WP2 Meeting #162

Tue 19 Nov 2019, 10:00 – 12:00

Chair:	G. Arduini
Speakers:	A. Alekou, D. Gamba, I. Karpov
Participants:	S. Antipov, H. Bartosik, E. Cruz Alaniz, R. De Maria, M. Giovannozzi, G. Iadarola, T. Levens, E. Métral, N. Mounet, F. Plassard, L. Sabato, B. Salvant, G. Sterbini, R. Tomás, F. Van der Veken

AGENDA

MEETING ACTIONS

Ivan, Benoit	Clarify and update as necessary the longitudinal and transverse impedance model for future studies of longitudinal dynamics.
Yannis, lumi team	Determine what would the impact on performance factors be: orbit, luminosity, crabbing angle at IP, assuming a residual of 100 μm non-closure of the CC bump
Rama	Propose a draft procedure for CC low-intensity setting-up and operation at high intensity

GENERAL INFORMATION (G. ARDUINI)

Actions of the previous meeting have been reviewed by **Rogelio**. For the collimator impedance measurements, **Alessio** is checking the possible beam offsets that might have affected the measurement. Sergey is studying the impact of orbit offset on octupole thresholds. **Benoit** is following up on bench measurements of resistivity.

Rogelio pointed out the WP has to review the requirements on halo cleaning. In particular, one has to decide on the exact primary collimator aperture settings and on the parameters of the hollow electron beam. More parametric studies will follow, led by **Daniele**.

Gianluigi summarized the Cost & Schedule review. Overall, the review was positive. Reviewers supported an extension of the scope of the project to include a hollow electron lens and crystal collimation, and an upgrade of the beam dump.

1 AOB: IMPACT OF RADIATION ON ORBIT CORRECTORS AND THEIR POSSIBLE FAILURE (D. GAMBA)

Davide reported on the progress on actions from the 139th meeting. For the corrector failures in Q6, a quadrupole movement does not seem to be a viable solution: it would affect both beams and would require a large displacement of 7.5 mm.

Looking at failure scenarios of Q9 correctors (the most affected by losses, hence most likely to fail), the impact on orbit seems tolerable: the machine's aperture should allow for a possible bump of up to 5 mm. In order to reduce the bump, additional Q10 correctors or replacement of MCBC with MCBY could be beneficial. Orbit movement to reduce the Q9 irradiation does not seem to be a solution.

Finally, an optimization of the TCL6 collimator does not help lowering the irradiation in the cells in question.

- **Riccardo** noted that the optimization of the TCL6 gaps assumed no optics modifications. One could reduce further the TCL gaps in mm, not in beam size, by optimizing the optics and the cost of tightening optics constraints. In that case the ATS could not be performed. Gianluigi noted that therefore this is not a solution
- **Gianluigi** noted that we might not upgrade anymore Q10 with an additional sextupole, in that case the replacement of the Q9 corrector might be preferable. **Massimo** proposed to check if one can intervene in the interconnection cryostat (Q11). Gianluigi noted that this would also require an intervention on the cryostat.

2 UPDATE ON LONGITUDINAL IMPEDANCE REQUIREMENTS (I. KARPOV)

Loss of Landau damping (LLD) in the longitudinal plane is an intensity limitation. The threshold is proportional to bunch length to the 5th power. As the length shrinks during acceleration the beam becomes unstable, if no mitigation measures are taken. Normally in operation emittance blow-up is used to stabilize the beam.

LLD has been measured in dedicated studies. Measurements are in good agreement with numerical simulations with the BLonD code but an analytical Sacherer formalism gives a 3-4 times higher threshold for the same longitudinal impedance. Thus two new approaches for analytical solution (based on existing theory work), have been implemented to make predictions on LLD: discretization of action variable and expansion of the azimuthal modes. Both approaches yield identical results on a test impedance Z = const.

For a broadband impedance the intensity threshold depends on the cut-off frequency, decreasing it when the cut-off frequency is increased. For example, in the LHC model the cutoff was increased from 5 to 50 GHz for transverse dynamic issues. This increase had significant implications for longitudinal stability, lowering the threshold by a factor 3. The cutoff therefore has to be revised. In future, a realistic impedance has to be used in studies.

Analysis shows that for HL-LHC at 450 GeV for some bunches one can come close to the limit of stability due to spread in bunch lengths, which is confirmed by MD studies. Overall, both 6 and 8 MV RF voltages are expected to be stable. 16 MV RF voltage provides sufficient stability at 7 TeV for 1.2 ns and 10% bunch length oscillations.

High order modes (HOMs) of crab cavities may result in longitudinal multibunch instabilities. In the worst case scenario (4 cavities with coinciding HOM frequencies) the impedance is within limits both at 450 GeV and at 7 TeV. One HOM appears to be close to the limit at 450 GeV – it is the 570 MHz HOM, whose impedance has increased as a result of a recent optimization.

- **Rama** noted that it would be useful if the 570 MHz mode could be damped without a major change.
- **Gianluigi** raised a question how physical the observed behavior of the cutoff is. **Sergey** mentioned that for transverse dynamics it is beneficial to have a greater cutoff frequency to avoid issues with numerical convergence. **Benoit** inquired why beam dynamics seems to be affected by high frequencies. **Ivan** replied that matter has to do with expansion of Van-Kampen modes into high frequencies.
- During discussion on the cut-off frequency, **Benoit** pointed out that normally for LHC hardware the simulations are performed until around 2 GHz, the physical cut-off of the beam pipes. Impedance at higher frequencies therefore can be inaccurate. The broadband impedance model makes sense for SPS, but might be less accurate for LHC. For LHC the broadband contributors at high frequencies make no impact on transverse dynamics. **Elias** emphasized that until now the team concentrated mainly on the transverse part. **Gianluigi** summarized the WP must review the impedance model to find a realistic impedance model both for longitudinal and transverse planes for future studies (Action: **Ivan, Benoit**).

3 UPDATE ON INSTRUMENTATION FOR CRAB CAVITIES (A. ALEKOU)

16 crab cavities (CCs) are assumed for this study: 2 cavities on each side of the two main interaction points (IP) per beam. Pairs of CCs are treated as one in simulation.

Beam Position Monitors measure the centroid position. Just like the SPS ones, the LHC BPMs have filtering, affecting the magnitude of the detected signal. The minimum detectable voltage is 6 - 14 kV at 450 GeV and 7-8 kV at 7 TeV. Voltages of this order can occur with imperfect cancellation of CC phases.

Head-tail (HT) monitors measure the transverse offset along the bunch due to crabbing. HT resolution of 100 μm is too small for a 1 MV kick for some studies cases (offset scales linearly with the voltage). HT resolution is insufficient to detect orbit leakage with all the CC ON as in an operational scenario both at 15 and 50 cm β*.

Wire scanner, synchrotron radiation, and gas vertex monitors measure beam profile change due to the kick. With a 6.8 MV kick the change is clearly observable apart from certain identified cases at Injection and in Collision.

- For the HT resolution, **Tom** commented the 100 μm is a rough estimate from the past instability measurements. In principle, HT can start distinguishing 30-40 μm offsets in a turn-by-turn mode and smaller average offsets. The key limitation from the hardware side is the hybrid. **Gianluigi** raised a question if one can observe the non-closure of the CC bump with BPMs. **Androula** replied this topic has not been studied yet. Gianluigi asked if an additional HT monitor would solve the problem. **Anroula** and **Tom** replied an additional HT is not efficient, as recently reported at WP2.
- **Rogelio** posed a question, assuming a residual of 100 μm non-closure of the CC bump, what would the impact on performance factors be: orbit, luminosity, crabbing angle at IP. **Action: Yannis and luminosity team**
- On the setup procedure, **Gianluigi** asked if one can be confident what one obtains during setting up with 1 bunch is representative of the situation with the full machine. **Rogelio** pointed out the orbit will differ with the full beam. **Rama** suggested varying phases and voltages to optimize the observed luminosity. **Rama** stressed that one can set the crabbing voltage to nearly zero, both with single bunches and trains; its fluctuations are controlled at 10^{-3} – 10^{-4} level. **Gianluigi** doubted it will be allowed to adjust the phases in Collision from machine protection point of view. **Rogelio** proposed the CC team to come up with a draft procedure for parameter optimization. A draft procedure for CC low-intensity setting-up and operation at high intensity should be established (Action: **Rama**).

4 ROUND TABLE

Next meeting will be held the 26th of November at start at 9 am due to a large number of reports.

Reported by S. Antipov