Machine Protection Working Group

Minutes of the 64th meeting held on March 30th 2007

Present: B. Dehning, B. Goddard, L. Jensen, J. Lewis, M. Ludwig, D. Macina, B. Puccio, R. Schmidt, J. Wenninger

Topics of this meeting:

- Post-mortem triggering (B. Puccio).
- AC Dipole (J. Wenninger).

Post-mortem triggering (B. Puccio)

B. Puccio summarized the discussions that took place in the past months between various people and in various places on the issue of Post-mortem triggering and linking of Beam Permit loops. The presentation is also a summary of a specification that is being prepared by **M. Lamont**, **B. Puccio** and **B. Goddard**.

The Beam Permit loops for LHC rings 1 and 2 are independent. Depending on the type of USER_INPUT, a beam dump will be triggered either for a single beam (1 or 2) or for both beams (1 and 2). The connection between client system and BIS defines if one or both beams are triggered. Approximately 2/3 of the USER_INPUTs provoke a dump of both beams.

For normal operation of the BIS, i.e. when it is triggered by one of the normal USER_INPUTS, it is planned to dump both beams independently of the source of the dump (i.e. even if the USER_INPUT in question requests only a dump of one beam). For such 'emergency' dump requests, the two Beam Permit loops will be coupled. In some machine modes, it is necessary to dump one beam only, and the Beam Permit loops should be de-coupled. The 'command' to link/unlink the Beam Permit loops may be sent for example by the LHC sequencer.

The general timing system will be able to trigger programmed beam dumps through a standard CIBU interface. Two timings events, "Dump Beam 1" and "Dump Beam 2", will be used to trigger a programmed dump of the beams (one beam or both beams) through a CIBU interface.

The state of the Beam Permit loops will be available to the LHC MTG through a hardware link. The following timing events will be sent out by the LHC MTG when it senses a state change of the Beam Permit loop state:

- "Beam 1 Dumped" and "Post-mortem" when the ring 1 Beam Permit loop state changes to FALSE.
- "Beam 2 Dumped" and "Post-mortem" when the ring 2 Beam Permit loop state changes to FALSE.

The "Beam Dumped" events indicate that the corresponding beam has been dumped. Those events are **ALWAYS** sent out when the corresponding Beam Permit loop changes state. The "Post-mortem" event is used to trigger the Post-mortem freezing of the PM buffers. The same event will be used for both beams.

To avoid triggering a PM acquisition for certain programmed beam dumps, it will be possible to suppress the "Post-mortem" event using another timing event. Yet another event is required to re-activate the generation of the 'Post-mortem" event.

During the discussion it was pointed out by some people that the preferred behaviour for PM suppression would imply an automatic re-enabling of the PM event N milliseconds after it has been suppressed**. J. Lewis** stated that re-enabling the PM event is the responsibility of the sequencer (or more generally OP) and that he has no simple means of deciding how and when to re-enable the events. The problem is that there is no protection to prevent (un-)intentionally sending out the PM suppression event, i.e. anyone may generate a timing table holding the suppression event without re-enabling the event.

It was also mentioned that for a programmed end-of-fill beam dump, the beam permit loops must not be unlinked.

AC Dipole (J. Wenninger)

J. Wenninger presented protection issues arising from the LHC AC dipole that has been recently resurrected in the CO group. **J. Serano** is presently responsible for the design. The excitation is provided by the Q-kicker driven with a special high power audio-amplifier. At 7 TeV the AC dipole should reach amplitudes of 1.2 mm/4σ with a rise time of 200 milliseconds for a distance between AC dipole frequency and machine tune of 0.01 (in tune units). From those parameters it is evident that at 450 GeV the amplitude reaches close to 20 mm, which is largely excessive. Furthermore, if the distance between AC dipole frequency and tune is accidently only 0.001, the maximum amplitude may be 10 times larger, i.e. 40σ at 7 TeV, with a similar rise-time! Such a failure case is only approximately a factor 4 slower than the D1 failure (1 mm in 5 milliseconds). Under such conditions the beam even moves by 1 mm per millisecond at injection, once of the fastest failures at injection.

The discussion on how to interlock the AC dipole is just starting, but it is already clear that:

- The maximum amplitude/power must be limited at injection by making use of the Safe Beam Energy information. The nominal amplitude for a tune distance of 0.01 should be limited to ~ 5-7σ (6-8 mm) at 450 GeV.
- The rise-time must be limited at injection by making use of the Safe Beam Energy information to avoid too fast amplitude growth.
- At injection the AC dipole must only be allowed to operate with Safe Beam. At 7 TeV the Safe Beam may be slightly too restrictive, a nominal bunch may be more adapted – to be studied.