FRANCE-JAPAN PARTICLE PHYSICS

TOSHIKO YUASA LAB.

D_R / R_1

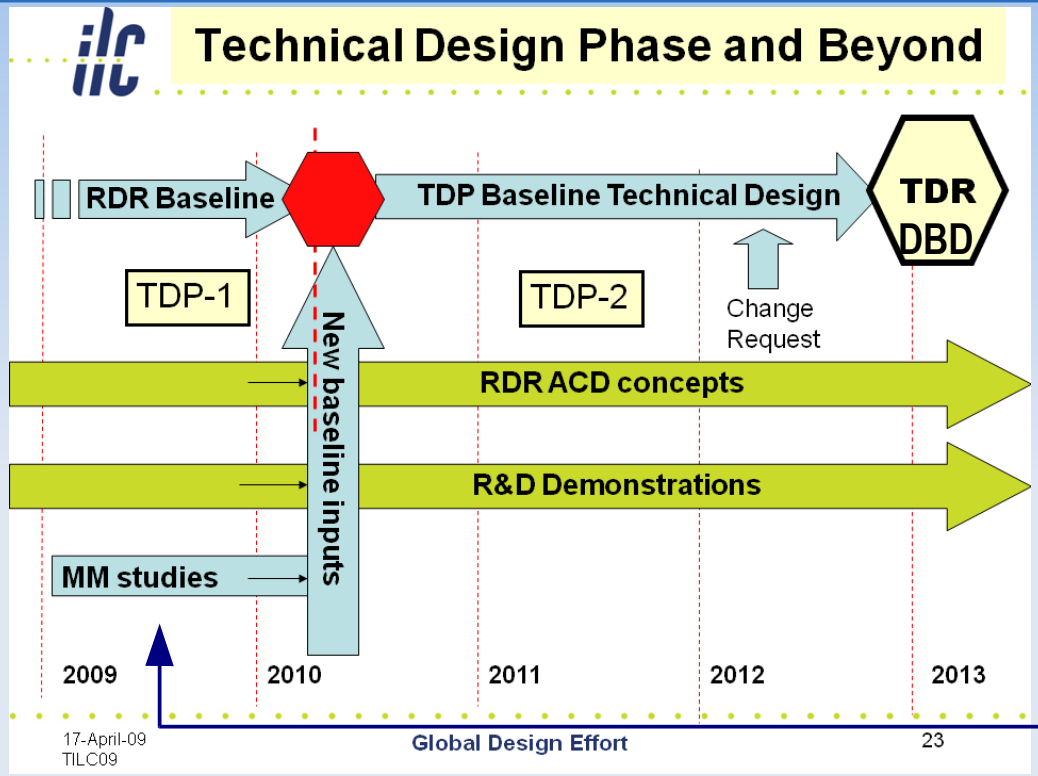
A common R&D on the new generation detector for the ILC

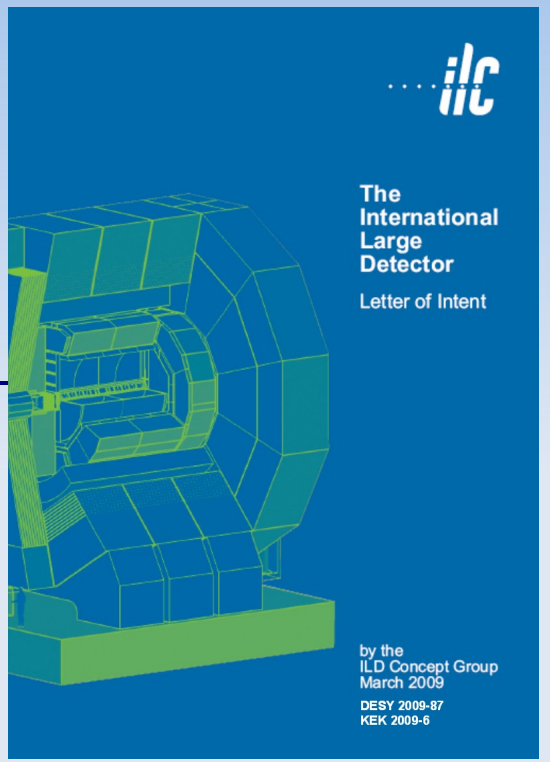
D_R / R_1

Vincent Boudry
LLR, École polytechnique

FJPPL'10
LAPP — Annecy
15/06/2010

ILC Calorimeter R&D biotope





ILD

> Boson tagging in jets decay needs to optimise the di-jet mass resolution
> Global Mechanical integration; Machine interface
> Simulation and PFA reconstruction
  - to test the performances on designed detectors
  - to analyse the test beam data

CALICE Calorimeter for ILC

> Design calorimeter optimized on PFA performances ...
> Lead to ultra segmented device e.g. SiW ECAL with 120 Mchannels
> Design & build ultra segmented prototypes tested with Beam

Road map to DBD

Aug 2009: IDAG: "At the LOI stage the progress of the Collaboration in realizing their detector concept is impressive and the path is clear for ILD to make continued progress"

Japan-France collaboration on ILC detector R&D:

2007-2008: "A common R&D on the new generation detector for the ILC"

- Detector Design (ILD from GLD & LDC)
- PFA Studies
- GRID use (KEK-IN2P3)
- Prototyping Ultra Segmented Calorimeter (Physical models)

✓ ILD LOI (March 2009)

2009-**2012** : "ILC Detector Design"

- Detector design (ILD), including MDI Integration
- PFA improvements with realistic models (dead material, services, ...)
- Prototyping Ultra Segmented Calorimeter (Technological models)

→ 2012 ILC proposal

Main members & meetings

France (+2010)

- H. Videau, C. Clerc, J.C. Brient, V. Boudry, Marc Anduze, M. Frotin, R. Cornat (LLR)
- R.Poeschl, M. Joré (LAL)

Japan

- K. Kawagoe (Kobe-U)
- T. Takeshita (Shinshu-U)
- S. Yamashita, T. Suehara (U-Tokyo)
- A. Miyamoto, T. Tauchi, Y. Sugimoto, H. Yamaoka (KEK)

Meetings (*)

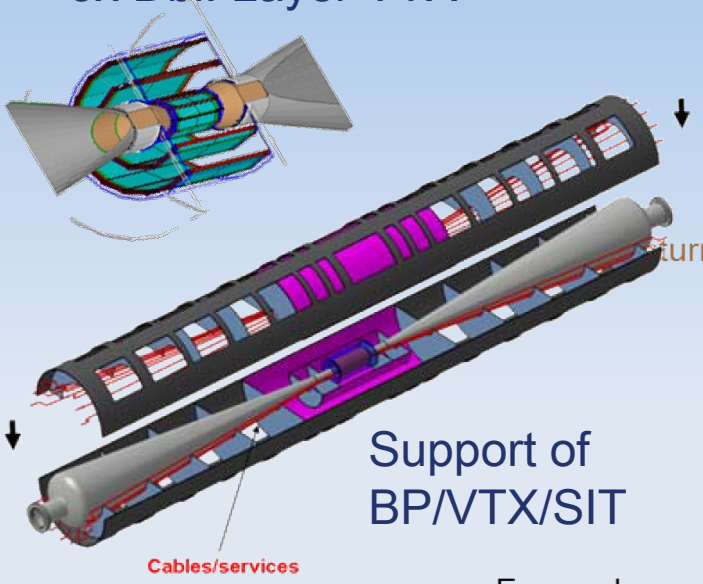
- 03—05 nov 2009, LCTW'09 (LAL, Orsay) : preparing the future ILC R&D TB program
- 10—12 jan 2010, “France Asia” meeting (Shinshu U. & KEK):
  Discussing hybrid ECAL, reconstruction, ILD MDI and future Si sensor cooperation
- Jan 27th–29th , 4th ILD WS (LLR Palaiseau & Paris) :
  preparing the simulation for 2012 DBD + // meetings on SW & MDI
- 6—8 July 2010: ILD SW & integration meeting DESY
- Sept 2010: Shinshu U. : discussion with Hamamatsu for Si sensors devt

(*) = + frequent (bi-monthly) video-conf

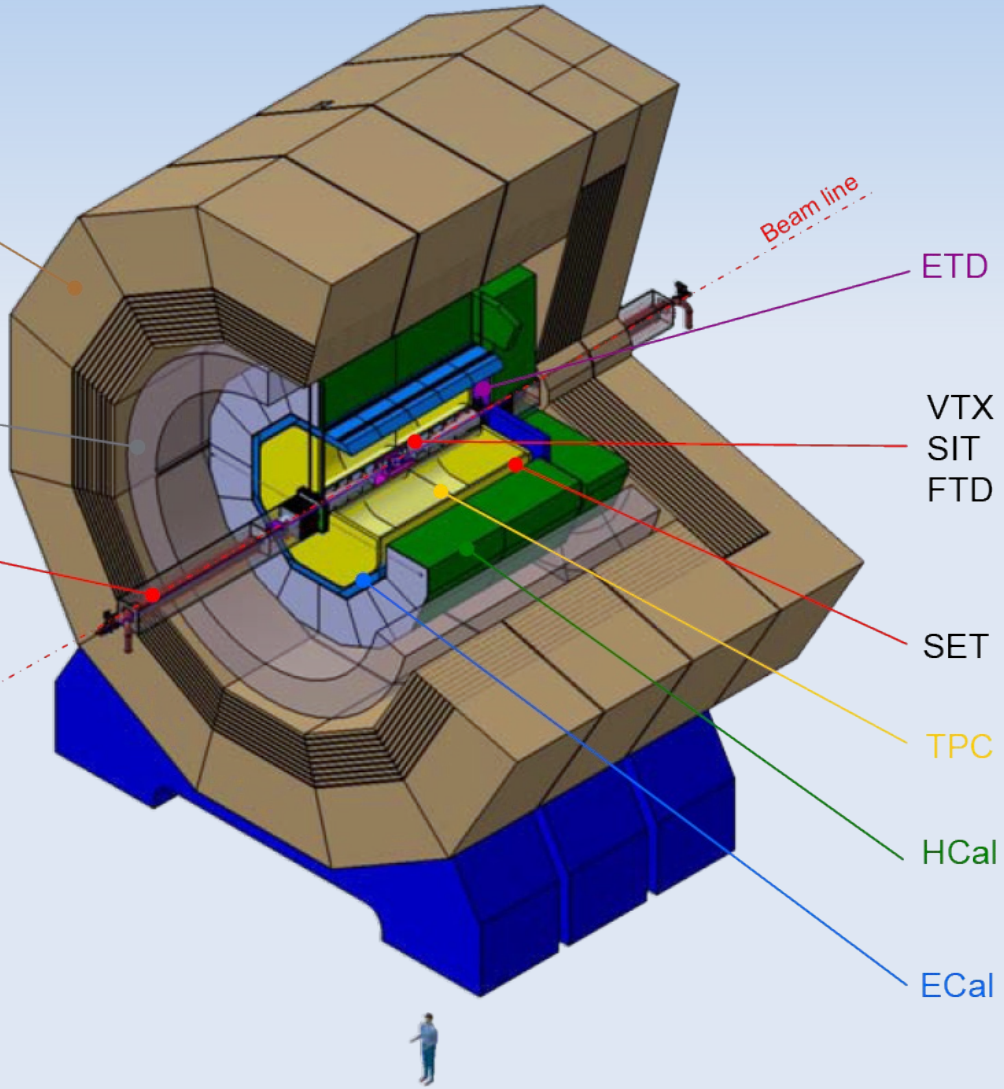
ILD Design

B=3.5T, RECAL=1.85m

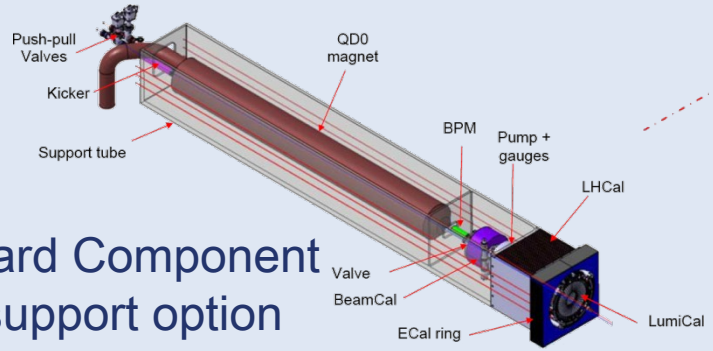
3x Dbl. Layer VTX



Support of
BP/VTX/SIT



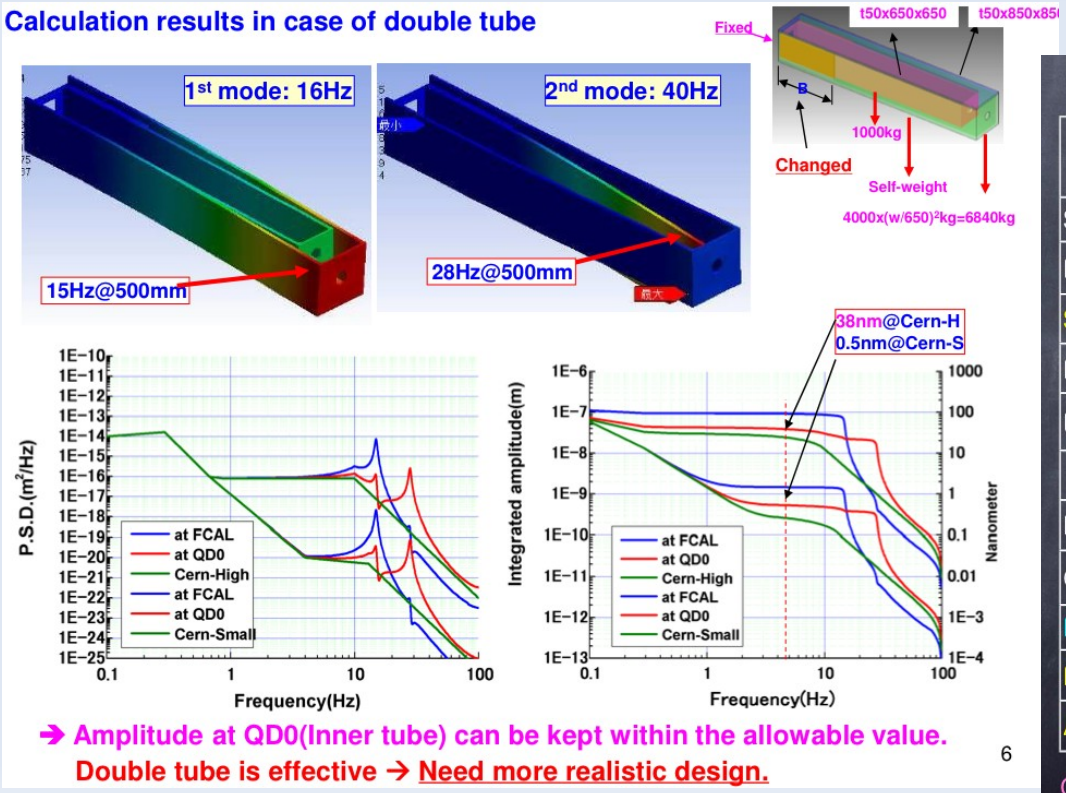
Forward components
(QD0 magnet – FCals)



Forward Component
Box support option

MDI studies

- Development of ILD technical design is the major task of coming years. Issues includes
  - Design of coil, cryostat, and structure; stability (vibrations)
  - Push-pull scenario: mechanical & optimisation of $\mathcal{L}$ losses
  - Detector integration and maintenance
- LLR and KEK members are heavily involved in MDI and Integration of ILD. The issues will be studied in this program



Detector Switchover Time Estimation : Goal

Procedures - about 2 days for the full push-pull operations after procedures have been optimized based on experiences	time in hours
Securing beams	1
Powering down of the detector solenoid (2GJ and 18.2kA to zero)	3
Stability work for pressure and temperature in the cryogenics system	3
Removing the radiation shield between detector and hall	2
Disconnecting all local supplies (in principle only the main bus-bar)	3
Disconnecting the beam pipe between the QD0 and the QF1 magnets	2
Moving the detector out towards its garage position (2.1mm/s in 15m)	2
Connecting back the main bus-bar in the garage position	3
Reversed procedure for the incoming detector	19
Pressure in the beam pipe: filled with inert gas and pumping to 10^{-5}Pa	several
Alignment and calibration of the detector system in the beam line	several

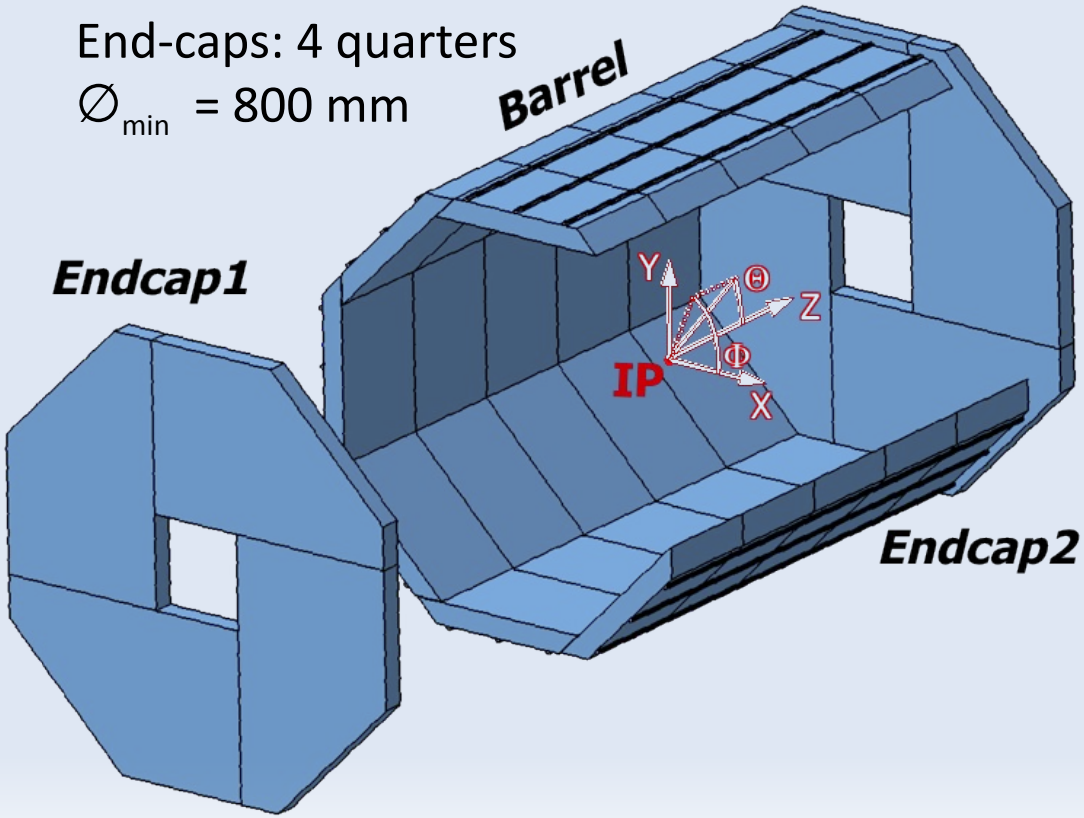
Comment : Stability due to movement of about 12kton detector - a site study

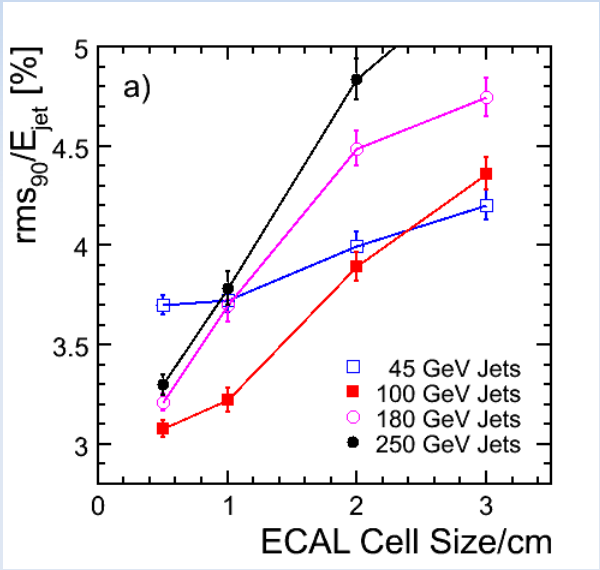
The ILD ECAL

- Finely granular PFA calorimeter with tungsten absorber
- Cell-size in baseline design ~ 5 x 5 mm² → ~100M cells in total
- Necessary to achieve less dead space, low production cost

Jet Energy Resolution
by M. Thomson

Barrel: 5 octogonal wheels
R_{min} = 1808 mm; R_{max} = 2220 mm
Width = 940 mm
End-caps: 4 quarters
$\varnothing_{min}$ = 800 mm



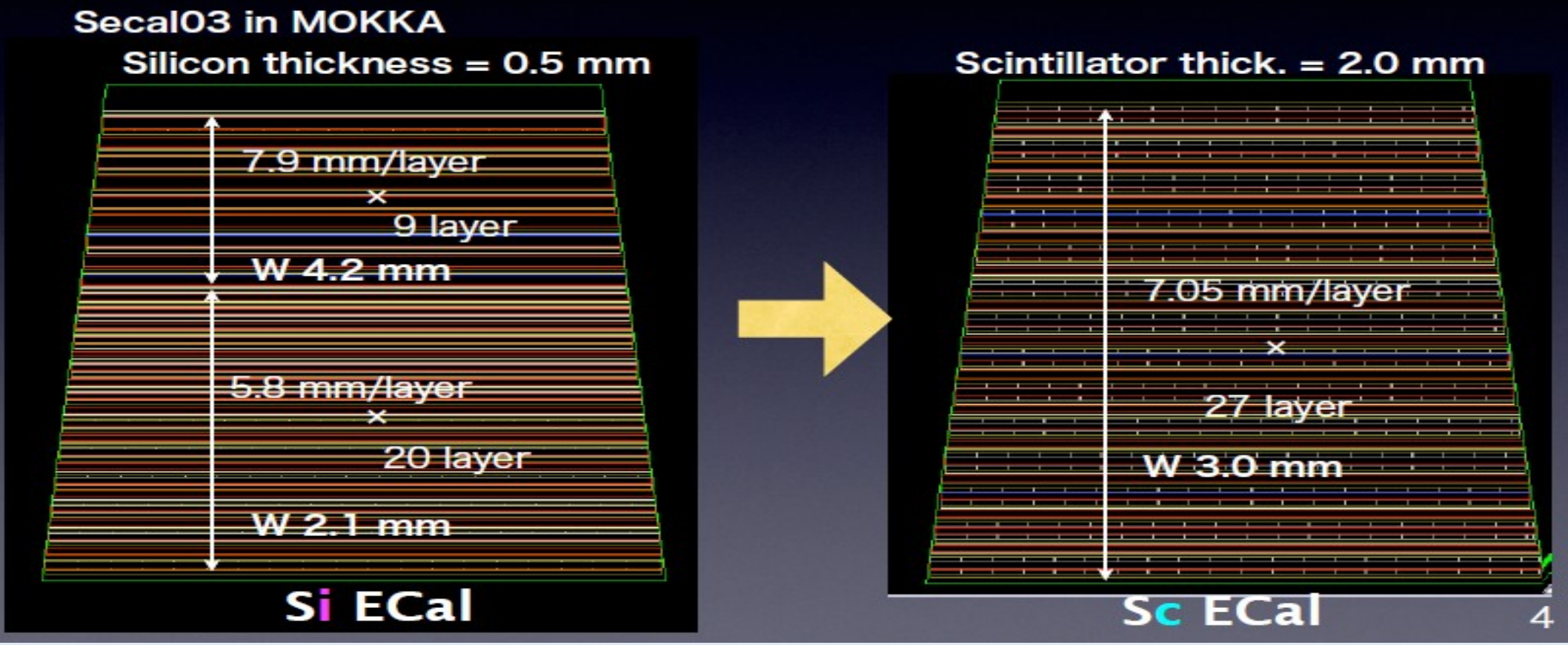


Candidate technologies :

- **Silicon-tungsten**
- **Scintillator-tungsten**
- **MAPS/DECAL (UK only)**

Making the tile ScWECAL in MOKKA

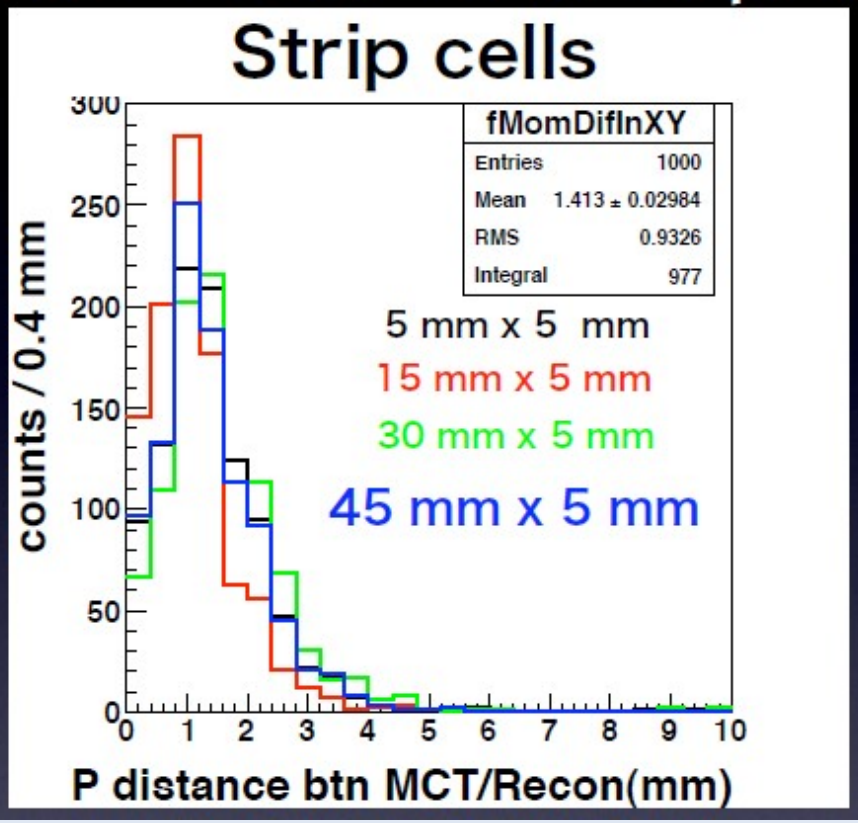
Still 5 x 5 mm² tiles

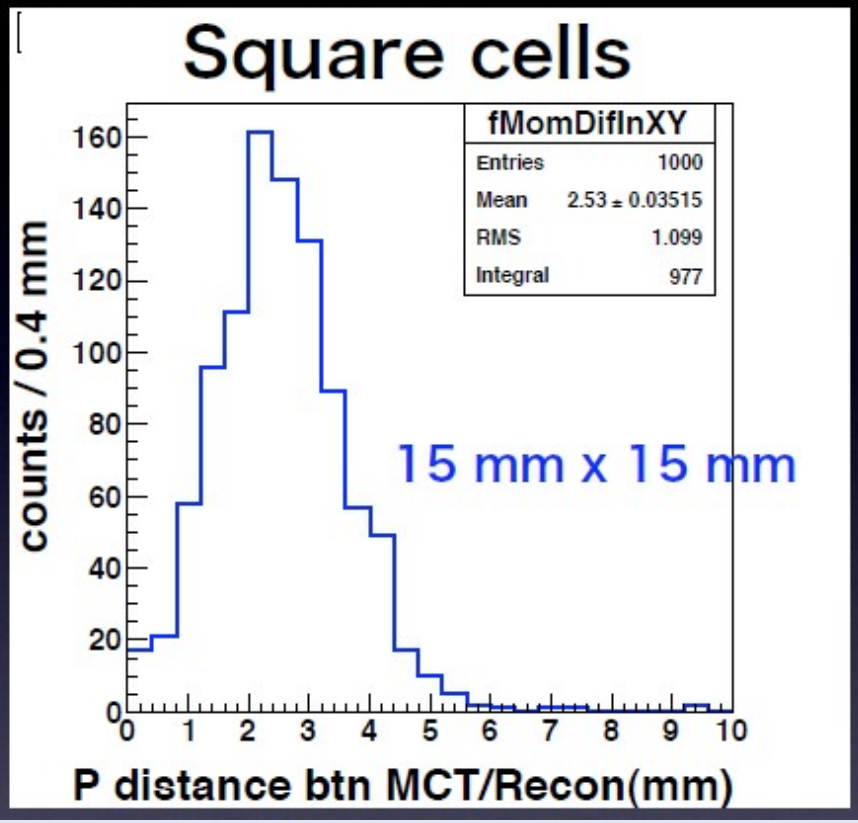


Scintillator Strip ECAL were originally developed in GLD and its simulator model and strip-clustering code were developed by using Jupiter and Satellites.
→ After LOI completion, ScECAL model were defined in Mokka and now analized by Marlin. It makes the comparison of performance easy.

Strip Scinti-ECAL Clustering

Comparison of position resolution btw Strip cell ECAL and Square cell ECAL 10 GeV 1000 photon



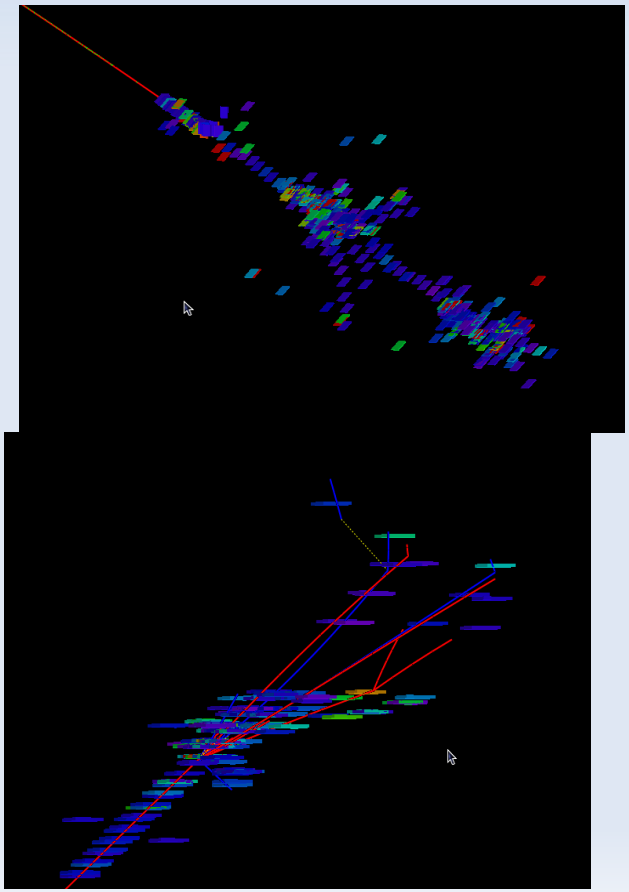


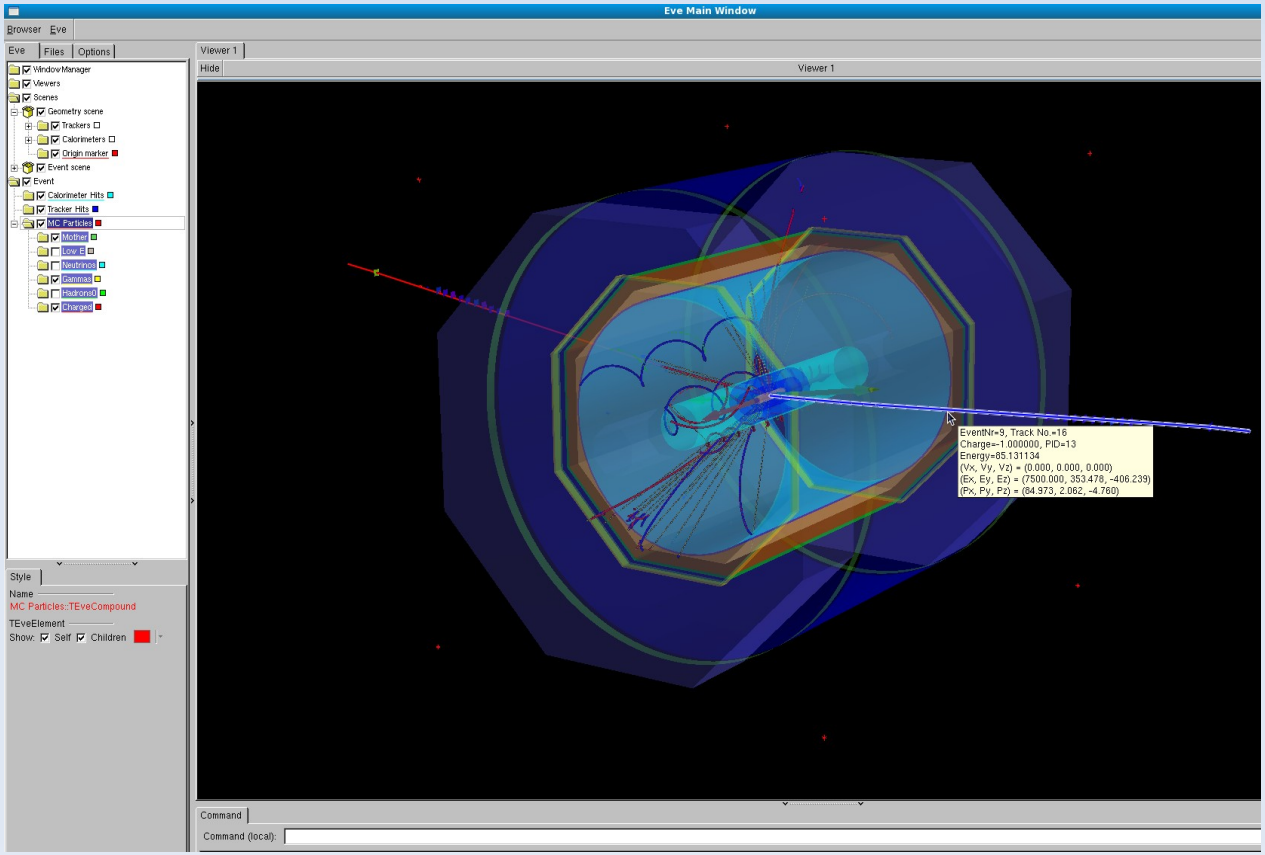
by Katsushige Kotera

- Position resolution of 10 GeV photon were studied with Strip-Scinit. ECAL
- Strip of 45mmx5mm size shows better resolution than tile of 15mmx15mm.
- Now, investigating jet energy resolution.

Analysis tools

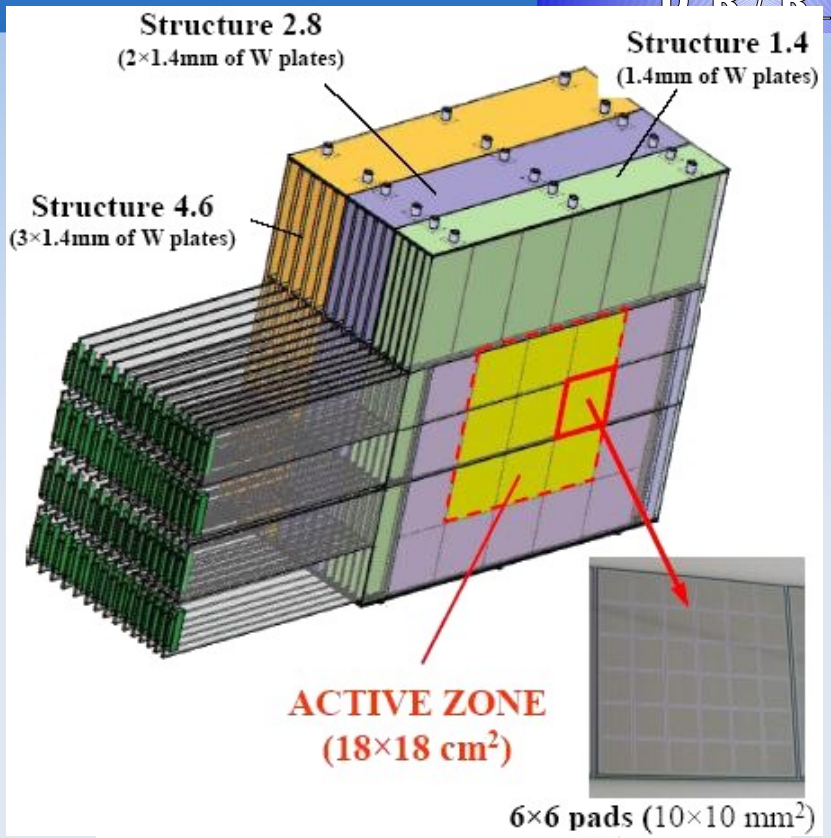
- Simulation of ScECAL in MOKKA
- Reconstruction
  - GARLIC clustering (γ finder) developped for SiECAL → ScECAL
  - Root based DRUID Event display based on a modified MOKKA version
    - Shower analysis in Highly Granular calorimeter

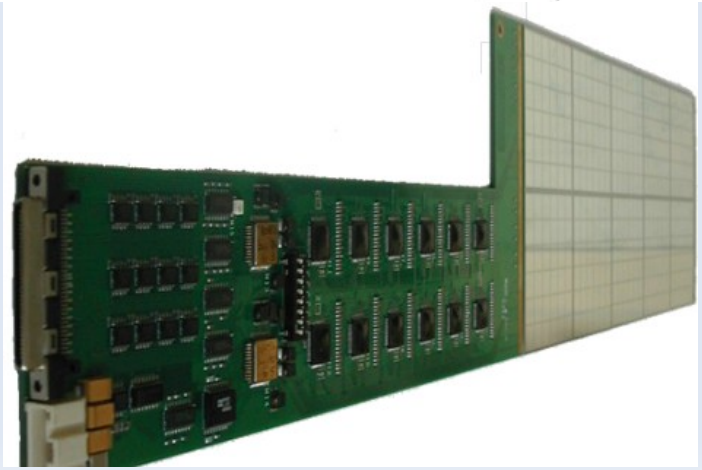




Silicon-tungsten ECAL

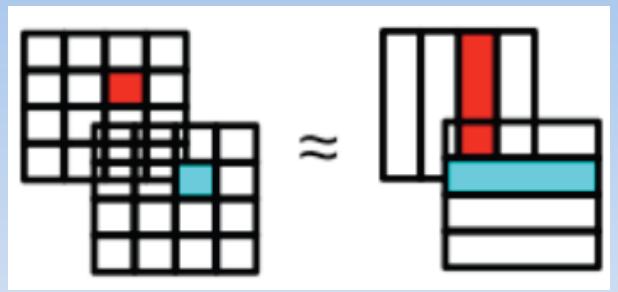
- **ILD Structure**
  - 20 layers of 2.1 mm ($0.6X_0$) W
    + 9 layers of 4.2mm ($1.2X_0$)W
  - 5x5 mm² granularity of Si
    ~ 108 M cells in total
- **10x10 mm² physics prototype tested in beam**
  - Energy resolution measured in test beam ~ 16.6%/√E(GeV) ⊕ 1.1% with S/N ratio of 7.5 for a mip signal
  - CERN (2006, 2007), FNAL (2008)
- **Remaining hardware R&D issues**
  - Power pulsing of FE electronics (common issue also for Sci ECAL)
  - **Si sensor cost reduction … need 2400 m², current price 10 euro/cm²**

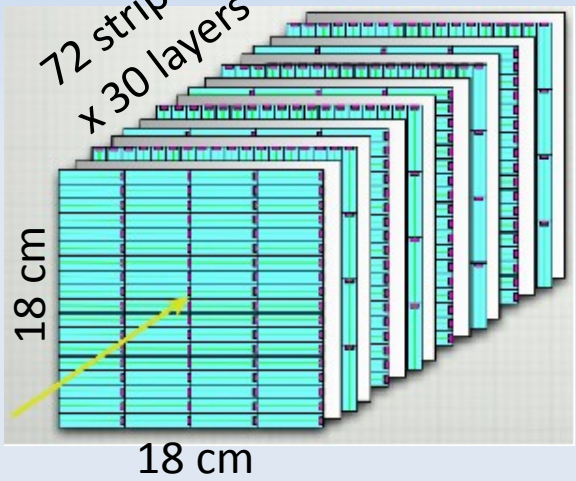




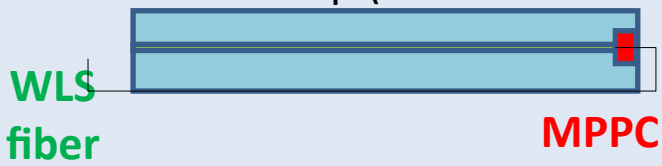
Scintillator-tungsten ECAL

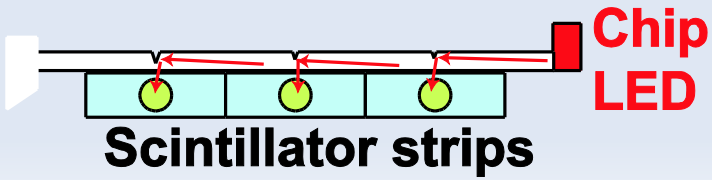
- Cost-effective scintillator strip calorimeter aiming to have virtual cells by x-y strips crossing.
- Beam tests of the physics prototype have been performed to prove feasibility.
  - DESY 2007 (small prototype)
  - FNAL 2008, 2009 (test with AHCAL)
- ILD structure
  - Scintillator strips with 5 mm width 2 mm thick without WLS fiber
  - 3 mm tungsten, ~21 X_0 in total
- Study of "strip-clustering" underway with realistic simulation
- Remaining Hardware R&D issues :
  - Study of 5 mm width scintillator-strip without WLS fiber
  - Dynamic range of photo-sensor
  - Establish design of the photo-sensor gain calibration system



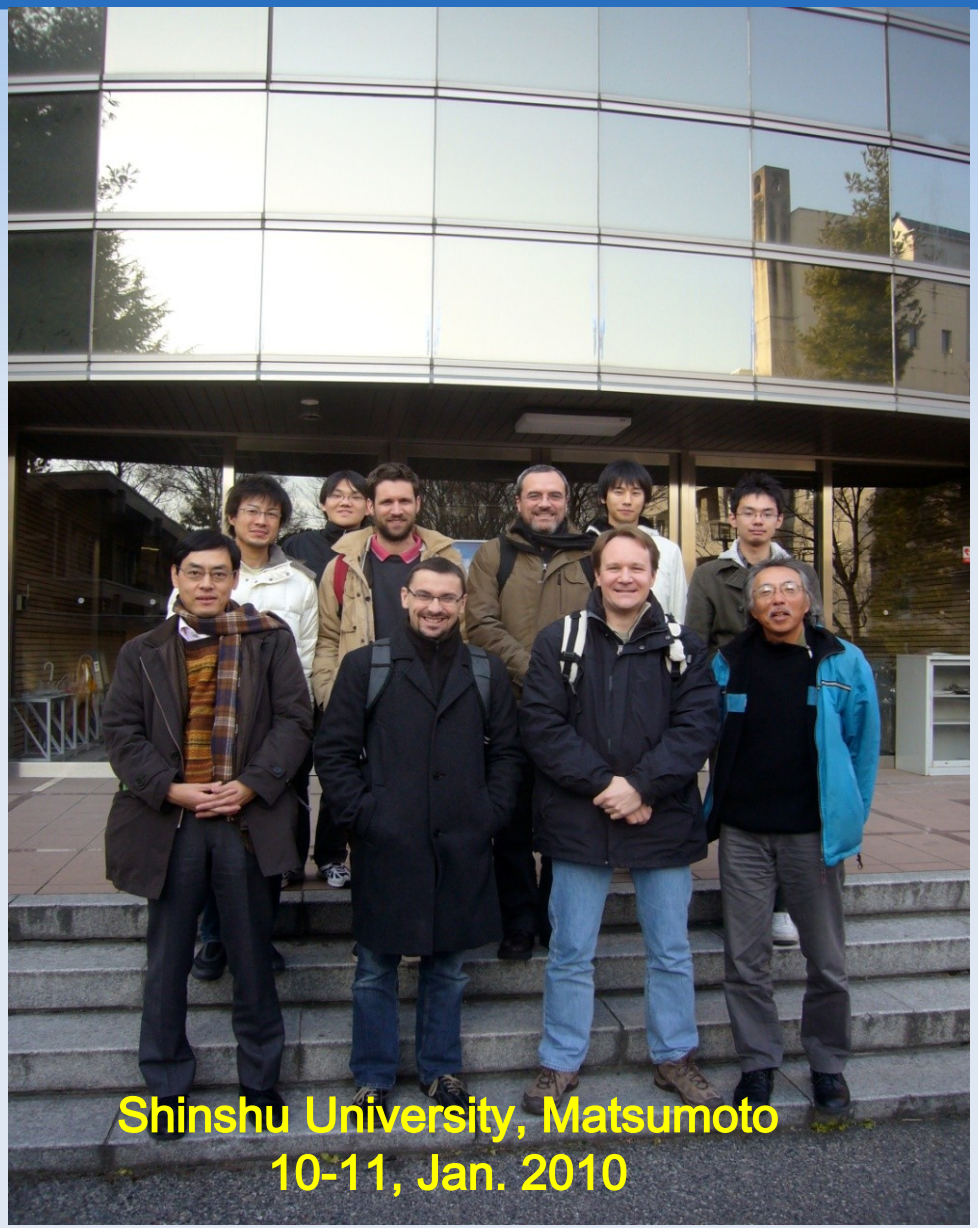


Scintillator strip (4.5 x 1 x 0.3 cm)

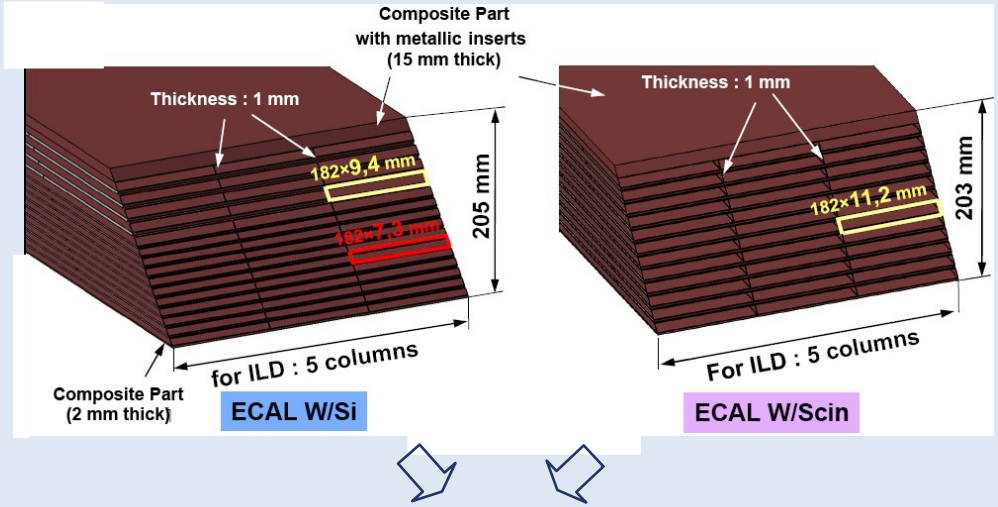




Toward a Hybrid ECAL



- Meeting at Shinshu Univ. (Jan. 2010) we developed a plan to study a Hybrid ECAL
- Study items include
  - Hardware design
  - Configuration optimization
  - Physics performance

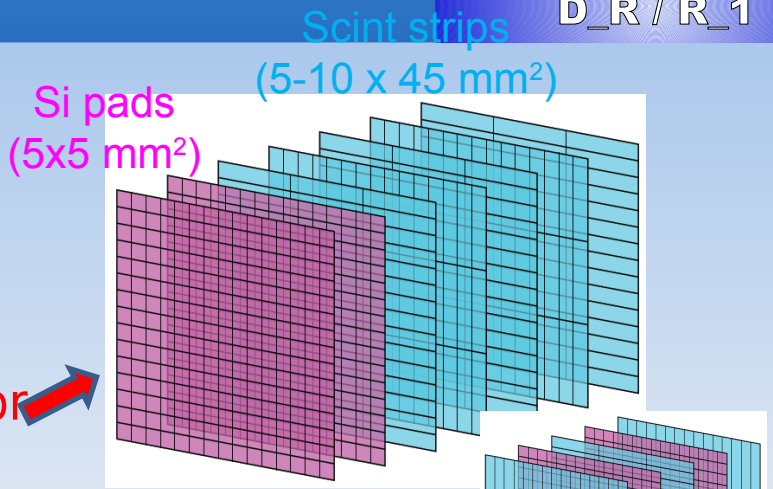


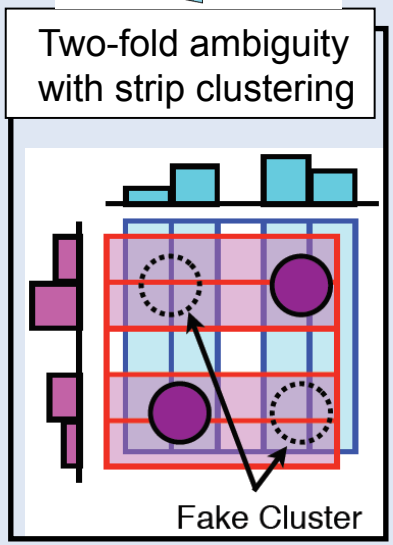
SiScECAL

Possible baseline design of the ILD ECAL

- 2 possible models
  - Silicon pads in pre-shower and shower-max region

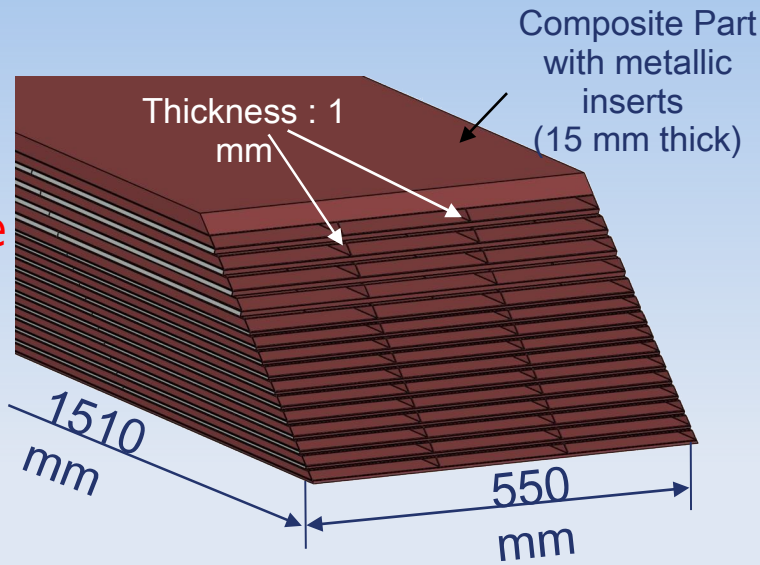
    Scintillator layers after the shower max.
  - Alternative: Si layers interleaved in scintillator layers
    - Cost-effective
    - No two-fold ambiguity for the strip clustering with silicon sensors
    - Can use established the silicon and Scintillator ECAL technologies.
  - Need extensive simulation study to determine configuration of Silicon / Scintillator layers
  - Specific cell & strip combined clustering must be developed.
    - Adaptation of GARLIC to strip under way.
- Mokka simulation of the hybrid-type ECAL under preparation.

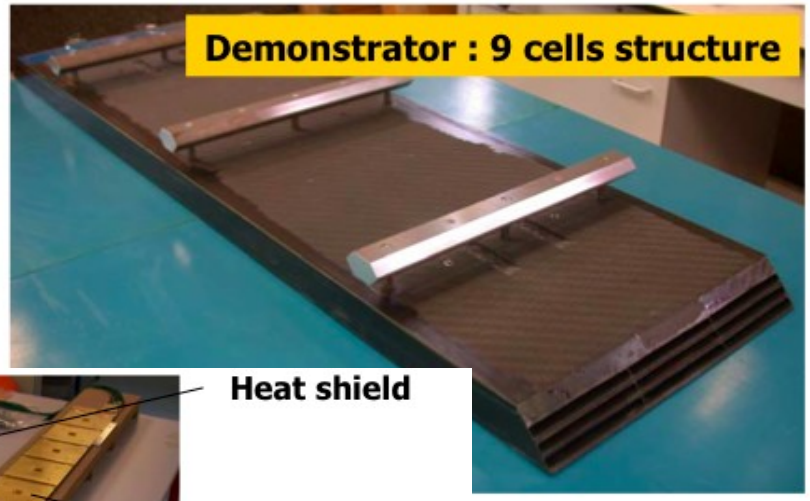


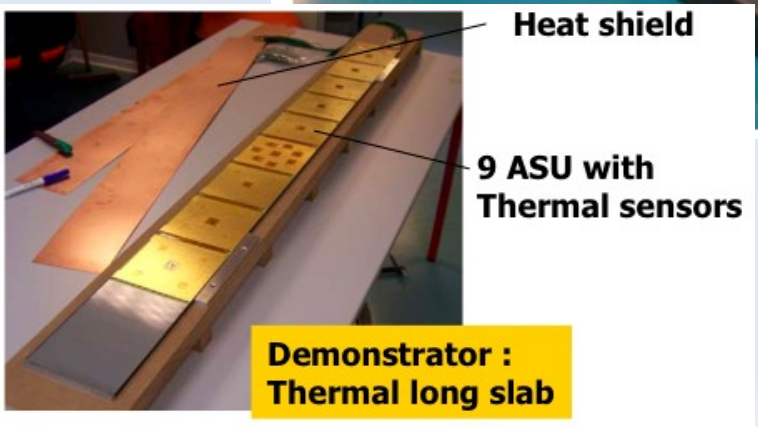


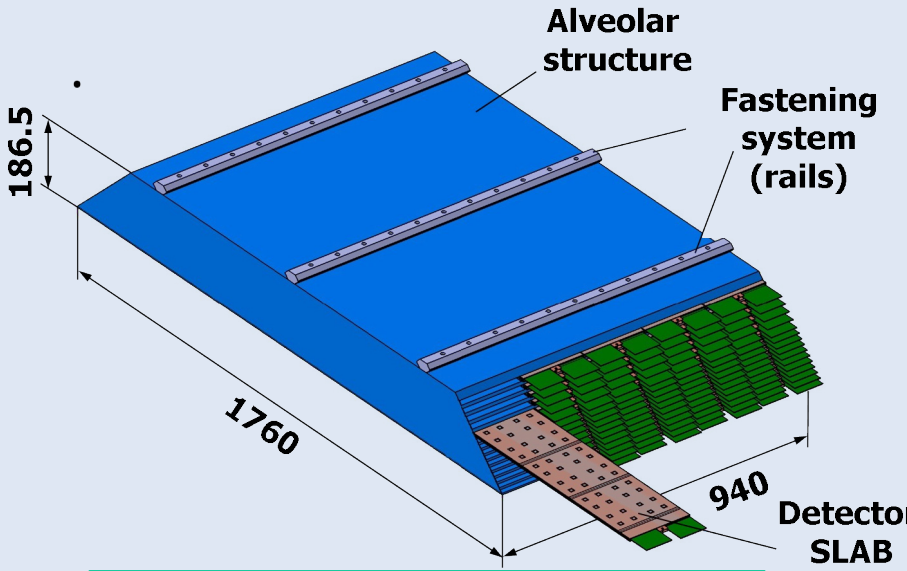
Si-W ECAL prototype "EUDET" module

- Design guide lines
  - Test technological solutions for ILD ECAL
  - Mechanical structure close to ILD detector module
  - Readout chips integrated within the detector volume
  - Demonstrator done; full structure in preparation





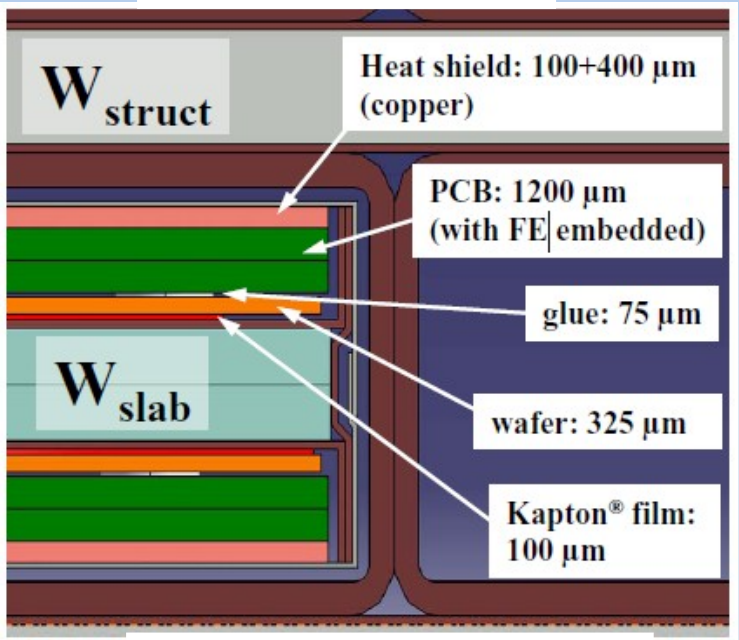




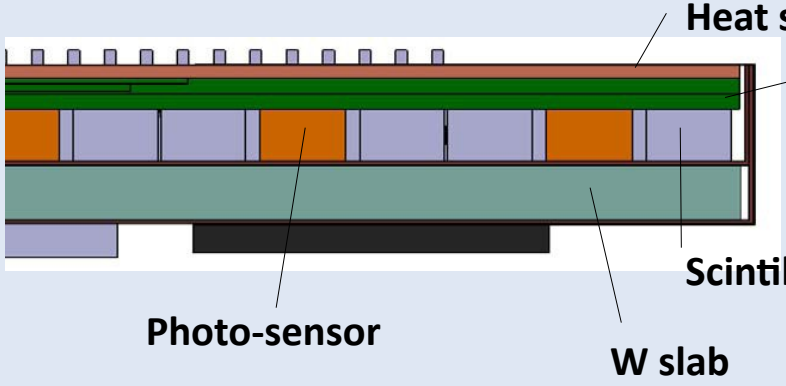
ILD ECAL module

The EUDET prototype

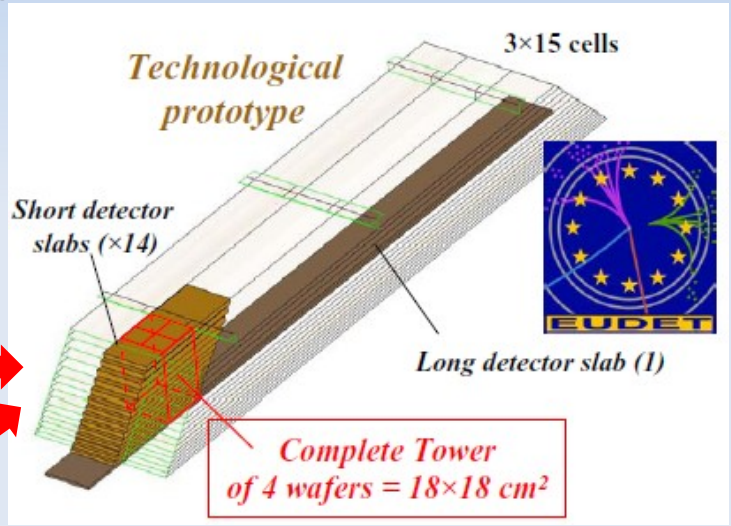
Silicon module



Scintillator module



- The EUDET alveolar structure can accommodate both Si / Sci ECAL modules.
- Discussion underway to make the compatible structure.



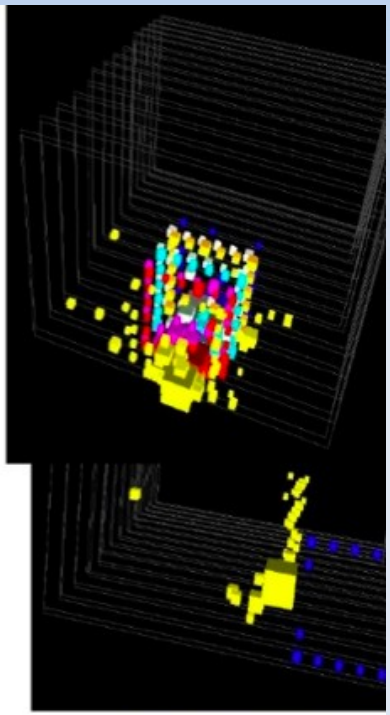
- Construction of the mechanical structure by end-2010.
- Implement detector modules ~ mid 2011.
- Future beam tests from ~ 2012
  - Si + Sci module test
  - Validate power pulsing
  - Test simulation with finer granularity

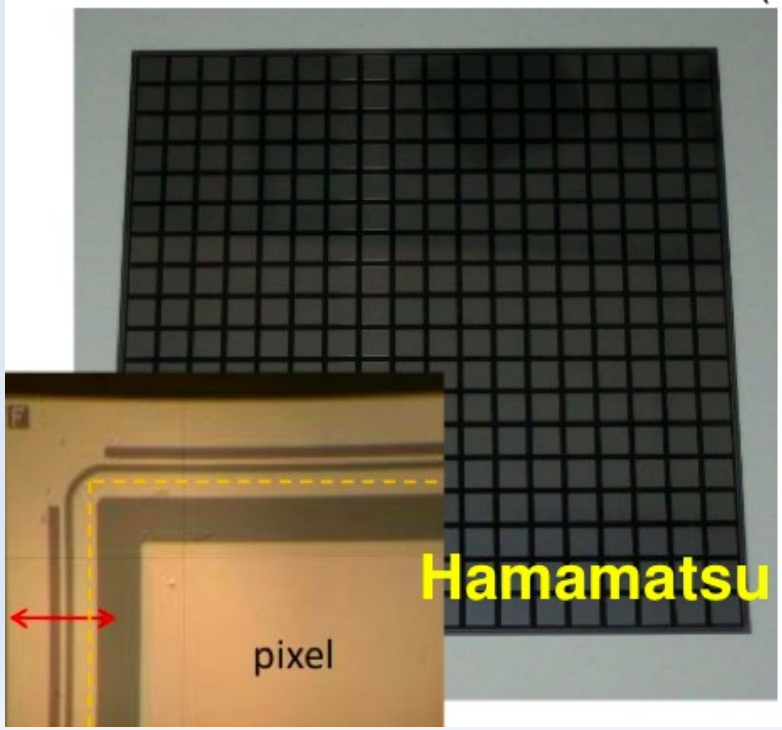
Si Sensor studies

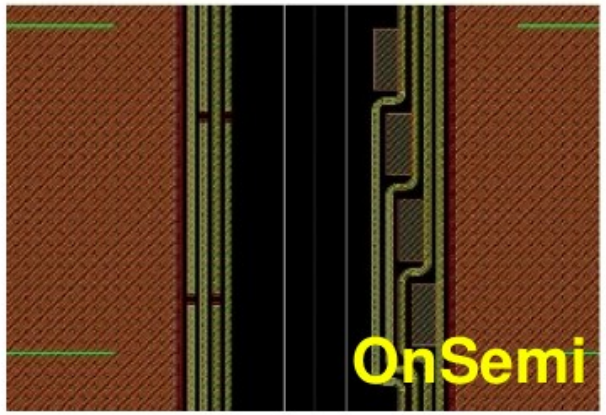
- Edge optimisation (Guard ring coupling, size, simplification, …)
- Cost reduction (7-8$ / cm² → 2-3$/cm² for 2400 m²)

Silicon sensors

Larger sensors – less dead edges
Smaller (5x5mm2) cells – better PFA performance
Segmented guard rings – reduce guard-ring X-talk
(square events)







Summary

- Both French and Japanese group are members of ILD
- ILD LOI was validated last September. We were requested to proceed towards Detailed Baseline Design (DBD) by 2012.
- DBD is to define a baseline design based on proved technologies and demonstrate a physics performance based on a realistic simulator model including faults and limitation.
- For ECAL in ILD,
  - Japanese group has been working Scintillator Strip calorimeter,
    - implementing the model in Mokka which was developed by LLR.
    - developing the digitizer and clustering code of strip readout, communicating with Daniel Jeans (LLR)
  - French group has been studying Si readout ECAL.
    - Mokka and ECAL geometry driver has originally developed at LLR.
    - Using SiECAL, GARLIC (γ reconstruction) and DRUID (event display) has developed, which will be used also by Japanese group.
  - Now developing Hybrid ECAL (Mixture of SiECAL and ScECAL)
  - Cooperation on Si Wafer being started

Outlook

- The **Japanese-French collaboration** in D_R/D_1 has been very useful
  One of the driving force :
  - on common work on simulation, optimization, and benchmarking of ILD detector concept.
  - on development of technically feasible high granularity ECAL for the ILD

- It will be mandatory for the development of the ILD technical design in the ILC TDR/DBD era.
  - Study and design of detector integration
  - Complete PFA study of strip ScECAL and hybrid ECAL and studies with more realistic model.
  - Proto-typing of ultra segmented calorimeter

- Somewhat less active in 2009 after the LoI
  (TB of ScECAL at FNAL, realisation of EUDET structure)
  - Very promising cooperation channels for 2010 with hybrid ECAL, and Si wafer R&D

Vincent.Boudry@in2p3.fr