MACHINE PROTECTION ISSUES AFFECTING BEAM COMMISSIONING REMARKS, SUGGESTIONS AND DISCUSSION

R. Schmidt and K. Dahlerup-Petersen, CERN, Geneva, Switzerland

MACHINE PROTECTION SYSTEM(S) AN OVERVIEW - BY R. SCHMIDT.

The comments and questions from the audience concerned in particular the relationship between the beam interlock and power interlock systems and their interfaces with various other equipment, such as the QPS, the power converters and the beam dumps.

In particular, the speaker stressed the role of the foreseen hardwired signals ensuring safe beam aborts and magnetic energy extraction in case of quenches, component breakdowns and mains failures.

The need to have the beam kicked out prior to current decay in the magnetic elements was emphasized. This is an important issue in the case of the warm magnets with small time constant, such as D1. For the superconducting chains the topics becomes vital in the cases where the energy extraction systems is activated and the DC switches deviate the excitation current into the dump resistors for a de-excitation with relatively low time-constant. This case was used by the speaker to illustrate the need for coherence across the systems and, in details, how the two interlock chains interact to ensure the correct abort sequence.

It was noted, that a number of machine protection parameters will have to be revised for operation with lead ions.

The use of the BCT's as a tool for machine protection was mentioned. However, in this context reliability and bandwidth limitations are issues of concern.

COLLIMATORS AND BEAM ABSORBERS FOR CLEANING AND MACHINE PROTECTION - BY R. ASSMANN

The comments and reactions mainly concerned functional aspects. The impact of the collimators on various machine parameters was highlighted. For the longitudinal impedance, measurements are still to be made in the SPS. The compatibility between the use of the collimator system for protection of the triplets and at the same time playing a role for the reduction of the background in the experiments was questioned. **K. Potter** pointed out that the background in the LHC experiments mainly originates from beam-gas collisions and that it is the mandate of his group to provide the necessary equipment for background cleaning.

The handling of used, radioactive collimators in case of manual interventions was questioned. The design of the absorber blocks and the driving mechanisms has been made so to assure a rapid removal. The disconnection of a set of collimator jaws should not take more than a few minutes.

Robustness has been a further design criterion for the TCC's. A single spare should, therefore, be sufficient.

LHC APERTURE AND COMMISSIONING OF THE COLLIMATOR SYSTEM - BY S. RADAELLI.

The presented study of the collimation efficiency and the beam loss distribution downstream of the collimators, mainly at injection, was based on calculations as well as measurements made in the SPS. The orbit simulations were made with uncorrected orbits and mostly without consideration of imperfections. Field imperfections were mentioned as a source of deviation from the presented performance. Also collimator imperfection would be interesting, but not trivial, to include in further evaluations. Finally, the tight tolerances of the β-function was mentioned.

The study has resulted in the determination of a number of critical locations, where quenches may occur. The number of such places is typically 20-30 and their locations are now fairly well defined.

BEAM INSTRUMENTATION OTHER THAN THE BLM'S LINKED TO THE MACHINE PROTECTION SYSTEM - BY R. JONES.

Following the presentation of the possible roles, which the beam position monitors (BPM's) and the beam current transformers (BCT's) could play in the protection of the LHC against oscillations and fast orbit changes, caused by failures such as a D1 switch-off, it was the general impression that the BCT, with its absolute measurement, may be considered as the ultimate saving element of the machine. Particle showers from the collimators through the BCT could, however, be a reason for concern. It was admitted that shower related calculations are urgently required.

The precise location of the BCT in IR4 seems now to be determined.

For operations with ions, the use of the BLM's is considered marginal, whereas the use of the BCT can be vital.

COMMISSIONING OF THE PROTECTION SYSTEM - BY J. WENNINGER.

With respect to the presented program for commissioning of the protection systems prior to injection and beam commissioning, a number of remarks were given during the discussion of the issue.

Threshold setting of the BLM's will be required at the first possible occasion as the preliminary calibration with radioactive sources needs to be complemented by measurements with the LHC beam. And the number and identification of those BLM's required for a safe commissioning will need to be determined. The case of a trip of the D1 returned to the forefront of the discussion, this time as a request for determination of possible test procedures for verification of the protection efficiency. Although the confidence is high that the four-fold redundancy of the BIC will provide sufficient protection a provoked test remains an option. The MPWG was requested to analyse possible test scenarios and make recommendations.

The unlikely situation of a complete failure of the beam dump system was evoked. A very slow scraping of the beam could be the only answer. However, this option requires some serious checking.

It was finally pointed out, that even when the powering and beam interlock systems will flawlessly fulfil their protection role, dangerous situations, occurring as a result of man-made mistakes, cannot be ruled-out. In addition to this 'human factor' comes the fact that the most likely critical situations are those which nobody has thought about.

OBJECTS CAPABLE OF TOUCHING THE BEAMS - BY P. COLLIER.

It was a general surprise that as much as 500 objects will be able to hit the LHC beams. Most of these objects are specific for each ring while a small number of them are common for the two beams.

Of the equipment presented, the two fast valves of LHCb (13 ms closing time) are considered as dangerous and interconnected with the beam dump is mandatory. For the four wire scanners the interlocking is considered to be difficult.

From the discussion, the following points have been retained:

- The valves in the dump line shall be treated as those in the machine.
- The faster an object is being moved towards the beam, the higher is the risk of damage to this component. It turned out that the moving speed of a few objects is high, thus the reason for concern.
- The Roman pots of CMS (and most likely also those of Atlas) will be moved in at the latest possible moment, i.e. just before start of collision data taking.
- For moving the various objects a coherent approach shall be pursued.
- All movement shall be coordinated from the CCC. It is even preferred that movements of objects which could present a danger for the LHC machine shall be performed from the CCC.
- All movements shall be monitored with post-mortem acquisition.

WILL WE EVER GET THE GREEN LIGHT FOR BEAM OPERATION - BY J. UYTHOVEN.

In the calculated availability figure for the complete machine, based on the quantitative failure assessments of each individual sub-system, the possible missed attempts to fill the LHC have not been included. Such missed attempts to inject have been relatively frequent at HERA and will add to the predicted 24 false aborts per year of operation of the LHC.

It was pointed out that failure rates vary in time and strongly depend on the performed maintenance. As example was mentioned the monthly checks in test mode of the quench protection (detection and heater firing) and energy extraction systems, including the switch-opening-failure scenario.

A flawless post mortem acquisition is also here of prime importance.

BEAM LOSS INDUCED QUENCH LEVELS - BY A. SIEMKO.

From the theoretical part of the presentation interest focussed on the quench origin and propagation. It is interesting to notice that at top energy the length of the resistive part of the conductor for a non-recoverable quench is as small as 1 mm.

Several questions concerned the comparison between calculated and observed quench levels in the LHC main magnets as well as comparison with the experience from operation of other machines, like RHIC and HERA. Presentation of results from such comparisons is scheduled for the forthcoming workshop on quench levels in the LHC.

In HERA the BLM's have been calibrated according to calculated and experienced loss rates.

As conductor movements in the LHC main magnet coils are more likely to take place in the coil ends rather than in the straight part, movement-induced quenches are mainly occurring at the extremities of the magnets. It was noted that the LHC magnets operate in much more critical conditions than the HERA magnets.

Loss calculations around the LHC are not trivial and exist only for a few locations. However, simple estimates in mW/cm^3 would be welcomed.

The consequences of a complete sector quench of one of the main circuits can have severe consequences. Calculations have shown that the maximum reverse voltage of a small number of cold diodes may be exceeded. Such failure will result in several weeks of intervention.

DAMAGE LEVELS: COMPARISON OF EXPERIMENT AND SIMULATION - BY V. KAIN.

In the proton bombardment experiment with stacks of high-Z metal plates (Zn, Cu, AISI 316L), conducted in the SPS, only the stainless steel part gave some discrepancy between the simulated and experimentally observed behaviour. Analysis is still on-going.

It was pointed out that the results of the experiment can be sensitive to the geometry of the target object. The results will also be different for different types of particles. For heavy ions for instance, damage is expected to occur already at the first plates in the stack. Bombardment with pions would also be meaningful because of the expected showers.

Only a few days of cool-down were required after the end of the test. This information can allow extrapolation for other parts to be installed in the LHC.