174th Meeting of the Machine Protection Panel

The meeting took place on January 25th in 774/1-079.
Participants:
F. Alessio, D. Lazic, B. Lindstrom, B. Petersen, B. Salvachua, J. Uythoven, J. Wenninger, C. Wiesner, W. Byczynski, V. Coco, P. Collins, O. De Aguiar Francisco, R. Ferreira, W. Funk, C. Parkes, X. Pons, S. Ravat, J. Sestak, H. Vestergard

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 the minutes from the 173rd MPP

- Additional comments to the minutes have been received. Further comments are still welcome. The minutes will then be updated on Indico and on the MPP website.

1.2 LHCb VELO - overview and short re-cap (Paula Collins)

- Paula presented an overview of the planned LHCb VELO upgrade. The new VELO will use a pixel design instead of the present strip configuration. The present cooling system was sufficient for the strip configuration, but it will not be sufficient for the pixel solution. Therefore, an improved cooling system is required.
- The challenge is to keep the sensor temperature below -20°C to cope with the harsh radiation environment close to the beam. This is provided by a novel cooling technique of evaporative CO_2 circulating within micro-channels inside a silicon substrate.
- The VELO is separated from the primary machine vacuum by a 1.1 m long, 250 µm thin RF foil, which also shields the detector and guides the beam wakefields. Based on an improved production technique, the new RF foil is now machined from a solid forged Aluminum-alloy block, which allows better control over the foil dimensions and tolerances.
- In case of a problem or damage to the foil, it could be removed and a wakefield suppressor could be installed instead. As a last resort, a beam pipe could be installed instead, which would require about 3 weeks to implement.
- In order to allow the VELO movement, 32 criteria have to be satisfied. The VELO was closed and opened about 2000 times without problems, excluding the issue on November 26, 2018 (see Federico's talk).
    - Jorg asked about the timeline for the planned installation. Wolfgang Funk replied that the new software will be tested this year. The delivery of the new foil is expected at the end of this year. Therefore, installation could start in 2020.

1.3 LHCb: problem with velo movement - overview of issue, solution and possible future improvements (Federico Alessio)

- During Fill 7474, on 26 November 2018 at ~2.30am, the VELO got stuck when moving in, shortly after Stable Beams had been declared. The expert was called and concluded that it was a hardware issue.
- It was decided to delay the required intervention and leave the fill in until it was dumped in the morning (~8am) to profit from non-on-call expertise. However, there was no injection permit because the VELO was stuck between its IN and OUT positions.
- The intervention started around 8 am. The power supply, the bridge rectifier and the fuse were replaced successively (see Slide 2 for details). Finally, the issue was tracked down to a combination of a broken bridge rectifier and a burnt fuse. The recovery could have been further delayed, if the expert of the system had not been at CERN by chance. During the intervention, an incompatibility between the spare parts and the original parts was found.
- The VELO was closed again at 18:12 hours without further problems. After the intervention, the VELO was found to be at the same position, i.e. no unwanted change of the position had occurred during the intervention.
- It was the first failure for the VELO motion system in 10 years of operation. The motion system is going to be completely replaced in LS2 due to the VELO upgrade.
- The VELO could have been moved out manually. However, it was decided not to do so because it might have created serious damage to the VELO cable connections. In addition, beam injection with the VELO half closed was investigated but finally discarded.
    - Jan asked why it had not been possible to move the VELO out by hand without damaging the cabling. Federico replied that in the future this functionality has to be ensured without the risk to damage equipment. Jan suggested to test the functionality regularly, e.g. once per year, so that it is operational when required. Jorg stressed that it is important to maintain this option for the future. Paula added that a manual movement of the VELO implies a recalibration of the system. → Action (LHCb): Clarify procedure for manual retraction of the VELO and for yearly testing of its functionality.
    - Jorg asked about the safe operation with the VELO in intermediate position, which is allowed by the present interlock configuration: What would happen if the beam starts moving while the VELO is stuck? Federico answered that the VELO was stuck but operational, i.e. a beam movement would still have been detected. However, since it would not have been possible to move it out, we would have been only protected by losses detected at the BCM just in front of the VELO. Wolfgang added that in the future the temperature of the foil will be measured and could be used to trigger a beam dump.

1.4 LHCb: new Velo Safety System - safety matrix and the interfaces (Wolfgang Funk)

- Wolfgang introduced the new VELO Safety System (VSS). The new VSS architecture consists of one central node, where all inputs and outputs come together.
- Wolfgang presented the triggered actions for the different input signals from vacuum, motion, CIBU, valves, and temperature readings (see slides for details). The following points were discussed in more detail.
- In case that the instant CO_2 leak detection system detects a leak in the secondary vacuum, the safety cooling valve is closed and the bypass cooling valve is opened (Slide 11).
    - An open question is if we should, in addition, close the sector valves.
    - Jorg emphasized that - if we pollute the triplets - we will have a serious issue. Therefore, it has to be checked with the vacuum group how much pressure rise is expected in this case. Wolfgang replied that the LHC primary vacuum should not be affected in this case. (See also Oscar's talk).
    - Jan mentioned that since this should be an extremely rare case, there should be no impact on availability. Therefore, we should go to the safest state which means: dump the beam and close the valves to protect the LHC vacuum.
- What actions should be triggered if the Stable Beam Flag (SSB) is 'not ok' (Slide 14)?
    - In the old VELO, for ADJUST (MDA not ok, SSB not ok), the beam would have been dumped and the VELO moved out, while for UNSTABLE BEAMS (MDA ok, SSB not ok) only the VELO would have been moved out and no beam dump would have been requested.
    - The new proposal is to treat both beam modes in the same way, i.e. always dump the beam and move the VELO out if the SSB is not ok.
    - Jorg reminded that the initial idea of UNSTABLE BEAMS was to have a beam mode that can be used in case of sudden beam degradation without prior notice to the experiments and without dumping the beam.
    - Jorg confirmed that UNSTABLE BEAMS has never been used operationally and that there are ongoing discussions if this beam mode should be dropped altogether. However, this would imply significant changes for different groups and has to be discussed in more detail (→ Action: OP/J. Wenninger). A decision can be expected for later in LS2.
- If one of the 15 temperature sensors at the RF foils gives 'not ok', the proposal is to interlock the LV/HV and dump the beam (Slide 19). Not dumping the beam would imply that the VELO would have to be moved in to reduce the temperature. Therefore, a beam dump is preferred.
    - Jan asked what happens if one sensor fails and gives a faulty reading. Wolfgang replies that individual sensors can be disabled by the experts via software. (See also Xavier's talk).

1.5 LHCb: actions on CO2 leak (Oscar Augusto De Aguiar Francisco)

- Oscar presented the new CO_2 cooling safety system. The heat generated by the electronics has to be absorbed via evaporative cooling with CO_2. (See also Paula's talk).
- In addition to the beam vacuum and the secondary vacuum, a new insulation vacuum for the cooling safety system will be used (see Slide 6).
- The maximum pressure variation between the beam vacuum and the secondary vacuum has to be smaller than 10 mbar to protect the RF foil.
- The first protection net in case of leaks are two shutoff valves that can isolate every two modules from the cooling plant and mitigate the pressure increase in the secondary vacuum.
- The pressure increase in the secondary vacuum caused by the CO_2 present in the cooling loops is estimated to be 6.7 mbar. For this estimation, the reaction time has been neglected.
- The second protection net is the emergency connection of the beam vacuum with the secondary vacuum in order to prevent plastic deformation or a rupture of the RF foil. This is achieved with membrane switches that react very quickly above a pressure difference of +10 mbar. It implies that CO_2 will enter into the beam vacuum.
    - The implications of this failure were discussed. A gas influx in the primary beam vacuum will, in principle, trigger the sector valves and dump the beam. However, the exact consequences depend on the size of the leak and the reaction time.
    - Jorg emphasized that, also as a lesson learnt from the 16L2 event, we have to prevent major gas influx into the cold parts. Therefore, the calculations and functional specifications have to be summarized in a written report. It should include the expected pressure increase and reaction time as well as the expected consequences and required switches and interlocks. → Action (LHCb/Vacuum).

1.6 LHCb VELO technical implementation and commissioning (Xavier Pons)

- Xavier presented the VELO Position Control and Safety System implementation.
- The present VELO Position Control System has been developed by NIKHEF. It consists of a vacuum tank with two movable detector halves. It allows the independent movement in the horizontal plane in the range of -5…+30 (+5, -30) mm and a common movement in the vertical plane in the range of -4.7…+4.7 mm.
- The control is performed in a dedicated rack by a Siemens S7-300 PLC. The system has been successfully operated since the start of LHC. For the upgrade, the hardware layout will be kept. The major change consists in replacing the PLC by Siemens with a PXI-FPGA by National Instruments, which is commonly used at CERN (TOTEM, ALFA, AFP Roman Pot Position Control System).
- Jan asked why the PLC would be replaced. Xavier explained that the original PLC had been developed at NIKHEF and that the present PLC developer is

retiring. Instead, FPGA expertise is available at CERN and there is synergy with other control systems, e.g. the ones for TOTEM and the Roman Pots.

- In the new system, the resolver position will be calculated directly at the FPGA level. The CIBU crate will be removed from the position control rack and will instead be installed in the VSS rack.
- The VSS is equivalent to the existing INTERLOCK BOX for the Roman Pot Position Control System. The movement logic and the interlocks will remain unchanged.
- The implementation of the logic and an MPP review are foreseen for 2019/20.
  → Action (MPP/LHCb – Xavier Pons): Review new movement control and interlocking logic/implementation in fourth quarter 2019.
- Jan asked how the interlock for a single temperature sensor can be disabled. Xavier replied that this requires a software action in expert mode, but no change in the FPGA. Wolfgang adds that, thus, the safety functionality is not affected.
- Jorg stated that he welcomes a more standardized approach and asked if, in addition, the use of a FESA class is planned. Sylvain replied that this functionality could be implemented, but for the moment it is not foreseen due to lack of manpower.

1.7 Open Actions

- The open actions from the meeting are:
  - Action (LHCb/Vacuum): The **functional specifications for the new CO_2 cooling safety system** have to be written down, including the expected pressure increase and reaction time as well as the expected consequences and required switches and interlocks.
  - Action (OP/J. Wenninger): It has to be clarified who is using the **beam mode UNSTABLE BEAMS** and what implications it would have to remove it. If removed, it should be removed consistently in all the experiments.
  - Action (MPP/LHCb – Xavier Pons): Review **new movement control and interlocking logic/implementation** in fourth quarter 2019
  - Action (LHCb): Clarify procedure for **manual retraction** of the VELO and for yearly testing of its functionality.

1.8 AOB

No AOBs were discussed.