Stefano Redaelli, 02-12-2004

47^{th} Meeting of the LHC Collimation Working Group, November 26, 2004

Present: Ralph Assmann (chairman), Alessandro Bertarelli, Nuria Catalan, Bernd Dehning, Gianluca Guaglio, Eva Barbara Holzer, Matteo Magistris, Laurette Ponce, Suitbert Ramberger, Christian Rathjen, Stefano Redaelli (scientific secretary), Guillaume Robert-Demolaize, Stefan Roesler, Mario Santana, Ruediger Schmidt, Markus Stockner, Guy Suberlucq, Helmut Vincke, Vasilis Vlachoudis.

1 BLM data from the collimator tests at SPS and TT40 (B. Holzer)

See slides at http://www.cern.ch/lhc-collimation/files/BHolzer_2004-11-26.pdf

Eva Barbara Holzer (EBH) discussed the BLM measurements carried out during the collimator tests with beam at SPS and TT40.

1.1 SPS test

Eight ionization chambers, installed a few meters downstream of the collimator, were used during the SPS tests. Two sets of 4 chambers were installed at a distance of 9 m and 12 m from the collimator. In order to study the azimuthal distribution of losses, the 4 chambers at each location were transversally placed at angles of $\pi/4$, $3\pi/4$, $5\pi/4$ and $7\pi/4$ around the vacuum chamber (see scheme in EBH's presentation, page 3).

BLM data were acquired during all three collimator MD's at the SPS of 4th October (preliminary tests), 11th October (first MD) and 18th October (second MD). Already in the preliminary tests it was noticed that the BLM signal showed long time decays if the collimator jaw was left inside the beam tail, at a fixed distance from the beam centre. Originally it was feared that this effect was induced by a long decay time of the BLM signal (see minutes of the 44th collimator working group meeting of 08/10/2004). On the other hand, dedicated measurements on October 11th demonstrated that the measured tails are instead induced by an outwards **diffusion of beam particles**.

The comparison of the various BLM's placed at the same longitudinal distance from the collimator shows that in some cases there are differences up to **30 %** between the monitors on the left and on the right side of the beam. The differences between top and bottom sides are of a few percent. These asymmetries of beam losses are still under investigation.

The activation of the BLM's was studied by measuring the losses when moving the collimator jaw inside and outside of the beam as fast as possible. This procedure was limited by the program for controlling the jaw motors. The jaw positions must be set by hand and this determines a minimum time before moving out the collimator (see EBH's slides, page 9). The preliminary measurements indicates that the signal is reduced by a factor 5000 after 4 seconds. Basically, no activation is observed.

1.2 TT40 test

Four ionization chambers and a secondary emission monitor (SEM) were installed at TT40 in the vicinity of the collimator. A layout of the BLM installation can be found in EBH's slides. The collimator locations were decided based on simulations by Matteo Magistris (see minutes of the 35th meeting of the collimation working group, held on February 6th, 2004). EBH said that the measured signals agree within the precision of the simulations (factor 2 or 3). The simulations were performed with coarse binning and low statistics in order to find appropriate positions for the BLMs (simulations should be re-run for precision comparisons with measured data).

BLM data were acquired for different beam intensities when the beams impacted on the collimator jaws and on the TED. For the maximum intensity of approximately 10^{13} protons (4×72 bunches), scans with different jaw impact parameters were also performed. As expected, for a given impact parameter, the measured BLM signals increase with the beam intensity. There is also a dependence on the BLM signal on the impact parameters. There are small differences when the beam impacts on the carbon-carbon and on the graphite jaw. More studies are ongoing.

1.3 Discussion

Ruediger Schmidt asked if there have been simulations of BLM activation. Bernd Dehning (BD) said that this is not the case. Stefan Roesler said that he can provide the data on isotope production in steel.

Vasilis Vlachoudis asked what is the error bar on the presented BLM's data. EBH answered that the error is below the 5 % level.

Ralph Assmann (RA) said that there are some urgent questions that require an answer soon: (1) how many BLM's have to be installed per collimator? (2) where will they be positioned? (3) do we want to use the machine protection BLM's also to adjust the collimators of will we have an independent system? BD said that the answers to questions (1) and (2) should be taken by the end of January. RA proposed to have a meeting in January to discuss the final decision.

Matteo Magistris said that it is important to know if the BLM locations have to be adjusted for each collimator depending on its azimuthal angle.

2 Update on energy deposition studies at IR7 (M. Santana)

See slides at http://www.cern.ch/lhc-collimation/files/MSantana_2004-11-26.pdf

Mario Santana (MS) presented the latest results on the IR7 energy deposition studies. The curved tunnel of the arc have been added to the FLUKA model of IR7. The geometry has been automatically generated from a MADX Twiss file. The first simulation results indicate that up to **0.3 W/cm^3** can be deposited in the dipole coils. This is within the quench limit. In the first quadrupole, up to **1 W** can be expected. The quoted results have error bars up to $\approx 50\,\%$ due to the poor statistics accumulated so far.

MS also estimated the energy deposited in the flanges of the collimator. On the downstream flange, **457 W** are expected (10 s transient). The energy deposition is not azimuthally symmetric but differences up to a factor 10 are found at different locations in the flange. It is expected that asymmetries will be flattened when beam 2 will also be considered.

2.1 Discussion

Christian Rathjen said that the quoted number might induce problems for the collimator flanges. He proposed that some test should be done to see if the flanges can stand the expected thermal gradient.

RA said that the next step should be estimate the total dose per year in the magnet coils.

Regarding the studies of radiations doses at the RR's of IR7, Vasilis Vlachoudis said that Katerina Tsoulou has implements a *chicane* for shielding the RR's. The first results of her simulations should be available by the next collimator working group meeting.

3 2-D thermo-mechanical analysis of the injection accident case (A. Bertarelli)

See slides at http://www.cern.ch/lhc-collimation/files/ABertarelli_2004-11-26.pdf

Alessandro Bertarelli (AB) reviewed the thermo-mechanical simulations performed with ANSIS for the injection accident case, i.e. the case of four full intensity batches of 72 bunches at 450 GeV/c impacting on the collimator jaw. In particular, AB focused the attention on the expected heating of the collimator jaw, for a comparison with the measured data at the TT40 robustness test (see next section).

After the passage of the 4 batches, i.e. 7.2 μs after the beam starts interacting with the collimator jaw, it is found that the instantaneous peak temperature at the downstream side of the carbon-carbon (CC) collimator jaw is 350°C. For the graphite jaw, the expected value is 322°C. On the upstream side, the instantaneous temperature are approximately 55 times smaller. At the location where the temperature sensors are installed in the TT40 collimator (see next section), the expected peak temperature rise on the downstream side should be up to 30°**C**. The time constant for the temperature decrease should be of the order of $\tau \approx 15\,\mathbf{s}$ (cooling with water at 27°C is assumed).

4 Measured temperature of the TT40 collimator during the robustness test (G. Robert-Demolaize)

See slides at http://www.cern.ch/lhc-collimation/files/GRD_2004-11-26.pdf

4.1 Measurements results

Guillaume Robert-Demolaize (GRD) presented the measured temperature of the TT40 collimator jaw with impacting beams of different intensities and impact parameters. Four PC100 temperature sensors were installed on each collimator jaw, 2 on the upstream side and 2 on the downstream side. The temperature measurements were recorded at the end of each SPS super-cycle, i.e. with a sampling time of approximately 30 s. Unfortunately, it was not possible to record data with a shorter sampling time. Data were recorded with impacting proton beams at 450 GeV/c, in the two following experimental conditions:

- increasing beam intensity from 7.00×10^{12} p to 3.13×10^{13} p, for fixed impact parameter of ≈ 5 mm;
- 5 different impact parameter (variations is steps of 1 mm) at the maximum beam intensity of $\approx 3.0 \times 10^{13}$ p.

The same measurements were repeated for both collimator jaws. It is noted that during the test the various sensors stopped working one after the other, most likely due to radiation. It is believed that the delicate connecting cables might have experienced some problems and caused the measurement to fail, because the sensors themselves are radiation hard. This will be verified as soon as we will be able to access the collimator at TT40. Nevertheless, at least one sensor survived until the end of the TT40 test. It is also noted that there is an uncertainty on the cable connection of the eight available sensors. This uncertainty will be solved by re-checking the sensor cabling.

Action: Check the cables connections of the temperature sensors of the TT40 collimator prototype (F. Decorvet, R. Losito).

GRD found that the peak temperature variation of the jaws after the beam impact increases for increasing beam intensities. However, the peak values do not always increase linearly with the beam intensity as expected. This feature requires more understanding. The **maximum measured jaw heating** is of 20°**C**.

The jaw heating also depend of the impact parameter. For fixed beam intensity of $\approx 3.0 \times 10^{13}$ p, the temperature increases of the carbon-carbon jaw ranged between 3°**C** and 20°**C** for impact parameters between **1 mm** and **6 mm**.

The temperature recovery in time after the temperature rise shows an exponential behaviour with **time constants** up to **25 minutes**. This is much larger than what is expected according to the simulations by AB.

4.2 Discussion

RA said that the maximum measured temperature rise of the collimator jaw is consistent with the expectations from the simulations by AB. The maximum temperature increase of 20°C suggests that the collimator did not experience major thermal problems. In any case, the collimator will be checked in detail when we will be able to take it out from TT40.

A. Bertarelli is worried by the large discrepancy of the temperature recovery times. The simulations foresee decay times of 15 s whereas the measurements indicate times up to 25 minutes and more. Helmut Vincke suggested that one could actually have measured the temperature rise of the PC100 sensors, which are made of metal, instead of the carbon jaws. This could be possible if the sensors were not in good thermal contact with the carbon. The heating could be induced by the radiation directly deposited in the sensors.

5 Comparison of expected and measured remanent radiation doses at TT40 (H. Vincke)

See slides at http://www.cern.ch/lhc-collimation/files/HVincke_2004-11-26.pdf

Helmut vincke (HV) commented on the remanent radiation doses at TT40. After a cooling time of **two weeks**, the measured remanent dose at the collimator is of **0.95 mS/h**. Simulations predicted a does of **1.1 mS/h**. There is an excellent agreement between simulations and measurements!

6 Paper submission to PAC05 (round table)

RA showed the list of proposed abstract related to LHC collimation issues, as they will be submitted to Steve Myers for approval. RA encouraged the submitting authors to send their abstract the the AB head office by today for the department approval.

7 A.O.B.

In the second week of December an LHC Machine Advisory Committee will take place. RA has two talks on the LHC collimation system. He will give a rehearsal of these talks at the next collimation working group meeting, scheduled in two weeks.

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Action Items:

- Verify the connection of the temperature sensors of the TT40 collimator (F. Decorvet, R. Losito).

The next meeting will be Friday, December 3rd, J.B. Adams room (864-2-B14).