

Impedance Police

Status on 26/10/2018

1. Y chambers in 1/2/5/8:

- a. The profile at the merging plane of the new Y-chambers in 1 and 5 should be rounded to avoid accumulation of charges as suggested by G. Rumolo. The origin of the very small increase of the imaginary part of the longitudinal impedance should be understood NEG coating should be assumed.
- b. Obtain the drawings of the 'as installed' Y-chambers in 2-8 and re-evaluate their impedance.

→ This was not done, but will be followed up.

2. Triplet BPMs:

- a. Design is now finalized as presented at the HL-TC on 21/9/2017: https://indico.cern.ch/event/666310/contributions/2722980/attachments/1527764/2389507/BI_Hilumi_TCC_21st_Sept_2017_IRBPM.pptx . Need to update the impedance estimates including possible coating of the BPMs

→ The new TECH with Nicolo paid by HL-LHC will perform simulations with the new triplet BPM model.

3. New deformable RF fingers:

These should be installed at:

- Transitions between new magnets will have deformable RF bridges
 - Cold to warm transitions will have deformable RF bridges (tbc)
 - For the crab cavities still to be decided
 - For new TCT/TCL collimators in IR1/5 to guarantee 5th axis (with the exception of TCLX/TCTX between D2 and Q4 where no 5th axis is considered) the use of deformable RF bridges is still to be decided
 - For the other collimators the old RF fingers are going to be used.
- a. A feedthrough should be foreseen for possible antenna to damp unwanted modes
 - b. Maximum acceptable angle of the fingers: $15^\circ \pm 5^\circ$ (corresponding to an elongation/contraction by ± 2.7 mm).
 - c. Any dependency between the maximum angle and the diameter and the convolution height from the impedance point of view?
 - d. Impact of possible misalignments and tilts to be studied
 - e. Investigation of the impact the outer bellow with the two-convolution design and scan of its diameter.
 - f. A proposal on the number of these components has been made at the TCC on 1/11/2018 (<https://indico.cern.ch/event/767512/>)

→ The deformable finger prototype was made ready for measurements in October and the RF team will perform measurements by the end of the year. The impact of misalignment and tilts will be studied there.

→ Looking at the TCC slides of Vincent, the current proposal is 52 Deformable RF bridges per beam, which matches the total we had assumed up to now (13 per beam per IP per side, see HL-LHC report p. 71).

4. **ALICE vacuum chamber:**

- a. No issue expected for HL-LHC

5. **VELO**

- a. design requires special attention and needs to be followed up (see presentation on 16/08/2016 -
https://indico.cern.ch/event/556760/contributions/2243233/attachments/1323597/1986054/Heat_load_estimates_for_the_experimental_vacuum_chambers_WP2_Aug16_v3.pptx). Temperature gauges should be installed according to e-mail from B. Salvant on 19/8/2016. This was discussed on 14/2/2017 at WP2 (<https://indico.cern.ch/event/610798/>). A meeting took place with M. Ferro-Luzzi on 15/3/2017. Proposal to make measurements on mock-up and study further optimization with LHCb. **Status ==> Action: Benoit**

→ Measurements and simulations on VELO mock-up done and presented at IWG on October 11th (<https://indico.cern.ch/event/764129/>). That was a big effort.

→ Additional request to install a SMOG detector (EDR on Nov 15th). Conclusion from our side:

- There is no indication that the addition of the SMOG2 alters longitudinal and transverse resonant modes significantly in both open and closed positions (see Fig. 1 and 2 for longitudinal) [3].

- The additional contribution to the low frequency broadband impedance due to the SMOG2 remains small compared to the VELO [4].

- As a consequence, with this information, LHC longitudinal and transverse beam stability is not expected to be altered significantly by the addition of the SMOG2 (replacing the VELO WFS upstream).

- With or without the SMOG2, the expected local power loss can reach up to of the order of 1.5 kW if the worst mode (~380 MHz, $R_s \sim 1.5 \text{ k}\Omega$) is hit by one of the main spectral lines of the HL-LHC beam (2748 bunches with 2.2×10^{11} p/b). It should be noted that hitting that single line is a possible but statistically unlikely scenario. However hitting one of the large number of modes above this frequency is much more likely, and would yield a power loss of the order of 350 W. The mechanical design of the SMOG2, as for the rest of the VELO, should therefore account for that possibility, and temperature monitoring is recommended.

- At the occasion of the bench RF measurements with the VELO mockup, the situation got much worse when the wakefield suppressor shape was altered by a bridge breaking. It is therefore very important that the mechanical design is robust enough to keep the design shape throughout LHC operation.

6. **MKI:**

- a. Identify minimum bunch length that allows operating without upgrading the injection kicker.

- b. Discrepancy between the expected power deposition from simulations and that inferred from measurements. See whether this is due to the impedance and/or to the thermomechanical model.
- c. The estimates of the heat load on the MKI should be performed with the distributions corresponding to the baseline agreed with Elena Shaposhnikova with given FWHM.
- d. The estimates of the temperature reached in operation for HL-LHC should be based on realistic parameter evolution (can be provided by Rogelio) and on optimum turn-around.

- A prototype with the new design with cooling is being installed for LS2 (<https://indico.cern.ch/event/764129/>) in the MKI8C slot. Even if successful, it is not clear that all kickers can be upgraded by the end of LS3.
- Power loss for different bunch profiles and bunch length was computed (including binomial).
- Transverse impedance also computed and being added to the model (large modes at 10 MHz).

7. **CMS vacuum chamber:**

- a. It is not clear why the double-conic shape was required and if the chamber can be made even smoother by reducing the opening of the cone. **Action: Massimo and Benoit to check with experiments and update at WP2.**

- No action taken there from impedance side so far.

8. **Electron lens:**

- a. no issue expected with the present design

- need to check if there is a newer design.

9. **TDIS:**

- a. ECR issued (<https://edms.cern.ch/ui/#!master/navigator/document?D:100178750:100178750:versions>). No pending points.

- Indeed, no pending point for now.

10. **HL-LHC Crab Cavities:**

- a. **ACTION (Jamie, Sergey):** Provide an update DQW HOM strength (**done** on 25/09/2018 - <https://indico.cern.ch/event/752409/>) and their impact on beam stability.

- Sensitivity to mechanical error for DQW was shown to be reasonable (see talk of Zenghai at HiLumi meeting).
- Large frequency shift observed for DQW modes (3 to 5 MHz): important to scan frequencies for worst case as we do now (Jamie's talk at HiLumi meeting), especially as all the power goes to only one coupler for the worst mode (960 MHz).
- DQW: Heat load contribution at 1.75 GHz to be understood.

→ DQW: Some modes underestimated by calculations (590 MHz by ~15 dB).

11. Impact of coating on impedance:

- Is there any issue to be expected from coatings (a-C, NEG)? **No. See note on HL-LHC impedance. The impact on longitudinal impedance will not be negligible if we coat the whole machine although there are some issues of compatibility with the possibility of making endoscopies and of running PIMS checks with the RF ball.**
- From meeting on 3/7/2018 (<https://indico.cern.ch/event/741104/>): Update the study of the impact of a-C coating on impedance - **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.
- Would it be acceptable to use the LESS technique in all the arcs: even by modifying the direction of the grooves (e.g. having them in the longitudinal direction?)
- - Studies done for the HiLumi report and for the ECLLOUD workshop (<https://agenda.infn.it/getFile.py/access?contribId=14&sessionId=3&resId=0&materialId=slides&confId=13351>).
 - Extrapolation of additional impedance due to LESS not easy as measurement at 3 frequencies only, for the real part only and without magnetic field.
 - For triplets, small impact as small length treated.
 - For all sectors, large impact could be expected, especially at injection (could require increasing the octupoles from 3 A to 20 A, just for impedance). At top energy, the impact is smaller since most of the impedance is due to collimators (still 10% increase in octupole threshold, i.e. 20 to 25 A).

12. Collimators:

- a. Determine the geometric part of the impedance of the collimators
 - See action d.i below.
- b. From meeting on 12/6/2018 (<https://indico.cern.ch/event/733521/>). **ACTION (Benoit)**: Evaluate the impedance of the new tertiary collimators
 - Discussion ongoing, new proposal done last week by EN-MME.
- c. From meeting on 24/7/2018 (<https://indico.cern.ch/event/743627/>) concerning dispersion suppressor collimators: **ACTION (Nicolo, Lorenzo)**: Finalize the impedance measurements and provide an update at one of the following meetings.
 - Measurements done and presented at IWG (<https://indico.cern.ch/event/756863/>). ECR approved.
- d. From meeting on 28/8/2018 (<https://indico.cern.ch/event/751331/>):

- i. **ACTION (Emanuela):** Verify the simulations of transverse impedance of the TCSPM-type tapers and check at what tapering angle the impedance starts diverging from a flat-taper formula.
 - ➔ Better convergence now between simulations and formula for tapers, will be reported by Emanuela.
- ii. **ACTION (Sergey):** Compile a list of potential octupole threshold gains from the reduction of geometric (including the improvement obtained in the new design, not included so far) and resistive wall impedance for each collimator and identify the most promising ones.
 - ➔ This is ongoing, I saw a plot gathering the information, but some aspects still needed to be checked (in particular the first taper for the primary collimators may have been forgotten).
- e. Study scenario of operation with asymmetric opening of the collimators (secondaries)
 - ➔ Work by Dimitr (student with Gianluca) presented at ColUSM (<https://indico.cern.ch/event/736735/>)

13. Beam Screen:

- a. From meeting on 29/05/2018 (<https://indico.cern.ch/event/731756/>): Perform an MD to study the beam screen impedance at injection energy.
 - ➔ DELPHI simulations showed we could not easily distinguish the impact in MD.
- b. From meeting on 12/06/2018 (<https://indico.cern.ch/event/733521/>):
 - i. **ACTION (Impedance team):** Propose and conduct an MD to measure the Beam Screen induced tune shift at Injection and test the conductivity of beam screen coating.
 - ➔ DELPHI simulations showed we could not easily distinguish the impact in MD.
 - ii. **ACTION (Benoit):** Check the measurement data on Cu thickness and its contamination. **Done by S. Calatroni – to be reported**
 - ➔ Sergio and Marco ready to present.
 - ➔ MD at 70 K and at 20 K, performed and being analysed by TE-MPE
 - ➔ Magnetic measurements in SM18 were done

14. VAX:

- a. **No pending points**

General actions:

Elias and Benoit Summarize in a note the status of the impedance estimate and the list of items of concern and the expected impact on impedance and present it at WP2 with the corresponding impact on beam stability (octupole current required for stabilization). **Done. Note sent to Lucio and Oliver**