27th Meeting of the HL-LHC Technical Coordination Committee – 30/3/2017

Participants: C. Adorisio, A. Apollonio, G. Arduini, V. Baglin, R. Bruce, O. Brüning (chair), H. Burkhardt, R. Calaga, F. Carra, S. Claudet, J. Coello de Portugal, R. De Maria, D. Delikaris, B. Delille, P. Fessia, A. Foussat, S. Gilardoni, F. Giordano, M. Hofer, T. Lefevre, H. Mainaud Durand, M. Martino, G. Mazzacano, E. Metral, S. Redaelli, B. Salvant, L. Tavian, R. Tomas Garcia, S. Yammine, D. Wollmann, M. Zerlauth.

Excused: M. Lamont, F. Cerutti, M. Giovannozzi, M. Gourber-Pace, J. Jowett.

The slides of all presentations can be found on the website and Indico pages of the TCC:

HL-LHC TCC homepage: https://espace.cern.ch/HiLumi/TCC/Default/Home.aspx

Indico link: https://indico.cern.ch/event/590417/

The minutes from the previous meeting were approved, with no actions to follow-up.

Q1 trim (R. Tomas Garcia - slides)

R. Tomas recalled the need for accurate β* measurements to ensure beam aperture (10 % accuracy required in β*) and a balanced luminosity to both ATLAS and CMS within 5 % (2 % accuracy required in β*). K-modulation without tune feedback is the best technique known at the moment for β* control. The current configuration gives 11% luminosity imbalance with 4 % in β* accuracy. The only known solution to meet the 5% luminosity imbalance tolerance (2 % in β*) is a 30 A Q1A trim.

The longitudinal alignment uncertainty has a limited impact on β* control. An uncertainty of 1 mm results in ~8% luminosity imbalance (3% in β*). Tightening imperfection tolerances in MQXF is not possible, therefore meetings are planned by WP2 with the relevant work packages to assess the feasibility of improving the longitudinal alignment accuracy.

L. Bottura commented that the goal of 1 mm longitudinal alignment is very unlikely to be reached, the current best estimate is 2 mm. He added that the current of 30 A is rather large to consider this item a 'trim'. He asked if it would be possible to go to 10 A instead. G. Arduini and R. Tomas confirmed that 30 A are required.

O. Brüning stated that the HL-LHC TCC gives the recommendation to follow-up this discussion in the Magnet Circuit Forum, including studies of possible hardware solutions.

ACTION: a presentation should be given in the HL-LHC TCC on the outcomes of the studies for the Q1A trim, including options for hardware implementations (WP 2-3-6-7).

R. Bruce pointed out that today we are operating with a 10 % beta beating, going to 2 % would bring an additional gain in aperture and therefore in β* reach.

Status of low-impedance collimators and 2017 MD plans (S. Redaelli - slides)

S. Redaelli reminded that the need for impedance reduction of LHC collimators is a key aspect of the HL-LHC collimation upgrade. The plan towards HL-LHC is to replace all 22 secondary collimators of IR7, following a staged installation, with 8 collimators replaced in LS2 and 14 in LS3 (plus spares). The plan is also to replace primary collimators with a low-impedance design based on un-coated MoGr, as these would not survive for all the LHC lifetime. The upgrade of the primary collimators is presently planned under the consolidation project.

A prototype low-impedance secondary collimator (TCSPM) has been installed in the LHC during the EYETS 2016-2017 for first beam tests. This prototype offers the possibility to expose to the beam three different materials (Mo-coated MoGr, TiN-coated MoGr, uncoated-MoGr). For the installation of the TCSPM, the slot that contributes the most to LHC impedance was selected. Thanks to the significant efforts invested in the last years to improve impedance measurements, it is now possible to isolate the contribution of individual collimators to the total LHC impedance. This is done by measuring tune shifts with an accuracy of about 1e-5 while changing single collimator gaps. Therefore, the goal of the beam tests is to measure the contribution coming from the different material options.

S. Redaelli presented the goals for the MD campaigns in 2017 and 2018:

- Assess with LHC beams the impedance gain for the baseline solution with coating, with the final collimator design.
- Comparatively assess, against impedance, different coating technologies (surface resistivity), as well as uncoated MoGr.
- Evaluate the robustness of coating against multi-turn circulating beam losses.
- Expose the TCSPM to operational, or even artificially higher beam losses

The outcome of such tests is of great importance. Stefano pointed out that EN/STI requested anyway to build a full prototype to validate the design before launching the series production, and the idea to test it with beam in the LHC provides additional important insight.

S. Redaelli reported on the discovered vacuum non-conformity of the TCSPM. The first acceptance test revealed 20 times higher outgassing than the acceptance limits. After the installation of two additional NEG cartridges, and 5 days after the bake-out the collimator was a factor 2 better than the acceptance limit. These findings were already reported to LMC where the installation was endorsed *(*LMC minutes 08/03/2017*)*. Following the second step, the installation of the collimators was approved. In these conditions, it will be difficult to perform high-intensity tests (3rd and 4th bullets in the list above), nevertheless the priority remains to measure the impedance reduction, so the MDs in 2017 will focus on this aspect (feasible to be studied with a single bunch), starting from the first MD block. The possibility to have a 'destructive' test at the end of the run to assess the effect of beam impact on the coating was also proposed.

O. Brüning agreed with the proposal to have tests already in the first MD block, in order to allow time for data analysis before the following tests.

O. Brüning asked about the results from HighRadMat tests for collimator materials. S. Redaelli explained that first results will be available in summer, then additional ones in October. These results are based on the synergy with the studies for TDI materials.

ACTION: S. Redaelli should report on the results of HiRadMat tests for collimator materials (summer 2017).

S. Redaelli mentioned that an internal workshop is scheduled to discuss the overall readiness for the production of collimators based on MoGr, where the observed vacuum non-conformity will be addressed.

ACTION: S. Redaelli should report on the vacuum non-conformity to launch the series production (end of May).

O. Brüning stated that the HL-LHC TCC supports the proposed MDs with very high priority.

Impedance measurements of low impedance collimators (N. Biancacci - slides)

N. Biancacci presented the status and plans for impedance studies of low-impedance secondary collimators.

Prior to the decision to proceed with the 3-stripe design of the TCSPM, it was shown in simulations that it is possible to distinguish the three different materials on the surface of the prototype collimator, provided enough thickness (5um) and width (10mm). Bench measurements were performed on a 3-stripes block and these qualitatively confirmed this behavior.

The test bench impedance measurements performed on the full collimator assembly of the TCSPM show different results than predicted by analytical and numerical 3D simulations. A good relative agreement was found for TiN/Mo (difference of ~0.1 Ohm), but an unexpected lower impedance for the MoGr stripe was observed. The presence of bad contacts could have played a role and this aspect is under investigation.

N. Biancacci proposed to measure the tune shift induced by each stripe in a dedicated MD. Further studies are being done to see if in addition the growth rate or stable phase shift could give measurable observables. Expectations predict a minimum tune shift of 3e-5 at 0.75 mm (4 sigma) half gap at flat top.

O. Brüning asked how the switch from one stripe to another would be executed (e.g. orbit bump). S. Redaelli explained that this can be done – while using low beam intensities - by a movement in the transverse axis of the collimators, which is possible even with beam in the machine. Detailed results on the available strokes within the design range of +/-10mm will be know at the end of the on-going hardware commissioning. As a back-up option, one could consider an orbit bump. Also, BPMs

are available to have a good control of the orbit. The commissioning will be done during the upcoming hardware commissioning campaign.

G. Arduini pointed out that it is important to understand the different behaviour shown by the different coatings. If nothing relevant is measured with beam tests, the possibilities to understand the difference could be limited. He proposed considering further tests in the laboratory on some samples. N.Biancacci suggested to perform quantitative loop measurements on a block of closer characteristics to the TCSPM ones (before was measured on CFC bulk and Mo/Cu stripes). B. Salvant commented that the tests in the laboratory were performed in a short time, therefore the confidence in the results is limited. If the same behaviour is observed with beam then one should perform a resistivity measurement of the jaws taken out from the tunnel.

O. Brüning stressed again that the HL-LHC TCC strongly supports this MD programme, starting already from the first block.

MD proposal for UFO investigation (D. Wollmann - slides)

D. Wollmann reminded about the importance of achieving a better understanding of UFO dynamics and identifying suitable detection mechanisms. Being able to effectively manage UFOs is a fundamental aspect of machine protection and availability, especially when considering operation of the LHC at 7 TeV and with increased beam current for HL-LHC.

The goal of the proposed MD is to measure UFO-like losses produced by a wire scanner at 6.5 TeV with diamond BLMs in IR7, to have a bunch-by-bunch resolution of the losses. This would improve the understanding of UFO-dynamics and potentially give hints on the sources of UFOs in the machine.

H. Burkhardt pointed out that data might already be available for the high-beta run. D. Wollmann stressed that the focus of these tests is on having bunch-by-bunch resolution loss data, which is still not available at the moment and requires further development of the diamond BLMs, the associated software for data readout and the UFO-buster.

G. Arduini pointed out that the limits for beam intensity for wire scanners at 6.5 TeV should be verified. He also mentioned that these measurements could be done parasitically, for example during the intensity ramp-up. R. Tomas Garcia encouraged to send a proposal for an End-Of-Fill MD during the intensity ramp-up, stressing that this is particularly relevant for 7 TeV operation.

O. Brüning supported the proposal and agreed that this is an important test for HL-LHC, possibly to be performed during the intensity ramp-up.

AOBs

The next HL-LHC TCC meeting will be held on 13th April.

The summary of the circuit review is scheduled on 4th May.