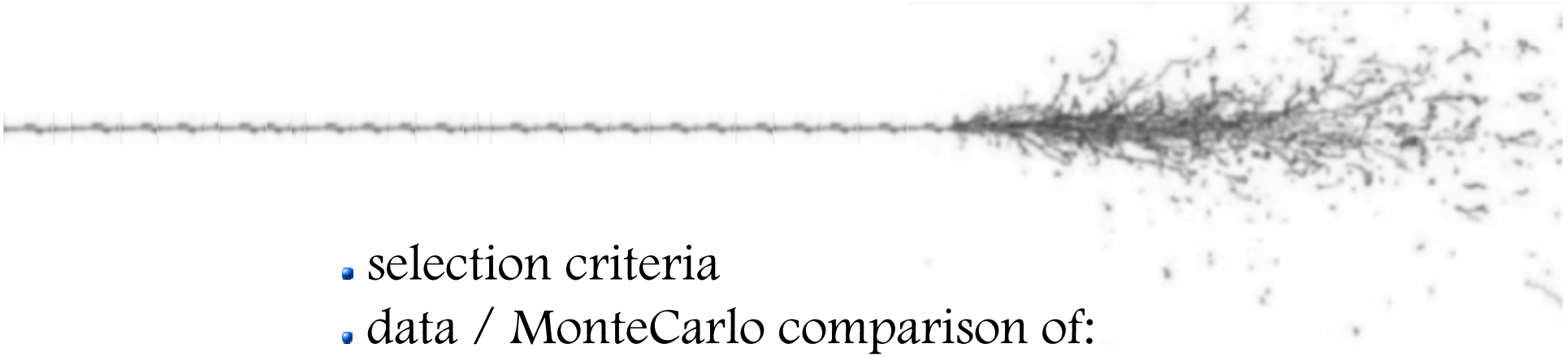
electromagnetic shower in the AHCAL



- selection criteria
- data / MonteCarlo comparison of:
  - handling
  - linearity
  - shower shapes

CALICE collaboration meeting may 10th – 12th 2007
Niels Meyer & Nanda Wattimena

DESY

CALICE Calorimeter for ILC

MC digitisation (reminder)

MOKKA Monte Carlo [GeV]:

!! not in released code !!

→ Monte Carlo [MIP]

→ light crosstalk to neighbouring tiles

→ add MIP calibrated pedestal events (from data)

→ remove hits below 0.5 MIP & uncalibrated channel

simulation of nonlinearity

→ convert to pixel with measured lightyield (pixel/MIP)

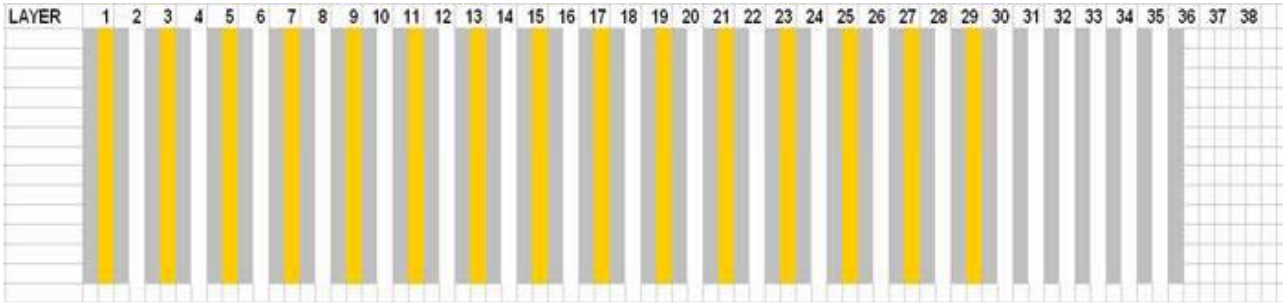
→ apply SiPM response curve measured at ITEP for each SiPM

→ convert back to MIP with same lightyield

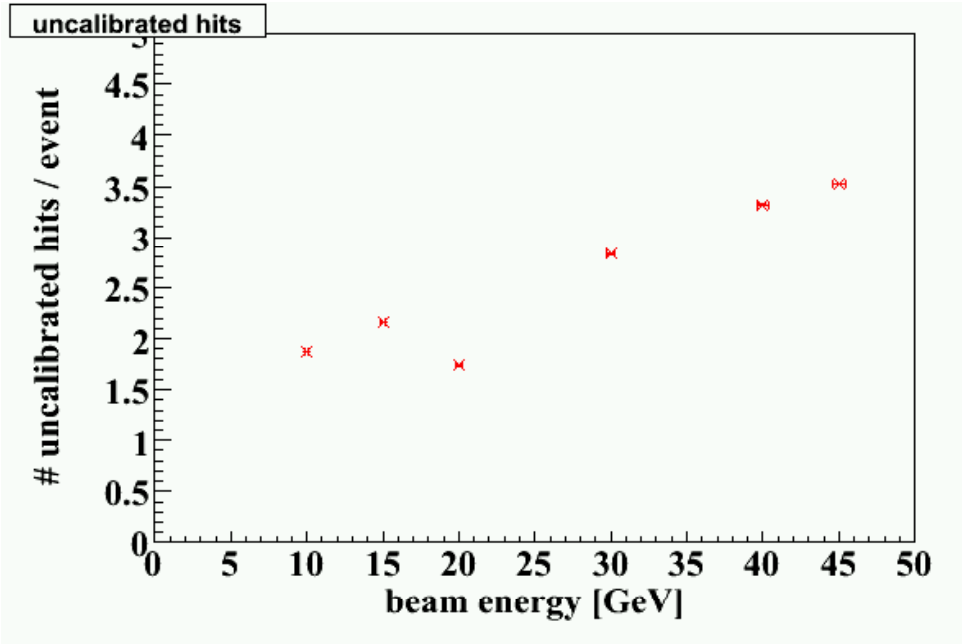
→ convert back to GeV

selection criteria

- HCAL only August runs (double sampling, wrong SiPM working point ~ 0.5 V too low Bias)
- 50 GeV secondary beam (320678, 320671, 320666, 320665, 320664, 320660)
- demanding 3x3 cm^2 trigger on & 1x1m^2 trigger off
- ignoring hits below 0.5 MIP
- ignoring uncalibrated (MIP, gain or intercalibration) channel



uncalibrated channel



- less than 4 hits in uncalibrated cells per event (mean value)
- no hits above ITEP measured curves at any energy

- hits in uncalibrated cells are removed from analysis
  the energy loss is not compensated for
- MC includes uncalibrated cells and treats them in the same way

non-linearity correction

!! different correction as in released code !!

SiPM response curves measured at ITEP

→ linear fit to first 3 points to fix „linear pixel“ scale

→ convert data from ADC channel to pixel

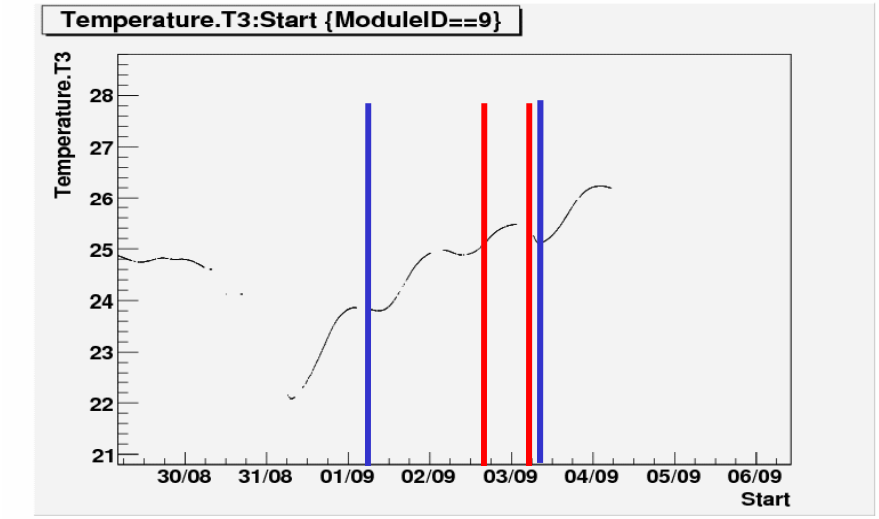
→ find corresponding „linear pixel“

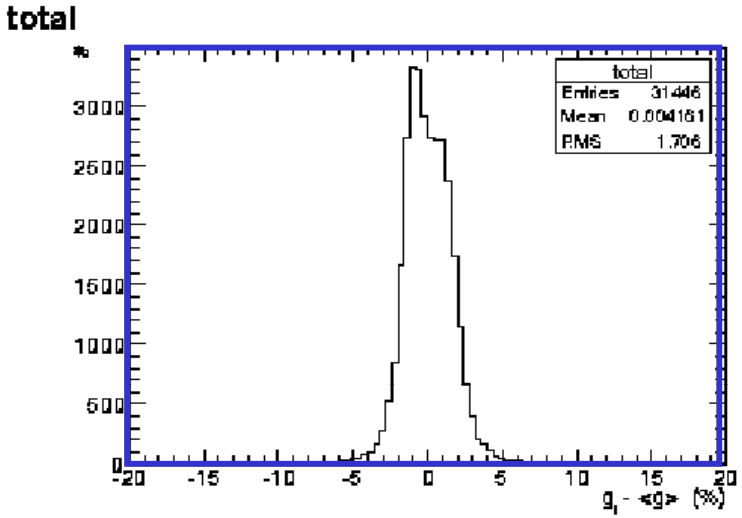
→ convert corrected pixel to MIP

→ convert MIP to GeV

- if no ITEP curve in database use arbitrary curve
- if data point higher than measured curve use last measured point

temperature variation





temperature variation in module 9
during the gain taking periode:
~ 2.5 K
during the electron runs temperature:
~ 0.5 K

gain variation during this periode:
< 2%

systematic uncertainties

temperature stable within ~0.5K (not corrected for → systematic error)

$$A[MIP] = f_{resp}\left(A[ADC] \cdot \frac{I}{G} \right) \cdot \frac{G}{I \cdot M}$$

gain calibration G from low LED light: $\sigma_G \approx 2\%$

⊕ intercalibration I from LED light: $\sigma_I \approx 2\%$

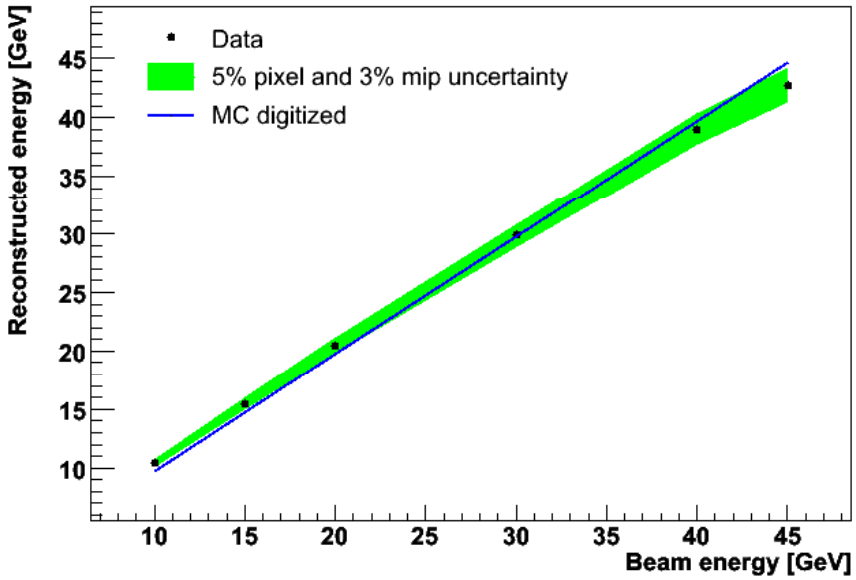
⊕ non-linearity correction f_{resp} from ITEP curves: $\sigma_f \approx 4\%$

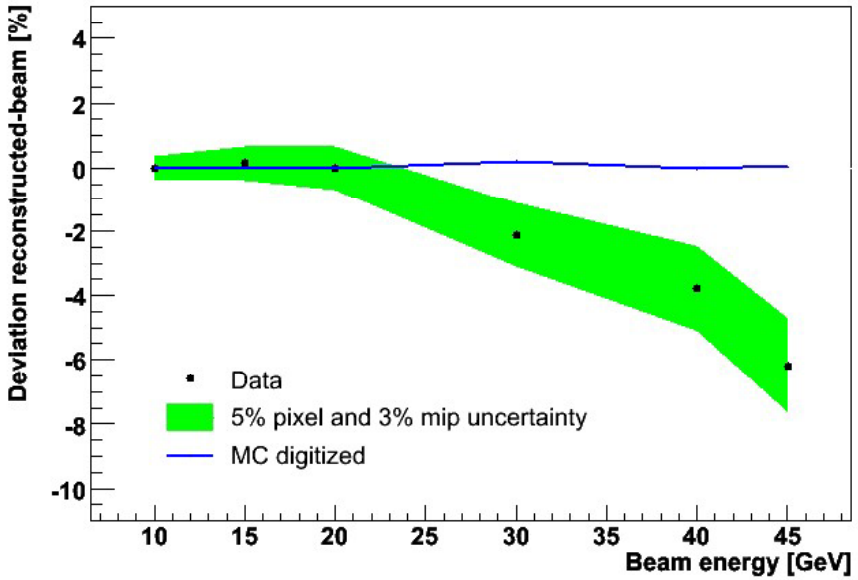
→ Pixel uncertainty: $\sigma_{pix} \approx 5\%$

⊕ MIP calibration M from muon beam: $\sigma_M \approx 3\%$

- σ_{pix} has to be propagated through non-linearity correction ☹
- fortunately this leads to σ_G & σ_I almost cancel out ☺
- σ_M is the dominating error

linearity

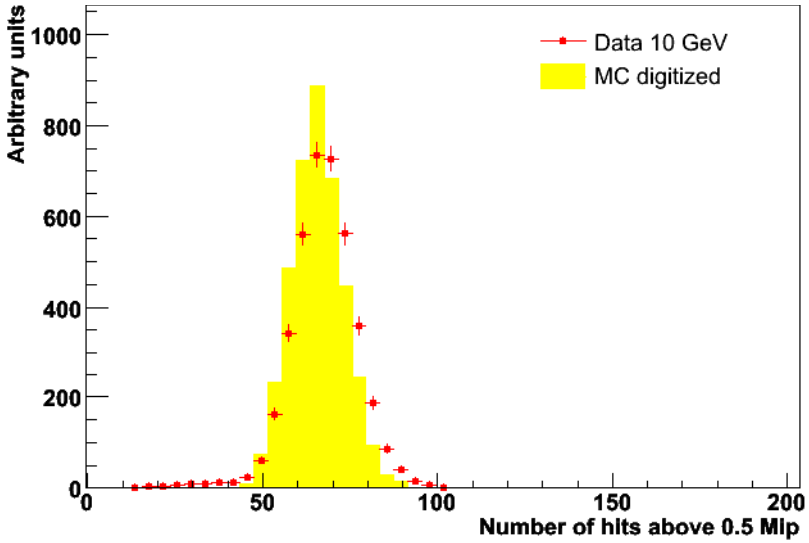


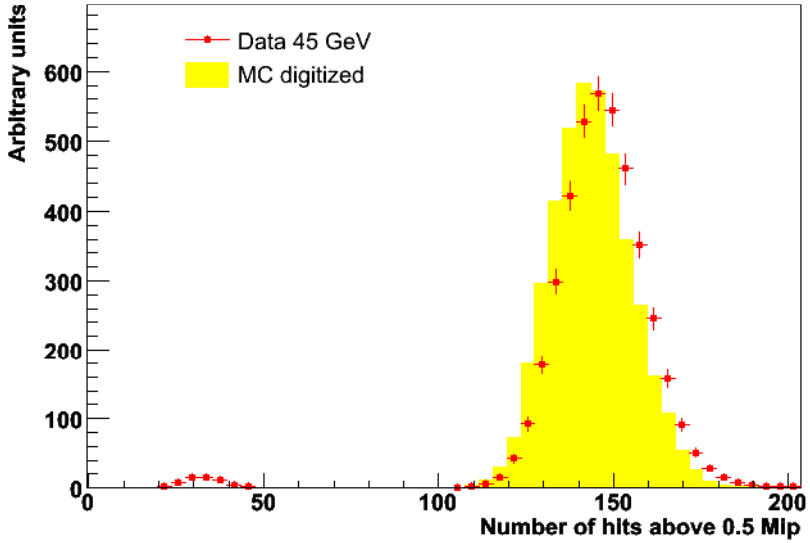


sampling factor SF_{data}(10-20 GeV): 34.75 MIP/GeV = 0.029 GeV/MIP
sampling factor SF_{MC}(10-20 GeV): 39.99 MIP/GeV = 0.025 GeV/MIP

data still shows saturation effects up to 6%
difference due to shifted working point: data taking – ITEP measurement ?

number of hits

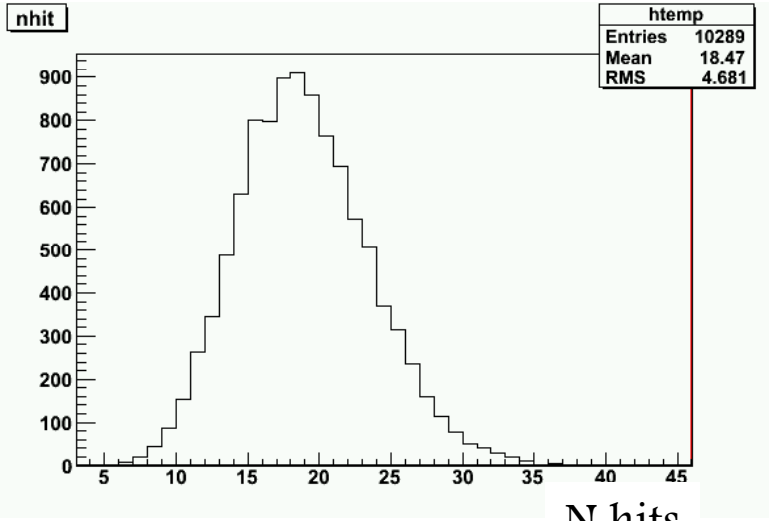




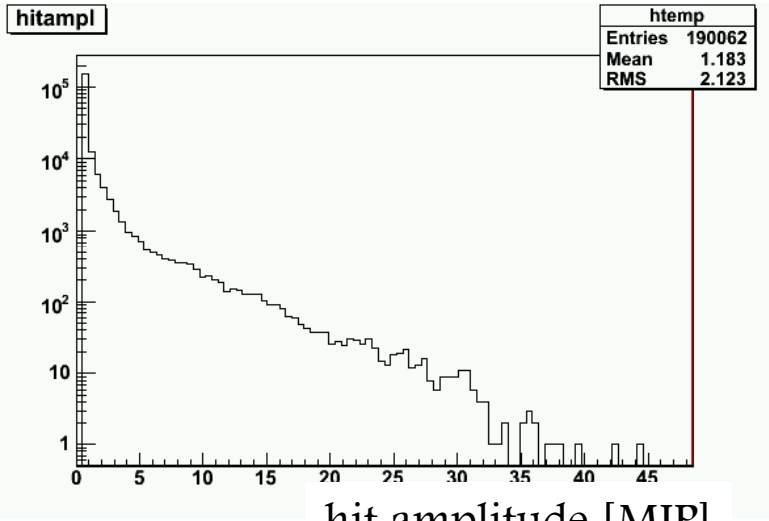
~ 2 more hits in data
→ within nonlinearity effect

still „MIP“- reminent at high energies
→ selection can be improved

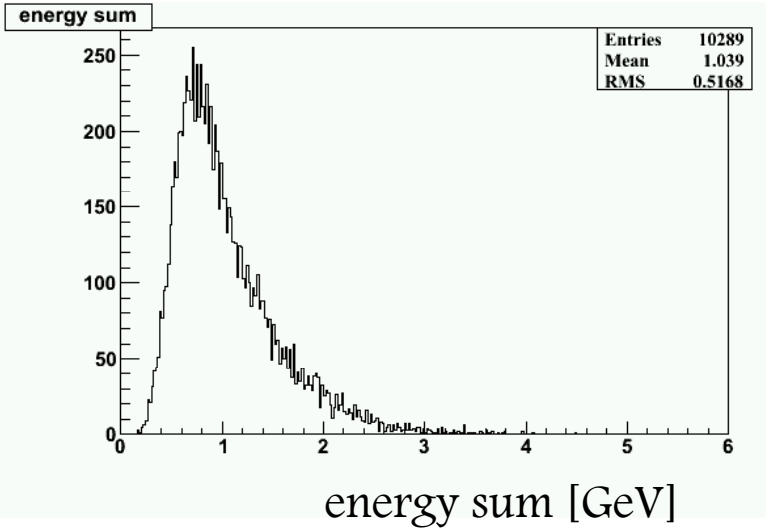
noise contribution



N hits



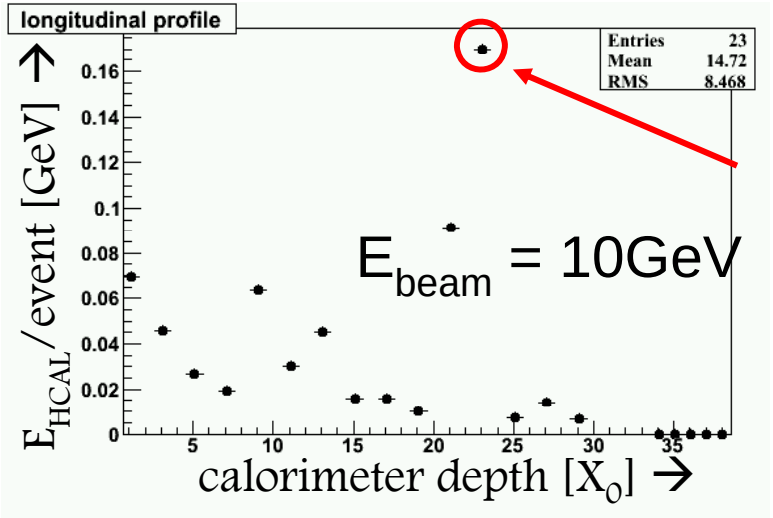
hit amplitude [MIP]



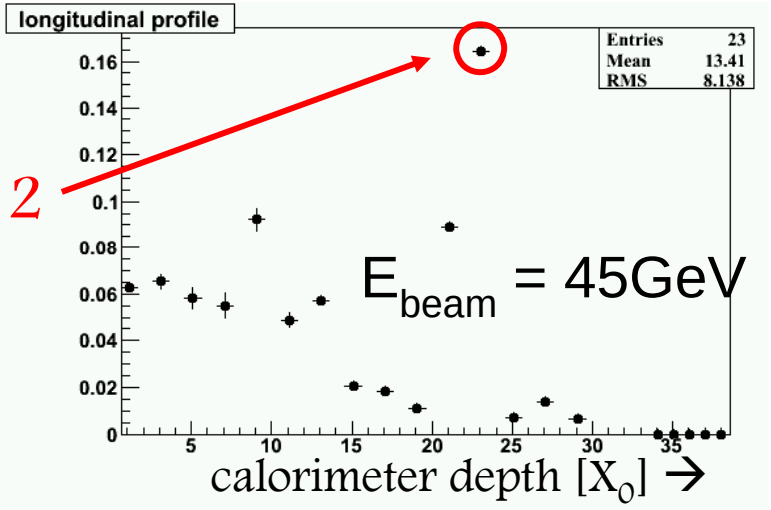
energy sum [GeV]

18 noise hits @ 20GeV beam
with 1.2 MIP per hit
times 1.8*0.029 GeV/MIP
→ 1.1 GeV noise

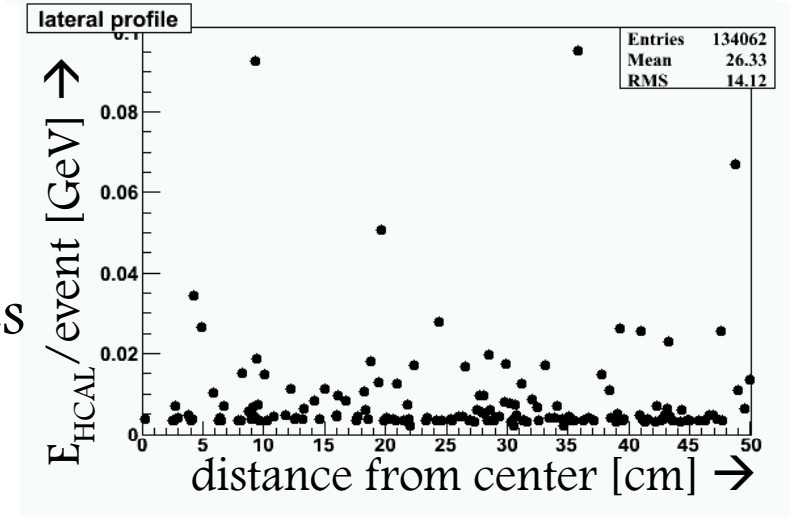
noise shape



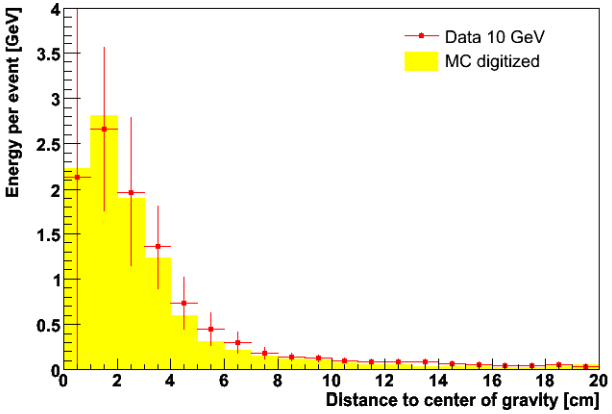
module 2

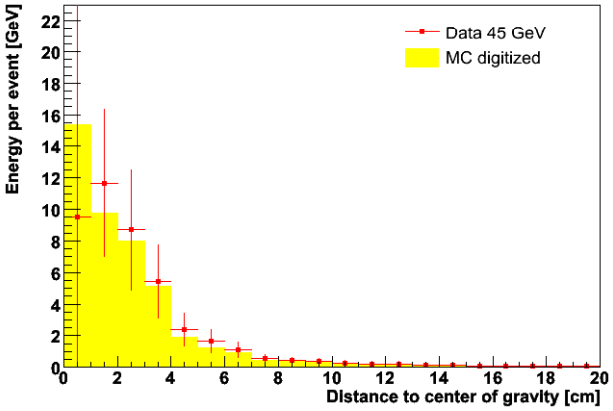


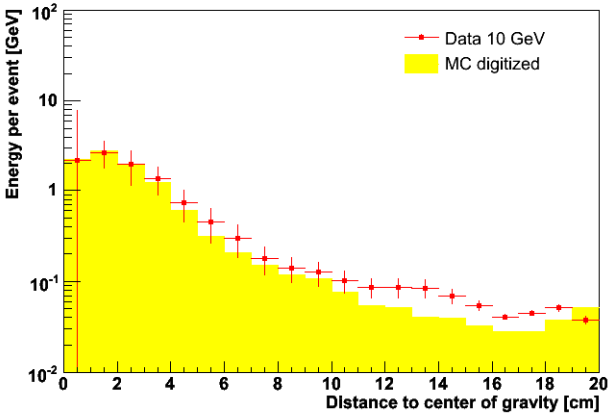
- lateral noise profile is flat
  (few outliners, though)
- longitudinal profile shows noisy modules
  (especially module 2 in layer 11)

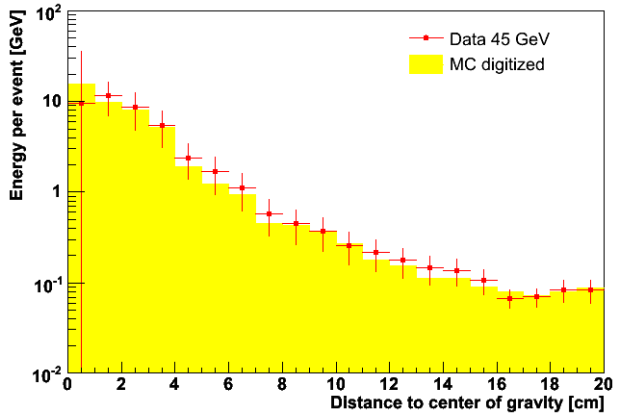


lateral shower profile



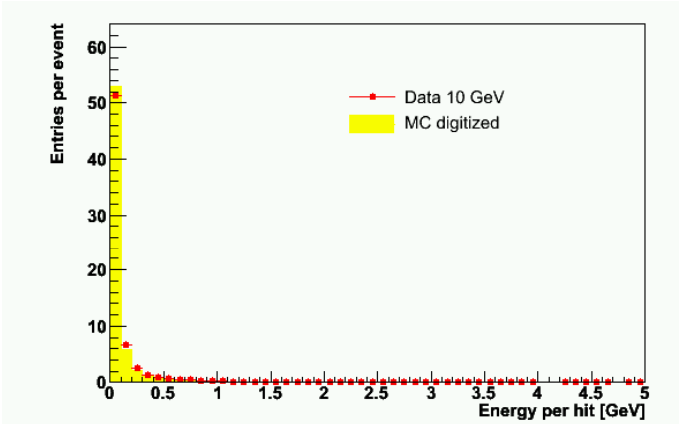


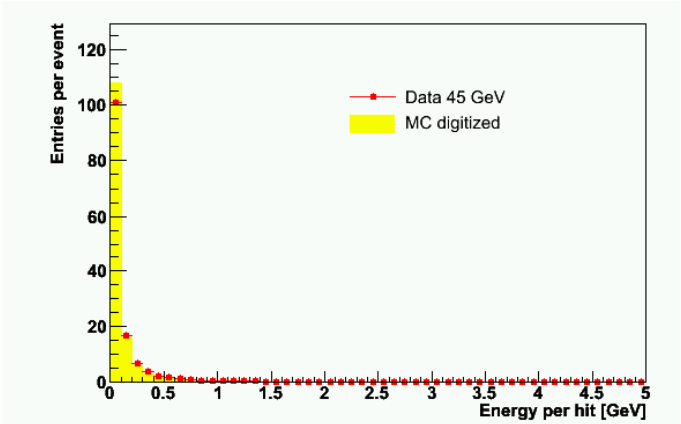


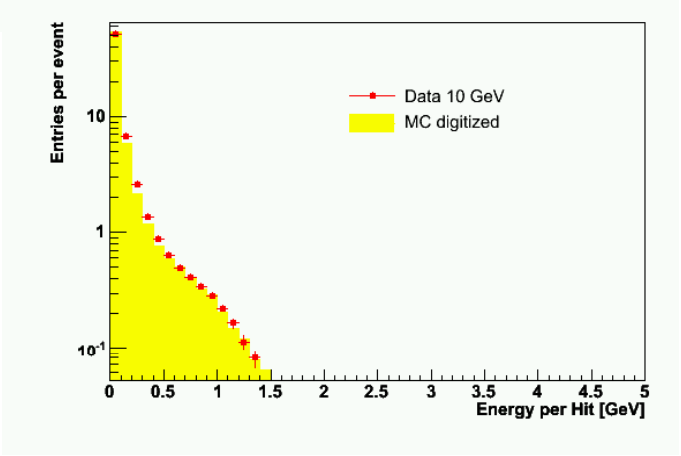


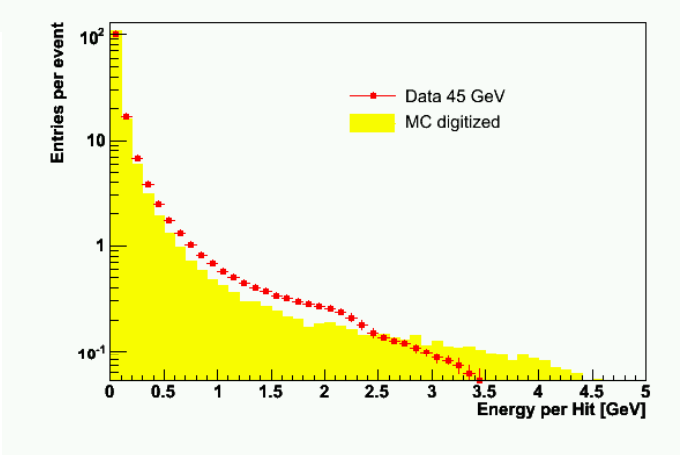
good agreement between data & MC
(within the rather large systematic uncertainties)

energy per hit



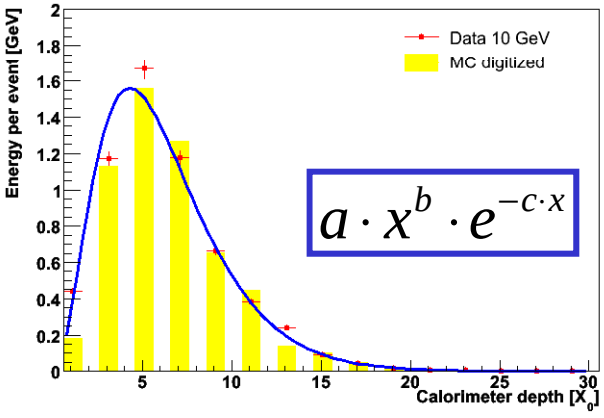


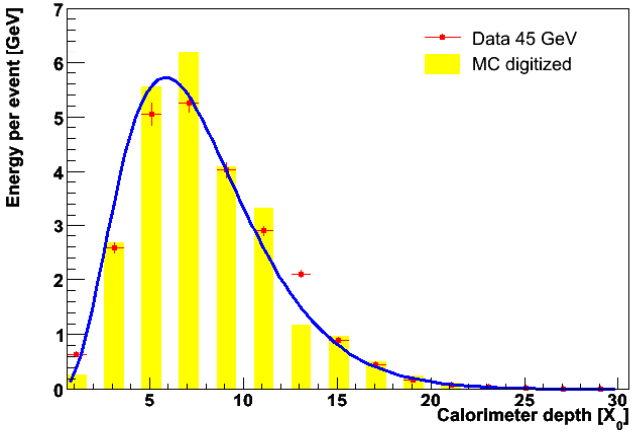


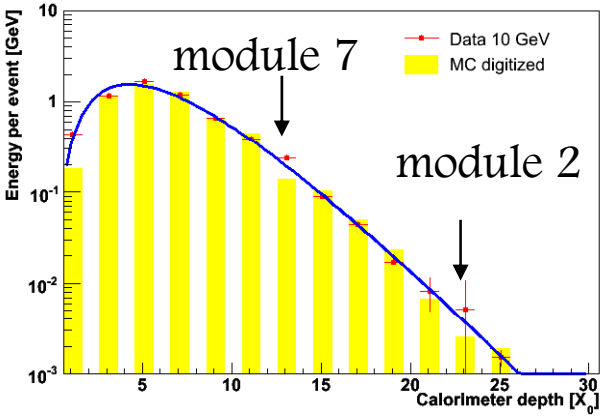


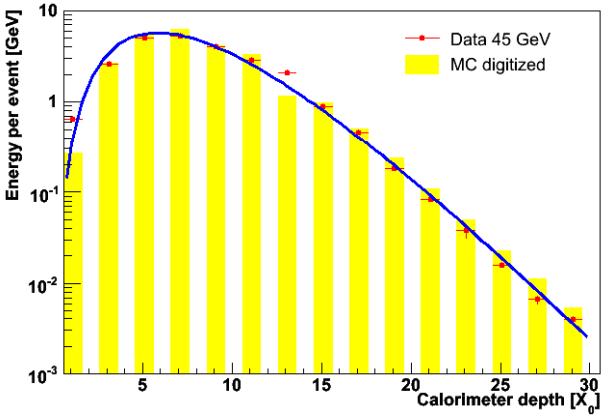
good agreement between data & MC at low energies (<20 GeV)
discrepancies at higher energies: beam profile & saturation

longitudinal profile









MC shower still starts too late (beam-line material in MC ?)
module 7: missing ITEP curve for 4 core cells

t_{max} & λ_{att}

shower depth $t_{max} = b / c$

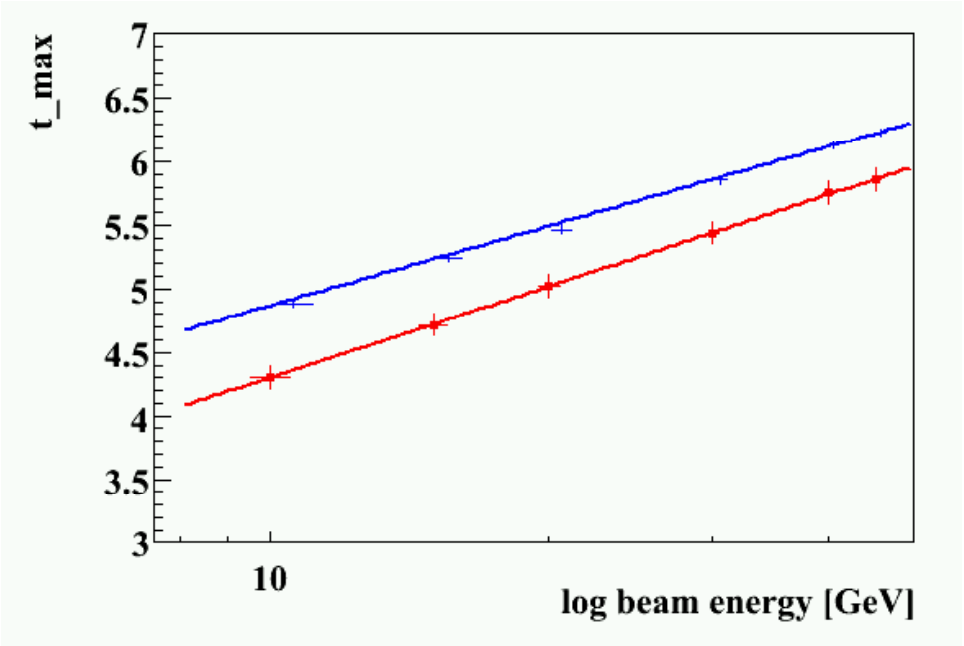
data: 1.04 • x + 1.91

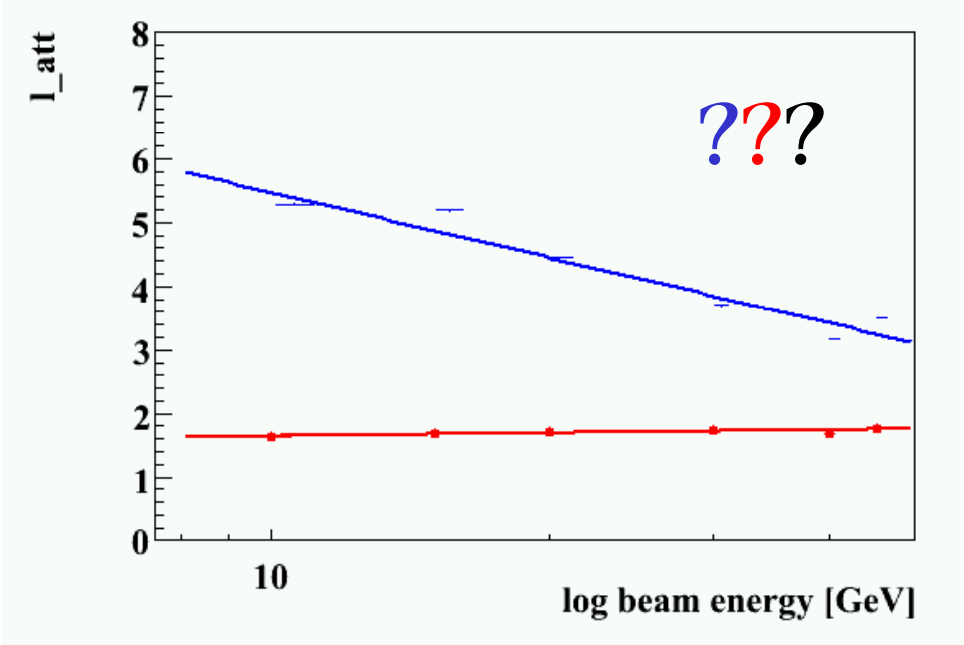
MC: 0.90 • x + 2.80

shower attenuation $\lambda_{att} = 1 / c$

data: 0.07 • x + 1.48

MC: ~1.48 • x + 8.87





summary & outlook

done:

✓ analysis chain fully established

☹ 6% nonlinearity remaining at high energy

✓ data & MC in agreement within remaining nonlinearity
dominated by systematic uncertainties

to do:

- repeat for October data
(more active layers, correct working point, but less data points)
- apply temperature correction (LED data)