Stefano Redaelli, 08-12-2006

79^{th} Meeting of the LHC Collimation Working Group, November 27th, 2006

Present: Ralph Assmann (chairman), Giulia Bellodi, Chiara Bracco, Markus Brugger, Helmut Burkhardt, Bernd Dehning, Andres Gomez Alonso, Barbara Eva Holzer, Daniel Kramer, Laurette Ponce, Stefano Redaelli (scientific secretary), Stefen Roesler, Mariusz Sapinski, Lucia Sarchiapone, George Smirnov, Ralph Steinhagen, Thomas Weiler.

1 BLM installation layout (L. Ponce)

After a brief recall of the transverse BLM layout that as been adopted for the LHC based on the study of beam loss distribution (discussed in the collimation working group meeting of June 19th, 2006) Laurette Ponce presented detailed drawings of the **longitudinal BLM installation layout** and asked approval/comments from to collimation working group. The installation of BLM's in the tunnel has already started and therefore any feedback should be given as soon as possible to the BLM team. It was noted that the BLM installation in 1st sector is almost finished. Tests of signal connections will start in the next weeks. These have not to be confused the the tests with movable radiation sources, which are instead scheduled for next summer.

Laurette Ponce showed various examples of the BLM layout drawings and warned everybody that in the database the BLM attached the a given cell, say cell 7, only appear in the drawing for the cell 7 even though longitudinally it is actually mounted on a magnet of the cell 8. This approach might seem confusing but it was preferred by the database people. It has some operational advantage because each monitor will automatically be attached to the magnet that it is installed for.

Laurette also showed in some details the installation of the BLM's close to the **collimators in the IR's**. Notably, the BLM are located immediately after the pumping modules assigned to each collimator. R. Assmann asked why in the IR's the monitors have not been installed on the support of the pumping module, as it is done for the collimators in the cleaning insertions. Bernd Denhing replied that this was asked from Roger Perret.

Laurette Ponce also stated that in some cases more inputs are needed in order to optimize the BLM layout. In several locations (e.g. at the quadrupoles where the beta functions is not maximum in the middle of the magnet) a better knowledge of the optics, or of the expected local loss patterns, could help optimizing the monitor locations. Laurette asked help from the collimation team.
Follow-up after the meeting: S. Redaelli provided to Laurette Ponce a `MADX` script to generate Twiss tables with the beta functions within any lattice element with arbitrarily small longitudinal space resolution. This will be used to find the location of maximum beta in the quadrupoles composed by several magnet modules.

Laurette commented that the additional monitors asked from the ion project have also been installed at the agreed positions. Shift of few tens of centimetres had to be applied in some cases in order to fit the monitor into the existing 3D layout (bellows, interconnections, magnet feet, ...). Giulia Bellodi confirmed that shifts below 0.5 m are not an issue. Laurette brought up the issue that **thresholds for the ion BLM's** should also be provided (**Action for the ion collimation team**).

R. Assmann asked if the BLM position transversally is the same for all quadrupole types. Laurette replied that this is the case. Bernd stressed that the proposed horizontal location should the best as far as the BLM signal is concerned.

George Smirnov asked about the flexibility of threshold settings. Laurette said that for the moment the thresholds are set based on simulations, which start from the magnet heating from proton lost and estimate loss signal in the monitor. These thresholds will be changed after operational experience. This calculation exist for protons but not yet for ions.

2 BLM's for ions in IR3 (G. Bellodi)

Giulia Bellodi presented her latest results of the IR3 beam loss studies for ion beams, which were used to propose a installation layout for the BLM's. Simulations are carried out with ICOSIM (see also Giulia's presentation at the collimation working group meeting of May 22nd, 2006) with some initial assumptions for $\delta p/p$ distribution of the ion beam. TCLA's of IR3 not taken into account for the moment. Details of the simulation setup can be found in Giulia's slides.

Compared with previous results for IR7, Giulia Bellodi found a qualitative difference in the dependence of the cleaning efficiency on the average skin depth of the initail beam distribution (page 7 of Giulia's slides).
Follow-up after the meeting: This was further discussed at the meeting of December 11th, 2006.

In order to investigate the sensitivity of the loss locations to machine imperfections (optics, aperture), Giulia Bellodi simulated the effect of closed-orbit distortions by scaling the aperture dimensions by ± 4 mm (LHC closed-orbit tolerance). Correspondingly, the locations of loss peaks can be shifted by up to several metres.

Based on the simulation results, Giulia proposed a BLM layout that covers the possible loss locations. The proposal foresees a tight coverage in cell 9 and 11, where most of the loss peaks occur, and less monitors in between (cell 10), where the dispersion function starts decreasing. Giulia pointed out that, in order to connect the proposed BLM's of cell 13 to the existing patches for the BLM connections, 30 metre-long cables will be needed. Bernd Dehning confirmed that this length is not a problem for the signal transmission.

Since existing patches are to be used to connect the new proposed BLM's, some of the monitors have to be coupled together if in a given patch there are not enough spare channels. Therefore, **in some cases we cannot acquire individual BLM signals** but we have to combine them (e.g. taking the sum). R. Assmann commented that this means that we will lose in some cases the possibility of performing 'spectroscopy' analysis of loss peaks by acquiring simultaneously and independently the signals from the different monitors. In addition, R. Assmann also pointed out that this could have serious implications on the choice of the thresholds. However, there is no other choice for the moment because all the spare channels are used.

Giulia further discussed an old pending action for the IR7 studies: the ion cleaning inefficiency versus primary collimator length. New simulations show that the cleaning performance does not improve for very short jaw lengths. In addition, it is also found that for lengths above 0.2 m there is enough interaction length for the ion. Bernd commented that, based on these results, one could conclude that there will be no need to align precisely the collimators to the beam envelope.

S. Redaelli asked why one finds the same amount of primary ion impacts on both jaws of the IR3 primary collimator. As one typically expects particles with negative $\delta p/p$ to be lost in the momentum cleaning, he would assume that one jaw should have many more primary impacting ions than the other jaw. Giulia Bellodi replied that in her simulations she assumed a symmetric dp/p distribution for the off-momentum ion beam.

Two issues were risen in the discussion that followed Giulia's presentation: (1) it was proposed that the proton loss maps should be also expressed in W/m in order to compare the results to the ion simulation. This will be followed up by Thomas Weiler (**Action**). (2) Bernd stated that the BLM thresholds for collimator damage should be provided (**Action for the FLUKA and TS teams**).

3 Expected orbit stability during betatron squeeze (R. Steihagen)

In his presentation, R. Steinhagen gave an overview of the required LHC orbit stability and discusses the expected orbit stability at the LHC during the betatron squeeze with an emphasis on the transient orbit drifts observed inside the cleaning insertions, which have the most stringent orbit stability requirements.

Focusing on the the beta-squeeze alone and assuming a worst-case quadrupole misalignment of about 0.5 mm r.m.s., the **uncorrected orbit transients** may reach about **30 mm r.m.s.** during the squeeze in either IP1 or IP5. Assuming a squeeze duration of about 20 minutes, this corresponds to transient orbit drifts rate of about 25 m/s which are compatible with the nominal COD ramping rate. The LHC orbit feedback is in principle able to minimise these drifts close to the residual BPM and COD noise level. Assuming a steady-state machine with non-moving quadrupoles, the required orbit corrections during the first squeeze could be fully incorporated into the next fills. However, based on estimates presented in CERN-AB-2005-087, random ground motion is expected to contribute to quadrupoles shifts in the order of 5-10 micron r.m.s., resulting in a fill-to-fill uncertainty of the orbit during squeeze of about 300 to 600 micron, if not compensated by beam-based feedbacks.

Comparing the expected drifts with the stability requirements of the nominal collimation system that require beam stabilities of 15 um (0.15 sigma) or better at the location of the collimator (see slides for details), Ralph Steihagen warned that the cleaning performance at the LHC is going to become too much dependent on the availability of a performing orbit feedback system. He asked the question whether it is good that a critical system like the collimation system becomes so much coupled to the feedback system, which originally was not foreseen to be an unavoidable system for the LHC operation. R. Assmann commented that more studies have to be done in order to understand whether we could relax the stability tolerances during the squeeze. We need to figure out in detail the operational settings during ramp and squeeze. C. Bracco has started working on these issues.

The next meeting will be announced.

Action Items:

- Provide BLM thresholds for ion (ion collimation team provide input to the BLM team).
- BLM thresholds for collimator damage (FLUKA and TS collimation teams).
- Express proton loss maps in W/m to compare the estimated deposited energy in superconducting magnets to what is found for ions (Thomas Weiler).