Stefano Redaelli, 22-11-2007

89th Meeting of the LHC Collimation Working Group, July 12th, 2007

Present: Ralph Assmann (chairman), Chiara Bracco, Markus Brugger, Fritz Caspers, Francesco Cerutti, Andres Gomez Alonso, Alexeij Grudiev, Daniel Kramer, Mikko Karppinen, Luisella Lari, Marco Mauri, Valentina Previtali, Stefano Redaelli (scientific secretary), Stefan Roesler, Lucia Sarchiapone, George Smirnov, Joachim Vollaire, Thomas Weiler.

1 Proposal for impedance measurements on the collimator prototype (F. Caspers)

Fritz Caspers presented a proposal for measuring the low-frequency transverse impedance of the LHC collimators in laboratory tests. This technique was proposed in 2002 by F. Caspers, A. Mostacci and L. Vos and Fritz took as a reference the transparencies that were presented then (see slides for details). For the specific case of the LHC collimator, a long coil would have to be inserted between the collimator jaws in order to measure the impedance. Actually, Fritz stated that as a first step one could just set-up a laboratory test stand with pieces of Carbon instead than a full collimator prototype, which would require more time to set-up. This simpler test stand would allow to get experience with the measurement set-up and would prove if the measurement can work.

R. Assmann stressed the importance of these low-frequency impedance measurements. The functioning of the LHC relies on the "by-pass" effect that predicts a reduction of the collimator impedance at low-frequencies. The impedance of the Phase I collimation system would be too high if this effect did not exist. Beam measurements at the SPS did not yet succeed to demonstrate that this effect is real (see E. Mtral presentation at the 80th meeting of the collimation working group of December 4th, 2006). R. Assmann also commented that more detailed measurements of collimator impedance will also give important hints for the design of the Phase II collimators. Therefore, R. Assmann welcomed Fritz' proposal and suggested to follow this up with high priority.

F. Caspers commented that he will provide support for the impedance measurements however his team does not have the resources to perform the measurements. Fritz looks for candidates ("victims") to follow this up. Preliminary tests with Carbon block can be performed in the RF workshop in the shade of other activities however the graphite material should be provided by the collimation team. After the meeting it was clarified that the measurements will be followed up by Federico Roncarolo (AB-ABP-LCU) and Benoît Salvant (AB-ABP-LIS). See also the minutes of the ABP-LCU section meeting of June 18th:
`http://ab-dep-abp.web.cern.ch/ab-dep-abp/LCU/LCU_meetings/2007/070618/agenda.html`
Preliminary tests with prototype coils have been already performed. Federico and Benoît will take contact with the collimation team in order to verify the availability of graphite jaws and eventually to organize tests with a real collimator. R. Assmann will follow-up the request to provide the Carbon material of the collimator jaws. Follow-up of this activity will be reported to the collimation working group.

S. Redaelli asked when would the impedance team be ready to perform measurements with a real collimator. One polluted collimator that will not be installed in the LHC is being used in the collimator workshop for controls tests and could be available for the impedance measurements. Fritz replied that measurements could be done in 1 or 2 months.

George Smirnov asked if temperature of graphite jaw can have an impact on the impedance. He wondered if anisotropies of the material in different condition could modify the impedance. Fritz replied that this should not be the case. R. Assmann replied that in any case at the LHC the collimators will be operated at room temperature.

A. Grudiev commented that for the collimator jaws it would be better to use a coil of 1 m rather then 0.2 m that appeared in Fritz's slides.

2 LHC passive absorbers (M. Brugger)

Markus Brugger presented the final results of the FLUKA simulations for the LHC passive absorbers of IR3 and IR7. These are non-movable elements that will be installed in front of some warm magnets in the line (dipole - MBW's - and quadrupoles - MQW's) to shield them from the products of hadronic showers generated in the collimators. This presentation summarized the work of the FLUKA team that was carried out in the last months in close collaboration with the collimation ABP and design teams. Markus reviewed the details of the proposed layout for the passive absorbers. The design of these elements is basically frozen and their production is ready to start.

In M. Brugger's slides one can find a list of the design constraints and of the relevant challenges related to the MBW and MQW magnets that have to be protected. In particular, Markus reminded that the coils of the warm magnets can be replaced however this operation is not always straightforward (in particular for the MQW's) and in any case it requires long waiting times for the magnets to cool down. In addition, Markus reviewed the geometry of the magnets as it has been implemented in FLUKA: the model is very accurate and all the relevant components are taken into account.

The best performance on paper was achieved with a "sandwich structure" in the absorber geometry (see page 26 of M. Brugger's slides). Ideally the best absorption would be achieved with absorbers fully made of Tungsten however this has practical problems because the structure would become to heavy and too expensive. The best compromise was found by using a layer of 1 cm of Tungsten close to the beam and Copper disks around for cooling. Additional iron shielding was also added (see the implemented geometry at page 15).

Next M. Brugger presented the results of the latest simulations performed with the final absorber design. The summary of the various case studies is given in the table at page 18 of his slides. The maps of deposited energy from FLUKA have been used for ANSIS simulations of the mechanical structures (A. Bertarelli). The stress analysis should that the response of the proposed design is under control.

By taking into account various sources of simulation errors and uncertainties, M. Brugger concluded that realistically we should use a safety factor of 2 or 3 on the results from the FLUKA studies. R. Assmann commented that this seems optimistic. For example, the particle losses in the collimators or in the warm magnets will depend on the optics in the cleaning insertion and it is not easy to foresee now what we will have in the LHC.

As an outlook for further improvements, M. Brugger commented that, if needed, a further protection of the MQW's could be achieved by adding an additional protection plate of 3 cm between the vacuum flange and the coil. In addition, there will be no vacuum pump in front of the dipole (C. Rathjen) and hence one could envisage that the magnet flange could be replaced with a special bellow that could serve as absorber itself. The expected possible improvement is of the order of 50 % (1.5 in magnet lifetime!). R. Assmann warned to be careful about speculations on vacuum layout changes. Any change of layout is very challenging in this phase of the project. The priority for the collimation project is to make sure that we can have something for the first year of operation. From our point of view, the passive absorber design is frozen and the production should go ahead. R. Assmann asked if M. Brugger wants to propose to stop the production and review the design. Markus replied that the FLUKA team is waiting for the latest simulations, which will come in a few days. This issue will be sorted out off-line after the meeting.

S. Roesler commented that we need to study repair scenarios for the passive absorbers. The RP team is available to help in discussion and perform dose calculations. In addition, Stefan warned that the Tungsten is brittle and can generate dust. This issue must be followed up. R. Assmann agrees that this is an important aspect to look at. As the doses calculations are available, we should contact material experts and see if this can be an issue.

3 RP aspects for passive absorbers (S. Roesler)

S. Roesler presented results of RP studies for the passive absorbers. As a side remark, Stefan requested that for future collimator design studies the RP team should be involved earlier on than what was done in this case. RP issues were taken into account by the FLUKA team and hence in this case it turned out that an optimized solution could be found.

S. Roesler showed a comparison between doses from the TCP/TCS collimators and the new passive absorbers by taking into account the revised FLUKA model of the cleaning insertion. The new simulations are in fairly good agreement with the results obtained with the simulation set-up of a few years ago, which makes people confident that layout geometry is correct.

After one day of cooling, similar radiation doses are expected for the primary collimators and for the first passive absorber (TCAPA) (differences are within about a factor 2). The iron shield around the absorbers does not contribute much to the residual doses. From RP aspects, it can be removed if this is necessary. The same conclusion also apply when looking at the results of air activation studies: the impact of the iron shielding is within the 10 % level. Plots of doses in the insertion were shown for different decay times. The hottest spots are found at the location of the TCAPA's in front of MBW and MQW. Without iron shielding, the peak would be moved to the magnets downstream but there is basically not impact for RP issues. The expected doses to personnel and the cooling water activation have not been calculated yet but the differences are expected to be small.

S. Roesler also commented on ALARA criteria and the ongoing documentation. The requirements to fulfill will be described in detail and distributed to the people concerned.

Concerning the uncertainties on simulation results, the contributions from FLUKA geometry (factor of about 2), and from models and methods ($\approx$ 30%) were quoted. S. Roesler also warned that dose rates are now calculated for the nominal LHC intensity that is only achievable with the Phase II collimators in place but the layout only contains Phase I collimators. this gives pessimistic estimates and this will be taken into account for more detailed estimates.

R. Assmann commented on the plots shown by S. Roesler. It seems strange that the vertical hot spot at the MBW is hotter for the horizontal halo case than for the V halo case. Stefan agrees. This does not affect significantly the dose estimates however it is worth investigating this further for the estimates of deposited energy. He also suggested that in future studies we should also consider other scenarios with larger collimator gaps and not only the nominal operational case considered so far. Stefan stated that he is willing to work on the RP studies for these new case studies when inputs will be available.

The next meeting will be announced.

Action Items:

- Perform measurements of collimator low-frequency impedance (F. Roncarolo, B. Salvant). Input from collimation team: collimator material procurement (R. Assmann) and availability of control test stand (M. Jonker).
- Finalize the layout of the passive absorbers. Do we need additional protection? Do we want to ask for a change of the vacuum layout? (FLUKA team, R. Assmann)
- Investigate repair scenarios for the passive absorbers (SC-RP team with uinput form the collimator design team).
- Dust production in the Tungsten material of the passive absorbers (R. Assmann).
- Investigate the operational scenarios: (1) larger collimator gaps; (2) reduced collimator system (FLUKA and SC-RP teams; inputs from the ABP collimation team).