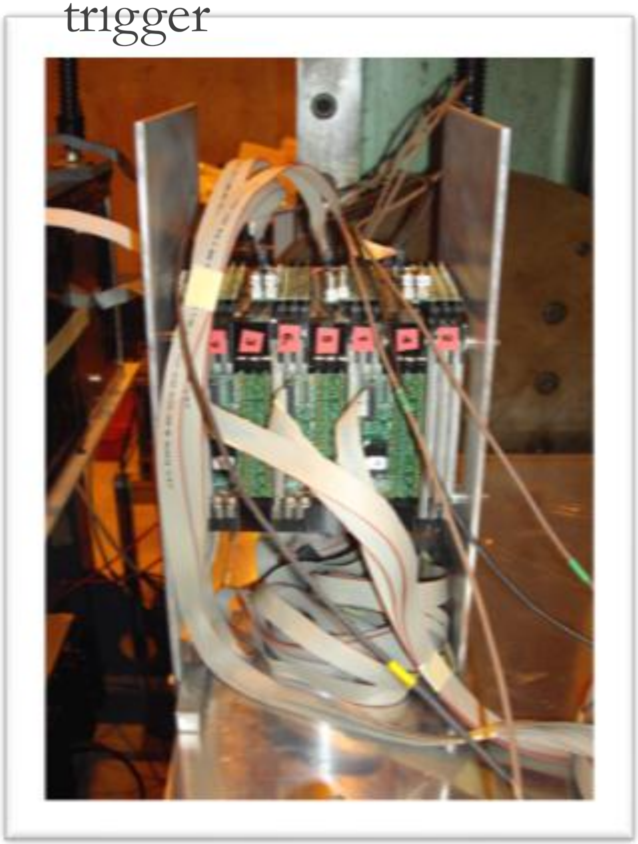
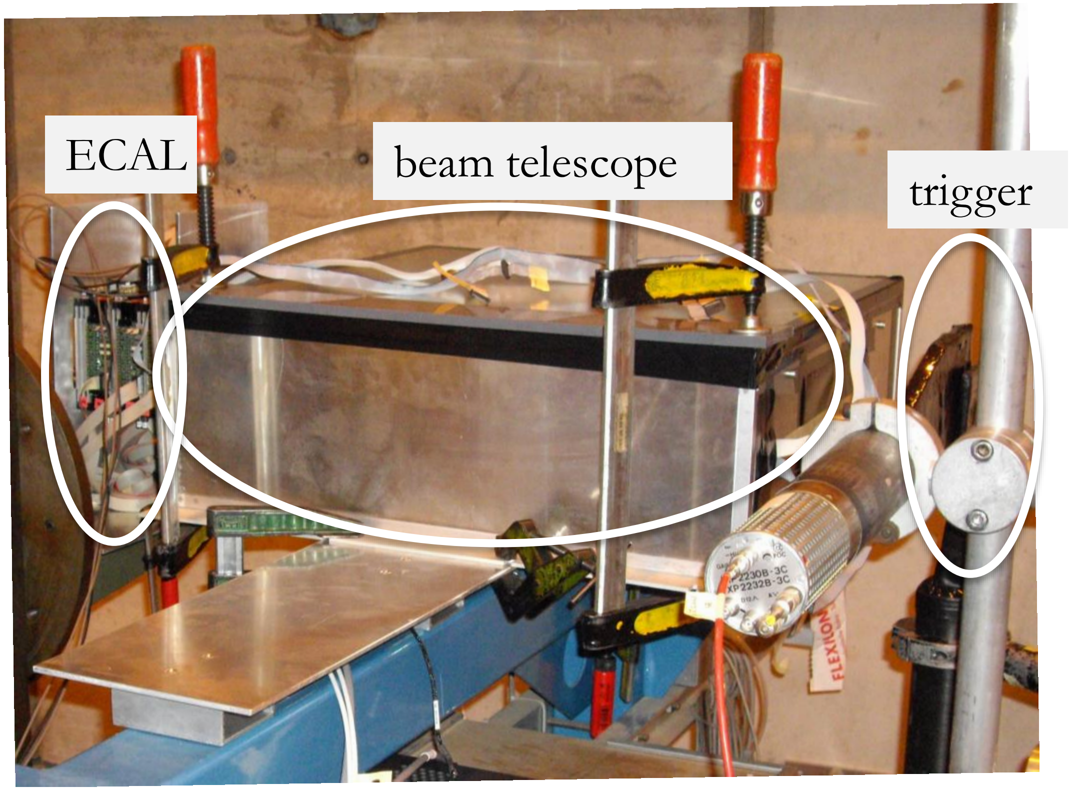
Testbeam analysis

Lesya Shchutska

Prototype II: peculiarities

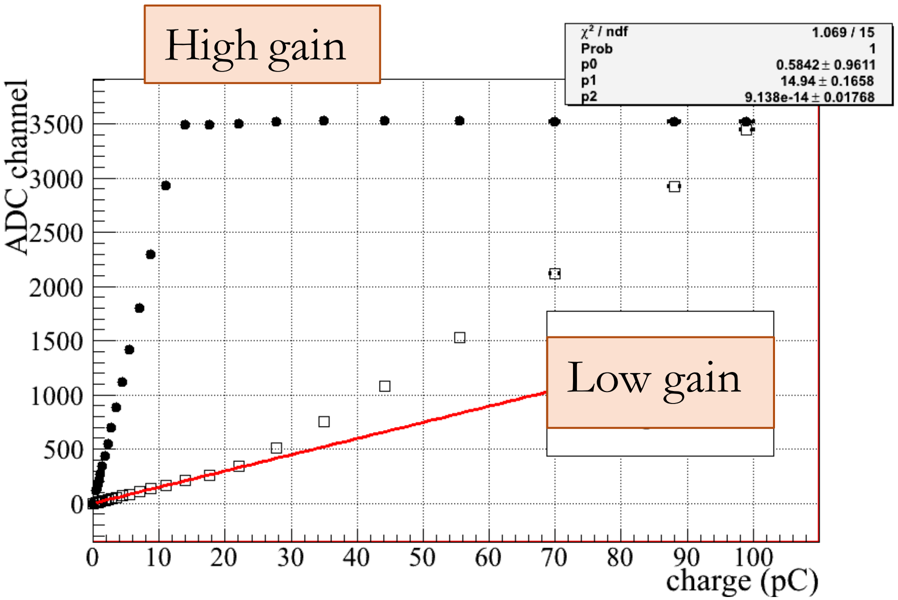
- **Testbeam setup:** prototype, beam telescope, 2 scintillators used for trigger

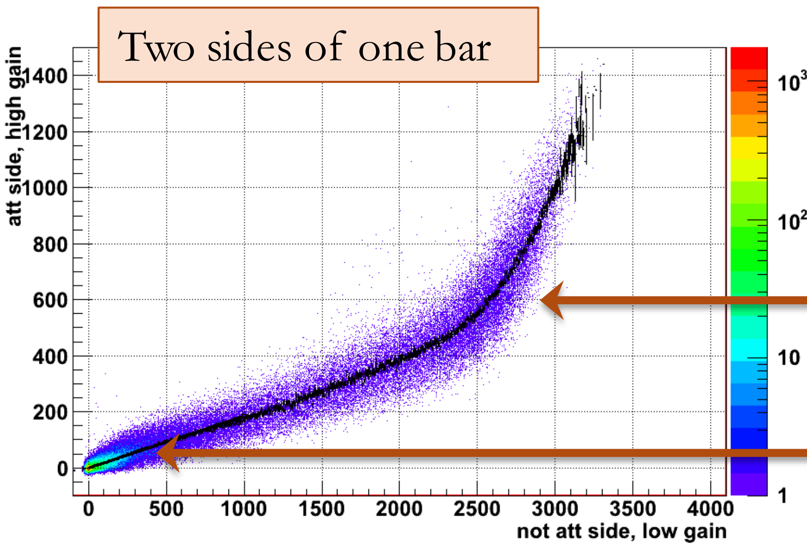




- **Prototype:** short bars ($3\times7.35\times114\ mm^3$), W absorber, 21 layer, 18 X_0
- **Readout:** Signal from each SiPM digitized with 2 parallel outputs:
  - High gain: noise 7 ADC
  - Low gain: attenuation by factor ~17, noise 4 ADC
  - ➔4 readouts with gain ratio: 1:~1/17:~1/5:~1/17 (counting from the previous)

Challenges of the SPIROC readout





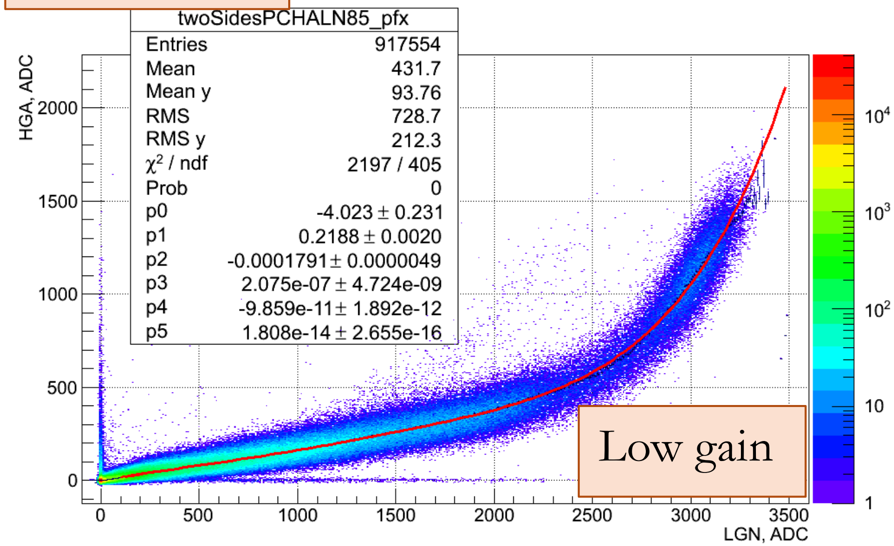
SiPM saturation visible at ~2500

Start of electronics non-linearity

- ✓ Baseline shift with RMS = 20 ADC in high gain: non-trivial correction for events occupying more than 60% of ECAL
- ❑ After the high gain saturation the low gain response is non-linear:
  - ❑ This region coincides with the SiPM non-linearity
  - ❑ Those non-linearities are opposite in sign!
- ✓ When subjected to the intensive high charge injection high gain exhibits disproportional (smaller) signal or stops working

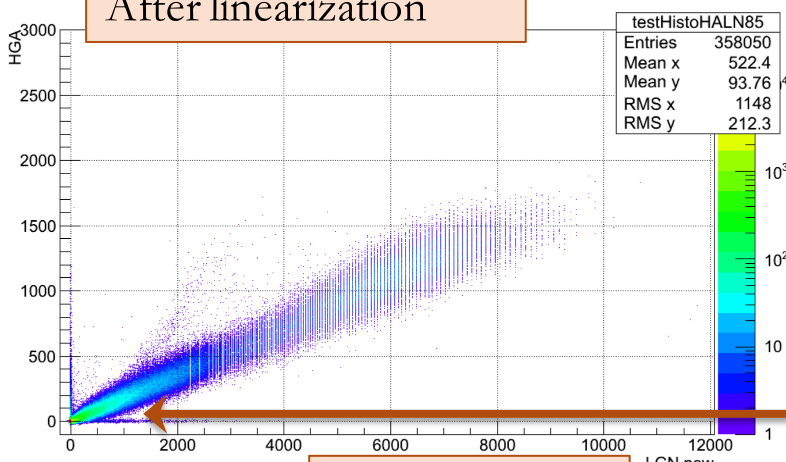
Low gain parameterization

High gain att



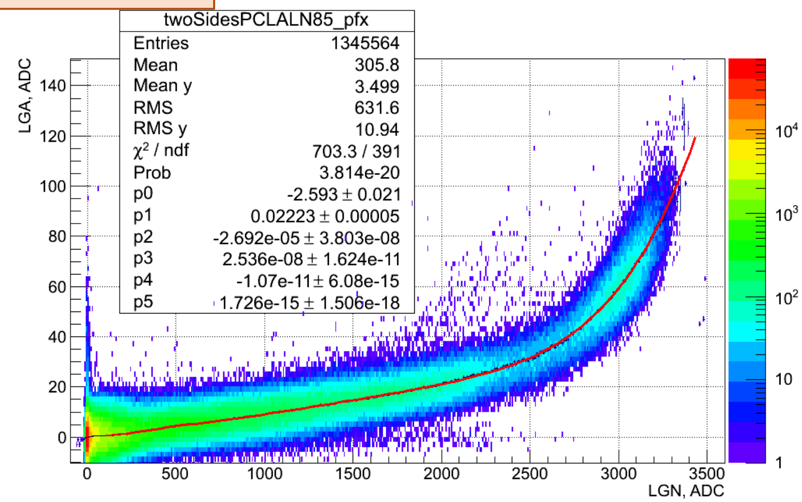
- ✓ Low gain vs. linear HGA and/or LGA is fitted with pol5.
- ✓ Then linearized as LGN_{new} = pol5(LGN)/calib. const
- ✓ Both original and linearized are analyzed for comparison.

After linearization



Low gain new

Low gain att

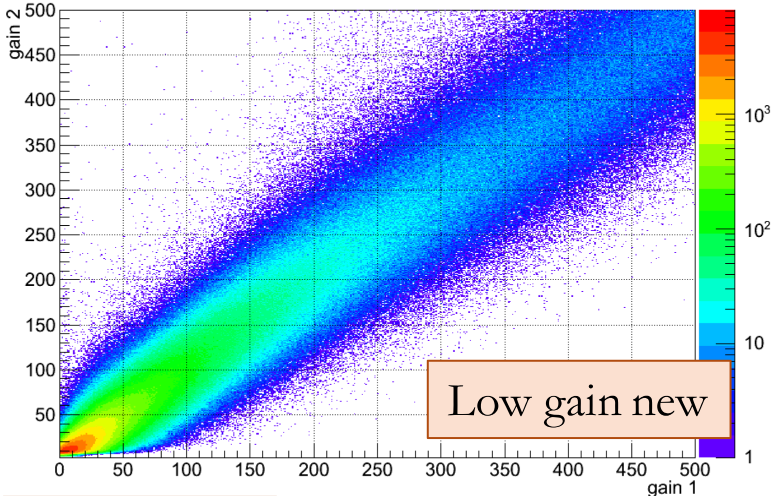


Start of electronics non-linearity

Low gain

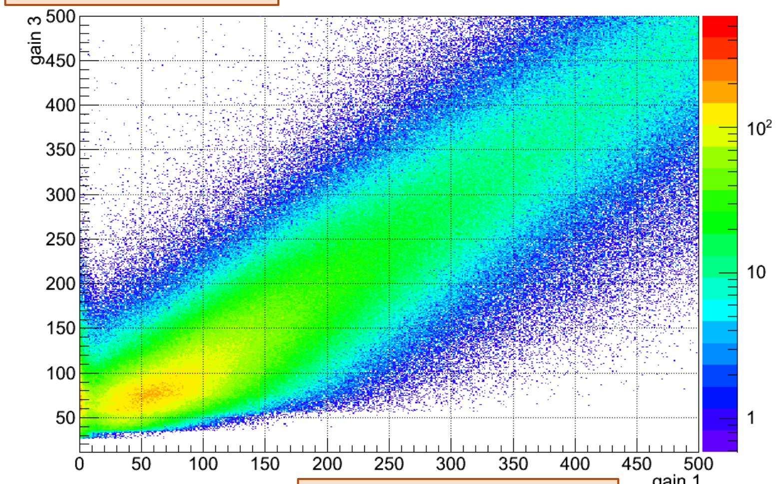
Gains comparison: e 125 GeV

High gain att



Low gain new

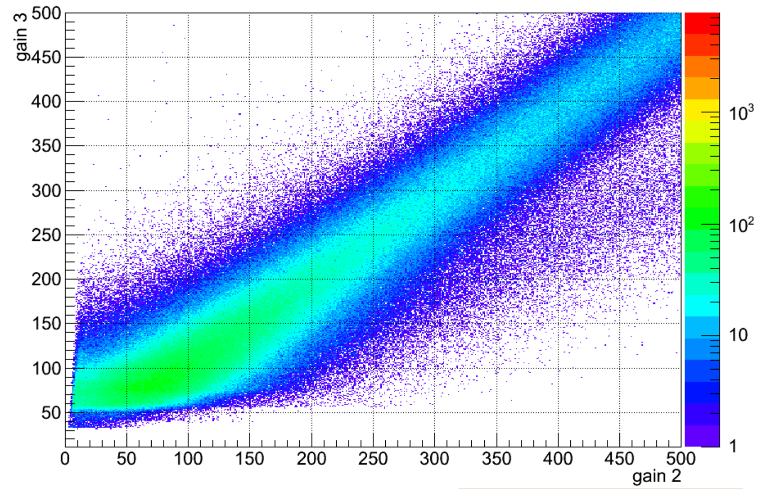
Low gain att



Low gain new

- ✓ 3 gains in pairs after applying calibration constants.
- ✓ Cut on noise level is applied

Low gain att

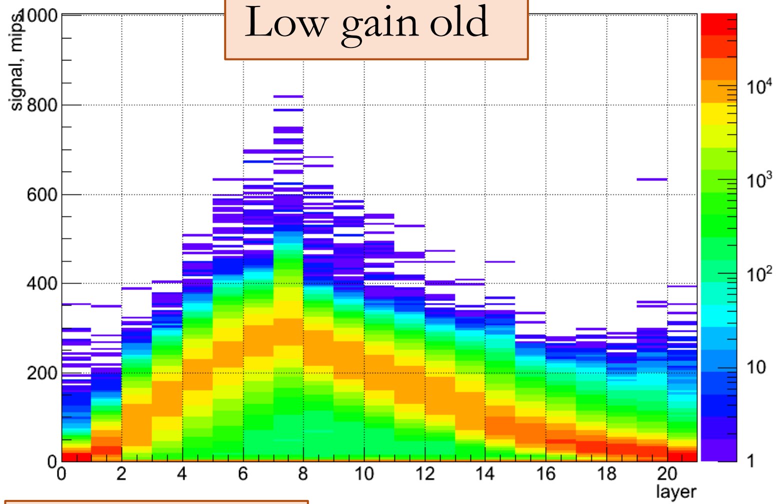


High gain att

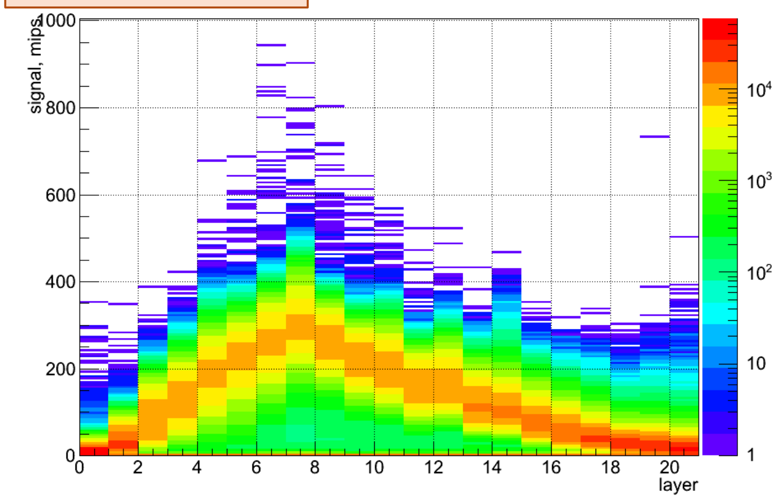
Showers: 1st configuration 25 GeV

✓ Data from several gains is combined with weighted errors

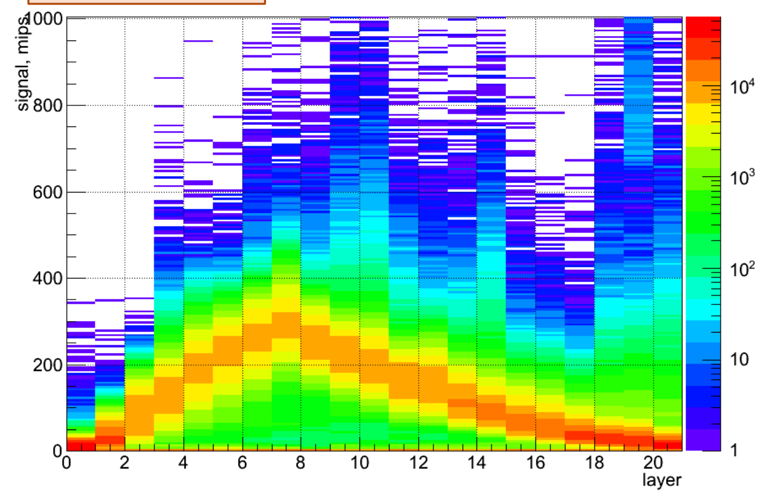
Low gain old



Low gain new

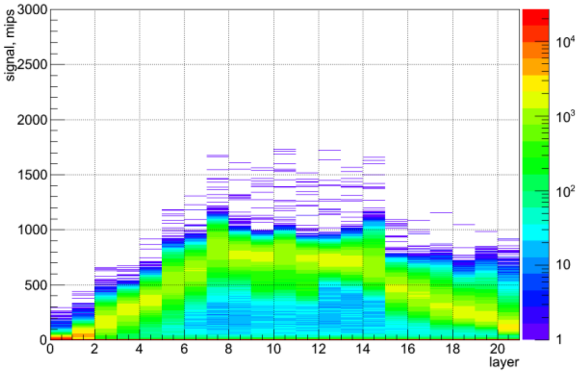


All 4 gains

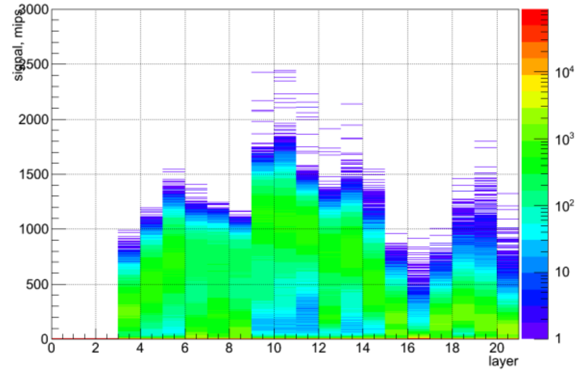


Showers: 1st configuration 125 GeV

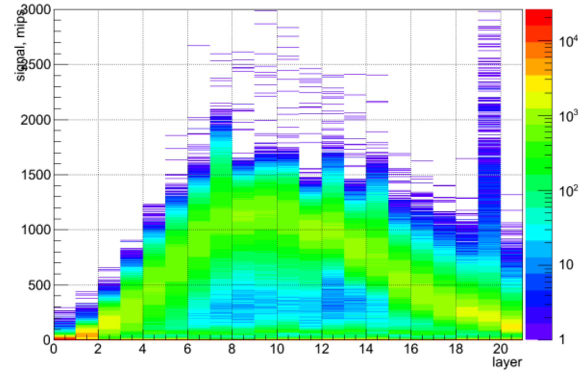
Low gain old



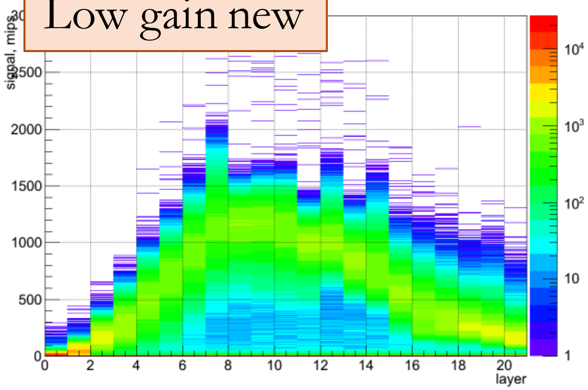
High gain att: broken channels



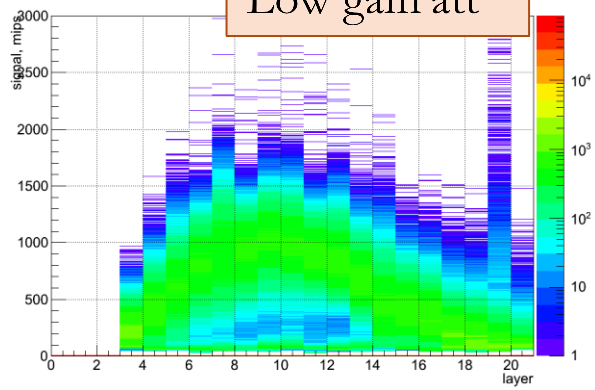
All 4 gains



Low gain new

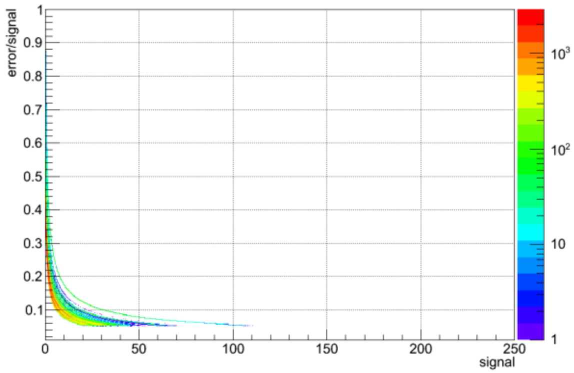


Low gain att

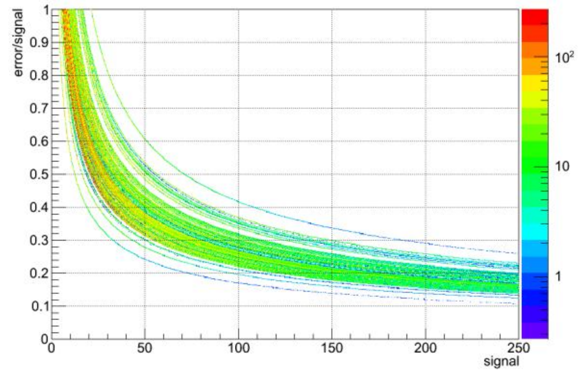


Showers: error calculation

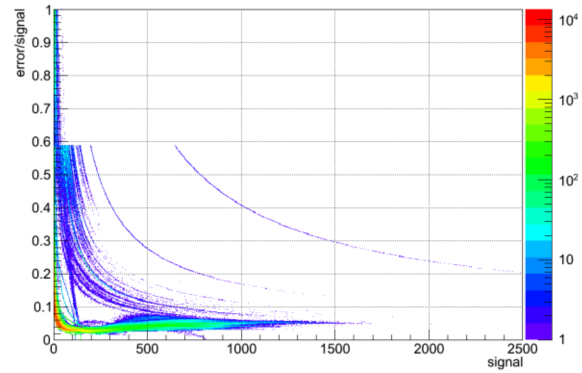
High gain



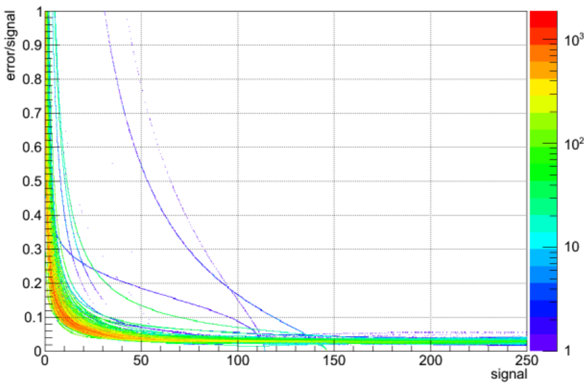
High gain att



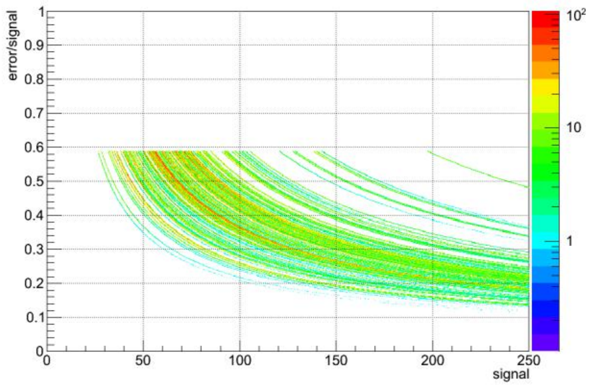
All 4 gains



Low gain new



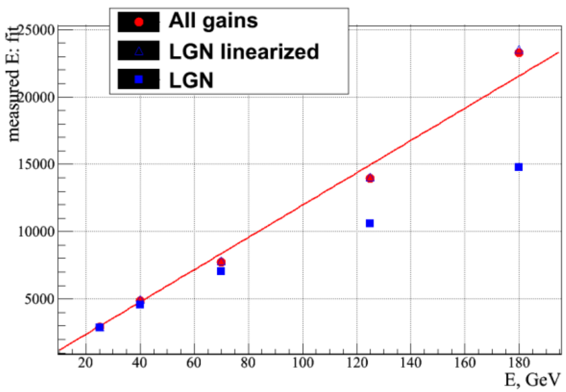
Low gain att



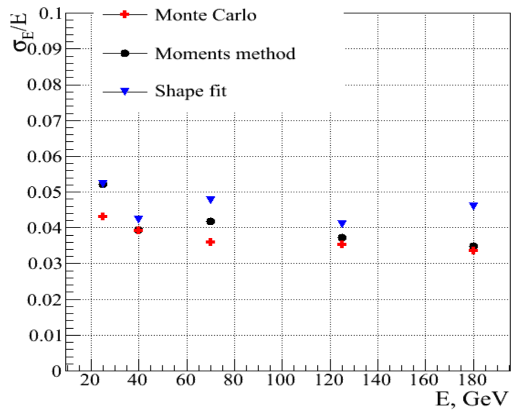
- ✓ Simple error estimate:
  - ✓ $\sqrt{N_\Upsilon} \oplus \sigma_{noise}$
  - ✓ Combined with weights

1^{st} configuration

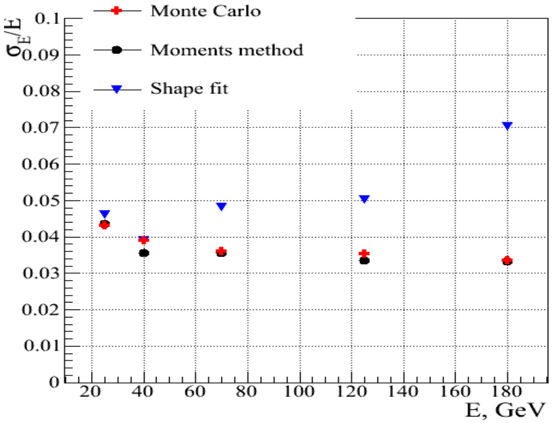
Calibration



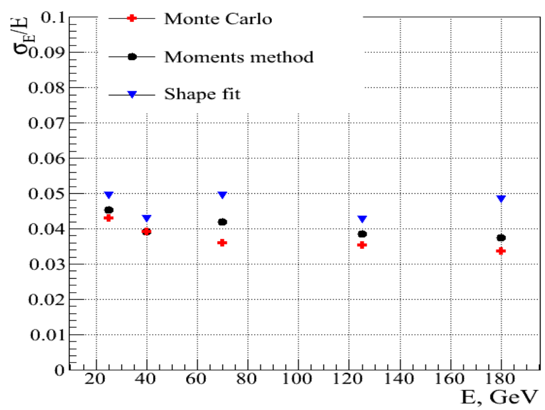
All 4 gains



Low gain



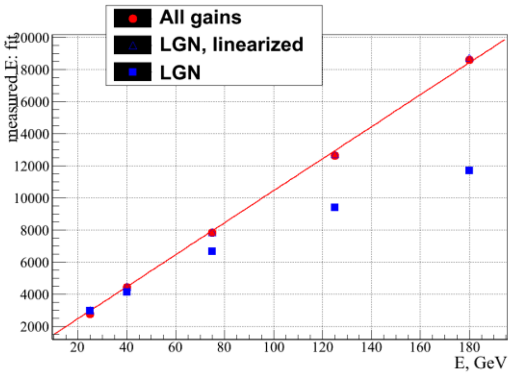
Low gain linearized



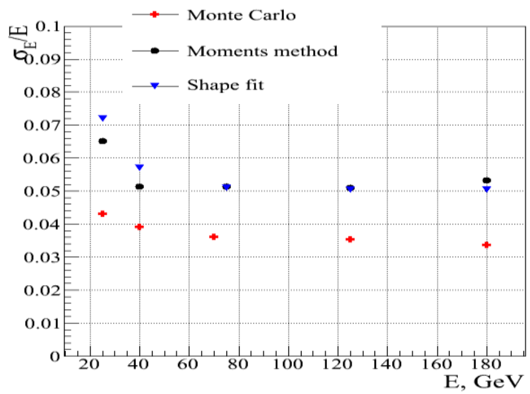
- ✓ Monte Carlo:
  - ✓ contains only fluctuation in energy deposit (no digitization)
- ✓ Data:
  - ✓ 21 layer
  - ✓ 3 configurations used for the analysis
  - ✓ per event shower shape fit is performed (result – blue triangles)
  - ✓ moment method is used alternatively
  - ✓ fit gives symmetrical parameter distribution (hence σvalues are larger)

2nd configuration

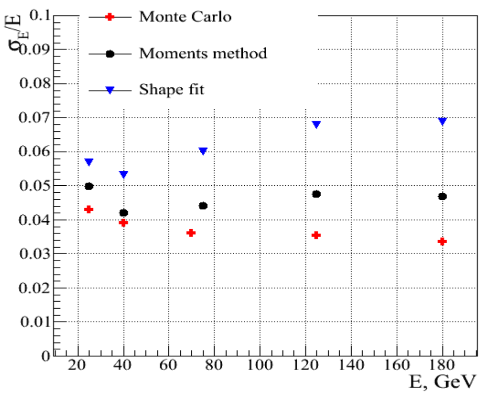
Calibration



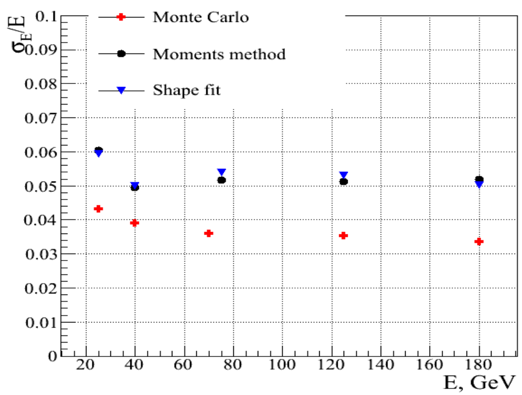
All 4 gains



Low gain



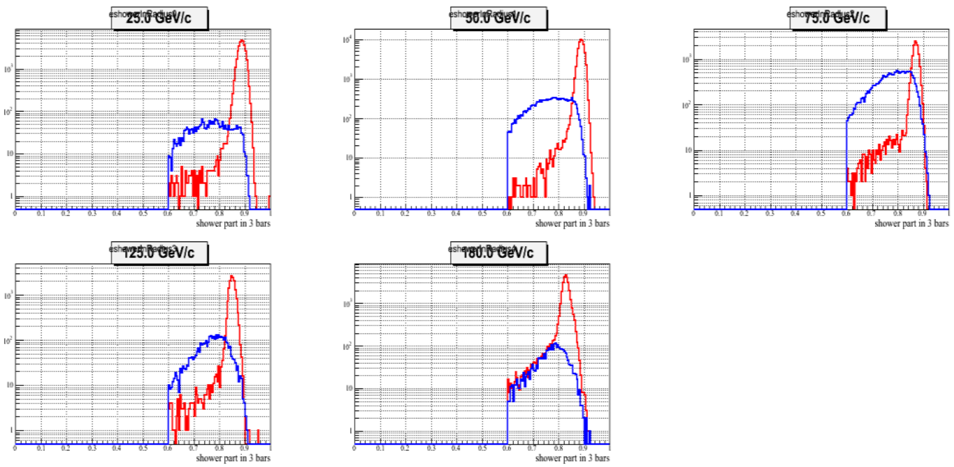
Low gain new



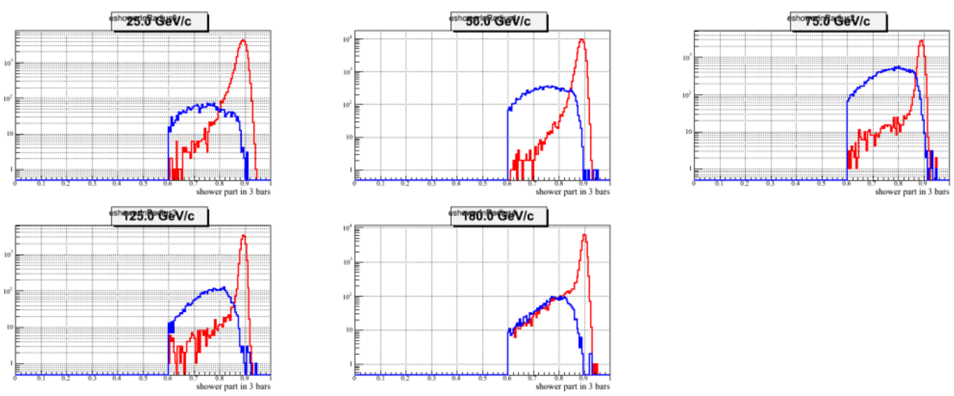
- ✓ Monte Carlo:
  - ✓ the same (21 layer)
- ✓ Data:
  - ✓ 18 layers
  - ✓ Resolution is immediately deteriorated

Saturation influences:

Saturated input



Not saturated input

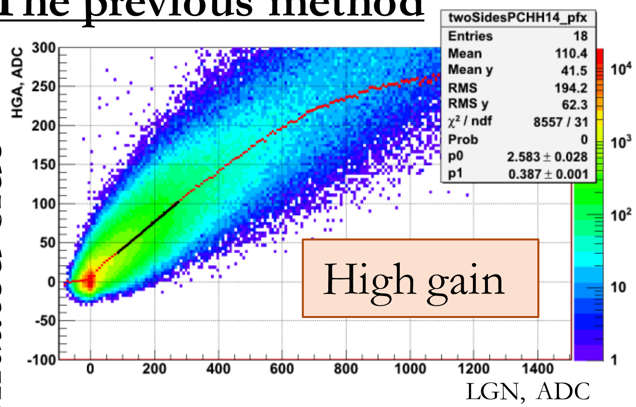


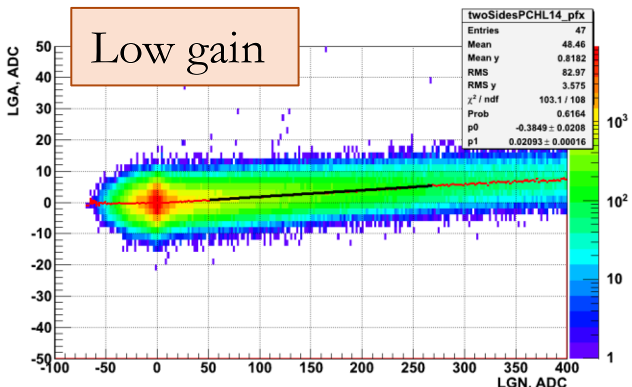
- ✓ Variables relying on energy density affected:
  - ✓ Molière radius containment
  - ✓ fraction of the shower energy in the tail
  - ✓ shower asymmetry
  - ✓ shower maximum
- ✓ Not affected or partially affected:
  - ✓ number of fired bars in ECAL
  - ✓ energy deposit (in e sense that cut on it anyway relies on the tracker info and ECAL calibration)
- ✓ As a result:
  - ✓ more cuts would rely on the tracker info (momentum knowledge) and will be less robust/universal.

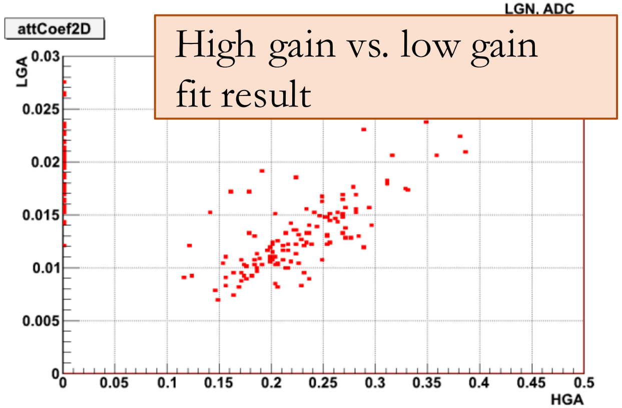
ECAL intercalibration II

The previous method

Attenuated side

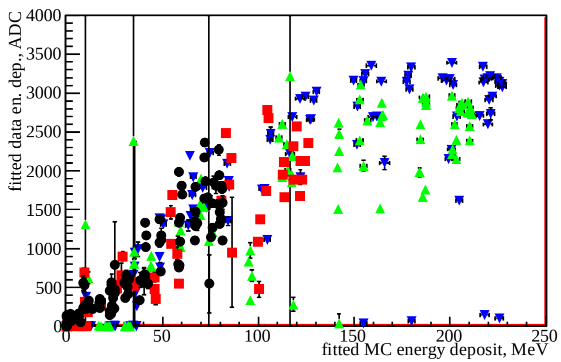






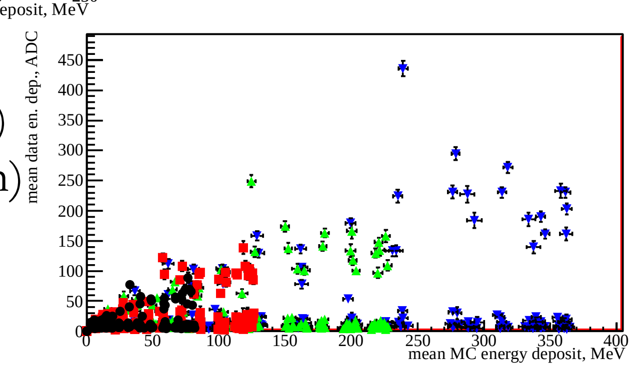
The new method tested:

- allows to parameterize all non-linearities
- uses GEANT4 description of the prototype
- energy deposit in each bar left by a particle passing through its central part is fitted with Gaussian for a range of energies and compared with MC result.



- Each color corresponds to e^- beam energy:
  - 25, 40, 75, 125 GeV
- Each point represents one channel

- Not attenuated side (up)
- Attenuated side (bottom)

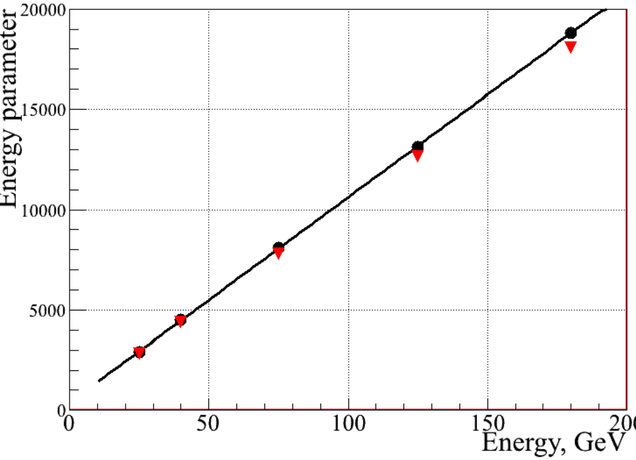


ECAL performance

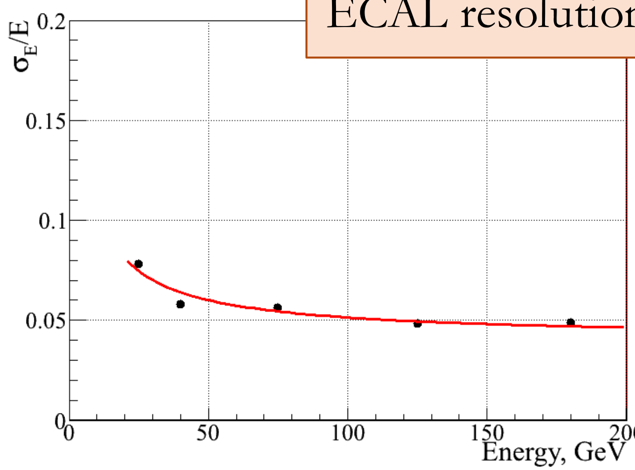
- Effectively 18 layers

Position resolution

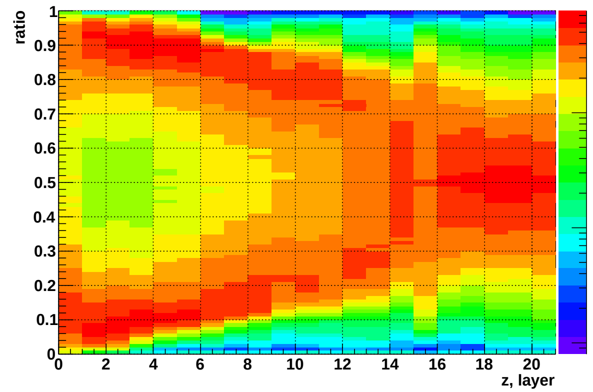
ECAL energy scale



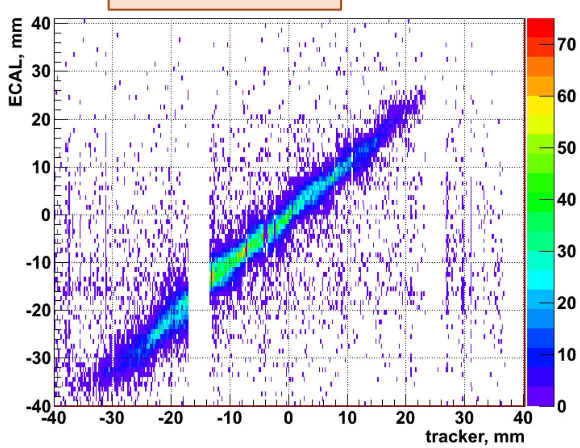
ECAL resolution



Ratio of signal in bars in cluster



σ≅ 2 mm



2nd layer position