Digital RPC-HCAL slice test studies with e^+

Georgios Mavromanolakis

Cambridge University

and **FERMILAB**

Outline

- **General**
- **Beam profile**
- **Misalignment**
- **Detector response and** $\Delta E/E$
- **Shower development**

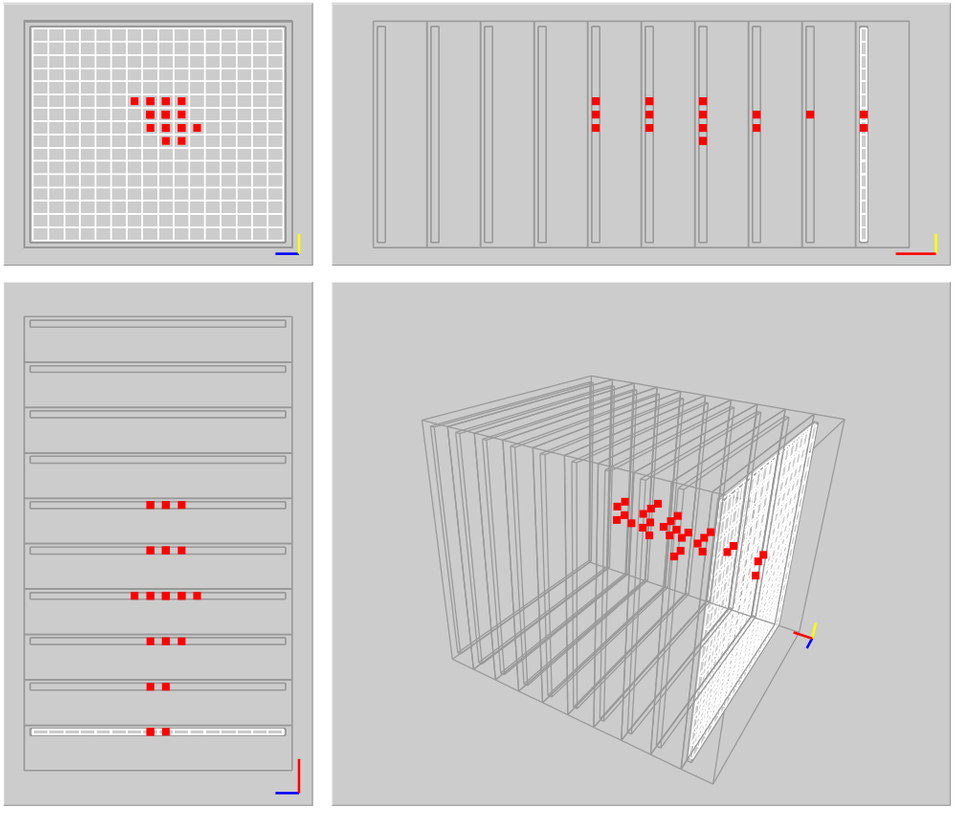
General

- **RPC-DHCAL slice test**
  - : first beam test at FNAL-MTBF in summer 2007 with a stack of 16×16 cm^2 RPC chambers readout by 1 cm^2 pads
  - : muon, positron and pion data collected
- **positron data at 1, 2, 4, 8, 16 GeV**
  - : independent analysis by J.Repond and G.M., then crosscheck results
  - : simulation to come soon (by B.Bilki)
- **reminder**
  - : **consider only the signal recorded from the first 6 chambers**
    (6 absorber layers, 16mm steel + 4mm Cu each $\simeq 1.19 X_0$ per layer)

DHCAL "slice test"

Run 262:0 Event 2

Time: 8080600
Hits: 29 Energy: xxx mips

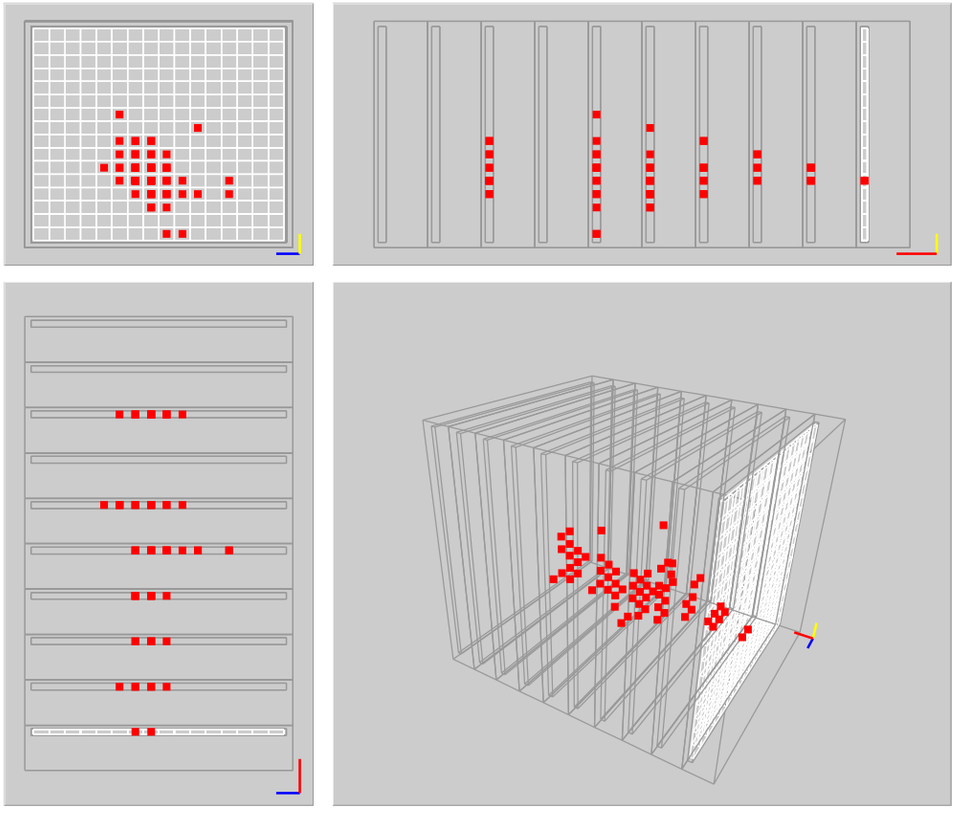


(6 chambers installed)

e^+ 2 GeV

Run 241:0 Event 107

Time: 724491
Hits: 67 Energy: xxx mips

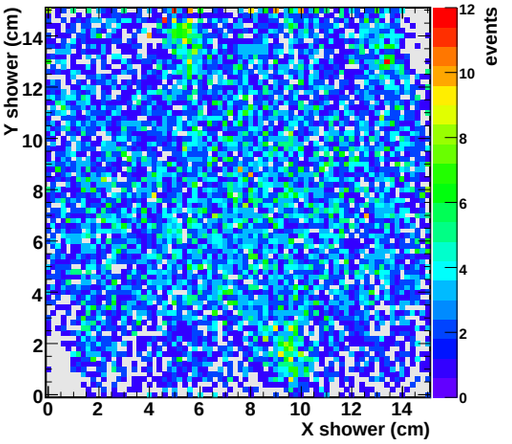


(7 chambers installed)

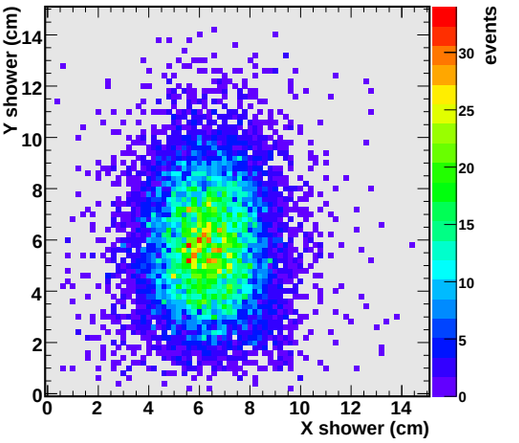
e^+ 8 GeV

Beam profile (Nevents per 2×2 mm^2 VS shower barycenter X,Y)

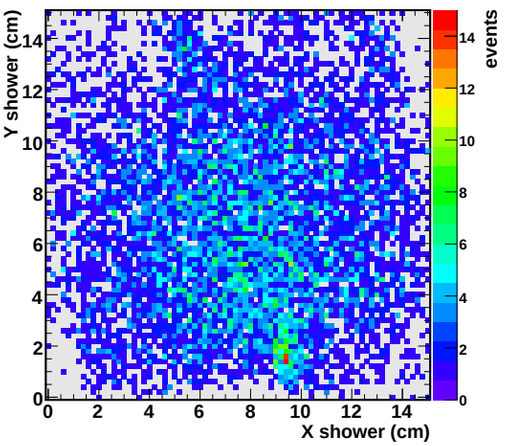
e^+ 1 GeV, Run270



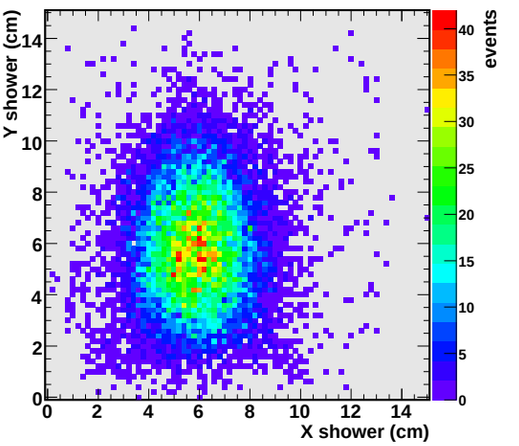
e^+ 8 GeV, Run241



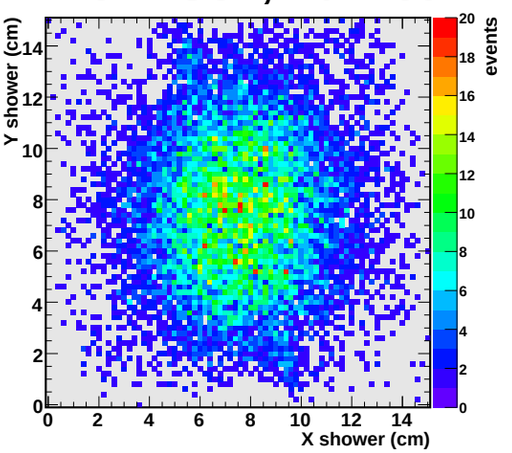
e^+ 2 GeV, Run262



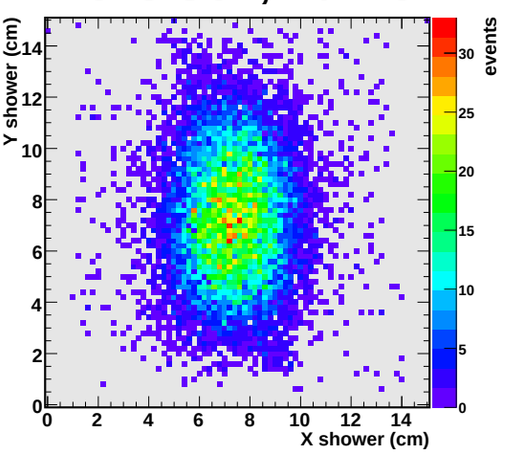
e^+ 8 GeV, Run242



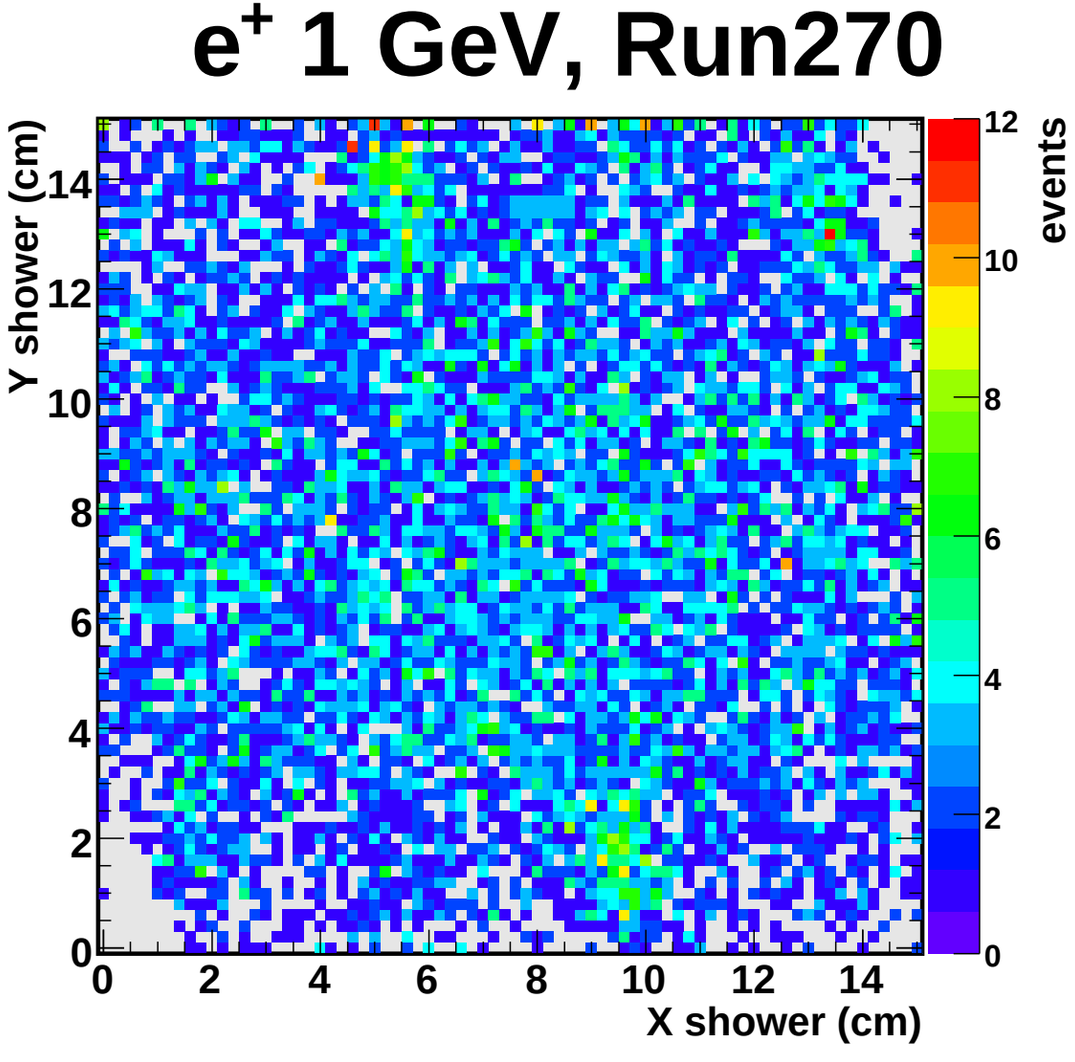
e^+ 4 GeV, Run260



e^+ 8 GeV, Run254

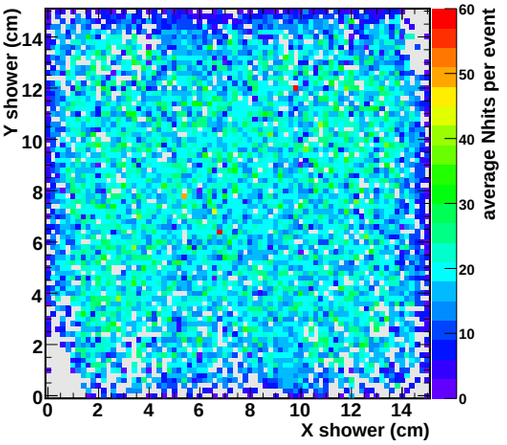


Hot/cold spots

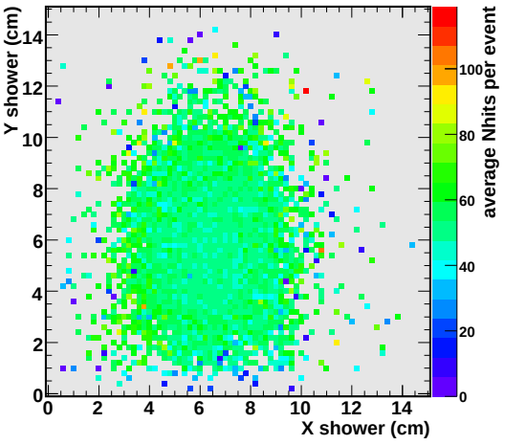


Detector response (average Nhits per event VS shower barycenter X,Y)

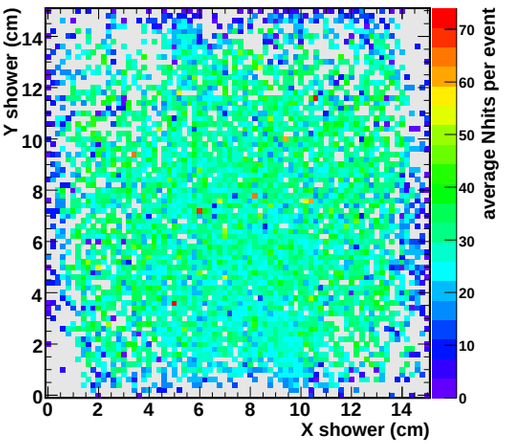
e^+ 1 GeV, Run270



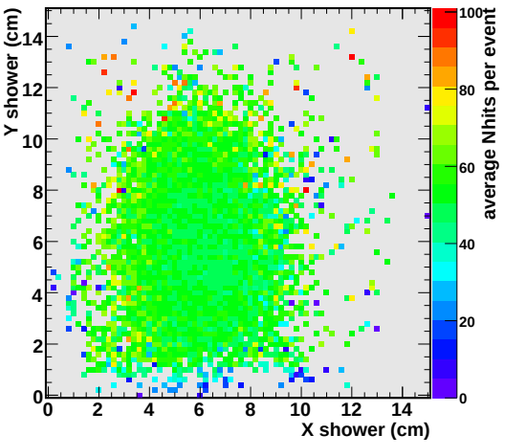
e^+ 8 GeV, Run241



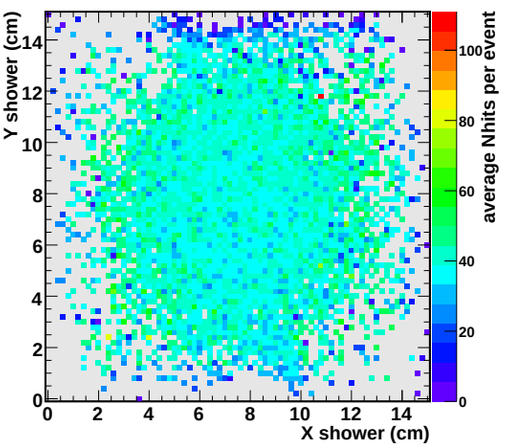
e^+ 2 GeV, Run262



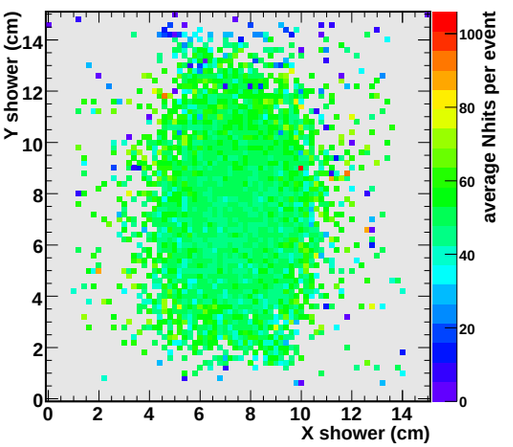
e^+ 8 GeV, Run242



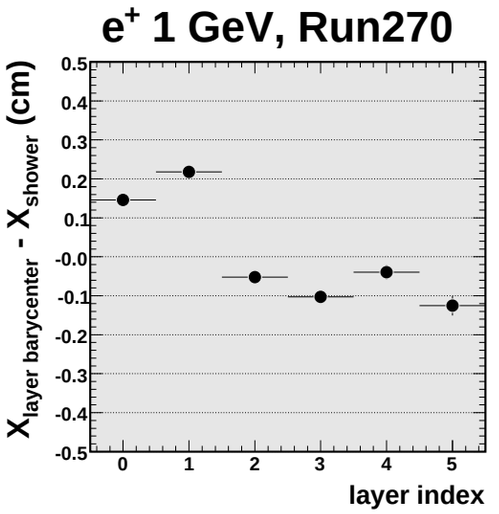
e^+ 4 GeV, Run260

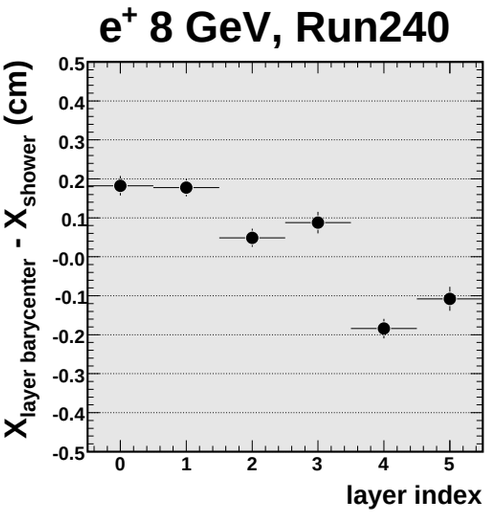


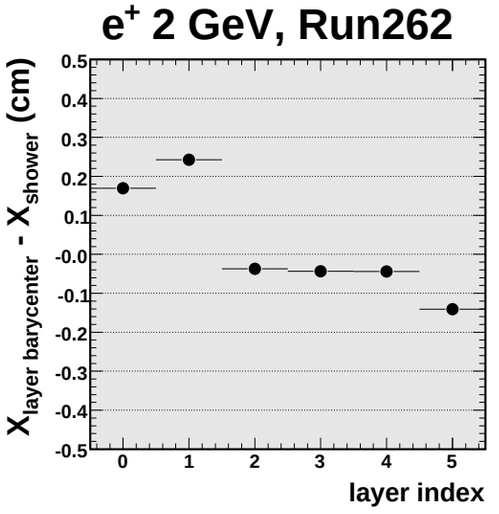
e^+ 8 GeV, Run254

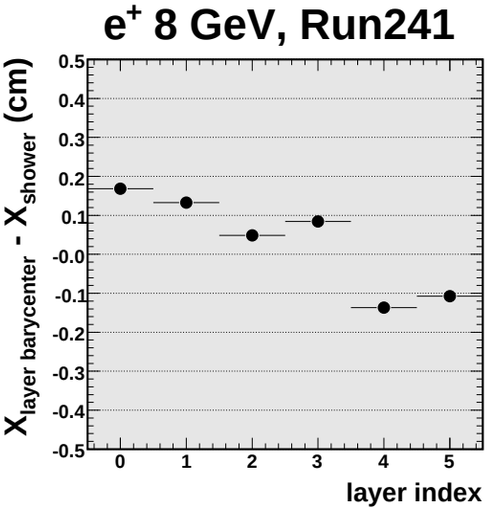


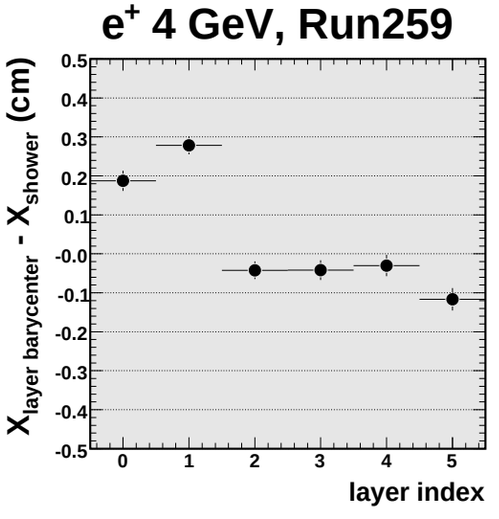
Misalignment along X

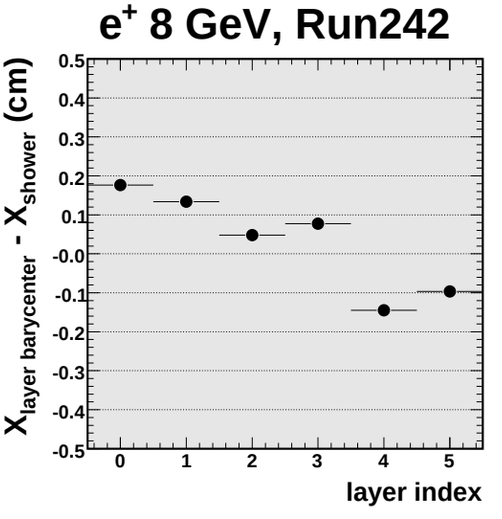


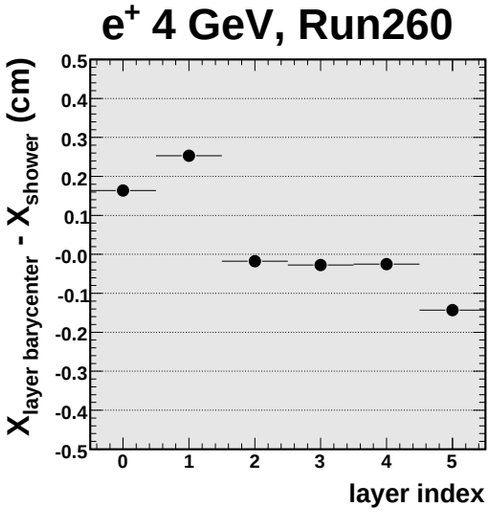


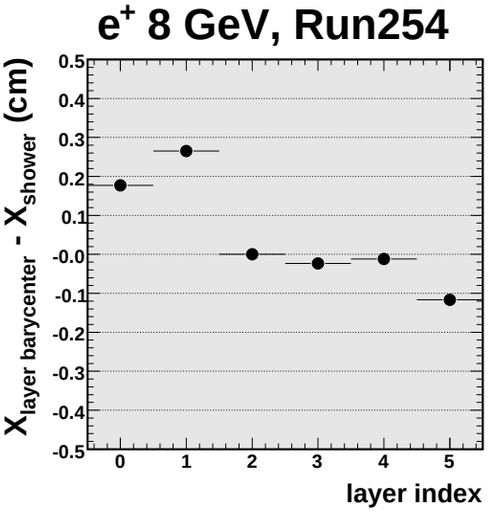




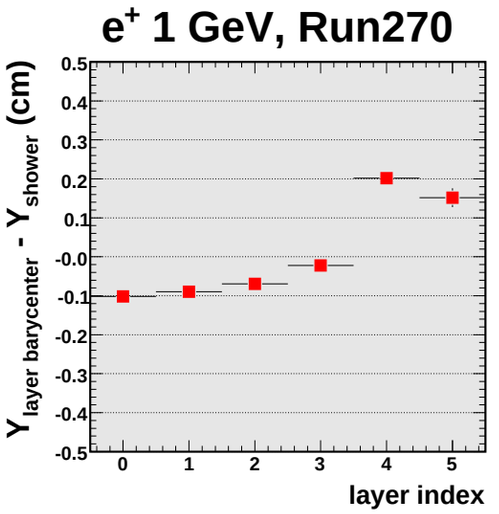


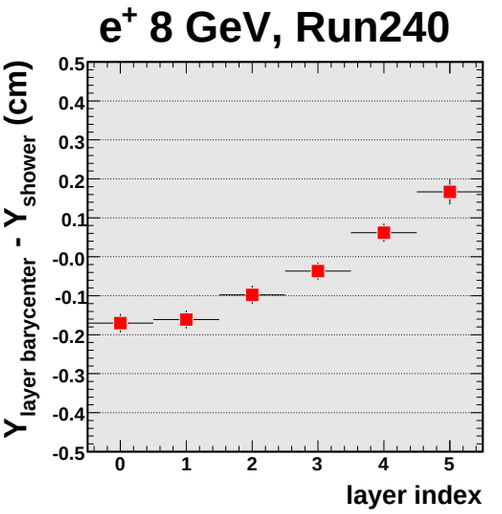


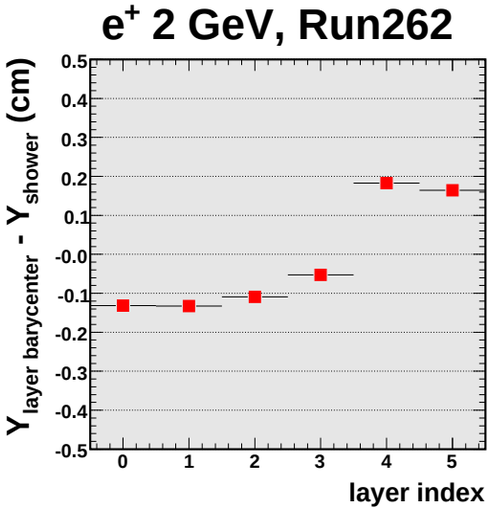


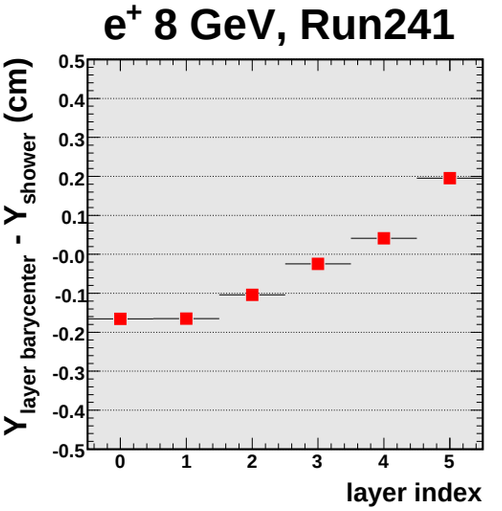


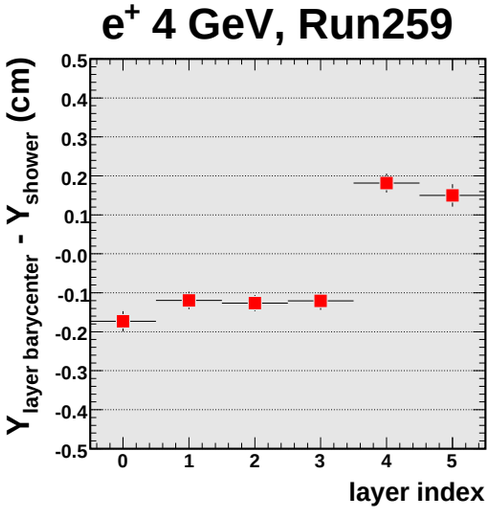
Misalignment along Y

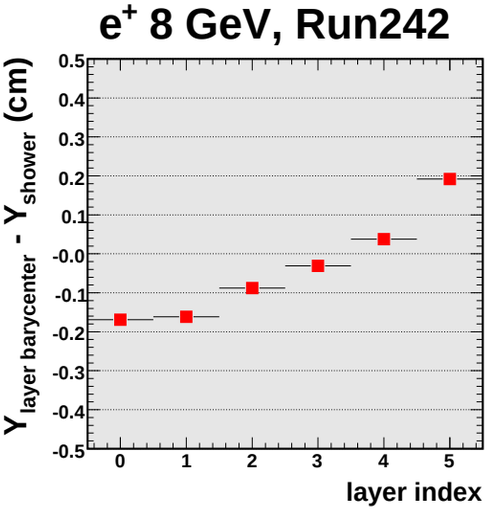


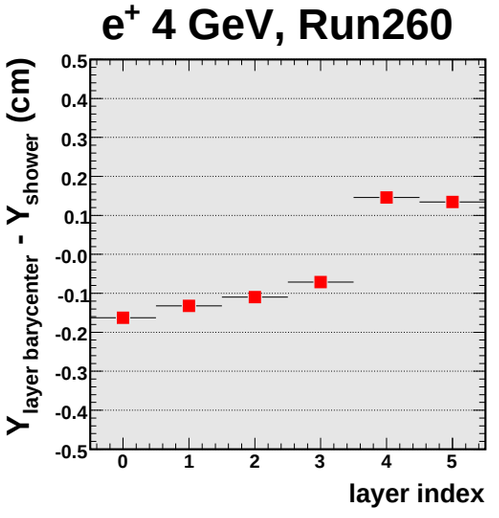


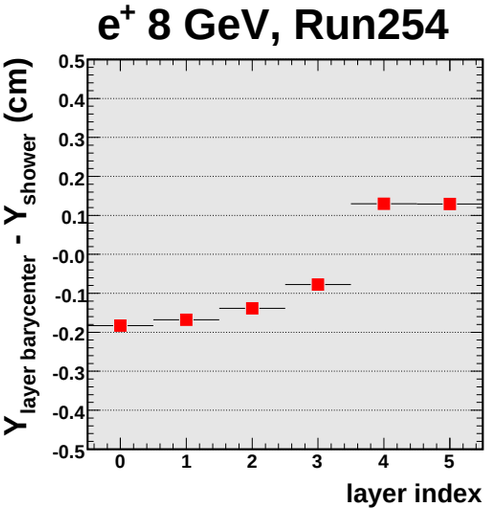




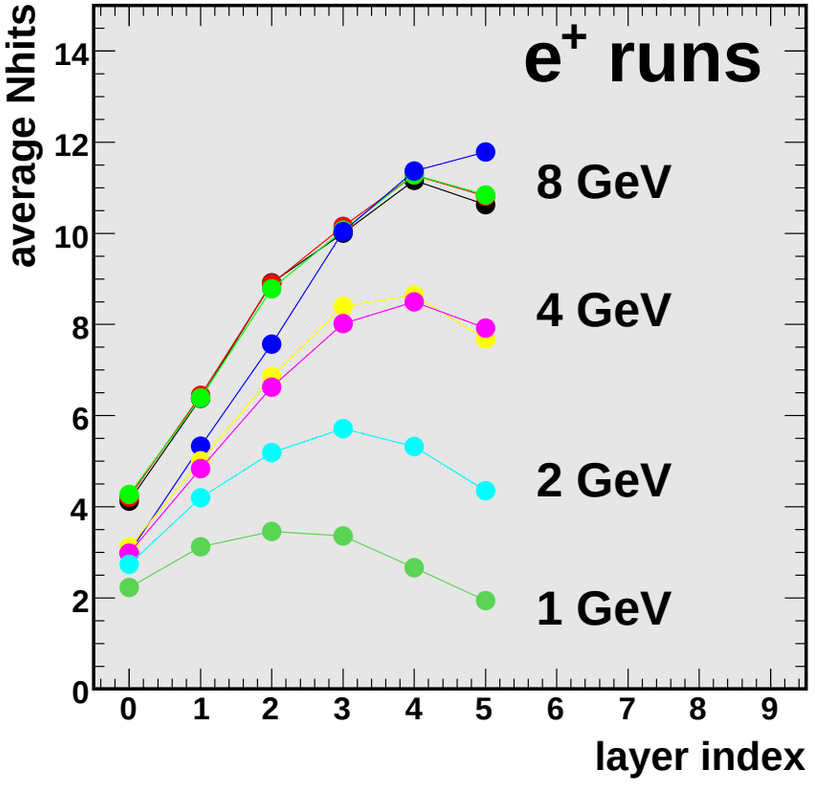








Shower longitudinal profile



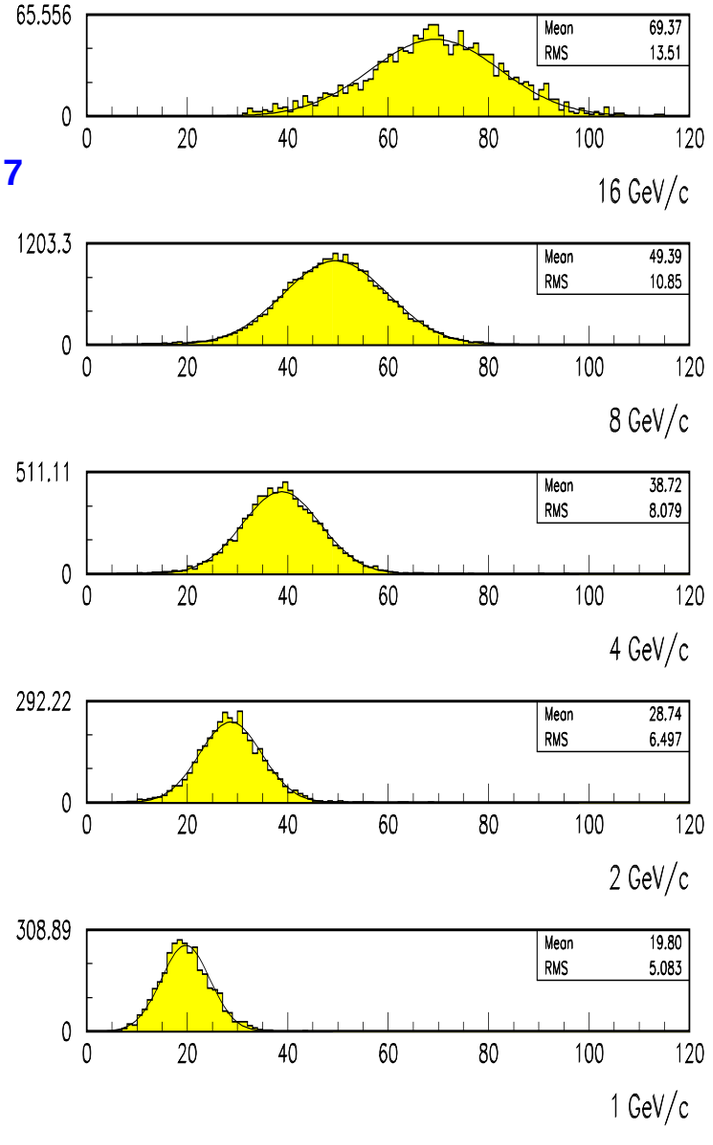
showers are not well contained (but shower maxima are, almost)

Response to positrons

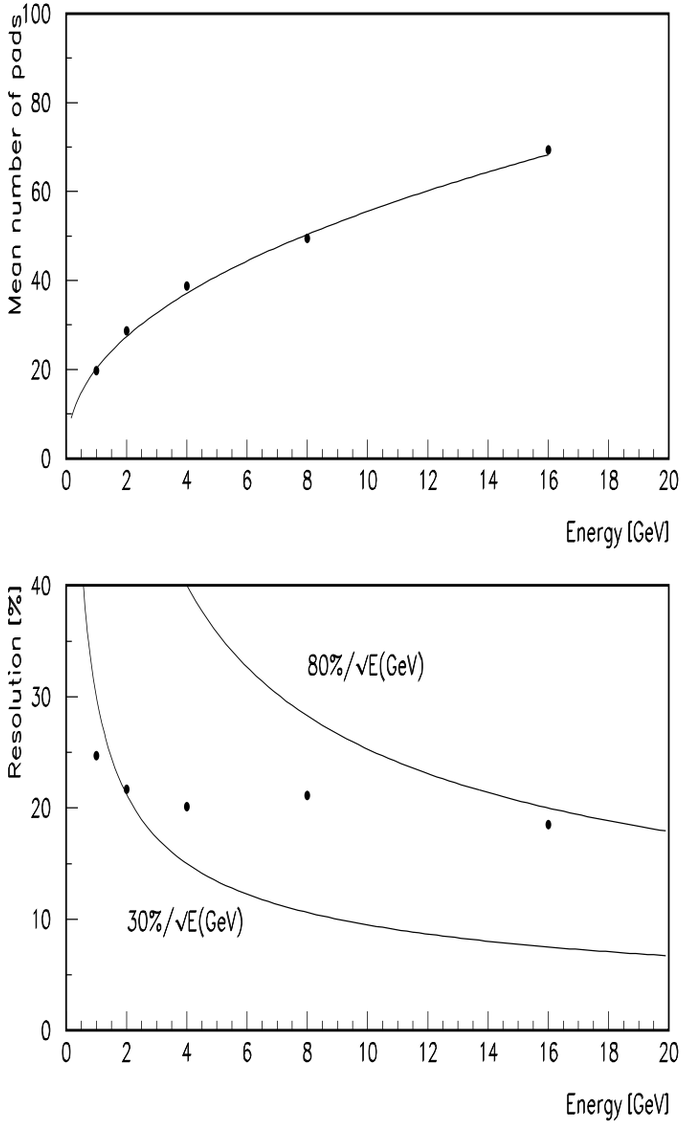
event selection

1 cluster in 1st layer
distance R<7 cm
Nhits in cluster of 1st layer < 7
at least 4 active layers
at least 1 layer with $\geq$ 3 hits

Number of hits - Positrons



Positron data - module of 7.2Xo



$\Delta E/E$ from non-linear response

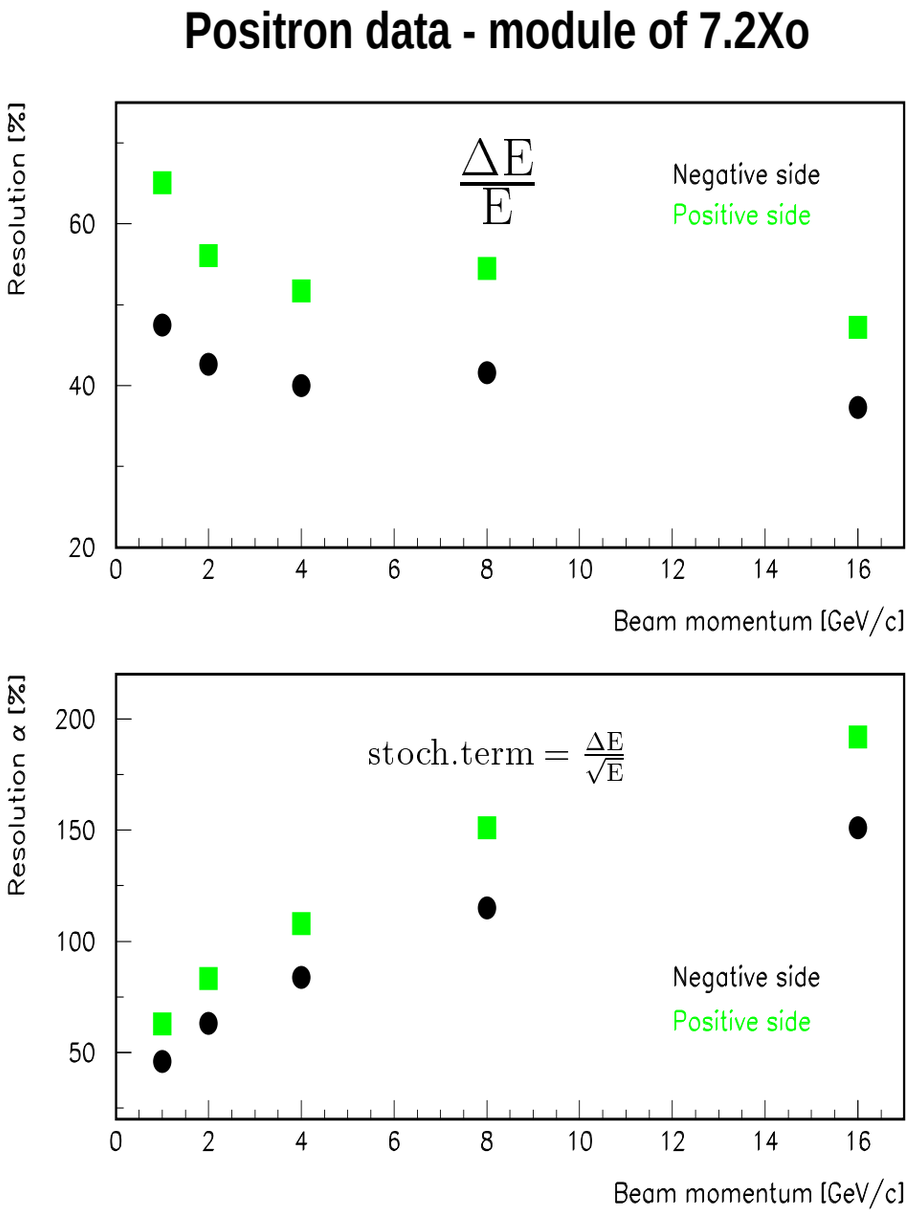
$E = f(N)$ **is non-linear**

$N + \sigma_N \rightarrow E + \Delta E_+$

$N - \sigma_N \rightarrow E - \Delta E_-$

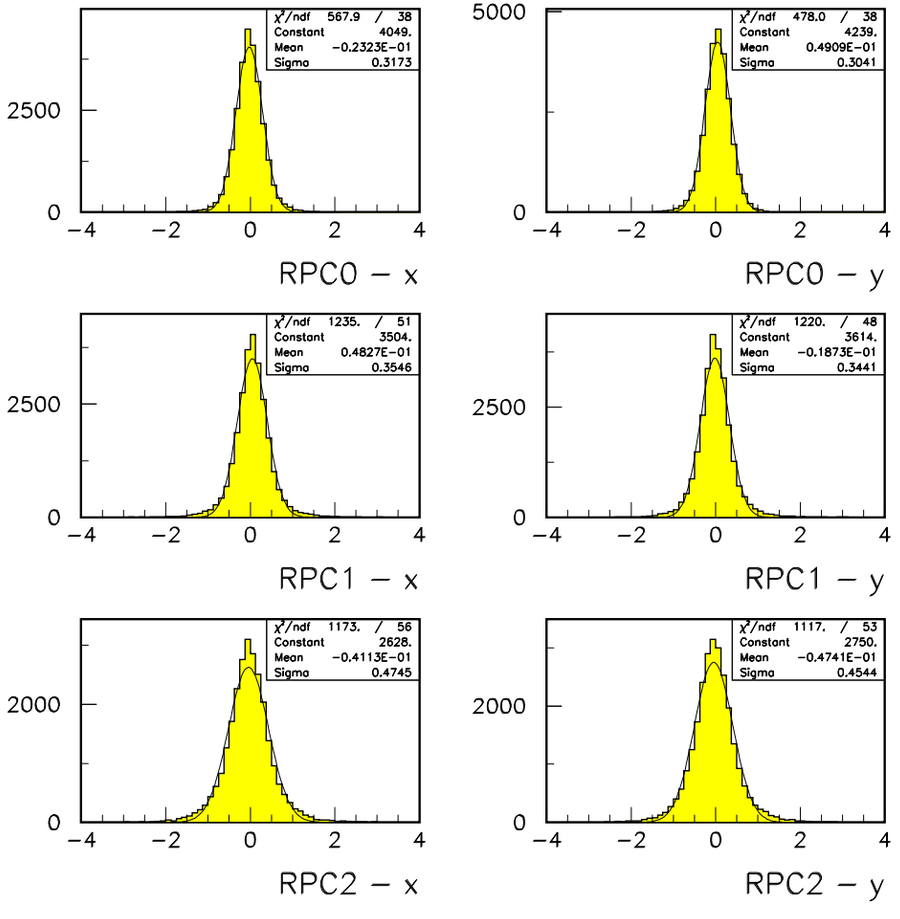
with $\Delta E_+ \neq \Delta E_-$

REMINDER
significant leakage
module of 7.2 X_0

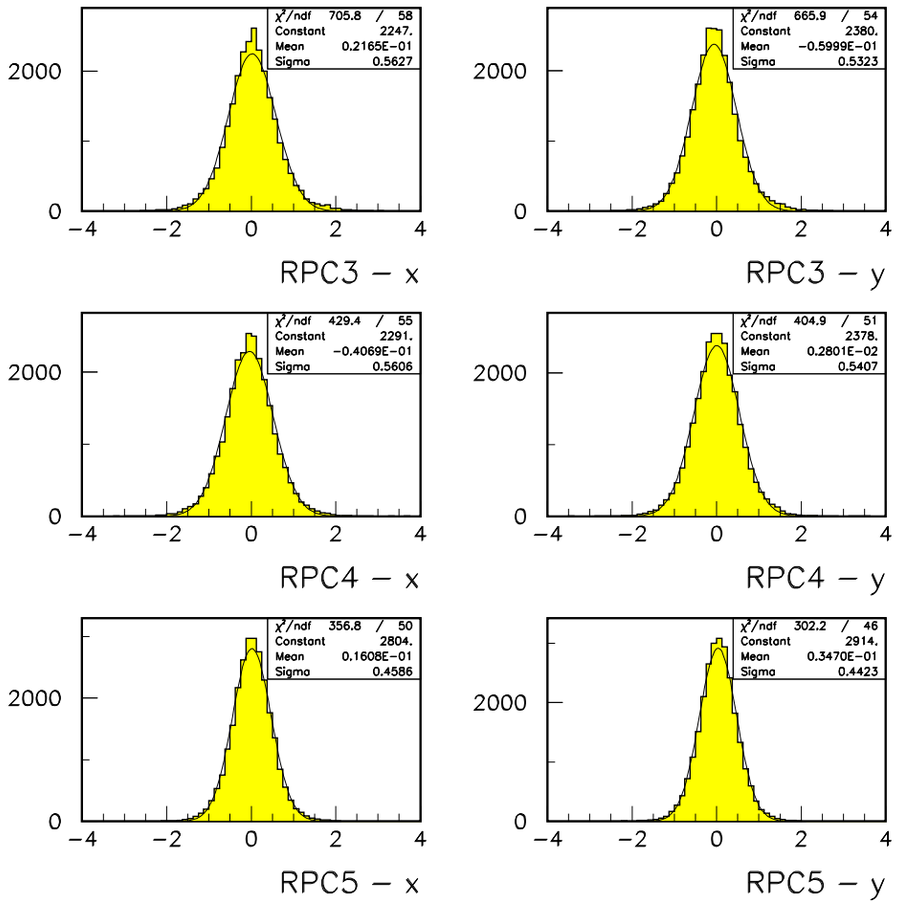


Shower development

Residuals (e+ at 8 GeV/c)

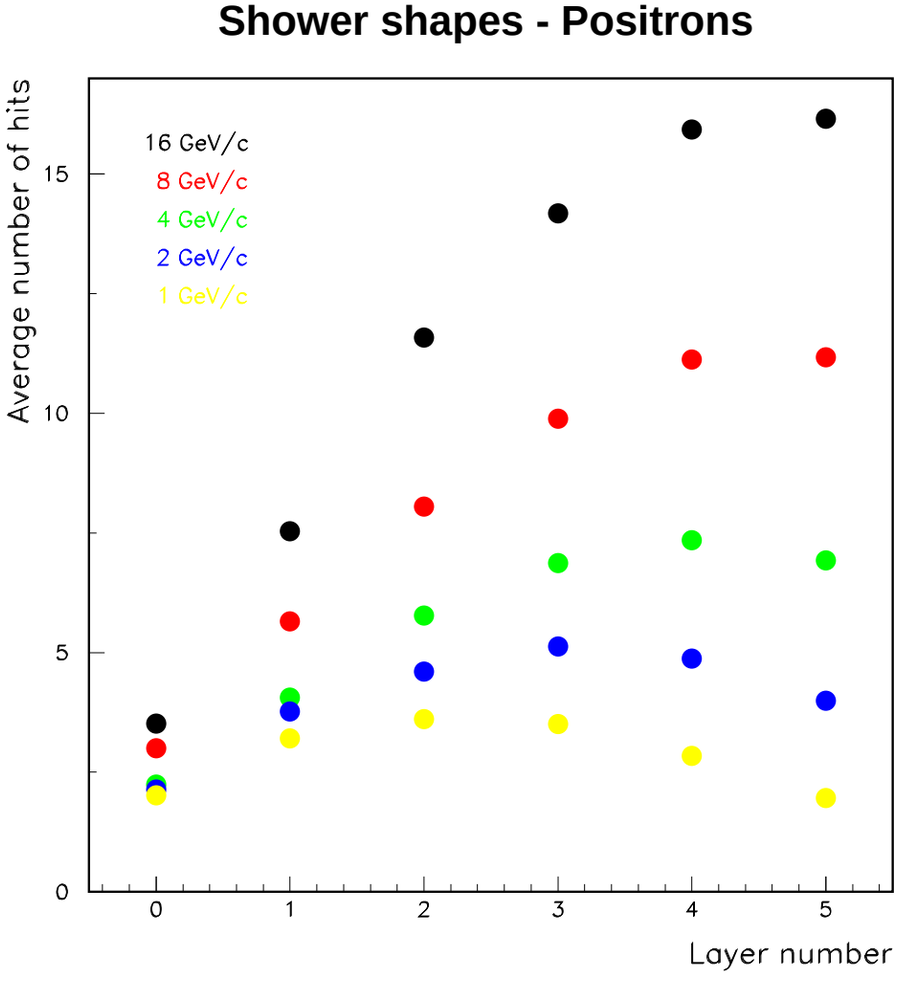


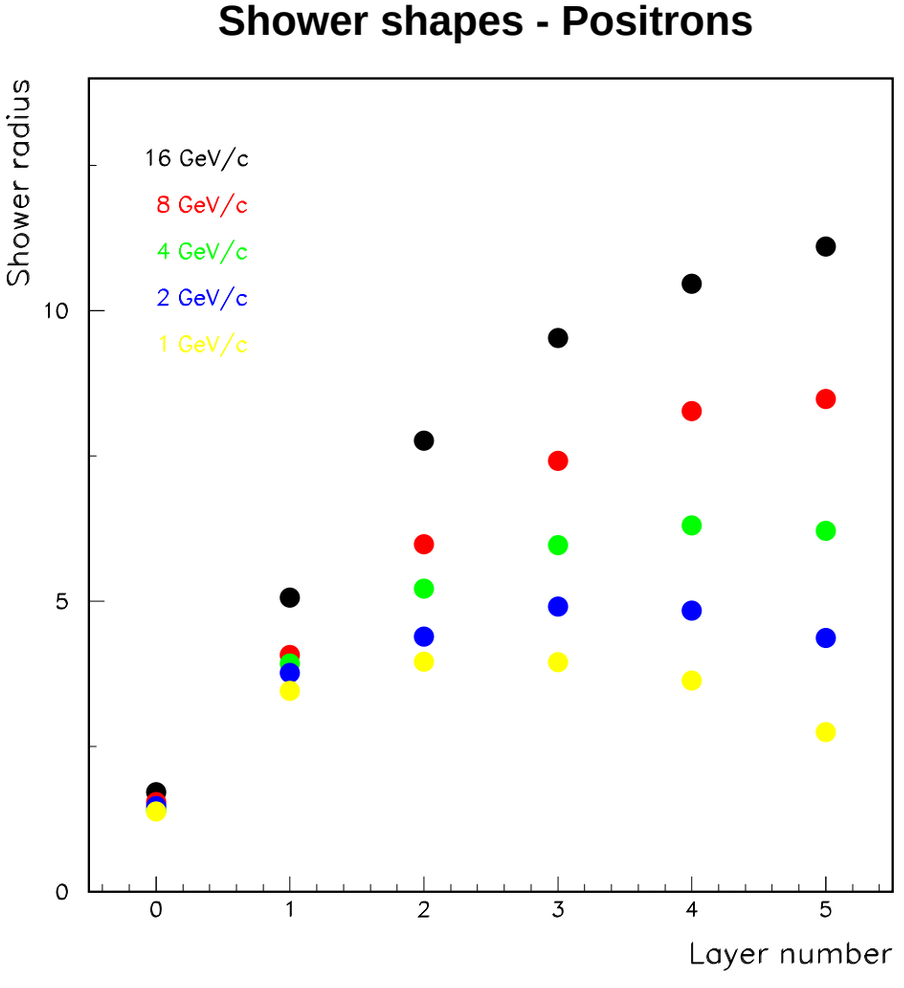
Residuals (e+ at 8 GeV/c)



(Residual in X,Y from straight line fits to showers. Offsets are < 1 mm)

Shower development





Shower longitudinal profile

- **· calorimetry basics**

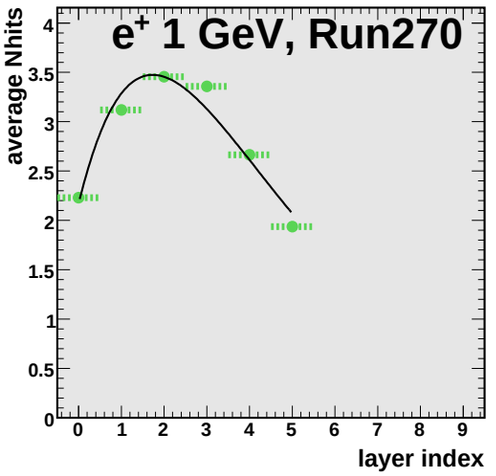
  : the mean longitudinal profile of the energy deposition in an electromagnetic shower is reasonably described by

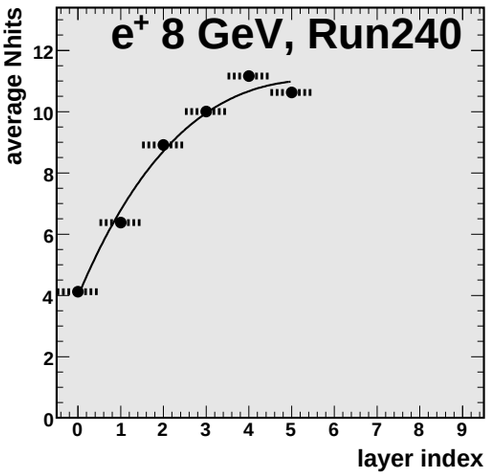
$$\frac{dE}{dt} = E_0 \cdot b \cdot \frac{(bt)^{a-1} e^{-bt}}{\Gamma(a)}$$ (with $t = x/X_0$)

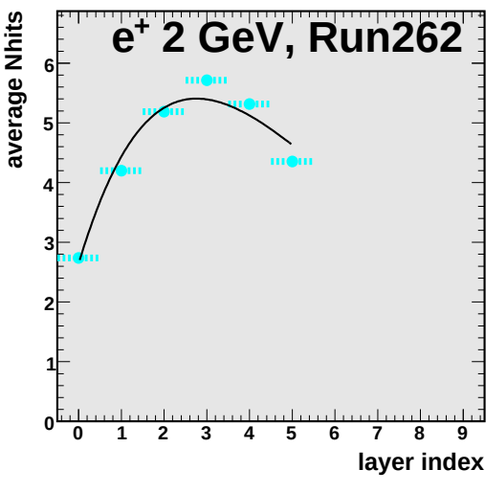
  : the maximum occurs at $t_{max} = (a-1)/b$ and it scales logarithmically with incident energy

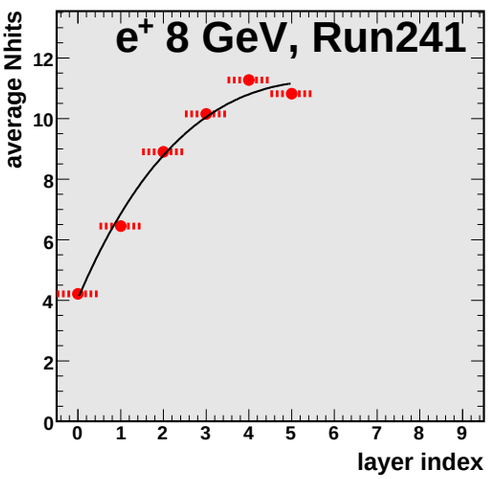
- **· Is this true for a digital calorimeter ?**

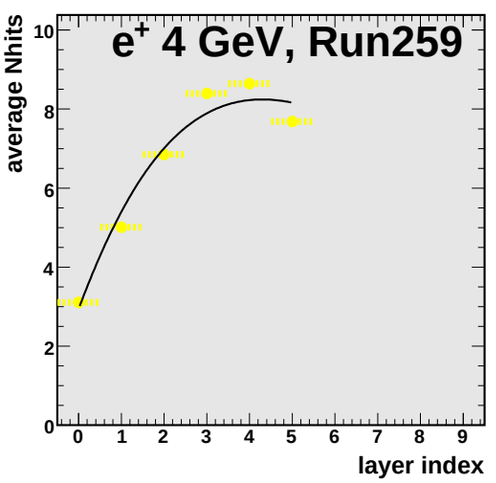
Shower longitudinal profile (per run)

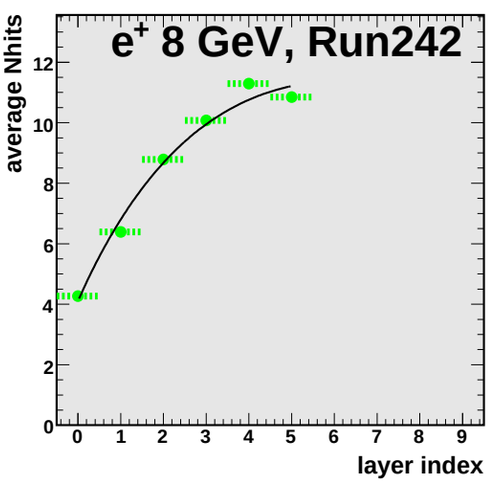


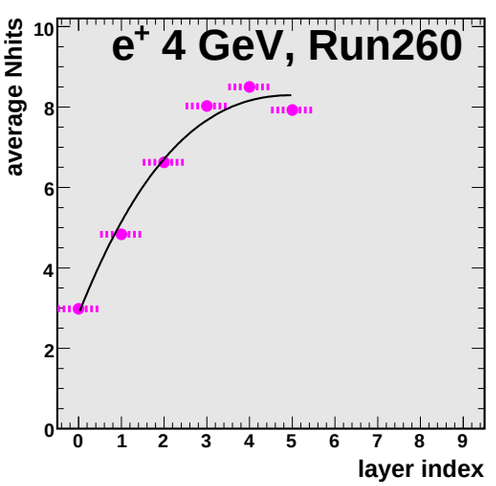


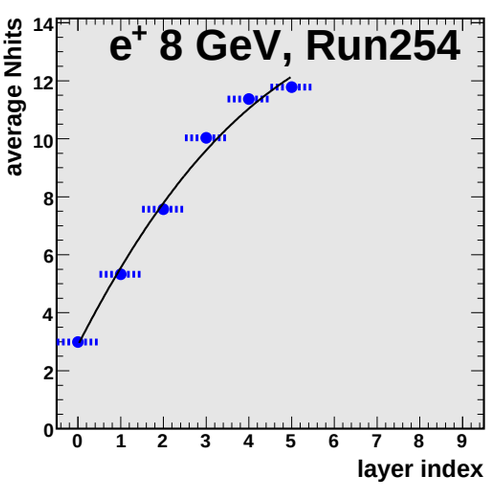




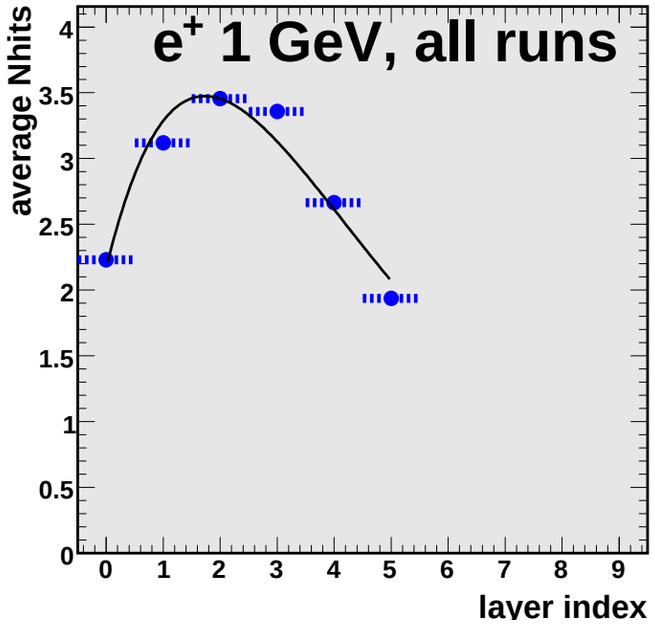


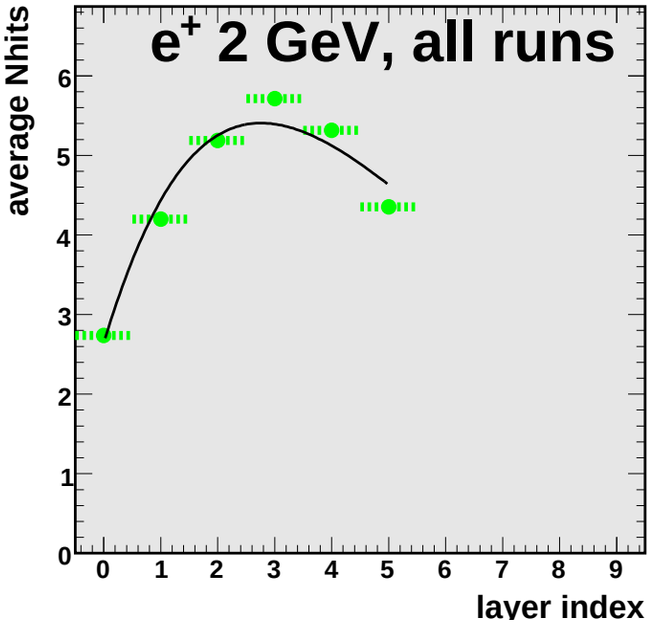


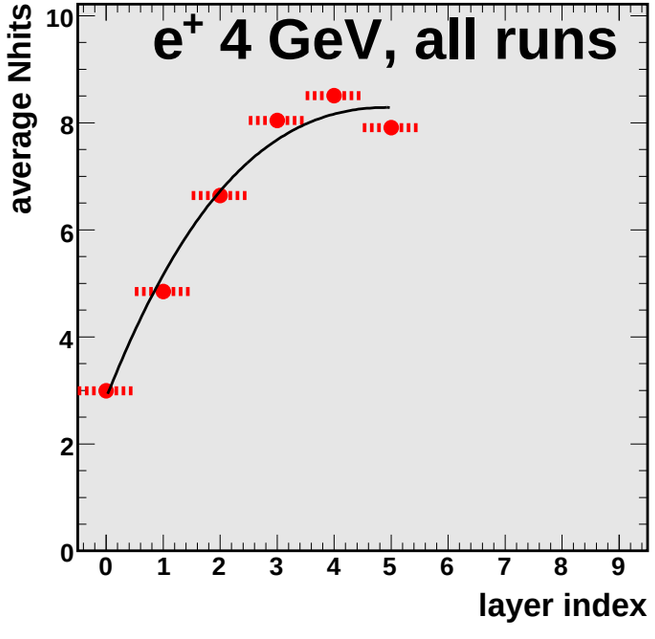


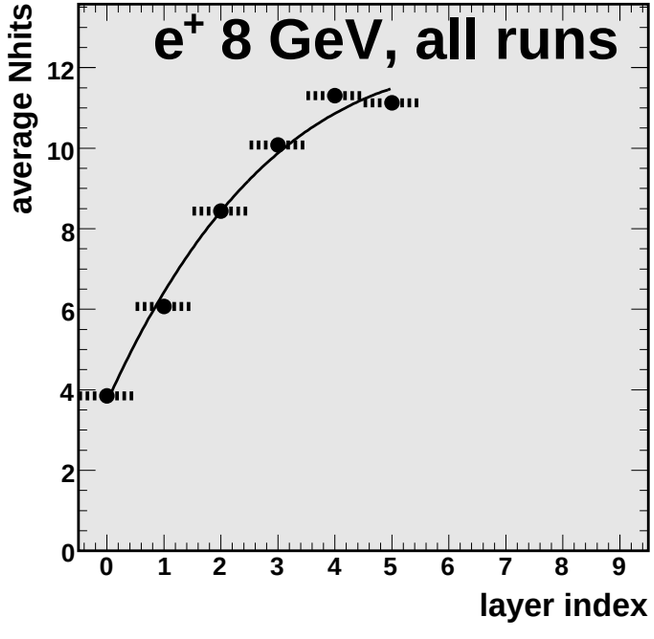


Same energy runs combined

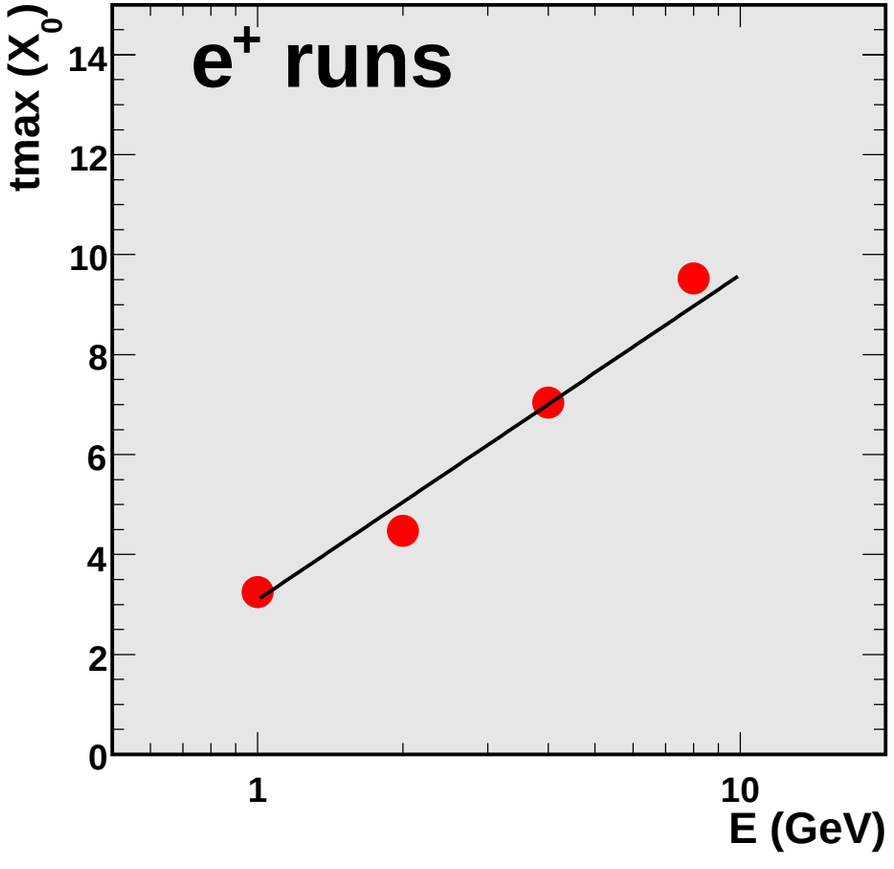






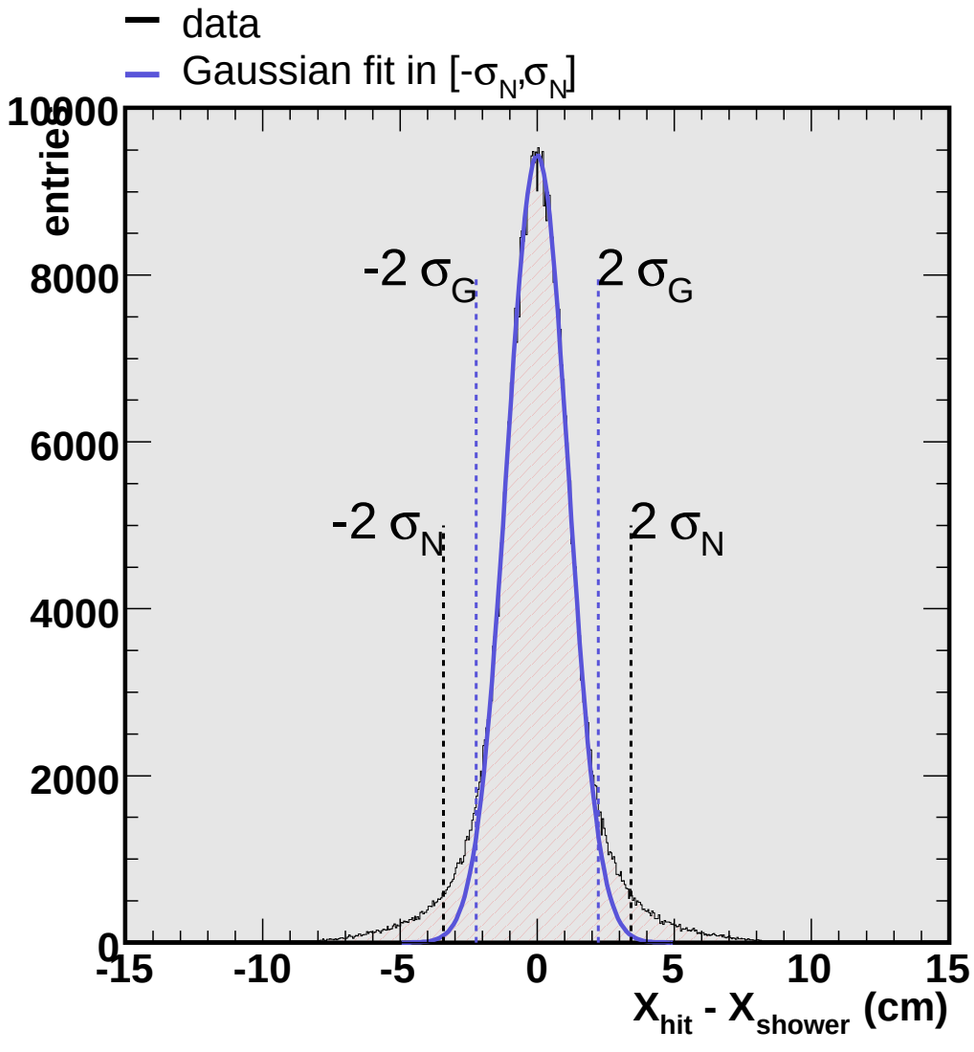


Shower maximum vs incident energy



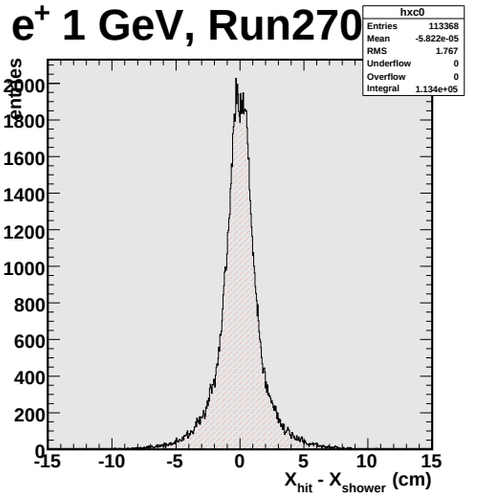
(with same energy runs combined)

Shower profile - example

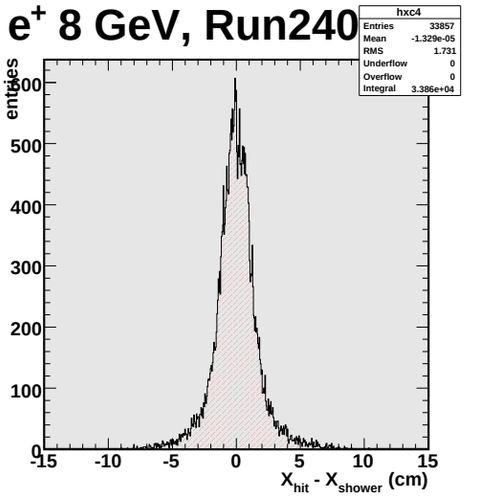


Shower profile X (distribution $X_{hit} - X_{shower}$)

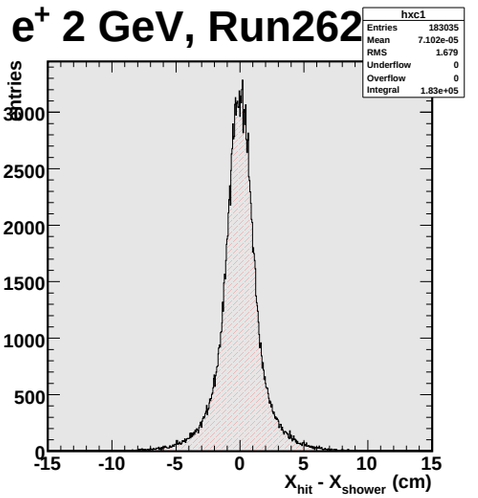
e^+ 1 GeV, Run270



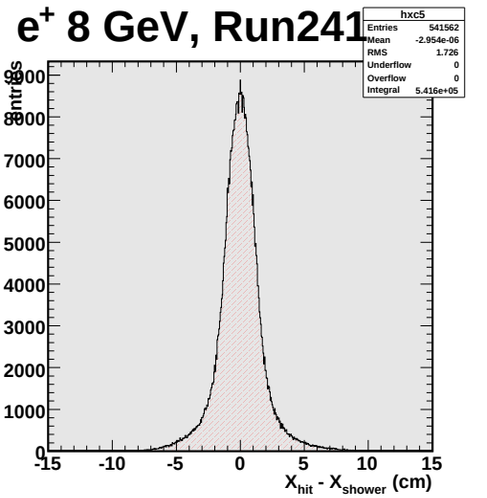
e^+ 8 GeV, Run240



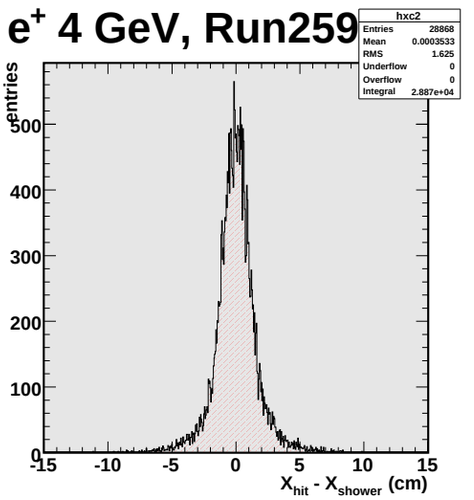
e^+ 2 GeV, Run262



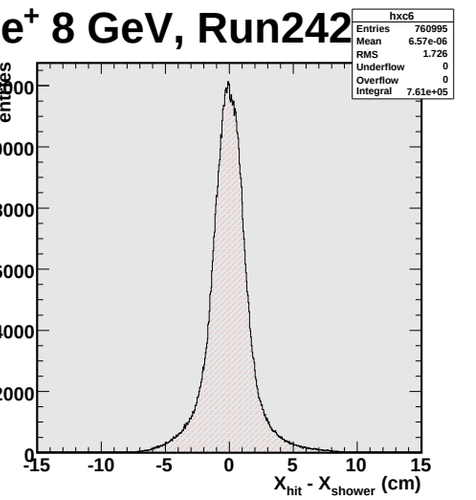
e^+ 8 GeV, Run241



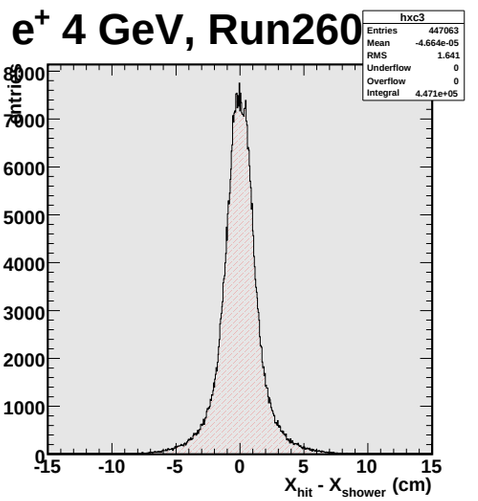
e^+ 4 GeV, Run259



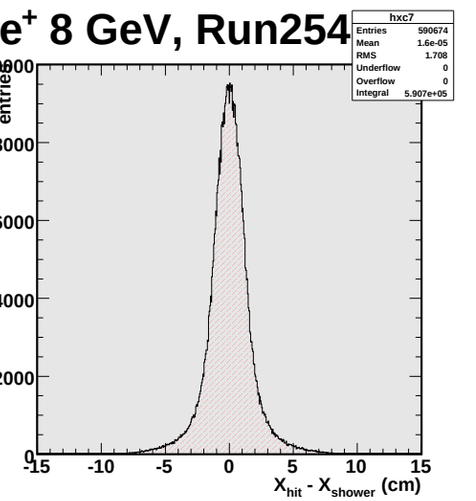
e^+ 8 GeV, Run242



e^+ 4 GeV, Run260

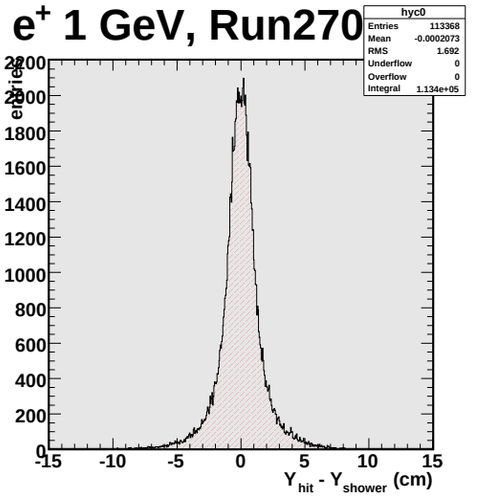


e^+ 8 GeV, Run254

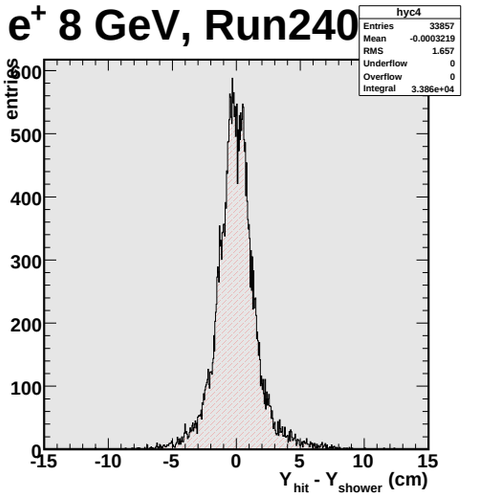


Shower profile Y (distribution $Y_{hit} - Y_{shower}$)

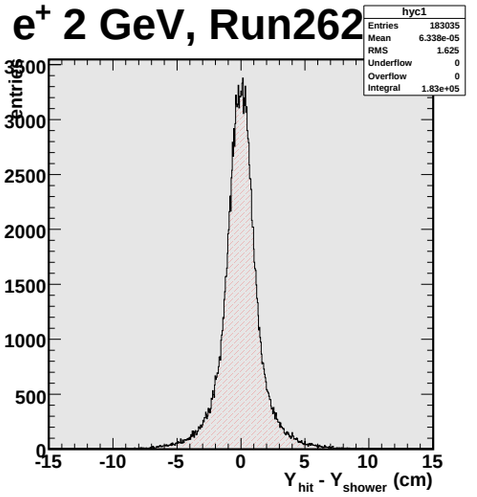
e^+ 1 GeV, Run270



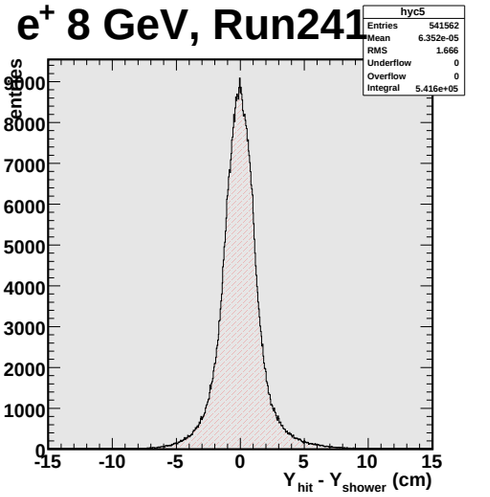
e^+ 8 GeV, Run240



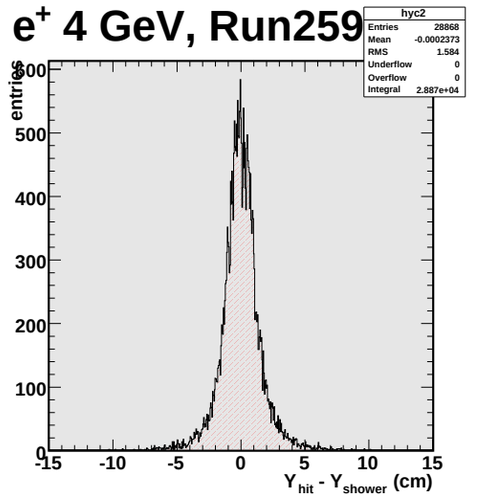
e^+ 2 GeV, Run262



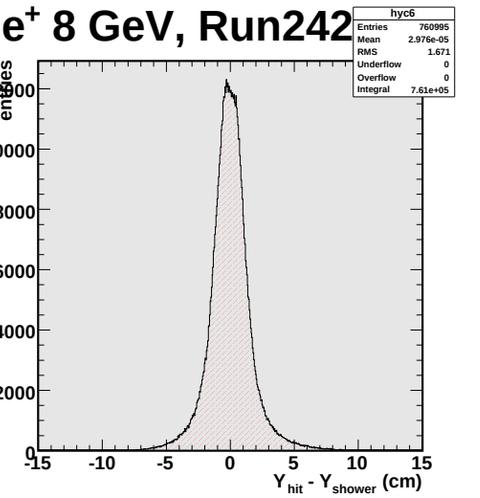
e^+ 8 GeV, Run241



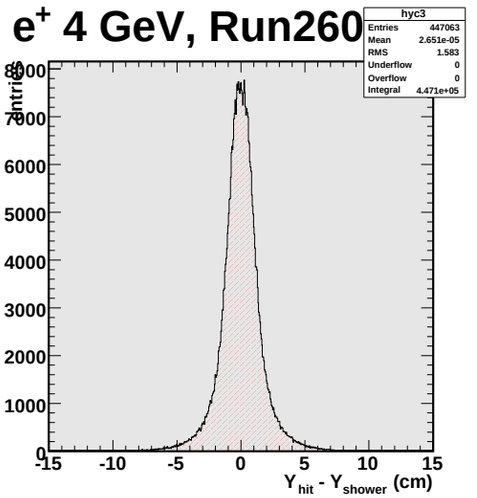
e^+ 4 GeV, Run259



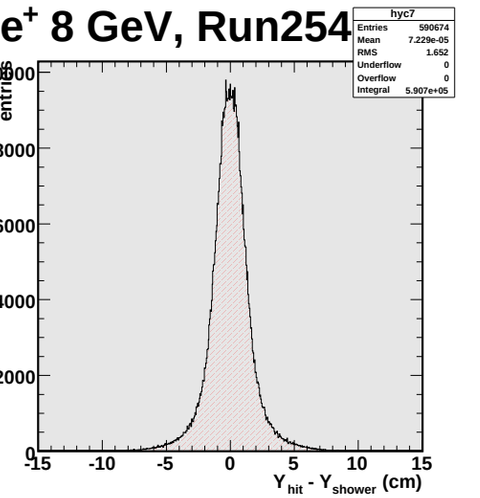
e^+ 8 GeV, Run242



e^+ 4 GeV, Run260

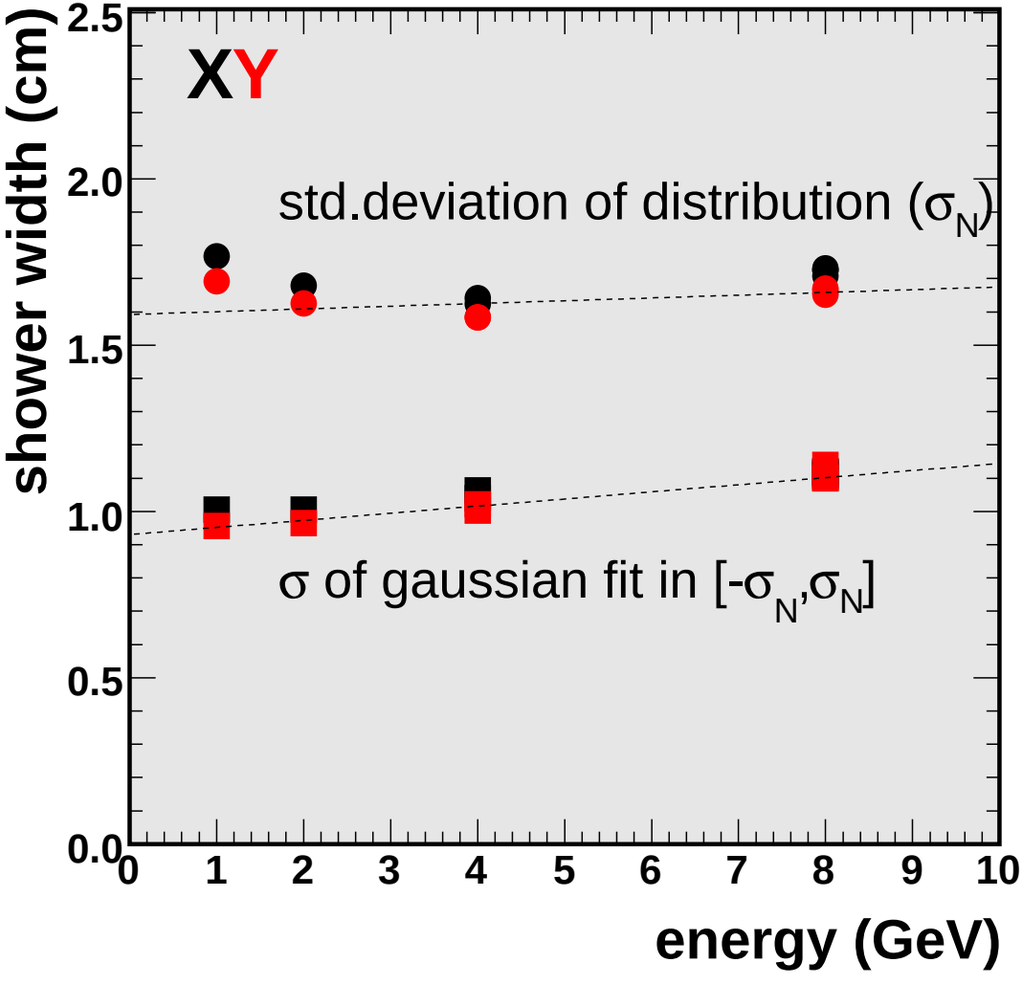


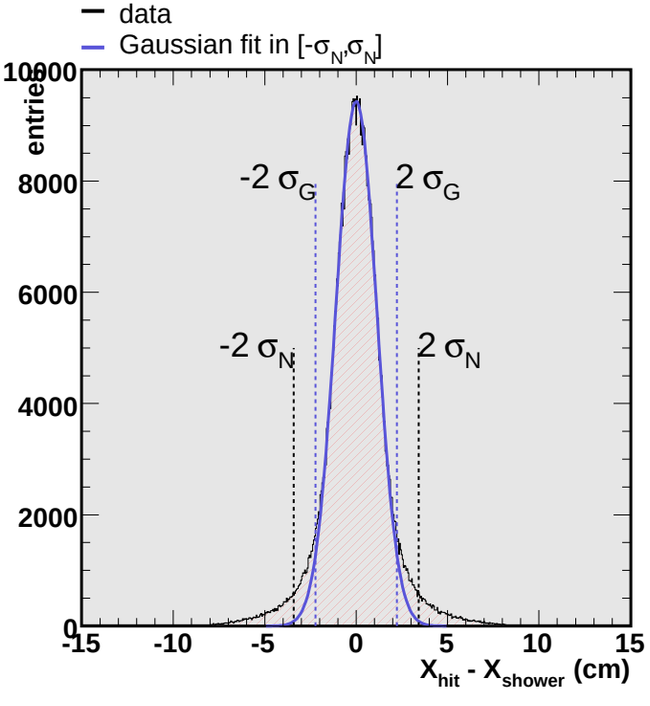
e^+ 8 GeV, Run254



Shower width vs incident energy

DHCAL slice of 7.2 X_0





Summary

- **RPC-DHCAL slice test at FNAL-MTBF**

  : valuable experience and valuable data collected in summer 2007

  : rapid progress into analysis wrt technical and calorimetric studies, see other talks at the "DHCAL" and "Analysis" sessions

  : **first studies with positron data discussed here, results show a promising calorimetric behavior**

- **outlook**

  : a new round of data collection with a larger prototype is next to come, soon preferably

  : hope the funding situation will maintain the enthusiasm and the pace of the group