Stefano Redaelli, 13-02-2004

35$^{\text{th}}$ Meeting of the LHC Collimation Working Group, February 6, 2004

Present: Ralph Assmann (chairman), Igor Baichev, Cathelijne Bal, Alessandro Bertarelli, Hans Braun, Markus Brugger, Helmut Burkhardt, Bernd Dehning, Gianluca Guaglio, Barbara Holzer, Jean-Bernard Jeanneret, Verena Kain, Matteo Magistris, Christian Rathjen, Stefano Redaelli (scientific secretary), Guillaume Robert-Demolaize, Peter Sievers, Marco Silari, Jan Uythoven, Vasilis Vlachoudis.

1 AOB

- The meeting was opened by Ralph Assmann (RA), who announced an update of the collimation installation at IR7. As originally foreseen, at the LHC startup the Phase I collimation system will have 30% less collimators than what corresponds to the space allocated for the full system. In order to reduce installation cost and effort, one primary collimator and five secondary collimators will not be installed. This reduces the total number of collimators in IR7 from 20 (4 primaries + 16 secondaries) to 14 (3 + 11). The corresponding reduction of the system efficiency is 10% and can be recuperated by later introduction of all collimators.
- Stefano Redaelli reported a message from Daniel Schulte (DS), who could not attend the meeting. DS proposes to present at the next Collimator WG the results of his study on collimator impedance, carried out with the `GDFILD` code.

2 Power deposition in the vacuum chamber of IR3 (J.B. Jeanneret)

J.B. Jeanneret (JBJ) presented the results of the studies that he performed with Igor Baichev (IB) on the power deposition in the vacuum chamber of IR3. This is reported in detail in the note `AB-Note-2003-085`. The motivation for these studies is a change of design of the vacuum system at the MQWs. Previously it was foreseen to have a four-fold symmetry chamber to be installed between the poles, very close to the iron yoke. This chamber caused problems in the magnet assembly and therefore it has been substituted with a smaller, elliptical chamber. An easier magnet assembly procedure (the elliptical pipe can simply be pulled into the assembled magnet) is preferred at the expenses of a smaller cooling efficiency of the refrigeration system, due to the reduced contact of the vacuum chamber with the iron yoke. In addition, the vacuum chamber must be baked-out and therefore insulated any beam-induced heat deposition will not be evacuated efficiently via the magnet yoke.

Simulations were performed with the `K2` and `MARS` codes and were still based on the optics version `v6.2` by using carbon collimators instead of copper and aluminium. A circular beam pipe is assumed. The simulations show that the quadrupoles most exposed to possible overheating are the `Q5L` (second element) and the `Q4R` (last element). For a minimum beam lifetime of **1 hour**, a maximum power deposition of **2.7 kW** is expected on the vacuum pipe (the length of the chamber is 3.3 m). On the base of the assumption that the thermal excursion of the chamber should not exceed 75° (steady situation) in order to avoid excessive out-gassing, the maximum steady power deposition on the chamber should be **1 kW**. This is probably too much in presence of bake-out systems. Therefore, the conclusion of JBJ is that a capillary cooling system should be envisaged if the present specification for minimum beam lifetime have to be kept. RA proposed that, once we have a proposal with AT/VAC, a decision must be taken at the LTC.

Christian Rathjen (CR) confirmed that the power deposition predicted by JBJ and IB can indeed induce out-gassing problems (power depositions below ≈500 W/m would not be a problem). On the other hand, the vacuum chamber will not be mechanically damaged by such energy deposition, nor the magnets will be over-heated. CR suggested to perform other simulation with the nominal aspect ratio of the elliptical vacuum chamber (JBJ calculations simulations had a slightly different value). IB and JBJ replied that new results can not be expected before several weeks.

JBJ also mentioned that a dose rate of 20 MGy over 20 years is expected at the MBW chambers assuming a beam lifetime of 90 hours. This numbers depend mainly on the total number of protons lost, not so much on beam lifetime.

3 Energy deposition on secondary collimators at IR7 (V. Vlachoudis)

See slides at http://www.cern.ch/lhc-collimation/files/VVlachoudis_06Feb2004.pdf.

V. Vlachoudis (VV) presented his results on the energy deposition on IR7 first collimators after a beam impact on the upstream primary collimators. His simulations have been carried out with the nominal geometry of the collimators and a simplified geometry of the beam pipe and the rest of the equipment. The case-study of a 7 TeV pencil-beam, with impact parameter of 200 nm, has been considered for the cases without (Phase I collimation system) and with (Phase II system) hybrid collimators. Simulations are done for a beam lifetime of 0.2 hour. The input of the simulations is based on beam loss maps on the collimators provided by RA. Three different maps (horizontal, vertical and 45 degree tilted halos) have been used, which show similar energy deposition scenarios. VV has found that most energy is deposited on the secondary collimators. Other components do not affect considerably the shower and are less exposed. A typical value of maximum deposited energy is 30 W/cm^3. Nevertheless, a significant amount of energy is also absorbed by the MQW modules. A total intercepted power of 233 kW is expected ($\approx$120 kW go into the tunnel) over the considered range of machine (500 kW total loss).

According to the results of VV, a peak deposition of $\approx$30 W/cm can be expected on the beam tube, right after the secondary collimators. RA pointed out that this vacuum pipe heating could be a problem outside of magnets. CR confirmed that the pipe over-heating could indeed be a problem because the beam pipe is well insulated (no flowing air). One should keep in mind that additional water cooling of the beam pipe might be required also after the secondary collimators. Movable, water cooled absorbers might also be envisaged.

IB raise the following point: The contribution of the impacting beam halo should also be properly taken into account. His two year experience suggests that the secondary beam halo could be the main source of the peak density of energy deposition. RA replied that this was done, but welcomed checks.

Bernd Dehning suggested to consider also the case of a beam which has not the nominal divergence and is not parallel to the beam pipe. What are the effects of beam angles on the energy deposition?

During the discussions it was mentioned that in the layout of IR3 and IR7 no specific space was included nor requested for the BLMs between the collimators. A space of approximately 50 cm, as close as possible to the beam, is needed per BLM. There are about 50 cm between collimator tanks, but additional equipment is installed there (e.g., vacuum pumps). This issue has to be followed up.

4 Radiation issues for the LHC collimator test at TT40 (M. Magistirs)

See slides at http://www.cern.ch/lhc-collimation/files/MMagistris_06Feb2004.pdf.

Matteo Magistiris (MM) showed his results of `FLUKA` simulation to estimate the energy deposition and the radiation damage to electronic equipment expected for the LHC collimator test at TT40. His approach was to use a simplified but complete modelling of the geometry of the experimental area. All the elements of interest are included in the simulations. A map of the expected silicon damage (1 MeV neutron equivalent fluence) upstream of the collimator was provided. At this location, the dominant contribution is given by neutrons. A maximum energy of 250 J/g is deposited in the collimators if the case of 4×72 bunches of 10e11 protons, with a sigma of 1 mm is considered. Note that the value of 600 J/g, presented by MM at the meeting, refers to a beam with a 1 mm FWHM. The deposition in the window is of approximately 10-100 J/g (both in the carbon layer and in the AlTi layer), where the largest value refers to a small region around the beam axis.

A rough estimate of the residual radiation predicts about $25\,\mu$Sv/h after one day at one metre distance from the steel pipe and $7\,\mu$Sv/h from the collimator (after one week, these numbers reduce to $10\,\mu$Sv/h and $2\,\mu$Sv/h, respectively). This is a limited estimate because known important contributions, such as the one of the concrete support, are not included. Nevertheless, these numbers suggests that the access to the tunnel should be carefully planned in the first days after the collimation test. MM will give the final version of his presentation to the people concerned. RA concluded that these results suggest that no fundamental problems are expected for the collimators or downstream equipment at the TT40 test.

Colleagues from BDI should decide whether their equipment can stand the expected radiation dose. In this respect, Barbara Holzer and Bernd Dehning would like to have additional information to estimate if the beam loss monitors (BLMs) can survive and to estimate the expected signal. Survival should be no problem, as other equipment was shown to be safe. In particular, it would be useful to know the irradiation of ionizing particles on the nitrogen and on other components of the BLMs. The best solution is probably to propose tentative locations for the BLM and then to ask MM to provide the fluxes expected at the TT40 test in those specific locations. This is not time-critical.

The next meeting will be announced.