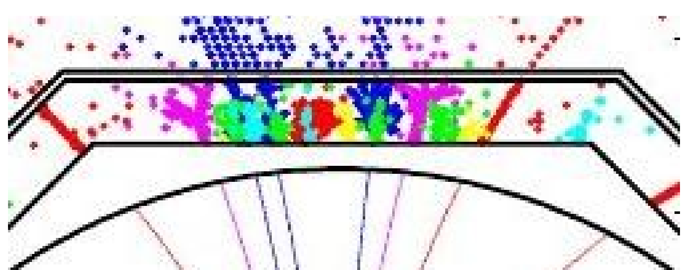
ECAL: overview, DBD status

Daniel Jeans, LLR

ILD workshop, Kyushu University, May 2012



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Overview, DBD status – Daniel Jeans

Si-W status – Roman Poeschl

Sc-W status – Katsu Coterra

Hybrid status – Tamaki Yoshioka

ILD ECAL

particle flow ECAL: distinguish particle showers
- small Molière radius, small (X_0/λ)
- highly granular readout

thin to limit coil radius
- -> minimise X_0

reasonable energy resolution
- σ_E/E = 15~20%/sqrt(E) will give small contribution to jet energy resolution

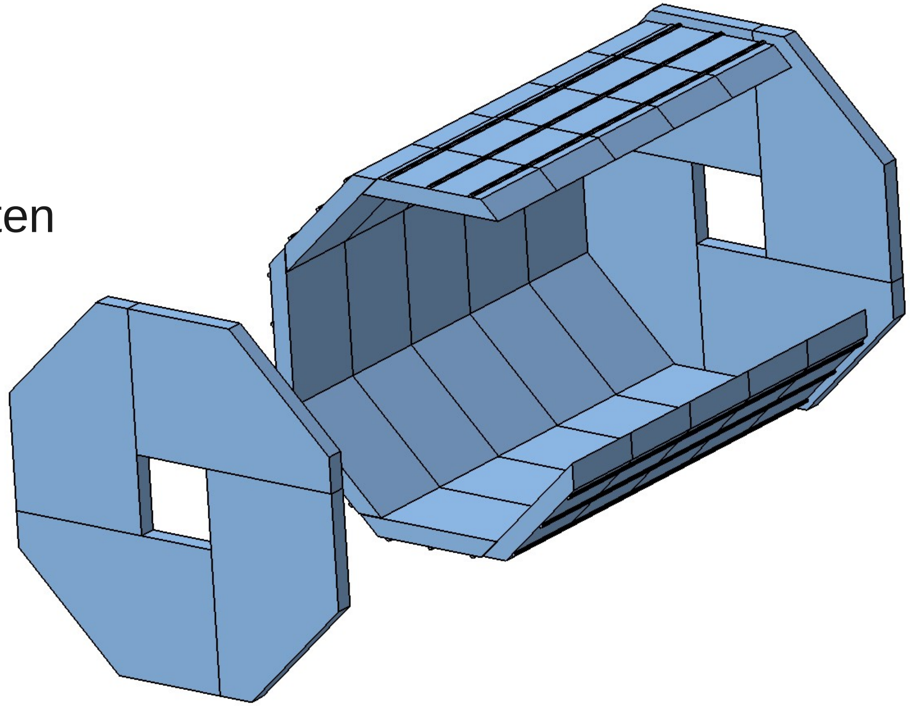
these requirements motivate our design
- sampling calorimeter
  - natural granularity (in one direction)
- tungsten radiator
  - suitable X_0 , λ , mechanical properties
- highly segmented readout layers
  - provides granularity

Detector development within CALICE

Calorimeter for ILC

Common elements

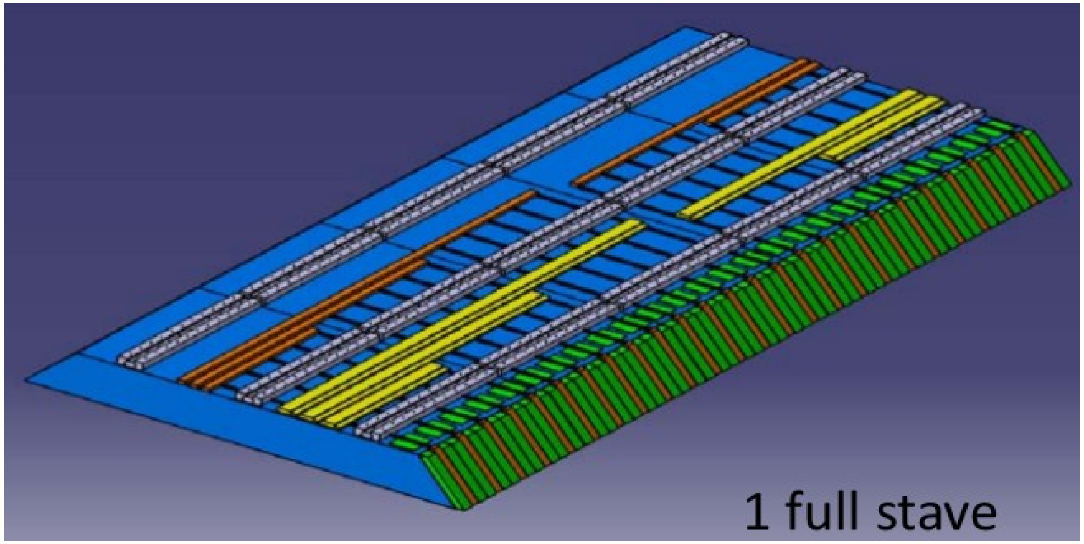
Mechanical structure
- carbon fibre composite incorporating tungsten
- attached to HCAL by system of rails



Front-end electronics
- same ASIC “family” (*ROC from OMEGA)
- power pulsed ~ 25 µW/channel

DAQ
- based on CALICE DAQ

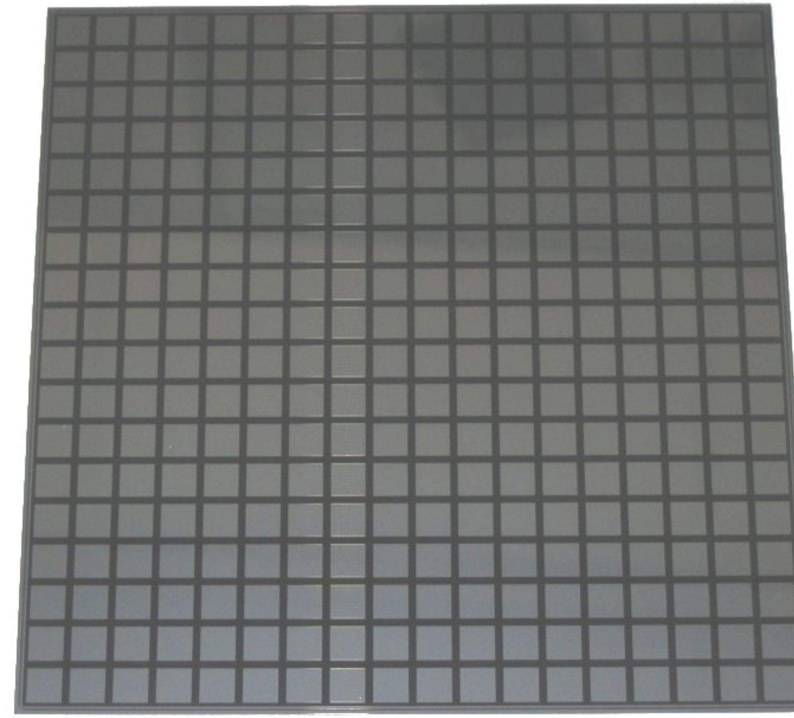
Cooling
- leak-less water-based system

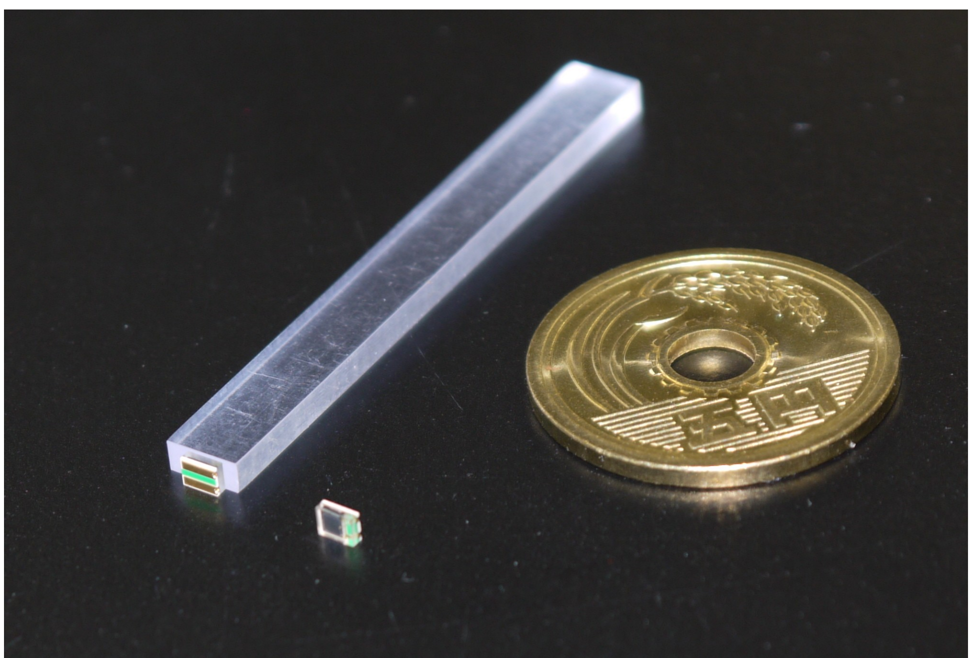


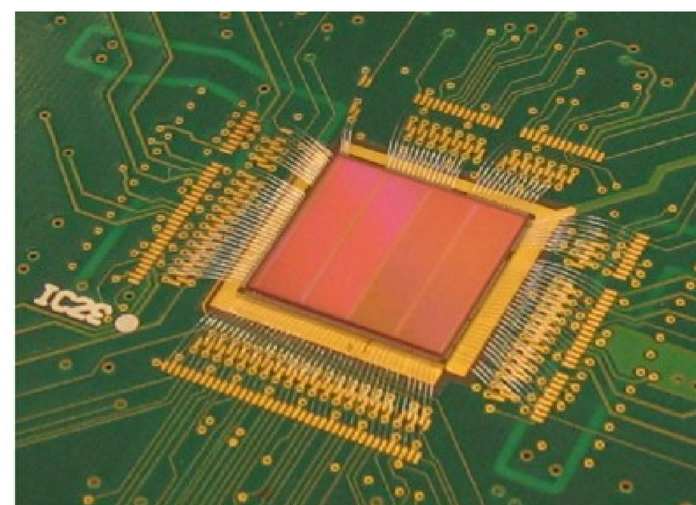
Different technological solutions proposed
for detection layers

"options"
Silicon PIN diodes (5x5 mm^2)
Scintillator strips (5x45 mm^2), MPPC readout
Silicon/scintillator hybrid

"alternative"
MAPS: 50x50 μm^2 pixels (CMOS), digital readout
UK groups: severe funding problems







Silicon and scintillator options both perform sufficiently well
and have similar level of technical maturity

Silicon thickness < scintilllator
-> effective Molière radius smaller

Strip geometry for scintillator
-> adds complication to reconstruction
recent good progress in this respect

Detector stability
MPPC somewhat temperature dependent
requires temperature monitoring:
offline correction demonstrated

ECAL is major cost element of ILD (not less than ~30%)

silicon option: driven by **area** of silicon sensors
~ 25×10^6 cm^2

scintillator option: driven by **number** of channels/MPPCs
use of scintillator strips allows this number to be reduced
~ 10×10^6

At current cost estimates,
scintillator option probably less expensive than silicon

I leave explicit cost/comparison to the costing group

Study of hybrid silicon/scintillator design

Such a hybrid design may give
performance and/or cost advantages
over single technology design
...at the expense of “simplicity”

Results of simulation studies will be shown by Tamaki

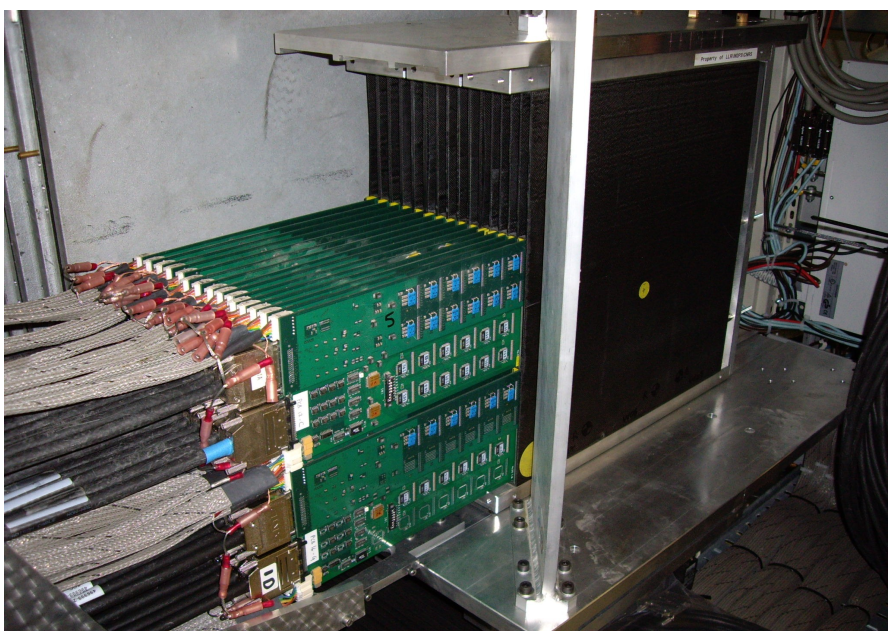
DBD status

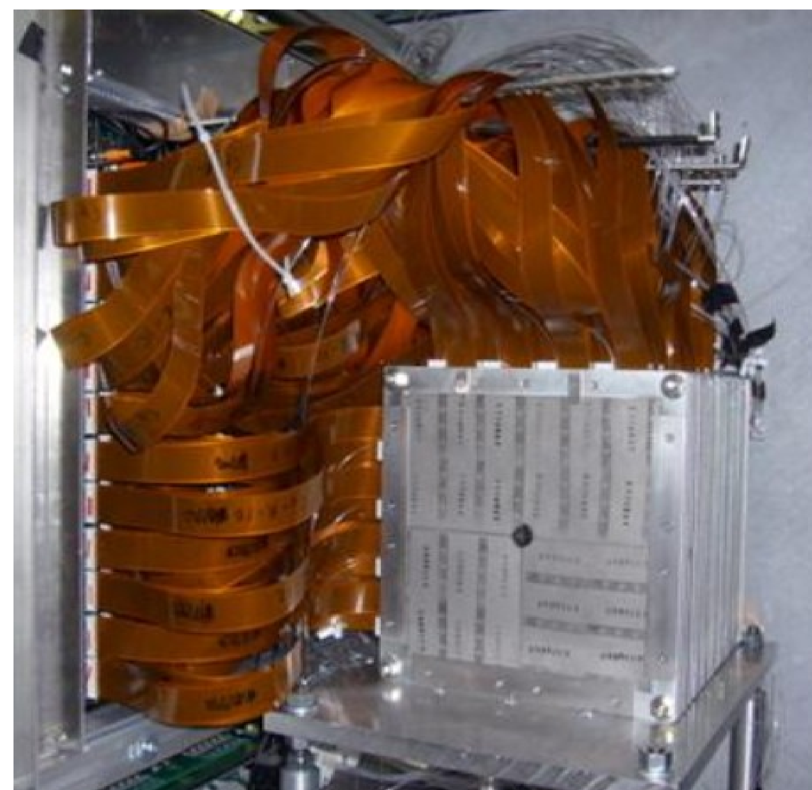
Input to ECAL DBD section comes largely from:

- results of CALICE “physics” prototypes
  demonstrate principle and performance of detector
- in-progress developments of “technological” prototypes
  demonstrate detector integration

described in CALICE document which provides
input to DBD process

-> more details in next talks
Roman and Katsu





Common Calorimeter section (before ECAL and HCAL sections)

implications of the particle flow approach for the calorimeter concept

roles of ECAL and HCAL for photon-hadron and charged-neutral separation
importance of high granularity, relevance of resolution, technologies chosen
system overview

challenges resulting from high granularity

electronics integration and power pulsing
read-out architecture from front end to DAQ
example read-out ASIC

test beam overview

emphasise common test beams

The Electromagnetic Calorimeter System

writers: K Kawagoe, T Takeshita, J-C Brient, R Poeschl, D Jeans

design concept (2 pages)

calorimeter for particle flow
particle separation most important, high granularity
small Molière, small x0/lambda
minimise thickness (coil radius), small x0
choose sampling calo, tungsten radiator, highly segmented readout
options: silicon pads, scintillator strips, hybrid structure
alternative: MAPS

detector optimization (1 page)

cell size (PandoraPFA performance from LoI)

scintillator strip length

number & arrangement of layers
including hybrid solution

[ECAL inner radius is a key parameter for PFA performance and cost,
but not treated quantitatively in calorimeter section]

detector implementation (4 pages)

Common aspects

mechanical carbon fibre/W structure
power pulsing of electronics
 first ECAL tests expected for DBD
 (can also quote SDHCAL results)
DAQ system
heat sources and cooling system
passage of power, signal and cooling services

technology-specific

Silicon
 sensor, PCB, SKIROC, wire-bonding, integration

Scintillator
 strips, reflector, MPPC, PCB, SPIROC, integration

test beam validation (4 pages)

extensive test beams (CALICE)

physics prototypes:

- operation
- calibration
- S/N
- electron energy response
- position resolution
- hadronic response

technological prototype:

- first tests arriving during 2012
- *e.g.* basic functionality, S/N, calibration

calibration and alignment (1 page)

si calibration:

- stability
- pre-calibration of sensors before installation
- monitoring after

MPPC calibration:

- LED system -> single pixel spectra
- tuning of bias voltage
- monitor temperature: corrections applied offline

alignment

- 100 micron alignment sufficient
- survey within module during assembly
- survey modules after installation
- relative ECAL-TPC with *e.g.* Bhabhas

future directions (1 page)

common:
- detector integration: PCB thickness
- power pulsing: further studies
- investigate reduced scope (for cost reasons):
  - reduced # layers, radius.
    - estimate of relative cost/performance scaling

silicon:
- sensor guard rings
- AC/DC coupling
- industrialised production, multiple vendors

scintillator:
- MPPC develoments: # pixels, package size
- coupling to scintillator

further simulation studies of hybrid configurations

alternative sensor technologies: e.g. MAPS

Summary

Well developed for scintillator and silicon based technologies

- extensive experience from prototypes
  - both are viable options

- hybrid design under study: may have advantages

- These make up the detector *options*

Mechanics, cooling, DAQ, electronics, services

- rather similar requirements -> single solution

MAPS is considered an *alternative* technology

- potential to be viable,
  - but not yet demonstrated, due to funding constraints