Minutes of the 38^{th} Collimation Upgrade Specification Meeting 16^{th} of May 2014

Participants: R. Bruce (RB), F. Carra (FC), F. Galluccio (FG), P. Gradassi (PG), P. Hermes (PH), A. Marsili (AM) (scientific secretary), S. Redaelli (SR) (chairman), R. Rossi (RR), P. Schoofs (PS), G. Valentino (GV).
Remote: G. Cavoto (GC), J. Molson (JM), M. Serluca (MSe).

Indico event here.

1 Comparisons between simulations and data for crystal-assisted collimation (D. Mirarchi)

Slides are available in pptx and pdf.

1.1 Summary of the presentation

DM started by apologising: a technical issue made his data unavailable for plotting in some cases, and some of the plots were recreated by hand as illustrations.

Crystals were installed in the IR7 at beginning of April, with the objective of testing them for future crystal-assisted Collimation. An extensive campaign of simulation was needed to prepare the tests and ensure reliable predictions for the LHC. This concerns mainly two points: the crystal routine itself, compared with data taken at the extraction line H8 (see next presentation), and the generation of loss maps, with was compared with crystal-assisted collimation tests in the SPS case.

The benchmark of the crystal routine has been performed with experimental data at 400 GeV. Several points were improved compared to the initial routine, including the modeling of amorphous interactions. DM presented the different quantities benchmarked, and the work still ongoing. The angular distributions of kicks given by the crystal to the incoming protons displays several of these quantities, such as the nuclear dechanneling length and the kicks given to channeled particles. As expected the models in the crystal routine are not accurate enough where the nuclear contribution is strong, i.e. where the bending radius is close to the critical one.

DM presented the schematic layout of the crystals installation in the SPS used for the benchmark of multiturn studies. The main difficulty in this benchmark is that the simulated loss map gives the number of protons lost on aperture whereas the beam loss monitors only measure at their location the secondary showers generated by protons lost. Consequently, the study focused on integrated losses in 5 regions of interest, which were presented. They differ by the sharing between betatronic losses and dispersive losses. The lost protons in the simulations can be sorted between protons coming directly from the crystal, or protons that have also hit the absorber. The distributions of the kicks received by protons interacting only with crystals are different between channeling and amorphous orientation.

The loss rate (protons lost/total protons lost) can be expressed similarly for the different regions of interest, for the two orientations. The ratio between the losses for the two orientations gives the loss rate reduction. It can be compared to the measurements, and was found to be well in agreement.

In conclusion, the loss rate in the SPS is dominated by protons escaping the Absorber. The reduction seen in the SPS is mainly due to the efficiency with which the extracted halo is absorbed. Loss rate reduction simulated all around the ring seems coherent with what measured. The crystal routine was benchmarked and upgraded according with experimental data on SPS extraction line (H8). Further benchmarking and upgrades based on new sets of H8 data have been started.

1.2 Discussion

SR commented that the new interpretation that loss rates are dominated by the absorber change completely the interpretation of the SPS data that always indicated a gain factor smaller than what was expected from an ideal crystal (measured cleaning factors 3-5 times worse than expected). This result was made possible by the integrated simulations with crystal, scattering in absorber, multi-turn tracking and detailed aperture model. RB asked if all particles see the full length of the absorber. DM answered that it is the case because of the channeling: all particles hit the collimator in a similar place, away from the edge.

SR concluded that the SPS results are different from what was assumed by simulations, so the real case should actually be better than thought if one can design a high efficient absorber that minimizes the leakage of the channeled beam. In the LHC layout, this can be achieved by using the TCLA collimators in addition to the secondary collimator used as absorber for the MD layouts.

2 H8 crystal data analysis (R. Rossi)

Slides are available in pptx and pdf.

2.1 Summary of the presentation

RR is a technical student from the university La Sapienza in Rome who joined the team in Dec. 2013 to work on the H8 data analysis. Measurements of key crystal properties (bending angle, channeling efficiency, etc.) are performed on the SPS extraction line (H8) with 400 GeV/c protons before testing crystals with circulating beams. RR presented the measurement set-up and the result analysis, which have been performed as part of his Master's thesis work. In order to measure the trajectories of protons interacting with the crystal, a "telescope" is used: two sets of two silicon micro-strip sensors, upstream (and downstream) the crystal, can reconstruct one incoming (and outgoing) track per event, and the impact point. Several runs are needed to set the system up, then perform the actual angular scan or high statistics acquisition. Two types of crystals were used: strip, with only one type of channel, and quasi-mosaic, presenting secondary channels 1/3 the size of the main ones.

A ROOT tool was developed to analyse the raw data; RR presented the results for one specimen as an example. The measured beam spot was presented, which can be represented accurately by a 2D Gaussian distribution. The value of beam divergence, crucial for the measurements, and the resolution of the telescope are also measured.

RR presented measurements of an important characteristic of the crystal which is called torsion: as a result, the channeling efficiency varies with both the horizontal impact angle and the vertical impact position. The channeling efficiency is defined as the number of channeled particles normalized to the total number of particles. The torsion must be corrected; the effect of the correction on the deflection were presented. Measurement of channeling efficiency at the critical angle with two different angular cuts were performed. The characteristic dechanneling length was measured in order to improve simulations, and is estimated to be 1.4 mm.

Angular scans of the whole volume reflection region were performed. They allow to study the volume capture. RR also gave an example of an angular scan for a quasi-mosaic crystal.

In conclusion, a complete analysis of the crystal tested in the H8 line has been done. The results of the present analysis fit the results in literature. Many fine systematic effect were analyzed. A complete list of experimental data and inputs are ready for crystal code developers. Further work includes the implementation of the analytical models to improve the crystal simulation routines.

3 MERLIN: Update on ATS PreSqueeze Loss Map with Sixtrack-like scattering routine (M. Serluca)

Slides are available here (pdf).

3.1 Summary of the presentation

SR recalled that these results, consistently collected for all crystals tested in H8, will be used as input to compare various crystal simulation tools developed by different team. This will be discussed in a dedicated session at an upcoming crystal workshop in October.

MS presented an update on the MERLIN simulations of different LHC optics, including Nominal optics, ATS PreSqueeze and ATS Squeeze. This is in preparation for a joint CERN, UNIMAN and Huddersfield paper submitted to IPAC'14. The difference between the dispersions generated by MERLIN and MadX is below $2\,\mu$m. Both beam separation and crossing angle are off in the PreSqueeze simulations. SR commented that both should be on, because it is the most critical situation, and also changes the dispersion.

MS presented the settings on the collimators used in simulations. RB commented that the setting of the TCTs in IR8 should be $12\,\sigma$ as in IR2 (for β^*=3 m), and not 8.3. MS also presented the halo used, and the aperture. It presents "holes" in the arcs, which do not affect the loss maps, and will be fixed soon.

Finally, the resulting loss maps for PreSqueeze and Nominal were presented. They show the extra loss clusters in arc 7–8 and 8–1 specific to ATS.

In conclusion, the loss map simulated by MERLIN look reasonable. Next steps include the latest ATS optics (HLLHCV1), using the new Single Diffractive routine in MERLIN, and higher statistics loss maps.

3.2 Discussion

RB asked which of the different β^* values considered during Squeeze was used in the simulations: MS answered that they used 44 cm. RB then suggested to simulate the different steps of the squeeze. AM suggested to add the TCLDs to the simulations and see if the peaks disappear.

SR asked how long a full simulation takes. MS answered that 6.4 million particles on 40 cores takes one day. On `lxplus`, this could go down to one hour. RN asked about the new scattering routine,a nd if it is still slower. MS answered that a few modifications are still needed, but the speed issue has been fixed.