Stefano Redaelli, 20-03-2007

84th Meeting of the LHC Collimation Working Group, March 19th, 2007

Present: Ralph Assmann (chairman), Giulia Bellodi, Patrick Bestmann, Dariusz Bocian, Chiara Bracco, Francesco Cerutti, Bernd Dehning, Simone Gilardoni, Daniel Kramer, Mikko Karppinen, Luisella Lari, Marco Mauri, Manfred Mayer, Valentina Previtali, Stefano Redaelli (scientific secretary), Stefan Roesler, Mariusz Sapinski, Lucia Sarchiapone, George Smirnov, Markus Stockner, Joachim Vollaire, Thomas Weiler.

1 Remote survey of collimator alignment in high radiation environment (P. Bestmann)

Patrick Bestmann from the Survey group discussed concepts for collimator alignment survey in a high radiation environment. Patrick did not discuss the details of the alignment techniques applied during collimator installation but offered to present this in a dedicated presentation if people are interested. The studies from the SC-RP group have shown that significant remanent doses are expected in the cleaning insertions after a few years of LHC operation and therefore it will be necessary to automatize as much as possible the procedures for the collimator survey in order to reduce the dose to personnel.

Patrick Bestmann reminded that the collimators are aligned with respect to a reference defined by the quadrupoles in IR7. A crucial step for a proper alignment is the correct fiducialization of each collimator on its support. Then, the alignment in the tunnel is achieved in three steps and the last one is a stretched-wire offset measurement. Movable tripods are used to stretch a wire along IR7 (maximum lengths up to 150 m). The absolute position of the wire is not important because it is only used to determine the nominal orbit defined by the quadrupole magnets, which is then used as a reference for the collimator positioning.

Patrick Bestmann proposed that the alignment survey at the LHC could be done remotely by means of the monorail train that runs along the insertion regions (see also the presentation of Keith Kershaw at the last collimation working group meeting of March 5th, 2007). A dedicated wagon should be equipped with (1) stretched-wire detection systems, used to determine the train position with respect to the wire and (2) 3 to 6 cameras used to measure the position of the fiducials mounted on reference quadrupoles and collimators. In addition, digital inclinometers will be used to determine the horizontal plane and longitudinal position sensors will measure the s position with accuracy of a fraction of millimeter. The basic idea is that, as the monorail moves along the insertion, the cameras measure the positions of photogrammetric targets mounted on collimators and magnets and this allows reconstructing the positions of the various elements by triangulation. The reference orbit is determined from the measurements of the quadrupoles and then this reference is used to determine the collimator positions.

The stretched-wire is used as temporarily reference to link the positions of the collimators and quadrupoles. The wire detection sensors also have photogrammetric targets and their position is also acquired by the cameras as a reference. Further details can be found in Patricks slides.

The remote survey system is designed to provide an alignment accuracy better than **0.2 mm**. However, detailed experimental programs are ongoing to assess the real performance. Notably, tests are foreseen in the period of March/May 2007 to understand the what can be achieved with the system combining the different sensors. Critical components are also the photogrammetric targets that have to be mounted on the collimators and on the magnets. The ones available on the market are typically not radiation hard and hence a solution has to be found for the LHC. Some prototypes are already in production.

Patrick Bestmann concluded his presentation by showing a detail work-plan for the months to come. He outlined the necessary steps for demonstrating the feasibility of the proposed system for the LHC.

1.1 Discussion

Stefan Roesler warned that we should not forget that ventilation doors are foreseen around the cleaning insertions. They could interfere with the movements of the monorail. Patrick Bestmann replied that he is aware of this problem. He requested a detailed 3D integration study to see if there is enough space left for the monorail.

Stefan Roesler asked if the proposed system could also be used for the initial collimator alignment and not only for the survey after installation. If this was the case, one could reduce the dose to personnel during the installation of the Phase II collimator. Patrick Bestmann replied that the proposed system has no active elements to displace collimators. It could therefore be used to measure the displacements that have to be done during the fine alignment but human intervention will always be needed to actually perform the movements.

Manfred Mayer asked whether the installation of the photogrammetric targets on the collimators (5 are needed) is foreseen. Patrick Bestmann replied positively. Prototypes are in fact under study at the workshop of bld. 252. The installation of this targets will be done on the fiducialization plate (which is precisely machined) and this additional pieces to mount will basically have no impact on the collimator assembly.

Bernd Dehning asked if the sagitta of the stretched-wire is properly accounted for. Patrick Bestmann replied that this is indeed the case. The relevant wire parameters (specific weight, tension, difference between heights of the extremities...) are measured as required.

2 FLUKA studies on passive absorbers for IR7 (F. Cerutti)

Francesco Cerutti reviewed the status of the FLUKA studies of passive absorbers for IR7. Francesco reminded that the passive absorbers (TCAP's) have been added to the layout in order to reduce the doses in the warm D3 dipoles and Q5 quadrupoles from the showers developed in the collimators. Previous studies were reported, amongst other, at the 59th meeting of the collimator working group of June 13th, 2005. As a result of an extensive FLUKA simulation campaign, it has been proposed to add three passive absorbers per beam (see page 2 of F. Cerutti's slides):

- a 1 m-long absorber made of Tungsten in front of the first D3 dipole magnet;
- a 0.2 m-long absorber made of Tungsten between the two D3 dipole magnets;
- a 0.6 m-long absorber made of Tungsten in front of the first Q5 quadrupole magnet.

It is noted that the case study was based on the nominal LHC optics at 7 TeV. All passive absorbers have an aperture of the same size of the close-by magnet aperture.

Francesco Cerutti also showed detailed energy deposition maps within the volume of the passive absorbers and of the coils. The front crossing of the Copper dipole coils at the magnet entrance is the most critical hot spot. All together, it is found that on paper the proposed layout fulfills the specification that were discussed by Suitbert Ramberger at the 45th meeting of the collimation working group. It is found that the highest dose is about **2.5 MGy/y** and this should ensure a magnet lifetime larger than 10 years.

Even though the statistical error on the presented results is only about 10 %, Francesco Cerutti warned that some safety factor should be taken on the estimates of peak deposited energy.

The next step for the FLUKA studies is to repeat simulations with an updated design of the passive absorbers, which will be provided by the TS collimator design team. The design of the passive absorbers is being followed up by the Collimator Design working group. Francesco Cerutti also commented that a "sandwich" solution, with a thin Tungsten layer around the beam pipe and the rest of the absorber made of iron, could be adopted instead of a full Tungsten block since the transverse propagation of the shower at 7 TeV can be attenuated without a lot of W.

Bernd Dehning asked if the passive absorbers will be water cooled. R. Assmann replied that this will be the case. However, the beam pipe will not be cooled, even though the simulation suggests that for low beam lifetimes the peak deposited energy in the pipe is close to its melting point. R. Assmann also commented that the final simulations with a more refined absorber geometry should also include estimates for the baking elements installed around the magnet beam pipe.

3 Results of 2006 BLM tests at the SPS and proposal for 2007 MD's (D. Kramer)

Daniel Kramer presented detailed analysis of the BLM data acquired during the 2006 collimator MD's at the SPS and discussed the proposed program for new MD's in 2007. Preliminary results were already discussed at the collimation working group meeting of December 11th, 2006. Beam loss measurements were performed with 270 GeV coasting beams by means of 4 LHC-type monitors installed 10 metres downstream of the collimator prototype in LSS5. Daniel Kramer reminded that three different beam loss acquisition were performed: (1) 1.7 s long *Post Mortem* buffer triggered by jaw movement requests with integration time of 40 μs; (2) 80 ms long *Post Mortem* buffer with integration time of 2.52 μs; (3) running averages corresponding to the 12 LHC integration times (1 Hz acquisition rate). Daniel's presentation was focused on the analysis of (1) and (2).

Daniel Kramer commented that there has been a mis-counting problem with the data acquisition of the *Post Mortem* buffer due to a bug in the electronics that systematically introduced additional counts. This problem has been fixed. All the acquired data could be corrected off-line and hence detailed analysis are possible.

Daniel analyzed the duration of the beam loss signals measured when the collimator jaws are moved in small steps. The duration is consistently correlated to the expected length of the jaw movement (nominal speed of 1 mm/s). A Fourier analysis of the BLM signal shows a reach frequency content of the signals. The dominant oscillation frequencies are 50, 150, 300, 450 and 600 Hz, which are induced by the 3-phase power supplied of the SPS magnets. This is a known feature of the SPS beam and Daniel pointed out that is literature one can find various papers that discuss similar effects measured in the beam tune spectrum. Daniel stated that it seems unlikely that this signal is induced by noise on the BLM cables and he rather believes that it is actually induced by real transverse beam oscillations. In addition, a strong peak is also found at 71 Hz but its source has not been identified yet.

Daniel Kramer also showed some examples of BLM signals with longer jaw movements (up to several hundreds of milliseconds, corresponding to steps of several hundreds microns). It was shown that the integration time chosen for the collimation data logging (item (2) in the list above) is not adequate to measure properly this kind of jaw movements because it is too short. Daniel also showed an example of reduction of BLM signal when the jaw is moved outside of the beam core. The DC loss level is reduced to negligible values within less than 50 ms.

In order to better understand the performance of the LHC-type BLM's, the BLM team proposed to repeat dedicated tests in 2007 at the SPS by using the collimator prototype that has been left in SS5. Notably, the BLM team requests MD time to (1) test the new

version of the electronics (bug *Post Mortem* buffer corrected); (2) investigate systematically the frequency content of the BLM signal and the influence of various machine parameters and equipment states (damper, power supplies, RF, ...); (3) test the final LHC-type SEM monitors; (4) optimize the dedicated collimator data logging in view of the setup of automatic alignment procedures.

The collimation working group fully endorsed the proposal for new MD's this year. R. Assmann reminded that the SS5 collimator prototype has been left in the SPS but there is no request for new collimator MD's. The collimator has not been updated to the LHC configuration for motors and position sensors but it can certainly be used for the proposed BLM studies. Ralph also reminded that collimator MD with ions are also foreseen, which will use this collimator prototype.

S. Redaelli commented that some of the electronics for the collimator control have been removed from BA5. The collimator MD's will therefore requires actions for the ATB and CO control teams and the people involved have to be informed in due time. Bernd Dehning stated that it would be advisable to perform the MD's as early as possible in order to freeze the LHC parameter sets. S. Redaelli will follow up the SPS MD planning and inform the people involved.

Actions: Follow-up the setup of the collimator controls preparation and the MD plan for the 2007 MD's (Stefano Redaelli).

Bernd Dehning also asked about the jaw vibration measurements performed in various tests with and without beam. It would be interesting to correlated the LM spectra with the spectra of the jaw movements. S. Redaelli commented that he can provide some vibration spectra from accelerator measurements. However, he does not have a direct measurement of the jaw vibration because the accelerometers are installed on the plate under the collimator assembly. R. Assmann reminded that laser vibration measurements were performed by Roman Wilfinger during the TT40 robustness test but results are not yet available.

Actions: Compare the spectra of jaw vibration measurements with the spectra of BLM signals (Stefano Redaelli).

The next meeting will be announced.