ILD concept group
Status and Plans

Masakazu Kurata
KEK
On behalf of the ILD concept group

ALCW2018, 05/28/2018-06/01/2018

Outline

- About ILD concept group
- Topics of the ILD concept group status
  - New detector model and Large Monte Carlo production
  - Detector R&Ds
  - ILD Integration
  - Preparation of ILD document
- Summary and outlook

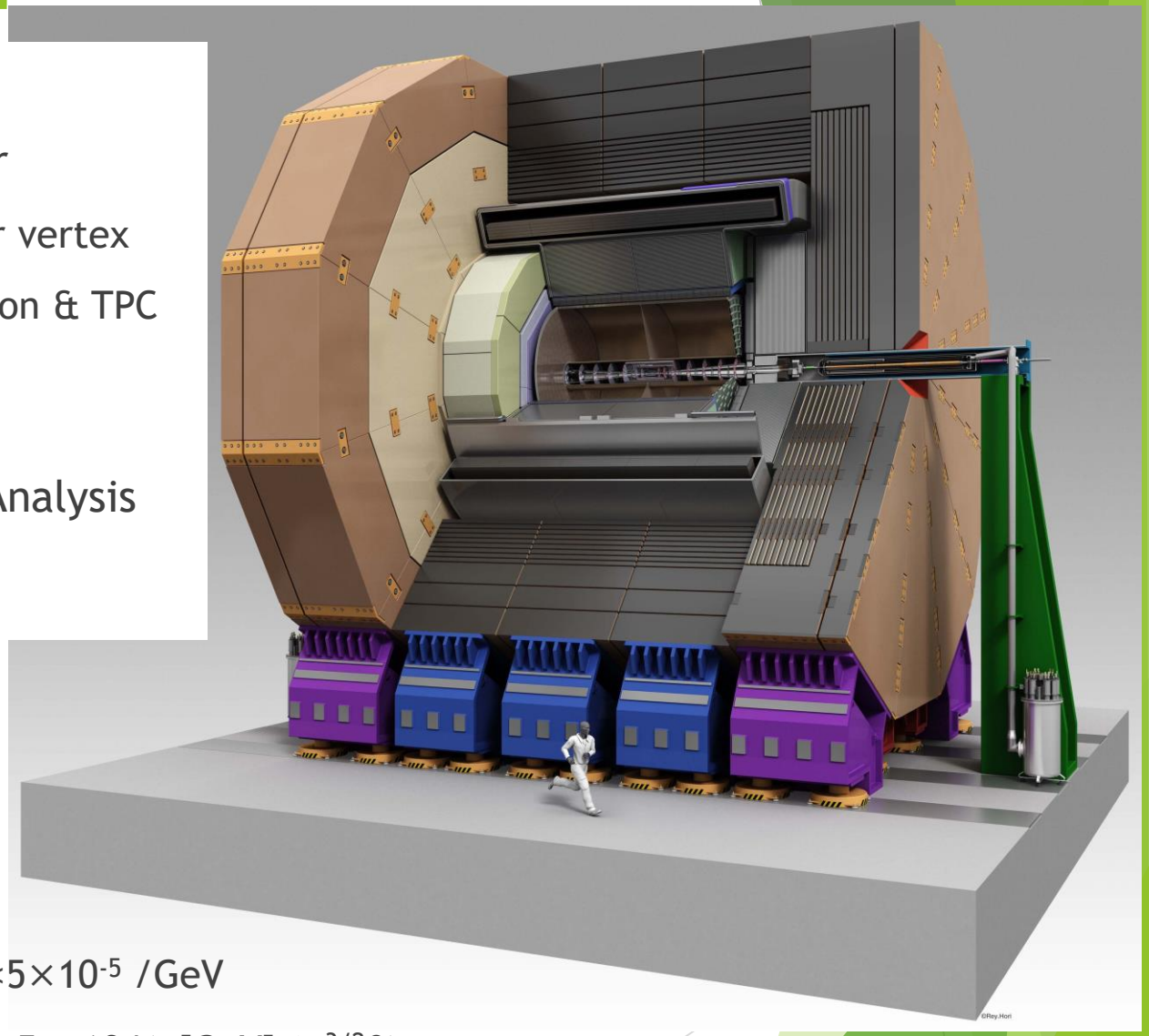
ILD Detector

ILD detector

Large multi-purpose detector

- High precision silicon for vertex
- Hybrid tracker with Silicon & TPC for robustness
- Granular calorimeters

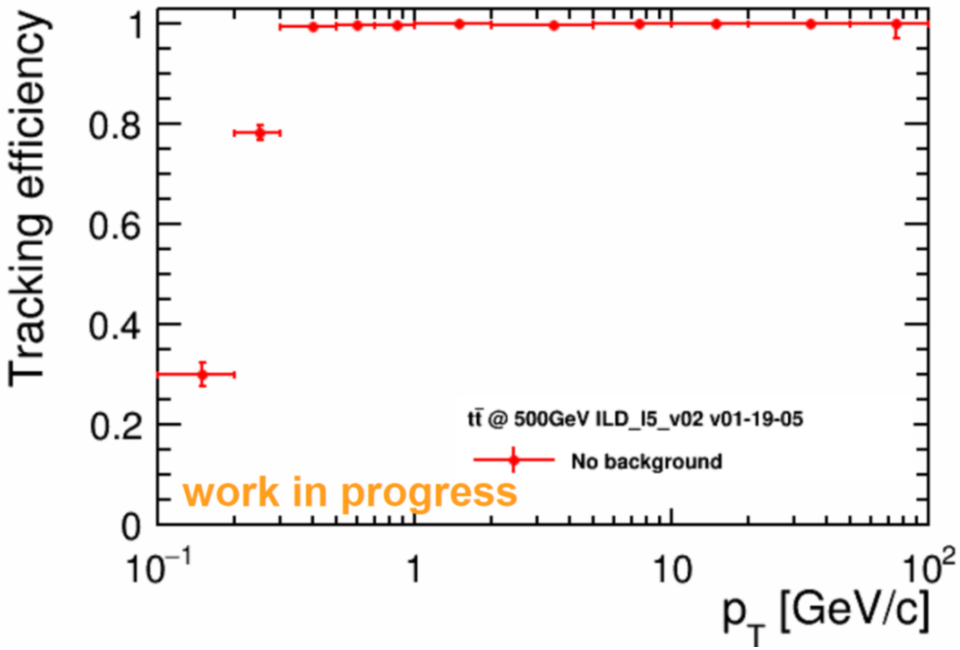
Optimized for Particle Flow Analysis



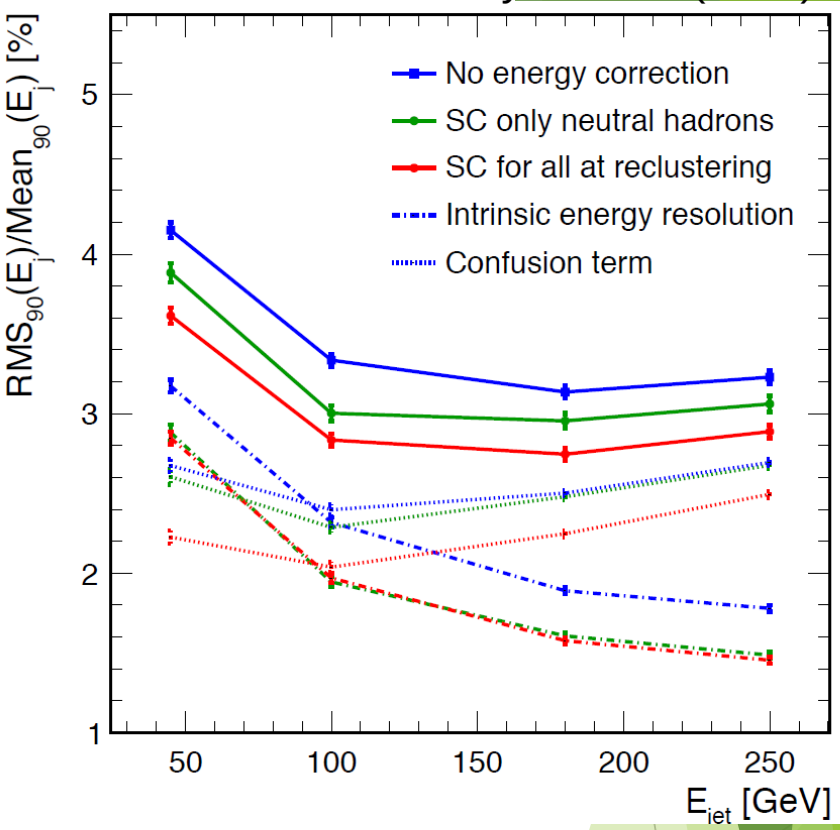
- Detector requirements
  - Track momentum: $\sigma_{1/p} < 5\times10^{-5}$ /GeV
  - Impact parameter: $\sigma_{d0} < 5 \oplus 10/(p[\mathrm{GeV}]\sin^{3/2}\theta)$ μm
  - Jet Energy Resolution: $\Delta E/E$ = 3-4%
  - Hermeticity: θ_{min} = 5mrad

Basic performance

S. Lu



Eur.Phys.J. C77 (2017) 698

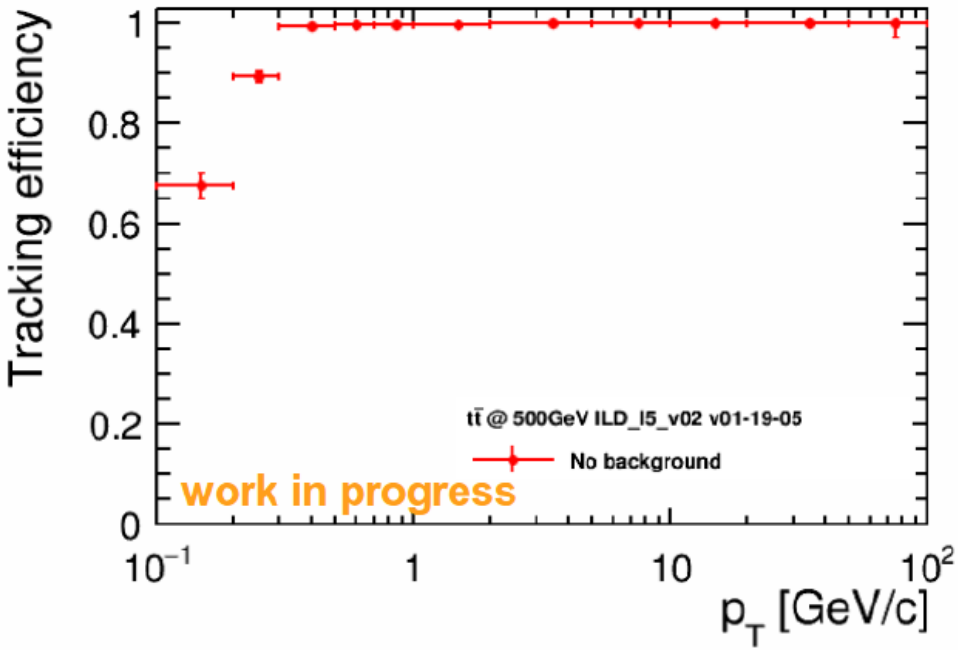


- Tracking: Excellent tracking efficiency:
  - For very low momentum tracks
  - Conformal tracking makes the tracking efficiency achievable
- Calorimetry: Good energy resolution for single particle
  - Software compensation provides better resolution for energy reconstruction

Basic performance

ConformalTracking

S. Lu



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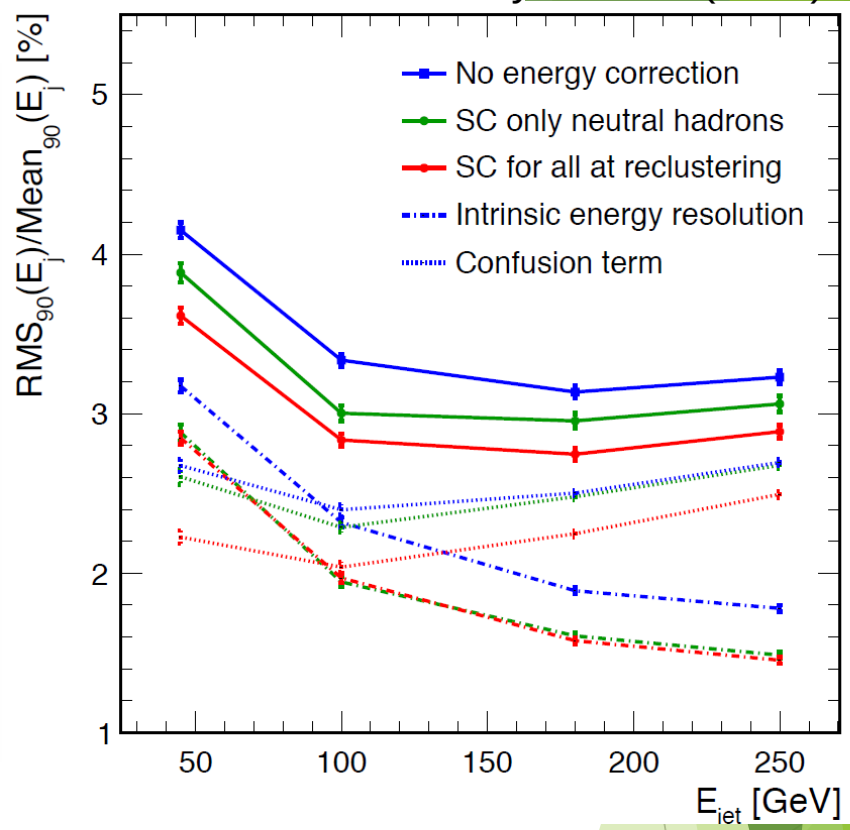

- Tracking: Excellent tracking efficiency:
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  - Conformal tracking makes the tracking efficiency achievable
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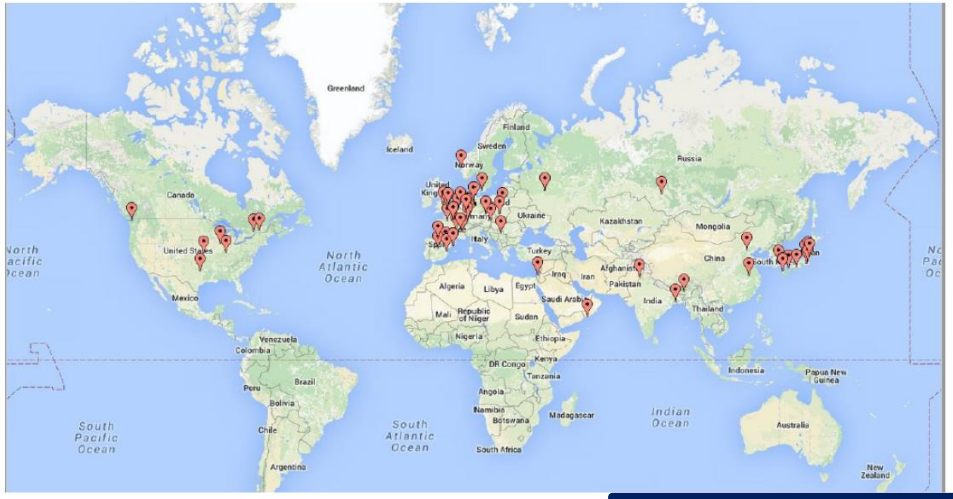
ILD organization

- 68 institutes sign up



ILD Meeting at Ichinoseki, 2018

Exective Team

Spokesperson: T. Behnke
Deputy: K. Kawagoe

Institute Assembly

Chair: M. Winter

Publication and Speakers Bureau
K. Kawagoe

Technical Coordinator
C. Vallee
(K. Buesser)

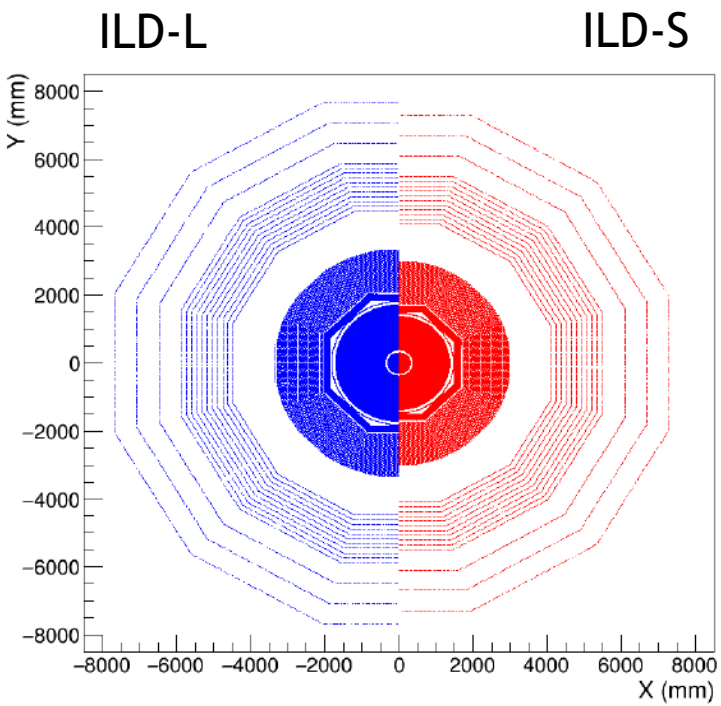
Software/Reco. Coordinator
F. Gaede
(A. Miyamoto)

Physics Coordinator
K. Fujii
(J. List)

4 members elected by IA
H.Videau
A Ruiz
Y. Sugimoto
G.Wilson

Optimization with 2 detector models

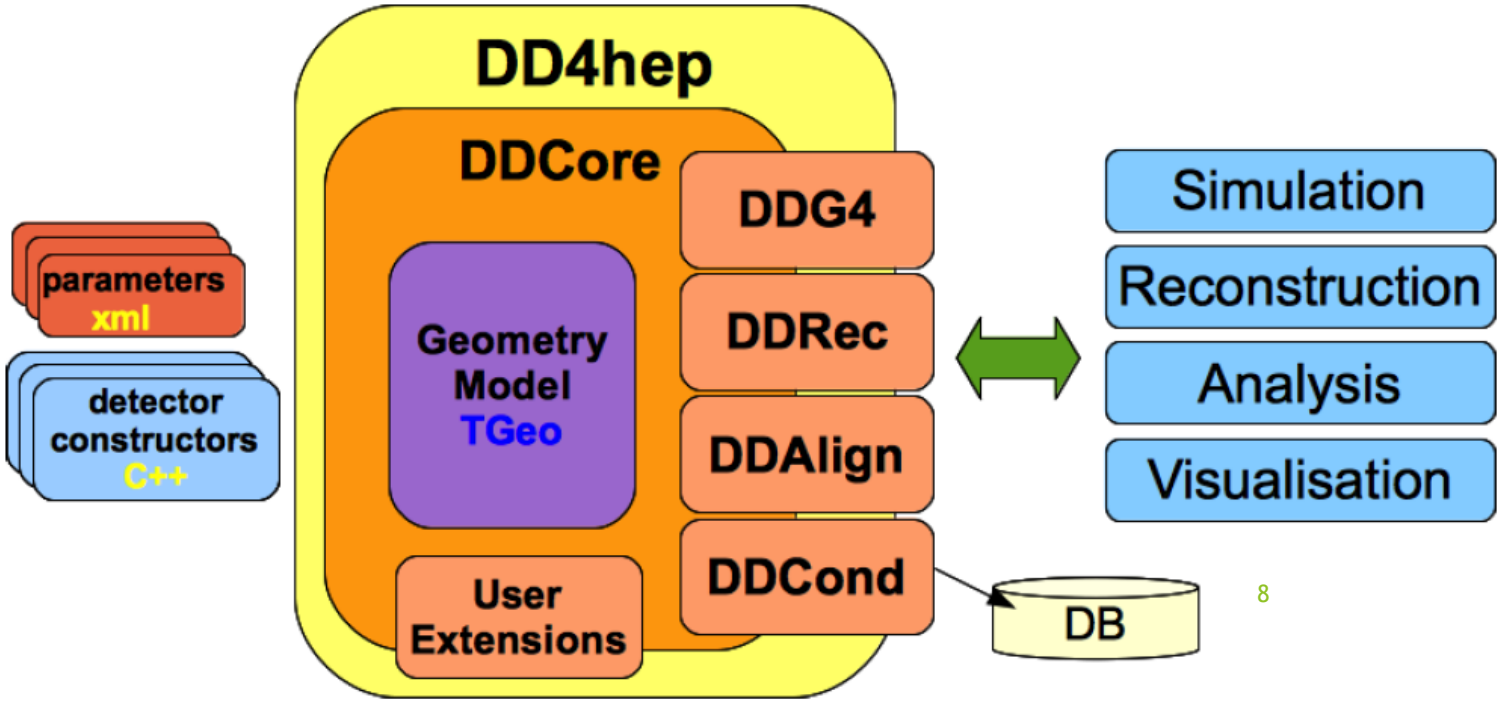
- Re-optimize ILD detector
  - Revisit optimization of cost and detector performance
    - overall cost profile (the smaller the better, but need to quantify the sacrifice)
    - relative cost weight with respect to other components yet to be defined (e.g. anti-DID)
  - We plan 2 detector models
- Need to compare any physics performance between these 2



Detector models	ILD-L	ILD-S
B-field	3.5T	4T
VTX inner radius	1.6cm	1.6cm
TPC inner radius	33cm	33cm
TPC outer radius	180cm	146cm
TPC length (z/2)	235cm	235cm
Inner ECAL radius	184cm	150cm
Outer ECAL radius	202.5cm	168.5cm
Inner HCAL radius	206cm	172cm
Outer HCAL radius	335cm	301cm
Coil inner radius	344cm	310cm

Software

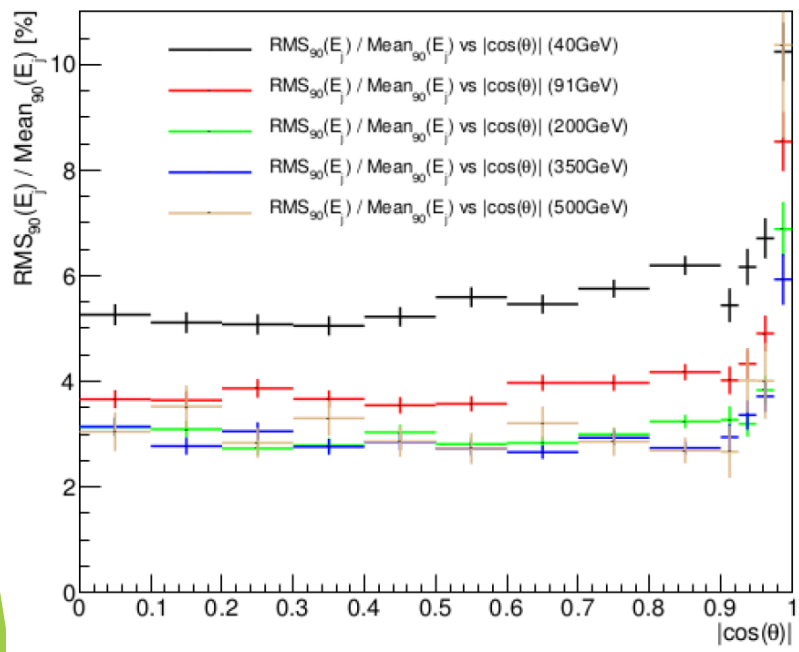
- Have implemented large and small ILD simulation models in DD4hep (lcgeo/DDsim)
- Start a large Monte Carlo sample production for new models:
  - Complete SM model samples@500GeV with Stdhep-files used in DBD era
  - After that, 250GeV samples with Whizard 2 will be started
  - Of course, physics benchmark samples we are interested(e.g. Higgs, Top, New particles) are also produced



For large production in new detector models

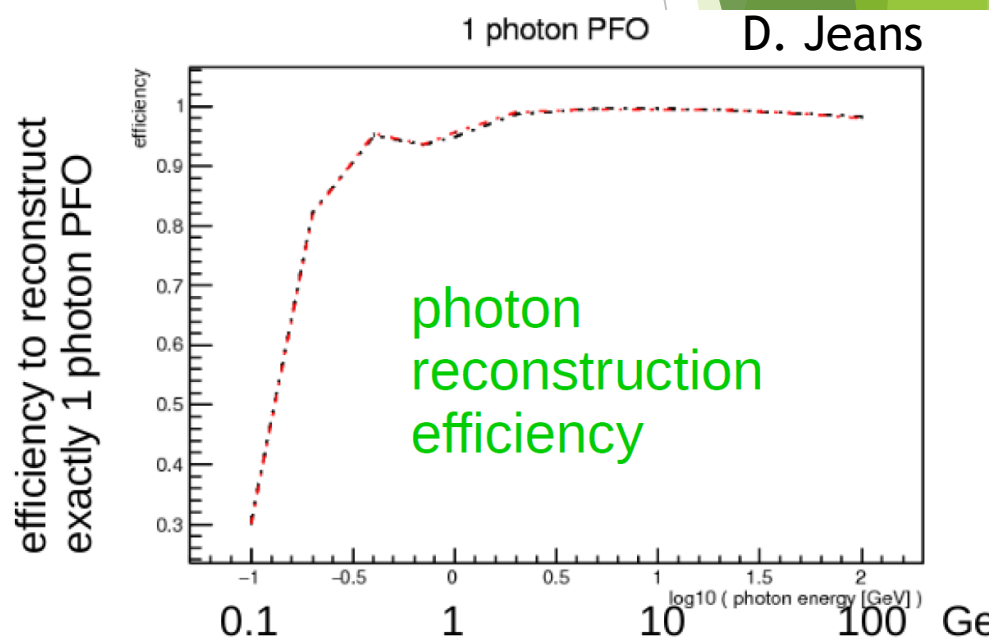
- For large Monte Carlo production, some detector performance were tested
  - Performance with single particles
  - Performance with jets
  - Vertex finding performance
  - Consistency check with DBD samples, comparison between models

Jet Energy Resolution, Bo. Li



ILD_l5_o1_v02

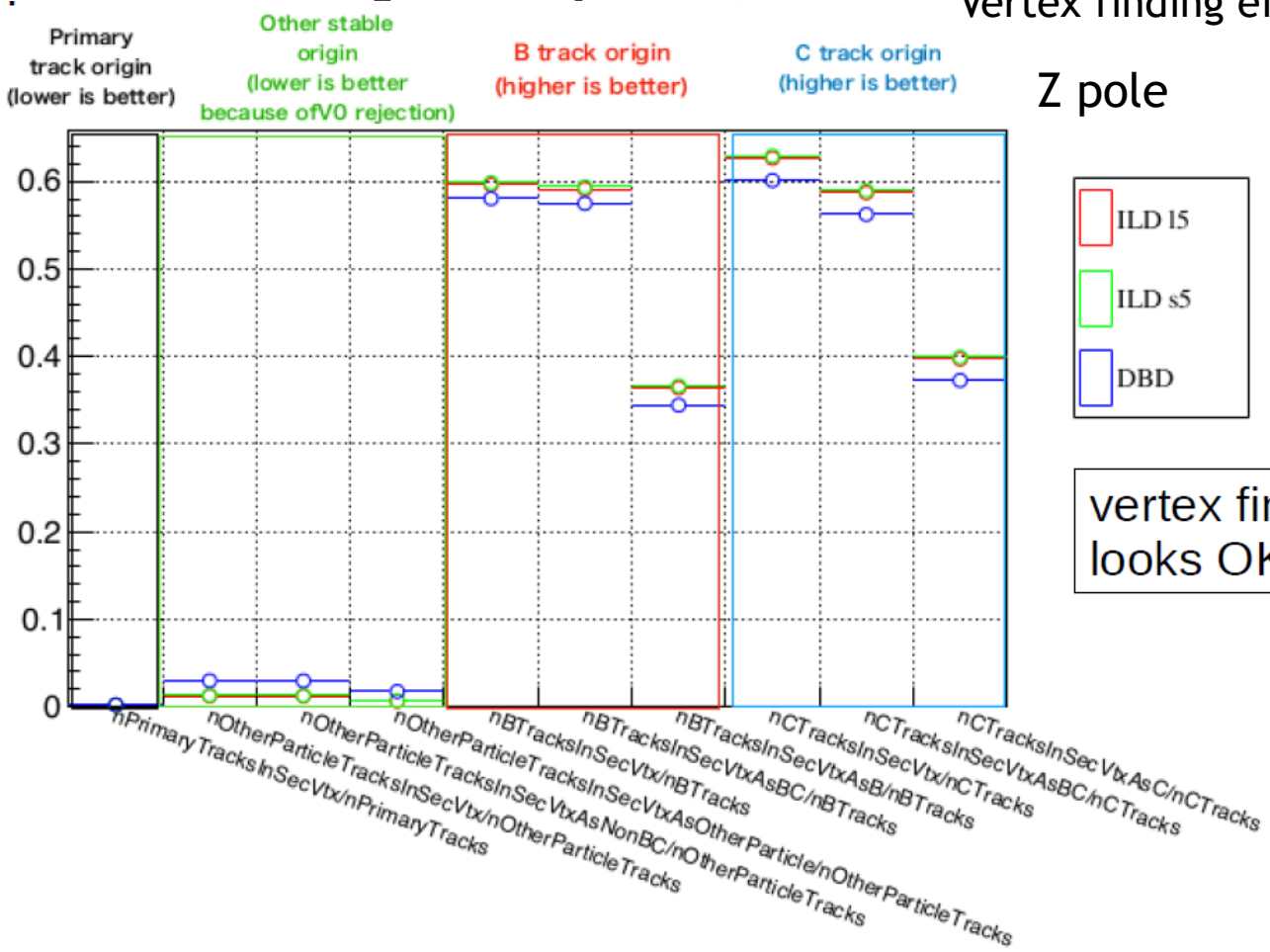
D. Jeans



For large production in new detector models

- Vertex finding efficiency
  - Evaluated with num. of tracks from secondary/ tertiary vertices attached correctly
  - Expected better finding efficiency from DBD

Vertex finding eff., R. Yonamine



Z pole

ILD l5

ILD s5

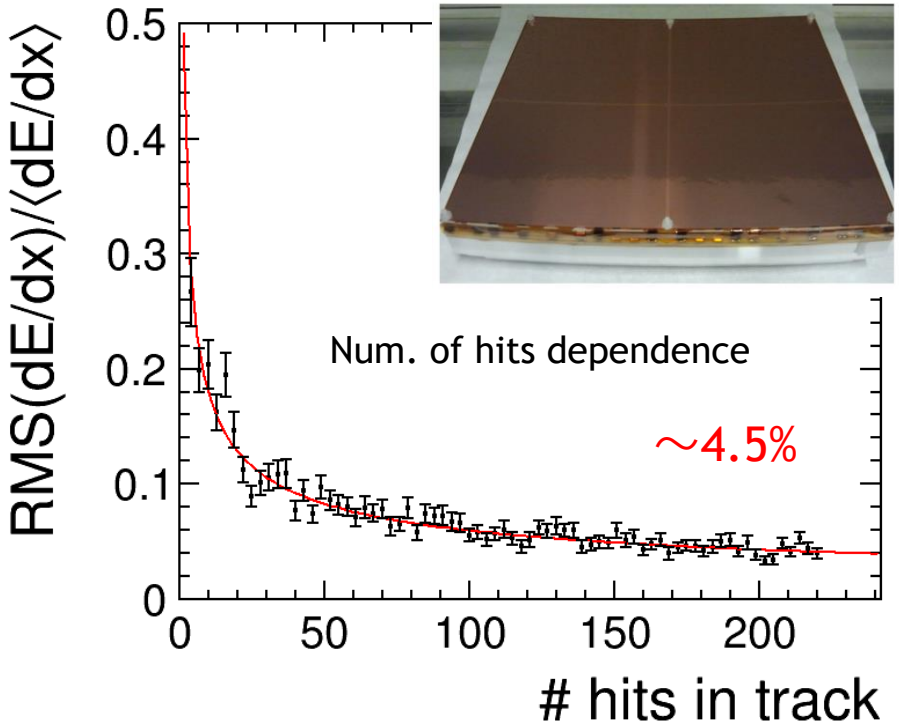
DBD

vertex finding looks OK

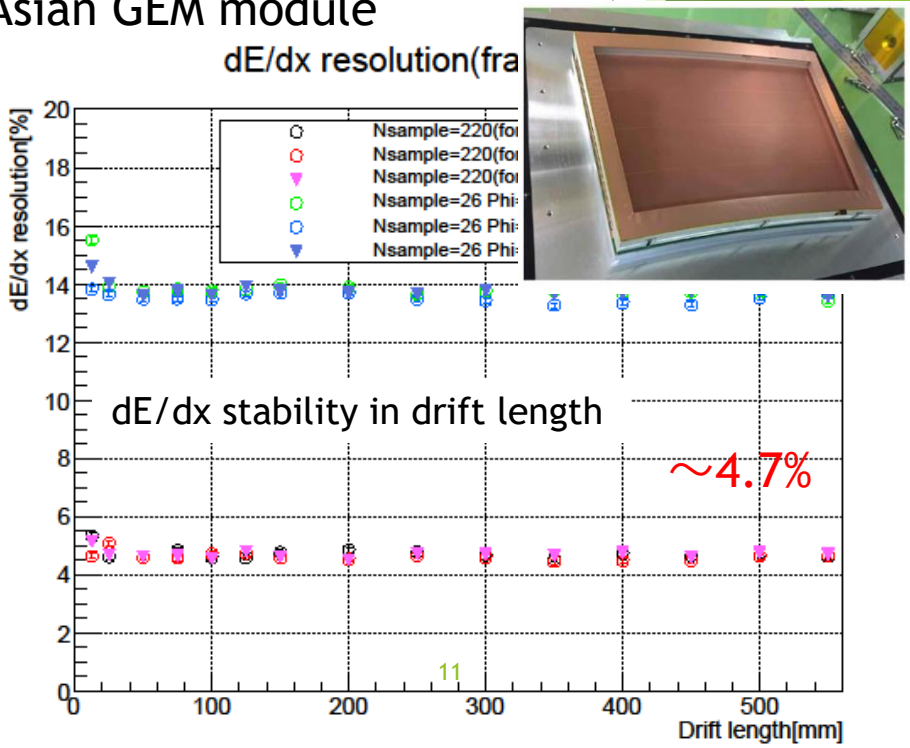
dE/dx

- LCTPC groups studied dE/dx resolution with each technology using their testbeam data
  - DESY: end of 2016 testbeam data
  - Asian GEM: 2016 testbeam data, 5GeV/c electron
  - Better than 5% resolution will be feasible in large detector model

DESY triple GEM module



Asian GEM module

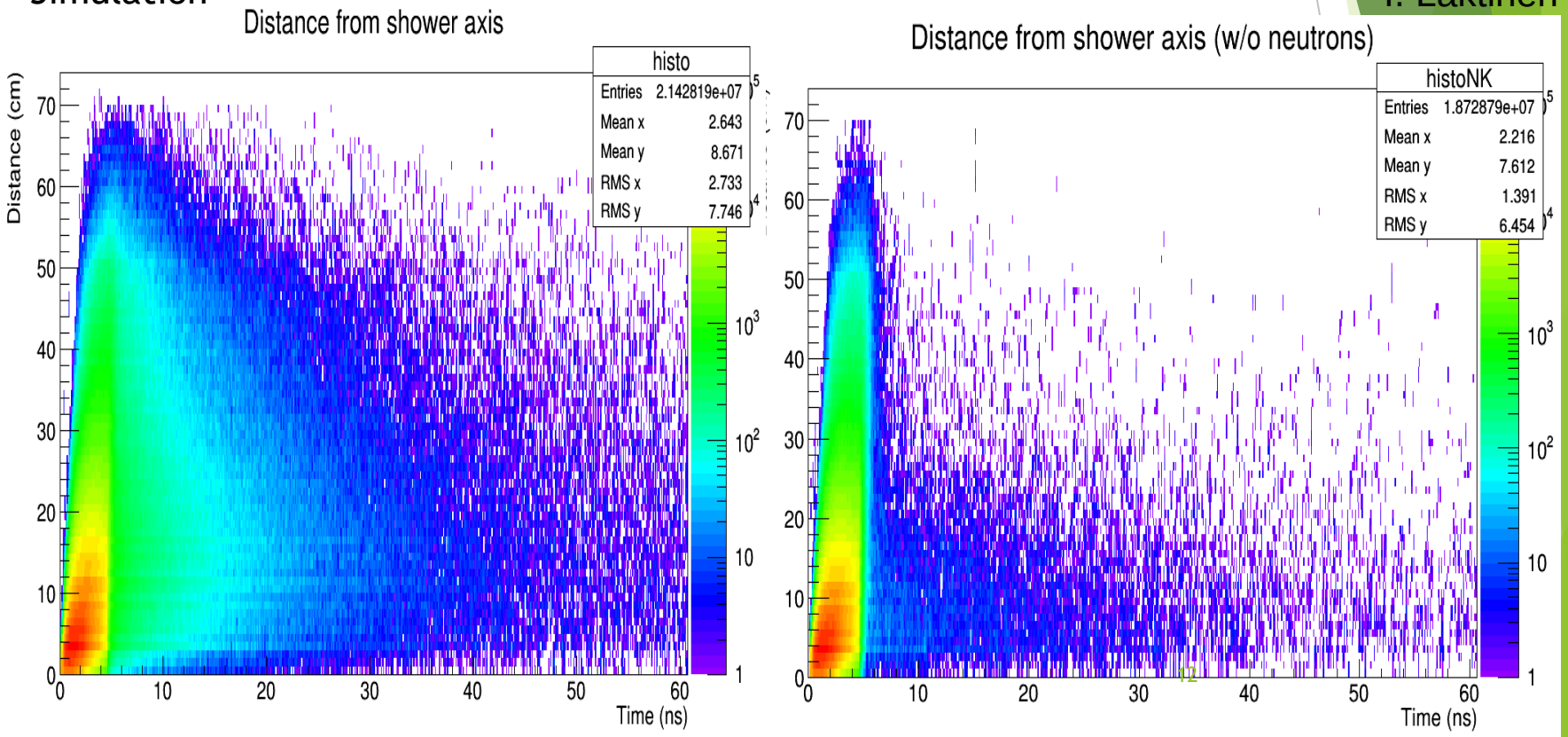


Trend: use timing information

- Example: SDHcal study
  - Timing could be an important factor:
    - To identify delayed neutrons and **better reconstruct their energy**
    - To **separate showers** and reduce confusion
    - ***O*(10ns) timing resolution necessary**

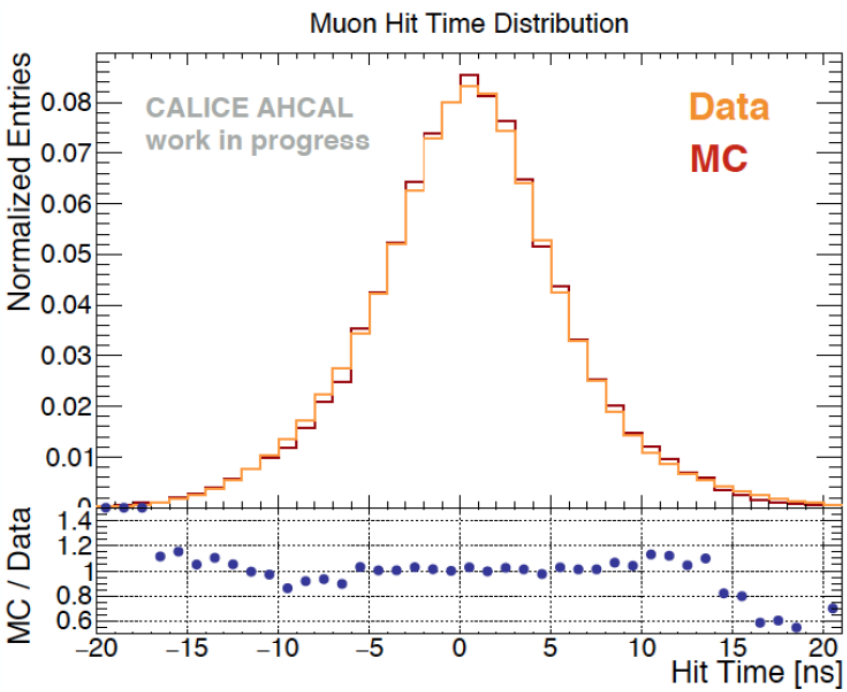
Simulation

I. Laktineh

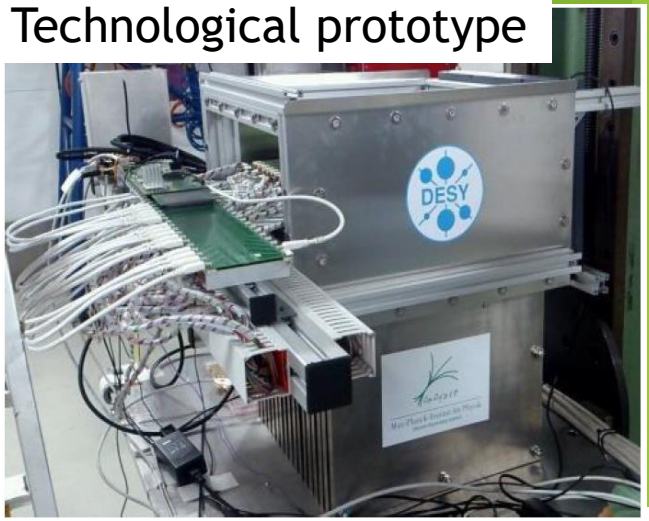


Several studies for timing information

- Most possible technologies: for Calorimeters
- AHCAL study
  - Technological prototype: ~5-10ns resolution is demonstrated
    - Already interesting for study of hadron showers
  - Improved time resolution will be possible in large prototype
    - Testbeam ongoing



Technological prototype



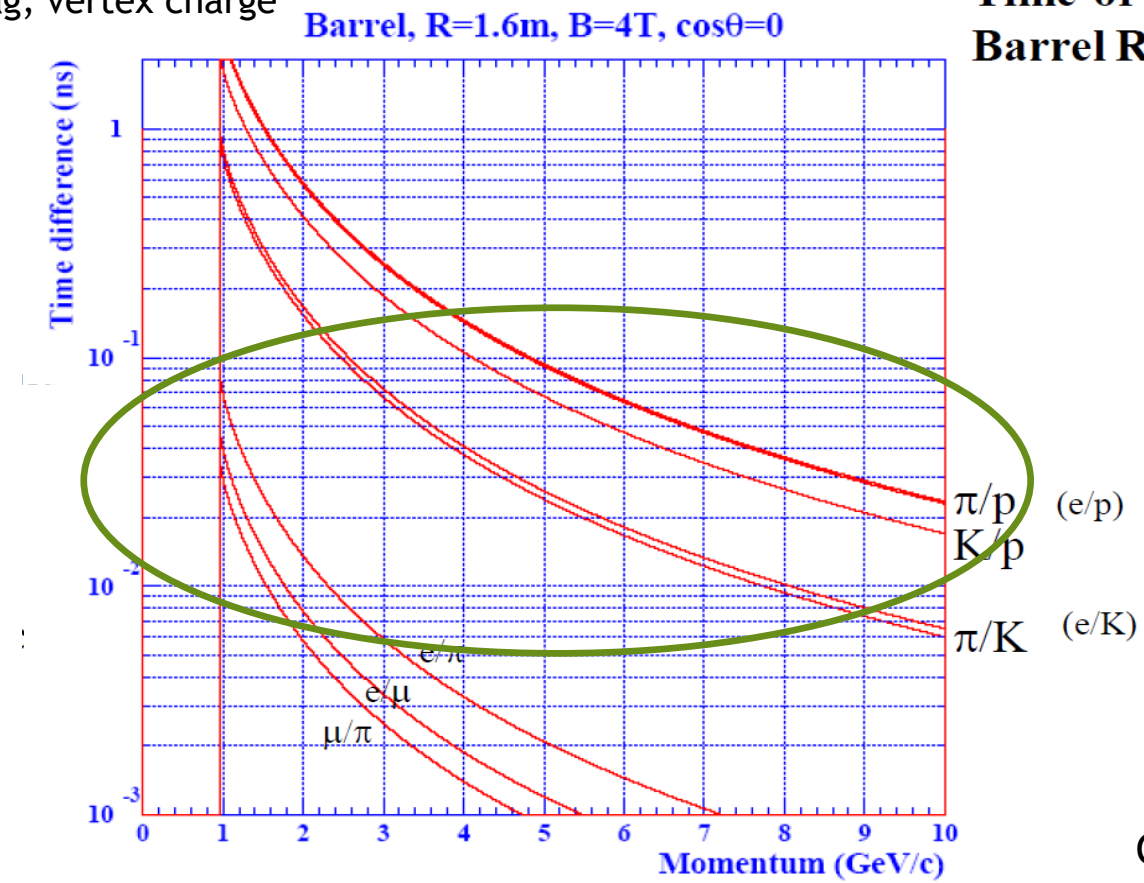
AHcal large prototype

Trend: use timing information

- Physics: improvement of PID
  - Particle ID with dE/dx & TOF
  - Will be able to improve to identify particle type @ low momentum range
    - *O*(10ps-100ps) resolution is very interesting for PID
    - Useful for: direct apply to physics analysis

flavor tag, vertex charge

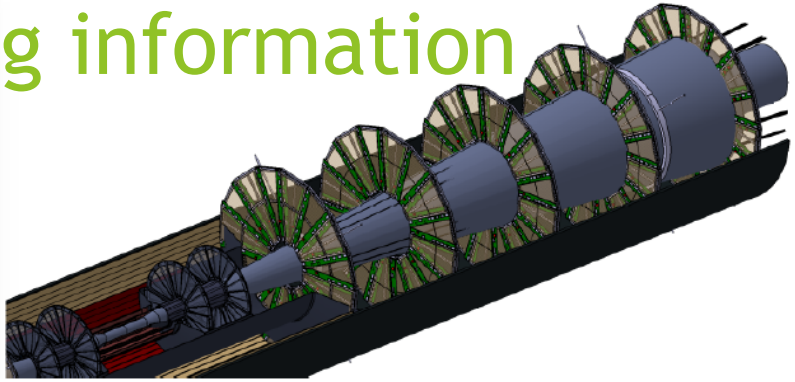
Time-of-Flight in Barrel Region

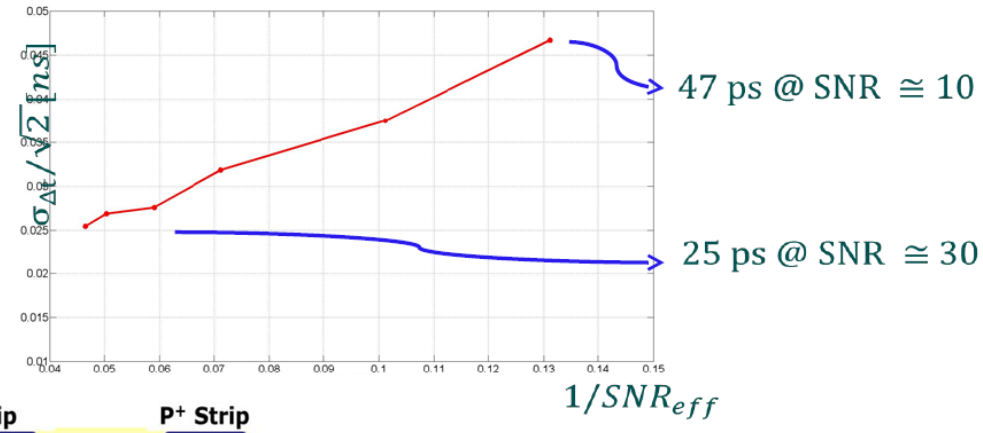


G.Wilson

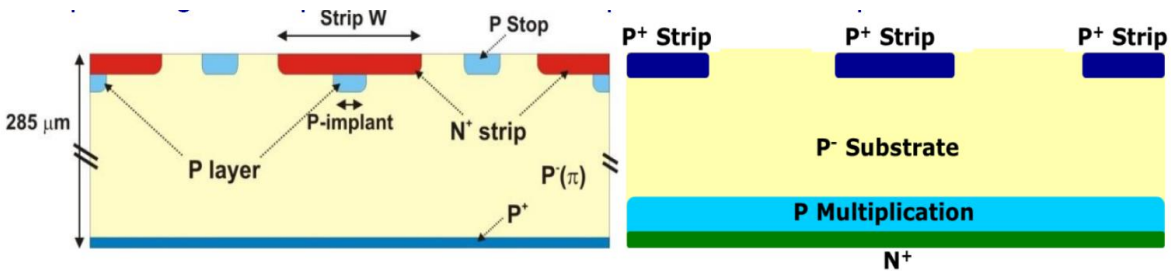
Several studies for timing information

- FTD study
- Technology for ultra-fast position sensitive silicon detector
  - LGAD technology will be able to meet the condition
  - iLGAD can achieve S/N∼40
  - ∼20ps resolution can be possible at censor level
    - How about system level?

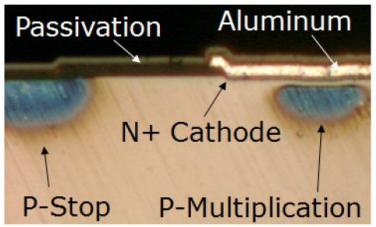


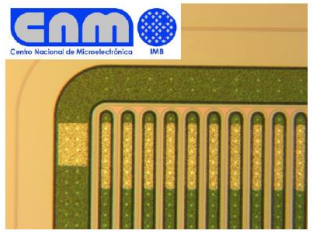


$$\sigma_{\Delta t}{}^2 = \sigma_{t1}{}^2 + \sigma_{t2}{}^2 \Rightarrow \sigma_{\Delta t} \propto \frac{1}{SNR_{eff}}$$



LGAD | N on P microStrip | P on P microStrip | iLGAD

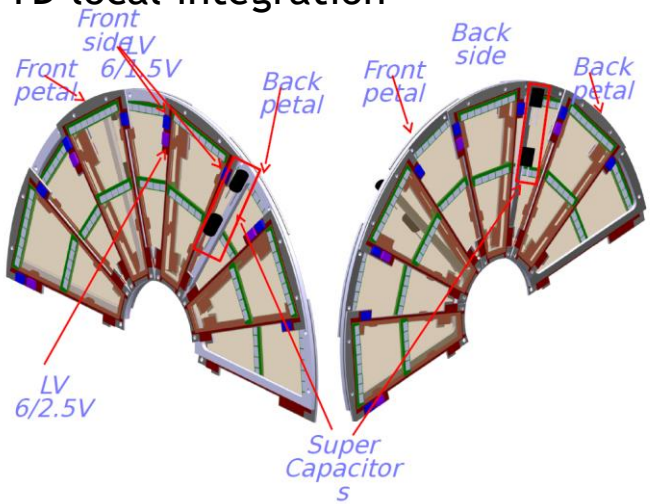




Other Detector R&Ds

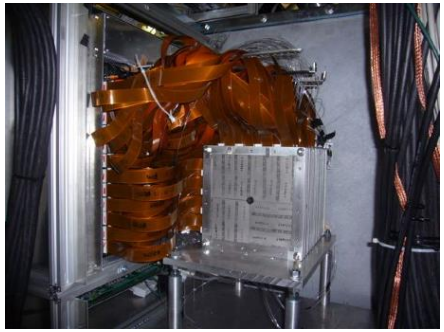
- Many subdetector R&Ds are ongoing
  - Technologies of each subdetector are actively being developed
  - Many technical prototypes are constructed
  - Electronics considered
  - Support structures
- Beamtests using prototypes were held
- All the subdetector groups start to consider ILD integration
  - Interface Control Documents
  - Input of Integration Task Force

FTD local integration



SiW Ecal Technogical prototype

ScECal Modules

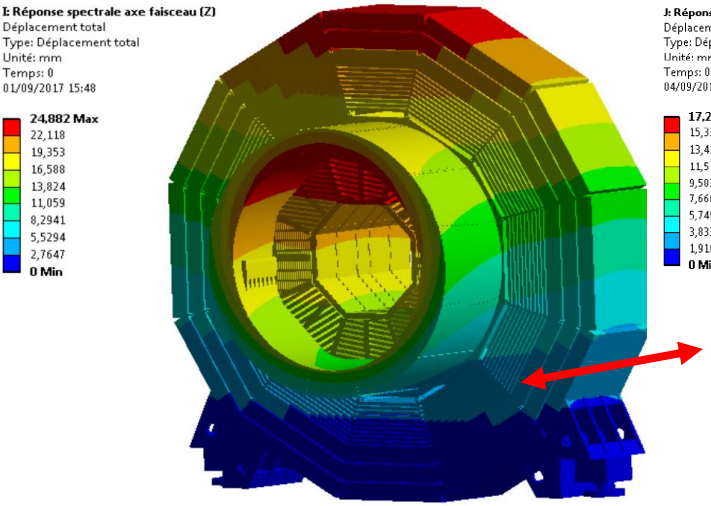


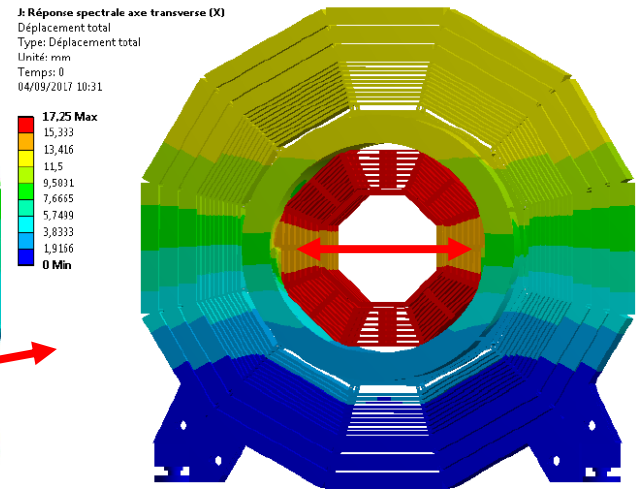
LumiCal Beamtest Modules

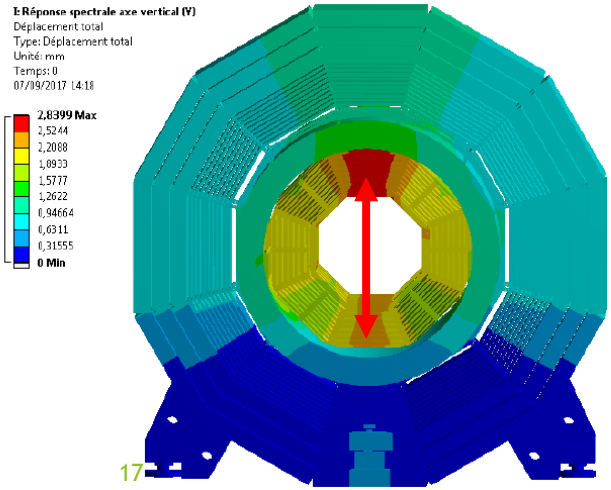
SDHCal Electronic Module

ILD Integration

- Integration Task Force is established
  - Kick-off meeting on Feb. 2nd @ LAL
  - Topics discussed:
    - Subdetector Integration and Documents
    - Services and cables
    - CAD model organization
    - Utilities in Kitakami site
- Study the effect of earthquakes
  - Started to look into impact of seismic events on ILD subdetectors(e.g. ECAL simulation study using eigenmodes)







ILD document

- Document ILD in a comprehensive way
  - Describe the ILD philosophy
  - Describe ILD subdetectors and options
  - Describe the ILD optimization process
- This Document should replace the LoI and the DBD
- Integrate and summarize progress of detector technology and software developments since DBD era
- Important input of next European Strategy update

End 2018: a short version as input to the European Strategy
Early 2019: the full report

- In this workshop, official kick-off for the writing and assembling

ILD Design Report

EDMS
Treebrowser

- ILD Technical Design Documentation
  - A-HCAL
  - Coil
  - Configuration Management
  - Design Integration
  - Detector Assembly and Operation Planning
  - Intermediate Tracking
  - Machine Elements
  - Physics Simulation
  - Project Management
  - Sc-ECAL
  - SD-HCAL
  - Si-ECAL
  - Site and Buildings
  - Specifications and Parameters
  - Structural Engineering
  - Technical Documentation
  - TPC
  - Vertex Detector
  - Very Forward Systems
  - Yoke+Muon

Summary and outlook

- Detector optimization with 2 detector models
  - For better understanding of detector optimization
  - Software development and validation for large production
  - Ready for the large Monte Carlo production with new Simulation tools
  - Will start physics benchmark analyses

- Detector R&Ds are actively ongoing
  - New trend: use timing information
    - e.g.) better energy resolution of calorimeters
    - Improved PID with dE/dx TPC & TOF
  - Technology development is underway
    - Many testbeams were/ are / are going to be held
    - All the subdetector groups start to consider integration
      - Integration task force is established

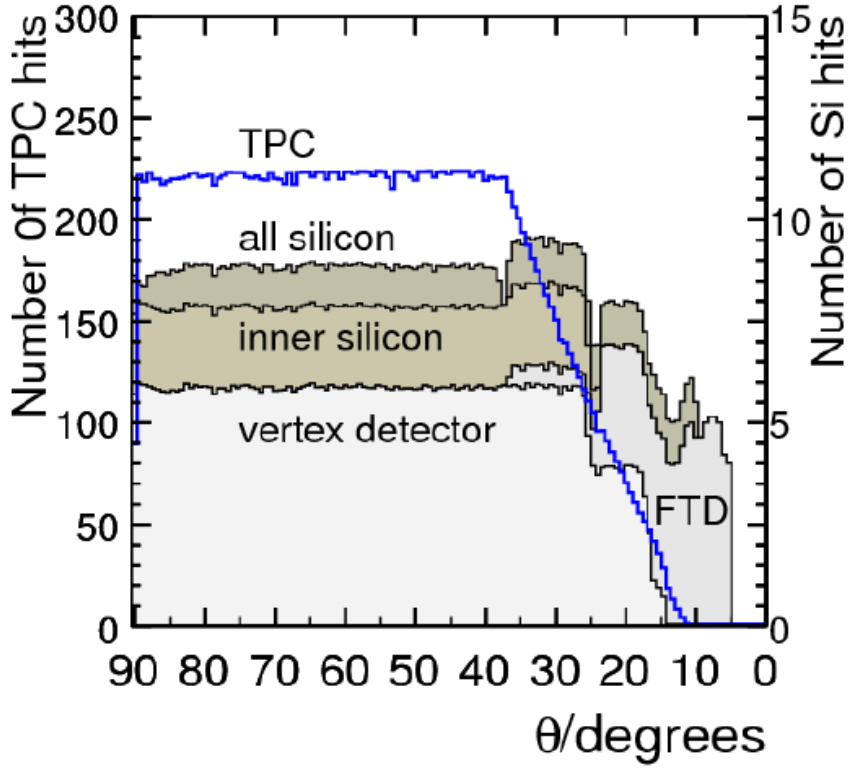
- Plan to prepare new ILD Document(ILD Design Report)
  - Summarize the progress from DBD era
  - Important input to Next European Strategy

Backups

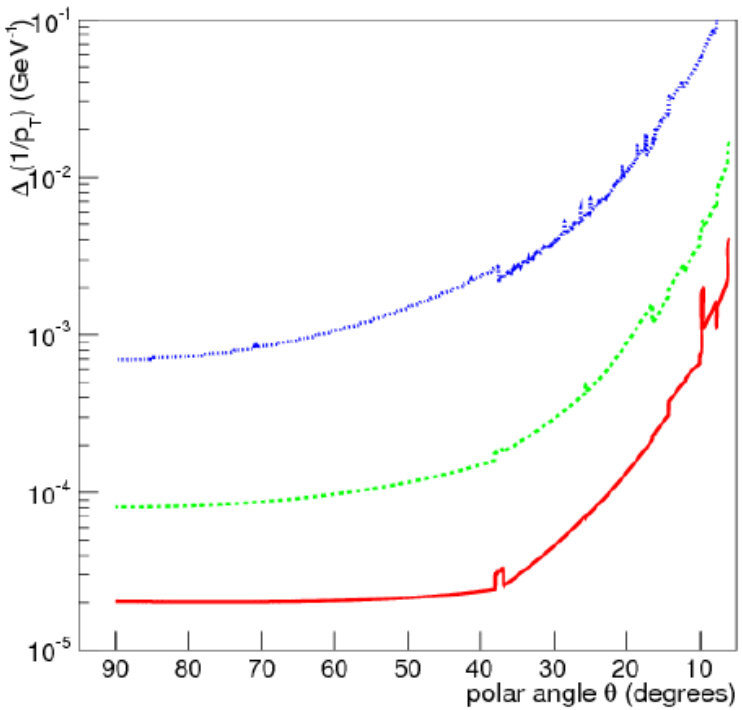
Physics Benchmarks

WG	Process	Physics	Detector	ECM	Who
Higgs & EW	**H->bb/cc/gg**	**BR**	**c-tag, b-tag, JER**	**500 GeV**	**NN + NN**
	H->bb	mass	JER, JES	500 GeV	Ali Ebrahimi (10%) + Junping Tian
	ee->tautau	A_FB, tau-pol, A_LR	tau-reco	500 GeV	Daniel Jeans **+ NN**
	H->mumu	BR	momentum resolution	500 GeV	Shin-ichi Kawada **+ NN**
	H->invisible	BR limit	JER, hermeticity	500 GeV	Yu Kato **+ NN**
	WW->qqlv	MW, TGCs, beam pol.	JES, JER, electron, mu	500 GeV	Kostiantyn Shpak **+ NN**
	vvqqqqq	**QGCs**	**JES / JER**	**1 TeV**	**Jakob Beyer + NN**
	gamma Z	**A_LR, sigma_tot, JES**	**photon, JER/JES, e, mu**	**500 GeV**	**NN + NN**
Top, Bottom & QCD	tt->bbqqqq	x-section, AFB	b-tag, vertex charge, PID	500 GeV	Amjad **+ NN**
BSM	low deltaM Higgsinos	natural SUSY	low-p tracking, PID, hermeticity	500 GeV	Swathi Sasikumar **+ NN**
	mono-photons	**WIMPs / WISPs**	**photon reco, BeamCal**	**500 GeV**	**NN + NN**
	Zh, mh < 125 GeV	limit on ZZh coupling	p res, e reco, JER, hermeticity	500 GeV	Yan Wang **+ NN**

One-slide summary



Number of hits in different sub-systems vs. polar angle



LiCToy transverse momentum resolution vs. polar angle for 1, 10, 100 GeV muons

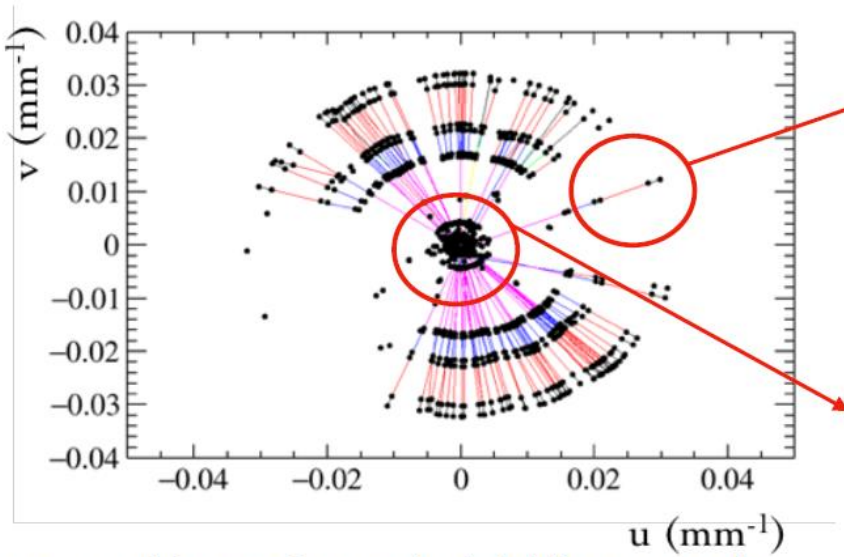
22

Looking for alternative tracking algorithm for ILD

Tracks in conformal space

- Conformal mapping applies a geometry transform that maps circles in the x,y plane passing through the origin into straight lines in the u,v plane

$$u = \frac{x}{x^2 + y^2} \qquad v = \frac{y}{x^2 + y^2}$$



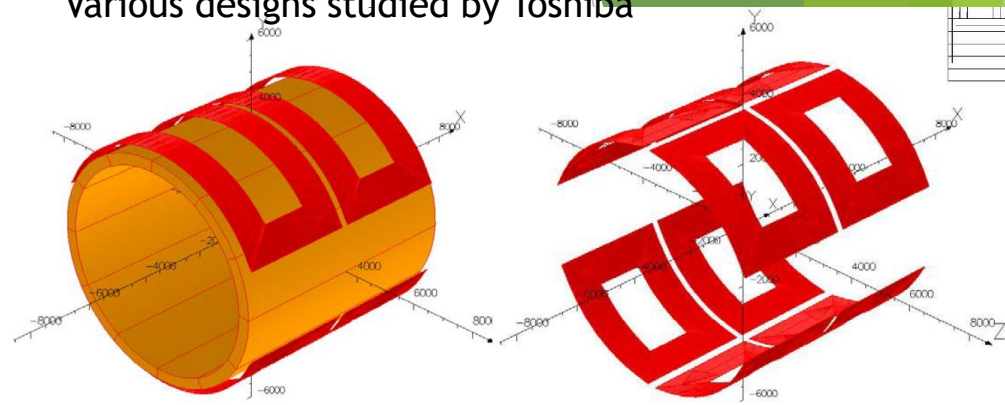
- hits from the vertex
- hits from the tracker

- Cellular automaton used to perform straight line search

Detector Integrated Dipole study

- Anti-DID: To reduce soft e+e- pair backgrounds
- Realized by adding dipole windings around the main solenoid

Various designs studied by Toshiba



S. Lukic

- There is still significant difference between each beam-beam background simulations
  - Various studies with different sim/model are factor 2-4 different
    - 2013: DBD with MOKKA
    - 2017: DBD with DD4hep
    - 2018: New model with DD4hep
  - Need to investigate more

System	Layer #	N_{hit} (cm^{-2} BX^{-1})	N(t>15ns)/N	N(z_{Vtx}>3m)/N	Ratio to DBD	Ratio to "noAnti-DID"
VXD	1	3.1 ± 0.5	7.3 x 10^{-3}	1.7 x 10^{-3}	1	1
	2	2.0 ± 0.4				
	3	0.14 ± 0.04				
	4	0.11 ± 0.03				
	5	0.032 ± 0.016				
	6	0.027 ± 0.015				
SIT	1	(3.5 ± 1.3) x 10^{-3}	0.86	0.56	1	0.64
	2	(2.8 ± 1.3) x 10^{-3}				0.70
	3	(2.0 ± 0.5) x 10^{-3}			~1.8	0.61
	4	(1.9 ± 0.6) x 10^{-3}				0.66
FTD	1	0.038 ± 0.011	0.44	0.36	1	1
	2	0.023 ± 0.010				1
	3	0.014 ± 0.004				0.7
	4	0.011 ± 0.002				0.7
	5	0.009 ± 0.003				0.7
	6	0.005 ± 0.002				0.7
	7	0.003 ± 0.002				0.6
System		N_{hit} (BX^{-1})				
TPC	Total	150 ± 440	0.56	0.07	2	1

- 2018 study: Anti-DID has little effect on vertex near beamline
  - Reduces factor ~2 further detectors