EPAC'06 abstracts contributed by ABP-RLC team members

Collective Effects (LHC+injectors) and LHC Upgrade

1. *Tune Shift Induced by the Nonlinear Resistive-Wall Wake Field of a Flat Collimator*

   F. Zimmermann, G. Arduini, R. Assmann, H. Burkhardt, F. Caspers, M. Gasior, R. Jones, T. Kroyer, E. Métral, S. Redaelli, G. Robert-Demolaize, F. Roncarolo, G. Rumolo, R. Steinhagen, and J. Wenninger

   We present formulae for the coherent and incoherent tune shifts due to the nonlinear resistive wall wake field for a single beam traveling between two parallel plates. In particular, we demonstrate that the nonlinear terms of the resistive-wall wake field become important if the gap between the plates is comparable to the transverse rms beam size. We finally compare the theoretically predicted tune shift as a function of gap size with measurements and simulations for an LHC prototype graphite collimator in the CERN SPS.

2. *Lifetime Limit from Nuclear Scattering for Bunched Hadron Beams*

   F. Ruggiero, F. Zimmermann

   We derive an approximate expression for the nuclear scattering rate inside a bunched hadron beam. Application to the LHC suggests that the loss rate due to nuclear scattering can be significant in high-energy proton or ion storage rings.

3. *Accelerator Physics Code Web Repository*

   F. Zimmermann, D. Abell, R. Bartolini, R. Basset, E. Benedetto, Y. Cai, Y.-H. Chin, S. Cousineau, V. Danilov, U. Dorda, L. Farvacque, M. Furman, M. Giovannozzi, J. Holmes, T. Katsouleas, D. Kaltchev, E.-S. Kim, K. Ohmi, K. Oide, Y. Papaphilippou, J. Payet, T. Pieloni, M. Pivi, J. Qiang, F. Ruggiero, G. Rumolo, G. Sabbi, F. Schmidt, T. Sen, A. Shishlo, E. Todesco, J.-L. Vay, B. Zotter

   In the framework of the CARE HHH European Network, we have developed a web-based dynamic accelerator-physics code repository. We describe the design, structure and contents of this web repository, illustrate its usage, and discuss our future plans.

4. *Resonance Trapping, Halo Formation and Incoherent Emittance Growth due to Electron Cloud*

   E. Benedetto, G. Franchetti, G. Rumolo, F. Zimmermann

   The pinched electron cloud introduces a tune shift along the bunch, which together with synchrotron motion, leads to a periodic crossing of resonances. The resonances are excited by the longitudinal distribution of the electron cloud around the storage ring. We benchmark the PIC code HEADTAIL against a simplified weak-strong tracking code based on an analytical field model, obtaining an excellent agreement. The simplified code is then used for exploring the long-term evolution of the beam emittance, and for studying more realistic lattice models. Results are presented for the CERN SPS and the LHC.

5. Maps for Electron Clouds: application to LHC

   T. Demma, S. Petracca (Un. Benevento), F. Ruggiero, G. Rumolo, F. Zimmermann (CERN)

   Electron Cloud studies performed so far were based on very heavy computer simulations taking into account photoelectron production, secondary electron emission, electron dynamics, and space charge effects providing a very detailed description of the electron cloud evolution. In [1] it has been shown that, for the typical parameters of RHIC, the bunch-to-bunch evolution of the electron cloud density can be represented by a cubic map. Simulations based on this map formalism are orders of magnitude faster than those based on usual codes. In this communication we show that the map formalism is also reliable in the range of typical LHC parameters, and discuss the dependence of the polynomial map coefficients on the physical parameters affecting the electron cloud (SEY, chamber dimensions, bunch spacing, bunch charge, etc.).

[1] U. Iriso and S. Peggs, “Maps for Electron Clouds”, Phys. Rev. ST Accel. Beams **8**, 024403 (2005).

6. *Simulations of Long-Range Beam-Beam Interactions and Wire Compensation with BBTRACK*

   U. Dorda, F. Zimmermann

   We present weak-strong simulation results for the effect of long-range beam-beam collisions in LHC, SPS, RHIC and DAFNE, as well as for proposed wire compensation schemes or wire experiments, respectively. In particular, we discuss details of the simulation model, instability indicators, the effectiveness of compensation, the difference between nominal and PACMAN bunches for the LHC, beam experiments, and wire tolerances. The simulations are performed with the new code BBTRACK.

7. *Large scale beam-beam simulations for the CERN LHC using distributed computing resources*

   W. Herr, E. McIntosh and F. Schmidt, CERN, Geneva, Switzerland

   D. Kaltchev, TRIUMF, Vancouver, Canada

   We report on a large scale simulation of beam-beam effects for the CERN Large Hadron Collider (LHC). The stability of particles which experience head-on and long range beam-beam effects was investigated for different optical configurations and machine imperfections. To cover the interesting parameter space required computing resources not available at CERN. The necessary resources were available in the LHC@home project, based on the BOINC platform. At present, this project makes more than 40000 hosts available for distributed computing. We shall discuss our experience using this system during a simulation campaign of more than 6 months and describe the tools and procedures necessary to ensure consistent results. The results from this extended study are presented and future plans are discussed.

8. *Models to study multi bunch coupling through head-on and long-range beam-beam interactions*

   T. Pieloni and W. Herr, CERN

   In the LHC almost 6000 bunches will collide in four interaction points where they experience head-on as well as clustered long range interactions. These lead to a coupling between all bunches and coherent beam-beam effects. For two colliding bunches this is well understood. However, for a large number of bunches colliding with different collision patterns, it results in a complex spectrum of oscillation frequencies with consequences for beam measurements and Landau damping. To study the coherent beam-beam modes, three complementary models have been developpped and will be described in this report. Two of these methods rely on self-consistent multi-bunch and multi-particle tracking while the third is a semi-analytic model based on a complex matrix algorithm. The three methods together provide useful information about the beam-beam coupling of multi bunch beams and together provide a deeper insight into the underlying physics.

9. *Simulation study on the energy dependence of the TMCI threshold in the CERN-SPS*

   E. Métral, G. Rumolo, E. Shaposhnikova

   This paper concentrates on theoretical studies of Transverse Mode Coupling Instability at the SPS. It shows the expected thresholds based on the HEADTAIL tracking model and on impedance values estimated from previous measurements. First, the effect of space charge is addressed as an important ingredient at the low energies. Subsequently, the change of TMCI threshold possibly induced by a higher injection energy into the SPS (plausible according to the upgrade studies) is investigated and a scaling law with energy is derived.

10. *Kicker impedance measurements for the future multi-turn extraction of the CERN Proton Synchrotron*

    F. Caspers, M. Giovannozzi, A. Grudiev, T. Kroyer, E. Métral

    In the context of the novel multi-turn extraction, where charged particles are trapped into stable islands in transverse phase space, the ejection of five beamlets will be performed by means of a set of three new kickers. Before installing them into the machine, a measurement campaign has been launched to evaluate the impedance of such devices. Two measurement techniques were used to try to disentangle the driving and detuning impedances. The first consists in measuring the longitudinal impedance for different transverse offsets using a single displaced wire. The sum of the transverse driving and detuning impedances is then deduced applying Panofsky-Wenzel theorem. The second uses two wires excited in opposite phase and yields the driving transverse impedance only. Finally, simulations with Ansoft HFSS, a finite-element electromagnetic simulator, have also been performed to crosscheck the measurement results, and study the effect of the finite kicker length.

11. *Time evolution of the fast vertical single-bunch instability at the CERN Super Proton Synchrotron injection*

    G. Arduini, H. Burkhardt, E. Métral, G. Rumolo

    Since 2003, high-intensity single-bunch proton beams with low longitudinal emittance and chromaticity have been affected by heavy losses after less than one synchrotron period. The effects of the impedance resonance frequency, longitudinal emittance and chromaticity on the intensity threshold were already discussed in detail in 2004, comparing analytical predictions with simulation codes. In this paper, the time evolution between injection and beam losses is our main concern. Measurements are compared to both analytical predictions and HEADTAIL simulations. A travelling-wave pattern propagating along the bunch, which is the signature of a Beam Break-Up or Transverse Mode Coupling instability, is clearly identified. The oscillating frequency, near ~ 1 GHz, is in good agreement with the usual Broad-Band impedance model deduced from beam-based measurements like the head-tail growth rate vs. chromaticity.

12. *Simulation study on the beneficial effect of linear coupling for the transverse mode coupling instability in the CERN Super Proton Synchrotron*

    E. Métral and G. Rumolo

    The intensity threshold of the transverse mode coupling instability in a flat vertical chamber, as in the CERN Super Proton Synchrotron, is much higher in the horizontal plane than in the vertical one. This asymmetry between the transverse planes led us to the idea that linear coupling from skew quadrupoles could be used to increase the intensity threshold. This technique is already applied, for instance, in the CERN Proton Synchrotron, where a slow head-tail horizontal instability due to the resistive-wall impedance is stabilized by linear coupling only, i.e. with neither octupoles nor feedbacks. This paper presents the results of the study of the effect of linear coupling on the transverse mode coupling instability, using the HEADTAIL simulation code.

13. *An Alternative Nonlinear-Collimation System for the LHC*

    J. Resta Lopez, R. Assmann, A. Faus-Golfe, S. Redaelli, G. Robert-Demolaize, D. Schulte, F. Zimmermann

The optics design of an alternative nonlinear collimation system for the LHC is presented. We discuss an optics scheme based on a single spoiler located in between a pair of skew sextupoles for betatron collimation. The nonlinear system allows opening up the collimator gaps and, thereby, reduces the collimator impedance, which presently limits the LHC beam intensity. After placing secondary absorbers at optimum locations behind the spoiler, we analyze the beam losses and calculate the cleaning efficiency from tracking studies. The results are compared with those of the conventional linear collimation system.

14. *First Observation of Proton Reflection from Bent Crystals*

    W. Scandale (CERN), Yu. Ivanov, A. Petrunin, Gavrikov, Gelamkov, L. Lapina, V. Skorobogatov, Schetkovsky (PNPI), V.I. Baranov, Yu. Chesnokov, A. Afonin, V.T. Baranov, V. Chepegin (IHEP), V. Guidi (Ferrara)

    We recently suggested using short bent crystals as primary collimators in a two stage cleaning system for hadron colliders, with the aim of providing larger impact parameters in the secondary bulk absorber, through coherent beam-halo deflection [1]. Tests with crystals a few mm long, performed with 70 GeV protons at IEHP in Protvino, showed a channeling efficiency exceeding 85%. We also observed disturbing phenomena such as dechanneling at large impact angle, insufficient bending induced by volume capture inside the crystal, multiple scattering of non-channeled protons and, for the first time, a proton flux reflected by the crystalline planes. Indeed, protons having a tangent path to the curved planes somewhere inside the crystal itself are deflected in the opposite direction with respect to the channeled particles, with an angle almost twice as large as the critical angle. This effect, up to now only predicted by computer simulations [2], produces a flux of particles in the wrong direction with respect to the absorber, which may hamper the collimation efficiency if neglected.

    [1] A. Afonin et al. Phys. Rev. Lett. 87.094802 (2001)
    [2] A.M. Taratin and S.A. Vorobiev, Phys. Lett. **A**119 (1987) 425

15. *Optics study for a possible crystal based collimation system for the LHC*

    R. Assmann and S. Redaelli, CERN

    The use of bent crystals as primary collimators has been long proposed as an option to improve the cleaning efficiency of the LHC betatron and momentum collimation systems. These systems are presently based on two-stage collimation with amorphous scatterers and absorbers. Crystals are expected to help by channeling and extracting the halo particles with large angles, resulting in higher cleaning efficiency. Independent of ongoing studies for crystal qualifications (not reported here) it is important to understand the required deflection angles and the possible locations of absorbers for the LHC layout. Optics studies have been performed in order to specify required angles for various LHC beam energies and possible locations of absorbers for the deflected halo beam. A possible layout for crystal-assisted collimation at the LHC is discussed, aiming for a solution which would not change the LHC layout but would make use of existing collimator location.

16. An additional EPAC06 abstract on an *SPS Crystal Channelling Test* may be submitted for approval by R. Assmann, W. Scandale, et al. in January 2006.

CLIC/CTF/ILC

17. *Efficient Collimation and Machine Protection for the Compact Linear Collider*

    R. Assmann, F. Zimmermann

We present a new approach to machine protection and collimation in CLIC, separating these two functions: If emergency dumps in the linac protect the downstream beam line against drive-beam failures, the energy collimation only needs to clean the beam tails and can be compact. Overall, the length of the beam delivery system is significantly reduced.

18. *CLIC Polarized Positron Source Based on Laser Compton Scattering*

    F. Zimmermann, J. Urakawa, T. Omori et al. (KEK), A. Variola. F. Zomer et al. (LAL), S. Guiducci, P. Raimondi (INFN Frascati), K. Moenig (DESY-Zeuthen), E. Bulyak, P. Gladkikh (NSC KIPT Kharkov), A. Tsunemi (Sumitomo), (Waseda U.), (Hiroshima U.), (Kyoto U.), J. Gao (IHEP Beijing), (IHEP Moscow) - 35 authors in total (”POSIPOL collaboration”)

    We describe the possible layout and parameters of a polarized positron source for CLIC, where the positrons are produced from polarized X-rays created by Compton scattering of a 1.3-GeV electron beam off a YAG laser. This scheme is very energy effective using high finesse laser cavities in conjunction with an electron storage ring. We point out the differences with respect to a similar system proposed for the ILC.

19. *Ion Effects in the Damping Rings of ILC and CLIC*

    W. Bruns, D. Schulte, F. Zimmermann

    We discuss ion trapping, rise time of the fast beam-ion instability, and the ion-induced incoherent tune shift for various incarnations of the ILC damping rings, taking into account the different regions of each ring. Analytical calculations for ion trapping are compared with results from a new simulation code.

20. *CLIC final focus studies*

    R. Tomàs, H.H. Braun, D. Schulte, F. Zimmermann

    The design of the CLIC final focus system is based on the local compensation scheme proposed by P. Raimondi and A. Seryi. However, there exist important chromatic aberrations that deteriorate the performance of the system. This paper studies the optimization of the final focus based on the computation of the high orders of these aberrations using MAD-X and PTC. The use of octupole doublets to reduce the size of the halo in the locations with aperture limitations is also discussed.

21. *Minimizing Emittance for the CLIC Damping Ring*

    E. Levitchev, P. Piminov, S. Siniatkin, P. Vobly, K. Zolotarev (BINP), H.H. Braun, M. Korostelev, D. Schulte, F. Zimmermann (CERN)

    The CLIC damping rings aim at unprecedented small normalized equilibrium emittances of 3.3 nm vertical and 550 nm horizontal, for a bunch charge of 2.6×10^9 particles and an energy of 2.4 GeV. In this parameter regime the dominant emittance growth mechanism is intra-beam scattering. Intense synchrotron radiation damping from wigglers is required to counteract its effect. Here the overall optimization of the wiggler parameters is described, taking into account state-of-the-art wiggler technologies, wiggler effects on dynamic aperture, and problems of wiggler radiation absorption. Two technical solutions, one based on superconducting magnet technology the other on permanent magnets are presented. Although dynamic aperture and tolerances of this ring design remain challenging, benefits are obtained from the strong damping. Only bunches for a single machine pulse need to be stored, making injection/extraction particularly simple and limiting the synchrotron-radiation power. With a 360 m circumference the ring remains comparatively small.

22. *Beam Dynamic Studies and Emittance Optimization in the CTF3 Linac at CERN*

    H.H. Braun, R. Corsini, S. Doebers, F. Tecker, P. Urschütz, CERN

Small transverse beam emittances and well known lattice functions are crucial for the 30 GHz power production in the Power Extraction and Transfer Structure and the commissioning of the delay loop at the CLIC Test Facility 3 (CTF3). Following beam dynamics simulation results, two additional solenoids were installed in the CTF3 injector in order to improve the emittance. During the run 2005 an intensive measurement campaign aiming at a detailed knowledge on Twiss parameters and beam size was launched. First results obtained by means of quadrupole scans for different modes of machine operation indicate emittances well below the nominal $\varepsilon_{n,rms} = 100\,\pi$ mm mrad and a convincing agreement with PARMELA simulations.

23. *Correction of Vertical Dispersion and Betatron Coupling for the CLIC Damping Ring*

    M. Korostelev and F. Zimmermann

    The sensitivity of the CLIC damping ring to various kinds of alignment errors have been studied. Without any correction, fairly small vertical misalignments of the quadrupoles and, in particular, the sextupoles, introduce unacceptable distortions of the closed orbit as well as intolerable spurious vertical dispersion and coupling due to the strong focusing optics of the damping ring. A sophisticated beam-based correction scheme has been developed to bring the design target emittances and the dynamic aperture back to the ideal value. The correction using dipolar correctors and several skew quadrupole correctors allows a minimization of the closed-orbit distortion, the cross-talk between vertical and horizontal closed orbits, the residual vertical dispersion and the betatron coupling.

24. *Effects of wake fields in the CLIC BDS*

    G. Rumolo, D. Schulte

    The wake fields due to collimators in the Beam Delivery System of CLIC are modeled using a conventional approach. According to the chosen ranges of parameters, differences in the transverse kicks due to both the geometric and resistive wall components for different regimes are highlighted (inductive or diffractive for the geometric wake fields, short- or long-range, ac or dc for the resistive wall wake fields). A module for particle tracking along the BDS including the effect of wake fields has been introduced in PLACET and first tracking results are shown.

25. *Recent Improvements of PLACET*

    A. Latina*, H. Burkhardt, P. Eliasson, L. Neukermans, J. Resta Lopez, G. Rumolo, D. Schulte, R. Tomàs

    The tracking code PLACET is used to simulate the beam transport in linear colliders from the damping ring to the interaction point and beyond. Recent improvements of the code are presented. They include the possibility to simulate bunch compressors and to use parallel computer systems.

26. *Simulation of Main Linac Tuning Bumps in the Presence of Noise*

    P. Eliasson*, D. Schulte

    Previous simulations for CLIC and ILC have shown that the use of emittance tuning bumps as a complement to beam-based alignment is very effective to reduce emittance growth caused by static imperfections. Dynamic imperfections, e.g. RF phase jitter and ground motion, which can only be corrected by feedback, may however complicate the emittance tuning. The interaction between the feedback systems and the tuning bumps has been investigated and the impact of dynamic imperfections on the static correction using emittance tuning bumps has been evaluated.

27. *Halo and Tail Generation Studies for Linear Colliders*

    L. Neukermans*, H. Burkhardt (CERN)

Halo particles in linear colliders can result in significant losses and serious backgrounds which may reduce the overall performance. We present a study of various halo generation processes with numerical estimates. The aim is to allow to predict and minimize the halo throughout the accelerator chain including the final focus up to the experimental detectors. We include estimates for the planned CLIC beam line.

28. *Luminosity Tuning at the Interaction Point*

    P. Eliasson, M. Korostelev*, D. Schulte, F. Zimmermann

    Minimisation of the emittance in a linear collider is not enough to achieve optimal performance, i.e. maximum luminosity. For optimisation of the luminosity, tuning of collision parameters, such as offset, angle, waist, etc., is needed and a fast and reliable tuning signal required. In this paper tuning knobs are presented and their optimisation using beamstrahlung as a tuning signal is studied.

29. *A Code to Simulate Collective Effect of Electrons and Ions*

    W. Bruns*, D. Schulte, F. Zimmermann

    A new code for computing multiple effects of slowly moving charges is being developed. The basic method is electrostatic Particle in Cell. The underlying grid is rectangular and locally homogeneous. At regions of interest, eg where the beam is, or near material boundaries, the mesh is refined recursively. The motion of the macroparticles is integrated with an adapted time step. Fast particles are treated with a smaller time step, and particles in regions of fine grids are also treated with a fine time step. The position of collision of particles with material boundaries are accurately resolved. Secondary particles are then created according to user specified yield functions.

30. *Progress on the CTF3-TBL*

    E. Adli, G. Rumolo, D. Schulte, I. Syratchev

    In CLIC, the RF power to accelerate the main beam is produced by decelerating a drive beam. The test beamline (TBL) of CTF3 aims at demonstrating the stable deceleration of this drive beam. It will allow to benchmark the computer codes used for the decelarator design. Different options of this experimental beam line are discussed.

31. *Implications of a Curved Tunnel for the Main Linac of CLIC*

    A. Latina*, P. Eliasson, D. Schulte

    Preliminary studies of a linac that follows the earth curvature are presented for the CLIC main linac. The curvature of the tunnel is modeled in a realistic way by use of geometry changing elements. The emittance preservation is studied for a perfect machine as well as taking into account imperfections. Results for a curved linac are compared with those for a laser-straight machine.

32. *Study of an ILC Main Linac that Follows the Earth Curvature*

    P. Eliasson, A. Latina, F. Poirier, D. Schulte, N. Walker

    In the base line configuration, the tunnel of the ILC will follow the earth curvature. The emittance growth in a curved main linac has been studied including static and dynamic imperfections. These include effects due to current ripples in the power supplies of the steering coils, the impact of the beam position monitors and beam energy errors.

33. *Studies on Failure Modes in ILC*

    P. Eliasson, A. Latina, F. Poirier, D. Schulte, N. Walker

Failures in the ILC can lead to beam loss or even damage the machine. Also failures that do not lead to beam loss can affect the luminosity performance, in particular since some time is required to recover from them. In the paper a number of different failures is being investigated and their impact on the machine performance is being studied.