Minutes of the 92nd WP2 Meeting held on 18/04/2017

Participants: S. Antipov, G. Arduini, X. Buffat, R. De Maria, P. Ferracin, S. Izquierdo, N. Karastathis, K. Li, E. Metral, D. Pellegrini, E. Todesco, J. Martinez Vazquez.

General Information (G. Arduini)

Gianluigi reports that in the last TCC a summary of the Crab Cavities review took place, it was stressed the importance of identifying the minimum voltage required for the SPS test in order to obtain significant measurements. Fanouria replies that Androula has this as one of her main activities.
Tests of Q7 in IR1 and 5 at nominal current were performed not only in 2008 but also in 2013 therefore it should not be necessary to have additional ones.

Status of the pacman in the HL-LHC (X. Buffat)

Xavier reminds that pacman bunches behave differently due to their position in the train, giving less long range interactions. The missing long range interactions cause obit oscillations up to half sigma all around the machine. Head-on interactions in particular give a beta beating going up to 15%, causing shifts of the tune and of the chromaticity. Mitigations come from the horizontal-vertical crossing schemes in IP5-IP1.

Although the orbit at the IP shows some displacement, this is symmetric for both the beams, so no loss of luminosity is expected from a single IP. When multiple IPs are present, there is a dependency on the phase advance, leading to a worst case separation of 0.4 sigma for the Pacman bunches. The total impact on luminosity is 0.6%.

The TRAIN code allows finding the self-consistent solution for the orbit by iteration. The orbit effects from the two main IPs are shown for the nominal filling scheme. Asymmetries between IP1 and IP5 are attributed to the phase advance; this could be further tuned if no other constraints are present.

The impact of the long range encounters in IP2 and IP8 is shown. In particular IP8 has an unfortunate phase advance with respect to the main IPs and gives an additional separation of 0.1 sigma (see Errata). When levelling with separation in IP2 and IP8 a coherent kick from the head-on is obtained, however the phase advance is favourable and no separation is introduced in the main IPs. It was noted that the value of the crossing angles in IP8 used for the simulations were not nominal. The simulations have been repeated for the nominal values after the meeting and attached (see errata)

The BCMS filling scheme produces identical orbits but the impact on luminosity is slightly higher as there are more pacman bunches. Xavier reports the need to add a global luminosity optimisation mechanism in TRAIN, while at the moment the luminosity follows directly from the self-consistent solution. The 8b4e comes with less impact on the orbit, but all bunches are suffering from it; the orbit optimisation is important to get a precise estimate of the impact on luminosity, which is not expected to be critical. Flat optics comes with a larger normalised separation and the impact on the orbit is reduced by 14%. **Action: Xavier to evaluate the impact on luminosity of long range effects for BCMS and 8b+4e).**

In general the values for the orbit shifts do not seem to be a concern for CC, aperture and beam stability. Collimation aspects, in particular hollow e-lens, are yet to be investigated in the details.

Concerning the tune, the round optics compensates very well the impact of the main IPs. In case of luminosity levelling with separation in IP8, the super-pacman has a large impact on the footprint depending on the separation; effects and compensation needs to be investigated. With flat optics the HV compensation is weaker and the footprints separate already for the case with only the main IPs. In this case the dynamic effects during the collision process might be even more important and should be evaluated. **Action: Xavier, Yannis**.

Good agreement between data from the LHC and simulations is shown.

Gianluigi asks to quantify the tune separation, he stresses that this is important to determine if all the bunch classes can fit in area of the good DA in the tune space. Xavier replies that the shift depends on the amplitude and it is not easy to give a single number. In addition pacman bunches tend to have better DA as they sense less non-linearity. Dario adds that DA tune scans should be performed at least for the worst pacman bunches and that we should check for overlap of good DA areas for all the different classes. **Action: Yannis, Dario to investigate the DA and tune margin PACMAN bunches.**

Gianluigi points out that the possible reduction of crossing angles as shown by Nikos is expected to give stronger effects and should be taken into account. **Action: Xavier to evaluate the PACMAN effects for the reduced crossing angle scenario.**

Gianluigi wonders if the orbit at the crab cavities is actually negligible. Riccardo reminds that the tolerance on the orbit is 1 mm in total, and 0.5 mm between the two consecutive CCs. Gianluigi suggests making a plot showing the offset at the CCs for a discussion with Rama. **Action: Xavier.**

Riccardo points out that the phase advances are different in optics v1.3. The constraints for the phase advance tuning should be identified. In addition LHCb might operate at high luminosity after LS4.

Elias asks about linear coupling. Xavier replies that strong non-linear coupling emerges from the long range interactions but no linear coupling is present, offline analysis confirms that the coupling is negligible even for diagonal crossings. Elias asks about experience in the LHC, Dario replies that we have already been able to move the tune closer to the diagonal therefore coupling appears to be well corrected.

<u>Update flux jumps (S. Izquierdo Bermudez)</u>

Susana reports the presence voltage spikes at low field values. These are critical for the QPS, requiring interventions on the thresholds, but the impact on field quality is reported here.

In general the intensity of the flux jumps depends on the temperature. The two technologies for the conductors: PIT and RRP, also show different behaviours.

When the current is ramped from zero to nominal (simulating a pre-cycle) some currents jumps at relative amplitude of 10^{-4} are observed in the first part of the ramp, going below the instrumental resolution of 10^{-5} of the maximum current towards the end of the ramp. The measures are at 50 Hz. No flux jumps are expected with steady current.

Measurements of the transfer function with the rotating coil at 1 Hz are within the noise. Better resolution is obtained for the harmonics (e.g. b6) and the observations of the flux jumps are consistent with the measurements of the magnetisation.

Gianluigi comments that in ramp and squeeze this could be particularly critical as the beta* is reduced during the ramp. A quick calculation from Riccardo shows that a 5 PPM jump in current taking place at 40 cm beta* gives a tune jump of few 10^{-4}.

Riccardo asks about the time scale of the jump. Paolo Ferracin indicates millisecond scale for the release of energy. Ezio adds that there is a filtering effect from the magnet, which is not easily measured. He clarifies that the flux jumps is a local phenomenon that does not have itself an impact on the gradient. The perturbation of the gradient comes only from the power supply, reacting to the voltage change.

Measurements of the transfer function seem to indicate jumps of a relative amplitude of up to $5x10^{-4}$ in the gradient of the triplets but the units used in the plot should be clarified. **Action: Ezio, Susana**.

Susana presents the possibilities for the next measurements, in particular the high frequency measurements (1-5 kHz) with fixed coils looks interesting for the b2 component.

Ezio stresses the importance of determining the scaling with the length of the magnet, although preliminary estimations are promising.

Gianluigi asks about the reproducibility of the measurements, Susana replies that it is very good, within 20%.

Reported by Dario, Gianluigi, Riccardo and Rogelio.