CALICE ECALs

Current status and future plans

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for the ECAL groups:

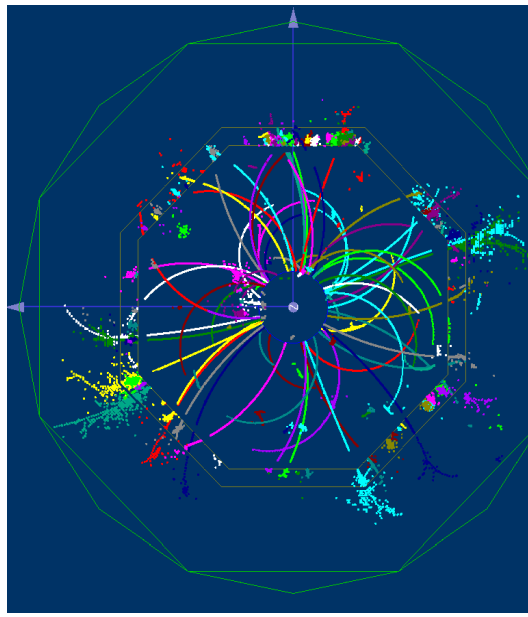
ScECAL: Kobe, Kyungpook, Shinshu, Tsukuba

SiECAL:

CALICE : R&D into calorimeters for a “Particle Flow”-based LC detector

“Particle Flow”:

- measure energy of each particle individually (e.g. in a hadronic jet)
- allows use of tracking system for estimation of (~60%) charged energy
- only neutral energy (photons, h0) measured in calorimeters
- calorimeters: identification of individual particles' energy deposits more important than single particle energy resolution



ECAL requirements:

- compact size
- small Moliere radius
- high segmentation, longitudinal and trasnverse

CALICE studies two ECAL technologies:

- both are sampling calorimeters with Tungsten absorber
- different active layers:

* SiECAL: Silicon detectors, 10x10 -> 5x5 mm2 pixels
* ScECAL: Scintillator strips, 10x45 -> 5x?? mm2 strips

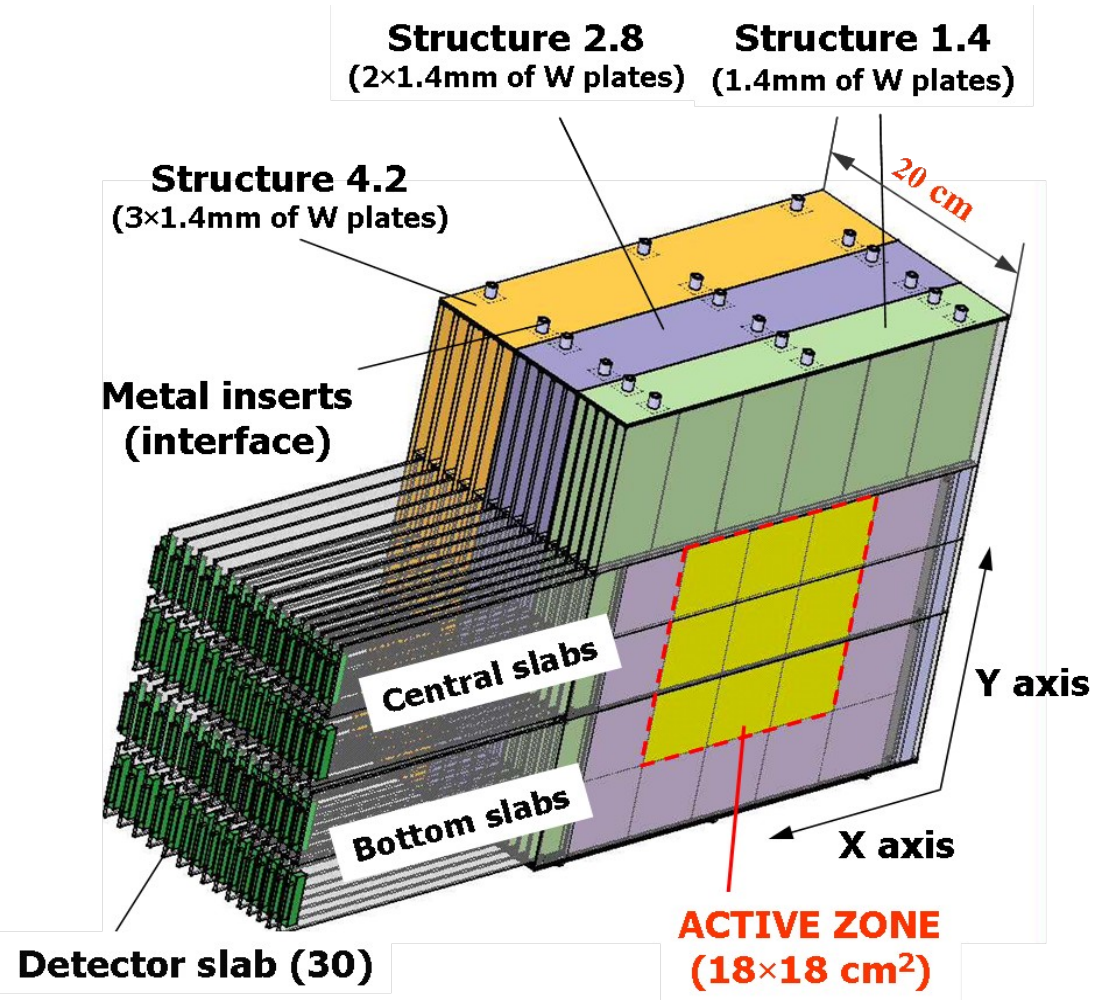
Both groups have built small “physics prototype” detectors, exposed to test beam

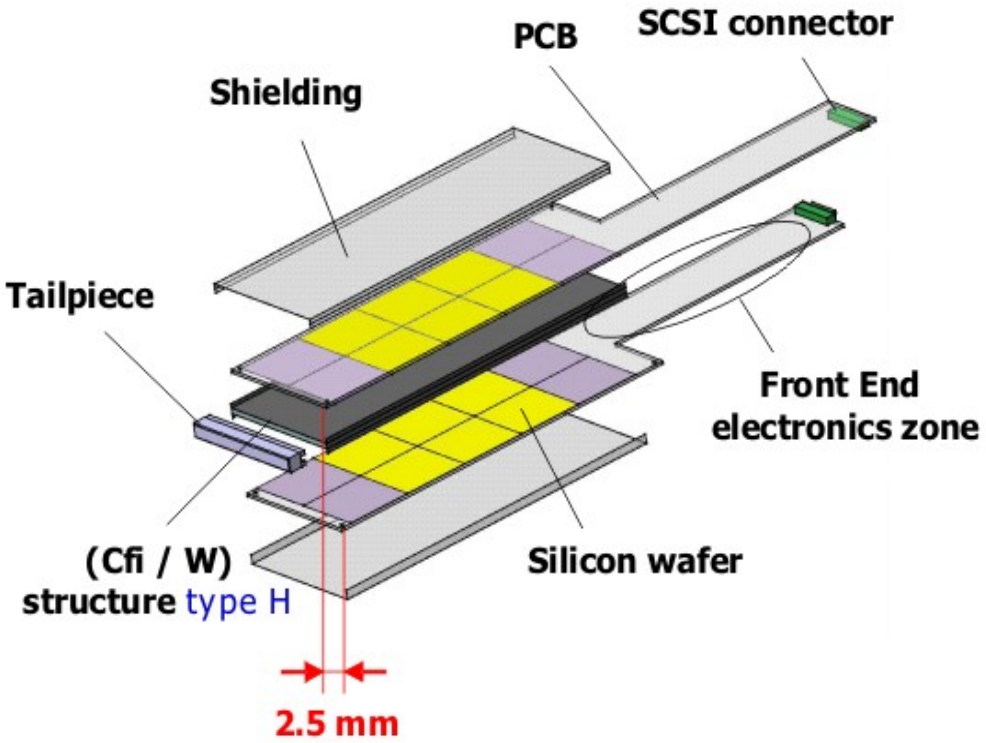
* Prove core technology
* Compare results to simulation

Now work is concentrating on the development of “technological prototypes”

* address integration issues in LC detector

Silicon – W ECAL physics prototype

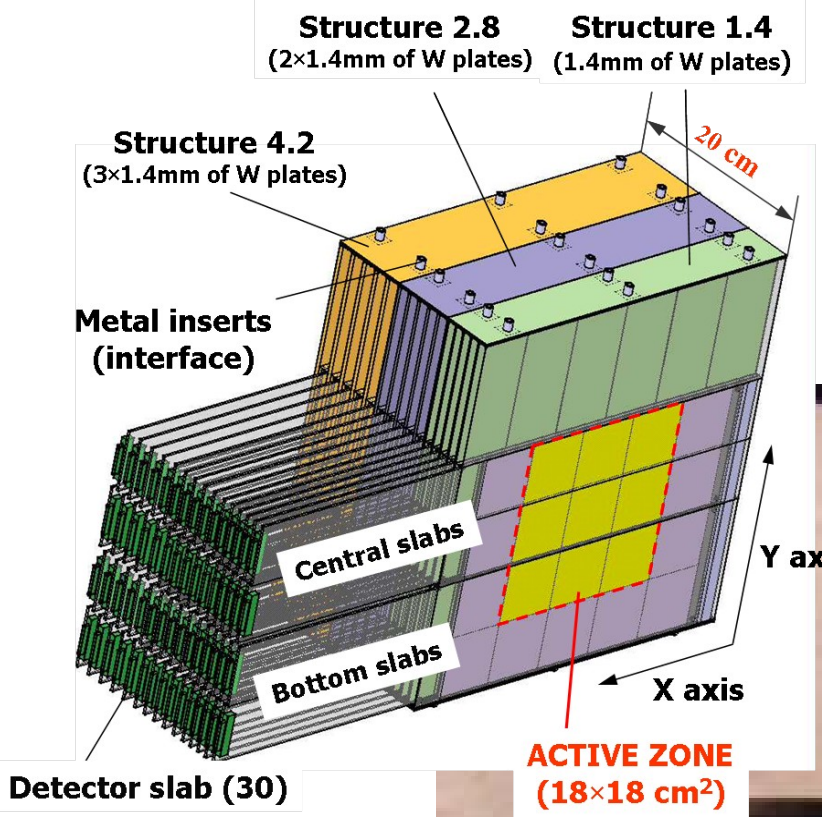


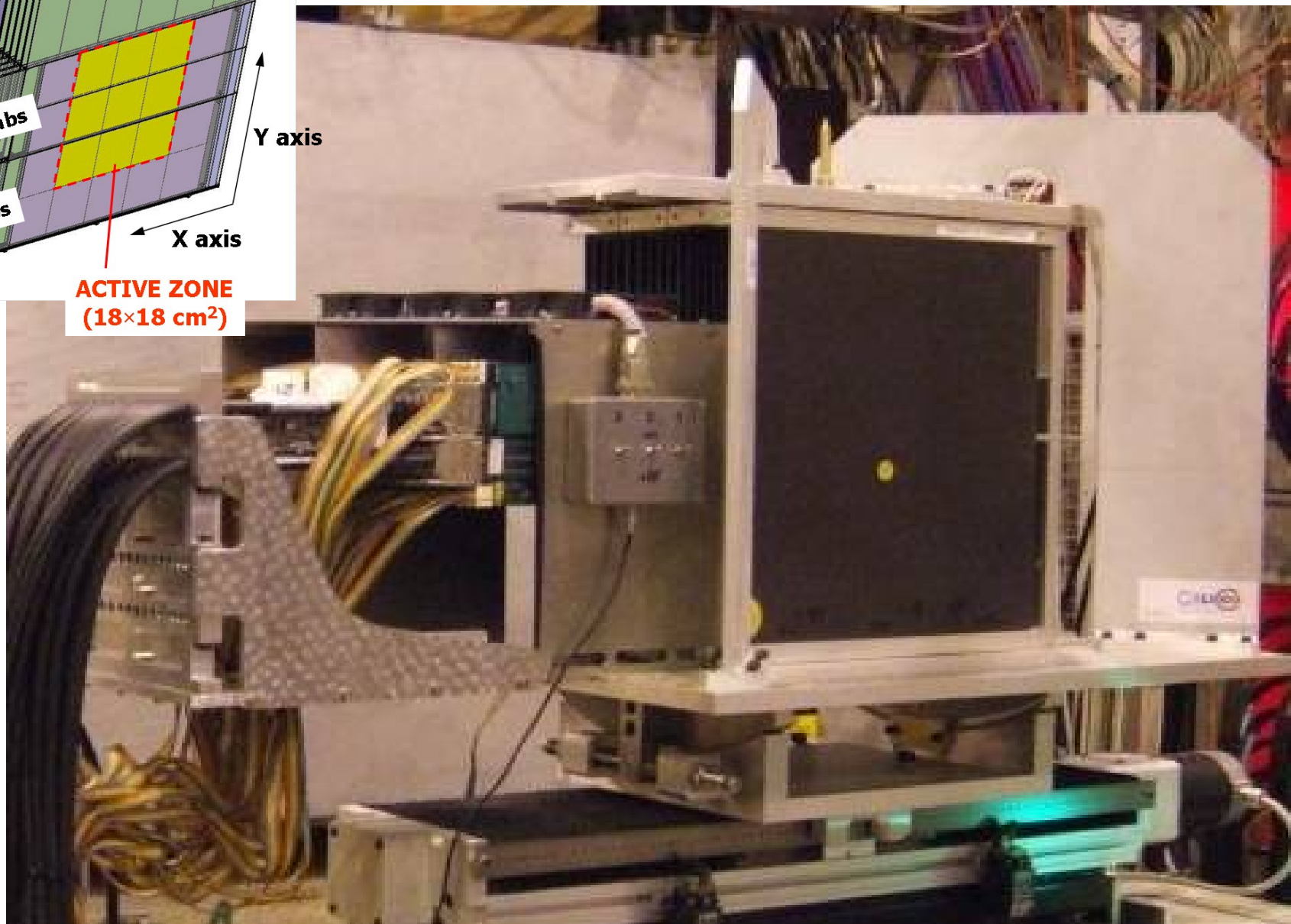


30 layers
- W absorber
- Silicon detectors
- 10X10mm2 PIN diodes
- ~10k readout channels
- Carbon Fibre composite mechanical structure

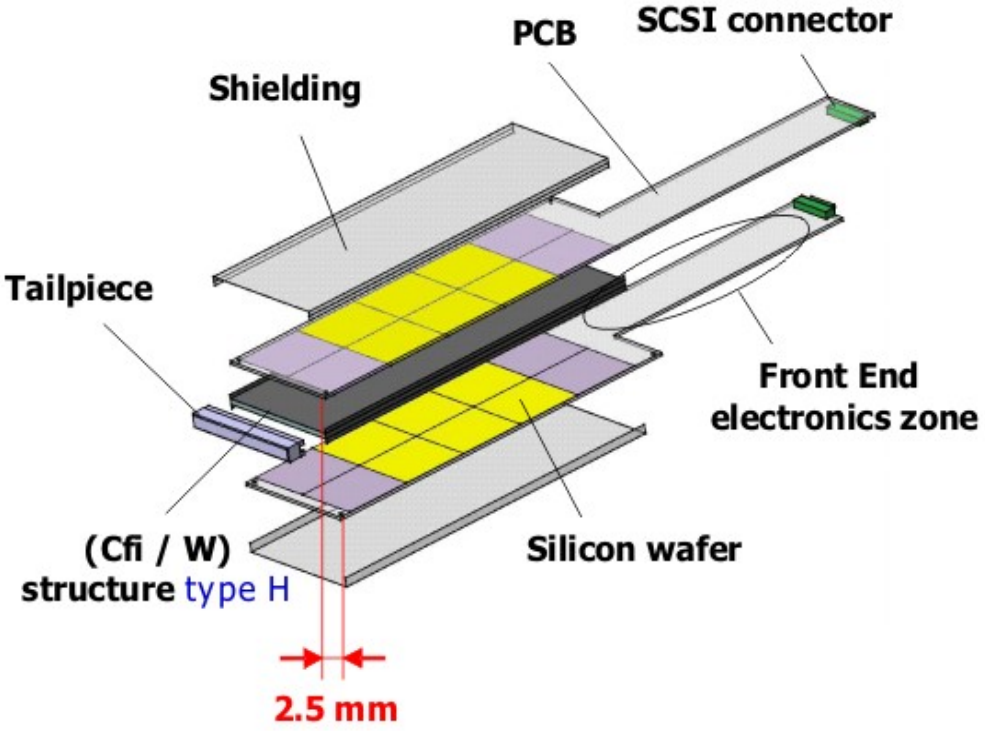
Finer sampling in first layers
- help low E photon identification
- keep cost under control

SiW physics prototype

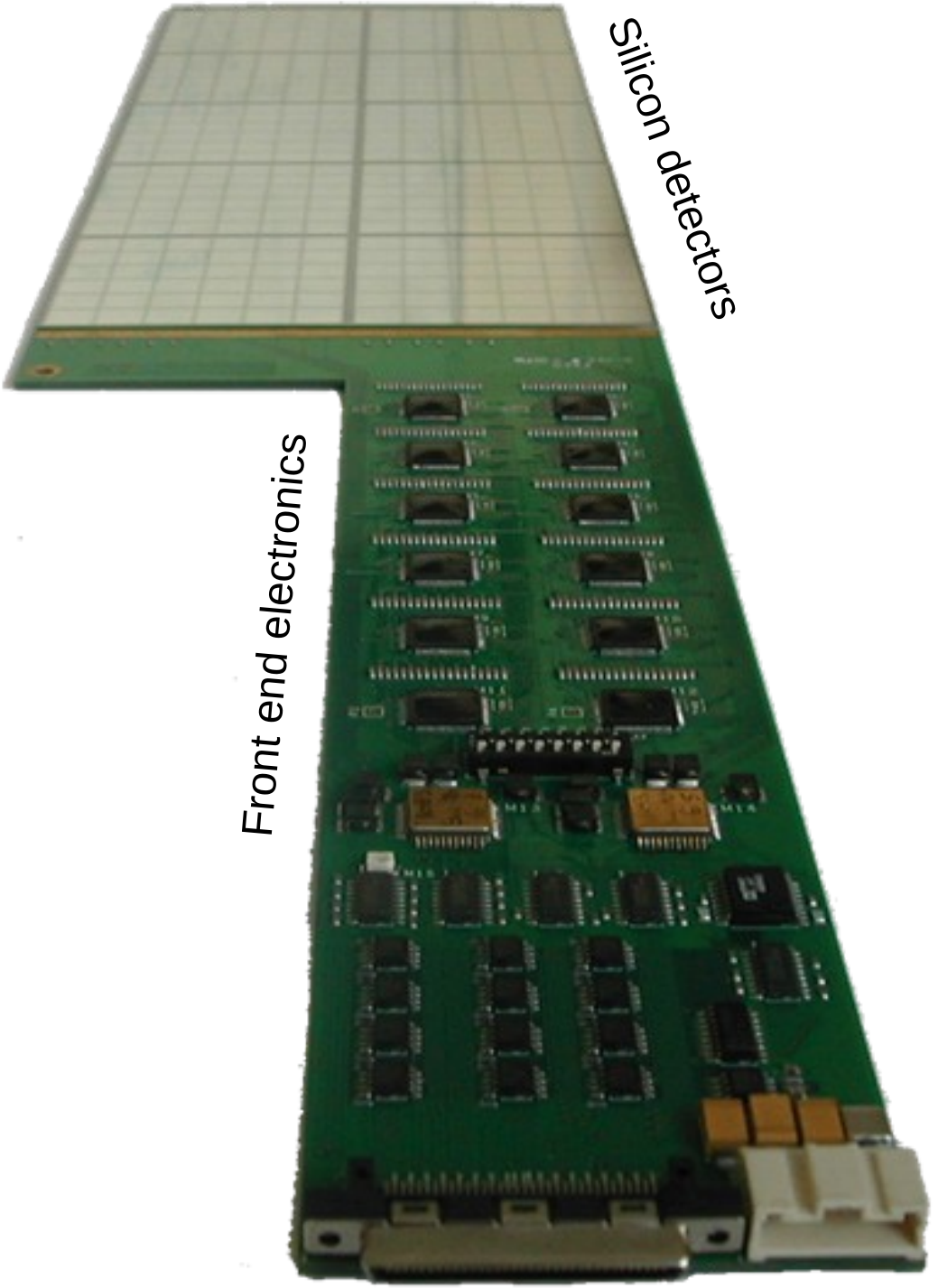




SiW physics prototype

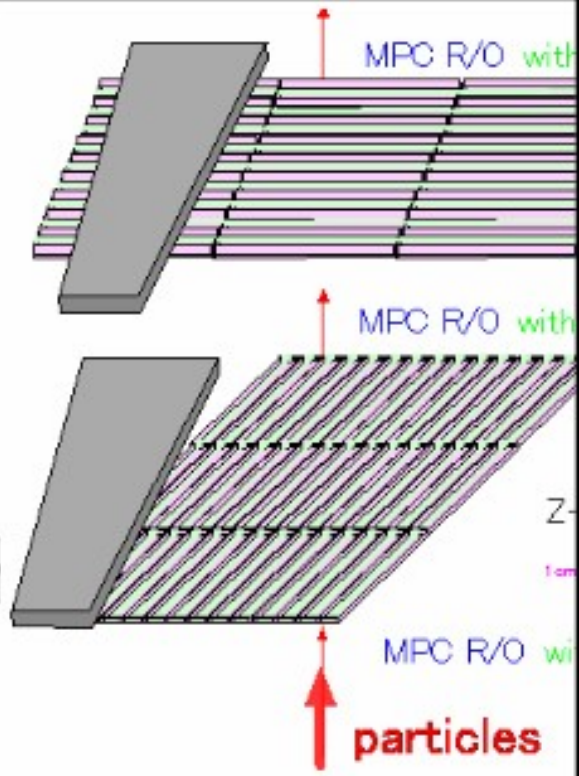


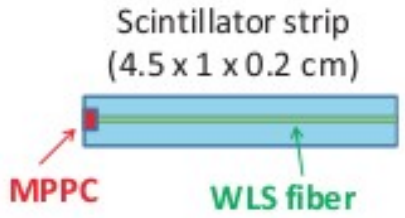
Si detector: 6x6cm2,
10x10mm2 pixels

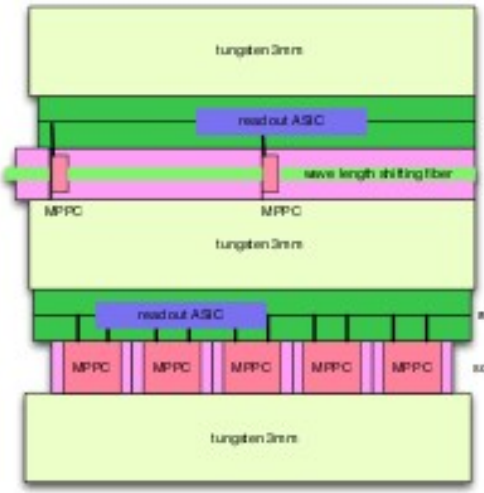


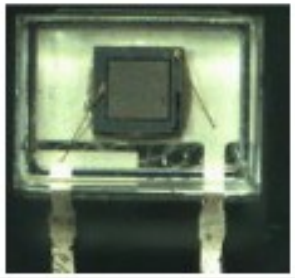
fine segmented scintillator cal.

- strip structure with wave lengtl shifting fiber read out
  - uniform along the WLSF
  - any length
- orthogonal directions in X & Y
- MPPC read out

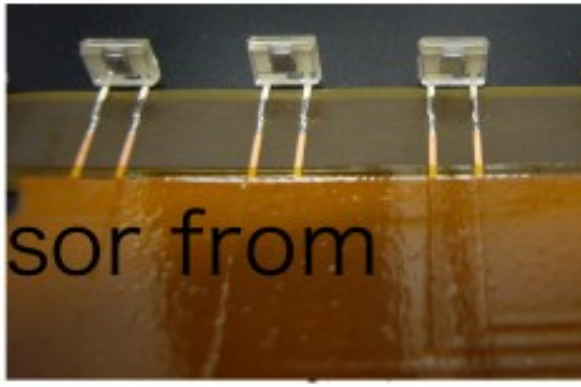




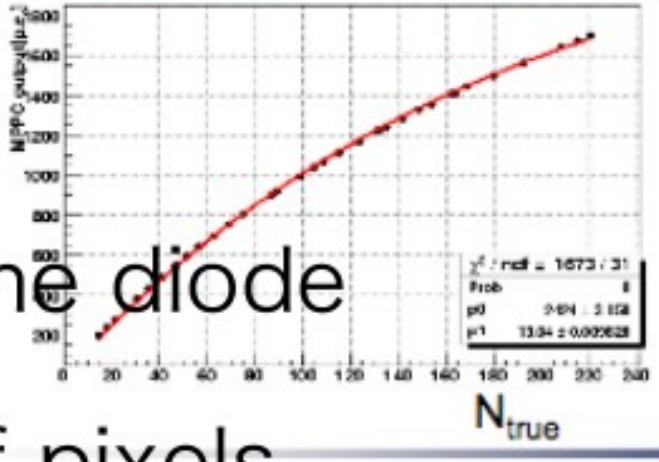




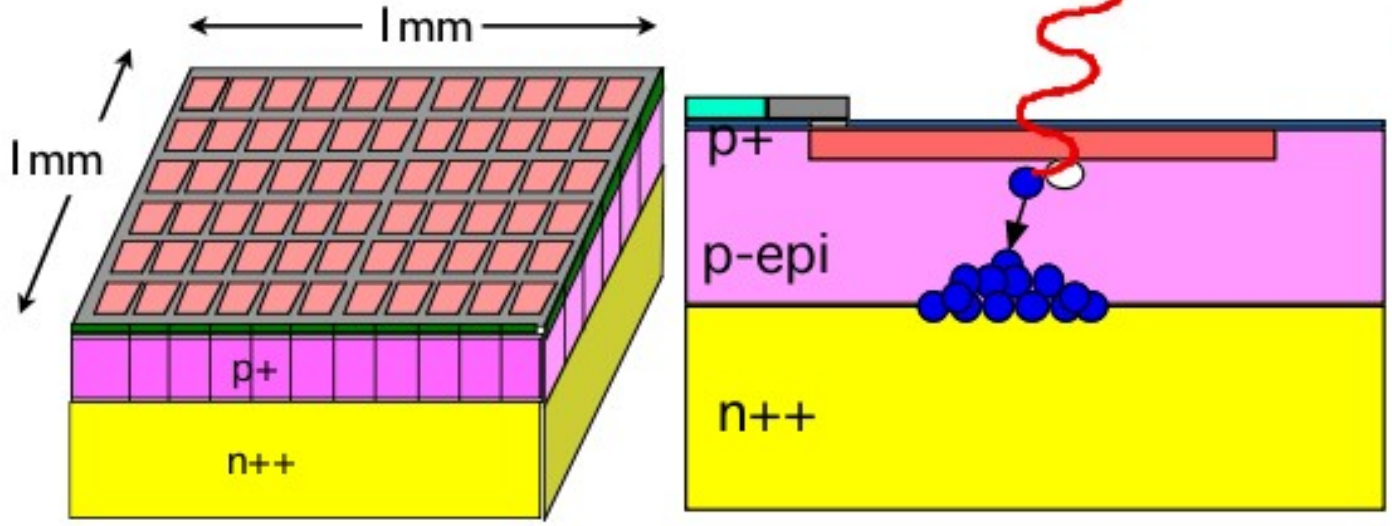
MPPC

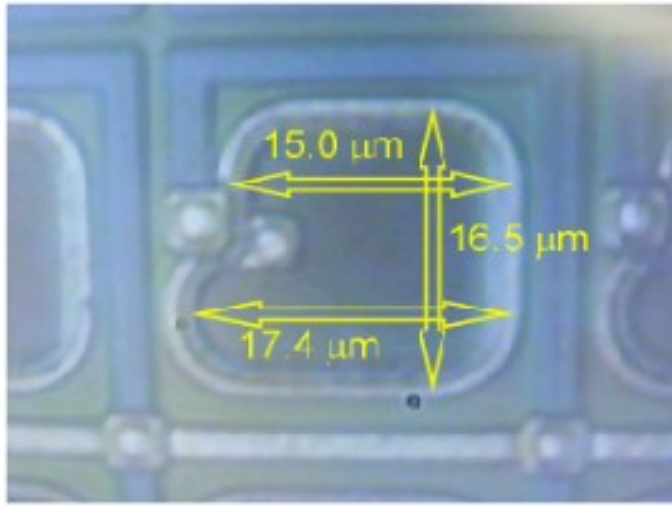


- a novel semiconductor photo sensor from Japanese Universities, KEK and Hamamatsu



- pixelated Geiger Mode Avalanche diode
- saturation effect limited by # of pixels

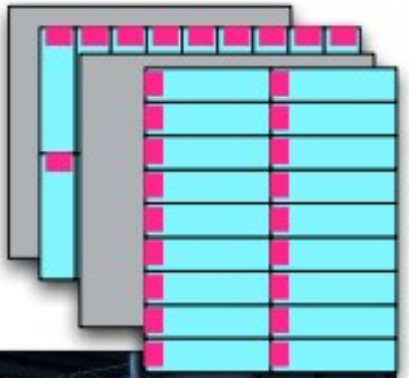


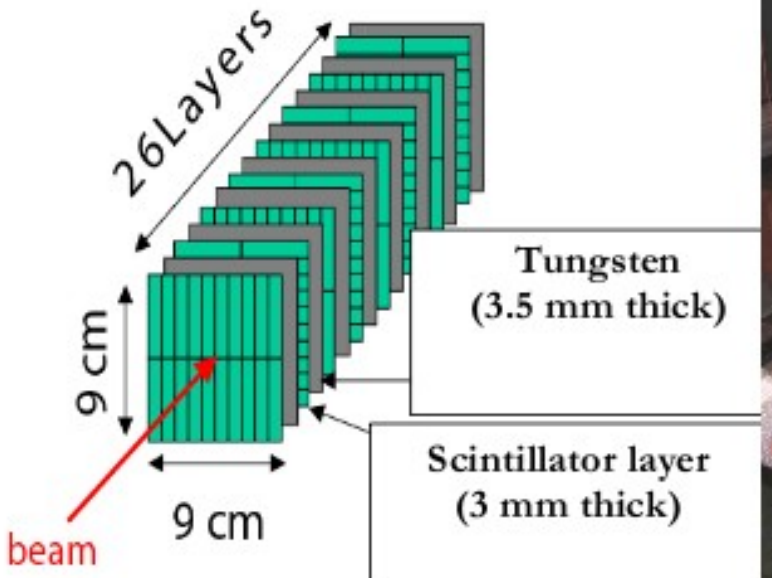


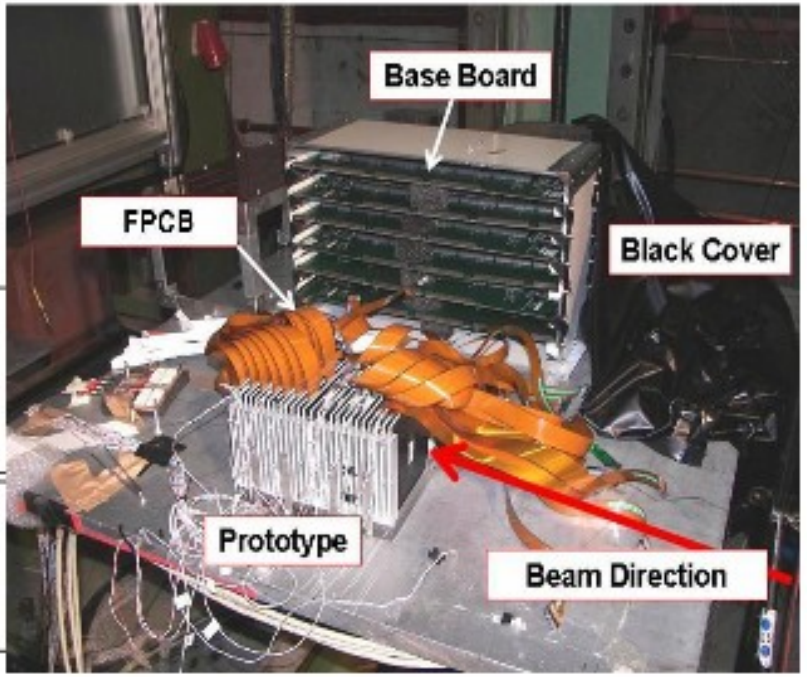
scECAL at DESY

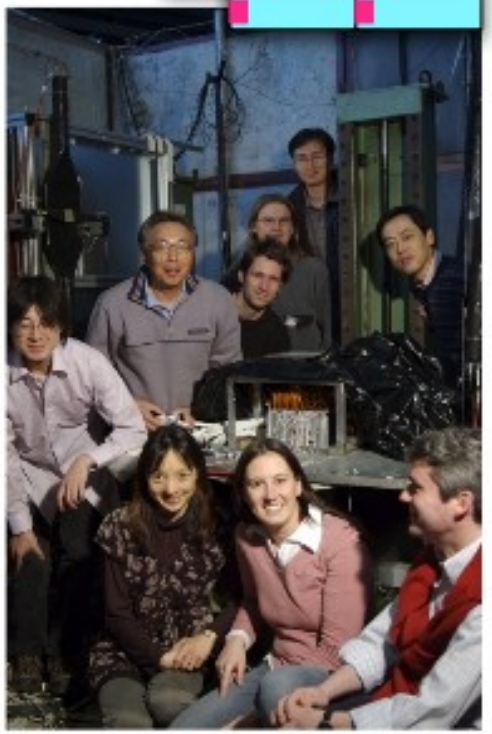
2007

- scintillator strips pf 1 x 4.5 x 0.3 cm3
- 2 x 9 in a layer x 26 = 468 ch
- tungsten absorber of 3.5 mm thick





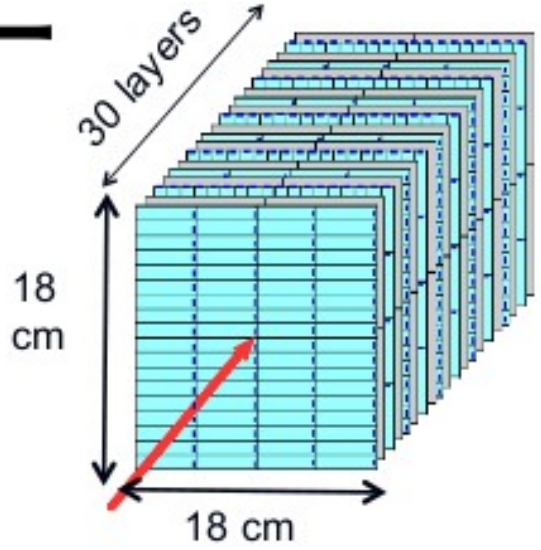




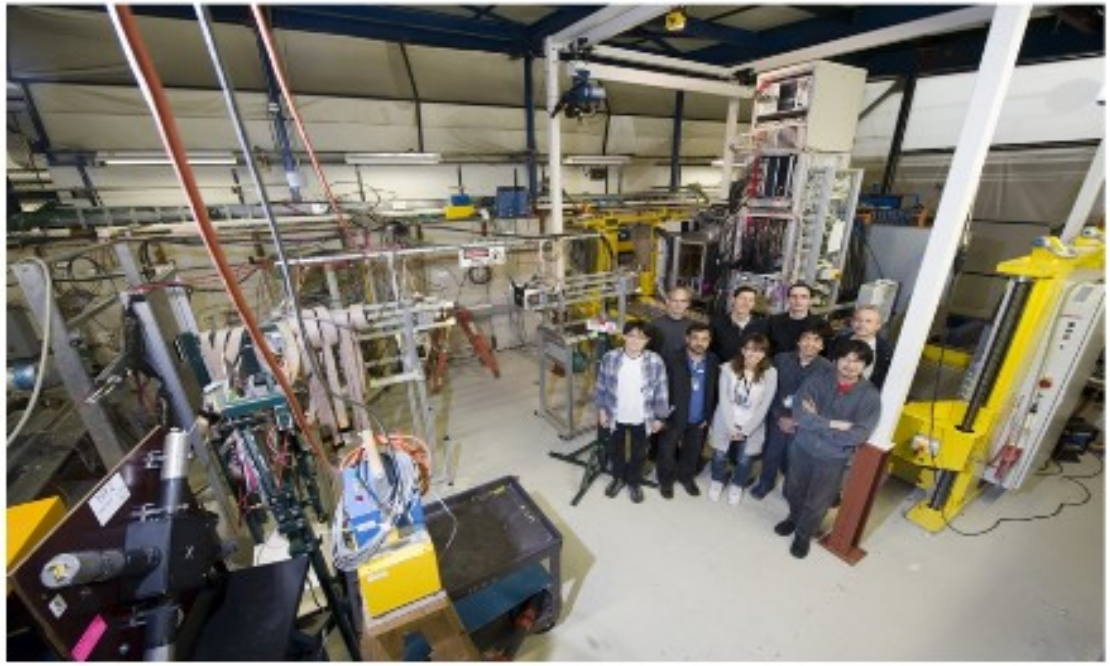
Test different types of scintillator

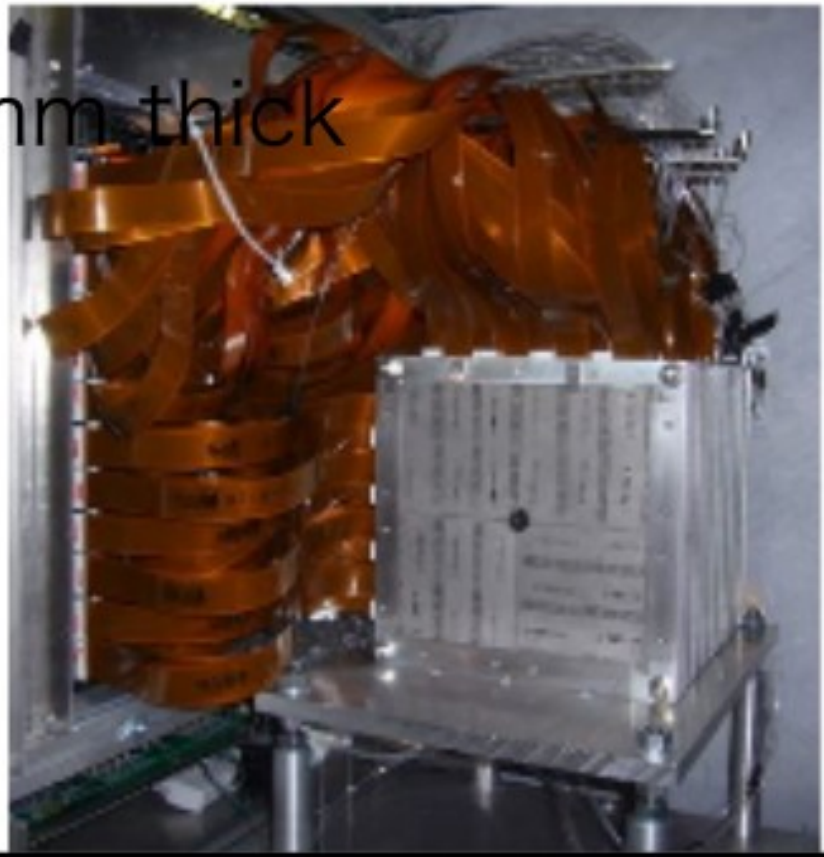
scECAL at FNAL

2008-2009



- extruded scintillator strips pf 1 x 4.5 x 0.3 cm3
- 4 x 18 in a layer x 30 = 2160 ch
- tungsten absorber of 3.5 mm thick





beam tests

ECALs have been exposed to beam

- Standalone tests
  - Debugging, first tests

- Combined beam tests with AHCAL and tail-catcher
  - Large-scale tests, different particle species
  - Test particle flow aspects
  - Multi-detector running

Summary of past testbeam activity

	SiW ECAL	ScW ECAL
2006	DESY & CERN	DESY
2007	CERN	
2008	FNAL	FNAL
2009		FNAL

Standalone
- largely debugging

Combined with
Analogue HCAL/TCMT

DESY: e+ beams, 1 -> 6 GeV/c

CERN: H6 beamline
e+-, muon, pion, proton
6->~100 GeV/c

FNAL: MTBF
e+-, muon, pion
Lower energy range

10s of millions of events collected in total

Combined CALICE beamtests

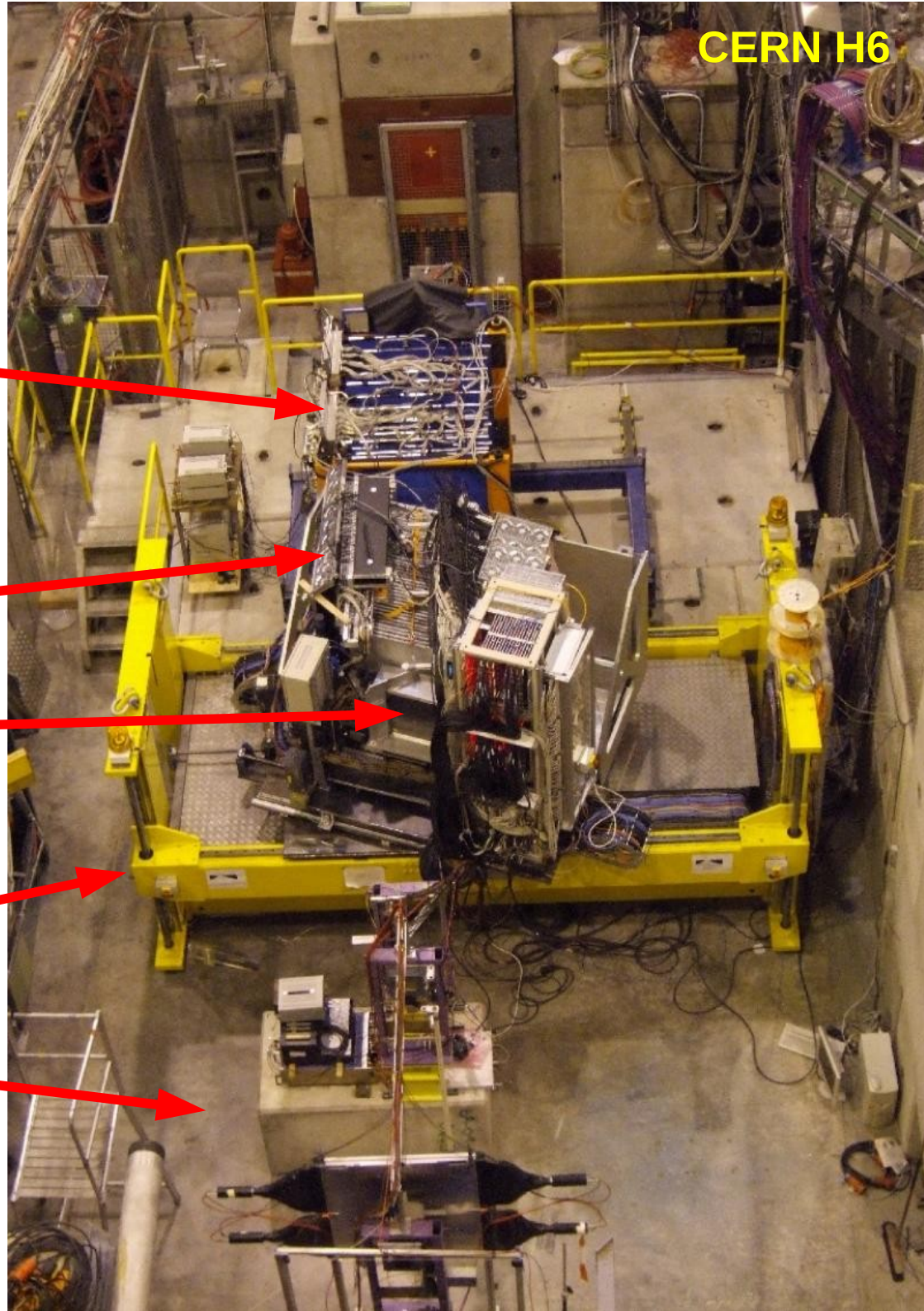
Tail Catcher/Muon Tagger (TCMT)

AHCAL

SiW or ScW ECAL

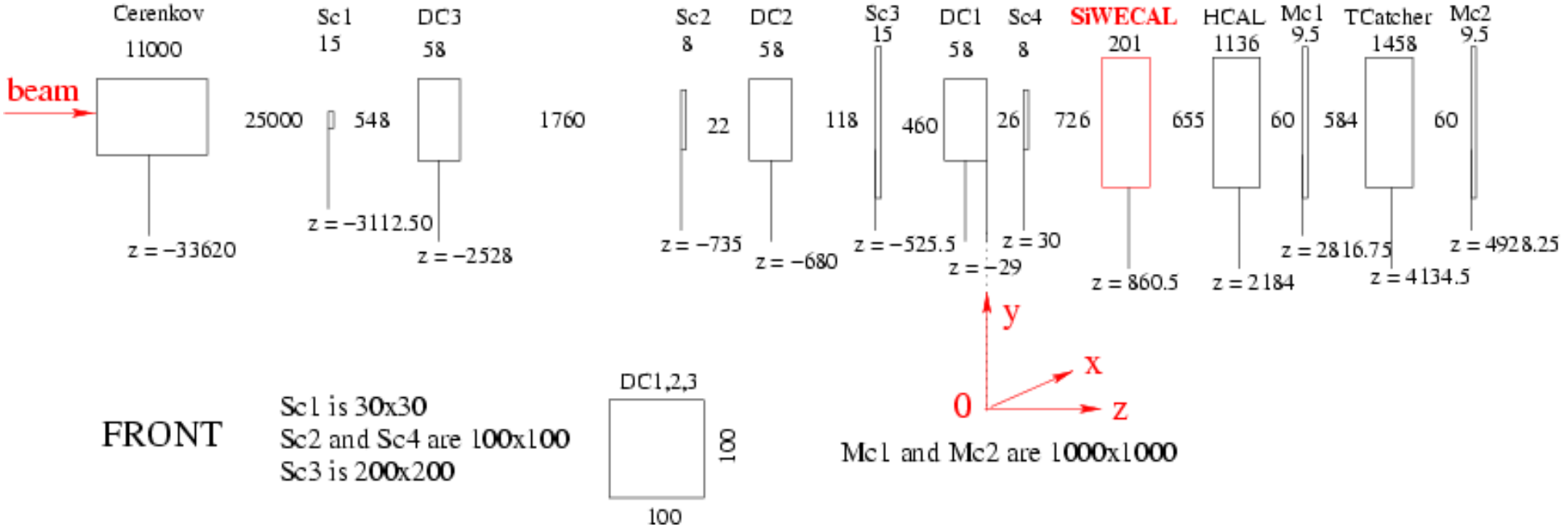
Movable stage

Beamline instrumentation:
scintillator triggers & vetos
drift chambers
cerenkov triggers

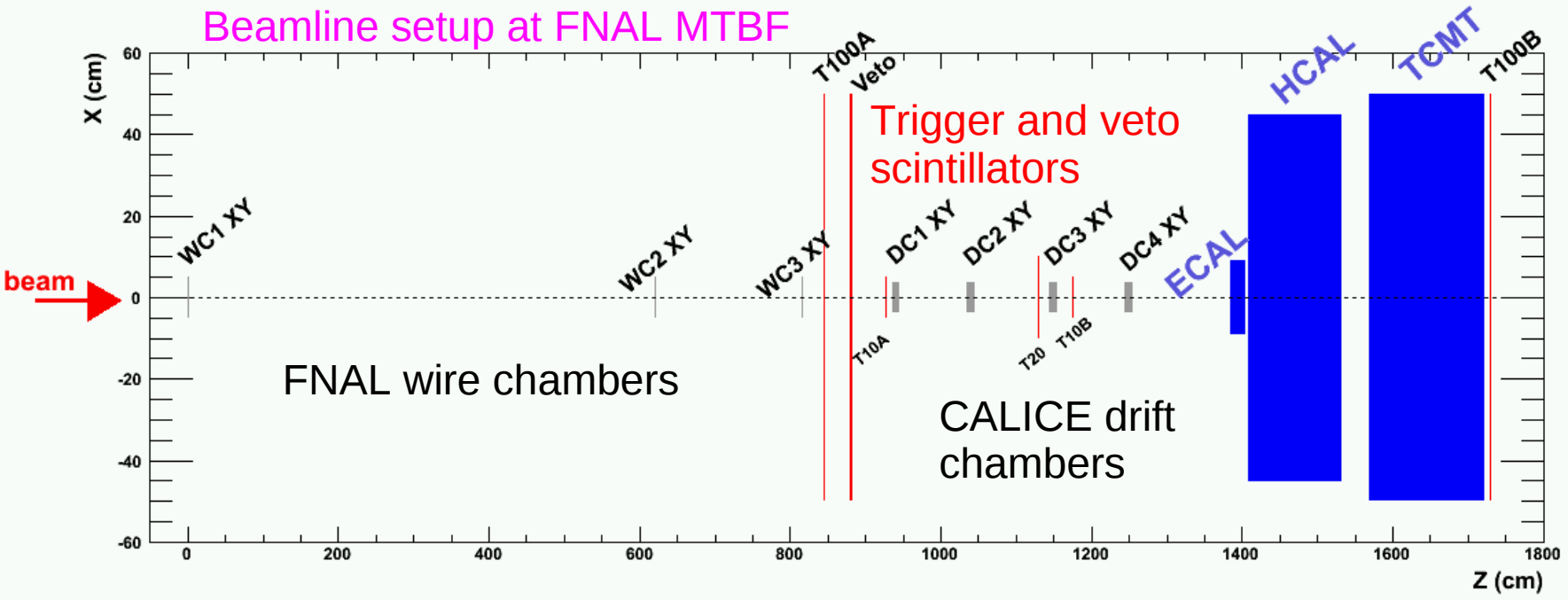


Combined CALICE beamtests

Beamline setup at CERN H6



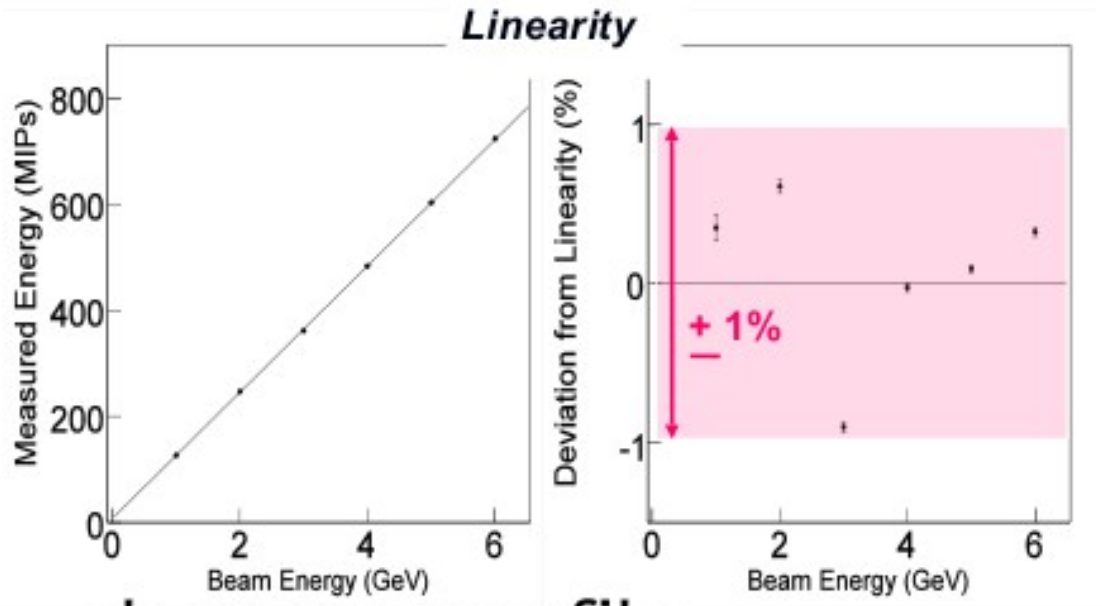
Beamline setup at FNAL MTBF

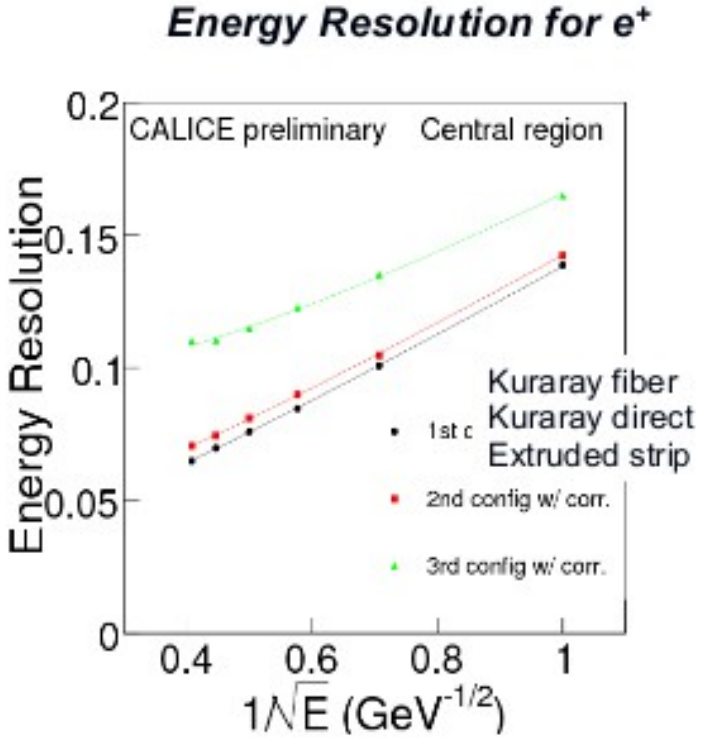


ScECAL

results at DESY

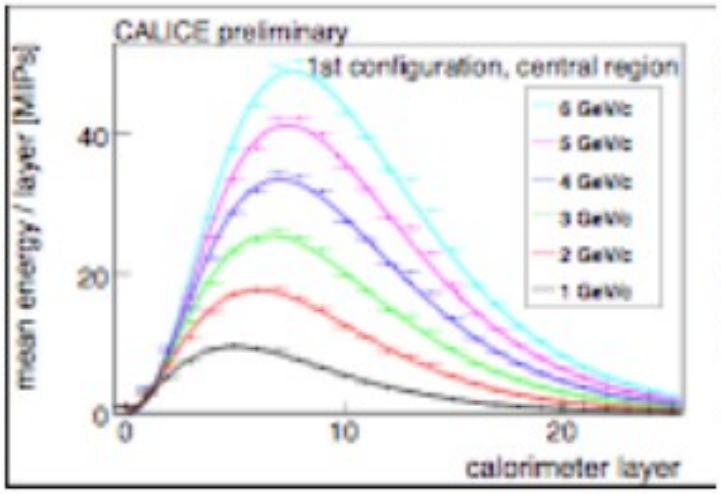
- linearity and resolution



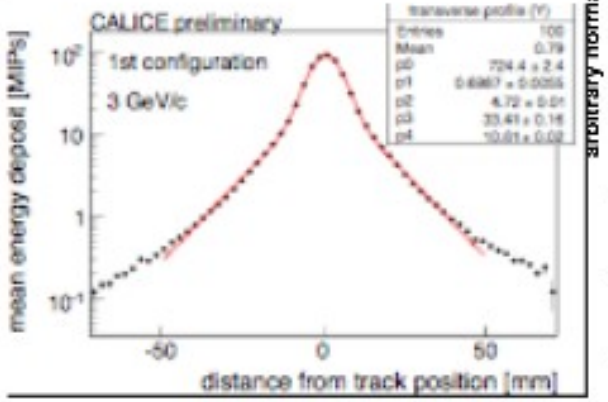


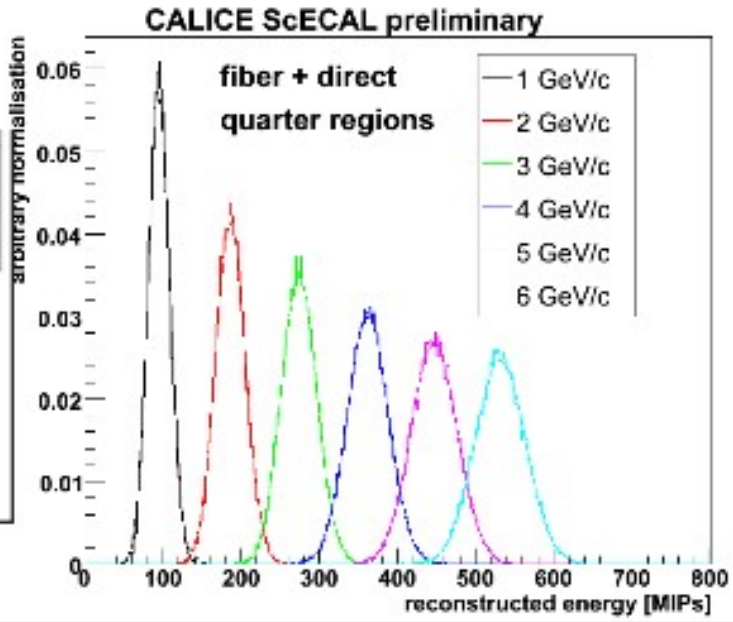
- shower profile

longitudinal



lateral

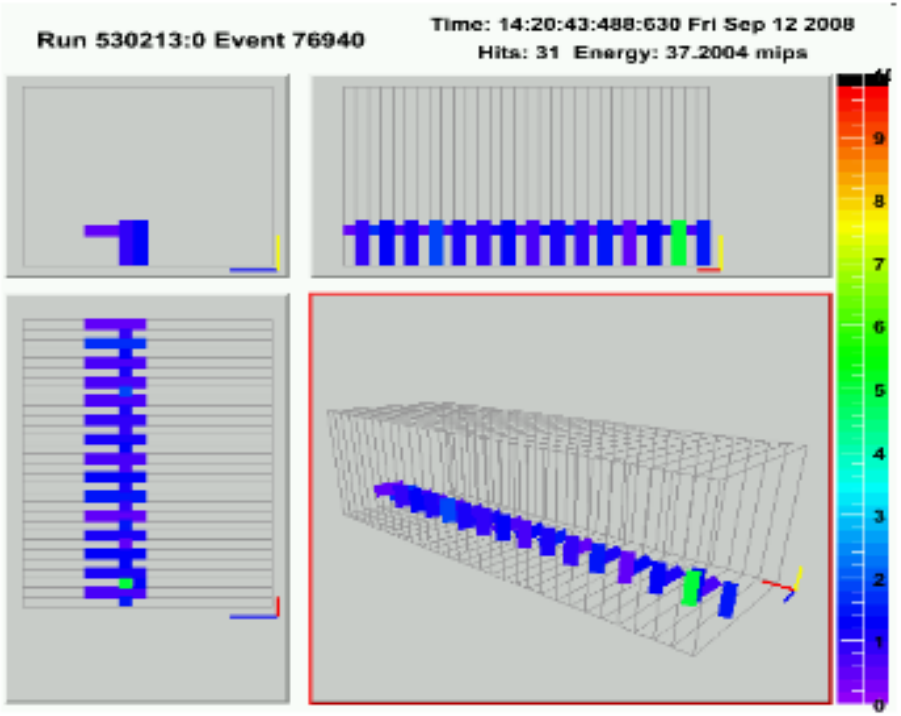


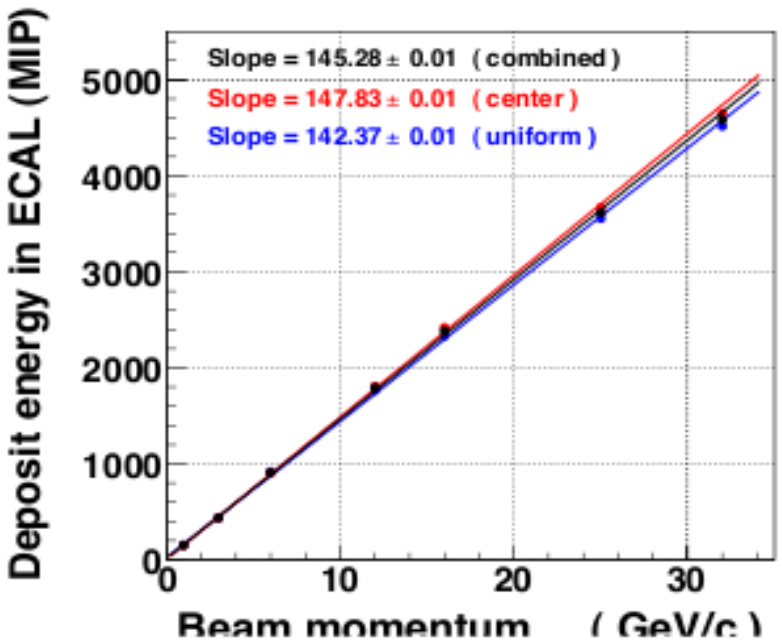


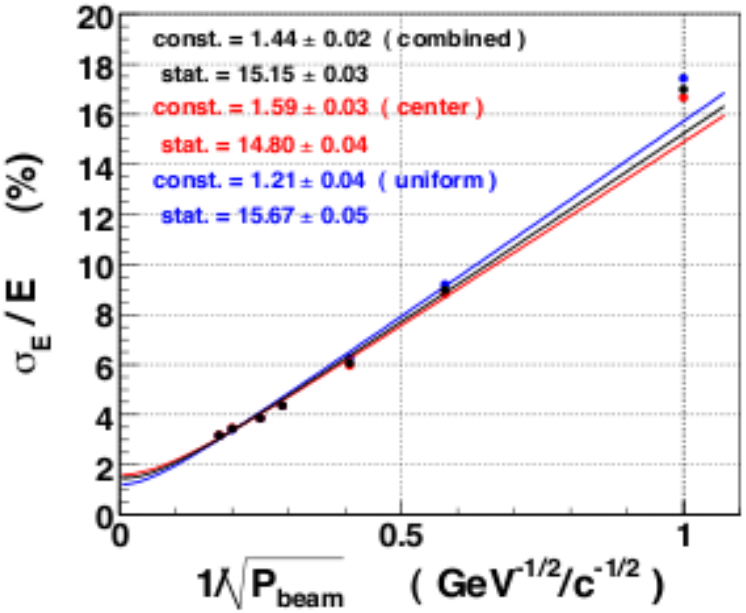
results at FNAL

- linearity and resolution

MIP calibration
(32GeV muon)



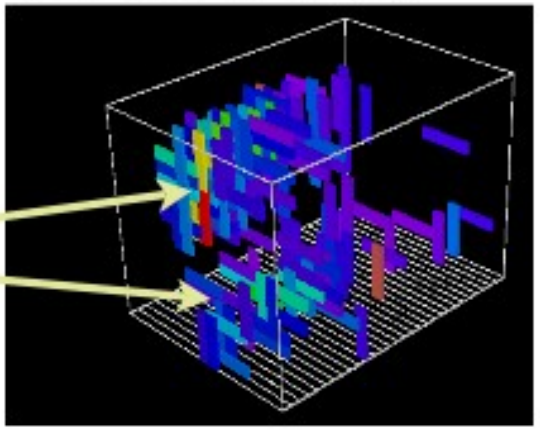


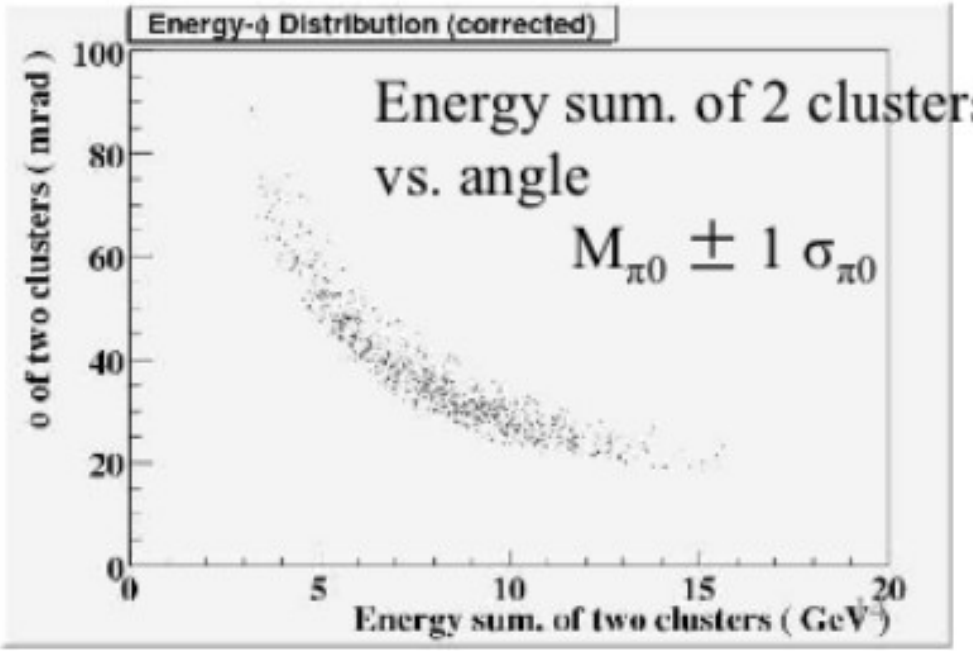


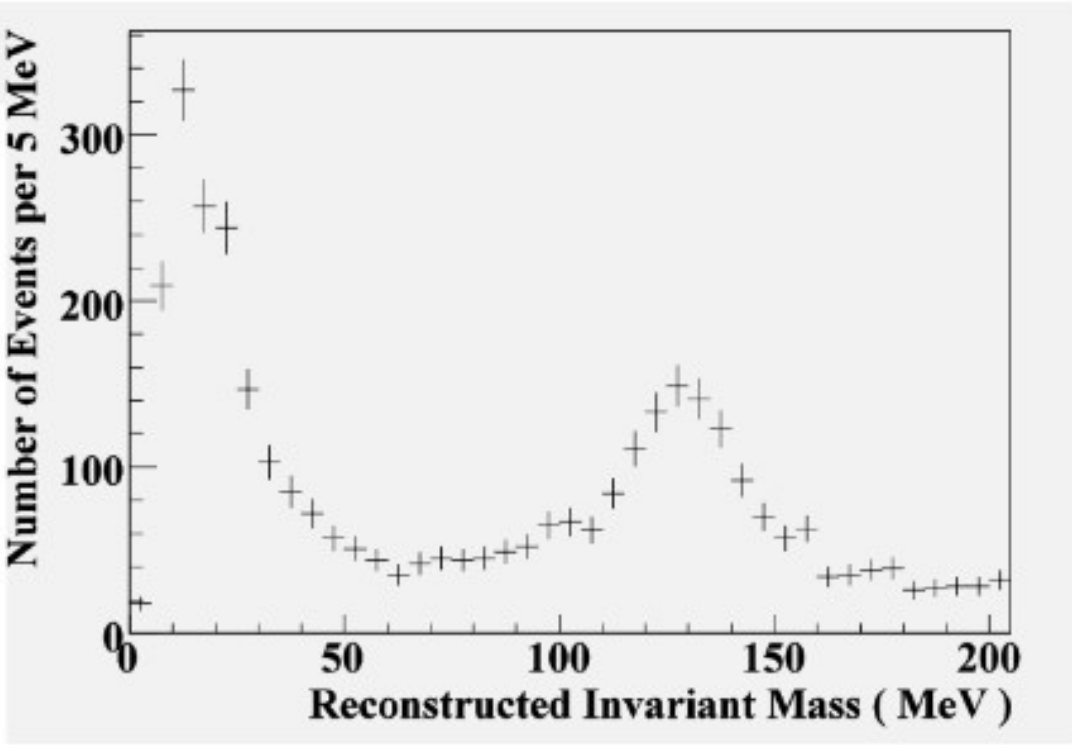
ScECAL

results at FNAL cont.

- neutral pion reconst.
  - target in pion beam to make π^0
  - find two isolated clusters
  - calculate its mass
  - with different Eπ

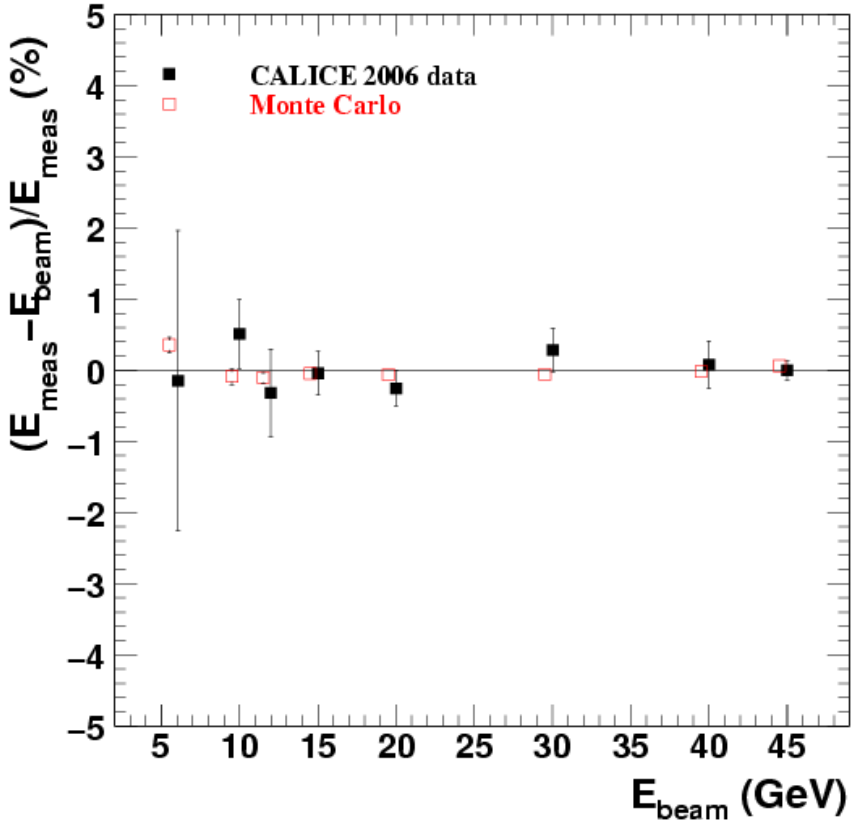




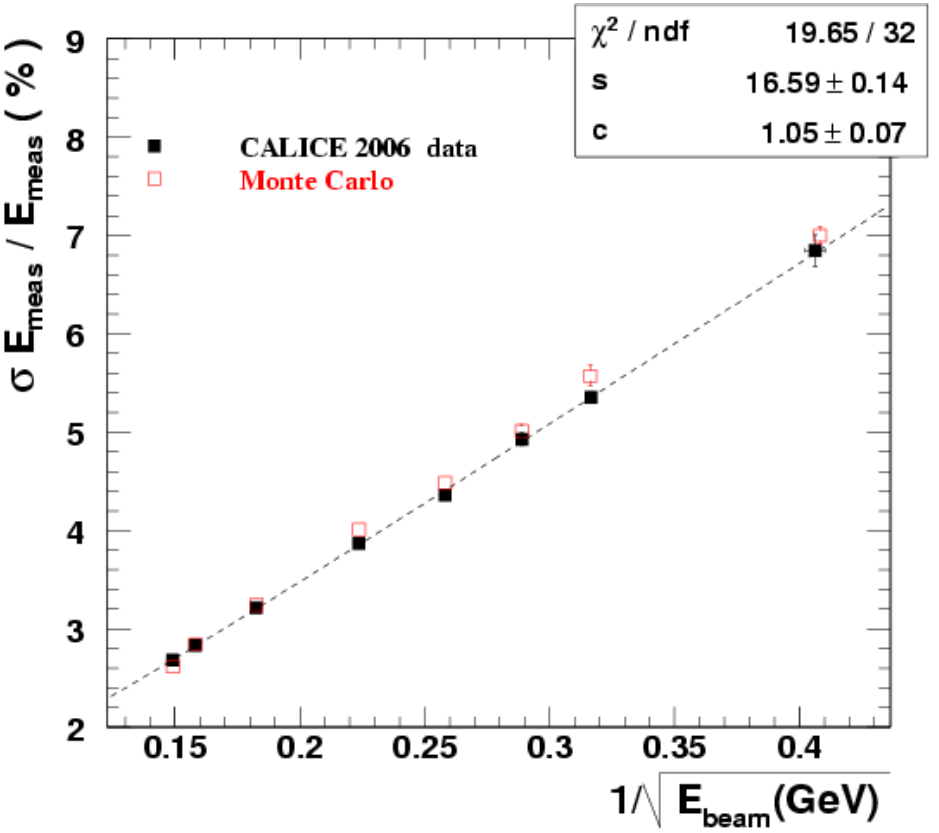


SiW ECAL results

Energy (non-) linearity



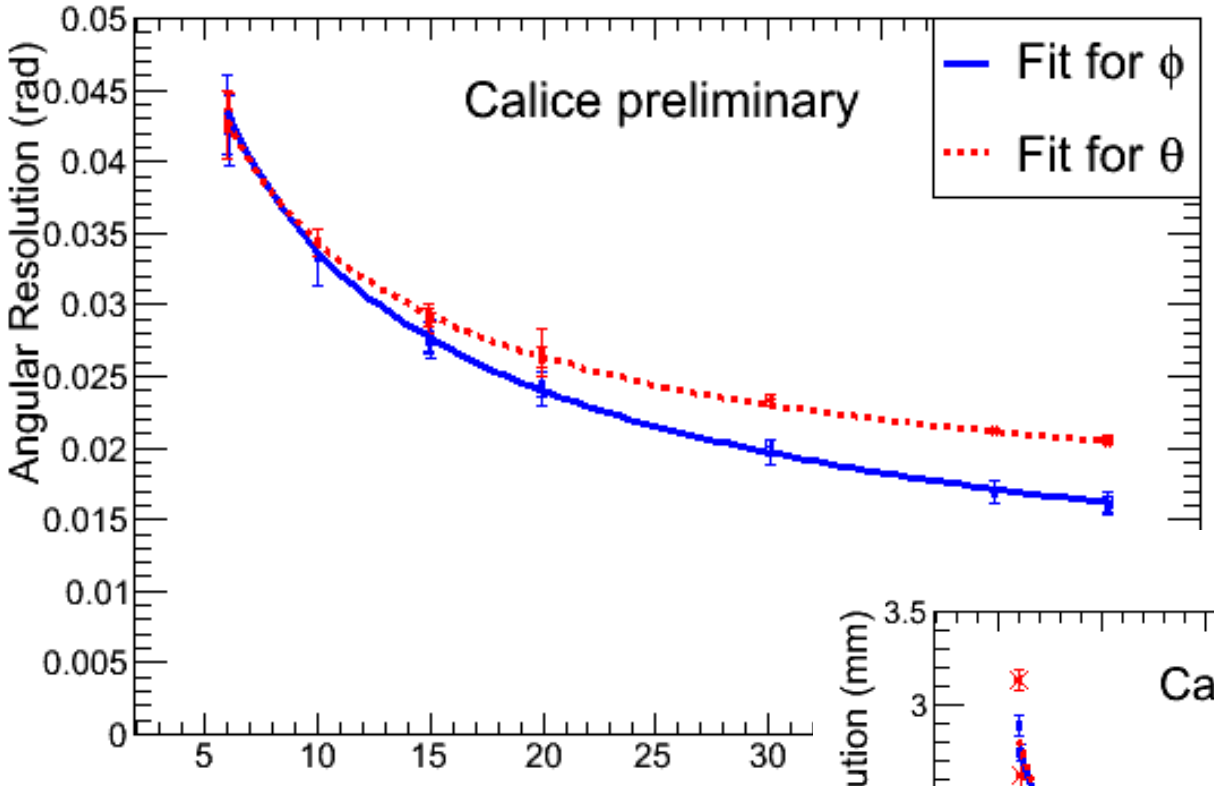
Energy resolution



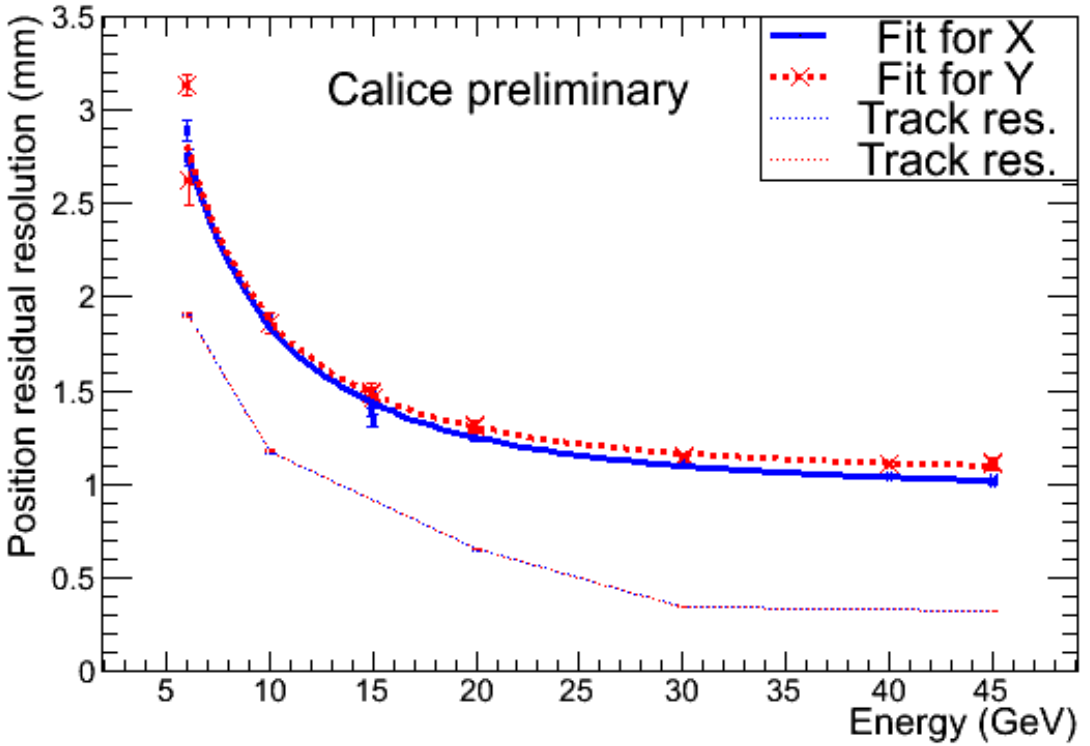
$$\frac{\sigma E_{Meas}}{E_{Meas}} = \left(\frac{16.6 \pm 0.1}{\sqrt{E(GeV)}} \oplus (1.1 \pm 0.1) \right)\%$$

SiW ECAL results

Angular resolution



position resolution

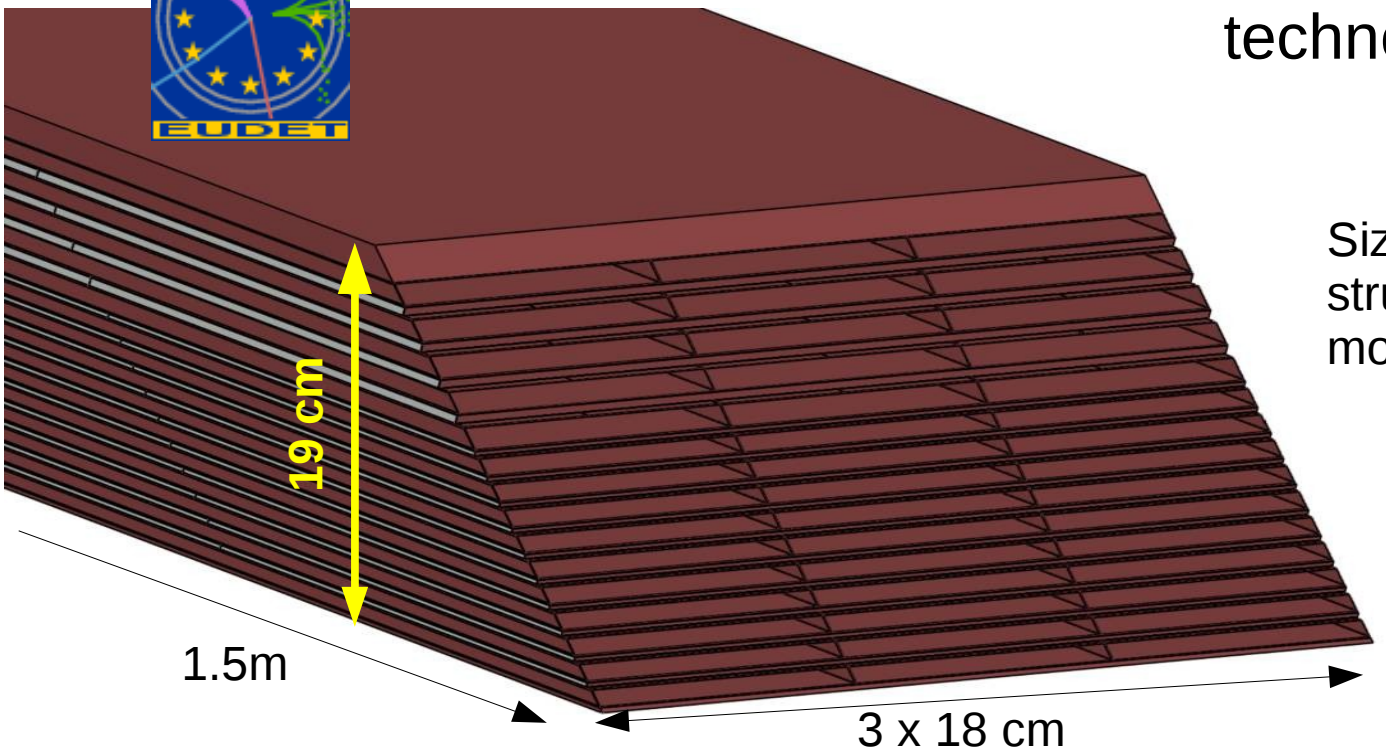


Next steps:

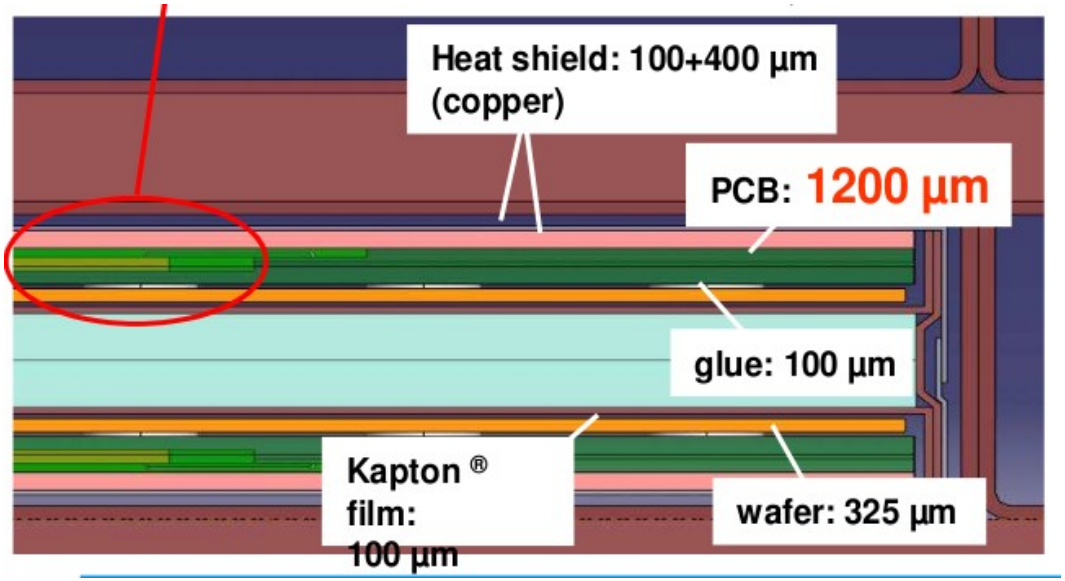
Technological prototypes

Address integration issues
- Embedded FE electronics
- ILC timing structure
- Cooling
- Large mechanical structures

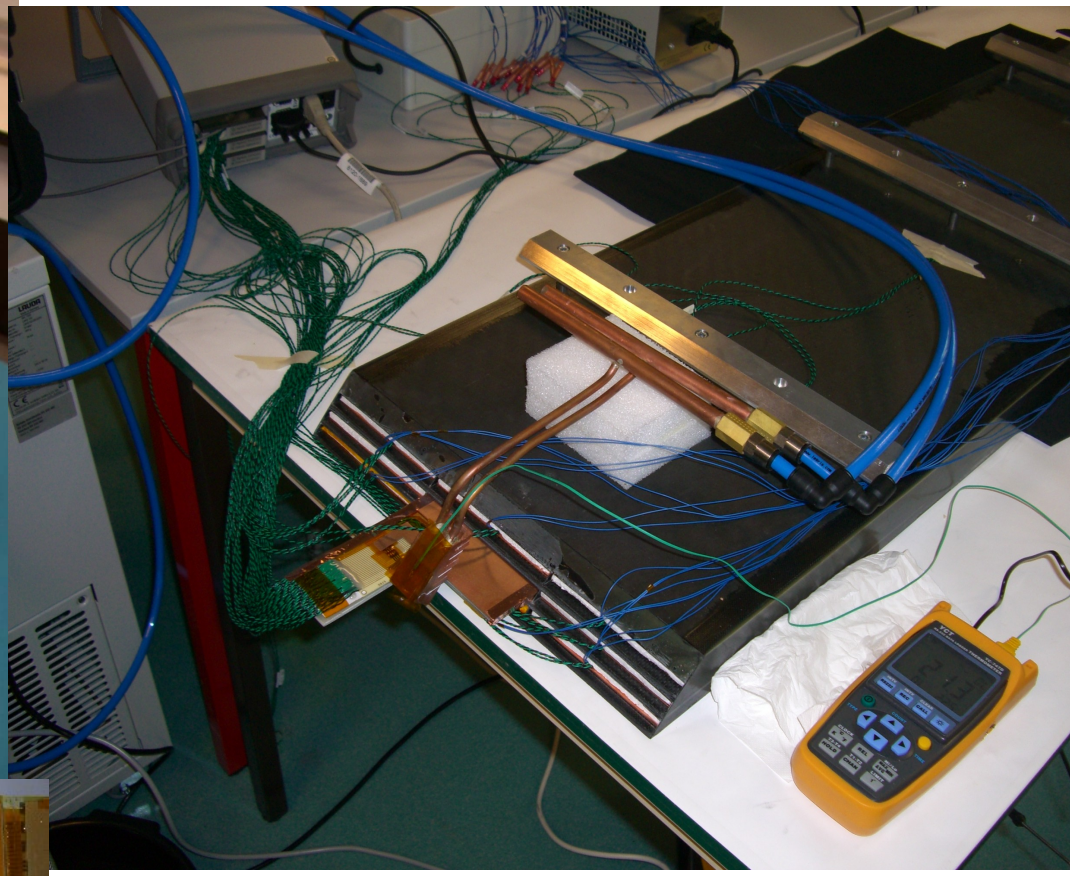
SiW ECAL
technological prototype

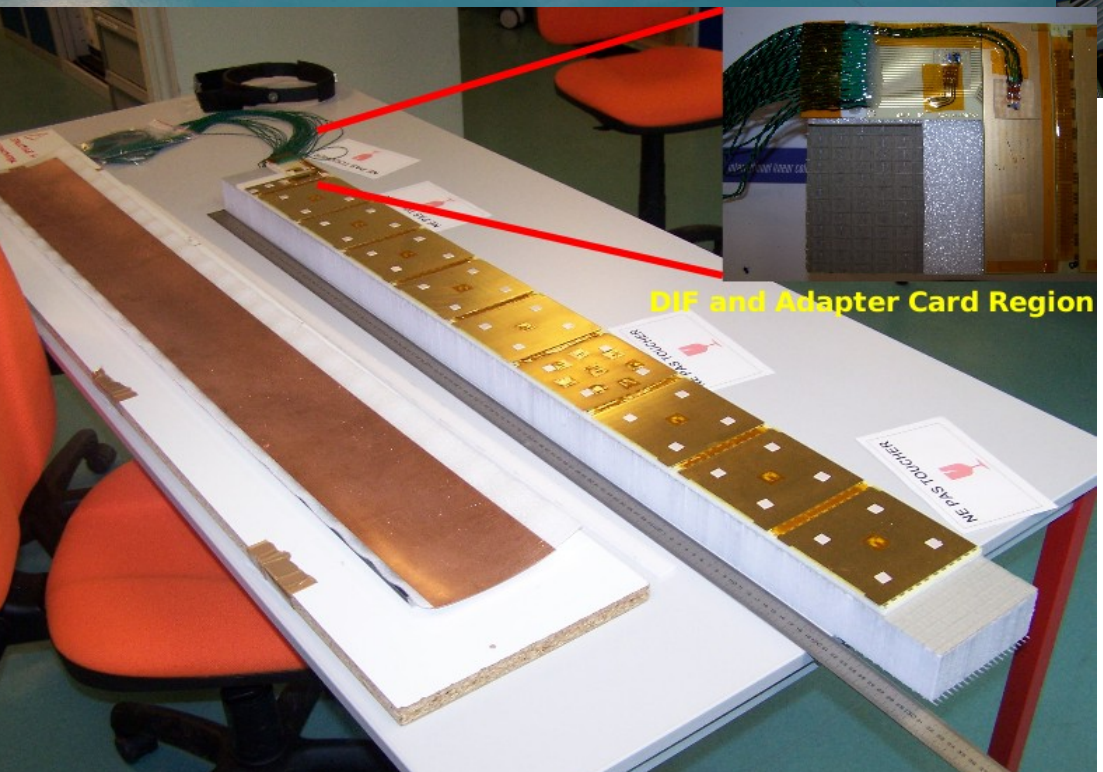


Size and mechanical structure close to LC detector module



Detector “slab” consisting of 2 sensitive layers

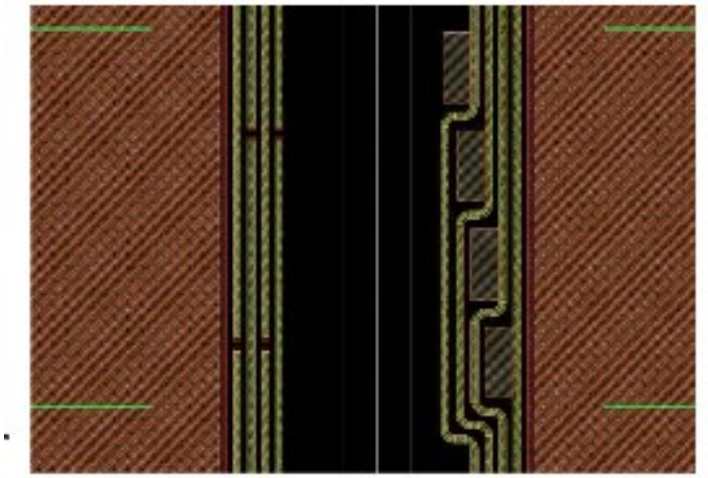




Mechanical and thermal tests underway...

Silicon wafer R&D

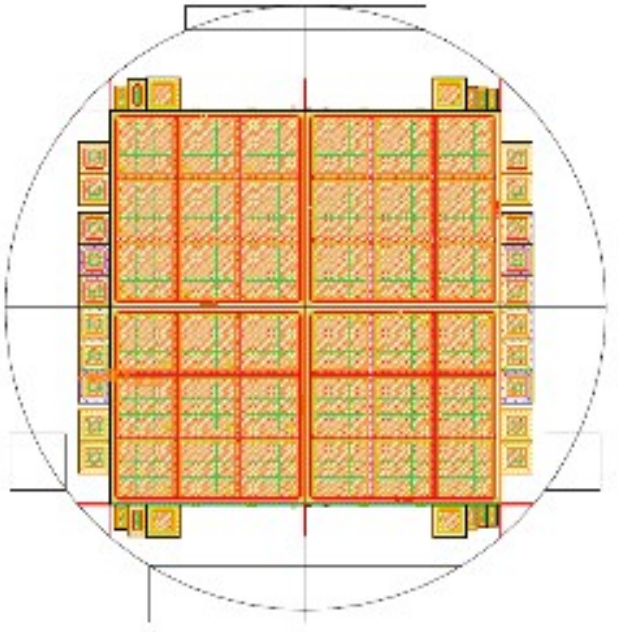
- improved sensor design
- larger size
- lower price



New designs of sensors

New Si sensors from Hammamatsu

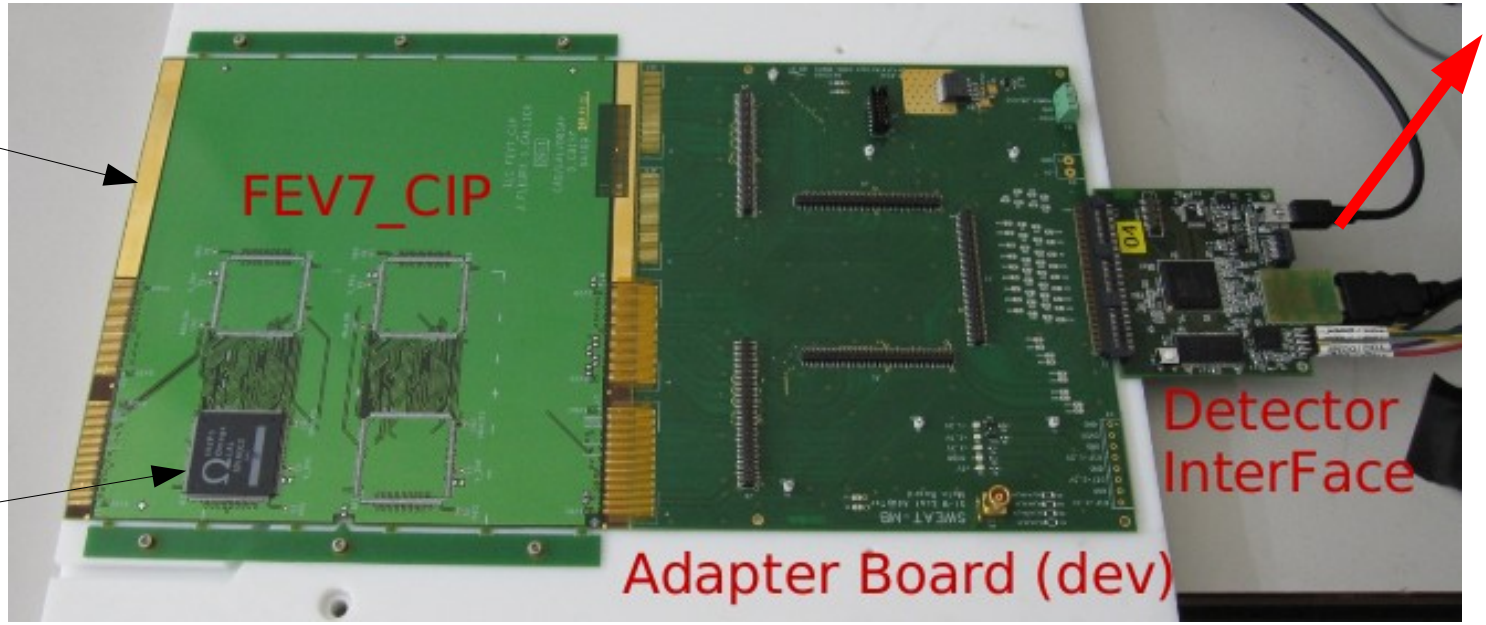
9x9 cm², 324 pixels



Front end electronics (SiW)

Si sensor on back side

Front-end chip (SPIROC2)



DAQ

Front-end chip eventually embedded into PCB

Chip designed for ILC time structure

- power pulsing
- this part needs to be tested

DAQ system overview

(**Detector Unit**: ASICs)

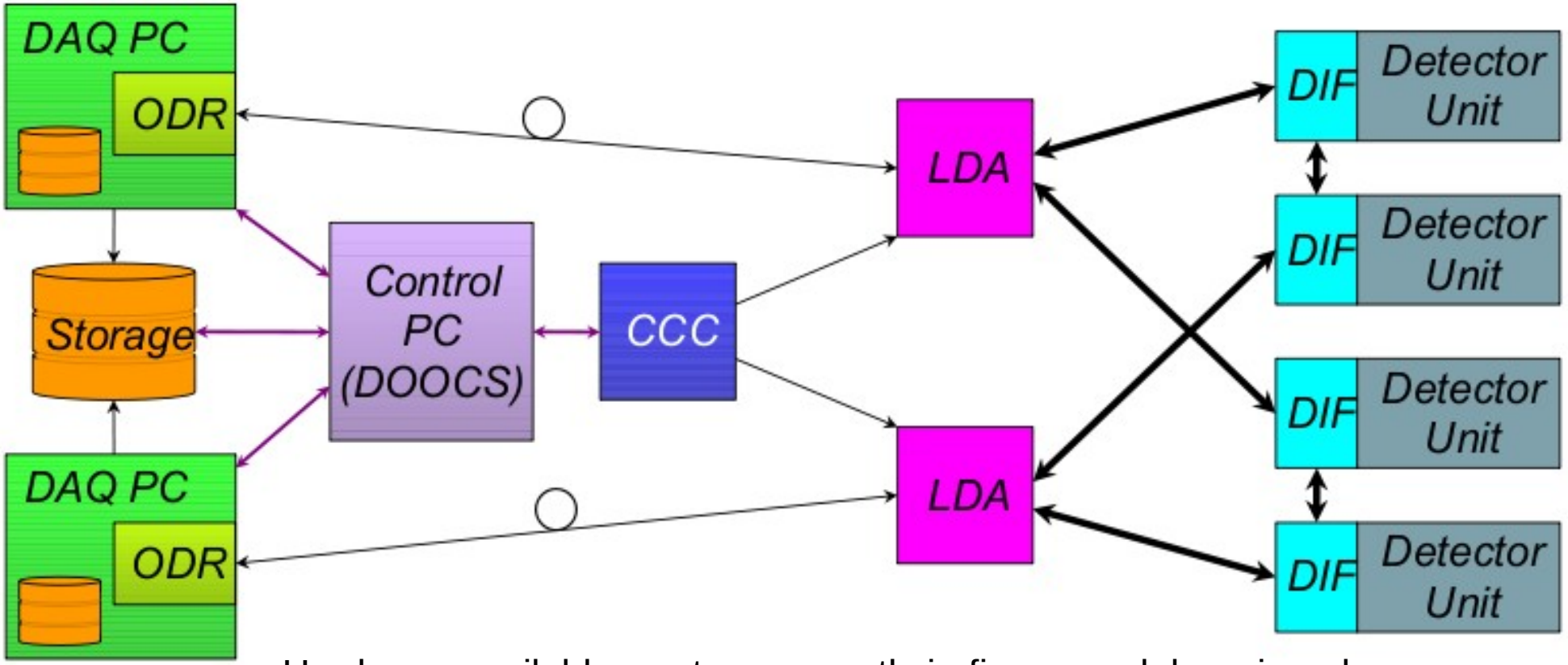
DIF: Detector InterFace connects generic DAQ and services

LDA: Link/Data Aggregator fansout/in DIFs and drives links to ODR

ODR: Off-Detector Receiver is PC interface

CCC: Clock and Control Card fans out to ODRs (or LDAs)

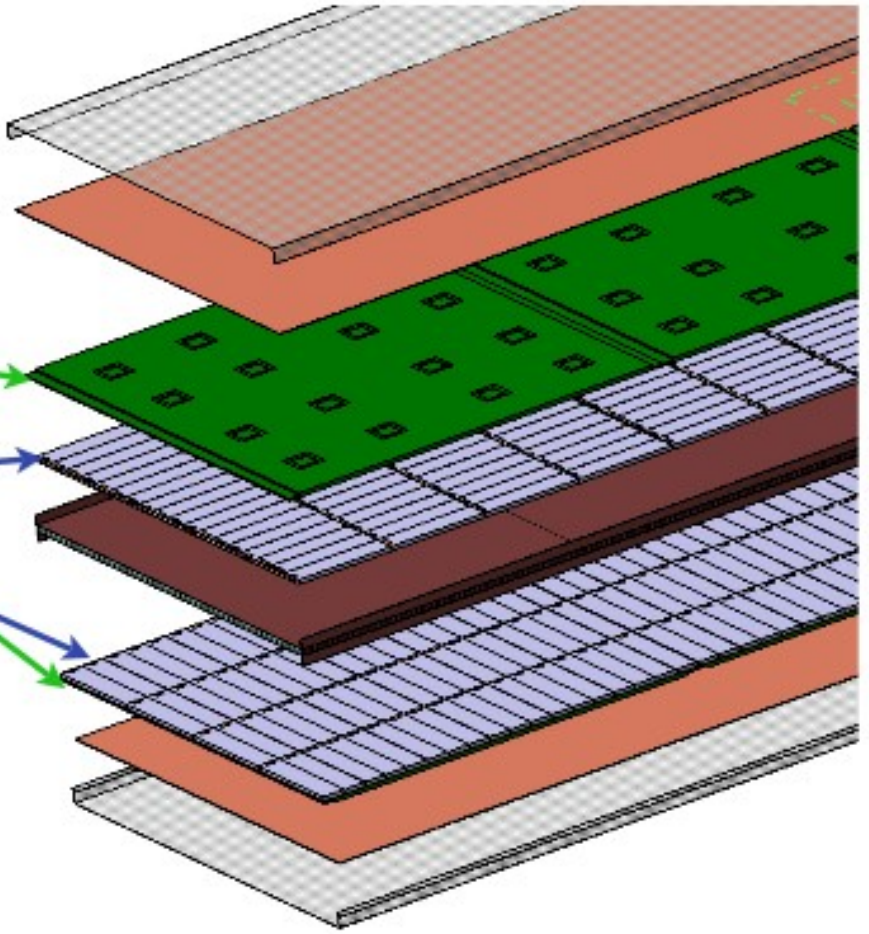
Control PC: Using DOOCS



Hardware available; system currently in firmware debugging phase

future plan

- readlout elex
- scintillator strips
- make and test
- a few layers



a ScECAL detector slab: this can be integrated with a SiW-like mechanical structure

Future testbeam plans

SiW ECAL

- probable combined testbeam of physics prototype with
  US digital HCAL / FNAL MT mid-2010 (?)

  Comparisons of AHCAL/DHCAL technologies

- Preparations for technological prototype

  - small-scale tests of next generation Si sensors and electronics
    Cosmics for first studies
    ILC beam structure highly desirable to test power pulsing of FE electronics

  - technological prototype progressively equipped as Si sensors arrive

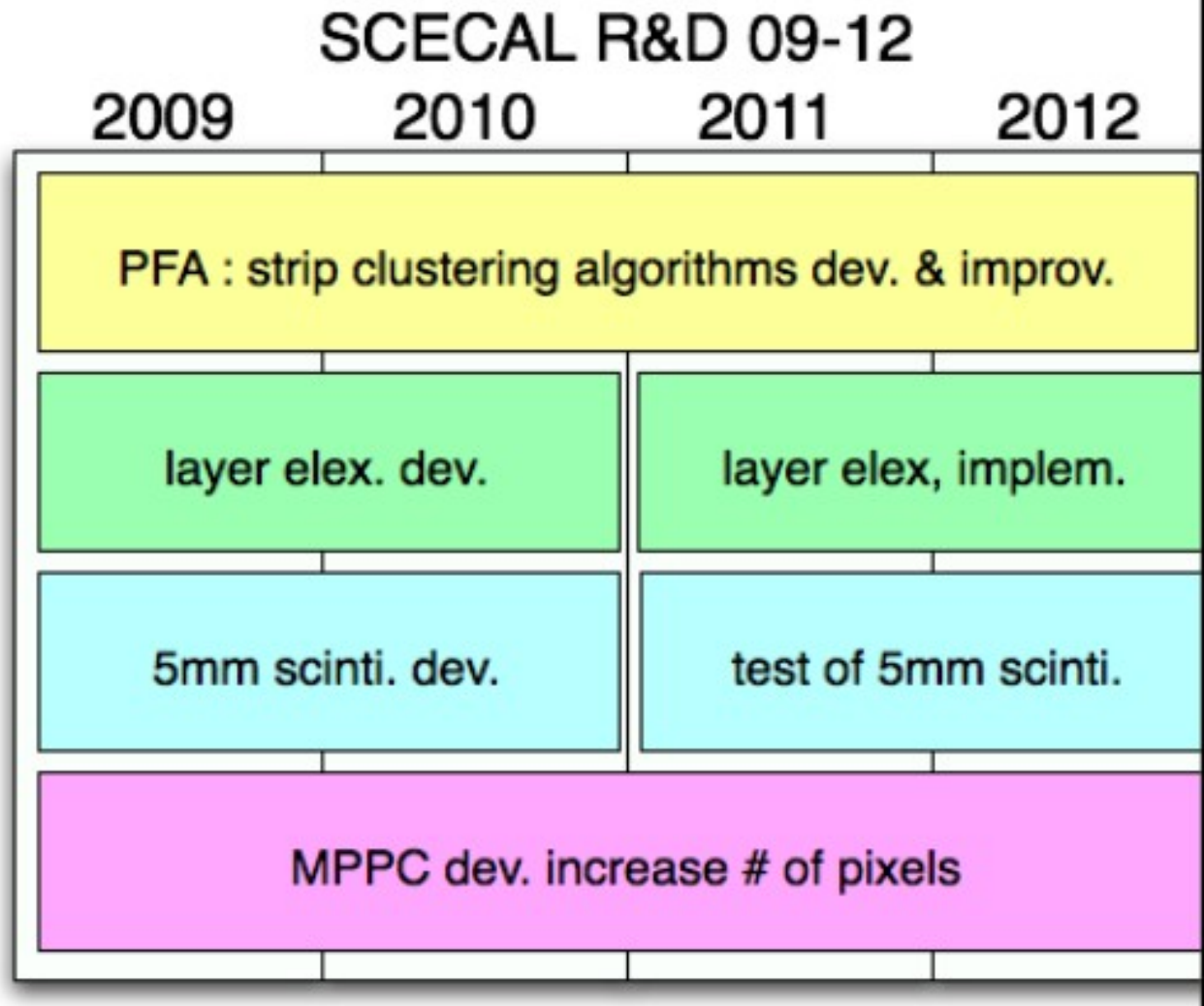
  - combined tests of “technological prototypes” ECAL / A-HCAL / (S)D-HCAL
    - starting 2011 with partially equipped ECAL

  Could incorporate one (or more) layers of scintillator ECAL into mechanical structure

ScECAL

future plan

- software
- hardware
  - some layers
  - smaller scint.
  - MPPC



Conclusions

Physics prototypes of 2 ECALs made wide use of testbeams
- Physics concepts validated

Entering phase of technological prototypes
- some small testbeams required in the next ~year to debug
- combined testbeams possible from ~mid 2011