69th 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 Proposed change of BLM positions in the arcs during LS1 – (M. Sapinski)

- The BLMs in the arc are put close to the quadrupoles. The BLMs were positioned due to simulations, which showed that the expected tertiary beam halo losses are highest at the MQs (aperture limit effect and beam size effect). For redundancy there are 3 BLMs installed per MQ. There is a 45m distance between the BLMs.
- The loss shape was measured in experiments. Two out of 3 BLMs at the MQs show comparable losses. I.e. there is redundancy in these BLMs.
- UFO losses were first reported in July 2010. These type of losses are very localized and on a time scale of ~1ms. To reduce the number of unnecessary dumps the BLM thresholds were raised by a factor 5. No magnet quench was observed. Dumps due to UFOs occur rarely.
- Observations in cell 19R3 (with additional instrumentation):
    - 2 classes of UFOs were observed:
        - Maximal signal in MB.B
        - Maximum signal in MB.C.
    - UFOs in the MB.A create a factor 50 lower signals in the BLMs in the MQ, i.e. they are difficult to detect with the current system.
    - UFOs are distributed all along the cell.
    - Simulations show that UFOs in the MB might quench the magnet (at 6.5 / 7 TeV) and the current BLMs cannot protect against this.

        - Ruediger comments, that so far we didn't have an UFO in a MB, which quenched the magnet. Anton mentions that this is true, but the simulations show that this might change at 6.5 / 7 TeV.

- Gain in signal with proposed additional BLMs on MB.B and MB.C in case of a UFO in the MB:

UFO location	BLM on MB.B	BLM on MB.C
MB.A	50	5
MB.B beginning	-	20
MB.B end	-	5

    - Ruediger asks, what the cross talk to the BLMs in the other beam is. Anton answers that the signal in the other beam is significantly reduced (about factor 5) compared to the signal in the BLMs in the same beam.
    - **Action**: Perform further simulations to study the possible gain from BLMs in the other beam. (Anton, Mariusz)
- Proposed 1st solution: Move the second BLM of the MQ to the beginning of MB.B. This would still allow for redundancy in the MQ and give the highest gain in BLM signal from UFOs in the MB.
    - Laurette asks why we do not move instead the third BLM at the MQ. Mariusz responds that this proposal was achieved by signal optimization. Anton mentions that the third BLM is needed to protect the MQ against losses in the MQ.
    - **Action (BI)**: Jorg proposes to check the different loss distributions from UFOs, to decide about, which BLM to move.
- Proposed second solution: Move one BLM from the MQ (as solution 1) and install an additional BLM in the beginning of MB.C. This would mean the production and installation of 800 additional monitors.
    - Bernd mentions that the cabling would be done by BE-BI. In addition 2 channels on the electronics card are still available.
- What do we expect after LS1:
    - More UFOs directly after LS1 due to deconditioning of the machine.

  - More UFOs expected with 25ns operation.
  - The quench limit might decrease by a factor 10 when going from 3.5TeV to 7TeV (QP3, Note 44). To validate these assumptions, the millisecond quench test is very important.
- Threshold estimation: With the new BLM layout the thresholds would be comparable to the ones now applied to protect the MQ.
  - Anton comments that the peak energy density in the coils cannot easily be predicted by the BLM signal. This depends also very much on geometrical factors.

Discussion:

- Jan comments that if one moves one of the BLMs from the MQs this affects the redundancy and reliability. The question is by how much. Mariusz answers that currently we allow disconnecting of one BLM per cell from the BIS (not in neighboring cells). Bernd comments that so far only once one BLM was deactivated.
- Andrzej comments that with this decision one reduces the protection of a less sensitive circuit.
- Ruediger comments that this is not protection but quench prevention. In addition the losses can be observed in many more BLMs around the machine. Thus, from experience we have much more redundancy and reliability. Arjan adds that we shouldn't be too afraid about quenches in the MBs and MQs after LS1. Ruediger mentions that this is more about machine availability.
- Markus asks how much time it would take to produce the BLMs for solution 2. Bernd responds it would take about a year.
- Ruediger adds that one could even think about moving two of the three MQ BLMs as redundancy would also come from the BLMs in the other beam, which sees cross talk.
- **Action:** Further simulations are needed to optimize the proposed solutions, to check as well the potential redundant protection provided by the BLM on the other beam.

- Jorg comments that there still seems to be something puzzling in the simulations with the factor 50 higher losses in the MB than measured in the MQ. It is surprising that we so far have not quenched an MB.
- Andrzej ask if it would be still feasible to produce and install the additional BLMs if the decision is done today. Bernd responds that this would be feasible.
- Markus summarizes that MPP is in favor of solution 1, still there is another iteration proposed to perform additional simulation to study the loss distributions.

1.2 Update of interlocked BPMs in IR6 (E. Calvo)

- Eva reminds us on the layout of the interlocked BPMs in IR6.
- As agreed with MPP the attenuators were removed.
- During the proton-ion MD the electronics worked at the high sensitivity mode and the beams were dumped several times. It is believed that this was caused by reflections in the cables. This caused big errors in the position measurement. The BPMs work reliable in low sensitivity mode.
- BI MD on the 8th of October: Reflections were confirmed in the BPMBS in the B2 with two bunches (9e9p and 3.06e10p).
- In high sensitivity mode the interlocked BPMs are sensitive enough to detect reflections and trigger the interlock on them.
- Strategies for compensating this for the proton-ion run:
    - Change the attenuators back to the previous setup. Unfortunately this is not a permanent solution.
    - It seems to be possible to adjust the low and high dynamic ranges of the interlocked cards differently. But beams with 4-5e10p/bunch will still create reflections, which are equivalent to the signals produced by beams >2e9p/bunch. Thus, this is not a long-term solution.
    - Probably best solution is to add remotely controllable variable attenuators. But this maybe considered as not reliable enough.
    - It would also be possible to block the reflected signal. This would need quite some time for installation and beam time for tests.

    - Installation of absorptive filters close to the monitors.
        - Markus asks if it is possible to measure this in the lab. Eva and Richard respond that these reflections may come from the cable path (bending etc.) and may not be easily reproducible in the lab.
- The effect needs to be reproduced during a technical stop with a generator to find the exact location of the defect that creates the reflection.
- As there is redundancy in the BPMs one could maybe mask one of the redundant BPMs and do tests on them. There are 8 BPMs per beam.
    - Ruediger ask what the BPMs are optimized to protect.
    - Jan mentions that one of the BPMs is optimized for the TCDQ.
    - Richard and Markus mention that one should probably use a vertical BPM.
- As there were occasions, where the dump reason could not be fully understood by the operators a debugging system was installed to test firm- and software improvements. Note this system only duplicates the digital system, not the analogue signals.
- Eva reminds us on the interlock logic, which is specified in EDMS file 984072:
    - H_{max}, H_{min}, V_{max} and V_{min} define the maximal orbit excursions of a bunch. T_1 and T_2 define for how many turns these limits can be violated and by how many bunches (BD_1 and BD_2) before a beam dump is triggered. Currently a beam dump is triggered, when 70 bunches (BD_1) are out of the limit for more than 100 turns (T_1).
- The post mortem buffer (last 1024 turns) contains (for every plane):
    - Min and Max ADC values acquired in a turn (HminTurn, HmaxTurn).
    - Number of acquisitions beyond the limits per turn (HBDTurn).
    - The number of acquisitions per turn (HBATurn).
- Note these data only available after the dump, not online.
- New firmware and FESA changes allow (slide 11):

  - New settings to define the maximal number of wrong acquisitions during T1 and T2: HErrorT1, HErrorT2, VErrorT1 and VErrorT2.
  - Additional registers to know in "real time" the interlock behavior: Number of bunches outside limits and number of errors during last T1 and T2 period.
  - Additional Post-mortem fields: Number of errors per turn and turn flags to indicate the start of T1 and T2 periods.
  - When 1 card triggers a dump the post-mortem buffers from the other cards can be "frozen".
  - Hmax, Hmin, Vmax and Vmin will be persistent fields. Before they were calculated at every reboot of the Front End taking the last calibration values at that time (not always 50ns filling pattern).
  - Hmax, Hmin, Vmax and Vmin were calculated without taking into account the non-linearity of the WBTN cards. The effective interlock margin was smaller than initially defined. Machine was safer, but availability was lower.
- In the post mortem data only the average orbit is visible, but not if individual bunches behave strangely. Therefore in the test system more fields were added for the post mortem.
- To make these additional data available to the operator we need an additional GUI.
  - Jorg and Markus comment that these data should go into the post mortem, where we need an additional GUI.
- The new firmware and FESA are unfortunately not yet ready for deployment. A few small issues, which affect the logged data in the Post-Mortem, should still be solved and tested.
- Future steps (… slide 14):
  - Extend the dynamic range of the two working modes (high and low sensitivity) without compromising the reliability and the availability.
  - Provide bunch-by-bunch post-mortem buffers (?)
  - In order to increase the memory available for the bunch-by-bunch post-mortem data, the number of DAB cards for these monitors

can be duplicated, and the signals split in surface. This way, half of the cards will be dedicated only to the interlock process, while the rest will take care of the orbit and capture modes.

- The FPGA present in the PT6 BPMS DAB cards can be upgraded to a bigger IC.
- The detection threshold of the low sensitivity range should be made still longer, with a lower limit of about 1e10p/bunch at 7TeV. This will make the system again sensitive to the reflections, this time also in the low sensitivity range. So, the reflection source should be found and mitigated.
- It was requested to get the bunch-by-bunch data.
  - Jan comments that it would clearly be good to have the raw bunch-by-bunch data to gain confidence on the analysis.

Discussion:

- Ruediger asks if there is any system, which records bunch-by-bunch data over 1000 turns in the LHC? Tobias and Jorg answers that the ADT does this for 70 turns.
- Ruediger, Jorg, Jan and Markus point out that even if the BPMs do not cause the dump such a post mortem information about all bunches in the last 1000 or even 500 turns would be a very valuable diagnostic tool.
- Ruediger asks if the system allows the use of low and high intensity bunches at the same time, e.g. during MDs. Eva responds one can clearly improve the dynamic range of the system, but still the dynamic range will be limited to the low and high intensity system.
- Ruediger asks if one could in theory interlock different bunches independently. Eva responds that in principal this would be possible but this would change the current specifications.
- Markus proposes to study the limitations of the system. If it would be possible to disable e.g. one vertical BPM from the interlock this one could be used to perform the needed studies.
- Jan, Mike and Jorg propose to change the attenuators for this year's proton-ion run.

- Jorg proposes to prepare all but one channel for the proton-ion run with attenuators and leave one channel to study the reflections.
- Jan says that first a clear plan for the proton-ion run should be defined.
- **Action:** Follow-up on reflections and post mortem buffer changes in a smaller team. (Jan, Markus, etc.)
- **Action:** Review the specification of the IR6 interlocks BPMs.

1.3 Miscellaneous

- Mariusz: MD to create very fast losses with kicker and ADT. This should be done at 450GeV and 4TeV. It was proposed to move all collimators (not IR6) to 11sigma but one TCP jaw in IR7, to allow having aperture limitations at a defined position in the machine.
- Beam intensity 10 pilots at 4 TeV.
- MPP proposes to put all collimators at 11sigma including TCSG and TCDQ in IR6. We have a slightly increased risk for an asynchronous dump, but with only a pilot, as the 10 pilots are distributed in the ring.
- If at 450GeV any un-expected losses are found there the plan for 4TeV should be re-considered and possibly adjusted.