Minutes of the 110th WP2 Meeting held on 7/11/2017

Participants: A. Alekou, G. Arduini, X. Buffat, F. Carlier, R. De Maria, S. Fartoukh, M. Giovannozzi, P. Hermes, S. Kostoglou, E. Metral, Y. Papaphilippou, D. Pellegrini, B. Salvant, K. Skoufaris, G. Sterbini, R. Tomas, F. Van Der Veken.

General Information (G. Arduini)

The minutes of the previous meeting have been circulated. Gianluigi summarises the actions from the previous meeting. No comments were received and the minutes are approved.

Update on the correlation DA/ lifetime without beam-beam (P. Hermes)

The procedure developed by Massimo and Pascal for DA/lifetime estimates consists in the following points:

1. The beam profile is modelled with a double Gaussian distribution. The parameters of the distribution are fitted according to tail scraping measurements with collimators. Analytical expressions for the tail content as function of the distribution parameters are derived. These allowed taking into account many distributions compatible with the observed losses.
   Rogelio asks if the integration boundary when computing the tail content should be the position of the collimator instead of infinity. Massimo replies that the collimators were only moved in to measure the distribution, but he agrees that the upper integration boundary should be the collimator position.
2. Tracking for various seeds is performed up to 100k turns. The evolution of the DA for larger turn numbers is extrapolated by means of scaling laws which are fitted to several estimates of DA between 0 and 100k turns. In order to take into account the uncertainty from the fit, for each fit the errors on the fit parameters are assumed as sigmas of Gaussian distributions and 10 different sets of parameters are extracted.
   Dario asks if possible correlations of the fitting parameters are taken into account. Pascal replies that they are not, as they appear to be almost uncorrelated from the covariance matrix.
3. Having statistical information on both the beam distribution and the DA evolution, it is possible to compute the beam losses at different time stamps.

Pascal shows several plots for the 2016 LHC injection optics presenting DA, relative losses, and emittance variations.

Stephane asks how the emittance growth is computed. Massimo replies that it is the second momentum of the distribution and the growth comes from the loss of the tails and from the normalisation. Yannis suggests that the computation of the non-linear invariant from the tracking data convoluted to the distribution can be used as an estimate of the emittance growth without the need of considering a boundary.

Rogelio notes a small difference between the DA of the two beams in agreement with what observed in the machine.

The losses at injection (until prepare ramp) are computed along the entire 2016 run. The data is superimposed to the losses predicted from simulations finding very good agreement when the emittance is reduced from 2.5 to 2.2 um. Dario recalls that an important moment in 2016 was the switch to BCMS bunches with a considerable emittance reduction. Massimo replies that this is a first check and one could refine it by taking into account many parameters. Yannis proposes to take into account measured distributions in order to constraint the model. Stephane suggests that the initial distribution might not be matched. Massimo replies that one can try different distributions.

Massimo points out the need of new measurements of the tails, possibly with the BSRT. Yannis replies that the wire can be more reliable for that, or possibly the coronagraph.

The procedure has been applied also to the HLLHC investigating the parameter space at injection in terms of Octupoles, Chromaticity and Tune space. The DA appears to be limited especially for Beam 1. The impact on losses is yet to be finalised.

Rogelio points out that scraping at injection took place also in an MD in 2017; the data could be used to refine the distributions. Yannis also recalls a recent test in which a lot of time was at injection, changing the chromacity and octupoles and taking several measurements with the wire scanners. Gianluigi congratulates Pascal and Massimo for the progress. It will be important to determine the correlation DA/lifetime to quantify the impact of field quality.

Update on the correlation DA/ lifetime with beam-beam (D. Pellegrini)

Dario clarifies the settings of the simulations that are kept constant in order to avoid alterations in the correlation between DA and lifetime.

Dario recaps the work done in 2016. The evolving machine conditions were closely followed by DA simulations which appeared to be well correlated to the losses in the first hour of stable beams. Dario stresses that one can push the machine settings and trigger small amount of losses (few per cents) while still increasing the integrated luminosity. The safe DA target without errors was fixed at 6 sigma, with the possibility to push down to 5 sigma after operational experience.

In 2017 crossing anti-levelling gave a huge boost to DA and lifetime studies. Aggressive levelling steps performed few times, resulted in clear increases of the effective cross section, in agreement with the expectations from DA simulations. The increase in effective cross section beyond the inelastic cross section does not mean necessarily a loss in performance as the losses mainly affect the tails of the distribution (for reasonable DA) which are not contributing to luminosity. A fill with increasing effective cross section was used to evaluate the impact on performance, still observing a gain of ~3 % in integrated luminosity. Another interesting test consisted in continuous variation of the crossing angle, following the DA curves; this was almost transparent in terms of cross section.

The fill from MD2209 was recently used to benchmark lifetime (burn off corrected) and dynamic aperture by feeding all the actions performed in the control room together with the measured beam parameters along the fill to DA simulations. The DA (minimum over the angles) correlates well with lifetime drops, although it cannot reproduce the lifetime increase at constant settings and when relaxing the crossing angle. This might indicate that diffusion at low amplitudes is negligible and only tails are affected, so that once they are cleaned, the lifetime gain is substantial.

Rogelio asks if one can conclude that 4 sigma DA give 30h lifetime. Yannis clarifies that a target of 6 sigma DA is needed to have margins with errors. Dario recalls that the lifetime is burn off corrected and one always wants to be in the shadow of burn off, giving about 20h lifetime. Stephane asks about the lifetime at larger DA. Yannis clarifies that the lifetime without burn off can be very high: above 100 h. Dario adds that indeed one can observe burn off-corrected lifetime up to 300 h in the plot, although the burn off correction introduces uncertainty.

Gianluigi stressed that it would be important to merge these results with the approach of Massimo and Pascal in order to determine the correlation between DA and lifetime (for a given distribution) and the impact on the core. **Action: Massimo Yannis Pascal Dario.**

MS10: can we do without it? Cases without and with beam-beam (R. De Maria)

Riccardo thanks Dario and Frederik for the support with simulations and Alessio for the up-keeping of the infrastructure.

Riccardo shows how the sextupolar strength is distributed along the arc, for the different options: baseline, without MS10 and by removing also MS14f. Two alternatives for the MS14f removal are identified: close to IR1 and IR5, or close to IR2, IR4, IR6, IR8. Effort was made to limit the strengths of the chromaticity sextupoles.

The impact of the different options is shown in terms of beta beat wave, chromatic correction and resonance driving terms.

One important point is the correction of the dispersion generated by the crossing scheme, which is performed by means of orbit bumps propagating into the arcs.

Riccardo shows the simulations without beam-beam from Frederik, comparing all the four scenarios. It is observed that without octupoles the options without MS14f allow recovering the baseline; however this is no longer the case when octupoles are turned on. In addition a general decrease of 2 sigmas is observed when applying the dispersion correction. This could be an effect of the feed-down form octupoles and Riccardo wonders if one could minimize this by acting on the number of Landau octupoles similarly to what has been attempted for the chromaticity sextupoles.

Riccardo shows the simulations with beam-beam from Dario. A set of simulations was done without dispersion correction, indicating a significant impact of not installing MS10 which is not fully recovered with the MS14f schemes. The MS14f option was also investigated with the dispersion correction applied, showing a worrisome impact on DA.

Stephane suggests applying a knob acting on QF and QD in order to readjust the phases in the MS14f option.

Gianluigi asks if all the previous simulations were done without the dispersion corrections. Dario confirms as the bug was discovered only recently, adding that Nikos and he are already running simulations for the baseline.

Riccardo points out that several issues were encountered with the computing infrastructure. This is confirmed by Frederik and Dario.

Gianluigi stresses the need to update the plots, especially for the baseline, including the dispersion correction.

Stephane asks about the impact on optics of the rephasing without MS14f. Riccardo replies that the optics becomes slightly more flexible in the presqueeze (giving larger crabbing angle for the same margin in the quadrupoles), while some of the IR6 flexibility is lost (resulting in a minimum MKD to TCT phase advance 35°, compared to 30° of the nominal).

Stephane suggests studying an optics with different phase also in the horizontal plane, falling back to the Phase I optics family. He stresses that is important to address the impact of optics dephasing in the arcs.

Gianluigi suggests uniforming the working point adopting the optimised tunes also for the future simulations without beam-beam.

AOB: Update on the beam stability in the squeeze (X. Buffat)

Xavier presents the contributions to the detuning with amplitude of sextupoles, octupoles at full strength, long range along the squeeze as extracted by tracking with MAD-X. For the ultimate scenario, by chance, the minimum tune spread is obtained when going in collision. Xavier proposes to anticipate the telescopic squeeze. Dario points out that one could go in collision with a larger crossing angle, reducing it later while colliding.

Gianluigi asks what the inputs requirements for the stability simulations are. Elias clarifies that, although long ranges and telescope are not included, beta* is used for the crab cavities.

Riccardo suggests quoting, in addition to the octupole current, the resulting R.M.S. tune spread estimated including the beam-beam long range effects. **Action: Elias, Xavier.**

Xavier points out that there is a non-linear contribution to the detuning from the long ranges. Riccardo suggests producing a realistic simulation matching the spread.

Riccardo points out that anticipating the telescope, the sextupoles will have smaller current and this will make it harder to use them to correct for dispersion, possibly having to reduce the crossing angle.

The possibility of having positive octupoles is discussed. The reduction in DA together with the need of accommodating non-colliding bunches prevents this option.

Round table (E. Metral, B. Salvant)

Benoit reports that the analytical formula for the collimators is close to Frasciello's model, although for small gaps (in the secondaries) the discrepancy raises up to 50%, the analytical estimate being more conservative.

Elias shows the updated collimator tables used for the simulations. He points out that there is no major contributor to the geometric impedance. The required octupole current appears now to be 300 A in the expected chromaticity range. Elias showed the expected and measured dependence of the octupole current required to stabilize the LHC beams as a function of chromaticity. Rogelio points out that there can be an uncertainty of 50 A. Elias shows that the dependency on chromaticity appears to be larger in the HL-LHC compared to the LHC. Gianluigi asks if the maximum octupole current required to stabilize the beam is in the range of chromaticities 10-20. Elias replies in the affirmative.

Benoit adds that there is a new set of parameters for the RF dipole crab cavity moving it away from resonances. He also reports that the new collimators jaws have a smaller angle of entrance.

Reported by Dario, Gianluigi, Riccardo and Rogelio.