Machine Protection Working Group

Minutes of the 29th meeting held on December 5th 2003

Present: J.-C. Billy, A. Burns, E. Carlier, B. Dehning, R, Denz, R. Filippini, R. Giachino, B. Goddard, G. Guaglio, B. Holzer, B. Jeanneret, V. Kain, J.P. Koutchouk, V. Montabonnet, B. Puccio, F. Schmidt, R. Schmidt, J. Uythoven , E. Vossenberg, J. Wenninger, M. Zerlauth

Topics of this meeting:

- Safe oscillation amplitudes for kickers (J.P. Koutchouk)
- Reliability studies : a general approach (R. Filipini)
- SPS Extraction Interlocks : the TED dump case (J. Wenninger)

Safe kick amplitudes for Q-meter/Aperture kickers (J.P. Koutchouk)

The question at the heart of **J.P. Koutchouk's** presentation concerns possible limits to kick/oscillation amplitudes and the conditions (bunch pattern and intensity) for which they apply. At injection the non-linearities in the machine may limit the dynamic aperture (DA): kick amplitudes of 6.5σ are required to study the non-linearities affecting the DA. **J.P. Koutchouk** presented a list of requested kick amplitudes and of possible limitations related to machine protection and quench protection.

In the subsequent discussion it was stated that kicks to amplitudes of 6.5σ at injection do not pose a problem provided the aperture kicker is interlocked by the Safe Beam Flag (SBF): this flag is generated by a BCT and will indicate if the intensity in the machine is below ~ 1-2 $\times 10^{11}$ protons at injection. The precise scaling is not defined yet, but it is likely that the threshold for a Safe Beam will be given by $E \times I <$ cut-off. The fact that the machine may quench when a 'Safe Beam' is kicked close to the aperture is not considered to be a major problem (but will be a nuisance for the experimenter !). For best performance of the resonant pickup, **A. Burns** prefers beams with a 25 ns (or possibly 75 ns) bunch structure. A beam with 12 bunches separated by 25 ns of ~ 1-2 $\times 10^{10}$ protons per bunch does not pose a problem to the PS and SPS, the same beam was in fact used in the second TT40 commissioning MD. A more precise intensity limit for the Safe Beam will be defined following some of the tests foreseen next year in TT40. **A. Burns** would also like to separate the Q-meter and Aperture kickers again (and not have a combined device, as proposed at the 23rd meeting of the MPWG in May 2003). The maximum amplitudes for the Q-kicker will be 2.5σ at injection and 0.7σ at 7 TeV. Such a kick amplitude should be safe at 7 TeV, at least from the point of view of damage. **B. Jeanneret** will verify that a large beam with cut-off tails kicked by 0.7σ does indeed not represent a problem for the primary and secondary collimators. Clearly a 0.7σ kick

cannot be used for a small emittance production beam. **B. Jeanneret** suggested that one should not kick straight away to 6.5σ, but to increase the kick strength gradually. The aperture kicker must in any case be interlocked with the SBF. At the same time, the beam position interlock in IR6 that is used to protect the beam dump extraction elements must be masked with the SBF. This should be possible, will however require more complex controls. **R. Schmidt** proposed a mechanism to limit the kick amplitude in a reliable way. With gaining operational experience the maximum kick amplitude could be modified.

Conclusions :

- **Q-meter kicker** : a kicker designed for kicks of 2.5σ at injection and 0.7σ at 7 TeV does not seem to pose a problem. The maximum amplitude at 7 TeV will however be verified – see action list. The length of the kick is ~10 μs.
- **Aperture kicker** : kicks to amplitudes of 6.5σ are acceptable at injection and at the end of the ramp (before full squeeze) provided the aperture kicker is safely interlocked by the Safe Beam Flag, by the Safe Beam Energy and possibly other signals to limit the maximum amplitude. Whether such large kicks are possible with a fully squeezed beam is not clear due to the limited aperture in the triplets (with crossing angle).

Actions :

- **B. Jeanneret** (& Collimation team) should verify that a 0.7σ amplitude Q-meter kick is acceptable for the collimation system**.**

Reliability studies : a general approach (R. Filipini)

The aim of the presentation by **R. Filipini** is to provide guidelines for the modelling of a complex system like the beam interlock system and to address the problem is dependability among its components. A hierarchical model is used to manage the complexity of the MP system. The function of each component is separated from its implementation. With such a model it is possible to study the dependability of the system. **R. Filipini** explained the problems and issues related to the modelling with a number of examples taken from the beam dumping system. Some of the issues concern assumption on statistical independency of failures and linearity of hazards that may bias reliability and risk. Auxilary functions like maintenance and diagnostics must also be considered to evaluate the dependability.

R. Schmidt commented that the MPWG should coordinate the effort to collect the reliability figures for each client system involved in the beam interlock system. **B. Dehning** suggests creating a sub-group to study the issues with some representatives for the different systems. **B. Dehning** and **G. Guaglio** said that they can provide a number of figures on the reliability for the beam loss system.

Action: A sub-WG will be formed that addresses the reliability of the overall system, reporting to MPWG. A mandate for the sub-WG will be proposed by R. Schmidt in collaboration with members from the MPWG.

SPS Extraction Interlocks : the TED dump case (J. Wenninger)

J. Wenninger presented a proposal to use a signal derived from the TED dump position in the long LHC transfer lines to provide a safe means of masking interlocks from the LHC. The transfer line extraction interlock system will include as client the LHC injection kicker and the state of the LHC beam permit loops (to avoid accidental injection when the LHC is not ready for beam). During operation of the LHC each of the 2 long transfer lines to the LHC (TI2 and TI8) must be tested before beam is injected into the LHC. Since the tests are likely to happen when the LHC is in 'recovery' after a beam dump (intentional or not), the LHC beam permit is likely to generate an interlock to the extraction from the SPS. On the other hand, as long as the TED dumps of the transfer lines are at position 'IN-BEAM', they will intercept any beam on its way to the LHC. The proposal, which was already part of the report on the new SPS interlock system albeit in a modified form, is to use a signal derived from the TED dumps in the same way as the Safe Beam Flag is used to allow masking of interlock at low intensity. Whenever this Safe TED Flag (STF) is present, the LHC interlock can be masked. If the TED is moved out of beam, the mask is removed as soon as the TED position is not on the IN-BEAM end-switch. Following the presentation it was agreed with **E. Carlier** that he should provide (or help provide since the TEDs are not the responsibility of AB-ATB) such a signal.
The question was addressed if partial commissioning of the LHC would be required, for example, tests of injection and transfer across on part of the machine, when the other parts are not ready. The general opinion was that such additional requirements for such operation should not complicate the interlock system.