Si-W ECAL activities

Daniel Jeans for the

CALICE-ASIA SiW ECAL groups
@ Kyushu, Tokyo

Tokusui annual meeting, KEK, December 2013

Silicon-W ECAL : CALICE / ILD

Active groups:

France
    LLR, LAL, LPSC, LPC, LPNHE

Japan
    Kyushu, Tokyo

Korea
    SKKU

Physics prototype (data-taking 2006 – 2011)

- Proof of principle
  - up to ~10k readout channels
  - many beam tests with muons, e+-, hadrons

Technological prototype (2010-)

- Ready to integrate into detector
  - Embedded electronics
  - Power pulsing
  - Industrialisable technologies and construction

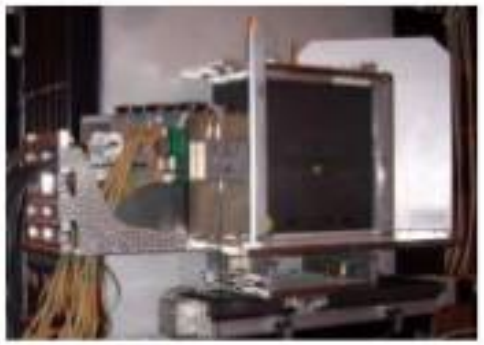
ILD studies

- Sensor development & mass testing
- Optimisation: performance, cost
- Reconstruction, analysis

Physics Prototype

Proof of principle

2003 - 2011



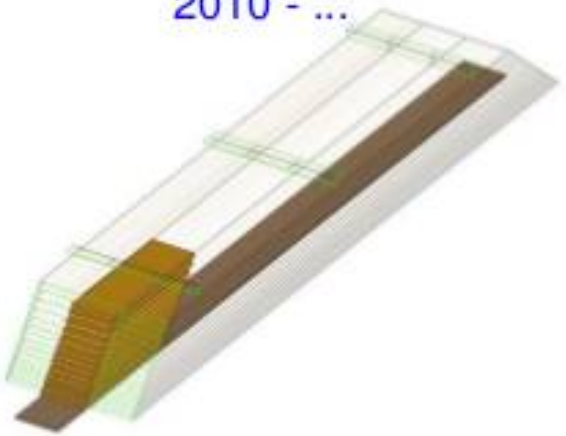
Number of channels : 9720

Weight : ~ 200 Kg

Technological Prototype

Engineering challenges

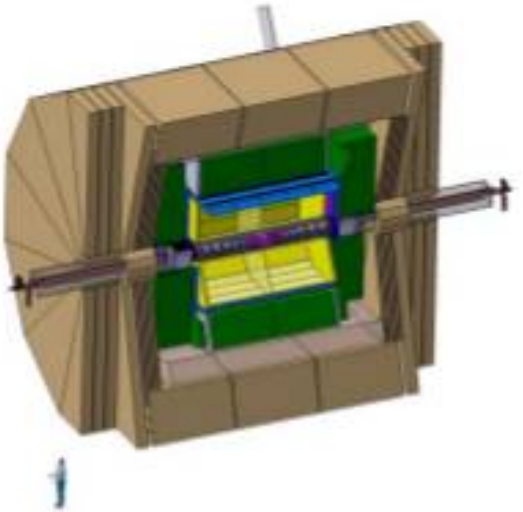
2010 - ...



Number of channels : 45360

Weight : ~ 700 Kg

LC detector



ECAL :

Channels : ~100 10^6

Total Weight : ~130 t

Physics prototype data analysis

Miyazaki

EM response using data collected at FNAL in 2008

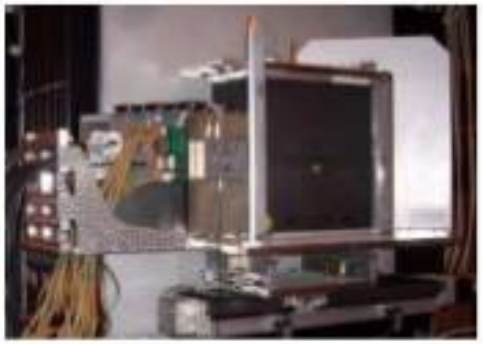
Chen

2-particle separation using over-layed events & Pandora PFA

Physics Prototype

Proof of principle

2003 - 2011



Number of channels : 9720

Weight : ~ 200 Kg

Measure ECAL response using events collected at Fermilab test beam in 2008 using positron beams in energy range 4-20 GeV

Compare to results of 2006 test beam at CERN.

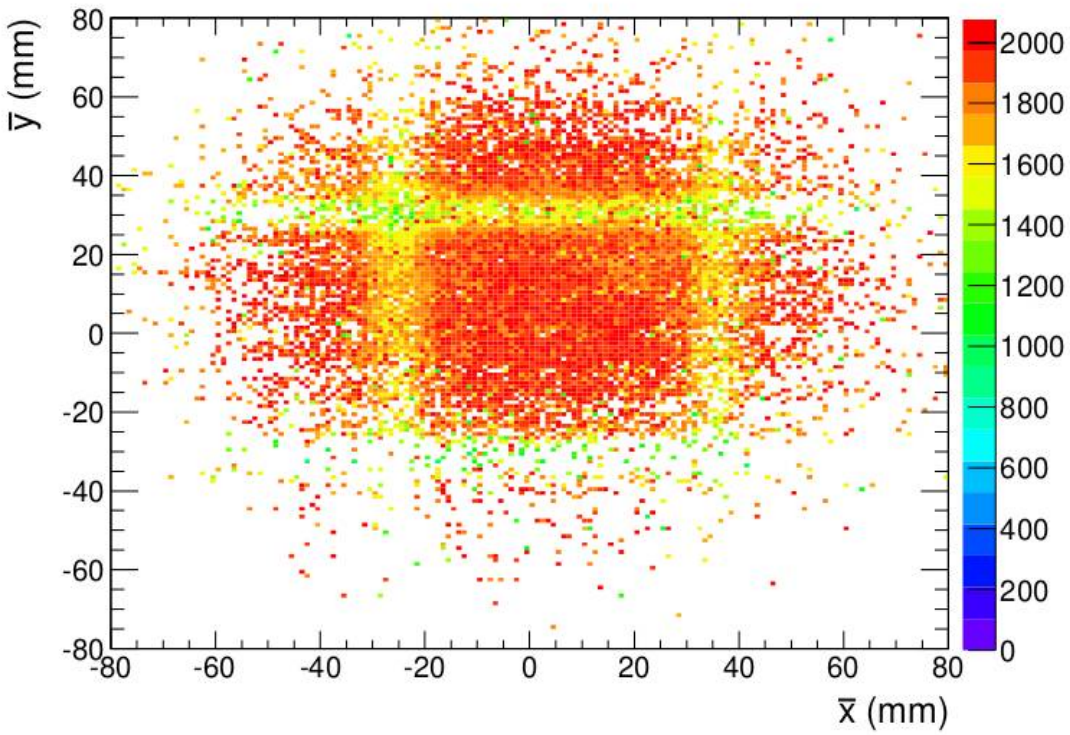
Demonstrate stable long-term behaviour

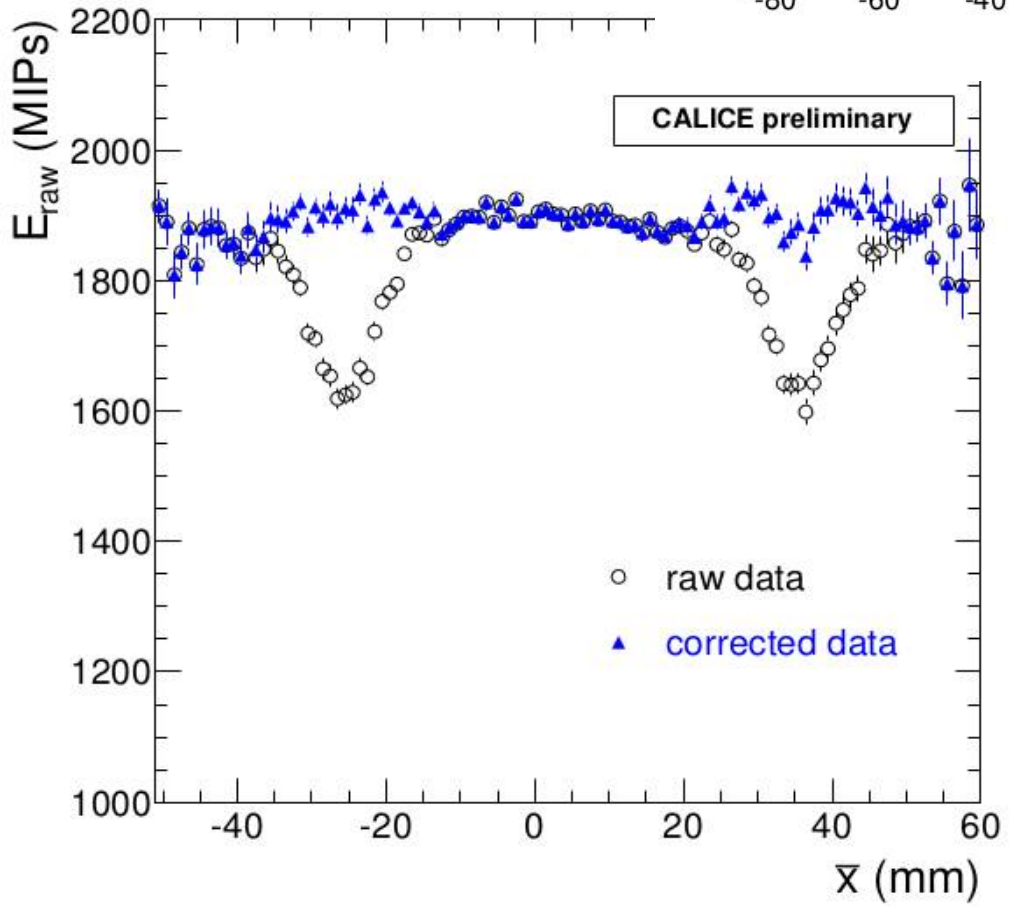
Described in public CALICE analysis note

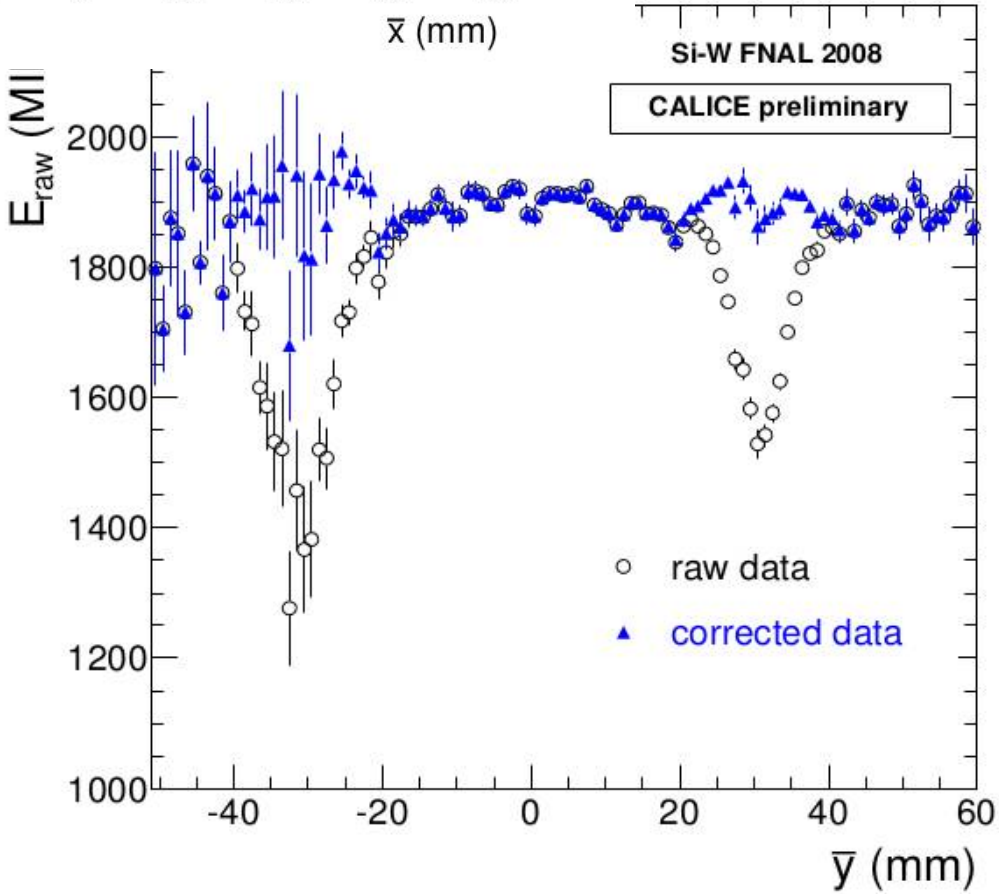
Miyazaki (Kyushu)

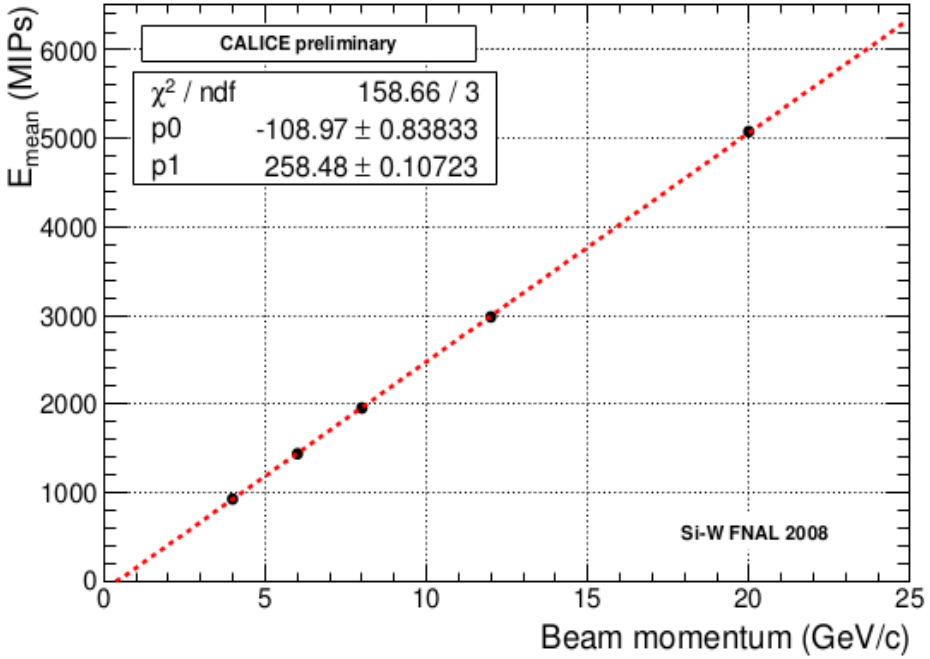
Investigate ways to treat gaps between wafers

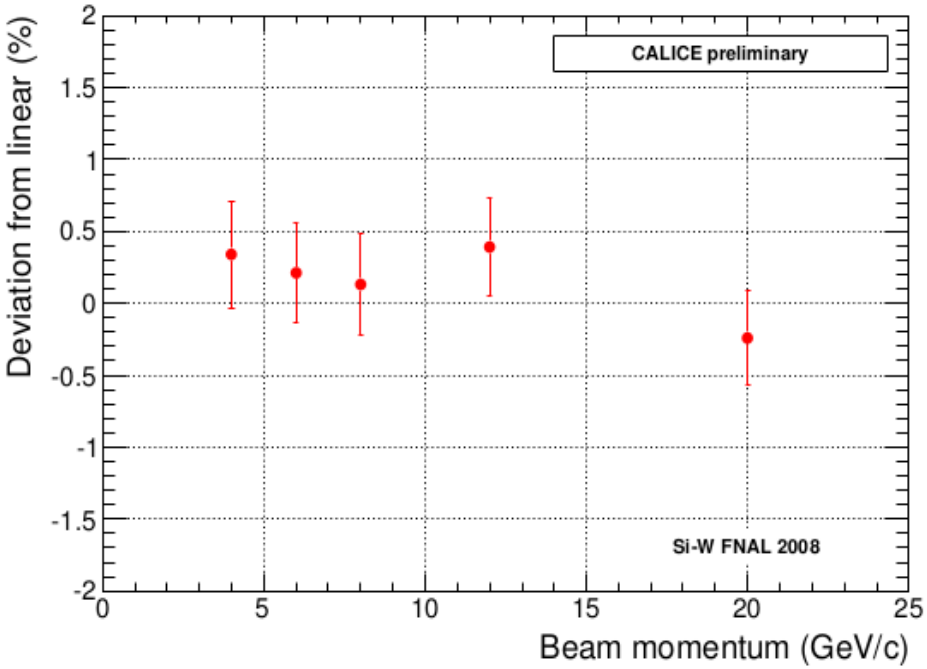
gaps are ~projective in prototype, but not in ILD

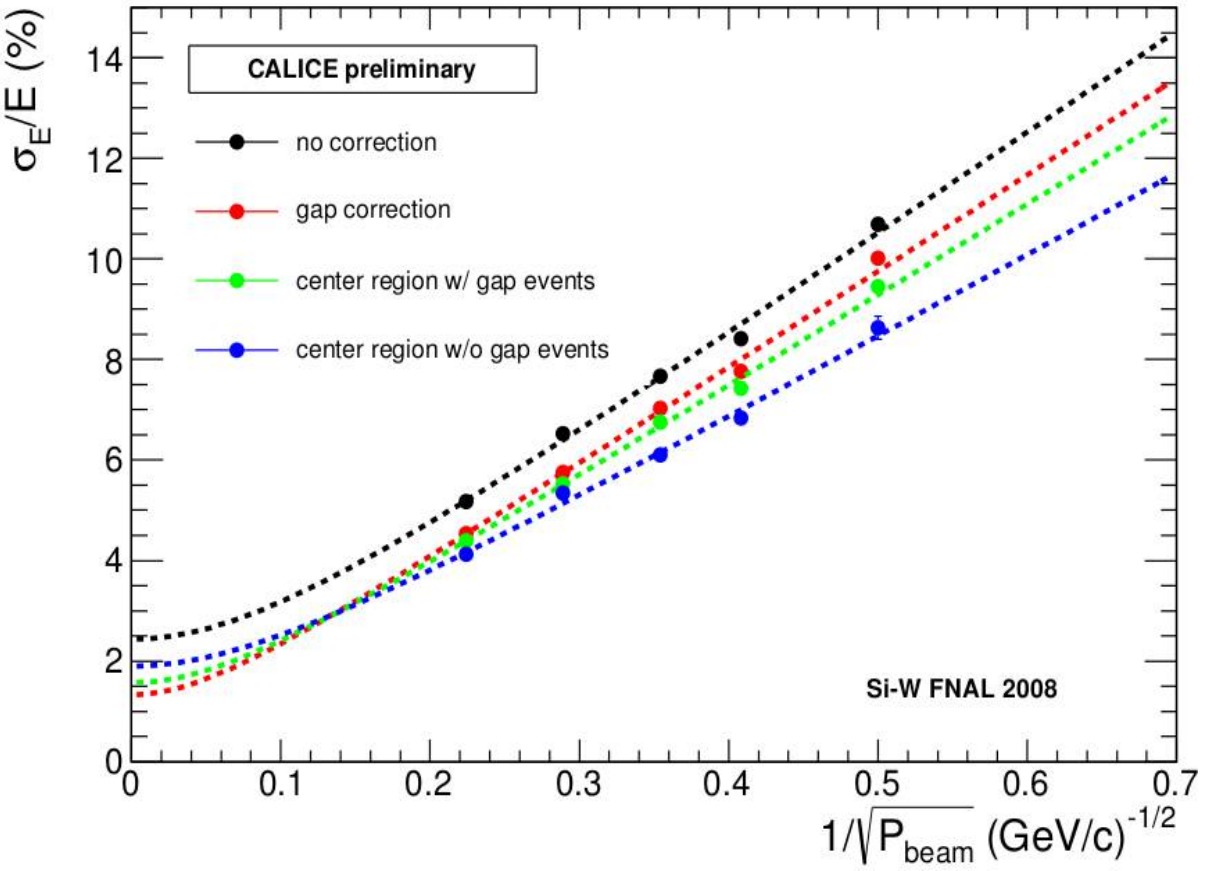












In central region (~no leakage),
including beam energy spread

$\sigma_E/E \sim$
$(16.5\text{-}18.3)\%/\sqrt{E} \oplus (1.6\text{-}1.9)\%$

depending on region

consistent with previous results

constant term larger due to
significant beam energy spread

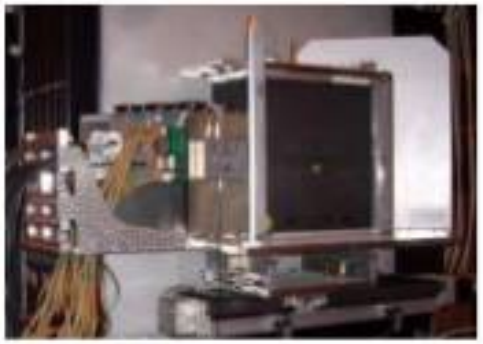
Measure how well 2 electron showers can be separated in ECAL

Investigate pattern recognition capabilities crucial for PFA

Physics Prototype

Proof of principle

2003 - 2011



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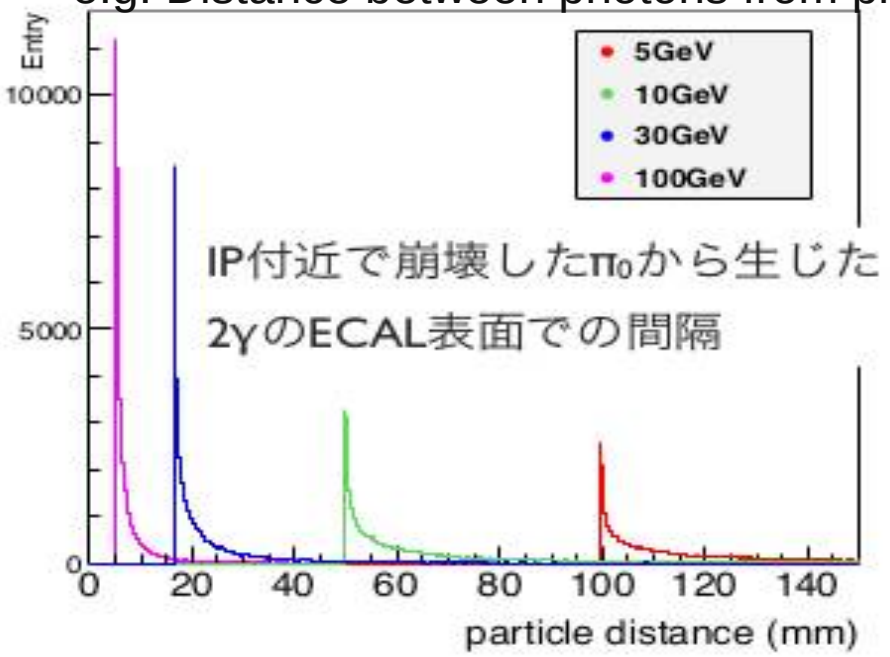
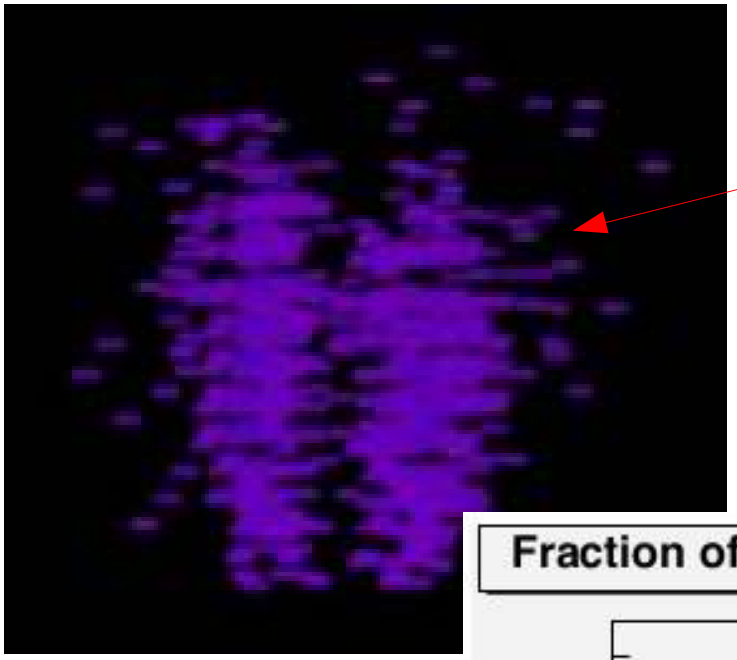
Weight : ~ 200 Kg

e.g. Distance between photons from pi0



Overlay 2 test beam events,
apply PandoraPFA
compare data & simulation

Chen (Tokyo)



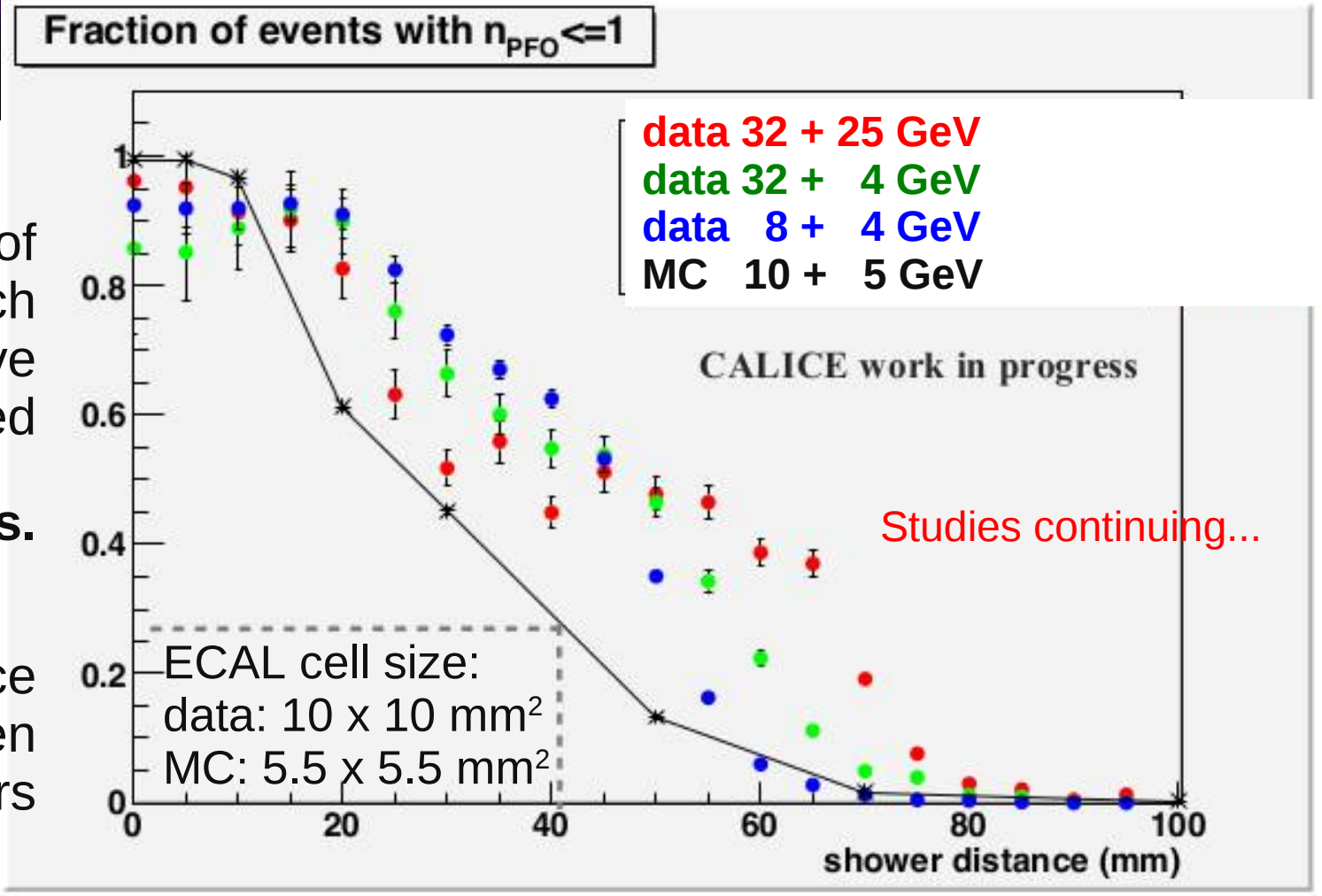
Two overlayed electron events from test beam

Apply PandoraPFA
(treat clusters as photons: ignore track information)

fraction of events in which clusters have been merged

vs.

distance between clusters



Studies continuing...

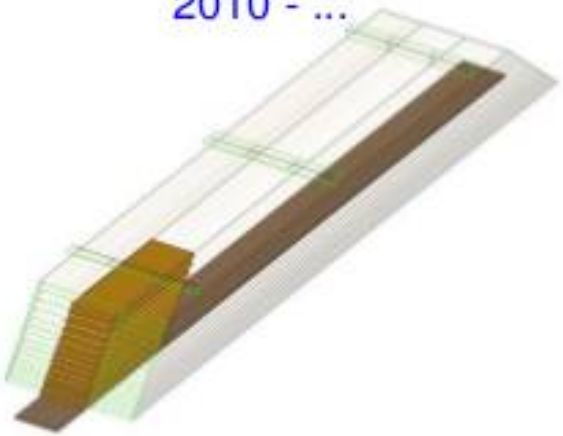
Technological prototype:

Develop, test and debug technologies
Critical stage for TDR preparation

Technological Prototype

Engineering challenges

2010 - ...



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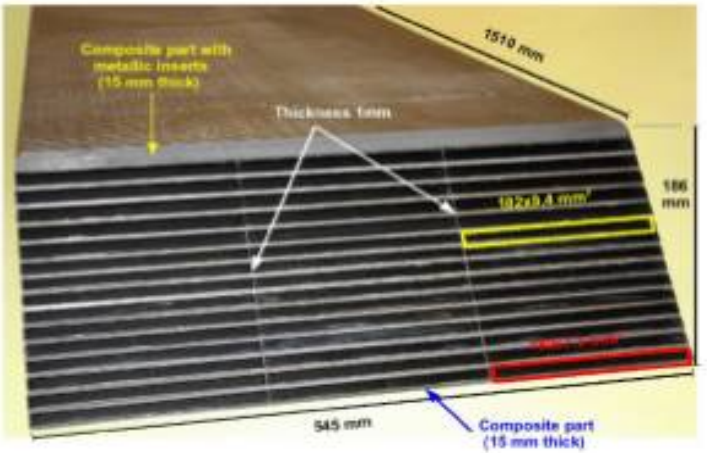
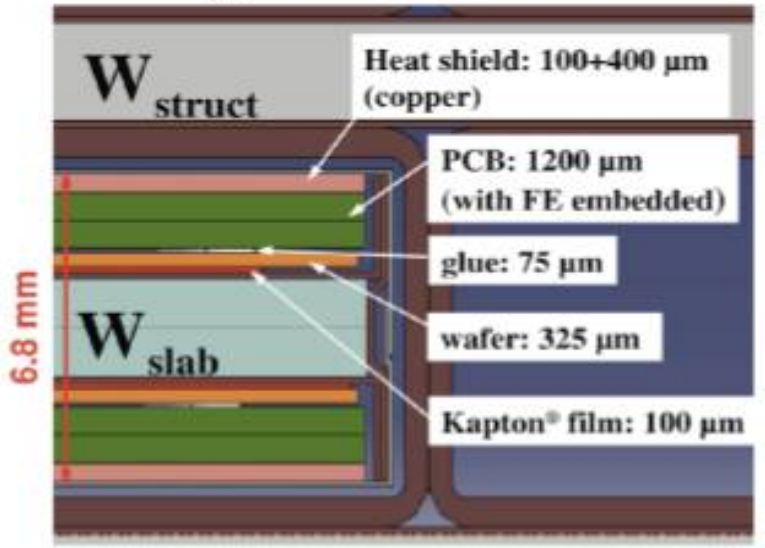
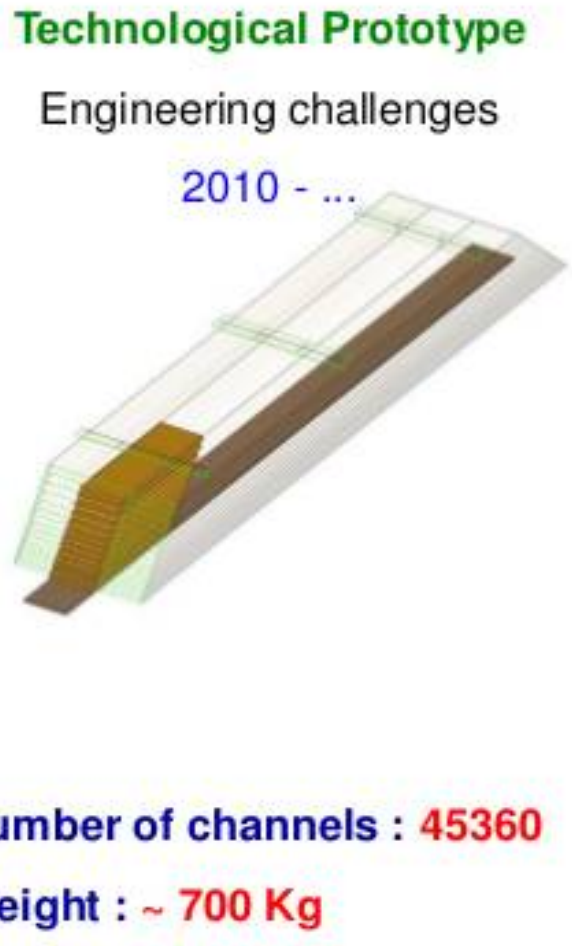


Prototype: 3/5 of one module.





Technological prototype:

Develop, test and debug technologies
Critical stage for TDR preparation

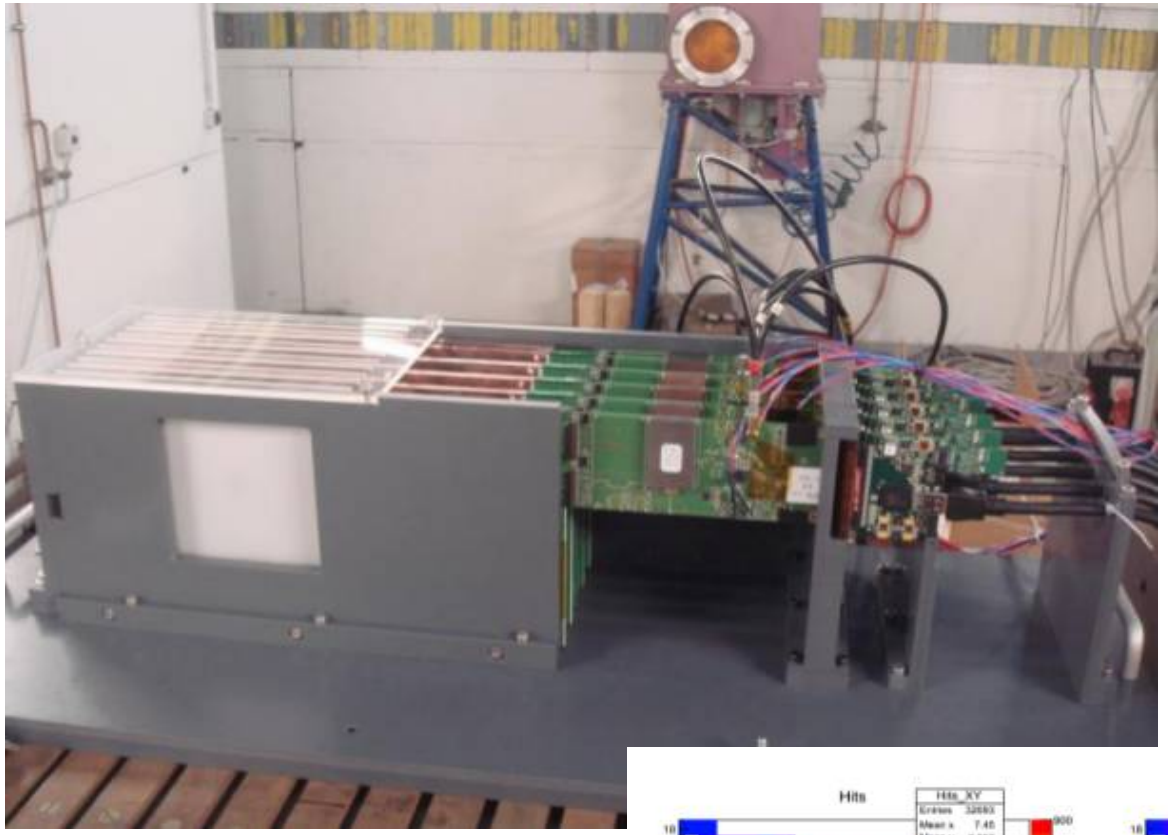
2nd testbeam @ DESY (July 2013)

~7 layers, each 9x9cm^2, 256 readout channels

System tests
including power pulsing

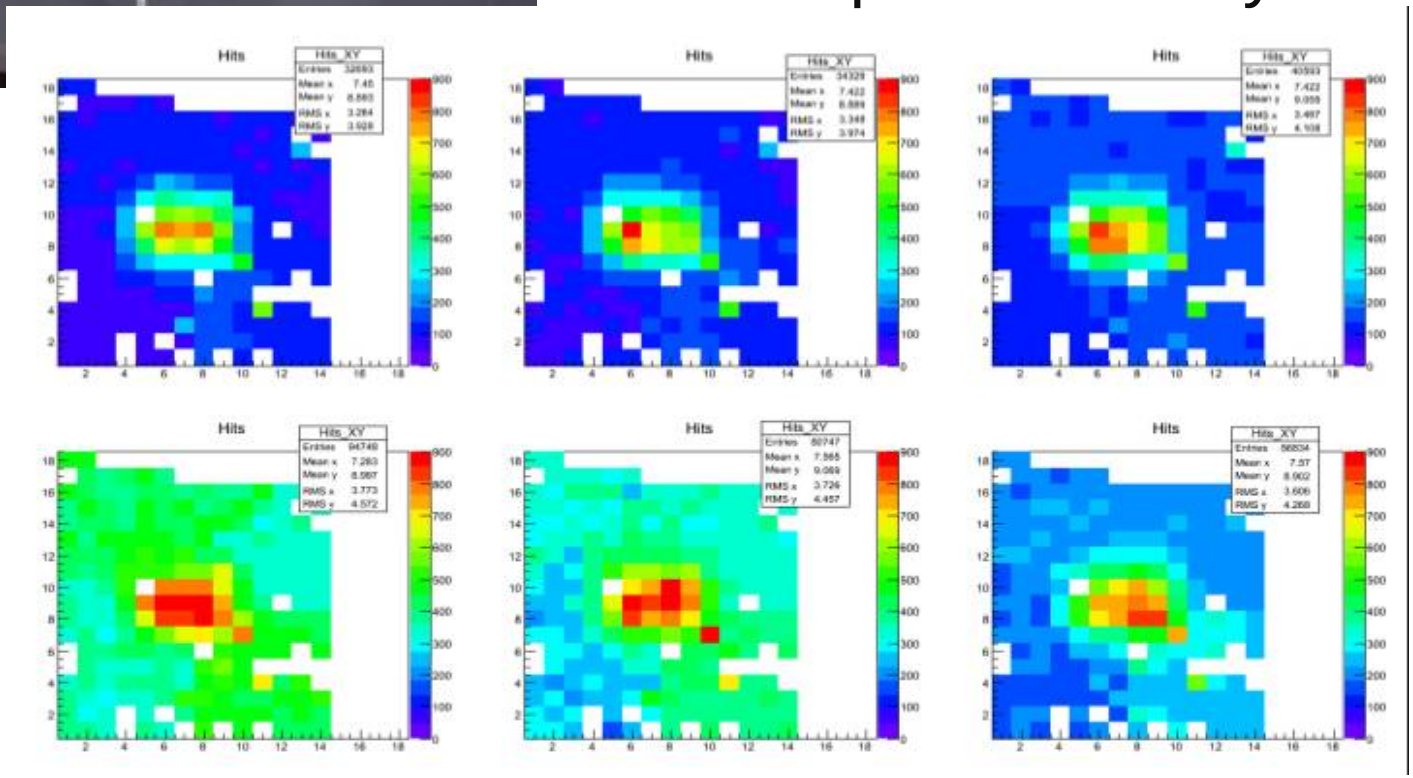
Large participation from Japan

Combined running with ScECAL layers



Testbeam @ DESY

Beam profile in 6 layers



More details in Sudo-san's talk later

Other ongoing engineering studies

(mostly in France)

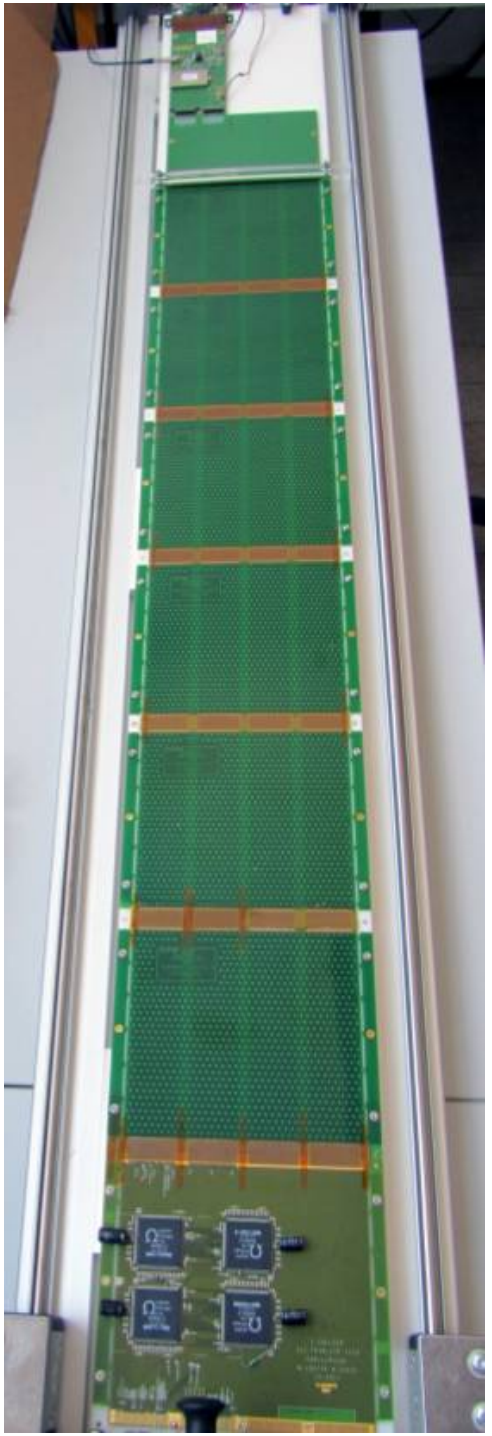
“Long slab”
- Preparations underway to test long detector slab
  - up to ~2m long required in ILD
- check clean signal propagation over long distances
- Practice detector construction and integration

“Relaxed” design of central PCB
- thicker → easier to produce flat board
  - (required for sensor gluing)
- ASICs in BGA package

“Agressive” PCB design:
- thinner → more compact detector
- Bare ASICs wire bonded into PCB

Cooling, services, integration, ...

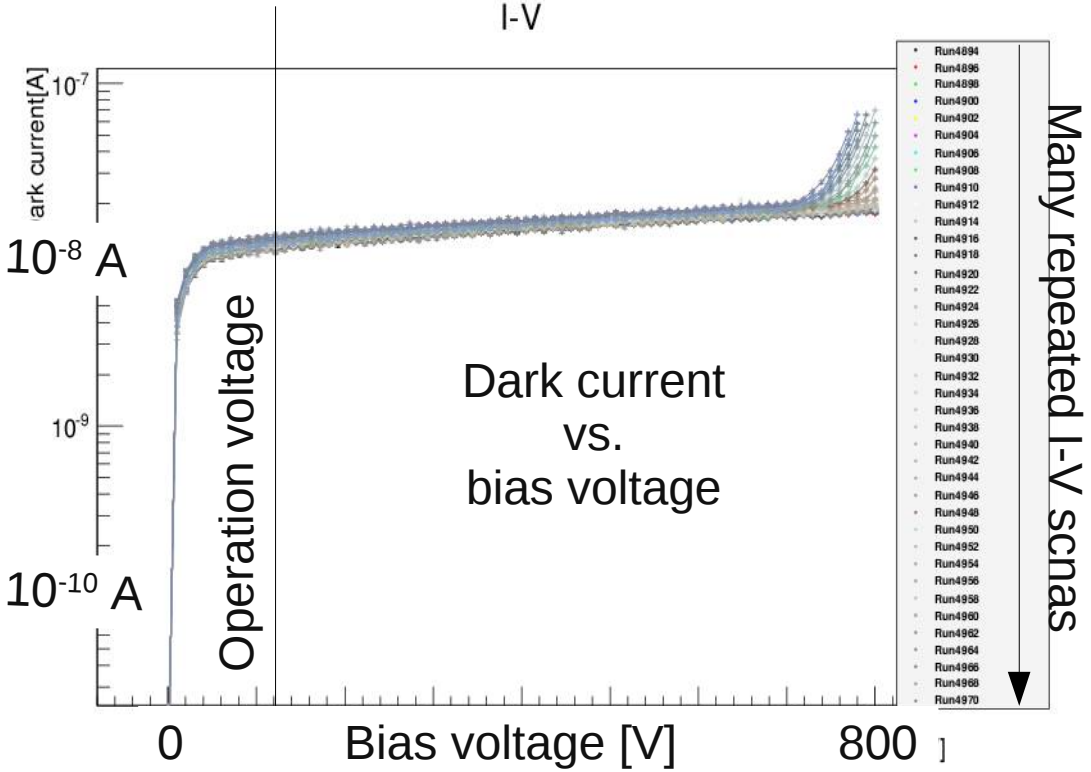
DAQ system
- Suehara-san @ Kyushu has started to work in this area
  - for hybrid si-scint ECAL readout



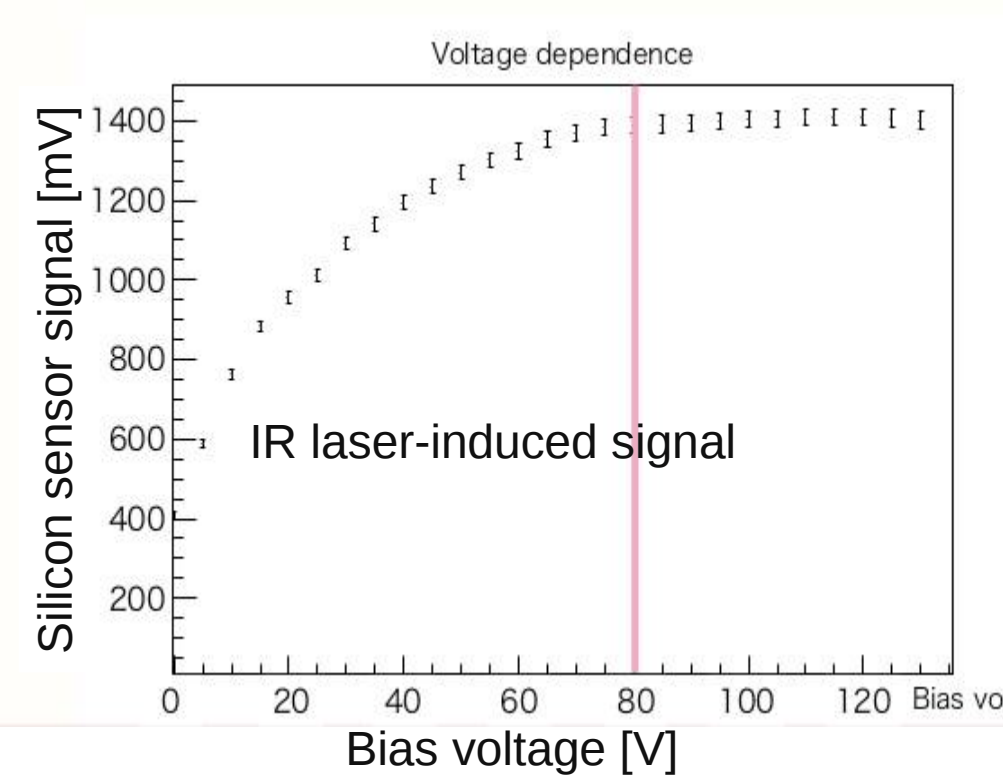
Measurement and development of silicon sensors

- investigate different designs
  (esp. of guard ring structure at sensor edge)
- Close relation to HPK (including cost estimates for large production)
- Preparing for future large scale testing

Electrical properties

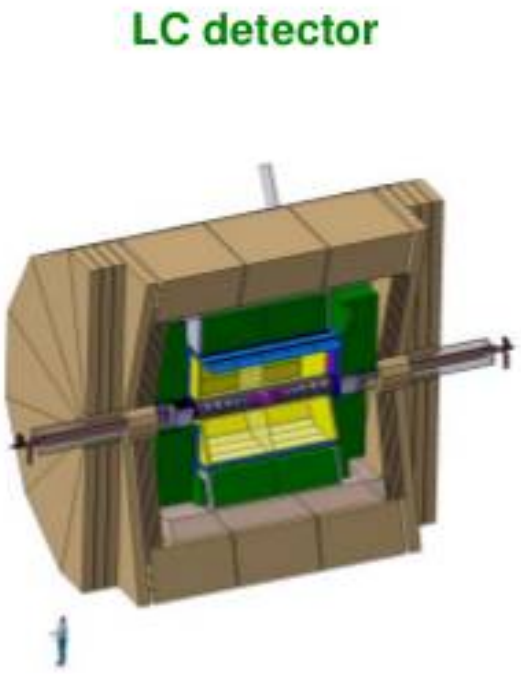


Laser injection



More details in Tomita-san's talk later

Preparations for ILC detector



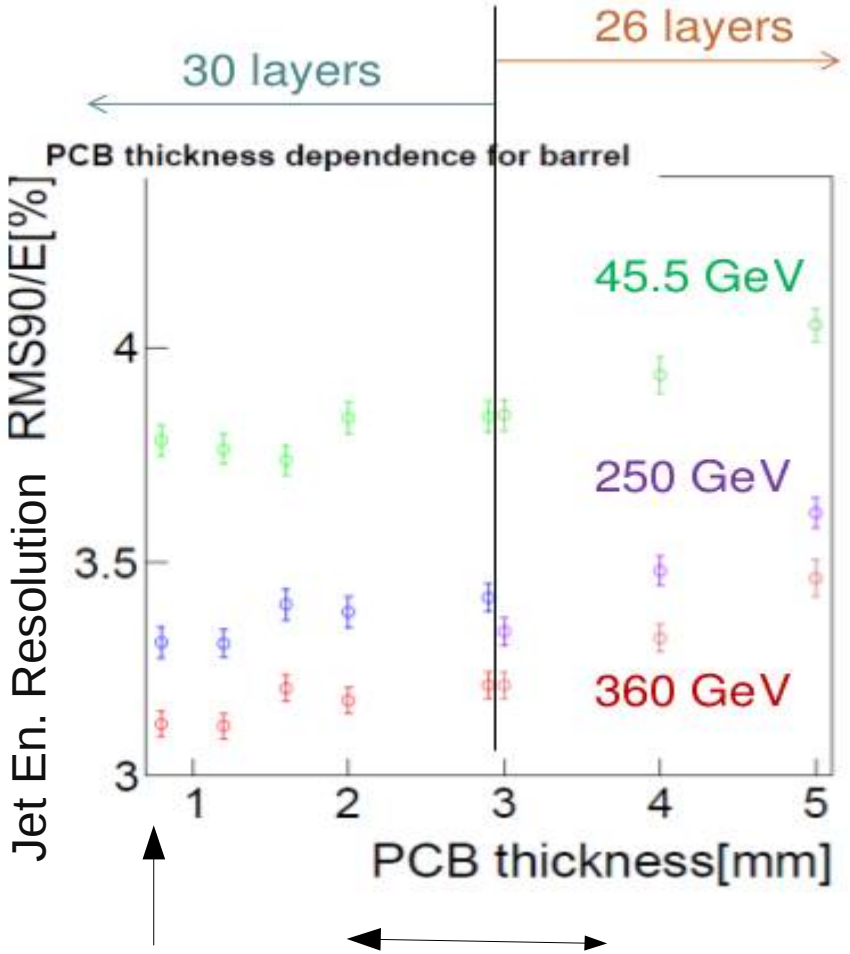
- finalise ECAL technical design
  realistic and proven technologies

- control cost (major fraction of ILD)
  Cost vs. performance
    global parameters
    internal parameters

Influence of design parameters

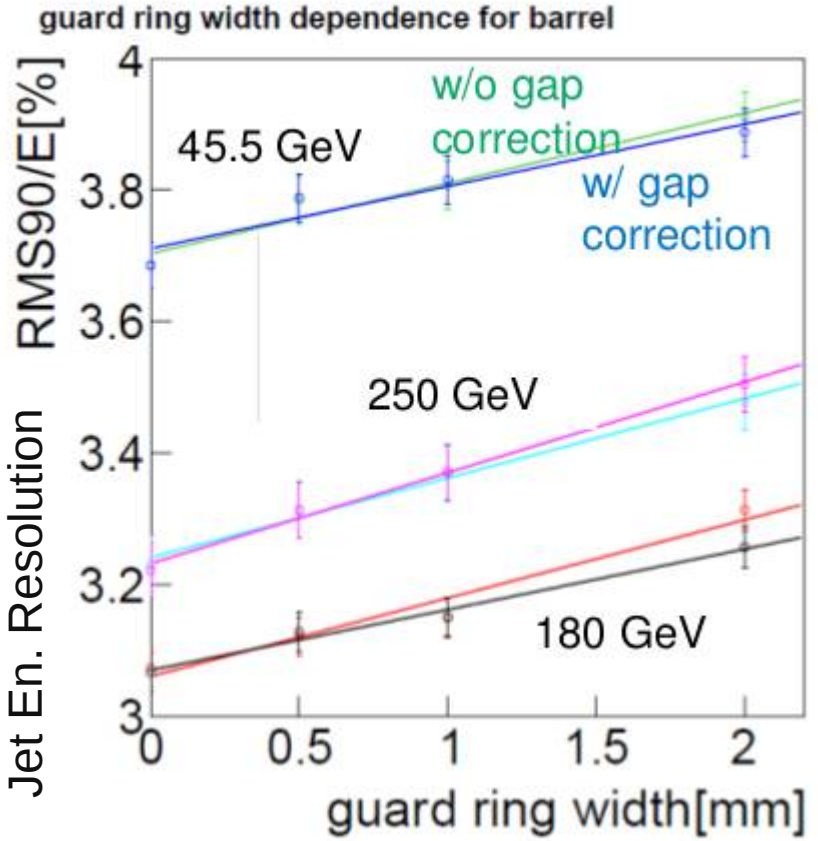
How aggressive does design really need to be?

Can we relax requirements?



Original aim ~LoI

Current reliable prototypes



Current prototypes

For Jet Energy Resolution, we have some space to relax

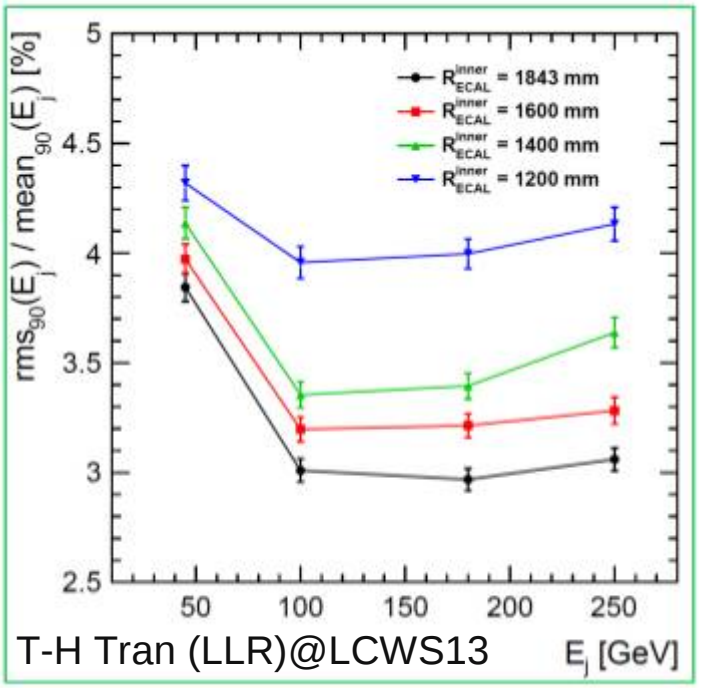
Other measures may be more sensitive will look at 2-particle separation

More details in Kozakai-san's talk later

Cost optimisation

Largest components of ECAL cost scale with sensitive area: Si sensors and PCBs

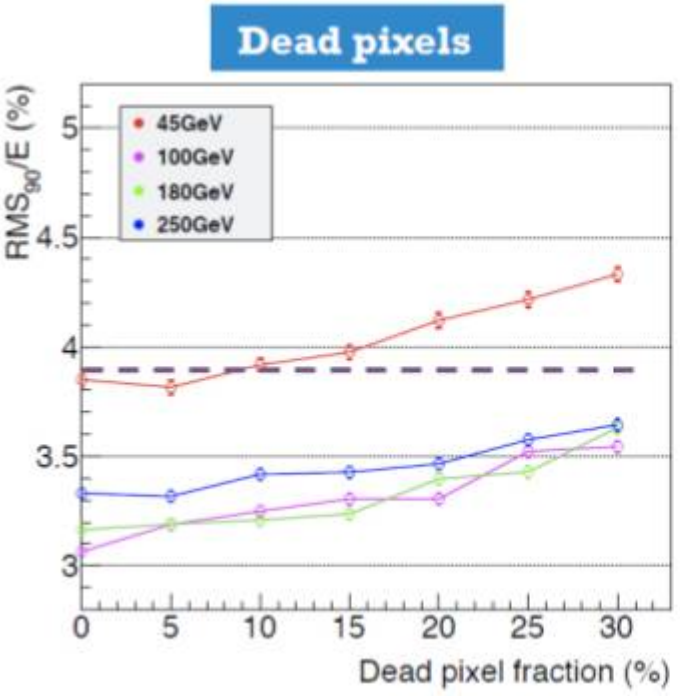
Number of ECAL layers, and radius of ECAL are therefore major cost parameters

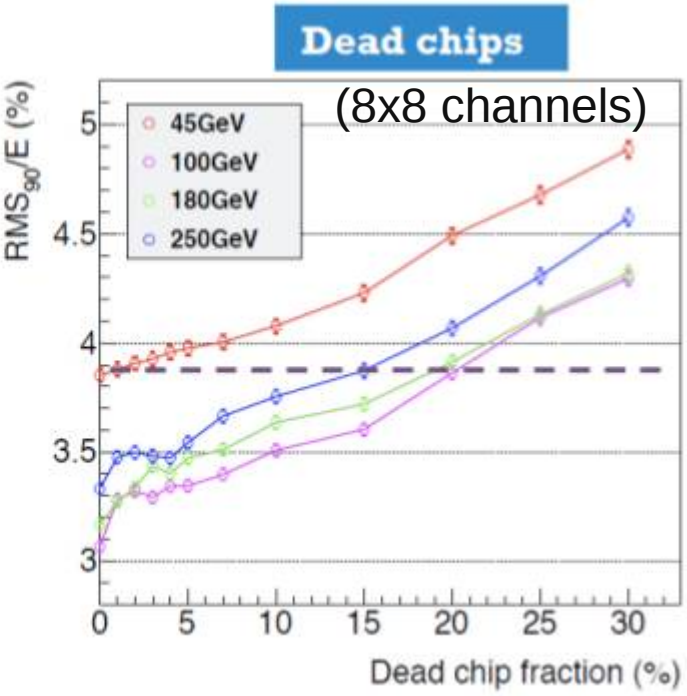


Largest cost component = silicon sensors
now have first cost estimate from HPK for large scale production

How important is sensor quality?

A few % unusable channels has ~no effect on jet energy measurement

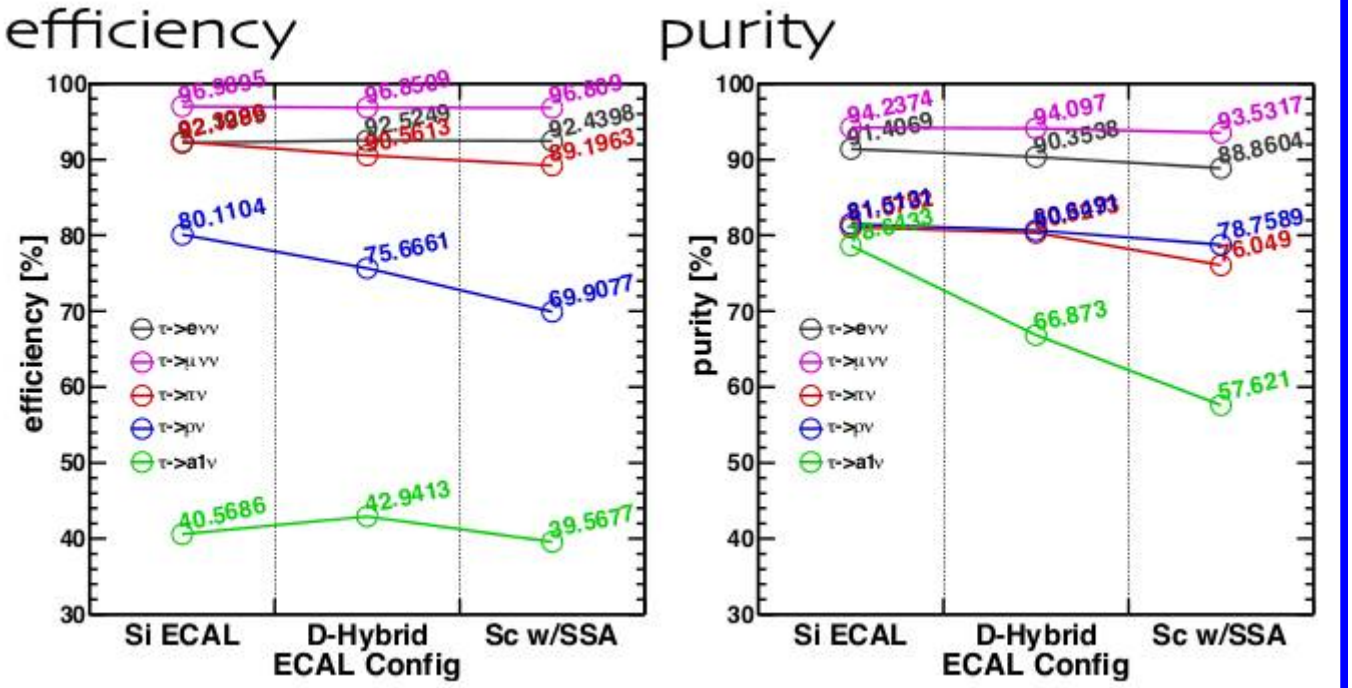




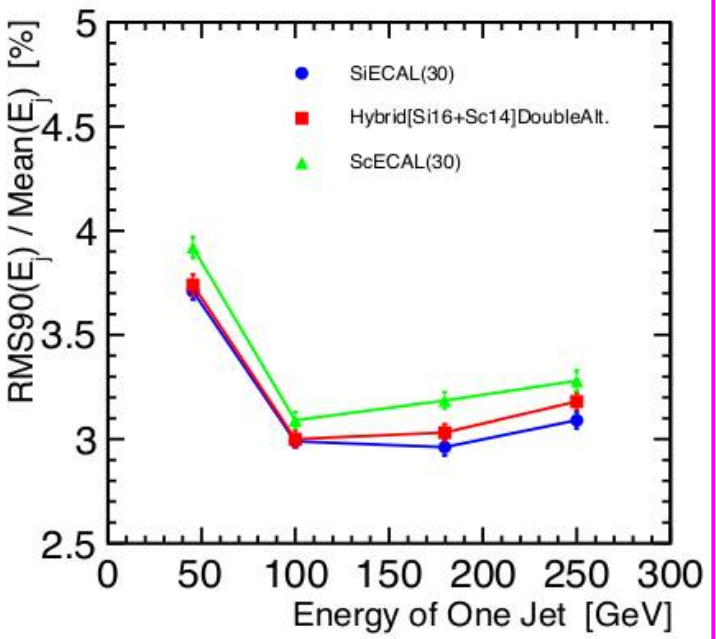
Studies of Hybrid silicon-scintillator ECAL

Studies by Ueno-san (Kyushu) and Ogawa-san (Shinshu) comparing silicon, scintillator and hybrid ECAL designs

Jet Energy Resolution and tau reconstruction



250 GeV tau decay mode reconstruction (Ogawa)



Jet Energy Resolution (Ueno)

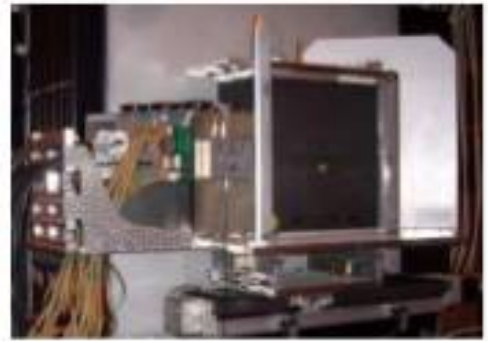
We are trying to define detector models and digitisation between technologies to ensure a similar level of confidence in simulation results

First (~parasitic) test beam trial in summer 2013; DAQ improvements underway @ Kyushu

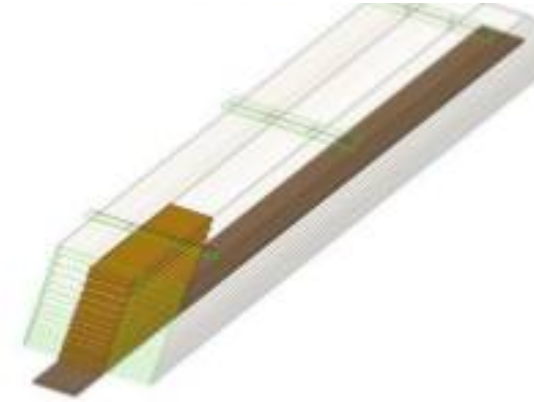
more details of hybrid studies in Ueno-san's talk tomorrow

Plans for next year

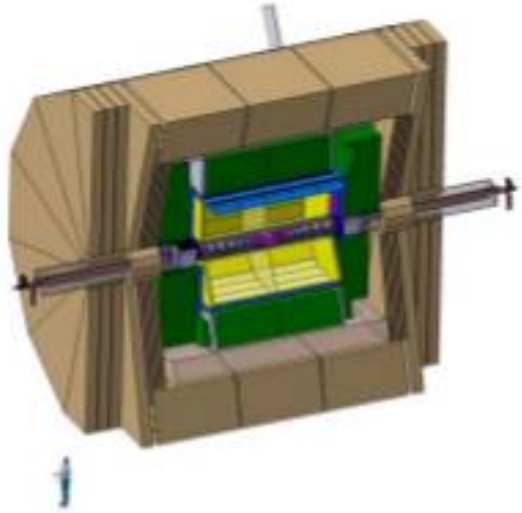
- further analyses of “physics prototype”
  - Finalise energy resolution study
  - Develop 2-particle studies



- development for technological prototype
  - Detailed comparison of different sensor designs
    - laser system
    - neutron radiation tests
  - Reliable combined operation of
    - silicon and scintillator layers
  - Manufacture of PCB in Japanese company

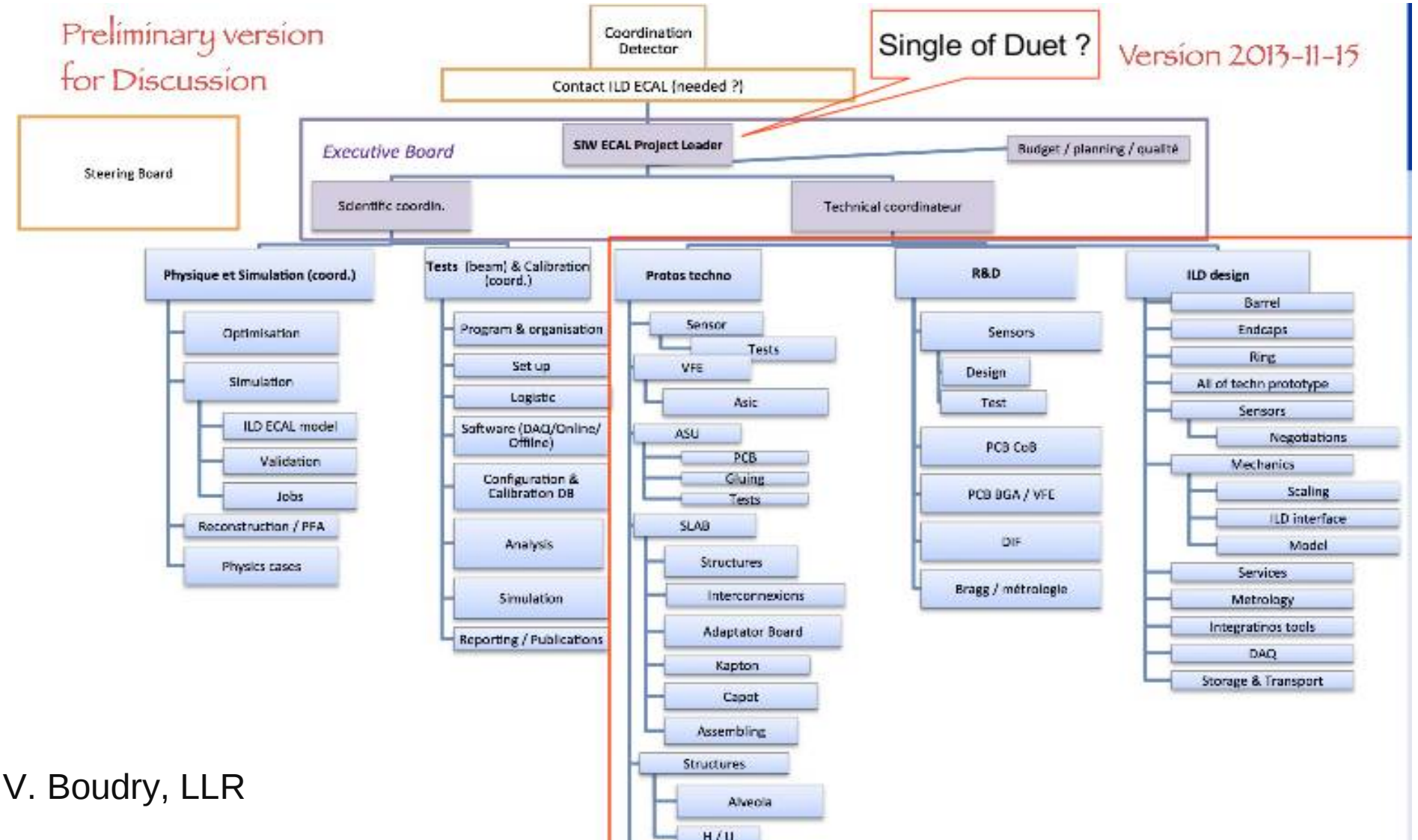


- further optimisation studies for ILD
  - ensure similar realism of different options' simulation
  - cost-performance studies



ECAL construction will take many years,
so we should not be much behind ILC schedule
We need to be ready to react quickly and efficiently after ILC decision
accept new contributors, finalise design, define and allocate work packages..

start thinking about how to organise and manage ECAL construction



V. Boudry, LLR

Summary

- performance of first “physics” prototype is
  well understood and stable

- technological prototype is under development
  to select technologies for final detector

- simulation studies underway
  to understand required quality, uniformity, …
  inform choice of final detector size, configuration & cost