195th Meeting of the Machine Protection Panel (joint with the Collimation working group)

LHC topics

October 16th, 2020 via Zoom

Participants:

Andrea Apollonio (TE-MPE), Cristina Bahamonde (EN-STI), Philippe Belanger (TE-MPE), Roderik Bruce (BE-ABP), Marco Calviani (EN-STI), Mario Deile (EP-CMT), Mario Di Castro (EN-SMN), Alex Fomin (BE-ABP), Marek Gasior (BE-BI), Cedric Hernalsteens (TE-MPE), Lars Jensen (BE-BI), Dragoslav Lazic (EP-UCM), Tom Levens (BE-BI), Björn Lindström (TE-ME), Daniele Mirarchi (BE-ABP), Filip Moortgat (EP-CMG), Nicolas Mounet (BE-ABP), Lawrence Nevay (BE-ABP), Jean-Baptiste Potoine (EN-STI), Stefano Redaelli (BE-ABP), Gianmarco Ricci (BE-ABP), Belen Salvachua (BE-BI), Benoit Salvant (BE-ABP), Brad Schofield (BE-ICS), Raffaello Secondo (TE-MPE), Pablo Serrano (EN-SMM), Matteo Solfaroli (BE-OP), Jan Uythoven (TE-MPE), Andreas Waets (EN-STI), Jorg Wenninger (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 (195th meeting).

Minutes from the 193th MPP meeting (LHC topics)

- No comment has been received.

Strategy for crystal interlocking and operation in Run 3 (S. Redaelli)

- S. Redaelli gave an overview of the strategy for interlocking and and operation of crystal collimators in Run 3. Crystal collimation was added to the baseline of the HL-LHC project as part of WP5. Moreover, it is important to have the crystal collimation operational in Run 3, as risk mitigation for schedule concerns with 11 T dipoles that may require using crystals in both beams. Following the present status the 11 T will not be installed in LS2 and the crystals shall ideally be deployed for one or two beams. This has no impact on the interlock specifications. Crystals were used successfully in special runs and significant gains are expected in cleaning performance of heavy ion beams. Redundancy in angle measurements has been added in the latest design of goniometers used to hold and orient crystals. The first phase of the upgrade scope involves replacing the 4 existing devices, ideally before the start of Run 3. Operational modes include MDs and low intensity runs with proton

beams, while crystal collimation will be deployed as baseline system for heavy ion beams operation. The main controls update in LS2 that will enable using crystals in high-intensity ion beams operation is the addition of ramp functions for linear-position limit interlocks.

- J. Uythoven asked if secondary collimators used to intercept the channelled particles are dedicated for crystal operations. S. Redaelli replied that they are standard secondary collimators routinely used in operations.

- J. Uythoven asked how many LVDTs are present. S. Redaelli and P. Serrano Galvez replied that only one linear axis is present, and it is interlocked using one LVDT, while the crystal angle is computed by an interferometer.

- J. Uythoven asked why the crystal angle is not interlocked. S. Redaelli replied that the noise on its measurement will be comparable to the critical channelling angle, introducing the risk to trigger a dump on noise. R. Bruce commented that the machine will not be exposed to any danger even if the channelling orientation is lost. S. Redaelli added that loss pattern and cleaning performance with crystals in amorphous are comparable to what is obtained with standard collimation. This aspect was assessed in 2018 prior to insertions at high intensity as end of fill studies.

- J. Wenninger commented that angle changes at the crystal during 10Hz orbit oscillations should be checked to ensure that they won't bring the crystal out of channelling orientation. S. Redaelli replied that few μrad of angle change are needed to lose the channelling regime. S. Redaelli added that the possibility to add crystals to constrain both sides of the beam has been studied and layouts are already available for possible future upgrades based on operational experience. This option involves more changes than the replacement of the existing devices, but it would be possible if the operation during Run 3 shows that this is required.

- J. Uythoven asked which interlock will be implemented to avoid insertion of crystals when not needed. S. Redaelli replied that a replacement chamber is present to physically prevent the insertion of crystals during high intensity proton operation. M. Di Castro commented that the replacement chamber can be moved only by EN-SMM experts. S. Redaelli added that an interlock on the chamber's moving state is also present. D. Wollmann commented that the critical moments are the transitions between low and high intensity operations, for which the procedure has been improved by adding checks in the operational sequence.

- J. Uythoven and D. Wollmann commented that commissioning procedure should be followed up off-line and documented. S. Redaelli added that hardware commissioning was performed and documented also in Run 2.

Action: Produce commissioning procedure for the crystals.
Action: Produce detailed operational scenarios and relative validation that needs to be done, when switching between proton/ion/MD mode.

- D. Wollmann asked where the channelled beam would go in case of injection errors. S. Redaelli replied that it is impossible that the channelled beam bypasses the TCSG used to intercept it. S. Redaelli added that there is no need of using crystals for cleaning improvement at injection but the main reason to have them always in place is to avoid the time needed to insert them before starting the ramp.

Action: Check orbit at the crystal during injection failure.

- R. Bruce asked if an interlock on the out position will be needed. S. Redaelli replied that only inner limits were present in operational tests in 2018 and the need of outer limits will depend on operational settings, i.e. if some of the standard collimators need to be retracted to improve cleaning performance. D. Wollmann added that there is no need of outer limits if the rest of the standard system is kept fully in place, while they would be needed if standard collimators are retracted. S. Redaelli commented that the only standard collimators that may need to be slightly retracted are TCPs. R. Bruce added that it would be important to have settings that won't need a complete re-validation of the system if crystals have to be retracted in the middle of the run.

- C. Wiesner asked if crystals will be added to the collimator fixed display. S. Redaelli replied that a dedicated fixed display is already available. C. Wiesner replied that it may be better to add them directly in the main fixed display. J. Wenninger commented that this may create confusion because crystals behave differently than other collimators and a dedicated display may be better. J. Uythoven proposed that a flag on the crystal status in the main fixed display could be added.

- D. Wollmann summarised that the proposed interlocking strategy for the crystal collimators in Run 3 is supported by the MPP.

- **Action (Collimation):** Check the angle change at the crystal during 10Hz orbit oscillations. Off-line follow-up show that a maximum change of 0.1 μrad is expected at the crystal, which is much smaller than the channeling acceptance of about 2.5 μrad at top energy.

- **Action (Collimation):** Produce commissioning procedure for the crystals.

- **Action (Collimation):** Produce detailed operational scenarios and required validation for the use of the crystals.

- **Action (Collimation):** Check orbit at the crystal during injection failure.

Update on collimator BPM interlocks for Run 3 (Marek Gasior, Tom Levens)

Tom first summarized the changes made during Run 2. DOROS channels have been interlocked via the SIS in LSS1, LSS5, and LSS6. The system is redundant to avoid unnecessary beam dumps: the BPM signals are split into two DOROS front-ends, and the interlock logic is such that in case of failure of one front-end, the other one can provide the interlocking functionality via the SIS.

During LS2, 14 new collimators have been installed in IP7 and 2 new in IP2. In IP7, all collimation planes are equipped with redundant front-ends while all orthogonal planes are without redundancy and interlock.

The decision to use redundant DOROS front-ends for the P2 collimators is an open question:

- **Comment** Jorg mentioned that during Run2, the TCTs in all IPs were interlocked but not equipped with redundant front-ends. Jorg suggested that IP2 and IP8 can be masked in case of an issue with the DOROS front-end, and Roderik added that they are much less critical for machine protection (IP2 TCTs are almost fully open).
- **Comment** Jorg asked if it is required to implement redundant front-ends for channels that are not critical. Roderik added that the new TCLDs in IP2 are only for ions, with large settings in millimeters and in sigma, so there is no need to interlock.

Tom reported on the progress of the work done during LS2:

- All collimators are installed except two in IP7;
- All cables have been installed;
- The electronics installation in TZ76 is done up to 50%; the rest is in production, and will be installed in spring 2021;
- The installation in IP2 will be done within the next few weeks;
- The work to put the software infrastructure back into operation is on-going and the software reliability tests are foreseen for the beginning of 2021.

For LS3, 10 new collimators will be installed in IP7. At the moment all the installation is foreseen in TZ76. Radiation estimations for UJ76 for Run 3 are now available (EDMS 2302154). In redundant configuration, the DOROS front-ends are expected to be fine for these radiation levels. One installation option for Run 3 is to move the IP7 electronics from TZ76 to UJ76 (shorter cable lengths, more rack space, no need to remove temporarily the existing electronics in TZ76 when installing the new one during LS3). A detailed radiation monitoring during Run 3 is required to validate that option.

Comments:

- Jorg commented on possible improvements of the diagnostics options for the SIS. He suggested using the approach now in place for Linac4: to move some logic out of the SIS core to a UCAP server. This has the advantage of being able to publish more information, in particular the different computation steps, which can then be logged by NXCALS. A disadvantage is the creation of an intermediate layer, which is possibly a reliability issue. Jorg proposed to try this out as soon as some front-ends start publishing data. Marek asked if that introduces an extra delay. Jorg responded that it is of the order of one second.

- Jorg commented that one option for the interlocking and redundancy strategy is to interlock on a non-redundant front-end and ignore the channel in case of signal loss.
- Daniel summarized that the strategy is to install all channels redundantly, except for the TCLD in IP2.

Actions:
- Circulate a list of expected redundancies for run III (Collimation / R. Bruce);
- Determine a strategy for P8 (Collimation / R. Bruce);
- Study the option of using the space in UJ76 during Run III (M. Gasior, T. Levens).

Summary of actions

The actions from the meeting are:
- Strategy for crystal interlocking and operation in Run 3:
    1. Check the angle change at the crystal during 10Hz orbit oscillations. Off-line follow-up show that a maximum change of 0.1 μrad is expected at the crystal, which is much smaller than the channeling acceptance of about 2.5 μrad at top energy (Collimation);
    2. Produce commissioning procedure for the crystals (Collimation);
    3. Produce detailed operational scenarios and required validation for the use of the crystals (Collimation);
    4. Check orbit at the crystal during injection failure (Collimation);
- Update on collimator BPM interlocks for Run 3
    1. Circulate a list of expected redundancies for run III (Collimation / R. Bruce);
    2. Determine a strategy for P8 (Collimation / R. Bruce);
    3. Study the option of using the space in UJ76 during Run III (M. Gasior, T. Levens).