Minutes of the 91th WP2 Meeting held on 11/04/2017

Participants: G. Arduini, R. De Maria, D. Gamba, M. Giovannozzi, P. Hermes, G. Iadarola, N. Karastathis, P. Kramer, D. Pellegrini, B. Salvant, K. Sjobaek, E. Todesco, R. Tomas, F. Van Der Veken.

DA sensitivity to mispowering (F. Van Der Veken)

The mispowering of the correctors derives from uncertainties of the beta function, whose impact depends on the corrector order. The values of the mispowering for each corrector order are evaluated for a beta variation of 10% and conservatively rounded up.

Selected plots highlight the trends of DA by plotting the average over all the angles for each seed within the minimum and maximum band with and without D2 correction. Asymmetries between the two beams are observed.

Few mispowering seeds show a big drop in DA for a specific angle. Massimo clarifies that this follows from a very unlikely combination of factors. He proposes to further investigate the DA in nearby angles and for small variations of mispowering. Riccardo adds to check the phase space. Preliminary offline investigations seem to relate this to data corruption. **Action: Frederik to verify and come back with the results of this verification.**

Mispowering of the skew and normal correctors tend to generate a flat DA response. In some cases the response is quadratic with some minor loss of DA at the extremes. Some correctors such as b3 exchange some DA between the two beams.

Statistical analysis, including all the mispowering at the same time, shows similar DA distributions as the nominal machine. The fact that the machine realisations with and without mispowering are in good agreement, without systematic deviations, points out that there are no correlation mechanisms between the multipole seeds and mispowering seeds.

The corrector misalignment studies have also been extended. No trends to small trends (<0.5 DA variation) are observed for specific misalignments up to 1 mm. The statistical analysis does not point out specific correlations or systematic variations. Massimo clarifies that 1 mm is a realistic value for the maximum misalignment as discussed with Ezio, however the difference between mechanical and magnetic axis should be clarified with Ezio. Rogelio adds that the closed orbit can also contribute. The range could be extended some more. **Action: Frederik to extend the range of misalignments considered.**
Action: Gianluigi to contact Ezio to get an idea of the expected difference between magnetic and mechanical axis for the correctors.

Gianluigi points out the importance of further investigate the different behaviour of the two beams. **Action: Frederik**

Update on the triplet RF finger simulations (K. Sjobaek)

The new RF contacts, with fixed extremities, can potentially generate HOMs with high Q. Suppression of the high-Q resonances was measured in presence of the outer bellow for the design with 3 convolutions

(this is the present baseline design for the RF fingers), but not for the one with 2; it is yet to be understood if this was due to non conformities.

Kyrre reports improvements with the importing and meshing of the geometry, now fully automated. A strategy for adding transverse deformation by morphing the mesh is in place. Kyrre states that a full mechanical deformation may lead to geometries that cannot be handled by the mesher, although this might be possible. Benoit points out that the high Qs can possibly come from RF fingers not behaving as expected, so a full deformation could be relevant. Gianluigi asks if mechanically deformed structures could be foreseen in the future. Benoit says that now that the meshing is done automatically, it could be possible to give a model. Kyrre asks about the total deformation, Riccardo reports that ground motion leads to 0.5 mm per year. 2 mm maximum should be a good target. **Action: Benoit to study the impact of possible misalignments and tilts.**

The simulated longitudinal impedance for the three-convolution design is shown for different models (with and without outer bellows, thin and thick RF fingers, first and second order computation) all the results are comparable. The investigation of the impact the outer bellow with the two-convolution design is foreseen, as well as a scan of its diameter. **Action: Benoit.**

The transverse impedances for the different cases are estimated by means of the Panofsky-Wenzel theorem and present a similar behaviour.

Riccardo reports requests from alignment to have not completely flat bellows, to allow for more flexibility. Gianluigi asks about the maximum angle acceptable, in the 77th WP2 Meeting Benoit indicated 15° as it was also presented at the 15th HL-LHC TCC. Gianluigi asks what is the tolerance around this value. Following the meeting Benoit confirmed that ±5° (corresponding to an elongation/contraction by ±2.7 mm) should be acceptable.

Benoit added that the vacuum team is planning to use this RF finger design also for several collimators although this has not been agreed for the time being. **Action: Gianluigi to verify with Vincent and Stefano.**

Impact of measured out-of-specs inner triplet field quality on DA (Y. Nosochkov)

Yuri reminds that measurements of a4 and b5 components showed fluctuations whose origin is not well understood, their expected maximum values are fixed to 2 and 1.5 respectively. Their impact on DA is therefore investigated. The model allows taking into account the fringe fields of the magnets, the error tables considered are shown. The a4 and b5 values are identical for all the tables.

Plots of minimum and average DA are shown for both round and flat optics for the different tables.
The DA evolution for progressively increasing a4 and b5 is shown. For the maximum expected case (a4=2, b5=1.5) the DA reduction is marginal although a stronger effect appears for larger values. Ezio asks if when going to high values the correctors are still within their capabilities, Yuri thinks that the correction is still fully implemented but will double check. The minimum DA drops below 3 sigma when the correctors are switched off. **Action: Massimo, Yuri to check whether the available corrector strength is compatible with the correction of a4 and b5 for the values considered above (this has been partially discussed in the US-LARP meeting: the maximum strength allows for a4 ≈ 2.2 and b5 ≈ 1.0)**

The phase advance between IP1 and IP5 allows recovering some fraction of sigma DA. Yuri stresses that the optimal phase depends on the specific realisation of the errors, so it could be further optimised for specific seeds.

Yuri reports significant increase of DA for reduced higher order terms, in particular b14m and u/r terms (definitions by R. De Maria in 67th WP2) for components of order ≥ 6. **Rogelio suggests that maybe the correction is not attacking the optimal resonant driving terms, Massimo mentions that it can be checked whether for the b5, a5, a6 correctors the current choice of the RDTs to be optimised is the best one. Action: Massimo.**

At injection energy a4 and b5 have a much smaller impact, with a basically stable DA even without correctors. Improvement is again obtained by tuning the phase advance between IP1 and IP5.

Gianluigi asks if the decay of DA below 3 sigma observed without correctors, appeared with the new table or if it was there already for the previous one. He also points out that this value implies that a problem to the corrector could compromise possibility to run. Massimo reports that the variation in DA due to switching off the non-linear correctors is almost exactly the value published in the IPAC13 paper on the specification of the non-linear correction system. He adds that the reference DA is now lower by about 2 sigmas therefore without correctors it drops to 3 sigmas (it was 5 sigmas at that time). **Action: Massimo to make a statement on whether there are correctors that are critical for operation.**

Gianluigi asks if studies with octupoles have been made, Yuri replies that a study with octupoles and nominal a4, b5 has already been completed; but all the results presented here are without octupoles. Massimo adds that strong octupoles tend to mask the impacts of imperfections.

Gianluigi wonders if the strong a2 component, coming from the current leads on one side, could be mitigated by optimizing the geometry of the current leads. Action: Ezio

Gianluigi asked which error table has been used for the DA estimates with beam-beam and field errors presented by Nikos at the last WP2 meeting. Version 5 was used.
It would be also important to determine the sensitivity to the various field errors in the presence of beam-beam.
Gianluigi added that we should aim to have an update of the DA for the HL-LHCv1.3 with round optics down to 15 cm without and with beam-beam for the Annual Meeting.

Round table Discussion

The need to uniform all the studies to the same version of the optics is pointed out. Currently Yannis' team is using v1.2 while Massimo's team is on v1.0.
A common switch to v1.3 looks possible in case this version will be finalised for June/July, allowing enough time to complete the studies for the annual meeting (November).
Massimo proposes to complete his studies with v1.0 and produce some comparisons with v1.2 in case v1.3 will not be ready yet.
The main missing steps for v1.3 are the squeeze and the optimisation of Q10. Flat optics has a lower priority. The optimisation of Q10 could be reverted also to v1.2.

Gianluigi concludes pointing out the need to prepare a timeline for the v1.3 and decide a strategy. **Action: Gianluigi to define a strategy with Massimo, Riccardo and Yannis in view of the HL-LHC annual meeting**

Reported by Dario, Gianluigi, Riccardo and Rogelio.