Si/W ECAL testbeam analysis

Cambridge University

Georgios Mavromanolakis *

* (also with **FERMILAB**)

Outline

- **Transverse shower size**
- **Response and resolution studies**
- **Event-by-event gap correction**

Transverse shower size

Outline

- **Event selection**

  (center-edge-corner of wafer)

- **Energy spectra and cuts**

- **Radius for 90% - 95% containment**

Event selection

- **hit energy threshold**
  - select hits with energy above 0.5 mip

- **suppression of noisy and double-particle events**
  - get mean and rms of event energy distribution
  - fit with a Gaussian in the range mean-rms/2 to mean+rms and get mean and sigma M_1, σ_1
  - fit again with a Gaussian in the range $(M_1 - \sigma_1)$ to $(M_1 + 2 \cdot \sigma_1)$ and get mean and sigma M_2, σ_2
  - accept events for analysis with energy in the range $(M_2 - 3 \cdot \sigma_2)$ to $(M_2 + 3 \cdot \sigma_2)$

Event selection

- · **center of wafer**

energy	run	Emin(mip)	Emax(mip)
1	230098	98.4	364.8
2	230099	294.3	669.1
3	230097	503.6	966.9
4	230100	730.0	1255.0
5	230104	928.6	1540.1
6	230101	1151.1	1809.0

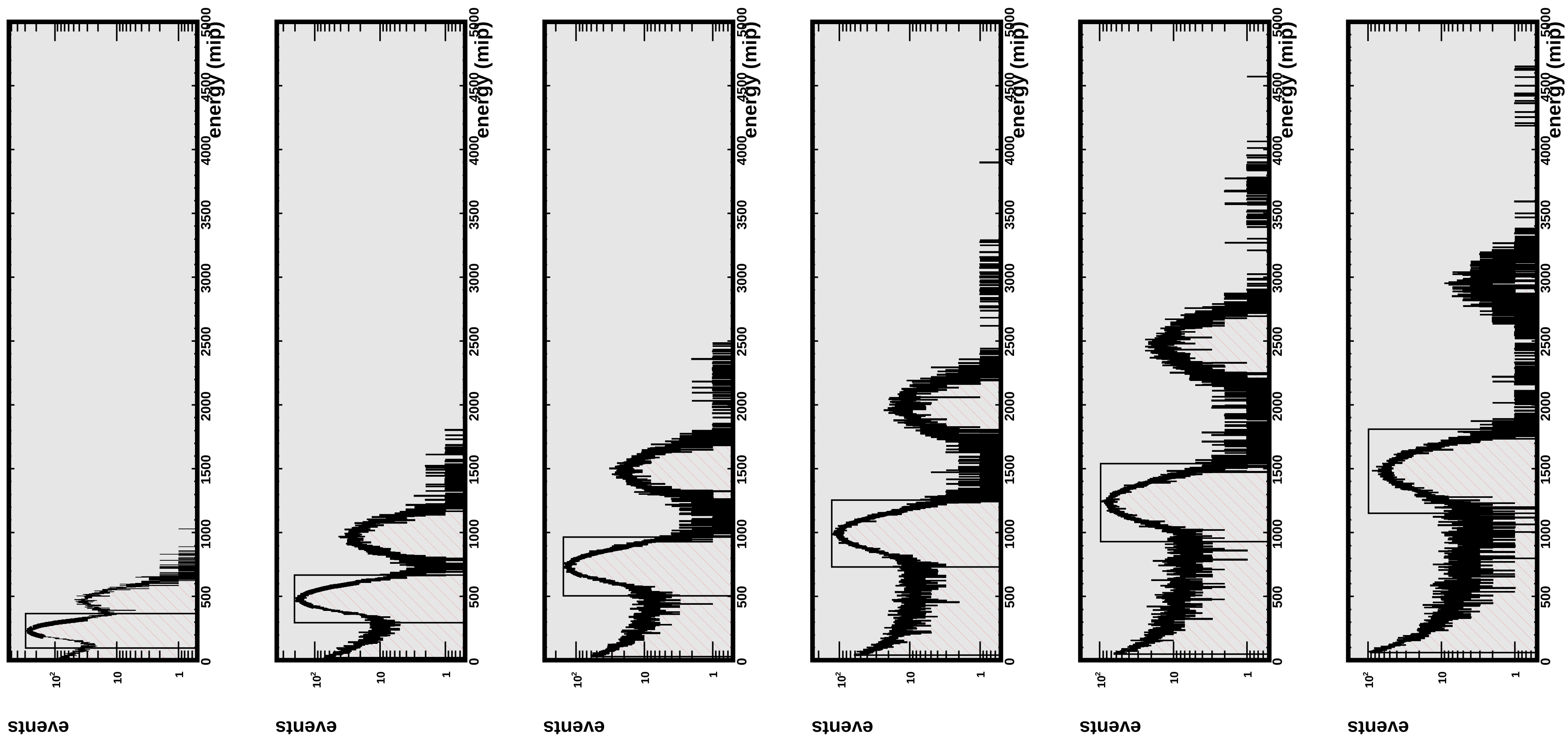
- · **edge of wafer**

energy	run	Emin(mip)	Emax(mip)
1	230132	107.7	354.8
2	230133	279.1	664.6
3	230134	459.4	951.7
4	230135	638.1	1232.2
5	230136	831.1	1515.7
6	230137	1008.0	1783.1

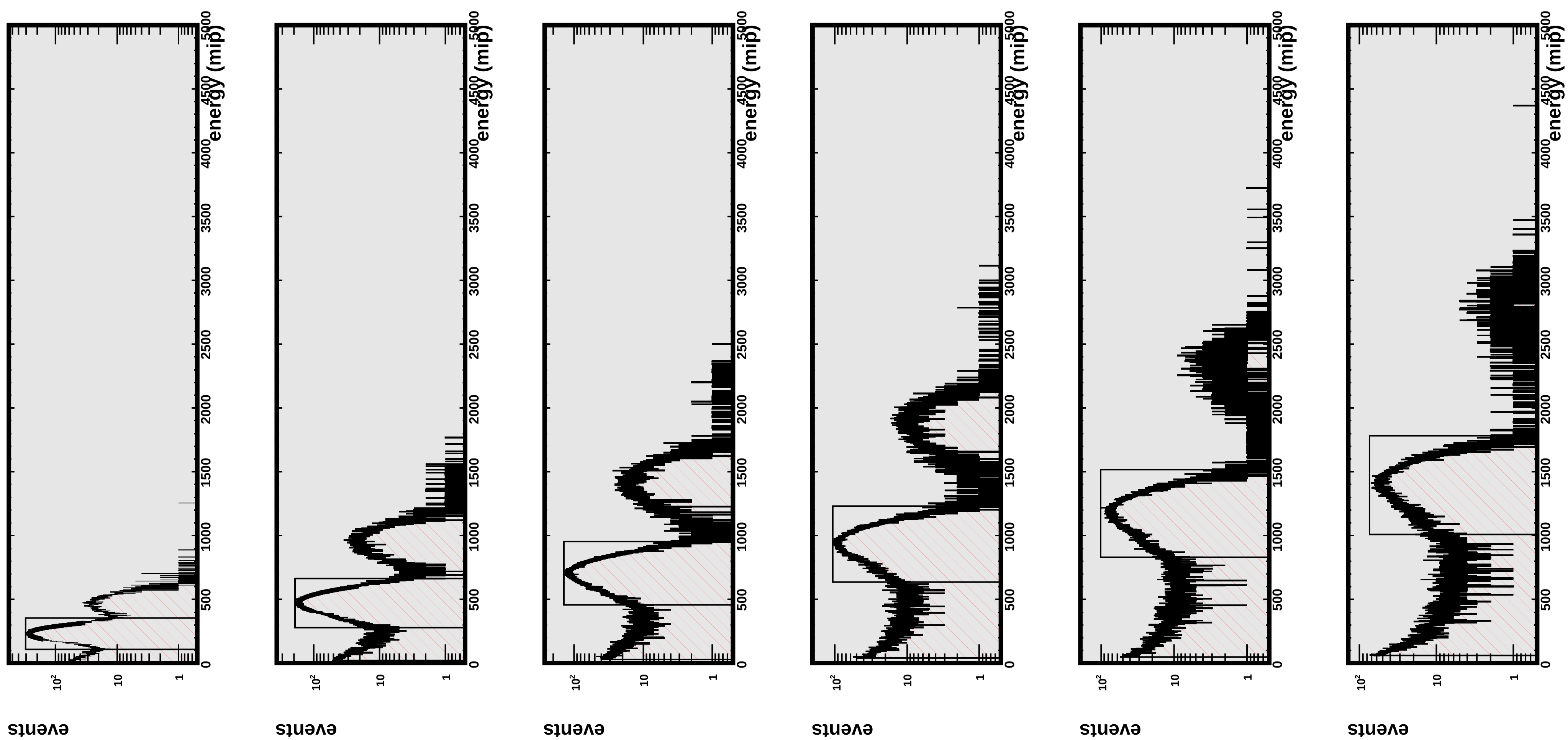
- · **corner of wafer**

energy	run	Emin(mip)	Emax(mip)
1	230138	94.1	353.8
2	230139	242.4	654.3
3	230141	384.6	939.6
4	230142	524.3	1230.9
5	230145	667.8	1514.1
6	230143	813.7	1762.1

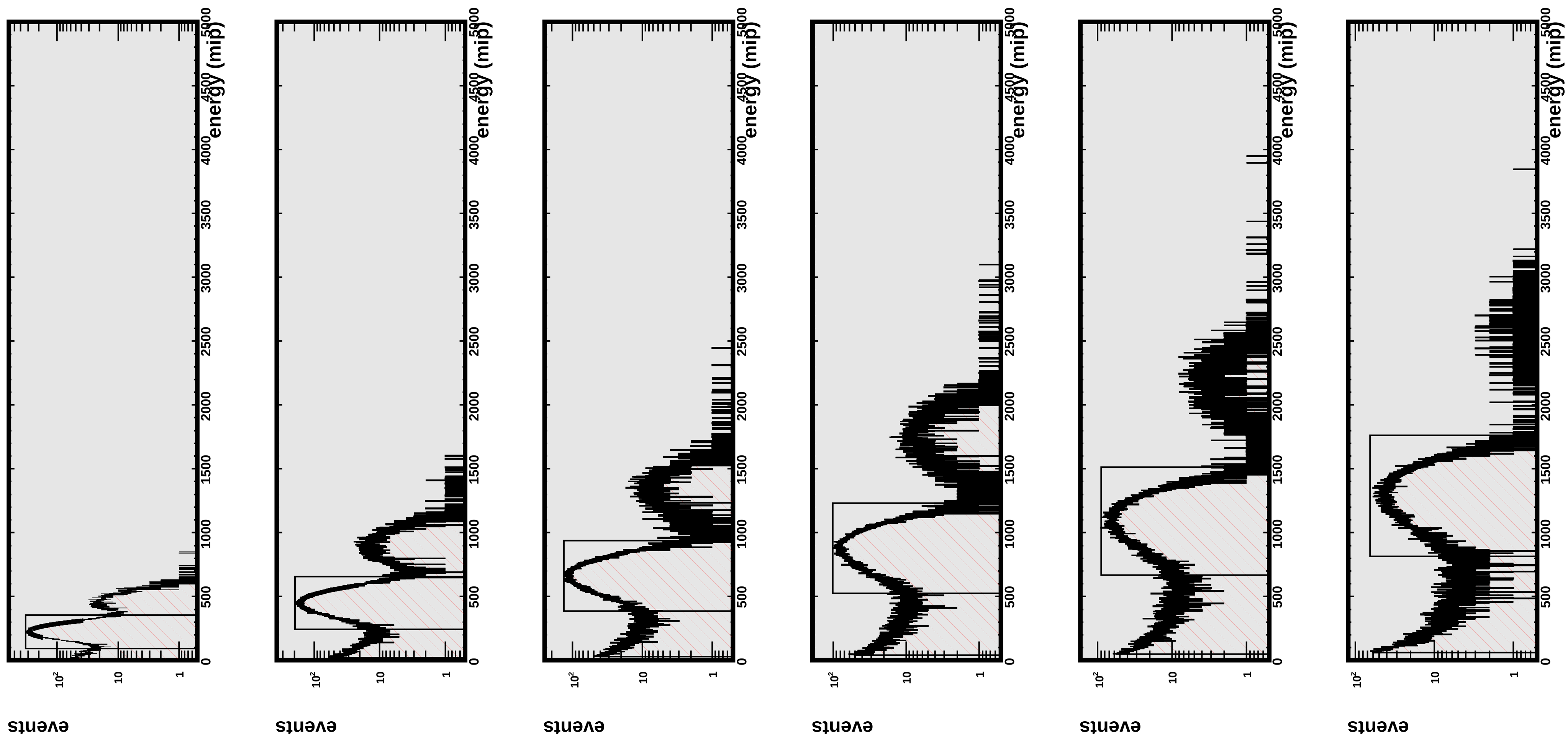
Center of wafer



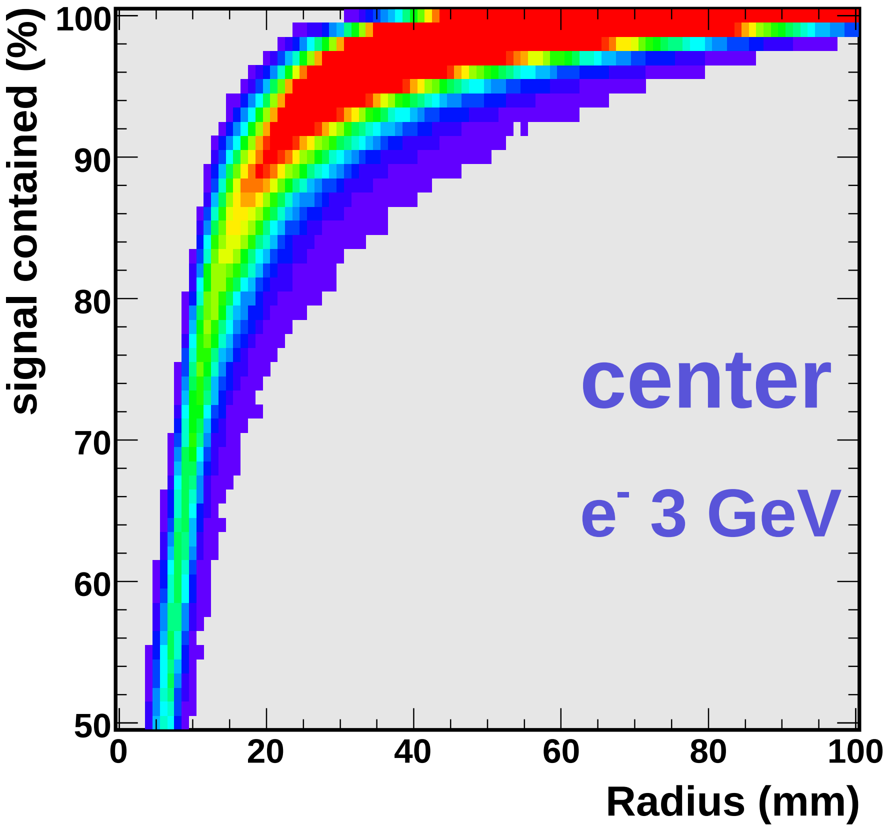
Edge of wafer



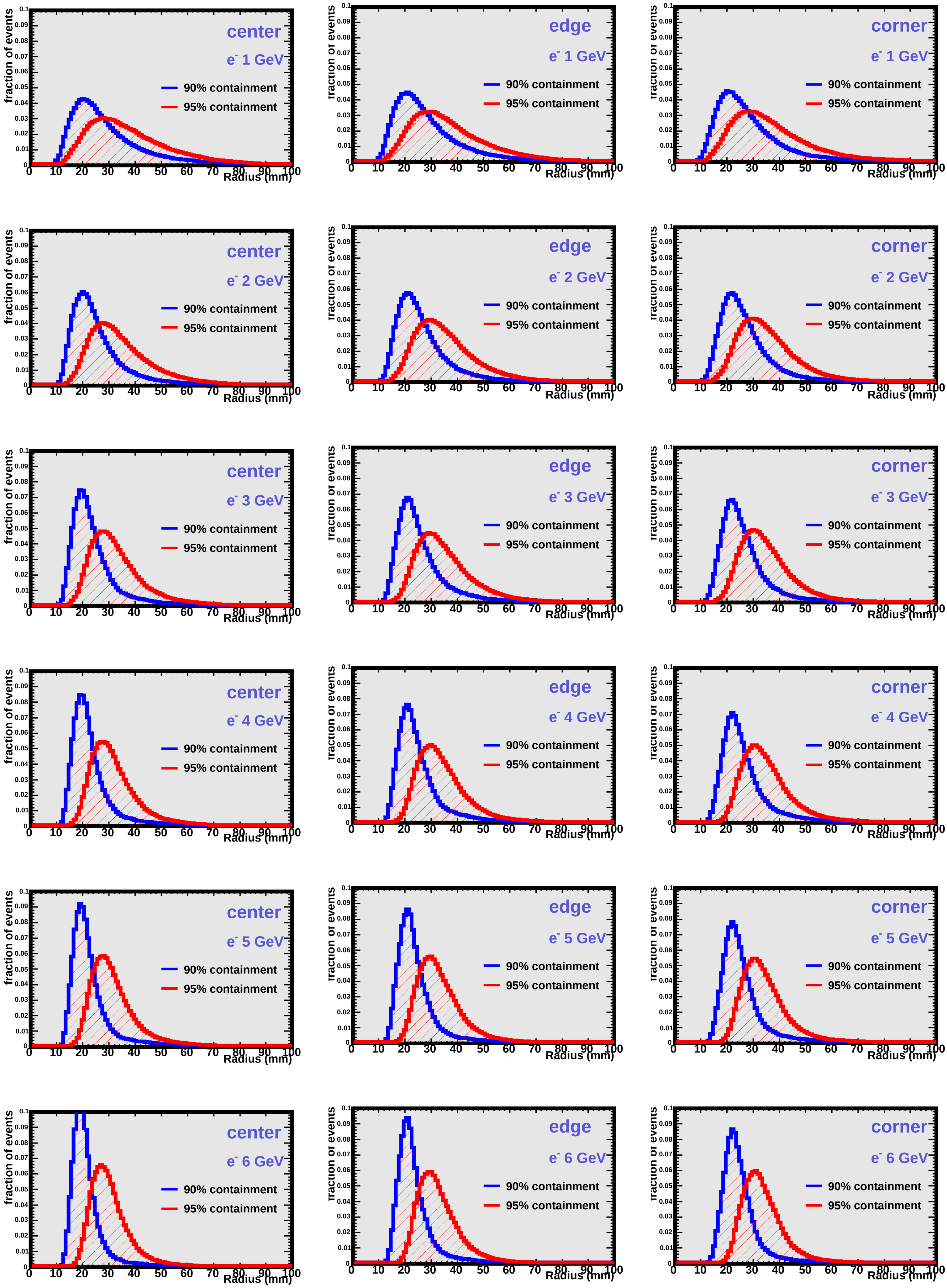
Corner of wafer



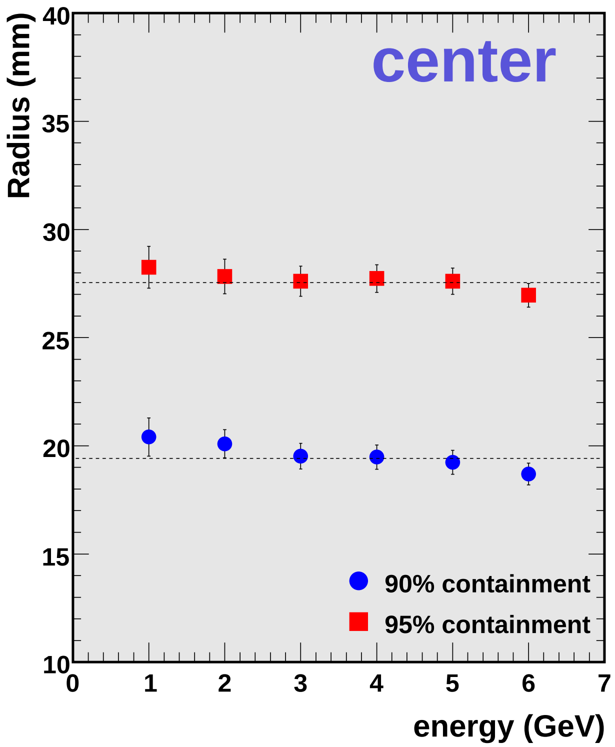
Signal containment vs Radius

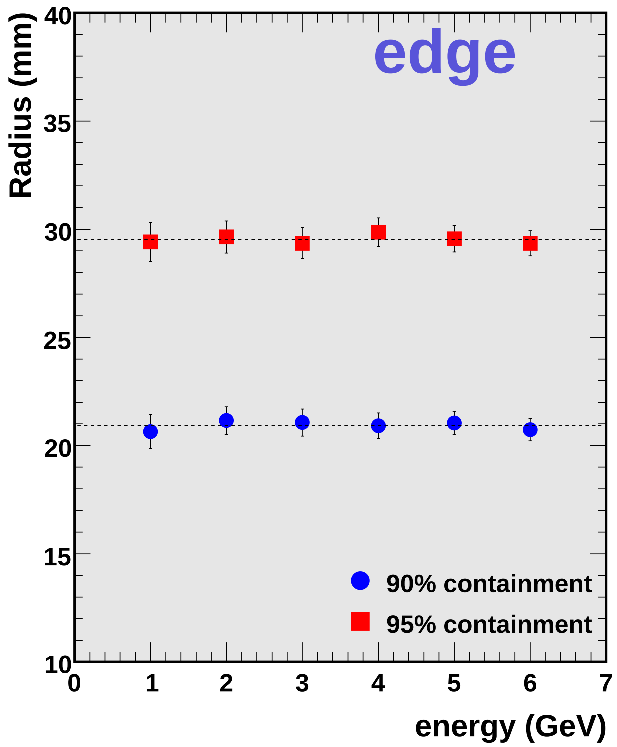


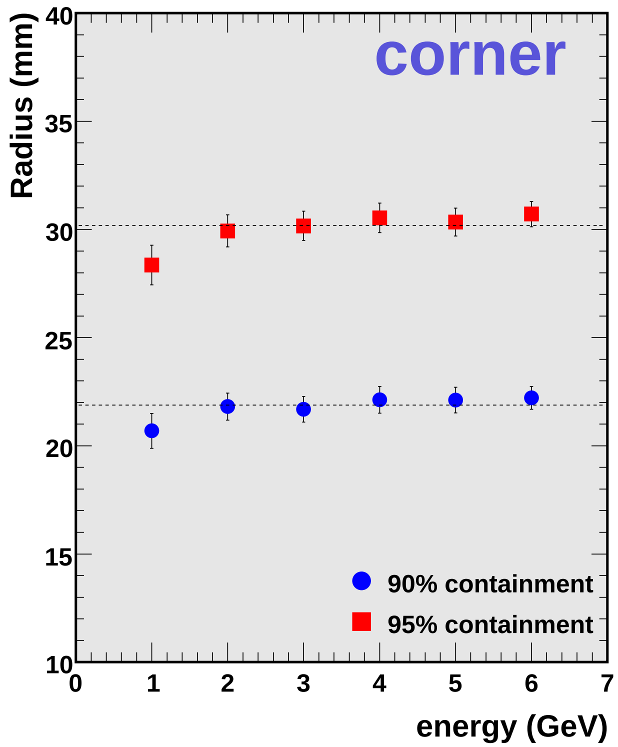
Radius for 90%-95% containment



Radius for 90%-95% containment







Response and resolution

Outline

- **Event selection**
- **Energy spectra and cuts**
- **Results**

Response and resolution studies

▸ · **event selection**

: select central part of wafer, ShowerX>-15mm .and. ShowerX<25mm

: exclude gap in y, ShowerY>-5mm .or. ShowerY<-15mm

: energy range cut to suppress double electron events (DESY runs)

: suppress pion contamination, HcalEnergy<10mip (CERN runs only)

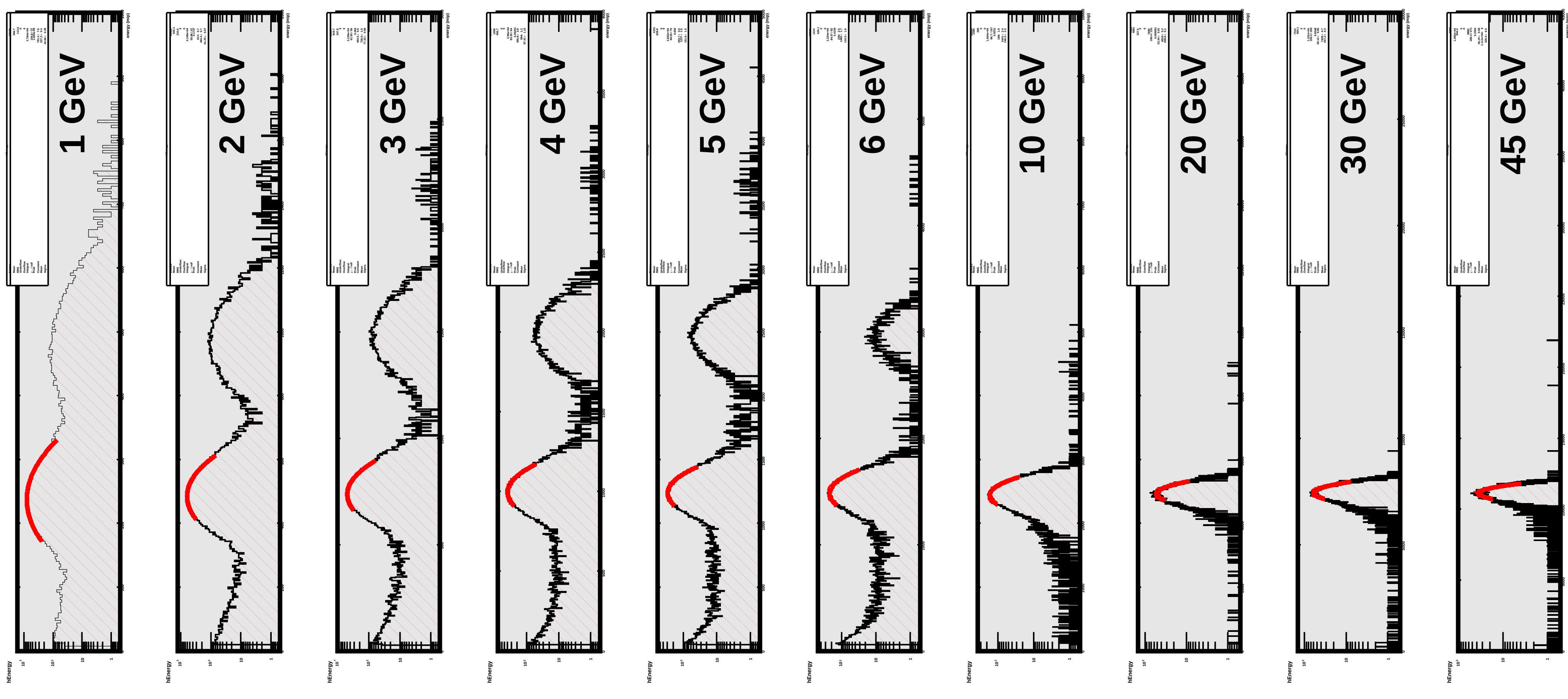
▸ · **runs under study** (initial samples of 50k events)

E(GeV)	e^- run(DESY)
1	230098
2	230099
3	230097
4	230100
5	230104
6	230101

E(GeV)	e^- run(CERN)
10	300672
20	300676
30	300207
45	300195

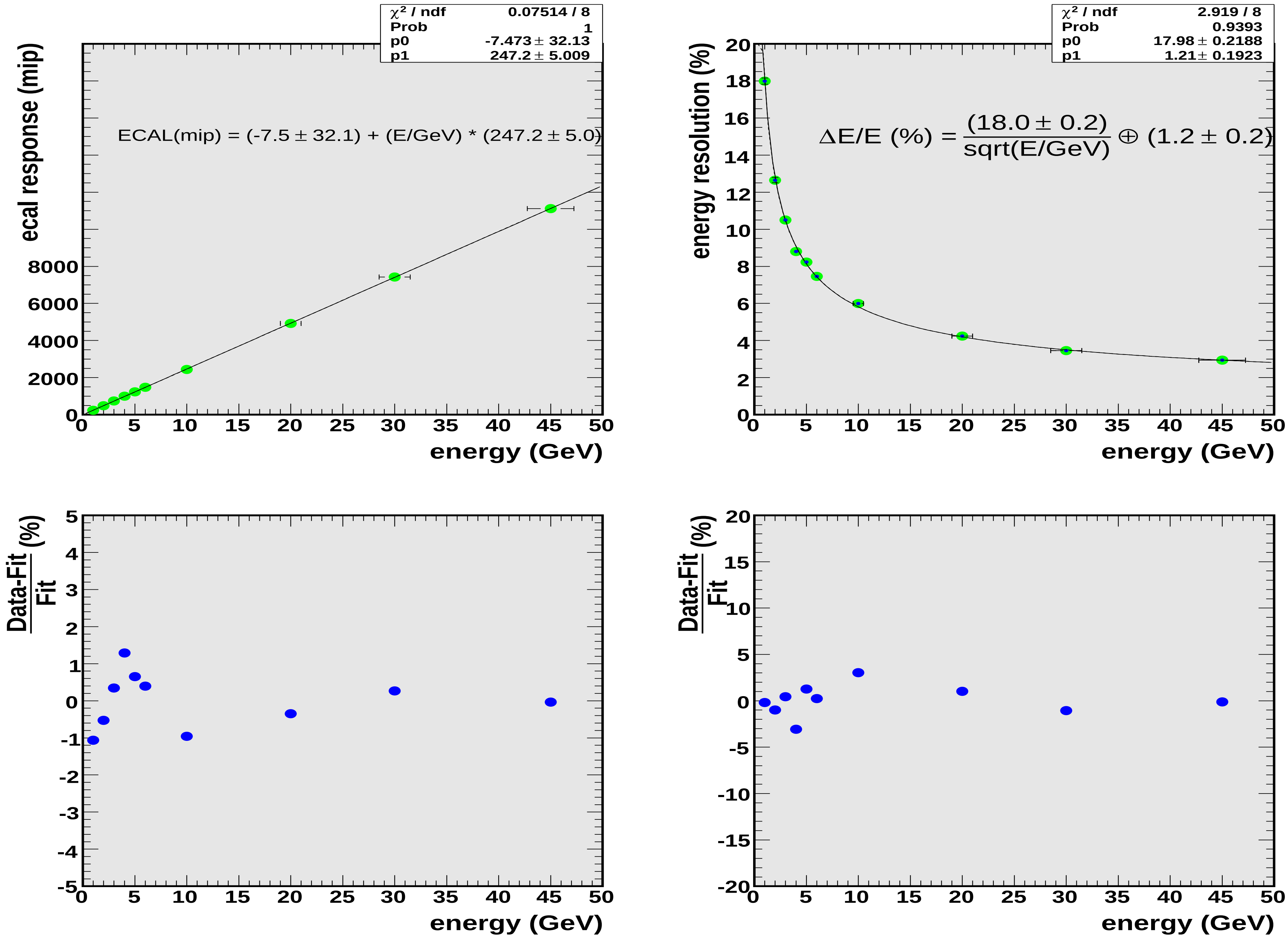
E(GeV)	e^+ run(CERN)
10	300731
15	300733
16	300734
18	300735
20	300736
30	300742
50	300744

Energy spectra

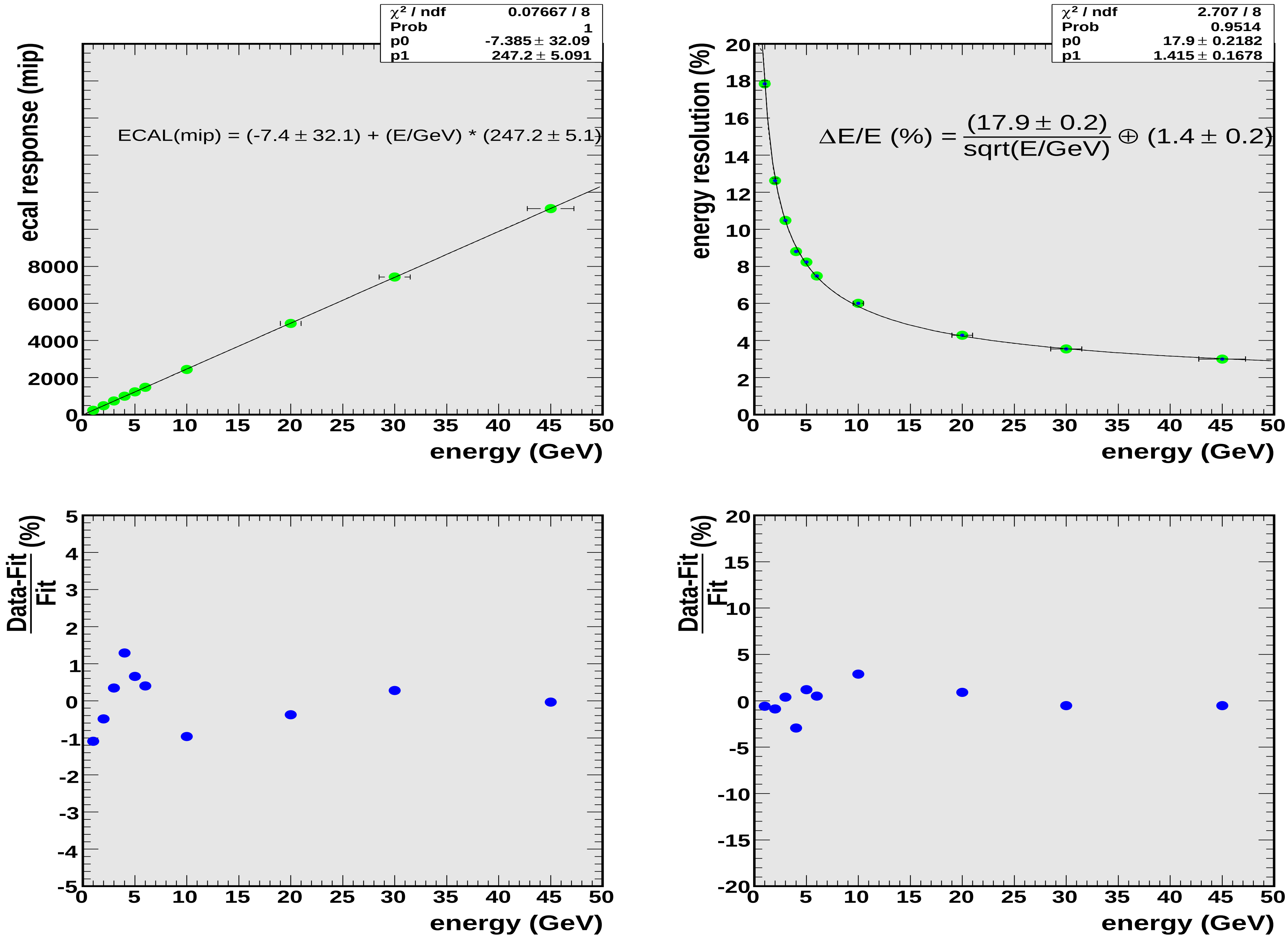


(1-6 GeV DESY runs shown without "energy range cut")

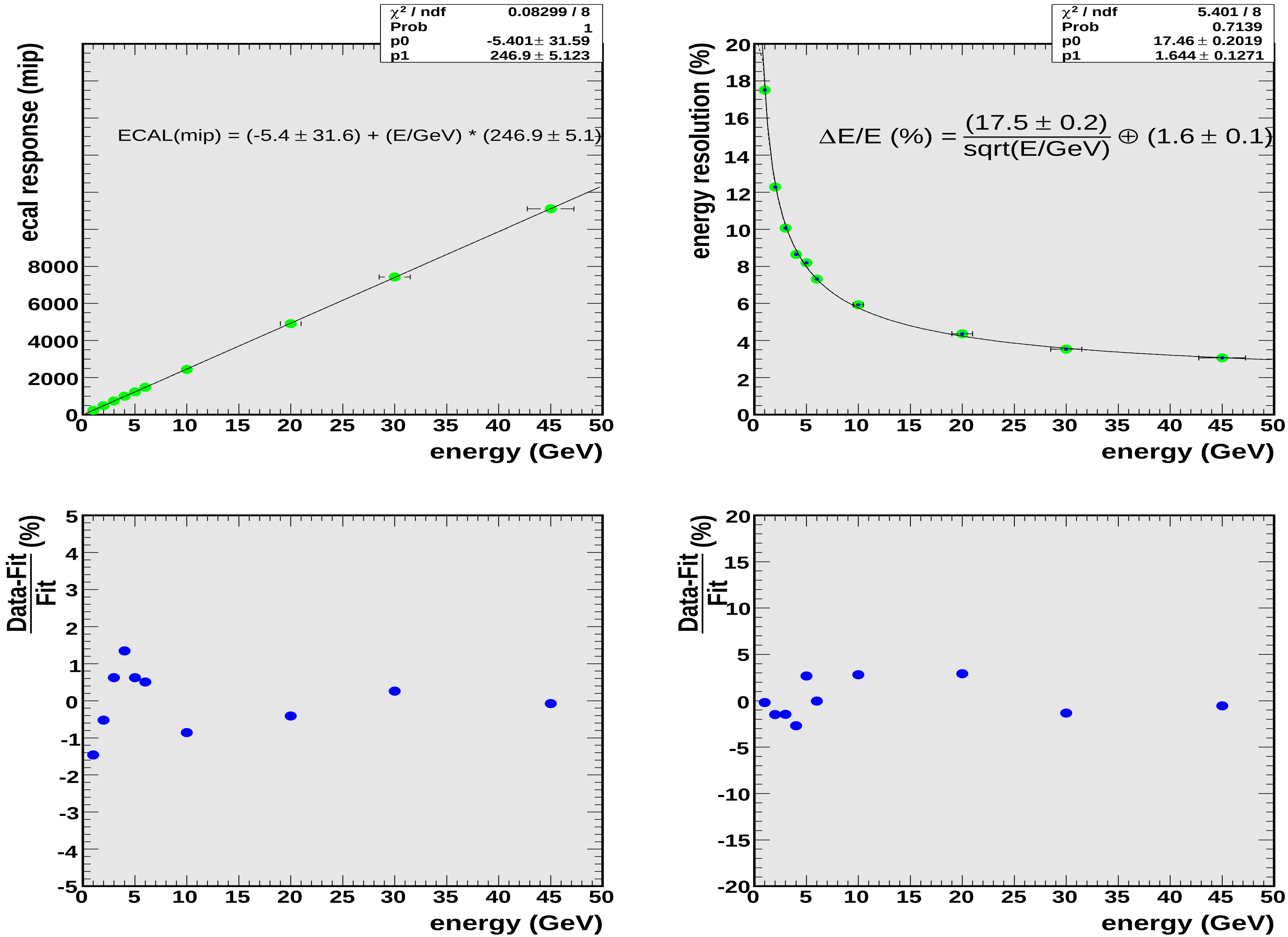
Energy spectra binsize fixed(4 mip), fit range [-1σ, 2σ]



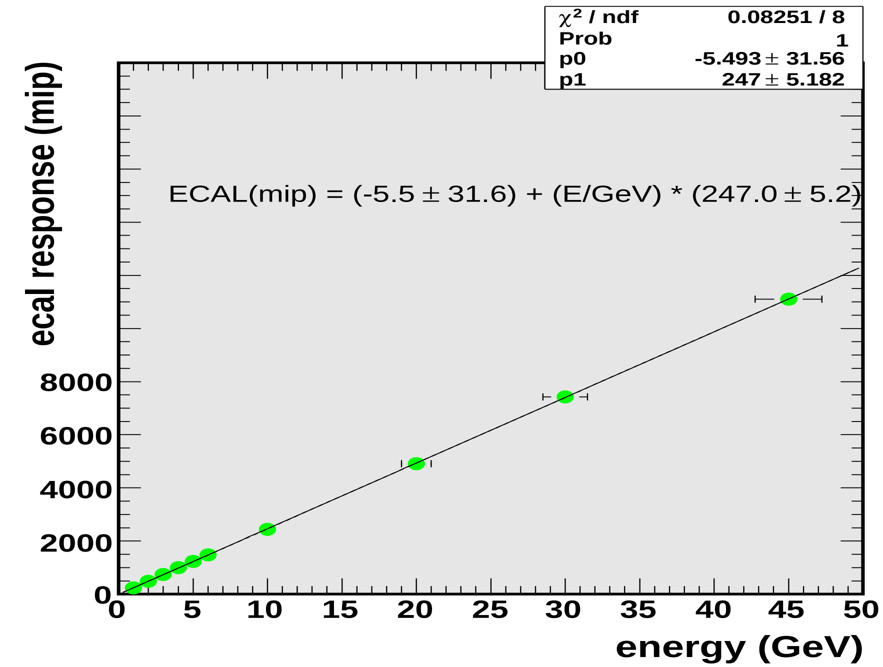
Energy spectra binsize variable(E/GeV mip), fit range [-1σ, 2σ]

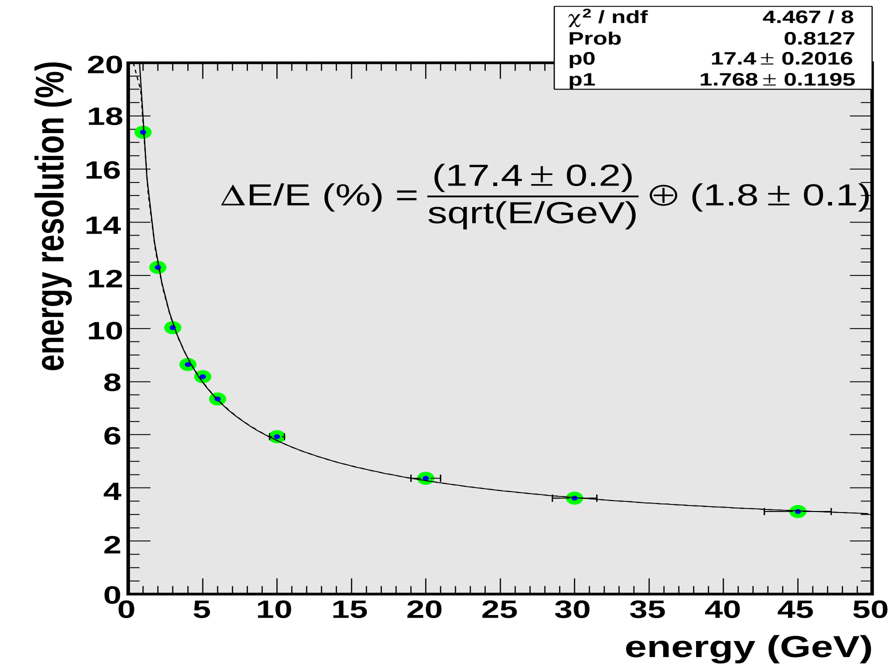


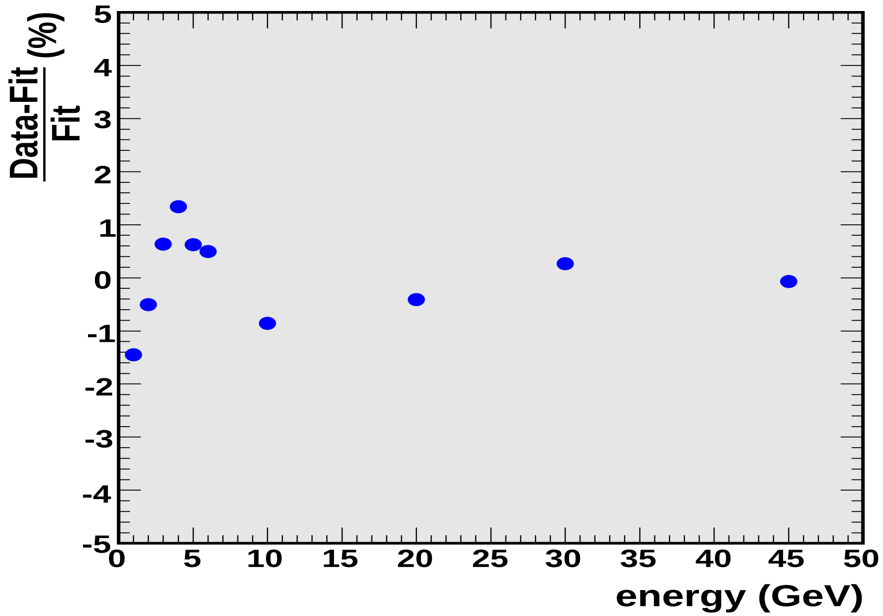
Energy spectra binsize fixed(4 mip), fit range [-1.5σ, 2σ]

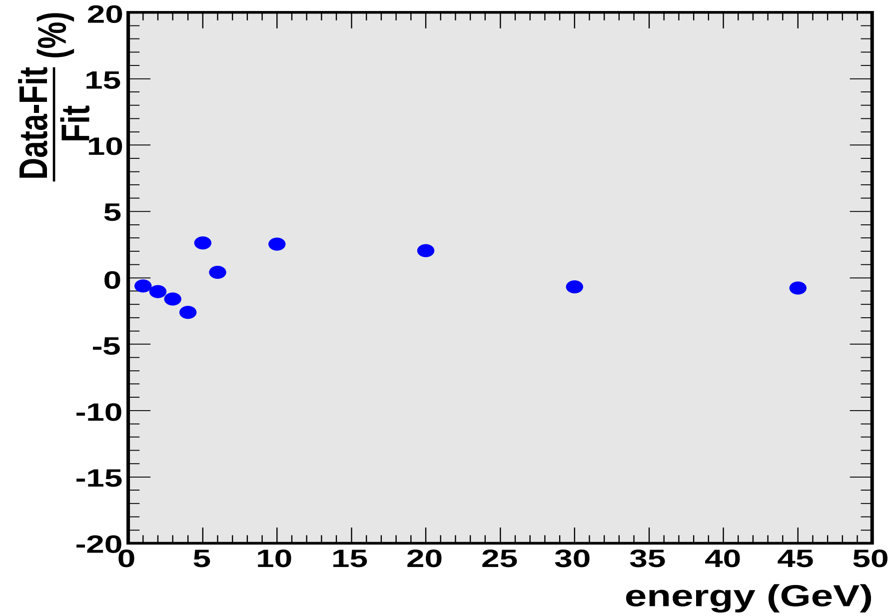


Energy spectra binsize variable(E/GeV mip), fit range [-1.5σ, 2σ]









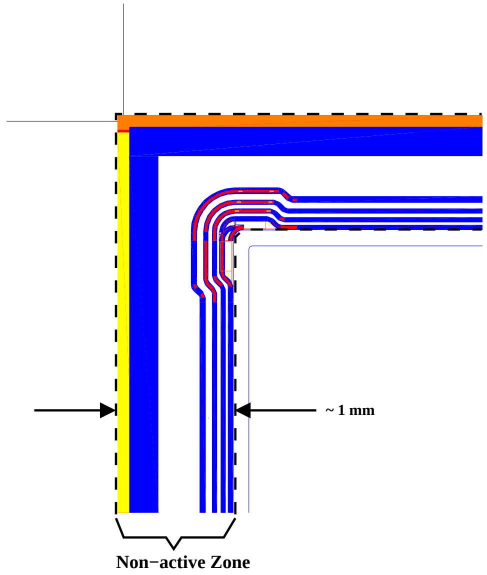
Event-by-event gap correction

Outline

- **Introduction**
- **Description of method**
- **Results from simulation**
- **Application to testbeam data**

Introduction

► · **wafer border**

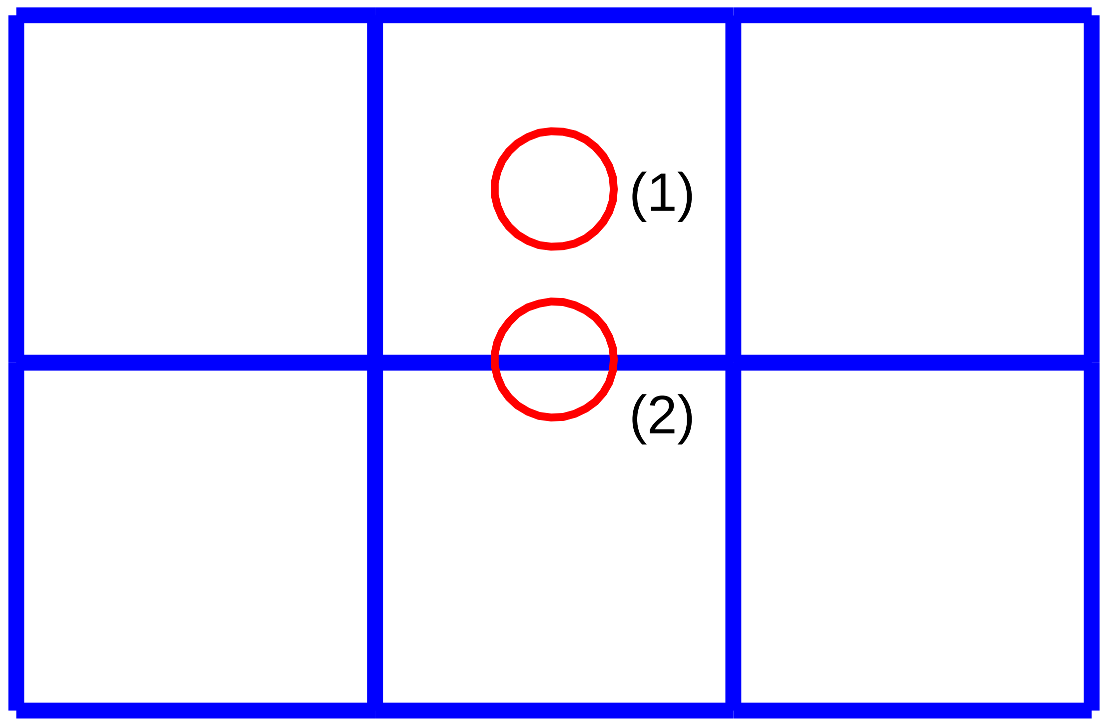


► · **interwafer gap correction**

: try to develop a gap correction method that works on an **event-by-event** basis

: i.e. can be applied to data from a real experiment where the incident particle energy per event is not known in advance

Interwafer gap correction



(1) signal $\propto \pi R^2$

(2) signal $\propto \pi R^2 - 2Rd_{gap}$

$$\frac{S_{correct}}{S_{readout}} = \frac{1}{1 - \frac{2dgap}{\pi R}}$$

Description of method

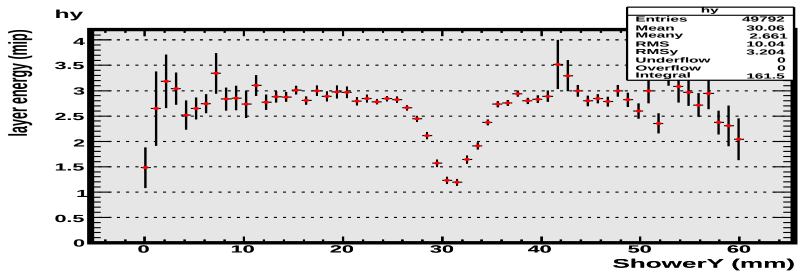
- **some formalism**
  - correction factor $= \frac{LayerEnergyCorrect}{LayerEnergyReadout} = 2 - A_R + \frac{2\cdot(A_R-1)}{1+(1-\exp((\frac{X-X_{gap}}{\sigma_x})^2)\cdot(1-\exp((\frac{Y-Y_{gap}}{\sigma_y})^2)}$
  - correction factor lies in $[1, A_R]$ with $A_R = \frac{1}{1-\frac{2d_{gap}}{\pi R}}$

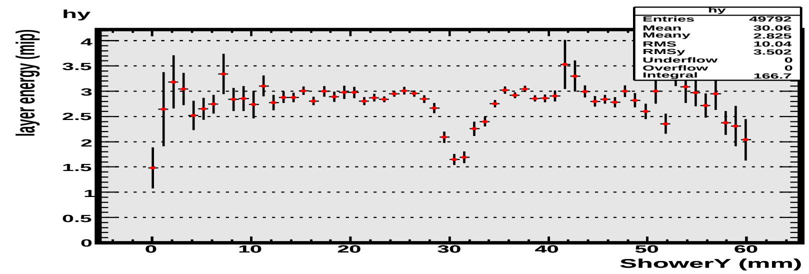
- **on an event-by-event basis do**
  - for all layers and events set $\sigma_x = \sigma_y =$ 5 mm, $d_{gap} =$ 2 mm
  - get position of gaps X_{gap}, Y_{gap} per layer (construction/engineering data)
  - get shower position X,Y per layer relative to gaps (tracking)
  - approximate R with the energy weighted RMS of X,Y of shower hits in layer
  - apply correction formula per layer

Layer

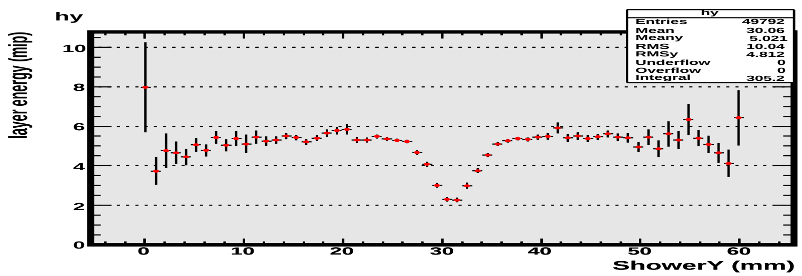
without correction

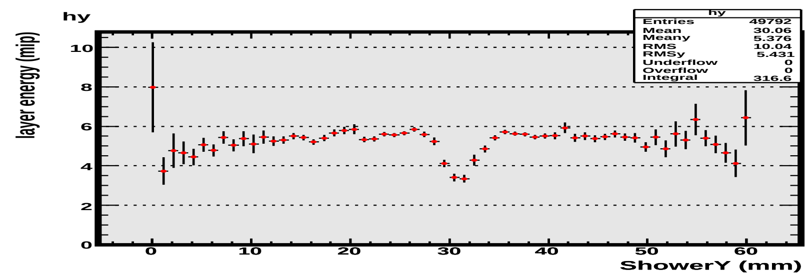
with correction



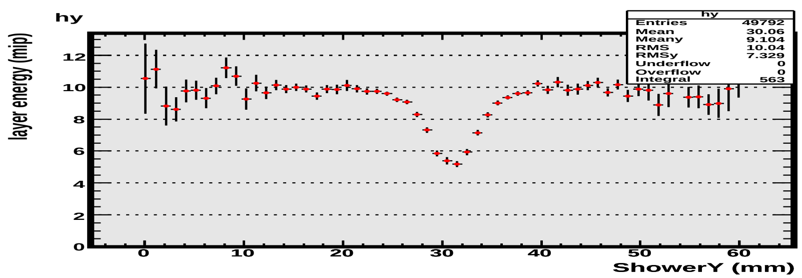


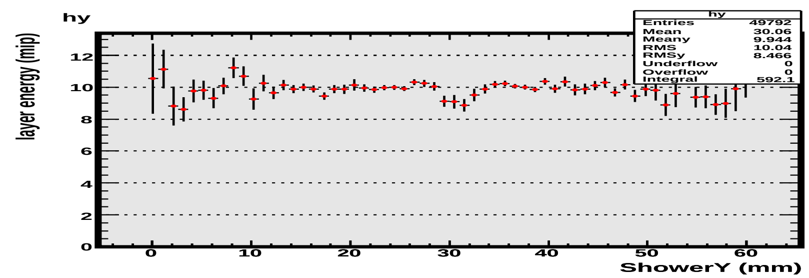
0



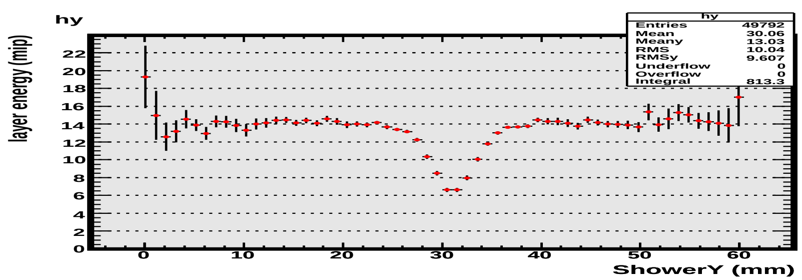


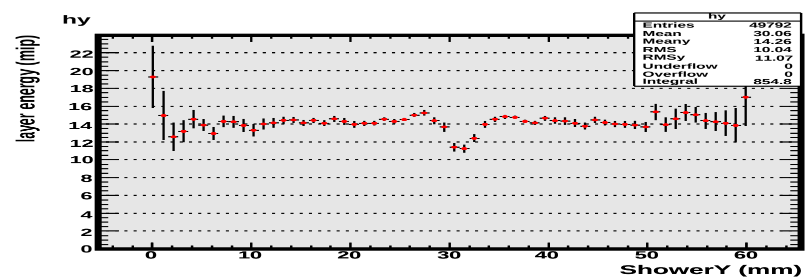
1



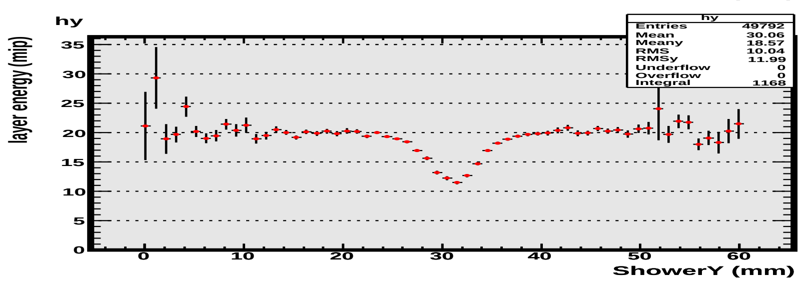


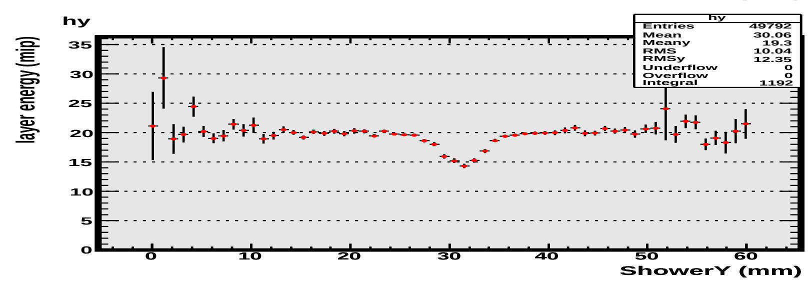
2





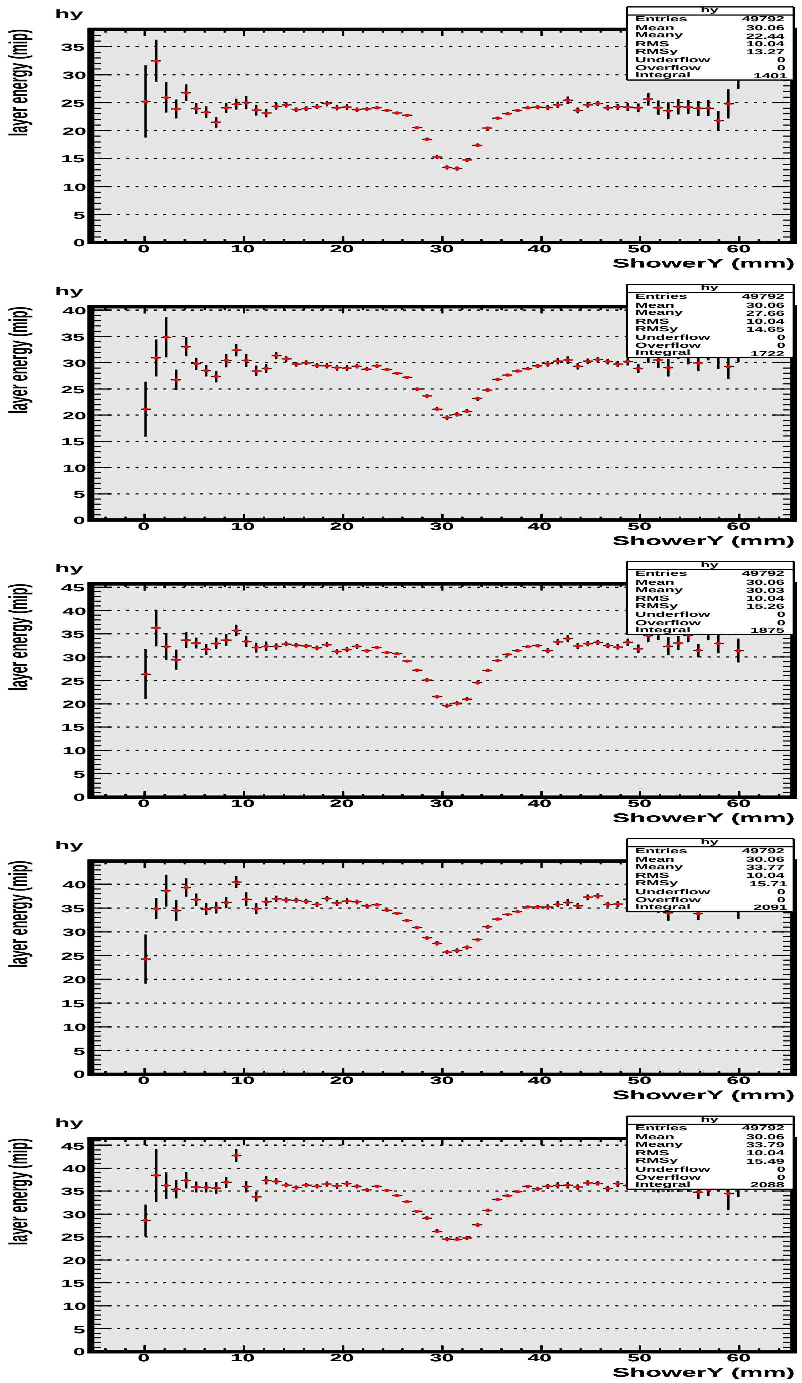
3

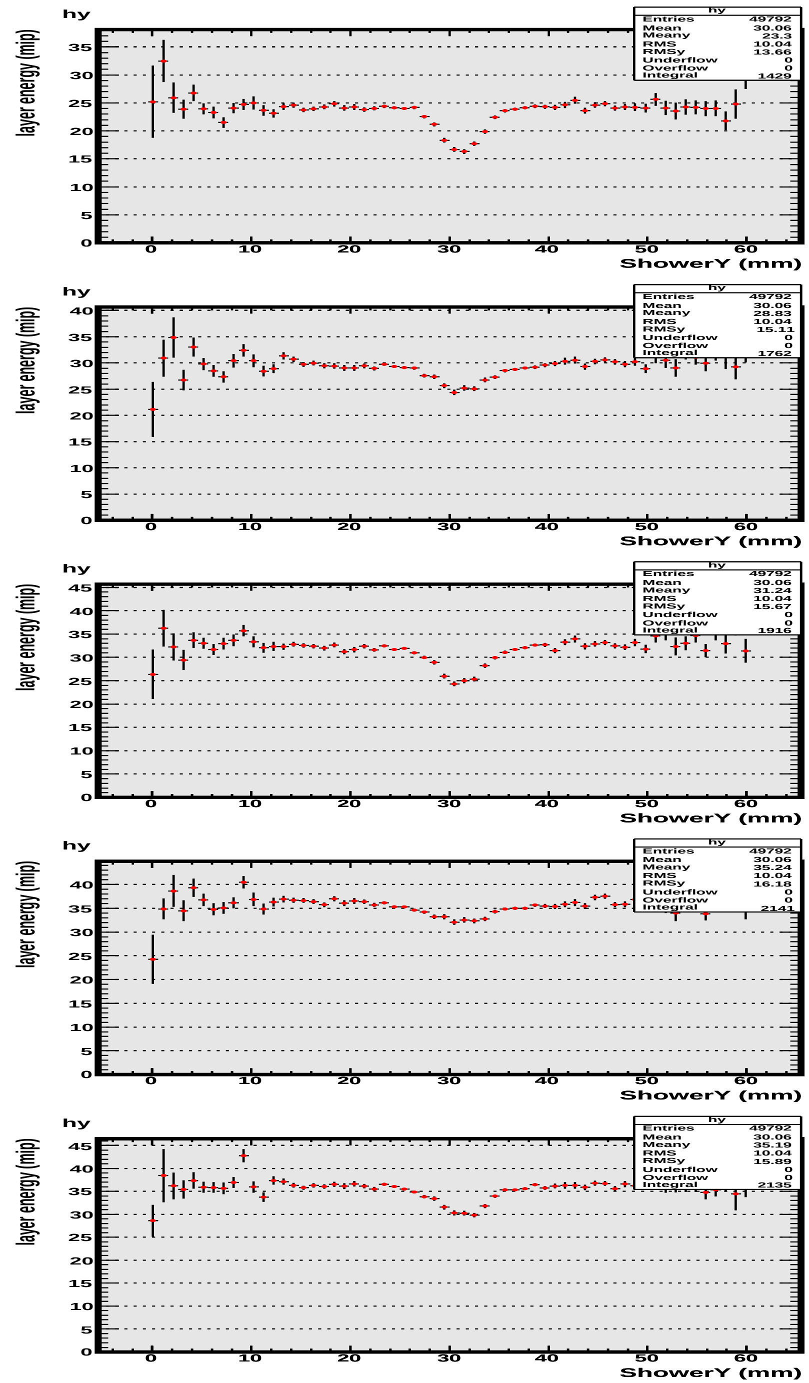




4

Layer | **without correction** | **with correction**





5

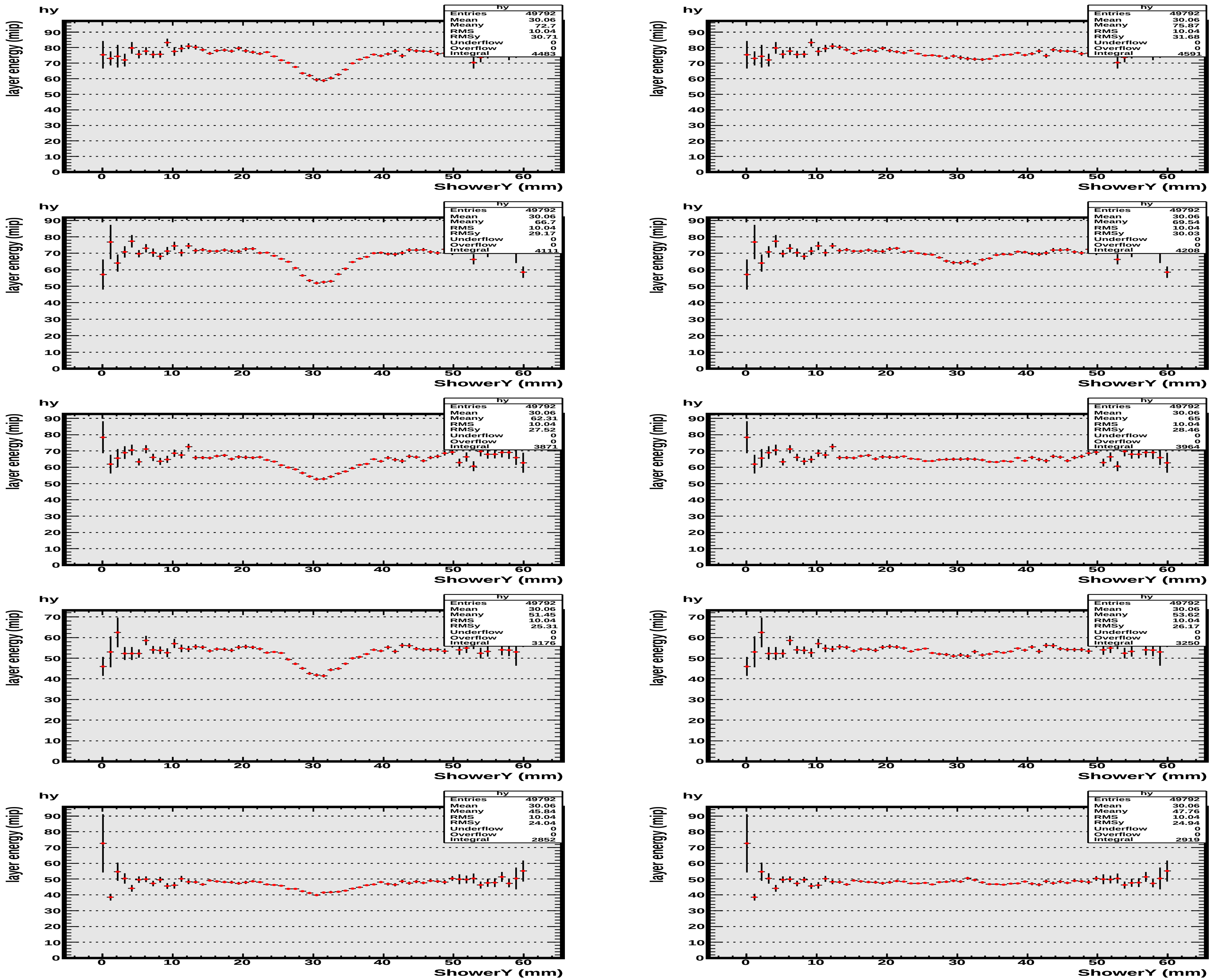
6

7

8

9

Layer | without correction | with correction



10

11

12

13

14

Layer | **without correction** | **with correction**

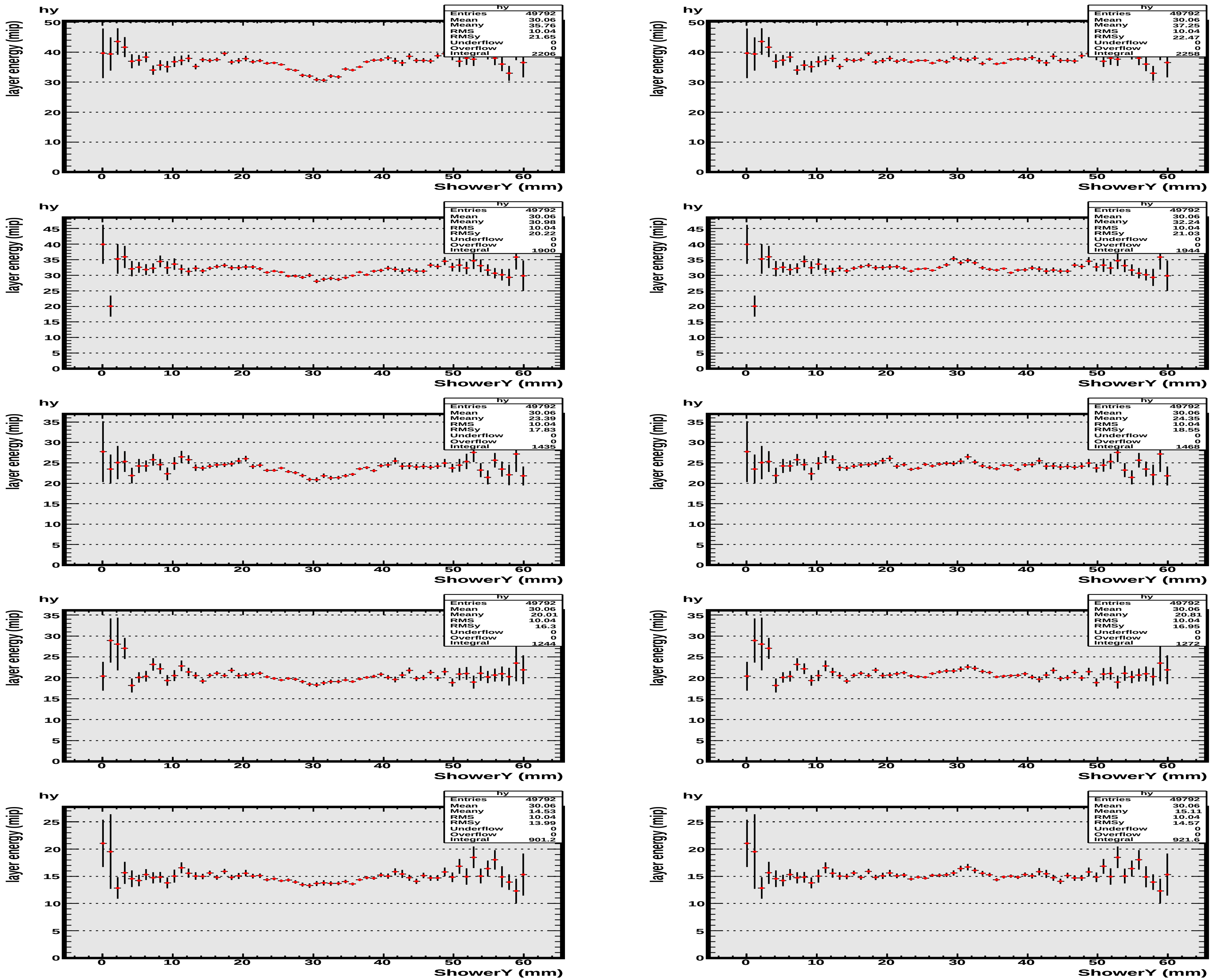
15

16

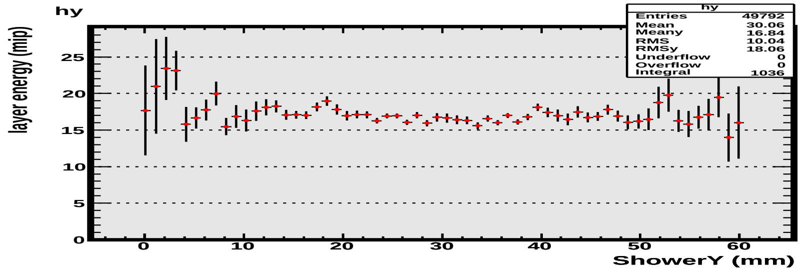
17

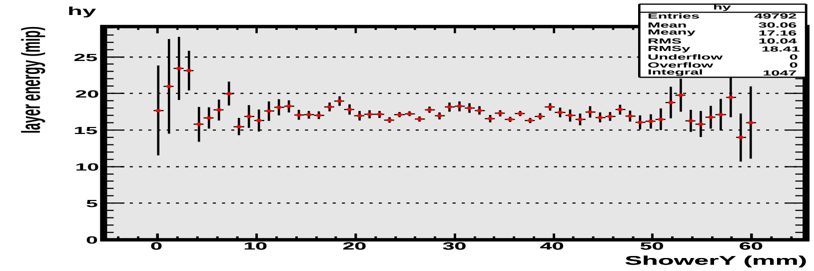
18

19

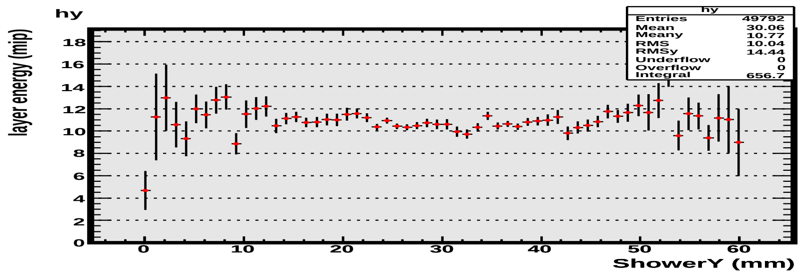


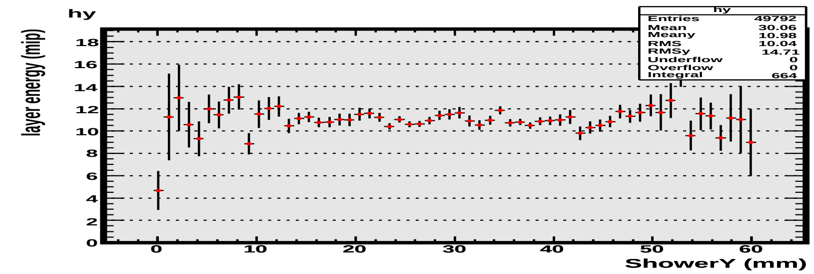
Layer **without correction** **with correction**



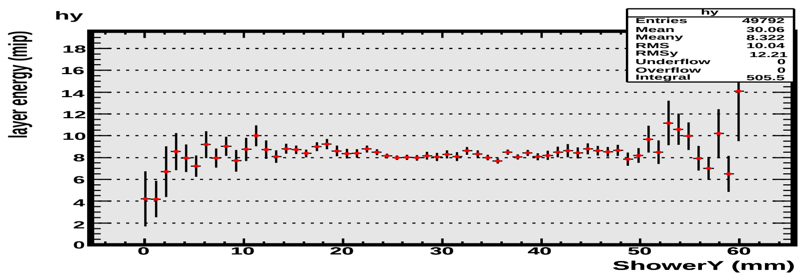


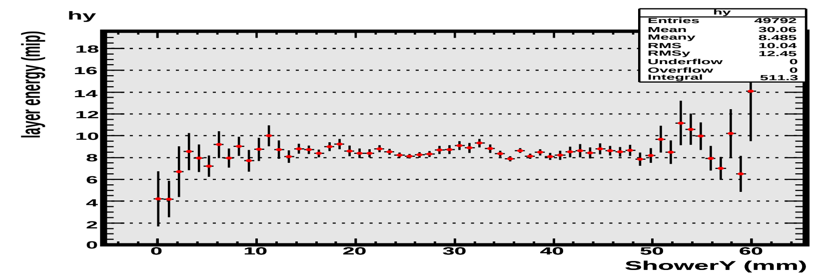
20



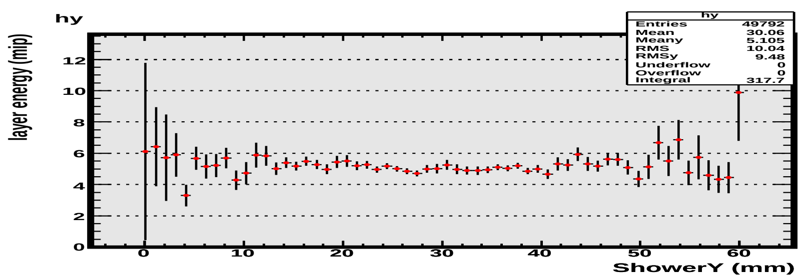


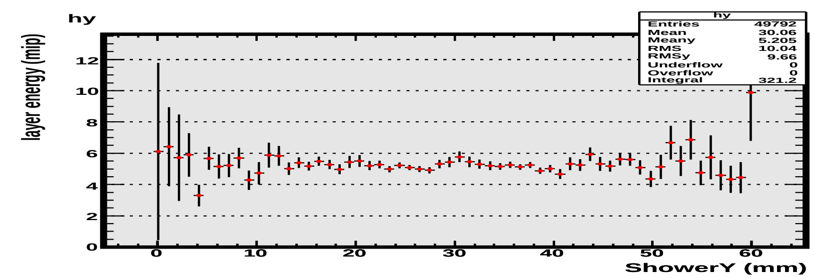
21



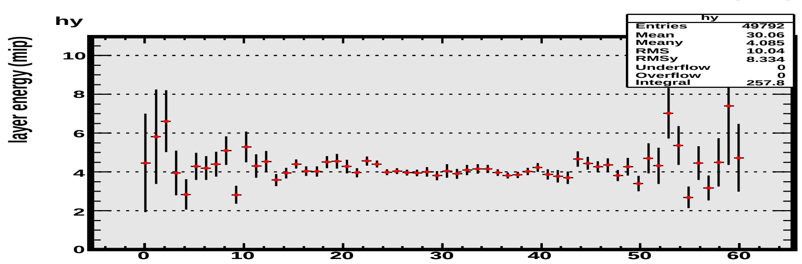


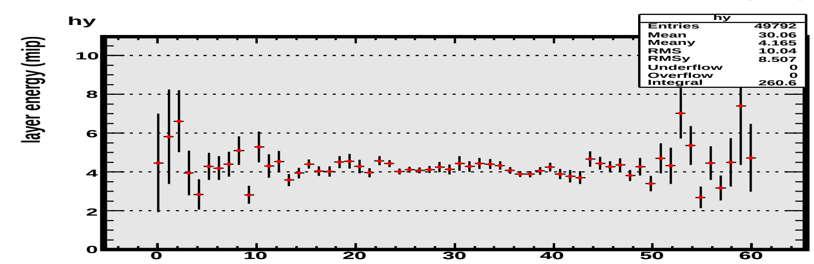
22





23



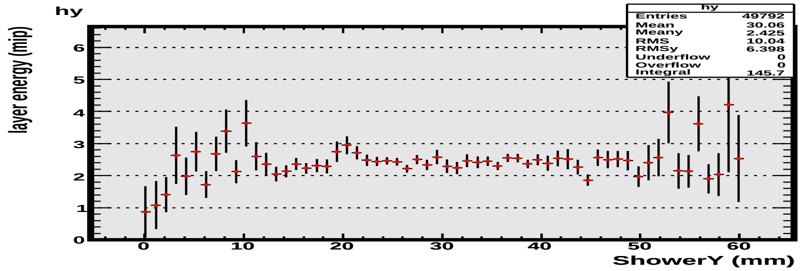


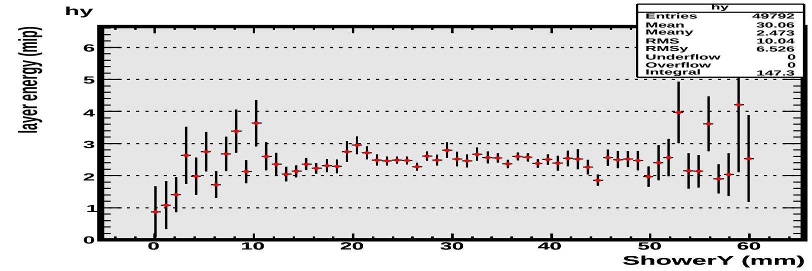
24

Layer

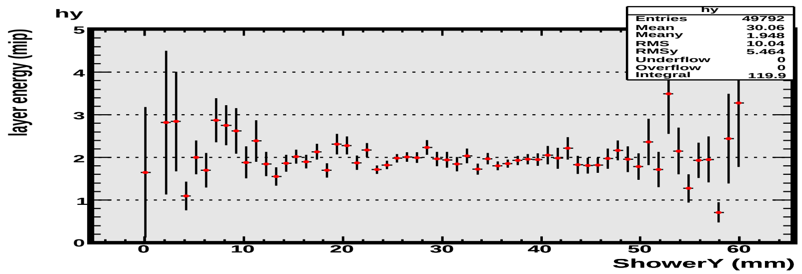
without correction

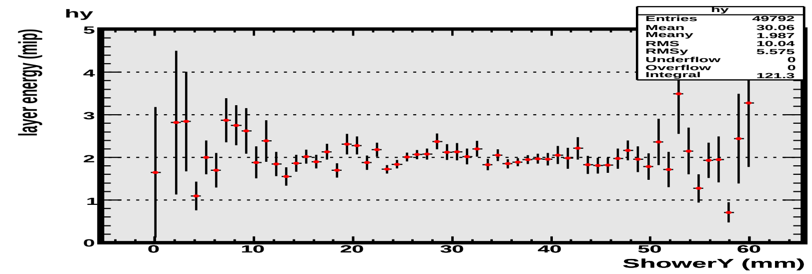
with correction



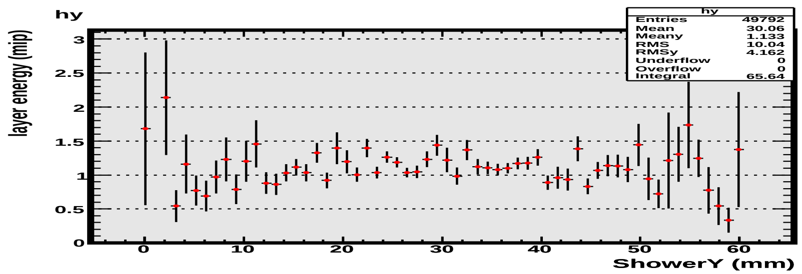


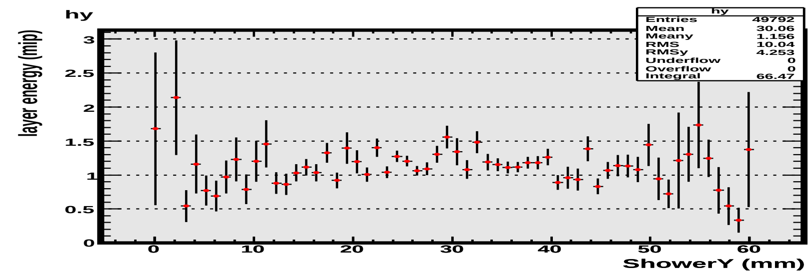
25



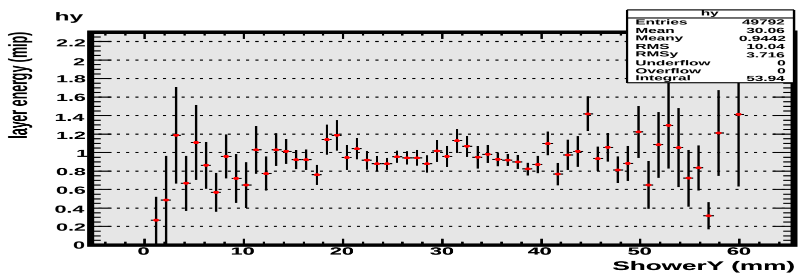


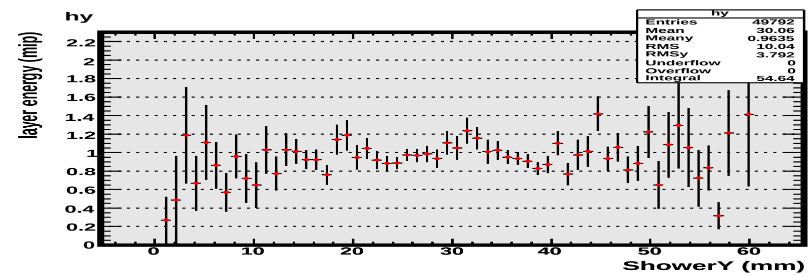
26



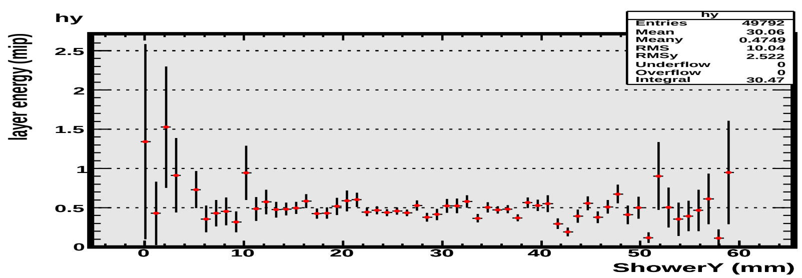


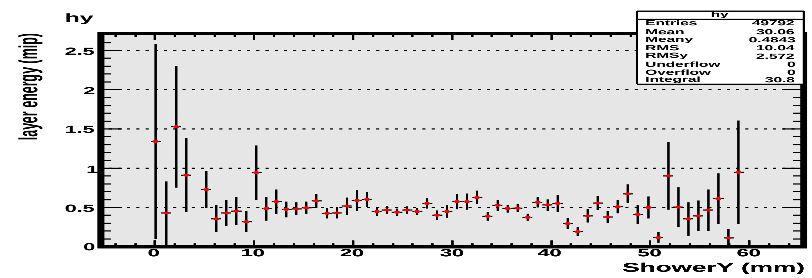
27





28

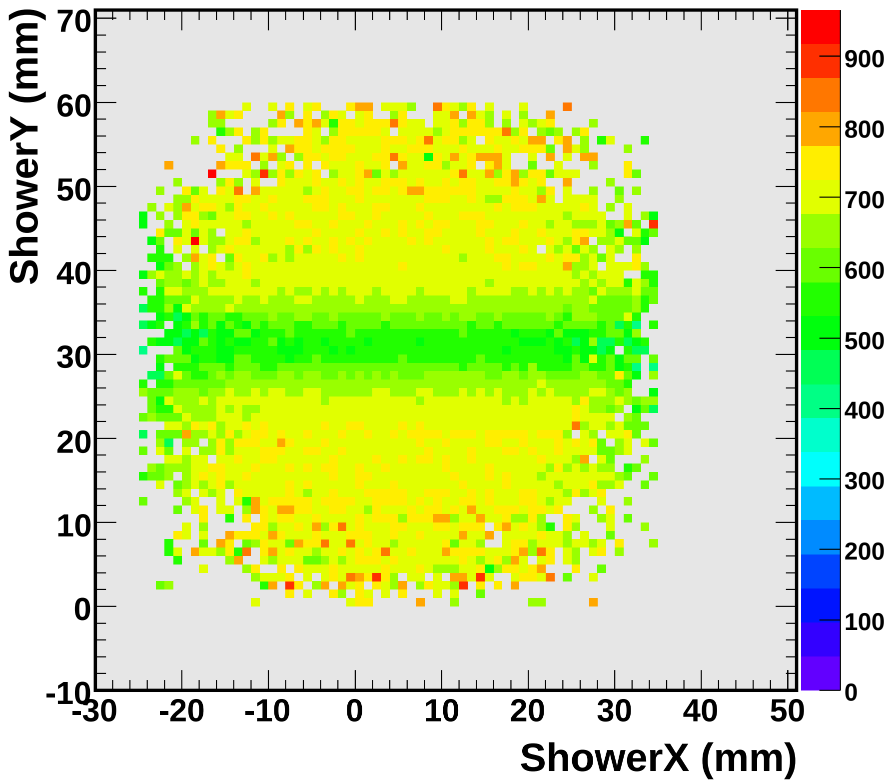




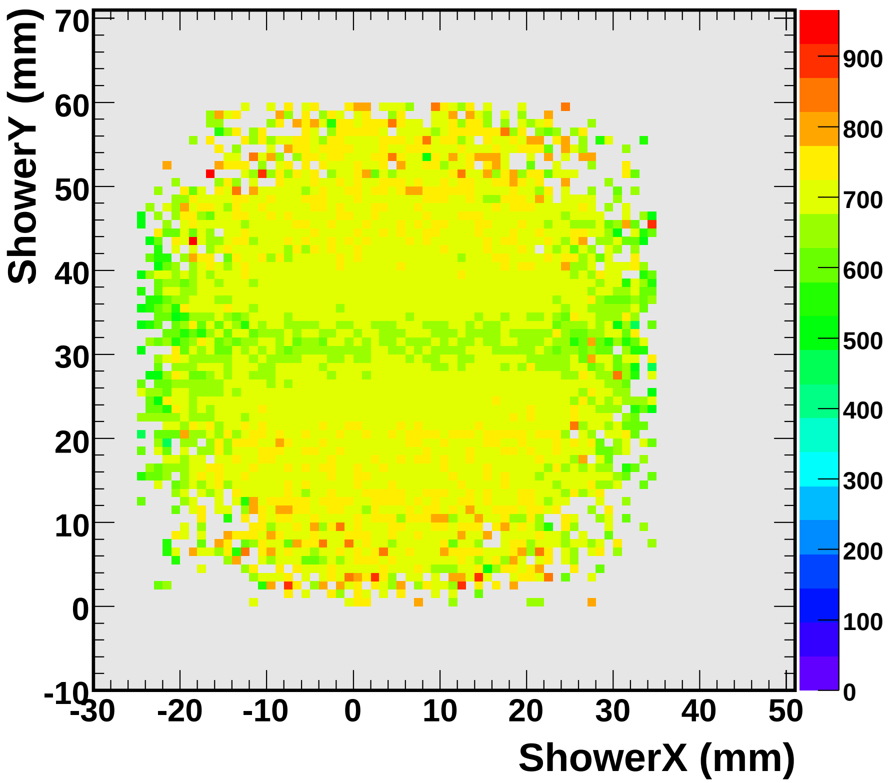
29

Simulation e^- 3 GeV

without correction

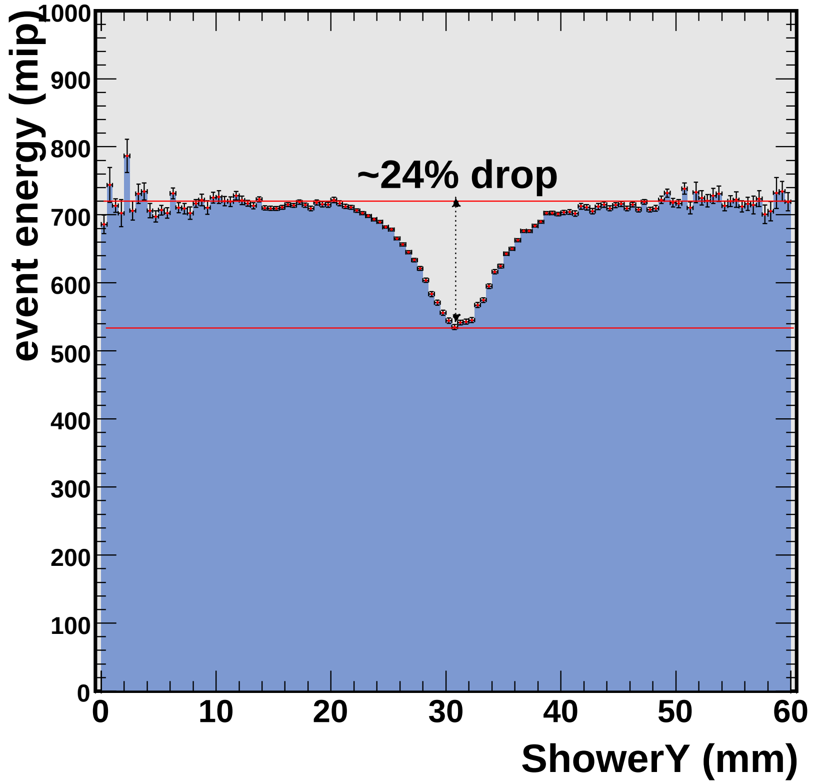


with correction

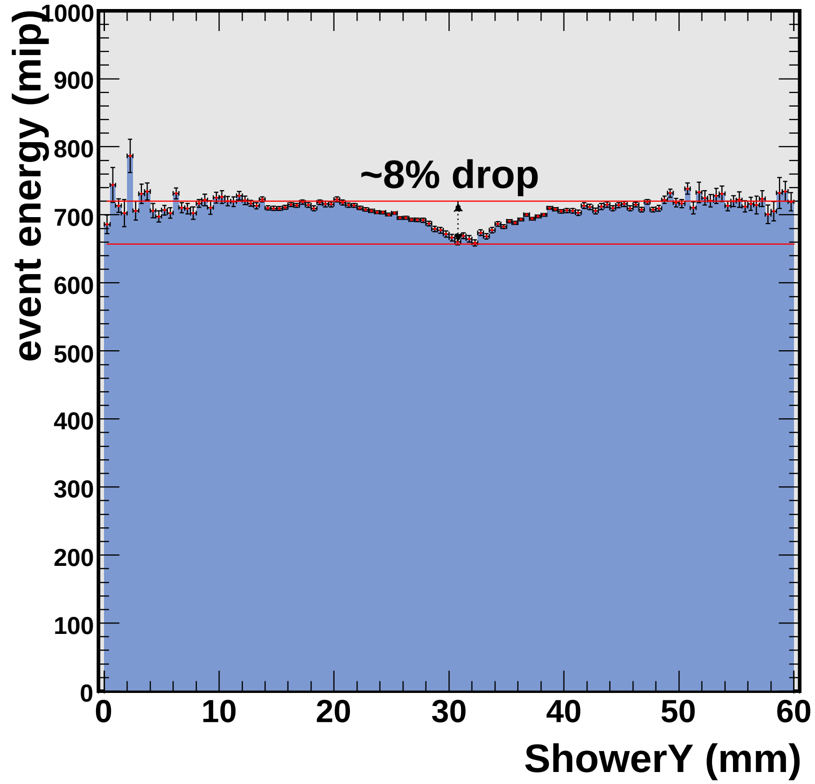


Simulation e^- 3 GeV

without correction

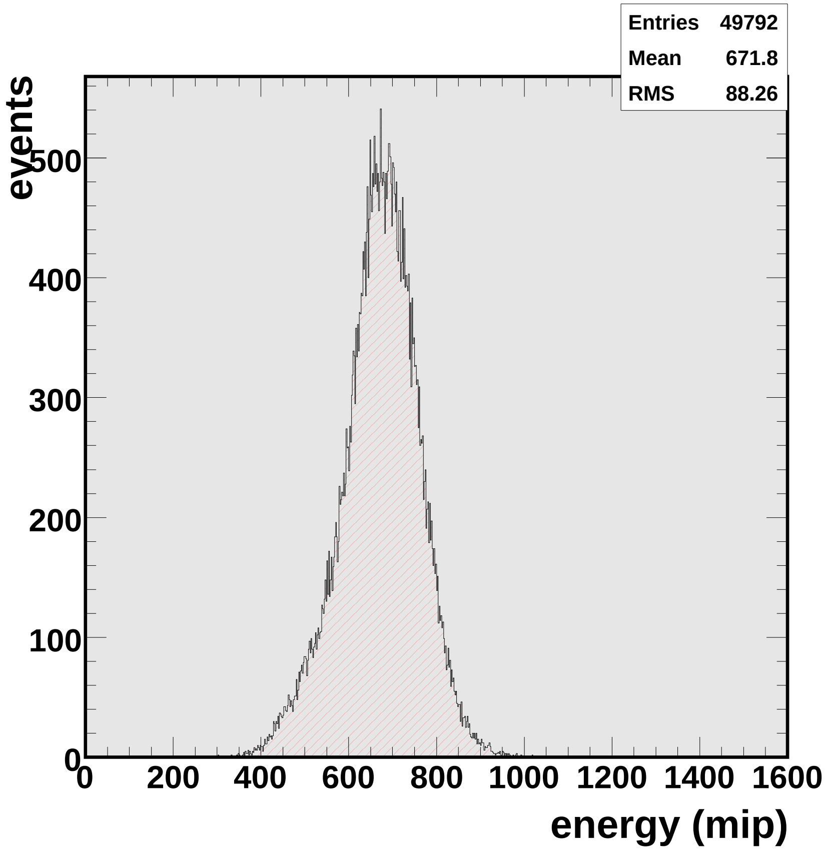


with correction

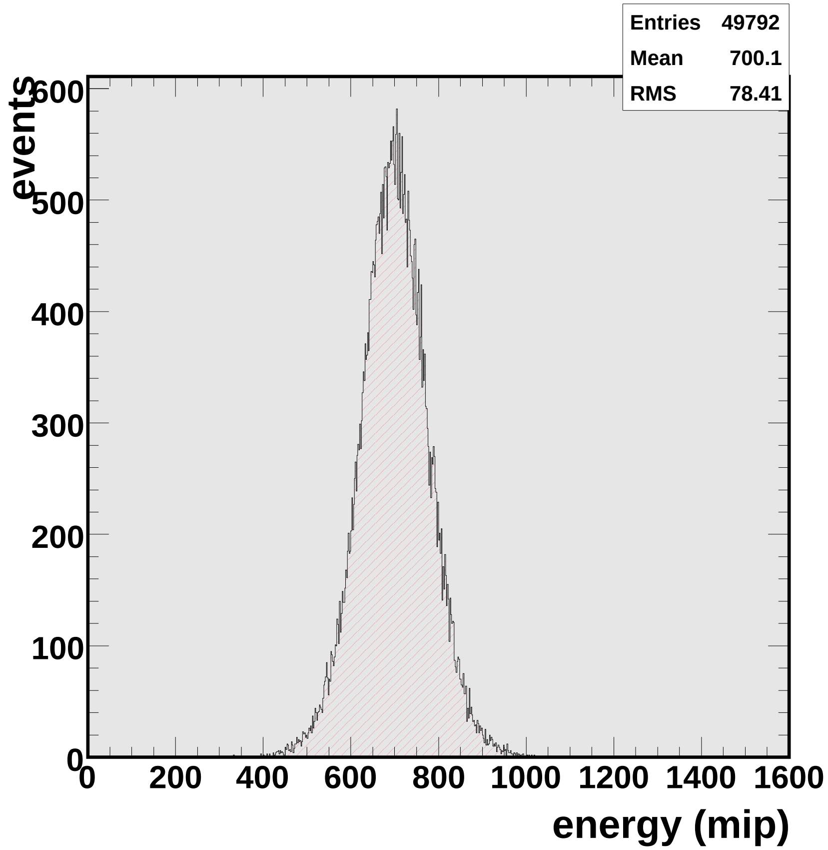


Simulation e^- 3 GeV

without correction



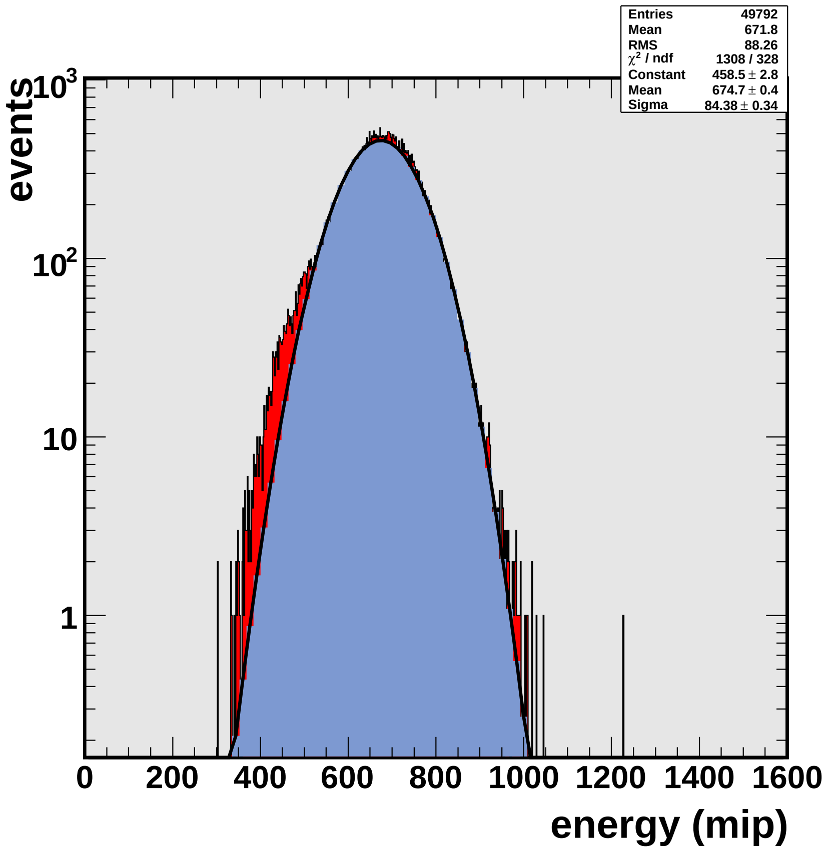
with correction



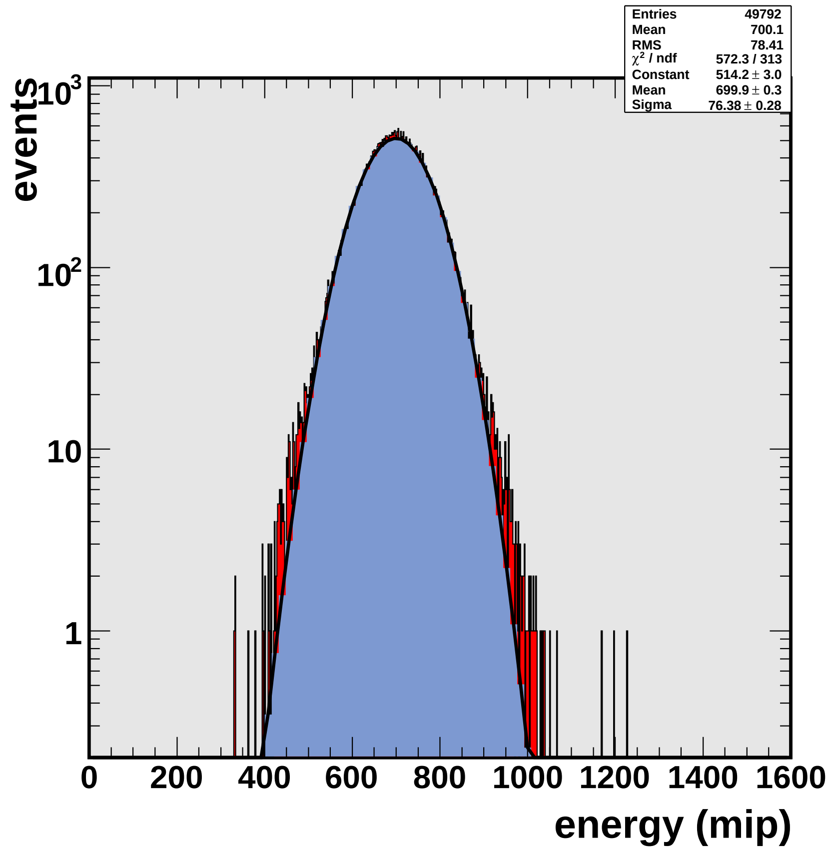
correction improves shape, mean, rms, rms/mean

Simulation e^- 3 GeV

without correction



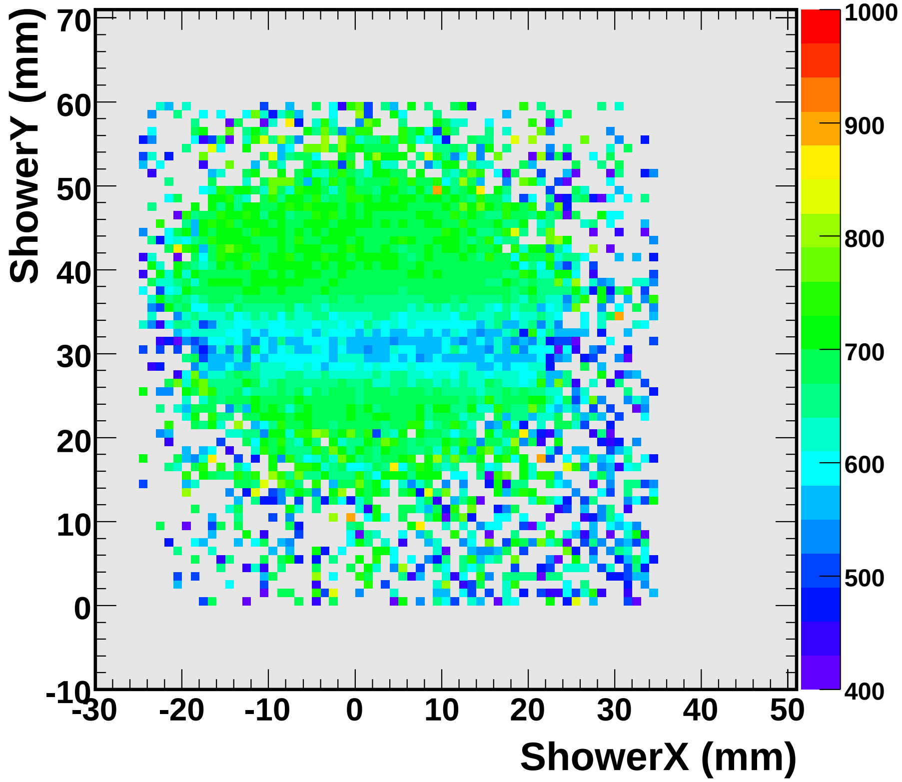
with correction



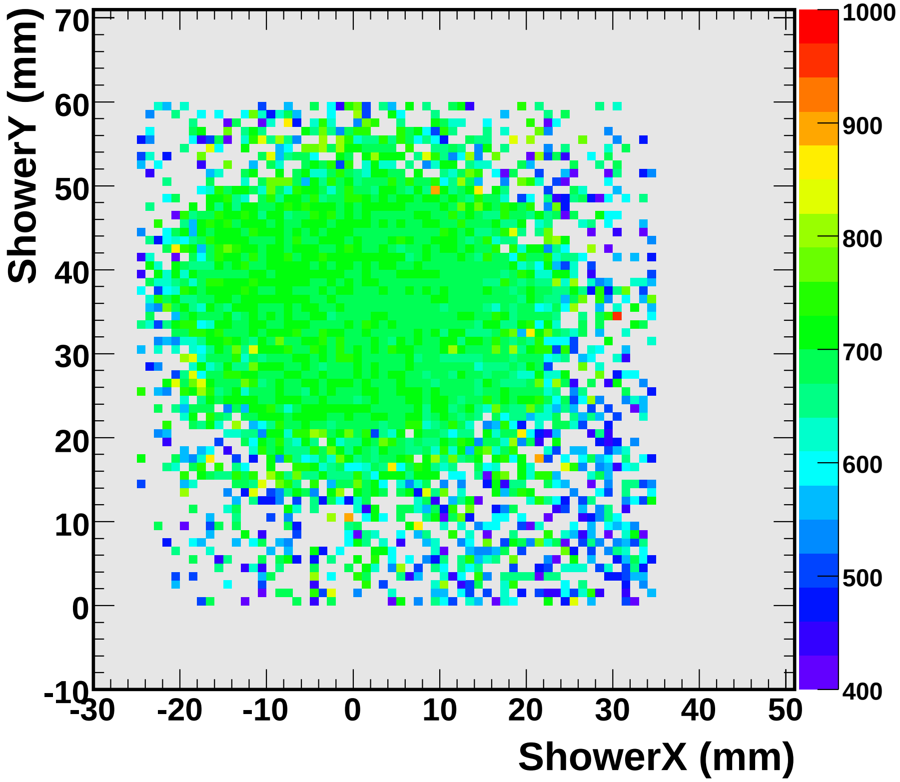
correction improves shape, mean, rms, rms/mean

Run230134 e^- 3 GeV

without correction



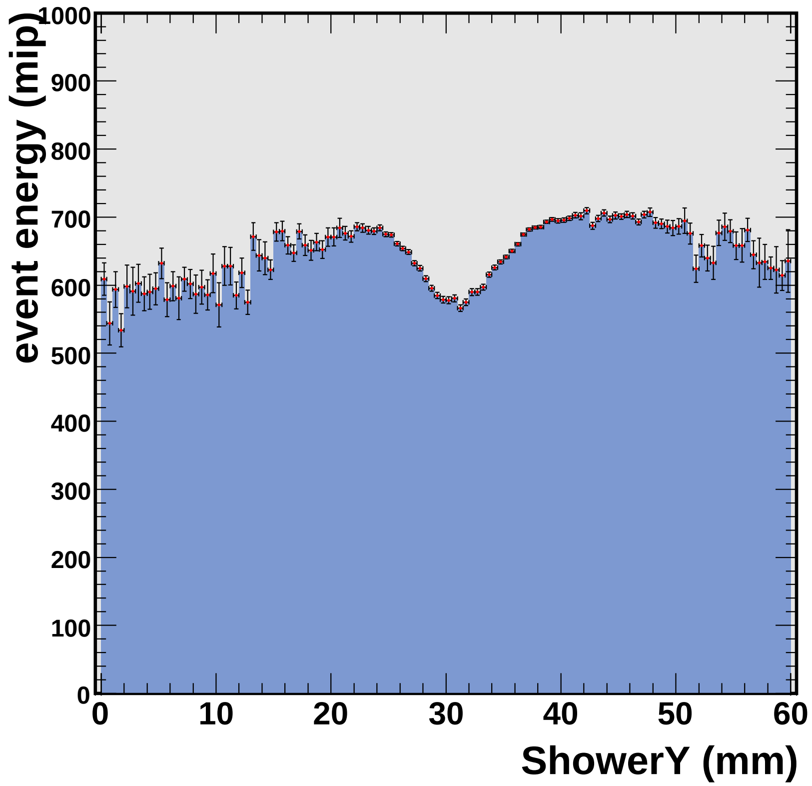
with correction



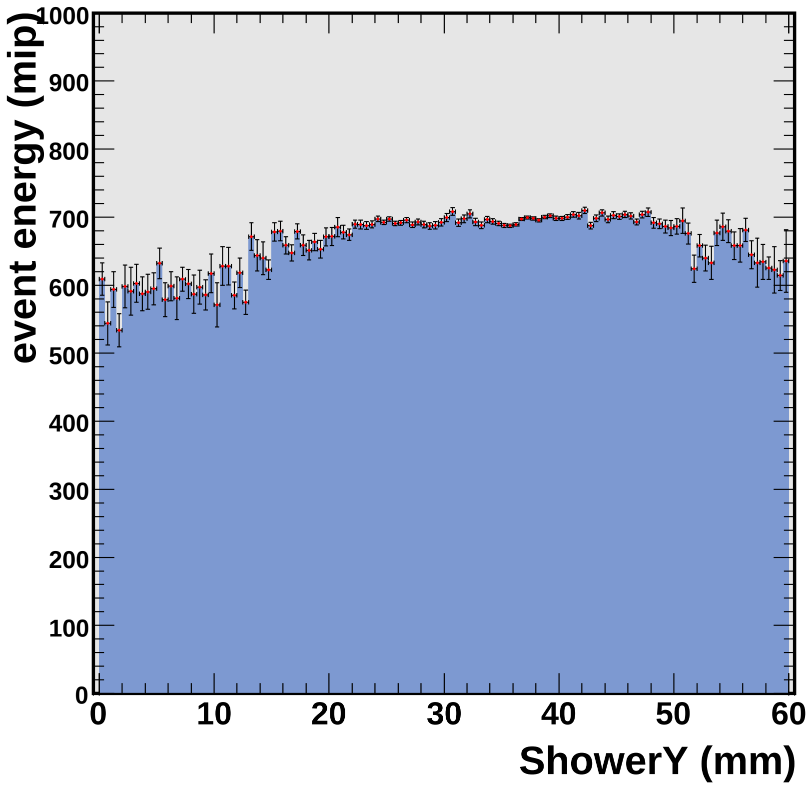
correction without any run specific tuning

Run230134 e^{-} 3 GeV

without correction



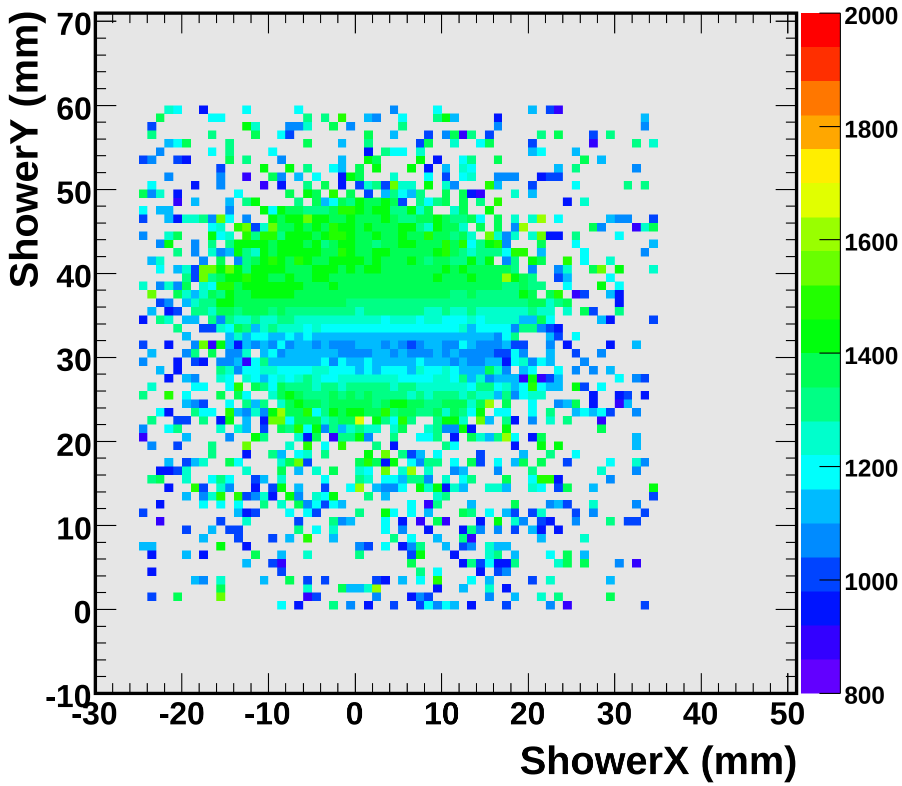
with correction



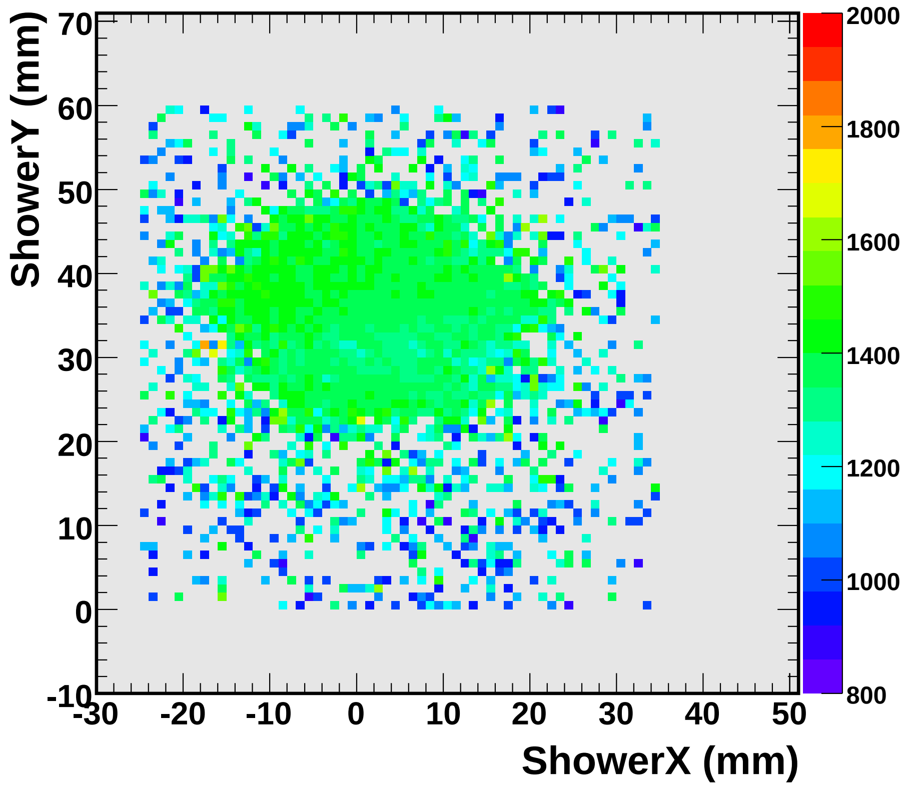
correction without any run specific tuning

Run230137 e^{-} 6 GeV

without correction



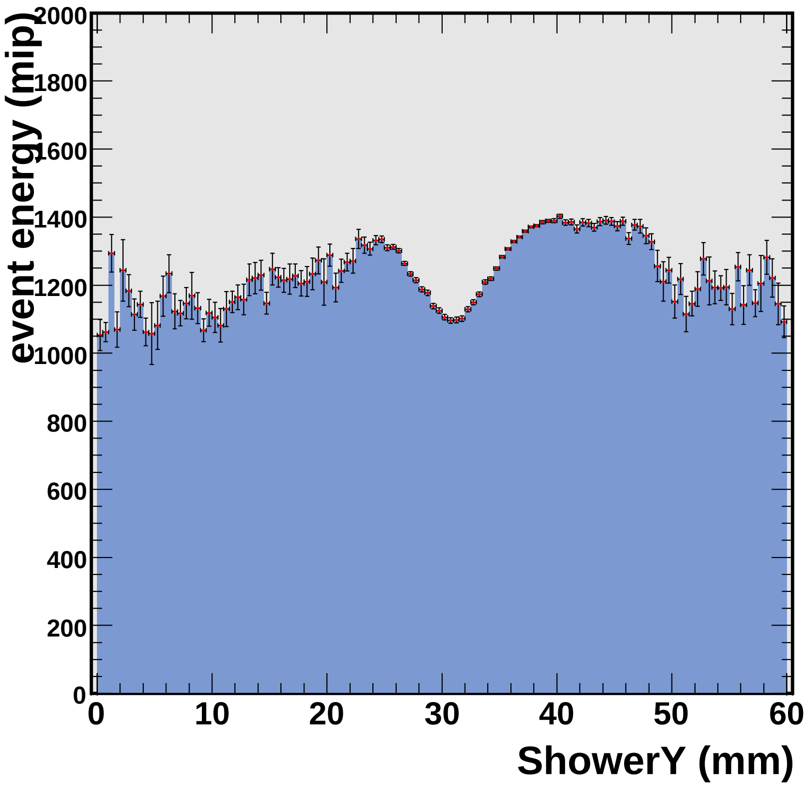
with correction



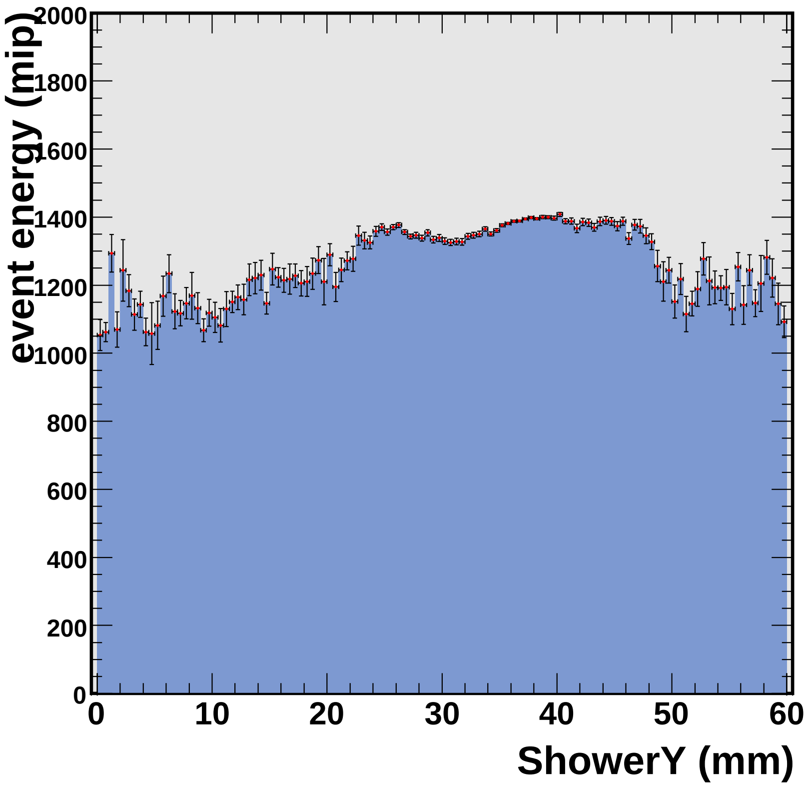
correction without any run specific tuning

Run230137 e^- 6 GeV

without correction



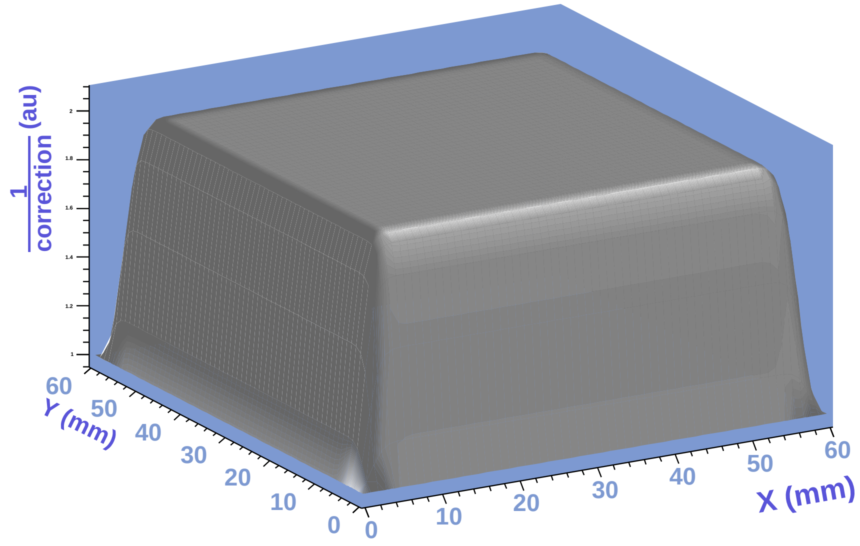
with correction



correction without any run specific tuning

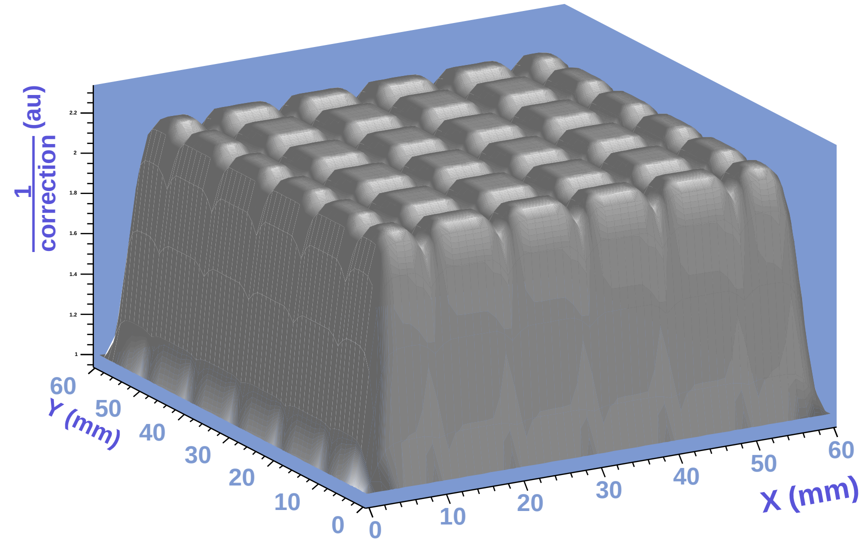
Inter-wafer/cell correction

wafer with 6 × 6 Si cells



interwafer correction only

wafer with 6 × 6 Si cells



interwafer and intercell correction

Summary (Event-by-event gap correction)

- **interwafer gap correction**

  : illustration of a correction method that works on an **event-by-event** basis

  : based on simple geometrical assumptions

  : shows significant recovery of response along ECAL gaps for low energy electrons (1-6 GeV)

  : similar or better performance is expected for higher energy particles where RMS X,Y approximates better the actual shower width per layer

- **"inter-cell gap correction" = cell charge collection efficiency**

  : in principle similar correction approach can be applied for the inter-cell gaps

- **see also method developed by L.Morin**