SUMMARY OF SESSION 7: MACHINE PROTECTION

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Abstract

This session reviewed the relevant aspects related to machine protection during 2016 LHC operation, focusing on improvements with respect to previous runs and aspects/issues to be followed up in the future.

Machine protection during 2016 run and review of machine protection strategy (D. Wollmann)

- The 2016 intensity ramp-up was very efficient, requiring only two weeks to reach 1700 bunches. Two standard ramp-up scenarios have been identified and performed: one following minor hardware interventions, requiring 2 fills for intensity ramp-up, and one following major interventions, requiring instead 3-4 fills.
- Additional gain could obtained by redefining minimal scenarios for asynchronous dumps and loss maps. A clear distinction should be made between performance studies and machine protection tests.
- For MDs, the approach followed in 2016 was very efficient: a detailed procedure was developed and approved for each MD. Three classes defined the risk related to MDs, from A to C, C being the one with highest risk. Class C MDs require approval by rMPP.
- Any change in machine protection settings or systems require approval by MPP.

Discussion

- *J. Wenninger* pointed out that the MD procedures used to be written by the MD users together with the EIC who was foreseen to be on shift during the MD. This implied too many complications in the follow-up and the practice was dropped. *G. Papotti* added that it is nevertheless important to continue the preparation of the MDs with EICs, as it allows more efficient preparation of settings and filling schemes.
- *J. Wenninger* stated that the machine was so reproducible during the p-Pb run that he took the decision, after consulting a small number of people, not to go for any special validation before switching back to 4 Z TeV at the end of the Pb-p run. *D. Wollmann* agreed with the excellent reproducibility of the machine, but commented that as some collimator settings were changed, this decision might have been reviewed.

BLM thresholds and UFOs: summary of 2016 and outlook for 2017 (A. Lechner)

- In 2016 about 2000 BLM thresholds were changed for proton operation, 50 for ion operation
- Applied thresholds are defined based on a master threshold (shared for all BLMs of the same family) and a monitor factor (can change individually for each BLM).
- Most changes were applied to avoid unnecessary dumps due to UFOs in the arcs and DSs
- The conditioning observed on the UFO rate continued in 2016.
- 22 UFO-induced dumps were registered in 2015, over 700 h of stable beams; 21 events were registered in 2016 over 1800 h of stable beams, demonstrating the effectiveness of the applied strategy for BLM thresholds. In both years 3 UFO-induced quenches were observed, but the statistics are too low to make any extrapolation for future operation.
- If we would have applied a quench preventing strategy, we would have observed 71 UFO-induced dumps and still one quench (too fast to be prevented)
- In 5 cases in the LSS the beams were dumped by the Beam Condition Monitors. An optimization of the related thresholds should be studied.
- In 5 cases beams were dumped by a UFO in cell 5L1, which could be mitigated with a local adjustment of the thresholds.
- It was proposed to keep the same strategy as 2016, namely keeping arc thresholds a factor 3 above the quench levels.

Discussion

- *J. Uythoven* asked what would have been the gain (if any), of setting the BLM thresholds at 5x the quench levels, as at the moment they are at 3x the quench levels. *A. Lechner* answered that there would not have been any significant gain with a factor 5, a factor 3 seems to be the optimum.
- *O. Bruning* mentioned that there was a spike in the UFO rate after beam screen warm-up. *A. Lechner* confirmed this effect was observed, but already in the next fill the rate was in line with the usual values in the arcs.

LBDS (E. Carlier)

- All dump requests were properly executed by the LBDS in 2016, with no asynchronous beam dump.

- Operation in 2016 was more demanding for LBDS than for the 2015 run, due to the longer time operating at 6.5TeV. Despite this, the total LBDS downtime was lower in 2016 as compared to 2015.
- Two MKBH self-triggers were observed, leading to synchronous dumps. The recovery from these events requires a generator exchange and a system revalidation (total of about 15 h). These issues will be addressed during the EYETS 2016-17.
- The problem related to the MKBH retrigger line coupling, potentially leading to a simultaneous misfiring of three MKB kickers, has been solved during EYETS.
- A local reliability run at 7 TeV will be performed during the EYETS 2016-2017 to re-assess the LBDS availability for 6.5 TeV operation and to re-evaluate the ability to go to 7 TeV.
- A remote reliability run with local BIS loops is needed to revalidate the system at the end of the EYETS (featuring upgrades on MKBH generators, TSDS and CIBDS).
- Standard Cold Checkout / Recommissioning with beam will be performed at the end of the EYETS.

Discussion

- *P. Baudrenghien* stated that due to the foreseen cavity phase modulation and full detuning running mode, the minimal length of the abort gap (or in general the beam gap) should be defined. What will be the longest gap in the filling scheme? *E. Carlier* answered that the abort gap itself should not be longer than 3us as from design. *W. Hofle* added that the last injected train should be as close to the abort gap as possible, in order to keep the beam gap short.
- *R. Bruce* asked what is the main reason for the very low rate of asynchronous beam dumps. *E. Carlier* answered that thanks to all clean-up and maintenance efforts the erratics were minimized, but it is not guaranteed that no asynchronous beam dumps will be observed in the future. *J. Uythoven* pointed out that this shows importance of LBDS reliability testing and dry runs. *E. Carlier* added that full sparking activity measurements will be carried out before the reliability run and after the reliability run.

QPS (J. Steckert)

- The QPS system has reached its nominal configuration in 2016
- All quenches were detected correctly and the system exhibited more than 99 % average availability
- The QPS showed an excellent performance with respect to radiation-induced failures: during the proton run no faults were registered, two unconfirmed events were observed during the ion run
- Faults induced by massive upgrades of QPS in LS1 have decayed (cables & connectors, cards not properly inserted, etc.)
- YETS 2015-16 interventions significantly improved system availability
- No major changes to the QPS are foreseen prior to LS2, the challenge is shifted towards keeping and improving the excellent performance of 2016 in the future

Discussion

- *M. Lamont* asked about the zero crossing spikes – do they come with beam? *J. Steckert* answered that the spikes are not correlated with the beam, but occur during the ramp-down of the circuit and pre-cycles. M. Lamont asked if it is needed to have the zero crossing. *D. Nisbet* answered that it is needed, it is an inductive circuit.
- *A. Apollonio* commented that as we have reached the maturity of the system (i.e. a constant failure rate), more rare events are probably going to show-up and these will be driving the downtime. *J. Steckert* confirmed this is the case, the piquets will have to deal with more and more exotic failure scenarios.

Collimation (A. Mereghetti)

- A limited number of hardware and software upgrades of the collimation system was performed during the YETS 2015-16. Nevertheless, these were relevant for speeding up commissioning and set-up activities (e.g. RF trim for off-momentum loss maps and BPMs for fast alignment)
- The collimation system exhibited excellent reliability and reproducibility in operation
- Given the good orbit stability, a SIS interlock on BPM readouts at TCTs (and IR6 TCSP) can be proposed
- The installation of new hardware during the EYETS 2016-17 is especially relevant for MD activities in view of HL-LHC (e.g. low-impedance collimator prototype and two collimators with long-range beam-beam wire compensator).

Discussion

- *J. Wenninger* pointed out that alignment times are now at the level of ~6 hours. Now we spend much more time testing out functions than actually aligning collimators, so this calls for taking these parts into account for further optimisation. *S. Redaelli* confirmed that indeed, the setup is not driven anymore by the alignment time.