# Minutes of the 23d Collimation Upgrade Specification Meeting, 7th of June 2013

**Participants:** F. Carra (FC), V. Chetvertkova (VC), F. Galluccio (FG), W. Hofle (WH), N. Mariani (NM), A. Marsili (AM) (scientific secretary), D. Mirarchi (DM), V. Previtali (VP) (Fermilab), S. Redaelli (SR) (chairman), W. Scandale (WS), D. Wollmann (DW). **Remote:** T. Markiewicz (TM), SLAC.

Indico event here.

## 1 Impact parameters on LHC collimator for different ADT settings (V. Previtali)

Slides are available here (pdf).

### 1.1 Summary of the presentation

VP presented the simulation results of the effect of the transverse dampers of the LHC (ADT). During collimation studies (loss map measurements), the ADTs are used to selectively blow up the horizontal or the vertical dimension of the halo. A broad-band excitation is used: with this method, the output spectrum is sufficiently flat and represents a white spectrum.

One point of this study is to understand if the losses with high impacts parameters (as created by ADTs) are representative of the losses with usual impact parameters as in normal operation.

VP developed a tool, called First Impact COde (FICO), to simulate the first impacts on a collimator for different ADT settings. Particles are generated in the normalized space and, at each turn, the synchrotron phases are updated according to a linear oscillation model with the appropriate synchrotron frequency. The code performs a normalized phase space analysis that utilizes the horizontal Twiss functions and phase advances to map the passage of each particle at the four ADT kickers, and at the horizontal primary collimator in IP7. Each particle receives a random normalized kick from the ADTs. For now, non-linearities are not included.

The initial particle distribution is assumed to be a double Gaussian both in the normalized betatron and in the normalized synchrotron space. Cuts are applied in the same phase space (since there are no non-linearities): energy cut (momentum acceptance), collimator cut, beam core cuts to the initial distribution to speed up the simulations.

Then, VP presented the simulation parameters for different optics and gain, and the corresponding results. The simulated impacts parameters vary between 150 and 700 $\mu$m at injection (depending on the gain), and between 20 and 100 $\mu$m at 7 TeV. Different fits were considered to characterize the results with few parameters. The simpler fit (exponential) already shows a clear energy dependency. The change of tune in squeeze plays a non-negligible role.

VP also simulated the time needed to lose the entire beam. The simulated values are conservative, and seem a bit high compare to measurements. This could be due to the lack of non-linearities in the model. For instance, without octupoles, the tune doesn't change much with amplitude. [**Action: VP**]

In conclusion, a new linear code – FICO (First Impact COde) – has been developed to quickly estimate the change in impact parameter on primary collimator when using ADT for heating the beam. The dependency of impact parameter of ADT gain has been calculated for different machine configurations. The next steps include: to correlate linear gain with operational parameters and compare with the used settings, to understand limits in the model, and to correlate with Sixtrack simulations.

### 1.2 Discussion

SR commented that these are interesting studies, that have never been done before for the LHC. They would be very useful for HL–LHC.

DW asked if there is only one TCP in this simulation; it is the case. SR asked if the results are independent of the initial distribution: VP answered that they are not, there are not enough turns to achieve it.

SR asked if the kick given in the "white noise" excitation mode is of the same intensity as the maximum possible single kick. WH answered that it is the case. WS and WH suggested to add the non-linearities to the model.

## 2 Proposed layout for crystal test at the LHC (D. Mirarchi)

Slides are available here (pdf).

### 2.1 Summary of the presentation

DM presented the different scenarios which have been considered for the installation of crystal collimators in the LHC. These layouts are based on collimation cleaning simulations done with SixTrack, for the perfect machine with no error. Parametric studies have been performed on the halo generation, by changing its amplitude and spread. The chosen values for the parameters are both realistic and simulation efficient.

The main question for this study was to assess the possibility to do better than the current collimation system by using crystal collimation, with minimum impact on the current layout. The role of the test is to demonstrate this during low-intensity machine developments. A semi-analytical analysis was performed to try and define the best position for the crystal. A first selection was made by choosing the layouts that give better impact parameters on the only secondary collimator used, at any energy. Then, full SixTrack simulations were ran with the chosen subset.

DM presented an example of the optics used, showing the beam envelope (different numbers of $\sigma$) and the trajectories of particles deflected by the crystal. Only one secondary collimator (TCSG) is used to intercept the deflected particles. Two options are considered: the other collimators can be completely open, or have settings corresponding to the $\beta*$ reach. The other collimators downstream can cure the leakage from the considered secondary. A minimum set of absorbers is needed, even in perfect case.

The loss maps for channeling and amorphous orientation were presented, for different locations of the crystal: at the TCP or before the TCSG in cell 5L7. The crystals absorb more particle in amorphous orientation, but deflect the protons less, and the inefficiency downstream IR7 changes from $2 \cdot 10^{-6}$ (channeling) to $10^{-4}$ (amorphous).

DM also presented the same study for the situation at injection. It showed a possible problem with the phase advance in the horizontal case: diffractive protons would not be stopped before the DS.

In conclusion, different positions for the installation of crystals in the LHC were studied. The 4 cases show similar results: crystal collimation seems feasible. The main differences are the warm losses, and the DS losses which can be cured using the current system. The best place for safe test would be near the TCSG. DM showed the proposed location on technical drawings.

Based on these results, the chosen locations are further away from the TCPs, in less active areas where the doses would be smaller, making the installation easier. The positions are: $s = 19843.82\,\mathrm{m}$ for the Vertical, and s = 19919.24 m for the Horizontal.

## 2.2 Discussion

SR pointed out that one current TCSG cannot withstand 1 MW of power on one collimator. The proposed setup would only be used for tests during Machine Development. It would be safe at low intensity (pilot beam).

Radiation protection could be an issue. WS commented that if the losses created during these tests are concentrated in one location, then it should be easy to protect against radiation with local shielding.

DW raised the issue that there is a channeled beam that could go all around the ring. DM answered that with the settings presented, nearly nothing escapes. The focused beam would not be dangerous.