222nd Machine Protection Panel Meeting (LHC)

Friday 01 April 2022 (Zoom)

Indico MPP Website

Participants

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Minutes from previous LHC MPP meetings

No comments were raised regarding the minutes of previous MPP LHC meetings. Therefore, the circulated minutes are considered approved.

Plans for luminosity levelling in 2022 and outlook for 2023 (M. Hostettler)

M. Hostettler presented the machine protection aspects of the luminosity levelling strategy for 2022 and 2023 implemented in the lumi server (operational server + GUI in the CCC).

As a recap, the lumi server was used operationally in 2017 for crossing angle change and in 2018 for Beta* levelling at the end of fill. Nothing is fundamentally new in the lumi server logic, but some functionality has been added to accommodate plans for 2022 and 2023.

M. Hostettler then explained the settings management aspects of the lumi server Beta* levelling implementation. All the settings are in LSA and generated per optics matchpoint. With this the lumi server is able to move between optics matchpoints. Conceptually it is not much different than a standard squeeze in step done via the sequencer during commissioning.

For machine protection point of view, the Beta* levelling is more dynamic than a standard squeeze since it also takes into account the resulting orbit of a levelling step and correctly keeps in sync the orbit feedback system, the collimators and the PcInterlock. PcInterlock has been adapted in 2018 to allow flexibility in the way limit functions are interpreted.

M. Hostettler stressed that the lumi server should never become critical for machine protection. Collimators movement is checked by the collimator system interlocks and the magnets are protected by the PcInterlock. This creates a safe envelope that allows the lumi server to not become a critical system.

M. Hostettler then presented the collimator's strategy during Beta* levelling discussed in the LHC Collimation Working Group [#256](#) and [#260](#). For 2022 there will be no crossing angle change and the levelling range is limited, therefore the TCT/TCL position and limit can be kept constant in millimeter. For 2023 the levelling range will be larger and the TCT/TCL position and limit will move along with the levelling steps.

M. Hostettler explained that the code to move the limits and the collimators for the 2023 strategy is already implemented in the lumi server. Lumi server will also perform best effort checks on the position that will be sent to the collimators in order to prevent the out of limits interlock. M. Hostettler stressed that this is not a machine protection check, but some additional check to increase availability and avoid dumping the beam if settings are not correct.

M. Hostettler explained that the collimator limits are Machine Critical Settings (MCS) in LSA. This means that the limit functions are signed and cannot be further split in order to be sent step by step to the hardware. In agreement with the collimation team, an LSA makerule is in place to cut and sign the limit functions per matchpoint which the lumi server is able to play during Beta* levelling steps (which results in a transition between matchpoints).

M. Hostettler presented two possible failure scenarios that might impact machine protection during Beta* levelling.

Failure scenario 1: due to a bug in the lumi server the wrong limit function is loaded for the collimators. In this scenario, the collimators PRS checks for continuity of the loaded functions and will throw an exception during the set on the hardware. Also, the best effort check will make sure that the jaws positions and collimator limits are in accordance. In the worst case, the collimator limit interlock will protect the machine by dumping the beam. Thus, this failure case would only manifest if two collimator limit segments start at the same value in LSA and the lumi server chooses the wrong one, along with consistent jaw position functions. The limits foreseen for Run 3 are monotonic, excluding such a scenario.

Failure scenario 2: collimators are not driven. Moving the collimators (and limits) during a Beta* levelling step is an option in the GUI that can be disabled (useful for MDs). In this case, the machine is still protected by the Beta* interlock on the collimators, which are stored in a separate beam process and are not touched.

In order to gain experience and confidence for the 2023 levelling scenario, M. Hostettler proposed to move the position and limits of the collimators in 2022 even if not needed by the agreed levelling schema. By having very small, semi-flat, functions, there will be no effect on the machine while still testing the mechanics of the lumi server.

This proposal was endorsed by the MPP and M. Hostettler was asked to prepare a detailed function proposal and discuss it with Collimation.

Discussion

D. Wollmann asked if the TCT movement is calculated by the lumi server. M. Hostettler clarified that the lumi server adjusts the jaws position according to the expected orbit evolution during a levelling step. The collimator gaps and limits are not calculated on the fly but LSA settings generated by the collimation team are used.

J. Uythoven asked if the references for PcInterlock are dynamic (calculated by the lumi server) as they might depend on, e.g., an incorporation. M. Hostettler commented that the circuit's references and limits are not touched by the lumi server (or any other system once generated). They are large enough to accomodate slight adjustment needed in operation.

Since the collimator position is calculated according to the expected orbit excursion, D. Wollmann asked if it could reach the limit and interlock. M. Hostettler confirmed that the collimators interlock on limits will protect the machine in such cases.

J. Uythoven asked if the collimators Beta* interlock is triggered by the collimators themselves. M. Hostettler confirmed it.

S. Fartoukh asked where the Beta* is fetched from since the Beta* interlock on the collimator relates the Beta* to the collimator gaps. M. Hostettler answered that Beta* is reconstructed by SIS. D. Wollmann commented that the Beta* is reconstructed by SIS then transmitted to the SMP. The SMP then broadcasts one value per IP.

D. Wollmann proposed to carry on with the test of the 2023 scenario this year. In this sense, lumi server will drive position and interlock limits with semi-flat functions to not interfere with levelling while still providing useful insight on the successful mechanism (action for M. Hostettler and D. Mirarchi).

S. Fartoukh asked how much time does it take to put into operation new functions for crossing angle or Beta*-dependent limits. D. Wollmann answered that a very small variation of, e.g., crossing angle should be fine, but anything more significant will require a full machine protection validation (collimator alignment, lossmaps, etc).

BSRTM operational scenario and interlocking strategy (E. Bravin)

E. Bravin presented the operational scenario and interlocking strategy for the BSRTM in order to validate the HL-LHC operational scenario for the BSRT devices.

E. Bravin explained that during LS2 new BSRTM device (B1 in 4L) were installed with the intent to verify that with Run3 beams the RF heating is under control, to study the properties of the new Synchrotron Radiation source and validate the design of the device. The installation is described in the corresponding ECR document.

E. Bravin described the aperture restrictions as a consequence of the new mirror movement. Specifically, when max insertion is reached (~11mm) it is not safe for injection. Max out position is instead of about 35mm. This raises the need for an interlock on the actuator that controls the mirror position. E. Bravin then presented the aperture limits calculated by the BE-ABP group to provide a value of the aperture limitation at injection and at flattop.

E. Bravin then described the actuator of the new BSRTM which is controlled by a stepping motor. Two linear potentiometers monitor the real position of the mirror support and a mechanical stop limits the insertion of the mirror to about 10mm. The device is controlled by two PXI (motion and potentiometer) systems provided by BE-CEM and a StepperAxis FESA class. The mirror position is controlled operationally by sequencer tasks and the position vs energy limits are stored in LSA as MCS parameters. The mirror temperature is monitored by a SY-BI FESA class and logged in NXCALS to be analyzed offline.

E. Bravin presented the interlocking strategy for the device which is based on the potentiometer readings. If the position read is outside of the limits, a maskable BIS interlock is triggered.

E. Bravin then specified that the mirror would operate at a position of about 23mm and 11.2mm for injection and flattop respectively. Some margin will have to be added to avoid unnecessary interlocks due to readout noise of the potentiometers.

Discussion

J. Uythoven asked which orbit measurement was taken into account while calculating the beam aperture limits. E. Bravin answered that the calculations are based on a 2mm orbit error plus other tolerances (standard aperture calculation procedure). It is guaranteed that in the worst case at injection the aperture is 13 sigma.

M. Solfaroli asked if the reading of the temperature of the mirror would be considered for an interlock or just logged into NXCALS. E. Bravin answered that the temperature should not change rapidly and no hardware interlock should be necessary. The temperature will be checked during the intensity ramp up.

J. Uythoven asked if it will be possible in the future to add an interlock on the temperature. E. Bravin commented that it can be done but due to the slow nature of the temperature signal it would be better to have a software interlock in SIS.

J. Wenninger asked if the settings for the new device would be stored in LSA or set by the sequencer via a direct set on the FESA class. E. Bravin answered that the settings will be set in LSA and G. Trad will look into it.

S. Fartoukh commented that it is important to distinguish the calculations derived from an emittance of 3.5um (standard for collimators in Run3) and 2.5um (standard for HL-LHC). J. Uythoven proposed an action together with the BE-ABP and collimation team to check the aperture limits for the new device (Action D. Mirarchi and R. De Maria). E. Bravin answered that the results were presented at the 195th HiLumi WP2 Meeting.

E. Bravin asked about which MCS role would need to be defined to protect the LSA settings. M. Solfaroli and J. Wenninger agreed that the collimator limits MCS role can be used since the collimation team will generate the settings.

Actions

- Provide semi-flat functions to test 2023 Beta* levelling mechanics in 2022 without interfering with levelling. In 2022, lumi server will move the collimators and limits according to these functions to gain experience and test the levelling mechanics in view of 2023 (M. Hostettler and D. Mirarchi)
- Check the aperture limits of the new BSRTM device are in accordance with Run3 parameters (D. Mirarchi and R. De Maria)