BEAM INTERLOCK SYSTEM AND SAFE MACHINE PARAMETERS SYSTEM: 2010 AND BEYOND

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Abstract

The Beam Interlock System (BIS) and Safe Machine Parameters (SMP) system are central to the protection of the Large Hadron Collider (LHC) machine.

The BIS has been critical for the safe operation of LHC from the first day of operation. It has been installed and commissioned, only minor enhancements are required in order to accommodate all future LHC machine protection requirements.

At reduced intensity, the SMP system is less critical for LHC operation. As such, the current system satisfies the 2010 operational requirements. Further developments are required, both at the SMP Controller level, and at the system level, in order to accommodate the requirements of the LHC beyond 2010.

BEAM INTERLOCK SYSTEM

All systems in the Super Proton Synchrotron (SPS), SPS Extraction, Transfer Lines, Injection and LHC Ring are operating to specification. Commissioning is complete for all inputs which are required for 3.5 TeV operations at reduced intensity.

Ongoing Work for 2010 Restart

Four areas are being improved for the 2010 restart:
1. There are some known bugs in the **Java Application,** which are not critical for operation. These are documented in JIRA and fixes are being implemented.
2. **Pre-Operational checks** and the **Internal Post-Operational Check** (IPOC) will be improved. Tests will be executed every fill, and test results will be used to issue the 'rearm' command to controllers.
3. User Systems are being encouraged to implement **automated interface tests** – systems which currently implement these tests are:
   - Powering Interlock Controllers (PIC)
   - Warm Magnet Interlock Controllers (WIC)
   - Fast-Magnet Current-Changes (FMCM)
   - Beam Loss Monitors (BLM)
   - Beam Screens (BTV)
4. **Additional inputs** will be enabled for the 2010 restart:
   - The redundant Beam Position Monitor (BPM) input in IR6 is to be commissioned.
   - The "Injection Kicker Timing is in Test Mode" input is to be commissioned.

SAFE MACHINE PARAMETER SYSTEM

The SPS System has been operational for two years, and has direct impact on extraction system availability. To date, there have been no faults in the SPS SMP and consequently no loss of accelerator availability.

The LHC System has been successful, and fulfilled 2009's operational requirements, but has known limitations:
1. No consistency check between energy (BETS) information is performed in the SMP Controller.
2. No truly-redundant path for producing flags is implemented in the SMP Controller.
3. General Machine Timing distribution of the parameters is not cross-checked with the SMP Controller status.
4. The User Permit connection from the SMP to the BIS has not been implemented, moreover, it will **not** be implemented in 2010.

Ongoing Work for 2010 Restart

SMP in the LHC is now the focus of Machine Interlock team (TE/MPE/MI). SMP needs software reinforcement to satisfy the requirements for 3.5 TeV operation at reduced intensity:
1. The Software Interlock System (SIS) will be used to check the energy is consistent between end-users and main-bend currents.
2. During normal physics fills, the LHC Setup Beam Flag (SBF) will be forced false, operation with the SBF unforced will only be permitted in predefined conditions.
3. During normal physics fills, the masks set on the LHC BIS will be removed, so even if the LHC SBF is unforced, the channels are taken into consideration. Activated masks will only be allowed in predefined conditions.

This is in progress and will be ready on time for the 2010 restart.

Beyond 2010

If it is to succeed in the long term, the SMP system requires an overhaul. Current specifications are inconsistent and the current approach will not result in a system which meets CERN's requirements.

In 2010, TE/MPE/MI will overhaul SMP, by start-up 2011 the controller will meet the dependability required for LHC operation at nominal values.

This overhaul consists of:
1. Re-writing all specifications, ensuring all stake-holders are in agreement.
2. Wherever necessary, re-designing the SMP controller to match the agreed specification.

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Depending of the requirements, 20-80% of the controller will need changes.

3. Externally reviewing the design of the controller (Hardware / Firmware / Software) with respect to the various specifications.

Other Requirements

The SMP can only be as strong as the weakest element it depends upon. There are two key dependencies which are of concern:

1. The quality of intensity information – Beam Current Transformer (BCT), and associated hardware.
2. The integrity of the transmission medium – General Machine Timing (GMT). GMT is not designed for highly dependable transmission of information, acceptable performance for the SMP is ensured by cross-checking the data delivered to clients by the GMT with the data received by the SMP controller.

The Machine Protection group (TE/MPE) would encourage that:

- The dependability requirements (safety, reliability, availability) and implementation of the BCT are clarified.

- The various solutions for cross-checking of parameter transmission over the GMT are investigated, before a final solution is chosen.

SUMMARY

The Beam Interlock System will be ready for the operation of LHC at reduced intensity, at 3.5 TeV. Software improvements are being implemented, and all critical channels with the exception of the SMP input, will be commissioned and activated.

The Safe Machine Parameters system currently installed is sufficient for the protection of the LHC during the reduced intensity run at 3.5 TeV. In order to be ready for LHC operation at higher intensity and energy, the system design requires renovation. Firstly, the SMP specifications must be ratified, and the controller design verified. Additionally, the SMP system's safety is currently limited by external factors, namely the Beam Current Transformer dependability, and verification of parameter transmission over the General Machine Timing,

These must be assessed before operation of the LHC at higher energy and intensity. This work must start now, to be ready for 2011.