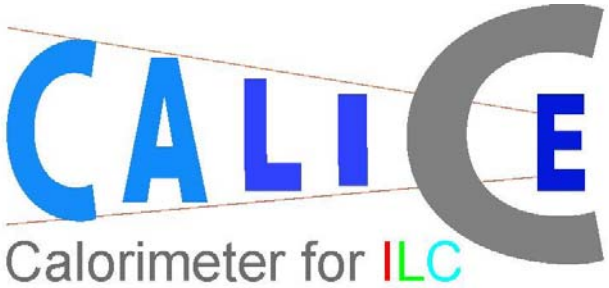


SiW Electromagnetic Calorimeter

Testbeam results

Michele Faucci Giannelli

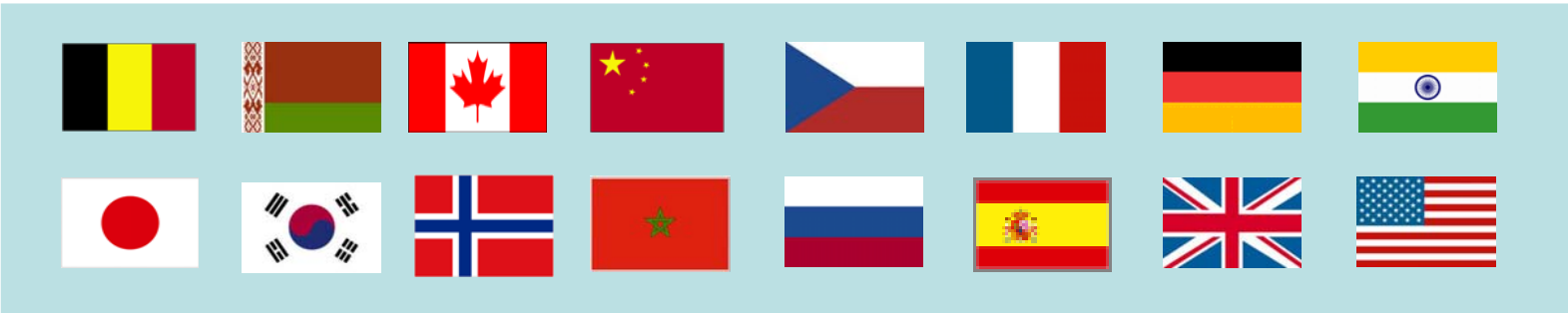
TILC09, Tsukuba, 18 April 2009

Overview

- The CALICE collaboration
- The Si-W prototype
- Testbeam results
  - Published results from 2006
  - Irradiation test
- Conclusion

The collaboration

Calorimeter R&D for ILC



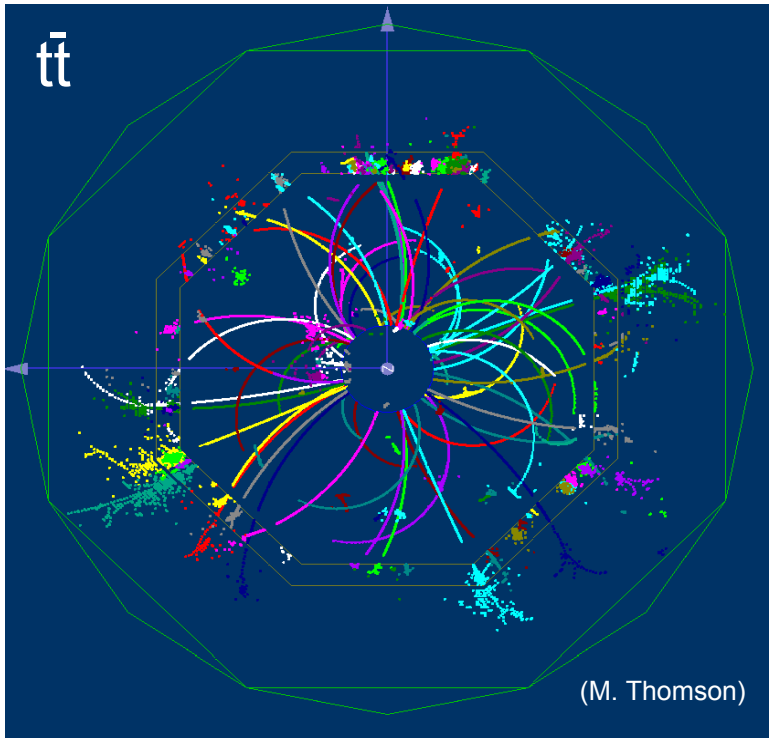
~297 physicists/engineers
53 Institutes
16 Countries
4 Continents

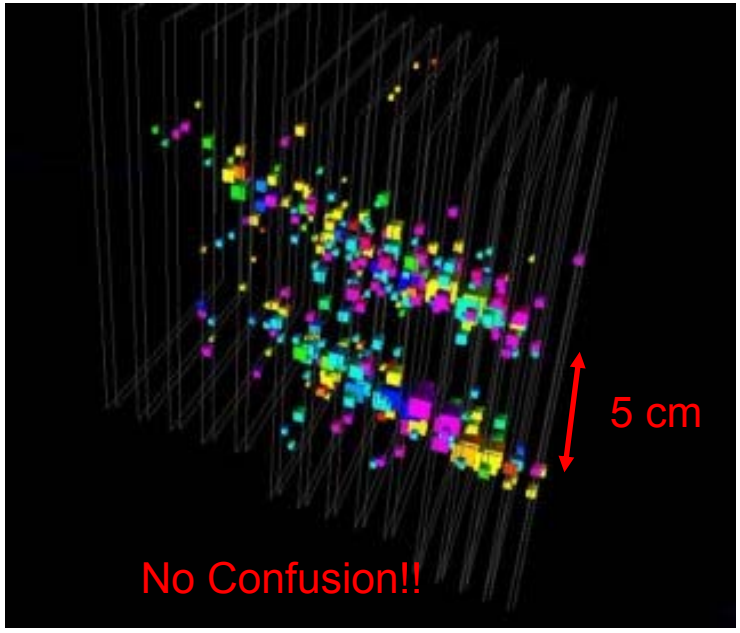
The goal

ILC goal:

The physics at the International Linear Collider will require good jet energy resolution which can be obtained with Particle Flow.

In order to reconstruct every particle a high segmentation is needed.



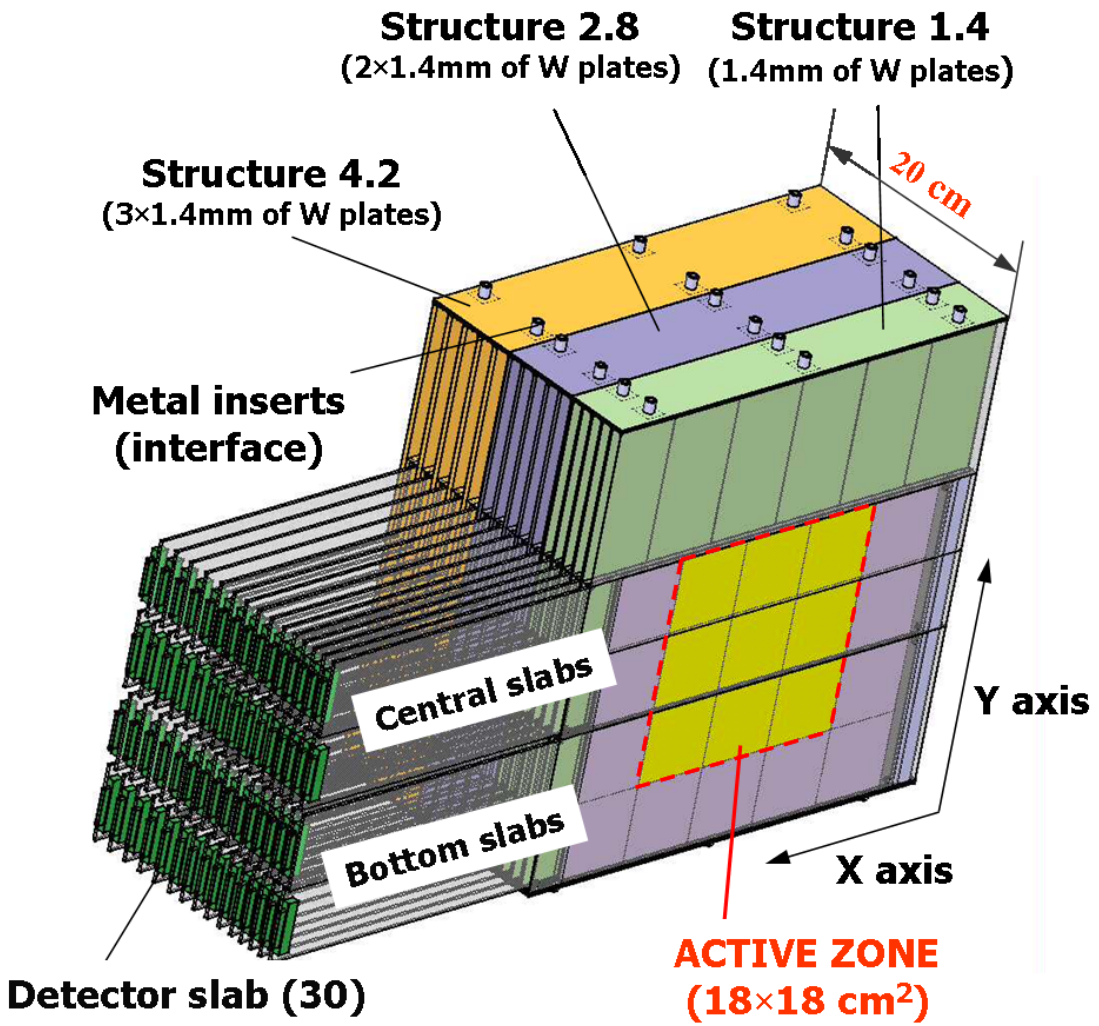


CALICE goal:

Several prototype calorimeters have been built to establish the technologies.

Data from testbeams will be used to tune clustering algorithms and validate existing MC models

Si-W ECAL



Absorber material: Tungsten

Active material: Silicon wafers

1x1 cm^2 cells

6x6 cells in a wafer

3x3 wafers in a layer

30 layers of Tungsten:
- 10 x 1.4 mm (0.4 X_0)
- 10 x 2.8 mm (0.8 X_0)
- 10 x 4.2 mm (1.2 X_0)
- ‣ 24 X_0 total

9720 channels

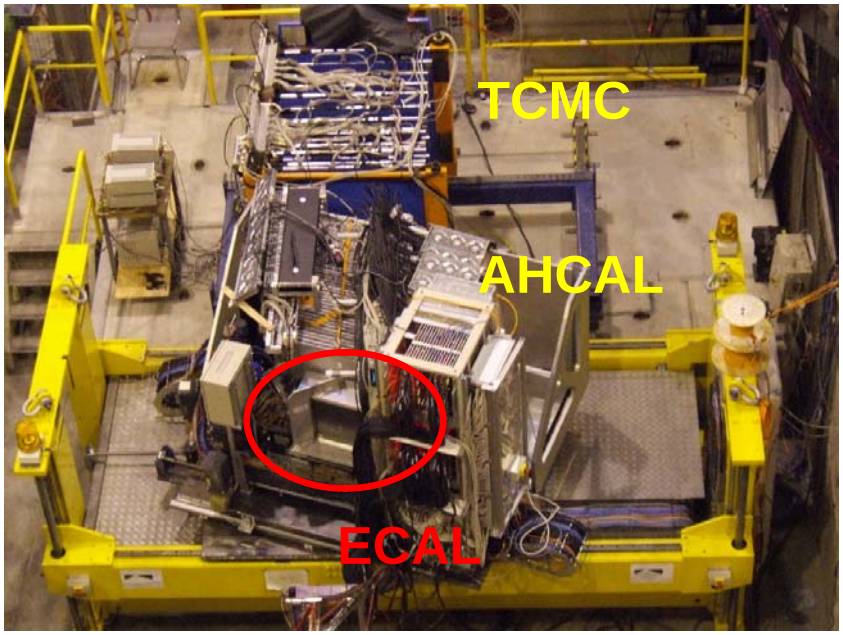
Testbeam program

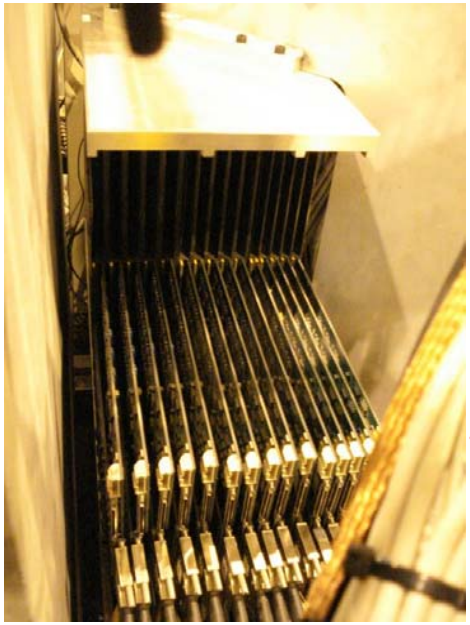
ECAL Testbeam:

2006 at DESY and CERN (2/3 equipped)

2007 at CERN (almost fully equipped)

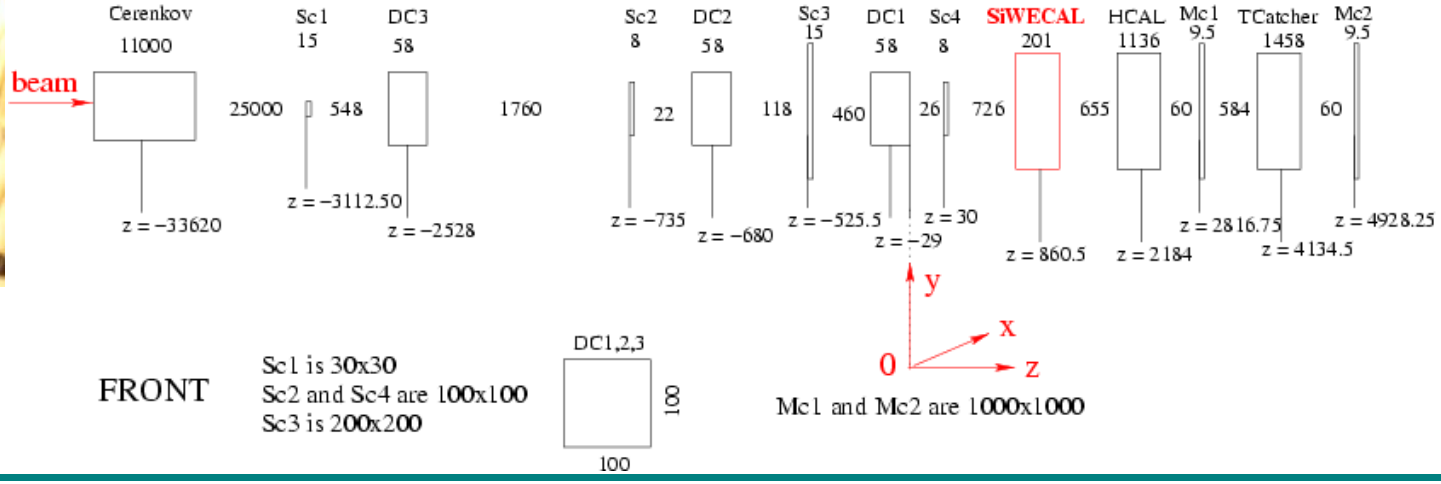
2008 at FNAL (fully equipped)



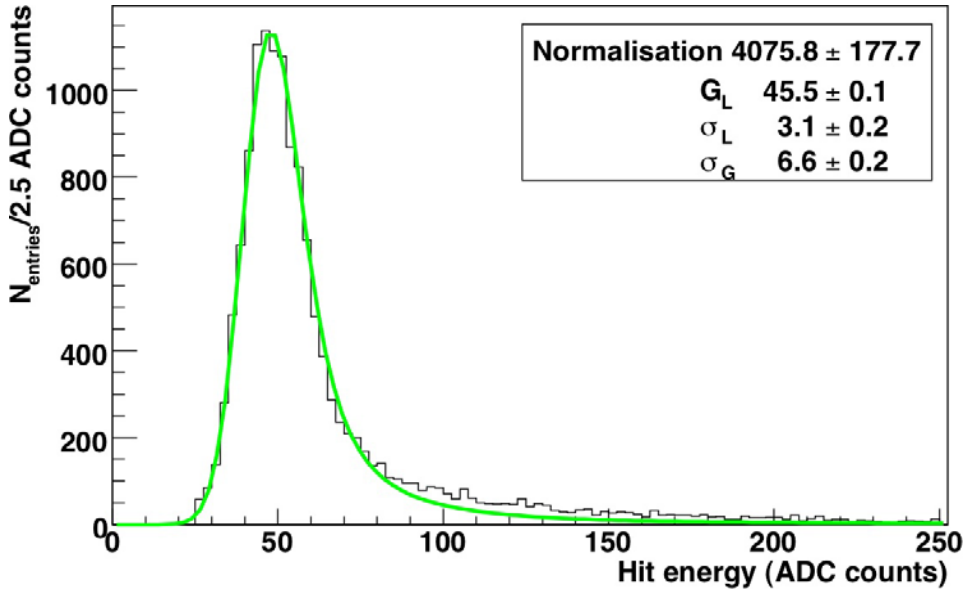


Slabs slit into alveolas

CERN H6 area



Calibration



Calibration with muon beam

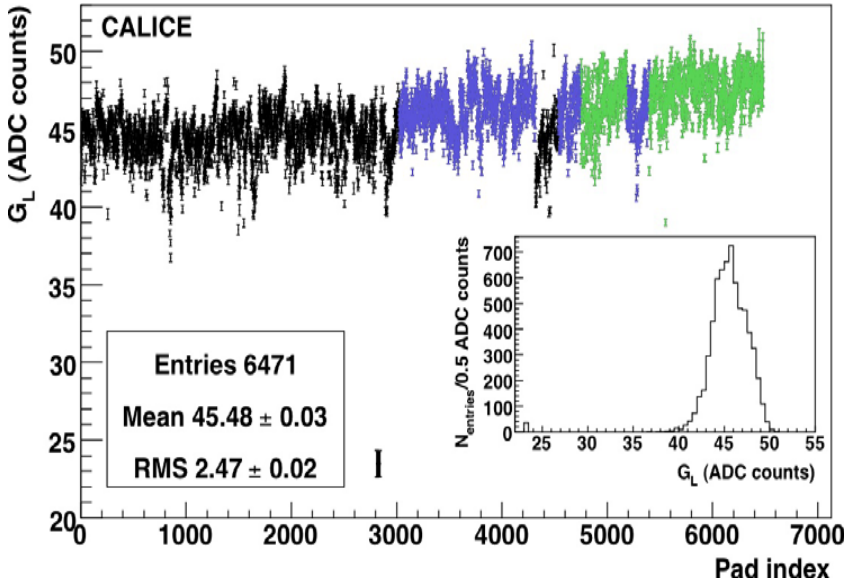
18 Mi. events

Only 0.14% of dead cells

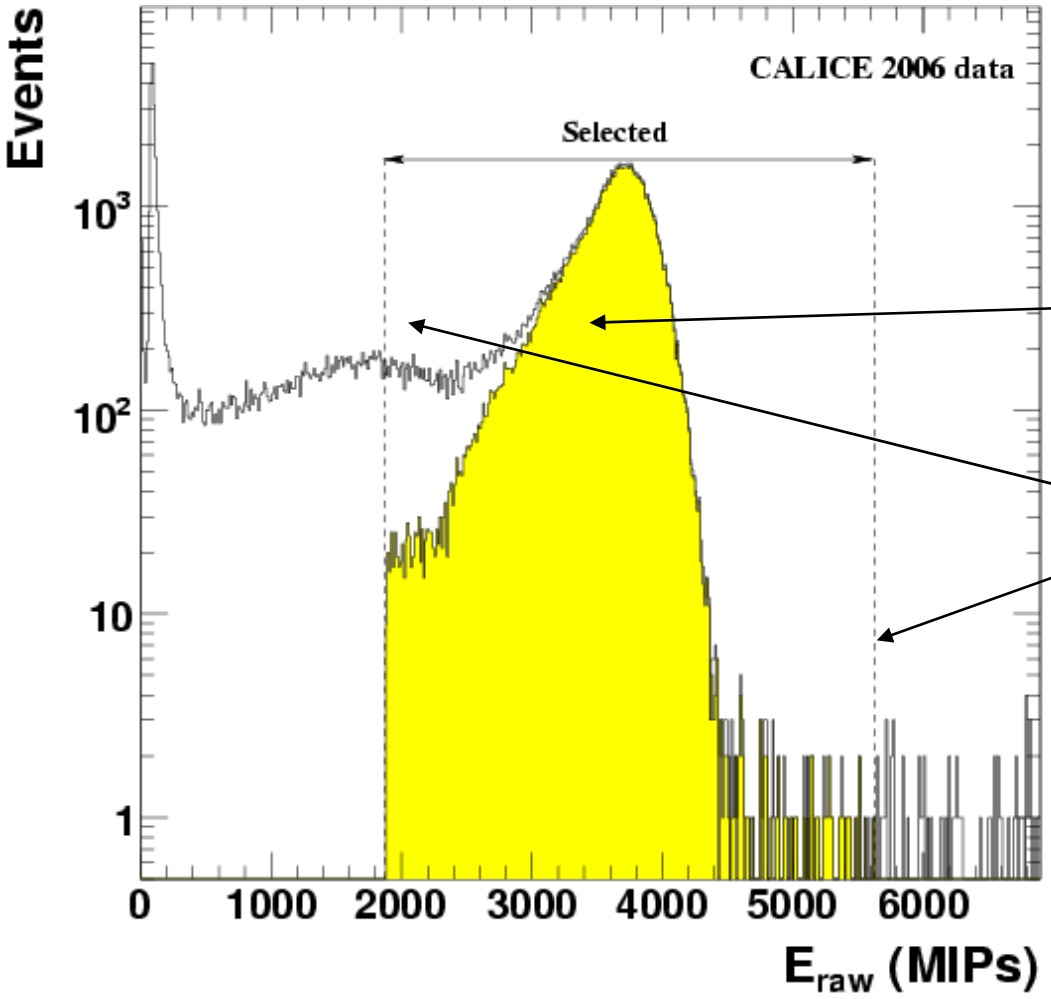
Uniform response

The differences can be associated with:
- Different manufacturers
- Different production

For final detector:
Experience to deal with different manufacturers to produce the needed ~3000 m^2



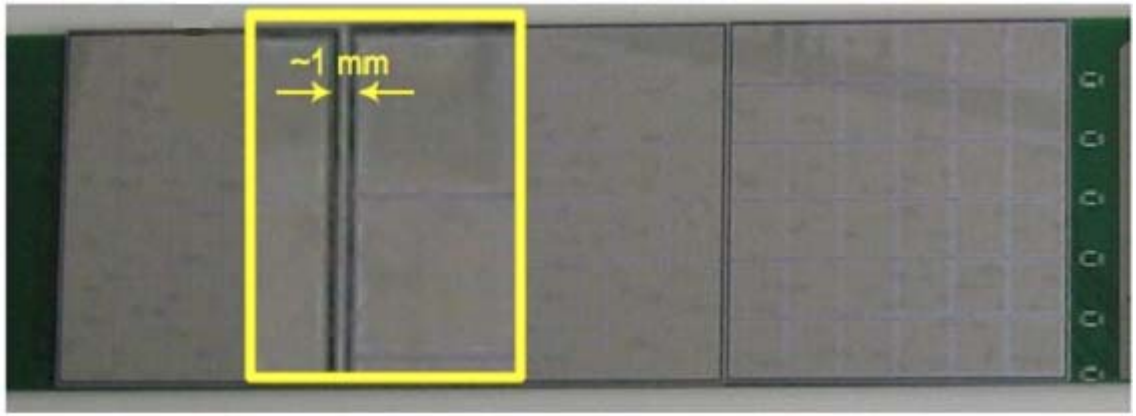
Electron selection



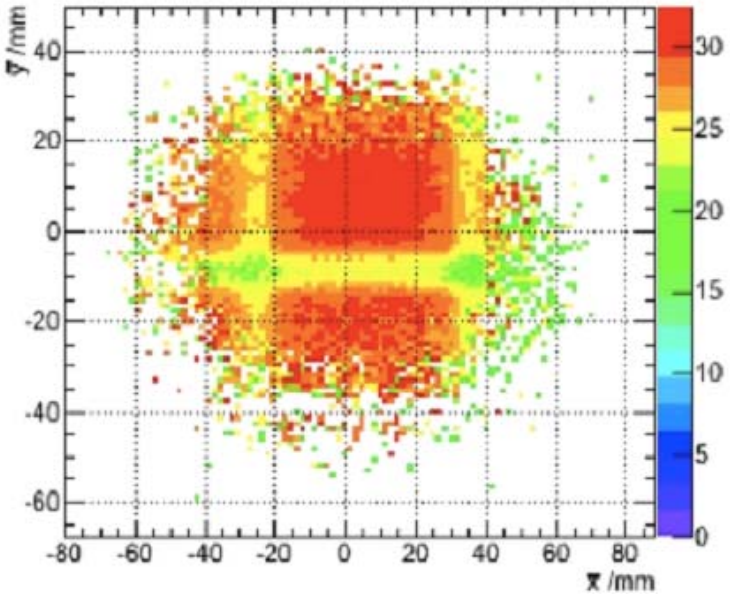
Cerenkov used to reject pions

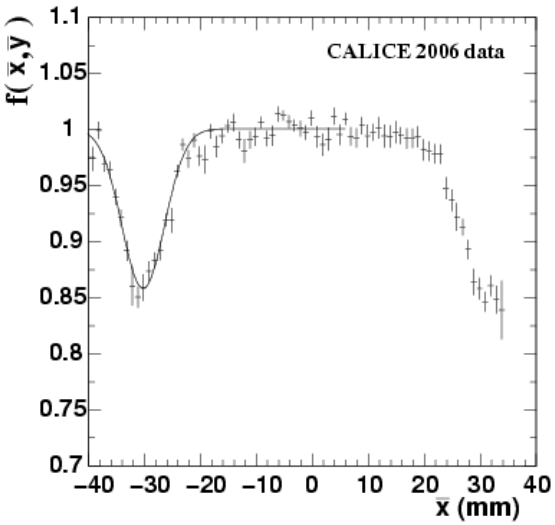
Energy cut to remove:
- pions
- double particle events

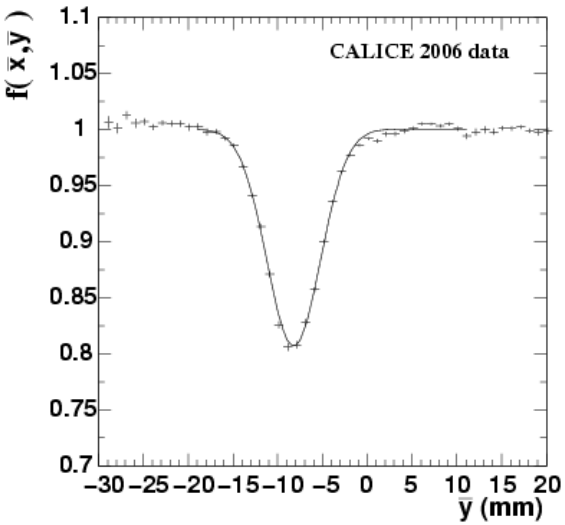
Detailed ECAL structure 1



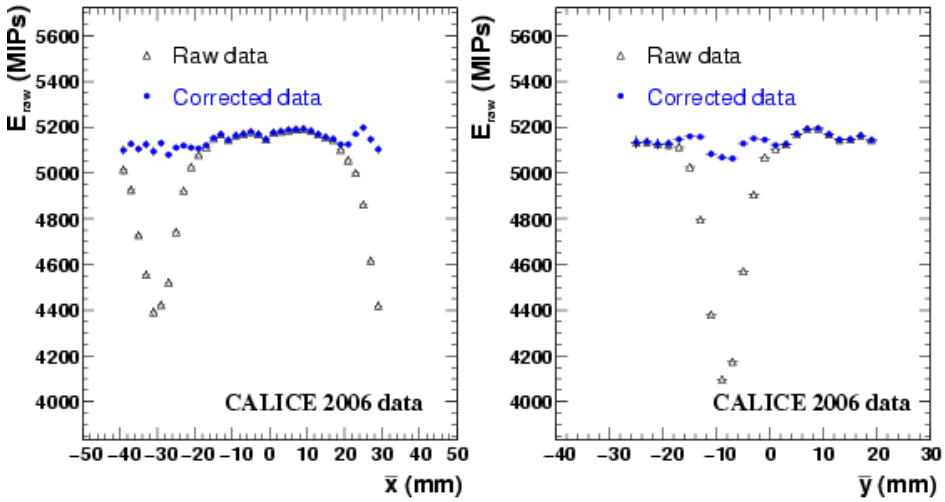
Wafers are separated by ~1 mm on both directions







Wafer correction

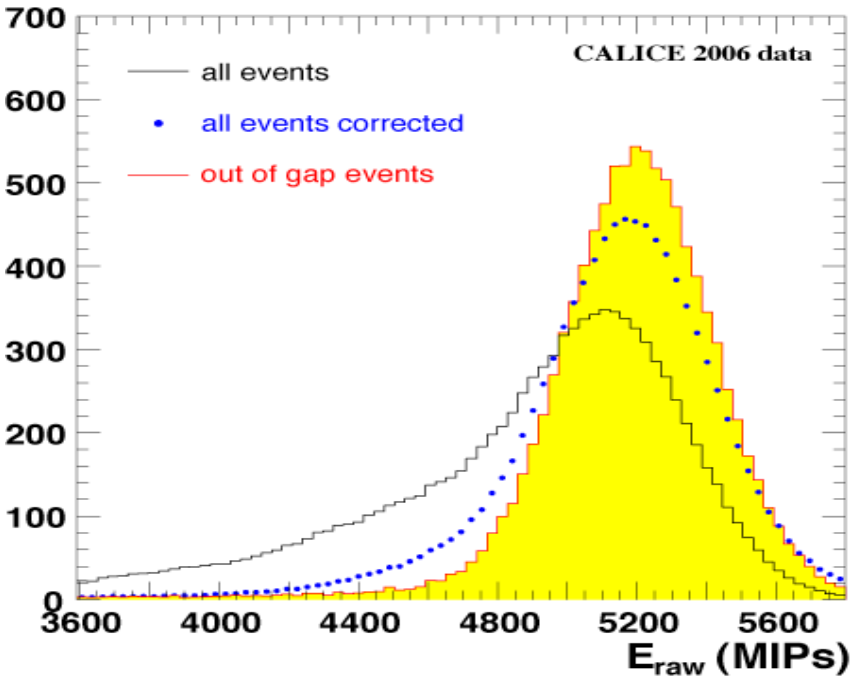


Gap region corrected using:

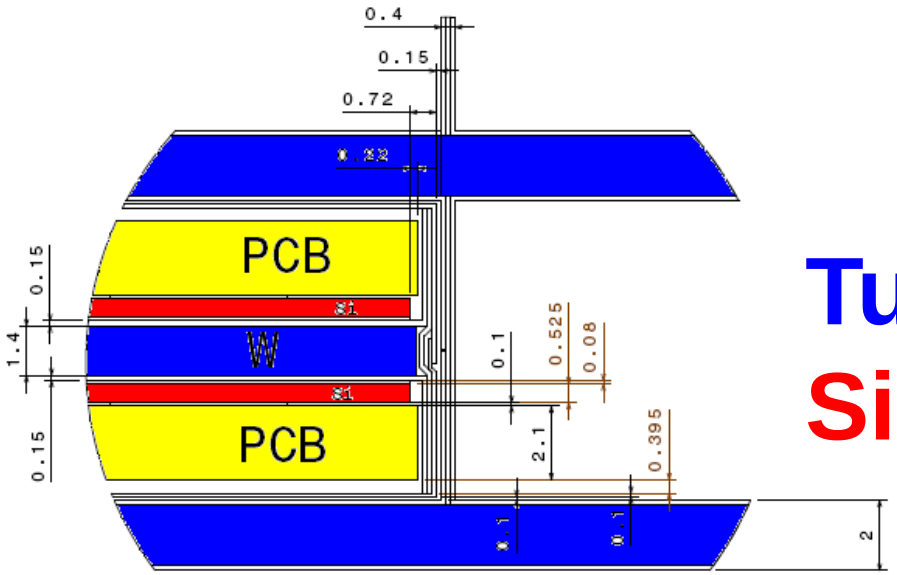
$$f(\bar{x},\bar{y}) = \left(1 - a_x \exp\left(-\frac{(\bar{x} - x_{gap})^2}{2\sigma_x^2}\right)\right)\left(1 - a_y \exp\left(-\frac{(\bar{y} - y_{gap})^2}{2\sigma_y^2}\right)\right)$$

Energy loss not fully recovered

This result will drive the next generation of detector that will have smaller gaps



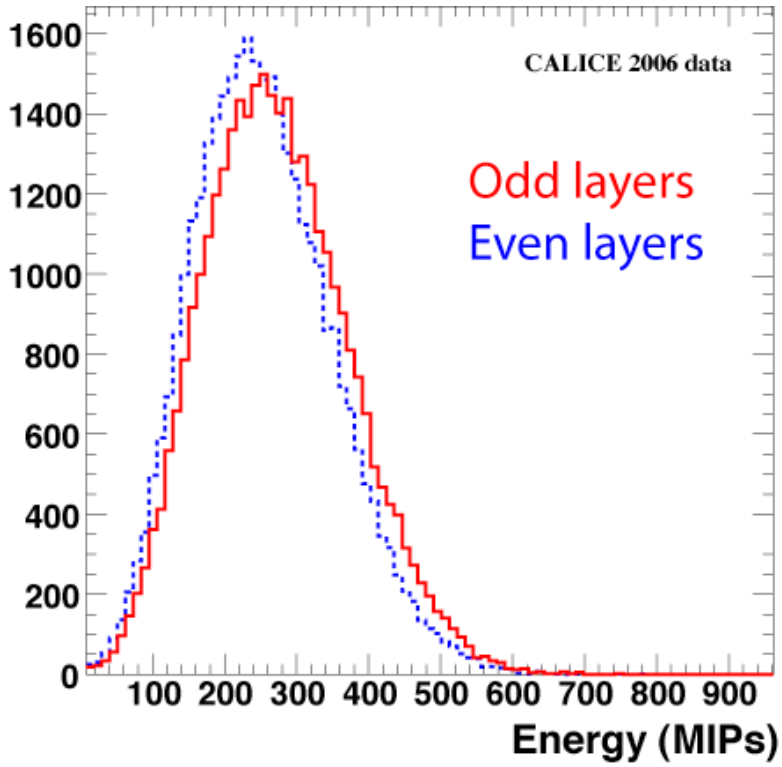
Detailed ECAL structure 2



Tungsten
Silicon

Odd and even layers have different material due to the PCBs

Material correction



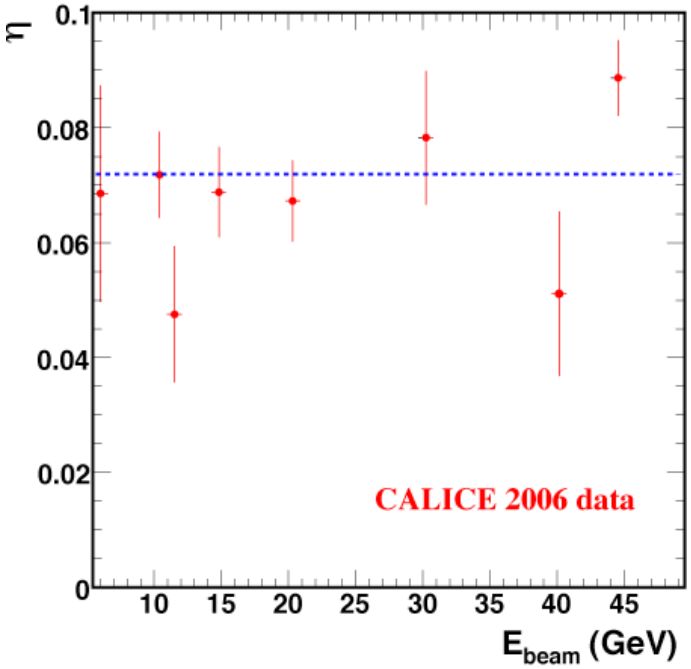
Sampling Fraction increases with calorimeter depth

$$E_{\mathrm{rec}} = \sum_i w_i E_i \quad \text{with} \quad \begin{array}{l} w_i = 1 \text{ for } i = 0,9 \\ w_i = 2 \text{ for } i = 10,19 \\ w_i = 3 \text{ for } i = 20,29 \end{array}$$

Different weights for odd and even layers:

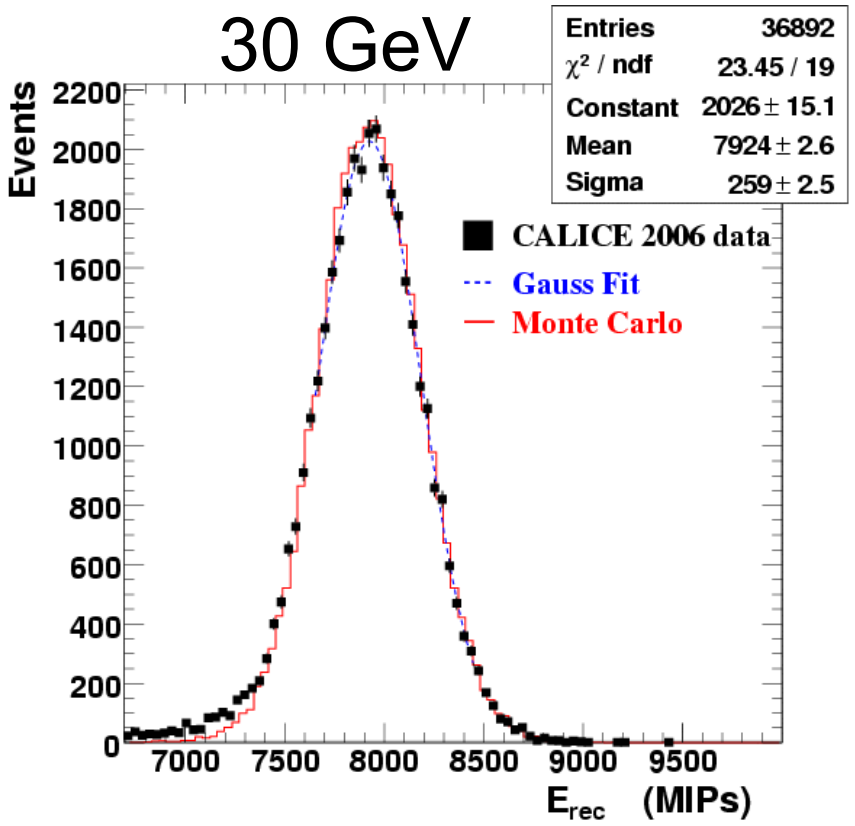
Odd layers: w = k + η

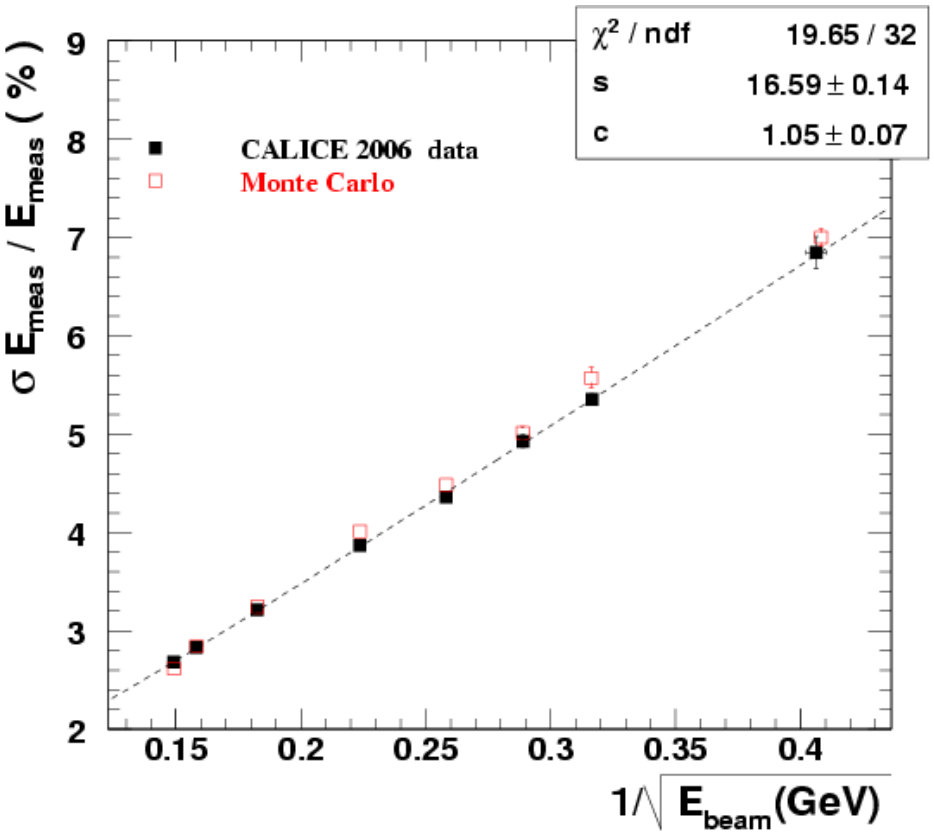
Even layers: w = k



η=(7.2 ± 0.2 ± 1.2)%

Energy resolution



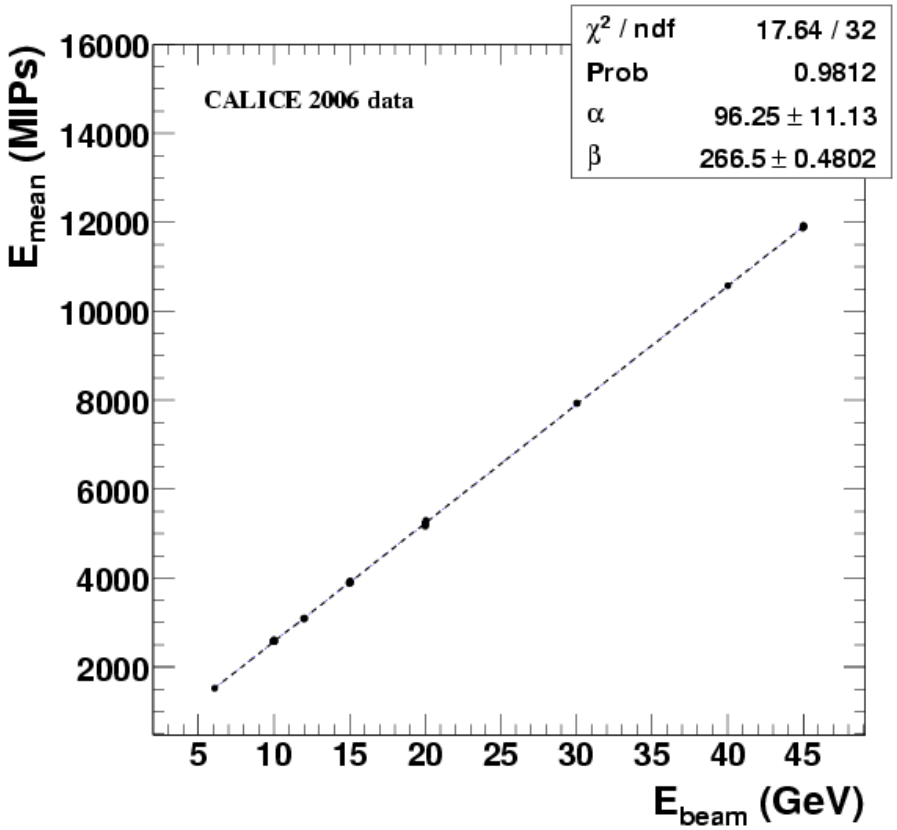


Good agreement between data end MC

Good energy resolution considering that the aim is to separate particles!

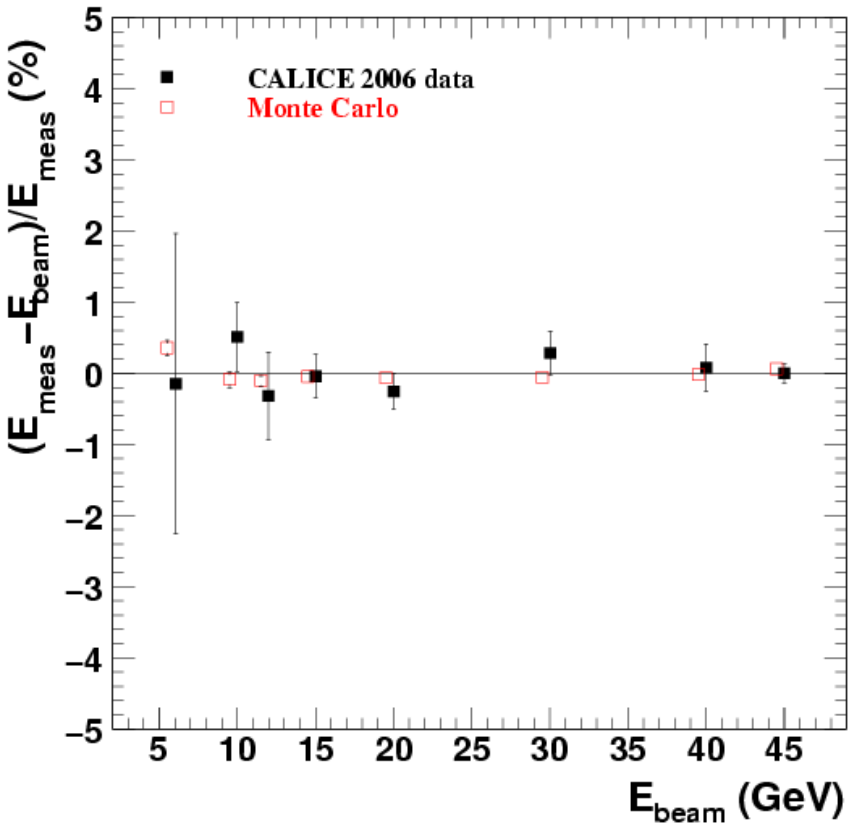
$$\frac{\sigma E_{Meas}}{E_{Meas}} = \left(\frac{16.6 \pm 0.1}{\sqrt{E(GeV)}} \oplus (1.1 \pm 0.1) \right) \%$$

Linearity



Good linearity over a large energy range

Good agreement between data and MC

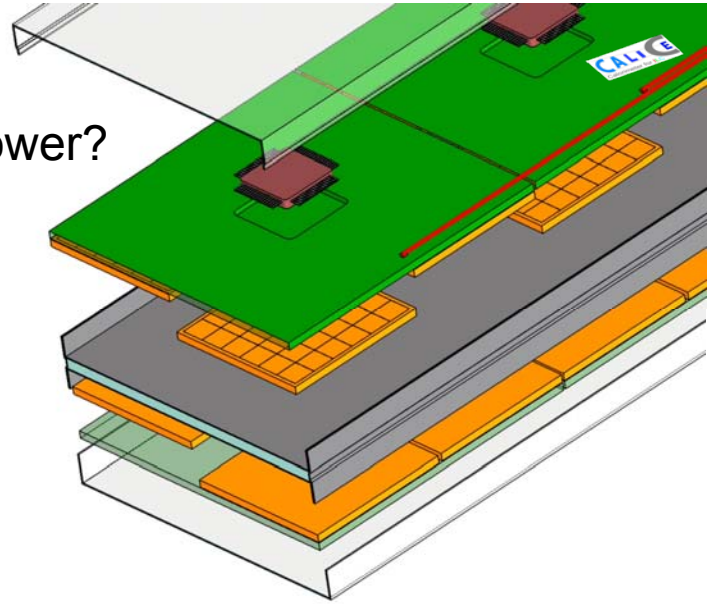


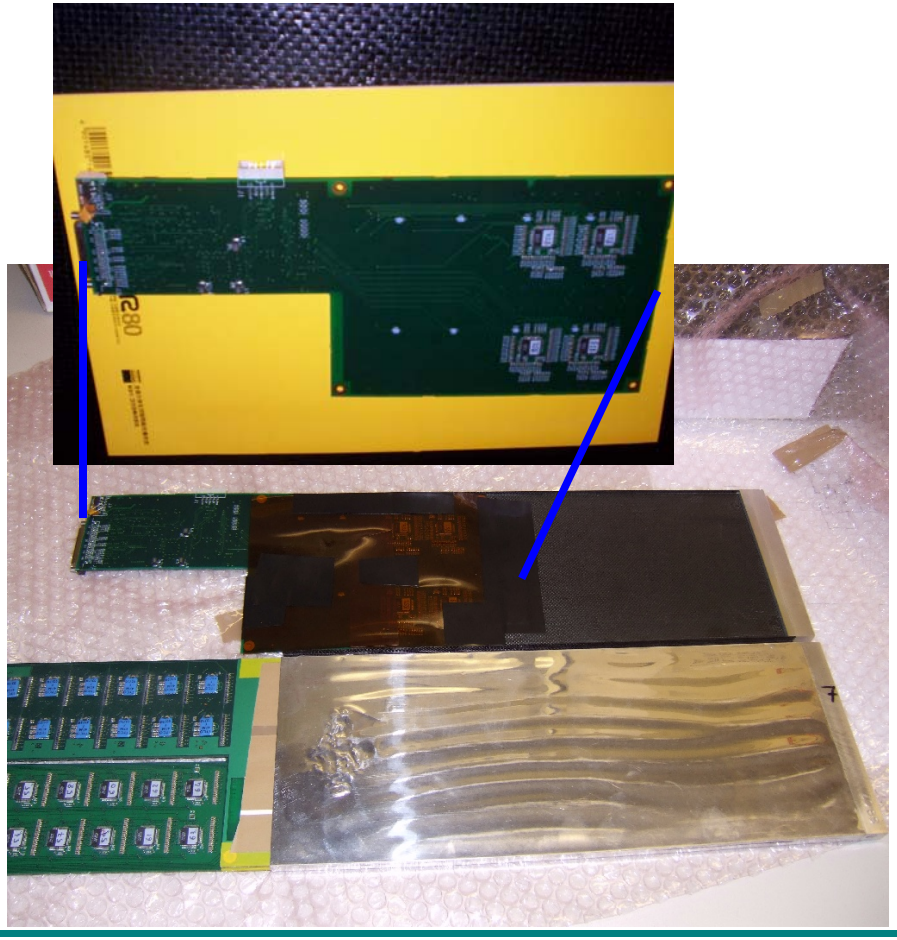
Linear response within 1%

Irradiation test

Final detector will have electronics embedded

Is any signal induced in the electronics by the EM shower?

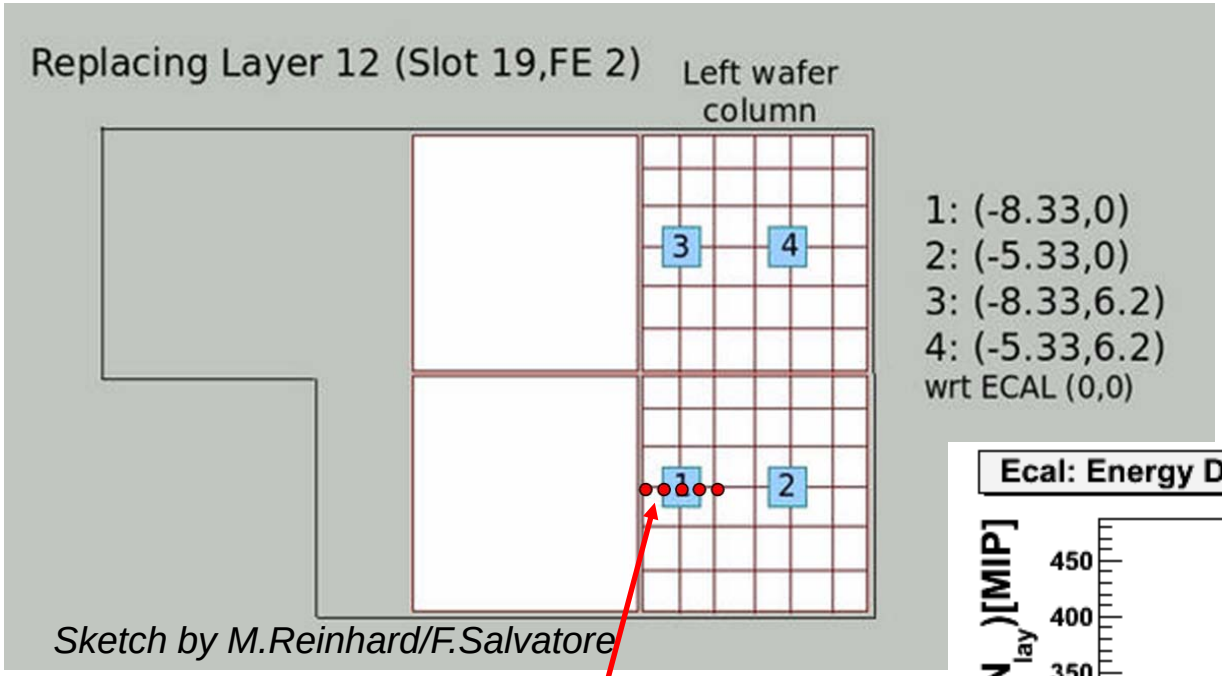




In 2007 a special slab was equipped with embedded chips (no Si wafers)

See poster session for further details!

Irradiation setup

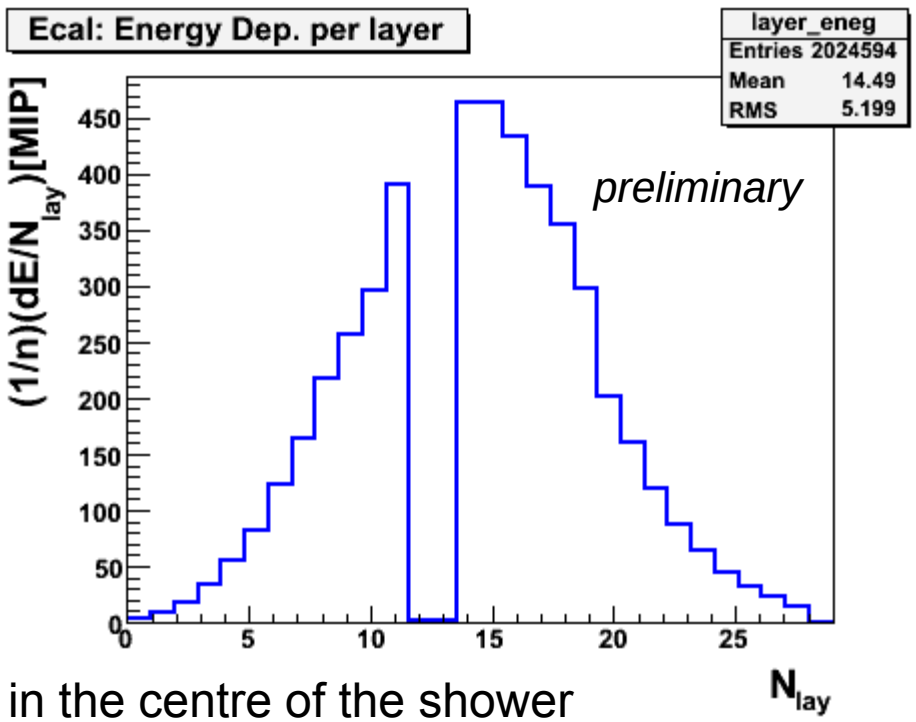


Nominal position of chips

Scanning points (repeated for each chip)

2.6 10^6 Events with 90 GeV Electrons

At least 70 K at each scanning point

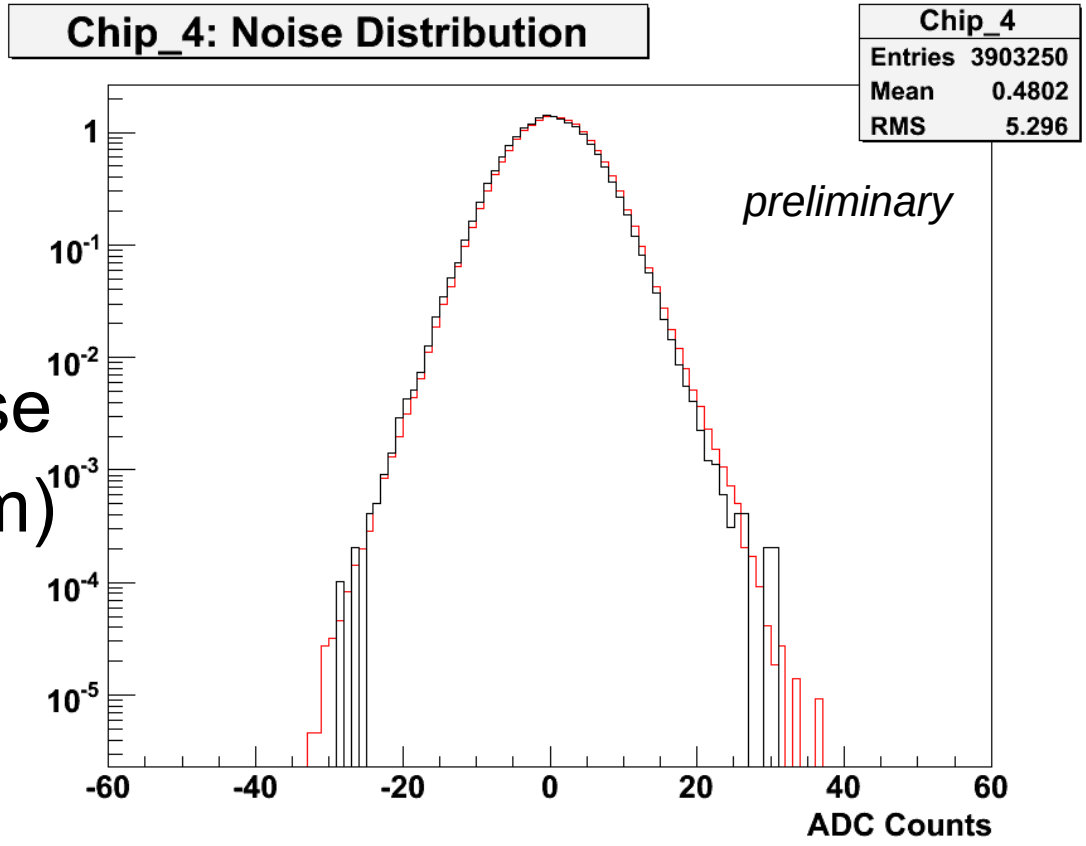


The special slab was placed in the ECAL in the centre of the shower

Methodology

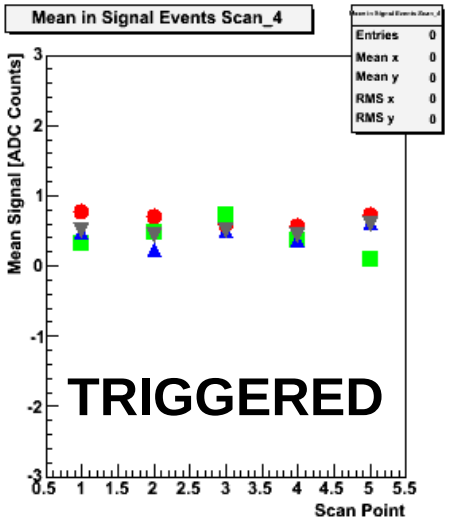
Two types of events:

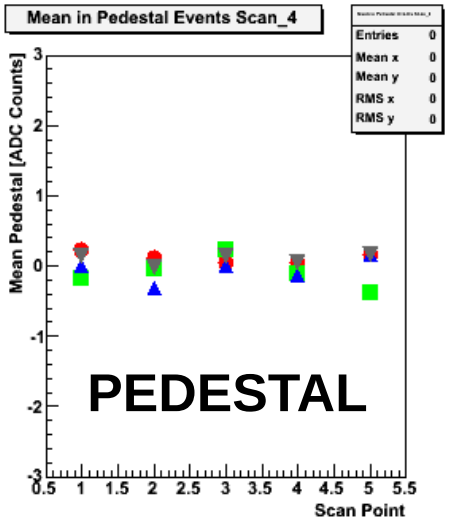
- triggered electrons
- pedestal events (noise run taken out of beam)

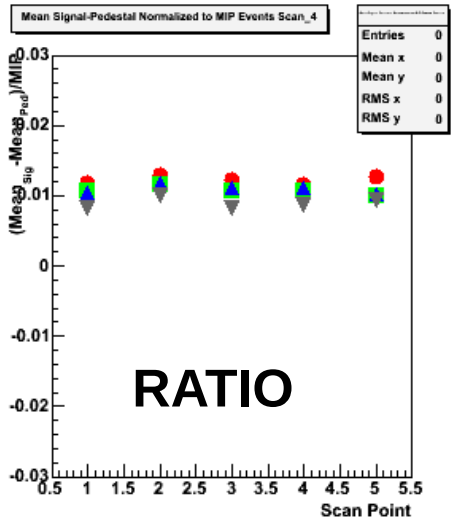


Tested global variables of noise spectra, mean and RMS

Results





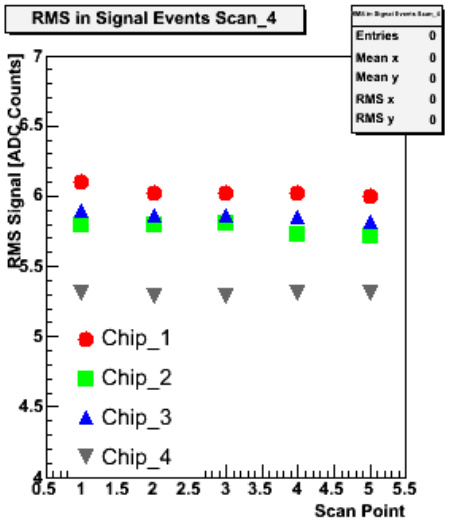


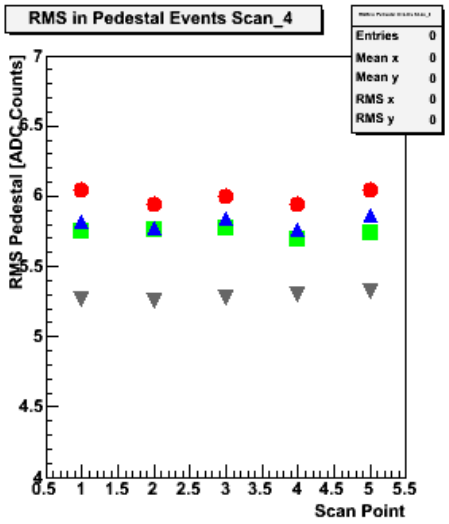
Scan of chip 4

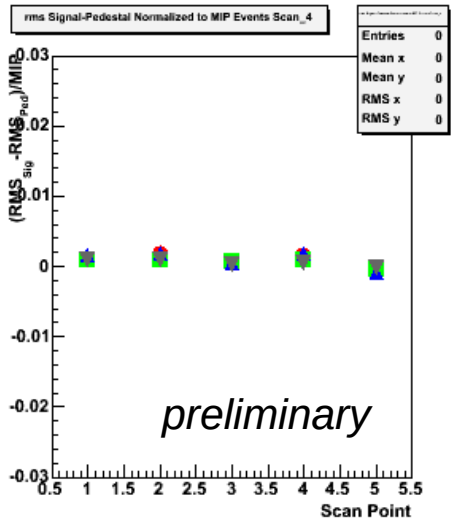
Mean

Global effect of 1% of MIP

Probably due to current into the detector







RMS

Global effect of <0.5% of MIP

No dependency on scan position visible

Conclusion

- The Si-W ECAL operated since 2006 in several testbeam with no major problems
- Response is stable with only 0.14% dead cells
- Linear response within 1%
- Energy resolution of $\left(\frac{16.6 \pm 0.1}{\sqrt{E(GeV)}} \oplus (1.1 \pm 0.1)\right)\%$

- Next generation ECAL will need embedded electronics:
  - From irradiation test there is no evidence of shower induced signal