WP2 Meeting #146

Tue 16 Apr 2019, 10:00 – 12:00

Chair:	G. Arduini
Speakers:	R. De Maria, A. Oeftiger, X. Buffat
Participants:	A. Alekou, S. Antipov, R. Bruce, D. Gamba, H. Garcia-Morales, M. Giovannozzi, S. Karastathis, N. Mounet, V. Olsen, K. Paraschou, F. Plassard, M. Sabate-Gilarte, B. Salvant, K. Skoufaris, G. Sterbini

AGENDA

The meeting was devoted to various pending beam dynamics issues, including TAXS/TAXN and D1 apertures, beam stability near Q' = 0, and long-range beam-beam kicks at injection.

MEETING ACTIONS

Francisco	Provide information about the TAS position non-conformity
Francesco	Study what length of TAXN is required from the energy deposition point of view
Riccardo	Update the aperture estimates taking into account the TAXN length and provide boundaries on it.
Elias	Continue the studies to determine the dependence of the stability limits on the longitudinal distribution.

GENERAL INFORMATION (G. ARDUINI)

Minutes of the previous meeting will be circulated shortly.

1 TAXS/TAXN APERTURES: UPDATE (R. DE MARIA)

An open question yet to be answered is whether or not TAXS and TAXN apertures can be reduced. That would be beneficial in particular for reducing the radiation doses.

The present LHC TAS has a 17 mm radius aperture, while the future HL-LHC TAXS will have a 30 mm aperture. There is a non-conformity of the TAS actual position with respect to the lattice model. While the length of TAS will be changed, its place of installation cannot change. The issue has not been discussed yet.

The present TAN has an aperture of 26 mm and the future TAXN – either 42.5 or 40 mm. TAXN will also be slightly shorter than TAN: 3332 mm vs 3500 mm. The length of TAN presents a trade-off between the aperture on one side and the energy deposition on the other. The change of length is on the IP side and has no impact on collimation.

In order to study the TAXN aperture limits v1.5 optics was used. This optics features a significant modification of the TAXN region with respect to v1.4. Analysis shows there is sufficient margin between TAN and the triplet both for Round and Flat optics, whit the margin being somewhat smaller for the Flat. In conclusion, 80 mm TAN seems viable from the aperture point of view. The aperture could potentially be reduced by another mm provided appropriate mechanical and alignment tolerance studies are performed.

Responding to the previously brought up question on the motivation behind the D1 beam screen aperture change, **Riccardo** reported that the proposed increase of the aperture by 1.5 mm helps restoring the aperture hierarchy by gaining 0.5σ. A step transition is envisioned. With this adjustment the aperture hierarchy is restored for the Round optics, but 0.2σ in D1 would still be lacking for the Flat optics (the aperture bottleneck should be in the triplet). A further gain of 1σ can be obtained by misaligning D1 by about 1.5 mm, but such an approach creates complications for interconnections.

- Regarding the TAS nonconformity, **Massimo** noted it is an old and known nonconformity. Roderick inquired how large the difference is. **Riccardo** replied it is of the order of centimeters for a 1.8-m-long device. **Gianluigi** suggested to have Francisco give information on the matter at WP2 (Action: **Francisco**).
- **Gianluigi** raised a question whether the tolerances have been discussed with Alignment WG. **Massimo** replied they will wait for the design of the bellows: it is linked to impedance minimization and the possible review of their design. **Riccardo** noted that the presented tolerances are conservative.
- For the TAXN, **Gianluigi** inquired whether or not an ECR has been submitted regarding the TAXN length change. **Roderick** recalled there was a small change of length to make the collimators fit

longitudinally. **Riccardo** replied there was no ECR regarding the TAXN length, Francesco is going to provide input on the length required from the energy deposition (Action: **Francesco**) **Gianluigi** stressed one has to make sure the finalized aperture and length are communicated and written down. **Gianluigi** also pointed out that the analysis of the aperture shall include the boundaries on the TAXN length – that will help optimizing it both for the aperture and the energy deposition (Action: **Riccardo**).

- Regarding the D1 magnet beams screens, **Benoit** commented that both rounding the taper and a sharp transition are acceptable from impedance point of view.
- What concerns misaligning the D1, **Gianluigi** summarized that there are sufficient margins for the baseline Round optics, this option could be used, if needed, for the Flat optics. **Massimo** reported the topic will be brought to the Integration WG and TCC. He also noted that at the moment the team is in contact with Paolo to discuss alignment tolerances.

2 STABILITY AROUND Q'=0 AND THE LHC DAMPER INSTABILITY (A. OEFTIGER)

Adrian presented a final summary of the macroparticle simulation research he had done for his fellowship. The investigation was motivated by the LHC octupole threshold measurements of L. Carver that did not match with predictions form DELPHI around $Q' = 0$: in reality 3 to 4 times the octupole current was needed to stabilize the beam. A slightly better agreement is obtained by considering the exact emittances in both planes but still a discrepancy remains.

A possible explanation could have come from the destabilizing effect of transverse feedback – coupling of two azimuthal modes through a resistive transverse feedback at low chromaticities. In order to assess its impact on the octupole current E. Metral extended the Stability Diagram (SD) theory to include two coupled modes. Hi results matched the predictions of single mode SD for sufficiently low intensities, below the TMCI threshold, which is the case in LHC and HL-LHC. These findings were confirmed in PYHEADTAIL with a broadband resonator model, where SD predictions were computed given the real tune shift from simulations.

Another source of discrepancy could had come from the impact of quadrupolar wakes and nonlinear synchrotron motion, which are not accounted for in the Vlasov solvers (presently used at CERN). Quadrupolar wakes seem to make little impact on the stability threshold, according to macroparticle simulations in COMBI by X. Buffat. PYHEADTAIL simulations with octupole are close to SD predictions with dipolar wakes term only for the LHC 2015 model as well as for the 2017 model. Non-linear synchrotron motion lowers growth rates as well as the octupole thresholds for all studied intensities.

A realistic beam distribution is expected to be more critical than a thermal Gaussian distribution, increasing both the grow rate at $Q' = 0$ and the width of the unstable region. The spread from the measurements reported by Lee could arise from differences in longitudinal distributions. A potential continuation of the research can focus on the impact on Landau octupole thresholds.

- **Gianluigi** inquired about the island of stability between *Q'* of 15 and 20, where simulations predict a significantly lower growth rate, in particular whether or not it should exist in practice. **Sergey** noted the width of the region as well as the growth rate there vary a lot with beam distribution. **Xavier** reckoned that increasing *Q'* up to +20 helped stabilize high intensity bunches once when nothing else worked.
- **Gianluigi** thanked **Adrian** and stressed that it would be important to continue the studies to determine the dependence of the stability limits on the longitudinal distribution at low chromaticity (Action: **Elias**).

3 OBSERVATIONS OF ORBIT EFFECTS DUE TO LONG-RANGE BEAM-BEAM INTERACTIONS DURING INJECTIONS (X. BUFFAT)

Observation at LHC reveal oscillations linked to PACMAN effects at Injection. No impact on emittance has been measured so far, although it may be hidden by other sources of emittance growth.

Presently the separation is about 20 σ in all Interaction Points (IPs), with long-range beam-beam kicks from IP1,5 being similar to IP2,8. According to macroparticle simulations done in COMBI, relative emittance increase due to injection beam-beam kick is at the level of 10^{-3} (for a 16σ beam separation). Injection oscillations in an injected beam lead to a 10^{-3} level of emittance increase of the circulated beam. Increasing the LR separation does not change the expected emittance increase significantly: the gain would not be greater than several units of 10^{-4}.

- **Gianluigi** noted that the impact of beam-beam kicks on bunch tails might be stronger than on their centers of mass. **Gianluigi** proposed to measure the impact of beam-beam long-range kicks at Injection in an MD. **Xavier** pointed out that it might be a tough measurement to perform, due to other sources of emittance blow-up that need to be kept under control. **Gianluigi** concluded it might still be worth it to check whether there are negative side effects to increasing the crossing angle at injection as the aperture is available. This is part of the studies has to be done with respect to field quality and incoherent beam-beam effects.
- **Riccardo** suggested one can study increasing the offset in IPs 2 and 8 in order to reduce their impact.

Reported by S. Antipov