**4) “A particle data model for HeadTail: design and implementation with examples”**

*Authors: Kevin Li, Giovanni Rumolo*

HeadTail has been developed in 2002 for the eﬃcient simulation of instabilities and collective eﬀects in large circular accelerators. Since then, the capabilities of the code have been continuously extended and the output data has become increasingly complex and large-scale ranging from the statistical description of single bunches to the statistical description of all slices within bunches up to the dynamics of the full 6D phase space over several thousands of turns. Processing this data in an eﬀective manner and enduing it with a structure that provides a physical concept calls for new and optimised data formats. To meet state-of-the-art standards, the hierarchical data format (HDF5) has been selected as native output data format together with H5Part and XDMF as native data structures. We describe the implementation of the H5Part and the XDMF data structures into HeadTail and show some illustrative examples for data processing.

**7) “Beam Coupling Impedance Evaluation of new beam screen designs for the LHC-MKI”**

*Authors: H. Day, M. J. Barnes, F. Caspers, R.M. Jones (UMAN, CI), E. Metral*

During the 2011 run of the LHC there was a measured temperature increase in the LHC Injection Kicker Magnets (LHC-MKI) during operation with 50ns bunch spacing. This was suspected to be due to increased beam-induced heating of the magnet due to beam impedance. Due to concerns about future heating with the increased total intensity to nominal and ultimate luminosities a review of the impedance reduction techniques within the magnet was required. A number of new beam screen designs are proposed and their impedance evaluated. Heating estimates are also given with a particular attention paid to future intensity upgrades to ultimate and HL-LHC parameters.

**8) “Beam coupling impedance localization measurements in the CERN SPS”**

*Authors: N.Biancacci, G.Arduini, T.Argyropoulos, H.Bartosik, R.Calaga, E.Metral, M.Migliorati, L.Palumbo, G.Rumolo, B.Salvant*

The beam coupling impedance leads to limitations in beam brightness and needs accurate quantification and continuous monitoring in order to detect and mitigate high impedance sources.
In the CERN SPS, kickers are expected to be the main contributors to the total impedance budget. Other known sources are the beam pipe, the RF cavities and the BPMs but comparisons with global impedance measurements indicate that still 35% of the total vertical impedance is missing.
In order to better detect the missing sources, the localization algorithm was applied for two different SPS optics, for which the tunes, phase advances and beta functions vary. In this work the main issues of the localization method applied to measured data as well as the results related to this measurement are presented.

**9) “Beam Coupling Impedance Simulations of the LHC TCTP collimators”**

*Authors: H. Day, F. Caspers, A. Dallochio, L. Gentini, A. Grudiev, R.M. Jones (UMAN, CI), E. Metral, B. Salvant*

As part of an upgrade to the LHC collimation system, 8 TCTP and 1 TCSG collimators are proposed to replace existing collimators in the collimation system. In an effort to review all equipment placed in the accelerator complex for potential side effects due to collective effects and beam-equipment interactions, beam coupling impedance simulations are carried out in both the time-domain and frequency-domain of the full TCTP design. Particular attention is paid to trapped modes that may induce beam instabilities and beam-induced heating due to cavity modes of the device.

**12) “Beta Beams for precision measurement of neutrino oscillation parameters”**

*Authors: Elena Wildner*

Neutrino oscillations have implications for the Standard Model of particle physics. The “CERN Beta Beam” has outstanding capabilities to contribute to precision measurements of the parameters governing neutrino oscillations. The FP7 collaboration “EUROnu” (2008-2012) is a design study that will review three facilities (Super-Beams, Beta Beams and Neutrino Factories) and perform a cost assessment that, coupled with the physics performance, will give means to the European research authorities to make decisions on future European neutrino oscillation facilities. "Beta Beams" produce collimated pure electron (anti)neutrino by accelerating beta active ions to high energies and having them decay in a storage ring. Using existing machines and infrastructure is an advantage for the cost evaluation; however, this choice is also constraining the Beta Beams. Recent work to make the Beta Beam facility a solid option will be described: production of Beta Beam isotopes, the 60 GHz pulsed ECR source development, integration into the LHC-upgrades, ensure the high intensity ion beam stability, and optimizations to get high neutrino fluxes. The costing approach will also be described.

**18) “Comparison between electron cloud build-up measurements and simulations at the CERN Proton Synchrotron”**

*Authors: Giovanni Iadarola (CERN & Universita' di Napoli Federico II), Fritz Caspers, Simone Gilardoni, Edgar Mahner, Giovanni Rumolo, Christina Yin Vallgren (CERN)*

The buildup of an Electron Cloud (EC) has been observed at the CERN Proton Synchrotron (PS) during the last stages of the LHC high intensity beam preparation, especially after the bunch shortening before extraction. A dedicated EC experiment, equipped with two button pick-ups, a pressure gauge, a clearing electrode and a small dipole magnet, is available in one of the straight sections of the machine. A measurement campaign has been carried out, in order to scan the EC build-up of LHC-type beams with different bunch spacing, bunch intensity and bunch length. Such information, combined with the results from buildup simulations, is of relevance for the characterization in terms of Secondary Emission Yield (SEY) of the chamber inner surface. The interest is twofold: this will enable us to predict the EC build up distribution in the PS for higher intensity beams in the frame of the upgrade program, and it will provide validation of the EC simulation models and codes.

**24) “Effect of the TEM mode on the kicker Impedance”**

*Authors: Carlo Zannini, Giovanni Rumolo*

The kickers are major contributors to the CERN SPS beam coupling impedance. As such, they may represent a limitation to increasing the SPS bunch current in the frame of a luminosity upgrade of the LHC. The C-Magnet supports a transverse electromagnetic (TEM) mode due to the presence of two conductors. Due to the finite length of the structure this TEM mode affects the impedance below a certain frequency (when the penetration depth in the ferrite becomes comparable to the magnetic circuit length). A 3D theoretical model based on transmission line (TL) theory was developed to take into account the impedance contribution due to the TEM mode. The model is found to be in good agreement with CST 3D EM simulations. It allows for generic terminations in the longitudinal direction. A few examples of kickers are analyzed taking into account also the external cables.

**25) “Effects of an asymmetric chamber on the beam coupling impedance”**

*Authors: Carlo Zannini, Kevin Shing Bruce Li, Giovanni Rumolo*

The wake function of an accelerator device appears to have a constant term if the geometry of the device is asymmetric or when the beam passes off axis in a symmetric geometry. Its contribution can be significant and has to be taken into account. In this paper a generalized definition of the impedance/wake is presented to take into account also this constant term. A few examples of devices where the constant term appears are analyzed. Moreover, HEADTAIL simulations are performed to examine the effect of this contribution on the beam dynamics.

**26) “Electromagnetic simulations of the impedance of the LHC injection protection collimator”**

*Authors: B. Salvant, B. Goddard, A. Grudiev, E. Métral, M. Timmins, B. Salvant*

During the 2011 LHC run, significant vacuum and temperature increase were observed at the location of the LHC injection protection collimators (TDI) during the physics fills. Besides, measurements of the LHC transverse tune shift while changing the TDI gap showed that the impedance of the TDI was significantly higher than the LHC impedance model prediction based on multilayer infinite length theory. This contribution details the electromagnetic simulations performed with a full 3D model of the TDI to obtain both longitudinal and transverse impedances and their comparison with measured observables.

**27) “COLLECTIVE EFFECTS IN THE LHC AND ITS INJECTORS”**

*Authors: Elias Metral*

Operation during 4-8 hours at a constant luminosity of five times the nominal one (with “leveling”) is required for the CERN HL-(High Luminosity)-LHC project to be able to reach integrated luminosities of ~ 250 fb-1 per year and ~ 3 ab-1 twelve years after the upgrade. This means that the potential peak luminosity should be at least two times larger than the leveled one, i.e. a factor more than ten compared to the nominal case is contemplated. Even though the LHC had a bold beginning, reaching one third of the nominal peak luminosity at the end of the 2011 run, a factor more than thirty remains to be gained, which will be achieved only if all the collective effects are deeply understood and mastered both in the LHC and its injectors. The observations made during the 2010-2011 runs are first reviewed and compared to predictions to try and identify possible bottlenecks. The lessons learned and the possible solutions and/or mitigation measures to implement in the HL-LHC and the LHC Injectors Upgrade (LIU) projects are then discussed.

**32) “HEADTAIL Simulations of LMCI in the SPS with Broadband and Space Charge Impedances”**

*Authors: H. Day, E. Metral, R.M. Jones (UMAN, CI)*

The single bunch stability limit in the regime of LMCI in the SPS above and below transition is investigated with HEADTAIL. A comparison of a Broadband impedance and space charge impedance singularly and combined are investigated. A comparison of the stability limits with injection both below and above transition are made and comments given.

**54) "Measurements and simulations of transverse coupled-bunch instability rise times in the LHC"**

*Authors: Nicolas Mounet, Elias Métral – Giovanni Rumolo – Verena Kain – Daniel Valuch – Laurette Ponce – Wolfgang Höfle – Reyes Alemany Fernandez – Delphine Jacquet – Stefano Redaelli – Ronaldus Suykerbuyk (CERN)*

In the current configuration of the LHC, multibunch instabilities due to the beam-coupling impedance would be in principle a critical limitation if they were not damped by the transverse feedback. For the future operation of the machine, in particular at higher bunch intensities and / or higher number of bunches, one needs to make sure the coupled-bunch instability rise times are still manageable by the feedback system. Therefore, in May 2011 experiments were performed to measure those rise times and compare them with the results obtained from the LHC impedance model and the HEADTAIL wake fields simulation code. At injection energy, agreement turns out to be very good, while a larger discrepancy appears at 3.5 TeV.

**55) "Mitigation of electron cloud instabilities in the LHC using sextupoles and octupoles"**

*Authors: Kevin Li, Giovanni Rumolo*

Coherent electron cloud instabilities pose a serious limitation for luminosity upgrades in the LHC. In particular, when bunch spacings reach below 50 ns electron cloud formation is enhanced which in turn drives beam instabilities. The beam can be stabilised by increasing the tune spread using sextupoles and octupoles causing the beam to decohere. The resulting values for the chromaticity and the detuning parameters must be selected with care, however, in order not to run into head-tail instabilities or to considerably reduce the dynamic aperture, respectively. A simulation study has been launched to determine the parameters necessary for stabilisation of the beam under the influence of electron clouds.

**77) "The mode matching method applied to beam coupling impedance calculations of finite length devices"**

*Authors: N.Biancacci, E.Metral, M.Migliorati, L.Palumbo, B.Salvant, V.G.Vaccaro*

The infinite length approximation is often used to simplify the calculation of the beam coupling impedance of accelerator elements. This is expected to be a reasonable assumption for devices whose length is greater than the transverse dimension but may be less accurate approximation for segmented devices.
This contribution present the study of the beam coupling impedance in the case of a finite length device: a cylindrical cavity loaded with a toroidal slab of material. In order to take into account the finite length we will decompose the field in the cavity and in the beam pipe into a set of orthonormal modes and apply the mode matching method to obtain the impedance.
To validate our method, we will present comparisons between analytical formulas and 3D electromagnetic CST simulations as well as applications to the impedance of short beam pipe inserts, where the longitudinal and transverse dimensions are difficult to model in numerical simulations.