Minutes of 11$^{\text{th}}$ Collimation Upgrade Specification Meeting

Participants: R. Bruce (RB), F. Cerutti (FC), L. Lari (LL), Y. Levinsen (YL), A. Marsili (AM) (scientific secretary), D. Mirarchi (DM), V. Previtali (VP) (Fermilab), E. Quaranta (EQ), B. Yee Randon (BYR), S. Redaelli (SR) (chairman), B. Salvachua (BS), G. Valentino (GV).
Remote: T. Markiewicz (TM), G. Stancari (GS).

Indico event here.

1 The electron lens: simulations for the SPS case. (V. Previtali)

Slides are available at this link.

1.1 Summary of the presentation

VP's presentation follows the one given at the previous ColUS meeting (#10), but this time in the case of the 120 GeV SPS beam. In the previous presentation, VP introduced the concept of an ideal hollow electron lens from the point of view of the proton beam, and its effect on the 7 TeV LHC beam. VP gave a summary of the previous presentation in her talk: what is a hollow e^- beam, and the three possible operation modes: DC mode, AC mode and diffusive mode.

This study is aimed at assessing the efficiency of an e^- lens as a LHC scraper. For this purpose, VP added an hollow e^- lens routine in SixTrack to study systematically the effect of this device on the particle dynamics. The SPS case is considered because installation there might be more feasible than in the LHC, during the first long shutdown.

The first difference between the two cases is that the maximum kick in the SPS case would be ten times higher than in the LHC case. Then, VP presented the effects of the three different modes on the tune of the SPS. The tune variations depend on the initial amplitude of each particle. The tune variation is lower than 10^{-4}.

In DC mode (electron lens always switched on), there is no effect in average on the particle amplitude, i.e. there is no additional diffusion that causes losses of halo particles. The considered electron lens would not be effective for the SPS case.

In AC mode, the electron lens varies at the same frequency as the oscillations of the particles in the transversal plan. Different particles have different tunes and will respond to different e^- lens oscillation frequencies. If a particle is captured in resonance mode, it can be lost extremely quickly (1000 turns $\sim$ 10 ms). In white noise mode, the electron lens is used as a slow diffusion enhancement.

The efficiency of this e^- lens as scraper was evaluated. For this, particles were tracked with Sixtrack, and the number of surviving particles was recorded. The particles are disturbed by the e^- lens and are lost on a primary collimator set at $6.2\,\sigma$. For long simulations (10^6 turns), there is no difference between the DC mode or no e^- lens at all: all particles survive. In random mode, only a third of the particles survive. For fast simulations in AC mode, the proportion of particles depends on the tune; for some values, the fraction of surviving particles is 0.19 after $2 \cdot 10^5$ turns. The AC mode is much faster, especially when turn by turn study shows that most particles are lost during the first 10^4 turns.

Another solution, which would be even more efficient, would be to modulate the e^- lens frequency. In this case, after $2 \cdot 10^5$ turns, 90% of the particles are lost and still being lost.

In conclusion, the SixTrack simulations of an ideal electron lens in the SPS case were presented, with three different operation modes. The DC mode is not effective for the studied case as for the LHC case; the AC mode is effective only if the resonance frequency is optimized; and the random mode is effective over longer periods. The newly presented continuous AC mode shows the fastest and more efficient cleaning.

1.2 Discussion

SR pointed out that this does not correspond to the usual collimator scrapings, and asked about the considered primary collimator. VP answered that there is for now in the simulation only one horizontal collimator set at 6.2 σ, but another collimator could be added at a location where the betatron oscillation is bigger in the vertical plane than in the horizontal one.

SR asked if the only possible shape for the e^- beam is to be round. VP answered that the shape is dictated by the shape of the cathode. It might be possible to change the shape of the cathode. GS added that rather than changing the shape in order to achieve scrapings in different planes, a simpler solution would be to move the electron beam up and down, or left and right, to achieve the desired scraping effect.

2 Status of multi–turn particle debris tracking (A. Marsili)

Slides are available at this link.

2.1 Summary of the presentation

AM presented the implementation and the setup of the multi–turn tracking of the debris created at the IPs in the LHC, as well as the primary results. The effect of the collisions on the particle is twofold: there is a decrease in momentum, and the protons gain extra kicks in the two transversal planes: $\delta x'$ and $\delta y'$. The distributions, provided by F. Cerutti, contained the values of $\delta p/p$ and θ (the angle with the z axis). The given distributions are cut at 0.1 for $\delta p/p$, and at the opening of the TAS (0.25 mrad) for θ. For the 4 TeV case, only 17.7% of the collisions are kept after the cut.

Then, an input file for SixTrack was created from these distributions. Initial distributions of positions (in x and y) and kicks (x' and y') without collisions were created. Then, the perturbations due to the collisions were added to the kicks. AM pointed out that these are wider by a factor ~ 3 than the initial distributions without collision. The SixTrack input file were created with the six coordinates : x, y, $x' + \delta x'$, y, $y' + \delta y'$, l, $E(1 - \delta p/p)$ where l is the position of the particle in the bunch and is left at zero for now. The crossing angle is added by SixTrack afterwards, hence why the distributions are still centred around zero. Then, these particles are tracked.

AM then presented the preliminary results of the tracking. In this case, the particles were tracked from IP1. The point with highest losses is as expected the absorber for physics debris: `TCL.5R1.B1`, set at $10\,\sigma$. The loss map showed some loss locations outside collimators that seem to be specific for this type of simulation; especially, losses downstream the TCL, in the dispersion suppressor. Losses at this location is one of the goals of this study. However, the results are only preliminary.

In conclusion, the whole simulation chain for debris tracking is running well, and proper physical results will soon be produced now that the technical aspects are well under control. After that, several actions will have to be performed: reproduce the losses measured during the TCL scans; set up the tracking simulations starting at other IPs; calibrate the losses in physical units for machine protection purposes; and update the FLUKA inputs to include different cuts, and elastic interactions [**Actions: AM, FC**].

The final goal is to have reliable tools to study the LS2 layout in the next two months.

2.2 Discussion

RB commented that the distribution of interactions between two Gaussian beams is indeed another Gaussian, but it standard deviation should be smaller by a factor $\sqrt{2}$. In this case, the width of the perturbation distributions would be overestimated. FC said that this might be taken into account when simulated the collisions in FLUKA . This has to be investigated.

SR pointed out that the cuts in the given distributions are not necessary: the particles would be lost during the tracking anyway. Moreover, the two effects (kicks and momentum shifts) might compensate each other, and some particles might survive despite having values over the cut thresholds. This will be taken into account when generating the new distributions.