APDs for tileHCAL

MiniCal studies with APDs in e-test beam

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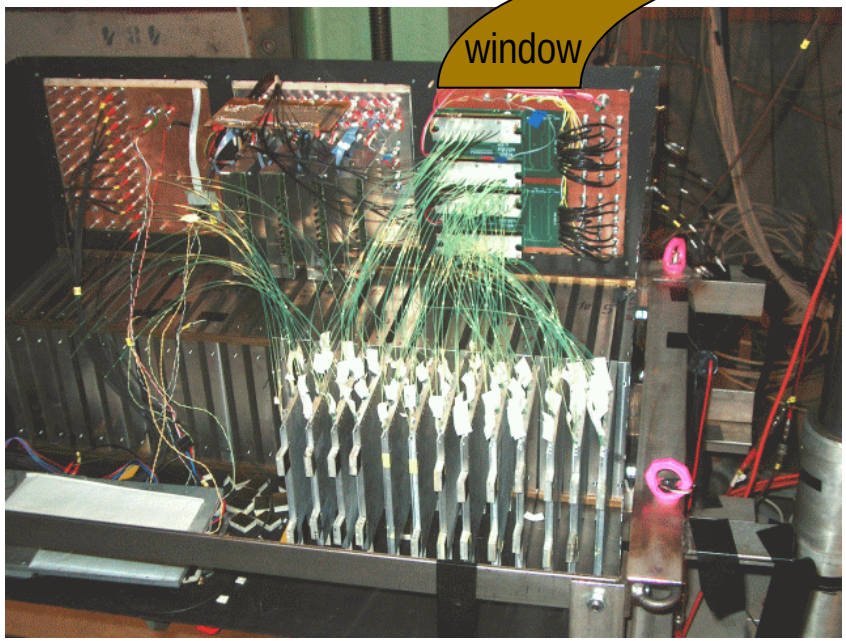
DESY and Prague tileHCAL group

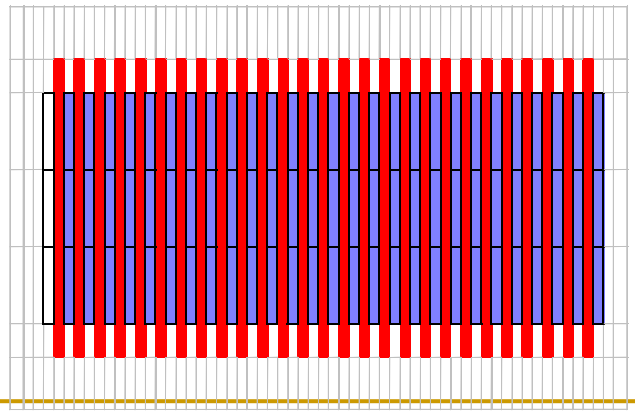
Include two basics steps:

- Calibration
- Energy scan

- with different preamplifiers
- with different working conditions
- comparisons

Measurement Setup





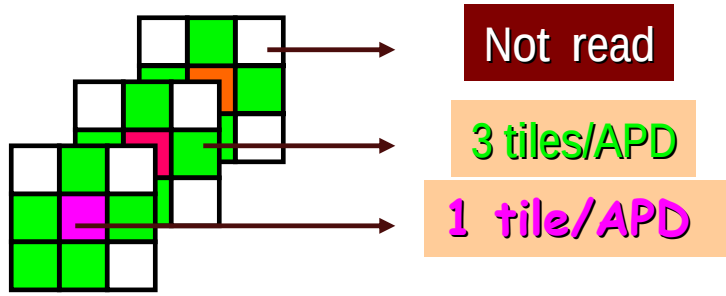
MiniCal structure: Fe + scintillator
- steel absorber 2 cm
- 12 sci layers with 3x3 tiles
- each 5x5x0.5 cm^3

Readout:
- WLS fibers
- APDs as photodetector
- preamplifier (exchangeable)
- DAQ (camac – adc)

Measurement procedure

MIP calibration

- using 3 GeV e-beam without absorbers
- shoot at MiniCal along its axis in 6 positions
  response in all tiles
- extraction of calib factors for each channel



Energy scan

- with beam energy of 1-6 GeV
- rescale of response in tiles using calibration
- sum up energy response (in MIPs) from all tiles

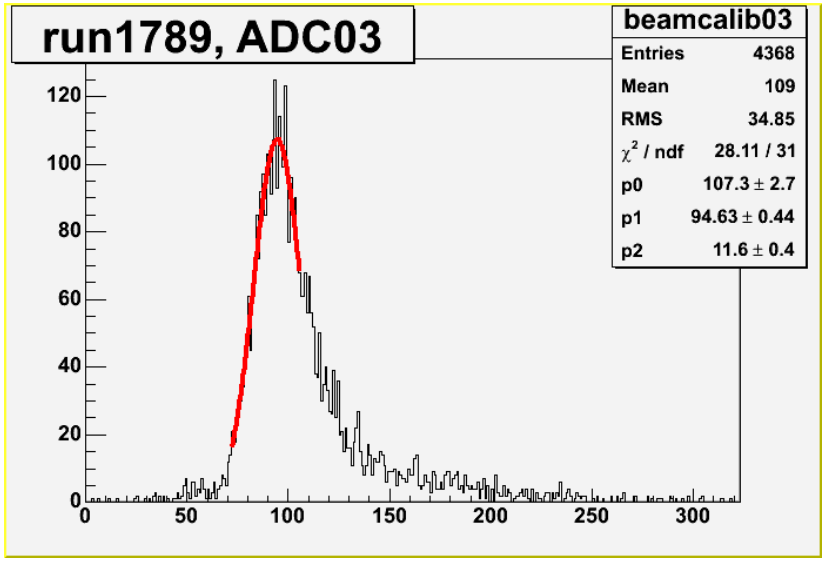
- 12 layers in geometry
- central stack: 1tile/1APD =12chan.
- 4 sides + 1 corner: 3tiles/1APD

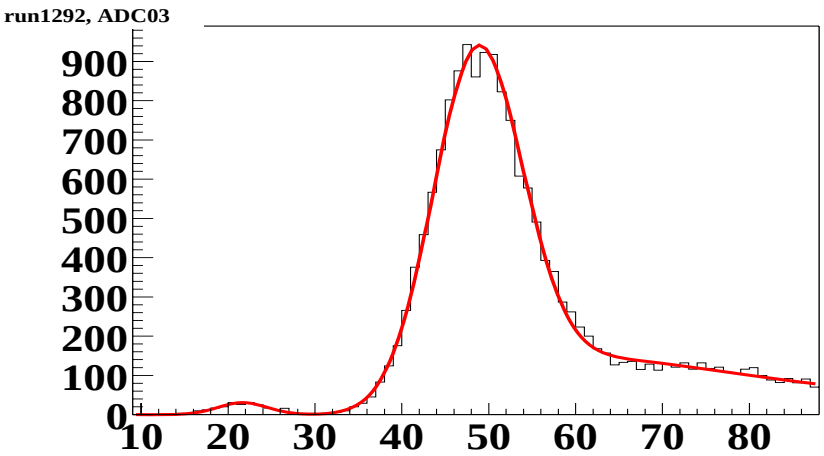
➢ in total 32 channels in readout

Several data sets taken

- two preamps: Minsk (charge sensitive) and Prague (voltage sensitive)
- various HV supply → different APD working points (gains)

MIP calibration of APD spectra





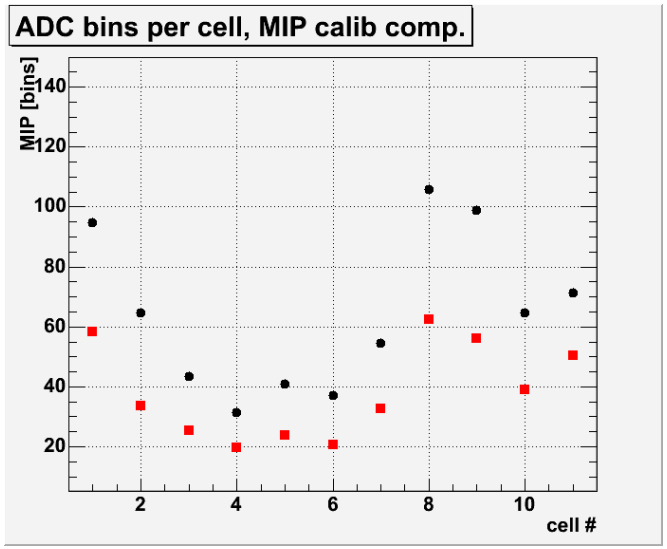
- Prague (IVO) preamp
  Signal/Noise = 6.6
  Mean/Sigma = 3.8

➢ Spectra from both preamps look similar
= gaussian shape of MIP response
+ Landau tail (sampling fluctuation)

➢ Particular characteristics of fitted spectra vary with channels → depend on working point of each APD
(gain given by HV and temperature)

- Minsk (Gilitzki) preamp
  Signal/Noise = 9.5
  Mean/Sigma = 5.4

MIP calibration for different HV



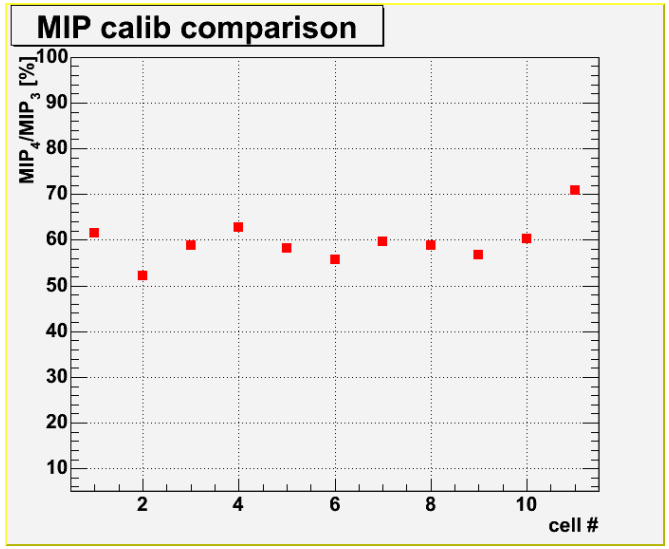
Prague preamp

HV1 = 434 V

HV2 = 429 V

MIP calib factors

for central stack

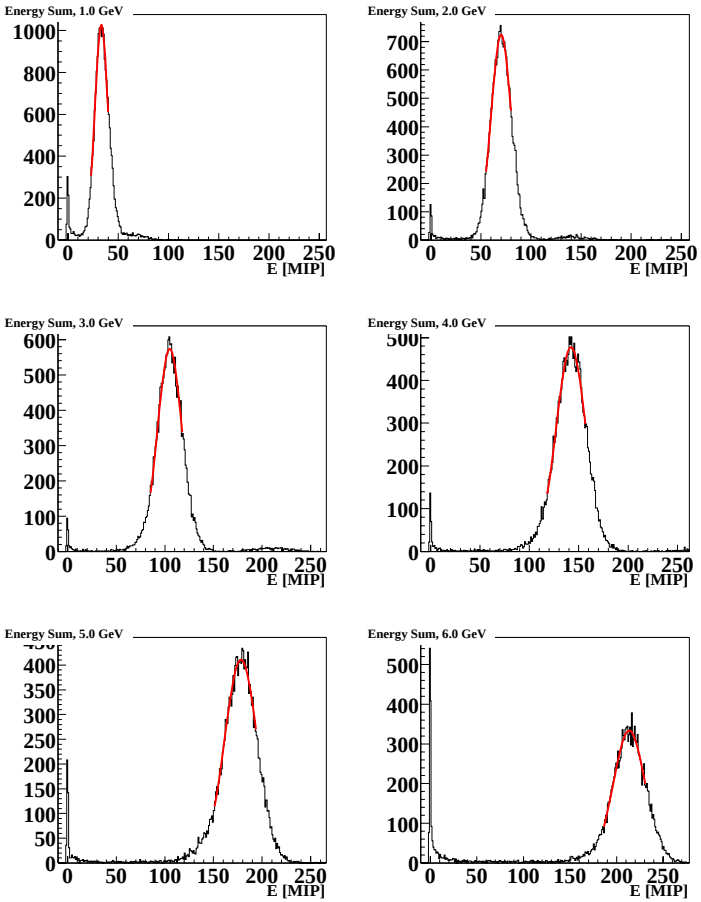


- MIP [in bins] = Peak – pedestal, determined by parameters of fits.
- Two data sets with different HV taken for Prague preamp resulting to ratio of approx 60% of gain
- ➢ Big difference of gain give nevertheless consistent results in energy reconstruction of showers in MiniCal.

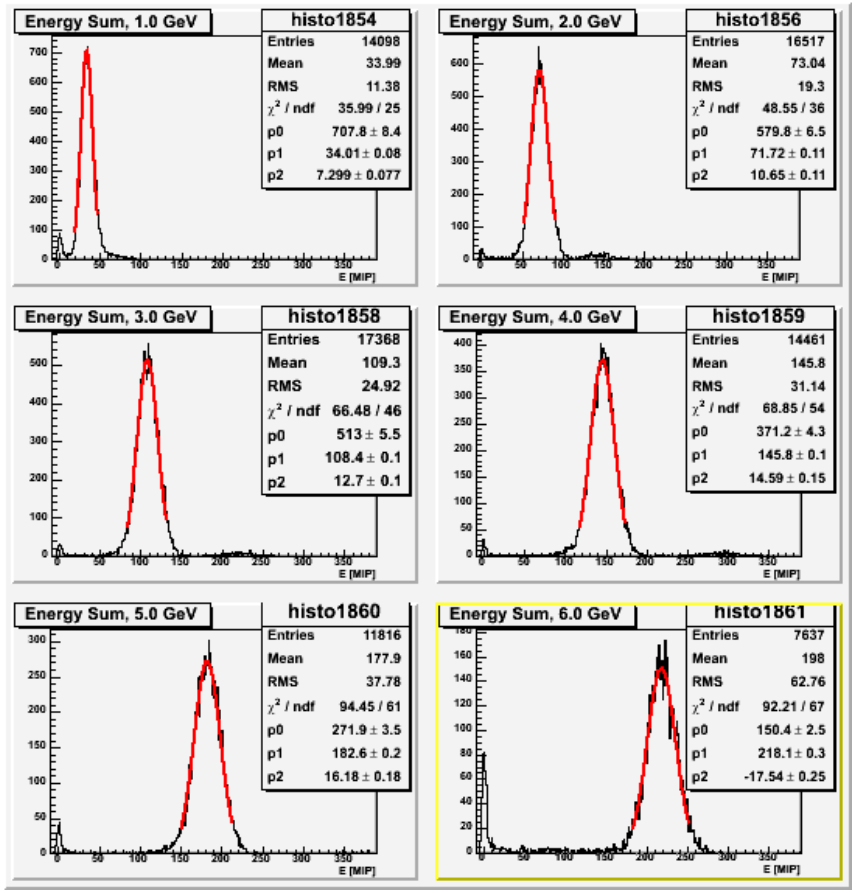
Energy sums

Reconstructed energy [MIPs] = gaussian mean in ± 2 sigma range

Minsk

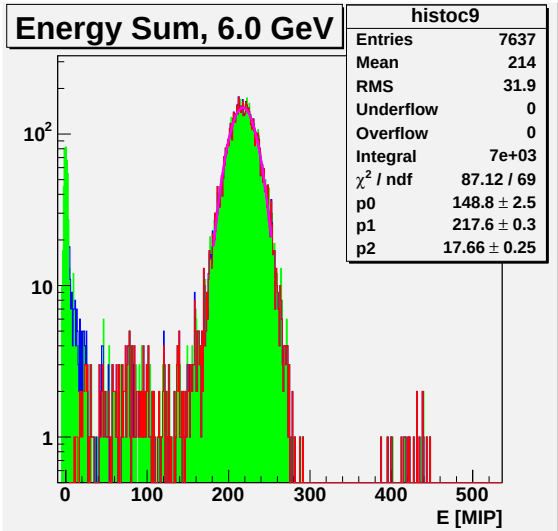


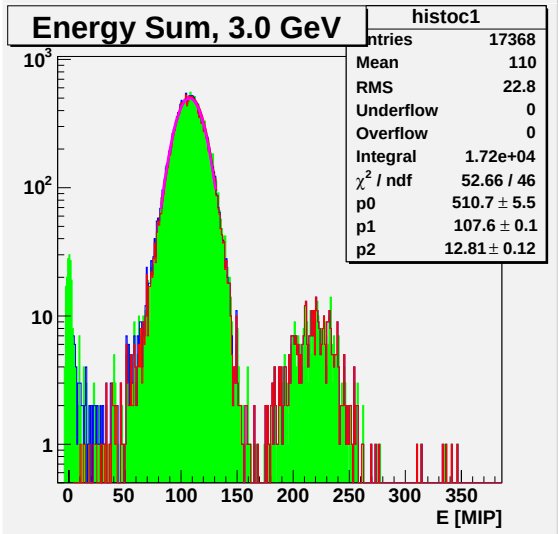
Prague

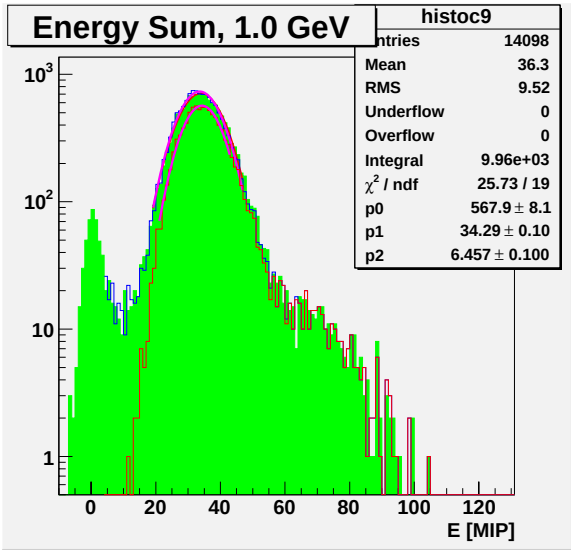


- energy sums for both preamps look as expected

Energy thresholds and cuts







Proposed energy cuts:

- green – standard sums
- blue – energy thresholds for all tiles (> 0.3 MIPs)
- cut > 3 MIPs on most energetic cells (core 2,3)

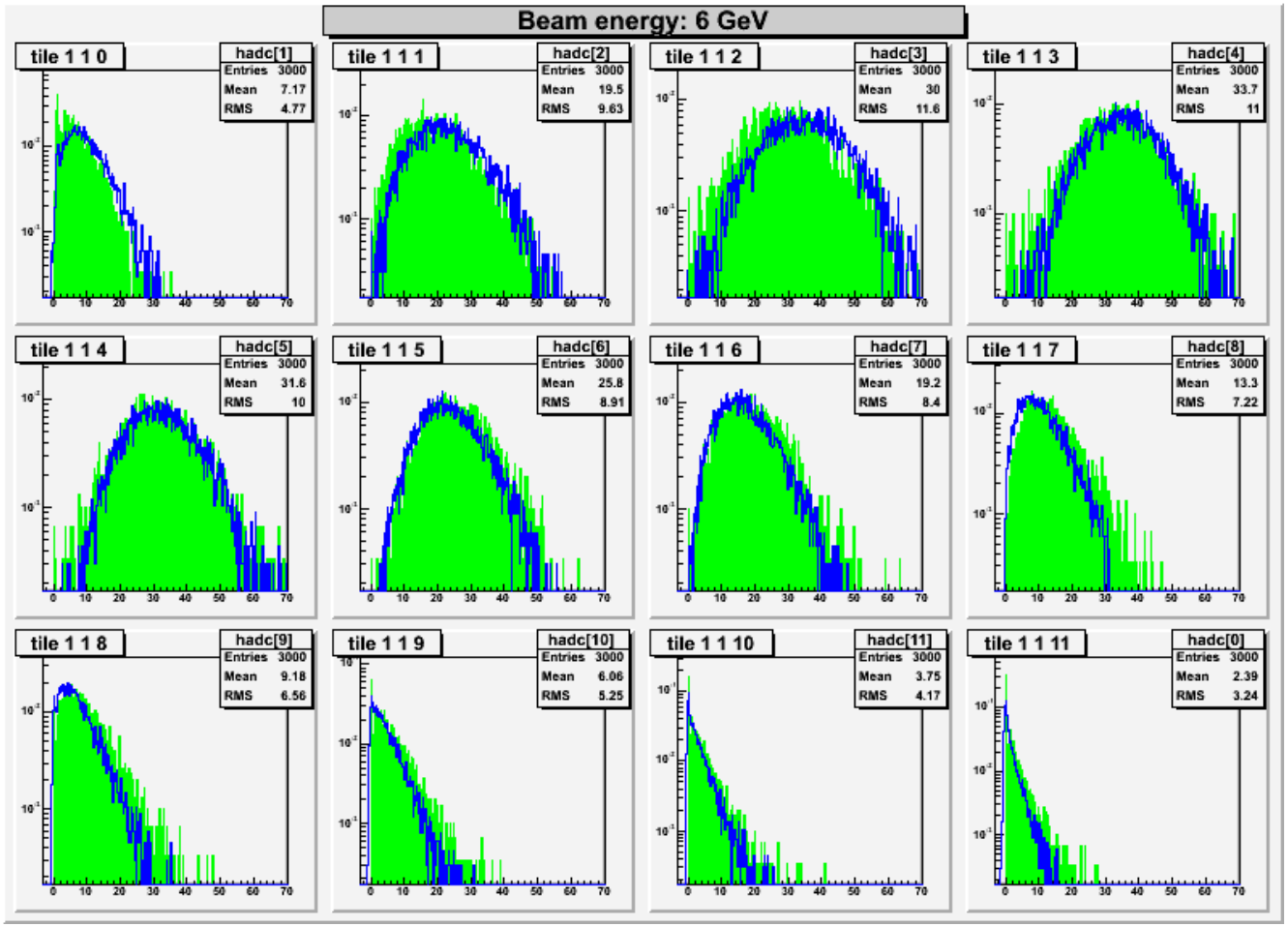
- significant effect only below 2 GeV
- eliminate negative and zero reconstructed energy
- improve energy resolution on low energy

- for higher energies no effect for mean of energy sums and resolution

- need triggering to exclude 2nd particle peak

Comparison of data and MC – Prague preamp

Longitudinal profile of particle showers for beam energy of 6 GeV

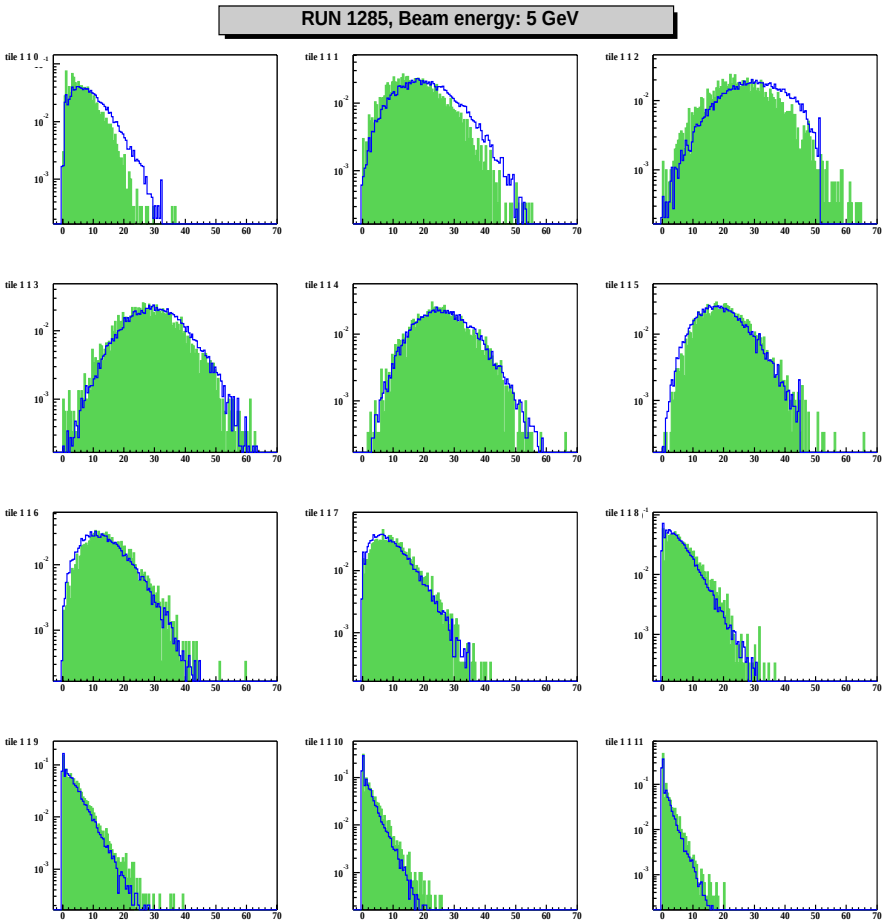


MC simulations
(full histograms)
Measured data
(open histograms)

Tiles 1-12
central stack
(beam view)

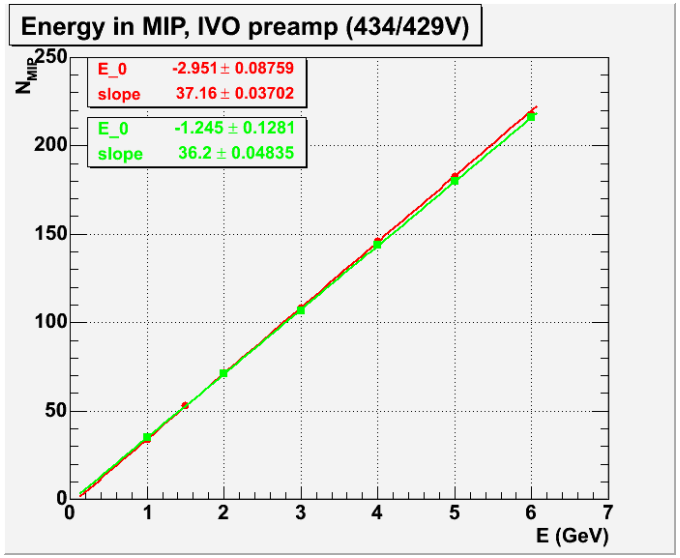
- most energetic cells: 3-5
- > 90 % in core

Comparison of data and MC - Minsk



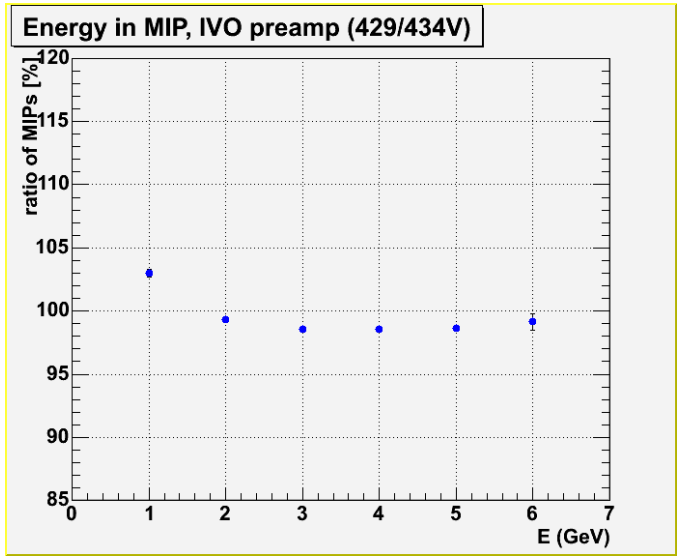
- both preamps similar spectra
- slight disagreement for front and back layers
- front: wider then MC, positive shift
- back: narrower then MC, negative shift
- seen in PM and SiPM as well
- denser material in MiniCal in comparison w/ MC ?

Linearity fit – Prague preamp



429 V (circles)
37.2 MIPs/GeV

434 V (boxes)
36.2 MIPs/GeV



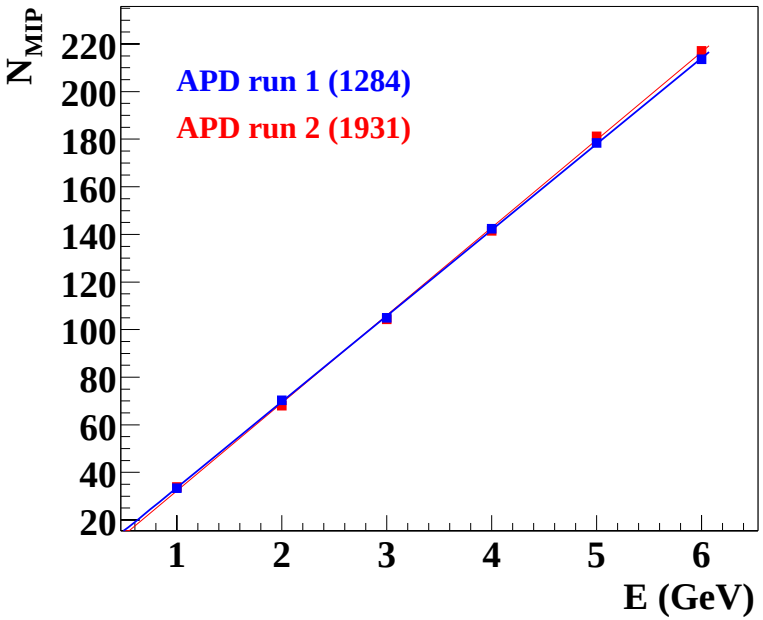
Linear fit to energy (in MIPs)

Ratio 434/429 vs energy

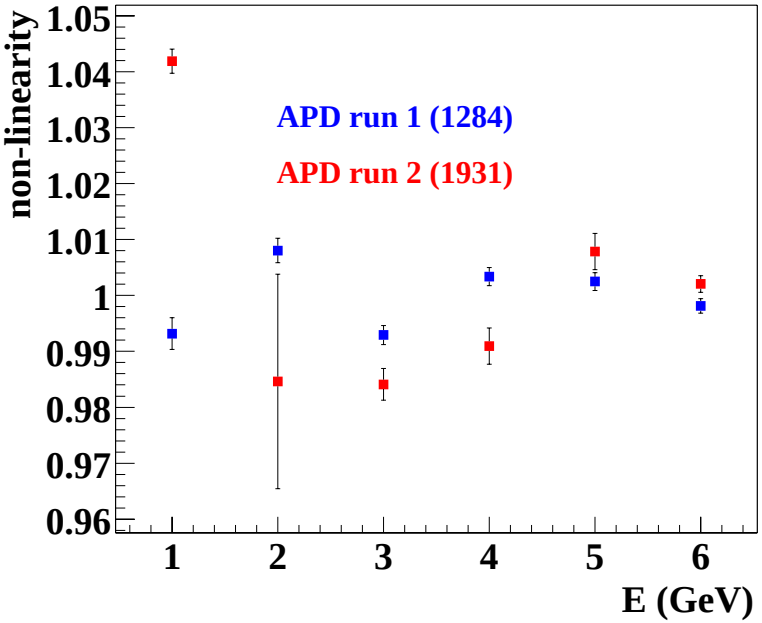
- Energy linearity between 2 HV runs in very good agreement
  - APD gain ratio of 1/0.6
- 434 V data are 1-1.5% lower (except for 1 GeV)
- Only statistic errors applied, not yet systematic uncertainties (from calibration, temperature correction, ADC effects, beam spread,…)

Linearity fit – Minsk preamp

Linear fit to energy (in MIPs)



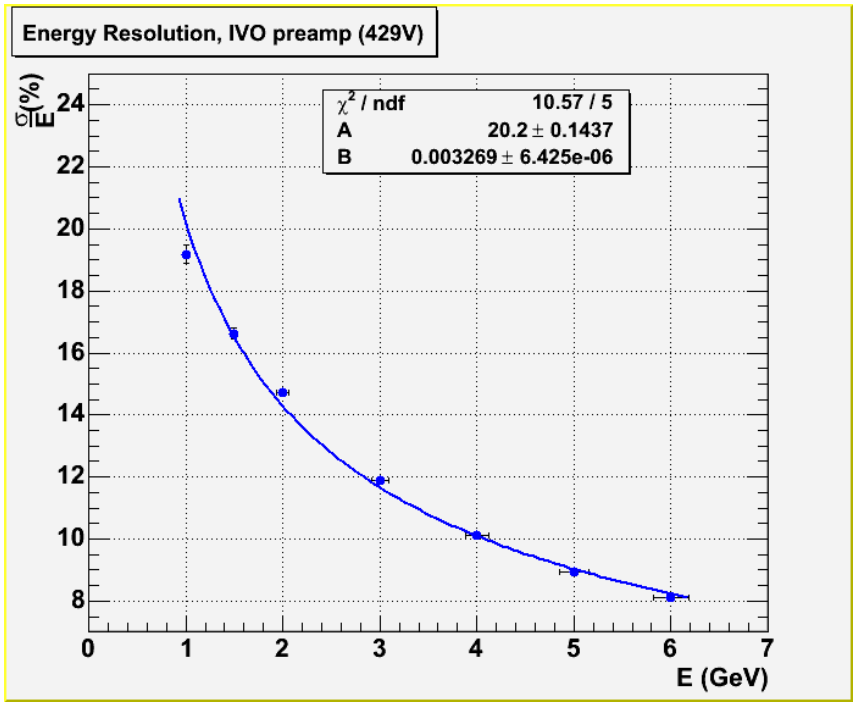
Deviation data points from linear fit



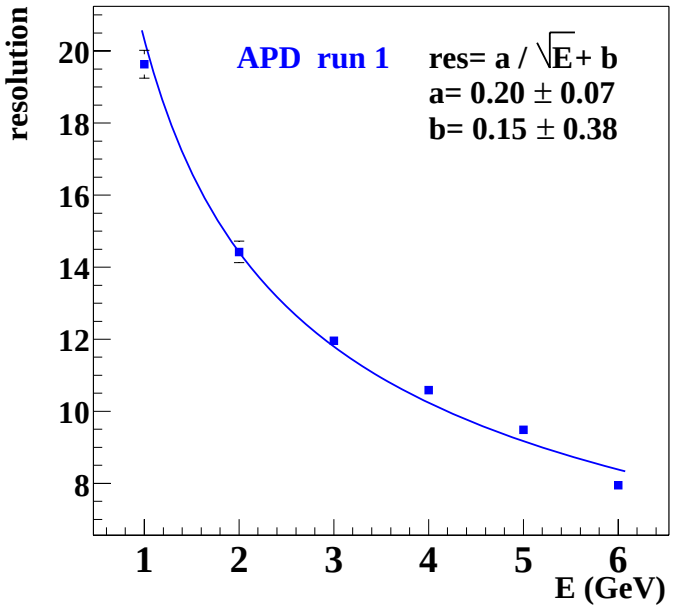
- again good agreement between two different data sets
- deviation of measured points from linearity fit at level 1%
- only statistic errors

Energy resolution fit to data

Prague preamp



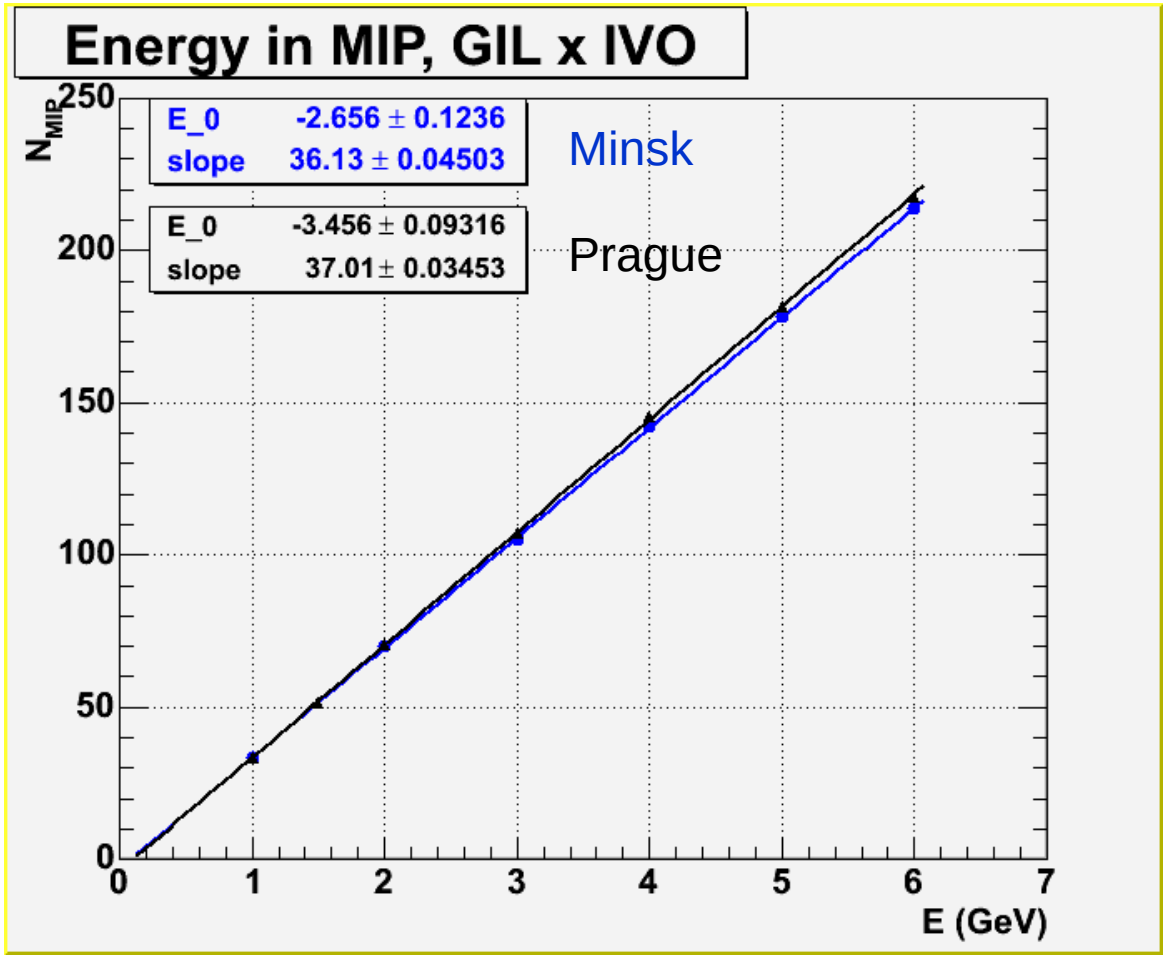
Minsk preamp



Energy resolution fit: $\sigma/E = A/\sqrt{E} + B$

- energy resolution fit for both preamps data are consistent

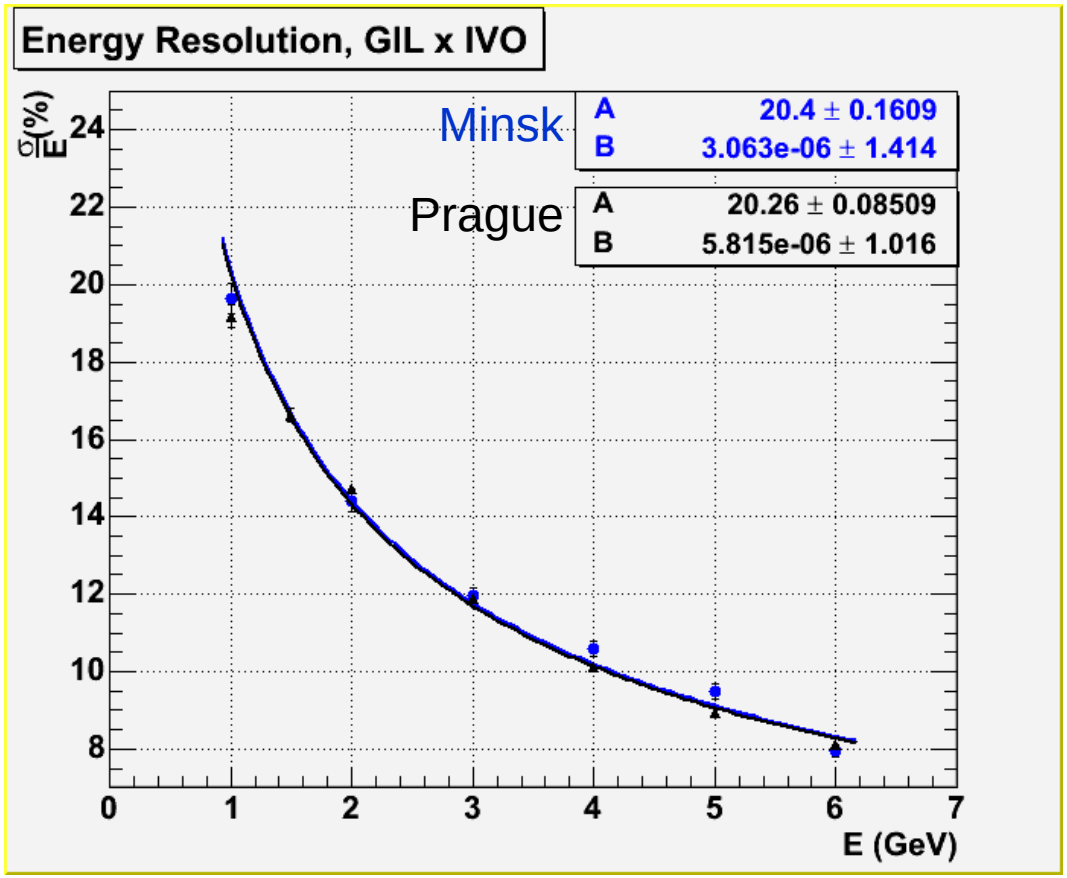
Linearity: two preamps



- Data taken with different preamps are consistent according to linearity fit on measured energy
- w/o syst. uncertainty

  36.1 x 37.0 MIPs/GeV

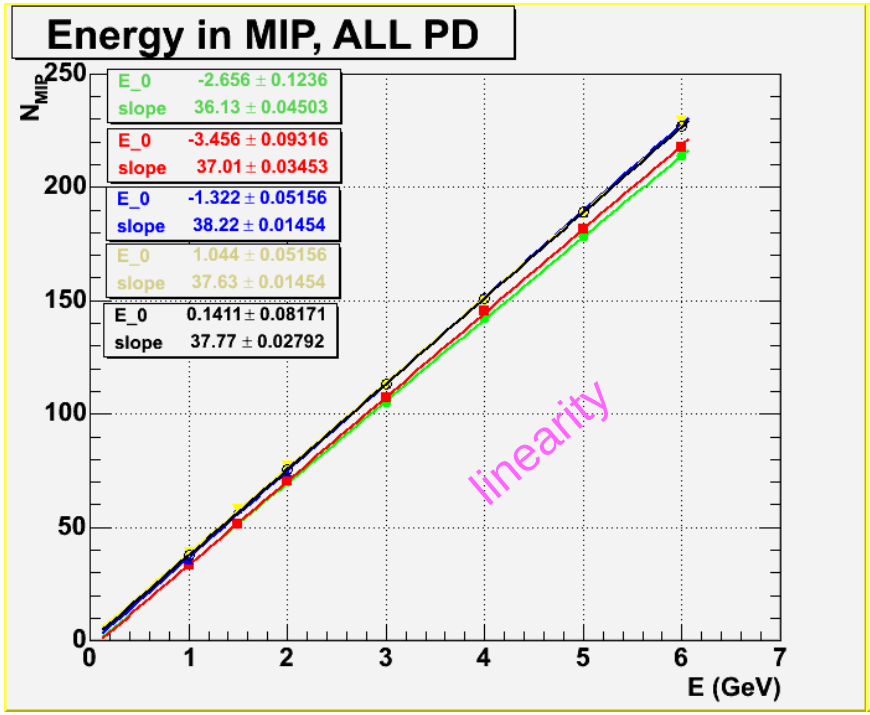
Energy resolution - comparison

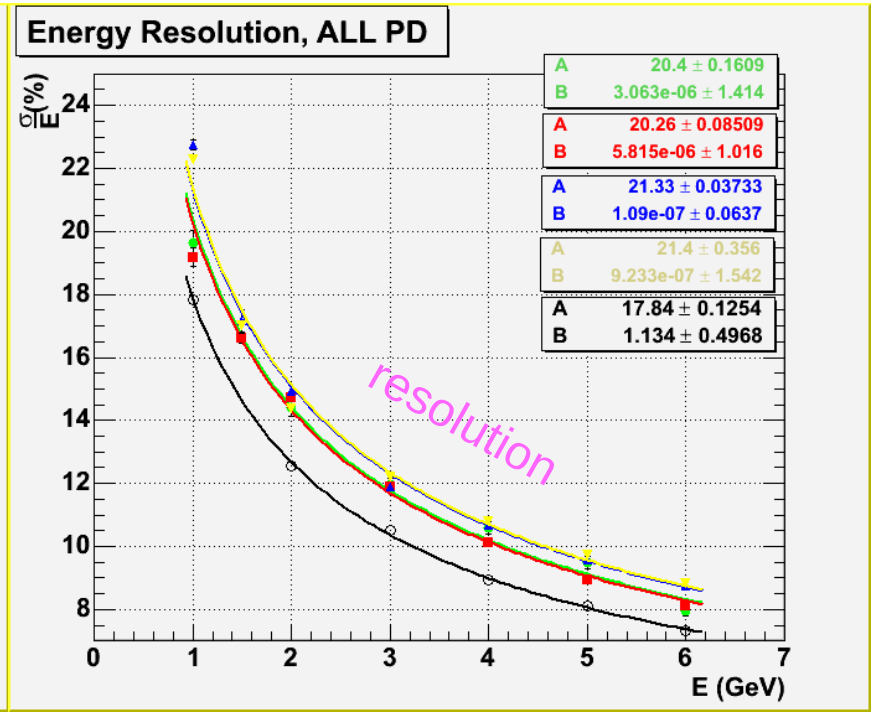


- Data taken with different preamps are consistent according to fit of energy resolution
- stochastic term for both preamps is about 20%
- fit is not sensitive to constant term (no systematic errors ?)

Different PhotoDetectors

APD-Prague APD-Minsk MAPM SiPM MC simulation





- Good agreement among different photodetectors for both energy linearity and resolution (NO systematic errors applied!)

Conclusion & Outlook

- Significant progress in measurement & analysis of APDs as photodetectors in MiniCal
- Data taken with different preamps are consistent in linear fit to measured energy

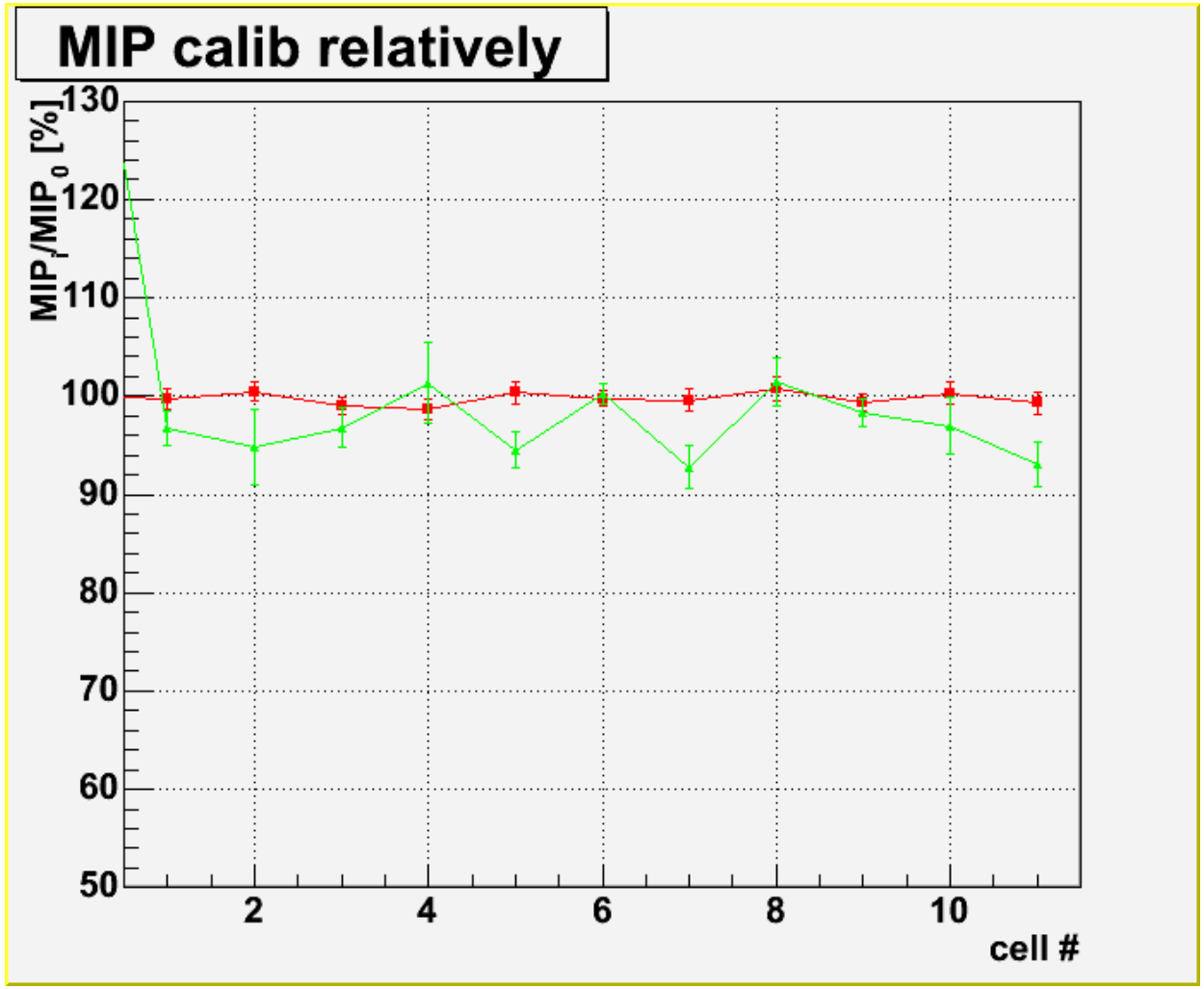
- Good agreement among data coming from various studied photodetectors (APD, PM, SiPM)

- For APDs we need final study on systematic uncertainties

APDs proven to be alternative photodetectors for the tile-HCAL !

Backup slides ....

Gauss versus Landau



Energy linearity- diff. cuts