SiW ECAL

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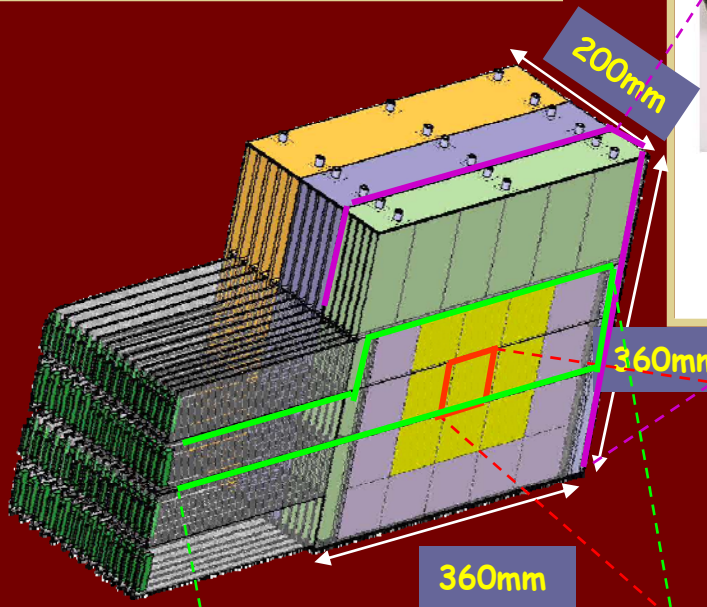
LCWS '08, Chicago

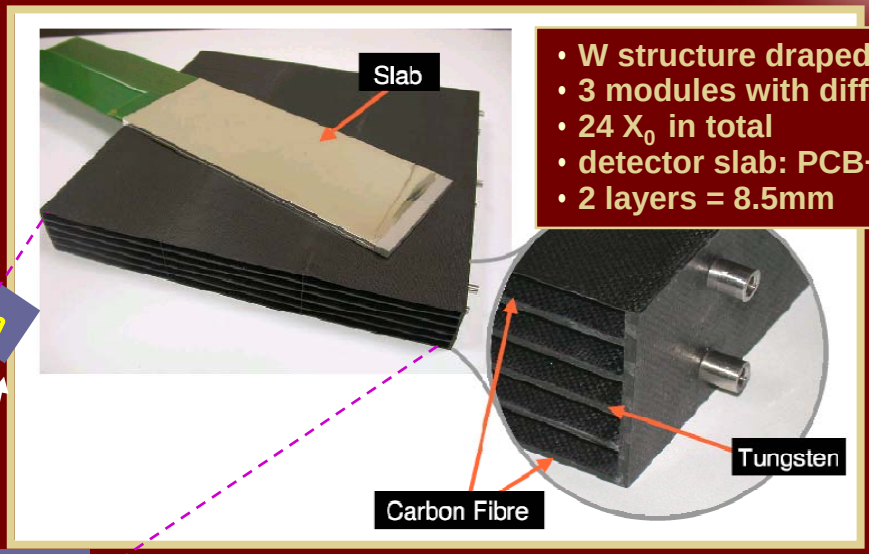
Overview

1. The CALICE SiW ECAL prototype
   - Test beam efforts
   - Test beam at FNAL ‘08
   - 2006 Test beam: results
   - Encountered dificulties
   - Ongoing studies
2. The SiW ECAL EUDET module
   - Module design
   - What EUDET will make better
   - Demonstrator

The SiW ECAL prototype

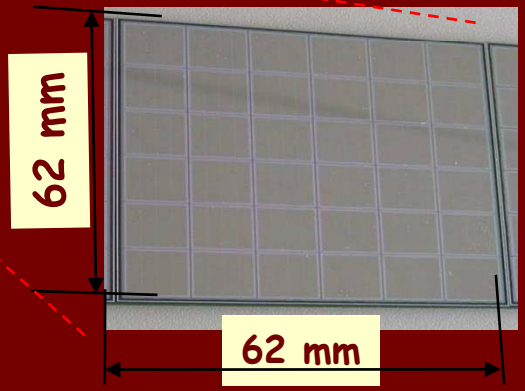
- 60 PCBs (30 layers)
- 216 channels/PCB (centre)
- 108 channels/PCB (bottom)
- 9720 total channels





- W structure draped in carbon fibre
- 3 modules with different W thickness
- 24 X_0 in total
- detector slab: PCB+Si+W+Si+PCB
- 2 layers = 8.5mm

6x6 1x1cm² Si pads glued conductively to PCB



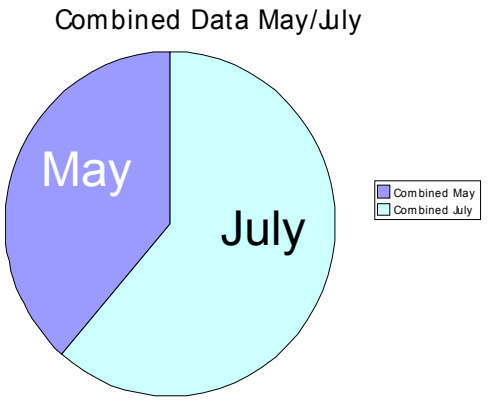
Test Beam Efforts

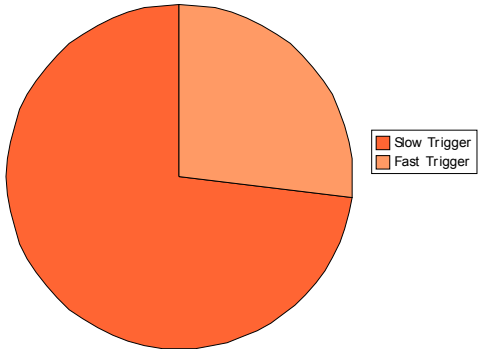
- First tests in 2005 (DESY)
- 2006: TB at DESY – 5184 channels
  - e^- from 1 to 6 GeV
- 2006: TB at CERN – 6480 channels
  - e^-/e^+ from 6 to 45 GeV, π^-/π^+ from 6 to 60 GeV
- 2007: TB at CERN – up to 9072 channels
  - e^-/e^+ from 6 to 90 GeV, π^-/π^+ from 6 to 180 GeV
- 2008: TB at FNAL – 9720 channels
  - e^-/e^+ from 1 to 30 GeV, π^-/π^+ from 1 to 60 GeV

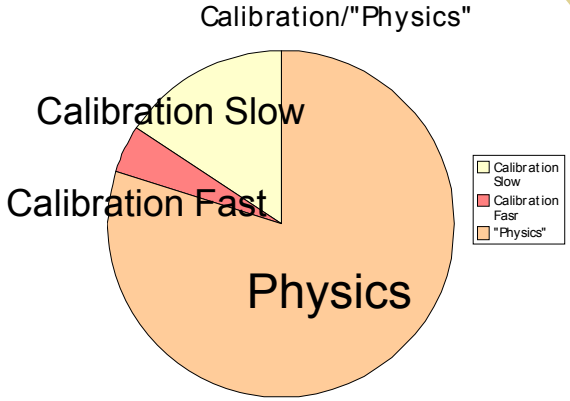
-

All tests including different impact angles!

TB @ FNAL 2008

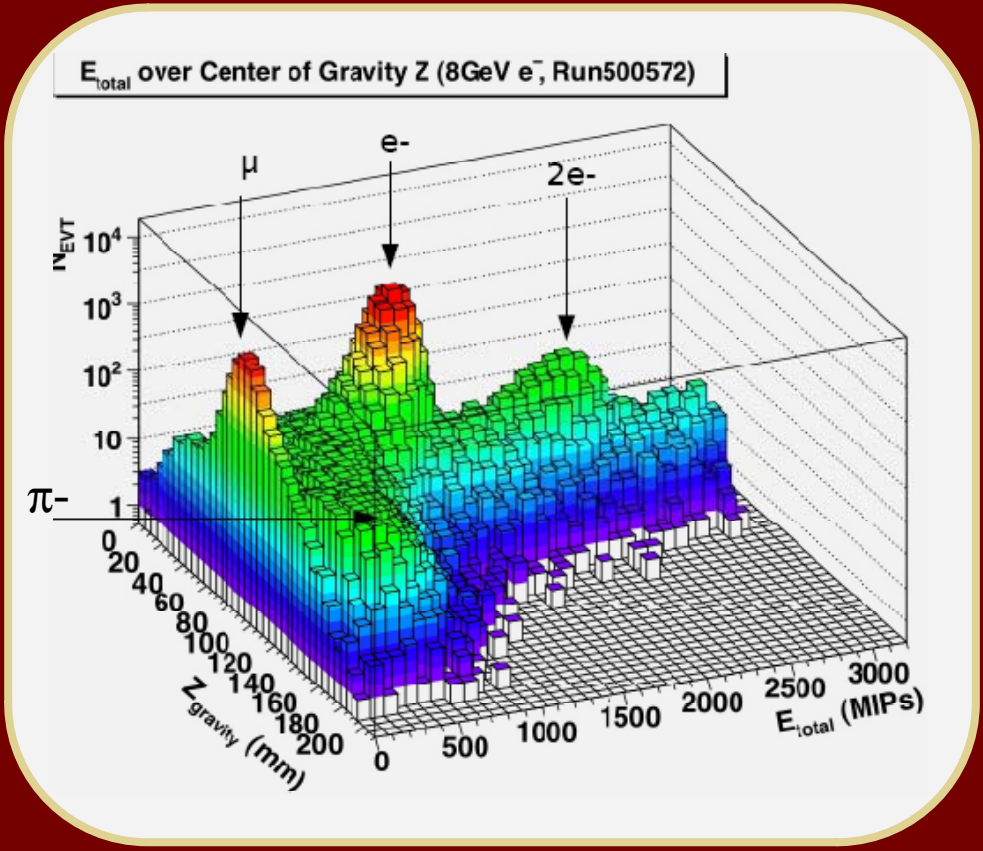






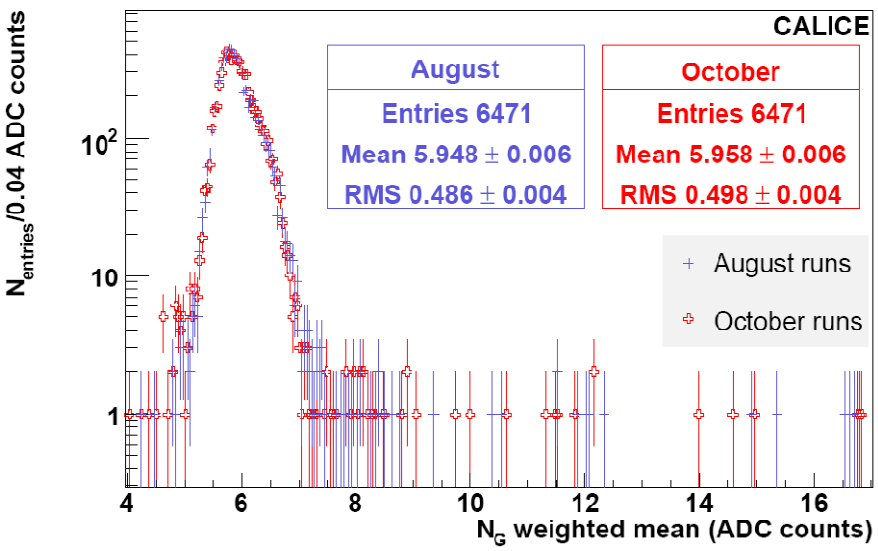
Added 17.3 MEvents to the existing tb data!

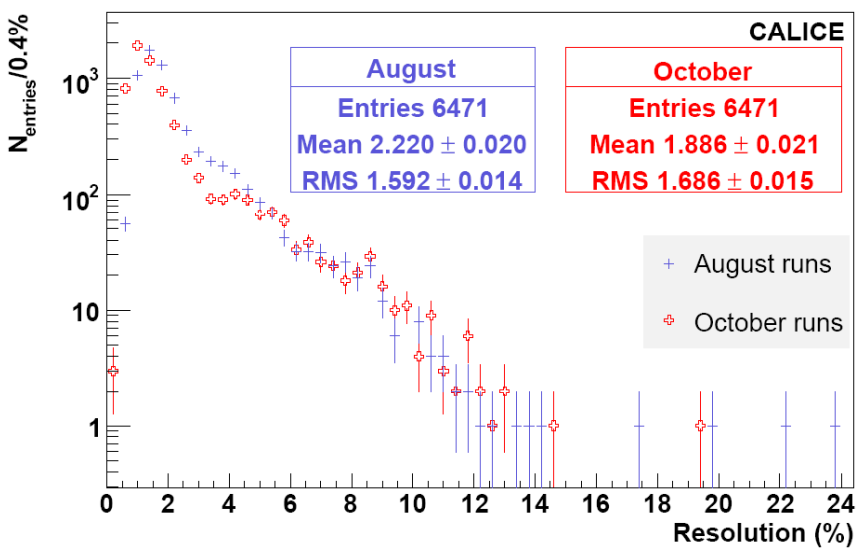
TB @ FNAL 2008



- Large muon contamination
- Multi-particle events (up to 5 π^-)
- Particle types are separated clearly in the ECAL

TB 2006: Noise





Mean noise = 12.9 ± 0.1 % of a MIP

S/N = 7.75

Taken from:

"Design and electronics commissioning of the physics prototype of a Si-W electromagnetic calorimeter for the International Linear Collider"

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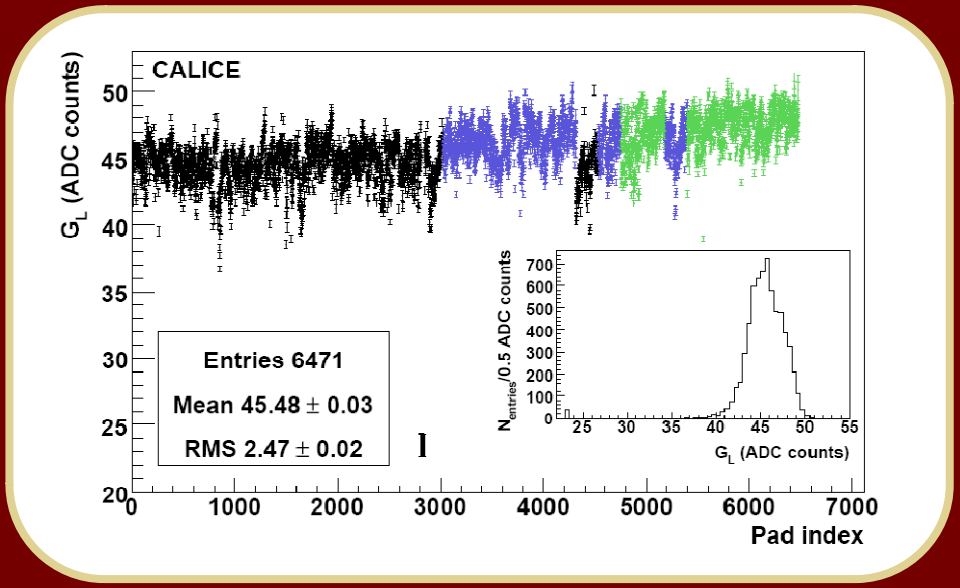
TB 2006: Calibration



- Only 9 out of 6480 cells without response = 0.14%
- Response level depends on
  - Production series (black-blue)
  - Manufacturer (black/blue – green)

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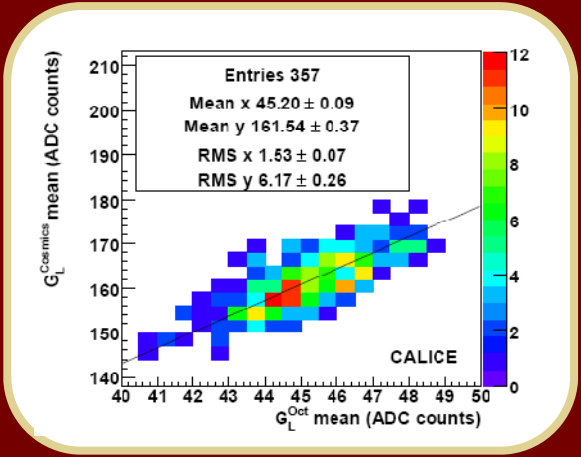
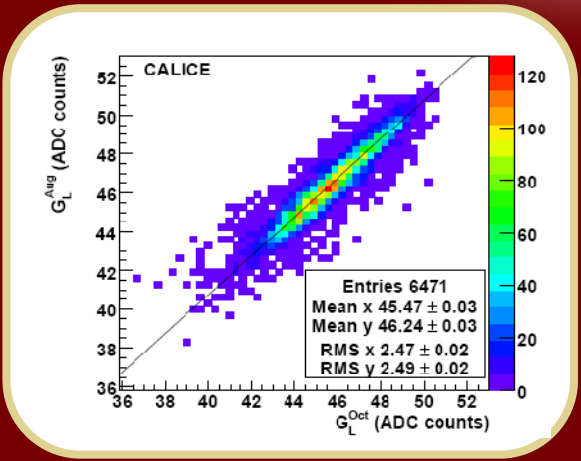
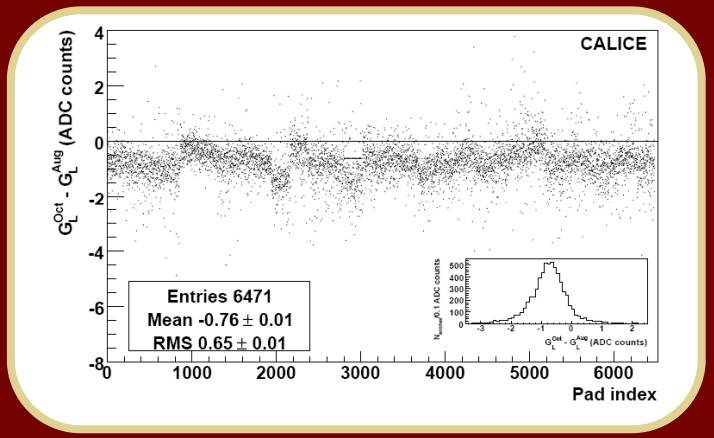
TB 2006: Calib. Stability





- Good correlation between cosmic test bench measurements (**2004**) and **2006** data, as well as between 2 data taking periods (Aug-Oct ’06)
- Offsets from differences in DAQ and trigger system
- Detector is stable in the long-term!



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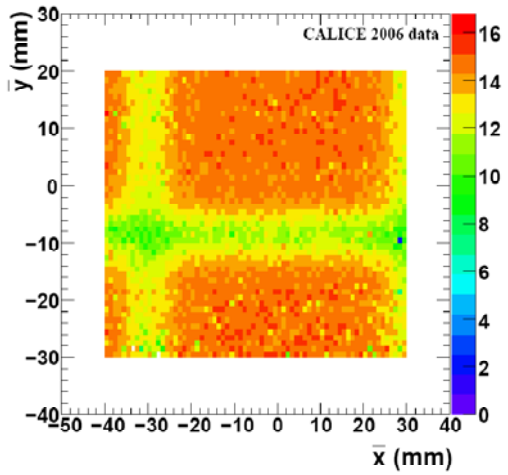
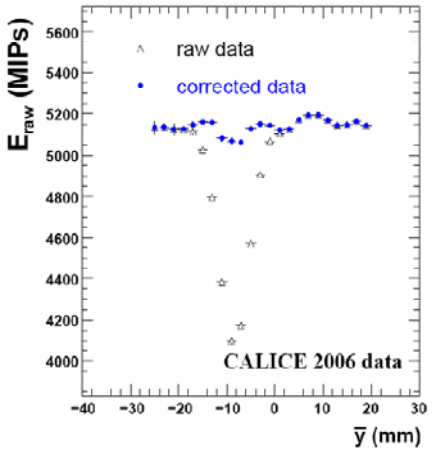
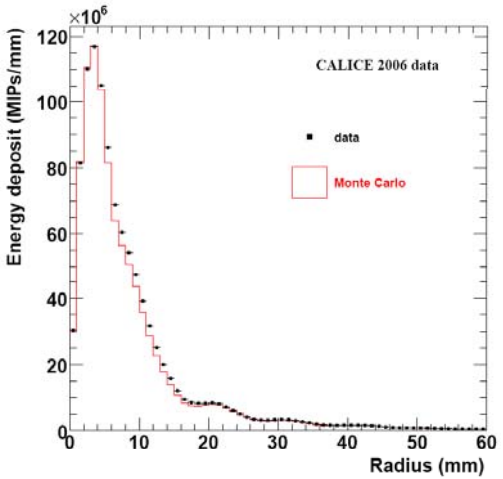
TB 2006: Event selection

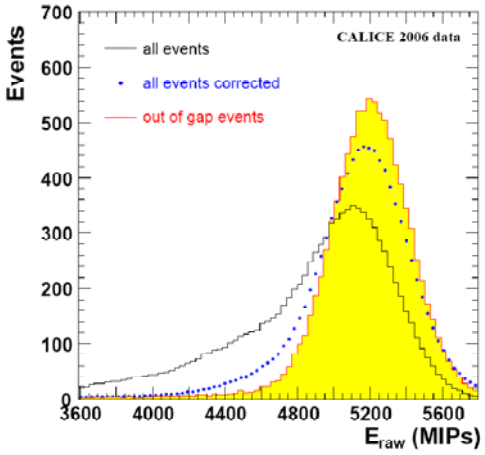


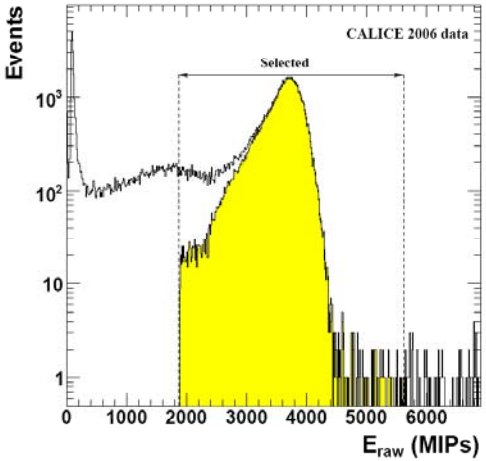




17.2mm from x gap
12.76mm from y gap
32mm from detector edge
Cerenkov counter

$$125 < \frac{E_{raw}(MIP)}{E_{beam}(GeV)} < 375$$





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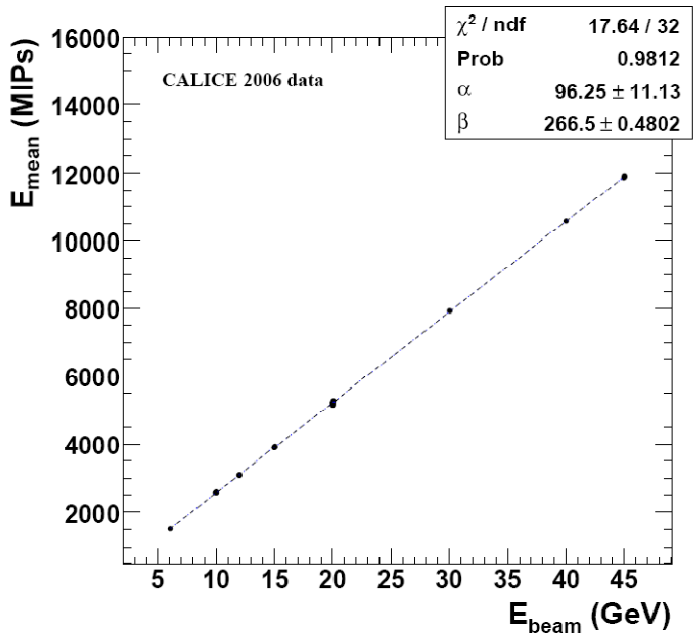
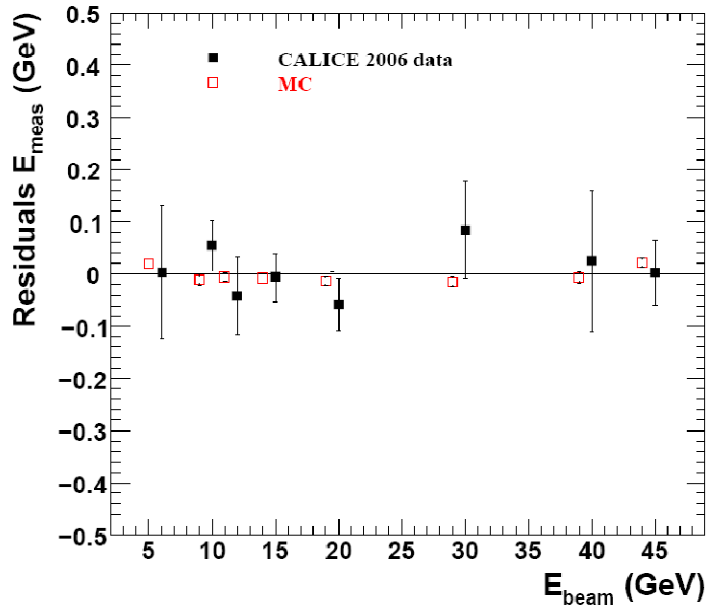
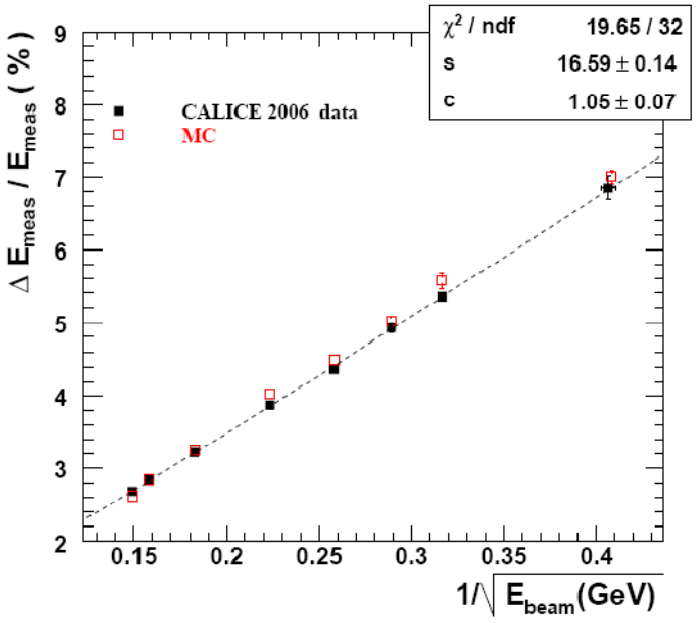
TB 2006: Linearity





Residuals agree within 1%
Consistent with zero non-linearity

TB 2006: Resolution

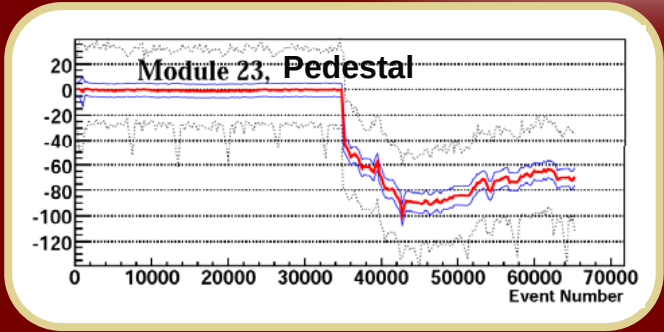


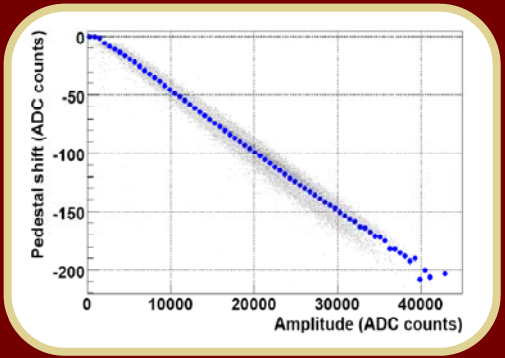
$$\frac{\Delta E_{meas}}{E_{meas}} = \left(\frac{16.6 \pm 0.1}{\sqrt{E(GeV)}} \oplus 1.1 \pm 0.1 \right) \%$$

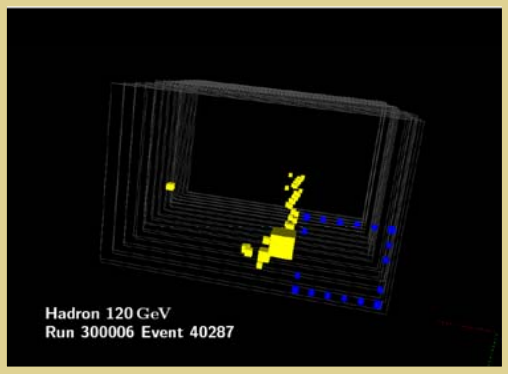
$$\frac{\Delta E_{meas}}{E_{meas}} = \left(\frac{17.3 \pm 0.1}{\sqrt{E(GeV)}} \oplus 0.5 \pm 0.1 \right) \%$$

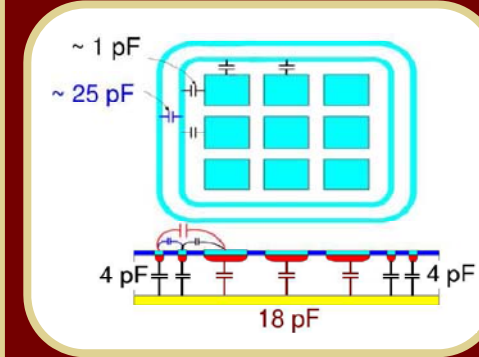
Encountered difficulties

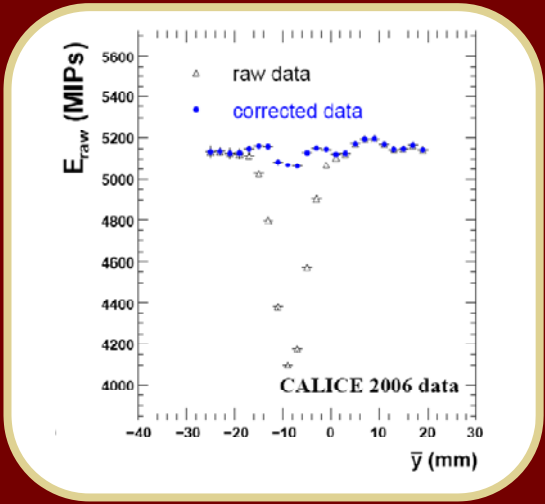
- Pedestal instabilities (module):
  - Due to fake differential in PHY3 chip
- Signal Induced Pedestal Shifts (per wafer):
  - Due to coupling to bias voltage
- Gaps:
  - Due to guard rings around wafers
- Square events and inner wafer crosstalk
  - Charge propagation over external and internal guard rings











Ongoing studies

- Longitudinal/transversal shower shapes
- Different impact angles
- Pions in the ECAL – comparison with MC
- Clustering algorithms
- Gap correction and optimization
- Cross-talk suppression (inner-wafer + guardring induced)
- Stability between different tb periods (= over 3 years!!!)

Overview

1. The CALICE SiW ECAL prototype
   - Test beam efforts
   - Test beam at FNAL '08
   - 2006 Test beam: results
   - Encountered difficulties
   - Ongoing studies
2. The SiW ECAL EUDET module
   - Module design
   - What EUDET will make better
   - Demonstrator

EUDET Prototype

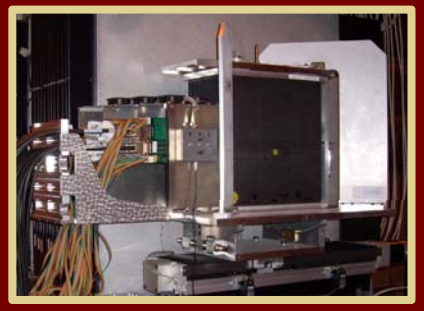
Physics prototype:

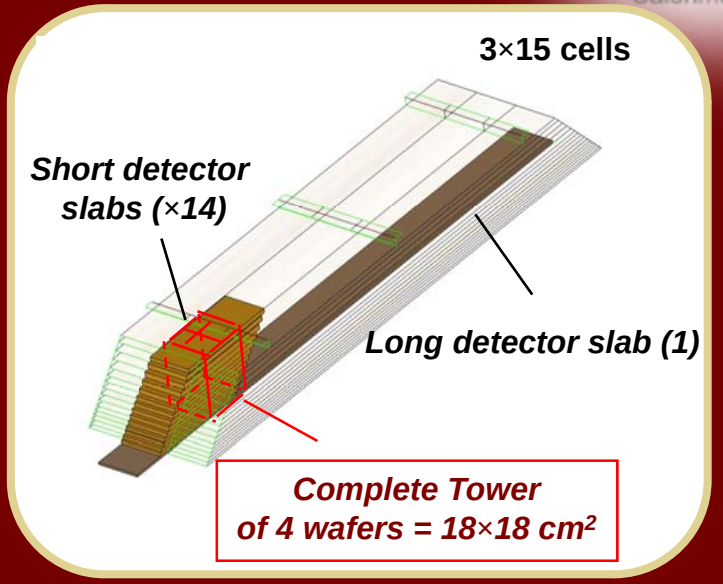
- Validated the main concepts: alveolar structure, slabs, gluing of wafers, integration, physics capabilities

Technological Prototype :

- Study and validate technological solutions wich could be used for the final detector: moulding process, cooling system, big sized structures,…
- Thereby taking into account industrialization aspect of process
- Cost estimation of one module

The next step towards an ILC detector

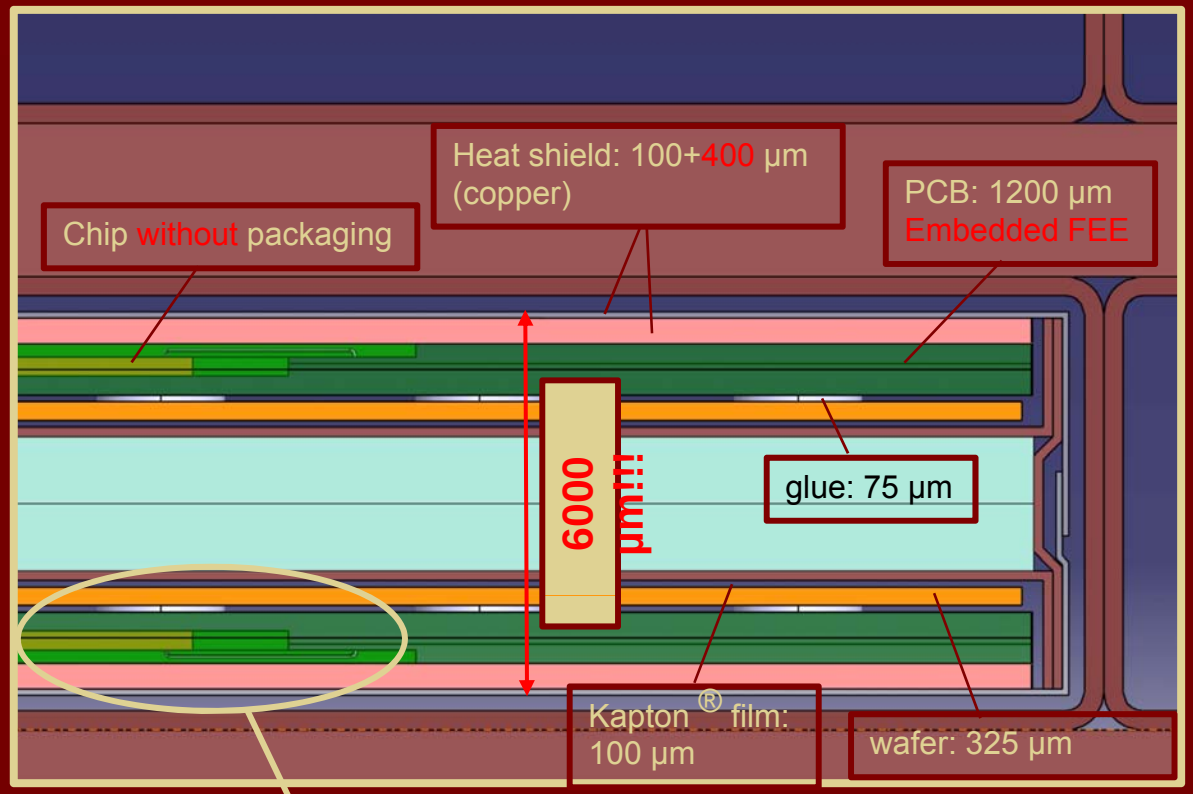




	Physics prototype	Technological Prototype
# Structures	3: (10×1,4mm + 10×2,8mm + 10×4,2mm)	1: (20×2,1mm + 9×4,2mm)
X_0	24	~23
Dimensions	380x380x200 mm^3	1560x545x186 mm^3
Thickness of slab	8.3mm (W=1.4mm)	6 mm (W=2.1mm)
VFE	Outside	Inside (zero-suppressed r/o)
# channels	9720	45360
Cellsize	10x10mm^2	5x5mm^2
Weight	~ 200 Kg	~ 700 Kg

EUDET slab design

Expected alveolar thickness: 7.3 / 9.4 mm

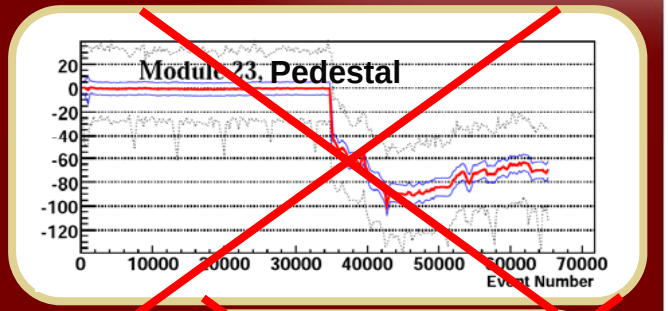


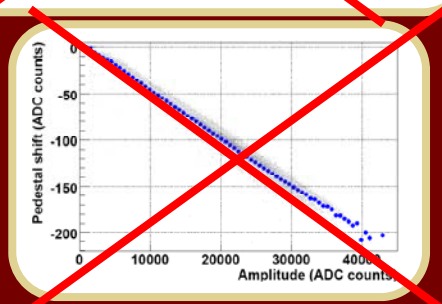
Chips and bonded wires inside the PCB

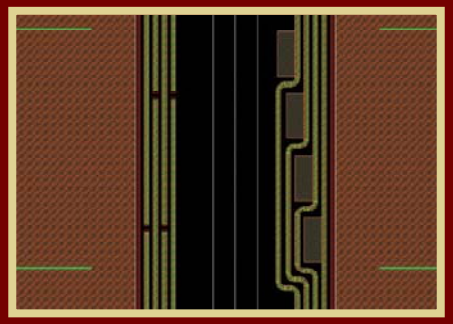
- Design of layout is fixed
- Compactness limited by PCB Thickness
- Dimensions are results of dedicated studies

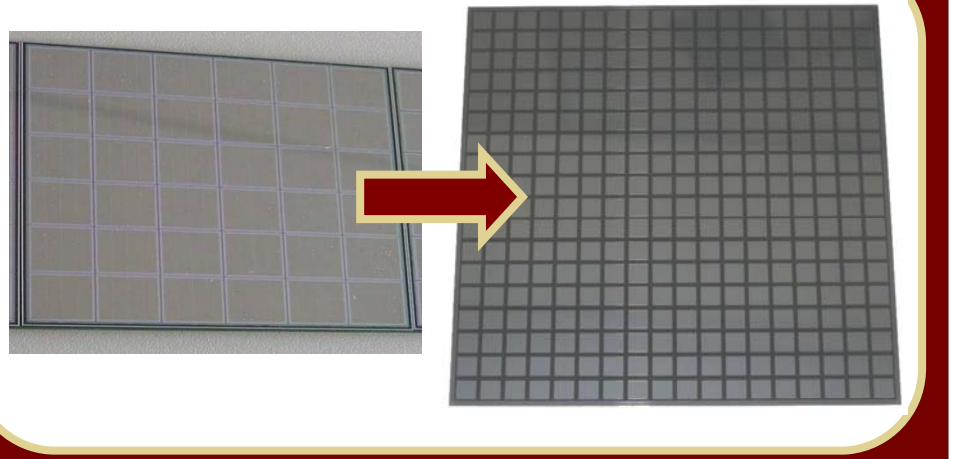
Why EUDET will make things better

- Pedestal instabilities:
  - New chip design with true differential
- Signal Induced Pedestal Shifts:
  - Review of electrical circuit
- Gaps:
  - Bigger wafer size (9x9 cm^2) results in less gaps
- Square events and inner wafer crosstalk
  - Suppression due to segmentation etc. (studies ongoing)



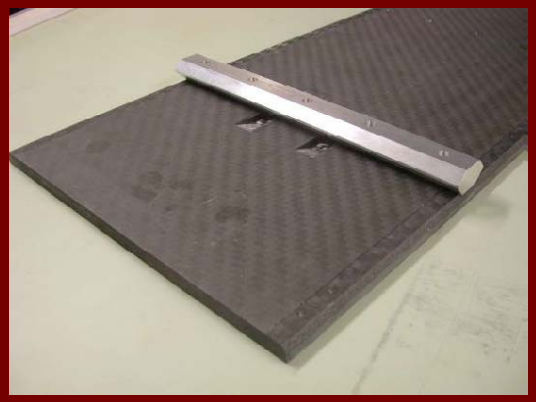


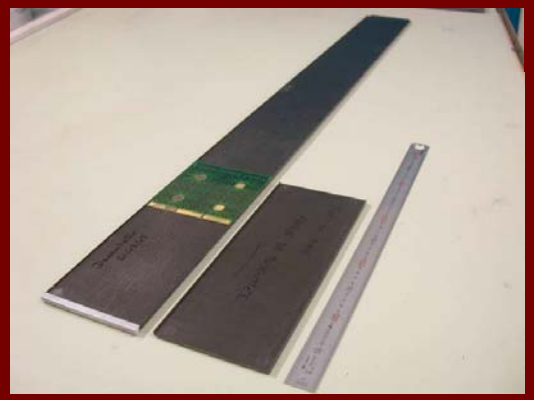


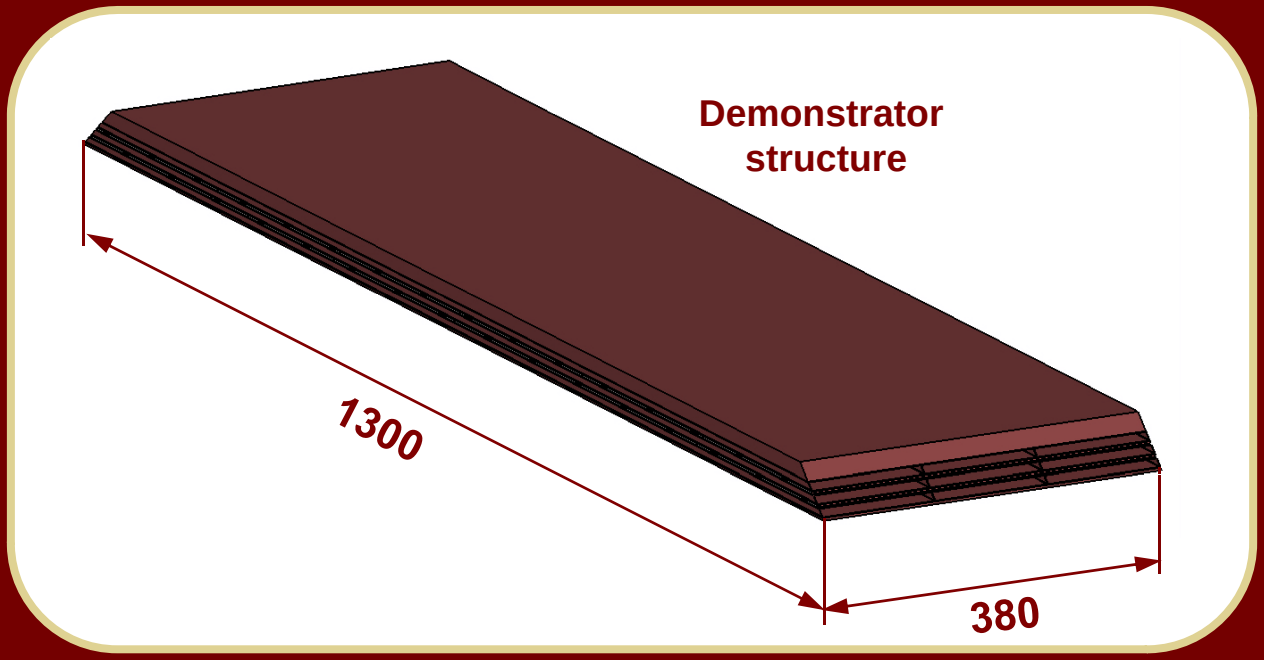


Intermediate step: The Demonstrator

- Validate all composite processes for the EUDET module
- Width based on physic prototype (124 mm)
- Thermal studies and analysis : design of a thermal PCB and cooling system
- Slab integration test (gluing, interconnection …)
- Will be finished by mid-January







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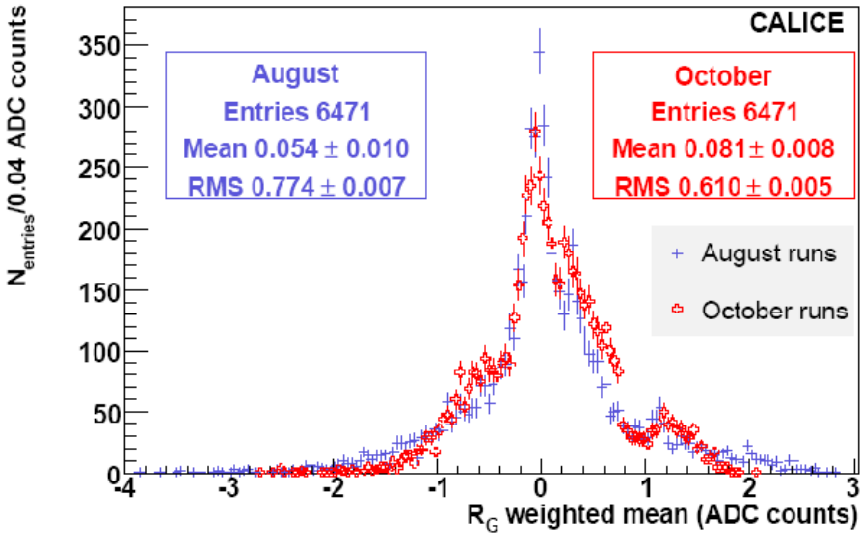
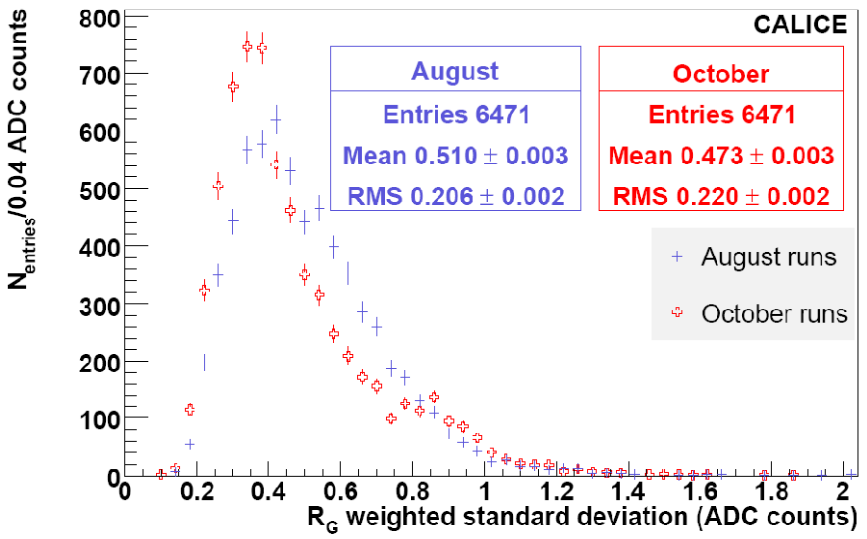
Conclusions

- Studies on physics prototype are fruitful and still ongoing (there are still a lot of things to exploit!)
- The estimation of the energy resolution of the physics prototype from test beam data turns out as expected and is suitable for the Particle Flow Approach!
- EUDET module design is fixed
- Demonstrator will be assembled until middle of January ‘09
- Production of EUDET module will start in ‘09

Backup

Pedestals

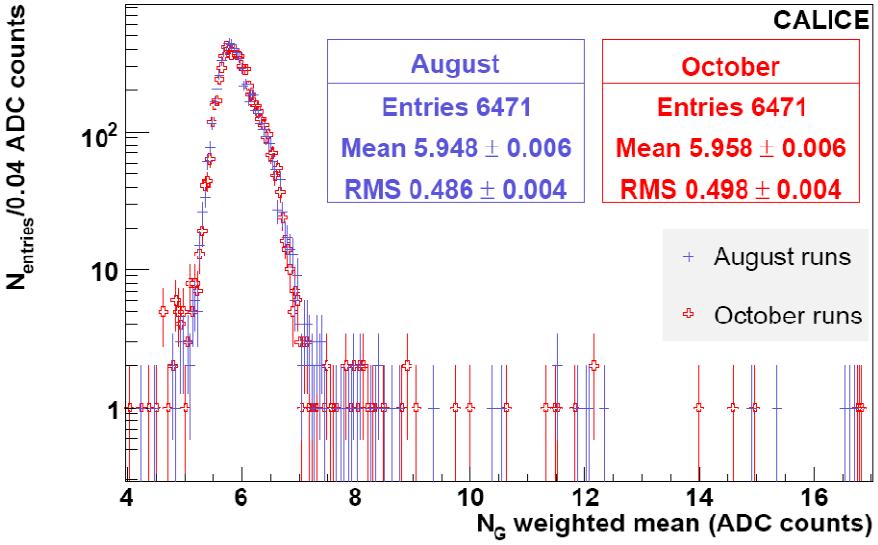


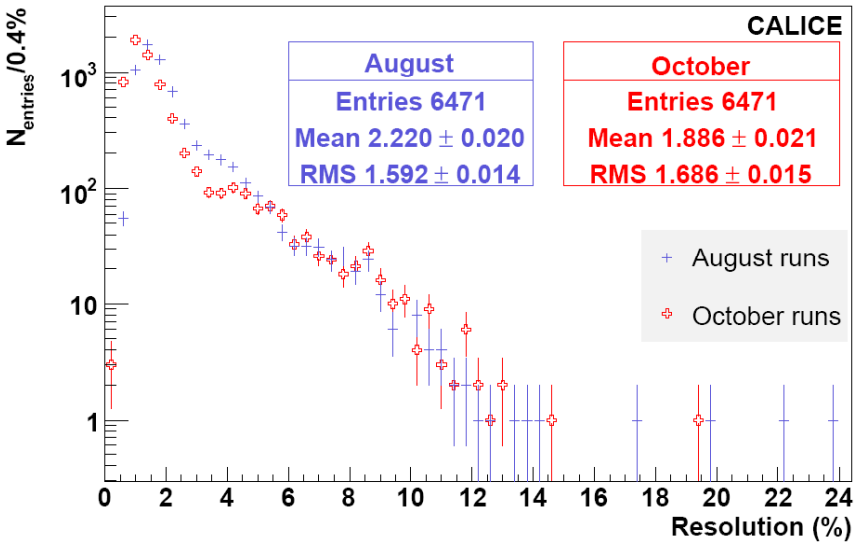


Mean pedestal offset < 0.17 ± 0.02 % of a MIP
Standard deviation channel-to-channel = 1.67 ± 0.02 % of a MIP

Residual offset run-to-run ≈ 1.1 ± 0.1 % of a MIP
Standard deviation channel-to-channel = 0.48 ± 0.01 % of a MIP

Noise





Mean noise = 12.9 ± 0.1 % of a MIP
Standard deviation channel-to-channel = 1.1 ± 0.1 % of a MIP

Relative spread run-to-run = 2.00 ± 0.03 % of a MIP
Spread channel-to-channel = 1.60 ± 0.01 % of a MIP

20 % of the channels have run-by-run variations > 3%
→ run-by-run noise measurement