219th Meeting of the Machine Protection Panel

Injector topics

February 4th, 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 (219rd meeting).

Minutes and actions from the 218th meeting (Injector topics)

The minutes of the 218th MPP meeting have been circulated and Daniel recalled the actions.

Issue with slowly drifting dipole in the NA62 beamline (J. Bernhard)

Johannes first introduced the North Area beamlines layout. The 400 GeV/c primary beam is slow-extracted from the SPS with a total intensity of about 3e13 protons per spill. The beam is then split between three production targets (T2, T4 and T6). The typical intensities of the secondary beams are 25e11 for T2, 80e11 for T4 and 150e11 for T6. The protons not interacting with T4 are further transported via the P42 beamline towards the T10 target (typically 45e11). From T10, the high intensity secondary beamline K12 delivers about 2e9 hadrons to the NA62 experiment at 75 GeV/c.

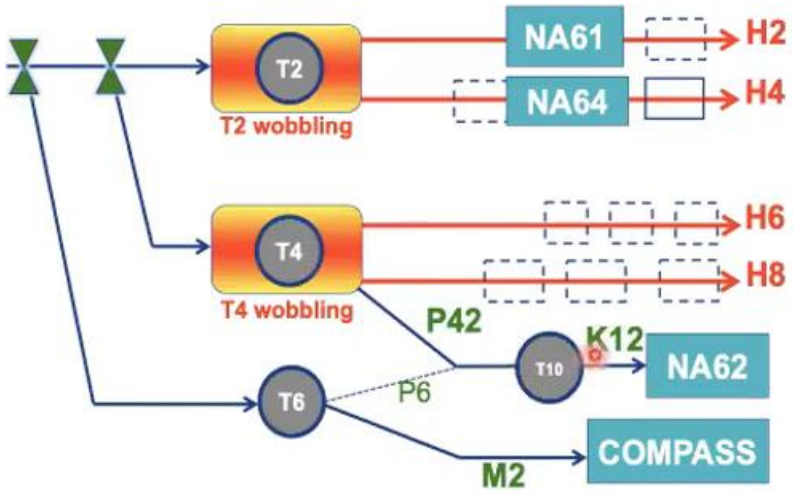

Figure 1 Schematic layout of the North Area targets, beamlines and experiments.

The P42 beamline transports protons from the T4 target to the T10 target over a distance of 838 m. Directly downstream of the T4 target, a spectrometer magnet distributes the secondary particles towards the H6 and H8 beamlines at different energies and deflects the primary beam into the P42 line (this is part of the so-called "wobbling"). Two vertically movable dumps (XTAXs) with different hole sizes select the acceptance for P42 and are used as EIS-b elements (e.g., for access to ECN3). The XTAXs are also closed when an interlock on magnet current occurs.

The K12 beamline transports hadrons from T10 to NA62 over 102 m. Two achromats are used to define and measure the beam momentum of 75 GeV/c, while the other elements of the line are used to clean the beam from hadrons outside of the NA62 acceptance, as well as of positrons and muons. The power supplies of K12 are interlocked, acting on the P42 XTAX located upstream.

The primary proton beam has a sufficiently high intensity to do serious damage to the beam elements. The interlock and magnet surveillance system in the area, "P0survey", is rather old and takes as input the currents in a selected set of 33 bending and quadrupole magnets which are continuously monitored. The measured currents are compared to reference values with a programmable tolerance. In case of a deviation outside the tolerance, the P42 XTAXs are closed.

The NA62 experiment is an experiment to search for ultra-rare decays of kaons in flight and needs to be protected in case of failure. Also, background subtraction is key to the measurement, so many detectors are constructed around the beam and very close to the beam. This means that a deviation of the set currents in bends and quadrupoles can deviate the beam inside the detectors. Several of the detectors are extremely sensitive and irreplaceable (e.g., LKr), so potential damage must be avoided.

For two occurrences in Run II, the vertical beam position measured at the end of the experiment was found drifting. Investigations showed a wrong current at the level of the magnet, not detected by the DCCT of the power supply. Thus, P0survey did not act, and the beam started drifting into the detectors. On both occasions, it was tried to adjust the current manually, but the maximum current of the power supply was reached. The deviation is in the order of a few amperes for a nominal current of 832 A. Changing the regulation card helped, however the error could not be reproduced when the previously used card was put back in for a test. The SPS SIS includes a monitoring of the vertical beam position, however this is intrinsically less reliable (single detector, not a direct current measurement, software chain). At the start of the run, something similar happened for the MNP33 spectrometer magnet, staying undetected by the P0survey. The experiment found wrong values during their physics data reconstruction, which allowed to discover the issue. The deviation was close to 1 mm at the time the effect was first observed.

The NACONS (North Area Consolidation) project is foreseen to consolidate all power supplies (>40 years old) and to deploy a BIS system for the North Area. For the secondary beams and P42, this is not planned before LS4. A risk assessment and user requirements document is available in EDMS-2435863 and the "North Area Interlocking Task Force" is looking at the technical specifications and implementation.

Short term solutions have already been proposed. The fully analogue power converters use one DCCT and the signal is then split into two channels: one for the controller card and one for the P0survey interlock. In the past, a second DCCT was made available at certain locations (e.g., BA80), but the electronics of the system was dismantled during the last update of the power supply controls in the early 2000s. This is thus not an option anymore. The most likely root cause of the issue is the drift of the amplifiers of the controller cards. This must be verified in the lab. In K12, the main bending magnets are most critical, comprising in total seven circuits. Therefore, the amplifiers on the controller cards for at least these circuits should be exchanged. The SIS relies solely on the readout of one wire chamber, adding another chamber to create redundancy for the SIS interlock is proposed. Additionally, a dedicated SIS instance for the North Area, independent from the SPS system should be setup.

Jorg asked after the meeting about the benefits of this new instance, and on what it will act (TAXs or directly via the SPS ring BIS).

The hardware BIS deployment will only take place during LS4 but could possibly be anticipated. This is linked to the consolidation of the power supplies and would require the reprofiling of several tens of MCHF.

For the short-term solution, the following actions are taking place:

- BI has been informed and a second wire chamber will be installed during YETS 21/22.
- The amplifiers of the control cards of the most critical seven circuits (the two achromats and dipoles) will be exchanged.
- The deployment of a dedicated SIS instance for the NA has been requested from CSS and is underway.

Medium term solutions are considered. The BIS crate will be implemented in LS3, but the power converters (BA82) will only be replaced in LS4. Considering the workload of EPC for LS3 and the required reprofiling of resources, it seems unrealistic that the change of the concerned power converters could be advanced. BLMs could be added close to the experiment. This could provide a redundant interlock signal to the SIS. Currently, no BLM is installed in the North Area, which means that no infrastructure is in place. This reinforcement of the interlock strategy could be envisaged for the medium term. The experiment could also provide a beam permit signal to the SIS, derived from conditions of their detectors. This is not possible during the YETS 21/22 but is possible for the YETS 22/23. An additional collimator would be the ideal element to protect the experiment, however, the experiment is designed hermetically and adding a collimator would compromise the detector acceptance. Finally, more amplifiers on the other control cards could be replaced, this will be investigated.

Discussion

David commented that the systems are indeed very old. David pointed out that an issue for the replacement of more control cards is the obsolescence and availability of spare parts. Regarding the schedule and the consolidation of the North Area, David mentioned that discussions are on-going to fit more activities within the new LS3 timeline.

Daniel asked about the lifetime of the replaced amplifiers as we need another 10 years extension for their use. David replied that this is hard to evaluate; these are first-generation circuit boards and are extremely fragile.

Daniel commented that it would be worth to reevaluate if additional parts of the consolidation activities of the NA can be advanced from LS4 to LS3 in view of the new schedule. From a machine protection point of view, it would be good to provide an overview of the most critical beam lines and experiments. A request could then be made to advance these critical points.

Daniel concluded that the described failure is a slow failure and the proposed improvements in the YETS 2021/22 will bring additional redundancy to allow a reliable protection of the experiment against slow drifts.

Summary of actions

No action was identified.