Verena Kain, 2003-05-05

25th Meeting of the LHC Collimation Working Group, May 2, 2003

Present: Ralph Assmann (chairman), Verena Kain (scientific secretary), Brennan Goddard, Rudiger Schmidt, Bernd Dehning, Jean-Bernard Jeanneret, Alfredo Ferrari, Igor Kourouchtkine, Stefano Redaelli, Stefan Roesler, Barbara Holzer, Hans Braun, Markus Brugger

1 Comments on Minutes of Previous Meeting

It was again stressed how important the reduction of the re-trigger time of the dump kicker magnet is. The CWG wants to reemphasize its appreciation of the hard work done by the BT group.

In the paragraph on BLM studies, it was said that JBJ had produced 100k events in K2 with the graphite system for simulations by IB. In fact these simulations will be done by IK and will only include collimators of IR3.

2 AOB

RS recommends to give a short summary of the working meetings on the TCDQ layout to the CWG. The specs of the TCDQ, as RA remarks, should be flexible as the settings of the collimators are linked to the TCDQ but will not be fixed in the near future.

RS and RA agree that crystal collimation should not be neglected. A small reserved space in the collimation area for future experiments might be considered. RS thinks that crystal collimators might be useful to concentrate losses on restricted areas and thus confine radiation.

Action Items:

- ▷ The minutes of RS of the TCDQ-meetings should be put on the web. (RS, VK)

3 List of foreseen collimators and absorbers in the LHC (JBJ)

The following list has been provided by JBJ and includes all collimators and absorbers in the LHC except of the TCDS and TCDQ. The list can be found under
http://www.cern.ch/lhc-collimation/files/JBJeanneret_a_2May03.pdf

At several locations in the LHC ring beam loss is near or exceeds the quench limit. Those locations were revealed in simulations based on the old Al-Cu collimation system (see LHC Project-notes 263 and 286). These simulations will have to be redone for the new collimation system. In order to protect the superconducting magnets at those locations absorber were foreseen. The absorbers can be understood as a third collimation stage, as RA remarks. The layout and detailed design of the absorbers are not fixed yet.

AF mentions that one has to care about the shielding material supplies (iron, concrete) as there might be no more iron around. JBJ would like to have a long term policy, so that one knows where the material goes. RA points out that the additional absorbers should not be treated along with shielding. He wants to know who is in charge of building the absorbers and whether we should include it in our budget.

RS remarks that the TCDD-absorber (absorbing in both planes) looks similar to the ATLAS and CMS triplet masks and raises the question whether one could think of combining functions, thus putting in case of IP2 and IP8 an additional absorber on the other side of the IP. The opening of the TCDD was planned to be fixed. RA mentions that if combining

functions the triplet absorber must be movable (as one should be able to run the three stage collimation system as a two stage collimation system.)

Furthermore JBJ addresses the fact that no TAN has been foreseen at the low-luminosity experiments at IP2 and IP8. The question whether a "mini-TAN" is needed or not was raised in the PLC meeting 3 years ago and seems to be still pending. JBJ is convinced that it is absolutely necessary. RS says that this topic should be stressed at the LTC to have people work on it. JBJ and RA would rather have the Machine Protection Working Group (MPWG) together with the CWG set up a memo in order to make sure that all relevant absorbers are included. The complete list would then be presented at the LTC.

RA asks RS as chairman of the MPWG whether there should be additional absorbers for machine protection. Even with the collimators' setting at 6 and 7σ oscillations with amplitudes up to 10.5σ get through the collimation section.

Action Items:

- ▷ Do we need a "mini-TAN" at IP2 and IP8?
- ▷ Who will build the absorbers required for collimation?
- ▷ Memo with list of required absorbers set up by MPWG and CWG?

4 Discussion on Collimation with Ions

H. Braun involved in CLIC affairs now investigates collimation for ions. The collimation system has to be designed such that it is also appropriate for ion collimation.

H. Braun points out that the energy per ion bunch is a factor 20 below the energy of a proton bunch. The bunch spacing is 4 times the bunch spacing with protons. Furthermore he mentions that the stopping power in material, which is proportional to Z^2, is 80 times larger in the Pb case. JBJ agrees that the mean free path for lead ions is smaller but the main body of the showers is as with protons. AF adds that the showers might have a different opening and in order to have an idea of the processes in case of slow losses (beam lifetime of 0.2h) simulations have to be done. AF also remarks that it is not clear whether the existing FLUKA version, which does not contain processes such as *electromagnetic dissociation* and *nuclear elastic scattering*, is sufficient for simulations with ions.

RS remarks that a collaboration with GSI Darmstadt has been set up where an accelerator facility (1 km long, main dipole field a factor 2 below LHC) for 350GeV ion beams is built to study among other things phase transitions in material during beam impact. They have appropriate simulation tools. He concludes that if it turns out that FLUKA does not treat ions properly, the collaborators at GSI might be asked to investigate our questions.

As a starting point a dump failure with ions could be investigated. RA would need the population per bunch and the bunch spacing. The resulting distribution of particles might serve as FLUKA input for AF.

RHIC observes problems with its collimation system. Out-scattered ion fragments caused magnet quenches. AF remarks that ion fragments may have the nominal ratio Z/A and approximately nominal energy and therefore may be transported in the accelerator. Hence the situation is much more complex than with protons. For assessing our predictive power in ion simulations the CWG agreed in a former meeting to investigate the RHIC problem: the loss locations shall be reproduced by means of FLUKA simulations and tracking.

Ions stemming from the IPs could quench magnets. H. Braun quotes Stephane Fartoukh who has said that the parasitic dispersion generated by off center ions going through the triplets might sweep the ions out. JBJ says that, as far as he knows, this might only be a marginal effect.

RA remarks that when simulating this scenario the equilibrium dispersion solution does not contribute. The particles have to be tracked in the "one-pass" mode. RA asks why no collimation is considered in the dispersion suppressor.

Action Items:

- For the simulation of a dump failure with ions: which ion species, what is the population per bunch and what is the bunch spacing? (H. Braun)
- Prediction of particle distribution in the dump failure case with ions (RA)

5 Ongoing and Future Studies with IHEP (JBJ)

See slides at http://www.cern.ch/lhc-collimation/files/JBJeanneret_b_2May03.pdf.

Simulations for BLM studies have been set up. JBJ produced a 500k impact map for injection and 100k impact map a top energy with K2 for the graphite collimation system. For the moment IR3 is investigated. IK will use the data to simulate the multi-turn energy deposition with MARS. The first results shall be ready by end of June. In the next runs n_1 and n_2 will be varied for every collimator jaw. The *triangular response matrix* will be calculated. It contains information on cross talk and thus useful input for diagnostics and for interpreting data in the control room. Another result of their calculations shall be the energy deposition in the BLMs which should determine the size of the detector.

RA would like to have all data available on the web, so that the basis of results can be understood in the future and no data gets lost. He could set up a web server to have enough disk space. There the data along with a small description could be stored.

IK will come back from Russia by the end of September. It will take him until the end of this year to do all the simulations for the BLM studies. RA mentioned that if this is a question of CPU, one could try to get additional computers.

6 Status of Radiation Studies in IR7 (MB)

See slides at http://www.cern.ch/lhc-collimation/files/MBrugger_2May03.pdf.

MB reported on the work done in collaboration with SR. Their radiation studies will clarify questions on maintenance of the collimators. Both MB and SR will not be around in June. It therefore has to be decided now which additional simulations, plots, values, ... will be needed for the presentation at the LTC meeting.
Questions which have to be answered:

1. How often do collimators have to be maintained?
2. Which access time is needed for collimator maintenance?
3. Which radiation levels can be expected?
4. How long do people have to wait before access?
5. What access time is acceptable?
6. Must there be remote handling?

The ambient dose equivalent rates (dose rate/hour) for collimator materials carbon (CC), copper and beryllium with and without shielding were investigated for a simplified geometry and more realistic geometry.

In the more simplified case a 10m long tunnel was assumed including a collimator, a cylindrical 20cm thick iron shield and a cylindrical 30cm thick tunnel wall. The beam pipe downstream of the collimator had a inner diameter of 80mm and was made of 2mm thick copper. A 7TeV pencil proton beam impacted at the center of the front face. The loss assumptions were based on 10^{16} protons per year with 180 days of continuous operation.

The results for Be and C (collimator length: C 126cm, Be 135cm; collimator thickness 6cm) are similar (maximum values of 1 year of LHC operation and one day of cooling: collimator 20mSv/h, shielding inside peak 40mSv/h, shielding outside peak 3mSv/h). Copper collimators (collimator length: Cu 50cm; collimator thickness 6cm) result in higher dose rates (maximum values of 1 year of LHC operation and one day of cooling: collimator 650mSv/h, shielding inside peak 100mSv/h, shielding outside peak 6mSv/h). The peak in dose rate in the beam pipe for Be and C is 20mSv/h for Cu it is 300mSv/h. 10m downstream those values go down to 2-10mSv/h.

The peak for C collimators is much flatter than for Cu collimators. C collimators are leaking most of the energy and the additional contribution to the dose rate from the shielding is not negligible. This does not necessarily mean that the situation for C gets worse with shielding. At the location of the collimator the resulting radiation would be less without shielding. But it might be needed to avoid quenching magnets further downstream. In the case of C collimators dose rates are dominated by the wall contribution (aisle: 1.0-2.2mSv/h). BG and RA remark that these dose rates imply that people must not stay near the wall more than 1h per month. It is mainly ^{24}Na to produce this radiation with a decay time of 15h. After a cooling time of 3 days the radiation of the gamma rays emitted by radioactive copper remains. JBJ wants to know whether additional lead shielding could help. AF replies that the gamma rays are in the MeV energy range, thus needing 5cm lead layers on the tunnel wall, but means it to be an unattractive solution.

For the more realistic case MB and SR set up their simulations with a 30m long tunnel including two secondary C collimators (252 cm long), a 3.5m long quadrupole magnet downstream of the collimator, a 2mm thick copper beam pipe (40mm inner diameter), various flanges, a 20cm thick iron shield and a tunnel with wall, floor and ceiling. It turned out that the resulting values scale with the simple assumptions from above.

RA comments on the assumptions of MB. In MB's simulations all losses occur on a secondary collimator. In reality 80% of the particles interact in the primary collimators, the second largest impact values occur at the first and second secondary collimators.

The situation in terms of radiation does not get better with short primary collimators if there is shielding, AF pointed out.

RS remarks that one day of cooling time is acceptable if it does not occur too often. MB mentions that it takes at least 3 days of cooling until the radioactive isotopes in the shield have decayed to acceptable radiation levels. BD says that in order to have realistic numbers on the frequency of the tripping of motors for the collimator jaws, the people working on the SPS-targets, where motors in high radiation areas are used, should be asked. RS remarks that the question whether people can walk in the collimation area during shutdown should also be looked at. RS guesses that there will be 2 to 3 collimator repairs per year.

RA reports shortly on the collimation at SLAC. They use consumable collimators, which should be able to stand 1000 dump kicker mis-firings. He points out that a consumable high Z collimator could still be an option if it turns out that because of radiation C collimators can not be used.

SR asks whether also other materials should be investigated. AF replies it is better to focus on C and have it well documented. RA mentions one possibility for a collimator layout where a 1.5cm C layer is put on top of copper. The dimensions of this object are not fixed yet.

For the LTC meeting it is agreed to have plots with the geometry of the more realistic case with full C and Cu collimators for cooling times of 1 hour, 1 day, 3 days and 1 month and a basic estimate of personal exposure to radiation.

Action Items:

- Plots for the LTC meeting (MB, SR): ambient dose equivalent rates for
  - collimator materials: full C, full Cu
  - cooling times: 1 hour, 1 day, 3 days, 1 month
  - geometry as in the more realistic case

  Plus an estimation for personal exposure based on a rough guess of required collimation maintenance provided by OA.
- Investigation of shielding: is it an option not to use shielding at the location of the collimators to have less radiation at the motors but provide shielding at the rest of the collimation insertions?

7 Dry Run of Contributed PAC Talk on Collimation (RA)

See slides at http://www.cern.ch/lhc-collimation/files/PAC03/pac03.ppt.

RA gave a dry run of his 10 minutes PAC talk.

The date of the next meeting will be announced.