Stefano Redaelli, 16-03-2004

10^{th} LHC Collimation Project Meeting, March 12, 2004

Present: Oliver Aberle, Ralph Assmann (chairman), Igor Baichev, Alessandro Bertarelli, Hans Braun, Samy Chemli, Enrico Chiaveri, Bernd Dehning, Alfredo Ferrari, Daniel Gasser, José Miguel Jimenez, Verena Kain, Igor Kurochkin, Daniela Macina, Matteo Magistris, Manfred Mayer, Christian Rathjen, Stefano Redaelli (secretary), Jean-Pierre Riunaud, Guillaume Robert-Demolaize, Stefan Roesler, Rudiger Schmidt, Daniel Schulte, Vasilis Vlachoudis.

1 Collimation Project approval of LHC collimator prototypes

1.1 Geometric impedance of the LHC collimator (D. Schulte)

Daniel Schulte (DS) and Francesco Ruggiero approved the prototype collimator installation into the SPS as far as the geometrical impedance is concerned. Indeed, a small modification is implied with respect to the total SPS impedance. A maximum power loss of about 100 W is expected for the SPS (open collimator, 60 mm). This value refers to an LHC type beam with nominal bunch spacing and intensity, but filling only half of the SPS ring circumference, and provides an upper heat load for the highest beam current to be circulated in the SPS.

An upper bound for the impedance has been estimated by considering collimators in the closed position (2.6 mm full-gap). Results are summarized in the following table:

Broad-band longitudinal impedance	$Z/n \sim 1\,\mathrm{m}\Omega$
Broad-band transverse impedance	$135\,\mathrm{k}\Omega/\mathrm{m}$
Real longitudinal impedance from narrow resonances	$30\,\mathrm{m}\Omega$

These values are negligible with respect to the total SPS impedance of several Ω. Therefore, the installation of the collimator in the SPS should not cause any problem for the heating nor for the impedance.

Two modifications of the collimator design are suggested: (1) An RF connection between collimator and tank; (2) A connection between graphite and stainless steel parts of the collimator jaws. The effect of RF contacts will be reviewed separately. It is noted that the item (2) is required for the collimator test at the SPS. The modifications will be discussed in the LHC Collimation Design Meeting.

1.2 Discussion and general comments

The LHC collimator design was approved for prototyping and SPS test. The impedance simulations for the LHC collimators should continue with high priority. SPS simulations will also continue.

2 Status of collimation heating test / TCS construction (M. Mayer)

Manfred Mayer (MM) reported on the status of the TCS collimator construction. A finite elements model and extensive thermal calculations have shown that the design is acceptable. Three collimator prototypes respecting the LHC design are now being built. Two will be used for the SPS test and one as a test bench (test of various materials and components). 70 % of the drawings are in production. The construction is on time but no contingency at all is left. The May deadline will be achieved.

MM also commented on the good results from the collimator heating test. Experimental results correspond to the predictions expected from simulations within the 0.2 ° level for total heatings up to 2.5 kW. Tests will also be carried out to verify the heating response up to 5 kW. Therefore, the basic design choice of cooling and clamping have been shown to work as predicted.

RA welcomed the very good news from the collimator heating test and congratulated the people involved.

3 Collimation Project approval of new IR3/IR7 layouts

3.1 Remarks on final layout (S. Chemli)

Before the meeting started, Samy Chemli (SM) attached the drawings of the final IR3 and IR7 layouts to the Adams room wall. People were invited to have a look at them after the meeting and to give their comments. The drawings were finalized after several interactions various groups involved. IR7 is now included in the data base and IR3 will be included early next week.

RA also asked a list of modifications between the layouts 6.402 and 6.5. CS will provide that once the final versions will be included in the data base.

The new layouts of IR3 and IR7 were approved.

3.2 Status of MAD lattice and aperture

Thys Risselada and Oliver Brüning could not attend the meeting. RA then reported on the status of lattice and aperture for IR3 and IR7. There have been discussions in the AB-ABP-LOC section on the aperture for the new V6.5 optics layout. Notably, IR3 shows a aperture bottleneck. Nevertheless, in agreement with Jean-Bernard Jeanneret, it has been decided to keep this optics version. No better solutions were found for and in any case the aperture was problematic also for the old layout.

Alfredo Ferrari (AF) asked if files with the new optics layouts can be accessed. RA answered that the MADX input files or twiss tables with main beam functions should be asked directly to Thys Risselada, who is the official ABP person in charge of the lattice.

3.3 Status of IR7 showering studies (M. Magistris)

Matteo Magistris reported on status and requirements for showering studies at IR7. Matteo believes that a full model can be finished by the end of April. AF commented that the model is made in a modular way by using the design of components used in previous simulations. This modularity allows an easy implementation of possible changes of some model components.

For the estimation of fluence in the Beam Loss Monitors (BLM) (discussed in the 35th Collimation Working Group Meeting) Bernd Dehning should provide to Matteo more information on the volume occupied by the BLMs (see later).

3.4 Status and requirements for IR3 showering studies (I. Baishev)

Igor Baishev reported on IR3 showering studies. He is waiting for input from Thys Risselada. The full model of IR3 should be finished by May, if the input is received soon. An equivalent CPU usage of 20 GHz for 24 h per day should be envisaged for the simulations, which should start from mid April.

RA pointed out that new CPU power was asked by the ABP group but will not be available before August. However, E. McIntosh from IT group has promised that, as temporarily solution, the required CPU power will be available starting from mid April.

3.5 Transverse space requirements for BLMs (B. Dehning)

Bernd Dehning (BD) presented the transverse space requirement for the BLMs. For single collimator adjustments, losses occur only at one collimator. This requires the use of ionizing chambers. With many collimators, losses occur at more than one collimator. This requires the use of secondary emission monitors (SEM) instead. The geometrical characteristics of these two types of monitors are listed in the following table. As a possibility for the installation of the collimation phase I, RA suggested that one could use the empty space allocated for the phase II collimators. Then some solution must be found for the moment when all collimators will be installed. The integration with collimators will be discussed in the Collimator Design Meeting with input from the vacuum group. 3D integration should be followed by BD and SC.

Monitor type	Diameter	Length	Max. dist. from beam	Long. dist. from coll.
Ionizing chamber	90 mm	600 mm	350 mm	∼300 mm
SEM	90 mm	225 mm	∼100 mm	∼300 mm

4 Requirements for ion collimation (H. Braun)

Hans Braun (HB) discussed the additional requirements for the ion collimation at LHC. (1) BLMs in thedispersion suppressors downstream of IR3 and IR7 should be foreseen. The number of BLM's has to be determined by shower simulations (2) It is known that the two stage betatron cleaning proposed for the proton beams does not work for the ion beams. HB has looked at a possible solution for the ion betatron collimation. The primary collimator could be put at a location with a large β function. Suitable locations can only be found downstream ofIP2 or IP5 for beam 1 and downstream of IP1 or IP5 for beam 2. The collimators at IR3 and IR7 could then be used as secondary collimators. Daniela Macina pointed out that a new particle detector has been proposed to be located at IP2. This should be kept in mind for future discussions.

5 Collimation Project decision on collimation cooling circuits

5.1 Possible solutions (D. Gasser)

Daniel Gasser (DG) presented the three possible solutions which have been considered for the collimator cooling circuit:

1) Independent central cooling stations for the collimation systems. This option ensures an inlet water cooling temperature below 15 °C but poses installation problems and is expensive.

2) The collimators could be connected to the existing circuit of demineralized water in IR3/IR7. This is the least expensive solution and allows keeping the water inlet temperature below 27 °C.

3) Connection to raw chilled water coming from surface. This would not require dedicated cooling stations. The ensured temperature would be below 15 °C.

5.2 Vacuum aspects (M. Jimenez)

Miguel Jimenez (MJ) stated that an higher water inlet temperature (27 °C instead of 15 °C) and a resulting higher temperature of the graphite hot spot can be accepted for the LHC ultra high vacuum system. MJ took into account recent simulation from Alessandro Bertarelli.

5.3 Radiation aspects - water activation in collimators (S. Roesler)

Stefan Roesler showed that the expected irradiation of the water from the collimators is comparable with what is expected from the LHC magnets. Therefore, as far as radiation issues are considered, the collimation water system does not need to be decoupled from the existing magnet system in the LHC tunnel. However, it should be kept in mind that (1) the cooling water has to be retained and checked before release, (2) a clear procedure for retaining the cooling water in case of interventions and for checking its activity before any release is required, (3) the chemical quality of the water has to be checked, (4) the amount of water released in case of accidental rupture has to be estimated.

5.4 Discussions and final decision

On the base of the previous contributions, it was decided to pursue the option (2), i.e. to use for the collimators the existing water circuit of demineralized water.

The possibility of adding independent valves to the collimation cooling circuit was discussed. This is required because not all collimators require the same water flow (RA) and in addition emptying of the collimator cooling channels is required for bake-out. The best option would be to have valves with remote controls. MJ strongly recommended not to pursue this option. Standard valves are much more reliable and should be used instead. It was agreed that standard manual valves will be used.

6 Status of LHC aperture model (S. Redaelli)

Stefano Redaelli (SR) reported on status and requirements for the 1 m-scale aperture model of the full LHC ring. This is required for the simulation of beam loss patterns in the LHC which are being setup.

- Most of the information required for modelling the beam screen aperture is already available in the date base and has been extracted as a MADX-usable sequence file (SC). Missing information on a small number of elements ($\lesssim$15) must be fixed by hand.
- The definition of the vacuum chamber aperture requires more work because the required information on several LHC sectors is not yet available in the data base. In addition, the VC layout is highly unstable (variations on the week time-scale often

happen). It was agree to freeze as soon as possible a study version of the VC aperture in order to have a usable version and to follow-up the definition of the missing parts.

- The aperture should be defined for all lattice elements, both warm and cold (magnets, BPMs, RFs, ...). This was done for the the LHC layout 6.4 (with the exception of some elements such as BPMs and RFs) and it must be made sure that the MAD sequence of new layout version will be updated (TR, SC). Missing elements must be added.

In addition, it is also important to define the aperture for special elements, such as TANs and recombination chambers, and for the transitions where no other elements are located (e.g., transition between two consecutive BSs). This will be followed up (SR, VK).

7 Proposal for tertiary collimators (V. Kain)

Verena Kain (VK) reported on a proposal for the location of the tertiary collimators (TCT) for cleaning and local protection at the superconducting triplets. The proposed location of the tertiary collimators are summarized in the following table.

	Vertical Collimator	Horizontal collimator
IR1	Just upstream of D1	Just downstream of D2
IR2	Just upstream of D1	Close to recombination
IR5	Just upstream of D1	Just upstream of D1
IR8	Just upstream of D1	Just downstream of D2

It is noted that:

- For the cases of IP1 and IP8, the horizontal collimators can also be put just downstream of D2, provided that enough space is available at this location.
- Downstream of D2 the intra-beam distance is smaller than at the location of IR3/IR7 collimators ($\approx$165 mm instead of $\approx$200 mm).
- It has been verified that during collision the phase advance deviation from zero from D2 to the triplet is acceptable ($< 5°$) and that during the beta squeeze at IP1 and IP5 the phase advance is acceptable also for $\beta^* = 2\,\mathrm{m}$ (SR).
- For the case of IR5, no space is available downstream of D2 due to the interference with the TOTEM experiment. The horizontal collimation can be done at the D1 location with only one horizontal jaw that protects the aperture outer side. Thanks to the horizontal crossing scheme, the non-protected side has a larger margin (e.g., at Q2, a margin of $25\,\sigma_x$ is left, taking into account the 3 mm error of the closed-orbit at this location). This argument does not apply to the case of IR1, with vertical crossing.
- A dedicated design for the vertical collimator located at D1 has to be envisaged. In order to avoid interference between the jaws and the outgoing beam, the jaws cannot be as wide as the beam chamber but should be “seen” by the incoming beam only. This is mandatory in particular for IPs with vertical crossing scheme.

Detailed follow-up of the TCT layout will be discussed in the LHC Collimation Working Group.

It is note here that Daniela Macina stressed again that a new particle detector could be installed downstream of IP2, which could possibly reduce the space for the TCTs. This has to be kept in mind in particular because for IP2 the available space close to D2 is limited (the ZDC of Alice is also present).

The next meeting will be announced.