Stefano Redaelli, 17-02-2005

51^{st} Meeting of the LHC Collimation Working Group, February 14, 2005

Present: Oliver Aberle, Ralph Assmann (chairman), Alessandro Bertarelli, Hans Braun, Sergio Calatroni, Samy Chemli, Paul Collier, Bernd Dehning Gianluca Guaglio, Alexej Grudiev, Roberto Losito, Matteo Magistris, Catherine Magnier, Manfred Mayer, Yvon Muttoni, Andy Presland, Rosario Principe, Paul Proudlock, Stefano Redaelli (scientific secretary), Stefan Reosler, Francesco Ruggiero, Guillaume Robert-Demolaize, Mario Santana Leitner, Katerina Tsoulou, Vasilis Vlachoudis.

1 Infrastructure layout of IR7 (P. Collier)

1.1 New layout of IR7

See slides at http://www.cern.ch/lhc-collimation/files/PCollier_2005-02-14.pdf

Paul Collier (PA) showed the latest design of the IR7 infrastructure layout. He pointed out that an ECR which contains the details of this layout is being published. PC showed the transverse cross section of the tunnel at IR7 (see page 2 of his slides). A special design of the air duct has been integrated and mosto cable trays are put at the transport side of the tunnel. The duct has a rectangular shape (it is not round like in the previous solution) and is located on the lower part of the tunnel (see scheme at page 2 of PC's slides).

Even if some details remain to be finalized and the final design has to be worked out, it seems that the proposed layout can achieve the requirements of IR7.

PC also pointed out that the new layout has the drawback of reducing the available space for transport. The transport of local warm magnets of IR7 is critical but possible. On the other hand, the main arc dipoles cannot be transported safely through IR7 once all the IR7 elements and cables will be installed. This may impose some restrictions on the installation timing.

PC also commented on the fact that the experience with other CERN accelerators shows that a critical issue for high radiation areas is the activation of the concrete floor. Mobile concrete panels may be considered as a possible solution to reduce the radiation levels of the floor at IR7. But this poses obvious installation problems.

1.2 Discussion

The presentation of PC triggered discussions on various issues related to air ventilation and activation. PC asked what is the required ventilation and the air cooling. Rosario Principe (RP) replied that 15 fan coils are foreseen for IR7 and that the required cooling power is of 35 kW per area. The exact positions will be defined by the integration group. All the required components are available and the definition of the positions should not be an issue.

There was some concern about the location of the ventilation end wall. RP stated that placing it closer to Q4 would be a preferred solution. Actually, RA and Stefan Roesler said that the latter option was originally foreseen because it is better for the radiation dose at the UJ76. Therefore, it was decided that the **last ventilation wall** should be placed **close to Q4**.

RA pointed out that we still do not have estimate of the ozone activation of the air. This issue should be followed up.

There was also some discussions about the issue of water activation. RA reminded that originally it was asked to have an independent chilled water system for the collimators. This option was excluded because (1) it implies a more complicated installation; (2) calculations by Stefan Roesler (SR) showed that the water activation from the collimators is comparable to the contribution of the warm magnets or IR7. It was therefore decided to connectthe collimator cooling system to the same water circuit as the other magnets at IR7. RP said that the design approved in 2002 (see LHC-FW-ES-0001 and LHC-FU-ES-0001) does not foresee any specific system for the recuperation of the demineralized water in case of failure or maintenance. This is today the scenario in case of bake out of the collimators or in case of maintenance of the warm magnets: the water quality is checked by the radio-protection service and dispersed in drain when possible, or collected in appropriate tanks if activated. SR replied that this is not going to be possible because the water of the IR7 has to be considered as radioactive. RP said then this information is important to know. Today we are close to the installation phase and a decision has to be taken rapidly. A modification of the LHC raising system or the construction of a separate circuit for the recuperation of the bake out water has big implications in terms of design, lay-out, etc. Nevertheless, it should be possible to **isolate the water of the IR7 section from the rest of the circuit** and to recuperate it in tanks before performing bake out. This option has to be followed up.

Bernd Dehning asked if the powering cables for the collimator motor will be put close to the measurement cables. This should not be the case because otherwise the measured signal could be considerably disturbed by the electromagnetic noise. RA agrees. The signal pollution has been an issue for other particle accelerators, like for example for Fermilab. PC stated that two trays are available for the collimator cables. It should be possible to arrange the cabling such as to separate powering cables from measurement cables. Since the available space with the new layout is more than what was originally foreseen for the collimator cables, no new limitations have been introduced in this respect.

RA asked how long it will take to access IR7 after machine shutdown. PC replied that the access to the UJ76 should be granted with no veto without circulating beam. SR said that the duct air should be flushed before accessing UJ76 (the air at UJ76 is coupled with the one in the tunnel) and this may required approximately 1 hour.

Stefan Roesler pointed out the the material of the duct should be properly chosen. Metals should be avoided because they will be activateed. In addition, a system for the stabilization of the flow rate through the collimation area is required. Some remote opening of the sealed IR7 regions would be useful. RP replied that the flow rate will be fixed to 750 m^3/h with an extraction fan. Concerning the material used in the duct construction, the detail of the contractor's proposal will be presented by CV to SC and discussed before execution.

2 Update on radiation doses at the RR's of IR7 with absorbers (K. Tsoulou)

See slides at http://www.cern.ch/lhc-collimation/files/KTsoulou_2005-02-14.pdf

Katerina Tsoulou (KT) presented the simulation results of radiation doses with the latest layout that includes the active absorbers (TCLA's) at IR7. As discussed at the last collimation working group meeting, the doses were calculated with two different positions of the `TCLA.A7R7.B1` absorber, which is located downstream of the dogleg magnets to protect the dispersion suppressor. This absorber could be located either upstream or downstream of the *chicane* proposed to protect the RR's. Upstream of the dogleg, three other absorbers are installed to shield the Q6 superconducting quadrupole. This is the same layout used in the energy deposition studies, as discussed in the last collimation working group meeting (see also next sections).

KT's simulations show that the overall doses in the IR7 regions are similar for the two considered positions of the `TCLA.A7R7.B1` absorber. The layout with absorber **before** the *chicane* seems better because in this case the doses at the RR's and at the UJ are smaller by approximately a **factor 3**. However, it should be noted that this is not a big factor compared with the statistical uncertainty on the simulations results.

The total achieved dose at the UJ76 is of a few Gy/y and this is not affected much by the new absorbers. It seems difficult to further reduce the dose at the UJ76 without additional shielding.

Roberto Losito (RL) asked what is the difference between the doses at the ground floor and at the first floor. This will have an impact on the choice of the location of the collimator electronics. Paul Proudlock (PP) says that as a general rule we should reasonably assume that the doses are of 5×10^8 particles/cm^2/s (some local shielding could be used to reduce the doses on the ground level if necessary). Ralph Assmann stated that it is still to early to conclude if we can put the collimator electronics at the UJ76. RL is following up this issue.

3 Update of energy deposition studies at IR7 with the new absorbers (M. Santana)

See slides at http://www.cern.ch/lhc-collimation/files/MSantana_2005-02-14.pdf

3.1 Simulation results

Following up the discussions of the last collimation working group meeting, Mario Santana Leitner (MS) calculated the energy deposited in IR7 for the new layout with four active absorbers (TCLA's). Notably, the fourth absorber `TCLA.A7R7.B1` is placed at the longitudinal location $s = 20243.94$ m with respect to IP1 (same layout as considered by KT, see previous section). It was noted that another location has actually been proposed. Results with this new location are not yet available but the expected differences are small.

Simulations show that with these 4 absorbers the deposited energy in the cold magnets is below the assumed quench limits of 5 mW/cm^3, with safety factors larger than 2. Indeed, it seems possible to reduce the number of absorbers from 4 to 3 while staying below the quench limit. Future simulations will assess if this is the case.

MS also showed simulations of RF finger heating. In the worst case, i.e. for the first secondary collimator, there is an highly asymmetric energy deposition in the RF finger. The peak deposited energy is approximately **80 W**.

MS estimated the energy deposited in the epoxy of the warm quadrupoles. In the worst case, an average power of 37 mW/cm^3 is deposited in the epoxy of the MQW coil out of the total 43.9 kW deposited in the magnet.

For future simulations, the FLUKA team should (1) consider the new location proposed for the `TCLA.A7R7.B1` absorber and (2) investigate the possibility of reducing the number of absorbers from 4 to 3 by eliminating one TCLA upstream of the dogleg. These studies will take 4 weeks to accumulate the required statistics. After that, the layout of IR7 can be frozen. PP and Samy Chemli said that this deadline is compatible with their needs.

RA pointed out that passive absorbers should also be considered to protect the warm elements. Space has been reserved for these absorbers, which are big blocks of metal to be placed in from of some warm magnet (See the presentation by Igor Kurochkin at the 45th LHC Collimation working group meeting of October 29th, 2004).

4 Cleaning efficiency with new absorbers (G. Robert-Demolaize)

See slides at http://www.cern.ch/lhc-collimation/files/GRD_2005-02-14.pdf

Guillaume Robert-Demolaize presented preliminary results of cleaning inefficiency and loss maps around the LHC ring with the new IR7 layout. The comparison with the cleaning performance of the old layout with no absorbers shows that the cleaning inefficiency above $10\,\sigma$ is reduced by almost a **factor 10** if the 4 new absorbers are taken into account. The same locations as used for the FLUKA simulations (see previous sections) have been considered. More studies are ongoing.

4.1 RF-finger heating and trapped mode damping in the LHC collimator (A. Grudiev)

See slides at http://www.cern.ch/lhc-collimation/files/AGrudiev_2005-02-14.pdf

Alexej Grudiev (AG) gave an update on trapped mode simulations for the collimators. Following up the request of the last collimation working group meeting, AG calculated the heating of each RF finger individually and found that the power is not evenly distributed. By considering the proper material for the fingers (CuBe) AG finds that at top energy (nominal beam parameters) the maximum energy absorbed in the fingers is 3.5 W without coating and **2.0 W with silver coating**.

The possibility of damping the mode at ≈ 1.2 GHz with ferrite was investigated. It is found that adding ferrite is very effective for damping this mode. The quality factor of the mode can be reduced to negligible values. In this case, the second predominant mode will become important (0.6 GHz). The overall reduction of deposited energy by using ferrite is about a factor 10.

Francesco Ruggiero (FR) pointed out that adding ferrite could also help in reducing the transverse impedance and he would therefore be interested in considering this option, though the gain is marginal. However, there is a general consensus that adding ferrite to the present collimator design is very tricky, in particular in the locations proposed by AG, and should not be done unless there are strong reasons to do so. Nevertheless, RA encouraged the people involved to find possible solutions to add ferrite to the present design. If this is not possible, we will stick to the present design. This investigation should not delay the finalization of the drawings.

4.2 RF fingers for secondary collimators (S. Calatroni)

See slides at http://www.cern.ch/lhc-collimation/files/SCalatroni_2005-02-14.pdf

Sergio Calatroni (SC) gave an overview of the recent work on design and test of the RF fingers for the LHC secondary collimators. Details are available on the slides of his presentation. Here, we point out that:

- The contact resistance of the entire set of fingers has been reduced to $0.5\,\mathrm{m}\Omega$. FR confirms that this value is acceptable for impedance considerations.
- If needed, the contact resistance between the carbon jaw and the fingers could be further decreased to approximately $0.03\,\mathrm{m}\Omega$ by fixing the fingers to the carbon jaw through a intermediate brazed metal plate.
- Copper-Beryllium alloy with high conductivity must be used for the finger. This is the only choice that ensures a finger survival for the entire life of the LHC. Alloys with

lower conductivity may reduce their elasticity and eventually lose it completely after many cycles at high temperature.

- SC has the feeling that the thickness of the finger must be 0.5 mm.

RA welcomed these results and congratulated of the people involved for the excellent work. It concluded that we should go ahead with the proposed design for the fingers.

Action Items:

▷ Simulations of deposited energy in IR7 with the final absorber position. Investigate the possibility of reducing the number of absorbers from 4 to 3. IR7 layout should be frozen in 4 weeks. (FLUKA team)

The next meeting will be February 28, 14:30, Adams room.