

MACHINE PROTECTION SESSION – DISCUSSION NOTES

W. Bartmann, M. Zerlauth, CERN, Geneva, Switzerland

Abstract

Session 5 of the 6th Evian Workshop on LHC beam operation focussed on machine protection aspects and was split into five talks as follows:

- Have we been operating safely in 2015? (D.Wollmann)
- How to obtain clean injections? (F.Burkart)
- BLM threshold evolution and 2016 proposal (M.Kalliokoski)
- BLM thresholds and damage limits for collimators (A.Mereghetti)
- BI for machine protection (T.Lefevre)

The aim of the session was to critically review machine protection aspects of the 2015 run, summarize ongoing efforts to further improve the dependability of the MP backbone whilst further maximizing the availability of the machine for physics operation and to define the machine protection envelope for 2016.

In the first contribution D. Wollmann analysed the 2015 run in view of machine safety and proposed possible improvements for 2016. This includes a more structured approach for the execution and bookkeeping of commissioning of the machine protection systems, as well as a close follow-up of the MP relevant issues that emerged during 2015 operation (erratic's in LBDS generators and resulting asynchronous dumps, beam losses, CIBDS, abort gap cleaning, TDE dump leak and the introduction of the BCCM..). He concluded with a first proposal for the intensity ramp-up in 2016, which combines the commissioning of the new machine optics and injection schemes with a fast intensity ramp-up until the expected conditioning of e-cloud and heat-load will become the predominant driving factor for the intensity ramp-up.

F. Burkart presented in the second talk differences in the loss behaviour at injection between run 1 and 2. He highlighted new measurement techniques which allow a more thorough understanding of beam loss origins at the SPS to LHC transfer thanks to the use of Diamond based Beam Loss monitors. Eight of these devices are currently installed in IR2 and IR8 downstream of the TDI, in IR7 as well as close to the extraction septa of the PS and SPS. Diamond BLMs allow for time resolutions of beam losses in the order of ns and hence for a precise understanding of their origin (SPS re-captured beam, injected beam losses...). The origin of transversal losses is by now well understood and under control, according mitigations for longitudinal losses are still being explored for the 2016 run (e.g. increasing the MKI flat top length, use of the SPS tune kicker)

The third and fourth talk focussed on the evolution of BLM thresholds. M. Kalliokoski first recalled the

mechanics of threshold calculation and the suggested improvements for 2016. More than 5700 changes of BLM thresholds were made ahead of the 2015 start-up, which were the basis for the good compromise between UFO induced beam dumps and magnet quenches which could be found by the end of 2015. The main changes foreseen for 2016 are the implementation of new thresholds for the collimator families and around experiments and a further increase of the thresholds for the UFO loss scenarios.

A. Mereghetti complemented the talk of BLM thresholds with results of damage limits for metallic collimators and proposed according BLM threshold updates for 2016, based on results obtained during the quench tests and an analysis of the losses observed during 2015.

In the last talk, T. Lefevre highlighted the status and planned improvements for the three main beam instrumentation systems related to machine protection: For the beam current change monitor first operational experience has been collected during 2015, however a more detailed design review has been triggered following the observation of unexpected false beam dumps of the system. The abort gap monitor has been working very reliably in 2015, and only minor changes are foreseen for 2016 to arrive at a fully automated cleaning process. On a similar note, the increased dynamic range of the interlocked beam position monitors in IR6 resulted in a considerable reduction of false dumps due to bunch intensities dropping below the sensitivity of the instrument.

The discussions that followed the various presentations are summarised in the following paragraphs.

HAVE WE BEEN OPERATING SAFELY IN 2015 – DANIEL WOLLMANN

M. Lamont asked if we had a dedicated machine protection checklist for the scrubbing runs and how often it was filled (as they will be required again in 2016).

D. Wollmann answered that there was indeed a dedicated checklist created for the scrubbing periods (including enhanced checks on e.g. heating/injection/Rf); as the intensity ramp-up is very quick a pragmatic approach was chosen and a single checklist was filled for the full scrubbing period.

M. Lamont asked where the number of three expected asynchronous beam dumps per year came from and why it changed from the run 1 assumption of one asynchronous beam dump per year.

B. Goddard replied that this estimate is derived from the analysis of the reliability run performed this year. One asynchronous beam dump per year was the initial target design value. There is also a dependency on the number of hours spent per year in physics production. During LS1 a

number of improvements were performed, e.g. high voltage hold-off with new insulators and better cleaning of dust; however, it is worrying that pieces of Latex gloves were found in critical parts of the generator switches. In 2016, 1-3 asynchronous beam dumps per year should be used as the most realistic estimate.

S. Redaelli enquired concerning the intensity ramp up in 2016, if there will be again 3 fills per step foreseen as in 2012.

D. Wollmann answered that the same strategy is proposed as baseline for the intensity ramp-up in 2016 (as usual with some flexibility in case things are very smooth, e.g. two long fills could be enough to step up).

HOW TO OBTAIN CLEAN INJECTION – FLORIAN BURKART

If the MKI length is increased for 288b injections, how can we handle the increased abort gap population?

It is foreseen to use injection gap cleaning to get rid of the inter-batch satellites, ideally one has to consider as well abort gap cleaning or aim at reducing the uncaptured beam already earlier in the injector chain.

M. Lamont asked whether it is possible to use a transverse damper already in the SPS?

W. Hoefle/D.V. aluch replied that this was studied as preparation for the LHC damper back then, but aperture restrictions were found; the beam was lost in the MBA/MBB interconnects rather than the vertical beam dump since there is no collimation system in the SPS. It needs to be investigated if a safe way to clean the satellites in the SPS can be found. Technically the SPS damper can do the job since the same digital RF system is in place as for the LHC.

E. Chapochnikova commented concerning satellite levels between 50 ns and 25 ns. It is understood from RF side that the satellite population is increasing with 25 ns beams. There is an increased beam loading due to the beam being more displaced in the buckets for 25 ns. There are potential mitigations like increasing the voltage for 40/80 MHz.

M. Wendt commented that the transfer of doublet beams caused more losses than nominal beams. Solutions should be developed to make these injections cleaner.

BLM THRESHOLD EVOLUTION AND 2016 PROPOSAL – MATTI KALLIOKOSKI

M. Zerlauth asked concerning a limitation of the DB generation, whether the lack of models allowing the mixing of loss scenarios, e.g. orbit bumps and UFOs, is still the case.

M. Kalliokoski replied that this is on the list to be solved, and can technically already be done by defining functions for the specific threshold case. An intermediate manual step for defining the functions is however still required at this moment in time.

R. Schmidt suggested a workshop like discussion to understand the outcome of the quench tests made in 2015 (as was the case with the quench tests performed during run1), to understand the long-term threshold evolution and to make extrapolations. B. Auchmann and B. Holzer agreed to follow this up.

BLM THRESHOLD AND DAMAGE LIMITS FOR COLLIMATORS – ALESSIO MEREGHETTI

Upon a question from R. Schmidt, A. Mereghetti replied that it is indeed proposed to reduce the BLM threshold on collimators for certain short running sums (slide 18). Some refinements of the dose/proton conversion have still to be done, but the results from the thermo-mechanical analysis suggest this curve. It has also to be seen what this means for the actual threshold, i.e. the 2015 data should be compared against the proposed thresholds to identify eventual additional dumps due to the lower thresholds.

M. Zerlauth commented that with higher ion intensities the optimization of unique thresholds is not always ideal. Should there be two sets of dedicated thresholds for some families between protons and ions?

B. Holzer confirmed that this concerns indeed a limited number of families and can be done.

BEAM INSTRUMENTATION FOR MACHINE PROTECTION – THIBAUT LEFEVRE

Concerning the specification of the BSRA accuracy at injection, B. Goddard confirmed that 50% instead of 5% is the correct value.

M. Zerlauth asked whether for the interlocked BPMs energy dependent thresholds are foreseen as a potential mitigation against the offset developed by the electronics for doublet beams (as in principle the problem is for scrubbing which happens at 450 GeV only).

B. Goddard commented that the physical aperture at the dump is not energy dependent, but the impact of an eventual failure is. To be studied in more detail.

Concerning a deployment of the BGI for abort gap monitoring: the LDM is doing a good job with 50 ps time slots while the BGI can only provide a few ns.