Minutes of 36^{th} Collimation Upgrade Specification Meeting

Participants: A. Bertarelli (AB), R. Bruce (RB), R. Jones (RJ), D. Perini (DP), S. Redaelli (SR) (chairman), A. Rossi (AR), B. Salvachua (BS), H. Schmickler (HS), G. Tranquille (GT).
Remote (FNAL): G. Stancari (GS), A. Valishev (AV).

Indico event here.

1 Introduction and strategy (S. Redaelli)

Slides available here: PDF.

1.1 Setting-up the scene

SR introduced this meeting as a preparatory discussion for the visit from the CERN team (collimation, MME and possibly BI) to FNAL to establish direct contacts between the hardware teams working on hollow e-beams. The visit will take place around the US-LARP collaboration meeting CM22 (May 6^{th} – 8^{th} 2013). SR took the opportunity to introduce D. Perini (DP) who has been appointed as technical coordinator for the hollow e-lens studies within MME. For the moment, it is planned that SR, AB and DP will visit FNAL.

SR recalled the milestones of the recent history of hollow e-lens studies for the LHC and the key decision-making points for the CERN strategy: review in Nov. 2012, internal discussions at the HL-LHC Technical Committee in April 2013, presentations at the 2013 US-LARP and Annual HiLumi meetings – see references in SR's slides. The effort of the last year has been focused on preparing a conceptual design report for an optimized hollow e-lens implementation in the LHC. CERN is willing to start getting competence on this hardware taking as a starting point a first conceptual design report that was prepared by Dec. 2013 (see next Section). In this moment it is therefore very useful to establish direct contacts between the hardware teams at CERN and FNAL working on this topics.

SR recalled that an important part of this study must address alternative methods for active halo removal, with the aim to identify techniques that could be applied on a shorter time scale than the hollow e-lens, should the post-LS1 operation indicate that an active halo control is needed at the LHC. These aspects related to alternative methods will also be discussed at the US-LARP CM22 to take profit of the experience from the FNAL team.

1.2 Discussion

AV asked who at CERN is working on alternative methods. SR replied that the ABP collimation team in collaboration with M. Giovannozzi will work on that. RB is for the moment the key player on simulations, but it is planned to have a fellow or a PhD student helping on that. The immediate goal is to identify hardware changes that could take place during LS1 for possible MD studies in 2015. The options under investigation are the tune modulation and the narrow band excitations with the transverse damper. The collimation team is working with the hardware teams to identify actions for LS1.

2 Status of conceptual design report (G. Stancari)

Slides available here: PDF.

2.1 Brief summary

GS presented in detail the status of the conceptual design report for a hollow e-lens for LHC collimation purposes. The first draft of this design document was already available in Dec. 2013 (latest version available at this link). SR requested a report at this meeting in order to identify the topics for discussions which will be brought up with the FNAL hardware teams during the CERN visit. The key interfaces concern the following systems: magnets, cryogenics, power converters, vacuum, integration.

GS introduced the main aspects of the hollow e-lens hardware and how it was used at the Tevatron. The experience accumulated at FNAL, both with the Tevatron beams and with the dedicated electron beam tests stand, is built upon and used to define a set of optimum parameters for the LHC. These are summarized in the next table, extracted from the design report document. Details are available in GS's slides.

Table 1: List of hollow electron lens parameters for the LHC as given in FERMILAB-TM-2572-APC .

Parameter	Value or range
Beam and lattice	
Proton kinetic energy, T_p [TeV]	7
Proton emittance (rms, normalized), ϵ_p [μm]	3.75
Amplitude function at electron lens, $\beta_{x,y}$ [m]	200
Dispersion at electron lens, $D_{x,y}$ [m]	≤ 1
Proton beam size at electron lens, σ_p [mm]	0.32
Geometry	
Length of the interaction region, L [m]	3
Desired range of scraping positions, r_{mi} [σ_p]	4–8
Magnetic fields	
Gun solenoid (resistive), B_g [T]	0.2–0.4
Main solenoid (superconducting), B_m [T]	2–6
Collector solenoid (resistive), B_c [T]	0.2–0.4
Compression factor, $k \equiv \sqrt{B_m/B_g}$	2.2–5.5
Electron gun	
Inner cathode radius, r_{gi} [mm]	6.75
Outer cathode radius, r_{go} [mm]	12.7
Gun perveance, P [μperv]	5
Peak yield at 10 kV, I_e [A]	5
High-voltage modulator	
Cathode-anode voltage, V_{ca} [kV]	10
Rise time (10%–90%), τ_{mod} [ns]	200
Repetition rate, f_{mod} [kHz]	35

GS stressed the important role of numerical simulations to define the requirements for the hollow beams. He reported recent improvements compared to what had been presented at the review in Nov. 2012. A. Valishev is continuing simulations initially set up by V. Previtali and has also performed frequency map analysis to address "edge" effects of the electron beam that crosses the path of proton beams at the entrance and at the exit of the hollow beams. The present results indicate that there are no relevant issues for the usage at the LHC. Simulations use recent measurements of hollow electron beam profiles as an input.

Indeed, GS recalled that an important ingredient to achieve good results for the LHC studies at FNAL was the availability of a test stand to characterize the hollow beams. He suggested that CERN should envisage a similar setup in order to develop an appropriate know-how.

2.2 Discussion

SR commented that a strong point of the parameter set is that this is based on what has been already achieved experimentally. All the parameters, including the time profile of the excitation, are achieved. This represent therefore a solid parameter set that we can rely upon in case we need urgently to build hollow e-lenses for LS2. If the time line for implementation in the LHC is relaxed, more challenging parameter sets can be considered (if needed).

HS asked if one could imagine beam the hollow e-beams in opposite directions in order to compensate the edge effects. This would require a "vertical" integration, as left(in) / right(out) configuration would not be possible due to the overlap with the other proton beam. GS replied that this would only compensate the edge effects in one plane and not in the other. So it is probably not worth adding this complexity.

HS commented that he sees a strong synergy with the ongoing effort in BI to develop halo monitoring techniques. He recalled the ongoing studies by A. Fisher at SLAC and studies of light background sources based in Liverpool (UK). He expects first concrete results in about a year.

SR asked if there could be interesting usages of a CERN e-lens test stand in terms of BI developments. HS commented that there is no much that one could do for halo diagnostics. However, GT commented that there is certainly a potential synergy for the development of BI for e-beam characterization.

HS challenged the e-beam team to design a beam with the parameters required for long-range beam-beam compensation. SR commented that the FNAL colleagues are well aware of this requirements and indeed have already studied this option (see first estimates available in FERMILAB-TM-2571-APC). Several discussion are schedules for a joint WP2/WP5 session at the CM22. HS commented that non-local compensation schemes should also be envisaged. AV replied that he has strong opinions that non-local compensation schemes will not work.

2.3 Actions triggered

Various actions were triggered that should be addressed before the CERN visit to FNAL at the beginning of May.

- Check the optimum optics locations in IR4 (round beams) for the hollow e-lens, for the latest HL-LHC optics baseline [**SR**].

- Definition of experimental and simulation studies that are still needed to demonstrate that the proposed parameter set for the hollow e-lenses is appropriate for the LHC. What still needs to be done? Do we need beam tests at RHIC? [**SR, GS**].
- Establish a work plan for alternative halo excitation methods that can be tested at the LHC in 2015 [**SR**].
- Define a set of parameters for a possible electron beam tests stand, taking into account LHC and ELENA requirements [**BI team**].

3 Status of ELENA electron cooler design (D. Perini)

Slides available in pptx and pdf.

3.1 Short summary of the presentation

DP presented the status of the MME studies on the ELENA electron cooler. CERN is responsible for the design and for the construction of all the cooler components except solenoids and bending magnets, which will be purchased. The design is well advanced. DP showed the highlight features and the critical points that the MME team is working on.

3.2 Discussion

DP asked what are the requirements for electron beam stability. This must be defined as soon as possible because this parameter has a major impact on the magnet design, with implications on the 3D volumes and on the integration. GS commented that the straightness was about 100 μm for the Tevatron and 50 μm for RHIC. He expects that the LHC requirements will be similar to the Tevatron ones. SR recalled that the optics in IR4 must be checked for HL-LHC (see action above).

DP also asked if the beam pipe must be cold. This is not the case and this indeed can simplify the design.

DP also recalled that there is a solenoid design ready for a field up to 6–6.5 T, with inner diameter of 160 mm. This can be used as base for further design studies. In the discussion that followed, it was pointed out that the aperture is much larger that what is needed. Indeed, we should aim at a 80 mm diameter that corresponds to the standard aperture of warm components at the LHC. GT commented that the aperture can be smaller also for the electron cooler.