Machine Protection Working Group

Minutes of the 21th meeting held on February 14th 2003

Present: R. Assmann, J.-C. Billy, E. Carlier, B. Dehning, R. Denz, R. Giachino, B. Goddard, E. Gschwendtner, G. Guaglio, B. Jeanneret, D. Macina, B. Puccio, F. Rodriguez Mateos, R. Schmidt, J. Uythoven, A. Vergara, J. Wenninger, M. Zerlauth

Excused : F. Balda

Main topics of this meeting:

- Machine failures and triplet protection (R. Schmidt)
- Beam Loss Monitor system reliability (G. Guaglio)
- AOB

Machine failures and triplet protection (R. Schmidt)

R. Schmidt gave a follow up on his presentation at the previous MPWG meeting. At 7 TeV the machine aperture is very large in the arcs, and without orbit errors, the triplet protected by the TCDQ. With orbit errors on the other hand, the triplet may no longer be in the shadow of the TCDQ. **R. Schmidt** simulated trajectories for the beam in ring 2 from the kicker to IR5 (CMS). He showed that for the present optics the trajectory adds up to the crossing angle bump in the horizontal plane, even though the phase is not quite the worst possible. For a perfect closed orbit (and optics) the 6σ envelope of the beam at the triplet is just within the aperture of the vacuum chamber for an asynchronous dump kick. When orbit errors are added (2 mm at the TCDQ) and the worst phase advance is assumed, the beam touches the beam screen of the triplet.

Concerning the protection of the triplet with an absorber, **R. Schmidt** pointed out that since there is practically no betatron phase advance between the D1 and the triplet, it is possible to install an absorber just upstream of the D1 where more space may be available for such an object. He also showed that in the non-crossing plane, the installation of an absorber could be somewhat simpler.

R. Schmidt concluded that an absorber in the non-crossing plane could be installed without loss of aperture and that such masks could even be fixed. To install an absorber in the horizontal plane for CMS would imply a change of the crossing plane in IR5. An absorber in the crossing plane would reduce the aperture slightly, and such an absorber should be movable. The absorbers could be installed on either side of the D1. With such an absorber in place, the operational flexibility of the machine would be increased significantly. In particular one no longer need to rely on a good closed orbit across the entire machine.

During the discussion **B. Goddard** pointed out that for a normal dump, the same arguments apply to the beam in the abort gap that can potentially end up in the triplet depending on the orbit quality. **R. Assmann** suggested that for the time being, we should not request a crossing angle change. One question that needs to be addressed is the required length and space for such absorbers. **B. Jeanneret** suggested to use standard secondary collimators as triplet absorbers.

Beam Loss Monitor system availability (G. Guaglio)

G. Guaglio presented a first analysis of the reliability of the LHC BLM system. The basic fault events of the system are :

- The BLM system should prevent magnet damage (MaDi event) due to high beam losses.
- The BLM system should not provoque false dumps (FaDu event).

The risk analysis is based on IEC norm 61508. The event likelihood is frequent, since roughly 100 MaDi events are expected per year. The consequences of a MaDi event are classified as major, while the consequences of a FaDu event are minor. The SIL approach leads to require a SIL3 level for MaDi and SIL2 level for FaDu events. Such SIL levels require that the failure probability be ~ 10^{-7} / hour.

The system consists of ~ 200 BLMs for collimators and ~ 3000 BLMs for the arcs. The monitors are scanned every 40 μs and checked every 1 ms. The signal dynamic covers 8 orders or magnitude. The detectors consist of ionization chambers that are very reliable (no failure for ~200 chambers during 20 years of operation in the SPS). The charge detected by the chamber is converted to a frequency (CFC electronics). Two optical links are used to transmit the frequency signal to the front-end crates. FPGAs will be used for the logic in the front-end.

The available reliability figures indicate that for the MaDi event, the expected reliability is 10^{-6}/hour, i.e. one order of magnitude to high. This number is dominated by the expected availability of the CFC electronics. This figure does not yet include the estimates for the reliability of the energy information. For the FaDu events the overall probability of 10^{-6}/hour translates into 10^{-10}/hour for each channel. Using the presently available estimates, the expected failure rates are 0.7/year for MaDi events and 35/year for FaDu events. For MaDi events the risk has to be considered as intolerable.

G. Guaglio concluded that the quality of the CFC must be improved. The ionization chamber must be tested as frequently as possible and the missing reliability figures must be collected. An important point is that if the detection of the high loss rates can be done with 2 or more monitors, then the situation is much better.

In the discussions, it was pointed out that in fact the collimator BLM are the most important components for the protection and that one can assume that more than one channel will detect the losses. **D. Dehning** wondered how the energy information will be distributed, and how reliable this information will be. He also thinks that one could consider maintaining a constant threshold for the beam losses. The question of the reliability of the UPS system was also raised. Most people agreed that the UPS system should not be included in the analysis since a failure of that system would also lead to many other failures.

AOB

R. Schmidt mentioned that an interlock on the beam position in IR6 must have a threshold of ~ 0.1 mm/turn. Such a threshold can be set for sufficiently high intensity, but clearly not for pilot bunches where the single turn noise/resolution is 0.2 mm. Details need to be worked out. In any case H. Schmickler and R. Jones of AB/BDI agree that such an interlock is important and possible to realize.

M. Zerlauth mentioned that **L. Serio** is presently studying the implementation of a cryostat for the solenoid that is proposed to slow down the response time of the D1 circuit. One possibility is the use of a standalone cryostat in the surface building. Such a cryostat could be refilled on a weekly basis.