113th Meeting of the LHC Collimation Study Group

March 15, 2010

Present: R. Assmann (chairman), A. Rossi (scientific secretary), D. Wollmann, R. Bruce, O. Aberle, H. Day, S. Roesler, L. Keller (SLAC), S. Lundgren (SLAC), J.C. Smith (SLAC), T. Markiewicz (SLAC), E. Metral, N. Mounet, K. Kershaw, J-Ph. Tock, F. Caspers, G. Bellodi, A. Dallocchio, G. Arnau-Izquierdo, J. Wenninger, N. Mariani, F. Carrara, Y.I. Levinsen, L. Xiao (SLAC).
Excused: J. Jowett, A. Bertarelli.

1 Comments to the minutes

No comments to the previous minutes.

2 Agenda of this meeting

1. Regular collimation status reports:
    a) Hardware and tunnel activities, if any
    b) Remote and beam commissioning
    c) Phase II activities at CERN
    d) Phase II activities at SLAC
    e) Cryo-collimators
    f) FLUKA work

2. Special reports :
    a) Studies on collimation with hollow electron beams – G. Stancari FERMILAB
    b) Time/resources of an intervention on continuous cryostat for cryo-collimators – J-Ph. Tock TE/MSC
    c) Discussion on trapped modes of SLAC Phase II collimator, and news on impedance for LHC Phase I and II – E. Metral AB/ABP

3 List of actions from this meeting

Action	**People**	**Deadline**
Present at the CWG materials being studied for Phase II collimation.	E. Metral	
Establish if octupoles are needed at 3.5TeV.	E. Metral	
Check heating power on collimator at nominal LHC operations.	E. Metral	
Give feedback on “alternative” solution for cryo-collimator integration.	J. Jowett	
Estimates of residual dose in IR3 for different shut-downs.	S. Roesler	

(Complete list at http://lhc-collimation.web.cern.ch/lhc-collimation/action.htm)

The next meeting will be on April 12th.

Minutes of the meeting

1 Regular collimation status reports

1.1 Hardware and tunnel activities (O. Aberle EN/STI)

- No hardware problem reported.
- A student from Graz University is coming next summer to work on the microphone signals. He is going to work on the signals of the existing microphones and state the requirements of the system for future operations.

Fritz asked if it is possible to distinguish between the real signal and electro-magnetic induced noise, and it was replied that it is not know at the moment.

- Oliver also checked if the SLAC – Collimator Phase II (circular tank) can be integrated in the LHC: the tank just fits in, but is very close to the parallel beam line. A solution has to be found for mounting heating jackets, either with an opening or including both the collimator tank and the beam vacuum chamber.

1.2 Remote and beam commissioning (R.W. Assmann BE/ABP)

- Remote commissioning worked fine.
- The collimators have been set at injection and not moved during ramp.
- We had a good lifetime (~100h per beam) with collimators.
- At 6E10 p/b the beam blew in the first 3 turns. Culprit could be chromaticity and stability of beam at SPS extraction (being checked).
- Ralph observed that the beam was unstable due to low chromaticity (-0.5), and improvement once chromaticity was corrected.
- Two talks will be presented at the LHC Beam Commissioning WG:
    - Results from Collimation Setup - D. Wollmann
    - Generating Machine Collimation Settings from Beam Data - R. Bruce

1.3 Phase II activities at CERN (A. Dallocchio, EN/MME) – see slides Cryo-collimators

- Alessandro described that the “deliverable” from EN/MME or cold region collimation (4 units).

During the meeting and in a special follow up meeting the detailed work responsibilities for the various involved parties was further discussed. It was agreed that EN/MME provides a WP on integrated mechanical engineering for the cryo-collimators and possible W/C transitions. The responsibility for overall design and work in the cold sections is with TE/MSC. L. Rossi also decided that V. Parma (TE/MSC) will be the TE/MSC contact for this work together with J-Ph. Tock (who will also have to follow up on other work).
This will be clarified in more details during implementation of Phase II collimation project.
Ralph also requested that the choice of material for Phase II secondary collimators should be presented to the CWG before proceeding.

1.4 Phase II activities at SLAC (J.C. Smith) – see slides

- CMM results: average measured flatness of RC0 ~38.5 μm, with peak at 50 μm.
- They believe they have understood how to improve it, since with RC1 the average measured flatness is RC0 ~8.25 μm, with peak at 10.8 μm.
- Effects of offset and angle concentricity are comparable to flatness.
- Material to be used Be-C or blidcop.

2 Special topics

2.1 Studies on collimation with hollow electron beams (G. Stancari FERMILAB) – see slides

G. Stancari gave a comprehensive overview on hollow electron beam collimation and its applications.

- Giulio described the principles and presented advantages (no material damage, low impedance, no ion breakup, extensive simulations, etc.) and disadvantages (small kick unless high current used, alignment, HEB instabilities).
- The kick will be proportional to the HEB current and length and inversely proportional to the beam size.

Ralph commented that small kicks might be an advantage. Should the HEB act on the beam core, the beam blow up would be slow.

- Experience in Tevatron – where protons and antiprotons circulate in the same vacuum chamber – showed that if properly timed with the abort gap, the HEB acting on protons did not sensibly affected the antiproton beam.
- Measurement results on the hollow beam profile suggest that the electron beam behaves like incompressible, frictionless 2D fluid: typical non-neutral plasma slipping-stream (`diocotron') instabilities arise, vortices appear. A strong magnetic field would freeze the distribution but make the hole very small.

Ralph asked if the evolution of the beam is related to the quality of the cathode. Giulio confirmed and added that one must either improve the quality or have a fragmented cathode while at low temperature the evolution may be due to field imperfections.

- Giulio
- Future experimental goals at Tevatron are:
    - verify hollow-beam alignment procedures
    - evaluate the effect on core lifetime
    - measure losses at collimators, absorbers and detectors vs HEBC parameters:
    - position, angle, intensity, pulse timing, excitation pattern
    - assess improvement of loss spikes

Ralph commented that the alignment is of high importance for the LHC since we would like to scrape from 20 to 3σ with 10-20 μm accuracy. Giulio replied that they have a reproducibility of 0.1mm, to be shown.

- Furthermore effort will be spent on modeling + benchmarking and possible hardware/software improvements.

Ralph pointed out that CERN is very much interested in the developments being the HEB one possible ‘soft’ collimators that could scrape LHC beam.

2.2 Time/resources of an intervention on continuous cryostat for cryo-collimators (J-Ph. Tock TE/MSC) – see slides

J-Ph. Tock presented intervention duration, as shown at the LHC-IR upgrade Phase I Task Force, for the installation of cryo-collimators, with details on integration.
The given estimates do not include C/W transitions or collimators.

- Only the ‘baseline’ in IR3 is being studied.
- Still waiting for feedback on the alternative solution (J. Jowett) even if it would be difficult to implement die to interference with the transport zone.
- For IR7 a different solution will have to be studied.
- Jean-Philippe underlined possible clashes with other installation/repair work since the same manpower is involved in splices reinforcement, work interconnects and on cryo-lines, and one cannot put more than 12-15 people over 150 m of tunnel.

Ralph asked if it will be necessary to repeat cryo-tests on the magnets that are de-installed and re-installed, and Jean-Philippe replied that it is not considered necessary.

2.3 Discussion on trapped modes of SLAC Phase II collimator, and news on impedance for LHC Phase I and II (E. Metral AB/ABP) – see slides

E. Metral made an overview on past work and comparison with evaluations between LHC and SLAC:

- According to estimates (2003) of the longitudinal and transverse impedance of collimators, the expected heating power for the dominant longitudinal trapped mode (for nominal LHC beam parameters) is about 13W.
- The transverse impedance of the trapped modes is of the order of the resistive wall transverse impedance (~10^5 Ω/m) in the frequency range 1.6 GHz to 2 GHz.

Fritz commented that the value of 13W should be checked and justified, since a value of the order of 1kW would results from a simple formula {RxI^2 = 1 kΩ x $(1\ A)^2$ }, and we should not consider the decay.

- Elias said that at the time it was recommended to put ferrite in collimators.

Ralph commented that at the time it was decided (in common accord with the RF team) that ferrite would be used only in double-beam collimators.

- Elias found SLAC results comparable to previous calculations and added that we shall put ferrite in these collimators.
- He gave the stability criterion for LHC collimators:

$$\sum_i N_i \frac{\beta_i}{\langle \boldsymbol{\beta} \rangle} R_t \ll G\Omega/m$$

- He also said that estimates on LHC impedance budgets so far have not taken into consideration the welds along the beam screen (not copper). This is being evaluated and an update will be given a.s.a.p.
- Elias proposed the use of ceramics for Phase II collimator with copper coating to combine the low imaginary part of the impedance of the ceramics with the low real part of the copper.

Ralph requested that the materials being discussed for Phase II are presented at the CWG.

- Regarding the use of Transverse Damper in the LHC, Elias needs more experience with beam before being able to answer. In the SPS it is used at injection and during the ramp. If the LHC Transverse Damper could be kept on at high energy, octupoles correction will not be required.

Ralph stated that it is now necessary to know whether we need to use the octupoles at 3.5TeV.