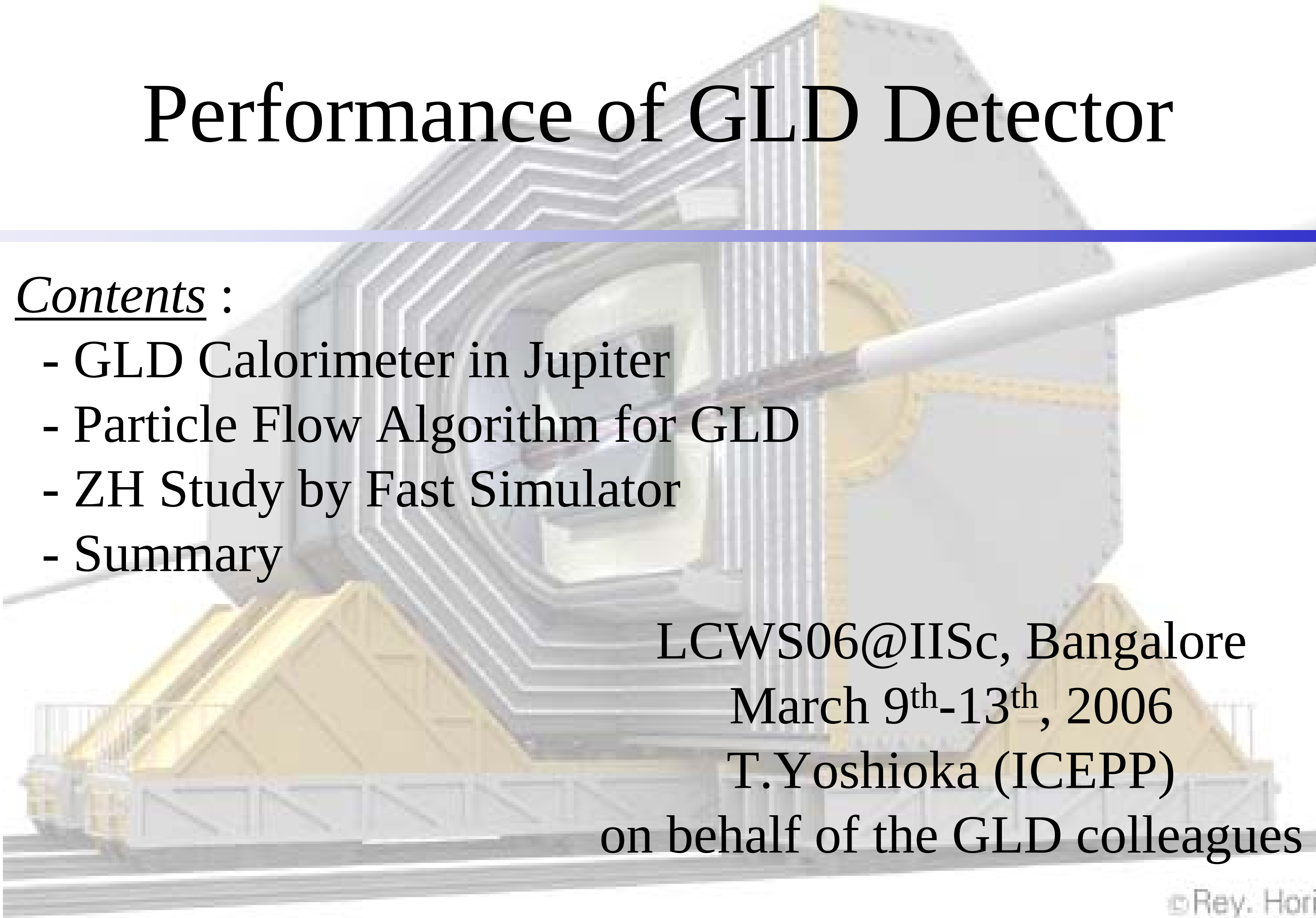
Performance of GLD Detector



Contents :

- GLD Calorimeter in Jupiter
- Particle Flow Algorithm for GLD
- ZH Study by Fast Simulator
- Summary

LCWS06@IISc, Bangalore
March 9th-13th, 2006
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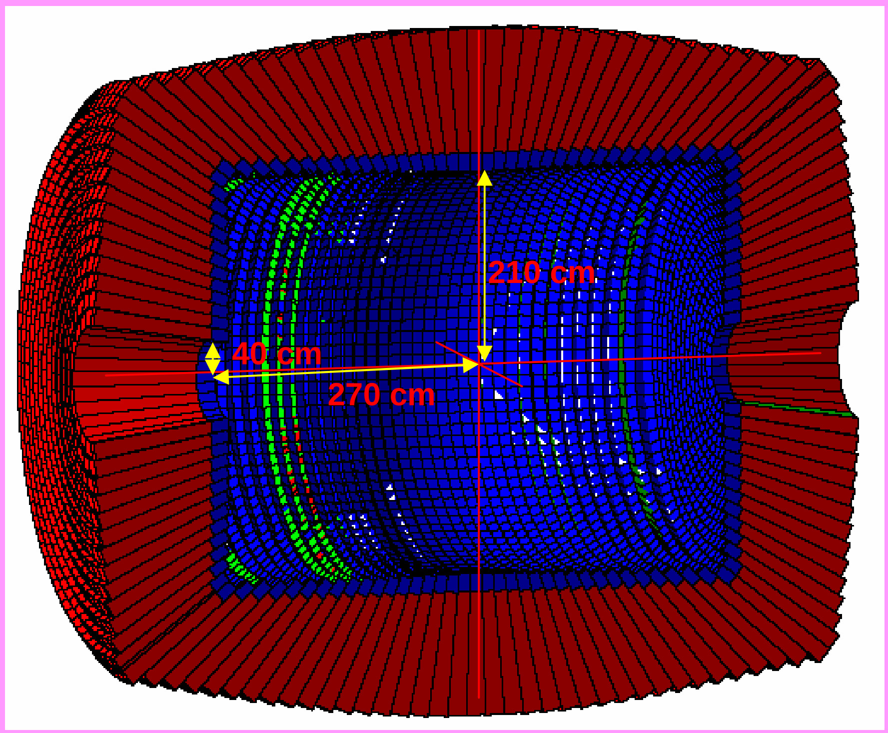
on behalf of the GLD colleagues

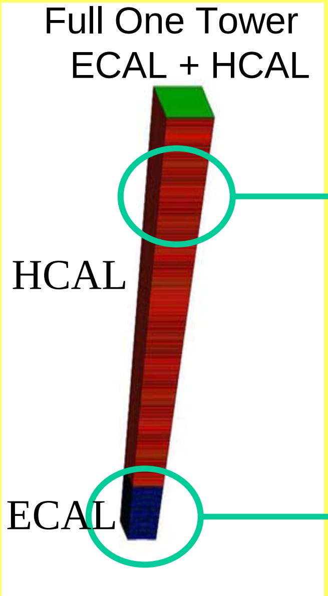
Calorimeter Geometry in Jupiter

- Side view



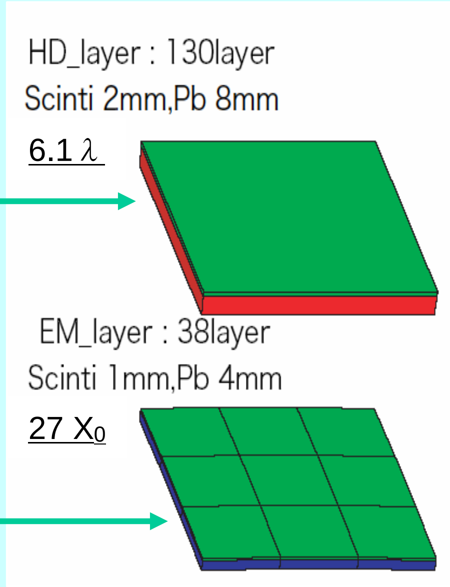
Barrel Tower Front : 210cm
Endcap Inner R : 40cm
Endcap Tower Front Z : 270cm

- Tower



- # of Layers
  ECAL : 38
  HCAL : 130

- Cell



- Cell Size
  EM : 4cm x 4cm
  HD : 12cm x 12cm

Cell size and material can be changed easily.

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 is not belong core of cluster

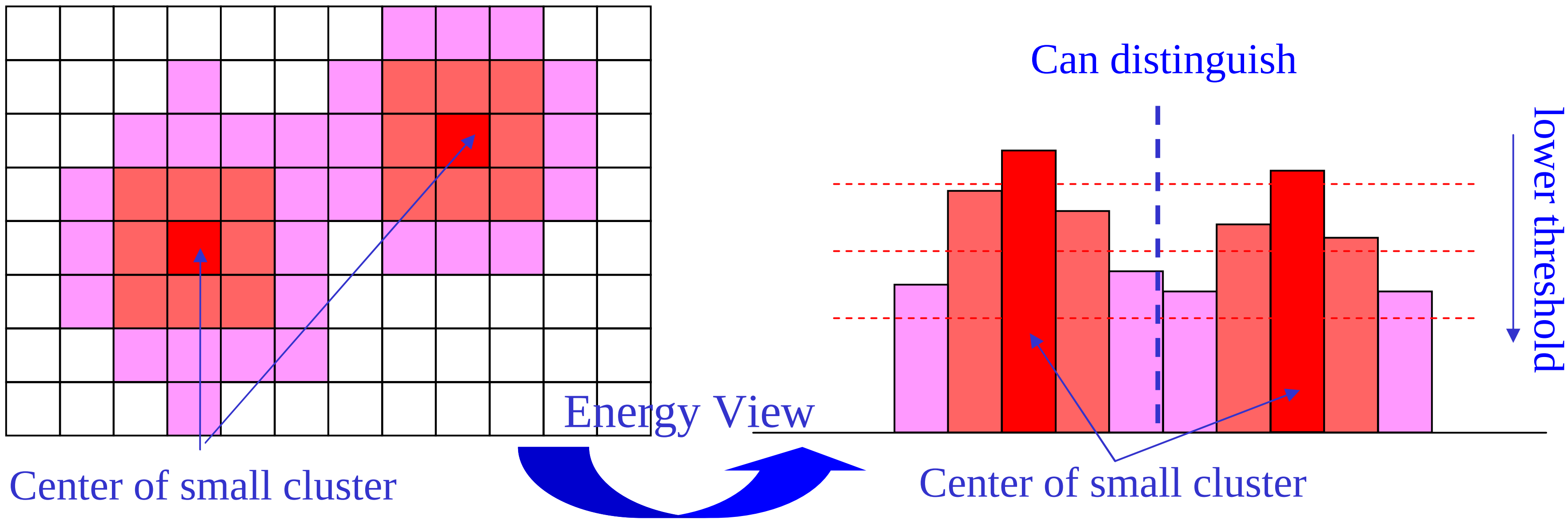
Note : Monte-Carlo truth information is used for the muon and neutrino.

Photon Finding Procedure

Photon Reconstruction

1. Clustering
2. Remove charged particles by using track information.
3. Identify photon by using cluster information.
4. Identify photon by using TOF information.

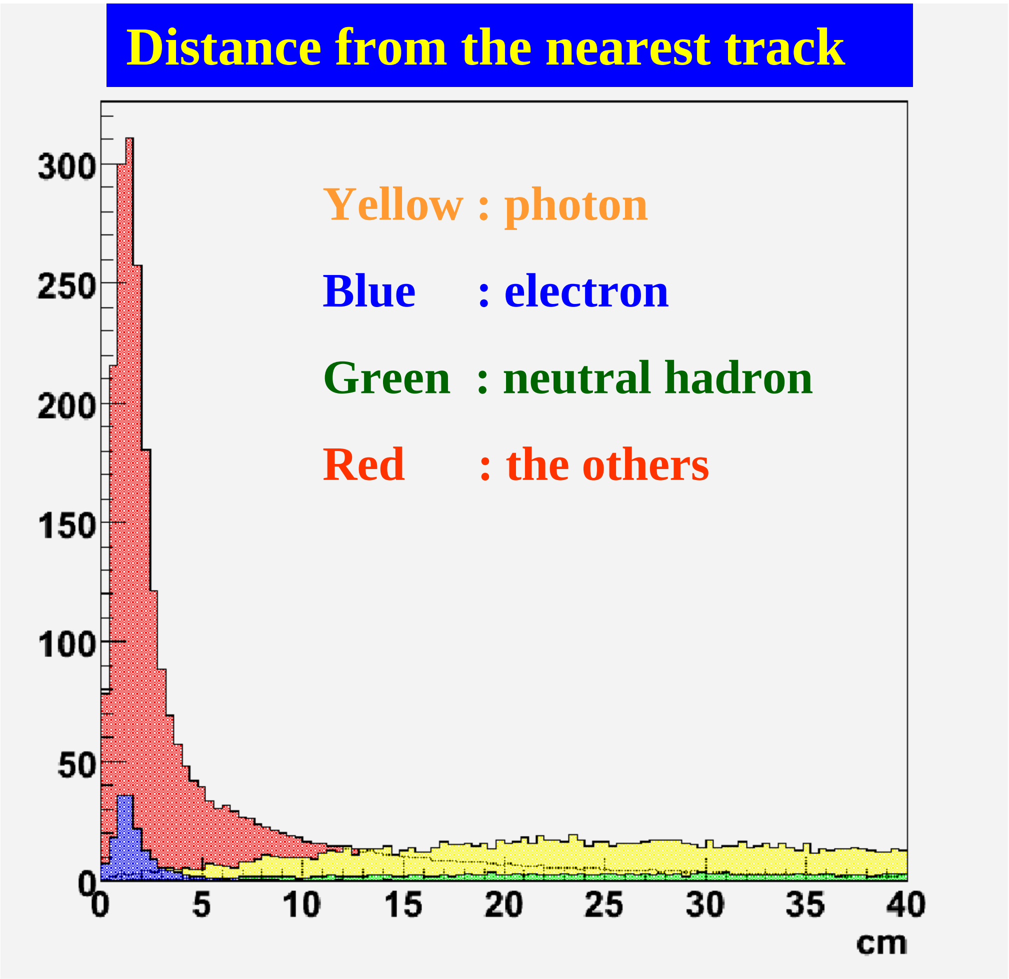
Clustering



1. Center of a cluster is looked for at higher energy threshold.
2. Neighbor cells are connected at lower threshold.
3. Continue #2 by lowering the threshold.

Distance from the Nearest Track

- Reject clusters if distance from the nearest track is small.
- This cut rejects large number of clusters due to charged particles.

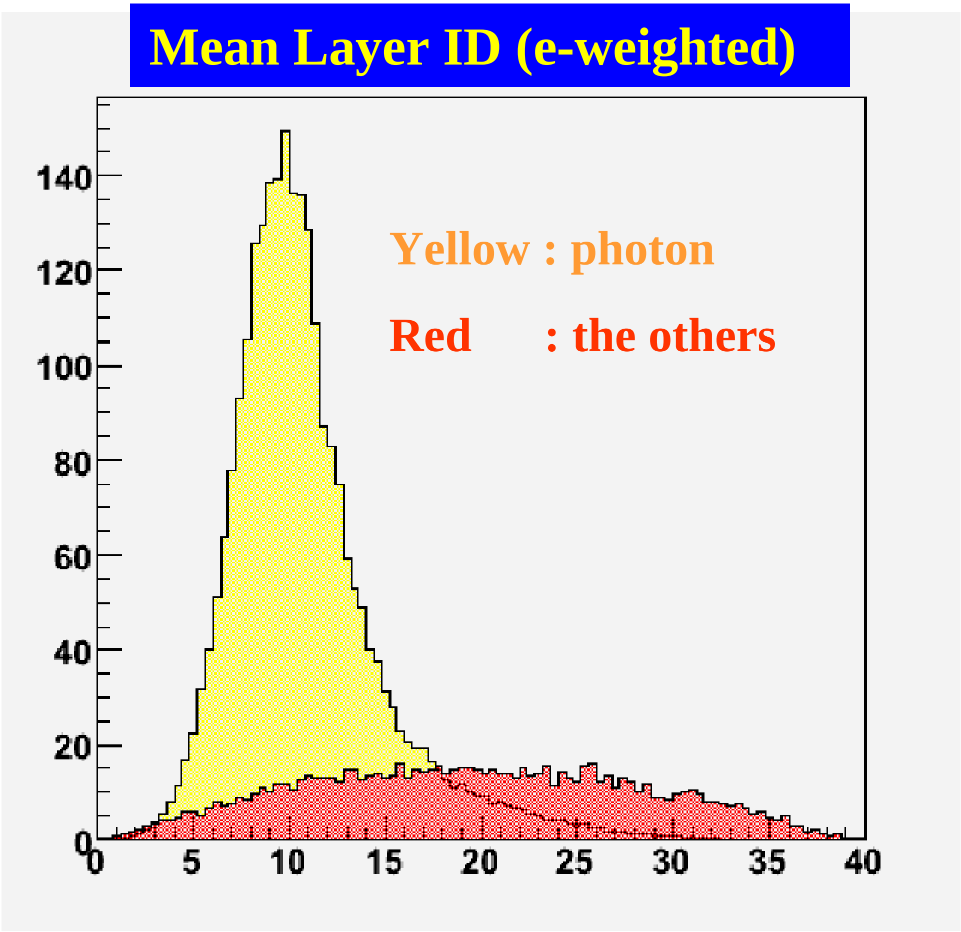


ECAL clusters in Z -> qqbar @ 91.2GeV

Shower Depth

- Calculate averaged layer ID of a cluster.
  (= shower depth)

- A cluster which has small averaged layer ID is regarded as photon.

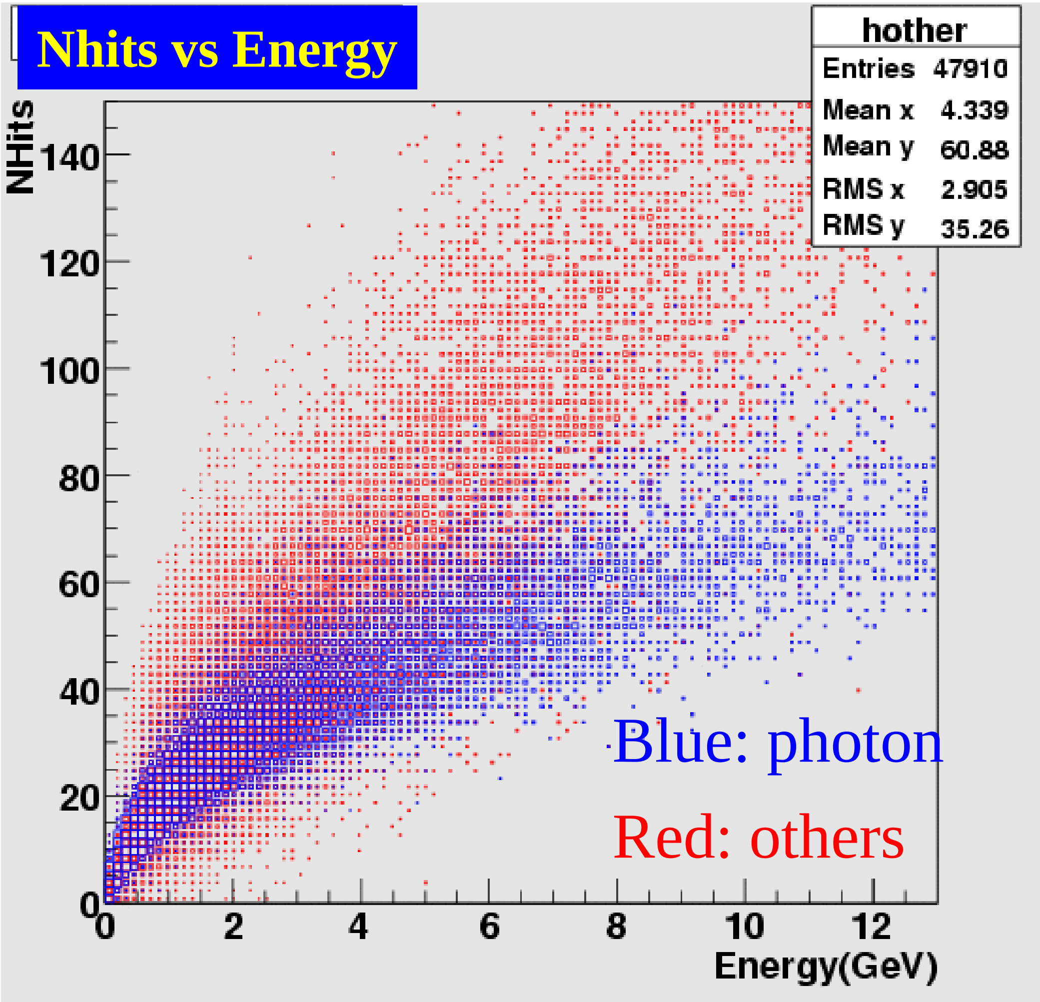


ECAL clusters in Z -> qqbar @ 91.2GeV

Nhits vs. Energy

- Correlation between Nhits and Energy can be used to identify a photon cluster.

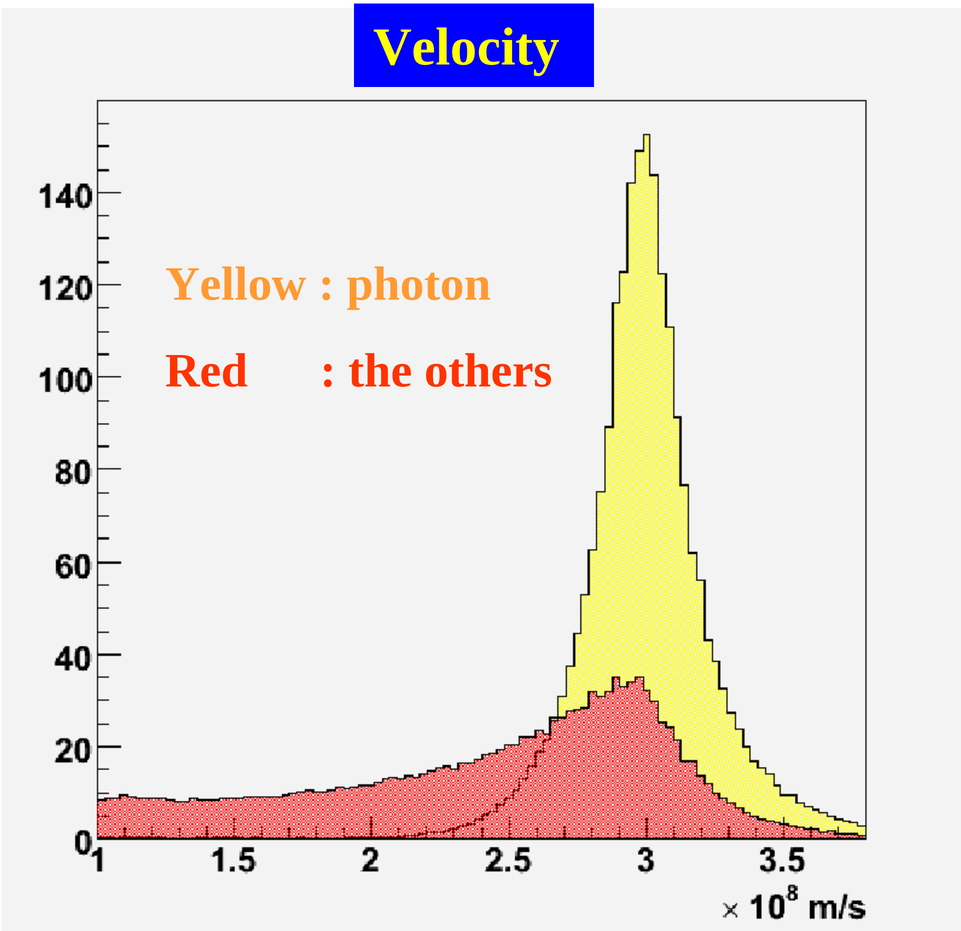
* Nhits : Number of hit cell in a cluster.



ECAL clusters in Z -> qqbar @ 91.2GeV

TOF Information

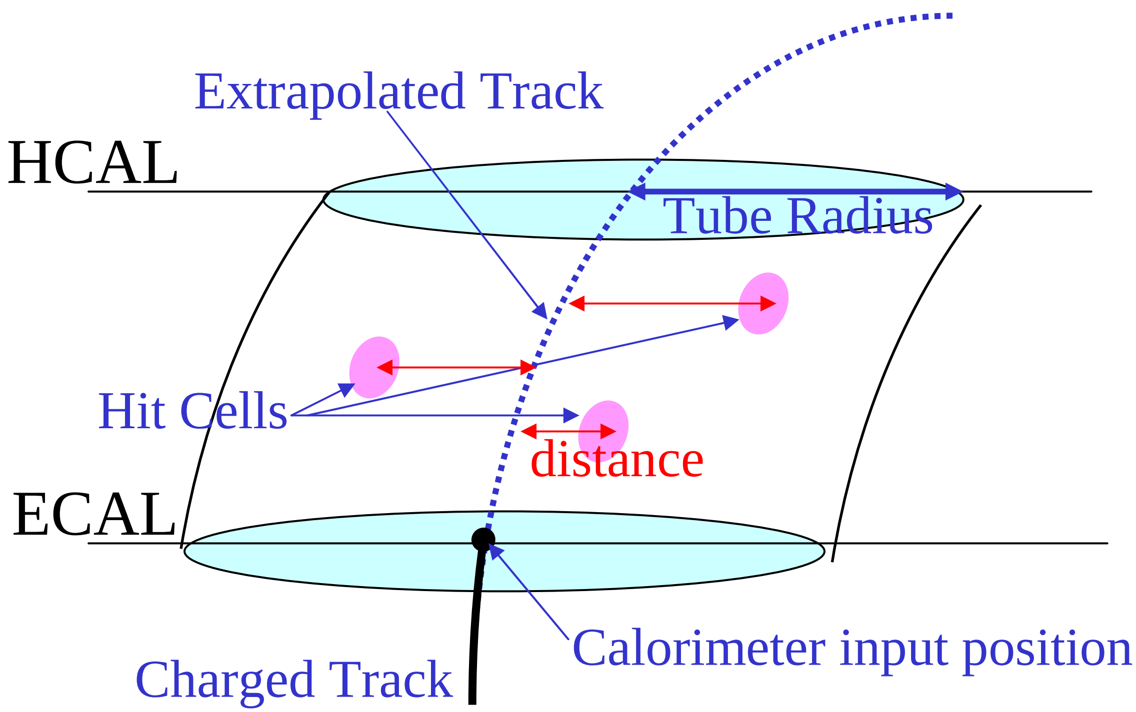
- Calculate velocity using cluster position and TOF information (R/TOF).
- TOF information of each hit is smeared by σ = 1.3 nsec Gaussian distribution in current simulator.



ECAL clusters in Z -> qqbar @ 91.2GeV

Charged Hadron Finding

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

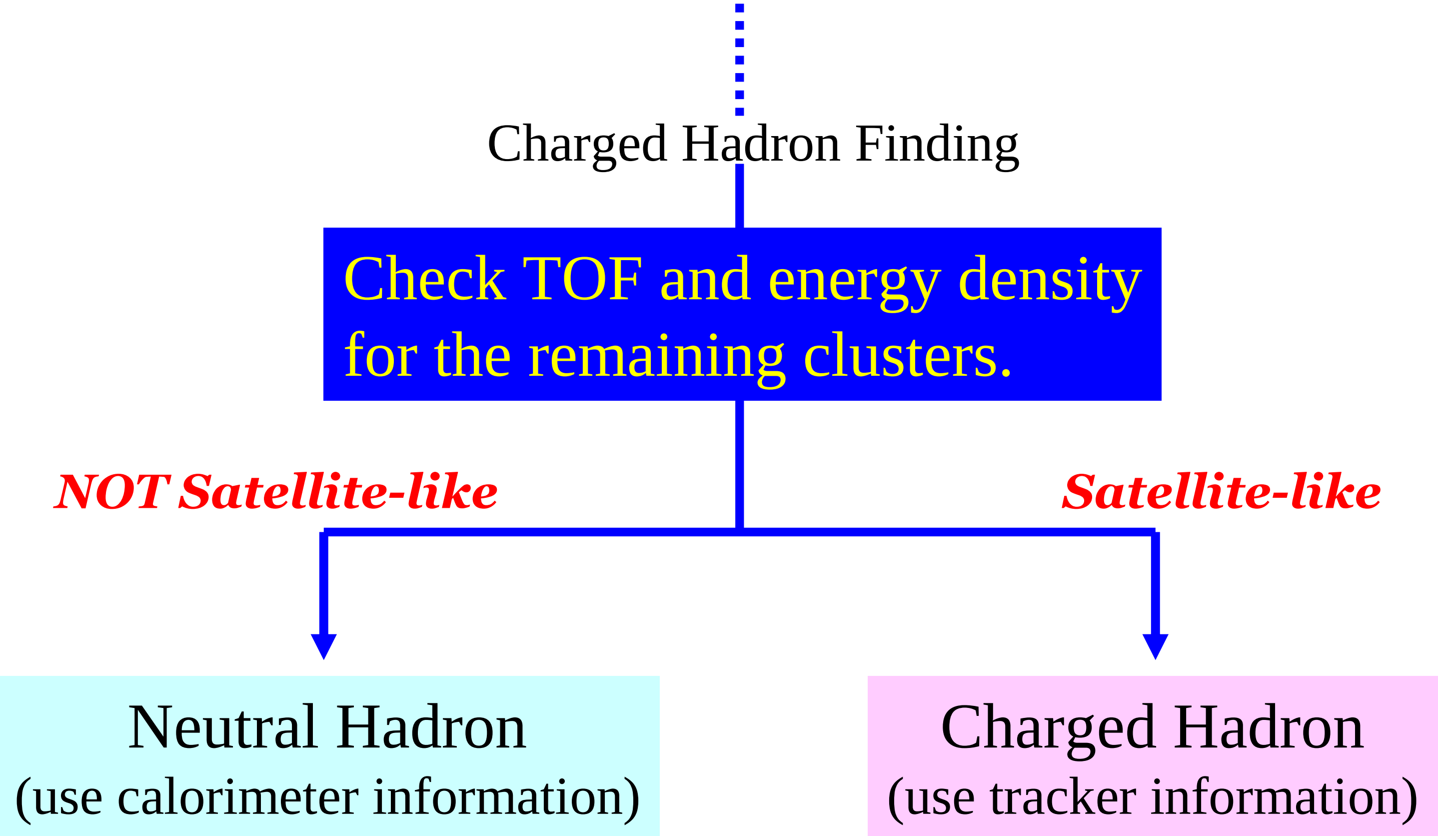


- Calculate the distance for any track/calorimeter cell combination.

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

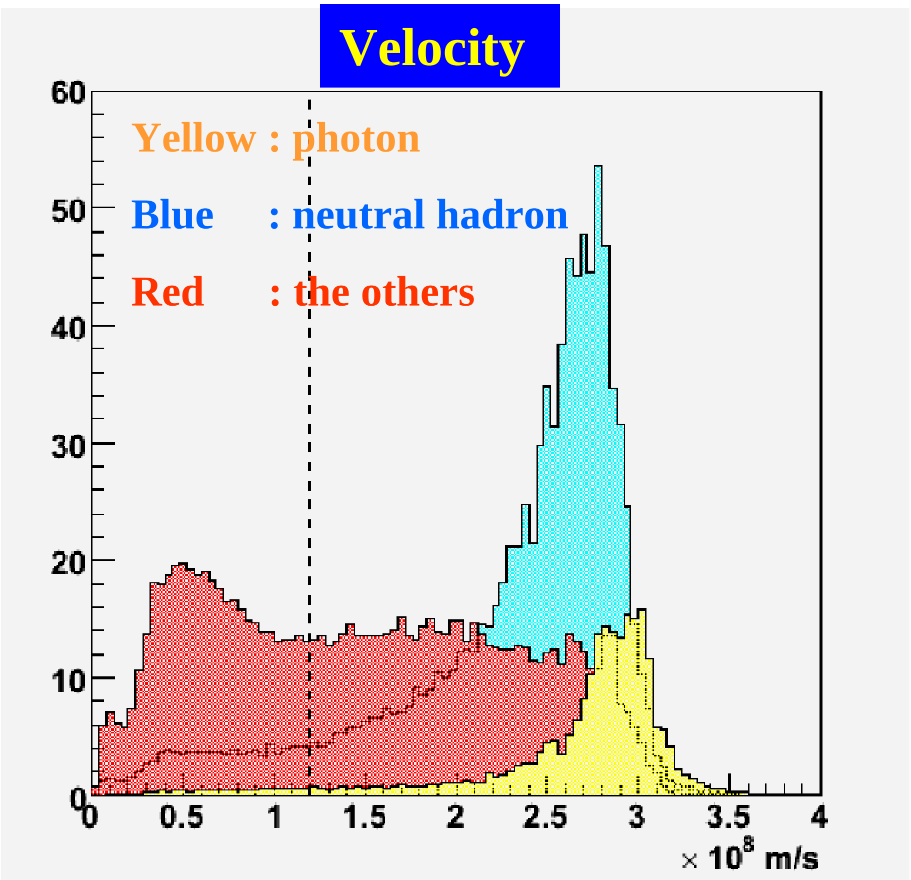
Neutral Hadron and Satellites Finding

Neutral Hadron and Satellites Finding



TOF Information

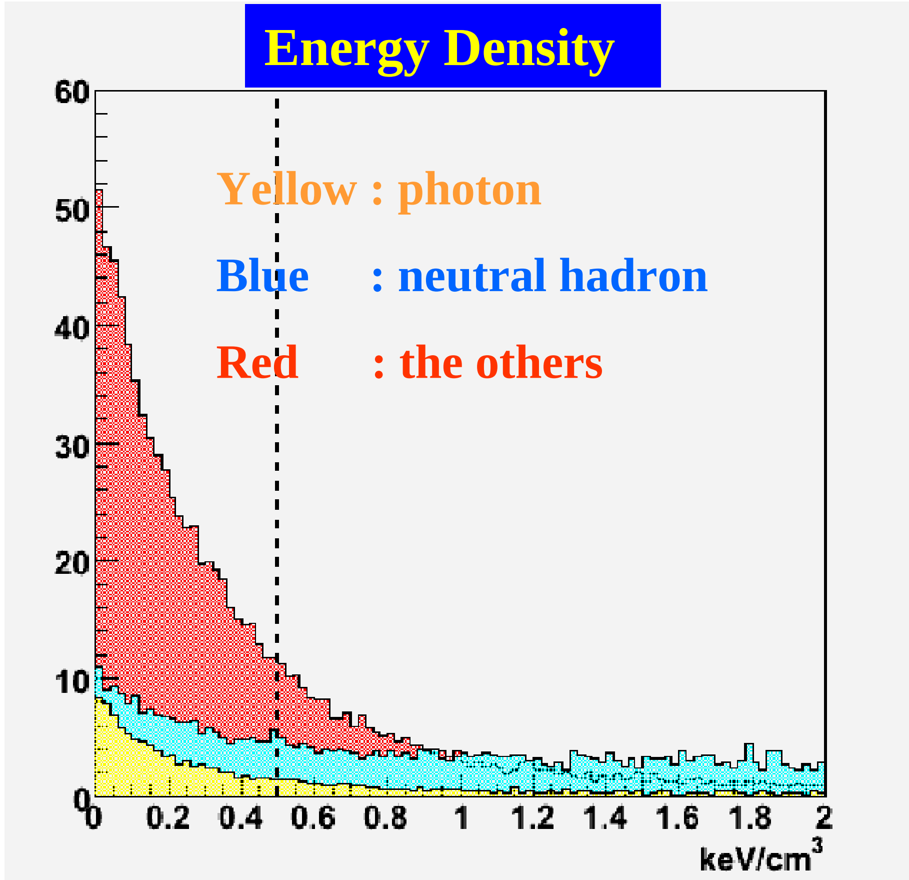
- Calculate velocity using cluster position and TOF information (R/TOF).
- Satellite hits due to charged hadron make a peak at slow velocity region.



Remaining clusters (Z -> qqbar @ 91.2GeV)

Energy Density

- Calculate energy density around a cluster center.
- Low energy-density cluster is regarded as satellite hits.



Remaining clusters (Z -> qqbar @ 91.2GeV)

Performance

Current total energy efficiencies are εphoton=85.2, εchd=84.4(94.9 with including satellites), εnhd=60.5 and cluster purities are Pphoton=92.2, Pchd=91.9 (89.0 with including satellites), Pnhd=62.2. (chd ≡ pi,p,K±, nhd ≡ n,K0L)

cluster type	ε photon	ε chd	ε nhd	Pphoton	Pchd	Pnhd
Photon	85.2	0.626	8.19	92.2	2.03	5.11
CHD	4.59	84.4	16.4	1.67	91.9	3.44
NHD	6.27	4.51	60.5	11.2	24.1	62.2
Satellite	3.94	10.5	14.9	8.90	70.9	19.4
CHD+Satellite	8.53	94.9	31.3	2.67	89.0	5.64

→ Pink one should be higher and blue one should be lower.

εxx ≡ (total xx E in collected hits)/(true xx total E in CAL) (efficiency)

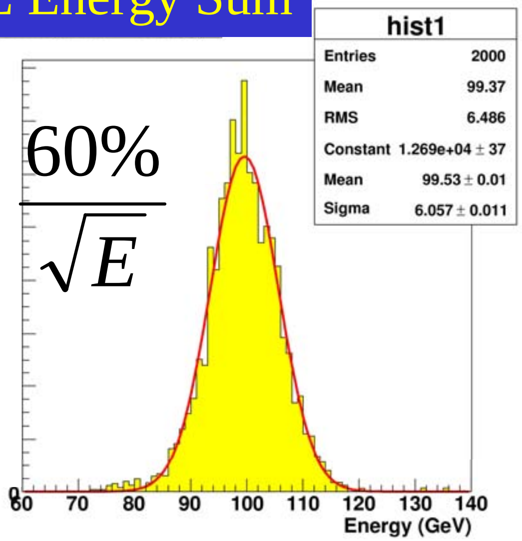
Pxx ≡ (total xx E in a cluster)/(total E in a cluster) (purity)

(both ε and P values are E-weighted one)

Z-pole Energy Resolution

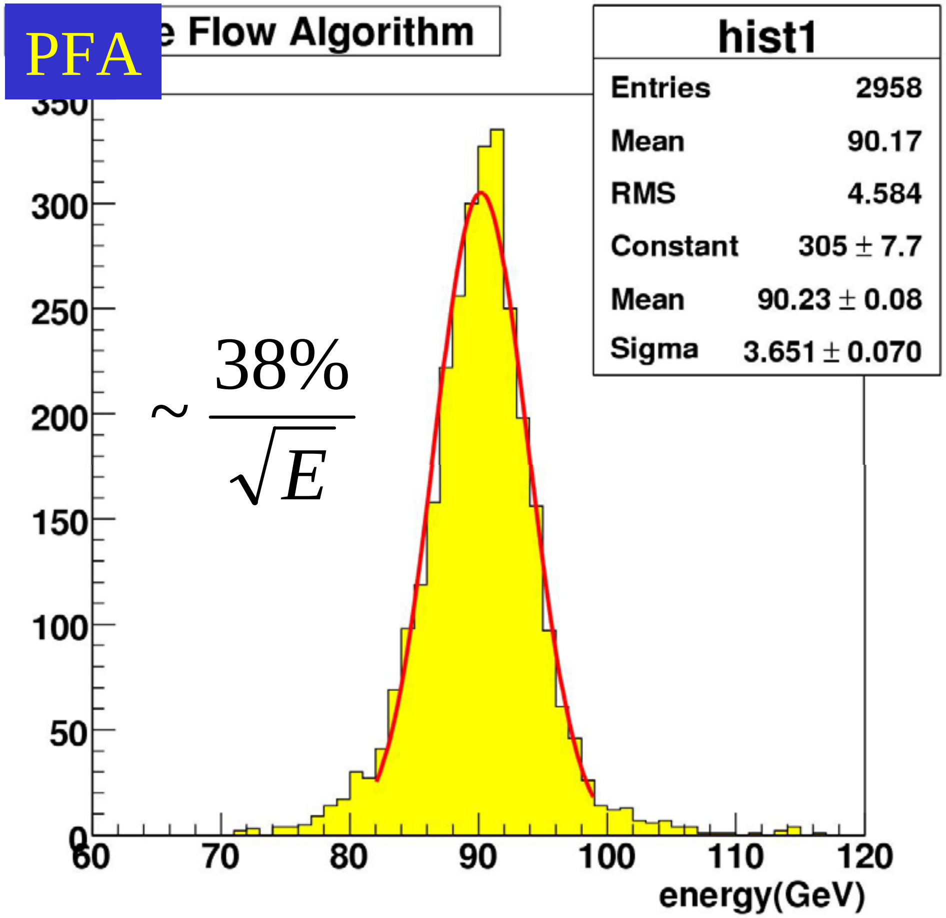
- $Z \rightarrow qq$ @ 91.18GeV

CAL Energy Sum



$\sim \frac{60\%}{\sqrt{E}}$

PFA



$\sim \frac{38\%}{\sqrt{E}}$

Simple way of PFA w/ GLD detector has achieved 38%/$\sqrt{E}$ energy resolution.

ZH Study by QuickSim

- $e^+e^-\rightarrow$Zh process has been studied by using fast simulator for GLD detector (QuickSim) in order to check performance of different parameter sets.

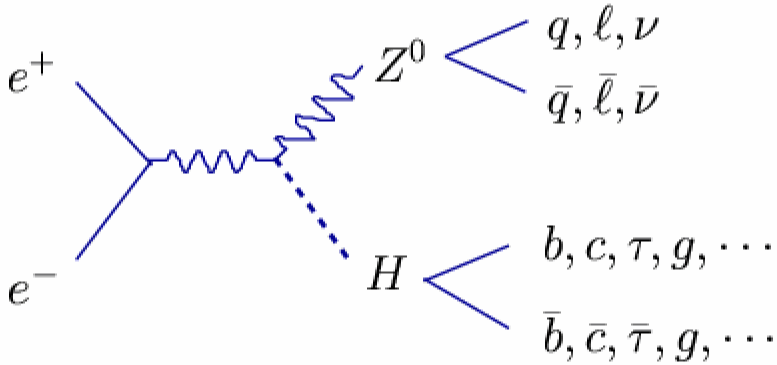
- Data equivalent to 500 fb^{-1} for both signal (ZH) and background (WW, ZZ, enW) have been produced.

- Center of mass energy and the Higgs mass were set to be 350 GeV and 120 GeV, respectively.

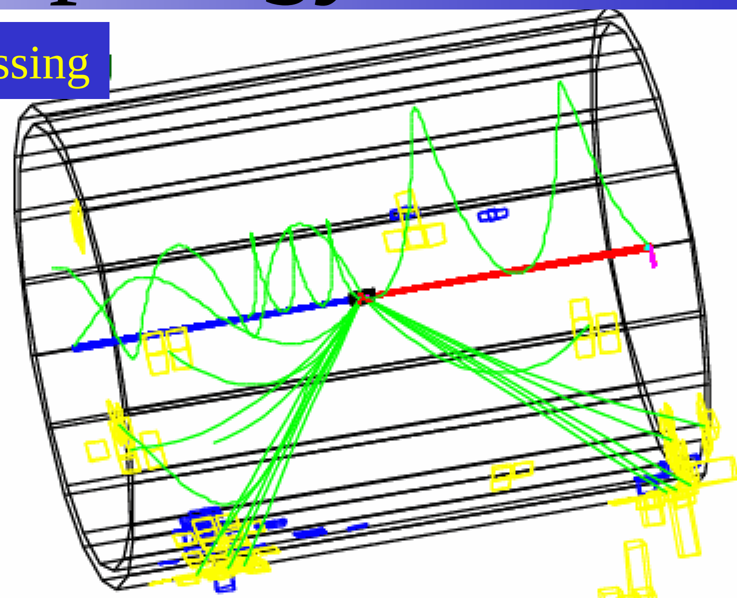
- Event selection was performed in each final state(i.e. 2-lepton, 2-jet and 4-jet in the final state).

Higgs Event Topology

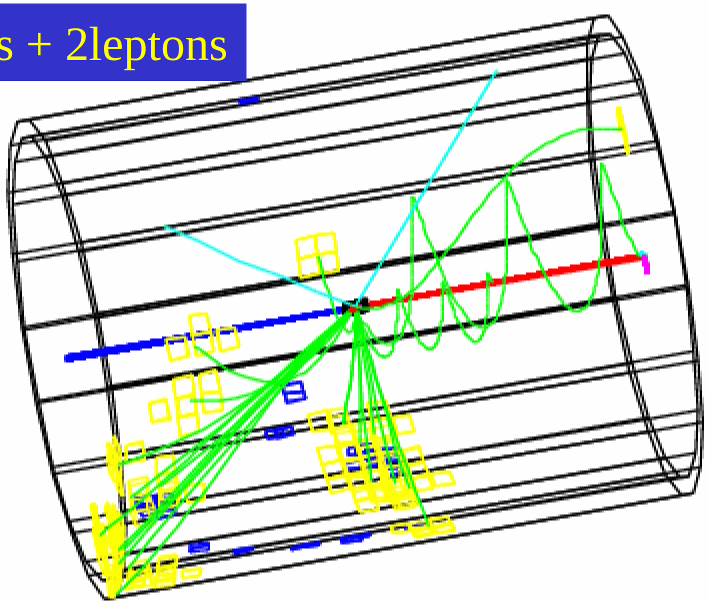
The Higgsstrahlung process can be classified according to its final state.



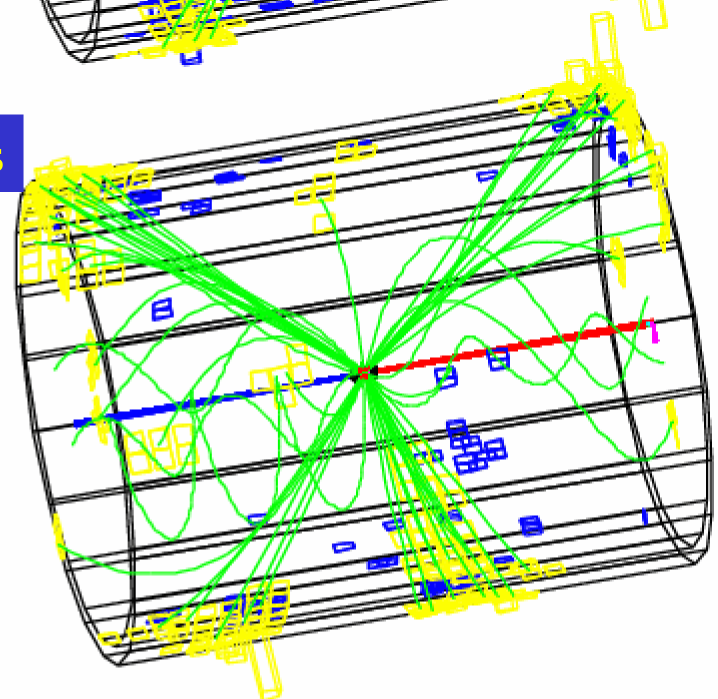
2jets + missing



2jets + 2leptons



4jets



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. Missing mass is consistent with the Z0 mass
2. Visible Energy 90 – 200 (GeV)
3. Missing Pt > 20 (GeV)
4. No. of Off Vertex Tracks > 6

Higgs Selection – 4-jet mode

- *Signal Signature : 4 jets*

Mass of 2-jet pair
= Mass of the other 2-jet pair = Z0

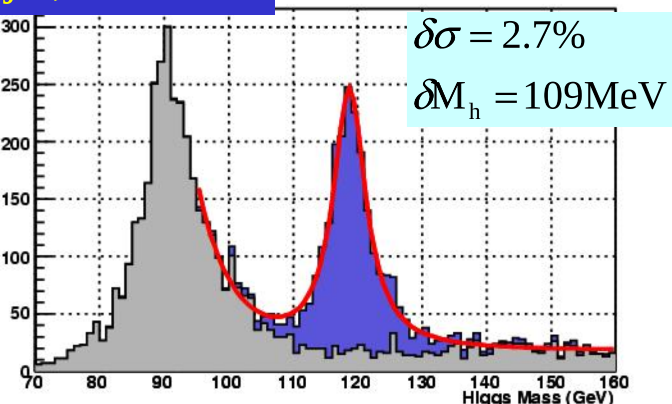
- *Selection Criteria*

1. Both invariant mass of a jet-pair and missing mass calculated from the other jet-pair are consistent with the Z0 mass.
2. Visible Energy > 240 (GeV)
3. Thrust < 0.90
4. No. of Off Vertex Tracks > 6

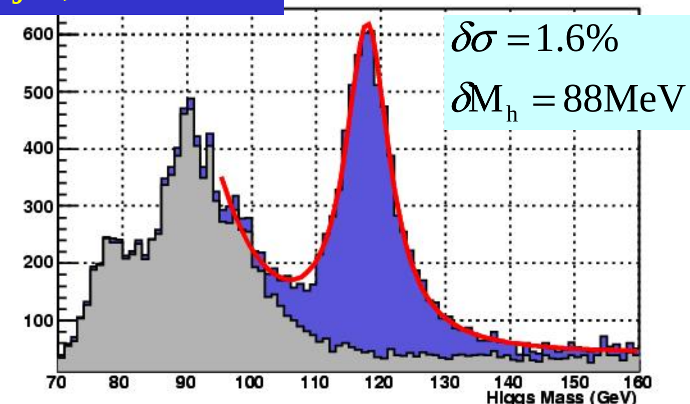
$e^+e^- \to Zh \to \nu\bar{\nu}b\bar{b}$ or $q\bar{q}b\bar{b}$

- E_{CM}=350GeV, M_h=120GeV, 500/fb, Background = ZZ, WW, eνW
- Different jet energy resolution (30%/$\sqrt{E}$, 40 %/$\sqrt{E}$)

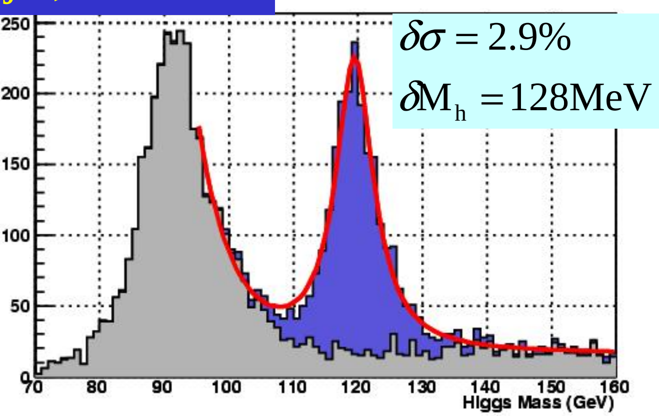
2jet, 30%/$\sqrt{E}$



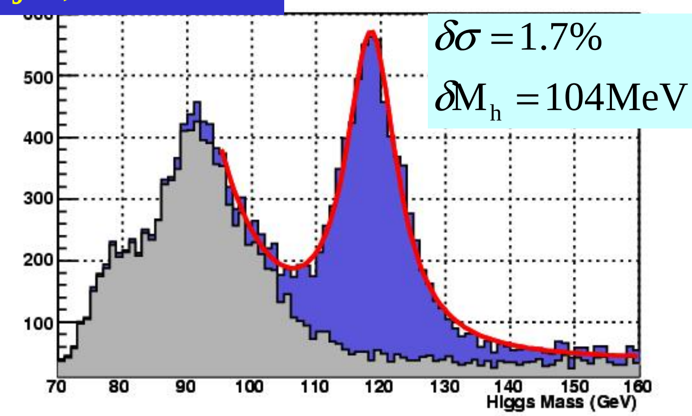
4jet, 30%/$\sqrt{E}$



2jet, 40%/$\sqrt{E}$



4jet, 40%/$\sqrt{E}$



Higgs Selection – 2-lepton mode

- *Signal Signature : 2 leptons + anything*

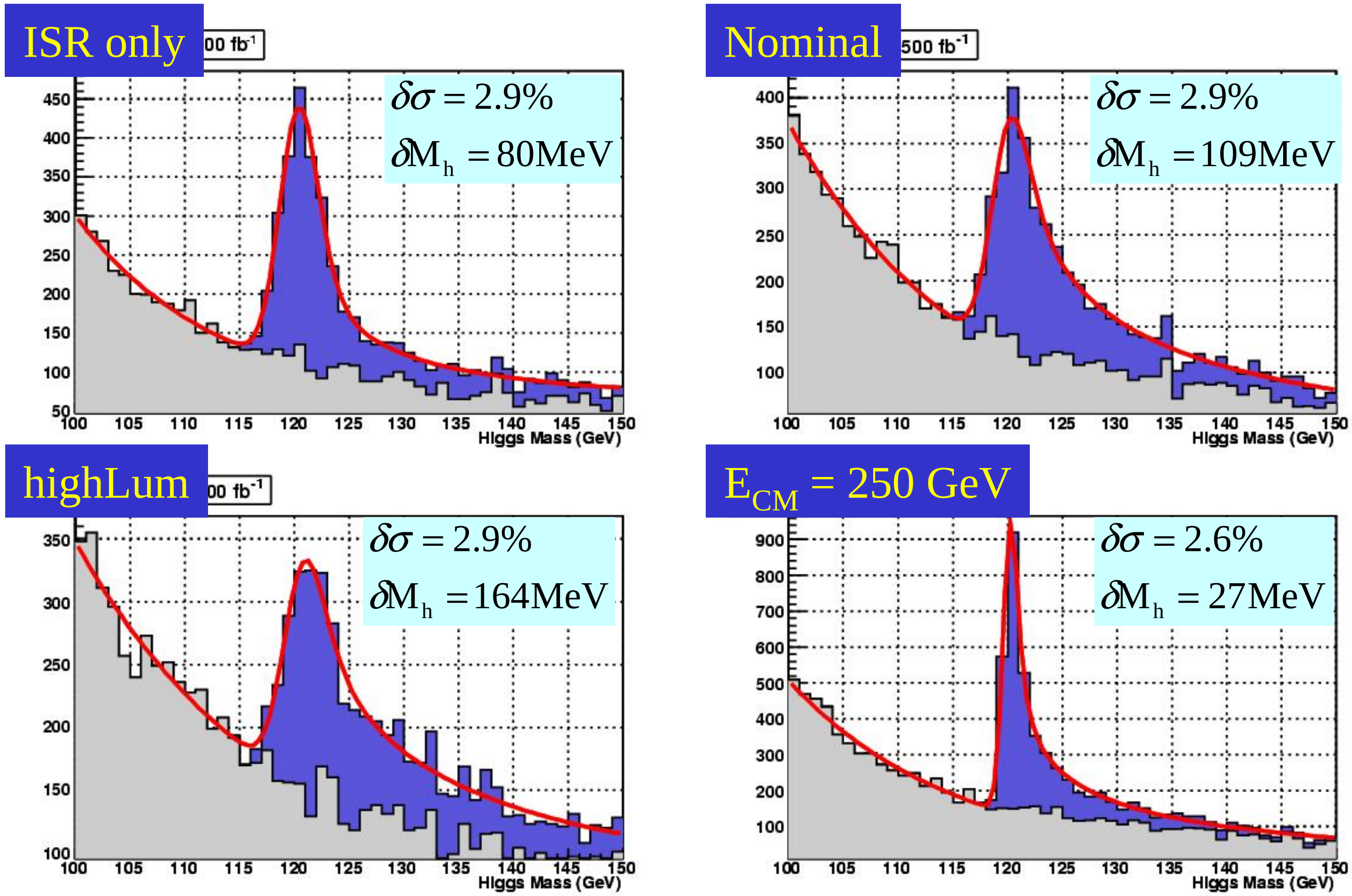
  Mass of 2 lepton pair = Z0

- *Selection Criteria*

  1. Invariant mass of 2 lepton pair is consistent with the Z0 mass.
  2. Visible Energy > 250 (GeV)
  3. $|\cos\theta_{1,2}|$ < 0.9
  4. No. of Off Vertex Tracks > 4

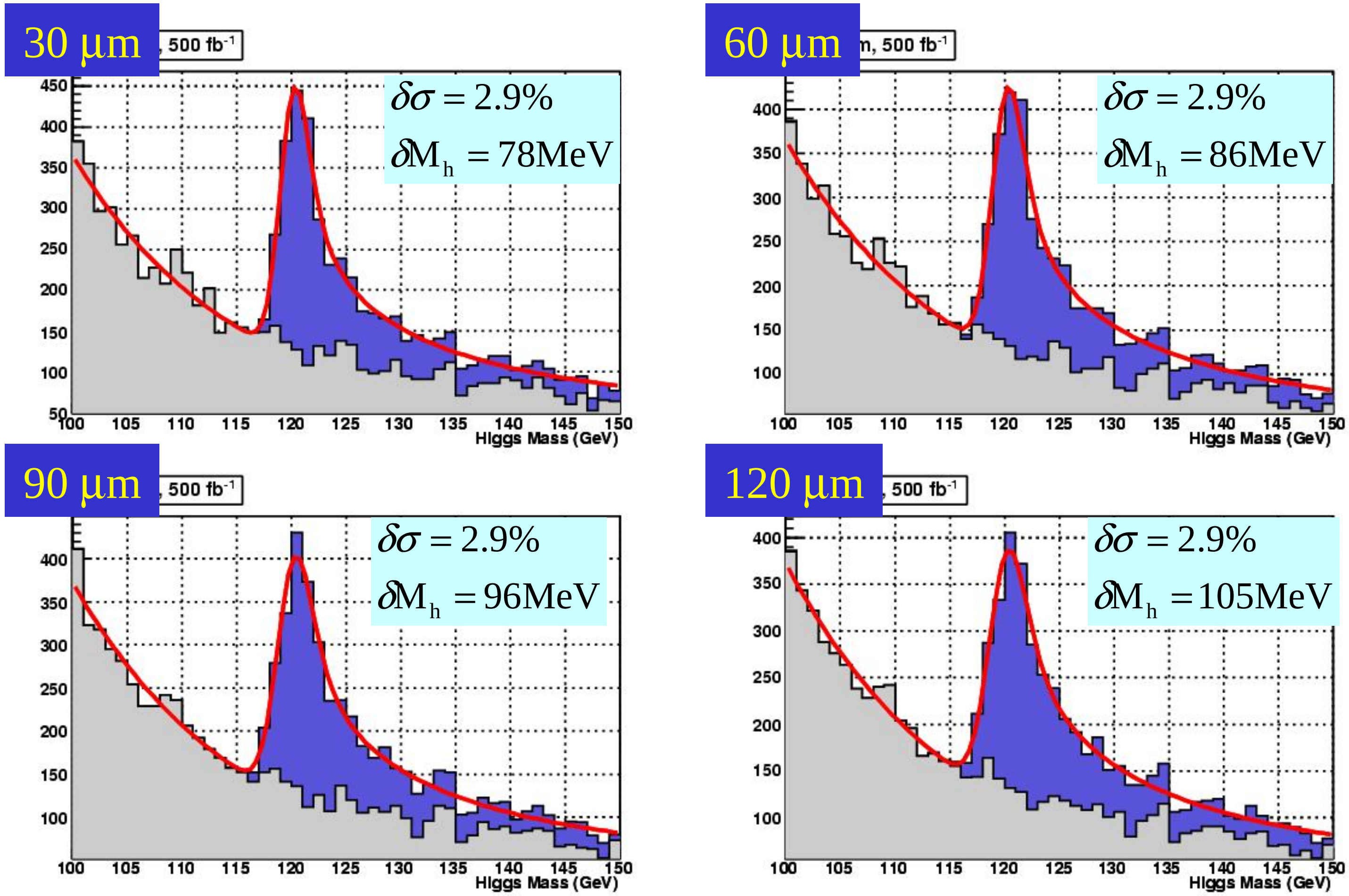
$e^+e^- \to ZH \to llX$

- E_{CM}=350GeV, M_h=120GeV, 500/fb, Background = ZZ
- Different machine parameters



$e^+e^- \rightarrow ZH \rightarrow llX$

- E_{CM}=350GeV, M_h=120GeV, 500/fb, Background = ZZ
- Different TPC spatial resolution



Summary

- Particle Flow Algorithm for GLD detector has been developed.
  For Z-pole event, we got the following performance.
  - Gamma Finding
    Efficiency : 85.2%, Purity : 92.2%
  - Charged Hadron Finding
    Efficiency : 94.9%, Purity : 89.0%
  - Energy Resolution : 38%/$\sqrt{E}$
- $e^+e^- \rightarrow Zh$ process has been studied by using the QuickSim
  with different parameter sets.
  - ~20% worse mass accuracy for the case of 40% jet energy resolution.
  - >20% worse mass accuracy with including beamstrahlung effect.
  - ~ 20% better mass accuracy for the case of 30μm of the TPC spatial resolution.