ECAL LED system update

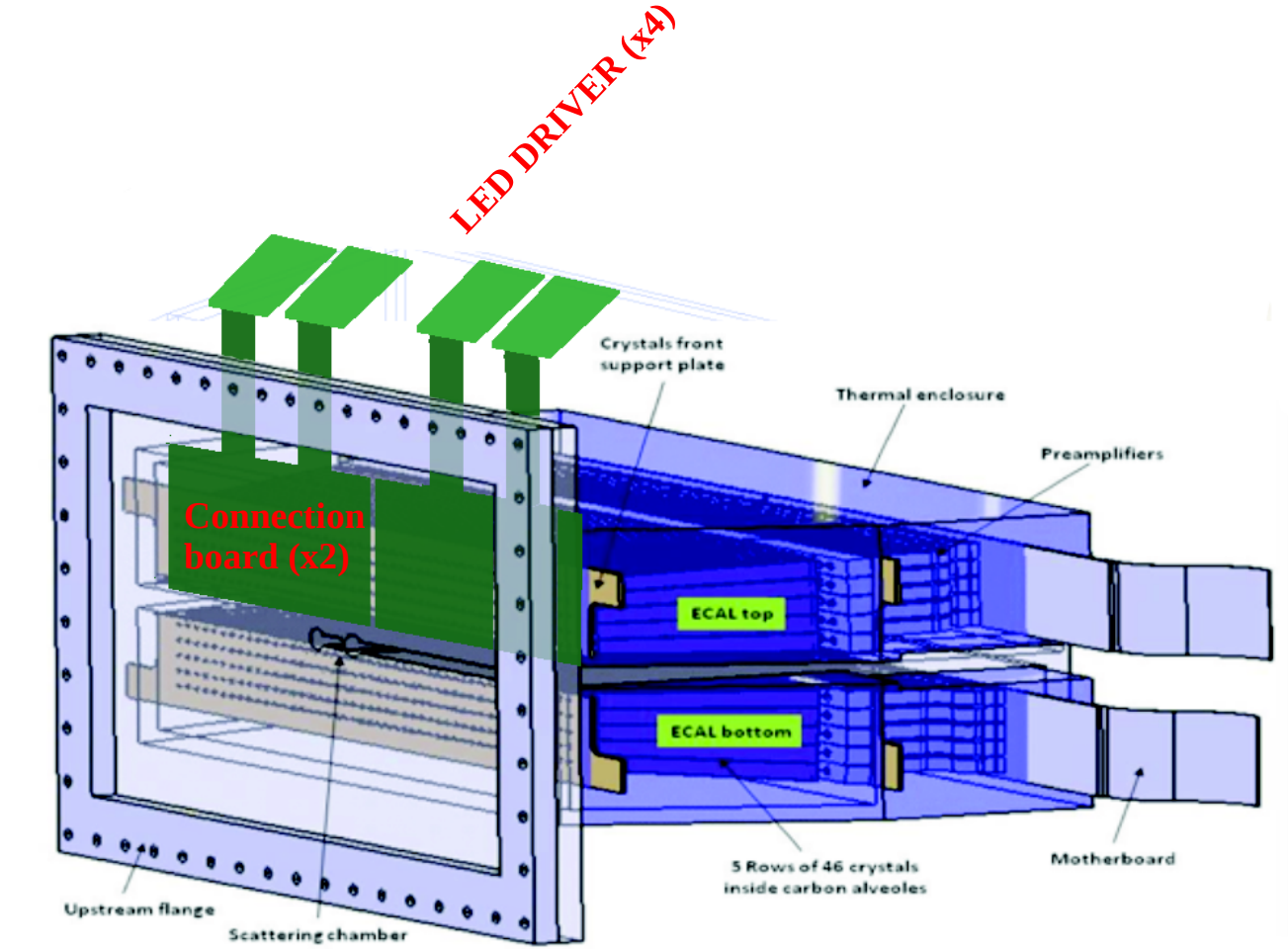
A. Celentano

ECAL LMS overview

Design: individual bi-color LEDs mounted in front of each $PbWO_4$ crystal.

Components:

- Main controllers (2 x)
- Driver Boards (8 x)
- Connection boards (4 x)
- LEDs (442 x)



Main controller - drivers

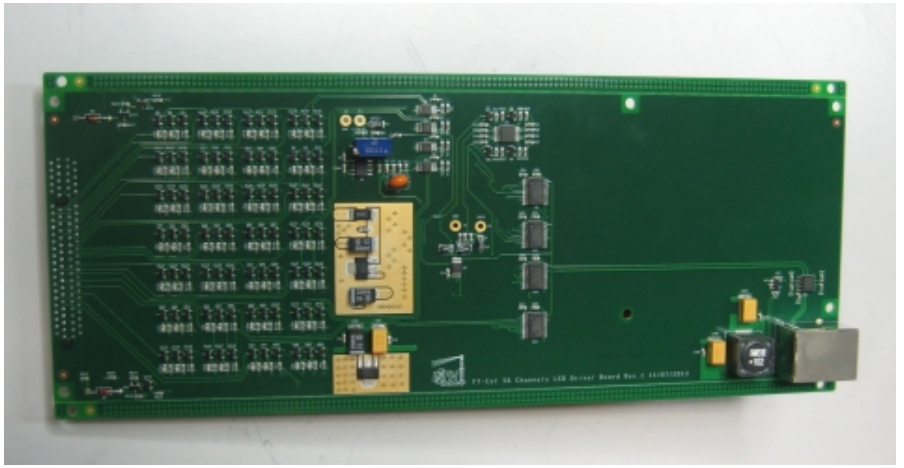
Main controller

- Provides communication with the system through Ethernet/USB interfaces.
- Handles 4 driver boards.
- Integrated in HPS slow controls via EPICS softIOC.
  - Expert GUI
  - User GUI

2 independent controllers, one for ECAL TOP, one for ECAL BOTTOM.
Clock is propagated from the first to the second for synchronization

Driver board

- Hosts **56** independent LED pulser circuits.
- Communicates via I^2C with the main controller, through Ethernet-like cable
- Mounted out of the calorimeter enclosure, it is connected to the LED board.



Connection board - LEDs

Connection board

- PCB mounted inside the calorimeter enclosure to connect LEDs to the Drivers.
- Calorimeter mechanical enclosure was modified with a feed-trough for the PCI-like connectors.

LEDs

- RAPID 56-0352 bicolor blue/red LEDs (common cathode)
  - Different color have different sensitivity to radiation damage in the crystals
- All LEDs were individually tested before being mounted in the system
  - Dynamic range 2.5 V
  - Pulse width < 150 ns

LEDs radiation damage

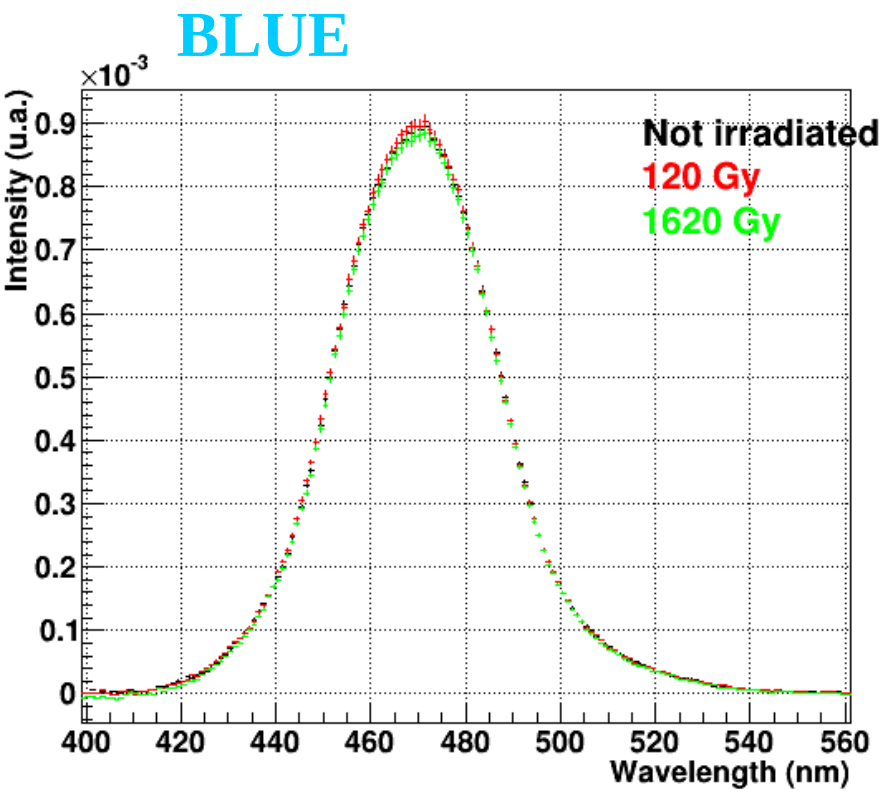
EM radiation:

- LED radiation hardness was evaluated by exposing LEDs to a known EM dose
- Emission spectrum measured before and after irradiation.
- Control LEDs (not-irradiated) showed no variation during different measurements.

Expected radiation dose in Ecal: ~ rad/hour

- 120 Gy: 100 days (with 5 rad/hour)
- 1620 Gy: 3.7 years (with 5 rad/hour)

No damage was seen at 1% (system accuracy)



LEDs radiation damage

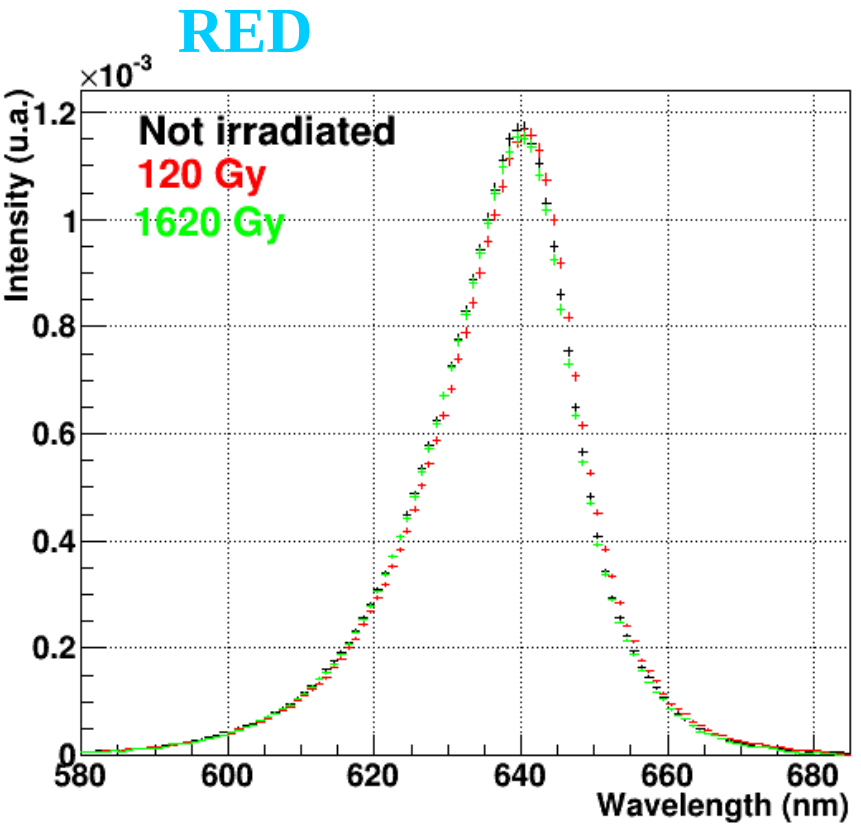
EM radiation:

- LED radiation hardness was evaluated by exposing LEDs to a known EM dose
- Emission spectrum measured before and after irradiation.
- Control LEDs (not-irradiated) showed no variation during different measurements.

Expected radiation dose in Ecal: ~ rad/hour

- 120 Gy: 100 days (with 5 rad/hour)
- 1620 Gy: 3.7 years (with 5 rad/hour)

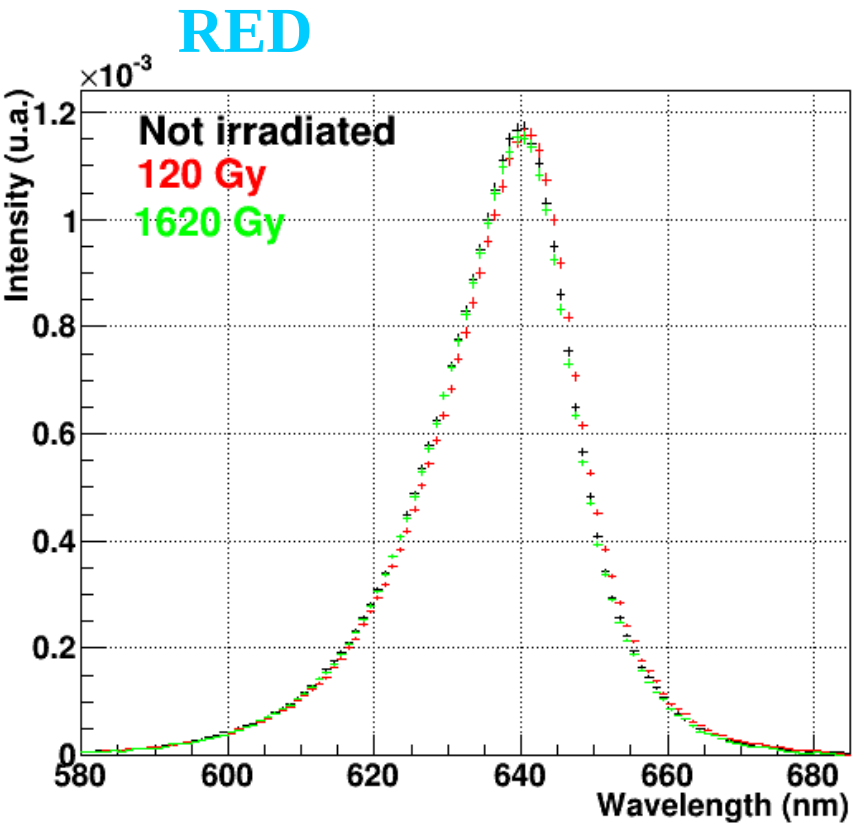
No damage was seen at 1% (system accuracy)



LEDs radiation damage

EM radiation:

- LED radiation hardness was evaluated by exposing LEDs to a known EM dose
- Emission spectrum measured before and after irradiation.
- Control LEDs (not-irradiated) showed no variation during different measurements.



Expected radiation dose in Ecal: ~ rad/hour

- 120 Gy: 100 days (with 5 rad/hour)
- 1620 Gy: 3.7 years (with 5 rad/hour)

No damage was seen at 1% (system accuracy)

Neutrons:

- LEDs exposed to neutron flux ~ 4 10^{11} n/cm^2 @ 14 MeV, equivalent to ~ 2 10^6 mrem
- Expected neutron flux in Ecal: 10 mrem/hour

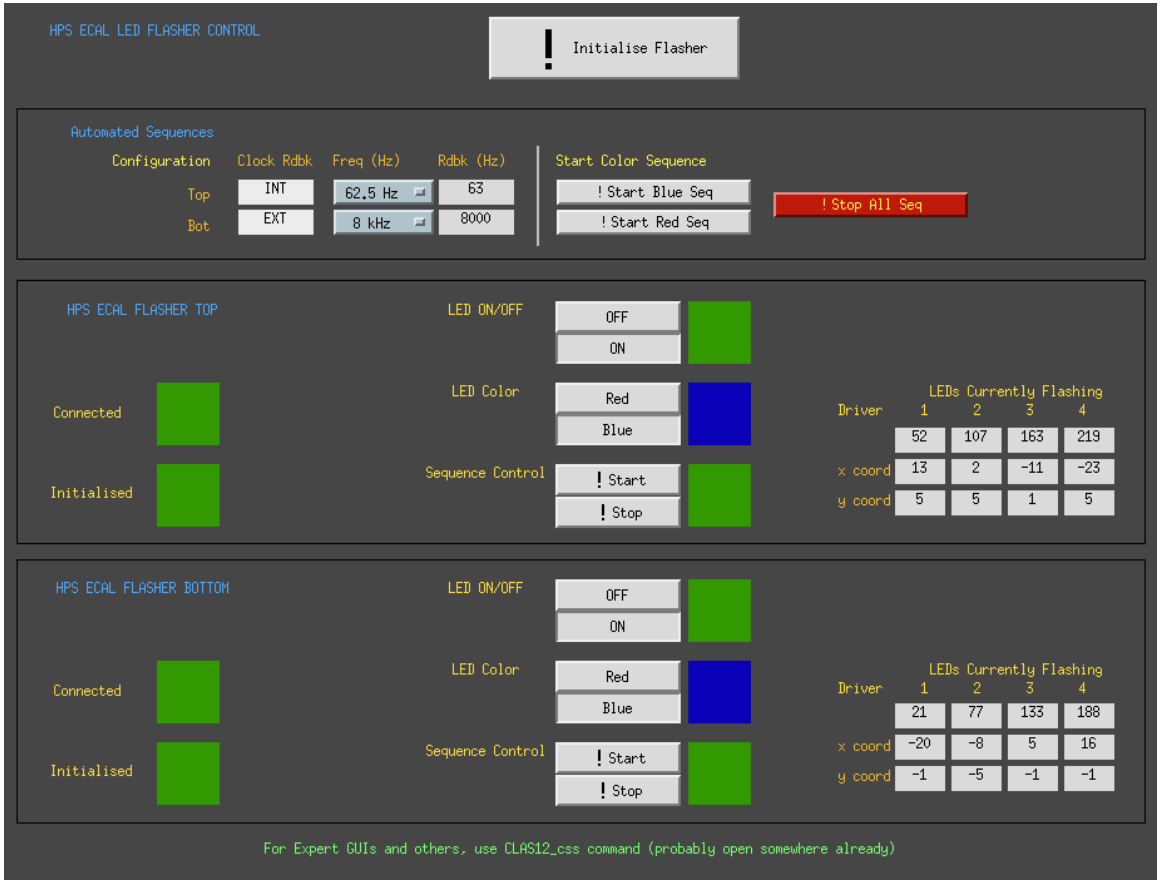
No damage was seen. System accuracy not better than 15% (normalization)

ECAL LMS current status

HPS-Ecal LED monitoring system is fully integrated in the experiment

- DAQ: dedicated Run and Trigger configurations
  - Ecal-only readout
    - MODE 7
    - MODE 1 for Debugging
  - Trigger from the LMS clock

- System control via GUIs
  - **User GUI**
  - Expert GUI

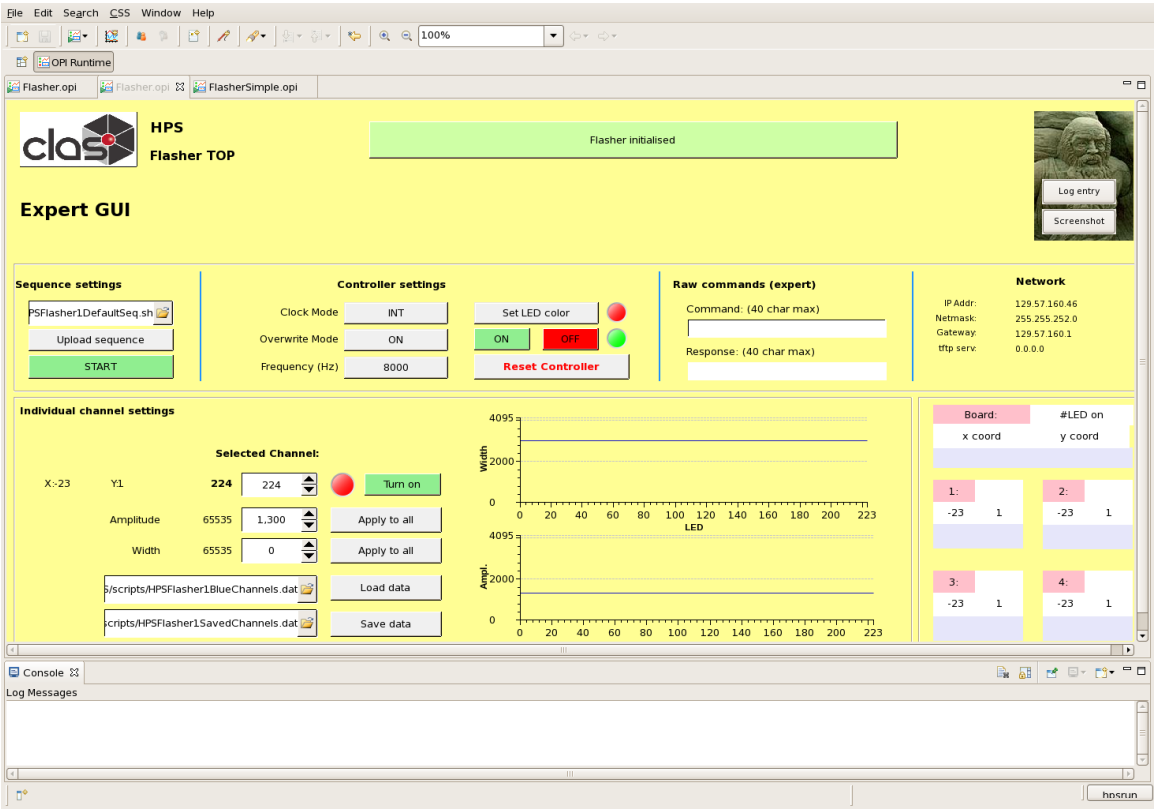


ECAL LMS current status

HPS-ECal LED monitoring system is fully integrated in the experiment

- DAQ: dedicated Run and Trigger configurations
  - ECal-only readout
    - MODE 7
    - MODE 1 for Debugging
  - Trigger from the LMS clock

- System control via GUIs
  - User GUI
  - **Expert GUI**



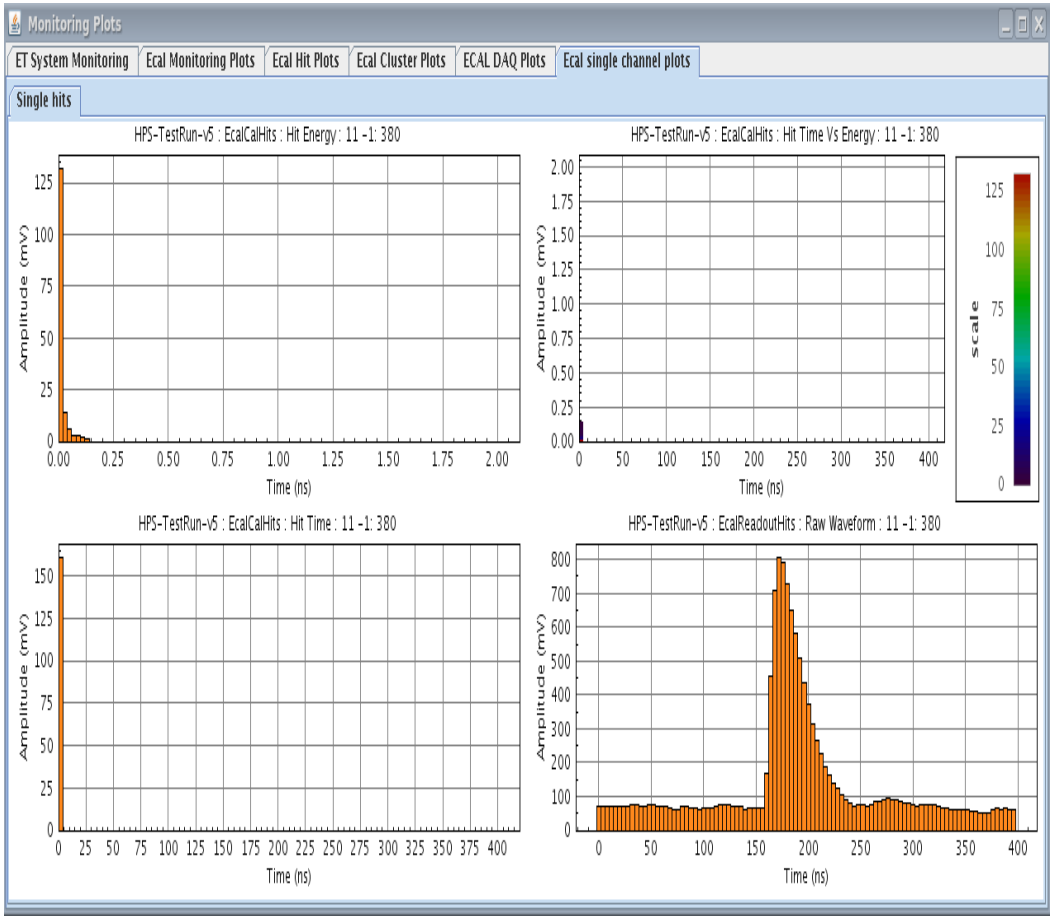
ECAL LMS current status

HPS-ECal LED monitoring system is fully integrated in the experiment

- DAQ: dedicated Run and Trigger configurations
  - ECal-only readout
    - MODE 7
    - MODE 1 for Debugging
  - Trigger from the LMS clock

- System control via GUIs
  - User GUI
  - Expert GUI

- Specific HPS-Java Online Monitoring System configuration
  - Event display
  - **Debug mode**
  - Run mode: online analysis



ECAL LMS: engineering run performances

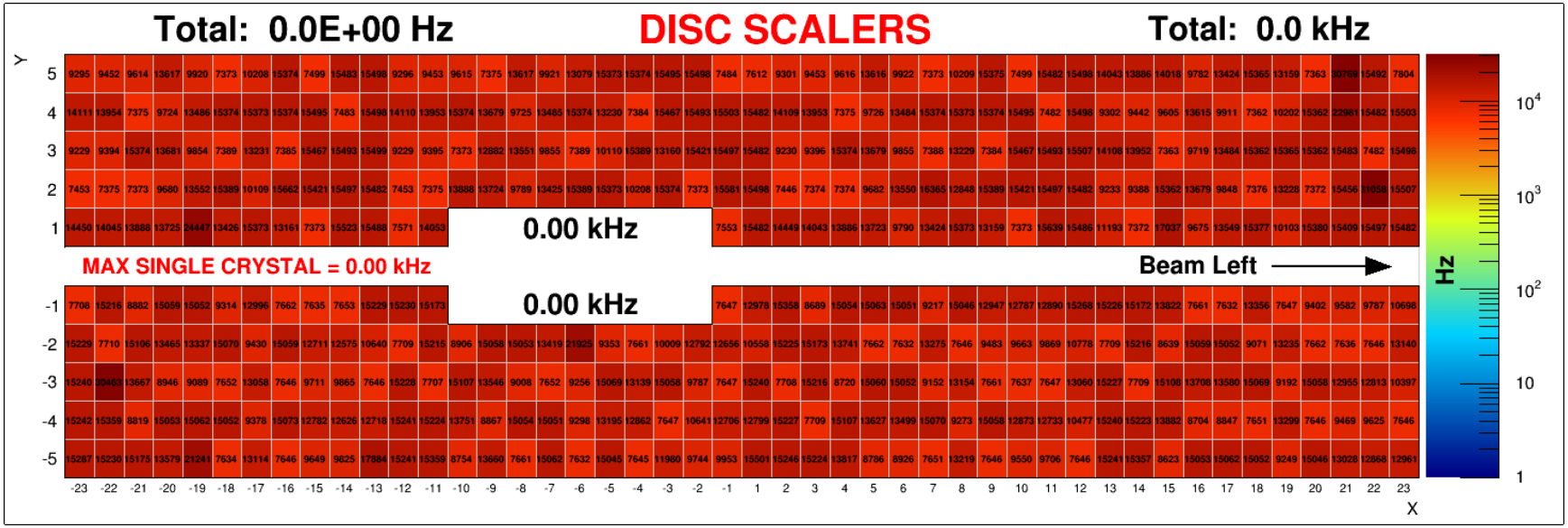
HPS-LMS has been extensively used during the 2015 engineering run

Ecal Commissioning

- Individually check all channels: identify bad cables/swaps/..
- Quick 2-minutes test of all channels via discriminators scalers

Trigger Commissioning

- Switch on a given channels pattern and verify trigger system responds as expected

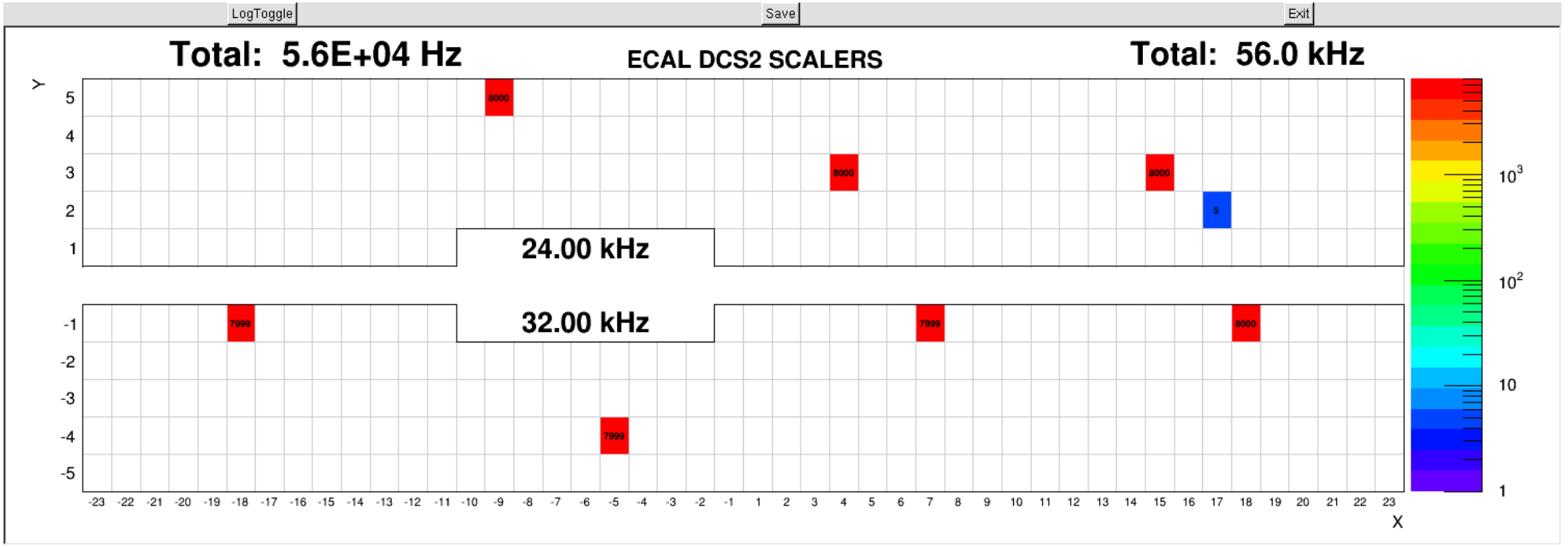


ECAL LMS stability studies

The LMS can be used to measure the stability of the Ecal and acknowledge any variation in a channel response

Procedure:

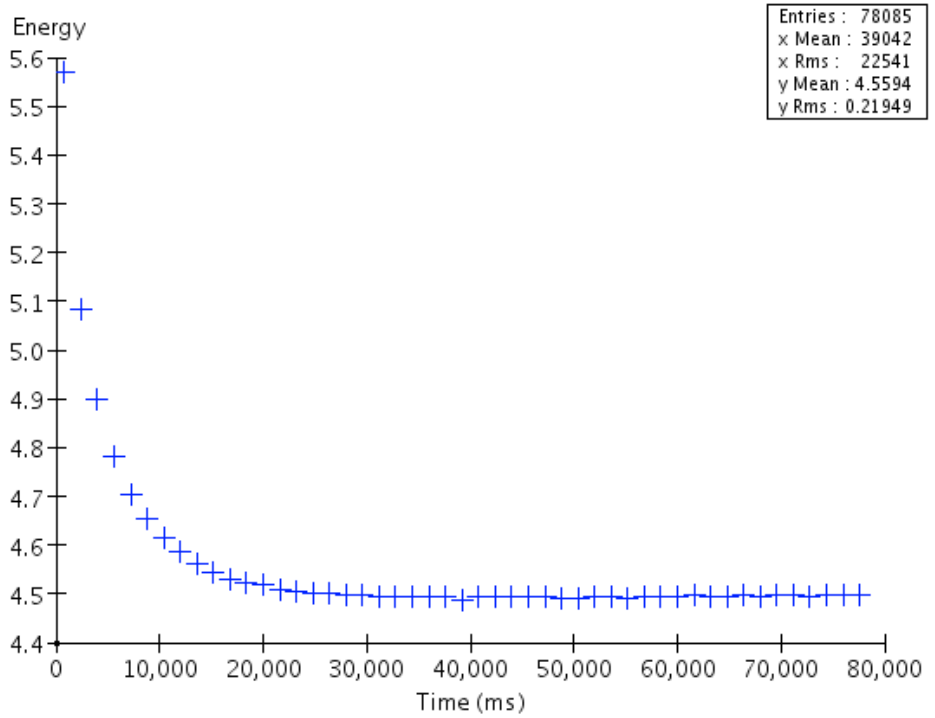
- LED sequence: 8 LEDs on at time / 10 s
- Evaluate average channel response
- Compare with previous measurements



ECAL LMS stability studies

Data analysis

- For each channel, select events with energy greater than a certain threshold (to exclude cross-talk events)
- Exclude first events, close to the LED switch-on instant t_0
  - Cut on the event time (wrt t_0)
  - Determine LED "decay-time" τ and cut after 5τ



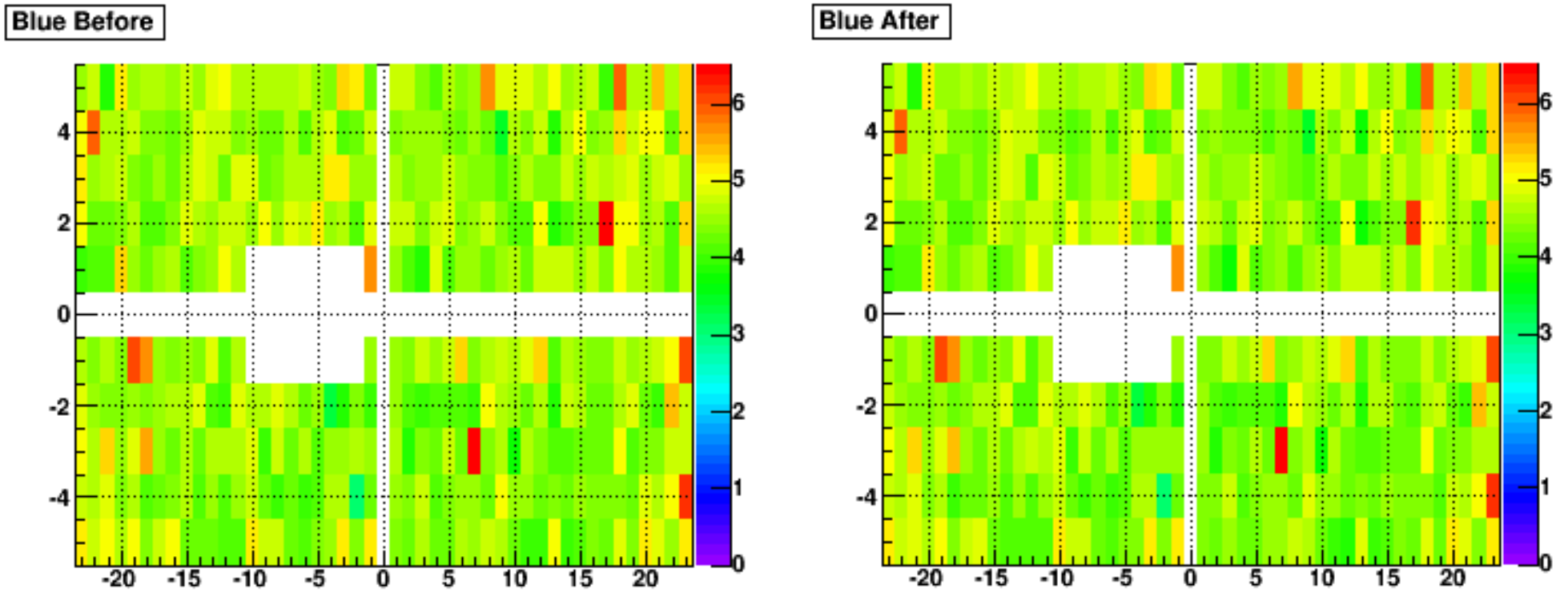
The procedure is currently implemented offline within HPS-Java.

- Current effort is to have this implemented **online –** via the Monitoring Application.
- Preliminary version of the code written. Need to validate it.
- Cross-check results with the offline version.

ECAL LMS stability studies: reproducibility

LMS results reproducibility is critical for stability studies

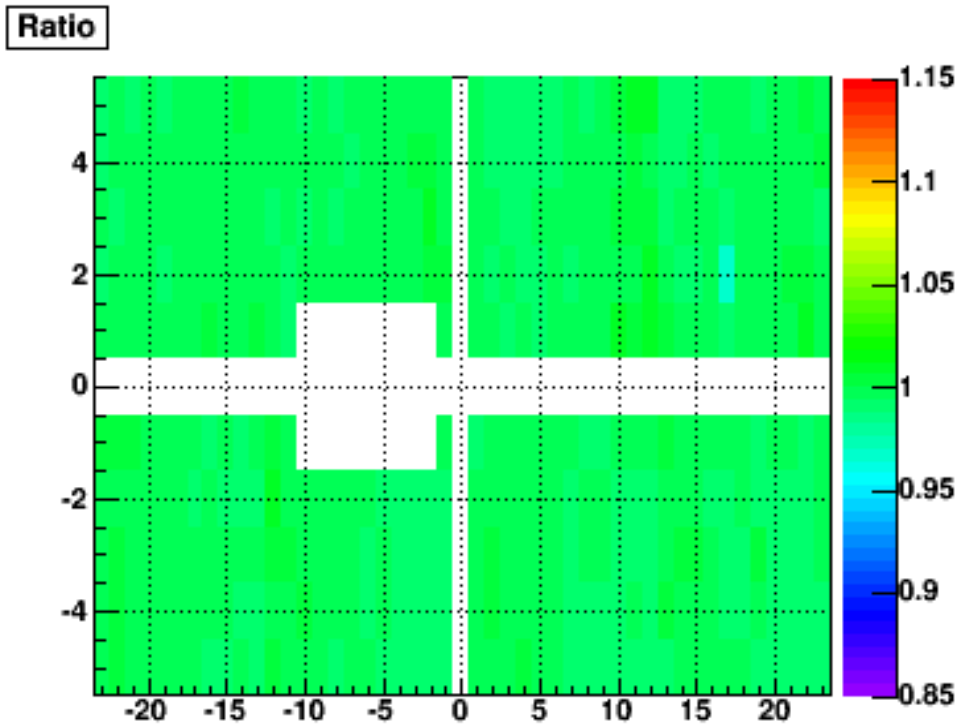
Evaluate by comparing two measurements taken in the same configuration

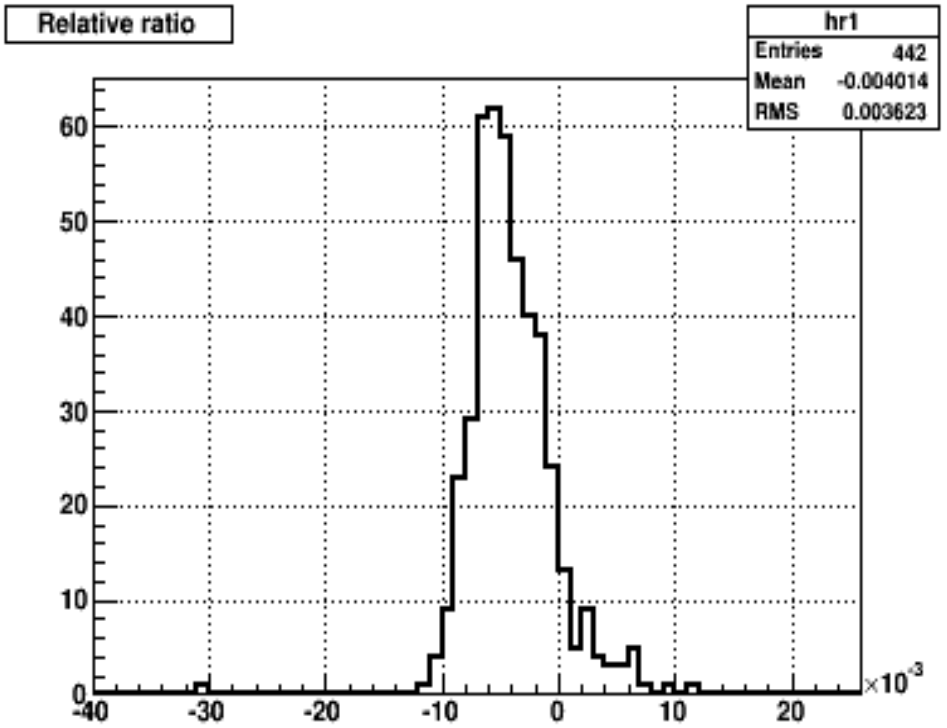


ECAL LMS stability studies: reproducibility

LMS results reproducibility is critical for stability studies

Evaluate by comparing two measurements taken in the same configuration



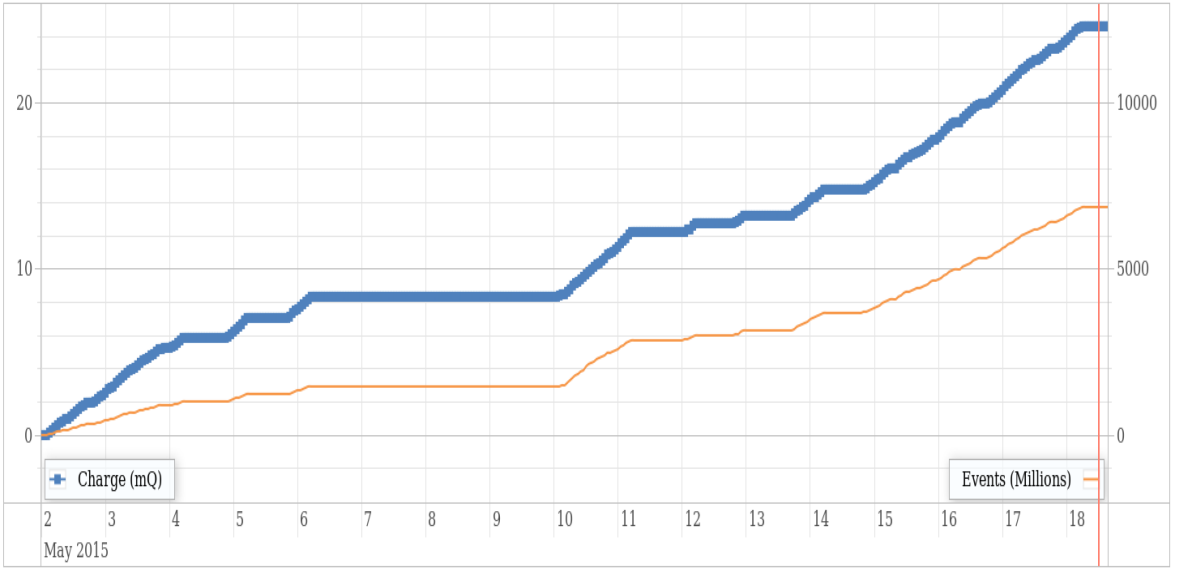


Reproducibility is better than 1% for almost all channels (same result with RED color)

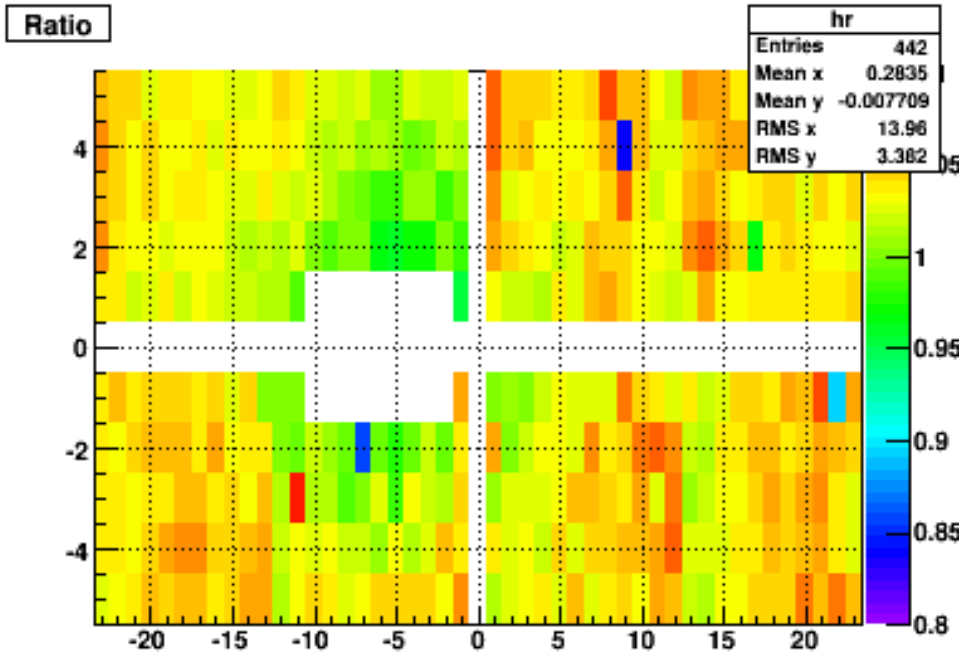
ECAL LMS stability studies: preliminary results

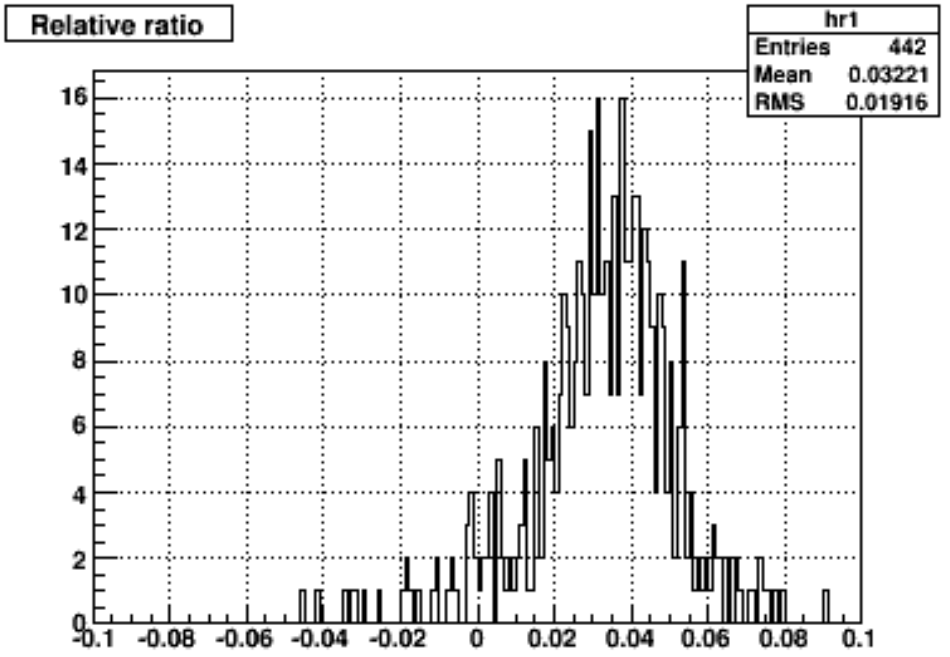
Engineering Run data
(blue only)

- Beginning: **11 March**
- End: **19 May**



Results:



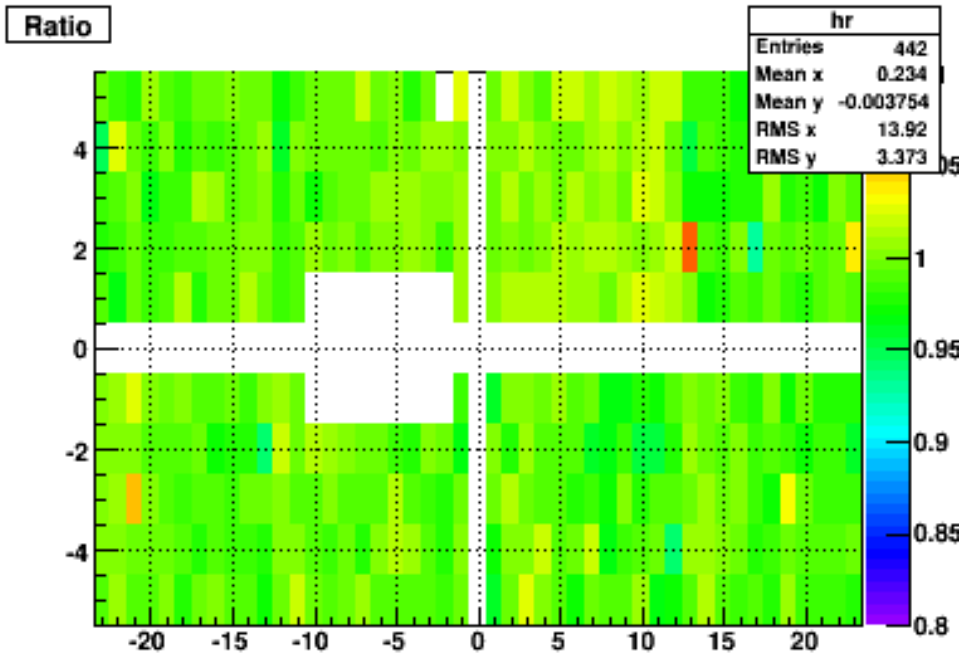


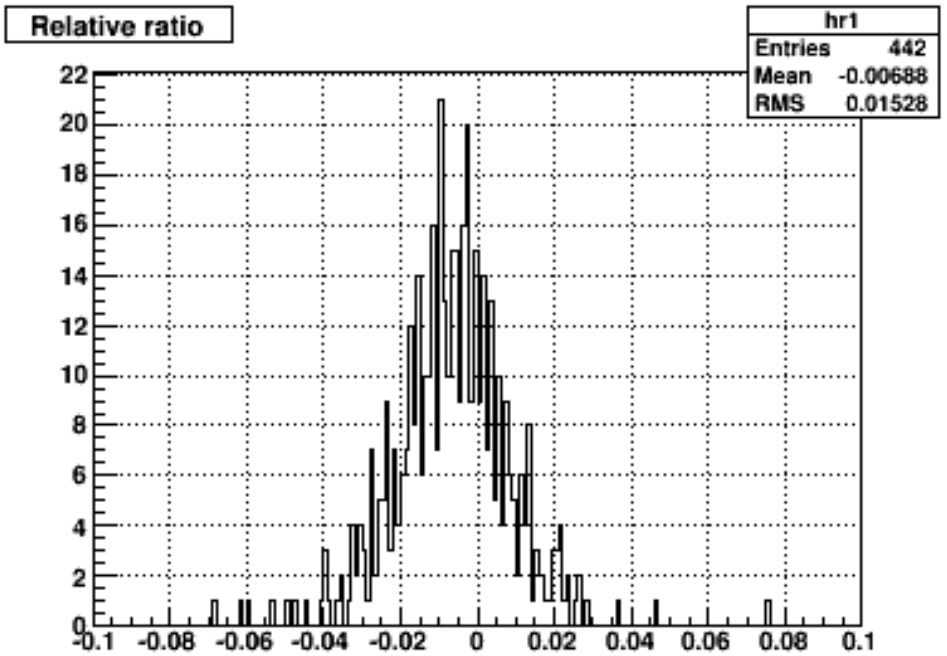
ECAL LMS: light annealing

LMS can be used to recover $PbWO_4$ EM radiation damage via light-annealing

- Turn on the LEDs continuosly: “DC-mode”
- Use a custom sequence: 24 LEDs on / time, 5 minutes / LED

Verify that this does not change the LED response itself: perform a measurement, start a DC sequence (~12 h), perform another measurement and compare





Conclusions

- The Led Monitoring System is installed in HPS and is fully operational
- The system has extensively been used during the Enginerring Run
  - Ecal Commissioning
  - Trigger Commissioning
- Further work is necessary to use it to measure Ecal long-term stability (radiation damage)
  - Complete the integration of the sequence analysis in the online monitoring system and in the conditions system
  - Compare offline and online results
  - Conclude the analysis of Engineering Run measurements