119th Meeting of the LHC Collimation Study Group

July 19, 2010

Present: R. Assmann (chairman), A. Nordt (scientific secretary), R. Bruce, D. Wollmann, D. Deboy, O. Aberle, G. Bellodi, T. Markiewicz (SLAC), V. Parma, N. Mounet, J. Wenninger, N. Mariani, J. Jowett, A. Bertarelli, D. Ramos, F. Carra, H. Day, E. Holzer, E. Nebot, E. Metral.
Excused: A. Masi, J-Ph. Tock, A. Ryazanov, A. Dallocchio , S. Redaelli, G. Smirnov.

1 Comments to the minutes

No comments on the previous minutes.

2 Agenda of this meeting

1. Regular collimation status reports:
   a) Hardware and tunnel activities
   b) Remote and beam commissioning
   c) Phase II activities at CERN
   d) Phase II activities at SLAC
   e) Cryo-collimators integration and interfaces
   f) Further Remarks in General

2. Special reports :
   a) Collimation set-up for ion commissioning – G. Bellodi, BE/ABP
   b) Modified Collimation Layout & Optics (for cryogenic collimators in IR3 with max. 4.5m displacement of elements) – J. Jowett, BE/ABP

3 List of actions from this meeting

Action	People	Deadline
Re-check with FLUKA team ion beam simulations (for BLM thresholds)	R. Bruce, G. Bellodi	
Check new RC task list (SLAC)	J. Smith, T. Markiewicz	
Send info about laser system for wirescanners to SLAC people	B. Holzer	
Check for optical fibre system for SLAC	A. Bertarelli	
BLM thresholds & damage level for ion beam	R. Bruce, G. Bellodi, B. Dehning, B. Holzer	
Re-check the results of BB stray field to beam with MAD	R. Assmann, V. Parma	

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

The next meeting will be on August 30th.

Minutes of the meeting

1 Regular collimation status reports

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

- Several things were checked in order to investigate the origin of the problems with the TCLAs in IR3 (06R3). The motor was tested and no problems occurred. No short circuits were found. It seems that the driver is faulty. These problems should be solved by 20th of July 2010.

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

- Ralph reported that tests with the roman pots were done. But due to the fact that the moving does not work perfectly, the tests have been postponed for now.

1.3 Phase II activities at CERN (R. Assmann BE/APB)

- Ralph reported about the status of the fabrication of the dispersion collimators. The manufacturing of the prototype is ongoing. A potential manufacturer has been found, but more material tests need to be done (extension for 4 more years).

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

- J. Smith presented the latest SLAC RC status report and the activities since 5th of July 2010.
- Even more testing was done for the rotation drives and actuators. The jaw bearing fixes has been finished.
- An independent method to verify the proper facet positioning has been determined.
- It had been discovered that the rotation mechanism will miss ratchets. The pawl helps but still it not guaranteed that no ratchets will be missed. The Geneva mechanism helps insulating the jaw from missed ratchets. Nevertheless, an independent way to directly measure the angular position of the jaw is needed.
- A solution for future collimators may be a resolver attached directly to the end of the jaw. For this prototype however using an optical sight and scribe lines on each facet will work well.
- Given the angular precision of the jaw of 0.154 degrees, a scribe line on the facet must be sighted to within 180microns. This is not a problem. The optical survey can do much better. Maybe it will be possible to set up a camera to image the sight but for now the “eye by eye” check is fine.
- In addition to aligning the jaw, the scribe lines will also allow the labelling of each jaw. The position of the jaw should be always obvious by simply looking at it. And by simply looking at the jaw it will be obvious which facet is facing the beam.
- Once the vacuum chamber is welded shut, it is needed to survey the jaws position relative to the drive table reference points. The viewport windows can be surveyed traditionally with the drive table. Then the laser micrometer can be used in order to measure the distance between the viewport and the jaw surface. It should be possible to get a 5 micron precision on the jaw position.
- For the next weeks it is planned to complete the rotation drive tests in the lab and to exchange the stainless screws with molybdenum screws.
- The final four mounting brackets for the arcs, thermistors and RF foils have to be fabricated as well as the final four “wavy arcs” for contact resistance and the Rhodiumplate. The scribe scope and scribe facets will be fabricated.
- For the final cleaning it is planned to use acetone and alcohol for all parts. The chemical cleaning of the upper vacuum tank-vessel has to be done. The bellows are already vacuum fired and leak tested.
- The welding of the bellows to the jaw supports and to the base-plate and also the reassembling of the jaws to the base-plate will be done in a real clean room.
- The VU tubing is now bent down and brazed to feedthroughs and the final alignment, survey and test of all parts will be done in the next weeks.
- Furthermore the vacuum tank has to be welded and the rotation drive needs to be tested and a vacuum bake-out has to be done.

- In a final step everything will be immobilized and protected (shock monitors will be installed) and the paperwork for the shipping will be prepared.
- The re-iterated RC task list should be checked with the previous list.
- Ralph commented that the viewport cannot be used in reality due to the exposure to radiation. It will be used only for the prototype.
- Barbara commented that the BLM team develops a laser system for wirescanners what could be useful for the survey positioning system. She will send more detailed information about that to J. Smith.
- Alessandro commented that his engineer has an optical fibre system as well available.
- Oliver confirmed the planning for the installation of the collimators in SPS over Christmas.

1.5 Cryo-collimators integration and interfaces (V. Parma TE/MSC) – see slides

- V. Parma presented some first results on BB stray field to beam. The ROXIE calculations were done by St. Russenschuck. B_x (vertical) is ~10^{-3} T and B_y (horizontal) is ~10^{-4} T, meaning there is a domination given by B_x. Joerg commented that this is a negligible effect and Ralph mentioned that it would be good to re-check the results with MAD, just in case there might be a problem.
- Ralph gave a short summary about the LHC collimation upgrade review on 8th of July 2010.
- The collimation group got the mandate to move ahead with the cryo collimators.
- See also the slides presented at http://indico.cern.ch/conferenceDisplay.py?confId=100156.
- J. Jowett commented that ATLAS and CMS are interested in the cryo-collimators as well (IR2 for 2016).
- Alessandro mentioned that they must remember the length of these collimators before implementing them.

1.6 Further Remarks in General

- Ralph mentioned that the collimation WG meeting will be split into 2 meetings from now on. One meeting will be dedicated to hardware issues and Phase II activities. And the other meeting will be more for operational issues, analysis of loss maps, beam loss analysis etc.
- Barbara introduced the new fellow for the BLM team: Eduardo Nebot del Busto. He will work 100% on thresholds for next few months in a first step.
- Daniel and Ralph introduced a new PhD student for the collimation group: Daniel Deboy.
- J. Smith has left the collimation group and he will not work anymore for collimation. He said:
  "It's an interesting project and I enjoyed my time on it. I wish the group (and the LHC) best of luck in the future, I'll certainly keep myself informed on how things are going."
  From now on J. Smith is at SETI working on the NASA Kepler mission searching for extra-solar planets.

2 Special topics

2.1 Safe Beam Flag and BLMs thresholds for LHC ion beam operation (G. Bellodi, BE/ABP) – see slides

G. Bellodi presented the follow up for the collimation set-up for ion commissioning.

- A summary of different parameters at 3.5 TeV (at collision) like energy/nucleon, number of ions (protons) per bunch, number of bunches and the stored energy per beam for early ions, nominal ions and protons was presented. In addition the ionisation energy loss (dE/Edx) for proton and ^{206}Pb collisions at 7 TeV, the MS RMS angle and the nuclear interaction length were shown.
- The robustness of collimators against mishaps has been discussed and simulations (FLUKA) from Vasilis Vlachoudis for a dump kicker single module pre-fire were shown. The higher ionisation loss makes the energy deposition at the impact side almost equal to the proton case, despite of 100 times less beam power. These results are taken from the LHC design report (H. Braun, 2005).
- In a second step the BLM thresholds for ion commissioning were discussed. The ratio between the heat deposited in the MB coils and the energy deposition in the BLMs is the same as for protons, being scaled by Z. But there are differences on the microscopic scale at the innermost 0.1mm of the beam screen (see LHC Project Note 402 from R. Bruce).
- The safe beam flag can be derived via: (E [GeV] / 450GeV) $^{1.7}$ x I $\leq$ threshold. The nominal threshold is set to 10^{12} proton charges in 2009-2010 and the relaxed threshold is 4 times nominal but less than 10^{12}. A

summary for the nominal thresholds and the relaxed thresholds for protons was presented. There were 2 questions: Why is it 10^{12}? And is it enough to simply rescale the thresholds for ions by the stored beam energy ratio? This would lead to the following thresholds: 10^{12} at 450 GeV for protons and $7x10^{7}x208x62=9x10^{11}$ up to 1.38TeV for early ions.

- It was mentioned that it could be worth it checking together with the FLUKA team the simulations that are done already and maybe ask them to do more studies and simulations. R. Bruce will follow up.
- The BLM thresholds for ion beam are the same as in case of proton beam for the quench level but not for the damage level of the elements in the LHC ring.
- A more detailed procedure for setting the BLM thresholds for the ion commissioning needs to be defined and R. Bruce, G. Bellodi, B. Dehning, B. Holzer will further investigate on this.
-

2.2 Modified Collimation Layout & Optics (for cryogenic collimators in IR3 with max. 4.5m displacement of elements) (J. Jowett, BE/ABP) – see slides

J. Jowett presented the latest results on the modified collimation layout and the optics for cryogenic collimators in IR3 with a maximum of 4.5m in displacement of the elements.

- An overview of the IR3 optics for beam 1 was shown. Beam 2 has the F and D quads inverted, but imperfect (left-right, x-y) asymmetry and has to be treated separately. The IR3 optics is constant and there is no change with energy, β-squeeze or others.
- In order to make space in right of IR3 (B1), the outer group of elements will be moved away from the IP for about 4.5m into the space of the missing dipole. The inner group of elements will be moved towards the IP to (roughly) compensate the change in geometry. A similar strategy should be used for the left side of IP3.
- The planned displacements along the reference orbit show that this vacates enough space in the right places in order to install the cryogenic collimators. Please note that the presented zoom on the displacements along the reference orbit are Courant-Snyder coordinates, so that one cannot see the change in geometry of the LHC.
- Due to the displacements of elements, several displacements of the reference orbit for beam 1 are expected. The longitudinal displacement mainly reflects a change in length of the reference orbit and can be fixed.
- The radial displacement of the reference orbit between the shifted sections is 46mm (Note: not the displacements of the elements). And the radial displacement of IP3 and the straight section due to a non-commutativity of rotations and translations is small enough to be neglected (-0.026mm).
- In the global Cartesian frame, the displacements of the outer and inner groups of elements include a component from the angle ("curvature") of the initial reference orbit. MAD and the LHC Layout Database use the "beads on a necklace" method of laying out the machine so everything downstream of IR3 moves and the ring does not close. This is not real of course but has to be corrected in our description.
- The small negative displacement of all elements downstream of IR3 along the reference orbit restores them to their original position in the global Cartesian system and closes the ring. New sequence descriptions have been created for both rings.
- The LHC circumference is then changed by -2.808mm. The new sequence names LHCB1CC and LHCB2CC will be used.
- In order to understand the optical perturbations an overview of the β-beating for the full ring (1) was shown as well as for the β-beating in IR3 (ring 1). A change in the layout perturbs the optical functions, giving about 20% β-beating which must be corrected everywhere outside the IR.
- The optics perturbation in IR3 would cause severe aperture losses. The rematch of IR3 for each ring should be done without using the common quadrupoles that affect both.
- Rematch of IR3 (beam 1): This is a perfect match since it is the same transfer matrix over IR3 (also for ring 2) and so it can be used in a modular way with all existing LHC optics configurations. The β- function peaks are adjusted and so the available aperture is not changed significantly.
- Rematch of IR3 (beam 2): Same as for beam 1, but more quadrupoles had to be used for the rematch than in the case for beam 1.
- A summary about the quadrupoles strengths after the rematch was presented (for beam 1 and 2). All quadrupoles are comfortably within the bounds at 7 TeV (for beam 1 and 2). The presented strengths should be used on top of any other set of strengths for LHC optics V6.503, with the new sequences LHCB1CC, LHCB2CC.

- The aperture of nominal IR3, for beam 1 at injection was discussed. An overview for n_1 in magnets over dcum was presented. n_1 is a quantity conventionally used to assess the aperture available to beams in the LHC. It includes x and y planes and various tolerances in a single number according to a recipe coded in MAD. Normally we require $n_1 > 7$. Note: the usual optics has a low n_1 in IR3.
- The aperture of nominal IR3, for beam 2 at injection was discussed as well: it is different from the reflected beam 1.
- In a next step the cryo-collimator optics in IR3 for beam 1 and 2 at injection have been shown. Here n_1 of the cryo-collimator optics is different.
- The differences in n_1 before and after the rematch, for ring 1 (IR3) and for ring 2, were shown. As a result one can see that there is some improvement in all worst places and a slight degradation in other places (ring 1) and also some improvement in bad places for ring 2 as well as a reduction at the worst place.
- Summing up, we can conclude that a new cryo-collimator layout for a maximum 4.5m shift of the dipoles and Q10 has been worked out. The optics for both beams are re-matched with a general improvement in aperture over standard IR3 optics. There is a reduction in one place for beam 2.