LHC Beam Dumping System

Reliability Run Summary

MPP 21.04.2017

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Thanks to all of my TE/ABT colleagues for their inputs

OUTLINE

- Summary of Winter Shutdown 7 TeV Tests
- Main LBDS activities during EYETS
- Main objectives of LBDS Reliability Run
- Preparation for LBDS Reliability Run
- Reliability Run Overview
- TSU & CIBDS retrigger pulses validation
- Summary of problems encountered
- Operation with MKBH reduced voltage

Winter Shutdown 7 TeV Tests

Initial conditions:

- MKD.LB1 cleaned following sparking tests in previous TS
- MKB generators untouched, but decoupling of retrigger lines on MKB generators done:
  - Isolation of MKBH retrigger boxes w.r.t. generator top cover (not ground actually)
  - Installation of nanocrystalline tores on retrigger lines between MKBHs.

Outcome (**B1:** 78h 7 TeV, 240h 6.750-6.875 TeV; **B2:** 350h at 7 TeV):

- 4x self trigger of MKD.LB1 (1x 6.9 TeV, 3x 7 TeV)
- 1x self trigger of MKBH.AB1 (6.875 TeV)
- 2x self trigger of MKBH.DB1 (during ramping up 6.473 TeV and 6.822 TeV)
- No problem on MKD B2 !
- 1x self trigger of MKBH.DB2 (7 TeV)

Conclusions:

- MKBH coupling removed after rejection of common mode signal on re-trigger lines
- Confirmation of MKBH generator weaknesses identified during 2016 run
- Good feeling for potential performance of LBDS for operation at 7 TeV
- Weakest generators identified and removed from operation beginning 2017

Main LBDS activities during EYETS

- Renovation of HV generators, following cleaning and sparking test campaign during this EYETS:
  - Full generators exchanged (1x MKD, 1x MKBH), only GTO stack exchanged (5x MKD, 9x MKBs)
  - Peltier module replacement (1x MKD)
  - Insertion of a separation between GTO stack and PTU crates on all MKBH generators

- MKB self-trigger coupling problem study and solving:
  - Problem reproduced in lab.
  - Decoupling of the retrigger boxes from top part of generator on all MKB generators
  - Addition of nanocrystalline tores on all retrigger-lines, to reduce common mode coupling.

- Upgrade of TSU cards:
  - Following card failure in 2016: Power supply weaknesses identified and corrected
  - New asynchronous dump scenarios identified: (138th MPP 2016 – E.Carlier)
    - In case of bad contact on the cable between TSU and RTD, a pulse is sent on the retrigger lines (Hardware upgrad)
    - In case of glitches on the BRF signal, synchronous triggers are issued asynchronously (Firmware upgrad).

- Upgrade of CIBDS cards:
  - New hardware, new firmware, added test mode capability (135th MPP 2016 – S.Gabourin)

- Increased CIBDS Re-Trigger Delay up to 320us.
- Preventive exchange of all LBDS PLC power supplies (154) / LBDS PLC ASi-Bus renovation
- Some software updates (PLC / IPOC)

All these changes need revalidation under operational conditions before operation with beam.

Main objectives of LBDS Reliability Run

- Validate the good state of LBDS HV generators:
  - We need a lot of dumps to validate the stability of kicker waveforms over time
  - We need cycles up to 7 TeV with long flat-tops to validate the HV sustainability, with some margin for operation.

- Validate the upgraded TSU & CIBDS cards:
  - We need a lot of arm / dump to validate the correct behaviour of TSU and CIBDS cards during arm/dump actions
  - We need long time with BIS armed to validate the stability of BIS loops.
  - We need a lot of dumps to check the presence and correct position of TSU & CIBDS pulses on the retrigger lines.

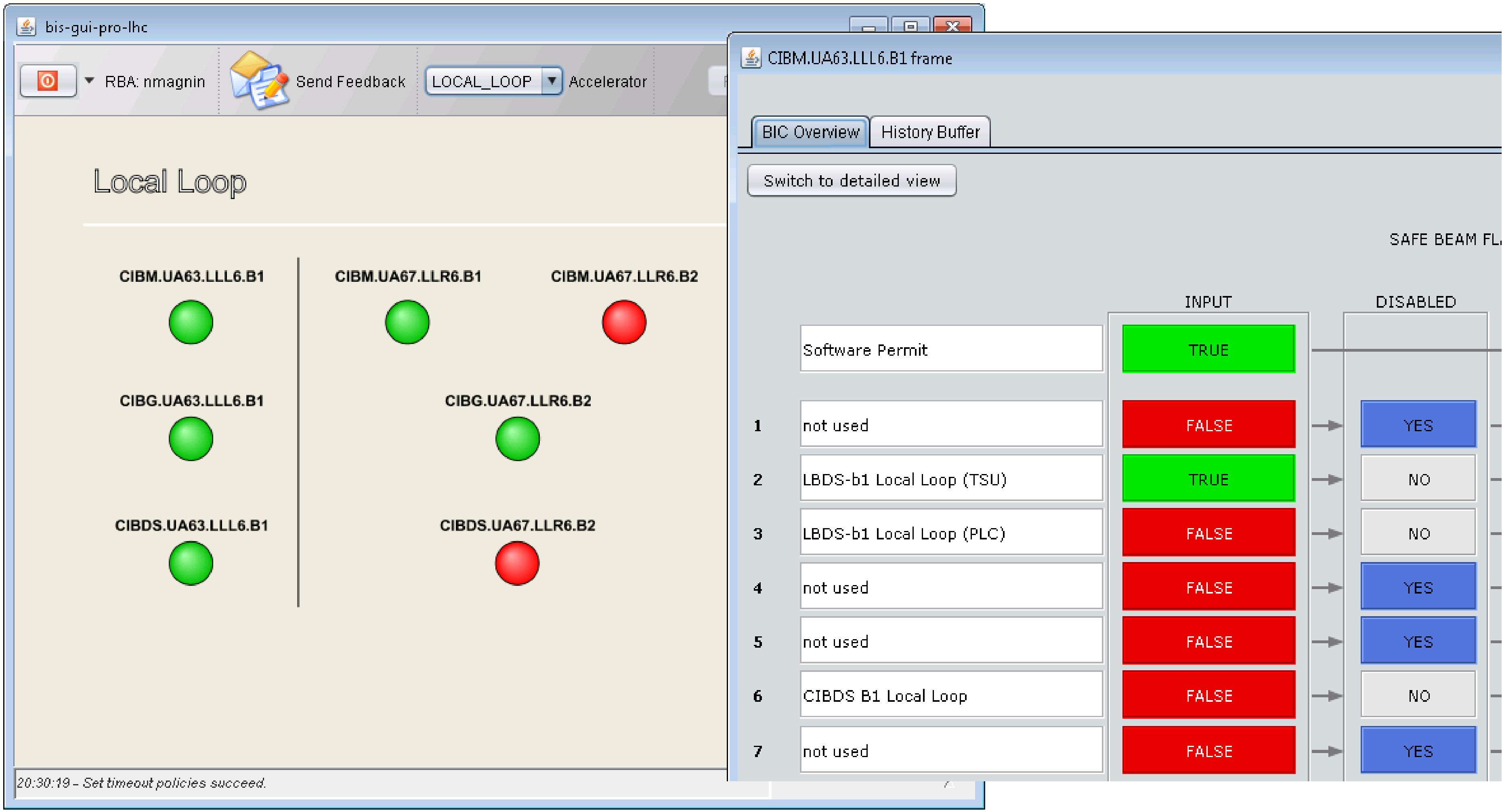
- Validate the upgraded PLC code and hardware:
  - We need a lot of arm / dump to validate the correct behaviour of PLCs.
  - We need many ramps to check the tracking of beam energy.

Not a lot of time available:

$\Rightarrow$ We can satisfied all these requests during a reliability run with Local BIS Loops

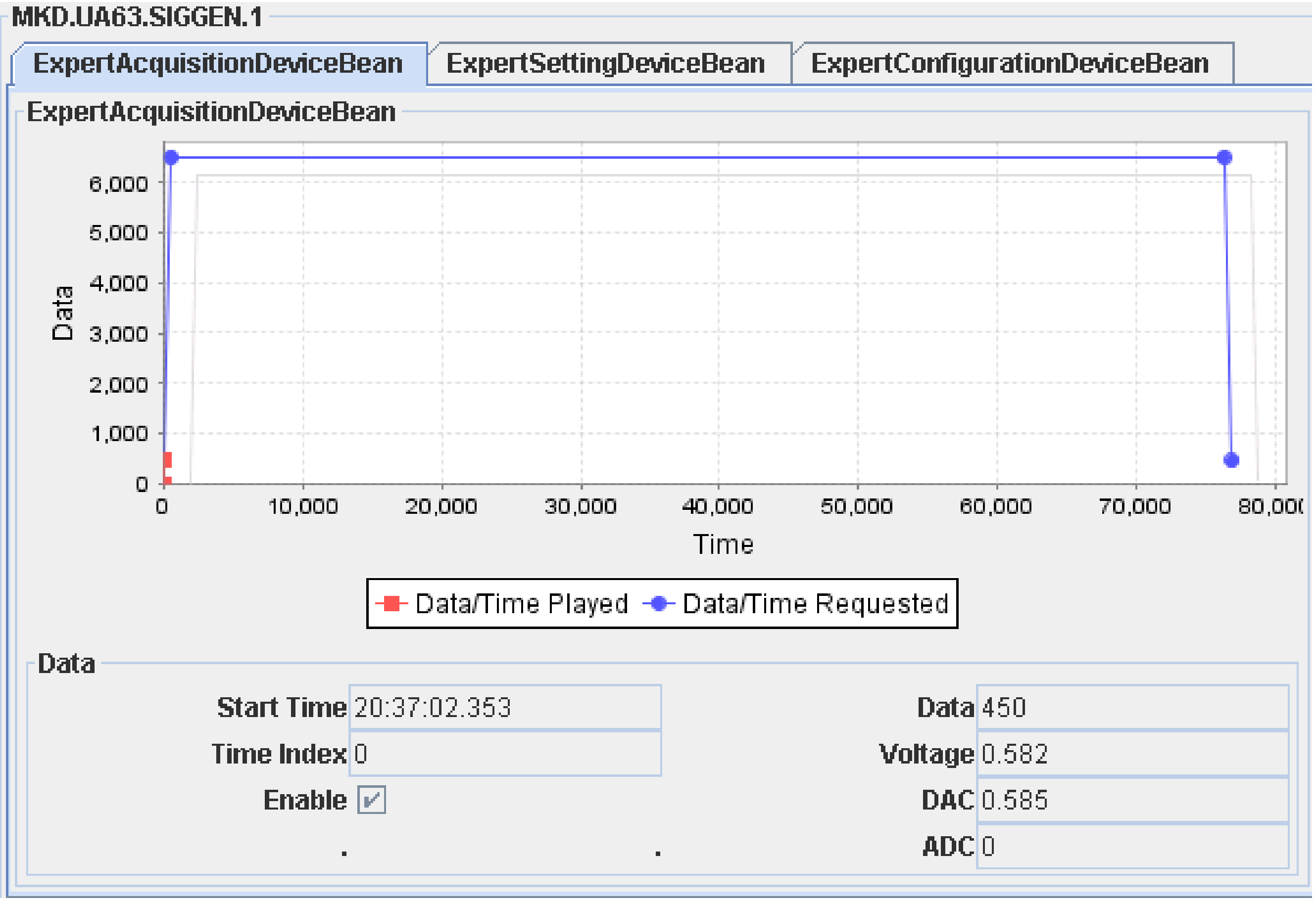
Preparation for LBDS Reliability Run…

- Local BIS loops: New BIS hardware and software deployed in Point6



Preparation for LBDS Reliability Run...

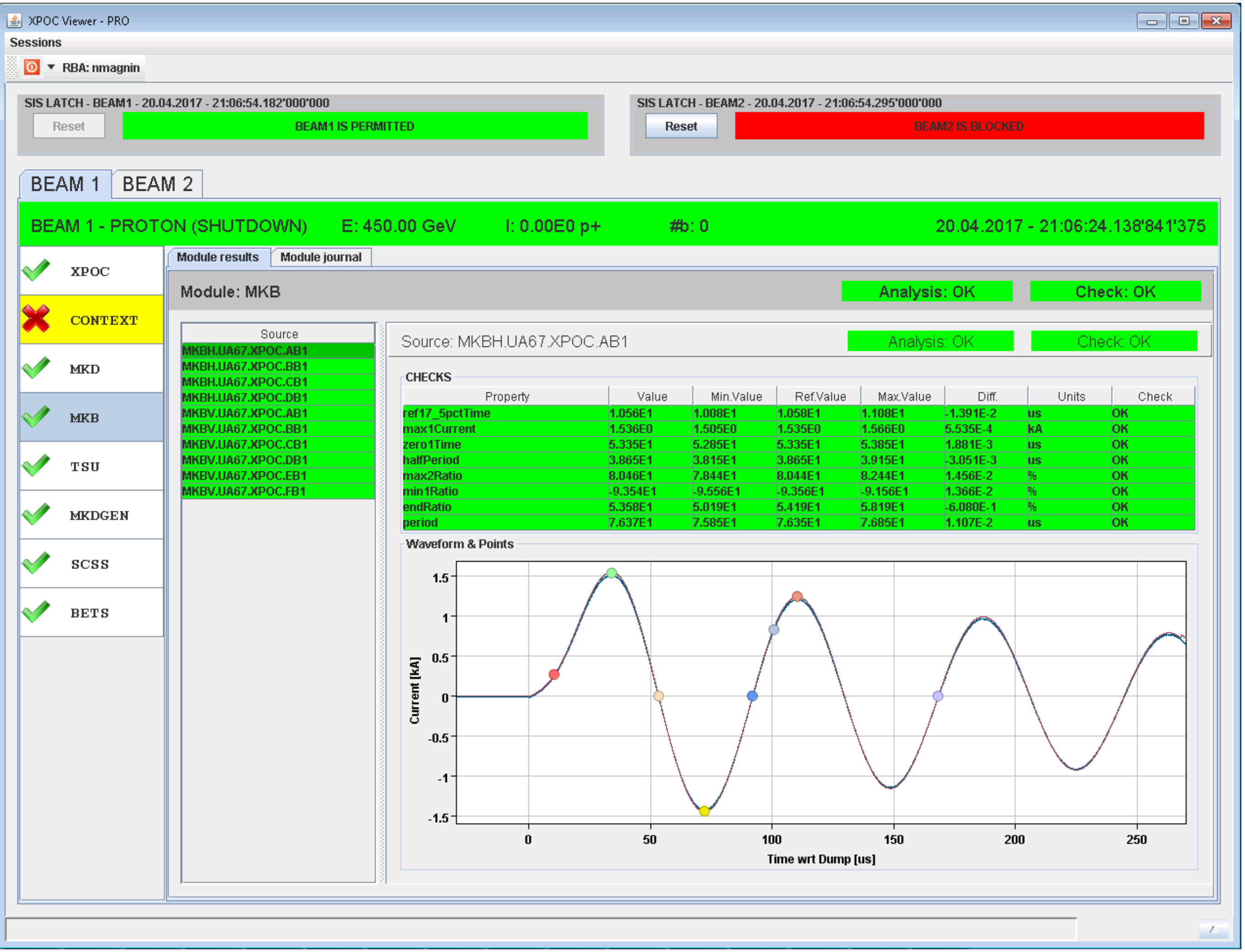
- BETS-Simulator used to generate the main bends current cycles for BETS



- BETS-Simulator connected to BEM cards.
- - MSD / Q4 BEI cards removed from BETS

Preparation for LBDS Reliability Run…

- New XPOC server for the validation of every dump action

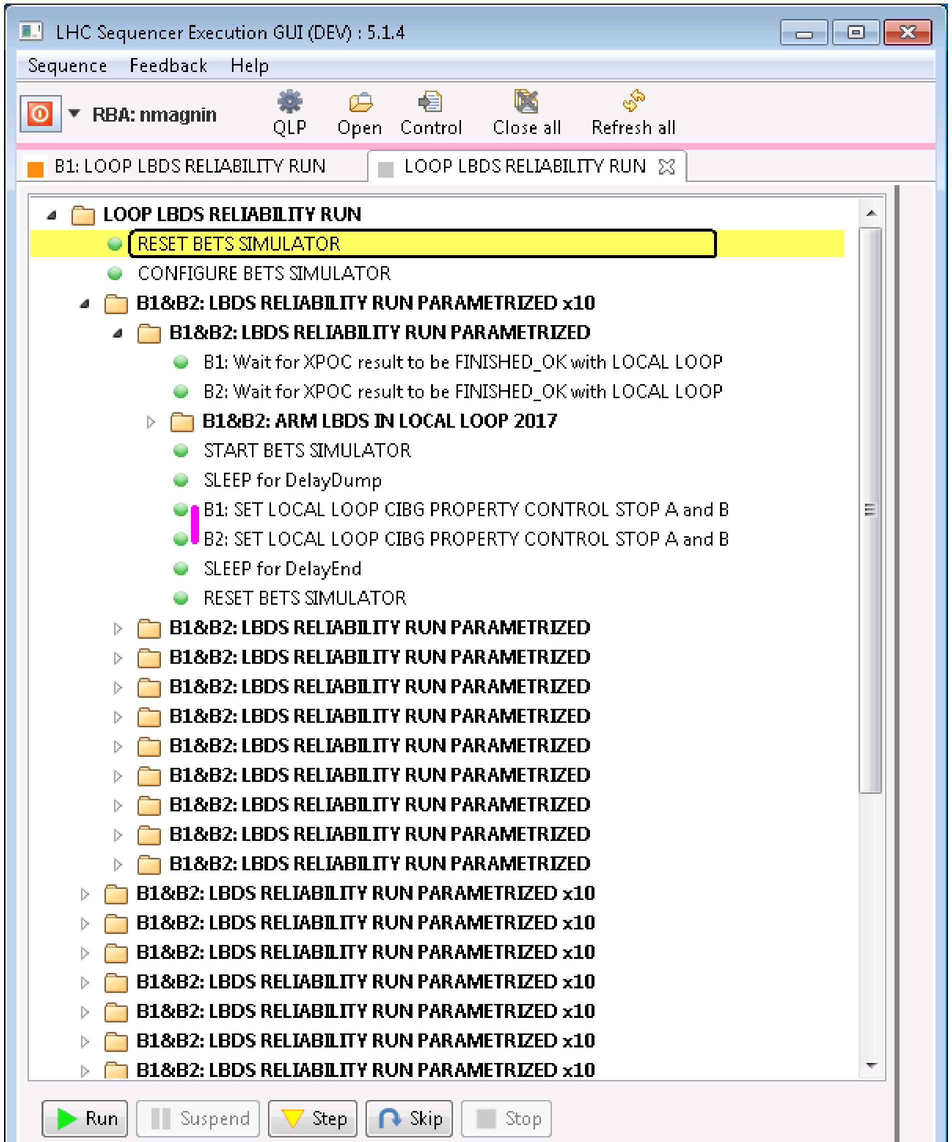


New XPOC-HWC configuration:

- Only ABT modules
- No BE/BI data
- “Beam Dumped” timing event not sent = XPOC-HWC server starts sessions on LBDS trigger

Preparation for LBDS Reliability Run…

- New Sequencer tasks needed to arm / start cycle / dump with local BIS



Sequence “LOOP LBDS RELIABILITY RUN”:

- 160x Dump / Arm at 450GeV every 60s
  = 2h 40min

- 1x Arm / 21h flat-top at 7 TeV / Dump
  = 21h 20min

24h cycle played in loop…

Preparation for LBDS Reliability Run

- **LBDS Reliability Run with Local BIS loops do not come for free!**
  - Many people involved from various groups
  - Complicated configuration of all these BIS, Sequencer, XPOC, etc applications
  - A lot of time requested for the follow up of this 24h/7d reliability run.
  - Very good support from other groups, even during evenings and week-ends !

Many thanks to our friends from BE/CO, BE/OP, TE/MPE… and TE/ABT for their help and collaboration !

LBDS Reliability Run Overview – Log

- 03.03.2017: Start Reliability run in LOCAL at 7TeV
- 10.03.2017: TSU back in LHC – Trigger and AGK delays adjusted – In Local BIS Loops
- 20.03.2017: LBDS switched to REMOTE first arming tests with Local IS loops
- 21.03.2017: Two E-Scan for reference, regeneration of all LBDS settings after EYETS
  - 23.03.2017: Compensation DCPS for MKD.GB1 failed, DCPS exchanged twice.
- 24.03.2017: Switch to REMOTE, start Reliability Run with Local IS loops
  - 28.03.2017: Two self triggers of MKBH.DB1 at 7 TeV, stack exchanged
  - 31.03.2017: Sparking activity on MKBH.DB1 after stack exchanged, generator exchanged
- 31.03.2017: B1: E-Scan and new settings after MKBH.DB1 replacement,
  LOCAL reliability run at 7TeV until 04.06.2017 for B1
- 31.03.2017: New CIBDS in LHC - In Local BIS Loops.
- 01.04.2017: Update of sequencer and BIS software to integrate the CIBDS
  - 05.04.2017: Dump from the BIS, no logging configured for the local BIS loops, not understood.
- 06.04.2017: B1 E-Scan for reference.
- 06.04.2017: B1 Switch back to REMOTE- Reliability Run at 7TeV
  - 07.04.2017: Self trigger of LBDS.B2, source not clear, could come from MKD.FB2
  - 10.04.2017: Switch ratio error on MKD.DB2 after dump at 7TeV
  - 11.04.2017: Replacement of stack on MKD.DB2, GTO in CC.
- 11.04.2017: UPS tests for LBDS, no problem found
- 12.04.2017: Stop of Reliability Run at 7TeV, continue at 6.5TeV
  - Many problems with PLC and BETS tracking, identified as PLC communication problems
- 21.04.2017: Continue Reliability Run over the week-end ?

LBDS Reliability Run Overview – Logging

BLUE= Energy up to 7 TeV.

RED= LOCAL, otherwise REMOTE (BIS armed most of the time)

LBDS Reliability Run Overview - Statistics

Statistics from 1st March 2017:

Time spent at 7 TeV (h)	433	393
Time spent at 6.5 TeV (h)	119	119
Number of triggers	4572	4044
Number of triggers at 7 TeV	121	118

Note: Number of triggers counts LOCAL + REMOTE (BIS Armed)

Main Problems found during Reliability Run

HV generators:

- 2x self trigger of MKBH.DB1, 2 stacks replaced , then generator exchanged
- Switch ratio error on MKD.DB2 after dump at 7 TeV, stack replaced
- Erratic on MKD B2, source not clearly understood, could come from MKD.FB2
  - no sparking visible on MKDGEN IPOC before erratic
  - Noise on retrigger line that triggered PTM, source is MKD sparking ?..

Electronic & Controls:

- Compensation DCPS for MKD.GB1 failed, DCPS exchanged twice.

TSU & CIBDS:

- One event of trigger from the BIS not understood (No logging configured for BIS).

PLC software

- Many problems of communication, between PLCs, yielding to tracking errors. Difficult to identify, still under investigation…

XPOC errors:

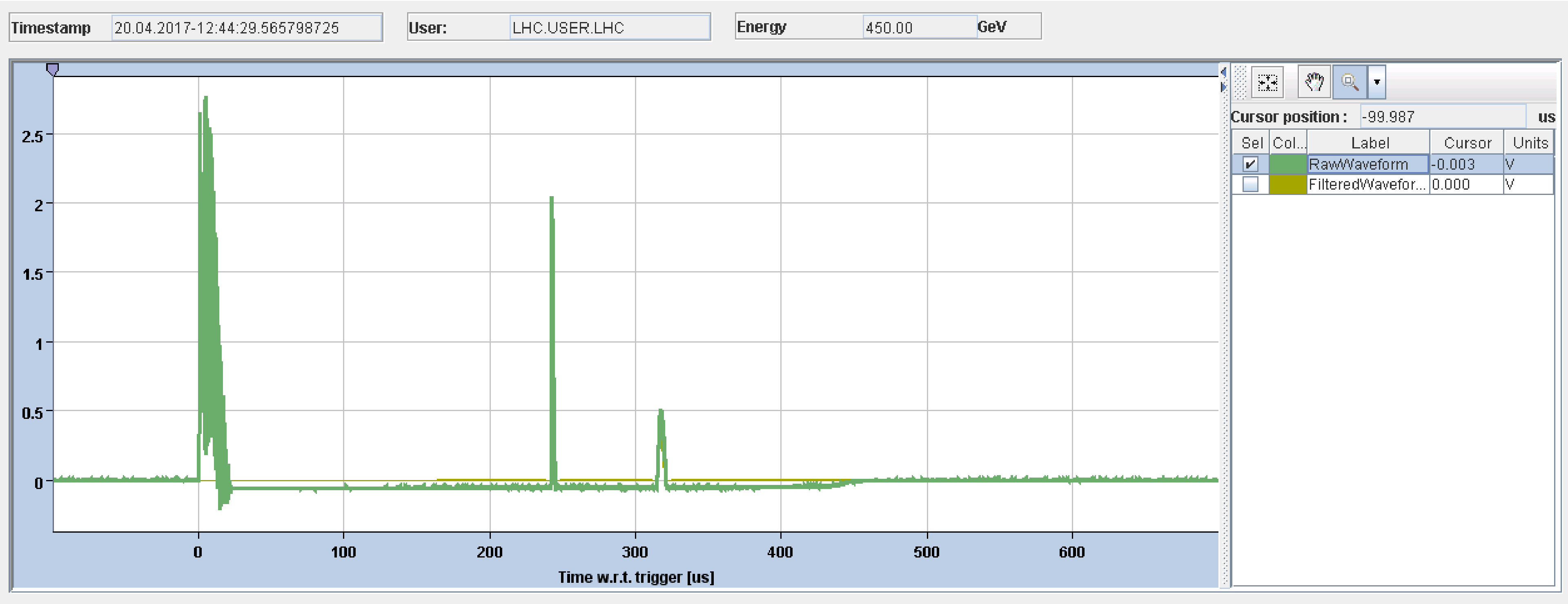
- TSU data missing = Old CTRV driver bug ?
- Missing some analysis sessions

Sequencer problems:

- Error waiting for XPOC result…

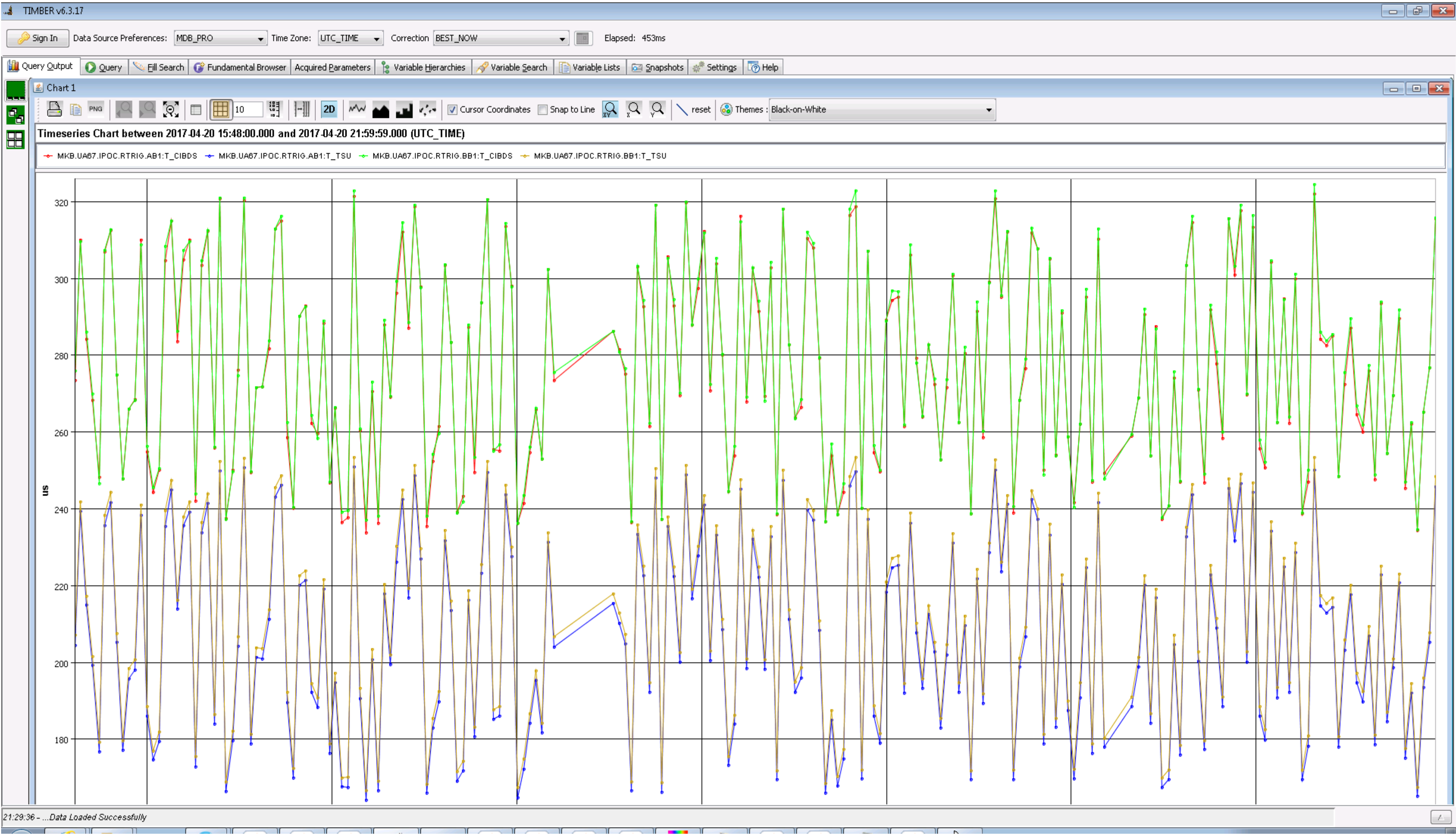
TSU & CIBDS retrigger pulses validation

- IPOC analysis of retrigger line pulses is implemented.
  - Signal on both ends of each retrigger line is analysed (4 waveforms per beam).
  - Position and Amplitude of TSU and CIBDS pulses stored in PM and Logging DB
- Deployed late in the Reliability Run, so all recorded waveforms are analysed off-line to check the presence of both TSU and CIBDS pulses.
- XPOC module implementation is still ongoing, should be released soon…



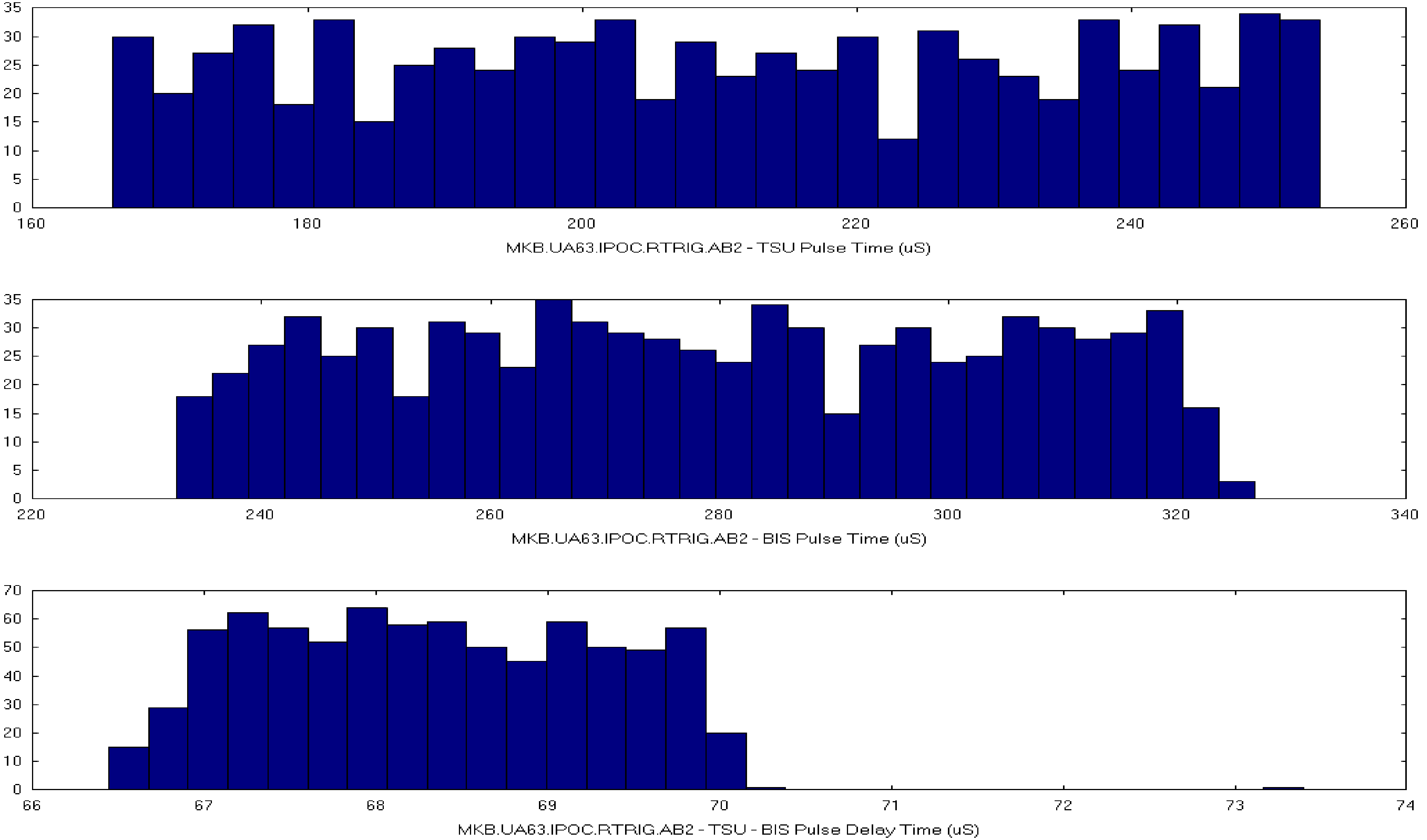
TSU & CIBDS retrigger pulses validation

New IPOC ReTrigger lines analysis implemented, data pushed to Logging DB.
Time difference between TSU & CIBDS pulses seem constant, as expected…



TSU & CIBDS retrigger pulses validation

Statistics on IPOC ReTrigger lines analysis results confirm that the time difference between TSU & CIBDS pulses is constant, as expected for BIS dump requests…



Operation with MKBH reduced voltage

Regarding running at lower horizontal dilution (90% ?):

Looking at performances during Reliability Run, we decided:

- To start with 100% dilution
- To apply normal procedure in case of self trigger
- Change to reduced horizontal dilution could be done during a TS, if needed
- Max 2 days required to compute the new settings and reconfigure the LBDS

Summary

Reliability Run indeed very useful for…

- Validation of HV generators, weakest ones removed from operation
- Validation of upgrades in Trigger Synchronisation and Distribution System (TSDS)
- Validation of upgrades in Controls software and hardware

Improvement of Re-Trigger line performances and diagnosis

- Removed MKBH coupling through re-trigger lines
- New IPOC to analyse re-trigger line pulses, all waveforms analysed off-line are OK

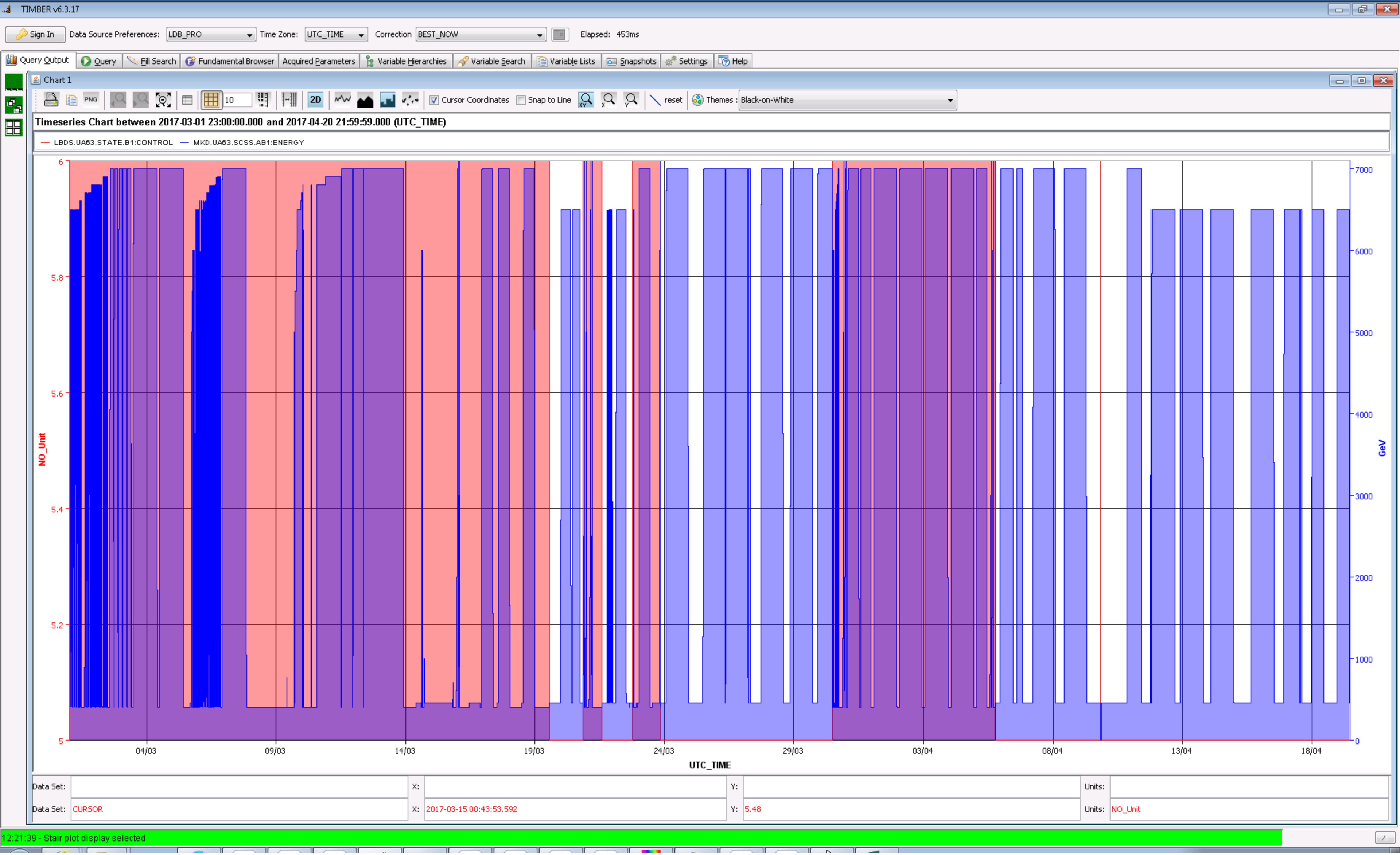
Good overall performance of LBDS during Reliability Run

Starting with 100% dilution, will discuss reduction if needed

We should plan a Reliability Run with Local BIS loops after every YETS !

Spares slides / Removed…

LBDS Reliability Run Overview – B1



LBDS Reliability Run Overview – B2