Stefano Redaelli, 07-06-2004

39^{th} Meeting of the LHC Collimation Working Group, June 4, 2004

Present: Ralph Assmann (chairman), Igor Baichcev, Hans Braun, Markus Brugger, Bernd Dehning, Alfredo Ferrari, Jean-Bernard Jeanneret, Gianluca Guaglio, Barbara Eva Holzer, Mario Santana Leitner, Daniela Macina, Matteo Magistris, Manfred Mayer, Stefano Redaelli (scientific secretary), Guillaume Robert-Demolaize, Rudiger Schmidt, Vasilis Vlachoudis.

1 A.O.B.

Ralph Assmann (RA) announced that the collimator prototypes are being assembled. The prototype production has proceeded very well! Some pictures are now available on the collimation project web page
`http://lhc-collimation-project.web.cern.ch/lhc-collimation-project/`
People interested are welcome to visit the workshop to see the collimators.

2 Energy deposition at IR3, proposal for local absorbers (I. Baichev)

See slides at http://www.cern.ch/lhc-collimation/files/IBaichev_2004-06-04.pdf

Simulation setup
Igor Baichev (IB) presented the first results of shower studies at the LHC momentum cleaning insertion (IR3). Work has been carried out with Igor Kuzochkin (IK) and Jean-Bernard Jeanneret (JBJ). Simulations are performed by using STRUCT, which provides the maps of proton interacting elastically or diffractively with the collimator jaws, and MARS, used for cascade development and energy deposition studies. The interest has been focused on the quench limit of superconducting magnets. The presented results are expressed in terms of ratio between quench limit ($5\,\mathrm{mW/cm^3}$) and power deposition energy per unit of cleaning rate. This enables directly calculating for each magnet the corresponding minimum allowed beam lifetimes in hours. Two different cases have been considered for the length of primary collimators: (1) 0.20 m (carbon) and (2) 0.60 m (carbon). Copper has been assumed for the absorber material because carbon is a bad absorber of high-energy gammas: the proton mean free path to e^+e^- pair production is 28 cm instead of 1.9 cm for the copper and the radiation lengths are 21 cm and 1.43 cm, respectively.

Proposed locations for the absorbers
With 0.20 m long primary collimators and with no absorbers, it is found that several superconducting elements downstream of the dog leg show an unacceptable level of deposited energy. Notably, the dipole corrector MCBCV has a corresponding minimum allowable beam lifetime of 150 hours, and the magnet B8B is 35.5 hours. This demonstrates the need of absorbers for the showers. Such absorbers had already been foreseen for the old system V6.4.

Simulations have then been performed with four additional absorbers. The proposed locations are listed in the following table (see also IB's presentation for a schematic view):

Location	Plane	Dist. from IP3	Jaw length	Required space
Upstream of D3	Vert.	90.5 m	1 m	2 m
Upstream of D3	Horiz.	92.5 m	1 m	2 m
Inside the dog leg	Horiz.	176.5 m	1 m	2 m
Upstream of Q7	Horiz.	248.5 m	1 m	2 m

Dog leg

It was noted that the dog leg at IR3 is only 1.5 cm. This means that basically the neutral products generated in the collimation section, which follow a straight path along the beam position before the dog leg, fit in the aperture of the D4 magnet downstream of the dog leg (see the scheme in IB's presentation). Therefore, if not stopped, the neutral particles and some off-momentum protons would travel undisturbed through D4 and would end up in a very small point on the inner coil beyond Q7. JBJ stressed that a few years ago he strongly fought to increase the dog leg separation but he did not succeed.

Performance with absorbers

IB found that, with long primary collimators (0.60 m) and with the proposed absorbers, the deposited energy in the superconducting magnets is considerably reduced. The corresponding minimum allowed beam lifetime is now **2.5 h** at Q8.

IB also showed some preliminary results that show the dependence of the deposited energy on the openings of primary collimators (n_1) at IR3. He finds that if $n_1 = 15$ (nominal settings) is used instead of $n_1 = 12.5$, the peak deposited energy at Q8 is less than 10 % larger. However, IB is worried by the trend of the shower downstream.

Bernd Dehning asked whether Q8 is the last critical point downstream of the momentum cleaning insertion. Are there other critical elements further downstream, in the dispersion suppressor? IB answered that this is not the case. The deposited energy from off-momentum protons falls down after Q8. Further downstream, some secondary peaks arise, but they are smaller.

Discussion on error estimate

Alfredo Ferrari (AF) asked what is the error bar expected on the results that IB showed. He wanted to point out that the intrinsic error of these kind of simulations is generally large. One should not believe the results within a few percent! IB agrees with this remark. The largest source of error comes from the uncertainty on the cross sections of the events of shower production (the tracking which provides the proton maps at the collimator jaws should be instead reliable). The error on the shower calculation increase for the estimates of deposited energy much downstream of the point where the proton impacts. Everybody agrees that an error of 50 % would be acceptable but it should be kept in mind that an error of a factor 2 would not be too unexpected.

Conclusions

RA welcomed the very good results of IB, IK and JBJ work. He concluded that the proposed additional absorbers should be included in our baseline collimation design. For the first time, we now have a clear and complete picture of one cleaning insertion. At this status, the collimation system of IR3 looks acceptable in all respects: robustness, cleaning efficiency and quench limit. The only point which should be studied in more detail is the damage of the various components (for instance, what is the heating rate at the absorbers?). RA also said that it should be estimated (1) what is the best performance achievable with even more absorbers and (2) what is the effect of angle errors on longer primary collimators.

However, RA pointed out that it is not clear whether we will have the additional absorbers from the LHC day 1. JBJ strongly believes that we cannot startup the LHC without these absorbers, not even with a reduced LHC performance. RA replied that in this case we could probably postpone the installation of the tertiary collimators, which will be required for the nominal luminosity performance, in favor of an early installation of the absorbers. The installation of additional absorbers, probably required to go below a 2 h beam lifetime, can be installed later. Therefore, studies of showering at IR3 should continue with high priority in order to have a full picture of the required space and to start the integration of the various components.

JBJ said that we shall check whether or not the fourth absorber conflicts with the DFB before that the DFB design is finalized.

3 Status of showering studies at IR7 A. Ferrari)

AF also commented on the ongoing studies for IR7. The model for the warm components is ready and by the end of next week some cold components should also be available. This will allow producing some simulation results.

4 Discussion on available space at IR5 (D. Macina)

See slides at http://www.cern.ch/lhc-collimation/files/DMacina_2004-06-04.pdf

Following the proposal of tertiary collimators at LTC (minutes will soon be available at `http://edms.cern.ch/lhc_proj/plsql/lhcp.page?p_number=7708&p_banner=0`), Daniela Macina (DM) follows up on integration issues on IR5. CMS prefers to have TCT's at the same good locations of ATLAS in IR1. This opens integration issues with TOTEM, further enhanced by a space conflict with the TCLP at D2. In addition, physics issues also arise for TOTEM. DM requests the following information, also to clarify conflicting information from N. Mokhov and IB/JBJ:

- How many TCLs are required at IP5?
- When will they be installed? Are they required from day 1?
- At which luminosity are these collimators required?

JBJ will follow up on DM's request and will provide the requested information by the Friday 11th june.

The next meeting will be announced.

Stefano Redaelli, 07-06-2004

A Beam lifetime and transient losses (JB. Jeanneret)

From: Bernard Jeanneret
Sent: Sunday, June 06, 2004 5:43 PM
To: Bernd Dehning; Ralph Wolfgang Assmann; Igor Baichev
Cc: Bernard Jeanneret
Subject: Lifetime and transient losses

Dear friends,
This is to clarify the point raised by Bernd Friday about lifetime
and '10s' duration with poor conditions.

Data are taken LHC REP 44. Tables 2 and 7

At top energy for long transient losses, DQ_cable = 3 10^{-2} Jcm^{-3}.
Consider continuous losses for which w_quench = 5 10^{-3} Wcm^{-3} -> for a duration
of dt=10s, DQ_cont = w_quench x dt = 0.05 Jcm^{-3}.

If the non-quenching continuous limit is tau_cont= 1hr, then for dt=10s, the lifetime
can be
Tau-10s = tau_cont x DQ_cont / (DQ_cable+DQ_cont) = 0.625 h
(agreed, does not grant the quoted 12' = 1/5h, but 0.6 better than 1)
But at top energy, we shall not expect so poor lifetimes (everything including
squeezing is very slow w.r.t. 10s)
I remember the '10s' spec for
-injection
-collimator integrity (did we promise so for quench? Or was that implicit?)

Injection:
w_quench = 0.01 -> DQ_cont = 0.1 Jcm^{-3} DQ_cable = 0.35 Jcm^{-3}
-> Tau-10s = tau_cont x DQ_cont / (DQ_cable+DQ_cont) = 1 x 0.1/0.45 $\approx$ 0.2h
Here we are on the good side. And the scheme proposed by Igor may offer better
lifetimes at 450 GeV.

Hope this clarifies the point.
Yours. Bernard