Minutes of 133rd Collimation Upgrade Specification Meeting

Participants: R. Barlow (RBa), R. Bruce (RBr), F. Cerutti (FC), M. D’Andrea (MDA) (scientific secretary), R. De Maria (RDM), G. Ferlin (GF), A. Fomin (AFom), A. Foussat (AFou), A. Lechner (AL), D. Mirarchi (DM), L. Nevay (LN), J. Oliveira (JO), D. Perini (DP), J.B. Potoine (JBP), S. Redaelli (SR) (chairman), A. Rossi (AR), M. Sabaté-Gilarte (MSG), P. Santos Diaz (PSD), A. Waets (AW).

Indico link

Actions from this meeting

- Provide a technical statement on the acceptable pressure at the solenoid level for the HL-LHC HELs, following recent studies regarding the energy released during a quench.

- Update functional specifications of the physics debris collimators of the HL-LHC following recent changes (loads with new apertures, change of materials if confirmed for the TCL6, final loads, etc.).

- Verify the effect of the larger TAXN diameter on the background at the experiments.

- Confirm the feasibility of aperture changes for the collimators.

1 Cryogenics considerations for the HL-LHC HELs (G. Ferlin)

Summary of the presentation

GF started by briefly mentioning that the installation of a third RF cavity module in P4, originally foreseen by the 2018 project, is no more part of the baseline, allowing a simplification of the transfer line design. The planned location for the installation of the HEL cryostat however has not changed. Various studies are currently ongoing to define the practical details of the installation, with the aim to limit the amount of pipes that would need to be cut in the QRL area. All magnets will be under saturated liquid helium, which in principle should be simple to remove once it evaporates when power is injected in the solenoids. During the evolution of the project, the gas cooled current leads were replaced by conduction cooled current leads, reducing the number of pipes needed and allowing for a simpler integration. All the instrumentation and sensors required for cryogenics monitoring have been listed already, although they are subject to adjustments. GF showed the latest 3D and 2D models available, highlighting the free room left between the solenoids for the installation of a Beam Gas Curtain element. A decrease in the "maximum design pressure" from 20 to 3.5 bar is currently being discussed in order to increase the available free room. This change is possible because of the limited amount of He in the HEL cryostat (≈40 kg). In order for the HELs to sustain the worst failure scenario, where the distribution line can reach 20 bar in case of massive quenches of other magnets, an additional valve needs to be added (see scheme in the presentation by GF). This avoids damaging the HEL in this scenario. The validation of the drawings is expected in 2021, with the production in Russia and assembly at CERN taking place between 2022 and 2024.
Discussion

- SR asked for some clarification on the installation procedure. GF replied that only the portion of pipe highlighted in green in the presentation would need to be cut, in order to make enough room for the installation.

- AFou asked for clarification on the pressure sensor, which is needed to have a working range of up to 20 bar according to the table shown in the presentation. GF replied that the list is indicative and subject to change according to the final specifics of the project, but even for a different design pressure the hardware would in principle with the same, requiring only a different calibration.

- SR clarified that the 3.5 bar design requires additional release valves to protect the lens against quenches of other magnets that would cause an over-pressure in the QRL. GF added that the safety assessment for this design is more complex.

- SR commented that the existence of a feasible solution for the lower pressure is very important to simplify the design in terms of cost and integration. AFou added that there has been some progress on the assessment of this solution, so the discussion on this front can continue offline.

- JO mentioned that an update on the HEL integration study will be given at the HL-LHC Integration Meeting on December 4th.

- SR commented that a technical document has been prepared by GF on the change of pressure [1], together with a document for the management by DP in order to ask for the approval of this choice [2].

- Further studies carried out by AFou after the meeting revealed that the energy released during a quench could go up to 1.2 MJ over 1 second (close to 100% of the stored energy), contrary to previous assumptions. This amount of rapidly released energy will create a heavy fluid expansion. As a result, the maximum pressure of 3.5 bar at the solenoid level cannot be confirmed at this point. A technical statement on this matter is necessary.

2 Impact on energy deposition in IR1/5 from the new TAXN aperture of 88 mm (M. Sabaté-Gilarte) [slides]

Summary of the presentation

MSG reported the results of energy deposition studies regarding the effect of the increased internal diameter of the TAXN in terms of heat loads in the TAXN and the TCLPX4 collimator, as well as the dose level in the D2-assembly. The worst case scenario of horizontal crossing (IR1) was considered, but the conclusions can also be extended to IR5. Results show that the heat load in the TAXN is reduced by 65 W, which are redistributed in the following way:

- 26 W in the collimators (mostly in the TCLPX4) and in the tanks;
- 12 W in the pipe immediately after the TAXN;
- 12 W in the tunnel walls;
- 12 W beyond the D2, most probably on the downstream collimators.

No significant difference is observed in the D2-assembly in terms of heat loads or peak dose distribution.
Discussion

- FC added that the physiological increase of heat loads on the collimator is not a showstopper if seen in the context of the total power specifications. In conclusion, the increased aperture can be safely endorsed.

- SR asked confirmation on the motivation for the increased aperture, which was related to manufacturing tolerances, and asked if there is still the possibility to eventually go back to 85 mm. This would be the case, for example, if the tolerances added up all in the same direction. PSD replied the indeed mechanical tolerances were the reason of the increase and the idea is to go ahead with that value if no issues are foreseen.

- FC added that no significant changes were observed even in earlier studies for an 80 mm aperture thanks to the improved effectiveness of the TAXN due to the increased beam-beam separation. As a result, an aperture adjustment over this range does not change the overall picture in a significant way.

- RDM asked about what would change if the TAXN was moved further towards the IP. FC replied that in that case the beam-beam separation would need to be reduced back, losing the improvement.

- RDM reminded that the choice between 85 mm and 88 mm can be considered completely transparent based on the machine aperture studies showed at the previous meeting. After the assessment of the aperture \[3\], it was also proposed to increase the flange aperture for the IR collimators. This proposal is being evaluated by the WPL.

- SR commented that the functional specification documents should be updated after the final assessment on the material of the TCL6, which FC confirmed to be pending. This matter can be followed up in a dedicated meeting potentially before the end of the year.

- RB asked that a statement can be made regarding the effect of this change on the background at the experiments, even though it should be negligible. FC agreed that this point should be made explicit. Similar study were presented in earlier stages, but a quantitative assessment after these changes should be provided to experiments. SR suggested to follow up this point offline and find a suitable place to present the results.

3 Status of Merlin development for collimation studies (R. Barlow) [slides]

Summary of the presentation

RBa gave an overview of the present status of Merlin, which has been integrated with many features over the years (including scattering models and HELs for LHC and HL-LHC collimation studies) and has been renamed Merlin++. Merlin++ is a general purpose simulation code and is organized as a library rather than a program, allowing for great flexibility and easier implementation of specific additional aspects. The code has gone under an extensive cleanup, improving usability and speed. It is currently implemented on a variety of systems, including HTCondor for high-volume work. Documentation on the code is readily available, such as a recently released paper on the latest version [4] and a website with a quickstart guide, installation instructions and tutorials.
Discussion

- RBr asked clarification about the ongoing development for heavy-ion routine, since the scattering process is much more complex in this case. RBa replied that at the moment the details of ion break-up are not being looked at in too much detail, focusing mainly on the different properties with respect to protons (charge, mass, cross sections, etc.). RBr commented that the break-up is particularly important for collimation purposes since it is what drives the cleaning inefficiency with heavy-ion beams. RBa replied that the focus still remains on the tracking, since other well established codes are already available to treat the ion-specific physics in detail (e.g. FLUKA or Geant4).

- SR recalled that there were some issues in the past about symplectic integrators. RBa replied that these issues have been dealt with and more information can be found in [4].

- RDM asked if results from Merlin have been benchmarked against SixTrack to get an idea of the difference. RBa replied that to his knowledge this has not been done. SR added that some loss map comparisons were done in the past and it would be interesting to repeat them for the latest version of the code. RBa added that however, comparisons with data have been performed [5].

- LN suggested that it would be interesting to present the Merlin scattering models at the Geant4 Technical Forum. RBa replied that he will look into that.

References

[1] Cryogenic considerations concerning studies of the Hollow-electron Lenses cryostat at P4, [2421901]
[5] Performance of the Large Hadron Collider cleaning system during the squeeze: Simulations and measurements, [PRAB.22.023001]