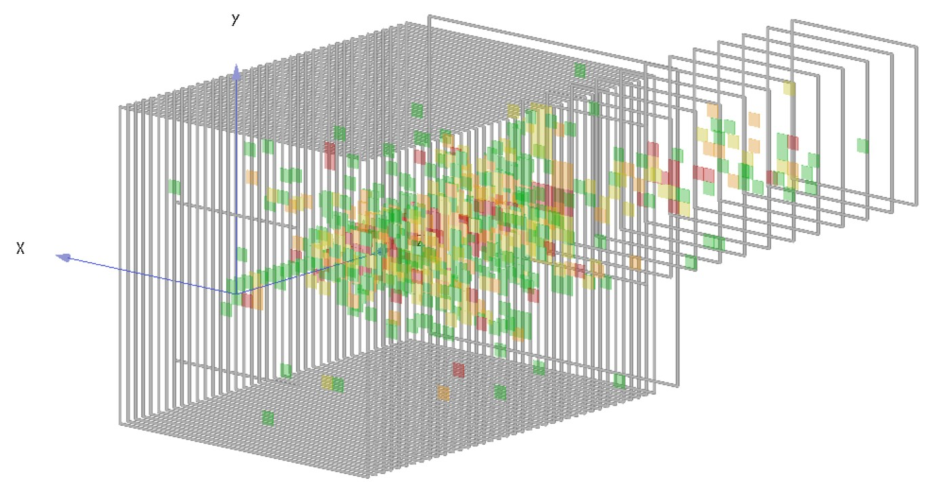
Report from AHCAL Analysis Workshop

- AHCAL testbeam prototype
- Testbeams at SPS in 2018
- Analysis Workshop



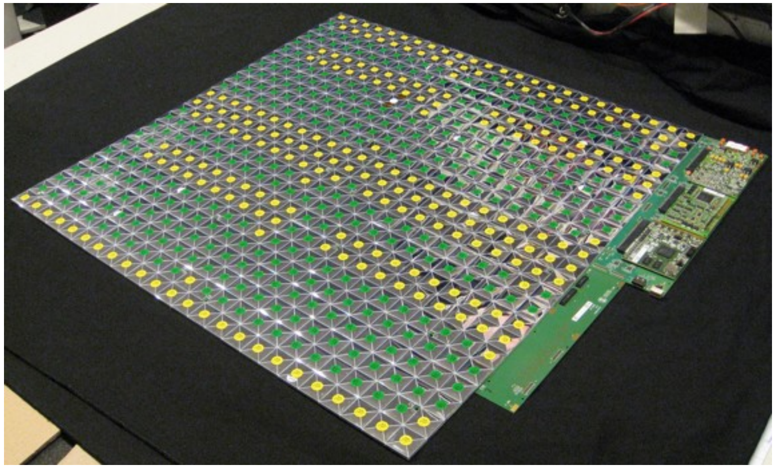
Katja Krüger

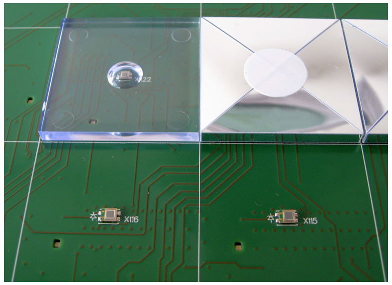
ILC project meeting
7. September 2018

HELMHOLTZ ASSOCIATION
CALICE
AIDA 2020
DESY.

New AHCAL Testbeam Prototype

- technological prototype with integrated readout electronics
- 38 active layers of 72*72 cm²
- 4 HBUs per module
  - 16 ASICs, 576 channels
  - in total: 608 ASICs, ~22000 channels
- all modules with surface-mount MPPCs
  - 2668 pixels
  - operated at 5V overvoltage
- very homogeneous detector
- built and tested during 2016 and 2017





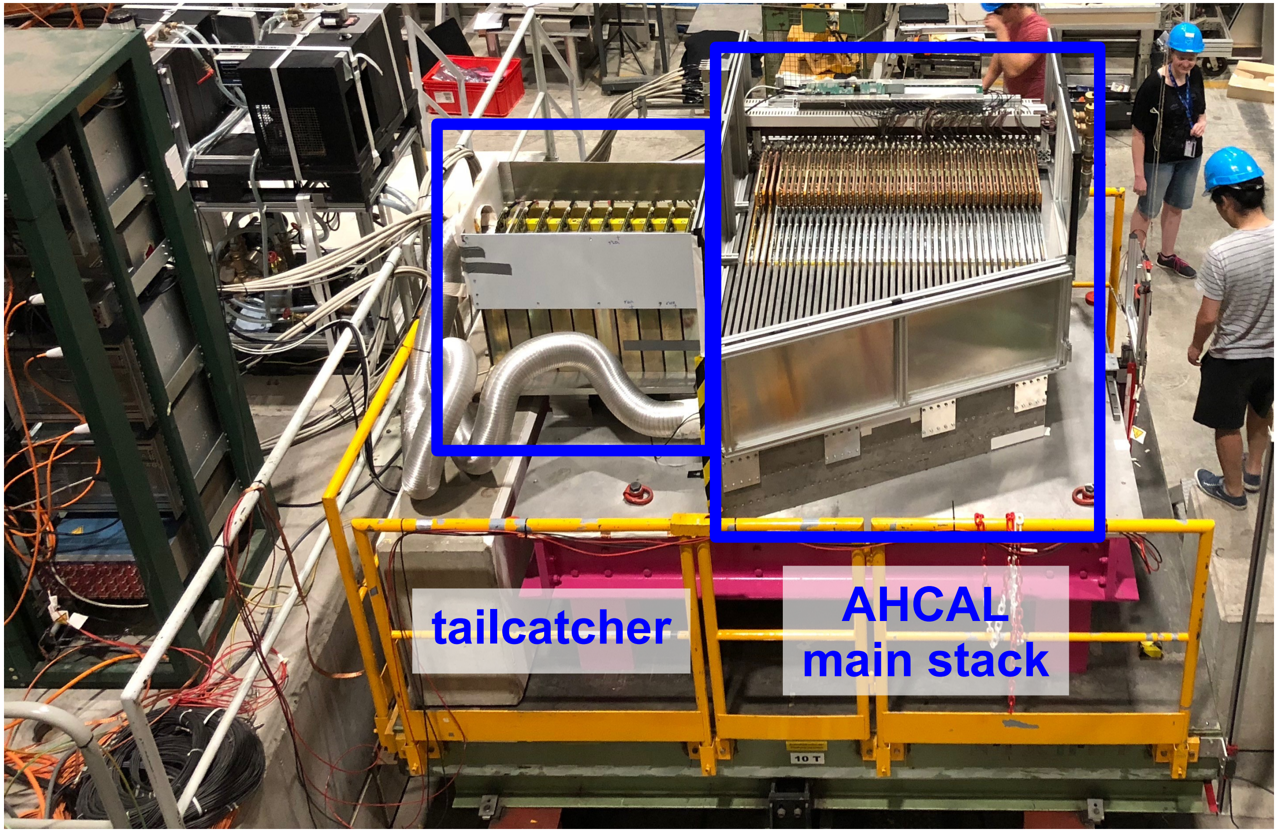
Goals of SPS testbeam

- technical
  - demonstrate capabilities of SiPM-on-tile calorimeter concept with scalable detector design
  - reliable operation of large prototype
- scientific
  - energy linearity and resolution for electrons and pions up to ~100 GeV
  - hit time correlations
  - shower profiles
  - shower separation
- data sets
  - wide muon beam for (cross check) of MIP calibration
  - energy scan electrons & pions
  - data at shifted beam positions

Testbeam setup 9. – 23. May 2018 in H2 at SPS

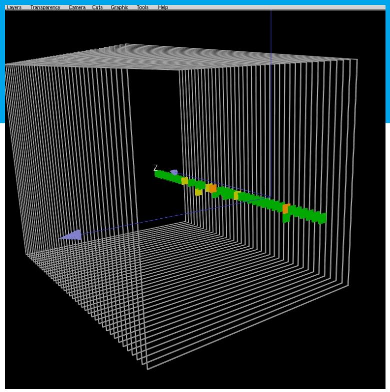
- 38 active layers of 72*72 cm² in steel absorber with 1.7 cm layer thickness (~4 λ)
- mounted on the movable platform (“scissors table”) in H2
- beam instrumentation: wire chambers, trigger scintillators, Cherenkov detector

Testbeam setup 27. June – 4. July 2018 in H2 at SPS

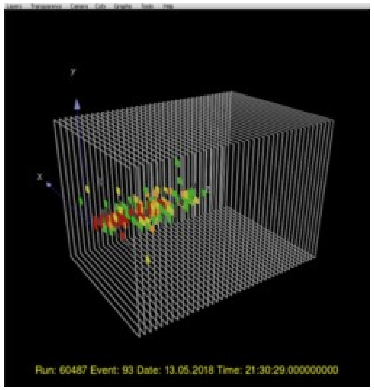


- as in May, plus:
  - added one module with 6*6 cm2 tiles
  - added CMS HGCAL “thick stack” (12 layers of 1 HBU, 7.4 cm steel absorber) as tailcatcher
  - added single HBU in front of absorber as “pre-shower” detector

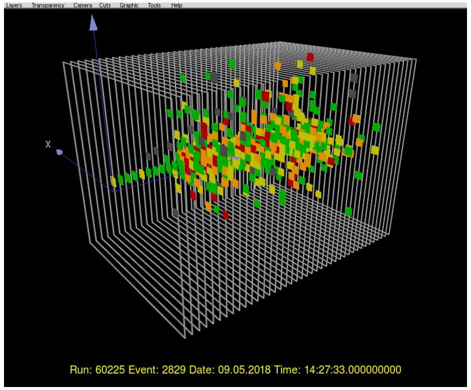
Data taking



- very stable running
- all 38 layers working well, **<1‰ dead channels**
- **muons** for calibration
  - several position scans
- **electrons**: energy scan
  - energies: 10, 20, 30, 40, 50, 60, 80, 100 GeV
    - with and without power pulsing
    - typically 200,000 to 400,000 ev. per energy



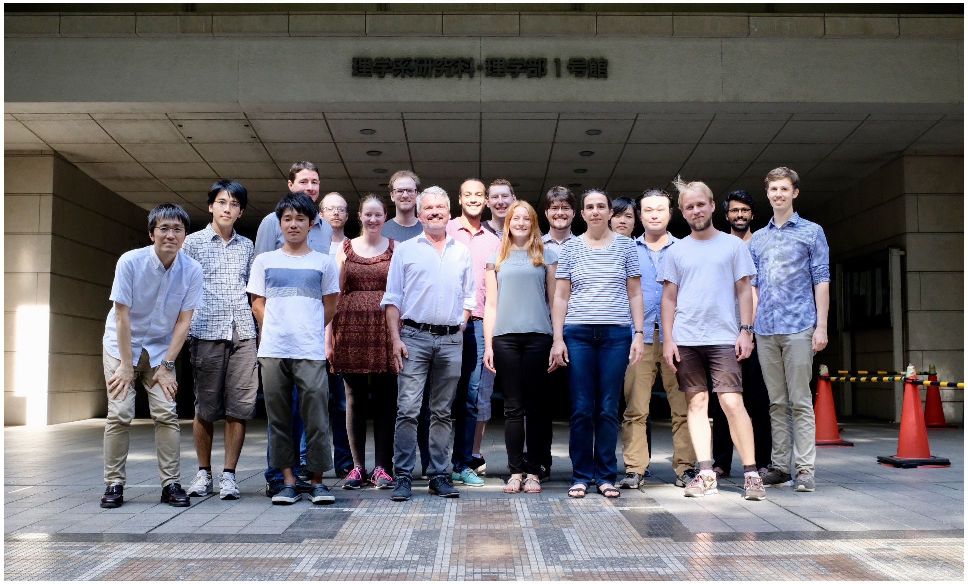
- negative **pions**: energy scan
  - energies: 10, 15, 20, 30, 40, 50, 60, 80, 100, 120, 160, 200 GeV (+ test at 350)
    - with and without power pulsing
    - typically 400,000 to 600,000 ev. per energy
  - shifted positions for particle separation studies
- additional technical tests
- in total collected several 10^7 events



Analysis Workshop at University of Tokyo

- 5. - 25. August 2018
- goals:
  - harmonize analyses for new data
  - first round of data quality checks and calibrations
  - getting to know each other
- participants
  - 10 students
  - 1 post-doc
  - 3 seniors
- a hands-on working meeting!

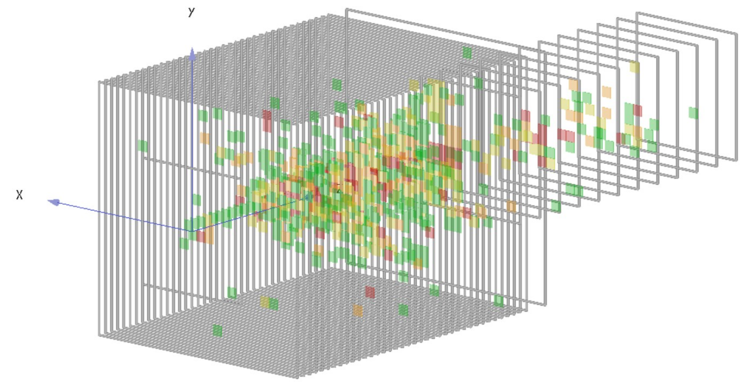
E-JADE
Europe -Japan Accelerator Development Exchange Programme



Structure of the Workshop

- first week
  - presentations of previous work, software status and strategy (3-4 talks per day)
  - lots of discussions!
  - a bit of hands-on work
- second and third week
  - a lot of hands-on work
  - 1-2 hours at the end of each day for status reports
- last 1.5 days
  - short presentations of work done and current status

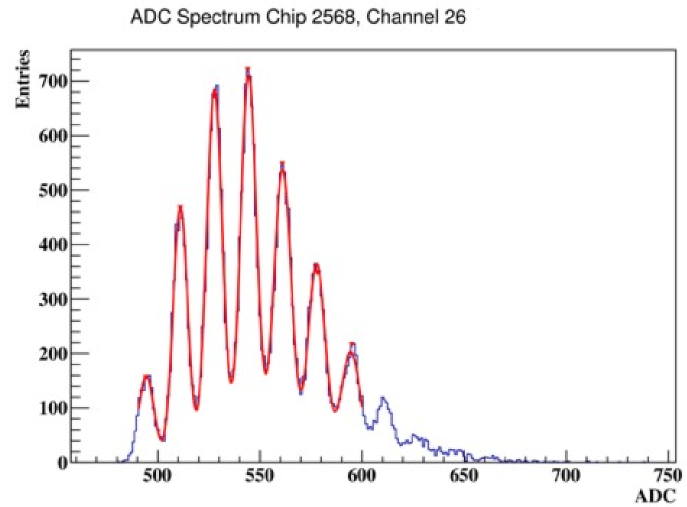
Software & simulation

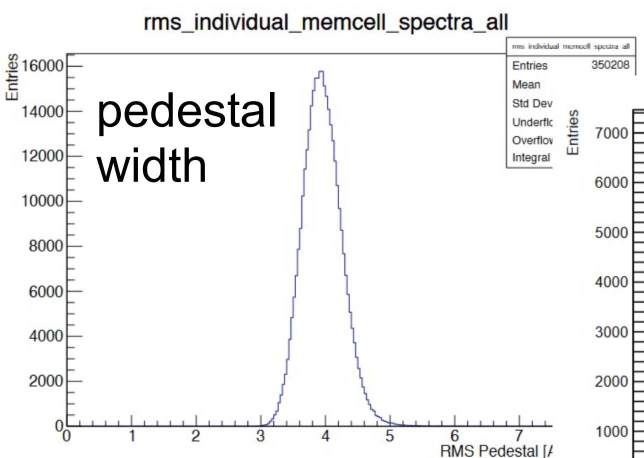


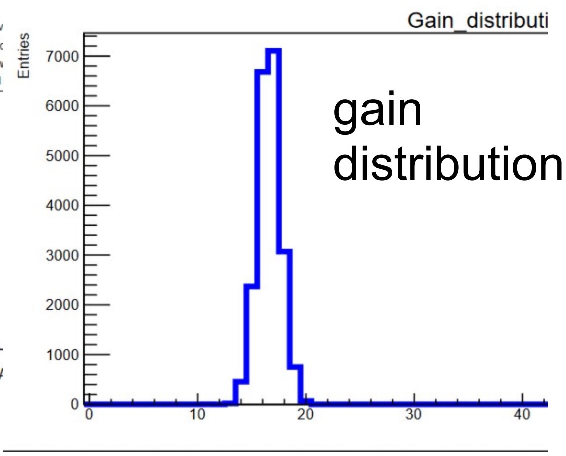
- preparation before the workshop
  - correct geometry description for May and June in database
  - first version of simulation running
  - copied code from DESY svn to stash (DESY git)
- status at the beginning
  - no clean code structure (many variables calculated in RootTreeWriter)
  - “historic” code
- many discussions on how to implement things in a clearly structured and reusable way
  - one Marlin processor for “standard” variables needed by many analyses
  - encourage to move analysis code to Marlin processors
- started to clean up and document software

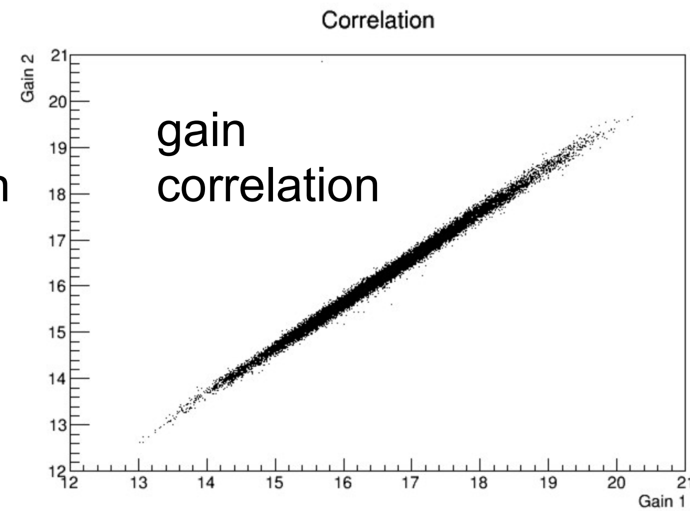
Calibration: LEDs

- LED data taken with external trigger
- pedestal can give information on dead and noisy channels
- gain from single-pixel-spectra
  - translation of signals to pixel scale, needed for SiPM saturation corrections
  - monitoring of detector stability
- **very homogenous gain, very stable operation**

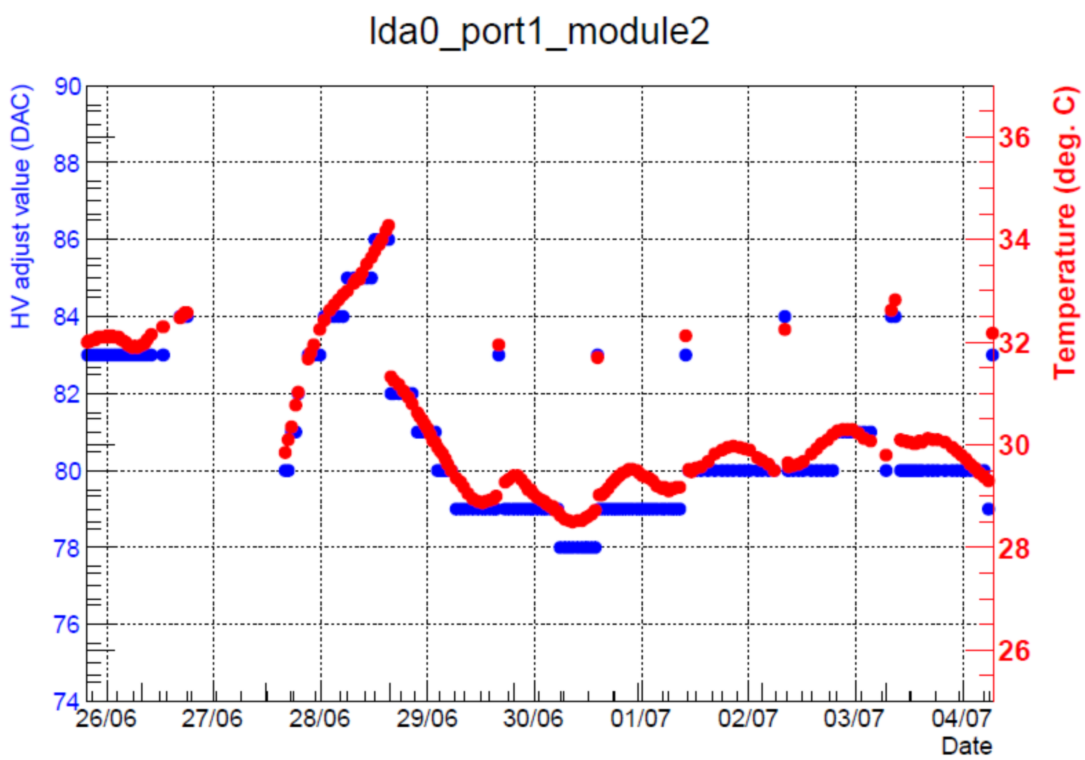






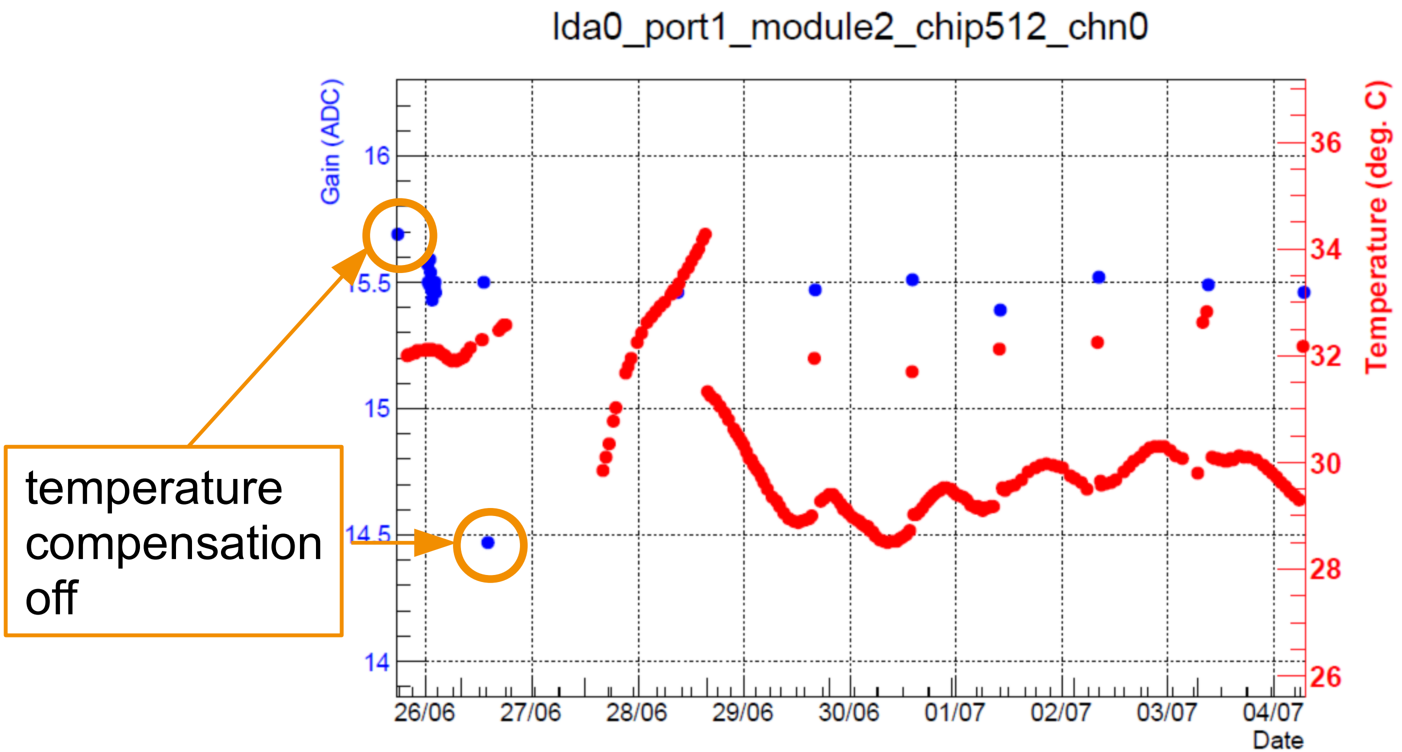


Temperature compensation



- gain and photon detection efficiency of SiPMs depend on temperature
  - can avoid changes by stabilizing temperature or adapting bias voltage (HV)
- temperature compensation: use mean temperature in a layer to adjust HV
- used routinely, HV changes as expected, gain stays stable

Temperature compensation



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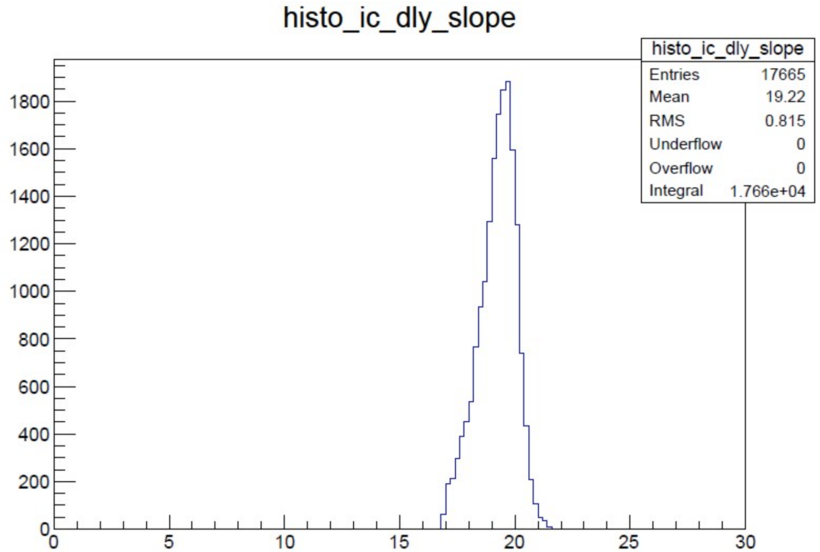
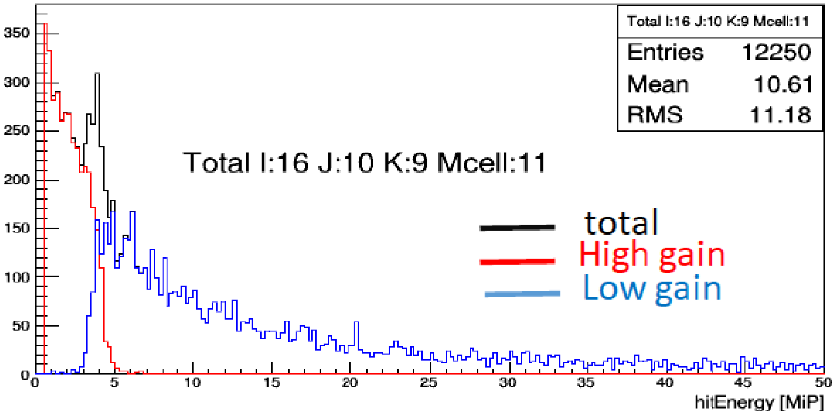
High gain / low gain intercalibration

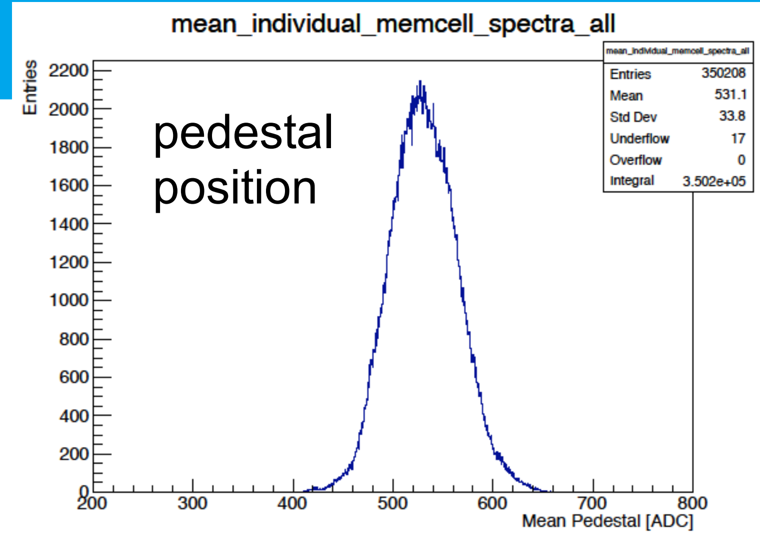
- ASIC has two preamplifiers: high gain and low gain
  - in normal runs, the ASIC choses depending on signal size (auto-gain)
  - can also do special runs where both gains are read out
- need to determine calibration constants
  - the gain ratio (intercalibration factor)
  - low gain pedestals
- extracted individual intercalibration factors from LED data for ~80% channels, application to beam data not yet satisfactory

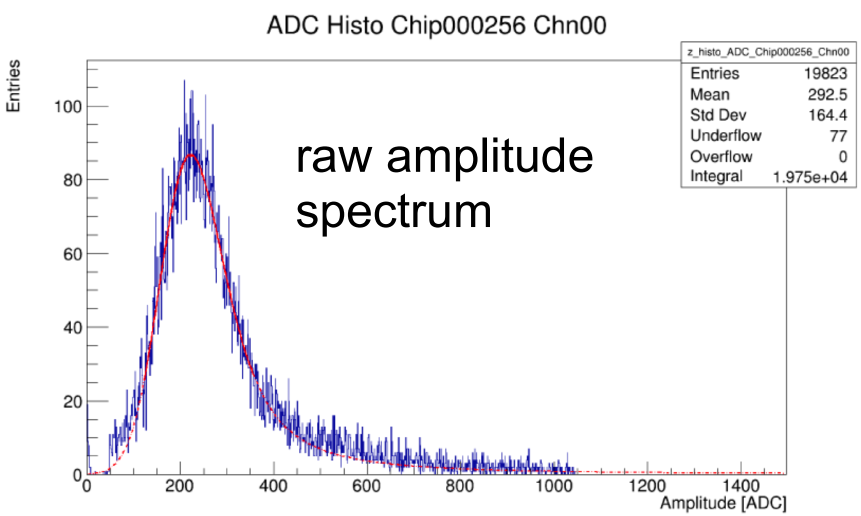


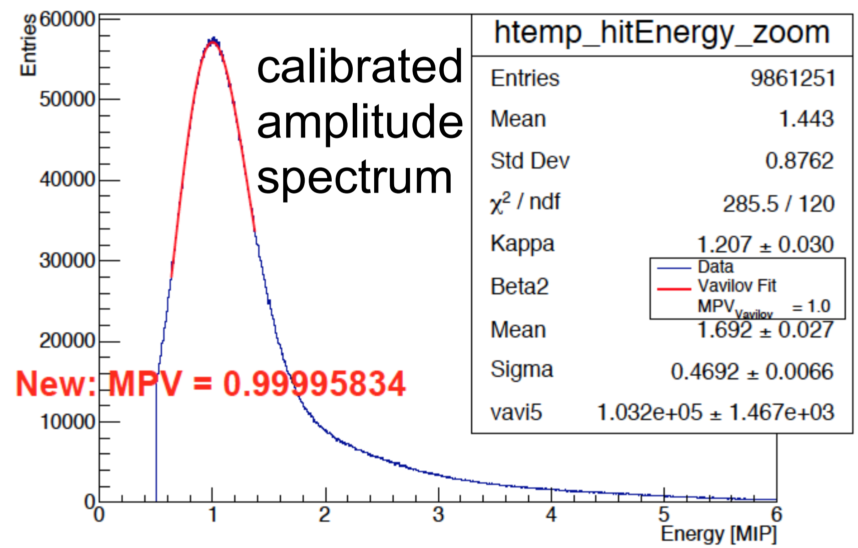


Calibration: pedestal and MIPs

- Muons: position scan of full detector
  - **pedestal** from non-triggered channels (>350 000 constants!)
  - determine **MIP scale** for all channels
- **May calibrations done, June started**

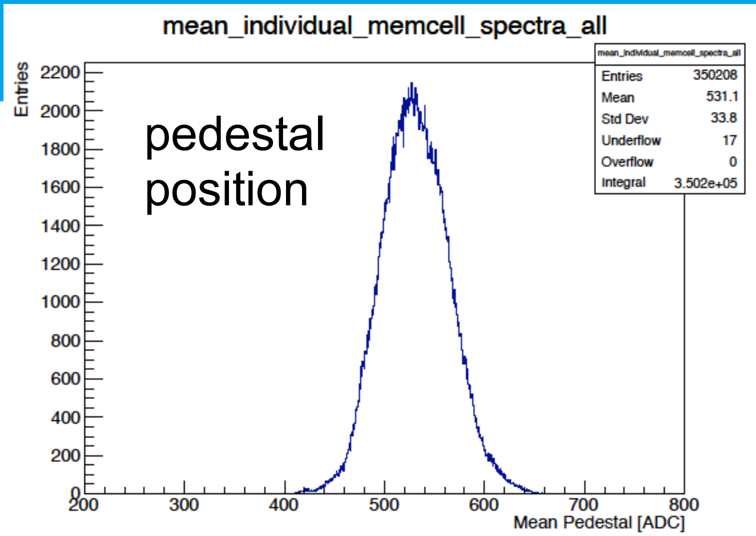


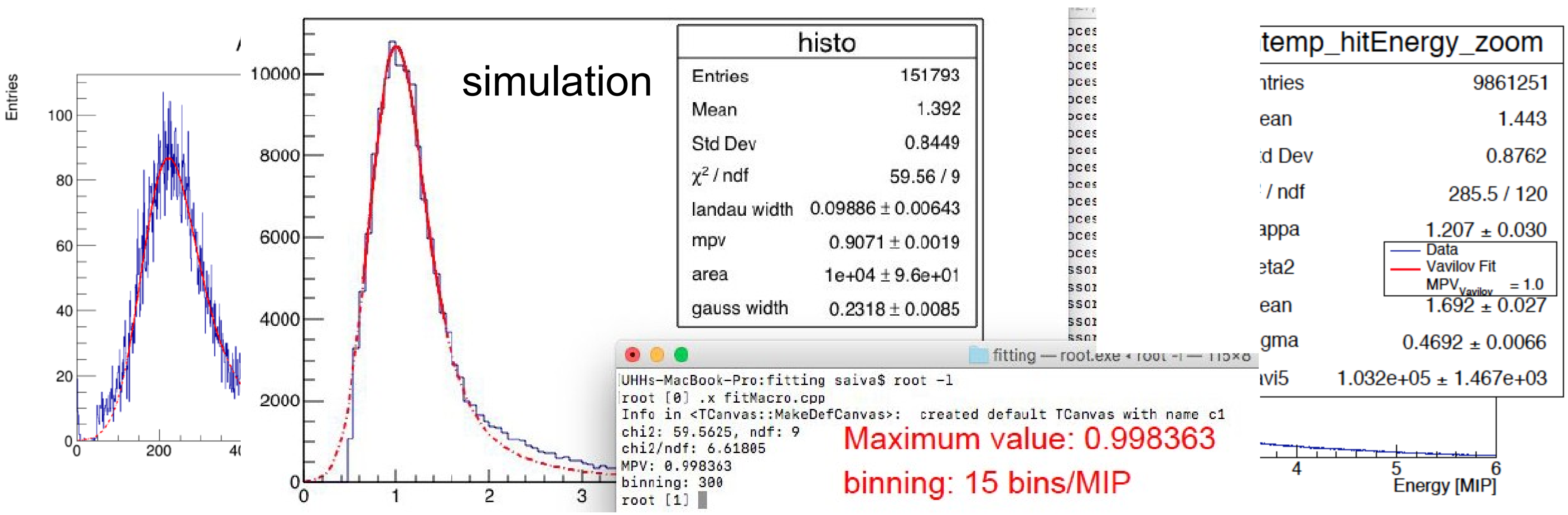




Calibration: pedestal and MIPs

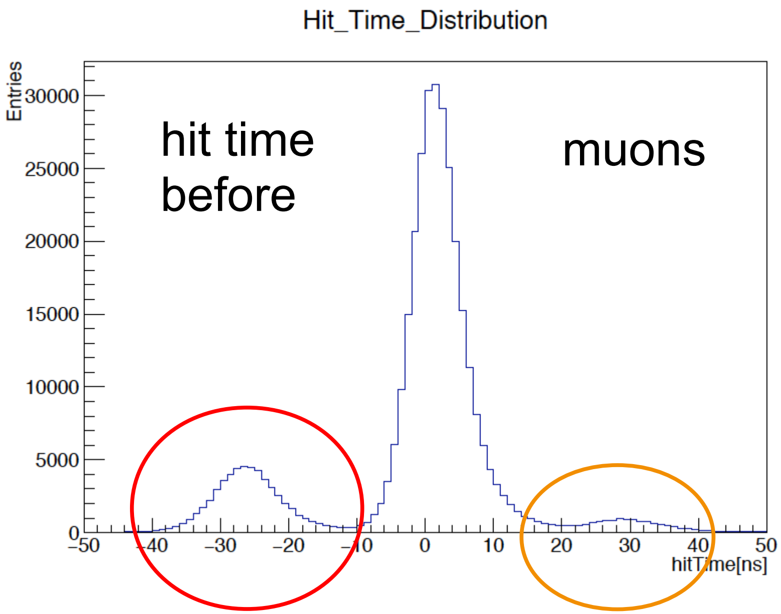
- Muons: position scan of full detector
  - **pedestal** from non-triggered channels (>350 000 constants!)
  - determine **MIP scale** for all channels
- **May calibrations done, June started**
- MIP calibration also for simulation

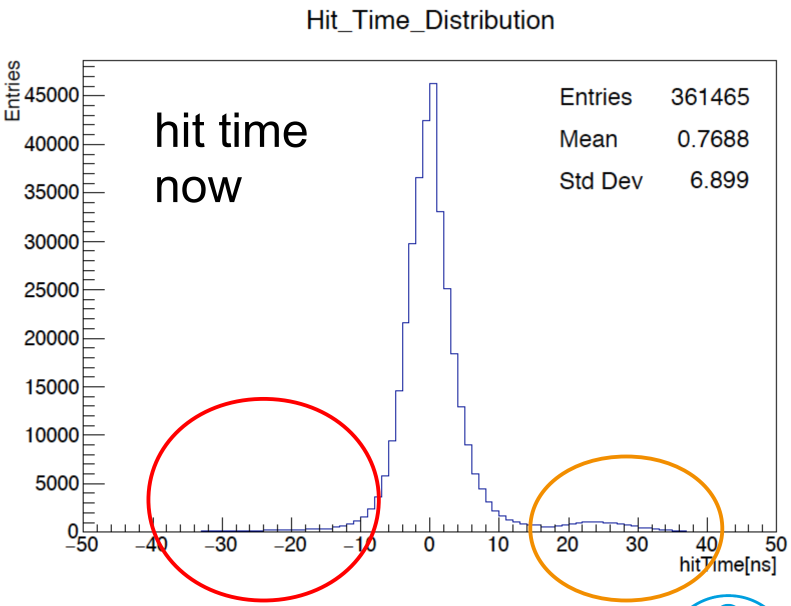




Calibration: hit time measurement

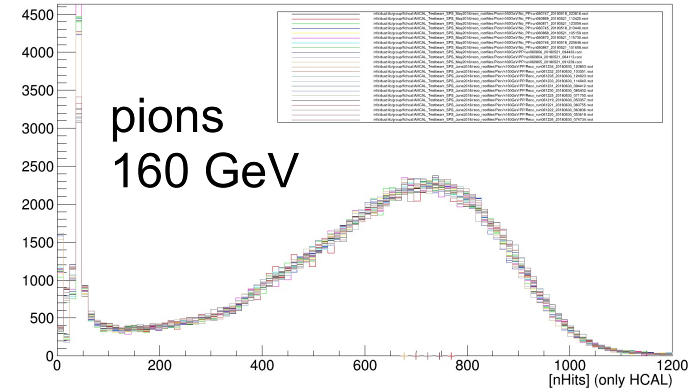
- time is measured with a TDC, so needs a similar calibration as the amplitude measurement
- starting point: initial calibration looks OK for muons, but see “satellite” peaks
  - mainly caused by (non-understood) electronics feature shifting the whole event, so can be corrected
  - remaining effect from single mis-calibrated channels
- investigating remaining effect, studying dependence on ASIC occupancy

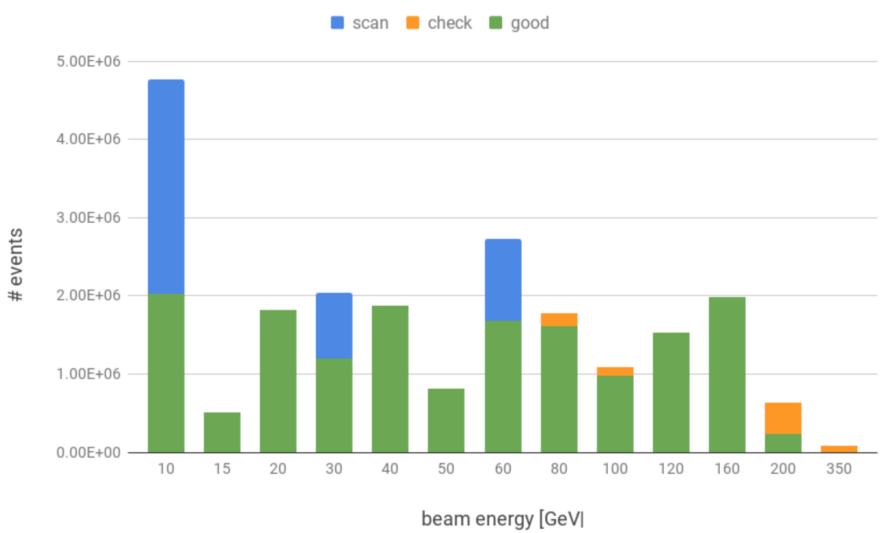


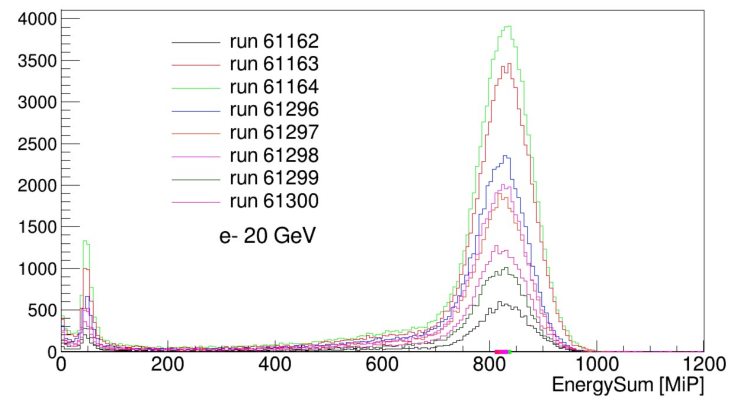


Data quality checks

- developed data quality criteria to judge run quality
  - classify into good, check, scan (other position, needs cross check), bad
- **all pion runs checked, no bad run**
- check of electron runs ongoing

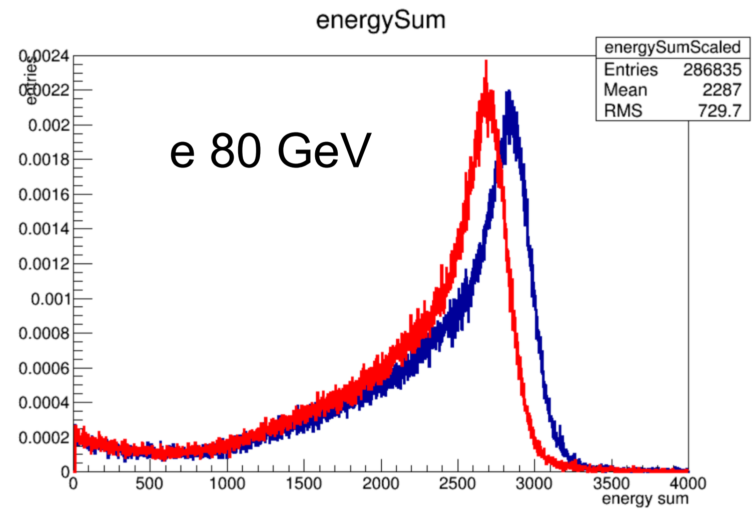


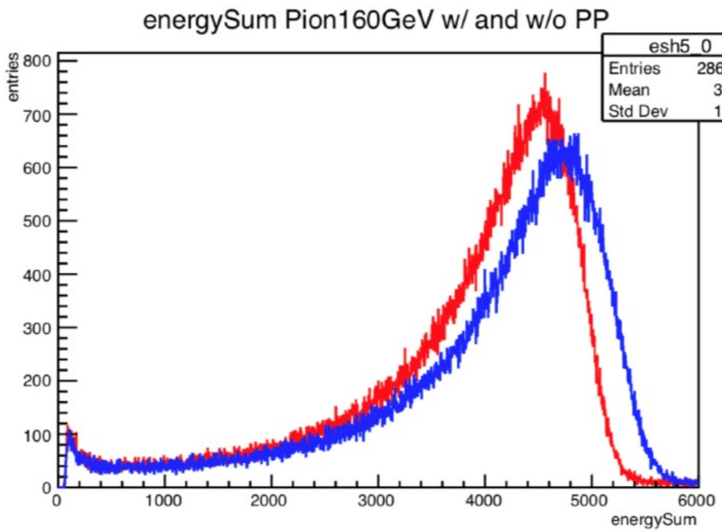


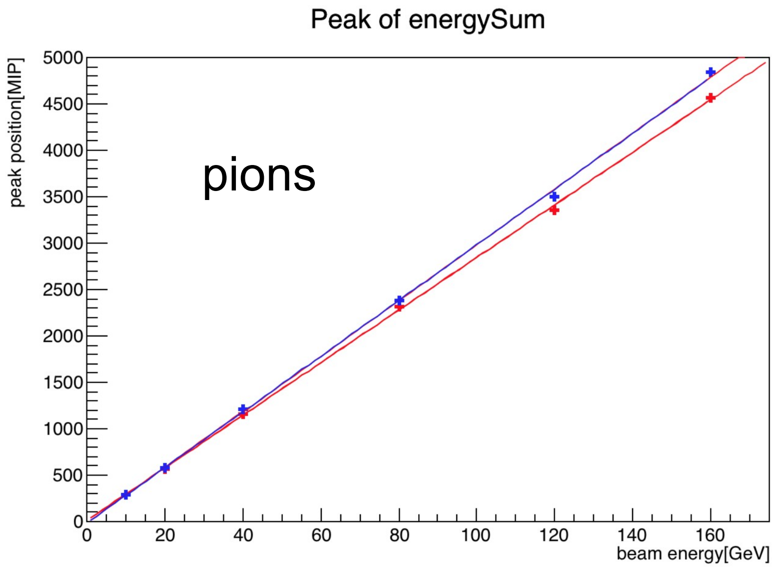


Comparison with and without power pulsing

- see a ~4% shift in energy sum (PP is lower)
  - effect in electron and pion data
  - effect everywhere in the detector
- number of hits agrees
- calibration issue? studies ongoing







Particle Identification

- adapted & tuned particle identification code from physics prototype
  - graphical representation to identify possible improvements
- implementation as Marlin processor in progress

MC 10GeV particles

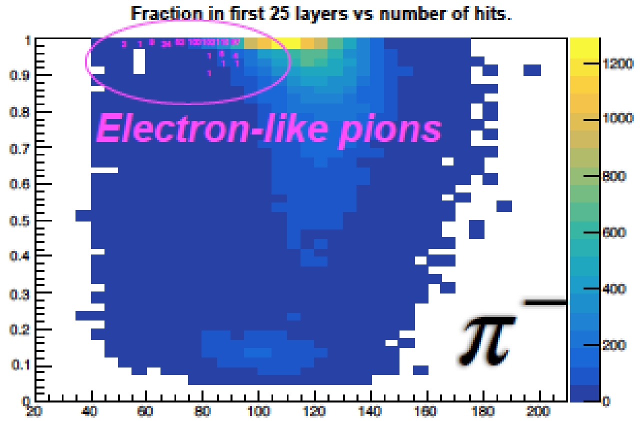
Before cuts:

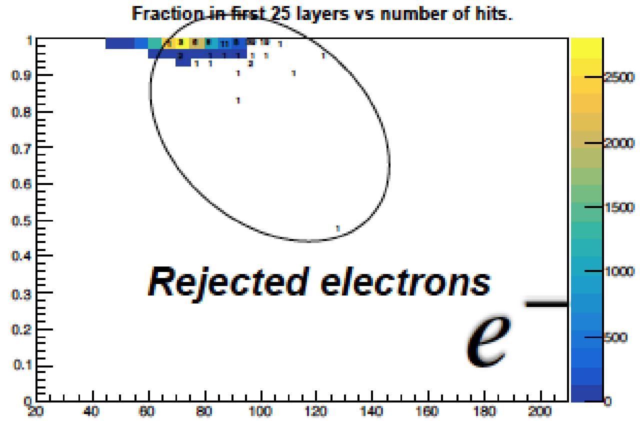
π^- : 70118 events

μ^- : 41858 events

e^- : 26419 events

$total$: 138395 events



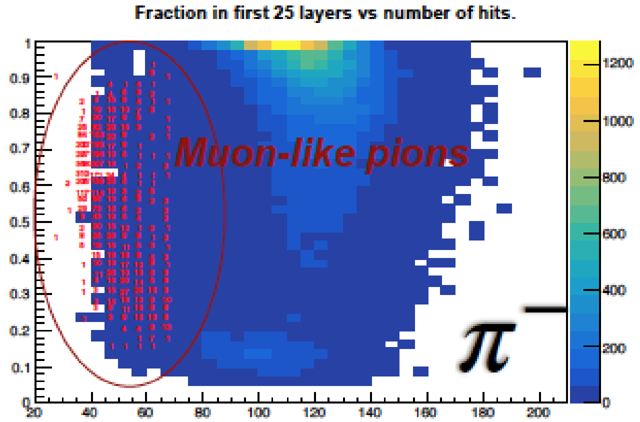


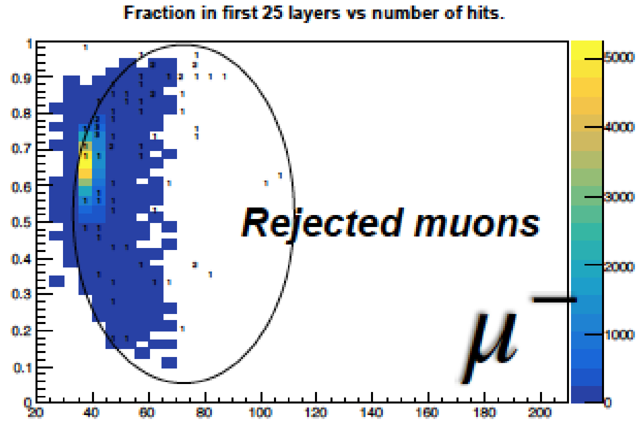
After cuts:

π^- : 64529 events (92%)

μ^- : 41783 events (99.7%)

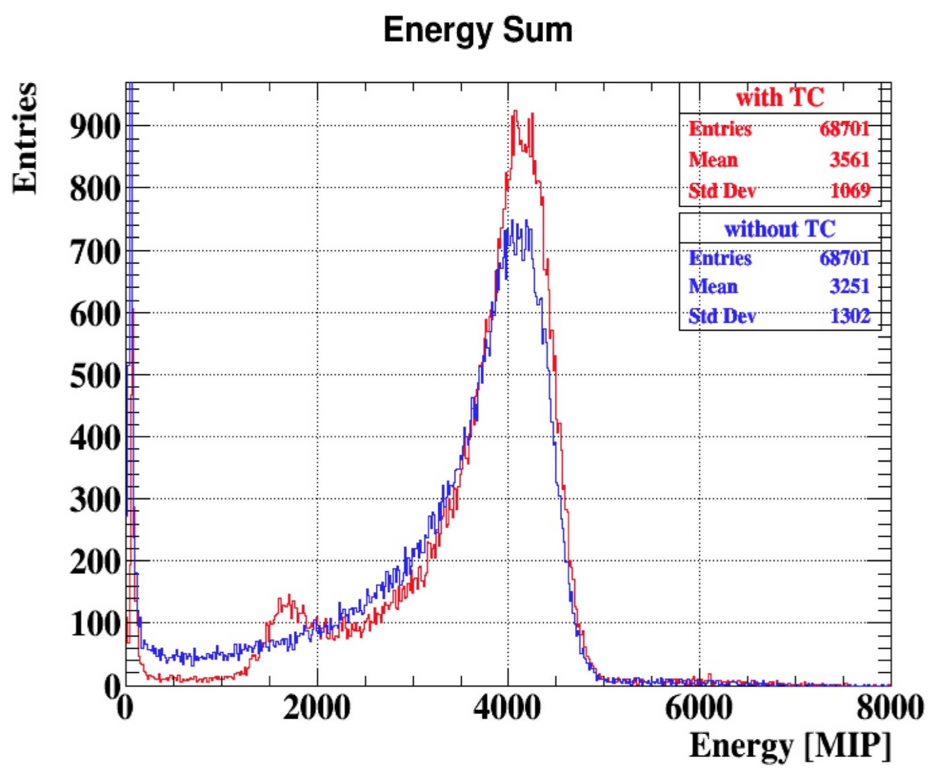
e^- : 26230 events (99.2%)





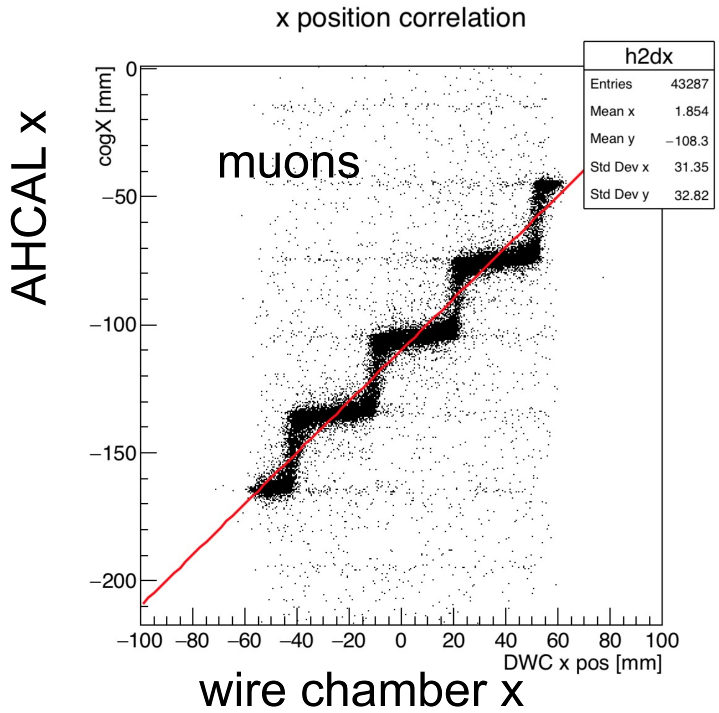
Tailcatcher (June)

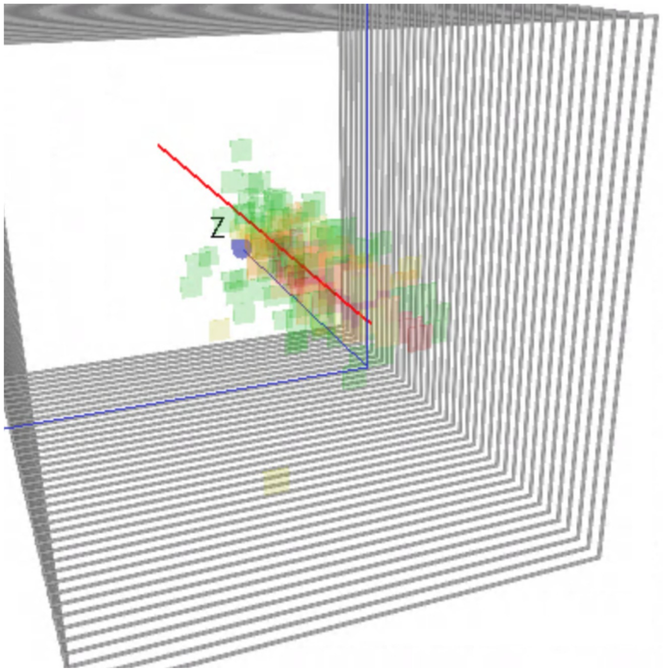
- tail catcher information only in ~80% of events (timing reasons)
  - developed clean selection
- simple summing of hit energies already improves energy sum
- next: determine optimal weights for hit energies



Wire chambers

- wire chambers can give more precise position information
- wire chambers read out separately, assignment to AHCAL events by time
  - encountered some unexpected effects, solved
- **wire chamber information now available in reconstruction and event display**
  - global alignment constants needed per detector position





Summary I


UHH
Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG
Thank you to all!
CALICE
Calorimeter for ILC
Thank you for your attention!
August 2018
Summary of the 2018 Tokyo Analysis Workshop - Saiva Huck
47

Summary II (very personal)

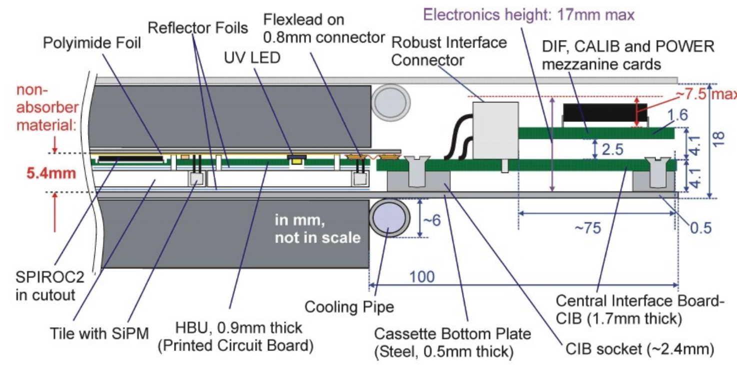
- first workshop of this kind for me, so structure was adapted ad hoc
- I learned a lot from the presentations
- I was VERY impressed with the amount of work that can get done in 3 weeks
  - when all experts are immediately available
  - with a good team spirit

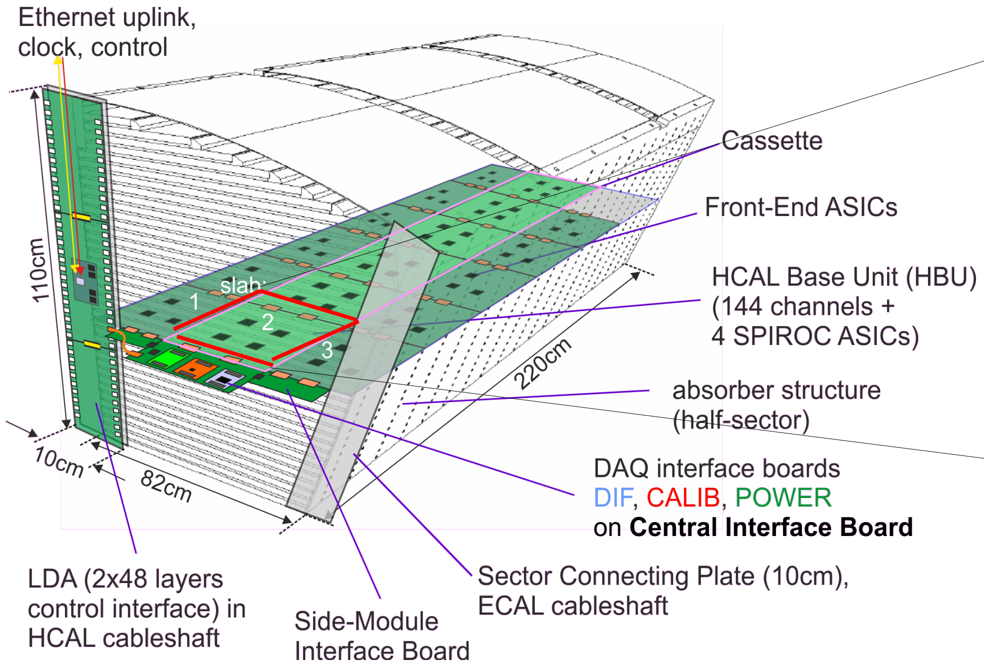
... and thanks for all the fish!

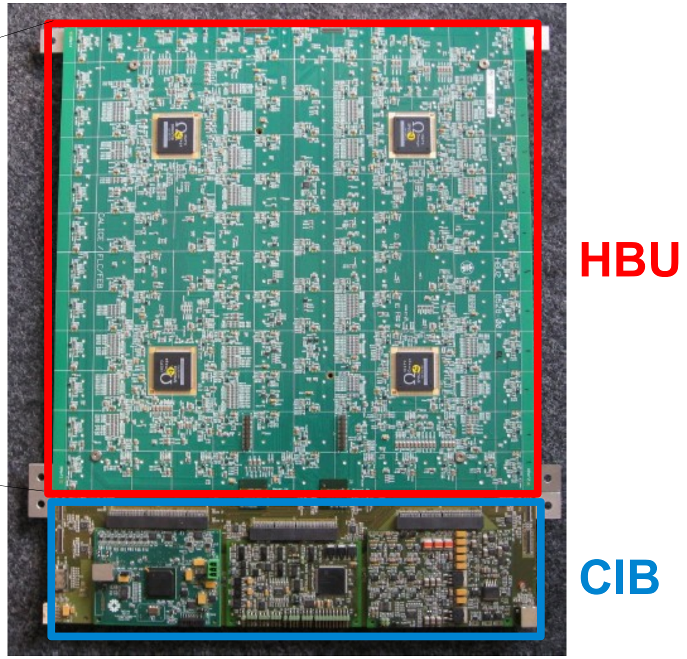
Backup

AHCAL technological prototype: Integrated Electronics

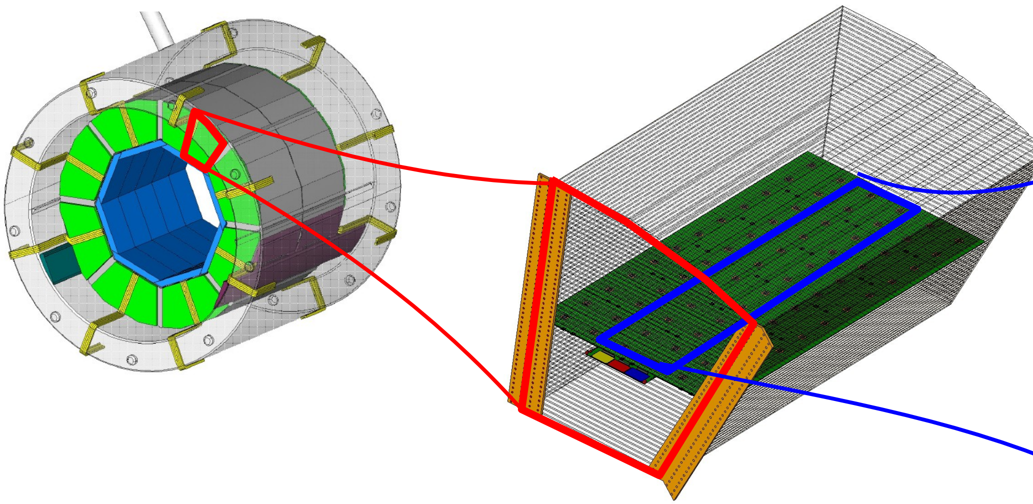
- **H**CAL **B**ase **U**nit: 36*36 cm^2, 144 tiles, 4 SPIROC2 readout ASICs
- **C**entral **I**nterface **B**oard: DIF, Calibration, Power for 1 layer
- 5.4 mm active layer thickness
- 1 layer has up to 3*6 HBUs

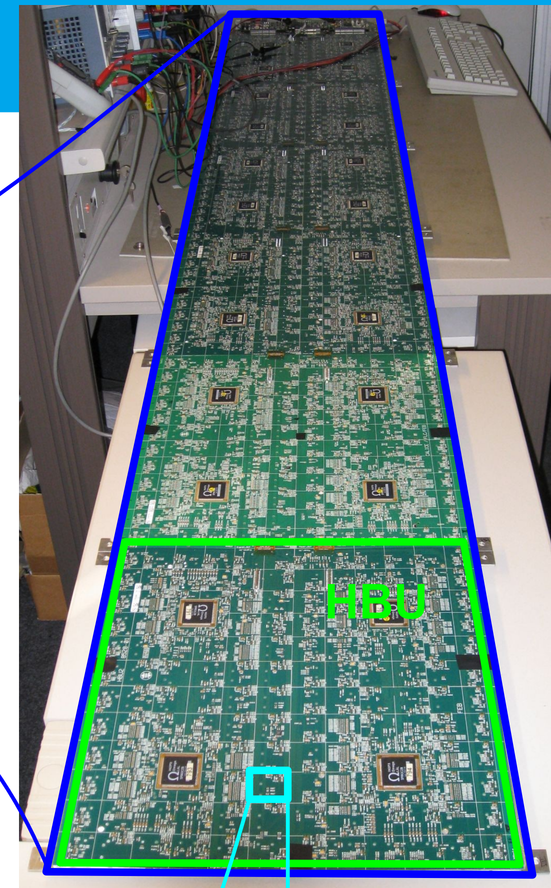




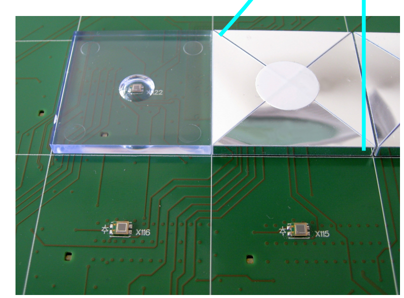


AHCAL technological prototype



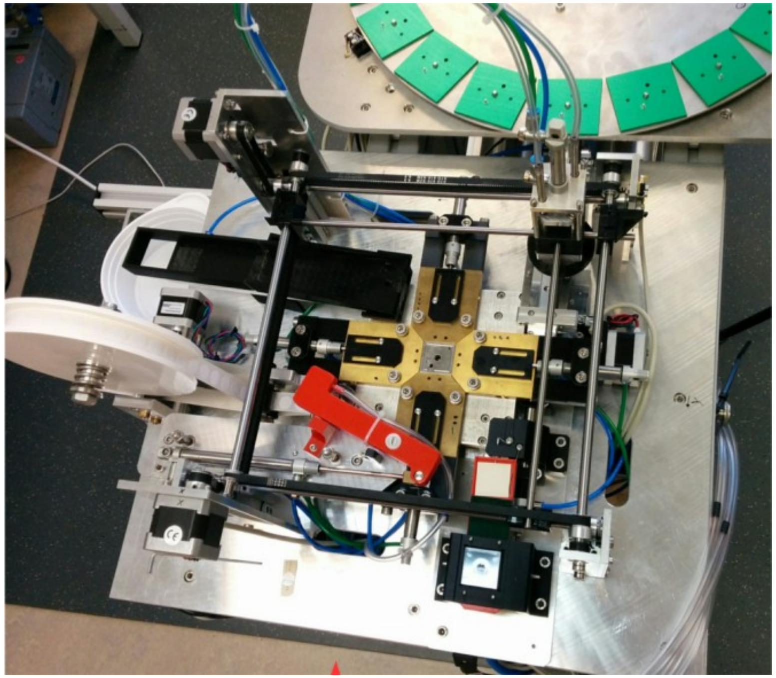


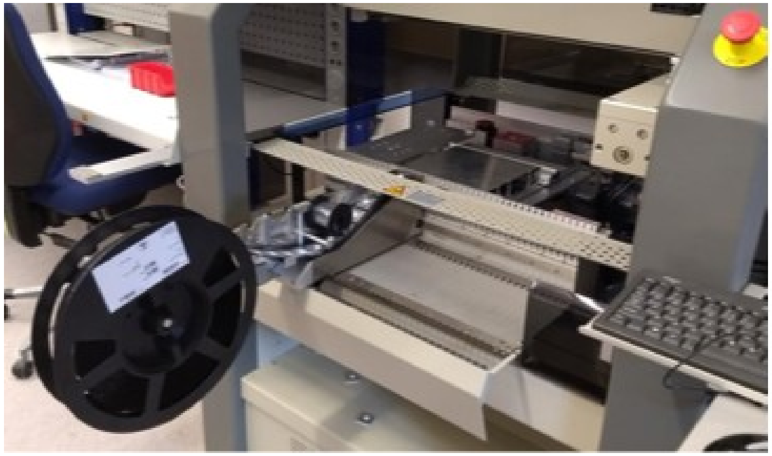
- highly granular scintillator SiPM-on-tile hadron calorimeter, 3*3 cm² scintillator tiles
- fully integrated design
  - front-end electronics, readout
  - voltage supply, LED system for calibration
  - no cooling within active layers
- scalable to full detector (~8 million channels)
- **H**CAL **B**ase **U**nit: 36*36 cm^2, 144 tiles, 4 ASICs
  - slabs of 6 HBUs
  - up to 3 slabs per layer



Mass production

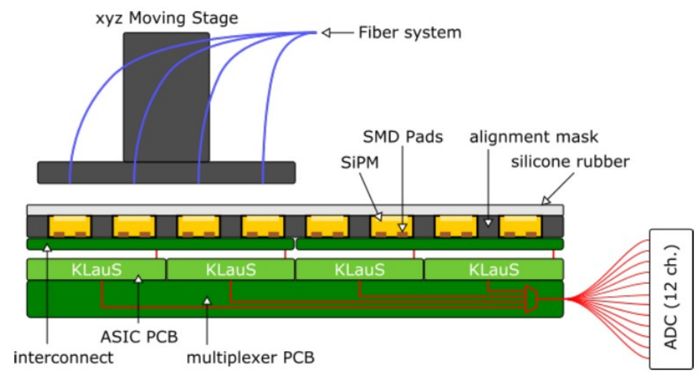
- design optimized for mass production
  - SMD SiPMs soldered automatically
  - injection-moulded polystyrene tiles, no further surface treatment
  - automatic wrapping in ESR reflector foil
  - glueing of tiles with screen printer and pick-and-place machine



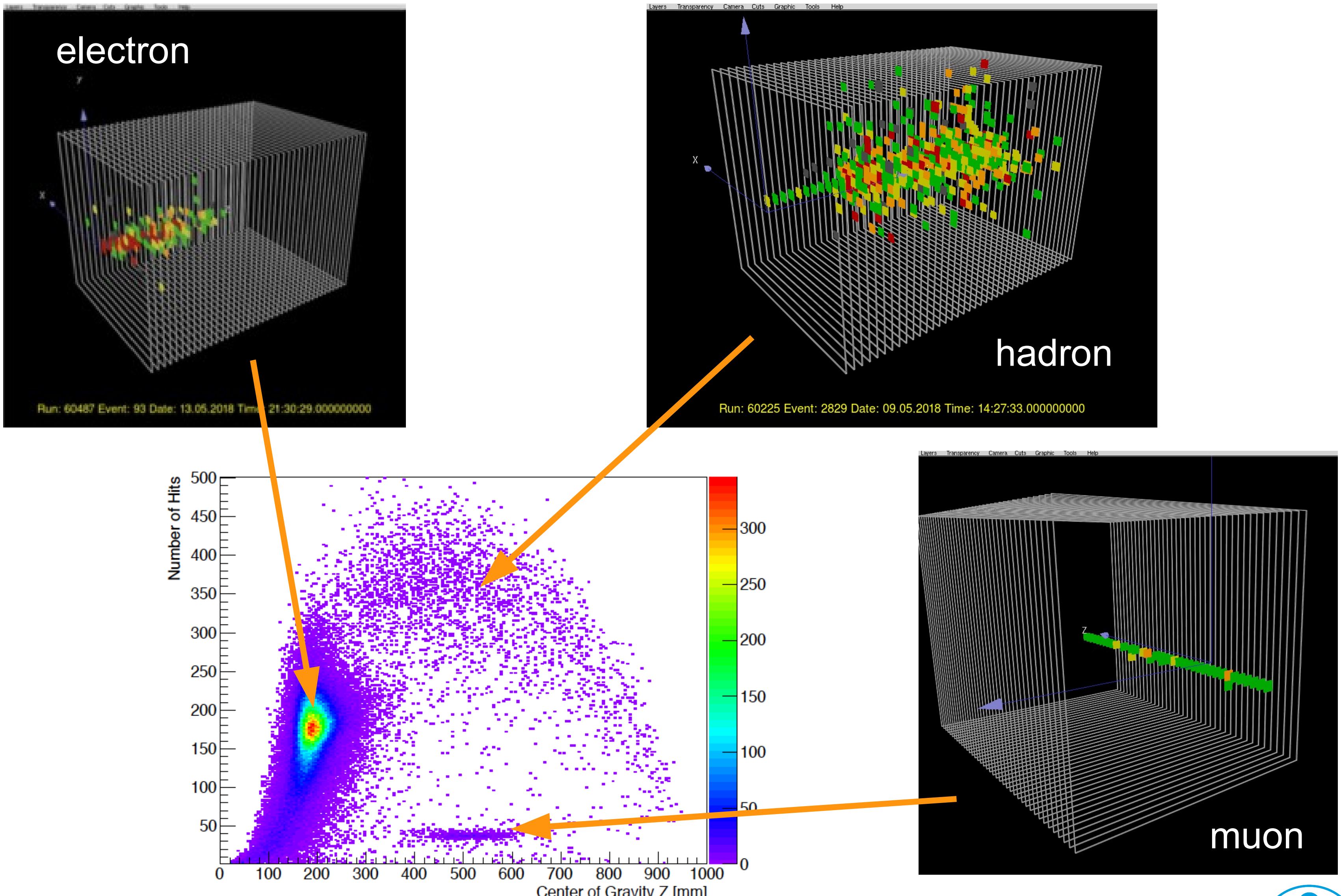


Quality assurance and calibration

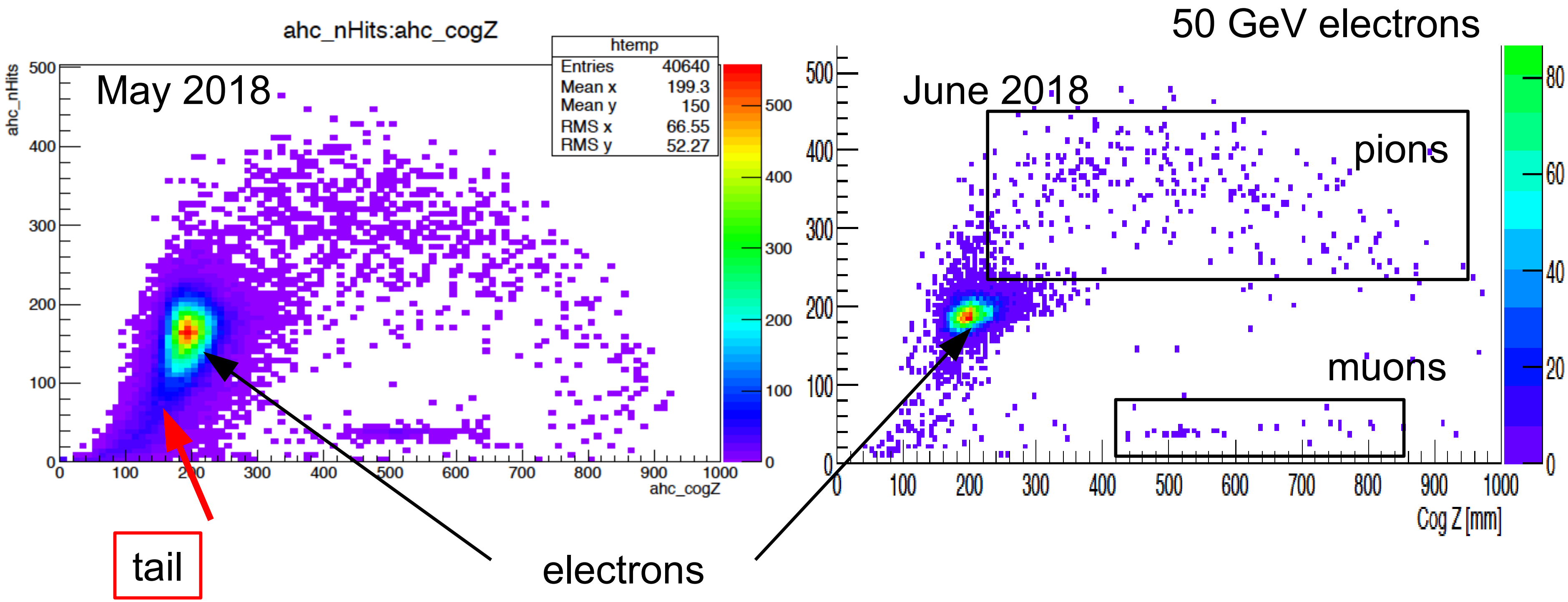
- SiPM sample tests
- tile sample tests
- test of all ASICs
- all individual HBUs tested and calibrated with LEDs and cosmics
- all modules (2*2 HBUs) tested with cosmics
- all modules calibrated with LEDs and DESY beam (3 GeV electrons as MIPs)
  - calibrate 4 modules in parallel, ~1 day per set
  - automated scan with automated control of the moving stage
  - many technical tests: gain switching, ...
- result: overall quality very good



Very first look into data

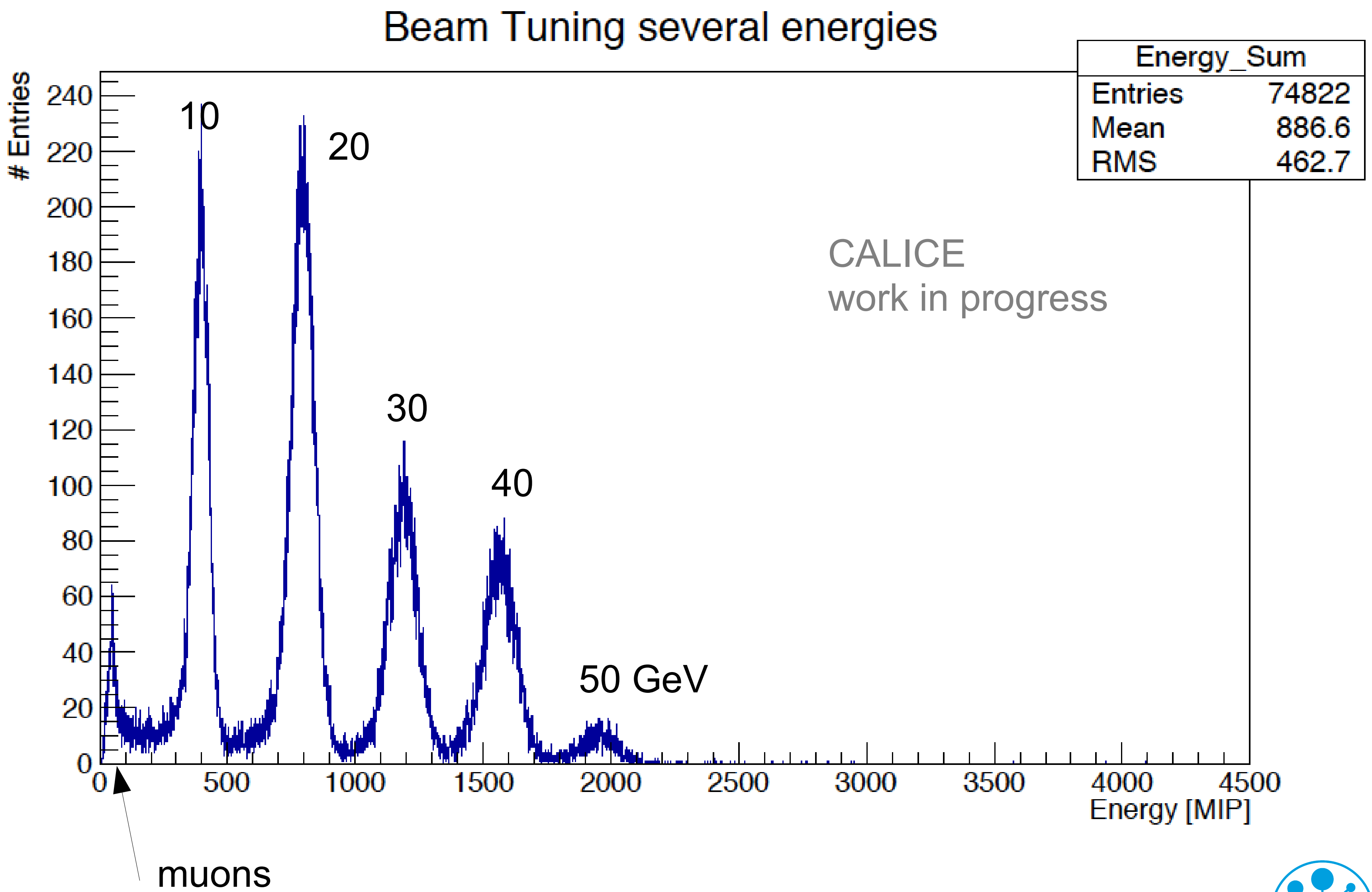


Very first look into electron data

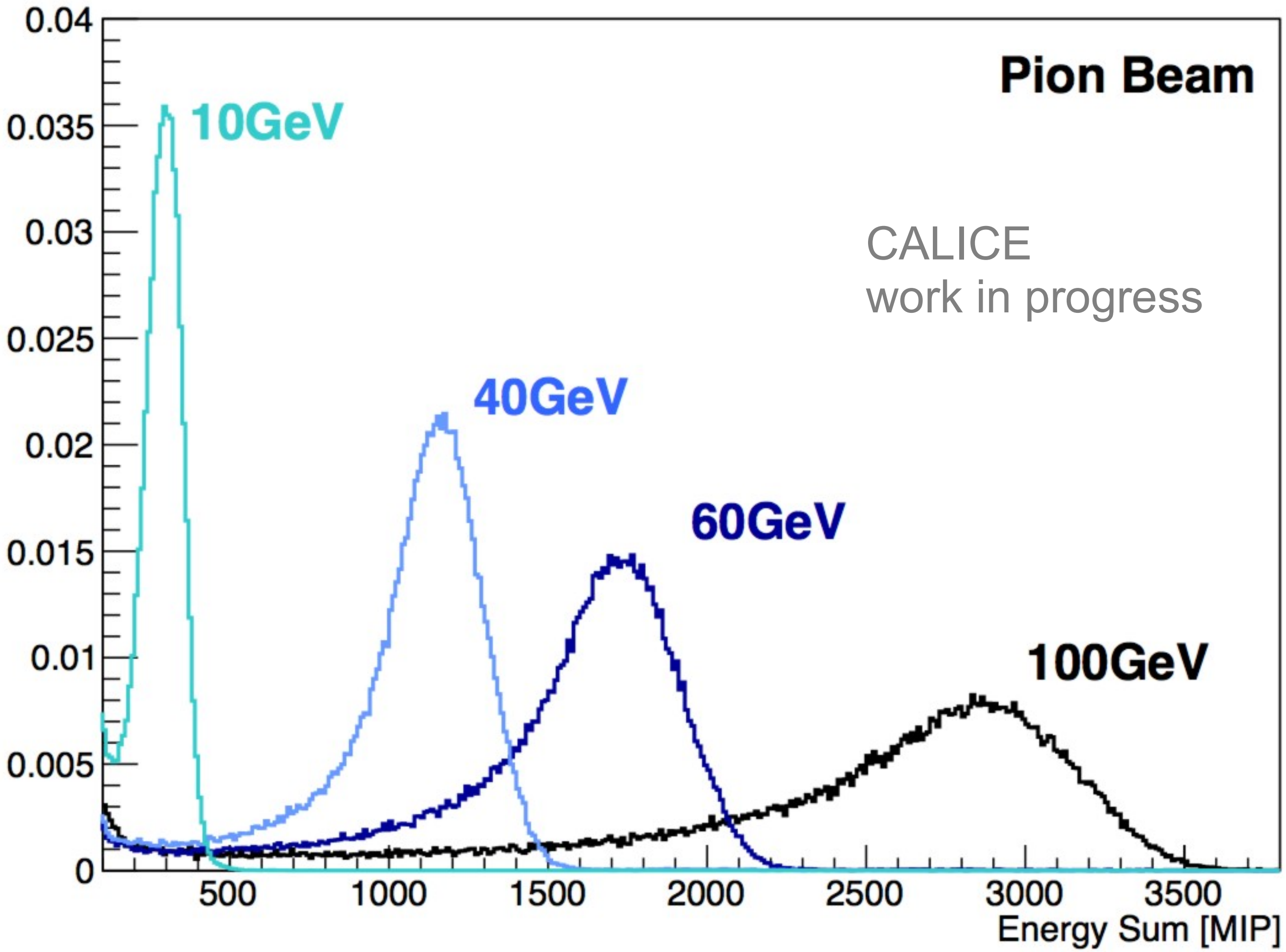


- May:
  - clear tail to smaller number of hits and earlier center-of-gravity
  - present for all electron energies
- June:
  - changed beam steering
  - tail gone, nice and narrow energy distributions

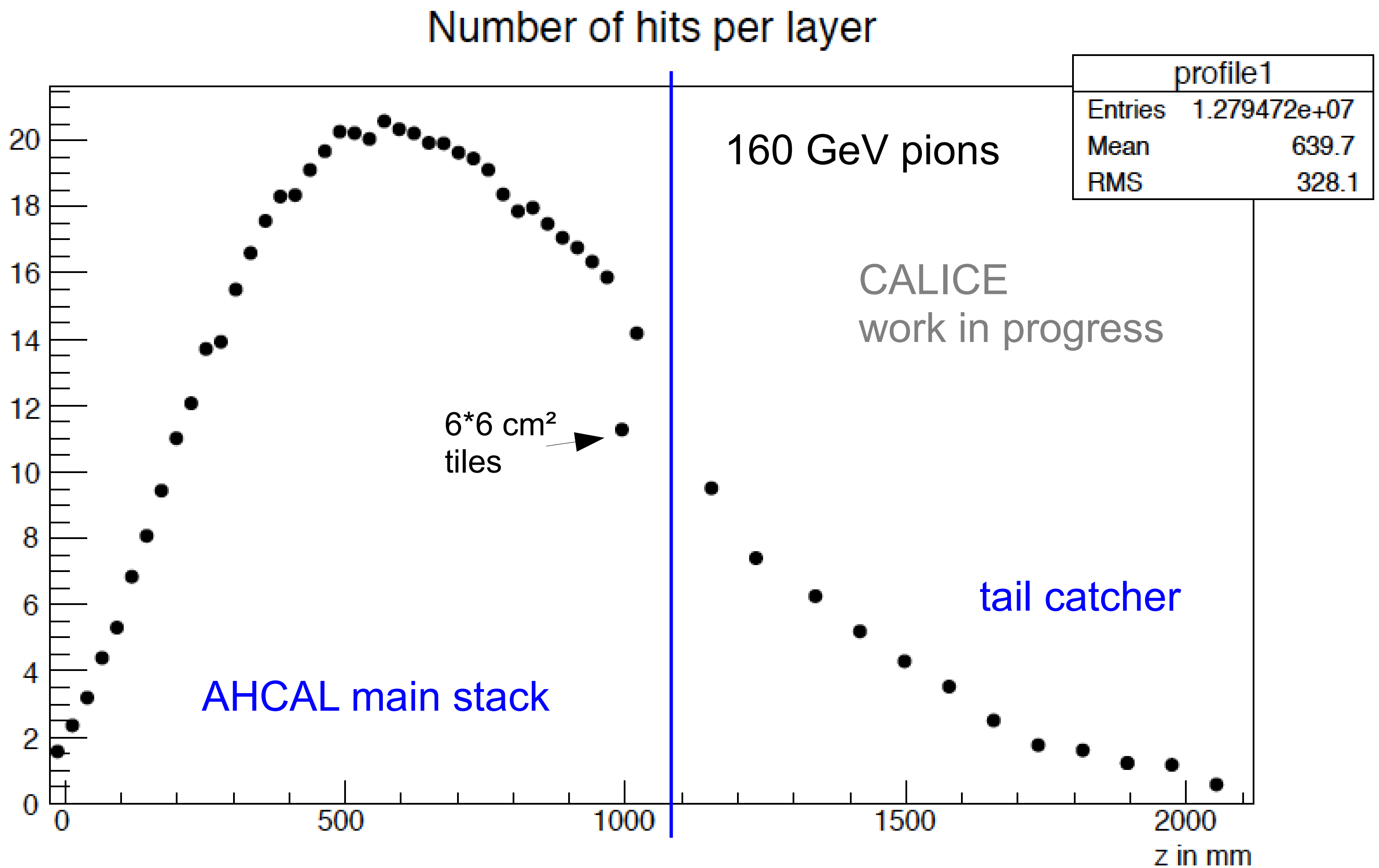
Electrons during beam tuning in June



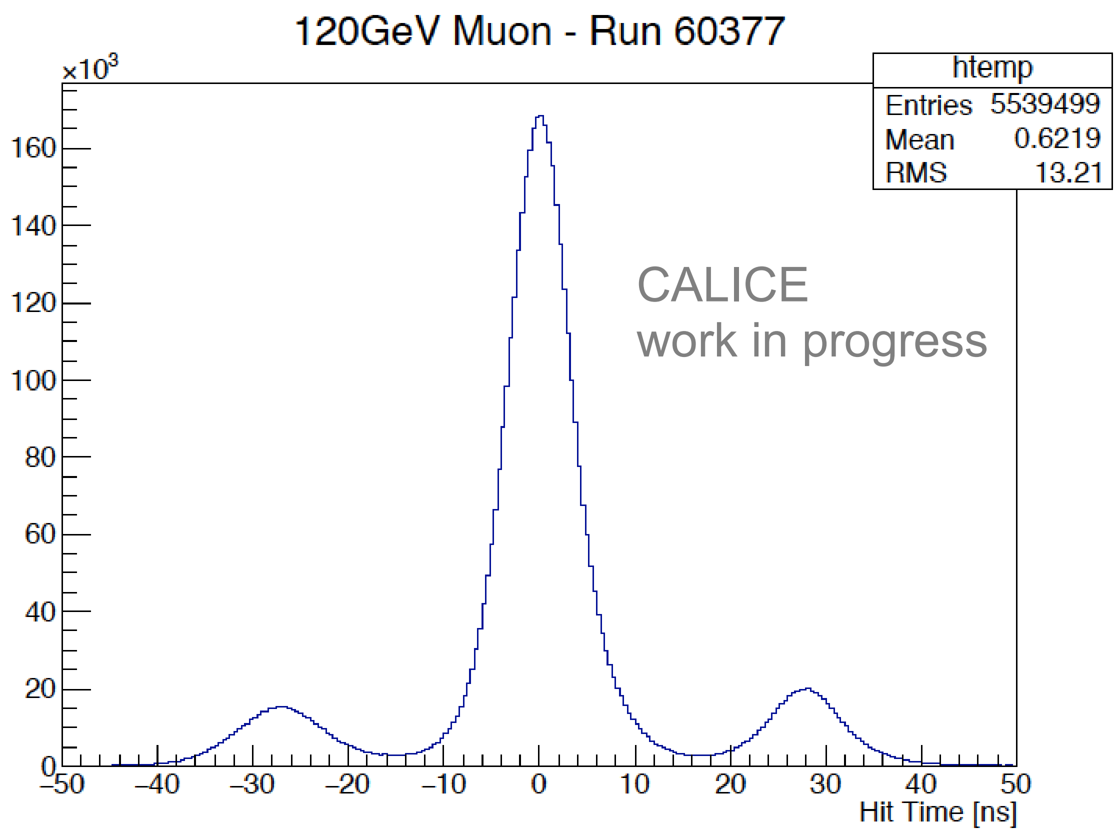
Very first look into pion data



Pions in June: importance of tail catcher



Timing analysis



- first attempt of calibration of the hit time measurement
  - promising resolution in core (~8 ns FWHM, with slow testbeam clock)
- additional peaks at ~28 ns under study
  - probably the whole event is shifted, so can be corrected in reconstruction