# MiniCal with APDs

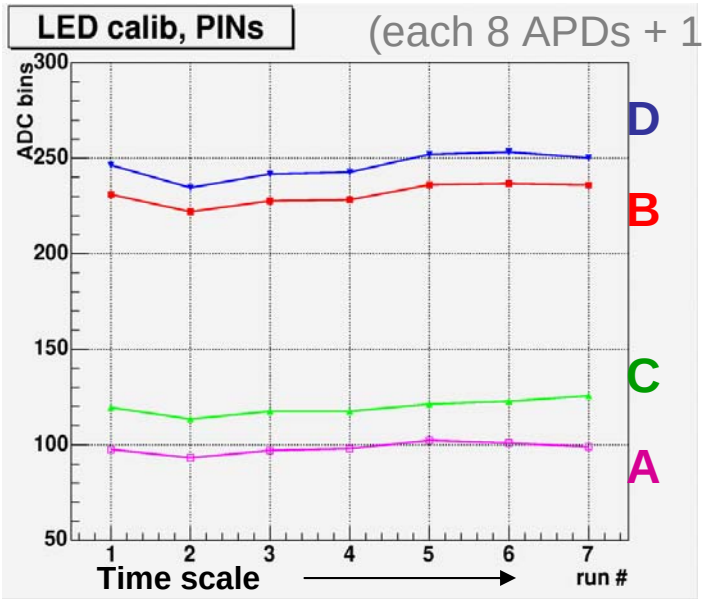
LED corrections and time stability

Results from APD analysis with errors

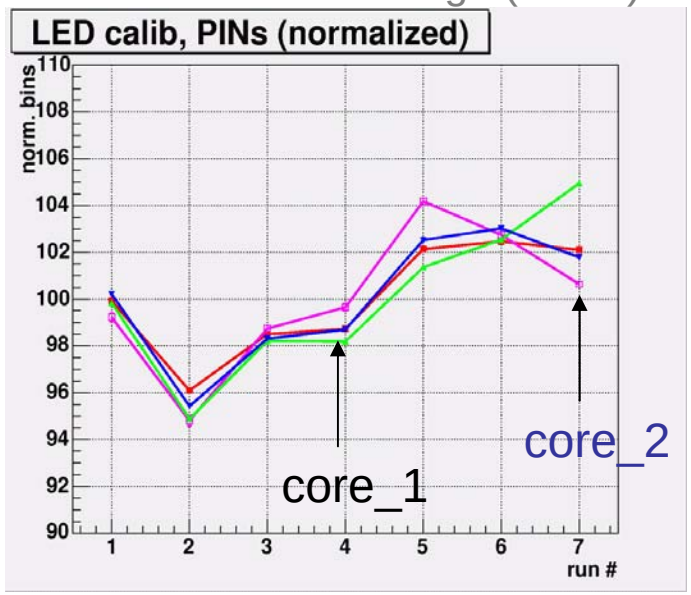
# PIN diode response to LED pulser

- studied during one set of MIP calibration data (typ. < 1h) as LED trigger
- 7 runs = 6 scan beam points + core stack scanned 2 times (for reproducibility)

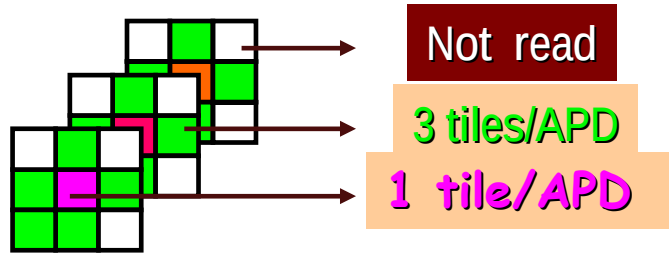
4 masks = 4 LEDs
(each 8 APDs + 1 PIN)




normalized to average (100%)

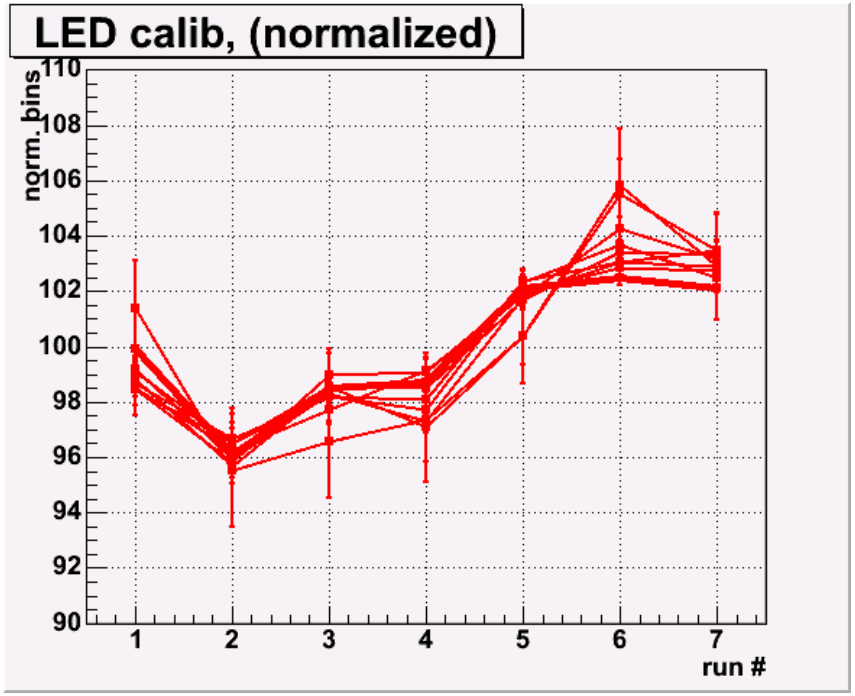



- similar behavior, abs. values 100-250 bins
- variation +/- 5% (in <1 hour) of LED system

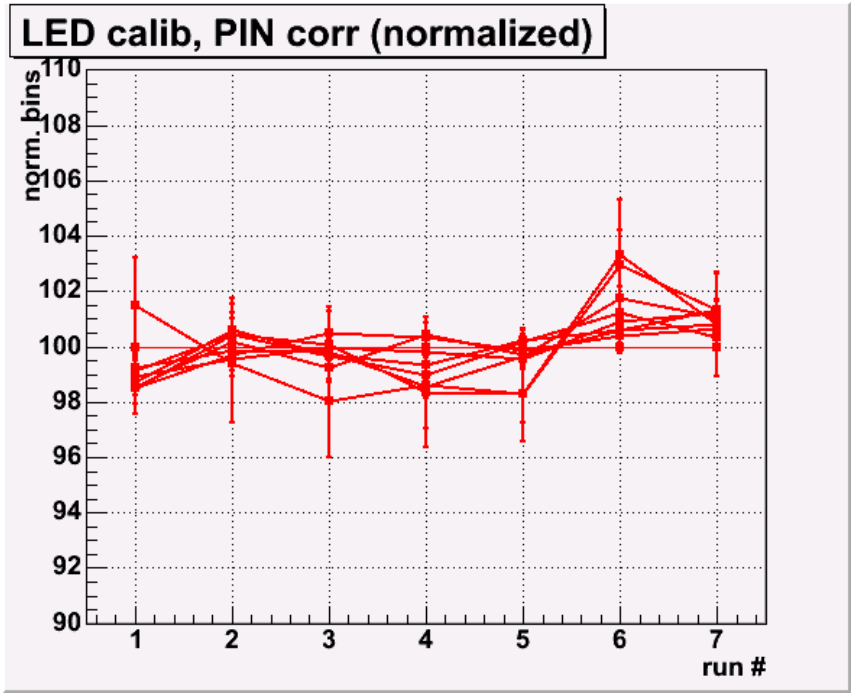


# APD response to LED pulser

**before PIN correction**



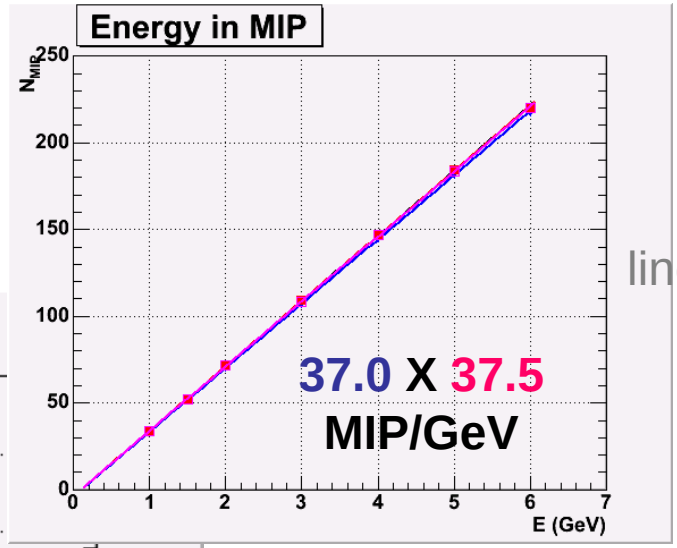

**after PIN correction**



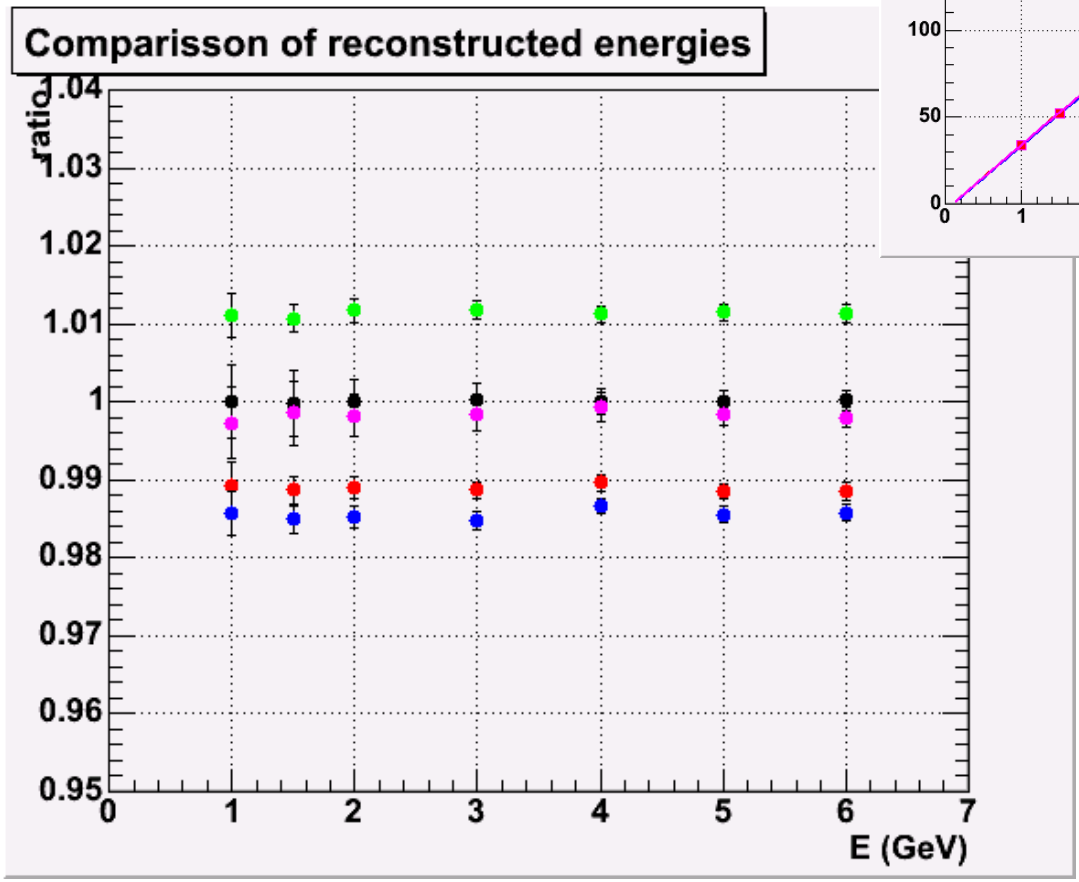

- same behavior as PIN's
- responses are smoother and flatter but still fluctuating after PIN corrections
- variation from average is mostly +/- 1.5% (several cells bigger = low response)
  - ➔ time instability of APD response within calibration procedure
  - ➔ can be taken as uncertainty or apply as LED correction to data → energy

# Influence of LED corrections on energy

Reconstruction of measured energy:
- using MIP calibration factors
- w/ applying LED corrections




linear fit to energy

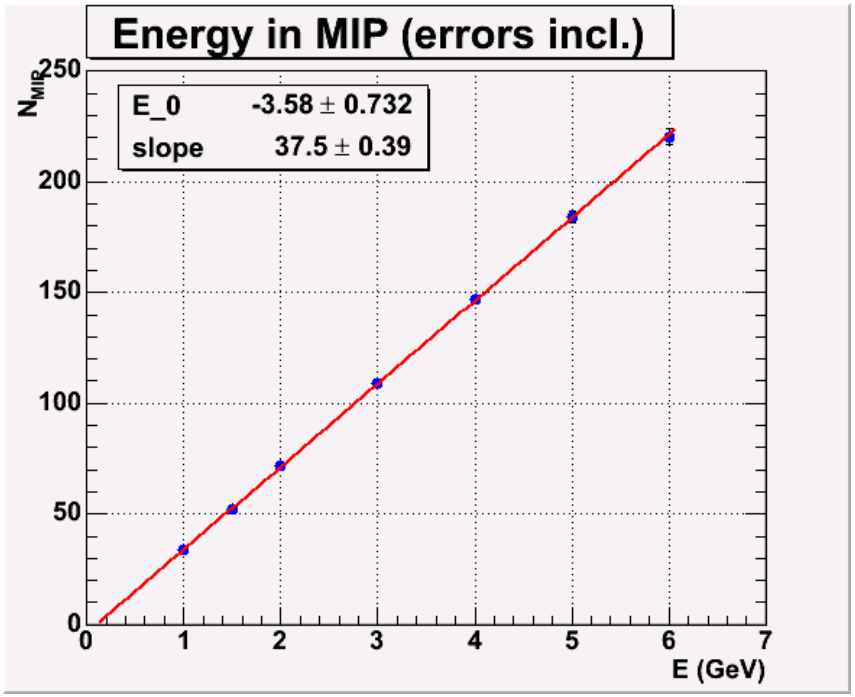


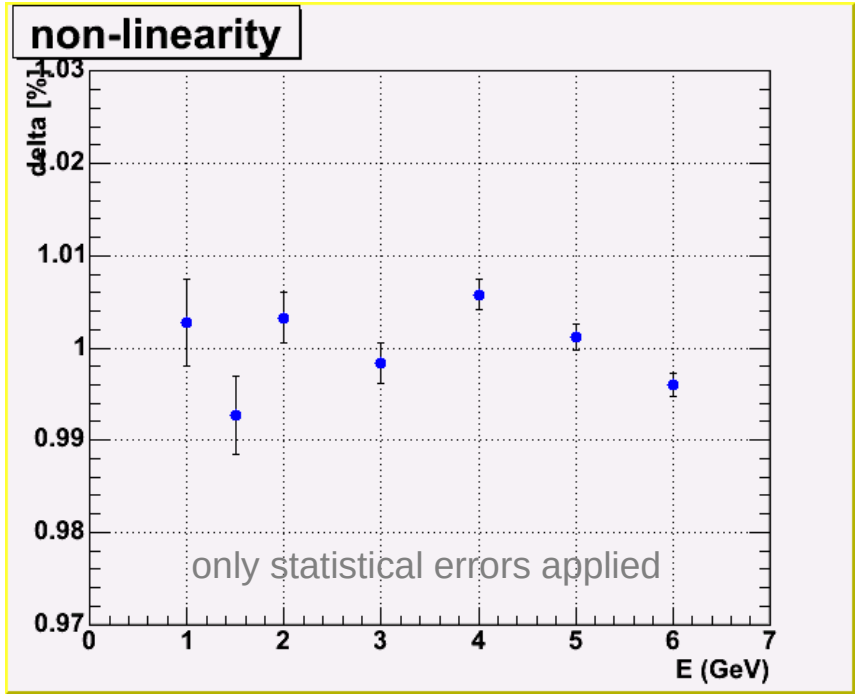

- original MIP calibration (core_1)
- + or – MIP calib error added
  → error on energy ~ +/– 1.0%

- new calibration run (core_2)
- core_2 w/ LED corrections

➔ applying LED correction lead to consistent results on energy (< 0.5%)

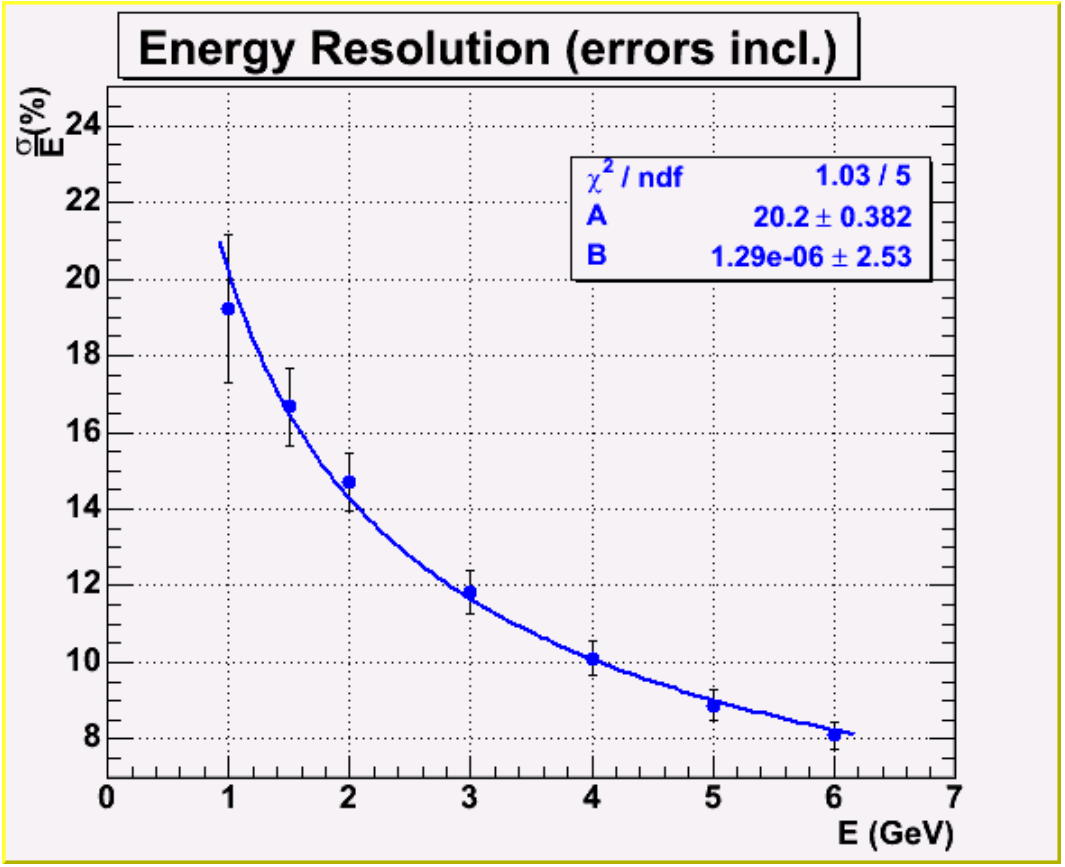
# Energy measurement: linearity




- systematic error of 1.5% applied:
  cover syst. uncertainties (calibration method, choice of fit, LED correction, …)
- changes of energy fit slope are directly proportional variations (errors) of MIP calib. factors (driven by most populated cells in core)
- linearity is better then 1%, but fit w/o absolute term changes slope of 4%
  (additional ADC nonlinearity ? , energy measurement time instability ?, ..?)

# Energy measurement: resolution




➢ **systematic errors:**

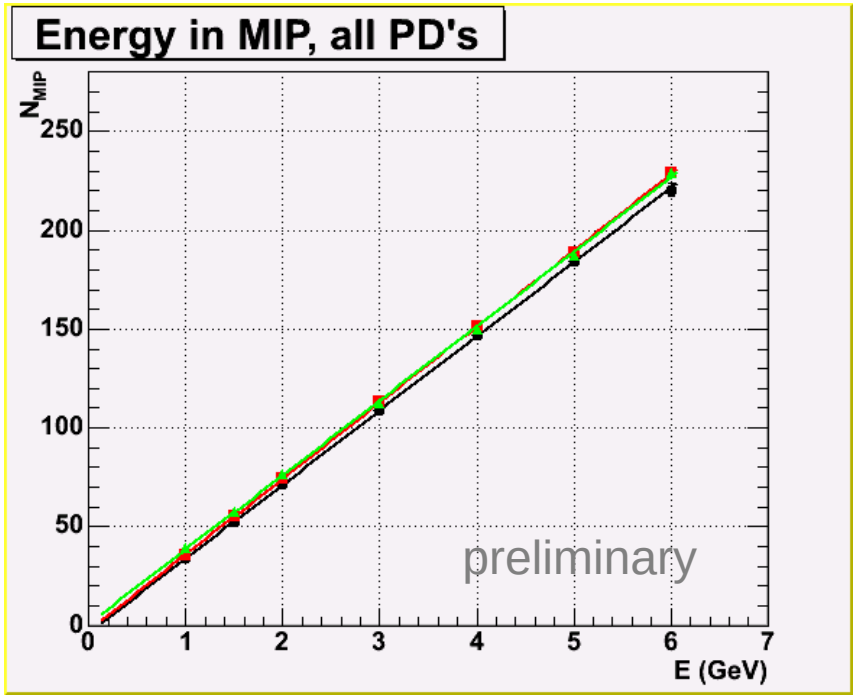
- due to noise - dep. on sigma of pedestal
- threshold uncertainty - ped separation, 2nd particle
- nonlinearity of measurement

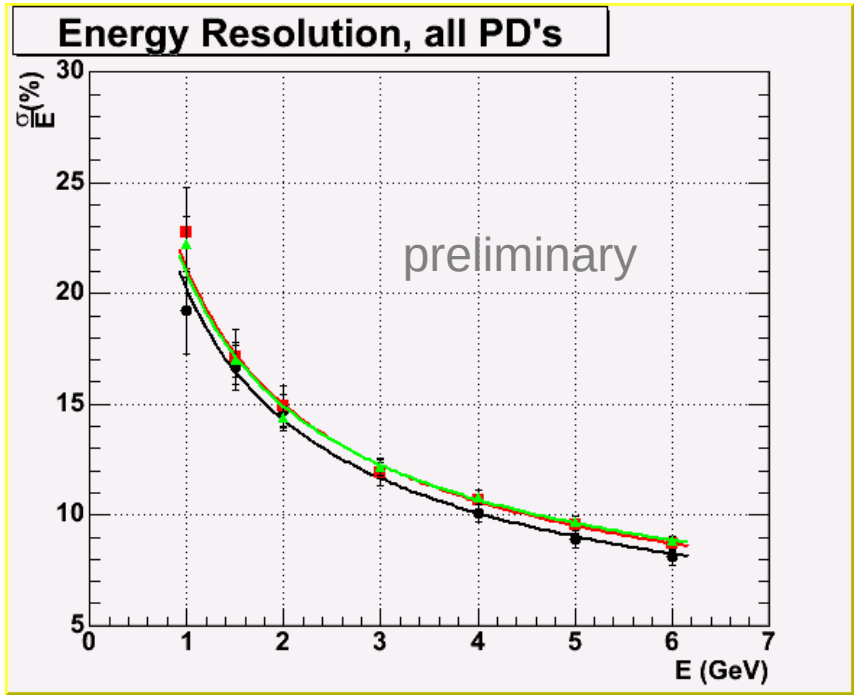
➢ **results:**

- stochastic term A = 20.2 ± 0.4
- constant term B = 0 ± 3

➢ fit is not sensitive to constant term

# Consistency among PDs: APD, MAPM, SiPM




- Linearity: 37.5 x 38.4 x 37.6 MIPs/GeV
- Resolution: 20.2 x 21.1 x 20.7 %/sqrt(GeV)

- APDs are in agreement with the others PDs at level of 5% (or better) (determination of systematic uncertainties is still in progress)

# Conclusion

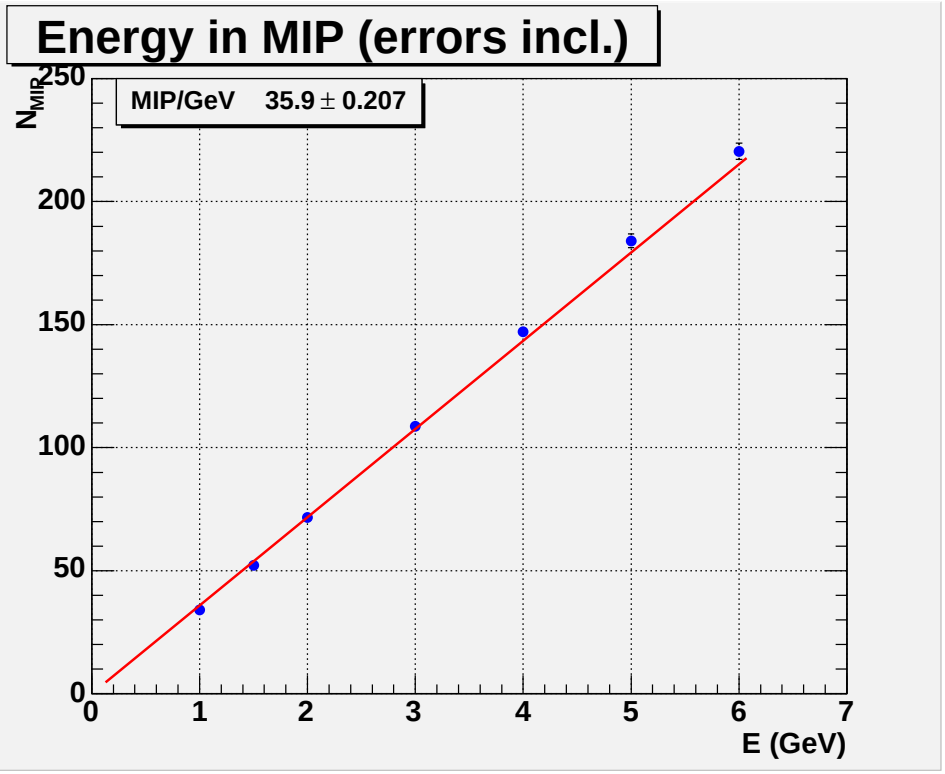
- LED corrections applied to calibration procedure
  ➔ improve time stability measurement
- Systematic uncertainties included in the fits
  to linearity and resolution (some has to be still discussed)

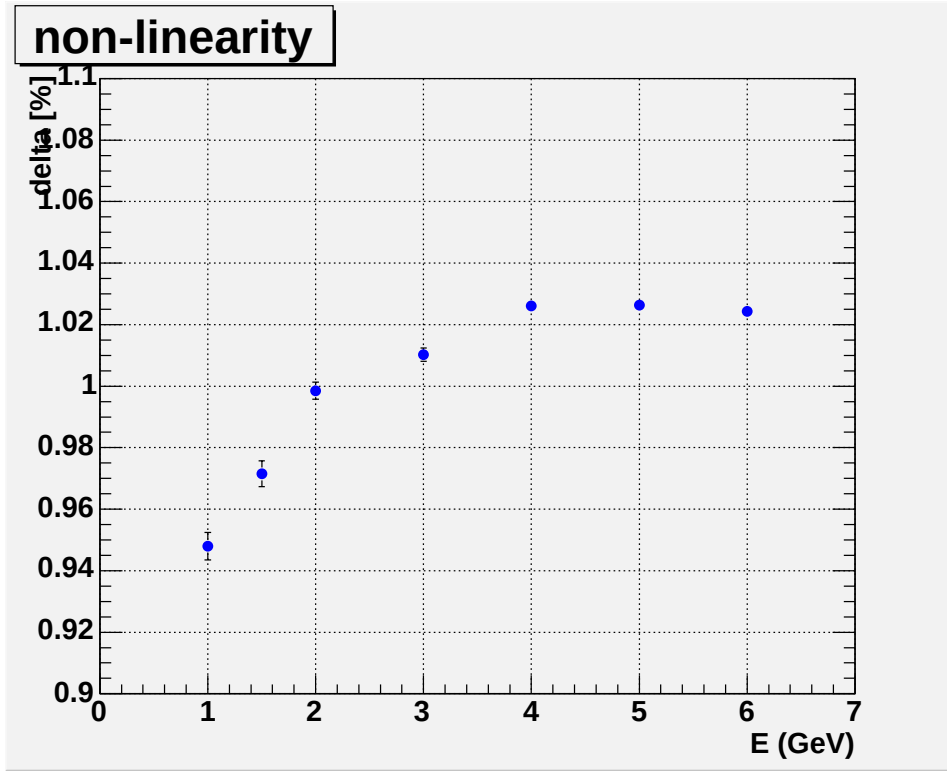
- APD results are in consistency with others PDs (of 5% level)
  (note: measurement setup a bit different)

➢ Analysis is about to go to paper

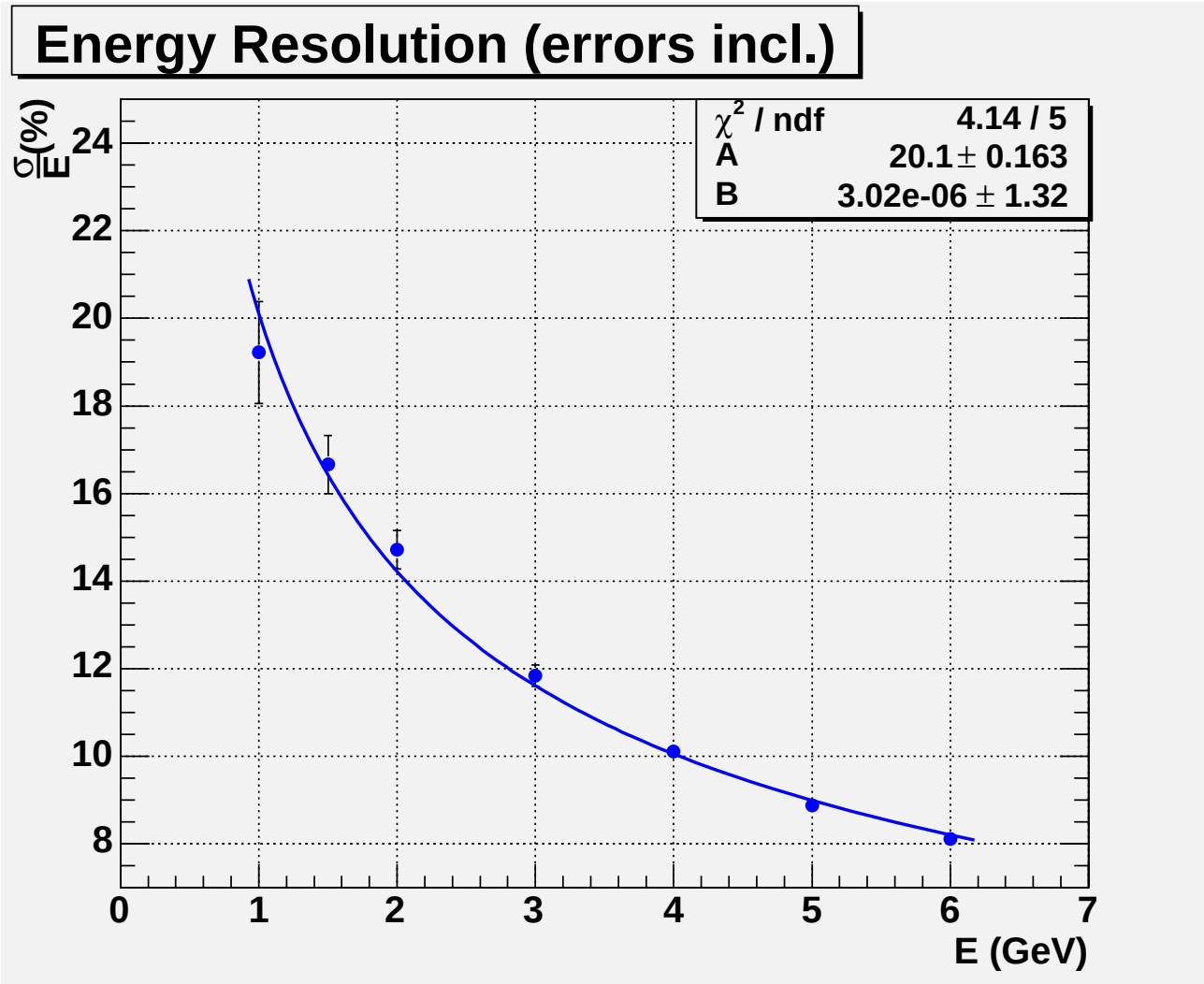
# Back up

# Linearity: w/o absolute term



# Energy measurement: resolution (v1)



# Energy measurement: resolution (v2)