Machine Protection Working Group

Minutes of the 66th meeting, 2nd November, 2007

Present: G. Bellodi, V. Previtali, T. Weiler, T. Bohlen, V. Montabonnet, A. Priebe, M. Sapinski, R. Steinhagen, F. Roncarolo, A. Gómez Alonso, J. Wenninger, M. Jonker, M. Stockner, M. Zerlauth, D. Swoboda, B. Dehning, D. Bocian, R. Schmidt.

Agenda:

- Measurements and Simulations for the LHC BLM System at the HERA Proton Beam Dump (M. Stockner)
- Particle losses at collimators during magnet powering failures: distribution of impact parameter (A. Gómez Alonso)

There were no discussions on the previous minutes. Discussions about the beam intensity that is safe for the experiments when injecting into an empty LHC were reported to the next meeting.

Measurements and Simulations for the LHC BLM System at the HERA Proton Beam Dump (M. Stockner)

M. Stockner presented the results of his PhD thesis about simulations for the LHC BLM System and measurements at the HERA Proton Beam Dump (slides). The calibration of the BLM had been done using simulations of the response of the Ionization Chambers which were validated in different experiments. **R. Schmidt** pointed out that according to the simulations, the BLM response does not depend on the type of particle for energies above 1 GeV (slide 5). Then the HERA proton Beam Dump was presented and the experimental setup presented.

The measurements of the BLM signals showed a time response with a peak at the loss moment (1s integration time) and a decay starting 3-4 orders of magnitude lower. BLM signal as a function of the deposited charge is non linear beyond a certain threshold when space charge starts having a relevance. **R. Schmidt** asked for equivalence between measured charge and number of protons in order to determine whether the linear range may be reached in the LHC (slide 13). **B. Dehning** replied if the beam hit a collimator the linear range could be exceeded, but other type of BLM detectors are in place to cover this loss scenario. **M. Stockner** continued his talk presenting the necessary correction factors to achieve good linearity in the measurements and the systematic uncertainties in the measurements.

The simulations of the HERA beam dump were then presented. Four different Monte Carlo methods were used and compared: QGSP-BERT-HP (Geant 4), FLUKA, FTFP (Geant 4) and LHEP (Geant4). The comparison with experimental data indicates that Geant4 with the QGSP-BERT-HP physics list or FLUKA (with low energy neutron transport) should be used for the simulations for LHC, with an expected error between 40% and 70% depending on the recording depth in the dump (slide 21).

The last part of the presentation covered an estimation of the BLM detector threshold using the simulated BLM response with simulated particle fluence spectra (MQY simulation by M. Sapinski and quench levels by D. Bocian and from LHC Project Note 44). The estimated thresholds at the quench level showed good agreement with previous results with an estimated uncertainty of 50%.

Discussion:

R. Steinhagen asked if estimates for ions had been done. **B. Dehning** suggested referring to the work of Roderik, who compared ion and proton impacts on a bending magnet.

R.Schmidt pointed out that, within a factor of two, we know where to set the BLM thresholds in the arc. **B. Dehning** suggested that with respect to previous results (LHC Project Note 44), the new quench levels calculated by D. Bocian should be taken into account. **D. Bocian** pointed out that for the LHC Project Note 44 enthalpy calculations were performed for MB magnet cables at 1.9K. The MQY magnet operates at temperature of 4.5K. The enthalpy limit of MQY inner layer cable is higher by a factor of around 5 due to the lower peak magnetic field - 6.16T (higher critical temperature of superconductor) compare to the MB magnets – 8.58T. New estimations of cables heat reserve are available in the note (EDMS 750204). The work on quench level estimations is in progress and the results were partially validated.

R. Schmidt continued asking about the quench levels calculation for fast losses in all LHC magnets. **D. Bocian** replied that the quench levels for transient losses are easier to estimate compared to the steady state beam loss because only enthalpy of the “dry” cable is need to be calculated – there is no contribution from the helium enthalpy for the loss time less than ~10μs. **R. Schmidt** suggested scanning the changes of the cable enthalpy with the temperature in ranges of 1.9K to 2.8K for magnets operating at 1.9K and 4.5K to 6K for 4.5K magnets. **B. Dehning** pointed out that numbers are available for all LHC magnets and there are more critical magnets as for example MQM at 1.9K.

Particle losses at collimators during magnet powering failures: distribution of the impact parameter (A. Gómez Alonso)

A. Gómez Alonso presented the evolution with time of the distribution of the impact parameter at collimators while a magnet powering failure develops (slides). The evolution of the beam during a powering failure was presented and a short introduction on general simulation procedure was made. The evolution with time of the distribution of the losses at the collimators can be obtained using MADX tracking with variable magnetic field. The results can then be used as input for FLUKA simulations in order to estimate the times from the beginning of the failure until the damage level or the BLM detection threshold are reached. Complementing these results with sixtrack simulations including scattered particles from collimators can lead to estimations of the time margin from the beginning of the failure until a quench happens.

The effects of quadrupole failures leading to losses were then presented. **S. Redaelli** asked how the twiss parameters had been calculated. **A. Gómez Alonso** answered that the twiss parameters referred to the closed orbit solution, instable for the last turns before a complete loss of the beam, while the size of the beam showing resonances had been calculated from the distribution of the tracked particles. Then, **A. Gómez Alonso** explained the influence of the speed of the failures on the distribution of the losses.

A. Gómez Alonso presented the evolution of the impact distribution for a worst case powering failure of RD1.LR1 at injection energy at TCSG.6R7.B1 and TCP.C6L7.B1. Most losses happen first at TCP.C6L7.B1 and then, as the failure develops, at TCSG.6R7.B1. **S. Redaelli** wondered if TCSG.6R7.B1 was a vertical collimator, in which case these results did not make sense. **T. Weiler** confirmed that TCSG.6R7.B1 is almost horizontal (0.5° skew). **A. Gómez Alonso** proposed a fit function as a way to represent the evolution of the impact distribution in a more compact form and some examples of the evolution of the impact distribution were shown.

Simulations performed with sixtrack, taking into account the particles scattered after an impact in the collimator were presented by **A. Gómez Alonso.** In the case of a magnet failure the average impact parameter of lost particles is more than two orders of magnitude greater than in the case of normal operation and the efficiency of the collimation system can't be assumed to be the same. Sheet beams were generated before the collimators at different impact parameters (slide 19) and for each case, the fraction of particles lost in the cold aperture was recorded. The combination of the evolution of the impact parameter with these simulations can be used to estimate the time margin between the beginning of a failure and a loss induced quench.

S. Redaelli asked about the optics used for the sixtrack simulations, since the magnetic field is changing during the failure. **A. Gómez Alonso** noted that nominal optics had been used. **S. Redaelli** claimed that this approach is a little bit optimistic and that it would be better to modify the sixtrack code to include variable magnetic field. **A. Gómez Alonso** noted that the latter approach had been discarded due to the high investment required. Besides, most of the particles were lost in the first turn close to the affected collimator. **R. Schmidt** pointed out that in this case, **S. Redaelli's** statement is true only in failures of magnets around IR7.

B. Dehning asked about the case of common failures. **R. Schmidt** noted that for each group of critical circuits that could fail simultaneously there was at least one with an FMCM installed.

AOB: None

Next Meeting: Friday, 16th November 2007

AGA