220th Meeting of the Machine Protection Panel

LHC topics

March 18th, 2022, via Zoom

Participants:

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The slides of all presentations can be found on the website of the Machine Protection Panel and on Indico (220th meeting).

Minutes and actions from the 217th meeting (LHC topics)

The minutes of the 217th MPP meeting have been circulated and have been approved.

Interlock strategies for LHC collimator temperatures and for TDE N2 pressure (M. Di Castro)

Collimators interlocks

Mario first summarized what has been done during Run II to change the strategy for the collimators and TDIS temperature interlocks. A continuous monitoring and logging is in place for the collimators and TDIS jaws (with PT100) and cooling water temperatures. In total, 731 temperature sensors are operational in the LHC collimators and connected to interlocks. Compared to Run II, the cooling water flow of the TDIS is now monitored (2 sensors per TDIS, 1 for upper jaw and 1 for lower jaw). A total of 12 PLCs are reading these sensors and are directly connected to the beam interlock system and to UNICOS WinCC OA SCADA.

During Run II, some LHC collimators and TDI temperature sensors failed for certain periods of time. In these cases, aberrant temperatures or very fast temperature changes were read by the PLC. If they persisted for more than 12 seconds, the interlock was triggered. A new filtering algorithm will be present during Run III operation, avoiding beam interlocks due to the non-physical readings of the collimator’s jaws temperature. This was discussed and proposed at the 176th MPP meeting.

With the new algorithm, a HW interlock will be triggered if:

- a jaw temperature reading exceeds 50 degrees for more than 12 seconds, not exceeding 500 degrees
- a cooling water temperature exceeds 40 degrees for more than 12 seconds, not exceeding 500 degrees
- the TDIS cooling water flow meter value goes below 0.5 l/min for more than 12 seconds.

The interlock temperatures thresholds can be adjusted during operation for each individual sensor, as done in the past, in agreement with OP and the equipment responsible.

In case an invalid temperature value is filtered, an alarm is published by PVSS and the BE-CEM piquet service will be notified by the BIDs-controls piquet monitoring tools. The piquet will follow-up with OP.

The system has been tested by an automated tool at the end of LS2.

Jan asked at which frequency this test is performed and suggested to perform the test more often than at the end of long shutdowns. Mario replied that the tests are performed internally for each YETS.

Daniel asked what will happen if a sensor consistently provides unphysical readouts. In the past the sensor would be disconnected, with the new system the value is effectively masked by the algorithm. In addition, Daniel asked what is in place to ensure that this does not happen to multiple sensors of a single collimator at the same time. Mario replied that alarms are received in any case and will be followed-up by the piquet and offline actions will be taken.

Benoit asked a question about the failure modes of the probes. Two failure modes are present, especially for the TDIS. One is the case where the readout becomes and remains invalid. The other mode is the case where the probe catches the EM field from the beam and the readout then scales with the beam current. Mario replied that in that case some temperature readings can be blocked during operation. However, this failure mode is similar to the normal heating mechanism of the jaw and will not be filtered out automatically.

Benoit asked if interlocks are present for the crystals. Mario replied that the interlock strategy of the crystal goniometers needs to be reviewed.

TDE N_2 pressure monitoring interlock

A new monitoring has been added to the N_2 pressure monitoring system. A Pirani N_2 pressure gauge has been installed and calibrated. The signal is acquired by electronics and PLCs located in UJ63 and UJ67 with cabling going through patches in UA63 and UA67.

During LS2 it was decided to generate, if needed, SIS interlocks connected to the two LHC TDEs N_2 pressure gauges. The readings have been connected through a PLC that is publishing pressure levels through FESA. The threshold values are stored in the PLC. The device names are the same as those used in Run II:

- VGMA.689462.B (B1, in UD68)
- VGMA.629462.R (B2, in UD62)

This infrastructure is ready to be connected to the BIS if required in the future.
All the data is logged in NXCALS at 1 Hz. In addition, acquisition points starting 180s prior to the dump event are logged in the Postmortem.

Jorg commented that the thresholds are not decided by OP but by the MPP.

Jorg proposed the following:

- A threshold is set in the PLC through FESA;
- The comparison between the measured value and the threshold is performed in the PLC;
- Instead of only publishing the so-called "beam permit", the actual value and the two thresholds (lower and upper limit) are also published.

Mario replied that this can be done.

Jorg commented about the risk of the pressure drifting and getting close to the thresholds without being noticed earlier on. Jorg proposed to implement an alarm in "Big Sister" based on the published data.

Chiara commented that pTDE pressure is also checked in the XPOC of the LBDS.

Daniel added that the thresholds (stored in the PLC) should be coherent with the values set in XPOC. Jorg asked if the limits in XPOC are hardcoded. Chiara replied that they are set independently.

Daniel asked if the thresholds can also be added to the Postmortem. Mario replied that the limits are anyway stored in NXCALS. Daniel agreed that this is sufficient.

Michi asked if the XPOC limit should in fact be tighter than the interlock limit so that it provides an early warning (through the latching). Jan commented that this is a good proposal. Chiara agreed as well. Jorg added that this can be added to "Big Sister" as well.

Chiara commented that there is no immediate risk for the dump, if the pressure drops below the threshold, as ignition can be excluded. Daniel agreed, but pointed out, that an injection inhibition in case the pressure in the beam dump drops below the lower limit will trigger a follow-up action to identify the reason of the pressure drop.

Daniel summarized that a SIS interlock (injection inhibit) on the TDE N2 pressure will be introduced (as in the past): the thresholds will be set in the PLC and the PLC will publish the interlock signal to the SIS as well as the measured pressure value and the upper and lower limits.

Actions:

- Implement the publication through FESA of the additional signals (threshold values and measured value) and update the EDMS document (Mario)

Status of MPS re-commissioning checklist (C. Hernalsteens)

Cédric presented that status of the MPS checklist for the 2022 re-commissioning, as implemented in the checklist tool. The checklist for the machine protection systems is available here.

For the 2021 beam tests, the re-commissioning procedures for the MPS systems had been migrated to the tool. Due to the limited intensity, numerous tests were not required and had been disabled.
For the 2022 recommissioning, the checklist has been updated with the latest version of the procedures (in particular for the injection protection system and for the LBDS). In addition, a new functionality added to the tool allowed to perform a partial reset including only the MPS checklist. This has been performed, so that all tests required for 2022 are now in a “to-do” state. In case some tests do not need to be performed again, they must be individually disabled with a comment from the expert.

The new partial reset can be used for specific procedures or even for individual tests at specific times during the run (following YETS, TS, etc.) as needed.

Christophe Martin asked what must be done for tests that do not need to be performed again. It was agreed that in this case the system expert marks the test as passed (green) with the comment that the previous test is still valid. The full test history (including the results of prior iterations of the test) will remain visible and accessible.

Update of machine-protection checklists for intensity ramp-up and cruise (C. Wiesner)

Christoph reported on the update of the machine-protection checklists for intensity ramp-up, cruise and scrubbing.

Four machine protection checklists are in place:

1. the commissioning checklist (see previous section)
2. the checklists for intensity ramp-up: based on stepwise increase of stored energy and number of injected bunches. For each intensity step, monitoring is performed for at least 3 fills and a total of 20h of stable beam, the machine protection systems are verified via the checklist
3. the checklists for scrubbing: an intermediate scrubbing checklist is done after an intensity increase to around 300 bunches, a final checklist is performed at the end of scrubbing
4. the checklist for intensity cruise: it is issued every 8 weeks (e.g., between TS) to check the behavior of machine protection systems.

Checklists 2, 3 and 4 use the same template. The final checklists are documented in EDMS in the rMPP tree.

The template includes an overview of the checklist period, including the bunch filling pattern, the fill numbers, the issues encountered, main beam parameters, MPS dump case and MPS expert comments. The template also contains statistics on the dump causes.

Christoph presented the list of responsible persons for each system covered by the checklist (the e-group lhc-intensity-checklist@cern.ch is used for that purpose).

The changes to the checklist were shown for each system. Potential changes for the collimation checklist in view of ion operation can be discussed later in the year.

In practice, shared Excel files will be used for the checklist validation in 2022, as for Run II.

Daniel thanked all the people involved in the review of the checklist tasks and summarized that the new checklist template is ready to be used.

AOBs

Issue with negative reading from BCT (S. Jackson, T. Levens)

Steven summarized the issue of corrupted data provided by the BCT system to the SMP. The headers were corrupted to the point that even the source identifier was unrecognizable.

During LS2, the FESA class was re-engineered. The BCT background reading, which drifts over time is corrected by a calibration offset. The calibration code was missing in the new FESA class, allowing negative readings in case the previous calibration offset became too large for the actual readings.

To mitigate the issue, the calibration code was re-implemented in FESA and a new sequencer task created, which is triggered before each fill. In addition, the value is clamped to zero to avoid negative readings.

As consequence of the mitigation, the system effectively hides negative values from the BCT and the negative values should not be seen if the sequencer executes the calibration code before each fill.

BIS channel disabling proposal for checkout (S23 and LHCb access) (J. Wenninger)

A large fraction of week 13 is dedicated to MP checkout tests for injection and LBDS. The local BIS loop in point 6 will be disconnected in week 12 and the LBDS will be put back on the nominal loop.

Unfortunately, some non-maskable inputs to the BIS loops will be false for some fraction of the time during the tests. This includes the access to the LHCb cavern, the training and powering tests in S23, the dump line vacuum (due to the window intervention) and the IP8 vacuum.

It is proposed to disable these channels during week 12 and to restore them in nominal configuration during week 14.

The access system has one direct input into the CCC BICs, but some additional indirect effect through un-maskable inputs to the BIS. The tests of the chain are performed by BE-OP-LHC for the BE DSO tests at every restart. The machine is in injection configuration and the LASS is then moved to access mode. The last test has been performed in October 2021 for the beam tests.

The complete list of BIS channels to disable includes those required by the LHCb access, the training of S23 and the dump line vacuum intervention. The signals are from points 2, 3, 6, 7 and 8 (see slides).

C. Martin commented that currently the LHCb velo input is masked on the user side (providing a beam permit of TRUE). So, the channel would not need to be masked at the CIBU level. Jorg clarified that the LHCb vacuum channel is the one that needs to be masked.

C. Martin added that a discussion needs to take place before the restart to decide if the LHCb velo channel is kept or masked for the startup.

Regarding Injection BIC, Jorg proposed to remove the input of the second BIC (experiment) into the first "master" BIC and to remove the input from the BIS loop to decouple injection and LBDS tests.

David N. commented that there are many channels that would be deactivated and asked what percentage that represents. Jorg replied that a total of 30 channels would be disable over a total of around 200 channels. Jorg and Daniel clarified that all channels will be tested, they are only disabled to allow for other tests to take place. The BIS ISTs will be performed by C. Martin once the channels are put back in place.

Jorg added that the sanity checks of the BIS will remain untouched, which means that the BIS will correctly report that some channels are deactivated.

Daniel requested that C. Martin informs the MPP of the list of channels that are disabled and then informs the MPP once the channels are enabled.

Action: Provide the list of disabled BIS channels to the MPP and inform the MPP once the channels are enabled again (C. Martin).

ALICE solenoid ramp down at 6.8 TeV in stable beams (J. Wenninger)

ALICE has a special request to have three fills where the spectrometer polarity will be changed (positive, negative, and off) including a ramp-down of the solenoid performed during the fill at top energy and in stable beams conditions.

The solenoid generated a very small coupling on the beam. In the presence of an orbit bump at the IP, the solenoid couples part of each bump into the other plan as an open closed-orbit oscillation over the entire ring. At injection the effect is by far largest due to the large internal crossing angle and larger solenoid impact due to the low energy. This contribution scales with the inverse beam energy squared. The external bumps scale inversely with the first power of the energy.

A measurement performed in 2015 showed that the orbit change during the ramp of the ALICE solenoid from 0 to 30kA for positive polarity and an external crossing bump of -170 µrad was of 0.2 mm rms.

In comparison to that case, the ALICE request involves a change to go down to half the maximum field only without separation bump (as the beams will be in collision). Therefore, the impact is expected to be at the level of 10 µm rms. Such an orbit change does not present a problem as the natural orbit drifts are larger. In addition, a test ramp down can be performed at the end of one of the commissioning fills.

Another aspect of the request is to perform the field ramp-down in stable beams, without transitioning to “adjust”. The beams would be separated to have ~ 0 luminosity, ramp down the magnet from 30 kA to 12 kA, then bring the beams back in collision.

Jorg commented that based on these considerations, there is no obstacle from the OP side to accommodate the request. The procedure should be tested during the commissioning at the end of a fill.

Daniel asked if it tests could be done with 3 bunches for each polarity, prior to performing the procedure with 75 bunches. Jorg confirmed and agreed.

MPP agrees to the proposed approach.

New SIS and BIS state publications (J. Wenninger)

Jorg presented new functionalities regarding the SIS and BIS data publication.

The LHC SIS injection and ring tree details are now available over CMW through 6 devices (LHC.SIS.RING_B1, LHC.SIS.RING_B2, LHC.SIS.RING_B1B2, LHC.SIS.INJ_B1, LHC.SIS.INJ_B2, LHC.SIS.INJ_B1B2). This is based on a developed done for the SPS. The final tuning is in progress and NXCALS logging of the device data will be activated soon.

Based on the published data, new simple web displays based on WRAP have been prepared, one for the SIS ring trees and one for the SIS injection trees. A similar display will be put in place for “Big Sister” to back up the audio messages.

Since 2006, the BIS monitor application has been used to analyze coherently the state of all inputs contributing to a BIS configuration: analysis of fast pulsing BIS inputs and list of FALSE BIC inputs, masks, etc. All deployed BIS configurations are covered.

A first of UCAP transformations have been setup to concentrate the BIC data corresponding to one of the BIS configurations. The concentrated data is published and processed by a second set of UCAP transformations that provide the same decoding than the BIS monitor application. The results are published over RDA3.

In the coming weeks, the devices will be moved from a test node to a production node. The NXCALS logging at 1 Hz will also be activated.

This fully decoded and logically grouped interlock data enables the automation of interlock tests, the construction of displays grouping SIS, BIS, external conditions, and the easy extraction of the history of interlocking channels (NXCALS).

Test of the LHCb spectrometer interlock (J. Wenninger)

After LS it is verified that the BIC input for the LHCb magnet interlock transitions to FALSE well before any current decay in the circuit.

The test has been performed only up to 1 kA (nominal current is 6.5 kA), fearing damage on the magnet. The test results are good, no current change was observed at the time of BIS input transition from TRUE to FALSE. The interlock was generated through the power converter and by the magnet interlock system.

It was requested by LHCb that the test at nominal current is skipped and that the test result at low current is considered valid at higher currents as well to avoid any unnecessary stresses on the magnet.

Jan commented that in case the power converter is tripped at higher current, then the current will decay faster (higher di/dt). David agreed. Jorg added that the magnet trips a few times per year in any case.

L. Roy commented that testing at lower current should not change the timing at all. David replied that this would be correct for the interlock timings but that the test also involves the initial di/dt.

Daniel asked if the fear of damage is justified as the test is only performed at the end of long shutdowns.

David suggested to review, revise, and approve the test procedure in detail.

Jorg suggested to use a natural occurrence of a fast abort as a test.

Daniel concluded that the discussion should continue offline.

Action:

- Analyze the changes to be made in the test procedure and study the consequences (L. Roy, MPP team)

Summary of actions

The actions from the meeting are:

- TDE N_2 pressure monitoring interlock:
    1. Implement the publication through FESA of the additional signals (threshold values and measured value) and update the EDMS document (Mario)
- BIS channel disabling proposal for checkout (S23 and LHCb access) (J. Wenninger)
    1. Provide the list of disabled BIS channels to the MPP and inform the MPP once the channels are enabled again (C. Martin)
- Test of the LHCb spectrometer interlock:
    2. Analyze the changes to be made in the test procedure and study the consequences (L. Roy, MPP team)