

LHC Machine Protection Review: Close-Out Remarks (Preliminary)

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- The review committee has not finalized the details and explicitly asked not to distribute the slides. There may be other points in the final version.
- I present here a summary of the main points, and the actions that we have/will be/should be implementing.

General Comments

- The committee is impressed about the smooth start-up of LHC beam operation and congratulates the whole team for this great success.
- The Committee thanks the organizers and all speakers for the careful preparation of their talks and for the lively and detailed discussions.

- The committee agreed with our own admission **that the human risk is a weak point and that more discipline must be enforced.**
- Procedure must be established for changes (firmware, thresholds, **sequences...**).
- **Comment:**
 - This is well established for the BLM system (thresholds and firmware) and for the BIC and SMP systems (firmware, new inputs etc).
 - Significant improvements can be made in many other areas.
 - **How/where to establish a central place for tracking all changes (links to the relevant documents)?**
 - Sequence changes are edited rather 'freely' for the moment - reflects the fact that we are still in commissioning !
 - **We should nominate a person responsible for the LHC operational sequence.**

- As much as possible aim for automatic logging of interventions on systems.
- Routine test procedures and firmware verification. System integrity checks (in particular after technical stops).
- **Comment:**
 - This is well established for the BLM system (automatic test ENFORCED every 24 hours), and partly for the BIC system.
 - LBDS system checks (IPOC/XPOC) after every dump, test dumps with beam after every technical stop.
 - A lot of work still needed here.
 - This also concerns systems not directly part of MP (electrical circuits, BCTs etc).

- The committee felt that the sequencer **presently represents a significant risk factor and it should not be used to probe the MPS!**
- A well defined luminosity production sequence must be defined, and the integrity of the sequence must be preserved. Paper instructions (→ manual tasks) must be avoided.
- The state machine concept must be developed to back the sequencer, and some controls integration work of other applications with the sequencer should be pursued.
- **Comment:**
 - Ongoing work, but the target may not be reached this fall.
 - State machine concept under development – pushed into OP in 2011.
 - **We need a person responsible for the sequence – see earlier slide.**

- Should the checks to declare stable beams should be more elaborate?
- **Comment:**
 - Included in the SMP STABLE_BEAM_FLAG is the mode (not safe...) and the machine energy (safer!). Does not protect against declaring stable beams in the middle of the squeeze... we could include b^* in the future (tbd).
 - The final judgment will always be made by the EICs.
- **The alarm application should be used by OP.**
 - Presently there are too many alarms that are not relevant. Better filtering required.

- The abort gap cleaning should be made operational before increasing the intensity so as not to rely only on the proper positioning of the absorbers.
- One should try to better understand the mechanisms that lead to abort gap filling.
- **Comment:**
 - Work ongoing... but no attempt to clean abort gaps in an operational way was made this year. Requires work on ADT/RF side.
 - We should have abort gap cleaning ready when we need it.
 - **The position of the absorbers must ALWAYS protect us against the asynchronous dump.** We rely on their correct positioning.

- The committee supports the idea of monitoring the cleaning hierarchy based on losses during regular operation.
- Such a continuous monitoring may reduce the need for dedicated loss maps and provide indications as to when a collimator setup must be made.
- **Comment:**
 - This was already proposed some time ago. Need to define a strategy and persons to implement this concept.

- Given the tight tolerances on beam position in order to safely operate at small b^* the committee feels that the issues of temperature drifts must receive much higher priority.
- **Comment:**
 - The larger aperture that we have thanks to very good orbit control (absolute orbit) and that was confirmed last week-end could help us relax tolerances and/or squeeze further.
 - Clearly the BPM stability is critical for cleaning (reproducibility) and for MP.
 - BI is working on this issue –more resources needed?

- How is the position limit as a function of the b^* of TOTEM and VELO ensured?
- **Comment:**
 - For TOTEM RPs we rely on:
 - Beam-based alignment,
 - Verification with loss maps,
 - Collimator-style interlocks (limits), controlled by collimation experts.
 - For LHCb we rely on:
 - The VELO automatic positioning system (based on vertex reconstruction). VELO movements are very slow, so we should also be protected in case the position is not correct.
 - The minimum gap (5 mm) is always protected at 3.5 TeV (all b^*).
 - BLMs provide ultimate protection in case the devices would be too close to the beam (but not for asynch dump !).

- The committee believes that our BLM thresholds are set rather conservatively since we had no quench yet (as an example), but do not see a need to increase thresholds as there is no impact on availability so far.
- **The understanding of the quench levels should be improved, including beam tests.** This could allow us to increase the BLM thresholds if needed (availability).
- **Comment:**
 - Theoretical work ongoing (BLM team + TE/MPE).
 - Quench tests planned – to be done soon !

- The committee strongly encourage following up a **the possibility of implementing 25ns loss recording based on diamonds at critical points around LHC. At the Tevatron the machine has their on monitoring of bunch level losses which are heavily relied on.**
- **Comment:**
 - Diamond detectors in IR7 provide first results. They have been re-located to gain sensitivity (for the fast 'UFO' BLM events).
 - We should consider installing such monitors also in the dump and injection regions for monitoring.
 - So far the readout relies on a local scope – should contemplate building a better readout system. What about the CMS BCM system, which is fully machine compatible ('copy' of BLM readout)? Work ongoing...

- Problems have been observed with the "Beam Presence" flag based on the FBCT.
- The replacement by an independent failsafe system based on a button electrodes is strongly supported.
- **Comment:**
 - Ongoing work (MPP, MTE, BI), launched a few months ago, to replace with a BBQ based system (and a BPM).
 - We hope to have this in place for 2011 – it will be used redundantly with the FBCT. Optical fiber must be order and prepared during the 2 month technical stop.



Software Interlock System

- The committee encourages regular reviews of the SIS to see what may require the reliability of the hardware interlock.
- **Comment:**
 - We will do this for the startup of 2013, making use of the 2012 shutdown to implement HW solutions. Example: more HW beam position interlocks.



Injection protection and TL collimators

- The committee asked to checked if the injection protection absorbers are currently retracted before the charging of the injection kicker is interlocked by the energy.
- **Comment:**
 - A software interlock has been put in place (TDI gap) in order not to depend on the sequences.
- It appears to be unsafe the procedure of changing thresholds in order to cycle the transfer line collimators for maintenance. Should be looked in to since the transfer line set up is critical for a safe injection.
- **Comment:**
 - We are aware... More discussions needed between ABT and collimation team.

- A protection of the wire-scanner should be put in place in order not to break the wire at higher intensity.
- The triplet alignment system motors should be disconnected for beam operation.
- **Comment:**
 - Protection for the WS is in place and active.
 - The motors should already be powered off (as specified in collaboration with MPP) during operation. We will check again.

- The leakage (secondaries and bunches) due to injection failure (no kick, asynchronous kick, over-injection) should be revised (measure + simulation) for the sake of Alice and LHCb.

- LHC is ready to go beyond 3 MJ.
- Before reaching 30 MJ one should
 - address the issues raised in previous slides,
 - establish criteria/commissioning steps for intensity increase.
- **Comment:**
 - We will do our best, but some issues will not be resolved in the coming weeks (longer term effort).
 - Commissioning steps for intensity increase concerns:
 - **Injection: beams become much more dangerous now !**
 - Criteria → see later.