116th Meeting of the Machine Protection Panel

Participants: A. Apollonio, J. Baechler, R. Bruce, F. Burkart, V. Chetvertkova, B. Dehning, M. Deile, B. Gorini, M. Kalliokoski, J. Kaspar, D. Lazic, S. Mazzoni, A. Mereghetti, G. Papotti, S. Redaelli, B. Salvant, R. Schmidt, H. Timko, J. Uythoven, A. Verweij, S. Wenig, J. Wenninger, D. Wollmann, M. Zerlauth.

1 Approval of Minutes

The minutes of the 113th, 114th and 115th MPP meeting were approved.
M.Kalliokoski commented on a previous action that the wire-scanner-MQY(cell6) thresholds had been cross-checked for compatibility with scanning 15 nominal bunches, which should be possible with the new proposed thresholds.
The ECR for the BCCM is completed and has been sent to Samy Chemli for approval. The activation of the BCCM has been endorsed by the LMC this Wednesday and the according BIS input has been activated during the TS#2 in the standard set of maskable BIS inputs, on channel 9 in UA47

2 Presentations

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

2.1 Review of TOTEM RP insertions during the intensity ramp up (M. Deile)

- Mario presented a summary of RP insertions during the intensity ramp-up:
  - 3rd July: Beam-based alignment of all 14 low-beta RPs
  - 4th July: Loss maps with RPs in very conservative positions (~ 30 σ horizontally, ~ 20.5 σ vertically) , TCL5 IN, TCL6 OUT
  - 5th – 14th July: successful RP insertions in all intensity steps of 50 ns intensity ramp-up (3 to 476 bunches)
  - 12th August: New loss maps were done with RPs closer by 1 mm (without safety margin) but agreed positions for 25ns ramp-up and operation are still with 0.5 mm safety margin (~ 25 σ horizontally, ~ 19.5 σ vertically), TCL5 OUT, TCL6 at 25 σ
  - 13th to 21st August: successful RP insertions in first part of 25 ns intensity ramp-up (2 to 315 bunches, 450 step is still missing)
- Mario showed an example (fill 3996) of measured BLM signals during the 50 ns ramp-up (slide 3):
  - The red curve describes the RP position. When RPs go IN, additional losses are observed
  - About 1/3 of XRP BLM rate comes from TCL5 (or further upstream)

- Mario then presented the evolution of measured BLM signals (RS09) as a function of the beam current (slide 4) for 50 ns:
  - The plot contains the highest value of measured losses after RP are IN (as shown in slide 3) for each intensity step
  - A quadratic dependence can be observed
  - B1 has almost 2 times higher losses than B2, something which is not fully understood yet
  - The highest losses are measured after cylindrical pots
- When plotting BLM signals as a function of luminosity, a linear behavior can be observed, indicating that losses are luminosity and not beam intensity driven.
- The same plots shown for the 50 ns ramp-up were presented by Mario for the 25 ns case
- Mario showed an example (fill 4243) of measured BLM signals during the 25 ns ramp-up (slide 6):
  - Losses can be observed in 3 different configurations:
    - only TCL5 IN
    - TCL5 OUT and TCL6 IN, RP OUT
    - TCL5 OUT and TCL6 IN, RP IN
  - With TCL5 OUT, the BLM signals decrease in all XRP BLMs except in the B6R5 BLM
  - Roderick commented that a crosstalk between H-V TCL BLMs was observed in the past (almost 50 % of the final signal with RP IN). To be further investigated, disentangling TCL5 and TCL6 movements in the sequence could help to better understand this.
  - TCL6 BLM sees mainly the showers from TCL6, a very small contribution is from XRPs
  - Only one BLM in the region doesn't provide data in TIMBER. Markus suggested checking if this is related to the BLMs renaming
- Also for 25 ns, when plotting BLM signals as a function of luminosity rather than beam intensity, a linear dependency can be observed
  - A linear extrapolation to the nominal luminosity $L=10^{34}$ cm^{-2} s^{-1} would lead to losses close to the dump limit.
  - The BLMs at the TCL6 would reach 103 % of the threshold at $L=10^{34}$ cm^{-2} s^{-1}
- More measurements are required for correct extrapolations to assess whether smaller retractions can be reached with RP (so far only two points are available)
- The proposed strategy is:
  - Complete the 25ns intensity ramp-up to highest luminosity
  - Measure BLM response at different distances: after automatic insertion retract in steps from 25 σ to 50 σ to have more constraints for the empirical extrapolation
  - Direct measurement: if the orbit proves to be reliable, remove (or reduce further) the 0.5 mm margin
- Daniel asked if loss spikes are observed when RPs move IN. Mario commented that no spikes were observed, he's more worried about possible 'plateau' losses exceeding thresholds

- Stefano asked if an extrapolation from loss maps luminosity could be useful, moving RP IN during loss maps. Mario replied that the signal would be too low for extrapolations with only 3b / beam
- Mario then presented vacuum related signals during a RP insertion (example in slide 9 for fill 4243 during 25 ns ramp-up)
- During the ramp a vacuum pressure increase is observed, which disappears only during adjust. Benoit commented this is behavior is observed the whole machine and at this position it is probably coming from the TCL5. It's definitively independent from RPs.
- This appeared in all fills with beam, it was not checked without beam
- ACTION: it should be checked whether the magnitude of the vacuum spike varies with intensity – this was verified offline by Mario and does not seem to be the case.
- Joachim commented it could be related to UFO activity, Giulia could look at the timestamps and verify this hypothesis
- Mario presented plots of vacuum pressure as a function of beam current, for B1 and B2, both for 50 ns and 25 ns
- Trends are more pronounced for 25 ns, highlighting a non-linear dependence of pressure on luminosity or current. In the next intensity steps one would expect a very significant rise, based on current observations
- Nevertheless vacuum thresholds are still about one order of magnitude higher than the observed pressure levels; still the situation needs to be closely surveyed.
- When looking at related temperature measurements for impedance monitoring, no dramatic temperature rise are observed
- Daniel asked what is the position of temperature sensors. Mario replied they are directly on the flange, so they should be sensitive.
- Joachim commented that also the position of the vacuum pumps could matter for the observation of the vacuum spike as there is no vacuum pump nearby the sensor where the highest peaks are observed.
- Mario added that temperature profiles seem to show a saturation effect within a few hours, i.e. they are reaching an equilibrium. Benoit commented that he would expect a faster equilibrium in this case, temperature is rather correlated with vacuum conditions in other cases
- Stefano suggested having sequential and step-wise (partial) insertions for the next intensity steps to disentangle where the different contributions to the signal comes from
- This would be done practically by a manual sequence executed from the CCC, doing the same for TCL5 and TCL6.
- Alessio added that thresholds at TCL6 are set for luminosity scaling reasons already, so this is not worrying for the moment, vacuum considerations should have higher priority
- Markus suggested keeping the same strategy for RP insertions as for the previous intensity steps
- Markus asked about software stability and Mario explained that it has been perfectly stable for two months. The sequence for setting of inner dump thresholds is still failing with an exception (see related MPP

meetings for details). The software bug was in the meanwhile identified and fixed by Sylvain, but a new (partial) interlock validation would be required to deploy this version in operation. In the morning of 4th September the PXI crashed, but it's not clear if it's related to the update. MPP requested to roll back to the previous, fully validated and archive version, even with the known bug still present (ACTION). As the problem could be on the FESA side, maybe it would be sufficient to do some simple tests

- Jan asked whether TOTEM is interested in participating in the initial ramp-up after the TS (50, 200 and 480). Joachim replied they are willing to participate. Stefano added that the parasitic scans (RP + TCL5 and TCL6) could be done together e.g. during the 200 bunches step, to be further discussed (ACTION)
- MPP recommended for TOTEM to participate as well in each fill of the intensity ramp-up.
- ALFA will come back in the next MPP for an update, but they are not part of the intensity ramp-up, ALFA is disabled until the high-beta run. Benedetto commented that their measurements could be interesting for UFO statistics

2.2 Issues during intensity ramp-up (D. Wollmann)

- Daniel presented an overview of the issues during the intensity ramp-up
- For each intensity step, a check-list was compiled to keep track of all discovered issues
- The 50 ns ramp-up featured 6 intensity steps (3, 13, 50, 152, 296, 476 bunches)
- Issues related to 50 ns ramp-up:
    - Magnet Powering:
        - SEUs in QPS board for splice protection led to trips of RBs sectors OR partial trip of sector by the PIC due to intermittent opening of the quench loop. The beams were dumped but the RBs staid powered. As a mitigation, the replacement of some boards was carried out in TS2 AND the opening of 13kA EE switches via SIS activated. Jorg commented that monitoring the 13kA EE was already active on the SIS side, but there were problems on the WinCC side, now it is implemented correctly and fully validated for operation
        - QPS_OK flickering: the signal is masked. Upon a question from Arjan, Jorg explained that the signal is actually filtered in the SIS, but still some flickering can still be observed and can possibly lead to a dump. Markus added that changes at the WinCC level are required and can only be solved the earliest for the end of the year
        - Transient earth fault in RB.A78
        - Earth fault in RCS.A78.B2: the circuit has been condemned
    - Interlocks and PM

- BIS: timing mis-alignment between LHC and INJ BIC was solved
- Communication problems between BLM crates and SIS (due to UFO study buffer) were mitigated via a FESA class update
- UFO dumps are intensity-dependent

- RF
  - Problems with phase loop caused beam to de-bunch, leading to dump due to losses
- Beam Instrumentation
  - Glitches of SBF due to noise on one B2 DCCT, the issue was solved
  - BLM PM data missing for R2, R3, and in IP6, solved via roll-back. The PM data collection module is being extended to check data collection and send automatic emails to experts in case of missing PM files.
- Collimation
  - Spurious ALFA dump due to glitch of position measurement (LVDT): a solution has been implemented, to be re-discussed in next MPP meeting (ACTION)
  - Resolver disabled in TCTPH.4R2.B2, TCSG.A4L7.B2, replaced?
  - LVDT drifts on some collimators (~50um)
  - Temperature sensor disabled on TCTPV.4R8.B2
- Operation and Feedbacks
  - Problems with QFB (50Hz lines), solved with filter review
  - Orbit drifts due to movement of triplet R8, the effect was mitigated by using a slow orbit feedback in collision. Jorg explained that the most likely explanation is a change in weight distribution of the triplet on its supports, following cryogenic refilling activities, therefore orbit drifts are observed. Measurements are available via wire pressure sensors
- LBDS
  - Generator exchanged following an asynchronous beam dump (MKD erratic B2, generator C)
  - BPMS software issues (FESA) prohibited to change interlock limits, solved
  - XPOC: PM BLM data missing; TSU data arriving too late, solved
- Injection
  - The missing BPM capture data of injection oscillations was solved as confirmed by Jorg. It was a string length problem, changes were implemented before the 25 ns scrubbing
- Heating of Equipment
  - Decrease of bunch length at flat top
  - TDI B2 temperatures increase steadily during the fill
  - TCSP.A4R6.B1 shows a different thermal dynamics than all other collimators

- The 25 ns ramp-up featured so far 3 intensity steps (up to 458 bunches, still to be finished)
- Issues related to 25 ns ramp-up:
  - Magnet Powering
    - Intensity-independent issues related to magnet powering are inherited from the 50 ns ramp-up
    - Malfunction power supply in EE switch of RQTF.A56.B2
    - Beam-induced quench of MB.8L6 due to UFO losses
    - Trip of the undulator in L4 due to slow increase of offset in U_RES. The sequencer check has been re-activated
  - Interlocks
    - UFO dumps, scaling with intensity to be assessed. Measurements are available for direct comparison of UFO rates for the same intensity step (280 bunches) with different bunch spacing and same conditioning
  - Collimation
    - Disabled temperature sensor on TCLA.B5L3.B2 due to non-physical behavior.
  - Operation/Instabilities
    - Blow up of B1 bunches within the first ~300 buckets leads to dump when reaching detection limit of BPMs. A shift of filling pattern should be discussed and BPMs run in high gain mode after TS2. Jorg added that this was observed also for B2. The hypothesis that this effect could be related to a malfunctioning of the damper was not confirmed by the analyses carried out by damper experts, who were not able to find anything misbehaving. A solution to this problem could be to make the affected colliding bunch pairs non-colliding
    - The BBQ-B1 gating on bunches is not usable below 2-3TeV with high gain
    - Loss of cryo maintain in MS R8
  - LBDS
    - MKD compensation power converter trip during ramp-down, it has been replaced.
  - Injection
    - High losses were observed in TI2 during injection of 12 and 24b trains
    - The TDI at IP8 interlocked 3 times going to injection settings. Jan commented this this was a mechanical problem with an end-switch support which has now been replaced
    - Jan added that huge vacuum spikes were observed on TDI8 (especially during the scrubbing run). This is a big concern for filling with high intensity in the future
  - Heating
    - Decrease of bunch length during fill. Benoit comments that the decrease in bunch length (due to the emitting of synchrotron radiation) is apparently no problem, as the

increase heating due to the decrease bunch length is compensated by the decrease in intensity. Thus, for the moment nothing to worry about. For the future a stronger bunch length increase during the ramp could be envisaged.
    - Transients on sector 12 and 23 increasing with intensity: now 10 W on top of a heat load of 15 W but explained by different cooling scheme of CRYO. Abrupt transients appear after injection and disappear during the ramp on most sectors. This seems to be a real effect.
    - TCSP.A4R6.B1 shows a different thermal dynamics than all other collimators. Temperature is increasing steadily during stable beam by 1 to 2 C and seems to be building up with short turnover.
    - TDI temperature reaching 80C
    - TOTEM pressure increase in both 6L5 and 6R5 when moving roman pots in.
- Daniel then presented a plot showing the normalized losses at the septum magnet (TCDS) during dumps for fills in 2015. A decreasing trend can be observed over time, i.e. 25 ns dumps appear to be cleaner. A more detailed discussion follows below.
- A few out-standing MPS tests remain to be performed:
    - Virtual beta* for TL collimators. This will likely be ready only by the end of the year. As we currently do not use the Q20 scheme from the SPS this is not a major issue.
    - TL steering & interlock to block injection of more than 12 bunches in case of injection oscillations
    - Redundant opening of 13kA switches by SIS due to PIC interlock
- Around the 750 bunches step, Jan and Jorg agreed that the trains to be used should be of 72 and 144 bunches, to prepare already for the next intensity step (~1200 bunches). Benedetto commented he will have to have a look at the details for optimizing the filling scheme
- Jan added that the rise time of the MKI will be verified to be 900 ns before stepping to ~700 bunches.

2.3 Losses during dumps (V. Chetvertkova)

- Vera presented more detailed studies on the observed losses at the dump during the 50ns and 25ns intensity ramp-up 2015.
- Vera first recalled the plot presented by Daniel, showing losses at the TCDS normalized by the total beam intensity. With such normalization it seems that losses decrease over time, going to 25 ns
- Including the dumps during the RF MD, when the abort gap cleaning was ON, high losses were nevertheless be observed
- Vera then presented the plot showing losses normalized to the intensity in the abort gap. In this case, BLM signals do not show significant differences for 50 or 25 ns spacing. This verifies that the losses measured

in the BLMs close to the septum magnet (TCDS) are proportional to the population of the abort gap.
- More studies should be carried out for a better understanding of individual cases, where the losses and the abort gap population are not proportional.
- Jan commented that the BSRA data is not reliable for intensities below 10^8
- Markus commented that the first plot shown (normalized to total beam intensity) gives a measure of the dependency on the filling scheme
- Jan added that the main interest is to study the causes and distribution of the abort gap population. Thus, the BSRA should be the main data source, one should not only focus on BLMs. The RF MD could be an interesting case study, as all ranges of bunch lengths and spacing are covered. Furthermore the change of the abort gap population during the cycle should be studied, which could help identifying the sources of the creation of un-bunched beam. This is especially true un-bunched beam during the ramp.

2.4 AOB

- Collimation qualification will follow the strategy presented by Belen in MPP 115th
- For direct dump BLMs new cables will be installed during the Christmas shutdown