# 243rd Meeting of the Machine Protection Panel

## LHC topics

March 1st, 2024, via Zoom

*Participants*:

*F. Alessio (EP-LBC), C. Bernius (EP-UAT), E. Bravin (BE-CEM), A. Butterworth (SY-RF), V. Coco (EP-LBD), C. Hernalsteens (TE-MPE), D. Lazic (EP-UCM), A. Lechner (SY-STI), B. Lindstrom (BE-ABP), D. Mirarchi (BE-OP), A. Radeva Poncet (BE-CSS), M. Solfaroli Camillocci (BE-OP), M. Trzebinski (EP-UAT), F. Van Der Veken (BE-ABP), J. Wenninger (BE-OP), C. Wiesner (TE-MPE), D. Wollmann (TE-MPE), C. Zamantzas (SY-BI).*

The slides of all presentations can be found on the website of the Machine Protection Panel and on Indico (243rd meeting).

## Minutes and actions from the 242nd meeting

The minutes of the previous MPP meeting have been distributed. Daniel recalled the actions and discussions from the last MPP meeting. Regarding the BIS v2 design implications on the LBDS, it has been clarified that the TSU renovation will proceed. In addition, reliability studies in collaboration between MPE and ABT have been initiated. The ECR on the IC BLM installations in IR7 has been approved by the LMC.

## MPS re-commissioning checklists (C. Hernalsteens)

Cedric presented the status of the LHC MPS commissioning checklists. The checklists were created prior to the 2021 commissioning based on the commissioning procedures of the MPS systems. The status of each test has been reset following the 2023-2024 YETS and the checklists are ready to be used for the commissioning in 2024. The history of past test iterations is preserved in visible in the online tool.

No major change has been implemented in 2024. Regarding the BBWC checklist, as all wires are now available the tests have been re-activated for all wires. The BCCM commissioning procedure has been revised and the checklist will be updated accordingly (see presentation at the 244th MPP). The LBDS checklist has been updated for the tests related to the LBDS test mode (see presentation at the 244th MPP meeting). The tests related to the blindable BLM functionality has been activated in the injection and BLM checklists.

The filling of the checklists by system experts is on-going.

Christoph W. commented that the test of the complete interlock chain following a power abort on one BBWC is still pending. Indeed, the Beam 1 wire in IR1 was not tested in that way. This test is foreseen for this year.

## 2024 machine revalidation strategy

### Collimation settings strategy and updated loss maps matrix (F. Van der Veken)

Frederik summarized the cycle changes for 2024 and presented the foreseen collimator settings. Specific consideration must be taken for the TCT in IP1 and for the TCL6 in IP1.

The TCL6 opening strongly influences the background for FASER. The proposal is to perform the commissioning with the TCL6 at the tightest possible gap, for which the best estimate is 14.5 sigma. This corresponds to 1.43mm at β*=93 cm and 1.23mm at β*=68cm. These settings could then be adjusted based on the measured background to FASER, either using gap levelling or relaxing the minimum setting of 14.5 sigma.

With the new RP optics an aperture bottleneck is expected in the D1, with the bottleneck in IR1 going down from 9.66 sigma to 9.09 sigma. Respecting a 1 sigma retraction for the TCT, this would mean that that the TCT in IR1 would be set to 8 sigma.

Frederik then presented the validation loss maps matrix. A difference compared to the previous years is to drop the "XRP OUT" loss maps. The only difference is the TCL5 closing, and it would save a fill. An extra loss map would be needed if the wires are used at 30 cm. The proposal foresees to perform the loss maps in two phases: every other matched point in the first phase while the remaining matched point would be performed in a second phase. A total of 7 (+2) fills would be needed.

#### Discussion on the TCL settings

Jorg commented that the most likely scenario is to start the levelling at β*=93cm. The gap would then be kept constant with levelling at 1.43 mm. Frederik highlighted that the background source and magnitude is not known at this stage. Daniele commented that the beam size at the TCL6 is very small and mentioned that the 400 µm margin to the interlock limits around the set gap might need to be reduced (in discussion with experts).

Maciej commented that it would be beneficial from a physics point of view to have the TCL4 and TCL5 more open, ideally to 20.6 and 44.8 sigma or more. This would increase the off-momentum acceptance for ARP. Frederik replied that there is a concern for the dose to the QPS in that area. Daniel suggested that this requires a cross checked with the FLUKA team.

**Action**: Verify with the FLUKA team if the TCL4-5 could be further open to benefit ARP (F. Van der Veken).

Daniel asked about the impact of changing the TCL6 settings if the proposal turns out to be not acceptable for the background to FASER. Frederik replied that the loss maps would need to be performed again at 60 and 30 cm.

### Discussion on the TCT settings

Daniel asked about the consequences in case the TCT must be closed down to 8 sigma. Frederik replied that the secondaries would probably need to be closed further.

### Discussion on the validation loss maps

The MPP endorses the proposal of not performing the XRP OUT loss maps and the proposal of performing the loss maps in two phases.

### Discussion

Christoph commented on the possible use of the wires. In the past the test with beam of the complete interlock chain following a fast abord was only performed for 3 out of the 4 wires. This would need to be performed for the last remaining wire and possibly revisited for all wires as the tune compensation strategy is changed with the RP optics (Q4 off).

## Phase advance and aperture margin between IR6 and IR5 TCT

Cédric summarizes the objective the method which was tested in MD and during the 2023 run. The method uses a closed orbit bump extending from IR6 to IR5 (for beam 2) as a mean to provide information on the correct phase advance between the TCDQ/TCSP and the horizontal TCT in IR5. This eventually validates the correct protection of the TCT from direct impact in case of an asynchronous beam dump.

The method was tested in an MD in 2022 (MD #2186) where the method was tested and validated for the nominal optics and for a purposedly detuned optics. The collimator BPM readings provided direct information on the IR5 TCT retraction margin for beam 2. The measurements were also performed at all luminosity levelling steps from 120cm to 30cm during the 2023 commissioning. The optics measurements were confirmed. This dataset served as reference for the post-TS1 measurements in 2023.

The proposal for the 2024 commissioning is as follows. The bump knob coefficient are computed for all optics matched point of the new optics. The procedure, using a pilot bunch will be identical to the one used in 2023 and will be implemented in the sequencer. For a given matched point, the orbit feedback is switched off. The bump amplitude is increased to 1.5 sigma at the TCSP (in steps of 0.3 sigma). The BPM measurements provide information on the bump closure. The collimators DOROS BPMs at the TCSP.A4L6.B2 and TCTPH.4R5.B2 are used to read the bumped-orbit amplitude. The bump is collapsed, and the orbit feedback is then switched off. The sequencer proceeds to the next matched point. The data analysis is performed offline.

No objection was raised, and the proposal will be included in the scheduled, in parallel to the validation loss maps.

## SIS tests in UCAP for TDIS and TCDIL interlocks, bunch length interlock and SIS v2 (J. Wenninger)

Jorg first summarized the situation regarding the interlocks on TCDILs and TDIS. Since Run I discussions took place for a redundant interlock on TCDI collimators to avoid inconsistencies following changes of the SPS optics (from Q26 to Q20 or vice-versa). It happened that the collimators gaps were left at the Q26 settings while the SPS ran with Q20.

The idea was to re-use the beta* gap interlock concept of the ring collimators, and the transfer line "Optics ID" was added to the telegram (similarly to the beta* information for the ring collimators). The optics ID is provided by the LHC SIS and is then checked after every SPS pulse using the TL quadrupole currents. This was never implemented.

This idea is now implemented in software form, as a test for SIS interlocks using UCAP. The code tests the gap against the SIS reference in LSA, with the reference settings being attached to a beam process, which allow to have different settings for protons and for ions. This concept happens to also fit the needs for the TDIS. The TDIS gap interlock in SIS was therefore modified for improved flexibility. In addition, each UCAP transformation also published all input value, the Boolean result and text messages regarding the interlock status.

For the 2024 run the TCDIL tests will become operational and the new TDIS tests (which were in testing mode in 2023) will replace the old ones.

In 2024, the SIS tests on the injection buckets and SPS beam intensity were converted to UCAP and will run in a similar way.

Jorg presented a list of pro's and con's regarding the rewrite of SIS JAVA tests to UCAP. It was concluded that it is still too early to proceed with a massive conversion from SIS JAVA to UCAP.

A bunch length interlock exists in SIS. It is only active during the ramp and has a threshold set at 0.8 ns (when the number of bunches is larger than 500), using 15 s averages. Given the issue with the warm vacuum modules, it is proposed to increase the threshold 1.05 ns in 2024 (for more than 300 bunches). This proposal is compatible with the observed bunch length in 2023 (see Figure 1).

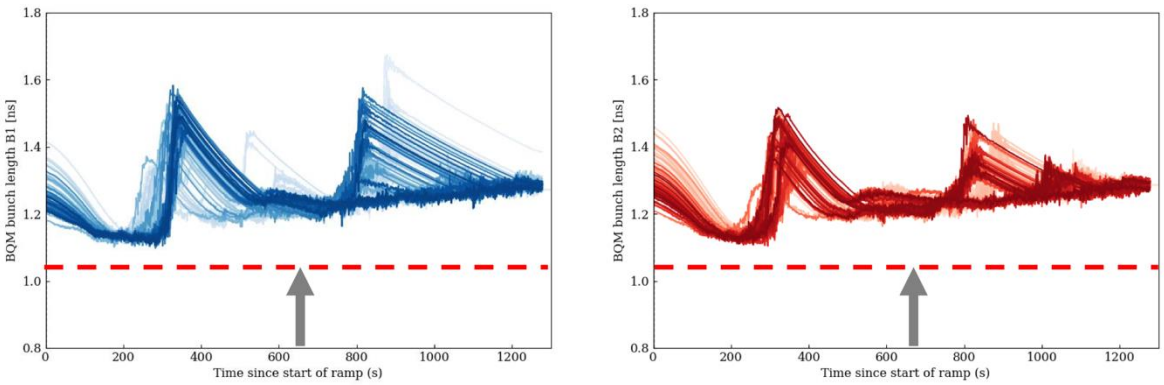


*Figure 1 Bunch lenght during the ramp (2023 data).*

In addition, the SIS interlock could be extended to stable beams. Figure 2 present the bunch length data for 2023 fills. The automated blow-up trigger process (implemented in UCAP) is very effective.

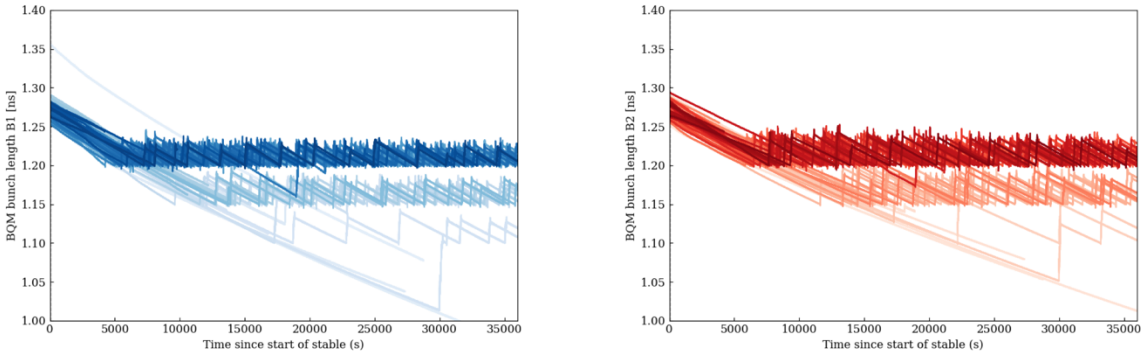


*Figure 2 Bunch length in stable beams (2023 data - Minimum 200 bunches).*

Jorg then outlined on-going SIS v2 discussions. BE-CSS is working on a first prototype for the injectors which would be testable in 2024, in parallel to the existing system. After OP discussions, it was agreed that the UCAP deserves more development, especially for administration and monitor tools. In addition, CSS-OP team with representatives from all machines will work on requirements and implementation of SIS V2.

## Summary of actions

To be added before final release.

- 2024 machine revalidation strategy
    - Collimation settings strategy and updated loss maps matrix
        1. **Action**: Verify with the FLUKA team if the TCL4-5 could be further open to benefit ARP (F. Van der Veken).