
CERN

PSB radiation alarm during L4 LBE run: post-mortem analysis and actions

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Context

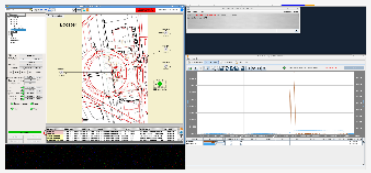
- On Friday 8th November, a radiation alarm in the PSB ring was triggered while sending beam to the LBE

08/11/2019 15:15 DAY LINAC 4 ln4op@CWO-CCC-B0LC

Radiation Alarm from PABX102 -> treshold overteken to 4500uSv/h.

Beam cut, the reson not yet found.

Beam To LBE destination removed from Supercycle until further notice.



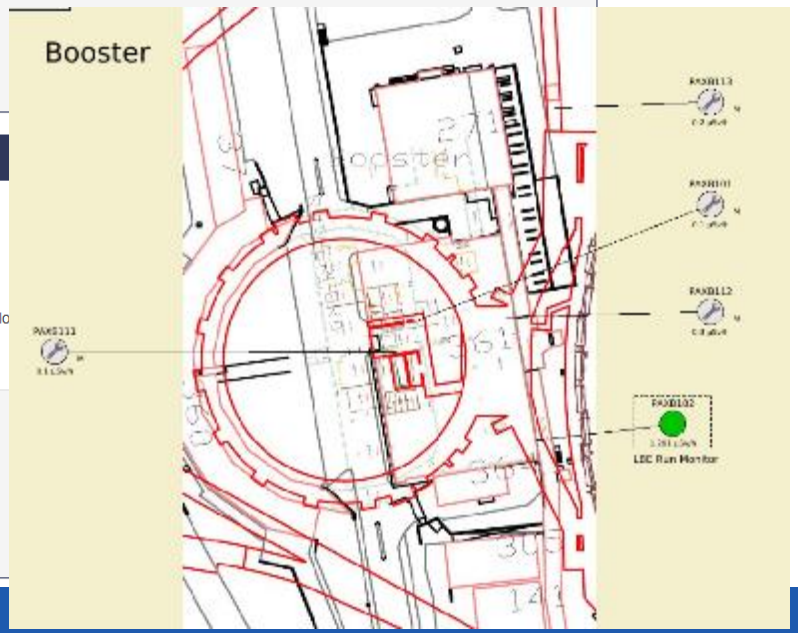
08/11/2019 15:20 DAY LINAC 4

Message from Markus:

Losses on 2 cycles (8/11/2019 15:06:11 and 15:06:16)

- Increased level on PAXB102 (Booster side): about 1.46 and 1.48 uSv per pulse
- Increased level on PATP502 (PS gallery towards PS ring centre, SS25): lower levels, but consistent with lo

PSk

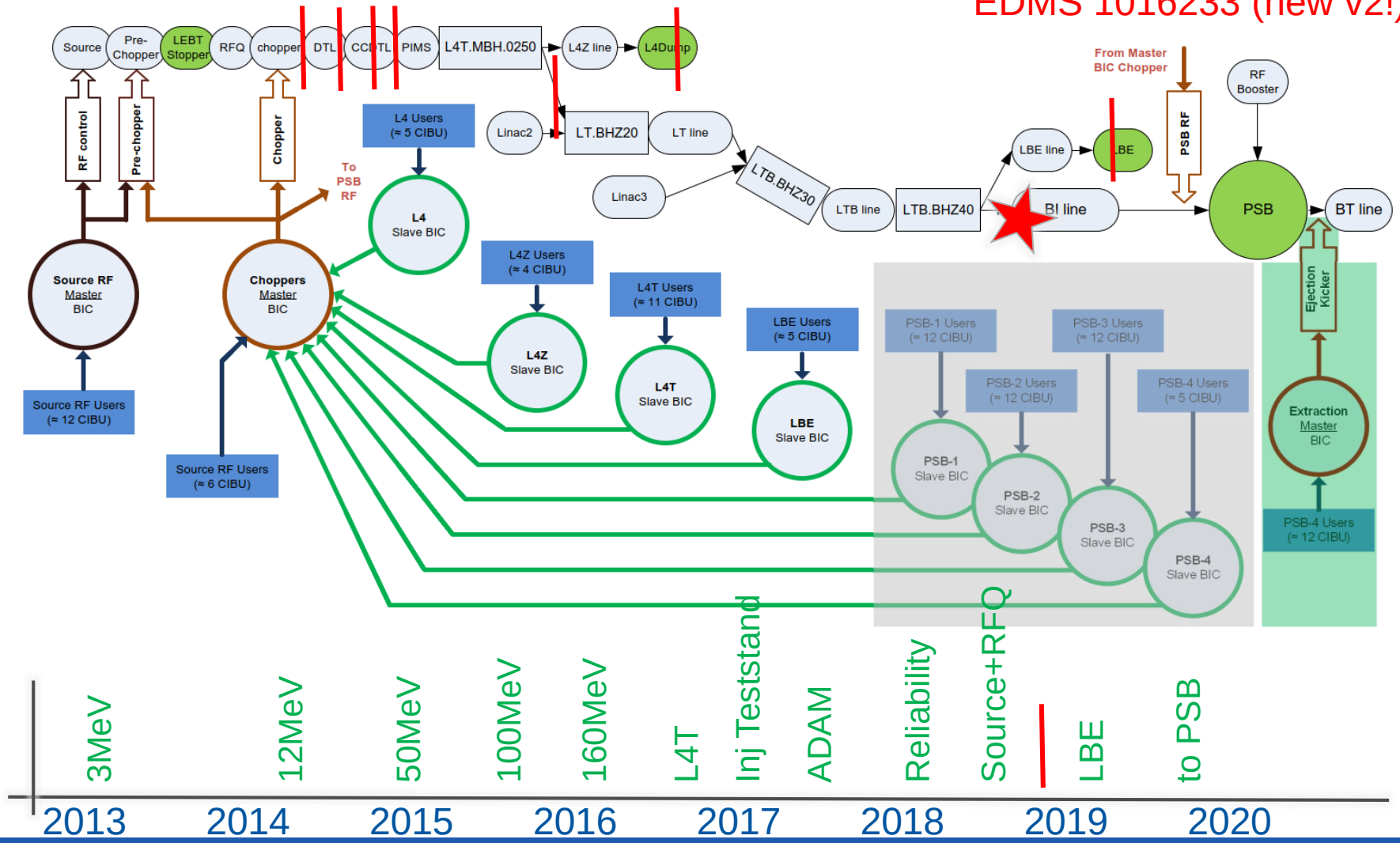


Questions triggered by event

1. What caused the initial beam loss?
   - Unplanned and unannounced intervention on LTB.RBHZ40 power converter…
2. Why was there a radiation alarm?
   - Calculations rechecked and an increase in concrete shielding implemented a few days later
3. Why was beam produced when the power converter was turned OFF?
   - Several factors examined in following slides

LINAC4 Machine Protection architecture

EDMS 1016233 (new v2!)



Event sequence

Key events from Friday 8th November:

15:06:07.222

LTB.BHZ40 to OFF

15:06:11.141

LBE settings, but BIS Beam Equation gives PERMIT for PSB -> alarm 1

15:06:15.941

LBE settings, but BIS Beam Equation gives PERMIT for PSB -> alarm 2

15:06:18.109

EPC interlock test = WIC interlock stops all PSB and LBE beams

15:06:39.336

LTB.BHZ40 to OFFLINE (FGC restarted) = AQN always FALSE

15:07:40.301

LTB.BHZ40 to OFF (FGC online) = AQN FALSE (need to resend settings)

Beam to PSB

15:06:11.141

LBE settings, but BIS Beam Equation gives PERMIT for PSB -> alarm 1

AQN LTB BHZ40_PSB	The corresponding USER_PERMIT is TRUE if the measured current is within the defined tolerance window corresponding to the destination PSB for H^-. This magnet is also used to bend ions into LBE and LBS.	CHOPPERS (Master)

LTB.BHZ40 settings correctly configured for LBE operation (I=-175A) and PSB operation (I=0A)

Examination of BIS matrix equations shows that it is possible to request LBE beam but send to PSB if both

{LTB.BHZ40 = 0A} AND {PSB rings 1-4 = OK}

(see next slide)

L4 Choppers Matrix

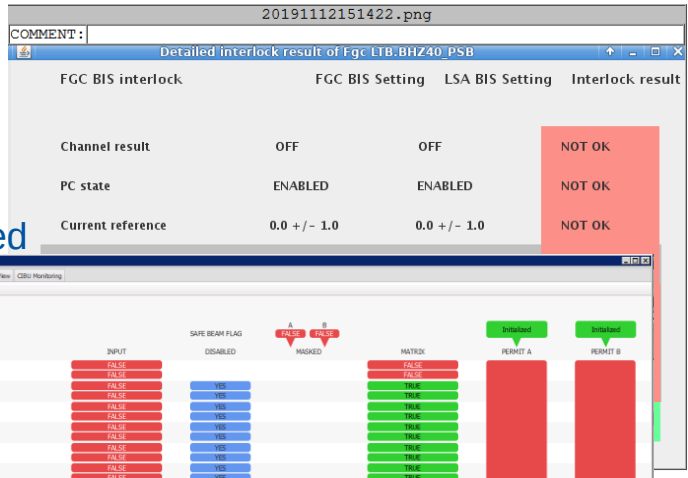
Following experience from alarm, action taken to ensure no PSB conditions can be true

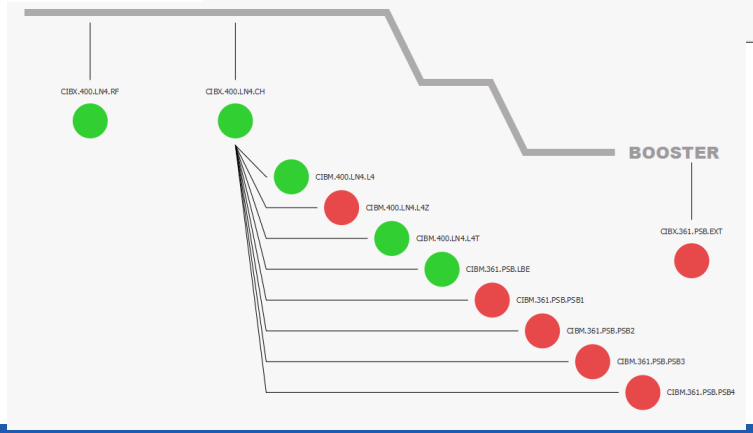
- AQN BHZ40 and PSB Ring BICs forced FALSE

If LBE settings, but {LTB.BHZ40 = 0A} AND {PSB rings 1-4 = OK} then PSB = PERMIT

Actions taken

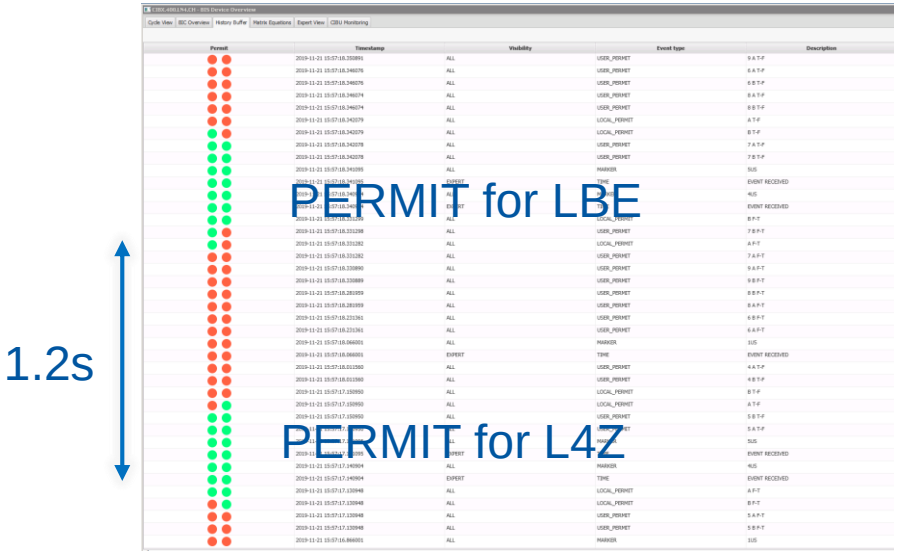
- Status on 8th Nov
  - BHZ40 PSB active when I=0A
  - All new PSB BICs connected to LINAC4, but inputs disabled
  - Hence PSB LOCAL PERMIT state is TRUE
- Status on 20th Nov
  - BHZ40 PSB forced to FALSE
  - SIS input forced to FALSE in FESA class
  - Hence PSB LOCAL PERMIT state is FALSE
- Definitive action (still to complete)
  - Remove disable jumper on 1 or more channels





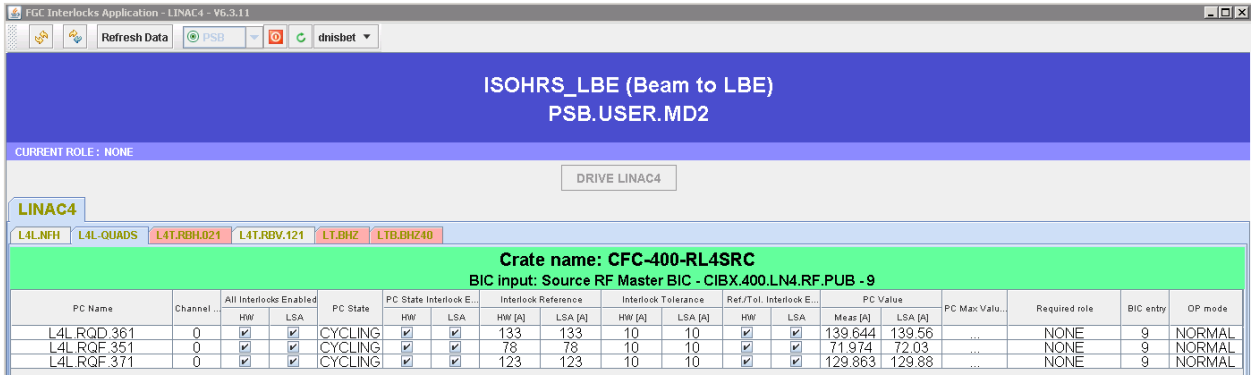
Other observations

- Offset in time-stamps of BIC history buffers
  - A jump of 1s can occur at any time
  - Can affect each BIC, but independently and randomly
  - Makes event reconstruction of cycling machines very difficult



Other observations

- FEI PSB application for FGC systems now in operation
- After the radiation alarms, some confusion in the CCC led to both machine settings and interlock settings being updated to wrong values
  - Would have generated a permit for a wrong setpoint
  - Indicates that enabling some settings protection is advised
- Recommendation
  - Machine Critical Settings (MCS) RBAC roles should be implemented, limiting access to protection settings
  - Allows OP_MCS roles to set values in hardware, but only EXPERT_MCS roles can modify the protection settings

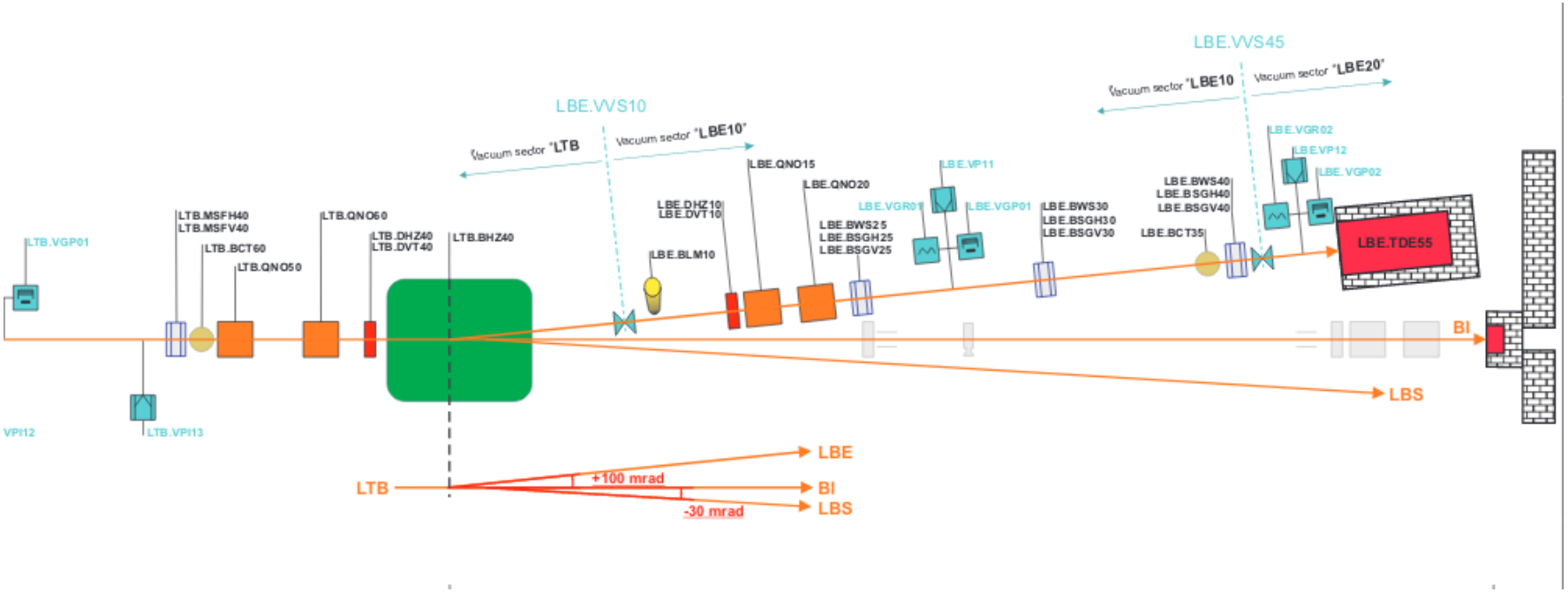


Conclusion

- Investigating PSB radiation alarm lead to some actions to assure protection integrity for the LBE run
  - Inhibit AQN for PSB of LTB.RBHZ40 power converter
  - Inhibit local permit from PSB ring BICs
- Some resulting actions still need to be followed up
  - How to ensure BIC history buffer has correct timestamps?
  - Implementing MCS RBAC roles for the power converter settings should be implemented as soon as reasonable
- Event reconstruction with matrix equations and ppm operation is challenging – may need improved tools for analysis?

Spare Slides

Geometry

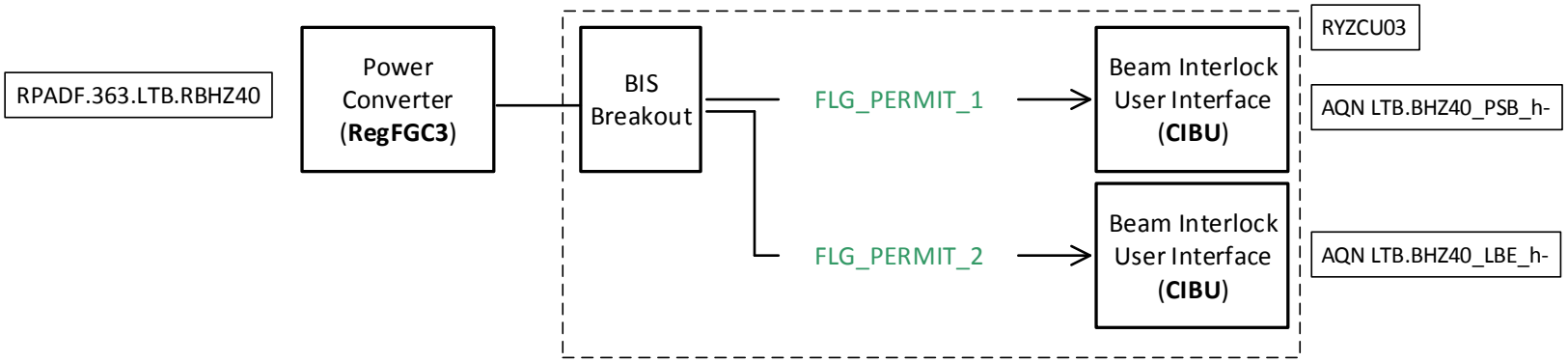


LTB.RBHZ40 switching magnet

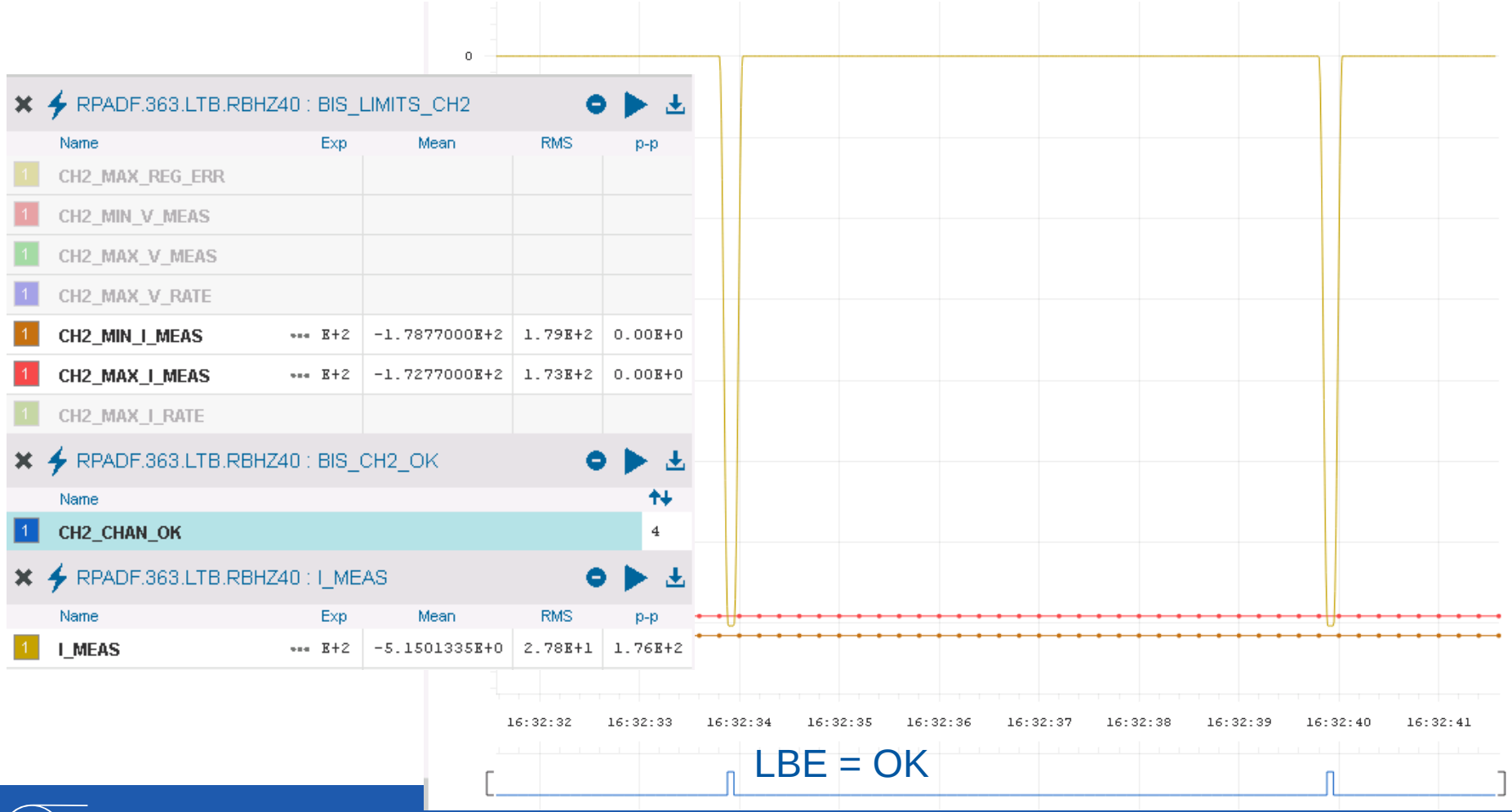
LBE_H- (-175A)	=> BIS surveillance
PSB_H- (0A)	=> BIS surveillance
LBS_IONS (-60A±5A)	=> not monitored by BIS
LBE_IONS (+95A±10A)	=> not monitored by BIS

LTB.RBHZ40 Hardware

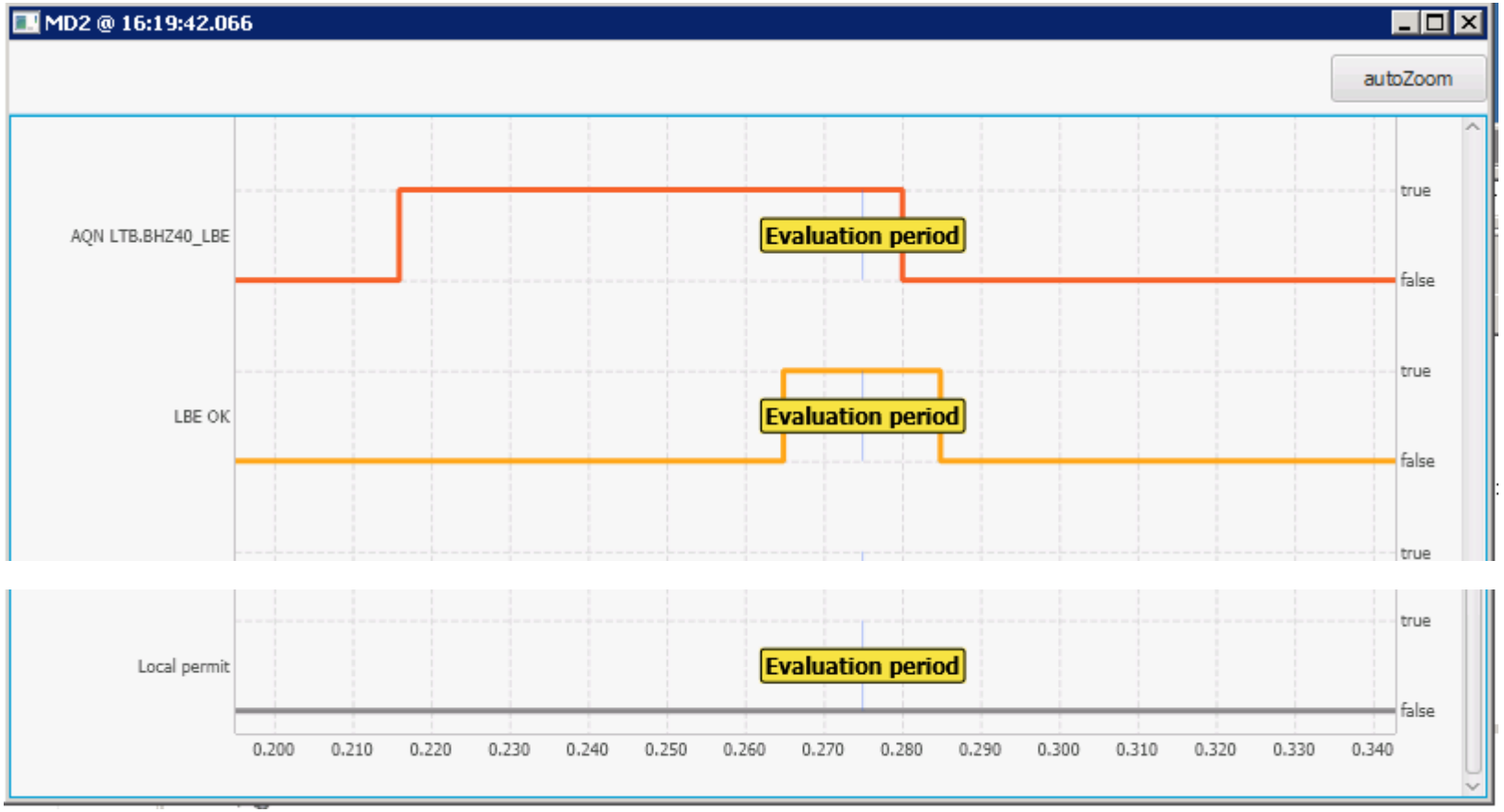
- On 8th November, both channels configured and active
  - For AQN PSB -> [0A ±1A]
  - For AQN LBE -> [-175A ±3A] AND [REGULATING]



LTB.RBHZ40 waveforms



View from L4 Chopper BIC

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