251st Meeting of the Machine Protection Panel

LHC topics

May 31st, 2024.

Participants:

Catrin Bernius (EP-UAT), Andy Butterworth (SY-RF), Yann Dutheil (SY-ABT), Luca Gentini (EN-MME), Cedric Hernalsteens (TE-MPE), Anton Lechner (SY-STI), Jan Uythoven (TE_MPE), Anastasiya Radeva Poncet (BE-CSS), Stefano Redaelli (BE-ABP), Adriana Rossi (SY-BI), Mathieu Saccani (SY-BI), Matteo Solfaroli (BE-OP), Christoph Wiesner (TE-MPE), Daniel Wollmann (TE-MPE).

The slides of all presentations can be found on the website of the Machine Protection Panel and on Indico (251st meeting).

Minutes and actions from the previous meetings

The minutes from the last two joint meetings with LBOC and Collimation Working Group are now on the MPP Indico page.

Procedure in case of sparking RF fingers (D. Wollmann)

End of May 2023 beam losses were observed at the triplet on the left side of IP1. These losses led to beam abort during the ramp. The losses were traced back to vacuum pressure spikes in the warm vacuum modules in cell 4 L1, caused by sparking rf fingers following a damage of the spring in a VMBG type vacuum module. The module was replaced, and operation continued with bunch intensities limited to 1.6e11 ppb.

The following observations were made during the EYETS:
- 8 warm vacuum modules of the VMBE showed degradations of springs and rf fingers;
- 3 warm vacuum modules with elliptical shape (VMCK, total of 24 units) in the recombination areas of IR1 and IR5 had developed defects of springs.

It was decided to prepare a procedure in case of sparking rf fingers and to monitor and limit beam intensity and bunch length. The procedure is detailed in the slides.

The proposed procedure is endorsed by the MPP. The procedure approval will be started on EDMS.

Action: ~~Start the approval of the sparking rf fingers procedure on EDMS (D. Wollmann)~~. *The procedure is now approved and released.*

Planned adjustment of the temperature interlock of the BBCW (A. Rossi)

The temperature interlock on one of the wire demonstrator triggered beam dumps earlier in 2024. Since then the operation has been limited at 90% of the nominal current (315 A instead of 350 A)

The interlock threshold is based on a voltage measurement across the wire (based on the temperature dependent resistance of the wire). Temperature measurements have been performed in a test setup in vacuum, without the wire being cooled by the collimator jaw cooling.

If the wire voltage exceeds 2.6 V then the hottest point will remain below 200 C for a current of 300 A. 2.7 V has been chosen as the threshold in the interlock box, which, when reaching this limit, will trigger a beam dump via the WIC. No test was performed at 350 A, however the voltage would be higher (due to the higher current) and this would induce more margin.

Daniel asked if the repaired part (connector) is within the voltage measurement probes. Adriana confirmed.

Federico suggested that the replaced connector is not tight enough and causes the overheating.

During the tests performed on April 4 the jaw temperature did not exceed 31C. During the test one of the wire went to higher voltage (offset). The tests did not show a temperature runaway.

Daniel mentioned that his worry is to have a failure case during machine shutdown with the cooling being switched off.

The reparation is proposed for TS1 when the connection will be tightened. After the repair, the tests will be repeated at 350 A over one hour with external temperature measurements via a thermal camera.

Discussion

Christoph asked why no direct temperature probe is installed. Marek commented that a temperature probe is anyway also a voltage measurement. Jan commented that this would however make the measurement independent on the current at which the wire is run.
Daniel concluded that the MPP agrees that there are no issue running with the thresholds set at 350 A as proposed. The fixes can be performed during the next TS. The wire should not be run below 300 A.

First experience of BCCM operation (M. Gasior, T. Levens)

Marek first provided a global overview of the system. The BCCM features extensive analogue processing to make the signals as “slow” as possible, which has multiple implications (see below). The BCCM BIS inputs have been activated on April 8.

A first BCCM dump occurred on May 9. Marek provided details on the PM data related to the May 9 event. The bunch length dependency is clearly visible. The turn-by-turn intensity logging is available in NXCALS. In the Post-Mortem, a summary of the flags and running sum status is available. NXCALS also received the logging of the turn-by-turn dump flags.

A second BCCM dump occurred on May 22. In this case the dump was caused by running sum 5 . The dump was caused by an RF trip, which caused debunching of the beams. The BCCM reaction was faster than the RF interlock.

Marek then detailed three identified weaknesses of the system.

Weakness 1 - Sensitivity to the bunch length (oscillations)

Marek show an example at the beginning of the ramp where the longitudinal blowup is visible. The change has an amplitude of 2.5e11 for an intensity of 3900e11, ie . 0.06% Which is a very small imperfection for an analogue signal processing. Marek recalled that the beam signals are taken from BPMs which are in first order high pass systems.

However, after LS3 the BCCM will have dedicated BPMs resulting in large beam signals which may allow extending the system bandwidth with flat frequency response. The wider flat response may reduce the bunch length sensitivity.

On running sum 4 (the worst) this might go to 60% of the threshold. (64 turns window). The other RS do not exceed 30%.

Weakness 2 - Spurious di/dt signals during injection

During injection, baseline shifts are caused by the signal duty cycle which increases during the filling of the machine. Due to its length, RS 4 is the most sensitive to this effect.

Dedicated settings on the test system C allowed an almost complete reduction of the spurious signals at the expense of very unfavourable settings for small intensities (pilots not seen at all). FPGA code development is on-going to allow more flexible settings.

Weakness 3 - Intensity overestimation for large bunch spacing

This issue is related to the unconventional use of key RF components, mainly an envelope detector chip, which cannot be replaced without deteriorating the performance of the system further.

Development is on-going to use the crucial component in a different way involving much faster sampling. This will also provide a gain in terms of reliability.

Conclusion

Marek conclude that the BCCM system is operational and reliable. Two dumps were triggered this year. Both were induced by de-bunching after an RF trip.

During physics fills the 64-turn window (W4) is typically the closest to the dump trigger level, with the highest values of 60% during the rf longitudinal blowup.

The system has however not undergone a thorough testing with beam. Dedicated beam time is still needed.

The PM automatic analysis module is under discussion.

Action: Prepare specifications for the PM analysis module (C. Hernalsteens, T. Levens, M. Gasior).

Discussion

Matteo commented on the on-going studies and MDs to reduce the effect of the bunch length blow-up during the ramp. Andy commented that no big change should be expected.

Jan congratulated the teams for the excellent performance on the system.

Jan added that the measurements with beam are excellent MD candidates. This could take place at injection.

Daniel commented that the issue with low intensity bunches is not critical as the system is designed to cover cases with high intensity beams.

Summary of actions

- First experience of BCCM operation
    1. Prepare specifications for the PM analysis module (C. Hernalsteens, T. Levens, M. Gasior).