron-ion collider (EIC) at Brookhaven National Laboratory (BNL) is designed to deliver a peak luminosity of 1e+34 1/cm2 1/sec. The EIC will take advantage of the existing Relativistic Heavy Ion Collider (RHIC) facility. Two additional rings will be installed: an electron storage ring (ESR) and a rapid cycling electron synchrotron ring (RCS).
This paper presents an update on the normal conducting magnet designs required for both the ESR and RCS rings. The ESR will store polarized electron beams up to 18 GeV and utilizes a triplet of dipole magnets to increase the emittance at 5 GeV and generate excess bending to create additional radiation damping to allow a larger beam-beam tune shift. The RCS will accelerate single bunches of spin-polarized electrons at various energies from 5 GeV to 18 GeV, with a ramp rate of 100 ms and 1 Hz repetition rate. Both rings require dipole, quadrupole and sextupole magnets with different specifications.

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North America

Monday Poster Session / 1984

Design and modeling of HOFI plasma channels for laser plasma accelerators

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Structured plasma channels are an essential technology for driving high-gradient, plasma-based acceleration and control of electron and positron beams for advanced concepts accelerators. Laser and gas technologies can permit the generation of long plasma columns known as hydrodynamic, optically-field-ionized (HOFI) channels, which feature low on-axis densities and steep walls. By carefully selecting the background gas and laser properties, one can generate narrow, tunable plasma channels for guiding high intensity laser pulses. We present on the development of 1D and 2D simulations of HOFI channels using the FLASH code, a publicly available radiation hydrodynamics code with specific improvements to model plasma channels. We explore sensitivities of the channel evolution to laser profile, intensity, and background gas conditions. We examine efforts to benchmark these simulations against experimental measurements of plasma channels. Lastly, we discuss ongoing work to couple these tools to community PIC models to capture variations in initial conditions and subsequent coupling for laser wakefield accelerator applications.

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Tuesday Poster Session / 1985

Application and comparative analysis of the APES_CBI module in BEPC-II experimental results

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This paper primarily explores the application and comparative analysis of the Accelerator Physics Emulation System Cavity-Beam Interaction (APES_CBI) module in the BEPC-II (Beijing Electron-Positron Collider) experiments. The APES_CBI module is an advanced time-domain solver, designed for analyzing RLC circuits driven by beam and generator currents and simulating the dynamic responses and synchrotron oscillations of charged particles within the cavity.
The paper details the module's application in BEPC-II experiments, particularly in simulating beam dynamics under strong beam-loading conditions and interactions with the accelerator's impedance. It focuses on analyzing the module's performance, accuracy, and efficiency in simulating synchrotron oscillations and beam-beam interactions under complex beam conditions.
By comparing the simulation results of the APES_CBI module with the experimental data from BEPC-II, this paper demonstrates the module's capability in accurately simulating complex physical phenomena within accelerators. This comparison not only validates the effectiveness of the CBI module but also offers valuable insights for future accelerator design and research.

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Asia

Monday Poster Session / 1986

High gradient testing of cryogenic C-band distributed coupling cavities

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High field radio frequency (RF) accelerating structures are an essential component of modern linear accelerators (linacs) with applications in photon production and ultrafast electron diffraction. Most advanced designs favor compact, high shunt impedance structures in order to minimize the size and cost of the machines as well as the power consumption. However, breakdown phenomena constitute an intrinsic limitation to high field operation which ultimately affects the performance of a given structure requiring dedicated tests. The introduction of a recent design based on cryogenic distributed coupling structures working at C-band (˜6 GHz) allows to increase the shunt impedance by use of alternative distribution schemes for the RF power while mitigating the breakdowns thanks to the low temperature. In this paper we introduce the plan for high field and breakdown tests envisioned for a simple two-cell version of the aforementioned structure. Moreover, we also discuss the joining procedure utilized to unify the two fabricated halves of such a structure and relying on the diffusion bonding technique which constitutes an attractive alternative to the brazing approach.

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North America

Thursday Poster Session / 1988

An online analysis platform to facilitate analysis at X-ray light source

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The design, execution, and analysis of light source experiments requires the use of sophisticated simulation, controls and data management tools. Existing workflows require significant specialization to accommodate specific beamline operations and data pre-processing steps necessary for more intensive analysis. Recent efforts to address these needs at the National Synchrotron Light Source II (NSLS-II) have resulted in the creation of the Bluesky data collection framework, an open-source library for coordinating experimental control and data collection. Bluesky provides high level abstraction of experimental procedures and instrument readouts to encapsulate generic workflows. We present a prototype analysis platform for coordinating data collection with real time analysis at the beamline. Our application leverages a flexible run engine to execute user configurable Python-based analyses with customizable queuing and resource management. We discuss initial demonstrations to support X-ray photon correlation spectroscopy experiments and future efforts to expand the platform's features for adaptive and machine-learning informed workflows.

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Monday Poster Session / 1989

Observation of skewed electromagnetic wakefields in an asymmetric structure driven by flat electron bunches

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Charged-particle beams with intense longitudinal fields in accelerating structures inevitably couple to transverse modes, potentially causing beam break-up instability. To maintain beam quality in applications like linear colliders, addressing this coupling is crucial. Flat-beams, featuring highly asymmetric transverse sizes, can delay the initial instability in slab-symmetric structures. However, this only serves as a temporary solution. In exploring the hazards of transverse coupling, our experiment focuses on a flat-beam near a planar dielectric lined structure. Measurements unveil a novel skew-quadrupole-like interaction when the beam is canted transversely, absent when the flat-beam is parallel to the dielectric surface. Using a multipole field fitting algorithm, we reconstruct transverse wakefields and generate an effective kick vector map through a theoretical model and particle-in-cell (PIC) simulations for realistic particle distributions.

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Tuesday Poster Session / 1990

Particle accumulator ring restart and readiness for Advanced Photon Source upgrade commissioning

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At the Advanced Photon Source (APS), a 425-MeV Particle Accumulator Ring (PAR) is used to stack 1-nC electron pulses from the linac and inject a single bunch into the Booster at a 1-Hz repetition rate. All the APS injectors, including PAR, were shut down in April 2023 at the start of the APS Upgrade Dark Time. In this paper, we report on PAR restart activities from October-December 2023. The PAR vacuum pressure was unexpectedly high when first powering the fundamental and harmonic RF systems, as well as when first injecting the beam, which initially limited both the beam charge and RF gap voltage. These limits were overcome through many weeks of systematic RF and vacuum conditioning. Additional restart activities include commissioning two new kicker chambers with a special low-impedance, eddy-current-suppressing coating, final commissioning and transition to operations of the digital low level RF system, and tests with the APS-U Injection Extraction Timing system. We demonstrated APS-U commissioning performance goals: a stable, 5-nC bunch charge with a bunch length short enough for injection into the Booster.

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Tuesday Poster Session / **1991**

Vacuum conditioning in the Advanced Photon Source upgrade storage ring

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With the goal of achieving the design beam lifetime, dedicated vacuum conditioning was carried out during commissioning of the APS Upgrade 6-GeV storage ring. Bakeout and activation of the non-evaporative getter (NEG) coating were used to initially condition the vacuum chamber surfaces without beam. The RF cavities, which are re-used from the former APS 7-GeV storage ring, were conditioned to high power similarly to the procedure used in the past. Vacuum conditioning was carried out with beam by optimizing the bunch charge, bunch number, and injection interval. In addition, vacuum scrubbing was tested using an orbit wave using orthogonal orbit knobs. The APS-U has new limits on injected beam power that derive from radiation safety modeling, and this constrains the vacuum conditioning beam parameters. These limits are imposed by a new Beam Shutoff Current Monitor safety interlock. In this paper, vacuum conditioning progress is presented and compared with predictions from simulations.

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Monday Poster Session / **1992**

Optimization of laser coupling into optically field ionized plasma channels for laser-plasma acceleration

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Laser-plasma accelerators (LPAs) can have high acceleration gradients on the order of 100 GeV/m. The high acceleration gradients of LPAs offer the possibility of powering future colliders at the TeV range and reducing the size of particle accelerators at present energy levels. LPAs need tightly focused, high intensity laser pulses and require guiding structures to maintain the laser focus over the optimum acceleration length. It is necessary to match the parameters of the guiding structure and the laser pulse to couple the maximum laser energy into the guiding structure. Optically field ionized (OFI) plasma channels are a guiding structure capable of matching the parameters of the petawatt (PW) laser facility at the Berkeley Lab Laser Accelerator (BELLA) Center [1, 2]. We will present results on the optimization of laser coupling into OFI plasma channels on BELLA PW. We will also discuss how optimization of laser coupling relates to upcoming staging experiments on BELLA PW.

Footnotes:

[1] A. Picksley et al., Phys. Rev. E 102, 053201 (2020)
[2] L. Feder et al, Phys. Rev. Research 2, 043173 (2020)

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Monday Poster Session / 1993

Progress on the capillary plasma discharge source at UCLA

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At UCLA, a plasma source using capillary discharge has been developed and studied for its potential use in plasma wakefield experiments at MITHRA and AWA facilities. This compact, 8-cm long source, has the ability to create plasmas covering a wide range of densities, making it suitable for various experiments involving plasma wakefield acceleration (PWFA). With a 3-mm aperture, it can transmit high-aspect ratio beams, and its adjustable density feature allows for a detailed exploration of the shift from linear to nonlinear PWFA stages. In this paper, we will delve into the construction and evaluation of this capillary discharge plasma source, as well as the utilization of an interferometric diagnostic system for measuring plasma density.

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Monday Poster Session / 1994

Flat beam transport for a PWFA experiment at AWA

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Particle beams with asymmetric transverse emittances and profiles have been utilized in facilities for driving wakefields in dielectric waveguides and to drive plasma wakefields in plasma. The asymmetric plasma structures created by the beam produce focusing forces that are transversely asymmetric. We utilize the ellipticity of the plasma ion cavity to model the beam evolution of the flat beam driver.

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Monday Poster Session / 1995

Beam transport and diagnostics study for a space plasma experiment at MITHRA

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The MITHRA facility being commissioned at UCLA, will be capable of producing low emittance beams with 100s pC of charge with bunch lengths in the 100s of fs range having an energy of 60 MeV. This can be used to drive plasma wakefields and the long bunch length compared to the plasma skin depth allows us to create a beam with a broadband energy spectrum. The energy spectrum resembles the electron spectrum observed in the radiation belts of Jupiter and can be used as a proxy for electron radiation exposure for flyby operations. In this paper, we discuss the beam transport, plasma source and diagnostics needed for the proposed experiment.

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North America

Monday Poster Session / 1996

Status of electron acceleration experiments at the BELLA center

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Co-authors: Alex Picksley [1]; Bo miao [2]; Cameron Geddes [1]; Carl Schroeder [1]; Carlo Benedetti [1]; Ela Rockafellow [2]; Eric Esarey [1]; Hai-En Tsai [1]; Howard Milchberg [2]; Jaron Shrock [2]; Jeroen van Tilborg [1]; Josh Stackhouse [1]; Kei Nakamura [1]; Raymond Li [1]

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Laser-plasma accelerators (LPAs) have potential to enable compact light sources and high-energy linear colliders. At the BErkeley Lab Laser Accelerator (BELLA) PW facility, electron bunches with energy up to 8 GeV have been generated using laser pulses with peak power of 0.85 PW (energy 31 J) and an acceleration length of 20 cm. In order to accelerate over this distance of 15 diffraction lengths, a preformed plasma waveguide based on inverse bremsstrahlung (IB) heating inside a capillary discharge was used [1]. Simulations show the energy gain can be increased to beyond 10 GeV, but with lower density than is feasible with IB heating. The recent addition of a second beamline to BELLA PW has allowed for the use of plasma channels formed by optically field ionization [2-4], which enables optimized density. We will present guiding and acceleration results using this new capability.

Footnotes:

[1] Phys. Rev. Lett. 122, 08401 (2019)
[2] Phys. Rev. E 102, 053201 (2020)
[3] Phys. Rev. Research 2, 043173 (2020)
[4] Phys. Rev. X 12, 031038 (2022)

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Wednesday Poster Session / 1997

Fast laser focal position correction using deployed models

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Ultrafast high repetition-rate laser systems are essential to modern scientific and industrial applications. Variations in critical figures of merit, such as focal position, can significantly impact efficacy for applications involving laser plasma interactions, such as electron beam acceleration and radiation generation. We present a diagnostic and correction scheme for controlling and determining laser focal position by utilizing fast wavefront sensor measurements from multiple positions to train a focal position predictor. We present the deployment and testing of this scheme at the BELLA Center at Lawrence Berkeley National Laboratory. Online optical adjustments are made to a telescopic lens to provide the desired correction on millisecond timescales. A framework for generating a low-level hardware description of ML-based correction algorithms on FPGA hardware is coupled directly to the beamline using the AMD Xilinx Vitis AI toolchain in conjunction with deployment scripts.

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Monday Poster Session / 1998

Comparison of flat beam PWFA analytic model with PIC simulations

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This paper explores the phenomenon of asymmetric blowout in plasma wakefield acceleration (PWFA), where the transversely asymmetric beam creates a transversely asymmetric blowout cavity in plasma. This deviation from the traditional axisymmetric models leads to unique focusing effects in the transverse plane and accelerating gradient depending on the transverse coordinates. We extend our series of studies on plasma wakefield acceleration (PWFA) by comparing our recently developed analytic model on the blowout cavity shape created by transversely asymmetric long beams, with Particle-in-Cell (PIC) simulations. The analysis focuses on validating the model's ability to predict the behaviors of different beam profiles in this regime.

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Monday Poster Session / 1999

Permanent magnet electron energy synchrotron 2–18 GeV with fixed betatron tunes

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We are presenting a design of a 2-18 GeV electron synchrotron accelerator made of permanent non-linear combined function magnets with fixed betatron tunes. It is based on the successfully commissioned CBETA Energy Recovery Linac where we used a single return beam line based on Fixed Field Alternating gradient (FFA) principle. The 2 GeV injection energy electrons come from the Recirculating LInear Accelerator (RLA) with 500 MeV linac and a single FFA linear combined function magnet beam line to return electrons to the linac. The electron collision energy uses the same single beam line avoiding the RF accelerating cavities during selected number of turns.

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North America

Monday Poster Session / 2000

Dynamic aperture of the EIC electron storage ring

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Design of the electron-ion collider (EIC) at Brookhaven National Laboratory continues to be developed. Particularly, the collider lattices have been further optimized. The evolving lattice design may affect the dynamic aperture which is required to be sufficiently large. In this paper, we discuss the Electron Storage Ring (ESR), where the recent lattice updates include modifications of the interaction region geometry, improved layout of spin rotator sections, and changes related to reuse of existing magnets. Optimization of non-linear chromaticity correction for the updated lattice at 18 GeV of electron energy and the latest results of dynamic aperture studies are presented.

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Thursday Poster Session / 2001

The LCLS-II beam loss monitor readout system

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The Linac Coherent Light Source II (LCLS-II) is a new addition to the SLAC accelerator complex. It is a 4 GeV, 120 kW superconducting Linac operating in continuous RF mode at 1.3 GHz with a beam repetition rate of up to 1 MHz. The prior generation of protection system beam loss monitors, whose operation is based on ion collection principles, are not suitable for operation in LCLS-II due to their slow recovery times. A new group of detectors have been identified and evaluated. These fall into three categories: scintillation detectors using optical fibers and photomultiplier pickups for distributed losses. Point detectors based on diamond pickups, and YAG:ce screens with photodiode pickups for burn through detection. These new detector elements require that new readout and signal processing electronics to be developed. In addition, because these detectors are part of the SLAC Beam Containment System (BCS), a certified safety system, a self-check mechanism is required to continuously verify the health of the detector and readout. This paper describes the design, operation and performance of the readout electronics.

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Tuesday Poster Session / 2002

RF system upgrade for 1.3 MW operation of J-PARC main ring

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The J-PARC Main Ring accelerates proton beam from 3 GeV to 30 GeV and delivers it to T2K neutrino experiment with fast extraction and hadron experiments with slow extraction. In the last two years the beam power to the neutrino experiment was increased from 500 kW to 750 kW. The T2K detector is scheduled to be replaced by the new Hyper-K detector; the latter will be able to accept a 1.3 MW proton beam by 2028. To achieve 1.3 MW beam power, J-PARC plans to upgrade the Main Ring by increasing intensity and repetition rate. The Main Ring uses low frequency, high bandwidth RF cavities with Magnetic Alloy cores, powered by two 600 kW tetrode tubes. Under the upgrade plan, the number of RF cavities will be increased to secure the RF voltage and longitudinal acceptance. The anode power supply will be upgraded to provide enough current for both gap voltage and beam loading compensation. The upgraded LLRF system will be optimized to control fundamental and 2nd harmonic RF voltages, suppress coupled bunch instabilities and compensate beam loading effects. Current operational status as well as details of the upgrade plan and related simulation results will be discussed in this paper.

Footnotes:

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Asia

Wednesday Poster Session / 2003

Parameters and process study of copper chamber coating with niobium thin films in DC and HIPIMS modes

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This study primarily investigates the parameters and processes involved in depositing Nb thin films on copper cavities under DC and HIPIMS modes. For this purpose, a high-power magnetron sputtering system was designed, conducting a total of 36 experiments. Improvement and optimization of parameters such as duty cycle (under HIPIMS mode), peak current, and bias voltage were undertaken to enhance film quality and performance metrics such as density. Surface morphology and superconducting properties of the films were characterized using SEM, XRD, Tc measurements, and other analytical methods. It was found that the Nb film deposited at a bias voltage of 100 V and a peak current of 150 A exhibited better performance. Lateral analysis of films deposited on different areas of the cavity revealed that in the DC mode, film grain sizes at the cell level were smaller with more defects, whereas in the HIPIMS mode, the niobium film exhibited finer and elongated grains, with grain sizes across various parts of the cavity being closer and defects reduced. This resulted in greater internal uniformity within the entire cavity, contributing to the enhancement of Q and E.

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Asia

Wednesday Poster Session / 2004

SiPM integration testing for FACET-II pair spectrometer

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A pair spectrometer, designed to capture single-shot gamma spectra over a range extending from 10 MeV through 10 GeV, is being developed at UCLA for installation at SLAC's FACET-II facility. Gammas are converted to electrons and positions via pair production in a beryllium target and are then subsequently magnetically analyzed. These charged particles are then recorded in an array of quartz Cherenkov cells attached to silicon photomultipliers (SiPMs). As the background environment is challenging, both in terms of ionizing radiation and electromagnetic pulse radiation, extensive beamline testing is warranted. To this end, we present the results of our tests, correlated with electromagnetic finite-element and Geant4 Monte Carlo studies.

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Wednesday Poster Session / 2005

New beam loss monitor system at the Australian Synchrotron

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A new beam loss monitor (BLM) system has been installed and commissioned at the Australian Synchrotron. The new system consists of 28 beam loss detector (BLD) units and 14 signal processing BLM units distributed around the storage ring. Each detector unit consists of a plastic scintillator coupled to a photomultiplier tube. The signal processing units are Libera BLMs from Instrumentation Technology. The new system can detect both integrated slow losses from the stored beam as well as turn-by-turn losses during injection. This paper will describe the calibration method, the commissioning results, and the implementation of the postmortem function.

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Asia

Tuesday Poster Session / 2006

Preliminary lattice design for Australian Synchrotron 2.0

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A new project is underway to develop the successor to the current Australian Synchrotron. The new storage ring is proposed to be 450 m in circumference operating at 3 GeV. A preliminary 7BA lattice has been designed which utilizes the higher-order achromat (HOA) scheme to suppress strong sextupole driving terms. The lattice has 24 sectors and a natural horizontal emittance of 50 pm-rad. This is achieved using a combination of strong combined function magnets and reverse bending magnets in the unit cell, as well as careful tuning of the bending angles to preserve positive momentum compaction factor. The dynamic aperture, momentum aperture and Touschek lifetime have been optimized by tuning the linear optics and sextupole strengths with a multi-objective genetic algorithm.

Footnotes:

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Asia

Tuesday Poster Session / 2007

Time-resolved evaluation of the transient responses of crystal optics to instantaneous heat deposition for wavefront integrity

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Co-authors: Bo Yang [2]; Juhao Wu [1]

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Our focus centers on numerical investigation into the transient response of optics when subjected to instantaneous heat deposition. The heat load deposited onto crystal optics, coupled with the emission of strain waves, has the potential to induce crystal deformation and vibrations. These phenomena carry detrimental consequences for optic performance, particularly in terms of wavefront preservation—an essential criterion for coherent XFEL beams. Our research involves an evaluation of optical performance at various time delays, accomplished by calculating reflectivity based on simulated transient deformation and strains. Ultimately, we aim to provide recommendations for establishing upper bounds on pulse energy and repetition rates during XFEL operation. These guidelines will play a pivotal role in optimizing XFEL performance while safeguarding wavefront integrity, thus advancing the capabilities of coherent X-ray beams in scientific and technological applications.

Footnotes:

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North America

Tuesday Poster Session / 2008

Flattening the field during injection in the Fermilab booster using dipole corrector magnets

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Co-authors: Chandra Bhat [2]; Dennis Barak [2]; Ed Cullerton [2]; Jean-Francois Ostiguy [2]

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The FNAL Booster is a fast cycling 15 Hz resonant circuit synchrotron accelerating proton beam from 400 MeV to 8 GeV. The linac pulse injected into the Booster is ˜32 μsec long and fills the ring by multi-turn charge-exchange injection. As part of the PIP-II project, the Booster injection energy and repetition rate will be increased to 800 MeV and 20 Hz respectively. Due to much reduced average current in the new superconducting PIP-II linac, the injection time will increase to 550 μs. A shorter machine cycle coupled to a longer injection time make flattening the injection porch B-field during injection important requirement for successful PIP-II operation. We aim to achieve: (1) flattening of the net bending during injection using dipole correctors, and (2) using a new system based on an Altera FPGA board, reduction of the cycle-to-cycle bending field variation caused by current jitter in the Gradient Magnet Power Supply (GMPS). While the flat injection scheme is essential to future PIP-II operations, it should also noticeably improve efficiency for present HEP operations.

Footnotes:

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North America

Thursday Poster Session / 2009

3D visualization and analysis of neutron scattering data in the control room

Author: Matthew Kilpatrick[1]

Co-authors: Alexander Kuhn [2]; Andrei Savici [3]; Boaz Nash [1]; Bogdan Vacaliuc [3]; Christina Hoffmann [3]; David Bruhwiler [1]; Dragos Tatulea [2]; Evan Carlin [1]; Gurhar Khalsa [1]; Jörg Mensmann [2]; Marc Nienhaus [2]; Matthew Tucker [3]; Peter Messmer [2]; Steffen Roemer [2]; Zachary Morgan [3]

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Neutron scattering experiments have undergone significant technological development through large area detectors with concurrent enhancements in neutron transport and electronic functionality. Data collected for neutron events include detector pixel location in 3D, time and associated meta-data, such as sample orientation and environmental conditions. Working with single-crystal diffraction data we are developing both interactive and automated 3D analysis of neutron data by leveraging NVIDIA's Omniverse technology. We have implemented machine learning techniques to automatically identify Bragg peaks and separate them from diffuse backgrounds and analyze the crystalline lattice parameters for further analysis. A novel CNN architecture has been developed to identify anomalous background from detector instrumentation for dynamical cleaning of measurements. Our approach allows scientists to visualize and analyze data in real-time from a conventional browser, which promises to improve experimental operations and enable new science. We have deployed a cloud based server, leveraging Sirepo technology, to make these capabilities available to beamline users in the control room.

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Monday Poster Session / 2010

Beam condition diagnostics and forecasting with non-destructive measurements at FACET-II

Author: Matthew Kilpatrick[1]

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Beam diagnostic technology is one of the foundations of large particle accelerator facilities. A challenge with operating these systems is the measurement of beam dynamics. Many methods such as beam position monitors have an inherent destructive quality to the beam and produce perturbations after the measurement. The ability to measure the beam conditions with non-destructive edge radiation allows for us to have a more stable understanding and predictability of the beam condition. We are developing a machine learning workflow for the downstream prediction and future forecasting of the beam condition utilizing the non-destructive edge radiation measurements and novel graph neural networks in collaboration with FACET-II at SLAC. We are developing machine learning algorithms with the beam physics integrated within each layer of the network. Additionally, we are developing an online surrogate model of edge radiation using SRW to allow for automatic generation of new beam states due to the changing parameters of accelerator facilities over time. We plan to integrate and test our prediction system at the SLAC facility to perform beam condition prediction and verification at FACET-II.

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North America

WEBN: Beam Instrumentation, Controls, Feedback and Operational Aspects (Contributed) / 2011

Complete 6D tracking of a single electron in the IOTA ring

Author: Alexander Romanov[1]

Co-authors: Giulio Stancari [1]; James Santucci [1]

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We present the results of the first experiments on 6-dimensional phase-space tracking of a single electron in a storage ring, using a linear multi-anode photomultiplier tube for simultaneously measuring transverse coordinates and arrival times of synchrotron-radiation pulses. This technology makes it possible to fully reconstruct turn-by-turn positions and momentums in all three planes for a single particle. Complete experimental particle tracking enables the first direct measurements of dynamical properties, including invariants, amplitude and energy dependence of tunes with exceptional precision, and chaotic behavior.

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North America

Wednesday Poster Session / **2012**

Improved symplectic particle tracking for modern vectorized architectures

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With modern accelerators encountering new physics regimes, 'elegant'code has added elaborate models of fringe fields, impedances, longitudinal gradient dipoles, and other elements to improve simulation accuracy. However, advanced models come with computational cost penalties. Fundamentally, elegant tracking is serial –it applies models to one particle at a time, preventing many compiler optimizations. This architecture is also inefficient on modern hardware because of two recent trends –a reduction in memory bandwidth per-core and strong push for vectorization (AVX-512, GPUs) to improve throughput. This paper describes our work on overhauling core symplectic tracking routines into a vectorized pipeline that works on 'tiles'of particles with size optimized based on cache size, element type, and other factors. We will show tests of HPC libraries like Kokkos, as well as hand-tuned AVX-512 intrinsics, and discuss profiling and testing techniques for finding bottlenecks. Overall, we archive a 2.5x speed-up in symplectic tracking, along with improved memory layout for future work, saving millions of core-hours on APS-U simulations.

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Tuesday Poster Session / **2013**

Radiographic source prediction for linear induction accelerators using machine learning

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The penetrating radiography provided by the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility is a key capability in executing a core mission of the Los Alamos National Laboratory (LANL). Historical data from the two DARHT Linear Induction Accelerators (LIAs), built as hdf5 data structures for over a decade of operations, are being used to train machine learning models to assist in beam tuning. Adaptive machine learning (AML) techniques that incorporate physics-based models are being designed to use noninvasive diagnostic measurements to address the challenge of predicting the radiographic spot size, which depends on the time variation in accelerator performance and the density evolution of the conversion target. Pinhole collimator images recorded by a gamma ray camera (GRC) provide a direct measurement of the radiograph imaging quality but are not always available. A framework is being developed to feed results of these invasive measurements back into the accelerator models to provide virtual diagnostic measurements when these measurements are not available.

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Wednesday Poster Session / 2014

Experimental designs of coherent synchrotron radiation in complex beams

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Co-authors: Gwanghui Ha [1]; Chengkun Huang [2]; Xueying Lu [3]; John Power [3]; Ji Qiang [4]

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Coherent synchrotron radiation (CSR) is one critical beam collective effect in high-energy accelerators, which impedes the generation of high-brightness beams. The Argonne Wakefield Accelerator (AWA) facility is unique in the experimental investigation of CSR effects in complex beams, offering a large parameter space for the bunch charge and size, various bunch profiles (round and flat beams), and the capability of generating shaped bunches through both laser shaping and the emittance exchange approach. This presentation will outline planned experiments at AWA and their designs, including a CSR shielding study using a dipole chamber with a variable gap size, and the effect of CSR on the beam phase space in a laser-shaped short electron bunch.
This work is part of a comprehensive study involving self-consistent CSR code development and experimental investigation. The experimental component aims to provide benchmarking with the advanced codes under development, explore the boundaries of 1/2/3D CSR effects on beam dynamics, evaluate CSR effects in complex beams, and eventually propose CSR mitigation strategies.

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Monday Poster Session / 2015

First-principle simulations of a laser-assisted bunch compression scheme

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High brightness electron beams with high peak current are critical to reducing the size of XFEL. A promising approach consists in combining low emittance beam generated high-frequency photoinjector with a laser-assisted bunch compression scheme. Such a compression consists in using an infrared laser to modulate the electron beam energy in a planar undulator and a low R56 chicane to compress these modulations and produced a micro-bunched beam. We present first-principle simulations of this compression process including the impact of coherent synchrotron radiation (CSR) on the beam dynamics. These simulations were performed using the large-scale self-consistent LW3D code for two compression configurations under study for compact XFEL designs.

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Monday Poster Session / 2016

A novel coherent synchrotron radiation simulation method using cavity Green's functions

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The mitigation of collective beam effects, in particular Coherent Synchrotron Radiation (CSR), is crucial for the development of particle accelerators with higher beam brightness. Among the strategies proposed in the literature, the use of appropriate shielding walls to curb CSR is an attractive strategy with many associated open problems. In particular, simulation methods that account for shielding effects usually employ image charges and assume free space potentials, making them only applicable for simple wall layouts. In this work, we will outline a novel simulation technique that makes use of cavity Green's functions to capture the field modes admitted by the shielding walls. In addition to better resolving the radiated fields, the proposed method will be robust to singularities that are typically encountered in the image charge approach. We will discuss the computational implications of using cavity Green's functions and discuss strategies to scale the method to complex geometries and large particle counts. The method will eventually be validated using results from a planned shielding study at the Argonne Wakefield Accelerator using a dipole chamber with variable gap size.

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Thursday Poster Session / 2017

SSRF superconducting wiggler coil voltage monitoring system and quench monitoring results

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The SSRF (Shanghai Synchrotron Radiation Facility) superconducting wiggler consists of three parts: a superconducting multipole magnet, a cryostat system and magnet power & control system. Superconducting multipole magnets can generate a strong magnetic field with a peak of 4.2 T, and the generated magnetic field alternates positively and negatively along the direction of electron motion in the storage ring. The superconducting wiggler is installed in the BL12 unit of the SSRF Storage Ring. The voltage monitoring system can monitor the voltage of each part of the coil of the superconducting multipole magnet through the voltage sense leads, thereby obtaining the voltage trends of each part of the coil when the coil quench occurs. The voltage monitoring system collects the voltage data of each coils through a Siemens S7-1512 PLC analog input modules which is an innovative method. And the system realizes the quench detection by recording the voltage cycle by cycle and judge by a delay threshold. Based on the PLC system both the equipment monitoring function and the voltage monitoring function are achieved. The quench voltage of each coil is captured and analyzed.

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Asia

Wednesday Poster Session / **2018**

Mitigation of ion effects with online bunch pattern optimization

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Ion effects present a big concern for APS-U operation. A lot of effort has been directed towards simulating and mitigating this phenomenon. Simulations predict that bunch gaps are an effective solution, especially if first and last bunches contain higher charge. However, it is desirable to minimize charge variation. This is an optimization problem - total charge should be optimized subject to constraint of avoiding beam blowup. We adapted our Bayesian optimizer to do this in an online manner by defining a set of knobs corresponding to per-bucket charge, a total charge objective, and a stability constraint based on bunch-by-bunch feedback strength. By precisely controlling injector charge and kicker scraping, arbitrary current patterns could be quickly established. Our results show that higher charge at the ends is beneficial in agreement with simulations. However, we also found that current variation can be minimized by a smoother increase over several border buckets, and that a few special configurations with asymmetric charge pattern have surprising stability, potentially indicating a new class of solutions. Simulation studies are in progress to model this behavior.

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Thursday Poster Session / **2019**

LANSCE electromagnetic chopper and beam dynamic simulation

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Electromagnetic choppers are a critical subsystem that slices particles at specific intervals and precisely directs them to a target or experiment. This simulation study was carried out to determine the correct operating parameters of the Electromagnetic Chopper, optimize it and increase its overall performance. At the same time, beam dynamics simulations aim to model in detail the movement of particles within the accelerator system. These simulations have been used as a comprehensive tool to evaluate and improve the operation of the Electromagnetic Chopper. The thesis examines the effects of these simulations on the Electromagnetic Chopper at LANSCE and their contribution to the performance of the system. Electromagnetic chopper and beam dynamics simulations are critical to ensuring LANSCE's accelerator systems operate more efficiently, optimizing targeting times, and better understanding the interactions of particles on the target.

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Europe

Monday Poster Session / 2020

High-intensity pulse propagation in multi-GeV laser plasma accelerator stages

Author: Alex Picksley[1]

Co-authors: Josh Stackhouse [1]; Carlo Benedetti [1]; Kei Nakamura [1]; Hai-En Tsai [1]; Raymond Li [1]; Carl Schroeder [1]; Jeroen van Tilborg [1]; Eric Esarey [1]; Cameron Geddes [1]; Anthony Gonsalves [1]

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Due to their compactness, laser-plasma accelerators are a promising approach to future energy frontier electron accelerators. To reach multi-GeV energies in a single accelerator stage, the high-intensity drive laser pulse must be kept focused over several tens of centimeters through a sufficiently low density plasma. Without an external guiding mechanism, the laser will diffract reducing the laser intensity, which in turn limits acceleration to ˜1 cm. Optically generated plasma channels have recently gained attention as a promising method to keep high-intensity laser pulses tightly focused over the meter scale [1,2]. Understanding how the laser pulse evolves in the spatial and temporal domain during propagation is critical for high energy gain, and maintaining high bunch quality. We present experimental results investigating drive laser propagation in optically formed plasma channels at the BELLA PW laser. We demonstrate conditions under which the channel can be tailored to match the drive laser focus at plasma densities suitable for multi-GeV accelerators.

Footnotes:

[1] A. Picksley et al., Phys. Rev. E 102, 053201 (2020)
[2] L. Feder et al., Phys. Rev. Research 2, 043173 (2020)

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North America

Thursday Poster Session / 2021

Commissioning of the IOTA proton injector

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The Proton Injector for the IOTA storage ring (IPI) has been constructed at the Fermilab Accelerator Science and Technology facility (FAST). It is a machine capable of delivering 20 mA pulses of protons at 2.5 MeV. IPI will operate alongside the existing electron injector beamline to facilitate further beam physics research and the continued development of novel accelerator technologies at the IOTA ring. This report details the results of the initial commissioning of IPI and an overview of the upcoming experiments with intense proton beams at IOTA.

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North America

Thursday Poster Session / 2022

Cooler error sensitivity study

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Current progress of the error sensitivity studies are presented in this paper.

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North America

Thursday Poster Session / 2023

Radiation levels in the LHC tunnel and impact on electronics during the 2023 Pb ion run

Author: Auriane Canesse[1]

Co-authors: Daniel Söderström [1]; Diego Di Francesca [1]; Eirini Tagkoudi [1]; Francesco Cerutti [1]; Giuseppe Lerner [1]; Ruben Garcia Alia [1]; Samuel Niang [1]

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The 2023 operation of the Large Hadron Collider (LHC) at CERN included a one-month-long run with fully stripped Pb ion beams, marking the first heavy-ion run since 2018, and delivering Pb ion collisions at an unprecedented center-of-mass energy of 5.36 TeV per nucleon pair. During this period, the radiation fields in the LHC tunnel have been measured by means of different radiation monitors, including Beam Loss Monitors (BLMs), RadMons, and distributed optical fiber dosimeters, with the primary goal of quantifying the radiation exposure of electronic systems. The radiation levels are driven by the Bound Free Pair Production (BFPP) and Electromagnetic Dissociation (EMD) processes taking place in all four interaction points, yielding significant radiation peaks in the Dispersion Suppressor (DS) regions of the tunnel. An overview of the radiation levels is presented in this contribution, with a special focus on the Insertion Region 2 (IR2) hosting the ALICE experiment, where a new collimator (TCLD) has been installed specifically for the ion run. The impact of radiation on the electronic systems and on the LHC availability during the run will also be discussed.

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Europe

Thursday Poster Session / 2024

Temporal profile optimization for beamline design using an improved multi-objective genetic algorithm

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Our research focuses on the design of a beamline. Due to the numerous beamline components involved, without strict optimization of each component's parameters, the transmitted temporal profile of beam may distort, failing to meet the expected requirements. Additionally, different initial temporal profile of the beam will undergo longitudinal shaping during transmission through the beamline. Therefore, we aim to determine the combination of initial beam temporal profile at the cathode and the parameters of the beamline components based on the specific beam distribution at the exit. We propose the application of an improved multi-objective genetic algorithm to solve this problem. Through multiple optimization iterations for a given temporal profile, our algorithm consistently identifies multiple suitable combinations of initial beam temporal profile and beamline component parameters to produce the desired specific temporal profile of the beam.

Footnotes:

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Asia

Monday Poster Session / 2025

Mechanical design and 3-D coupled RF, thermal-structural analysis of the quarter wave stub for 197 MHz crab cavity

Author: Jean Clifford Brutus[1]

Co-authors: Binping Xiao [1]; Douglas Holmes [1]; Subashini De Silva [2]; Zachary Conway [1]

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Two distinct crab cavities are planned to compensate the luminosity loss of the 25 mrad crossing angle at the Electron Ion Collider (EIC) interaction point. The crab cavity systems being developed will operate at either 197 MHz or 394 MHz and the 197 MHz system will provide up to 11.5 MV of transverse voltage with up to 60 kW of fundamental mode power with a coaxial coupler. The 197 MHz crab cavity fields and high power transmission characteristics of the coaxial coupler require water cooling of the inner conductor. To introduce water into the inner conductor a coaxial tee with a quarter-wavelength stub is proposed with the water supply/return located at the zero voltage plane. This paper provides an overview of the current design, electromagnetic, thermal and structural analyses for the Quarter Wave Stub.

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North America

Tuesday Poster Session / 2027

Development of a fast pulsed magnet system for the MYHRRA collaboration

Author: Johannes Ruf[1]

Co-authors: Jarno van de Walle [2]; Michael Barnes [1]; Miguel Diaz Zumel [1]; Ot Dams [2]; Thomas Kramer [1]

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In the framework of the MYRRHA collaboration, a large-scale Accelerator Driven System (ADS) being implemented by SCK-CEN in Belgium, a fast pulsed magnet system is being designed and specified at CERN. A complete design study has been performed to develop the specifications and drawings for a kicker magnet as well as the associated pulse generator to deflect the 100 MeV proton beam. This paper outlines the numerical simulations that have been set up to evaluate the performance of the kicker magnet featuring a 5 µs rise time with a variable flat top of 10 to 500 µs and a 250 Hz repetition rate. The design concluded on a water-cooled lumped inductance magnet with two half coils each 2 turns featuring a magnet aperture of 90 mm x 57 mm. The outside vacuum magnet design requires a coated ceramic vacuum chamber to pass the fast kicker field of 18.5 mT. The associated pulse generator has been designed to deliver pulses of 1.6 kV and 200 A matching the kicker rise time and is outlined together with the cable choice.

Footnotes:

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Europe

Tuesday Poster Session / 2028

Engineering studies on collimators for CERN's experimental areas

Author: Giulia Romagnoli[1]

Co-authors: Francisco Sanchez Galan [1]; Jan Buesa Orgaz [1]; Jerome Lendaro [1]; Laurence Nevay [1]; Maud Wehrle [1]; Nikolaos Charitonidis [1]; Ramon Folch [1]; Sylvain Girod [1]; Vasiliki Stergiou [1]; Vincent Marchand [1]

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In the framework of consolidation of the North Experimental Area at CERN, the 4-block secondary beamline collimators have been assessed with engineering studies and optimized for present beamline operation and future performance with higher beam intensities. Insights gained from experience and through an analysis of fault registration during operation, lead to improvements in the collimator mechanical design. FLUKA Monte Carlo simulations and finite element (FE) thermo-mechanical simulations were used to assess the performance of the collimator for the present beam characteristics. The simulations were cross-checked using experimental data from temperature sensors during beam testing. Similar FE studies using the Ansys software were conducted to assess the collimator limits for a future higher intensity beam. The results of these analyses are presented in this contribution.

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Europe

Wednesday Poster Session / 2029

Reflectivity studies and production of surface coatings for the Cherenkov threshold detector flat mirrors for CERN's experimental areas

Author: Jan Buesa Orgaz[1]

Co-authors: Aboubakr Ebn Rahmoun [1]; Francisco Sanchez Galan [1]; Giulia Romagnoli [1]; Inaki Ortega Ruiz [1]; Jocelyn Tan [1]; Maarten Van Dijk [1]; Michael Lazzaroni [1]; Miranda Van Stenis [1]; Nikolaos Charitonidis [1]; Thomas Schneider [1]; Vincent Marchand [1]

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The Cherenkov threshold detectors (XCET) are used as particle counters in the experimental areas at CERN. The XCET detectors observe the Cherenkov light emitted by particles travelling inside a pressurized gas vessel. A key component of the XCET detector is the 45-degrees flat mirror reflecting the Cherenkov photons produced by the traversing particles, to the photomultiplier detector. A thorough analysis and optimization was conducted on the design and materials of the mirrors, along with the surface coatings and coating techniques. The main objectives were to minimize the thickness of the mirror to reduce both the multiple scattering and energy loss of particles, while simultaneously enhancing the reflectivity of Cherenkov photons in the UV spectrum. A suitable fabrication process was selected, and the first mirror prototypes were produced, installed, and tested in the East Area at CERN. Experimental data obtained during beam tests is presented to compare the efficiency of the new coating and materials used.

Footnotes:

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Europe

Thursday Poster Session / 2030

Improvement of the LHC orbit feedback testing framework

Author: Andrea Calia[1]

Co-authors: Diogo Alves [1]; Jorg Wenninger [1]; Michi Hostettler [1]; Stephen Jackson [1]

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Corresponding Author: andrea.calia@cern.ch

During the Long Shutdown 2 (LS2 2019-2021) of the LHC, the orbit feedback correction software (OFB) of the LHC was redesigned to satisfy new requirements for LHC Run 3 (2022-2025) and to clean up legacy functionalities. The OFB is an essential component of LHC high intensity operation since the orbit must be stabilized to a fraction of the beam size during the entire LHC machine cycle. Redesigning such an essential and complex system during shutdowns requires thorough testing of the system functionality. The existing OFB testing system has been reviewed and improved based on the experience of LHC Run 2. An automatic, continuous integration tool has been put in place to validate future software developments before putting them in production. The solution for the OFB testing will be presented in this contribution.

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Thursday Poster Session / 2031

Study of stripping magnets design for LACE at the SNS

Author: Timofey Gorlov[1]

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We study possibility of laser assisted charge exchange injection at the SNS. The realistic injection of LACE injection and accumulation into the Ring of SNS is considered. The design of stripping magnets at the injection area is one of the most challenging problems toward operational scheme of LACE at the SNS. Basic requirements and needed parameters of stripping magnets are studied. Based on this study the possibility of real stripping magnet design is considered.

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Tuesday Poster Session / 2032

Topologies for the kicker systems of the FCC-ee collider and injectors

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Co-authors: Giorgia Favia [1]; Michael Barnes [1]; Miguel Diaz Zumel [1]; Sen Yue [2]; Thomas Kramer [1]; Yann Dutheil [1]

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A central part of CERN's Future Circular collider study (FCC) is a ˜91 km circumference lepton collider and its injector complex. This contribution outlines the various kicker systems needed to transport the lepton beams from the electron source up to the collider dump system. The individual system requirements are presented, and the choice of design parameters and technology options for both, beamline elements and pulse generators are discussed. Potential challenges like the fast rise time of 50 ns for the damping ring kicker system working at 200 Hz repetition rate are highlighted, together with considerations on energy recovery. Ferrite loaded kicker magnet topologies are compared with system concepts employing strip lines. The paper concludes with a summary on the feasibility aspects and a recommendation for eventually needed prototype studies.

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Monday Poster Session / 2033

Operation of the LHC during the 2023 proton run

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In 2023 the LHC restarted after the yearly winter shutdown with a new machine configuration optimized for intensities of up to 1.8e+11 protons per bunch. In the first two months of the 2023 run the bunch intensities were pushed up to 1.6e+11 protons per bunch until a severe vacuum degradation, caused by a damaged RF bridge, occurred close to the ATLAS experiment. Following repair, the decision was taken to stop the intensity increase. After a period of smooth operation, a leak developed between the cold mass and insulation vacuum of a low-beta quadrupole, leading to an abrupt stop of the LHC. Thanks to a rapid intervention, the leak could be repaired without warning up large parts of the machine, and the LHC was ready for beam again early September. Special runs at very large beta* were completed in the remaining time before switching to Lead ion operation. The performance achievements and limitations as well as the issues that were encountered over the year will be discussed in this paper.

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Thursday Poster Session / 2035

Qualification of components for installation in LHC kicker magnets

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Co-authors: Chiara Bracco [1]; Dylan Standen [1]; Giorgia Favia [1]; Laurent Ducimetière [1]; Michael Barnes [1]; Pavlina Trubacova [1]; Tobias Stadlbauer [1]

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LHC injection kickers (MKI) are pulsed at high voltage to achieve magnetic field pulses with fast rise time. The MKIs contain a beam screen to help shield their ferrite yoke from beam induced heating.

However, additional means of mitigating beam induced heating, for the high luminosity LHC (HL-LHC) era, are required. To achieve this, the MKIs are sequentially being upgraded to low impedance versions (MKI Cool) with several critical components including (a) a 3-m long alumina tube, installed in the magnet aperture, used to hold screen conductors that help shield the magnet yokes from beam induced heating; and (b) an RF damper which moves beam induced power from the ferrite yoke to a ferrite cylinder which is part of the damper. This paper discusses the measurements carried out to qualify these components for installation in an MKI Cool. In addition, for the alumina tube, the interpretation of the measurement data is discussed together with the optimization of the angular orientation of the tube in the magnet aperture.

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Tuesday Poster Session / **2036**

SPS injection kicker system: 2023 operational experience and upgrade proposals for high-luminosity LHC

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The SPS injection kicker system comprises twelve MKP-S (small aperture) modules and four MKP-L (large aperture) modules. An upgraded MKP-L magnet was installed in the SPS, during December 2022, in view of the higher beam intensity needed in the future for High-Luminosity-LHC. The upgrades have significantly reduced the beam coupling impedance and consequent beam induced heating. The improved performance is due to a new beam screen, consisting of silver fingers painted on an alumina chamber, inserted in each magnet's aperture. Additionally, a surface coating on the chamber's inner surface reduces its secondary electron yield and hence dynamic vacuum activity. The effectiveness of these upgrades was demonstrated during the 2023 operation. This paper provides an in-depth exploration of the initial year of operational experience with the upgraded MKP-L, giving a comparative analysis of dynamic vacuum and beam induced heating with the MKP-S modules. An alternative approach for upgrading the MKP-S modules, to reduce their temperature, is also proposed.

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Monday Poster Session / 2037

Multiphysics modeling of accelerators through code integration

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This work aims to improve the ability of particle accelerator researchers to develop high-performance accelerator cavity designs by creating an overall multiphysics framework that integrates and couples existing application codes. This framework will allow accelerator researchers to build multiphysics models that will optimize cavity design, improve understanding of whole-device performance, and reduce the development and fabrication costs of accelerator research. We utilize the open-source VizSchema data standard as an intermediate data structure interface layer to standardize interfaces between individual application codes. VizScema is extensively documented online, and plugins for VizSchema are available for popular visualization packages, including VisIt and ParaView. Currently, the work focuses on coupling the EM field solver COMSOL and the electron gun code MICHELLE to allow COMSOL field-solve results to be seamlessly used by MICHELLE for particle-solve. Later work will extend this integration to include other fields, particles, and thermodynamics simulation codes.

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TUAN: Beam Dynamics and Electromagnetic Fields (Contributed) / 2038

Measurement and modeling of beam transport in the FODO line of the Spallation Neutron Source Beam Test Facility

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Ongoing studies at the Spallation Neutron Source (SNS) Beam Test Facility (BTF) seek to understand and model bunch dynamics in a high-power LINAC front-end. The BTF has recently been upgraded with a reconfiguration from a U-shaped line to a Straight line. We report the current state of model benchmarking, with a focus on RMS beam sizes within the FODO line. The beam measurement is obtained via three camera/screen pairs in the FODO line. This presentation discusses the methodology and results of this measurement.

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Monday Poster Session / 2039

Adjoint optimization of accelerator cavities

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A new, rapidly converging cavity optimization tool is presented that uses adjoint methods. The tool is able to work with any cavity solver that can output and input the results of cut-cell meshing of a cavity. Because it is an adjoint method, one needs only a single forward solve for each iteration in the process of convergence. One also needs a backward solve for each optimization target or constraint. Being a derivative based optimization, it converges rapidly. Results for cavity optimization will be shown.

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Wednesday Poster Session / 2040

Niobium-tin as a transformative technology for low-beta linacs

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Niobium-tin has been identified as the most promising next-generation superconducting material for accelerator cavities. This is due to the higher critical temperature (Tc = 18 K) of Nb3Sn compared to niobium (TC = 9.2 K), which leads to greatly reduced RF losses in the cavity during 4.5 K operation. This allows two important changes during cavity and cryomodule design. First, the higher Tc leads to negligible BCS losses when operated at 4.5 K, which allows for a higher frequency to be used, translating to significantly smaller cavities and cryomodules. Second, the reduced dissipated power lowers the required cryogenic cooling capacity, meaning that cavities can feasibly be operated on 5-10 W cryocoolers instead of a centralized helium refrigeration plant. These plants and distribution systems are costly and complex, requiring skilled technicians for operation and maintenance. These fundamental changes present an opportunity for a paradigm shift in how low-beta linacs are designed and operated. Fabrication challenges and first coated cavity test results are discussed.

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Wednesday Poster Session / 2041

Installation and commissioning of the APS-U bunch lengthening system

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A new bunch lengthening cryomodule based a single-cell superconducting cavity operating at the 4th harmonic (1408 MHz) of the main RF has been installed into Argonne's Advanced Photon Source (APS) storage ring as part of the U.S. DOE APS Upgrade project. The system will be used to improve the Touschek lifetime by increasing the bunch length by up to several times. The 2-meter long cryomodule is installed in the first half of one of the APS straight sections. The superconducting cavity will operate at 2.1 K and provide up to 1.3 MV of potential for bunch lengthening. System features include a pneumatic slow mechanical tuner and a pair of adjustable RF power couplers to adjust the loaded quality factor, providing a means of stabilizing the beam over a wide range of beam currents and fill patterns. Beam induced higher-order modes (HOMs) are extracted along the beam axis and damped using a pair of room temperature beam line absorbers based on silicon carbide.

The cavity and cryomodule are cooled using a new 4.3 K liquid helium refrigerator combined with JT expansion inside cryomodule. We report here on results of initial cool down and testing.

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Monday Poster Session / 2042

Particle-in-cell modeling of low-temperature plasma ion sources for ion implantation

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Numerical modeling of low-temperature plasma (LTP) ion sources provides cost-effective techniques for developing and optimizing beam characteristics for ion implantation and other applications, including plasma processing and etching. Particle-in-cell (PIC) models are a powerful tool for simulating plasma formation and dynamics in LTP sources. Beam formation and transport of the beam through extraction optics can benefit from reduced physical models. One can couple a PIC model for plasma chambers with a different transport model in the extraction region. However, this coupling is ad hoc, and it is often not clear that the models are physically consistent with each other.
We present an integrated modeling capability that couples plasma chamber modeling with beam formation using the VSim computational framework. We leverage advanced modeling techniques such as energy-conserving PIC and variable meshing to improve simulation performance. We present results for modeling and optimization of beams for ion implantation. Our results show that our integrated models can improve optimization of beam currents, beam uniformity, and emittance for LTP ion sources.

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Monday Poster Session / 2043

High-performance magnet simulation software

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We present a high-performance solver for the magnetostatic equations. The solver can simulate nonlinear and anisotropic magnetic materials on a highly variable grid, enabling efficient resolution of fine features even in very large systems. It is built on the Tpetra parallel sparse linear algebra package, allowing it to handle problems with billions of degrees of freedom and employ hardware acceleration with Nvidia graphics processing units. Integration into the VSim electromagnetics software allows users to design magnetic systems using existing graphical interface features. Example simulations of nonlinear magnets, with application to particle accelerator magnet design, will be shown.

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Monday Poster Session / 2044

E-320 at SLAC

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The E-320 collaboration is colliding an electron beam generated at FACET-II with a 10 TW laser pulse [1,2]. In the rest frame of the electron beam, the laser field intensity is comparable to the Schwinger limit, allowing for the study of Strong-Field QED (SFQED). In this regime, quantum corrections to classical synchrotron radiation become important and the probability for electron positron pair production through the decay of emitted gamma photons is not exponentially suppressed [3-5].
In E-320 we are planning to observe the transition from the perturbative to the non-perturbative regime. During this transition qualitative changes to the gamma photon emission spectrum are expected to occur, such as the Compton edges being redshifted significantly and the spectrum becoming quasi-continuous. In this contribution, we discuss the commissioning and planned observations of E-320.

Footnotes:

[1] V. Yakimenko et al., Phys. Rev. Accel. Beams 22, 101301 (2019)
[2] S. Meuren (for the E-320 collaboration), talk at FACET-II PAC Meeting (2022)
[3] A. Fedotov et al., Phys. Rep. 1010, 1 (2023)
[4] A. Gonoskov et al., Rev. Mod. Phys. 94, 045001 (2022)
[5] A. Di Piazza et al., Rev. Mod. Phys. 84, 1177 (2012)

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Monday Poster Session / 2046

Characterization of low-emittance electron beams using a new photocathode drive laser NEPAL at the European XFEL

Author: Ye Chen[1]

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An ultrafast laser system for driving the photocathode RF gun at the European XFEL has been recently put into operation. The new laser system, NExt generation PhotocAthode Laser (NEPAL) is capable of providing drive laser pulses of variable pulse lengths and shapes, supporting the facility to extend its capabilities to operate in multiple user-desirable FEL modes. In this paper, we present a preliminary characterization of the low-emittance electron beam produced by NEPAL in the photoinjector. Both experimental and numerical results will be shown and discussed.

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Thursday Poster Session / 2047

Sextupole offset effects on the storage ring linear optics

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Even though the strengths are weaker, different from quadrupole offsets, sextupole offsets are causing more complicated disturbances on the storage ring optics. They are making orbit distortion and quadrupole kicks as well as couplings. The offsets in chromatic sextupoles can affect the correction of chromaticity too. The closed orbit corrections in modern storage rings are fast and reliable, but their main focus is correcting the orbit to the quadrupole centers and the orbit distortion from a sextupole offset can make orbit offsets at other sextupoles which can be iterated. In this paper, we study the impact of the sextupole offsets on the linear optics in NSLS-II storage ring.

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Wednesday Poster Session / 2048

Using WarpX to simulate linear induction accelerators

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This study is a review of WarpX, a particle-in-cell code optimized for high performance computing at the exascale, and its development towards the simulation of linear induction accelerators.

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Monday Poster Session / 2049

Beam loss mitigation in H- linac

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Charge-exchange injection is a key to overcome the Liouville's theorem and to get over the intensity barrier. Specifically negative hydrogen linac injector for a ring is mostly used to obtain high intensity pulsed proton beam for high-energy physics or neutron application. However, different from proton linac, beam loss due to stripping can be a significant issue. For instance, the intra-beam stripping (IBSt) can be the dominant source of residue radiation in a high-intensity H- linac. IBSt rate can be only affected by focusing structure. It is of interests in J-PARC linac, which has an original equi-partition design and flexibility to manipulate a considerable range. The H0 resulting from stripping generates a broad loss pattern, which is sensitive to the aperture. We studied the dependencies and achieved consistency between simulation and measurements from beam loss monitors and residue radiation, and found a systematic way for beam loss mitigation for operation. We successfully removed abnormal hot spots and mitigate the total residue radiation by half. These results provide insights into optimizing existing H- linac performance as well as design strategies of future H- linacs.

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Monday Poster Session / 2050

Overview of R&D activities for the production and characterization of high energy photon beams beyond 25 keV at the European XFEL

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Scientific opportunities with very hard XFEL radiation demands dedicated facility development towards FEL operation in the sub-ångström regime. Very hard X-rays provide capabilities of high Q-range coverage and high penetration, and also allow access to the K-edge spectroscopy of high-z

materials. Production of such X-rays using FELs takes advantage of general FEL characteristics such as large coherence, short pulse option, variable pump-probe delay control and higher brightness compared to conventional storage ring sources. R&D activities in the characterization and production of high energy photon beams beyond 25 keV has been launched since 2020 at the European XFEL. Photon beams of 30 keV have been routinely produced, characterized and delivered to experimental hutches. In this paper, we give an overview of the overall development. Both experimental and numerical results will be presented and discussed.

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Tuesday Poster Session / 2053

Progress towards the completion of the Proton Power Upgrade project

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The Proton Power Upgrade project at the Spallation Neutron Source at Oak Ridge National Laboratory will increase the proton beam power capability from 1.4 to 2.8 MW. Upon completion in early 2025, 2 MW of beam power will be available for neutron production at the existing first target station (FTS) with the remaining beam power available for the future second target station (STS). The project has installed seven superconducting radio-frequency (RF) cryomodules and supporting RF power systems to increase the beam energy by 30% to 1.3 GeV, and the beam current will be increased by 50%. The injection and extraction region of the accumulator ring are being upgraded, and a new 2 MW mercury target has been developed along with supporting equipment for high-flow gas injection to mitigate cavitation and fatigue stress. The first four cryomodules and supporting systems were commissioned in 2022-2023 and supported neutron production at 1.05 GeV, 1.7 MW with high reliability. The first-article 2 MW target was operated successfully for approximately 4400 MW-Hours over two run periods. The long outage began in August 2023 for installation of the remaining technical equipment and construction of the Ring-to-Target Beam Transport tunnel stub that will enable connection to the STS without interrupting operation of the FTS. The upgrade is proceeding on-schedule and on-budget, and resumption of neutron production for the user program is planned for July 2024.

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Thursday Poster Session / 2054

Canadian Light Source developments of the ALBA /CLS DLLRF system

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Located in Saskatoon, Saskatchewan, Canada, the Canadian Light Source (CLS) has been operation since 2003. CLS is a 3rd generation Synchrotron Light Source operating at 2.9GeV. The CLS Booster RF system uses a 100 kW, 500 MHz solid-state power amplifier to power two 5-cell "PETRA"cavities. Recently ALBA and CLS collaborated to commission a CLS-constructed version of the ALBA Digital Low-Level RF system in the CLS Booster ring RF system to replace the aging analog low-level RF system. Changes were required to address differing configuration and requirements between the CLS and ALBA RF systems. Challenges and opportunities for system machine safety, reliability, and performance improvements identified during and after commissioning have been addressed. Hardware configuration changes were implemented. Additional hardware devices have been produced and incorporated to streamline interfacing and to mitigate some risks. Software and machine code changes were made to alter and automate functions, and to reduce potential stresses on high-power RF equipment components.

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Wednesday Poster Session / 2055

Xsuite: a flexible python toolkit for beam dynamics

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Xsuite is a modular simulation package bringing to a single flexible and modern framework capabilities of different tools developed at CERN in the past decades notably MAD-X Sixtrack Sixtracklib COMBI and PyHEADTAIL. The suite consists of a set of Python modules (Xobjects, Xpart, Xtrack, Xcoll, Xfields, Xdeps) that can be flexibly combined together and with other accelerator-specific and general-purpose python tools to study complex simulation scenarios. Different computing platforms are supported including conventional CPUs as well as GPUs from different vendors. The code allows for symplectic modeling of the particle dynamics combined with the effect of synchrotron radiation impedances feedbacks space charge electron cloud beam-beam beamstrahlung and electron lenses. For collimation studies beam-matter interaction is simulated using the K2 scattering model or interfacing Xsuite with the BDSIM/Geant4 library and with the FLUKA code. Methods are made available to compute and optimize the accelerator lattice functions, chromatic properties and equilibrium beam sizes. By now the tool has reached a mature stage of development and is used for simulations studies by a large and diverse user community.

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Tuesday Poster Session / 2056

Analysis of neutron spectra of candidate materials for potential moderator locations in the NEAR station at the CERN/n_TOF facility

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The n_TOF is one of the few neutron spallation facilities in the world capable of delivering neutron spectra. These spectra are used for precise neutron-induced cross-section measurements using the time of flight technique. The facility has made significant contributions to a wide range of scientific fields including astrophysics, nuclear technologies and medical applications since the beginning of its operation in 2001. The n_TOF facility produces neutrons by directing a 20 GeV pulsed proton beam extracted from the proton synchrotron onto a pure lead target cooled with nitrogen gas.
In 2021, the third irradiation area, the NEAR station, was built next to to the n_TOF target. The station consists of two study locations. One of the locations is situated inside the shielding of the

n_TOF target. Its aim is to study irradiation damage of high doses (in the order of MGy) in materials. The other location, outside the shielding, uses a collimator to convey the high-intensity neutrons to the outside area.
In this work we incorporate MCNP6 code and the FENDL-3.1 cross-section library, along with the generated weight windows of the target for variance reduction, to simulate the irradiation of materials in the NEAR station. Three locations in the NEAR station were irradiated and neutron spectra were estimated for different moderator candidate materials. The results will be used during neutron capture cross section measurements by the activation method at the n_TOF NEAR Station.

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Wednesday Poster Session / 2057

Mapping of an SRF electron gun focusing solenoid assembly

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SLAC's LCLS-II-HE upgrade will expand the energy regime of their XFEL at high repetition rates. Due to the low emittance requirement, a superconducting QWR based electron gun was proposed by SLAC and is being developed by FRIB in collaboration with ANL and HZDR. The emittance compensation solenoid consists of two main coils, along with horizontal and vertical dipoles as well as normal and skew quadrupole correctors. To validate the performance and characterize the field profile of the magnet, we developed a mapper system. We utilized a SENIS 3D Hall probe on a cantilevered rail driven by an Arduino controlled stepper motor. With high repeatability, we were able to measure peak field strengths and fall off. Further data analysis allowed us to determine their relative locations, in addition to confirming alignment and integrated field strengths. In accordance with design specifications, we measured the peak solenoid fields to be about 172mT and their centers to be less than 0.1mm apart transversely. The mapping design, assembly, process, analysis, and lessons learned are discussed herein.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

North America

Prize Session / 2058

APS Winston Award Talk

Author: Kaoru Yokoya[1]

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Winner will talk about his career highlights and the projects he has been involved in.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Monday Poster Session / 2059

Development of a novel segmented THz-driven electron source

Author: Reza Bazrafshan[1]

Co-authors: Franz Kaertner [1]; Junhao Zhang [1]; Moein Fakhari [1]; Nicholas Matlis [2]; Tobias Kroh [2]

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Scaling the RF-accelerator concept to terahertz (THz) frequencies possesses several compelling advantages, including compactness, intrinsic timing between the photoemission and driving field sources, and high field gradients associated with the short THz wavelength and high breakdown threshold promises vastly smaller and cost-efficient accelerators. These benefits, however, come at the cost of smaller dimensions and tighter tolerances which are challenging to reach in practice. Experiments to test and characterize a multi-layered structure easy-to-implement electron source with tunable interaction length powered by 2 × 120 μJ of twin single-cycle THz pulses predicted to produce 100 fC electron bunches with 200 keV energy, < 1 % energy spread, 0.01 - 0.07 mm mrad transverse emittance and a bunch duration of 20 − 40 fs are currently in progress. Besides the gun structure, the performance characteristics of the THz-driven electron source, including the generation of terahertz pulses, UV beam profile, coupling efficiency of the gun structure, electron beam dynamics, etc are discussed in detail. Such THz-based accelerator prototypes are not only promising as injectors for compact THz-based LINACs but also as a source for ultrafast electron diffraction experiments.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Europe

Wednesday Poster Session / 2061

Final design of the Cryogenic Current Comparator for FAIR

Author: Thomas Sieber[1]

Co-authors: David Haider [1]; Herbert De Gersem [2]; Jocelyn Tan [3]; Lorenzo Crescimbeni [4]; Marcus Schwickert [1]; Matthias Schmelz [5]; Max Stapelfeld [4]; Nicolas Marsic [2]; Ronny Stolz [5]; Thomas Stoehlker [1]; Volker Tympel [6]; Vyacheslav Zakosarenko [7]

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Cryogenic Current Comparators (CCC) are ultrasensitive DC-Beam Transformers based on superconducting SQUID technology. With the aim to provide a robust and high resolution intensity measurement for application at FAIR and CERN machines, numerous steps of optimization were carried out over the last years by a collaboration of institutes specialized on the various subtopics. Different types of CCCs with respect to pickup, magnetic shielding, SQUID types and SQUID coupling have been developed and were tested in the laboratory as well as under beamline conditions. In parallel, the cryogenic system has steadily been optimized, to fulfill the requirement of a standalone liquid helium cryostat, which is nonmagnetic, fit for UHV application, vibration damped, compact and accessible for maintenance and repair.
We will present the particular development steps and describe the final version of the CCC for FAIR as their outcome. The latest beamtime results are shown as well as recent tests with the cryogenic system. The CCC for FAIR will be a so called Dual-Core CCC (DCCC), which runs two pickups in parallel with independent electronics for better noise reduction and redundancy. The magnetic shielding will have an axial meander geometry, which provides superior attenuation of external magnetic noise.

Footnotes:

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Paper preparation format:

Word

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Europe

Thursday Poster Session / 2062

Optics design of a compact helium synchrotron for advanced cancer therapy

Author: Heli Huttunen[1]

Co-authors: Foteini Asvesta [1]; Elena Benedetto [2]; Luca Bottura [1]; Daan Flier [1]; Tirsi Prebibaj [1]; Rebecca Taylor [3]; Maurizio Vretenar [1]

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The design of a helium synchrotron for cancer therapy is being studied and optimized in the context of the Next Ion Medical Machine Study (NIMMS) at CERN. In particular, the effects of combined-function magnets and their geometry on the optics functions and hence on the beam size are evaluated. Moreover, the introduction of defocusing quadrupoles in the lattice is investigated as a means of better controlling the optics in both planes, while sextupoles for chromaticity control and resonant extraction are introduced. The updated lattice design is simulated to identify potential limitations in terms of nonlinear dynamics due to the low periodicity of such a compact design and propose a regime for operations from the transverse beam dynamics'perspective.

Footnotes:

Funding Agency:

Paper preparation format:

LaTeX

Region represented:

Europe

Prize Session / 2063

APS Outstanding Dissertation Award Winner: advanced methods for storage ring nonlinear beam dynamics design and implementation

Author: Minghao Song[1]

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Nonlinear lattice optimization and correction become increasingly important as storage ring light sources continue to push towards ultra-low emittances. An advanced algorithm based on machine learning technique, called multi-generation Gaussian process optimizer (MG-GPO), was applied to find optimal nonlinear lattice solutions, and was demonstrated to outperform traditional algorithms. It was also implemented in online optimization and resulted in improved machine performance. The need to drive and maintain large beam oscillation amplitude for nonlinear beam dynamics measurement and correction motivated the study of resonant driving with swept frequency. We discovered that there exists a drive amplitude threshold for successful beam excitation. The dependence of the

threshold on frequency sweep rate and lattice parameters is theoretically analyzed. The results were verified by both simulations and experimental data.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

North America

Student Poster Session / 2065

Effects of implantation temperature and annealing on structural evolution and migration of ruthenium in glassy carbon

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The use of glassy carbon (GC) as a future nuclear waste storage material depends on its capability to retain all radioactive fission products found in spent nuclear fuels. Ruthenium (Ru) is one of the most important fission products in nuclear reactors. This work investigates the effects of implantation temperature and annealing on the structural evolution and migration of Ru implanted in GC. To achieve these objectives, 150 keV Ru+ was implanted into GC samples separately at room temperature (RT) and 200℃ to a fluence of 1×10ˆ16 cmˆ−2. Some of the as-implanted samples were annealed at two temperature regimes (from 500 to 1000℃ and from 1000 to 1300℃–in steps of 100℃) for 5 h and characterized by Raman spectroscopy, X-ray diffraction (XRD), atomic force microscopy (AFM), and Rutherford backscattering spectrometry (RBS). Both Raman spectroscopy and XRD showed that implantation caused defects in the GC structures, with more defects in the RT as-implanted sample. Annealing caused the healing of both sample types but retained some radiation damage. No migration of Ru atoms was observed after annealing the as-implanted samples up to 800℃. However, a different migration behavior was seen after annealing the RT and 200℃ samples from 900 to 1300℃, attributed to the aggregation, trapping and de-trapping of Ru atoms in different amounts of defect induced by implantation.

Footnotes:

Implantation, Aggregation, Migration, Stress, Glassy Carbon

Funding Agency:

Paper preparation format:

Region represented:

Asia

Student Poster Session / 2066

An electron beam modulation laser for steady-state microbunching

Author: Xinyi Lu[1]

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Steady-state microbunching (SSMB) represents an innovative scheme for generating high-power coherent radiation. This approach is expected to generate kilowatt-scale extreme ultraviolet (EUV) radiation for lithography in the semiconductor industry. During the second phase of the SSMB proof-of-principle experiment (SSMB PoP II), the creation of quasi-steady-state microbunches requires specific modulation of the electron beam. This modulation is achieved through a phase-locked laser with a high repetition rate, which enables the detection of continuous coherent radiation over multiple turns. To meet the requirements of SSMB PoP II, a high-power, high-repetition-rate, phase-stabilized pulsed laser has been developed. The single-frequency pulsed laser has been achieved using an electro-optic modulator stage, three amplification stages, and a phase-locked feedback system. Here we report on the development and test results of the electron beam modulation laser.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Student Poster Session / 2067

Monte Carlo modeling of spin-polarized photoemission from NEA GaAs with low-temperature and strained-lattice effects

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Co-authors: Ambar Rodriguez Alicea [2]; Luca Cultrera [3]; Oksana Chubenko [4]; Siddharth Karkare [4]

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[4] *Arizona State University*

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GaAs-based photocathodes activated to negative electron affinity (NEA) is the only existing technology that can deliver intense and highly spin-polarized electron beams for the forthcoming Electron-Ion Collider as well as enable spin-polarized scanning tunneling microscopy, ultrafast spin-polarized low-energy electron diffraction, and other cutting-edge experiments. The degree of spin-polarization of electrons photoemitted from unstrained GaAs is usually considerably less than the theoretical maximum of 50%. However, it has been experimentally observed that the degree of electron spin polarization can be increased and even exceed the theoretical maximum when the sample is cooled to low temperatures. Additionally, in strained lattice samples, the theoretical maximum of spin polarization increases to 100%. The previously developed Monte Carlo approach to spin-polarized photoemission from unstrained, room temperature NEA GaAs provides excellent agreement with

experimental data in a wide range of doping densities and photoexcitation energies. This study aims to extend the model's capabilities by incorporating both low-temperature and strained-lattice effects into the band structure and exploring their impact on spin and momentum relaxation mechanisms. Modeling of both low-temperature and strained NEA GaAs will provide a foundation for modeling photoemission from novel spin-polarized materials and complex layered structures.

Footnotes:

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North America

Student Poster Session / 2068

BAGELS: a general method for spin matching electron storage rings

Author: Matthew Signorelli[1]

Co-authors: Yunhai Cai [2]; Georg Hoffstaetter [1]

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[2] *SLAC National Accelerator Laboratory*

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We present a novel method for minimizing the effects of radiative depolarization in electron storage rings by use of vertical orbit bumps in the arcs. Depolarization is directly characterized by the RMS of the spin-orbit coupling function in the bends. In the Electron Storage Ring (ESR) of the Electron-Ion Collider (EIC), as was the case in HERA, this coupling function is excited by the spin rotators. Individual vertical corrector coils in the arcs can have varying impacts on the spin-orbit coupling function globally. In this method, we use a singular value decomposition of the response matrix of this coupling function for each corrector coil to define a minimal number of most effective groups of corrector coils, motivating the name "Best Adjustment Groups for ELectron Spin"(BAGELS) method. The BAGELS method can be used for obtaining the best knobs to minimize the depolarizing effects in the design lattice, and for obtaining fine-tuning knobs to perform this minimization in rings with realistic closed orbit distortions during operation. Its application has significantly increased the asymptotic polarization in simulations of the planned 18 GeV ESR, beyond achievable with conventional methods.

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North America

Student Poster Session / 2069

Comparison of WarpX and GUINEA-PIG for electron positron collisions

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As part of the Snowmass'21 planning exercise, the Advanced Accelerator Concepts community proposed developing multi-TeV linear colliders and considered beam-beam effects for these machines [1]. Such colliders operate under a high disruption regime with an enormous number of electron-positron pairs produced from QED effects. Thus, it requires a self-consistent treatment of the fields produced by the pairs, which is not implemented in state-of-the-art beam-beam codes such as GUINEA-PIG. WarpX is a parallel, open-source, and portable particle-in-cell code with an active developer community that models QED processes with photon and pair generation in relativistic laser-beam interactions [2]. However, its application to beam-beam collisions has yet to be fully explored. In this work, we benchmark the luminosity spectra, photon spectra, and the recently implemented pair production processes from WarpX against GUINEA-PIG in ultra-tight collisions, ILC, and Cˆ3 scenarios. This is followed by a run-time comparison to demonstrate the speed-up advantage of WarpX. Ultimately, this work ensures a more robust modeling approach to electron-positron collisions, with the goal of scaling up to 15 TeV.

Footnotes:

[1] T. Barklow et al. Journal of Instrumentation 18, P09022 (2023).
[2] L. Fedeli et al. 2022 SC22: International Conference for High Performance Computing, Networking, Storage and Analysis (SC). IEEE Computer Society 2022.

Funding Agency:

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Europe

Student Poster Session / 2070

Enhanced harmonic stability in magnet resonant power supplies via multi-harmonic closed-loop control and current feedforward

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As the China Spallation Neutron Source (CSNS) Phase II project upgrades beam power to 500 kW, maintaining horizontal beam orbit stability necessitates more precise output current from the main magnet power supplies. The existing control strategy, suited for 100 kW extraction power, falls short of the higher precision requirements for the output current, characterized by a quasi-sinusoidal waveform with 25 Hz and its higher-order harmonics. Moreover, this strategy is highly sensitive to environmental temperature, causing significant fluctuations in the amplitude and phase of the high-order harmonics, thereby adversely affecting the power supplies' performance.
This paper proposes a new control scheme that merges high-order harmonic current compensation with double PI closed-loop control, enabling up to sixth harmonic control in the main magnet power supplies. Leveraging the existing Digital Power Supply Control Module (DPSCM) controller in the power supply system, this approach achieves precise and efficient control of the 50 Hz harmonic current output which was previously the source of the largest ripple error.
The study confirms that the new control scheme effectively mitigates temperature drift issues and reduces the output ripple of the entire 50 Hz reference current waveform. As a result, the performance of the main magnet resonant power supplies in Rapid Cycle Synchrotron is significantly enhanced, leading to a marked reduction in the variation of beam orbit deviation.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Student Poster Session / 2071

Space charge compensation in ultra-high brightness RF photoinjectors

Author: Oliver Betteridge[1]

Co-authors: Can Davut [2]; Oznur Apsimon [1]; Robert Apsimon [1]

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This study delves into the intricate realm of space charge effects within ultra-high-brightness RF photoinjectors, aiming to unveil their detrimental consequences on beam quality, including emittance growth, increased beam size and beam instabilities. Building upon the foundational work of B.E. Carlsten and many others, our research extends compensation techniques to encompass higher-order, non-linear terms of space charge forces. This expansion offers valuable insights into the underlying mechanisms responsible for undesirable beam quality issues.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Europe

Student Poster Session / 2072

A pole design optimization method for permanent quadrupole magnet

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Permanent quadrupole magnet (PQM) has good physical properties and extremely high economic performance, which can be used in proper physical design to adjust the central magnetic field gradient and at the same time greatly reduce the operating cost of modern gas pedals, but the design and optimization of the PQM's pole is still a difficult problem that needs to be solved at present. We hope to expand the range of the permanent magnet quadrupole's good field area, lower its high harmonic order of magnitude, and create a permanent magnet quadrupole magnet with a better magnetic field quality by applying new optimization algorithms.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Student Poster Session / 2073

Towards mitigation of challenges in development of high power ISOL targets

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Co-authors: Alexander Gottberg [1]; Carla Babcock [1]; Luca Egoriti [1]; Tobias Junginger [1]

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Worldwide Isotope Separation On-Line (ISOL) facilities face growing demand for producing and extracting high-purity exotic radioactive ion beams to serve nuclear physics, astrophysics and medical applications. In this technique, a particle beam interacts with a suitable target material to produce the desired isotopes through a combination of mechanisms like spallation, fragmentation and fission. TRIUMF has the world's highest-power ISOL facility—ISAC, handling 50 kW of proton beam power. The formidable challenge is to suitably handle the power deposited within the target material and maintain it at 2000℃ to optimize the diffusion and effusion of the radioactive products. The intricacy of this design requires precise knowledge of the thermal properties of the target material. Typically, a blend of metallic carbide and graphite, these targets exhibit varying porosity and morphology and have effective thermal properties differing from individual constituent elements. To investigate these properties, a combined numerical-experimental approach is employed. This contribution discusses the optimization of target material sample size using numerical tools and outlines the exploration of thermal properties using an experimental apparatus, the Chamber for Heating Investigations (CHI), developed at TRIUMF.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

North America

Student Poster Session / 2074

Numerical methods for emittance computation from luminosity

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The beam transverse emittances play a critical role in high-energy colliders. Various measurement techniques are employed to measure them. In particular, the so-called luminosity emittance scans (or Van der Meer scans) are used in order to evaluate the convoluted beam emittances. This method assumes different emittances in the two planes but identical emittances in the two beams. In this paper, we propose an approach to remove this constraint. After having presented the new measurement protocol, we will discuss its potential and limits, including the statistical measurement error of the luminosity value as obtained from numerical studies.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Europe

Student Poster Session / 2075

An experimental study on plasma cleaning of room temperature copper cavity: design and analysis

Author: Qianxu Xia[1]

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The development and standardization of in-situ plasma cleaning for superconducting radio frequency (SRF) cavities have a well-established history. This technique has demonstrated efficacy in reducing dark current and electron multiplication, thereby enhancing the acceleration gradient and stability of SRF devices. However, applying in-situ plasma cleaning to normal-temperature copper (NTC) cavities presents a unique challenge due to the absence of defined parameters, processes, and experimental data. Unlike SRF cavities, NTC cavities face difficulty removing surface oxide to increase the work function. Addressing this challenge, Tsinghua University conducted a study to investigate the application of argon-oxygen plasma for the removal of organic matter, gas, and burrs, and argon-hydrogen plasma to reduce copper oxide on NTC cavities specifically. The findings from this research contribute valuable insights that can serve as a guide for the effective implementation of in-situ plasma cleaning in NTC cavities.
This paper is only for experimental results and data analysis. The related plasma physics formulas and COMSOL calculation results will be presented in future papers.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Student Poster Session / 2076

Transfer learning for field emission mitigation in CEBAF SRF cavities

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The Continuous Electron Beam Accelerator Facility (CEBAF) operates hundreds of superconducting radio frequency (SRF) cavities in its two linear accelerators (linacs). Field emission (FE) is an ongoing operational challenge in higher gradient SRF cavities. FE generates high levels of neutron and gamma radiation leading to damaged accelerator hardware and a radiation hazard environment. During machine development periods, we performed invasive gradient scans to record data capturing the relationship between cavity gradients and radiation levels measured throughout the linacs. However, the field emission environment at CEBAF varies considerably over time as the configuration of the radio-frequency (RF) gradients changes or due to the strengthening of existing field emitters or the abrupt appearance of new field emitters. To mitigate FE and lower the radiation levels, an artificial intelligence/machine learning (AI/ML) approach with transfer learning is needed. In this work, we mainly focus on leveraging the RF trip data gathered during CEBAF normal operation. We develop a transfer learning based surrogate model for radiation detector readings given RF cavity gradients to track the CEBAF's changing configuration and environment. Then, we could use the developed model as an optimization process for redistributing the RF gradients within a linac to mitigate field emission.

Footnotes:

Funding Agency:

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Paper preparation format:

Region represented:

North America

Student Poster Session / 2077

Characterization and optimization of a C-band photoinjector for inverse Compton scattering radiation sources

Author: Giovanni Campri[1]

Co-authors: Anna Giribono [2]; Armando Bazzani [3]; David Alesini [2]; Francesco Demurtas [2]; Giorgio Turchetti [3]; Massimo Placidi [4]; Simone Di Mitri [5]

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[2] *Istituto Nazionale di Fisica Nucleare*

[3] *Bologna University*

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We performed an optimization study of a C-band photoinjector for high brightness electron beams. Such a device is capable of producing high quality electron beams, with low energy spread and small transverse emittance, which are properties required by Inverse Compton Scattering radiation sources and compact light sources in general. This work aimed to carry out, via numerical simulations, an optimization of the beam generated by such photoinjector, in the pursuit of its real application in the context of current projects, namely EuPRAXIA@SPARC_LAB*, and proposals such as BoCXS** at the University of Bologna.

Footnotes:

- M. Ferrario et al., Design study towards a compact FEL facility at LNF EuPRAXIA@SPARC_LAB, arXiv, (2018). ** M. Placidi, et al., BoCXS: A compact multidisciplinary X-ray source, Physics Open, (2020).

Funding Agency:

Paper preparation format:

Region represented:

Europe

Student Poster Session / **2078**

Design and development of array multipoint accelerator tube

Author: Liang Zhang[1]

[1] *NUCTECH Company Limited*

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Linear accelerators with multiple ray sources are widely used in detection imaging technology. In this paper, an S-band multipoint source traveling wave accelerator tube is designed and developed. The accelerator tube consists of 8 parallel-arranged accelerator cavity units and uses a power source to output 8 X-ray beams alternating from different positions. The acceleration tube operates at S-band 2998 MHz. In this paper, the physical design of the accelerator tube is introduced, the dynamic design of the accelerator tube is completed by numerical calculation, and the verification calculation is carried out by PARMELA. After machining, the cold test tuning and high power beam test are carried out. The beam energy range is between 0.5 and 1 MeV, and 8 beams can be switched arbitrarily.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Student Poster Session / **2079**

Generation of attosecond electron bunches through terahertz regulation

Author: Yian Wang[1]

Co-authors: Renkai Li [1]; Yingchao Du [1]; Zhichao Dong [1]; Han Chen [1]

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Obtaining ultrashort electron bunches is the key to the studies of ultrafast science, yet second and higher order nonlinearities limits the bunch length to a few femtoseconds after compression. Traditional regulation methods using rf higher order harmonics have already optimized the bunch length to sub-fs scale, yet the energy loss and rf jitter are not negligible. In this paper we demonstrate the second order regulation with THz pulses through a dielectric-loaded wave-guide. Simulations suggest that with higher order correction, the MeV electron bunches with tens of fC charges can be compressed to a 679 attoseconds rms and the second order distortion can be compensated. The transverse beam size is also optimized to 16.8 um rms. This scheme is feasible for a wide range of electron charges. The relatively short bunch length is expected to find a better time resolution in UED, UEM and other ultrafast, time-resolved studies.

Footnotes:

Funding Agency:

Paper preparation format:

Region represented:

Asia

Student Poster Session / 2080

Beam dynamics study of the bimodal RF cavity for advanced light source

Author: Dinghui Su[1]

Co-authors: Wencheng Fang [2]; Jianhao Tan [3]; Cheng Wang [2]; Zihe Gao [1]; Yusen Guo [4]; Hanyu Gong [1]; Yixing Lu [2]; Xiaoxia Huang [2]; Jia Hao Tian [4]; Yiming Xu [2]

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Beam lengthening is significant for improving the beamlife of storage rings. Based on the previously proposed design of a room temperature conducting bimodal RF cavity, we conducted relevant dynamic simulations. The results showed that in a simulated storage ring lattice with the beam energy of 2 GeV and the synchronous radiation energy of 0.0356 MeV, the bimodal cavity realizes a same bunch-lengthening performance that is comparable to the double RF system composed of a main high-frequency cavity and a third harmonic cavity. This works provides reference materials for the design of bimodal cavities and provides strong support for application.

Footnotes:

Funding Agency:

Paper preparation format:

LaTeX

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Asia

Student Poster Session / 2081

Design and measurement of the septum magnet for Hefei Advanced Light Facility

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Co-authors: Chunyu Xu [1]; Feng-lei Shang [1]; Lei Shang [1]; Wenbin Song [1]

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Corresponding Author: dingxiaomm@msn.cn

The septum magnet with shorter drive pulse has a smaller leakage field and stray field time tail. The examination is performed experimentally and theoretically.

Footnotes:

septum, leakage field, Hefei Advanced Light Facility (HALF)

Funding Agency:

Hefei Advanced Light Facility Pre-research Project

Paper preparation format:

Region represented:

Asia

Student Poster Session / 2082

New design techniques on matching couplers for travelling wave accelerating structures

Author: Zhicheng Huang[1]

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Numerical optimizations on couplers of the traveling wave accelerating structures usually require lots of calculation resources. This paper proposes a new technique for matching couplers to an accelerating structure in a more efficient way. It combines conventional Kroll method with improved Kyhl method, thereby simplifying the tuning and simulation process. We will present the detailed design of a constant-gradient C-band accelerating structure based on this new method.

Footnotes:

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Paper preparation format:

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Student Poster Session / 2083

Experimental characterization of the timing-jitter effects on a beam-driven plasma wakefield accelerator

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Plasma wakefield acceleration is nowadays very attractive in terms of accelerating gradient, able to overcome conventional accelerators by orders of magnitude. However, this poses very demanding requirements on the accelerator stability to avoid large instabilities on the final beam energy. In this study we analyze the correlation between the driver-witness distance jitter (due to the RF timing jitter) and the witness energy gain in a plasma wakefield accelerator stage. Experimental measurements are reported by using an electro-optical sampling diagnostics with which we correlate the distance between the driver and witness beams prior to the plasma accelerator stage. The results show a clear correlation due to such a distance jitter highlighting the contribution coming from the RF compression.

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Student Poster Session / 2084

Analyzing sudden beam loss in the SuperKEKB/Belle-II experiment with RFSoC technology

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In the SuperKEKB/Belle-II experiment, a multitude of elementary particle reactions is initiated through the collision of 4 GeV positrons with 7 GeV electrons, paving the way for the exploration of new physics. The experiment includes plans for the substantial enhancement of luminosity in the future, aiming to achieve an integrated luminosity approximately 100 times the current level. However, the realization of this goal is impeded by a recurrent occurrence of a phenomenon known as "Sudden Beam Loss," which entails the abrupt disappearance of the beam within tens of microseconds. The cause and location of these occurrences have not yet been identified.
To provide the tools to diagnose and debug these sudden beam loss events, a new Bunch Oscillation Recorder (BOR) has been developed to analyze this phenomenon, utilizing the Radio Frequency System on Chip (RFSoC) from AMD/Xilinx. The beam position of each individual bunch is measured and recorded by the BOR just prior to the onset of sudden beam loss. We will present how the signal from the button beam position monitor of the beam pipe is processed by RFSoC, along with the results obtained from observing the actual SuperKEKB beam using RFSoC.

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Student Poster Session / 2085

Crystal collimation for the HL-LHC upgrade using MERLIN++

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This paper details the implementation and benchmarking of crystal collimation within MERLIN++ accelerator physics library and demonstrates its application in simulating crystal collimation process for the High Luminosity upgrade of LHC at CERN. Crystal collimation is one of the key technologies suggested to enhance the current collimation system according to the requirements of HL-LHC upgrade due to its increased beam energy and luminosity. This paper outlines the proposed methodology for this study which includes implementing the demonstrated physics of particle crystal interaction in MERLIN++, benchmarking it with the existing experimental data and simulating the HL-LHC operational scenarios with the crystals as primary collimators. MERLIN++ has already been efficiently used for multiple LHC collimation studies which highlights its importance , making it an essential simulation tool for comparative analysis with other simulation tools, as relying on

a single tool for concluding the HL-LHC collimation system is often insufficient. As collimation systems are fundamental for machine protection , accurately predicting the crystal collimation performance is of utmost importance to know how they will perform in HL-LHC to guarantee that the HL-LHC meets its intended objectives with crystal collimators.

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Student Poster Session / 2086

High power experimental results of a multicell dielectric disk accelerating structure

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A Dielectric Disk Accelerator (DDA) is a metallic accelerating structure loaded with dielectric disks to increase its shunt impedance. These structures use short RF pulses of 9 ns to achieve accelerating gradients of more than 100 MV/m. Single cell and multicell clamped structures have been designed and high power tested at the Argonne Wakefield Accelerator. During testing, the single cell clamped DDA structure achieved an accelerating gradient of 102 MV/m with no visible damage in the RF volume region. The minimal damage that was seen outside the RF volume was likely due to RF leakage from uneven clamping during assembly. Based on the success of that experiment, a clamped multicell DDA structure has been designed and tested at high power. Simulation results for this new structure show a 108 MV/m accelerating gradient with 400 MW of input power with high shunt impedance and group velocity. Engineering designs were improved from the single cell structure for a more consistent clamping over the entire structure. Up to this point in the high power experiments, the results show a peak input power of 222 MW correlating to an accelerating gradient of 80 MV/m. Testing of this structure will continue January 2024.

Footnotes:

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Student Poster Session / 2087

A large momentum acceptance gantry for light-weight proton therapy facility: its beam lattice, magnets design and clinical advantages

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As one of the state-of-the-art radiotherapy approaches, proton therapy possesses conformal dose profiles yet expensive cost. Designing a facility with a small footprint and a high treatment efficiency is the main goal for researchers to fulfill the potential of proton therapy and make it more affordable both for vendors and patients. In this contribution, the design of a light-weight proton therapy gantry based on the alternating-gradient canted-cosine-theta (AG-CCT) super-conducting (SC) magnet is presented. The AG-CCT magnets adopt large bores and combined function design. With fine field harmonic control and fringe field shape optimization of the magnets, the multi-particle tracking results prove that the gantry achieves a momentum acceptance of ±8%. So that the full energy range from 70 to 230 MeV can be covered with merely 3 field switch points. Combined with a fast degrader component, whose switch time is below 50 ms, the energy modulation speed can be greatly fastened. To fully utilize the advantages of the large momentum acceptance gantry, the energy spread of the proton beam is expanded and a reduced treatment plan is proposed. Compared with the standard treatment plan, the energy layers number of a prostate case is reduced by 61.3% with comparable plan quality. In summary, the proposed gantry has significant superiority both in manufacture and clinical aspects.

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Asia

Student Poster Session / 2088

First implementation of KO extraction at COSY

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Radio Frequency Knock Out (RF KO) resonant slow extraction is commissioned at the Cooler Synchrotron (COSY) Jülich for the first time to extract the stored beam and deliver spills with constant particle rates to the experiments. Therefore, transverse RF excitation generated with a software-defined radio is applied to control the extraction rate. A built-in feedback system adjusts the excitation amplitude to maintain the desired extraction rate. To suppress fluctuations of the particle

rate on timescales of milliseconds and below, an optimization algorithm is used to tune the RF signals used for excitation. The method was used extensively during the final run of COSY in 2023, delivering stable beams to the various users.

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Europe

Student Poster Session / 2089

Studies of space-charge compensation of positive ions by creating time-dependent secondary electrons in low-energy beam transport line

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The space-charge neutralization of an ion beam by created electrons when the beam ionizes the gas is investigated using a three-dimensional electrostatic particle-in-cell code. Different kinds of injected gases are considered, and their space-charge compensation transient times are compared. The created secondary electrons by the beam collision with neutral gas along the beam trajectories are loaded in the simulation by a Monte Carlo generator, and their space charge contribution is added to the primary beam space charge densities. The injection and accumulation of secondaries are time-dependent and this process is continued until total space charge densities reach a steady state. In this study, a 2.4-meter LEBT line with two solenoid magnets is considered. Usually, the proton beam energy is 25 keV and the current level is around 10-15 mA. Additionally, beam extraction studies are conducted, and the extracted beam is used in both IBSIMU and Tracewin codes for LEBT lines to validate the results.

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Student Poster Session / 2090

Impact of octupoles on the Schottky spectra of bunched beams

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Schottky monitors serve as non-invasive tools for beam diagnostics, providing insights into crucial bunch characteristics such as tune, chromaticity, bunch profile, or synchrotron frequency distribution. However, octupole magnets commonly used in circular storage rings to mitigate instabilities through the Landau damping mechanism, can significantly affect the Schottky spectrum. Due to the amplitude-dependent incoherent tune shift of individual particles, the satellites of the Schottky spectrum are smeared out as the octupolar field increases. This study investigates the impact of octupoles and their incorporation into theory, with the goal of improving beam and machine parameter evaluation from measured spectra. Theoretical findings are validated through macro-particle simulations conducted across a range of octupole strengths, encompassing typical operational conditions at the Large Hadron Collider.

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Europe

Student Poster Session / 2091

RF design of a C-band spherical pulse compressor for Super Tau-Charm linac

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Pulse compressors have been widely used to generate very high peak RF power in exchange for the reduction in the RF pulse length for linear accelerators. As compared to a traditional SLAC Energy Doubler(SLED), a spherical pulse compressor is more compact while maintaining a high energy gain. A C-band spherical pulse compressor is studied in this paper, which consists of a dual-mode polarized coupler for producing two orthogonal TE11 modes simultaneously, as well as a resonant cavity working at TE113 mode for storing energy. Through optimizations, an average energy gain of 4.7 with a coupling factor of 6.6 can be achieved for such a spherical pulse compressor. The RF design of this pulse compressor has been finalized, the fabrication and measurement of prototype can be expected in the next step.

Footnotes:

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Asia

Student Poster Session / **2092**

SRF cavity instability detection with machine learning at CEBAF

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During the operation of the Continuous Electron Beam Accelerator Facility (CEBAF), one or more unstable superconducting radio-frequency (SRF) cavities often cause beam loss trips while the unstable cavities themselves do not necessarily trip off. The present RF controls for the legacy cavities report at only 1 Hz, which is too slow to detect fast transient instabilities during these trip events. These challenges make the identification of an unstable cavity out of the hundreds installed at CEBAF a difficult and time-consuming task. To tackle these issues, a fast data acquisition system (DAQ) for the legacy SRF cavities has been developed, which records the sample at 5 kHz. A Principal Component Analysis (PCA) approach is being developed to identify anomalous SRF cavity behavior. We will discuss the present status of the DAQ system and PCA model, along with initial performance metrics. Overall, our method offers a practical solution for identifying unstable SRF cavities, contributing to increased beam availability and facility reliability.

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Student Poster Session / **2094**

Picometer scale emittance from plasmonic spiral photocathode for particle accelerator applications

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In this work we demonstrate the generation of a record low root mean square normalized transverse electron emittance of less than 30 pm-rad from a flat metal photocathode –more than an order of magnitude lower than the best the emittance that has been achieved from a flat photocathode. This was achieved by using plasmonic focusing of light to a sub-diffraction regime using plasmonic Archimedean spiral structures resulting in a ˜40 nm root mean square electron emission spot. Such nanostructured electron sources exhibiting simultaneous spatio-temporal confinement to nanometer and femtosecond level along with a low mean transverse energy can be used for developing advanced electron sources to generate unprecedented electron beam brightness for various accelerator applications.

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North America

Student Poster Session / 2095

Near-Infrared noise in intense electron beams

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Requirements for the noise in electron beams (NEB) have recently approached the Shot-noise level in some new applications. The density fluctuations of intense beams in the near-infrared (NIR) region are being measured at the Fermilab Accelerator Science and Technology (FAST) facility. The main goal of the experiment is to accurately compare the Shot-noise model with the observations of optical transition radiation (OTR) generated by the gamma=63 electron beam transiting an Al metal surface. In addition, evidence for longitudinal-space-charge-induced microbunching for the chicane-compressed beam was obtained with coherent enhancements up to 100 in the various bandwidth-filtered NIR OTR photodiode signals. With micropulse charges up to 1 nC, the beam parameters are close to those proposed for a stage in an Electron-Ion Collider (EIC) with coherent electron cooling (CEC). In this paper we present the current progress of the NEB project and compare the low electron energy measurements with ImpactX simulations.

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North America

Student Poster Session / **2097**

ELISA: a compact linear accelerator for societal applications

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ELISA (Experimental LInac for Surface Analysis) is a linear proton accelerator installed in the Science Gateway exhibition at CERN since October 2023. Its development is built upon the experience gained at CERN from the R&D for LINAC4, with an innovative design of the Radio Frequency Quadrupole (RFQ). With a footprint of only 2x1 square meters, ELISA has the potential of full portability and requires manufacturing capabilities already established in industries involved in medical and societal applications of accelerators. ELISA consists of an ion source, a one-meter-long RFQ working at 750 MHz and an analyzing line dedicated to Particle Induced X-ray Emission (PIXE). The system can accelerate a proton beam (extracted from the source at 20 keV) up to an energy of 2 MeV. In this paper we present the ELISA source commissioning and the optimization process that allowed to achieve the required brilliance. High energy beam commissioning will be also discussed, including beam current measurements at 2 MeV, investigation of the beam quality after acceleration and RFQ power scans to characterize the ELISA RFQ.

Footnotes:

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Europe

Student Poster Session / 2098

Beam dynamics research for high-repetition-rate infrared FEL linac

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Compared to conventional free-electron lasers (FELs), high-repetition-rate FEL has the ability to generate laser pulses at a higher frequency, thereby significantly enhancing the laser's mean power. The high-repetition-rate infrared FEL (IR-FEL) device aims to incorporate optical resonator-based FEL technology, powered by a photocathode RF gun and a superconducting RF accelerator. This paper outlines the design layout and optimization of the primary parameters of the high-repetition-rate IR-FEL device. Beam dynamics simulations of the injector, accelerator, and bunch compressor are performed using the codes ASTRA and CSRTrack. Code Genesis 1.3 is used to simulate the physics in the undulator sections. During the simulation, the collective effects like space charge, coherent synchrotron radiation (CSR), and longitudinal cavity wake field effects are taken into consideration.

Footnotes:

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Asia

Student Poster Session / 2099

A study for emittance growth compensation by space charge effects at the injector of KEK-STF after dry ice cleaning of the RF gun

Author: Sayantan Mukherjee[1]

Co-authors: Masao Kuriki [1]; Zachary Liptak [1]; Keisuke Date [1]; Hitoshi Hayano [2]; Masafumi Fukuda [2]; Masakazu Kurata [2]; Naoto Yamamoto [2]; Xiuguang Jin [2]; Yasuchika Yamamoto [2]; Kazuyuki Sakaue [3]

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The International Linear collider (ILC) is an electron-positron linear collider with a center-of-mass energy up to 1 TeV. At the interaction point, the beam shape must be flat in the transverse space to maximize the luminosity and minimize the energy spread by Beamstrahlung. The flat beam is obtained by asymmetric emittance in x and y made up by radiation damping with a 3 km damping ring. We propose a new method to make asymmetric emittance based on emittance exchange techniques

known as Round to Flat beam transformation (RFBT) and Transverse to Longitudinal Emittance Exchange (TLEX). We use ASTRA simulations to understand the transverse motion along the beamline of KEK Superconducting Test Facility (STF) with the goal of minimizing the emittance growth due to space charge effects. In the KEK STF facility the RFBT experiment was performed. In December 2023, to investigate the cause of unexpected emittance growth in previous experimental runs, we performed a detailed study of the STF injector with the cryomodules detuned. Here we report the results of this study and plans to achieve emittance compensation.

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Asia

Student Poster Session / 2101

Study of the beam-beam interaction in an electron-positron collider with large Piwinski angle and crabbed waist

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To achieve very high luminosity, the next generation circular colliders adopt the crab waist collision scheme with a large Piwinski angle. In this scheme, beams collide with high current, low emittances, and small beta functions at the interaction point (IP). However, several effects arising from these extreme parameters, especially the coherent X-Z instability, will significantly impact the collider's performance, necessitating dynamic processing of longitudinal motion in a three-dimensional self-consistent treatment. The transverse vibration becomes coupled with the longitudinal motion, as well as the increase in horizontal beam size alters the interaction between beams and corresponding beam-induced effects. These instabilities limit the stable high luminosity area for the selected working point of the original design. Therefore, it is necessary to optimize the safe area of the working point by readjusting the parameters of the IP.In this paper, based on the Super Tau-Charm Facility (STCF) project in China, the instability caused by beam interactions is studied through numerical simulation. The relationship between the parameters at the IP and the stable selection area of the working point is systematically explored. The regularities found from simulations can assist future high luminosity electron-positron colliders in selecting the corresponding parameters. Additionally, some methods, such as adding adjustable devices to achieve stable high luminosity, are also proposed.

Footnotes:

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Asia

Student Poster Session / 2102

SRF cavity fault prediction using deep learning at Jefferson Lab

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In this study, we present a deep learning-based pipeline for predicting superconducting radio-frequency (SRF) cavity faults in the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab. We leverage pre-fault RF signals from C100-type cavities and employ deep learning to predict faults in advance of their onset. We train a binary classifier model to distinguish between stable and impending fault signals, where each cryomodule has a uniquely trained model. Test results show accuracies exceeding 99% in each of the six models for distinguishing between normal signals and pre-fault signals from a class of more slowly developing fault types, such as microphonics-induced faults. We describe results from a proof-of-principle demonstration on a realistic, imbalanced data set and report performance metrics. Encouraging results suggest that future SRF systems could leverage this framework and implement measures to mitigate the onset in more slowly developing fault types.

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Student Poster Session / 2104

Decoupling of nitrogen and oxygen impurities in nitrogen doped SRF cavities

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The performance of superconducting radiofrequency (SRF) cavities is critical to enabling the next generation of efficient, high-energy particle accelerators. Recent developments have focused on altering the surface impurity profile through in-situ baking, furnace baking, and doping to introduce and diffuse beneficial impurities such as nitrogen, oxygen, and carbon. However, the precise role and properties of each impurity are not well understood. In this work, we attempt to disentangle the role of oxygen and nitrogen impurities through time-of-flight secondary ion mass spectrometry of niobium samples baked at temperatures varying from 75-800℃ with and without nitrogen injection. From these results, we developed treatments recipe that decouple the effects of oxygen and nitrogen in doping treatments. Understanding how these impurities and their underlying mechanisms drive further optimization in the tailoring of impurity profiles for high performing SRF cavities.

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Student Poster Session / 2105

Beam correction for multi-pass arcs in FFA@CEBAF: status update

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This work examines the multi-pass steering of six electron beams in an FFA arc ranging from approximately 10.5 GeV to 22 GeV. Shown here is an algorithm based on singular value decomposition (SVD) to successfully steer all six beams through the arc given precise knowledge of all beam positions at each of one hundred and one diagnostic locations with one hundred individual corrector magnets: that is successive application of SVD to different 100 × 101 response matrices—one for each beam energy. Further, a machine learning scheme is developed which only requires knowledge of the energy-averaged beam position at each location to provide equivalent steering. Extension of this scheme to other beam optics quantities as well as transverse and longitudinal coupling is explored.

Footnotes:

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North America

Student Poster Session / 2106

Optimizing the beam parameters for plasma wakefield acceleration at FACET-II

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At the FACET-II accelerator, a pair of 10 GeV high-current electron beams can be used to study a method called Plasma Wakefield Acceleration (PWFA) in a few-cm short laser-ionized gas jet. While PWFAs allow for astonishingly high accelerating gradients of 10s of GeV/m, matching the electron beam into the plasma wake with micrometer precision to maintain beam quality requires precise tuning of linac parameters. The purpose of this study was to explore how start-to-end simulations could be used to optimize two important measures of beam quality, namely maximizing energy gain and minimizing transverse emittance growth. These two beam characteristics were investigated with an in-depth model of the FACET-II accelerator using two simulation techniques: i) varying experimental parameters, including plasma density and the strengths of focusing quadrupole magnets, within predefined ranges and examining their impact on beam quality. ii) Numerical optimization of quadrupole magnet strengths to transverse emittance growth. These results demonstrate the importance of simulating beam-transport simulations in tandem with particle-in-cell simulations to get insight into optimizing these two important beam characteristics without the need to devote significant accelerator physics time tuning the FACET-II accelerator.

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Student Poster Session / 2107

Towards operating low mean transverse energy alkali antimonide photocathodes at Argonne Cathode Test-stand

Author: Tariqul Hasan[1]

Co-authors: Eric Wisniewski [2]; John Power [3]; Oksana Chubenko [4]; Philippe Piot [1]; Gongxiaohui Chen [3]

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The performance and scientific reach of advanced electron accelerator applications, such as particle colliders, x-ray free electron lasers, and ultrafast electron diffraction, are determined by beam brightness. The beam brightness is constrained by the quality of photocathodes and is associated with low Mean Transverse Energy (MTE) of photoemitted electrons. To meet the requirements for applications demanding a bright electron beam, photocathodes must exhibit ultrasmooth physical and chemical roughness, a long operational lifetime, and robustness under high applied electric fields and laser fluences. In this work, we present the development of an experimental setup for the growth and in-situ characterization of high-quality, low-MTE alkali antimonide photocathodes. Additionally, we describe the modifications made to the Argonne Cathode Test-stand (ACT) at the Argonne Wakefield Accelerator (AWA) Facility, necessary for studying the performance of alkali antimonide photocathodes under real photoinjector conditions.

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Student Poster Session / 2108

Measurement of stability diagrams in the IOTA ring at Fermilab

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Nonlinear focusing elements can enhance the stability of particle beams in high-energy colliders through Landau Damping, by means of the tune spread which is introduced. Here we discuss an experiment at Fermilab's Integrable Optics Test Accelerator (IOTA) which investigates the influence of nonlinear focusing elements, such as octupoles, on the beam's transverse stability. In this experiment, we employ an anti-damper, an active transverse feedback system, as a controlled mechanism to induce coherent beam instability. By utilizing the anti-damper we can examine the impact of a nonlinear focusing element on the beam's transverse stability. The stability diagram, a tool used to determine the system's stability, is measured using a recently demonstrated method at the LHC. The experiment at IOTA adds insight towards this stability diagram measurement method by supplying a reduced machine impedance to investigate the machine impedance's effect on the stability diagram, as well as by aiming to map out the full stability diagram by using a large phase range of the anti-damper. From this experiment in IOTA, we present the first results of stability diagram analysis with varying octupole currents.

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Student Poster Session / 2110

Mechanical design and cryo-module of a C-band cryogenic bi-periodic accelerating structure

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The energy upgrade of the Shanghai Soft X-ray Free Electron Laser(SXFEL) requires a higher gradient accelerating structure. The performance of oxygen-free copper is significantly improved in many aspects at low temperatures, so it can withstand higher surface fields, so that the accelerator can achieve a higher accelerating gradient. Therefore, a stable and uniform low temperature environment is extremely necessary. For this purpose, the mechanical model of the accelerating structure at normal temperature is designed, and the design of the cryo-module is completed. This is a standing wave bi-periodic structure, with a total length of 1m, divided into four independent parts, which feed power separately. The special RF design of the structure makes it possible to set tuning screws outside the accelerating cavity, as well as the coupling cavity. There is a cooling belt outside the structure, which transmits heat to four coolers. In the future, the manufacturing of the structure and the cryo-module will be completed, and they will be tested.

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Student Poster Session / 2111

Fabrication and tuning of a 325 MHz ion-injector for particle therapy facility

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In order to miniaturize ion injectors for particle therapy, a design of ion injectors based on a 325 MHz operating frequency was completed. The LINAC was consist of a 2.0 m length RFQ and a 3.8 m length IH-DTL, which was designed to accelerate 12C4+, 3H+, 3He+ and 18O6+ beams to 7 MeV/u. The RFQ cavity and the first DTL tank was been manufactured using aluminum. This paper gives an overview of the fabrication and tuning procedure of the prototype. The quadrupole electric field of the RFQ is adjusted flat by the tuner while reducing the dipole field components in both directions. The measured DTL electric field distribution after tuning is in good agreement with the simulation results.

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Student Poster Session / 2112

Magnetron diagnostics with a novel optical fibre-Cherenkov detector

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Development of an optical fiber-based beam loss monitor (OBLM) is in progress at the Cockcroft Institute (CI), UK. The novel sensor utilizes the Cherenkov radiation (CR) emitted in optical fibers by relativistic particle showers generated in beam loss or RF breakdown events.
RF breakdowns are a problem for high-power magnetrons, such as those in medical accelerator facilities, as damage to the magnetron cathode reduces the device efficiency and lifetime. These events can be detected by emitted CR channeled along the fibers to photomultiplier detectors, and a time-of-flight method can be used to calculate the RF breakdown location from the CR arrival time. This has previously been demonstrated with the OBLM system on RF cavities (at CLARA, Daresbury Laboratory, and CTF3, CERN); and allows for rapid and reliable breakdown detection which is important for damage mitigation.

This contribution presents proof-of-concept measurements from OBLM studies into magnetrons at Teledyne e2v, Chelmsford. It also discusses design adjustments made to improve the detector sensitivity and how the performance can be enhanced using the sensor (or similar).

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Student Poster Session / 2113

Exploring high gradient limit with cryogenic experiments at FREIA laboratory

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Field emission (FE) and vacuum arcs limit the maximum achievable accelerating field of both normal and superconducting cavities. The performance of accelerating cavities can be improved after a long conditioning process. Understanding this process and the formation of vacuum arcs is important for all technologies where vacuum arcs cause device failure. The understanding could be more complete with novel diagnostic tools and tests in variable environments.
The cryogenic HV system in FREIA laboratory is used to study different aspects of conditioning using DC pulses at a wide range of temperatures, down to 4K. We are currently measuring FE currents during conditioning for Cu, Nb and Ti electrodes in function of temperature and breakdown rate. We are also developing a new characterization method, evaluating the surface resistivity of the electrodes during conditioning. Changes in the surface resistivity could indicate the formation of dislocations below the surface, which has been speculated to be a very important process behind conditioning.
We will present the results of conditioning with the FE measurements and the surface resistivity measurements.

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Student Poster Session / 2114

Design, fabrication, and testing of a W-band corrugated waveguide for Wakefield acceleration

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In the field of structure wakefield acceleration there is considerable interest in radiofrequency (RF) structures capable of producing high gradients. Structures in the sub-terahertz (sub-THz) regime are of note due to their high gradient and high efficiency, allowing for a low physical footprint. In the pursuit of this goal we have designed a metallic corrugated W-band structure using the CST Studio Suite. After optimizing for the maximum achievable gradient from a nominal Argonne Wakefield Accelerator (AWA) electron bunch at 65 MeV with a Gaussian distribution we attempted to achieve a higher transformer ratio using a shaped bunch. Shaped bunches such as these are achievable at the AWA emittance exchange (EEX) beamline. Preliminary results from the structure testing at AWA using shaped electron bunches will be presented. Further tests are planned, involving a comprehensive optimization of the beamline at AWA.

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Student Poster Session / 2115

Lattice design of a pulsed synchrotron for a muon collider fitting within the Fermilab site boundary

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A muon collider allows one to have a high energy reach for physics studies while having a relatively compact footprint. Ideally such a machine would accelerate muon beams to about 5 TeV. We present a preliminary lattice design for a pulsed synchrotron that will accelerate muon beams to

their maximum collision energy and having a circumference of 16.5 km, which would allow it to fit just within the Fermilab site boundary. We wish to estimate the maximum energy that muons can be accelerated to on the Fermilab site based on a realistic lattice layout. To achieve a high average bend field, superconducting fixed field dipoles are interleaved with iron-dominated dipoles whose field is rapidly ramped from negative to positive field. Multiple RF stations are required to ensure that the beam energy and the dipole fields are reasonably well synchronized and to avoid longitudinal losses due to the large synchrotron tune. We use FODO arc cells with dispersion suppressed into the RF straights. We will discuss tradeoffs between maximum energy, energy range, and muon decays. We will consider whether to mix superconducting and iron quadrupoles like the dipoles.

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Student Poster Session / 2116

Dark current studies for a SW C-band electron gun with a deflector

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To generate the very high brightness beams in light sources, injectors based on radiofrequency photoguns with very high peak electric fields on the cathode are used. However, this very high surface electric field on the surface of a radio frequency cavity leads to the generation of dark current due to the field emission effect which can damage the instrumentation and radio-activate components. Consequently, it is important to reduce the emission of these electrons and evaluate the subsequent transportation. In this paper, the deflector has been innovatively positioned at the exit of the photogun so as to reduce the dark current as much as possible. The dark current emission and spectrum of the dark current of the C-band electron gun have been evaluated by Particle-In-Cell simulations. The dark current before the accelerating sections has been captured and observed both with and without the deflector.

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Student Poster Session / 2117

Optimization of nanostructured plasmas for laser wakefield acceleration using a Bayesian algorithm

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Nanostructures are currently attracting attention as a medium for obtaining ultra-high-density plasmas for beam-driven or laser-driven acceleration. This study investigates Bayesian optimization in Laser Wakefield Acceleration (LWFA) to enhance solid-state plasma parameters towards achieving extremely high gradients on the order of TV/m or beyond, specifically focusing on nanostructured plasmas based on arrays of carbon nanotubes. Through Particle-In-Cell (PIC) simulations via EPOCH and custom Python scripts, we conducted a parameter analysis for various configurations of carbon nanotube arrays. Utilizing the open-source machine learning library BoTorch for optimization, our work resulted in a detailed database of simulation results. This enabled us to pinpoint optimal parameters for generating effective wakefields in these specialized plasmas. Ultimately, the results demonstrate that Bayesian optimization is an excellent tool for significantly refining parameter selection for nanostructures like carbon nanotube arrays, thus enabling the design of promising nanostructures for LWFA.

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Student Poster Session / 2118

Measurement, tuning and test for the two-mode TDS

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SSRF/SXFEL has develop the advanced transverse deflecting structure TTDS (two-mode transverse deflecting structure) to perform variable polarization based on the design of a dual-mode structure. The 15-cell prototype of the TTDS was designed and fabricated at SSRF/SXFEL. The non-resonant perturbation was chosen as the measurement for HEM modes and improved for the two modes in TTDS respectively. At the same time, a new method to tune two modes simultaneously were designed and applied at SSRF/SXFEL. The low power test was perform and all the results are summarized in this paper. The TTDS has been tuned to required performance and is ready for high power test.

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variable polarization, two-mode TDS, low power test, measurement and tuning

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Student Poster Session / 2122

Characterization of single-cell elliptical niobium thin film cavity at cryogenic temperatures

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Niobium thin films play a crucial role in both macroscopic SRF cavities for particle accelerators and microscopic superconducting qubits used in quantum computing applications. This study aimed to investigate the RF performance of a 1.3 GHz single-cell elliptical Nb thin film cavity deposited using the DC bias High-Power Impulse Magnetron Sputtering (HiPIMS) technique. Experimental testing of the cavity was conducted in a helium dewar of Vertical Cavity Test Stand (VCTS), at temperatures of 2 and 1.5K. Prior to testing, the cavity was backed in-situ at 340℃ for 1-hour, or vacuum furnace baked at 600℃ for 3-hour. The RF results obtained from the Nb thin film cavity were compared with those from a bulk Nb cavity, providing insights into the distinctive characteristics and potential advantages of Nb thin film cavities under cryogenic conditions. At low fields, Nb thin film cavity exhibited better performance than bulk Nb cavities. Baking treatment at 340℃ has increased the quench field by approximately 25%. Furthermore, backing the cavity at 600℃ led to a notable increase in the Quality factor (Q) and a remarkable improvement in the quench field, with a boost of approximately 35%. These findings are significant and warrant further investigation for their potential impact on SRF technologies.

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Student Poster Session / 2123

Multi-mode cavity design and characterization

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We present the design and initial characterization of a multi-mode cavity, a novel electromagnetic structure with potential benefits such as compactness, efficiency, and cost reduction. The 2nd Harmonic mode was chosen to linearize the fundamental mode for use as an accelerating and bunching cavity. The reduction in the number of cavities required to bunch and accelerate promises cost and space savings over conventional approaches. Superfish and COMSOL simulations were used to optimize the cavity's geometry with the goal of balancing various design parameters, such as quality factor (Q-factor), harmonic modes, and mode coupling. A 3D-printed copper-plated cavity was used to validate code predictions.
The cavity's multi-mode nature positions it for use with other harmonic modes with small deviations in design. For example, a 3rd Harmonic can be used to decrease energy spread by widening the peak of the fundamental. This research lays the foundation for further exploration of the cavity's applications and optimization for specific use cases, with potential implications for a wide range of accelerator fields.

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Student Poster Session / 2124

Bunch-by-bunch simulations of beam-beam driven particle losses in the LHC

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Recent experimental measurements in the Large Hadron Collider (LHC) have shown a clear correlation between beam-beam resonance driving terms and beam losses, with a characteristic bunch-by-bunch signature. Due to the encounter schedule of the different bunches as they cross the interaction points, it is known that different bunches experience different long-range interactions with bunches of the other beam. This creates interesting conditions to study particle stability. Over the past few decades, early chaos indicators, frequency map analysis and dynamic aperture studies have been commonly used to study particle stability in circular machines. However, the underlying mechanisms driving particles to large amplitudes in the presence of high order resonances is still an open question. In preparation for the High-Luminosity upgrade of the LHC and other future circular colliders, a better understanding of slow particle losses is needed, alongside possible compensation schemes to reduce strong nonlinearities. Leveraging on years of development on particle tracking tools, this paper presents full-fledged bunch-by-bunch beam loss simulations in the LHC and shows the evolution of macroscopic observables for the beam over a time scale of 30 minutes (2e+7 turns). The experimental observations from LHC Run 3 are reproduced and compensation schemes are proposed.

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Student Poster Session / 2125

Study on high energy coupling efficiency of laser-electron interaction via vortex beam

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Manipulation electron beam phase space technology by laser-electron interaction has been widely used in accelerator-based light sources. The energy of the electron beam can be modulated effectively under resonant conditions by using an intense external laser beam incident into the undulator together with the electron beam. It is of great significance to improve the modulation efficiency for seeded free electron laser (FEL) and other devices. In this paper, we propose a new scheme to improve the efficiency of laser-electron interaction by using the interaction of vortex beam and electron beam in a helical undulator. Three-dimensional time-dependent simulation results show that the modulation repetition rate of laser-electron interaction by vortex beam can be improved by one order of magnitude compared with the Gaussian beam at the same input power.

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Student Poster Session / **2127**

Magnetic field study for air-cored HTS skeleton cyclotron

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Skeleton cyclotron is a compact size air-cored cyclotron with a high temperature superconducting (HTS) coil system. HTS coils'high critical current density and high heat stability allow magnetic field induction without using any iron core. With this advantage, the magnetic field configuration can be adjusted quickly without consideration for the hysteresis from iron. The purpose of skeleton cyclotron is to change the beam type quickly between proton, deuteron and alpha particle for the needs of various RI production. In order to achieve this goal, the coil system has to be designed with superconductors'properties taken into account, such as critical current density under strong external magnetic field etc. In this work, the coil system and magnetic field designed for the skeleton cyclotron will be presented. The capability of accelerating various beam type will also be discussed.

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Student Poster Session / **2129**

Current status of MINIBEE –minibeam beamline for preclinical experiments on spatial fractionation in the FLASH regime

Author: Aikaterini Rousseti[1]

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In vivo studies support that the combination of protons and spatial fractionation, the so-called proton minibeam radiotherapy (pMBT), enhances the protection of normal tissue for a given tumor dose. A preclinical pMBT facility for small animal irradiation at the 68 MeV cyclotron of Helmholtz-Zentrum Berlin (HZB) will improve the understanding of this method. A two-step energy-degrading system will first define the maximum energy of the beam and further degrading will occur before the target forming a spread-out Bragg peak (SOBP), if necessary. Beam size and divergence will be adjusted by slit systems before a 90-degree magnet bending the beam into the experimental room. At the current stage, a magnetic quadrupole triplet placed close to the target demagnifies the beam by a factor of ~5. The goal is to generate a magnetically focused minibeam of 50 micrometer sigma. Scanning magnets will enable a raster-scan application in the tumor. Conventional dose rate delivery will be allowed while FLASH applications can be achieved with the possible use of a ridge filter. The results of beamline simulations by TRACE-3D and BDSIM will be presented.

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Student Poster Session / 2130

Various methods for computing dominant spin-orbit resonance strengths in storage rings

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The strength of a first-order spin-orbit resonance is defined as the amplitude of the corresponding Fourier component of the spin precession vector. However, obtaining this Fourier spectrum is often infeasible in practice. If a resonance is sufficiently strong, then to a good approximation, one can neglect all other depolarizing effects when near the resonance. Such an approximation leads to the single resonance model (SRM), for which many aspects of spin motion are analytically solvable. In this paper, we calculate the strength of first-order resonances using various formulae derived from the SRM, utilizing spin tracking data, the direction of the invariant spin field, and amplitude-dependent spin tune jumps.

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AGS Booster model calibration and digital-twin development

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An accurate physics simulation model is key to accelerator operation because all beam control and optimization algorithms require good understanding of the accelerator and its elements. For the AGS Booster, major discrepancy between the real physical system and online simulation model mainly comes from magnet misalignments, which also lead to beam degradation and prevent the beam from reaching the desired specifications (e.g., polarization). In this work, we propose a Bayesian optimal experimental design (BOED)-based approach for identifying the magnet misalignments using a Bmad model of the AGS Booster. This approach can find magnet control variables (i.e., currents) which are expected to lead to beam position data that most reduces uncertainty in the magnet misalignment parameters. The misalignment values can then be used to calibrate the physical model of the Booster, leading to a more accurate simulation model for future polarization optimizations, and to the development of a fully functional digital-twin.

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Student Poster Session / **2132**

Design of prototype magnet for FETS-FFA

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Capable of achieving a high repetition rate with strong focusing, Fixed Field Alternating gradient (FFA) accelerators have the potential to be used for pulsed high intensity operations. With no pulsed high intensity FFA ever built so far, a prototype machine called FETS-FFA has been proposed to study the FFA option for the next generation spallation neutron source (ISIS-II). One of the essential components of this machine will be the main magnets which must satisfy the following conditions: zero chromaticity during acceleration, flexibility in operating tune point to test dynamics for high beam intensity and a large dynamic aperture to avoid uncontrolled loss. The chosen lattice design utilizes spiral magnets to provide edge focusing to focus in the vertical direction while also introducing a reverse bending magnet to better control the vertical tune. A three-dimensional study is being carried out in OPERA 3D software to investigate the parameters of the magnets to achieve the required field. The details on the design will be presented in this paper.

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Student Poster Session / 2133

Characterization of meter-scale Bessel beams for plasma formation in a plasma wakefield accelerator

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A large challenge with plasma wakefield acceleration (PWFA) lies in creation of a uniform-density plasma with profile and length that properly match the electron beam. Using a laser-ionized plasma source provides control in creating an appropriate plasma density ramp. Additionally, using a laser ionized plasma instead of ionization from the electron beam, allows for the accelerator to run at a higher repetition rate. At the Facility for Advanced Accelerator Experimental Tests (FACET-II), located at SLAC National Accelerator Laboratory, we ionize hydrogen gas with a 10 TW ultrashort laser pulse that passes through an axicon lens, imparting a conical phase on the pulse that produces a focal spot with an intensity distribution described by a two-dimensional Bessel function. This presentation will provide an overview of the diagnostic tests used to characterize and optimize the

focal spot along the meter-long focus. In particular, we observe how wavefront aberrations in the laser pulse impact the plasma formation. Furthermore, I will discuss measurements of the nonlinear plasma defocusing effect that broadens the laser focus within the plasma.

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Student Poster Session / 2134

Bayesian optimization scheme for the design of a nanofibrous high power target

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High Power Targetry (HPT) R&D is critical in the context of increasing beam intensity and energy for next generation accelerators. Many target concepts and novel materials are being developed and tested for their ability to withstand extreme beam environments; the HPT R&D Group at Fermilab is developing an electrospun nanofiber material for this purpose.
The performance of these nanofiber targets is sensitive to their construction parameters, such as the packing density of the fibers. Lowering the density improves the survival of the target, but reduces the secondary particle yield. Optimizing the lifetime, production efficiency, and length of the target poses an interesting design problem, and in this paper we study the applicability of Bayesian optimization to its solution.
We first describe our architecture for the simulation of the in-beam operations of a nanofiber target with prescribed construction parameters, which requires a heat transfer model specialized for nanofibrous media. We then explain the optimization loop setup. Thereafter, we present the optimal design parameters suggested by the algorithm, and close with discussions of limitations and future refinements.

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Student Poster Session / 2135

Progress on pulsed electron beams for radiation effects characterization of electronics

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Ultrafast high-energy pulsed electron beams can provide deep penetration and variable linear energy transfers by controlling the characteristics of the electron bunch, both of which currently oversubscribed heavy ion facilities cannot provide. Early experiments at the UCLA PEGASUS beamline (~3 MeV) with ~1 ps electron bunches and a 50 µm spot size yielded charge collection transients that were not correlated well with standard heavy-ion data. Sub-micron focusing of the beam would allow for the electron bunch to mimic ion tracks by saturating the charge collection in a small cross-sectional area while simultaneously providing high spatial resolution to allow for the targeted testing of microelectronic components. Using a 10 µm collimator and strong lens, current experiments are planned at UCLA to characterize standard photodiodes with smaller spot sizes to achieve stronger correlations with the heavy-ion data.

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Student Poster Session / 2136

Waveguide system for SRF cryomodule in KEK

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A superconducting radio frequency (SRF) cryomodule (CM) for the International Linear Collider (ILC) Technology Network (ITN) is being developed at KEK. In the scope of this, a waveguide system is being designed. Its main features are a low center of gravity, a reduced number of corners and waveguide elements, and a compact bellow for connecting it to the input power coupler. Furthermore, the waveguide layout was designed to stay within the CM. This will avoid interference between components in the case of a multi-CM assembly. It is planned to adapt both the waveguide system and the installation process for the ITN.
Analytical calculations and simulations have shown that most of the reflected power is dissipated in the load of the variable hybrid on removing the circulator. Thus, in the initial layout of the waveguide, the circulator is strategically installed to allow a future replacement with an H-corner integrated with a directional coupler, without disrupting the other waveguide components. Furthermore, a low-power test on a similar waveguide system showed that analytical calculations and simulation matched the measured values well.

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Student Poster Session / 2137

Topology optimization of a dipole magnet using normalized gaussian network

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The precision of the proton therapy beam depends on maintaining high field quality in the magnet' s good field region. Iron yoke is employed in magnets to increase the magnetic field and reduce the fringe field. However, when providing a high magnetic field for transporting relatively high-energy particles, the saturation effect of the yoke can distort the field quality. To mitigate this effect, tuning holes and pole shape optimization are adopted in the iron yoke to adjust the magnetic flux, which helps in maintaining a higher field quality for particles with different energies. Optimizations are often limited by human expertise. In this paper, we use a topology optimization method that employs a non-dominated sorting genetic algorithm for the prototype design of an iron yoke in a dipole magnet. To achieve a smooth distribution of material, we represent the shape of the iron yoke using a normalized Gaussian network. This method effectively mitigates the field error at different energy levels. Shape optimization is performed to compare it with topology optimization. It is suitable for the application of topology optimization in the beam line system for the proton therapy system.

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Student Poster Session / 2138

Findings of simulation studies for the fast corrector magnets of PETRA IV

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Fourth-generation synchrotron radiation sources, which are currently being planned in several accelerator laboratories, require fast orbit feedback systems to correct distortions in the particle orbit and thus meet stringent stability requirements. Such feedback systems feature corrector magnets powered at frequencies up to the kilo-hertz range, giving rise to strong eddy currents. To understand the eddy current effects and the characteristics of these fast corrector magnets, elaborate finite element simulations must be conducted. This paper gives an overview of the most important findings of our simulation studies for the fast corrector magnets of the future synchrotron radiation source PETRA IV at DESY, Hamburg, Germany. Using a homogenization technique for the laminated yokes, we simulate the magnets over a wide frequency range. We investigate the integrated transfer function of the magnets and the phase shift between the field in the aperture and the current in the coils.We show the impact of different material choices for the yoke, of various beam pipe layouts, and of the cross-talk with the neighboring quadrupoles. By presenting a concise summary of our findings, we aim to bring valuable insights to researchers working on fast orbit feedback systems for the next generation of synchrotron light sources.

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Student Poster Session / 2139

Single-shot meV-resolution hard X-ray spectrograph for CBXFEL diagnostics

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A cavity-based x-ray free-electron laser (CBXFEL) is a possible future direction in the development of fully coherent hard x-ray sources of high spectral brilliance, a narrow spectral bandwidth of ~1-100 meV, and a high repetition rate of ~1 MHz. A diagnostic tool is required to measure CBXFEL spectra with a meV resolution on the shot-to-shot bases. Here we present test results of a single shot hard x-ray angular-dispersive spectrograph designed for this purpose.
Angular-dispersive x-ray spectrographs are composed of a dispersive element —Bragg reflecting crystals arranged in an asymmetric scattering geometry, a focusing element, and a pixel detector [1]. The CBXFEL spectrograph was designed to image 9.8 keV x-rays in a ~200 meV spectral window with a spectral resolution of a few meV. Two Ge asymmetrically cut crystals in the dispersive 220 Bragg reflection geometry were used as the dispersive element. A compound refractive Be lens was used as the focusing element.
The spectrograph was built and tested at the Advanced Photon Source beamline 1-BM-B. The spectrograph operates close to design specification featuring a 185 meV (FWHM) spectral window of imaging, a 1.4 μm/meV linear dispersion rate, and a spectral resolution of 15 meV estimated with a 40 meV width of the spectral reference benchmark available in the test measurements.

Footnotes:

[1] Yu. Shvyd'ko. Theory of angular-dispersive, imaging hard-x-ray spectrographs. Phys. Rev. A, 91 (2015) 053817.

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Student Poster Session / 2140

Emittance growth studies due to Crab Cavity induced amplitude noise in the SPS

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In the context of the HL-LHC upgrade, RF Crab Cavities (CCs) are one of the key components. Due to the increased intensity, the collider will operate with a large crossing angle scheme and these CCs will be used to counteract the geometrical reduction factor coming from the crossing angle. Amplitude and phase noise injected from the Low-Level RF, are known to induce transverse bunch emittance growth. This contribution presents the latest measurements of emittance growth induced by amplitude noise. The measurement was performed thanks to the SPS Beam Synchrotron Radiation Telescope (BSRT), that has been used to characterize the evolution of the transverse distributions.

The measured emittance growth was found to be dependent on the amplitude detuning induced by the SPS octupoles, although no dependence was predicted by the available theories and models. In this paper, the measurement results will be presented and discussed.

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Student Poster Session / 2141

Dark current reduction for NSRRC photoinjector system by collimation

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NSRRC THz facility provides MW-level superradiant radiation with wavelengths ranging from 100–500 μm from a U100 planar undulator. An S-band laser-driven photocathode radio-frequency (RF) gun has been used in its 25 MeV linac system to generate a sub-picosecond high brightness relativistic electron beam for coherent emission of undulator radiation. However, the high accelerating field in the gun cavity is found to be the main cause of electron field emission that generates the non-negligible background current (dark current) in the system. A portion of the field-emitted electrons with launching conditions close to that of the main beam can be accelerated to high energies in the booster linac structure located downstream. Collision of these unwanted high energy electrons with the vacuum vessel in the system becomes the main source of excessive radiation dosage. In order to limit the transportation of these unwanted electrons to the booster linac, a collimation system will be implemented upstream of the linac. In this work, a model of the drive linac system has been setup with 3D space charge tracking code –IMPACT-T for main beam and dark current simulation. Particle trajectories under various launching conditions are also analyzed. Best location of the collimator has been chosen for dark current reduction.

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Student Poster Session / 2143

Energy deposition and radiation level studies for the FCC-ee experimental insertions

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The Future Circular Collider (FCC) study foresees the construction of a 90.6 km underground ring where, as a first stage, a high-luminosity electron-positron collider (FCC-ee) is envisaged, operating at beam energies from 45.6 GeV (Z pole) to 182.5 GeV (ttbar). In the FCC-ee experimental interaction regions, various physical processes give rise to particle showers that can be detrimental to machine components as well as equipment in the tunnel, such as cables and electronics. In this work, we evaluate the impact of the synchrotron radiation emitted in the dipoles and the beamstrahlung radiation from the interaction point (IP). The Monte Carlo code FLUKA is used to quantify the power deposited in key machine elements, such as the beamstrahlung dump and the dipole and quadrupole magnets, as well as the cumulative radiation levels in the tunnel. We also examine the effect of synchrotron radiation absorbers in the vacuum chamber, in combination with additional shielding. The results are presented for the different operation modes, namely Z pole and ttbar.

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Student Poster Session / 2144

Simulating a rectilinear cooling channel using BDSIM for the 6D muon cooling demonstrator

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Muon colliders hold promise for high luminosity multi-TeV collisions, without synchrotron radiation challenges. However, this involves investigation into novel methods of muon production, acceleration, cooling, storage, and detection. Thus, a cooling demonstrator has been proposed to investigate 6D muon ionization cooling. The MICE experiment validated ionization cooling to reduce transverse emittance. The demonstrator will extend this to also cool longitudinal emittance. It would also use bunched beams instead of single particles from a muon source. The 6D cooling lattice comprises successive cells which consist of: solenoids for tight focusing, dipoles to introduce dispersion in the beam, wedge-shaped absorbers for differential beam absorption, and RF cavities for reacceleration. In this paper, the simulation and further optimization of the rectilinear cooling channel is discussed. This analysis extends existing theoretical and numerical work using BDSIM, a Geant4-based accelerator framework built to simulate the transport and interaction of particles. The study also incorporates beams from existing proton drivers, using output from targetry and capture designs for the same.

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Student Poster Session / 2145

Expanding the CERN ion injector chain beyond Pb ions: beam-dynamics and lifetimes studies of novel ion candidates

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The present ion physics program in the CERN accelerator complex is mainly based on Pb ion beams. The ALICE3 detector upgrade proposal at the Large Hadron Collider (LHC) requests significantly higher integrated nucleon-nucleon luminosity compared to the present Pb beams, which can potentially be achieved with lighter ion species. These lighter ion species have also been requested by the fixed-target experiment NA61/SHINE in the CERN North Area (NA). To assess the performance capabilities of the CERN Ion Injector chain (consisting of Linac3, LEIR, PS and SPS) for light ions, for which there is little or no operational experience at CERN, beam-brightness and intensity limitations need to be studied. This contribution presents tracking simulation results for the PS and SPS, compared against recent experimental beam data for Pb in the Ion Injectors. These simulations include limiting beam-dynamics effects such as space charge and intra-beam scattering, and their impact on the intensity and emittance evolution is discussed. These simulation models are used to predict the optimal ion species for maximum performance out of the Ion Injector Chain.

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Student Poster Session / 2147

Simulations of simultaneous measurement of GHz bunches using a fast kicker

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High quality electron bunch trains enable investigations in scientific frontiers with high resolution and efficiency and are earnestly desired by various accelerator facilities, including inverse Compton scattering (ICS), high energy computed tomography, and free electron lasers. An average beam flux can be greatly increased by using the bunch train mode. A bunch train with an average current of 1 A is required in the future steady-state microbunching light source with a bunch spacing of 350 ps (2856 MHz). It is essential to measure each bunch in a bunch train and ensure that each bunch has roughly the same quality. Thus, we proposed utilizing a fast kicker to measure different bunches simultaneously. Different bunches get varying deflection angles by utilizing the kicker's rapidly rising edge, and eventually, different bunches can be measured simultaneously. The measuring methods of real space bunches profile, bunch energy, longitudinal phase space, and its corresponding simulation results are presented.

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Student Poster Session / 2148

Focusing of high-energy electron beam using silicon crystals for application in radiotherapy

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By using a high-energy electron beam (beam energy of several hundred MeV) strongly focused on the tumor lesion area, radiotherapy can be performed with a relatively simple beam generation and handling system while resulting in a suitable shape of the deposition energy curve in a tissue-like material. Quadrupole magnets are typically used for beam focusing, which makes the beam delivery system complex and challenging from an engineering point of view. In the Geant4 simulation toolkit, we performed a feasibility study of an alternative solution, in which focusing is achieved by using a bent silicon crystal with an appropriately shaped exit surface. However, the focusing strength is still not high enough. Research to find the optimal crystal shape to achieve the ideal focusing strength is ongoing. Such a crystal lens can be a very light object (mass in the order of grams), allowing for a much simpler beam delivery system for radiotherapy facilities.

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Student Poster Session / 2149

Detailed simulation study of wakefield induced beam dynamics in the dielectric dechirper at CLARA

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Minimizing the energy spread within the electron bunch is essential for an optimal performance of free electron lasers. Wakefields from corrugated and dielectric structures have been demonstrated to be effective in bunch dechirping. However, the repercussions in beam quality are not yet well understood. Here, a dielectric wakefield structure, manufactured to be included in CLARA facility, has been studied by simulations. It consists of two planar and orthogonally oriented dielectric waveguides with adjustable dielectric gaps. This geometry allows the longitudinal wakefield to compensate the energy spread while controlling the undesirable effect of the transverse wakefields in the beam quality. Simulations have been performed using the in-house developed code called DiWaCAT. These simulations included different bunch lengths, beam energies and dielectric gaps to allow a better understanding of longitudinal and transverse wakefields beam effects within the dechirper.

Footnotes:

- Gong, YW. et al (2021). Beam performance of the SHINE dechirper. doi:10.1007/s41365-021-00860-8 ** Antipov, S. et al (2014). Experimental demonstration of energy-chirp compensation by a tunable dielectric-based structure. doi:10.1103/PhysRevLett.112.114801 *** Pacey, T. H. et al (2018). Simulation studies for dielectric wakefield programme at CLARA facility. doi:10.1016/j.nima.2017.12.038.

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Student Poster Session / 2150

Real time monitoring of the crystal collimation system at the CERN Large Hadron Collider

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At the CERN Large Hadron Collider (LHC), bent crystals play a crucial role in efficiently redirecting beam halo particles toward secondary collimators used for absorption. This innovative crystal collimation method leverages millimeter-sized crystals to achieve deflection equivalent to a magnetic field of hundreds of Tesla, significantly enhancing the machine's cleaning performance particularly when running with heavy ion beams. Nevertheless, ensuring the continuous effectiveness of this process requires the optimal channeling angle with respect to the beam to be constantly maintained. The primary goal of this study is to improve the monitoring of crystal collimation by providing a tool that detects any deviations from the optimal channeling orientation. These deviations can arise from both crystal movement and fluctuations in beam dynamics. The ability to adapt and compensate for these changes is crucial for ensuring stable performance of crystal collimation during LHC operation. To achieve this, a feedforward neural network (FNN) was trained using data collected during the 2023 lead ion physics run at the LHC. The results demonstrate the network's capability to supervise these crystal devices, accurately classifying when the crystal is optimally aligned with respect to the circulating beam. Furthermore, the model provides valuable insights into how to adjust the crystal's position to restore optimal channeling conditions when required.

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Student Poster Session / 2151

Beam studies using a Cherenkov diffraction based beam position monitor for AWAKE

Author: Bethany Spear[1]

Co-authors: Collette Pakuza [2]; Eugenio Senes [3]; Manfred Wendt [3]; Michal Krupa [3]; Philip Burrows [1]; Stefano Mazzoni [3]; Thibaut Lefevre [3]

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A beam position monitor based on Cherenkov diffraction radiation (ChDR) is being investigated as a way to disentangle the signals generated by the electromagnetic fields of a short-pulse electron bunch from a long proton bunch co-propagating in the AWAKE plasma acceleration experiment at CERN. These ChDR BPMs have undergone renewed testing under a variety of beam conditions with proton and electron bunches in the AWAKE common beamline, at 3 different frequency ranges between 20-110 GHz to quantify the effectiveness of discriminating the electron beam position with and without proton bunches present. These results indicate an increased sensitivity to the electron beam position in the highest frequency bands. Furthermore, high frequency studies investigating the proton bunch spectrum show that a much higher frequency regime is needed to exclude the proton signal than previously expected.

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Student Poster Session / 2153

Generation of symmetrical optical caustic beams for precise alignment

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Generating layers of symmetrical optical caustic beams using a specific configuration of cylindrical lenses is an innovative idea with potential application in precision alignment and other fields. The technique allows the generation of layers of non-diffracting beams with opposite accelerating directions. This approach can be extended in two dimensions or to create rotationally symmetric beams. Prior methods have produced similar beams using spatial light modulators, but the presented approach with cylindrical lenses reduces setup complexity and cost, thereby opening the possibility for new applications. In the context of particle accelerators, these include particle acceleration using high-power lasers and alignment of accelerator components. The presented research emphasizes the possibility for this technique to be used as a reference line for precise alignment. It allows the generation of reference lines with a thickness in the order of millimeters for distances of tens to hundreds of meters, which is advantageous for large accelerator facilities. A brief description of the sensors used to detect misalignment is also presented.

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Student Poster Session / 2154

PIP-II laser beam profile monitor laser system

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Fermilab is currently engaged in the development of an 800 MeV superconducting RF linac, aiming to replace its existing 400 MeV normal conducting linac. PIP-II is a warm front-end producing 2 mA of 2.1 MeV H-, followed by a sequence of superconducting RF cryomodules leading to 800 MeV. To mitigate potential damage to the superconducting RF cavities, PIP-II uses laser-based monitors for beam profiling via photoionization. This abstract provides an update on the project's beam profiling, focusing on advancements made since the initial prototype. The prototype profile monitor featured a high-repetition-rate, low-power fiber laser and fiber optic transport that was tested with a 2.1 MeV H- beam at the PIP-II Injector Test (PIP2IT) accelerator. Since then, the fiber laser and fiber transport have been upgraded to a diode laser based system and free-space optical transport. This highlights a significant evolution in the laser system, enhancing its efficiency and adaptability. This talk will focus on a variable pulse width drive laser system via gain-switching, and the stability of a free-space propagated optical beam. In addition, this presentation will also share findings related to transverse and longitudinal beam profile measurements given different laser profiles.

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Student Poster Session / 2155

High fidelity numerical modelling and condition monitoring applied to septum magnets at CERN

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The CERN Accelerator Beam Transfer group has recently launched a study to investigate the life cycles of pulsed septum magnets. The development is aiming to enhance the prediction of anomalies, leading to reduced life cycles of these beam transfer equipment. For this reason, the standard vacuum operated, direct drive septa magnet has been chosen to investigate critical design features. In the initial project phase, a so called High-Fidelity (HF) numerical simulation has been carried out, providing insight on critical components, like brazed joints, reducing the fatigue life. In parallel a dedicated test setup with state-of-the-art instrumentation has been developed, allowing to confirm the predicted system response. The novel approach for the beam transfer equipment will allow to review presently established design criteria. In a further iteration, the project is now aiming to demonstrate an anomaly detection and their prediction based on novel machine learning techniques. This paper presents the initial phase of developing the HF model, as well as the results of the instrumented magnet tests which will be compared to results from the numerical simulations.

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Student Poster Session / 2156

Final cooling with thick wedges for a muon collider

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In the final cooling stages for a muon collider, the transverse emittances are reduced while the longitudinal emittance is allowed to increase. In previous studies, Final 4-D cooling used absorbers within very high field solenoids to cool low-momentum muons. Simulations of the systems did not reach the desired cooling design goals. In this study, we develop and optimize a different conceptual design for the final 4D cooling channel, which is based on using dense wedge absorbers. We used G4Beamline to simulate the channel and Python to generate and analyze particle distributions. We optimized the design parameters of the cooling channel and produced conceptual designs (corresponding to possible starting points for the input beam) which achieve transverse cooling in both x and y by a factor of ˜3.5. These channels achieve a lower transverse and longitudinal emittance than the best design previously published.

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Student Poster Session / 2157

Optimizing current density measurements for intense low beta electron beams

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The cathode test stand at LANL is utilized to test velvet emitters over pulse durations of up to 2.5 µs. Diode voltages range from 120 kV to 275 kV and extracted currents exceed 25 A and depend on cathode size and pulse duration. Current density measurements taken with scintillators or Cherenkov emitters produce inconsistent patterns that disagree with the anticipated beam profile. Several factors contribute to the measured beam distribution, such as electron scatter, X-ray scatter, and Snell's law. Here, we present a range of experiments designed to evaluate both electron scatter and Cherenkov emission limits in efforts to optimize current density measurements. For electron ranging studies, metal foils of different densities and thicknesses are coupled with a scintillator, which is then imaged with an ICCD. Similarly, Cherenkov emission and Snell's law are investigated through imaging materials with differing indices of refraction over a range of beam energies. MCNP6® modeling is utilized to further guide and evaluate these experimental measurements.

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Student Poster Session / 2158

Modeling and optimization of the FACET-II injector with machine learning algorithms

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Linear particle accelerators are elaborate machines that demand a thorough comprehension of their beam physics interactions to enhance performance. Traditionally, physics simulations model the physics interactions inside a machine but they are computationally intensive. A novel solution to the long runtimes of physics simulations is replacing the intensive computations with a machine learning model that predicts the results instead of simulating them. Simple neural networks take milliseconds to compute the results. The ability to make physics predictions in almost real time opens a world of online models that can predict diagnostics which typically are destructive to the beam when measured.
This research entailed the incorporation of an innovative simulation infrastructure for the SLAC FACET-II group, aimed at optimizing existing physics simulations through advanced algorithms. The new infrastructure saves the simulation data at each step in optimization and then improves the input parameters to achieve a more desired result. The data generated by the simulation was then used to create a machine learning model to predict the parameters generated in the simulation. The machine learning model was a simple feedforward neural network and showed success in accurately predicting parameters such as beam emittance and bunch length from varied inputs.

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Student Poster Session / 2159

The design of the proton-EDM injection line, from BNL AGS booster

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Co-authors: Francois Meot [2]; William Morse [2]; Haixin Huang [2]; Nicholaos Tsoupas [3]; Yannis Semertzidis [4]

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The proton Electric Dipole Moment (pEDM) storage ring to measure the electric dipole moment of the proton [1] is proposed to be built in the tunnel of the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory (BNL) by storage ring EDM (srEDM) Collaboration. We proposed that the AGS Booster to pEDM ring transfer and injection line (BtP) would use the partial portions of the existing BtA (AGS Booster to AGS) transfer line optics. In this practice, both of BtP Clockwise orientation (CW) and Counter-clockwise orientation (CCW) injection line are designed and matched in the hypothesis of a single turn injection scheme. The injecting beam-properties are matched to pEDM ring Twiss functions.

Footnotes:

[1] Zhanibek Omarov et al. Phys. Rev. D 105, 032001 (2022)

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Student Poster Session / 2160

Mechanical design, structural requirements and optimization of the FCC e+e- interaction region components

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This paper describes the mechanical design of the Future Circular Collider e+e- interaction region. The Future Circular Collider, as a forefront particle accelerator project, demands meticulous attention to the mechanical integrity and performance of its components, to the integration of the different systems and to the respect of the spatial constraint. The vacuum chamber design, the support tube and the bellows design are reported, highlighting the solutions adopted. The structural optimization method of the support structure is also presented, as well as the results obtained.

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Student Poster Session / 2161

Novel materials for beam acceleration

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Bulk niobium is currently the standard material for constructing superconducting radio frequency (SRF) cavities for acceleration in particle accelerators. However, bulk niobium is limited, and new materials and surface treatments may allow greater performance to be reached. We present progress on novel materials and treatments for SRF cavity fabrication.

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Student Poster Session / 2163

Differentiable modeling of Siberian Snakes in BNL's AGS: nonlinear maps, symplectic tracking, and optical compensation

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Meaningful prediction and enhancement of spin-polarization in the RHIC and EIC accelerators relies on accurate modeling of each sub-component. While nonlinear beam propagation and symplectic tracking is well established for common accelerator components, it has hitherto not been established for Siberian Snakes, which are essential for the acceleration of polarized protons in storage rings. Here we describe the first differentiable model, applied to both snakes of the AGS, which injects polarized beam into RHIC and the HSR of the EIC. This enables the full power of nonlinear maps to be applied to the AGS, including normal form theory and symplectic tracking. We show how important this is for long-term beam motion in the AGS: without the symplectic representations, simulated particle motion destabilizes during about 1000 turns spent close to injection energy. Including the new snake representations, the Bmad toolkit was used to optimize the closed orbit and the optics between injection and extraction, including corrections to the coupling and to the vertical dispersion that the snakes currently create. Finally, we use simulation results to compare randomly generated lattice misalignments with surveying data measurements.

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Student Poster Session / 2164

Proposal for a proton-bunch compression experiment at IOTA in the strong space-charge regime

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The longitudinal compression of intense proton bunches with strong space-charge force is an essential component of a proton-based muon source for a muon collider. This paper discusses a proton-bunch compression experiment at the Integrable Optics Test Accelerator (IOTA) storage ring at Fermilab to explore optimal radio frequency (RF) cavity and lattice configurations. IOTA is a compact fixed-energy storage ring that can circulate a 2.5-MeV proton beam with varying beam parameters and lattice configurations. The study will aim to demonstrate a bunch-compression factor of 2 to 10 in the IOTA ring while examining the impact of intense space-charge effects on the compression process.

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Student Poster Session / 2166

Dynamic aperture of the RCS during bunch merges

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The Rapid Cycling Synchrotron (RCS) of the Electron Ion Collider (EIC) will be used to accelerate polarized electrons from 400 MeV to a top energy of 5, 10, or 18 GeV before injecting into the Electron Storage Ring. At 1 GeV, the RCS will perform a merge of two bunches into one, adding longitudinal dynamics that effects the dynamic aperture, depending on the merge parameters. In this paper, results for different merge models will be compared, as well as finding the relationship between the merge parameters of the RCS and its dynamic aperture.

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Student Poster Session / 2168

Energy dependence of PS main unit harmonics

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CERN Proton Synchrotron (PS) is featured with 100 C-shaped combined-function Main Units (MUs) magnets with a complicated pole shape. The operation and the modelling of the PS-MUs has been historically carried out with empirical beam-based studies. However, it would be interesting to understand whether, starting from a proper magnetic model and using the predicted harmonics as input to optics simulations, it is possible to accurately predict the beam dynamics behavior in the PS, and assess the model accuracy with respect to beam-based measurements. To evaluate the magnetic model quality and its predictions, bare-machine configurations at different energies were prepared, where only the Main Coil is powered and the additional circuits are off. In this paper, a comparison of tunes and chromaticity measurements with the predicted optics is reported, showing the saturation of the quadrupolar and sextupolar components at high energy, which affect these quantities.

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Student Poster Session / 2169

LHC ion commissioning

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In 2023, about 2 months of the LHC operation were devoted to the Heavy Ions physics, after more than 5 years since the last ion run. In this paper, the results of the 2023 Ion optics commissioning are reported. Local corrections in Interaction Point (IP) 1 and 5 were reused from the regular proton commissioning, but the optics measurement showed the need for new local corrections in IP2. We observed that an energy trim of the level of 10e-4 helped to reduce the optics errors at top energy. The dedicated measurements during the energy ramp revealed a larger than expected beta-beat, which is consistent with an energy mismatch. Furthermore, global corrections were performed to reach a β-beating of about 5% for the collision optics.

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Student Poster Session / 2170

Performance optimization design of photocathode injector based on multi-objective genetic algorithm

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Generating beam with nC-level charge is of great significance for particle colliders. In order to achieve lower emittance and length of bunch, based on the photocathode injector, we designed a L-band gun and L-band accelerating tube. However, with many coupled parameters, it is difficult to optimize its performance to the limit when optimizing them separately. Therefore, we employed a multi-objective genetic algorithm for searching in the multi-dimensional parameter space and utilized a deep Gaussian process as a surrogate model to solve the high-dimensional parameter optimization problem. Through optimization, we successfully obtained the normalized transverse emittance of 3.4 π mm·mrad and the bunch length of 1.0 mm for a fixed charge of 5 nC. This indicates that our method can effectively improve the performance of the photocathode injector.

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Student Poster Session / 2171

Development of novel beam instrumentation for in vivo and in vitro end stations for Laser-hybrid Accelerator for Radiobiological Applications

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Radiotherapy is an effective, non-invasive, widely used treatment for cancerous tumors that uses x-ray photon, electron and ion beam sources. The Laser-hybrid Accelerator for Radiobiological Applications (LhARA) is a proposed novel laser-driven accelerator system under development that aims to deliver a multi-ion Particle Beam Therapy (PBT) technique. This study aims to develop a novel technique to deliver different light ion minibeams to the in vivo and in vitro end stations. A novel technique will produce the desired beams and minibeams by magnetically focusing the incoming proton and light ion beams, without collimation. This solution focuses the beam magnetically to the required 1 mm spot distribution with an energy of 15 MeV, for the low energy in vitro end station's experimental requirements. A novel spot-scanning beam delivery modality simulation is also being developed. This simulation allows the beam delivery system to deliver the beam to spots in the treatment field, through a dynamic rotational motion.

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Student Poster Session / 2172

The design of a 2.3-cell X-band photocathode RF electron gun

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Recent advancements in electron beam compression methods have enabled the production of ultrashort electron beams at the sub-femtosecond scale, significantly expanding their applications. However, the temporal resolution of these beams is primarily limited by the flight time jitter, especially during their generation in photocathode RF electron guns. This paper explores the dynamics of electron beams within different cell structures of the photocathode RF electron gun and introduces a novel RF cavity design. This design enables the electron beam's output energy and the flight time within the gun to remain unaffected by microwave phase jitter simultaneously. Moreover, the power coupler of this RF cavity has been optimized for high efficiency. Our results indicate that this design not only stabilizes ultrashort electron beams but also paves the way for novel advancements in ultrafast science.

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Student Poster Session / 2173

Improvements to 4-rod RFQs with additive manufacturing processes

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The institute of applied physics (IAP), university of Frankfurt, has been working for years on the development of increasingly powerful 4-Rod RFQ accelerators for hadron acceleration. The need for such accelerators has increased significantly in the recent past, as accelerator-driven neutron sources are becoming increasingly important following the closure of various test reactors. High beam currents, particle energies and operational stability are often required from those LINACs. In order to meet these requirements, the copper structure of the RFQ is to be manufactured using a new type of pure copper 3D printing in order to be able to introduce optimized cooling channels inside the copper parts. Comprehensive multiphysics simulations with ansys, cst and autodesk CFD will first be carried out to evaluate the operational stability and performance. In addition, it will be clarified whether the printed copper fulfills the necessary vacuum and conductivity requirements after CNC processing, or whether galvanic copper plating should be carried out.

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Student Poster Session / 2174

A faster algorithm to compute lowest order longitudinal and transverse resistive wall wake for non-ultrarelativistic case

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With the development of the steady state micro bunching (SSMB) storage ring, its parameters reveal that the ultra relativistic assumption which is wildly used is not valid for the electron beam bunch train, which has length in the 100 nm range, spacing of 1 μm and energy in hundreds MeV range. The strength of the interaction between such bunches and the potential instability may need careful evaluation. At the same time, the effect of the space charge inside a single bunch due to space charge effect also needs to be considered. In this article, we reorganized the lowest-order longitudinal wakefield under non-ultra relativistic conditions, and modified the inconsistent part in the theoretical derivation in some essays of the lowest-order transverse wakefield. We present the modified theoretical results and analysis. Then based on the result we have derived, we give a algorithm which is thousands time faster than direct calculation. It lays foundation in future research.

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Student Poster Session / 2175

Superradiant cooling and dynamics of ultrashort electron beams

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Accelerator-based light source can produce extremely high brightness radiation and has been an indispensable tool in various fields. By exploiting the collective dynamics of electrons in external fields, high-gain free electron lasers can generate radiation with powers several orders of magnitude higher than typical synchrotron radiation. This collective enhancement, could also be realized in future synchrotrons with ultrashort electron beams stored. The classical theory of storage ring cannot be extended to describe such devices since it assumes the emission of radiation is independent for each electron. To incorporate this collective radiation effect, a fundamentally different theory of storage ring physics has to be developed. In this paper, we consider a quantum electrodynamics treatment of the collective radiation of electrons in storage rings. We find that the ultimate limit on beam brightness in classical theory will break down due to the failure of the independence assumption and electrons will be cooled superradiantly. Moreover, we give a complete analysis of the intricate beam dynamics under the coherent synchrotron radiation effect and superradiant cooling effect.

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Student Poster Session / 2176

Dark current simulations in accelerating structures operating with short RF pulses

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The attainable acceleration gradient in normal conducting RF accelerating structure is limited by RF breakdown, a major challenge in high gradient operation. Some of the recent experiments at the Argonne Wakefield Accelerator (AWA) facility suggest the possibility of breakdown mitigation by using short RF pulses (on the order of a few nanoseconds) to drive the accelerating structures. To understand the physics of RF breakdown on a nanosecond time scale, we simulated the dark current in few accelerating structures in both long-pulse and short-pulse regimes comparatively, and studied multiple potential breakdown initiators, including field emission and multipacting. Our simulations suggest the potential of a class of accelerators designed to work in the short-pulse regime.

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Student Poster Session / 2177

Direct measurements of RHIC BPM data at the IP using linear regression

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Many mature methods to study the betatron function of a lattice rely on beam position monitor (BPM) data and the model of the whole machine. In this study, we focused on analyzing specific parts of the lattice of the Relativistic Heavy Ion Collider (RHIC), taking advantage of BPMs separated by drift space near interaction points (IPs) of RHIC. This (local) approach would provide a alternative measure of beta*and s* at specific regions which can be compared to previous (global) methods. This process utilizes the phase transfer matrix built from existing BPM data from RHIC using Linear Regression techniques. Results at the IPs were compared to B3/B4 magnet sections. These were then compared to previous methods. It was found that this local method does just as well as existing global methods in certain regions (around IP10 and 12) while doing subpar in other regions (around IP6). However, we propose that AC dipole data will perform better than the previous set of BPM data, though results are currently pending. This method of considering specific regions with special conditions could be extended to experiments at NSLS-II and the upcoming EIC for further luminosity optimization.

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Student Poster Session / 2178

Design of a 3-cell rectangular deflecting cavity for a compact THz-FEL

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In this paper, we present the design of a multipurpose 3-cell deflecting RF cavity for a compact terahertz (THz) free electron laser (FEL) facility. The 3-cell deflecting RF cavity is mainly used for longitudinal bunch length measurement and a chopper system to cut off the bunch tail caused by the thermionic gun. Single-cell cavities suffer from orbit offset, while a 3-cell cavity is possible to eliminate the offset effect. In addition, rectangular deflector is decided for its superiority in fabrication and mode separation when compared to a cylindrical deflector. We used CST for cavity design and placed the results of the analysis of the cavity in this paper. Particle tracking is performed with the Astra code, and space charge effect is taken into account. It is shown that the time resolution are 500fs when used as a longitudinal bunch length measurement. When used as a beam chopper, the beam orbits are free of offset while cutting off the tail particles, which has less impact on the subsequent beam transport.

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Student Poster Session / **2179**

An ultimate single-ion source using a Coulomb crystal in a Paul trap

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An ion cloud confined in a Paul trap eventually reaches a Coulomb crystalline state when strongly cooled toward absolute zero. The normalized emittance of the Coulomb crystal can be in the sub-femtometer range. The trap is thus usable as a unique ion source for nano-beam production, though the available beam intensity is limited. This new concept was first discussed nearly 20 years ago*and later experimentally demonstrated by several research groups (*,**). In this paper, we report on the result of a recent experiment where an attempt was made to extract Ca+ or N2+ ions one by one from a compact linear Paul trap. In addition to the regular extraction scheme based on a string Coulomb crystal, the possibility of using a multi-shell crystalline structure is explored in detail.

Footnotes:

- M. Kano et al., J. Phys. Soc. Jpn. 73, 760(2004). ** W. Schnitzler et al., Phys. Rev. Lett. 102, 070501 (2009). *** K. Izawa et al., J. Phys. Soc. Jpn. 79, 124502 (2010).

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Student Poster Session / 2180

An experimental proposal for the strong-filed Terahertz generation at SXFEL facility

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Strong field Terahertz (THz) light source has been in-creasingly important for many scientific frontiers, while it is still a challenge to obtain THz radiation with high pulse energy at wide-tunable frequency. In this paper, we introduce an accelerator-based strong filed THz light source to obtain coherent THz radiation with high pulse energy and tunable frequency and X-ray pulse at the same time, which adopts a frequency beating laser pulse modulated electron beam. Here, we present the experimental preparation for the strong filed THz radiation at shanghai soft X-ray free-electron laser (SXFEL) facility and show its simulated radiation performance.

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Student Poster Session / 2181

Application of common points selection method based on uniformity dividing space in HALF

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The alignment installation work of Hefei Advanced Light Facility (HALF) is usually carried out in tunnels. We convert the coordinates of the landmark points to the global coordinate system through coordinate transformation, and accurately adjust them to the corresponding coordinate values for alignment and installation. However, tunnels are often long and narrow, which can easily lead to ill-conditioned normal equations and loss of accuracy when solving coordinate transformation parameters. Therefore, to quickly and accurately obtain the coordinate transformation parameters, this paper proposes a common point selection method based on uniformity division space, which divides the coordinate transformation space according to the uniformity in different directions to select the optimal common points combination, and uses simulation and measured data to verify the method in this article. The results show that the conversion parameters solved by this method are more accurate and more stable, avoiding accuracy loss due to aggregation in a certain direction, and are suitable for narrow and long layout scenarios.

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Student Poster Session / 2182

Research on spatial alignment of laser and electron beam in the generation of ultra-short electron pulses by laser modulation

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The utilization of laser modulation techniques shows potential in producing sub-femtosecond electron beams within photoinjector electron guns. The precise spatial alignment between the modulated laser and electron beam is crucial for the stable emission of sub-femtosecond electron beams. In practical applications, inevitable lateral positional fluctuations are present in both the modulated laser and electron beam pulses, resulting in uneven and suboptimal modulation effects of the laser on the electron beam. Photocathode electron guns commonly utilize solenoid focusing for transverse electron beam concentration, inducing transverse phase space coupling and causing the laser-induced transverse jitter in the electron gun to not accurately reflect the transverse jitter of the electron beam. This study seeks to employ coherent lasers and devise a solenoid coil to disentangle the transverse phase space of the electron beam, ensuring that the transverse jitter of the electron beam aligns with the jitter of the modulated laser at the focal point.

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Student Poster Session / 2183

Study of band gap alteration in CVD-grown few-layer MoS_2 under swift-heavy ion irradiation

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The distinctive electronic band structure characteristics of 2D materials enable various advanced applications in electrical and optoelectronic devices. The present work reports on a simple CVD technique that employs alkali halide to synthesize high-quality few-layer MoS2 by reducing growth temperature from 850℃ to 650℃ and its ion-irradiation study for band gap modification. The Raman peak position difference of A_1g to E1_2g is ≈24.5 cmˆ-1 for the synthesized MoS2, which corresponds to a few layers (< 5 monolayers) of MoS2 on the substrate, as also confirmed by the AFM. The optical image shows the continuous distribution of flakes throughout the substrate; the average area of flakes is ≈0.2 µmˆ2, as confirmed by SEM and TEM analysis. SHI irradiation at 100 MeV ion energy of 1e+11 to 1e+13 ions/cmˆ2 ion fluences have been used to modify the band gap in MoS2. UV-vis spectroscopy shows the absorption peak shifts from 680 nm to 674 nm for the A-peak and 630 nm to 624 nm for the B-peak. As a result, 100 MeV Ni ions with an (S_e) of 11.3 keV/nm have modified the band gap of a MoS2 (20 meV), due to ion irradiation-induced strain.

Footnotes:

two-dimensional (2D), Chemical vapor deposition (CVD), Swift heavy-ion (SHI), electronic energy loss (S_e)

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Student Poster Session / 2184

Generating tunable X-ray optical frequency combs using a free-electron laser

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As an important experimental tool, the Optical Frequency Combs (OFCs) has had a profound impact on research in various fields, whereas, generating high power high repetition frequency OFCs at tunable frequencies is still a limitation for most of the existing methods. In this study, free-electron laser (FEL) is proposed to generate coherent X-ray OFC with a tunable repetition frequency and high pulse energy. The approach involves using a proper seed laser with frequency modulation, followed by amplification in the Echo-Enabled Harmonic Generation (EEHG) mode to generate X-ray OFCs. Numerical simulations using the realistic beam parameters of the Shanghai soft X-ray free-electron laser facility have demonstrated the feasibility of generating X-ray OFCs. These OFCs have a peak power of about 1.5 GW and repetition frequencies ranging from 6 THz to 12 THz at Centre energies carbon K edge (~284 eV). The proposed technique presents new possibilities for resonant inelastic x-ray scattering (RIXS) spectroscopy and Terabit-level coherent optical communication, etc.

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Student Poster Session / 2185

Simulations of an electro-optical in-vacuum bunch profile monitor and measurements at KARA for use in the FCC-ee

Author: Micha Reissig[1]

Co-authors: Anke-Susanne Mueller [1]; Bastian Haerer [1]; Erik Bruendermann [1]; Gudrun Niehues [1]; Meghana Patil [1]; Robert Ruprecht [1]

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The Karlsruhe Research Accelerator (KARA) is an electron storage ring and synchrotron light source for accelerator research at the Karlsruhe Institute of Technology (KIT). It features an electro-optical (EO) in-vacuum bunch profile monitor to measure the longitudinal bunch profile in single shot on a turn-by-turn basis using electro-optical spectral decoding (EOSD). A simulation procedure has been set up to evaluate its suitability as a beam instrumentation for the operation of the future electron-position collider FCC-ee. In order to assess the simulations, this contribution focuses on a comparison to EO sampling (EOS) measurements at KARA and a study on the heat load of the EO crystal due to the expected high bunch repetition rate envisioned for FCC-ee.

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Student Poster Session / 2186

Novel positron beam generation based on Shanghai Laser Electron Gamma Source

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The Shanghai Light Source has been operated since 2009 to provide synchrotron radiation to 40 beamlines of the electron storage ring at a fixed electron energy of 3.5 GeV. The Shanghai Laser Electron Gamma Source (SLEGS) is approved to produce energy-tunable gamma rays in the inverse Compton slant-scattering of 100 W CO2 laser on the 3.5 GeV electrons as well as in the back-scattering. SLEGS can produce gamma rays in the energy range of 0.66 –21.7 MeV with flux of 1e+5 –1e+7 photons/s*. A positron source based on SLEGS is designed to produce positron beams in the energy range of 3 – 16 MeV with a flux of 1e+5 /s and energy resolution of ˜7% with an aperture of 10 mm collimator. The positron generated has been simulated by GEANT4, uses a SLEGS gamma injected into a single-layer target, and a dipole magnet deflect positrons. Based on the energy-tunable SLEGS gamma rays, the optimized parameters at each gamma energy were simulated to obtain an energy-tunable positron source.
We have confirmed positron generation in the commissioning. We plan to construct the positron source in the summer of 2024. We present the positron source based on results of simulation and test measurements.

Footnotes:

- H. H. Xu, G. T. Fan, H. W. Wang, H. Utsunomiya, L. X. Liu, Z. R. Hao, et al. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 2022 Vol. 1033 Pages 166742. &. Wang, HW., Fan, GT., Liu, LX. et al. Commissioning of laser electron gamma beamline SLEGS at SSRF. NUCL SCI TECH 33, 87 (2022).

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Student Poster Session / 2187

Introducing a semi-Gaussian mixture model for simulating multiple coulomb scattering in RF-Track

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Co-authors: Rudolf Frühwirth [2]; Andrea Latina [1]; Daniel Schulte [1]; Jochen Schieck [2]

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The deflection of charged particles in matter can be characterized by multiple-Coulomb scattering. Simulating the interaction of each particle with the Coulomb forces of the material is prohibitively time-consuming from a computational perspective. To address this, scientists have developed a scattering probability models, such as the Moliere model, which have seen refinements and contributions from various researchers over the past decades. In the context of a design study of a LINAC for ionization cooling, RF-Track has recently incorporated particle interactions with matter. This inclusion enables simulations for applications like ionization cooling channels for muon colliders and the design of machines for medical purposes. Within RF-Track, a novel Semi-Gaussian mixture model has been introduced to describe the deflection of charged particles. This innovative model comprises a Gaussian core and a non-Gaussian tail function to account for the effects of hard scattering. To validate the accuracy of our results, we conducted a benchmarking against other particle tracking codes, with the outcomes demonstrating a high level of agreement.

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Student Poster Session / 2188

Optimizing initial beam parameters for efficient muon ionization cooling

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Ionization cooling is only cooling technique capable of efficiently reducing the phase space of a muon beam within a short timeframe. The ultimate cooling phase of a muon collider aims to minimize transverse emittance while simultaneously curbing longitudinal emittance growth, to achieve optimal luminosities within the collider ring. This study shows that achieving efficient cooling performance requires selecting the best initial muon beam parameters. We present a technique that enables the determination of these optimal initial parameters through simulations and compare them with analytical models.

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Student Poster Session / 2190

Devices and preparation methods for niobium coupon samples used to investigate high-Q mechanism

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A surface treatment device has been established at the Wuxi Platform, enabling chemical polishing treatment on coupon samples. Currently, several samples treated with buffered chemical polishing (BCP) have been utilized in the investigation of nitrogen doping and medium-temperature baking mechanisms. This paper presents the development process of this device along with the experimental outcomes. In the future, we plan to enhance the device to facilitate electropolishing (EP) treatment on coupon samples.

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Student Poster Session / 2191

Particles and photon attenuating behavior of lead free Eu^{3+} doped barium phosphate glass system

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The study investigates the radiation attenuation performance of five ternary glass systems with varying chemical compositions: $50P_2O_5$-(50-x)BaO-xEu_2O_3, where x = 0, 1, 2, 4, and 6 mol%. It utilizes theoretical and Monte Carlo methods to determine shielding parameters such as attenuation coefficients, mean free path, value layers, electron densities, conductivity and neutron removal cross-sections across an energy range from 1 keV to 100 GeV. In addition to these analyses, the study explores kinetic energy stopping potentials and projected ranges of ions (H^+, He^+, and C^+) through the Stopping and Range of Ions in Matter database. Furthermore, research evaluates the dose rate attenuation behaviour and trajectories of photons bombarded from ^{137}Cs and ^{60}Co sources using Particle and Heavy Ion Transport code System. Obtained results show that sample: $50P_2O_5$-44BaO-$6Eu_2O_3$ with higher Eu^{3+}-doped glass has a potential for radiation shielding application among selected samples and is comparable with previously recommended, tested polymer and glass samples.

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Student Poster Session / 2192

3D beam tracking studies including intrabeam scattering

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Particle tracking serves as a computational technique for determining the mean field of dynamically tracked charged macroparticles of a particle beam within an accelerator. Conventional solver tend to neglect collisionality, resulting in loss of relevant information (particle and momentum redistribution). In this study, macro-particle collisions are incorporated into a 3D Poisson solver. In the previous studies, identifying close particles have been performed in a static condition (IPAC23-Macroparticle collisionality in PIC solver). The requirement to uphold energy momentum within a dynamic tracking is initiated in simple lattices and the results are presented. A comparison with analytic model of the Bjorken-Mtingwa or Conte-Martini is included to verify.

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Student Poster Session / 2193

Diffusion and acoustic properties of Nb thin films studied by time-domain thermoreflectance

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The thermal diffusion and acoustic properties of Nb impacts the thermal management of devices incorporating Nb thin films such as superconducting radiofrequency (SRF) cavities and superconducting high-speed electronic devices. The diffusion and acoustic properties of 200-800 nm thick Nb films deposited on Cu substrates were investigated using time-domain thermoreflectance (TDTR). The films were examined by X-ray diffraction, scanning electron microscopy, and atomic force microscopy. The grain size and thermal diffusivity increase with film thickness. The thermal diffusivity increased from 0.100± 0.002 cm2s-1 to 0.237± 0.002 cm2s-1 with the increase in film thickness from 200 nm (grain size 20±6 nm) to 800 nm (grain size 65±16 nm). Damped periodic photoacoustic signals are detected due to laser heating generated stress in the Nb film, which results in an acoustic pulse bouncing from the Nb/Cu and the Nb/vacuum interfaces. The period of the acoustic oscillation gives a longitudinal sound velocity of 3637.3 ms-1 inside the Nb films, which is in good agreement with the values reported in the literature.

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Student Poster Session / 2195

Development of new method of NEA Activation with Cs-Sb-O

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Negative Electron Affinity (NEA) activated GaAs photocathodes are the only one capable of generating spin-polarized electron beam larger than 90%. However, the NEA layer currently made from mainstream cesium (Cs) and oxygen (O) is chemically unstable, the NEA-GaAs photocathode has a rapid QE degradation over time or electron beam. As a result, it requires an operating vacuum pressure of 1e-9 Pa and has a short lifetime. Recently, a new NEA layer using heterojunctions with semiconductor thin film of alkali metals and antimony or tellurium has been proposed. The latest research shows that the NEA activation method using Cs-Sb-O is made by co-evaporation of Cs,

O2 and Sb. However, the co-evaporation method has high demands on equipment. Therefore, in this work, we attempted to fabricate a Cs-Sb-O NEA layer using a separation evaporation method. Specifically, we attempted four recipes and successfully fabricated the NEA layer by Cs-Sb-O. We also evaluated the dependence of QE on Sb thickness and found that it is easy to form a NEA layer with 0.2 nm of Sb.

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Student Poster Session / 2196

Quest for an optimal spin-polarized electron source for the Electron Ion Collider

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Superlattice GaAs photocathodes play a crucial role as the primary source of polarized electrons in various accelerator facilities, including CEBAF at Jefferson National Laboratory and the Electron Ion Collider (EIC) at Brookhaven National Laboratory. To increase the quantum efficiency (QE) of GaAs/GaAsP superlattice photocathodes, a Distributed Bragg Reflector (DBR) is grown underneath using metal organic chemical vapor deposition (MOCVD). There are several challenges associated with DBR photocathodes: the resonance peak may not align with the emission threshold of around 780 nm, non-uniform doping density in the top 5 nm may significantly impact QE and spin polarization, high-temperature heat treatment may lead to interlayer material diffusion, and the number of DBR pairs may not be optimal, affecting both QE and spin polarization. In this paper, we will report our progress of addressing these challenges to hunt for suitable photocathodes for the EIC.

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Student Poster Session / 2197

Review of MAD-X for FCC-ee studies

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The design of the electron-positron Future Circular Collider (FCC-ee) challenges the requirements on optics codes (like MAD-X) in terms of accuracy, consistency, and performance. Traditionally, MAD-X uses a transport formalism by expanding the transfer map about the origin up to second order to compute optics functions and synchrotron radiation integrals in the TWISS and EMIT modules. Conversely, particle tracking uses symplectic maps to propagate particles. These approaches solve the same problem using different approximations, resulting in a mismatch between the models used for tracking and for optics. While in a machine like LHC these differences are not relevant, for FCC-ee, given the size and the sensitivity to phase advance, the different approaches lead to important differences in the models. For instance, a tapering strategy that matches the tunes for optics needs to apply approximations that would mismatch the tune in tracking and vice versa. In this paper, we show the effectiveness of advanced methods that bring the maps used for optics and tracking closer and that will be used to reduce the gap between optics and tracking models to an acceptable level for FCC-ee studies.

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Student Poster Session / 2198

Studies of beams with non-factorizable transverse beam distributions at the CERN PSB

Author: Elleanor Lamb[1]

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Beam profile measurements in the LHC injector complex show heavy tails in both transverse planes. From these profile measurements, it is not possible to determine if the underlying 4D phase space distribution is statistically independent. A measurement campaign in the CERN PSB was carried out to introduce cross plane dependence in bunched beams in controlled conditions, in view of characterizing the operational beam distributions. The results of the measurement campaign demonstrate how heavy tails can be created via coupled resonance excitation of the lattice in the presence of space charge in accordance with predictions from the fixed line theory. The coupled resonance introduces dependence between the transverse planes of the 4D particle distribution, as demonstrated by beam profile measurements for different levels of scraping in one transverse plane.

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Student Poster Session / 2199

Luminosity effects of heavy tailed beams with transverse x-y correlation

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The luminosity of particle colliders depends, among other parameters, on the transverse profiles of the colliding beams. At the LHC at CERN, heavy-tailed transverse beam distributions are often observed, and the luminosity is modeled with the assumption that the x-y planes are independent in each beam. Analytical calculations show that the solution of inverting 1D heavy-tailed beam profiles to transverse 4D phase-space distributions is not unique. For the same transverse profile, the distributions can be dependent or independent in the transverse planes in absence of machine coupling. In this work, the effect of transverse x-y dependence of the 4D phase space distribution on the luminosity of a particle collider is evaluated for heavy-tailed q-Gaussian beams.

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Student Poster Session / 2201

Simulations of CXFEL with the MITHRA code

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The CXFEL project at ASU will produce coherent soft x-ray radiation at a university-scale facility. Unlike conventional XFELs, the CXFEL will use an optical undulator in addition to nanobunching the electron beam instead of a static magnetic undulator. This reduces the undulator period from cm-scale to micron scale and lowers the requirements on the electron beam energy. CXFEL's overtaking geometry design reduces the effective undulator period to 7.86 μm to produce 1 keV photons. This is accomplished by crossing the laser and electron beam at a 30 degree overtaking angle, and using a tilted laser pulse front to maintain temporal overlap between the electron beam and laser pulse. The inverse Compton scattering interaction between a microbunched electron beam and an optical undulator falls out of the range of most accelerator codes. We employ MITHRA, a FEL full-wave FDTD solver software package which includes inverse Compton scattering to simulate the FEL lasing process. We have adapted the code to the CXFEL instrument design to simulate the radiation/electron beam interactions and report results of studies including scaling of key parameters.

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Student Poster Session / 2202

Optimizations and updates of the FCC-ee collimation system

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The Future Circular electron-positron Collider, FCC-ee, is a design study for a 90 km circumference luminosity-frontier and highest-energy e+e- collider. It foresees four operation modes optimized for producing different particles by colliding high-brightness lepton beams. Operating such a machine presents unique challenges, including stored beam energies up to 17.5 MJ, a value about two orders of magnitude higher than any lepton collider to date. Given the high stored beam energy, unavoidable beam losses pose a serious risk of damage. Thus, an adequate protection system has to be implemented. To address this challenge, a beam collimation system to protect the sensitive equipment of

this machine is indispensable. This paper presents the studies that led to a new collimation system baseline and a collimation performance evaluation under selected beam loss scenarios.

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Student Poster Session / 2203

Minimizing space charge tune spread and increasing beam quality parameters with circular modes

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Space charge has been a limiting effect for low energy accelerators inducing emittance growth and tune spread. Tune shift and tune spread parameters are important for avoiding resonances, which limits intensity of the beam. Circular modes are round beams with intrinsic flatness that are generated through strong coupling, where intrinsic flatness can be transformed to real plane flatness through decoupling. It is understood that flat beams increase the quality parameters of a beam due to one of the plane emittances being smaller than the other plane since luminosity and beam brightness depend inversely on the beam emittances. We show that circular mode beams manifest smaller space charge tune spread compared to uncorrelated round beams, which allows better systematic control of operating point of the beam. Minimized tune spread allows flexible operating points on the tune map. We also dedicate current and intrinsic flatness ratio limits on circular modes, which increase quality parameters without detrimental effects on the emittance increase.

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Student Poster Session / 2205

Status of coil-dominated discrete-cosine-theta quadrupole prototype for high rigidity isotope beams

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Iron-dominated superconducting magnets are one of the most popular and used design choices for superconducting magnetic quadrupoles for accelerator systems. While the iron yoke and pole tips are economic and effective in shaping the field, the large amount of iron also leads to certain drawbacks, namely, unwanted harmonics from the sextupole correctors nested inside of quadrupole iron pole tips. Additional problems include the nonlinear field profile present in the high-field regime caused by the presence of steel, the cryogenic design challenges of the iron yoke being part of the cold mass, and the mechanical challenges of mounting the sextupole and octupole, which will generate significant forces for apertures of the size being proposed. The Facility for Rare Isotope Beams is developing a coil dominated quadrupole as a future upgrade, and the presented work discusses the advantages of using an iron-free quadrupole, along with the methods and choices of the design and the current status of prototype fabrication. The methods and work presented will include the model results and the aspects of the model that have been verified up to the current status of prototype fabrication.

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Student Poster Session / 2206

Beam dynamics and injection condition in a ring-type dipole of a laser-accelerated electron beam for compact light sources

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We are developing a compact synchrotron light source using laser electron acceleration, focusing on creating a tabletop accelerator-based radiation system. Our approach involves a small ring-type dipole with block-shaped permanent magnets, prioritizing cost and weight reduction. Simple beam

dynamic calculations revealed that a smaller electron beam divergence angle results in a more stable orbit and the field modulation of peak magnetic strength improves the stability without the additional quadrupoles. CST simulations shows that the magnetic field of the ring-type dipole includes the field modulation of peak magnetic strength along the orbit due to shape changes. The injection to the ring-type dipole is the one of the issues to be solved for a compact light source. In this paper, we present the studies on designing and optimizing the ring-type dipole including the injection of electron beam and the extraction of dipole radiation.

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Asia

Student Poster Session / 2207

Compact high peak power THz source driven by thermionic RF gun

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This work unveils the design of a compact high-power terahertz source, a collaborative effort between UCLA and RadiaBeam Technologies. The system, driven by a thermionic RF gun, features an alpha-magnet beamline that effectively compresses the beam, resulting in short bunch lengths and an additional S-band linac that elevates the beam energy to 10 MeV. The key to achieving high-efficiency radiation in the 1–1.5 THz range lies in using the tapered undulator equipped with a waveguide. This innovative approach serves a dual purpose: compensating for diffraction effects and ensuring optimal matching between the group velocity of the beam and the radiation field. The synergistic combination of these elements results in a compact terahertz source with high peak power, promising advancements in various scientific and technological applications.

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Student Poster Session / 2208

Detailed characterization of coherent synchrotron radiation effects using generative phase space reconstruction

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Coherent synchrotron radiation (CSR) effects in linear accelerators, such as projected emittance growth and microbunching, have been well studied. However, traditional measurement techniques lack the precision to fully comprehend the intricate multi-dimensional aspects of CSR, particularly the varying rotation of transverse phase space slices along the longitudinal coordinate of the bunch. This study explores the effectiveness of our generative-model-based high-dimensional phase space reconstruction method in characterizing CSR effects at the Argonne Wakefield Accelerator Facility. Additionally, we assess the current limitations in resolution of the phase space reconstruction method and conduct an analysis of its accuracy and precision through simulated scenarios. Finally, the reconstruction algorithm is tested using synthetic beams that emulate distributions affected by CSR.

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Student Poster Session / 2209

Thermal emission measurement and research of cesium telluride photocathodes

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The thermal emission of photoelectric cathodes significantly influences the emittance of electron beams. Employing cesium telluride as the cathode material, the hard X-ray free-electron laser device utilizes thermal evaporation deposition for fabrication. The typical thermal emission value for cesium telluride cathode materials is ~0.7 mm-mrad/mm. Poor processes and formulations lead to decreased cathode quality and increased thermal emission. Therefore, a measurement device is required to assess the thermal emission of cathodes produced under different processes, optimizing fabrication methods and maintaining emission within specified ranges. Traditional emittance measurement methods rely on large accelerator installations, incurring high construction costs, complexity, and environmental demands. We have chosen a pore-anode-based thermal emission measurement scheme that operates within laboratory settings. This approach is independent of large

accelerator installations, compact in structure, compatible with cathode fabrication setups, allowing for offline rapid measurement of cathode thermal emission.

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Student Poster Session / 2210

Study of the radiation field from multiple out-coupling holes in an infrared free electron laser oscillator

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A new infrared Free-Electron Laser (FEL) facility FELiChEM has been established as an experimental facility at the University of Science and Technology of China. It consists of two FEL oscillators driven by a normal-conducting S-band linac, covering the spectral ranges of 2.5-50 μm and 40-200 μm, respectively. This coverage is achieved by adjusting the beam energy from 12 to 65 MeV. The facility is dedicated to energy chemistry research, and output power is one of the most crucial parameters concerned by users. The output power is typically achieved by an out-coupling hole located in the center of a cavity mirror. Nevertheless, the spectral gap phenomenon has been observed in FEL oscillators with partial waveguides, which means that output powers are drastically reduced at certain wavelengths. Such power gaps have an adverse effect on experimental results since numerous experiments require continuous spectral scanning. In this paper, we propose the utilization of multiple out-coupling holes on the cavity mirror, instead of relying solely on a central out-coupling hole, to reduce the adverse impact of the spectral gap phenomenon.

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Student Poster Session / 2211

Instability of asymmetric electron drive beams in hollow plasma channels

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Using hollow plasma channels is one approach to compact positron acceleration, potentially reducing the cost and footprint of future linear colliders. However, it is prone to transverse instabilities since beams misaligned from the channel axis tend to get deflected into the channel boundary. In contrast, asymmetric electron drive beams can tolerate misalignment and propagate stably after the initial evolution, but this has only been reported for short distances. In this work, we use quasi-static particle-in-cell simulations to demonstrate the instability of asymmetric drivers even after splitting into two beamlets and reaching equilibrium. As the driver decelerates, its particles gradually return into the channel, making the driver susceptible to deflection by the transverse dipole mode. To understand this behavior, the transverse motion of an individual beam particle is modeled. Strategies to mitigate this instability are also proposed.

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Student Poster Session / 2213

Design of an X-band parallel-coupled travelling-wave accelerating structure for future linacs

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As compared to conventional travelling-wave (TW) structures, parallel-coupled accelerating structures eliminate the requirement for the coupling between cells, providing greater flexibility in optimizing the shape of cells. Each cell is independently fed by a periodic feeding network for this structure. In this case, it has a significantly short filling time which allows for ultrashort pulse length, thereby increasing the achievable gradient. In this paper, a design of an X-band parallel-coupled TW structure is presented in detail.

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Student Poster Session / 2214

Simulations of beam loading compensation scenarios with RF-Track

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The beam loading effect results in a gradient reduction of the accelerating structures due to the excitation of the fundamental mode when the beam travels through the cavity. A recent implementation of this process in the tracking code RF-Track allows the simulation of realistic scenarios, thus revealing the impact of this phenomenon in start-to-end accelerator designs. In this paper, we present the latest update of the beam loading module which allows the simulation of the compensation of this effect and we explore the potential of the developed tool in heavy-loaded scenarios.

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Student Poster Session / 2216

Superconducting thin films on higher order mode antennas for increase the CW performance of SRF cavities at MESA

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The Mainz Energy-Recovering Superconducting Accelerator (MESA), an energy-recovering (ER) LINAC, is currently under construction at the Institute for Nuclear physics at the Johannes Gutenberg-Universität Mainz, Germany. In the ER mode continues wave (CW) beam is accelerated from 5 MeV up to 105 MeV. The energy gain of the beam is provided through 2 enhanced ELBE-type cryomodules containing two 1.3 GHz 9-cell TESLA cavities each. By pushing the limits of the beam current up to 10 mA, a quench can occur at the HOM Antennas. The quench is caused through the increased power deposition induced by the electron beam in ER mode. Calculation shown that an upgrade from 1 mA to 10 mA is increasing the deposited power in the HOMs up to 3080 mW. 30% of this power will be out coupled with the HOM couplers and can be used as a thermal input. Simulations show a power limit of 95 mW which includes the power for 1 mA but is exceeded at 10 mA. A solution to increase the power limit are superconducting thin films which provides higher critical fields, temperature and currents. As candidates are Nb3Sn and NbTiN are chosen. First simulations of the power limit for coated HOM antennas are shown.

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Student Poster Session / 2217

Buffered chemical polishing process of 3.9 GHz cavities for SHINE

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The linear acceleration part of the SHINE project consists of two 3rd harmonic cryogenic modules which are operating at 3.9 GHz. Each of the cryomodules consists of eight 3.9 GHz 9-cell superconducting cavities. The SHINE specifications of the 3.9 GHz cavities are Qo >2.0e+9@13.1 MV/m and maximum accelerating gradient >15 MV/m. The 3.9 GHz cavities were treated with buffered chemical polishing (BCP) baseline combined with 2-step low-temperature baking surface treatment process to meet the specifications. In order to achieve the required performance, the BCP process had been optimized at the SHINE Wuxi surface treatment platform, especially the acid ratio. Vertical tests of all 3.9 GHz bare cavities treated with the optimized BCP process showed Qo up to 3.0e+9@13.1 MV/m and maximum accelerating gradient over 20 MV/m. The optimized BCP process applied to the 3.9 GHz cavities and related vertical test results were presented in this paper.

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Student Poster Session / 2218

High gradient operation of cryogenic C-band RF photogun at UCLA

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Future electron accelerator applications such as x-ray free electron lasers and ultrafast electron diffraction are dependent on significantly increasing beam brightness. We have designed and produced a new CrYogenic Brightness-Optimized Radiofrequency Gun (CYBORG) for use in a new beamline at UCLA to study the brightness improvements achievable in this novel low temperature high gradient accelerating environment. We are currently in the process of commissioning the photogun for operation with peak cathode fields in excess of 120 MV/m. We report here on the status of conditioning the photogun and report on dark current measurements and maximum field achieved thus far.

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Student Poster Session / 2219

Simulation optimization of electrom beams from the ELBE superconducting RF gun for ultrafast electron diffraction

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Moving towards beam energies around 2-6 MeV in ultrafast electron diffraction (UED) experiments allows achievement of larger coherence length for better k-space resolution, while the temporal resolution is improved when shorter electron bunches are generated and the velocity mismatch between the optical pump and UED probe is reduced.
At Helmholtz-Zentrum Dresden-Rossendorf (HZDR), a series of superconducting cw RF (SRF) guns has been designed, build, and tested, with the latest version currently in routine operation as one of the electron sources for the ELBE Center for High Power Radiation. This SRF photoinjector produces bunches with a few-MeV energies at up to MHz repetition rates, making it a suitable electron source also for MeV-UED experiments. The high repetition rate provides a significant advantage for the characterization of samples with low scattering cross-sections such as liquids and gases.
In this paper, we outline the conceptual MeV-UED instrument program under development at HZDR. We also showcase the beam quality achieved in first simulations of the ELBE SRF gun operating at low bunch charge as an electron source for diffraction experiments.

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Student Poster Session / 2220

Enhanced position resolution of L-band cavity BPM via matching its resonance frequencies

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Three L-Band cavity BPMs were tested at the Accelerator Test Facility (ATF) for raising beam position resolution. In the previous study, we found each BPM has a different resonant frequency due to manufacturing tolerance. From the earlier experiment, the position resolution was around 324 nm, while data incoherence problems occurred. Recently, we developed a Local oscillator (LO) to compensate for different BPM resonance frequencies during the L-Band BPM test at ATF2. The LO generates three channels corresponding to each BPM to yield intermediate frequencies, 80 MHz in the L-Band down-convertor. We achieved around 200 nm position resolution by using the developed LO. In this paper, we will explain the differences between the former beam test and the present beam test, its configuration, and the experiment method.

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Student Poster Session / 2223

Irradiation damage characterization of positron source materials

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Co-authors: Alice Thiebault [2]; Andriy Ushakov [3]; Brice Geoffroy [2]; Christine Le Galliard [2]; Dieter Lott [1]; Eric Voutier [2]; Frederick Gauthier [2]; Gudrid Moortgat-Pick [4]; Joseph Grames [3]; Kurt Aulenbacher [5]; Manuel Formela [6]; Marco Dehn [7]; Remy Dorkel [2]; Sabine Riemann [4]; Sami Habet [3]; Sandry Wallon [2]; Thomas Beiser [8]

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The secondary beam production target at future positron sources at the Continuous Electron Beam Accelerator Facility (CEBAF), the International Linear Collider (ILC) or the Future Circular Collider (FCC), features unprecedented mechanical and thermal stresses which may compromise sustainable and reliable operation. Candidate materials are required to possess high melting temperature together with excellent thermal conductivity, elasticity and radiation hardness properties. In order to substantiate the material choice for the CEBAF and ILC positron sources, the response of candidate materials such as titanium alloys, tungsten, and tantalum to electron beam irradiation was experimentally investigated. CEBAF and ILC expected operating conditions were mimicked using the 3.5 MeV electron beam of the MAMI facility injector. The material degradations were precisely analyzed via high energy X-ray diffraction at the HEMS beamline operated by the Helmholtz-Zentrum Hereon at the PETRA III synchrotron facility. This work reports the results of these measurements and their interpretation.

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Student Poster Session / 2224

Simulation study of nanosecond pulse power based on gyromagnetic nonlinear transmission line

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On-axis injection mode is planned to use in the Southern Advanced Photon Source (SAPS), which requires high quality to injection pulsed power supply. Gyromagnetic nonlinear transmission line (GNLTL) is introduced as a pulse compressor to meet the needs for pulse width. In this paper, 3-D finite element model is established based on Landau-Lifshitz-Gilbert equation and Maxwell's equations. The influence of geometrical sizes and bias magnetic field to output pulse is analyzed for better design of NLTL. A prototype was built with nanosecond pulse width and sub-nanosecond rise time to verify the simulation.

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Student Poster Session / 2226

The gamma activation measurements at Shanghai Laser Electron Gamma Source

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SLEGS is a Laser Compton Scattering gamma source. The gamma energy is 0.66 to 21.7 MeV, and the gamma flux is approximately 4.8e+5 to 1.5e+7 phs/s. Gamma activation method is used in beam flux monitor, medical isotpoe production and nuclear astrophysics in SLEGS. *Gamma beam flux under different collimated apertures has been checked by gamma activation method by using various half-life nuclide targets with an online activation and offline measurement platform. It is consistent with the flux measured with direct method by the LaBr3 detector. The activation method will be uniquely advantageous for monitoring gamma beam with short-life nuclide in a short time.A series of potential* *medical isotopes giant resonance production cross sections are measured by gamma activation method, which will provide key data for medical isotopes production by photonuclear reactions. The p-nuclei's photonuclear cross sections**, for example Ru, are measured by photoneutron and gamma activation, which can provide favorable data on the much larger abundance of 98Ru, 96Ru. The activation experiment of SLEGS provides a reliable option for different experimental research objectives in photonuclear physics.

Footnotes:

- Wang H W, Fan G T, Liu L X, et al., Commissioning of Laser Electron Gamma Beamline SLEGS at SSRF[J], Nuclear Science and Techniques, 2022, 33, 87. **Gy. Gyürky, Zs. Fülöp, F. Käppeler, G. G. Kiss, and A. Wallner, The Activation Method for Cross Section Measurements in Nuclear Astrophysics[J], Eur. Phys. J. A 55, 41 (2019).

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Student Poster Session / 2227

Optimization of bunch charge distribution for space charge emittance growth compensation in the PERLE injector

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Low energy electron bunches experience emittance growth due to space charge. This effect can lead to large emittances which are unacceptable for a facility like PERLE at IJCLab. PERLE will be an ERL test facility circulating a high current electron beam. The traditional method to reduce emittance due to this effect is already planned for the PERLE injector, this has a limit of how small the emittance can be reduced to. This limit is defined by the quality of the bunch as it is upon production at the cathode. The transverse and longitudinal properties of the laser pulse incident on the cathode defines some characteristics of the bunch, to which the space charge effect is related. In addition, the complex evolution of the bunch along the injector could result in optimal laser parameters which are different from the simple flattop distribution currently simulated. Presented here are simulation-based studies of the bunch charge distribution at the cathode and its subsequent evolution along the injector. An optimization of the laser parameters which create the bunch is also performed. We find that there is an optimal bunch charge shape which corresponds to minimal emittance growth.

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Student Poster Session / 2228

First FCC-ee lattice design with combined function magnets

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The Future Circular Electron-Positron Collider (FCC-ee) represents a cutting-edge particle physics facility designed to further investigate the Z0, W± and Higgs boson in addition to the top quark. The implementation of Combined Function Magnets (CFMs) in the FCC-ee arc cells would maintain high luminosity and reduce its energy consumption. The use of these special magnets induces changes in the damping partition numbers. To mitigate this the dipole fields in focusing and defocusing quadrupoles have to be different. This solution gives rise to incompatibility problems for the machine layout between the different energy configurations as the optics is also changed. This problem is tackled by defining different bending and geometric angles for the combined function magnets. The beam dynamics and performance aspects of the new lattice are studied in this paper.

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Student Poster Session / 2230

Optical matching procedure employing multi-objective optimization in the transfer line of the Muon Collider

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The conceptual design of the Muon Collider aims to achieve muon beam collisions at approximately 10 TeV. Challenges, such as the imperative for a short pulse and an intense beam to prevent muon decay, necessitate an investigation into crucial design parameters. This study specifically addresses the transfer line lattice, which includes FODO-cells and a triplet, situated between the muon-proton compressor and the target. The aim is to determine the optimal lattice design for effective matching. In addressing this goal, we introduce multi-objective optimization techniques for obtaining design variables tailored to the requirements of the final focusing parameters in the presence of space charge. Additionally, we present an optimized numerical computing technique enabling parallelization and GPU acceleration, specialized for simulating the beam dynamics in the transfer line.
By comparing its performance and accuracy trade-off with a physics-constrained neural network surrogate model, our goal is to establish a time-effective tool for optimizing the muon transfer-line lattice across various input beam parameters.

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Student Poster Session / 2231

Implementing bunch-by-bunch diagnostics at the KARA booster synchrotron

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In the upcoming compact STorage ring for Accelerator Research and Technology (cSTART), LPA-like electron bunches are only stored for about 100 ms, in which the equilibrium emittance will not be reached. Therefore, to measure parameters such as bunch profiles, arrival times and bunch current losses, bunch-resolved diagnostics are needed.
The booster synchrotron of the KARA accelerator accepts pre-accelerated bunches from a racetrack microtron and accelerates them further over a 500 ms long energy ramp. As the KARA booster synchrotron has a similar circumference and injection energy as the cSTART storage ring, new bunch-by-bunch diagnostics developed there can be transferred to the cSTART project with minimal effort. Currently the diagnostic system of the booster is not designed for bunch-by-bunch diagnostics, thus after using the booster as a testbed for cSTART, such a system could be used permanently.
At the booster synchrotron we use the picosecond sampling system KAPTURE-II to read-out a button beam position monitor and an avalanche photo diode at the synchrotron light port and compare the results with a commercial bunch-by-bunch system.

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Student Poster Session / **2232**

Radiation load studies for the proton target area of a multi-TeV muon collider

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Muon production in the multi-TeV muon collider studied by the International Muon Collider Collaboration is planned to be performed with a high-power proton beam interacting with a fixed target. The design of the target area comes with a set of challenges related to the radiation load to front-end equipment. The confinement of the emerging pions and muons requires very strong magnetic fields achievable only by superconducting solenoids, which are sensitive to heat load and long-term radiation damage. The latter concerns the ionizing dose in insulation, as well as the displacement damage in the superconductor. The magnet shielding design has to limit the heat deposition and ensure that the induced radiation damage is compatible with the operational lifetime of the muon production complex. Finally, the fraction of the primary beam passing through the target unimpeded poses a need for an extraction channel. In this study, we use the FLUKA Monte Carlo code to assess the radiation load to the solenoids, and we explore the possible spent proton beam extraction scenarios taking into account the constraints stemming from the beam characteristics and the required magnetic field strength.

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Student Poster Session / **2233**

Optimization of ELSA electron beam transport for its inverse Compton scattering X-ray source

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ELSA LINCS (ELSA Linac INverse Compton Source) at CEA DAM DIF is an Inverse Compton Scattering X-ray source in the 5-40 keV range, through interaction between 10-30 MeV electrons with a Nd:YAG laser. The source was upgraded to increase the X-ray flux produced in the 5-40 keV range. The new experimental setup and imaging systems have been modified for compatibility with fundamental emission at 1064 nm and for better mechanical stability. The upgrade also includes installation of a new RF linearizing cavity before magnetic compression, to improve bunch compression. Experimental optimization of the beam transport has been achieved, relying on recent detailed simulation work. Results taking advantage of this optimization are presented: achieved bunch duration, emittance, dimension at interaction point, for several electron energies and several bunch charges between 50 pC up to 1 nC. Comparisons with simulations provide an insight about major contributions to emittance growth. Achievable X-ray flux through Inverse Compton Scattering and applications are discussed.

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Student Poster Session / 2234

Investigating X-ray detector systems using Monte Carlo techniques

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Digital Tomosynthesis (DT) is a 3D mode of x-ray imaging. Adaptix Ltd have developed a novel mobile DT device enabled by implementing an array of R-ray emission points and a flat-panel detector. This device gives access to human and animal 3D imaging, as well as to non-destructive material evaluation. DT is not as clinically popular as Computed Tomography (CT) or radiography, and flat-panel source DT even less so, thus creating scope to investigate the optimal flat-panel detector technology for this modality. Geant4, a Monte Carlo Particle Transport code, has been used to simulate the Adaptix Ltd system to do this. Parameters such as the material composition of the detectors, the exact detection method and the inclusion vs exclusion of a scintillation layer are tested in this simulation environment. This work aims to find the optimal flat-panel detector design by comparing

different scintillator compositions and structures for this DT method. Therefore, the ideal detector that preserves the advantages of this low-cost, low-dose scanning approach is determined.

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Student Poster Session / 2236

Real-time measurements of the RF-path of an electro-optical bunch arrival-time monitor with integrated planar pickup-structure with low-charge electron beams at ELBE

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Ultra-low-charge operation of free-electron lasers down to 1 pC or even lower, requires adequate diagnostics for both, the users and the operators. For the electro-optical bunch-arrival time monitor a fundamental design update is necessary to yield single-digit fs precision with such low charges. In 2023 a vacuum sealed demonstrator for a novel pickup structure with integrated combination network on a printed circuit board was built for operation of the free-electron laser ELBE at HZDR. Together with a new low-pi-voltage ultra-wideband traveling wave electro-optical modulator, this concept reaches an estimated theoretical jitter charge product of 9 fs pC. As a proof-of-concept measurements done at ELBE with the pickup demonstrator were carried out: In this contribution we analyze the effects of the variation of different beam properties, e.g., charge and position.

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Student Poster Session / 2237

Exploiting optical interference effects to enhance the quantum efficiency of photocathodes

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We present measurements of quantum efficiency (QE) modulations in CsSb and Cs3Sb photocathodes that arise from optical interference of reflections from the underlying substrate that has multiple semi-transparent layers. The photocathode films are grown on a cubic silicon carbide layer (3C-SiC) which itself is grown epitaxially on Si(100) during fabrication. We find that the QE modulates by up to a factor of two over a laser wavelength range of 30 nm, and that a modulation peak can be tuned to coincide with a desired laser wavelength by changing the thicknesses of both the photocathode and the silicon carbide layer in the substrate. A model for the QE modulations is derived and fitted to QE measurements of CsSb and Cs3Sb films, which have different indices of refraction, in addition to QE measurements of Cs3Sb films grown on 3C-SiC substrates with two different silicon carbide layer thicknesses. Good agreement is found between the model and measurements, confirming the optical interference effect can be exploited to enhance quantum efficiency at desired visible wavelengths.

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Student Poster Session / 2238

Background mitigation concepts for Super-NaNu

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Super-NaNu is a proposed neutrino experiment as part of the SHADOWS proposal for the high intensity facility ECN3 in CERN's North Area. It aims to detect neutrino interactions downstream of a beam-dump that is penetrated with a 400 GeV high intensity proton beam from the SPS. The experiment would run in parallel to the HIKE and SHADOWS experiments, taking data with an emulsion detector. Simulations show that various combinations of muon backgrounds pose the major limiting component for NaNu operation. As muons will leave tracks in the emulsion detector, their flux at the detector location is directly correlated to the frequency of emulation exchange and therefore with the cost of the experiment. Finding ways of mitigating the muon background as much as possible is therefore essential. In this paper, we present a possible mitigation strategy for muon backgrounds.

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Student Poster Session / 2239

Preliminary design consideration for CEPC fast luminosity feedback system

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With very small beam sizes at IP (several tens of nanometers in the vertical direction) and the presence of strong FFS quadrupoles in the CEPC, the luminosity is very sensitive to the mechanical vibrations, requiring excellent control over the two colliding beams to ensure an optimum geometrical overlap between them and thereby maximize the luminosity. Fast luminosity measurements and an IP orbit feedback system are therefore essential. In this paper, we will show the preliminary design consideration for a fast luminosity feedback system at CEPC.

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Student Poster Session / 2240

Microscopic understanding of the effects of impurities in low RRR SRF cavities

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The SRF community has shown that introducing certain impurities into high-purity niobium can improve quality factors and accelerating gradients. We question why some impurities improve RF performance while others hinder it. The purpose of this study is to characterize the impurities of niobium coupons with a low residual resistance ratio (RRR) and correlate these impurities with the RF performance of low RRR cavities so that the mechanism of impurity-based improvements can be better understood and improved upon. The combination of RF testing, temperature mapping, frequency vs temperature analysis, and materials studies reveals a microscopic picture of why low RRR cavities experience low BCS resistance behavior more prominently than their high RRR counterparts. We performed surface treatments on low RRR cavities to evaluate how the intentional addition of oxygen and nitrogen to the RF layer further improves performance through changes in the mean free path, grain structure, and impurity profile. The results of this study have the potential to unlock a new understanding on SRF materials and enable the next generation of high Q/high gradient surface treatments.

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Student Poster Session / 2242

Electron cloud build-up studies for DAΦNE collider and FCCee damping ring

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DAΦNE is a a medium energy electron-positron collider operating in the National Laboratory of INFN at Frascati, Italy. The accelerator complex consists of two rings with an approximate circumference of 97 m. High-intensity electron and positron beams circulate and collide with the center of mass energy of around 1.02 GeV. The FCCee is an ongoing lepton collider project and its current injector design includes a damping ring for emittance cooling of positron beams. The electron cloud is one the most important collective effects and can represent a bottleneck for the performances of accelerators storing particles with positive charge. Several undesired effects such as transverse instabilities, beam losses, emittance growth, energy deposition, vacuum degradation may arise due to interaction of the circulating beam with the e-cloud. The aim of this presentation is to provide e-cloud buildup simulations for the DAΦNE positron ring and the Damping Ring of FCCee. This study will also include experimental studies concerning the instabilities induced by the e-cloud exploiting the opportunity offered by the positron beam at DAΦNE.

Footnotes:

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Student Poster Session / 2243

The FORTRESS Beamline at Tsinghua University

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High-brightness photoinjectors generate low emittance, ultrashort electron beams that are capable of tracking dynamical states of matter with atomic-scale spatio-temporal resolutions via ultrafast electron scattering, as well as providing precisely-shaped electron beams for advanced acceleration research and large-scale facilities such as free-electron laser and inverse Compton scattering. In this paper, we report on the status of the newly constructed FORTRESS (Facility Of Relativistic Time-Resolved Electron Source and Scattering) beamline at Tsinghua University, which will be dedicated for studies of advanced electron sources and photocathodes, new electron beam manipulation and

characterization methods, and ultrafast electron scattering applications. The layout, beam dynamics simulation, initial beam measurement results, as well as main hardware components will be discussed in detail.

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Student Poster Session / 2244

Commissioning and experiments with a compact transverse deflecting system at FLUTE

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A Compact Transverse Deflecting System (Compact-TDS) designed for longitudinal electron bunch diagnostics in the femtosecond regime is presently undergoing commissioning at the Karlsruhe Institute of Technology (KIT). This technique, based on THz streaking with a Split-Ring Resonator (SRR), demands a high level of electron beam controllability and stability at the micrometer scale. To meet these requirements, the Ferninfrarot Linac- Und Test-Experiment (FLUTE) has undergone an upgrade in 2023, incorporating a new RF system equipped with a state-of-the-art modulator, RF photoinjector and solenoid magnet. In this contribution, we present first experiments conducted with the Compact-TDS at FLUTE, utilizing the enhanced RF setup.

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Student Poster Session / 2245

Novel method for transverse narrow-band impedance calculation by coupled-bunch instability measurements in circular accelerators

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In the research and development phase of accelerators, impedance and instability analysis of the storage ring are typically conducted in advance for performance evaluation. However, the pre-calculated impedance often deviates from the actual measurement results. For built accelerators, the impedance of individual components can be measured with various methods such as the coaxial wire method. However, modern accelerators are typically composed of a large number of complex components, such as cavities, magnets, and solenoids, each with unique geometric shapes and structures. Measuring the impedance of each component individually is therefore a challenging and time-consuming task. This paper proposes a novel method to estimate the overall impedance parameters of the storage ring by analyzing the change in the growth rate of beam instability modes with beam current. This method provides an effective impedance measurement solution for built accelerators, furthering our understanding and optimization of accelerator performance. This novel method is also applied in BEPCII.

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Student Poster Session / 2246

Gas jet-based beam profile monitor for the electron beam test stand at CERN

Author: Oliver Stringer[1]

Co-authors: Adriana Rossi [2]; Alexander Webber-Date [1]; Ashley Churchman [2]; Carsten Welsch [3]; Cristina Sequeiro [2]; Gerhard Schneider [2]; Hao Zhang [1]; Marton Ady [2]; Muhammed Sameed [4]; Narender Kumar [1]; Ondrej Sedlacek [3]; Peter Forck [5]; Raymond Veness [2]; Serban Udrea [5]; Stefano Mazzoni [2]; Thibaut Lefevre [2]

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A non-invasive bidirectional beam profile monitor using beam-induced fluorescence upon a thin sheet of gas has been developed at the Cockcroft Institute in collaboration with CERN and GSI. This device is particularly suited to the Electron Beam Test Stand, and as such, a bespoke gas injection has been optimized for this specific use-case to provide diagnostics unavailable to conventional scintillator screens. The bidirectionality allows for the observation of beam reflections back along the beam path as a result of a beam dump with non-optimized repeller electrode potential. Furthermore, the heating effects of a high current DC beam are negated by the self-replenishing gas sheet. These benefits make this device ideal for use in the Electron Beam Test Stand.
This contribution summarizes the optimization study of the gas jet generation performed with a multi-objective genetic algorithm to meet required screen dimensions whilst maintaining acceptable vacuum levels.

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Student Poster Session / 2247

Second generation Cherenkov diffraction radiation studies at Diamond Light Source

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Diamond Light Source (DLS) is a 3 GeV synchrotron facility in the UK, which has been a part of the Cherenkov diffraction radiation (ChDR) collaboration since 2017 and is now in its second phase of experiments. The current experiment aims to produce and test a one-dimensional beam position monitor (BPM) that utilizes ChDR at visible and near-infrared (NIR) wavelengths. This paper will cover the characterization of the ChDR setup, including: the changes observed to the ChDR signal due to both beam specific and target specific variations.

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Student Poster Session / 2248

Magnetic measurements for Halbach-type permanent quadrupoles using a single-stretched wire system

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In the framework of the acceleration techniques, the Plasma Wake Field Acceleration (PWFA) is one of the most promising in terms of high machine compactness. For this purpose, a crucial role is played by the particle beam focusing upward and downward the plasma-beam interaction, performed by high gradient Permanent Magnet Quadrupoles (PMQs). In the framework of the INFN-LNF SPARC_LAB (Sources for Plasma Accelerators and Radiation Compton with Laser And Beam) six Halbach-type PMQs have been tested before installing them into the machine. This paper presents the outcomes of magnetic measurements conducted using a Single-Stretched Wire (SSW) system. The results include comprehensive details on integrated gradients, magnetic multipole components, and roll angles of the magnets. By considering the operational parameters of the machine, the results show that the tested magnets can be feasibly installed only within limited triplets configurations.

Footnotes:

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Student Poster Session / 2250

Optimization of cooling distribution of the EIC cooler ERL

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The Electron-Ion Collider (EIC) Hadron Storage Ring (HSR) will use strong hadron cooling to maintain the beam brightness and high luminosity during long collision experiments. An Energy Recovery Linac is used to deliver the high-current high-brightness electron beam for cooling. For the best cooling effect, the electron beam requires low emittance, small energy spread, and uniform longitudinal distribution. In this work, we simulate and optimize the longitudinal laser-beam distribution shaping at the photo-cathode, modeling space charge forces accurately. Machine parameters such as RF cavity phases are optimized in conjunction with the beam distribution using a genetic optimizer. We demonstrate the improvement to the cooling distribution in key parameters.

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Student Poster Session / 2252

Investigation of hot-spot and quench location due to trapped flux in niobium superconducting radiofrequency cavities

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One of the significant sources of residual losses in superconducting radio-frequency cavities is magnetic flux trapped during the cool-down due to the incomplete Messier effect. If the trapped vortices are non-uniformly distributed on the cavity surface, the temperature mapping revealed the "hot-spots"at the location of high density of pinned vortices. In this contribution, we present the results of combined temperature and magnetic mapping measurements on a single cell 3.0 GHz and 1.3 GHz niobium single-cell cavities. The results show the direct evidence of pinned vortices induced "hot-spots".

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Student Poster Session / 2253

Measuring transverse momentum space of alkali-antimonide photocathodes with the Cornell cryo-MTE-meter

Author: Charles Zhang[1]

Co-authors: Adam Bartnik [1]; Elena Echeverria [1]; Chad Pennington [1]; Alice Galdi [2]; Christopher Pierce [1]; Jared Maxson [3]

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The brightness of the beam in any linear accelerator can be no greater than at its source. Thus characterization of source initial conditions, including spatial and momentum distributions, is then critical to understand brightness evolution in a linac. Often measurement of the initial momentum distribution and closely related quantities such as the mean transverse energy (MTE) is hampered by imperfect knowledge of either the spatial source distribution or the downstream particle optics. Here, we experimentally demonstrate a method* that reconstructs the initial transverse momentum space without the aforementioned limitations, only assuming the beam transport is linear. This method entails scanning the excitation laser across the photocathode and simultaneously measuring the 4D phase space of the beam via aperture scans. We also measure the transverse momentum space and MTE with other methods, including solenoid scans and m11=0 imaging, and compare the results. Lastly, we will discuss the measurements of initial transverse momentum spaces across a spectrum of photocathode temperatures and excitation energies for an alkali-antimonide photocathode.

Footnotes:

- C. Zhang et al., "Reconstructing 4D source momentum space via aperture scans", in Proc. IPAC'23, Venice, Italy, May 2023, pp. 4595-4597. doi:10.18429/JACoW-IPAC2023-THPL071

Funding Agency:

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Student Poster Session / 2254

Novel high-intensity X and Gamma-rays sources using crystals

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Co-authors: Alessia Selmi [2]; Alexei Sytov [1]; Andrea Mazzolari [1]; Davide De Salvador [3]; Davide Valzani [1]; Erik Vallazza [4]; Francesco Sgarbossa [3]; Gianfranco Paternò [1]; Giulia Lezzani [2]; Laura Bandiera [1]; Lorenzo Malagutti [1]; Luca Lanzoni [5]; Marco Romagnoni [1]; Mattia Soldani [1]; Michela Prest [2]; Nicola Canale [1]; Pietro Monti-Guarnieri [2]; Stefano Carsi [2]; Vincenzo Guidi [1]

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The research is focused on finding new ways to generate high-intensity, monochromatic X and gamma-rays, surpassing the capabilities of existing methods. While Free-Electron Lasers (FEL) have limitations on photon energy, and Inverse Compton Scattering relies on powerful lasers, the search for alternatives continues. TECHNO-CLS, a PATHFINDER project funded by the European Innovation Council, is dedicated to crafting innovative gamma-ray Light Sources (LSs), utilizing linear, bent, or periodically bent crystals. Similar to magnetic undulators, crystals leverage a strong interplanar electrostatic field to prompt particle oscillation, resulting in electromagnetic radiation. By reducing the oscillation period to sub-mm dimensions, these undulators can produce tens of MeV in photon energy when exposed to GeV electron beams*. As a passive and sustainable element, CLSs show great promise. In the initial phase of the project, we identified techniques to realize CLSs, using alternated pattern deposition on silicon, using simulation to optimize the pattern and conducted experiments at CERN PS with Tungsten and Iridium crystals.

Footnotes:

- A.V. Korol, A.V. Solov'yov, Novel Lights Sources Beyond Free Electron Lasers, Particle Acceleration and Detection series, Springer Nature Switzerland, Cham (2022), 214 p., ISBN: 978-3-031-04281-2

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Student Poster Session / 2255

Optimizing the sextupole configuration for simultaneous correction of third order resonances at the recycler ring

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For the Recycler Ring at Fermilab, space charge tune shifts of almost 0.1 will have to be dealt with under the Proton Improvement Plan (PIP-II) framework. This will lead to the excitation of third order resonances. The minimization of Resonance Driving Terms (RDTs) allows to mitigate the harmful effect of these betatron resonances. Past work has shown that previously-installed sextupoles can compensate the RDTs of individual third order resonance lines, thus reducing particle losses in these operational regimes. Nevertheless, trying to compensate multiple resonances of the same order simultaneously with these existing sextupoles is limited due to current constraints in the magnets. The following study showcases the procedure to install additional sextupoles in order to aid the compensation of multiple resonances. This includes the optimization of the new sextupoles' locations in order to cancel out multiple RDTs while minimizing the currents needed. This is followed by a verification of their effectiveness by means of the RDT response matrix.

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North America

Student Poster Session / 2256

Experimental study into the invasiveness of a gas jet beam profile monitor for charged particle beams

Author: William Butcher[1]

Co-authors: Carsten Welsch [2]; Hao Zhang [1]; Milaan Patel [2]; Narender Kumar [1]; Oliver Stringer [1]

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A non-invasive gas jet in-vivo dosimeter for medical treatment facilities is being developed at the Cockcroft Institute, (UK) to provide full online (real time) monitoring with less frequent calibration. The monitor functions via a thin, low-density, gas jet curtain, intersecting with the beam. Online monitoring is crucial for hadron beams where acceptable dose tolerances are narrow, hence the beam should be perturbed only by the minimum amount necessary to acquire a signal. An experiment to determine the level of invasiveness of supersonic gas jet beam profile monitors was undertaken to quantify how much the gas jet perturbs the beam. This was accomplished using a 10 keV electron gun with a maximum current of ~100 nA, available in the DITAlab of the Cockcroft Institute. A scintillator screen and Faraday cup were placed in path of the beam to measure the change in beam size and current respectively. A simulation study using GEANT4 was completed with the experimental beam parameters to verify the results. This contribution examines the perturbation experienced by a particle beam from a gas jet beam profile monitor, and quantifies the effect the jet has on the beam size and current.

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Student Poster Session / 2257

Computational fluid dynamics design of a very high-power rotating positron target

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Computational Fluid Dynamics (CFD) has been used to design a very high-power rotating tungsten target to produce a positron beam. The positrons will be produced by a primary 1 mA electron beam with energy 120 MeV impinging on a rotating tungsten wheel through bremsstrahlung. The W target will be instrumented with water cooling to remove the estimated 17 kW of heat deposited by the primary electron beam in it [1]. The target will be central to accomplishing a rich experimental program using a positron beam at Jefferson Lab. In this contribution, I will present the status of the CFD-driven design of the target and the path towards a production positron target.

Footnotes:

[1] J. Grames et al., "Positron beams at Ce+BAF", in Proc. IPAC'23, Venice, Italy, May 2023, pp. 896-899. doi:10.18429/JACoW-IPAC2023-MOPL152

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Student Poster Session / 2258

Theoretical derivation of figures of merit for a dielectric disk accelerating structure

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A Dielectric Disk Accelerator (DDA) is a high gradient, metallic accelerating structure loaded with dielectric disks to increase its shunt impedance. So far, multiple of these structures have been fabricated and high power tested, reaching accelerating gradients higher than 100 MV/m with no significant damage. After the success of these experiments, derivations are being carried out to calculate the figures of merit of the geometry, such as accelerating gradient, shunt impedance, Q, etc. This work will be used to optimize the geometry of a structure for future design work. Results of these derivations as well as optimized geometries will be presented and discussed.

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Student Poster Session / 2260

Characterization of FEL mirrors with long ROCs

Author: William Delooze[1]

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FEL oscillators typically employ a two-mirror cavity with spherical mirrors. For storage ring FELs, a long, nearly concentric FEL cavity is utilized to achieve a reasonably small Rayleigh range, optimizing the FEL gain. A challenge for the Duke storage ring, with a 53.73 m long cavity, is the characterization of FEL mirrors with a long radius of curvature (ROC). The Duke FEL serves as the laser drive for the High Intensity Gamma-ray Source (HIGS). As we extend the energy coverage of the gamma-ray beam from 1 to 120 MeV, the FEL operation wavelength has expanded from infrared to VUV (1 micron to 170 nm). To optimize Compton gamma-ray production, the optimal value for the mirror's ROC needs to vary from 27.5 m to about 28.5 m. Measuring long mirror ROCs (> 10 m) with tight tolerances remains a challenge. We have developed two different techniques, one based on light diffraction and the other on geometric imaging, to measure the long ROCs. In this work, we present both techniques and compare their strengths and weaknesses when applied to measure mirror substrates with low reflectivity and FEL mirrors with high reflectivity.

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Student Poster Session / 2262

Discovering transient models of emittance growth via mode interaction of phase space nonuniformities

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Co-authors: Irving Haber [1]; Levon Dovlatyan [1]; Patrick O'Shea [2]; Tom Antonsen [1]

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One of the Grand Challenges in beam physics is development of virtual particle accelerators for beam prediction. Virtual accelerators rely on efficient and effective methodologies grounded in theory, simulation, and experiment. We will address one sample methodology, extending the understanding and the control of deleterious effects, for example, emittance growth. We employ the application of the Sparse Identification of Nonlinear Dynamical systems algorithm–previously presented at NAPAC'22 and IPAC'23–to identify emittance growth dynamics caused by nonuniform, empirical distributions in phase space in a linear, hard-edge, periodic FODO lattice. To gain further understanding of the evolution of emittance growth as the beam's distribution approaches steady state, we compare our results to theoretical predictions describing the final state emittance growth due to collective and N-body mode interaction of space charge nonuniformities as a function of free-energy and space-charge intensity. Finally, we extend our methodology to a broader range of virtual and real experiments to identify the growth(decay) of (un)desired beam parameters.

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North America

Student Poster Session / 2263

Experimental investigation of zero transverse force modes in sub-THz dielectric lined waveguide

Author: Cassandra Phillips[1]

Co-authors: Brendan Leung [1]; Daniel Mihalcea [1]; Eric Wisniewski [2]; Gongxiaohui Chen [3]; John Power [3]; Philippe Piot [1]; Scott Doran [3]; Xueying Lu [3]

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Dielectric-lined waveguides have been extensively studied for high-gradient acceleration in beam-driven dielectric wakefield acceleration (DWFA) and for beam manipulations, including the application of zero transverse force modes in the waveguides. In this paper, we investigate the zero transverse force modes excited by a relativistic electron bunch passing through a dielectric waveguide with a rectangular transverse cross section. Numerical simulations were performed to optimize the start-to-end beamline using Opal-t, ELEGANT, and WARPX. A Longitudinal Phase Space (LPS) measurement system is used to understand the interaction of the beam with the waveguide modes, and analysis of the resolution of the LPS system was conducted. We will discuss preliminary experimental data collected at the Argonne Wakefield Accelerator (AWA) benchmarked with the simulation results.

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Student Poster Session / 2264

The design of a rocket based RF electron accelerator for space applications

Author: Christopher Roper[1]

Co-authors: Quinn Marksteiner [1]; Geoffrey Reeves [1]; Michael Holloway [2]; Doug Patrick [1]; Ryan Hemphill [1]; Angus Guider [1]; Bruce Carlsten [1]

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Beam Plasma Interactions Experiment (Beam-PIE) is a NASA sounding rocket experiment that successfully ran in November 2023. Beam-PIE used space as a laboratory to explore wave generation from a modulated electron beam in the ionosphere. Beam-PIE electron accelerator used a 10keV electron gun and a 5-GHz RF cavity, enabling the acceleration of the electron beam to a total energy of ˜25–60 keV. The experiment was pulsed at VLF frequencies ranging from 5 to 500 kHz. The third parameter was duty cycle which ranged from 2.5% to 10%. In total, 32 different combinations of beam parameters were used and repeated every 32 seconds through the flight at various altitudes and background plasma conditions. Each of these different beam parameters ran for a ½-second beam pulse, separated by ½-second intervals when the beam was off. Beam-PIE was successful at generating plasma waves. We present an outline of the accelerator design, theoretical predictions, and experimental results of generated plasma waves. Results will be used to quantitatively test our understanding of beam-plasma-wave interactions in the space environment with applications to space communication and radiation belt remediation.

Footnotes:

[1] Reeves, Geoffrey D., et al. "The beam plasma interactions experiment: An active experiment using pulsed electron beams." Frontiers in Astronomy and Space Sciences 7 (2020): 23.
[2] Marksteiner, Quinn, et al. "Beam dynamics and radiation modeling for the Beam Plasma Interaction Experiment." AGU Fall Meeting Abstracts. Vol. 2021. 2021.
[3] Yakymenko, Kateryna, et al. "Beam physics in support of active experiments in space." APS Division of Plasma Physics Meeting Abstracts. Vol. 2019. 2019.

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Student Poster Session / 2265

Analysis of laser engineered surface structures' roughness and surface impedance

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Co-authors: Marcel Himmerlich [2]; Patrick Krkotic [2]; Sergio Calatroni [2]

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[2] *European Organization for Nuclear Research*

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This study examines Laser Engineered Surface Structures (LESS) in the context of their potential application within particle accelerators. These structures are investigated due to their efficient reduction of secondary electron yield to counteract the formation of electron clouds, a phenomenon detrimental to accelerator performance. A critical aspect of their evaluation involves understanding their radio-frequency characteristics to determine their influence on beam impedance.
LESS involves intricate surface modifications, integrating etched grooves and deposited particulates, resulting in a complex surface topology. Measurements are conducted on two distinct surface patterns, from which particulates are then removed with incremental cleaning. Acquired data form the basis for mathematical models elucidating observed results.
Novel approaches are investigated in addition to several established surface roughness models, including analysis of geometrical attributes of the surface topology and the associated electric currents. The aim is to develop a framework that describes roughness's influence across varying scales to assist in selecting appropriate treatment parameters.

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Europe

Student Poster Session / 2266

Commissioning of spectral diagnostics and future concepts for the PAX experiment at FACET-II

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The ongoing Plasma-driven Attosecond X-ray source experiment (PAX) at FACET-II aims to produce coherent soft X-ray pulses of attosecond duration using a Plasma Wakefield Accelerator [1]. These kinds of X-ray pulses can be used to study chemical processes where attosecond-scale electron motion is important. For this first stage of the experiment, PAX plans to demonstrate that <100 nm bunch length electron beams can be generated using the 10 GeV beam accelerated in the FACET-II linac and using the plasma cell to give it a percent-per-micron chirp. The strongly chirped beam is then compressed in a weak chicane to sub-100 nm length, producing CSR in the final chicane magnet at wavelengths as low as 10s of nm. In this contribution we describe the commissioning of the spectral diagnostics as well as the results expected of this experiment.
Additionally, we describe a future iteration of the experiment in which short undulators are used to drive coherent harmonic generation to produce attosecond gigawatt X-ray pulses at 2 and 0.4 nm, with lengths comparable to the shortest attosecond pulses ever measured at 2 nm using HHG.

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Student Poster Session / 2267

Bayesian optimization for beam centroid correction at ISAC

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Tuning of radioactive beams in a post-accelerator facility such as TRIUMF's ISAC involves a considerable amount of overhead and often leads to tunes which diverge from the theoretical optimum

for the system, introducing undesirable effects such as aberrations or chromatic couplings. We hereby present the development and application of a Bayesian Optimization algorithm for corrective transverse steering of the low-energy electrostatic beam transport optics; specifically through the polarizer beamline, which contains a 2-metre section where beam can be electrically neutralized, to the beta-NMR experiment. This work holds promise for enhancing the efficiency and reliability of beam delivery at ISAC, supporting TRIUMF's scientific mission. Current developments involve multi-objective Bayesian Optimization using beam profile monitors and eventual integration of other diagnostic devices, such as CCD cameras. The developments presented herein aim to enable autonomous tuning methods, facilitating user-friendly operation by operators.

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Student Poster Session / 2268

UV-Soft X-ray betatron radiation characterization from laser-plasma wakefield acceleration

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The spontaneous emission of radiation from relativistic electrons within a plasma channel is called betatron radiation and has great potential to become a compact x-ray source in the future. We present an analysis of the performance of a broad secondary radiation source based on a high-gradient laser-plasma wakefield electron accelerator. The purpose of this study is to assess the possibility of having a new source for a non-destructive X-ray phase contrast imaging and tomography of heterogeneous materials. We report studies of compact and UV-soft X ray generation via betatron oscillations in plasma channel and in particular measurement of the radiation spectrum emitted from electron beam is analyzed from a grazing incident monochromator at Centro de Laseres Pulsados Ultraintensos (CLPU).

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Student Poster Session / 2269

Optimizations for ultrafast electron diffraction with a cryogenic C-band gun

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Ultrafast electron diffraction (UED) is a growing accelerator application that enables the study of transient material processes at sub-picosecond timescales with nanometer spatial resolution. In this proceeding, we present simulations of the Cryogenic Brightness-Optimized Radiofrequency Gun (CYBORG) beamline using the General Particle Tracer (GPT) code that are optimized for the application of UED. We explore advantages of performing UED with a beamline equipped with a low intrinsic emittance photocathode, extraction fields approaching 200 MV/m, and a cathode temperature below 77 K. The electron beam bunch length and the 4D transverse emittance are critical metrics for achieving high spatial and temporal resolution in UED, and are minimized at the sample location in our optimization using a Non-Dominated Sorting Genetic Algorithm II (NSGA II).

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Student Poster Session / 2270

Improvements of longitudinal stability with LLRF optimization at SIRIUS

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SIRIUS is a 4th generation synchrotron light source built and operated by the Brazilian Synchrotron Light Laboratory (LNLS). Recently, investigations of noise sources and the storage ring RF plant identification enabled a fine-tuning of digital low-level radio frequency (DLLRF) parameters. This paper presents the main improvements implemented, which include the mitigation of 60Hz noise from the LLRF Front End and the optimization of the control system parameters. Optimizations in the machine were made based on an adjusted model of the SIRIUS storage ring RF plant. Tests with the model's parameters showed that the system's stability was strongly dependent on the system phase, which is affected by the output power due to the system's non-linearity. The new parameters significantly improved the control performance, increasing the bandwidth of the system and reducing longitudinal oscillations. BPM and BbB systems were employed to quantify longitudinal beam stability improvements.

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Student Poster Session / 2271

Field emission assisted heating of Cs2Te photocathode: implication toward RF breakdown

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The occurrence of breakdown events are a primary limiting factor for future accelerator applications aiming to operate under high field-gradient environments. Experimental evidence often leads to a hypothesis that breakdown events are associated with temperature and dark current spikes on the surface of RF devices. In the past decade, there has been increased interest in unveiling the mechanism behind breakdown in metal copper and copper alloys; however, there has been a limited effort regarding breakdown phenomenon in photocathode relevant semiconductors.
In this work, we explore field emission assisted localized heating via Nottingham and Joule processes. Field emission from intrinsic cesium telluride ultra thin film coated on top of a copper substrate was modeled within Stratton–Baskin–Lvov–Fursey formalism, describing the processes and effects in the bulk and at the surface of a semiconductor exposed to a high applied electric field. These heating effects were incorporated into the surface diffusion model, where the surface gradient of the chemical potential defines the time evolution and resulting reorganization of the surface.

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Student Poster Session / 2272

Thermomechanical and nonlinear plasmonic modeling of laser-field emission from extended nanostructured cathodes

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Laser-field emission is a process that can produce electron beams with high charge density and high brightness with ultrafast response times. Using an extended nanostructure, such as a nanoblade, permits plasmonic field enhancement up to 80 V/nm with an incident ultrafast laser wavelength of 800 nm. Stronger ionizing fields lead to higher current densities, so understanding how this field is attained will aid in further increasing brightness. In this analysis we study the nanoblade system thermomechanically and plasmonically. The structure is a silicon wedge with a 20-40 nm thick gold coating. We model the constituent materials as temperature-dependent, nonlinear dielectrics. The bulk geometry is well-represented in the finite element framework. We first perform a modal analysis of the surface plasmon polaritons using a 2-D slice of the blade. Next, we perform a 3-D steady-state calculation of the electromagnetic fields, the electron temperature, and the lattice temperature within a frame following the perturbing laser pulse. With these tools we study the peak fields and temperatures achieved as functions of the blade geometry and laser parameters.

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Student Poster Session / 2273

Intrinsic emittance measurements of alkali-based photocathodes

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Intrinsic emittance is one important figure of merit to determine the photocathode performance in accelerators fields. We present and measure the intrinsic emittance of alkali-based photocathodes with a concise design using MCP-YAG detector. Simulations for electric fields are also performed by Possion/Superfish software. The final emittance results are compared with a simple photoemission model and show good results. It is possible to connect this design to photocathode growth systems making it easy to characterize photocathodes and study photoemission physics under high electric fields.

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Student Poster Session / 2274

Automation upgrade of the CXLS photoinjector

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The automation upgrade of the photoinjector for the Compact X-Ray Light Source (CXLS) at Arizona State University is described. As the accelerator vault of the CXLS is only 10 meters long, the photoinjector drive laser is located in an enclosure inside the vault. Since ionizing radiation is present in this room during operations, it necessitates remote control of all devices used to optimize the laser spot. This includes multiple shutters, Galil motors, picomotors, a mirror flipper, LEDs, and remote lens controllers. To actuate these devices, a GUI was created with the use of MATLAB AppDesigner which communicates with the hardware through EPICS (Experimental Physics and Industrial Control System). Challenges with this GUI are described, along with the team's efforts to finalize the control software. After these upgrades, the photoinjector laser characteristics can be adjusted remotely during operation and changes to the drive laser's position, shape, and intensity can be made without interrupting beam time.

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Student Poster Session / 2275

Chemical robustness enhancement of negative electron affinity photocathodes through cesium-iodide deposition

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Photocathodes at Negative Electron Affinity (NEA), like GaAs and GaN, allow for efficient production of spin-polarized electrons. When activated to NEA with cesium and an oxidant, they are characterized by an extreme sensitivity to chemical poisoning, resulting in a short operational lifetime. In this work, we demonstrate that deposition of a cesium iodide (CsI) layer can be used to enhance the dark lifetime of both GaN and GaAs photocathodes activated with cesium. The mechanism behind this improvement is investigated using X-ray Photoelectron Spectroscopy (XPS) and Atomic Force Microscopy (AFM) techniques.

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Student Poster Session / 2276

Pulsed Compton Gamma-ray beam generation using pulsed FEL beam

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For certain photonuclear experiments utilizing Compton gamma-ray beams, beam-uncorrelated background poses a significant challenge. At the High Intensity Gamma-ray Source (HIGS), we have developed methods to generate pulsed free-electron laser (FEL) beams by transversely or longitudinally modulating the storage ring FEL. Both methods enable periods of FEL interaction: one by transversely manipulating the electron beam orbit, the other by de-synchronizing the electron and FEL beams. The recently-developed longitudinal method has proven superior: it avoids beam loss and is applicable across a wide range of electron beam energies. In this work, we describe the operational principle of pulsed FEL beam generation using longitudinal modulation, and we present measurements of the macro- and micro-temporal structure of the FEL beam. Furthermore, we present experimental results demonstrating the effectiveness of using a pulsed gamma-ray beam to reduce beam background.

Footnotes:

M.W. Ahmed et al. https://doi.org/10.1016/j.nima.2003.08.166.
S.F. Mikhailov et al. https://accelconf.web.cern.ch/IPAC2015/papers/tupma012.pdf

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High-energy and narrow-bandwidth X-ray regenerative amplifier FEL design for LCLS-II-HE

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LCLS-II-HE is an energy upgrade of the LCLS-II linac from 4 GeV to 8 GeV. The X-ray FEL photon energy (Self-Amplified Spontaneous Emission mode) will extend towards 12 keV (from the present 5 keV) based on the current beam emittance. To reach higher photon energy range towards 20 keV, a new injector with a much brighter electron beam will be required. Here we study an X-ray regenerative amplifier FEL (XRAFEL) configuration that enables reaching 20 keV photon energy with the current LCLS-II injector parameters, by reamplifying the cavity-returned X-rays in the LCLS-II undulator over multiple passes. At 20 keV, the Bragg mirrors have very narrow angular and wavelength acceptances. In this paper, we discuss how to layout the cavity optics in combination with the electron-beam based Q-switching method to generate fully coherent bright high-energy X-rays with 20 meV spectral bandwidth.

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Student Poster Session / 2278

Dynamics study of the crab crossing at the electron ion collider using square matrix and iterative methods

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Crab crossings are designed to increase the luminosity of accelerators by ensuring beam interactions are closer to a head on collision. One will be implemented at the Electron Ion Collider (EIC) at Brookhaven National Laboratory. It is then important to examine how the crab cavity will affect beam dynamics at the EIC. Methods such as Frequency Map Analysis (FMA) have been shown to be helpful in examining the phase space of accelerators in order to find properties such as resonances and the dynamic aperture. An alternative to such methods is an iterative method based on square matrix method that has been shown to reveal similar properties as FMA while reducing the computational power needed,*. This method has been applied to the crab crossing scheme in order to find and explain effects of the higher order mode of crab cavities on the particle dynamics of the EIC.

Footnotes:

- K.J. Anderson, Y. Hao, and L.H. Yu, "Study of Nonlinear Dynamics in the 4-D Hénon Map Using the Square Matrix Method and Iterative Methods", in Proc. NAPAC'22, Albuquerque, NM, USA, Aug. 2022, pp. 232-235. doi:10.18429/JACoW-NAPAC2022-MOPA81 ** L.H. Yu, Y. Hao, Y. Hidaka, F. Plassard, and V.V. Smaluk, "Progress on Convergence Map Based on Square Matrix for Nonlinear Lattice Optimization", in Proc. NAPAC'22, Albuquerque, NM, USA, Aug. 2022, pp. 823-825. doi:10.18429/JACoW-NAPAC2022-WEPA80

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Student Poster Session / 2279

Autofocusing accelerator beams

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A novel tuning approach, Model Coupled Accelerator Tuning (MCAT), has been applied to the separated function DTL at TRIUMF's Isotope Separator and Accelerator (ISAC). A digital twin of the rare-isotope postaccelerator is used for transverse and longitudinal tune optimizations, which are then loaded directly into the control system. Beam-based testing produced accelerated beam with a 0.26% error in output energy, with a 1.6% energy spread. This method significantly reduces the operational complexity of tuning interventions, rendering them more efficient. An analysis of the high energy beam lines (HEBT) is also presented, including analysis of dispersive couplings in certain sections of the beamline. A mitigation strategy involving buncher cavities is discussed.

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Dark current in the LCLS-II Injector: characterization and mitigation strategies

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In addition to the desired electron beam, RF photoinjectors such as the one in LCLS-II produce dark current via field emission. Left unchecked, the dark current can cause various operational issues in the accelerator, such as increased radiation, damage to accelerator components and diagnostics, and desorption of gases from vacuum chamber surfaces. In this contribution, we present measurements of the dark current in the LCLS-II injector, including imaging, current, and energy distributions of the observed dark current emitters. These measurements allow us to characterize each emitter in terms of the Fowler-Nordheim model of field emission, which in turn enables us to more accurately model the behavior of the dark current in the accelerator. Taking these results into account, we also present potential active and passive mitigation strategies.

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Student Poster Session / 2281

CXLS ionizing and laser radiation safety interlock systems

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The Compact X-ray Light Source (CXLS) requires the acceleration of electron bunches to relativistic energies, which collide with focused IR laser pulses to produce X-rays which are then transported to the experiment hutch. A class 4 UV laser is used at the photocathode to liberate the electrons that are generated via the photoelectric effect. During electron acceleration bremsstrahlung radiation (gamma and neutron) is generated through electron interactions with solid matter. In the experiment hutch the X-rays then interact with the sample under test in pump-probe configuration where the pump laser is another class 4 laser with a wide spectral range from deep UV to THz. Interlock systems have been designed and deployed to protect users of the facility from exposure to these ionizing and laser radiation hazards. We present the design architecture of CXLS interlock systems. In this description we make clear what systems are independent, and which are interdependent and what administrative override modes are made available and why. We also provide an overview of our monthly interlock system testing protocols and conclude with comments on overall system performance.

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Student Poster Session / 2282

Linking edge-ML X-ray diagnostics and adaptable photoinjector laser shaping for leveraging the capabilities of LCLS-II

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SLAC's LCLS-II is rapidly advancing towards MHz repetition rate attosecond X-ray pulses, opening new opportunities to leverage the abundance of data in combination with advances in machine learning (ML) to better align the x-ray source with specific experimental goals. We approach the challenge from both ends of the facility. Starting at the X-ray output, we showcase our low latency, high throughput ML algorithms implemented at-the-edge for X-ray detection and reconstruction in the Multi-Resolution 'Cookiebox' (MRCO) angle resolved electron spectrometer with its 16 electron time-of-flight detectors. MRCO performs spectro-temporal characterization of X-ray profiles with a resolution that allows single shot identification of well-seeded shots versus SASE background at MHz rate. MRCO enables fast feedback, so we also tackle the problem as a control issue, focusing on programmable photoinjector laser shaping to adjust the initial electron bunch. Towards this end of using advances in ML to explore the parameter space for optimizing X-ray production, we present our progress towards a digital twin linking the photoinjector laser all the way through MRCO in the endstation diagnostics.

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Student Poster Session / 2283

Measuring uniformity and gas density of gas sheet profile monitor for use with heavy-ion accelerators

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We report updates on design work* and ongoing development of a fluorescence-based molecular gas curtain which will be used to observe the 2D transverse profile of multi-charge state heavy ion beams at the Facility for Rare Isotope Beams (FRIB). The device will produce an ultra-thin, rarefied nitrogen gas sheet and requires that the gas curtain be uniform and thin to prevent distortion of the collected signal in operation. To determine the characteristics of the generated curtain, we evaluate the design using a combination of bench-testing with a Bayard-Alpert gauge and molecular dynamics simulations using MolFlow+. This paper details the design and bench testing of the sheet generator, gas removal system, and interaction chamber of the device, as well as expected photon generation from these parameters.

Footnotes:

- A. Lokey and S.M. Lidia, "Status of Gas Sheet Monitor for Profile Measurements at FRIB", in Proc. 12th Int. Beam Instrum. Conf. (IBIC'23), Saskatoon, Canada, Sep. 2023, pp. 415-417. doi:10.18429/JACoW-IBIC2023-WEP027

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Student Poster Session / 2284

Slow longitudinal mode-1 instability in electron storage rings with harmonic cavities

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Recent studies have revealed an intriguing longitudinal instability that may develop in electron storage rings featuring higher-harmonic cavities. The instability, also referred to as periodic transient beam loading, manifests as a slow oscillation of bunch longitudinal profiles following a coupled-bunch mode-1 pattern. In this contribution, we applied the well-established theory of longitudinal mode-coupling to assess the thresholds and oscillation frequency for this instability. Results obtained through this semi-analytical approach, considering different storage ring and harmonic cavity parameters, were validated using macroparticle tracking and compared against other methods proposed in previous investigations.

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Student Poster Session / 2285

Evaluation of ultrafast terahertz near-fields for electron streaking

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THz-frequency accelerating structures could provide the accelerating gradients needed for compact next generation particle accelerators. One of the most promising THz generation techniques for accelerator applications is optical rectification in lithium niobate using the tilted pulse front method. However, accelerator applications are limited by losses during transport and coupling of THz radiation to the acceleration structure. Applying the near-field of the lithium niobate source directly to the electron bunch removes losses due to transport and coupling, yielding a simplified and efficient system. Using electro-optic sampling we have reconstructed the full temporal 3D THz near-field close to the lithium niobate emission face and shown that it can be controlled by manipulating the generation setup. Analysis of the results of this measurement shows an estimated peak field strength of 86 MV/m. A future THz near-field electron streaking experiment is currently planned as a first test of manipulating an electron bunch with the THz near field. Analysis for this planned experiment has yielded an estimated THz near-field kick strength of 23 keV.

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Simulating the transverse probing of laser-driven plasma wakefields using ultrarelativistic electrons

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Laser wakefield accelerators (LWFAs) are capable of supporting accelerating and focusing forces on the order of 10–100 GeV/m, about three orders of magnitude greater than conventional RF accelerators. While theoretical solutions for the electromagnetic (EM) focusing fields have been developed, the field structures have yet to be verified experimentally. In this poster, we present simulation results for transverse probing of laser wakefields using ultrarelativistic electrons. We study the behavior of the probing electrons by implementing filtering masks to investigate focusing characteristics of thin electron "bands". The deflection of these bands after propagating through the wakefield is then used to characterize the EM forces. The simulated focusing behavior of these electron bands is in reasonable agreement with a theoretical model developed based on a thin lens model of the wakefield. Simulation results show the focusing of the bands to be an effective experimental diagnostic for verifying the EM field structure. This provides an analytic framework needed for the first

direct measurements of focusing forces in an LWFA at the Accelerator Test Facility at Brookhaven National Lab.

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Transport and dosimetry of laser-driven proton beams for radiobiology at the BELLA center

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Co-authors: Kei Nakamura [1]; Lieselotte Obst-Huebl [1]; Sahel Hakimi [1]; Morgan Cole [1]; Laura Geulig [2]; Samuel Barber [1]; Jamie Inman [1]; Antoine Snijders [1]; Anthony Gonsalves [1]; Jeroen van Tilborg [1]; Cameron Geddes [1]; Carl Schroeder [1]; Eric Esarey [1]

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Laser-driven ion accelerators (LDIAs) are well-suited for radiobiological research on ultra-high dose rate effects due to their high intensity. For this application, a transport system is required to deliver the desired beam intensity and dose distribution while online dosimetry is required due to the inherent shot-to-shot variability of LDIAs. At the BELLA Center's iP2 beamline, we implemented two compact, permanent magnet-based beam transport configurations for delivering 10 or 30 MeV protons to a biological sample, along with a suite of diagnostics used for dosimetry. These diagnostics include multiple integrating current transformers (ICTs) for indirect online dose measurements and calibrated radiochromic films (RCFs) to measure the dose profile and calibrate the ICT dosimetry. Benchmarked Monte-Carlo (MC) simulations of the beamline allow us to predict the dose received by the sample and correct the linear energy transfer (LET)-dependent response of the RCFs. This work not only further establishes the practicality of utilizing LDIAs for radiobiological research but also highlights the BELLA Center's capacity to accommodate further experiments in this domain.

Footnotes:

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Student Poster Session / 2288

Computational simulations and beamline optimizations for an electron beam degrader at CEBAF

Author: Victor Lizárraga-Rubio[1]

Co-authors: Amy Sy [2]; Cristhian Valerio-Lizárraga [3]; Dennis Turner [2]; Joseph Grames [2]; Yves Roblin [2]

[1] *Universidad de Guanajuato*

[2] *Thomas Jefferson National Accelerator Facility*

[3] *Facultad de Ciencias Fisica-Matematicas,*

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An electron beam degrader is under development with the objective of measuring the transverse and longitudinal acceptance of the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab. This project is in support of the CE+BAF positron capability. Computational simulations of beam-target interactions and particle tracking were performed integrating the GEANT4 and Elegant toolkits. A solenoid was added to the setup to control the beam's divergence. Parameter optimization of the solenoid field and magnetic quadrupoles gradient was also performed to further reduce particle loss through the rest of the injector beamline.

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Student Poster Session / 2289

Design and implementation of an instrumentation & control system for cathodes and radio-frequency interactions in extremes project

Co-authors: Brian Haynes [1]; Evgenya Simakov [1]; Tyagi Ramakrishnan [1]; Walter Barkley [1]

[1] *Los Alamos National Laboratory*

The Accelerator Operations and Technology division at Los Alamos Neutron Science Center (LANSCE) is working on designing and implementing an Instrumentation and Controls System (ICS) for the Cathodes and Radio-frequency Interactions in Extremes (CARIE) project. The system will utilize open-source Experimental Physics and Industrial Control System (EPICS) developed for scientific facilities for control, monitoring, and data acquisition. The hardware form factors will include National Instrument's (NI) cRIO automation controller for industrial-like slow inputs/outputs and NI's PXIe for high-speed data acquisition for diagnostic signals featuring masked and event-based time window capture. In this paper, we will discuss the reasons that led to the design, the hardware and software design specifics, the challenges that we faced during implementation, including the EPICS device support for NI PXIe, as well as the advantages and drawbacks of our system given the experimental nature of the CARIE project.

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Student Poster Session / 2290

Test of a metamaterial structure for structure-based wakefield acceleration

Author: Dillon Merenich[1]

Co-authors: Brendan Leung [1]; Charles Whiteford [2]; Darrell Doran [2]; Eric Wisniewski [3]; Gaurab Rijal [1]; Gongxiaohui Chen [2]; John Power [2]; Wanming Liu [2]; Xueying Lu [2]

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Metamaterial accelerators driven by nanosecond-long RF pulses show promise to mitigate RF breakdown. Recent high-power tests at the Argonne Wakefield Accelerator (AWA) with an X-band metamaterial structure have demonstrated to achieve a gradient of 190 MV/m, while we also observed a new acceleration regime, the breakdown-insensitive acceleration regime (BIAR), where the RF breakdown may not interrupt acceleration of a main beam. Statistical analysis between different breakdown types reveals that the characteristics of the BIAR breakdown are beneficial to high-gradient acceleration at short pulse lengths.

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Student Poster Session / 2291

Application and comparative analysis of the APES_CBI module in BEPC-II experimental results

Author: Siyuan Feng[1]

Co-author: Tianmu Xin [2]

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This paper primarily explores the application and comparative analysis of the Accelerator Physics Emulation System Cavity-Beam Interaction (APES_CBI) module in the BEPC-II (Beijing Electron-Positron Collider) experiments. The APES_CBI module is an advanced time-domain solver, designed for analyzing RLC circuits driven by beam and generator currents and simulating the dynamic responses and synchrotron oscillations of charged particles within the cavity.
The paper details the module's application in BEPC-II experiments, particularly in simulating beam dynamics under strong beam-loading conditions and interactions with the accelerator's impedance. It focuses on analyzing the module's performance, accuracy, and efficiency in simulating synchrotron oscillations and beam-beam interactions under complex beam conditions.
By comparing the simulation results of the APES_CBI module with the experimental data from BEPC-II, this paper demonstrates the module's capability in accurately simulating complex physical phenomena within accelerators. This comparison not only validates the effectiveness of the CBI module but also offers valuable insights for future accelerator design and research.

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Student Poster Session / 2292

Optimization of laser coupling into optically field ionized plasma channels for laser-plasma acceleration

Author: Josh Stackhouse[1]

Co-authors: Alex Picksley [1]; Anthony Gonsalves [1]; Cameron Geddes [1]; Carl Schroeder [1]; Carlo Benedetti [1]; Eric Esarey [1]; Hai-En Tsai [1]; Jeroen van Tilborg [1]; Kei Nakamura [1]

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Laser-plasma accelerators (LPAs) can have high acceleration gradients on the order of 100 GeV/m. The high acceleration gradients of LPAs offer the possibility of powering future colliders at the TeV range and reducing the size of particle accelerators at present energy levels. LPAs need tightly focused, high intensity laser pulses and require guiding structures to maintain the laser focus over the optimum acceleration length. It is necessary to match the parameters of the guiding structure and the laser pulse to couple the maximum laser energy into the guiding structure. Optically field ionized (OFI) plasma channels are a guiding structure capable of matching the parameters of the petawatt (PW) laser facility at the Berkeley Lab Laser Accelerator (BELLA) Center [1, 2]. We will present results on the optimization of laser coupling into OFI plasma channels on BELLA PW. We will also discuss how optimization of laser coupling relates to upcoming staging experiments on BELLA PW.

Footnotes:

[1] A. Picksley et al., Phys. Rev. E 102, 053201 (2020)
[2] L. Feder et al, Phys. Rev. Research 2, 043173 (2020)

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Student Poster Session / 2293

Flat beam transport for a PWFA experiment at AWA

Author: Pratik Manwani[1]

Co-authors: Derek Chow [2]; Gerard Andonian [1]; James Rosenzweig [1]; Yunbo Kang [2]

[1] *University of California, Los Angeles*

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Particle beams with asymmetric transverse emittances and profiles have been utilized in facilities for driving wakefields in dielectric waveguides and to drive plasma wakefields in plasma. The asymmetric plasma structures created by the beam produce focusing forces that are transversely asymmetric. We utilize the ellipticity of the plasma ion cavity to model the beam evolution of the flat beam driver.

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Student Poster Session / 2294

Comparison of flat beam PWFA analytic model with PIC simulations

Authors: Pratik Manwani[1]; Yunbo Kang[2]

Co-authors: Gerard Andonian [1]; James Rosenzweig [1]; Joshua Mann [1]

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This paper explores the phenomenon of asymmetric blowout in plasma wakefield acceleration (PWFA), where the transversely asymmetric beam creates a transversely asymmetric blowout cavity in plasma. This deviation from the traditional axisymmetric models leads to unique focusing effects in the transverse plane and accelerating gradient depending on the transverse coordinates. We extend our series of studies on plasma wakefield acceleration (PWFA) by comparing our recently developed analytic model on the blowout cavity shape created by transversely asymmetric long beams, with Particle-in-Cell (PIC) simulations. The analysis focuses on validating the model's ability to predict the behaviors of different beam profiles in this regime.

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Student Poster Session / 2295

Parameters and process study of copper chamber coating with niobium thin films in DC and HIPIMS modes

Author: Jiawen Kan[1]

Co-author: Tianmu Xin [1]

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This study primarily investigates the parameters and processes involved in depositing Nb thin films on copper cavities under DC and HIPIMS modes. For this purpose, a high-power magnetron sputtering system was designed, conducting a total of 36 experiments. Improvement and optimization of parameters such as duty cycle (under HIPIMS mode), peak current, and bias voltage were undertaken to enhance film quality and performance metrics such as density. Surface morphology and superconducting properties of the films were characterized using SEM, XRD, Tc measurements, and other analytical methods. It was found that the Nb film deposited at a bias voltage of 100 V and a peak current of 150 A exhibited better performance. Lateral analysis of films deposited on different areas of the cavity revealed that in the DC mode, film grain sizes at the cell level were smaller with more defects, whereas in the HIPIMS mode, the niobium film exhibited finer and elongated grains, with grain sizes across various parts of the cavity being closer and defects reduced. This resulted in greater internal uniformity within the entire cavity, contributing to the enhancement of Q and E.

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Asia

Student Poster Session / 2296

SiPM integration testing for FACET-II pair spectrometer

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A pair spectrometer, designed to capture single-shot gamma spectra over a range extending from 10 MeV through 10 GeV, is being developed at UCLA for installation at SLAC's FACET-II facility. Gammas are converted to electrons and positions via pair production in a beryllium target and are then subsequently magnetically analyzed. These charged particles are then recorded in an array of quartz Cherenkov cells attached to silicon photomultipliers (SiPMs). As the background environment is challenging, both in terms of ionizing radiation and electromagnetic pulse radiation, extensive beamline testing is warranted. To this end, we present the results of our tests, correlated with electromagnetic finite-element and Geant4 Monte Carlo studies.

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Student Poster Session / 2297

Temporal profile optimization for beamline design using an improved multi-objective genetic algorithm

Author: Zheng Sun[1]

Co-author: Tianmu Xin [1]

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Our research focuses on the design of a beamline. Due to the numerous beamline components involved, without strict optimization of each component's parameters, the transmitted temporal profile of beam may distort, failing to meet the expected requirements. Additionally, different initial temporal profile of the beam will undergo longitudinal shaping during transmission through the beamline. Therefore, we aim to determine the combination of initial beam temporal profile at the cathode and the parameters of the beamline components based on the specific beam distribution at the exit. We propose the application of an improved multi-objective genetic algorithm to solve this problem. Through multiple optimization iterations for a given temporal profile, our algorithm consistently identifies multiple suitable combinations of initial beam temporal profile and beamline component parameters to produce the desired specific temporal profile of the beam.

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Asia

Student Poster Session / 2298

Measurement and modeling of beam transport in the FODO line of the Spallation Neutron Source Beam Test Facility

Author: Trent Thompson[1]

Co-authors: Alexander Aleksandrov [1]; Alexander Zhukov [1]; Austin Hoover [1]; Kiersten Ruisard [1]

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Ongoing studies at the Spallation Neutron Source (SNS) Beam Test Facility (BTF) seek to understand and model bunch dynamics in a high-power LINAC front-end. The BTF has recently been upgraded with a reconfiguration from a U-shaped line to a Straight line. We report the current state of model benchmarking, with a focus on RMS beam sizes within the FODO line. The beam measurement is obtained via three camera/screen pairs in the FODO line. This presentation discusses the methodology and results of this measurement.

Footnotes:

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Student Poster Session / 2299

Feasibility study of electron beam probe based longitudinal bunch shape monitor in high-intensity proton linac

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Corresponding Author: wangheng21@mails.tsinghua.edu.cn

The knowledge of the longitudinal bunch shape is of high interest to accelerator performance optimization and advanced beam application. Attracted by the ability to continuously monitor the beam in real time, there is always a demand for bunch-by-bunch and non-invasive diagnosis. However, such diagnosis is difficult to achieve for proton beam with high intensity and high repetition. Using the principle of electron beam deflection, electron beam probe has the potential of multi-function beam diagnosis. Here, we proposed the concept of real-time longitudinal bunch shape monitor with photocathode DC electron gun. Considering the realistic bunch distribution, we investigated the feasibility of this monitor using particle tracking simulation. The results and analysis of feasibility are reported in this paper.

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Student Poster Session / 2300

Mapping of an SRF electron gun focusing solenoid assembly

Author: Christopher Jones[1]

Co-authors: Chris Adolphsen [2]; Hai Nguyen [1]; John Lewellen [3]; John Smedley [2]; John Wenstrom [4]; Ting Xu [5]; Xiaoji Du [1]; Yoonhyuck Choi [5]

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Corresponding Author: jonesch@frib.msu.edu

SLAC's LCLS-II-HE upgrade will expand the energy regime of their XFEL at high repetition rates. Due to the low emittance requirement, a superconducting QWR based electron gun was proposed by SLAC and is being developed by FRIB in collaboration with ANL and HZDR. The emittance compensation solenoid consists of two main coils, along with horizontal and vertical dipoles as well

as normal and skew quadrupole correctors. To validate the performance and characterize the field profile of the magnet, we developed a mapper system. We utilized a SENIS 3D Hall probe on a cantilevered rail driven by an Arduino controlled stepper motor. With high repeatability, we were able to measure peak field strengths and fall off. Further data analysis allowed us to determine their relative locations, in addition to confirming alignment and integrated field strengths. In accordance with design specifications, we measured the peak solenoid fields to be about 172mT and their centers to be less than 0.1mm apart transversely. The mapping design, assembly, process, analysis, and lessons learned are discussed herein.

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North America

Student Poster Session / 2302

A wireless method for beam coupling impedance bench measurement of resonant structures

Author: Chiara Antuono[1]

Co-authors: Andrea Mostacci [2]; Andrea Passarelli [3]; Carlo Zannini [1]; Maria Rosaria Masullo [3]; Mauro Migliorati [4]

[1] *European Organization for Nuclear Research*

[2] *Sapienza University of Rome*

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The Beam Coupling Impedance (BCI) is a crucial aspect in the realm of accelerator physics, as it describes the electromagnetic interactions between charged particle beams and the accelerator structure. The measurement and quantification of BCI is an essential requirement to assess and mitigate its impact, particularly when introducing new components or addressing problems within existing devices. The stretched Wire Method (WM) is a well-established technique for BCI evaluations, although with well-known limitations. These are particularly prominent when dealing with cavity-like structures. In that case, the estimates obtained below the cut-off frequency of the beam pipe can be inaccurate. It is worth noting that this frequency range is particularly relevant for many accelerator applications. To overcome these well-recognized limitations, a different bench measurement technique has been identified and thoroughly examined. This novel approach has been subjected to comprehensive testing in both virtual and real measurements, with a particular focus on a pillbox cavity.

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Europe

Student Poster Session / 2303

Simulation studies of laser cooling for the Gamma Factory proof-of-principle experiment at the CERN SPS

Author: Peter Kruyt[1]

Co-authors: Davide Gamba [1]; Giuliano Franchetti [2]

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The proof-of-principle (PoP) experiment at the Super Proton Synchrotron (SPS) at CERN aims at demonstrating laser cooling of high energy Li-like Pb79+ in a synchrotron. First laser cooling simulations with realistic laser and beam parameters of the Gamma Factory proof-of-principle experiment (PoP) in the Super Proton Synchrotron (SPS) at CERN are presented. Furthermore, we investigate the expected cooling performance for various laser-pulse types, such as Fourier-limited and continuous wave lasers, and compare their performance metrics such as emittance reduction and the required laser power.

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Thursday Poster Session / 2304

Updates to Xopt for online accelerator optimization and control

Author: Ryan Roussel[1]

Co-authors: Dylan Kennedy [1]; Kathryn Baker [2]; Tobias Boltz [1]; Christopher Mayes [1]; Auralee Edelen [1]

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The recent development of advanced black box optimization algorithms has promised order of magnitude improvements in optimization speed when solving accelerator physics problems. These algorithms have been implemented in the python package Xopt, which has been used to solve online and offline accelerator optimization problems at a wide number of facilities, including at SLAC, Argonne, BNL, DESY, ESRF, and others. In this work, we describe updates to the Xopt framework that expand its capabilities and improves optimization performance in solving online optimization problems. We also discuss how Xopt has been incorporated into the Badger graphical user interface that allows easy access to these advanced control algorithms in the accelerator control room. Finally, we describe how to integrate machine learning based surrogate models provided by the LUME-model package into online optimization via Xopt.

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Wednesday Poster Session / 2305

Two slit emittance measurement with thermal emittance isolation for an SRF injector

Author: Benjamin Sims[1]

Co-authors: John Lewellen [2]; Sergey Baryshev [1]; Ting Xu [3]

[1] *Michigan State University*

[2] *Los Alamos National Laboratory*

[3] *Facility for Rare Isotope Beams*

Corresponding Author: simsben1@msu.edu

This study focuses on the beam source for the LCLS-II-HE Low Emittance Injector (LEI) design: a state-of-the-art superconducting radiofrequency (SRF) gun. The LEI is intended to enable extending the LCLS-II-HE's useful photon energy to 20 keV without additional cryomodules. We consider a robust two-slit emittance measurement optimized for the LEI SRF gun, compatible with the current LEI gun-to-linac beamline design, and extensible to measuring photocathode mean transverse energy (MTE) with the cathode at or below 4 K. In-situ measurement of photocathode MTE, and evolution thereof, could help optimize the overall performance of the LEI.
A two-slit method enables determination of the detailed phase-space distribution of the electron bunch, beyond the normal Twiss parameters and emittance provided by methods such as solenoid scans. Additionally, we investigate the RF emittance by recessing the cathode. This allows us to study the influence of the RF field on the bunch phase space.
In summary, our work introduces a cutting-edge two-slit emittance measurement methodology that combines different emittance-dampening techniques to isolate intrinsic emittance from the photocathode. Detailed results will be presented at the workshop to highlight established trends, dependencies, and a summary/concept of the future photocathode characterization beamline implementation.

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Student Poster Session / 2306

Two slit emittance measurement with thermal emittance isolation for an SRF injector

Author: Benjamin Sims[1]

Co-authors: John Lewellen [2]; Sergey Baryshev [1]; Ting Xu [3]

[1] *Michigan State University*

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[3] *Facility for Rare Isotope Beams*

Corresponding Author: simsben1@msu.edu

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North America

Wednesday Poster Session / 2307

Hybrid on- and off-axis injection scheme optimisation for the FCC-ee collider

Authors: Sen Yue[1]; Yann Dutheil[1]

Co-author: Eliott Johnson [1]

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In order to maximize the integrated luminosity of the future circular lepton collider (FCC-ee), a top-up injection scheme is required. Amongst the four operation modes of FCC-ee, the Z operation mode has the highest stored beam energy in the collider ring with about 20 MJ per beam. Consequently, it is for this mode that the injection scheme is primarily optimized and is the focus of this contribution. Due to the synchrotron radiation cone of the injected beamlet at the interaction point (IP), the conventional off-axis injection scheme is not favored. As for the on-axis injection, it necessitates an energy offset for the injected beam and sufficient dynamic aperture in the collider ring. However, the energy acceptance of collider ring is only around ±1% for the latest baseline lattice of the Z mode, making this scheme challenging. Therefore, an hybrid on- and off-axis injection scheme is proposed to satisfy the requirements of dynamic aperture and energy acceptance. This contribution introduces the concept and discusses the optimization process used to balance energy and position offset of the injection scheme.

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Europe

Tuesday Poster Session / 2308

Magnetic field modelling and symplectic integration of magnetic fields on curved reference frames for improved synchrotron design: first steps

Author: Silke Van der Schueren[1]

Co-authors: Daniel Barna [2]; Elena Benedetto [3]; Mauro Migliorati [4]; Riccardo De Maria [1]

[1] *European Organization for Nuclear Research*

[2] *Wigner Research Centre for Physics*

[3] *South East European International Institute for Sustainable Technologies*

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Compact synchrotrons, such as those proposed for cancer therapy, use short and highly bent dipoles. Large curvature drives non-linear effects in both body and fringe fields, which may be critical to control to obtain the desired dynamic aperture. Similarly to current practice, for straight magnet, our long-term goal is to aim at finding a parametrization of the field map that requires few terms to capture the relevant long term dynamical effects. This parametrization will then be used to optimize the performance of the synchrotron by long-term tracking simulations and, at the same time, drive the development of the magnet design by providing measurable quantities that can be computed from field maps. This paper presents the first steps towards the goal of representing the field with a few key parameters.

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Student Poster Session / 2309

Magnetic field modelling and symplectic integration of magnetic fields on curved reference frames for improved synchrotron design: first steps

Author: Silke Van der Schueren[1]

Co-authors: Daniel Barna [2]; Elena Benedetto [3]; Mauro Migliorati [4]; Riccardo De Maria [1]

[1] *European Organization for Nuclear Research*

[2] *Wigner Research Centre for Physics*

[3] *South East European International Institute for Sustainable Technologies*

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Prize Session / 2310

IEEE PAST Award Winner

Corresponding Author: gennady@xlight.com

Speaker will share thoughts, using examples from my own research, about why accelerator theory is important and what helps to make inventions.

Footnotes:

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North America

Prize Session / 2311

IEEE PAST Award Early Career Winner: attosecond x-ray free-electron lasers: accelerator physics and x-ray science at extreme timescales

Corresponding Author: marinelli@slac.stanford.edu

Attosecond x-ray free-electron lasers (XFEL) are the brightest source of isolated sub-fs pulses, with a peak brightness that surpasses table-top high-harmonic generation sources by seven orders of magnitude. In my talk I will discuss the development of attosecond x-ray science capabilities at the Linac Coherent Light Source: from the first demonstration of isolated attosecond pulses to the observation of electronic dynamics with pump/probe experiments. Finally, I will discuss the future of attosecond XFELs and the unique opportunities enabled by the high-repetition rate LCLS-II upgrade and advanced plasma-based electron sources.

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Prize Session / 2312

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Student Poster Session / 2313

Beam Tomography using Markov Chain Monte Carlo

Author: Anthony Tran[1]

Co-author: Yue Hao [2]

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[2] *Facility for Rare Isotope Beams*

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Beam tomography is a method to reconstruct the higher dimensional beam from its lower dimensional projections. Previous methods to reconstruct the beam required large computer memory for high resolution; others needed differential simulations, and others did not consider beam elements' coupling. This work develops a 4D reconstruction using Markov Chain Monte Carlo.

Footnotes:

Funding Agency:

Paper preparation format:

LaTeX

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North America