SUMMARY OF SESSION 4 OF MPP WORKSHOP 2013: LHC COLLIMATORS AND MOVABLE DEVICES

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Abstract

This paper summarizes the discussions that followed the presentations of the "Collimators and movable devices" session at the LHC Machine Protection Workshop. The session summary, as presented at the workshop, and the identified action items are also given.

INTRODUCTION

The fourth session of LHC Machine Protection workshop was dedicated to the LHC collimators and movable devices and included five presentations:

1) **LHC Movable Devices**, by Stefano Redaelli;
2) **Settings generation, management and verification**, by Gianluca Valentino;
3) **Beam-based validation of settings**, by Belen Salvachua;
4) **Collimator hierarchy limits: assumptions and impact on machine protection and performance**, by Roderik Bruce;
5) **Updated robustness limits for collimator materials**, by Alessandro Bertarelli.

For each presentation of the session a summary of the discussion that followed the presentations is given, followed by a summary of the critical points and open actions.

LHC MOVABLE DEVICES (S. REDAELLI)

Discussion

K. Fuchsberger asked if one could use for determining the beam separation versus time (for collimator interlock purposes) a similar mechanisms as for orbit correctors setting checks (with a new tool). S. Redaelli replied that this should be possible. On the other hand, he stressed that the implementation should check the values based on the energy and beta* information that is distributed as safe machine parameters in the timing.

R. Jacobsson asked if there are principle objections to move collimators during beta* levelling. S. Redaelli replied that this is not the case. Only, one has to be very careful if this is done in stable beams mode, as transient losses at the TCTs that could cause a beam dump cannot be excluded. Although the TCTs will not directly touch the beams, if there are losses in IR7 (e.g. due to orbit drifts) the leakage to the TCTs might be seen by the experiments.

R. Schmidt asked whether we should consider passing the responsibility of the loss maps analysis for the collimator settings validation to the OP shift crew. S. Redaelli replied that this is in principle possible. However, the detailed analysis done for the final validation is not trivial and he does not see that this can be done by everybody in operation: people in the collimation team need several weeks of training before getting "qualified"' for the loss map validation. Is this something that we want to have for all the OP team? A common strategy should be established, covering similar problems for other systems' validation (injection, dump, orbit, ...).

Summary

- No major changes of movable devices that require reviewing interlock strategy are foreseen during LS1. One single outstanding issue concerns new fast vacuum valves in IP4. This is being addressed by the MP team.
- One main hardware change affects the collimators: a new design with integrated BPM will be adopted for 18 collimators in the ring, in IP6 and all experiments. This has a great potential to improve the interlocking strategy. A learning period will be required, so at start-up this feature will be used for collimator alignment only.
- Clearly, the verification of settings remains a very hot topic for movable devices. Isolated but potentially very critical problems did occur. It was pointed out that LSA has some weaknesses related to setting management. The change of a resident beam process is not adequately protected and this affects in particular injection protection settings. The safety conditions still rely in some cases on manual interventions!
- A possible improvement for the TCT interlocking might come from a new implementation of dump limits versus beam-beam separation. The collimation team will come with a proposal for a possible implementation during LS1. In parallel, this requires the development of a reliable calculation and distribution of a new parameter to be added as SMP in the timing.
- It was pointed out that the conditions for critical settings preparation/validation were not always ideal. People were often handling critical settings manipulations under pressure from the machine side. Enforcing improvements for the operation at 7 TeV (e.g. authorizing the change of critical settings during day time only), should be considered.
- For possible operation of beta* levelling, one should look into the scaling of TCT losses at 7 TeV versus thresholds of the beam loss at the detectors.

- Should we consider giving more responsibility to the shift crew in the validation of systems critical for machine safety?

SETTINGS GENERATION, MANAGEMENT AND VERIFICATION (G. VALENTINO)

Discussion

A. Siemko asked how the beam separation was taken into account for the settings generation of tertiary collimators. G. Valentino replied that the change of collimator centres follows the linear variation of beam separation versus time, as defined by the orbit correctors.

R. Schmidt asked about the use of the aperture meter and of the colour coding. S. Redaelli pointed out that this tool was unfortunately mainly used during commissioning and MDs (aperture measurements) and not in standard operation. He also pointed out that the colour coding is indicative - the system is anyway not connected to the beam interlock.

S. Claudet commented that, based on his experience with fixed displays for the cryogenic system; one should aim at very simple displays and colour coding. The collimator displays seemed to be too complicated. R. Giachino commented that, in his opinion, one should not see red boxes, which would mean that everything is under control. S. Redaelli replied that the system is intrinsically rather complicated: for example, red boxed in stable beams are associated to injection interlocks caused by injection protection devices in "out" position. S. Redaelli suggested to get a clear statement from OP about preferences for the display design (some prefer to have more expert-like displays to understand better the systems, others prefer simpler displays that just indicate problems).

Summary

- The new software for setting checks seems adequate to address problems encountered in 2012. Some further improvements are in the pipeline. We should consider how it could be extended to the injection protection settings.
- The discussion was animated by very lively debates about operational displays. The present tools are adequate for expert usage but could be improved for shift crew operation. It was proposed to improve the collimator fixed display with a machine-mode-dependent status (ok / not-ok). At the same time, it was agreed that a mini-team should be formed in OP to agree on fixed display design, to provide feedback to the system experts. On the same line, OP was also encouraged to use the ALARM system more often.
- The aperture meter within the online model packages has a great potential and should be developed further. Appropriate software support should be made available.

BEAM-BASED VALIDATION OF SETTINGS (B. SALVACHUA)

Discussion

B.E. Holzer asked if one can distinguish horizontal and vertical losses during standard operation. This could open the possibility to use operational losses instead of or alternatively to standard loss maps. B. Salvachua commented that it's possible to compare with reference cases. S. Redaelli added that in any case it would be hard to avoid dedicated loss maps: we cannot guarantee that in standard operation we have regularly horizontal and vertical losses in the phases of the cycle that require validation. On the other hand, he acknowledged that monitoring of losses during the fill can provide an early detection of possible problems.

Concerning the excitation of non-colliding bunches with the ADT during standard fills, J. Uythoven commented that we should be careful in having intentionally very high losses when the machine is full. This option must be evaluated in detail.

Summary

- There was a great improvement for betatron loss maps thanks to the ADT excitation. On the other hand, the asynchronous dump validation and off-momentum loss maps determine the minimum required number of validation fills. The strategy for this type of tests in the future (how many do we really need?) and possible improvements (like using controlled RF trims) must be addressed.
- The possibility to perform individual bunch excitations with machine being full (loss maps at the end of each physics fill?) should be evaluated.
- Online monitoring of losses should continue. It was however pointed out that clean-loss-maps conditions cannot be entirely avoided. Also note that in 2012 we almost never repeated loss map measurements for regular validation: the loss maps validations were triggered by the many requests of machine configuration changes.

COLLIMATOR HIERARCHY LIMITS: ASSUMPTIONS AND IMPACT ON MACHINE PROTECTION AND PERFORMANCE (R. BRUCE)

Discussion

B. Dehning asked if the uncertainty on the orbit is included in the simulations. R. Bruce replied that the simulations assume a pessimistic scenario, based on the analysis of the fill-to-fill orbit measurements. J. Wenninger commented that part of the orbit changes is an artefact of measurements, but it is not easy to quantify this.

A. Siemko asked about the long-term stability of the collimators. How often do we need to re-align them?

S. Redaelli commented that the stability is very good, to the extent that only one alignment per year is sufficient to ensure an adequate performance. Collimators in the IRs have to be aligned when the machine configuration changes.

R. Schmidt suggested that one could identify most critical collimators likely to be affected by large losses. One could think of addressing these critical cases first. S. Redaelli replied that it is foreseen to build prototypes based on new collimator material and one could indeed envisage to intervene first at the locations that are more exposed.

Summary

- The models for understanding beam losses in case of fast failures, based on semi-analytical analysis and complete particle tracking, are very well advanced. We are confident in the validity of the results. The simulation results might be used to relax some of the pessimistic design assumptions.
- Even in case of asynchronous dumps, the settings are chosen in a way that makes severe damage improbable. On the other hand, we have to be very careful during the collimator alignment when fragile collimators will be close to the beam with few bunches in the machine.
- The beta* reach based on old assumptions is between 31 cm and 60 cm. We will not rely on the full potential from the new BPM design before we are confident that it can be used as expected.
- We should understand in detail the protection level of the triplet magnet with the presently allocated margins between TCT and triplet apertures.
- There are some ideas to use the phase advance as a free parameter to relax machine protection constrains.
- The collimation project is considering with high priority the possibility to build few collimators using new materials to improve the machine performance.

UPDATED ROBUSTNESS LIMITS FOR COLLIMATOR MATERIALS (A. BERTARELLI)

Discussion

B. Goddard asked if the damage limits depend on the beam emittance. A. Bertarelli replied that in case of large impact parameters and high intensity (as addressed in his talk) the dependence on emittance is limited. This parameter can be important for the precise onset of damage, though.

B. Goddard also asked about the confidence in the scaling to high energy. A. Bertarelli replied that the results depend on the energy profile in the material volume. The errors in the scaling should not be very significant: they depend on the scaling of cross section for various interactions in FLUKA.

R. Schmidt asked about availability of equation of state. A. Bertarelli replied that it is very difficult to get them from outside, as they are often protected as military secrets. We are trying to build here the relevant parameters, thanks to the available data from beam tests.

Summary

- The results on real collimators and material samples from HiRadMat are impressive.
- The simulations are - unfortunately - in the good ballpark. The extrapolated safe limits for metallic collimators at top energy are below a nominal bunch. This will have an impact on the commissioning strategy.
- The damage onset dependence on the beam emittance should be addressed in more detail.
- A panel of new materials for future collimators and targets is being built, including the information to define appropriate equations of state.
- A working group attached to the collimation working group will be formed to come up with an executive summary of the HRM test, to prepare new tests after LS1 and to identify new materials for future collimators.
- A rich program on the effects of radiation is ongoing in collaboration with Kurchatov Institute and BNL.