Stefano Redaelli, 21-06-2005

59th Meeting of the LHC Collimation Working Group, June 13, 2005

Present: Ralph Assmann (chairman), Roger Bailey, Chiara Bracco, Oliver Brüning, Rocio Chamizo, Paul Collier, Bernd Denhing, Alfredo Ferrari, Brennan Goddard, Gianluca Guaglio, Jean-Bernard Jeanneret, Barbara Eva Holzer, Yacine Kadi, Mike Lamont, Jacques Lettry, Roberto Losito, Matteo Magistris, Suitbert Ramberger, Stefano Redaelli (scientific secretary), Guillaume Robert-Demolaize, Stefan Rösler, Mario Santana-Leitner, Rüdiger Schmidt, Vasilis Vlachoudis, Jorg Wenninger.

1 Brain-storming on possible collimation priorities for the LHC startup (round table)

1.1 Possible collimation priorities (R. Assmann)

See slides at http://www.cern.ch/lhc-collimation/files/RAssmann_2005-06-13.pdf

Ralph Assmann (RA) presented possible views on collimator priorities for the LHC startup. The collimation production has started and it is now the time to address the installation schedule issues. Basically, it has to be decided whether for the collimator installation (1) the standard ring installation schedule should be followed or if (2) a performance optimized schedule should be proposed (i.e., define a minimal set of collimators to be installed to achieve the first year LHC performance). The option (1) has obvious advantages because in this case the collimators would be installed with all the other equipment and various tests (vacuum, magnet cool-down, etc.) could be performed has foreseen according to the standard installation plan. This option could be met if the all the collimators were delivered to CERN according to the contractual schedule. However, the production schedule is very tight and there are **significant risks** that some **delays** might occur. For example, the present schedule requires a full production rate also during the summer break of 2006, which seems difficult to achieve. The question now is to decide whether a **performance optimized installation schedule** should be defined as an alternative plan in case of delays in the collimator delivery.

This brain-storming meeting was organized to collect information and feedback from from the various colleagues of LHCOP, MPWG, etc. It is noted that a meeting with the people in charge of the installation schedule was also carried out, where input was collected about the plans for the installation in the tunnel.

RA also commented that, in case of missing collimators, **all the required infrastructure** (vacuum flanges, pumping modules, etc..) **would be installed**. The collimator itself has been designed for a quick connection (estimated time during operation is of the order of several minutes). There will certainly be some overhead for the first installation but installation time should is expected to be small. In any case, the collimator installation **does not interfere** with the installation of **cold components**. It is also noted that a simple vacuum pipe could be installed at the place of the collimator for performing vacuum tests in the rest of the line (estimate cost of approximately 2 kCHF per chamber).

1.2 Discussion

The introduction by RA triggered many comments

- Jean-Bernard Jeanneret (JBJ) said that it will be unlikely to have in the first year a performance with a nominal β^* of 0.55 m *and* the nominal crossing angle schemes. If

one could give up one of these two requirements, one could certainly ensure that the tertiary collimators (TCT's) at the interaction regions will not be required in the first year because there will be enough aperture. People agreed with this statement that there was a general agreement that nobody can commit on not having **both** small β^* and crossing angles in the first year.

- Brennan Goddard stated that **without the transfer line collimators** (part of which also is included in the order for ring collimators) the injected intensities will be limited to **3-5 % of the nominal value**. Therefore, delaying their installation would certainly impose a severe limitation of the LHC performance.

- Oliver Brüning commented that the requirements from the experiments should be obtained from the LEMIC, where the problem of collimation priorities should be raised to get additional input.

- Mike Lamont said that the **goal for the first year** operation is to achieve a **luminosity of** $\approx 10^{32}\mathbf{cm}^{-2}\mathbf{s}^{-1}$. As a baseline, this should be achieved a nominal spacing of 75 ns, an intensity per bunch of 4×10^{10} protons, $\beta^* > 2$ m and without crossing. However, everybody agreed that fixing a goal for the luminosity does actually not limit any other parameter, because the required luminosity can be achieved by playing with different parameters.

- Paul Collier asked if it would be possible to operate the machine without momentum cleaning at IR3. JBJ replied that this seems very unlikely because the losses of particles out of the bucket will be significant, in particular with a poor initial understanding of the dynamic effects at the beginning of the ramp.

- BG asked if there is room to improve the production speed. RA replied that this seems very unlikely. There are various bottlenecks during the production (e.g., installation of the precision switched, which require detailed metrology measurements at the company). Rüdiger Schmidt commented that some high precision laser tracker machines (*Leica*) are presently used to survey the LHC dipoles and will certainly be available for other uses later (according to Rocio Chamizo, a couple should be available already from September 2005). People agreed that we should verify if these machine could be of some use for the collimator metrology.

In conclusion, it was agreed that the issue of collimation priorities should be discussed at the LTC. The priority will be to ensure that in the first year of LHC operation the collimation system will be adequate to achieve a luminosity of $\approx 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$.

2 Cleaning performance and beam losses with 0.6 m long primary collimators (S. Redaelli)

See slides at http://www.cern.ch/lhc-collimation/files/SRedaelli_2005-06-13.pdf

Stefano Redaelli (SR) presented simulation results on cleaning performance and beam losses with **0.6 m long primary collimators at IR3 and IR7** (TCP) instead of the original value of 0.2 m. The proposal of increasing the length of the primary collimators at IR3 was discussed at the 39th meeting of the collimation working group (June 4th, 2004). According to simulations by Igor Bayshev, increasing the length of the TCP's at IR3 reduces significantly the deposited energy in the downstream elements, which improves the magnet lifetime and gives larger margin for the quenches of superconducting magnets. After finalizing the design of IR7, which now includes also five active absorbers per beam, it was decided to

investigate the option of increasing the TCP length also at IR7 (see minutes of the 58th collimation working group meeting). A beneficial effect is expected as for the case of IR3. Nevertheless, this proposal should be assessed (1) by verifying the new cleaning performance and (2) by repeating energy deposition studies with the new layout.

Simulation results show that, as expected, longer primary collimators at IR7 **improve the cleaning performance** of the overall system. The study of beam losses all around the ring shows that in some locations the losses are reduced and in general the loss patterns are not worse than with short TCPs. In addition, the locations of inelastic impacts within all the LHC collimators are now available and will be provided to the FLUKA team for energy deposition studies. It is found that with longer TCP's more particles are absorbed at the TCP's themselves, with a consequent reduction of the load on the other downstream collimators. Therefore, there is no reason to expect problems at the downstream collimators. The doses to other beam line elements should be investigated.

In conclusion, from the study of cleaning performance and beam losses the proposal to increase the TCP length from 0.2 m to 0.6 m is **fully supported**. It is also noted that there are no indication of significant improvements with TCP length above 0.6 m. SR also commented on the fact the a detailed study of the effect of the TCP alignment is also required.

2.1 Discussion

RA commented that, as expected, there are no bad surprises from the cleaning performance and we can adopt the solution of longer TCP. We should only decide whether we wait for the FLUKA simulations for approving this choice. Alfredo Ferrari (AF) said that he would not wait for the simulation results, which will take at least 3 weeks, because there is no clear reason to have a worse performance than with shorter TCP's. Jacques Lettry agrees. It was then **decided** to **approve the new layout with 0.6 m long primary collimators**.

AF believes that on paper the cleaning performance should be better with longer TCP's but he stressed the importance of understanding the **effect of the jaw tilt**. At the first impact, the beam will always see a small fraction of the TCP length and hence one should not expect so much better results in reality. SR agrees but said that the losses at the TCP are a **multi-turn effect**. Even if at the first interaction the impact parameter is small, at the following turns it will be larger and there is where the collimator length becomes important for the proton absorptions.

Vasilis Vlachoudis said that the TCP survival should be checked for the accident case scenarios. There was a general agreement that, since this case was verified for the 1.0 m long secondary collimators, there should be no reason for the 0.6 m long TCP to be damaged. Nevertheless, the losses downstream could change and it is worth checking.

Bernd Dehning asked if the longer TCP induce a different signal for the BLM's. BD is worried that, if more losses occur at the TCP, the ratio between signals at TCP's and TCS's might become close to one. SR replied that from the simulation results there is indication that in any case the ratio of losses at TCP's and TCS's does not change significantly.

Action: Reaped energy deposition studies in IR7 with long TCP's (FLUKA team, input provided by the ABP collimation team).

Action: Effect of TCP angle on cleaning inefficiency (ABP collimation team).

Action: Accident scenarios at 7 TeV with long TCP's (FLUKA team, input provided by the ABP collimation team).

3 Preliminary energy deposition studies with passive absorbers at IR7 (M. Magistris)

See slides at http://www.cern.ch/lhc-collimation/files/MMagistris_2005-06-13.pdf

Matteo Magistris (MM) presented preliminary results on the energy deposition studies with **passive absorbers at IR7**. These are blocks of metal (most likely, iron) which are placed right in front of warm magnets in order to reduce the deposited energy in the coils so to increase the magnet lifetime. Magnet lifetime is in particular an issue for dogleg magnet D4 that is placed downstream of the IR7 primary collimators (MBW modules). The design of the passive absorbers has not yet been carried out in detail. In the simulations, a similar design to the one proposed for IR3 was assumed: the passive absorber is 1 metre long and its aperture surrounds the vacuum chamber of the magnet. In order to provide the best magnet shielding, the absorber should be placed as close as possible to the MBW.

As a baseline for the simulations, it was assumed that the MBW magnets can withstand **50 MGy** before being replaced (data provided by Suitbert Ramberger). The goal for the design of the IR7 layout is to deposit less than **5 MGy/year** in the magnet, which ensures a 10 year lifetime.

MM simulations indicate that, in order to significantly reduce the deposited energy in the magnet, **the aperture of the passive absorber** should be **smaller that the magnet aperture**. Otherwise, the reduction of the deposited energy in the coils is negligible because the main contribution to the coils comes from the magnet beam pipe itself. This result is qualitatively different from what was concluded for IR3, where a aperture as big as the vacuum chamber ensured a significant reduction of the doses to the dogleg magnet coils.

There are indications that a significant improvement could be achieved by using a passive absorber aperture of **0.02 m radius**, which is half of the aperture of the drift vacuum chamber in the vicinity of the MBW. Circular aperture has been assumed in the simulations. The feasibility of this option (available aperture, vacuum, etc.) remains to be assessed.

Suitbert Ramberger said that one should look in detail to what happen in the first part of the coil, which faces the incoming beam. In this region very high doses are expected because the coil gets very close to the beam. This feature was found in the energy deposition studies at IR3. **Action:** Deposited energy in the coil just above the beam (FLUKA team).

RA said that it would be certainly worth looking at the deposited energy studies with 0.6 m long primary collimators. As for the reduced aperture of the passive absorbers, SR believes that a 2 cm radius should not be a problem. He encouraged MM to contact Christian Rathjen to check the feasibility of this solution.

4 A.O.B.

Bernd Dehning **maps of deposited energy at the beam loss monitor locations at IR7**. In particular, BD would like to distinguish between the contribution to the signal from each collimator.

Alfredo Ferrari replied that maps of deposited energy are available and will be provided as soon as possible. However, in the available data all the IR7 collimators are taken into account at the same time. In order to calculated the contribution from each single collimator, dedicated simulations are required.

Action: Provide maps of deposited energy at the beam loss monitor locations (FLUKA team).

The next meeting will be June 27th, J.B. Adams.

Action Items:

- Reaped energy deposition studies in IR7 with long TCP's (FLUKA team, input provided by the ABP collimation team).
- Effect of TCP angle on cleaning inefficiency (ABP collimation team).
- Accident scenarios at 7 TeV with long TCP's (FLUKA team, input provided by the ABP collimation team).
- Provide maps of deposited energy at the beam loss monitor locations (FLUKA team).
- Follow up with AT-VAC (Christian Rathjen) the feasibility of reducing the aperture of the passive absorbers at IR7 (M. Magistris, FLUKA team).
- Deposited energy in the coil just above the beam for the dogleg dipoles at IR7 (FLUKA team).
- Provide maps of deposited energy at the beam loss monitor locations (FLUKA team).