CALOR 2008

Response of the CALICE Si-W ECAL prototype to electrons

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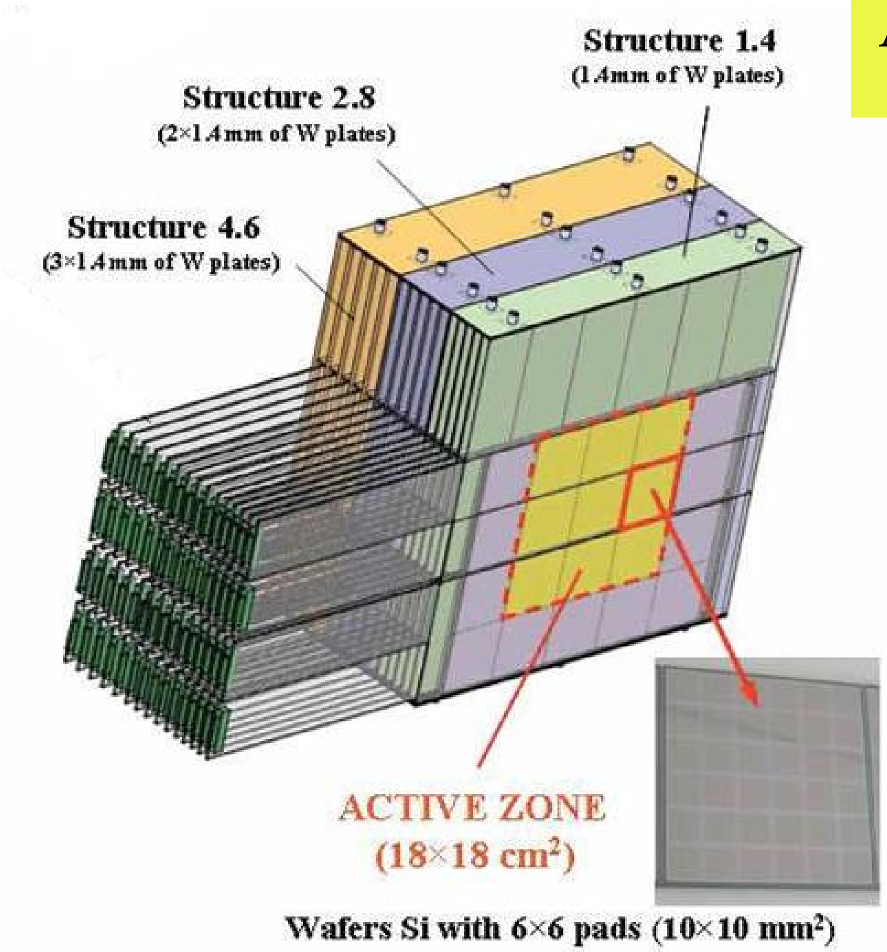
on behalf of the CALICE Collaboration

Summary

- Introduction
- Electron selection
- Uniformity of the response of the ECAL
- Performance (resolution, linearity)
- Longitudinal and transverse shower development
- Conclusion and outlook

ECAL Prototype

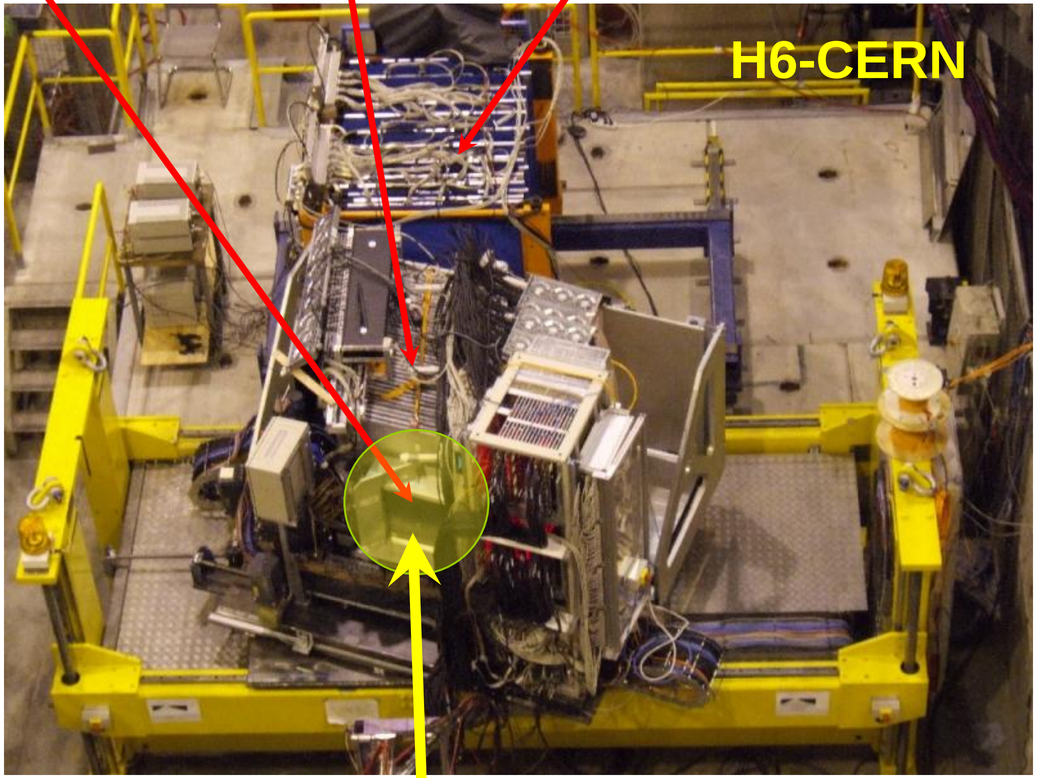


A high granularity calorimeter optimized for *Particle Flow* for ILC physics

- **Absorber :** tungsten
- **Active element :** silicon
- **High sampling :** 30 layers
- **High granularity :** 1x1 cm^2 cells
- **Compact :** ~ 20 cm depth for 24 X_0
- **Channels :** 6471 (2006)

Test Beam campaign of CALICE at CERN

Si-W ECAL HCAL Tail Catcher



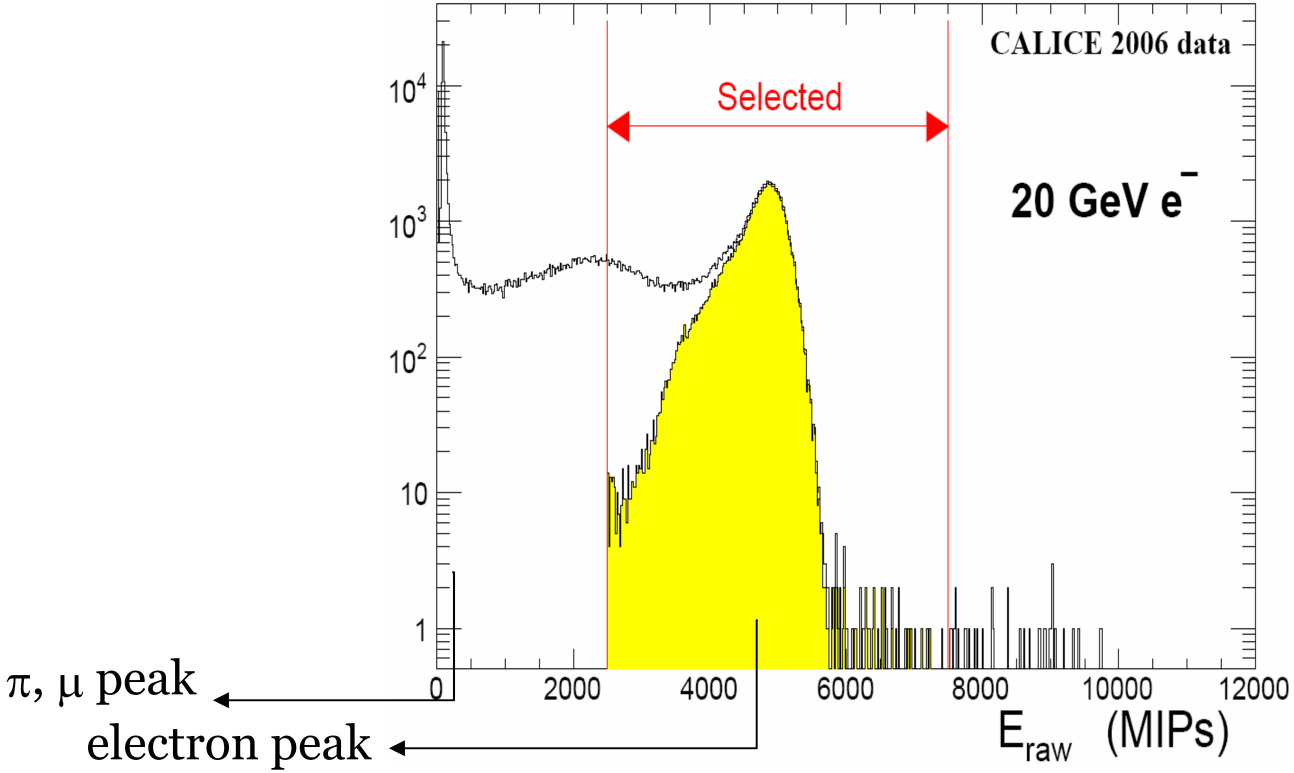
Beam (e^- or π)

AIM

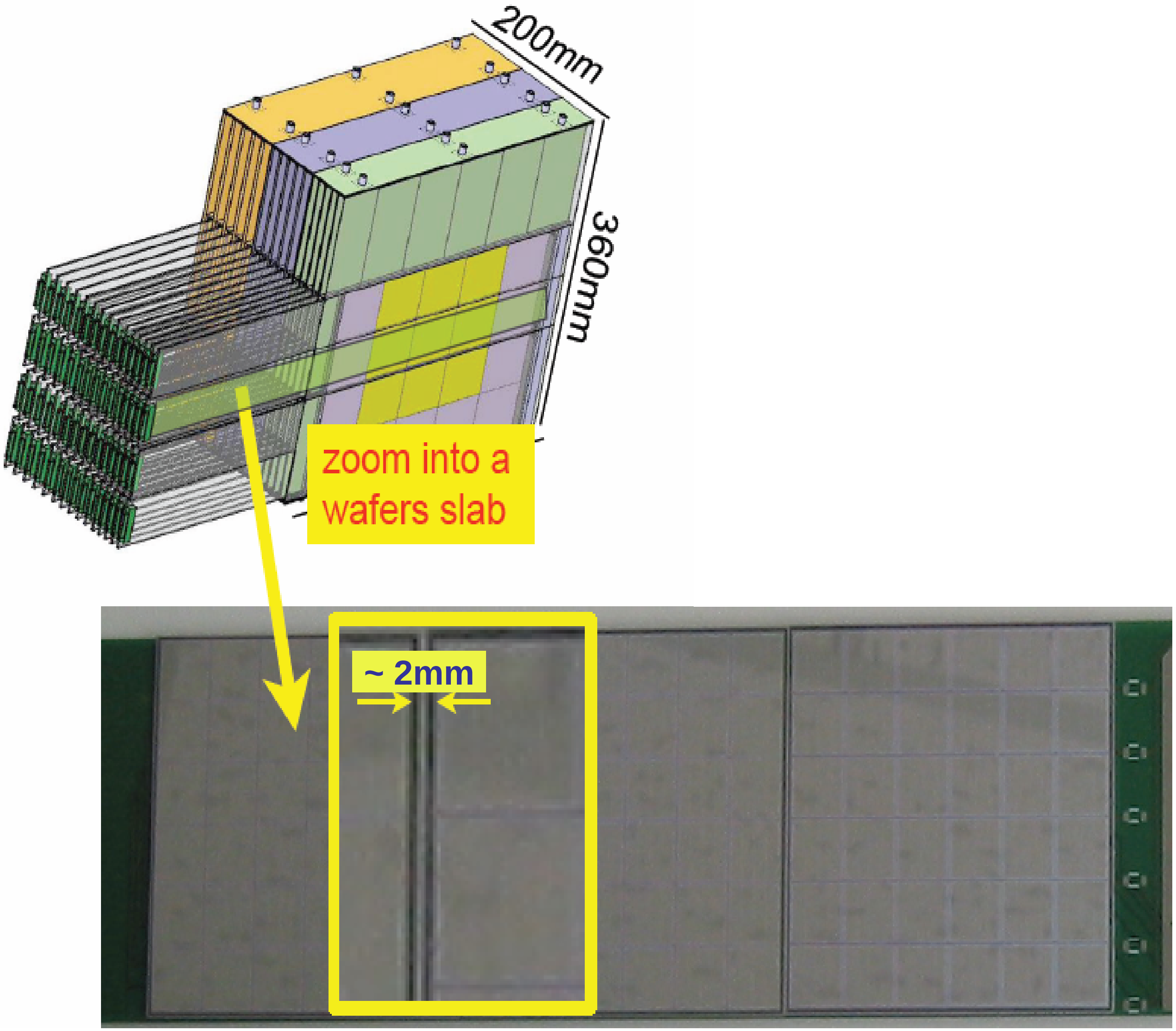
- **Validate the Si-W technology**
- **Characterisation of the prototype**
  - Response in energy (resolution, linearity)
  - Spatial resolution
  - Response uniformity

Event selection

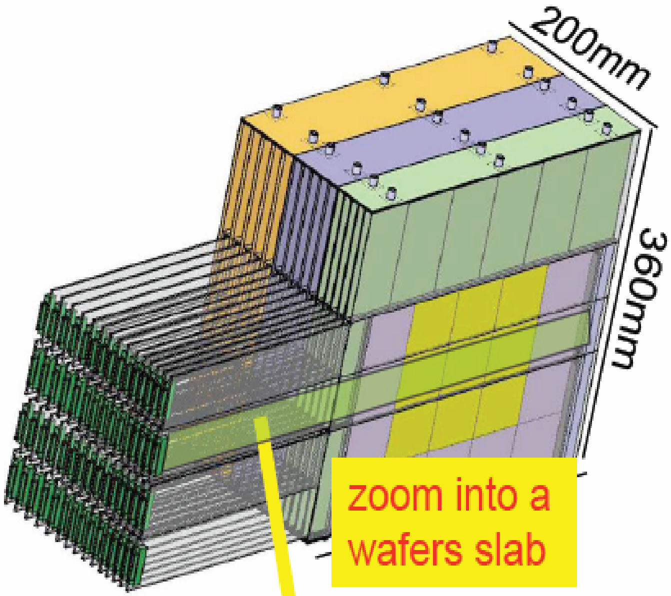
- $$E_{\mathrm{raw}} = \sum_{i=0}^{i=9} E_i + 2\sum_{i=10}^{i=19} E_i + 3\sum_{i=20}^{i=29} E_i$$
- **Energy window :** $125 < E_{RAW} / E_{beam} < 375$: μ and π rejection
- **Cut on Čerenkov counter :** π rejection
- **Beam halo rejection**

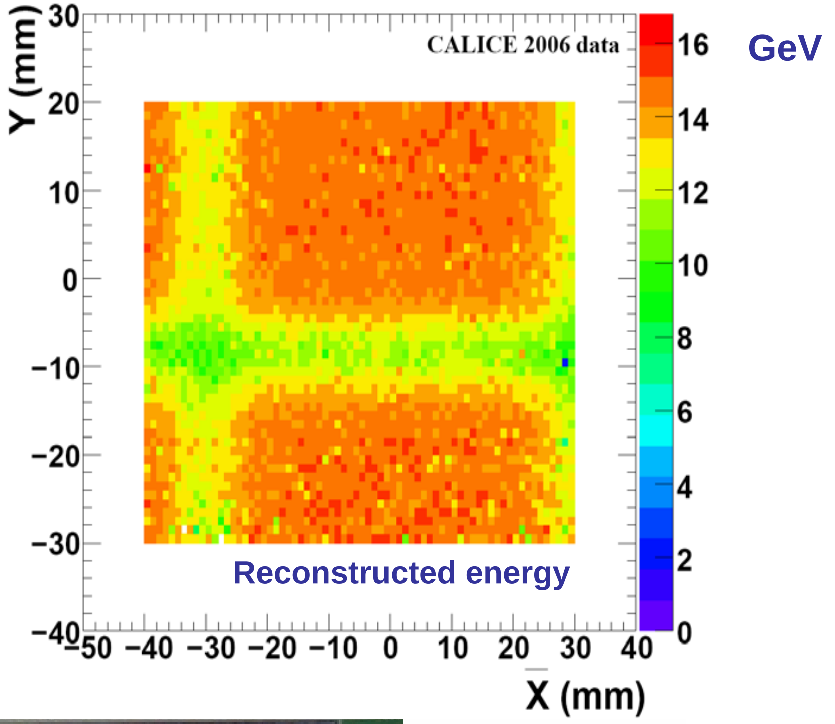


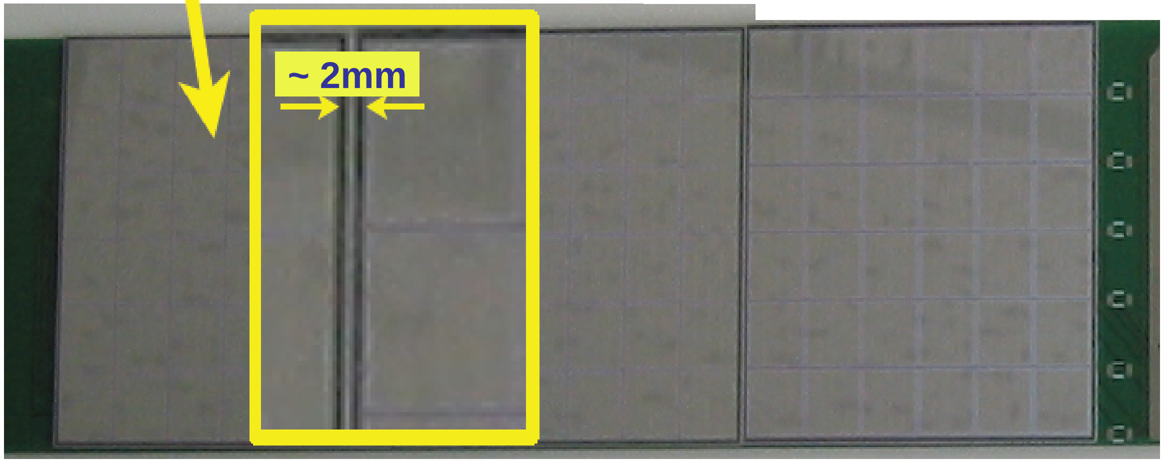
Control of the uniformity response



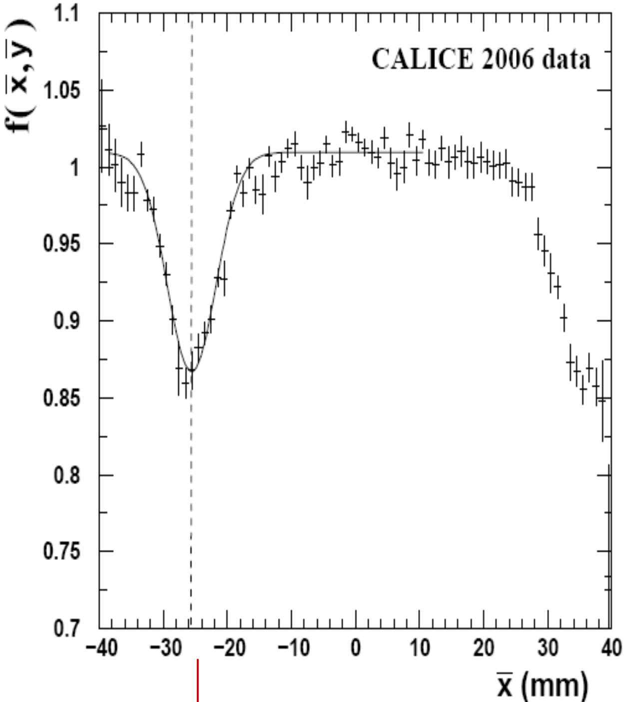
Control of the uniformity response

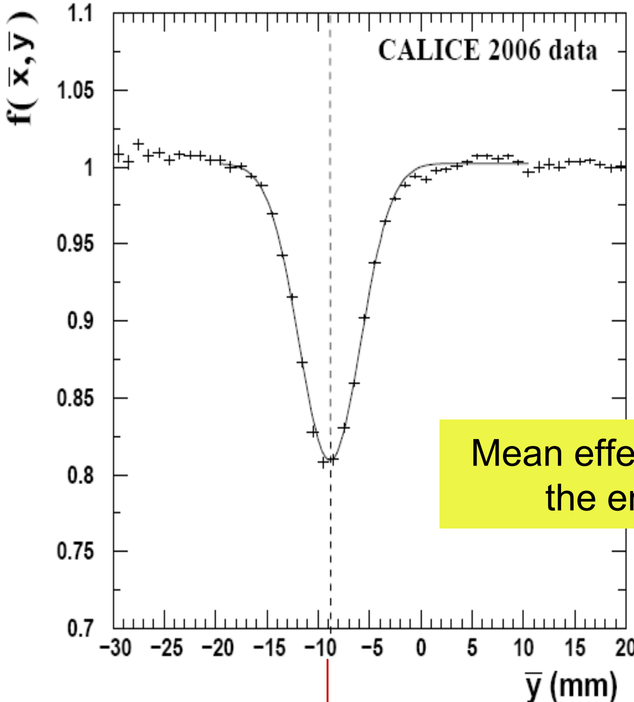






Measurement of the energy gaps





Interwafer gap

Interwafer gap

Mean effect observed on electrons in the energy range 10-30GeV

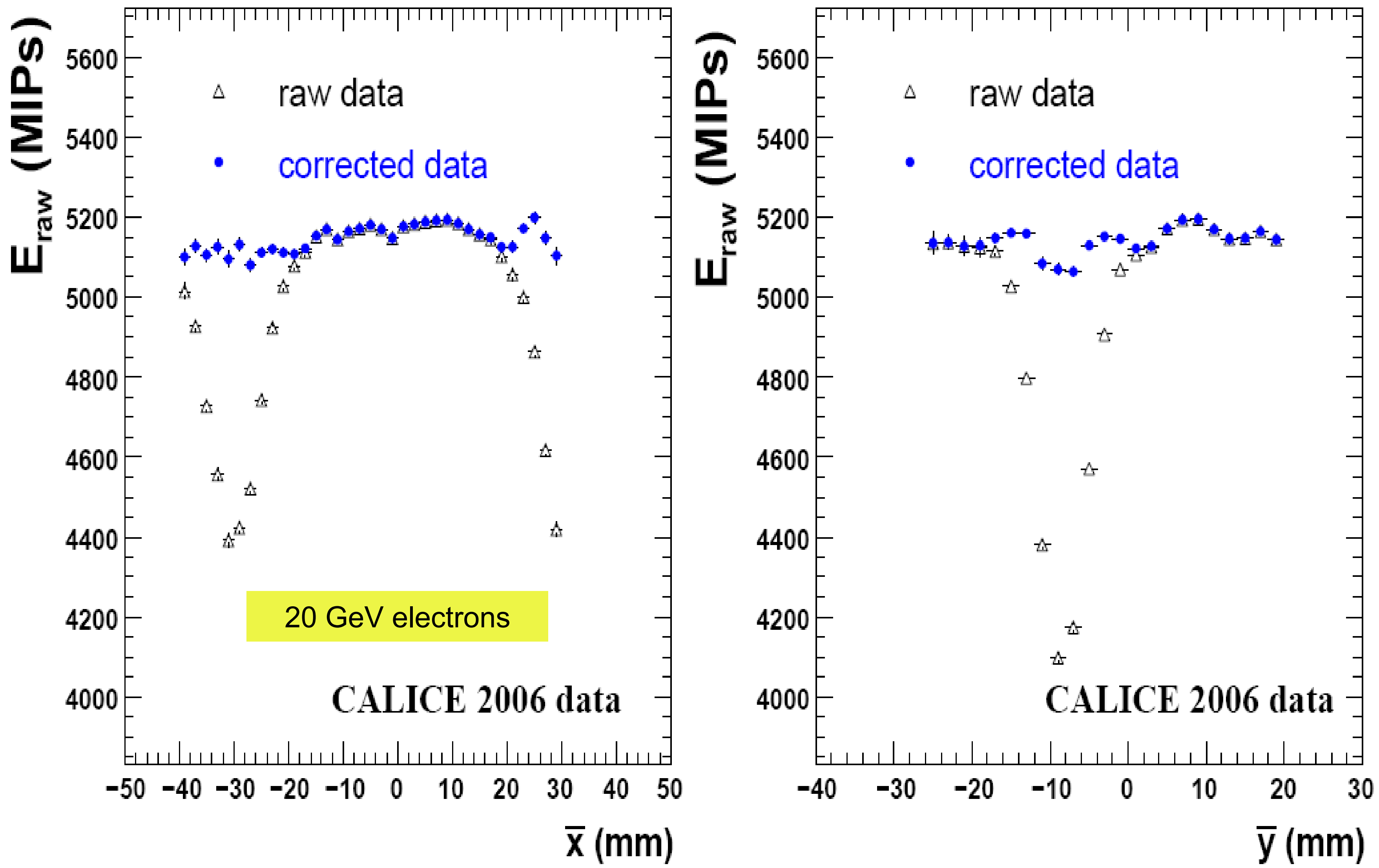
- **Simple and robust model**

$$f(\bar{x},\bar{y}) = \left(1 - a_x e^{-\frac{(\bar{x}-x_{gap})^2}{2\sigma_x^2}}\right)\left(1 - a_y e^{-\frac{(\bar{y}-y_{gap})^2}{2\sigma_y^2}}\right)$$

- **Function of the shower barycenter only**

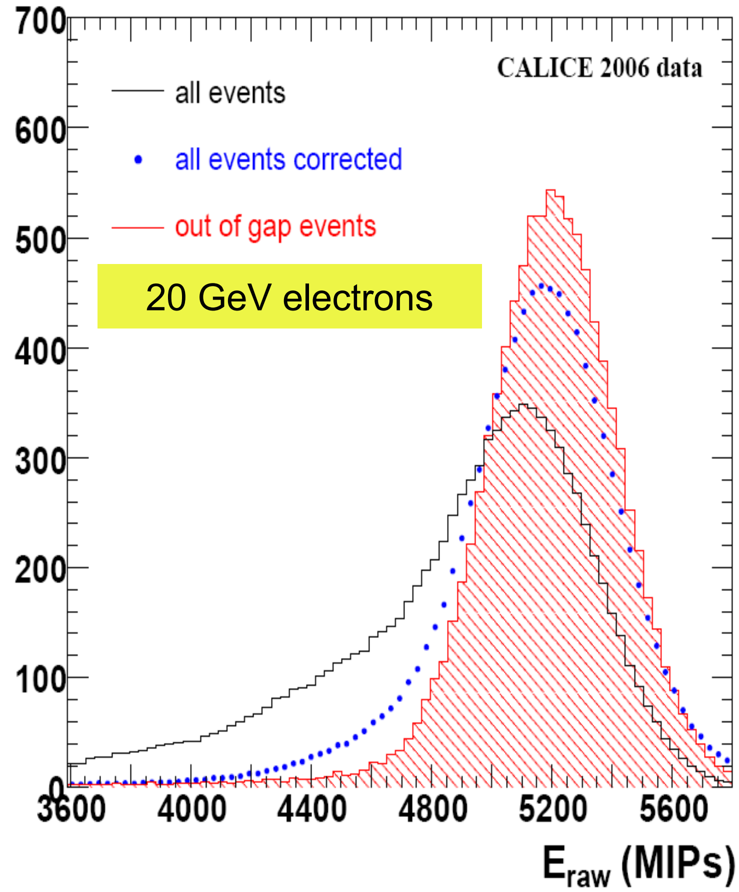
  → works both for photons and electrons

Correction of the energy gaps



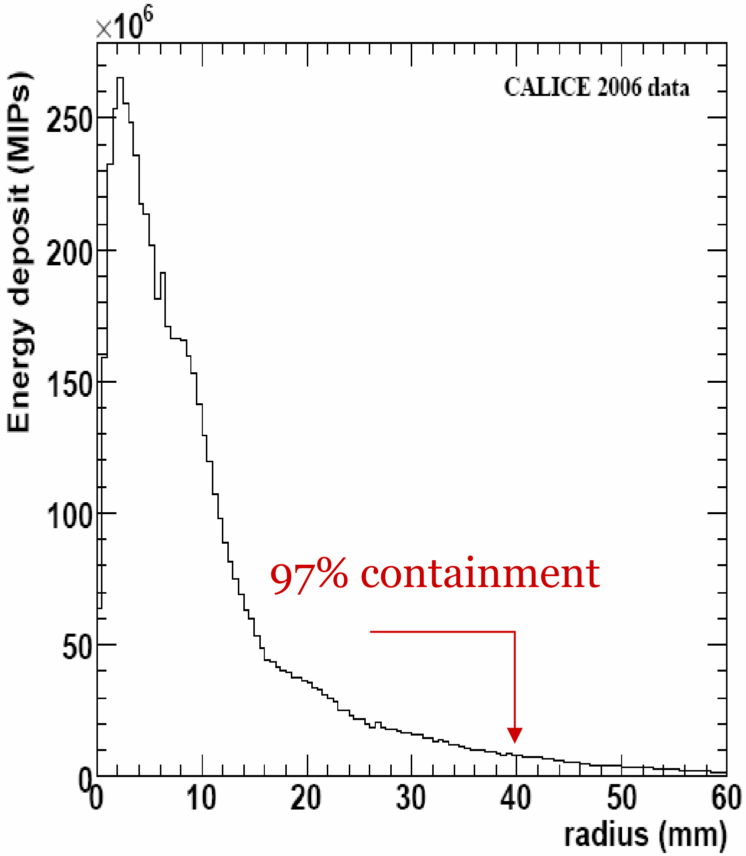
Correction of the energy gaps

Correction for the energy loss in the inter-wafer gap improves the shape of energy distribution



Energy reconstruction

- **Event/event cut on barycenter to inter-wafer gap distance**
  - Distance >4σ
- **Event/event cut on barycenter to ECAL border distance**
  - Cut corresponding to 97% containment
  - No leakage
- **The beam energy :**
  Uncertainty on the beam energy is modelled by



$$\frac{\Delta E}{E} = \frac{0.12}{E} \oplus 0.1\%$$ → determined by the observed momentum spread

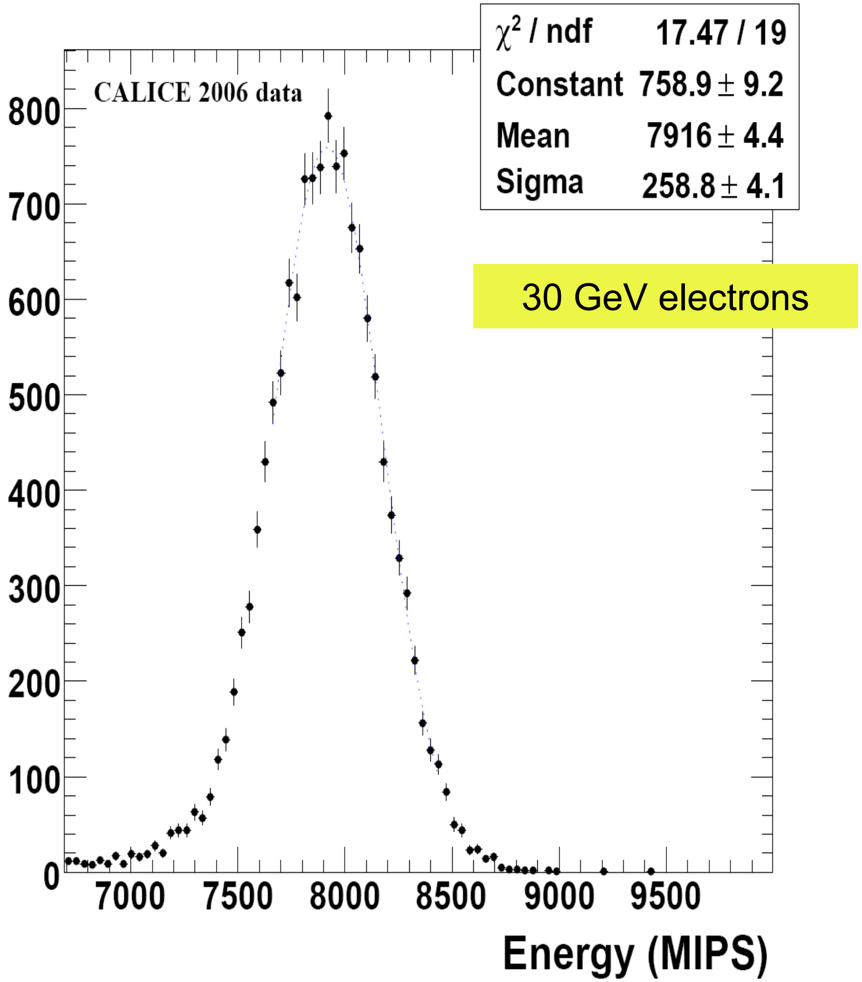
Used data – CERN 2006

Data sample used to characterise the prototype

Energy (GeV)	particle	date	statistics (kevts)
6	e^-, e^+	Oct	10.6
10	e^-, e^+	Aug, Oct	55.9
12	e^-, e^+	Oct	32.1
15	e^-, e^+	Aug, Oct	60.4
20	e^-, e^+	Aug, Oct	76.9
30	e^-, e^+	Aug, Oct	43
40	e^-	Aug	27
45	e^-	Aug	129.3

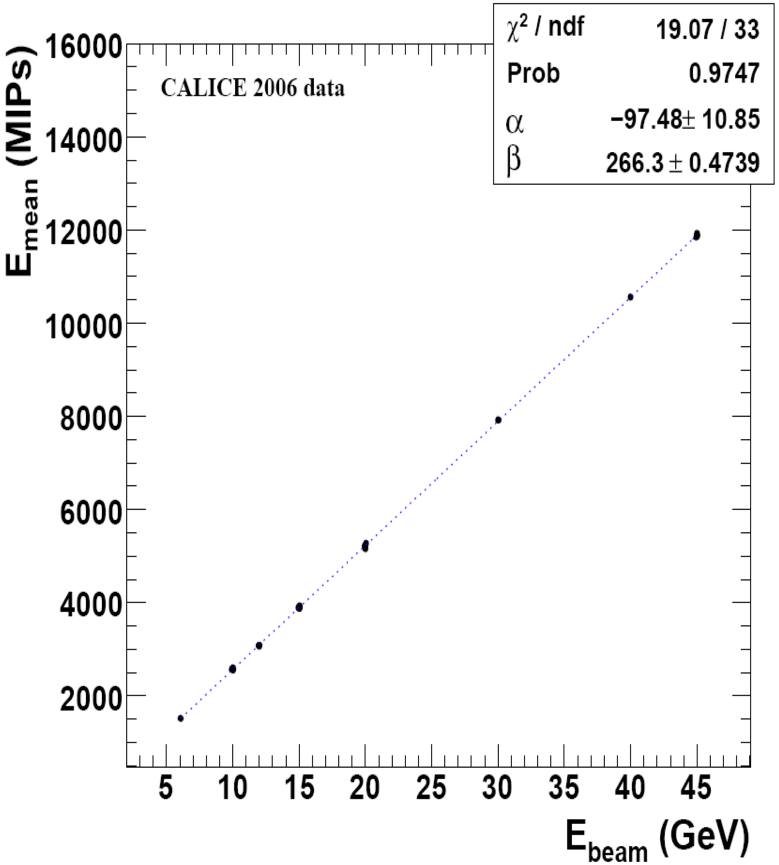
Sample size after the full selection

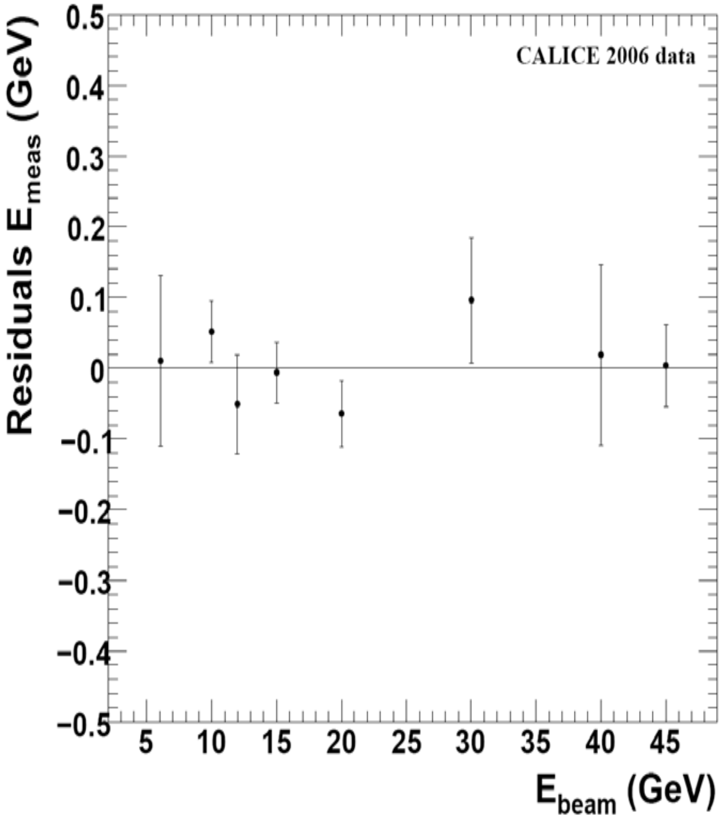
Reconstructed energy



Mean and width extracted using a Gaussian fit [-1σ, +2σ]

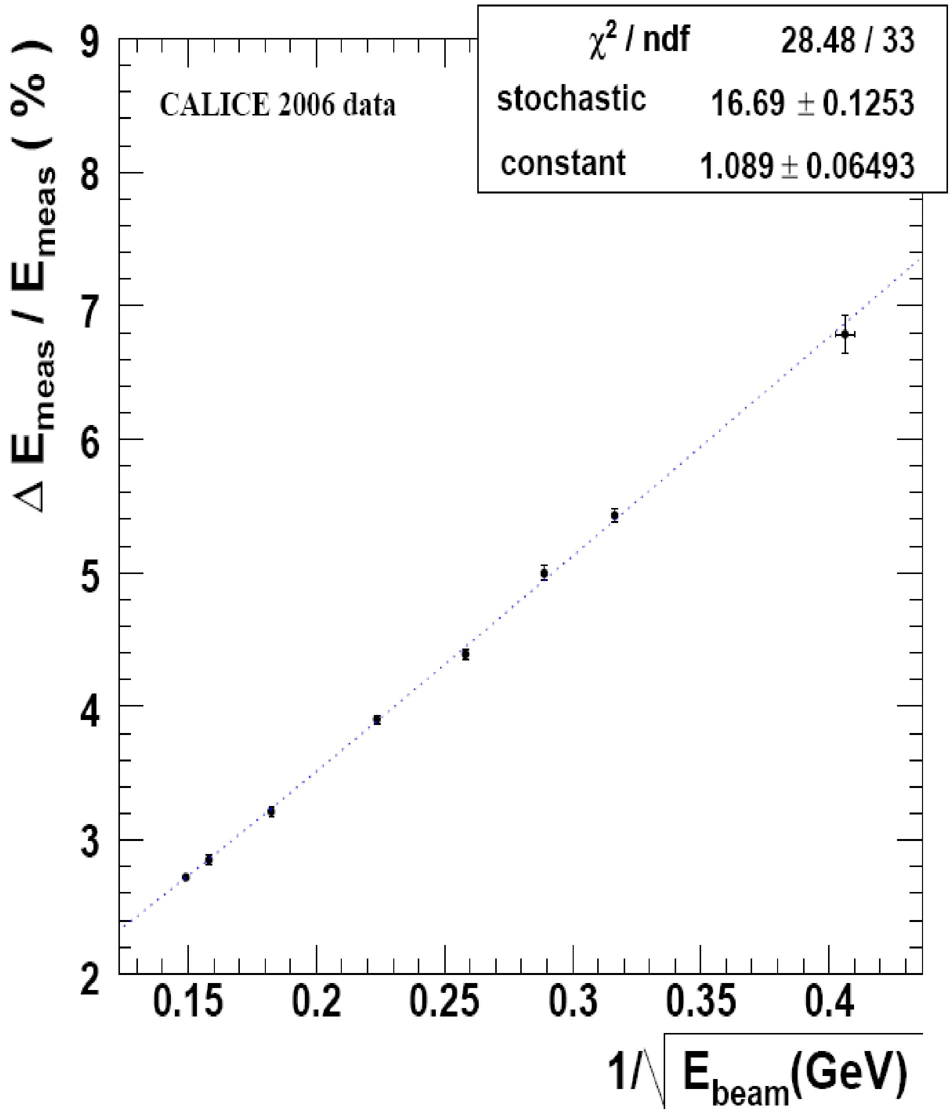
Linearity of the response





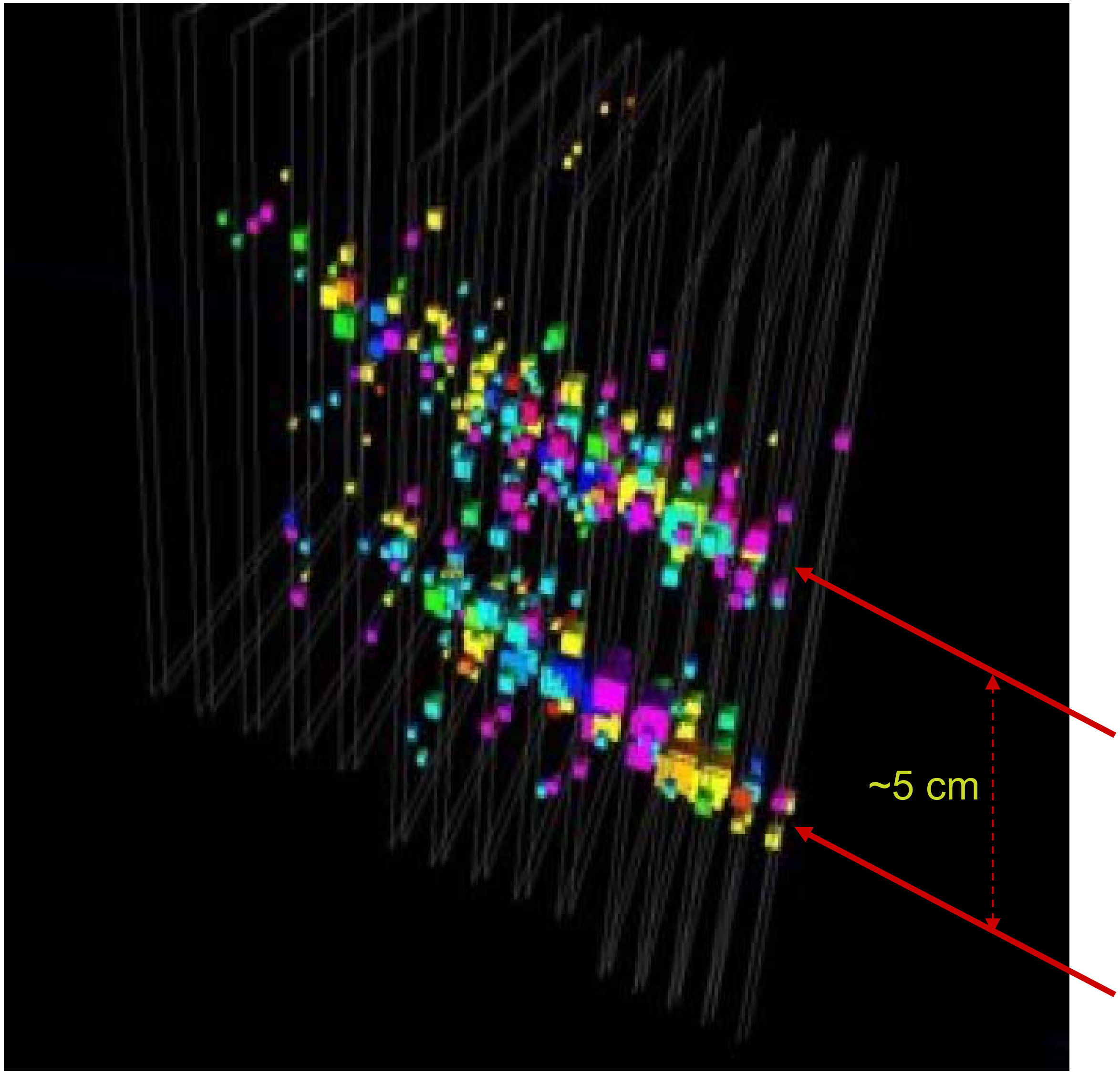
- **The prototype is linear at 1% level**
- $E_{meas} = (E_{raw} - \alpha) / \beta$
  - α = -97 MIP
  - β = 266 MIP/GeV

Energy resolution

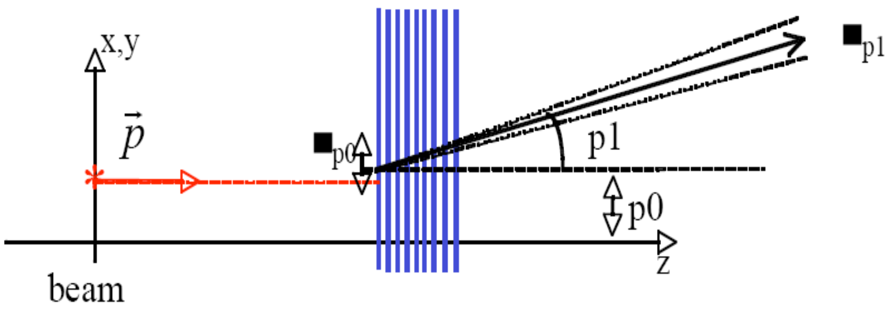


Beam spread subtracted from ΔE/E

Illustration of the spatial resolution



Spatial resolution



- Linear fit: $$\chi^2 = \sum_{i,j} (x_{meas} - x_{th})_i W_{ij} (x_{meas} - x_{th})_j$$

$$x_{th} = p_{0x} + p_{1x} \times z$$

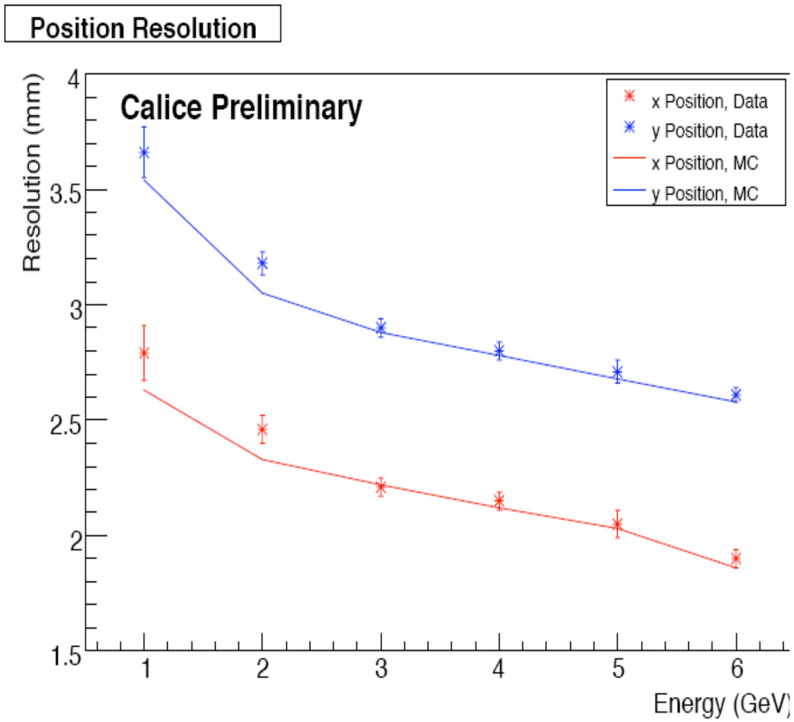
$$x_{meas} = \frac{\sum_i E_i x_i}{\sum_i E_i}$$

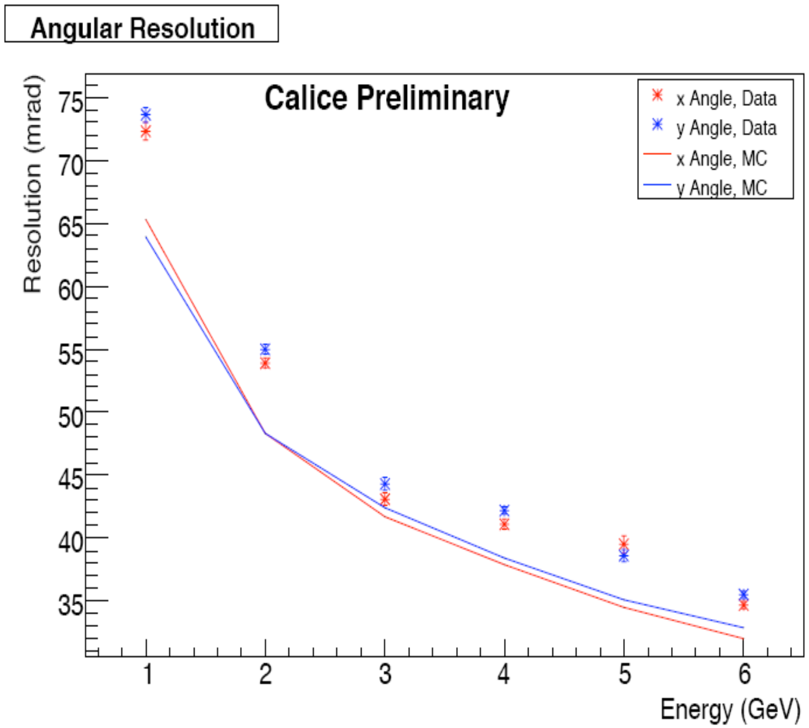
i = hits in layer L.

- Error matrices extracted from the simulation (per energy)
  - x and y uncorrelated
  - two error matrices W_{ij}
  - two independent fits

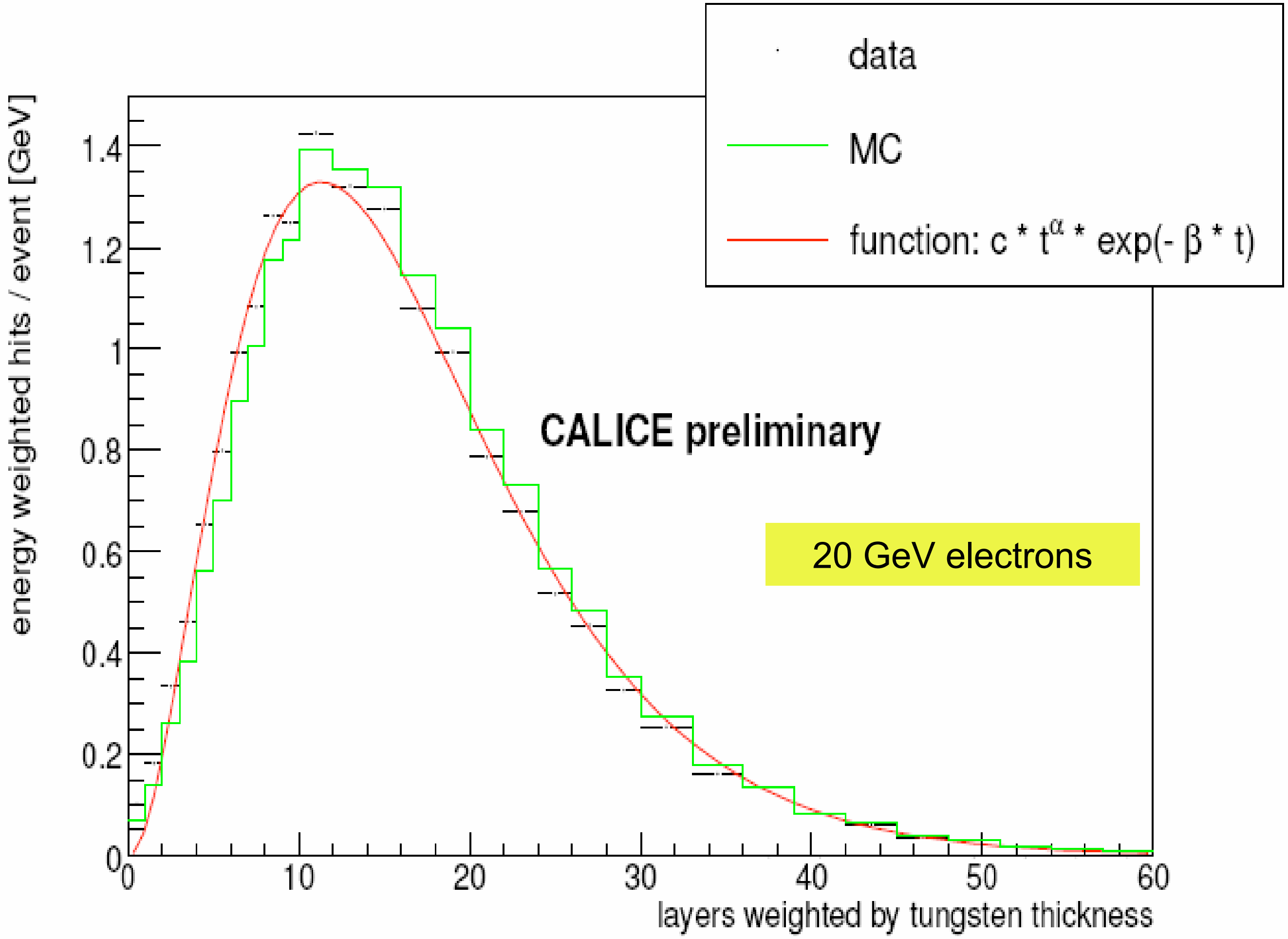
- Minimize χ^2 with respect of p_{0x}, p_{1x}

Spatial resolution

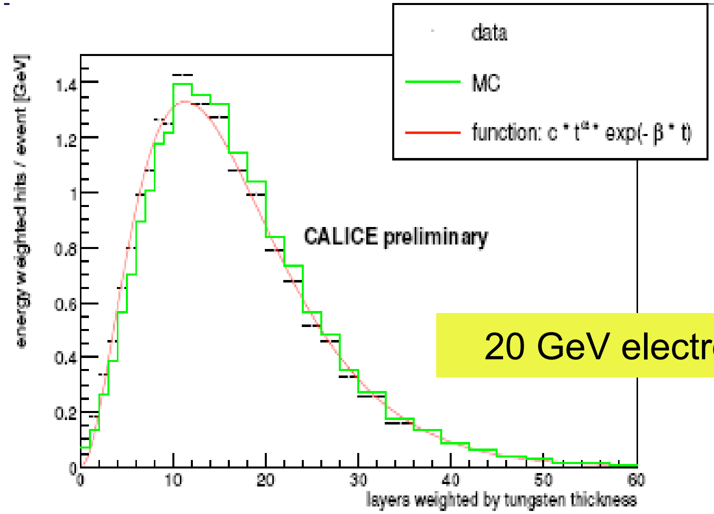




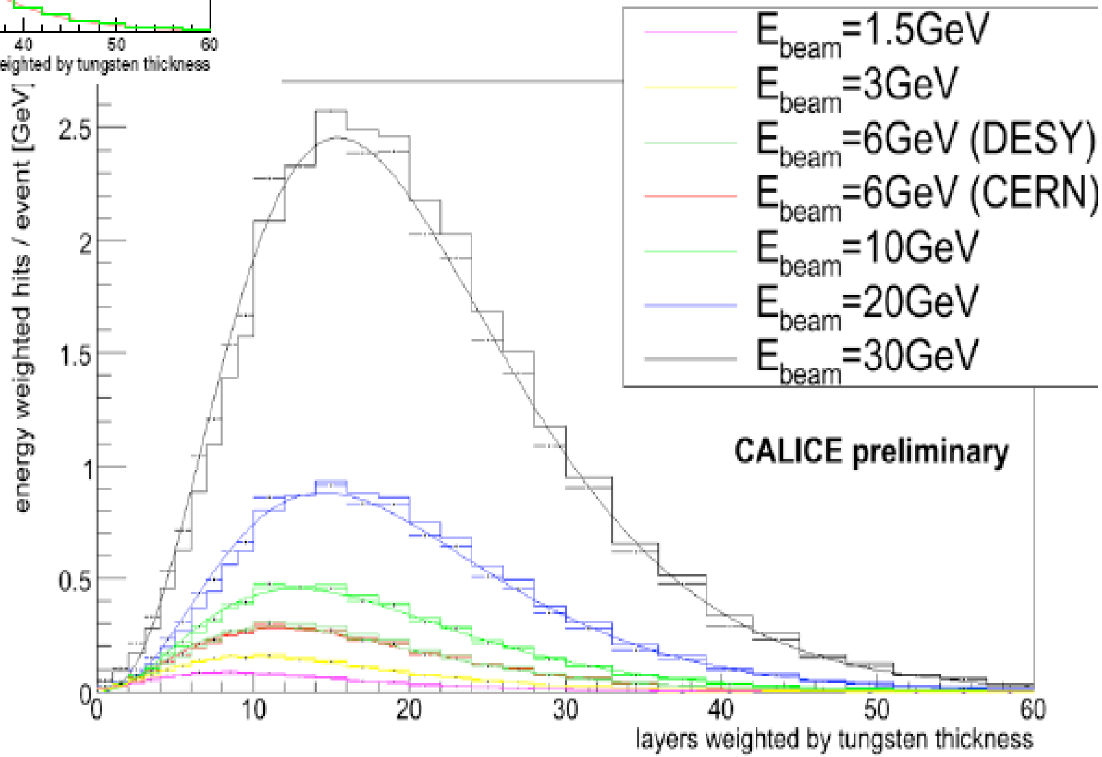
Longitudinal shower development



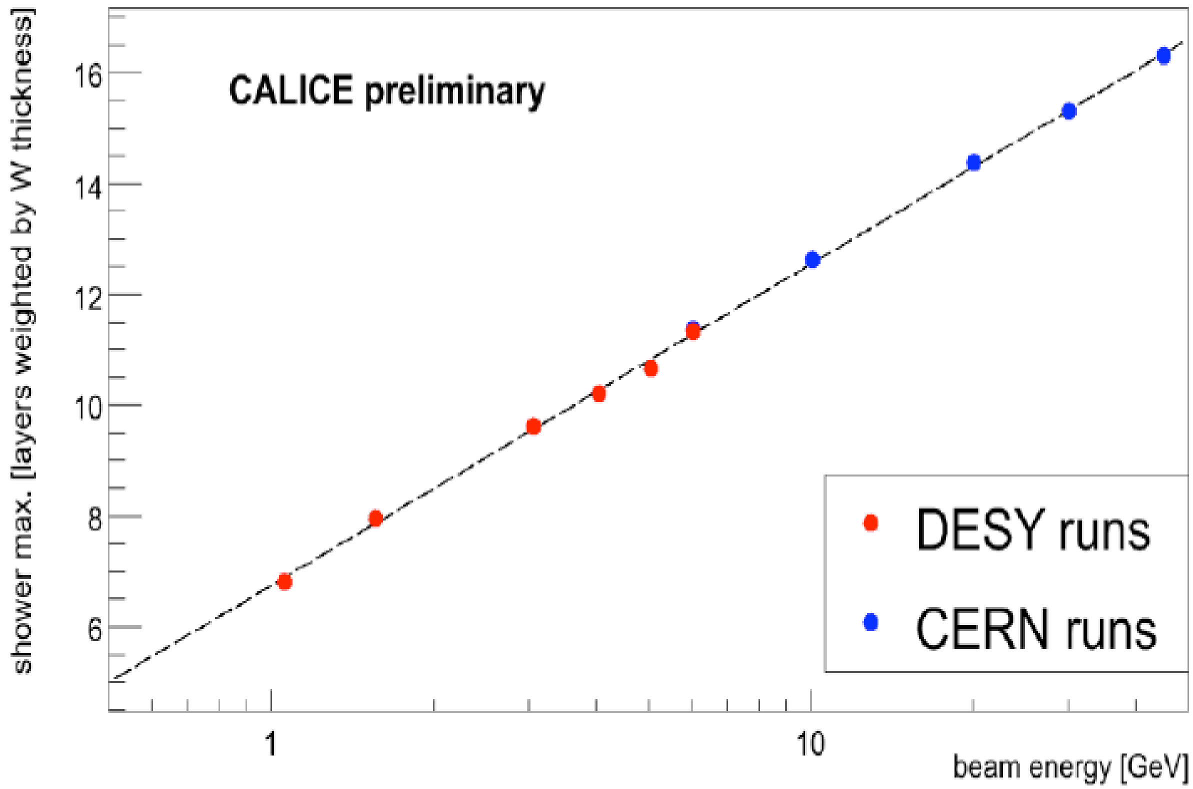
Longitudinal shower development



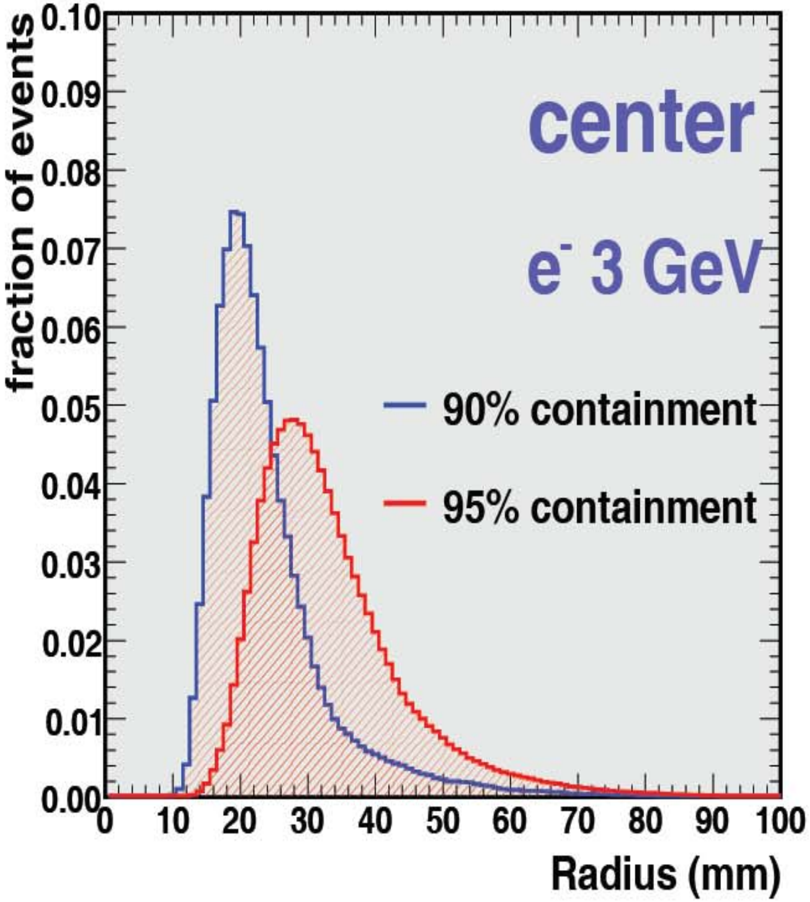
20 GeV electrons

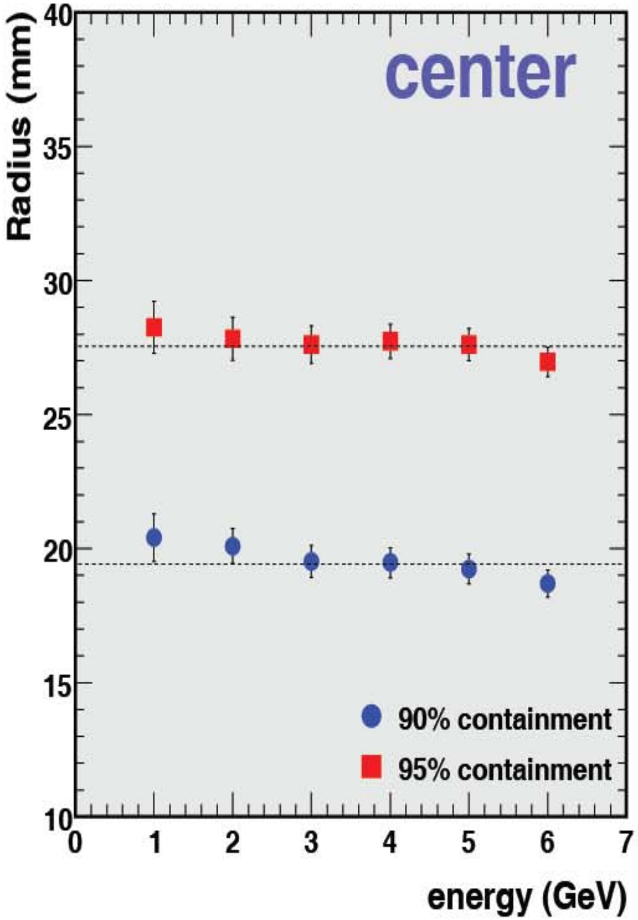


Longitudinal shower development



Radial development of the shower





Conclusion and outlook

- The Si-W ECAL prototype operated successfully in 2006 at CERN and DESY
- The characterisation of the ECAL was performed with 6471 operating cells (99.86 % operating cells)
- The study of the 2007 data with an up scaled version of the ECAL (up to 9400 channels) is ongoing
- More data are being taken at Fermilab (2008)