61th Meeting of the Machine Protection Panel

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1 Presentations

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

1.1 Studies on crab cavity failure scenarios for HL-LHC (T. Baer)

- As seen in KEK crab cavity failures are potentially fast, i.e. in the order of 100μs.
- Calculated maximal beam displacement due to a failure in one crab cavity: 4.05 sigma.
- Slow (external) failure scenarios:
  - Power cuts
  - Thermal problems
  - Mechanical changes (tuner problems)
- Fast external failures:
  - Control logics failures
  - Operational failures
  - Equipment failures
- Internal failures (fast, < 1 turn):
  - Arc in coupler
  - Multipacting
  - Cavity quenches
- In the present scheme the crab cavities are made of pure niobium. An alternative would be a niobium coated copper cavity, which are maybe more stable against quenches.

- Due to an instantaneous voltage drop in one crab cavity, the beam gets tilted at the TCP.C during the first turn. In the second turn this tilt gets worse. In the third turn this tilt is compensated. This behavior is due to operating with a tune close to one third.
- The beam displacement can reach maximal 5 sigma (one crab cavity scheme) or up to 1.7 sigma (three crab cavity scheme).
- Dynamic voltage failure: Maximal transvers displacement in x (z) direction due to a voltage failure is 2.1 sigma (2.4 sigma) within 5 turns (one crab cavity scheme).
- Phase failure: The maximal displacement due to de-phasing of the crab cavities (between the crabs on the two sides of the IP) is up to 2.1 sigma within 5 turns.
- Scaling law: the displacement scales inversely with the number of crab cavities (assuming non correlated failures in the crab cavities).
- Measurements in the LHC showed that we can have up to ~4% of the beam in the beam tails above 4 sigma.
- Note: Failure scenarios depend strongly on the optics.
- Mitigation strategies:
    - Depletion of the transvers tails (e.g. hollow electron beam lens)
    - Larger β^*
    - Smaller crossing angles
    - Higher crab cavity frequency
    - Crab kick by several independent crab cavities
    - Larger Q_{ext} (= slower time constant of ext. failures)
    - Coupled RF feedback

Discussion:

- Rama comments that the dispersion from the crab and the normal dispersion adds quadratic. The equation can be found in Yee Peng's paper.
- Markus asks if also beam loss pattern for these failure cases exist. Tobias responds that the focus of the studies is to reach the requirement of losses below 1MJ within 5 turns. This should then be included in the margins for the protection systems.

- Rama comments that beam loss pattern are already available for the nominal LHC with a resolution of 10cm. Work is ongoing for the HL-LHC optics.
- Markus comments that even 5 turn failures are the fastest failure case for the LHC. Maybe the reaction of the beam interlock and beam dumping system could be reduced to below 3 turns through the use of direct links and eventually provoking asynchronous dumps.

1.2 SMP cross checker (B. Todd)

- The hardware cross checker (CISC) compares the timing of the safe machine parameters (SMP) to the GMT. In case of inconsistencies the CISC causes a hardware interlock and beam abort.
- Warnings are recorded when GMT drops parameters or the GMT rearranges parameter transmission orders.
- An interlock is raised, when the GMT drops three consecutive parameters or the GMT changes the payload.
- In the CCC the CISC can be found in the SIS, CCR, input channel 2.
- In the lab all test were successfully performed. Maybe also a test in the machine could be performed? **Action: A forced test in the machine would be highly appreciated.** This could be done by sending a fake timing event.
- The SMP hardware project will be closed
- **Action: Qualification of Safe Beam flag for LS1**

Discussion:

- The system is constantly comparing the GMT signal to the previous values (rolling). If the GMT signal matches to one of the past 10 values, the CISC doesn't cause an interlock.

1.3 SMP (cross-checker): Diagnostics and Pre-Post Operational checks (J.-C. Garnier)

- The cross checker compares the SMP configuration to a reference model from the database, in case of major problems it causes an interlock in the SIS.

- Errors interlock the SIS. This interlock is mask able. In addition a message is put into the LHC-OP and the TE-MPE logbook and a warning email sent to the bis-smp-expert egroup.
- DIAMON is currently monitoring the crate status, the correct configuration of the SMP system and the correct parameter reception. For the future the comparison with the reference model from the database should be implemented. Preparations for DIAMON2 are ongoing with CO.
- The SMP GUI application is available in the CCC. All information about the SMP system (including history buffers) is displayed there.
- LOGGER: this is an automatic java process, which converts the data into separate variables and sends them to timber.
- POST-OP: tools in the post mortem analysis framework, which include an history buffer and a register decoder. A SMP status analyzer is currently under development.

Discussion:

- The model database is different from LSA (i.e. the CO configuration DB), but still managed by the database section.
- Markus comments that all the tools are now available to monitor and diagnose the system.

1.4 PC current surveillance for orbit interlocking (K. Fuchsberger)

- Motivation: Presently the SIS compares the PC currents with reference values including tolerances. Due to using only constant limits, the interlock limits are very loose.
- Therefore a new PC interlock system was developed, which compares the PC currents to reference functions.
- The main processes run on the cs-ccr-lhcsis2 server with a frequency of 1Hz. A supervision GUI is available in the CCC.
- Checking with data from the past weeks (beginning of April up to now), the PC current surveillance would not have triggered as the measured changes were significantly below the defined 15µrad threshold.

- Currently the system is connected to the SIS, but masked. The server has been running stable for several days in a row. Thus, the system is ready to be switched on (unmask SIS). The system includes for the moment only orbit correctors
- Further development:
    - Add a way to edit the tolerances in the GUI.
    - Protect reference functions and tolerances against undesirable changes.
    - Include more power converters into the supervision.

Discussion:

- Joerg comments that in collision the limits for the orbit correctors will probably need to be increased, as they are currently running with ~25 sigma.
- Markus points out that the system only dumps if 2 correctors run out of the threshold.
- Joerg mentions that the SFB flag currently masks the surveillance module automatically.

1.5 Miscellaneous

- There will be a quench workshop organized by the MPE group in the coming autumn.
- **Action: Introduce a page with actions from the minutes** (DW).
- **The next meeting will take place on the 1st of June.**