Student Poster Session

25 August 2024

SUSB001

Design of a beam transport line for external injection of plasma wakefield acceleration experiments based on BEPCII

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Laser wakefield accelerator (LWFA) and plasma wakefield acceleration (PWFA) have attracted a wealth of research interests since they can provide an accelerating gradient of ~100 GV/m. Recently, a series of LWFA/PWFA external injection experiments are foreseen to be carried out based on the linear accelerator (LINAC) of Beijing Electron-Positron Collider II (BEPCII). We hereby present a design of the beam transport line from the BEPCII LINAC to the LWFA/PWFA experimental chamber. The constraint of the existing building and beamline of the BEPCII was considered carefully in the design. The performance of the transport line is evaluated using the particle tracking simulations, demonstrating that the bunch length of the electrons with energy of 2 GeV and charge of 2 nC can be compressed from 10 ps to 1 ps (RMS), and the beam spot size is focused from about 850 µm to 116 µm (RMS).

SUSB002

Thin Au layers on niobium for SRF cavities

Sadie Seddon-Stettler (Cornell University (CLASSE))
Matthias Liepe, Thomas Oseroff (Cornell University (CLASSE)), Nathan Sitaraman (Cornell University)

New materials beyond the standard bulk niobium have the potential to greatly improve the performance of Superconducting Radio Frequency (SRF) cavities. Specifically, thin coatings of normal conductors such as gold have the potential to improve the key RF performance metric of quality factor. We present progress on depositing thin gold layers onto 2.6 GHz SRF cavities and testing their RF performance.

U.S. National Science Foundation under Award PHY-1549132, the Center for Bright Beams; U.S. Department of Energy under Award DE-SC0024137.

SUSB003

Mitigation of longitudinal beam losses in the FRIB linac

Alec Gonzalez (Facility for Rare Isotope Beams, Michigan State University)
Alexander Plastun, Peter Ostroumov (Facility for Rare Isotope Beams, Michigan State University)

The linear accelerator at the Facility for Rare Isotope Beams (FRIB) at Michigan State University uses a thin liquid Lithium film for charge stripping of high-intensity heavy ion beams. Energy straggling of the beam in the non-uniform Lithium film affects the energy distribution in the beam. This can lead to non-linear "tails" in the longitudinal phase-space beam distribution after bunching at the two 161 MHz Multi-Gap Bunchers (MGBs) between the stripper and the next accelerating segment. Some particles in these "tails" are lost in the downstream accelerator cryomodules. To mitigate these losses, we have designed a room-temperature IH-type buncher cavity with a resonant frequency of 322 MHz. The new harmonic cavities will be installed next to each MGB, linearizing the waveform of the effective bunching voltage and eliminating the formation of non-linear "tails." The increase in the energy acceptance of the post-stripper part of the accelerator reached over 50% according to our simulations. We present the electromagnetic design of this cavity along with beam dynamics simulations that demonstrate how the losses are mitigated. The construction and installation of the cavity are being pursued as an accelerator improvement project.

This material is based upon work supported by the U.S. Department of Energy, Office of Science, High Energy Physics under Cooperative Agreement award number DE-SC0018362 and Michigan State University.

SUSB004

Compact ion source extraction system for high-current medical applications

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In the framework of the medical application research at CERN, a very compact (~ 2 cm) system of electrodes has been designed to facilitate high-current proton beam extraction and matching to an RFQ. Tailored to the already existing LINAC4 ion source, known for its capability of delivering high current proton beams, this system benefits from the capabilities of a fully operational test stand equipped with comprehensive diagnostics. Results from beam dynamics simulations conducted using two codes, Travel and IBSimu, have confirmed the system's ability to deliver a broad range of high currents with excellent beam quality. The mechanical design, including material selection for its implementation in the LINAC4 test stand, stands out for its innovative approach, characterized by compact dimensions and stringent tolerances. This paper provides an overview of the key design considerations, the mechanical layout and measurements planned to validate this design.

SUSB005

Beam dynamics simulation for IR-THz FEL

Yimin Yang (University of Science and Technology of China)

The development of a high-repetition-rate infrared terahertz free-electron laser (IR-THz FEL) is advancing through its preliminary research phase, aiming to meet the demand for a tunable, high-power light source within the long wavelength spectrum. This initiative aligns with the broader objectives of the Hefei Advanced Light Facility (HALF) project. This paper presents simulation outcomes for key components: the injector, the bunch compressor, and the main linear accelerator. The research delves into the calculation of RF parameters for the acceleration sections and the selection of parameters for the bunch compressors, facilitated by the ASTRA and CSRTrack simulation codes. Additionally, radiation simulations for the modulator and the radiator have been conducted using the Genesis 1.3 code, leveraging particle distribution data from beam dynamics simulations. The anticipated outcome is the generation of IR-THz FEL radiation with wavelengths spanning from 5 μm to 1000 μm.

SUSB006

Beam dynamics design for a proton Linac for a compact accelerator based neutron source

Mina Abbaslou (TRIUMF)
Marco Marchetto, Philipp Kolb, Robert Laxdal, Tobias Junginger (TRIUMF)

A prototype Canadian compact accelerator-driven neutron source (PC-CANS) is proposed for installation at the University of Windsor. The source is based on a high-intensity compact proton RF accelerator that delivers an average current of 10 mA of protons at 10 MeV to the target. This study can serve as a basis for the design of an initial stage of a new high-intensity compact accelerator-driven neutron source (CANS). The accelerator consists of a short radio frequency quadrupole (RFQ), followed by an efficient drift tube linac (DTL) structure. Different variants of DTL were investigated for our studies. APF, KONUS, CH-DTL, and Alvarez DTL as normal conducting cavities with a frequency of 352.2 MHz and a superconducting cavity with a lower frequency of 176.1 MHz were considered in our Linac design. Details of the beam dynamics of the RFQ and different types of DTL are presented in this paper.

SUSB007

High pulsed power measurements of superheating fields for SRF materials

Nicole Verboncoeur (Cornell University (CLASSE))
Adam Holic, James Sears, Liana Shpani, Matthias Liepe, Ryan Porter, Thomas Oseroff (Cornell University (CLASSE))

The Cornell High Pulsed Power Sample Host Cavity (CHPPSHC) is a new system designed to measure the superheating field of candidate superconducting RF (SRF) materials, giving insight into their operational limits. This system is designed to reach peak magnetic fields of up to 0.5 T in only a few microseconds, allowing us to achieve a pure magnetic field quench on the sample. We present an overview of the CHPPSHC system and proof of principle data from a niobium sample.

SUSB008

Development of plasma processing of 1.3 GHz superconducting radiofrequency cavities at TRIUMF

Daniel Hedji (TRIUMF)
Philipp Kolb, Robert Laxdal, Tobias Junginger, Vladimir Zvyagintsev, Zhongyuan Yao (TRIUMF)

Superconducting RadioFrequency (SRF) technology is a key component in many particle accelerators operating in a continuous wave, or high duty cycle, mode. The on-line performance of SRF cavities can be negatively impacted by the gradual reduction in the accelerating gradient that can be attained within a reasonable field emission level. Conventional cleaning procedures are both time- and resource-exhaustive as they are done *ex-situ*. As such, *in-situ* techniques are quite attractive. Plasma processing is an emerging *in-situ* method of cleaning which utilizes a mixture of oxygen and an inert gas to chemically remove hydrocarbon-based field emitters through plasma. At TRIUMF's Advanced Rare IsotopE Laboratory (ARIEL), an R&D program is in place to develop plasma processing procedures using fundamental power couplers on 1.3 GHz ARIEL 9-cell cavities. Single cell and multi-cell processing has been performed off-line. The studies involve varying the input parameters and testing the effectiveness of the treatment through RGA analysis. The progress on the developments will be reported.

SUSB009

Beam emittance and Twiss parameters from pepper-pot images using PINNs

Ian Knight (Georgia Institute of Technology)
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In the field of accelerator physics, the quality of a particle beam is a multifaceted concept, encompassing characteristics like energy, current, profile, and pulse duration. Among these, the emittance and Twiss parameters—defining the size, shape, and orientation of the beam in phase space—serve as important indicators of beam quality. Prior studies have shown that carefully calibrated statistical methods can extract emittance and Twiss parameters from pepper-pot emittance meter images. Our research aimed to retrieve these parameters with machine learning (ML) from a transverse image of the beam after its propagation through a pepper-pot grid and subsequent contact with a scintillating plate. We applied a Convolutional Neural Network (CNN) to extract the x and y emittances and Twiss parameters (α and β), producing a six-dimensional output by simply looking at the image without calibration information. The extraction of divergence-dependent parameters, such as α and emittance, from a single image presented a challenge, resulting in a large Symmetric Mean Absolute Percentage Error (SMAPE) of 30%. To mitigate this issue, our novel method that incorporated image data from two points along the particles' propagation path yielded promising results. β prediction achieved a low SMAPE of 3%, while α and emittance predictions were realized with a 15% SMAPE. Our findings suggest the potential for improvement in ML beam quality assessment through multi-point image data analysis.

This work was supported by the U.S. Department of Energy, under Contract No. DE-AC02-06CH11357. This research used the ATLAS facility, which is a DOE Office of Nuclear Physics User Facility.

SUSB010

Effective thermal load mitigation in cERL injector prototype coupler through warm section modification

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Fundamental power couplers are utilized in SRF accelerators to transfer RF power from a source to the accelerating cavities. However, the issue of thermal heat load during high-power transmission in continuous wave (CW) mode operation poses a significant challenge for power couplers. To address this concern critical modifications have been implemented within the warm sections of the cERL injector prototype coupler which was previously tested for 30kW power level in CW mode operation. The modification includes implementation of active water cooling in the warm section of the coupler and material change from copper coated stainless steel to oxygen free copper for the inner conductor.

As a result, the thermal load at the inner and outer conductor was effectively mitigated during high power transmission in CW mode. Prior to the modifications, the inner conductor of the warm section reached a maximum temperature of 183°C at 27 kW power in CW mode. However, with the modified inner conductor with water cooling, the temperature was a mere 25°C. Additionally, the overall coupler temperature of the modified coupler was significantly reduced due to the conduction cooling effect applied to other components. These results underscore the effectiveness of the implemented modifications and represent a highly effective approach for mitigating thermal load in critical coupler components.

SUSB011

Design of 5 MeV SRF electron linac for wastewater purification

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Superconducting Radio Frequency (SRF) technology is a proven solution for generating high-power electron beams (EB), suitable for tasks like purifying wastewater from challenging impurities such as Per- and polyfluoroalkyl substances (PFAS). This paper elaborates on effectiveness of EB treatment and outlines design considerations for a 1.3 GHz SRF linac operating at 5 MeV with an average beam current of 10 mA. To get the high average beam current, attaining a high bunch repetition rate is important. The primary focus of the paper is on designing an injector which is able to generate high repetition beam with suitable short bunches for smooth acceleration to 5 MeV in a 1.3 GHz linac. Numerical analyses for accelerator system, ensuring that the beam reaches 5 MeV with the desired characteristics, lead to a compact beamline structure. This structure includes a 100 kV thermionic gridded gun, a 650 MHz buncher cavity, a 1.3 GHz 3-cell low beta booster cavity, and three 2-cell 1.3 GHz accelerator cavities, along with necessary focusing solenoids, all compactly fitting within approximately 4 meters. The results of the numerical studies conducted for all these components will be presented in this paper.

SUSB012

Advanced algorithms for linear accelerator design and operation

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In this paper, we investigate the usage of advanced algorithms adapted for optimizing the design and operation of different linear accelerators (LINACs), notably the superconducting linac ALPI at INFN-LNL and the ANTHEM BNCT facility to be constructed at Caserta, Italy. Utilizing various intelligent algorithms and machine learning techniques such as Bayesian optimization, genetic algorithms, particle swarm optimization, and surrogate modeling with artificial neural networks, we aim to enhance the design efficiency, operational reliability and adaptability of linear accelerators. Through simulations and case studies, we demonstrate the effectiveness and practical implications of these algorithms for optimizing LINAC performances across diverse applications.

SUSB013

Development of Bi-Alkali antimonide photocathodes for implementation in a 1.3 GHz superconducting rf photo-injector

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Electron beams with low emittance are vital for a wide range of accelerator-based applications, including free-electron lasers, Thomson scattering sources, and ultrafast electron diffraction. Superconducting Radio Frequency (SRF) photo-injectors can produce low-emittance electron beams, particularly in continuous wave (CW) operation. Among the various photo-emissive layers, bi-alkali antimonide is favored for its high quantum efficiency (QE) and compatibility with visible light wavelengths. In 2022, an SRF photo-injector system, including a photo-cathode coating chamber, a 1.3 GHz 1.5-cell jacketed cavity, and tuner, was transferred from KEK to FRIB for R&D purposes. R&D at FRIB is oriented toward the integration of advanced photocathodes into an SRF photo-injector. This paper describes modifications to the cathode preparation chamber and first cathode deposition and characterization trials. A K2CsSb film was produced with a notably extended dark lifetime, albeit with a modest QE of approximately 2%. Extensive spectral response analyses of the layer were conducted, along with thorough assessments of measurement procedures and hardware. This presentation offers insights into the factors contributing to the low measured QE and describes plans for improving the cathode preparation chamber and the experimental procedures.

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SUSB014

Simulations of field emitters and multipacting in PIP-II Single Spoke Resonator Type-2

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It has been found in benchmark tests that some Single Spoke Resonator Type-2 (SSR2) cavities have early field emission onset as well as strong multipacting barriers. A longstanding hypothesis is that field-emitted electrons in the high electric field accelerating gap can migrate and ignite multipacting bands in the low electric field regions of the cavity periphery. In this study, we use simulation techniques to examine multipacting behavior in SSR2 cavities from electrons seeded in common field emitter locations. Additionally, we investigated seed locations for areas in SSR2 cavities which may have poor coverage during high pressure water rinsing and compared the multipacting behavior.

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SUSB015

Smith-Purcell radiation studies towards a compact high-resolution longitudinal diagnostic

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A new longitudinal diagnostic has been proposed, the SPACEChip (Smith-Purcell ACcElerator Chip-based) diagnostic, which can infer information about the temporal profile of a particle bunch from the Smith-Purcell radiation spectrum generated when the bunch passes close to a dielectric grating. This is done using the bunch form factor after retrieving the phase. A simulated dielectric grating has been excited by Floquet modes to investigate the angular distribution of the Smith-Purcell radiation. Progress on the SPACEChip experimental campaign at the ARES linac at DESY will be reported, along with the expected photon yield from the structure with the ARES operational parameters.

SUSB016

Physics-informed neural network approach for temporal profiles shaping

Zheng Sun (Institute of High Energy Physics)
Tianmu Xin (Institute of High Energy Physics)

The importance of shaping temporal profiles in accelerator physics is highlighted by a wide range of applications, such as optimal plasma acceleration and improved performance in free electron laser applications. In our study, we focus on controlling the parameters in a beamline and Initial beam to achieve diverse temporal profiles. The transmission of electron beams through dispersive regions, such as bunch compressors and transport lines, can significantly impact the beam's temporal profile due to CSR effects, wakefield interactions, and space charge effects. Considering the effects of these factors, achieving the desired longitudinal distribution accurately at the chicane exit poses a challenge. In this paper, we propose a physics-informed neural network approach to inversely solve for the initial beam bunch information required to achieve a specific longitudinal distribution and the parameters of the chicane.

SUSB017

Design and simulation of Virtual Pepper Pot method for low energy proton beam

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The Virtual Pepper Pot (VPP) is a 4D transverse phase space measurement technique based on pepper-pot-like patterns that are generated by crossing each measured horizontal slit-based beamlet with all measured vertical slit-based beamlets. The VPP beam phase space distribution reconstruction and simulation are performed using the Beam Delivery Simulation (BDSIM) code, which is a Geant4 toolkit. The configuration includes a VPP 3D model slit, a scintillator screen, and a user-defined 1 MeV energy and 10 mA current proton beam distribution, characteristic of the KOMAC RFQ beam test stand. Besides VPP, pepper pot mask simulation is carried out, and the intensity and emittance differences are observed. The input beam distribution is generated from a TraceWin output file for comparison of results. The comparison between the VPP analysis results and the TraceWin input shows satisfactory results, ensuring accurate estimation of the emittance.

SUSB018

Anomalous frequency shifts near Tc of fundamental and higher-order modes in medium-velocity 644 MHz superconducting elliptical cavities

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Recent studies indicate the magnitude of an anomalous decrease in the resonant frequency, so-called frequency dip, near critical temperature of superconducting niobium cavities, Tc, correlates to the cavity quality factor, Q0, and impurities introduced into the superconducting niobium surfaces, such as nitrogen or oxygen. We measured frequency dips in both 644 MHz fundamental mode (FM) and 1.45 GHz higher-order mode (HOM) of single-cell elliptical cavities for FRIB energy upgrade (FRIB400) R&D. These measurements were performed in cavities with the following surface treatments: 1) electropolished (EP) only, 2) nitrogen-doped (N-doping), 3) medium-temperature (mid-T) baked and then hydrofluoric (HF) acid rinsed. We will present measured frequency dips and compare them to cavity Q0 performance in the FM. Frequency-dependent behavior of frequency dips with various surface treatments will also be discussed as our experimental setup has a unique feature compared to previous studies, which allows for measurement of frequency dips in different modes within the same cavity, in other word, on the same surfaces.

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SUSB019

Dust contamination in the TRIUMF electron linear accelerator: charging, detachment and migration of micrometer sized particulates

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Devon Lang, James Keir, Philipp Kolb, Thomas Planche (TRIUMF)

Dust particulates are always present to some degree inside the vacuum space of particle accelerators, causing a variety of issues. At the LHC, beam loss events have been linked to the interaction of charged dust with the proton beams. In superconducting rf cavities, dust contamination leads to field emission, limiting the accelerating gradient and causing damage to external beamline components. Facilities such as the SLAC LCLS-II and TRIUMF electron linear accelerator see progressive onsets in field emission that cannot simply be explained by vacuum events. The environment of a particle accelerator provides an ideal opportunity for dust to gain charge, which is one of the main drivers of dust grain dynamics in vacuum. However, fundamental parameters such as the dust composition and charge to mass ratio of these grains are unique to each accelerator environment and remain largely unknown. We will present an analysis of dust samples taken from TRIUMF linear accelerators, detailing their size, composition and potential sources. Preliminary results from experimental studies on the charging, detachment and migration mechanisms acting on micron sized particulates will also be presented.

SUSB020

Evaluating beam neutralization and transport dynamics in laser-driven ion accelerators

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Hironao Sakaki, Keisuke Nagashima, Tomoyuki Endo, Masayasu Hata (National Institutes for Quantum Science and Technology), Yukinobu Watanabe (Kyushu University)

We are developing a laser-driven ion accelerator aimed at downsizing heavy ion therapy devices. The ion beam produced by this accelerator exhibits a broad energy spectrum (from keV to MeV) and a large divergence angle (up to approximately 10 degrees), with a very short pulse width (about picoseconds). As a result, the peak current reaches the kA level. However, explosive beam divergence is mitigated by co-moving electrons that neutralize the beam in the high-density region immediately following acceleration. This study involved transport calculations of proton beams over 30 cm (up to just before the quadrupole magnet) using the Particle-in-Cell (PIC) simulation code to assess the ion beam's neutralization characteristics. This presentation will show the results of our simulations using the PIC code, which analyzed the degree of neutralization by electrons, divergence angles, and loss rates at various energy levels, and compared the impact of target thickness. The results suggest the potential for optimizing target thickness when utilizing of specific energy ions produced by laser-driven ion acceleration.

SUSB021

Data acquisition and characterization software for radio-frequency (rf) systems

Sohum Suthar (Argonne National Laboratory)

In accelerator physics, radio-frequency (rf) systems play a pivotal role in particle beam acceleration and diagnostics. This work presents a graphical interface designed with Python for interaction with rf instruments, enabling efficient data acquisition, processing, and visualization. Leveraging advanced software tools, the system enables efficient management and analysis of rf data. This capability is crucial for optimizing experimentation and streamlining data flow. The modular architecture is implemented on various systems and is demonstrated with the current 200kW Solid State Amplifier (SSA) test setup at the Advanced Photon Source.

SUSB022

Halo formation based on 2D and 3D particle-core model

Xinmiao Wan (Sichuan University)
Zhihui Li (Sichuan University)

Using 2D and 3D particle-core models, we thoroughly studied potential resonance interactions between particles and core in matched beams within complete periodic and double periodic channels. By keeping consistent geometrical structures and phase advances, we compared the Poincaré sections obtained from both models. The findings show that the differences between the models are negligible. This implies that the predicted resonance orders remain consistent, and the size of the resonance island shows only minor discrepancies.
We conducted in-depth studies on resonance behavior in matched beams within periodic structures with varying zero-current phase advances (σ0) using a 3D particle-core model. Our research discovered that a 4:1 resonance phenomenon is triggered when σ0 surpasses 90°. Particularly, in beams influenced by space charge effects, particles within the 4:1 resonance island have the potential to transform into halo particles, a transformation not observed in beams governed by emittance. When σ0 is less than 90° and space charge effects are substantial, 6:1 resonance may emerge. Contrary to the conventional belief that 2:1 resonance caused by mismatch in uniform focusing channels drives particles towards higher amplitude regions, our study revealed that not 2:1 resonance results in particle migration to larger amplitudes. Our research employed TraceWin to confirm these insights, offering valuable contributions to the comprehension of beam dynamics in SCLs.

SUSB023

RF Tuning analysis of a 750 MHz Carbon RFQ for Medical Applications

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Jorge Giner Navarro (Instituto Universitario de Ciencia de los Materiales), Concepcion Oliver, Daniel Gavela, Pedro Calvo , Miguel Lopez, Ángel Rodríguez Páramo, Jone Etxebarria, Jose Perez Morales (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas), Alessandra Lombardi (European Organization for Nuclear Research) ,Unai Etxebeste Rodríguez (Egile Mechanics S.L.)

This work is part of the development study of a linac injector for hadron therapy with carbon ion beams. The initial cavities of the future injector consist of two 750 MHz Radio Frequency Quadrupoles (RFQ), which are based on the compact CERN High-Frequency RFQ. These RFQs are designed to accelerate the ions from 15 KeV/u to 5 MeV/u. Each RFQ, with a length of 2 meters, comprises four individual modules and 32 tuners, 8 per module.

Certain design choices, manufacturing imperfections, and misalignments lead to local variations in the frequency and field distribution within the RFQs. The tuning procedure corrects these perturbations in the TE210 operating mode using a bead pull system and movable tuners.
The aim of this article is to determine the maximum field correction achieved through this tuning without affecting the beam dynamics. For this purpose, a set of electromagnetic deviations that introduces significant dipole components to the cavity is simulated, using CST Studio. Using the tuning algorithm, this EM deviation is corrected while the dynamic beam modifications are studied.

SUSB024

Laser assist scattering with thermal electron in elliptical and circular polarized laser field

Saddam Dhobi (Tribhuvan University)
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The objective of this research work is to design and develop laser-assisted thermal electron and hydrogen scattering, using theoretical model for elliptical and circular polarized laser. To develop the model, Volkov wave function for thermal case in elliptical and circular polarized laser field was designed and designed wave function is used to obtain S-matrix using Kroll-Watson approximation and born first approximation, with the help of S-matrix, T-matrix was obtained to study the DCS for elliptical and circular polarized laser. The obtained T-matrix was used to compute nature of DCS for linear and elliptical polarized laser field using MATLAB with computing parameters value for laser photon energy (1 eV to 3 eV), incidence thermal electron energy (0.511 MeV to 4 MeV) and temperature (280 K to 300 K). The DCS nature found decrease with increasing in incidence energy of thermal electron with constructive and distractive interference as well as superposition also take palce. In addition, the DCS with thermal electron found higher than non-thermal electron in presence of laser field with scattering angle and incidence energy of the electron.

SUSB025

Advancements in Nb3Sn growth for SRF technology at Cornell University

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Nb3Sn is the most promising alternative material for the future of superconducting radio-frequency (SRF) technology, steadily advancing towards practical applications. Having a critical temperature twice that of niobium, Nb3Sn offers the potential for developing smaller, more powerful, and more efficient accelerators. We present recent developments at Cornell University that address the primary practical challenges currently limiting this material from realizing its full potential.
Work supported by the National Science Foundation under Grant No. PHY-1549132, the Center for Bright Beams and U.S. DOE grant No. DE-SC0008431.

SUSB026

Feasibility study for dual higher-order-modes for plasma processing of FRIB superconducting coaxial resonators

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In-situ plasma processing is a promising technique to reduce field emission in superconducting radio-frequency cavities and thus maintain maximum accelerator performance for long-term operation. Continuous-wave accelerators such as FRIB are more challenging than pulsed accelerators due to relatively weak coupling (Qext = 2E6 to 1E7 for FRIB) via the fundamental power coupler (FPC). This results in an unfavorable mismatch at room temperature and makes fundamental-mode plasma processing difficult. Hence we have investigated the use of higher-order-modes (HOMs) with less FPC mismatch. Several HOMs are promising for lower-mismatch plasma generation. However, HOMs often present a less favorable plasma distribution. To improve the plasma distribution, we are studying techniques to drive the plasma with two HOMs simultaneously. Plasma development results will be presented for FRIB beta = 0.085 quarter wave resonators and beta = 0.53 half wave resonators, including ignition threshold measurements and plasma distribution assessments. Plasma modeling with COMSOL is being done in parallel with experimental work to better understand ignition dynamics and plasma distribution/uniformity.

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SUSB027

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 evaluate how differences in the mean free path, grain structure, and impurity profile affect RF performance. 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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SUSB028

Measurement of CSR-affected beams using generative phase space reconstruction

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Linear accelerators with dispersive elements experience projected emittance growth due to coherent synchrotron radiation (CSR) effects which become relevant for highly compressed beams. Even though this is a widely known effect, conventional measurement techniques are not precise enough to resolve the multi-dimensional effects in detail, namely the different rotations of transverse phase space slices throughout the longitudinal coordinate of the bunch. In this work, we apply our generative-model-based six-dimensional phase space reconstruction method in the detailed measurement of CSR effects at the Argonne Wakefield Accelerator Facility in simulations. Additionally, we study the current resolution limitations of the phase space reconstruction method and perform an analysis of its accuracy and precision in simulated cases.
This work was supported by the U.S. National Science Foundation under Award PHY-1549132, the Center for Bright Beams.

SUSB029

Decoupling of nitrogen and oxygen impurities in 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 nitrogen and oxygen impurities through time-of-flight secondary ion mass spectrometry of niobium samples baked at temperatures varying from 75-800 C 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-performance SRF cavities.

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SUSB030

Preliminary design of Transverse deflecting structure systems for Shenzhen Superconducting Soft-X-ray Free Electron Laser

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Transverse Deflecting Structures (TDS) are commonly used in Free Electron Laser (FEL) facilities for the measurement of longitudinal information of electron beam, including bunch length, temporal distribution, slice emittance, etc. Shenzhen Superconducting Soft-X-ray Free Electron Laser (S3FEL) is a high-repetition-rate FEL recently proposed for scientific research and applications. In S3FEL, TDSs that work at S-band (2997.222 MHz) and X-band (11988.889 MHz) will be utilized for the diagnosis and analysis of longitudinal phase space of electron bunches along the beamline. In this manuscript, we present the preliminary design of both S-band and X-band TDS systems of S3FEL, including system layout, deflecting structures, pulse compressors, RF distribution networks, etc. Additionally, we introduce a new parallel-coupled TDS cavity with variable polarization for multi-dimensional phase space diagnostics.

SUSB031

Circular modes for linacs

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Circular mode beams are beams with non-zero angular momentum and strong inter-plane plane coupling. This coupling can be achieved in linear accelerators (linacs) through magnetization of electrons or ions at the source. Depending on the magnetization strength, the intrinsic eigenmode emittance ratio can be large, which produces intrinsic flatness. This flatness can either be converted to real plane flatness or can be maintained as round coupled beam through the system. In this paper, we discuss rotation invariant designs that allow circular modes to be transported through the lattice while accelerating and maintaining its circularity including low-energy space charge effects. We demonstrate that with rotation invariant designs the circularity of the mode can be preserved as round beam while maintaining intrinsic flatness to be converted to flat beam later or injected into a ring.

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SUSB032

Automation of sample alignment for neutron scattering experiments

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Sample alignment in neutron scattering experiments is critical to ensuring high quality data for the users. This process typically involves a skilled operator or beamline scientist. Machine learning has been demonstrated as an effective tool for a wide range of automation tasks. RadiaSoft in particular has been developing ML tools for a range of accelerator applications including beamline automation. In this poster we will present recent developments for selecting and aligning multiple samples at the HB-2A powder diffractometer at HFIR.

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SUSB033

Impact of coherent synchrotron radiation effect on generalized longitudinal strong focusing lattice

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Steady-state microbunching (SSMB) storage ring is a promising high-power coherent light source for the future. The generalized longitudinal strong focusing (GLSF) scheme exploits the low vertical beam emittance in a planar ring to achieve steady-state ultra-short bunch through vertical-longitudinal coupling. When the bunch length is extremely short, the coherent synchrotron radiation (CSR) effect typically has significant impacts on the beam dynamics, such as increasing the vertical emittance, which prevents the bunch length from compressing to the expected value. In this work, we use CSRtrack to simulate the beam dynamics and investigate the impact of CSR effect on GLSF lattice.

SUSB034

Accelerating structures for the FCC-ee pre-injector complex: RF design, optimization, and performance analysis

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The Future Circular Collider electron-positron (FCC-ee) pre-injector complex demands high-performance RF accelerating structures to achieve reliable and efficient acceleration of beams up to 20 GeV. In this study, we describe analytical approach to RF design for the traveling-wave (TW) structures including pulse compression system to meet the rigorous specifications of the FCC-ee pre-injector complex. The fundamental mode at 2.8 GHz and Higher Order Mode (HOM) characteristics were determined through the utilization of lookup tables and analytical formulas, enabling efficient exploration of extensive parameter ranges. Optimization of the structure geometry and in particular the iris parameters was performed to address key challenges including maximizing effective shunt impedance, minimizing surface fields, and effectively damping long-range wakes through HOM detuning. Moreover, we investigated the impact of beam-loading effects on the bunch-to-bunch energy spread. Comprehensive thermal and mechanical analyses were carried out to evaluate the impact on the accelerating structure performance during operation at very high repetition frequency of 400 Hz.

SUSB035

Physical design of the heavy-ion injector for the XiPAF-upgrading project

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Xi'an 200 MeV proton application facility (XiPAF) dedicated to proton single particle effect studies is undergoing heavy-ion upgrading and renovation. A heavy-ion injector will be constructed for XiPAF to provide the heavy-ion beam. The single particle effect studies will be expanded to cover proton and heavy-ions. In this paper, physical design of the heavy-ion injector for XiPAF-upgrading is presented. The heavy-ion injector consists of an electron cyclotron resonance (ECR) heavy-ion source, a low energy beam transport line (LEBT), a radio frequency quadrupole (RFQ), an interdigital H-mode drift tube linac (IH-DTL), and a linac to ring beam transport line (LRBT). The range of the mass-to-charge ratio of the heavy ions is 3~6.5. The ion beam with an energy of 4 keV/u produced by the ion source is accelerated to 0.4 and 2 MeV/u by the RFQ and DTL, respectively. The LRBT can transport and adjust beams to meet all injection requirements of the synchrotron.

SUSB036

Compact field emission electron gun driven by terahertz wave

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Accelerator-based light sources require high brightness electron bunches to improve performance in exploring structure of matter. Higher acceleration gradient is the key to generate high brightness electron bunches and is more feasible with higher frequency and shorter pulse length electromagnetic wave according to previous empirical formulas. A tapered rectangle waveguide structure driven by terahertz wave is designed as a compact electron gun. A nanotip is fabricated by focused ion beam (FIB) in the center to enhance the field and to emit electrons. The average emission charge per pulse is measured by Pico ammeter, and the peak value reaches 10fC. The max electron energy beyond 4keV is measured from the signal of channel electron multiplier behind a -4kV metal girds, revealing that maximum acceleration gradient is beyond 100MeV/m. These results indicate promising performance of compact terahertz electron gun in high brightness electron injection. Further research will be done in the future.

SUSB037

MCMC tomography

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Beam tomography offers a distinctive approach for indirectly reconstructing a beam's phase space using downstream measurements. Our study introduces a novel algorithm utilizing Markov Chain Monte Carlo techniques to reconstruct a four-dimensional phase space upstream. Notably, this method can be easily parallelized, leading to enhanced efficiency compared to existing beam tomography methods. Subsequently, we explore the algorithm's robustness in experimental settings, providing valuable insights into its practical applications.

SUSB038

Limitations of the EuXFEL 3rd harmonic cryomodule in high duty cycle operation

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Future high duty cycle (HDC) operation scenarios of the European X-ray Free Electron Laser (EuXFEL) promise increased bunch repetition rate and photon delivery, at the cost of changing system requirements and moving away from the proven mode of short pulse (SP) operation. To assess the applicability of the currently installed 3rd harmonic cryomodule, key parameters of its spare sibling installed at the accelerator module test facility are examined for long pulse (LP) and continuous wave (CW) operation. For radio-frequency (RF) related energy efficiency, the cavity resonance tuning precision and the loaded quality factor tuning range are investigated. As performance indicators, limitations on attainable cavity gradient and RF stability are quantified. The results show that the module in its current design is not sufficient for LP at high duty cycles and CW at the required operating points. The installed 3-stub tuners only yield maximum quality factors between 5.3 e6 and 1.9e7, and the mechanical cavity tuner prohibits tuning precision within the intended cavity half bandwidth. Also, some higher order mode couplers do not allow CW operation at required gradients. Nevertheless, closed-loop RF stability measurements with single cavity control almost fulfill the current EuXFEL SP requirements if assembled to a pseudo vector-sum.