Stefano Redaelli, 22-11-2004

46^{th} Meeting of the LHC Collimation Working Group, November 12, 2004

Present: Oliver Aberle, Ralph Assmann (chairman), Alessandro Bertarelli, Frederik Bordry, Helmut Burkhardt, Alfredo Ferrari, Markus Brugger, Matteo Magistris, Laurette Ponce, Suitbert Ramberger, Stefano Redaelli (scientific secretary), Markus Stockner, Katerina Tsoulou, Roger Valbunea, Vasilis Vlachoudis, Thjis Wijnands.

1 Comments on last minutes

- Ralph Assmann (RA), Christian Rathjen and Bernard Jeanneret (JBJ) have followed up the space request for the absorbers at IR3. They have met Rob van Weelderen (RW) to solve a problem of super-imposition between the propose absorber locations (see minutes of the 45th collimation working group meeting) and some superconducting current links at IR3. The space constraint has been solved. However, during the meeting another issue was discussed: the current links will be installed all along the insertion region and hence they may quench due to the high radiation levels. The quench limit of the SC link has to be compared with the expected radiation levels (provided by Igor Bayshev). RA, JBJ and RW are following up this issue. This possibility of adding shielding to the superconducting cables will be investigated.
- At the last meeting, Suitbert Ramberger commented on the radiation hardness of the warm magnets at IR3 and IR7. During the last week he sent out a mail to the people concerned to clarify what was discussed at the meeting. This mail is appended as an appendix to these minutes.

2 Comment on the successful completion of the collimator tests with beam (R. Assmann)

RA stated that all the collimator tests with beam have now been successfully completed. The robustness test, carried out on Monday 8th at TT40, showed that both collimator jaw (Carbon-Carbon and graphite) could stand without apparent damage the impact of 5 full-intensity LHC beams at 450 GeV. The jaw cooling system and the mechanical functionalities of the collimator (jaw movements, sensors for jaw position measurements) were not damaged. Eight temperature sensors, placed inside the jaws, stopped working one after the other during the test, which proves that the robustness test was indeed challenging for the equipment. A more detailed inspection of the collimator will be carried out within the next weeks and will give more details about the effect of the beam on the collimator. RA reported the congratulations from Steve Myers and Paolo Ciriani to the whole collimation team for this success!

Amongst others, vibration and sound measurements were carried out. The noise of a 450 GeV beam impacting on the collimator jaw, as measured by Alessandro Masi, Stefano Redaelli and Giocanni Spiezia, can be listened to at this link:
`http://lhc-collimation-project.web.cern.ch/lhc-collimation-project/sounds%20and%20movies.htm`

3 Shielding studies for the regions RR73, RR77 and UJ76 (K. Tsoulou)

See slides at http://www.cern.ch/lhc-collimation/files/KTsoulou_2004-11-12.pdf

3.1 Simulations of dose attenuation versus shielding thickness

At the last collimation working group, the FLUKA team was asked to estimate the radiation doses at the RR/UJ regions at IR7 and to investigate how much shielding would be required to reduce the doses to a level acceptable for the electronic equipments. Last September, Katerina Tsoulou (KT) carried similar calculations (see minutes of the 43rd collimation working group meeting, held on September 20th) but since then the IR7 layout has changed. Additional absorbers have been proposed to reduce the tertiary halo on the superconducting magnets downstream of the dog-leg and this might change the previous estimates of radiation level at the RR's. In addition, the option of shielding the RR's has to be considered because the first simulations suggested radiation levels up to 100 times larger than what was originally expected.

Katerina Tsoulou has run some simulations by including the new absorbers, at the locations proposed by Matteo Magistris (MM), as presented at the last collimation working group. The absolute values of radiation levels with the new layout could not be estimated yet since there was no time to accumulate enough statistics. On the other hand, is has been possible to perform a sensitivity study of the reduction of radiation levels in the RR's versus thickness of the shielding. Iron and concrete shielding slabs have been considered in this study. These simulations were independent from the IR7 geometry but used as input the particle spectra scored at the entrance of the RRs, as generated from the (still running) simulations by KT. The particles are tracked through slabs of steel and concrete of different thickness to estimate the attenuation from the shielding. It is found that **3.5 metres of concrete** or **2 metres of iron** would be required to reduce by two orders of magnitude the the number of neutrons that reach the RR's. The absolute number of hadron fluences, which does not modify the quoted attenuation from factor from the shielding, will be given as soon as more statistics is accumulated.

3.2 Discussion

RA pointed out that the location of the additional absorbers at IR7 has not been finalized yet. The presented studies are only used to estimate the thickness of the required shielding. More complete studies will have to be carried out once the layout will be finalized.

Roger Valbuena (RV) pointed out that the installation of the shielding at IR7 would have to be designed carefully. Some free space has to be foreseen for the passage of the vehicles used for installing/moving the various equipment in the tunnel. This requires a movable shielding and hence some space would also have to be left for the material to be removed when the vehicles have to pass. The definition of a possible layout for the shielding requires several iterations between RV and the FLUKA team.

Alfredo Ferrari commented on the fact that muons have not been included in the simulations of doses attenuation versus shielding thickness. The muons mostly travel tangentially to the beam direction and hence there are not many at large angles, which could reach the RR's. Nonetheless, the muon can have large energies. Their contribution is negligible for the moment because it is hidden by the contribution of neutrons and hadrons. However, if shielding will be introduced to reduce the neutron fluences by some orders of magnitudes, the relative contribution of muons could become more significant and this could then require to take the muons into proper account.

The presentation of KT triggered a discussion on the radiation levels acceptable for the equipments to be installed in the RR's. Thijs Wijnands (TW) said that the design of the equipments for the RR's was carried out by considering the total doses per year expected with a nominal LHC operation (200 days per year of operation at nominal beam intensity). What matter for the electronics is the total fluence of neutrons with energies larger that 20 MeV. Most of the equipment have been tested in radiation environments and it has been found that they can stand doses up to 10 MGy/y without significant damage. However, TW also said that estimations of radiation doses at IR7, carried out in 1998, suggested very low radiation level at the RR's. As a consequence of that estimates, power converters were also installed there. These power convertes have not been tested with radiation and for the time being it is not possible to provide estimates on their radiation hardness.

Frederick Bordry confirmed that several components of the power converters have not been designed to stand radiation (notably, the electric card for the interlocks). Most of the componets have been already ordered and cannot be easily changed to be make radiation hard. It would be good to have more precise estimated of the radiation levels and of the effect of a possible shielding before taking actions.

RA and AF agree that the radiation limit of electronics equipment should not only consider the nominal case of standard beam losses but should also consider that peak losses induced by reduction of the beam lifetime. In the case of 0.2 hour beam lifetime (for ten seconds), which is considered as a reference for the design of most collimator components, should also be considered! This corresponds to spikes of radiations doses that are up to 10^5 times larger than the average over 200 days of standard operarion! This may definitely limit the performance of the equpment at the RR. Therefore, RA strongly recommended that the estimates of radiation hardness of the equipment at the RR's take into account realistic scenarios of spikes of proton losses induced by drops of beam lifetime, as estimated by the OP team (see, for example, the talk by Mike Lamont at the external collimator review, at `http://lhc-collimation-project.web.cern.ch/lhc-collimation-project/review04-v1.htm`).

It was agreed to have an informal meeting next week. KT will present the results of the absolute radiation doses at the RR's (the required statistics should be available within some days) and TW will review the tolerance for the electronics equipment at the RR's. The goal is to figure out what is the limit during short radiation spikes induced by drops of beam lifetime. Paul Proudlock, who could not attend the meeting of today, will also be there.

3.3 Update on simulations of energy deposition at IR7 with absorbers

AF said that simulations up to the Q7 magnet are not implemented on the FLUKA model of IR7. Simulations are limited by the available CPU power. New processors have been ordered and should be available by January 2005. RA said that the FLUKA could use that cluster setup for collimation studies. Guillaume Robert-Demolaize or Stefano Redaelli should be contacted in order to use the collimator cluster.

Action Items:

- ▷ Compare the quench limit of the superconducting links at IR3 with the expected energy deposition (Ralph Assmann, Bernard Jeanneret, Rob van Weelderen, Christian Rathjen).

- Define the radiation hardness of the equipment at thr RR's of IR7 for spikes of radiation doses during drops of beam lifetime (Thijs Wijnands).
- Provide the absolute values of radiation doses at the RR's of IR7 with and without shielding (Katerina Tsoulou, FLUKA team).

The next meeting will be Friday, November 26th, J.B. Adams room (864-2-B14).

A Update on warm magnet resistance to radiation (S. Ramberger)

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From:  Suitbert Ramberger
Sent:  Wednesday, November 03, 2004 3:26 PM
To:  Ralph Wolfgang Assmann; Mario Santana Leitner; Alfredo Ferrari
Cc:  Willi Kalbreier
Subject:  Heat deposition and radiation on NC magnets in IR3 and IR7

Dear colleagues,

I tried to estimate some effects due to energy deposition on the
normal-conducting magnets in order to give some orientation for
optimizations:

In his presentation on Friday, Mario showed an energy deposition of
38.5kW on the MQW magnets in the 10s loss scenario.  It turns out that
the quick energy deposition of 385kJ will not create any problem for the
magnet *if* it is distributed well over the magnet.  For comparision, the
energy stored in the magnets due to Ohmic losses corresponding to a
temperature increase by 10K on average is about 1MJ in the Water, 5MJ in
the copper, 1MJ in the Insulation and about 50MJ in the yoke.

In a steady state scenario (> 1h) the MQW and MBW magnets can stand a
maximum energy deposition of about 10kW and 15kW respectively *if*
distributed well over the magnet.  However, the higher heat load will
lead to a coil temperature increase of 10K and reduce the life-time of
the magnets by increased aging of the insulation material.  Unfortunately
the quantitative relationship is not known.

As Igor showed in his presentation, there will be heat spots on the
front parts of the coils.  For an MBW for example, the outermost
conductor of the pancake closest to the beams will also be the hottest
from the heat up by the Ohmic losses.  Close to it on the connection side
are the thermo-switches which will trigger at about 65degC. This
temperature corresponds to an additional heat up of the coil by about
15K. This temperature rise could be reached by heat deposition of 1-2kJ
in a small region on the mentioned conductor, e.g.  in 5cm3 of the
conducter above the vacuum chamber by a deposition of 20W/cm3 during
10s.  This failure is reversible and no particular damage on the magnet
would result.  Any such failure should be avoided though.

I must also mention, that this failure mechanism is only one of several
similar that could be envisaged, and that they clearly depend on the
distribution of the energy deposition.  I am ready to study other
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scenarios that turn up in the simulations.

In the long run, I would rather see the accumulated radiation dose on the insulation as the major factor for magnet failure. In order to stay within the limits that are known from material tests and with respect to the discussion in the last collimation working group, I suggest that the radiation dose should be kept well below 3MGy/year to guarantee a theoretical (as it does not take into account aging at elevated temperatures) life-time of at least 10 years. As the simulations for IR3 show, this should be achieved with the absorber before the MBW proposed in the talk of Igor. In my opinion, a similar solution must be considered for IR7 as well. As the simulations also show, passive absorbers can deliver factors of improvement in radiation dose, they are much cheaper than a magnet and should not deteriorate over time.

Best regards,
Suitbert