Minutes of 124th Collimation Upgrade Specification Meeting

Participants: C. Bahamonde Castro (CBC), A. Bertarelli (AB), R. Bruce (RB), F. Carra (FCa), F. Cerutti (FCe), M. D’Andrea (MDA) (scientific secretary), L. Gentini (LG), I. Lamas Garcia (ILG), A. Lechner (AL), A. Mereghetti (AM), J. Molson (JM), J. Oliveira (JO), S. Redaelli (SR) (chairman), M. Sabate Gilarte (MSG), A. Waets (AW).

Remote: J. Guardia Valenzuela (JGV).

Indico link

Actions from this meeting

- Define with the magnets team the procedure for removing the currently installed masks;
- Establish with the vacuum team if a getter is needed for the new masks.

1 Final results of tests for TDI coated materials at HiRadMat

(C. Bahamonde Castro) [slides]

Summary of the presentation

CBC started with an overview of the motivation and background for these studies. The TDI is a beam intercepting device which protects downstream devices from a potential misfiring of the injection kickers. The previously installed BN-coated TDI was found to be severely damaged. To ensure the integrity during all service lifetime of the currently installed Cu-sputtered graphite TDI, the LMC recommended to test the performance of Cu-sputtered graphite under the worst impact conditions expected during Run 2, so HiRadMat tests were planned for 2017. Other coating configurations were also tested to gain knowledge on their behaviour. Three different impacts were selected to reproduce the worst case scenarios (deep impact, grazing impact in the coating and grazing impact with tilted jaw). No post irradiation experiments were done on MoGr, because after the test, it was realized that the coating was not applied following the standard procedure, since the available MoGr samples were slightly radioactive from previous tests at HighRadMat. Tests on the coating were carried out for graphite and CFC samples, while tests on the substrate include SiC-SiC as well. Tomography performed on the substrate shows that damage dissipates at 20 µm depth, becoming unrecognizable past 100 µm. The elastic properties of the substrate were also checked. The adhesion of the coating was checked with a scratch test, which showed satisfactory results for both Mo and Cu on graphite and Mo on CFC. RF resistivity tests performed by N. Biancacci showed a factor 2 increase due to beam damage for graphite with both Mo and Cu coatings, while the effect was non discernible for CFC. As for optical microscopy, the most damage is given by grazing impact for MoGr and deep impact for Cu. In particular, the Cu coating shows signs of melting and later solidification, while the Mo coating shows spallation damage in the middle of the jaw. Experimental results for graphite samples were compared with simulations performed using a combination of FLUKA (energy deposition) and ANSYS (thermodynamic calculation). The results were consistent with post irradiation experiments for both Mo and Cu coating. Mo coating on CFC also shows spallation, although it looks different from graphite as the material is not as homogeneous (which is also the reason why it could not be simulated).
Discussion

- SR asked if the tested samples were installed longitudinally one after the other in HiRadMat. CBC replied that they were all in separate jaws except for the SiC-SiC sample, which is right after a CFC one;

- FCa commented that the tomography results indicate surface impacts as the most dangerous, as expected and also observed in other tests;

- SR asked if the post irradiation tests were performed at CERN, which was confirmed by IGL;

- AB asked what is the size of the area monitored by the resistivity tests. IGL replied that it is 25x25 mm$^2$, which is about a factor 10 larger than the effective damage area. Both SR and AB commented that in this case it is strange to observe a macroscopic effect on the resistivity measurements;

- SR asked why the simulation results for positive and negative tilt angle are asymmetric. AL and CBC replied that it depends on a combination of the impact parameter and how much material is available to develop showers;

- AB asked what was the rationale for testing and simulating different angular alignments. IG and AL replied that it was done in order to cover possible misalignments and study the worst possible scenarios;

- AB pointed out that an indirect measurement to reconstruct the alignment, beam size and angle was the position of the intensity peak along the length, and asked if anything like that was possible for these tests. AL replied that the resolution is probably not enough;

- FCe asked why a finer scoring mesh was required compared to the standard for FLUKA simulations. CBC replied that otherwise there was no convergence in ANSYS. FCe pointed out that this is not an ideal setup, as the information used as input in ANSYS might result biased;

- SR pointed out that Mo is below the melting point and asked what exactly is causing damage in this case. CBC clarified that it is mechanical spallation;

- SR commented that the different structure of CFC could also be the reason why it has worse resistivity;

- SR asked if the spallation can be attributed to the coating not being done with the ideal cleaning or if it would have appeared even in ideal conditions. AB replied that the Mo coating on graphite was done properly. In fact, in that case the intensity was enough to melt part of the Mo coating, leading to a combination of local melting and spallation. FCa confirmed that the mechanical component is more important than the melting itself. However this kind of damage does not constitute a problem for operational conditions.

2 Status of HL-LHC TCLM mask design (L. Gentini) [slides]

Summary of the presentation

LG started by summarizing the specifications of the three masks that will be installed in Point 1 and 5, left and right. Two different designs are used, sharing the same support. The INERMET
design (TCLM4) is composed by two Cu half shells welded by electron beam together with stainless steel flanges at the extremities. Absorber blocks made of W (divided in three sectors for cost and tolerance optimization) are clamped around the chamber by screws and pins. The two halves of the blocks are separated by a gap of 0.1 mm to guarantee the contact between blocks and chamber. The Cu design (TCLM5 and TCLM6) uses instead two half Cu OFE blocks that are brazed together at high temperature and then with the flanges at low temperature. The absorbers will be installed on their support, with no later adjustments expected. The targets are aligned with respect to the beam axis while the absorbers are pre-aligned on the surface (but the TCLM6 needs to be manually re-aligned after installation).

**Discussion**

- AL pointed out that it was required not to have any gap between the W blocks in order to avoid particles passing through. AB recalled that the direction of the gap was looked into in order to avoid undesirable situations. However, LG commented that when the blocks are tightened, there is a slight deformation that effectively closes the gap. AB pointed out that still the gap should be considered at least from a theoretical point of view. FCe commented that having a gap for the whole length of the W blocks is not ideal. AL suggested a slight tilt to the blocks to solve these issues, but ILG replied that the gap will disappear anyway once they are clamped. SR suggested to rotate the three 33 cm long INERMET modules with respect to each other, to avoid having the respective gaps aligned along 1 m;

- In the discussion of the relative alignment between the TCLM5 and the downstream quadrupole, SR commented that if it simplifies the design, the option of not having the same remote connection support (without motion/cabling) could be considered;

- ILG asked if the removal of only one mask from the beam is foreseen, as both masks are solidal with each other. SR replied that this should be sorted out with the magnets team;

- SR asked LG if he had the chance to talk with the vacuum team about the need of a getter. LG said that this is still an open point, but anyway there is no issue from the design point of view;

- SR commented that in the proposed scenario, all two-beam masks actually use only two design variants (Cu and INERMET) for the absorbing element, in different orientations. Having only two designs is very beneficial in terms of cost and spare policy.

3 Update on energy deposition on HL-LHC fixed masks (M. Sabate Gilarte) [slides]

**Summary of the presentation**

MSG reported the outcome of energy deposition studies on the masks. In the original model used in FLUKA the masks are cylinders surrounding the pipe, made of INERMET with 1 mm Cu for the inner pipe. Results show a worse case in terms of total power deposition in horizontal crossing for TCLM5 and TCLM6, and in vertical crossing for TCLM4. Swapping INERMET for Cu in TCLM4 results in a higher deposition on the first corrector, which leads to the conclusion that the mask should remain in INERMET. TCLM5 and TCLM6 on the other hand do not show major issues when moving to Cu, the differences being within uncertainties.
Discussion

- AB asked clarification on the 1 mm of Cu. MSG replied that those were the specifications of the original design but it was later found out that at least 2 mm are required from the point of view of the vacuum. The final design can be incorporated into the simulations once it is settled. FCe commented that a priori the results will not improve but will not be significantly worse either;

- FCe pointed out that since the worst case for TCLM4 is in vertical crossing, there is some margin given by the possibility to split the operation time between up and down, effectively reducing the impact on the magnet;

- SR pointed out that the power deposition on the correctors is quite small anyway, so the main concern is the dose. FCe added that the required limits are being looked into, including tests of a new insulator and plans for replacing the correctors.