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ABSTRACTS BOOK

S101 NICA Synchrotrons and Their Cooling Systems

Speaker Evgeny Syresin (JINR, Dubna, Moscow Region)

Authors Evgeny Syresin, Andrey Butenko, Andriy Kobets, Sergey Aleksandr Melnikov, Igor Nikolai Meshkov, Anatoly O. Sidorin, Grigoriy Trubnikov (JINR, Dubna, Moscow Region), Alexander Bubley, Vasily Parkhomchuk, Vladimir Borisovich Reva (BINP SB RAS, Novosibirsk), Ivan Gorelyshev, Konstantin Osipov (JINR/VBLHEP, Dubna, Moscow region)

Abstract The Nuclotron-based Ion Collider fAcility (NICA) is under construction in JINR. The NICA goals are providing of colliding beams for studies of hot and dense strongly interacting baryonic matter and spin physics. The accelerator facility of collider NICA for ion mode consists of following accelerators: The new acting heavy ion linac HILAC with RFQ and IH DTL sections at energy 3.2 MeV/u, new acting superconducting Booster synchrotron at energy up 600 MeV/u, acting superconducting synchrotron Nuclotron at gold ion energy 4.5 GeV/n and mounted two Collider storage rings with two interaction points. There is the electron cooling system in the Booster synchrotron, the Collider has electron and stochastic cooling systems. The status of acceleration complex NICA and its cooling systems is presented. The application of cooling systems to operation of the NICA accelerators - the Booster and the Nuclotron are discussed.

S102 Elements of High Voltage Electron Cooling System for NICA Collider

Speaker Maxim Igorevich Bryzgunov (BINP SB RAS, Novosibirsk)

Authors Maxim Igorevich Bryzgunov, Evgeny Bekhtenev, Oleg Vital'evich Belikov, Alexander Bubley, Vladimir Chekavinskiy, Andrey Petrovich Denisov, Mihail Fedotov, Anatoly Danilovich Goncharov, Konstantin Gorchakov, Victor Constantinovich Gosteyev, Igor Gusev, Gennady Karpov, Mikhail Kondaurov, Nikolay Kremnev, Vitalij Panasyuk, Vasily Parkhomchuk, Dmitriy Pureskin, Alexander Putmakov, Vladimir Borisovich Reva, Dmitriy Senkov, Dmitry Nikolaevich Skorobogatov, Roman Vladimirovich Vakhrushev, Aleksandr Zharikov (BINP SB RAS, Novosibirsk)

Abstract Beam cooling plays a key role in the project of the NICA collider. In order to achieve needed luminosity it is important to provide effective cooling during beam accumulation and during experiment. For this purpose, the ring will be equipped with both electron and stochastic cooling systems. The article describes construction of the electron cooler and status of its production by Budker INP.

S103 Development of Electron Cooler Components for HIAF Accelerator

Speaker Lijun Mao (IMP/CAS, Lanzhou)

Authors Lijun Mao, Jie Li, Mingrui Li, Haijiao Lu, Fu Ma, Xiaoming Ma, Xiaoping Sha, Meitang Tang, Kaiming Yan, Xiaodong Yang, Lixia Zhao, Yunbin Zhou (IMP/CAS, Lanzhou)

Abstract The 450 keV electron cooler was proposed to boost the luminosity of high-density internal targets experiment in the spectrometer ring at HIAF. The project is funded since the end of 2019. The cooler is designed based on changes of the 300 keV cooler at IMP, which was made by BINP in 2004. In this paper, experimental testing results of the prototypes of the coils,

electron gun and collector are reported. The technical challenges and solutions on the 450-kV high voltage system are discussed.

S201 Electron Cooling With Space-Charge Dominated Proton Beams at IOTA

Speaker Nilanjan Banerjee (Enrico Fermi Institute, Chicago, Illinois)

Authors Nilanjan Banerjee, John Brandt (Enrico Fermi Institute, Chicago, Illinois), Brandon Cathey, Sergei Nagaitsev, Giulio Stancari (Fermilab, Batavia, Illinois), Young-Kee Kim (University of Chicago, Chicago, Illinois)

Abstract We describe a new electron cooler which is being developed for 2.5 MeV protons at the Integrable Optics Test Accelerator (IOTA) which is a highly reconfigurable storage ring at Fermilab. This system will enable the study of magnetized electron cooling in the presence of intense space-charge with transverse tune shifts approaching -0.5 while under the influence of non-linear integrable optics. We present an overview of the design, simulations and hardware to be used for this project.

S202 Cooling and Diffusion Rates in Coherent Electron Cooling Concepts

Speaker Sergei Nagaitsev (Fermilab, Batavia, Illinois)

Authors Sergei Nagaitsev, Valeri Lebedev (Fermilab, Batavia, Illinois), William Frederick Bergan, Erdong Wang (BNL, Upton, New York), Gennady Stupakov (SLAC, Menlo Park, California)

Abstract We present analytic cooling and diffusion rates for a simplified model of coherent electron cooling (CEC), based on a proton energy kick at each turn. This model also allows to estimate analytically the rms value of electron beam density fluctuations in the "kicker" section. Having such analytic expressions should allow for better understanding of the CEC mechanism, and for a quicker analysis and optimization of main system parameters. Our analysis is applicable to any CEC amplification mechanism, as long as the wake (kick) function is available.

S203 Microbunching Coherent Electron Cooling for the EIC Project

Speaker Gennady Stupakov (SLAC, Menlo Park, California)

Authors Gennady Stupakov (SLAC, Menlo Park, California)

Abstract Reaching maximal luminosity for the planned electron-ion collider (EIC) calls for some form of strong hadron cooling to counteract beam emittance increase from IBS. The microbunched electron cooling (MBEC) is currently considered as a viable method for cooling hadrons in the collider. In this work we discuss the physics of the cooling and describe the mathematical models used in theoretical analysis and simulations to optimize of the cooling rate. We also place limits on the necessary electron beam quality. Some practical challenges of building the MBEC cooler will also be discussed.

S301 Stochastic Cooling System for the Collector Ring at FAIR

Speaker Christina Dimopoulou (GSI, Darmstadt)

Authors Christina Dimopoulou, Axel Bardonner, Roland Markward Böhm, Oleksii Gorda, Rainer Hettrich, Claudius Peschke, Stefan Wunderlich, Chuan Zhang (GSI, Darmstadt), Bernd Breitkreutz, Rolf Stassen (FZJ, Jülich)

Abstract An overview on the demanding stochastic cooling system of the Collector Ring at FAIR is given. The system operates in the frequency band 1-2 GHz, it has to provide fast 3D cooling of antiproton, rare isotope and stable heavy ion beams. The main challenges are (i) the cooling of antiprotons by means of cryogenic movable pick-up electrodes and (ii) the fast two-stage cooling (pre-cooling by the Palmer method, followed by the notch filter method) of the hot rare isotope beams. Progress in designing, manufacturing, testing and integrating the hardware is discussed. The performance of the stochastic cooling processes is predicted by dedicated simulations (rate equations for transverse cooling, Fokker Planck approach for longitudinal cooling).

S302 Recommissioning of the CERN AD Stochastic Cooling System in 2021 after Long Shutdown 2

Speaker Wolfgang Höfle (CERN, Geneva 23)

Authors Wolfgang Höfle, Joao Carlos Oliveira (CERN, Geneva 23), Christian Carli, Fritz Caspers, Bruno Dupuy, Davide Gamba, Reinier Louwerse, Laurette Ponce (CERN, Geneva), Vebjorn Roed Myklebust, Stephane Franck Rey, Lars Thorndahl (CERN, Meyrin)

Abstract The power system of the Stochastic Cooling System of the anti-proton decelerator AD at CERN, installed on top of the shielding blocks of the AD ring, was completely dismantled during the long shutdown 2 (LS2) at the end of the 2018 run in order to gain access to the accelerator for magnet consolidation. At start-up, this required finding and verifying the correct delays for all 48 power amplifiers feeding to the two kickers by means of beam transfer functions for the two cooling plateaus at 3.57 GeV/c and 2 GeV/c. We describe the methods used for the setting up and the results of the optimization for the cooling in all three planes, longitudinal, horizontal and vertical. An experimental set-up has been put into operation for the automatic monitoring and correction of the notch position of the longitudinal cooling at 3.57 GeV/c with optical delay lines. We also comment on the lessons learnt during the recommissioning including the repair work for a vacuum leak in the water cooling circuits of the kicker following bake-out and the verification of the internal loads by RF reflectometry.

S303 Electron Cooling of Molecular Rotations in the Low-Energy Electrostatic Ion Storage Ring CSR

Speaker Andreas Wolf (MPI-K, Heidelberg)

Authors Andreas Wolf (MPI-K, Heidelberg)

Abstract In the CSR at the Max Planck Institute for Nuclear Physics in Heidelberg, Germany, a cryogenic electrostatic storage ring for ions up to 300 keV kinetic energy per charge,* a merged and velocity-matched electron beam was used to cool the rotational states of CH+ molecular

ions in a 300 keV stored beam. Diagnostics of the relative populations in the J = 0, 1 and 2 rotational levels was achieved by photodissociation in a laser beam with a wavelength close to the CH+ dissociation threshold. During a storage time up to 10 minutes, slow spontaneous rotational cooling to the J = 0 ground state occurs by radiative emission of rotationally excited CH+ ions. Applying electrons in the electron cooling geometry (11.8 eV beam energy) at a density near 7e+5 per cm³ and a temperature near 2.3 meV boosted the rotational cooling rate by a large factor (~4). Using the laser-based rotational population measurements, the electron-induced rotational cooling rates could be measured.** This presents the first detailed measurement of rotationally inelastic collision cross sections on a molecular ion, as important for the diagnostics of cold astrophysical media. - Presented for the research team.**

* R.v.Hahn et al., Rev.Sci.Instr. 87, 063115 (2016)
** Á.Kálosi, M.Grieser, R.v.Hahn, U.Hechtfischer, C.Krantz, H.Kreckel, D.Müll, D.Paul, D.W.Savin, P.Wilhelm, A.Wolf, O.Novotný, submitted

Funding Agency Max Planck Society, Germany, and in part by NSF, AST-1907188.

S401 CSR in the Bend-Based Ultra-Relativistic CeC Schemes

Speaker Yaroslav Serg Derbenev (JLab, Newport News, Virginia)

Authors Yaroslav Serg Derbenev (JLab, Newport News, Virginia)

Abstract I present a "hand-work" analysis of the ultra-relativistic Coherent electron Cooling (CeC) of hadron beams in the bend-based conceptual schemes taking into account the microwave coherent synchrotron radiation (CSR) process in the electron beam. The CSR in the e-beam driven by strong bends appears a major, dominant player of the gain process which actually can smash the desirable gain effect of the Coulomb's interaction of electrons. Limitations to the magnitude of the dipole magnetic fields when the CSR can be neglected are derived. On the other hand, here I undertake an attempt to reach understanding of that, would it be possible to re-direct the CSR from its destructive influence to a functional serving of the bend-based CeC as a consistent gain agent. Limitations of the gain in both, the Coulomb¿s and the CSR regimes, by the Landau damping due to the energy spread in the e-beam is taken into account as well as the smearing impact caused by the e-beam radial size.

S402 An Innovative Transverse Emittance Cooling Technique using a Laser-Plasma Wiggler

Speaker Oznur Apsimon (Cockcroft Institute, Warrington, Cheshire; The University of Liverpool, Liverpool)

Authors Oznur Apsimon, Aravinda Perera, Carsten Peter Welsch (Cockcroft Institute, Warrington, Cheshire; The University of Liverpool, Liverpool), Monika Yadav (Cockcroft Institute, Warrington, Cheshire; The University of Liverpool, Liverpool; UCLA, Los Angeles, California), Daniel Seipt (HZDR, Dresden), Yong Ma (Michigan University, Ann Arbor, Michigan), Guoxing Xia (UMAN, Manchester), Dino Anthony Jaroszynski (USTRAT/SUPA, Glasgow), Alexander Thomas (University of Michigan, Ann Arbor, Michigan)

Abstract We propose an innovative beam cooling scheme based on laser driven plasma wakefields to address the challenge of high luminosity generation for a future linear collider. For linear colliders, beam cooling is realised by means of damping rings equipped with wiggler magnets and accelerating cavities. This scheme ensures systematic reduction of phase space volume through synchrotron radiation emission whilst compensating for longitudinal momentum loss via an accelerating cavity. In this paper, the concept of a plasma wiggler and its effective model analogous to a magnetic wiggler are introduced; relation of plasma wiggler characteristics with damping properties are demonstrated; underpinning particle-in-cell simulations for laser propagation optimisation are presented. The oscillation of transverse wakefields and resulting sinusoidal probe beam trajectory are numerically demonstrated. The formation of an order of magnitude larger effective wiggler field compared to conventional wigglers is successfully illustrated. Potential damping ring designs on the basis of this novel plasma-based technology are presented and performance in terms of damping times and footprint was compared to an existing conventional damping ring design.

This work is currently under review by Physics of Plasmas and Controlled Fusion.

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S403 Experimental Demonstration of Optical Stochastic Cooling

Speaker Jonathan Jarvis (Fermilab, Batavia, Illinois)

Authors Jonathan Jarvis, Daniel Robert Broemmelsiek, Kermit Carlson, Dean Richard Edstrom, Dave Franck, Valeri Lebedev, Sergei Nagaitsev, Mark Obrycki, Henryk Piekarz, Alexander Leonidovich Romanov, Jinhao Ruan, James K Santucci, Giulio Stancari, Alexander Valishev (Fermilab, Batavia, Illinois), Swapan Chattopadhyay, Austin Dick, Philippe Regis-Guy Piot (Northern Illinois University, DeKalb, Illinois), Ihar Lobach (University of Chicago, Chicago, Illinois)

Abstract Simon van der Meer's Stochastic Cooling (SC) was vital in the discovery of the W and Z bosons in 1983 as it enabled sufficient accumulation of antiprotons and delivery of the required beam quality*. This execution of the innovative SC concept promptly earned van der Meer a share of the 1984 Nobel Prize in Physics. A terahertz-bandwidth extension of SC was proposed in 1993 by Mikhailichenko and Zolotorev**. This Optical Stochastic Cooling (OSC) used visible or infrared light rather than microwaves and was extended shortly after by Zolotorev and Zholents to the so-called transit-time method of OSC***. The world's first experimental demonstration of OSC has just concluded at Fermilab's Integrable Optics Test Accelerator (IOTA) ring. In this presentation, we will describe the OSC concept, the IOTA ring and OSC apparatus and then present the first experimental results for cooling and heating in one, two and three dimensions. We will also describe experimental studies of a single electron interacting with itself via the OSC physics.

* S. van der Meer, CERN-ISR-PO-72-31 (1972)
** A.A.Mikhailichkenko, M.S. Zolotorev, Phys. Rev. Lett. 71 (25), p. 4146 (1993)
*** M. S. Zolotorev, A. A. Zholents, Phys. Rev. E 50 (4), p. 3087 (1994)

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S404 Electron Cooler of the NICA Booster and Its Applications

Speaker Sergey Aleksandr Melnikov (JINR, Dubna, Moscow Region)

Authors Sergey Aleksandr Melnikov, Ekaterina Ahmanova, Andriy Kobets, Dmitry Sergeevich Korovkin, Oleg Orlov, Sergei Semenov, Anton Sergeev, Aleksei Anatolievich Sidorin (JINR, Dubna, Moscow Region), Andrey Ivanov (BINP SB RAS, Novosibirsk), Anton Alexandrovich Baldin (JINR, Dubna), Andrey Butenko, Igor Nikolai Meshkov, Konstantin Osipov, Anatoly O. Sidorin, Evgeny Syresin (JINR/VBLHEP, Dubna, Moscow region)

Abstract The report presents the results obtained during the commissioning the Electron Cooling System (ECS) of the Booster, the first in the chain of three synchrotrons of the NICA accelerator complex. The dependences of the electron beam current on the ECS parameters for different electron energy values were experimentally obtained. The specific features of operation of electron gun of the Booster ECS are hollow beam formation due to creation of virtual cathode confirmed both experiments and by numerical simulation. The work was performed without an ion beam and with a circulating ion beams 4He1+ and 56Fe14+ at ion injection energy of 3.2 MeV/u. In the first experiment (December 2020) with a circulating 4He1+ion beam, the effect of reducing the lifetime of the circulating ions was observed when the velocities of the cooling electrons and the cooled ions coincide. In second experiment (September 2021) the effect of electron cooling of 56Fe14+ ion beam was both for longitudinal and transverse degrees of freedom using `Schottky noise spectrometer and ionization profilometer.

S501 Future Developments for the HESR Cooler Prototype at Helmholtzinstitut Mainz

Speaker Kurt Aulenbacher (IKP, Mainz)

Authors Kurt Aulenbacher (IKP, Mainz)

Abstract At HIM in Mainz the test setup for the magnetized relativistic cooler is progressing. The first 600 kV module at 1:1 scale for the HESR-cooler has been installed in its pressure tank. Our goal is to show the scalability of the approach aiming at stacking 13 modules in the final version at HESR. Plans for the near future are reported. Ideas for converting the prototype into an experimental facility are presented.

S502 Observation of BIF at the Electron-Cooler Test-Bench at HIM

Speaker Thomas Beiser (HIM, Mainz)

Authors Thomas Beiser, Kurt Aulenbacher, Juergen Dietrich (HIM, Mainz)

Abstract Further wavelength-resolved studies of the beam-induced fluorescence have been made at the cooler teststand. As a new feature a low-noise, cooled sCMOS-camera was utilized. Beam-current dependence of the fluorescence has been recorded. Data evaluation is imminent and options for further experiments will be discussed.

S503 AD/ELENA Electron Cooling Experience During and after CERNs Long Shutdown (LS2)

Speaker Davide Gamba (CERN, Geneva)

Authors Davide Gamba, Lajos Bojtar, Christian Carli, Alexandre Frassier, Lars Varming Joergensen, Laurette Ponce, Gerard Tranquille (CERN, Geneva)

Abstract Electron cooling is a key ingredient of the Antimatter Factory at CERN, now composed of the AD and ELENA rings, both featuring an electron cooler. After the successful commissioning of the ELENA ring and electron cooling with antiprotons in 2018, the facility was shut down for the CERN long shutdown (LS2). In the meantime, ELENA has been operating with H- ions generated from a local source, and electron cooling of H- was demonstrated. The facility has restarted with antiproton operation during summer 2021, and it is now delivering 100 keV production beams through newly installed electro-static extraction lines to all the experiments for the very first time. We will give an overview of the experience gained and difficulties encountered during the restart of the AD and ELENA electron coolers. The experience with electron cooling of H- beam in ELENA and the comparison with antiproton cooling will also be presented.

S601 Electron Cooling of Colliding Ion Beams in RHIC: Status and Perspectives

Speaker Alexei V. Fedotov (BNL, Upton, New York)

Authors Alexei V. Fedotov, Wolfram Fischer, Xiaofeng Gu, Dmitry Kayran, Jorg Kewisch, Michiko Minty, Vincent Schoefer, Sergei Seletskiy, He Zhao (BNL, Upton, New York)

Abstract An electron cooling of ion beams employing a high-energy approach with rf-accelerated electron bunches was recently implemented at BNL using LEReC accelerator. Following successful cooling commissioning in 2019, it was used to cool ion beams in both collider rings with ion beams in collision. Electron cooler LEReC successfully operated for the RHIC physics program in 2020 and 2021 and was essential in achieving the required luminosity goals. Apart from its use in RHIC operations, LEReC is being used to study various aspects of electron cooling physics using short electron bunches. This presentation will summarize experience with electron cooling of colliding ion beams in RHIC, as well as ongoing studies.

Funding Agency Work supported by the U.S. Department of Energy

S602 Theory and Observation of Circular Attractors in Cooled Ion Bunches

Speaker Sergei Seletskiy (BNL, Upton, New York)

Authors Sergei Seletskiy, Alexei V. Fedotov, Dmitry Kayran (BNL, Upton, New York)

Abstract In electron coolers, under certain conditions, a mismatch in either gamma-factors or trajectory angles between an electron and an ion beam can cause formation of a circular attractor in the ion beam phase space. This leads to coherent excitations, rather than damping, of the ions with a small synchrotron or betatron amplitude and results in an unusual beam dynamics. In this paper we consider the effect of such coherent excitations, report the first observation of the circular attractor in a relativistic electron cooler and discuss the implications of this effect for high energy electron coolers proposed for the Electron Ion Collider (EIC).

S603 Magnetized Dynamic Friction Force in the Strong-Field, Short-Interaction-Time Limit

Speaker Ilya V. Pogorelov (RadiaSoft LLC, Boulder, Colorado)
Authors Ilya V. Pogorelov, David Leslie Bruhwiler (RadiaSoft LLC, Boulder, Colorado)

Abstract Relativistic magnetized electron cooling is one of the techniques explored for achieving the ion beam luminosity requirements of the presently designed electron-ion collider (EIC) facility at Brookhaven National Lab. Because the cooling system will have to operate in previously untested parameter regimes, accurate computation of magnetized dynamic friction is required at the design stage in order to obtain reliable estimates of the cooling time. At energies of interest to the EIC cooling system design, the beam-frame interaction time in the cooler becomes short compared to the plasma period, and some assumptions applicable to the physics of cooling at lower energies become invalid in this high-gamma setting. We present and discuss the results of first-principles modeling of magnetized dynamic friction force in the strong-field, short-interaction-time regime, as well as a parametric longitudinal friction force model that we developed starting with a reduced ion-electron interaction potential. The model parameters are related in a simple way to the interaction time and the ion charge. We compare our simulation results to the predictions of previously developed theoretical models.

Funding Agency This work was supported by the U.S. DOE Office of Science, Office of Nuclear Physics, under Award Number DE-SC0015212.

S701 Muon Ionization Cooling Experiment (MICE): Results & Prospects

Speaker Vittorio Carlo Palladino (INFN-Napoli, Napoli)
Authors Vittorio Carlo Palladino (INFN-Napoli, Napoli)

Abstract A high-energy muon collider could be the most powerful and cost-effective collider approach in the multi-TeV regime, and a neutrino source based on decay of an intense muon beam would be ideal for measurement of neutrino oscillation parameters. Muon beams may be created through the decay of pions produced in the interaction of a proton beam with a target. The muons are subsequently accelerated and injected into a storage ring where they decay producing a beam of neutrinos, or collide with counter-rotating antimuons. Cooling of the muon beam would enable more muons to be accelerated resulting in a more intense neutrino source and higher collider luminosity. Ionization cooling is the novel technique by which it is proposed to cool the beam. The Muon Ionization Cooling Experiment collaboration has constructed a section of an ionization cooling cell and used it to provide the first demonstration of ionization cooling. Here the observation of ionization cooling is described. The cooling performance is studied for a variety of beam and magnetic field configurations. The outlook for an experiment to measure muon ionization cooling in all six phase-space dimensions as part of the demonstrator facility being considered by the international Muon Collider collaboration will also be discussed.

Funding Agency STFC, NSF, DOE, INFN, CHIPP and more

S702 Plasma Lens in Parametric Resonance Ionization Cooling

Speaker Katsuya Yonehara (Fermilab, Batavia, Illinois)

Authors Katsuya Yonehara (Fermilab, Batavia, Illinois), Yaroslav Serg Derbenev, Vasiliy Morozov, Amy Sy (JLab, Newport News, Virginia), Rolland Paul Johnson (Muons, Inc, Illinois)

Abstract We present a concept of a plasma lens in a parametric resonance ionization cooling (PIC) for extra cooling of muon colliders. The PIC concept has been developed to overcome most aberrations. However, parasitic non-linear aberrations which is induced in an ionization cooling material still reduce a dynamic aperture of the PIC. The plasma lens generates an azimuthally symmetric focusing field in gas-filled RF cavities that is several orders of magnitude stronger than the conventional superconducting magnets. It allows for reduction of the beam size at the beam expansion points. This reduces the size of the aberrations and therefore greatly simplifies their compensation.

S703 Ionization Cooling Beamline for a Muon Collider

Speaker Diktys Stratakis (Fermilab, Batavia, Illinois)

Authors Diktys Stratakis (Fermilab, Batavia, Illinois)

Abstract A Muon Collider requires a reduction of the six-dimensional emittance of the captured muon beam by several orders of magnitude. We present a complete cooling scheme that should meet this requirement. The scheme starts with the front end of a proposed Neutrino Factory that yields bunch trains of both muon signs. Subsequently, a 6-dimensional ionization cooling lattice reduces the longitudinal emittance until it becomes possible to merge the trains into single bunches, one of each sign. Further 6-dimensional ionization cooling is applied to the single bunches followed by final linear transverse cooling within multi-Tesla solenoids. We review the main accelerator components involved in the above scheme as well detail the required beam and lattice parameters for successful cooling.

S801 Beam Dynamics in a Two Energy Storage Ring Cooler

Speaker Yuhong Zhang (JLab, Newport News, Virginia)

Authors Yuhong Zhang, Yaroslav Serg Derbenev, Vasiliy Morozov (JLab, Newport News, Virginia), Geoffrey Arthur Krafft (JLab, Newport News, Virginia; ODU, Norfolk, Virginia), Bhawin Dhital (ODU, Norfolk, Virginia), Fanglei Lin (ORNL RAD, Oak Ridge, Tennessee)

Abstract A high-current electron storage-ring cooler is proposed to cool ion beams in a collider to reduce the beam emittance and compensate the emittance degradation due to the intra-beam scattering (IBS) effect. Such a storage ring cooler is consisted of two sections with significantly different energies: the low energy section is designed for an optimum cooling of ion beams and the high energy section is optimized for desired damping parameters of electron beams. An energy recovering superconducting RF structure is used to provide the necessary energy change. Beam dynamics in this two-energy storage ring is different from and more complicated than it in a single energy system. This paper presents the linear optics design and particle tracking simulation results. IBS time versus damping time and optimization of beam parameters are also discussed in this paper.

Funding Agency This material is based upon work supported by the U.S. Department of Energy, Office of Science, and Office of Nuclear Physics under Contracts DE-AC05-06OR23177 and DE-AC02-06CH11357.

S802 Status of Coherent Electron Cooling Experiment at BNL

Speaker Vladimir N. Litvinenko (BNL, Upton, New York)

Authors Vladimir N. Litvinenko (BNL, Upton, New York)

Abstract We present currents the status and plans for the Coherent electron Cooling experiment (CeC X) at BNL. Since 2020, the CeC X utilizes a 4-cell Plasma Cascade micro-bunching Amplifier (PCA) with bandwidth of 20 THz. We report on results obtained during CeC X runs 2020 and 2021. These include measurements of ion imprint in electron beam, demonstration of high PCA gain and observation of recombination of electrons and Au ions. While we were unable to clearly established CeC cooling, we clearly observed weak regular electron cooling of 26.5 GeV/u ions - the record energy for electron cooling. We discuss challenges experienced during last run, improvements to the CeC X system and our plans for demonstration of CeC cooling in run 2022.

Funding Agency Work supported by Brookhaven Science Associates, LLC under Contract No. DE-AC02-98CH10886 with the U.S. Department of Energy and NSF Grant No. PHY-141525

S803 Wiggler Enhanced Plasma-Cascade Amplifier for Coherent Electron Cooling

Speaker Gennady Stupakov (SLAC, Menlo Park, California)

Authors Gennady Stupakov (SLAC, Menlo Park, California), Alexander Zholents (ANL, Lemont, Illinois)

Abstract Coherent electron cooling* using a plasma-cascade amplifier (PCA) can provide about hundred thousand times faster cooling rates of hadrons than the conventional microwave stochastic cooling due to an extremely wide bandwidth of a pickup modulator, a kicker, and the amplifier. PCA proposed in ** creates unstable plasma oscillations using modulation of a plasma frequency by means of the modulation of the transverse beam size using strong field solenoids. Instead we propose to use modulation of the average longitudinal velocity of electrons replacing the solenoids by the wiggler magnets. This approach promises obtaining a more compact amplifier due a more efficient modulation of the plasma frequency, although it requires separation of the hadron and the electron orbits in the amplifier region.

* V. N. Litvinenko and Ya. S. Derbenev, Coherent Electron Cooling, PRL 102, 114801 (2009).
** V. N. Litvinenko et al., Plasma-cascade instability, Phys. Rev. Acc. and Beams, 24, 014402 (2021).

Funding Agency This work supported by the Director, Office of Science, Office of Basic Energy Sciences, of the U.S. Department of Energy under Contracts No. DE-AC02-06CH11357 and DE-AC02-76SF00515.

P1001 Simulation of High Energy Proton Beam Cooling in EicC

Presenter Fu Ma (IMP/CAS, Lanzhou)

Authors Fu Ma (IMP/CAS, Lanzhou)

Abstract The hadron beam cooling plays an important role in the future electron-ion collider machine to achieve its physics goals. Because of the large initial emittance and high energy in the polarized Electron Ion Collider facility in China (EicC), a two-stage beam cooling scheme is proposed. A traditional electron cooler is used to reduce the ion beam emittance at the booster ring (BRing), and a high energy bunched electron beam cooling system which is based on an energy recovery linac (ERL) is necessary to compensate for the intra-beam scattering effect and maintain the ion beam emittance during the collision at the collider ring (pRing). In this paper, we report some simulation studies on how the cooling rate will be affected by the electron bunch size, magnetic field, and ring parameters in the cooling section of the high energy bunched electron beam cooling and obtain some initial results.

P1002 Simulation of Transverse Electron Cooling and IBS of 20 GeV Proton Beam at EicC

Presenter Xiaodong Yang (IMP/CAS, Lanzhou)

Authors Xiaodong Yang (IMP/CAS, Lanzhou)

Abstract The transverse cooling and intra-beam scattering processes of 20 GeV proton beam were simulated with the help of the code at Electron Ion collider in China. The transverse cooling time were obtained in the different parameter configurations of storage ring, proton beam, electron cooling device and electron beam. The scattering time of proton beam were presented in the cases of different initial emittance and particle number. The final equilibrium transverse emittance were estimated in the cases of different initial emittance and particle number. From the simulated results, the transverse cooling time of 20 GeV proton beam is over 100 seconds. The transverse cooling time can be shorten with the help of proper configuration of the parameters.

P1003 Recommissioning of the CRYRING@ESR Electron Cooler

Presenter Claude Krantz (GSI, Darmstadt)

Authors Claude Krantz, Zoran Andelkovic, Christina Dimopoulou, Wolfgang Geithner, Thomas Hackler, Frank Herfurth, Regina Hess, Michael Lestinsky, Esther Menz, Andreas Reiter, Jon Roßbach, Claus Schroeder, Alexander Täschner, Gleb Vorobjev (GSI, Darmstadt), Christian Weinheimer (Institut für Kernphysik, Münster), Carsten Brandau, Stefan Schippers (Justus-Liebig-University Giessen, Giessen), Volker Hannen, Daniel Winzen (Westfälische Wilhelms-Universität Münster, Münster)

Abstract The cooler storage ring CRYRING has been recommissioned at GSI as a Swedish in-kind contribution to FAIR. Within the CRYRING@ESR project, it complements the heavy-ion facilities of GSI by a dedicated low-energy machine. Large parts of the CRYRING@ESR

experimental programme rely on electron cooling as a means of beam preparation. itionally, the cooler serves itself as low-energy internal electron target in atomic physics experiments. Upon installation of the cooler at GSI/FAIR, a number of technical upgrades have been made to improve operational performance and flexibility as an experimental platform. These include custom-made precision voltage dividers for monitoring the acceleration potential on the < 10 ppm level, as well as an experiment control system allowing rapid modulation of the electron energy. In recent GSI beamtimes, the electron cooler has been used successfully for cooling of highly-charged and singly-charged heavy-ion beams. Further hardware upgrades and dedicated experiments to characterise machine performance are planned.

Funding Agency Parts of this work have been supported by the German Federal Ministry of Education and Research (BMBF) under contract numbers 05P19PMFA1 and 05P19RGFA1.

P1004 Simulation of Bunched Schottky Spectrum for Laser-Cooled O5+ Ions at CSRe

Presenter Hanbing Wang (IMP/CAS, Lanzhou)

Authors Hanbing Wang, Dongyang Chen, Xinwen Ma, Weiqiang Wen, Youjin Yuan (IMP/CAS, Lanzhou)

Abstract Laser cooling of O5+ ion beams with an energy of 275.7 MeV/u was successfully achieved at the storage ring CSRe in Lanzhou, China. In order to explain the experimental results, by employing the multi-particle tracking method we made simulations of the bunched Schottky spectrum of O5+ ions with and without laser cooling. In the simulation, both of the transverse oscillation and the photon-ion resonant interaction process are considered while intra beam scattering is ignored. For bunched ion beams without laser cooling, the power of the central peak is about several orders of magnitude larger than that of the sideband peaks, which was called the "coherent effect". The simulation systematically studied the relationship of the Schottky power and the ions number at different observation harmonics and make clear about this ¿coherent effect¿ for the first time. For laser-cooled bunched ion beams, with more ions laser-cooled to center of the bucket, the distribution of the Schottky spectrum becomes narrower than that of the uncooled ion beams. However, the simulated bunched Schottky spectrum for laser-cooled ion beams shows strong sidebands at the position where laser resonant interacts with ions. The reason is that the beta-oscillation in the laser cooling straight section is simplified by using a mean betatron-function value. The further simulation is in progress. With this simulation, the dynamics for the laser cooling of bunched ion beams are fully understood for the first time.

P1005 Comparison of Available Models of Electron Cooling and Their Implementations

Presenter Agnieszka Elzbieta Borucka (Warsaw University of Technology, Warsaw; CERN, Geneva)

Authors Agnieszka Elzbieta Borucka (Warsaw University of Technology, Warsaw; CERN, Geneva), Davide Gamba, Andrea Latina (CERN, Geneva)

Abstract Modelling of the electron cooling process is complex and challenging. The simulation needs to include elements like ions, plasma of electrons, the thermal effects of electrons and the

influence of the magnetic field. In this work, the performance of three available tools, namely RF-Track, Betacool, and JSPEC, are discussed taking into account only the cooling effect and neglecting any heating effect. The friction force and cooling times are studied in a wide range of different parameters presenting the main behaviour of the available models together with the limitations of particular simulation codes. Furthermore, a qualitative comparison with experimental data is performed.

P1006 Design of the SRing Electron Target

Presenter Jie Li (IMP/CAS, Lanzhou)

Authors Jie Li (IMP/CAS, Lanzhou)

Abstract An electron target is proposed for high precision experimental measurement at the SRing (Spectrometry Ring) of HIAF (High Intensity heavy ion Accelerator Facility). It provides low temperature electron beam with a few meV at the energy of 10-80 keV. The routine method is adopted by magnetic adiabatic expansion with a factor of 30 after acceleration within 1.2 T longitudinal magnetic field at gun section. In this paper, the optimized design of the electron target is introduced.

P1007 High Voltage Power Supply System for Electron Cooler for NICA

Presenter Dmitry Nikolaevich Skorobogatov (BINP SB RAS, Novosibirsk)

Authors Dmitry Nikolaevich Skorobogatov, Alexander Putmakov, Vladimir Borisovich Reva (BINP SB RAS, Novosibirsk)

Abstract The high-voltage power supply system for the electron cooling system of NICA collider ring in the JINR (Dubna, Russia), currently developing at the BINP. The main features are - two accelerating columns with maximum voltage of 2500 kV, stability - 10 ppm, with the load ability 1 mA and nominal current 100 uA. The key points of this design are presented in this article.

P1008 Demonstration of Electron Cooling using a Pulsed Beam from an Electrostatic Electron Cooler

Presenter Haipeng Wang (JLab, Newport News, Virginia)

Authors Max Wilhelm Bruker, Stephen Vincent Benson, Andrew Hutton, Kevin Jordan, Tom Powers, Robert Rimmer, Todd Satogata, Amy Sy, Haipeng Wang, Shaoheng Wang, He Zhang, Yuhong Zhang (JLab, Newport News, Virginia), He Zhao (BNL, Upton, New York), Jie Li, Fu Ma, Xiaoming Ma, Lijun Mao, Xiaoping Sha, Jiancheng Yang, Xiaodong Yang, Hongwei Zhao (IMP/CAS, Lanzhou)

Abstract Electron cooling continues to be an invaluable technique to reduce and maintain the emittance in hadron storage rings such as the EIC and EICC where stochastic cooling is inefficient and radiative cooling is negligible. Extending the energy range of electron coolers beyond what is feasible with the conventional, electrostatic approach necessitates the use of RF fields for acceleration and, thus, a bunched electron beam. To experimentally investigate how the relative time structure of the two beams affects the cooling properties, we have set up a pulsed-beam cooling device by adding a synchronized pulsing circuit to the conventional electron source of the CSRm cooler at Institute of Modern Physics. Using both constant and modulated synchronization between electron pulses and ion bunches, we have measured the effects of the electron bunch length and longitudinal ion focusing strength on the temporal evolution of the longitudinal and transverse ion beam profile and demonstrated the detrimental effect of timing jitter as predicted by space-charge theory and simulations. Our experiment suggests a need for further investigations of specific aspects of bunched cooling such as synchro-betatron coupling and phase dithering effects when using short electron bunches to cool longer ion bunches. However, given the comparatively long IBS lifetime of higher-energy proton storage rings like the EIC, slow dithering could potentially provide an option to save cost on the electron cooler linac.

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P1009 JSPEC - an Open Source Program for IBS and Electron Cooling Simulation

Presenter He Zhang (JLab, Newport News, Virginia)

Authors He Zhang, Stephen Vincent Benson, Max Wilhelm Bruker, Yuhong Zhang (JLab, Newport News, Virginia)

Abstract The intrabeam scattering can affect the accumulation, the lifetime, and the property of a high-intensity beam. Electron cooling is a method to mitigate the intrabeam scattering effect. JSPEC (JLab Simulation Package on Electron Cooling) is an open-source program developed at Jefferson Lab, which includes various numerical models and friction force formulas for intrabeam scattering and electron cooling simulations. JSPEC has been benchmarked with BETACOOL and experimental data. In this report, we will introduce what features JSPEC provides to the users and how it carries out the computations. Numerical examples are presented to demonstrate the performance and the validity of JSPEC.

Funding Agency This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under contract DE-AC05-06OR23177.

P1010 Optimization of the Electron Emission From Carbon Nanotubes for Electron Cooling in ELENA

Presenter Bruno Galante (CERN, Meyrin)

Authors Bruno Galante, Gerard Tranquille (CERN, Meyrin), Javier Resta-Lopez (ICMUV, Paterna), Carsten Peter Welsch (The University of Liverpool, Liverpool)

Abstract Electron cooling is a process that guarantees beam quality in low energy antimatter facilities. In ELENA the electron cooler allows to reduce the emittance blow-up of the antiproton beam, thus delivering highly focused and bright beams at the unprecedented low energy of 100 keV to the experiments. In order to have a "cold" beam at such low energy, the electron gun of the cooler must emit a monoenergetic and relatively intense electron beam. Simulations have shown that efficient cooling can be achieved with a 5 mA electron beam having transverse

energy spread of less than 100 meV and longitudinal energy spread of about 1 meV. A thermionic gun is currently used in operation, although it limits the performances due to a relatively high transverse energy of the emitted beam (>> 100 meV). Therefore, an optimization of the ELENA e-cooler gun is currently being studied, with the aim to develop and design a cold cathode e-gun based on carbon nanotubes acting as cold electron field emitters. The use of carbon nanotube arrays for electron emission implies the need of an extracting grid in order to allow a stable and uniform emission at relatively low electric fields. The grid and its features become then critical to control the electron beam properties. In this contribution we present a simulation study of the current extraction from a field emitting material involving different extracting grid types and how they affect the beam properties. Eventually, we propose a new gun layout.

P2001 Short Solenoid 21, 28, 35, and 42 T Cooling Channel for a Muon Collider

Presenter John Acosta (Universidad Distrital Francisco Jose de Caldas, Bogota)

Authors John Acosta, Nelson Libardo Forero, Sandra Jimena Oliveros (Universidad Distrital Francisco Jose de Caldas, Bogota), Lucien Cremaldi, Terrence Lee Hart (UMiss, University, Mississippi)

Abstract Many scientists are presently discussing the need to build a high luminosity muon collider. A drastic 6D emittance reduction is required. A 45T solenoid prototype with a 14 T superconducting insert and a 31 T copper outset operating in Florida makes the required magnetic fields feasible. A final muon cooling scheme using short 21, 28, 35, and 42 T solenoids is explored by ICOOL simulations. The scheme takes four 57 meters long cooling stages with short HTS solenoids up to 42 T for a 200 MeV/c muon beam. This stage reduces the emittance to (90,90,850) microns from the (280,280,1570) microns obtained on previous cooling channels. A septa system makes the muon bunch transversely sliced into 16 parts. Trombones space the 16 bunches into a 3.7 meter long train. One 14 nanosecond kicker aligns all 16 bunches. Finally, a dogbone accelerates the bunch train for injection into a 21 GeV/c ring. RF and snap bunch Coalescence remove empty spaces in the train in 55 microseconds (muon survival is 87%). The final xyz muon emittance is (25, 25, 17000) microns.

P2002 Suspended Ground Microstrip Coupled Slotline Electrode for Stochastic Cooling

Presenter Stefan Wunderlich (GSI, Darmstadt)

Authors Stefan Wunderlich, Claudius Peschke (GSI, Darmstadt)

Abstract An alternative design of a slotline electrode has been developed and simulated. In contrast to the planar slotline pick-up designed for FAIR CR and the slot-ring electrode built by FZJ for FAIR HESR, the presented design uses suspended microstrip lines for the coupling to a planar slotline. This has some advantages and disadvantages for kicker and pick-up applications in respect of losses, power handling, and mechanical aspects.

P2003 Control Features of the Plunging Pick-Up Electrodes With Real Time Digital Data Processing

Presenter Rainer Hettrich (GSI, Darmstadt)

Authors Rainer Hettrich (GSI, Darmstadt)

Abstract The Pick-Up electrodes of the CR Stochastic cooling can be positioned very precisely and fast. In normal operating state a function without jerk provides the set values for an underlying position control loop. Merging the electrodes however with the drive parts within a narrow tank is expected to be very challenging. For installation and service it might need a manual control facility, which allows to steer the mobile drive rods slowly to the connecting electrodes. Hence eight hand wheels, one at each drive, are to be expected a manual positioning of each. A star-shaped network from several wheel-controllers to a central computer was implemented. A smooth and data saving transmission is intended to be achieved by the application of approved techniques from real time data processing. The equipment of analog drive systems with digital regulation and control systems allows to change the proportion between drive distance and angle of rotation of a hand wheel only by means of software.

P2004 A New Electron Cooler for the CERN Antiproton Decelerator (AD)

Presenter Gerard Tranquille (CERN, Geneva)

Authors Gerard Tranquille, Jean Cenede, Alexandre Frassier, Alexandre S. Sinturel (CERN, Geneva), Lars Varming Joergensen, Jose Antonio Ferreira Somoza (CERN, Meyrin)

Abstract The current electron cooler at the Antiproton Decelerator (AD) at CERN was built in the second half of the 1970s and is thus well over 40 years old. It was built for the Initial Cooling Experiment (ICE) where stochastic and electron cooling were tested to ascertain the feasibility of using these techniques to generate high intensity antiproton beams for the SPpS. The ICE electron cooler was subsequently upgraded and installed in LEAR (Low Energy Antiproton Ring) to help generate intense beams of antiprotons at low energies. After the stop of the antiproton physics at LEAR in 1996 and two years of studies of electron cooling of Pb ions, the electron cooler was moved to the AD where it has been in use ever since. With the new ELENA ring becoming operational, a major consolidation project has been launched to extend the life of the AD and as a part of this a new electron cooler for the AD is being built. In this paper, we describe some of the design considerations and challenges of this project as well as the expected gains in terms of cooling performance.

P2005 Tests of the Gun Prototype for the Electron Cooling System of the NICA Collider

Presenter Andrey Petrovich Denisov (BINP SB RAS, Novosibirsk)

Authors Andrey Petrovich Denisov, Maxim Igorevich Bryzgunov, Alexander Bubley, Vladimir Chekavinskiy, Anatoly Danilovich Goncharov, Andrey Ivanov, Vasily Parkhomchuk, Vladimir Borisovich Reva (BINP SB RAS, Novosibirsk), Eldar Rustamovich Urazov (NSU, Novosibirsk)

Abstract The efficiency of the electron cooling depends on the electron beam quality produced be the electron gun. The characteristics of the electron gun were tested on the test bench with the linear transport channel. For the beam diagnostics, we used beam position monitors alongside with the W-Re wire sensor for 1-D quantitative profile measurements. We also used a high-definition CCD camera with high sensitivity for qualitative 2-D measurements of the electron density distribution via the wire thermal radiation.

P2006 Cascade Transformer for High Voltage Coolers

Speaker Vasily Parkhomchuk (BINP SB RAS, Novosibirsk)

Authors Vasily Parkhomchuk, Maxim Igorevich Bryzgunov, Anatoly Danilovich Goncharov (BINP SB RAS, Novosibirsk), Vladimir Borisovich Reva (BINP SB RAS, Novosibirsk; NSU, Novosibirsk)

Abstract The acceleration and deceleration tubes need the electric power for operation. At BINP different systems were used: many cascade transformers, pressed gas turbine generators, dynamitron system. Experience of using the different systems for powering the high voltage coolers is discussed.

P2007 Anomalous Longitudinal Schottky Signals of Coasting Ion Beams with Interaction of a CW laser at Storage Ring CSRe

Presenter Dongyang Chen (IMP/CAS, Lanzhou)

Authors Dongyang Chen, Zhongkui Huang, Xinwen Ma, Hanbing Wang, Weiqiang Wen, Youjin Yuan (IMP/CAS, Lanzhou), Dacheng Zhang (Xidian University, Xi'an)

Abstract Laser cooling of relativistic heavy ion beam is considered as frontiers at the current heavy storage ring CSRe as well as the future High Intensity heavy-ion Accelerator Facility (HIAF) at the Institute of Modern Physics in China. Laser cooling of lithium-like 16O5+ ion beams with a relativistic energy of 275.7 MeV/u has been realized for the first time at the CSRe. In this experiment, a very broad interaction range of the counter-propagating fixed cw laser with a coasting ion beam has been observed on the longitudinal Schottky spectrum, which is much broader than the estimated width caused by the natural linewidth of the laser and ion¿s optical transition*. In order to understand this anomalous observation, a single-particle tracking method has been developed to investigate the interaction of coasting ion beams and a cw laser. It is found that the interaction range is highly enlarged by the betatron oscillations of the ion beams in the transverse plans caused by the focusing and defocusing of quadrupoles in the straight section of the CSRe. The good agreement between simulations and experimental results lay a foundation for our simulations of the laser cooling of bunched ion beams and paves the way for the forthcoming experiments of laser cooling and precision laser spectroscopy at the storage ring CSRe.

* W. Wen, H. Wang, Z. Huang, et al., Hyperfine Interactions, 240:45 (2019).

P2008 Improvements to Simulations of Microbunched Electron Cooling for the EIC

Presenter William Frederick Bergan (BNL, Upton, New York)

Authors William Frederick Bergan (BNL, Upton, New York)

Abstract Microbunched electron cooling (MBEC) is a promising new technique for cooling dense hadron beams. It operates by copropogating the hadron beam with a beam of electrons, during which time the hadrons induce an energy modulation on the electrons. This is amplified, turned into a density modulation, and acts back on the hadrons in order to give them energy kicks which tend to reduce their initial energy spread and emittance. We plan to use this technique to cool the proton beams at the Electron-Ion Collider (EIC). In order to better understand the process, we have expanded on our simulation codes of cooling times and saturation effects, allowing us to explore such issues as variable Courant-Snyder parameters within the lattice elements.

Funding Agency Work supported by Brookhaven Science Associates, LLC under Contract No. DE-SC0012704 with the U.S. Department of Energy.

P2009 A Perturbative Technique for 3D Modeling of the Microbunched Electron Cooling Concept

Presenter Ilya V. Pogorelov (RadiaSoft LLC, Boulder, Colorado)

Authors Ilya V. Pogorelov, David Leslie Bruhwiler, Christopher Hall (RadiaSoft LLC, Boulder, Colorado), Gennady Stupakov (SLAC, Menlo Park, California)

Abstract Because the efficacy of conventional electron cooling falls off rapidly with energy, reaching the cooling times at collision energy targeted by the Electron-Ion Collider (EIC) design can be challenging. A possible solution is offered by cooling schemes that are based on fundamentally different techniques such as microbunched electron cooling (MBEC). Regular PIC simulations of MBEC in the parameter regime of the EIC cooling system would require a prohibitively large number of particles to resolve the evolution of the ion-imprinted phase space density modulation. We explored a solution to this problem by developing and implementing in the code Warp an approach based on two perturbative techniques, the beam-frame delta-f method and a variant of the distribution difference (DD) technique. To model the dynamics of the ion-seeded modulation in the MBEC chicanes, we developed an approach that combines the DD and quiet start techniques with analysis of correlations between the divergence of DD trajectories and their location within the e-beam. We have also prototyped in Warp the computation of the time-dependent 3D wakefield in the MBEC kicker.

Funding Agency This work was supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under Award Number DE- SC0020592.

P2010 Features of the Pickup Diagnostic at Low Energy in the Cooler of NICA Booster

Presenter Vladimir Borisovich Reva (BINP SB RAS, Novosibirsk)

Authors Vladimir Borisovich Reva, Maxim Igorevich Bryzgunov, Vasily Parkhomchuk (BINP SB RAS, Novosibirsk)

Abstract This work deals with an experimental study of changes in the amplitude of the sum signal induced at pickup stations, which can be associated with the formation of space charge waves arising along the electron beam. In the case of low electron energies, the space charge of the beam can have a significant effect on the interpretation of the obtained experimental data.