

# 246<sup>th</sup> Meeting of the Machine Protection Panel

## LHC topics

April 5<sup>th</sup>, 2024, on 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 \(246<sup>th</sup> meeting\)](#).

## Minutes and actions from the 245<sup>th</sup> meeting

The minutes of the previous meeting have been distributed; Daniel recalled the actions. Two actions were completed. The LSA threshold value for the new SPS bunch intensity interlock has already been made MCS. Christoph and Victor implemented the VeLo checks in the intensity ramp-up checklist.

## BBWC commissioning and operation for 2024 (G. Sterbini)

Guido first summarized the presently installed hardware. Four wires are installed in the LHC since 2017. The wires are one-meter-long Cu and carry a nominal current of 350 A. The wires have been used in physics fills in Run 3 since 2022. The tune compensation in 2022 and 2023 was based on a feedforward on the Q4 quadrupoles. In 2022, following the failure of one B1 and one B2 wires, a consolidation study was launched. The B2 wires were repaired during the EYETS 22-23 and has been used in 2023 physics fills (on B2 only). The B1 wires was repaired during the YET23-24. All wires are available for physics fills in 2024. The proposal for the 2024 run is to use the wires at the end of the fills at  $b^* = 30$  cm.

Following the decision of deploying the Reversed Polarity (RP) optics in 2024, the IR1 Q4s were locked-out. The tune feedforward knob now uses matching (of all Twiss parameters) using 9 quadrupoles (Q5 to Q13 for IR1, Q4 to Q13 (skipping Q6) for IR5). The new knob is tele-index independent and acts locally. It does not affect the transport matrix from the IP to the Roman Pots which is beneficial for the experiments. The orbit feedback is expected to correct for the orbit drift induced by the correction (as Q4-5 are in the crossing bumps).

The polarity of the wires was successfully tested on March 17. All the WICs of the 4 BBWC were tested on March 26. The WIC behaved as expected while simulating an overheating of the wires. The 5<sup>th</sup> axis alignment of the collimators was performed to center the wires on the beams on March 30 (once the “Golden Orbit” was established). The final values were deployed on April 3.

The full interlock chain was tested with beam. The TCTPH.4L5.B1 was tested in fill 9456 (April 3) and the TCTPV.4R1.B2 was tested during fill 9461 (April 4).

The loss maps with wires switched on are still to be analyzed. The optics measurements with the wires powered are scheduled.

## **Discussion**

Daniel asked about the orbit effect of the tune feedforward, has it been observed and is the orbit feedback fast enough to correct for it. Guido replied that the trim of the wire current (and feedforward) is very slow, and the orbit feedback has enough time to compensate. In case of a failure of the wire no orbit shift is expected as there is no dipolar component.

Christoph commented on the tests of the interlock chain with beam. Christoph reported on the analysis of the post-mortem data. The tests are successful and conclusive.

Daniel asked about the residual tune shift that has been seen with beam. Guido commented that the tune shift shown ( $3e-3$  B2) is a bit larger than expected ( $2e-2$  for the wire tune shift). Investigations are on-going. Guido explained that the wires have a strong octupolar effect which changes the beam transverse spectrum which can lead to systematic error on the tune measurements. Matteo added that the change is not so small in absolute value and that the source is not fully clear as the optics measurements could not yet be performed. Matteo proposed to investigate and proceed with physics fills without powering the wires. Daniel agreed that the effect should be better understood. The wires could be used later in the intensity ramp-up. Matteo also mentioned that we could wait for TS1 and start using the wires during the ramp-up following TS1.

Jan asked what would be needed to gain a better understanding. Matteo replied that the optics measurement could be performed next week. Daniel added that we need to conclude before the 400b step if we want to use it before TS1. Guido added that the systematic effect on the tune measurement due to the nonlinearities induced by the wires should be assessed.

Daniel asked if anything can be learned by using the wires on the first ramp-up steps (3-12 bunches). Matteo replied that not much would be seen before the 75 bunch fill.

Daniel concluded that the wire will not be used for the start of the ramp-up. The optics measurements should be scheduled, and the situation will be re-assessed afterwards.

## Readiness for first Stable Beams

### ALFA/AFP (M. Trzebinski)

The AFP beam-based alignment was performed on April 3 and 4. The pots are kept at the same distance in mm for all the  $b^*$  steps. No obvious issue was spotted during the loss maps. No issue was observed with the pot moment during beam-beam alignment.

### Beam Loss Monitor system (B. Salvachua, M. Sacconi)

In IR7 new BLMs were installed at transversally displaced positions and new BLMs were installed on the tunnel wall on the inner side of the machine. The loss maps were finalized yesterday and must be looked at to evaluate the monitor factors for these new BLMs. It is proposed to switch the interlocking BLMs from the original BLMs to the new “Wall BLMs”. This will be followed up next week.

Mathieu added that the sanity check issue observed by OP has been fixed.

The system is ready for first stable beams.

### BIS (I. Romera)

No change was performed on the LHC BIS during the EYETS 23-24. All MPS tests were successfully completed. The IPOC performed after every beam dump did not reveal any non-conformity. To be noted that the user interlock verification is missing for the RF, BCCM, BPM and crystals. Daniel commented that the main ones are RF and BPM. Matteo added that this has been performed.

### SMP (I. Romera)

The system is ready for first stable beams. The commissioning of the SBF equations is on-going.

### PIC (I. Romera)

The RQ4.L1 and RQ4.R1 circuits were removed from the PIC configuration. All interlocks have been tested.

### WIC (I. Romera)

The system is ready for first stable beams. Tests were performed using the new automated test sequence for the first time (later to be integrated in ACC\_TESTING).

### FMCM (I. Romera)

No change to the FMCM during EYETS. All FMCMs successfully tested with no beam. The test with beam on RD1.LR1 at flat-top needs to be repeated due to an incorrect command sent

to the power converted (which triggered the WIC first, before the FMCM). The test on RD1.LR5 is also pending. Matteo commented that this will be scheduled. Daniel and Jan commented that this can be done as an end-of-fill test (in Adjust) with up to 75 bunches.

#### Injection & LBDS (Y. Dutheil)

Injection protection tests are all done. Some BLM thresholds must be adjusted during the intensity ramp-up. The commissioning of the blindable BLM should still be done.

The abort gap cleaning is not yet commissioned. Daniel asked if this is critical. Yann replied that this is not critical at the moment. Matteo agreed and will add it to the schedule.

#### Collimation (F. Van der Veken, D. Mirarchi)

The background for FASER doubled with respect to last year. It does not appear to be influenced by the TCL6 opening. The TCL6 opening is now constant at 1.62mm during the beta\* levelling. The TCL4 and TCL5 are more open in IP1 to accommodate AFP.

The aperture bottleneck of 9 sigma at the D1 in IR1 is confirmed. The TCTs close to 8.3 instead of 8.5 sigma (vertical only) and the crossing angle reduced to 150 urad at the last levelling step. The secondary collimators were not adjusted following the adjustment of the TCT to a smaller gap.

The loss maps are not yet fully analysed. Final results obtained after the meeting confirmed that the loss maps were valid. The collimation system was ready for first stable beam.

Christoph commented that the dump losses are higher in 10L6 than in the previous years. Frederik commented that the analysis of the asynchronous beam dump loss maps show the TCSP losses at similar levels compared to last year. Chirara and Yann commented that the AGK is not yet commissioned. Christoph commented that the AG values are anyway very low.

#### Vacuum system (G. Pigny)

The checklist is completed.

#### TOTEM/CT-PPS (M. Deile)

The alignment was completed on April 3-4. If the loss maps are validated, the system is ready for stable beams.

The pot XRPV.B6L5.B2 showed a resolver problem but it is not used in operation.

#### SIS (J. Wenninger)

SIS is operational, the new interlocks on TDIS and TCDIL gaps are tested and in operation.

The bunch length interlock for the ramp was revisited. The logic was moved to UCAP with one device per beam. A new LSA critical setting was introduced for the minimum bunch length

and bunch number threshold below which the interlock does not act. This interlock is only applied by SIS if in beam mode RAMP. The logic could be made more complex later during the run if required.

During the MPS test for LBDS the rf frequency interlock did not work. The root cause was an incorrect configuration of a rf FESA class. Once correctly configured the rf frequency interlock worked as expected.

Daniel asked if the SIS interlock on the PM and the QPS\_OK have been unmasked. Matteo confirmed.

RF (A. Butterworth)

Everything is fine.

ADT (A. Butterworth)

Currently working on the setup for the 12 b trains.

Conclusion

Daniel concluded that pending the final validation of the loss maps, the systems are ready for the first stable beams at flat-top without the BBCW.

BETS TCDQ upgrade (C. Bracco)

Chiara presented the ECR regarding the TCDQ BETS upgrade.

Currently the TCDQ closes during the energy ramp to follow the adiabatic reduction of the beam size with energy. The optics at the TCDQ remains constant during the squeeze in IR5 and therefore the TCDQ position does not change once at flat top.

The TCDQ control system consists of two separate functional units based on independent PLCs: the motor drive and control (MDC) and the position readout and survey (PRS). The MDC controls the positioning system and its protection logic. The PRS surveys the relative position of the jaw compared to the interlock limits (managed as MCS settings). It requests a beam dump via the BIS in case of an incorrect position.

The interlocking logic is completely equivalent to the one applied to the collimators. An additional fully independent verification of the position against the beam energy is performed by the Beam Energy Tracking System (BETS) using an additional potentiometer. It prevents any movement of the jaw outside thresholds at fixed energy.

For HL-LHC it becomes challenging to keep the beta-function at the TCDQ constant for all optics and squeeze scenarios. The TCDQ would have to move at top energy which is incompatible with the present BETS.

The BETS will be upgraded during LS3 in order to receive from the SMP the beta values as calculated by the BIS. It was agreed with experts that the use of the beta-value signal transmitted by the SMP fulfils the safety level required by the BETS. The SIS could also provide the beta values to the SMP via two separate processes on separate boards. The logic will then be modified to ensure compatibility of the change of the TCDQ position with beta\* in IP5 at fixed energy.

The movement of the TCDQ during levelling could then be orchestrated by the levelling tool as implemented already for the TCTs.

In addition, the new BETS should also be able to load different sets of thresholds for different machine cycles (ions, Van der Meer, etc.). One fixed position and one offset position that would be applied for the proton physics optics. The final position and thresholds can be given by the sum of the position plus the offset from the two tables (first option). A second option would be to provide, via the SMP, the horizontal beta value at the TCDQ with the relative fixed offset. This is the preferred option, the feasibility to calculate and the beta value at the TCDQ must be assessed.

## Summary of actions

No action was identified during the meeting.