Minutes of the 24th Collimation Upgrade Specification Meeting, 21st of June 2013

Participants: C. Adorisio (CA), A. Bertarelli (AB), R. Bruce (RB), M. Brugger (MB), F. Cerutti (FC), P. Fessia (PF), R. Kwee (RK), A. Marsili (AM) (scientific secretary), D. Mirarchi (DM), V. Previtali (VP) (Fermilab), S. Redaelli (SR) (chairman), A. Ryazanov (ARy) (NRC KI), B. Salvachua (BS) E. Skordis (ES), D. Tommasini (DT).
Remote: L. Lari (LL), T. Markiewicz (TM) (SLAC).

Indico event here.

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

Slides are available in pdf or pptx.

1.1 Summary of the presentation

NM presented an update on the irradiation studies of the new collimator materials which are ongoing both in the Kurchatov Institute, and in Brookhaven National Laboratory. The two programs are complementary, and one material is being tested in both institutes.

The goal is to assess the degradation of physical and mechanical properties of selected materials (Molybdenum, Glidcop, CuCD, MoGRCF) as a function of *displacement per atom (dpa)*. This would help predicting the lifetime of collimators designed with these materials. Several sample shapes have been designed to tests the different properties.

The specimens are encapsulated into special vacuum tight capsules mounted into a holding box. The samples are identified depending on position. They are at different distances from the center, which will provide different irradiation doses to each sample, probing different flux from incoming Gaussian beam. The cooling is made by water flowing between adjacent capsules.

Recently, N. Simos reported that two capsules have been damaged during the irradiation, leading to an emergency stop of the irradiation. This could be due to the cooling not being sufficient: the samples expanded and broke the vacuum capsule, contaminating the cooling system with radioactive isotopes. The swelling of the samples under the radiation might have played a role as well. The two holders were removed, creating extra space and more cooling.

NM summarized all the actions that are already completed, and the ones still remaining. This includes the production of the composite material samples. The radiation campaign is now started, and will take 9 to 10 weeks to be completed.

In conclusion, the irradiation campaign is progressing. The situation is not ideal because there is no redundancy of some sample any more, due to their removal. We hope that the tests can be completed for the rest of the samples. The origin of the incident was quickly understood and corrected, and the irradiation campaign is still ongoing. The contaminated samples might still be used for further testing.

1.2 Discussion

ARy asked if the cooling is water, and if the beam comes through the water. Both are correct. ARy then pointed out that the some energy can be absorbed when a proton beam passes through water. NM answered that this was taken into account in the FLUKA simulations.

AB asked about the temperature of the samples. This will be answered by NS. AB asked if the contamination came from the broken capsule, which is the case.

SR said that LL and MB had expressed concern about the water. LL added that the peak temperature might also be an issue.

SR asked what is the status of the samples measured before irradiation. NMa answered that the tests are destructive, so they are done on different samples. However, these samples are produced the same way, from the same raw material. NMa added that has no news from NS on the plans for measurements.

MB asked if the beam size is measured: it is the case. MB stressed that the exact beam parameter (measured) should be used for energy deposition simulations. [**action: LL**]

2 Review of radiation resistance of cold magnets and status of IR7 warm magnet: MBW–MQW (P. Fessia)

Slides are available in pdf or pptx.

2.1 Summary of the presentation

PF gave a presentation on the lifetime and the hardness of the warm dipoles and quadrupoles in IR3 and IR7. The emphasis was put on IR7, where the situation is the most critical. For the warm dipoles, there are mainly 2 circuits powering 10 magnets. This could create a possible limitation in current. The magnets are roughly all the same type. The installation scheme in IR7 was also presented.

The main question to answer is how long will the magnets survive: up to LS3? The energy used in the simulations of the deposited dose is 6.5 TeV.

PF then presented all the ratios of peak and total energy depositions, from one magnet to another. It must be noted that the ratio for the total dose is underestimated compared to the ratio for the peak dose; but the peak is the limiting factor. FC observed that the calculations were not done for the Q4, and raised the question of the extrapolation. The dose distribution in MBW is quite flat, simplifying extrapolations.

PF presented the radiation hardness of the different resins used in the magnets. The main issue is that the strength of the resin (expressed in MPa, for deformation and breaking) degrades with irradiation. This gives the limits in use. They are not pure resin: there is also glass fibers inside, which gives much better mechanical properties and increase lifetime. The limiting factor in lifetime is when one of the main properties has been decreased by 50 % of its original value. However, the first property to degrade might not be a relevant one in our case.

One of the solutions to increase the lifetime of the resins is to add screens between the poles, to shield better the coil from the beam losses. These shields could even be replaceable. They are being produced for prototyping. FC specified that the screen could even be longer than the magnets and come out in front, to increase the protection. SR asked if the screens would be cooled individually. This is not the case, only the whole magnet would be cooled. AB raised the issue of the thermal deformation, and asked for an estimate of the power lost in the magnets. FC answered that one hour of lifetime corresponds to 3 kW in the magnets.

PF then presented a table summarizing the different cases for further reference. It shows the magnets which should be able to withstand the dose. The given factors give the extra protection needed from the beam screens to reach LS3.

Another solution was mentioned: replacing the most critical magnet by an absorber would actually suppress the most critical magnet, and reduce the load on the other. It might be possible to achieve without major change to the optics.

In conclusion, the expected lifetime of the warm magnets were presented and compared with the forecasted time for LS3. Different solutions were presented for the cases when the lifetime is not long enough. further work include new computations with the current list of magnets, and with one magnet replaced by an absorber.

2.2 Discussion

AB asked about to origin of the integrated luminosity numbers. They are quoted from the HL–LHC project (L. Rossi). A security margin of an extra 50 fb^{-1} has been added to these numbers. SR pointed out that, on top of this there is also a dependency on the intensity, but it is small (10 %). FC specified that the values of deposited dose are extracted from the IPAC'13 paper by BS.

SR stated that the losses can be very different for the same integrated luminosity. For instance, in some locations, they have doubled after a technical stop.

MB also commented that the losses migh not be purely proportional to the luminosity, and that the amount of loss per unit of luminosity might decrease in future (must decrease in order to keep a long enough lifetime).

3 Optics flexibility in IR3/7 (M. Giovannozzi, S. Redaelli)

Slides are available in pdf or pptx.

4 Summary of the presentation

SR gave a presentation by M. Giovannozzi about the possibility to remove warm magnets from the LHC, to increase the number of spares. This would change the optics at the collimators. The point is to know if the optics can be adjusted after removing the magnets. This would have to be evaluated, but does not seem impossible. The difference at the collimators would have to be quantified, and possibly soon.

Alternative approaches were presented, corresponding to the presentation by PF. The main numbers to consider are:

- the short term heat load (40 s) and the possible deformation;
- the long term heat load (over several hours);

- the integrated dose.

This will be followed up in close contact with PF.

4.1 Discussion

AB pointed out that the reference values of the loss cases for the collimator design were 12 minutes lifetime (transient) and 1 hr lifetime in steady state. This might not be a steady state from the collimators point of view.