Minutes of 47th Collimation Upgrade Specification Meeting

Participants: C. Adorisio (CA), A. Bertarelli (AB), R. Bruce (RB), F. Burkart (FB), M. Fiascaris (MF) (scientific secretary), R. Kwee (RK), A. Lechner (AL), F. Maciariello (FM), D. Mirarchi (DM), L. Nevay (LN), E. Quaranta (EQ), S. Redaelli (SR) (chairman), G. Valentino (GV) D. Wollmann (DW).
Remote: H. Garcia (HG), S. Gibson (SG), M. Kitzmantel (MK), H. Rafique (HR).

Indico event here.

1 Final program of KEK Annual meeting (S. Redaelli)

SR showed the preliminary agenda of the KEK Annual meeting, which will take place on 17-21 November 2014 (see link to the agenda here). There will be two plenary talks on collimation, by RB and SR, plus several other work package parallel sessions. SR asked to look at the detailed program and give feedback. Although the plenary sessions cannot be changed, there is still flexibility for the parallel sessions.

2 Report on x-ray diffraction measurements on collimator material at BNL (E. Quaranta)

Slides are available here.

2.1 Summary of the presentation

Collimator materials must stand the exposition to high radiation environments. A joint program between the collimation team and BNL is investigating radiation-induced damage in present and novel collimator materials. EQ presentation reports on recent x-ray measurements performed at BNL on LHC collimator materials.

Materials such as Glidop, Molybdenum, MoGr, CuCD and Graphite were irradiated at BLN in different conditions: 200 MeV proton irradation for 8 weeks; spallation neutrons from 112 MeV protons; focused 28 MeV proton beam to provoke localized damage. Irradiated materials were analyzed at the NSNS (National Synchrotron Light Source) using a 2D x-ray diffraction system and an energy dispersive x-ray diffraction for phase and strain mapping. EQ participated to the X-ray measurement campaign that took place at the end of September.

After a description of the experimental setup, EQ summarized the status of the tests. X-ray diffraction measurements have been completed on all samples that were sufficiently cold, while measurements on samples irradiated by 200 MeV protons are waiting for the cooling of the highly radioactive samples. The largest remaining task is the macroscopic analysis of termo-mechanical and electrical properties of virgin and irradiated samples, which is foreseen for 2015.

2.2 Discussion

SR commented that he plans to hire a student and send him to BNL for six months to help Nick Simos perform the complete analysis of collimator samples. AB asked if the macroscopic measurements are going to be performed on irradiated samples in special environment (such as hot cells). The answer from EQ was no. The samples irradiated with 200 MeV protons will be measured at the end of next year, after being removed from the hot cells . SR asked what was the total dose. EQ answered that it was lower than 10^{20}, but the actual value should be checked. Finally SR commented that there are also more standard material availables, such as CFC and tungsten.

3 Expected damage to accelerator equipment due to impact of the full LHC beam: simulations and experimental verification (F. Burkart)

Slides are available at here.

3.1 Summary of the presentation

FB presentation's describes simulation and experimental studies of damage to the accelerator equipment caused by the impact of the full LHC beam. Simulations showed that the impact of the full LHC beam would penetrate 35m in copper because of hydrodynamic tunneling. An experiment was performed in HiRadMat to verify the simulations. The SPS beam impacted on 3 copper targets. A different configuration of number of bunches and beam size was used for each target (108 or 144 bunches with 1.5e11 p per bunch and beam size $\sigma = 0.2$ or 2 mm).

The extent of penetration in the target is inferred indirectly from the location of copper "spray" on the cover of the targets. The penetration depth measured was compared to the results from simulations. The standard FLUKA simulation was observed to underestimate the damage penetration depth because it does not take into account the density change caused by hydrodynamic tunneling.

A better simulation with FLUKA and BIG2 was then used. The FLUKA-BIG2 simulation uses an iterative approach where FLUKA computes the energy deposited by the impacting protons and BIG2 simulates the thermodynamic and hydrodynamic response of the target. In each iteration, the output of FLUKA (energy deposition data) is used as input for BIG2 which computes the density distribution in the target, then passed as input to FLUKA for the next iteration. Results from this more accurate simulation agree very well with the measurements.

The extrapolation to the LHC parameters confirms the estimates of 35m penetration in copper. Simulations with the FCC parameters are under way. In addition, futher examination of the HiRadMat targets and studies of other materials and impact distributions are foreseen.

3.2 Discussion

It was pointed out that we should assess the reliability of FLUKA for simulation hits on material in plasma state. RB commented that it would be interesting to know what would happen to the LHC TCDQ in case of full beam impact. DW answered that these simulations are for an irrealistic scenario since we do not expect that the full LHC beam impacts on the TCDQ. However it is still important to estimate the potential damage in case we get close to some possible unforeseen scenario. AL commented that there are more suitable methods for analysing the spots on the copper target. AB asked if there is any result from the diamond detectors that were installed in HRM to identify the extent of penetration. FB answered that they are waiting for results on diamond detector data.

4 Status of BDSIM simulation (L. Nevay)

Slides are available at here.

4.1 Summary of the presentation

The Beam Delivery Simulation (BDSIM) combines a fast in-vacuum tracking code with Geant4 for simulating the interaction of primary particles with the accelerator and for tracking secondary particles. It was developed for linear colliders and has been adapted for circular colliders. LN presented the status of BDSIM for LHC simulations of collimation cleaning. This work is carried out within the HiLumi-WP5 studies.

BDSIM has been tested using the optics of 2012 4TeV B1 in collisions using a generic geometry for lattice magnets and a halo of 6 σ in one dimension and Gaussian in the other. The simulation was run for 650k particles and used an energy cut-off of 20 GeV. Loss maps obainted from BDSIM were shown and were compared qualitively with the measurements and the SixTrack simulations at 3.5 TeV, recently published in *Phys. Rev. ST Accel. Beams 17, 081004 (2014)*.

More models are being prepared. These include higher statistics for 4 TeV LHC, including simulations for B2, as well as models for HL-LHC. In each case it is planned to have a quantitative comparison with current simulations and experimental data.

Some improvements for the simulation code are also planned. The first one aims at improving the speed and hence the statistics by factorizing the tracking routine. Since significant processing time is spent for Geant4 processes, the idea is to use tracking routines until a particles approaches a collimator and only then switch to Geant4. The development of the tracker development is already in the final stage and tests are underway. Furthermore, the geometry is also being improved, with the addition of a Geant4 geometry for LHC quadrupoles and dipoles, as well as a more realistic collimator design.

4.2 Discussion

SR congratulated the RHUL team for having achieved the first Geant4 simulations. It would be now useful to agree on set of analyses for comparison with the existing tools. In particular we should think towards the meeting in Japan where people from the FLUKA team will be present. **Action in view of the Japan meeting**: For the 4 TeV case clear

comparison criteria should be identified and the discussion should concentrate on the status of the quantitative comparison. This could include for example a few standard plots and some more detailed comparisons in IR7. In particular, SR suggested to extract from the BDSIM simulation the inelastic impact at the collimators for a detail comparison against SixTrack results around the ring. **Action**: reverify with the optics section the issue with the orbit non closure from survey files.

RB asked how are collimators treated currently in the simulation. LN answered that they are treated as single blocks, but they are in the process of implementing a library of geometry more suitable to LHC (eg. to have a 2 jaw collimator)

RB commented that to improve the statistics one could also tighten the cut-off (eg. to 1 TeV) to focus on regions that are of most interest for a given study.

SR recalled that in Ferrara a routine for crystal simulations based on Geant4 is being developed. One could consider using this routine the in the Geant4 based BDSIM setup. Answering a question from RB, SR reported that at the recent crystal workshop in Capri, it was reported that Geant4 can now also simulate reliably interaction of ions with matter.