

## 41<sup>st</sup> Meeting of the LHC Collimation Working Group, August 27, 2004

*Present:* Oliver Aberle, Ralph Assmann (chairman), Igor Baichcev, Alessandro Bertarelli, Alessandro Dallocchio, Hans Braun, Markus Brugger, Nuria Catalan Lasheras, Enrico Chiaveri, Bernd Dehning, Barbara Eva Holzer, Verena Kain, Mario Santana Leitner, Manfred Mayer, Laurette Ponce, Suitbert Ramberger, Christian Rathjen, Stefano Redaelli (scientific secretary), Alexander Ryazanov, Peter Sievers.

### 1 A.O.B.

Ralph Assmann (RA) announced that Stefano Redaelli (SR) has taken the place of Verena Kain (VK) as scientific secretary of the LHC Collimation Working Group and Project meetings. He thanked VK for the excellent work. VK will become scientific secretary of the Injection Working Group. RA also announced that the two first collimator prototypes have been successfully installed in the SPS and TT40 tunnels for our tests with beam. The installation did not encounter any major problems. The motor remote control was tested and proved to work correctly.

### 2 Discussion on the report from the external collimation review (R. Assmann, round table)

See slides at [http://www.cern.ch/lhc-collimation/files/RAssmann\\_2004-08-27.pdf](http://www.cern.ch/lhc-collimation/files/RAssmann_2004-08-27.pdf)

The report from the external collimation review has recently been published and is now available on the Collimation Project web page:

<http://lhc-collimation-project.web.cern.ch/lhc-collimation-project/review04-v1.htm#Report>:

RA showed some transparencies about the main concerns of the external review and opened the round-table discussion with his personal thoughts about the consequences of the recommendations from the committee. Amongst others, the following items were mentioned:

- The carbon-carbon (CC) composite was explicitly recommended for the collimator jaws instead of the graphite. The order of the required material should be carried out as soon as possible because there are some concerns about the delivery times from industry.
- The copper coating of the carbon jaws was discouraged for the phase I collimation. This recommendation should be discussed with the team of Francesco Ruggiero, who is studying collimator impedance issues.
- The NEG coating has not been tested with radiation and it could cause problems.
- The effect of temperature gradients and of radiation on the springs, which keep the cooling circuit in contact with the carbon jaw, should be addressed. This is a critical component because the cooling efficiency depends on these springs.
- Some other material instead of copper should be envisaged for the pipes where the cooling water circulates because the required water velocity of 3 m/s could be too high and induce erosion in copper.
- Reliability studies should be started.

- The issue of the energy deposition in the flanges should be addressed.
- For investigating the radiation resistance of the collimators, close collaborations should be started with BNL and Fermilab, which have experience on proton effects on carbon. RA also said that after the TT40 test some samples of the bombarded jaws might be sent to the Kurchatov institute for investigating in detail the carbon degradation from impacting proton beams.
- Cautions should be taken when placing the order for the collimation motors. The review recommends to experimentally validate the claim from industry about the radiation resistance of the motors. The best would be to test the motors with radiation from protons before placing the order, for example at Tevatron.
- The committee realized that some motors are difficult to access and their position should then be optimized. However, this is difficult to achieve.
- Regarding the accelerator physics studies, more emphasis should be addressed to the understanding of short time-scale losses and of induced detector background, which are important issues for HERA and Tevatron.
- The review was worried about the role of the collimation system for the machine protection. The machine protection should be addressed in a separate review.
- The quench limit of superconducting magnets should be studied in more detailed in order to provide reliable estimate of the beam loss induced risk of quenches.
- The review stressed that the energy deposition studies at IR7 should be carried out with high priority (see next section for a status of ongoing studies). Other studies shall include the carbon dpa (displacement per atom) equivalent due to the impacting proton beams. The tritium generation in the collimator cooling water should also be studied.

It is noted that the latter topics is being addressed by Alfredo Ferrari and by the team of Prof. Alexander Ryazanov (Kurchatov Insitute). The estimate of equivalent dpa in carbon from proton beams will be included in FLUKA. The issue of the tritium generation in cooling water was already looked into and did not show significant problems for the LHC parameters (Markus Brugger). More detailed studies will confirm this preliminary conclusion.

**Action:** Check the tritium production in the collimator cooling water (Markus Brugger).

Regarding the item of the precise estimate of the quench limit of superconducting magnets, Bernd Dehning commented that a fellow was asked without success in the last selection, in order to study this problem in detail. This work was planned to be performed in strong collaboration with the magnet group (Andrzej Siemko, AT-MTM). BD will try again to have a fellow in the next selection.

Some discussion about the choice of the collimator jaw material and the timing for placing the order to industry followed the presentation by RA. Enrico Chiaveri (EC) asked why the committee was so much in favor of the CC option for the collimator jaw. RA explained that, according to the documentation provided by the committee (see complete report), the CC composite show much better mechanical properties that the graphite. Notably, the CC composite shows smaller stress tensions (as proven by measurements performed at BNL, see appendix to external review report, by N. Simos). Alexander Ryazanov confirmed that many years of studies of carbon composites have proved that the mechanical behaviour of CC under radiation is better than graphite. However, Alessandro Bertarelli (AB) and Peter Sievers (PS) pointed out that a better mechanical behaviour under an impacting beam is not necessarily a parameter to prefer CC to graphite. The important parameters which are relevant for the collimator survival and for the efficiency of the overall collimation system (i.e.,

electrical resistivity, thermal expansion coefficient and radiation resistance) have not been tested sufficiently well so far and require more understanding. It should not be forgotten that the CC was chosen for the SPS collimator because it showed a smaller electrical resistivity with respect to the graphite, which is good for the impedance. In this respect, the TT40 material test could provide very useful information because both a graphite and a CC jaw will be bombarded with proton beams. Everybody agreed that we should go ahead with the CC option.

AB is worried because the experience with the carbon samples delivered so far at CERN has shown that the chosen companies were not able to provide with sufficient precision the required information about the acquired material. The order could be placed immediately if we could rely on the promised carbon properties!

### 3 Status of energy deposition studies at IR7 (M. Santana Leitner)

See slides at <http://www.cern.ch/lhc-collimation/files/MSantana.2004-08-27.pdf>

Mario Santana Leitner (MS) showed the preliminary results of the his simulations of energy deposition at IR7. The case of a transient beam lifetime of 0.2 hours has been considered (which means that the given results should be divided by a factor 5 to estimate the steady state with 1 hour beam lifetime. Simulations are performed by using a tool developed over the last months by Vasilis Vlachoudis, Matteo Magstris and MS (see talk by MM at the collimation review). This tool allows the user to combine various pre-defined objects, such as collimators, or magnets, and to repeat them in the tunnel to construct the full beam line. MS showed preliminary results of deposited energy in the first three primary collimators, in some secondary collimators and in warm and cold quadrupoles. It is found that the maximum deposited energy in the collimator is approximately **22.6 kW** (secondary collimator TCSG.A6.L7). The third primary collimator is considerably irradiated because it see the showers developed in the previous primary collimators. RA pointed out the the given results could be in an extreme case three times smaller than the realistic values because in the used input files horizontal, vertical and skew halos were equally distributed. In the coil of the cold quadrupole MQTLH.A6R7, a deposited energy up to 300 mW/cm<sup>3</sup> is found, which is by far larger than the quench limit of 5 mW/cm<sup>3</sup>. Absorbers will fix this. The maximum energy deposited in the coils of the warm MBW dipoles is 5 W/cm<sup>3</sup>. Future studies will be focused on the quantification of the effects of the beam profile and on the choice of possible locations of additional absorbers to minimize the heat deposition in sensitive areas.

AB asked if the results for the energy deposition in the collimators are available and reliable. This data are needed as an input for the finalization of the mechanical analysis studies with ANSIS. MS answered that the presented results for the collimators are reliable but the final level of deposited energy will obviously depend on the location of the additional absorbers, yet to be defined. RA suggests to wait for more advanced results before performing the final ANSIS analysis (unless there are problems of availability of manpower involved in these studies).

M. Brugger pointed out that from the given plots it seems that air has been used instead of vacuum at either sides of the collimator, outside the vacuum tank. This may have an effect in the estimated heating of the flanges and hence this inconsistency should be corrected.

**Action:** Check the collimator model used in FLUKA (Mario Santana, Vasilis Vlachoudis).

### 4 Topics of future studies (round table)

RA showed the new web page with the list of future topics to be addressed by the collimation team. This page can be accessed through the collimation Working Group page:

<http://lhc-collimation.web.cern.ch/lhccollimation/topicsfuture.htm>

Everybody should look at this list to be informed on the required work. Suggestions on additional items were welcomed and should be transmitted to the RA or SR. Amongst the topics which require an urgent follow up, it was mentioned (1) the definition of optimal locations for the BLM's in the SPS test, (2) the proposed location the cooling pipes, (3) the ozone issue in IR7, (4) the radiation studies in the RR's for shielding and (5) the detailed definition of the measurements to be carried out in the SPS MD's. The latter topics will be discussed in a collimation working group meeting next week.

BD had already a few suggestions for future topics. He proposed to add to the the list the study of radiation effects on the optical fibres used for the BLM's. Results are needed fairly urgently (within one month at most) because various orders have to be placed soon. The results of these simulations will have an important impact on the cost of the BLM system. BD also proposed to add to the future topics list the pollution to the BLM's cables from the electromagnetic noise of other equipment such as the collimator motors and the required electronics. In addition, BD said that it should be decided soon how many BLM's have to be installed per collimator. Further discussions are required.

Nuria Catalan said that another issue to study is the effect of showers induced by lost particles all around the LHC ring. This can have an effect on the quench performance of cold magnets because these showers can increase the local heating.

## 5 Basic design parameters of different collimator type (R. Assmann)

In view of the call for tender to be placed for the LHC collimators, RA has prepared a list with the design parameters of the various types of collimators. The list is available at the web page

[http://lhc-collimation-project.web.cern.ch/lhc-collimation-project/collimator\\_list.htm](http://lhc-collimation-project.web.cern.ch/lhc-collimation-project/collimator_list.htm)

Everybody is welcomed to have a look at this page and cross-check the given numbers. In total, we have 101 to 109 collimators and 7 different designs (taking into account major design differences only).

Design and location of primary (TCP) and secondary (TCS) collimators have been frozen. On the other hand, some information about the tertiary collimators (TCT's) is still missing. VK will check the given longitudinal positions and provide the missing values. Once the data are available, Christian Rathjen should check if there are no problems for the TCT integration at the proposed location. VK and Brennan Goddard should also cross-check the given information about the absorbers for injection protection (TCLI's). These collimators have the same design and material as the TCS.

**Action:** Check the TCLI design parameters listed on the web (VK, MB).

RA also showed the design parameters of the absorbers for showers in cleaning insertions (TCLA's). Igor Baishev confirmed that the given numbers are consistent with what he has used for his simulations of deposited energy in IR3.

### Action Items:

- ▷ Check the collimator design in the FLUKA model - air inside the flanges? (M. Santana, V. Vlachouis)
- ▷ Tritium production in the collimator cooling water (M. Brugger)
- ▷ Cross-check the design parameters of the TCLI's (B. Goddard, V. Kain)

**The next meeting will be Friday 3rd September 2004, J.B. Adams room.**