Minutes of 18th Collimation Upgrade Specification Meeting

Participants: A. Bertarelli (AB), R. Bruce (RB), M. Brugger (MB), L. Lari (LL), N. Mariani (NMa), A. Marsili (AM) (scientific secretary), E. Metral (EM), N. Mounet (NM), S. Redaelli (SR) (chairman), A. Ryazanov (AR).
Remote: T. Markiewicz (TM), H. Rafique (HR).

Indico event here.

1 HL LHC collimator scenarios: some impedance considerations (N. Mounet)

Slides are available here.

1.1 Summary of the presentation

NM presented the results of impedance calculations for different upgrade scenarios of the LHC collimators, and compared them to the current situation.

In the current situation, the total impedance of the LHC is dominated by the collimators, both for the real and imaginary part. NM's plots of fractional impedance contribution for the different sources indicate that the primary and secondary collimators, made of carbon, are largely dominant. SR asked if the addition of 2 more TCLs per beam in LS1 will be acceptable from the impedance point of view. NM confirmed that this should be the case, even if they have rather small gaps, because they are make of Copper.

The comparison between tune shift from LHC measurements and simulations was then presented. The measurements are a factor 2 higher than the simulations. This is still under investigation.

NM presented the components of the impedance model. EM commented that the electric resistivity must be know precisely to compute the impedance. Small difference could justify for example the discrepancy between models and measurements. For the carbon collimators, SR suggested to cross-check the resistivity values inferred from SPS impedance measurements in 2004 and 2006 [**Action**: summary of the past measurements here (pdf)]. AB pointed out that the bulk material chosen in the calculations for the jaws of the metallic secondary collimators (on top of the molybdenum coating), namely graphite, is a very pessimistic choice and that a more realistic material (such as CFC or Mo–C) should be taken instead [**Action**].

NM then presented impedance calculation results for 4 HL cases: relaxed and nominal collimator gaps for the present and new collimator material (Mo). The best case shows an improvement for nearly all frequencies except a band at frequencies lower than $2 \cdot 10^5$ Hz. The improvement factor is 2 everywhere else.

AB noted that an improvement of a factor 100 in resistivity leads only to an improvement in impedance of a factor 2. NM answered that this are ratios of the total impedance of the whole machine (including other elements than collimators). In practice, the secondary collimators contribution to the total impedance is reduced to negligible values if metallic collimators are used. Note that in the model only the TCSGs in IR7 were changed: the IR3 collimator remained at nominal settings and carbon was assumed.

SR pointed out that, for reference, we should also have plots that illustrate the improvement factors for the collimator impedance only, in order to quantify precisely the effect of materials/settings on the collimation contribution only.

The ratio of impedances for two different settings of the graphite collimators was presented. The change of setting only accounts for a 20% improvement. SR added that the gap of the primary could be increased in order to decrease the impedance, even if goes against the current tendency (decreasing the gap). AB said that the primary could even be replaced.

NM presented the ratios of the impedances for different thicknesses of the Molybdenum coating with respect to a 100 μm coating. It must be noted that the choice of the material of the bulk of the collimator is pessimistic. EM pointed out that the value of frequency affected depends on the value of the thickness. AB warned about possible robustness issues depending on the material of the bulk.

Then, NM compared the impedances of the relaxed settings, metallic collimator scenario with the current one. The gain would be 20%. RB asked if this included the different collimator setting corresponding to the different energies; it is the case. NM specified that the impedance calculations do not depend on energy for given half–gaps in mm; however, the tune shift depends on energy as well as the Landau damping.

In conclusion, the presented studies show that the total impedance can be decreased. There can still be impedance issues for metallic secondary collimators depending on the beam parameters, even if the nominal case seems fine. Beam stability has still to be studied in details.

1.2 Discussion

RB asked what is the gap visible between 10^9 and 10^{10} Hz on the real part of the impedance. It is an effect of the broadband model (roughness of the beam pipe) and depends on the cuts.

SR asked if a safety factor is taken into account in these simulations: it is not the case.

The values of the resistivity of different materials were discussed.

AB asked what is the most relevant bandwidth for the LHC impedance. NM answered that this can shift, but it is mainly above $10^7 - 10^8$ Hz, at least for the single–bunch regime at high chromaticity as at the end of 2012. It depends mainly on the chromaticity and on the damper settings.

2 Collimator Materials for LHC Luminosity Upgrade: Proposal of Irradiation Studies at BNL (N. Mariani)

Slides are available in pptx and pdf.

2.1 Summary of the presentation

NMa presented different aspects of the proposal of irradiation studies of possible materials for the LHC collimators. This activity was proposed to the US-LARP collaboration by SR at the last collaboration meeting and was approved by the US-LARP management. The goal of this tests is to characterize candidate materials for future collimators in conditions of extreme irradiation.

Two laboratories are considered for the radiation studies. A program is already ongoing at the RRC-Kurchatov Institute (Moscow) to assess the radiation damages on three materials: CuCD, MoCuCD, and SiC (or MoGRCF). A proposal has been submitted at the Brookhaven National Laboratory (New York) for the following materials: Molybdenum, Glidcop (Cu), CuCD, MoGRCF. The characteristics of the irradiations were presented. SR suggested to keep in the RRC test program the SiC, as initially included in the contract with RRC. The overlap of two materials between the tests at the two institutes should be sufficient for a comparison. It is interest to extend the panel of tested materials by including also SiC, even if it is not considered anymore as TCS material candidate (due to large impedance).

The goal of these irradiation studies is to assess the degradation of the properties of the material, including the relevant parameters for collimators. The considered degradation would be up to 1.0 displacement per atom. AR pointed out that this value might be difficult to reach with a 200 MeV beam. NMa answered that the irradiation might last up to 7-10 weeks according to the estimates by N. Simos from BNL who is in charge of these tests.

The installation and the characteristics of the beam were presented. NMa presented the shape of the target: the material is divided into specific tensile sample shapes, and the complementary shapes to use up all the available volume. This is not applicable for composite materials. A preliminary analytical estimation shows smooth energy degradation through the foreseen sample and structure layout.

The next steps include several analysis that are already ongoing: energy deposition, and thermo-mechanical analysis of water coolant flow. The next in line is the isotope production and sample activation. All the elements needed to create the samples are already available or will soon be. The production can start as soon as it is validated.

In conclusion, the new proposed irradiation campaign at BNL is paramount to complement the material characterization from the radiation hardness point of view for future collimators design. The preparations for this campaign are well advanced, and the production of samples can start soon.

2.2 Discussion

LL pointed out that the geometry of the BNL radiation area for FLUKA was done during her PhD and is available. She suggested to re-consider the order of samples in the irradiation area to improve the shower production in the target area. This will be followed up off-line between LL and NMa.

The plan is to rely on the Gaussian incoming beam to irradiate to a different extend different samples (samples in the Gaussian tails will get less doses than the ones exposed to the beam core). AR pointed out that is is important that the irradiation on the samples is well homogeneous otherwise it might be difficult to measure precisely the required properties. AB agrees and commented that we must sort out this point directly with N. Simos.