Verena Kain, 2003-04-18

24th Meeting of the LHC Collimation Working Group, April 11, 2003

Present: Helmut Burkhardt, Peter Sievers, Verena Kain (scientific secretary), Ralph Assmann (chairman), Brennan Goddard, Rudiger Schmidt, Bernd Dehning, Markus Brugger, Jean-Bernard Jeanneret, Dobrin Kaltchev, Gianluca Guaglio, Gianfranco Ferioli, Christos Zamantzas, Barbara Holzer, Thys Risselada

1 Follow-up on Action Items

See slides at http://www.cern.ch/lhc-collimation/files/HBurkhardt_11Apr03.pdf.

The CWG meeting overlaps with the Accelerator Performance Committee (APC) chaired by FR which is scheduled the same time as this meeting. Postponing the CWG meeting one week after the Easter holidays to be out of phase with the APC meeting is an option.

RA comments that electron-cloud studies have not been continued yet as Frank Zimmermann is waiting for input from AF.

HB has set up a thick-lens version of combined optics SPS-TI8-LHC for a tracking with black collimators in MAD-X. To start his tracking studies he needs an updated version of the apertures in the transfer line. For the LHC he uses the most updated version but has problems with losing the information on apertures when merging the optics in MAD-X. A list of hardware tolerances for his studies has been set up, containing information on expected ripples of magnets, orbits in the SPS, etc.

RA reports that AF will investigate irradiation at the triplet and background at the experiments for a three stage collimation system. JBJ commented that old data out of a collaboration with IHEP (Portvino) still exists and might be scaled for the conditions of the new collimation scheme, and thus saving a lot of time. JBJ will review the results of the old studies in the next CWG meeting.

RA had presented the status of the LHC collimation system at the LEMIC (LHC Experiment Machine Interface Committee) on April 8, 2003. He had been asked about the time scale for the layout of the collimation system. RA had replied June 2003. People did not oppose studying the option of a three-stage system.

RA points out that there is a TIS document on Beryllium safety requirements available under
http://edms.cern.ch/file/335747/LAST_RELEASED/IS25_F.pdf
If there is a Beryllium contamination special companies have to deal with situation which possibly do not have access to high radiation areas.
The TIS document recommends that Be should be avoided if possible.

RS has to talked to Paul Proudlock concerning the 3 m space reservation at the D1 magnets for additional tertiary collimators in case this option is finally adopted. The space will be allocated in the new LHC optics version V6.4.02 which will be released in the near future.

RA had distributed the MAC comments via email and reported shortly on them. The feedback of the MAC is positive. The main concerns regard the not yet simulated longitudinal loss distributions which is important for judging on the required cleaning efficiency and as input for instrumentation to diagnose beam loss.

A discussion on BLM simulations is ongoing. RA wants to know which input data is needed for BLM studies. BD is for example interested in the average number of loss locations.

Action Items:

- ▷ Overview on the results of irradiation studies from the collaboration with Portvino. (JBJ)
- ▷ Which input data is needed for BLM studies from the CWG? (BD)

2 Re-Trigger Time in case of accidental pre-fire of one of the Dump Kicker Modules (JU)

See slides at http://www.cern.ch/lhc-collimation/files/JUythoven_11Apr03.pdf.

The old number of 1.3μs of re-trigger time included a safety margin and assumptions as no measurements existed. In fact measuring the re-trigger time gave, according to Etienne Carlier, at maximum 700ns above 3 TeV/c beam momentum. At lower energies one can most certainly expect re-trigger times up to 1200ns. Detailed measurements for the low energy case will be made this summer.

700ns re-trigger time occurs for the maximum length of a cable of 40m between two generators. With a delay for the cable of 5ns/m a delay of 40*5/14=14ns can be assumed between two adjacent generators (the dump kicker magnet consists of 15 modules). Thus the re-trigger time for the other modules in case of an accidental pre-fire is between approximately 500ns and 700ns, with the worst case if the pre-fire occurs at the first or last module.

The updated numbers will be the new baseline for the second phase of simulations. The present effort to select the best material will be continued with the old re-trigger time. The collimation team appreciated the hard work by the BT colleagues (JU, Etienne Carlier, ...) to reduce the re-trigger time to a minimum.

3 Proton Impact for New Dump Re-triggering Time & Specifications for the BLM System (RA)

See slides at http://www.cern.ch/lhc-collimation/files/RAssmann_11Apr03.pdf.

3.1 Proton Impact for New Dump Re-triggering Time

RA had produced new numbers for the proton impact on the collimators during a pre-fire of one module with subsequent re-trigger of the other modules of the dump kicker. In his simulations he had assumed that all modules re-trigger at exactly the same time, which is an idealization. For collimators closed ($\pm$1mm) at top energy the new re-trigger time gives a factor of 2.5 of improvement. About 7-8 bunches impact between 5 to 10σ. 1.3μs re-trigger time gave 6 bunches in the first sigma compared to 2 bunches in the first sigma for the new re-trigger time. Under these conditions and simply scaling the FLUKA and ANSYS results it is found that there is only 30% in robustness missing for simple graphite. For Be it is still a factor 3 to 4. With open collimators at top energy after the ramp (collimators at $\pm$4mm) about the same number of bunches can hit the collimator jaw, however, spread over 20σ. (The calculations where done with a beam size of 200μm.)

RS remarks that during the ramp the collimators should be moved somewhat further in than $\pm$4 mm. BD points out that despite of the improvement in the number of protons

per sigma with the new re-trigger time the transverse setting of the collimators is such that the steep slope part of the curve dN_p/dx versus x is cut, and thus orbit changes may be significant. RA replies that only one failure at a time is expected, with the assumption of non-correlation of, for example, fast orbit shifts and dump failures. If the loss of the surveillance of the gap (tripping of the beam sync clock, ...) results in dumping the beam, then this non-correlation can be guaranteed. It is no longer true for a case where first the surveillance is lost without detecting this error and then the beam is dumped because of a magnet quench which causes an orbit shift. The MPWG will address this question and provide an estimate. RS as chairman will follow up.

3.2 Specifications for the BLM System

The specifications for the BLM system were put for approval recently. RA reported that they specify a BLM system nicely suitable for quench protection. In the judgment of RA they do, however, not address all needs for collimator and machine tuning. RA has discussed his concerns with Jean-Pierre Koutchouk, JBJ, RS and it was agreed to include additional requirements in the specifications. The dynamic range of the BLMs should be adjusted. RA proposed that the specified usage of the BLM system should include

1. **Set-up of the LHC collimation system with the BLMC**
   The *collimator tuning* will be done at low beam intensities and decent beam lifetimes. Preliminarily an intensity of $5 \cdot 10^{11}$ 7 TeV protons for a beam lifetime of 30h is considered (non-destructive tuning). The tuning would not mean any risk for the collimators (the collimators will be able to withstand impact of 0.1% of the nominal beam intensity) but for the machine. The loss rate of $4.6 \cdot 10^6$ during the 30h lifetime is 130 times lower than the lower specified limit for BLMCs. An extension of the lower limit of the dynamic range is required. For injection tuning, where a full batch ($=3 \cdot 10^1$3p) can be lost at the collimators without risk, a lifetime of 5h could be considered. This results in a loss rate of $1.7 \cdot 10^9$, still less than a factor of three below the lower limit for the BLMCs given in the specifications. There are still open questions (Does the loss rate really correspond to the loss rate at one collimator jaw or respectively the corresponding BLM?...). HB wanted to know how collimator tuning would be done. RA and JBJ answered jaw by jaw for the first adjustment. BG asked whether it would be possible to do the tuning with the copper jaws in a hybrid system, as during the tuning secondary collimators would be used as primary collimators. RA suggested that the tuning should possibly first be done with graphite jaws.

2. **Running at the best cleaning efficiency with nominal (and ultimate?) intensity**
   The collimation system will be designed to stand 0.2h lifetimes without collimator damage and no magnet quenches. The BLMCs are specified to go into saturation for lifetimes of 0.23h for nominal intensity. Thus the BLM system could cause a beam dump because of saturation while it is still possible to run the machine. BD pointed out that "saturation" in this connection means "defined observation range" in the collimation section, which was defined without having considered these lifetime issues.

3. **Minimization of injection losses**
   With the present scheme the BLMs would be saturated for a 1 turn loss of a fraction of 10^{-5} of a nominal injected batch. Thus quenches due to a 1% loss of particles in the TDI region leading to off-momentum particle losses of $3 \cdot 10^{-4}$ in the downstream arc could not be "tuned away" easily as the BLMs would already be in saturation. Hence a loss of for example 2% of injected batch in the warm region should be allowed.

RA explained that these remarks and estimates should be considered as a starting point for further discussions in order to arrive at more accurate estimates later.

As 10^8 protons over 1ms could destroy the collimator PS asked if the BLMs could observe impact over periods short as 1ms, where the integrated number of protons might be comparatively small.

RS remarked that he thinks that the BLM's can do better than specified in the document. The really required improvements will be smaller than presented by RA, who just considered the specified dynamic range and not the actual performance of the BLM's. RS will show his numbers in the next meeting.

JBJ mentioned that he produced 100k events in K2 with the graphite system to provide input for IB to simulate resulting BLM signals.

4 Trial Moves of IR7 Quadrupoles to provide Space for Longer Collimators (DK)

See slides at http://www.cern.ch/lhc-collimation/files/DKaltchev_11Apr03.pdf.

DK rematched the optics in the collimation area trying to provide 2 times the space initially needed in the insertion (now 40m) for a graphite system with longer jaws but two jaws at each collimator location. Apart from separating quadrupole blocks no major problems occurred. For beam1 the amplitudes getting through the collimation area when matching for the old tune become slightly larger but can be considered unchanged for practical purposes.

In the last CPM on April 4, 2003, a possible collimator layout with one jaw per device (thus needing two devices to have both jaws one after the other) was presented. This collimator scheme would need more than twice the space as the graphite system with two jaws at each collimator location. JBJ is convinced that this additional space could be provided. DK mentions that one has to be aware of the limit set by the optic. In case of the single-jaw collimators the required space for the collimators would be 20% of the 400m in the insertion. RA wants DK to check the possibilities of 80m of space. In the course of the discussion on the possible collimator layout, RA makes clear that it is required to guarantee the absolute value of the gap between collimator jaws with good accuracy ($\approx 50\mu$m). The gap is then adjusted empirically around the orbit. With collimators with one jaw only followed by a second device with the opposite jaw this must be foreseen. Furthermore the ratio between n_1 and n_2 must be accurate within 0.5σ.

BD remarks that for the quality of the BLM data it would be useful to suppress cross-talk between signals from collimators of different beams. Thus putting collimators for different beams as far as possible apart from each other would be helpful.

RS wants to know about irradiation studies in the tunnel enlargement at IP3. JBJ answers that studies are being redone for the graphite jaws.

Action Items:

- ▷ Investigation of the optics possibilities for 80m of collimators in IR7 (DK)

The next meeting will be on May 2, 2003.