• Si/W ECAL undersampling studies

• Energy composition and transverse profiles of e^-/e^+ showers

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* (also with **FERMILAB**)

Outlines

- Event selection
- Weighting schemes
- Results
- General
- Shower composition
- Transverse profiles
- Summary

Undersampling studies

- .

  : study how the performance of the Si/W ECAL changes
  with respect to absorber thickness per layer

  : "emulate" different average effective W thickness per layer
  by undersampling the calorimeter and varying accordingly the
  weight of each layer

- **. reminder**

  full Si/W prototype (24 X_0)

  ▷ 30 layers $\times$ 18 cm $\times$ 18 cm, interleaved with 0.5 mm Si pads

  ▷ readout by 1 $\times$ 1 cm^2 cells, total: 9720 channels

  ▷ **W absorber, 10+10+10 layers, 1.4 mm:2.8 mm:4.2 mm thick per respective layer**

Event selection

- **· ... the usual selection criteria ...**
  - : 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)

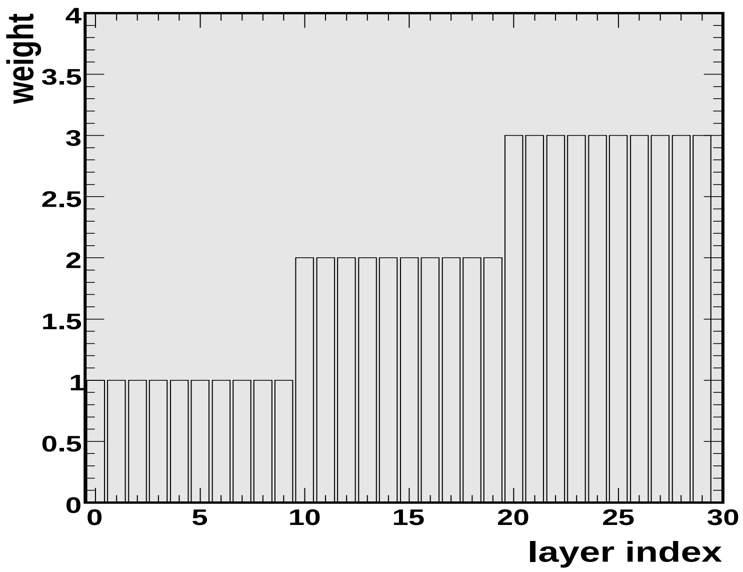
E(GeV)	e^- run(DESY-06)
1	230098
2	230099
3	230097
4	230100
5	230104
6	230101

E(GeV)	e^- run(CERN-06)
10	300672
20	300676
30	300207
45	300195

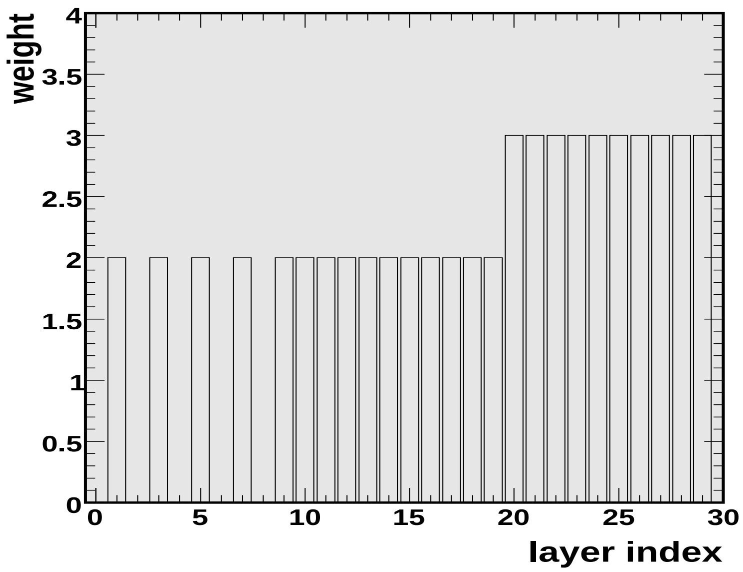
E(GeV)	e^+ run(CERN-06)
10	300731
15	300733
16	300734
18	300735
20	300736
30	300742
50	300744

Weighting schemes

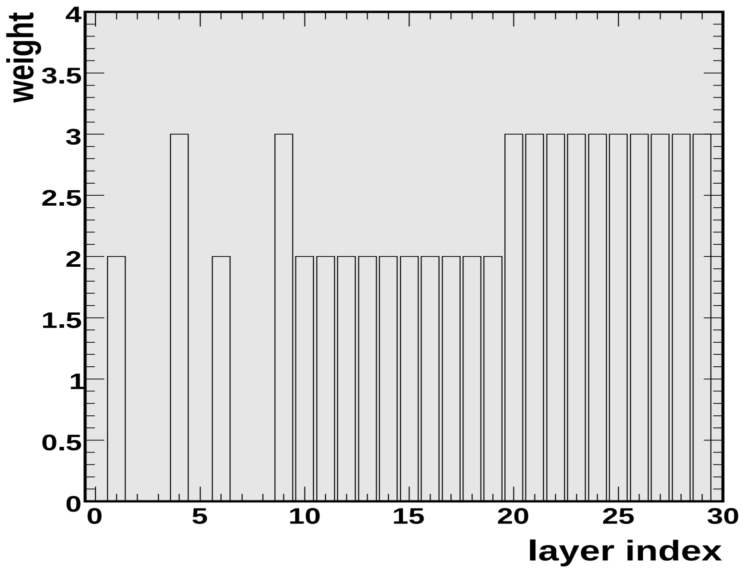
"nominal" (W1)



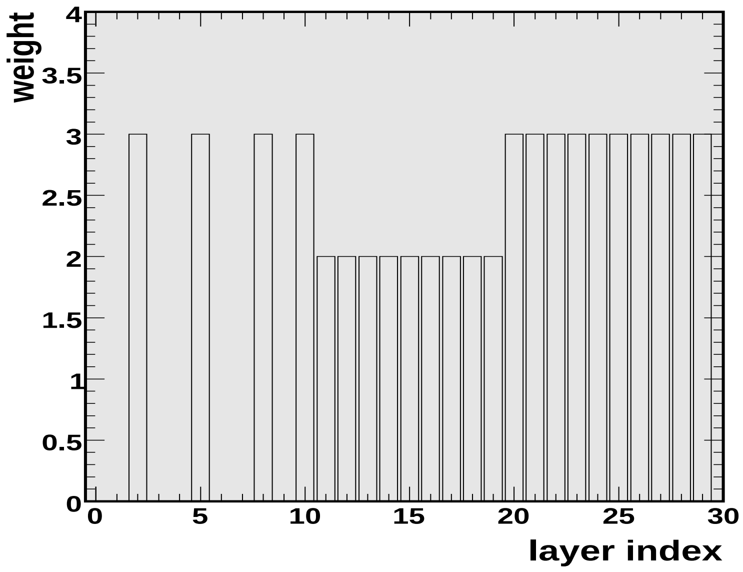
scheme 2 (W2)



scheme 3 (W3)



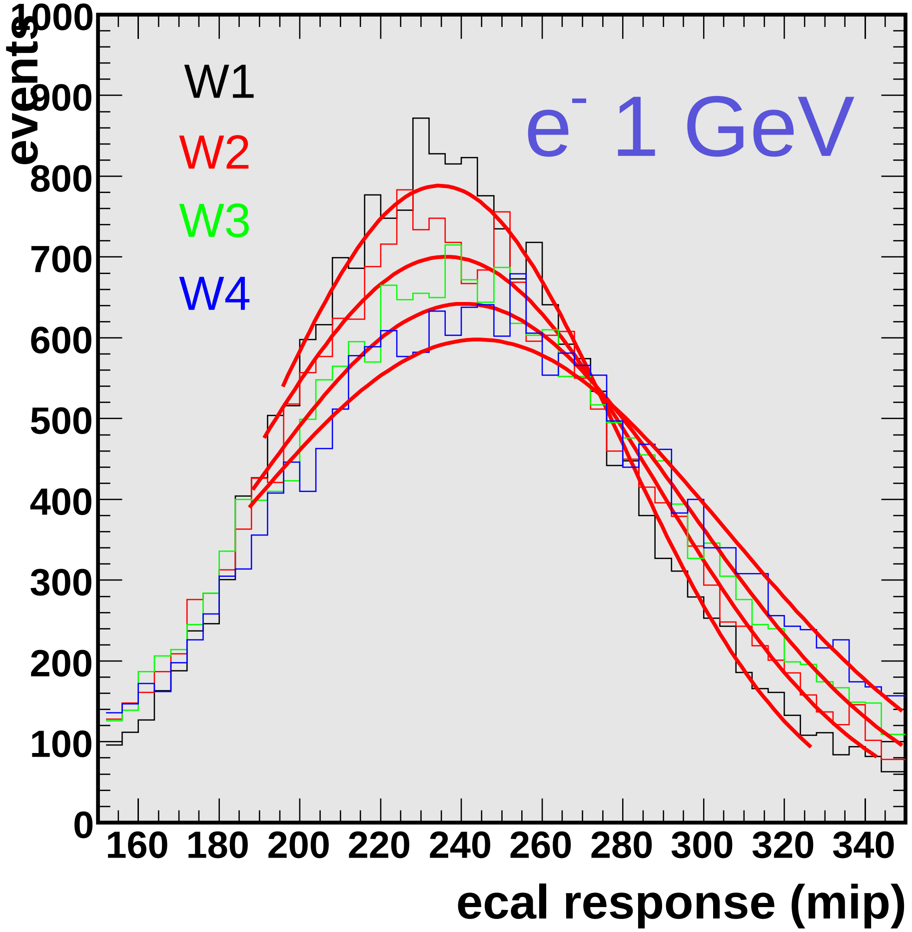
scheme 4 (W4)



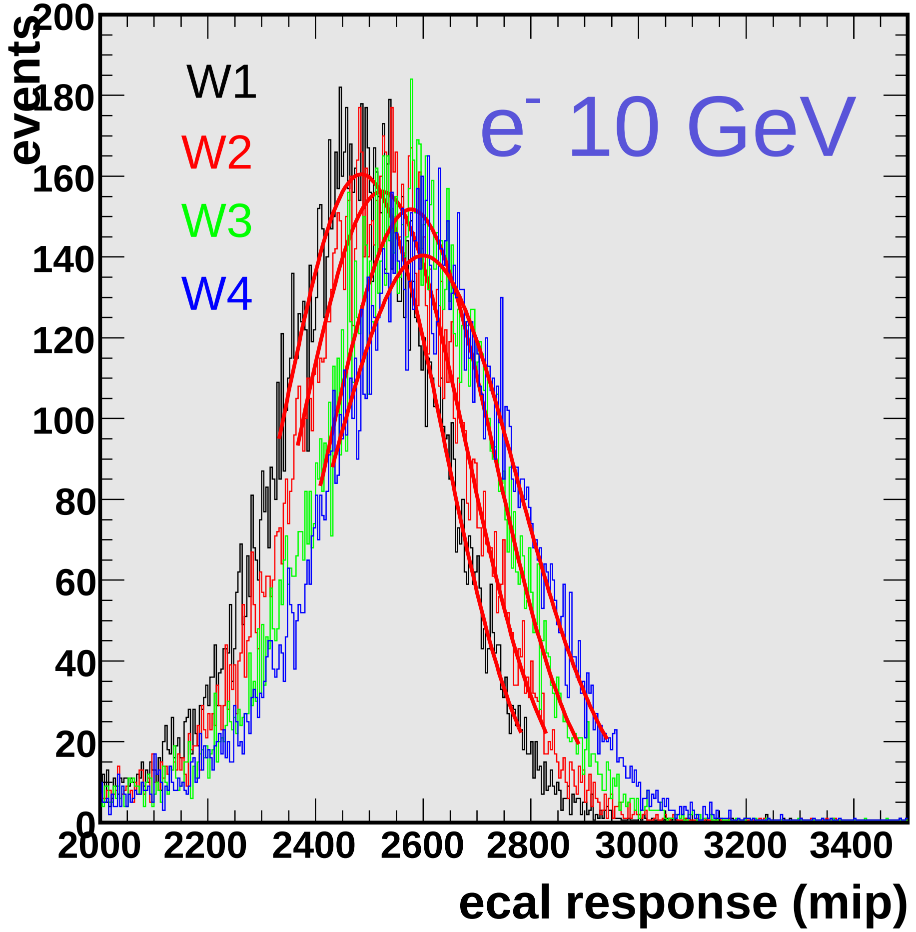
Weighting schemes

weighting scheme	total Nof layers	average thickness per layer (mm)
W1	30	2.80 ± 1.16
W2	25	3.36 ± 0.70
W3	24	3.50 ± 0.71
W4	23	3.65 ± 0.70

Response

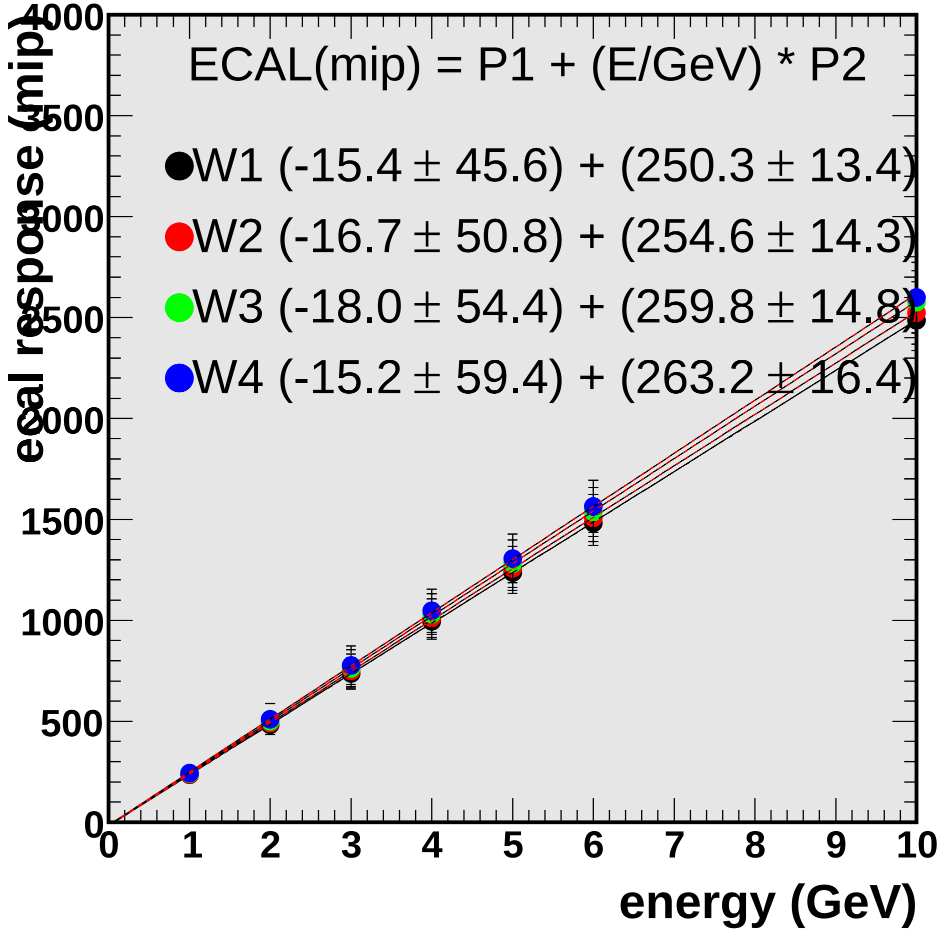


events
W1
W2
W3
W4
e- 1 GeV
0
100
200
300
400
500
600
700
800
900
1000
160 180 200 220 240 260 280 300 320 340
ecal response (mip)

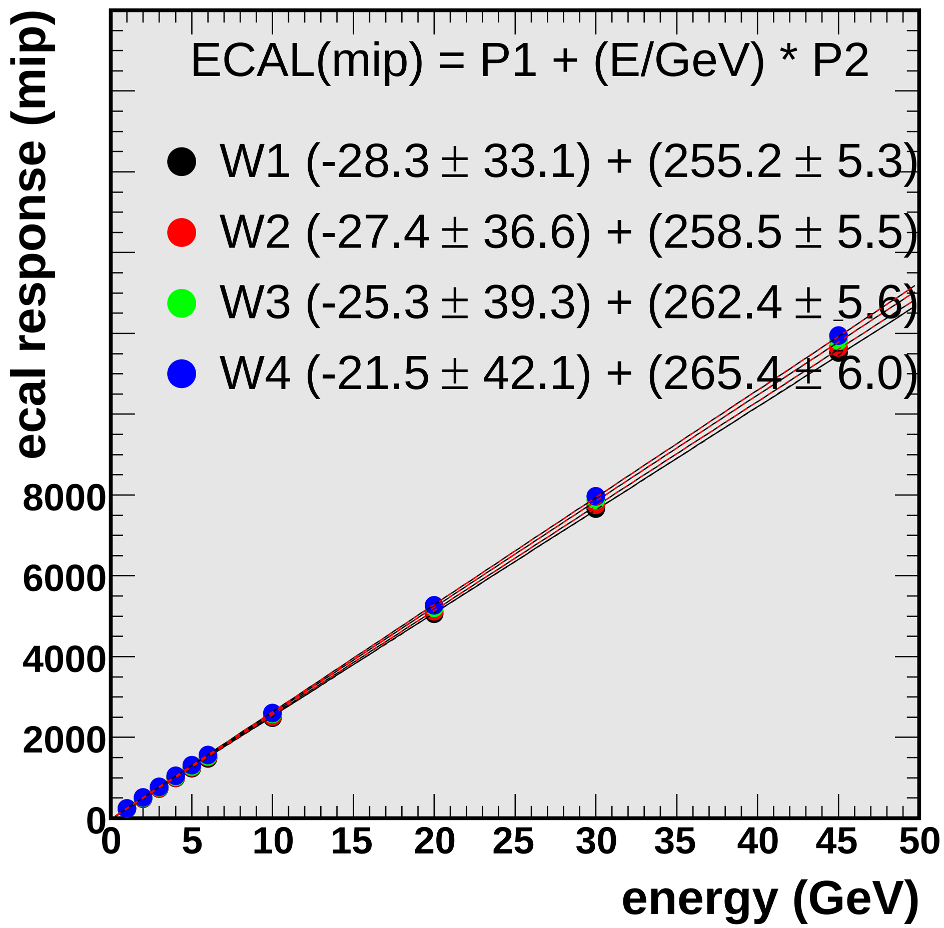


events
W1
W2
W3
W4
e- 10 GeV
0
20
40
60
80
100
120
140
160
180
200
2000 2200 2400 2600 2800 3000 3200 3400
ecal response (mip)

Response

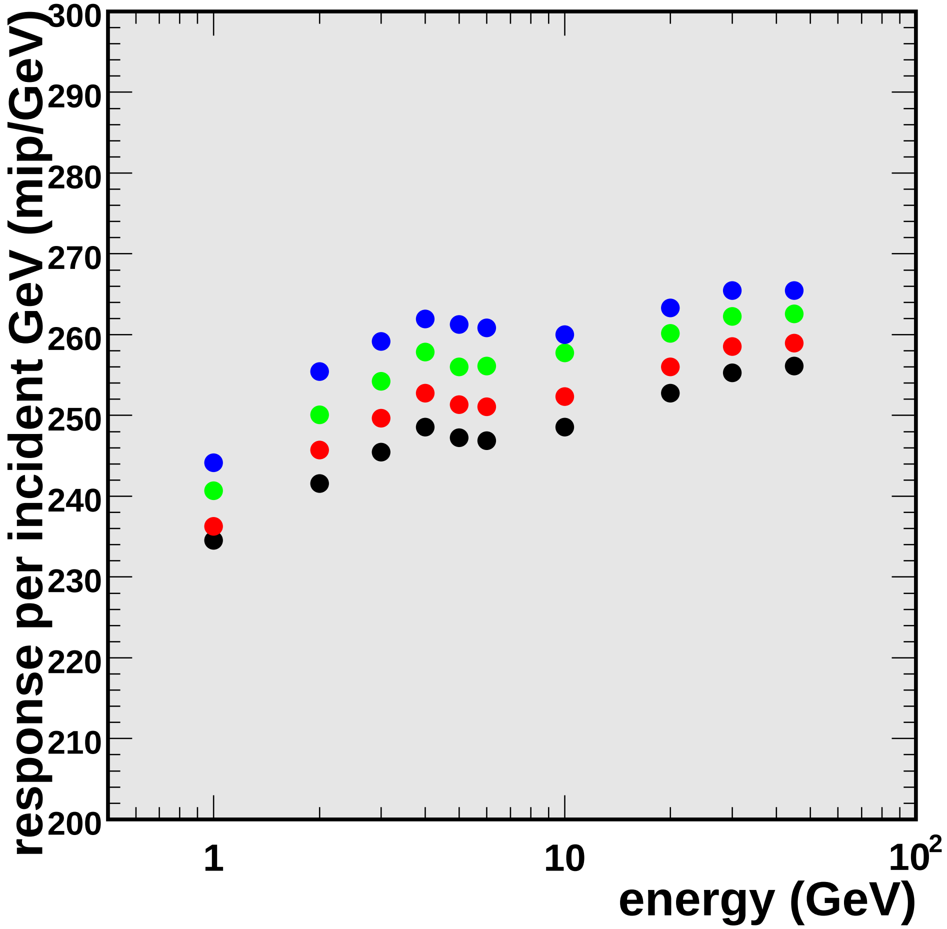


(fit range 1-10 GeV)

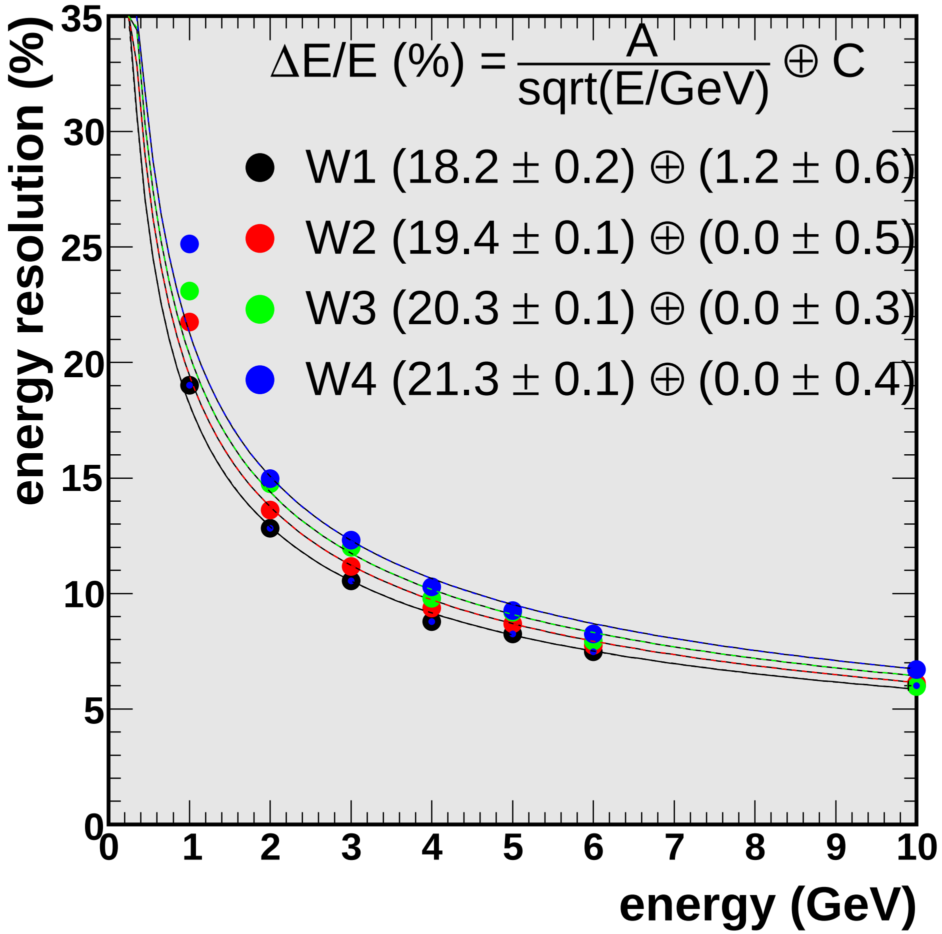


(fit range 1-45 GeV)

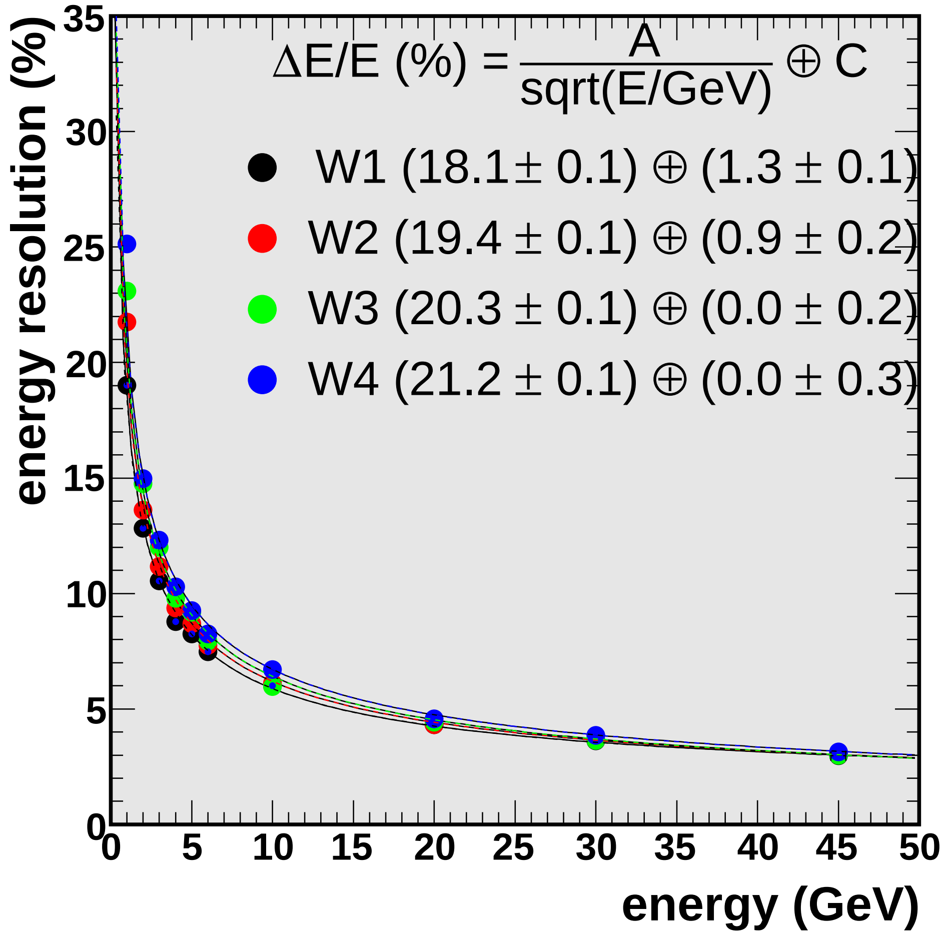
Response per incident energy



Energy resolution

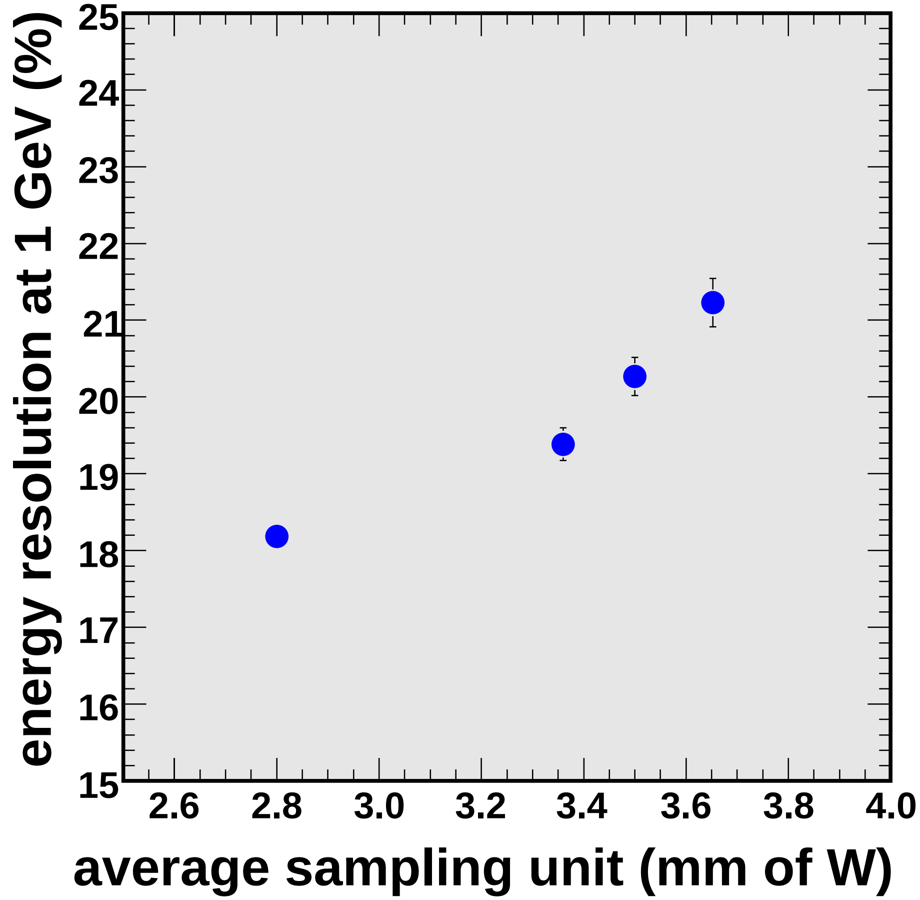


(fit range 1-10 GeV)



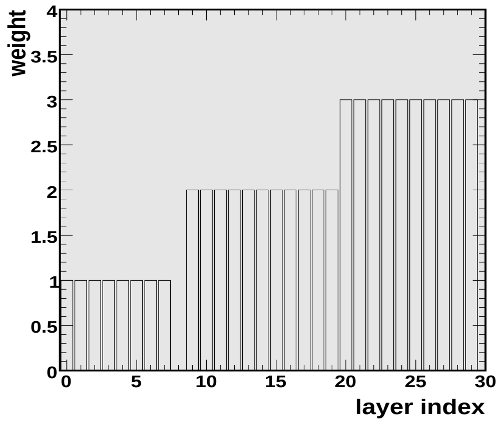
(fit range 1-45 GeV)

Resolution vs absorber thickness per layer

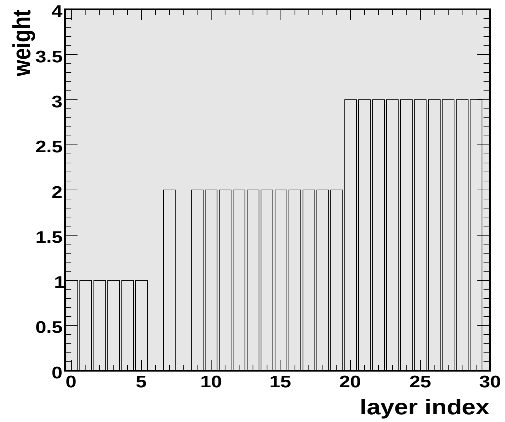


adding some more points

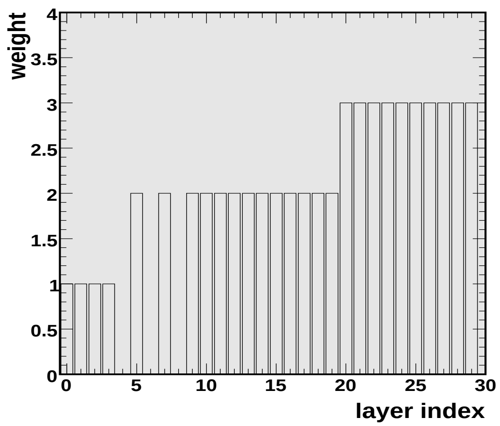
(W2a)



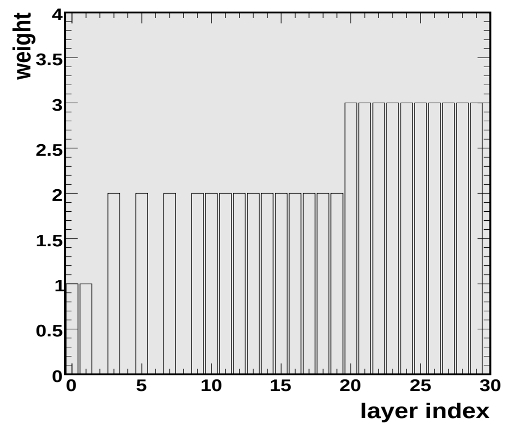
(W2b)



(W2c)

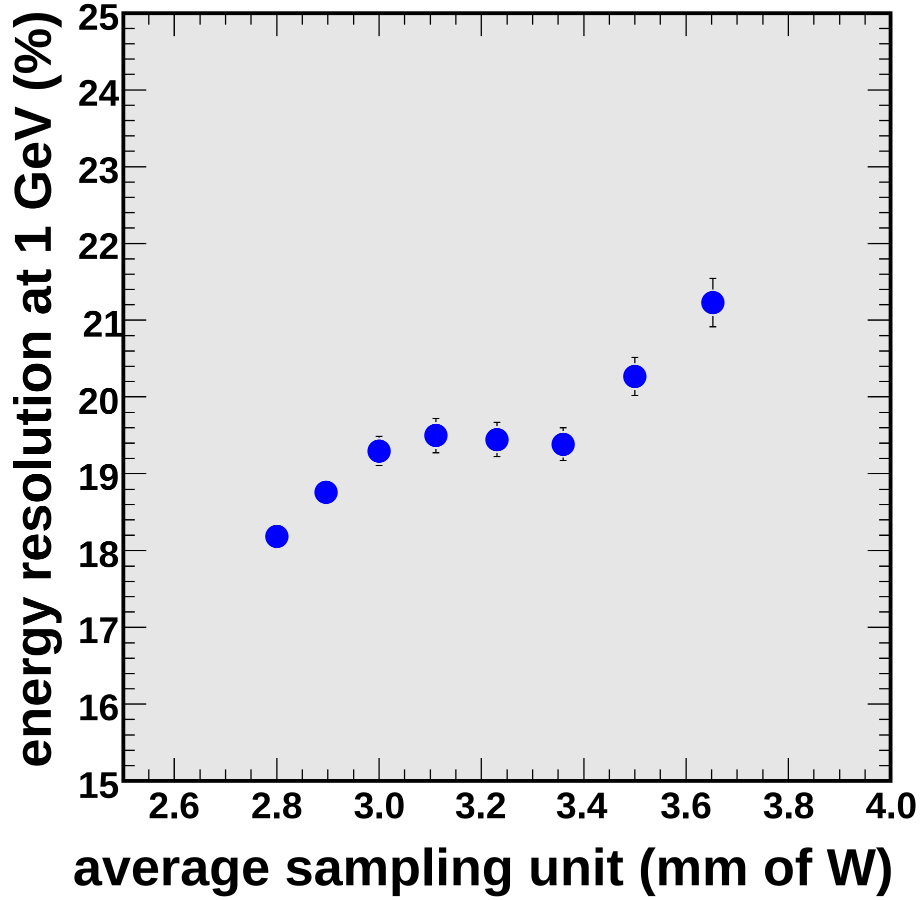


(W2d)



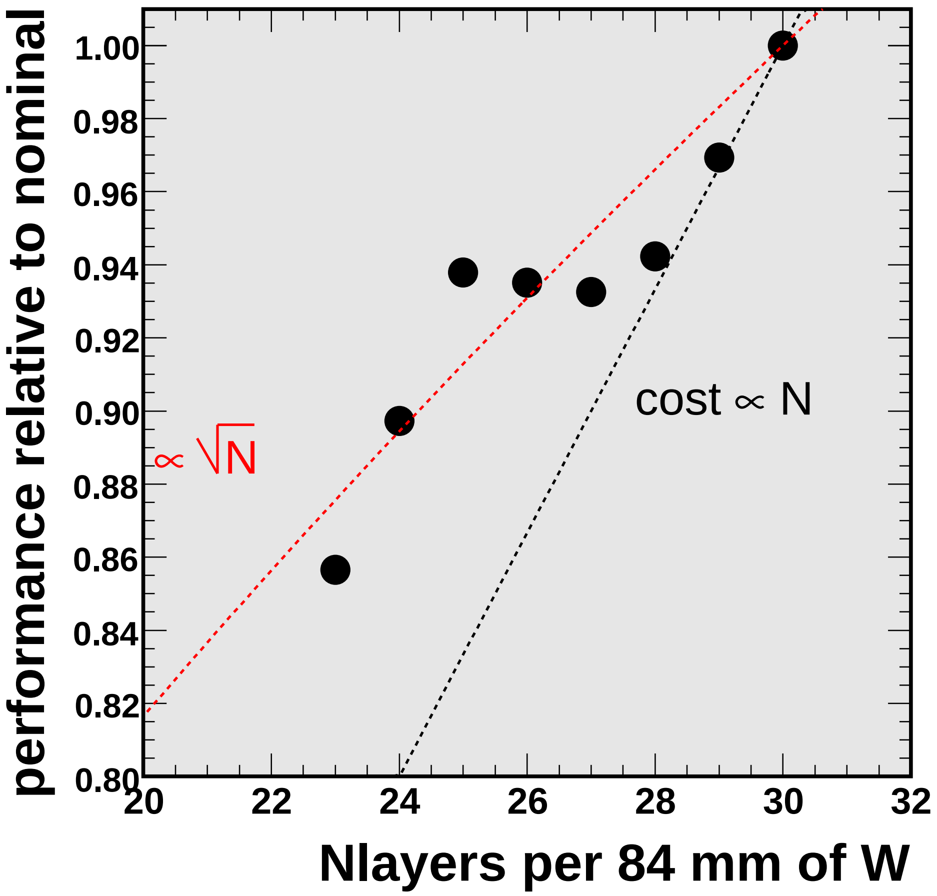
weighting scheme	total Nof layers	average thickness per layer (mm)
W2a	29	2.90 ± 1.12
W2b	28	3.00 ± 1.06
W2c	27	3.11 ± 0.98
W2d	26	3.23 ± 0.86

Resolution vs absorber thickness per layer



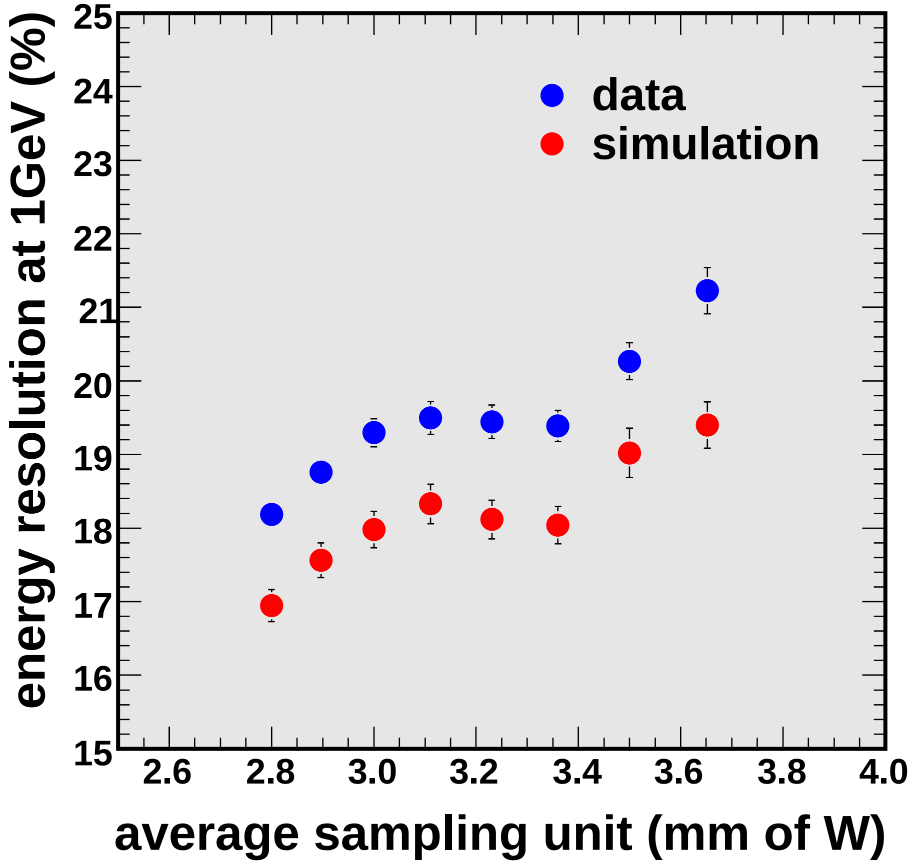
"Performance" and "cost" trends

("performance" = 1/resolution)



(cost $\propto$ N if it scales linearly with Si area)

Resolution vs absorber thickness per layer



simulation files from N.Watson and D.Ward

Energy composition and transverse profiles of e^-/e^+ showers

Outline

- **General**
- **Shower composition**
- **Transverse profile per component**
- **Summary**

General

- : the Si/W ECAL prototype has very high transverse and longitudinal segmentation

  : it is an imaging calorimeter with which we can decompose a shower into its **spatial and energy subcomponents**

- **study with e^- and e^+ runs**

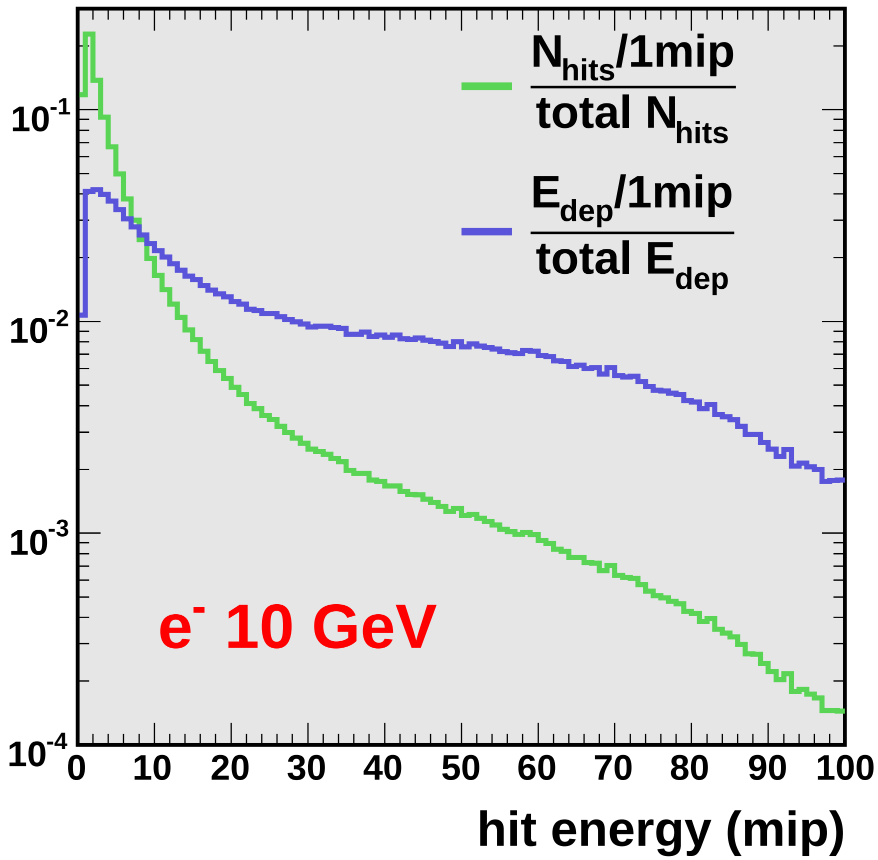
  (shower energy profile/composition
  shower transverse profiles per component
  overall transverse containment (Moliere radius)) as a function of incident energy

- **event selection**

  : ... the usual selection criteria ...

  fiducial cuts to select events hitting the central part of a wafer,
  energy range cut to suppress double electron events (DESY runs),
  suppress pion contamination (CERN runs)

Shower composition



- e.g. for a 10 GeV electron shower

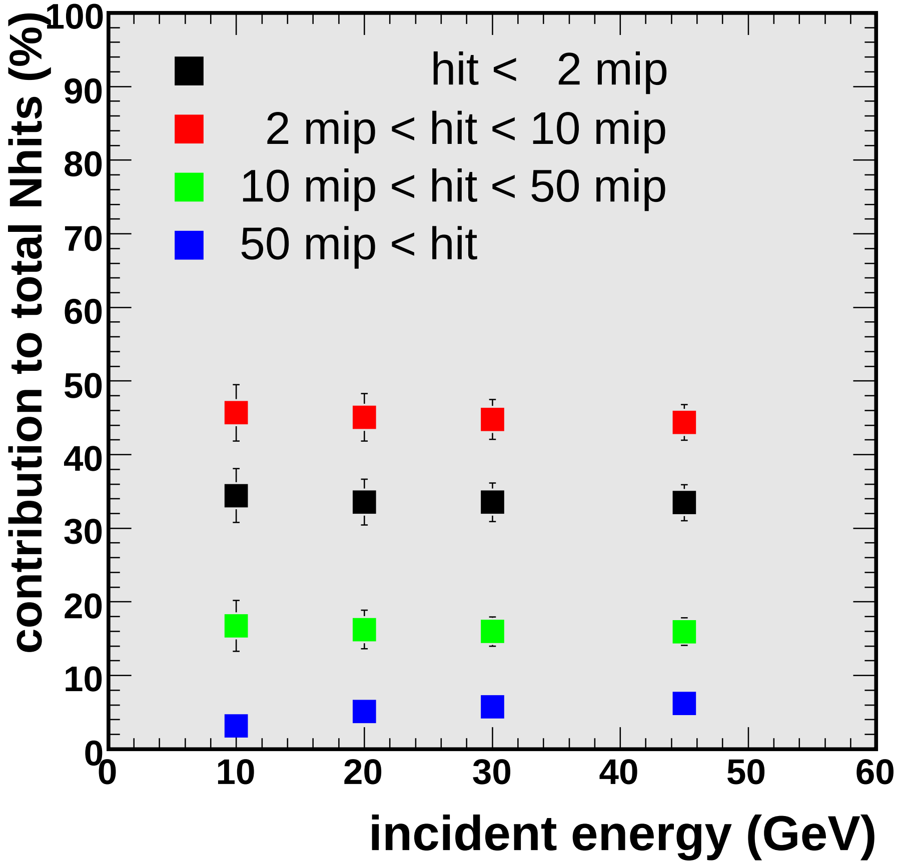
  the low-end : the lower energy hits that
  account for 22% of the total Nhits
  contribute 2.6% of the total deposited energy

  the high-end : the higher energy hits that
  account for 3% of the total Nhits
  contribute 24% of the total deposited energy

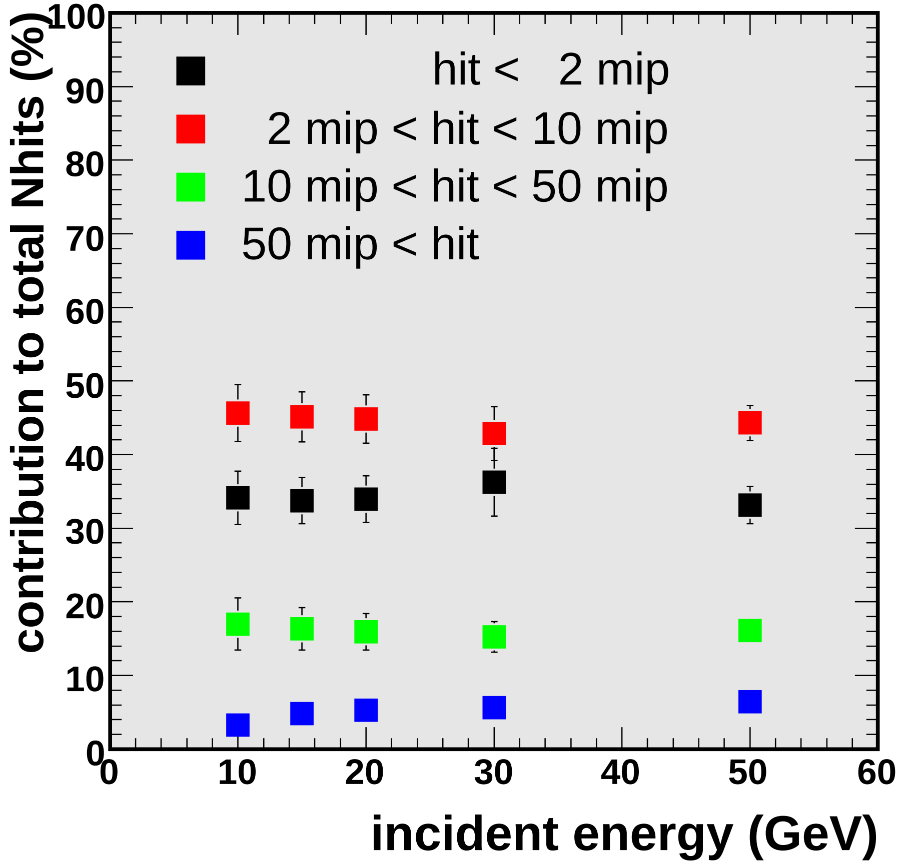
- divide shower in 4 "components"
  and study their contributions, profiles, etc

  Ehit < 2 mip
  2 mip < Ehit < 10 mip
  10 mip < Ehit < 50 mip
  50 mip < Ehit

Shower composition wrt Nhits

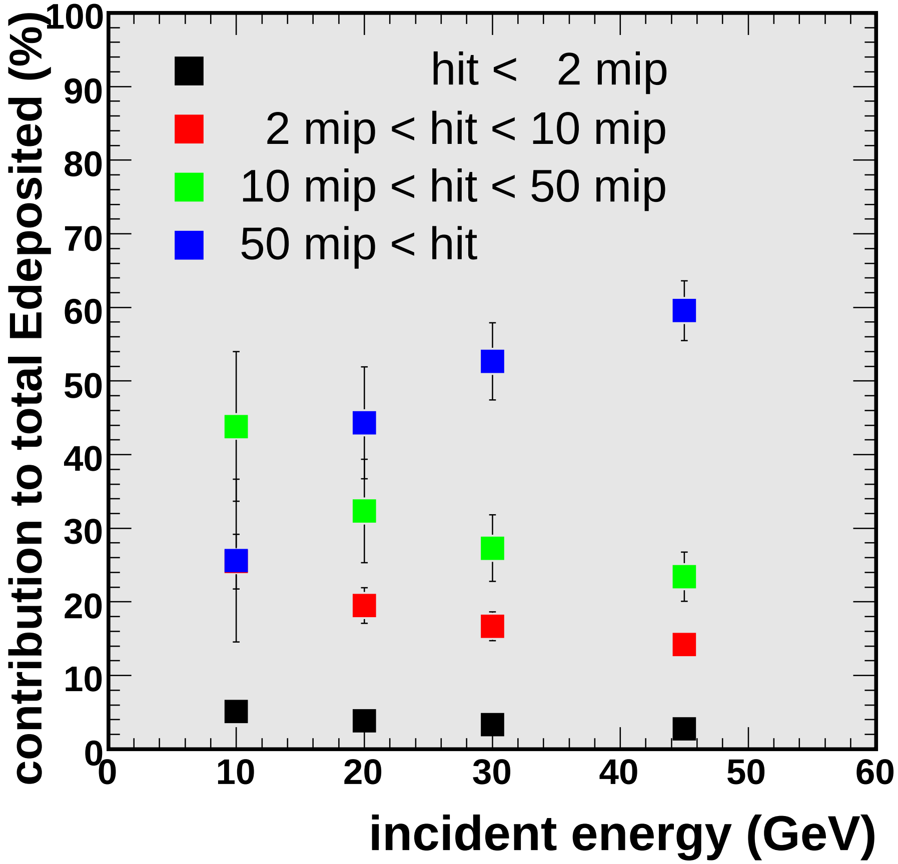


(electron data CERN2006)

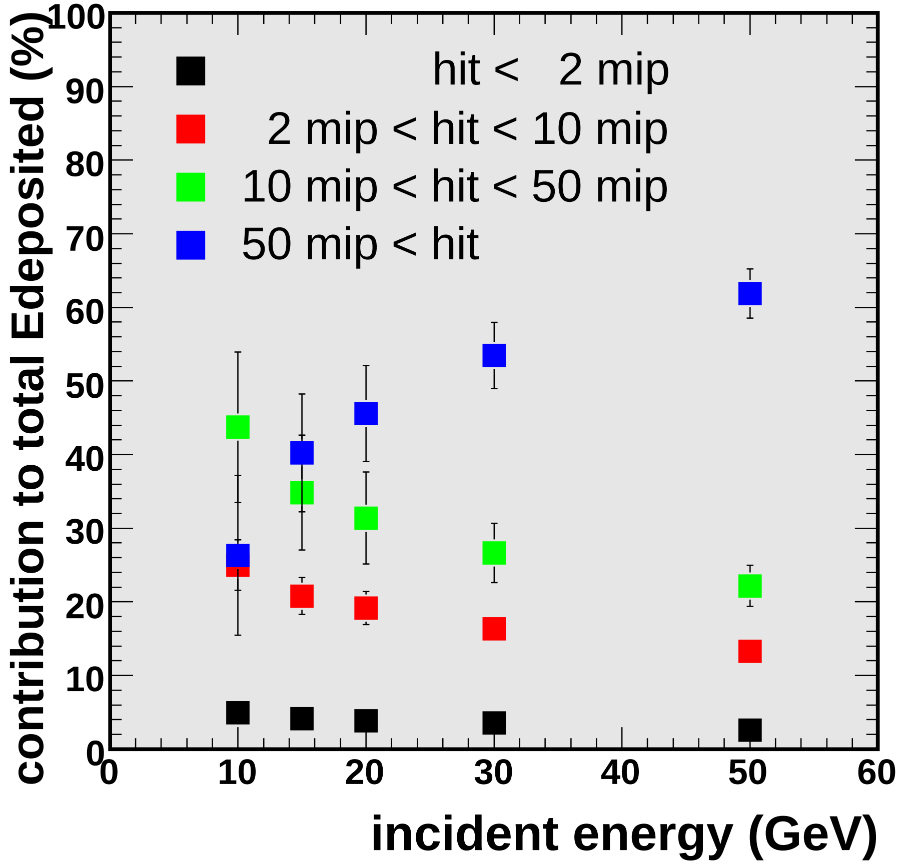


(positron data CERN2006)

Shower composition wrt Edeposited



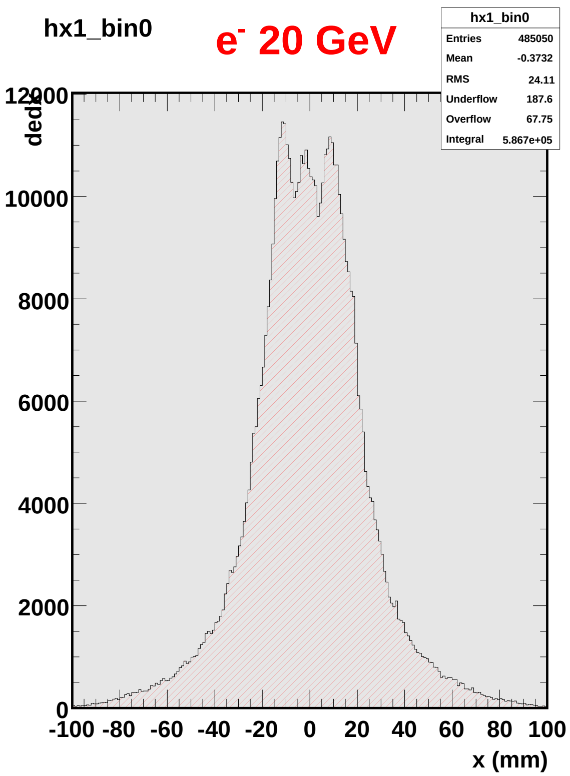
(electron data CERN2006)



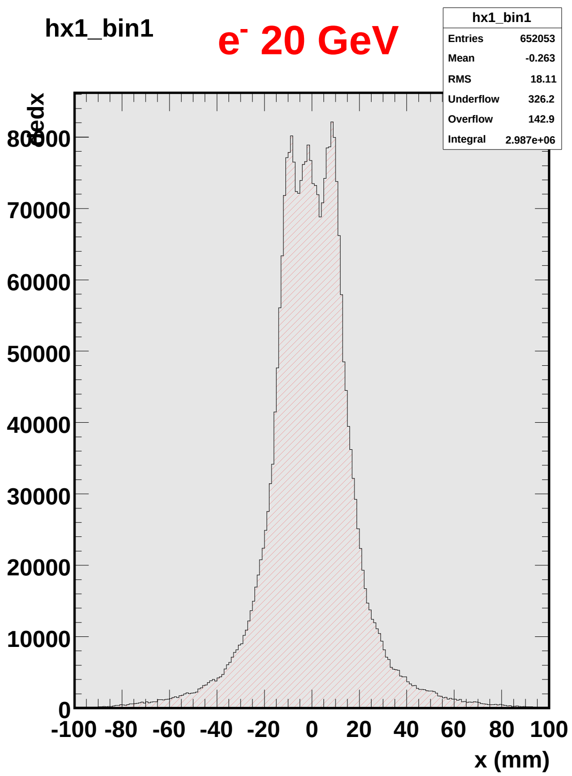
(positron data CERN2006)

Shower profiles along X (e$^-$ example)

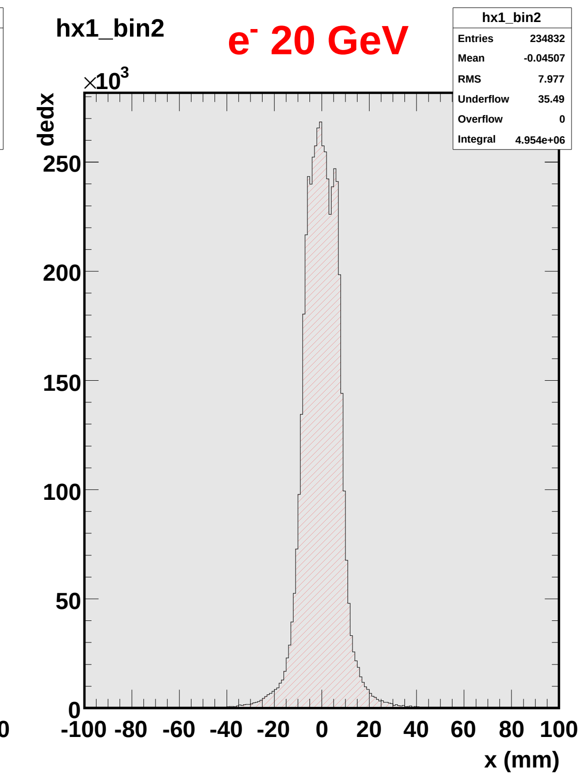
(energy weighted distribution of $X_{hit} - X_{barycenter}$)



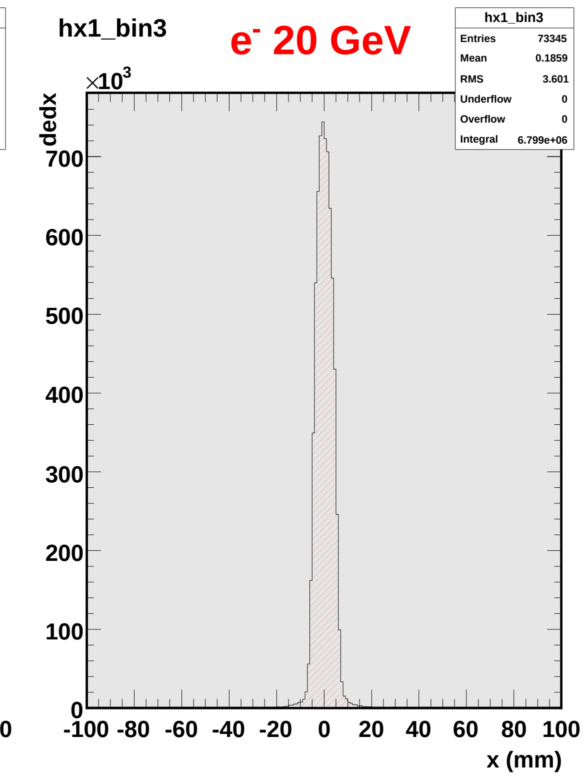
(hit < 2 mip)



(2 mip < hit < 10 mip)



(10 mip < hit < 50 mip)

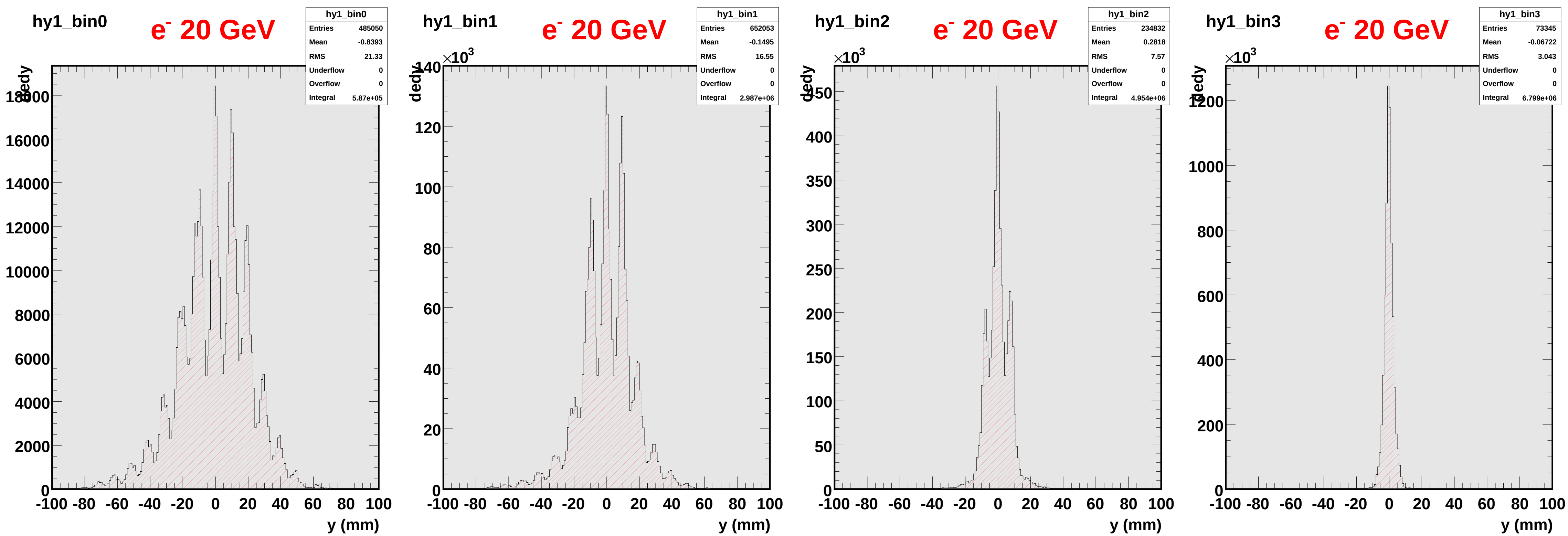


(50 mip < hit)

alternate layers are staggered along X (by 2.5mm)

Shower profiles along Y (e$^-$ example)

(energy weighted distribution of $Y_{hit} - Y_{barycenter}$)

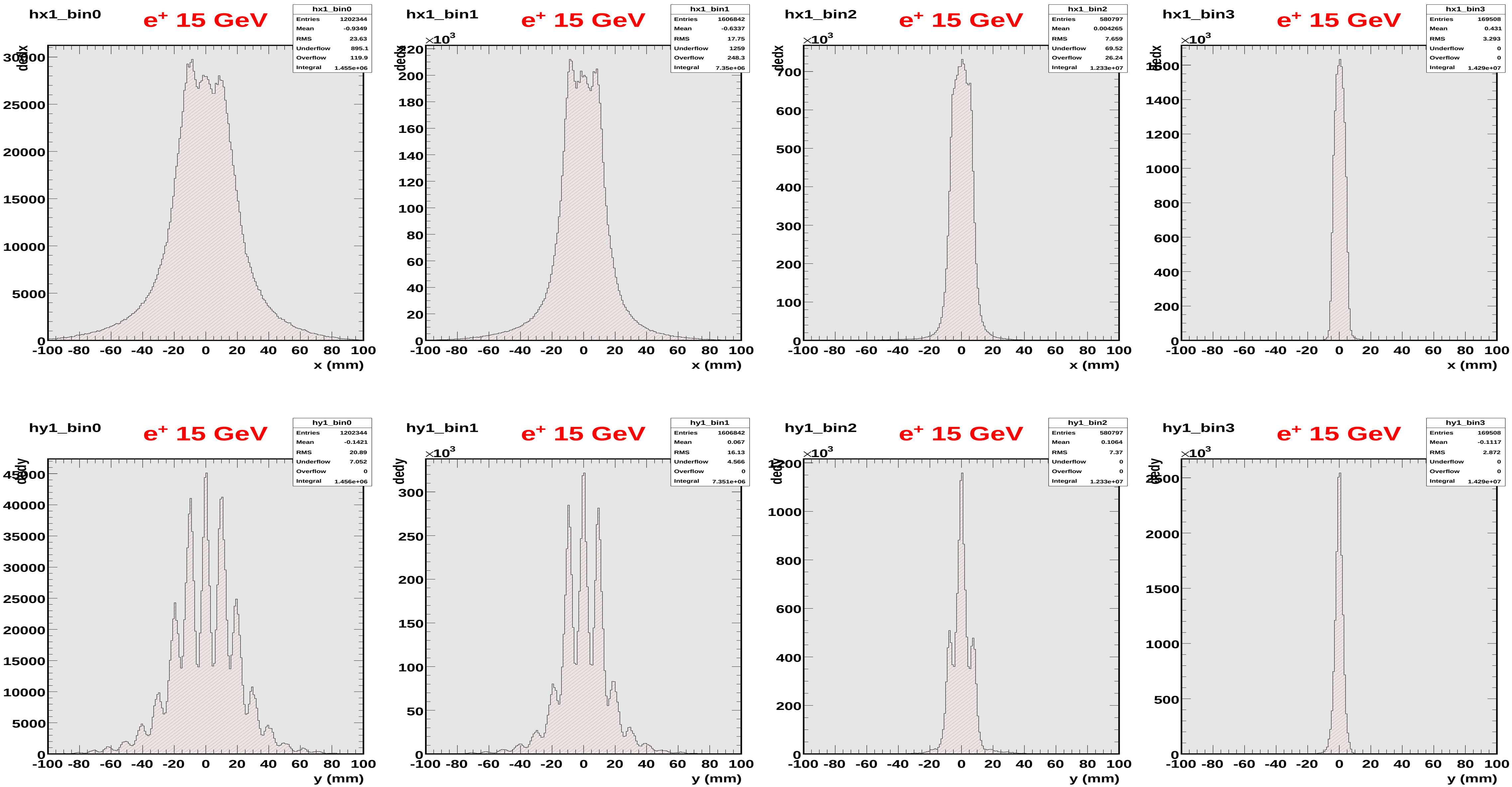


(hit < 2 mip) **(2 mip < hit < 10 mip)** **(10 mip < hit < 50 mip)** **(50 mip < hit)**

alternate layers are NOT staggered along Y

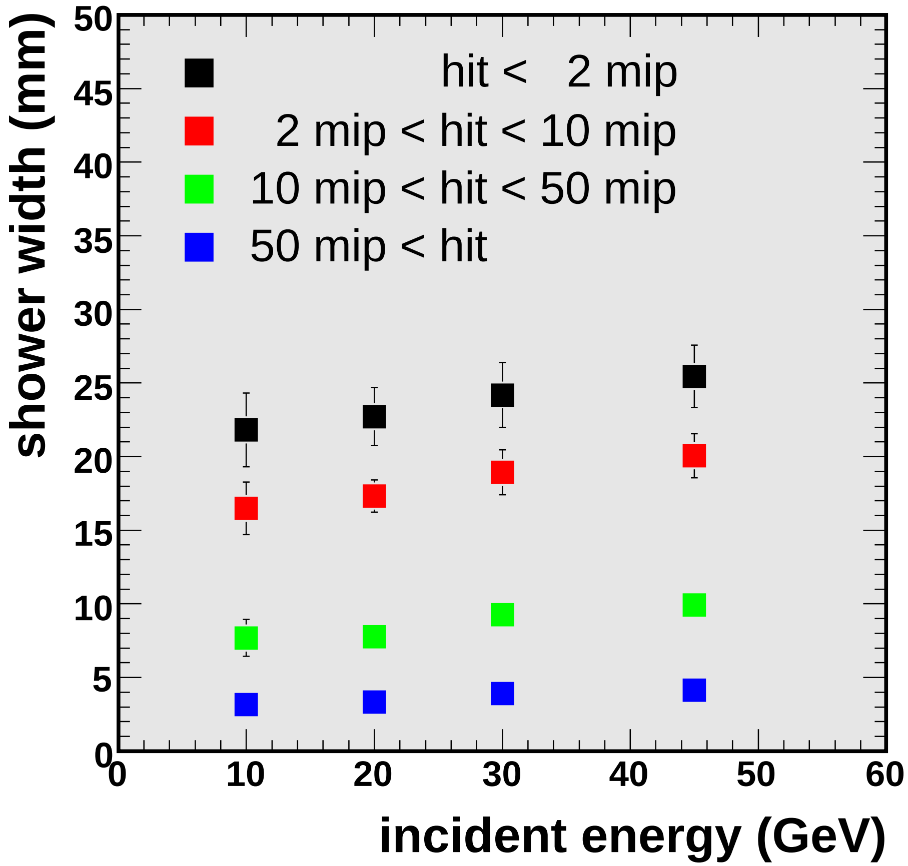
Shower profiles (e$^+$ example)

(energy weighted distribution of $X_{hit} - X_{barycenter}$, $Y_{hit} - Y_{barycenter}$)

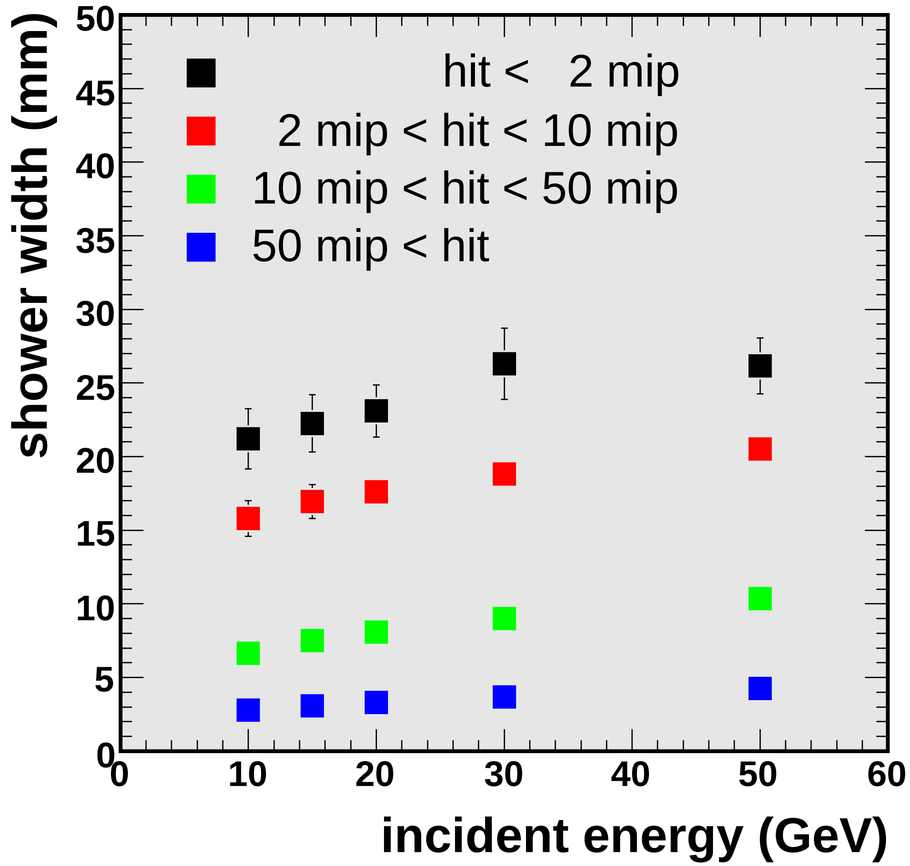


(hit < 2 mip) **(2 mip < hit < 10 mip)** **(10 mip < hit < 50 mip)** **(50 mip < hit)**

Transverse width per component



(electron data CERN2006)



(positron data CERN2006)

Transverse containment (Moliere radius)

- **· theoretical definition**

  : for an infinitely long and wide calorimeter
  shower energy is contained at 90% within radius $\sim 1\ R_M$
  95% $\sim 2\ R_M$
  99% $\sim 3.5\ R_M$

  : e.g. for solid tungsten, $R_M \simeq$ 10 mm

- **· practical definition**

  : quote radii for 90% and 95% level of "signal" containment and $R_M \equiv R_{90\%}$

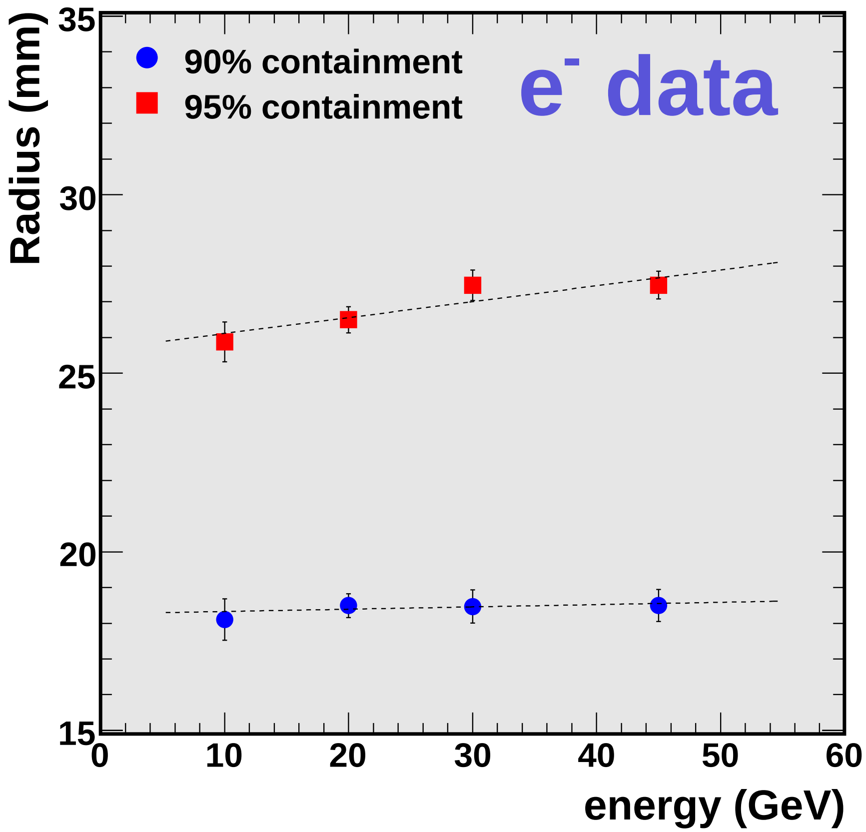
- **· Si/W ECAL**

  : case 1 **"signal" = measured energy** = $\sum E_i$, i=1,Nhits

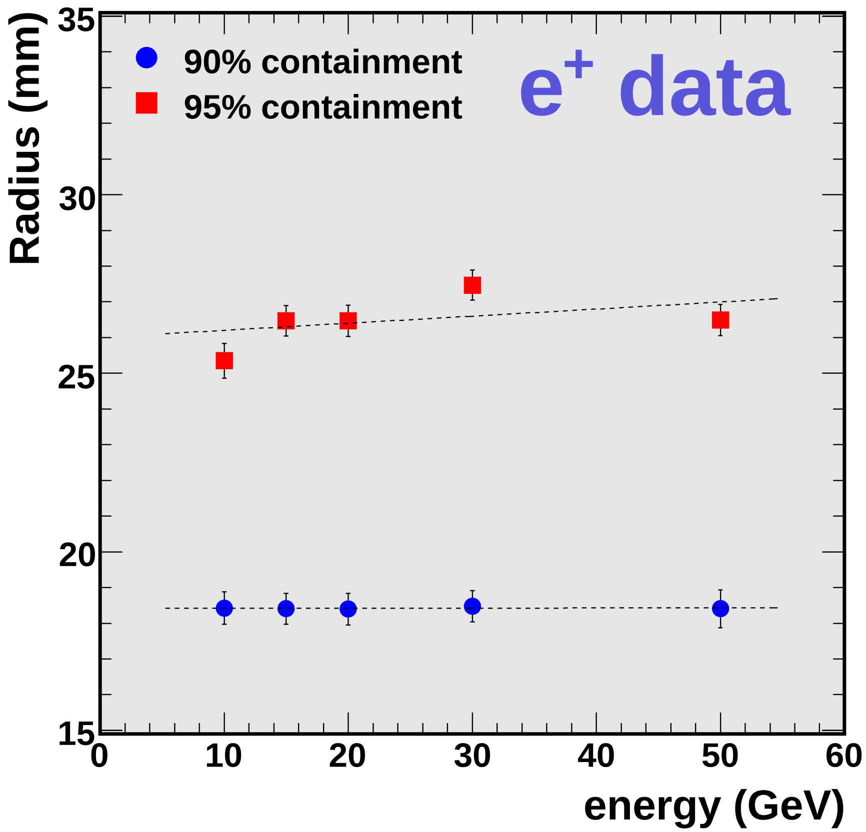
  : case 2 **"signal" = reconstructed energy** = $\sum W \cdot E_i$
  with W=1,2,3 for layer# 0 to 9, 10 to 19, 20 to 29

Transverse containment

(signal = measured energy)



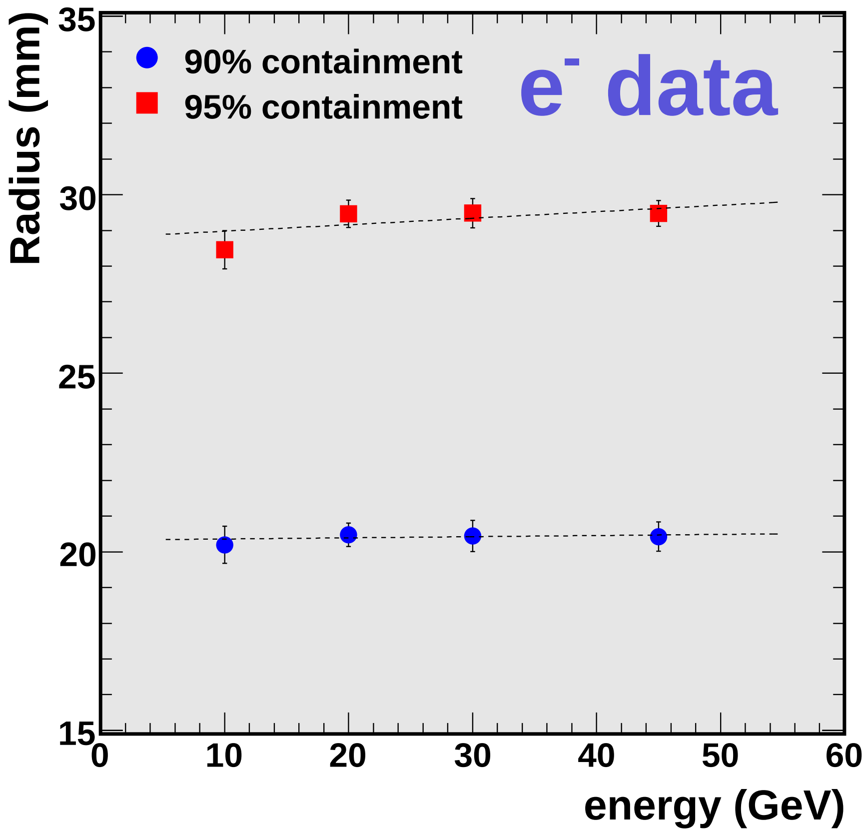
(electron data CERN2006)



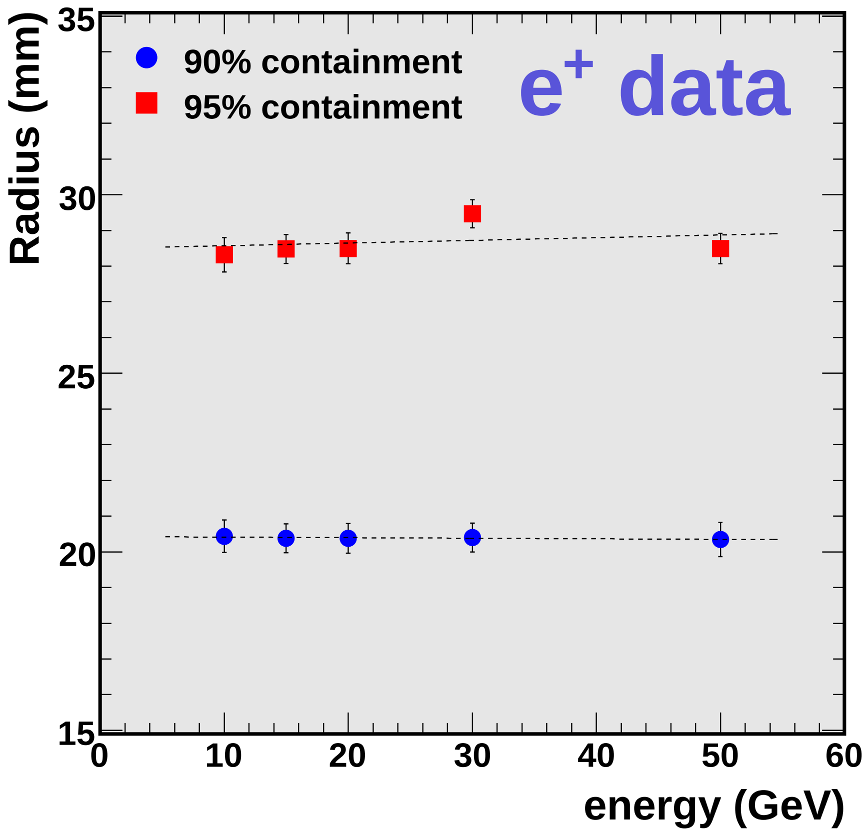
(positron data CERN2006)

Transverse containment

(signal = reconstructed energy)



(electron data CERN2006)



(positron data CERN2006)

Summary

- ▶ · **study with e^- and e^+ data at 10 to 50 GeV energy range**

  (shower energy profile/composition
  shower transverse profiles per component
  overall transverse containment (Moliere radius)) as a function of incident energy

- ▶ · **the Si/W ECAL prototype has very high granularity and we can probe an electromagnetic shower down to its core in great detail**