Stefano Redaelli, 27-04-2005

56th Meeting of the LHC Collimation Working Group, April 25, 2005

Present: Oliver Aberle, Ralph Assmann (chairman), Markus Brugger, Helmut Burkhardt, Alfredo Ferrari, Massimo Giovannozzi, Igor Kuzochkin, Matteo Magistris, Manfred Mayer, Elias Métral, Laurette Ponce, Andy Presland, Suitbert Ramberger, Stefano Redaelli (scientific secretary), Guillaume Robert-Demolaize, Adriana Rossi, Mario Santana Leitner, Vasilis Vlachoudis.

1 Collimator impedance: SPS measurements vs theory (E .Métral)

See slides at http://www.cern.ch/lhc-collimation/files/EMetral_2005-04-25_1.pdf

See slides at http://www.cern.ch/lhc-collimation/files/EMetral_2005-04-25_2.pdf

See slides at http://www.cern.ch/lhc-collimation/files/EMetral_2005-04-25_3.pdf

Elias Métral (EM) summarized the latest studies of tune shifts induced by the collimator impedance. The tune measurements as a function of the collimator gap performed at the SPS are compared with the expectations from theory. EM gave a comprehensive description of the latest refinements of the theoretical models used to predict the collimator impedance. Notably, the measured values of beam intensity and bunch length and the measured values of surface resistance of the jaw ($\rho = 10\mu\Omega$m) are now properly taken into account in theory. Details of the calculations are available in the slides of EM's presentations.

In conclusion, the linear theory for the collimator impedance **agree very well** with the measured tune shift induced by the collimator at the SPS, for **gaps above** $\approx$ 1.75 **mm**. The **discrepancy** between theory and measurements for **smaller gaps** is at most a **factor 2**. It is noted the estimated **error** on the theory is of the order of **50%** and is mainly induced by the effects related to the uncertainty on the bunch shape.

EM pointed out that there have not been measurements of **inductive by-pass effects** during the SPS test. This could be an issue for the LHC and hence it should be foreseen to measure this effect at the SPS in the 2006 run, even if from the theoretical point of view we are now very confident that his effect exist (all different formalisms converge, i.e. there is no more discrepancy with the theory by Bruno Zotter by a factor 100 as it was found in the past).

1.1 Discussion

Ralph Assmann (RA) welcomed the good results of the many people involved in the impedance measurements and in the theoretical understanding of the SPS experimental results.

RA agrees with EM on the importance of the inductive by-pass effects. RA said that dedicated measurements should definitely be foreseen for the SPS tests in 2006 and encouraged everybody to propose ideas to measure this effect.

Stefano Redaelli (SR) pointed out that the centre of the beam with respect to the collimator gap was not systematically measured during the impedance measurement. SR asked how sensitive the results are on the beam centring. EM replied that his model cannot take into account misalignments of the beam with respect to the beam but Frank Zimmermann's program can. EM will transmit this request to FZ.

There was also some discussion about the **PAC2005 paper** on collimator impedance. Helmut Burkhardt (HB) is the submitting author and will prepare as soon as possible a draft version of this paper. HB said that there will be a lot of material for this paper, which cannot be a complete and detailed description of all what has been done. He hence proposed

to focus on the main experimental achievements and to leave a more complete overview of the theoretical studies for more detailed publications. RA agreed and said that we should try to publish our complete results in a journal paper as soon as possible.

For the estimation of the **total contribution from the collimators to LHC impedance**, EM asked the settings of all the collimators in the ring (not only primary and secondary collimators of IR7 as it has been considered so far). Guillaume Robert-Demolaize will provide the requested information as soon as possible.

2 Update on vacuum pump functional specifications (A. Rossi)

See slides at http://www.cern.ch/lhc-collimation/files/ARossi_2005-04-25.pdf

Adriana Rossi (AR) gave an update on the vacuum pump functional specification and on the status of the pumping module order. In the pumping module integration, Christian Rathjen could **reduce the number of module types** with respect to what was presented at the 53rd meeting of the collimation working group of March 14th, 2005. Only **four variants** will now be required for the LHC instead of the originally foreseen eight variants. Notably, this reduction has been made possible by accepting tapering angles larger than 15 degrees in the transition. This modification has been approved by Francesco Ruggiero, who confirmed that it will induce no problem for the LHC impedance.

AR asked for approval for the following geometrical and mechanical functional specifications of the pumping modules:

1) The module should guarantee an aperture diameter of 60 mm in all positions during operations. This aperture was accepted by Jean Bernard Jeanneret because it is not smaller than the aperture bottlenecks of the quadrupoles at the warm insertions.

2) The pumping modules shall compensate up to 10 mm transverse displacement, to be obtained with a force below 500 N.

3) The pumping modules should compensate for thermal expansion during bake-out.

4) The module installation should proceed with collimators in the position of zero transverse displacement (vertical direction).

5) During bake-out, the maximum transverse displacement between the pumping module and the near-by collimator is 3 mm.

In particular, the items (4) and (5) require that the collimator should be moved back to the zero vertical position during bake-out. AR said that they are ready to buy some prototypes in these functional specifications are approved by the collimation working group. Notably, some measurements of impedance are foreseen to check if the proposed design is acceptable for the LHC impedance budget.

There was a general agreement with the proposed functional specifications and hence RA encouraged to go ahead with the production of the pumping modules. RA commented that we will certainly be able to align the collimators to the near-by pumping modules to within better than 3 mm. AR should provide more precisely **the tolerance** in the relative alignment as required during the bake-out.

RA also asked how many spares are foreseen in the production. AR replied that we will have **10% of spares**. The determination of number of spares that we can pay for needs to be followed up.

3 Energy deposition studies for failure scenarios at 7 TeV (A. Presland)

See slides at http://www.cern.ch/lhc-collimation/files/APresland_2005-04-25.pdf

Andy Presland (AP) presented the results of FLUKA simulations for the asynchronous dump failure scenario at 7 TeV. The simulations have been focused on the effect on the first horizontal primary collimator. Proton distribution at the collimator are generated by RA and Stefano Redaelli. It has been calculated that, in case of misfiring of the beam dump, eight bunches with amplitudes between 5 and 10 beam sigmas might impact on the collimator. More information on this failure scenario can be found at the web page
`http://lhc-collimation-project.web.cern.ch/lhc-collimation-project/AccidentInput.htm`

AP found that a **maximum temperature** increase of approximately **20 degrees** is induced on the hit primary collimator. The output of the FLUKA simulations will be provided to Alessandro Bertarelli, who will perform thermo-mechanical ANSIS calculations. The final conclusion on the collimator behaviour under this failure scenario depend on the results of this simulations. A. Bertarelli will report the results in one of the next collimation working group meetings.

RA asked what is the energy deposited in various component close to the collimators, such as the vacuum flanges. The flange heating is an important issue for the operating machines because large and asymmetric heating can induce leakages. AP can score the particle fluxes at any location and calculate the corresponding heating. AP will report on that as soon as possible in one of the next collimation working group meetings.

4 Update on IR7 energy deposition studies (M. Santana Leitner)

See slides at http://www.cern.ch/lhc-collimation/files/MSantana_2005-04-25.pdf

Mario Santana Leitner (MS) gave an update on the energy deposition studies at IR7. A bug was found in the geometry on the FLUKA model of IR7. This explains some unexpected features such that the highly asymmetric positioning on the beam in the first secondary collimator downstream of the dogleg. After correcting the bug, it has been found that the heat load in the Q6 quadrupole (first cold magnet downstream of the warm insertion) is approximately **40%** larger than what was previously presented but still **within the quench limit**.

MS also investigated the effect of changing material for the active absorbers (TCLA's). He finds that if **Tungsten** is used instead if Copper, the energy deposition in Q6 is **reduced by a factor 4**, from $\approx 0.8\,\mathrm{mW}$ to $\approx 0.2\,\mathrm{mW}$. Alfredo Ferrari commented that this beneficial effect is entirely induced by the larger density of Tungsten. Nevertheless, he also pointed out that this material change is very helpful in decreasing the local protection of some elements close to the absorbers but does not change the loss patterns further downstream, outside of the warm region.

In addition, MS reported that now a more detailed treatment of the magnetic field in bending dipoles is implemented in the simulations. the effect of the bent trajectory is taken into account. The first results show no basic differences with respect to the old results.

4.1 Discussion

RA asked to perform with high priority the comparative study to find the best absorber position among the two slots reserved for the moment (positions "A7R7" and "B7R7" located downstream of the dogleg). This issue is becoming fairly urgent and the final absorber

locations should be given as soon as possible to freeze the IR7 layout. AF replied that this study will require two weeks for accumulating enough statistics. Results will be then reported at the collimation working group meeting.

RA also said that we should consider using Tungsten instead of Copper also for the active absorbers at IR3 and for the tertiary collimators that protect the superconducting triplets. The studies for IR3 will need follow-up by Jean Bernaed Jeanneret.

5 A.O.B.

5.1 Availability of collimator prototypes for laboratory measurements (O. Aberle)

See slides at http://www.cern.ch/lhc-collimation/files/OAberle_2005-04-25.pdf

Oliver Aberle discussed the availability of collimator prototypes for laboratory measurements. The TT40 prototype used for the robustness test is in the radioactive storage and will be completely dismounted to study in detail the effects of the impacts of the high intensity, 450 GeV proton beams. People interested in additional tests on this prototype should be propose some measurements as soon as possible. The prototype will stay assemble until the end of May.

The fully-equipped SPS prototype has been taken out from the tunnel and is available for tests. Notably, Fritz Caspers will perform **impedance measurements with wires**. FC has asked some modifications of the collimator motor control because he needs to have moving gaps at a fixed frequency. Also connection flanges require some modifications. The collimator should be ready for impedance tests in **two weeks**.

In addition, Stefano Redaelli asked to perform **microphonic tests** on the SPS collimator prototype. SR is waiting for the equipment that was used in the TT40 test, which is presently being radiation checked. Markus Brugger will follow up how the radiation measurements are going in order to make the sensors available as soon as possible.

Guillaume Robert-Demolaize asked to perform a cabling check of the **temperature sensors** installed in the TT40 collimators because there was some uncertainty on the sensor connections. OA replied that it is foreseen to verify the sensor connection on the collimator itself but it might be difficult to check the connection of the tunnel cables to trace back the experimental conditions during the tests with beam. OA follow up these checks.

5.2 Report from US-LARP meeting (R. Assmann)

RA reported on the US-LARP activities on LHC collimation studies, as it was discussed in a collaboration meeting held in USA at the beginning of April. RA welcomed the excellent results from our US colleagues, who are actively participating to the LHC collimation studies. In particular, great progress has been made by the SLAC colleagues on the design of a prototype of the phase II collimators. It is planned that they will build a prototype of the rotating collimator to install and test at the LHC.

At Fermilab, N. Mokhov has started some studies on beam losses and background issues at the tertiary collimators of IP1 and IP5. In addition, there is a collaboration with Brookheaven on radiation effect on collimator material. Samples of the material used for the LHC collimator production will be sent at RHIC for radiation tests.

The next meeting will be May 2nd, J.B. Adams.