Minutes of the 124th WP2 Meeting held on 03/07/2018


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1 GENERAL INFORMATION (G. ARDUINI)

The minutes of the previous meeting have been circulated. Gianluigi reviewed action items of the past meetings.

Riccardo is planning to bring up the test of Q7 at the ultimate current at the TCC. Action: Riccardo.

Xavier and Ariadna are working on a note on PACMAN effects. Roderik came back with a proposal to include the PACMAN-related tolerance of 0.1 rms beam size ($\sigma$) into the final tolerances for collision. Gianluigi noted that although the impact is minor, it is beneficial to account for all the effects. Action: Roderik

Benoit raised the point that an MD on LHC impedance at the injection energy has been requested to qualify the resistivity of the beam screen copper layer, but been assigned a low priority in view of the limited MD time and taken into account that Elias had some doubts on the feasibility of the measurement. Gianluigi proposed to discuss the MD program for MD blocks 3 and 4 at one of the following WP2 meetings.

Following up the recent LMC meeting, Benoit raised a question if the recently observed triplet quench suggests any problem with lamination. In that event the kick of two beams was asymmetric: beam 1 received a strong orbit kick in a few turns, while the orbit of beam 2 remained largely unaffected. Gianluigi noted that what happened needs to be studied and understood in detail. Rogelio suggested that an asymmetric kick might have been produced by a quench protection system (QPS). Massimo pointed out the increase in temperature in triplet before quench, which might indicate a problem with cooling. Orbit change of beam 1 is too large to be explained by the kick of QPS heater. Rogelio proposed to review the event at one of the future meetings.
**2 REQUEST FOR UNSHIELDED VAX BELLOWS FOR HL-LHC (B. SALVANT)**

Benoit presented an analysis of the impact of new unshielded bellows in the VAX region on the machine’s impedance. The new bellows are required to (a) cope with a large displacement of VAX area of the experimental side – up to 10 mm and (b) support the remote handling of vacuum components – for that reason the baseline design does not have RF fingers.

A new design of RF shielded valve has to be done. The baseline involves new 80 mm valves, this is the only design satisfying both impedance and aperture requirements. The standard 63 mm and 100 mm design might potentially create RF cavities, affecting impedance at beam frequencies and create aperture constraints (63 mm).

There will be up to 24 unshielded bellows (2-3 double bellows per HL-LHC IP side, 16-24 bellows it total); each contributing an effective longitudinal impedance of \( \text{Im} \frac{Z}{n} = 0.04 \text{ m}\Omega \) and a broadband imaginary transverse impedance of \( \text{Im} Z_t = 200 \text{ k}\Omega/\text{m} \). At the end of \( \beta^* \) squeeze (\( \beta^* = 15 \text{ cm} \) – worst case scenario) they would yield around 1 m\( \Omega \) of longitudinal and 200 k\( \Omega/\text{m} \) of transverse impedance in total (about 1% of the overall impedance budget). This contribution is relatively small thanks to the optimization of the design and, in particular, to the short length of the bellows. The 1% increase of the transverse impedance shall not lead to more than 5 A increase of the octupole current, according to numerical simulations in DELPHI.

- Massimo pointed out that a 10 mm excursion might be an overestimate and suggested to review the figure at the alignment WG. Gianluigi inquired where the 10 mm value comes from. According to Massimo, it is not clear since movement of the CMS cavern over a year is certainly smaller, of the order of a couple mm, and the area can be realigned during a Year End Technical Stop (YETS). Benoit commented that, assuming the design can be optimized for a smaller gap (i.e. 5 mm), it would significantly reduce the impedance thanks to the strong, quadratic, dependence.

- Gianluigi asked to clarify why it is important to have 80 mm valves. Benoit replied that otherwise the valves may trap modes that would be close to beam spectrum. Gianluigi summarized that he impact on impedance is 1% but can be further reduced and 80 mm valves have to be pursued, asking to check if the 80 mm valves are also foreseen for the crab cavities.

**ACTION (Massimo):** Organize a discussion at the alignment WG to review the required maximum offset for VAX area bellows and the potential of their impedance reduction.

**ACTION (Benoit):** Check with Jaime and Vincent that the 80 mm valves are included in the layout, including the crab cavity area.
3 IMPACT OF a-C COATING ON IMPEDANCE (S. ANTIPOV)

Sergey presented simulation results on amorphous carbon (a-C) coating of HL-LHC triplet areas. HL-LHC inner triplet beam screens will be coated with a thin layer of a-C on Ti substrate during Long Shutdown 3 (LS3). In addition certain beam screens of Q5 and Q6 quadrupoles in points 2 (right) and 8 (left) will be coated during LS2. The primary goal of the study was to check if there are impedance and beam stability constraints on the thickness of a-C coating, Ti substrate, and beam screen temperature.

Four coating options have been studied: (1) an ‘as-is’ with no carbon coating; (2) with coating of the triplets; (3) with coating of the triplets and LS2 quadrupoles; (4) and finally, carbon coating of the whole ring. Beam screen temperature was considered to be 20 K, except for the triplets in scenarios (2-4) where it was assumed to be 50 K, based on the input from vacuum group (not related to carbon coating).

While the beam screen is responsible for a large portion of machine’s impedance at injection, the resistive wall component is not the main part of its impedance due to a significant contribution of pumping slots. The resistive wall component can be safely increased without significant effect on beam stability. At the relevant beam frequencies skin depth of Ti and a-C is much larger than their thickness (below 500 nm), making them essentially transparent, with no significant effect on the real part of impedance. The imaginary part of transverse impedance does increase in the high frequency range, above 100 MHz, that is relevant for single-bunch stability, but the overall impact in minor compared to the other sources of impedance. No significant change of the effective longitudinal impedance $\text{Im} \frac{Z}{n}$ is expected, except for a hypothetical option of coating the whole machine, where the increase can be as high as 10 mΩ, or over 10 % of the overall budget.

- Gianluigi noted that the temperature of the beam screens in the IP1,5 triplets will likely be in the range of 60-80 K; the triplets in IP2,8 will be coated but stay at 20 K as the rest of the ring. Benoit made a comment that, based on the recent input from the vacuum team, the thickness of carbon coating will be smaller than the one studied: 50 instead of 100 nm. The decrease in thickness will further improve the impedance. Sergey replied it is straightforward to update the numbers once the exact values are known.

**ACTION (Sergey):** Check the temperatures of Q5,6 quadrupoles with Gianni and update the results for the latest parameters of coating thickness and beam screen temperature.

4 ROUND TABLE

The schedule of the next meetings will be determined and sent around in the coming days.