Stefano Redaelli, 28-06-2005

60^{th} Meeting of the LHC Collimation Working Group, June 27, 2005

Present: Gianluigi Arduini, Ralph Assmann (chairman), Dariusz Bocian, Chiara Bracco, Hans Braun, Markus Brugger, Bernd Denhing, John Jowett, Laurette Ponce, Andy Presland, Stefano Redaelli (scientific secretary), Guillaume Robert-Demolaize, Mario Santana-Leitner, Rüdiger Schmidt, Vasilis Vlachoudis, Jorg Wenninger.

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Jorg Wenninger (JW) and Hans Braun (HB) repeated at the collimation working group meeting the talks that they recently presented at the LHC Machine Advisory Committee (MAC) of June 9-11, 2005. See more details at the webpage
`http://mgt-lhc-machine-advisory-committee.web.cern.ch/mgt-lhc-machine-advisory-committee/`
The comments of the MAC are not publically posted on the web but can obtained upon request on the MAC web site.

1.1 Orbit feedback for collimation (J. Wenninger)

See slides at http://www.cern.ch/lhc-collimation/files/JWenninger_2005-06-27.pdf

JW discussed the architecture of the feedback system for the LHC orbit control. A precise orbit control will be crucial for various LHC subsystem but in particular for the collimation system, which requires an overall control of the relative jaw position with respect to the beam of $\mathbf{0.6}\,\sigma$ ($\approx 160\,\mu$m at 7 TeV). This included mechanical tolerances, collimator setup errors, beta-beat and orbit stability. With reasonable budgets for the other tolerances, the orbit stability budget can be as small as $50\,\mu$m. It is therefore clear that the orbit position will not be a free play parameter but a dedicated **real time orbit feedback** has to be put in place since the early LHC days.

JW commented that the problem of the orbit feedback control was realized early enough and studies have started in time. Details of the foreseen system for the orbit control at the LHC are given in JW's slides. JW stressed in particular the **very promising experimental results** achieved at the SPS. It was shown that the baseline architecture worked well and the beam orbit could be stabilized to a **total RMS motion below 2 micrometres**. JW commented that the orbit noise level can be further reduced by increasing the averages on the BPM readings. The price to pay would be a reduced time response of the feedback.

JW commented that there are known problem with the orbit system, which require additional studies:

(1) The acquisition system of the BPM's is affected by the **bunch length**. At the SPS, this effect reached the $\mathbf{200}\,\mu$m level but it is expected to be less relevant for the LHC (short bunches).

(2) The BPM reading depend on the **bunch intensity**. In principle, this problem could be faced by setting up the orbit feedback at low intensity with nominal bunch population (low intensity = few nominal bunches).

(3) At the SPS it has not been possible to test in detail the effect of beam losses on the feedback system. Tests were done during the collimator MD, which showed no considerable effect, but there is some concern that the produced beam loss rates were not sufficiently high to draw firm conclusions.

1.2 Discussion

Ralph Assmann (RA) commented that it could be interesting to test at the 2006 SPS run different **feedback algorithms** (optimize peak orbit or RMS noise). Two collimator MD's are foreseen and the tests could be done in parallel. JW agreed.

Action: Follow-up/organization of a feedback test during the 2006 collimator MD's at the SPS (J. Wenninger, R. Assmann).

RA also asked if the orbit feedback is sensitive to the transverse bunch distribution, in particular to the shape of the beam tail. JW replied that this is a know issue for linear colliders but should be negligible for circular machines, where the beam orbit is calculated as the average over many turns.

Hans Braun (HB) asked if the orbit feedback is somehow connected to the energy feedback, e.g. during ramp. JW replied that dispersive contributions are taken into account but, other than that, there is no connection.

HB also asked what happens in case of strong coupling. JW replied that most likely the LHC will not work for other reason before the feedback system will be affected by coupling.

1.3 LHC ion collimation (H. Braun)

See slides at http://www.cern.ch/lhc-collimation/files/HBraun_2005-06-27.pdf

Hans Braun (HB) review the LHC ion collimation issues. It is known that for the time being the is not yet a satisfactory system that ensures a sufficient collimation with the nominal LHC ion beam. The two stage collimation system proposed for protons does not work for ions because the carbon primary collimators do not act for ions as betatron scattered. Instead, they change the mass/charge ration of the ions, which are then lost in the next dispersive region.

HB described in some details his ion simulation tool. This was cross-checked with experimental data from RHIC and a fairly **good agreement** is found (see also the minutes of the 52nd meeting of the collimation working group, held on February 28th, 2005). It seems that one of the most important sources of uncertainty comes from the **assumed values of the quench limits of superconducting magnets**, which yet have not been agreed with the magnet builders.

Another important issue is the **signal ratio between BLM location and superconducting coil**. Is this ratio the same for ions and protons? Simulations suggest that the ratio is indeed the same, which means that the BLM locations proposed for protons will also be suitable for ions. HB also commented that from RHIC there is experimental evidence that this should really be the case. Private communication from Wolfram Fisher suggests that, for beams with the *same rigidity*, at RHIC the quench thresholds are set to the same values for different ion species.

Other issues that, according to HB, require followup are the effect of **finite beam size** and of **pair production**.

HB also commented that, as a possible remedy for the ion collimation, one could increase the strength of the dogleg magnet at IR3. This solution seems extremely difficult to put in

1.4 Discussion

Since the issue of the assumed quench limit is regularly discussed and there is no a clear position from the magnet builders, it was agreed to formally ask a table with reliable quench limit for all the LHC magnet types. RA will follow this issue up and request the quench limit to Lucio Rossi, who committed on collecting this information.

Action: Request to L. Rossi the quench limits of the various types of LHC superconducting magnets (R. Assmann).

There were also several concerns about the issue of the signal ratio between BLM location and superconducting coil. In particular, Rüdiger Schmidt is not convinced that the simulation results presented by HB are consistent with what was previously simulated by Vasilis Vlachoudis (case of impacting proton on Carbon collimator). HB replied that this is only an effect of the bin size used in the simulations (for CPU reasons, bigger bins must used to simulate the full LHC dipole). It was agreed to have a separated meeting among the people involved to make sure that simulations agree. RA also proposed to invite Roderik Bruce - the technical student working with John Jowett who actually did the simulations - to report details of his model at one of our next meetings.

Action: Cross-check simulation results of deposited energy for ions (H. Braun, J. Jowett, V. Vlachoudis, R. Bruce)

Stefano Redaelli asked if the simulation code of HB properly takes into account crossing and separation schemes at the LHC. SR would expect larger losses around the experimental regions than was is found by HB. HB replied that in principle that tracking should be correct because the magnet strength are directly obtained from `MADX`. But HB will check if this is really the case.

Action: Verify crossing and separation schemes in the loss pattern simulations for ions (H. Braun).

RA commented that the simulations of HB take into account simultaneously the different halo types (horizontal, vertical and skew primary collimators have the same load particle load). RA believes that it is worth considering the contributions of each halo type separately. People agreed that this this study should be addressed.

Action: Estimate the contribution of various halo types: horizontal, vertical and skew (H. Braun).

2 (A. Presland)

See slides at http://www.cern.ch/lhc-collimation/files/APresland_2005-06-27.pdf

Andy Presland (AP) gave an update on the FLUKA simulation of asynchronous dump error scenario. Preliminary results were already reported at the 56th collimation working group meeting of April 25th, 2005. Details of the simulations can be found in the minutes of that meeting and on AP's slides. AP's has corrected a small bug on the assumed curve of specific heat versus temperature. The new results are more consistent with previous estimated by Vasilis Vlachoudis.

New simulations indicates that **9 kJ** are deposited in the horizontal primary collimator. Then, most of the shower energy is deposited in the next secondary collimator (`TCSG.A6`). The flanges get up to several hundreds of joule. The maximum temperature increase if of the order of 10° C for the Carbon jaw and of 0.4° C for the Copper matrix that houses the cooling pipes behind the Carbon jaw.

2.1 Discussion

AP said that the curves of of specific heat versus temperature are taken from previous CERN internal notes. RA recommended to use instead formulas published in the latest journals!

It was agreed that the simulated values of deposited energy should be transmitted to AT-VAC to check if this is acceptable for the collimator flanges.

It was also agreed that, as a next step, the case of misfired bunches impacting on secondary collimators should be investigated.

Action: Is the deposited energy acceptable for the collimator flanges? (FLUKA team, C. Rathjen).

Action: Review used formulas for the temperature dependence of specific heat (A. Presland).

Action: Energy deposition studies for asynchronous dump at 7 TeV with misfired bunches impacting on secondary collimators (A. Presland, FLUKA team).

The next meeting will be announced.

Action Items:

- Follow-up/organization of a feedback test during the 2006 collimator MD's at the SPS (J. Wenninger, R. Assmann).
- Request to L. Rossi the quench limits of the various types of LHC superconducting magnets (R. Assmann).
- Cross-check simulation results of deposited energy for ions for the estimate of signal ratio between energy deposited in the magnet coils and in the BLM (H. Braun, J. Jowett, V. Vlachoudis, R. Bruce)
- Verify crossing and separation schemes in the loss pattern simulations for ions (H. Braun).
- Estimate the contribution of various halo types (horizontal, vertical and skew) in the LHC ion simulations (H. Braun).
- Check if the deposited energy on the collimator flanges is acceptable (asynchronous dump failure case at 7 TeV) (FLUKA team, C. Rathjen).
- Review used formulas for the temperature dependence of specific heat (A. Presland).
- Energy deposition studies for asynchronous dump at 7 TeV with misfired bunches impacting on secondary collimators (A. Presland, FLUKA team).