The performance of Strip-Fiber EM Calorimeter

response uniformity, spatial resolution

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- Shower profile
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- Angle measurement
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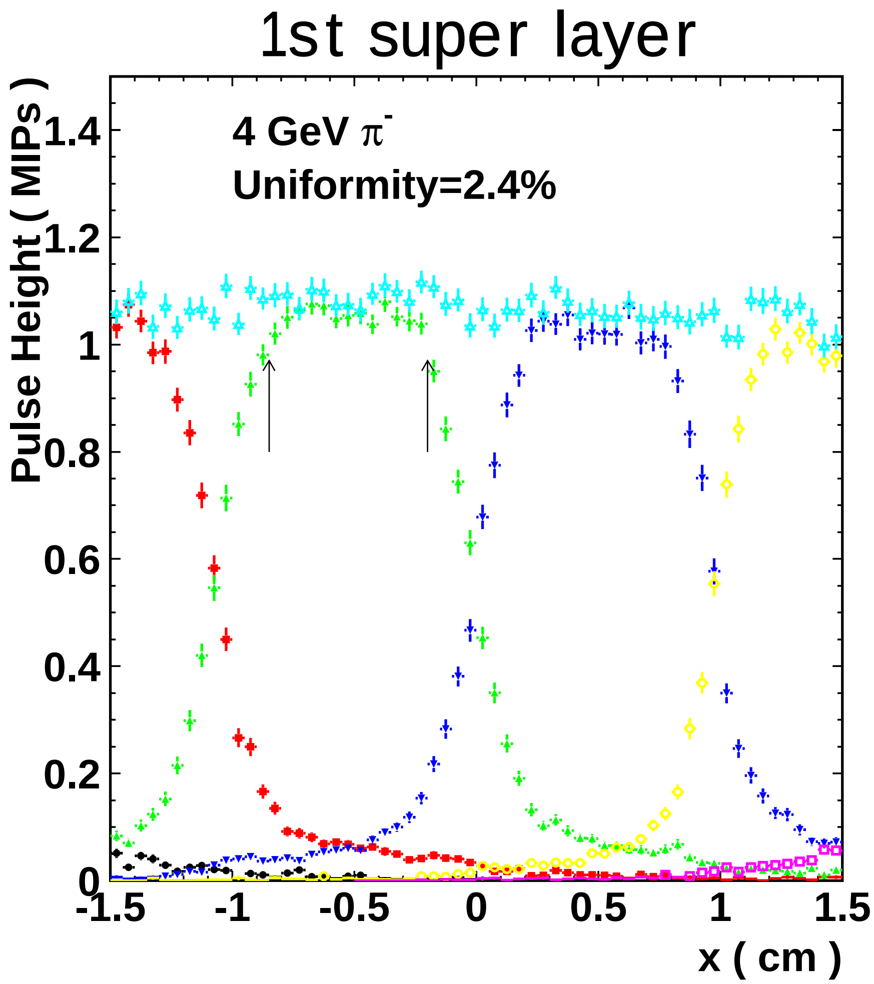
Response uniformity in the 1 cm-width direction

The minimum ionizing particle (MIP)

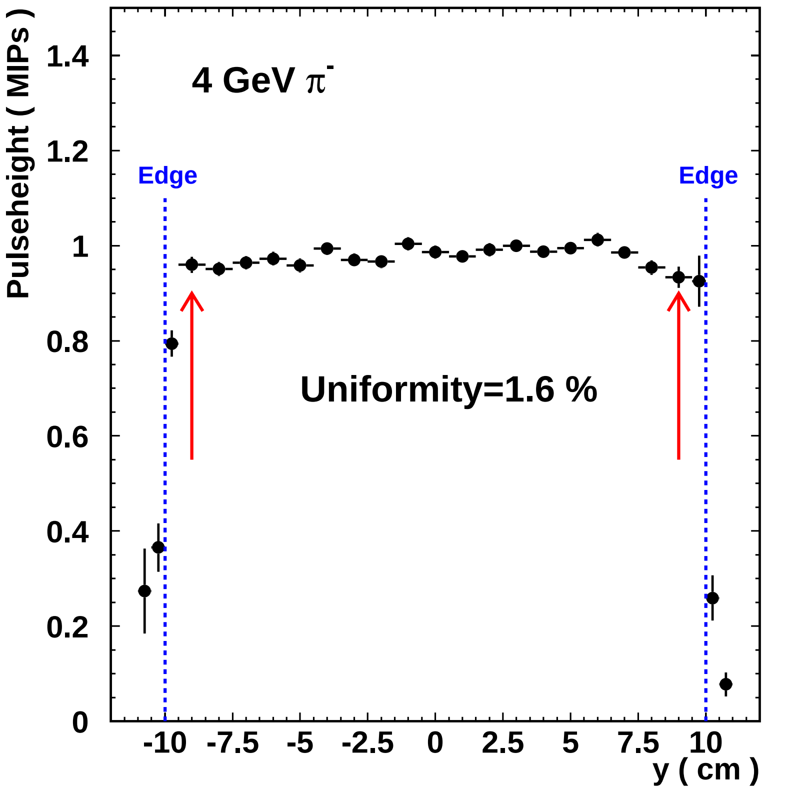
- Response uniformity is examined to check if it is uniform enough to keep the good energy resolution
- Scanning step : 0.5 mm
  - Tracking resolution : 0.3 mm
- The response uniformity is calculated as a RMS of the response over a mean of the response in a central region of 7mm.
- Response uniformity in the 1 cm-width direction : 2.4 %



Response uniformity in the 20 cm-long direction

The minimum ionizing particle (MIP)

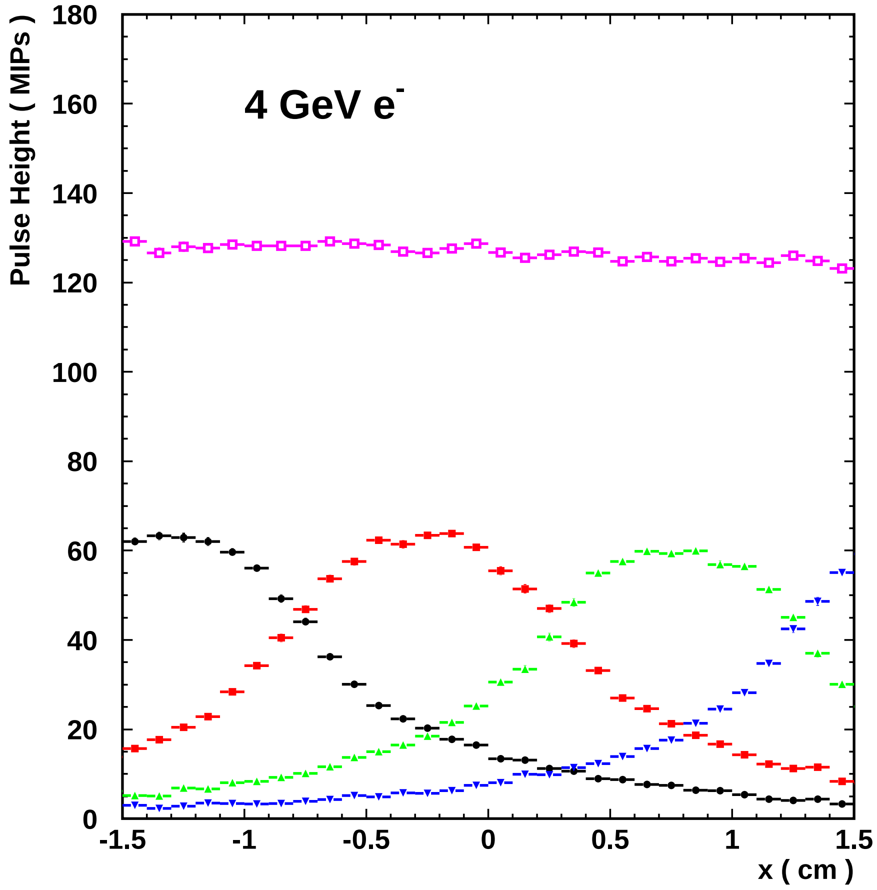
- Scanning step : 1 cm
- Uniformity in the 1st super layer superposed 9-11 strip events.
- Read out is +10cm, Wave Length Shifter fiber attenuation is seen.
- The response uniformity is calculated as deviation from the fitted straight line in a central region of 18cm.
- Response uniformity in the 20 cm-long direction : 1.6 %



Response uniformity in the 1 cm-width direction

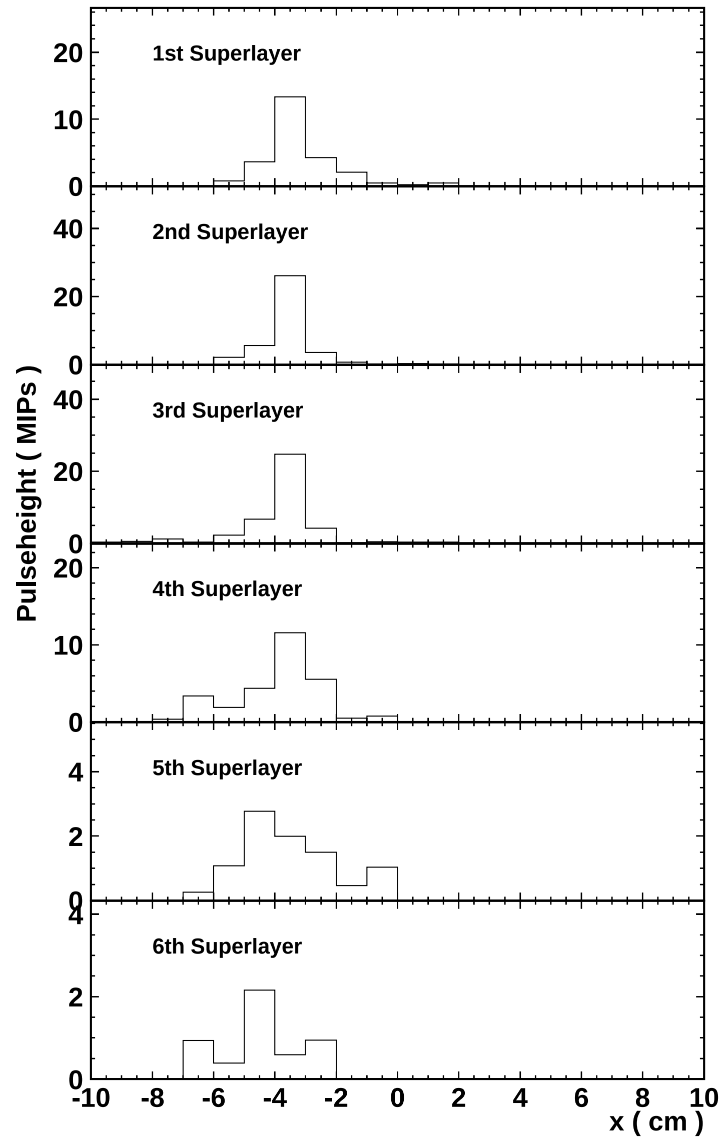
4 GeV electron

- Scanning step : 1 mm
- Response uniformity in which the response sum over the longitudinal strips and the response sum over all x-strips are plotted as a function of the incident beam position.
- Response uniformity for x-layer : 1.1 %



Shower profile

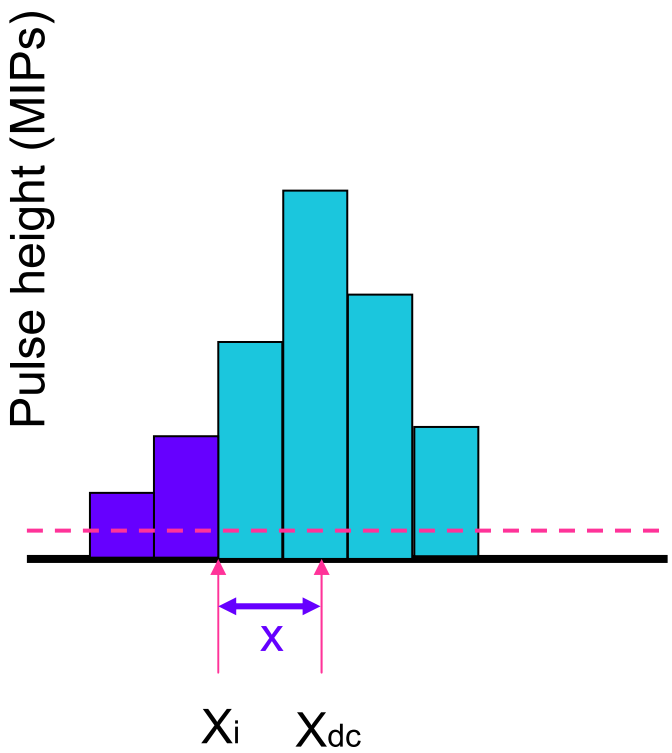
- In the idea of the fine-segmented electromagnetic calorimeter, it is very important to have a good capability of separating photon-originated electromagnetic clusters from charged tracks.
- A typical event display for 4 GeV electron.



Integrated lateral shower profile

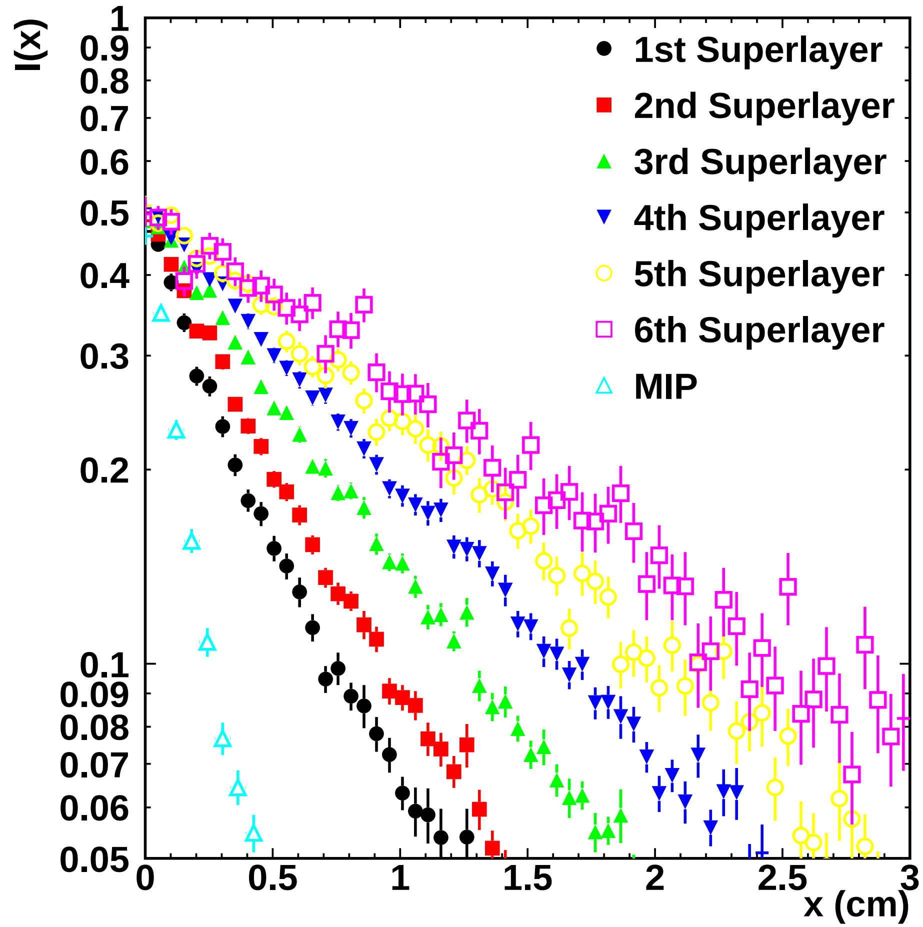
- The energy fraction $I(x)$
  - X_{dc}; the incident position reconstructed with drift chamber
  - X_i ; position of i th strip.
  - $x = X_{dc} - X_i$
  - $I(0) = 0.5$

$$I(x) = \int_{-\infty}^{x} dxPH \Big/ \int_{-\infty}^{+\infty} dxPH$$



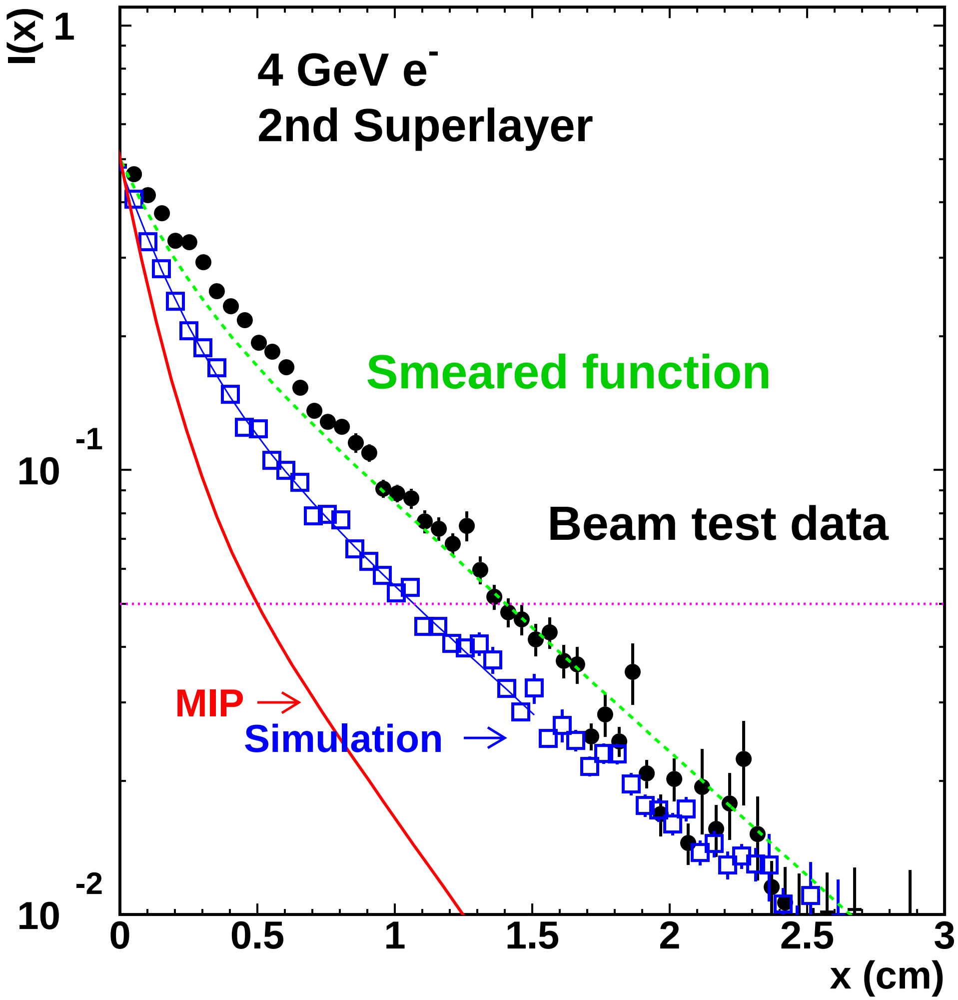
Integrated lateral shower profile

- Integrated shower profile, I(x) of a shower cluster for 4 GeV electron and MIP.
- The widths for 90 % shower containment : 1.5 cm at 2nd super layer (shower max).
- The MIP spread which originated from the light leakage between adjacent strips is much smaller than electron spread.



Smeared function of the lateral shower spread

- A small deviation between 4 GeV electron data and GEANT3-based shower simulation.
- This deviation is thought to come from the detector effect such as light leakage between adjacent strips.
- The smearing of the lateral shower spread in the simulation using the information on the light leakage seen in the MIP signal spread.



Lateral shower profile

- Integrated lateral shower profile I(x) can be parameterized as a double exponential of the following form:

$$\boxed{f(x) = p4 \times \{p3 \times \exp(-x/p1) + (1-p3) \times \exp(-x/p2)\}}$$

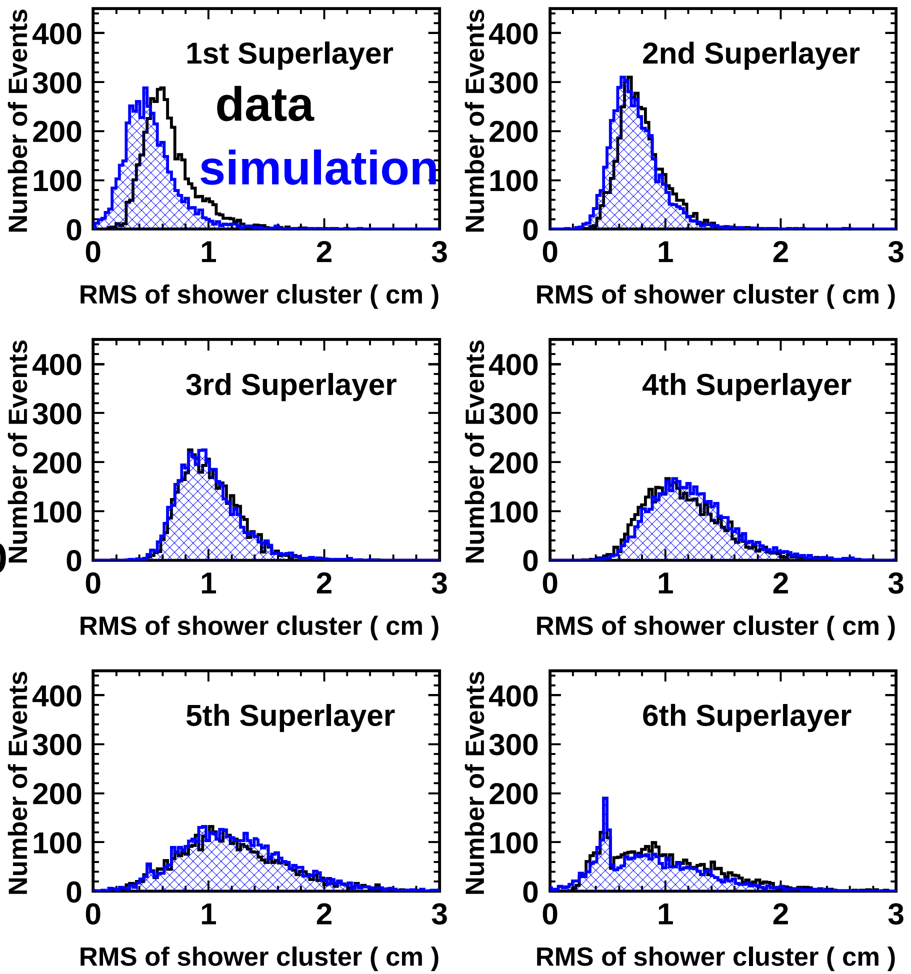
- The smeared function fs(x) is defined by the following equation

$$\boxed{f_s = \int_0^{\infty} dx' f_e(x - x') \times f_{MIP}(x')}$$

- This smeared lateral shower profile in the simulation is consistent with the lateral shower profile for electron data.

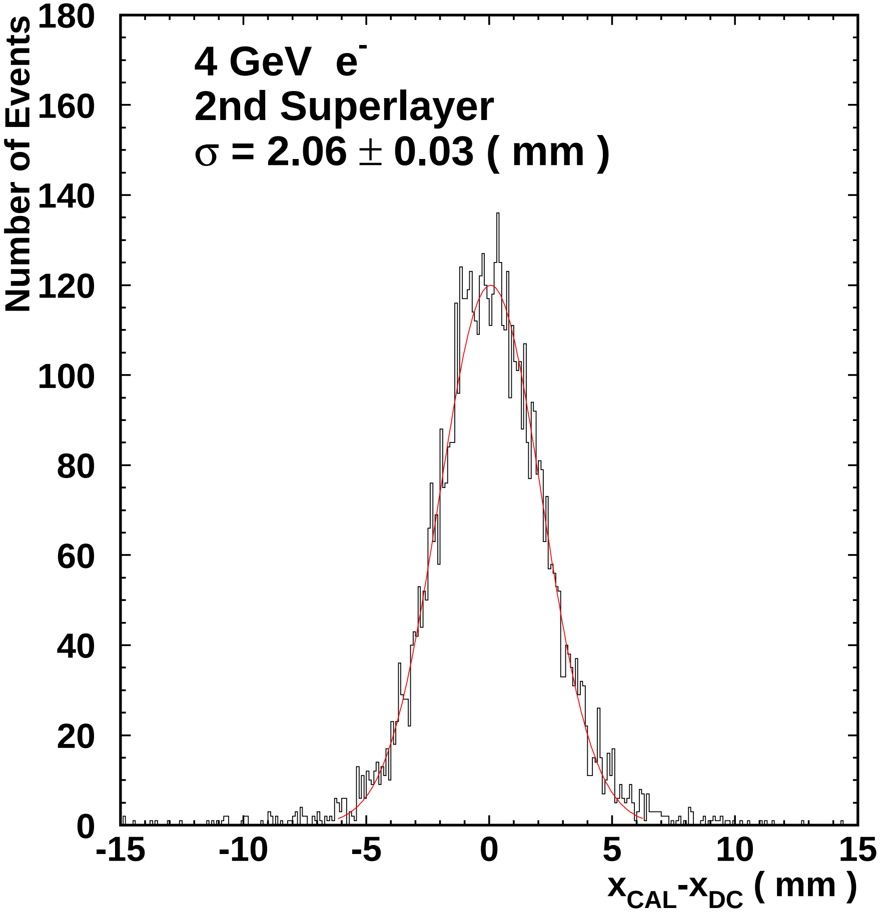
RMS of lateral shower profile

- RMS of the cluster
- To examine the fluctuation of the lateral shower profile.
- The measured lateral shower profile for electron data was found to be well described by the simulation, including the fluctuation on the shower by shower basis.



Spatial resolution at 2nd super layer for 4 GeV electron

- The shower centroid , x_{shower} is obtained by the fitting energy deposits in 5 strips to a Gaussian.
- The distribution of the position difference between the shower centroid, x_{shower} at the 2nd super layer and the track extrapolation, x_{dc} for 4 GeV electron.

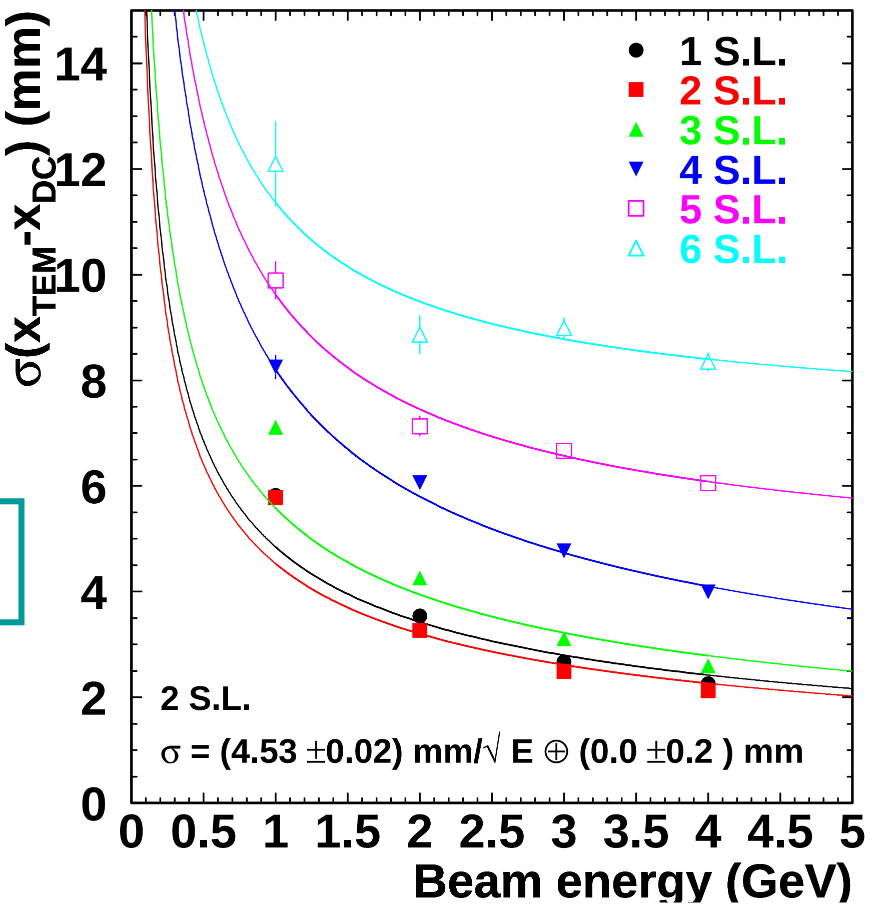


Spatial resolution

- The position resolution can be parameterized as the following form :

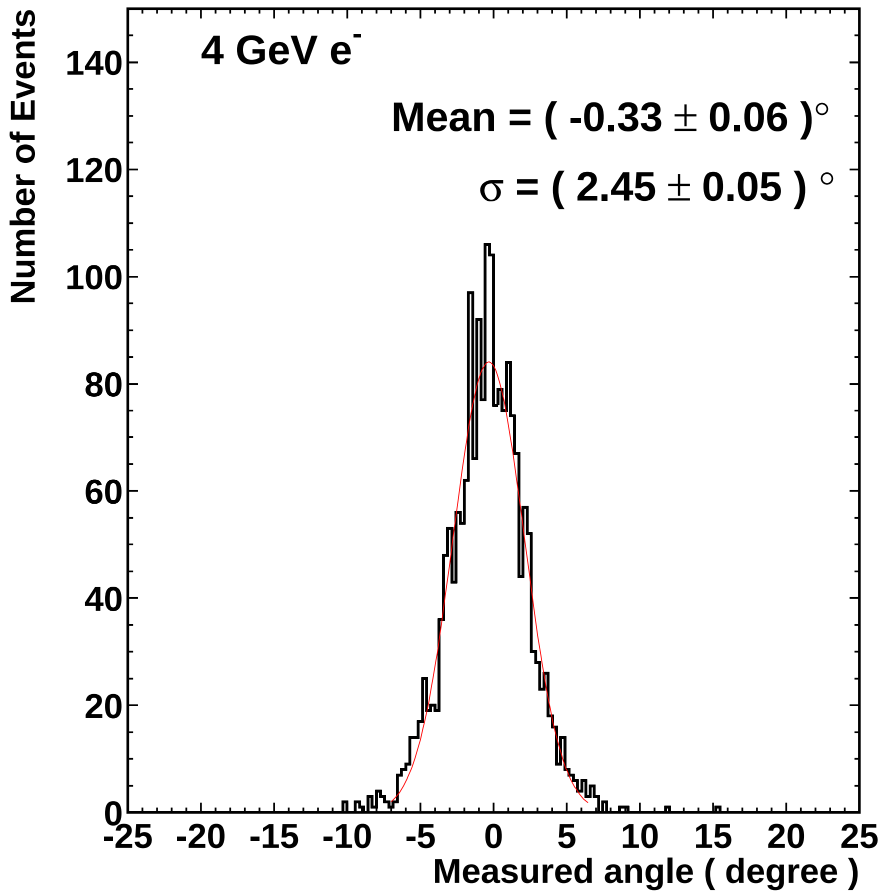
$$\sigma = (4.53 \pm 0.02)\mathrm{mm}/\sqrt{E} \oplus (0.0 \pm 0.2)\mathrm{mm}$$

at the 2nd super layer in the energy range 1 GeV and 4 GeV.



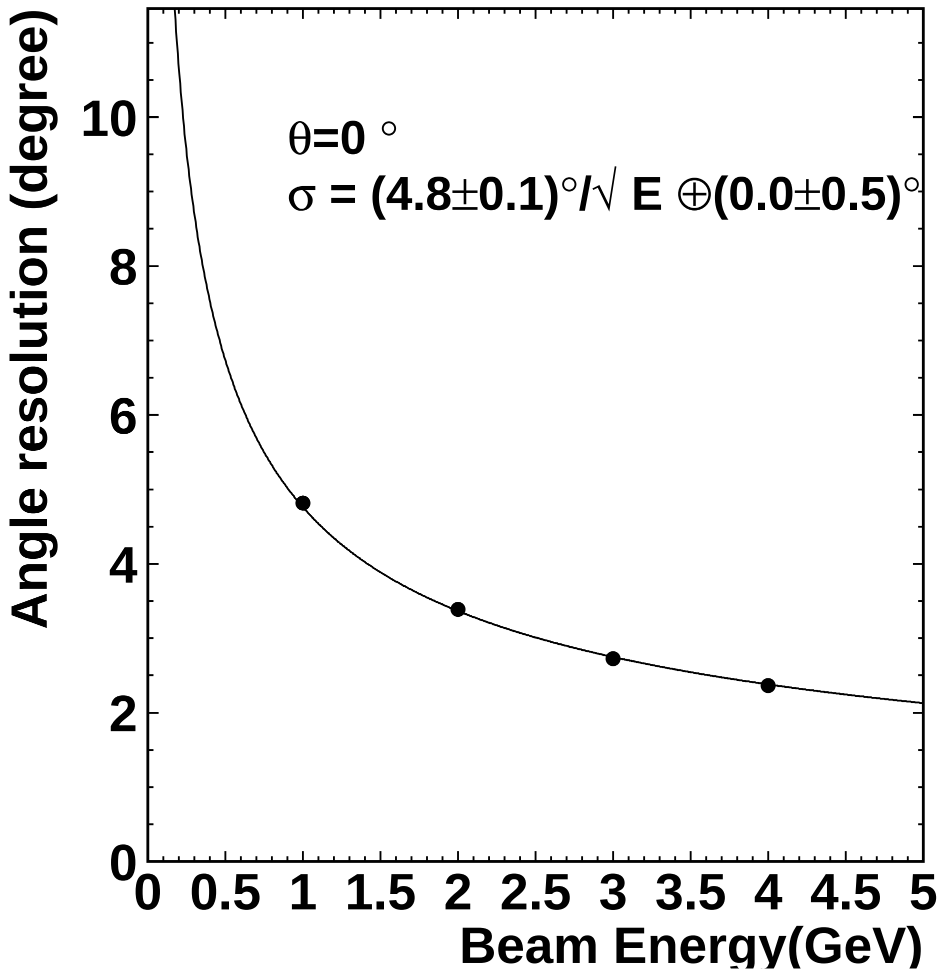
The angle distribution measured by the calorimeter

- The shower direction is obtained by a linear fit of the centroid positions in the super layer
- In this calculation, only first 4 super layers are used for fitting because in the last 2 super layers the signals are small and the resolutions are worse.



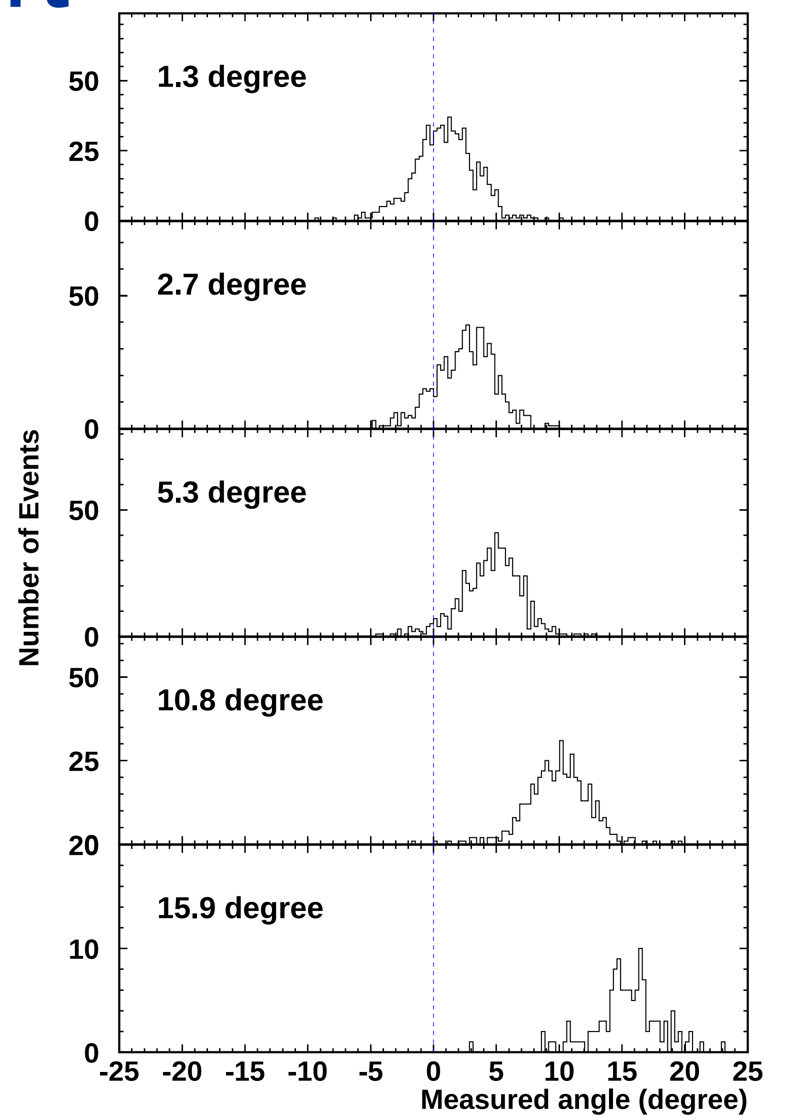
The angular resolution

- The angular resolution using the electron beams with 0 degree in the energy range between 1 GeV and 4 GeV.



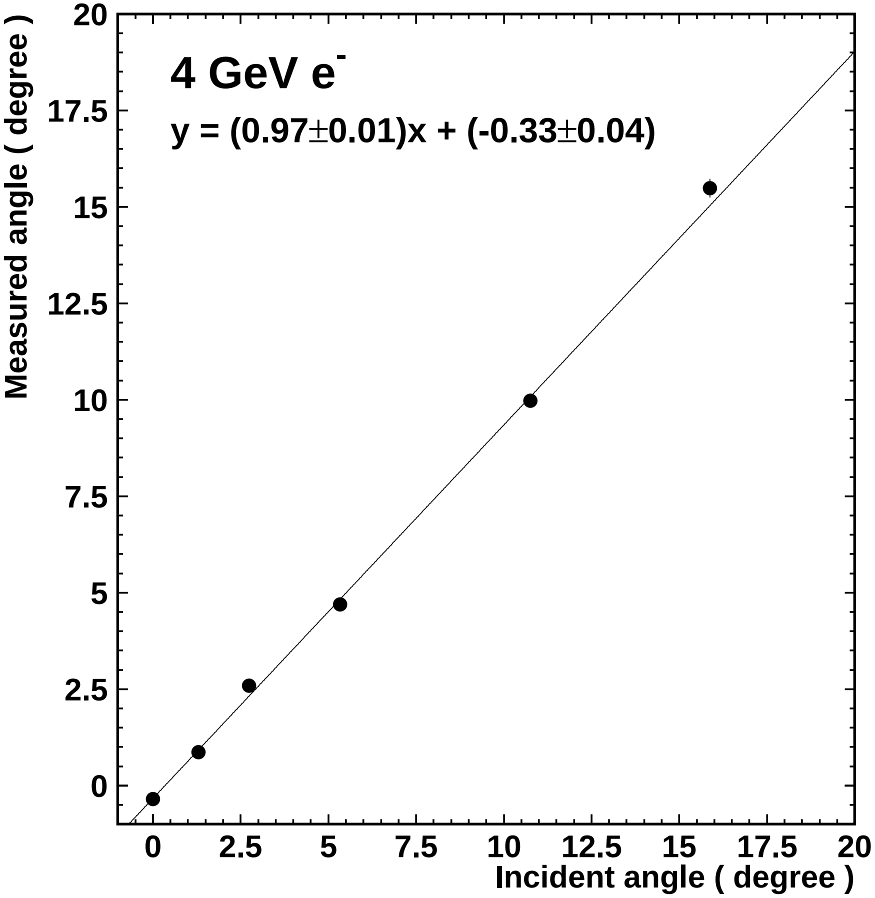
Angle measurement

- In the beam test, we performed data taking with the electron trigger, with an incident beam angle varying from 0 to 15.9 degree.
- The distribution of the angle measured by the calorimeter.



The comparison with the incident angle

- The comparison of the angles measured by the calorimeter with the incident angle.



Summary

- Response uniformity
  - MIP 1cm-width direction : 2.4 %
  - MIP 20cm-long direction : 1.6 %
  - 4 GeV electron x-layer : 1.1 %
- Lateral shower spread
  - The width for 90 % shower containment
    1.5 cm at 2nd super layer
- Position resolution at 2nd super layer

$$\sigma = (4.53 \pm 0.02)\mathrm{mm}/\sqrt{E} \oplus (0.0 \pm 0.2)\mathrm{mm}$$

- Angle resolution

$$\sigma = (4.8 \pm 0.1)^\circ/\sqrt{E} \oplus (0.0 \pm 0.5)^\circ$$

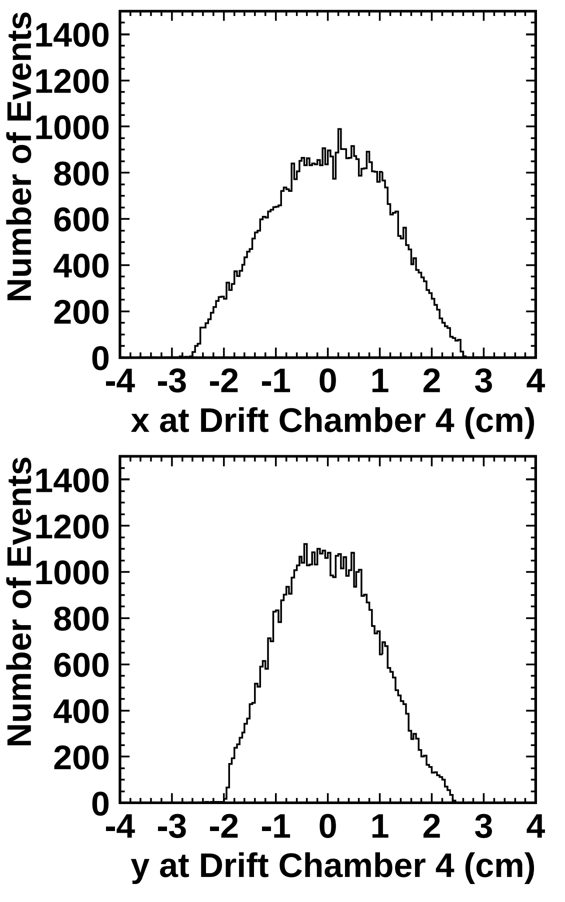
Appendix

- Tracking
- Longitudinal shower profile
- Spatial resolution

Tracking

Position distribution

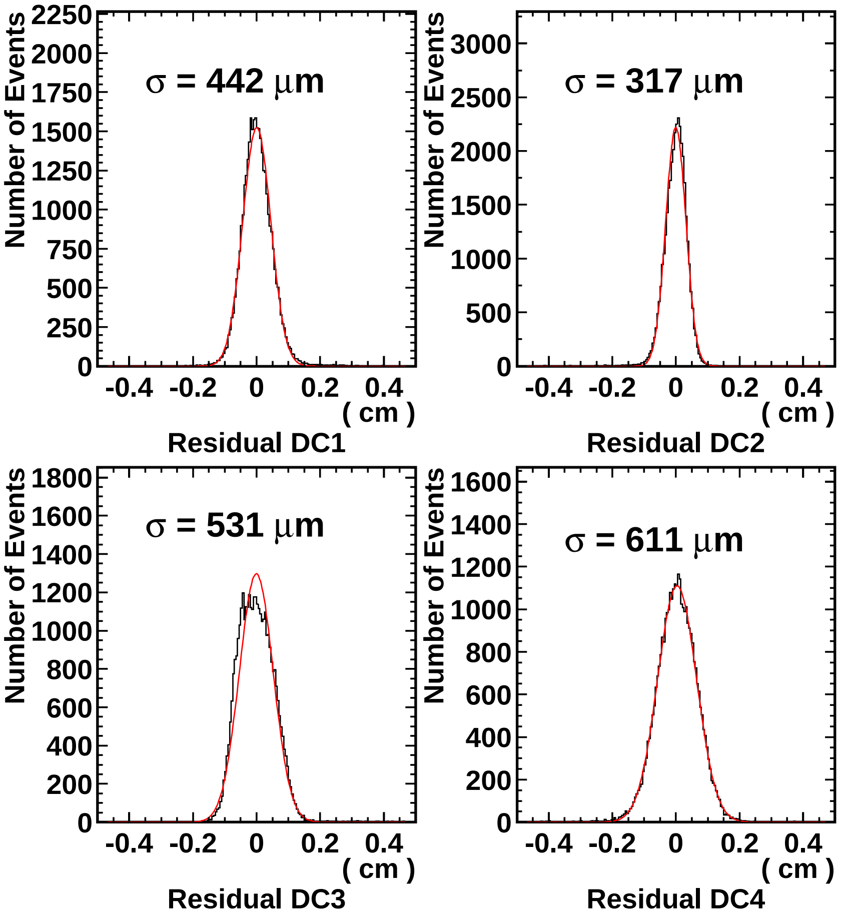
- Position distribution at the most down stream chamber.
- This beam profile indicates that the beam profile is smaller than the size (5x5 cm) of the nearest trigger counter.



Tracking

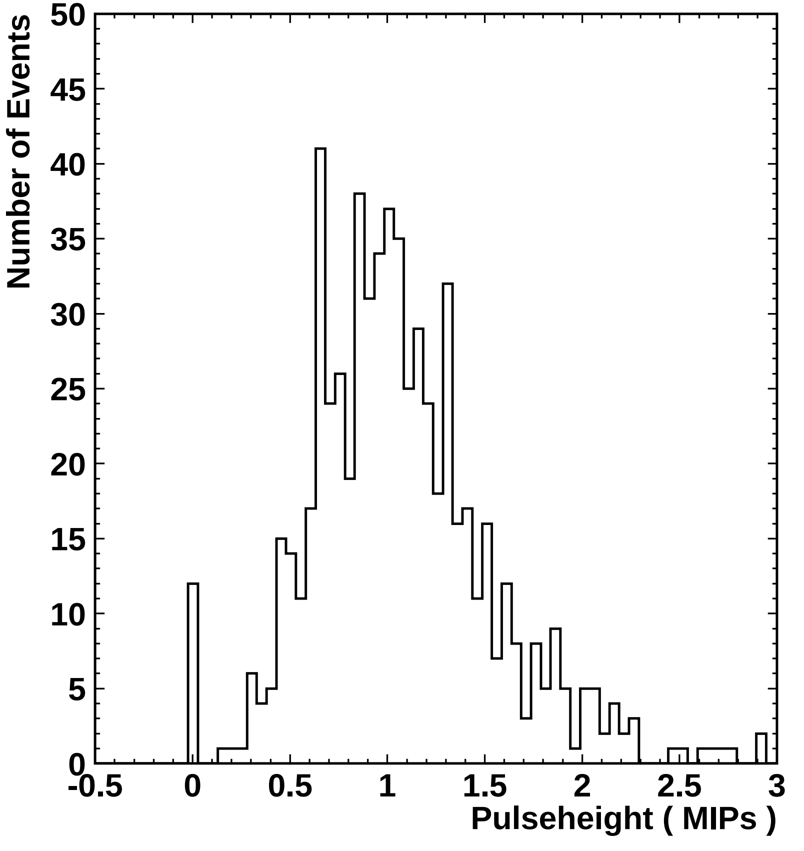
Residual distribution

- The incident position resolution at the calorimeter surface is evaluated to be 300 micro m



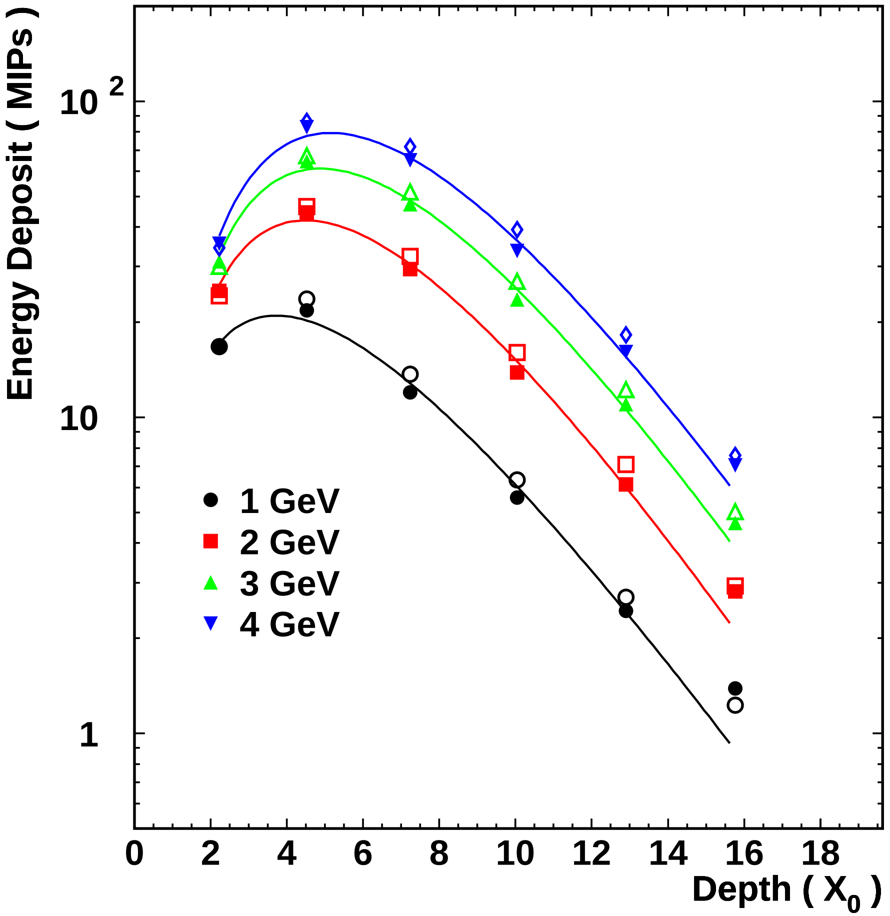
The response at x=-0.5 cm

- The response in a certain region of each scintillator is determined by the mean of the pulse height distribution.



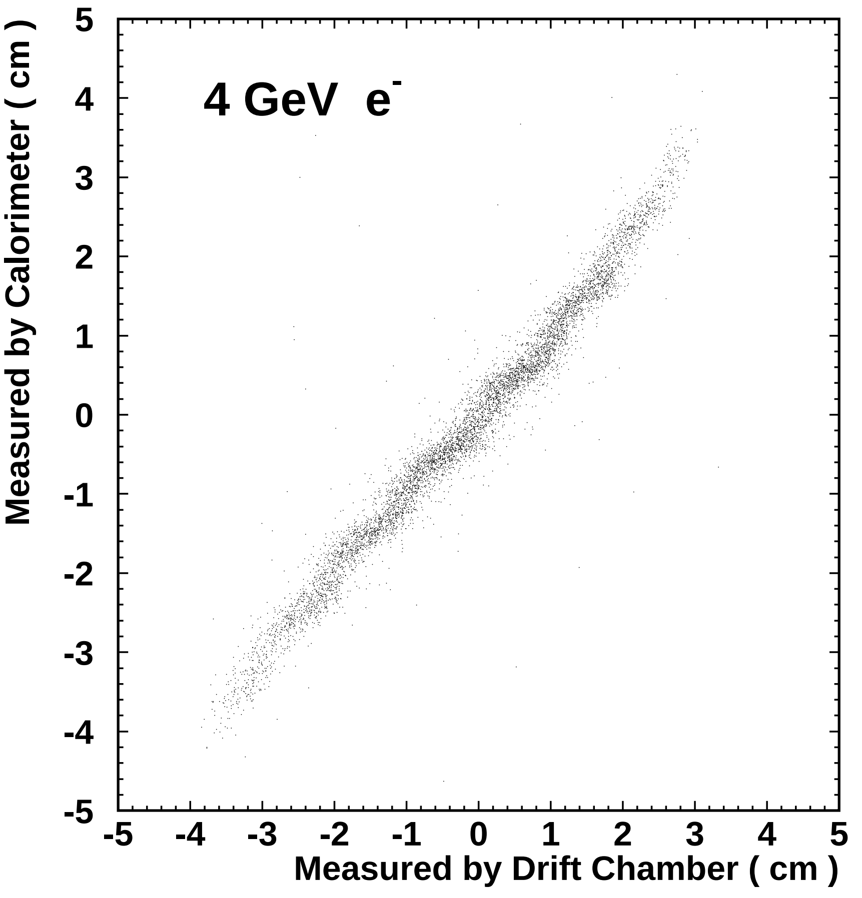
Longitudinal shower profile

- The longitudinal shower profiles for electron data are also consistent with the simulation result.



Correlation plot at the 2nd super layer

- The position calculated by the method is compared with that determined with the drift chamber.



The position resolution at each super layer