Stefano Redaelli, 29-01-2007

81st Meeting of the LHC Collimation Working Group, December 11th, 2006

Present: Reyes Alemany Fernandez, Ralph Assmann (chairman), Giulia Bellodi, Chiara Bracco, Markus Brugger, Francesco Cerutti, Andres Gomez Alonso, Verena Kain, Daniel Kramer, Jacques Lettry, Laurette Ponce, Valentina Previtali, Stefano Redaelli (scientific secretary), Guillaume Robert-Demolaize, Mariusz Sapinski, Lucia Sarchiapone, George Smirnov, Maciej Sobczak, Markus Stockner, Thomas Weiler.

1 Update on ion cleaning efficiency versus impact parameter (G. Bellodi)

As a follow-up of previous meetings, a study was carried out on the dependence of the ion collimation inefficiency on the impact parameter and TCP length in IR7. Varying the primary collimators' length at constant skin depth of the initial beam distribution (equivalent to a constant average impact parameter) does not affect the collimation efficiency as long as the collimator's length is larger than the mean path length for nuclear interactions of the ions in the collimator material (≈2.5 cm) [slide1]. On the other hand, varying the skin depth parameter of the beam distribution at fixed TCP length, one finds a linear correlation between the effective path length travelled by the lead ions inside the collimators and the average impact parameter upon the first machine turn. The collimation inefficiency calculated after the first turn ($\eta(1)$) presents a somewhat expected behaviour, falling off at high impact parameters (the longer the distance travelled, the higher the probability that the particles are stopped and absorbed in the collimators). However, after 250 turns, this dependence looks more complicated, as the efficiency improves also for very small values of the impact parameter [slide2]. This is most likely due to a multi-turn effect, whereby particles that are scattered off at their first impact with a collimator, eventually hit at a later revolution with a much bigger impact parameter (factor 10-100) and are consequently effectively stopped in the collimator [slide3]. The turning point between the two regimes, at around $< b >$=0.7-0.8 microns, corresponds to the case where the effective path length in the TCPs is comparable to the average nuclear interaction length (≈2.5 cm for lead ions).

2 Beam-based alignment and tail re-population (C. Bracco)

C. Bracco presented preliminary results on the beam-based alignment procedures and on tail re-population studies carried out at the SPS collimator MD's. C. Bracco described in detail the **procedure used to centre the collimator jaws** around the circulating beams and the precision that can be achieved with this method. The alignment procedure relies on the study of the signals from dedicated beam loss monitors mounted close to the collimators. The losses are continuously monitored at the frequency of 1 Hz as when the jaws are moved and "touch" the beams. C. Bracco showed examples of the SPS data and claimed that we could achieve an accuracy of the order of 20 μm in the beam based collimator alignment. The reproducibility of the beam orbit throughout one MD was also stable to within better than 30 μm in the first MD and to within better than 50 μm in the second MD.

Next C. Bracco discussed the shape of the BLM signal tails for different collimator settings. She reviewed the results obtained during the 2004 SPS tests and presented the results of the new **tail re-population studies**. Typical decay times of the BLM signal are of the order of 25-30 seconds. This is the time required for the signal to stabilize to a DC level after that the collimator has been put close to the beam (see page 10 of Chiara's slides).

In some cases it was observed that the BLM signal does not stabilize to a DC level but instead it suddenly jumps to higher values after 0.5-1 minutes. The signal shape during the spikes can be fitted by a second order polynomial fit. C. Bracco showed some examples of these findings. The source of such effect is still under investigation.

This year we also performed measurements of **effect of tune changes** on the losses at the collimator. The SPS horizontal tune was changed form 0.125 to 0.3 and for each case the losses induced by collimator movements were recorded. C. Bracco showed that for some tune values we could measure a **"tail echo effect"**: loss spikes where measured synchronously to collimator jaw movements and then appeared again after a few seconds. See page 14 of Chiara's slides. This effect is under investigation.

2.1 Discussion

Jacques Lettry asked if there were attempts to set the parallelism of the collimator jaws with respect to the beam envelope. C. Bracco replied that we tried but we saw puzzling results, which are still under investigation.

Jacques also asked if one can cross-calibrate the measure BLM signal with the deposited energy on the collimator jaw. S. Redaelli replied that this would require a FLUKA model for the full SPS geometry, which has not been setup.

Jacques asked if other tail measurements were available at the SPS for a comparison with the tail population inferred from the BLM signals. S. Redaelli replied that this is not the case. The BLM signals are measured with collimator jaws fairly far from the beam centre (amplitudes of several beam sigmas). At the SPS there are no devices that can measure accurately the beam population at amplitudes significantly above 3 σ.

R. Assmann commented that the results on the effect of the tune on the beam loss response are very interesting and he encouraged C. Bracco to look in detail into the data and to try and fit the observed losses as a function of time.

3 Beam scraping studies (T. Weiler)

T. Weiler presented preliminary results on the beam current effects induced by the collimator scraping. Notably, Thomas investigated the calculation of beam position and sigma during **full beam scraping** obtained by moving one jaw across the beam centre. This method was proposed at the 50th collimation working group meeting of January 31st, 2005, as a mean to cross check the beam based alignment procedure based on the BLM signals (as discussed in the previous section). T. Weiler analyzed various available measurement sets from this year's SPS MD's, when the beam was fully scraped with left or right collimator jaw. He found that the beam size estimated with the appropriated Gaussian fit of the beam current data versus jaw position are in very good agreement with the wire scanner measurements. On the other hand, the estimated position of the beam centre differs by several hundreds micrometres with respect to the values measured with the BLM-based procedure.

This discrepancy can be induced by a **problem of synchronization** between the jaw position data: it was found that position data expected to be synchronized had actually delays up two 1 second. Furthermore, the delay are not constant throughout the MD by vary in an unpredictable way (Stefano Redaelli). This problem prevents detailed comparisons between the two methods for the beam based alignment because the uncertainty. on the jaw position due to timing error is larger than the alignment accuracy that we want to achieve.

T. Weiler also commented on the quality of the measured data during the collimator MD's. He pointed out that (1) in the first MD some jaw position readouts had a wrong sign; (2) the SDDS data format used for the beam current data had some problems with the timing and showed often non-physical zero values at the end of the data vectors; (3) the BLM data during the second were often corrupted, which did not prevent the data analysis but made it more cumbersome. T. Weiler also commented that the for later measurements it would be more convenient to have synchronized data sets for the various measurements (jaw positions, beam loss signals and beam current measurements).

S. Redaelli commented on the problems with the measurements data: (1) the wrong sign of some position sensors was known and was corrected at the top level during the first MD; (3) The problems with the BLM data are under investigation with the BLM team.

4 Fast beam loss data (D. Kramer)

Daniel Kramer presented the results of transient beam loss measurements induced by collimator movements. In view of the automatic beam-based procedure that will be implemented at the control middle level, for the 2006 MD's we set up a dedicated acquisition of fast beam loss data extracted from the *post-mortem* buffer. The acquisitions are triggered by collimator movements and this allows studying the transient losses during collimator movements. Daniel Kramer showed preliminary results of the data analysis. The acquisition chain worked correctly and we could record fast data at 40 microsecond acquisition frequency. This provides more information that the 1 Hz data that are sent to the top level for the beam-based jaw alignment. For example, Daniel showed plots of the integrated losses from 2.5 ms bin data for different jaw distances from the beam core. More detailed analyses are ongoing to understand all these data.

Daniel Kramer also commented on a problem experienced during the MD: if the triggers from collimator movements are too fast, the data from the *post-mortem* buffer can be lost. This problem is under investigation.

The next meeting will be announced.