HELMHOLTZ GEMEINSCHAFT

Analysis of electromagnetic showers in CALICE Analog Hadron Calorimeter prototype (AHCAL)

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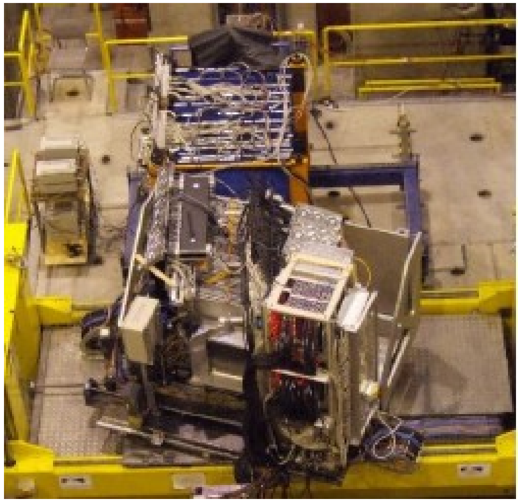
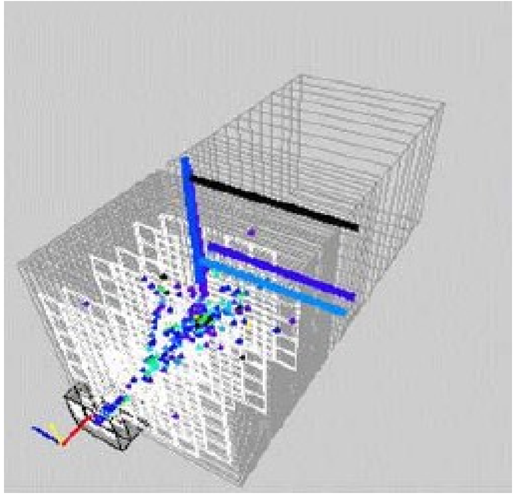


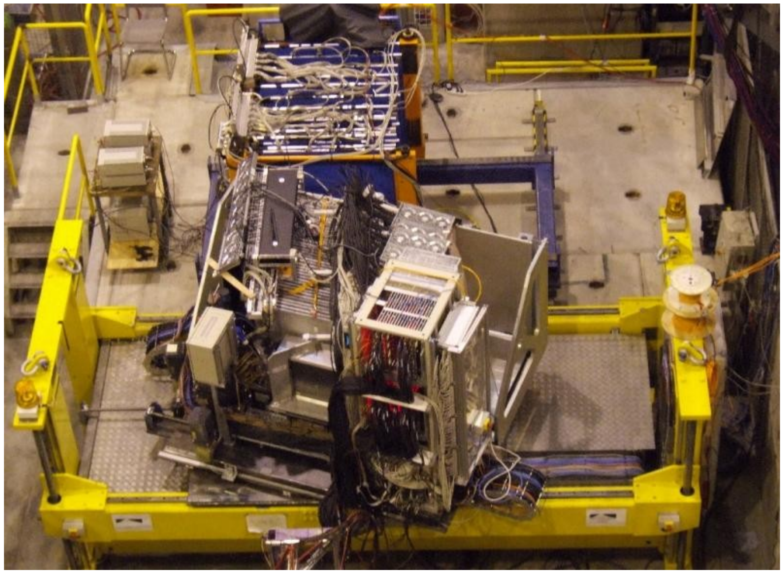


Universität Hamburg

CALICE Calorimeter for ILC

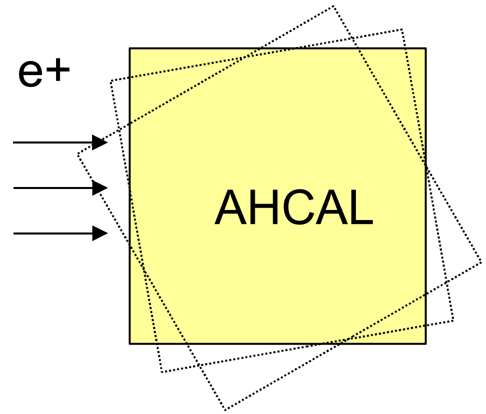
Analysis of electromagnetic showers in CALICE AHCAL prototype

CALICE tile AHCAL prototype at CERN 2007 test beam facility



AHCAL prototype:

- 38 layers (30 with high granularity at central region)
- each layer has 2cm of absorber (steel) and 0.5cm of active scintillator layer
- length: 114.57 cm, hadronic: 5 λ_0, e/m: 43.7 X_0

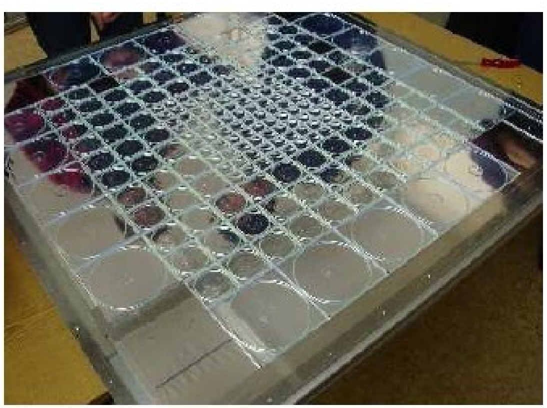


Positron runs collected:

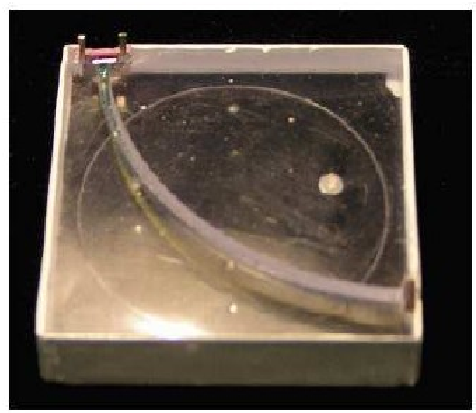
Energy: 10 - 50 GeV

Position of beam: 0, +6cm, -6cm

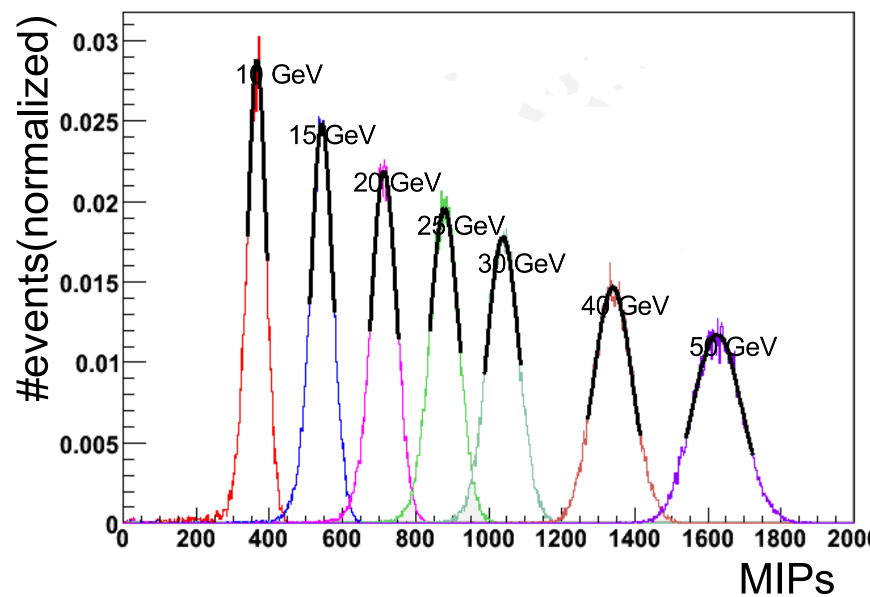
Angles: 0,10,20,30 degrees



HCAL layer with 216 tiles (3x3, 6x6,12x12 cm)



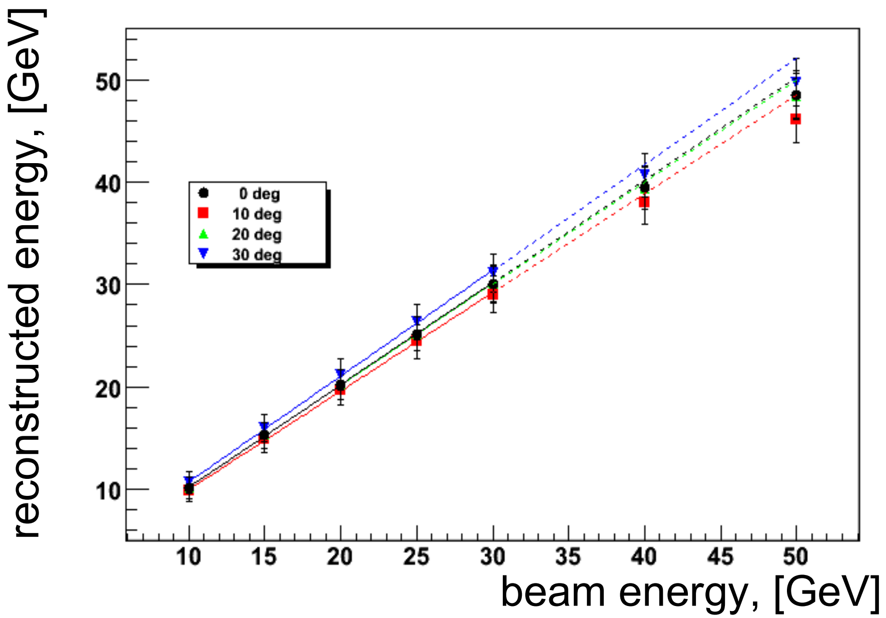
3x3 scintillator tile with WLS fiber and SiPM

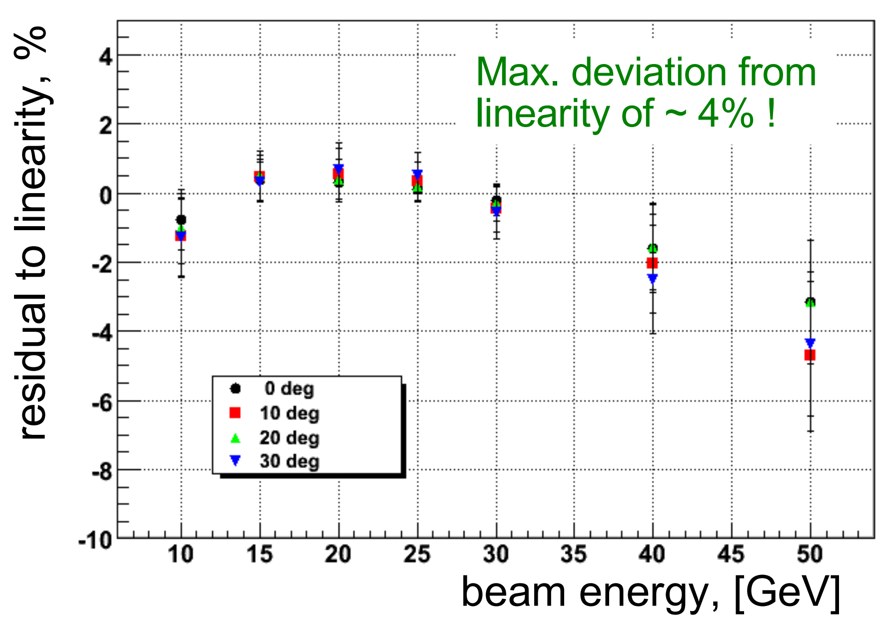


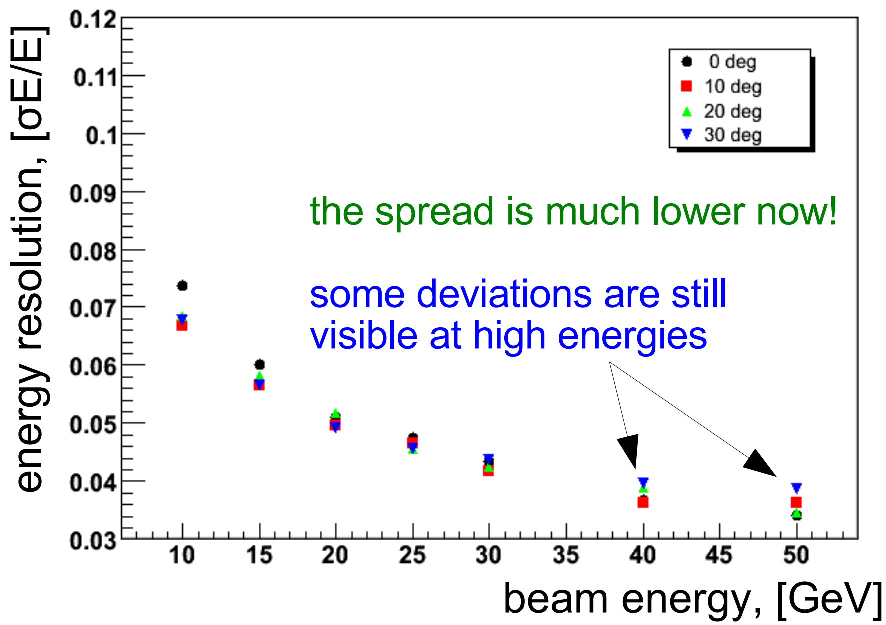
e+ energy reconstructed spectrum in Minimum Ionizing Particle (MIP) scale

Analysis of electromagnetic showers in CALICE AHCAL prototype

the very first results from e+ data analysis..







- 4 data samples have been analyzed
- removing “bad” tiles from analysis
- more accurate calibration (a re-scaling of SiPM's saturation curves)
- a temperature correction for SiPM is applied

Longitudinal profile study..

An electromagnetic shower's energy profile:

$$dE/dt = p_1 \cdot t^{p_2} \cdot e^{-p_3 \cdot t}$$

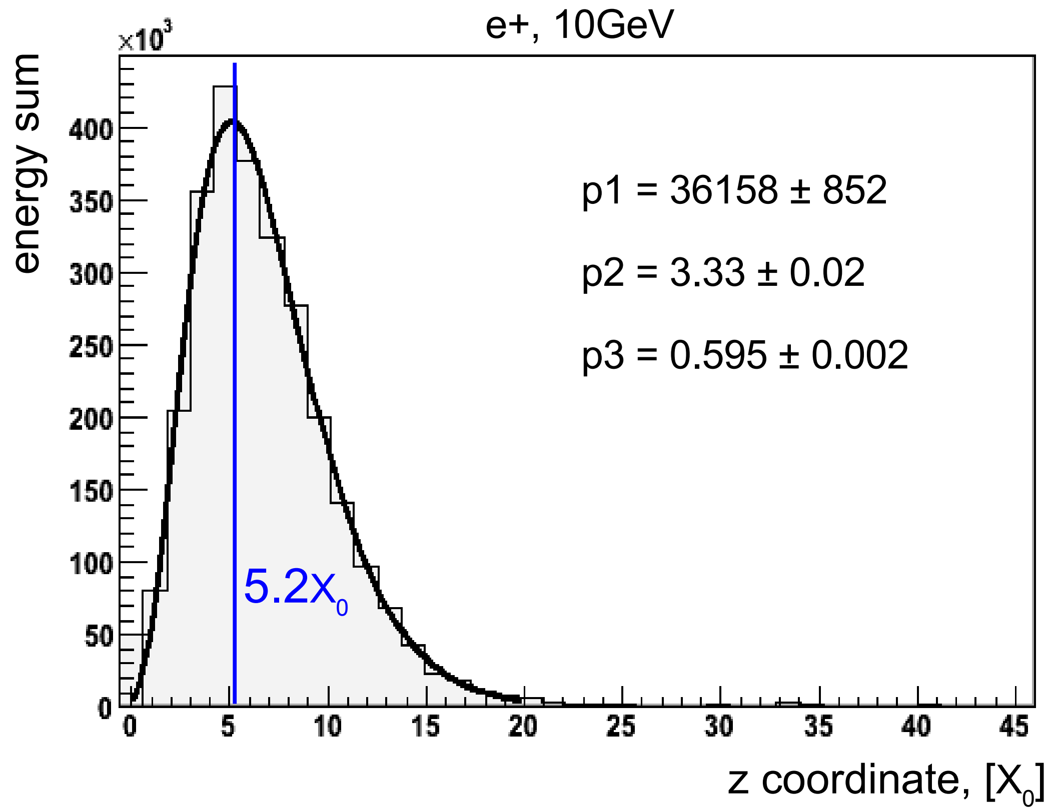
where E – energy deposited, t – depth in calorimeter

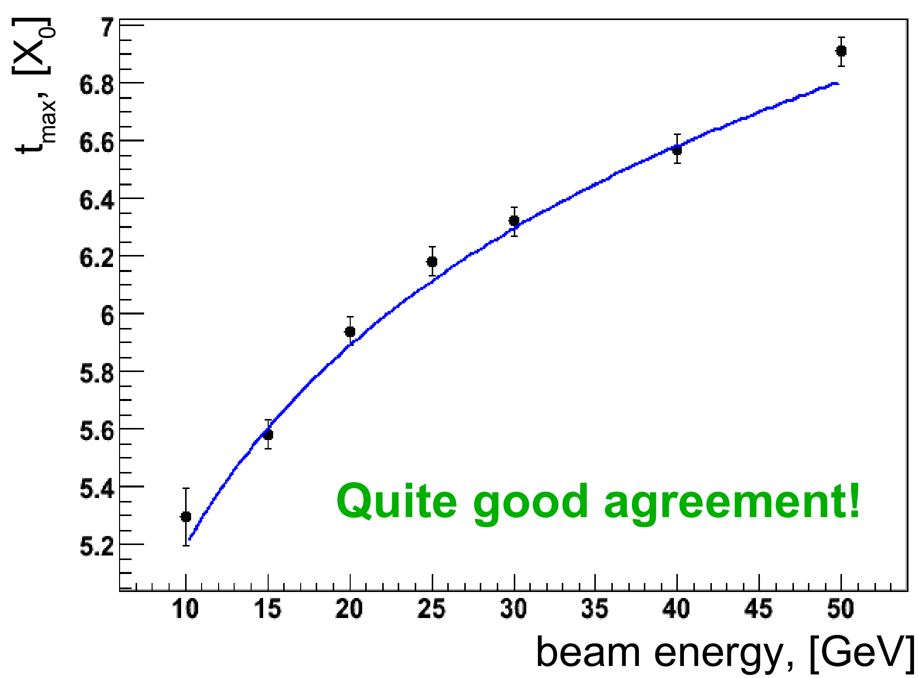
The maximum depth of an e/m shower in calorimeter for e+(e-):

t_{max}= [ln(E/e_c) - 0.5] [X_0]

E – particle energy
e_c – critical energy (≈ 33.6 MeV)

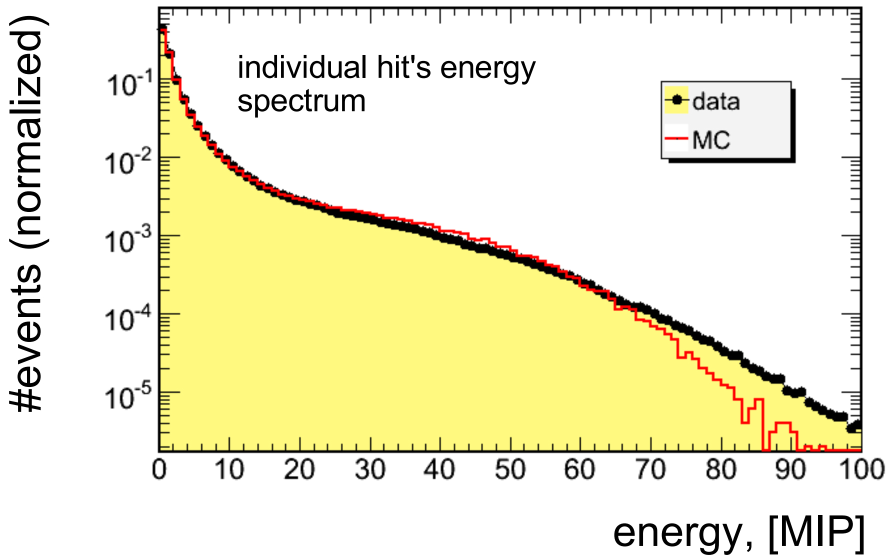
Calculated:	From data:
$t_{max} \approx 5.2\ X_0$	$t_{max} \approx 5.3\ X_0$

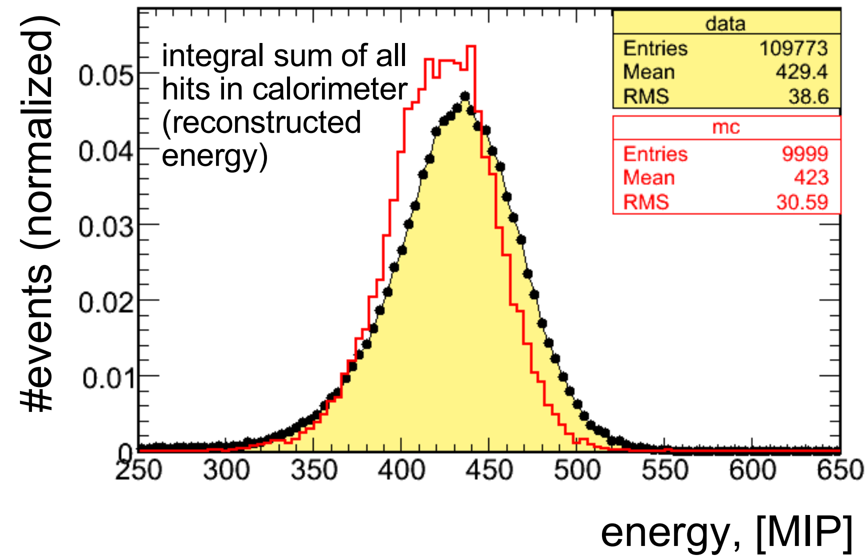


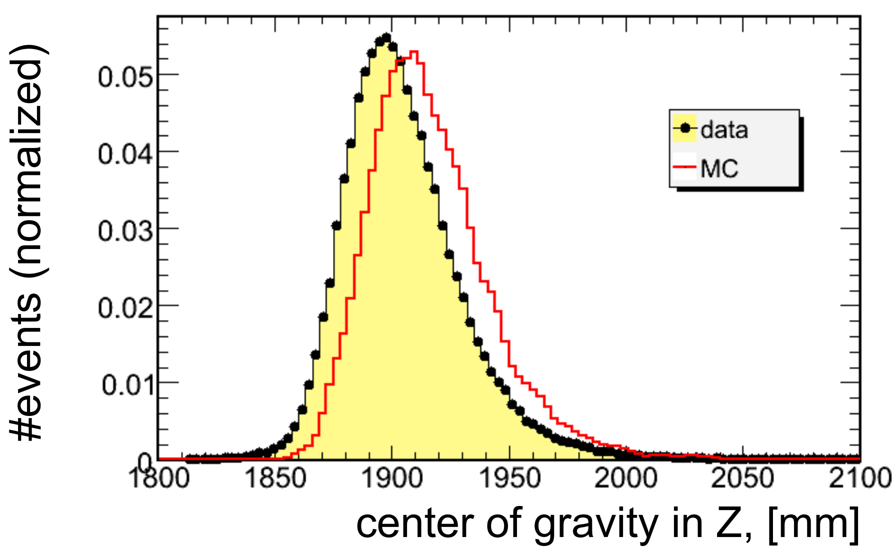


Analysis of electromagnetic showers in CALICE AHCAL prototype

exp (black) and MC (red) with re-scaled saturation and temperature correction





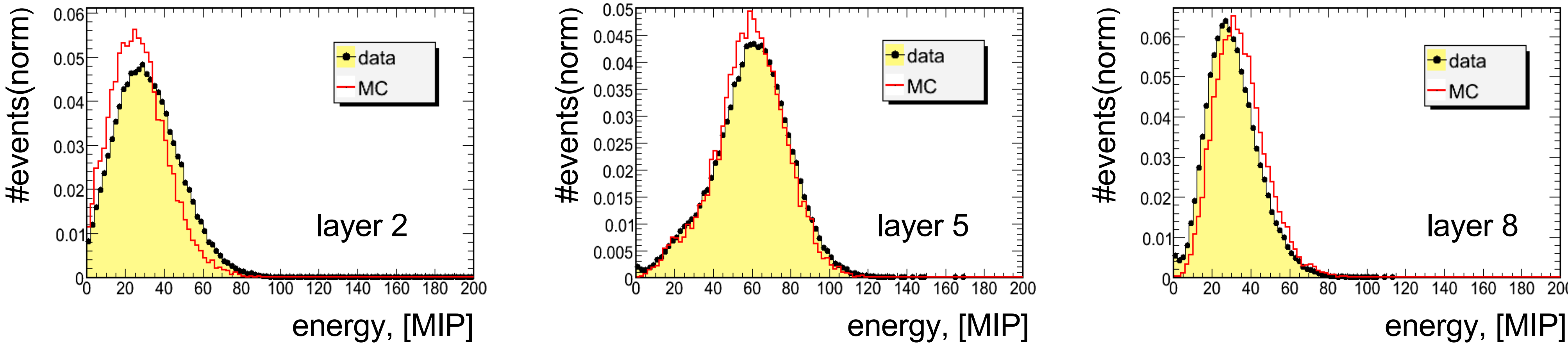


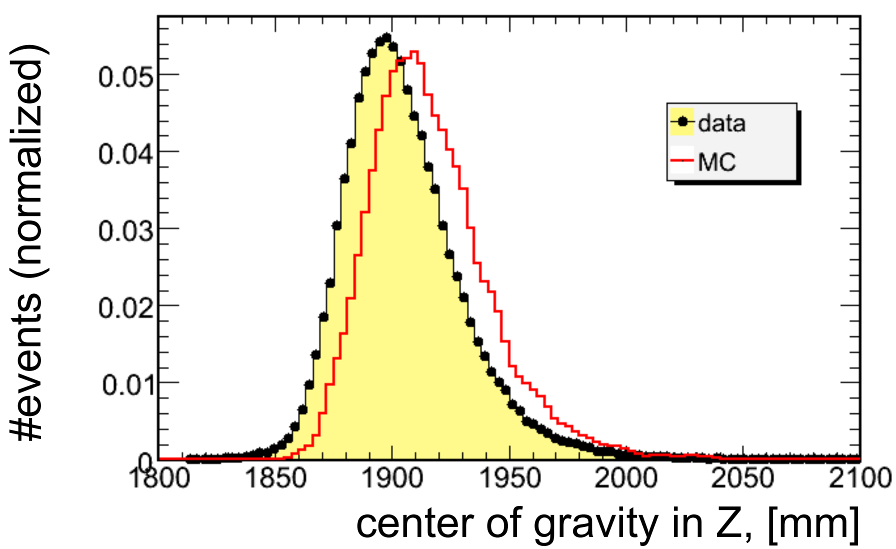
The main problem of MC so far:

- the geometrical position of an e/m shower is shifted w.r.t. the data.

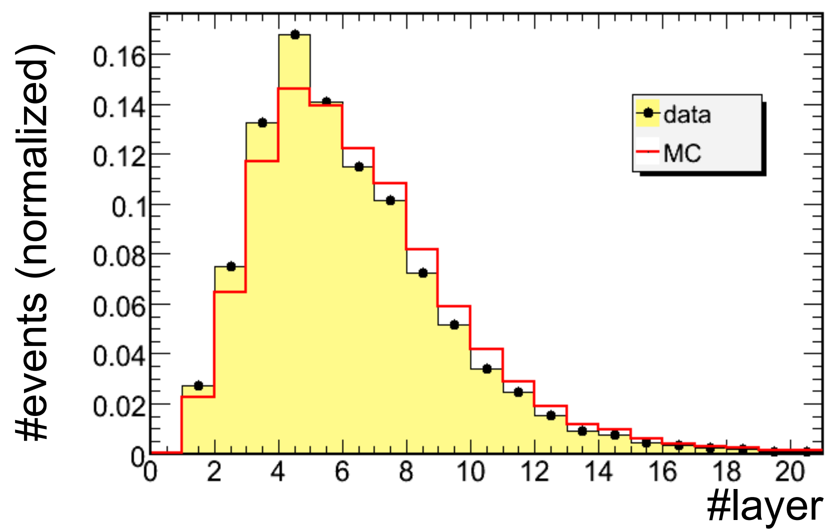
Uncertainties in integral spectrum (1.5%) is within expected region (2% expected).

exp (black) and MC (red) all effects included





energy profile of a shower

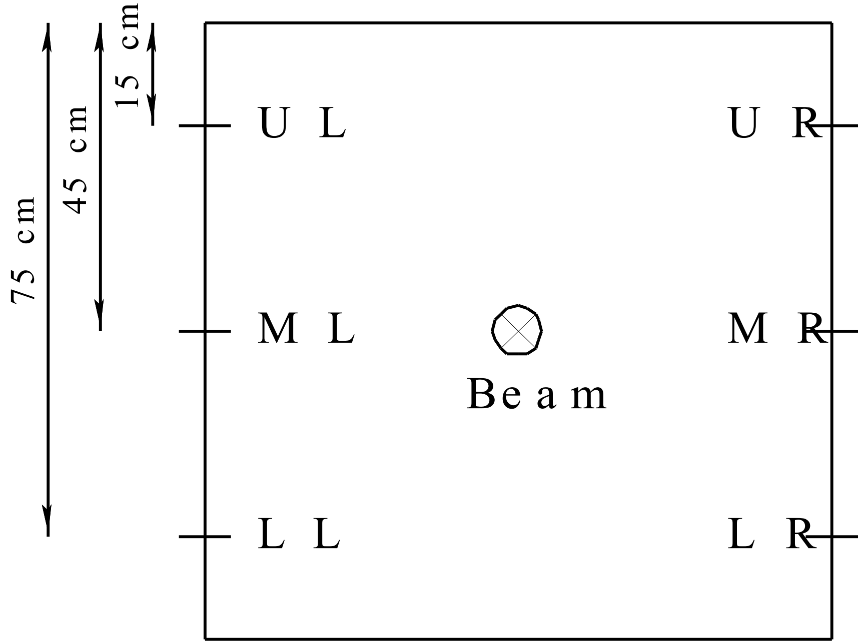


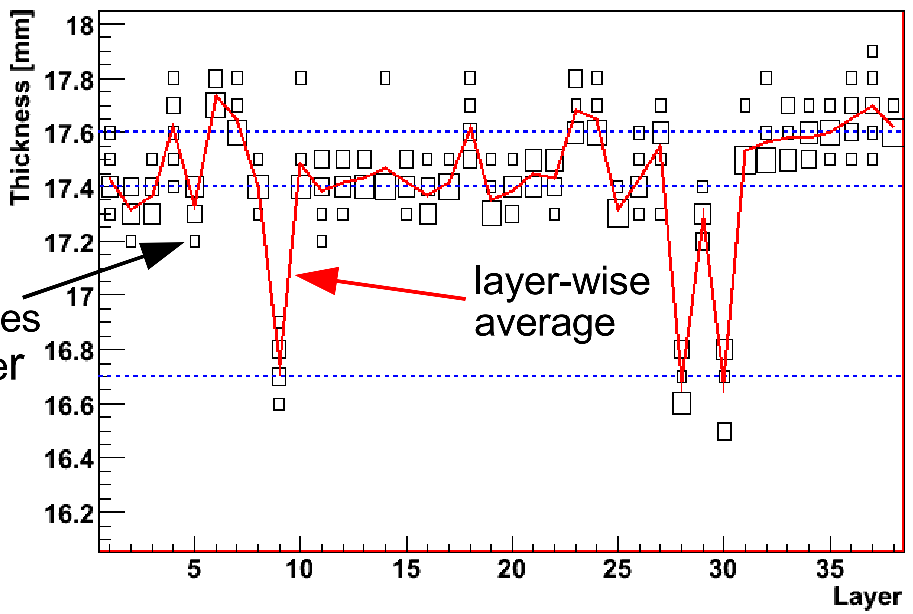
A precision measurements of the absorber's thickness.

- a stack is still assembled, only edges accessible
- measurement of six points at each plate with an accuracy of ~ 100μm

The thickness in the GEANT4 Mokka model by default: 16mm of steel

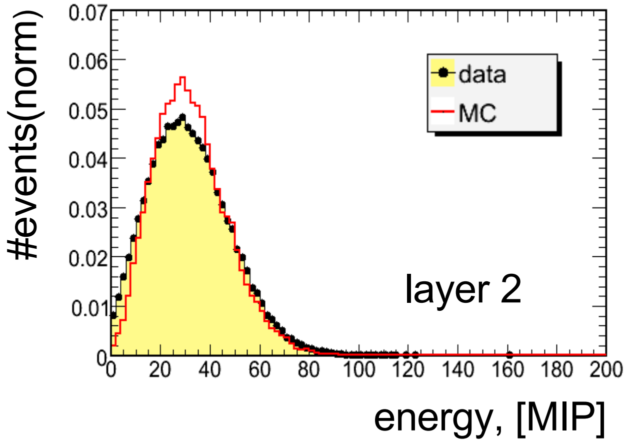
..and now we have more complicated picture:

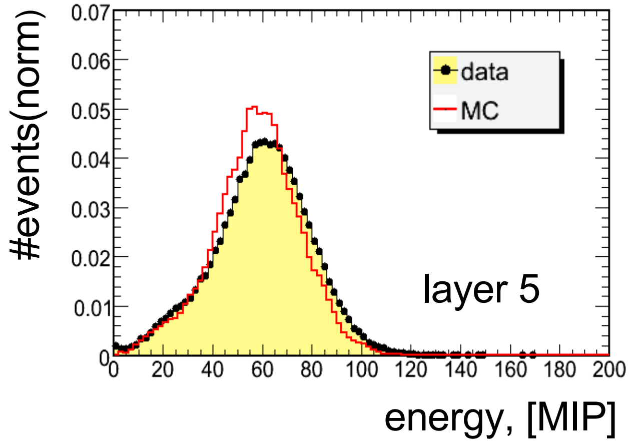


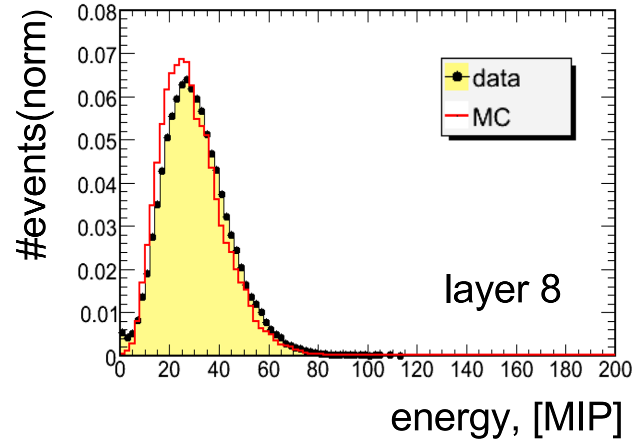


Analysis of electromagnetic showers in CALICE AHCAL prototype

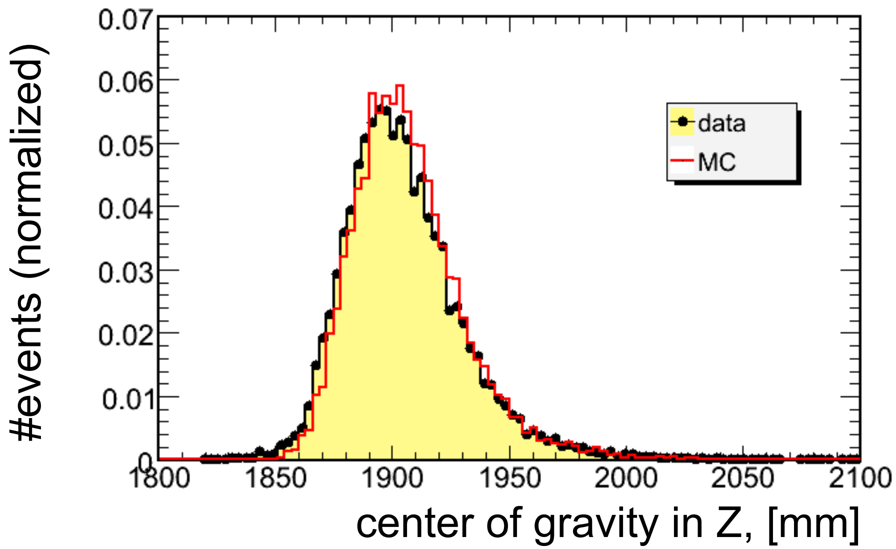
exp (black) and MC (red) + measured thickness of each Layer



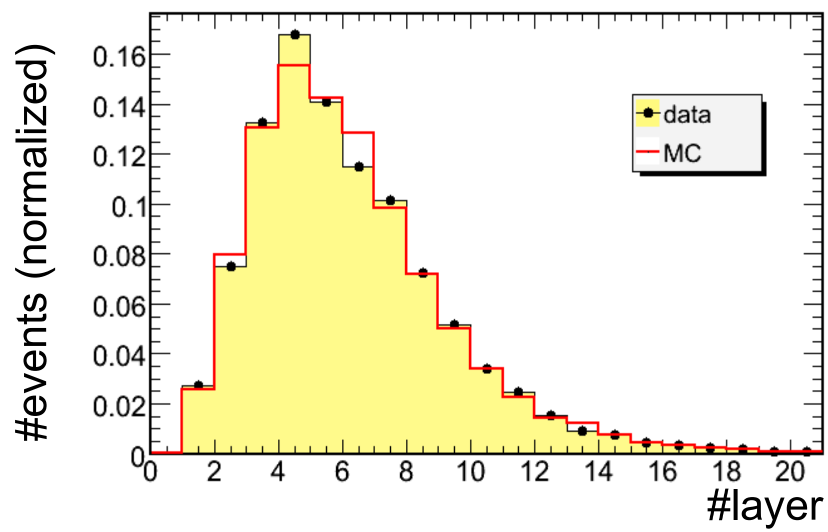


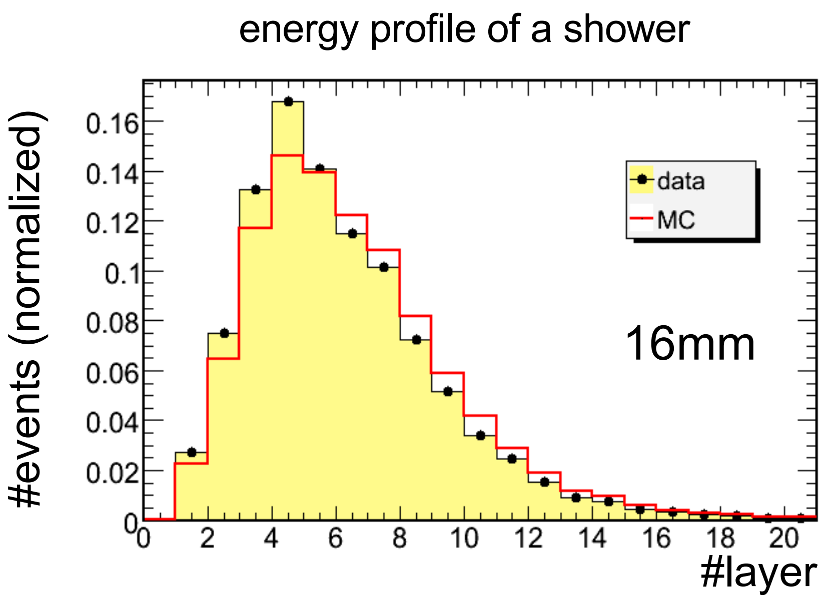


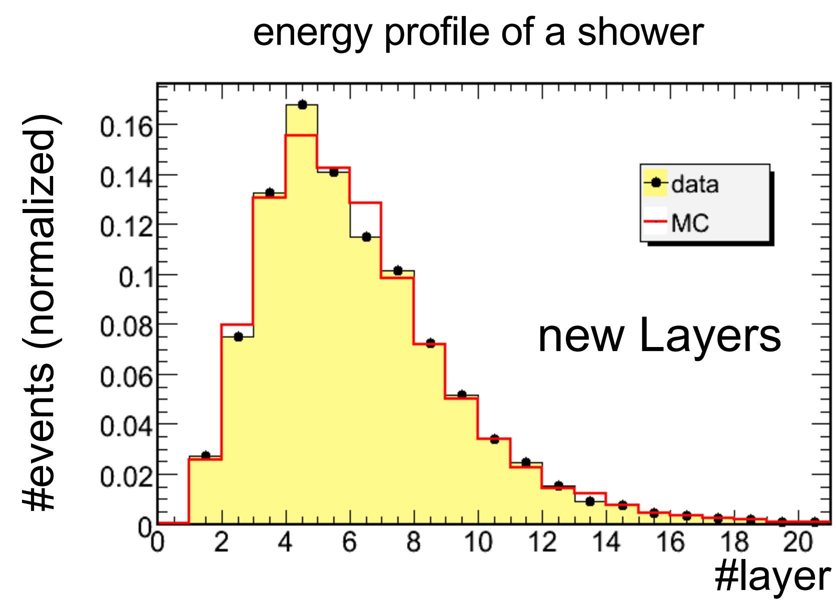
shower center of gravity in Z (beam) direction

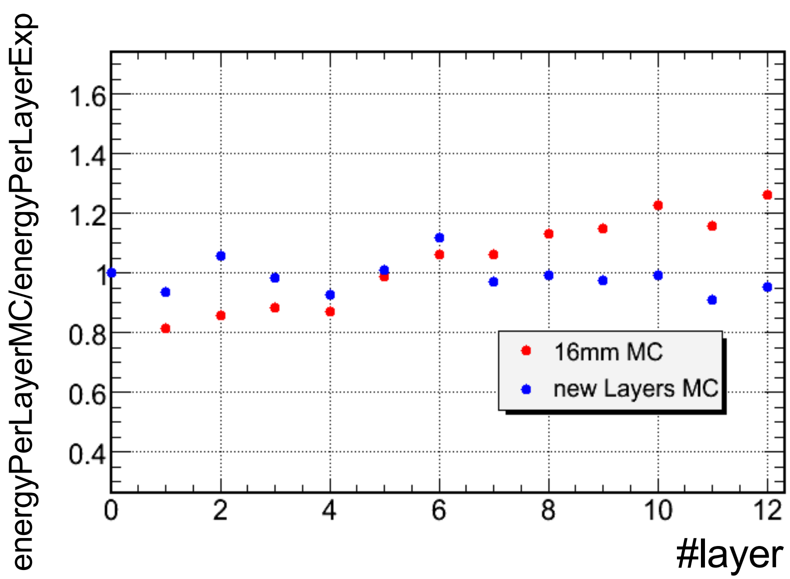


energy profile of a shower









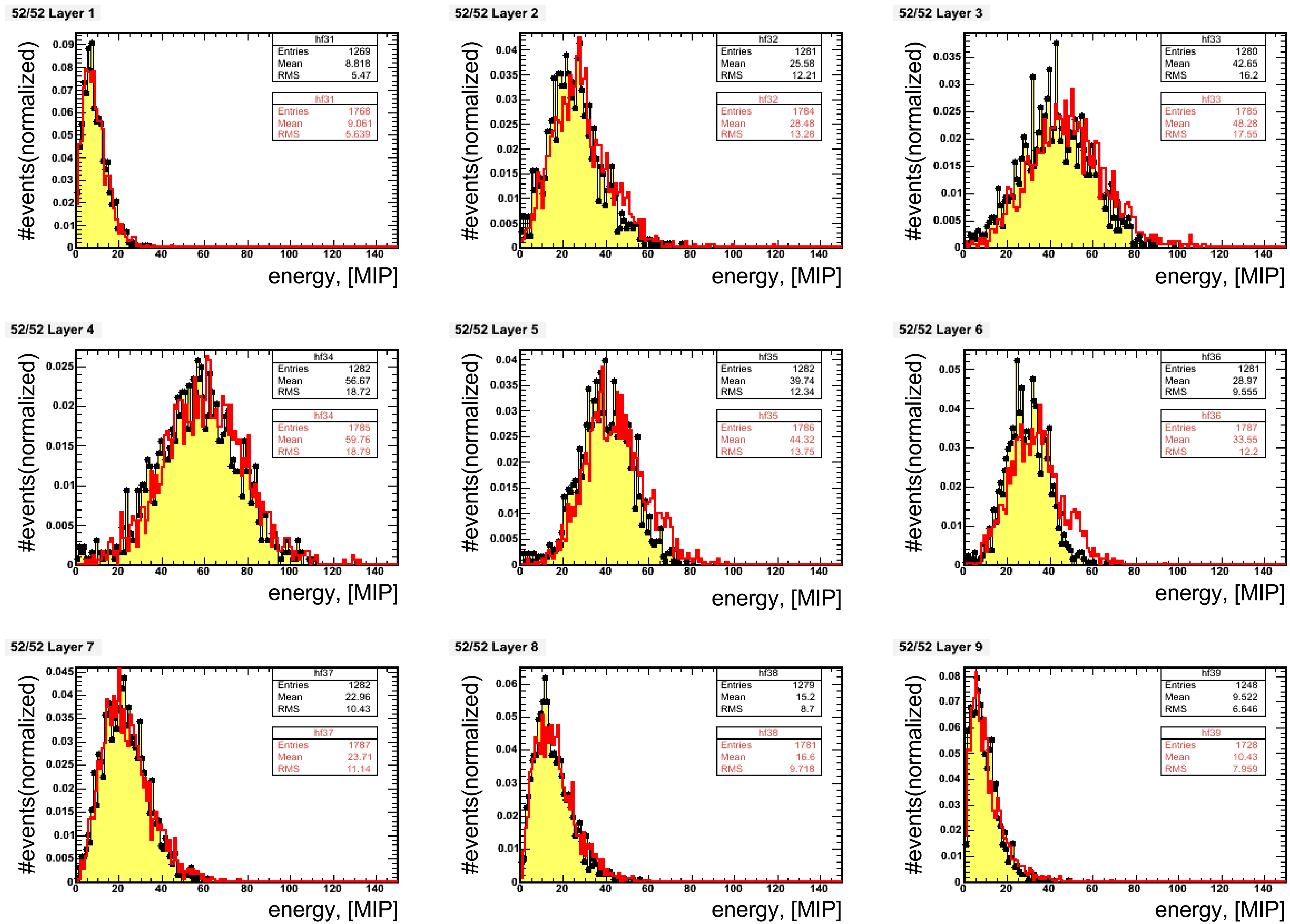
With new Layer thickness implementation we have much better consistency between data and MC!

Also we can check an individual tile response:

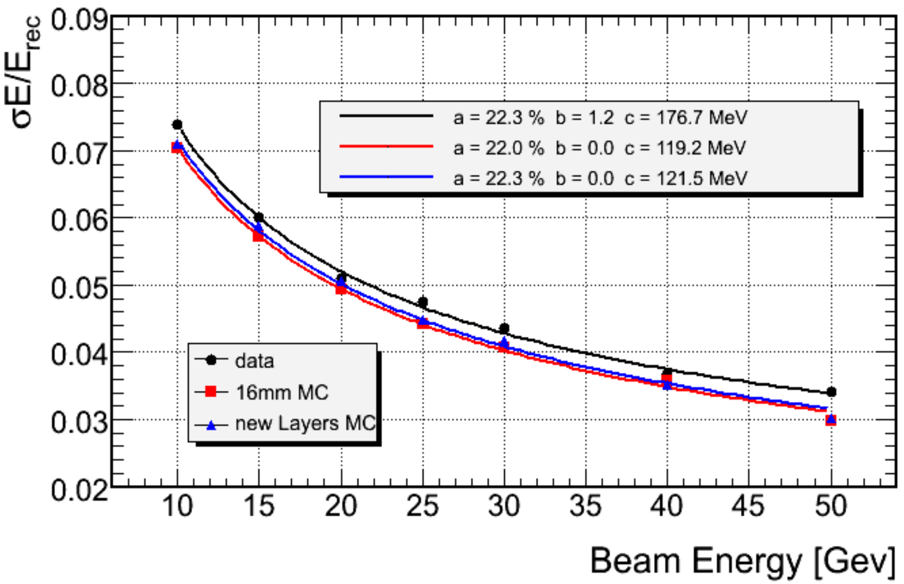
- compare the data and MC in shower core tile (52/52) where we have the highest saturation effect

Analysis of electromagnetic showers in CALICE AHCAL prototype

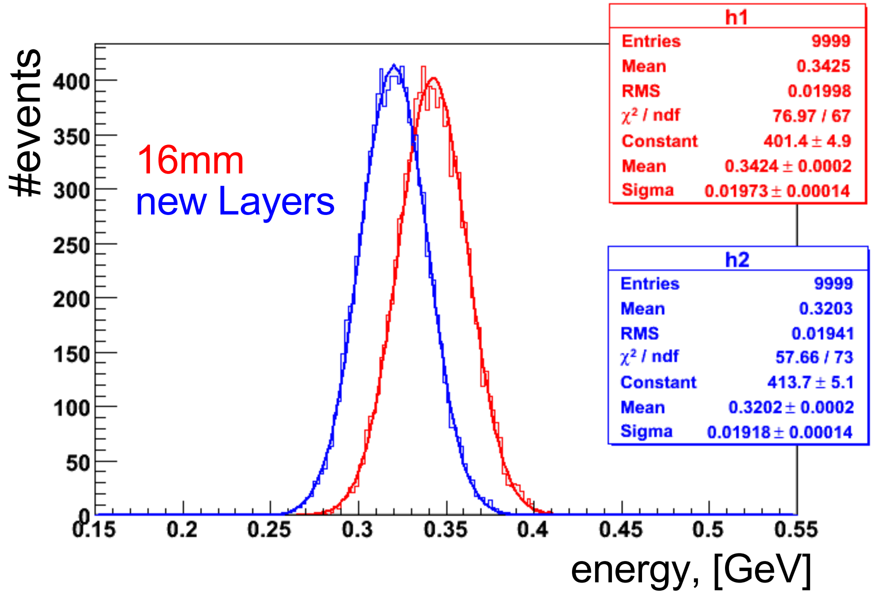
central tile for various layers   all corrections included data (black) and MC (red)



2007 e+ data (black), 16mm absorber plates MC (red), and new layers' thickness MC (blue)



10 GeV e+, pure energy in GEANT4



pure MC:

5.67% (16mm) and 5.99% (new) ~ 4% effect

+ digitization (+temp correction)

7.04% (16mm) and 7.11% (new) < 1% effect

Summary & Outlook

- Electromagnetic showers in Analog Hadron Calorimeter is a very good tool for validating the calibration procedure as well as checking and validating the Monte Carlo geometry models and digitization procedures

- After an accurate and precision calibration and corrections:

  a) an expected 2% level of uncertainties in reconstructed energies of positrons is achieved

  b) a linearity of the calorimeter response for positrons is less then 4% (residuals to the linear fits) in 10 – 50 GeV range

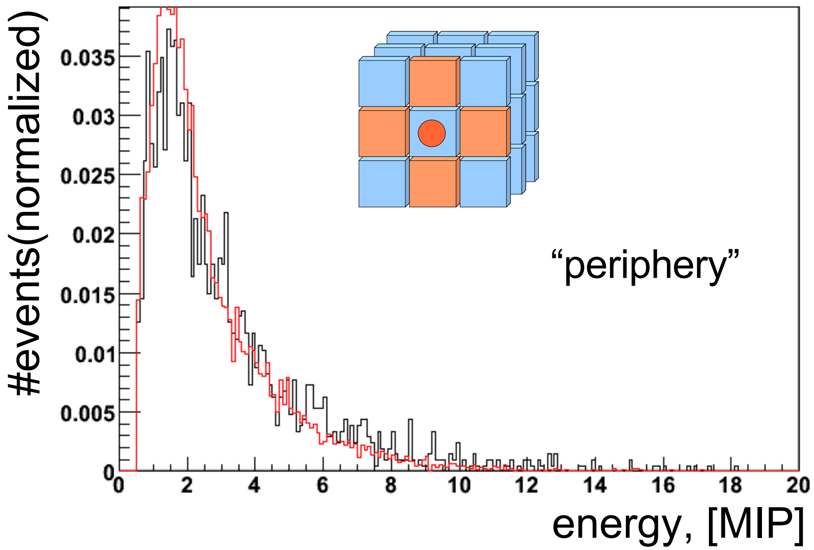
- new Mokka model with real layer thicknesses is introduced. Monte Carlo study of this model shows quite good agreement for geometrical e/m shower positions in AHCAL

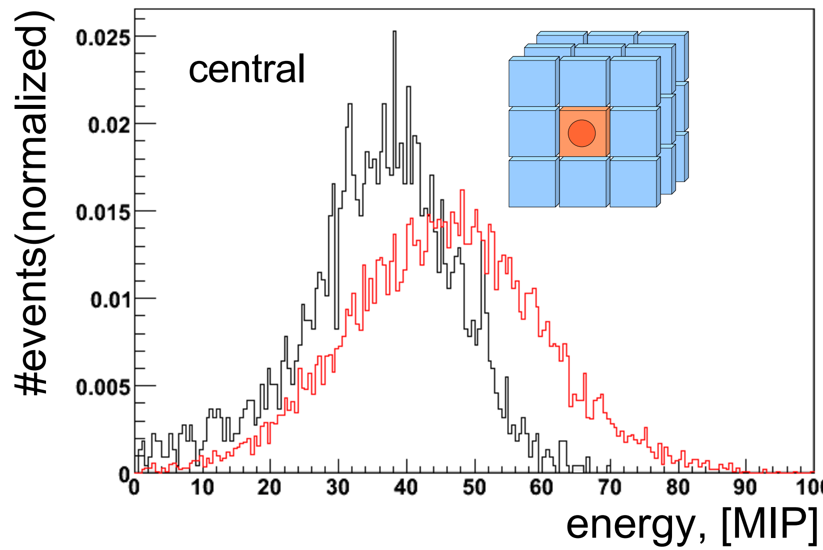
- further Monte Carlo studies are coming for different angles of rotation

Backup slides

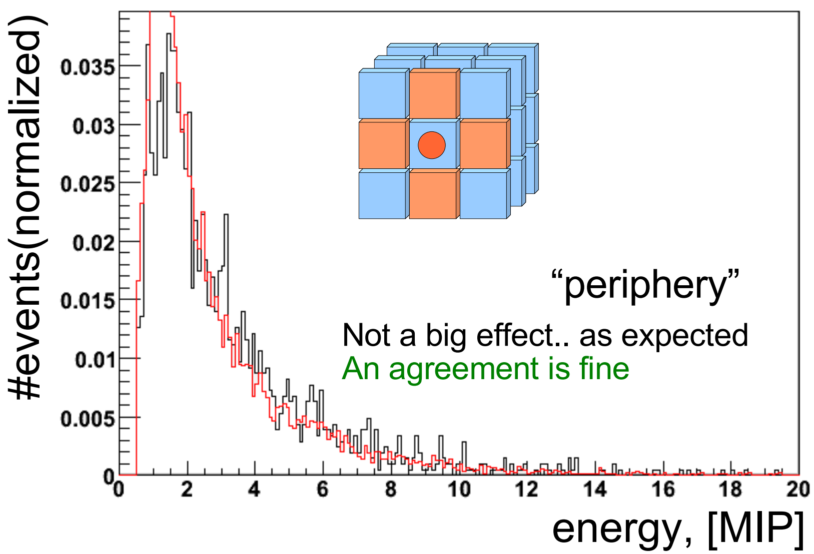
Analysis of electromagnetic showers in CALICE AHCAL prototype

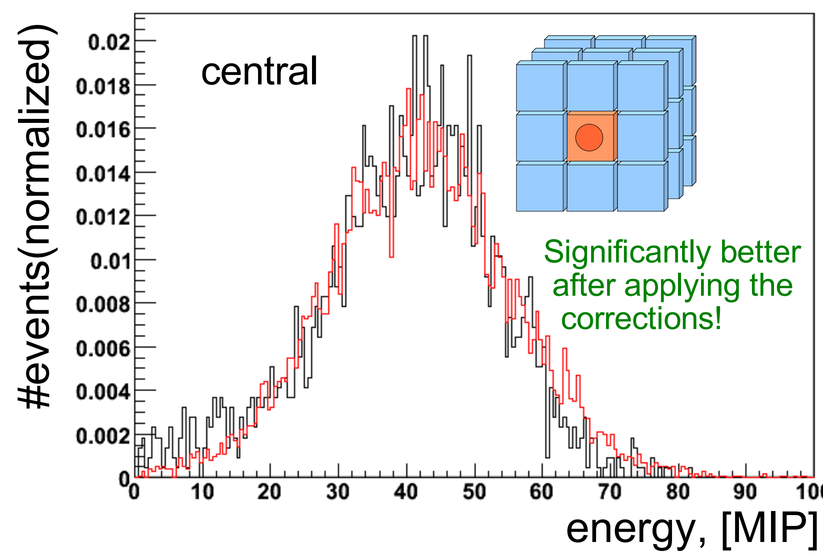
data (before corrections) (black) and MC (red)





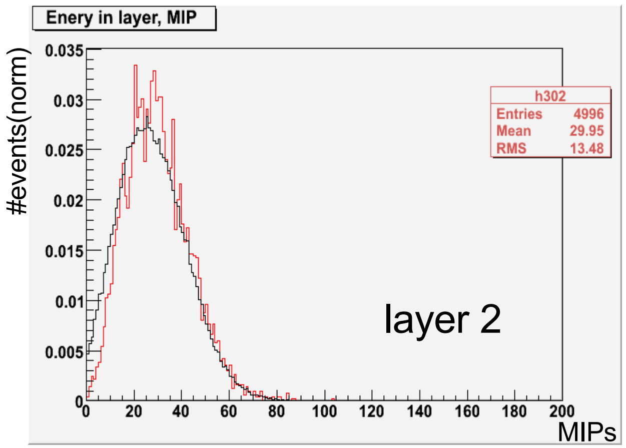
data (all correction included) (black) and MC (red)

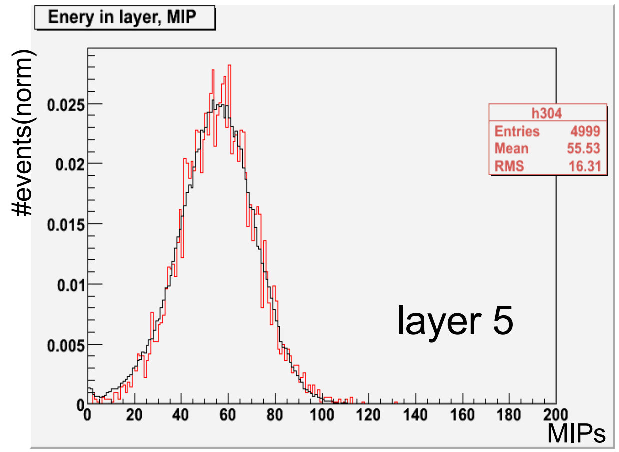


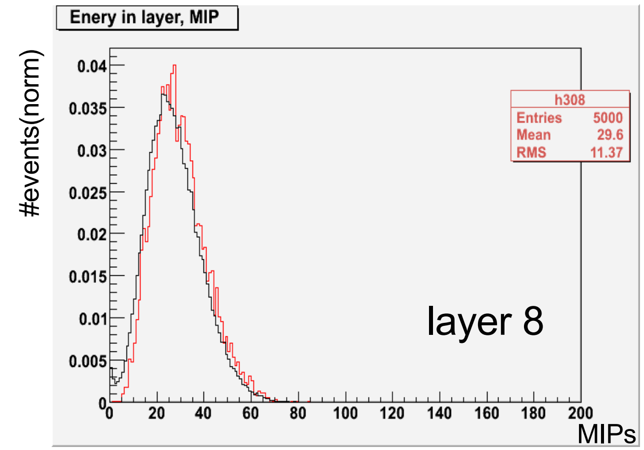


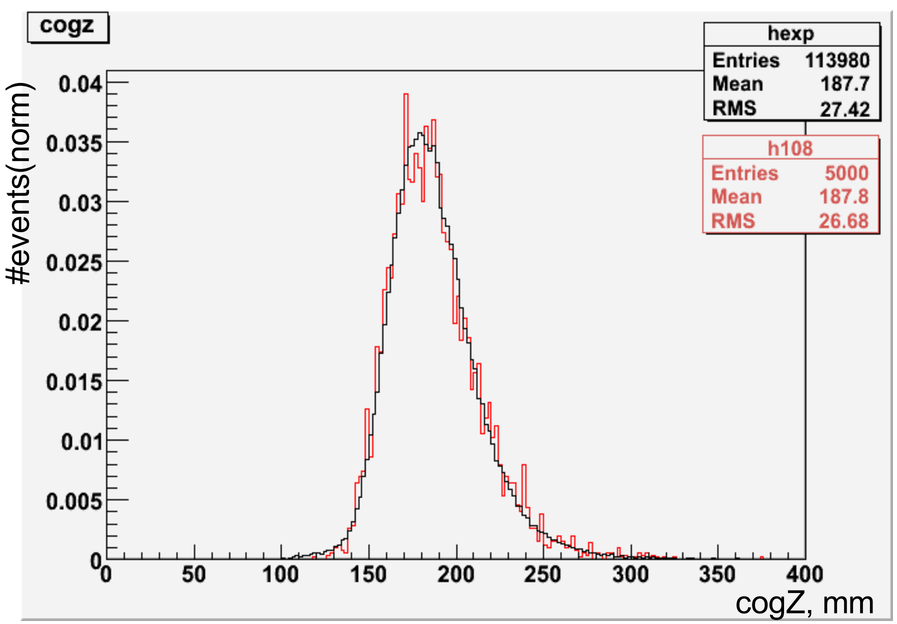
Analysis of electromagnetic showers in CALICE AHCAL prototype

exp (black) and MC (red) + 5mm of Fe just before 1st layer of AHCAL

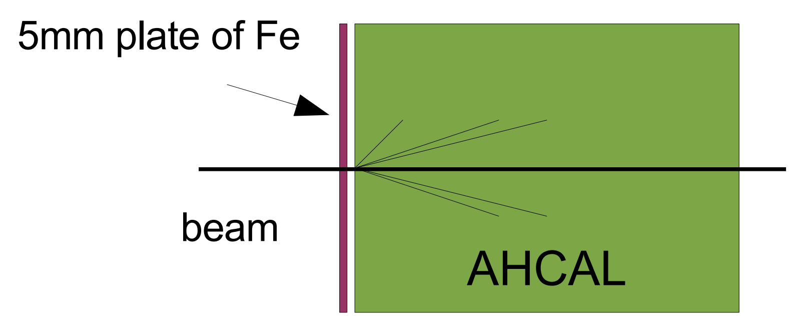








shower center of gravity in Z direction



..need more material along the test beam line in Monte Carlo simulation (?)

or some material inside AHCAL (!?)