175th Meeting of the Machine Protection Panel

The meeting took place on **March 15th 2019** in 774/1-079.
Participants: A. Apollonio, C. Bracco, A. Lechner, T. Levens, K. Li, D. Nisbet, P. Odier, B. Petersen, B. Salvachua, J. Uythoven, J. Wenninger, D. Wollmann, C. Wiesner, M. Zerlauth
The slides of all presentations can be found on the website of the Machine Protection Panel: http://lhc-mpwg.web.cern.ch/lhc-mpwg/

1.1 Minutes from the 174th MPP

No comments have been received for the minutes of the 174th MPP. The open actions resulting from the discussion on the LHCb VELO are listed on the MPP homepage.

1.2 New dIdt interlock for SPS: planned technical implementation, thresholds and protection scenario (Kevin Li)

- Kevin presented the **requirements and development status of the new dI/dt interlock for SPS**. The presentation was a follow-up from the discussion at the 168th MPP (31/08/2018) about the beam incident at SPS. A dedicated discussion with BI has already taken place at the BI Technical Board meeting on 15/11/2018.
- The specification document (SPS-B-ES-0005-00-10) is in preparation and can be found in EDMS.
- The direct **motivation for implementing a new dI/dt interlock** is the failure that happened on 20/8/2018, when a wrong tune setting led to a resonant excitation of the beam. As a result the vacuum chamber was damaged and the dipole magnet had to be replaced, leading to two days of downtime for the SPS. During this event, about 80% of the beam was lost at the aperture bottleneck over a time period of only 15 ms, which was faster than the 20 ms reaction time of the BLMs in the arc. (See Kevin's presentation in the 168th MPP and the Minutes of the 168th MPP).
- So far, the only **diagnostics for general fast failures in the SPS ring** are the BLMs that have a 20 ms reaction time (supported by only a few faster BLMs at known aperture bottlenecks). In addition, there are different interlock BPMs. The idea for the new interlock is to monitor fast drops in the total beam intensity based on the DC BCT measurement.
    - Jan asked about the **current status and functionality of the BPM interlocks** and their connection to the BIS. Kevin replied that for the analog interlock the potentiometer has to be set manually, and that the current functional status is not fully clear. → Action (Kevin/SPS OP): Check status and proper functioning of the BPM interlocks and their connection to the BIS. [1]

[1] After the meeting, Jorg commented that there are two different BPM interlocks: 1) An extraction BPM interlock, which is on the closed orbit (not on turns) and has a delay of many milliseconds. It is connected to the BIS since 2008 and is designed for LHC beams and extraction, not for fixed targets beams, where it is not active. It acts on the extraction and not the dump. 2) A beam position interlock implemented by analog HW some time ago. It is only acting in the horizontal plane as it has been designed for RF failures (radial beam movement). It is an analog device set by a potentiometer.

- The **requirements for the new dI/dt system** are summarized on Slide 5: The total beam losses should be monitored with two different integration times with configurable threshold settings and, ideally, a response time of 1 ms for a loss of 3e11 protons and 10 ms for a loss of 1e12 protons, which is very similar to the specification for the LHC system. The system would require a dedicated, maskable BIS input to the SPS ring BIS. The interlock should trigger when the threshold levels are crossed and simultaneously latch the SIS. For programmed dumps or during fast extraction, an additional logic that prevents the SIS from latching has to be implemented in the SIS.
- It was discussed whether the **resolution requirements** could be relaxed. Kevin stated that also a 2 ms time resolution, which is still a factor 10 faster than today, might be acceptable. However, it is not clear how much margin we have to the damage threshold.
    - Daniel commented that the **damage level** depends on the energy density, i.e. not only on the intensity but also on the beam size at the loss location. An energy deposition of approximately 6 kJ per cm^3 is sufficient to melt copper. He added that the damage levels were experimentally studied with SPS energies by extracting beam onto solid targets installed in TI8 (see V. Kain's Ph.D. thesis). Kevin replied that for the SPS incident the beam size is not known in detail since it was a resonant failure with a grazing impact.
      Jan remarked that **energy-deposition studies** might be required to verify the damage limit and that, thus, the FLUKA team should be contacted.
      → Action (Kevin/SPS OP/FLUKA team): Evaluate and define damage limit for SPS beams, based on FLUKA studies if required. Provide the limit as input for BI.
    - Markus stresses that less safety margin in what concerns the threshold setting is required for SPS than for LHC, since the consequences in terms of damage and downtime are much less critical than at LHC. In addition, the effect of false triggers on availability is less sever for a cycling machine like the SPS than for the LHC.
- The **technical implementation** for the dI/dt interlock will be based on the DC BCT detector in LSS5, which will be connected to the BI VME crate in BA5 and then to the CIBU. The CIBU is requested and expected during LS2. Details have been presented in the BI Technical Board meeting on 15/11/2018.
    - Jan asked about the achieved **time and amplitude resolution**. Patrick replied that the resolution was tested in the lab, but the behaviour in the machine is not known. Tom added that the detector will be moved to a new location and new cables will be installed. Therefore, the device should be measured in the machine. Tom stated that the requirements as presented from Kevin are reasonable, but improving even further would require a lot of effort as the noise in the system will limit the achievable sensitivity.
    - Markus asked about possible **synergies with the development of the dI/dt system for LHC**. Tom replied that the idea of the dI/dt is the same for both machines. However, the main difference is that the solution for SPS has to work also for un-bunched beam, which has significant

implications for the noise level. If the system had to operate only with bunched beam, a lower noise level could be achieved. Patrick added that a compromise between filtering and reaction time has to be found. In addition, the specification of measuring losses also for un-bunched beam excludes the use of the BPMs, which are used for the newest design of the BCCM in the LHC.

  - Markus asked **what design strategy is planned for the boards**. Patrick replied that it is not foreseen to develop new VME hardware. Instead, a standard carrier board should be reused and equipped with a new, dedicated firmware. He added that the requirement for the accepted number of false dumps is more relaxed than at the LHC because the filling of the SPS is much faster than at the LHC.

- Patrick asked how the **commissioning procedure for the dI/dt system** would look like. Jan proposed to start running with the new system after LS2, but keep the BIS input masked until final validation of the system with nominal beam intensities. After gathering enough experience and confidence, the interlock should then be unmasked. Patrick estimated that several months of operation are required to collect sufficient data. Kevin commented that this should not be an issue since SPS had been operating without this kind of interlock for the last 20 years, and that LIU beams will not be available directly after the restart. This should provide enough time to test the interlock such that it is ready when needed for operation with LIU beams.
- Markus highlighted that the **dI/dt interlock will also be beneficial to mitigate other possible operational mistakes** that we are not aware of since it acts directly on the overall losses. Kevin added that it will also improve the protection for trips of certain equipment. For example, in the same week of the incident in the SPS, the horizontal damper tripped. In this case, it was not critical because we were protected in the horizontal plane by the LSS BLMs. However, if the vertical damper had tripped, the consequences could have been as serious as for the one in August 2018.

1.3 MPP Workshop: announcement and overview (M. Zerlauth)

Markus announced the MPP workshop. It will be a non-residential 2-days workshop.

- The workshop will take place on **May 7th and May 8th 2019** in the vicinity of **Chavannes de Bougis**. It will focus on LHC but also cover injector-related topics.
- The **draft mandate** is to *review the status, foreseen and required changes in the machine protection systems during LS2 to prepare operation with LIU beams and their impact on machine protection*.
- The workshop has been approved by the TE department, and the detailed organization is ongoing. Around **60-70 participants** are foreseen. Since the workshop is non-residential, the option remains that people just participate for one day. The groups are asked to provide their feedback on potential speakers, so that the draft program can be finalized by March 30th. The final invitations should then be sent out by April 6th.

- Markus gave an **overview of the planned sessions** and presented the draft Indico page.
    - Jorg proposed to adapt the title of the session on “Machine Protection Related Software” such that it fits better for topics as the “Lumi server”, which are not directly machine-protection software.

1.4 AOB

No AOBs were discussed.

1.5 Open Actions

The actions from the meeting are:

- Action (Kevin/SPS OP): Check status and proper functioning of the BPM interlocks and their connection to the BIS.
- Action (Kevin/SPS OP/FLUKA team): Evaluate and define damage limit for SPS beams, based on FLUKA studies if required. Provide the limit as input for BI.