M. Valette

Joint meeting of the Collimation Working Group and Machine Protection Panel

Participants: R. Bruce, D. Mirarchi, D. Wollmann, S. Fartoukh, S. Jakobsen, H. Garcia, J. Wagner, Y. Nie, M. Patecki, M. Pojer, R. De Maria, K. Sjobaek, A. Santamaria Garcia, C. Schwick, M. Deile, C. Bracco, J. Uythoven, D. Lazic, A. Siemko, S. Redaelli, M. Valette, A. Apollonio, M. Zerlauth, K. Fuschberger, A. Rossi, M. Schumann, J. Wenninger.

The slides of all presentations can be found on the website of the Machine Protection Panel:
http://lhc-mpwg.web.cern.ch/lhc-mpwg/

1.1 ATS 2017: Consequences of increased phase advance between MKD and TCT on TCT/triplet protection (R. Bruce)

- R. Bruce summarised the status of machine protection studies for 2017 optics, with main focus on phase advance from dump kickers (MKD) to tertiary collimators (TCTPs) / triplets. Optimal phase advance is either 0 or 180 degrees. S. Fartoukh asked what the worst case of MKD module failure is. R. Bruce replied that the MKD.A is the worst in terms of phase advance, but the MKD.O is the worst in terms of number of impacts on TCTs because of the different beta function value.
- J. Uythoven asked which imperfections are taken into account for tracking simulations of asynchronous dump. R. Bruce replied that random jaw tilts, gap errors and centre offsets of collimator are simulated using 20 different seeds, and final results are given by the average over these 20 simulations. S. Fartoukh added that should be useful to consider also phase errors.
- S. Fartoukh asked if it would be possible to reduce the margins on operational TCTPs settings with respect to settings where TCTPs would be exposed to damages in case of an asynchronous dump, without losing in machine availability. R. Bruce replied that this would be possible if interlocks on orbit drifts measured by BPMs in the TCTPs jaws are put in place.
- Regarding possible phase shift/drift during the year, J. Wenninger commented that the tune is stable within 10^{-3}. S. Fartoukh added that this would be equivalent to a few degrees of phase shift.
- In conclusion, reduced margins to damage limits during asynchronous dump are present with ATS optics compared to a ''perfect'' phase. However, plenty of margin should be present in the case of β*=40 cm, TCTPs at 9-9.5 σ, TCDQ at 7.3 σ; while with β*=33 cm, TCTPs at 7.9 σ, TCDQ at 7.3 σ orbit interlocks at TCTPs are required and 1 σ margin should still be present from the limit of the interlocks. Redundant interlocks on Power Converters (PCs) could be used to dump in the case of phase shifts.

- K. Fuchsberger asked if the interlocks on BPMs/PCs are needed for any β* choice. R. Bruce replied that they are not necessary for β*=40 cm, while for β*=33 cm they are strongly recommended because margins become tight. S. Redaelli commented that in 2016 the BPMs interlocks were already in place but not activated, and dumps were not triggered. Thus, they should be not needed if β*=40 cm will be present also in 2017. M. Zerlauth and D. Wollmann added that it is possible that beams will be squeezed to β*=33 cm during the year, and that could be useful to activate them from the beginning of the run with β*=40 cm in order to gain some operational experience.
- S. Fartoukh asked if the TCDQ settings will be changed and validated as a function of the β* in the initial commissioning. R. Bruce replied that TCDQ settings are fixed for each β* and validated only in the case of changes of β* during the year. S. Redaelli added that presently the TCDQ cannot be moved after flat top is reached. Thus, J. Wenninger added that the complete system validation should be repeated from flat top in the case of β* changes. S. Fartoukh asked if the same settings for TCTPs and TCDQ at β*=33 cm could be used directly with β*=40 cm. R. Bruce replied that this would be not ideal in terms of collimation hierarchy and impacts of secondary halo.
- S. Redaelli commented that would be good to have a proposal of measurements to demonstrate if the reduced margins with ATS, due to the worse phase advance, are still well above damage threshold.

1.2 PC interlock - experience from 2016 operation (M. Schumann)

- The PC interlock works by subscribing to the power converters (PC) and comparing the delivered currents to functions +/-margin. The Quadrupoles PCs were included last year and the goal is to include all PCs eventually.
- The Quadrupole PCs were distributed in 5 families and a phase margin is attributed to each one out of the 30 degrees variation allowed for the phase advance from the MKD to the TCT.
- The current in the Main, triplet, matching and warm quadrupoles is very stable through the year, a maximum of +/-0.02A was observed. The trim quadrupoles show more variation with +/-2A from fill to fill and +/-3A during a fill (out of the 22A tolerance). There is some margin to reduce the tolerances.
    - Stephane stated that 3A change for the trim quadrupoles was very small and corresponds to only a fraction of a degree in phase advance variation. Michaela answered this comes from a phase margin arbitrarily allocated to each family, the trim quadrupoles got 5 degrees out of the 30 available.
- With ATS optics, if the phase advance from the MKDs to the TCTs is already 26 degrees, only 4 degrees of margin are left. If the phase margin is distributed between the different families proportionally to the current one the margin for the matching quadrupoles and triplet quadrupoles would be very tight. Some margin might have to be reallocated.

  - Jog observed that by adding one degree tolerance in the phase advance, the PC interlock thresholds could be relaxed a lot.
- There is an issue for the squeeze when the current is ramped quite fast in the quadrupoles. If there is a delay on the signal from the PC, the current could jump out of tolerance since the margin is comparable to the current change per second. The fastest ramping rate is now in the matching quadrupoles; assuming a realistic timing delay of 2s, the tolerance of the matching quadrupoles would have to be 32A. One could relax the margins during the squeeze and tighten them afterwards.
- In conclusion, the set tolerances were well above the observed variations in 2016. For ATS optics, the distribution of available phase margin has to be studied more as well as the situation during the ramp.
  - S. Redaeli asked if the corresponding difference in β at the TCTs and MKDs, if the current in the quadrupoles changes, could be out of the +/-10% tolerances. R. Bruce has already looked into optics errors versus margin losses, the situation is mostly fine but there are some outlying magnets.
  - D. Wollmann commented that if one goes for ATS this year, the 40cm optics will be put first with a larger margin in terms of phase advance to the TCTs and there would be some time to gain some operational experience before going to smaller β*.

1.3 ATS 2017: Verification of phase advance between MKDs and AFP / CT-PPS Roman pots (M. Valette)

- In 2016 all the roman pots were on the safe side of the beam in case of an asynchronous beam dump. With both 33 and 40 cm ATS optics, some roman pots will be on the side of the beam where they will be vulnerable to the MKD kick. For example the XRPH.B6R1.B1 will have a 27 degrees phase advance with respect to MKD-A, which is comparable to the situation of the TCTs. Since the Roman Pots (RPs) have more retraction than the TCT they should be sufficiently outside the beam.
  - S. Redaelli made the comment that relying on phase advance protection is not the same for RPs and for TCTs. The possibility of having a different retraction for RPs located on the good side of the beam was discarded because one should always assume the worst case to set the RP retraction. Mario Deile confirmed that this situation would support going for a more conservative setting for the RPs.

1.4 ATS 2017: Preliminary studies and discussion on AFP and CT-PPS minimal settings (R. Bruce)

- In 2016 the minimum setting for the roman pots was 15 σ. Since the ATS optics will lead to smaller β functions at the RPs a margin in mm might be added to account for asynchronous beam dumps and tertiary halo.

- **Proposal:** 3 σ retraction behind the TCTs (9+3 σ) + 300 µm or a minimum of 1.5 mm (for reference the closest achieved in 2016 was 1.8 mm).
    - S. Redaelli asked whether the TCL4 would have to be moved in to protect the RPs because scenarios in which the RPs are closer than TCL4 were not envisioned. Mario Deile answered that TOTEM would then lose the high mass events and would change a lot of things so this has to be discussed within TOTEM. S. Redaeli stated that some debris tracking simulation will have to be done by the CWG to see if anything critical appears. Some follow up will have to be done in March.
    - For AFP the situation is different as there is less operational experience. The AFP RPs would be inserted progressively during the year, the limit would be the same: the highest setting between 12 σ + 300 µm and 1.5 mm.

AOB - all

- We will have another meeting in a few weeks to conclude on this.