218th Meeting of the Machine Protection Panel

Injector topics

December 17th, 2021, via Zoom

Participants:

G. Bellodi (BE-ABP), A. Butterworth (SY-RF), G.P Di Giovanni (BE-OP), Y. Dutheil (SY-ABT), L. Esposito (SY-STI), V. Kain (BE-OP), J. Lallement (BE-ABP), B. Mikulec (BE-OP), R. Mompo (TE-MPE), F. Moortgat (EP-CMG), D. Nisbet (SY-EPC), M. O'Neil (BE-ABP), M. Saccani (SY-BI), J. Sanchez Alvarez (BE-OP), B. Schofield (BE-ICS), R. Scrivens (BE-ABP), P. Skowronski (BE-OP), J. Uythoven (TE-MPE), D. Wollmann (TE-MPE).

The slides of all presentations can be found on the website of the Machine Protection Panel and on Indico (218rd meeting).

Minutes and actions from the 215th meeting (Injectors topics)

Daniel recalled the action from the 215th meeting. All actions from the 215th meeting have been implemented. The source tests have successfully been performed.

Beam dump matrix modifications of the WIC in the PSB and PSB extraction lines (G.P. Di Giovanni)

During LS2, the WIC for the PSB and for the PSB extraction lines was upgraded as part of the LIU project. The WIC is connected to the BIS. Changes to the WIC and to the configuration were required due to the addition of new power converters (QSTRIPS and multipoles, which need to be interlocked) to be installed during the YETS (see EDMS-2607246). Additionally, the interlocking logic has been reviewed, considering the operational experience. The changes only affect the BIS and not the protection of the magnets ensured by the WIC.

It is proposed (see EDMS-2649462) to disable the WIC "user permit" sent to the BIS for the normal quadrupole converters QNO 311L1, 412L3, 816L1 and 816L3 in the PSB. These were originally included based on the pre-LS2 resonance compensation scheme for the half-integer resonance. Currently, the beam is not injected above the half-integer. If the beam was injected above the half-integer resonance, a large fraction of the beam would be lost. These losses would be equivalent to the levels currently routinely experienced and deemed acceptable. ABP studies indicate that it should be possible to compensate for the loss of these quadrupoles with other magnets to restore an acceptable compensation of the resonance. Also, in the worst-case scenario, it should be possible to provide beam with lower intensity (degraded mode) in the affected ring. To maintain the PSB availability, as this failure mode affects only one ring, the other rings could still be used without blocking the entire proton chain.

The beam loss monitors and the watchdog (both connected to the BIS) also provide an additional layer of protection.

It is proposed to disable the WIC "user permit" signal of the new main power supply POPS-B. The equipment is already protected with a direct connection already existing in the BIS. Additionally, it is also proposed to remove the "user permit" signal from the WIC to the BIC for the old power supply (PSB MPS). It would provide a backup against catastrophic scenarios, e.g., long-term issues with POPS-B. The MPS would then be connected to the BIS as part of the switching procedure (EDMS-2379626). Another layer of protection is then provided by the external condition (timing).

Richard M. commented that the procedure mentions that the BIS connection needs to be performed but no detail is given. David added that work is on-going, and that the procedure will be updated. Richard also explained that the connection to the BIS in the WIC matrix does not allow for swapping between the two power converts. Richard confirmed that it is the same signal going to the WIC and going to the BIS.

The PSB QSTRIP system consists of two chains of electrically isolated windings on the main focusing and defocusing quadrupole magnets for each ring. It provides additional trim on top of the main quadrupole magnets; its purpose is to allow for ring-by-ring adjustment of the tunes. The magnets in sectors 3 and 14 are removed from the chain and powered separately because an additional fast correction for beta-beating compensation is necessary. The beta-beating is induced by the decay of the BI.BSW of the new PSB injection chicane.

The proposal is to disable the WIC "user permit" signal sent to the BIS. It was originally included based on the pre-LS2 operational experience: the PSB would rely on the QSTRIPS to tweak the injection tune to optimize the injection transmission. Currently, with the new tune controller and injection schema, they are powered at very low current.

An MD was carried out to measure the effect of disabling the chains one by one. No significant impact in terms of losses was measured, neither in the ring nor at extraction. Operationally, it was proven that it is possible to run without one of the circuits in sectors 3 or 14 for the fast beta-beating correction, as occurred for 10 days (issue on BR3.QCD03) without major loss of performance.

Daniel asked how it was possible to operate at the time the connected interlocks. This was possible because the power converter was not in fault, but the current dropped to zero due to a circuit problem.

The beam loss monitors connected to the BIS provide an additional layer of protection.

New power converters (EDMS-2607246) will be used to double the number of QSTRIP power converters, to cope with the high induced voltage from POPS-B and ensure a long-term reliability. This will also increase the number of power converters available for multipole magnets. The proposal is to disable the "user permit" signal from the WIC to the BIS, following the same logic as for the existing power converters.

For the correctors installed in the PSB extraction lines (BT, BTM, BTP), the proposal is again, to disable the WIC "user permit" signal to the BIS. Operationally, it should be possible to compensate for a non-working correction with others, and to restore acceptable trajectories. A

few tests have been successfully carried out by the PS team, showing that the PS injection could be recovered.

For the BTP.QN010 quadrupole, installed in the wall between the PSB and the PS, it is proposed to disable the WIC to BIS "user permit" signal. This equipment is difficult to access for repairs and is not used in operation, only for special MDs for optics studies. In this case it is proposed to simply limit the intensity to a single LHC bunch nominal intensity, as done pre-LS2.

Equipment in the recombination line at the extraction of the PSB (bending magnets, septa and kickers) are also affected by the proposal. The kickers are interlocked by the external condition and by the SIS, and operation can continue with less than four rings. In case of a failure on one of the septa, all operations would be stopped. A septum failure can be more critical than a kicker failure, as the beam can hit the septum blade. This has been studied in detail by Jan B. who concluded that the failure modes should not be destructive for the septum. The maximum expected temperature is 140 C, but the beam should be interrupted by the BLMs and by the vacuum interlocks before reaching this temperature. Also, the septa are protected by the SIS.

Daniel stressed that there is a first line of protection with the vacuum interlock. Richard mentioned that there are plans to run ISOLDE at 2 GeV and asked if this changes the picture. Gian Piero mentioned that this is part of a long discussion and won't happen before LS3.

Gian Piero concluded that the proposed changes would increase the flexibility, especially with the LHC filling in mind, and keep the equipment safe. The next steps are to update the ECR, submit it for approval and implement the changes for next year's operation.

Jan commented that this has been a good and important work and the proposed solution is very solid.

David asked if the diagnostics is sufficient to understand the change of performance. Gian Piero answered that it should be fine, considering that the alarms and the WIC diagnostics are still active. David then asked how many circuits will still be connected to the BIS via the WIC. Richard answered that basically all power converters are now removed. It remains that the WIC is protecting the equipment but is not needed for machine protection against losses. The WIC remains to protect the magnets and will dump the beam if there is a problem with the magnets. However, the main dipoles and quadrupoles are connected directly to the BIS. Verena mentioned that this same argument is not applied in the other machines.

Richard explained that no cable will be disconnected, it is a change in the PLC matrix only.

Daniel concluded that the MPP supports the proposed ECR and will close the approval round for the second week of January. Proper hardware commissioning will be required following the changes. This will be integrated in the planning.

A discussion followed on the coherence of the removal of all the PC from the beam interlock matrix but leaving magnets on the beam interlock matrix. Jan pointed out that a magnet failure justifies a beam dump, as this is an important event, however it is not more critical regarding beam losses than a power converter failure. Verena added that this way of mixing the functions is normal for the injectors and is justified. Jan mentions that stopping the beam is the best way to let operations know that there is a serious problem.

Actions:

- Update the ECR and circulate it for approval (GP)
- Review the inconsistency that the WIC will not interlock the beam in case of a power converter failure, but still interlocks the beam in case of a magnet failure (G.P. Di Giovanni, MPP, David)

Operational experience of continuous caesiation at Linac4 (J.-B. Lallement)

Jean-Baptiste reported on the operational experience on the continuous Cesiation. This follows up from the 180th MPP meeting, with specific contributions from Michael O'Neil. The implementation was first briefly summarized: it can be switched off, be in continuous mode or single shot mode. Only one interlock event happened on 25 November 2021, with a test source. The vacuum pumping of the source stopped while the Cesium valve was open, the valve closed as expected. In 2021 the Cs valve was almost continuously open. The reservoir temperature was generally between 50 and 60 C and never exceeded 80 C. No single shot Cesiation, at higher temperatures, was needed. The valve temperature was kept 20 Kelvin above the reservoir temperature and the transfer line temperature slightly above the valve temperature.

Regular tests of the interlock system were made, with a test done at the beginning of every run. The source experts monitor the parameters daily. Overall, the experience is very good, with only continuous mode in 2020-21. A new source is foreseen for 2022, which is a copy of the source which has been running before and might show a slightly different behavior.

Richard mentioned that the spark rate of the RFQ was very low, there is no sign that Cesium is sent to the RFQ.

AOB: Crystal collimators in SPS LSS4

EN-EL has confirmed that the interlock cables have been installed for the TECA.41777 (crystal goniometer in LSS4). The goniometer will be interlocked on the end-switch position during normal operation. For MDs this interlock will be masked. The masking of the interlock requires to follow the MD procedure which has been agreed between OP and MPP.

Summary of actions

The actions from the meeting are:

- Beam dump matrix modifications of the WIC in the PSB and PSB extraction lines (G.P. Di Giovanni)
    1. Update the ECR and circulate it for approval (G.P. Di Giovanni).
    2. Review the inconsistency that the WIC will not interlock the beam in case of a power converter failure, but still interlock the beam in case of a magnet failure (G.P. Di Giovanni, MPP, D. Nisbet).