Verena Kain, 2003-10-16

31st Meeting of the LHC Collimation Working Group, October 10, 2003

Present: Ralph Assmann (chairman), Brennan Goddard, Verena Kain (scientific secretary), Helmut Burkhardt, Gianluca Guaglio, Peter Sievers, Jan Uythoven, Rüdiger Schmidt, Vasilis Vlachoudis, Paul Collier, Roger Bailey, Miguel Jimenez, Bernd Dehning, Alessandro Bertarelli, Ghislain Roy, John Poole

1 Proposal for an LHC Collimator Test in the SPS ring and TT40(R. Assmann) Proposal for a Material Test in TT40 (R. Schmidt)

See slides at http://www.cern.ch/lhc-collimation/files/RAssmann_10Oct03.pdf.

The meeting had been announced to discuss and finalize the draft of a proposal for a collimator test in the SPS written by R. Assmann (RA) and distributed beforehand. The tests could take place before the shutdown of the SPS in 2004.

During the preparation of the proposal for the collimator tests the idea of an additional model validation test for different materials had been brought up. R. Schmidt (RS) presented a proposal for the material test, possibilities for the experiment done along with collimator test or even a joint proposal were discussed.

There will be another meeting on October 20, 2003, to review the questions raised in the meeting of October 10 and to agree on a final proposal. This final version could be sent to the committees on October 21, 2003. The next steps will be a presentation of the topic for approval at the ATC on October 23 and a discussion of the MD plans and required beam time at the APC on October 24.

Three different experiments at two different locations were suggested:

1. Functionality test of single carbon collimator in SPS ring
2. Robustness test of carbon jaw in TT40
3. Model validation/material test in TT40

1.1 LHC Collimator Test in the SPS Ring

Installing a collimator in the SPS ring offers the possibility to test its functionality. The impedance of a carbon jaw could be measured, possible unforeseen HOMs could be investigated, BLMs could be used to get beam loss maps downstream and the vacuum behavior could be checked. It is not foreseen to induce much beam loss, scraping bits of the beam however is envisaged for a few hours of beam time.

Upstream of QF522 was agreed upon as an ideal location for the collimator. The initially considered place at QD519 near already existing collimators and scrapers has the disadvantage of having radiation sensitive equipment of BI around. The location should also be preferable from the point of view of radiation. B. Dehning (BD) is in favor of doing the test in point 4 and not point 5 where it would be less problematic for BI instrumentation. An argument for point 5 is the LHC BPMs which could be tested with collimation (1 LHC pick-up in 4, 5 LHC pick-ups in 5 (J. Wenninger (JW))).

There might be electron cloud experiments in this area (P. Collier (PC)). In order to avoid interference one has to check with the vacuum group. M. Jimenez has not seen any problem.

A vertical collimator would be installed (thus the dispersion at QF522 does not pose a problem). The length needed in the ring would be 3m (50cm+2m+50cm).

1.1.1 Measurements

(For all proposed tests in the SPS ring see slides).
Impedance: B. Goddard (BG) asks whether a single collimator (two opposing jaws) results in a measurable contribution to the impedance. R. Assmann (RA) replies that one collimator - as it could be moved in (minimum gap: $\sim$ 3mm) - should change the impedance by 10% to 20% (calculated numbers for impedance: see slides). The jaws will not have coating. BG thinks it to be a good opportunity to test whether coating sticks. RA says that it is more important to verify impedance estimates. Having a large impedance will certainly facilitate its measurement.
HOMs: P. Sievers (PS) wants to know whether the jaw is expected to get heated. RA says there will be RF heating of 0.5kW/m.

1.1.2 Vacuum Requirements, Installation

According to MJ the vacuum sector where the collimator will be placed is short enough so that 2 valves, one on each side of the of the collimator tank, are sufficient. Spare valves are available, no extra budget is necessary. There will be no bake-out in the ring, it would need too much time. The bake-out will take place in the lab. PS remarks that a bake-out in the ring could be of interest (behavior of the jaw,...).

Alignment of the collimator will not be a major challenge due to a "plug-in-system" for the collimator jaw (A. Bertarelli). The fast replacement of a collimator jaw will be tested.

BG asks whether the motorization concept is already fixed. RA replies that there is no new one for the time being; the LEP-solution is an option. However, it would be useful to have the LHC motors by the time of the experiments in order to test them.

As point 5 used to be a low-β insertion there should be cables around for the collimator test (PC).

1.1.3 Instrumentation

(A summary of the proposed instrumentation can be found on the slides.)
The jaw will be equipped with cooling. J. Uythoven (JU) points out that, for cooling with water, flow meters should be added. For the measurements of the electron cloud induced by the collimator jaw, MJ proposes shielding pick-ups as easiest solution (the availability of cables has to be checked). PS asks what the micro-phonic sensors are meant for as it is not proposed to put beam on the collimator. RA mentions that there will be some scraping; the read-out under normal conditions will be measured. PS adds that it could become a robustness test for the collimator edges. According to results of V. Vlachoudis beam impact on short edges could lead to large temperature rises.

1.1.4 Beam

RA proposes two modes for the tests.

- LHC type beam of $4 \cdot 72$ bunches, $1.1 \cdot 10^{11}$ protons per bunch
- single dense bunch

with

- normal LHC cycle, 450GeV
- stored beam, 270GeV

Scraping tests are proposed for 270GeV LHC type stored beam.

PC mentions that the cycle for 270GeV will have to be set up specially for the tests, it is not run now. JU and PC explain that LHC beam cannot be stored for a long time because of heating the kicker (1-2h would most certainly lead to a beam interlock). JU proposes: 2 times 15 minutes with a break in between. The situation could be better for low current.

BG remarks that the synchronization of the stored beam with the abort gap has to be checked. JW adds that it is normally automatically synchronized, unless there are emergency dumps.

Parasitic MDs are not planned so far, but might be feasible with fast orbit bumps during the cycle.

1.1.5 Schedule

Installation shall take place in August 2004, the measurements would be done in September and October 2004. A guess for the duration of the set-up is 2 shifts (RA).

1.2 LHC Collimator Test in TT40

The robustness of a collimator jaw can be tested with a shock impact of a fast extracted 450GeV full SPS batch on the collimator face in the extraction beam line. This is the impact which is used for the design scenario to determine the required robustness of the jaws. There is $\sim$1.4m space available upstream of the extraction dump TED in TT40. In this way the predicted shower development and heating downstream of shock beam impact could be verified. Damage is not expected.

A jaw of a secondary collimator would be used as a sample, length 1.2m, installed on regular metallic support with cooling. The set-up would have to be movable, to facilitate operation. The jaw shall be in vacuum.

H. Vincke will investigate radiological issues in this area (neither an irradiation nor a contamination zone), also the consequences of the backscattered products. The forward scatter products will end up on the TED.

1.2.1 Tests

RA proposes 5 shots on the collimator jaw face at different transverse locations getting closer and closer to the center of the face. JW wants to know how precisely the beam has to get to the edge. RA mentions steps of 2mm towards the middle of the jaw face. To get the different transverse settings the jaw will be moved, not the beam.

Temperature sensors downstream on the beam pipe might be used to measure energy deposition. BG has proposed an additional movable material probe downstream of the collimator jaw to investigate this issue.

RS asks how shock wave measurements could be done. PS replies that measurements would have to be done on the μs-basis. Even the "ringing afterwards" (RS) might not be trivially measured. Micro-phonic sensors could tell something.

In case of damage it might be difficult to tell afterwards which shot has actually lead to damage; or between the shots to tell whether there has been damage.

Ideas for detection methods: Damage leads to vacuum spikes, thus vacuum could serve as a "damage instrument". Also the measurement of shock waves might be done via vacuum, as vibration leads to the release of dust and hence to vacuum spikes. Another possibility are radiation hard cameras which could take a picture after each shot. BD will have a look at such cameras. If the tests are done with coating, the resistance could be checked along the jaw to check for damage of the coating, RS mentions. PS adds that the Cu-layer might be too thin for proper measurements.

The maximum temperature rise expected in the carbon jaw is 600°C. BG wants to know whether cooling still works in connection with the Cu base plates where a temperature between 200° and 250°C can be expected. PS says that there is no estimate for the behavior of the water, thus the experiment.

Installation so far is proposed for August 2004 in one of the eight hour slots of the SPS. In this case the set-up would have to stay in place during the TI8 tests.

The high intensity needed for the collimator test in TT40 ($2 \cdot 10^{14}$ protons) poses a challenge. TT40 as well as the window infront of the TED have never experienced such intensities. Commissioning of high intensity extraction will have to be done. One shift is proposed for the set-up with the TED, one for the tests with the carbon collimator jaw and one for the material tests (see below). The all in all schedule for the experiments together with the planned TI8 tests is not fixed yet (there are several ideas like: having an additional spare day for the tests with the second TI8 test moved forward by one week and the TT40 experiments at the end of the second TI8 test).

1.2.2 Material Test in TT40

See slides at http://www.cern.ch/lhc-collimation/files/RSchmidt_10Oct03.pdf.

The proposal of a material test in TT40 presented by RS is the proposal for a validation of the models used to simulate the material response after beam impact in terms of temperature rise, stress, etc. These models are used to design equipment robust enough to stand high beam loads. The main assumption is that deposited energy directly leads to localized material heating. In case of beam impact on short time scales this might not be true (there might be excitation of phonons, etc.).

A way to verify the assumptions is to put a fast extracted SPS beam on a sliced material sample. The length of the block and the intensity of the beam would have to be chosen such that phase transitions in the material could take place (e.g. reaching the melting point). The location of the material damage could be compared with the simulated temperature rise along the block. In order to guarantee no damage to surrounding equipment a containment around the test sample is suggested. Several shots with different intensities would be needed. Test scenarios, required intensities and layout have not been worked out yet. (A test with copper would need $\sim 2 \cdot 10^{12}$ protons at 450GeV for reaching the melting point.)

PS remarks that for the experiment with the sliced material block one would be in need of a very experienced metallurgist to distinguish between plastic deformation and melting followed by cooling down.

As already mentioned it was agreed on having a movable set-up for the collimator test in TT40. An integration of the collimator test and the material test into one set-up, which can switch from one experiment to the other, is welcome by the SPS operation. Any time of changing the set-up by installing the one for the other experiment in TT40 would interrupt the whole SPS operation. However, there is no space for flexible joints to switch between the two tests due to the length of 1.2m of the collimator jaw and a total available length of 1.46m in TT40. RA is concerned about having both experiments in one tank without a separating wall (possible collimator damage due to unforeseen destruction of the material sample).

The next meeting will be on October 20, 2003.