SAP2025 - the 15th Symposium on Accelerator Physics

Report of Contributions

Contribution ID: **3** Contribution code: **THP01** Type: **Poster Presentation**

Design and preliminary implementation of the laser Compton polarimeter for BEPCII

Thursday 4 September 2025 18:55 (1h 35m)

As a key R&D project for polarized lepton beams at future colliders, a laser Compton polarimeter has been designed for the electron storage ring of BEPCII, utilizing the X-ray beamline and experimental hutch from a dismantled wiggler source. As of July 2025, we have preliminary completed laser transmission, focusing, circular polarization adjustment, and observed laser and electron beam collision signals on beam less monitors. However, laser focusing and detector still need to be improved, the potential modifications in the near future also be discussed in this article.

Footnotes

Funding Agency

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Yes

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Session Classification: Poster Session

Track Classification: MC3: Circular and Linear Colliders

Contribution ID: **4** Contribution code: **WENC5** Type: **Contributed Oral Presentation**

Modeling of CSR and its cancellation in DBA/Chicane type compressors

Wednesday 3 September 2025 16:50 (20 minutes)

In advanced accelerator-based light sources and colliders, bunch compressors like arc-type (DBA) and linear-type (chicane) are widely used to generate high-quality electron beams with kiloampere (kA)-level peak currents. However, a serious problem in increasing the peak current even higher is the significant degradation of beam quality caused by the Coherent Synchrotron Radiation (CSR) effect. To tackle this, we develop a new analytical model for CSR that can describe beam transport with varying bunch lengths, establish a practical framework for analyzing CSR in both DBA and chicane-type compressors, and design CSR-suppressed DBA compressors (arc-type) as well as non-symmetric C- and S-shaped chicanes (linear-type). General analytical conditions for CSR cancellation are derived for these designs. Simulations show that, with these new compressors, high beam quality can be maintained even when the peak current is increased up to 10 kA. This work provides important guidance for enhancing the performance of existing accelerator facilities, as well as for the development of next-generation accelerator-based light sources and colliders.

Footnotes

Funding Agency

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Yes

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Session Classification: Parallel Talk Session 1

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **5** Contribution code: **THP07** Type: **Poster Presentation**

Longitudinal collective dynamics in laser modulators of an SSMB storage ring based on macroparticle model

Thursday 4 September 2025 18:55 (1h 35m)

The mechanism of the steady-state microbunching (SSMB) storage ring is being actively investigated. In the conceptual design, a laser modulator used to modulate the electron beam include the co-propagating laser beam, undulator magnets and potential cavity mirrors, forming a laser modulator cavity. In this work the longitudinal single-bunch and multi-bunch collective dynamics are studied that may arise due to coherent undulator radiation, based on the macroparticle model. For multi-bunch multi-turn case, the dispersion equation is derived, and a detuning parameter is introduced to characterize the frequency deviation between the external laser and the resonant undulator radiation, and solve for the instability growth rates of different multibunch modes. When the detuning approaches a specific multi-bunch mode divided by the number of total microbunches, this instability mechanism tends to amplify that mode. Furthermore, possible mitigation effect of the potential well on the instability is discussed. This work may shed light on the underlying physical mechanisms of longitudinal collective beam dynamics in the laser cavity modulators of an SSMB storage ring.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **6** Contribution code: **THP08** Type: **Poster Presentation**

Coherent kW THz radiation from an SSMB storage ring via self-sustained laser modulation

Thursday 4 September 2025 18:55 (1h 35m)

Due to the unique role of terahertz (THz) radiation in the electromagnetic spectrum, it possesses significant scientific value and potential applications in fundamental science, biomedical research, spectroscopy, and etc. This paper proposes a novel mechanism for generating continuous kilowatt-level coherent terahertz radiation in steady-state microbunching storage rings, based on self-sustaining laser modulation processes. The analysis employs the transfer matrix method from accelerator physics, considering the dynamical evolution of electron beams during multiple passes through the laser modulator, as well as radiation damping and quantum excitation effects in the storage ring. Numerical tracking results demonstrate the feasibility of this mechanism. In a demonstrative case, we show that 1 kW continuous coherent radiation can be achieved at 5 THz frequency, corresponding to electric field strengths on the order of MV/m. Since this scheme is based on free electrons, its radiation output characteristics can be tuned over a broad frequency range of 1-10 THz, offering extremely high application value in scientific research.

Footnotes

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **7** Contribution code: **THP10** Type: **Poster Presentation**

Quick estimate of CSR-induced microbunching Instability in a multibend transport beamline

Thursday 4 September 2025 18:55 (1h 35m)

Microbunching instability (MBI) driven by short-range wakefields in high-brightness electron beams has been an active area of research over the past decade. While most existing studies focus on single-pass or linear accelerators — particularly few-dipole bunch compressor chicanes — MBI studies in multi-bend transport lines has relied predominantly on time-consuming numerical simulations. In this work, we present a quick estimate for evaluating MBI gain in generic multi-bend beamlines, thereby avoiding computational costs. Starting from Volterra integral equation governing the bunching factor, we first find the optimal wavelength and introduce physically motivated simplifications to derive the maximum gain. A gain spectrum is then constructed based on physical insights into MBI amplification mechanisms. The results show good agreement with detailed numerical calculations from Vlasov solver. The developed approach enables quick and reasonably accurate estimates of the MBI gain using only the lattice optics functions and the initial beam parameters, offering a practical tool for beamline design and mitigation of MBI.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **8** Contribution code: **THP09** Type: **Poster Presentation**

Quasi-linear theory of single-pass microbunching instability

Thursday 4 September 2025 18:55 (1h 35m)

The existing theoretical treatment of single-pass microbunching instability (MBI) typically assumes a coasting beam and adopts a linear framework, within which the microbunching gain may grow without bound. While the inclusion of intrabeam scattering (IBS) introduces damping effects that may suppress excessive gain, these models remain fundamentally linear and do not capture saturation behavior. In this work, we develop a quasi-linear theory of MBI based on the Vlasov equation, incorporating the evolution of beam energy spread induced by the instability itself. The quasi-linear formulation yields a set of coupled equations describing the evolution of the bunching factor and energy spread, still under the coasting beam approximation where different modulation wavelengths evolve independently. This approach provides a more realistic description of the nonlinear evolution of MBI and offers insight into its natural saturation mechanism.

Footnotes

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **9** Contribution code: **THP11** Type: **Poster Presentation**

Bunched-beam theory of microbunching instability

Thursday 4 September 2025 18:55 (1h 35m)

Conventional theory of single-pass microbunching instability (MBI) is primarily based on the coasting-beam approximation, which assumes that the modulation wavelength is much shorter than the bunch length. However, in isochronous beamlines, the characteristic modulation wavelength may sometimes become comparable to the bunch length, rendering the coasting-beam assumption invalid. In this paper we develop a bunched-beam theory of MBI, starting from the linearized Vlasov equation, aiming to quantify the impact of finite bunch length on the evolution of density modulations. Our analysis reveals that the final MBI gain, or the amplified bunching factor, exhibits a dependence on the initial modulation phase, a feature absent in the existing coasting-beam model. The proposed bunched-beam formulation may offer additional physical insights into the underlying mechanism of MBI, particularly in regimes where the finite extent of the bunch plays a non-negligible role.

Footnotes

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **10** Contribution code: **THAI3** Type: **Invited Oral Presentation**

Steady state microbunching high power light source

Thursday 4 September 2025 11:20 (25 minutes)

Steady state microbunching (SSMB) proposed by Alexander Chao and Daniel Ratner is a new concept of accelerator light source, which means to maintain the microbunching in storage rings for coherent radiation production. By combining the high coherence and high repetition rate, SSMB can provide very high average power radiation. And the radiation wavelength can cover THz to soft X-ray.
To promote the SSMB physics research and develop a SSMB-EUV light source, a taskforce has been established in Tsinghua University since 2017. Recently, we are continuing the proof of principle experiment and have observed multi-turn coherent radiation by modulating the electron bunch with laser single-turn on MLS storage ring. The experiment results are in very good agreement with theoretical prediction, which proof this kind of mechanism (maintain micro-bunch in storage ring) can work well.
We have also proposed a complete design for high average power EUV radiation based on SSMB. The proposal will provide kW EUV average power at the radiation wavelength of 13.5 nm within 2% bandwidth. We have done the start to end study for this proposal and the researches on the key technologies are also underway. This kind of EUV light source may open a new roadmap to meet the requirements of EUV lithography.

Footnotes

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Session Classification: Plenary Talk Session 3

Track Classification: MC6: Photon Sources and Electron Accelerators

Contribution ID: **11** Contribution code: **THMC1** Type: **Contributed Oral Presentation**

Energy stablization of high-charge electron bunches from Plasma Wakefield Acceleration

Thursday 4 September 2025 16:00 (20 minutes)

Plasma Wakefield Acceleration (PWA) promises to reduce the scales of advanced light sources and high-energy colliders due to its ultrahigh accelerating gradients. However, the relatively large energy jitter and energy spread (typically 1˜10% level) of the electron bunches generated by PWAs remain a major obstacle for practical applications. In this work, we propose two independent schemes: 1) a combination of a laser-driven active plasma dechirper and a passive plasma dechirper with two magnetic chicanes; and 2) a beam-driven active plasma dechirper integrated with a magnetic chicane. The simulation results demonstrate that these schemes can reduce both energy jitter and energy spread of PWA-generated electron beams with charges ranging from hundreds of pC to several nC from the 1% level to 0.1% or lower. In addition, we preliminarily study the transverse coordinate offsets induced by the coherent synchrotron radiation effect in chicanes, as well as the feasibility and experimental design of these schemes.

Footnotes

Funding Agency

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Session Classification: Parallel Talk Session 3

Track Classification: MC5: Novel Particle Sources

Contribution ID: **12** Contribution code: **THP51** Type: **Poster Presentation**

Research on higher-order mode suppression in CEPC electrostatic separators

Thursday 4 September 2025 18:55 (1h 35m)

The electrostatic separator is a key component of circular colliders (such as the CEPC), but the unique geometry of its vacuum chamber excites higher-order modes (HOMs), leading to significant narrow-band impedance. Previous studies have shown that adding absorbing materials at the feedthrough (holder) terminals of the electrostatic separator can effectively suppress HOMs, thereby improving the multibunch coupled instability threshold in the CEPC. However, since the electrostatic separator of the CEPC must operate in the magnetic field environment generated by bending dipoles magnets, the solution of adding absorbing materials at the feedthrough cannot be implemented. Therefore, new damping schemes must be explored, and non-magnetic materials must be used for the damping material. Based on the CST simulation software, this paper systematically investigates the approach of loading non-magnetic SiC absorbing rings at different positions of the electrostatic separator. Through simulation analysis, the suppression effects of different schemes on the quality factor (Q value) of HOMs and the transverse impedance are quantitatively evaluated, providing a basis for optimizing the design of the CEPC electrostatic separator and reducing the risk of beam instability.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC6: Photon Sources and Electron Accelerators

Contribution ID: **13** Contribution code: **THP12** Type: **Poster Presentation**

Suppression of emittance variation for the HALF storage ring

Thursday 4 September 2025 18:55 (1h 35m)

The Hefei Advanced Light Facility (HALF) is a diffraction-limited storage ring light source. The HALF storage ring lattice has relatively long damping times, which can result in substantial variations in beam emittance when the gaps of insertion devices change. In this paper, we study different ways to suppress the emittance variation of the HALF storage ring, including the usage of damping wigglers in long straight sections, wigglers in short dispersive straight sections and leaked dispersion in long straight sections.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **14** Contribution code: **THP04** Type: **Poster Presentation**

Minimizing the fluctuations of storage ring resonance driving terms using the step-by-step chromaticity compensation method

Thursday 4 September 2025 18:55 (1h 35m)

Our recent studies showed that reducing the fluctuations of resonance driving terms (RDTs) can enlarge the dynamic aperture (DA) of a storage ring very effectively. In this paper, we use the step-by-step chromaticity compensation method to minimize RDT fluctuations for DA optimization. For the minimization of third-order RDT fluctuations, this method yields the same optimization result as evolutionary algorithms. Crucially, however, this method exhibits faster convergence than evolutionary algorithms.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **15** Contribution code: **THP30** Type: **Poster Presentation**

SOFT: Single-Optics 4D phase space Tomography via double-rotated 2D measurements

Thursday 4 September 2025 18:55 (1h 35m)

Detailed knowledge of high-dimensional phase space distributions is crucial for predicting and controlling the evolution of intense beams. Conventional beam tomography techniques require measurements under multiple beamline configurations, introducing reconstruction errors due to transport nonlinearities and model uncertainties while complicating the beamline design. This paper introduces SOFT (Single-Optics Four-dimensional Tomography) , a novel technique that reconstructs the complete 4D distribution using measurements from a single beamline setting. SOFT conducts 2D phase space scans with two independently rotatable slits to extract otherwise inaccessible cross-plane information. We present a rigorous proof demonstrating SOFT's ability to acquire sufficient data for full 4D reconstruction. Physics-informed analytical tools based on 4D geometry were developed to optimize the design and minimize measurement errors. SOFT's efficacy is validated through simulations, and the status of the prototype experiment is discussed.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **16** Contribution code: **THP29** Type: **Poster Presentation**

Position-phase error cancellation effects in beam-based linac alignment and synchronization

Thursday 4 September 2025 18:55 (1h 35m)

As prerequisites for automatic phase setting and fault compensation, precise longitudinal alignment and RF phase calibration are critical for high-intensity superconducting hadron linacs. While multiple facilities have successfully aligned or synchronized their linacs with time-of-flight (TOF) beam-based methods, existing error analyses typically assume uncorrelated position and phase uncertainties. This work rigorously derives intrinsic correlations between position and phase errors in beam-calibrated linacs. We demonstrate how these correlations can induce error cancellation effects that improve the accuracy of energy measurements and phase setting. Having validated these effects through simulations, we analyzed their implications for beam-based calibration experiments with applications to HIAF and CiADS commissioning.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **17** Contribution code: **THP06** Type: **Poster Presentation**

Preliminary scheme for electron cooling using longitudinal hollow electron beam

Thursday 4 September 2025 18:55 (1h 35m)

The intra-beam scattering in high charge state intense heavy ion beams is a problem worth considering. By controlling the longitudinal distribution of the ion beam, it may be possible to alleviate the ion beam loss and improve the lifetime of the ion beam caused by intra-beam scattering. Unlike the traditional cooling process of direct current electron beams or longitudinal uniform distribution electron bunch beams, a longitudinal hollow electron beam is used to cool heavy ion beams. Ions at the edge of the ion beam will receive stronger cooling, while ions at the center of the ion beam will receive weaker cooling, avoiding overcooling at the center of the ion beam. This paper discusses the generation, measure-ment, and related issues of longitudinal hollow electron beams. Corresponding solutions and suggestions have been proposed for the problems and challenges that may be encountered in the research. The cooling process of longitudinal hollow electron beams will be simulated and experimentally studied in the future, with the hope of obtaining beneficial effects.

Footnotes

Funding Agency

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Yes

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Session Classification: Poster Session

Track Classification: MC4: Hadron Accelerators

Contribution ID: **18** Contribution code: **THP05** Type: **Poster Presentation**

GPU-accelerated simulation of longitudinal single-bunch instability in electron storage rings

Thursday 4 September 2025 18:55 (1h 35m)

Longitudinal single-bunch instability driven by high-frequency impedance is a major challenge for achieving optimal performance in fourth-generation synchrotron light sources and future electron-positron colliders. Accurate simulations of this instability are critical, yet computationally intensive, often requiring millions of macro-particles and fine slicing to resolve bunch density distributions. To address this, we have developed a GPU-accelerated tracking code that enables efficient simulations of longitudinal single-bunch instability. Our solution is specifically designed to run on a desktop computer equipped with a high-performance GPU, providing an accessible and cost-effective alternative to computing clusters.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **19** Contribution code: **THP21** Type: **Poster Presentation**

Modeling of transverse trapped-mode impedance for In-Vacuum Undulators of HALF

Thursday 4 September 2025 18:55 (1h 35m)

The In-Vacuum Undulator (IVU) exhibits exceptionally strong trapped-mode impedance due to its distinctive ridge-loaded waveguide structure and narrow magnetic gap design, which may lead to beam instability issues. This study systematically investigates the trapped-mode impedance in the Hefei Advanced Light Facility's (HALF) IVU using both eigenmode and wakefield solvers in CST Studio Suite, with comparative calculations of vertical trapped-mode impedance for structures with and without pumping ports. The results demonstrate that impedance values significantly exceed the synchrotron radiation damping threshold.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **20** Contribution code: **THP24** Type: **Poster Presentation**

Bunch lengthening study with harmonic cavities for HLS-III

Thursday 4 September 2025 18:55 (1h 35m)

Hefei Light Source II (HLS-II) is currently planned for an upgrade to Hefei Light Source III (HLS-III). To increase beam Touschek lifetime and suppress beam instabilities, HLS-III will employ harmonic cavities for bunch lengthening. This study evaluates bunch lengthening performance for different RF frequencies and harmonic cavity orders using theoretical analytical formulations, identifying the required cavity voltages and quantifying the corresponding Touschek lifetime improvement factors. This study provides critical guidance for the selection of RF frequencies and harmonic cavity parameters for HLS-III.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **21** Contribution code: **THP22** Type: **Poster Presentation**

Base-e exponential fitting of long-range transverse resistive wall wakefunction

Thursday 4 September 2025 18:55 (1h 35m)

In high-intensity storage rings, long-range transverse resistive wall wake fields serve as the dominant source of coupled-bunch instabilities. Conventional particle tracking algorithms handling these wake fields require storing per-bunch, per-turn centroid position histories, resulting in excessive memory consumption and computational inefficiency. This paper proposes fitting the long-range transverse resistive wall wake fields through a linear combination of exponential functions. This method eliminates the need for historical bunch centroid position storage during tracking computations while facilitating GPU-based parallel implementation, thereby significantly enhancing computational efficiency. This paper presents detailed analyses of fitting deviation dependencies on exponential function count and optimization algorithms.

Footnotes

Funding Agency

I have read and accept the Privacy Policy Statement

Yes

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **22** Contribution code: **THP34** Type: **Poster Presentation**

Analytical study on measurement errors induced by nonlinear transport and fringe fields in a sector-based energy analysis system

Thursday 4 September 2025 18:55 (1h 35m)

Energy Analysis (EA) systems based on sector-magnets, with simple structure and high resolution, are widely applied in particle accelerators. As core components, sectors directly determine the accuracy of beam momentum spectra evaluations. However, for low-energy electron beams below 15 MeV, nonlinear-transport in large-dispersion sectors causes errors in results from linear-transport models; unavoidable fringe fields from magnet design/manufacturing introduce extra errors. The longitudinal transport of 1D beams in the sector-based system is first theoretically derived. A compensation scheme (considering high-order momentum spread terms) is proposed and verified via 1D dynamic virtual measurements. Further, fringe field-induced aberrations and their impact on momentum spectra are studied analytically; high-order optical transport is validated with beam dynamics simulations, and correction of second-order aberration errors via data processing is explored. These methods and conclusions improve the accuracy of built/operational EA systems without extra costs.

Footnotes

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **23** Contribution code: **THP03** Type: **Poster Presentation**

A universal numerical optimization framework for studying seeded free-electron laser schemes

Thursday 4 September 2025 18:55 (1h 35m)

Seeded free-electron lasers (FELs) have become indispensable tools across numerous scientific fields, owing to their high coherence and stability. To facilitate the discovery and optimization of such FELs, we propose a general-purpose framework utilizing intelligent optimization algorithms for identifying high-performance seeded FELs. In this paper, we demonstrate that our framework can automatically reproduce established seeded FELs, eliminating the need for prior physical analysis. Furthermore, this framework has the potential to discover novel schemes through the systematic incorporation of additional physical elements.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC6: Photon Sources and Electron Accelerators

Contribution ID: **24** Contribution code: **THP27** Type: **Poster Presentation**

Quantifying differences between high dimensional beam phase space distributions with f-divergences

Thursday 4 September 2025 18:55 (1h 35m)

Quantifying differences between high-dimensional phase space distributions is essential for analyzing beam measurements and simulations. While f-divergences such as KL or JS divergence are increasingly used for this purpose, including in machine learning applications, their values lack physical interpretability. This work conducts the first systematic study of the difference quantification characteristics of several typical f-divergences for high-dimensional beam distributions commonly used in accelerators. The aims are to identify the most suitable f-divergence metric for the field of accelerator beam physics and to reveal the physical meanings represented by f-divergences values within this field. We first study the f-divergences properties among different types of beam distributions with the same covariance matrix. Subsequently, we demonstrate that various f-divergences between these distributions exhibit definite correspondences with the mismatch factors and the emittance differences. Finally, based on these correspondences, we establish assessment standards for f-divergences, which can interpret the specific meanings represented by their values in the context of beam phase space distributions. These findings provide guidance for selecting statistical divergences to quantify differences in high-dimensional phase space beam distributions.

Footnotes

Funding Agency

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **25** Contribution code: **THP02** Type: **Poster Presentation**

Tracking simulation of longitudinal beam dynamics in a triple RF system for electron storage rings

Thursday 4 September 2025 18:55 (1h 35m)

For diffraction-limited storage rings, a triple RF system scheme has been proposed, aimed at achieving longer bunch lengthening or meeting the specific requirements of longitudinal injection. In such a system, the choice of RF cavity parameters plays a critical role in the longitudinal beam dynamics, which typically requires precise analysis through macroparticle tracking simulations. This paper extends STABLE code [T. He et al., Phys. Rev. Accel. Beams 24, 104401 (2021)] to investigate the longitudinal dynamics of the triple RF system proposed for the Hefei Advanced Light Facility (HALF) storage ring. The simulation results reveal that two key factors limit bunch lengthening.

Footnotes

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **26** Contribution code: **THP42** Type: **Poster Presentation**

Spectral form function with applications in beam physics

Thursday 4 September 2025 18:55 (1h 35m)

To describe longitudinal fine structure within a particle beam like microbunching, a classical approach is to define a bunching factor or form factor which is the Fourier transform of the particle density distribution in longitudinal dimension. Such a 1D definition of form factor can be generalized to 6D spectral form function (SFF) to describe more complicated structure in phase space. The complex SFF is another complete description of beam in spectral domain and can offer complementary and valuable insight in beam dynamics study which usually invokes the real particle density distribution. The basic property and Fokker-Planck equation of the SFF is presented, along with its solution in a general coupled linear lattice. The example applications of SFF in electron storage ring physics and laser-induced microbunching are presented.

Footnotes

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **27** Contribution code: **THXC4** Type: **Contributed Oral Presentation**

The design progress of the high-intensity muon source at CiADS

Thursday 4 September 2025 18:35 (20 minutes)

A high-intensity muon source named MuST has been proposed for several years at CiADS. Utilizing the 5-mA proton beam of CiADS linac on targets, multiple muon beamlines can be fed, and the intensity of the DC muon beam is expected to be record-breaking. Here, the conceptual layout of MuST, including the tandem targets, the muon beamlines, and the terminals, is presented. The development plan and the conceptual design progress are reported. The study of the liquid jet target, which is more efficient in producing surface muons than graphite and has the potential to withstand a 3-MW proton beam, is presented. The design details and overall performance of the muon beam lines are introduced. The key beam parameters of the surface muons and decay muons are given.

Footnotes

Funding Agency

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Session Classification: Parallel Talk Session 4

Track Classification: MC5: Novel Particle Sources

Contribution ID: **28** Contribution code: **FRMC6** Type: **Contributed Oral Presentation**

Real-time comprehensive electron beam diagnostics through machine learning in ultrafast electron diffraction system

Friday 5 September 2025 11:45 (15 minutes)

Ultrafast electron diffraction (UED) is a powerful technique for observing atomic-scale structural dynamics in materials. Electron beam parameters—beam size, divergence, energy spread, and bunch length—determine spatio-temporal resolution. Traditional diagnostic methods require complex instrumentation that cannot be integrated into routine workflows, particularly for high-repetition-rate facilities. We present a machine learning approach enabling comprehensive, non-invasive extraction of electron beam parameters directly from diffraction patterns. Deep neural networks trained on physics-based simulations decode signatures that beam parameters imprint on diffraction images. The method exploits distinct physical mechanisms: geometric effects from beam size, angular distortions from divergence, chromatic aberrations from energy spread, and temporal convolution from bunch length. This enables bunch length measurement without dedicated temporal diagnostics—traditionally one of the most challenging parameters to access non-invasively. The trained models can be deployed across UED facilities using standard imaging detectors, democratizing access to advanced diagnostics. This approach eliminates expensive specialized equipment and enables real-time beam monitoring and optimization, enhancing experimental throughput and data quality for ultrafast materials characterization.

Footnotes

Funding Agency

I have read and accept the Privacy Policy Statement

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Session Classification: Parallel Talk Session 5

Track Classification: MC1: Advanced acceleration concept

Contribution ID: **29** Contribution code: **FRNC2** Type: **Contributed Oral Presentation**

The start-to-end beam dynamics simulation study and its application in the high-intensity cyclotron of CIAE

Friday 5 September 2025 10:50 (20 minutes)

The neutron yield of the neutron source based on the 18MeV/1mA high-intensity cyclotron developed by the China Institute of Atomic Energy (CIAE) has reached 7×10ˆ13 n/s and has been successfully applied in high-resolution neutron imaging and Boron Neutron Capture Therapy (BNCT) experiments. Precise and quantitative start-to-end beam dynamics simulations facilitate a better understanding of the complex beam dynamics behavior of high-intensity beams, which is one of the key technologies for high-intensity cyclotrons. The beam dynamics simulation technology for cyclotrons is relatively mature. However, it is typically implemented independently in each subsystem. During the simulation process, assumed initial conditions are introduced multiple times, making it difficult to obtain quantitative results and carry out a global optimization design of beam dynamics. Start-to-end beam dynamics simulation is used in the 18MeV/1mA high-intensity cyclotron. It quantitatively simulates the beam dynamics behavior of high-intensity beams in each subsystem, including the injection line, spiral inflector, central region, acceleration region, extraction region, and uniform beam transport line.

Footnotes

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Session Classification: Parallel Talk Session 5

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **30** Contribution code: **WEMC3** Type: **Contributed Oral Presentation**

Generation of coherent pulses via multiple-echo-enabled harmonic generation in storage rings

Wednesday 3 September 2025 16:50 (20 minutes)

In comparison to free electron lasers, storage ring light sources (SRLS) can reuse a single electron beam to serve multiple users, offering high repetition rates and cost efficiency. However, despite the transverse emittance reaching the X-ray diffraction limit in fourth-generation SRLS, the storage ring suffers from limited longitudinal coherence. Enhancing longitudinal coherence has been shown to significantly improve spectral brightness, time resolution, and energy resolution. Laser modulation schemes for SRLS have been explored for their potential to induce strong microbunching, thereby enhancing spectral power and coherence. However, these methods modulate each bunch only once per revolution, limiting their application to a single beamline and underutilizing the multi-user capacity of storage rings. To enable coherent radiation delivery to multiple beamlines, we propose a multiple-echo-enabled harmonic generation scheme. This approach modulates the electron beam multiple times, generating coherent pulses at different wavelengths. By leveraging the multi-user capability of storage rings while simultaneously improving longitudinal coherence, our method enhances both spectral and temporal performance.

Footnotes

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Session Classification: Parallel Talk Session 1

Track Classification: MC6: Photon Sources and Electron Accelerators

Contribution ID: **31** Contribution code: **THNC3** Type: **Contributed Oral Presentation**

Preliminary physical design of the transport lines for the Positron Damping Ring of the Super Tau-Charm Facility

Thursday 4 September 2025 16:40 (20 minutes)

The injector of the Super Tau-Charm Facility (STCF) should provide high-quality electron and positron beams for the collider ring according to different injection schemes, which is one of the key systems to ensure the high brightness of STCF. The transport line of the injector mainly consists of the electron transport section, the injection and extraction section of the positron damping ring, and the transport section from the main linear accelerator to the collider ring. Due to the complex structure, each transport section has different requirements for beam emittance, energy spread and other parameters. Preventing the beam quality from being damaged during transportation is one of the main challenges. In this report, we will introduce the physical design of the STCF transport line of different injection schemes, as well as the key issues and the optimization result in different transport sections.

Footnotes

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Session Classification: Parallel Talk Session 3

Track Classification: MC3: Circular and Linear Colliders

Contribution ID: **32** Contribution code: **THP37** Type: **Poster Presentation**

Physical design of microwave electron gun optimized for carbon nanotube cathodes

Thursday 4 September 2025 18:55 (1h 35m)

Since the maximum electric field strength that a carbon nanotube field-emission cathode can withstand is less than 13 MV/m, the optimization scheme of shortening the length of the first cavity based on the traditional 1/2+1 cavity-type microwave electron gun fails to solve the problems of electron phase slippage and back-bombardment. Therefore, in accordance with the emission characteristics of the carbon nanotube field-emission cathode, beam dynamics optimization was conducted on different cavity structures to select a more suitable cavity structure. Subsequently, the radio frequency (RF) design of the electron gun was completed through fine parameter adjustment of the cavity structure. Finally, the engineering design of the electron gun was accomplished after considering multiple aspects such as the gun's assembly, cathode structure, microwave feed-in structure, and electron beam output structure.

Footnotes

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Session Classification: Poster Session

Track Classification: MC5: Novel Particle Sources

Contribution ID: **33** Contribution code: **FRNC5** Type: **Contributed Oral Presentation**

AVASX: a GPU-based high-performance beam dynamics simulation code using hybrid tracking methods for ion linear accelerators

Friday 5 September 2025 11:50 (20 minutes)

In high-intensity ion accelerators, particle dynamics is significantly influenced by nonlinear collective effects, particularly the space charge effects. The Particle-in-Cell (PIC) method is widely used to study these effects, but the computational burden restricts the applications in accelerator design, failure compensation, and machine learning dataset generation. In this work, a high-performance beam dynamcs code, named AVASX (Advanced Virtual Accelerator Software X), was developed with CUDA (Compute Unified Device Architecture) and performed on NVIDIA GPUs (Graphics Processing Units). The AVASX framework implements an adaptive particle tracking method that alternates between time and position as the independent variable. This switching mechanism optimizes the trade-off between the simulation accuracy and the computational efficiency. For the purpose of improving computing performance in charge deposition with atomic operations performed on GPU global memory, three optimization schemes, such as the thread aggregation method, the strategy of scattering data processing scopes, and the use of duplicate memory instances, were employed in this work and profiled using NVIDIA Nsight Compute to prove their effectiveness. According to the test results of simulating different beamlines, the GPU-based code is reliable and achieves 320 ˜ 450 times faster than the CPU-based code performed on 56 cores.

Footnotes

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Session Classification: Parallel Talk Session 5

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **34** Contribution code: **WEXC6** Type: **Contributed Oral Presentation**

Beam extraction and darkcurrent study of a C-band RF photo gun

Wednesday 3 September 2025 19:50 (20 minutes)

C-band RF photo gun is being developed worldwide for better electron bunch emittance, aiming to be used in advanced light sources such as diffraction-limited storage rings and free electron lasers. Initial beam tests of a 3.6-cell C-band RF photo gun achieved 6.6 MeV beam energy at 137 MV/m cathode gradient were conducted, along with high dark current; Surface checks revealed electron damage on cathodes and disk apertures after these tests. To understand and suppress the dark current, surface cleaning methods and preliminary numerical simulations have also been conducted, and the results are discussed.

Footnotes

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Session Classification: Parallel Talk Session 2

Track Classification: MC5: Novel Particle Sources

Contribution ID: **35** Contribution code: **THP15** Type: **Poster Presentation**

Lattice design optimization of the interaction region for a super tau-charm facility

Thursday 4 September 2025 18:55 (1h 35m)

The Super Tau-Charm Facility (STCF), a new-generation high luminosity e+/e− collider of in the low-energy region of 1-3.5 GeV. To achieve the target luminosity of larger than 5×10ˆ34 cmˆ−2sˆ−1, the collision scheme combining a large crossing angle and crab-waist correction is applied. However, the strong nonlinearity within the interaction region (IR), significantly decreases both dynamic and momentum apertures and limiting Touschek lifetime. Consequently, designing as a transparent (achromatic) IR as possible holds critical importance in enhancing the Touschek lifetime. In this paper, the modular linear lattice design for the STCF IR is designed to facilitate nonlinear optimization. The H-invariant is constrained less than 0.02m to help increase the local momentum acceptance. Up to third-order local chromaticity correction is implemented by using Montague function as indicator to broaden the momentum aperture, thereby improving the Touschek lifetime. Fringe field and detector solenoid effects on beam dynamics is designed and optimized.

Footnotes

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Session Classification: Poster Session

Track Classification: MC3: Circular and Linear Colliders

Contribution ID: **36** Contribution code: **THP44** Type: **Poster Presentation**

Physical design study of the main magnet for the CIAE 75 MeV cyclotron

Thursday 4 September 2025 18:55 (1h 35m)

A 75 MeV cyclotron is currently under development at the China Institute of Atomic Energy (CIAE). This machine is designed to extract a beam with a rated power exceeding 60 kW for the production of medical radioisotopes, such as ^{68}Ge, ^{223}Ra, and ^{225}Ac, aiming to meet the growing domestic demand for diagnostic and therapeutic radionuclides. This paper addresses key challenges and solutions in the design and computational analysis of the main magnet. The magnet poles adopt a structural design scheme featuring integrated straight-edged sectors with a slight spiral angle at the trailing edges. The isochronous magnetic field distribution is achieved through an axial shimming method. Magnetic field optimization was performed using the numerical simulation software OPERA-3D, thereby enhancing the acceleration efficiency of the cyclotron. Furthermore, deformation simulation and mechanical structural optimization were carried out for the main magnet. Under the premise of ensuring overall performance, the deformation of the main magnet, which has a diameter of 4.4 meters and a weight of 130 tons, was controlled within acceptable engineering tolerances.

Footnotes

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Session Classification: Poster Session

Track Classification: MC2: Beam Dynamics and EM Fields

Contribution ID: **37** Contribution code: **THNC2** Type: **Contributed Oral Presentation**

CEPC accelerator physics challenges and research progress

Thursday 4 September 2025 16:20 (20 minutes)

The Circular Electron-Positron Collider (CEPC) is a dual-ring accelerator with a design circumference of 100 kilometers, prioritizing operation at the Higgs particle energy (center-of-mass energy of 240 GeV). To achieve its high-luminosity collision goals, the CEPC accelerator physics team addresses core challenges through design optimization, including beam optics design under strong radiation effects to ensure sufficient beam lifetime, simulation and mitigation of collective effects and nonlinear dynamics from intense beam-beam interactions, development of efficient injection methods despite short beam lifetimes, luminosity optimization for ultra-high energy beams, self-consistent handling of compound effects with precise component modeling and improved computational efficiency, and high-polarization collision design. The team is now conducting more rigorous and comprehensive performance assessments for the physical design, alongside beam physics experimental validation and specialized software development tailored for CEPC.

Footnotes

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Session Classification: Parallel Talk Session 3

Track Classification: MC3: Circular and Linear Colliders