

92nd Meeting of the Machine Protection Panel

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1 Presentations

The slides of all presentations can be found on the website of the LHC and SPS Machine Protection Panel:

<http://lhc-mpwg.web.cern.ch/lhc-mpwg/>

1.1 Beam intensity for Collimator alignment and Loss maps – (G. Valentino).

- Collimator alignment:
 - Beam intensity limited by “Very Relaxed SBF”. During Run1 normally 1 nominal bunch at Injection and Flat Top were used for the alignment of the collimation system. For establishing collisions and the qualification after the alignment (so called loss maps) more than 1 bunch was required.
- Beam Loss maps.
 - The generated losses were usually high and therefore risked to dump the beam. This was mainly the case for the crossing of the third order tune resonance.
 - Beam intensity was limited by the “Very Relaxed SBF”. 1 nominal bunch was used for the tune resonance method, several smaller bunches were used in case of ADT blow-up.
- In a previous MPP, Vera presented a first proposal to updated the values for the SBF for Run 2:
 - Restricted SBF. Intensity per bunch depends on the number of bunches: The total intensity would be restricted to 1.4×10^{11} p either in one or up to 12 bunches of 1.1×10^{10} p/bunch. The question is if these intensity limits will be sufficient for collimation and efficient commissioning.

- Gianluca present the minimum intensity required to achieve sufficient loss spikes during the alignment of the collimator jaws:
 - 7×10^9 p (alignment at 3.5 TeV, March 2010)..
 - The estimated intensity required per spike is 1×10^7 p, i.e. a full alignment including all ring collimators would consume $\sim 7 \times 10^{10}$ p.
- The required bunch intensities and bunch configurations for loss maps depends strongly on the applied method (resonance crossing, excitation via ADT).
 - Using the resonance crossing method, $\sim 2 \times 10^{11}$ protons in 2 bunches are required.
 - For the ADT blow-up method: Several bunches (> 2) with $1 \div 4 \times 10^{11}$ protons were used in run1.
- The minimum intensity lost during loss maps, to measure the cleaning inefficiency :
 - $\sim 8 \times 10^9$ p/s (at 4 TeV)
 - this has to be re-estimated for 7 TeV:
 - Jan asks why the loss maps could be done with “unsafe” intensities. Gianluca replies that the losses were done in a controlled way (ADT) and stayed below the BLM thresholds. Laurette adds that the idea is to do loss maps without masking. Roderik says that it is needed to increase by a factor $2/3$ depending on the resolution. Markus reminds that response from BLMs is different at 7 TeV, therefore ADT settings should be re-assessed.
- Off-momentum loss maps are currently the efficiency bottle neck.
 - The maximum loss at the TCP in IR3 is reached for a frequency change of ~ 150 to 200 Hz, with an orbit drift of about 3-4 mm. The off-momentum loss appears when the beam is $4 \div 5 \sigma_{\text{nom}}$ of the collimator jaw.
 - Dedicated beam tests are required to find a frequency change with higher losses in IR3 before dumping.
 - Markus asks if it's needed to stay below respective level of the RF.

- Gianluca comments that the full beam is lost at 200 Hz already.
- Two bunches are needed for establishing and optimizing collisions; for loss maps: 2 nominal + non colliding probes (1 per plane), as only non-colliding bunches can be exited by the ADT without causing cross talk with the other beam.
- Constraint from BPM: sensitivity limit $5e10$ p for all BPMs, it is reduced to $2e10$ p for interlocked BPMs.
- If the SBF is too low it might be needed to do loss maps with unsafe beam and without masking the BLMs, the alignment should be done with emittance blow-up.
- Operational efficiency: Possible to complete the alignment of all 86 ring collimators in a single fill. Alignment and qualification could be performed at all the machine modes because of the ADT.
 - In order to be able to perform with 2 nominal + pilots the experience should be gained.
 - Reyes reminds that only nominal bunches are monitored by the interlock BPMs in IP6 (because the sensitivity will be switched), pilot are not monitored. Markus comments it was already done this way. The total beam intensity is registered.
 - Jan asks if there is a need to mask anything. Daniel replies that the pilot is not a problem, because it's at the limit of being unsafe.
 - Markus comments that doing the alignment and qualification in one fill means a high level of optimization. We should not expect this for the beginning of run2.
- For the start-up commissioning 1÷2 fills per machine mode are required, a 3rd fill is needed for asynchronous dump.
 - Gianluca shows the table with intensity and bunch configuration for alignment and loss maps at different machine modes: Injection, Flat Top, After Squeeze, Collisions.

- Daniel asks why there are 2 nominal bunches at Flat Top. Shouldn't be 1 nominal + 2 pilot? Gianluca replies that the collimation prefers is to have 3 nominal bunches to allow for operational margin (no need to dump and refill in case the intensity is slightly above the SBF limit).

Discussion:

- Markus comments that the TCTs don't need to touch the beam halo, for alignment after setting up collisions, as they will have BPM buttons.
- Stefano asks about the interlock at Pt6. Jan comments that it will be used as before. No problem with masking BLMs at collimators.

1.2 Setup Beam Flag updated proposal – (D. Wollmann).

- Intensities needed for setup:
 - Depending on the location of the BPMs, the intensity limits vary from $2e10$ p/bunch (IR6) up to $5e10$ p/bunch (orbit/ring; collimators).
 - Setup collisions: 2 bunches with $\sim 1e11$ p/bunch.
 - Collimation alignment and qualification: full setup will consume $\sim 7e10$ p, each transverse loss map $1e10$ p.
 - Jan comments that at 6.5 TeV the quench level is higher than $1e10$ p.
 - Stefano comments that in Collision there are not only TCTs but also TCLs that need to be set up.
 - Daniel reminds that if the machine modes "Squeezed non-colliding" and "Collisions" changed order, the number of tests will still stay the same.
- Qualification, 30.03.2012.
 - In the beginning of the run the cycles for collimation qualification will also serve for testing the machine cycle and gaining experience.
 - Restricted SBF (unsafe beam) should be used only when crucial and with care.

- Stefano comments that there is no need to align the collimator to protect the triplet aperture.
- Markus comments that the validation of the whole system is needed after changes in the orbit etc.
- Updated values for SBF:
 - Normal SBF: 1.1×10^{10} @ 6.5 TeV.
 - Restricted SBF (special users, e.g. collimation setup and qualification): $2 \times 1.25 \times 10^{11}$ @ 6.5 TeV.
 - Restricted SBF (MDs with MP docs): $16 \times 1.5 \times 10^{10}$ @ 6.5 TeV.
 - Markus comments that the bunch intensities for the second restricted SBF will be interlocked by the SIS. The risk depends on the time spent in this mode. After gaining experience it might not be needed to mask the BLMs during the alignment or loss maps. Jan is worried about the dump septa. He comments that it is possible to mask the orbit interlock in Pt6, but the standard way should rather be not to need doing it.
 - Stefano asks if the machine could be masked for 1 nominal bunch, what is the reason not to allow for 3 nominal bunches. He points out that 3 bunches are not more dangerous, it's just a factor 3 higher probability for a failure. Giulia comments that with 2 bunches there is one collision per IP. With 3 bunches the luminosity is twice higher.
 - Daniel responds that we want to allow for an efficient setup and at the same time limit the risk for the machine by allowing only the intensities really needed. During run1 3×10^{11} p were not used for qualifications and collimation setup.

Discussion:

- Jan asks what is the intensity needed for beta-beat measurements. Stefano replies that 1×10^{10} protons are needed, however in the EDMS the stated value

is 3e10 p. He adds that blowing-up the intensity has advantages when not knowing the orbit. Daniel states that the 25ns trains has a different orbit than 50ns one. Markus comments that Joerg is planning to study the reproducibility of the orbit changes between pilot bunches, nominal bunches and trains. This would possibly allow for a correction of the different BPM responses for the different beams.

1.3 Machine Protection workshop revisited: Open issues, progress and decisions on major topics – (D. Wollmann).

Daniel gives an overview of follow-ups with focus on commissioning and restart of the LHC after LS1. He outlines open issues, progress and decision on major topics.

- Material damage/failure scenarios: Review of the SBF has high priority. Review/update LHC failure scenarios and expected damage (work ongoing).
 - Roderick comments that it is needed to know the damage limit of the triplet (80K is very pessimistic scenario). Stefano suggested checking the status of protection level of triplet and of the damage limit of tungsten collimator with realistic impact distributions.
- Moveable devices.
 - Specifications for Collimators with buttons were distributed.
 - Collimation qualification strategy: ongoing.
 - TCDQ upgrade - 3rd block, resolvers as redundant measurement.
 - TCT position limits as a function of separation – implementation is prepared as backup solution.
 - Stefano comments that this implementation in the low-level software cannot be seen as backup solution, as it would require significant overheads for setting up and testing the correct functioning. Such an implementation could only be done during a winter stop.
 - Improved setting verification – application available.
 - Protect changes of beam process – not obvious how to implement.

- Improved handling of critical settings, more responsibility to shift crews – TBD.
- Fast vacuum valves – decision taken by LMC that they will not be installed.
- Injection and LBDS.
 - Redundant BIS-LBDS retriggering: reliability analysis finished, production – ongoing.
 - TCDIs interlock transfer line optics via virtual beta* limit: implemented in the collimator low-level.
 - Interlocking of SPS-LHC beam transfer: consolidation of LBDS powering.
 - Jan asks if UPS was tested. Markus responds that the tests will be done in July.
 - MSI current, TDI gap, TCDQ gap interlocking in BETS.
 - Reyes reminds that to modify the interlock limits one needs to go to the tunnel. If the limits have to be changed during the operation, how could this be done? Jan responds that it could be done in a few iterations: change by less than 1%.
Once it is set up initially, it doesn't need to be changed.
 - Refurbishment of TDI (redundant gap measurement): ready to be installed in Christmas break.
 - TDE block temperature and pressure increase due to repeated beam dumps at 6.5/7TeV is not critical for Run2.
 - Beam position in TCSG(IR6) interlock from SIS to BIS – to be decided at the beginning of the Run.
 - MKB vacuum interlock: gauges and pumps have been replaced.
 - Review number of test-pulses.
 - Scan of MKD waveform – to be performed during commissioning with beam.
 - Improve transparency in case of operation in “degraded” mode.
 - Upgrade of MKIs: finished.
- Circuit related protection/Electrical Distribution.
 - Full revalidation of QPS and BLM systems: starting soon.

- Interlocking of fast power aborts for CMS, LHCb and 60A correctors: no info from CMS and LHCb; 60A: PVSS logic corrected, PP60A telegram changed.
 - Markus comments that this will be deployed in all the experiments. Richard adds that logic stays the same.
- Specific powering test: planned in July for sector 5-6.
- QPS implementation of critical updates: not planned in LS1.
- QPS mitigations to decrease system vulnerability: improved supervision for parameter management and remote configuration implemented in hardware. Software tools to be developed.
- FMCM: improve rejection of network: not before Run2.
 - Markus comments that design was started, but tests will not take place before Christmas 2015.
- UPS consolidation: full scale test in preparation.
- UPS + new switching frequency: tests with the ADT planned in October-November 2014; factor 5 lower noise.
- COD current checks – checked in PC interlock.
- Extend PC interlock to other PCs – improve COD tolerances
 - Stefano asks about the details of the system. Markus comments that it was done by Kajetan, could be presented during LBOC.
- Circuit classification (maskable/non maskable/transparent) : done for PIC in agreement with ABP, to be applied to Cryo and OP.
- Markus mentions that cryo-team has an own classification for the relevance of the circuits for operation. The classification should be unified between the different systems.
- Beam instrumentation:
 - Beam current change monitor – Hardware is being tested in the lab.
 - BPMs (IR6) improved dynamic range: hardware mitigations performed.
 - Markus asked if there was an issue with data. Jan comments that it needs to be checked.

- BLM: LIC in injection region: EDMS document is in preparation.
- BLM: review of thresholds
- BLM: displacement of monitors – EDMS document.
- Threshold generation in LSA.
 - Jan mentions that there will be independent BLM buffers for B1 and B2.
 - Barbara asks about the strategy for the firmware for the blindable crates. Markus suggests that it was agreed to first focus on the operational version of the crate firmware and as soon as the validation is done a second version including the blind-out of the BLMs connected to the special crate will be developed.
- BSRT: reliable abort gap monitoring – EDMS document being prepared.
- BSRT: heating mirrors – BSRT was redesigned.
- Q-feedback versus QPS thresholds: increase of thresholds is expected.
- Improved reliability of OFB: development is starting in Sep. 2014.
- Check BPM functionality before every fill.
- Operation/Software tools.
 - Tracking of changes in MP systems – Acctest procedures.
 - Markus comments that the first implementation was started.
 - XPOC improved/reduced number of false latching – separate buffers requested for BLMs.
 - IQC improvement to require fewer tests is not obvious;
 - Jan: if the windows set large, leads to fewer falses.
 - Facilitation of loss-map checks.
 - Stefano: highest priority for BPM software.
 - Applications for BLM system
 - Markus: internal BLM tools. Barbara: apart from the monitor factor, the others are internal tools.

- Additional RS and higher resolution of BLMs in PM:
Implementation is planned.
- Aperture meter and online model for ring and transfer lines.
 - Stefano comments that Piotr started with this task recently.
- Testing BIS inputs: regular checks of BIS channels:
 - Markus comments that the strategy is in preparation.
- Masks/SBF consistency check before beginning of ramp to avoid false dumps.
- Additional PM modules, review Alarms in LASER, fixed displays and SIS GUI.
- Software to help identify unsafe machine states.
- Commissioning
 - Review/update commissioning procedures: discussion ongoing.
 - rMPP after LS1
 - Jan asks if doing rMPP piquet is planned. Markus comments that the so-called rMPP piquet does not mean an piquet service in the classical understanding but having one person per week who follows-up with MP issues during operation and is the contact between OP and coordinators and rMPP.
 - Review/update MP procedures, MD documents: tbd.
 - Powering tests: review is ongoing.
 - MPP<->MP3 interplay
 - Implementation of a fault tracker: the project's started.