20th Meeting of the LHC Beam Cleaning Study Group / Collimation Working Group 31.1.2003

Present: *O. Aberle, R. Assmann (chairman), M. Brugger, L. Bruno, Bryant, H. Burkhardt, B. Dehning, G. Ferioli, A. Ferrari, E. Gschwendtner, G. Guaglio, J.B. Jeanneret, M. Jimenez, R. Jung, H. Preis, F. Ruggiero, R. Schmidt, P. Sievers, V. Vlachoudis, L. Vos, F. Zimmermann*

1) The Collimation WG and the Collimation Project (R. Assmann)

R. Assmann reported on the set-up of the collimation project. Details are available on the web: http://www.cern.ch/lhc-collimation-project

Names have been assigned to the relevant tasks, covering activities in different groups and divisions. The LHC Beam Cleaning Study Group (BCSG) will continue its activities as LHC Collimation Working Group (CWG). As before this WG is open to all interested colleagues and a two-weekly meeting will be held on Friday afternoons. The mandate of the BCSG/CWG remains to cover accelerator physics and operational aspects of the LHC collimation system, including considerations for required beam instrumentation and radiation aspects. The focus will remain on the cleaning insertions IR3 and IR7, however, all movable absorbers and collimators in the LHC will now be included into the discussions. On request of V. Mertens the mandate was extended to include AP and OP issues for these additional devices (TDI, TCDI, TCDQ). The CWG should:

1. provide all required AP/OP input for the designers of the collimator hardware, the BLM system, and other related hardware.
2. make sure that the hardware choices are appropriate for cleaning efficiency and operation.

The mechanical design of the collimators that are part of the LHC Collimation Project (TCP, TCS, TCL type) will be discussed at a Collimator Project Meeting which alternates with the CWG. The Collimator Project Meeting will be in charge of the technical decisions, the prototyping, the productions, and installation of the collimators. In view of the short time schedule a strong support from the CWG is required to ensure that the design choices can be made without delay and in full consistency with the LHC requirements. RA thanked the participants for their support.

The members of the CWG introduced themselves and their expertise in a 'tour de table'.

2) Impedance Constraints for Collimation (F. Ruggiero)

Francesco Ruggiero reported on the impedance constraints for LHC collimation, supported by L. Vos (see slides at http://www.cern.ch/lhc-collimation/files/CWG20_ruggiero.pdf). He pointed out that detailed information can only be given once the technical designs of collimators are more advanced and that his remarks should be taken as general guidelines.

20 m total length of collimators, sitting at a 6 σ distance (~1.25 mm) from the beam, were assumed. PB asked why it is required to be so close to the beam. JBJ explained that this is required in order to protect the aperture in the triplet at 7 TeV. RA mentioned that the collimator aperture can be larger at 7 TeV when running with higher β*.

FR showed that the impedance from the collimators can be very important. For example, using a thick insulator for collimator jaws could more than double the impedance in the LHC. A tolerance of 10-20% of the total impedance should be respected, corresponding to 25-50 mOhm.

A) Ceramic: If a ceramic (e.g. BN) was used impedance would be unacceptably large without a coating. For a 1 mm thick insulator coating would range from 10 micron (Cu) over 20 micron (Be) to 100 micron (Ti). MJ commented that such a thick coating would probably fall off. LB commented that this would be inconsistent with the design of the TDI, foreseeing 4-5 micron coating. LV clarified that coating can be thinner if the thickness of the insulator is larger (e.g. as few cm's instead of 1 mm). Its exact thickness also depends on the detailed mechanical layout. JBJ asked for additional explanations about this statement.

B) Carbon: Impedance from Carbon jaws looks acceptable, however, heating due to the beam image currents can reach several kW/m. MJ commented that Carbon is problematic for the vacuum, as illustrated by the problems at the LHC dump. The vacuum pressure could be two orders of magnitude worse if graphite is heated by 100 degrees. A coating would be required for carbon in order to reduce surface heating. PB asked about allowable interruptions in coating

(RF cages have gaps), PS asked about allowable width of "carbon stripes". FR agreed to look at this question.

C) Conductivity: FR explained that the important issue is to provide conductivity along the direction of the beam. PS mentioned the possibility to "dope" Graphite with Cu (mixing of powders). RJ asked about the azimuthal distribution of the image current.

D) Tapering and RF contacts: FR asked to foresee a tapering with a maximum angle of 15 degree. Good RF contacts are required. PS asked about the allowable widths of gaps. RJ mentioned that LEP had 1 mm gaps.

E) Layer thickness: The layer thickness is important for resonances. In case of naked insulators , thin layers (<0.5mm) are preferable for avoiding these resonances.

RA asked about allowable distance between collimator slices, in case collimator jaws will be realized in discrete slices (sawtooth surface). FR agreed to check on this and recommended to measure it with a prototype. PB asked about transverse wakefield kicks at the collimators. LV and FR pointed out that LHC operates with long bunches (very different from linear collider beams) and transverse wakefields play no role. FZ asked about the effect from the tapering angle.

Action items:

- Review boundary conditions for non-continuous coating, e.g. stripes of carbon. (FR, LV)
- Review allowable distance between collimator slices, in case collimator jaws will be realized in discrete slices: sawtooth surface. (FR, LV)
- Measure impedance of prototypes, once these exist. Contact would be F. Caspers.
- Review vacuum issues for Carbon. (MJ)
- Check transverse wakefield kick with proposed tapering angle. (FZ?)

3) Need for TCL-type collimators (J.B. Jeanneret)

RA had asked the question whether installation of TCL-type collimators can be delayed until after LHC start-up. Some of them are only required for high luminosity (> 10^{33} cm^{-2} s^{-1}). JBJ explained that the TCL collimators used for injection must be ready for start-up, probably even for the sector test. JBJ showed that they must fit into a space constrained by a cryo line. A compact design is therefore required. The present assumption calls for 1 m long Cu jaws. This is based on the assumption that only one single bunch impacts at injection. The jaw might still survive the impact of a few bunches. JBJ recommended revisiting the material question for the TCL collimators. RA asked whether fixed masks could be used for the TCL injection collimators. JBJ answered that they are supposed to sit at 10 σ centered on the orbit. This is incompatible with the requirements of aperture.

Action items:

- Revisit beam impact on TCL collimators at injection (HB).
- Revisit material choice for TCL collimators, at least for injection (Collimator Project Meeting).
- Start design of TCL collimators for installation in 2005, before the sector test (Collimator Project Meeting).

4) Transfer line collimation (TCDI) and protection at injection (H. Burkhardt)

HB summarized activity on the transfer line collimation and protection at injection. Work is ongoing and he proposed to review the situation at an upcoming meeting. The topic will also be discussed at Chamonix. In particular HB also requested to have the TCL injection collimators already for the sector test. LB asked about the basic requirement for transfer line collimators. HB stated that these collimators should be able to take a full SPS batch (280 bunches). LB pointed out that this is a difficult requirement and that input for the technical design of these collimators is required soon.

Action items:

- Review of transfer line collimation and protection at injection (HB).
- Provide detailed input for mechanical design of transfer line collimators (HB).

5) First discussion on e- cloud (round-table)

PS asked about the local e- cloud and a discussion evolved on this issue. RA mentioned that he was worried about this as the SNS project in the US expects that 30% of its electron cloud wakefield arises at the collimators. No estimate was done for the LHC and it should be evaluated whether a significant problem is expected and whether any constraints on the collimator design will be imposed (clearing electrodes, solenoids, material properties, …).

The discussion showed that the high power load in the warm cleaning insertions (up to 500 kW for 0.2 h lifetime at 7 TeV, 100 kW for 1 h) is relevant when compared to the synchrotron radiation losses. For comparison, the average synchrotron radiation power in the LHC at 7 TeV is about 3.7 kW (or 215 mW/m). FZ stated that an e- cloud could easily be seeded, collimator wakefields could play a role, the beam could be perturbed by the electron products of the shower, and the effect is not just concentrated at the collimator but extends downstream. FZ and FR recommended making a basic estimate. MJ suggested putting clearing electrodes which could help to avoid problems.

The input data for e- cloud studies is not easily available. AF explained that FLUKA can provide e- distributions per incident p, but only down to the keV level. FZ stated that his usual input consists of eV electrons. There was agreement that some worst case assumption should be made to assess the order of magnitude of the problem.

Action items:

- Review SNS studies on local e- cloud at collimators (FZ).
- Estimate order of magnitude of problem for the LHC (FZ, FR).
- Specify required boundary conditions on material, surface properties, clearing electrodes, … (MJ) .

6) Topics for upcoming meetings (round-table)

The following topics were identified for upcoming meetings:

- Update on outstanding impedance questions (FR).
- Review of transfer line collimation requirements (HB).
- Review of SNS studies and e-cloud at collimators for the LHC (FZ).
- Review of vacuum issues for Graphite jaws (MJ at collimator project meeting?).