Minutes of 114th Collimation Upgrade Specification Meeting

Participants: C. Bahamonde (CB), E. Belli (EB) (scientific secretary), R. Bruce (RB), M. d’Andrea (MdA), G. de Rijk (GdR), A. Fomin (AF), N. Fuster (NF), G. Gobbi (GG), A. Mereghetti (AM), D. Mirarchi (DM), J. Molson (JM), L. Nevay (LN), D. Perini (DP) S. Redaelli (SR) (chairman)

Indico link.

1 Update on 2018 crystal collimation studies (M. D’Andrea)

Summary of the presentation

MdA presented an overview of the measurements performed during 2018 for crystal collimation with both proton and Pb ion beams. The main advantage of crystal collimation compared to the standard LHC multi-stage system is the reduction of inelastic interactions, thus reducing the off-momentum losses in the DS region. The present layout consists of four bent crystals installed in IR7, two per beam, one per plane. Two MDs have been performed with proton beams to characterize the crystal devices through angular and linear scans and several loss maps were performed at flat top with different collimator settings on both beams and planes. During 2017-2018 YETS, a new strip crystal was installed on B2H and the performance of the new hardware was evaluated during the MDs, showing a significant discrepancy between the measured bending angle at injection and top energy. A known difference between the two H crystals is the miscut, higher for the B2H. It is being investigated if this could cause the difference. These MDs also showed that crystals can be kept in channeling conditions during the energy ramp. Another MD was performed in November 2018 to evaluate the performance of crystals with Pb ion beams. After a first set of measurements to characterize the crystal devices with Pb beams, an extensive campaign of loss maps was carried out at flat top to compare the cleaning performance of the standard and crystal-assisted systems with different collimator settings, showing a factor 2-7 improvement for all crystals. Linear scans at flat top confirmed what already seen for protons, i.e. a reduction of multturn channeling efficiency and enhanced dechanneling for B1H crystal due to its extreme bending. Also in the ion case, channeling conditions were kept for all crystals during the whole squeeze. Tests with high loss rate and all crystals in place showed a very clean loss pattern around the entire machine compared to the standard system.

Discussion

• SR asked how the miscut could explain the discrepancy. DM replied that this is not obvious, but potentially the miscut could lead to different effective lengths of the crystalline planes inducing different deflections depending on the crystalline channel used. However, this hypothesis has to be validated with more detailed studies.

• RB asked why B1H gives the best results in terms of cleaning while having the worst multturn channeling efficiency. DM replied that a possible explanation is the much larger impact parameter of the channeled beam on the absorber with respect to B2H having a smaller bending angle. On the other hand, for vertical crystals this can be due
to the QM technology which features smaller crystalline channels than strips. In fact, strips and QM behave similarly for protons.

- SR commented on some points that in his opinion need further checks/studies:
  
  1. Channeling was lost in the ramp following a trip of the orbit correctors. This is probably coming from an orbit shift on the other side of the crystal, but this should be checked explicitly. This is important to demonstrated the need for the optimum layouts with one crystal per side of the beam.  
     **Action for MdA: Check the orbit change at the crystal during the orbit correctors’ trip along the ramp.**
  
  2. **Action for MdA: Check the absolute value of cleaning inefficiency and not only the relative gains.**
     SR asked if the B2H is the worst also in this case.

- RB commented about losses at the Q7, which increase with crystal collimation, and asked if this can be an issue. SR replied that he will check the status of these simulations with the FLUKA team.

2 Review of the HEL magnetic system (D.Perini) [slides]

**Summary of the presentation**

DP presented an overview of the magnetic system proposed for the Hollow Electron lenses for HL-LHC. In this system, electrons are emitted by the cathode of an e-gun and travel toward a system of superconducting solenoids cooled at 4.5K that generates the magnetic field to tune the size and steer the trajectory of the electron ring. All the solenoids and correctors are wound with the same Nb-Ti wire. The insulated wire has a size of 1.65 mm x 1.05 mm with a copper to Nb-Ti ratio of about 4. The minimum critical current measured at 5 T is 750 A.

Regarding the main circuits in the straight part, the maximum current for the two main solenoids is 350 A while the nominal current for bending solenoids and dipole corrector is 330 A. In the e-gun cryostat there are two independent solenoids with a maximum current for all circuits of 350 A.

Concerning the correctors, four circuits are foreseen in the straight part (two horizontal dipoles and two vertical dipoles for each solenoid) while in the e-gun cryostat there will be one horizontal dipole and one vertical dipole, with a maximum current for all circuits of 250 A. However, dipole correctors are still under study.

One can refer to document EDMS 2036694 for further details.

**Discussion**

- SR commented that some changes have been done in the design compared to the one presented at the 2017 review. A summary in the following:
  1. Increase of main solenoid field from 4T to 5T
  2. Additional windings at the extremities of the solenoids
  3. There are 3 more circuits as tilted solenoids and new dipole which are not anymore in series to the main solenoids
  4. The orbit corrector dipole has been added
5. There are now new correctors for the angle of the e-beam
6. The QPS is now needed
7. A shielding for the magnetic field is also needed (but not yet designed)
8. Quadrupole corrector are not anymore part of the design
9. Smaller beam aperture, now set to 60mm.

- GdR suggested that a iron shield should be integrated into the design. DP replied that this is planned.

  **Action for the design team: provide specifications for the shielding.**

- SR commented that we should check if there is a need for the shielding from the beam dynamics point of view, by assessing the residual field effect on the other beam.

  **Action for SR/GG: provide the optics team with the field maps for the latest design.**