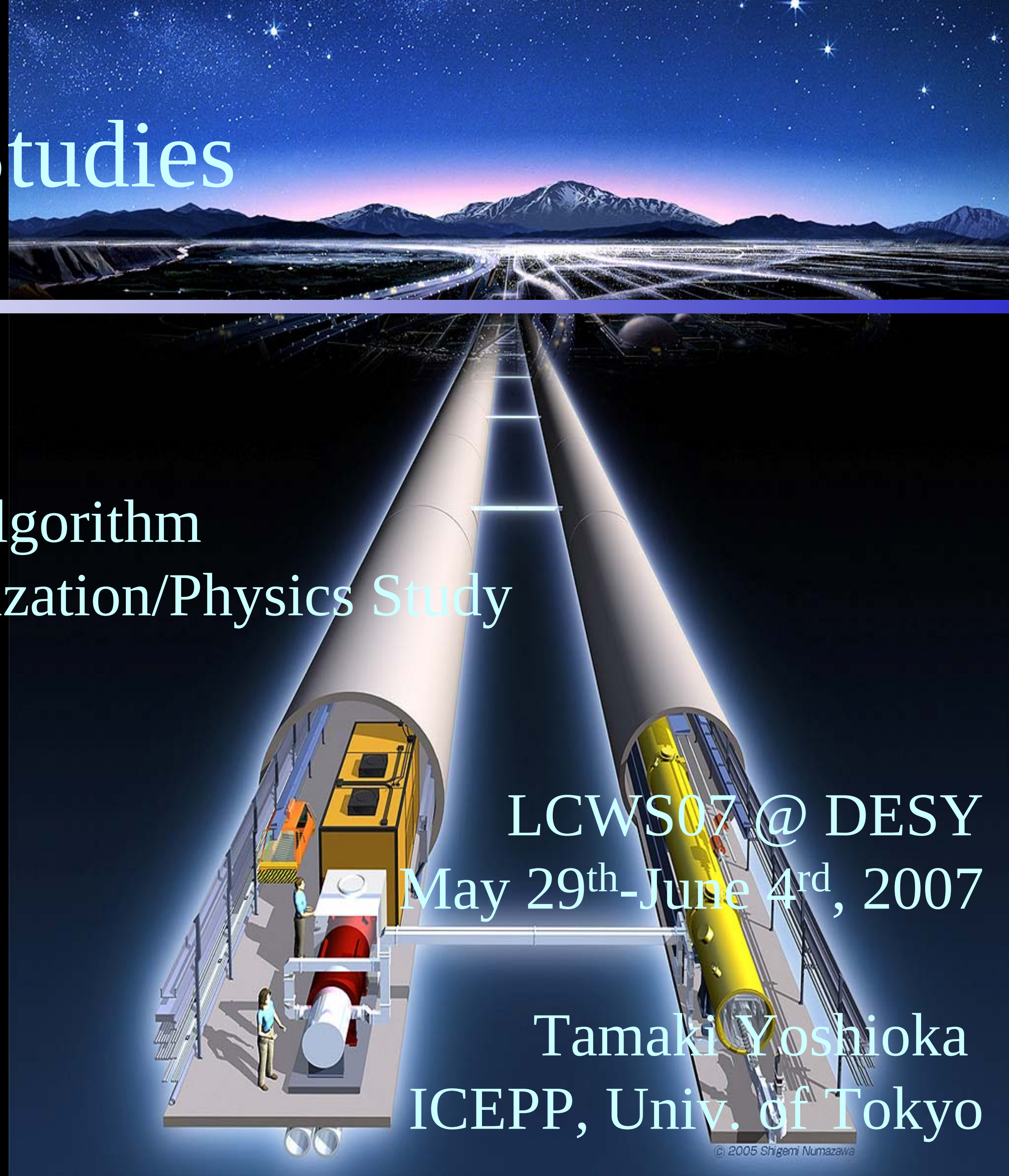
GLD-PFA Studies

<u>*Contents*</u>



LCWS07 @ DESY

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ICEPP, Univ. of Tokyo

Introduction

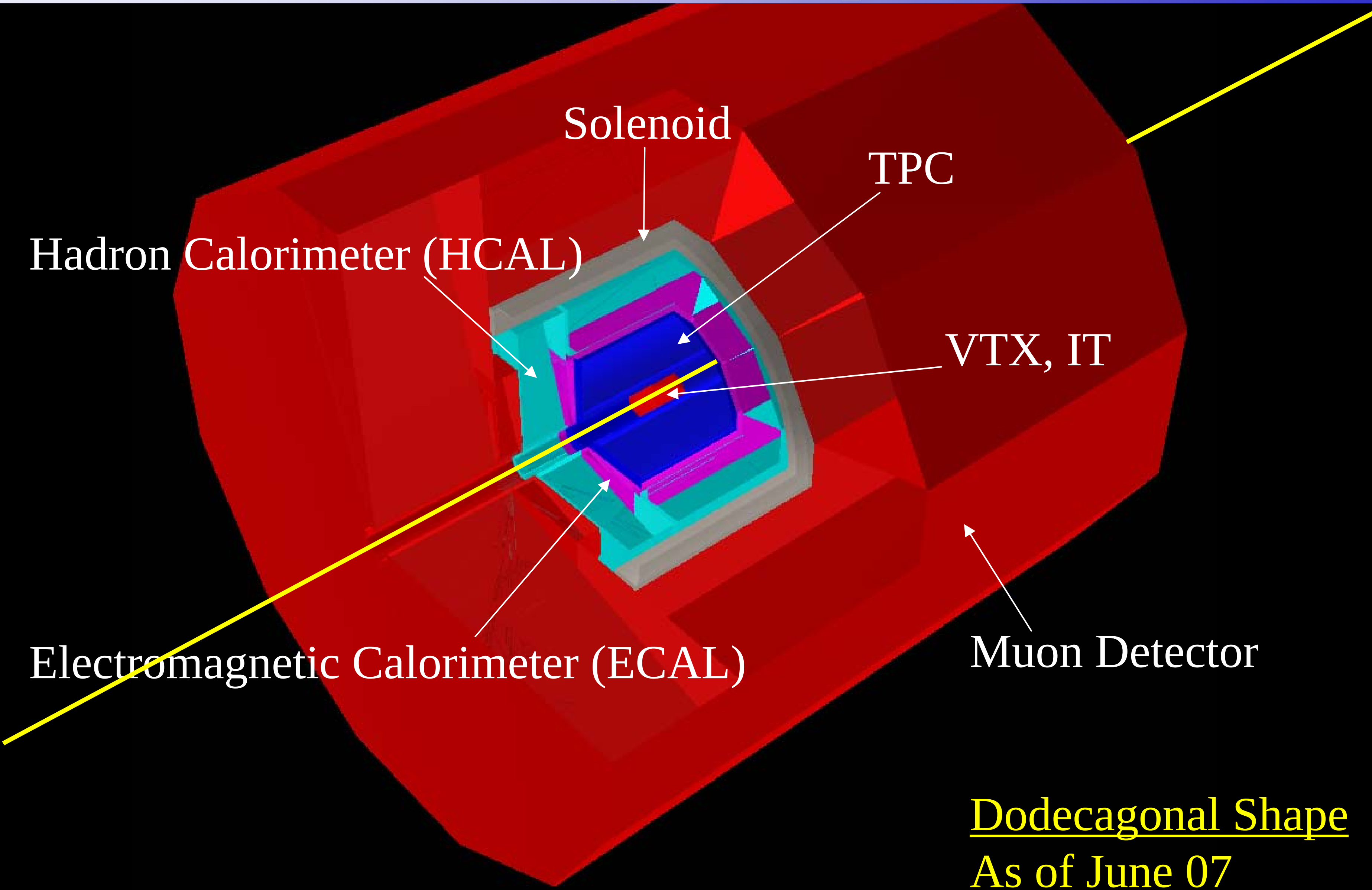
- Most of the important physics processes to be studied in the ILC experiment have multi-jets in the final state.
  → **Jet energy resolution is the key in the ILC physics.**

- The best energy resolution is obtained by reconstructing momenta of individual particles avoiding double counting among Trackers and Calorimeters.
  - Charged particles (~60%) measured by Tracker.
  - Photons (~30%) by electromagnetic CAL (ECAL).
  - Neutral hadrons (~10%) by ECAL + hadron CAL (HCAL).

  → ***Particle Flow Algorithm (PFA)***

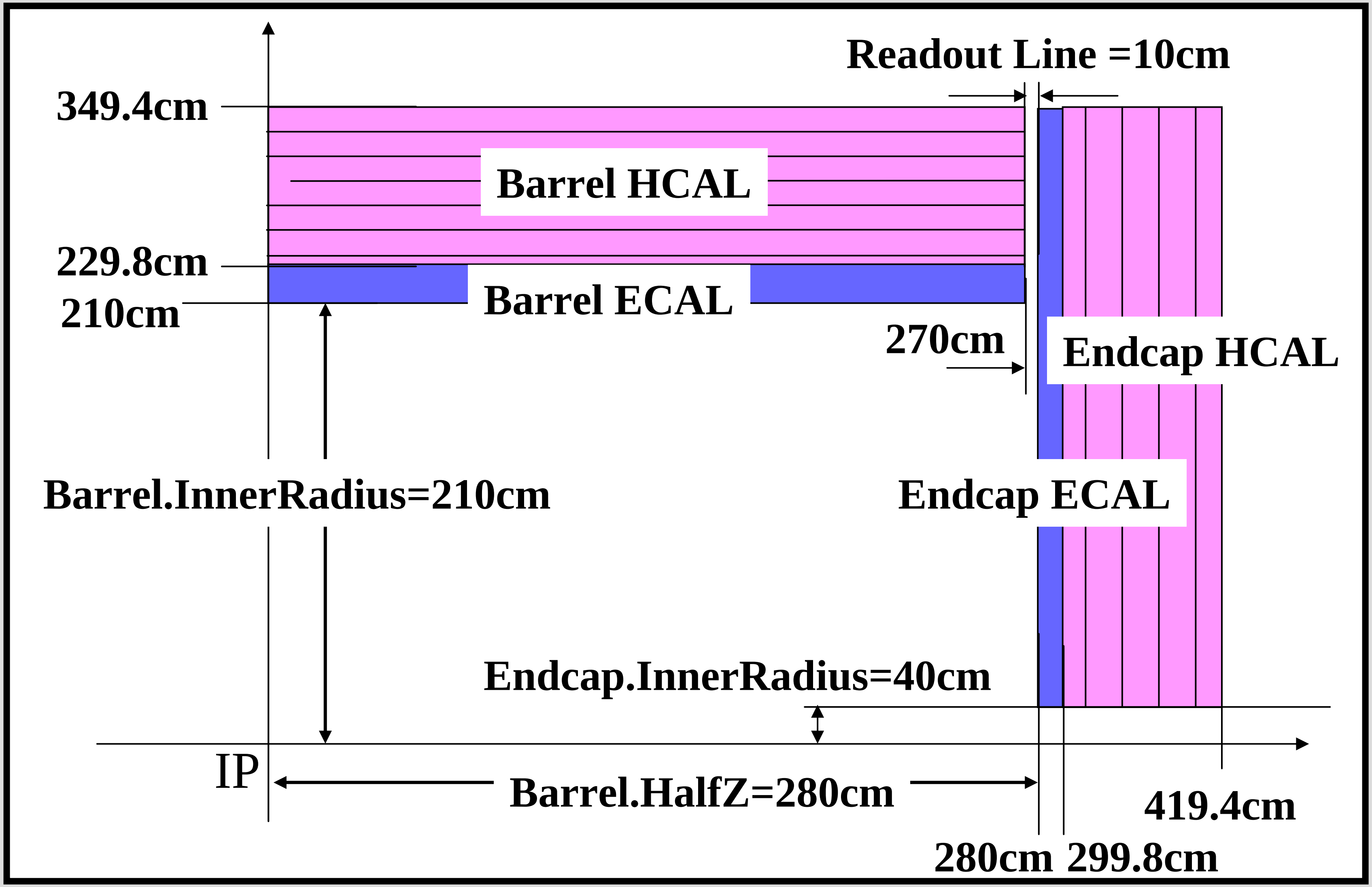
- In this talk, general scheme and performance of the GLD-PFA, using the GEANT4-based full simulator (Jupiter), will be presented.

Geometry in Jupiter

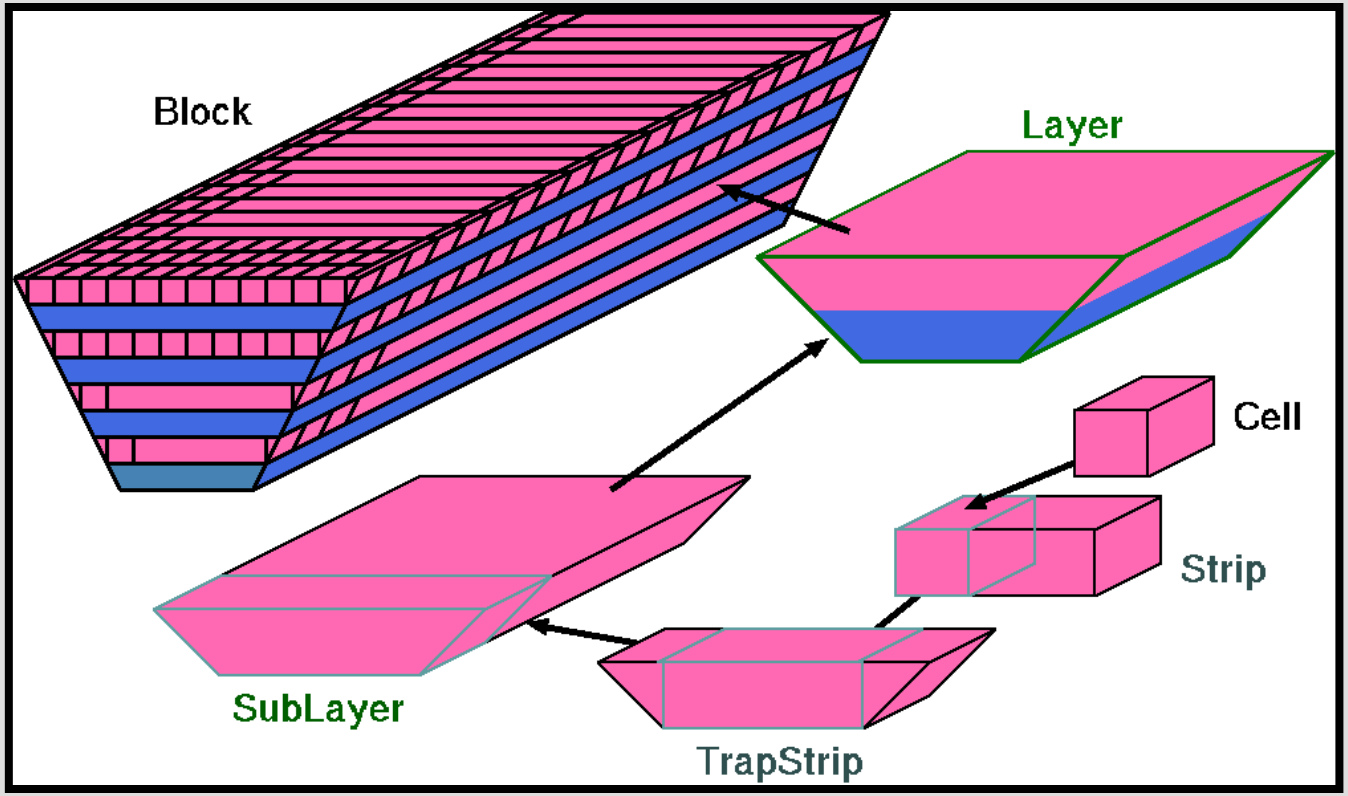


Dodecagonal Shape
As of June 07

Calorimeter Geometry in Jupiter



Calorimeter Structure



Active Layer

Absorber

Current cell size : 1x1cm

Can be changed.

ECAL	HCAL
W/Scinti./Gap	Fe/Scinti./Gap
3/2/1 (mm) x 33 layers	20/5/1 (mm) x 46 layers

Particle Flow Algorithm for GLD

Flow of GLD-PFA

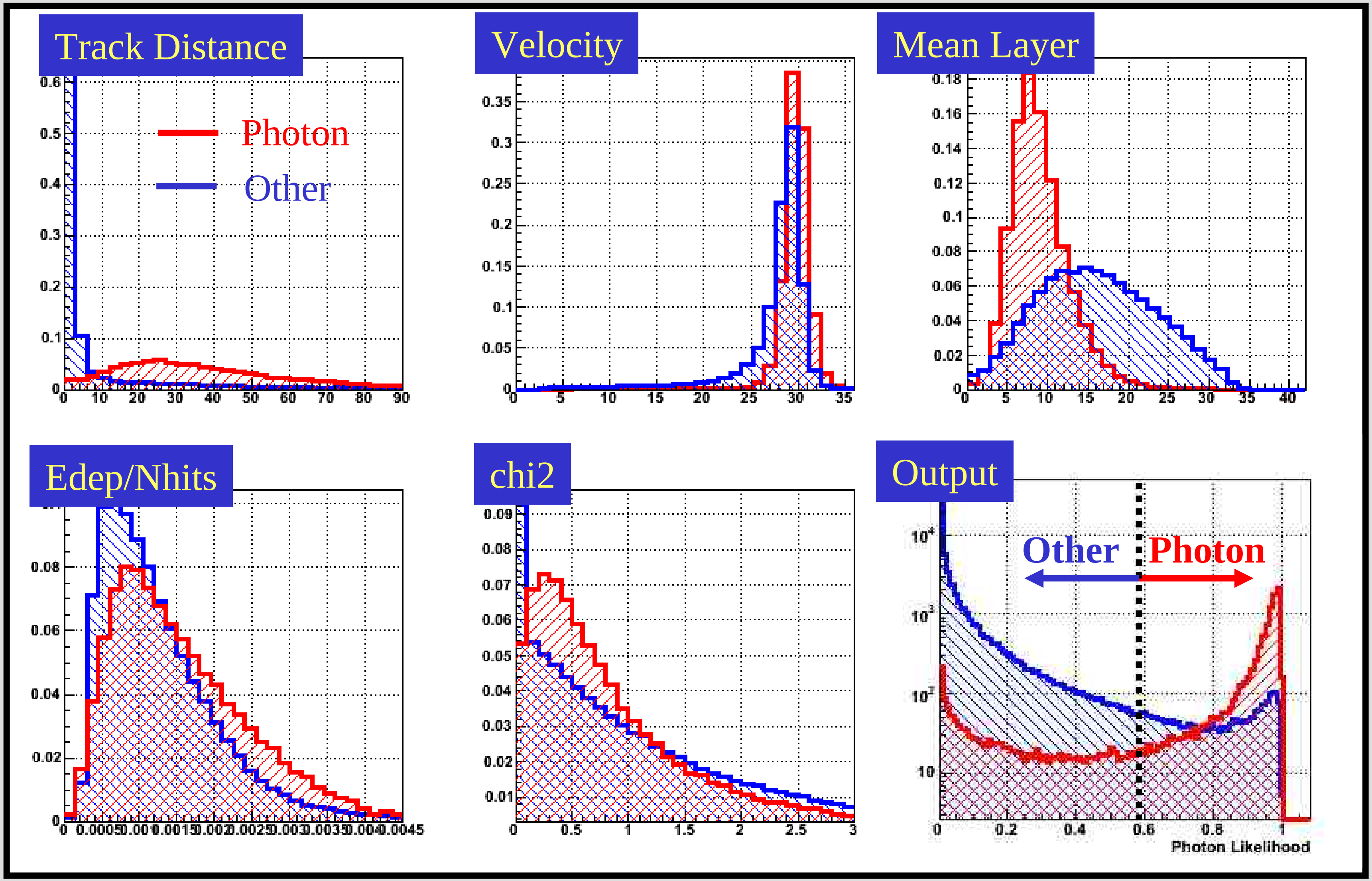
1. Photon Finding
2. Charged Hadron Finding
3. Neutral Hadron Finding
4. Satellite Hits Finding

*Satellite hits = calorimeter hit cell which does not belong to a cluster core

Note : Monte-Carlo truth information is used for muon and neutrino.

Photon Likelihood

- Five variables are selected to form the photon likelihood function.



Particle Flow Algorithm for GLD

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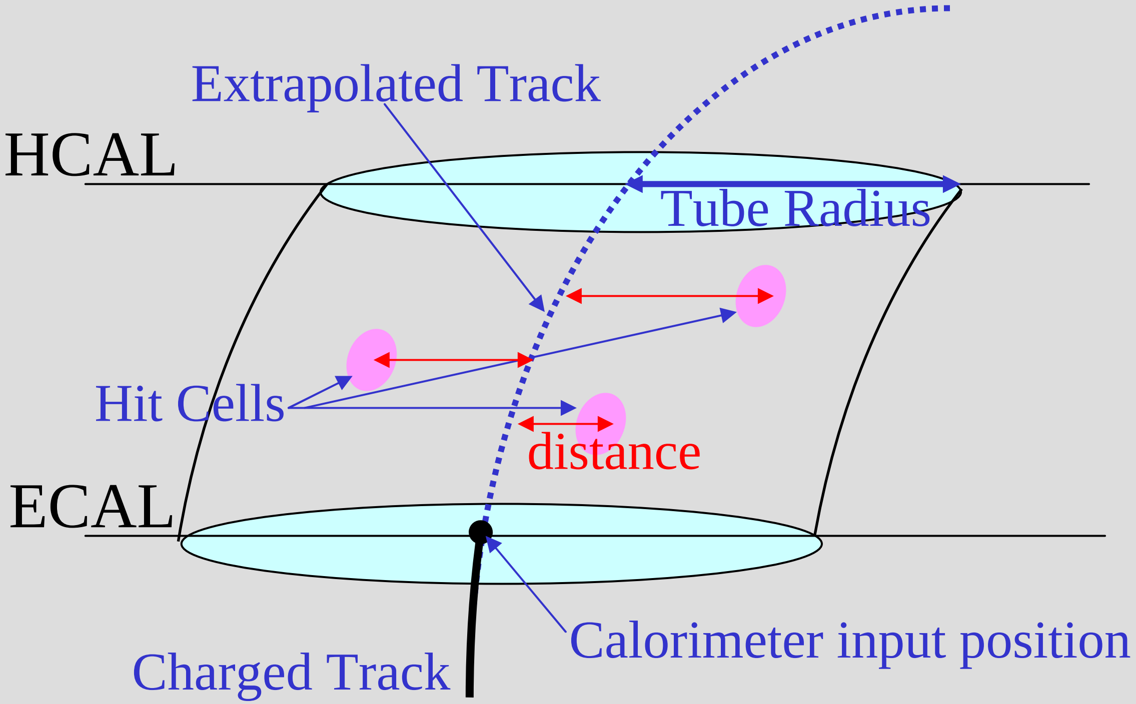
Charged Hadron Finding

- ***Basic Concept*** :
Extrapolate a charged track and calculate a distance between a calorimeter hit cell and the extrapolated track. Connect the cell that in a certain tube radius (clustering).



- Calculate the distance for any track/calorimeter cell combination.

- Tube radius for ECAL and HCAL can be changed separately.

Particle Flow Algorithm for GLD

Flow of GLD-PFA

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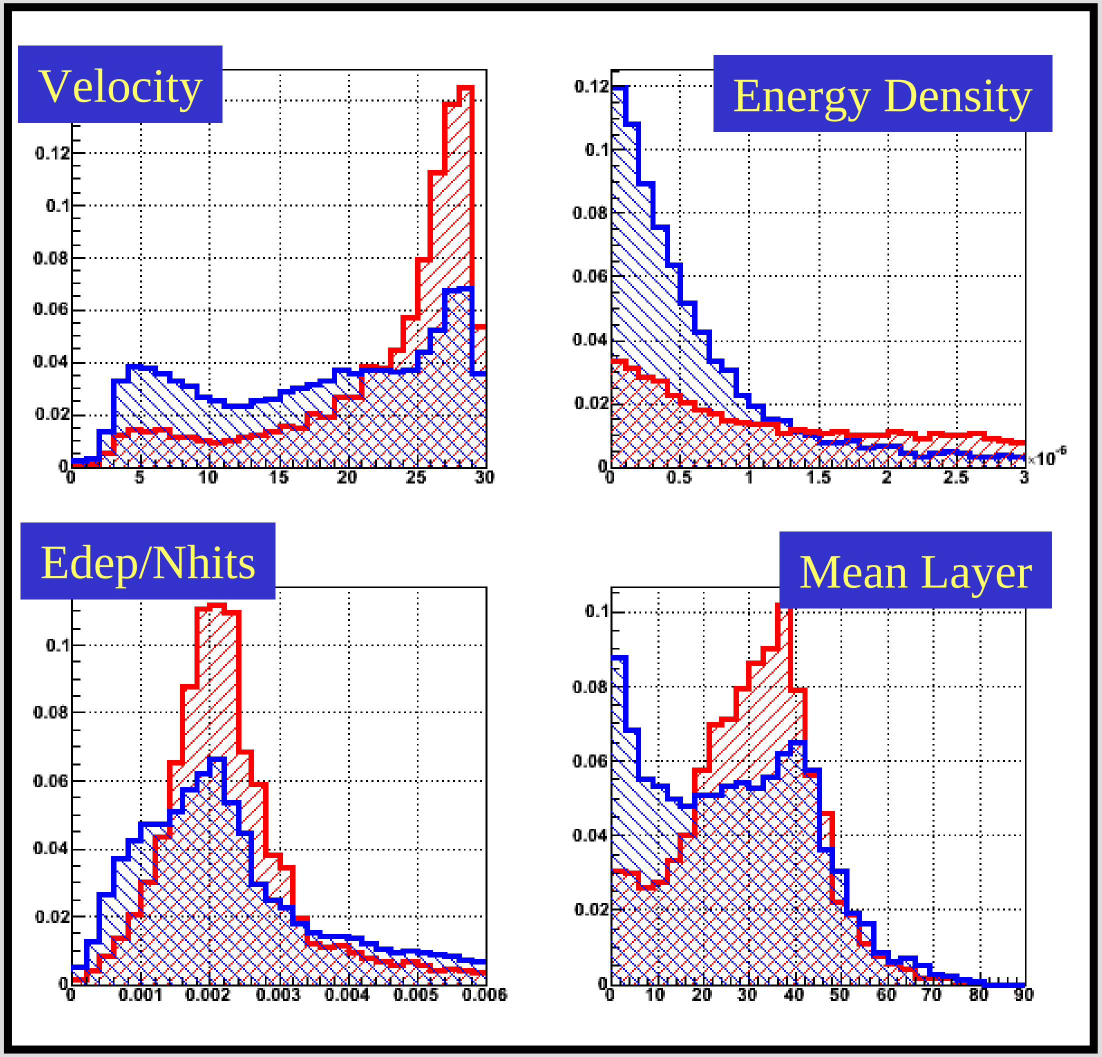
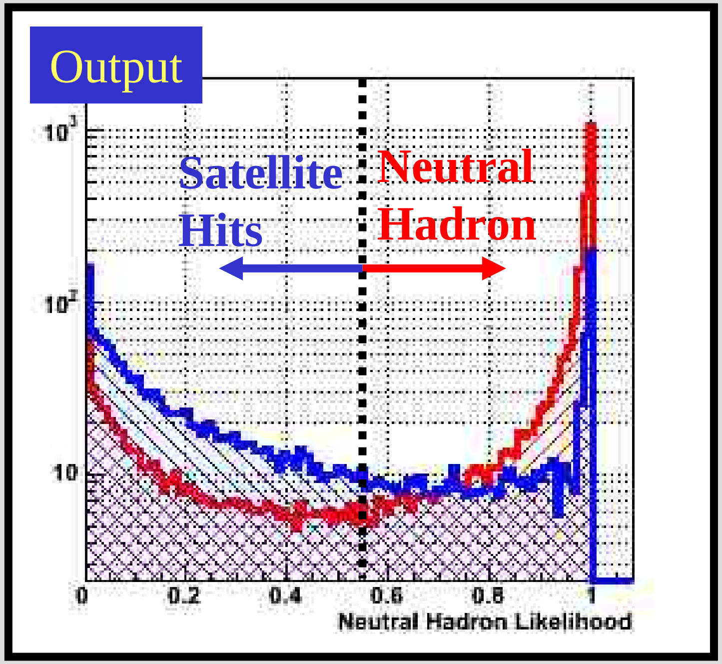
Neutral Hadron Likelihood

- Four variables are selected to form the NHD likelihood function.





— Neutral Hadron

— Satellite Hits

Particle Flow Algorithm for GLD

Flow of GLD-PFA

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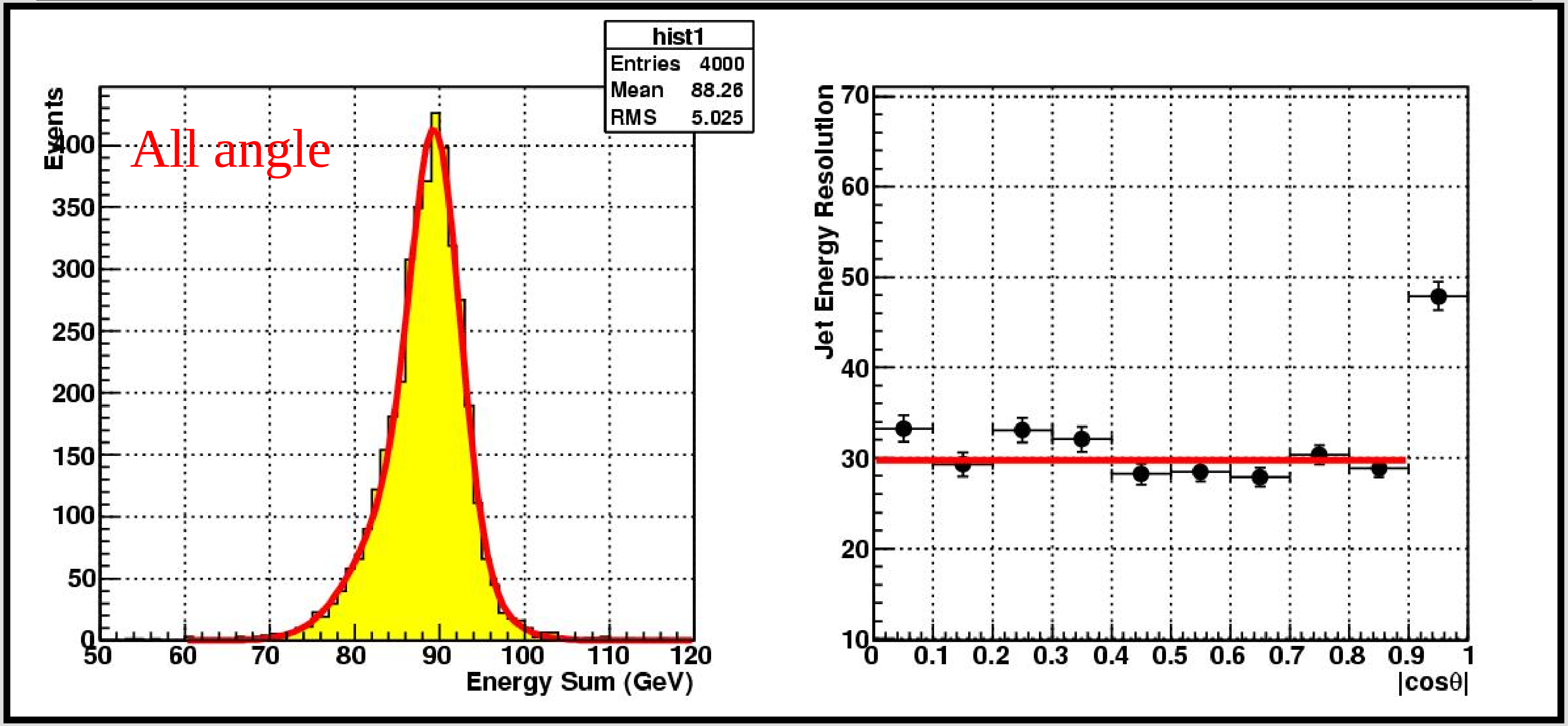
Jet Energy Resolution (Z-pole)

- Z → uds @ 91.2GeV, tile calorimeter, 1cm x 1cm tile size



- Almost no angular dependence : ~30%/√E for |cosθ|<0.9.
- cf. 60 %/√E w/o the PFA (sum up the calorimeter energy)

Jet Energy Resolution (Z-pole)

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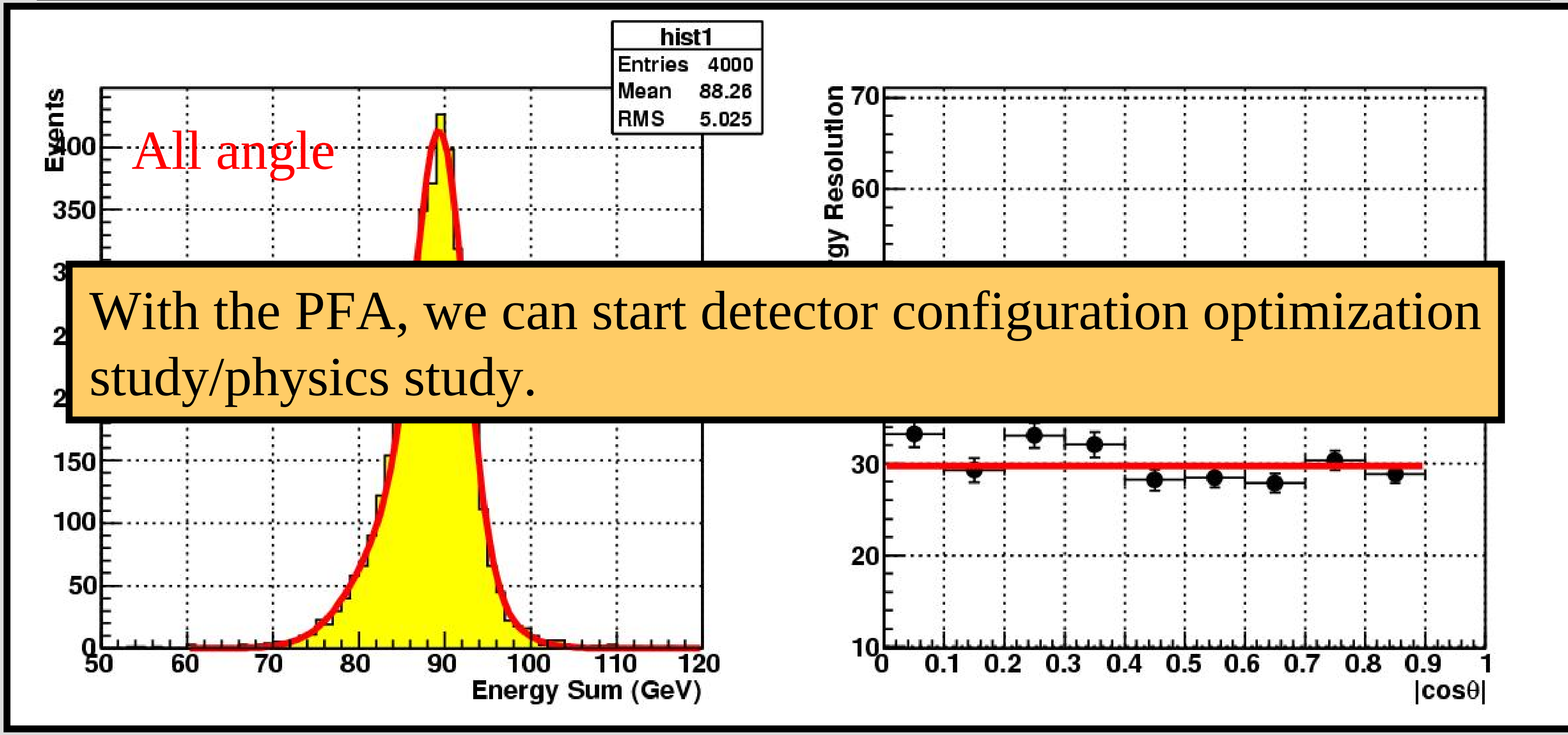
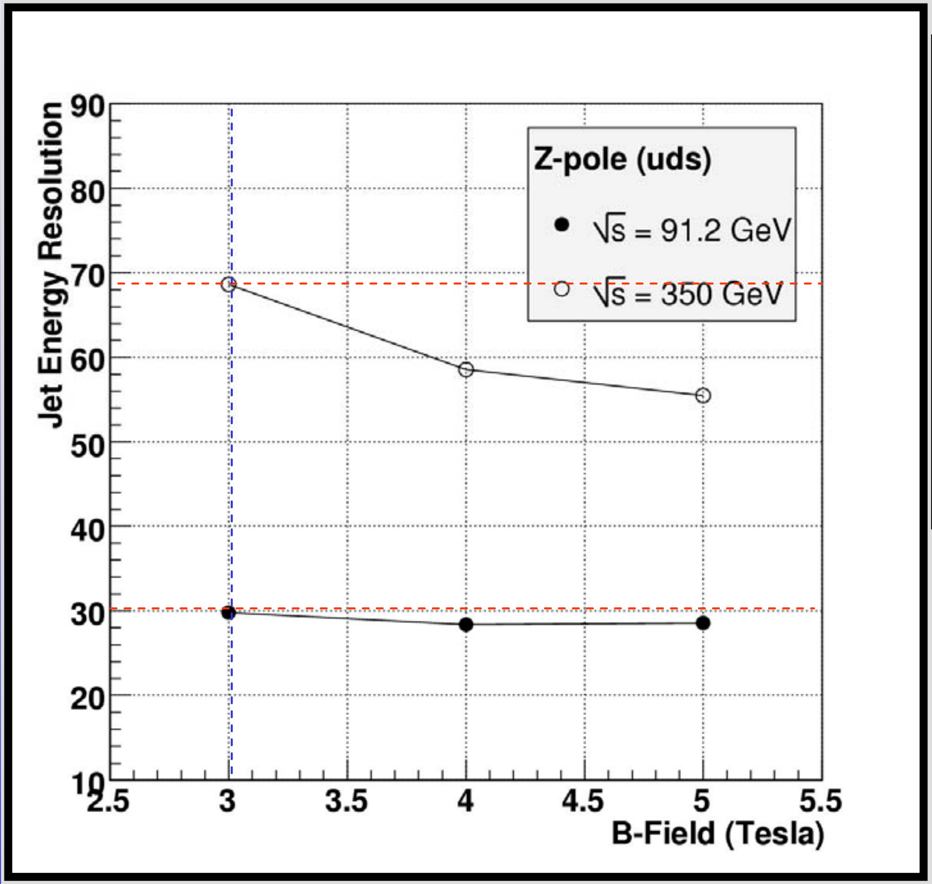


With the PFA, we can start detector configuration optimization study/physics study.

- Almost no angular dependence : ~30%/√E for |cosθ|<0.9.
- cf. 60 %/√E w/o the PFA (sum up the calorimeter energy)

B-field Dependence

- B-field dependence of the PFA performance is studied.
  Default B-field = 3 Tesla, 1cm x 1cm cell size.

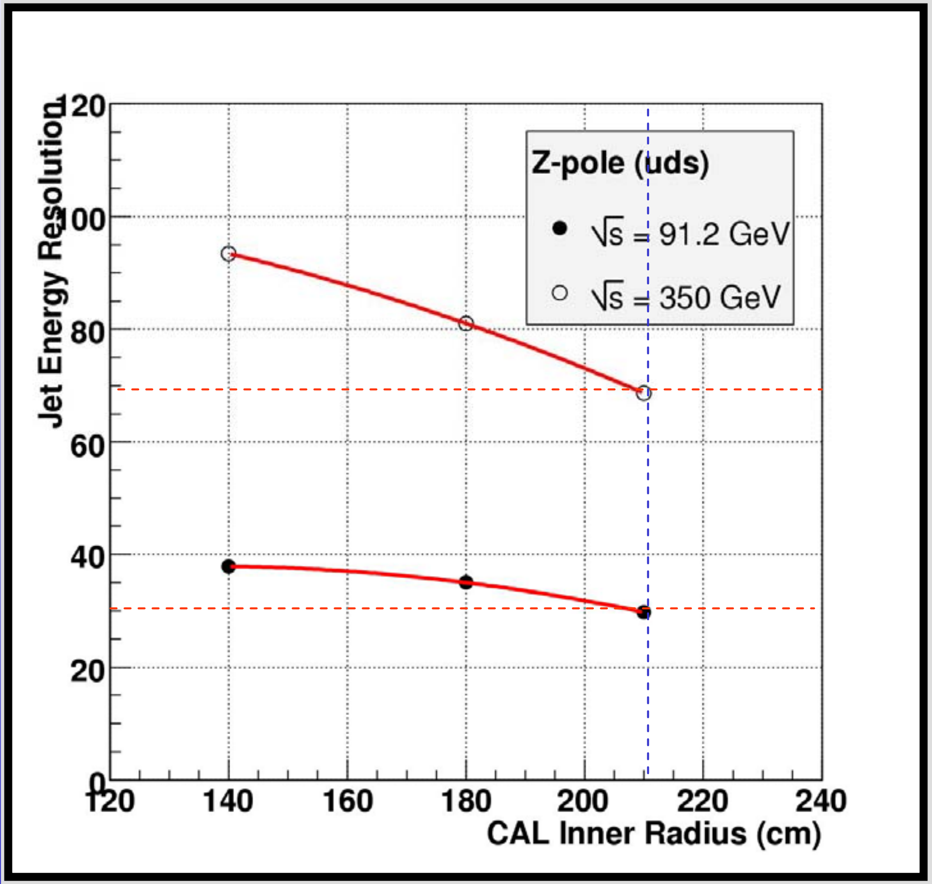


- Higher magnetic field gives better PFA performance as expected.
- 5 Tesla case does not improve PFA performance very much.
→ Due to low momentum tracks?

Ecm	3 Tesla	4 Tesla	5 Tesla
91.2	29.8±0.4	28.4±0.3	28.6±0.3
350	68.7±1.1	58.5±1.0	55.5±0.9

ECAL Radius Dependence

- ECAL inner radius dependence of the PFA performance is studied.
  Default Radius = 210 cm, 1cm x 1cm cell size.

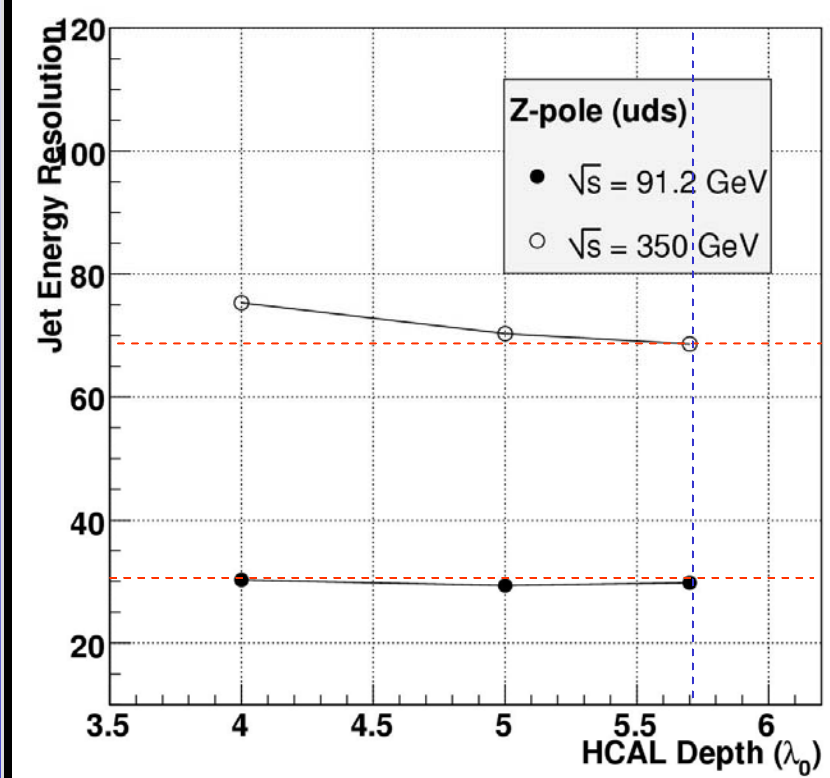


- Larger calorimeter radius gives better PFA performance as expected.
- PFA performance depends on the CAL radius squared.

Ecm	140 cm	180 cm	210 cm
91.2	37.9±0.4	35.0±0.4	29.8±0.4
350	93.4±1.5	81.0±1.3	68.7±1.1

HCAL Depth

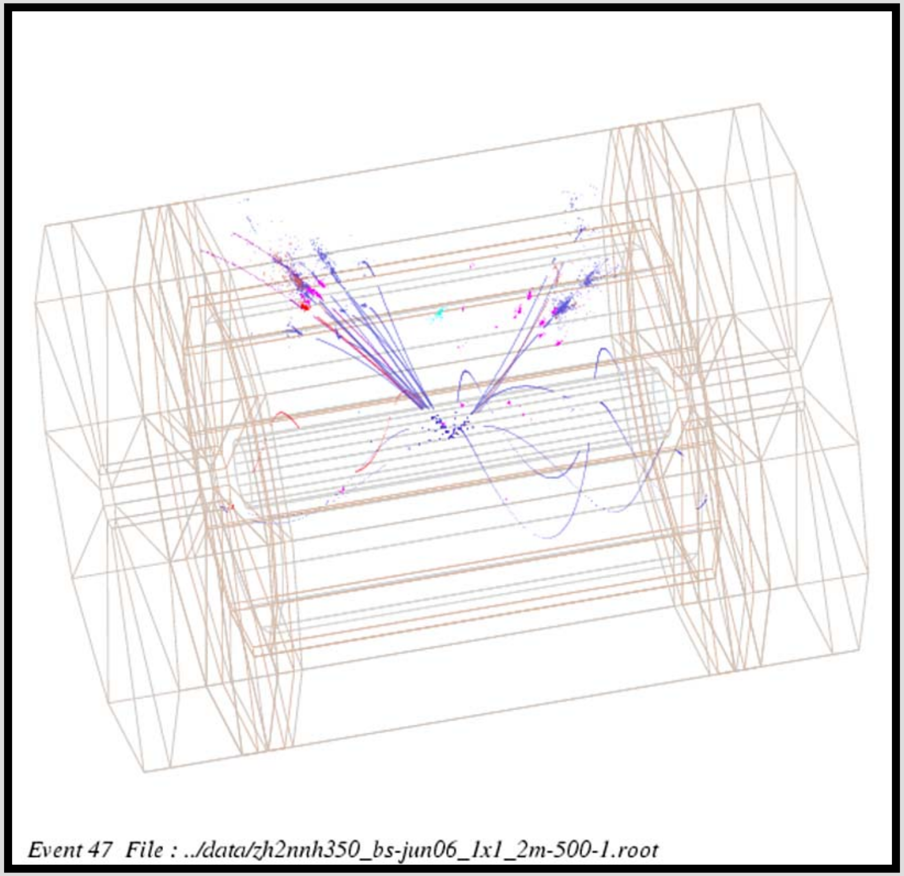
- HCAL depth dependence of the PFA performance is studied.
  Default thickness = 5.7 λ_0 , 1cm x 1cm cell size.

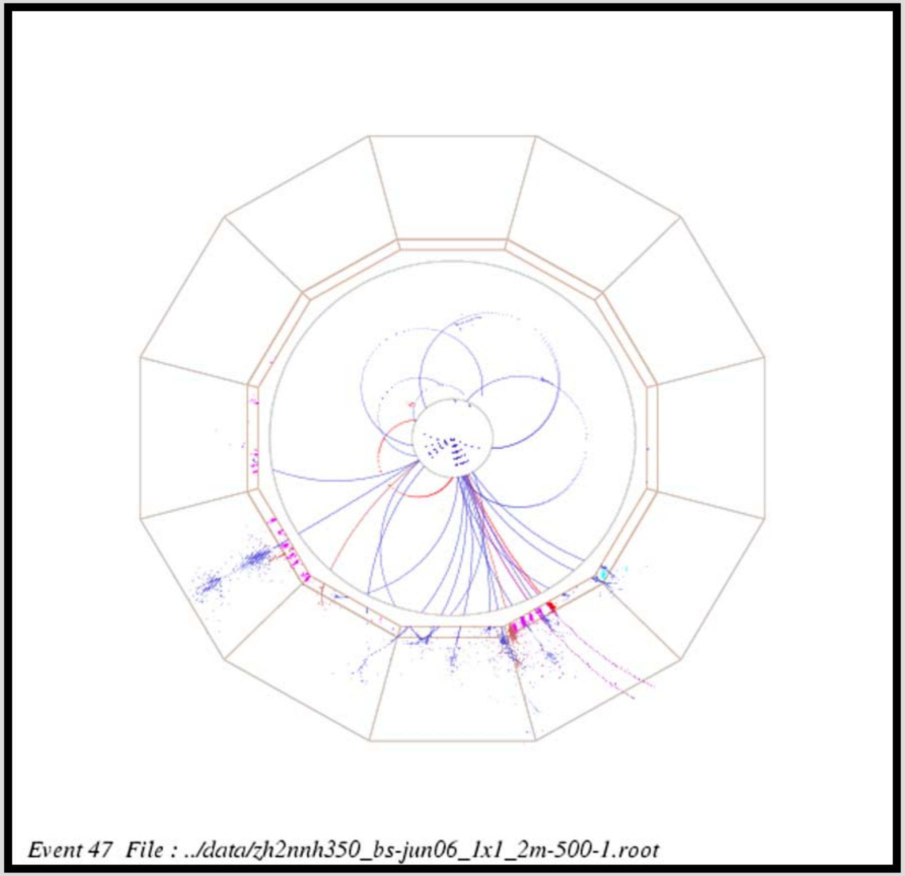


- Thinner HCAL gives worse PFA performance due to shower leakage.
- 5 λ_0 HCAL does not degrade PFA performance so much even for Ecm = 350GeV.

Ecm	4.0 λ_0	5.0 λ_0	5.7 λ_0
91.2	37.9±0.4	35.0±0.4	29.8±0.4
350	93.4±1.5	81.0±1.3	68.7±1.1

ZH → nnqq Study





- Ecm = 350 GeV, Mh = 120 GeV
- ZH → ννh : Two jets from Higgs can be seen.

Higgs Selection – 2-jet mode

- *Signal Signature : 2 jets + large missing energy*

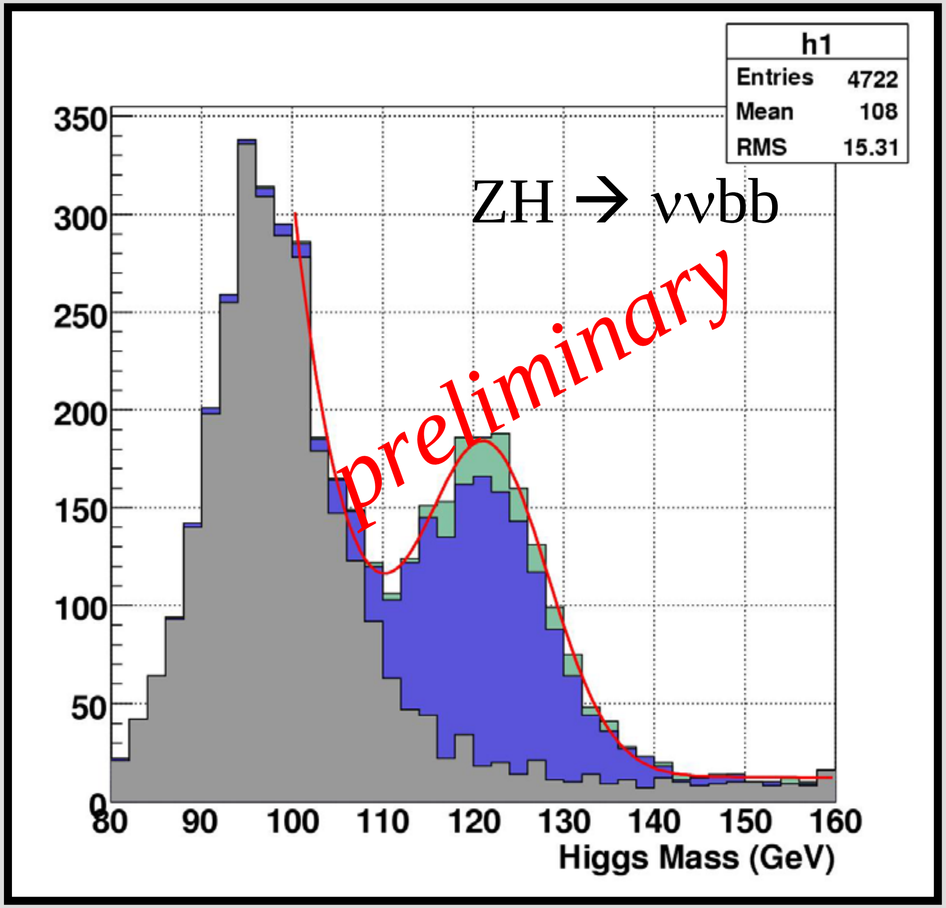
Mass of Observed particles = Higgs
Mass of Un-observed particles = Z0

- *Selection Criteria*

1. Visible Energy	90 – 200 (GeV)
2. Cosine of jet axis	-0.8 – 0.8
3. Missing Pt	> 20 (GeV)
4. Missing Mass	31.2 – 151.2 (GeV)
5. No. of Off Vertex Tracks	> 4

Higgs Search – 2-jet mode

- Invariant mass of 2 jets, Ecm=350GeV, Mh=120GeV, 200fb-1



Signal (Higgs Strahlung)

Signal (t-channel W exchange)

Background(ZZ→nnqq)

Summary

- Realistic PFA has been developed using the GEANT-4 based full simulator of the GLD detector.

- Jet energy resolution is studied by using $Z \rightarrow qq$ events. ILC goal of $30\%/\sqrt{E}$ has been achieved in the barrel region of the Z-pole events.

- PFA performance with various GLD configuration has been studied.
  → High B-field/Large Calorimeter gives better performance as expected.

- Physics studies w/ current PFA are in progress. Stay tuned.