Stefano Redaelli, 07-07-2006

72^{nd} Meeting of the LHC Collimation Working Group, June 19, 2006

Present: Ralph Assmann (chairman), Giulia Bellodi, Dariusz Bocian, Markus Brugger, Bernd Dehning, Barbara Eva Holzer, Daniel Kramer, Daniela Macina, Laurette Ponce, Stefano Redaelli (scientific secretary), Guillaume Robert-Demolaize, Mario Santana-Leitner, George Smirnov, Rüdiger Schmidt, Markus Stockner, Thomas Weiler, Thijs Wijnands.

1 A.O.B.

R. Assmann announced that the members of the LHC machine advisory committee expressed a very positive feedback on the progress made by the LHC collimation team.

2 Plans for future FLUKA studies

Alfredo Ferrari and Vasilis Vlachoudis could not attend this meeting because were involved in a FLUKA collaboration meeting. The discussion of future IR7 energy deposition studies was postpone to the next meeting.

3 BLM locations based on proton loss maps (L. Ponce)

3.1 Simulation setup and proposed BLM locations

Laurette Ponce presented the proposed locations of the LHC beam loss monitors (BLM's). The BLM locations must be optimized for an efficient detection of losses in order to dump the beam before quenches or damage occur. Laurette's studies are based (1) on proton loss maps in SSS and arcs, provided by the ABP collimation team; (2) on GEANT 3 simulations of secondary showers created by the protons hitting the beam pipe and (3) on the simulation of the BLM response signal (calculated by M. Stockner with GEANT 4). Simulations are carried out for both beams.

Typical simulation results show that the shower maximum occur approximately 1 metre downstream of the proton impacting point. Loss peaks in the MQ's are typically two times larger than in the MB's. Depending on the azimuthal distribution of losses, the shower peaks show differences up to 40 % (larger peaks for losses on the outermost side of the beam pipe, closer to the outside wall of the cold mass). The dependence on the beam energy was also investigated, finding that the locations of the maximum shower peaks are the same at 450 GeV and at 7 TeV but their amplitude can vary by a factor 20. In some cases the energy from secondary showers at 450 GeV cannot escape from the magnets and cannot be seen. This is the case for the second largest peak.

Based on these simulations, the positions of the beam loss monitors have been chosen to cover the total shower signal from typical proton loss patterns. **Six BLM's per arc quadrupole** will be installed (three per beam). See L. Ponce's slides for detailed drawings of the installation layout. The BLM positions were optimized to (1) catch the losses at both interconnects and at the quadrupole magnet centre, (2) to minimize the ratio of deposited energy in the monitor and in the superconducting coil and (3) to allow disantangling the signals coming from the two opposing beams.

The BLM locations in the long straight sections (LSS's) were chosen with the same criteria as for the arc. Each LSS requires an *ad-hoc* solution because the layouts are significantly different. Examples were shown for the proposed locations around the superconducting triplets. Simulations take into account various scenarios of optics errors (inputs from C. Bracco and

G. Robert-Demolaize). In the dispersion suppressors the distribution of secondary showers are similar as in the arc and the same BLM installation layout will be adopted (6 BLM's per quadrupole).

Additional constraints for ion collimation were also taken into account, as it was extensively discussed in the previous meeting of the collimation working group. Additional BLM's are also forseen for proton runs on the dipoles of the dispersion suppressors at either side of the cleaning insertions, where some off-momentum halo is lost. Similarly, dedicated BLM's are required at IR8 for the injection case because off-momentum halo protons escape from the injection protection collimators and can be lost in dipoles.

3.2 Discussion

The issue of the quench limits was discussed. The uncertainty on the tolerable deposited energy before quench obviously traslates into an uncertainty on the choice of the BLM thresholds. D. Bocian states that he has some new results on measured quench levels of various LHC magnet types. He agreed to report his results at one of the next collimation working group meeting, after these results will be discussed among the magnet experts. D. Bocian announced that he finds significantly lower quench limits than the ones assumed so far.

T. Wijnands asked which shower particles are taken into account in simulations. L. Ponce said that only charged particles are considered. G. Smirnov warned that neutral particles like π^0 will generate gammas and this should also be folded into the BLM response. R. Schmidt believes that this should not be a relevant contribution. To be checked! B. Dehning reminded that at HERA they have installed monitors after Lead shielding, which cuts low-energy part of the spectrum.

M. Santana-Leitner said that the deposited energy in the coils should be dominated by what leaks out from the collimators and not by showers from the beam protons. The FLUKA simulation provide the whole spectrum of particles that comes out of the collimator insertion, including what ends up into the BLM in IR7. He will present this at one of the next meeting, together with the recent results of IR7 energy deposition studies on the passive absorbers. However, it was noted that L. Ponce discussed BLM locations all around the ring also where the showers from the collimators are negligible and the dominant effect comes from direct proton losses (S. Redaelli). For detecting losses close to the collimators, dedicated BLM's are installed at each collimator.

R. Assmann asked if also for beam 2 two BLM's per collimator will be installed. B. Dehning replied that this is indeed the case.

L. Ponce asked if also the dispersion suppressor of IR3 should be equipped with additional BLM's to detect losses of off-momentum protons. R. Assmann replied that the physics involved is the same and one should also expect off-momentum losses in the dipoles downstream of IR3, as it is for IR7. Therefore, the same monitoring equipment should be foreseen. C. Bracco will start systematic studies on the proton momentum cleaning and will provide inputs to the BLM team as soon as possible. As for the ions, the additional BLM's proposed for IR7 should **not** be installed. Dedicated simulations are on-going (G. Bellodi) and we should wait to get results before taking the final decision.

R. Assmann also commented that we cannot predict in simulations all the possible locations of losses. It will be enough to steer the orbit to significantly modify the loss pattern. B. Dehning agreed and stressed that exactly for this reason it is important to study early on new possible error scenarios. There was clearly a general agreement on that. Work is on-going within the ABP collimation team(see report by C. Bracco at the collimation working group meeting of May 22nd, 2006). R. Schmidt commented that a new PhD student has just started working on modelling failure scenarios under his supervision.

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4 Systematic differences between B1 and B2 losses (R. Robert-Demolaize)

Following up a pending action of the last meeting, G. Robert-Demolaize discussed systematic comparisons between loss maps of beam 1 and beam 2 in order to understand the differences. Notably, it is found that beam 2 presents losses in various locations in the arc 7-8, even at large distances from IR7, whereas beam 1 only shows significant losses up to the end of the dispersion suppressor.

G. Robert-Demolaize explained that the differences in the loss patterns immediately downstream of IR7 can be understood by considering the different optics functions. The locations of maximum horizontal dispersion and beta functions occur at different cells for the two beams (the dispersion function is not symmetric with respect to IR7). G. Robert-Demolaize also argued that the differences in phase advance for the two beams could explain part of the differences. However, there was a general agreement that this cannot be a significant source of difference because the optics is basically the same for the two beams.

Another significant difference between beam 1 and beam 2 is found at IR6. This is explained by the fact that for B2 IP6 is immediately downstream of the betatron cleaning and therefore the TCDQ elements intercept more beam halo. This difference was already discussed in detail in previous meetings (L. Sarchiapone on May 8th and T. Weiler on May 22nd, 2006). G. Robert-Demolaize commented that some off-momentum halo leaks out of the TCDQ elements and as a result simulations predict losses in the dipoles of IR6.

L. Ponce asked if the ratio between the losses in the TCDQ and in Q4 stays the same for various optics imperfections. R. Assmann replied that C. Bracco is working on various failure scenarios and will report her results as soon as possible.

R. Schmidt asked how the quench limits quoted by G. Robert-Demolaize compared to the ones used in the FLUKA energy deposition studies. S. Redaelli replied that for proton losses we still use approximate quench level expressed in lost proton per metre. No full energy deposition studies are yet carried out starting from distribution of proton losses. R. Assmann commented it would certainly be a nice achievement to put everything on the same scale. This is in our pending action list but is not done yet.

R. Assmann commented that the B2 losses further down in the arc 7-8 are actually not understood yet and hence should be investigated further (**action for the ABP collimation team**).