Machine Protection Working Group

Minutes of the 17th meeting held on November 1st 2002

Present: R. Assmann, J.-C. Billy, F. Bordry, H. Burkhardt, E. Carlier, E. Ciapala, B. Dehning, R. Denz, E. Gschwendtner, R. Giachino, G. Guaglio, B. Jeanneret, R. Lauckner, D. Macina, V. Mertens, G. Mugnai, R. Schmidt, J. Wenninger, M. Zerlauth

Excused : F. Balda, B. Puccio

Main topics of this meeting:

- Beam collimation in the SPS-LHC transfer lines (H. Burkhardt)
- Report from a visit to BNL (R. Schmidt, B. Puccio)

Beam collimation in the SPS-LHC transfer lines (H. Burkhardt)

H. Burkhardt recalled that the transfer lines between SPS and LHC are pulsed and see very high beam intensities. A protection should be foreseen for the injection elements (septum and kicker) and for the LHC in case of failures in the SPS or in the lines. Presently the TDI absorber is the only protection element foreseen for certain injection failures. The TDI block will be placed at ~ 8 σ from the beam and provides protection in the vertical plane, but only for a given phase of the incoming beam since its main role is to protect the LHC against kicker misfiring. No protection is foreseen in the horizontal plane.

The main idea for this collimation system in the transfer line is to provide passive protection in front of the septum as well as momentum collimation in the first part of the lines. Some compromise has to be found between a cheap and simple system (fixed aperture collimators) and the ease of operating the lines. A collimator placed in front of the septum with an aperture of 5 σ would require an opening of ±9.5 mm in the horizontal and ±3.2 mm in the vertical plane. The length of this object would be around 3-4 m. The complete protection scheme considered by **H. Burkhardt** consists in 4 collimators. A first collimator could be installed ~ 650 m from the extraction point in the SPS at a location of high (~ 3 m) horizontal dispersion. This collimator would be used for momentum collimation. Three other collimators are proposed for the end of line in order to cover most phases of incoming trajectories. They are placed at locations of high horizontal and vertical betatron functions.

H. Burkhardt has now generated a new MADX sequence for TI8. In MADX, it is now possible to directly define the machine elements with their aperture, thereby avoiding to have separated sequences as it was the case with MAD8. He has started first tracking tests on the line. During the development of MADX a problem related to the reference frame for transfer lines with tilted dipoles has been (re-)discovered. It is not clear if this has major consequence for the TI lines, but **H. Burkhardt** will follow this up with **B. Goddard** who is now in charge of the lines.

During the discussion **R. Assmann** noted that the aperture of the line is only 6 σ at the tightest spots (this figure also includes orbit tolerances). When passing through the lines, the beam halo is therefore likely to be 'cleaned' by the apertures. He also insisted that in a single stage collimation system as proposed for the lines, the collimation process will generate a halo of particles and this side-effect must also be analysed. From the specifications of the collimators, it seems that they should be able to absorb a complete SPS extraction of ~ 300 bunches. There was a rather general consensus that a complete tracking of particles through the lines and the LHC is required to understand what happens to the particles in the LHC for various initial (failure) conditions. **B. Jeanneret** proposed to consider an isotropic particle source at the end of the line to study what happens in the LHC. **R. Assmann** pointed out that with fixed collimators, it is not possible to adjust the opening to the local optics and orbit. Some range of tuning is also likely to be required to match the line to the conditions in the LHC ring. **V. Mertens** indicated that the collimators would be installed in 2006/2007, but that more detailed information of the collimation scheme should be prepared for mid-2003.

Report from a visit to BNL (R. Schmidt, B. Puccio)

In the first part of the report, **R. Schmidt** presented some general points on operation and machine protection at BNL. Some of the main points concerning machine protection are:

- From the RHIC experience, a complete coverage of the machine with beam loss monitors (BLMs) is highly recommended. Due to their layout in the LHC ring, the BLMs cannot detect particle losses due to pressure bumps in the middle of a cell. Some form a radiation monitoring would be very useful. It seems that the output level of the amplifiers used in the QPS is sensitive to integrated radiation doses of 30-50 G and could therefore signal large radiation levels. For lower levels, a radiation survey of the ring is probably required once per year, as is done for the SPS (and LEP).
- The delay from the detection of a fault to the beam dump is ~ 3 turns, i.e. quite similar to the LHC.
- Initial operation of the interlock system was difficult due to the absence of systematic post-mortem recording and precise time-stamping.
- Presently the MTBF of the PCs is quite good, with 1-2 weeks operation between 2 failures (for a total of ~ 1000 PCs).
- During the last run, 3 beam induced quenches were observed.
- RHIC is switched off whenever the weather report signals thunderstorms to avoid damage to the machine components. To apply a similar policy to the LHC would require weather information from the region around Genissiat (EDF power plant on the Rhone). **F. Bordry** remarked that all equipment that complies to the specification for electrical components (LHC-EM-ES-0001, EDMS # 113154) should be able to withstand a 100 ms long drop of one phase.

For the PCs this will certainly be the case, including the high power converters. **F. Bordry** says that this avoids over 90% of the powering problems due to thunderstorms.

- A system to times-stamp state changes of PCs, quench detection and interlocks is now put in place.
- Concerning self-triggering of beam dump kickers, the available information is rather contradictory.

Following the presentation, **F. Bordry** asked whether any information on radiation damage to equipment is available from RHIC. **R. Schmidt** said that only equipment installed near the beam dump had to be replaced due to damage.

In the second half of the report, **B. Puccio** (represented by **R. Schmidt**) gave more details on the interlock system itself. The system is based on the FERMILAB interlock system. It uses a VME platform, with modules linked together by optical fibres. There are 35 modules in total. Each module is equipped with 3 FPGAs to manage inputs, set masks and time-stamp the events. The client interface is based on standard TTL on 50Ω, 20 to 30 mA being necessary to activate the internal opto-couplers that are used to provide galvanic insulation. Each module has 8 inputs and the response time is ~ 10 ns. The system, which was initially designed for RHIC, is now used in the whole accelerator chain. **R. Schmidt** remarked at this stage that this gives us confidence that we should be able to use a similar approach for the SPS and LHC interlock, i.e. use the same hardware for both machines. The initialisation of the interlock loops at BNL is quite complex. A number of timing signals are used/are available inside the system. Supervision software is available in the control room to visualize interlock states, masks… The reliability of the system is very high, with a MTBF of the interlock modules of ~ 500 khours. The reliability of the VME power supplies is ~ 100 khours.