Calorimeter Summary

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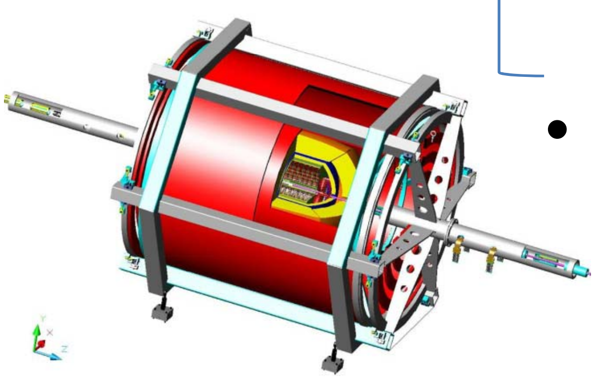
Mar 2-7 TILC08@Sendai

Many interesting talks :

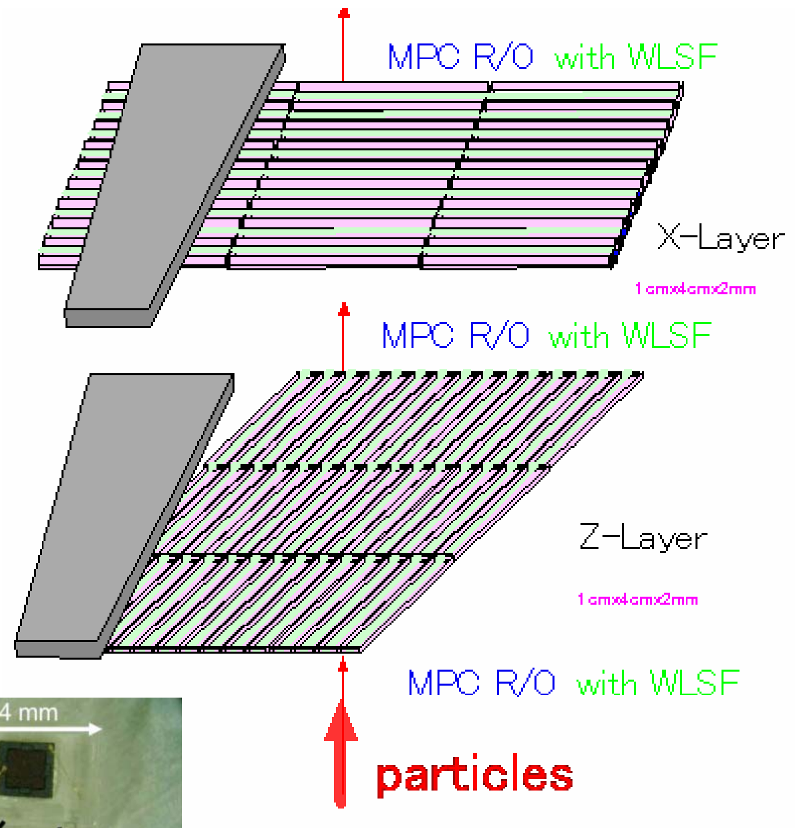
- CALICE Scintillator-W ECAL
  - DESY BT analysis (D. Jeans)
  - Scintillator-strip performance (M. Nishiyama)
  - MPPC radiation resistivity (T. Ikuno)
- CALICE Silicon-W ECAL
  - Testbeam results (R. Poeschl)
  - MAPS ECAL (Y. Mikami)
- CALICE Scintillator HCAL
  - Calibration and Readout (F. Sefkow)
  - IRL for Scintillator-HCAL (V. Zutshi)
- Dual-readout calorimeter for 4th
  - Testbeam result and simulation (J. Hauptman)

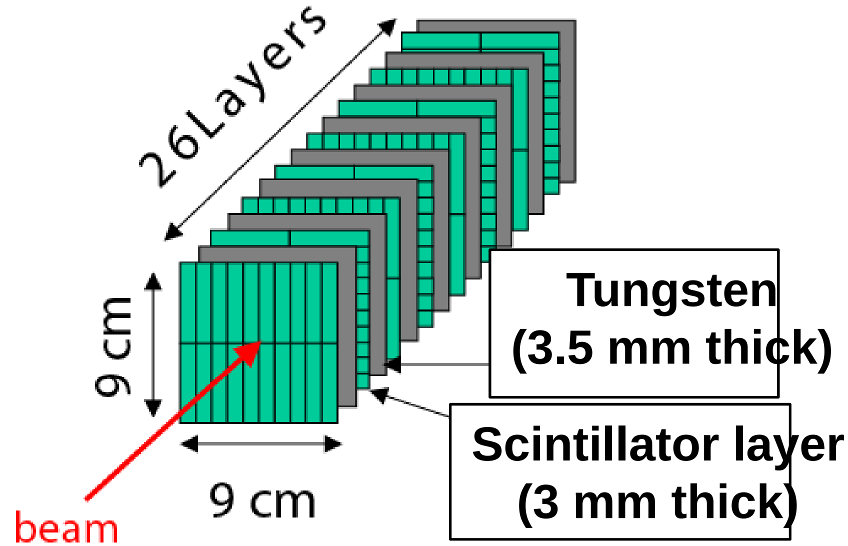
Calorimeter for ILC

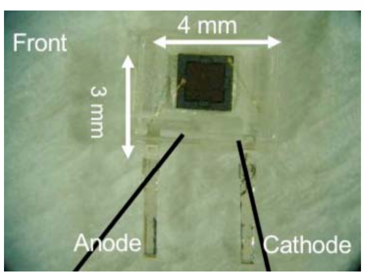


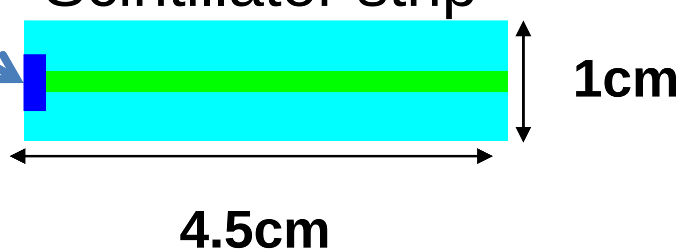
CALICE Scintillator-W ECAL

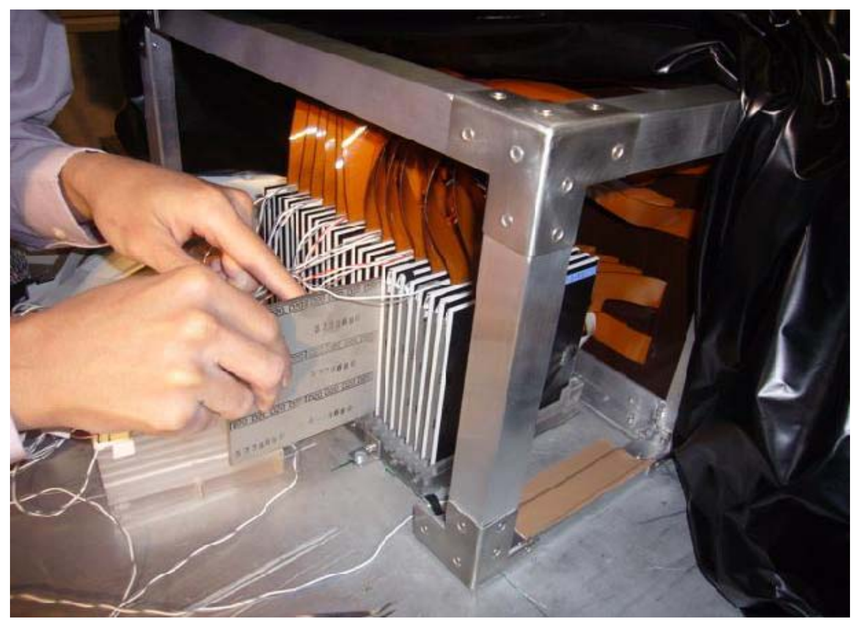
A ScECAL prototype has been exposed to 1-6 GeV e+ beam at DESY 03/07











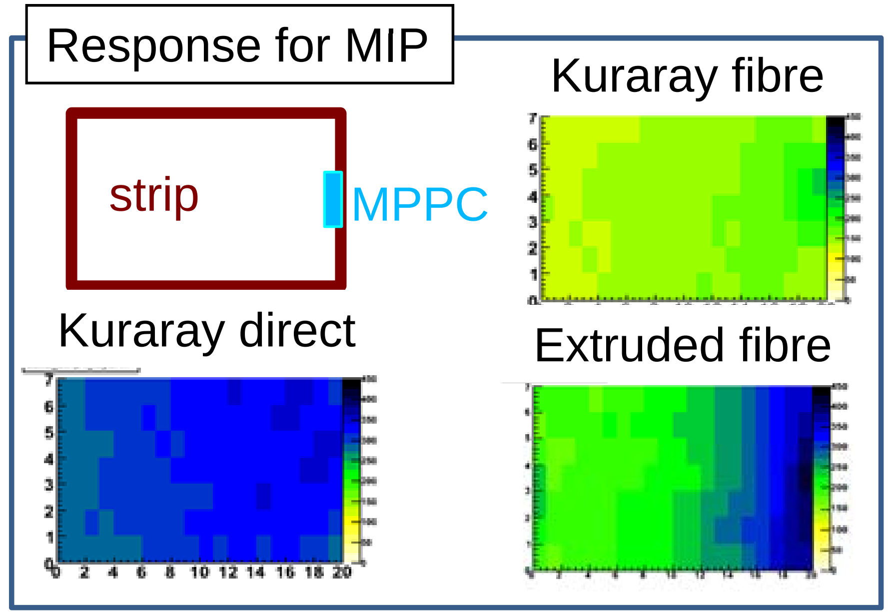
Scintillator-W ECAL BT results

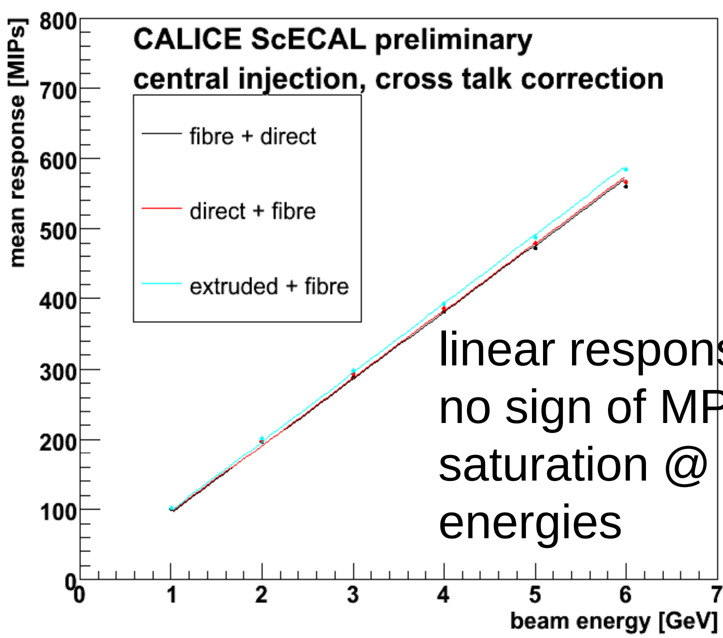
produced 3 half-modules (13 layers each)
with different scintillator types

tested 3 configurations

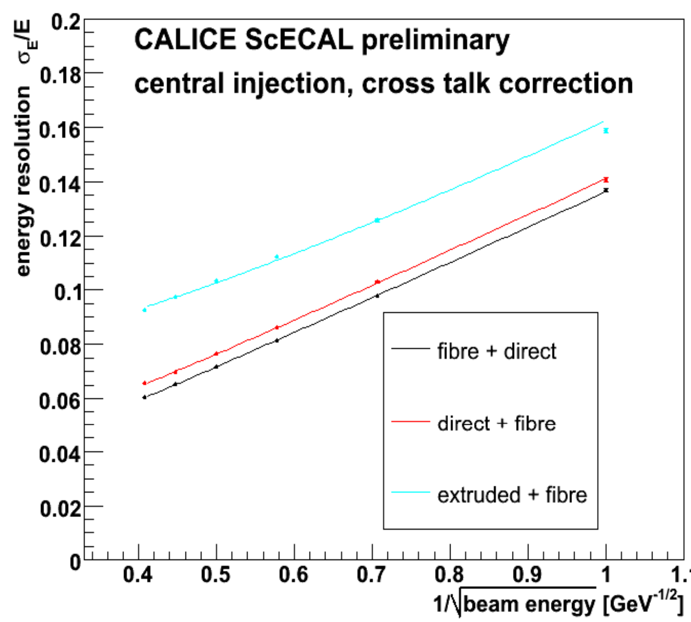
- Kuraray (fibre) + Kuraray (direct)
- Kuraray (direct) + Kuraray (fibre)
- Extruded (fibre) + Kuraray (fibre)

compare performance of configurations

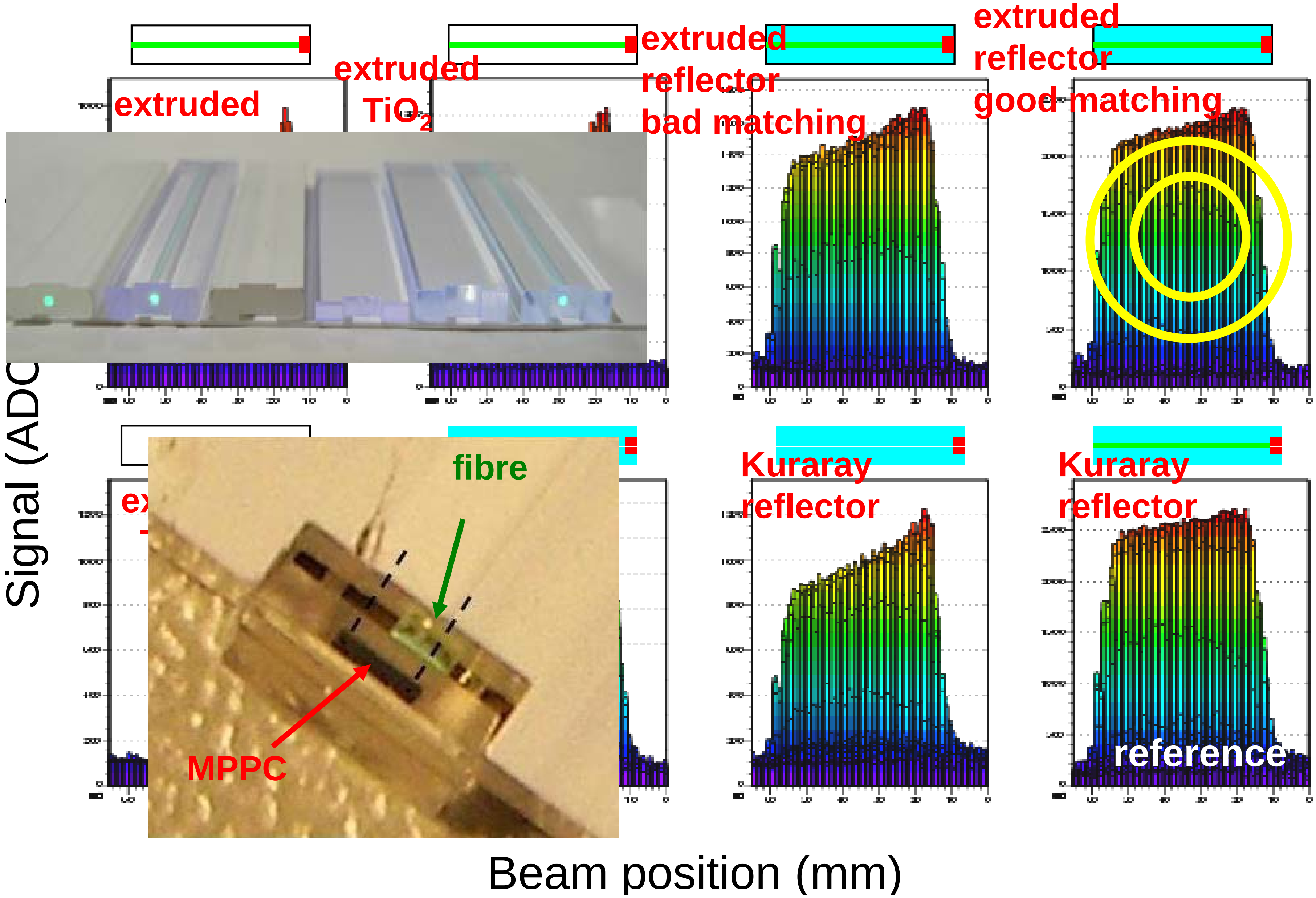




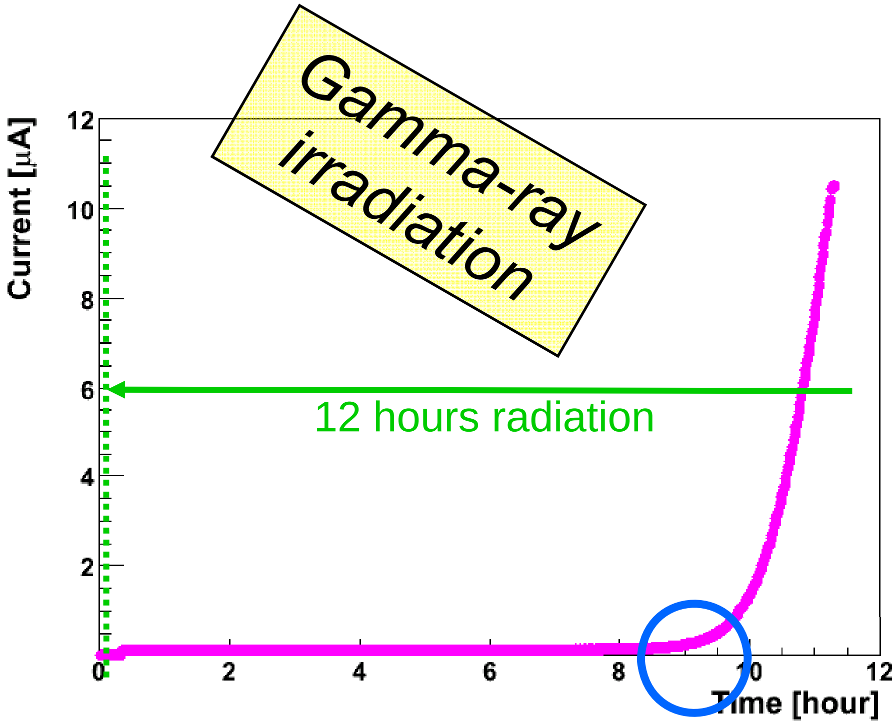
linear response :
no sign of MPPC
saturation @ higher
energies

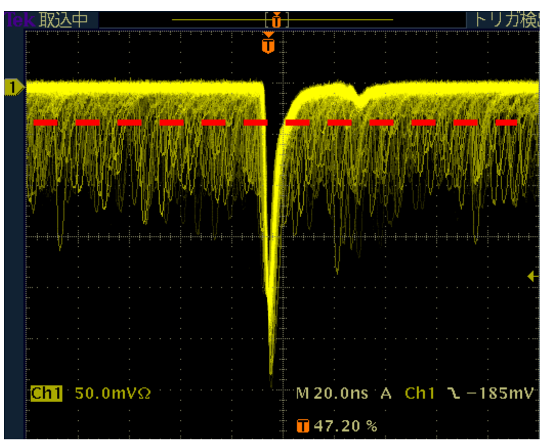


Improved scintillator-strip test
@ KEK e+ beamline



Scintillator-ECAL : MPPC radiation Resistivity





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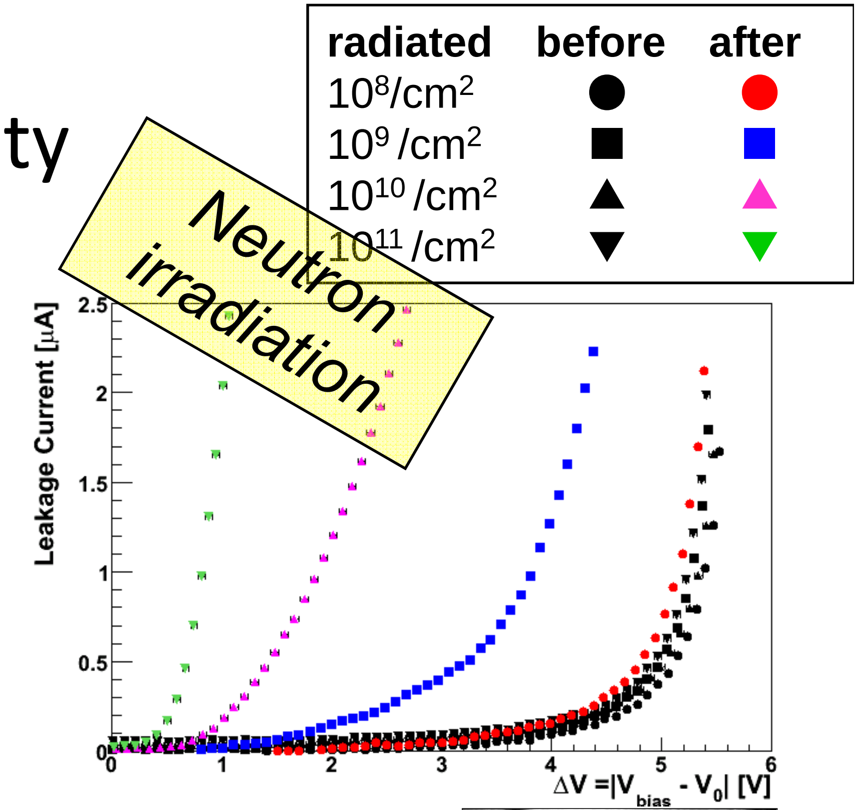
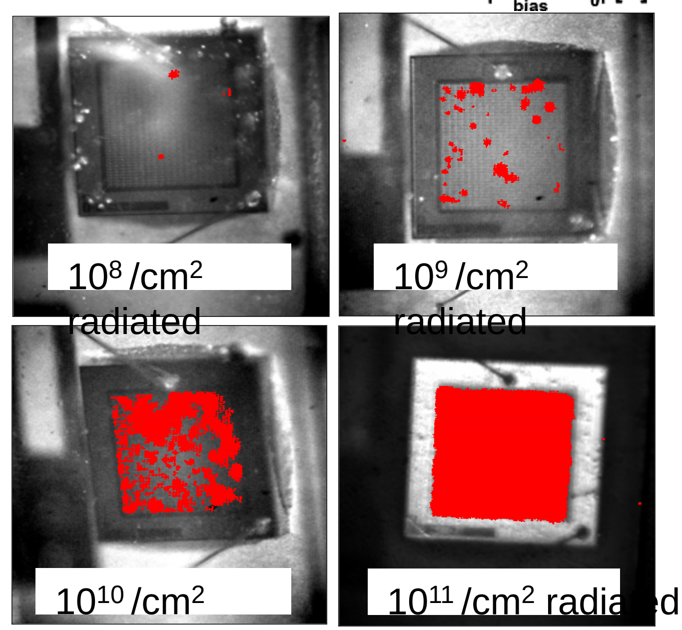
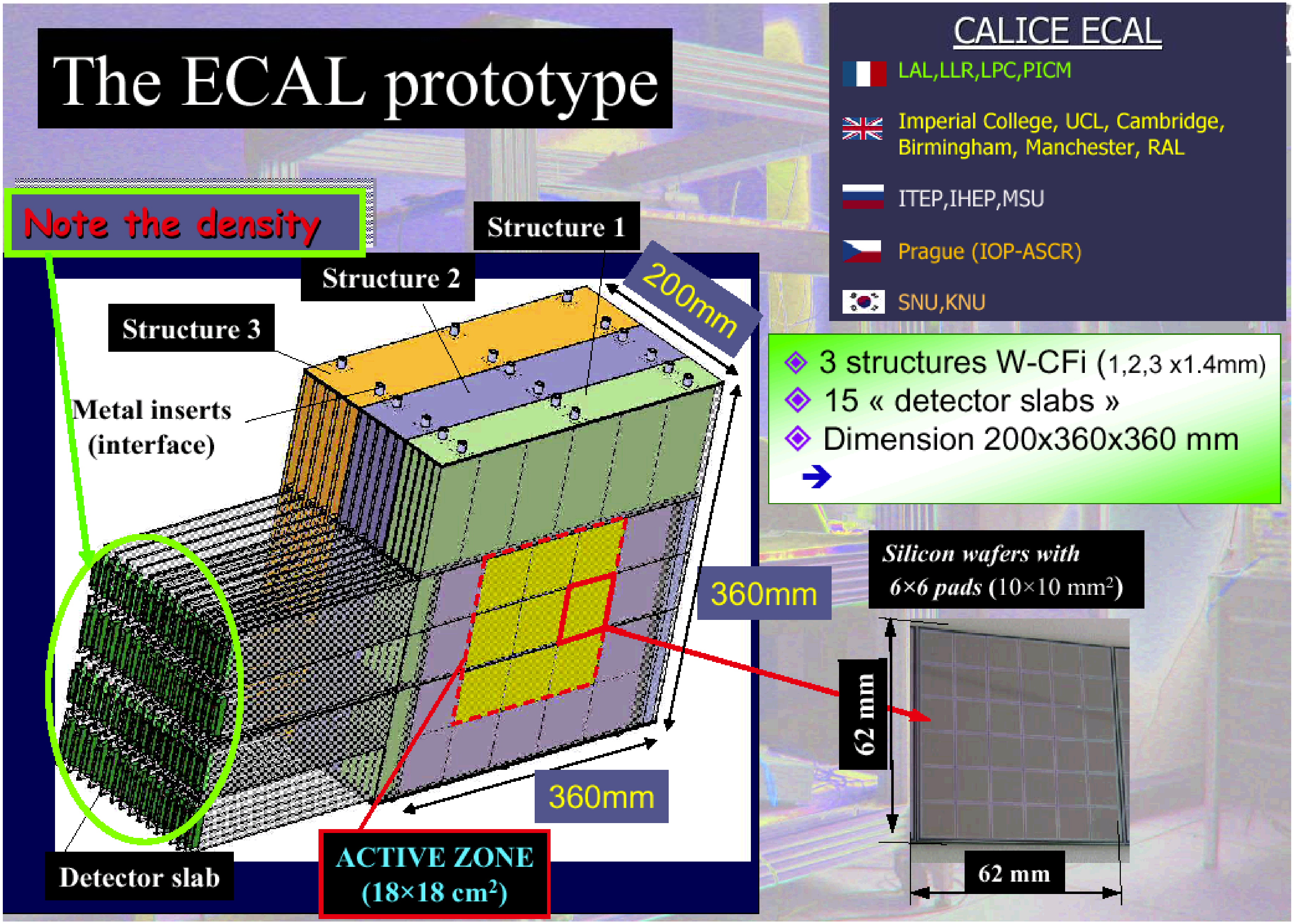


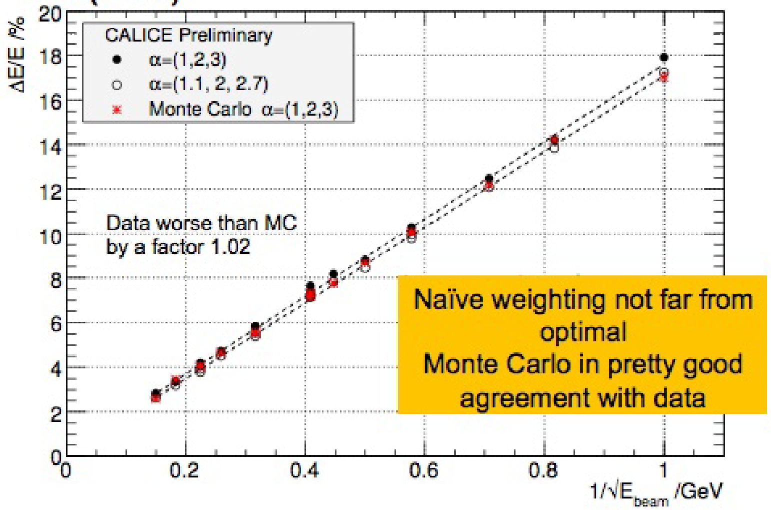


Silicon-W ECAL



Si-W ECAL : Beam Test Result (Energy Resolution)

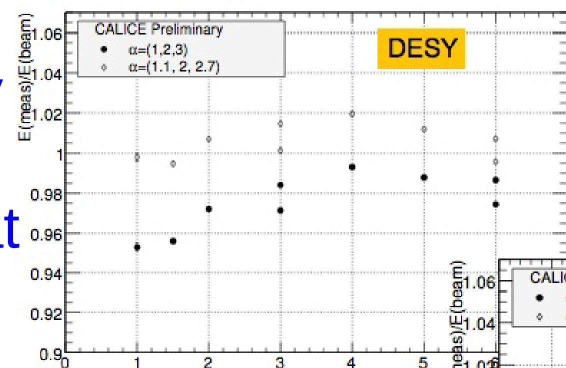
$$\frac{\Delta E}{E}(\%) = \frac{17.7 \pm 0.07}{\sqrt{E\,(\mathrm{GeV})}} \oplus (1.1 \pm 0.08) \qquad (\alpha_1, \alpha_2, \alpha_3) = (1, 2, 3)$$

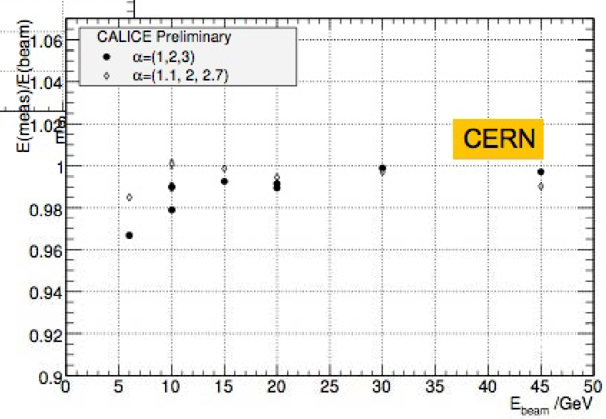


Statistical Term independant of "Sampling Factors"
Good description by Monte Carlo – Mokka/G4
Correct weighting under investigation

$$\frac{\Delta E}{E}(\%) = \frac{17.1 \pm 0.07}{\sqrt{E\,(\mathrm{GeV})}} \oplus (0.5 \pm 0.15) \qquad (\alpha_1, \alpha_2, \alpha_3) = (1.1, 2, 2.7)$$

Low Energy points measured at DESY May 06

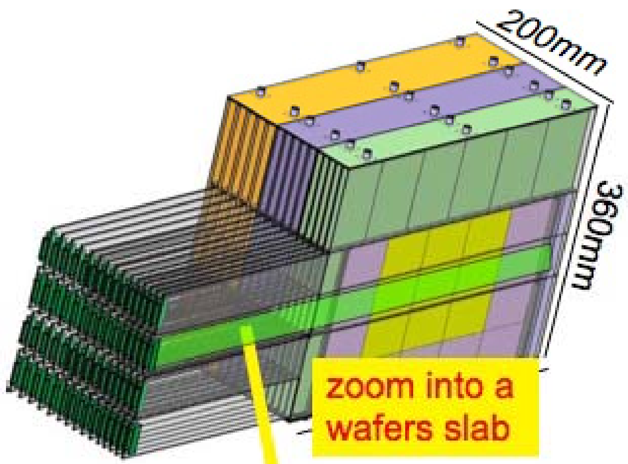


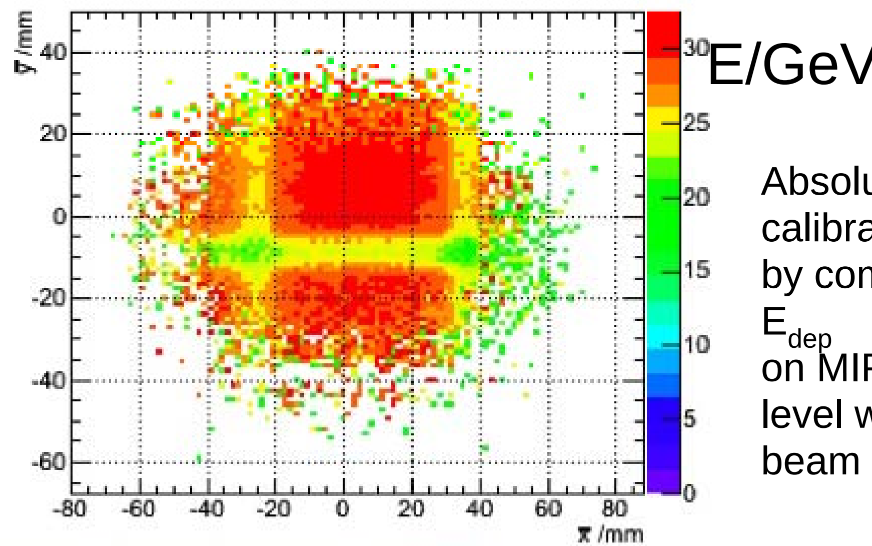


High Energy Points measured at CERN Summer/Autumn 06

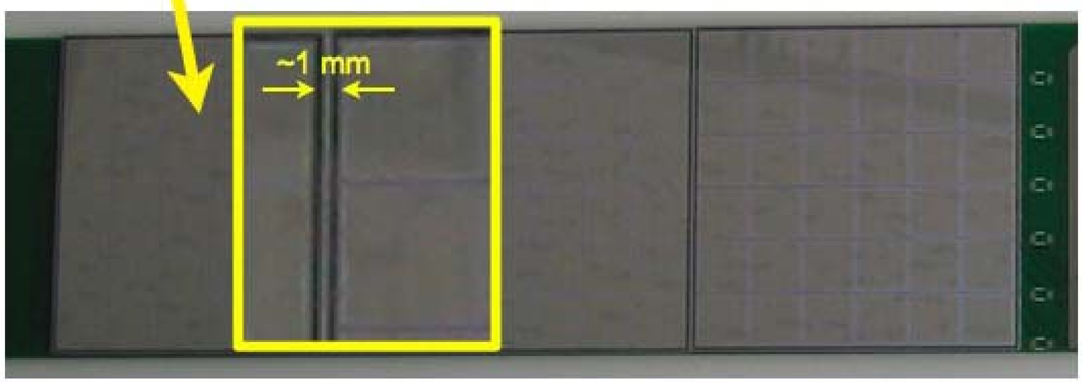
SiW-Ecal : Beam Test Result

Dips in energy measurement by inter wafer gaps (needed for isolation)





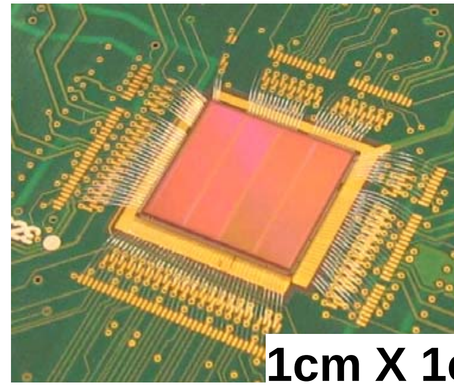
Absolute calibration by comparing E_{dep} on MIP level with beam energy



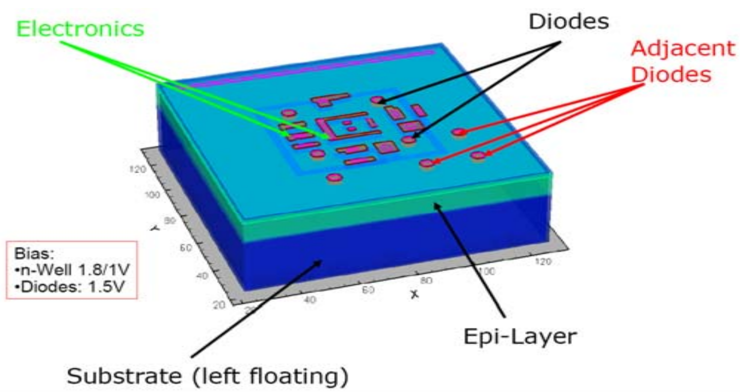
Need to take geometrical acceptance into account

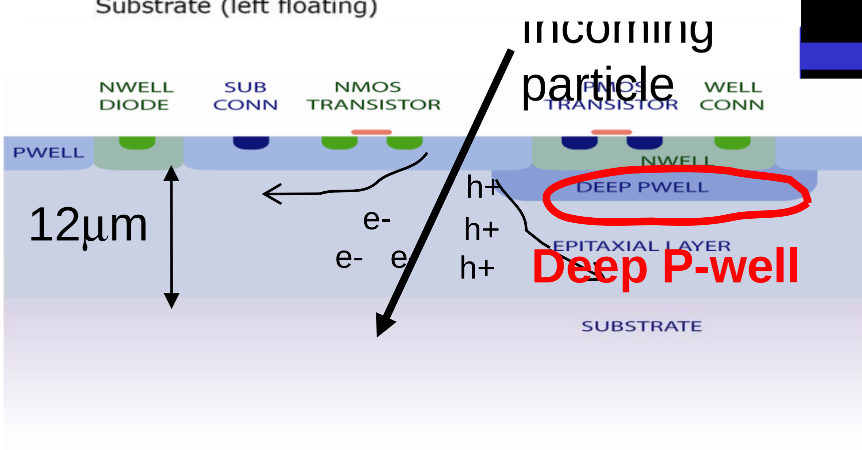
MAPS (Monolythic Active Pixel Sensor) ECAL

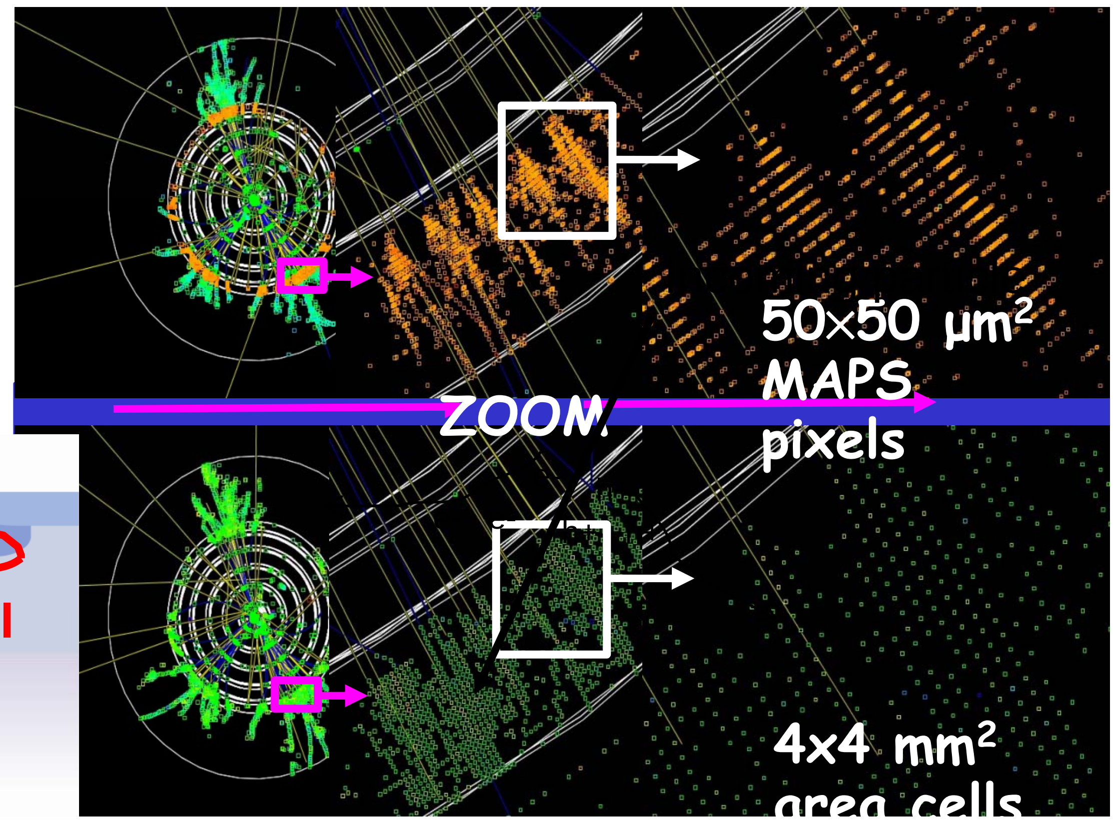
- Extremely fine segmentation
  (cell size ~ 50 x 50 μm)
- Very low hit occupancy
- Low cost solution in Si-W ECAL
- Charge accumulated in diffusion effect
- Dead area ~ 11 %



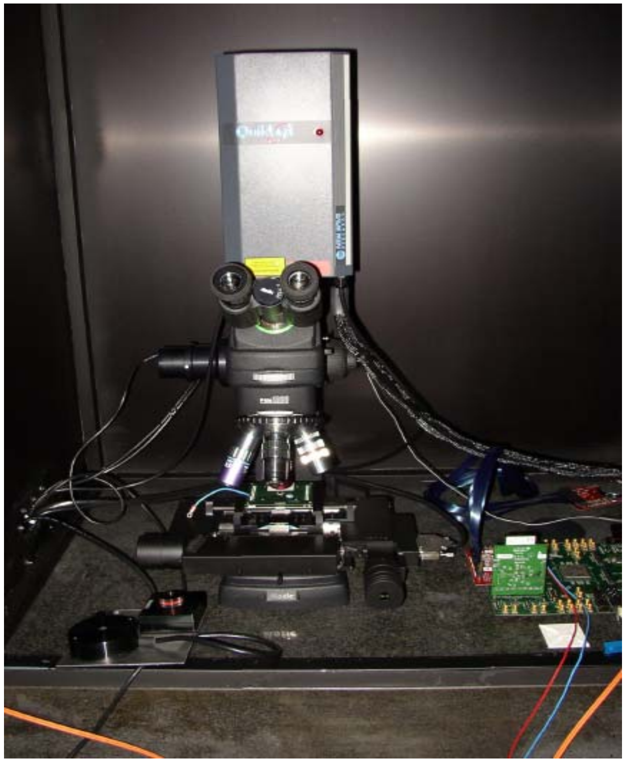
1cm X 1cm sensor







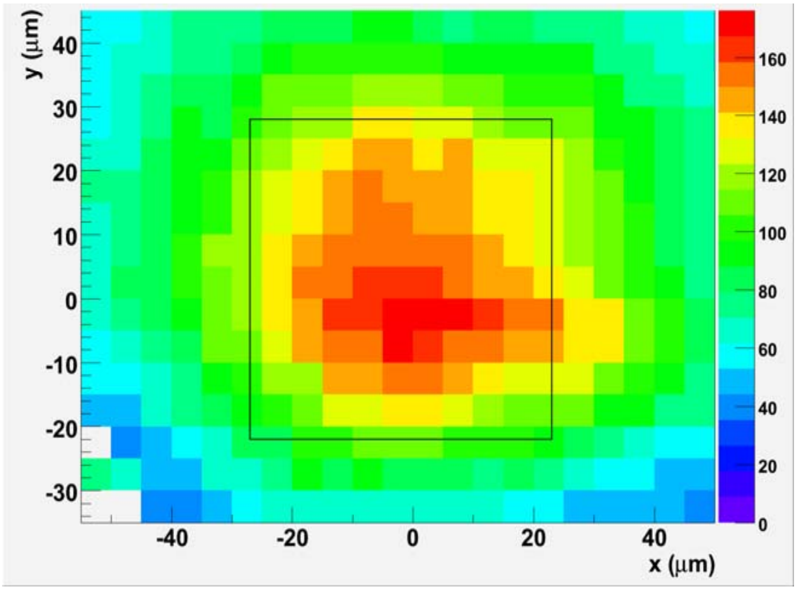
MAPS ECAL : Laser Scan (Preliminary)



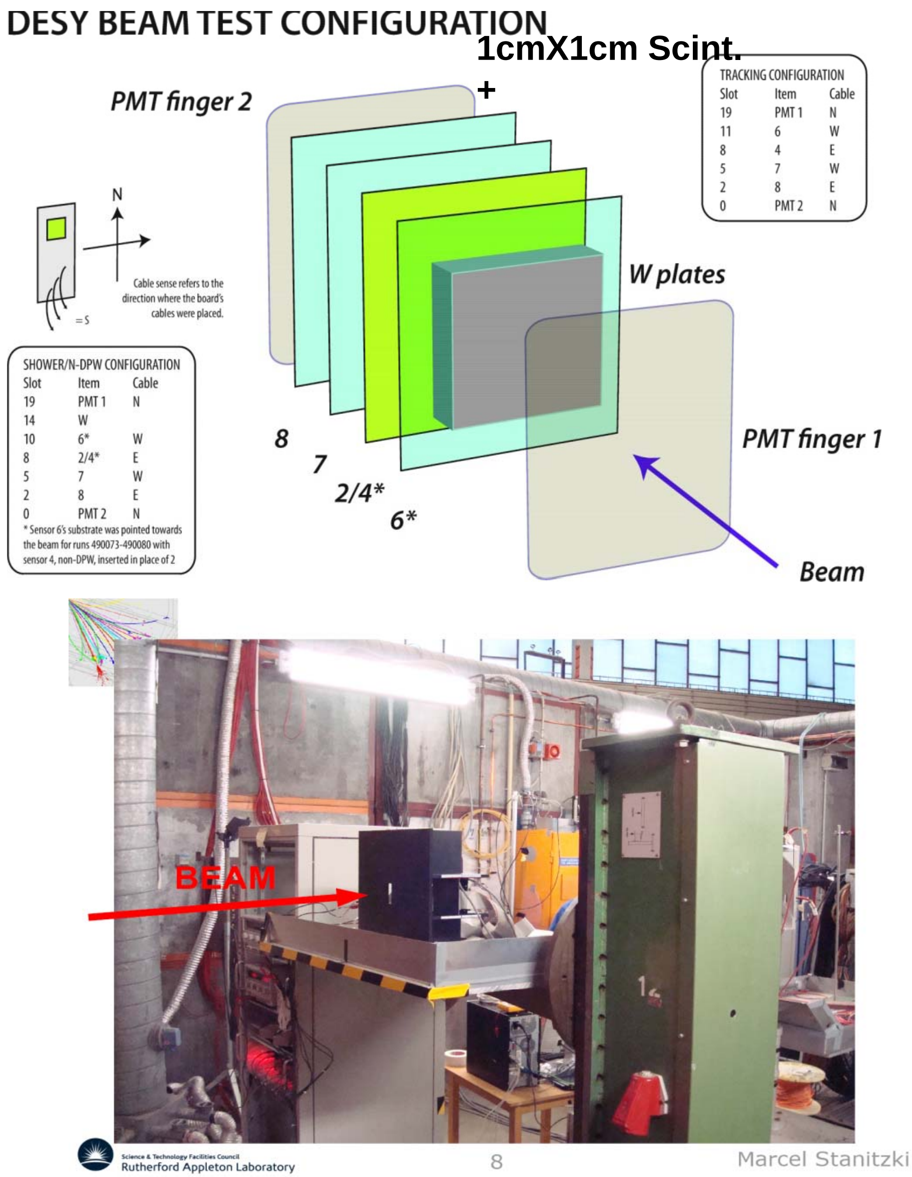
Focussed Laser

- **4ns pulse at 1064nm wavelength**
- **Focussed to 4x4 μm^2 on rear of sensor**
- **Uncalibrated analogue signal**
- **Step by 5μm in x and y**
- **Record & plot signal size for each position**

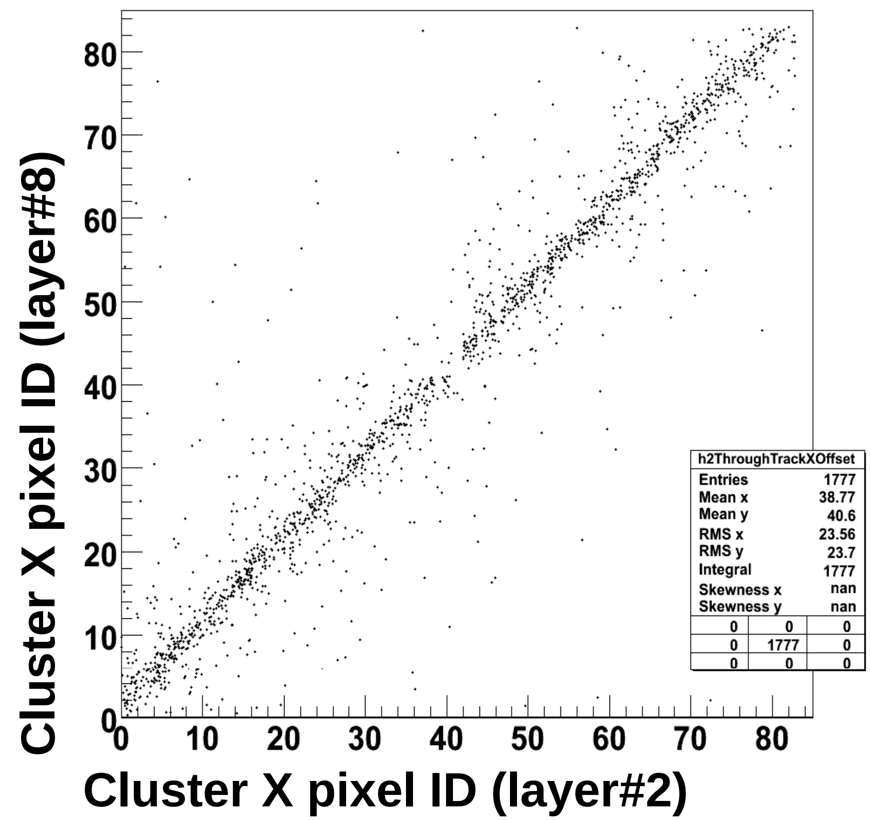
12μm epitaxial-layer + Deep P-well



MAPS ECAL : DESY Beam Test (Dec 2007)
First test with 1-6GeV e+ with 4 layers



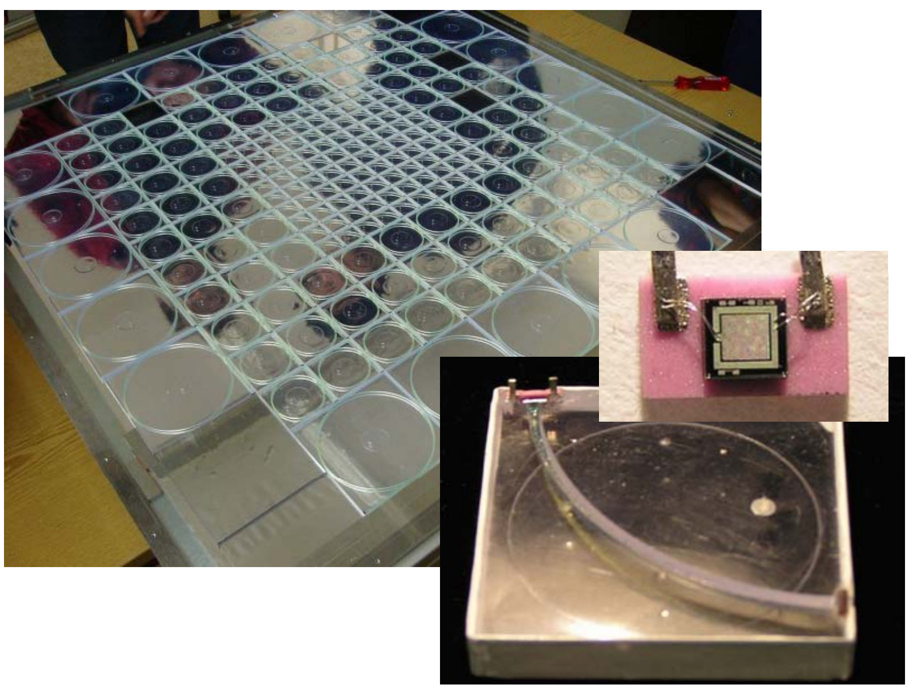
Example for
X correlation plot of two layers
(Very preliminary)



CALICE Scintillator HCAL

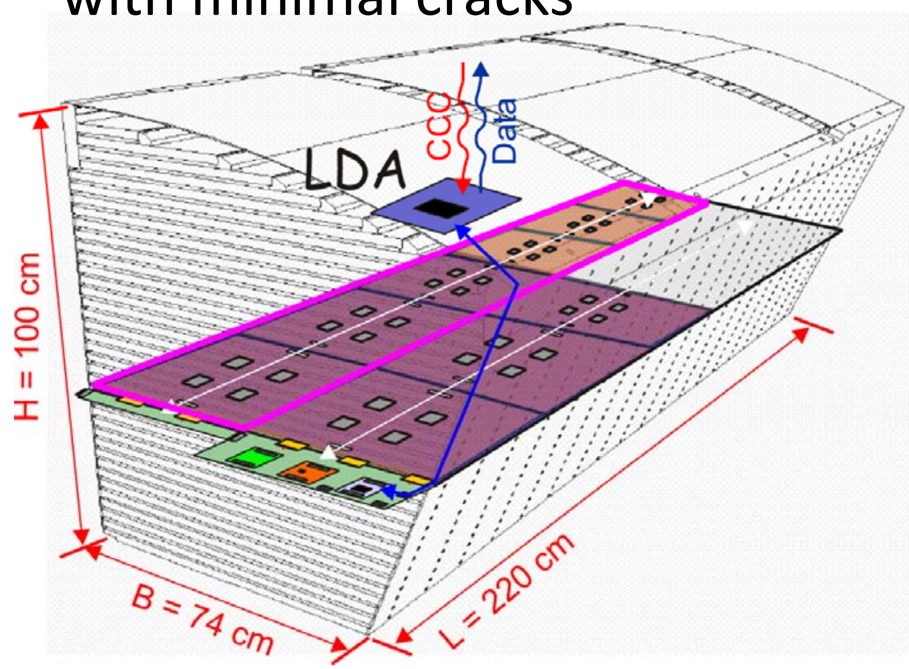
Current Prototype :

- Steel scintillator sandwich
- 38 layers, 2cm steel absorbers
- Scintillator tiles 3x3x0.5cm^3
- 7608 SiPMs (MEPhI / Pulsar)



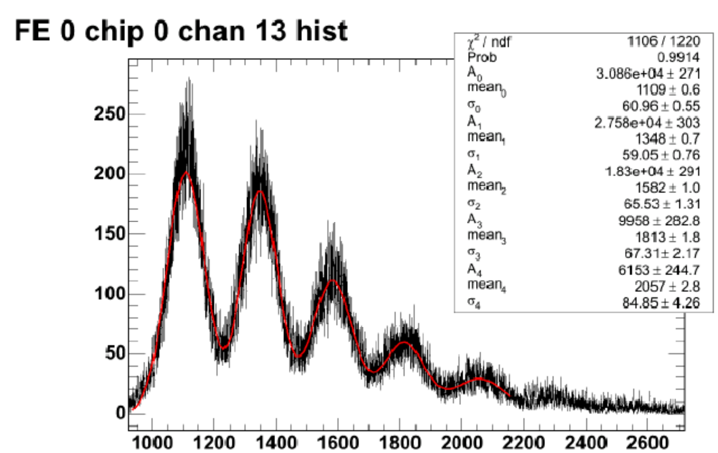
→ Technical prototype (near future)

- Realistic structure with embedded electronics
- Realistic test with calibration system, absorber mechanics with minimal cracks



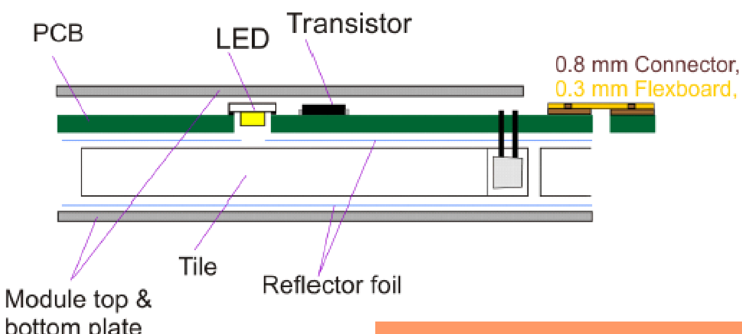
Auto-calibration

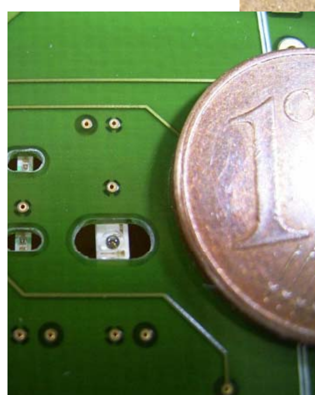
- With single photo-electron (pixel) peaks the pixel photo-diode provides its own reference scale
- Promising tool for monitoring temperature-induced response variations
- Opens possibilities for further simplification of calorimeter design
  - No external reference
  - Small amplitudes
  - Loose stability requirements
- Stability of saturation correction
  - Under study, so far OK

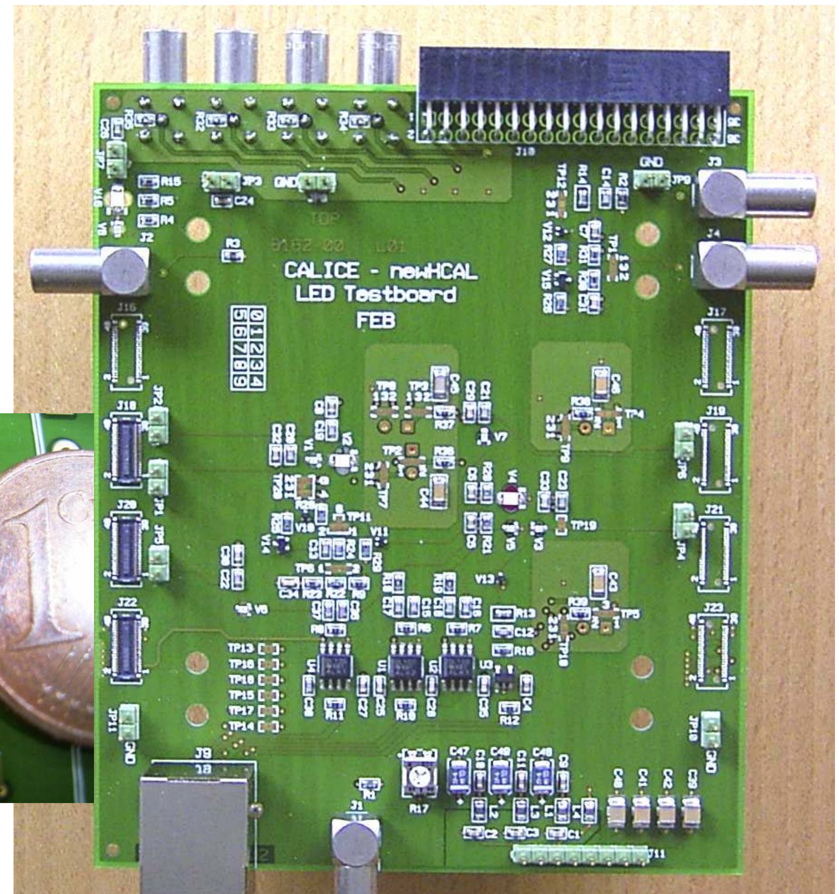


LED on board

- Attractive option - **if** auto-calibration of SiPM sufficient
- Proof-of-principle test borad, check for cross-talk, uniformity, dynamic range,…





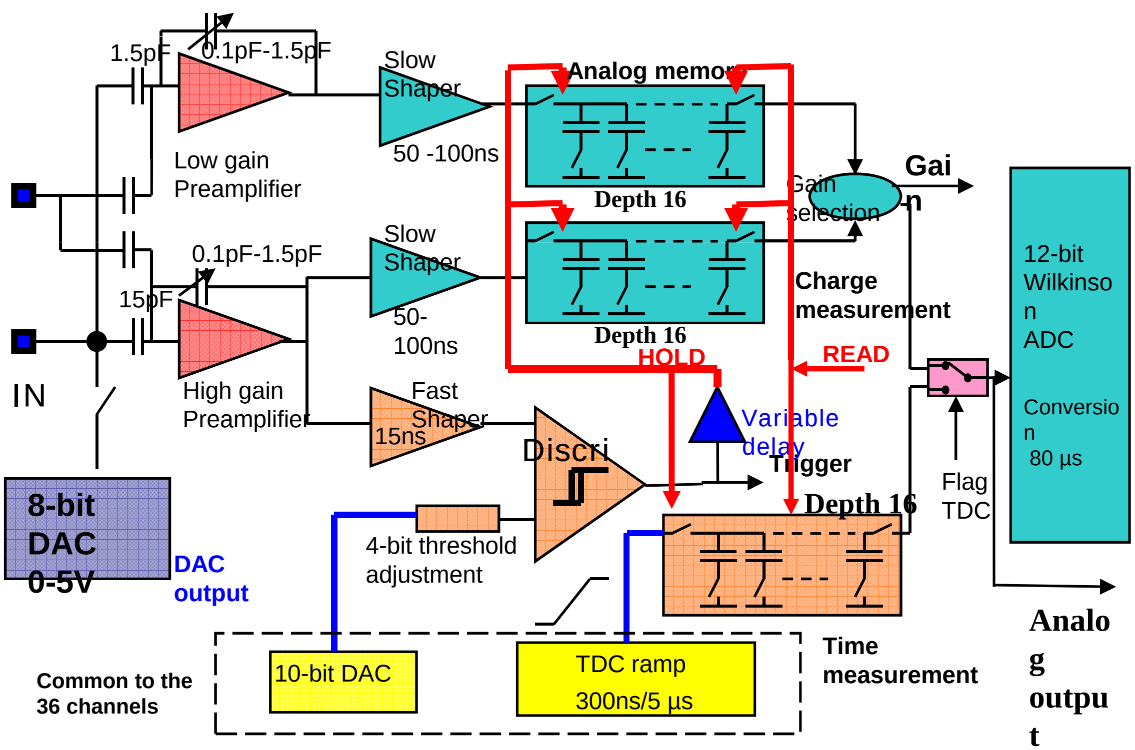


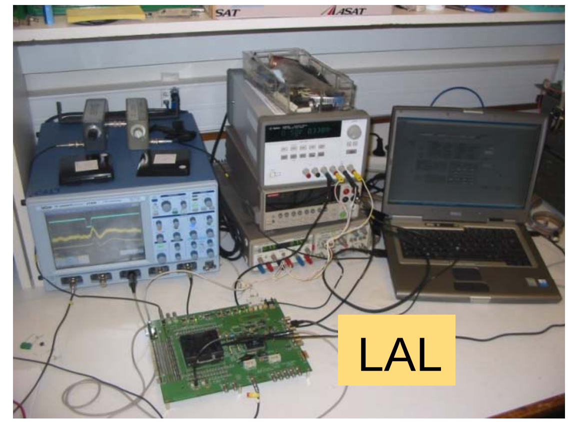
First tests:
electrical cross-talk small

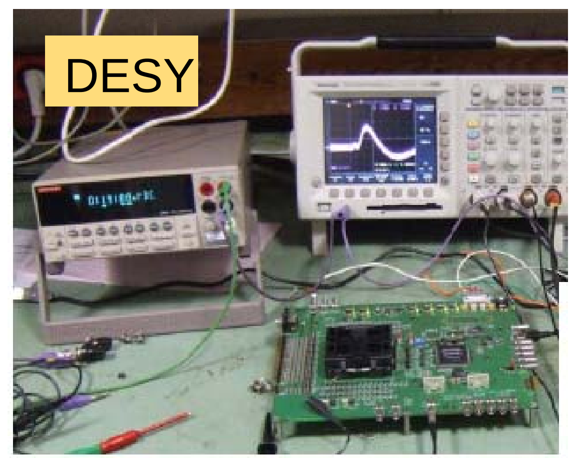
M.Reinecke, DESY

New ASIC on the test benches

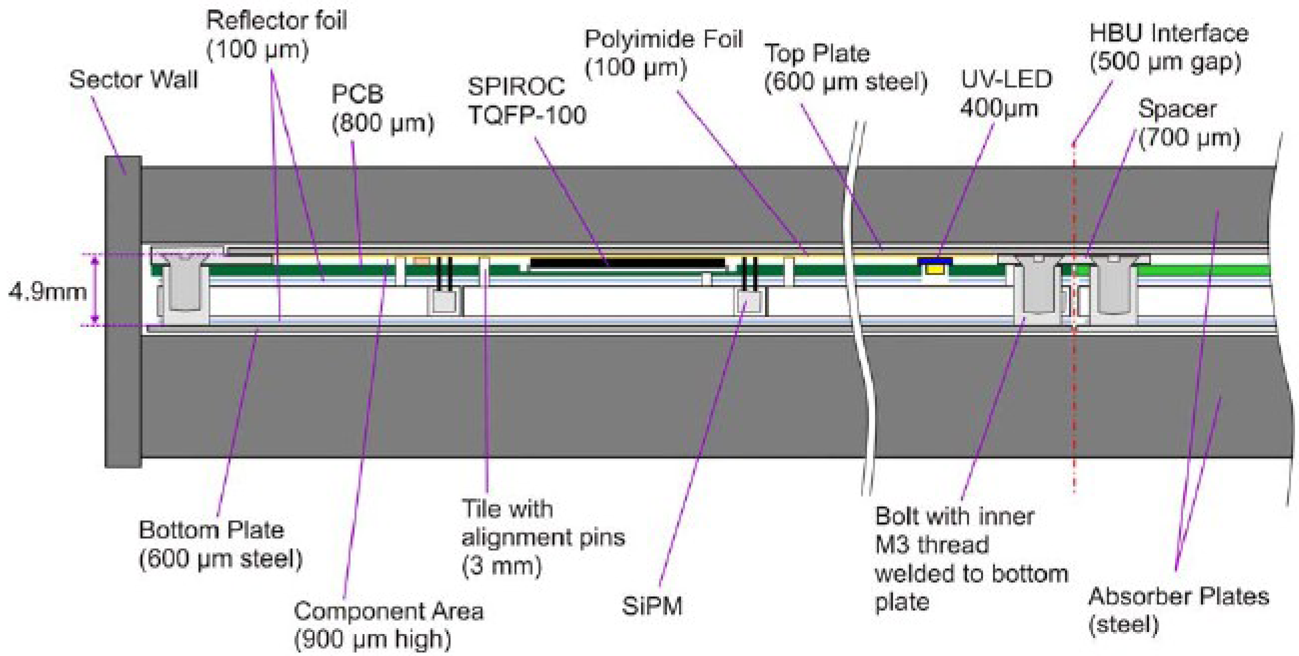
- Auto-triggering and time measurements
- ADC and TDC integrated
- Power pulsing, low (continuous)

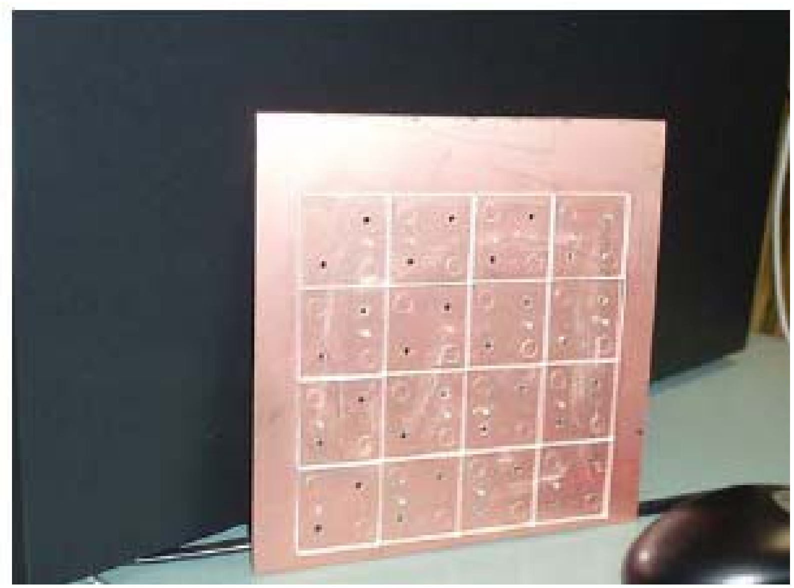






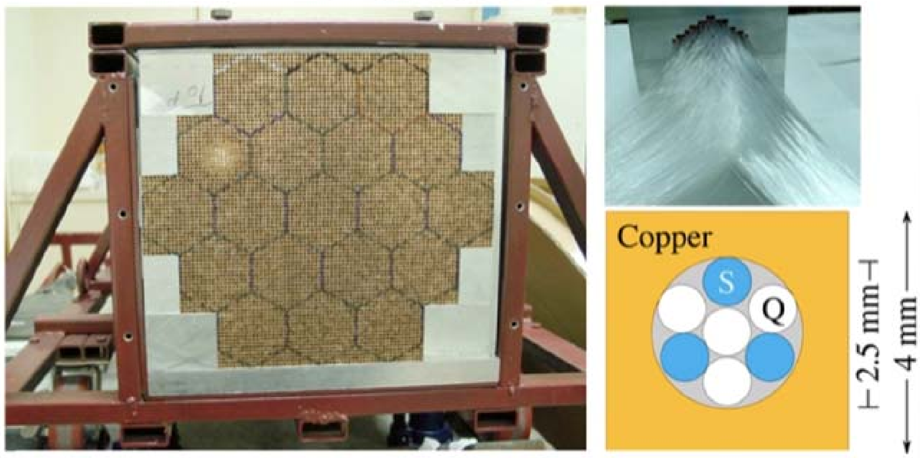
IRL for CALICE Scintillator-HCAL

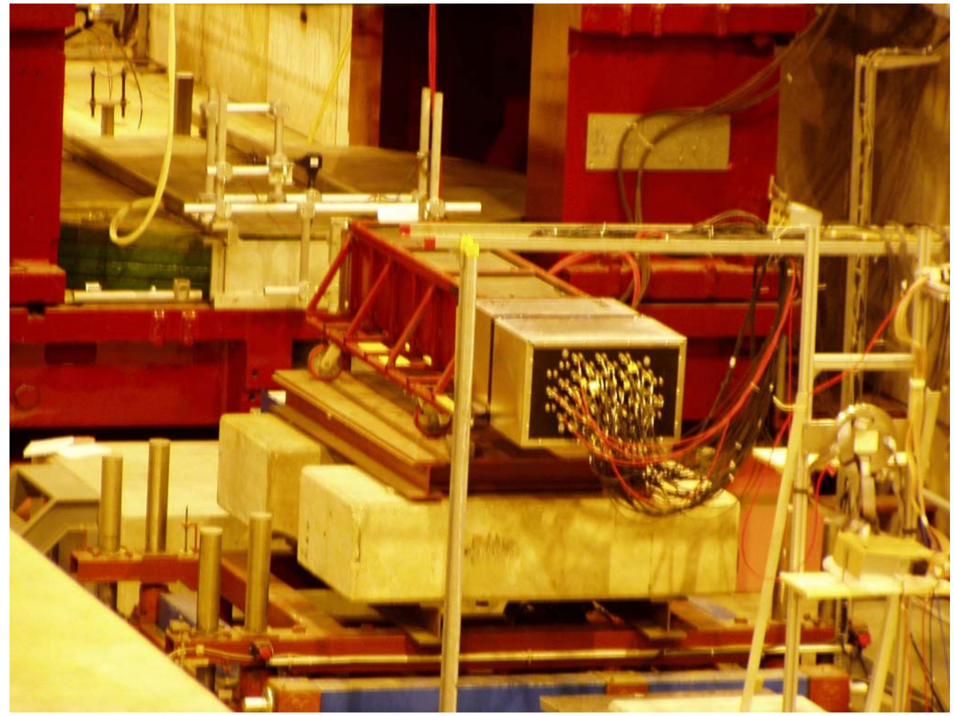




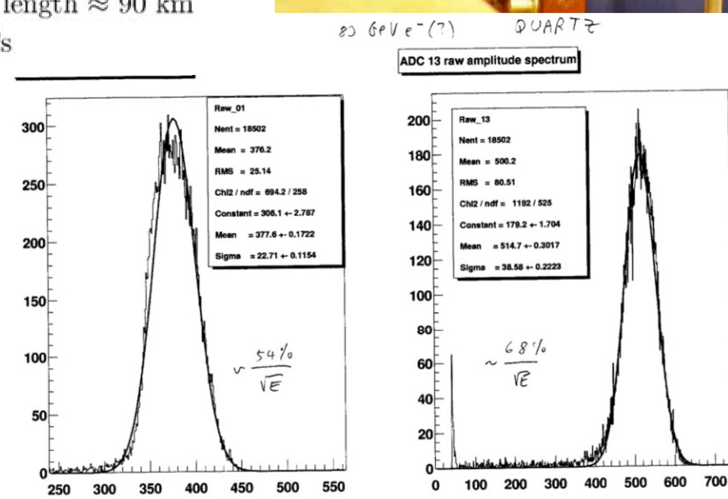
Dual-readout calorimeter : Beam Test

DREAM: Structure

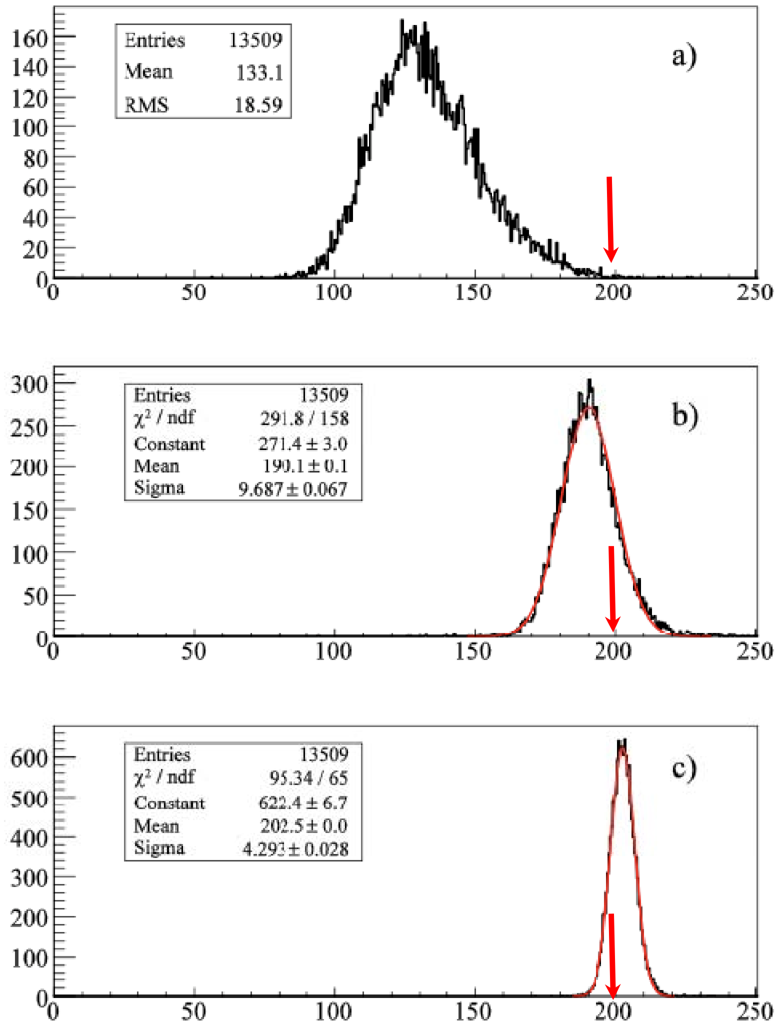




- *Some characteristics of the DREAM detector*
  - Depth 200 cm (10.0 λ_{int})
  - Effective radius 16.2 cm (0.81 λ_{int}, 8.0 ρ_M)
  - Mass instrumented volume 1030 kg
  - Number of fibers 35910, diameter 0.8 mm, total length ≈ 90 km
  - Hexagonal towers (19), each read out by 2 PMTs



DREAM data: 200 GeV π^- energy response



Scintillating (S) fibers only

Dual-readout of S and Cerenkov (C)

f_{EM} □ $(C/E_{shower} - 1/|_{C})$

(4% leakage + neutron BE loss fluctuations, and limited by photoelectron statistics in C)

Dual-readout of S and C:

f_{EM} □ $(C/E_{beam} - 1/|_{C})$

(suppresses leakage and BE fluctuations; too optimistic)

Data NIM A537 (2005) 537.

We are measuring (DREAM) and calculating (ILCroot) (i) neutrons, (ii) a full ILC detector, (iii) Cerenkov pe statistics, and (iii) two different crystals, to understand and improve this.

Summary

- Very successful CAL sessions, many reports, useful discussions.
- Each talk shows much updates and good prospects.
    - Analysis of several beam tests extensively ongoing.
    - Many groups expect to have beam tests.
- Many more interesting results are expected in this “Beam-test year”!