

ILC Detector Activities in Japan

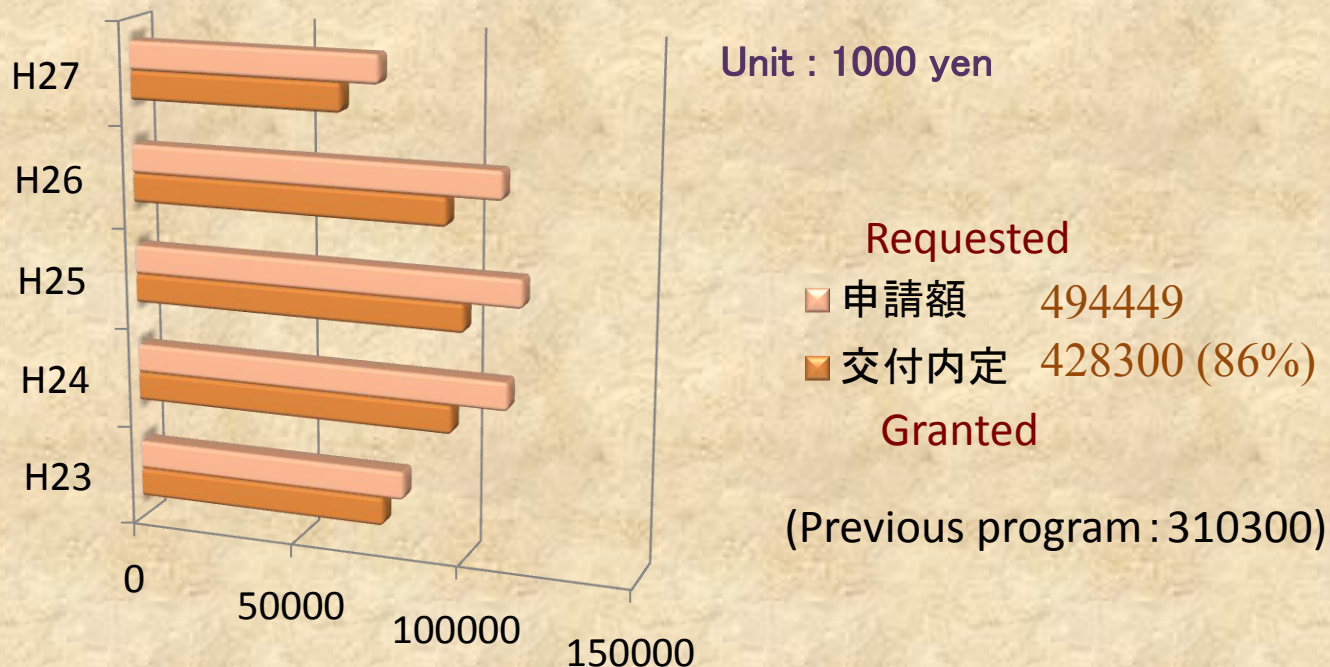
Hitoshi Yamamoto
Tohoku University
IRFU Linear Collider Days, Sacley
November 29, 2013

JSPS specially-promoted research

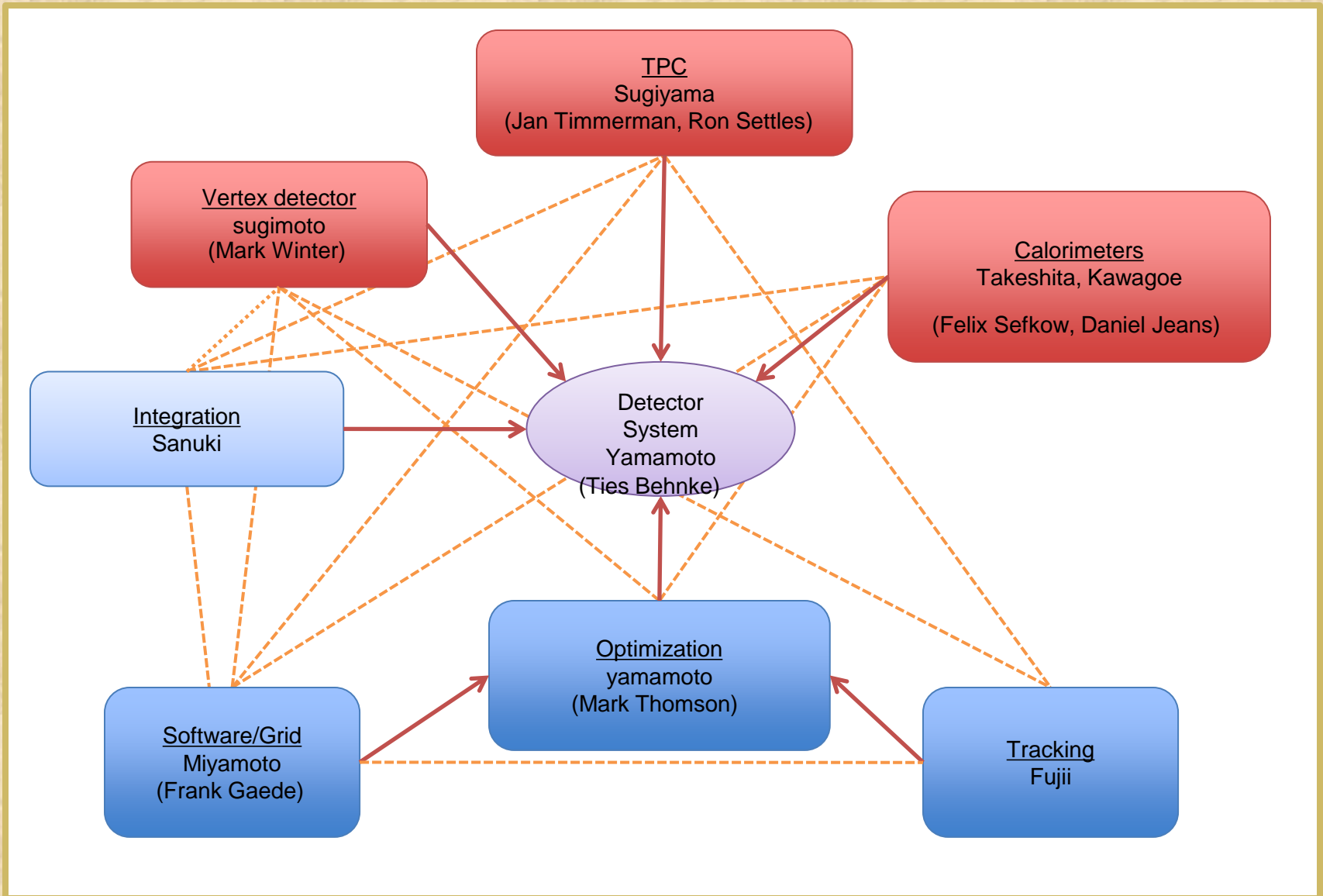
A Global R&D Program of a State-of-the-art Detector System for ILC

A large part of the ILC detector R&D funds in Japan

Budget profile: direct costs including personnel



Organization



TPC

ILD-TPC Asia

■ Within LC-TPC collaboration

- Japan, China, Phillipines



GEM module

■ GEM-TPC

- Double GEM (laser-etched)
 - 100 μm thick, 140 μm pitch
- 1.2 mm x 5.4 mm readout pads
 - 5152 channels/module
- Readout electronics
 - (S-)ALTRO chip
- Tested on the 'Large Prototype'
 - w/ PCMAG from KEK brought to DESY



PCMAG



Large prototype endplate

TPC Beam tests

DESY T24 Beamline ($P_e = 5 \text{ GeV}$)

■ 2010 (Sep 1 – 16)

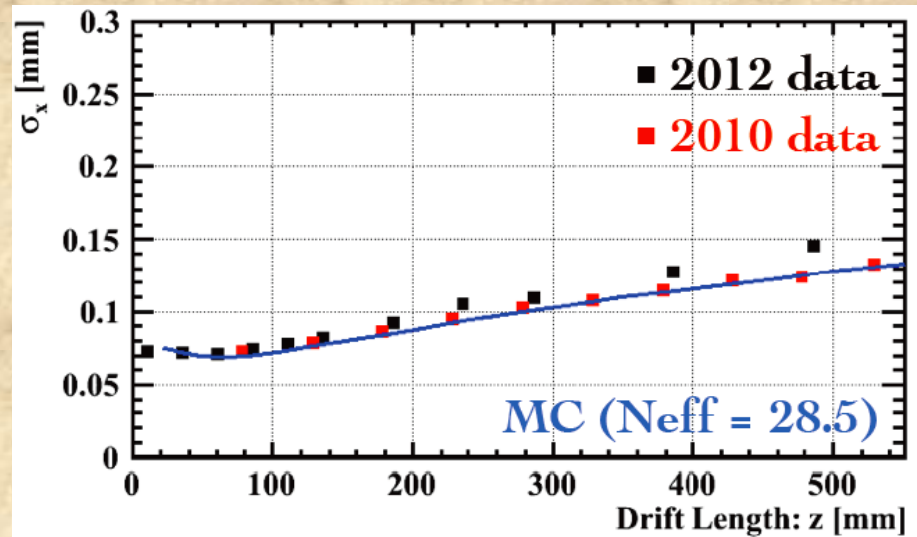
- $B = 1\text{T}$
- GEM model partition = 2
- Discharge problem

■ 2012 (Nov 19 – Dec 18)

- $B = 0\text{T}, 1\text{T}$
- GEM module partition = 4
 - To suppress discharge
- Protection circuits etc.
- More region in area/angle of beam

■ Spatial resolutions:

- Understood from 1st principles
- ILD requirement is more or less met



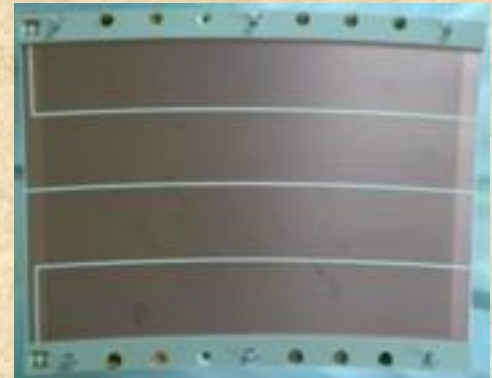
Field Distortion

■ 2012 beam test

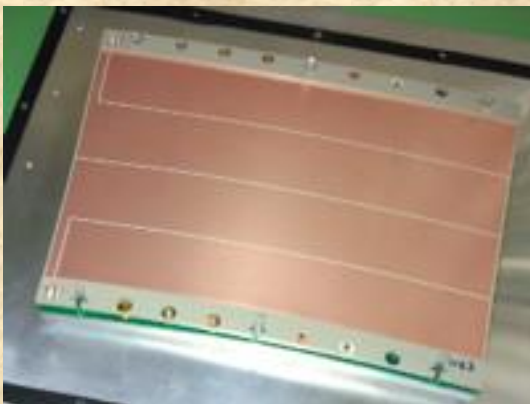
- Field distortion seen at GEM electrode boundaries (1 mm gap)

■ UV laser test & simulation

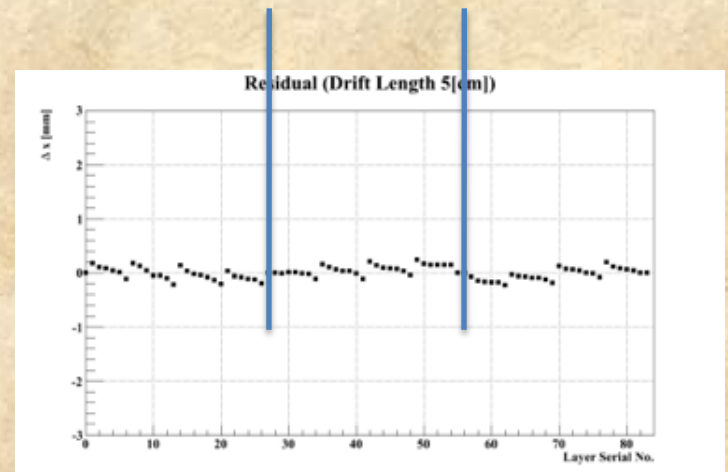
- Verified the distortion
- New GEM with narrower gap made (0.5 mm gap)



2012 GEM



New GEM



Residual

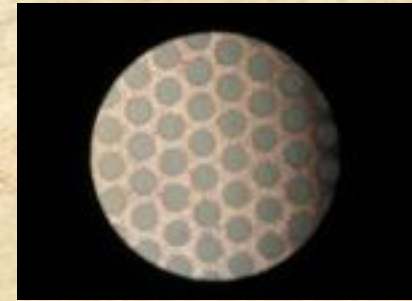
Ion Gates

■ Default: GEM gate

- 140 μm pitch, hole $\phi = 90 \mu\text{m}$
- Problem: electron transparency $\sim 35\%$
- Improved GEM proposed
 - Larger geometrical aperture
 - Electron transparency $> 70\%$ by sim.
 - Fabrication?

■ Backup: Wire gate

- Wires put radially (dead area)
 - Can cause field distortion
- Tested with Fe55: OK
- To be laser-tested



Current GEM gate



Improved GEM gate (ANSIS model)



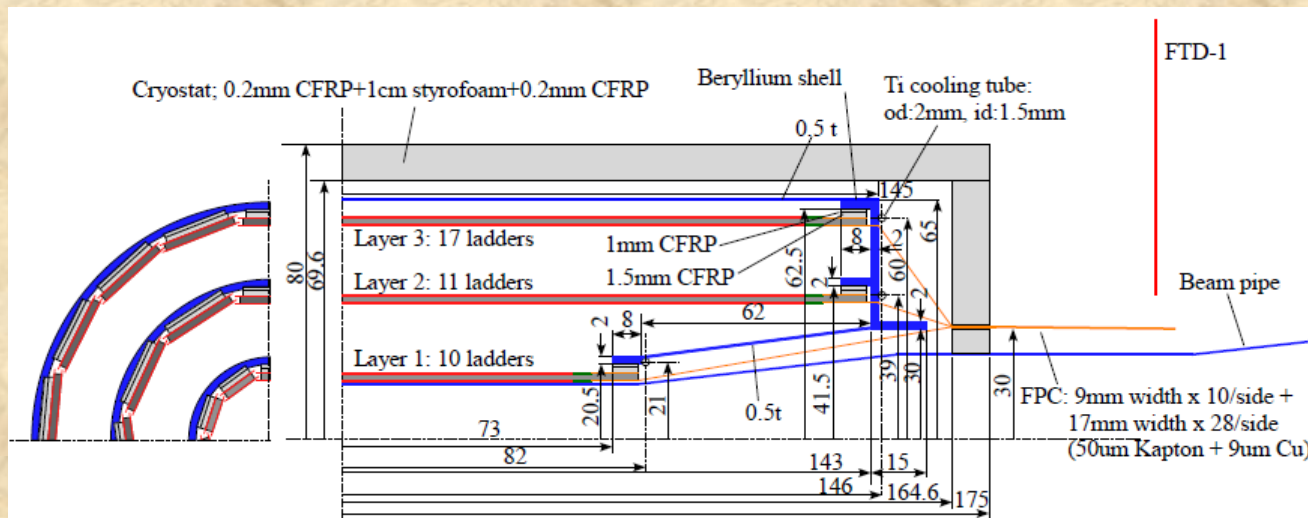
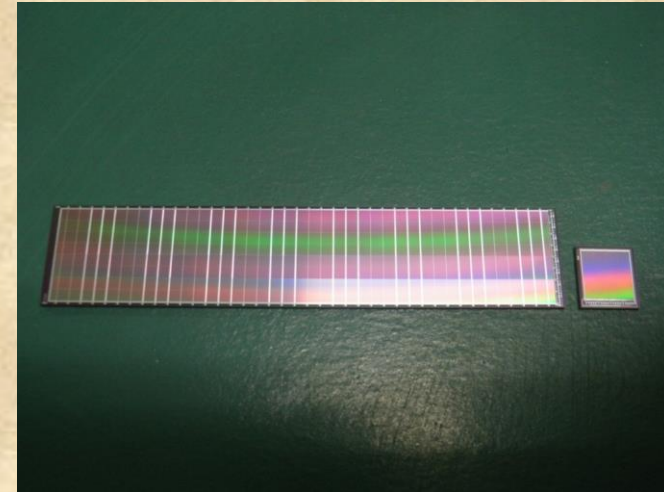
Wire gate module

Vertexing

FPCCD

■ Our choice: FPCCD (fine pixel CCD)

- 5 μm x 5 μm pixel (inner layers)
- Signal integrated over a whole train
- Fully-depleted
 - Reduce diffusion (thus occupancy)
- Operated at -40°C

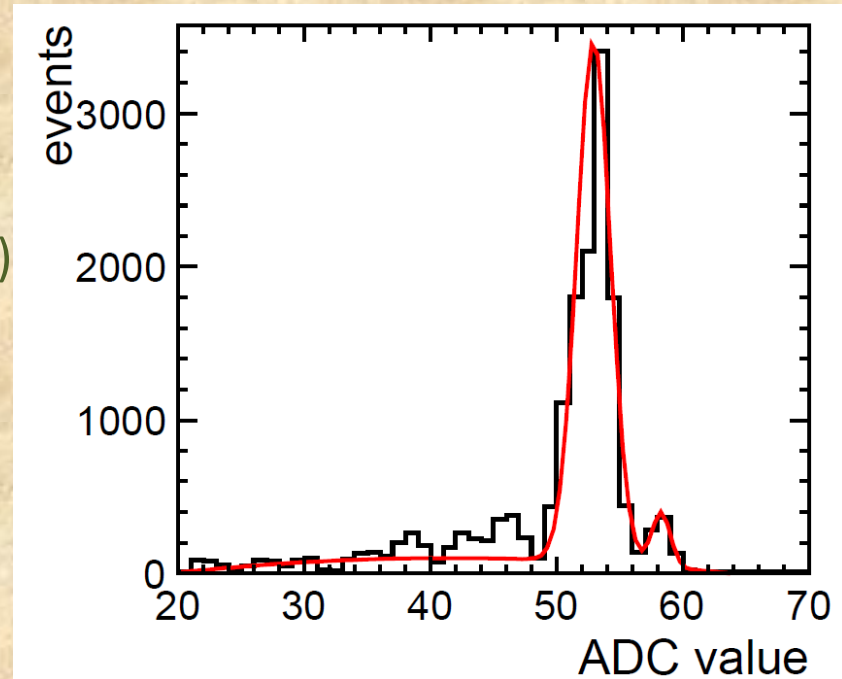


FPCCD Sensor R&D

FY	Sensor
2004	Fully depleted CCD, 24um pixel
2005	Fully depleted CCD, 24um pixel
2006	Fully depleted CCD, 24um pixel
2007	1 st FPCCD: small size (6mm ²), 12um pixel
2008	2 nd FPCCD: small size, 12um pixel (modified output amp)
2009	3 rd FPCCD: small size, 12, 9.6, 8, 6um pixel
2010	4 th FPCCD: small size, 12, 9.6, 8, 6um pixel (modified process) Thin wafer: 50um
2011	Small size, 12, 9.6, 8, 6um pixel (modified process), thin wafer
2012	Small size, 6um pixel, 4ch, different H-register size Large size (12x64mm ²), 6, 8, 12um pixel, 8ch Small size, 6um pixel, thin wafer (for beam test)
2013	Small size, 5um pixel ? Large size, thin wafer ?

R&D Status

- 6 μm pixel works
 - Full well capacity is still to be improved (>10000 e)
- Large prototype works
- Fe55 X-ray signal seen
 - w/ 2.5 MHz RO speed (goal : 10MHz)
- New readout ASICs being developed
 - AFFROC-1
- Neutron test



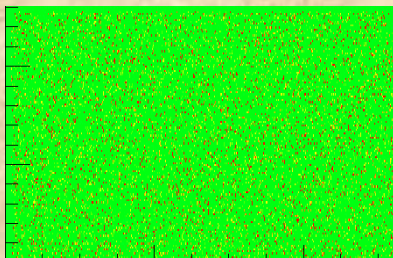
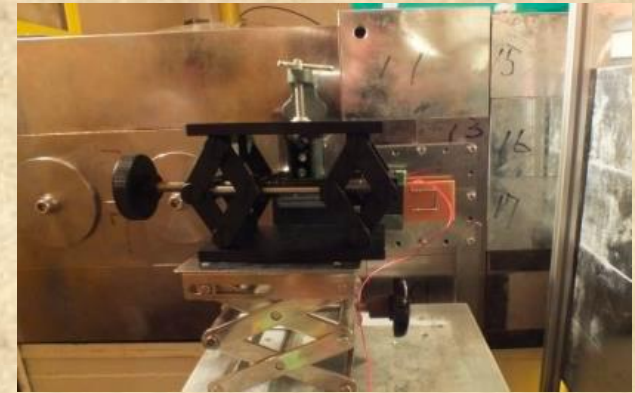
Neutron Test of FPCCD

■ Neutron source

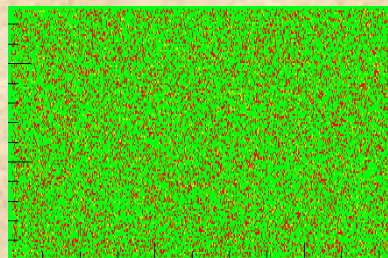
- Tohoku University CYRIC
- Proton beam to Li target

■ Irradiation

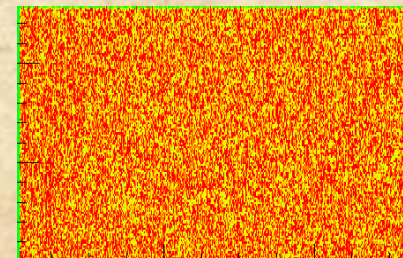
- $9.4 \text{ E}8$ neutrons on CCD
- Hot pixels increased



-20 ° C



-0 ° C



20 ° C

- CTI increased:
 - X direction: $1.8 \text{ E-}6/\text{pix} > 6.4 \text{ E-}6/\text{pix}$
 - Y direction: $4.7 \text{ E-}6/\text{pix} > 27.3 \text{ E-}6/\text{pix}$

CO2 Cooling

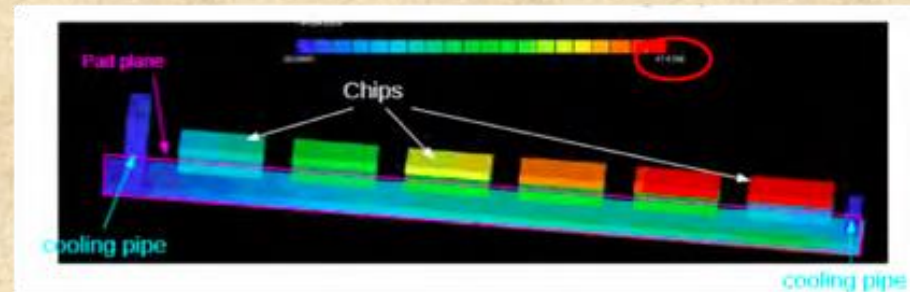
- 2-phase CO2 cooling
 - Being developed at KEK
 - Used for FPCCD, TPC, ...
- Delivered to NIKHEF
- System will be setup at DESY also



Test bench



At NIKHEF



Heat Simulation

Calorimeters

Calorimeter Activities in Japan

■ Mostly within the CALICE framework

■ Scintillator calorimeter

- ECAL
 - Strip : 2 x 5 x 45 mm³
 - Read out by MPPC (Hamamatsu ~ SiPM)
- Beam tests

■ Silicon calorimeter

- Testing Si sensors
- Beam tests

■ Hybrid ECAL calorimeter

- Si and Sci
- Optimization simulation study

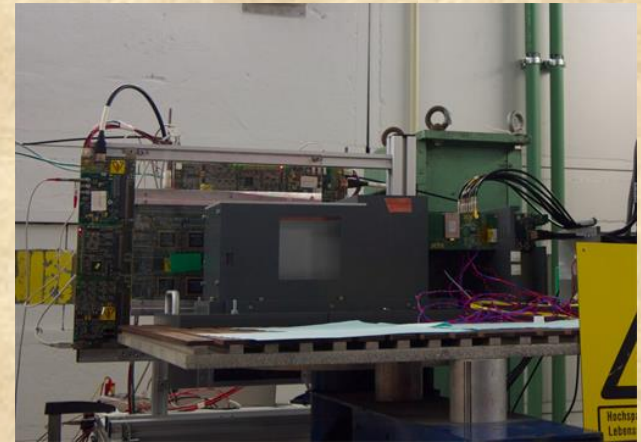
■ Software

- PFA by strips

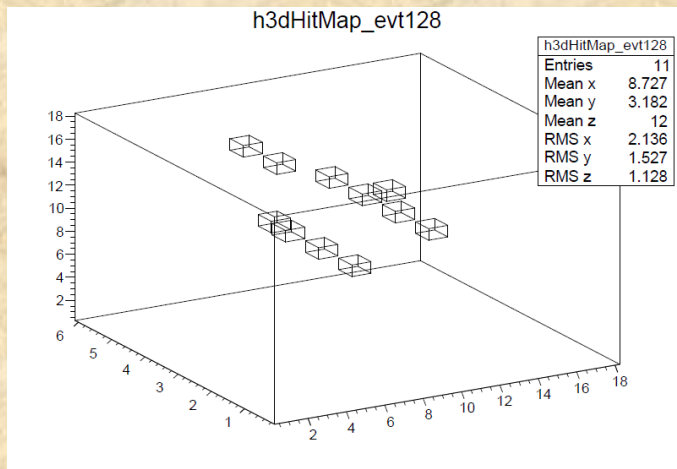
Beam Tests

■ ECAL beamtests

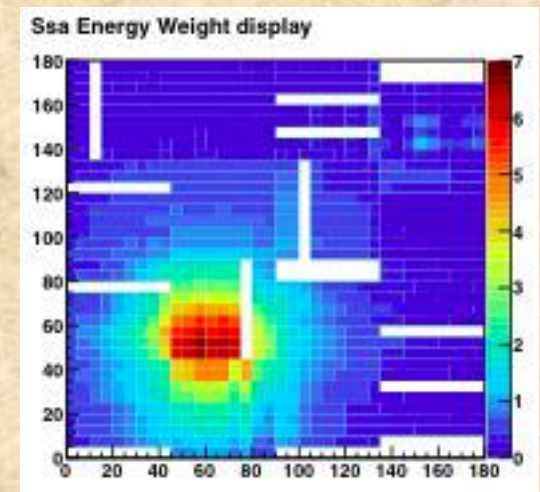
- DESY, July&Oct 2013 (Recent ones of many)
- 2 lyrs Sci ECAL + 7 kyrs Si ECAL
 - Not a true 'hybrid'
- Sci ECAL technological prototype
 - Being analysed



Beam test setup



Si ECAL 2-track event



Sci ECAL hit distribution

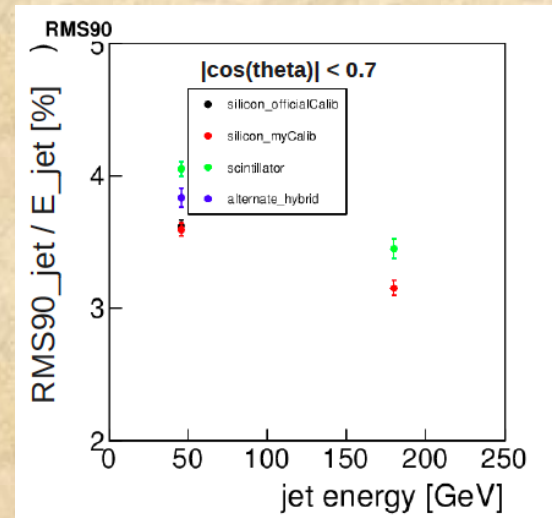
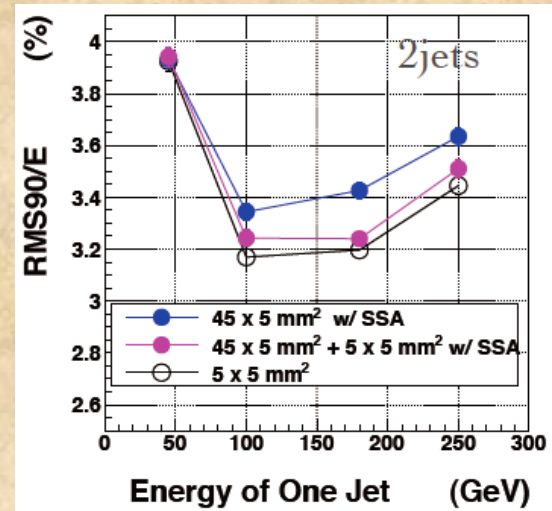
Simulation Studies

■ Strip ECAL PFA

- Strip-splitting algorithm
- Works reasonably well

■ Hybrid ECAL

- Sci and Si
- Optimization of configuration



Other ILC Detector Activities in Japan

■ Beam Profile Monitor

- 'Pair monitor' : Si pixel technology < FCAL collaboration

■ MDI/Integration

- Detector Hall Design
- Assembly Scheme
- Detector solenoid design
- MDI working group (Now in LCC)

■ Software/Computing

- In collaboration with other regions
- Software&Computing Working Group (Now in LCC)

■ Physics

- European Strategy Input
- Snowmass input
- More to come
- International collaboration

Summary

■ ILC detector efforts in Japan:

- Funding level is 'reasonable'
- fully integrated into the international efforts now headed by LCC

■ Hardware efforts:

- Focused on Vertexing (FPCCD), TPC, and Calorimeters
- TPC within LCTPC collaboration, Calorimeters in CALICE collaboration

■ Physics studies:

- Done in concert with other regions