ICFA mini-Workshop on ”Mitigation of Coherent Beam Instabilities in particle accelerators” MCBI 2019

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Book of Abstracts

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* Study of Collective Effects in the FCC-ee Top-up Booster

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The CERN FCC-ee top-up booster synchrotron will accelerate electrons and positrons from an injection energy of 20 GeV up to an extraction energy between 45.6 GeV and 182.5 GeV depending on the operation mode. These accelerated beams will be used for the initial filling of the high-luminosity

FCC-ee collider and for keeping the beam current constant over time using continuous top-up injection. Due to the high-intensities of the circulating beams, collective effects may represent a limitation in the top-up booster. In this work we present a first evaluation of the impedance model and the effects on beam dynamics. Methods to mitigate possible instabilities will be also discussed.

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Advanced Landau damping with radio-frequency quadrupoles or nonlinear chromaticity

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Landau damping is a powerful mechanism to suppress impedance-driven coherent instabilities in circular accelerators. In the transverse planes it is usually introduced by means of magnetic octupoles. We will discuss a novel method to generate the required incoherent betatron tune spread through detuning with the longitudinal rather than the transverse amplitudes. The approach is motivated mainly by the high-brightness, low transverse emittance beams in future colliders where detuning with the transverse amplitudes from magnetic octupoles becomes significantly less effective. Two equivalent methods are under study: a radio-frequency quadrupole cavity, and the nonlinear chromaticity. The underlying beam dynamics mechanisms are explained based on a recently extended Vlasov theory, and relevant results are discussed for different longitudinal beam distributions and under certain approximations. Finally, the analytical studies are benchmarked against numerical simulations employing a circulant matrix and a macroparticle tracking model.

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Mitigation of Coherent Beam Instabilities in FCC-ee

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In order to achieve a high luminosity in the electron-positron Future Circular Collider (FCC-ee) very intense multi-bunch beams with low emittances are accumulated in two separate rings and collide in two interaction regions exploiting the crab waist collision scheme. In order to preserve beam quality and to avoid collider performance degradation a careful study of beam collective effects is required. In this talk we overview coherent beam instabilities potentially dangerous for FCC-ee and discuss measures and techniques for their mitigation.

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Identification of the horizontal instability mechanism at the CERN Proton Synchrotron Booster

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A horizontal head-tail instability has been observed in the CERN Proton Synchrotron Booster (PSB) since the '70s. Beam-based measurements of losses versus the horizontal working point reveal a dependence of the instability on the horizontal tune. Macro-particle simulations and the Sacherer formalism suggest that the unmatched kicker termination is responsible for the observed beam losses and exponential growth. The extraction kicker was finally unambiguously confirmed to be the source of the instability. This was achieved with beam-based measurements with a temporarily modified termination, adjacent to the thyratron switch of the extraction kicker system, from a high impedance termination, required for operation, to a matched termination using a 6.25 Ω resistor. With this configuration, no sign of the instability was any longer observed.

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* TMCI, why is the horizontal plane so different from the vertical one

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Based on the recent work of R. Lindberg on transverse collective instabilities (PRAB 19, 124402,(2016)) it was observed that if the ratio of quadrupolar to dipolar impedance is equal to -1, there is no TMC-instability. This relationship is actually fulfilled by horizontal resistive wall impedance. "Headtail" simulations were carried out to check if this formal observation could be confirmed.
Additionally the effect of radial modes on the TMCI threshold was studied.

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Suppression of the longitudinal coupled bunch instability in DAFNE in collisions with a crossing angle

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In DAFNE, the Frascati e+/e- collider operating since 1998, an innovative collision scheme, the crab waist, has been successfully implemented during the years 2008-09. During operations for the Siddharta experiment an unusual synchrotron oscillation damping effect induced by beam-beam collisions has been observed. Indeed, when the longitudinal feedback is off, the positron beam becomes

unstable with currents above 200–300 mA due to coupled bunch instability. The longitudinal instability is damped by colliding the positron beam with a high current electron beam (of the order of 2 A) and a shift of about -600 Hz in the residual synchrotron sidebands is observed. Precise measurements have been performed by using both a commercial spectrum analyzer and the diagnostic capabilities of the longitudinal bunch-by-bunch feedback. The damping effect has been observed in DAFNE for the first time during collisions with the crab waist scheme. Our explanation, based both on theoretical consideration and modeling simulation, is that beam collisions with a large crossing angle produce longitudinal tune shift and spread, providing Landau damping of synchrotron oscillations.

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* Measurements and Damping of the ISIS Head-Tail Instability

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ISIS is the pulsed spallation neutron and muon source at the Rutherford Appleton Laboratory in the UK. Operation centres on a rapid cycling proton synchrotron (RCS) which accelerates 3e13 protons per pulse from 70 MeV to 800 MeV at 50 Hz, delivering a mean beam power of 0.2 MW.
Research and development at ISIS are focused on key aspects of high intensity operation with a view to increasing beam intensity on target; understanding loss mechanisms and identifying viable upgrade routes. At present, the main limitation on beam intensity at ISIS is beam losses associated with the head-tail instability.
This paper presents new measurements of the head-tail instability in both RCS and storage ring modes whilst highlighting the differences between these and theoretical predictions. Macro-particle simulations of the instability are shown in comparison with experimental data. Finally, preliminary tests of an active transverse feedback system to damp the instability are also presented.

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Coherent and incoherent effects of e-cloud

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Electron cloud generated by photo-emission, ionization and secondary emission is build up in vacuum chamber. The electron cloud causes single and multi-bunch coherent instability of the beam. The cloud also induces tune shift and emittance growth as incoherent effects. We discuss theory, simulation and experiments of these coherent and incoherent effects.

Poster Session / 73

* Implementation of RF Modulation in Booster for Mitigation of the Collective Effects in the Transient Process after the Swap-out Injection

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The on-axis swap-out injection is a promising injection scheme for the ultra-low emittance storage rings with generally small dynamic apertures. However, previous studies show that the initial mismatch in longitudinal phase space may lead to collective effects, such as transverse oscillations, emittance growth, and even particle loss before approaching the equilibrium state after injection, especially in the high bunch charge situation. We present our study of mitigating the collective effects in the transient process after injecting beam in storage rings by implementing RF modulation technique in booster. Both bunch lengthening and the increase of energy spread could be observed in the extracted bunch from booster. Furthermore, the bunch distribution in the longitudinal phase space after modulation will deviate significantly from the Gaussian distribution, the influences of which are also presented.

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* Impedance-induced collective beam instabilities with elliptical beam pipe

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Within the ultrarelativistic limit, the impedance is investigated for the elliptical beam pipe with finite thickness. Fielding matching method is used to determine the electromagnetic fields in different layers. Additionally, numerical results are given to show the behavior of the longitudinal and transverse wake function or its corresponding impedance. The transverse tune shifts induced by the dipolar and quadrupolar impedance of the finite thick elliptical beam pipe are also investigated. The influence of the wall thickness on the impedance and collective beam instabilities are discussed.

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* Effects of chromaticity on beam-beam interactions in CEPC

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In recent years, strong-strong simulations and following theoretical analysis has shown a novel strong coherent head-tail type instability induced by the beam-beam interaction in case of large Piwinski angle The width of stable working point limited by the instability is very narrow when we try to reach the beam-beam limit at CEPC. In this paper the chromaticity is considered, the luminosity performance especially the x-z instability is studied by analysis and simulation.

Poster Session / 76

* A new code for beam-ion interaction in electron rings

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The beam-ion interaction is one of the critical issues leading to beam phase space distortion, emittance growth and collective instability in electron rings, especially at the first beam commissioning state. To have a clear picture on the evolution of beam and ion in the rings with various filling patterns and different type of gas, a multi-ion multi-beam code model is developed to depict the basic process in detail, where the interaction between ion and beam is described by the Bassetti-Erskine model. The HEPS lattice proposed by IHEP will be used as a demonstration to show the both the effects of fast ion instability and ion-trapping phenomena. Due to the lack of self-consistence of the Bassetti-Erskine equation, for the further study, more effort will be focused on the self-consistent particle-in-cell solver development.

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* Wakefield of Two Counter Rotating Beams

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The High Luminosity Large Hadron Collider (HL-LHC) Project at CERN calls for increasing beam brightness and intensity.
In this framework, it is crucial to reduce the electromagnetic coupling between the particle beams and the surrounding environment (by means of the concepts of wakefield and impedance) in order to minimize undesired effects as beam instabilities and RF-heating.
In the past the interest for the wakefield generated by two counter rotating beams crossing the same vacuum chamber has been little, only few papers about the topic appear in the literature.
However, in the interaction chambers of all colliders two counter rotating beams interact one with each other through their wakefields (among other effects).
Furthermore, other devices could experience the passage of two counter rotating beams in their vacuum chambers, as, for example, the Target Dump Injection Segmented (TDIS) in the CERN Large Hadron Collider.
Understanding the phenomenon is crucial to avoid possible instability and RF-heating problems in the future high brightness, high intensity colliders.
Thus, first this paper reviews the theory developed in previous works.
Then, it specializes this theory for some particular cases and benchmarks it against simulations results.
In particular, this is done for the case of a pill box cavity and for the case of a resistive pipe of finite length.

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Feedback Design for Control of the Micro-Bunching Instability based on Reinforcement Learning

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The operation of ring-based synchrotron light sources with short electron bunches increases the emission of coherent synchrotron radiation in the THz frequency range. However, the micro-bunching instability resulting from self-interaction of the bunch with its own radiation field limits stable operation with constant intensity of CSR emission to a particular threshold current. Above this threshold, the longitudinal charge distribution and thus the emitted radiation vary rapidly and continuously. Therefore, a fast and adaptive feedback system is the appropriate approach to stabilize the dynamics and to overcome the limitations given by the instability. In this contribution, we discuss first efforts towards a longitudinal feedback design that acts on the RF system of the KIT storage ring KARA (Karlsruhe Research Accelerator) and aims for stabilization of the emitted THz radiation. Our approach is based on methods of adaptive control that were developed in the field of reinforcement learning and have seen great success in other fields of research over the past decade. We motivate this particular approach and comment on different aspects of its implementation.

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* Status of negative momentum compaction operation at KARA

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For future synchrotron light sources different acceleration modes are of interest. Therefore various modes are currently being tested at the Karlsruhe Research Accelerator (KARA) including optics for a negative momentum compaction factor. These optics have been calculated and are under commissioning at KARA. Additionally, studies about expected collective effects in this regime are being performed, including the head-tail and microbunching instabilities.
In this contribution we will present the status of operation in the negative momentum compaction regime as well as first results on the studies of expected collective effects.

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* Systematic studies of the microbunching and weak instability at short bunch lengths

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At KARA, the Karlsruhe Research Accelerator of the Karlsruhe Institute of Technology synchrotron, the so-called short-bunch operation mode allows the reduction of the bunch length down to a few picoseconds. The microbunching instability resulting from the high degree of longitudinal compression leads to fluctuations in the emitted terahertz radiation. For highly compressed bunches at KARA, the instability occurs not only in one but in two different bunch-current ranges that are separated by a stable region. The additional region of instability is referred to as short-bunch-length bursting or weak instability. We will presents measurements of the threshold currents and fluctuation frequencies in both regimes. Good agreement is found between the measurement and numerical solutions of the Vlasov-Fokker-Planck equation. This contribution is based on the paper Phys. Rev. Accel. Beams 22, 020701.

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* Identification of longitudinal impedance in a section of SPS using SSC method

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The LHC Injectors Upgrade (LIU) project plans doubling the bunch intensity in the LHC injector chain in order to meet the requirements of the High Luminosity LHC (HL-LHC) project. The longitudinal beam impedance of the Super Proton Synchrotron (SPS), part of the injector of the LHC, is currently one of the limitations in reaching higher beam intensities due to instability issues. In the context of LIU, components with high contribution to the impedance of SPS have to be identified and optimized. In this paper, the State Space Concatenation method (SSC), which is a numerical method for simulating a large structure by decomposing it into its components, is used to calculate the eigenmodes of a long straight section of the SPS ring. The modes with high contribution to the longitudinal impedance are then identified and methods to mitigate them are proposed.

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Landau Damping with Electron Lenses in Space-Charge Dominated Beams

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It is shown that the Lorentz forces of a low-energy, magnetically stabilized electron beam, or "electron lens", can introduce transverse nonlinear focusing sufficient for Landau damping of transverse beam instabilities in accelerators. Unlike other nonlinear elements, the electron lens provides the frequency spread mainly at the beam core, thus allowing much higher frequency spread without lifetime degradation. An estimate for the parameters of the Future Circular Collider is given.

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Identification and reduction of space-charge and beam-beam effects

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Space-charge and beam-beam interaction affect both incoherent and coherent motion of particles potentially leading to instabilities and deterioration of the beam parameters. An overview of these phenomena will be given with an emphasis on the observable spectral characteristics and the mitigation methods of their harmful effects.

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* Vlasov solvers and simulation code analysis for mode-coupling instabilities in both longitudinal and transverse planes

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Two Vlasov solvers for the longitudinal and transverse planes are used to study the frequency shift of coherent oscillation modes and possible mode-coupling instability in case of a broad-band resonator impedance model. In parallel to this approach, a new method to study the coherent frequency shift from the results of simulation codes is presented. Comparisons between the two methods are discussed, as well as simple analytical formulae, which clearly reveal how to mitigate these instabilities.

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Low-impedance design with example of kickers (including cables)

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Recently unmatched terminations of single elements were identified
as responsible of instabilities in the CERN-PSB and CERN-LEIR. Impedance models are needed to estimate the impedance of similar devices and assess potential intensity limitations.
Circuital model and simulation techniques to include the effect of coupling to cables on the beam coupling impedance will be discussed. Moreover, examples of low impedance design with special emphasis on the mitigation of ferrite kickers impedance (e.g. longitudinal serigraphy or coated ceramic inserts), optimisation of transitions and shielding of unintentional cavities. Guidelines for low impedance design will be provided.

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Active methods of suppressing longitudinal multi-bunch instabilities

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Longitudinal multi-bunch instabilities limit the beam intensity and quality reach of hadron synchrotrons. In case the impedance source driving the instability is well known, for example an RF cavity, an active feedback can be set-up locally to reduce its effect on the beam. For multi-bunch instabilities excited by other impedances, global feedback systems are needed. A combination of both types is required to produce the high intensity beam for the future High-Luminosity LHC (HL-LHC) in the CERN Proton Synchrotron (PS). All RF cavities at 10 MHz, 20 MHz, 40 MHz and 80 MHz involved in the generation of LHC-type beams are equipped with direct, wide-band feedbacks. To achieve an impedance reduction beyond their electrical stability limit, they are complemented by upgraded local 1-turn delay and multi-harmonic feedbacks. Additionally, a global coupled-bunch feedback operating in the frequency domain with a Finemet cavity as longitudinal wideband kicker damps all possible dipole oscillation modes. Beam measurements in the PS are presented, highlighting the key contributors to stabilize highest intensity beams for the LHC.

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Mitigation of Space Charge Effects Using Electron Column at IOTA Ring

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We investigate a novel method to mitigate space charge effects of high intensity proton beams propagating in circular accelerators by means of trapping and controlling electrons generated from beam-induced residual gas ionization. This compensation method uses Coulomb repulsion force between a proton beam and electrons to mitigate self-space charge effects of the beam if it passes through a plasma column. The transverse electron-proton (e-p) instability in the plasma column is well controlled by the longitudinal magnetic field of a solenoid magnet and the bias voltages on electrodes. In this report, we will show simulation results how to control distributions of electrons and ions as well as that of the proton beam inside the column. We will also present updates on the status of multi-pass simulation results at Fermilab IOTA Ring using the Synergia-Warp hybrid code.

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* Identification of impedance sources responsible of longitudinal beam instabilities in the CERN PS

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Longitudinal instabilities in the CERN PS are an important limitation in the framework of the LHC Injector Upgrade project to reach the expected beam intensity and longitudinal emittance at PS extraction. The observed instabilities include dipolar and quadrupolar coupled-bunch instabilities, as well as uncontrolled longitudinal emittance blow-up with protons. A microwave instability develops quickly at transition crossing with ion beams. To identify the potential sources of these instabilities, two strategies were adopted. Firstly, measurements were performed for different impedance configurations, i.e. by partially detuning the main rf cavities. Secondly, a thorough survey of the devices in the machine and rf studies allowed to refine the PS impedance model, in order to find potentially missing sources. Measurements were compared with particles simulations using the updated impedance model of the PS. Although the source of dipolar coupled-bunch instabilities was already identified in the past, this study led to the identification of the impedance sources driving the other types of longitudinal instabilities.

Poster Session / 91

* Space Charge and Coherent Stability

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This work presents measurements demonstrating the impact of space charge on the historical vertical SPS instability. The instability has first been encountered as an intensity limit in the SPS Q26 optics. The framework of the fast head-tail instability (or transverse mode coupling instability) describes the behaviour of the found intensity thresholds well. Now, for the first time, we explore the impact of space charge on these findings – and discover that different transverse emittances for otherwise identical beam parameters strongly impact the coherent stability of the proton beam. Since the influence of space charge on the fast head-tail instability is a long-standing topic of discussion since M. Blaskiewicz [1998] first described the problem, we hope to shine some light on the mechanisms with these new measurements.

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Suppression of the Fast Beam-Ion Instability by Tune Spread in the Electron Beam due to Beam-Beam Effects

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The fast beam-ion instability (FII) is caused by the interaction of an electron bunch train with the residual gas ions. The ion oscillations in the potential well of the electron beam have an inherent frequency spread due to the nonlinear profile of the potential. However, this frequency spread and associated with it Landau damping typically is not strong enough to suppress the instability. In this work, we develop a model of FII with takes into account the betatron frequency spread in the electron beam due to the beam-beam interaction in an electron-ion collider. We show that with a large enough beam-beam parameter the fast ion instability can be suppressed. We estimate the strength of this effect for the parameters of the eRHIC electron-ion collider.

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* Overview of collective effects in SLS 2.0

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At the end of 2017, the conceptual design for an upgrade of the Swiss Light Source was finished, promising a 50 fold increase of the brilliance from the current value. From the point of view of collective effects, the main changes in the new design are a reduced chamber size, fully coated with NEG, and operation at small and negative momentum compaction with low synchronous frequency. We give an overview of the latest results for the ring. Most critical is the threshold for the longitudinal single bunch current. Taking into account the combined effect of wake impedances and CSR, we have to rely on bunch stretching by a higher harmonic system to arrive at stable operation at nominal current.

Session 4 / 94

Interplay of transverse damper and head-tail instability

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Transverse head-tail instability is a major limitation of a single-bunch beam current in circular accelerators. Beam-based feedback is now a commonly used tool to suppress the instability. The feedback systems (transverse dampers) provide active suppression of the beam oscillations by electromagnetic fields, the amplitude of which is calculated in real time from the measured beam position. Applicability and efficiency of the transverse dampers are analyzed. The processes of excitation and damping of the instability are studied including chromatic and nonlinear effects. Analytical formulae of the mode-coupling theory are compared with numerical simulations and experimental results.

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* Mitigation of longitudinal multi-bunch instability in the CERN SPS triggered by higher order modes (HOMs) in the accelerating structures

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Beam intensities required by the High-Luminosity (HL-) LHC can presently not be delivered by the CERN SPS, mainly due to beam loading, but also due to a longitudinal multi-bunch instability. This instability is known to be triggered by the third harmonic passband of the 200 MHz multi-cell accelerating structures at an intensity threshold three times below the nominal LHC intensity in the 200 MHz single RF mode. In this case it has not been possible to sufficiently suppress the coupled bunch instability by merely damping the quality factors (Qs) of the HOMs, even when deploying near-to-optimal HOM-couplers. Additional mitigation of the large geometry factors (R/Qs) is required by a slight change of structure, for example in the form of non-resistive, resonant elements that couple to the HOMs, but must leave the fundamental accelerating mode untouched. These mitigation techniques are developed using coupled resonator theory and the electromagnetic simulation codes CST and ACE3P. Their performance is confirmed by RF bench measurements using the probe and perturbation methods. The impact of the HOM suppressors on the accelerating mode is measured as well and the thorough study is completed with multi-physics considerations like RF voltage breakdown and surface heating.

Poster Session / 96

* Synchronous phase shift measurements for evaluation of the longitudinal impedance model at the CERN SPS

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The High Luminosity LHC (HL-LHC) requires 2.3e11 protons per bunch (ppb) at LHC injection. For the SPS, the injector to the LHC, this goal requires a doubling of the injected intensity to 2.6e11 ppb. Longitudinal instabilities were observed in the SPS for intensities below the required 2.6e11 ppb. Identifying, and ultimately mitigating, the impedance sources driving the instabilities requires an accurate impedance model.
Here, we report on measurements of the synchronous phase shift and corresponding energy loss. Using the loss factor to compute the energy loss from the measured bunch spectrum and the SPS impedance model leads to significant disagreements with measurements. This disagreement is investigated for the simplified case of a single resonator. However, simulating matched bunches using the SPS impedance model yields better agreement with measurements.

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* Consequences of longitudinal coupled-bunch instability mitigations on power consumption during the HL-LHC filling

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During the filling of the Large Hadron Collider (LHC), it is desirable to keep the rf cavity voltage constant both in amplitude and phase to minimize the emittance blow-up and injection losses. To have a constant voltage and to minimize power consumption, a special beam-loading compensation scheme called half-detuning is used in the LHC, for which the cavity fundamental resonant frequency needs to be detuned from the rf frequency by an appropriate value. This, however, can result in fast coupled-bunch instabilities caused by the asymmetry of the fundamental cavity impedance. To mitigate them, a fast direct rf feedback and a one-turn delay feedback are presently used in the LHC. The semi-analytical model that describes the dynamics of the low-level rf system in the LHC shows that, depending on the mitigation scenario, the required rf power during injection could significantly exceed the steady-state value. This means that for High-Luminosity LHC (HL-LHC) beam intensities, one can potentially reach the limit of available rf power. In this paper, the model is described and benchmarks with LHC measurements are presented. We also revisit the damping requirements for the longitudinal coupled-bunch instability at injection energy, to find a compromise between longitudinal stability and rf power consumption for the HL-LHC beam.

Poster Session / 98

* CLIC-DR Electron Cloud Build up Simulations

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Electron clouds are produced by photo-emissions, residual gas ionizations and secondary emissions during positively charged beam circulations in particle accelerators. The interaction between the beam and electron clouds leads to critical instabilities which may cause beam losses, trajectory changes and wake fields. In this study, we investigate electron cloud build-up for CLIC-DR's with 0.5ns and 1ns bunch spacings for two different filling patterns. VSim Plasma Discharges and Plasma Acceleration and PyEcloud are used for the 2D electrostatic PIC simulations where the effects of space charge, secondary and photoelectrons are included. We observe electron build-up's for two scenarios using different secondary emission yield models and quantify the total number of electrons and photoelectrons vs. time.

Poster Session / 99

* A wake fields evaluation for beam collimators and the 60 pC electron beam at the Compact ERL at KEK

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When a high intensity charged beam passes through locations with narrow apertures, such as the rod of a collimator, undesirable wake fields can be generated and adversely affect the beam. The Compact ERL at KEK mainly uses five beam collimators (one at the injector line, one at the merger section, and three in the recirculation loop) to remove the beam halo and to localize the beam losses. Those collimators are composed of four cylindrical rods of 7 mm in radius made of copper. Rods can be inserted independently from the top, bottom, left, and right of the beam chamber. There are no tapers in these rods, and the bunch length of the beam is usually as short as a few ps or less. We investigated the effect of the collimator on the beams. Namely, the emittance increase due to the transverse wake field caused by the shape and the resistivity of the collimator. And the energy loss of the beam due to the longitudinal wake field. The longitudinal and transvers wake fields of the collimator were calculated in CST simulation. Here, we report both the simulated and evaluated longitudinal and transverse wake fields and their effects on the beam.

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* Electromagnetic characterization of Amorphous Carbon in the sub-THz

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Modern accelerators and light sources often require special treatment of the vacuum chamber surface in order to avoid undesirable effects and to maximize machine performance. Coatings with Amorphous Carbon (a-C) have been extensively tested and used with very effective results since it allows to reduce the secondary electron yield (SEY) of the pipe walls due to electron cloud and to avoid the relevant beam instability. An electromagnetic characterization a-C coating is therefore fundamental to build a reliable impedance model. Our characterization method is based on time domain measurements of an electromagnetic wave passing through a tailored half-waveguide, closed with a bulk piece where the coating is deposited. This configuration is designed to have a homogeneous coating thickness large enough to allow a good signal to noise ratio but also to avoid peel-off and blistering. The electromagnetic characterization is performed in the frequency range from 0.1 to 0.3 THz.

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* Transverse Instabilities and Mitigation in Cycles of SIS100

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The SIS100 synchrotron, presently under construction in Darmstadt, Germany, will provide high intensity ion beams to the different experiments of FAIR. Numerous types of RF and ramp cycles for the full range of ions are planned for the operation. Here we identify a few reference cycles for the heavy-ion and proton beams and consider the transverse stability along the time scenario of the beams. The recent data for the transverse impedances are used to calculate the instability growth rates. For mitigation, the octupole magnets and the chromaticity requirements are considered. The effects of space-charge on Landau damping are taken into account. The role of a feedback system is discussed.

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* Metamaterial-based absorbers for the mitigation of beam coupling impedance effects

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Resistive-wall impedance constitutes a significant percentage of the total beam-coupling impedance budget of an accelerator. A number of different reduction techniques have been proposed during the years depending on the specific applications, ranging from higher order modes damping to solutions entailing high electrical-conductivity coatings of the pipe. This paper investigates the use of metamaterial-based absorbers for sensibly reducing or nearly cancelling resistive-wall impedance. We design and fabricate sub-wavelength two-dimensional metallic resonant structures based on the split ring resonator (SRR) geometry that can be employed as mode dampers in accelerating structures. A number of prototypes are fabricated and measured in a "test model" pillbox cavity. Experimental results agree well with full wave electromagnetic simulations and with the constitutive effective parameters of the SRR-based metamaterials retrieved using a numerical analysis. This study opens up to the possibility of considering metamaterials as a valid alternative to other devices for impedance mitigation in experimental setups commonly operating along a particle beam line, such as accelerating cavities or collimators, and more in general for the development of filters with a large out-of-band signal rejection in specific applications.

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Closing remarks

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* Landau damping with an electron lens

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Electron lenses are one of the ways to provide incoherent betatron tune spread for Landau damping of transverse coherent beam instabilities. We investigated the effect of transverse electron beam profile size and shape for Landau damping with electron lens. Another point of interests is Landau damping provided by a pulsed electron lens with homogeneous transverse beam profile. This type of electron lens is developed for space-charge compensation in SIS18.

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Student Prize Announcement

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