Partical dynamics in accelerators and storage rings and cooling methods

Invited Oral

MOZCH01 Beam Instability Phenomena observed at HIRFL-CSR in the Presence of Electron Cooler

Speaker Xiaodong Yang (IMP, Lanzhou)

Authors Xiaodong Yang, Guohon Li, Jie Li, Peng Li, Xiaoming Ma, Ruishi Mao, Tailai Yan, Jiancheng Yang, Youjin Yuan, Tiecheng Zhao (IMP, Lanzhou), Lijun Mao (FZJ, Jülich; IMP, Lanzhou)

Abstract The 35kV and 300kV electron coolers of HIRFL-CSR have come into routine operation. Some signal samples acquired from BPM and Schottky probes during operation were presented in this paper, and they were observed in the different operation periods such as during injection, after cooling and cooling force measurement. These signals were considered related with the ion beam instability. The central frequency of ion beam varied with the time. Some were caused by the ripple of hardware, the other were created by ion beam itself. The reasons which caused these phenomena were analysed. The possible solutions were suggested, and some necessary upgrade and improvements were expected. These results were helpful to attempt the Schottky Mass Spectrometry measurement in the CSR.

TUXCH01 High Voltage Electron Cooler

Speaker Vasily Parkhomchuk (BINP SB RAS, Novosibirsk)

Authors Vasily Parkhomchuk, Maxim Igorevich Bryzgunov, Vitalij Panasyuk, Vladimir Borisovich Reva (BINP SB RAS, Novosibirsk), Alexander Bubley (BINP, Novosibirsk), Juergen Dietrich, Vsevolod Kamerdzhiev (FZJ, Jülich)

Abstract The results of commissioning with electron beam the high voltage electron cooler for COSY synchrotron will report.

TUXCH02 New Developments in High Energy Electron Cooling

Speaker Juergen Dietrich (DELTA, Dortmund)

Abstract Electron cooling of hadron beams is a powerful technique by which accelerator facilities achieve the necessary beam brightness for their physics research. An overview on the latest developments in high energy electron cooling (electron beam energy higher than 500 KeV) is given. Technical feasibility for electron beam energy up to 8 MeV is discussed.

TUXCH03 Approach to the Low Temperature State oriented for Crystalline Beam

Speaker Akira Noda (Kyoto ICR, Uji, Kyoto)

Authors Akira Noda, Masao Nakao, Hikaru Souda, Hiromu Tongu (Kyoto ICR, Uji, Kyoto), Hiromi Okamoto, Kazuya Osaki (HU/AdSM, Higashi-Hiroshima), Yosuke Yuri (JAEA/TARRI, Gunma-ken), Igor Nikolai Meshkov, Alexander V. Smirmov (JINR, Dubna, Moscow Region), Manfred Grieser (MPI-K, Heidelberg), Koji Noda, Toshiyuki Shirai (NIRS, Chiba-shi), Zhengqi He (TUB, Beijing)

Abstract With the use of S-LSR, an ion storage and cooler ring at ICR, Kyoto University, approach to attain the low temperature beam has been continued in these several years. Based on the realization of one dimensional ordered state of 7 MeV proton beam by an electron cooling*, effort to reach lower temperature by laser cooling with much
stronger cooling force, has been continued for 40 keV Mg ion beam. With the use of synchro-betatron resonance coupling (SBRC), longitudinal cooling effect can be well expected to be transferred to the transverse directions** and we have experimentally demonstrated of such effect***. The transverse cooling efficiency is, however, not so good deteriorated by intra-beam scattering (IBS) effect for the beam intensities higher than 10E7. Although the reduction of the beam intensity keeping enough S/N ratio for observation of the beam, is not so easy, we are now challenging "controlled scraping", which controls the horizontal scraper position according to the extent of the indirect horizontal laser cooling by SBRC. In the present paper, our research stream from electron cooling to multi-dimensional laser cooling is surveyed at first and then challenge toward the crystalline beam is to be presented.

TUXCH04 ELENA Project: An Overview
Speaker Stephan Maury (CERN, Geneva)
Authors Stephan Maury (CERN, Geneva)
Abstract Approved in June 2011, the aim of the Extra Low ENergy Antiproton ring (ELENA) is the increase of the number of antiprotons delivered to the Antiproton Decelerator (AD) physics community. ELENA is a small machine and decelerates the antiprotons injected from AD at 5.3 MeV kinetic energy to 100 keV. The ring is equipped with an electron cooler to compensate the adiabatic blow-up to avoid beam losses during deceleration and to reduce beam phase space at extraction. Design work is progressing on machine parameters, ring, transfer lines, vital subsystems and the infrastructure.

TUYCH01 Application of the Beam Cooling Methods at the NICA Project
Speaker Grigoriy Trubnikov (JINR, Dubna, Moscow Region)
Authors Grigoriy Trubnikov, Igor Nikolai Meshkov, Anatoly O. Sidorin, Alexander V. Smirnov, Sergey Yakovenko (JINR, Dubna, Moscow Region), Takeshi Katayama (GSI, Darmstadt)
Abstract The Nuclotron-based Ion Collider fAcility (NICA) is a new accelerator complex being constructed at JINR aimed to provide experiments with colliding heavy ions up to Au for experimental study of hot and dense strongly interacting baryonic matter and search for possible signs of the mixed phase and critical endpoint in the centre-of-mass energy range \( \sqrt{s_{NN}} = 4-11 \) GeV. This facility includes new 3 MeV/u linac, 600 MeV/u booster synchrotron (Booster), upgraded superconducting (SC) synchrotron Nuclotron (4.5 GeV/u maximal kinetic energy for ions with \( Z/A = 1/3 \)) and collider consisting of two vertically separated SC rings, which provide average luminosity of the order of \( 10^{27} \text{cm}^{-2}\text{s}^{-1} \) at high energies. Beam cooling systems are proposed for elements of the NICA project. The Booster synchrotron will be equipped with an electron cooling system. Two beam cooling systems – stochastic and electron will be used in the collider rings. Parameters of the cooling systems, proposed scenario of operation and peculiarities of their design intended to achieve required beam parameters are presented in this report.

TUYCH02 Beam Cooling at NICA Collider Project
Speaker Takeshi Katayama (GSI, Darmstadt)
Authors Takeshi Katayama (GSI, Darmstadt), Igor Nikolai Meshkov, Grigoriy Trubnikov (JINR, Dubna, Moscow Region)
Abstract At the NICA collider project it is planned to make collision of 24 short bunches, each containing around \( 1 \times 10^9 \) 197Au79+ ions, at the two colliding points in the ring. The operation energy is envisaged from 1 GeV/u to 4.5 GeV/u. To prepare such beam conditions, the beam cooling technique, stochastic and electron beam, is employed at the beam accumulation from the injector Nuclotron and the following short bunch
formation stage. Rather long pulse beam could be injected and accumulated in the collider with use of barrier voltage and beam cooling. After the enough beam accumulation, typically 2.4e10, the high voltage RF with harmonic number 24 is applied to the accumulated coasting beam as well as the beam cooling which allow us to make the required short bunch of around 1nsec rms bunch length. The equilibrium condition is attained after 100~200 sec cooling, with the balance of RF force, cooling effects, IBS diffusion and the space charge repulsion force. In the present paper, detailed simulation results of beam accumulation and short bunch formation with stochastic cooling and electron cooling are presented including the space charge effects.

**TUCH03 Stored Low-Energy Ion Beams and Electron Cooling at eV Energies**

**Speaker** Andreas Wolf (MPI-K, Heidelberg)

**Authors** Andreas Wolf (MPI-K, Heidelberg)

**Abstract** Molecular ion beams are applied for studies of basic quantum dynamics in molecules and clusters and for investigating molecular processes important in astrophysical and terrestrial low-temperature plasmas. In the 1.5-m magnetic storage ring TSR, molecular ions of masses up to ~40 were stored at energies below 3 MeV. Here, efficient electron cooling was performed with low-energy electron beams from a photocathode at laboratory electron energies of, e.g., 54 eV for CF+ and 34 eV for D2Cl+ and the beams were used for studying cross sections, product branching ratios and product momenta for dissociative recombination at collision energies down to ~1 meV (10 K thermal energy). For further studies of this type a cryogenic low-energy electrostatic storage ring (CSR) operated at 10 K, is under construction at MPIK in Heidelberg. The ring represents a bridge between cooler storage rings and electrostatic trapping devices and follows new approaches for most of its key parts, from ion creation to fragment imaging with cryogenic detectors. It will incorporate an electron cooling device for 1 eV laboratory energy electron beams. Experimental results and operation at TSR as well as progress toward the CSR will be presented.

**Contributed Oral**

**TUACH01 Status of the High Voltage Electron Cooler Project for NICA Collider**

**Speaker** Sergey Yakovenko (JINR, Dubna, Moscow Region)

**Authors** Sergey Yakovenko, Ekaterina Ahmanova, Alexander Ivanov, Andriy Kobets, Igor Nikolai Meshkov, Alexander Rudakov, Alexander V. Smirnov, Nikolai Dmitrievich Topilin (JINR, Dubna, Moscow Region), Alexey Shabunov (JINR/VBLHEP, Moscow)

**Abstract** The electron cooling system at electron energy up to 2.5 MeV for the NICA collider is under design at JINR. The magnetic system and system of transfer of capacity on high potential is developed. The high voltage generator prototype on 250 kV was tested. The technical design of the electron cooling system was started.

**TUACH02 Long Term Beam Dynamics Simulation with the BETACOOL Code**

**Speaker** Alexander V. Smirnov (JINR, Dubna, Moscow Region)

**Authors** Alexander V. Smirnov (JINR, Dubna, Moscow Region)

**Abstract** General goal of the BETACOOL program is to simulate long term processes (in comparison with the ion revolution period) in the ion storage ring leading to variation of the ion distribution function in 6 dimensional phase space. The ion beam motion inside a storage ring is supposed to be stable and it is treated in linear approximation. Results of the numerical simulation of the beam dynamics for new projects FAIR (GSI, Germany) and NICA (JINR, Russia) are presented.
Invited oral

TUZCH01  Current Plans for Beam Cooling at FAIR
Speaker  Markus Steck (GSI, Darmstadt)
Authors  Markus Steck (GSI, Darmstadt)
Abstract  In the new FAIR accelerator facility the production of intense secondary beams largely relies on beam cooling. The pre-cooling of secondary beams, either antiprotons or rare isotopes, is performed in the large acceptance Collector Ring (CR). A stochastic cooling system is under development which can be applied to both species, although they have different velocities. After transfer of the pre-cooled beams to the High Energy Storage Ring (HESR) stochastic and electron cooling will be available. In the HESR cooling allows accumulation of secondary beams, improvement of beam quality and luminosity for internal experiments and compensation of beam heating by the internal target. The proposed cooling procedures and the status of the beam cooling systems will be reviewed.

TUZCH02  Mathematical Modeling and Optimization of Beam Dynamics in Accelerators
Speaker  Dmitri A. Ovsyannikov (St. Petersburg State University, St. Petersburg)
Authors  Dmitri A. Ovsyannikov (St. Petersburg State University, St. Petersburg)
Abstract  In this paper we treat the problem of beam dynamics optimization as a control theory problems. We consider different mathematical model of optimization. The approach to solving optimization problem for charged particle dynamics in accelerators includes: construction of mathematical model of controlled dynamical process; choice of control functions or parameters of optimization; construction of quality functionals, which allow efficient evaluation of various characteristics of examined controlled motion; analytical representation of the functional variations, which allow to construct various methods of optimization for quality functionals; construction of methods and algorithms of optimization. Problem of statement is considered on the pattern of RFQ channel.

Contributed oral

TUCH01  Transient Beam Response in Synchrotrons with a Digital Transverse Feedback System
Speaker  Vyacheslav Zhabitsky (JINR, Dubna, Moscow Region)
Authors  Vyacheslav Zhabitsky (JINR, Dubna, Moscow Region)
Abstract  The transient beam response on an externally applied impulse force in synchrotrons with a digital transverse feedback system is studied. Experimental data from the LHC on damping of coherent transverse oscillations excited by the discrete-time unit impulse are analysed. Good agreement on the measured and theoretically predicted decrements has been obtained. A method of feedback fine tuning, based on measurements of bunch response on harmonic excitation impulse, is discussed.

TUCH02  Study of Beam Dynamics in JINR Phasotron
Speaker  Leonid Onischenko (JINR/DLNP, Dubna, Moscow region)
Authors  Sergey Kostromin (JINR, Dubna, Moscow Region), Leonid Onischenko (JINR/DLNP, Dubna, Moscow region)
Abstract  JINR Phasotron is a synchrocyclotron with spiral sectors focusing magnetic structure. Beam dynamics was studied by means of simulations of acceleration and extraction process with a specially developed computer code. The beam extraction efficiency in the preliminary calculations was found to be more than 40%. Beam transverse
parameters calculated during tracking through the extraction channel.

**TUCCH01 New Ideas for Crystal Collimation**

**Speaker** Alexei Igorevich Sytov (Belarussian State University, Minsk)

**Authors** Victor Vasilievich Tikhomirov, Alexei Igorevich Sytov (Belarussian State University, Minsk)

**Abstract** Beam halo represents considerable threat for superconducting magnets. Crystals can increase the efficiency of collimation system being used both in channeling and volume reflection modes. We suggest to facilitate both these approaches using, respectively, the crystal cut method* to increase channeling capture efficiency and multiple volume reflection from different planes of one bent crystal(**,***) to increase the volume reflection angle. Efficiency of these methods drastically depends on the halo particle transverse distribution. The first approach is most efficient at smallest transverse diffusion rate while the second one in the opposite case. We also demonstrate that the miscut, i.e. the nonparallelity of lateral crystal surface and atomic planes, can considerably affect the collimation efficiency at present crystal collimation SPS experiments while will not be so important in the real LHC environment.

**TUCCH02 Beam Dynamics Investigations for 433 MHz RFQ Accelerator**

**Speaker** Yuri Svistunov (NIIEFA, St. Petersburg)

**Authors** Yuri Svistunov (NIIEFA, St. Petersburg), Alexander Durkin (MRTI RAS, Moscow), Alexander D. Ovsyannikov (St. Petersburg State University, St. Petersburg)

**Abstract** Modeling results for deuteron dynamics in RFQ structure with operational frequency 433 MHz and 1 MeV output energy are presented. The results are compared with experimental data. The purpose of investigation is to find optimal input RFQ emittance parameters for off-nominal values of input current and vane voltage.

**Invited Oral**

**WEXCH01 IOTA – Integrable Optics Test Accelerator at Fermilab**

**Speaker** Sergei Nagaitsev (Fermilab, Batavia)

**Authors** Sergei Nagaitsev (Fermilab, Batavia)

**Abstract** The use of nonlinear lattices with large betatron tune spreads can increase instability and space charge thresholds due to improved Landau damping. Unfortunately, the majority of nonlinear accelerator lattices turn out to be nonintegrable, producing chaotic motion and a complex network of stable and unstable resonances. This presentation will outline the main challenges, theoretical design solutions and construction status of the Integrable Optics Test Accelerator underway at Fermilab.

**Poster**

**TUPPB001 Study of Dynamical Aperture of NICA Collider with Account of Magnetic Field Errors and Coulomb Effects**

**Presenter** Pavel Romanovich Zenkevich (ITEP, Moscow)

**Authors** Pavel Romanovich Zenkevich, Alexander Bolshakov (ITEP, Moscow)

**Abstract** By use of MADX code beam dynamics in NICA collider has been studied. NICA collider has comparatively small kinetic ion energies (1.5-5 GeV/u) that results in one beam Coulomb effects. These effects are simulated by set of "BEAM-BEAM" elements with appropriate chosen strength and location. Besides it was taken into
account beam-beam interaction and influence of systematic and random errors of the magnetic field. The simulation results are given and discussed.

**TUPPB002 Influence of the Effect of Bare Gold Nuclei Recombination in Electron Cooling System on Working Regime of NICA Collider**

**Presenter** Alexandr Victorovich Philippov (JINR/VBLHEP, Dubna, Moscow region)

**Authors** Alexandr Victorovich Philippov, Alexey Victorovich Eliseev, Oleg Kozlov, Aleksey Kuznetsov, Anatoly O. Sidorin, Alexey Tuzikov (JINR/VBLHEP, Dubna, Moscow region), Igor Nikolai Meshkov (JINR/DLNP, Dubna, Moscow region)

**Abstract** Based on experimental data of heavy bare nuclei recombination the production of gold ions $^{197}_{78}$Au and $^{197}_{77}$Au as a result of step-by-step recombination of bare nucleus $^{197}_{79}$Au with free electrons in electron cooling system of Collider NICA is presented. In view of the magnetic structure and vacuum chamber aperture of the Collider NICA analyzes of ions beam $^{197}_{78}$Au and $^{197}_{77}$Au lifetimes and influence of these ions losses on dynamic vacuum in the Collider NICA as well as the influence of ions $^{197}_{78}$Au as background particles on accuracy of physical experiments data acquisition are discussed. The choice of the reloading modes of the Collider NICA by bare gold nuclei with their recombination losses in the electron cooling system is given.

**TUPPB003 Correction System of NICA Booster Synchrotron**

**Presenter** Aleksandr S. Valkovich (JINR, Dubna, Moscow Region)

**Authors** Aleksandr S. Valkovich, Oleg Kozlov, Igor Nikolai Meshkov, Vladimir Mikhailov, Anatoly O. Sidorin, Grigory Trubnikov (JINR, Dubna, Moscow Region)

**Abstract** New collider facility NICA * is envisioned to be built at The Joint Institute of Nuclear Research. The work presented explores issues of correction system of the Booster Synchrotron. The optimal arrangement of Beam Position Monitors and Orbit Correctors along the ring was investigated in order to achieve decent quality of the orbit correction. The SVD properties of the orbit correction system are presented. Optimal arrangement of the sextupole lenses for the correction of chromaticity of the ring was obtained. The reduction of the dynamical aperture due to the presence of the sextupole lenses was minimized by means of proper choice of betatron phase advances between the lenses.

**TUPPB004 Development of Stochastic Cooling Technique for NICA Project: Experimental Measurements and Simulations**

**Presenter** Nikolay Shurkhno (MSU, Moscow)

**Authors** Nikolay Shurkhno (MSU, Moscow), Lars Thordahl (CERN, Geneva), Rolf Stassen, Hans Stockhorst (FZJ, Jülich), Takeshi Katayama (GSI, Darmstadt), Andriy Kobets, Anatoly O. Sidorin, Grigoriy Trubnikov (JINR, Dubna, Moscow Region)

**Abstract** The experiment on stochastic cooling at Nuclotron, initiated two years ago as a test bench for NICA collider, is progressing. Important results of runs performed at Nuclotron (December 2011 and March 2012) are the following: beam Shottky-noise in the energy range 0.5-4 GeV/u had been measured for deuteron and carbon beams with new pick-up structure and methodology for notch filter and delay setting (closed-loop measurements) had been tested. New methods of stochastic cooling process modeling were developed and implemented into BETACOOL program: solvation of coupled Fokker-Planck equations for each degree of freedom within RMS dynamics and particle tracking algorithm. This report presents the results of first beam stochastic cooling tests at Nuclotron, modified and improved scheme of stochastic cooling system. Results of beam dynamics simulation with stochastic cooling, electron cooling and IBS effects for Nuclotron and NICA collider using new
developed methods are presented.

TUPPB005 LEPTA Project: Towards Positronium

Presenter Andriy Kobets (JINR, Dubna, Moscow Region)
Authors Andriy Kobets, Ekaterina Ahmanova, Viatcheslav Lokmatov, Igor Nikolai Meshkov, Valentin Pavlov, Alexander Rudakov, Aleksei Anatolievich Sidorin, Sergey Yakovenko (JINR, Dubna, Moscow Region), Marat Kanalbekovich Eseev (NAFU, Arkhangelsk)

Abstract The project of the Low Energy Positron Toroidal Accumulator (LEPTA) is under development at JINR. The LEPTA facility is a small positron storage ring equipped with the electron cooling system. The project positron energy is of 2 – 10 keV. The main goal of the facility is to generate an intense flux of positronium atoms – the bound state of electron and positron. Storage ring of LEPTA facility was commissioned in September 2004 and was under development up to now. The positron injector has been constructed in 2005 - 2010, and beam transfer channel – in 2011. By the end of August 2011 experiments on electron and positron injection into the ring have been started. The recent results are presented here.

TUPPB006 Compression and Confinement of Positron Clouds in the Surko Trap of LEPTA Facility

Presenter Marat Kanalbekovich Eseev (NAFU, Arkhangelsk)
Authors Marat Kanalbekovich Eseev (NAFU, Arkhangelsk), Ekaterina Ahmanova, Andriy Kobets, Igor Nikolai Meshkov, Alexander Rudakov, Sergey Yakovenko (JINR, Dubna, Moscow Region)

Abstract A bunch of positrons confined in a cylindrical Penning-Malmberg trap can be compressed radially by applying a rotating asymmetric dipolar electric field. An explanation of this effect presented in the report is based on the solutions of particle 3D dynamics equations in the fields of the trap taking into account the positron collisions with a neutral buffer gas. The result agrees well with experimental data obtained at the positron injector of LEPTA facility at JINR. Essential feature of the compression process is resonant character of applied rotating field and coincidence its frequency with the frequency of longitudinal positron bouncing in the trap.

TUPPB007 Transfer Channel from Booster to Nuclotron at the NICA Facility

Presenter Georgiy A Filatov (JINR, Dubna, Moscow Region)
Authors Georgiy A Filatov, Igor Nikolai Meshkov, Vladimir Mikhailov, Anatoly O. Sidorin, Nikolai Dmitrievich Topilin, Grigoriy Trubnikov, Alexey Tuzikov (JINR, Dubna, Moscow Region)

Abstract In the last years the Nuclotron-based Ion Collider fAcility (NICA) project is developed at Joint Institute for Nuclear Research (JINR), Dubna, Russia. Important elements of the NICA are two synchrotrons: Booster and Nuclotron. Connection between these synchrotrons is provided with the transfer channel for heavy ions at energy of 600 MeV/u. The transfer channel includes a stripping station and charge separation system. General goal of the optic design is to minimize emittance at the exit of the channel. Magnetic system of the channel will be constructed using magnets of the Nuclotron type.

TUPPB008 SNOP – Beam Dynamics Analysis Code for Compact Cyclotrons

Presenter Victor Smirnov (JINR/DLNP, Dubna, Moscow region)
Authors Victor Smirnov (JINR/DLNP, Dubna, Moscow region), Sergey Vorozhtsov (JINR, Dubna, Moscow Region)

Abstract The program complex intended for particle dynamic simulations in a compact
cyclotron from an injection line to the extraction system is described. The main features of the program SNOP are usage of 3D electric and magnetic field maps, beam space charge effect calculation and analysis of the beam losses on structure elements of the facility under consideration. An optimal usage of the modern computer capabilities and graphic libraries for visualization is a key issue in the program development. The beam dynamic modeling results for various cyclotrons are presented.

**TUPPB009 Self–Consistent Electron Beam Dynamics Simulation in THz Generator Based on Photoinjector and Cherenkov Decelerating System**

**Presenter** Oleg Aleksandrovich Tatsyuk (MEPhI, Moscow)

**Authors** Taras Vladimirovich Bondarenko, Sergey Markovich Polozov, Oleg Aleksandrovich Tatsyuk (MEPhI, Moscow)

**Abstract**

The generator of high intensity monochromatic radiation in sub-mm band is currently under R&D at the Department of Electrophysical Facilities of MEPhI. This generator is based on photoinjector and irradiating Cherenkov capillary. It is necessary to have high brightness electron beams to generate of monochromatic radiation in this type of structure. These beams can be produced by photocathode and accelerated to energy of several MeV using short structure having high rate of energy gain. Irradiating capillary represents metal tube having inner radius of the radiation wavelength order and covered with dielectric layer or made of corrugated waveguide. It's important to study the self-consistent dynamics of the beam during the acceleration as the pulse current is equal several A, i.e. the beam dynamics should be studied taking into account RF (radiation) field and Coulomb field of self space charge. Another task is to study the electron beam dynamics and fields irradiated by it in decelerating structure in the absence of external fields. The scheme of the facility, its operation mode and high-current beam dynamics simulation results in accelerating and irradiating structures are presented.

**TUPPB010 RF Quadrupole Focusing Lattices**

**Presenter** Alexander Sergeevich Plastun (MEPhI, Moscow)

**Authors** Alexander Sergeevich Plastun, Sergey Markovich Polozov (MEPhI, Moscow)

**Abstract**

Spatial homogeneity of a conventional RFQ allows to estimate parameters of the lattice easily. Hybrid-RFQ structures with spatially periodic RFQ lenses are more complicated in respect of beam dynamics. Transverse stability of beam motion is defined by lattice parameters. Basically parameters of RF focusing lattices are influenced by longitudinal emittance of a bunch in contrast to static focusing lattices. The paper presents a method which allows to evaluate parameters of a very wide class of RF and static quadrupole lattices. Transverse acceptance and acceleration rate could be determined. The method is useful to compare Hybrid-RFQ structures with a conventional RFQ.

**TUPPB011 Analytical Approach for Beam Matching**

**Presenter** Vyacheslav Sergeevich Dyubkov (MEPhI, Moscow)

**Authors** Vyacheslav Sergeevich Dyubkov, Sergey Markovich Polozov (MEPhI, Moscow)

**Abstract**

Charge particle beams transportation with small cross-sections and low energies is an actual problem for a gantry. That beams are used actively for isotope therapy. Beam emittance is its quality factor, and it should be matched with a facility channel acceptance. The method for beam dynamics analysis in lattice is developed in terms of non-coherent particle oscillation study. Nonlinear beam dynamics is investigated by using this method. It is shown that this technique allows one to realize effective beam emittance control. Analytical results obtained are verified by means of
numerical simulation.

### TUPPB012 Search of the Motion Integral at Linac with RF Focusing

**Presenter** Vyacheslav Sergeevich Dyubkov (MEPhI, Moscow)

**Authors** Vyacheslav Sergeevich Dyubkov (MEPhI, Moscow)

**Abstract**

The problem of the effective low-energy linac design is of interest to many fields of science, industry and medicine. It is well known that nonsynchronous harmonics of RF field (RF undulator) are focusing the particles. Analytical beam dynamics investigation can be carried out by means of the averaging method over the rapid oscillations period (the so-called smooth approximation) in the oscillating fields. Motion equation is presented in the form of the Hamilton's equations. Motion integrals are found by means of Poincare mapping.

### TUPPB013 Dependence on Betatron Oscillations of the Angular Velocity

**Presenter** Oleg Evstropovich Shishanin (MSIU, Moscow)

**Authors** Oleg Evstropovich Shishanin (MSIU, Moscow)

**Abstract**

An examination of this topic among other factors is necessary to an understanding of the role of electron vibrations at the formation of synchrotron radiation. Mentioned problem was resolved by author in various periodic magnetic fields. Influence on radiation of the correction terms to the angular velocity for storage rings is also discussed.

### TUPPB014 Cooling of Electron Beams

**Presenter** Vladimir M. Khoruzhiy (NSC/KIPT, Kharkov)

**Authors** Vladimir M. Khoruzhiy (NSC/KIPT, Kharkov)

**Abstract**

Cooling of electron beams (transversal velocities reducing) in storage rings (cyclic accelerators) may be realized using gyromonotron device as part of storage ring at straight-line portion. The gyromonotron is a HF oscillator for cm and mm band of wavelength in which electron beam with nonzero transversal velocities is used for excitation electromagnetic wave. Energy of transversal motion of electron beam converts into energy of electromagnetic wave during multiple passing the same bunches with repetition frequency f0 through gyromonotron. We choose frequency f0 (and corresponding wavelength AL) as minimal frequency (H111 mode) for gyromonotron's resonator. As well known, frequency f0 of H111 mode gives possibility to determine radius of the resonator R~AL/(2*1.71). We assumed above that resonator's length L/(2*R)>1. It is possible for gyromonotron's solenoid to determine longitudinal magnetic field Hz(kOE)=11/AL(cm) for low relativistic beam's energy. For gyromonotron's operation at given frequency it's needed realization of condition for relativistic cyclotron frequency Om_rel/(2*3.14)~ f0. Emitted beam radiation dissipates inside gyromonotron’s resonator (output window is absent). Q-quality gyromonotron’s resonator and pitch factor PF of electron beam have to satisfy condition Q* PF>1 (for "warm" or superconducting (SC) resonators).

### TUPPB015 The Parameters Extracted Beams in Recirculator SALO

**Presenter** Ivan Guk (NSC/KIPT, Kharkov)

**Authors** Ivan Guk, Stanislav Kononenko, Fedor Peev, Alexander Tarasenko (NSC/KIPT, Kharkov)

**Abstract**

Taking into account the nonlinearity of the dipole and quadrupole lenses are calculated beam parameters on the output channels of the recirculator SALO.
### The Nonlinear Resonance of Third Order

**Presenter** Yuriy Bashmakov (LPI, Moscow)  
**Authors** Yuriy Bashmakov (LPI, Moscow)  
**Abstract** The nonlinear resonance of third order plays an important role in the particle dynamics in circular accelerators, colliders and storage rings and is widely used for slow extraction of particles from synchrotrons. Consideration is carried out in the canonical variables X, Y which at a given accelerator azimuth are simply related to the angle and the deviation of the circulating particles relative to the equilibrium orbit. The problem is reduced to the construction of the phase trajectories, which are the curves of the third or fourth order and determine the type of the motion near the resonance under consideration. The construction of the phase trajectories is performed by the Klein's perturbation method. The influence on the particles dynamics of octupole component of the magnetic fields is investigated.

### TUPPB017 Multi Frequency Stored Energy RF Linac

**Presenter** Vyacheslav Kurakin (LPI, Moscow)  
**Authors** Vyacheslav Kurakin (LPI, Moscow), Pavel Kurakin (Keldysh Institute of Applied Mathematics, Moscow)  
**Abstract** Due to beam loading, accelerating gradient in rf linac is reduced in time if the energy acquired by charged bunches is not compensated by external generator that feeds the linac. Since the bunch energy gain in this mode of operation correlates strongly with bunch number, the energy spectrum of total bunch train might be corrected in order to suppress this additional spectrum widening. This spectrum control might be achieved with the rf cavity that operates at frequency shifted relative the main one in such a way, that any new bunch sees the cavity field in the appropriate phase correlated with bunch number. The first bunch traverses correcting cavity in field node while the last one in the phase, where the energy acquired by this bunch is equal to resulting bunch train energy spread arising from beam loading effect. Equations of beam - rf cavity interactions are derived followed by coherent beam dynamics exploration in the system described. Measures for suppression of non coherent bunches spectrum widening are suggested leading to insertion additional cavity excited at frequency shifted relative the main and adjacent frequencies. Direct Digital Synthesis technique is suggested as well to provide necessary frequencies and phase's correlations in linac. Advantages of proposed technique as well its possible applications are discussed.

### TUPPB018 Simulation of Hollow Ion Beam Formation Line

**Presenter** Helen Barminova (ITEP, Moscow)  
**Authors** Helen Barminova, Nikolay Nikolaevich Alexeev, Alexander Golubev, Timur Kulevoy, Alexey Sitnikov, Tatyana Tretyakova (ITEP, Moscow)  
**Abstract** Heavy ion beams can be used for the matter extreme state generation*, and forming line must satisfy to certain strict requirements for beam brightness and focus position. In paper** system was proposed for hollow beam formation in order to generate laboratory plasma with energy deposition in cylindrical target. The system is based on the principle of the beam rotation by means of RF-cavities (so called "wobbler"). The similar system is proposed in ITEP***, where the basic part of line consists of two four-cell cavities and focusing quadrupole triplet. To calculate wobbler and magnetic triplet parameters two codes were used – "Transit", developed in ITEP, and G4Beamline, developed in Muons Inc. The beam was simulated for two kinds of particles – multicharged ions of Co and protons with equivalent energy. A comparative analysis of optical system parameter and beam parameter obtained in both simulations was performed. In condition of focus position restriction and spot geometry required aberrations were shown to be taken into account correctly.
### TUPPB019  Ion Beam Slow Extraction from UK Ring of ITEP-TWAC Facility

**Presenter** Maria Evgenievna Rodionova (ITEP, Moscow)  
**Authors** Maria Evgenievna Rodionova (ITEP, Moscow)  
**Abstract** Synchrotron, part of the accelerating-storage complex ITEP-TVN, is being used to accelerate ions to energies of several hundred MeV/nucleon. The accelerated ions can be derived from the ring for one turn mainly to charge-exchange injection into the ringU-10, which is used as the drive of the nuclei with an energy injection, or for further acceleration of the injected beam. To improve the efficiency of the complex ITEP-TVN is supposed to create an additional channel for slow extraction of the accelerated beam from the synchrotron. Slow withdrawal of the particle beam from the booster synchrotron is being developed to work in the following areas: The development of in ITEP ion (carbon) therapy; conducting radiation tests of electronic devices for space application; biological and other studies of ion beams.

### TUPPB020 Mathematical Model of Beam Dynamics Optimization in Traveling Wave

**Presenter** Alexander Shirokolobov (St. Petersburg State University, St. Petersburg)  
**Authors** Alexander D. Ovsyannikov, Alexander Shirokolobov (St. Petersburg State University, St. Petersburg)  
**Abstract** In works by B.I. Bondarev, A.P. Durkin, A.D. Ovsyannikov mathematical model of optimization of charged particles dynamics in RFQ accelerators was proposed. In this paper a new mathematical model of optimization of particle dynamics in traveling wave is considered. Joint optimization model of program and disturbed motions is investigated.

### TUPPB021 Calculation of Tolerance and Statistical Test

**Presenter** Yevgeny Valeryevich Yelaev (St. Petersburg State University, St. Petersburg)  
**Authors** Yevgeny Valeryevich Yelaev (St. Petersburg State University, St. Petersburg)  
**Abstract** In the paper mathematical methods of tolerance determination of different parameters of accelerating and focusing structures are considered. The determination of tolerances is based on the analytical representation of variation of functional characterizing the beam dynamics. Method of statistical analysis of calculated tolerance values is represented. The purpose of the work is to determine the maximum possible deviations of the real (actual) parameters from nominal, when the qualitative structure function satisfies to the required modes.

### TUPPB022 Mathematical Model of Beam Dynamic Optimization

**Presenter** Vladislav Vladimirovich Altsybeyev (St. Petersburg State University, St. Petersburg)  
**Authors** Vladislav Vladimirovich Altsybeyev (St. Petersburg State University, St. Petersburg)  
**Abstract** We treat here the process of simulation of charged particle dynamics using so called hybrid system. Hybrid system is a system with continuous and discrete parts, described by differential and difference equations, respectively. In this case new mathematical model of beam dynamics optimization is suggested. The main parameters of optimization are: coefficient of particle capture in the acceleration mode, phase and energy spectra of particles at the exit of the accelerator, the transverse beam characteristics, etc. Optimization was carried out for the drift tubes accelerator.

### TUPPB023 Analytical Method For Calculating the Coulomb Field of the Inhomogeneous Axially Symmetric Beam of Charged Particles

**Presenter** Vladimir Alexandrovich Kozyuchenko (St. Petersburg State University, St. Petersburg)
**Authors** Vladimir Alexandrovich Kozynchenko (St. Petersburg State University, St. Petersburg)

**Abstract** The model of an axially symmetric inhomogeneous beam of charged particles is considered, which is a set of the charged nested hollow cylinders placed in a round metal tube of constant radius. It is proposed to approximate the function of the beam charge density by an analytic function. Using the analytical solutions of boundary value problems for Poisson's equation, the analytical formulas for the intensity of the Coulomb field of charged particle beam are derived. Based on the analytical expressions obtained, the method for calculating the Coulomb field of the inhomogeneous axially symmetric charged particle beam is developed.

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**TUPPB024** Development in C ++ of the Program for Simulation and Optimization of Beam Dynamics in Accelerator Injection Systems

**Presenter** Sergey Kozynchenko (St. Petersburg State University, St. Petersburg)

**Authors** Sergey Kozynchenko (St. Petersburg State University, St. Petersburg)

**Abstract** At present, more and more attention is paid to the design and creation of accelerator systems for precision beams. Their injection systems in many aspects determine the output characteristics of the beam, so the questions of the design of such systems are of great importance. In such cases both simulation and optimization of beam dynamics in electromagnetic fields close to real may be necessary. In this paper the program for simulation and optimization of beam dynamics in injection systems is considered, which at the same time allows the choice of parameters of the accelerating-focusing system. This permits designing the injection system during optimization process, taking into account the required output characteristics of the beam. The given program is based on Win 32 API dialog boxes and is developed in standard C++, using parallel programming tools based on the MPI-1.

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**TUPPB025** Investigation of Program and Perturbed Motions of Particles in Linear Accelerator

**Presenter** Elena Suddenko (St. Petersburg State University, St. Petersburg)

**Authors** Irina Rubtsova, Elena Suddenko (St. Petersburg State University, St. Petersburg)

**Abstract** Beam control model for program and perturbed motions with interaction account is realized.

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**TUPPB026** Comparison of the Matrix Formalism and Step-by-step Integration of the Long-term Spin Dynamics Simulation in Electrostatic Fields

**Presenter** Andrei Ivanov (St. Petersburg State University, St. Petersburg)

**Authors** Andrei Ivanov (St. Petersburg State University, St. Petersburg)

**Abstract** An approach based on matrix formalism for solving differential equations is described. Effective in sense of performance matrix formalism can be tested with less efficient, but accurate traditional algorithm of numerical simulation based on the Runge-Kutta scheme. In both cases the symplectic version of the algorithms are used. Moreover the additional corrections for energy conservation are indicated. The results coincide to analytical calculations, but some disagreements have been identified. The approach implementation is demonstrated in the problem of long-term spin dynamics in electrostatic fields.

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**TUPPB027** Some Problems of Beam Slow Extraction

**Presenter** Serge Andrianov (St. Petersburg State University, St. Petersburg)

**Authors** Serge Andrianov (St. Petersburg State University, St. Petersburg)

**Abstract** In this paper we discuss some problems of modeling of beam slow extraction systems. It is known that similar type of beam extraction is used for different kind of circular
accelerators. Among the most important requirements for such systems is necessary to mention the time uniformity of the extracted beam. There exist the following two key causes. The first of them is induced by time discontinuity of the corresponding steering electrical currents, and the second cause is induced by an beam inertia which usually connected with beam feedback mechanism, which is usually used for temporal smoothing of the corresponding magnetic (and electrical) fields. In the base of our approach we put the matrix formalism for Lie algebraic tools, which allows us to analyze different kind of the time discontinuity cause.

**TUPPB028 Degenerate Solutions of the Vlasov Equation**

**Presenter** Oleg Igorevich Drivotin (St. Petersburg State University, St. Petersburg)

**Authors** Oleg Igorevich Drivotin (St. Petersburg State University, St. Petersburg)

**Abstract** The report deals with degenerate solutions of the Vlasov equation. By degenerate solution we mean a distribution which have support of dimension smaller than dimension of the phase space. Well known example is the Kapchinsky-Vladimirsky (KV) distribution, when particles are distributed on the 3-dimensional surface in the 4-dimensional phase space. We use covariant formulation of the Vlasov equation developed previously*. In traditional approach, the Vlasov equation is considered as integro-differential equation with partial derivatives on phase coordinates. Covariant approach means tensor formulation. For the covariant formulation of the Vlasov equation, we use such tensor object as the Lie derivative. According to the covariant approach, a degenerate solution is described by differential form which degree is equal to the dimension of its support. Main attention is paid to the KV distribution, which is described by the differential form of the third degree. It is demonstrated that the KV distribution satisfies to the Vlasov equation in covariant formulation. It is shown, how one can set initial partialt positions in the phase space to simulate that distribution. Some other distributions are also considered. This work has theoretical as well as practical significance. Presented results can be applied for description and simulation of high-intensity beam.

**TUPPB029 Transverse Dynamics of Ring Beam in Coaxial Two-Channel Dielectric Waveguide**

**Presenter** Alexander Altmark (LETI, Saint-Petersburg)

**Authors** Alexander Altmark (LETI, Saint-Petersburg), Alexei Kanareykin (Euclid TechLabs, LLC, Solon, Ohio)

**Abstract** The most critical issue of wakefield accelerating schemes is transformer ratio (maximum energy gain of the witness bunch/maximum energy loss of the drive bunch) which cannot exceed 2 in collinear wakefield accelerator with use of Gaussian bunches. We observe new scheme of wakefield acceleration in collinear two-channel waveguide where accelerating field created by electron bunch with annular charge distribution passing in vacuum layer. This radiation is used for acceleration of witness beam which passing through central vacuum channel. These vacuum areas separated by dielectric tube. Transformer ratio for this scheme can be much greater than 2. The main problem of wakefield accelerators is transverse beam dynamics of the driver bunch, because of high value of its charge and low energy of the particles. We present results of the beam dynamics calculation of the annular drive beam by "macroparticle" method based on analytical expressions for Cerenkov radiation. The upgraded BBU-3000 code has been used for calculation of the beam dynamics in coaxial dielectric wakefield accelerating structures. It is shown that dynamics depends on radial and azimuthally structures of HEM modes excited by the drive beam there. Initial beam imperfections to the beam dynamics was carried out.
TUPPB030 Computer Simulation of the Electron Beam Energy Spectrum Measurement by the Magnetic Analyzer Method Based on Scanning System of the Sterilization Installation

Presenter Peter Alexeevich Bystrov (MRTI RAS, Moscow)
Authors Nikolay Evgenievich Rozanov, Mihail Anatolievich Alekseev, Peter Alexeevich Bystrov (MRTI RAS, Moscow)

Abstract A method for measuring the characteristic, which makes possible to find the energy spectrum of the electron beam of the accelerator is described. This method uses the magnetic analyzer, which is based on the scanning system of the standing wave linear electron accelerator, mounted on the radiation sterilizer. This characteristic is the dependence of beam current, that reaches the induction sensor at the accelerator output window, on the magnetic field, deflecting the beam from the axis of the system. The results of the measurements of these characteristic, which were performed on the sterilization installation in MRTI, are presented. The computer simulation of electron beam dynamics in the scanning system for the case of these experiments was performed with the help of developed program "BEAM SCANNING". The similar dependence of the beam current on the magnetic field was obtained. The necessity of taking into account the effect of electron reflection from the walls of vacuum chamber is stated. To describe this effect the additional features were implemented in the program. As a result of calculations with the account of this effect, the correspondence of the calculated curve and experimental one was reached. This means that the calculated spectrum corresponds to the actual energy spectrum of the electron beam in the experiment.

TUPPB031 Measurement of Beam Parameters in the VEPP-5 Damping Ring Using Betatron Oscillations Decoherence

Presenter Kseniya Astrelina (BINP SB RAS, Novosibirsk)
Authors Alexey Petrenko, Kseniya Astrelina (BINP SB RAS, Novosibirsk)

Abstract The measurement of beam parameters during the commissioning of VEPP-5 Damping Ring is presented. Coherent betatron oscillations of the 380-MeV electron beam were induced by a fast kick. Electrostatic beam position monitors were used to obtain the turn-by-turn transverse beam position data. The form and behaviour of the envelope of oscillations are determined by the beam parameters, chromaticity and nonlinear detuning. Beam emittance and energy spread values have been obtained from the analysis of the beam envelope, nonlinear detuning and chromaticity measurements. The results are in a good agreement with theoretical predictions which were made for calibrated model of the Damping Ring. Independent analysis of betatron spectra envelope have been performed for energy spread measurements as well.

TUPPB032 Simulation of Hollow Electron Beam Collimation in the Fermilab Tevatron and LHC Colliders

Presenter Ivan Morozov (BINP SB RAS, Novosibirsk)
Authors Ivan Morozov, Dmitry Shatilov (BINP SB RAS, Novosibirsk), Giulio Stancari, Alexander Valishev (Fermilab, Batavia)

Abstract The concept of augmenting the conventional collimation system of high-energy storage rings with a hollow electron beam was successfully demonstrated in experiments at the Tevatron. A reliable numerical model is required for understanding particle dynamics in the presence of a hollow beam collimator. Several models were developed to describe imperfections of the electron beam profile and alignment. The features of the imperfections are estimated from electron beam profile measurements. Numerical simulations of halo removal rates are compared with experimental data taken at the Tevatron. Simulations for the LHC collider are presented.
TUPPB033  Simplified Beam Line with Space Charge Compensation of Low Energy Ion Beam
Presenter  Andrei V Dudnikov (BINP SB RAS, Novosibirsk)
Authors  Andrei V Dudnikov (BINP SB RAS, Novosibirsk)
Abstract Simplified beam line for low energy ion implantation is considered. Compensation of
the space charge of high perveance, low energy ion beam in beam lines for ion
implantation and isotope separation has been investigated. Space charge
compensation and overcompensation by ions will be considered. Different
mechanisms of the compensating particle formation such as ionization by the beam,
secondary emission of electrons and negative ions, electronegative gas admixture, and
external plasma sources will be discussed. Advanced space charge compensation
increases an intensity of low energy ion beam after analyzer magnet up to 3–4 times.
Space charge compensation of positive ion beam by admixture of electronegative
gases and damping of the beam instability will be discussed. Up to 6 mA of 11B+
ions with energy 3 keV, 11 mA with 5 keV, and 18 mA with 10 keV have been
transported through an analyzer magnet of a high current implanter with space charge
compensation by electronegative gases.

TUPPB034  Low Energy Cooler for NICA booster
Presenter  Alexander Bubley (BINP SB RAS, Novosibirsk)
Authors  Alexander Bubley, Maxim Igorevich Bryzgunov, Vitalij Panasyuk, Vasily
Parkhomchuk, Vladimir Borisovich Reva (BINP SB RAS, Novosibirsk)
Abstract Low energy cooler for NICA project is being currently designed at BINP in
collaboration with JINR. From the point of view of its features it is similar to previous
low energy coolers manufactured at BINP, i.e. equipped with variable electron beam,
electrostatic bending, high precision solenoid etc. The article describes some technical
solutions applied to the cooler design.

TUPPB035  The Kicker Parameters Estimation for Longitudinal Instability Damping of
the Beam at SR Storage Ring "Siberia-2"
Presenter  Antonina Smygacheva (NRC, Moscow)
Authors  Antonina Smygacheva, Vladimir Korchuganov (NRC, Moscow), Alexander Vernov
(RRC, Moscow)
Abstract RF system of the Kurchatov Institute Synchrotron Radiation storage ring "Siberia-2"
consists of three cavities. Each of them has two HOMs tuners. Due to the shunt
impedance and quality factor of HOMs are high, the beam-cavity interaction leads to
the instability and the beam loss as the result. We have to develop a longitudinal
feedback system based on the kicker, to cure the longitudinal instabilities. In the
article the investigations of the field spectra of the cavities at the beam energy 450
MeV and 2.5 GeV, excited by the beam and the generator, are presented. According
to the measurements of the field spectra of the cavities, the most strong HOMs were
found. Main parameters of the kicker such as a frequency, a shunt impedance, a
quality factor and a power, were calculated.

TUPPB036  Study of Proton Beam Transverse Phase Space Variations During Injector
High Voltage Pulse
Presenter  Oleg Timofeevich Frolov (RAS/INR, Moscow)
Authors  Aleksandr Belov, Oleg Timofeevich Frolov, Eugene Semjonovich Nikulin, Valentin
Petrovich Yakushev, Valeri Zubets (RAS/INR, Moscow)
Abstract The proton injector of INR RAS linac provides a pulsed beam with the following
parameters: current – up to 100-120 mA; duration – 200 mks; pulse repetition rate – 50 Hz; energy of ions – 400 keV. The results of numerical calculations and experimental study of beam phase space variations during injector high voltage pulse are presented. It is shown that these variations are caused by instabilities of both beam current and accelerating tube intermediate electrode potential. Instability of beam current has been minimized by using of noiseless mode of operation for the pulsed duoplasmatron and by stabilization of ion source discharge current. The high voltage pulse stability is now better than +/-0.1%. High frequency oscillations at high voltage pulse plateau have been diminished by both decreasing of high voltage pulse generator artificial line characteristic impedance and filtration of high frequency component of the diode-capacitor stabilizer rack current. The beam transverse normalized emittance for 90% of beam current has been measured to be of 0.08 pi cm*mrad. Variations of the emittance during the high voltage pulse are in limits of +/-4% value.

TUPPB037 Chromaticity Correction as a Key for Successful Mass Measurements of Exotic Nuclei In The Isochronous Mode Of the Collector Ring (CR) at FAIR

Presenter Sergey Litvinov (GSI, Darmstadt)
Authors Sergey Litvinov, Christina Dimopoulou, Alexei Dolinskii, Oleksii Gorda, Fritz Nolden, Markus Steck, Helmut Weick (GSI, Darmstadt)
Abstract Today the challenge is to measure masses of exotic nuclei up to the limits of nuclear existence which are characterized by low production cross-sections and short half-lives. The large acceptance Collector Ring (CR) at FAIR tuned in the isochronous ion-optical mode offers unique possibilities for such measurements. However, the mass-measurement resolution is inversely proportional to the transverse acceptance of the ring. In order to reach a resolving power of 10^5 the transverse beam emittance has to be limited from 100 to 10 mm mrad in both planes, which drastically reduces the transmission of the exotic nuclei. We demonstrate that the negative influence of the transverse emittance on the mass resolution can be significantly compensated by a proper chromaticity correction. Numerical simulations as well as analytical studies will be presented and the influence of the imperfections of the magnets will be discussed.

TUPPB038 Stored Electrons in the KATRIN Spectrometers: Origin, Problems and Counter Measures

Presenter Lutz Bornschein (KIT, Eggenstein-Leopoldshafen)
Authors Lutz Bornschein (KIT, Eggenstein-Leopoldshafen)
Abstract The Karlsruhe Tritium Neutrino Experiment (KATRIN) will probe the absolute neutrino mass scale with a sensitivity of 200 meV (90% C.L.) by precision spectroscopy of tritium beta-decay electrons. KATRIN uses an ultra-luminous windowless gaseous tritium source with an activity of about 10E+11 Bq. The decay electrons are adiabatically guided to the spectrometers by a magnetic field, while the Tritium molecules are removed by differential and cryogenic pumping units. The beta-spectrum is analyzed with an electrostatic spectrometer combined with magnetic collimation. To reach the design sensitivity a very low background rate is required. The potentially dominating background sources inside the spectrometers are electrons emitted by the decay of radon and tritium. A single stored electron in the volume of the main spectrometer can produce an enhanced background level for up to several hours. Therefor passive and active countermeasures are carried out. Tritium is pumped by non-evaporable getter pumps which are on the other hand the principle radon source. So these pumps are separated from the spectrometer volume by liquid nitrogen cooled baffles. To remove already stored electrons, a novel method based on
stochastic heating by using the technique of electron cyclotron resonance will be applied. These measures will allow the KATRIN experiment attaining its full physics potential.