191th Meeting of the Machine Protection Panel

LHC topics

May 15th, 2020 via Zoom

Participants:

Andrea Apollonio (TE-MPE), Andrea Boccardi (BE-BI), Michele Bozzolan (BE-BI), Chiara Bracco (TE-ABT), Roderik Bruce (BE-ABP), Andy Butterworth (BE-RF), Eva Calvo (BE-BI), Irene Degl'Innocenti (BE-BI), Cedric Hernalsteens (TE-MPE), Lars Jensen (BE-BI), Dragoslav Lazic (EP-UCM), Tom Levens (BE-BI), Bjorn Lindstrom (TE-MPE), Lukas Malina (BE-ABP), Christophe Martin (TE-MPE), Filip Moortgat (EP-CMG), David Nisbet (TE-EPC), Brian Petersen (EP-ADT), Lars Soby (BE-BI), Matteo Solfaroli (BE-OP), Rogelio Tomas (BE-ABP), Jan Uythoven (TE-MPE), Arjan Verweij (TE-MPE), Manfred Wendt (BE-BI), Jorg Wenninger (BE-OP), Daniel Wollmann (TE-MPE), Christos Zamantzas (BE-BI).

The slides of all presentations can be found on the website of the Machine Protection Panel and on Indico (191th meeting).

Minutes from the 187th and 190th MPP meetings

- No comments on the minutes of the last MPP meetings on LHC topics (187th and 190th MPP) have been received. The open actions have been added to the MPP homepage.

AC-dipole operation with three bunches (Lukas Malina)

- The OMC team proposed to perform optics measurements using the AC dipole with 3 pilot bunches, instead of a single pilot bunch as it has been done so far, due to machine protection restrictions. This would allow to reduce the time required for the measurements significantly.
- With the current method, a single acquisition of usable data takes five to ten minutes, as the AC-dipole needs to cool down after each excitation. Thus, the shortest possible range in which optics variations can be measured is about ten minutes. The main improvement due to this change would be for optics measurements during the ramp, which currently require the combination of multiple ramps, as the phase at which the bunch sees the AC-dipole excitation is not controlled. With the proposed three bunch method this could be done within one ramp.
- The proposal is to measure the optics with the AC dipole using three equidistantly spaced pilot bunches of 1e10 protons per bunch, i.e. a total intensity of about 3e10. In this case, the bunch-to-bunch phase difference with respect to the AC-dipole will be between 30 and 40 degrees.
    - A first drawback of the proposed scheme is that it is more likely that one of the bunches will be hit in case of an asynchronous dump.
    - Roderik commented that this risk is important and should be highlighted.

- The simulation studies assess the impact of the three bunches (three times the intensity) on two collimator jaws which form the aperture bottleneck, in the worst-case scenario: a coherent excitation from the AC-dipole (locked on the tune) in a single plane, with no dilution in the other plane (no linear coupling, etc.). The normalized kick received from the AC-dipole depends on the beam size, on the beta-beating at the AC-dipole, on the beam emittance and on the energy. The normalized kick is typically considered to be of 1.6 sigmas, at 7 TeV, for a 1 mm.mrad emittance and 30% beta-beating at the AC-dipole. The losses appear at a single bottleneck, the two centered jaws of the TCT at 7 sigmas. All results represent the "worst possible phasing" with respect to the AC-dipole (phase at which the initial kick occurs, and all subsequent kicks as they are coherent).
- The simulations determined the minimum time (minimum in the sense that it is the worst case wrt. the phase of the kick) between the BLM trigger and reaching the damage limit of the TCT. The TCTs are made of Inermet and the onset of plastic deformations is expected at 4.6E9 protons impacting at a single spot at 7 TeV.
    - Jan asked if the plastic deformation depends on the beam size. Roderik replied that it does and that a conservative limit is considered here.
- For the perfectly centered jaws the simulations show that the scheme with 3 bunches actually increases the available time between detection and reaching the damage limit.
    - Manfred remarked that this is counter intuitive. Lukas replied that this comes from the fact that the increased intensity allows the BLMs to trigger faster and that the margin is increased. Jan commented, that this is not actually safer, just that the trigger comes earlier.
- The results also showed that the margin is reduced for TCTs at 15 sigmas.
    - Roderik asked why this is the case. Lukas replied that the AC-dipole adds the kicks constructively and that the amplitude in the ramp increases linearly. The amplitude of the oscillation is thus quadratic in time. Therefore, if the losses start later (because the collimators are further out) then the increase in the loss rate will be higher, reducing the time between triggering and deformation limit.
    - Jan asked if the phase difference between the bunches strongly influence the results. Lukas replied that up to 1000 buckets variations, the results are weakly influenced.
    - Daniel remarked that the results on slide 14 are for ideally positioned jaws. What would happen for jaws with an offset, would all the losses shift to the other jaw? What would be the conclusion in that case? From slide 16 one could get the impression that the margin is reduced by about 10 turns in this case?
    - Jorg commented that for nonlinear optics measurements, with a scan over the crossing angle, the jaws of the TCTs are asymmetric. Slide 16 also shows that case, the trend, with the improved situation with 3 bunches is still better than for a single bunch.
    - Manfred asked if the required intensity for the "fat pilot" will remain at 1E10. Rogelio commented that below 6E9 the measurement results are not useful. Jorg also commented that the process is not loss-less, and, thus, requesting an intensity of 1E10 at flat-top (with additional margins at injection) is realistic.

Machine protection for OMC measurements with 3 pilot bunches

- Daniel remarked that this proposed method would currently be blocked by the setup beam flag, which allows about ~1e10p in the machine at flat top. To avoid this and not to allow a wide-open intensity space (when using for example the beam setup flag) the existing SMP 'Restricted' flag could be adapted for this case.

- **Action** Propose a solution for the modification of the Restricted SMP equation for OMC operation with a maximum total intensity of 4E10 protons flat over all energies (J. Uythoven / MPE-MI).

- Jan commented that in some cases three pilots lead to a worse situation than with a single bunch in the machine. He proposed to start the initial commissioning with only one pilot bunch to limit the total intensity. Daniel added that we have to assume the worst-case scenario for an unknown machine, with all the intensity at the same phase wrt. the AC dipole. We thus need to keep a low intensity for the first measurements. Rogelio commented that this is reasonable and that we can consider to go for 3 pilots once we reach about 30% beta-beating. There was some discussion of the actual limit and flexibility on this: it was concluded to aim for a maximum beta-beat of 20 % before going for measurements with three pilots and the new SMP flag.
    - **Action** Prepare a procedure for use of 3 bunches after first optics optimization for OMC measurements (OMC team).
- Rogelio remarked that for nonlinear optics measurements with a single bunch the maskable BLM at the TCT was masked. It was agreed that in case of 3 pilot bunches the BLM must not be masked. Rogelio added than in that case it might not be possible to use the 3 pilots' scheme for nonlinear measurements. The situation of the maskable BLM for a single bunch should be reviewed as well.
    - **Action** Check the interlocking with triplet BLMs for 1 pilot and for 3 pilots and compare to the TCT damage limits (OMC team / L. Malina / R. Tomas / Collimation team).

Proposal for iBPMs layout in Run3 (Michele Bozzolan)

- Michele presented the iBPM plans and proposed layout for Run 3. The initial motivation for the new system was the inability of the present system to operate with doublet beams. With the new system, this issue will be solved. The resolution with doublet beams will be a factor two worse than for normal 25ns beams (< 400 um versus < 200um), due to the shorter spacing, as the signal to the ADC will be twice as short. As the doublet beams are not part of the LHC program anymore (but can always come back), the new iBPM system is nevertheless justified by the increased intensity range, required for LIU bunches. An additional advantage of the proposed system is the reduced temperature sensitivity.
- In the first phase one existing BPM SX from beam 2 (BPMSX.A4R6.B2) will be connected to the new electronics. This new system will be connected to a new CIBU in UA67. The signal from the second BPM SX in beam 2 will be split and fed into the existing electronics in SR6. Thus, there is a small loss of redundancy by using one single BPM SX and up to the splitter a single pair of cables to feed into the two existing B2 iBPMs electronic systems.
- The cables to connect the CIBU of the new system in UA67 (and later also in UA63) to the BIC in SR6 have been requested by TE-MPE and were installed by EN-EL.
    - Jan remarked that, despite the need to evaluate the performance of the new system with logging data from the BIC, it should only be connected when its correct functioning has been shown with the first beams, to avoid an overload of the BIC buffers. Tom proposed to connect the system but to disable the output via the firmware. It was agreed that this mechanism should be foreseen. However, the connection of the new system to the CIBU should only be performed in agreement with TE-MPE-MI after first experience.

    - Andrea added that the new system is heavily digital and that new failure cases could become apparent.
    - **Action** Prepare a discussion on the iBPM firmware with MPP experts and evaluate possible new failure cases (A. Boccardi).

- The test system will be installed by the end of LS2. The hardware installation includes 2x2 ways RF power combiners (one per plane) connected to the upstream ports of the BPM support and 4x2 RF resistive power splitters, which will be installed in UA67.
- The ECR "Installation of the test system for the new LHC interlock BPMs" is under preparation and almost ready for distribution. It should only mention the test phase of the iBPM installation (phase one).
- Phase two will happen after the successful validation of the new system and include the removal of the existing electronic crates in SR6. The installation of the final system will most likely take place during the 2022/23 YETS. The crates with the new systems and all CIBUs will be placed in UA63 and UA67 and connected in a "single CIBU per beam per side" configuration, as agreed between BE-BI and TE-MPE.
    - **Discussion** What are the criteria for the validation of the system?
    - During 2021 and 2022, data with LHC beam will be collected for several months. Is that enough to validate the system? Are special conditions or MDs required?
    - **Action** Propose criteria for iBPM validation before switching to the new system (performance / specifications / reliability criteria) (A. Boccardi / M. Bozzolan).

- Daniel asked Chiara if the loss of redundancy is acceptable for ABT for the connection of the prototype. Chiara replied that this is acceptable. In case of failure, one can go back to the old configuration.
- Manfred asked about the status of the doublets. The system design is based on the idea of having doublets, even though with a lower resolution. However, if doublets will never be used again, then the design could be simplified (different filter configuration, simpler and more reliable). Jorg replied that at the moment the doublets are off the table but cannot be fully excluded for the future. Thus, the new system should contain the ability to operate with doublets.
- Daniel summarized that the MPP is recommending to go for the testing phase using the proposed configuration. The ECR for phase one should be finalized and then distributed for comments and approval. For phase two a new ECR will be prepared.

Status of IQC and future development (Jorg Wenninger)

- Jorg presented the status of the refactoring of the IQC (Injection Quality Check) application. The goal of the work done during LS2 is twofold: clean up the code and ensure that there is enough internal OP knowledge to adapt and maintain it during run 3 and onwards.
- The structure of the code has been split into two Gitlab repositories: "IQC analysis" (processing and storage of the raw data) and "IQC display" (subscribing to the analysis process and displaying the GUI). The GUI work is in progress; the playback functionality has been fixed. Jorg proposed to add a computation of the 'dp/p' at injection from a dispersive trajectory fit, to complete the future RF determination using the tomography.

- Jorg commented that changes to be made on FESA classes, in particular the update from FESA 2 to FESA 3, must be carefully checked in order to maintain the backward compatibility as much as possible.
- At the moment, the code is not releasable as it depends on the RDA2 library which has been removed by BE-CO. Jorg is able to work from his local environment, but the application cannot be deployed.
    - Regarding the dBLMs, Christos commented that the oscilloscopes have been removed and the diamonds will be read out by the new standard BI readout electronics.
    - **Action** Discuss the use cases and give inputs for the FESA/firmware preparation for the new dBLM readout electronics (Jorg / Eva)
    - **Action** Add an update of the IQC settings for abort gap keeper settings changes (ABT / OP)

Summary of actions

1. AC-dipole operation with three bunches:
    a. Propose a solution for the introduction of a separate SMP equation for OMC operation with 3 pilot bunches (4E10 protons) (J. Uythoven / MPE-MI);
    b. Prepare a procedure for use of 3 bunches after first optics optimization for OMC measurements (OMC team);
    c. Check the interlocking with triplet BLM for 1 pilot and for 3 pilots (OMC team / L. Malina / R. Tomas / Collimation team).
2. iBPMs layout in Run3:
    a. Discussion on iBPM firmware and possible failure cases (A. Boccardi);
    b. Propose criteria for iBPM validation before switching to the new system (performance / specifications / reliability criteria) (A. Boccardi).
3. IQC application and future development:
    a. Discuss the use cases and give inputs for the FESA/firmware preparation for the new dBLM readout electronics (J. Wenninger / E. Calvo);
    b. Add an update of the IQC settings for abort gap keeper settings changes (ABP / OP).