HiLumi WP2 Meeting on D2 options

Thursday 18th July 2024, 16:00 – 17:00

Chair:	Rogelio Tomas
Speakers:	Thomas Pugnat, Joshua Dilly, Tobias Persson
Participants (10):	Yannis Angelis, Hannes Bartosik, Joshua Dilly, Massimo Giovannozzi, Ewen Hamish Maclean, Tobias Persson, Thomas Pugnat, Felix Soubelet, Guido Sterbini, Rogelio Tomas;

AGENDA

MEETING ACTIONS

Thomas: verify if the D2 b3 correction is successful thanks to the use of the correctors of the L/R side.

Massimo, Thomas: add to the slides the DA results as soon as they will be available.

Massimo: verify with **Patrick Bestmann** the polarity of the HL Q4 apertures (Started).

Joschua: complete the analysis of the D2's a2 correction, including the flat optics and the RDT related consideration.

Tobias: verify with **Paolo Fessia** about the integrability constraints of a double-aperture skew quadrupole in the D2-Q4 region (Started).

1. General Information (Rogelio Tomas)

Rogelio introduced the meeting as a follow-up from the D2 Field Quality options presented in the last WP3 meeting.

2. DA with b3 errors in D2 (Thomas Pugnat)

Thomas presented the general context of the problem (slides). The recent measurement results of the D2 field quality show that, for most of the magnets, the b3 component is higher than anticipated, and, even more importantly, not well correlated between the two apertures. This prevents using the single aperture sextupolar corrector in the CP to improve the field quality of the D2 magnets. Studies have been conducted to check the impact of the increased b3s (systematic component of the b3) and to improve the nonlinear correction of the field quality of D2.

DA simulations were performed, varying the b3s from -6 to +6 units. The correction strategy was effective in the full range, and namely, even in the worse scenario with four D2 with large |b3s| (conservative approach).

During the last WP3, the expected values of b3s for two different strategies to pair the available coils (referred to as First and Second Coupling Strategy) were presented for the 3 D2s in the production phase.

DA studies were slowed down because of a software problem, and a full simulation set was not available at the time of the meeting. Nevertheless, the expected b3s were compared with the statistical distributions of the old results (providing acceptable DA). For both Coupling Strategies, the b3s seems within the distribution of the old seeds statistics, hence expected to be acceptable. This last point has to be verified directly via DA simulations.

Discussion:

- **Massimo** clarified that in the plots of the slide 7-8 there are 6 lines, corresponding to the b3 components of the 3 D2s object of the study, for each of the two coupling strategy scenarios.
- **Rogelio** asked if each D2 is compensated using the correctors of its side or using the L/R correctors. **Thomas** will check it offline (**Action**), but mentioned that he expected the compensation is using the correction of both sides.
- **Massimo** commented that, in slide 5, the correction strategy for the b3s appears to be very effective as in the numerical simulations there are cases in which the two apertures are not well correlated in terms of b3 errors.
- **Massimo** informed that, to gain time, the submission of the HTCondor jobs is performed manually and 25% of the simulations were done in the last 2-3 days. By next Thursday, the full set of DA results should be available (**Action**).
- **Rogelio** commented that the overall emerging picture seems positive.

3. COUPLING ISSUES WITH A2 ERRORS IN D2 (JOSHUA DILLY)

Joshua gave an oral update on the effect of the a2 errors in the D2 on the coupling correction. In particular, the error in the beam size along the machine was discussed. MAD-X computation confirms the analytical results, that is the induced relative beating in the beam size can be as high as 1% (in the half arc adjacent to the D2 with the a2 error, before the first MQS used for the correction). The results with the flat optics and in terms of RDT have not been yet analysed (**Action**).

Discussion:

- **Rogelio** asked if the 1% corresponds to a single D2 with a2 error (best scenario). **Joshua** confirmed.
- **Rogelio** commented that despite the sigma beating being minimal at the IPs and at the CCs, the 1% in the arc for the best scenario is not comfortable.
- **Rogelio** asked about the correction strength used for the MQS. **Joshua** answered that in some MQS the correction for an a2 error of 6 units goes up to 30%. **Rogelio** commented that the latest information mentioned a2 errors up to 12 units, that would correspond to 60%. **Rogelio** expressed concern about this correction budget. **Joshua** agreed, commenting that the full ring correction takes about 40% of the correction strength.
- **Joshua** mentioned that one can investigate the use of the MQSX or the tilt of the Q4. **Rogelio** is not confident on the use of MQSX. **Massimo** and **Tobias** expressed their concern in adding the Q4 in the correction strategy. **Massimo** will verify with **Patrick Bestmann** (**Action**) the field direction in Q4 apertures, to see if there could be a favourable compensation between the a2 of the D2 and the Q4 field tilts. He also mentioned that the FRAS will be available, which might bring some improvement. **Rogelio** also pointed out that if the tilt is on the order of 1 mrad one can continue to explore it, even if the chance that the compensation can work for both D2 apertures is limited.
- **Tobias** mentioned that for the sigma matrix computation in MAD-X (used by **Joshua**), one has to make sure the 4D TWISS is used (by disabling the RF cavities).

4. OPTIONS FOR ADDING A WARM SKEW QUADRUPOLE NEXT TO D2 (TOBIAS PERSSON)

Tobias presented the option to add a warm skew quadrupole next to the D2 in the HL era to correct locally its a2 error (slides). This analysis is mainly based on the recent works of the LHC Triplet Task Force, hence is mainly focused on the LHC (not the HL) case.

In the LHC there is a risk that the MQSX will start failing due to radiation. In case of failure, several options were studied to replace it with a warm skew quadrupole. For the LHC, given the time constraint, the proposal is to install a single aperture skew quadrupole on the non-IP side of the D1, namely using some of the 9 spares of the SPS LQS.

The phase advance between the MQSX and the MQWSX is small, and it makes it ideal to replace the MQSX but not to find a combination with a MQSX-like magnet to compensate for both Beam 1 and 2.

Assuming an a2 of 6 units in the D2, the integrated field that can provide the MQSX is 11x larger (hence 5.5x larger if we consider a2=12 units in D2).

Installing one/two single aperture warm skew quadrupoles close to the D2 is also an option (e.g., in the non-IP side of the Q4). It was warned that in that position one has to consider the geometrical constraints imposed by the two beam lines (194 mm distance between the B1/2 reference orbits).

Discussion:

- **Massimo** observed that for HL-LHC one should target an ad-hoc design, e.g. a combined-aperture skew quadrupole, to have the possibility to correct independently the two apertures. The dedicated design would also address the tight space constraints.

- **Rogelio** asked **Tobias** to verify with **Paolo Fessia** the availability of the space and the constraints of the integration (**Action**). **Guido** observed that in the non-IP side of the Q4 is pre-reserved for the wire compensators (9 m). Currently, the wire hardware is only taking 4.5-5 m of the total 9 m of the space reservation. **Guido** added that, based on the feedback on the wire compensators, the integration of the cabling will be another point to consider.

5. AoB

The next WP2 meeting will be announced in due time.

Reported by Guido Sterbini