CALICE Testbeam Program 2006

G.Mavromanolakis, University of Cambridge

Outline

- **General**
- **Overview per testbeam period**
  - : DESY May
  - : CERN Jul
  - : CERN Aug
  - : CERN Oct
- **Summary**

General

- **. particle flow paradigm**

  : highly granular EM and HADR calorimeters to allow very efficient pattern recognition for excellent shower separation and pid within jets to provide excellent jet reconstruction efficiency

- **. CALICE ECAL and HCAL prototype studies**

  : debug technology/detector concept(s)

  : detector characterisation

  : test "particle flow paradigm", interplay between hard/soft-ware

  : test-validate-improve simulation codes and shower packages

Testbeam Program 2006

- **DESY, 22 May - 31 May**

  : ECAL testbeam with electrons at 1-6 GeV

- **CERN, 28 Jul - 9 Aug**

  : ECAL testbeam with electrons at higher energy

  : HCAL, TCMT commissioning

- **CERN, 24 Aug - 3 Sep**

  : mainly HCAL technical run with electrons/pions

- **CERN, 12 Oct - 24 Oct**

  : combined (ECAL+HCAL+TCMT) physics run with electrons/pions

ECAL testbeam at DESY, May 2006

- **Si/W prototype**

  : 24 layers (10 at 1.4mm W + 10 at 2.8mm + 4 at 4.2mm) equipped with 18×12 matrix of active Si cells, **cellsize: 1×1 cm^2**,
  total: **5184 channels**

- **in summary (configurations: position $\times$ energy $\times$ angle)**

  : testbeam with electrons

  : position scan (center - edge - corner of wafers)
  energy scan (1, 1.5, 2, 3, 4, 5, 6 GeV)
  angle scan (0°, 10°, 20°, 30°, 45°)

  : **total: $\sim$ 8 Mevents**

ECAL board

6 active wafers

- 36 silicon PIN diodes each
  $\longrightarrow$ 216 channels per board.
- Diode size: $1 \times 1\,\mathrm{cm}^2$.

Calibration chips

- 2 calibration switches chips.
- 6 calibration channels per chip.
- 18 diodes per calibration channel.

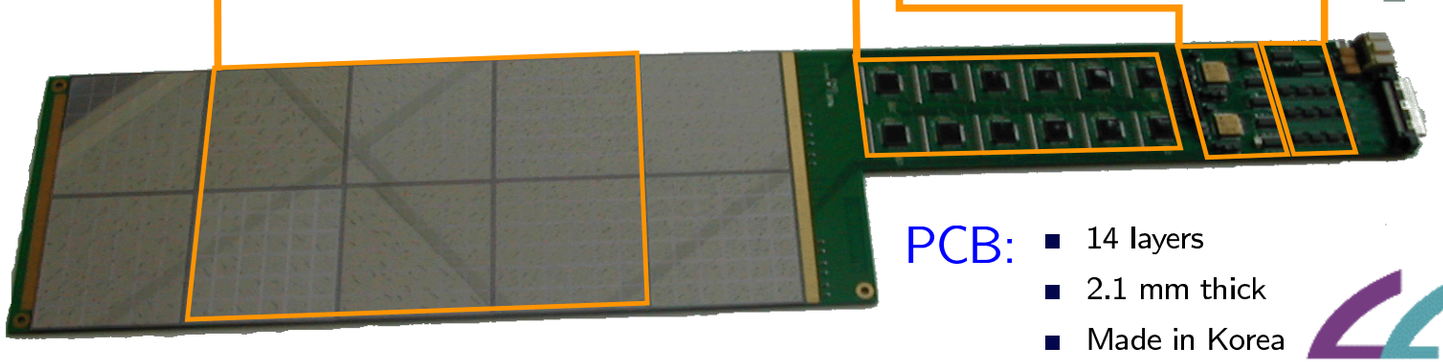
Front-End chip

12 FLC_PHY3 front-end chip

- 18 channels / chip
- 13 bit dynamic range

Line buffers

- To DAQ part
- Differential.

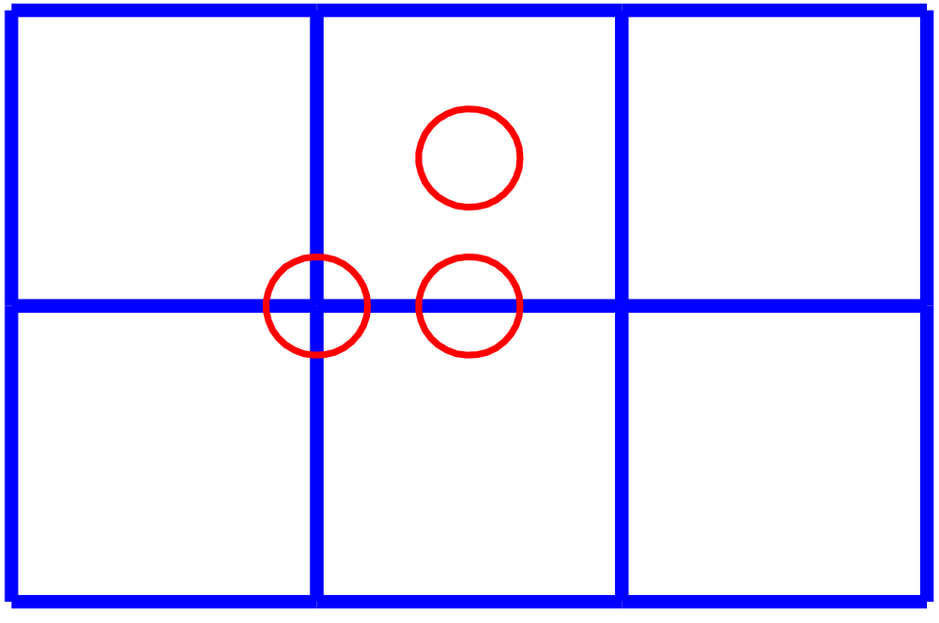


PCB:

- 14 layers
- 2.1 mm thick
- Made in Korea

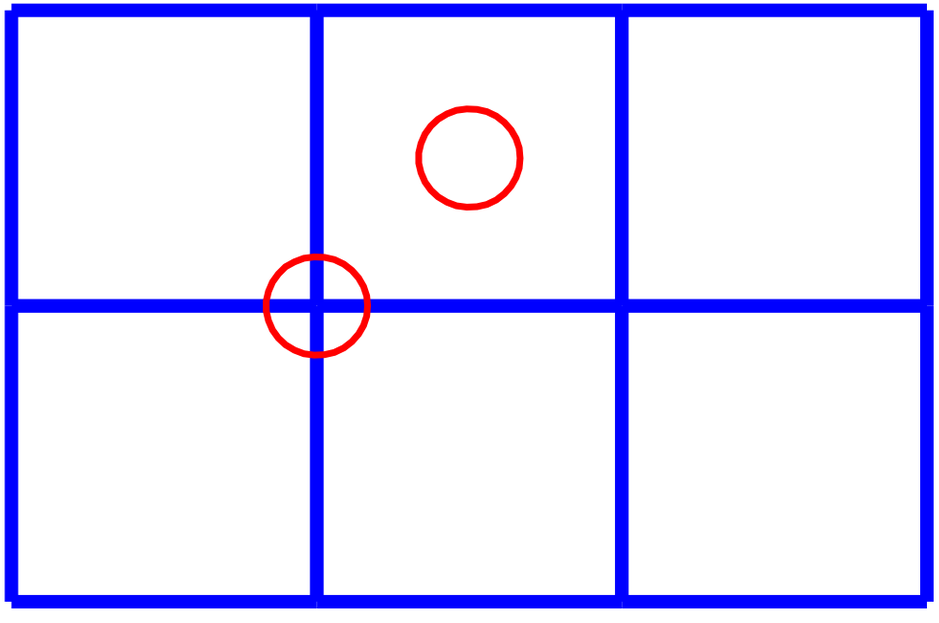
(G.Gaycken)

Testbeam at DESY with electrons



- **ECAL at 0°**
  three position points
- **energy scan (1, 1.5, 2, 3, 4, 5, 6 GeV)**
- **100k events per sample**

Testbeam at DESY with electrons



- angle scan (10°, 20°, 30°, 45°)
  two position points
- energy scan (1, 1.5, 2, 3, 4, 5, 6 GeV)
- 100k events per sample

Remarks

- **Tracker**

  : 4 drift chambers with non-flammable gas

- **Beam/trigger quality**

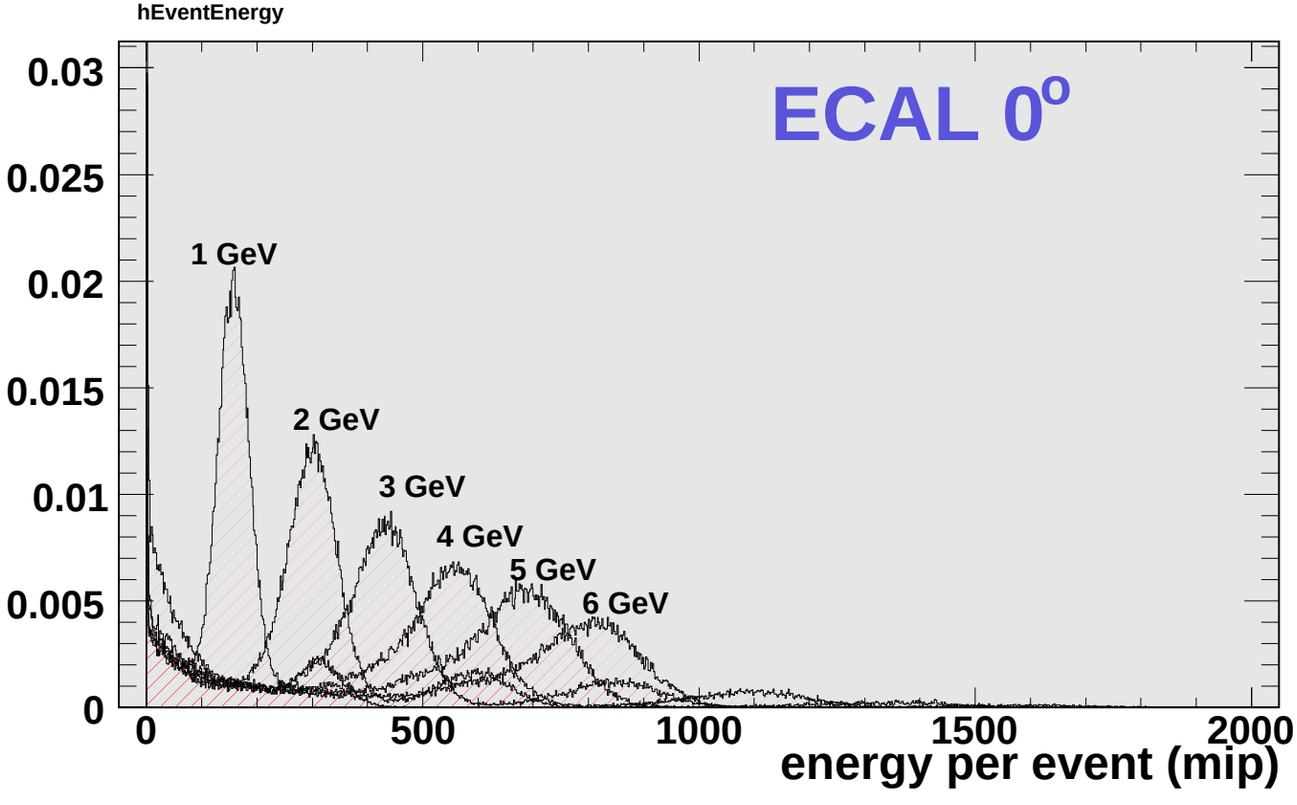
  : empty/garbage events

  : multiparticle events

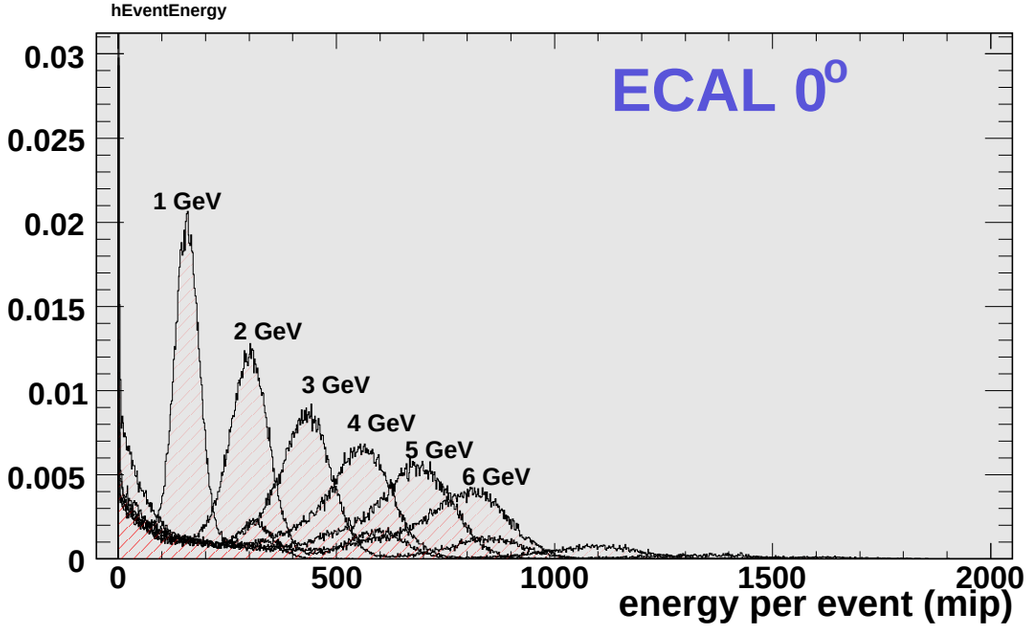
- **DAQ**

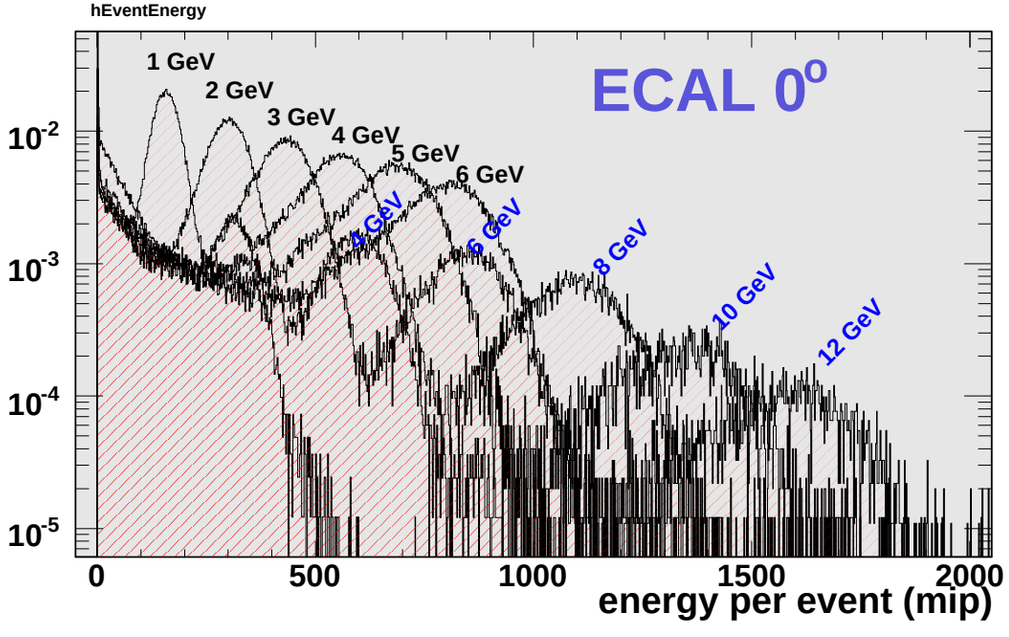
  : first test of combined ECAL+HCAL readout

Response to electrons



Response to electrons

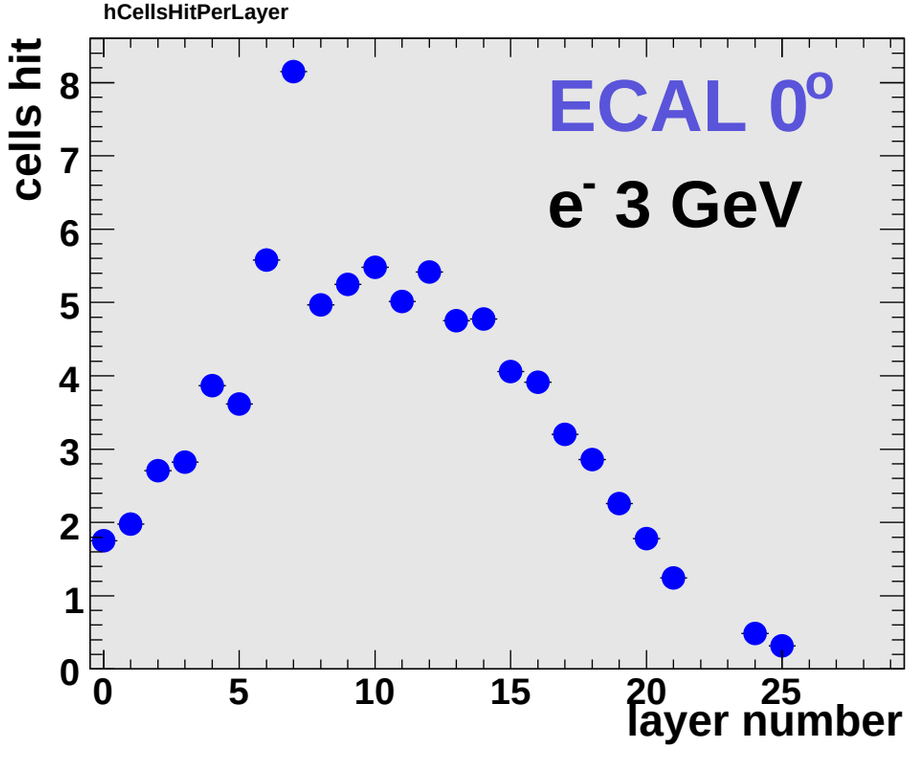




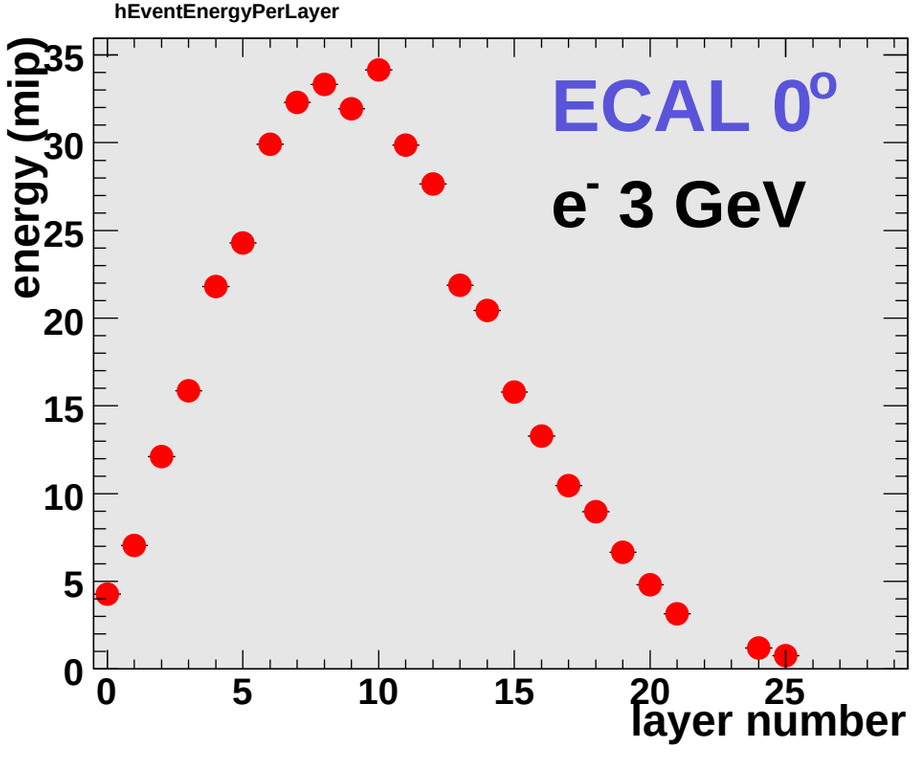
▷ **a lot of double-particle events observed**

Shower longitudinal profile

Hits per layer



E per layer



- showers are well contained
- some layers show high noise

ECAL testbeam at CERN, Aug 2006

- **Si/W prototype**

  : 30 layers (10 at 1.4mm W + 10 at 2.8mm + 10 at 4.2mm) equipped with 18×12 matrix of active Si cells, **cellsize: 1×1 cm^2**,
  total: **6480 channels**

- **run plan**

  : ECAL testbeam with electrons at higher energy

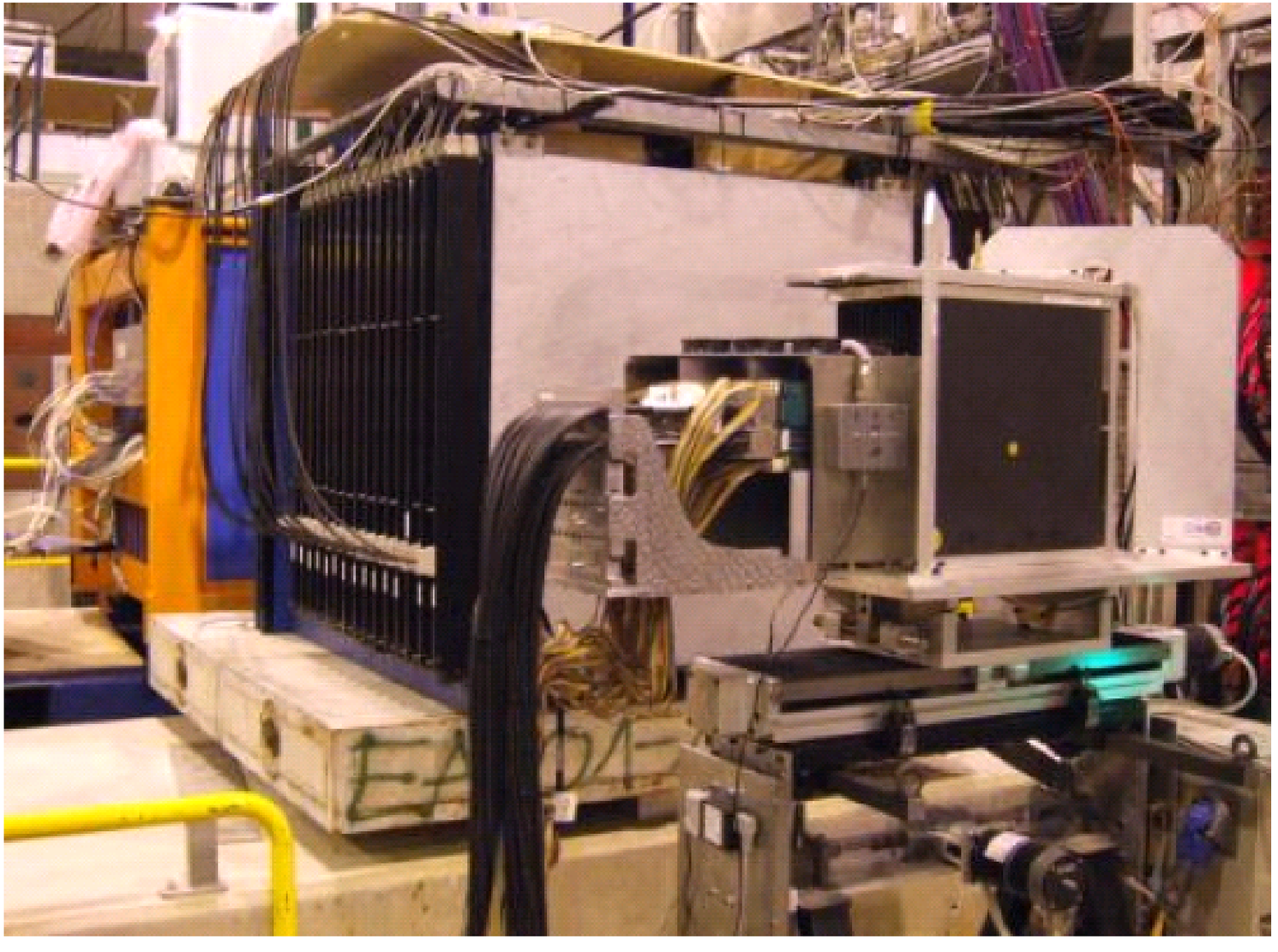
  : HCAL+TCMT commissioning

  : beam tuning

- **C A N C E L L E D**

  : CERN suffered a severe power failure, all testbeams cancelled

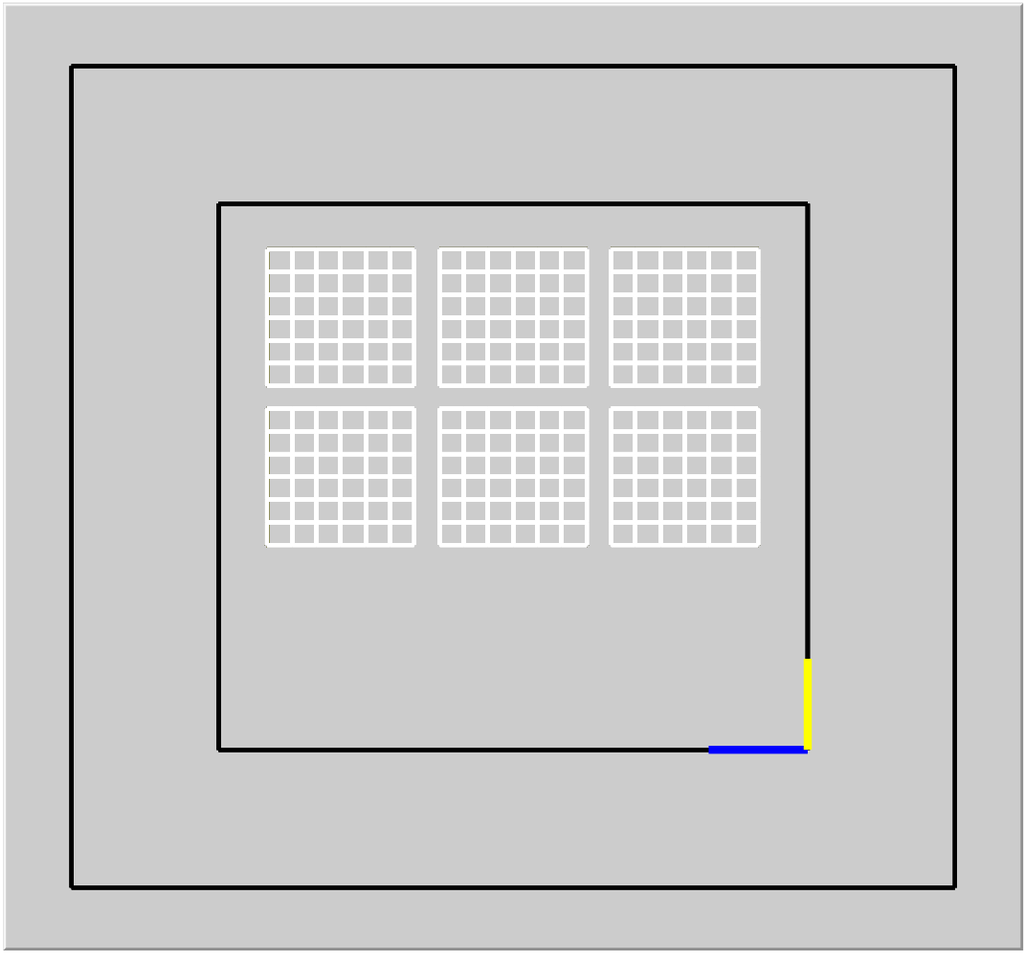
CALICE testbeam at CERN



Transverse granularity

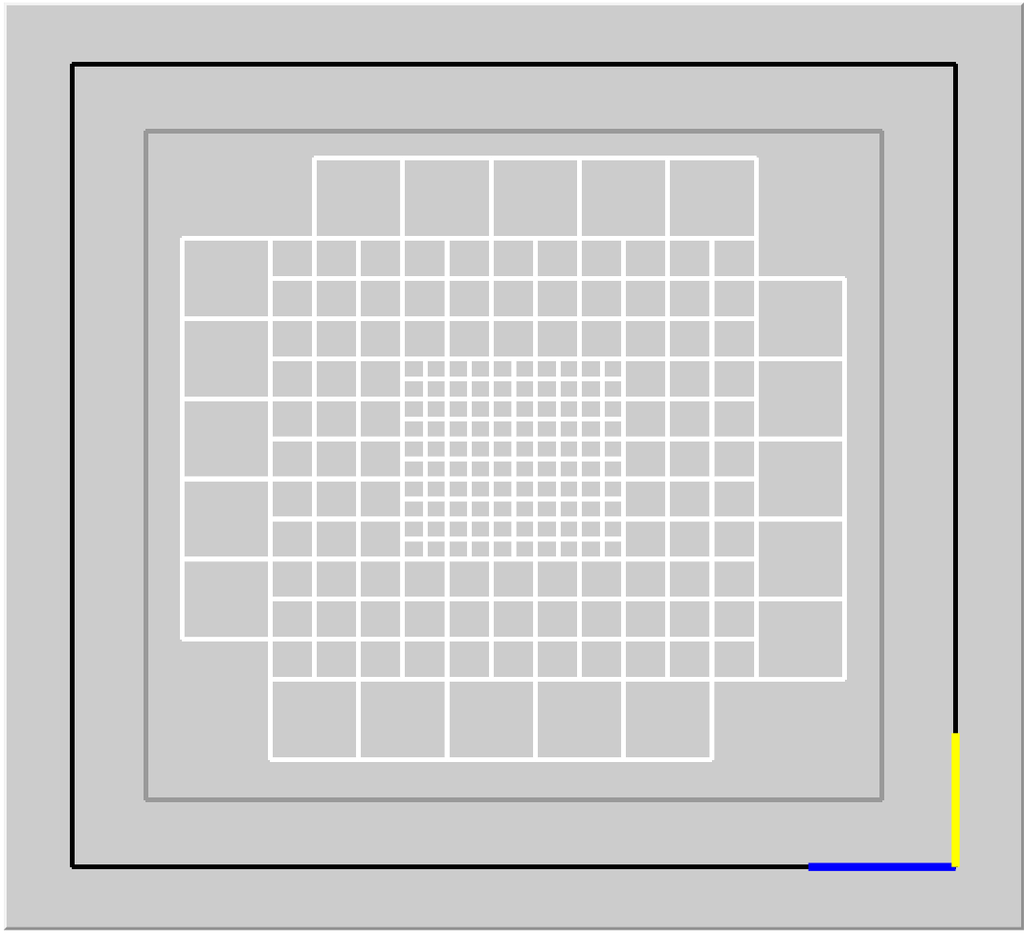
ECAL 18$\times$18 cm^2

Si cells of 1$\times$1 cm^2



HCAL 100$\times$100 cm^2

scint.tiles of 3$\times$3, 6$\times$6, 12$\times$12 cm^2



HCAL testbeam at CERN, Aug 2006

- **Particle ID**
  - : Cherenkov counter, 1 bit signal
- **Tracker**
  - : 3 XY chambers
- **Calorimeters**
  - : ECAL: 30 layers, 6480 channels
  - : HCAL: 15 modules, 3240 channels
  - : TCMT: 8 modules, 160 channels

HCAL testbeam at CERN, Aug 2006

- **HCAL alone, no ECAL in front**

  : electron beam, energy scan (6, 10, 15, 20, 30, 40, 45 GeV)

  : pion beam, energy scan (6, 10, 15, 20, 30, 40, 50, 60, 80 GeV)

- **ECAL+HCAL**

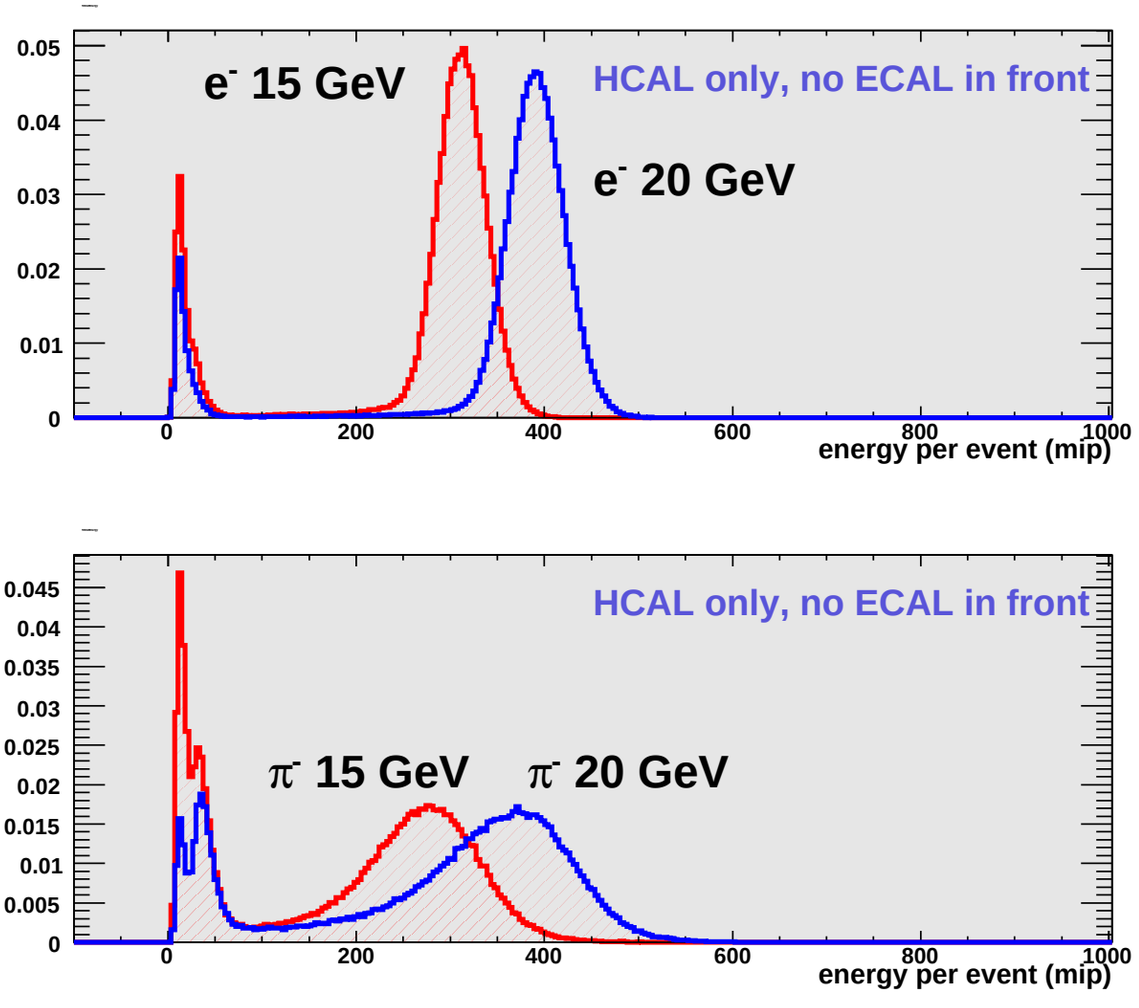
  : pion beam, energy scan (30, 40, 50, 60, 80 GeV)

- **ECAL**

  : electron beam, energy scan (10, 15, 20, 30, 40, 45 GeV)
  angle scan (0°, 30°, 45°)

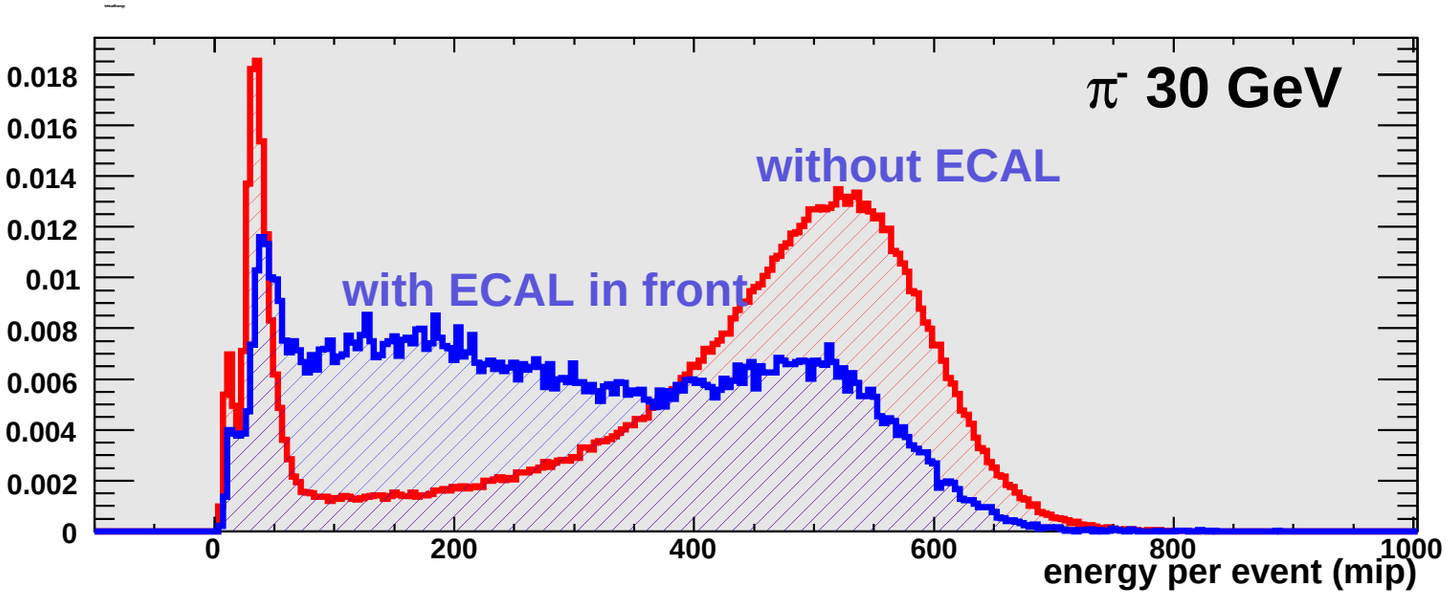
- **samples of 500-600k events collected**

HCAL e/π ratio



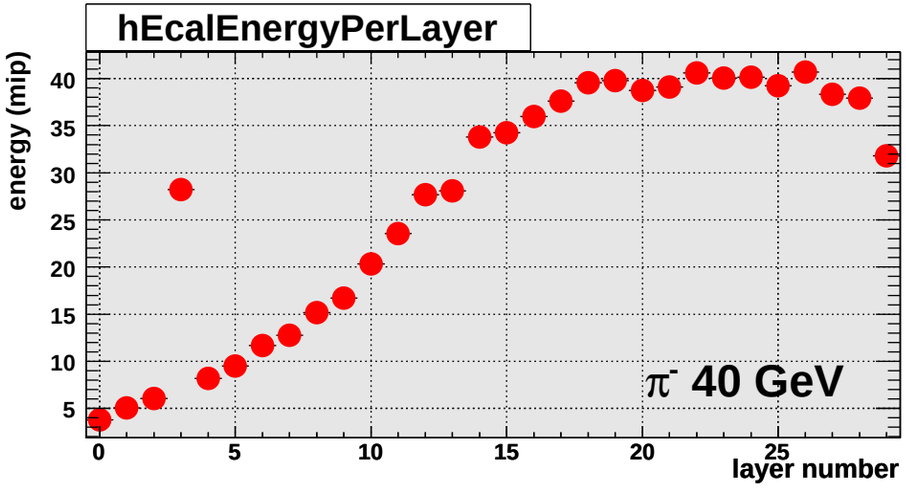
▷ **HCAL prototype shows good compensating behaviour**

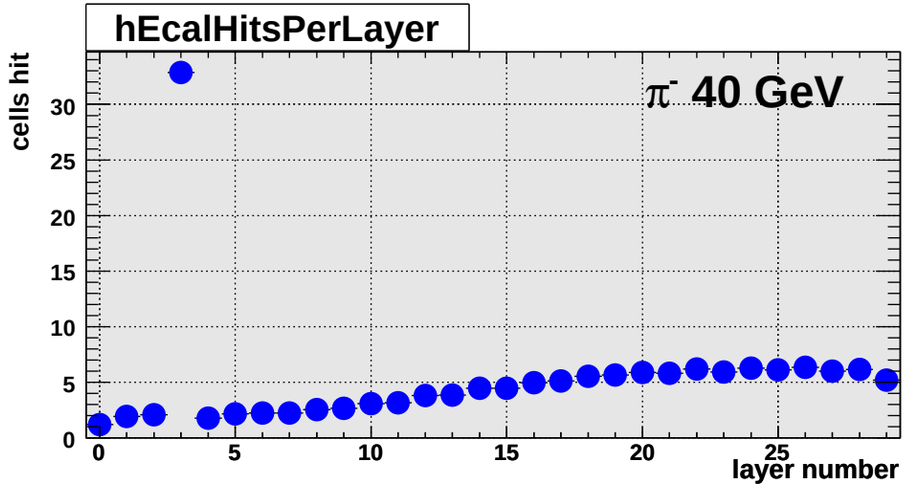
HCAL response with/without ECAL in front



Shower longitudinal profile

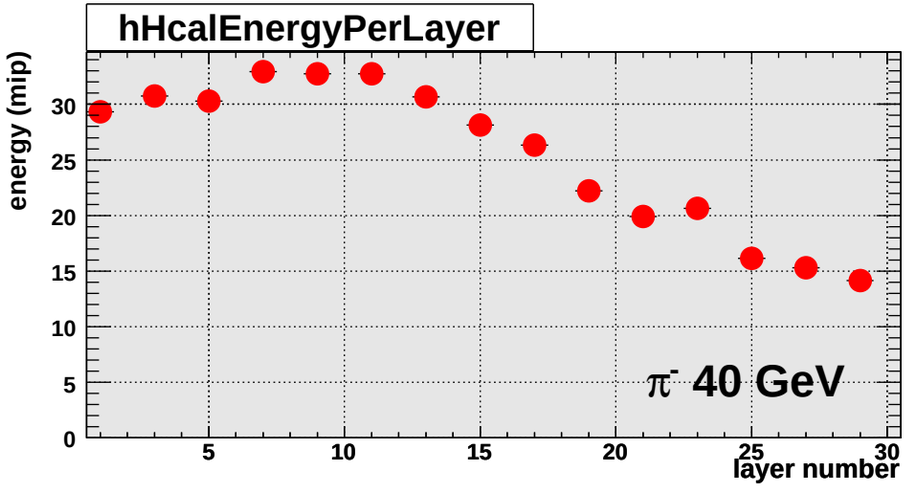
ECAL

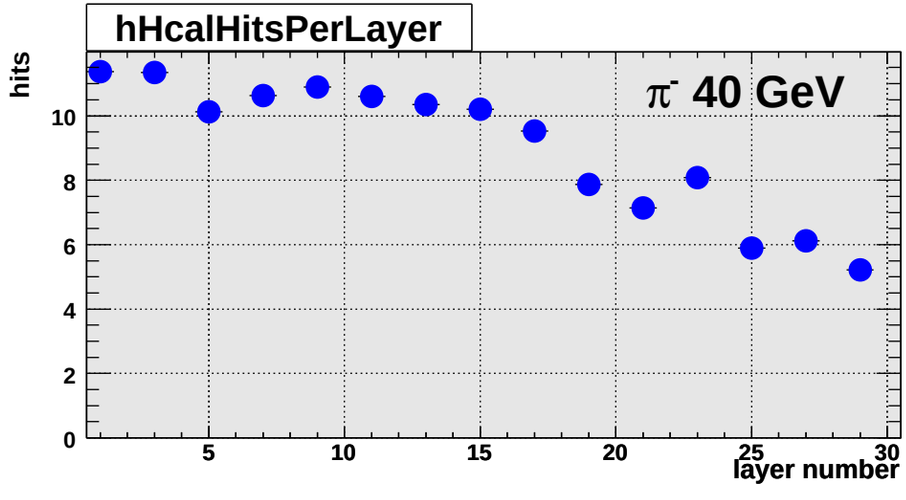




▷ some layers with high noise

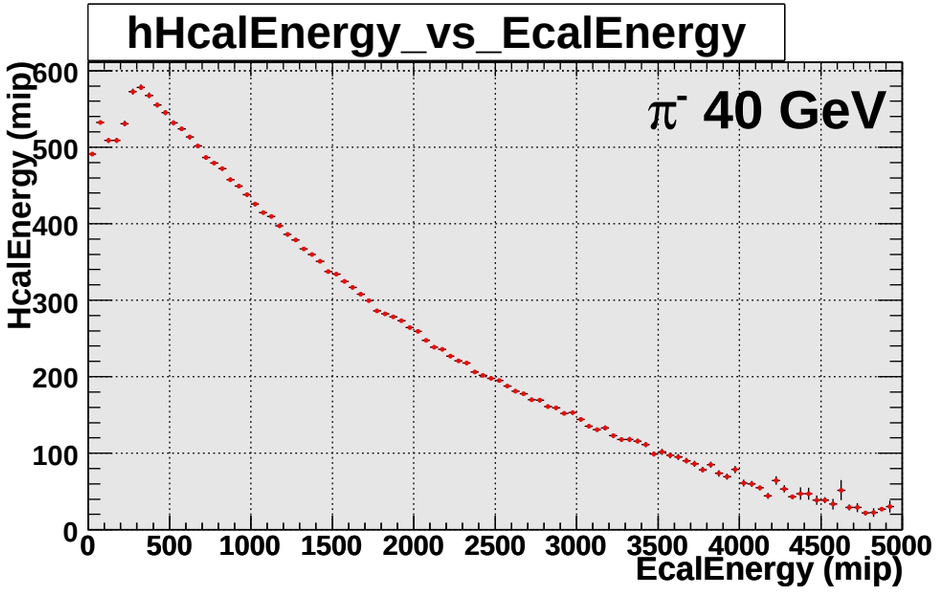
HCAL

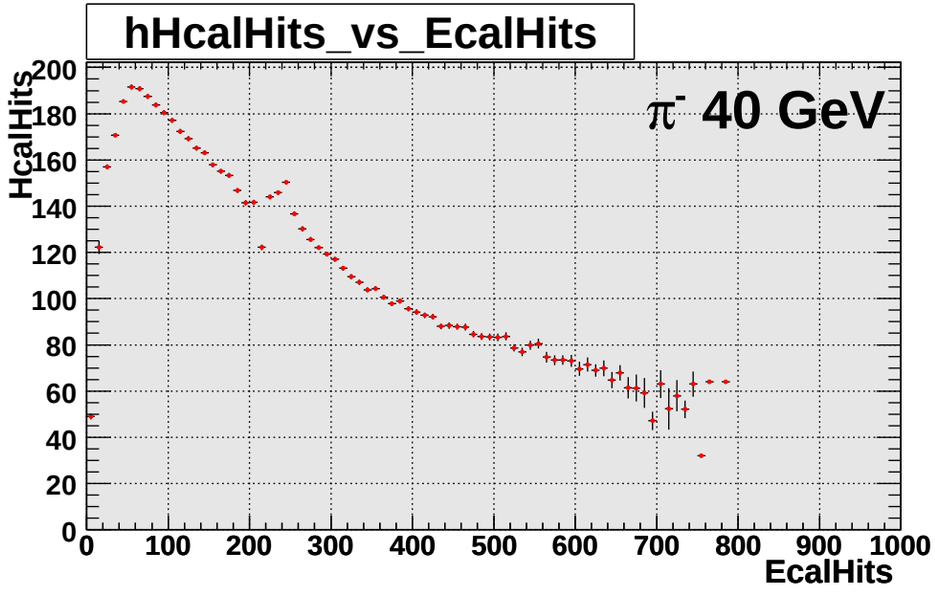




▷ only odd layers equipped and readout

ECAL vs HCAL response





▷ **as expected strong anti-correlation observed**

Combined testbeam at CERN, Oct 2006

- **Particle ID**
  - : Cherenkov counter, 1 bit signal
- **Tracker**
  - : 3 XY chambers
- **Calorimeters**
  - : **ECAL: 30 layers, 6480 channels**
  - : **HCAL: 23 modules, 4968 channels**
  - : **TCMT: completed, 16 modules, 320 channels**

Combined testbeam at CERN, Oct 2006

- **ECAL+HCAL+TCMT**

  : pion beam, energy scan (6, 10, 15, 20, 30, 40, 50, 80 GeV)
  samples of 500k events

- **ECAL**

  : positron beam, energy scan (10, 16, 15, 18, 20, 30, 50 GeV)
  samples of 300k events

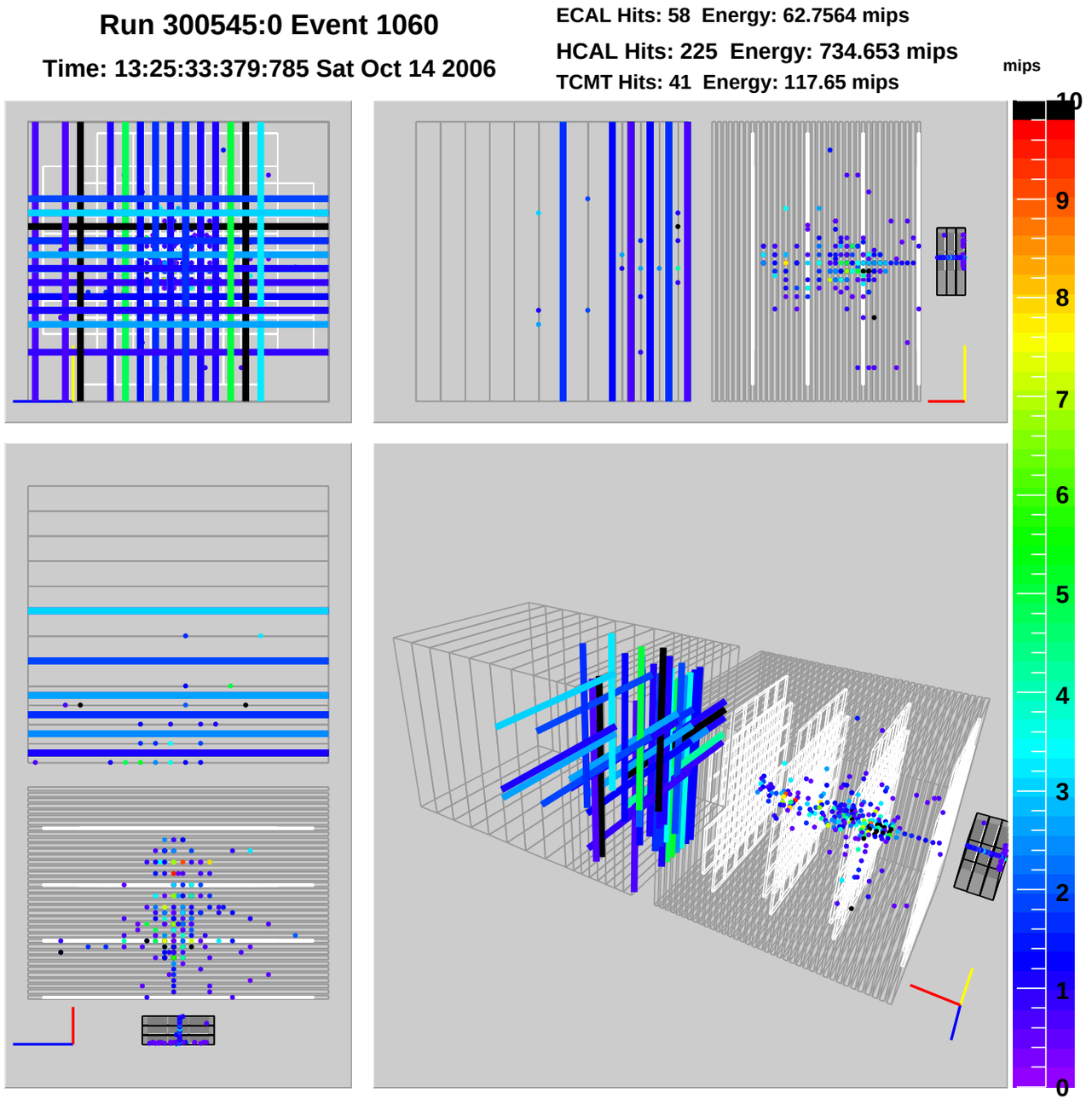
- **HCAL alone, no ECAL in front**

  : positron beam, energy scan (10, 15, 20, 30, 50 GeV)
  samples of 600k events

- **parasitic run**

  : 25M muon events collected

CALICE testbeam at CERN

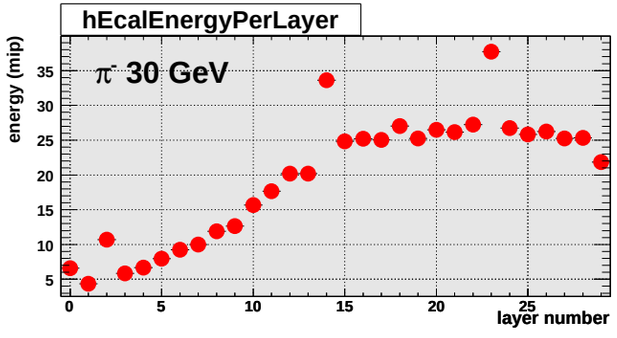


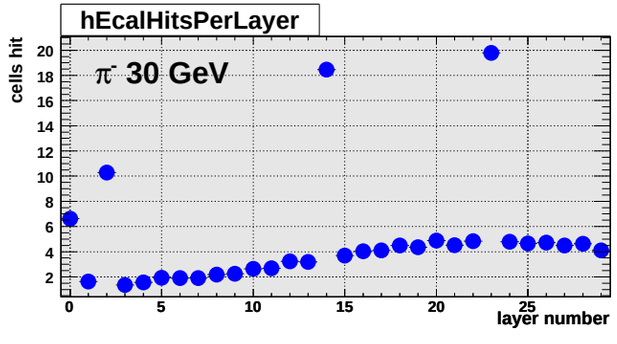
π^- 30 GeV

ECAL threshold = 0.5 mip
HCAL threshold = 0.5 mip
TCMT threshold = 0.7 mip

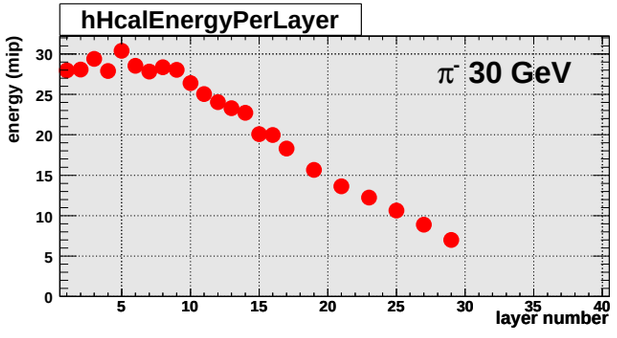
Shower longitudinal profile

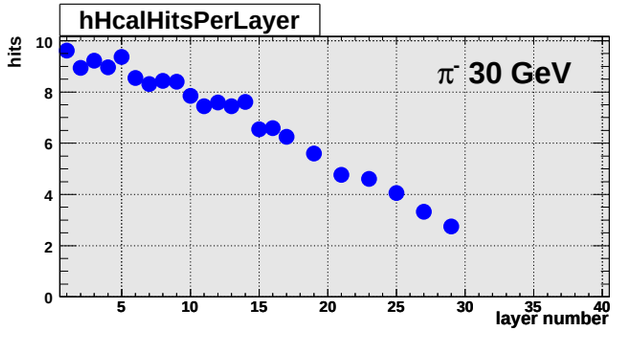
ECAL



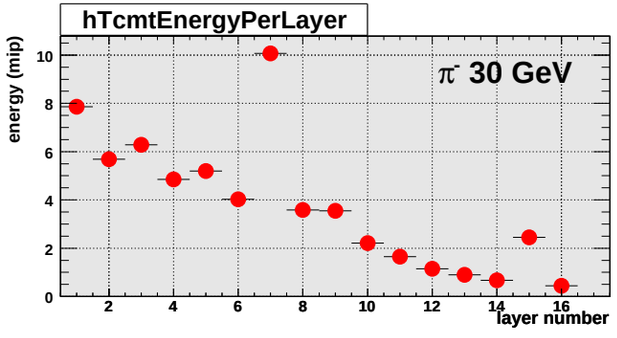


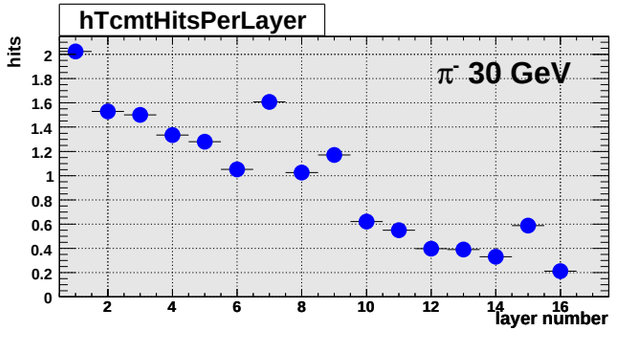
HCAL



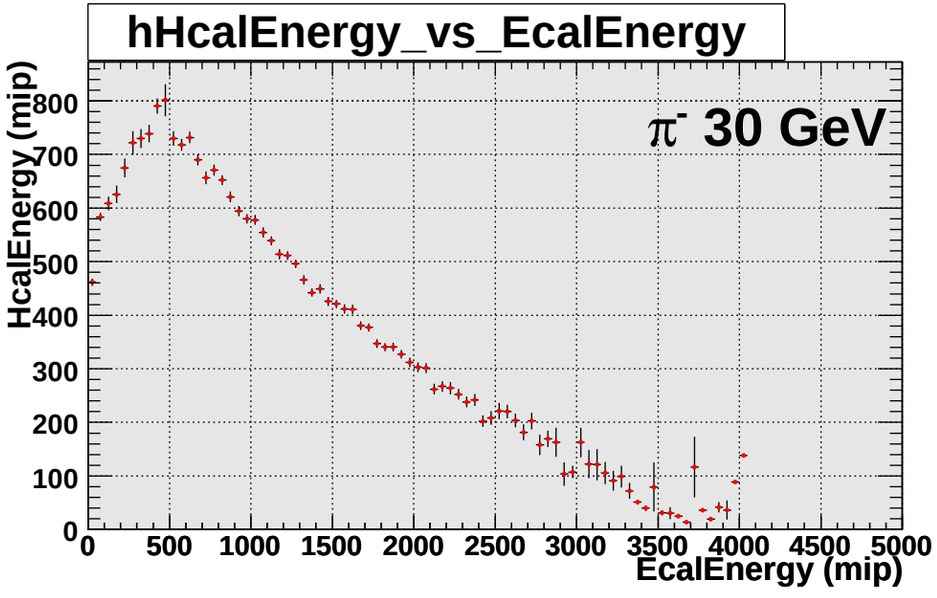


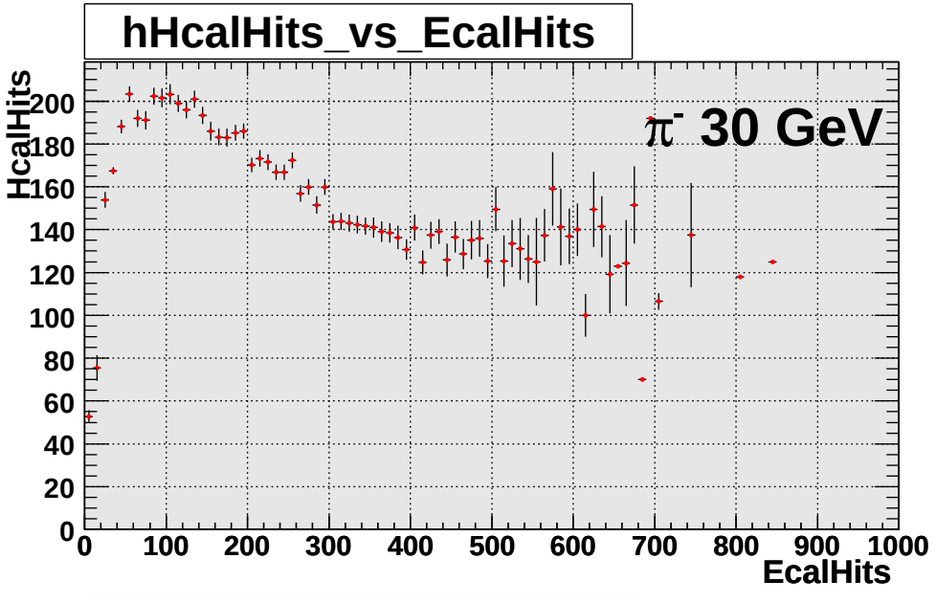
TCMT

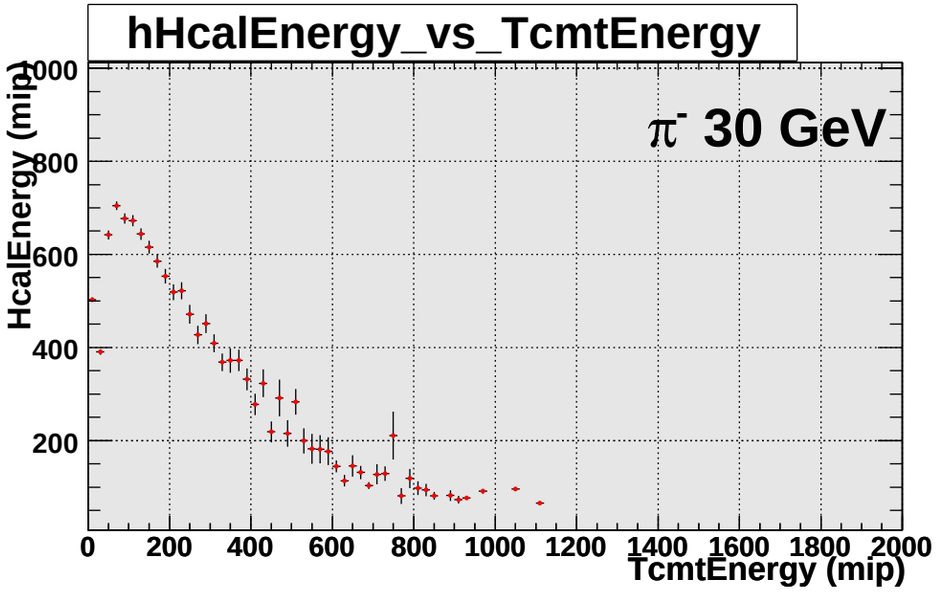


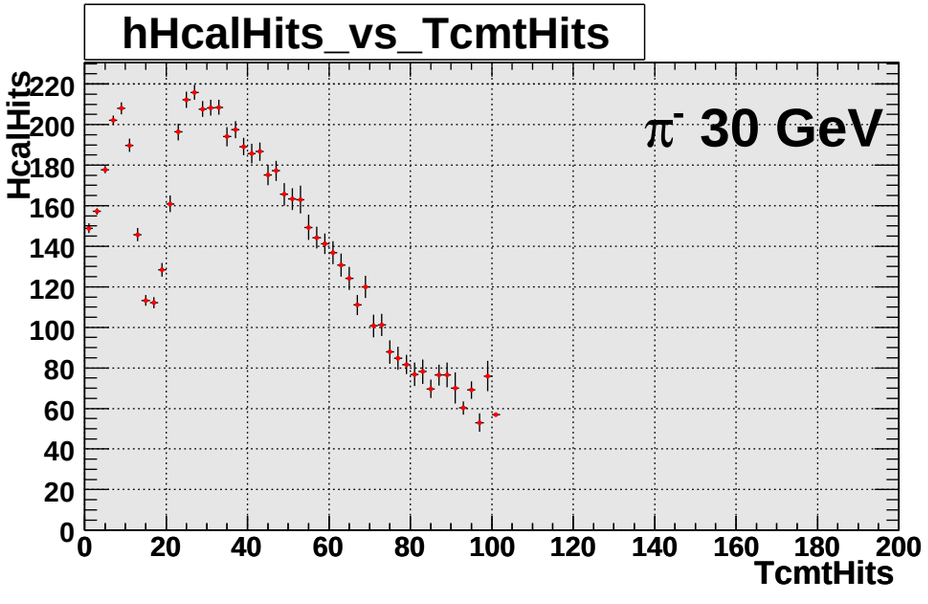


ECAL vs HCAL vs TCMT response

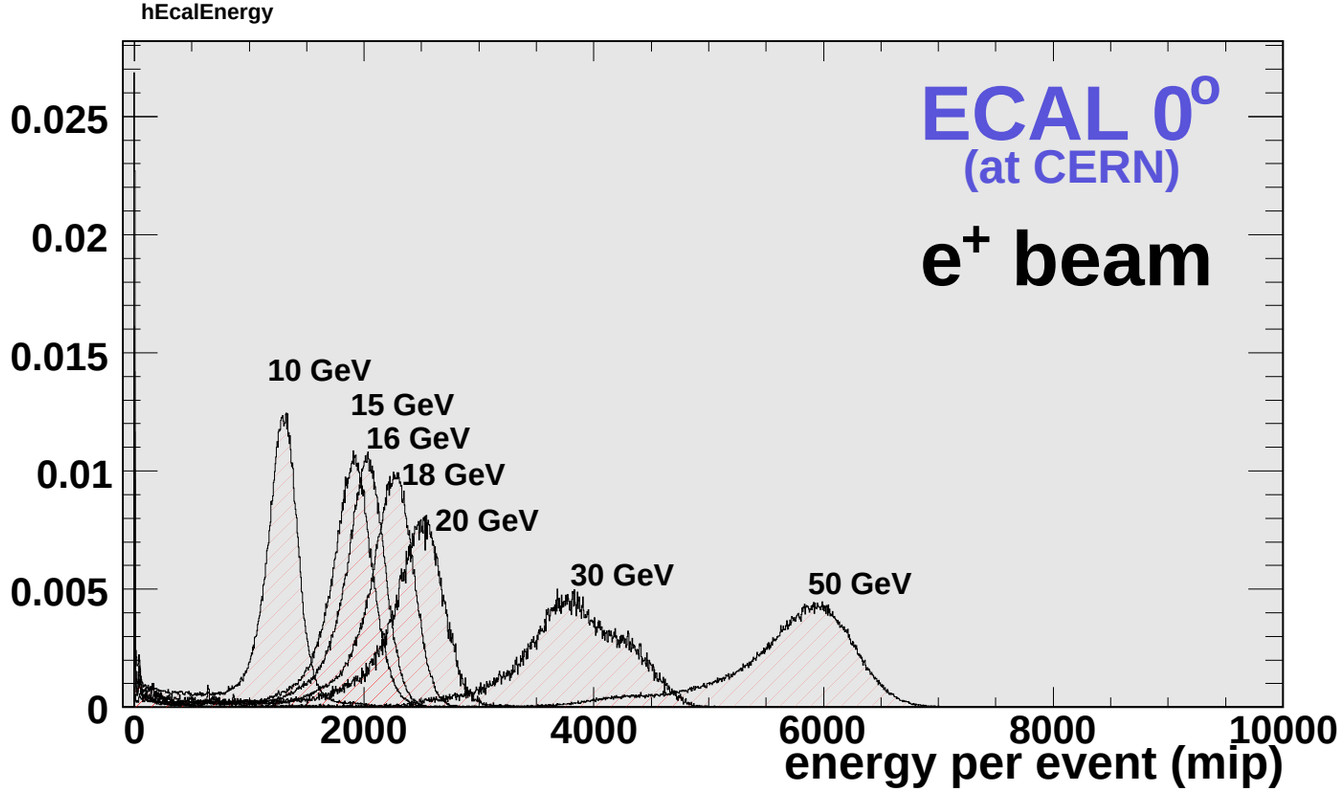






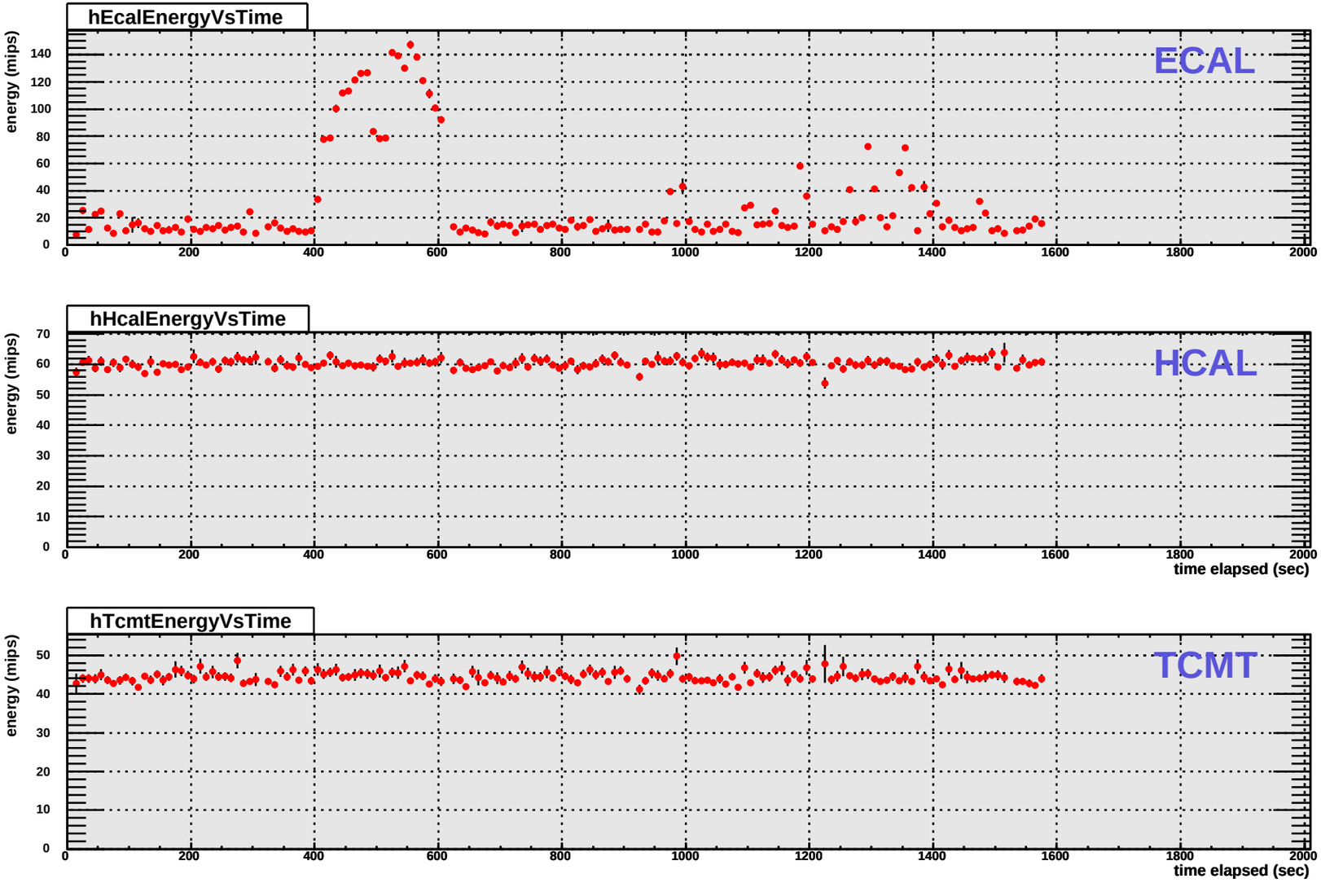


ECAL response to positrons



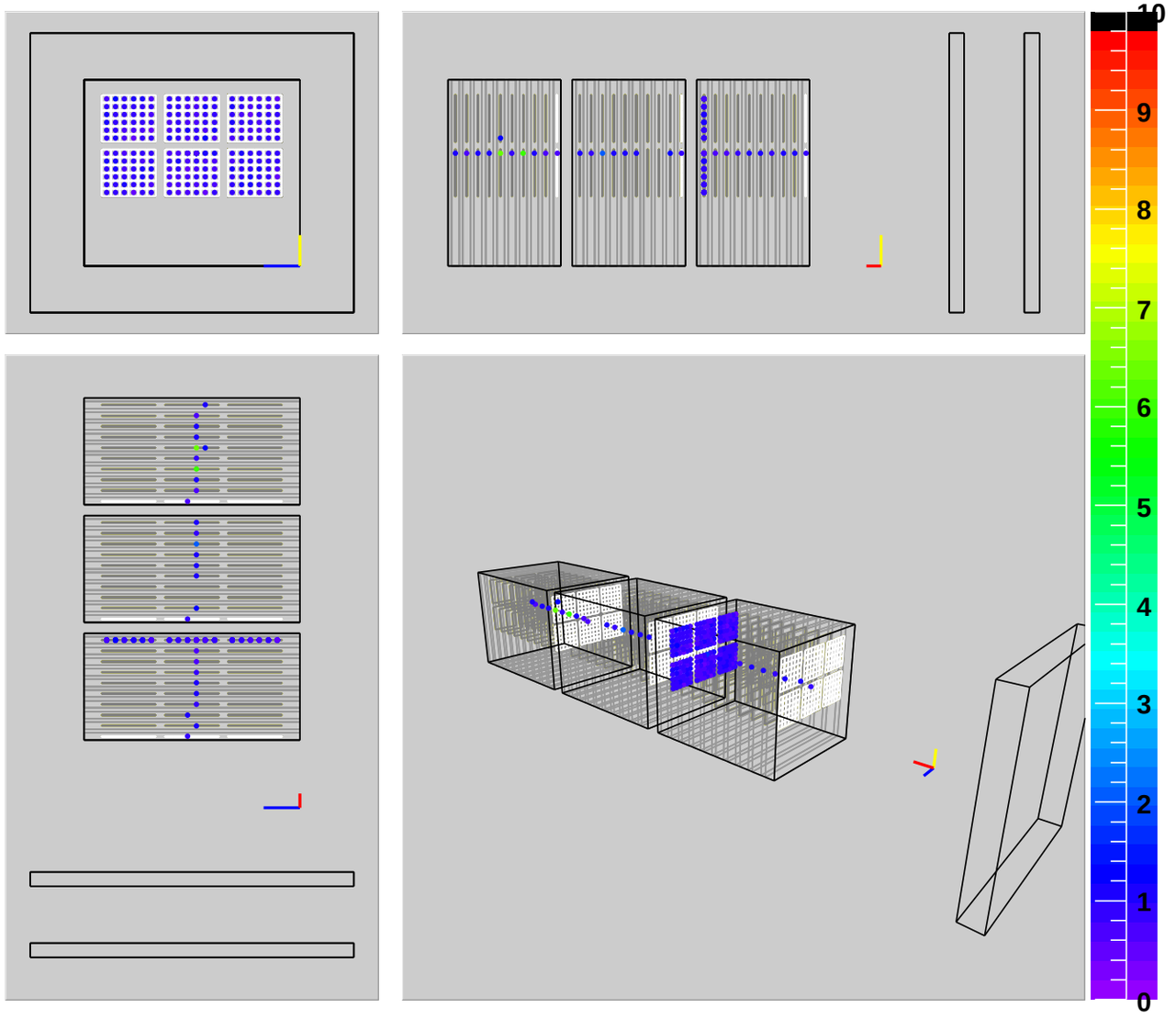
- most runs with nice and typical behaviour
- at 30 GeV run response spoiled by noisy/unstable layers

Stability problems



▷ **example of ECAL stability problem**

CALICE testbeam at CERN



(ECAL Display not to scale)

muon

ECAL threshold = 0.5 mip

Summary

- **CALICE Testbeam Program 2006**

  : several rounds of technical and physics runs at DESY and CERN

  : huge amount of data collected

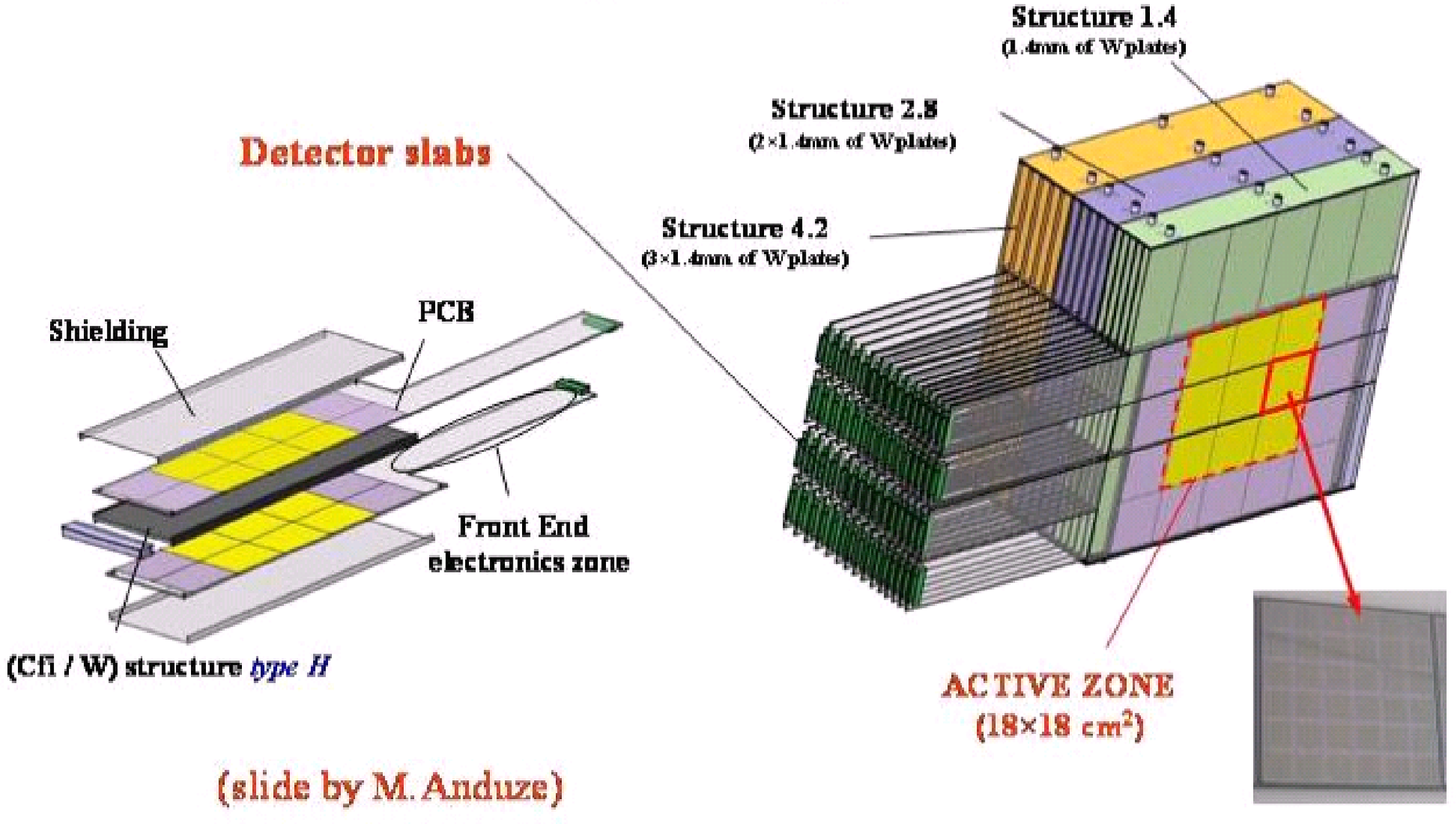
  : possible only with huge and constant effort of all involved

- **Happy Data Analysis**

  : not so trivial task

  : again constant effort of all involved required

CALICE ECAL prototype



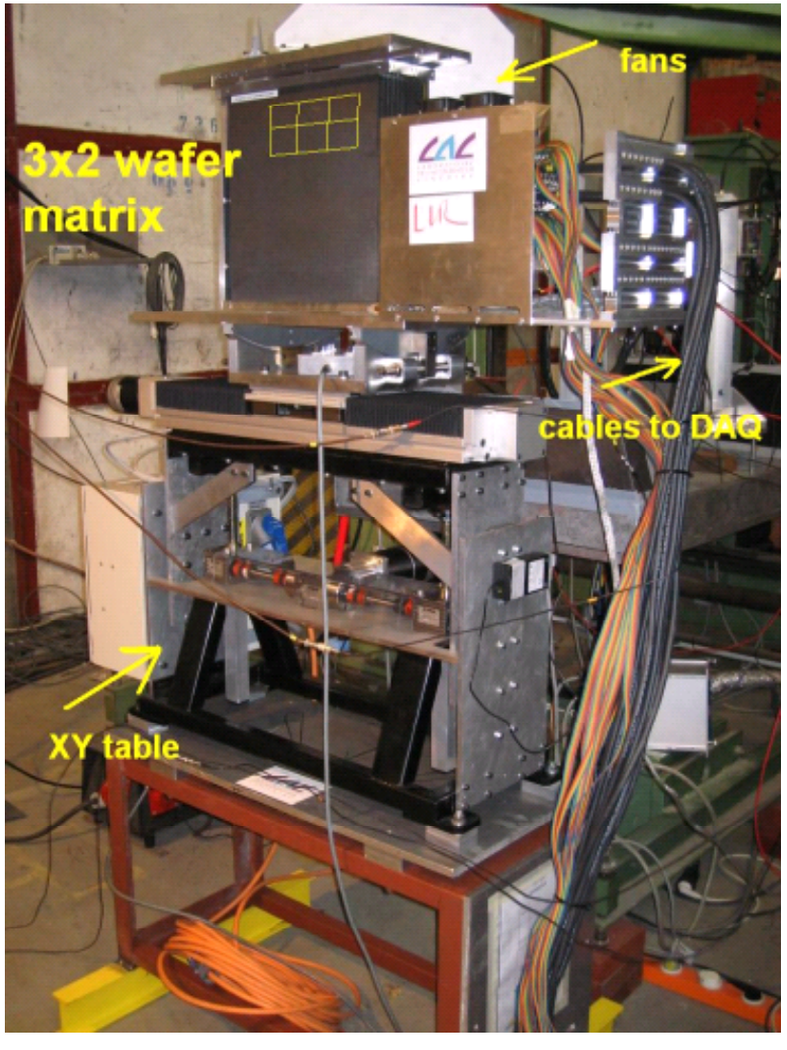
(slide by M. Anduze)

full Si/W prototype (24 X_0)

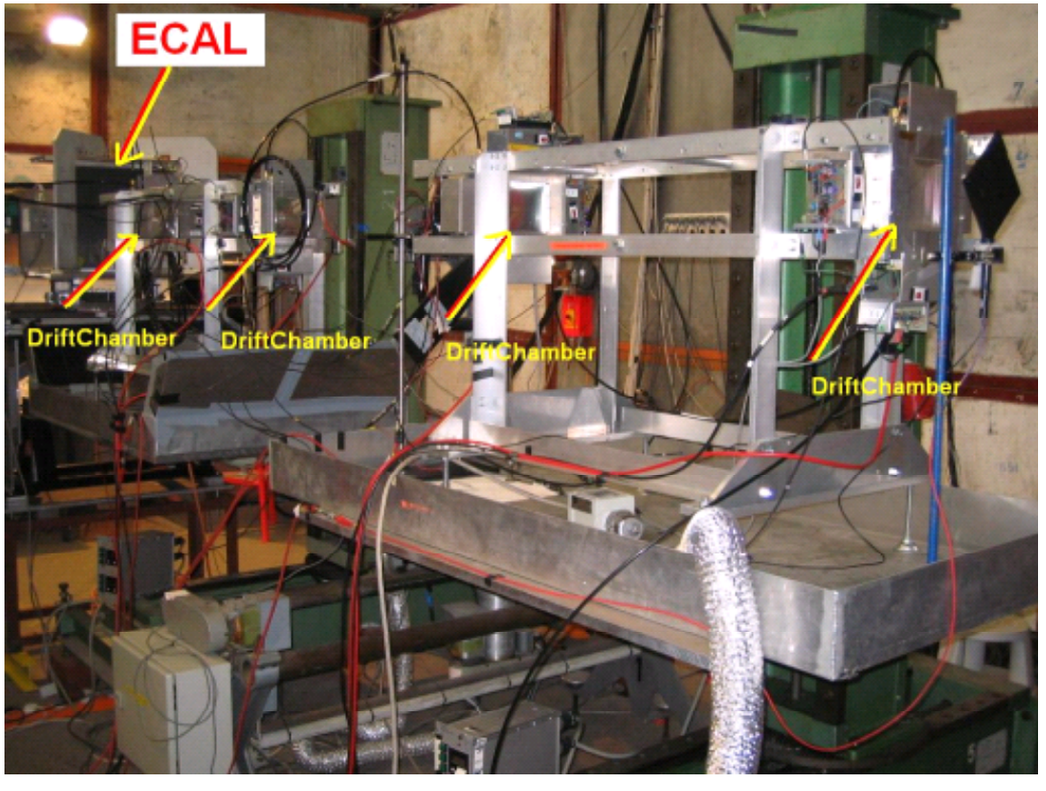
- 30 layers $\times$ 18 cm $\times$ 18 cm, interleaved with 0.5 mm Si pads
- W absorber, 10+10+10 layers, 1.4 mm:2.8 mm:4.2 mm thick per respective layer
- readout by **1 $\times$ 1 cm^2 cells, total: 9720 channels**

CALICE-ECAL testbeam at DESY

ECAL



layout at DESY T21



DriftChambers and installation courtesy of Tsukuba Univ. and Kobe Univ.