Minutes of the 78th WP2 Meeting held on 23/09/2016

Participants: F. Antoniou, G. Arduini, N. Biancacci, X. Buffat, M. Giovannozzi, G. Iadarola, E. Métral, D. Pellegrini, B. Salvant, A. Santamaria, E. Shaposhnikova, K. Sjobaek, R. Tomas, F. Van Der Veken.

Minutes, Follow-up of Actions, General Information (G. Arduini)

Minutes of 23/8 are waiting for a comment from W. Hofle. The minutes for the last meetings will be circulated.

From the last meeting on IR non-linear errors, Rogelio commented the feed-down due to misalignment and orbit errors are thought to be the main source of discrepancies between model and measurements.

Massimo reported that there were discussions on the last TCC for the options on orbit correctors, in particular if without change of crossing plane one can use only 3 correctors in Q4. Luca Bottura said that this could avoid building a new cold mass. Riccardo commented that this is being studied but it is not trivial if we keep open the possibility of changing the crossing plane in IP1 and 5 as initially requested by the Project Management in June (this would also require an intervention on the crab cavities).

Massimo added that we should also consider margins for the ultimate energy. Gianluigi replied that the requests for ultimate energy have not really formalized and he will verify with Lucio and Oliver whether margins should be included for that. **Action: Gianluigi.**

In the LIU-SPS review for a High Bandwidth Feedback it was concluded that a bandwidth of 4 GHz would be required to fight potential electron cloud instabilities at high energy.

G. Iadarola has presented the results of the estimate of the heat load in all the twin bore magnets for the HL-LHC insertions in a dedicated WP2-WP9 meeting. According to the last estimates of the available cryogenics cooling power, a reduction of the SEY of the beam screen of elements in the matching sections in IP2 and 8 might be required. WP9 are going to come back with a final analysis ahead of the HL-LHC annual meeting.

Longitudinal stability limits and bunch length specifications (E. Shaposhnikova)

Elena presented a summary of the stability and bunch length specification. The conclusions are based on calculations from the PhD thesis of Juan Muller.

Bunch length evolution changed between 4.0 TeV run (2012 growth) and 6.5 TeV (2015 reduction) due to the impact of the synchrotron radiation at high energy and reduced bunch population. Shorter bunch lengths may lead to instabilities.

During MDs (2015, 2016) one can observe bunch length bifurcation during emittance blow-up. This is the concurrent result of the reduced frequency spread in synchrotron frequency for short bunches and the narrow bandwidth of the noise that finally leads to a less efficient blow-up of shorter bunches as compared to that of longer bunches. The problem would not occur in with a double frequency RF system.

During the ATS MD, the emittance was blown-up at maximum gain (by mistake) and the maximum bunch length measured was 1.5 ns. This indicates that this is the maximum bunch length achievable by longitudinal blow-up with acceptable losses.

There are important variations in the bunch length achieved for different bunches (bunch length and population), but also in between beams and fills. This may lead to different instability threshold.

The synchrotron frequency spectrum during the fill (half an hour from flat top) assumes a peculiar shape: two peaks located at the synchrotron dipole and quadrupole frequencies. The reason is that the phase loop fights against the phase noise.

Bunch length is a very sensitive parameter for the longitudinal instability threshold. The stabilization mechanism is only Landau damping. The instability leads to dipole oscillations of some bunches that might propagate to others due to the limited bandwidth of the phase loop and finally to bunch length increase. Coupling between Beam 1 and Beam 2 have been observed by Benoit.

Full detuning scheme will be used in HL-LHC operations. In the framework of double RF operation, only bunch shortening mode (BSM) is feasible, because bunch lengthening mode (BLM) will be phase dependent and not compatible with the full detuning mode.

For HL-LHC parameters, the instability threshold is at a bunch length of 1.0 ns, too close to the nominal 1.1 ns, taking into account the expected spread. In case of 800 MHz system operated in bunch shortening mode the threshold would decrease to 0.85 ns. The plot assumes 16 MV. In case of HL-LHC, the IBS and damping are more in equilibrium at the beginning of the fill. Elias asked whether the impedance of 800 MHz cavity would increase again the threshold. Elena replied that the threshold as a function of bunch length is not very sensitive to impedance variations. Recent measurements show that stability starts at 1.1 ns for 2.0 10^{11} ppb, although the cavity were not at 16 MV (but about 10-12 MV to be confirmed). Action: Elena to confirm the RF parameters during the measurement. Gianluigi and Elias suggested that it would be important to get operational experience with 16 MV. Rama commented that today with a half-detuned scheme it might not be possible to run at 16 MV and nominal LHC current. Elias commented that the instability threshold should scale linearly with voltage and inversely with longitudinal impedance at constant bunch length, therefore increasing the voltage would allow increasing the bunch population.

In case of 200 MHz system one could have bunches longer than 1.5 ns.

In summary the 400 MHz RF system longitudinal stability of bunches with nominal HL-LHC length of 1.08 ns does not allow any margin for bunch-to-bunch differences. Some margins are required due to bunch-to-bunch and beam-to-beam (BUP) variation and SR shrinkage. Bunch length should be above 1.2 ns in single RF operation or a new 800 MHz system should be added with 4 MV. Beam lifetime for bunch length more than 1.5 ns in the 400 MHz RF is reduced.
New operation regime with long (> 1.5 ns) bunches in 200 MHz (+ 400 MHz) RF system has many advantages. In addition a double RF system should make emittance blow-up more reliable.
There are still possible uncertainties due to increased HL-LHC impedance in multi-bunch operation and coupled bunch instabilities.

Gianluigi asked what would happen with unstable bunches in collision. Elena said that this can be tried in the machine. Benoit mentioned that there is a request to collide highly populated bunches in shorter trains.

All measurements are done with phase loop, while estimates are computed without taking into account in phase loop.

It was agreed that 1.2 ns would be proposed as the new nominal bunch length for the baseline (which is not assuming an 800 MHz system)

Crab cavity failure scenarios with 200 MHz (A. Santamaria)

Andrea presented an analysis of crab cavity failure scenarios with 200 MHz. The losses in case of crab cavity failure scenarios are less critical for a 200 MHz system as compared to a 400 MHz system.

AOB: Update on BPM impedance (N. Biancacci)

Nicolo` presented an update on the presentation on BPM impedance. The discrepancy between CST and analytical formula was resolved. In summary the octagonal shape gives 50% more impedance (longitudinal and transverse) for the triplet BPMS, but this remains negligible as compared to the total impedance. The largest contributions to the longitudinal impedance remain the upgraded LHCb VELO and the crab cavities.

Reported by Gianluigi, Riccardo and Rogelio.