124th Meeting of the Machine Protection Panel

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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#123's minutes

- Actions from 123rd MPP:
  - The LINAC4 watchdog was implemented by Juan Carlos and commissioned.
  - Recommissioning of BIS for users who did upgrades went fine, details of the user logic are still being followed up by D. Nisbet.
- Markus informed about an unintentional disconnection of an EXP User_Permit (due to a maintenance activity) to the BIS which provoked a beam dump with a nominal bunch in the machine. While this is not a safety issue, all BIS users shall at this moment of commissioning and operation announce any intervention on their system to the CCC and the MPP team (in order to decide on an eventual re-commissioning of the connection).
- No additional comments were received on the minutes, therefore they are considered approved.

1.2 New type of asynchronous BD with erratic on 3 MKDs (M. Fraser)

- Observations of the hardware during energy scans was presented in detail in LIBD 15/3/16
- A new type of erratic dump kicker firing was observed on Feb 26: Three kickers O, N & M triggered and retrigger started the remaining ones.
- The M, N & O generators are under close observation during operation ever since. After the event they were successfully conditioned to 7 TeV then stayed 6h at 7 TeV without problems.
- Since then 165h at 7 TeV and 6 energy scans up to 7.1 TeV were performed without problems.
- Major difference to type 2 erratic is: voltage is slowly creeping up first, and reaching normal rise time later.
- Usually the erratic probability increases with voltage and time of exposure, which was not the case during this event and is hence not yet fully explained.
- Tests were performed in the lab to mimic the erratic with a perturbation signal in the retrigger line. The tests showed to activate the fast retrigger path (having twice lower sensitivity), resulted in slow commutation and

current losses -> lower field at the end and risk for GTO stack, as energy is deposited during the commutation in the stack.

- Mitigations:
  - Short term: additional instrumentation during energy scans and tests in the lab.
  - Long term: modification of fast retriggering path, logic path, analogue power
  - Timescale: EYETS 2016/17
- Results of simulation of the effect on the beam and the collimation system will be shown by Roderik, in the next presentation
- Test erratic at 1-2 TeV (lab experiment): erratic type 2 is worse than erratic type 3 and, thus, remains the default worst case.
- Conclusion: Origin of the erratic is slowly rising signal in the retriggering line, no deep understanding or explanation of the source of this signal, hence difficult to estimate on an eventual increased failure rate (and asynch dump occurrence).
- Type 2 remains the worst case for impact on the TCTs and was considered and validated for the 2016 run.
- Presently working on upgrades for run 3, aiming to mitigate error sources and a retrigger signal surveillance system.
- Markus: Were eventual correlations with other systems/events in the tunnel done?
  - Etienne: It is clearly the LBDS that puts the power in the re-trigger lines. Source of the power injected in the lines is still unidentified but strong suspicion that the power was coming from the compensation circuit of one of the first three generators. Sensitivity to such an event can probably be reduce be removing a transistor (in the fast activation path) but type 1 erratic would become much worse.
  - Markus: the fast retrigger guaranties 0.8µs of re-triggering delay, what would be the time without it?
    - Etienne: the normal path will take 200-300ns longer, as more electronic delay is in this line.
- Etienne: It is too early to do meaningful statistics with one event only, no modification on the estimation of spurious async BD per year.
  - Markus: the estimated number is still 3, maybe when reaching higher energy it will be updated as this is expected to have a larger impact on spurious firings.
- William: after YETS we have not seen any sparking, due to cleaning and replacement of perforated shields, which were initially introduced to allow for better cooling. These have been replaced by closed shields (resulting in a slight temperature increase) to avoid contamination with dust, fibres. The situation is now significantly better than after LS1.
- **Action:** Perform lab tests on stacks with 7TeV to confirm criticality of type 3 erratic. (V. Senai)
- **Action:** Initiate discussion and review upgrade needs for the triggering electronics (maintaining both fast and slow) for the LBDS. (ABT)

1.3 Impact of type 3 erratic on collimation - first results (R. Bruce)

- Miskicked beam can hit sensitive material, magnets, tungsten collimators ...
- Erratic type 2 is still considered the worst because of the larger retriggering delay. The dangerous kicks/kick area are passed slower.
- If we have 3 kickers fire, the rise of the total kick will be faster and it is hence less critical.
- Simulated modified type 3 with 1 and 2 MKDs firing, still ok.
- Additional tests with type 3 data depending on the MKD position were done. They reach 6-sigma kick after different times. For type 2, pre-firing of the extremities (A and O) are more concerning. For the new type 3 erratic on kicker N is not worse than type 2 on kicker O. But there is a lot of beam which will receive a small kick, which could be bad for secondary collimators sitting close to 90-degree phase to the MKDs.
- Potentially more critical for IP7 collimators, to be studied further, the secondary collimators (TCSGs) are designed to survive the impact of 8 nominal bunches at 7 TeV.
    - Daniel: Is this worse than the 288 bunches BCMS @ 450GeV?
    - Markus: do you have a feeling on what can happen in IR7?
    - Roderik: We can do an estimate: few more bunches before 6-sigmas, factor two but not factor 7, so it should be ok.
    - Daniel: Could these studies be combined with the on-going studies to update the damage limits of the different collimator families?
    - Roderick: The damage limit studies are already almost done, the remaining question is concerning the BLM response. We can perform some tracking simulations, and if we see that this is critical we can add FLUKA and then ANSYS simulations.
    - Daniel: this would be the most critical case if it happened at 6.5 TeV?
- **Action:** confirm number of extra bunches on IP7 (secondary) collimators and assess if this is critical.

1.4 Beam lost in TI2 due to undetected wrong current in TT60 bending - event analysis and proposed mitigations in SPS FEI (M. Magrans)

- Beam and extraction interlocks for the Fast Extraction Interlock (FEI) of the SPS power converters are generated in the MUGEF controls of the power converter and fed into the CIBU of the extraction BIS.
- Two independent signals are generated, beam dump delta-t 150ms.
- Fast extraction allows between 1 and 10% precision.
- During first extraction attempts, the full beam was lost in TI2, all the system looked ok but the beam could not pass TT60.
- Good practice: Using pilot beams for initial setup as it implies no damage risk.
- Diagnostic was already difficulty, but it could be more challenging to identify and track back if it would have been a quadrupole circuit. Concerning the severity the dipole is definitely the worst case.
- SPS uses only one DCCT for the current measurement, power converters are generally not designed for protection, however part of the diagnostics chain

is used for protection purposes and should be made as reliable as reasonably possible (the same is true for e.g. BI instrument used for MP which were not originally designed for that purpose).

- Possible failure modes:
  - Mismatch of reference and actual value due to wrong calibration (as happened during this event)
  - Wrong LSA threshold, currently protected using special operator settings
  - Changing of DCCT gain
- There are no operational and non-operational RBAC modes like in LHC, it would be a good upgrade.
  - Jorg: the really dangerous case for the LHC would be if an intervention happens in the middle of injecting high intensity beam, and after the repair one resumes immediately with high intensity. Normally operators will always assure to revert first back to low intensity, but this is not enforced by interlocks.
- Possible improvements can only be done during longer technical stops: EYETS, LS2, LS3.
- MUGEF end of life expected during LS2, where all controls will be replaced by FGC3, providing DCCT redundancy+ automatic equipment checks.
- PC electronics old and hard to maintain, possible issues with spares are to be monitored.LHC like controls would certainly increase safety but not mitigate all possible failure cases.
  - Jorg: Also LHC has a probe beam circulating before any high intensity beam
- Short term, periodic checks of FGC MUGEF thresholds and inclusion in MCS
- Longer term: automatic equipment settings, redundant DCCT measuring system
  - Markus: Information about the event will be distributed within EPC and the intervention procedure will be updated to avoid similar mishaps in the future.
  - A Logbook entry was added explaining the details of the event. The operators were informed.
  - Jorg: sending a probe after every intervention, especially for HiRadMat, would prevent such issues.
  - Markus: A completely external and independent system to measure and interlock the current would be the safest solution, obviously this comes however with an added complexity and cost which may not be reasonable for all converters currently interlocked by an FEI Nevertheless this requirement is a recurring one in many machines.
  - J.P.Burnet: With additional 10kCHF more per PC is this would indeed be considered excessive. Especially as the power converter itself will have exactly such a failsafe solution internally integrated. This would probably be an overkill.

Action: EPC is currently investigating the possibilities and will provide a proposal to OP and MPP, which then can be iterated on.

1.5 Summary of AFP commissioning results (M. Trzebinski)

- All interlock tests were performed successfully.
- Two non-conformities were observed:
  - Sometimes the beam permit was lost for B2 as no B2 pots are installed. Therefore, this part of the USER_PERMIT to the ATLAS 'concentrator' was masked in the following.
    - Sune asked if the system was revalidated after this hardware change? The philosophy is to make the final test once it is not changing anymore, hence it should be considered to be repeated for the relevant parts.
- For illegal positions during stable beams, no dump but retraction of the instrument.
- Summary: tests with ATLAS and AFP/ALFA, injection permit and user permit are ok. Are there any questions?
  - Markus: Is the dependency on the running FESA class for all 3 experiments solved in the COLL application?
  - Maciej: Indeed this behavior is still there, if one FESA class goes down, the application freezes for all three systems (TOTEM, AFP and ALFA). Protection is not impacted; however no pot can be moved anymore.
  - Jorg: Currently this is not a major concern as FESA has never been observed to go down.
- Beam based alignment and loss maps: AFP will be ready from 17th of April together with TOTEM.
  - Jorg: the alignment it is not finally scheduled yet. Neither is the dispersion bump where discussions between the coordinators are still ongoing.
  - Markus: how close would AFP want to go to the beam?
  - Maciej: 20-sigma, 50 at high intensity, maybe with some insertions @20 sigma as end of fills, depending on the background.
  - Daniel: the closest envisaged setting has to be validated during the intensity ramp up beforehand, just like with TOTEM last year; once the AFP XRPs are validated for some settings they are not forced to be insert all the way.
  - Maciej: Does the final optics for 0.4m exist already? Yes, the recent changes for the TOTEM bump do not concern IR1, hence the optics there can be considered final.
  - MPP needs to know the closest setting to be validated.
- **Action:** Document defining the closest settings for TOTEM and a second for AFP due in the next week (Action Belen S.).
- Maciej: we would like to join in on low pile up runs with standard optics
  - Jamie commented that such runs are currently not foreseen, pending a strong request from the experiments.
  - It is under discussion, maybe one 10h fill, will be requested by ATLAS-RC.
- For high luminosity: study beam environment and alinement, prove safe insertion and co running with ATLAS.

  - Radiation problems for ALFA have been observed in the past (depending on settings of TCLs) AFP might have the same effect and therefore cause intensity limitations.
- **Action:** Sune enquired whether the logic has been re-tested after putting the jumper in the system to force the home switch signal for the not installed B2 pots to true? To be verified.
- **Action:** Check with Gianluca, to disentangle the three experiments (TOTEM, ALFA, AFP), as for the moment if the FESA of one of these three is down, none can be used in the GUI for movement.

AOB – strategy for TOTEM roman pot setting (R. Bruce)

- Proposed strategy: we accept 15-sigma (i.e. TCT settings plus 6 sigma retraction) as closest settings. Initial validation will take place at these settings (without orbits margins). The beam size at the TOTEM XRPs is 120-200um. Up to TS1, an additional orbit margin of 500µm will be added to the validated settings.
  - 500µm corresponds to around 3-4 additional sigmas (with another 6 sigma retraction behind the TCTs).
  - There were jumps at times, caused by people playing with the RF.
- Fractional phase advance from MKDs to roman pots: the limit defined for the TCT retraction from the TCDQ is +/-20deg.
  - The vertical ones are not of major concern.
  - The kick is only one direction, the pots on the other side don't need to be considered either.
  - Daniel: it would be worth verifying that the roman pots are on the good side.
  - Roderik: if possible a few end of fill insertions to 15-sigma could be done (without orbit margins) before TS1
  - Markus: It might be necessary to approach the final settings during Intensity ramp up to check for heating.
  - Mario responds that this is true, but heating the pots takes time, time constant for beam heating is ~2h
  - Inserting RPs in 2015 never caused an unwanted beam dump event, but we intend to operate with more aggressive settings this year.
- Markus: If there are no other questions or objections, MPP endorses the proposal for the TOTEM XRPs.
  - The urgent thing is defining the limits for AFP because it affects operation.
- **Action:** Verify the side of the XRPs as in respect to expected beam offset due to asynchronous beam dump