FJPPL: HEP_02: ILC ECAL Progress and Plans

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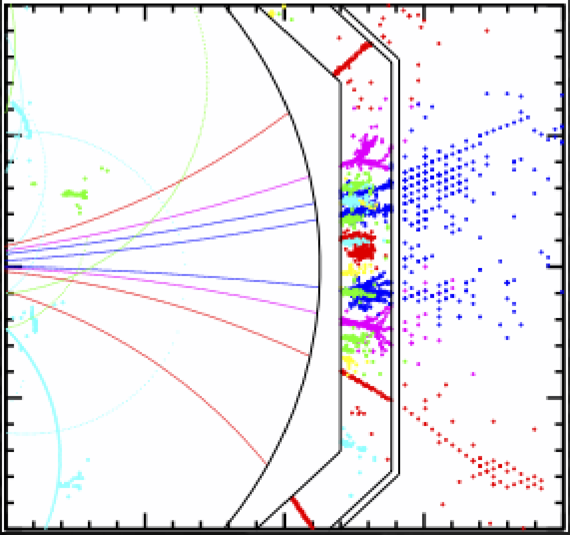
ILC and PFA detector

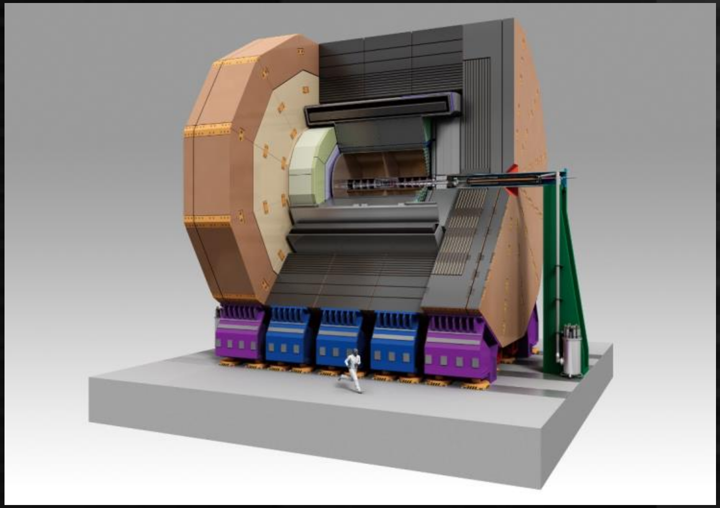
“Particle flow” is a key concept for ILC detectors

	Detector	Fraction	Resolution
Charged Particle	Tracker	~ 60%	0.1% / $p_T \sin\theta$ (GeV) for each
Photon	ECAL	~ 30%	15% / $\sqrt{E}$ (GeV)
Neutral Hadron	HCAL	~ 10%	60% / $\sqrt{E}$ (GeV)
ILC Calorimetry	All		30% / $\sqrt{E}$ (GeV)

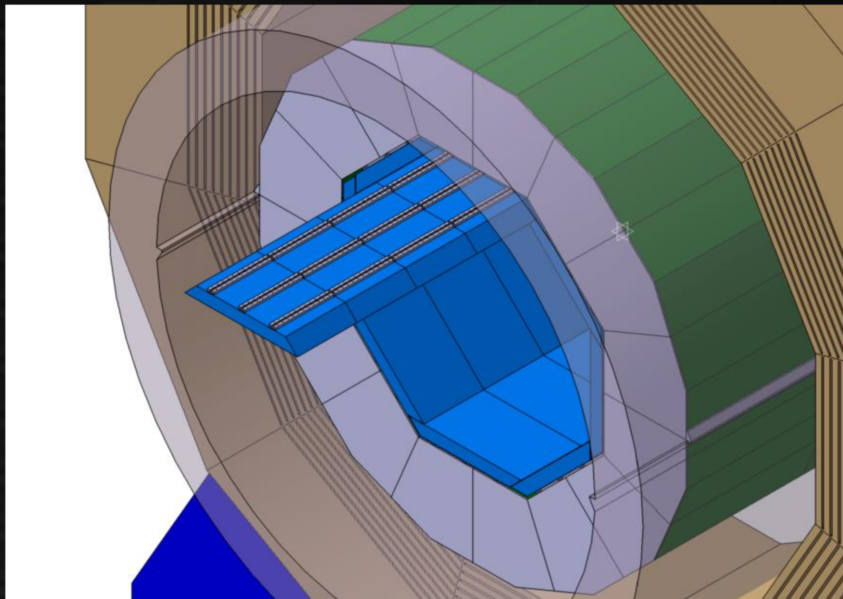


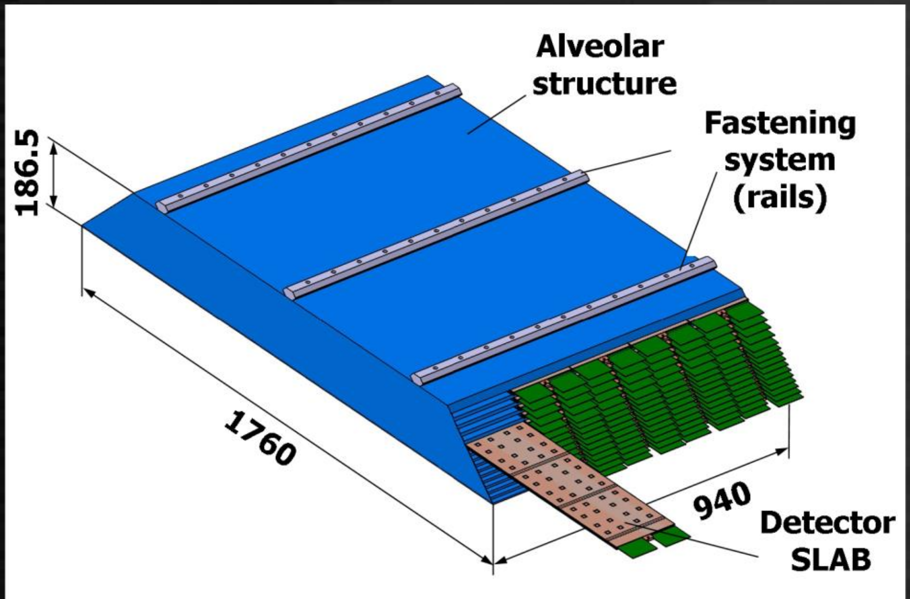
Perfect particle separation
→ ~ ½ reduction on
jet energy resolution!

High granularity esp. in ECAL
is essential for particle separation

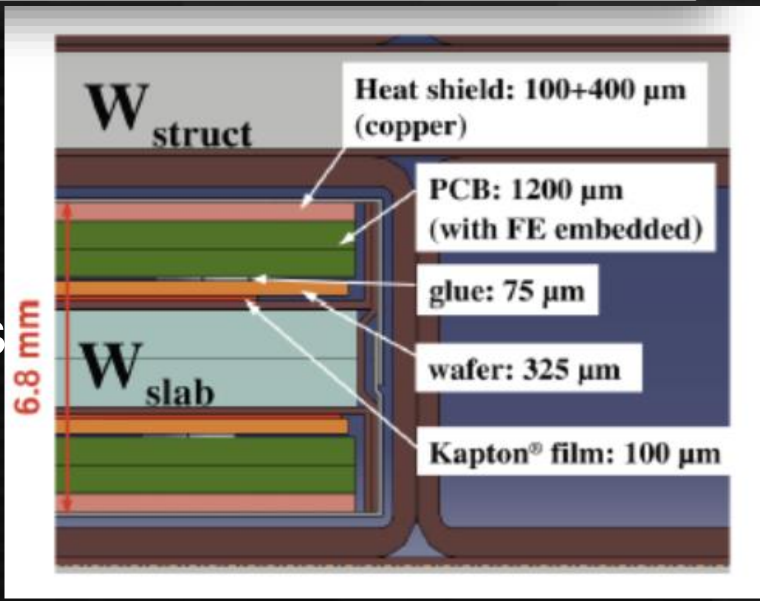


ILD ECAL: overview





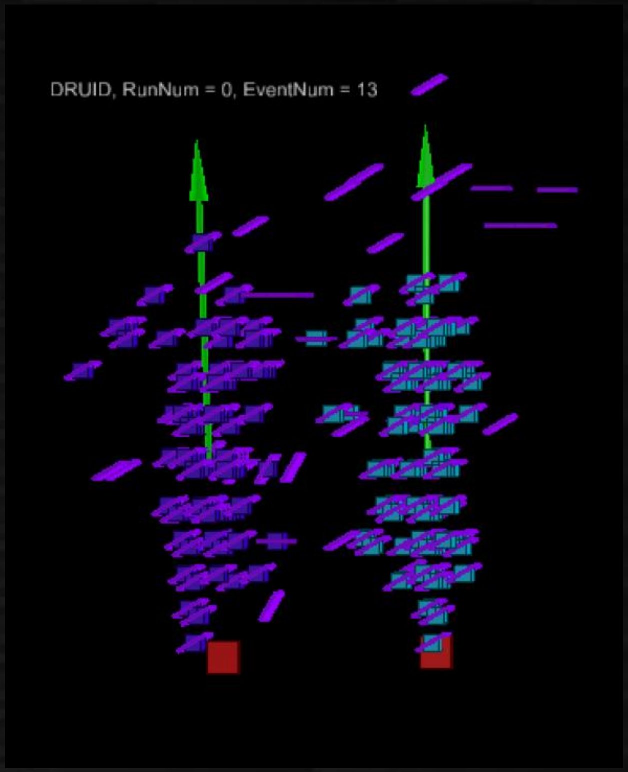
ILD: one of two ILC detector concepts
ILD ECAL: 30 layers of sandwich calorimeter with tungsten absorber and 5x5 mm - segmented silicon diodes
(Scintillator option also exists)
PCB with ASICs embedded



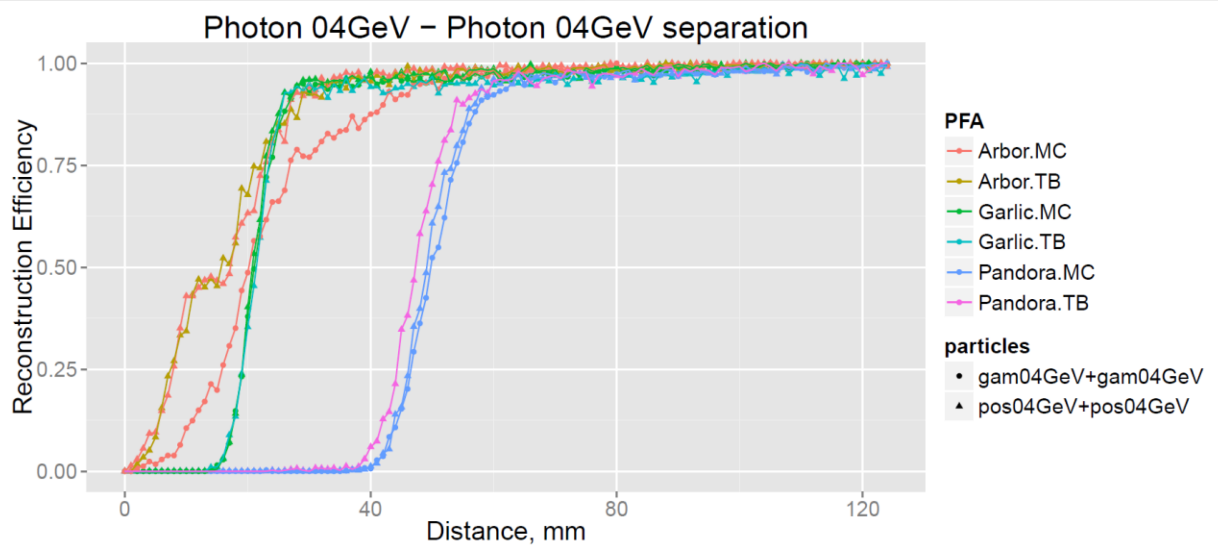
Progress in FY2015

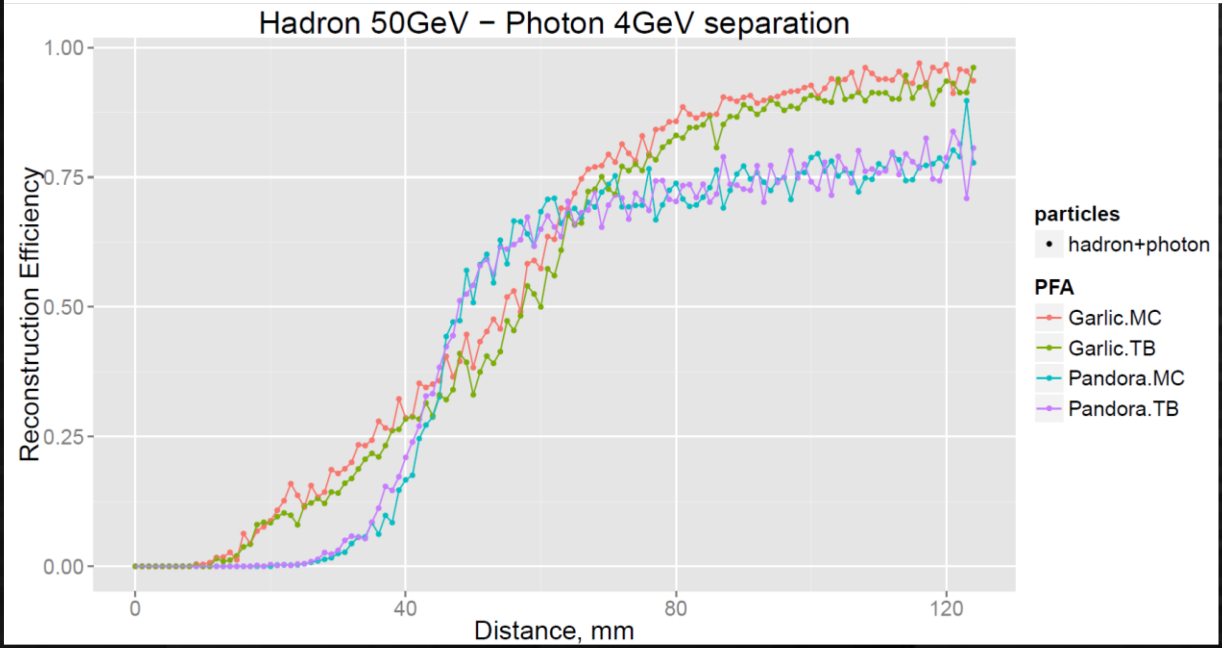
- Simulation studies of photon/tau reconstruction
- Development of technological prototype of ILD ECAL
- Irradiation tests of silicon sensors

Photon reconstruction



Two 4 GeV photon
in 6 cm offset,
GARLIC reconstruction
with 5 x 5 mm^2 SiW-ECAL





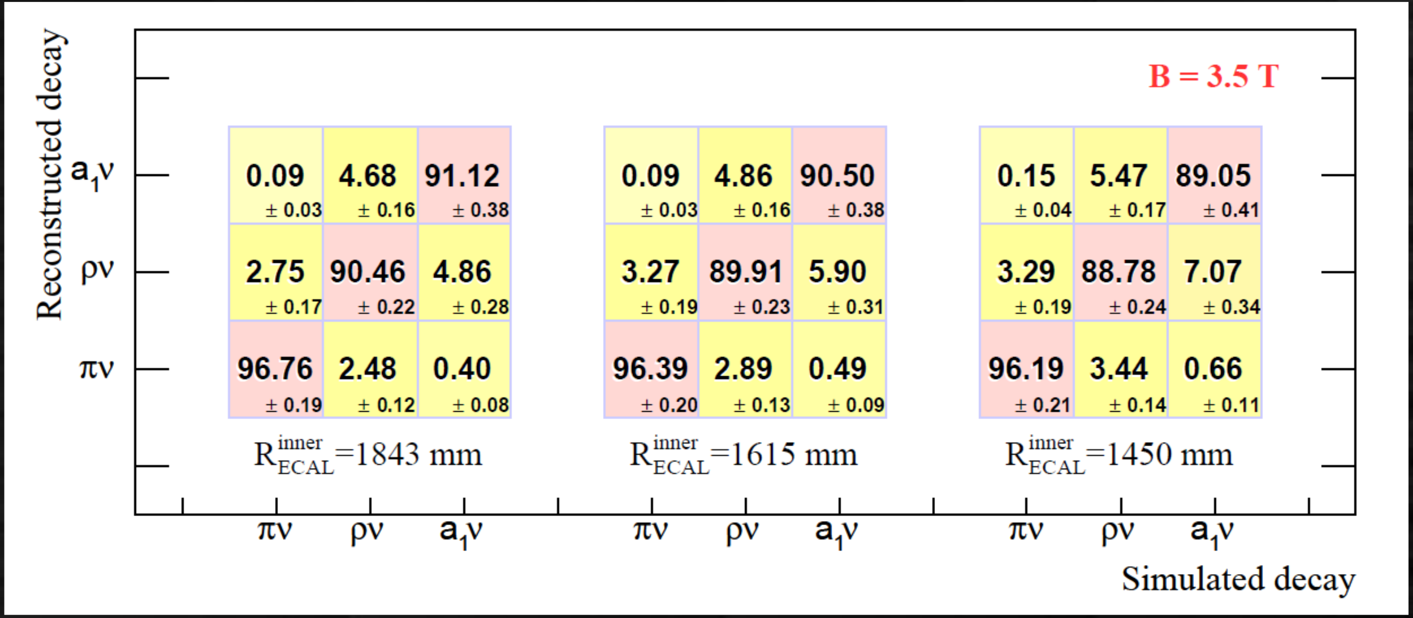
Tau decay ID & detector size

ECAL inner radius is a cost driver in ILD
Reduced radius may degrade particle separation

Decay mode	Branching fraction [%]
$\pi^+\bar{\nu}_\tau$	10.83 ± 0.06
$\rho^+\bar{\nu}_\tau$ $(\rho^+ \to \pi^+\pi^0)$	25.52 ± 0.09
$a_1^+\bar{\nu}_\tau$ $(a_1^+ \to \pi^+\pi^0\pi^0)$	9.30 ± 0.11

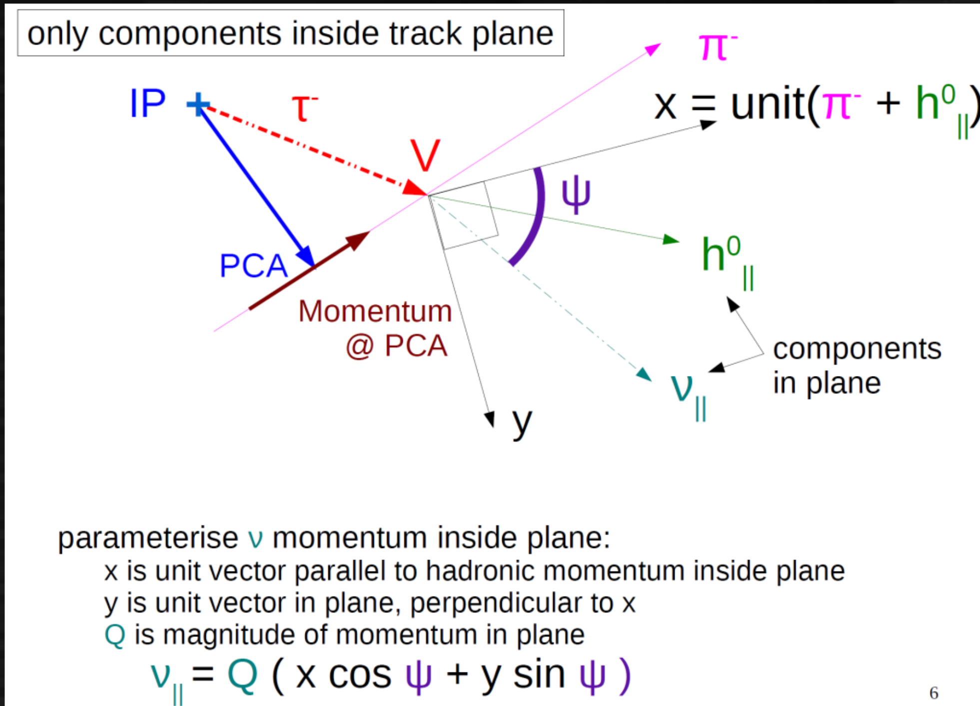
0/2/4 photons to separate

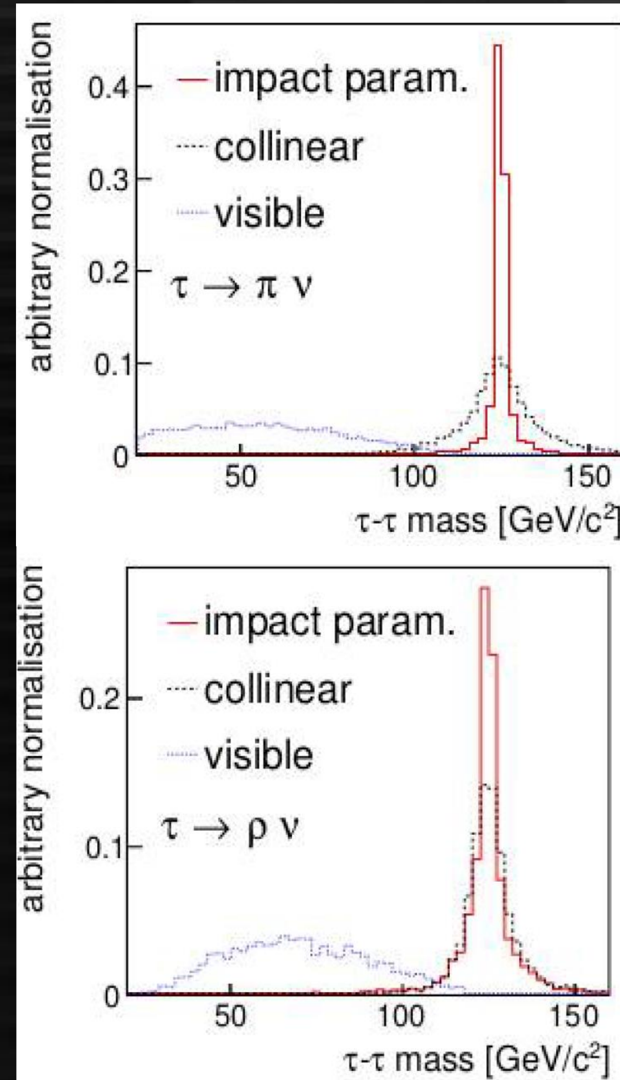
Boosted tau (125 GeV) is a good example



arXiv:1510.05224, submitted to JINST

Full kinematic tau reconstruction



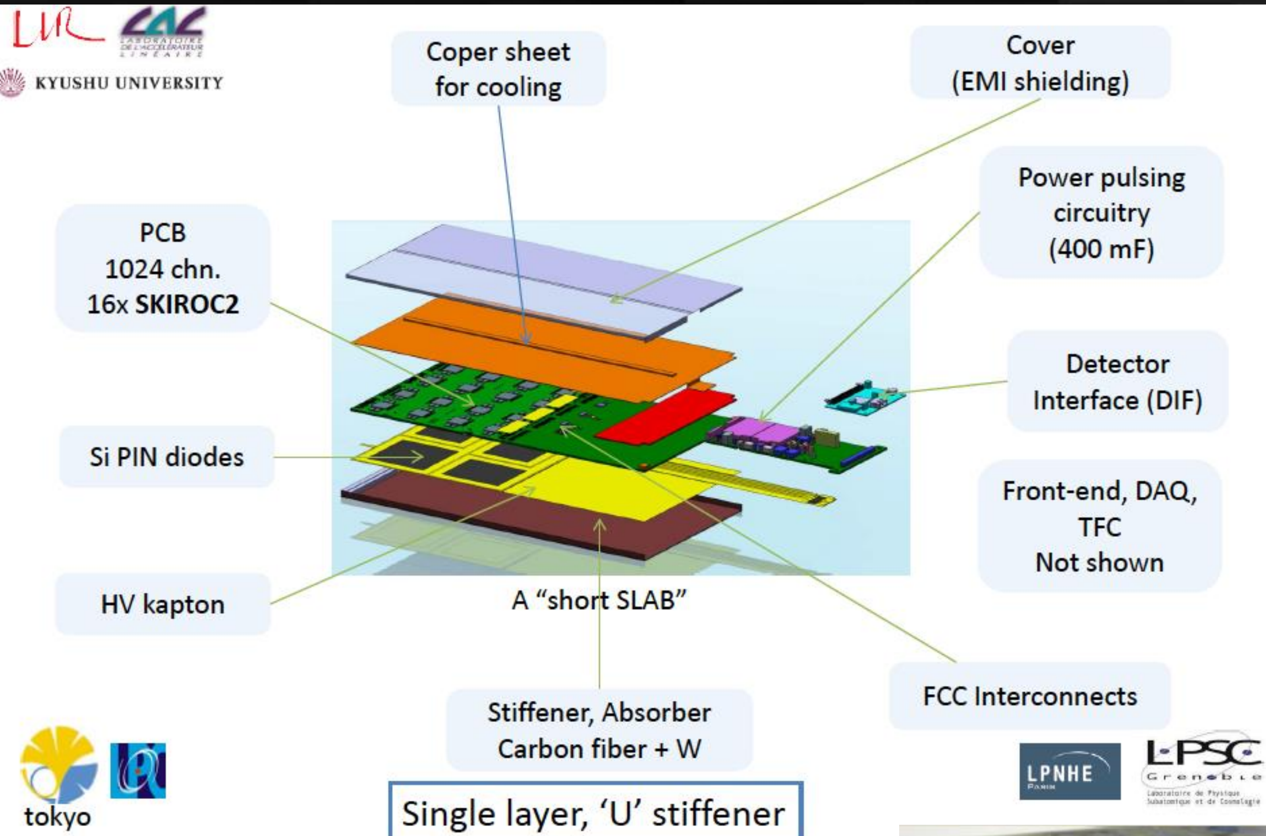


Including impact parameter and tau mass, three DoF of neutrino momentum reduced to 1

ZH→llττ: 2 DoF + 2 pT balance
→ full kinematic determination!

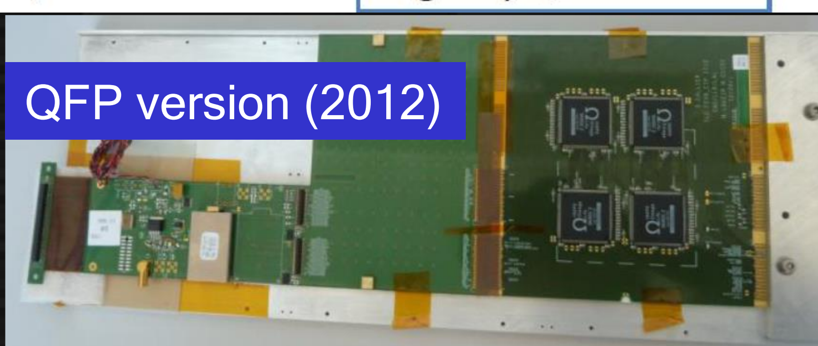
Nucl.Instrum.Meth. A810 (2016) 51-58

Technological prototype



Silicon sensors are glued to PCB
PCB has embedded ASICs (SKIROC2)

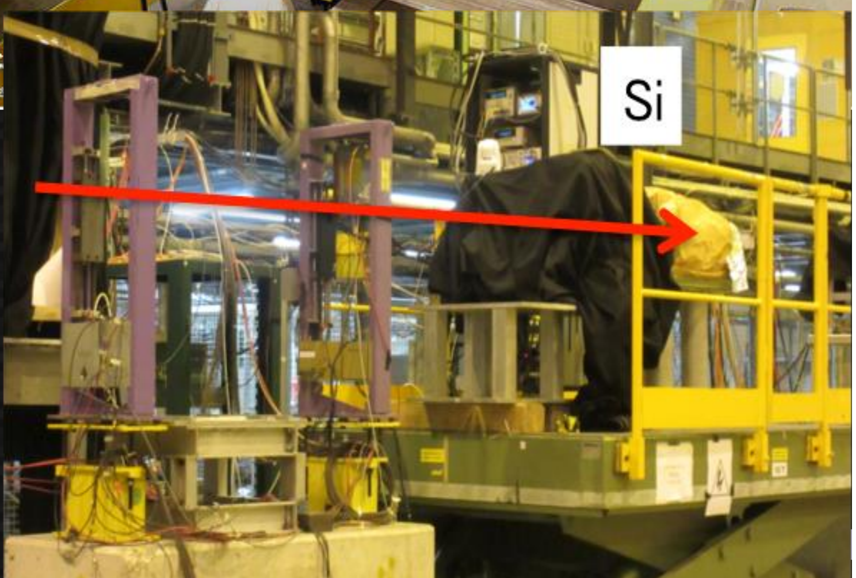
ASIC output is daisy-chained to the end part, having digital output to PC

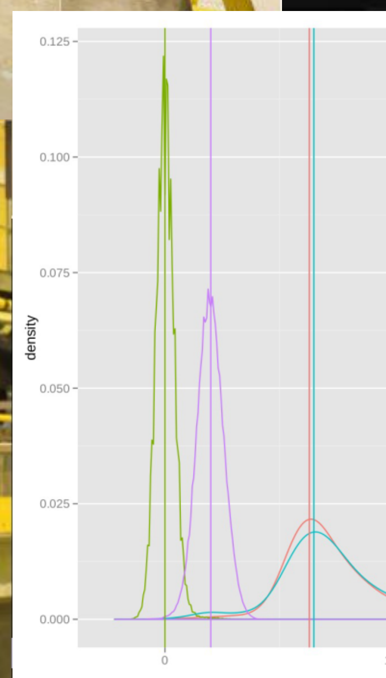


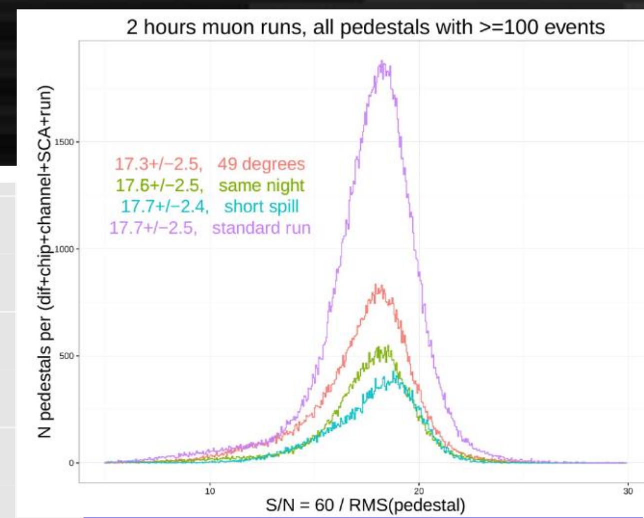
COB version also under development on FKPPL:
see talk by Prof. Jong-Seo Chai

Test beam at CERN SPS 2015

Three short slabs are successfully tested with electrons, muons, pions up to 150 GeV
Analysis ongoing



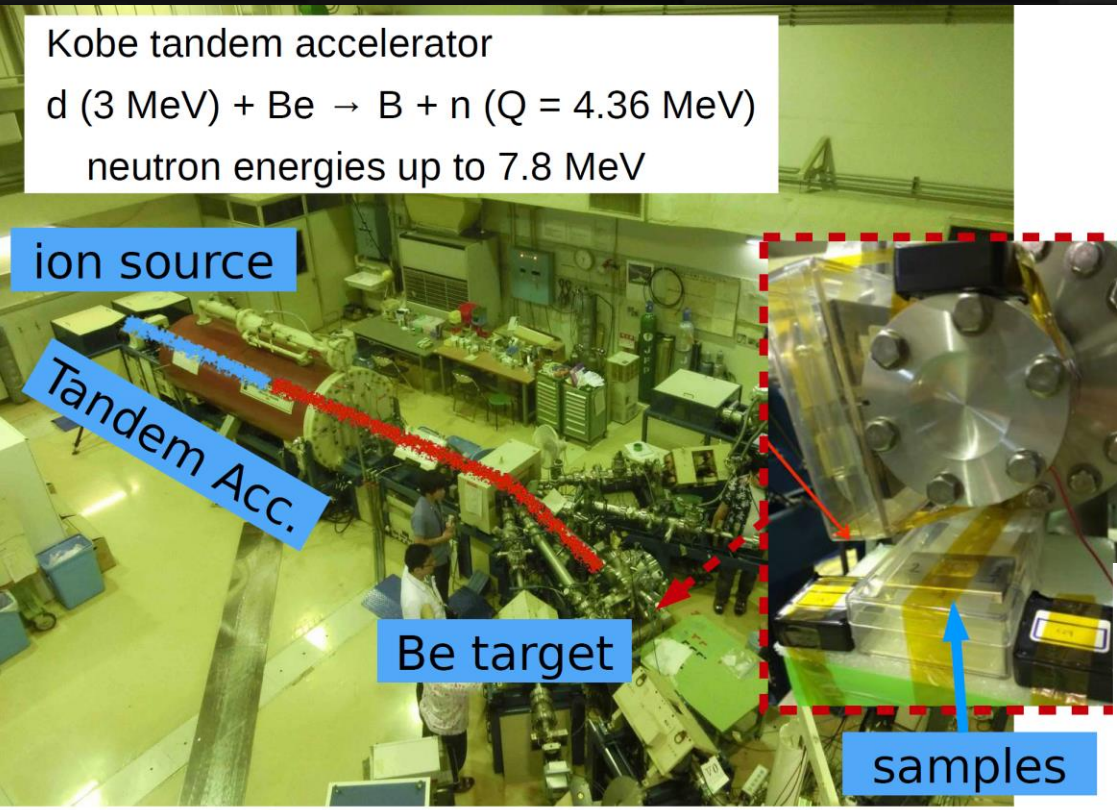


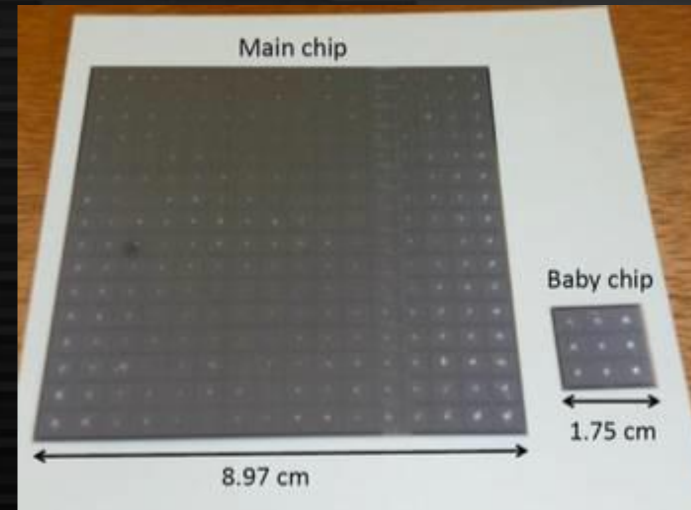


Good S/N of 17-18 seen

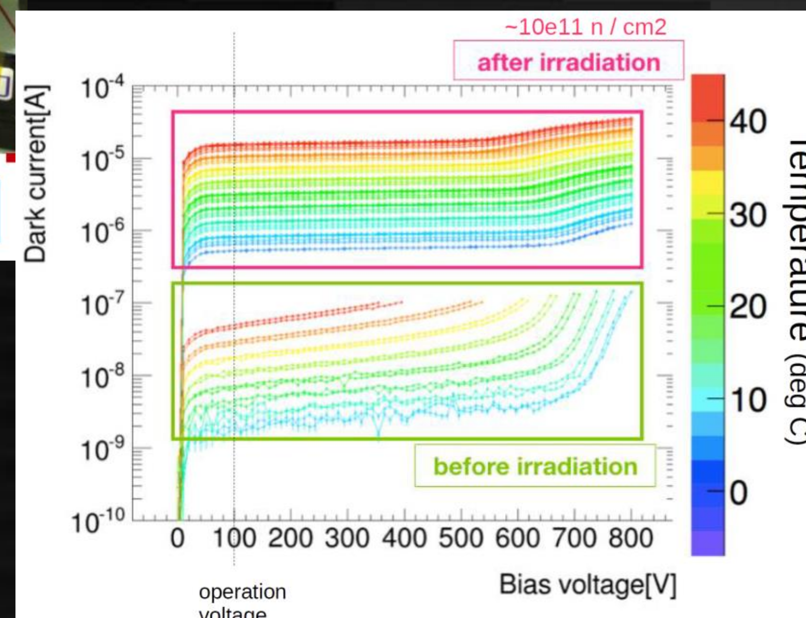
“double pedestal” observed

Neutron irradiation tests





Irradiation of neutrons on baby sensor
Increase on dark current is acceptable considering ILC-1 TeV 10 year radiation dose estimation



Plans in FY2016

- Expanding collaboration

FY2015	FY2016
LLR	LLR LPNHE LAL
Tokyo Univ.	Tokyo Univ. Kyushu Univ.

Badget request: 2.5 kEUR (FR) + 1.36 MY (JP)

Plans in FY2016

- Technological Prototype Development
- Analysis of the 2015/16 TB data (continue)
- Test of new SKIROC2 chips
- Comparison of S/N ratio on various configuration with SKIROC2
- Measurement of Position Sensitive Detector
- Gamma irradiation
- MC study on photon/π_0/τ algorithms and Higgs CP measurement

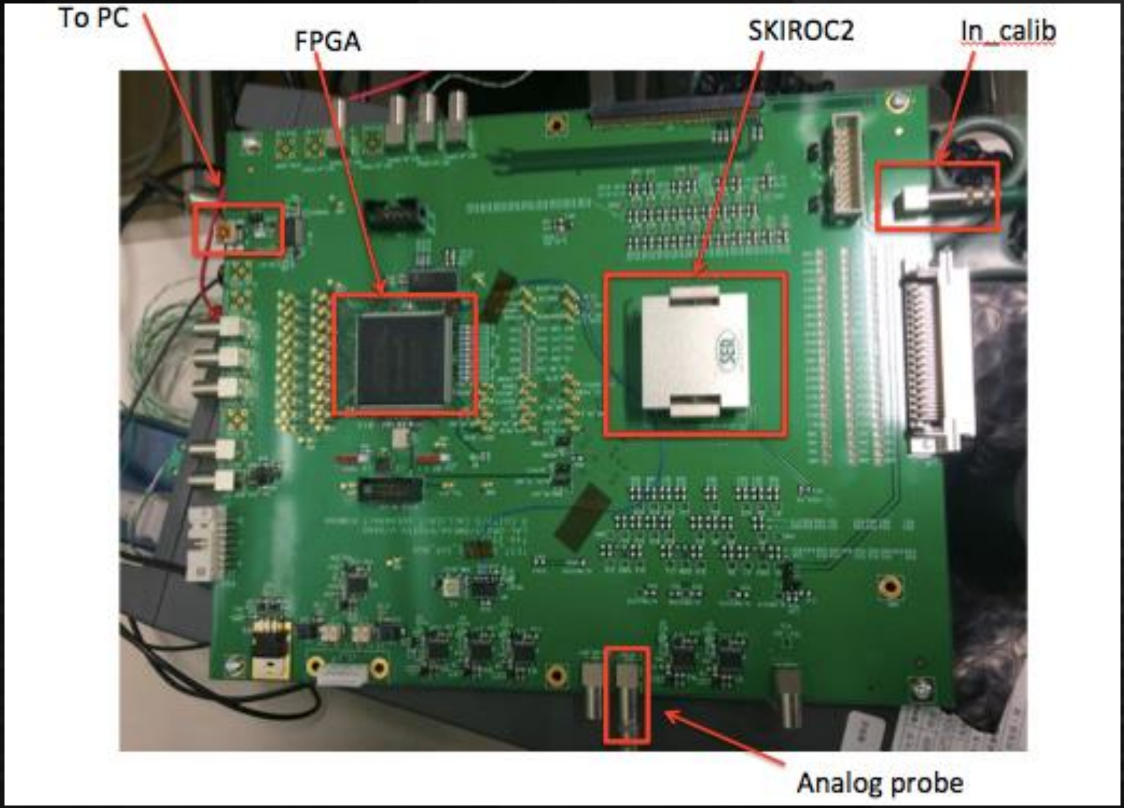
Technological Prototype: 2016 plan

- Test beam SiW-ECAL + SDHCAL (Jun. 7-21, CERN SPS)
  - Fully equipped layers (with interconnection and shielding)
  - More Si layers (7?)
  - Silicon sensor without guard rings (to avoid square events)
  - new mechanical ECAL structure
  - Common test beam with SDHCAL (with synchronization)

Participation: LLR, LAL, Kyushu, Tokyo

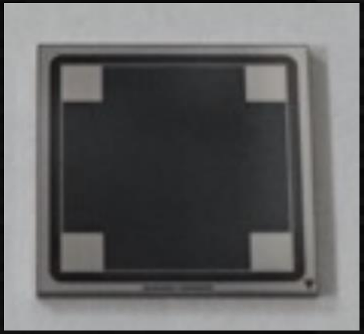
SKIROC2 studies

- SKIROC2A (with various bugfixes) will be arrived in summer
- Properties have to be checked with evaluation board in Kyushu
- S/N ratio should be compared: new/old SKIROC2, BGA/QFP package, PCB version…



Sensor studies

- PSD (Position Sensitive Detector)
  - Multi-pad cell with charge sharing to obtain center-of-gravity position
  - Common technique in laser optics
  - Good S/N ratio of electronics needed
  - Two samples arrived: performance to be checked (linearity, reproducibility, etc.)
- Irradiation
  - Gamma irradiation on sensor/electronics



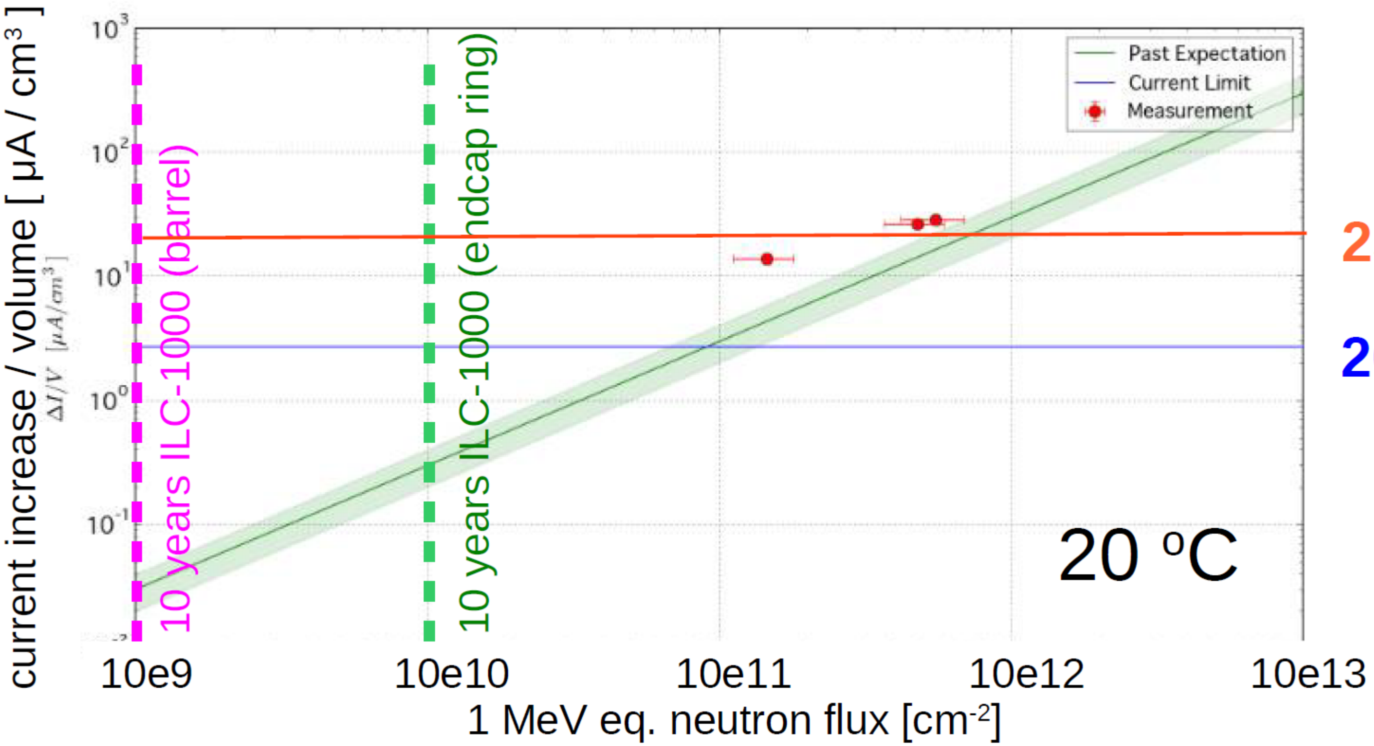
Monte-Carlo study

- Full kinematic reconstruction of $\tau \rightarrow \rho\nu/a_1\nu$ with reconstructed π^0 information
- Tau decay mode separation (cont.)
- Higgs CP analysis and performance dependence on detector resolution
  - With full kinematic information
- Photon separation study and improvement

Summary

- 2015 Achievements are on:
  - Tau/photon reconstruction
  - Development of technological prototype and test beam
  - Neutron irradiation
- 2016 Plans with expanded team are on:
  - Finalize tech. prototype production and test
  - SKIROC2 study (current and new)
  - Sensor study (PSD, gamma irradiation)
  - Tau/photon study including Higgs CP

Neutron damage & ILC



25 μW / pixel @ 100V

20 nA / pixel

@ 500 μm thickness

Probably OK