# ECAL FEE calibration – 2019

ECAL/HODO Meeting minutes & Documentation:

https://confluence.slac.stanford.edu/pages/viewpage.action?pageId=263756689

Cosmic/FEE gain calibrations (A. Celentano, L. Marsicano)

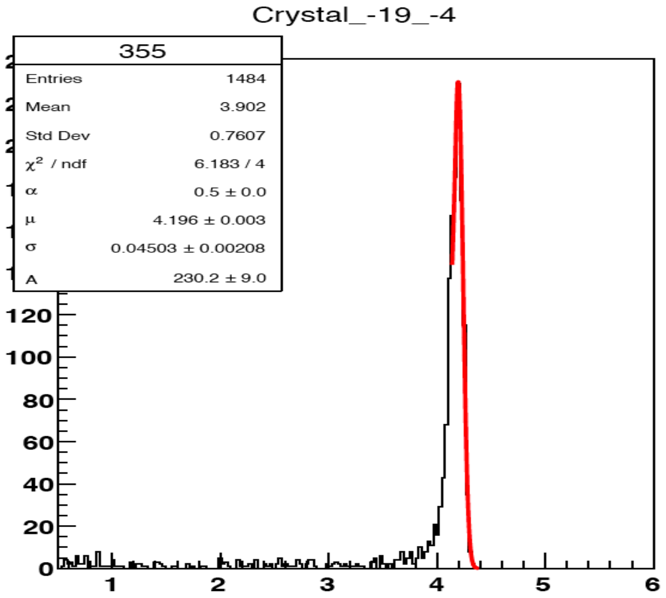
Alignment and timing calibrations (N. Baltzell)

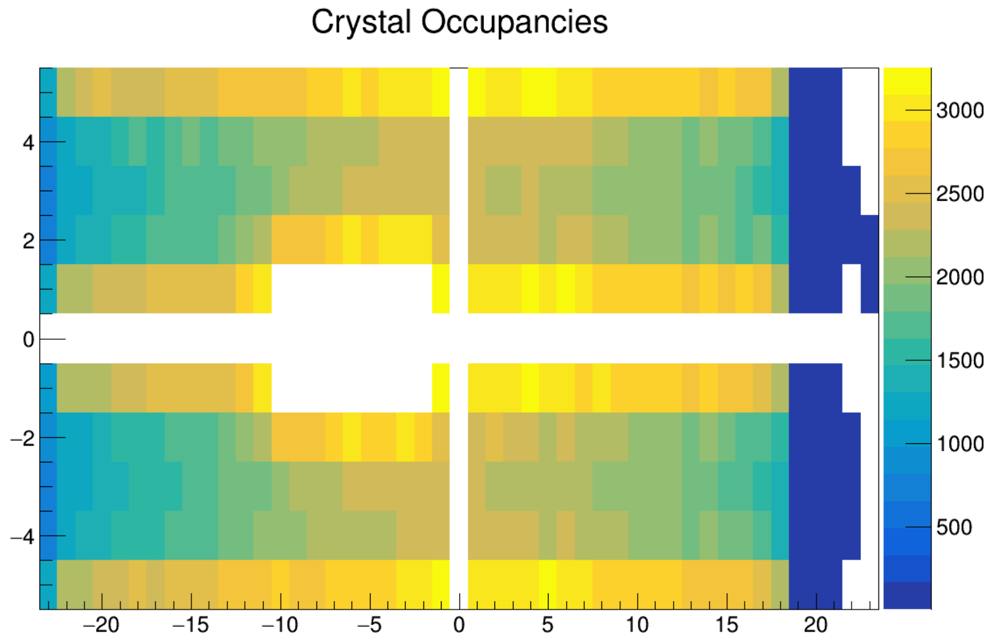
# Procedure

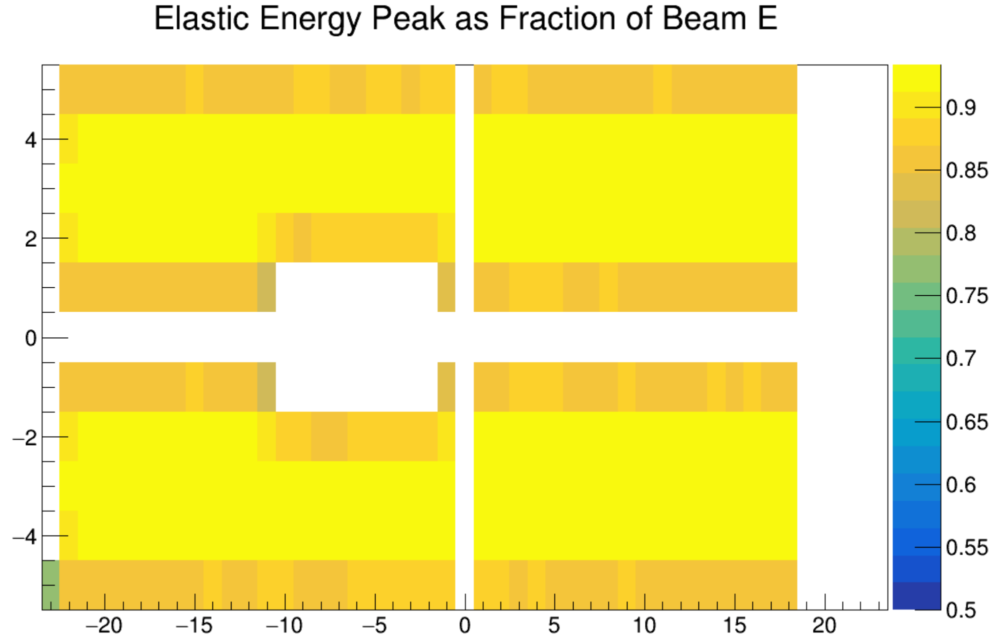
- Use cosmic calibration as starting calibration point
- Select a clean data sample of FEE clusters, construct the cluster energy distribution for each seed crystal
- For each crystal, fit the energy spectrum and determine the FEE peak position
- Repeat the procedure for MC and determine the MC FEE peak position per each crystal
- Compute the ratio $PeakPos_{MC}$ / $PeakPos_{DATA}$ and use it to correct the crystal gain.
- Iterate the procedure until the ratio is close to one for all crystals

# Simulation

- 4.556 GeV electrons generated from (0.,0.,-7.5) covering the SVT acceptance (courtesy of N. Graf) - 2M events generated and reconstructed
- Cluster selection:
  - Etot > 2
  - Eseed / Etot > .6
  - No requirements on tracking
- No coverage for column X=-23 / X=19..23
  - Same result in 2015 / 2016
- Fit with Crystal Ball function to determine MC FEE peak position



# Data

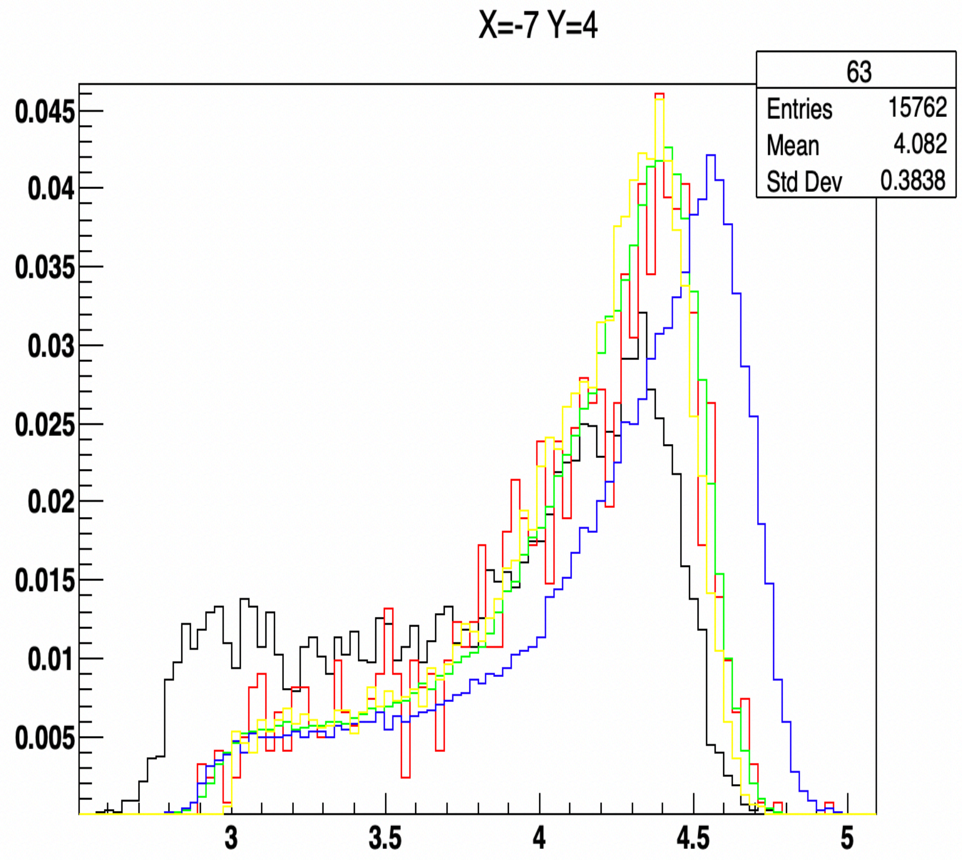
All FEE events (as identified by FEE trigger bit) for all 2019 runs >= 10004 have been filtered and reconstructed.

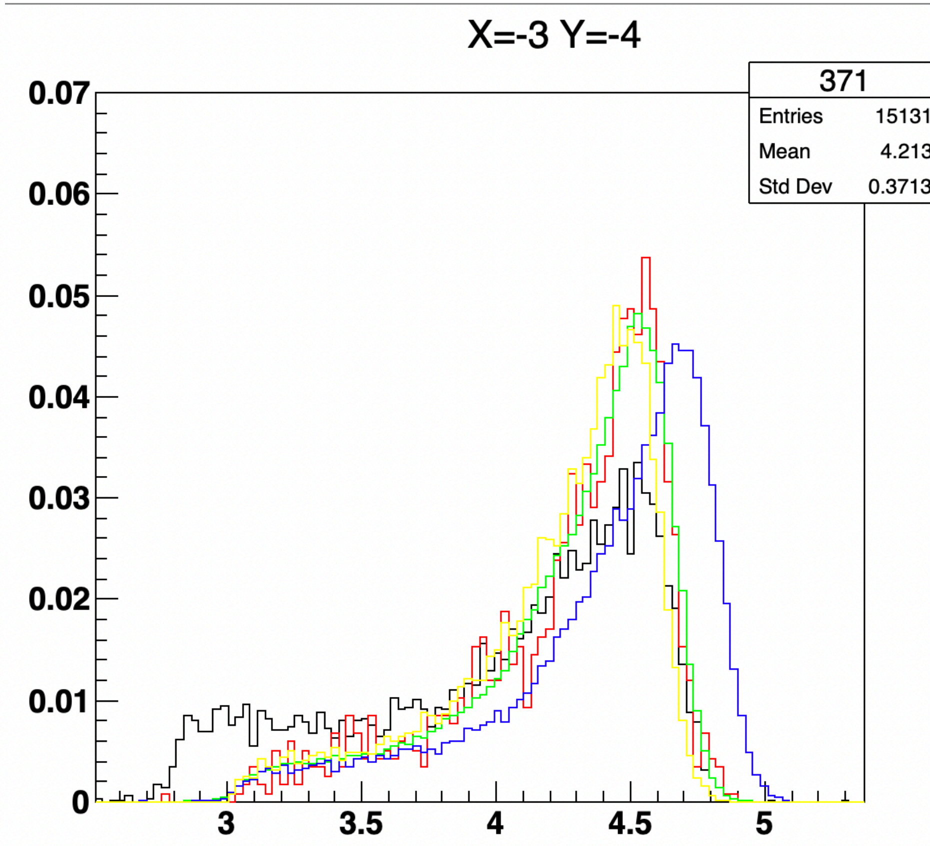
evio: /mss/hallb/hps/physrun2019/production/evio-skims

Found FEE energy distribution in the same crystal for different runs are not compatible.

Comparing different runs:

9371 6/22, 150 nA 4 um NO SVT
9920 7/21 150 nA 8um
9921 7/21 150 nA 8um
10103 7/30 17:35 150 nA 8um
10717 9/7 120 nA 20um

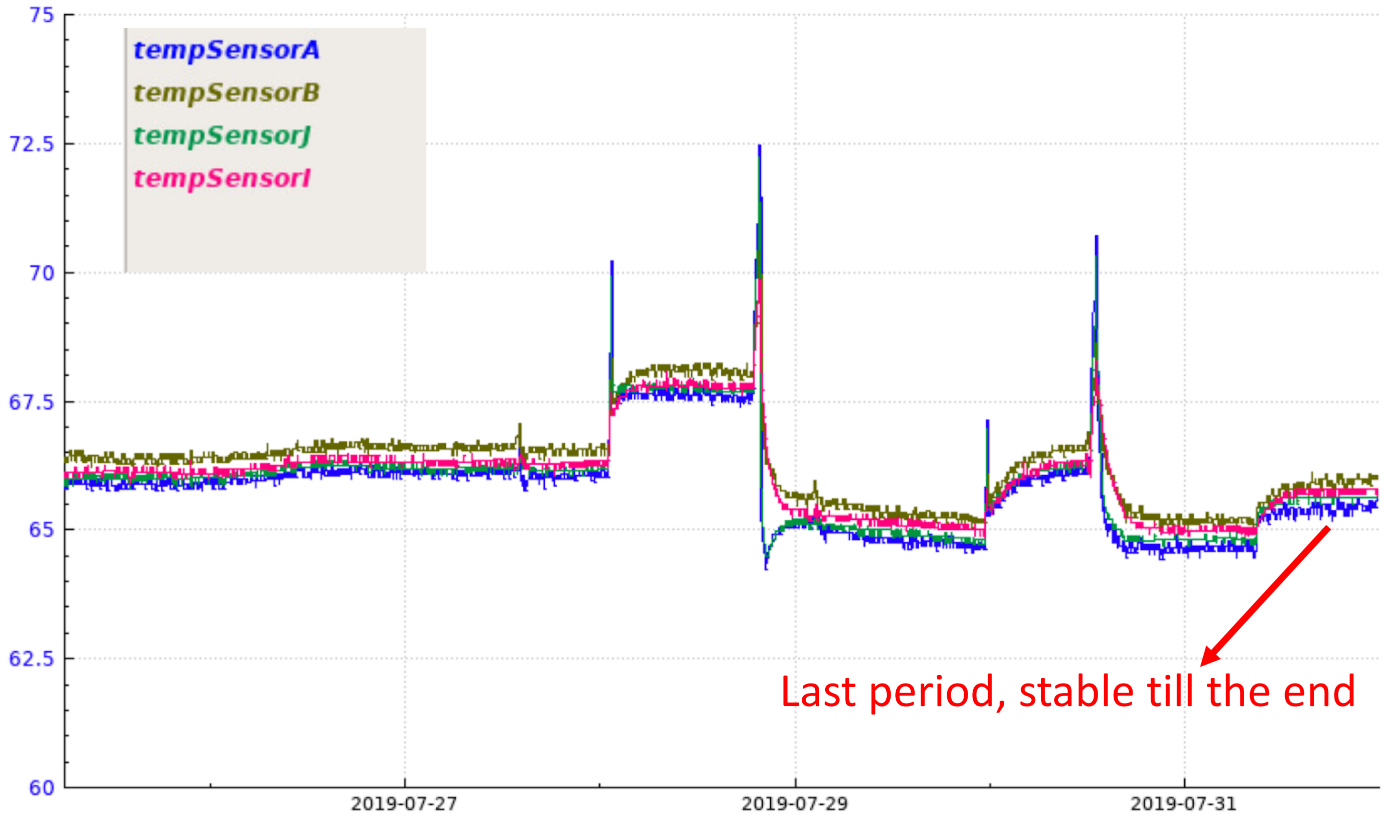


# Data - Stability

Temperature stability was investigated and found to be the issue, which is not surprising given the issues we had with the chiller and ambient conditions in the alcove.

Runs were divided into 6 periods, calibrated independently.

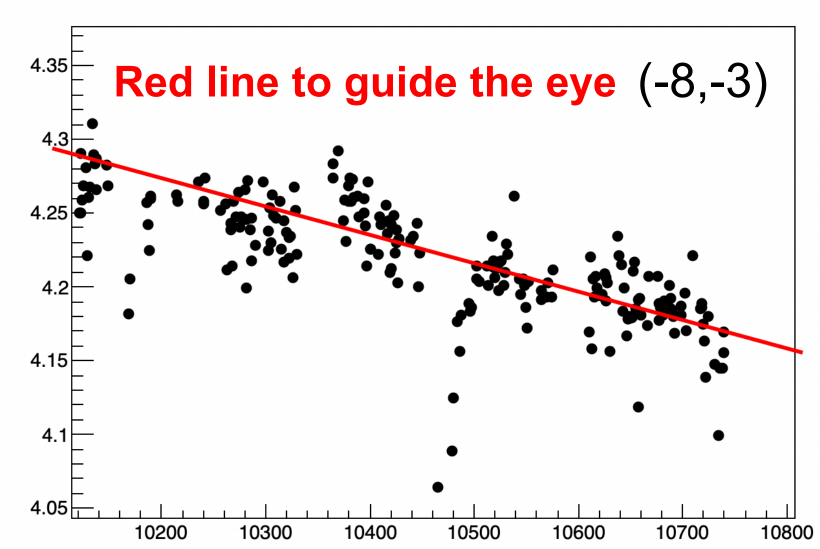


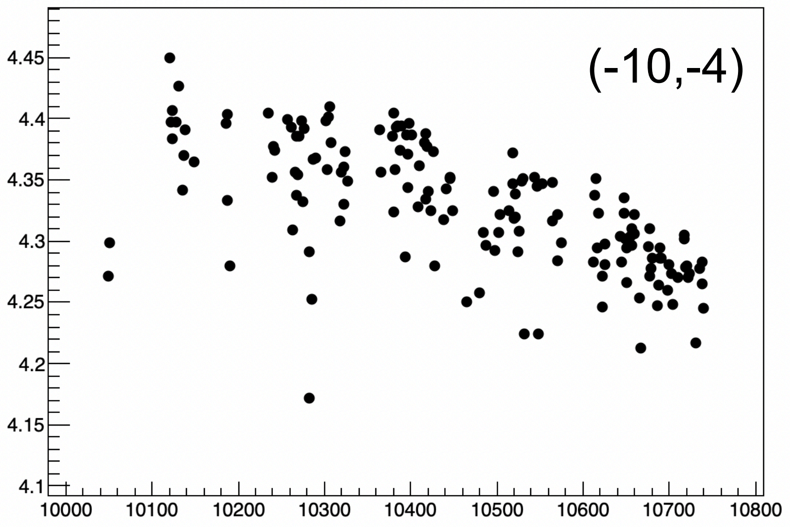

| # | From | To | Run range | Events |
|---|---|---|---|---|
| **1** | 25/7 06:00 | 28/7 01:05 | 10004-10064 | At the end, chiller stopped: https://logbooks.jlab.org/entry/3711089 |
| **2** | 28/7 02:00 | 28/7 19:30 | 10065-10069 (10070 junk?) | At the end: https://logbooks.jlab.org/entry/3711453 |
| **3** | 29/7 00:01 | 29/7 22:30 | 10072-10084 (10085 junk?) | https://logbooks.jlab.org/entry/3711954 |
| **4** | 30/7 00:01 | 30/7 11:30 | 10087-10093 | At the end: new chiller replacement (https://logbooks.jlab.org/entry/3712197) |
| **5** | 30/7 16:30 | 31/7 08:45 | 10101-10115 | At the end: chiller temp changed from 15 to 15.5 according to MYA. Nothing on logbook. |
| **6** | 31/7 08:44 | end | 10115-end | **Golden Period** |

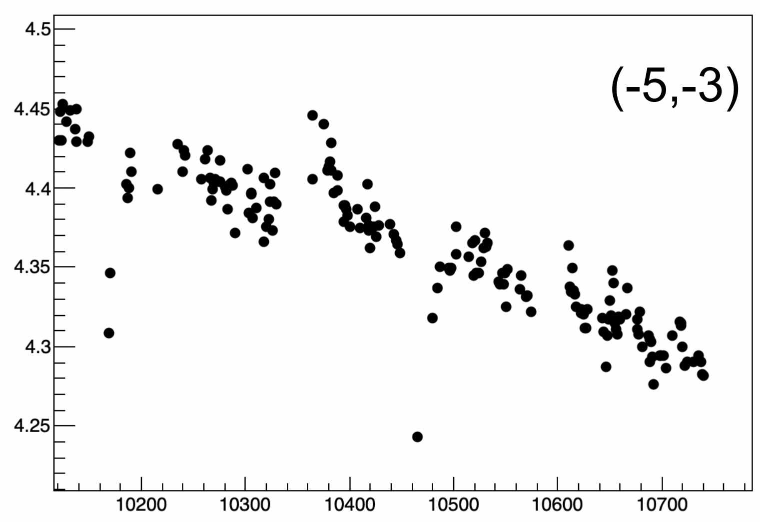
# Data – Stability – Golden Period

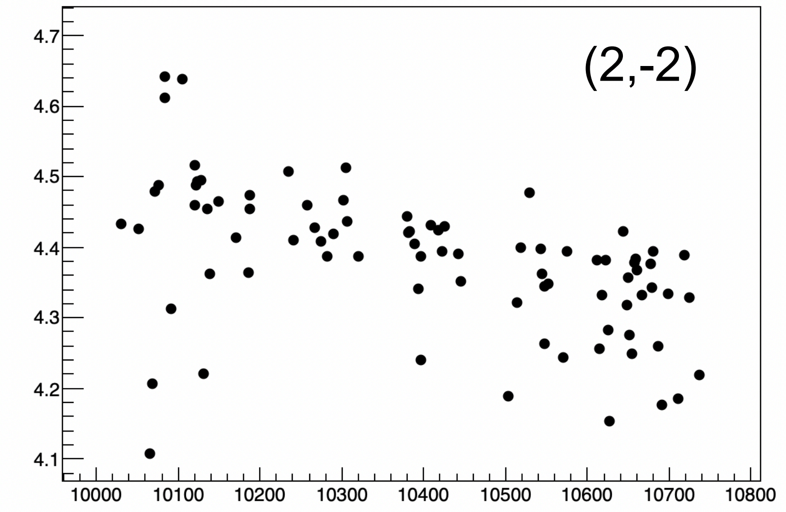
Golden period (run >= 10115) was considered at first.

Non-negligible FEE peak position dependence as a function of run number (i.e. time)




The trend is clearly visible also for crystals at significant distance to the beam hole, like (-2,2)

For crystals at larger distance, low statistics prevents a run-by-run comparison

# Data – Stability – Golden Period

Golden period (run >= 10115) was considered at first.

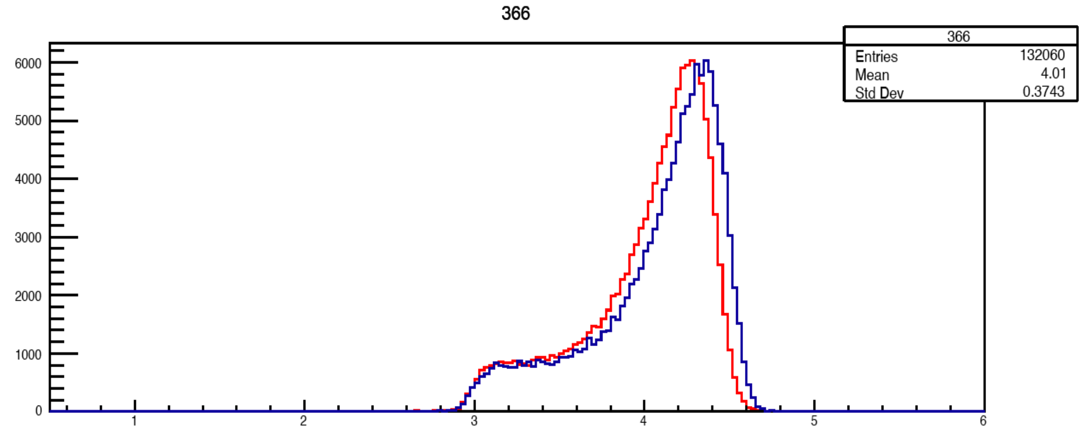
Non-negligible FEE peak position dependence as a function of run number (i.e. time)

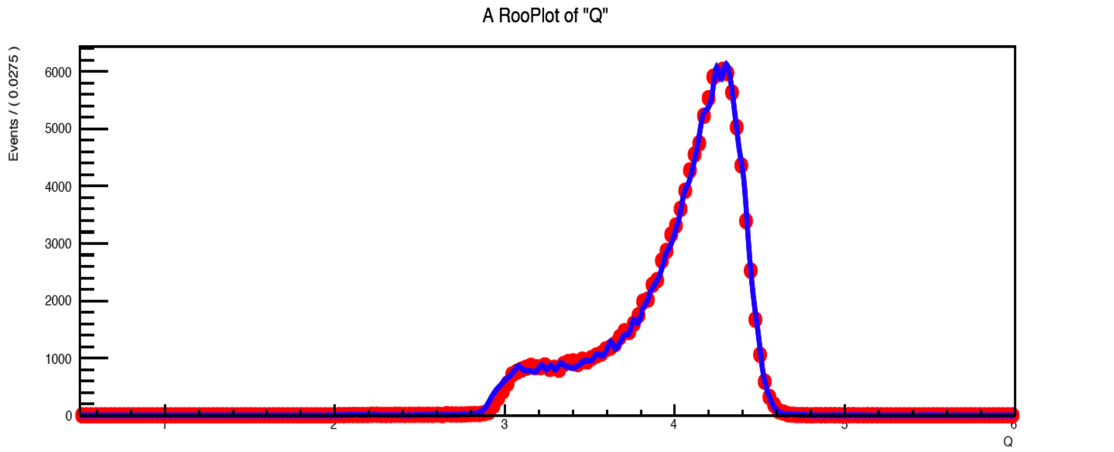
To check if this is a radiation damage effect, I grouped together following runs:

- 10200-10300 “PRE”
- 10600-10700 “POST”

For each crystal - or group of crystals for low statistics areas – I compared PRE and POST

- Visually
- Using PRE to derive a pdf and fit it to POST - single free parameter is a scale parameter (using RooFit)

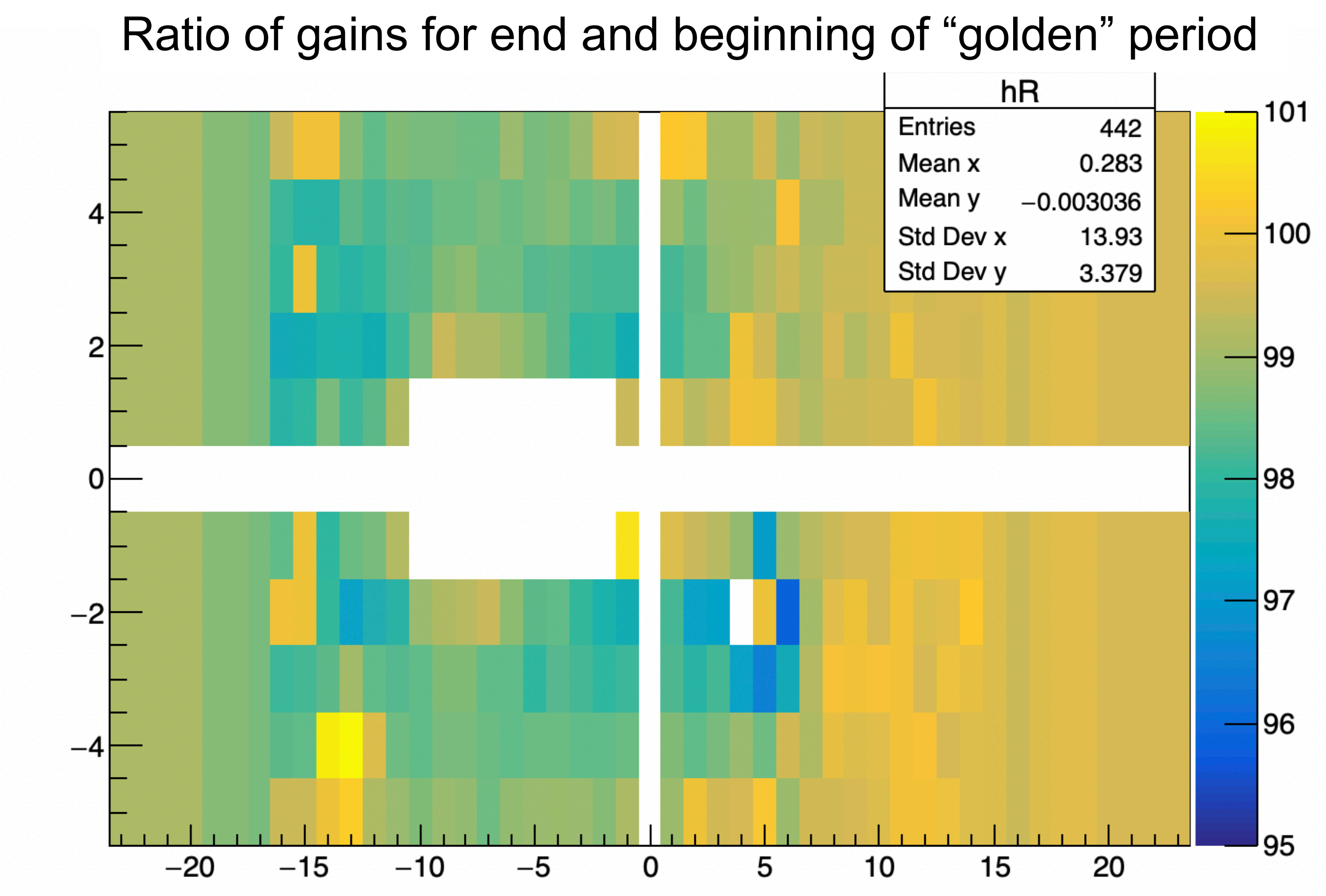


# Data – Stability – Golden Period

Golden period (run >= 10115) was considered at first.

Non-negligible FEE peak position dependence as a function of run number (i.e. time)



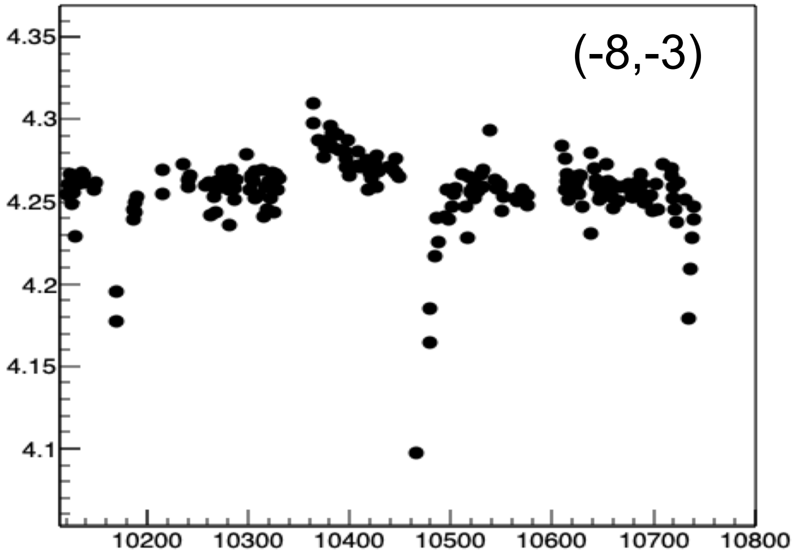

This is a 1% - 2% effect (at maximum), non uniform across the calorimeter.

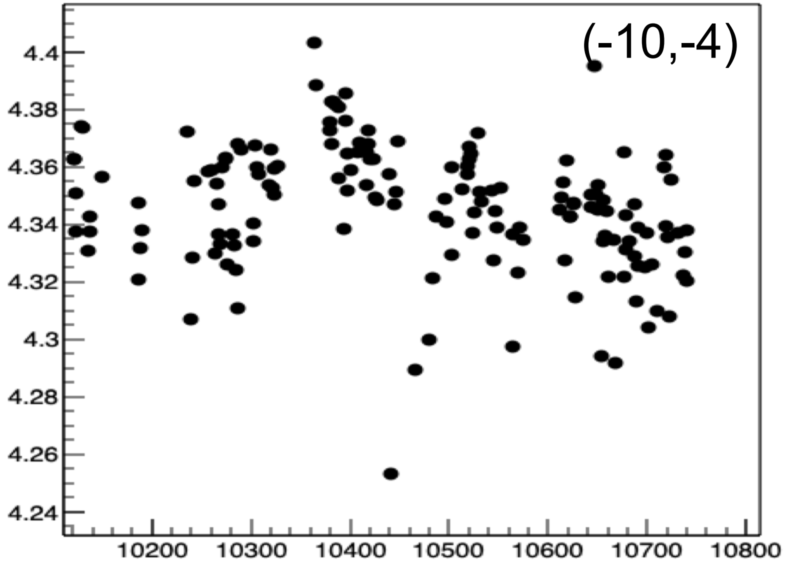
A run-by-run correction was derived by assuming a linear FEE peak position dependence on the run number.

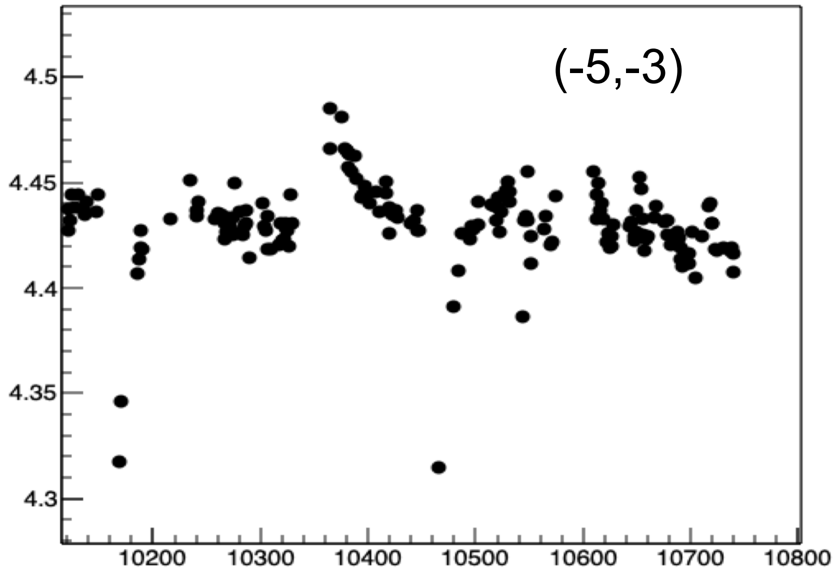
The slope was determined from the POST/PRE ratio as obtained from the template fit.

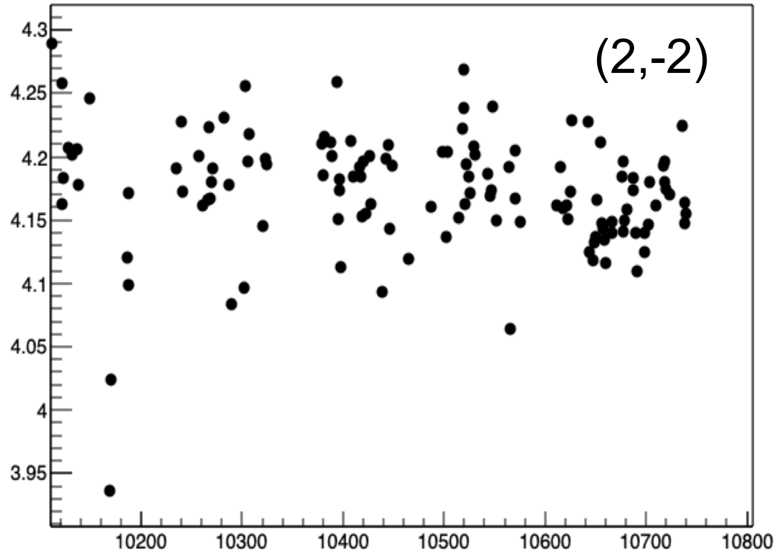
# Data – Stability – Golden Period

Golden period (run >= 10115) was considered at first. After implementing the correction:



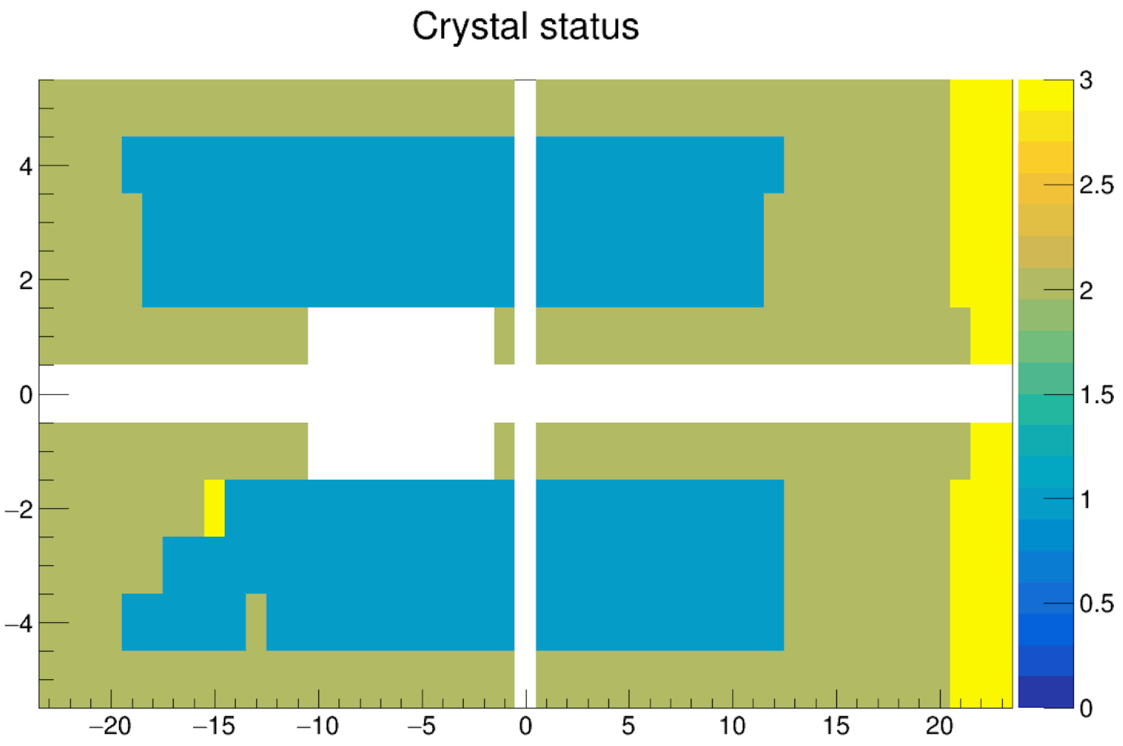

There a residual effect for runs starting from 10360 and ending 10450

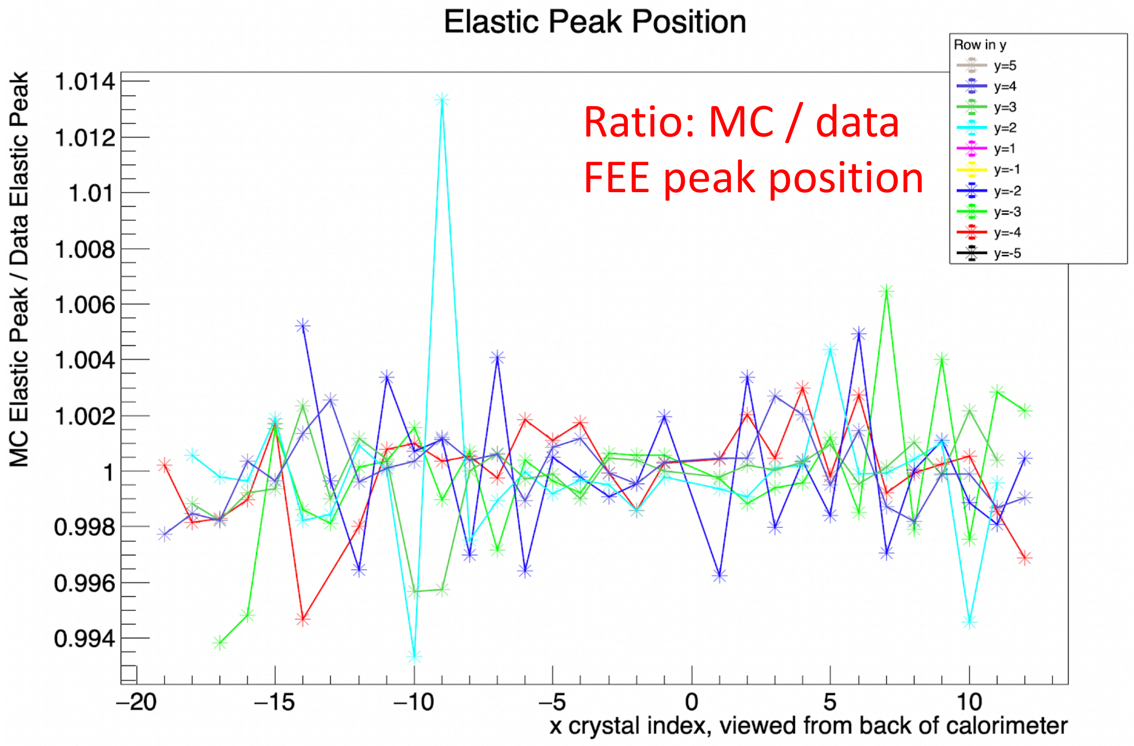
- 10360: 17/8/2019

No significant temperature changes

# Data – Golden Period calibration

Result after four iterations.

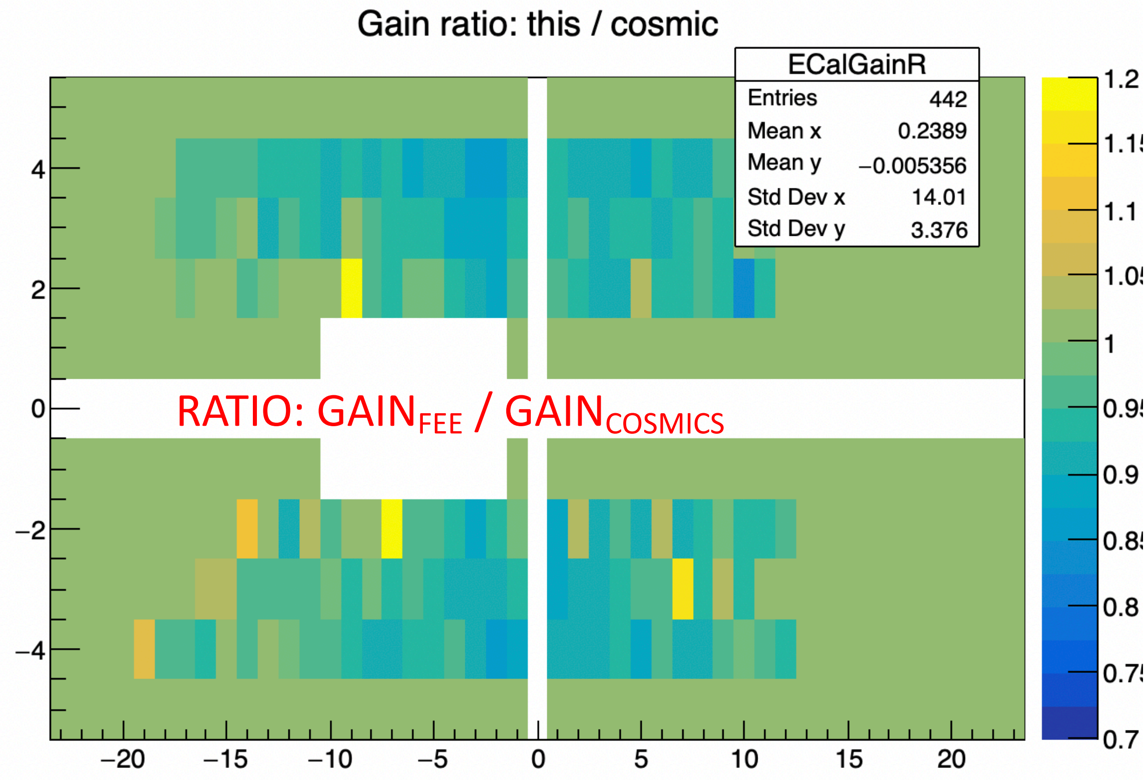


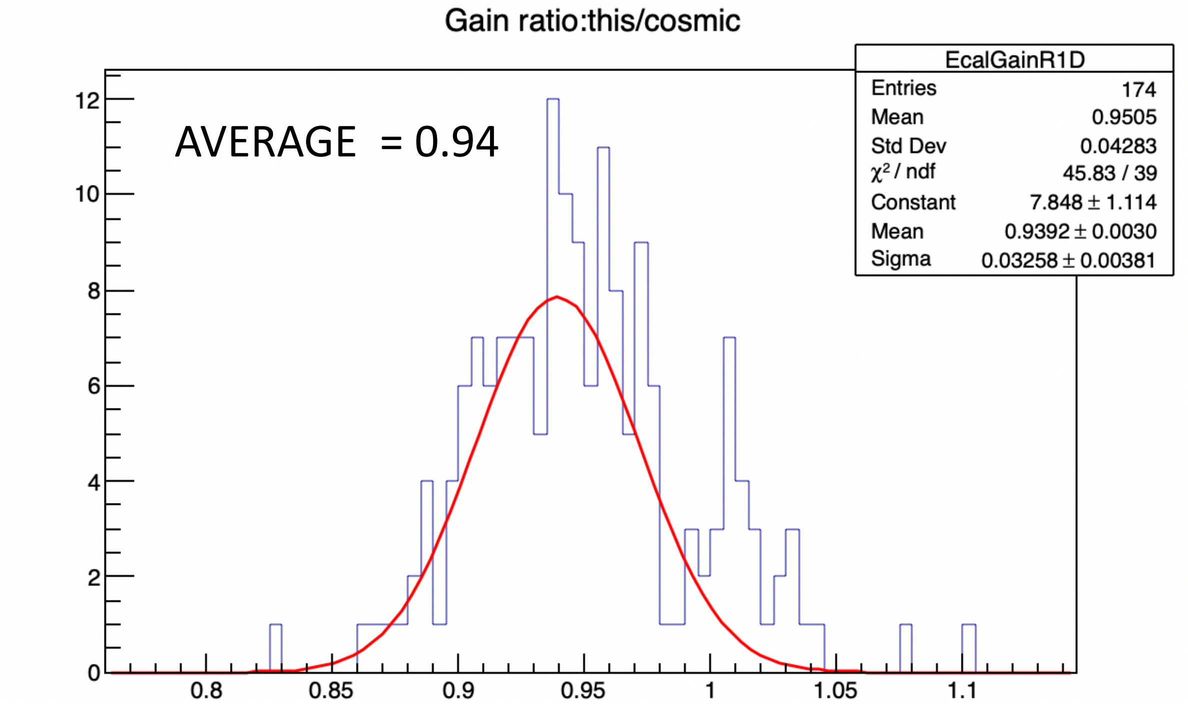




Blue: Crystal was calibrated. A clear FEE peak was visible.
Yellow: No statistics.
Brown: FEE peak not clean.

# Data – Golden Period calibration

For crystals not calibrated with FEE method, comics are used.



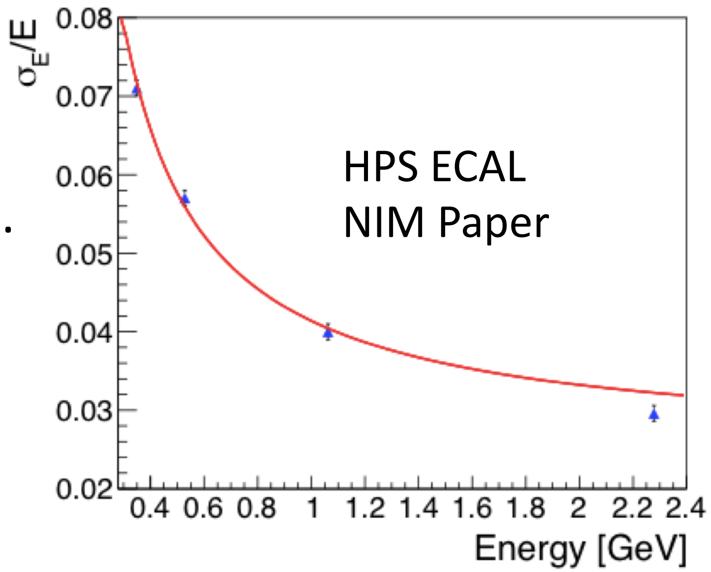




- $G_{cosmics}$ = 18.3 MeV / $Q_{cosmics}$
- $G_{FEE} = E^{FEE}_{MC}/E^{FEE}_{Data} * G_{cosmics} = E^{FEE}_{MC} / Q^{FEE}$
  - Simplifying the iterative procedure to a single iteration
- Ratio = $G_{FEE} / G_{cosmics}$ = ($E^{FEE}_{MC}$ / 18.3 MeV) * ($Q_{cosmics} / Q^{FEE}$)

**Possible explanations:**

- Cosmic energy 18.3 MeV was too high
- Temperature effect (different temperature between cosmic run and this run)

# Data – other periods calibrations




All the other 5 periods have been calibrated with the same method.
Due to the much shorter time interval, no run-by-run corrections were done.

Consistency was found between $G_{FEE}$ / $G_{cosmics}$ and temperature.

*At this point, a first version of the calibration constants for all crystals and for all runs >= 10004 is available.*

*Spot-checking a couple calibrated crystals, it looks like ~3% resolution is already achievable, which falls very close to the curve from the NIM paper at 4.5 GeV (3.2% according to the quoted equation)*

**TODO:**

- The code to perform golden period run-by-run correction is a hps-java driver that I have in my own steering file. Better to use run-by-run calibrations and load them to DB.

- Improvement: when tracking will be available, check track / cluster matching and select only events where the e- impacts at least ~half crystal from the edge to try to also calibrate crystals at the edge.