Machine Protection Working Group

Minutes of the 67th meeting, 16th November, 2007

Present: R. Jacobsson, S. Wenig, G. Murnacchi, M. Ferro-Luzzi, J. Uythoven, M. Jonker, M. Deile, R. Hall-Wilton, D. Stickland, A. Di Mauro, T. Kramer, M. Lamont, J. Spalding, A. Macpherson, A. L. Perrot, D. Macina, L. Ponce, R. Alemany, B. Dehning, B. Puccio, B. Todd, J. Wenninger, R. Schmidt, A. Gómez

Agenda:

- Machine considerations and constraints for the Safe Injection Flag and Safe Beam Flag (J. Wenninger)
- Proposed values for the Safe Injection Flag and Safe Beam Flag (ATLAS, S. Wenig)
- The CMS protection system and its reliability (R. Hall-Wilton)

There were no comments on the previous minutes.

Machine considerations and constraints for the Safe Injection Flag and Safe Beam Flag (J. Wenninger)

J. Wenninger presented the limitations and requirements imposed by the LHC operation for the Safe Beam Flag (SBF) and the Safe LHC Injection Flag (SLIF) as well as the protection strategy during injection (slides).

The meaning of the Beam Presence Flag and SBF was explained (slides 3-4), followed by the differences by the previous LHC injection logic and the new one. In the new approach, a new flag is added in the SPS (SLIF) to allow for more flexible injection interlocking than just with the SBF (slide 6). The injection in an empty LHC should normally start with a pilot bunch containing 5 10^9 protons, not enough to quench a magnet. However, in some cases this intensity might be too low.

J. Wenninger went on explaining some particular cases of injection into an empty LHC that could lead to machine protection issues. In the case of injection with screens a pilot bunch should produce reasonable data but injection of some 10^{10} p should be better. A particular scenario where higher intensities will be needed is the setting of the aperture of the Transfer Line collimators, essential for machine protection. 3-5 10^{10} protons might be enough for this purpose. Another possibility would be to inject a pilot and then bunch per bunch to perform up to 100 measurements, but this would still mean to store 10^{13} p in the machine.

A discussion was initiated by **R. Schmidt** where several points were clarified. An over-injection with circulating pilot bunch is always possible, but would lead to deposition of the pilot bunch into the TDI, which is to be avoided if not necessary. The preferred action is to dump the pilot bunch in the beam dump prior to injection of any other beam. **R. Schmidt** asked for activation limits in the TDI and **B. Dehning** pointed out that activation measurements have been carried out in the TCS whit SPS beam and that remnant radiation lasted a few days. **M. Ferro-Luzzi** enquired about the risk when adjusting the collimators with high intensity. **J. Wenninger** replied that using safe beam is a possibility and that 10^{12} p do not suppose a risk for the Transfer Line, neither should it be for the experiments since in the beam would most probably hit other elements, in particular for injection protection. **R. Schmidt** suggested checking the relevance of this scenario with V. Kain. **M. Ferro-Luzzi** and **S. Wenig** asked for the frequency of the alignment of the transfer line collimators. **J. Wenninger** replied that it should be in the order of one to three times a year, and probably a bit more often for the commissioning.

J. Wenninger went on presenting the dependency of the BPM measurements on the intensity of the beam, leading to differences around 0.2 mm for the measurements of the same real orbit with pilot bunch and nominal bunch. This could be a problem for the orbit feedback in case of frequent intensity changes (pilot to nominal) during injection. Another fact to be taken into account during injection is the time needed by the accelerator chain to change between pilot and nominal bunches, about 1-2 min in the optimal case. This leads to a loss of efficiency if the pilot bunch is to be injected before every new injection.

To conclude, **J. Wenninger** suggested that 1.2 10^{11} would be a good limit for the SLIF intensity limit, and that in any case this should not be set below 3-5 10^{10} for acceptable machine operation – lower values would imply limitations in the cases presented.

D. Macina wondered about a possible change of the intensity limit for SBF depending on the injection mode. **J. Wenninger** replied that the SBF is associated to a single intensity value for all modes of injection, and the procedure so far is to inject the pilot bunch first and a nominal bunch only when the pilot bunch is stable.

R. Jacobsson asked about the relevance of the lag time during different injections. **J. Wenninger** clarified that this lag time is necessary only when changing the injected bunch intensity and that once the beam circulates in the machine there is no need to change to the pilot bunch for the successive injections. **J. Wenninger** pointed out too that enforcing safety implied a loss of flexibility for the machine operation.

Proposed values for the Safe Injection Flag and Safe Beam Flag (ATLAS, S. Wenig)

Before starting his presentation (slides), **S. Wenig** clarified that the presentation had been made based on the conclusions of the workshop in June without taking into account what was just presented by **J. Wenninger**.

S. Wenig started his talk with a presentation of the ATLAS Pixel Detector. The device that is closest to the beam and the most sensitive to failure scenarios. The device removal is a complex operation that would require several months and in case of damage, no replacement of some components would be available until 2012. The BCMs and beam pipe are integrated with the PD.

Next, **S. Wenig** summarized two failure scenarios simulated by D. Bocian. In the worst case the PD could receive an instant dose up to 0.02 Gy ($4\ 10^8$ times more than during normal operation). **B. Dehning** asked about the radiation tolerance of the PD. **S. Wenig** replied that the total dose is 10^5 Gy, but in terms of instant dose it is not really known.

A test was done with the PS beam in order to estimate the damage limit for the PD, but with long bunches. Under the experimental conditions (slide 8) the device was able to absorb 3 Gy without permanent damage. **R. Schmidt** asked about the influence of the powering of the electronics in the test. **S. Wenig** clarified that no difference was expected and that the test was done with the operating conditions since the PD would not be switched off during the injection period. Then, **R. Schmidt** asked about the relevance of the heating of the PD due to beam losses, to what it was answered that the power dissipation of the PD was about 15kW, and the heating due to beam losses was negligible. Continuing with his presentation, **S. Wenig** explained that a factor of 100 should be applied in order to take into account the difference of the time structure between the beam used in the test and the LHC injected beam. **M. Ferro-Luzzi** stated that it is not well known how these values have to be scaled for shorter splashes (few ns instead of 40 ns).

To conclude, **S. Wenig** compared the results of the test with the simulations and stated that from the ATLAS point of view, the SLIF threshold should be set to $5\ 10^9$ p and the SBF threshold as small as allowed by the machine operation requirements.

The discussion following the presentation was centered on three main lines: the possibility to perform further tests or/and simulations, the consideration of the Software Interlocks and the definition of clear procedures for minimizing the risks.

Concerning further tests or simulations (proposal by **M. Ferro-Luzzi**), **J. Wenninger** explained the difficulties of using the SPS beam. **R. Schmidt** pointed out that, if tests were to be redone, they should be done with beam from the SPS that is used for LHC injection. For the simulations

D. Macina highlighted that the simulations by D. Bocian covered the worst case scenarios and the differences with the present configuration were not very important. She suggested using these simulations since it is not possible to consider all the possible options. **J. Wenninger** reminded of the risk of closed bumps at injection and it was agreed that further simulations should be performed.

R. Schmidt suggested using Software Interlocks to prevent injection in case of wrong magnet settings, since the differences that are needed to produce damage in the experiments are quite high (about 30%, **D. Macina**). He proposed:

- 10^{11} protons as the limit for the SLIF (Hardware Interlock)
- 5 10^{9} protons as the limit for the Software Interlock

J. Uythoven pointed that the SW interlock is not as reliable as hardware interlocks, and that there should be an option in case that the SW interlock fails.

The conclusions of the presentations by **J. Wenninger** and **S. Wenig** suggest that the limits required for safe operation for the experiments and minimal operation of the LHC may not be compatible. **R. Jacobsson** underlined the need to find a good compromise and define the procedures that would minimize the risk for the experiments while ensuring a fairly smooth LHC operation. He suggested the following steps for injection:

- Evaluate the SW interlocks
- Use the pilot bunch systematically
- Be very careful when injecting without circulating pilot bunch

R. Schmidt concluded that this point had to be seriously considered in a future with:

- A better knowledge of the available SW interlocks
- Concrete proposals for the injection procedure

With a suitable proposal in hand, the decision on the intensity should be transferred to higher level committees. Following the meeting it has been decided to present the issue at the LTC as soon as possible, which is likely to be on 5th December 2007.

S. Wenig recalled the request from ATLAS: potential accident scenarios during beam commissioning and operation should be cross checked and followed up. ATLAS simulation results depend dramatically on incident direction and position of beam. Possible failure scenarios include closed bumps, aperture scans, squeezing and miss-kicked beam at extraction.

The CMS protection system and its reliability (R. Hall-Wilton)

R. Hall-Wilton presented the design of the CMS protection systems (slides). The architecture of the system is similar to that used for the LHC BLMs. **R. Hall-Wilton** explained why Chemical Vapor Deposition (CVD) diamonds were used instead of the BLMs ionization chambers and presented the internal design and layout of the BCMs. Two BCMs are installed close to the beam pipe and their readout and communication electronics are identical to those used with the BLMs.

R. Hall-Wilton presented then the reliability and redundancy of the system. The reliability is similar to the BLMs and the tests so far have not shown any issue. More tests will be carried out when the BLM COM cards are available. **B. Dehning** noted that they should be available in spring 2008. **R. Alemany** asked about the commissioning of these systems with respect to the commissioning of the BIC. **R. Schmidt** explained the commissioning procedure (first functionality without beam, then tests with beam) and suggested that even if the Dump Request tests were not done for each individual BLM they should be done for each experiment. **R. Schmidt** asked for confirmation that the injection interlock had been accepted by all the experiments. Since it is the case, the implementation of the injection interlock from the experiments is to be set up.

Following his talk, **R. Hall-Wilton** commented on the issue that for the time being, a power cut in CMS not affecting the LHC operation would trigger a dump request. To avoid this, a possible solution is to use the LHC UPS for the powering of the BCMs. This technical solution is awaiting approval from the CMS Safety Officers.

R. Hall-Wilton presented then the results of the ongoing calibration and cross-calibration measurements of the BCM detectors as well as the damage levels. He then concluded on the considerations for setting the initial values of the BCM thresholds, to be tuned with operational experience.

At the end of the presentation, **R. Jacobsson** asked about the value of the threshold in current. **R. Hall-Wilton** gave the value of 500 nA and **R. Schmidt** explained that the thresholds for the BLMs used in the machine were dependent on the energy and on the integration window. **R. Jacobsson** wondered whether there was any logic applied for the dump request between the two BCMs. **R. Hall-Wilton** answered that there is no logic and **R. Schmidt** explained that in the LHC only one BLM is enough to dump the beam. This was decided based on reliability considerations for the LHC Beam Loss Monitors system, as well as on the experience from HERA. To conclude about the threshold values, **R. Hall-Wilton** said that they will be adjusted in the same way as for the LHC BLMs. **J. Wenninger** added that it is important to leave the possibility to change these thresholds open.

AOB: None

Next Meeting: will take place Friday 14th December 2007.

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