

184th Meeting of the Machine Protection Panel

The meeting took place on **November 22nd 2019** in 774/2-058.

Participants: Andy BUTTERWORTH (BE-RF), Alessandra LOMBARDI (BE-ABP), Christophe MARTIN (TE-MPE), Bettina MIKULEC (BE-OP), David NISBET (TE-EPC), Michael O'NEIL (BE-ABP), Belen SALVACHUA FERRANDO (BE-BI), Brad SCHOFIELD (BE-ICS), Jan UYTHOVEN (TE-MPE), Jorg WENNINGER (BE-OP), Christoph WIESNER (TE-MPE), Daniel WOLLMANN (TE-MPE), Markus ZERLAUTH (TE-MPE)

The slides of all presentations can be found on the [website of the Machine Protection Panel](#) and on [Indico](#).

1.1 Minutes from the 182nd MPP meeting

- No comments have been received for the minutes of the last MPP meeting on injector topics (182nd MPP). The published minutes can be found [here](#).

1.2 Follow-up actions on continuous caesiation for LINAC4 & recent experiences (Michael O'Neil)

- Michael gave an update on the follow-up actions and recommendations from the review of LINAC4 continuous caesiation ([180th MPP](#), 30.8.2019).
- The status of the recommended changes are summarized on Slides 2/3. Most recommendations have been already implemented. Some of the recommendations have been adapted, following the outcome of a preparation meeting between Alessandra, Christoph, Jan, and Michael:
 - The temperature of the Caesium (Cs) oven valve will not be kept 10K higher than the Cs transfer line since the temperature measurement at the transfer line is only indicative and recent experiences imply that a higher transfer line temperature might be beneficial. The thermal connection between the temperature sensor used for the regulation of the transfer line temperature and the transfer line is quite indirect. A change of the valve temperature also causes an increase of the measured temperature at the transfer line sensor without a physical temperature change there. Therefore, it might be better to revert back to a power regulation scheme for the transfer line and use the temperature sensor only for interlocking.
 - The increased redundancy for the hardware part of the interlock system will be implemented after the LBE run by adding a second temperature relay and sensor in series. They will act on the Cs valve, and not on the sector valve, to prevent unnecessary downtime of the linac in case of failure of the interlock system.
 - The use of a new generation Siemens PLC (S7-1500) is planned for the next version of the control system (operational spare), but no upgrade is foreseen for the running system.
 - The SILECS/FESA implementation will be kept. No migration to UNICOS is planned for the moment.

- Brad remarked that the use of SILECS and UNICOS is not mutually exclusive, and the two could be combined.
 - All changes and implementations were endorsed.
- Michael then presented the operational experience on LINAC4 with continuous caesiation during the LBE run.
 - The source was mainly operated with a Cs reservoir temperature of $60\pm 5^{\circ}\text{C}$, with 65°C appearing to be the optimum value. Initially, Cs boosts with 80°C were performed.
 - The ratio of extracted electrons to H^{-} ions (e/H) remained mainly below an acceptable value of 10. A long-term trend towards larger e/H ratio was observed since the beginning of October and has still to be understood. Possible explanations are a polluted plasma electrode or Cs line restrictions that reduce the flow of Cs into the source.
 - The calculated accumulated amount of Cs used during the two month of operation has been only 16 mg, which indicated that the recommended 1 g per year should be largely sufficient.
 - So far, no faults have occurred on the interlock system. One high-voltage spark induced a false temperature reading, which correctly triggered the interlock.
 - All documentation related to the Cs system will be stored in [EDMS](#).
 - After a failure and replacement of the puller electrode, a single-shot caesiation was performed at 120°C .
 - Replying to a question from Daniel, Michael clarified that in this caesiation mode the transfer line temperature was around 150°C . Therefore any accumulation of Cs in the transfer line should have been cleared during this time.
- Jan summarized that the interlock system has shown an excellent performance so far, and that one should continue working in this direction.

1.3 Recent PSB radiation alarm during LINAC4 LBE run: post-mortem analysis and actions (David Nisbet)

- David described the events leading to the radiation alarm at the PSB. On Friday, 8th November 2019, a radiation alarm in the PSB ring was triggered while beam was supposed to be sent to the LBE line. This occurred while works at the PSB were ongoing.
- The reconstruction of the event resulted in the following event sequence:
 - An unplanned and unannounced EPC intervention took place on the power converter (PC) for the bending magnet LTB.BHZ40 that switches the beam between the LBE line and (at zero deflection) the BI line connecting to the PSB. The plan was to test PC interlock functionalities, being unaware that beam operation was ongoing.
 - Due to the intervention, the status of LTB.BHZ40 changed to OFF (15h06m07s). The beam continued to be extracted from LINAC4, but instead of being transported to the LBE line, the beam travelled through the bending magnet without being deflected and hit the temporary dump installed in the BI line. This lead to two consecutive radiation alarms in the PSB.

- At 15h06m18s, the WIC was triggered due to the EPC interlock tests during the work on the power converter and stopped the beam. The WIC trigger was unrelated to the radiation alarm. Without the WIC trigger, beam extraction to the BI line might have continued.
- Due to the following circumstances, no interlock was triggered that stopped the beam transport towards the PSB:
 - The PSB-1 to PSB-4 slave BICs inputs to the Chopper Master BIC had previously been forced to TRUE by using jumpers, motivated by allowing increased operational flexibility during commissioning.
 - The LTB.BHZ40 settings allow two tolerance windows centred at I=-175A (for LBE operation) and I=0 A (for PSB operation). The AQN LTB BHZ40_PSB input to the BIS was configured such that I=0 A and status OFF would give a TRUE.
 - The BIS matrix equations allow to request LBE beam but send it to the PSB if a) the switching magnet is set to zero deflection {LTB.BHZ40 = 0A} AND b) the PSB beam permits are true {PSB rings 1-4 = OK}. Both conditions were fulfilled after the LTB.BHZ40 was switched off and with the PSB BIC inputs forced to true. The BIS, thus, correctly allowed the beam injection into the PSB.
- The following actions were already taken to prevent a similar event :
 - The AQN LTB BHZ40_PSB input to the BIS now requires I=0 A AND status ON to be TRUE.
 - The jumpers on the PSB-1 to PSB-4 slave BICs inputs were removed the afternoon after the meeting and these inputs are now forced to FALSE.
 - The AQN BHZ40_PSB input is forced to FALSE.
 - The concrete shielding between the temporary dump and the PSB was reinforced.
- The following additional observations were made during the event analysis:
 - A one-second jump in the timestamps of the BIC history occurs occasionally, which complicates the event reconstruction for a cycling machine. Jan commented that the problem is known and is being addressed.
 - David remarked that after the radiation alarms the machine settings as well as the interlock settings were updated to wrong values, which implies that the protection functionality was lost. This underlines that appropriate RBAC roles for machine critical settings (MCS) have to be implemented, allowing OP_MCS roles to set hardware values but only EXPERT_MCS roles to modify the protection settings.
 - Bettina explained that the required new application only became available at the very last moment, such that the specific training could only start after the event. Jan reminded that the topic was already on the tentative agenda for one of the next MPP meetings. David added that the strategy might be appropriate during a commissioning phase but that the issue has to be solved before the start of regular operation.

- Action (Bettina/BE-OP, David/TE-EPC): Propose RBAC roles for Machine Critical Settings at LINAC4/PSB for implementation as soon as reasonable.

1.4 Proposal of rMPP on Injectors (Jan Uythoven)

- For time reasons, this topic was postponed to the next MPP meeting on injector topics.

1.5 Open Actions

The actions from the meeting are:

- Action (Bettina/BE-OP, David/TE-EPC): Propose RBAC roles for Machine Critical Settings at LINAC4/PSB for implementation as soon as reasonable.