135th Meeting of the Machine Protection Panel

Participants: D. Lazic, C. Schwick, A. Rossi, D. Wollmann, E. Carlier, C. Martin, J. Uythoven, A. Antoine, B. Puccio, M. Zerlauth, R. Denz, C. Zamantzas, M. Kalliokoski, S. Gabourin, Y. Nie.

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#134's minutes

- Actions from 134th MPP:
  - Prepare specifications for WIC interlocking of wire temperature via resistance / voltage supervision and present to MPP after the protection electronics and algorithm has been designed and tested. (Coll-team, Adriana)
    - Adriana has presented the results from the voltage supervision test in the 135th MPP meeting.
  - Study possibility to connect new TDE pressure measurements to VAC controller in UA63/UA67 and implement a HW interlock via the vacuum system. (Guiseppe)
- No additional comments were received on the minutes; they are therefore considered approved.

1.2 Beam-Beam Wire - report on results of developments for temperature supervision via wire resistance (A. Rossi)

- The wire will be protected from overheating via the WIC triggered by the wire voltage that is temperature dependent.
- The in-jaw wire has been tested under vacuum. The wire voltage has been measured as a function of wire current with and without cooling. 8 thermocouples were used to measure the wire temperature at different parts.
- For the cooled wire under vacuum, the wire temperature behaves as expected by simulations. The wire temperature always becomes stable a few minutes after the current jump, as long as the current is below 200 A. At higher currents, the wire temperature keeps rising along with the time, due to the weak cooling capacity which will definitely be improved in the operating collimator system. The highest wire temperature observed is 120 °C at 350 A.
- Without cooling, the relationship between the wire temperature of the hottest part (not in contact with jaw) and the voltage has been measured at 100 A, 200 A and 300 A. The wire temperature recorded is up to 520 °C at 300 A. A comparison between simulation and measurement has revealed that thermal radiation becomes more and more relevant as the wire temperature increases.
- It can be concluded that the wire temperature will stay below 200-300 °C, as long as the wire voltage doesn't exceed the limit of 2.5-3 V. Once the voltage

exceeds this limit, the power converter needs to be switched off via WIC, in order to protect the wire.
  - Jan commented that details of connection to the WIC need to be specified.
  - Markus raised the concern that there might be connection problems when measuring the wire voltage. If there is a short, the measured voltage might be 0 V, but the wire current and hence the wire temperature can be high. Therefore, a lower limit should be set as well for the interlock level.

Action: Verify the reliability of the wire voltage measurement system (Adriana). Specify connection to WIC (Adriana, Jan).

- In operation, only the jaw temperature is monitored. Once the jaw temperature reaches 50 °C, the beam will be dumped, and the power converter should be switched off.
  - Jan commented that one should be able to test the wire even if there is no beam in the machine.
  - Daniel asked whether the power converter could be switched off directly by the condition that the jaw temperature exceeds 50 °C.
  - Finally, it was agreed not to implement such functionality to maintain a maximum of flexibility of testing the wire with or without beam.

1.3 Technical specification for CIBDS V2.0 (D. Calcoen / S. Gabourin)

- Once the LHC beam dumping system (LBDS) is triggered by the BIS CIBM, TSU can generate fully redundant synchronous beam dump triggers, and at the same time generate redundant asynchronous beam dump triggers by sending a trigger pulse to the retriggering system after applying a delay of 250 µs via the trigger delay unit (TDU). However, the TSU are still a single point of failure, even though the former issue of common +12 V power supply of the TSDS VME crate has been solved.
- As a result, the CIBDS has been introduced to add a direct link from the BIS to the retrigger lines via a TDU. The CIBDS works in parallel to the TSU to request an asynchronous beam dump in a completely independent way. To avoid spurious asynchronous beam dumps, the CIBDS is connected as a user system on a CIBM via its CIBU, so that it can simultaneously generate synchronous beam dump triggers via TSU. The asynchronous beam dump trigger generated by the CIBDS is delayed by 270 µs via the TDU, to attempt the correct execution of the synchronous dump prior to the asynchronous trigger.
  - Following Stephane's remark in the presentation, Jan asked to check if the delay of 270 µs is sufficient or not, taking into account the time for the BIS signal to go around the machine. We might need to increase a bit the 270 µs.
  - Daniel added that it should be possible to detect the arriving time of removal of the beam permit by the CIBDS in the TSU and find this in older post mortem data.

- Stephane confirmed that the pulse time can be checked.

Action: Check the timing of the CIBDS retrigger pulse so as to decide if we need to increase the TDU delay time of 270 µs for the CIBDS asynchronous beam dump trigger (Stephane).

- A few issues with the CIBDS V2 have been solved with the CIBDS V5. During LS1, the issue of lack of electrical protection on connections with the outside world (PLC, CIBU, TDU) has been solved with CIBDS V3. The issue of dump trigger pulses that were sent to the LBDS retrigger lines even during arming has been solved with CIBDS V5. During operation after LS1, the issue of arming sequence was too long has been solved with the LHC Sequencer. The issue of nonconformity with CIBU commissioning has been solved with CIBDS V3 and within V2. Test mode for the CIBU has been added in CIBDS V5.
- 2 Dumps induced in 2015 were the result of the normal behaviour of the CIBDS, due to darkening of the BIS fibres.
- CIBDS V3 suffered from fabrication issues, V4 was finally cancelled as V5 was coming. CIBDS V5 will come for the following EYETS.
- There are three main modifications from the operational CIBDS V2 to V5. The first one is a different logic between asynchronous and synchronous paths. For CIBDS V5, asynchronous dump triggers to the TDU are triggered only by a loss of beam permit after a successful arming sequence and LBDS in REMOTE mode. Synchronous user permit to the CIBU is given during the arming sequence and normal operation. The LBDS local / remote command from LBDS PLC affects both asynchronous and synchronous links for the V2, but only the asynchronous link for the V5.
    - Stephane asked Etienne for the possibility of requesting synchronous dumps to the CIBU during arming sequence and normal operation.
        - Etienne answered that it is possible.
        - Jan added that in local the LBDS is never armed.
- The second modification is related to merging beam permit detection A and B for user permits in synchronous paths. If merging, one has normal user system behaviour, the user permits are fully redundant and the BIS-IPOC doesn't complain. In this configuration, Loop A (or B) is induced by A or B and vice versa. If not merging, one has normal BIS behaviour (A and B are fully independent from the beam permit measurement to the user permits). Loop A and loop B can have different values (although they will be identical during normal operation). A spurious trigger may lead additionally to a longer synchronous reaction time.
    - Jan asked if we need to be more reliable by linking the loops in CIBDS. How about the simultaneous failure of TSU and CIBDS?
    - Jan commented that the failure modes of the AND gate (and the prior electronic path) need to be checked in case of linking. The linked loops are not necessarily more reliable.
    - Markus doubted on the extra reliability added by this linked loops and said that it is necessary to perform a reliability study to confirm.
    - Reiner asked to check if the failure modes are fail safe in case of linking.

- Daniel summarized that based on the current knowledge about reliability of the CIBDS, the recommendation from the MPP is not to merge A and B signals.

Action: Don't merge A and B signals for user permits (Stephane).

- The third modification is adding a CIBU test mode as required for LHC user systems in the synchronous paths.
- A hardware review has been performed on 18 October. Hardware modifications, firmware implementation and EDMS engineering specification are ongoing.
- For the following EYETS, the works include production of CIBDS V5 boards with Java monitoring, installation of V5 into BIS local loop for reliability runs and to define whether V2 or V5 will be used for operation in 2017.
  - Jan added that the critical point is if the CIBDS really increases the reliability or not. So it is necessary to define parameters of CIBDS reliability run and to fit in the global planning.
  - Jan said that a reliability run in local is already foreseen for a few weeks. One could do this for a large part in remote.
  - Etienne added that the complete reliability studies will need weeks.

Action: Define, plan and perform reliability run for the CIBDS V5 (ABT and MPE).

AOB – None