# 253rd Meeting of the Machine Protection Panel

## LHC topics

September 13th, 2024.

*Participants*:
*Federico Alessio (EP-LBC), Catrin Bernius (EP-UAT), Andy Butterworth (SY-RF), Roderik Bruce (BE-ABP), Andrea Calia (BE-OP), Cedric Hernalsteens (TE-MPE), Anton Lechner (SY-STI), Anastasiya Radeva Poncet (BE-CSS), Belen Salvachua (SY-BI), Brad Schofield (BE-ICS), Matteo Solfaroli (BE-OP), Frederik Van Der Veken (BE-ABP), Jorg Wenninger (BE-OP), Christoph Wiesner (TE-MPE), Daniel Wollmann (TE-MPE), Chiara Zampolli (EP-AIP).*

The slides of all presentations can be found on the website of the Machine Protection Panel and on Indico (253rd meeting).

## Minutes and actions from the previous meetings

The minutes of the 251st MPP meeting and 252nd MPP meeting are now available on Indico (251st, 252nd), and via the website of the Machine Protection Panel.

## Update on BBCW status and plan (A. Rossi)

Adriana first summarized how the voltage calibration for the temperature interlock of the BBCW was performed. The temperature was directly measured on a spare unit as a function of the current in the wire. The threshold has been set to 2.7 V corresponding to the hottest point in the jaw reaching 200 C for a current of 300 A. In case the threshold is exceeded, the WIC interlock is triggered.

An issue occurred on April 9 when the interlock on TCTPH.4L5.B1 triggered at 350 A after 40 minutes. The operation was later resumed at a reduced current of 315 A.

During TS1 the connections were tightened, and the tests were repeated at 350 A for over one hour, including a measurement of the temperature outside the tank. During the repair the clamps were replaced with the proper double-sided clamps. The test at 350 A was repeated for more than three hours. The interlock did not trigger.

The interlock threshold voltage was increased from 2.7 V to 2.8 V only for the right jaw which is inner side of the tunnel (1 out of 8 in total). This is meant to compensate for the local overheating of the wire extremities which are shorter (2 cm instead of 3 cm). The new threshold has been tested using the standard procedure. Since then, the wires have been regularly powered at 350 A with no issue.

Daniel asked that the interlock change should be properly documented for future reference.
**Action**: Document the interlock change (A. Rossi)

## Recent changes to the PC Interlock following the injection of a pilot bunch into the LHC with a D1 power converter in off state (A. Calia)

Andrea summarized the status of the protection mechanisms as they stood before the issue. The SIS monitors the circuits operational modes (operational or simulation). During LS2 the monitoring of the circuit state has been removed. In case the mode is wrong, the SIS prevents the injection. The PIC monitors and interlocks the faulty states of circuits and dumps the beam in case a fault state is detected. However, the "OFF" state is not considered faulty. The PC interlock monitors the currents and verifies that it is within given tolerances. It does not consider the circuit state or mode by design. Only circuits in states IDLE, ARMED or RUNNING are considered. In case the current is outside of the tolerance the beams are dumped via the SIS.

This situation had a weakness as circuits in OFF states were not monitored.

On April 10, 2024, a successful MPS test was performed, involving switching off RD1.LR1. The machine was then prepared for beam and a pilot beam was injected with RD1.LR1 accidently left in "OFF" state. This resulted in the quenching of the inner triplet in Point 1. Following that event, a series of mitigations were devised and put in place.

### Mitigation #1 – SIS

The state of the power converters is now checked in SIS. Only the states "IDLE", "ARMED", "RUNNING" and "ABORTING" are considered valid. All other states are considered invalid, and the injection interlock is triggered. These checks are performed for all circuits, with additional logic for the correction circuits. This was deployed on April 10, 2024.

### Mitigation #2 - PC interlock

The PC Interlock now checks the state depending on the circuit family. For example, the state is ignored for the orbit correctors however for other circuits, like the RD1, the interlock would be triggered for inactive states.

This new implementation has been tested and is ready to be deployed to PRO. The deployment is foreseen during TS2. After its deployment the new version of the PCInterlock will be validated with the circuits in the LHC.

### Discussion

Christoph commented that an integral part of the LHC machine protection system is to enforce that only a probe beam can be injected into an empty machine. The event underlines the importance of this decision.

Daniel asked if the new SIS implementation will be removed once the PC Interlock check is deployed. Matteo replied that we should avoid duplicate checks however it could remain in place.
Daniel proposed to run with both systems (once the PC Interlock check is deployed) until the end of the year. It could then later be removed from the SIS during the YETS. Jorg agreed.

It was decided to document the event in the form of a Report on a Major Machine Protection Event.

**Actions**:

1. Deploy the new PC Interlock implementation during TS2 (A. Calia, BE-OP)
2. Review the interlock situation during the YETS24-25 and consider the removal of the additional SIS implementation (A. Calia, BE-OP).
3. Document the event (injection of a pilot bunch into the LHC with a D1 power converter in off state) and the following mitigations in the form of a Report on a Major Machine Protection Event (A. Calia, BE-OP).

## Intensity ramp-up for ion run 2024 (C. Wiesner)

The ion run is scheduled to start on November 2, 2024, following the p-p reference run. The 2023 ion intensity ramp-up was performed as planned but slowed down by several issues. Intermediate intensity steps were thus added (350b, 650b, 1100b) and additional ramp-up fills were performed. Finally, 1240b (full machine) was reached but for regular operation it was stepped back to 960 to 1080 bunches, to reduce the risk of dumping on beam losses in the ramp and to avoid limits on injected intensity at the TDIS by using shorter trains.

The configuration for the 2024 ion run is similar to the 2023 configuration, with additional mitigations for the issues observed last year included.

The proposal for the intensity ramp-up for 2024 is to keep the same ramp-up steps as agreed for 2023:

- Cycle setup with low intensity
- 80b, one fill, more than 2 hours in stable beams
- 250b, two fills, more than 5 hours in stable beams
- 450b, two fills, more than 5 hours in stable beams
- A combined checklist before going to the next intensity step
- 850b, two fills, more than 5 hours in stable beams
- 1240b (full machine) corresponding to 20 MJ of stored beam energy.

A point of attention is to monitor carefully the behaviour of the crystal collimation.

After the ALICE spectrometer polarity reversal one cycle with low intensity is required, followed by one 450b fill (>2h in SB), before going back to operation with full machine.

Catrin asked if stable beams are required for the cycle with low intensity. Christoph replied that this is not required from a machine protection point of view.

The MPP endorsed the intensity ramp-up plan as presented.

## Summary of actions

- Update on BBCW status and plan
    1. Document the interlock change (A. Rossi)

- Recent changes to the PC Interlock following the injection of a pilot bunch into the LHC with a D1 power converter in off state (A. Calia)
    1. Deploy the new PC Interlock implementation during TS2 (A. Calia, BE-OP)
    2. Review the interlock situation during the YETS24-25 and consider the removal of the additional SIS implementation (A. Calia, BE-OP).
    3. Document the event (injection of a pilot bunch into the LHC with a D1 power converter in off state) and the following mitigations in the form of a Report on a Major Machine Protection Event (A. Calia, BE-OP).