

# D\_RD\_01: ILC detector design

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Université Blaise Pascal, Clermont-Ferrand





In2p3



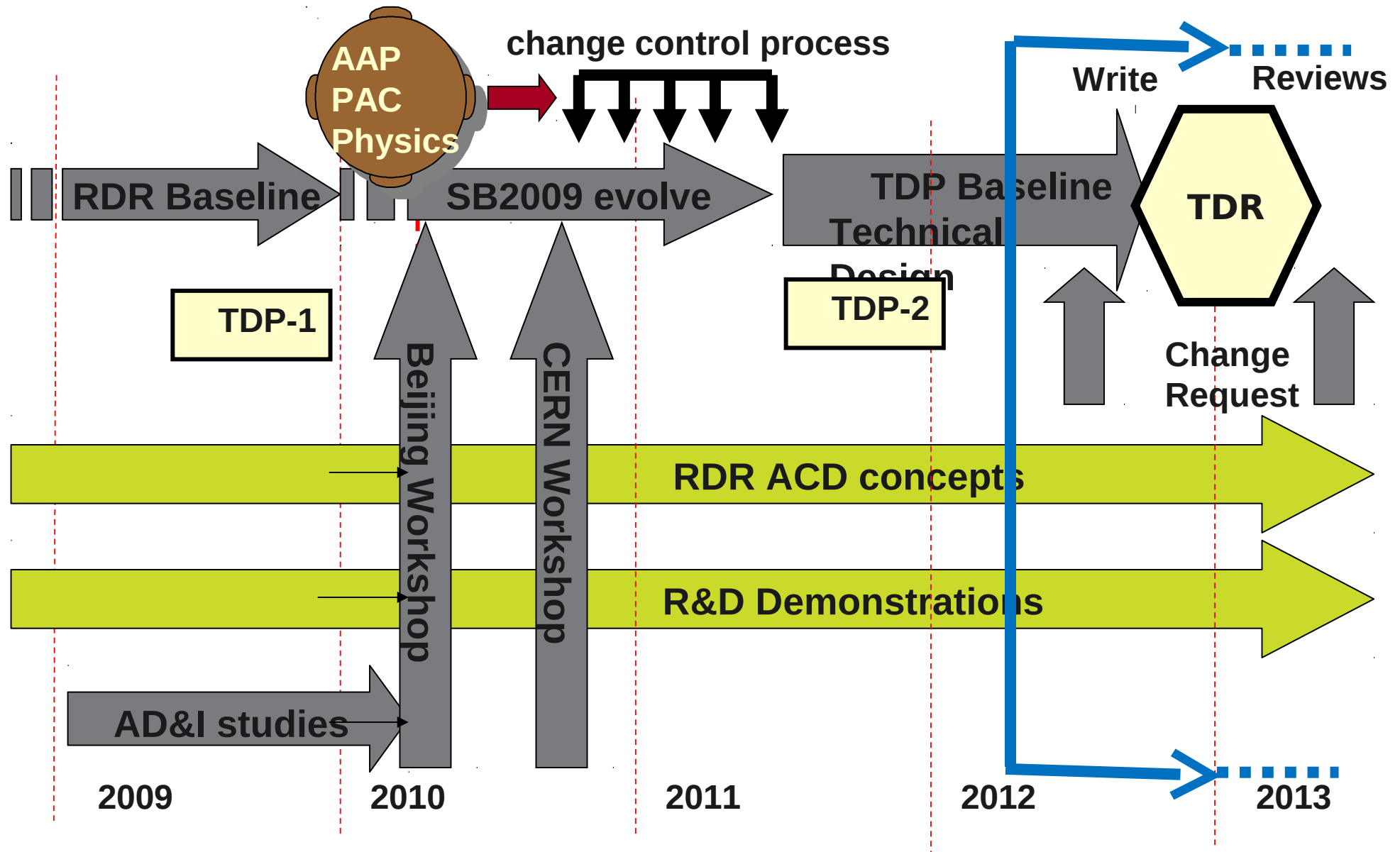
Status of ILC: machine & detector

Detector concept: ILD

ECAL hardware development

Simulation & Reconstruction

# Technical Design Phase



## The time line of the LOI process

- **Oct. 2007: Call for LOIs was made by ILCSC**
  - Jan. 2008: Detector management was formed
  - Mar.2008: IDAG formed, 3 LOI groups known
  - **Mar.2009: 3 LOIs submitted**
  - Summer 09: **IDAG recommendation for validation and ILCSC's approval**
  - Oct 2009: Work plan of the validated groups
  - **Mar:2009: IDAG began monitoring the progress**
  - **End 2010: Interim report completed**
  - ***DBD outline to be monitored***
  - **End 2012: Detailed Baseline Design Report**
- 
- The timeline diagram is a blue arrow pointing downwards, representing the progression of time from 2007 to 2012. The years are labeled on the right side of the arrow. Key events are marked with colored dots and stars, and labeled with text. Red arrows point from the text on the left to the corresponding markers on the timeline. A yellow arrow points from 'KILC12' to the 2012 marker.
- | Year | Event   |
|------|---|
| 2007 | Oct. 2007: Call for LOIs was made by ILCSC  |
| 2008 | Jan. 2008: Detector management was formed<br>Mar.2008: IDAG formed, 3 LOI groups known  |
| 2009 | Mar.2009: 3 LOIs submitted<br>Summer 09: IDAG recommendation for validation and ILCSC's approval<br>Oct 2009: Work plan of the validated groups<br>Mar:2009: IDAG began monitoring the progress |
| 2010 | End 2010: Interim report completed  |
| 2011 | DBD outline to be monitored   |
| 2012 | End 2012: Detailed Baseline Design Report   |

ILC project is nearing a phase transition

International Linear Collider ILC GDE will submit TDR at beginning of 2013

building on:

Reference Design Report (RDR 2007)

Technical Progress Report (2011)

ILD and SiD detector concepts will submit Detailed Baseline Document (DBD)  
on similar timescale

building on:

Letters of Intent (LoI 2009)

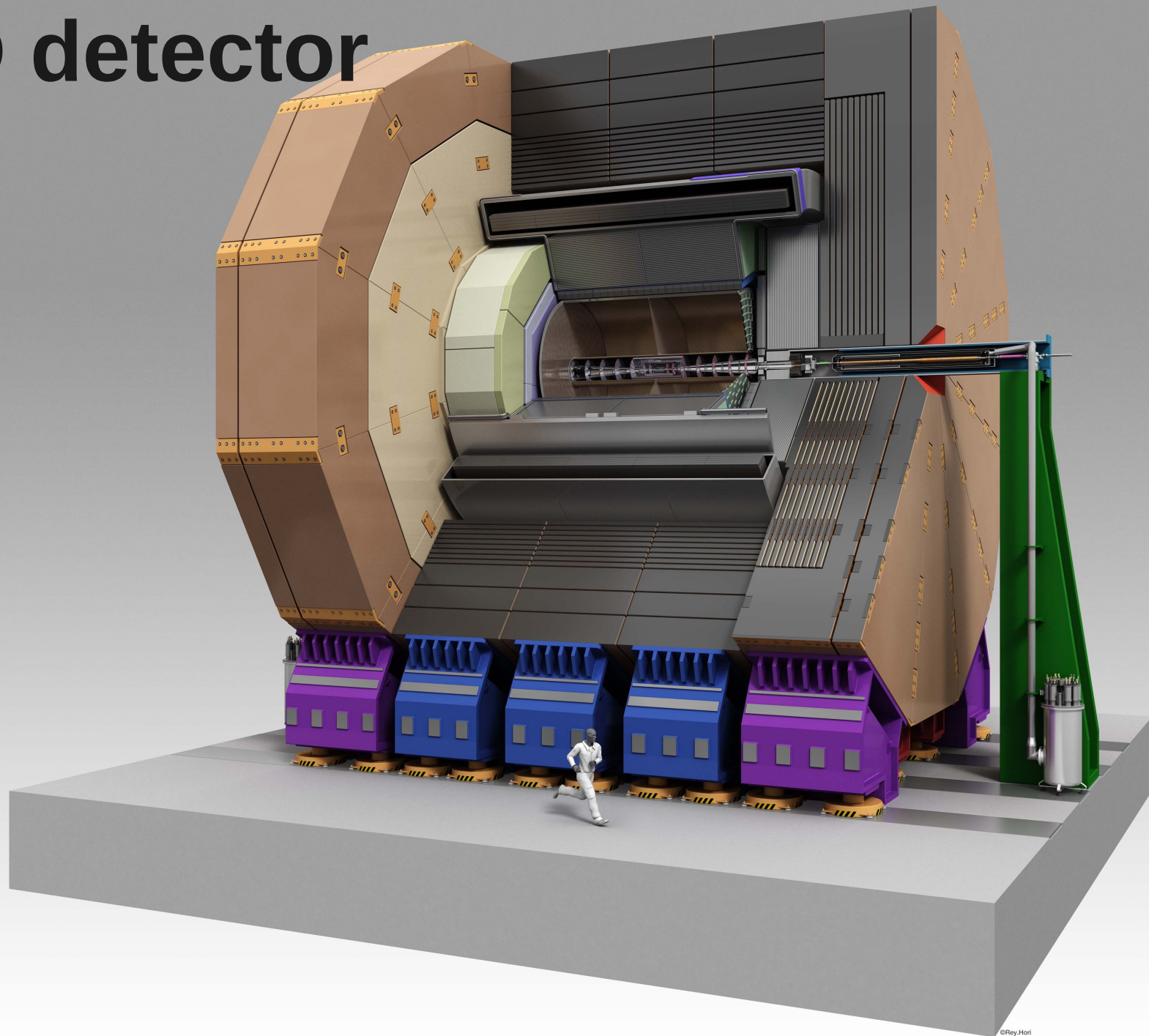
ILC physics and Detectors status report (2011)

Expect interesting and relevant LHC results during 2012

essential input to motivation for ILC: Higgs factory?

will help define our roadmap after 2012

# ILD detector

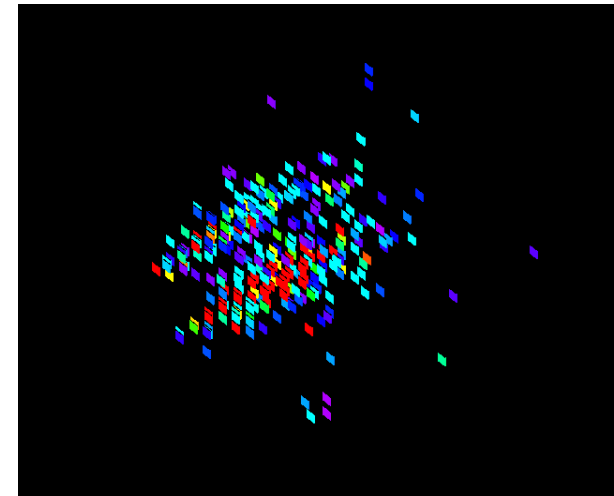
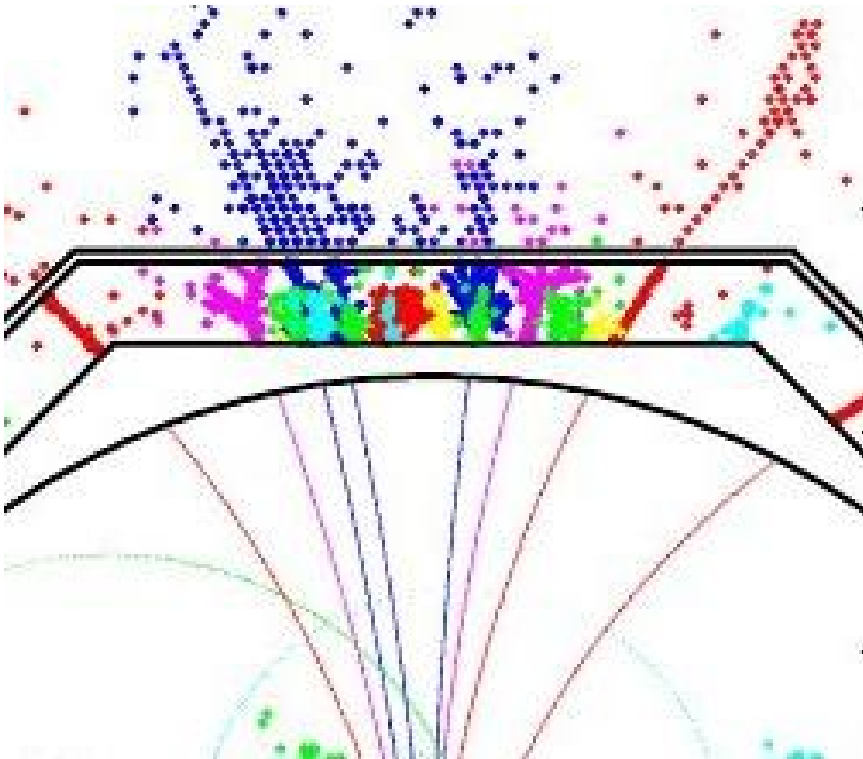


ILD detector designed for “particle flow” reconstruction  
to provide unprecedented jet energy resolution ( $\sim 2$  x better than LEP)

tracking detectors used to measure charged energy  
calorimeters used only for neutral particles

must reconstruct individual particle showers in the calorimeters  
requires highly granular calorimeter readout

TYL project concerns development of hardware and reconstruction  
methods for the ILD electromagnetic calorimeter

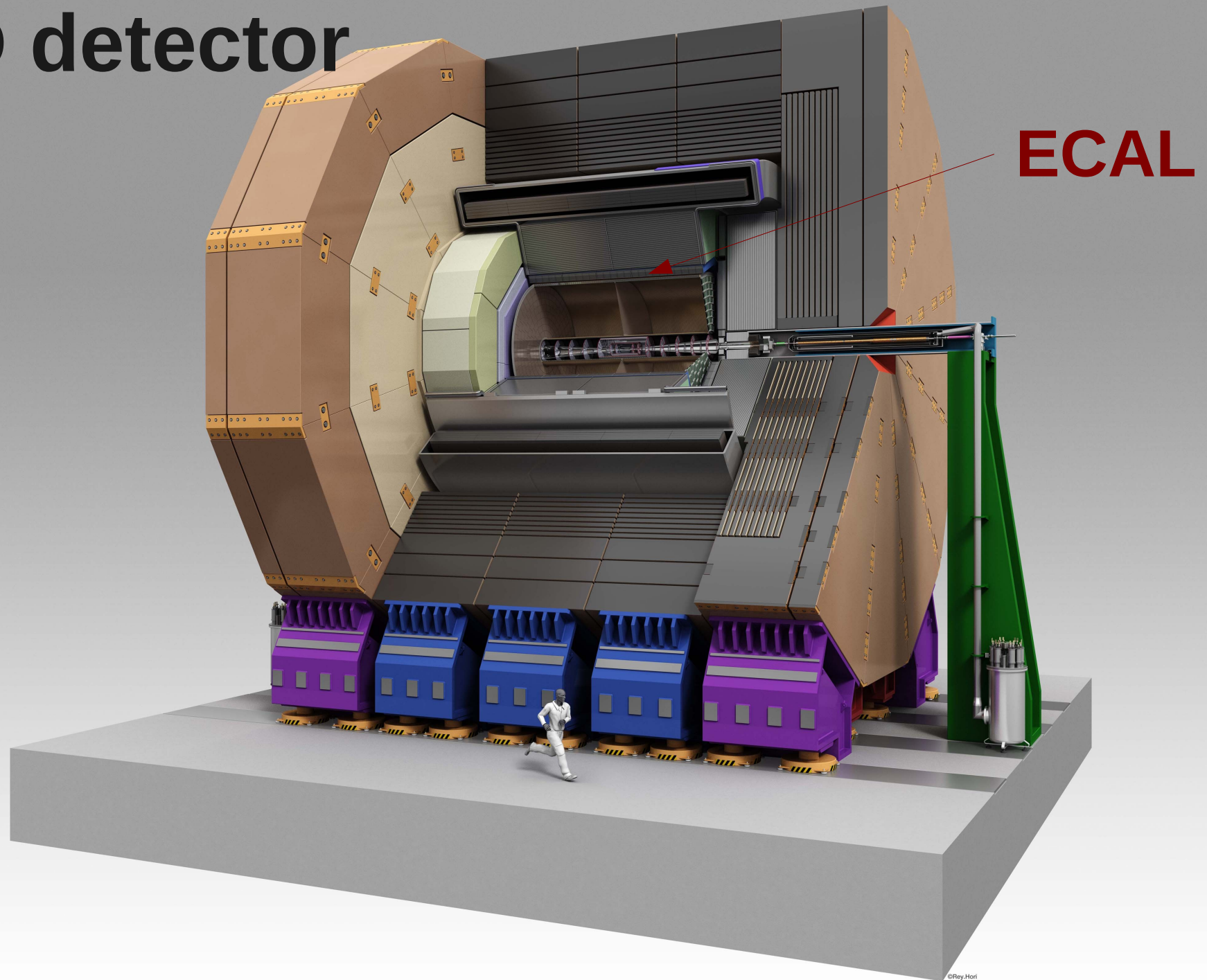


Hardware aspects carried out within

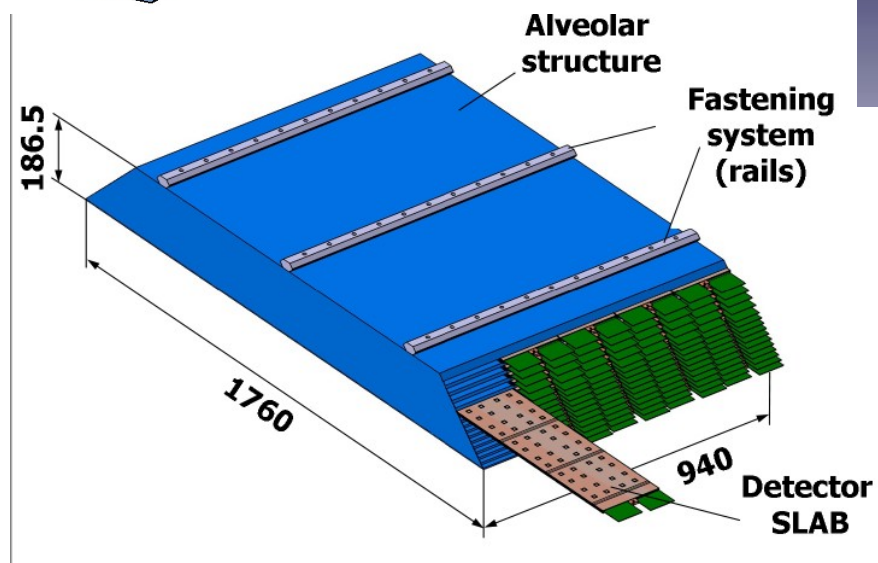
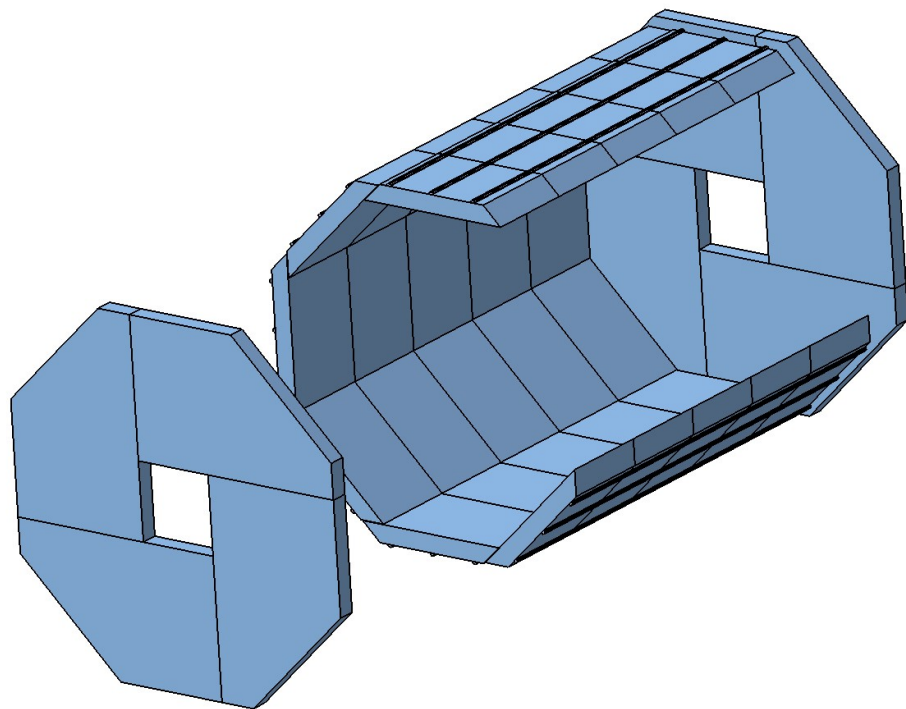




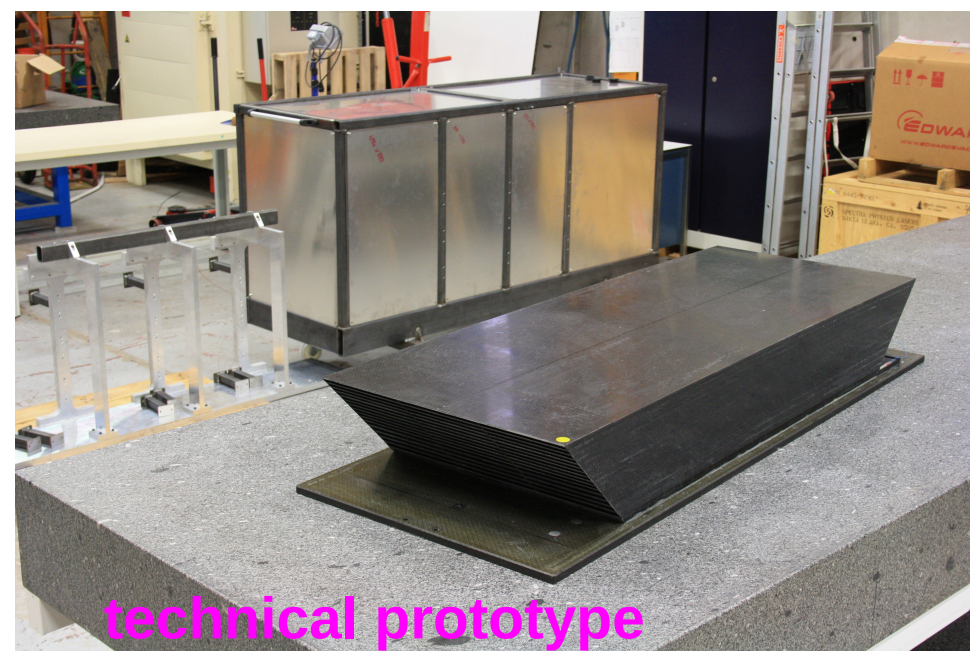
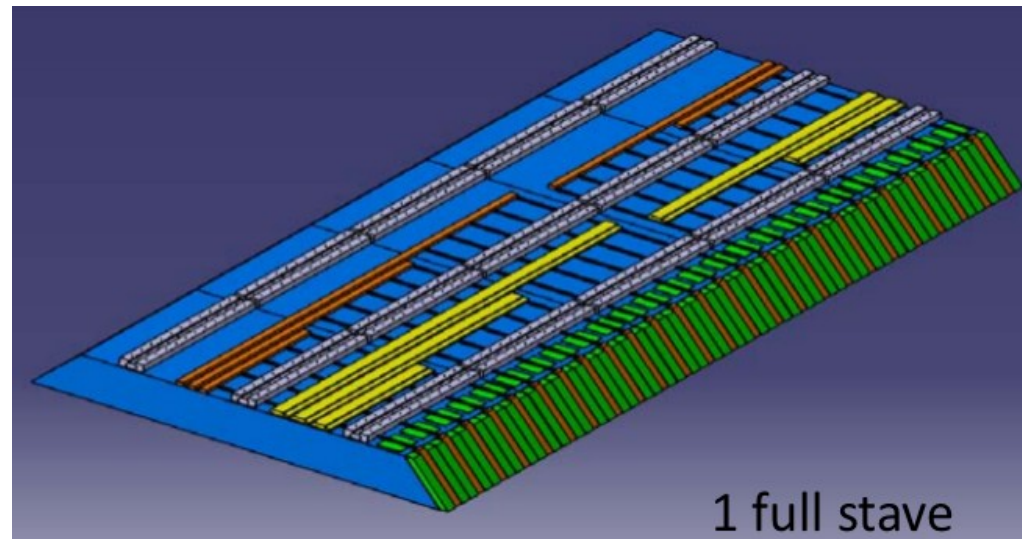
# ILD detector



# ECAL



5 mm granularity  
 $\sim 10^8$  readout channels





Basic concept:

Sampling calorimeter

Tungsten absorber

20~30 sampling layers

Active material must be

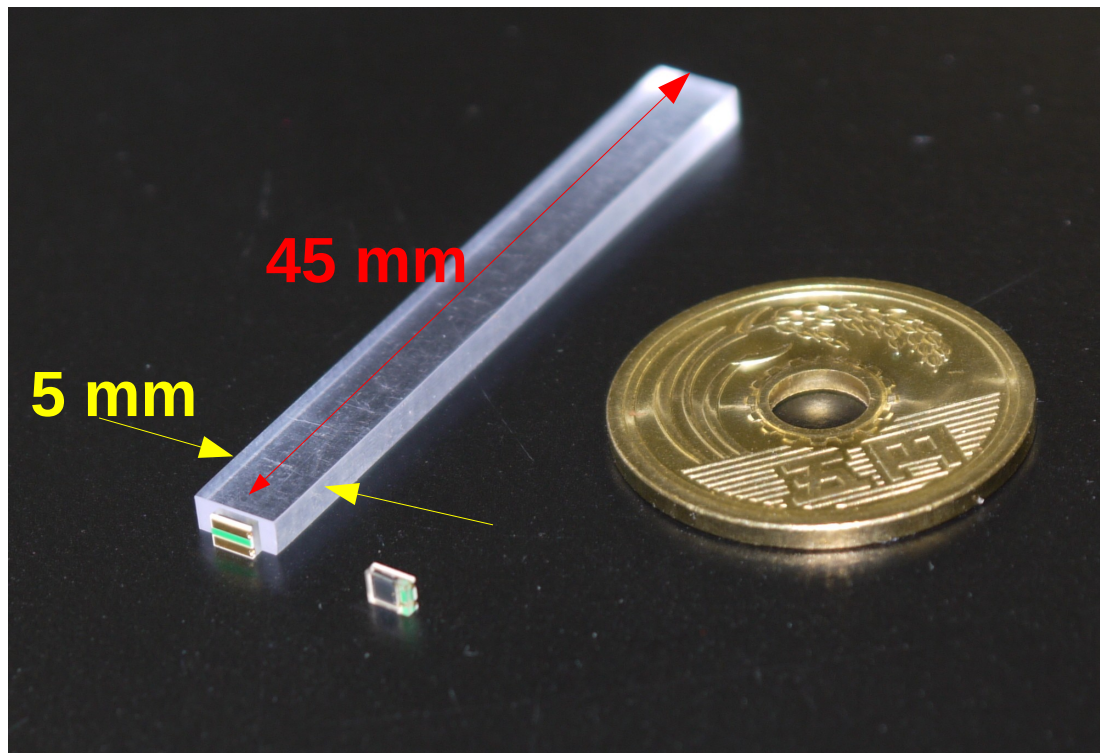
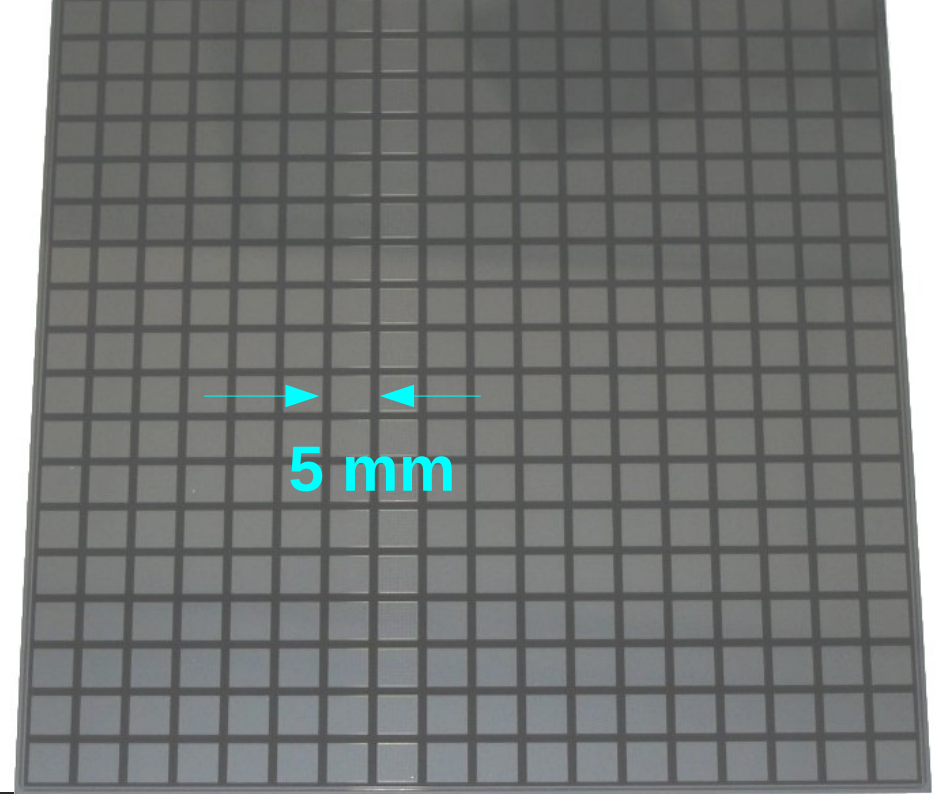
as thin as possible

segmented to ~5 mm

good S/N for single MIP

measure up to ~2500 MIP

stable, practical to operate



Different technological solutions proposed for detection layers

- \* Silicon PIN diode matrix  
~300  $\mu\text{m}$  thick high-resistivity silicon
- \* Scintillator strips (5x45 mm<sup>2</sup>)  
MPPC readout

Common approach to several aspects

Mechanical structure

Readout electronics

Cooling

Data Acquisition

ECAL accounts for around 1/3 of ILD's projected cost

- large area of sensitive detectors
- large channel density

Silicon technology has some advantages over scintillator

- thinner
- easy to make square segmentation: robust reconstruction
- more stable operation / calibration
  
- however probably somewhat more expensive

Proposal for hybrid design

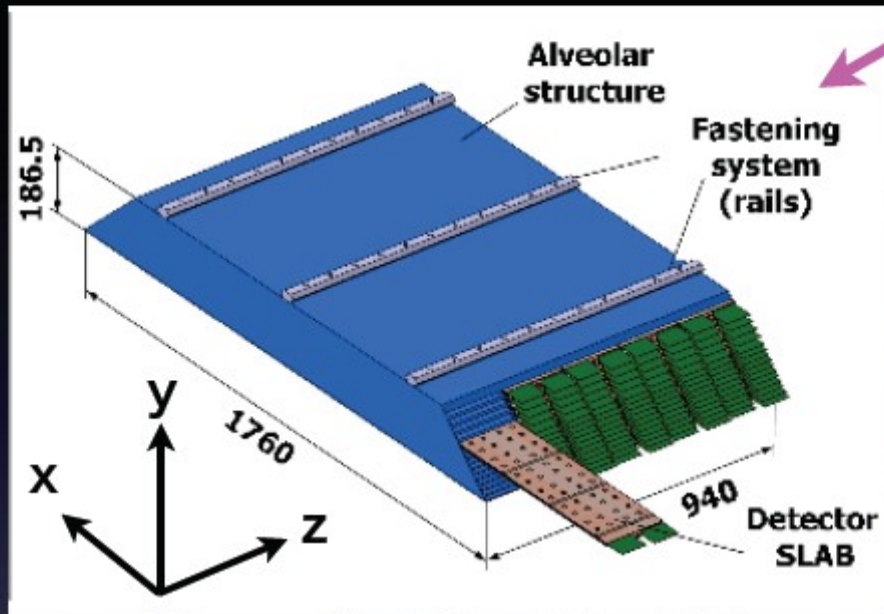
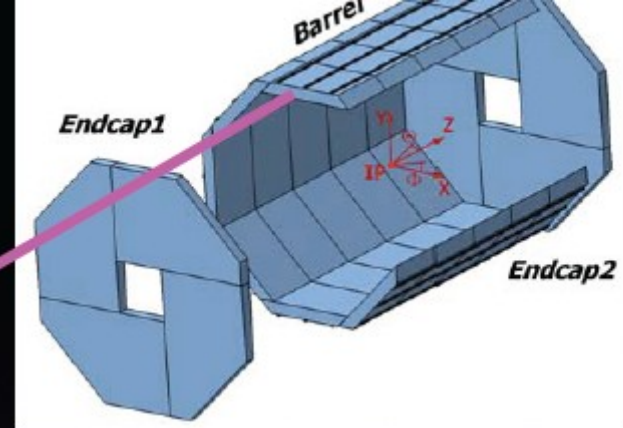
- mixture of silicon and scintillator layers
- attempt to keep advantages of both technologies

# Hardware development

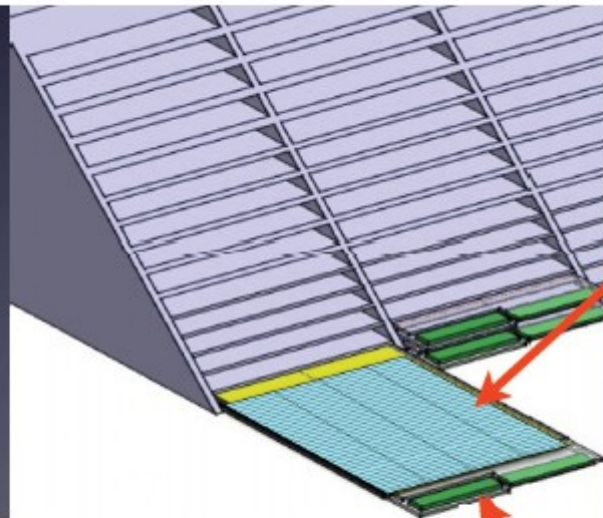
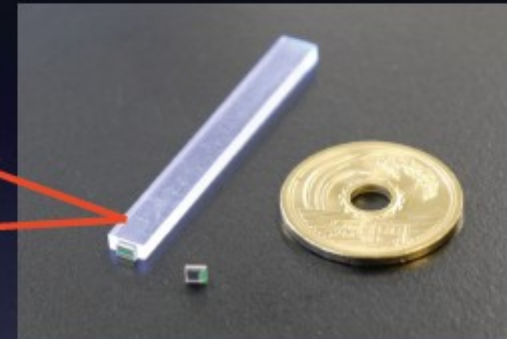
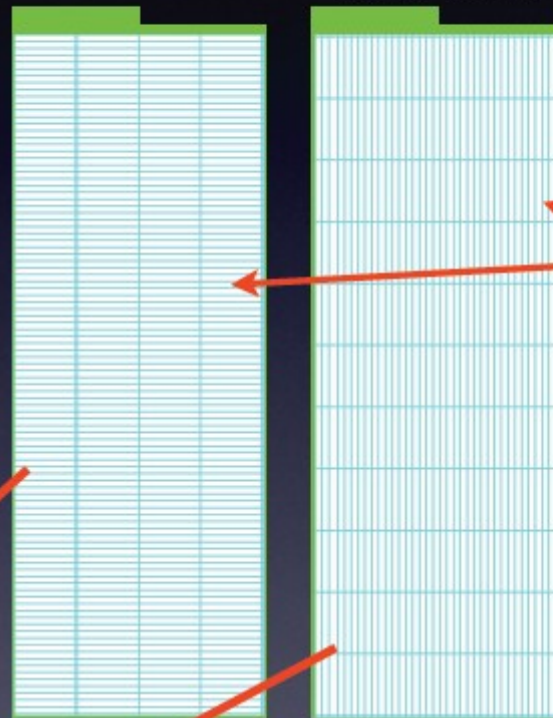
- scintillator
- silicon

# ScECAL in ILD

A module in the top stave of Barrel



fine in x      fine in z



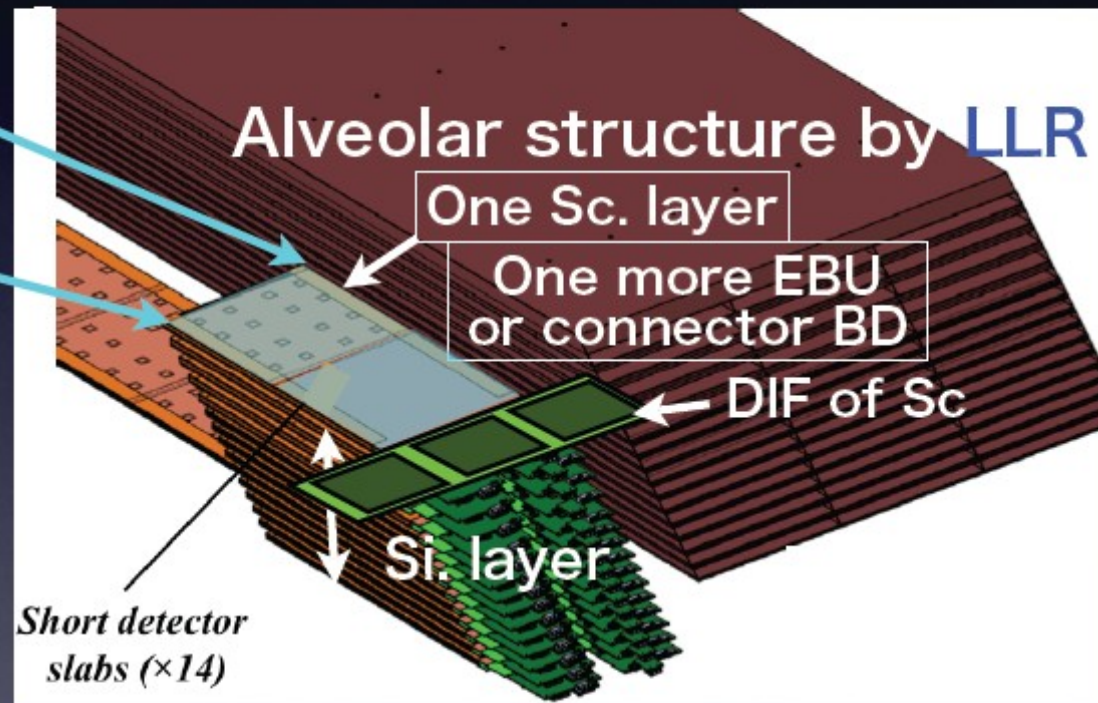
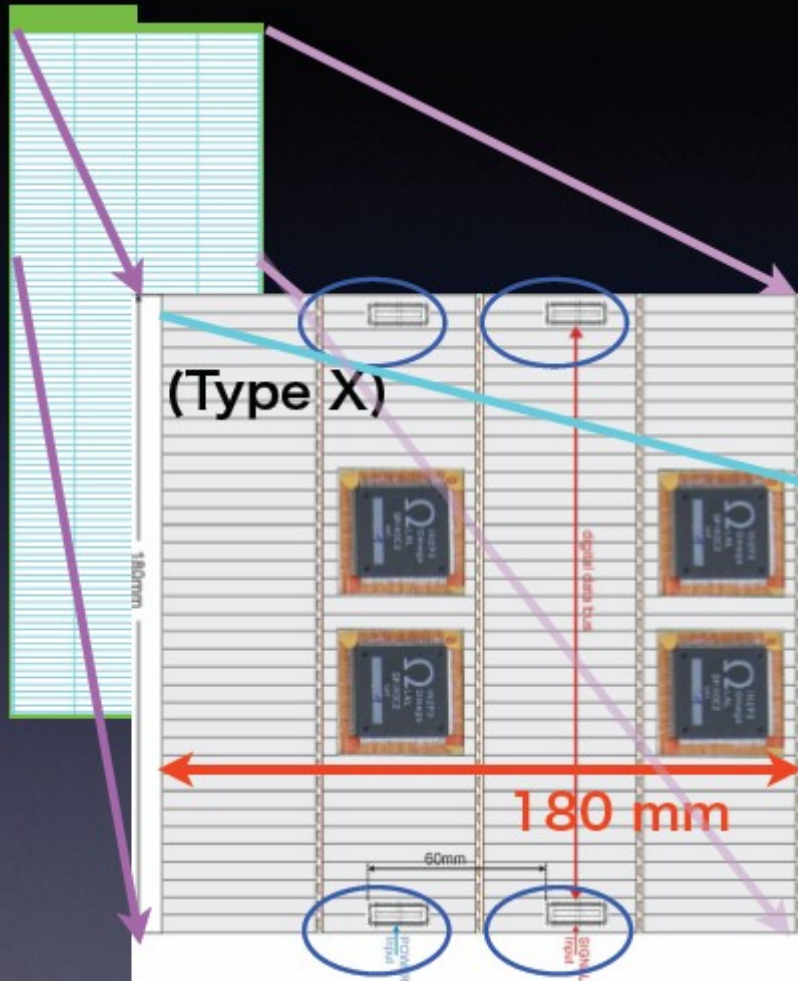
a pair of layers is inserted into the alveolar structure

a x layer and a z layer are put back to back on the H structure W layer



# Plan for Technological plototype

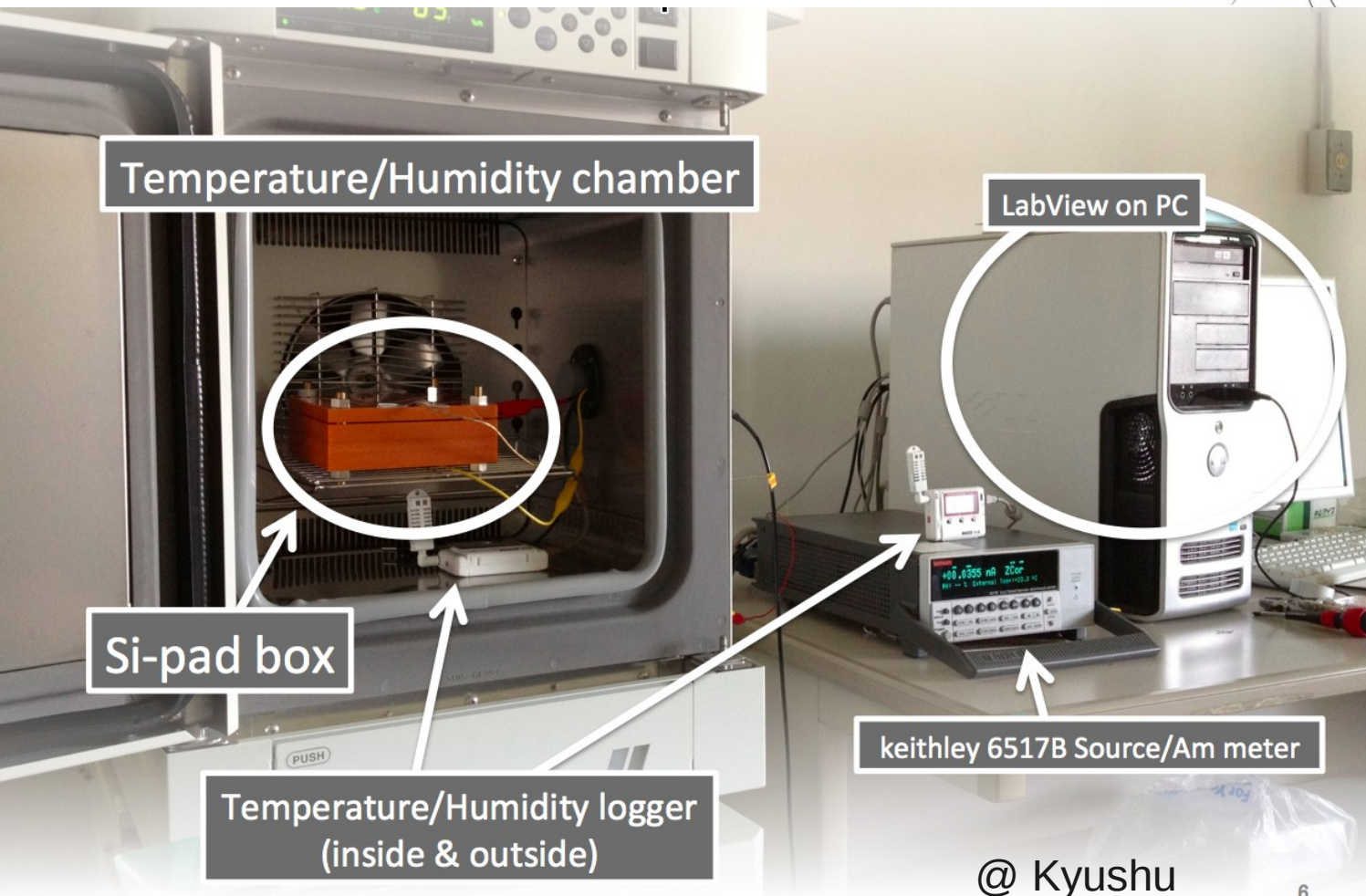
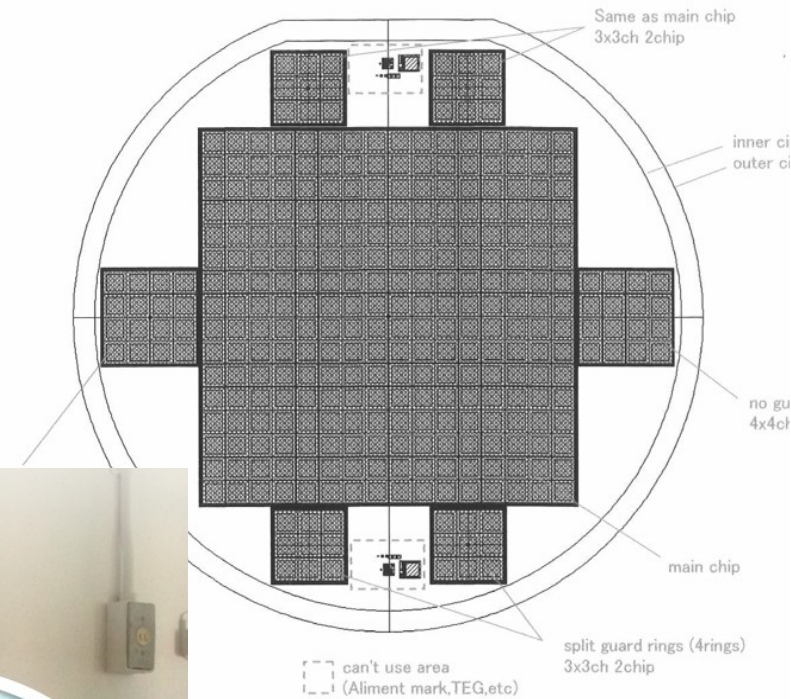
# TB Sep 2012 @DESY



## Silicon sensor studies

In close contact with Hamamatsu PK

Sensor testing setup at LLR and recently Kyushu  
to measure sensors' electrical properties



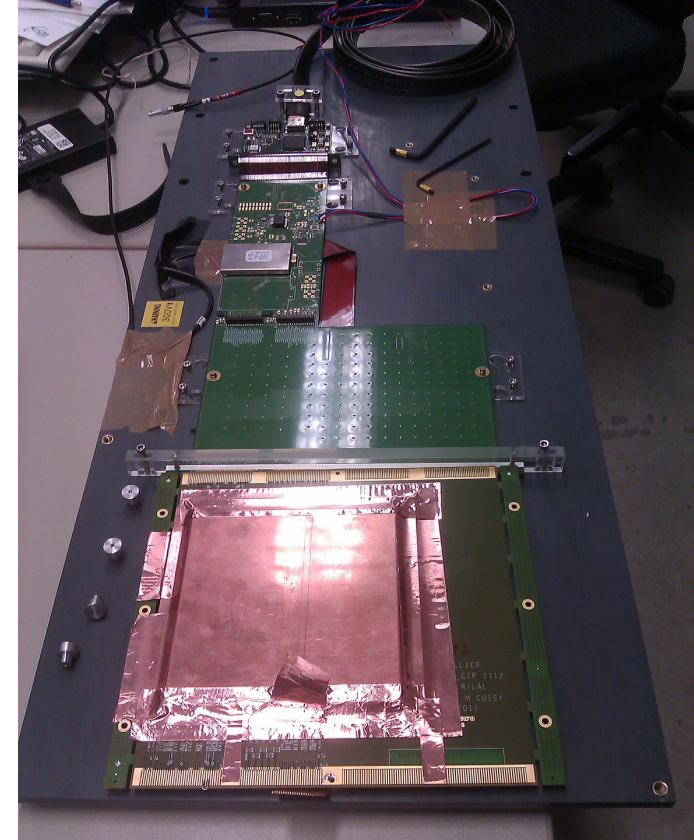
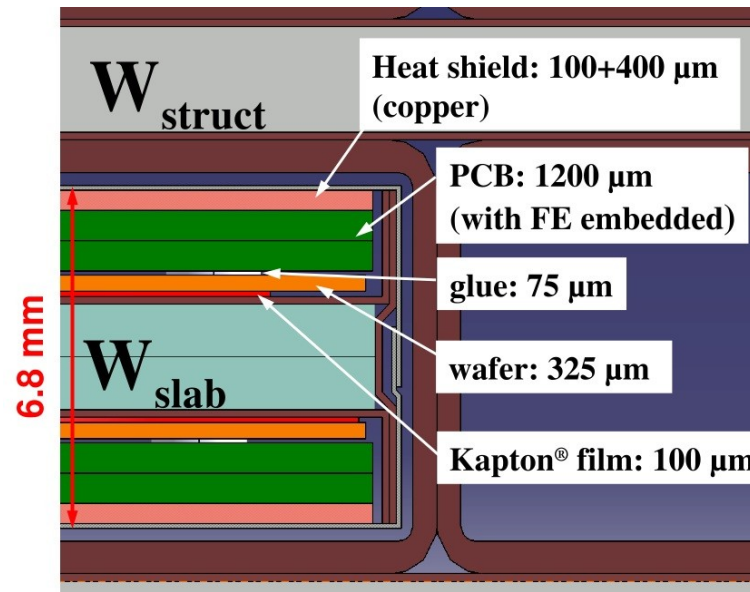
@ Kyushu



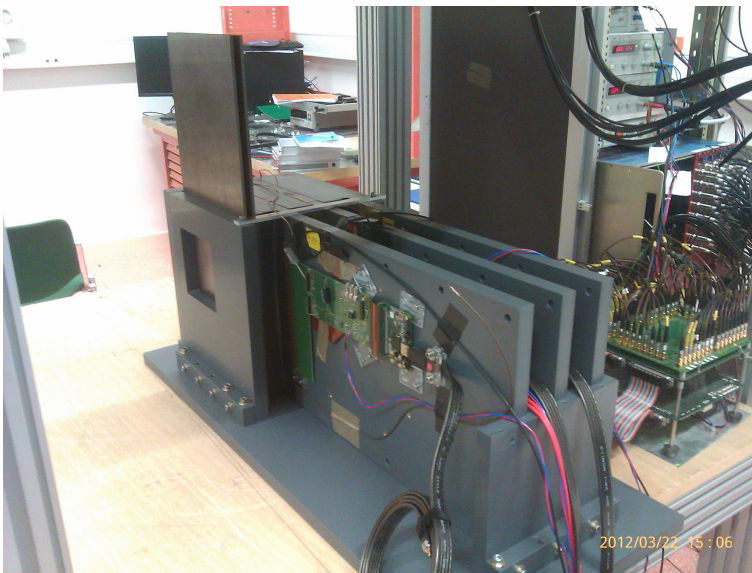
Silicon-W ECAL  
technical prototype

towards integration  
into detector

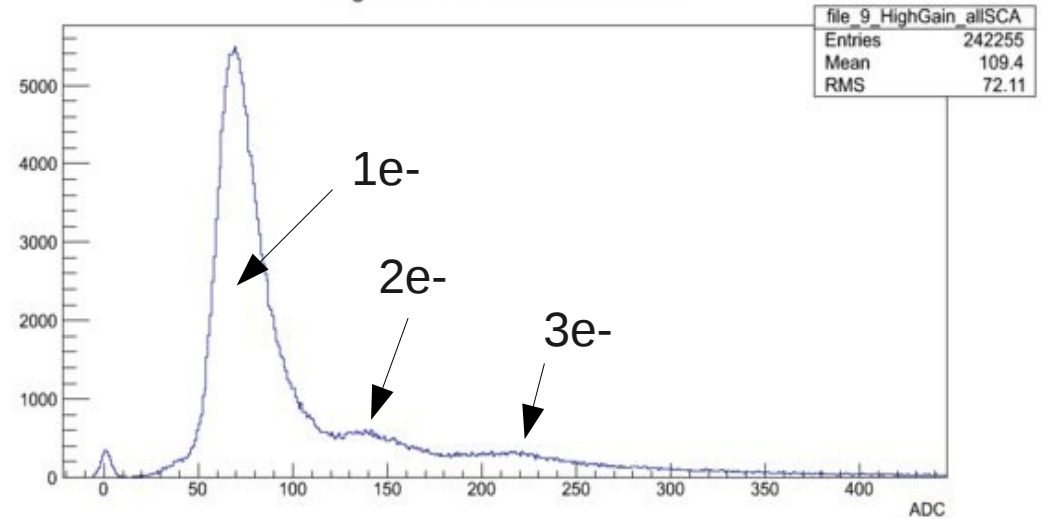
Embedded electronics  
Compact DAQ system  
Cooling system



First test beams 3/2012 @ DESY 1-6 GeV electrons



High Gain for all the SCA - file 9



Clean particle peaks seen: noise under control

Further beam-tests in summer; eventually combined Si-Scintillator tests

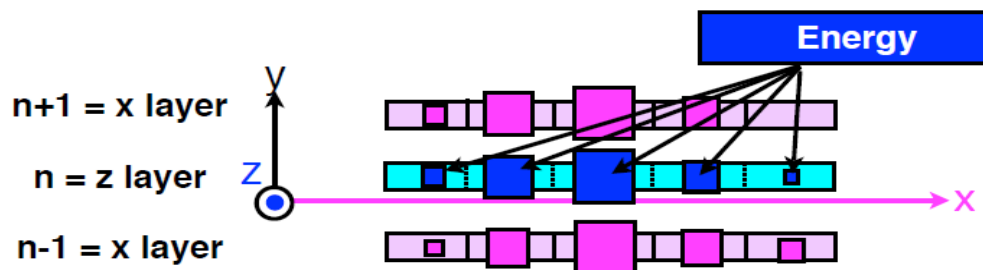
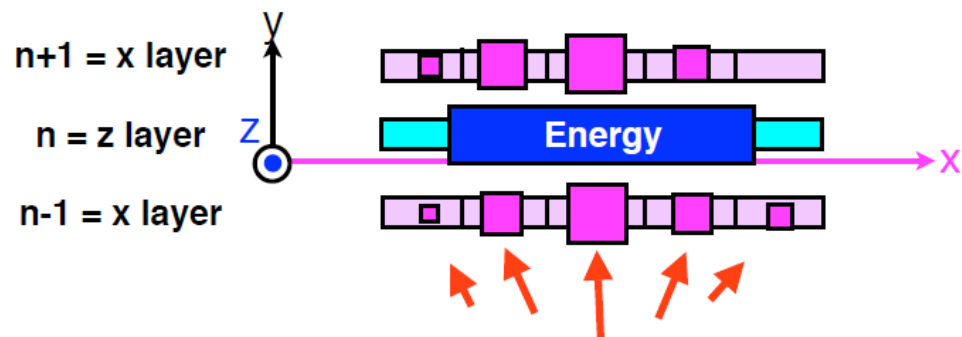
## Reconstruction and simulation studies of highly granular ECAL

- strip-based calorimeter reconstruction
- photon reconstruction
- hybrid ECAL studies

# Split Strip Algorithm

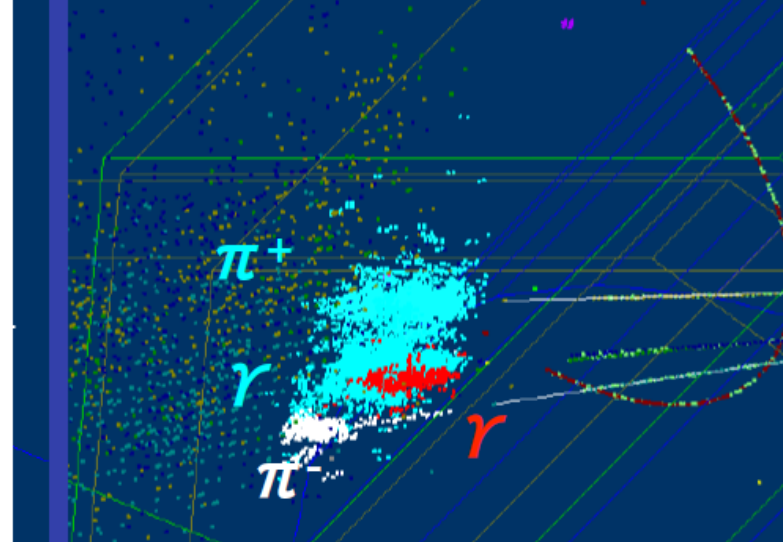
Reconstruct strip-based calorimeter geometry  
orthogonal strips in successive layers

Split method

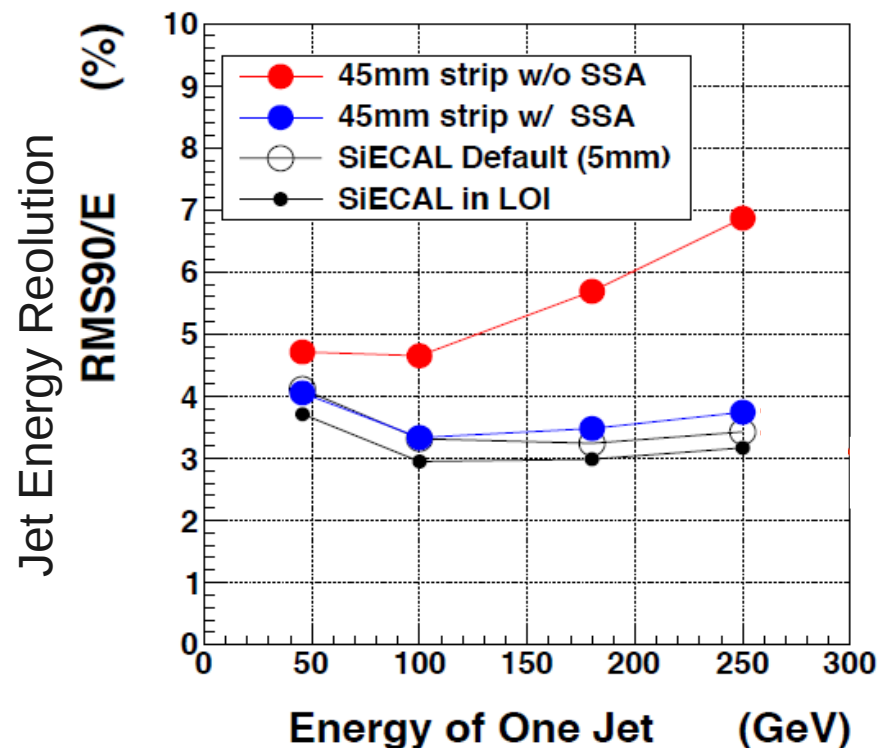


Strip Splitting Algorithm

Recon.w/ SSA  
+ PandoraPFA



Recently a lot of good progress

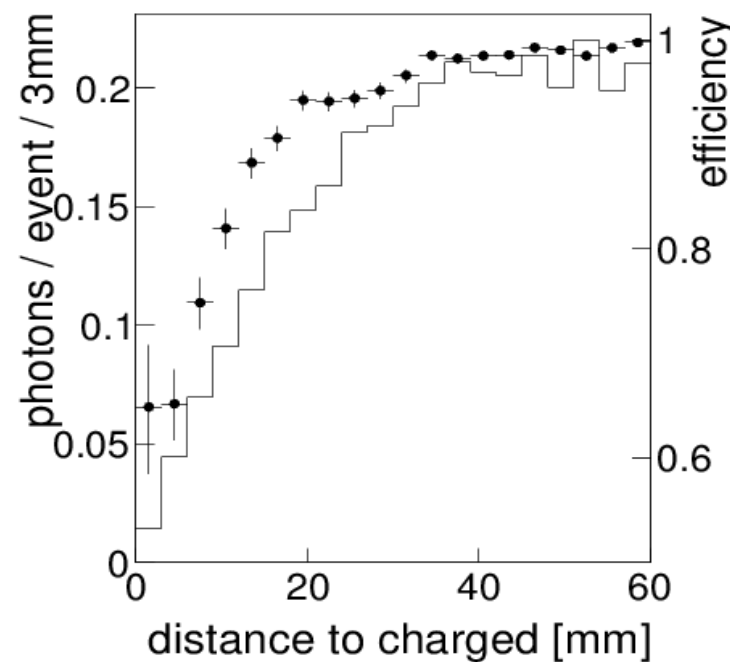
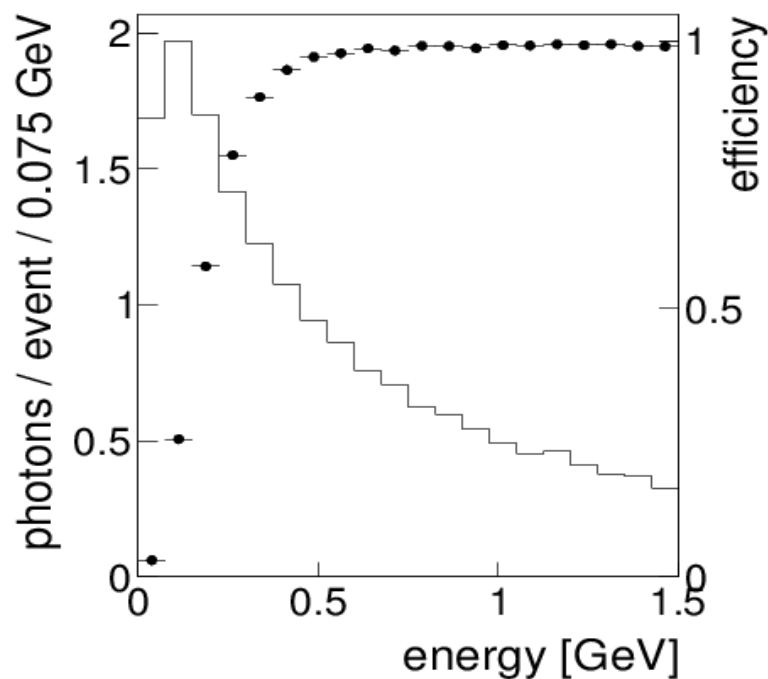
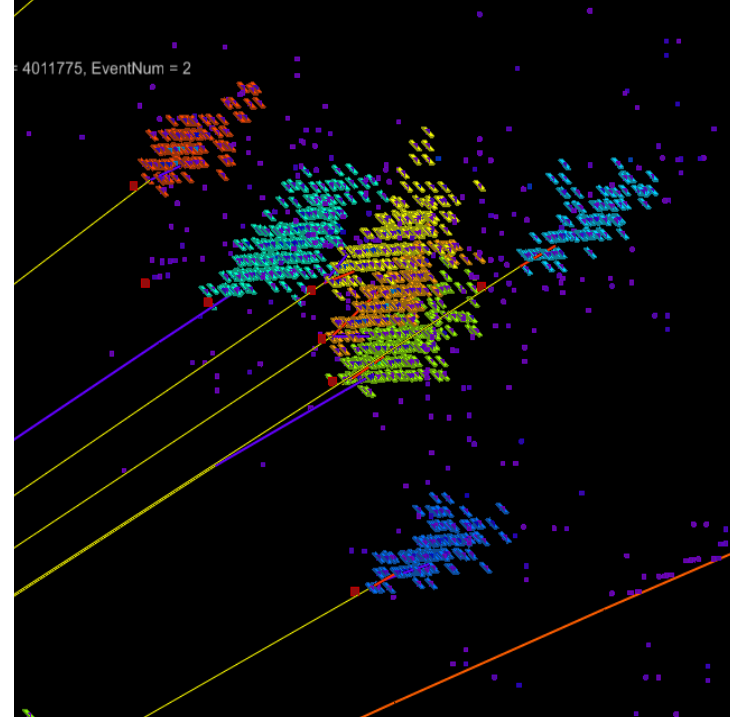


# Photon identification: GARLIC algorithm (Gamma Reconstruction at a Linear Collider)

Identify photons in dense jet environments  
essential to particle flow

Dedicated photon clustering algorithm,  
Multivariate photon cluster selection

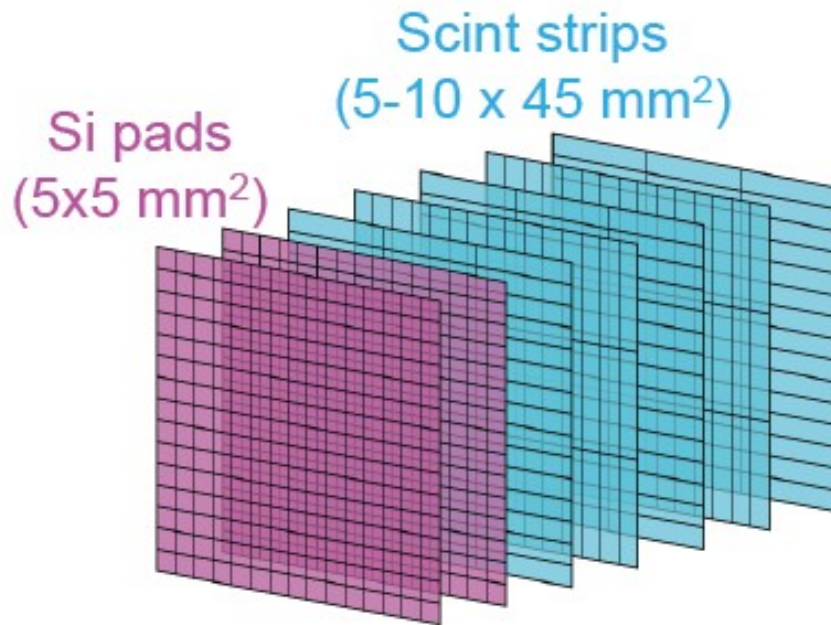
Recent re-write and development of algorithm and code  
released as [ilcsoft](#) reconstruction package



Performance in 4-jet events produced in 500 GeV  $e^+e^-$  collisions



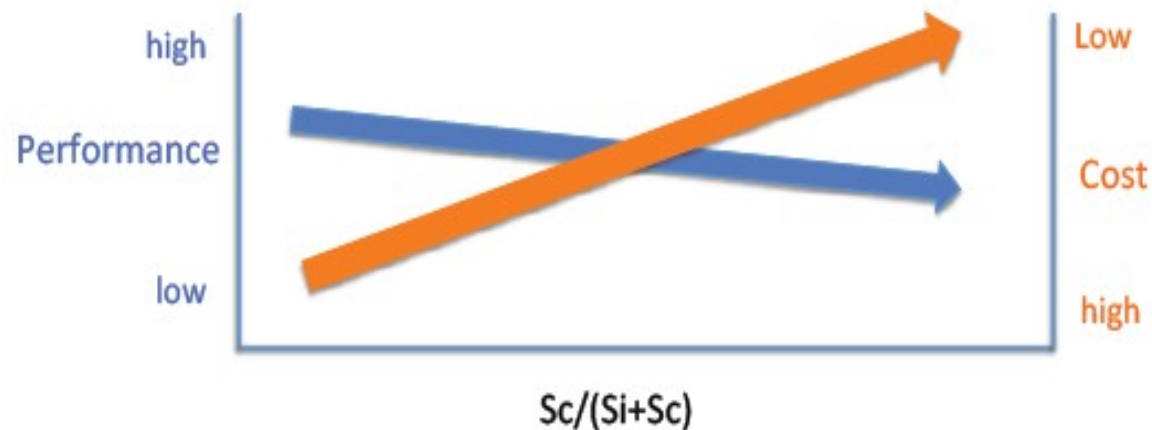
# Hybrid ECAL



- Silicon-Tungsten ECAL
  - ✓ Excellent PFA performance
  - ✓ Dominant cost driver of ILD
- Scintillator Tungsten ECAL
  - ✓ Good cost performance
  - ✓ Strip structure needs a complicated shower reconstruction

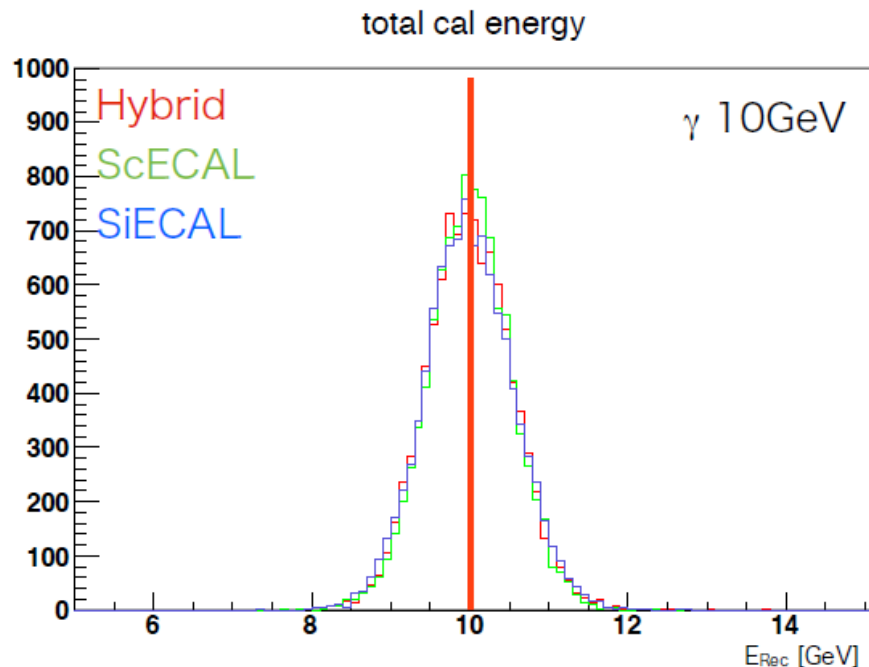
Hybrid ECAL could achieve good PFA performance with low cost

Simulation studies to investigate this option have recently started

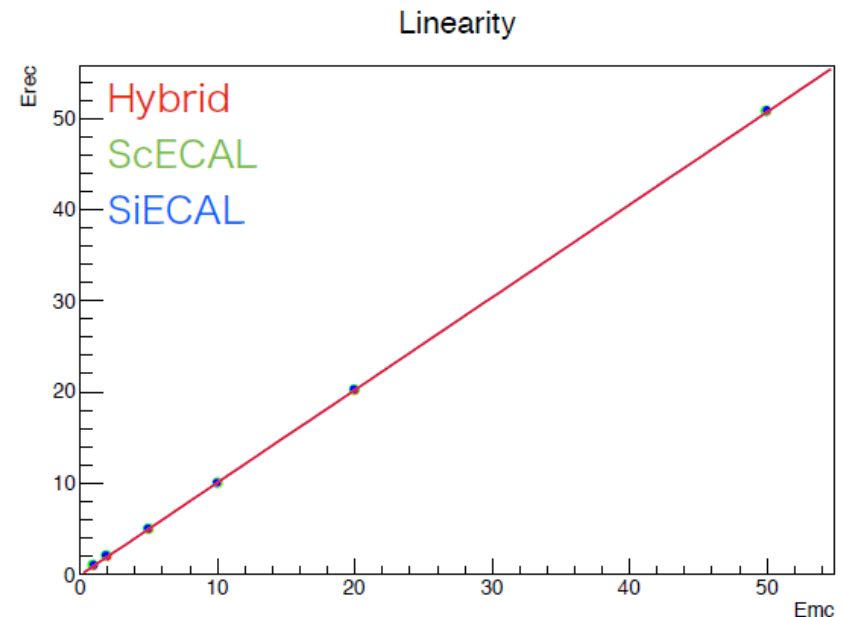
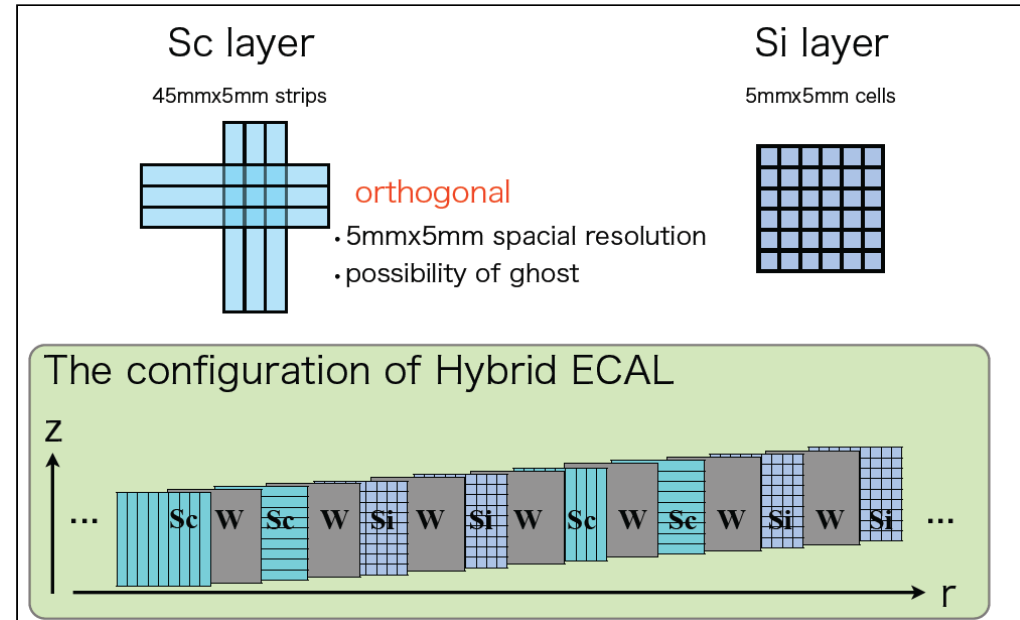


# First attempt: Basic Hybrid ECAL Perf.

- Energy resolution and linearity for a single gamma event are studied and good results as shown below have been obtained.
- A study of jet energy resolution has started. We plan to test another configuration as well.



## A test Hybrid configuration



# Summary

2011/2012: preparations for Detector Baseline Report for ILC

joint research on ECAL detector

common technologies: mechanics, electronics, DAQ...

two proposals for active technology

recent work on hybrid design

Working on aspects of

Hardware

Simulation

Reconstruction

TYL support has greatly facilitated travel between groups for workshops and meetings