

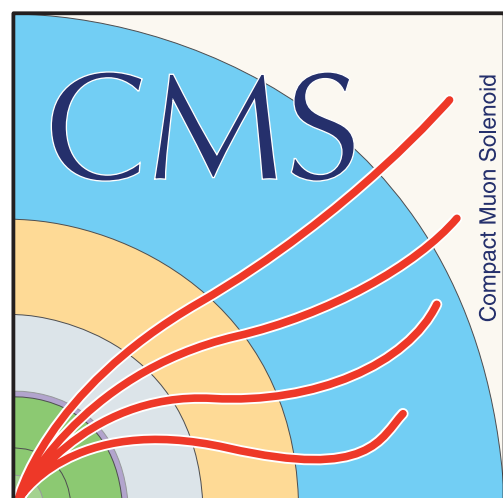


ECAL Laser report

ECAL readiness review
5th March 2023

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*CEA Paris-Saclay



New ECAL laser room



The laser room in USC55 had to be relocated on surface to make room for the CO₂ Phase2 cooling of HGCAL and ETL

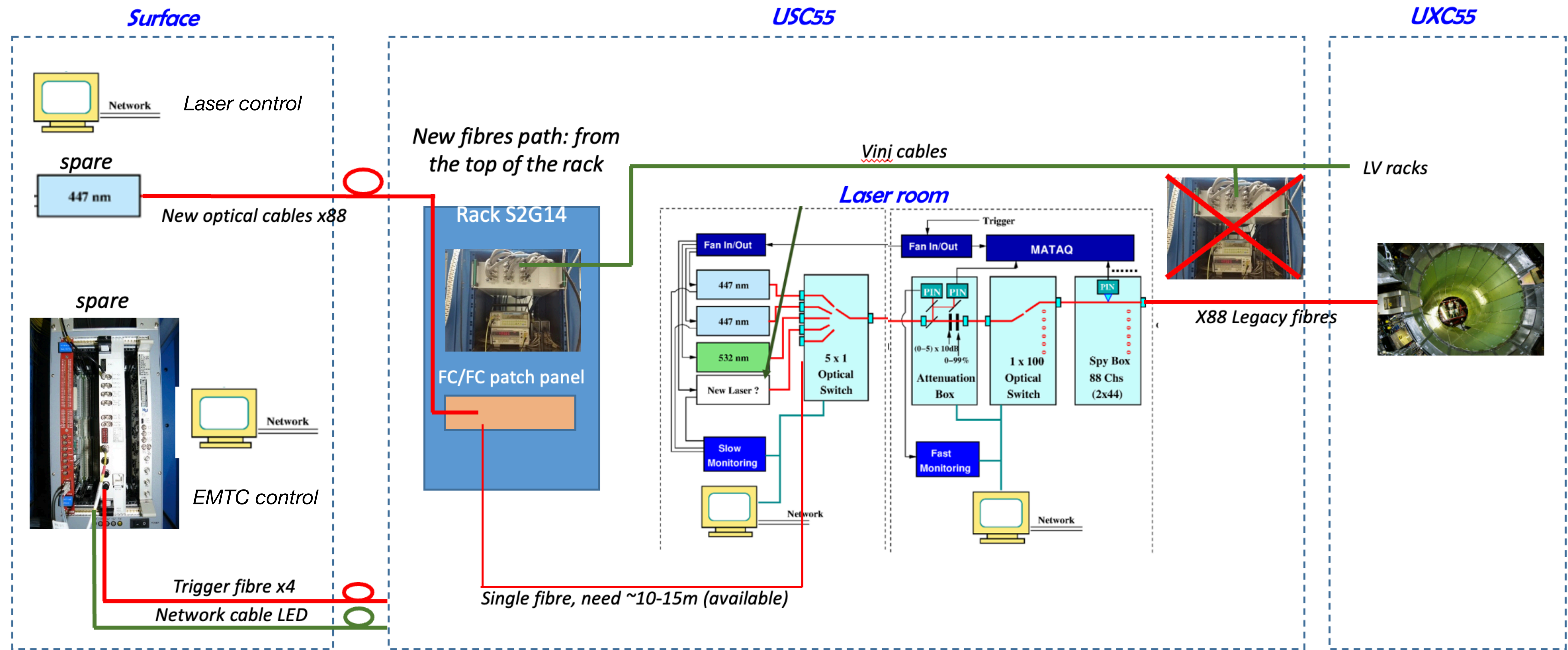
ECAL and CMS TC worked together to create a new room with HVAC and services meeting the laser room requirements and provided a new laser and extra fibers from surface to USC55

- **Pilot run of the new laser room in June**
 - Successfully defined new laser parameters to operate from surface
 - Tested all the trigger fibers and for both spare blue and green laser (one for each partition) and LED
- **Commissioning of the new green laser started at the end of August**
 - Featuring higher power to see light in dark crystals at highest η
 - Observed pulse instability and shooting in physics, solved by anticipating WTE BGo
- **Test of the HVAC system in September**
 - Found configuration to have temperature and humidity stability within requirements (with few caveats, being improved)
- **Final laser room relocation in November**
 - Physical relocation of all the equipment from the legacy lab underground to the new laser room on surface
 - Tuning of parameters and long stability tests
- **Commissioning of the latest setup in January/February**
 - New green laser + new EMTC firmware + new TCDS configuration
 - Defined all the parameters to run with new TCDS configuration at the end of January
 - Tested successfully only with ECAL at end of January, final commissioning with all subsystems in February

Laser room pilot run



Scheme of the setup for the new **laser room pilot run** during Machine Development 1 and Technical Stop 1 (weeks 24 and 25 of 2023)

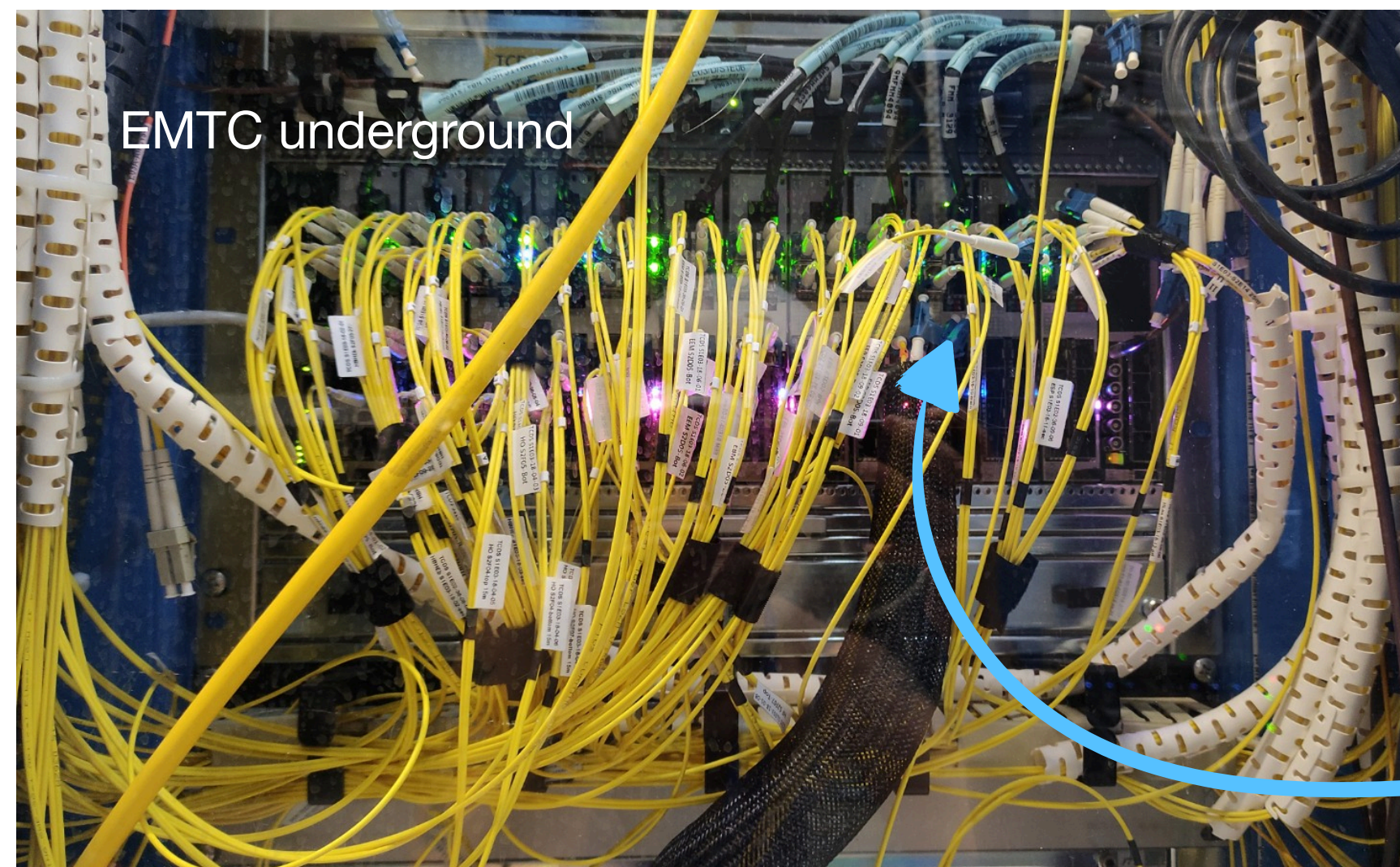


Laser room pilot run

Set up of the system during MD1 and TS1, from Wednesday 14th to Friday 23rd June 2023:

- Set up of the fibres to provide **laser triggers to the new laser room for all partitions**
- Definition of all **parameters** related to laser delay and amplitude
- **Long runs in miniDAQ** and **in global** to check the system functionality
- **Verified that the system with additional 150m fibres in the laser path behaves as expected**
- **Validation of LEDs** trigger from surface and delay tuning

<http://cmsonline.cern.ch/cms-elog/1187058>

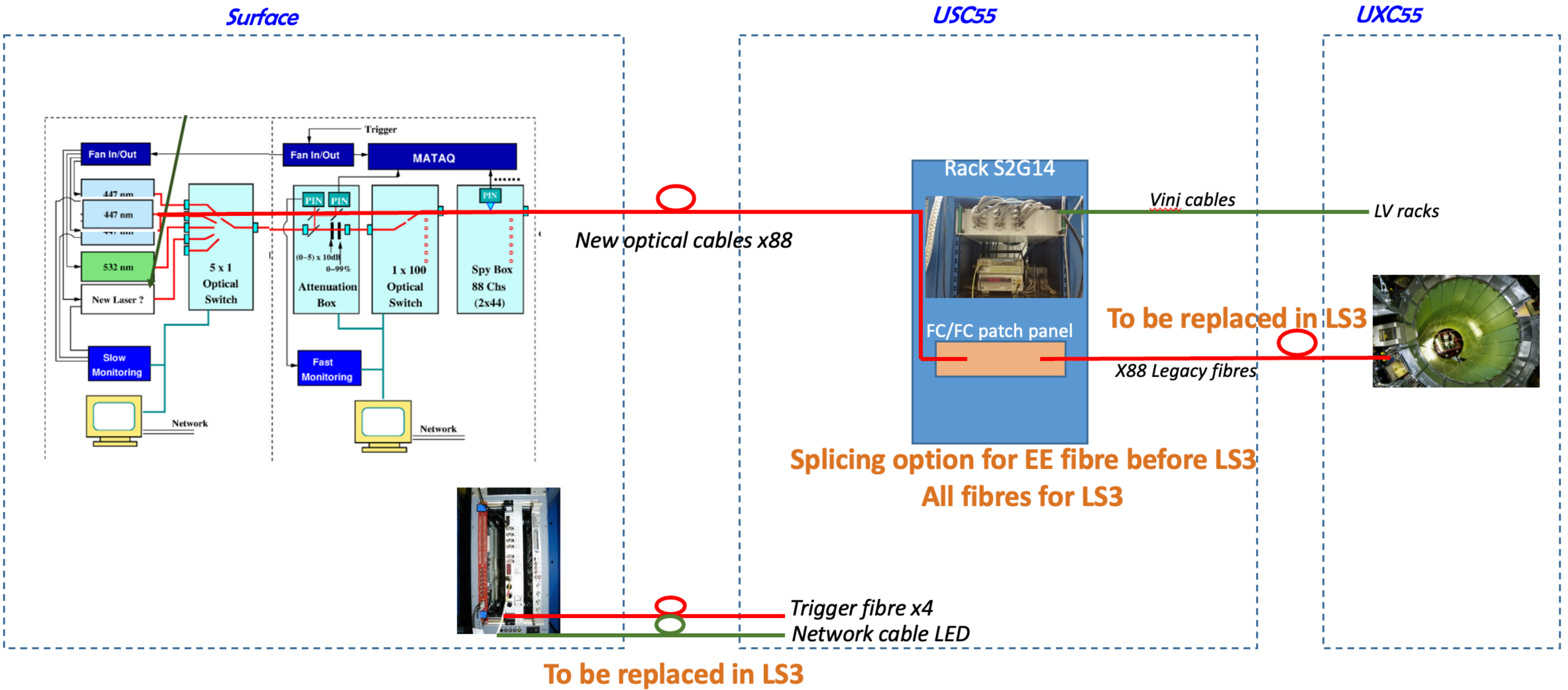


Laser room on surface

New laser room



Scheme of the **final setup for the new laser room during operations**



Laser relocation activities

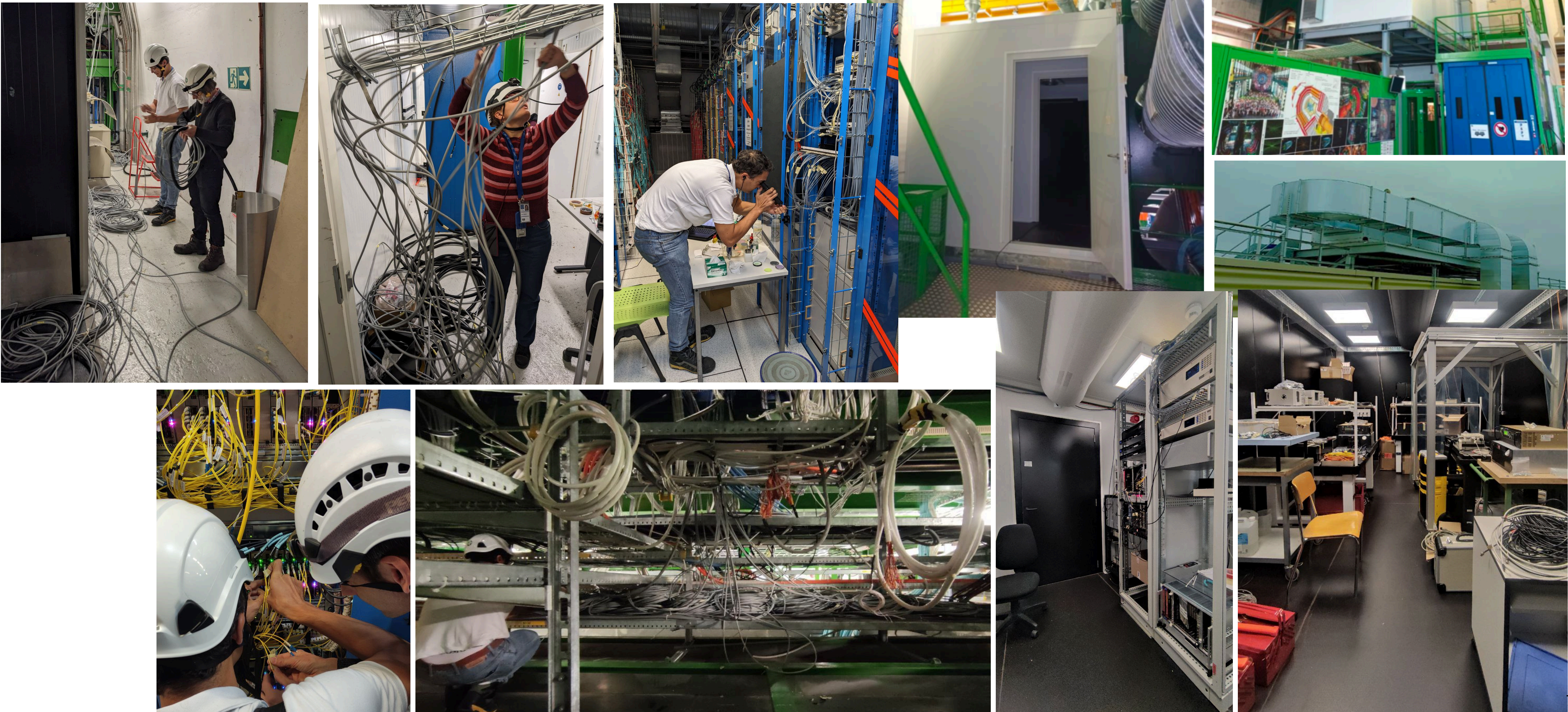


- Work on the relocation started on October 30th
- Completed cabling arrangement underground on November 7th
- Switched ECAL on and started taking data from November 8th
- All runs with EE+ and EB+ included, EB- and EE- included when possible according to YE- status
- Following data taking remotely from November 14th
- Data taking ended on November 25th

Laser parameters after relocation: <http://cmsonline.cern.ch/cms-elog/1201618>, <http://cmsonline.cern.ch/cms-elog/1202151>

More details on each day's activities in the backup

Relocation pictures

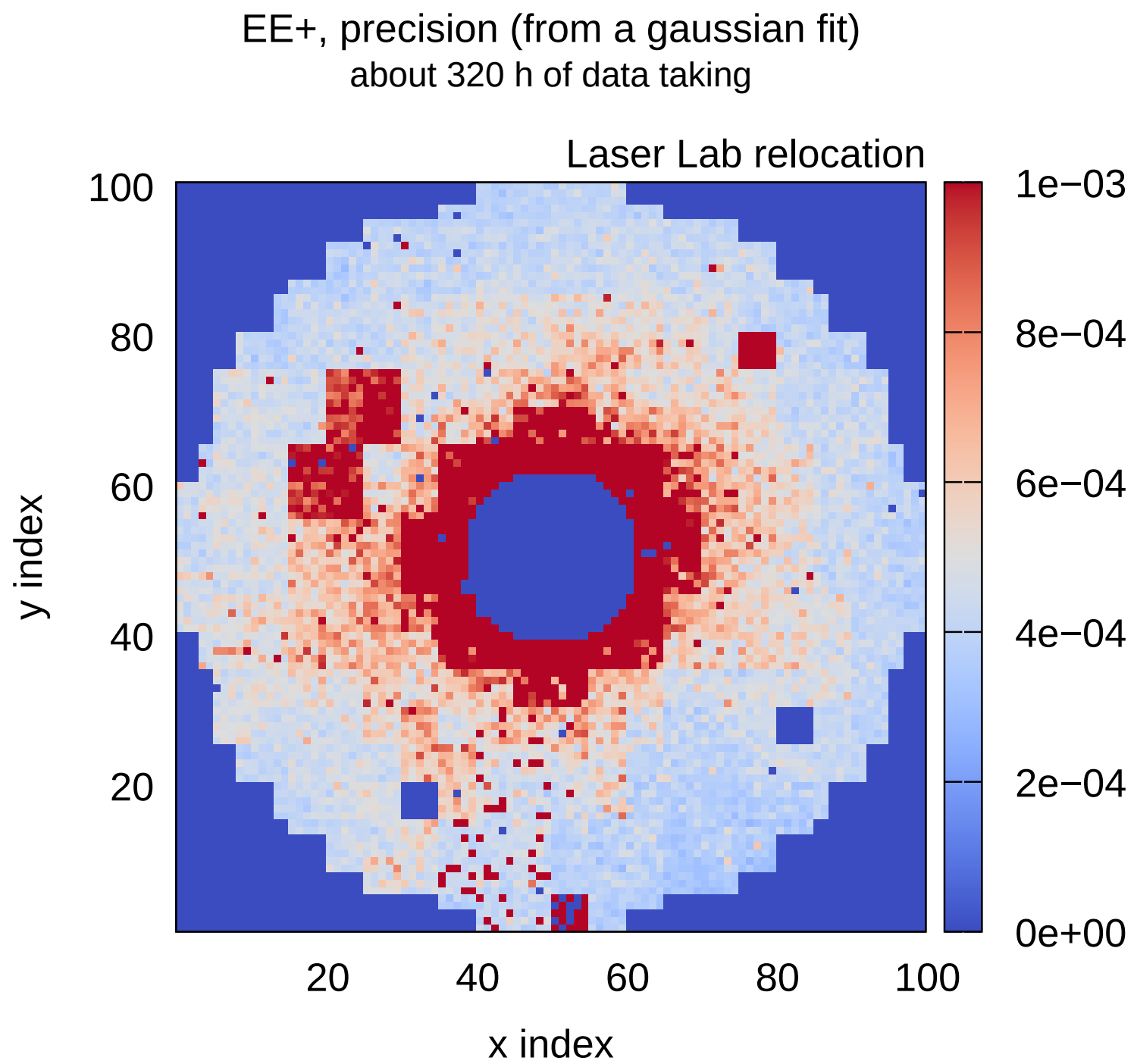
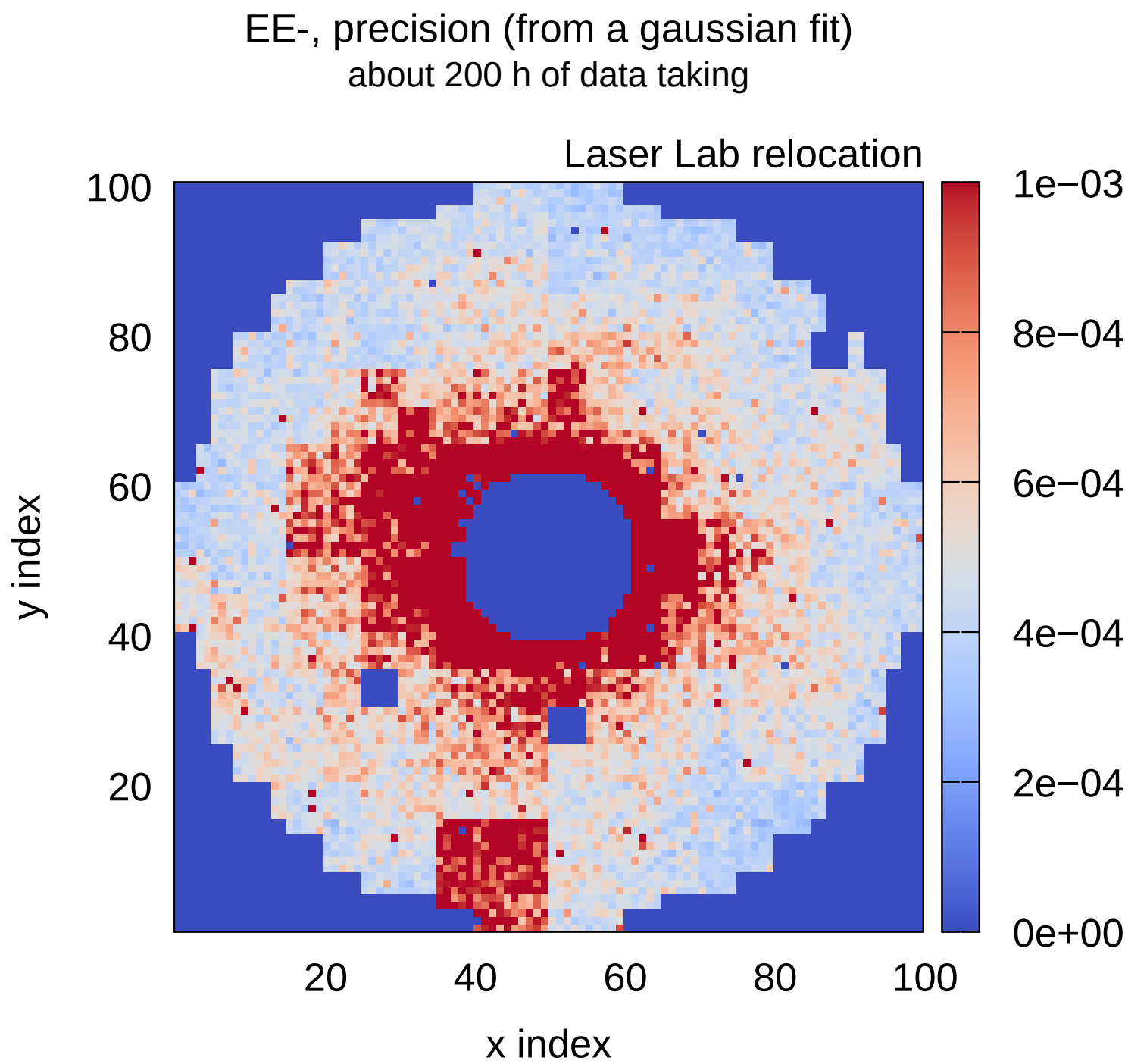
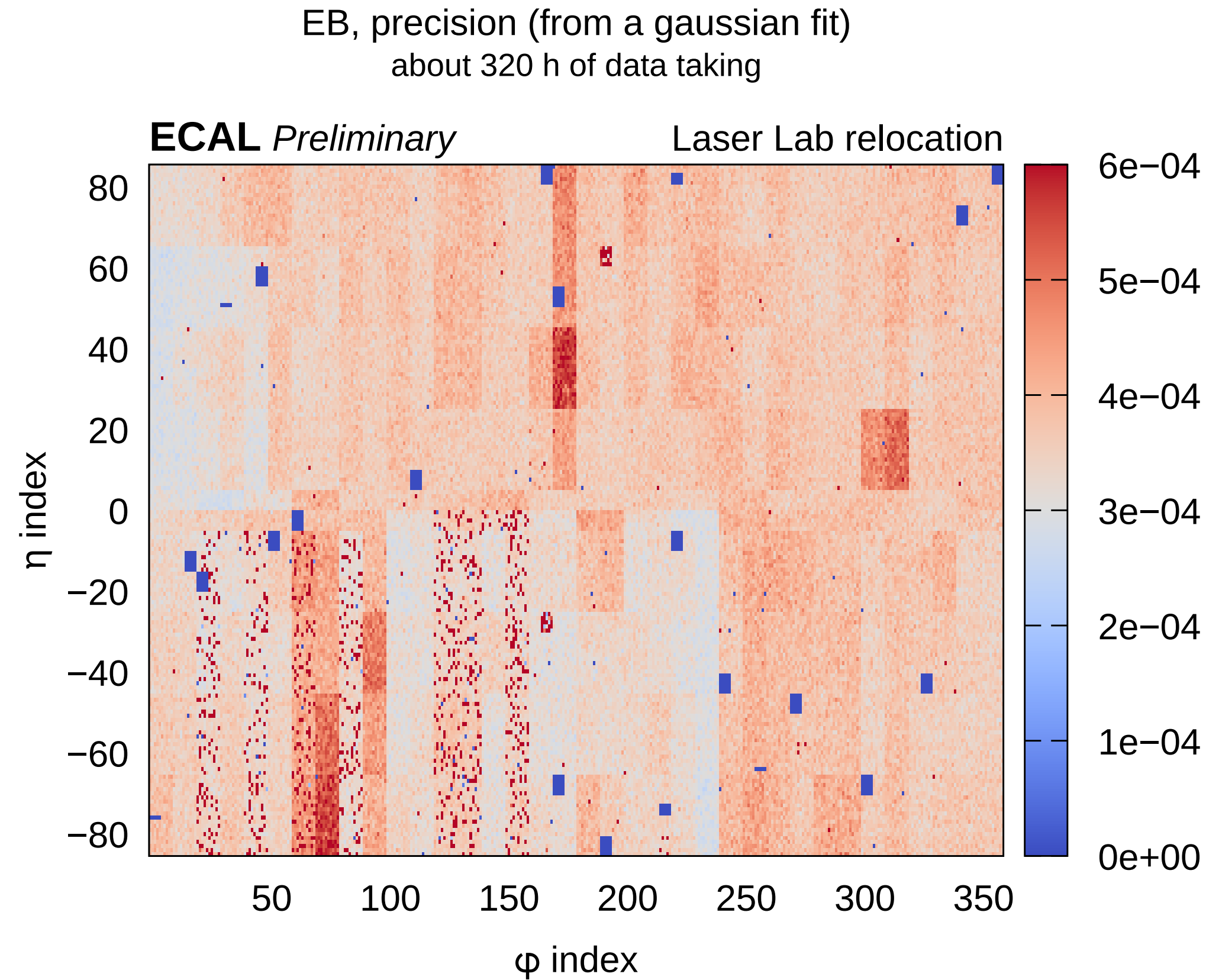


Laser relocation: system stability



Precision for each crystal represented in 2D maps for ECAL barrel and endcaps

- Precision $< 6 \times 10^{-4}$ in the barrel
- **Endcap precision degrading to 1×10^{-3} in inner regions** due to radiation damage of the crystals, but still within requirements



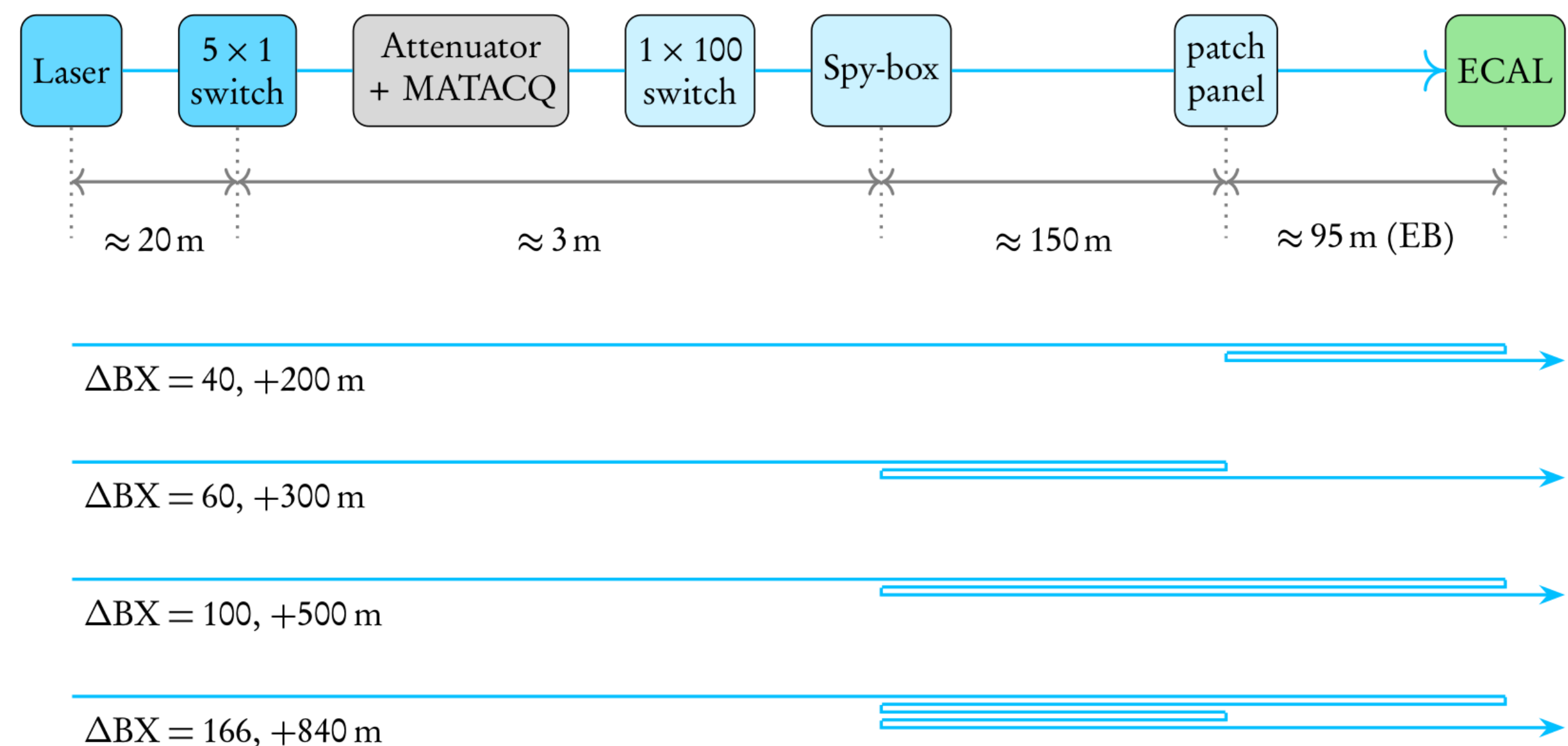
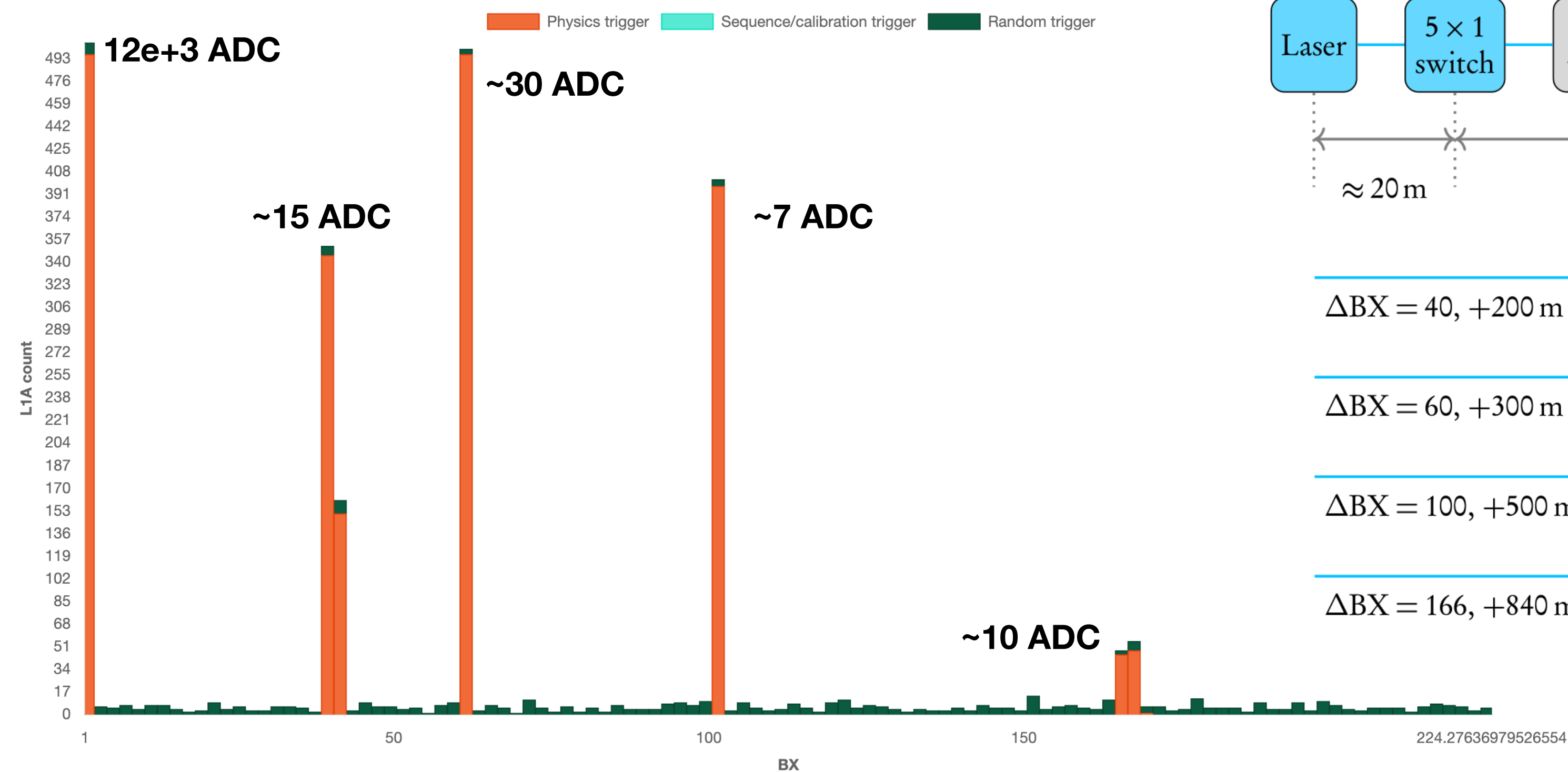
Laser relocation: tests at maximum power



Performed tests with **lasers at maximum power** to check the maximum amplitude we can see in ECAL with legacy lasers
Observed **laser reflection** with trigger in

- Dedicated tests** performed to further investigate the issue:
- Set laser delay to see the main pulse on BX=1
 - Observing both blue and green lasers **shooting in physics also in BXs 40-41, 62, 102, 165-169**
 - Checked the amplitude of each component with DQM

L1A histo



Laser relocation: laser reflection



The reflection doesn't prevent us from running reliably the new laser room

Reflections observed **only at maximum power** (more than 10 times higher than the one used up to now)

- Reflection amplitude is **500 times lower than the main pulse**
- **With current laser power the amplitude of the reflection won't trigger in physics**

What if none of the solutions work and we need to significantly increase the laser power to mitigate large transparency loss?

- The amplitude of the reflection decreases as much as the main pulse, so **it will keep not triggering in physics**
- Laser power can be **adapted for each laser monitoring region**
- Coherent background, if any, **can be removed offline**
- **No reflection observed in the endcaps** by now, where higher power might be needed

Further tests are ongoing

- Observed and increase of reflections when removing the spybox + monitoring box + 1x100 switch in the laser lab, under investigation

New green laser and new TCDS configuration



Laser lab equipped with a **new, more powerful, green laser** to be used during Run3 to mitigate the significant transparency loss at high eta in the endcaps

Goal: use the new green laser with the legacy blue in the laser sequence in 2024

Shooting in physics observed due to the large latency of the new green laser during the commissioning performed between August and October 2023 (time between trigger and firing: 600 us instead of 100 us)

- Solution: **EMTC firmware and TCDS configuration have been modified** in collaboration with DAQ and trigger experts: WTE B-Go signals are now sent 8 orbits before the calibration orbit (instead of 1 orbit before)

Commissioning of the change started at the end of January

- **New EMTC firmware and new TCDS configuration tested successfully** with only 1 EB SM in global at the end of January
- **Parameters for legacy blue, legacy green and new green lasers** defined at the end of January <http://cmsonline.cern.ch/cms-elog/1202551>
- **LED parameters** defined last week <http://cmsonline.cern.ch/cms-elog/1204553>
- **Commissioning in global with other subsystems** (all except CTPPS and RPC) from February 19th - no shooting in physics or issue due to new TCDS configuration observed up to now
- **Final validation with all subsystems in to be done**
- **New DQM thresholds to be defined**

HVAC system



Dedicated HVAC system for temperature and humidity control of the new laser lab

→ Specs: ± 0.3 °C for laser performance, <40% humidity for the optics

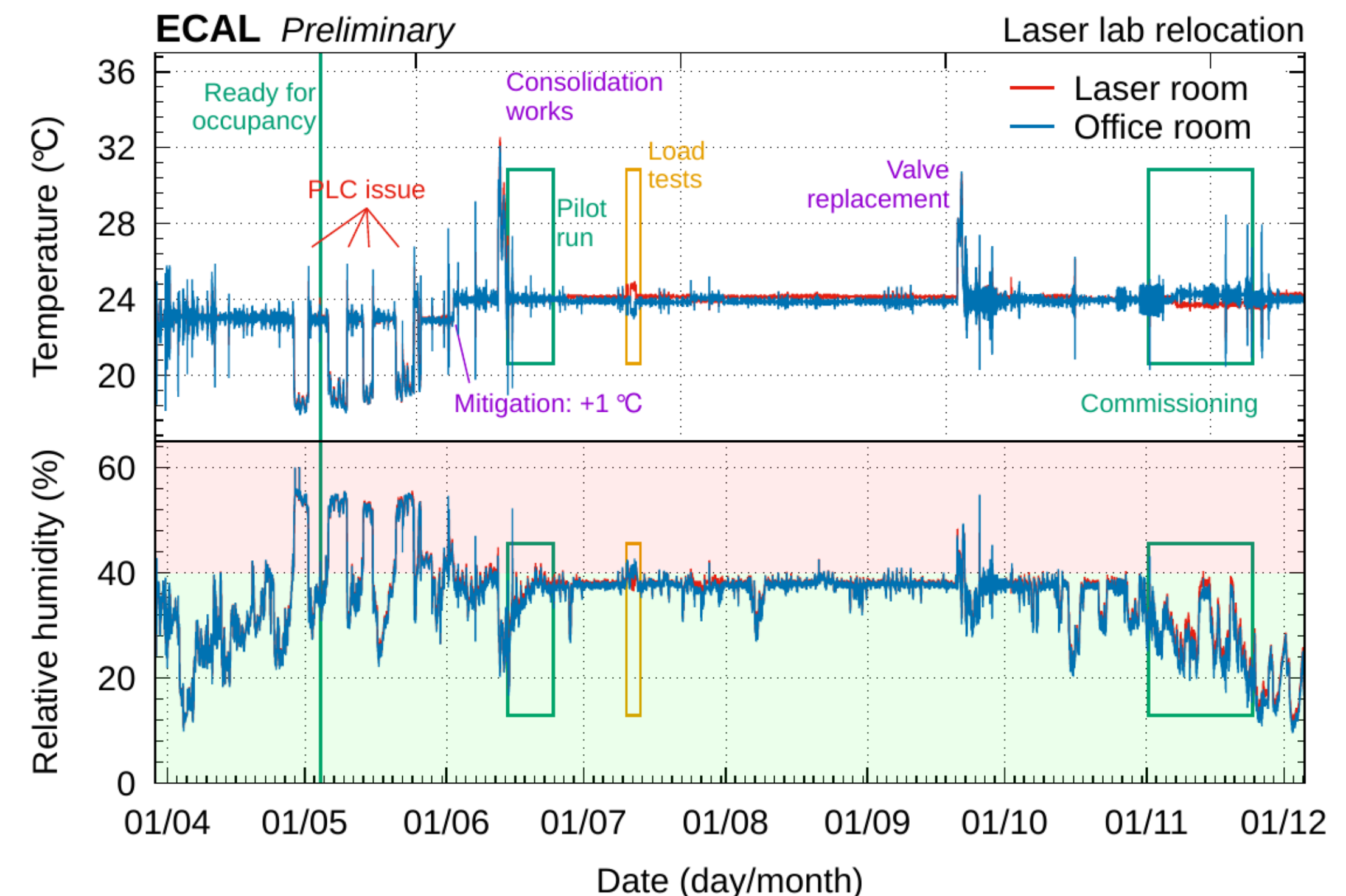
HVAC system worked well during the pilot run in June

Issue found in July using a heater, solved by replacing a valve with a more powerful one to allow more fresh air

System tested at the end of September/beginning of October with presence of people in the lab coming in and out

The systems keeps stable **the mean values** of temperature and humidity **of the two rooms** in the laser lab

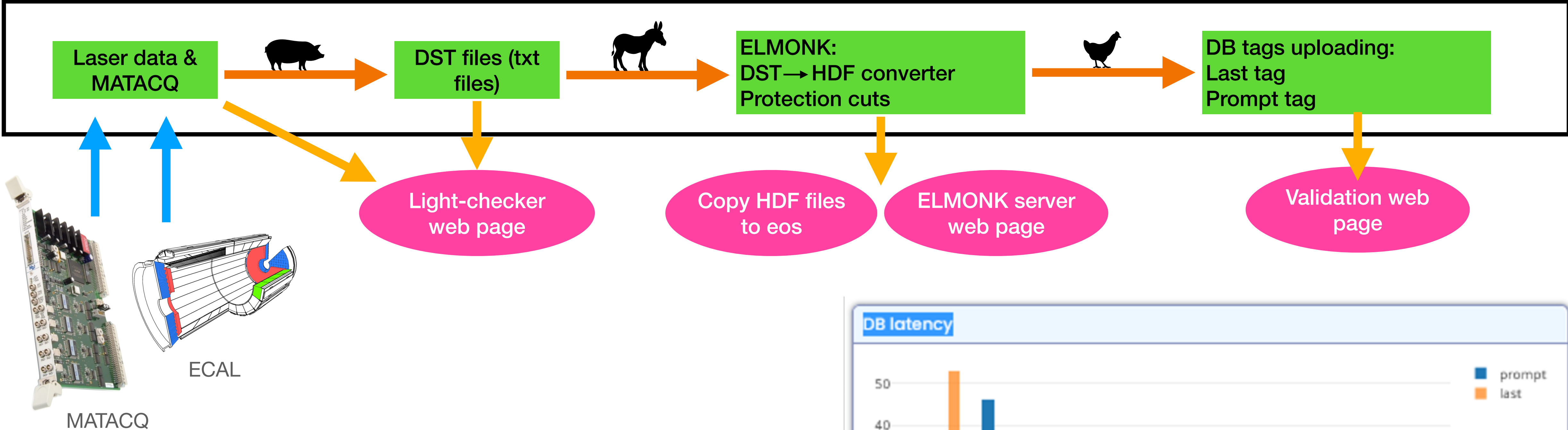
- The two rooms have **different thermal loads**
- The system is being upgraded with a **new servo-monitor** to induce a similar thermal load in the two rooms through different air fluxes
- **If the system stability won't meet the requirements the HVAC will be further upgraded** to control separately the parameters of the two rooms



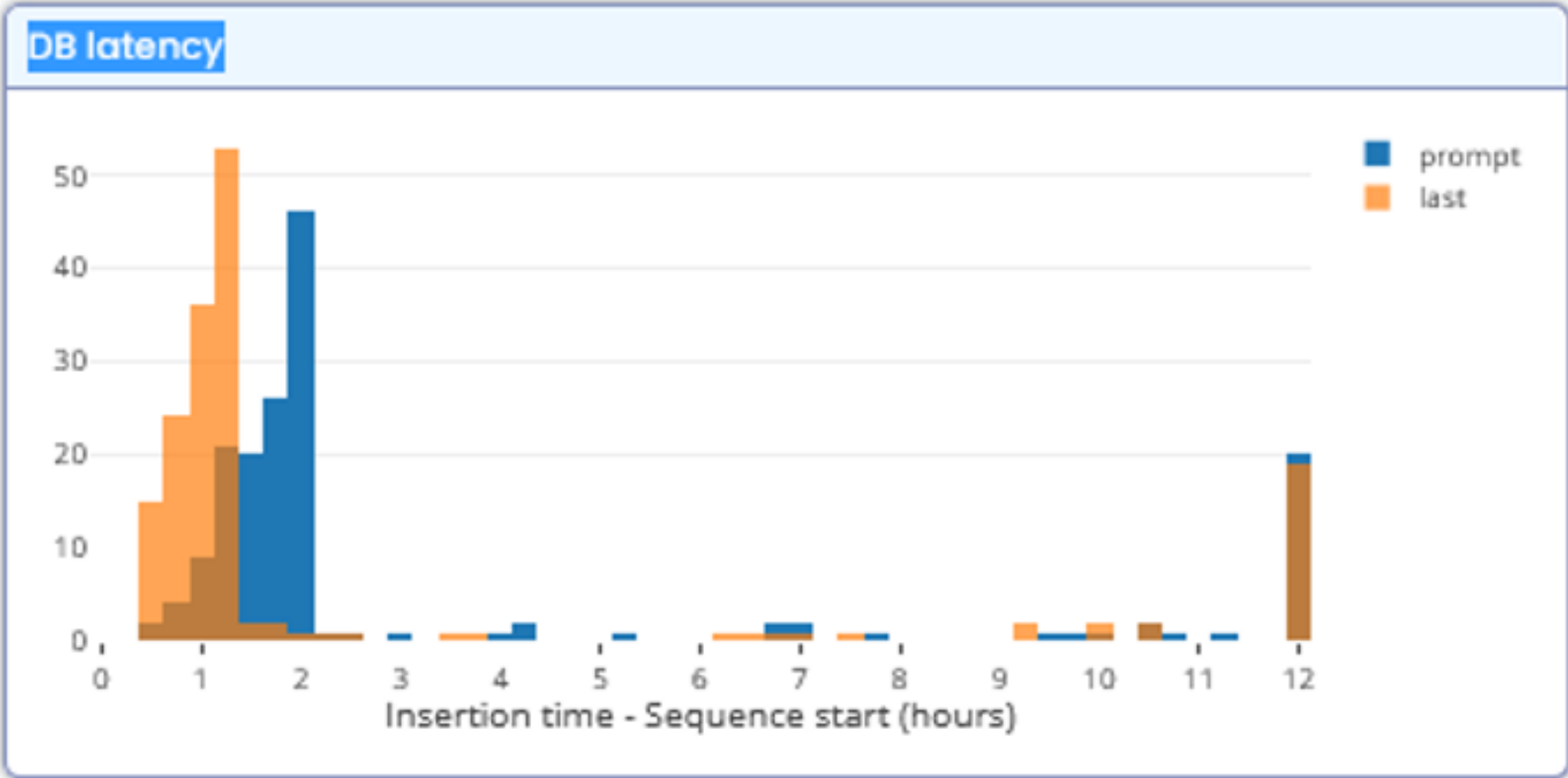
Laser data flow



Thanks to Tatyana Dimova for the material!



- **Stable working during 2023 data taking**
- **Quick uploading into DB**
- HDF files at eos allow to perform **quicker analysis** of laser data than with old FillCorr code



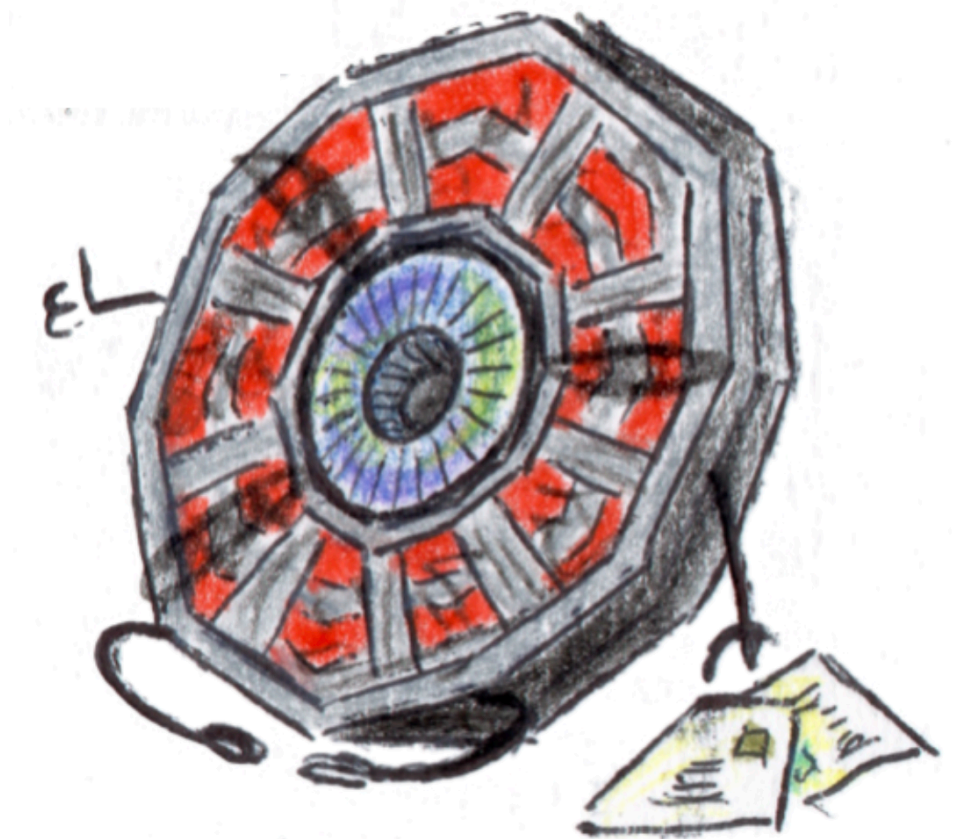
Conclusions and future steps



New laser room commissioning completed successfully and on schedule

- **Pilot run in June** to verify the correct functionality of the system with lasers on surface
- **Relocation of the laser room** performed between end of October and beginning of November
- **New laser lab stability** verified thanks to data taking from 8th to 25th of November
- **New EMTC firmware and new TCDS configuration commissioning** from end of January to include the new green laser
- **HVAC system being finalized**

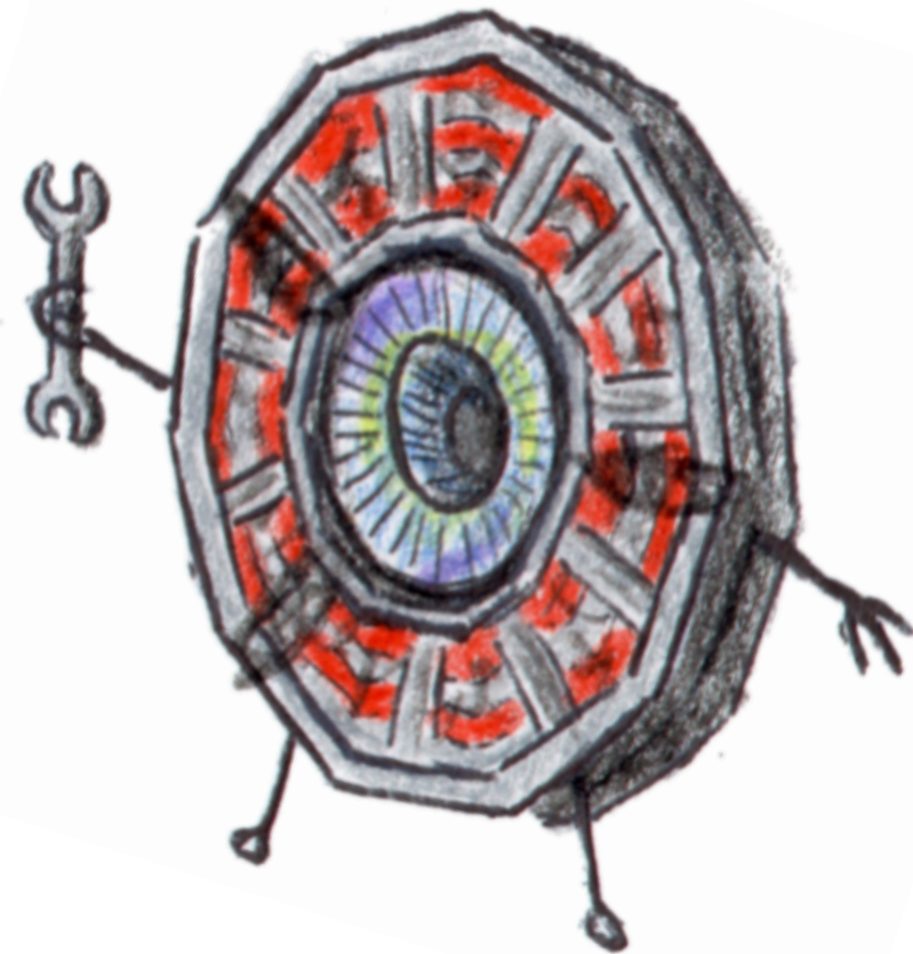
Current laser data flow is stable and allows quick upload and data analysis



→ System ready to take data reliably in 2024!

Pending actions to be followed up

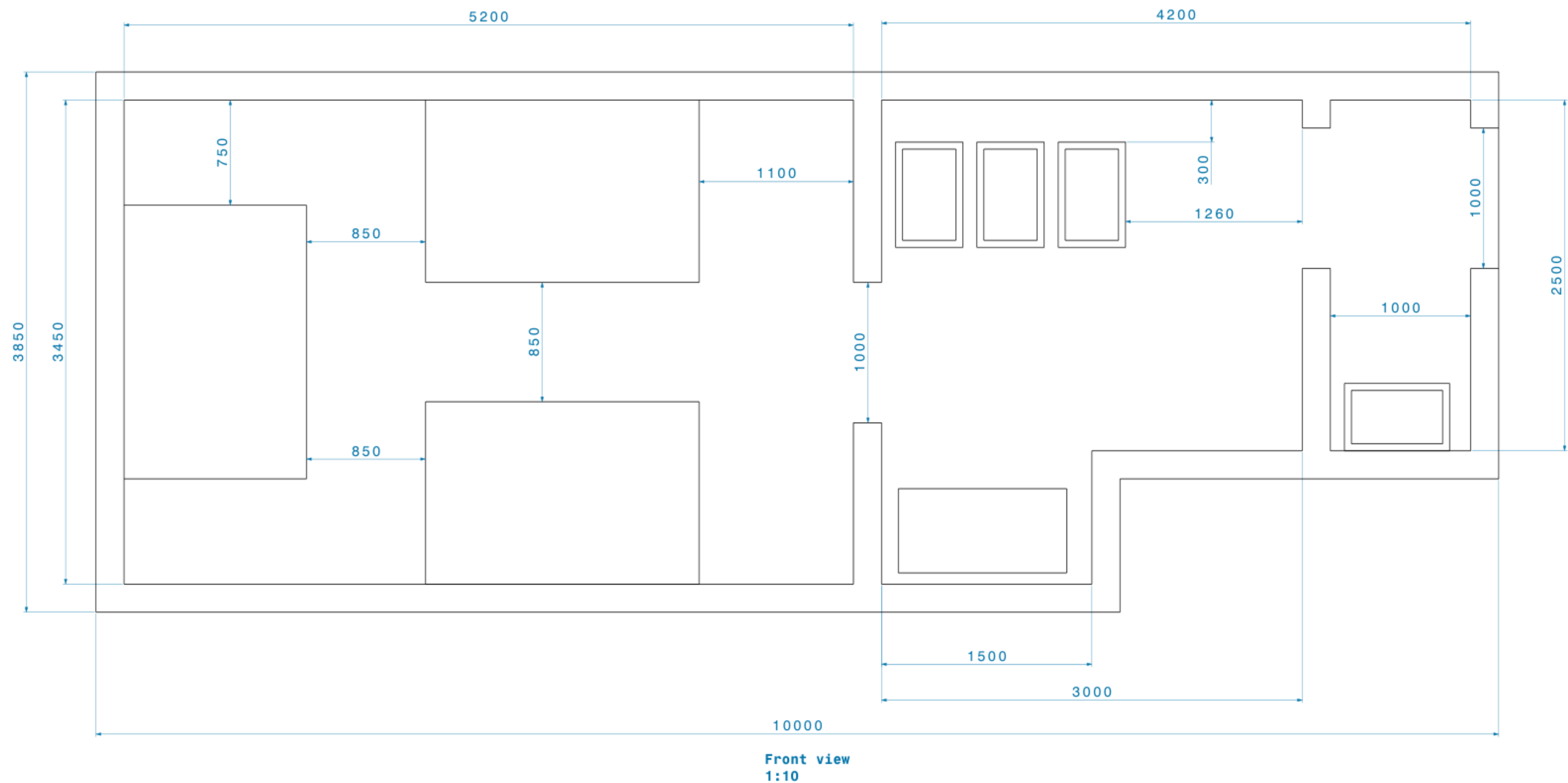
- **Final validation of new laser system with all subsystems**
- **Laser reflections at high power** to be investigated
- **HVAC system to be monitored** after the latest upgrade
- **Update of DQM plots**





Backup

New laser room



Laser relocation activities



- **Monday 6th and Tuesday 7th November** (elog: <http://cmsonline.cern.ch/cms-elog/1201374>)
 - routing of fibers and MEM LV cables
 - connection via the patch panel in USC55 of the fibers coming from surface to the those going to ECAL
 - connection of the new laser trigger fibers to the EMTC
 - finalisation of connections and lasers powerup in the lab on surface
- **Wednesday 8th November** (elog: <http://cmsonline.cern.ch/cms-elog/1201431>)
 - EB+ and EE+ switched on
 - Definition of parameters to correctly see spare blue and legacy green both on MATACQ and DQM
 - Rearranged swapped fibres
 - Started data taking in global with spare blue and legacy green
- **Thursday 9th November** (elog: <http://cmsonline.cern.ch/cms-elog/1201471>)
 - Definition of parameters to correctly run LED in the sequence
- **Friday 10th November** (elog: <http://cmsonline.cern.ch/cms-elog/1201510>)
 - EB- and EE- switched on, all ECAL in the runs
 - Rearranged swapped fibres
 - Adjustment of lasers power
 - Tests with maximum power of the lasers, observed reflection on the laser path

Laser relocation activities



- **Monday 13th November** (elog: <http://cmsonline.cern.ch/cms-elog/1201575>)
 - Improvement of the jitter of the system with cable replacement
 - One run with all ECAL in with legacy blue, green and LEDs, then back to spare blue + legacy green
- **Tuesday 14th November**
 - EB- and EE- switched off, EB- back on in the afternoon
- **Monday 20th November**
 - EE- switched back on, running with all ECAL in
 - Issue with safety door due to bad contact solved
- **Wednesday 22nd November** (elog: <http://cmsonline.cern.ch/cms-elog/1201920>)
 - Tests with blue laser at maximum power and main pulse shooting in BX=1 to observe the reflection
- **Thursday 23rd November** (elog: <http://cmsonline.cern.ch/cms-elog/1202012>)
 - Repeating tests of Wednesday 22nd adding a 21m-long fibre on different points of the laser path
- **Saturday 25th November**
 - ECAL switched off around h20, end of new laser room commissioning

Final laser parameters: <http://cmsonline.cern.ch/cms-elog/1201618>, <http://cmsonline.cern.ch/cms-elog/1202151>

Laser relocation: runs

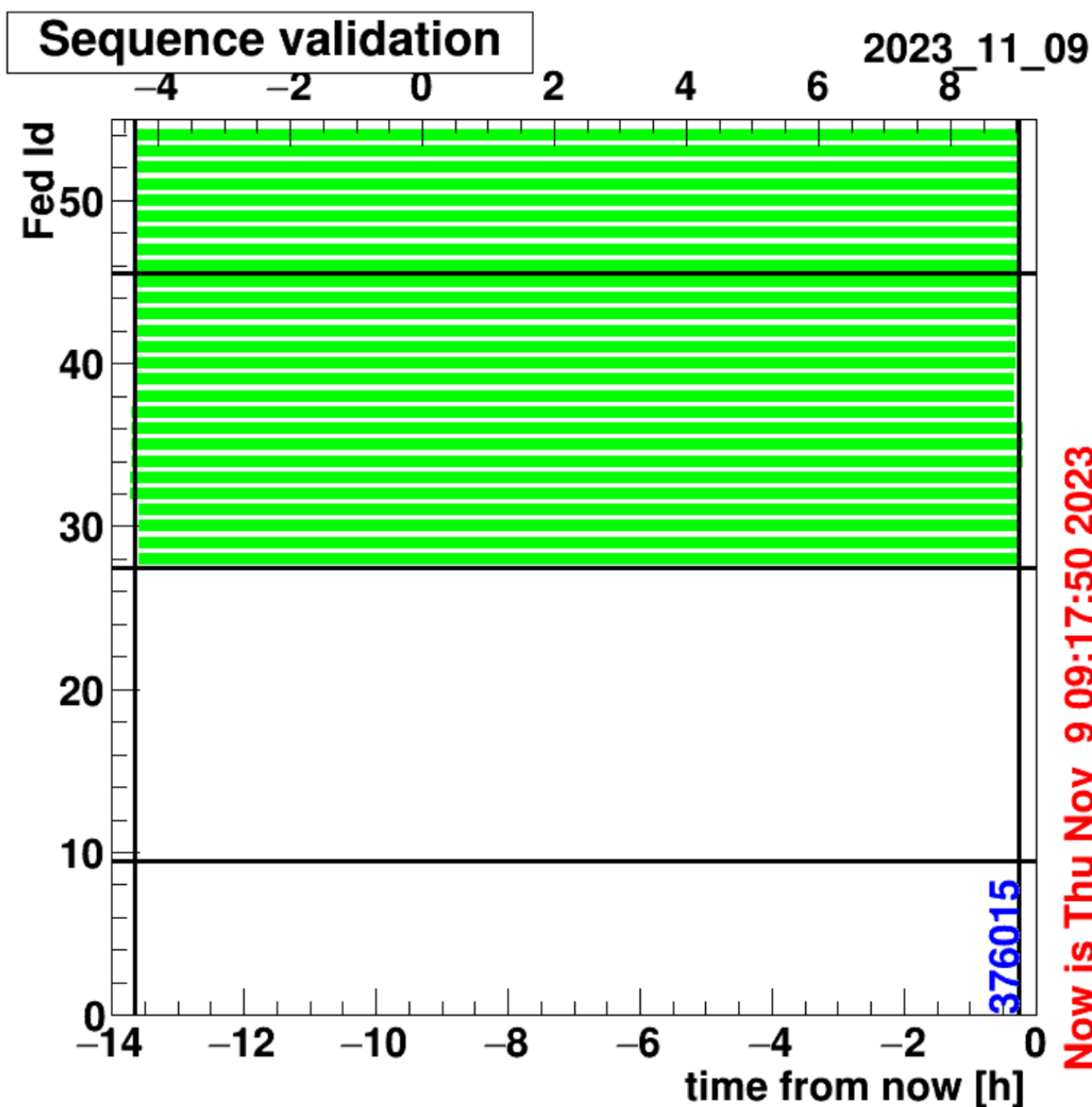
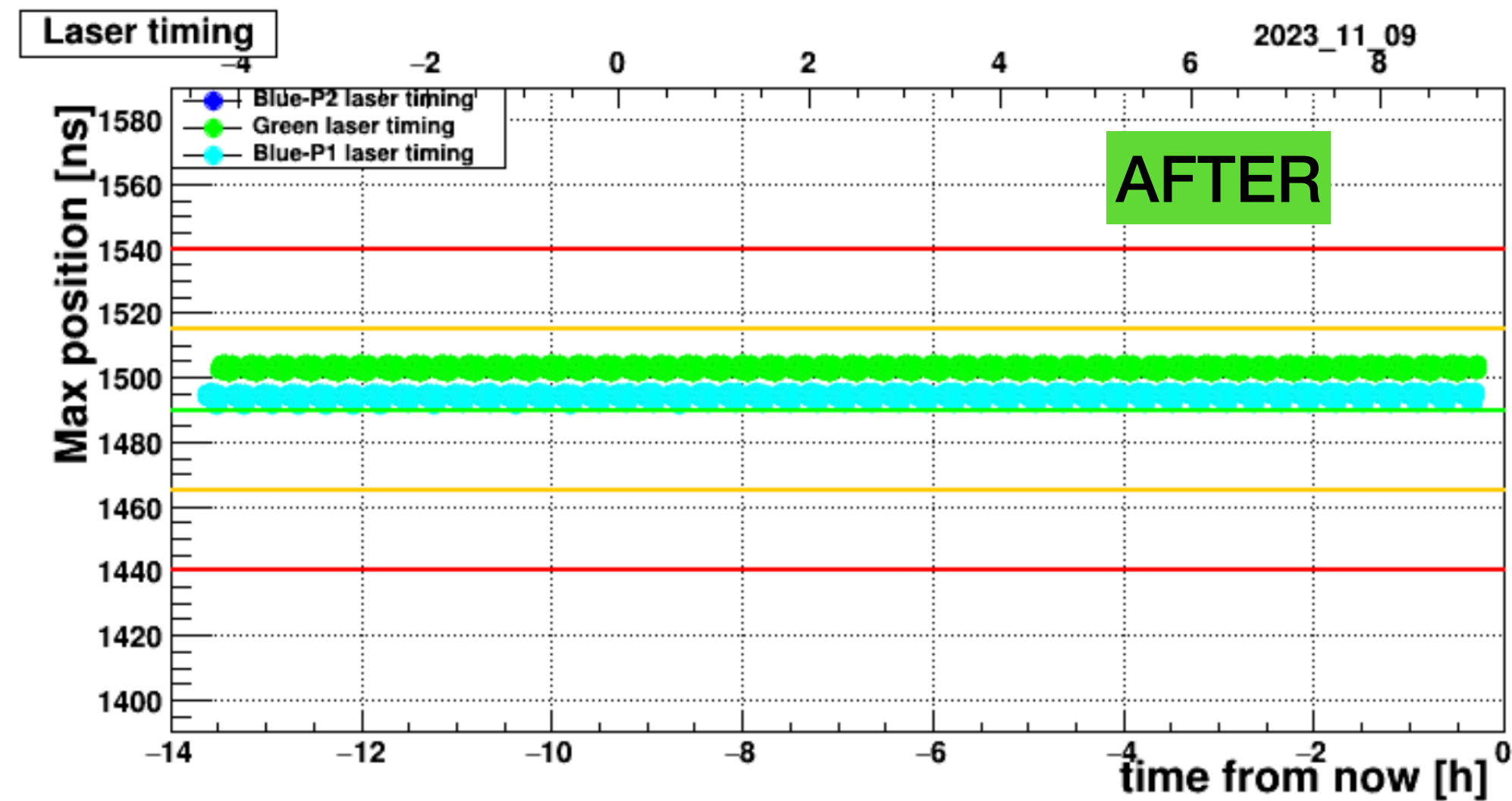
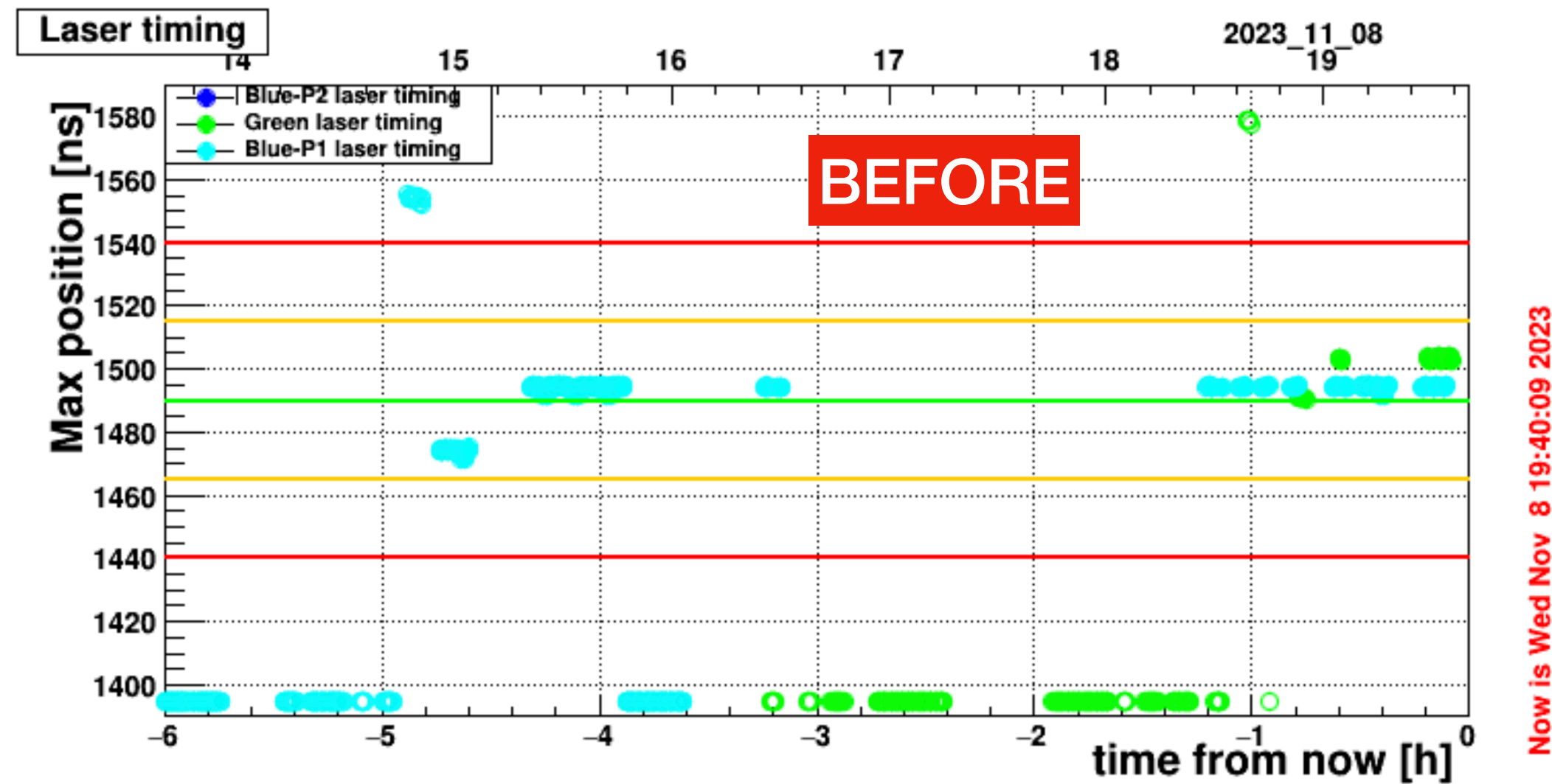
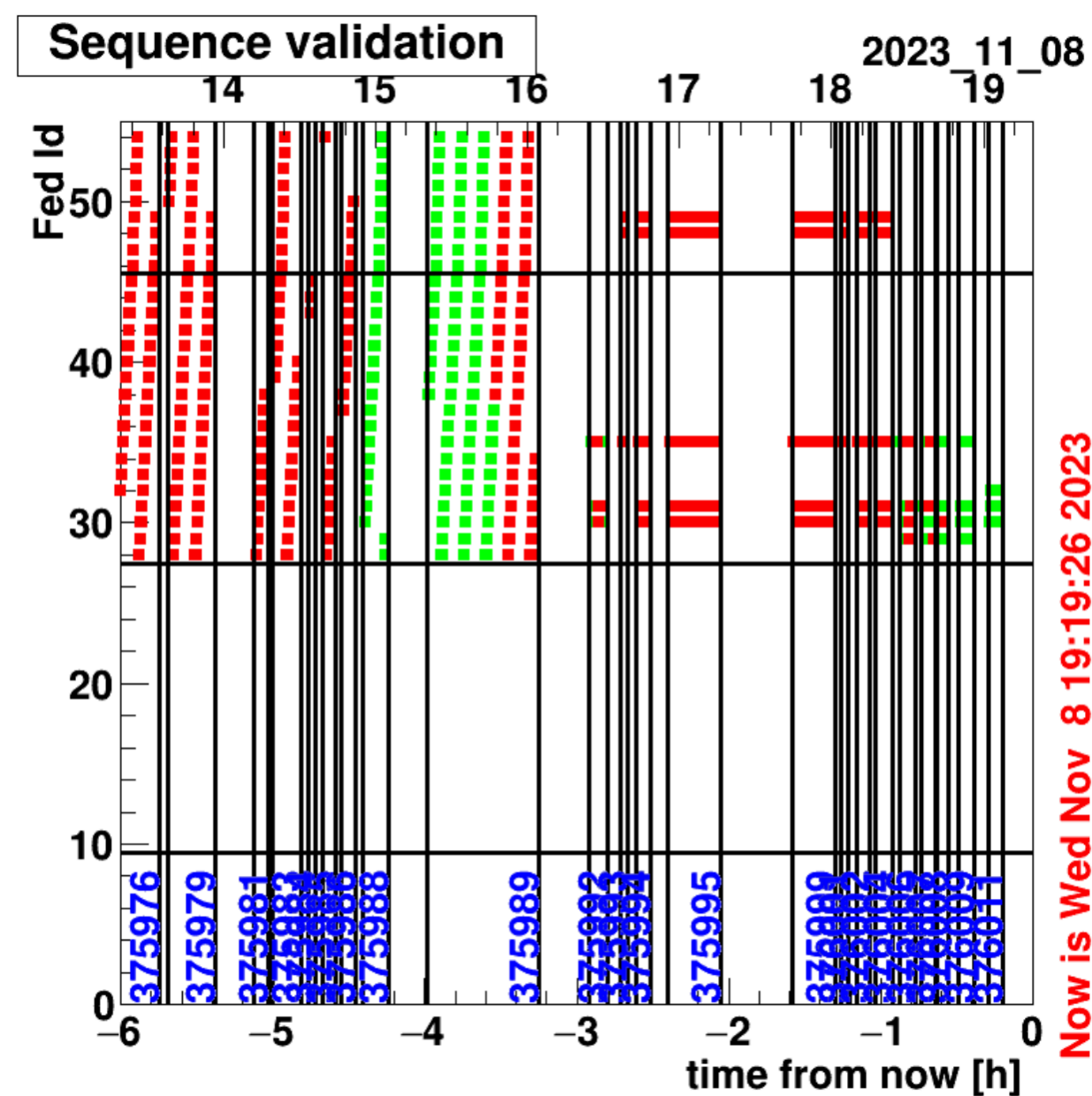


Global runs summary:

All ECAL	376038, 376055, 376156, 376159, 376167, 376186, 376189, 376192, 376238, 376244, 376259, 376260
ECAL with FED 617 out	376060, 376077 (with legacy blue, green and LEDs), 376082
ECAL with FED 617 and 618 out	376063, 376071
EB+, EB-, EE+	376084, 376099-376102 (token ring failure in FED 652), 376108, 376109, 376127, 376147
EB+, EB-, EE+ with FEDs 640-642 out	376146
EB+ EE+	376015, 376017, 376020, 376031, 376083

- FED 617 and 618 out due to LV channel failure
- FED 640-642 out due to issue with VME crate
- Failure of a HV channel in EB from run 376186
- Runs in-between (starting from run 375969) used to tune laser parameters and perform tests
- First run for laser tuning taken in miniDAQ (375961-375966)

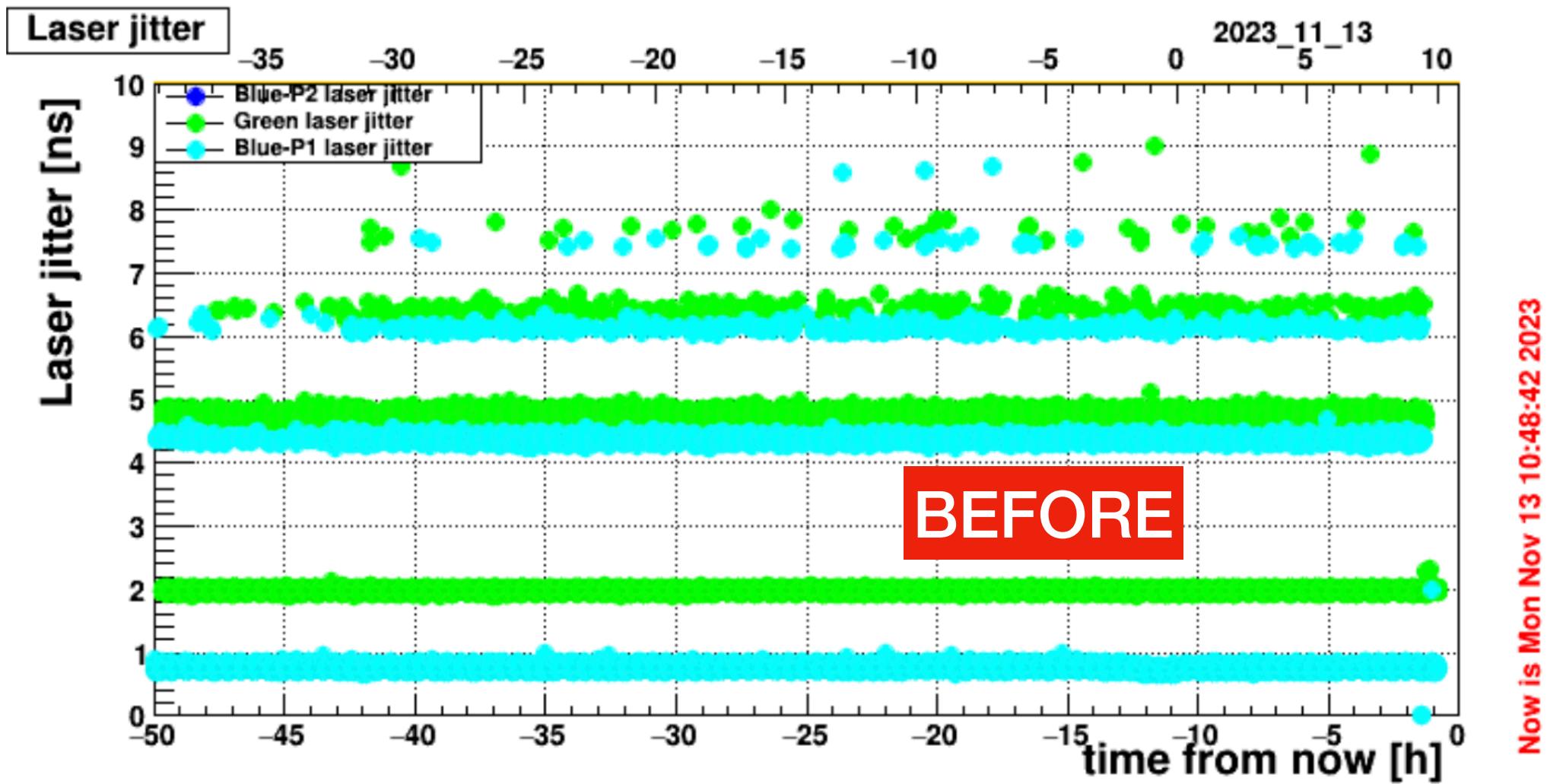
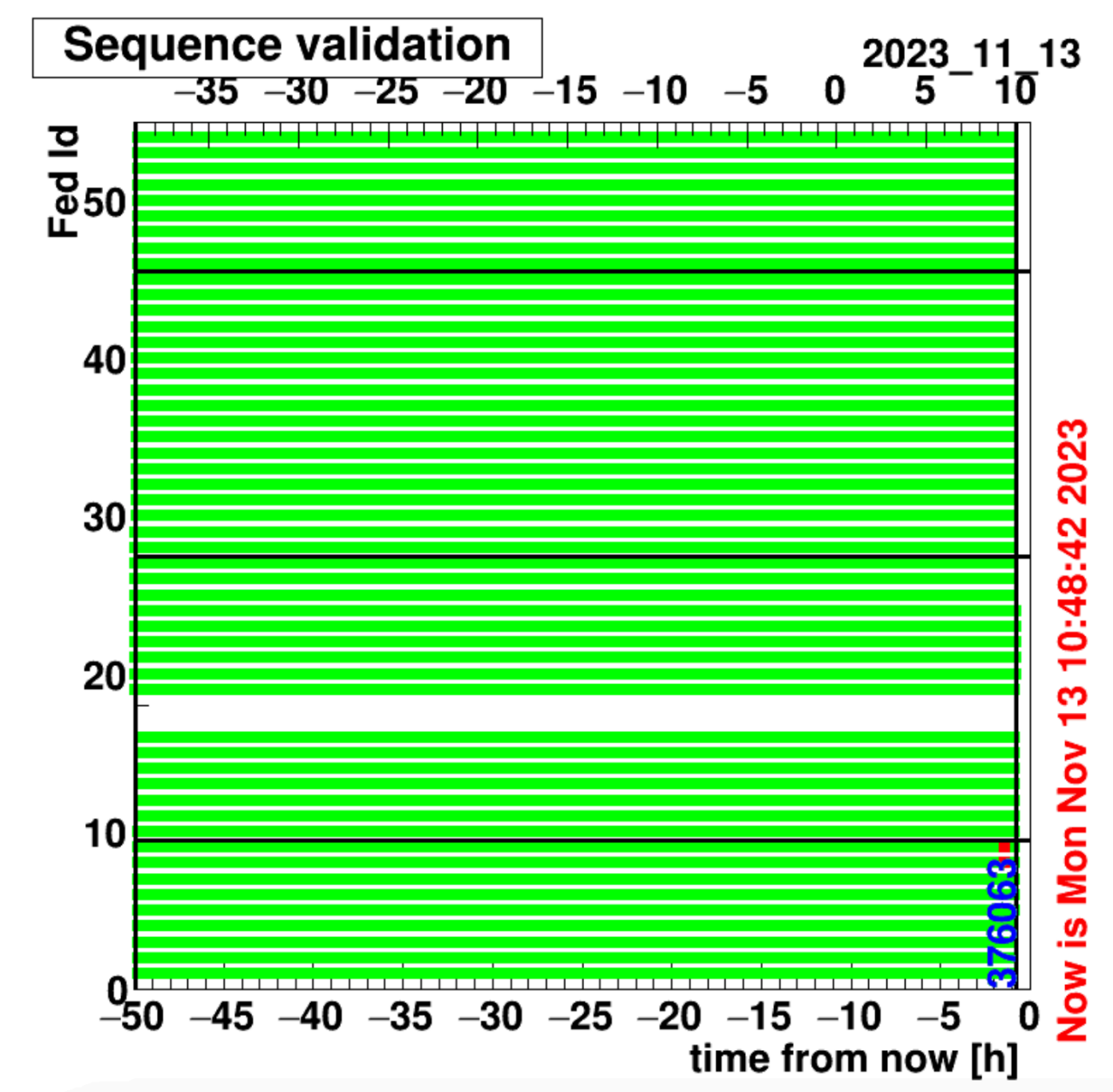
Laser relocation: parameters tuning



Centering of the laser pulses in the middle of the MATACQ acceptance window to ensure correct shooting in the middle of the orbit gap

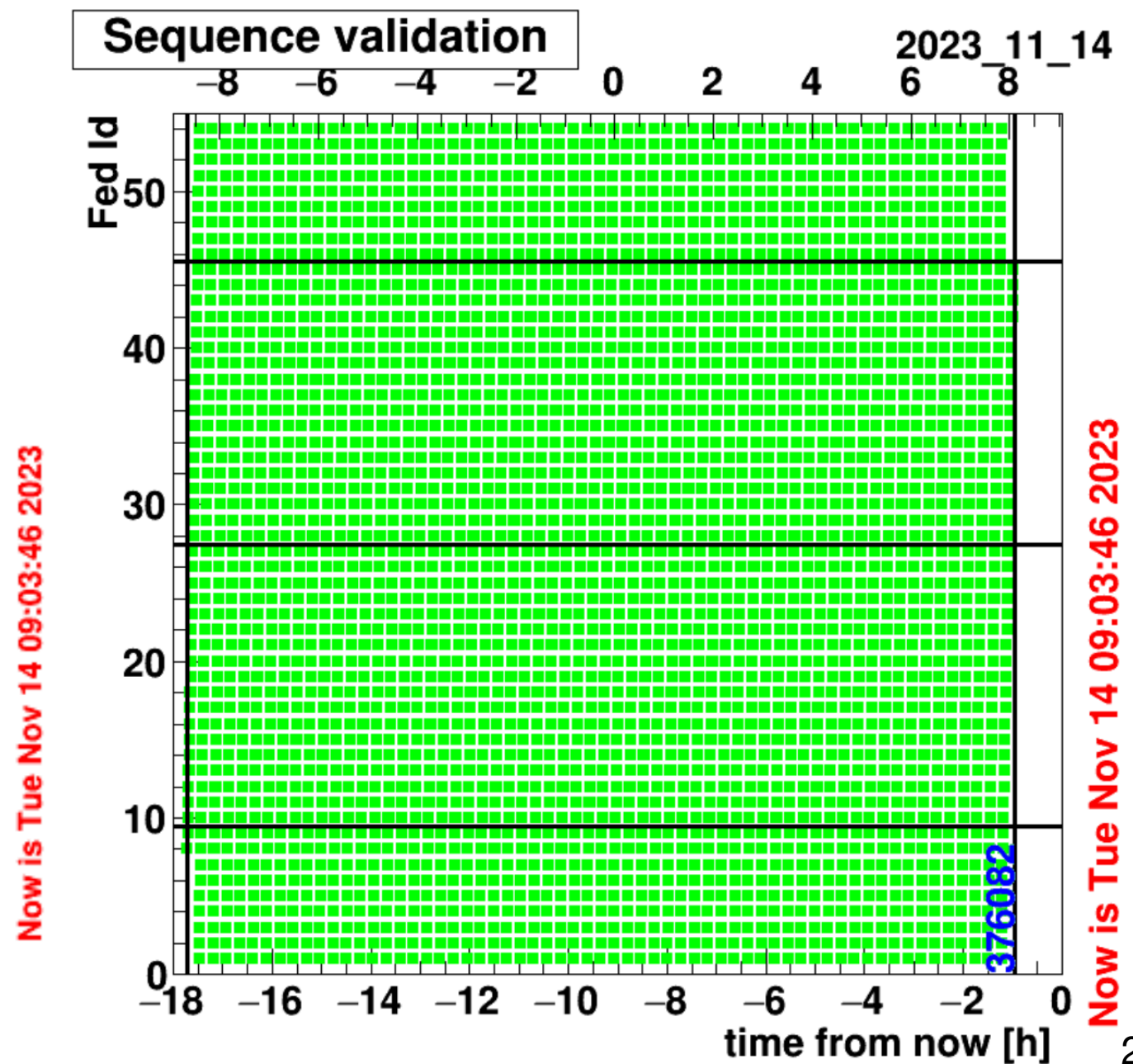
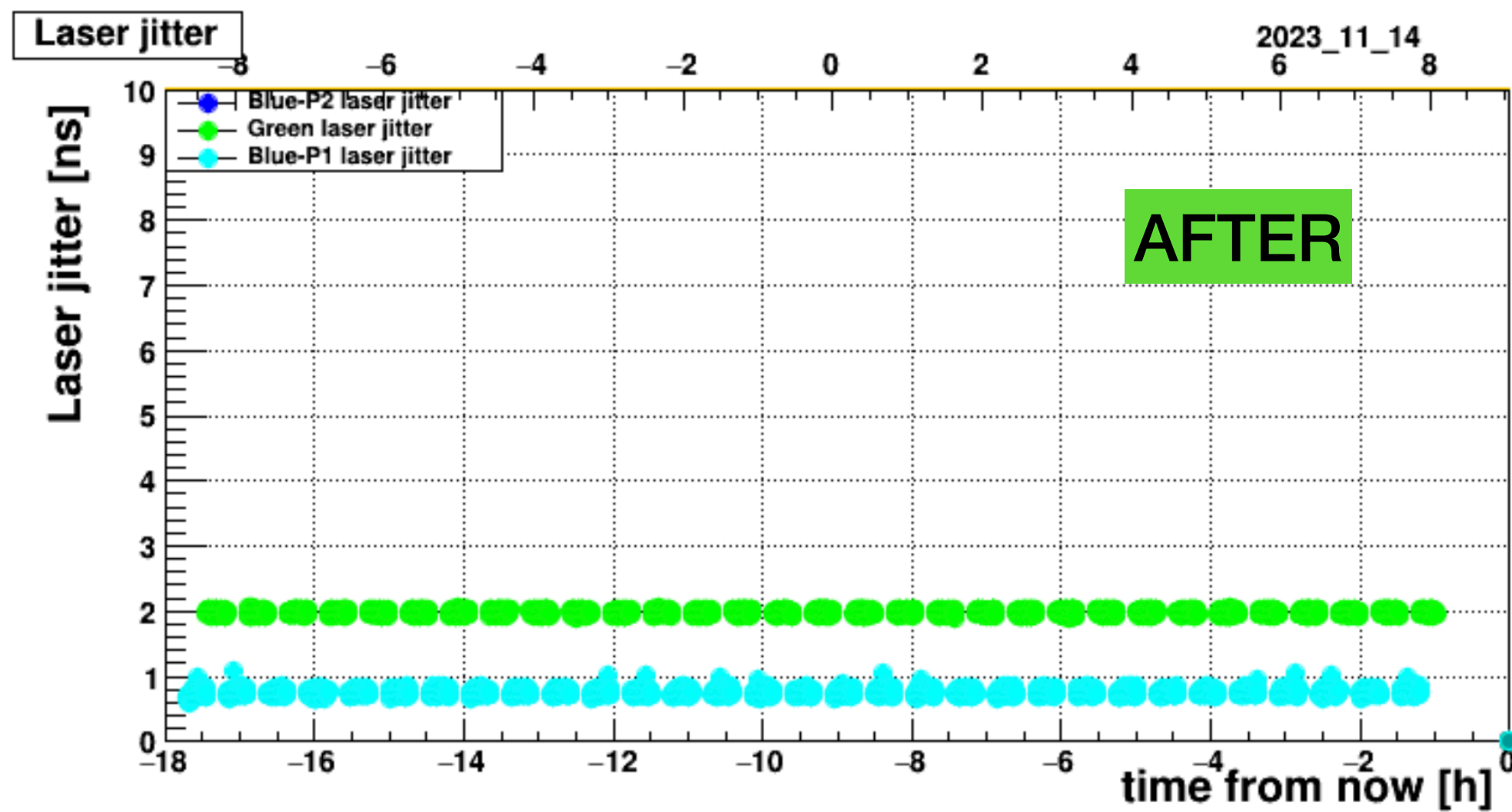
Sequence validation do not show any red points after finding the correct timing

Laser relocation: parameters tuning



jitter tuning

Bad cable identified and replaced to improve the laser jitter

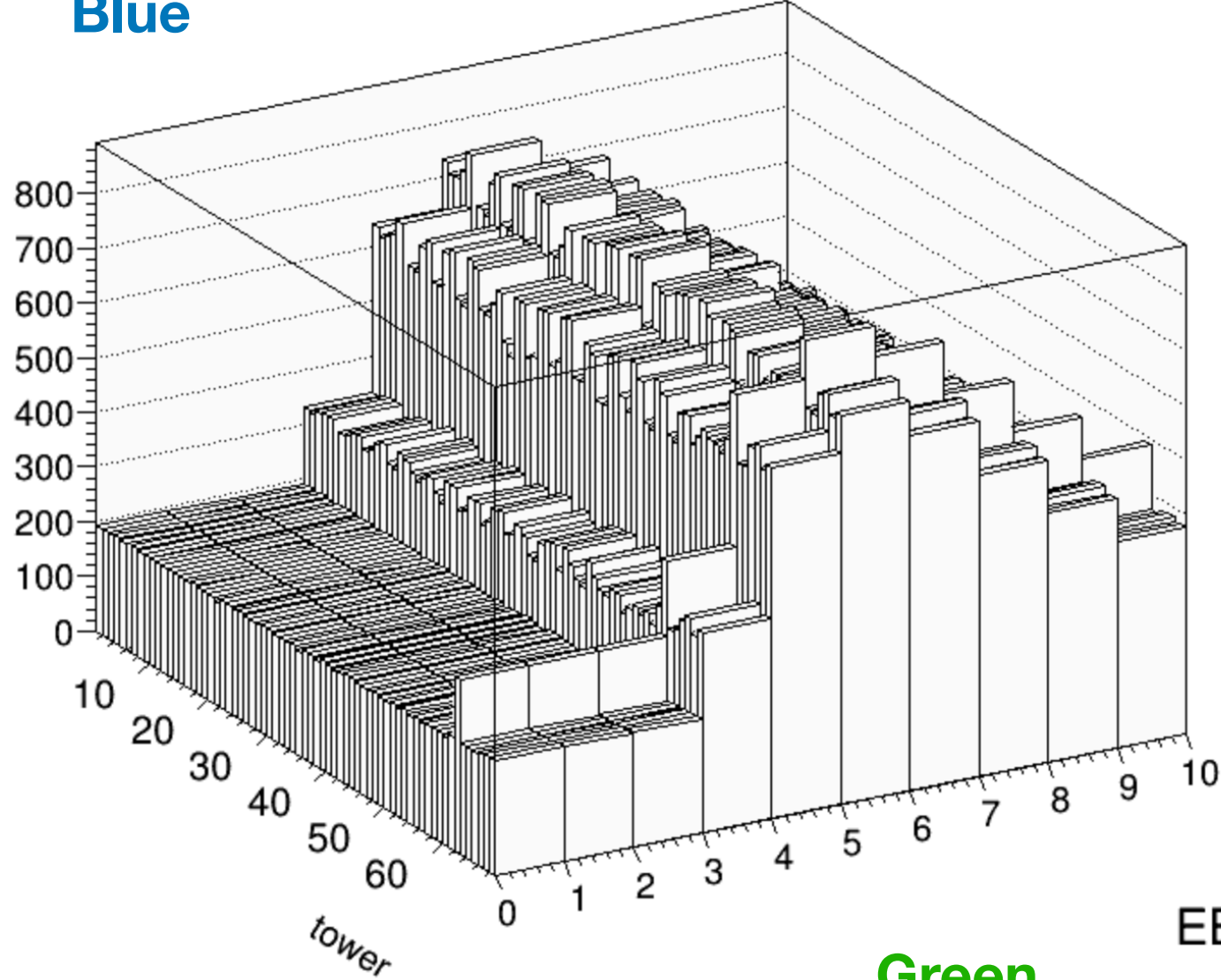


Laser relocation: parameters tuning



EBLT shape EB+06 L3

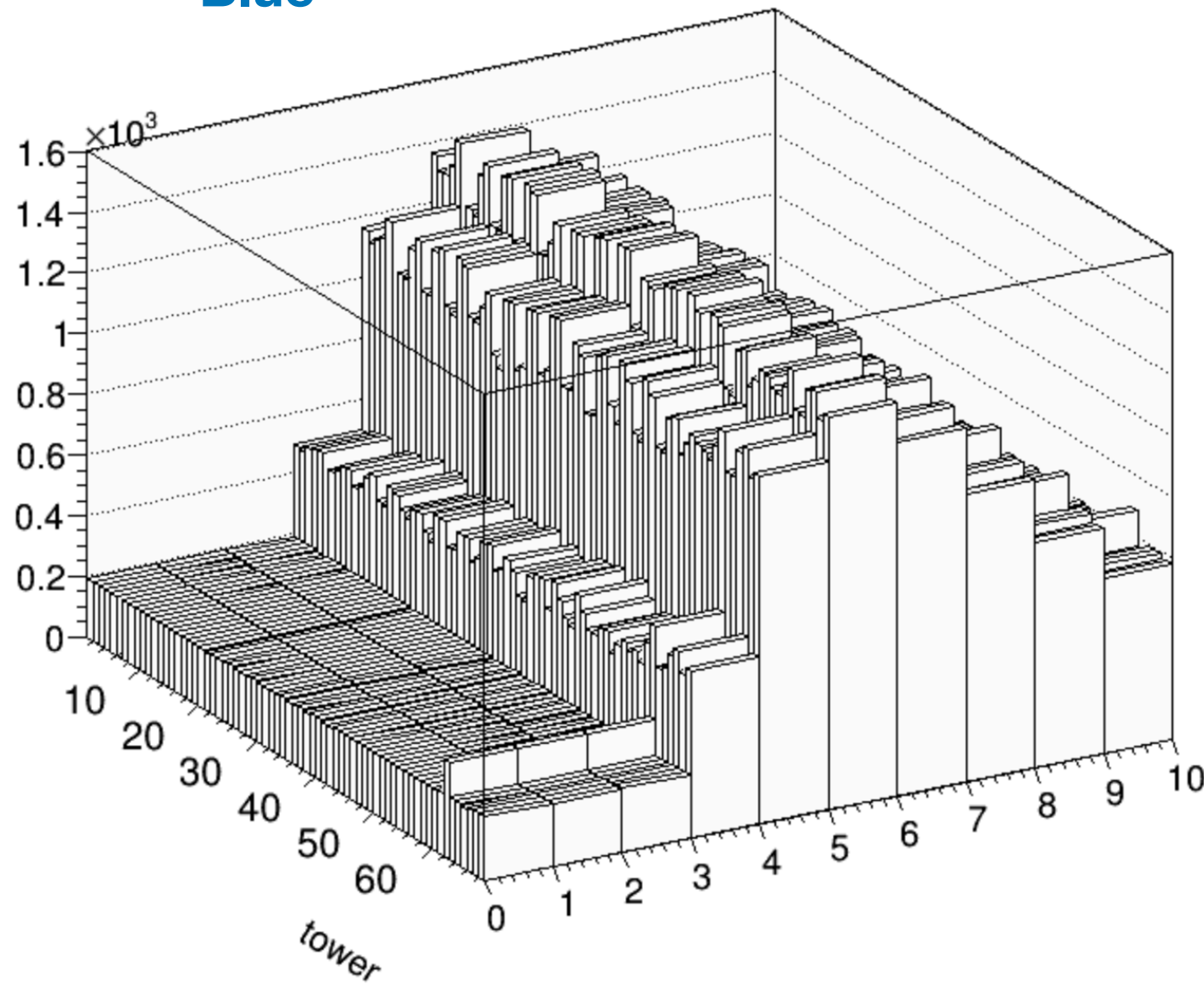
Blue



Power tuning

EBLT shape EB+06 L3

Blue

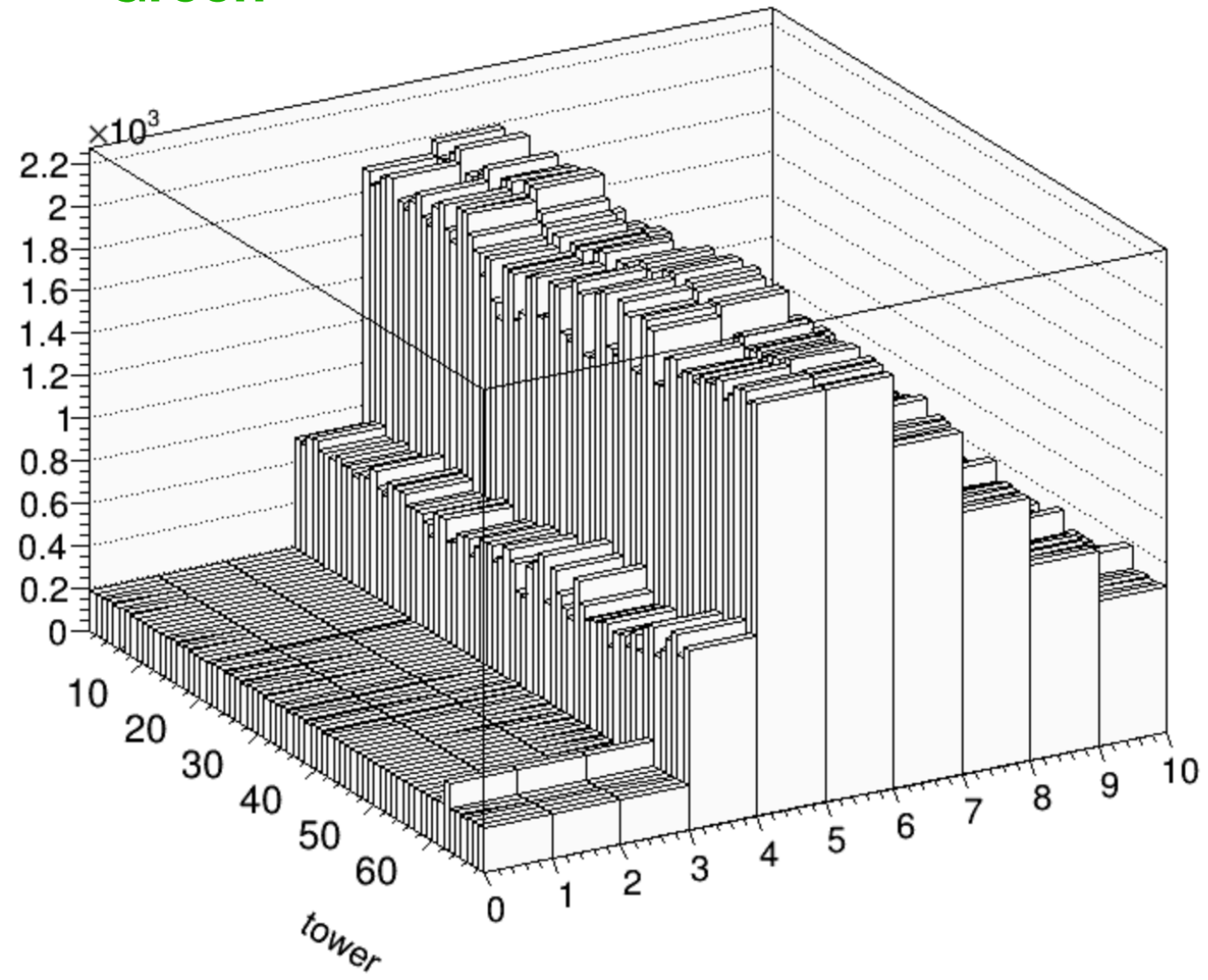


AFTER

EBLT shape EB+06 L2

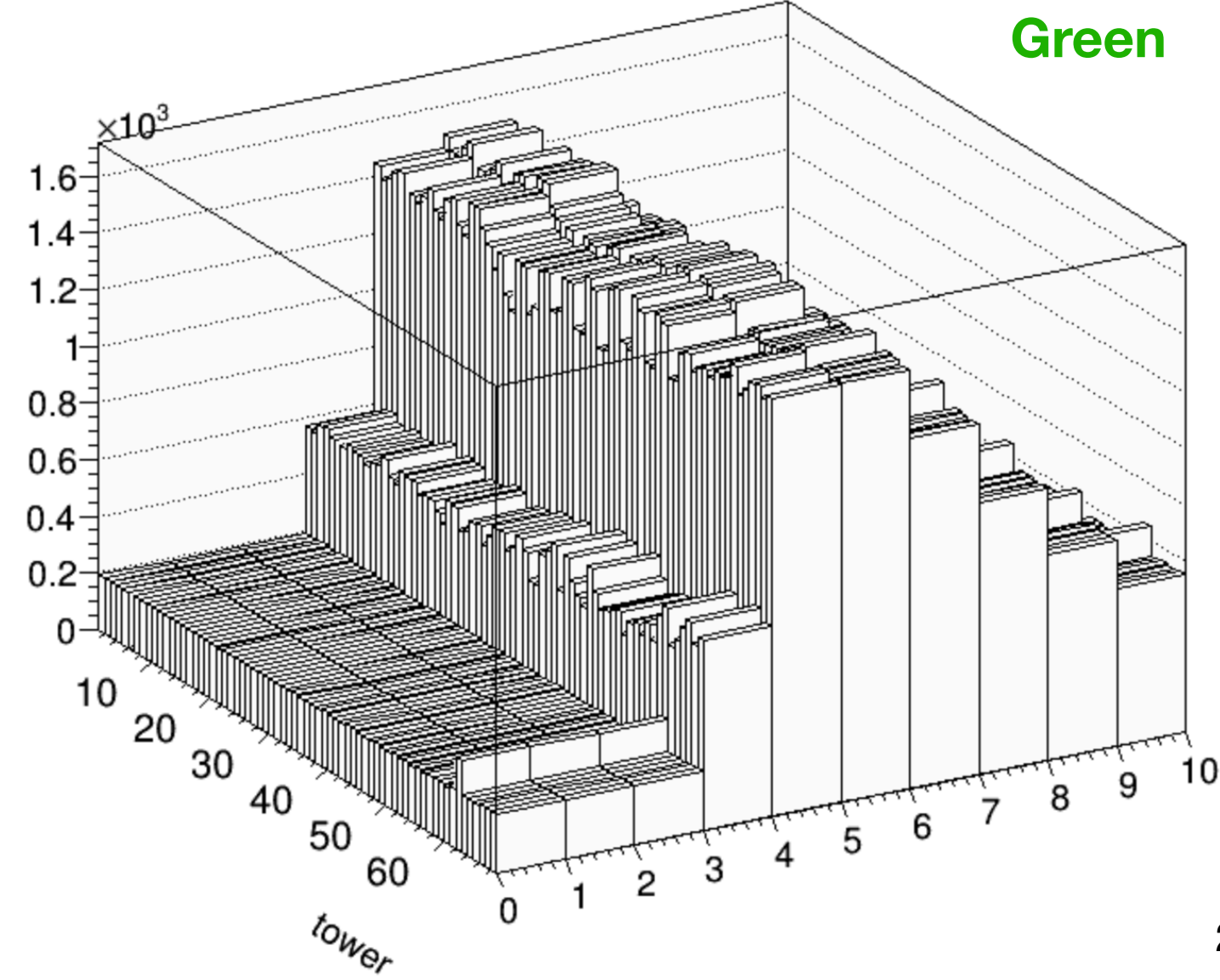
Green

BEFORE



Adjustment of laser power to observe on DQM large enough pulses without saturating

Green

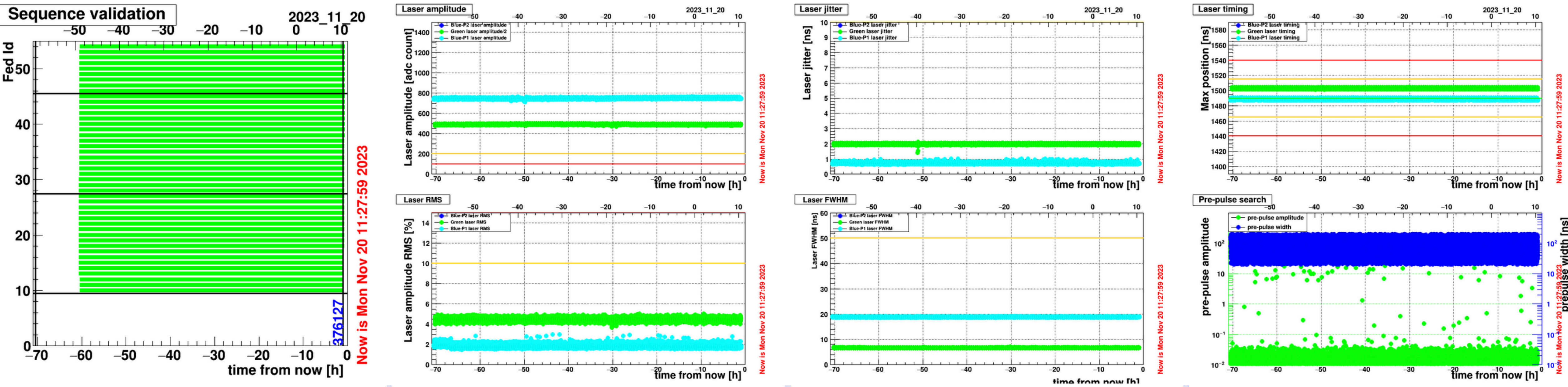


Laser relocation: system stability



Longest run with a duration of 69 h 41 min 46 s

All the following runs are no longer than 16h to avoid the laser DB to get stuck

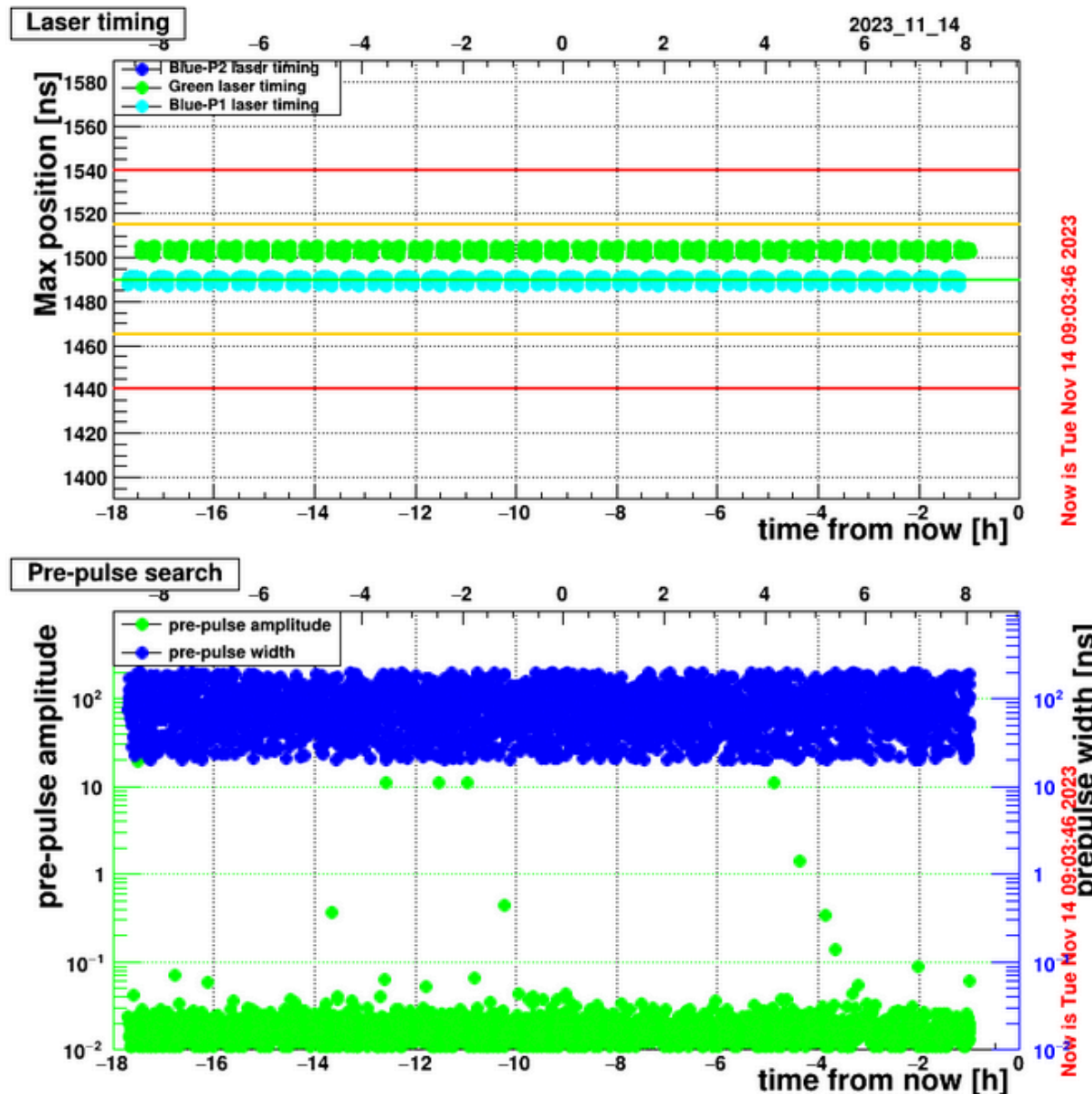
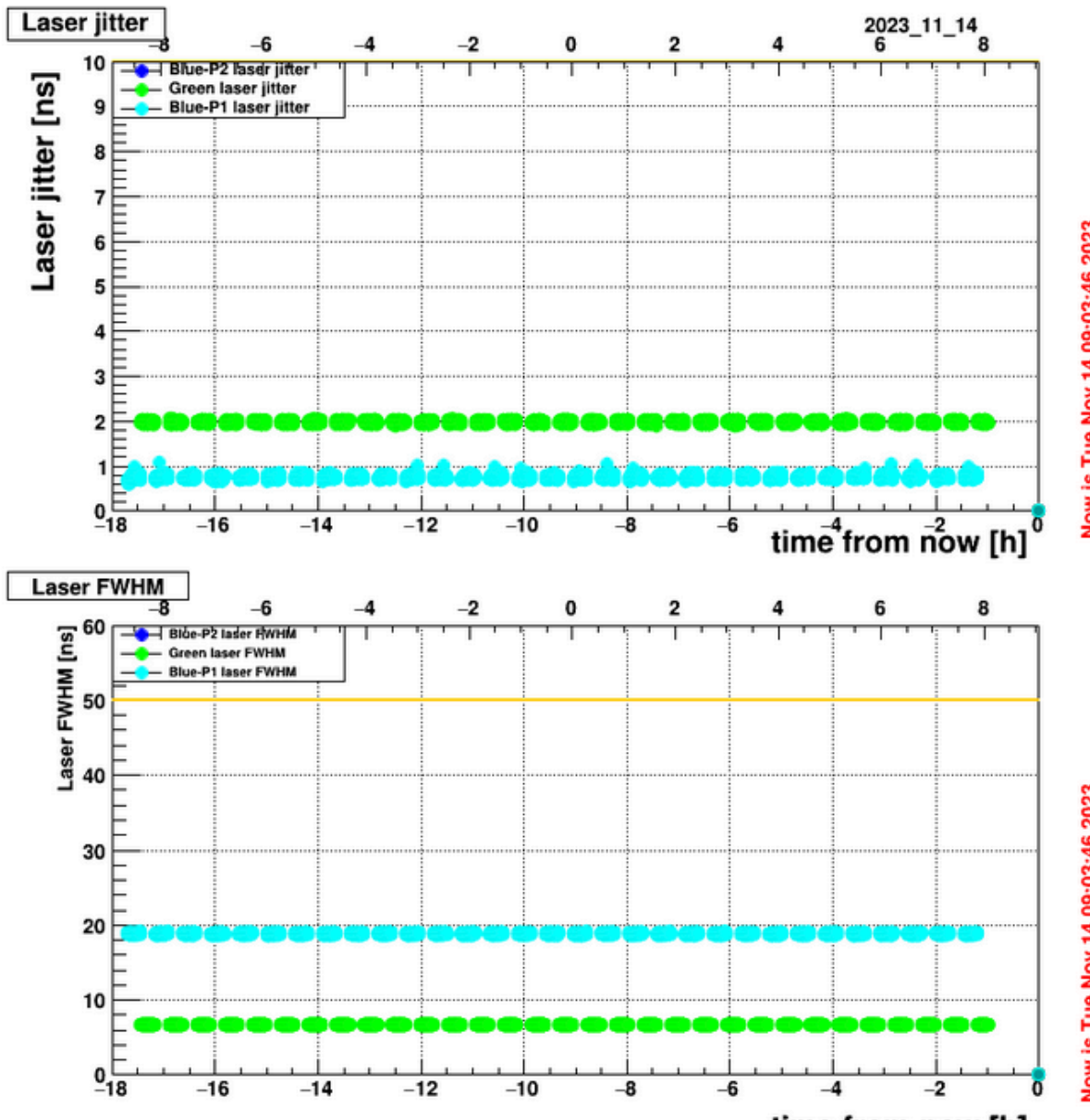
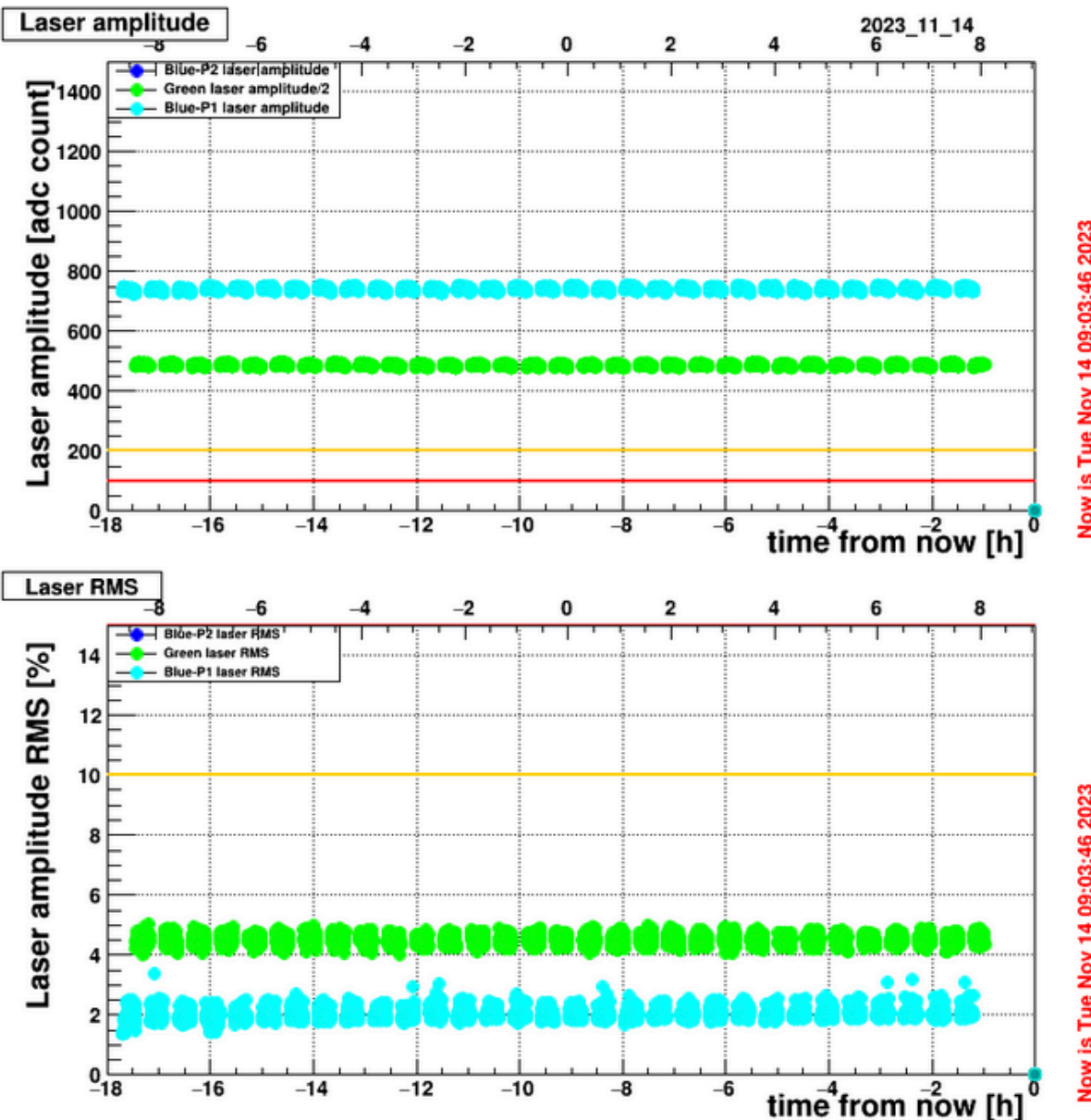
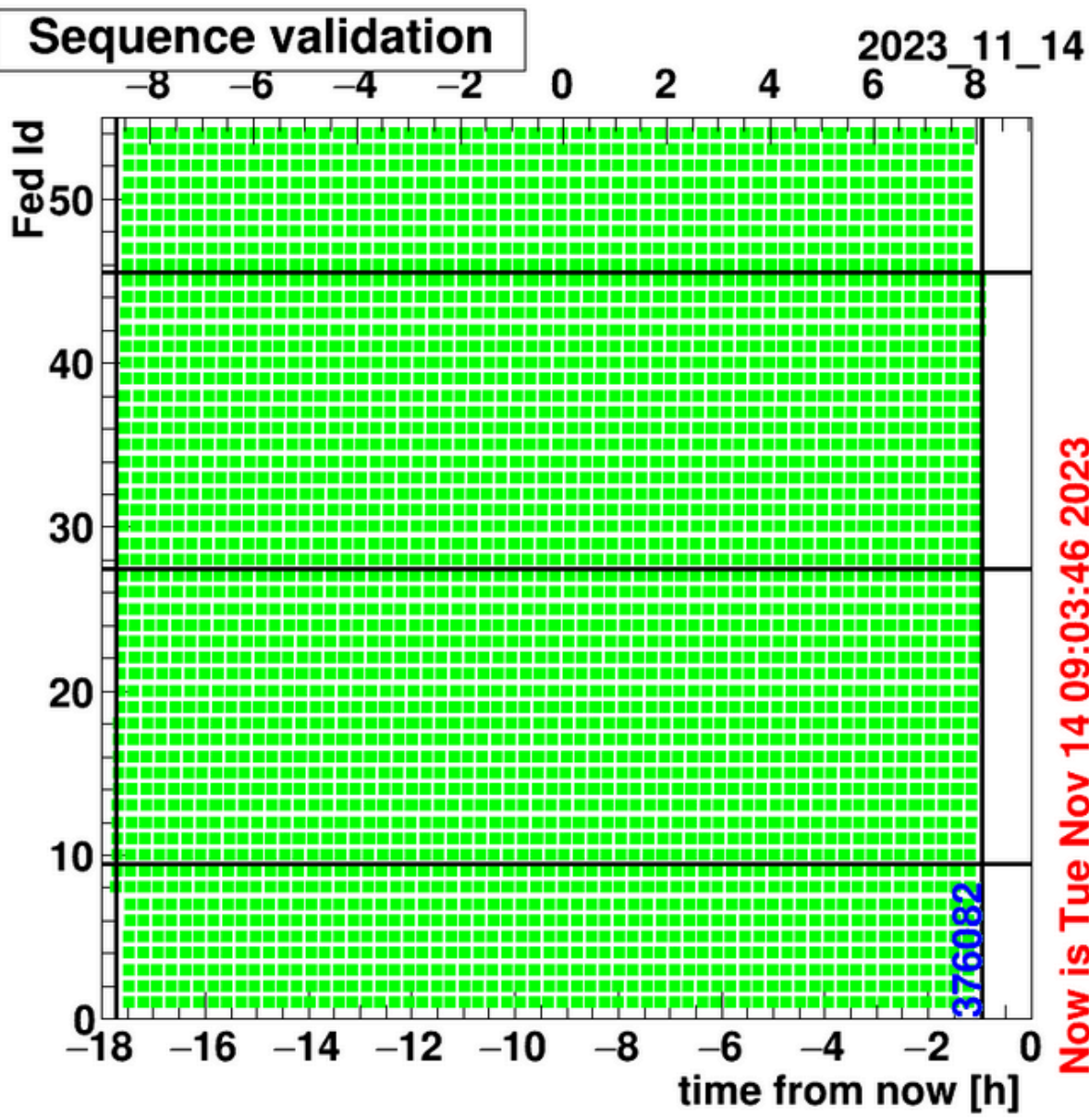


- **Very good laser stability looking at LightChecker plots**
- Preliminary analysis of first runs of the commissioning show **excellent stability, well within requirements** (order of 10^{-4} without corrections for recovery)

Laser relocation: system stability



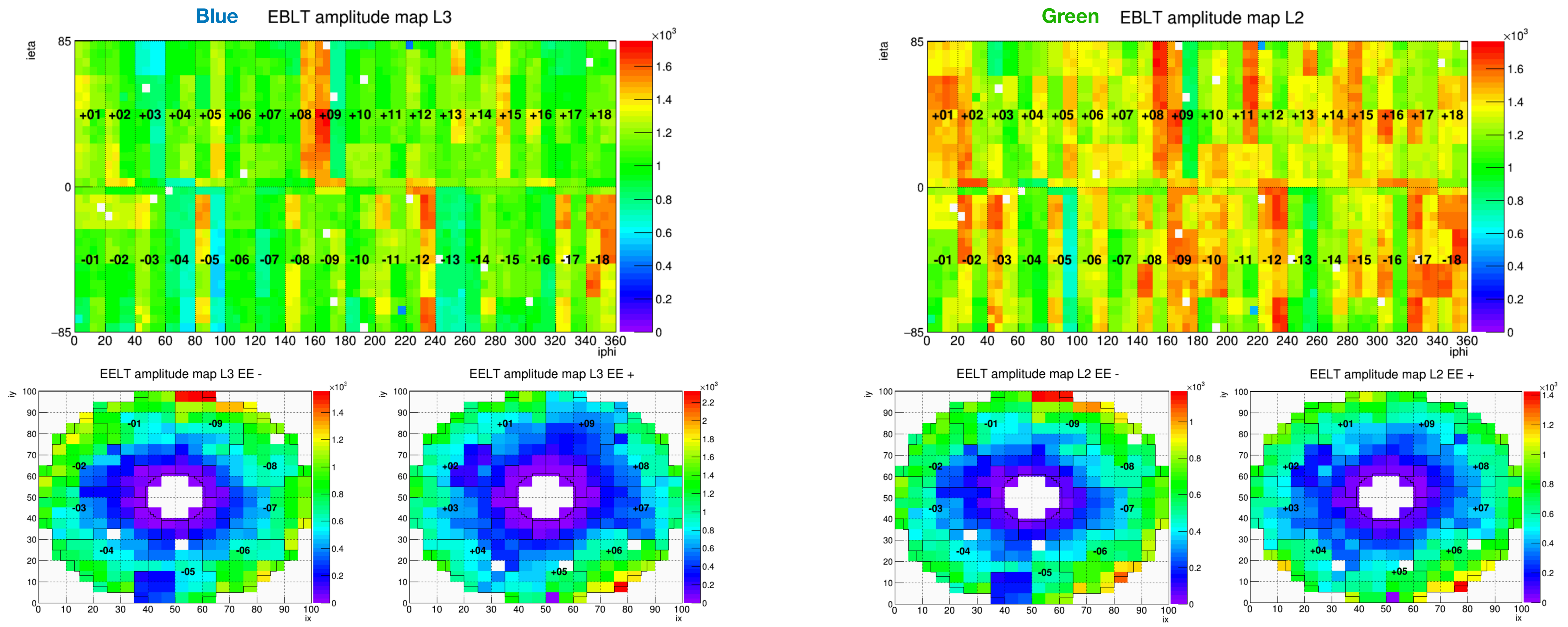
Example of MATACQ plots for a run with all ECAL in



Laser relocation: system stability



DQM plots look as expected

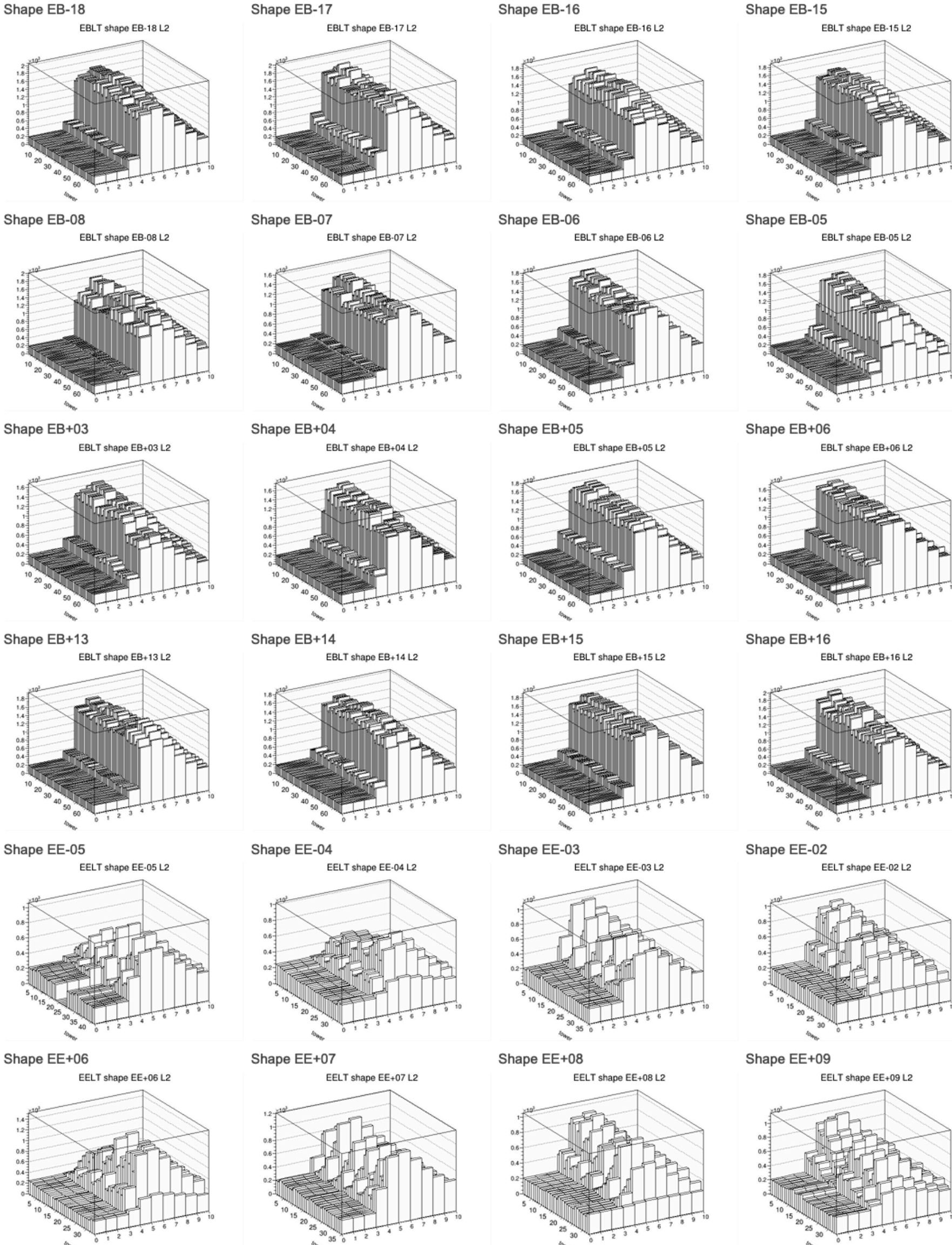
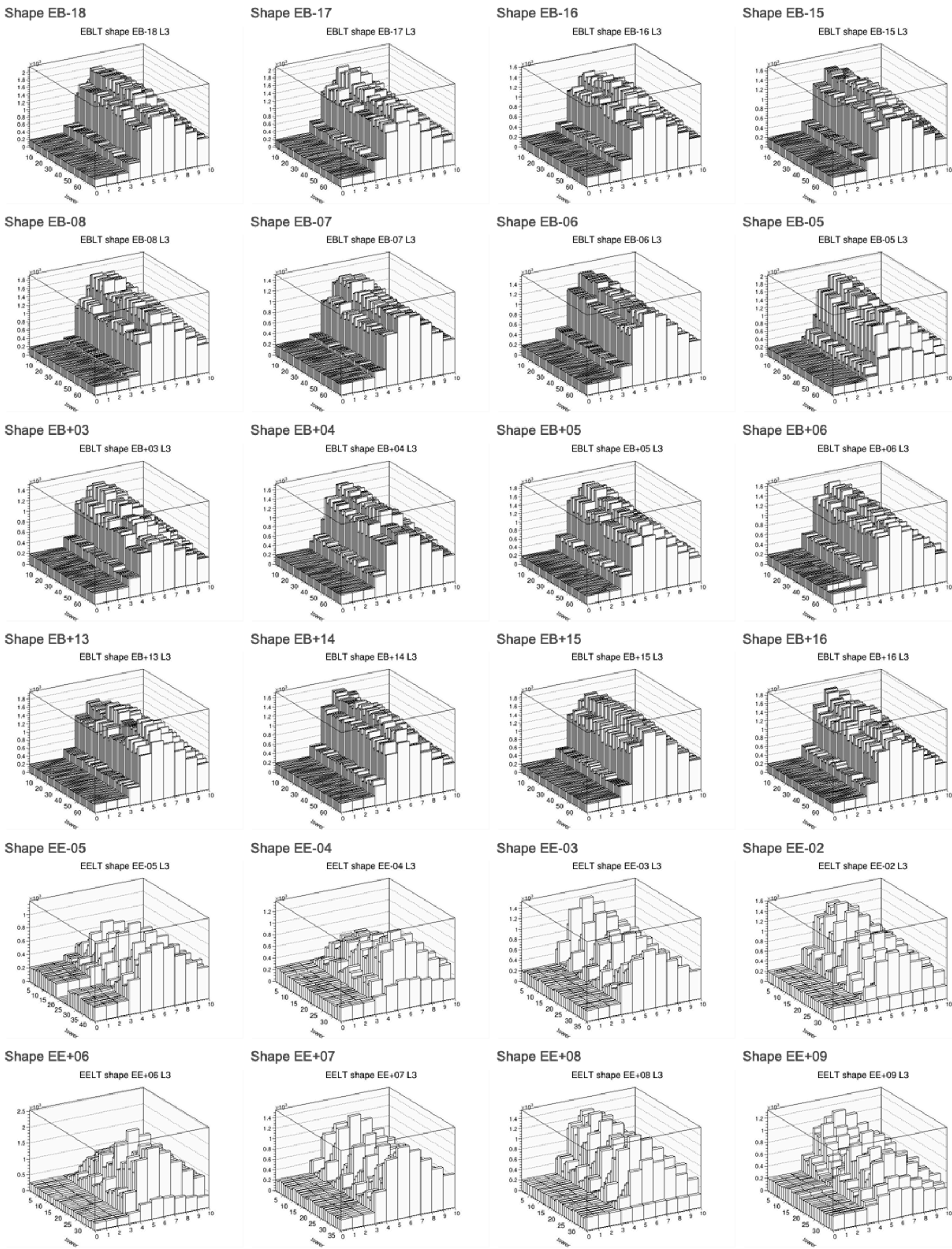


Laser relocation: system stability



Blue

Green

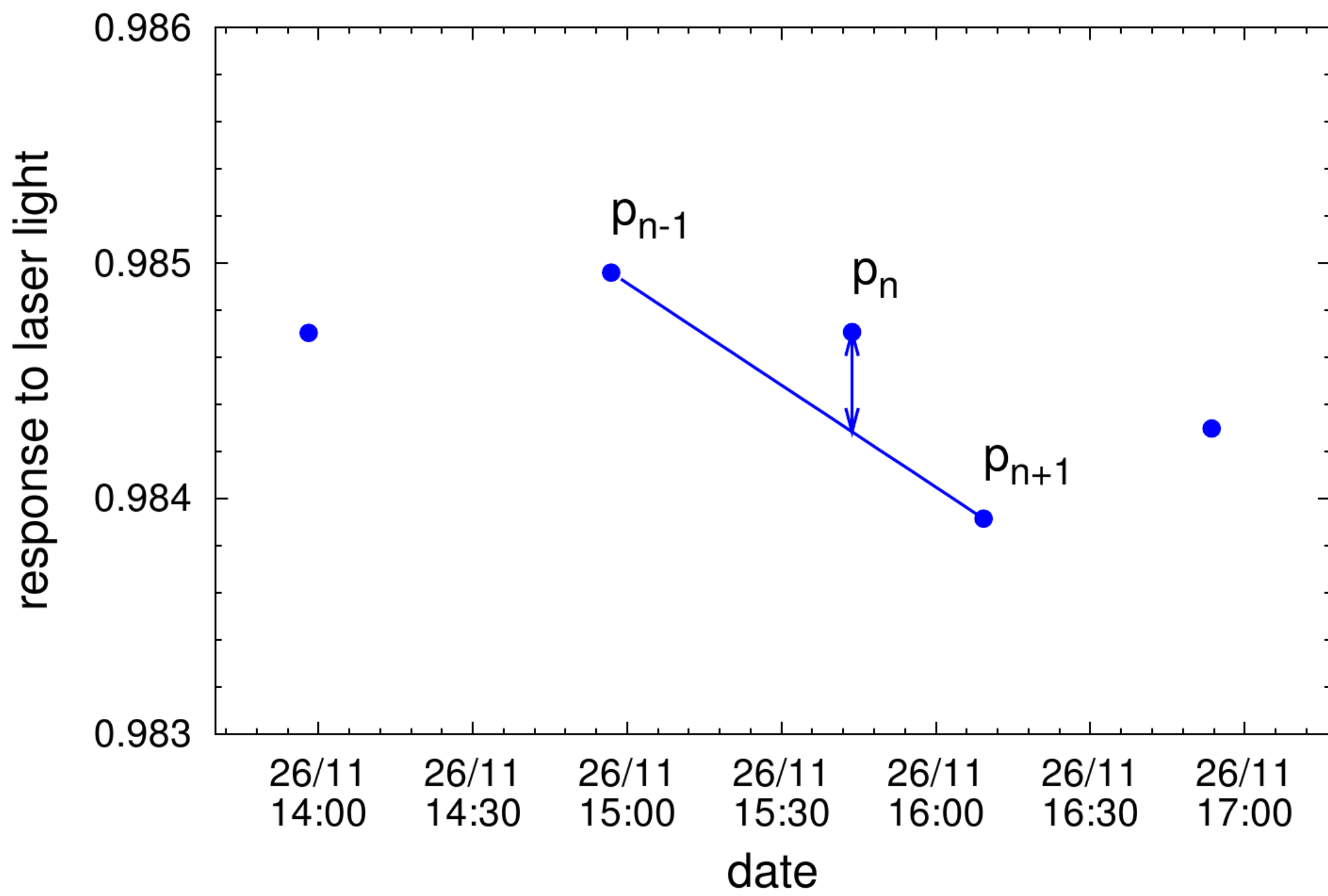
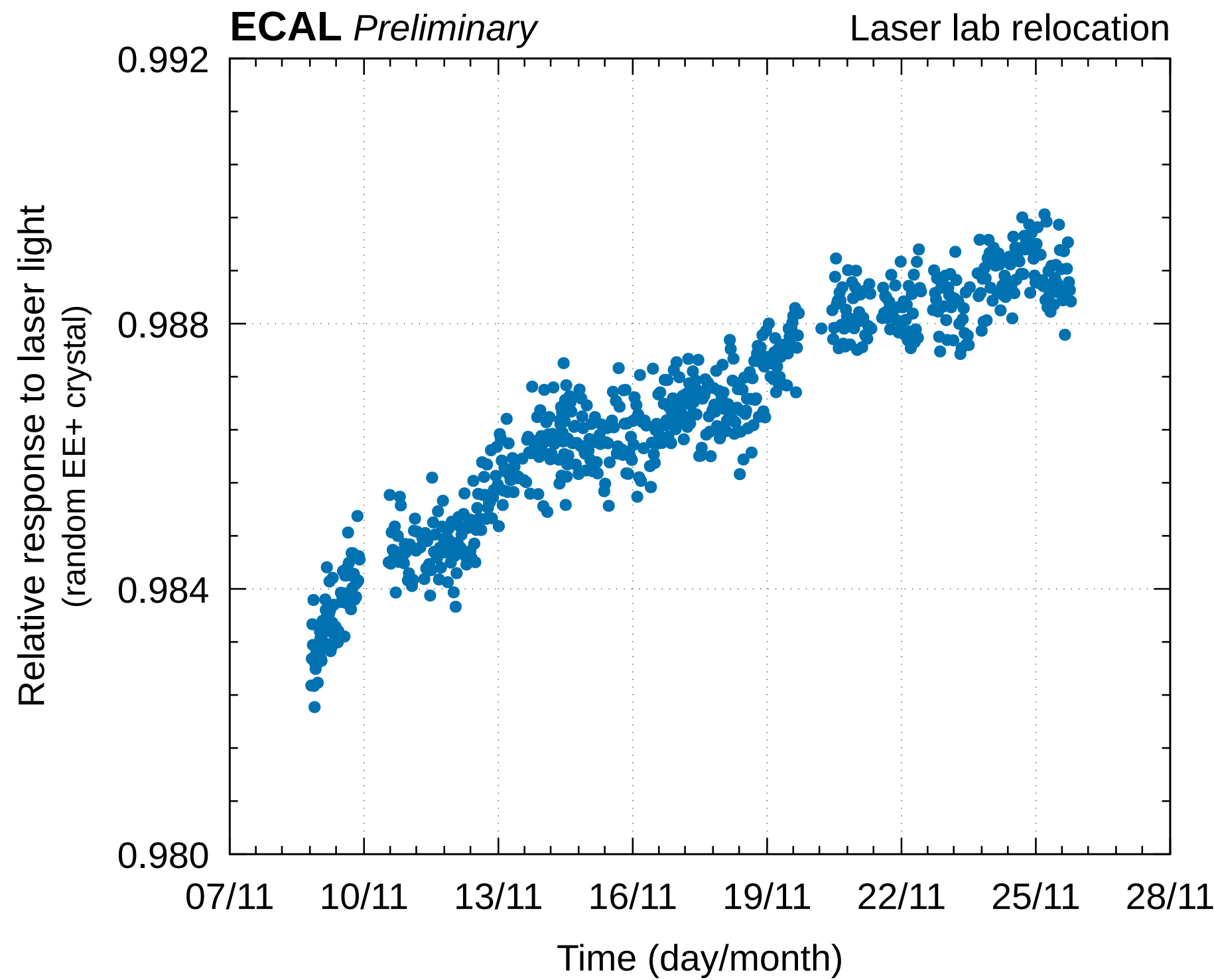


Laser relocation: system stability



Results on laser precision produced analysing data from all runs of the November commissioning

- Computation of **APD/PN for each crystal as a function of time**
- Computation of the distance d of the point p_n from the line interpolating points p_{n-1} and p_{n+1}
- Computation performed every three points to avoid mutual correlation
- The **sigma of the distance d distribution represents the precision of the laser monitoring system**



Laser relocation: system stability



Mean value of laser precision slightly shifted for **ECAL barrel**, but the **sigma is unchanged wrt 2011**
Broader distributions for endcaps due to larger variation of transparency loss within the partition

