M. Valette

173rd Meeting of the Machine Protection Panel

The meeting took place on December the 14th in 774/0-030.
Participants: W. Bartmann, R. Bruce, P. Di Nezza, D. Lazic, K. Li, B. Petersen, A. Rossi, B. Salvachua, B. Salvant, C. Schwick, J. Uythoven, M. Valette, J. Wenninger, C. Wiesner, D. Wollmann, 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 Approval of MPP#172's minutes

- No actions from the 172nd MPP.

1.2 LHCb: plans for new SMOG2 system (P. Di Nezza)

- Daniel explained that the presentation on the LHCb SMOG2 detector has the aim to prepare a presentation to the LMC. MPP requested a presentation to identify, if there are any machine protection issues concerning the proposed SMOG2 detector.
- Paolo presented the physics case and mechanical implementation for the upgraded SMOG2 detector to be installed next to LHCb.
- The central piece of the SMOG2 is a storage cell with a diameter of 1 cm and a length of 20 cm, where the beam will pass through. A gas inlet is positioned in the center of the storage cell. The confined gas will provide 10^{13} atoms per cm^2. The wings of the system are required to trap the injected gas. The system can be aligned with a precision of +/-50 µm. The SMOG2 detector will be fixed permanently to the VELO detector and will open and close together with this detector. The storage cell closes 0.5 mm before the rest of the VELO detector. Assuming an alignment of 0.1 mm the aperture requirement of 19.5 sigma is fulfilled.
- The identified possible impacts on LHC operation by the storage cell would be limited to vacuum and impedance. Vacuum considerations were checked with VSC. The injection system would allow to inject a variety of gases: H2, D2, He, N2, O2, Ne, Ar, Kr, Xe.
- The Impedance team stated that the replacement of the current wake field suppressor by the SMOG2 system would not lead to new resonant modes both transverse and longitudinal in both open and cold position. The local power loss could reach 1.5 kW assuming a specific filling pattern and very high bunch intensity which is unlikely but losses in the order of 350 W should be expected and considered in the SMOG2 design (especially via conduction cooling), temperature monitoring is also recommended. This is especially relevant as the VELO detector is operated under cryogenic

conditions. Paolo added that the device would be monitored by 4 temperature sensors and a dedicated BLM.

- Regarding aperture calculations the new VELO appears better than the previous one, as confirmed by Roderik, and the aperture should be similar to the one of the magnets even when closed with squeezed optics (10 mm available and a maximum of 3 needed for VdM scans). Background calculations were performed in Geant4 and the additional material would have a negligible impact on the background for LHCb.
- In case of a problem the system could be replaced by the existing wake field suppressors within 4 weeks. This time is dominated by the required bake out. Running LHCb with an open VELO would represent a major disaster for the physics program of LHCb.
- A prototype was tested for stress and fatigue and survived 15.000 cycles, i.e. about 10 years of LHC operations.
- In conclusion Paolo stated that the project is mature and presents a unique physics opportunity.
    - Wolfgang asked about the position interlocking of the device. There would be no separate interlock and it would be concentrated together with the LHCb interlock. The VELO logic would prevent injection if the device is stuck or not in garage position. Daniel added that the interlocking strategy will be treated in a follow-up meeting after Christmas, as this is generally relevant for the entire VELO and not only for the storage cell of SMOG2.
- Daniel summarized that the impact on impedance and the stability of the mechanical system have to be given special attention during the further development, the test and construction of prototypes and the final system. The status of the SMOG2 detector should be presented in the MPP after the future prototype tests and in case any new issue concerning machine protection is identified.

Note: the topic of “New DiDt interlock for SPS” from Kevin had to be postponed.

1.3 Plans of using Beam-Beam Long-Range (BBLR) compensators in B1 and B2 during high intensity operation - impact on interlocking and protection strategy (A. Rossi)

- Adriana recalled the evolution of the collimation hierarchy in the last few years of operation and presented the protection aspects of using the BBLR wire compensators during physics.
- The compensation of beam-beam effects was clearly demonstrated during MDs in run II with improved beam lifetimes. Especially the test of the configuration with two wires per collimator powered in series has been very successful in 2018. Therefore, it is proposed to move the downstream B2 wires to B1 during LS2 to confirm the measurements from B2 and to allow the use of the wires during normal physic operation.
    - Daniel stated that this is a fundamental change in the use of the system. So far, the wires were foreseen for the use during low intensity MDs only. For their use during regular physics fills the interlocking strategy has to be significantly tighter and appropriate hardware interlocks have to be implemented.
- The wires are currently interlocked against over-heating. The power converter will be disabled but no beam dump will be issued. Currently no interlock is implemented to protect the case of a trip of the power converter and the resulting effects on the circulating beams. The proposal is to dump the beam in both cases and to replace the SIS interlock with a hardware one.
- Heating tests were performed in the past on the spare wire-in-jaw collimator and showed, that the temperature stays below 200 degrees Celsius if the voltage remains below 2.6 V at 375 A. This is the limit chosen for the protection of the collimator jaw and not of the wire. The heating up to these peak temperatures, even at full power and without cooling, takes several minutes.
- In the current usage, the wires of the neighbouring Q4 and Q5 are trimmed to compensate for the quadrupolar component of the wire field. In case a wire fails and powers down a tune shift in the order of 1E-2 and a beta beating in the order of 10% will be observed. Combined failures are not a concern as the failures would be compensating.
- Roderik investigated the effect on collimator hierarchy of a trip of the wires. The effective collimator settings would be shifted by 0.2 σ and, in the most critical case of 25 cm optics, the TCDQ to TCT margin would be reduced to 0.1 σ. This would risk a breakage of the hierarchy and therefore the use of the wires was not permitted in 2018 at beta*=25 cm. Phase advances between the MKDs and critical elements would not be affected. Roderik recommended to verify the impact of the beta beating with the run III operational optics.
- The time needed for the current to reach 0 A from 350 A is between 30 and 40 ms (measured at 100 Hz). Another measurement allowed to measure that a maximum of 5 A are lost in the first 2 ms, which is the critical time for interlocking. Adriana suggested that the time constants involved allow for a standard WIC interlocking.

- Roderik commented that loss maps need to be performed with and without wires (including the Q4/Q5 correction) if they are to be used operationally.
- Jorg added that the tune shift from the wire is outside tolerances and can push the tunes through the third order resonance. Last year the shift was in the good direction but it should be checked as well for the future. The Q4/Q5 trim could also be set to the measured wire current and not the set one. Ultimately this could be part of the phase advance interlock (PC interlock system) and could depend on the beam currents.
- Jan commented on the measurement delay from the FGC to the converters and suggested the current decay measurement be done with adequate equipment. If the decay time is too short, adding an inductor in the circuit can introduce some delay without affecting operation.
- Jorg commented on the number of validation fills needed to commission this device which has to be integrated in the commissioning plans.
- Daniel re-iterated that a full hardware interlock is required for the operational use of the wires.

- Recommendations for the next step of interlocking the BBLR wire collimators:
  - Investigate current decay times following power converter failures with higher resolution measurements.
  - Verify beta beating in case of a failure with the collimation team.
  - MPP will study the effect of the wire independently and evaluate the required reaction time of the interlock.
  - As Run 3 optics are not final yet, effects of a failure should be checked when they are available, sufficiently early to allow further iterations.