WP2 Meeting #143

Tue 5 Mar 2019, 10:00 – 12:00

Chair: R. Tomás

Speakers: L. Blondel, G. Skripka

Participants: A. Alekou, S. Antipov, S. Fartoukh, M. Giovannozzi, G. Iadadola, S. Kostoglou, V. Lebedev (FNAL), E. Métral, A. Oeftiger, Y. Papaphilippou, F. Plassard, B. Salvant, G. Sterbini

Agenda

The meeting covered two topics of HL-LHC performance: electron cloud effect and possible ways to introduce transverse beam cooling.

MEETING ACTIONS

Frederick, Massimo	Study the effect of MCBRD a3/b3 errors on linear optics distortions, as proposed by S. Fartoukh
Gianni or WP2?	Ask the cryogenics experts to commit to a cooling power value that can be provided throughout the Run 3 and HL-LHC?

General information (R. Tomás)

Rogelio reviewed the minutes of the last meeting. **Stéphane** made a comment on the analysis of MCBRD a3/b3 errors, proposing to take a look at linear optics distortion, induced via feed-down, pointing that it is, in general, the best criteria to look at for specifying the field quality. **Massimo** noted they will take into account Stephane's suggestions and come back with the results for a future discussion (Action: **Frederick**)

Nicolas Magnin will give a talk on the 16th of April

1 Scaling of ecloud effects with bunch population (G. Skripka)

LHC has differences in heat loads between different sectors and beams. For example, in some cells a heat load from Beam 1 can be significantly higher than the heat load of Beam 2. Studies performed in instrumented cryocells show that the heat load levels off with the beam intensity. This behavior was reproduced in numerical electron cloud build-up simulations.

The main hypothesis is that the different heat loads in the machine could be explained by different Secondary Emission Yeilds (SEYs) in its components. Implying an average sector's SEY from the heat load data for Standard beam at top energy, one can reproduce in simulations the measured heat load in that sector for both injection and top energies and various filling schemes with good accuracy.

In general, 8b4e and 12 bunch beams feature significantly lower heat load that Standard beams in both drifts, dipoles, and quadrupoles.

Agreement with the measurements can be further improved using a cell-by-cell model. This improvement removes the predicted 'bump' in the heat load vs bunch population plot, not observed in the measurements. Using this improved SEY model for the HL-LHC beam parameters in the high load sectors one would need 10 kW/arc cooling capacity, which is above the official HL-LHC limit of 8 kW/arc. 10 kW/arc could probably be delivered by cryogenics, assuming the cryoplants perform as well as in 2018. In case the heat load is too large the 8b4e beam seems to be a good back-up option for HL-LHC.

- **Rogelio** inquired how large is the uncertainty of SEY in quadrupoles compared to the one in the dipoles. **Galina** replied it is hard to estimate the spread of SEY in the quadrupoles. **Gianni** noted there may be large systematic uncertainties as well which they plan to study.
- **Stéphane** reckoned that the cryogenics should be able to provide 10 kW/arc for the entire Run 3. **Rogelio** proposed to ask cryogenics experts and ask them on the differences between Run 3 and HL-LHC (Action: **Gianni or WP2**).
- **Valeri** pointed out that one can compute the maximum possible heat load for a sufficiently high SEY, as the electron current would ultimately be limited by its space charge. **Gianni** replied this 'flattening' of the load has never been observed in simulations, implying the ultimate heat load should be much higher than what is presently observed in the machine.

2 TRANSVERSE BEAM COOLING IN LHC (L. BLONDEL)

An electron lens is proposed for HL-LHC, and it could, in principle, be used for beam cooling. The cooling with co-propagating beams does not work at high energies as the heating overcomes the cooling (the cooling time increases with γ^3). Instead it is proposed to look at colliding e and p or ion beams, since in this configuration the energy exchange scales with γ^2, and he cooling time (after RF re-acceleration) only scales with γ.

For this analysis a 10 keV electron and a 7 TeV proton beam were assumed. Collisions are deemed to be perfectly elastic. The energy loss per collision is rather small, around 10^{-16} eV for the proton beam (10^{-7} eV/turn assuming a 1 m long e-lens with a DC current of 1 A, i.e. a collision with 10^{11} electrons). The equilibrium emittance is given by the equilibrium of heating and cooling processes and turns out to be too large – higher that in the machine. The cooling rates are also rather slow to be practically useful with typical cooling times around 10^{13} s for p or 10^{11} for Pb ions. A plan for further investigation includes studying different media and wakefield effects to enhance the cooling rate and also an “academic” configuration with a series of radial electron guns at different azimuthal position (such as inducing not only an energy loss, but also a direct longititudinal kick in the direction of each individual protons).

- **Elias** made a comment that cooling of colliding beam has already been studied in the past. **Stéphane** answered that this configuration (proton cooling by electron back-scattering) has not been found in the literature (contrary the well-known cases of e-p co-propagating beams) and asked for references to benchmark the results in case some would be available. **Valeri** pointed out that the proposed technique is essentially very similar to ionization cooling, with a difference that here the beam serves as a medium. The only difference is that the diffusion in this system is twice the one of traditional ionization cooling. He further emphasized that the equilibrium emittance is far too large for being useful for a proton machine, as it is given by the ratio of the masses.
- **Rogelio** inquired if a stochastic cooling concept could be applicable for LHC. **Valeri** replied that based on experience at IOTA, with optical stochastic cooling one would expect a less than 1 hour cooling time in LHC and proposed to discuss possible applications in case there is an interest.