Meeting on Roman Pot Operation (MPP)

Participants: M. Aleksa, N. Bacchetta, J. Baechler, V. Boccone, C. Bracco, F. Cerutti, M. Deile, B. Farnham, M. Ferro-Luzzi, P. Fassnacht, S. Jakobsen. M. Lamont, A. Masi. E. Meschi, T. Pauly, X. Pons, S. Ravat, F. Ravotti, S. Redaelli, R. Schmidt, J. Wenninger, S. Wenig, D. Wollmann, M. Zerlauth

1 Presentations

The slides of all presentations can be found on the MPP website (http://lhc-mpwg.web.cern.ch/lhc-mpwg/MPP-Minutes-2010.html).

1.1 Introduction: Roman Pots and Machine Protection (R. Schmidt)

Several issues observed with RPs:

- RPs stuck due to PXI problems.
- Inconsistencies between motor positions and LVDTs.
- Wrong direction of movement (towards beam instead away).
- Issues with position RESET procedure.
- RPs outside the shadow of TCTs.
- Issue on 6/11/2011.

The high luminosity operation of RPs in physics settings is not acceptable under these conditions. We need to take these things as warning and take measures for improvements during the Xmas stop.

1.2 Status of FLUKA machine models from the RP locations to the DS for IP1 and IP5 (V. Boccone)

Presentation:

- IP 1 & 5 have been studied in detail for different cases but not with RPs.
- RPs will be treated as collimators (moving devices, acting on single beam, asymmetric positioning around IPs).
- A FLUKA RP model (TOTEM) was built from the production drawings. A modular approach was taken (V-H, H-V units, detector).
- TOTEM RPs integrated in IR5 LHC FLUKA framework model.
- Additional detectors (BLMs, RadMon, etc.) can be added on request.
- Missing information:

  - Prepare accidental scenarios with MPP.
  - Define beam optics cases (thick lens TWISS, beam offsets).
  - Normalization factors, aperture/positions of the detector.
  - Detector model, integration, drawing (help by ALFA, TOTEM for FLUKA model of detector?).
  - Contact person for detector.
  - Input parameters (optic, physics case, ?).

- The Time schedule depends on the arrival of the missing information and the scenarios to be simulated.

Discussion:

- R. Schmidt comments that the parameters for these simulations should be very similar to the ones previously used for TCDQ simulations (see parameters defined by Brennan). V. Boccone asks if multi turn effects need to be taken into account as RPs are different to the TCDQs? This would take much more time for simulation. J. Wenninger answers that we should start with a failure of the asynchronous dump and this is a single turn failure. I.e. what happens when a single bunch hits the RP?
- V. Boccone emphasizes that machine protection should define the scenarios to be studied.
- M. Deile comments that one should start with the previously defined scenarios: i.e. shoot a nominal bunch in the centre through the bottom foil of the RP. This is considered to be the worst case.
- R. Schmidt and J. Wenninger explain that this is exactly the asynchronous dump failure scenario.
- V. Boccone mentions that local simulations maybe fast, but the tracking down into the DS will take quite some time ($\sim$ months) as this would require to combine different simulation codes.
- S. Redaelli adds that we should use the same assumptions as for the asynchronous dump studies on the TCTs (see presentation last Chamonix).
- R. Schmidt asks if we need to consider the angular distribution of the beam. S. Redaelli responds that this is not needed for the worst case scenario. R. Schmidt then proposes to use a flat distribution, which would allow to easily reconstruct other distributions.
- **Action: Define accident scenarios (MPP, TOTEM, ALFA).**
- Input from ALFA: P. Fassnacht comments that the position and the mechanical supports of the ALFA stations can be directly copied from TOTEM (removing the horizontal pots).
  Action: ALFA will clarify the details and provide a contact person for the detector.
- **Action: MPP and Collimation will provide a contact person to FLUKA.**

1.3 Description of the HW system (M. Deile)

Presentation:

- TOTEM and ALFA design and position are the same (exception: ALFA only vertical).
- RP can only be moved from the CCC.
- HW switches protect against mechanical damage of the RPs.
- Pots can be extracted by mechanical springs or via an emergency button (only in ALFA and TOTEM control room, not in CCC).
- Position measurements by resolver counter (problem in case of moving out by springs, reset needed), LVDTs are only used for position interlocks.
- Interlocks: RP position, User Permit, Injection Permit, BLMs.
- BIC level interlocks are not mask-able, position limits can never be overwritten!

Impacts limiting LHC availability:

- Stable beams=0 causes extraction of pots by springs even when in HOME switch (i.e. pot position lost), no masking possible → change to avoid extraction of pots if all are in HOME switches. → less number of recalibrations needed.
- New inner limit was introduced without warning levels (unnecessary dumps, as pots would be extracted when reaching the warning). → add warning levels.
- FESA/PXI crashes or reboots: no change of limits possible, no interlocks, pots move out.
- PXI crash: no change of limits possible, no interlock if limits were not violated.
- Soft reset of PXI: move out pots, no dump.
- Hard reset of PXI causes beam dump

Used solutions to allow LHC operation in case of non-operational RPs:

- TOTEM: Jumpers to bridge LVDT comparison signals from PXI to interlock card. Afterwards disable all power of RPs.
- ALFA: Key panel instead of jumpers to overwrite the LVDT comparison signals from PXI to interlock card. Power for the pots needs to be cut separately.
- Comment from Machine Protection: **Both solutions should not be used again until a proper procedure was defined!**
- Action: TOTEM and ALFA are requested to specify an interlock system that guaranties that this functionality can only be used if the power was cut in all RPs (TOTEM/ALFA) and the out switches of all RPs (TOTEM/ALFA) are active. The details and drawings should then be provided to MPP.

Discussion:

- M. Zerlauth asks if there shouldn't be an emergency switch to extract the RPs in the CCC.
- A. Masi wants to know what happens if the PXI gets stuck? M. Aleksa explains that if the PXI is stuck the pots are extracted automatically (watch dog).
- A. Masi comments that, if the spring takes out the pot, the position should still be readable from the resolvers (multi-turn information in the electronics). Only in case of a power loss the position information would then be lost. The same is true for collimators. S. Ravat comments that this is currently not possible due to the low-bandwidth acquisition card which is too slow to resolve such fast changes. **Action: Mitigation in LS1.**
- M. Aleksa elucidates that the DAC card is too slow to count the multi-turn information when the pot is extracted by the springs. So the multi-turn information is lost in case of the RPs.
- A. Masi mentions that the accuracy of the resolver is 13 bits, i.e. 1/8 of a full step.
- R. Schmidt mentions that there is a possibility from ATLAS to overwrite the injection permit. This could allow injection when the ALFA pots are still in. Answer from ALFA: This overwrite was introduced to allow injection when a hardware switch is broken.
- R. Schmidt asks if we shouldn't first extract the horizontal pots before dumping the beam? Answer: The position dump limits of the RPs are defined as such that the beam can still be safely extracted.
- M. Deile mentions that the LHC beam mode *Unstable Beams* does not dump the beams but causes the RPs to move out.
- J. Wenninger explains that the key panel in ALFA bypasses all machine protection. Machine protection shouldn't be compromised for machine efficiency.
- S. Redaelli asks if the bypassing by the key panel can be done with a full machine at top energy? As this is only seen in a change of the injection permit signal in it is unlikely that anybody will take notice of this action in the CCC. M. Deile comments that it is possible to use this key with the full machine.
- A. Masi comments that in case of cutting the motor power the pots are moved out by the springs (guaranteed by the hardware). Therefore the CCC can be unloaded.
- R. Schmidt and J. Wenninger explain that such a key panel can only be accepted if it is guaranteed that the pots are in the out position (hardware switches active) and that the power to the motors is automatically cut by the same key panel.
- A. Masi comments that the responsibility to bridge interlock signals should be in the CCC.

- J. Wenninger emphasizes that such a key panel is too easy. In addition a formal decision process (MP, OP) needs to be defined. R. Schmidt adds that the hardware solution should guarantee that the pots are on the out switches, in case the key is used to bypass the LVDT interlock limits.
- **Action: Jumper/key panel (TOTEM/ALFA) to bridge LVDT comparison signals from PXI to interlock card should not be used again in their current status.**
- **Action: TOTEM and ALFA are requested to specify an interlock system that guaranties that this functionality can only be used if the power was cut in all RPs (TOTEM/ALFA) and the out switches of all RPs (TOTEM/ALFA) are active.**
- **Action: TOTEM/ALFA will propose/specify a procedure to safely allow the reboot of the PXI without causing a beam dump.**

1.4 Software and Controls for RPs (S. Ravat)

Presentation:

- Same FESA class code and RBAC maps run on ALFA and TOTEM production systems.
- Electrical stoppers are used as mechanical reference for step counters (repeatability $\leq 10\,\mu$m).
- RESET procedure initializes the step counters to the position of the electrical stoppers. RESET needs to be always performed when the pots were extracted by the spring, when the RP is in HOME position.
- Update of RESET procedure to avoid mismatch of LVDT and resolver position, as happened on the 6th of November. $\rightarrow$ improved Roman Pot state machine with two new states: un-configured, calibrating.
- Cross talk (spikes) between the stopper signals can compromise the RESET procedure. In the past this caused the observation of *non-moving* pots.
- Mitigation:
  - use filter
  - logically combine stopper & home switch signals

Discussions:

- M. Zerlauth comments that it seems like the spikes are caused by electromagnetic coupling. This could e.g. be solved by twisting the cables. It would be good also to find a mitigation for the reason of the spikes and not only fight the effect.
- M. Deile proposes to implement in any way the logic (home switch and stopper) and resolve the reason of the problem.

- S. Ravat explains that the modification of the state machine is needed to automatically re-initialise the positions when the pots are moved out. This will be implemented soon.
- R. Schmidt reminds that for the long term it would be good to replace the resolver cards bu those with an appropriate bandwidth. This would make the RESET method obsolete. In addition the full resolver signals would bring additional redundancy.
- It is agreed to use the logic (home switch and stopper) to overcome the spike problem in the RESET procedure.

1.5 Operational procedures and observations (S. Redaelli)

Presentation:

- RP movement under control of OP (CCC), positions must respect collimation hierarchy.
- RESET of the motor counters is only done in *Stable Beams* or with overwrite key = *true* (otherwise RPs cannot move). RESET is done manually.
- RP operation modes:
  - Beam based alignment in dedicated low-intensity.
  - Data taking during high intensity fills.
  - Special runs with high intensity fills. This mode became *standard* in 2011.
- Operational settings are qualified by loss maps.
- Procedures for high-intensity fills were followed without problems until 6th of November.

Discussions:

- S. Redaelli mentions that the position limits are typed manually into the system after approval.
- J. Baechler comments that the manual input introduces a risk of errors.
- M. Ferro-Luzzi asks what is needed to perform an independent hierarchy check. S. Redaelli replies that the configurations qualified by loss maps were implemented in the beam processes before. If the position of the pots is wrong we would see it in loss maps. J. Wenninger proposes to test this statement once by willingly putting the pots further in then the TCTs.
- P. Fassnacht mentions that the response of the application is often slow (3-4 seconds) and asks what causes this long time outs. S. Redaelli replies that this is maybe due to many pots connected to a single grate, which is different from collimators.
- R. Schmidt proposes to split the RPs into several PXI units to overcome this problem.

1.6 How to use the Roman Pots in 2012 and beyond (ALFA P. Fassnacht)

Presentation:

- Only two incidents during first season of running(for ALFA) in 2011 (PXI reboot, reset during ION loss maps).
- Plans for 2012:
  - Loss maps, standard optics 1 bunch (pots @ 7 mm)
  - Commissioning data at 25 mm during high intensity fills.
  - Maybe have to repeat 90 m data taking due to background problems.
  - Reach coulomb nuclear interference region → go to compatible (highest possible) beta* (with 2011 beam parameters this would mean ∼800-900 m).
- If possible it should be avoided to perform beam based alignments / qualification for commissioning runs at high intensity fills (RPs ∼25 mm).

Discussions:

- S. Redaelli asks if this means that ALFA doesn't want to run during high intensity fills. P. Fassnacht responds that high intensity fills are needed for commissioning of the RP of ALFA.
- M. Ferro-Luzzi points out that one should think if it is really needed to invest the full time to set-up and qualify the RPs for high intensity fills. Probably there is no point to make beam based alignments for the commissioning of the ALFA detectors in settings ∼25 mm.

1.7 How to use the Roman Pots in 2012 and beyond (TOTEM, M. Deile)

Presentation:

- Repeat beta* = 90 m run.
- Run at high beta* of ∼850 m.
- Running at standard fills in *Stable Beams* at low beta*. More conservative settings have to be explored for the horizontal pots couldn't be put the 18 sigma, as the loss level was too high. Running with the vertical pots at 14 sigma worked well.
- Intensify the collaboration with CMS for the high intensity fills.
- No end of Roman Pot operations in the foreseeable future, i.e. it is worth to improve the systems for the long term.

Discussions:

- S. Redaelli wants to know if all the RPs will be used, even the stations that were not used this year? M. Deile responds, that TOTEM wants to use the whole system, although this means additional set-up time.
- J. Wenninger asks if this means that TOTEM will run in every other luminosity fill?
- J. Baechler responds that this depends on the radiation damage in the detectors, which needs to be checked after the current run.
- Massi comments that the time consuming points in the TOTEM program are setting up the special optics and the RPs compared not the data taking time. So it would probably to optimise these times.
- M. Zerlauth stresses that more set-up configurations increase the probability for errors and increases the overhead also for Machine Protection.

2 Action list (summary)

- **Provide missing information to FLUKA team (TOTEM, ALFA).**
- **Provide contact people for FLUKA (TOTEM, ALFA, MPP, Collimation).**
- **Define accident scenarios for FLUKA simulations (MPP, TOTEM, ALFA).**
- **Jumper/key panel (TOTEM/ALFA) to bridge LVDT comparison signals from PXI to interlock card should not be used again in their current status.**
- **TOTEM and ALFA are requested to specify an interlock system that guaranties that this functionality can only be used if the power was cut in all RPs (TOTEM/ALFA) and the out switches of all RPs (TOTEM/ALFA) are active.**
- **TOTEM/ALFA will propose/specify a procedure to safely allow the reboot of the PXI without causing a beam dump.**
- **Allocate time for the RPs during the commissioning after the Christmas stop. Note: All interlocks, the modified state machines, etc. need to be fully recommissioned before RP can be allowed in 2012.**
- **Discuss possibilities to ensure that the correct position interlocks are loaded for the RPs the different operation modes. This is especially relevant, when the modes are switched, e.g. form special RP fills to high intensity fills. Would it be possible to implement a software check of the redundant inner position limit? (MPP, OP, Collimation).**
- **Implement and commission the modification of the state machine for 2012 start-up (ALFA/TOTEM).**
- **Implement and commission the modification for the cross-talk between stopper signals for 2012 (ALFA/TOTEM).**