WP2 Meeting #160

Tue 24 Sep 2019, 9:00 – 12:30

Chair:	G. Arduini
Speakers:	S. Claudet, K. Brodzinski, E. Belli, E. Maclean, S. Papadopoulou, G. Iadarola
Participants:	K. Brodzinski, R. Bruce, E. Belli, R. Calaga, S. Claudet, E. Cruz Aloniz, R. De Maria, J. Dilli, I. Efthymiopoulos, H. Garcia-Morales, M. Giovannozzi, G. Iadarola, E. Maclean, S. Papadopoulou, F. Plassard, B. Salvant, G. Sterbini, R. Tomás, F. Van der Veken

AGENDA

MEETING ACTIONS

Serge	Study the maximum initial instantaneous luminosity still compatible with no preload (e.g. 2.5 10^{34} $cm^{-2}s^{-1}$ instead of 1.0 10^{34} $cm^{-2}s^{-1}$)
Eleonora	Look in detail the possibility to slowly change the settings of the primaries to gain in margin
Eleonora	Investigate the possibility of a limited misalignment of the upstream and downstream elements

Xavier	Check stability limit for an increase of the opening of the primaries and secondaries by 1 sigma
Rogelio	Include the effect of longitudinal blow-up in the vertical emittance growth studies.
Rogelio, Ilias, Stefania	Check luminosity formula for bunches with different emittances.
Stefania	Clarify if the luminosity algorithm takes into account elastic scattering

GENERAL INFORMATION (G. ARDUINI)

Minutes of the previous meeting have not been circulated.

1 TUNING THE CRYOGENIC SYSTEM TO HILUMI LUMINOSITY (S. CLAUDET)

The cooling system is different from the LHC, the dynamics plays a more important role, and requires active control. The new plant does not exchange with fluid with the LHC by default, in case of problems the LHC arc cryogenic plant can feed the triplet, but for low luminosity. The transient head load during the ramp is already as large as the static one during the ramp (factor 2 higher for both with respect to the LHC). But even more significant is the heat load transient induced by the energy deposition of collision debris that in the LHC is a fraction of the overall heat load in the arcs.

The transient can be controlled by heaters, but the solution wastes energy and requires radiation resistant heaters. The number of bayonets gives capacity, but does not help for the transient. Injection of “warmer” gaseous He could also be used to control transient, however the solution is not fully studied yet at the level of the integration in cryostats.

Simulation shows that the ramp is feasible, while for luminosity one the acceleration of the cold compressor is not sufficient to avoid transients in pressures. The luminosity will create a bump in pressure (above the acceptable level) and temperature (close to 1.9K) even with 5 minutes for luminosity ramp up. A realistic scenario with no pre-load and assuming LHC cold compressor characteristics would require a slow increase of the luminosity from 1.0 10^{34} $cm^{-2}s^{-1}$ to 5.0 10^{34} $cm^{-2}s^{-1}$. The starting point could be discussed.

Solution for heaters in the magnets are under studies (electric or serpentine). G. Arduini asked whether the LHC circuit could help. S. Claudet replied that this could be oreseen for quenches, implying however hours for recovery, but would not be possible for regular operation. Instantaneous increase to the maximum could be achieved with reliable heaters.

Action. Serge to study the maximum initial instantaneous luminosity still compatible with no preload (e.g. 2.5 10^{34} $cm^{-2}s^{-1}$ instead of 1.0 10^{34} $cm^{-2}s^{-1}$).

2 MAXIMUM COOLING CAPACITY FOR CRYOGENICS IN RUN 4(K. BRODZINSKI)

K. Brodzinki introduced the LHC cryogennics and comparison among Runs from I to IV. Run II required increasing cooling capacity from 85 W/hc to 160 W/hc and a different strategy has been implemented to reduce power consumption and increase reliability. The same strategy is proposed to Run III (with the upgrade of the cryo-plant in Point 4) and IV.

For the HL-LHC, the cooling capacities for the beam screen will increases for 5 sectors, and in case of 3 sectors (2-3, 6-7 and 7-8) will remain on the level of 200 W/hc.

The estimates are based on present experience (6.5 TeV), at 7 TeV difference will be expected. Run III will more effected, as triplets system does not change, than Run IV. S. Claudet remarked that Sector 7-8 is a concern, in particular since LHCb is studying a luminosity upgrade, because it impacts the margin for the LHC beam screen. This scenario, besides budget, is technically challenging.

3 MITIGATION OF LOSSES ON 11T DIPOLE (E. BELLI)

E. Belli introduced the motivations of the 11T dipole project for the cold losses in IR7. The introduction of the 11 T dipole reduce the cold losses, however the expected losses on the first dipole are only 1.4 times lower than the expected quench limit. Several strategies involving orbit bumps, collimator settings, offsets have been studied to increase the margin
An offset of 2 mm in the 11 T dipoles reduces losses by 39%. An orbit bump can also be implemented. G. Arduini highlighted that the doses on the corrector magnets should also be checked. Answering a question form Rogelio, Massimo clarified that an orbit bump is needed as the amplitude of a potentially alternative misalignment is limited by hardware constraints. Roderik clarified that the layout of the 11 T dipoles cannot be changed anymore, although placing the TCLD first would have helped. The trim power converter of the 11 T circuit if used as an orbit corrector, would increase the amplitude of the bump at the 11 T which is compatible with the aperture. Roderik clarified that this solution is not favored by OP. An optimization of the collimator hierarchy can further reduce losses by 11%. Rogelio proposed to look in detail the possibility to slowly change the settings of the primaries to gain in margin and to investigate the possibility of a limited misalignment of the upstream and downstream elements. **Action: Eleonora**

In conclusion a scenario with offset, orbit bump, is proposed and further studied.

Gianluigi noted that from the discussion it appears that an increase of the opening of the primaries and secondaries by 1 sigma appears to be achievable and proposed that Xavier should check the stability limit for this case first. **Action: Xavier**

4 OCTUPOLES AND POSSIBLE SOURCE OF HALO AND EMITTANCE BLOW-UP (E. MACLEAN)

E. Maclean proposes dynamic non-linear islands as mechanism for losses and emittance growth during the ramp. The mechanism is similar to the MTE extraction, with particles in the islands transported to higher amplitude when octupoles are ramped down. Measurement and simultion in Run1 demonstrated particle transport via islands to the collimator aperture during octupole rampdown leading to beam losses. Measurements during 2018 MD demonstrated the combination of large Q’ and octupoles ramping down induced emittance growth for the nominal injection configuration. Simulations suggest this is compatible with an island based mechanism. In addition adiabatic damping during the ramp shrinks the phase space but not the position of the islands, implying an increasing of the measured emittance.

Ewen proposed several tests to confirm the mechanism and mitigation strategies. Gianni observed that the blowup of the longitudinal emittance occurring during the ramp could also enhance the mechanism. Ewen clarified that the mechanism is clearly vertical. Gianni clarified that lowering vertical tunes are limited by coupling and Rogelio confirmed that coupling should be better corrected during Run III. Machine studies comparing ramps with low octupoles and chromaticity and ramps with nominal settings should be tested in MDs with few bunches of intermediate intensity. The effect of longitudinal blow-up could be also studied. This could allow validating the simulations. **Action: Rogelio**

5 EMITTANCE EVOLUTION (S. PAPADOPOULOU)

Stefania presented a summary of the observation of the emittance evolution. The B2H emittance is nonphysical at stable beam and it has been corrected and /or filtered. The understanding of the discrepancy is important. The B2V emittance was smaller in 2016 (Q' and octupole current should not have been too different in particular at the end of 2016). The measured distribution of bunch population is about 4%. The injector are expected to deliver a distribution of 3%. In terms of emittance the variation is up to 9%. The resulting luminosity variation is 11%. Rogelio commented that luminosity formula should take into account that colliding bunches have different emittances. **Action: Rogelio, Ilias, Stefania to check offline.**
Gianluigi also inquired on the model that is used to account for the effect of elastic collisions. The algorithm used should be clarified. **Action: Stefania**
A rough estimation of emittance growth at flat bottom due to noise explains 30-50% of the extra (on top of IBS and e-cloud) growth, which is only correlated with injected vertical emittance. At collision there is no correlation with initial emittances and intensity.

6 BEAM LIFETIME IN COLLISION - LHC EXPERIENCE (G. IADAROLA)

Gianni presented an analysis of beam life time in 2017-2018. There are important differences between bunches depending on their position in the train. The first bunch of each train show important emittance blow-up for unknown reasons and it is not included in the analysis. The bunches can be split in 4 families depending on the e-cloud and LR beam-beam interactions. The worst bunches loose up to 20% of the particles after 9 hours.

The losses do not depends on the emittance at the beginning and after the losses. Gianluigi asked to look at the evolution of the bunch length. The observations lead to the conclusion that the mechanism is only due to e-cloud.

The crossing angle anti-levelling has an impact on the losses, but increases the luminosity. In 2017 with the 8b-4e the effect disappear. At large beta* and large beta in the arcs the effect disappear as well, hinting that the e-cloud in the triplet is the driving mechanism.
Based on the above analysis the outlook for HL-LHC is positive due to the improvement due to coating of the triplet beam screen that should eliminate the source of blow-up.

Reported by R. De Maria and G. Arduini