Verena Kain, 2003-04-04

$23^{\rm rd}$ Meeting of the LHC Collimation Working Group, March 28, 2003

Present: Oliver Aberle, Helmut Burkhardt, Luca Bruno, Peter Sievers, Verena Kain (scientific secretary), Ralph Assmann (chairman), Brennan Goddard, Rudiger Schmidt, Bernd Dehning, Mike Lamont, Miguel Jimenez, Jean-Bernard Jeanneret, Alfredo Ferrari, Lucien Vos, Nuria Catalan Lasheras, Dobrin Kaltchev, Vasilis Vlachoudis, Igor Kourouchtkine, Gianluca Guaglio, Gianfranco Ferioli, Christos Zamantzas

1 Comments on Minutes of Previous Meeting

In the last minutes it was indicated that limiting the re-trigger time in case of a pre-fire of one of the modules of the dump kicker magnet could reduce the number of protons between 5 and $10\sigma_x$ by a maximum factor of 4. In discussions afterwards it turned out that in practice this factor would be 3. Using an anti-kicker instead of reducing the re-trigger time could give in principle a factor of 4 improvement.
It was talked about the TCDQ as uncoated in the last minutes which is not yet clear.

Because of the war on Iraq PS has decided not to attend the Halo Workshop in the US. JBJ proposed to include PS's results on material issues in his presentation at the workshop.

2 Follow-up on Action Items

The question "How can BLM-specifications be used for collimator tuning?" should be treated.

LV and PS mentioned that due to the $1/d^3$-dependence of impedance on the distance d between object and beam using **stripes of carbon** in the collimators would not yield any improvement.

LV made clear that **sliced collimators** for a length of the collimation area of 20m would cause an inductance one third to one half of the inductance caused by the $\sim 4 \cdot 10^6$ holes of the beamscreen (PS proposed a scheme with 10cm of material followed by slits in the order of 1mm). PS mentioned that the slits could be made more narrow, 0.2mm is mechanically feasible.

HB informed the audience about his progress on setting up a combined optics for either TI2 (transfer line for beam1) and ring1 of LHC or TI8 (transfer line for beam2) and ring2 with MAD-X. He proposes to include scattering in his simulations. RA and JBJ made clear that, as specifications for **transfer line collimation** are due very soon (by June 2003), HB should start with loss maps at black absorbers and care about scattering in a second iteration. RA also pointed out that combining full showering studies (FLUKA) and MAD-X is not a realistic option anyway and furthermore the scattering of primary protons (K2) can be used with already existing less elaborate but faster linear trackings. (However, K2 studies are more suitable for designing a multi-stage collimation system. There is only primary collimation in the transfer line.)

HB is worried about possible changes of collimator locations. Depending on where possible coupling correction and tilts are put in the transfer line the foreseen locations of collimators before and after the stopper could be changed. Changes could be such that these two collimators would be placed before the stopper and thus protection of bends more downstream in the transfer line might be lost.

In order to provide specifications for collimation the questions "How many particles escape the transfer line with transfer line collimation after a full batch is lost?" (it still must be proven that this failure scenario is important) and "What is the impact map of primary beam on TCL collimators?" must be answered. The issue to be focused on until

June is protection rather than efficiency. LB remarks that the scheme of 2*4 collimators in the transfer line presented at Chamonix (the majority of the collimators movable and robust enough to stand the impact of a full SPS batch) exceeds the foreseen budget of 400k CHF. This budget includes 6 collimation and absorber components, all fixed.

Action Items:

▷ Simulations for dump kicker failures after the ramp when the collimators are not yet moved close to the beam must be carried out (RA).

3 Impact of Injection Kicker Failures (BG)

See slides at http://www.cern.ch/lhc-collimation/files/BGoddard_28Mar03.pdf.

BG reported on the probability of flashovers in one of the 33 cells of one of the 4 injection kicker magnets (MKI). The prototype measurement of the MKI resulted in a flashover rate of 2 ($\pm$ 2) per $4 \cdot 10^5$ pulses. This means 8 flashovers during a 20-years-lifetime of LHC with 200 days of LHC run a year. Kicks between 6 and 9σ are dangerous for the collimators. As a flashover in cell N produces twice the nominal kick (= 0.55σ) in the first N cells and zero kick in the remainder, a flashover needs to happen either in one of the cells 6-9 or 24-27 to make the batch receive a dangerous kick. The total probability per year to have a dangerous event is 10% (8*8/33 events in 20 years).

As rise time and fall time for the kicker are doubled, the first and last 1μs of the beam are swept from zero to the wrong value of the kick and back again. BG proposed for his group to investigate the triggering of the dump switch to reduce the nominal kick duration by 50%.

Furthermore he pointed out the need to quantify of the effect for the systematic component of 1.5σ injection oscillation due to for example the MKI waveform enevlope.

PS asked what the reasons were for the flashovers. BG replied that it was difficulties in the system but electrical contacts should be improved now. RS wanted to know whether the rate of flashover could rise due to radiation.

A "functional specification" for collimation in the transfer line, at injection and at the TCL collimators according to a set of most relevant failure scenarios should be provided.

Although BG mentioned the impact of half of a batch as worst case, RA proposes to stick to the requirement of collimators to be able to stand a full batch during injection in view of the work already done and the fact that injection requirements are not the driving requirements. For the final judgment certainly all updated results will be included.

Action Items:

▷ HB should assume most of a SPS batch between 6 and 9σ as worst case for his simulations.

4 News on Re-trigger Time of Dump Kicker Magnet

On behalf of Jan Uythoven RA mentioned the good news on re-trigger time for the dump kicker magnet. The re-trigger time assumed so far for specifications and simulations was 1.3μs. For beam energies larger than 3 TeV the re-trigger time is now said to be 700ns. In this case impact on collimators could be reduced by a factor of about 3. JU will give a presentation in the next CWG meeting.

Action Items:

- ▷ What is the detailed beam impact distribution on collimators during pre-fire with a re-trigger time of 700ns? (RA)

5 Rediscussing the Three Stage Collimation System

See slides at http://www.cern.ch/lhc-collimation/files/LTC_status_march03_ra.pdf.

Replying to worries of JBJ concerning collimators at the triplet RA said that the amount of showering due to collimation at this location had to be quantified and agreed with JBJ that only parts of these showers are swept out by the D1. The rest still might lead to an increase of background at the experiments. RA points out that if in trouble with keeping backgrounds low the three-stage collimation system can always be run as a two-stage collimation system.

LV asks whether the length of 50cm of the carbon secondary collimators of the hybrid system which are used during injection and ramping are sufficient. RA replies that cleaning efficiency during injection is not so critical and 50cm carbon collimators would do the job. NCL asks whether the copper and the carbon secondary collimators are both moved during squeeze. RA replies that only the Cu-collimators would be moved in, the carbon collimators would not change their positions.

RS asked whether it is really necessary to have carbon collimators for injection. RA explained that the aperture bottleneck at the triplets only exists at top energy with squeezed optics. In order to protect the arcs and dispersion suppressors during injection collimators are needed at 7σ where metallic collimators are ruled out.

JBJ wants to have more details on specifications on impedance. He raises questions such as:

1. What is the acceptable value for impedance?
2. What would the thickness of Be on C have to be to make the combined structure look metallic for the beam? LV replied immediately: 1mm of Be would do it. A calculation by LV after the meeting gave: 1mm of Be has 1.35 times the impedance of a pure Be jaw. A layer of 1.5mm of Be has the same impedance as a jaw entirely made of Be.
3. Which thickness of C on Be could make C transparent in terms of impedance? RA added 2mm of C might be enough for robustness (if Be works at injection). LV calculated after the meeting that the thickness of C on Be would have to be less than 25μm to obtain about the same impedance as for Be.

Numbers for impedance for frequencies other than 8 kHz are available. LV presented them at the last LTC meeting (March 19, 2003).

JBJ mentioned considerations on new absorbers at Q6 after the collimation sections. Beam loss with previous settings of the collimators was near the quench limit. The simulations will have to be redone for the new collimation layout.

Action Items:

- ▷ Overview on all required absorbers to avoid quenches in the LHC (JBJ)
- ▷ In case of using Be for the collimators which requirements and specifications are needed (installation of filters, breathing masks for the vacuum people when dealing with collimators, ...)? (TIS-group)

6 Space-reservation for additional collimators at the triplets

See slides at http://www.cern.ch/lhc-collimation/files/RSchmidt_28Mar03.pdf.

The initial number of 2m of space to be reserved at the D1 was reconsidered. The collimators will be used as component of the machine protection system as well as the beam cleaning system. The additional requirement for collimation (vertical and horizontal collimator both movable) needs so far 3m of space reservation. RS will deal with it.

Action Items:

- ▷ The implications on the D1 of IP2 and IP8, as they are cold, have to be checked not to run into trouble if putting collimators there. (RS, JBJ)

7 Temperatures in Short Collimators with Transient and Continuous Proton Losses (PS)

See slides at http://www.cern.ch/lhc-collimation/files/PSievers_28Mar03.pdf.

PS calculated the temperature rise in short collimators due to transient and continuous proton losses taking into account cooling or respectively thermal diffusion.

He looked at two conditions "steady state with cooling" and "semi-infinite body with no cooling but diffusion for 1s and 10s of transient impact". In his model the energy deposition of multi-traversing ($\sim$ 40 times) protons at top energy occurs only on the surface of the collimator, in an area of a half circle with r = 0.25 mm. PS showed that in the case of non-accidental losses the temperature increases moderately. AF doubts some of PS's assumptions (no energy-deposition in the volume). Further calculations for long collimators will have to be done with FLUKA.

From his considerations he concluded that C and Be (collimator length 1cm) can stand about 10^{12} p/s over a period of 10s or permanently with cooling. With Al (collimator length 0.9cm) and Cu (collimator length 0.3cm) it is $4 \cdot 10^{11}$ p/s over 10 s or permanently with cooling (for Cu some of the assumptions have to be checked). An open question is where the escaping power goes and where it is absorbed.

The next meeting will be on April 11, 2003.