155th Meeting of the Machine Protection Panel

Participants: A. Antoine, G. Baud, M. Gasior, D. Lazic, T. Lefevre, B. Lindstrom, A. Mereghetti, Y. Nie, J. Olexa, J. Uythoven, M. Valette, J. Wenninger, D. Wollmann, M. Zerlauth.

The slides of all presentations can be found on the website of the Machine Protection Panel:
http://lhc-mpwg.web.cern.ch/lhc-mpwg/

1.1 Approval of MPP#154's minutes

Actions from the 154th MPP:

- Matthieu: follow up on the SPS crab cavity failure tests and LLRF interlocking.

1.2 Redundancy of the SIS DOROS front-ends (M. Gasior)

- Marek presented a proposal for adding redundancy in the DOROS BPM front ends.
- The DOROS system consists of 6 interlocked readouts for BPMs embedded in collimators. If one of the front-end breaks it would cause a dump and prevent injection. In order to avoid delays when an intervention is needed, a redundant system should be implemented. The considered hardware failure are estimated to happen only once every 50 years per system, leading to a failure every 8 years on average with 6 systems. This estimate on mean team between failures comes from operational experience with the 25 systems currently installed throughout the accelerator complex which experienced one failure in two years of operations. This estimate is conservative, because the DOROS system runs in standalone and needs less network communications than the standard system.
    - Jorg commented the DORSO system have led to faults a few times in the LHC already. Marek answered these were network or connection failures (for which mitigations are currently under work), therefore hardware failure requiring replacement are the source of concern here.
- A first proposal for a redundancy scheme is presented in slide 4, whereas the redundancy would be from the upstream to the downstream system in IP1 and IP5, the cost would only be two additional front ends (for IR6 where the scheme cannot be applied) but would imply exotic software configuration.
- A second option is presented in slide 5, and would imply full redundancy of all the front ends with split signals. This solution would be more costly as a full set of 6 front ends would have to be bought and would allow straightforward setting of parameters. This would come at the cost of 40% less signal on each channel, which would not affect the measurement for

nominal proton bunches but might lower resolution on pilots and ion bunches.
    - Jorg commented the two front ends operating on the same BPMs would have to be powered from different networks to provide full redundancy.
    - Daniel asked how the interlocking would be implemented in practice. Jorg proposed a voting system in which two out of four BPMs reading the same beam and plane would have to be out of tolerance.
- In summary, the duration of an intervention to change one of the DOROS front ends is unknown but not going for this redundancy schemes would imply establishing a piquet service and the BPM team is small. Out of the two options for implementing this redundancy, the second one is preferred as there are enough spares to use, with a small extra cost coming from the mechanical installation. The implementation would take up to a week.
    - Jorg asked when the DOROS software was last updated because he recently observed jumps of up to 200 µm of the orbit in the IPs. Marek answered it was done after fill 6470.
    - As a more general question, it was asked how many more DOROS front ends will be needed for collimators in the future. Alessio commented all future collimators will be equipped with buttons but mostly for alignment only, not for interlocking. It might be necessary to interlock on the IR7 collimators which would imply two extra systems with full redundancy.
        - Thibaut observed that the read out system was not meant for radiation intensive areas so it might not be copy pasted to IR7, or IR3.
        - Jorg added the system is not fast, which is OK for most places but might not be suited for IR7 where any movement of the orbit leads to high loss power where the BLMs provide protection.
        - Thibaut explained that the project can go in several direction from now, radiation hardness would be one but should be decided soon as the purchase of new components is ongoing.
        - Jorg concluded that IR7 would need hardware interlocks with turn by turn data and not software ones.
    - Daniel explained there are two scopes: 2018 operations and post-LS2 operations. For 2018, there are no objections to install the full redundancy option during the YETS. This will allow learning more about the systems and estimate the mean time between failures more accurately. Then, for the long term future, how many systems will have to be installed and how many should be interlocked is still an open question. Alessio stated there would be less than 20 collimators with interlocked BPMs, Marek commented this was already useful information. Jan suggested editing a small note on the topic to document it and so OP could comment.

- Finally, Daniel recalled a statement from Ralph that BPMs on collimator lead to better alignment and larger retraction, hence, lower β*.

Action (CollWG): Define use cases for the DOROS BPMs in IR7 collimators.

1.3 Configuration change of PIC to interlock all RQS circuits (A. Antoine)

- Alain presented a reminder on the PIC and BIS status and the implementation of RQS interlocking.
- The PCI allows three different configurations for the generation of interlocks towards the BIS:
  - Unmaskable, for example: RB, RQF, RQD, RQX, RD1-4, RQ4-10.
  - Auxiliary, RCS, RQT, RSD, RSF, ROD, ROF.
  - No impact, RQS and other higher order corrector circuits.
- There were 30 trips of RQS in the past, 80% of them without beam. For the others, 2 trips caused a dump via the BLM afterwards and 5 trips caused a lifetime dip but no dump. On average, interlocking would add 5 dumps per year.
- All events up to now are relatively similar: a quench/trip of the circuit than a dump one second later with very slowly rising losses. The second event was faster with a dump after 400 ms.
  - Daniel asked if these event were due to real quenches. Markus answered the PIC sees a fast powered abort being triggered and cannot make the distinction itself, most cases are however rather due to spurious triggers of the QPS as these correctors almost never quench.
- Interlocking would have an impact on availability but would mean the protection from these failures is redundant and self-consistent within PIC. Redundant protection is important to protect against redundant failures like of the BLMs. The recommendation from MI is nevertheless not to include the RQS in the PIC.
  - Daniel stated one would interlock to avoid collimator damage. Jan answered collimators are not a concern but quenching magnets are, as the standard philosophy for interlocking is to cut at the source of the problem and not the associated losses. In this case, the loss levels are low and develop very slowly so one might prioritize availability.
  - The cause of the failures is always different but Daniel observed the DCCT is often involved, which might come from the sensor. Markus replied there is a consolidation plan from QPS to upgrade them in LS2 (using additional $\frac{dI}{dt}$ sensors).
  - Matthieu suggested that the structure which appeared in coupling correction from this year might be checked next year in case it becomes even stronger.

- Daniel concluded the RQS would not be interlocked but it is a good thing to finalize this study now that more statistics are available.

AOB - all

- In two weeks, the last MPP of the year will be held with Manfred presenting the BPM upgrade for LS2 and a decision on the removal of flat top corrections for 2.5 TeV.