ECal Performance and Calibration

HPS Collaboration Meeting, JLab

4 May 2017

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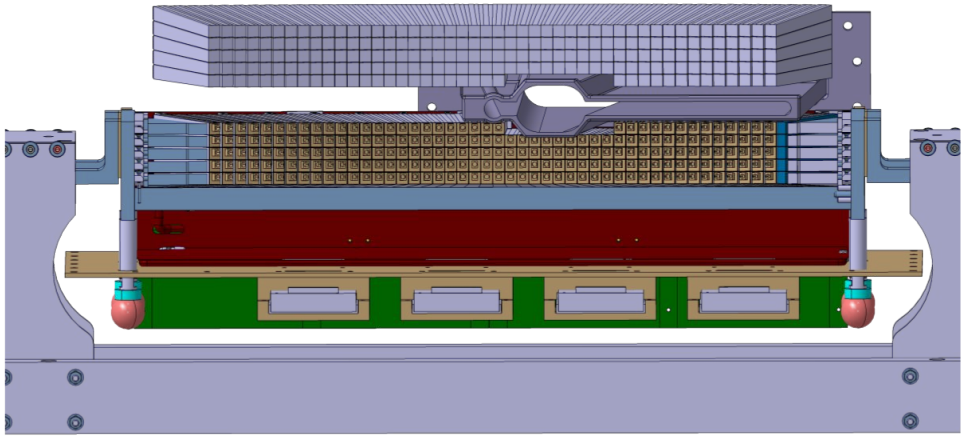
College of William and Mary

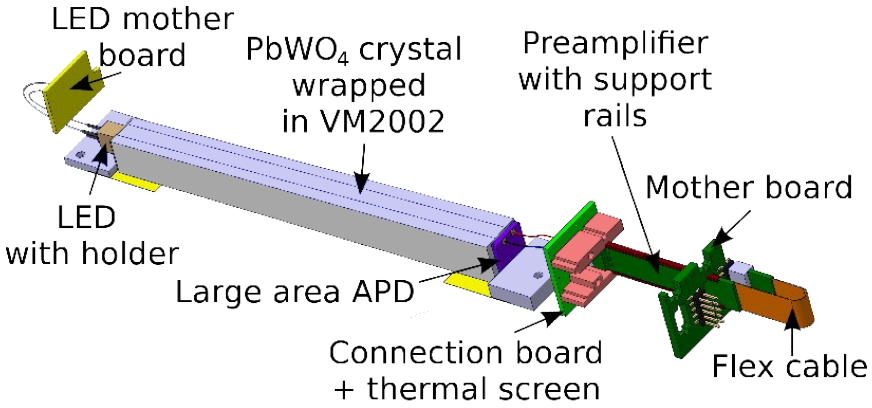
*with some slides borrowed with permission from Holly Szumilla Vance

and Raphaël Dupre's talks from the previous collaboration meeting

Outline

- Performance
  - NIM paper
  - trigger & resolutions
  - live monitoring
- Calibrations:
  - Gain calibrations:
    - Cosmics
    - FEEs
    - Time Dependent
  - Timing calibration
    - cluster time - rf time
    - time walk
  - Track-cluster match (UPDATE)





NIM Paper

- **Both datasets: 2015 and 2016**
- **The paper is done**
  - Accepted and approved by NIM
  - https://arxiv.org/pdf/1610.04319.pdf
- **Coordinated by G. Charles and M. Garçon**
  - Thanks to the main contributors
    - Holly, Kyle, Nathan, Rafayel, Valery, Andrea, Norman

The HPS electromagnetic calorimeter

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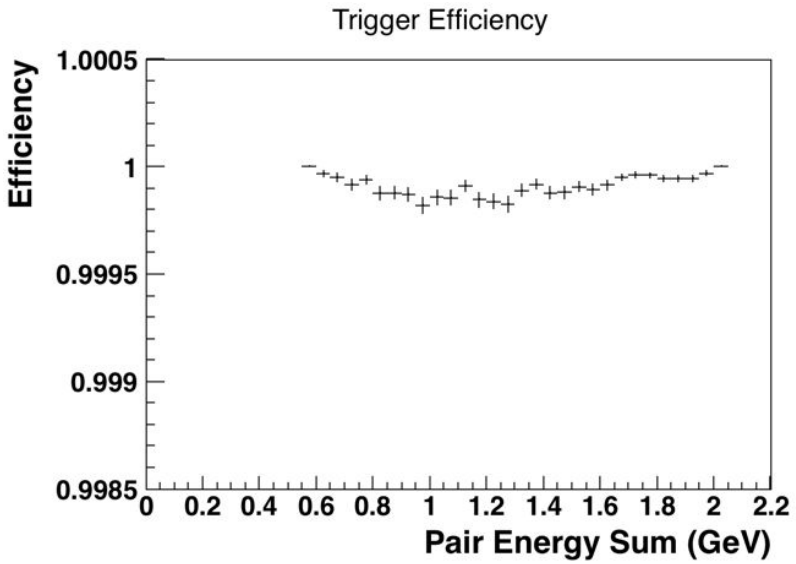
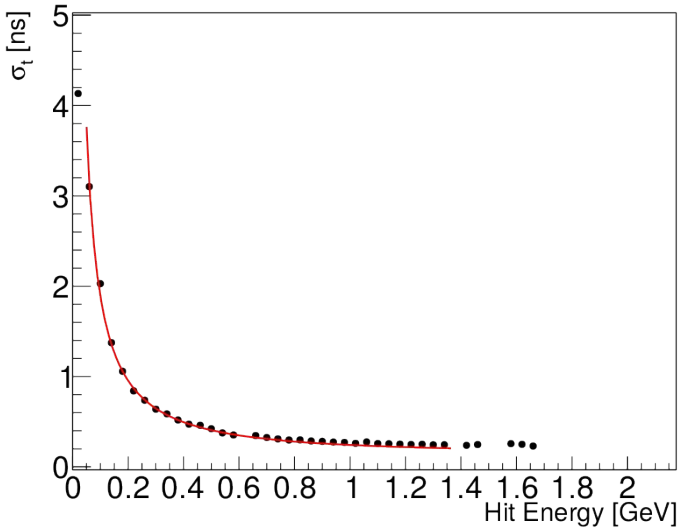
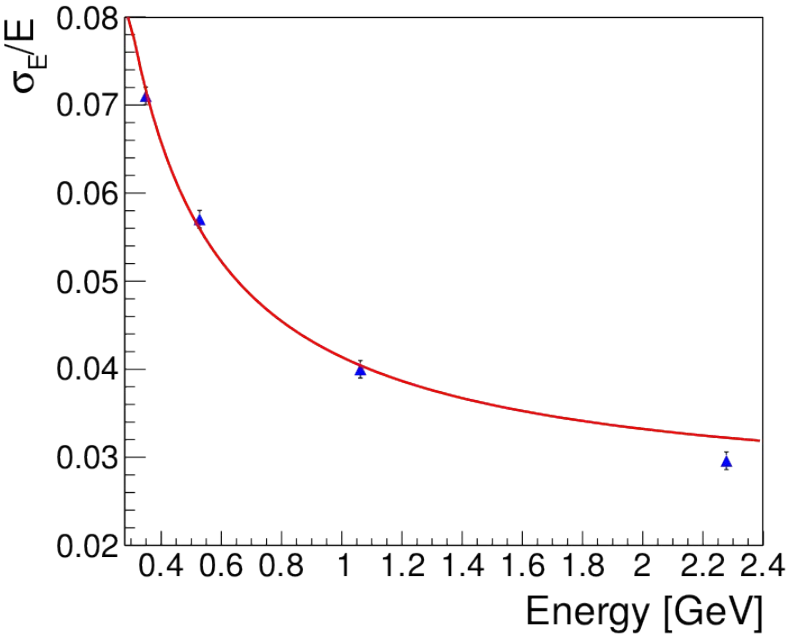
Performance

- **Resolutions at the level expected**
  - Cluster time difference resolution down to ~330 ps
  - Energy resolution
    - $\frac{\sigma_E}{E}(\%) = \frac{1.62}{E} \oplus \frac{2.87}{\sqrt{E}} \oplus 2.5$
    - A bit better since TDC removal (2.3 GeV point)
- **High trigger efficiency**
  - Stable with energy

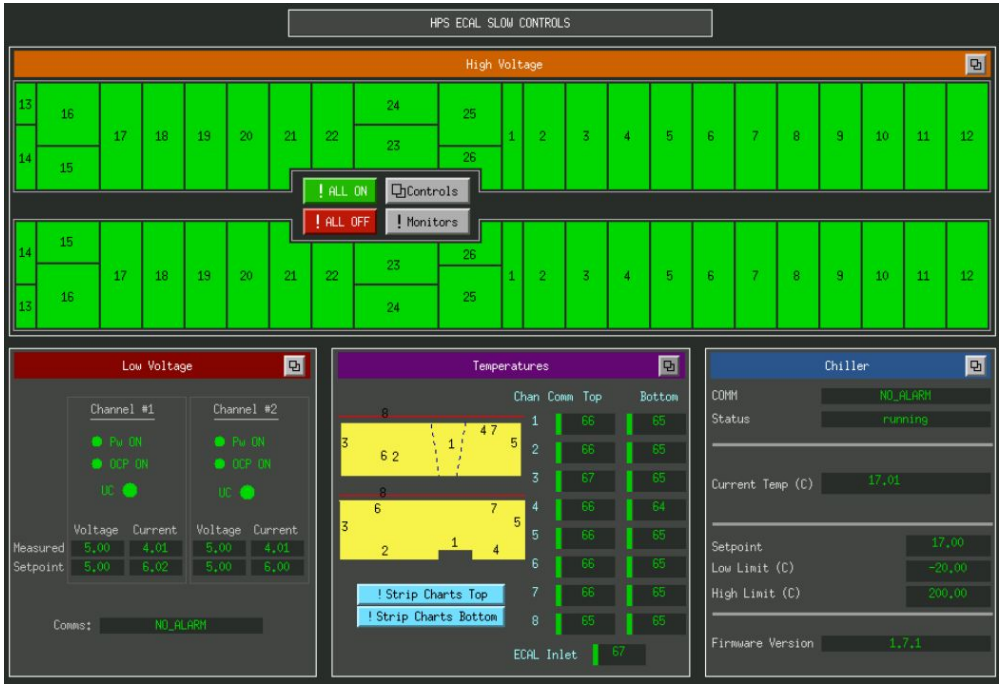


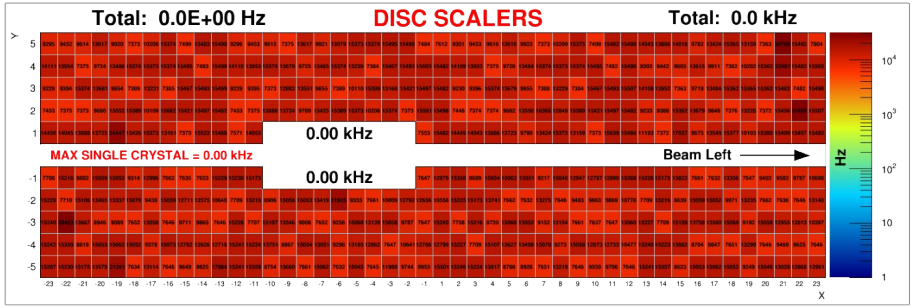


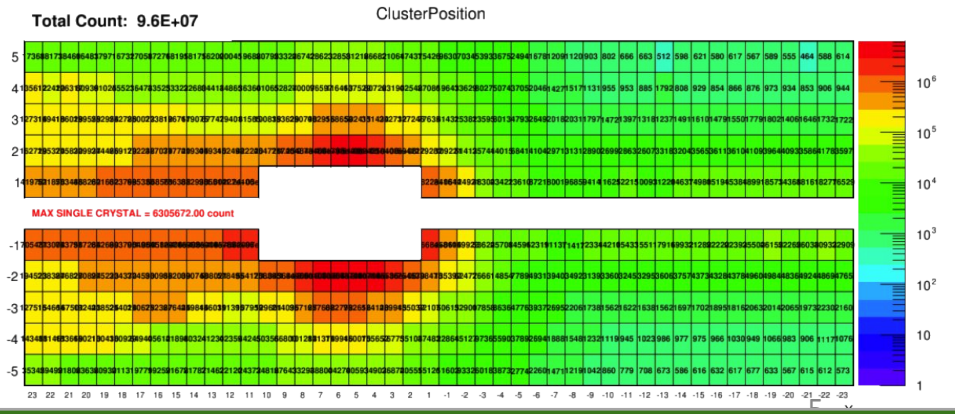


Live Monitoring

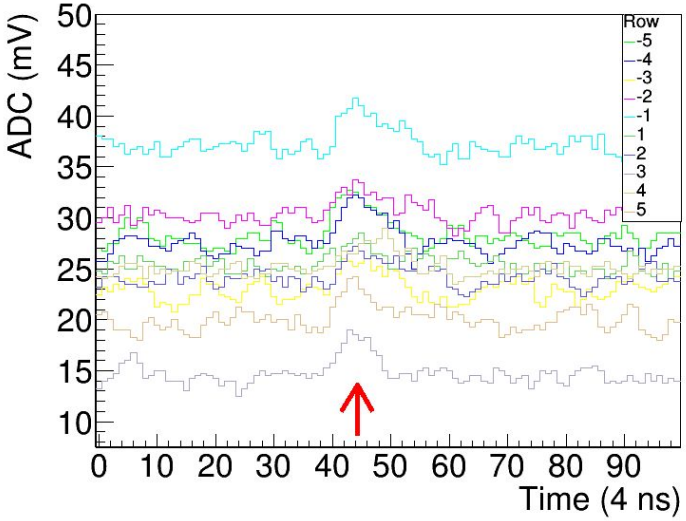
- **Very useful scalers**
  - Allow to spot any problem within minutes
- **LED system**
  - Allow for full check of the ECal in less than 5 minutes off beam
- **Slow Controls**
  - Allows control but also monitor and and records of all necessary data
    - Voltages and temperature
- **These tools allowed for a very smooth running of the calorimeter**

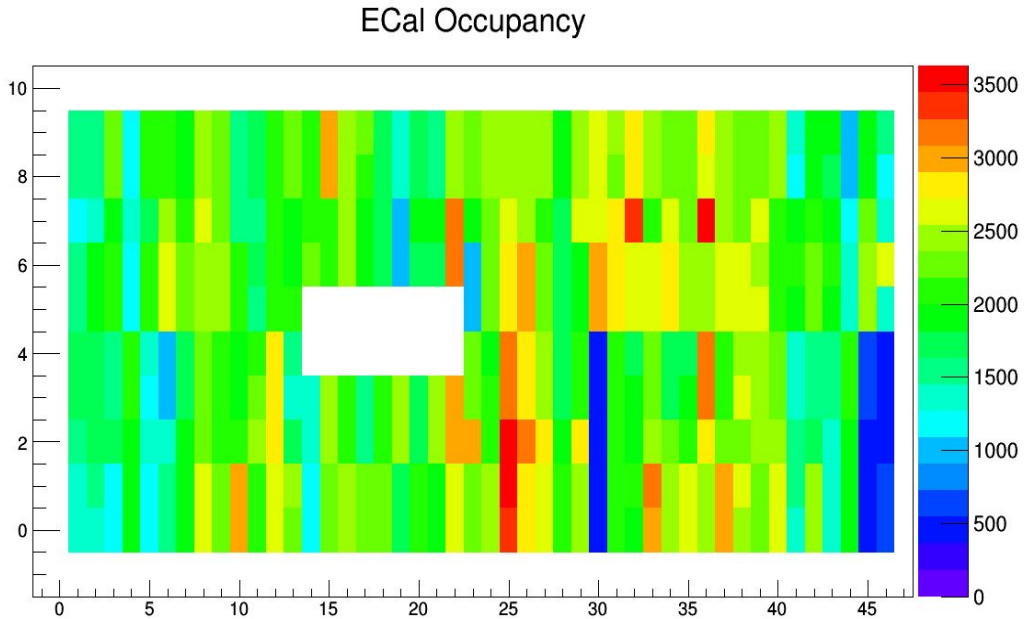


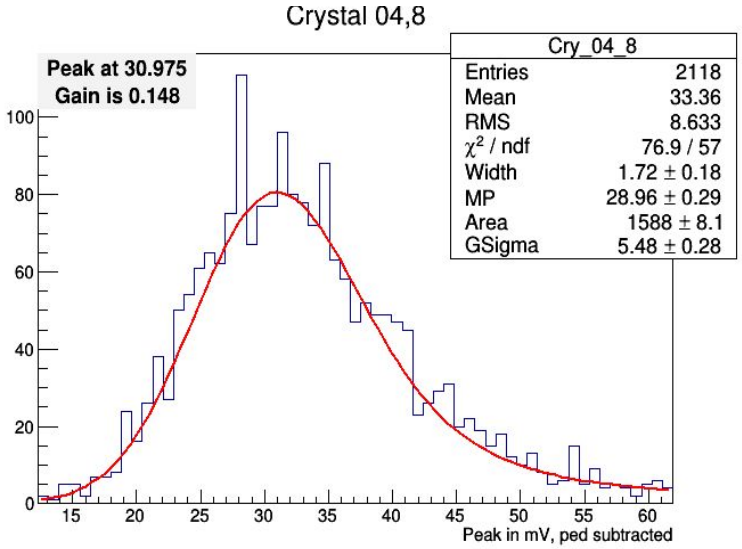


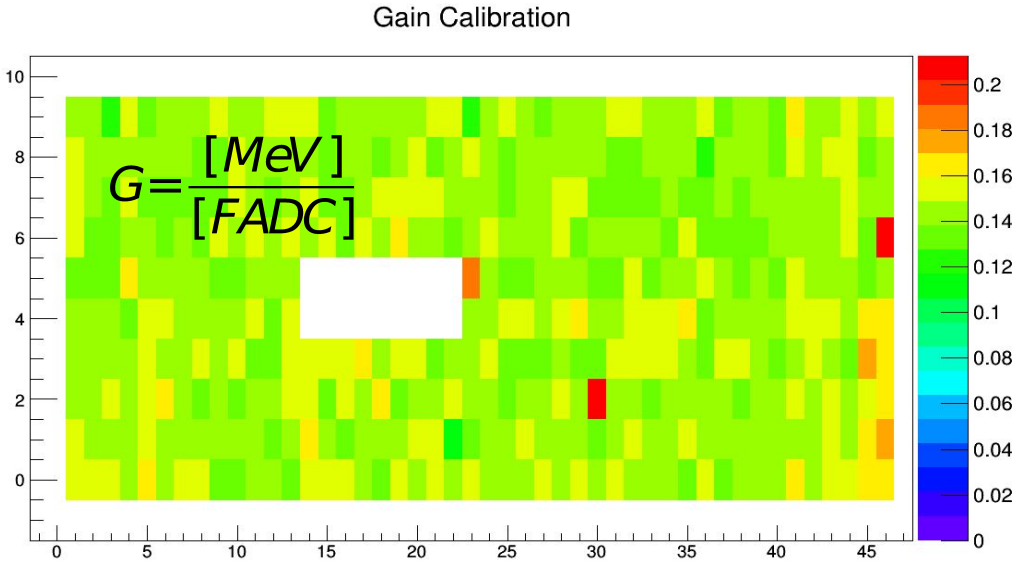


Cosmic calibration









https://userweb.jlab.org/~hszumila/calibration/cosmic/cosmics.html

FEE calibration --procedure

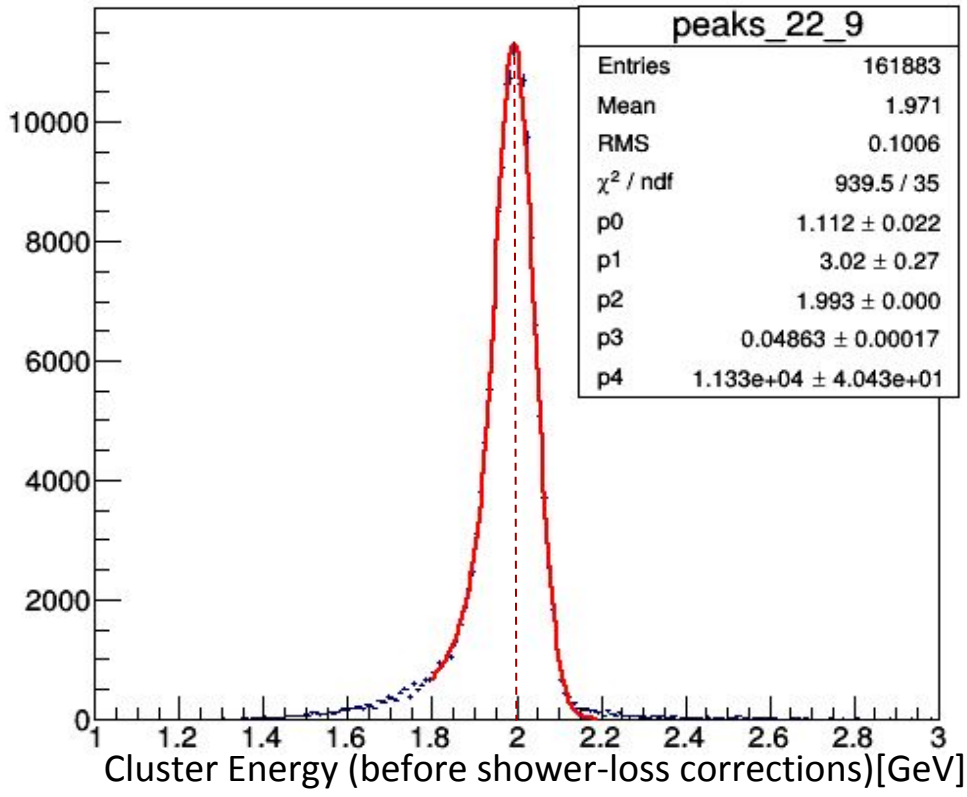
Select clusters where:

- Seed energy carries >60% cluster energy
- Seed energy > 1.1 GeV

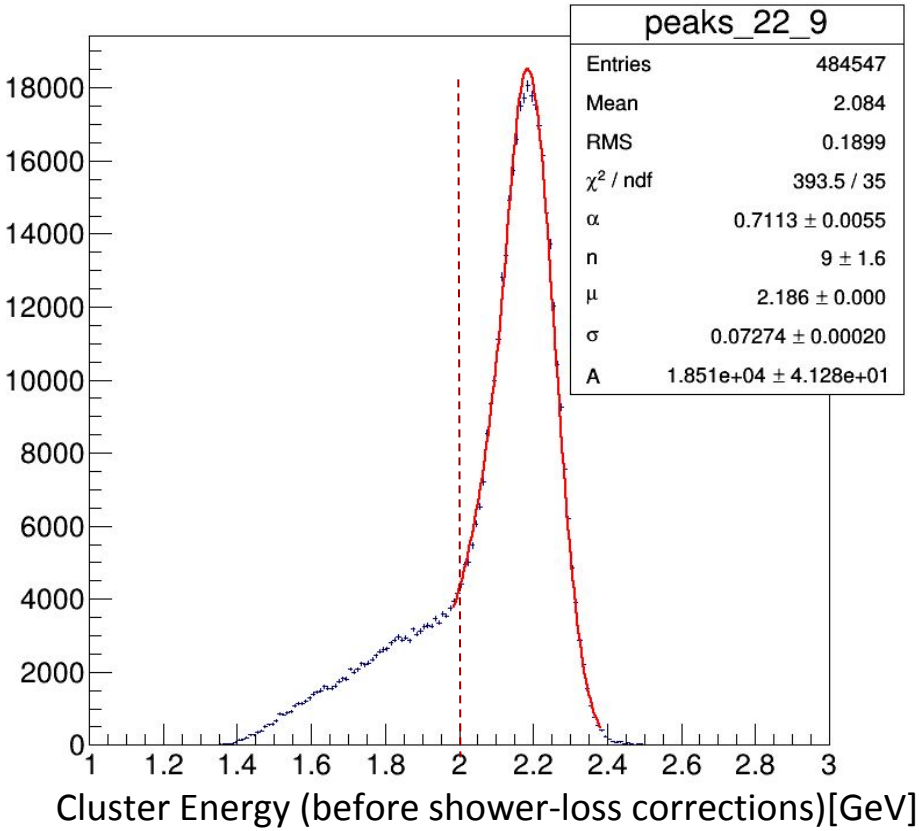
Obtain iteration coefficients by fitting cluster peaks.

$$C_i = \frac{Peak_{MC}}{Peak_{data}}$$

Single Crystal Cluster FEE Peak -**MC**

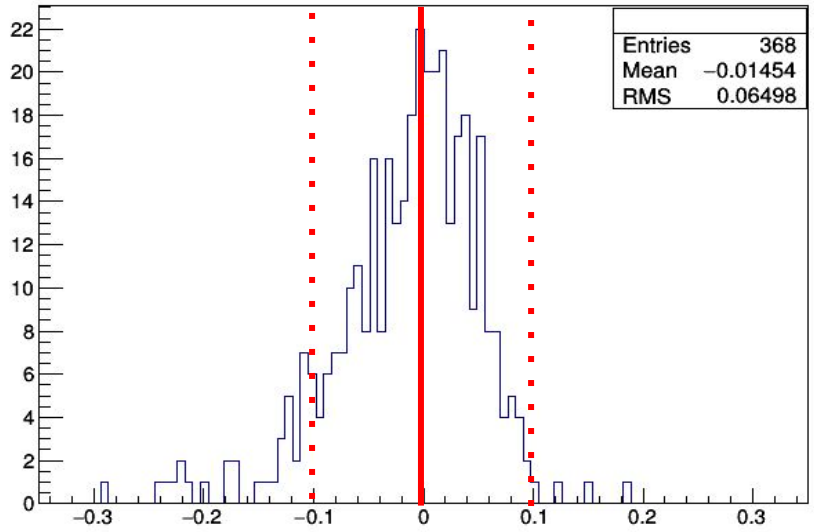


Single Crystal Cluster FEE Peak -**data**

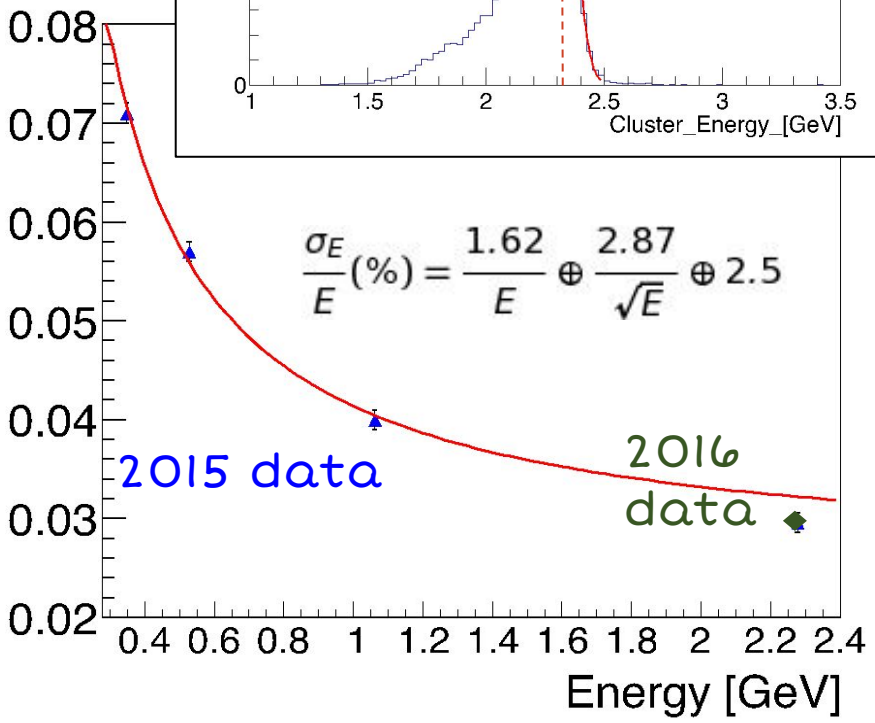


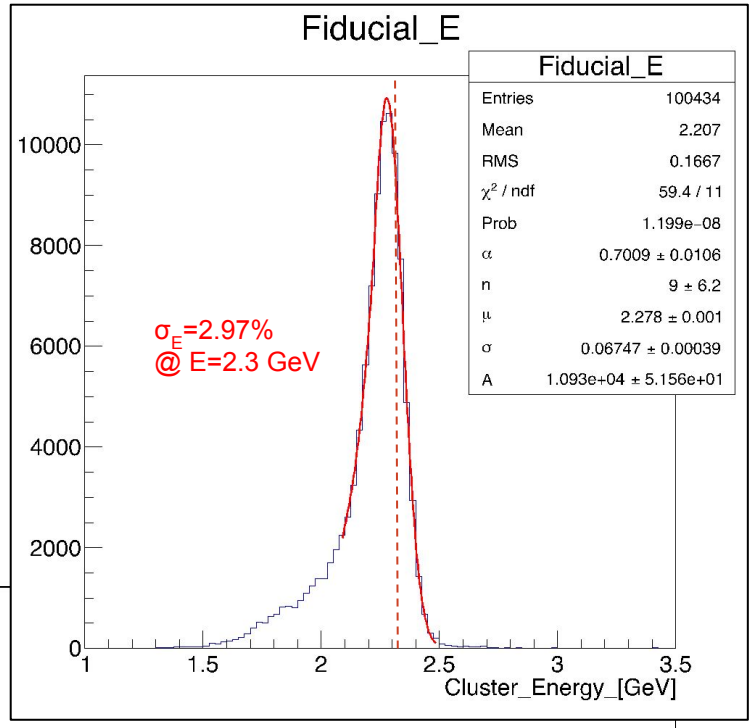
FEE calibration

All crystals that are re-calibrated using FEEs:



σ_E/E





Time Dependent Gains

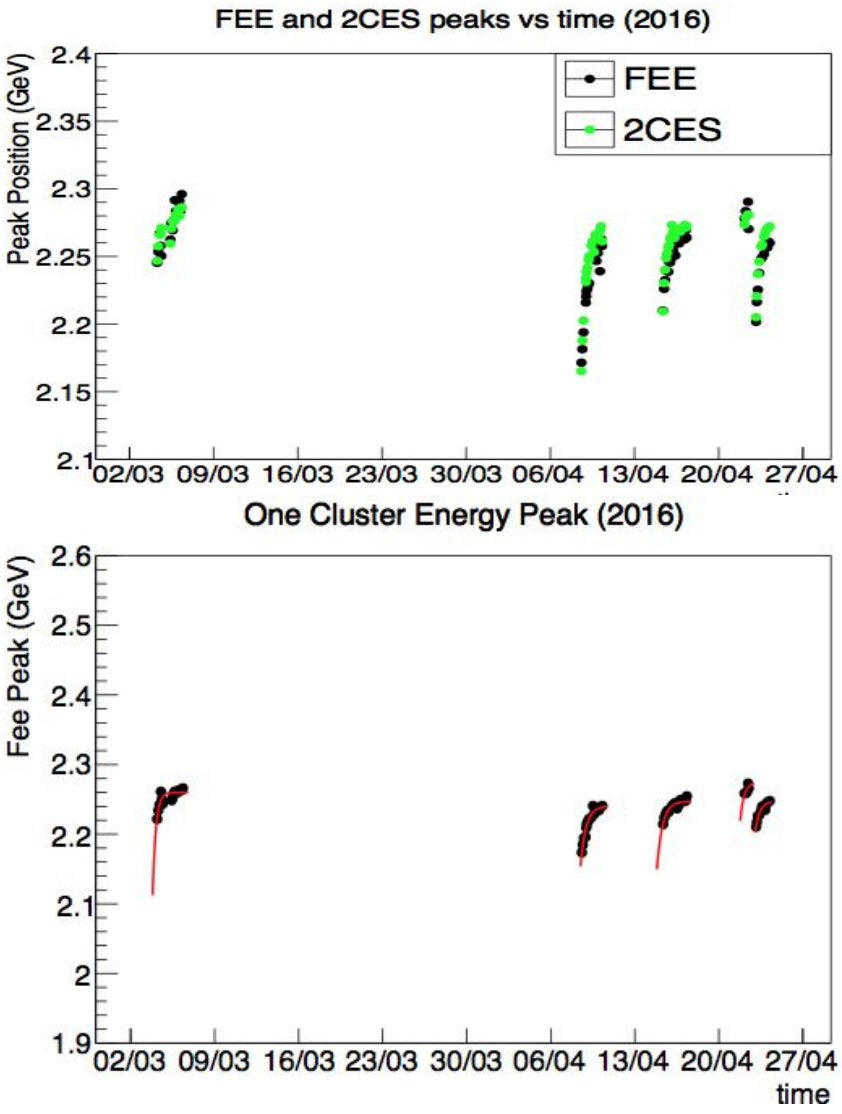
-**Why?** We observed that the FEE energy and 2 cluster energy sum peaks drift over time.

-**How much?** up to +7% correction for a few runs

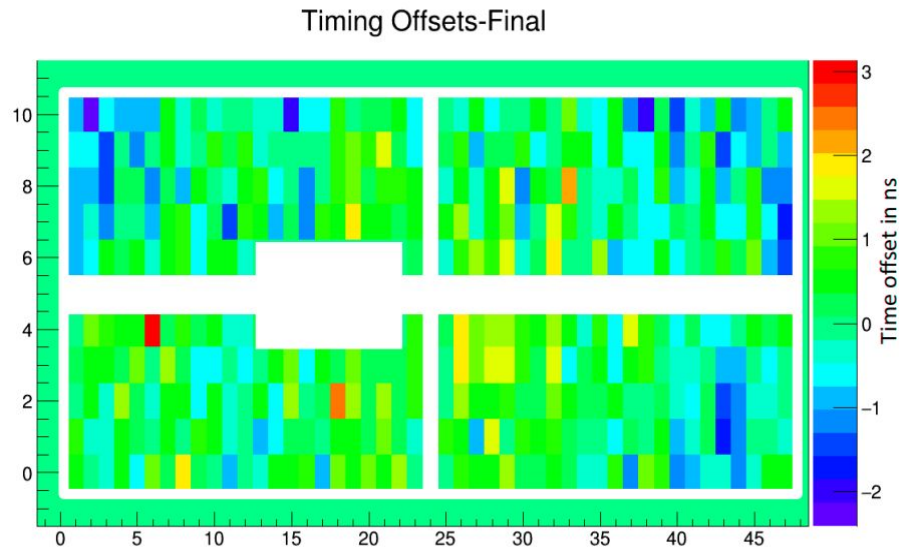
-**Which runs are most affected?** The first few runs after the beam turns on after being off for an extended period of time.

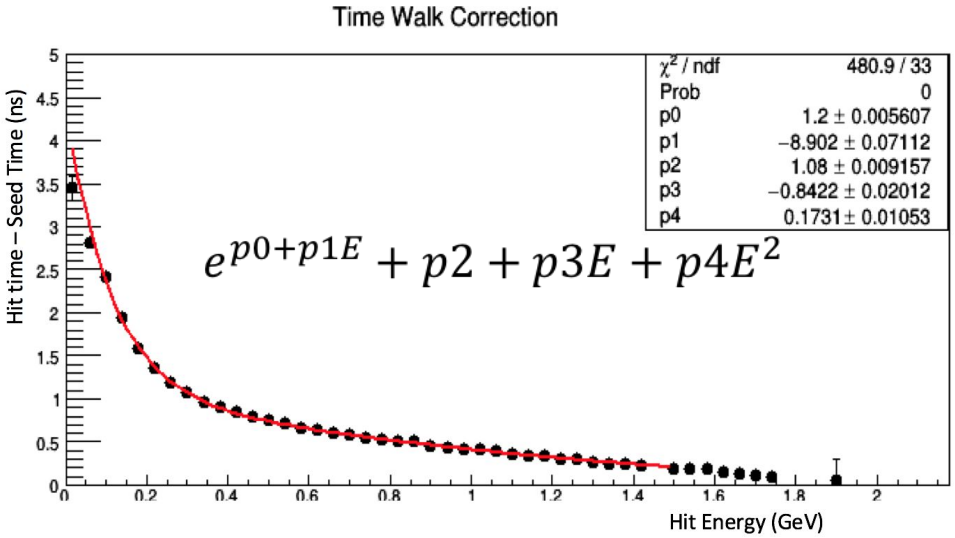
-**Priority?** MODERATELY LOW (only really important if we plan to combine ecal+svt for improved mass resolution)

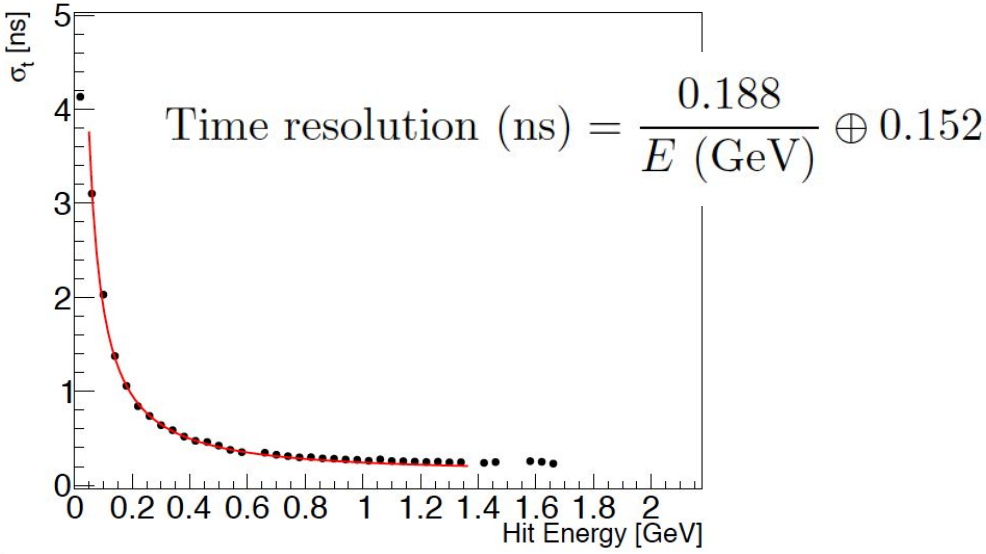
Development is on a branch

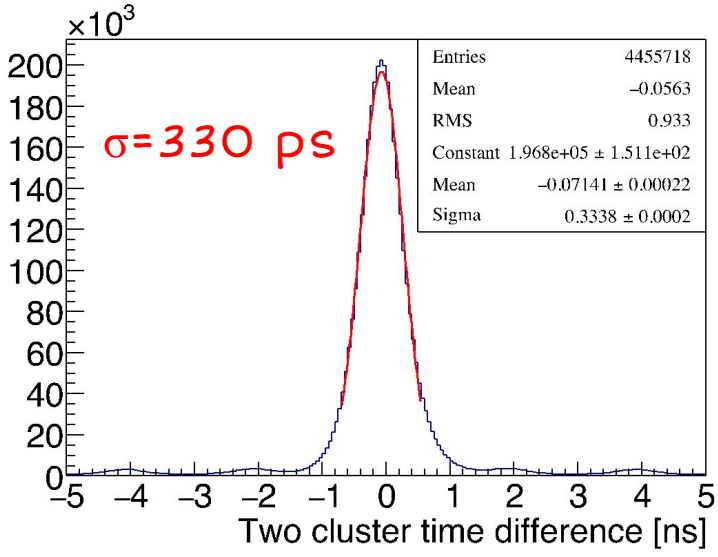


Timing calibration









Track Cluster Match

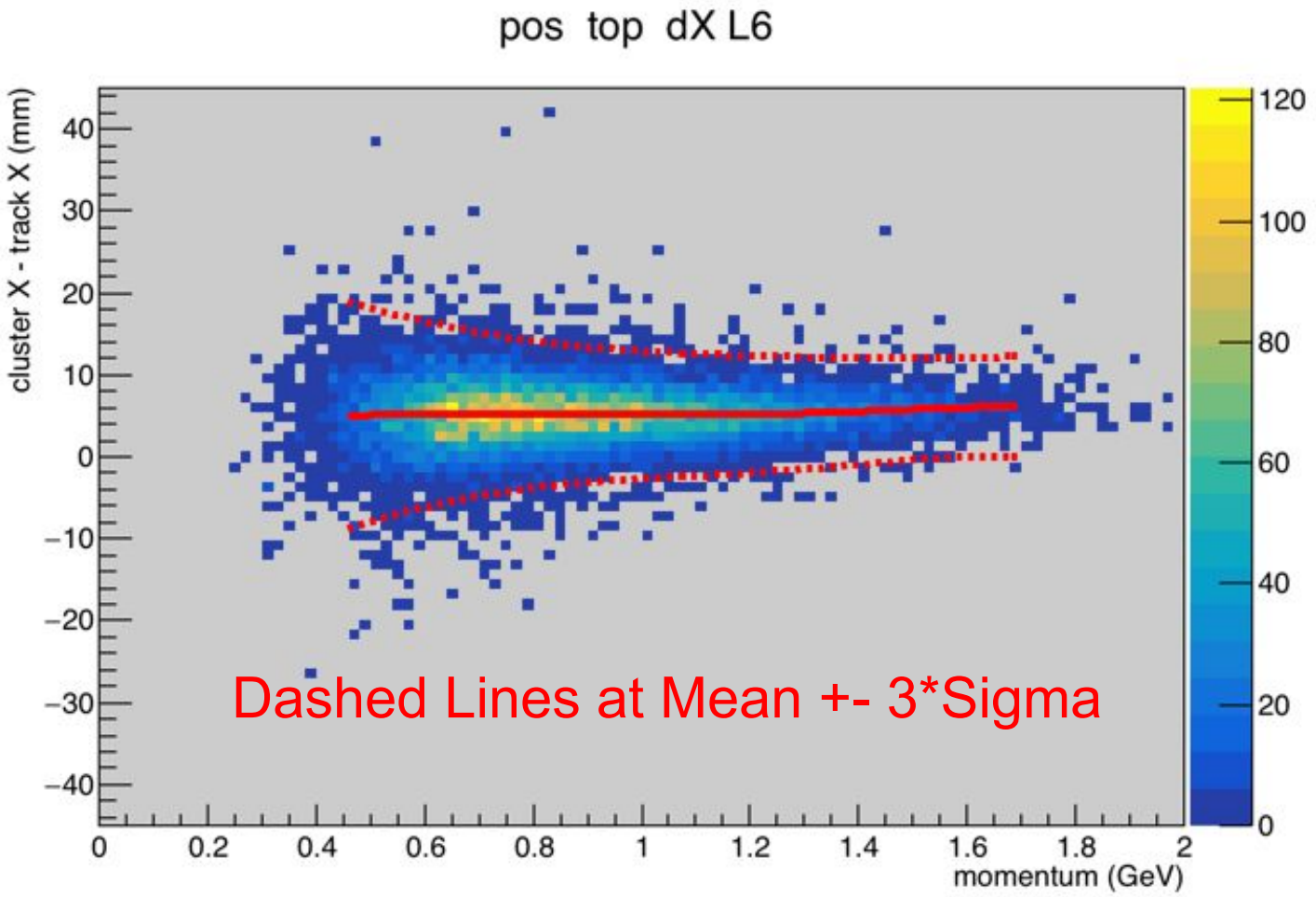
$$n_\sigma = \text{hypot}\left(\frac{x_{cl} - x_{tr} - \mu_x(p)}{\sigma_x(p)}, \frac{y_{cl} - y_{tr} - \mu_y(p)}{\sigma_y(p)}\right)$$

Changes:

- μ(p), σ(p) are 5rd order poly fits, separately calculated for:
  - top/bottom
  - has/doesn't have L6 hit
  - charge (+/-)
- Special case: track extrapolates within ½ crystal from Ecal edge
  - y_{track} set to ½ crystal from edge in calculation.

Track-Cluster Match

Parameter Extraction Example:

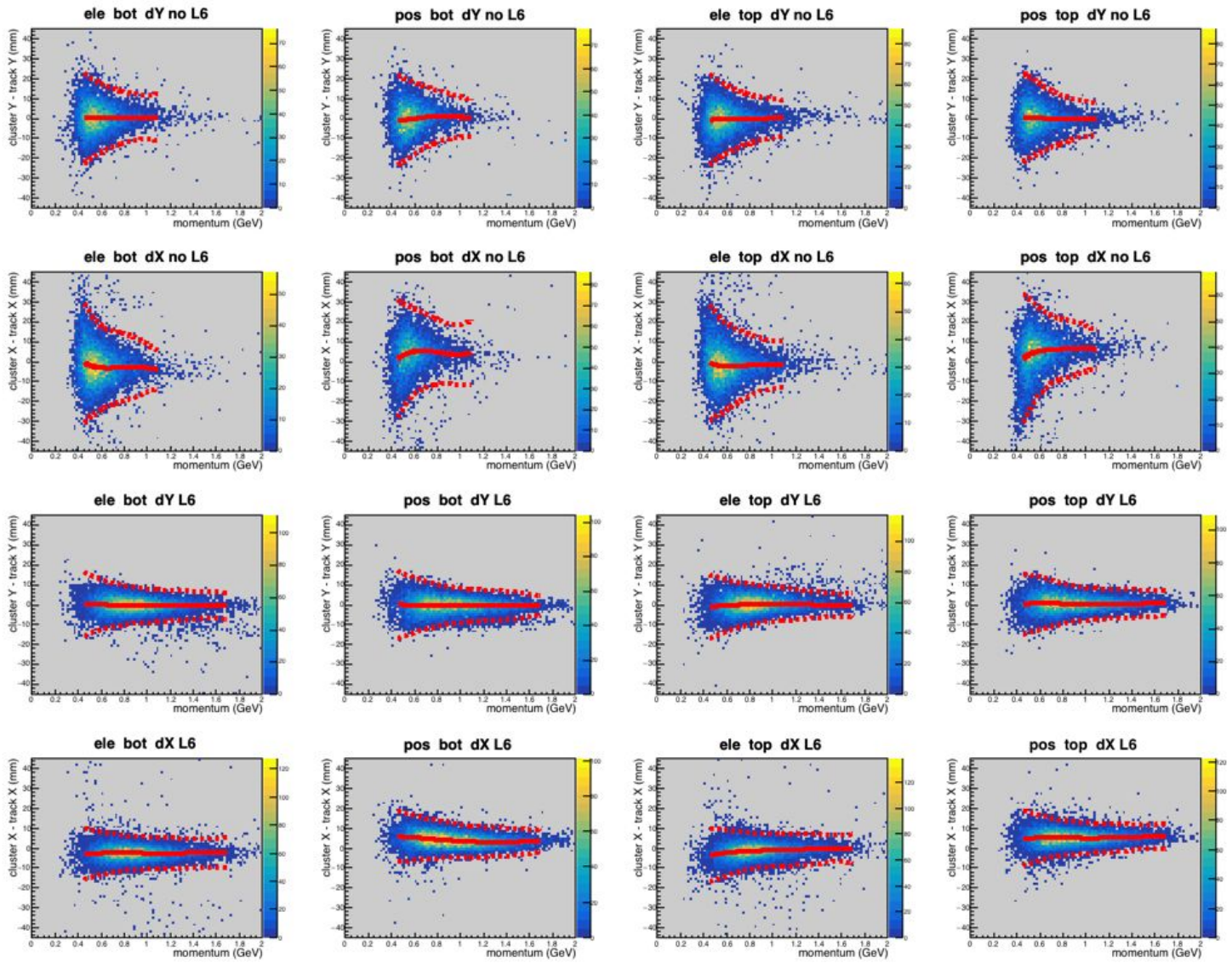


Track Cluster Match

Parameter Extraction: All cases

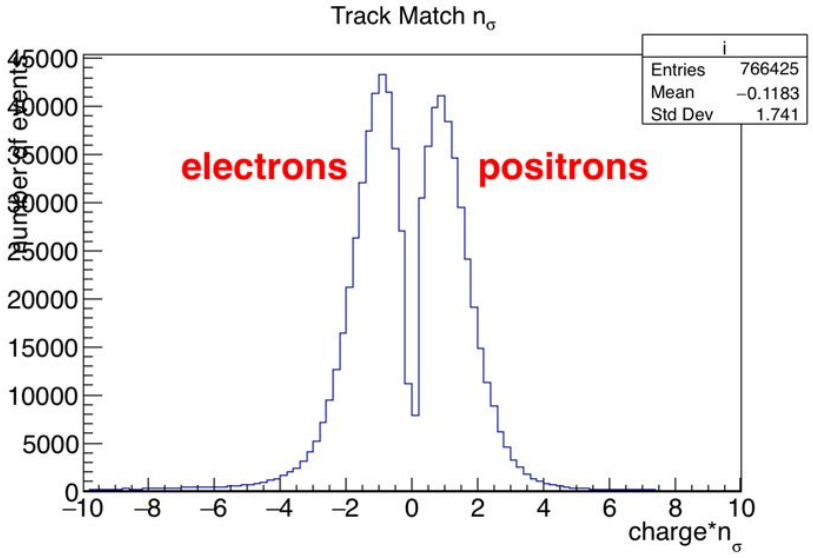
Without Layer 6

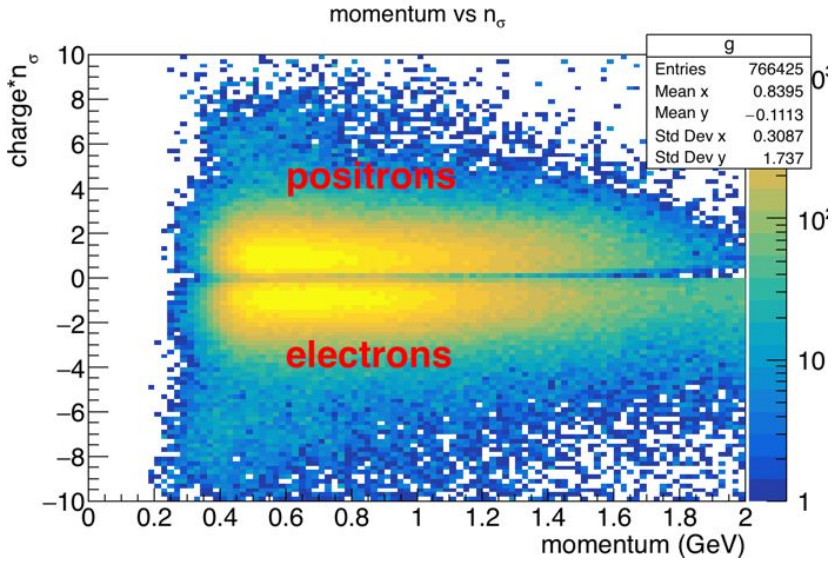
With layer 6

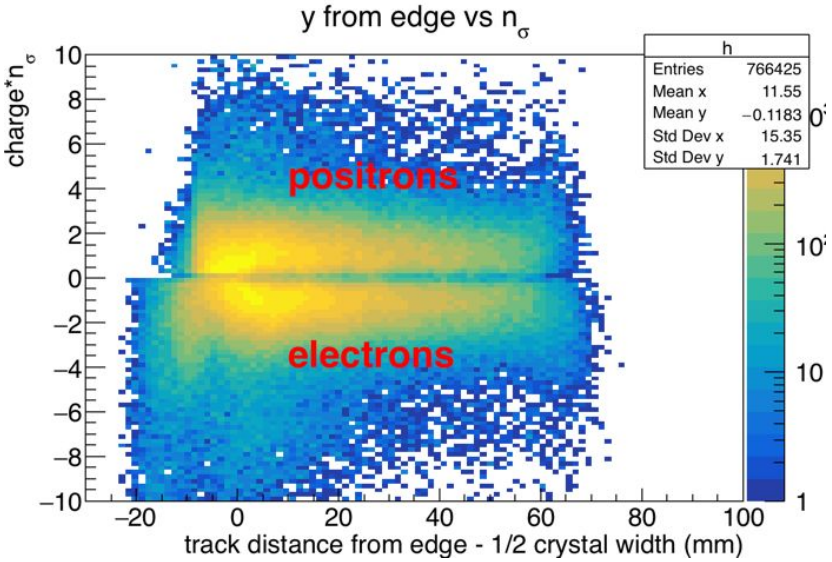


Track Cluster Match Results

- Results shown are from trident tuples
  - Loose cuts:
    - Track Chi^2/ dof < 5
    - Track-cluster time difference within +-4.5 ns window
  - Need to test inside HPS java before making pull request
- n_σ distributions look good







Homework before next pass

- We have two modification-branches that need a little more testing before being merged to master
  - track-cluster match
  - time-dependent ecal gains
- Check if edge-corrections to energy (calculated for 1.05 GeV) are still valid at 2.3 GeV

Summary

- NIM paper approved
- Ecal has been calibrated for:
  - Gains (using cosmics and FEEs)
  - Time (w/ time-walk corrections)
- Track Cluster matching
  - New set of parameters created for 2.3 GeV running
  - Improved matching algorithm for particles near the edge.