WP2 Meeting #148

Tue 21 May 2019, 10:00 – 12:00

Chair: G. Arduini

Speakers: E. Maclean, F. Van Der Veken

Participants: S. Antipov, D. Gamba, H. García-Morales, M. Giovannozzi, N. Karastathis, N. Mounet, T. Persson, F. Plassard, E. Todesco

AGENDA

MEETING ACTIONS

Ezio	Review the error tables used for the simulations
Ezio	Study what measurement could be performed to quantify magnetic alignment with respect to the center of the triplet.
Ezio	Investigate the b4 discrepancy in the magnetic measurement data
Ewen	Document a proposed procedure of optics correction based on the knowledge from previous LHC runs
Frederik	Provide an update on dynamic aperture, including effects of MCBXF and MCBRD, by the end of June – early July

GENERAL INFORMATION (G. ARDUINI)

Minutes of the 146th meeting have been circulated, minutes of the last, 147th meeting will be reviewed by Gianluigi and released promptly.

1 COMPARISON OF BEAM-BASED IR NON-LINEAR CORRECTIONS TO MAGNETIC MEASUREMENTS (E. MACLEAN)

Ewen started his report by raising a question about which error table should be used for model-based correction. Before 2011 the table had unseeded errors in sextupole, octupole, and decapole field components of the triplet quadrupoles (every seed in simulation got assigned the same value of error). The present table has mostly seeded errors, except for b4 in MQXB and a6 in MQXA. There is no apparent reason why these particular b4 and a6 are not seeded.

For normal sextupole corrections in IR-1, there is a discrepancy between corrections calculated from the model and a beam-based correction of around 10^{-3} m^{-2} in the integrated strength, or around 20 A. For skew sextupoles, a similar discrepancy of 20-30 A is observed. Normal and skew octupole correction impact the sextupole in IR-1 due to feed-down. It is estimated that a beam offset (or magnet misalignment) of the order of 1 mm in one of the MCOX spoils the a3 correction while a beam offset of 1 mm in horizontal plane in MCOSX R1 spoils the b3 correction. Therefore, one has to pay close attention to corrector alignment. Currently the tolerance limits are set at ±1 mm based on the dynamic aperture studies. A consistent IR-corrector misalignment at this level might complicate HL-LHC commissioning.

IR-2 sextupole errors show a good agreement of feed-down and measured coupling. The error is dominated by b3 of the cold D1 magnet. During the 2018 ion commissioning the team was not able to completely correct the b3 errors; the reason is not completely understood and is being followed up.

Skew octupole correction shows a good agreement between the beam-based and the model-based corrections. For the normal octupole though the measured amplitude detuning is about 30% off from the model-based prediction before correction. The source of discrepancy is identified to come from IR-5 and implies that IR5 corrector strengths are a factor 2 lower than predictions from magnetic measurements. Alignment errors might explain not more than 10% of the b4 discrepancy. Explanation via feed-down requires an extra non-conformity (orbit/alignment/higher-orders). While the discrepancy is not completely understood the following correction approach is in place: first, a correction for IR-1 comes from the tables, and then the IR-5 is done to minimize the remaining detuning. Overall, this combined approach allows correcting the octupole component strength from around 300 A of Landau octupole equivalent (depending on β^* and ATS scheme) to nearly 0 A.

- **Ezio** asked if the variations from magnet to magnet are seen in the model. **Ewen** confirmed. **Ezio** supposed the variation is associated to the measurement error. **Massimo** proposed to quantify the variation and check if it matches the measurement error. **Ezio** proposed to have a look at the error tables (Action: **Ezio**).

- **Ezio** emphasized that the currents related to sextupole correction discrepancies constitute extremely small errors and, for practical matters, have to be viewed in perspective of the total available corrector strength. **Gianluigi** pointed out that the discrepancies are still larger that the measurement error and inquired about its possible source, since one needs to understand to what extent magnetic measurement data can be relied on. **Ezio** suggested that alignment or feed-down might contribute to the observed discrepancy.
- **Ezio** inquired what was referred as alignment in the context of octupole correction. **Massimo** explained the quoted 1 mm value is the maximum deviation between mechanical and magnetic centers. Even if the mechanical centers (seen by the physical aperture) are perfectly aligned the magnetic centers (affecting the multipoles and seen by the dynamic aperture) can be elsewhere. **Ezio** summarized that it is important to know magnetic alignment with respect to the center of the triplet; it is expected to be within 0.1-0.2 mm. **Ezio** and proposed to investigate the possibility of performing a measurement (Action: **Ezio**).
- For the normal octupole correction discrepancy, **Massimo** suggested exploring the effect of CMS solenoid field. **Ezio** supported the idea, quoting that the MQXA magnets should all have the same large systematic b4 multipole. **Ewen** pointed out that b4 in MQXA seems to be smaller in IP1 than IP5, the same applies for MQXB. **Gianluigi** proposed performing an experiment with a CMS solenoid off. For **Ezio** the large b4 discrepancy is worrying, he proposed to review the data on magnetic measurement (Action: **Ezio**)
- **Sergey** asked if around 100 A of octupole equivalent current can be used to enhance tune spread and Landau damping. **Ewen** replied it is hard to say how effective the nonlinearities are, it will depend on the polarity as there is no cross term.
- **Gianluigi** raised a question on the procedure for optics correction for HL-LHC. **Ewen** replied at the moment it can be done without compensating for nonlinear errors, for the latter one needs to start from an analysis built magnets. It is likely though that the linear optics commissioning at End-Of-Squeeze will already require nonlinear corrections in place, raising the need for an iterative approach to linear/nonlinear optics commissioning starting with either magnetic model-based corrections, or beam-based corrections determined at larger β^*. **Gianluigi** asked to start documenting the procedure based on what is learned so far (Action: **Ewen**)

2 Update on field quality, including impact of MCBRD (F. Van Der Veken)

Frederik completed the analysis of the impact of MCBRD on the DA in v1.0 optics – no significant impact has been found. Numerical tracking simulations show that β-beating is small and has no significant correlation with DA, switching of the crossing planes does not change the DA picture, the cross talk between the planes (that changes the expected a3 and b3 errors) has no significant effect, and various sign configurations (studied a subset of 150 of out of about 600) do not give a spread of more than 1 σ in the minimum DA.

In more recent layouts each magnet has a horizontal and a vertical corrector, compared to two of the same kind in v1.0, but that change is unlikely to have an impact on DA thanks to similar β-functions.

- For the switching of the crossing planes, **Gianluigi** pointed out a notable effect on the minimum DA values. **Massimo** replied these are potential outliers, there is no effect on the average DA.
- **Gianluigi** suggested continuing the studies with the v1.4 optics. **Frederik** noted it also makes sense to postpone the MCBXF studies until the v1.4 to make sure the signs are correct. **Gianluigi** inquired about a time estimate for the study. **Frederik** answered it would take around a month, accounting for developing and testing the new routines. **Gianluigi** proposed aim for an update at the end of June or early in July (Action: **Frederik**).

3 AOB: Study of Crossing Angle at Injection (F. van der Veken)

Answering the question raised by **Riccardo** how large the crossing angle at Injection can be **Frederik** studied dynamic aperture for a variety of chromaticities, octupole currents, and crossing angles. There is nearly no effect on DA, around 5% decrease between the half crossing angles of 295 and 500 μrad

- **Gianluigi** suggested that the crossing angle is increased after confirming with beam-beam.

Reported by S. Antipov