Minutes of the 30th Collimation Upgrade Specification Meeting 18th of October 2013

Participants: A. Bertarelli (AB), R. Bruce (RB), F. Carra (FC), F. Cerutti (FC), L. Gentini (LG), L. Lari (LL), A. Lechner (AL), A. Marsili (AM) (scientific secretary), D. Mirarchi (DM), E. Quaranta (EQ), D. Ramos (DR), S. Redaelli (SR) (chairman), G. E. Steele (GES), C. Tambasco (CT), G. Valentino (GV).
Remote: T. Markiewicz (TM) (SLAC), G. Stancari (GS).

Indico event here.

1 Summary of actions

List of actions decided during this meeting:

- Check loss maps of IR7 for larger gaps of TCLD [**action: RB**]
- Produce reference case with 11 T dipoles and no collimator to compare losses [**action: RB**]
- Check if present design can be modified to allow jaw to move across the zero position [**action: LG**]
- Conclude if whole design, including cryogenic bypass, would fit in [**action: LG**]
- Check if possible to replace ferrites by RF finger in current design [**action: LG**]
- Detailed integration study with the 80 cm jaw baseline [**action: LG, DR**]
- Circulate draft of the e^- lens conceptual design [**action: GS**]

2 Preliminary results of the FLUKA TCLD study (IR7) (G. E. Steele)

Slides are available here (pdf).

2.1 Summary of the presentation

GES presented the status of the FLUKA studies of the future DS collimators (TCLD) in IR7. Several simulations of the losses in the DS were performed: the nominal case without TCLD, and test cases with two TCLDs in cells 8 and 10, with jaw lengths of 80 or 100 cm. The simulations are a two-stage process, where the input is the single impacts on the collimator as simulated by SixTrack (R. Bruce, ColUSM#29). The output distribution is simulated by FLUKA ; then, the energy deposition in the magnets is calculated.

GES showed the energy deposition profiles in the DS left of IR7 (Beam 2), for the cases with and without two 80 cm-long TCLDs. The main effect of the TCLDS is to decrease the losses in cells 9 and 11, as expected. Another effect is to increase the losses in the 11 T dipole directly downstream the TCLD in cell 8 (and to a lesser extend in cell 10). This is thought to be due to direct showering from the collimator. FC specified that this result was not expected and is considered preliminary.

GES then presented the comparison between energy deposition profiles for the cases with 80 cm or 100 cm jaws. The results are qualitatively very similar. AB pointed out that, in particular, the most critical locations don't get worse. One of the differences is in the 11 T dipole of Q11. The deposited energy is slightly higher for the 80 cm jaw. This could again be explained if the main factor is a secondary shower: a longer collimator jaw would absorb more secondary particles.

In conclusion, the FLUKA energy deposition studies were presented for 2 TCLDs with 80 cm or 100 cm jaws in IR7. The results are qualitatively similar do those of SixTrack. The main conclusions that 80 cm and 1 m provide equivalent protection are confirmed by energy deposition studies. The increase in the quadrupole could be due to secondary showers. GES noted that the plots show statistical limitations.

2.2 Discussion

RB pointed out that since the loss maps are generated from impacts on the TCLDs by Six-Track, the only difference is then the physics processes inside the collimators. He suggested that direct comparisons of these specific loss maps could be made between SixTrack and FLUKA , for instance in the case with no TCLD (or any other case).

SR commented that no increase of energy deposition in the quadrupole had been noted before, for instance not in IP2 with the ions. GES answered that it is because this specific comparison — with and without collimators and the same place — had not been done before. In the ion simulations the collimator was inserted to protect against a peak occurring just after it, in the same cell, where the 11T would be. An energy deposition due to showering remained there, dependent on length and material of jaw. In the proton case, the collimator is inserted to protect against a peak in the following cell. The magnet immediately afterwards did not previously have a peak, hence the contribution due to showering is more noticeable.

AB asked if the material of the simulated collimators was Tungsten or Inermet (Tungsten alloy with Nickel and Copper). AL answered that in this case it is really Tungsten.

Other actions were mentioned:

- check larger gaps of TCLD [**action: RB**]
- Produce reference case with 11 T dipoles and no collimator to compare losses [**action: RB**]

3 Updated design of TCLD with reduced jaw length (L. Gentini)

Slides are available in pdf or pptx.

3.1 Summary of the presentation

LG presented the status of the 80 cm-long TCLD design with as little modifications of the available design as possible. LG first presented the existing QTC (Cryostat assembly): it seems difficult to gain space at both ends, around the collimator. This study concentrates on saving space with the collimator itself, which would be 80 cm instead of 1 m.

The reduction in length would be achieved by removing one 20 cm-long insert (standard collimator are made of 5 inserts). Most of the design would be kept the same: there would still be one support, aligned once and for all, and a collimator base that allows collimator replacement without realignment. Only a part of the frame has to be modified.

The new collimator would have less axes than the standard ones, with no jaw tilt and no movement beyond the beam center (negative jaw position). SR expressed concern about this limitation. At this point, the half-gap in RB simulations is $\simeq 1.2$ mm ($10\,\sigma$). SR reminded the audience that the tolerance on the orbit is 4 mm. This is not compatible with the baseline settings: if the beam moves by 3 mm, one of the jaw could not follow past the zero position. SR requested to check if present design can be modified to allow jaw to move across the zero position [**action: LG**].

The collimator jaws are mounted in overhang, so in this aspect a smaller (lighter) jaw is better. The RF system and the BPMs would stay the same.

LG mentioned that another aspect would be changing the width of the jaw, but would bring other consequences (such as issues with cooling pipes). DR added that this would make a completely new design, lighter and more compact. SR and AB answered that there is also a time issue in the development of a new design.

The new collimator would have the RF contacts on one side and the ferrites as in the present TCTP design. LG also pointed out that the distance between the BPM and the surface of the jaw is different between TCLD and TCLP. LG presented a table giving the advancement of the different aspects of this design.

In conclusion, it seems possible to implement the 80 cm design using the existing design with minor modifications. The main uncertainty remaining is the cryogenic bypass, to conclude if the whole design would fit in [**action: LG**]. Other specifications would imply more modifications.

3.2 Discussion

SR asked if ferrite should be removed from baseline, and replaced by RF fingers touching the tank in the design [**action: LG**]. RB mentioned that B. Salvant may give a presentation on impedance in a few weeks.

Other action include a detailed integration study with the 80 cm jaw baseline [**Action: LG, DR**]

4 Hollow electron beam collimation for the LHC upgrade (G. Stancari)

Slides are available here (pdf).

4.1 Summary of the presentation

GS presented the talk he gave at the NAPAC'13 in Pasadena, and a few extra slides on the effects of asymmetries in the electron beam. Electron beams are a new way of collimating high-power hadron beams when radiation damage and impedance limit the use of conventional collimators. The concept is an electron beam which is hollow, i.e. presenting a radial symmetry and electrons only between two values of the radius, which gives extra kicks to the protons. The device is made of three parts: the electron gun and the injection, an zone where the e^- beam overlap the proton beam, and the extraction of the electrons.

The concept was demonstrated experimentally at the Tevatron. GS presented a plot showing the smooth decrease in intensity following scraping for different radii and currents of the e^- beam. GS added that there is no scraping device in the LHC able to withstand the high energy and intensity, and presented the different advantages of an e^- lens. Although not directly related to collimation, one may note that electron lenses with different current-density profiles were also shown to affect the tune spread of the beam. This may help mitigate instabilities in the LHC. More operation experience is still needed. GS showed a picture of the hollow gun used to create the beam.

Numerical simulations are needed because the kicks are non-linear, have a random component, and the resulting effects depend on beam parameters and machine lattice. The effect is very different between the LHC and the Tevatron. GS referred to a recent report by V. Previtali et al. (July 2013).

Most Tevatron tests were performed in continuous mode (constant electron current). The abort gap cleaning were performed in resonant mode, which excites betatron oscillations. The stochastic mode (which includes a random component) is very robust in simulations, but it has not yet been tested experimentally.

GS presented the possible installation locations in the LHC, in IR4. The cryostat would have to be redesigned to fit in the LHC. The time needed for installation is dominated by cryogenics, requiring a shut down of at least 3 months. Longitudinal impedance considerations may require redesigning the vacuum chamber.

GS presented the first considerations on azimuthal asymmetries in the e^- beam. These asymmetries arise from the injection and extraction bends, and from distortions in the overlap region. They were measured with pin-hole for current density measurement. The main issue is if the created field has multipole components, especially quadrupole and sextupole, which could affect the core in resonant mode.

For the injection and extraction bends, a simplified simulation was performed with a static distribution of charge, allowing to calculate the electric potential and field, and the kick given to protons. More advanced 3D simulations with Warp particle-in-cell code are ongoing. The corresponding maps were parameterized and included in tracking codes. Simulations with imperfections in resonant mode were started.

A draft of the conceptual design will be circulated in the next weeks [**Action: GS**]. Both teams would collaborate on a technical design in 2014. Construction of two electron lenses for the LHC would take about 3 years. It could start in 2015 after gaining operational experience at 7 TeV and after assessing the needs and requirements for halo scraping.

4.2 Discussion

AB asked if the long-range beam-beam compensators can be considered for halo diffusion control. GS answered that they are alternative techniques. SR commented that in theory, the wire might be used to act on halo diffusion but there are no detailed studies on this options, which is only considered as a brainstorming one.

AB stated that the collaboration is greatly appreciated. He asked if a design is already existing for integration purposes, or if there are any engineering reports, so they can have a look. GS answered that it is the case: some documentation and drawings were collected. They are available on line and will be sent around.[**Action: GS**]

SR commented on exploring the possibility of having a flexible electron beam profile control for halo scraping (hollow) and for tune spread enhancement (Gaussian), while specifying that this was yet a step further.