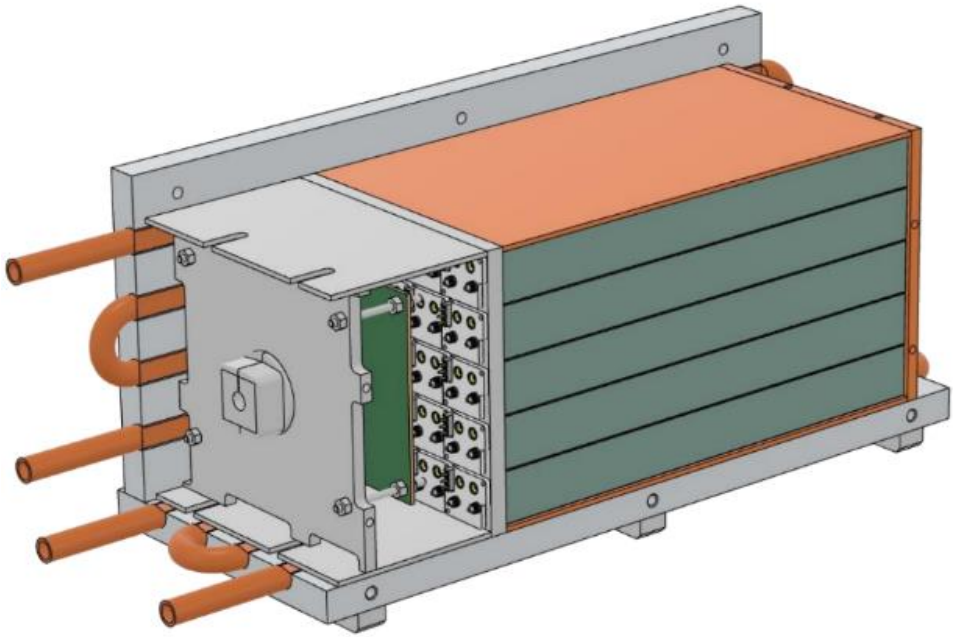


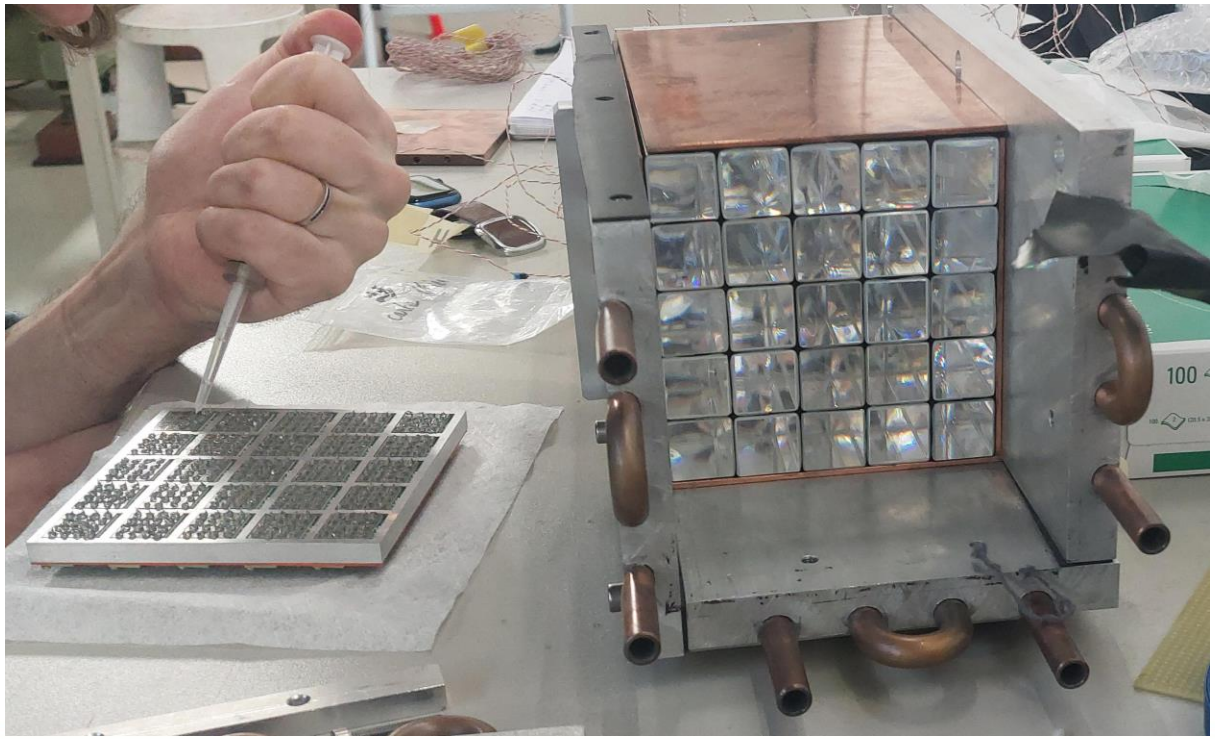
Backward ECal Test Beam

DESY, Dec 8 - 21 (2025)

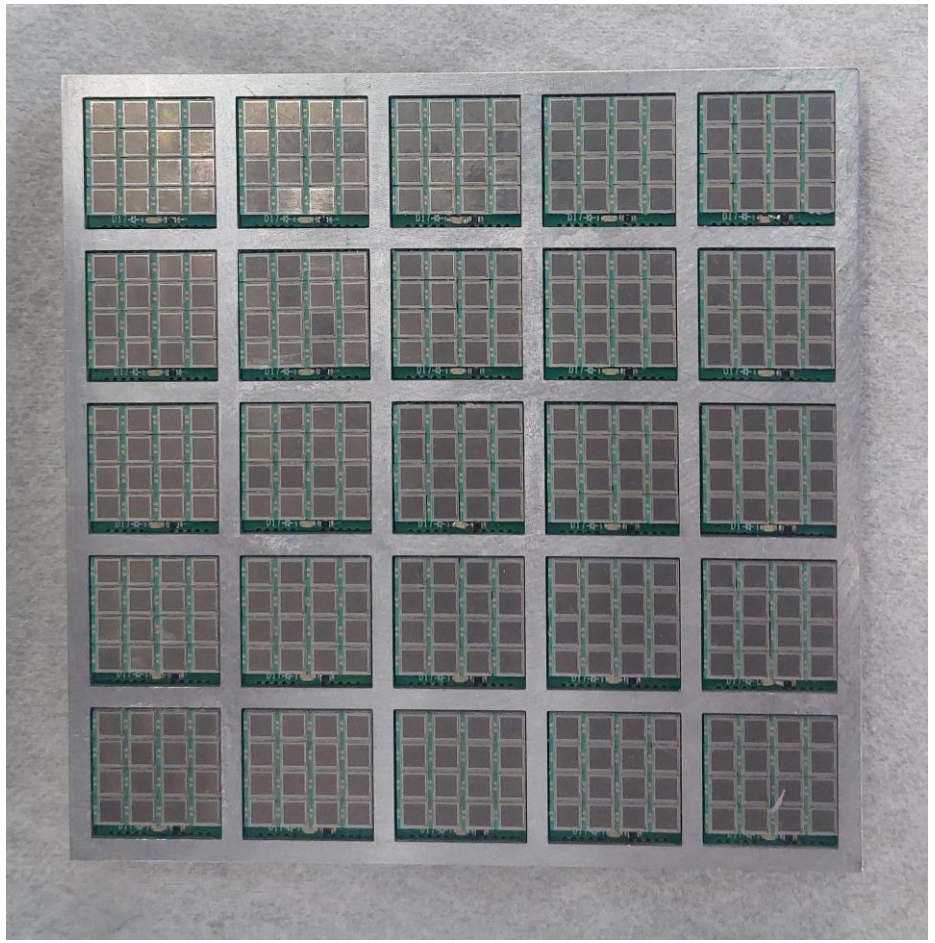
TIC Meeting
Feb 9 2026

5x5 PWO prototype with 16 SiPMs per crystal

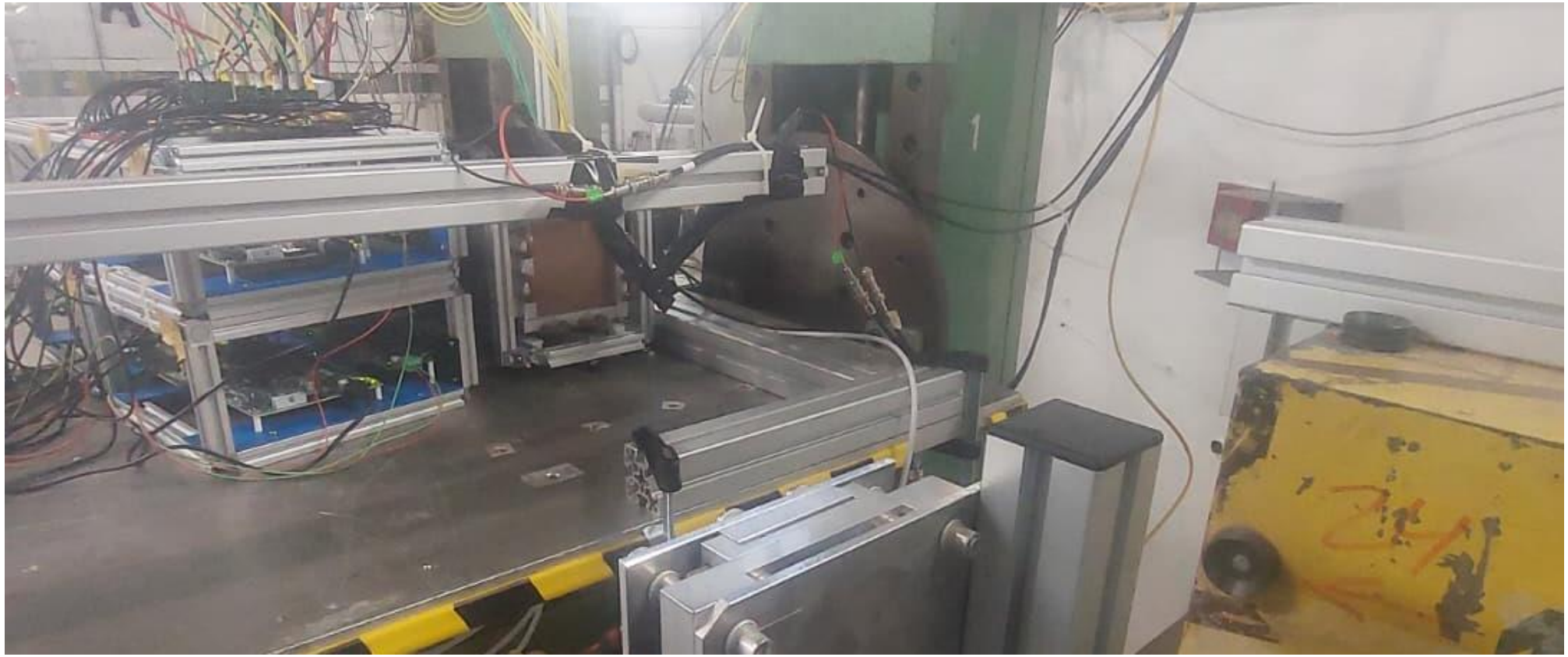
- 25 PWO crystals from CRYTUR
- SiPM readout
- Cooling and temp control



SiPMs: Hamamatsu S14160-3015PS
(3x3 mm^2; 15μm pixel size)



Setup at T24 in DESY test beam facility



- 1 – 5 GeV electron beam through a 10x10 mm^2 collimator downstream (9x9 mm^2 upstream)
- Triggered by 2 scintillators
- Rate limited to ~50 Hz by introducing a 10 ms veto period after each trigger with NIM logic
- Prototype on a X-Y table with 0.1 mm position accuracy

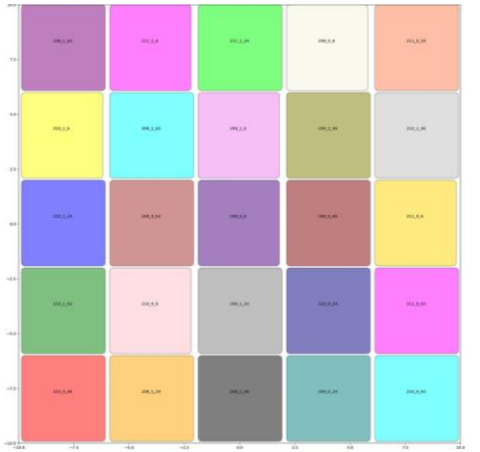
Improvements wrt to Feb'25 beamtest

- Better power supply (for SiPM gain stability)
- Improved grounding in PCBs and connectors
- More recent version of the H2GCROC chip (3B vs 3A)
- Better trigger and collimator setup

Readout options

- Each SiPM individually
- 400 channels
- 530 pF per channel

Readout with H2GCROC3b chip

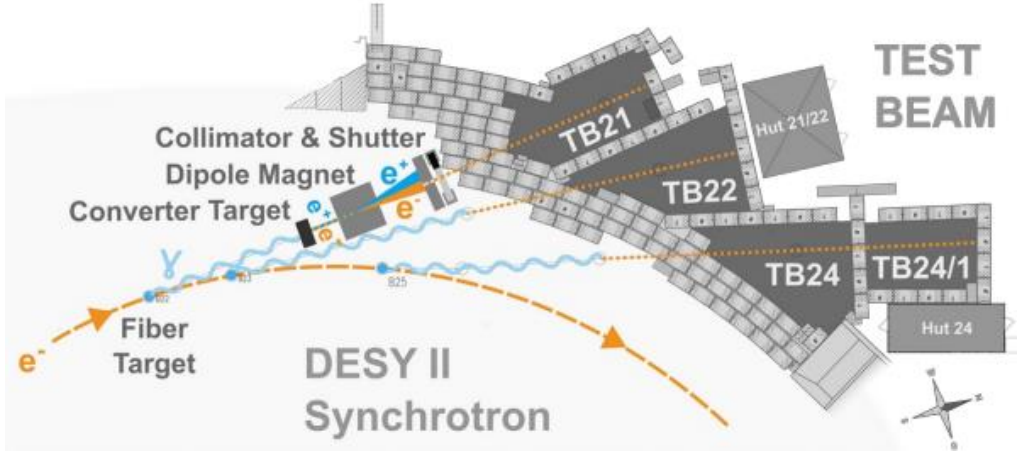


- All 16 SiPM in a crystal read in parallel
- 25 channels
- 8480 pF per channel

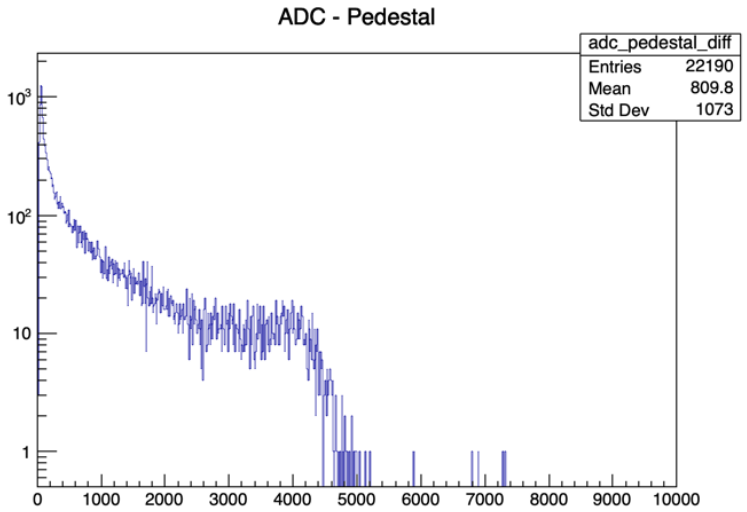
+ preamp board &
CAEN V1725S 14-bit 250MS/s digitizers

Justin's talk later

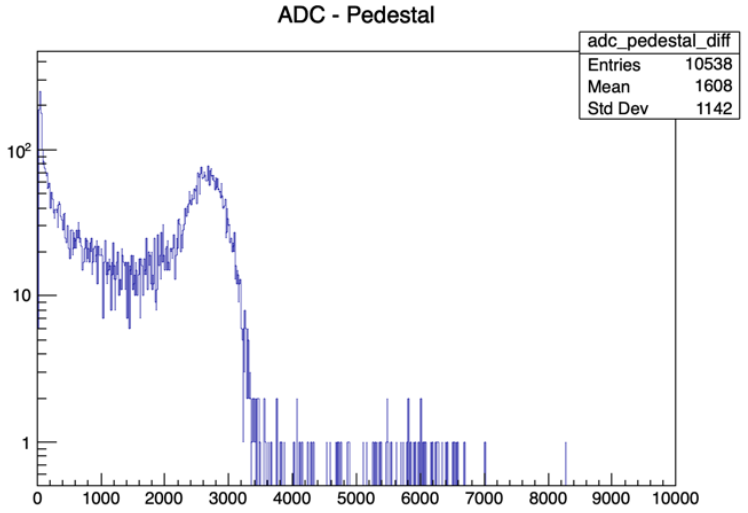
Collimators



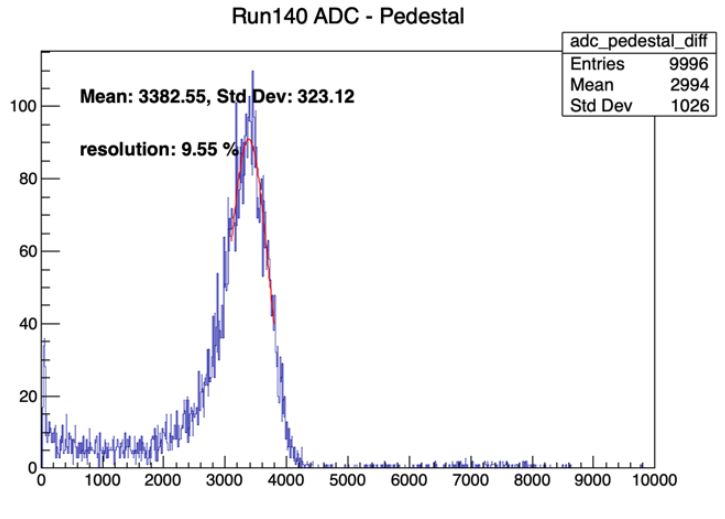
10x10 ups; 2x2 dwns



10x10 ups; 5x5 dwns



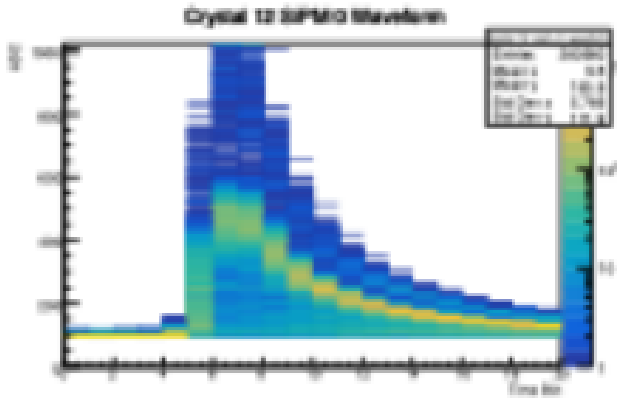
8x8 ups; 10x10 downs

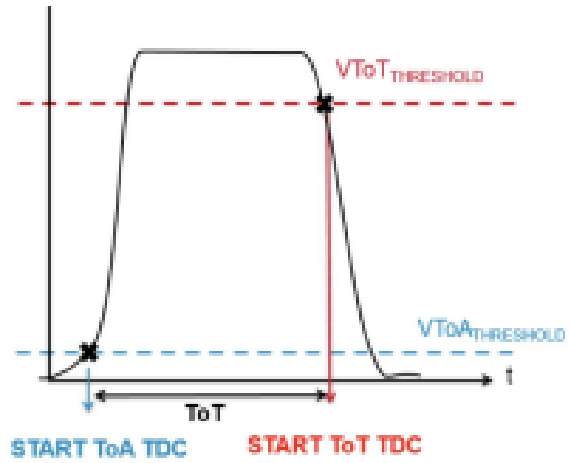


1 GeV electrons in central crystal

HGCROC readout

- Used as 40 MHz sampling readout
- 72 channels per ASIC
- ADC for high gain readout
- Time over threshold measurement for low gain readout
- 2 ASICs connected to each FPGA, data sent via UDP to DAQ PC
- Synchronization based on event counters and time stamp deltas
  - High (>95%) reconstruction efficiency!



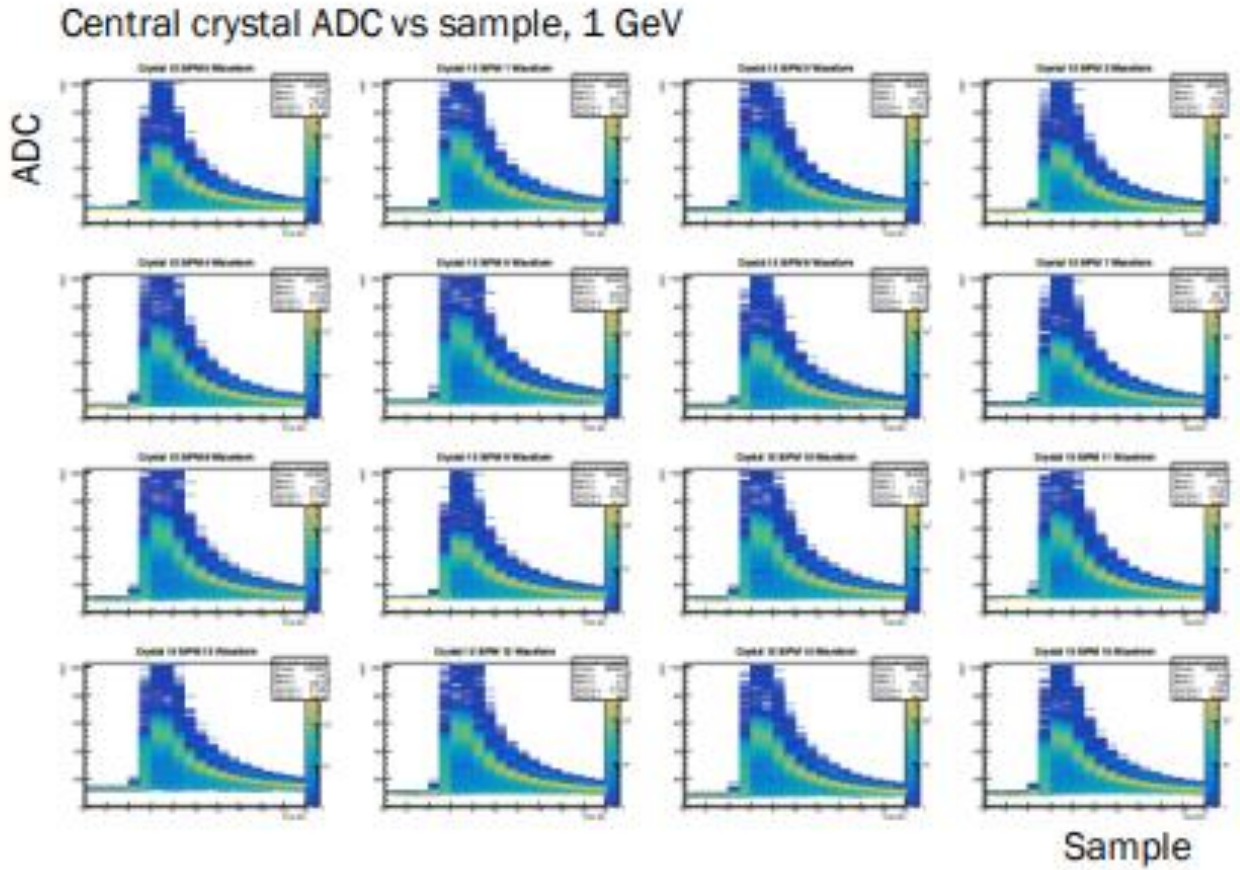


Protzman - EEEMCal HGCROC Analysis

Data analysis by T. Protzman (Lehigh U.)

Signal extraction

- 20 samples per trigger, taken 25 ns apart
- ADC signal
  - Define the per-event pedestal: $p = \frac{1}{3}(s_0 + s_1 + s_2)$
  - Let i be the index of the largest ADC value
  - The signal E is then $E = s_{i-1} + s_i + s_{i+1} + s_{i+2} - 4p$
- Several other methods are under investigation

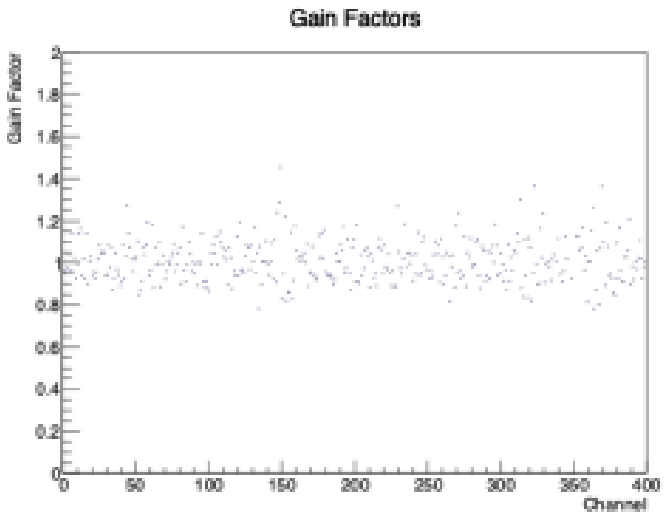


Data analysis by T. Protzman (Lehigh U.)

ADC calibration

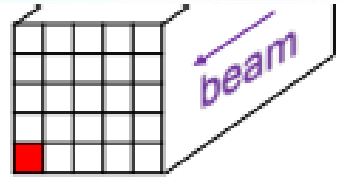
Gain Matching, SiPMs

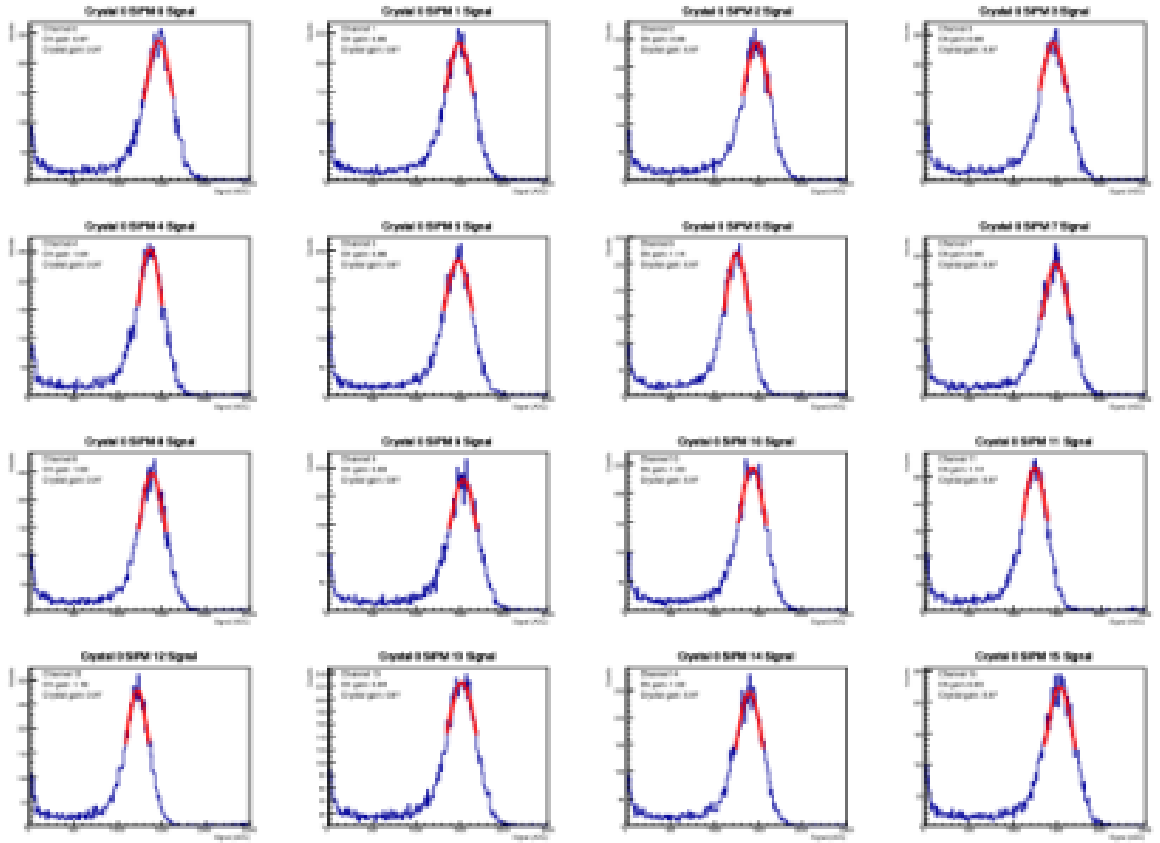
- Locate the signal peak for each of the 16 SiPMs on a crystal
- Calculate then mean signal peak per crystal, and define a gain factor such that all SiPMs peak there
- Most values between 0.85 and 1.15



- At 1 GeV all channels are in the ADC region
- After relative gain (offline) adjustments, we can calibrate the total ADC signal to 1 GeV

1 GeV electrons, centered on crystal 0

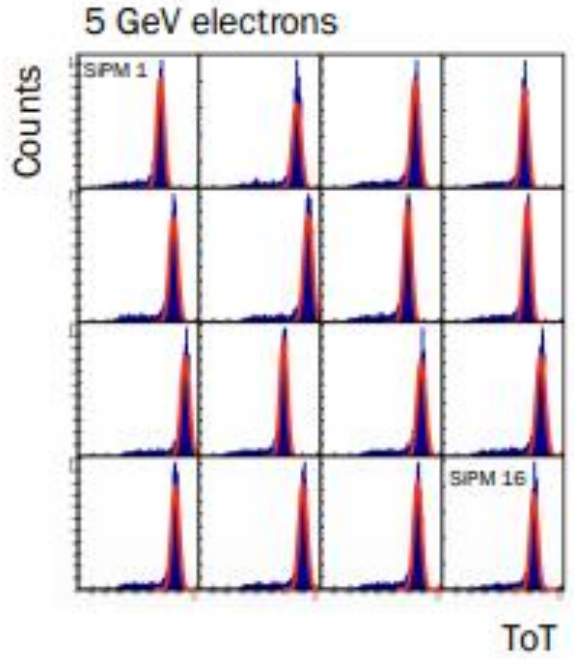


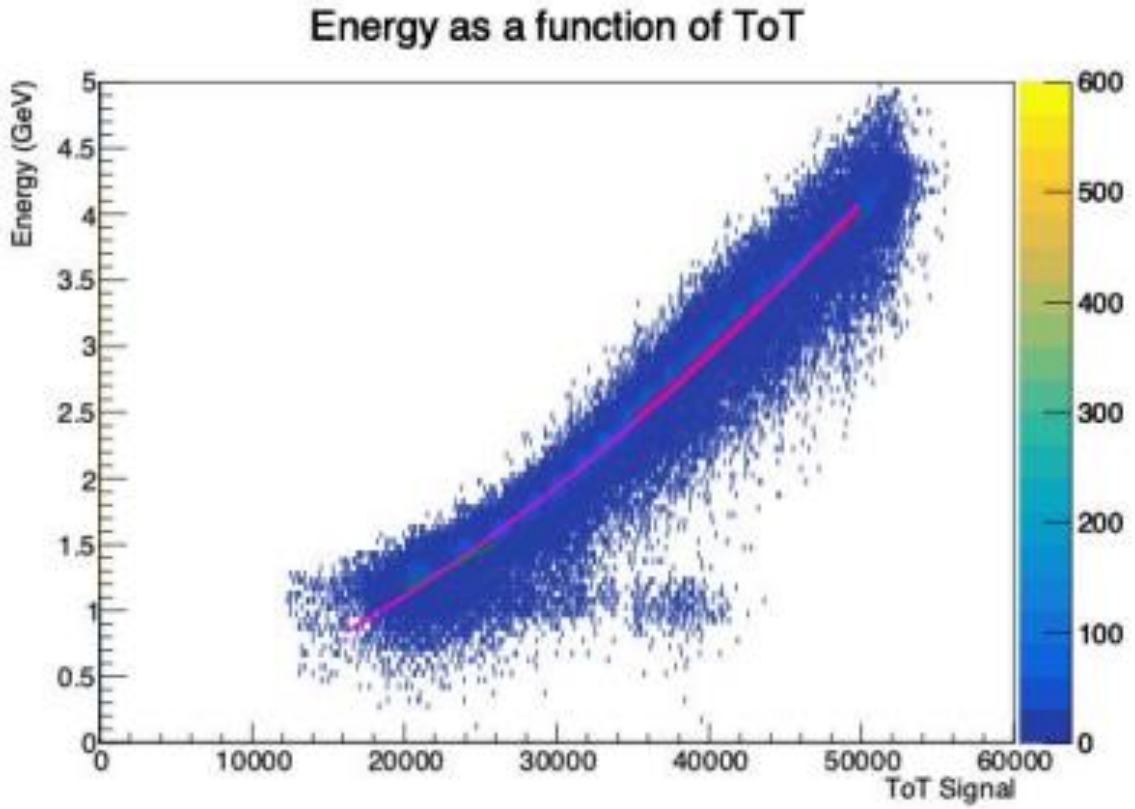


Data analysis by T. Protzman (Lehigh U.)

ToT calibration

- To clean up the signal, the peak is fit and only ToT within $\pm 1.5\sigma$ are kept
- Fit with a 2nd order polynomial seems reasonable

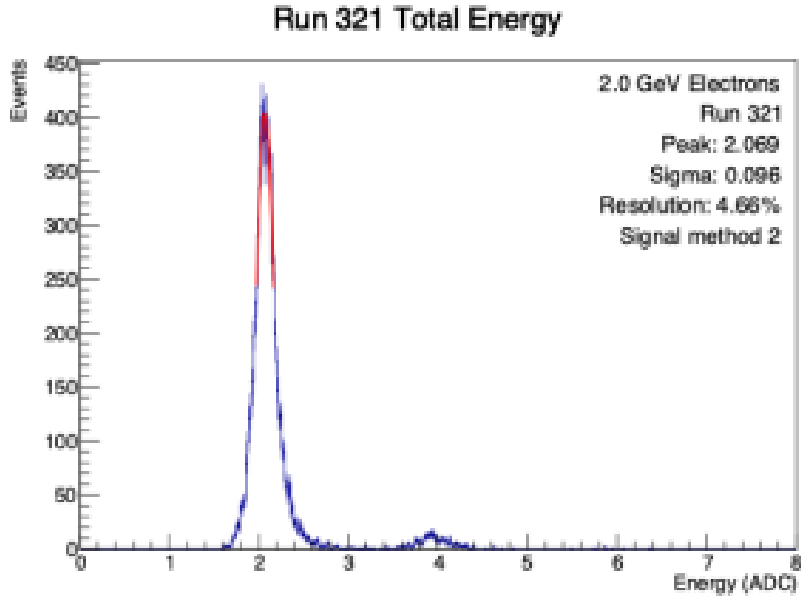


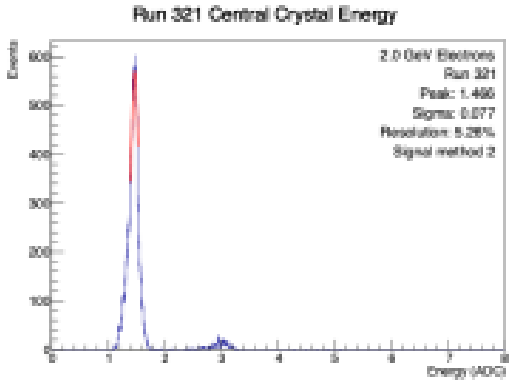


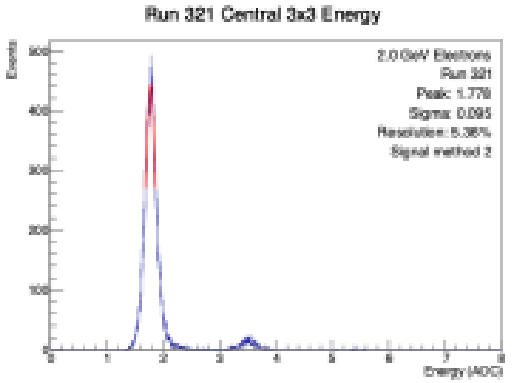
Data analysis by T. Protzman (Lehigh U.)

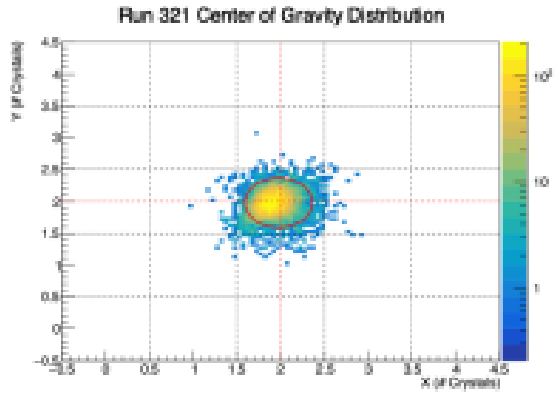
Energy resolution

- Using all 25 crystals, the total energy measured by the calorimeter can be summed
  - Pile-up peak visible at 2x energy!
- Cuts on the CoG of the cluster
- σ/E extracted from the width over the mean
- Repeated for all energies and different crystal combinations
  - Center only, 3x3, 5x5





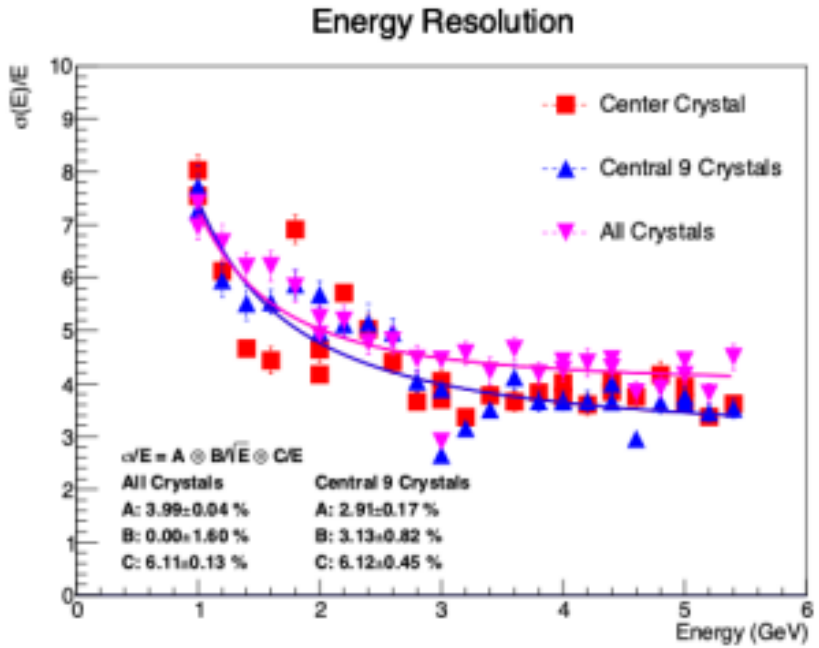




2σ cut around center

Data analysis by T. Protzman (Lehigh U.)

Energy resolution



- A: Constant term
- B: Stochastic term
- C: Noise term
- Still plenty of work to go integrating all 25 crystals
- Hard to constrain fit well over such a small energy range

- Adding all crystals slightly worsen resolution (wrt central 9)
  → Still noise present
- Resolution still far from the target goal in both the ADC and TOT region

Outlook:

- ➢ Study noise in pedestals (correlated or uncorrelated noise)
- ➢ Effect of cross talk
- ➢ Further LED studies on the bench

Data analysis by T. Protzman (Lehigh U.)