

Impedance Police - Status on 23/08/2019 => Answers with BenoitS + comments in red during the meeting

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.

- i. Following the change in distance D1-D2 the design of the Y chamber for IR1 and 5 has to be reviewed and rechecked for impedance aspects (see WP2 meeting on 14/5/2019 - <https://indico.cern.ch/event/813823/>)

→ The model has already changed a little bit but Francisco did not send it to BenoitS as it is still supposed to change much more within the next month. The angle will probably increase from ~9 degrees to ~15 degrees. Seems still some issues with the updated model...

- b. Obtain the drawings of the 'as installed' Y-chambers in 2-8 and re-evaluate their impedance.

This should be done by end of January 2019. Presented at WP2 meeting on 2/4/2019 (<https://indico.cern.ch/event/804347/>). IR2 chamber simulated No issue found. Included in the impedance model for LHC, HL-LHC. Status for IR8?

→ BenoitS will also do IR8 (easy but not high priority) and we need to check it is now included in all the models (seems not in Run3 model for the moment). The contribution is small.

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

This should be done by end of February 2019. 3D models were being simulated at WP2 meeting on 2/4/2019. Status?

→ Work of AdnanK (for 1 model), but the models are not yet finalized, especially for 2 out of 3 BPMs. Next: wait for BI for 2 out of 3. For the other one, do we wait for AdnanK (to do the 3 BPMs together) or not? Gianluigi will discuss/check with RhodriJ

3. Special BPMs:

- a. EO-BPM for crabbing
b. QPU for emittance meas.
c. Cherenkov Monitor for Longitudinal Meas

will be installed between Q5 and Q6 in IP4 (see presentation at WP2 meeting on 11/6/2019 - <https://indico.cern.ch/event/823530/>)

The impedance of these objects should be studied.

→ Yes, indeed. Impedance team is working on the first one with collaborators from Liverpool (CST simulations under way). BenoitS checked with ThibautL for the other two devices, and there should be more information in September. See comment above

4. 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.
Not needed?
- From ChristineV's measurements, there are no unwanted modes, so no need for antenna (see IWG #32 <https://indico.cern.ch/event/820005/>).
- b. Maximum acceptable angle of the fingers: 15° ±5° (corresponding to an elongation/contraction by ±2.7 mm).
- Was Ok for the general case studied by BenoitS (TCC on 15/09/2016). To be studied on a case by case basis. Elongation/contraction depends on the length of the RF fingers, which are not always the same.
- c. Any dependency between the maximum angle and the diameter and the convolution height from the impedance point of view?
- There is Ng's formulae that link impedances to convolution length (L), height (h) and diameter (2b): $\text{Im}(Z_{//}) \propto hL/b$ and $\text{Im}(Z_{\perp}) \propto hL/b^3$ for square bellows. The same angle and convolution height adds therefore much more impedance at smaller diameter (with $1/b$ and $1/b^3$).
- d. Impact of possible misalignments and tilts to be studied.
- No impact on mode was observed for transverse offsets. The impact on broadband impedance is expected to be less significant. Tilts were not studied. No tilt allowed for Crab Cavities. Ask RamaC to give a value of the tilt of the Crab Cavities
- e. Investigation of the impact the outer bellow with the two-convolution design and scan of its diameter.
- That was not done. Do not plan to follow this up unless designs with two convolution bellows come back on the table.
- 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/>) → This matches with what described in the HL-LHC report on impedance. No further follow-up for that. The rest of the actions should be completed by the end of 2018. A DRAFT note by the vacuum team has been issued on 12/07/2019 – e-mail from A. Carvalho. Numbers of bellows being cross checked.
- BenoitS received the mail from Gianluigi during the Summer and is following this up. Deadline for the end of the month.

At the meeting on 2/4/2019 it was mentioned that analysis was ongoing and results could be reported soon. Status?

→ ChristineV can report on the RF measurements (no mode observed with offset).

5. ALICE vacuum chamber:

- a. No issue expected for HL-LHC

6. 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 performed on the mock-up confirm the results of the simulations. Presentation to be scheduled.**

→ Simulation campaign presented at IWG #30 and 31 and TREX #22 (<https://indico.cern.ch/event/814592/>), and included in the related ECR. Can be presented at any time at a WP2 (BrankoKP).

7. MKI:

- a. Identify minimum bunch length that allows operating without upgrading the injection kicker or identify the maximum bunch population that does not require upgrading the MKI.

→ Slides of Mike Barnes at WP2 (02/04/2019): Performance reach of post-LS1 MKIs is expected to be $1.3e11$ ppb ($1.6e11$ ppb) with 1 ns (1.2 ns) bunches. We should use the Binomial distribution and see what would then be the bunch intensity limits. Should study the effect of MKI heating vs. bunch length and in particular turn-around time.

- 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.

→ Not clear to BenoitS how one can do that.

- 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. Reiterated at WP2 meeting on 02/04/2019. Benoit commented that the worst case scenario has been taken. A Gaussian distribution gives 30% higher power loss as compared to binomial. Is this unduly pessimistic?

→ It is pessimistic but 30% seems a reasonable margin. The binomial was done and gives 30% less (24th IWG, 11/10/2018). See comment above.

- 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. Reiterated at WP2 meeting on 02/04/2019.

→ Such dynamic thermal simulations are very challenging, but indeed the impact of decreasing current along the fill is large. Do we need to estimate the power loss vs. time with the parameters along the fill? This is indeed feasible. See comment above => Yes, to be done.

e. Presentation at the WP2 meeting on (02/04/2019): <https://indico.cern.ch/event/804347/>.

a) The MKI model has to be added to the HL-LHC Impedance model. **Not done yet. Impact on stability should be assessed (it was ongoing on 2/4/2019). Status.**

→ MKI included in the LHC model (see IWG meeting on 19/09/19 => No effect observed on beam stability in all configurations studied, but to be checked as the effect on impedance is clearly visible...). Next: include this also for HL-LHC. Deadline for the end of the month.

8. 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.**

→ Can be done but isn't it too late for that?

9. 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. **Further update based on the latest values of the HOM to be made at the beginning of 2019. Presentation at WP2 meeting on 2/4/2019 (<https://indico.cern.ch/event/804347/>).** Mode at 1.92 GHz remains of concern for DQW cavity for transverse impedance. Further measurements ongoing. Update?

→ See crab cavity review talk by Jamie: horizontal mode still there and well above the 1 MOhm/m limit. ~50 A octupole current needed. Can we still do sth to reduce this required octupole value (we said yes at some point, mentioning that it started not to be negligible...)? Check that all our estimates of required octupoles current with impedance model are including these 50 A for Crab Cavities?

→ Eric recently asked for a meeting as they have manufacturing issues with the RFD HOM couplers.

10. Collimators:

a. From meeting on 12/6/2018 (<https://indico.cern.ch/event/733521/>). **ACTION (Benoit):** Evaluate the impedance of the new tertiary collimators. **Update on February 2019. Still pending after meeting on 2/4/2019**

→ Just got the new models from Luca. Deadline for the end of the year.

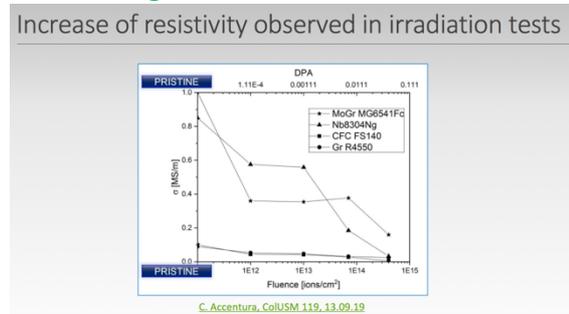
b. Study scenario of operation with asymmetric opening of the collimators (secondaries). **This is still interesting for the collimation team. Impedance estimate should be done for the configuration proposed by the collimation team (see proposal made at ColUSM on (<https://indico.cern.ch/event/736735/>)).** WE should also determine the sensitivity matrix of impedance reduction (relative reduction of the octupole current) per mm asymmetric opening of one of the jaw for the various primary and secondary collimators.

→ Nicolob and BenoitS have requested a talk by the former student of AlessioM (or AlessioM himself) on this topic. Waiting for it.

c. Status of the beam-based TCSPM impedance measurements and status of the follow-up of the impedance of coated samples (MoGr, graphite, CFC). Effect of radiation on

resistivity. Presented at the WP2 meeting on 14/5/2019 (<https://indico.cern.ch/event/813823/>): the status of the follow-up of the impedance measurements on coated samples is progressing and no significant deviations have been noted from the first measurements. The results of the beam based measurements performed in 2018 need to be reported. **Action: Benoit.**

→ Was discussed at the IWG on 19/09/19 and SergeyAnt could report about it at a future WP2 meeting.



→ Reminder: from latest analysis by DavidA on LHC tune shifts vs. intensity at high energy on B1H, B1V, B2H and B2V, the measurements are larger than predictions by a factor between 1.3 and 1.6 (see talk for PHD defense for instance). A factor 1.3 could be explained by an increase of CFC resistivity from 5 uOhm.m (i.e. the past measured value, which has been used in our impedance model for some years) to 8.5 uOhm.m (i.e. increase in resistivity by a factor 1.7). The factor 1.6 can be explained by an increase from 5 to 13 uOhm.m (i.e. increase in resistivity by a factor 2.6). Note that before the LHC started, our computations were made for CFC resistivities of 14 uOhm.m and 10 uOhm.m... To be followed up closely! => It would be great to have the estimated amount of radiation of all the collimators.

⇒ We should try and measure the resistivity of a collimator which was in the past in the LHC to see what the resistivity is.

DTI Mo and Cu coatings have been tested on Graphite and resistivity measured both at DC and High Frequency. Due to high roughness of the surface larger values have been measured for Mo on graphite both at DC and High Frequency. Cu coating on graphite appears to be less sensitive to roughness of the underlying surface. Impacted graphite collimators (at HiRadMat) have been measured (cavity measurement) both for Cu and Mo coating (coating done at CERN). Resistivity is approximately 70 nOhm.m for both Mo and Cu coated non-impacted surfaces and it increases to 140 (Mo) and 160 (Cu) nOhm.m in the impacted areas. The intensity of the beam impacting the collimator jaws should be specified and the measurements of the jaws impacted with lower intensities should be performed too. **(Action: Benoit)**

→ Which measurements exactly to be done? => The question is what was the intensity in the HIRADMAT test, which was impacting the jaws?

11. Beam Screen:
 - a. None

Additional points to follow up:

→ BenoitS had a meeting with CT-PPS and they have some quite wild plans for HL-LHC. That was confirmed by PaoloF. Need to follow this up, as well as the crystal installations => Potential requests for more crystals in LHC => **A. Mostacci and D. Quartullo came to CERN to make some measurements and they could summarise these measurements at some point.**

→ Action from WP2 held on 03/09/19: Simulation of the possible modes for shorted stripline monitors.

→ Action which was for Transverse Stability: “From WP2 meeting on 29/1/2019 (<https://indico.cern.ch/event/788818/>): Analysis of the ~~stability and~~ heat load in the presence of the crab cavity HOM should be repeated also for the 8b4e beam and possibly for hybrid schemes.”