**Minutes of 138th Collimation Upgrade Specification Meeting**

**Participants:** G. Azzopardi (GA), R. Bruce (RB), R. Cai (RC), F. Carra (FC), M. D’Andrea (MDA) *(scientific secretary)*, J. Daricou (JD), M. Di Castro (MDC), L.S. Esposito (LSE), A. Fomin (AF), P.D. Hermes (PDH), J. Jowett (JJ), A. Lechner (AL), D. Mirarchi (DM), J. Molson (JM), L. Nevay (LN), J. Oliveira (JO), J.B. Potoine (JBP), S. Redaelli (SR) *(chairman)*, B. Salvachua (BS), A. Waets (AW).

**Indico link**

**Actions from this meeting**

- All appointed speakers for the 11 T review have received comments and feedback on their respective presentations, both during this meeting and in offline discussions (RB, MDA, MDC, SR).

**1 Introduction (S. Redaelli) [slides]**

**Summary of the presentation**

SR introduced the scope of this meeting, which is dedicated to the preparation for the upcoming review of the 11 T magnets by the CMAC. The website of the review is available at this [link](#) (restricted access). He then summarized the key messages of the introductory talk prepared by O. Brüning for the review. The working assumption for Run 3 and HL-LHC is that the collimation system should be able to deal with lifetime dips of 0.2 h for 10 s. These specifications were chosen as precaution on the safe side given the higher intensities foreseen, even though LHC operation showed better performance in Run 2. No limitations are expected for proton operation in Run 3. Quench limits might be reached in Run 4 with the full-intensity HL-LHC beams. Ion operation with the present configuration is at risk of quench already in Run 3 when the final HL-LHC beam intensities will be reached. This led to the decision to include TCLD collimators and 11 T dipoles in the upgrade baseline. The alternative solution of crystal collimation, included in the baseline as mitigation for potential schedule issues with the dipoles, is presented, showing the cleaning gain factors measured in 2018. The upgrade foreseen for the crystal control system to make it ready for operations is recalled. Crystal collimation is the only mitigation for ion beam losses that will be available for Run 3.

**Discussion**

- RB asked if the scope of the review is mainly Run 3 rather than Run 4, since the 11 T dipoles and the TCLDs are expected to be installed by then. SR replied that, in his understanding, the main goal is to assess the effect on Run 3 operations, but this review also aims at showing the decision-making process for the installation in view of Run 4. To this end, SR will present the proposed program of quench tests during Run 3 to address remaining open points.

- RB recalled that more open collimator settings are now being considered for Run 4 together with WP2, and the cleaning in this configuration without TLCDs has not yet been estimated. PHD asked if this is motivated by impedance reasons. RB confirmed that
indeed these settings were proposed in order to have a larger stable area in the tune space. SR proposed that tests in these sense could be added to the proposed plan for Run 3.

- SR showed the agenda for the review. RB will summarize the experience and foreseen scenarios for operations with proton beams in Run 3, possibly with additional contributions from the talk by AW at this meeting. MDA will focus on operational experience gathered during Run 2 with ion beams, focusing on the measured performance of crystal collimation. MDC will present the status of the present crystal hardware and the foreseen upgrades. SR will then present the proposed program of quench tests for Run 3.

- JJ asked about the planned collimation configuration for light-ion runs. SR replied that crystal collimation should in principle be used in that case too, especially since it was already tested with Xe ions. RB commented that since the stored energy is higher by a factor 3 with light ions compared to Pb ions, the capability of secondary collimators to be safely used to catch channeled halo should be verified.

2 Beam Losses with new materials and no TCLDs in IR7 (A. Waets) [slides]

Summary of the presentation

AW presented an update on power deposition studies for the IR7-DS. SixTrack-FLUKA coupling simulations were first ran to calculate the touches distribution on primary collimators. These are then used to simulate the impacts of primary and secondary particles on the aperture of IR7 and the DS. Finally, the energy deposition on the DS magnetic coils is calculated. The nominal cleaning scenario of 7 TeV HL-LHC proton beams was simulated, and only horizontal losses were considered. In this presentation only results for Beam 2 (HL-LHC optics v1.2) are shown. The following collimator configurations were simulated:

- All CFC.
- All MoGr.
- HL baseline: 2 MoGr TCP 1 + CFC TCP, 1 and 3 TCSG in CFC, all other MoGr TCP 3.

The results show that MoGr collimators allow to reduce the peak power deposition to 75% of the value obtained with CFC. The values were also scaled down to lower bunch intensities for Run 3.

Discussion

- RB asked clarification on the reported TCSG settings for HL-LHC optics v1.3, used for Beam 1. AW replied that the 9.1 σ settings is the baseline, but 8.1 σ is also mentioned as it was used in the past as a case study.

- RB commented that in the simulated scenario only horizontal losses are considered. AW replied that for completeness both the horizontal and the vertical planes should be investigated, but the horizontal one is known to be the worst case in terms of peak power values, which is why it was chosen as the default configuration. RB added that the case of a primary skew loss should also be checked. AW agreed.
SR asked if only the bunch intensity was scaled to get the results for Run 3. AW confirmed that this is the case, all other parameters of the simulation were kept the same.

PHD asked if the reason for the improvement observed with MoGr collimators is understood. AW replied that, while the probability of single diffractive scattering is practically the same between CFC and MoGr, the reduced peak power density in the DS superconducting magnet coils can be better understood by taking into account the probability of (in)elastic interactions in both materials. The qualitative effect is in accordance with previous lossmap studies but follow up studies in FLUKA are planned for a more quantitative assessment. RB added that there is a higher probability of inelastic interactions in the primary because of the higher density of the material.

RB asked if the errors on the resulting values are completely statistical or if they include other contributions. AW confirmed that it is indeed only the statistical error. RB commented that in principle there could be systematic contributions, so a safety margin should be taken into account (even if a factor 3 is already included to account for non-perfect scenarios). Furthermore, the reference quench limit refers to 7 TeV and should be scaled down to 6.37 TeV. This matter can be followed up offline before the review.

3 Round table (R. Bruce, M. D’Andrea, M. Di Castro, S. Redaelli)

The round table was dedicated to any other comments, questions or suggestions related to the preparation for the 11 T review. More feedback on the presentations will be provided to the appointed speakers offline.

Discussion

MDC mentioned that his presentation on the crystal control system is going to be similar to what he previously presented at the TCC, and he will stress in particular the foreseen exchange of the two vertical crystals. RB asked if the two crystals that will not be exchanged before Run 3 are expected to have an impact on the performance. MDC replied that the only one which is close to the limits of its movement range is one of the two that will be replaced, while the others are still in working conditions. However, the risk of losing the reference orientation, while rare, should still be taken into account for the remaining old devices. MDC added that the installation timeline for the new devices can be added to the presentation.