Neutral Particle ID Status in PFA

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for Steve Magill, U.S. LC Calorimeter Group

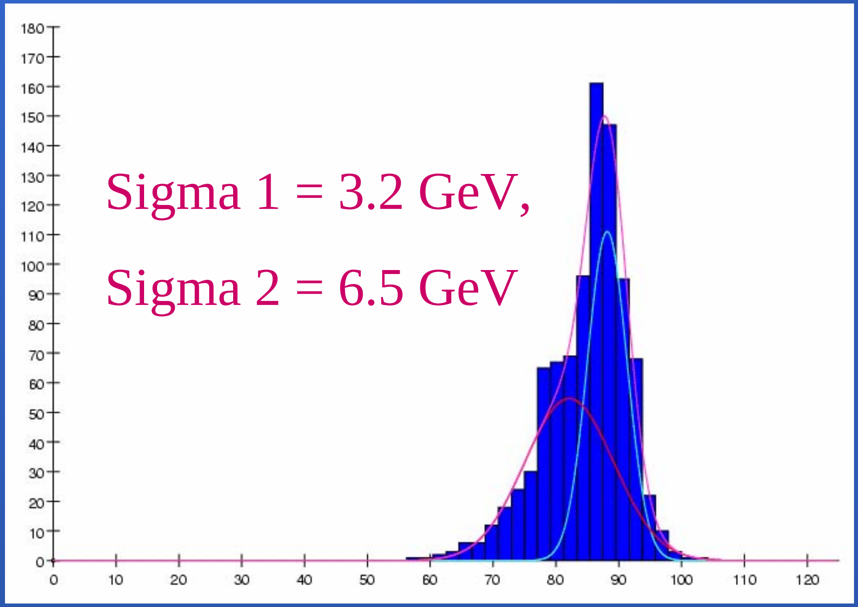
Photon ID Update With HMatrix

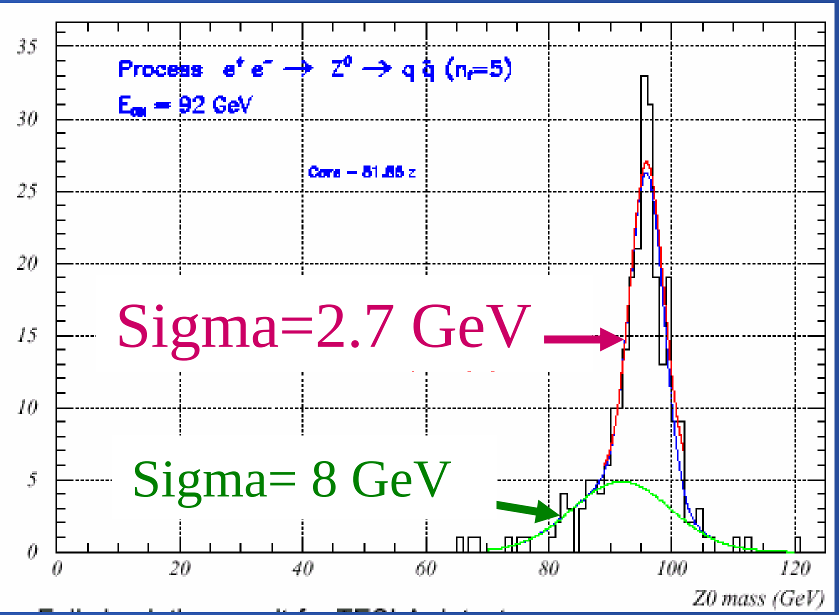
Photon/Neutron Tagging with Neural Net

Modified Slide From Jan PFA meeting

Magill, Kuhlmann, …, "SiD-Like" Detector

Morgunov et al. PFlow, "SNARK" Package, "LDC-Like" Detector





Si Tracker, Small Size, RPC HCal, Si/W Ecal…

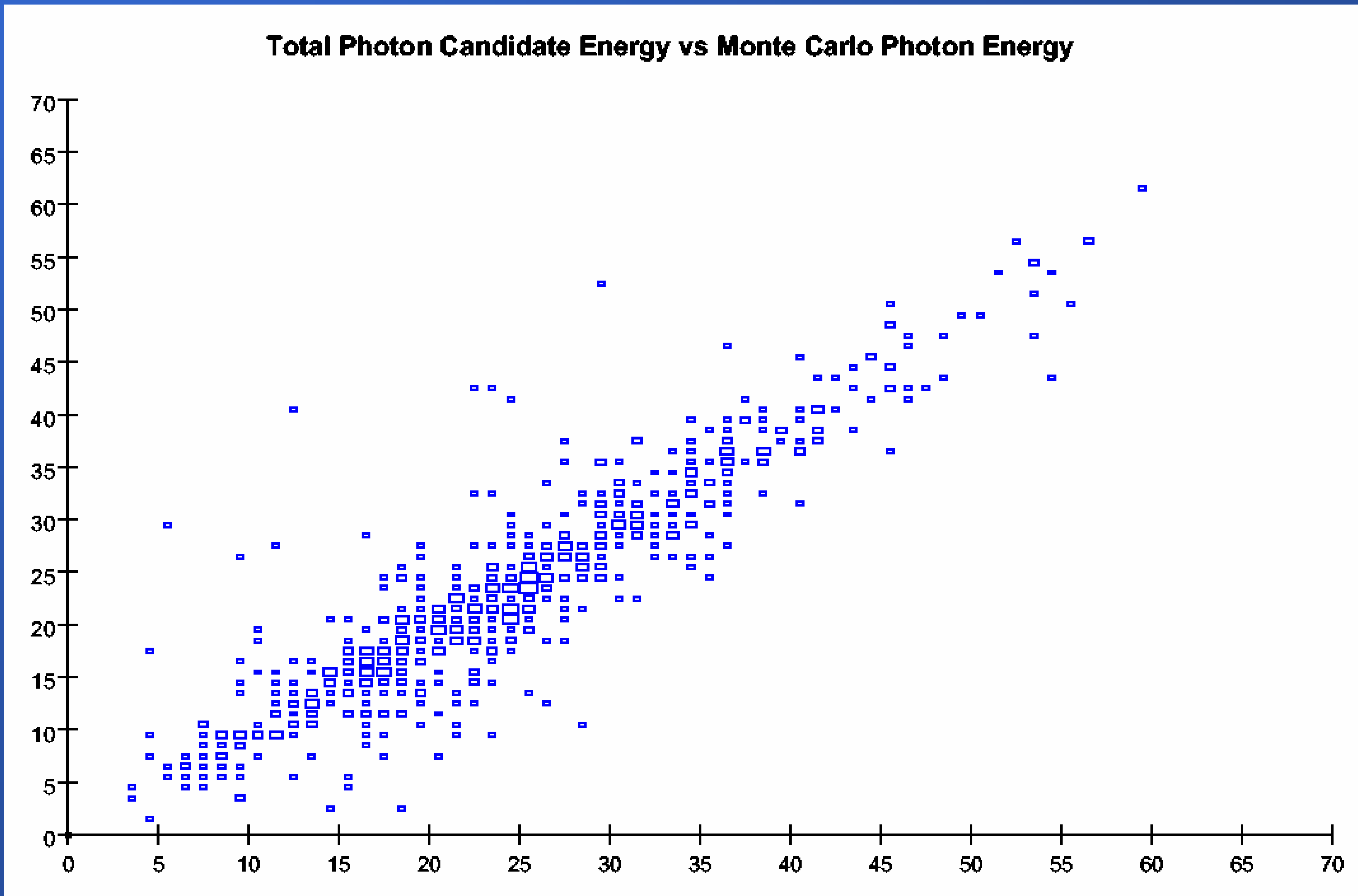
Gas Tracker, Medium Size, Scint HCal, Si/W Ecal…

- Remove MIP Hits from Tracks (finished and in org.lcsim)
- Remove Hits From Photons Using Real Algorithm (Snowmass goal)
- Then Remove Remaining Hits from Tracks (finished and in org.lcsim)
- Then Cluster the Remaining Hits for Neutrons/K_{Long} (finished and in org.lcsim)
- Add a Neural Net for Neutron/K_{Long} Quality and Energies (Snowmass goal)

Simple 3 cut photon finder from Jan 2003 (!), not good enough for champagne

1. Reject EM Clusters if within Delta-R<0.03 from Track (0.2% loss of real photons)
2. Shower Max Energy > 30 MeV (MIP=8 MeV)
3. Reject EM Cluster if Delta-R< 0.1 AND E/P<0.1

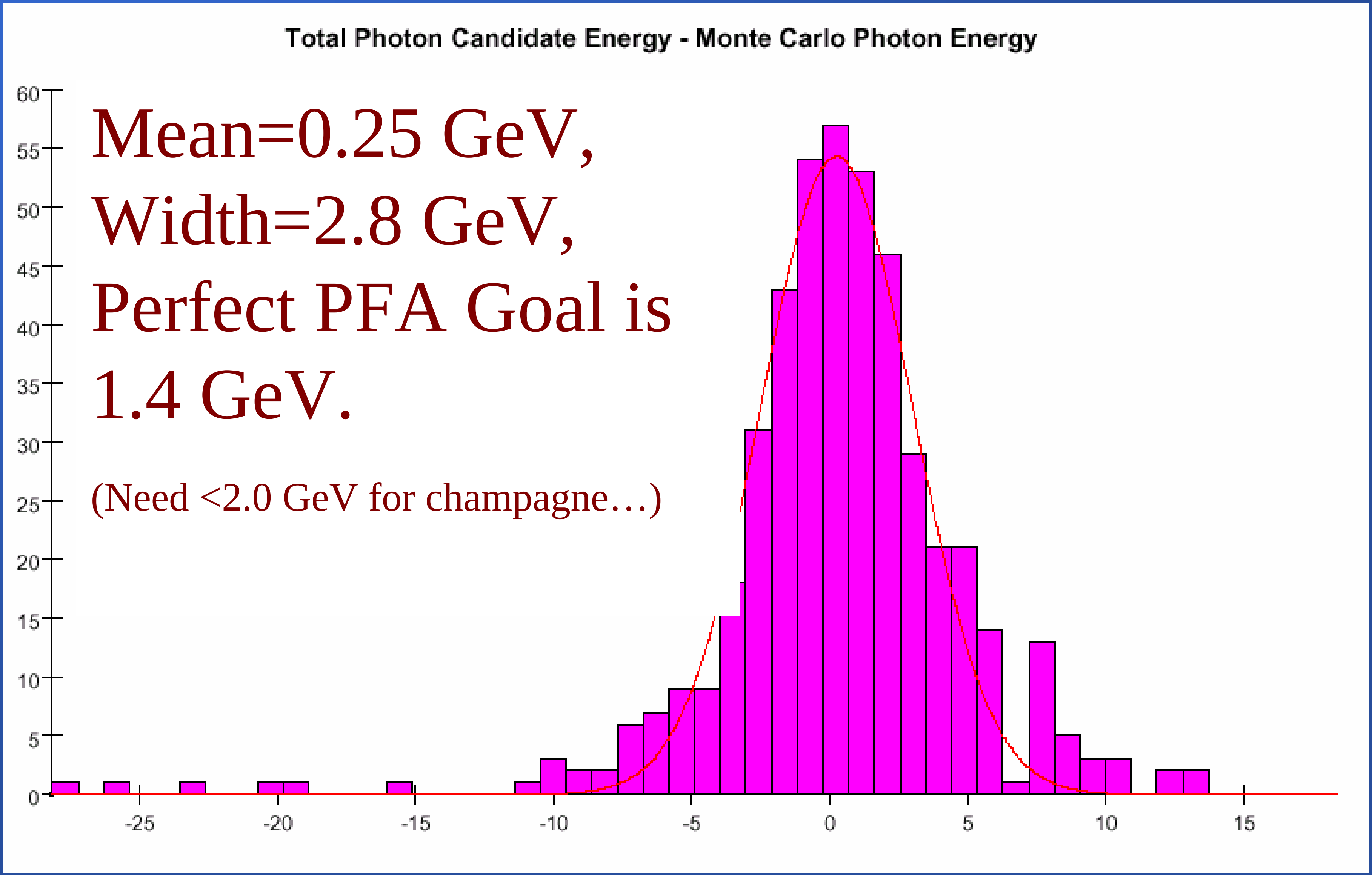
Hadronic Z Decays at $\sqrt{s}$ = 91 GeV



Total Photon Candidate Energy

Total Hadron Level Photon Energy (GeV)

Hadronic Z Decays at √s = 91 GeV



Total Photon Energy - Total Monte Carlo Photons (GeV)

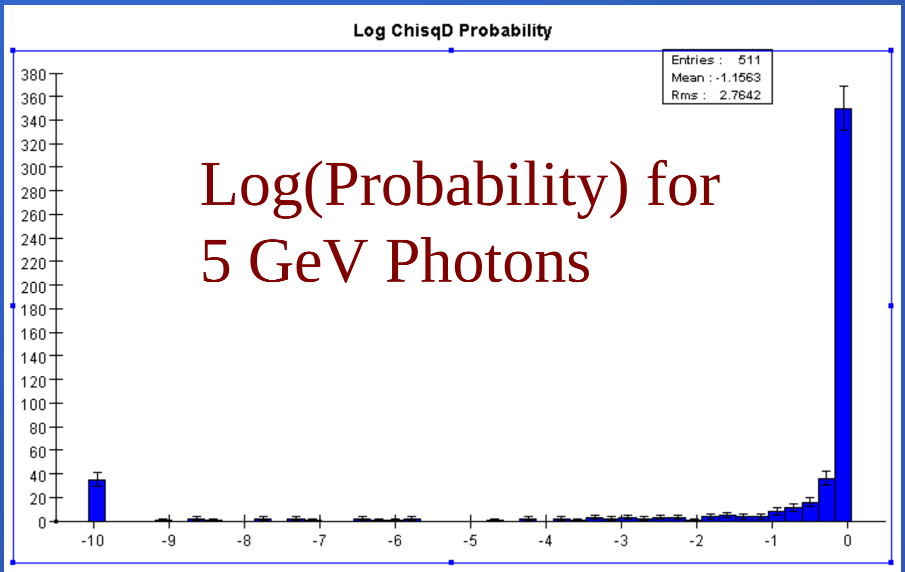
1. Reject EM Clusters if within Delta-R<0.03 from Track (0.2% loss of real photons)

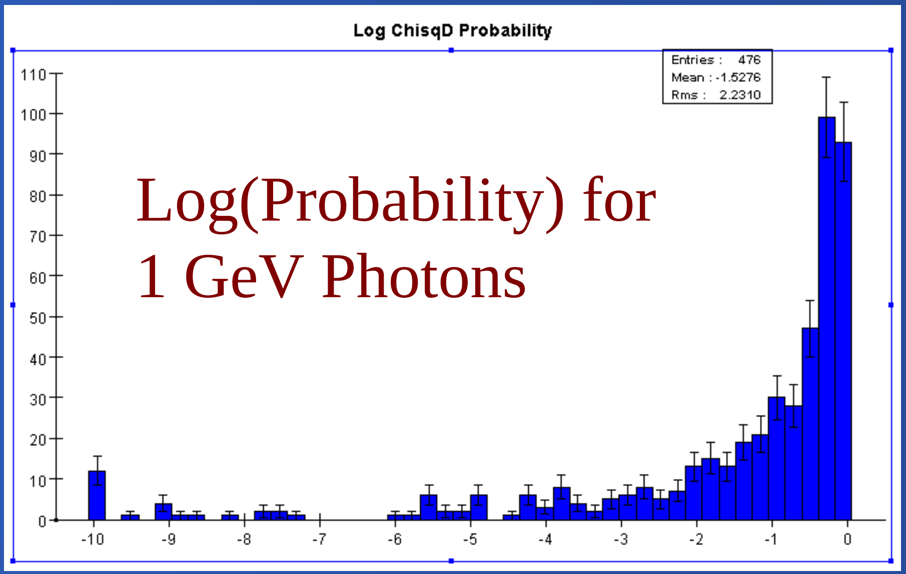
2. Shower Max Energy > 30 MeV (MIP=8 MeV)

3. Reject EM Cluster if Delta-R< 0.1 AND E/P<0.1

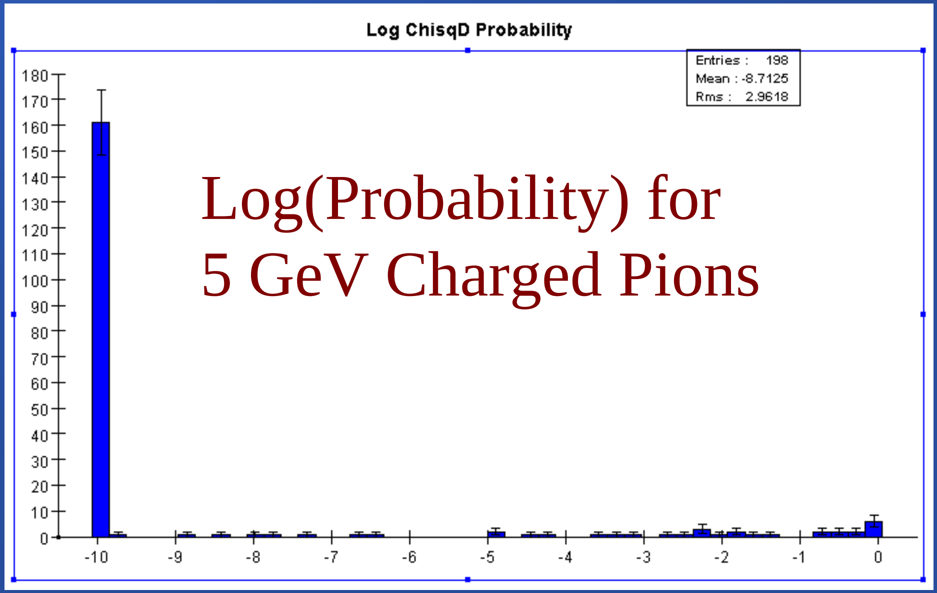
Replace with
Norman’s HMatrix

HMatrix Performance

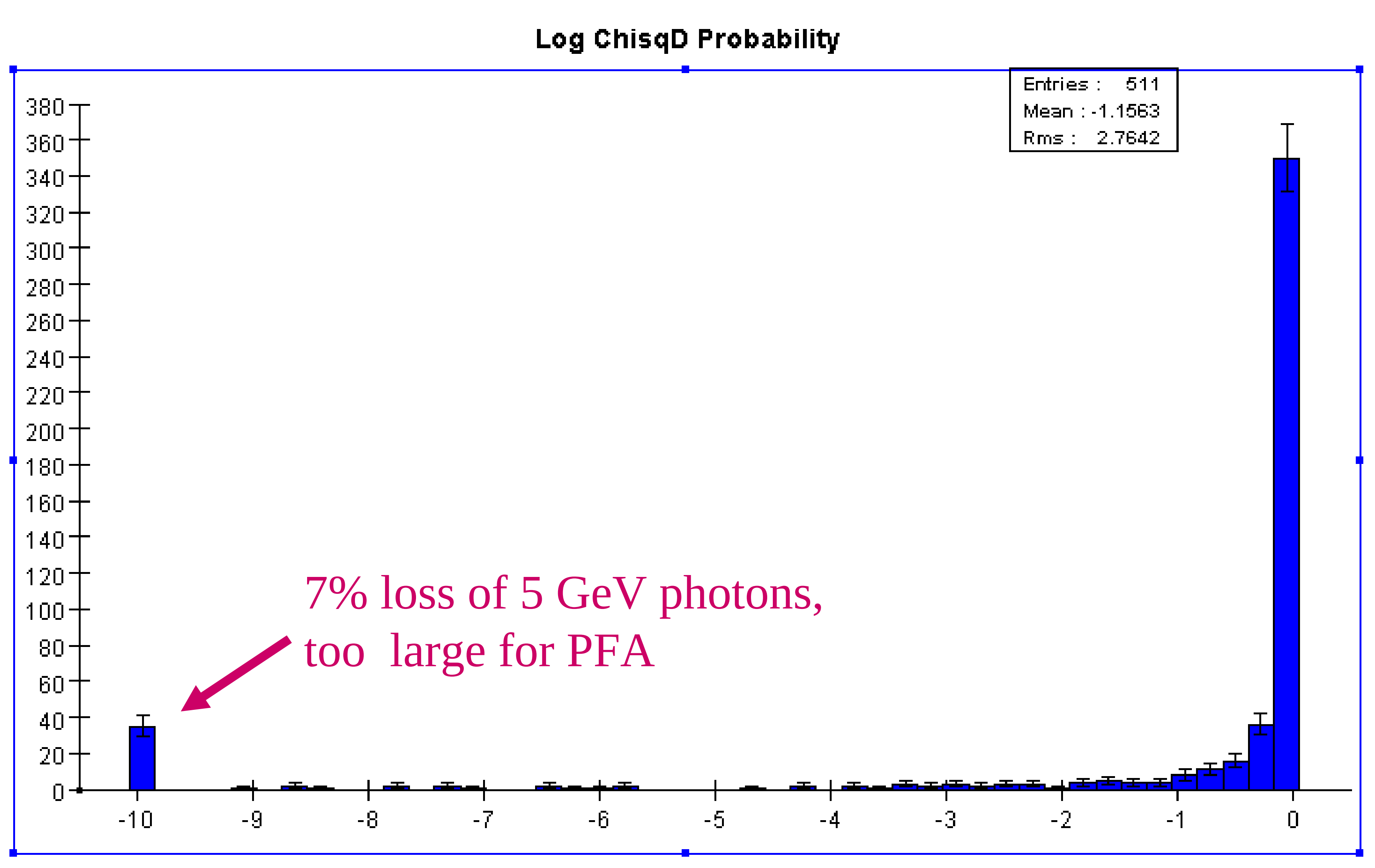




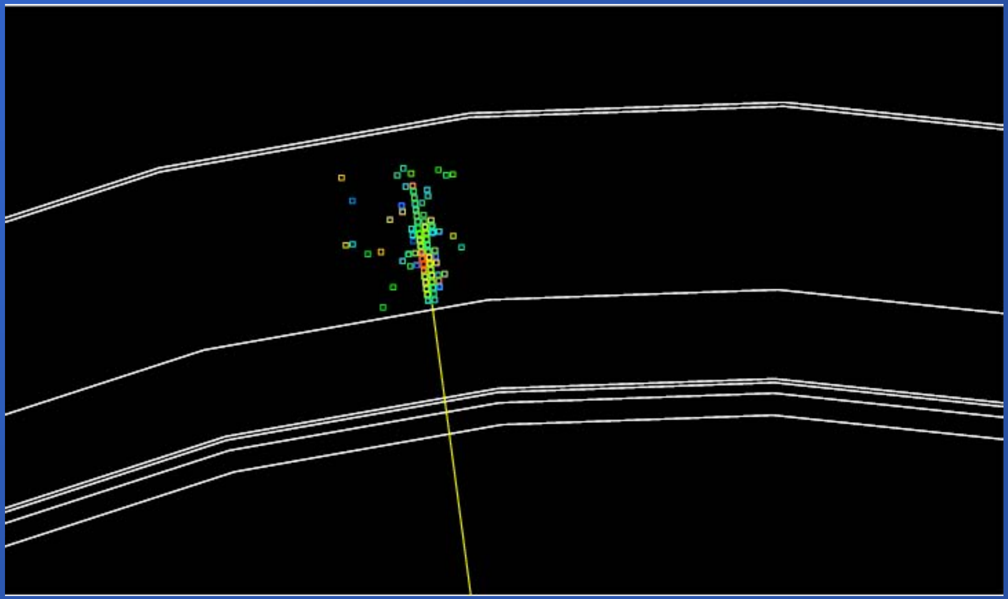
Need samples with 250, 500, 750 MeV

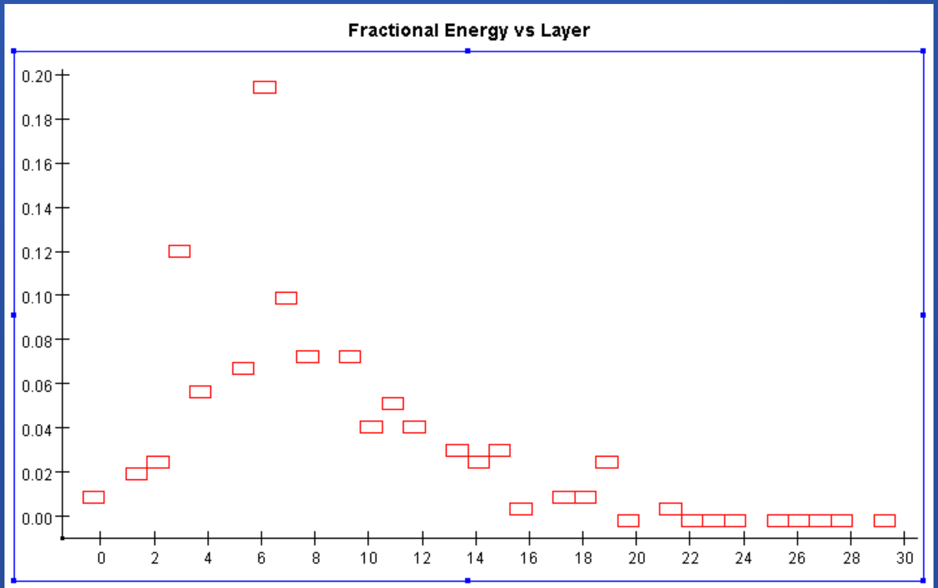


HMatrix Performance

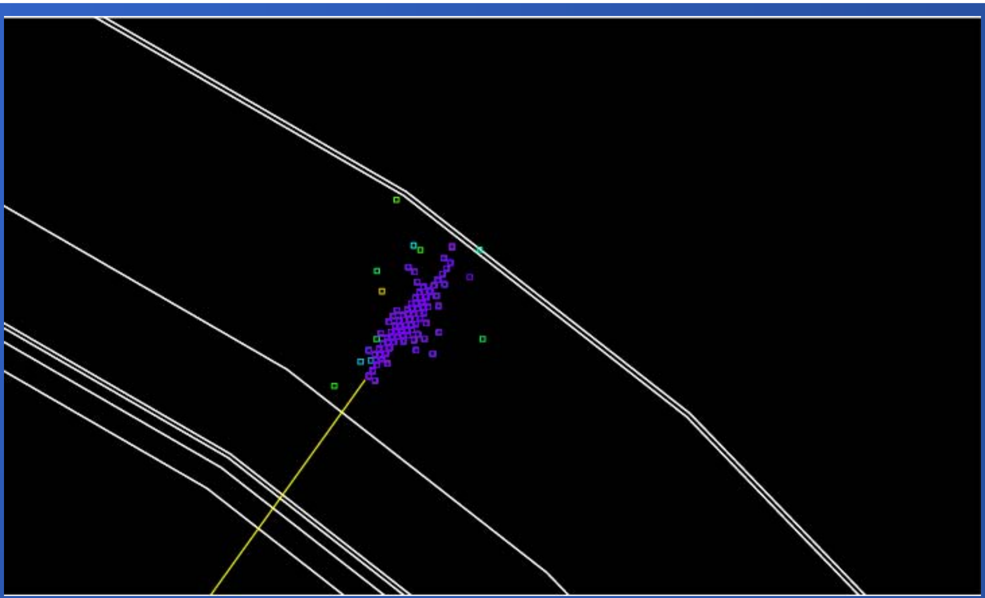


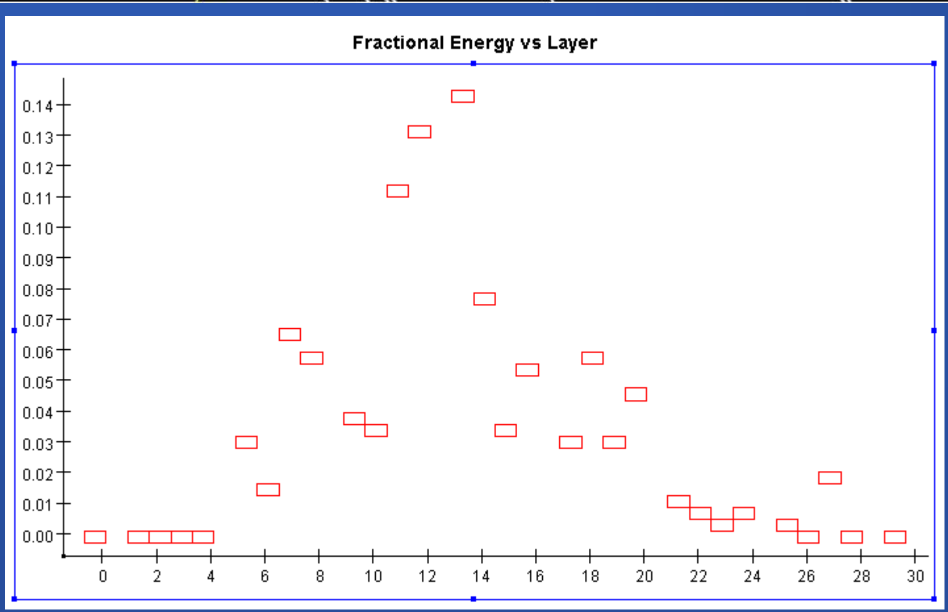
Example of Good Chisq





Example of Bad Chisq

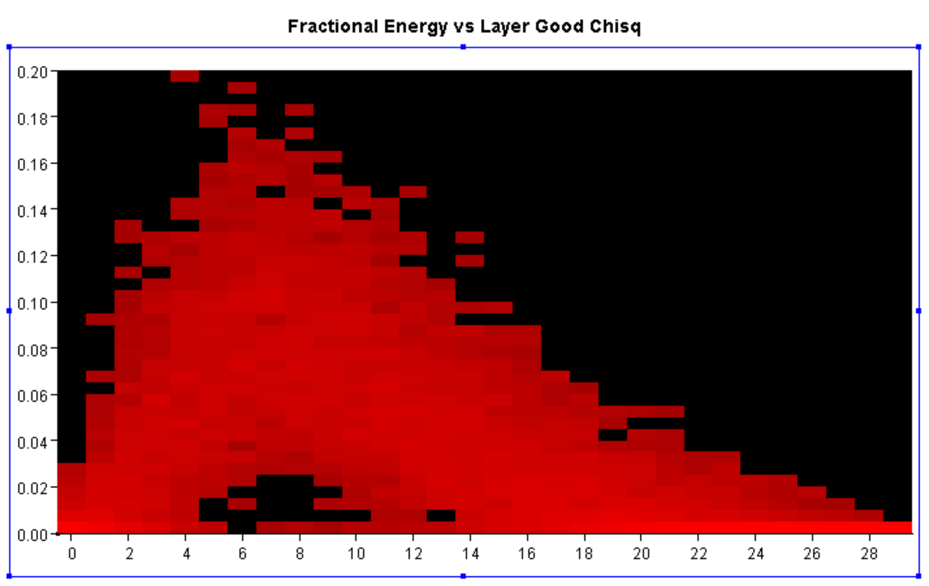


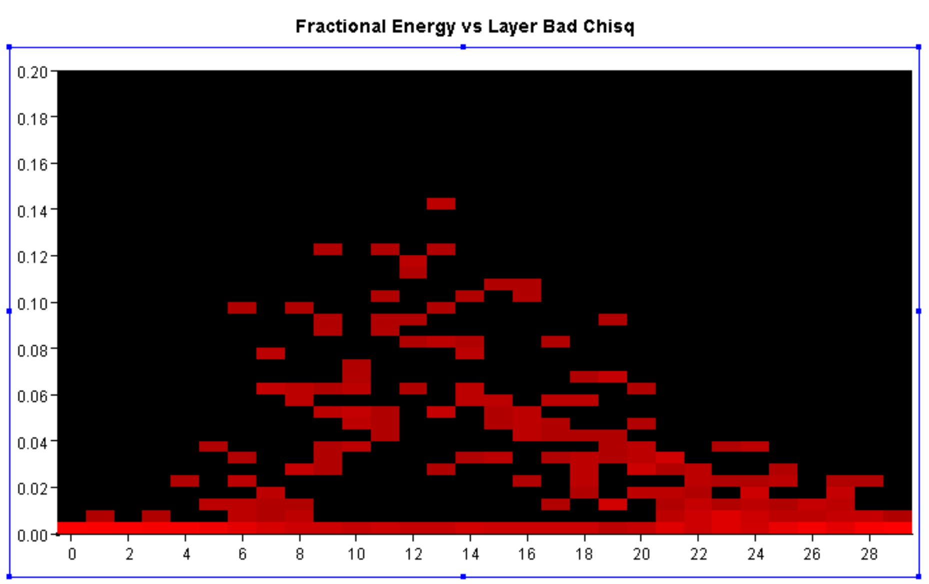


Good vs Bad Chisq

5 layers = 3.3 X0

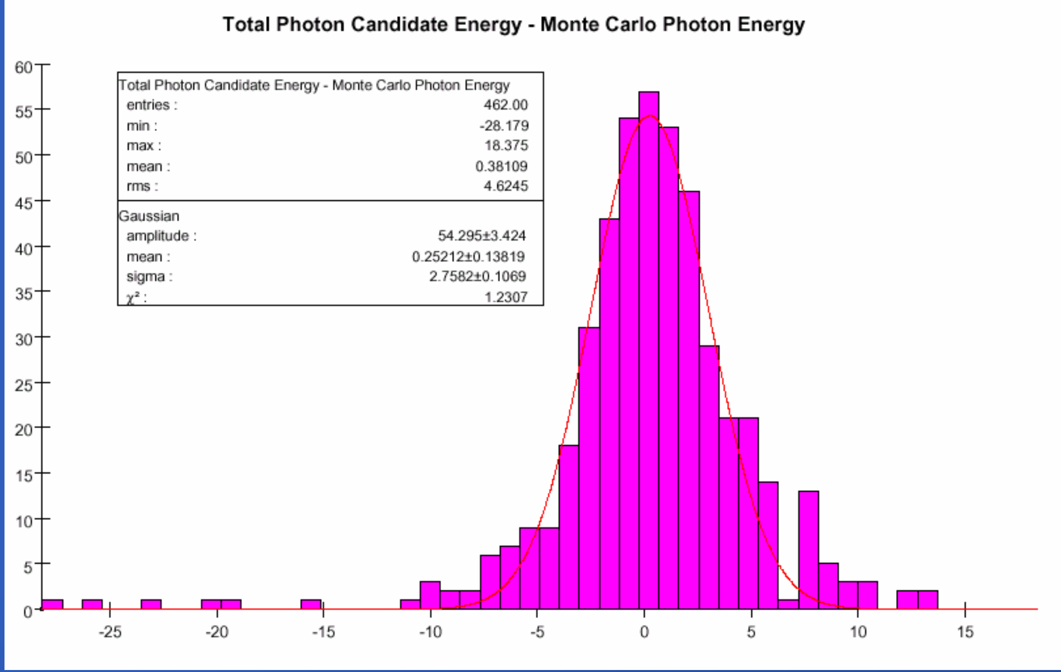
1 – EXP(-7/9 * 3.3) = 7%





Hadronic Z Decays at $\sqrt{s}$ = 91 GeV

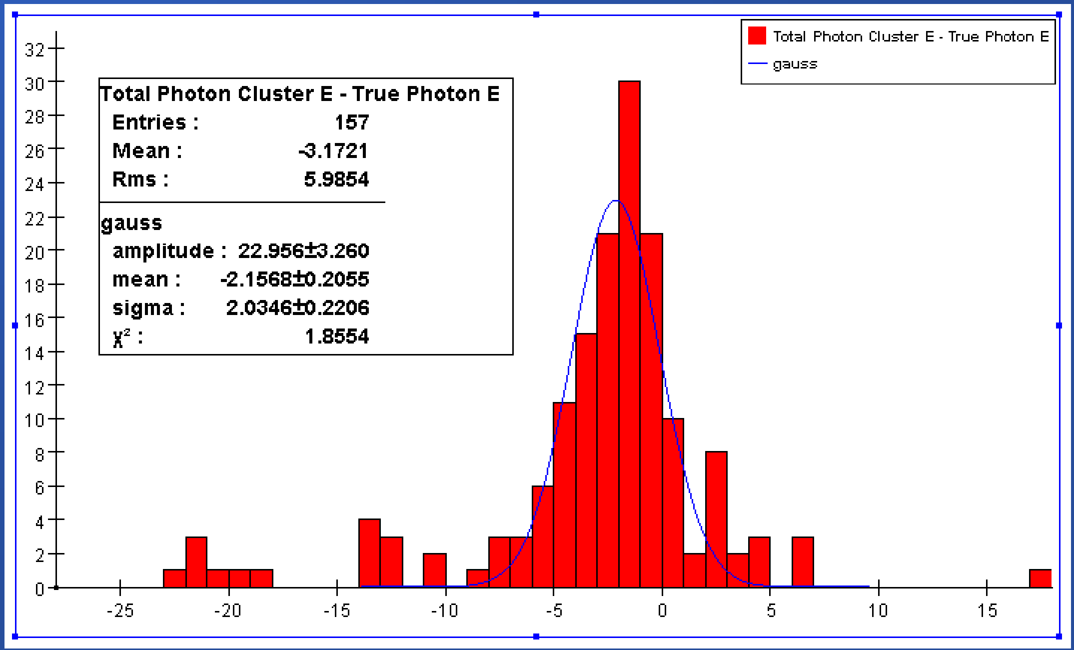
Simple 3 cut Photon Finder,
Peak 0.25 GeV, Sigma 2.8 GeV



HMatrix

Peak -2.2 GeV, Sigma 2.0 GeV

Larger Tails



Total Photon Energy - Total Monte Carlo Photons (GeV)

Next step in neutron algorithm is to send unused hit clusters to the SLAC Neural Net for quality cut.

Test hep.lcd example code (done)

Convert to org.lcsim (debugging)

Retrain net with latest detectors?

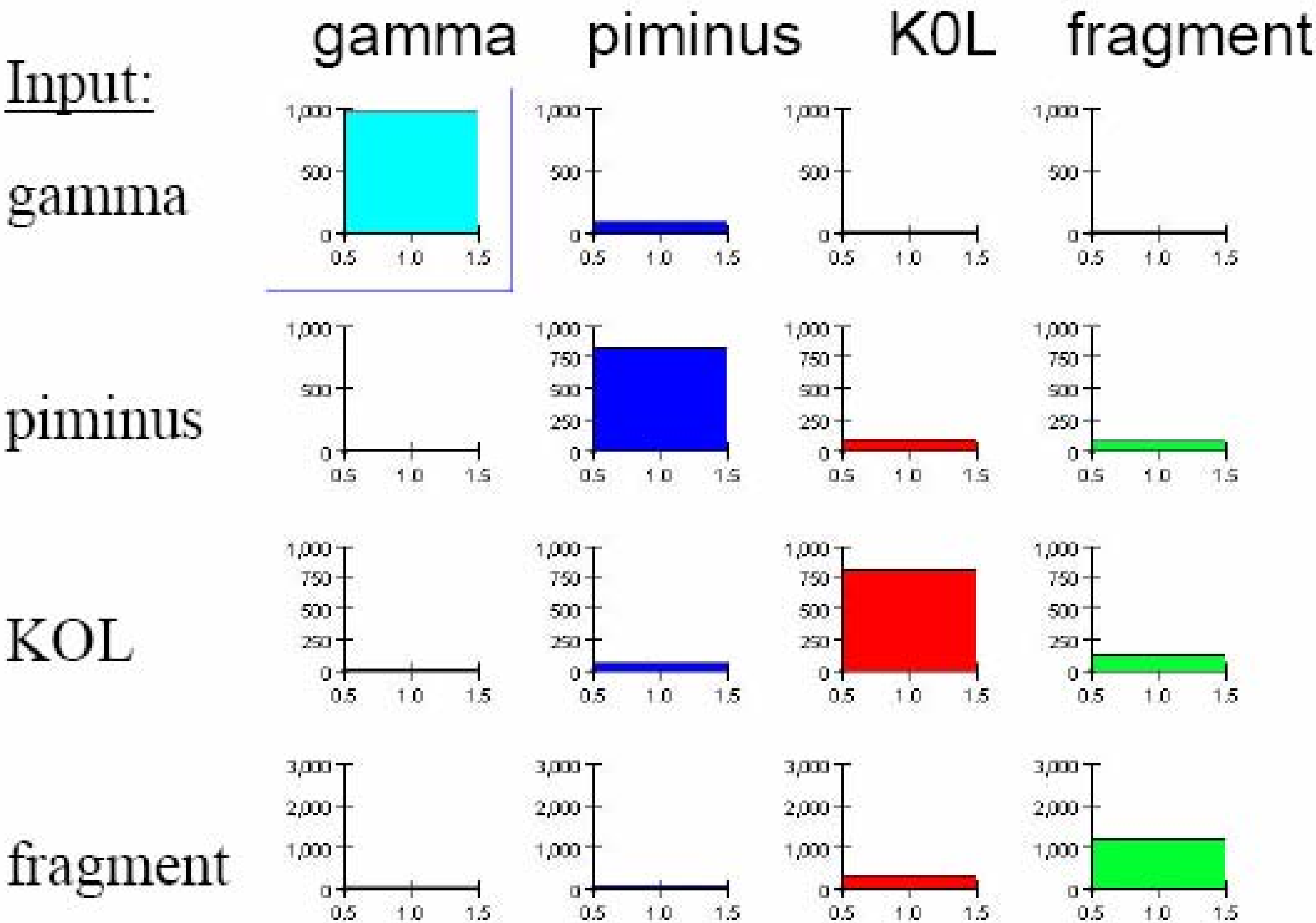
Cluster identification

- Use cluster properties + a neural net to identify the particle that created the cluster.
- The ClusterID algorithm (by Bower, Cassell, Pathek) currently identifies gammas, charged hadrons, neutral hadrons and fragments. Available in CVS.
- http://wwwsldnt.slac.stanford.edu/nld/ClusterID/
- Web page is underdevelopment.

15 Discriminators

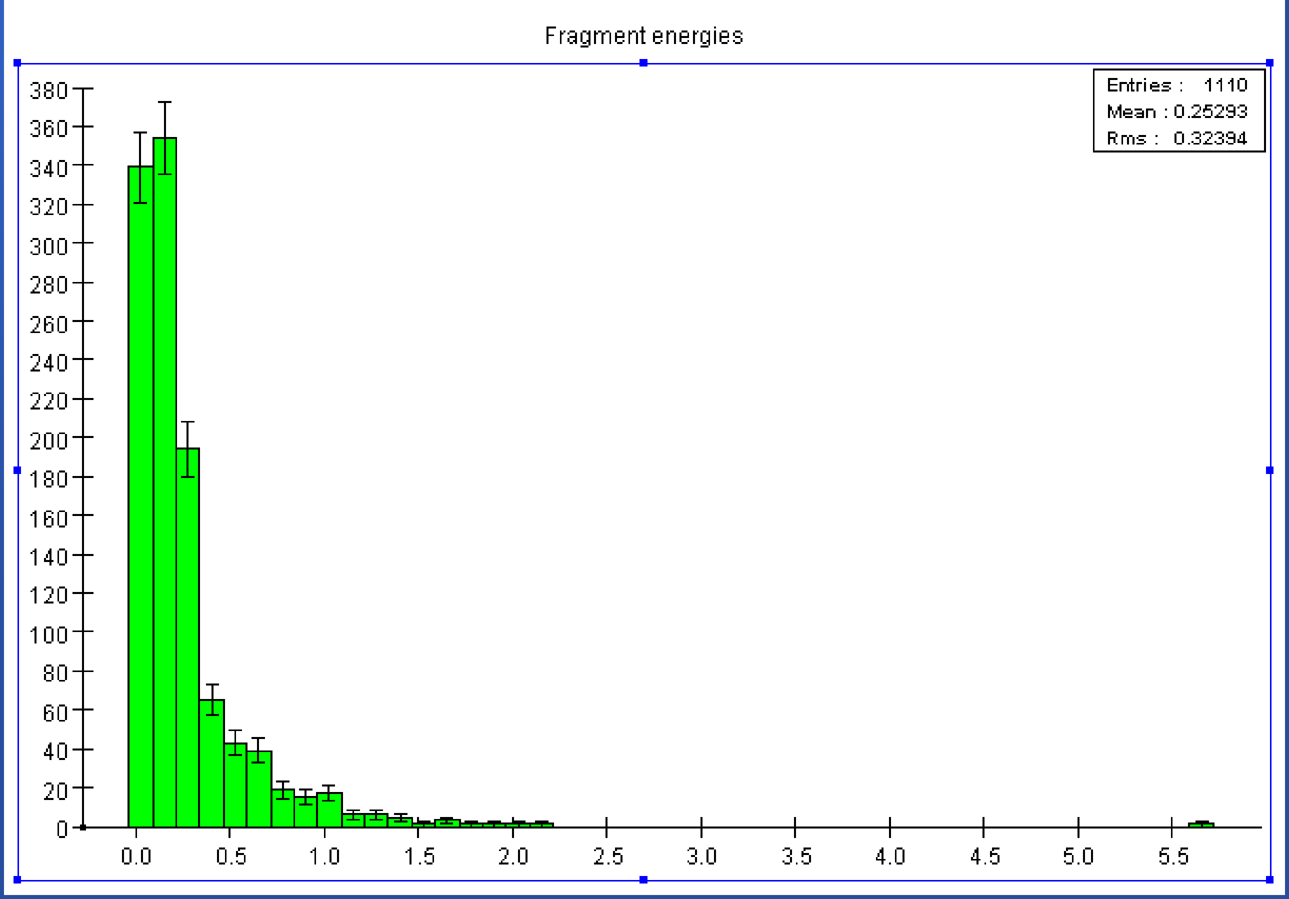
- 3 normalized energy tensor eigenvalues, ne1,ne2,ne3.
- ne1/ne2, ne2/ne3.
- First layer hit, last layer hit, length of cluster, (firstL+1)/length.
- Angular separation between e1-axis and IP.
- Energy in first 5 layers.
- Nhits in first 2 layers.
- z-coordinate of center of energy.
- Nhits
- Measured cluster energy.

(Santa Cruz) ID result with cuts:



1110 fragments in 500 charged pion events

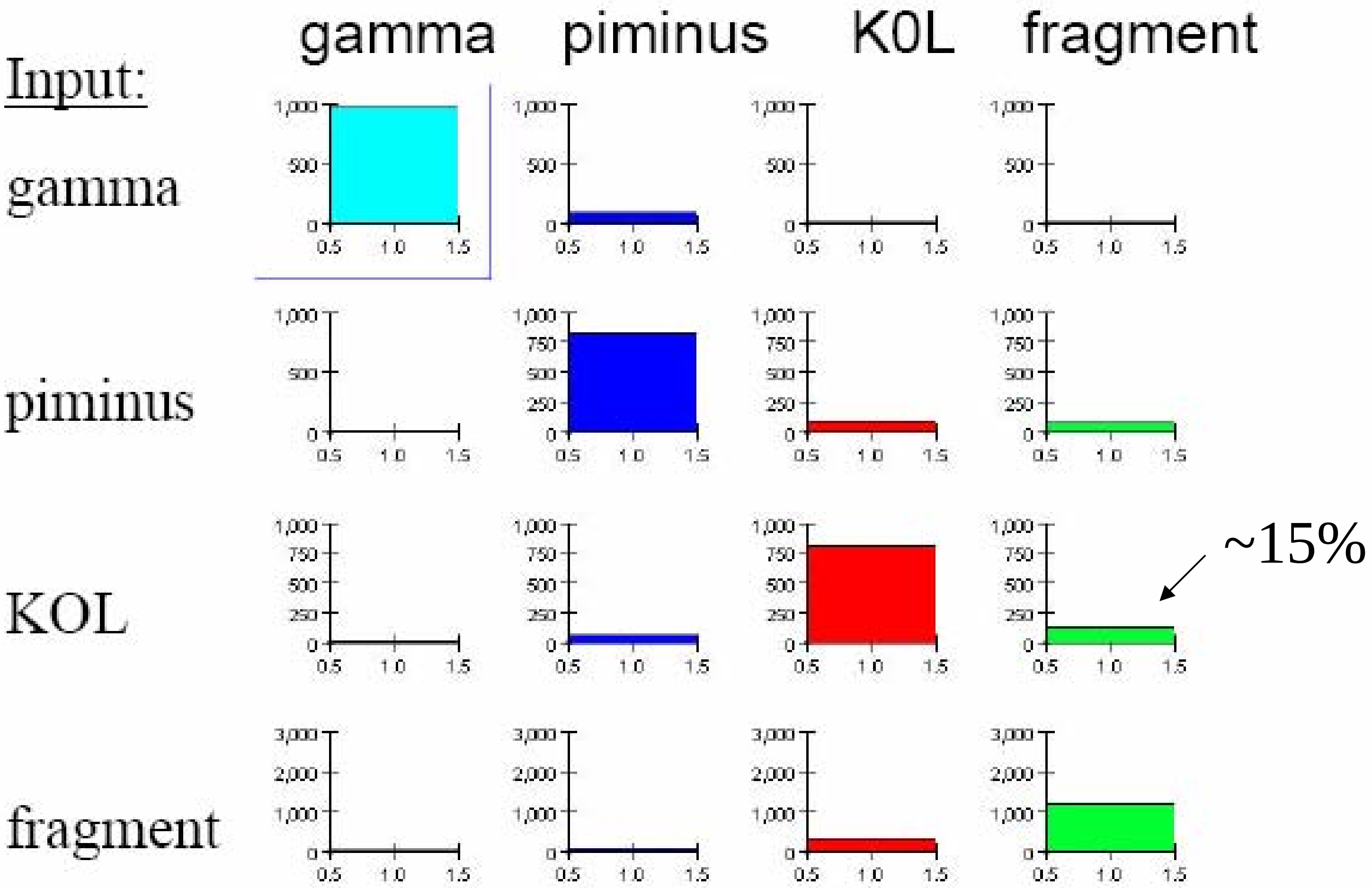
226 ID'd as charged pion, 27 as photon,
822 as Fragment, 35 as neutral hadron (3%)



Gamma, Pi-, Neutron all 5 GeV, Fragments come from Pi-

Input	Gamma	Pi-	Neutron	Fragment
Gamma	100%	0%	0%	0%
Pi-	8%	44%	37%	11%
Neutron	11%	12%	44%	33% (would like smaller)
Fragment	2%	21%	3% (promising)	74%

(Santa Cruz) ID result with cuts:



Conclusions

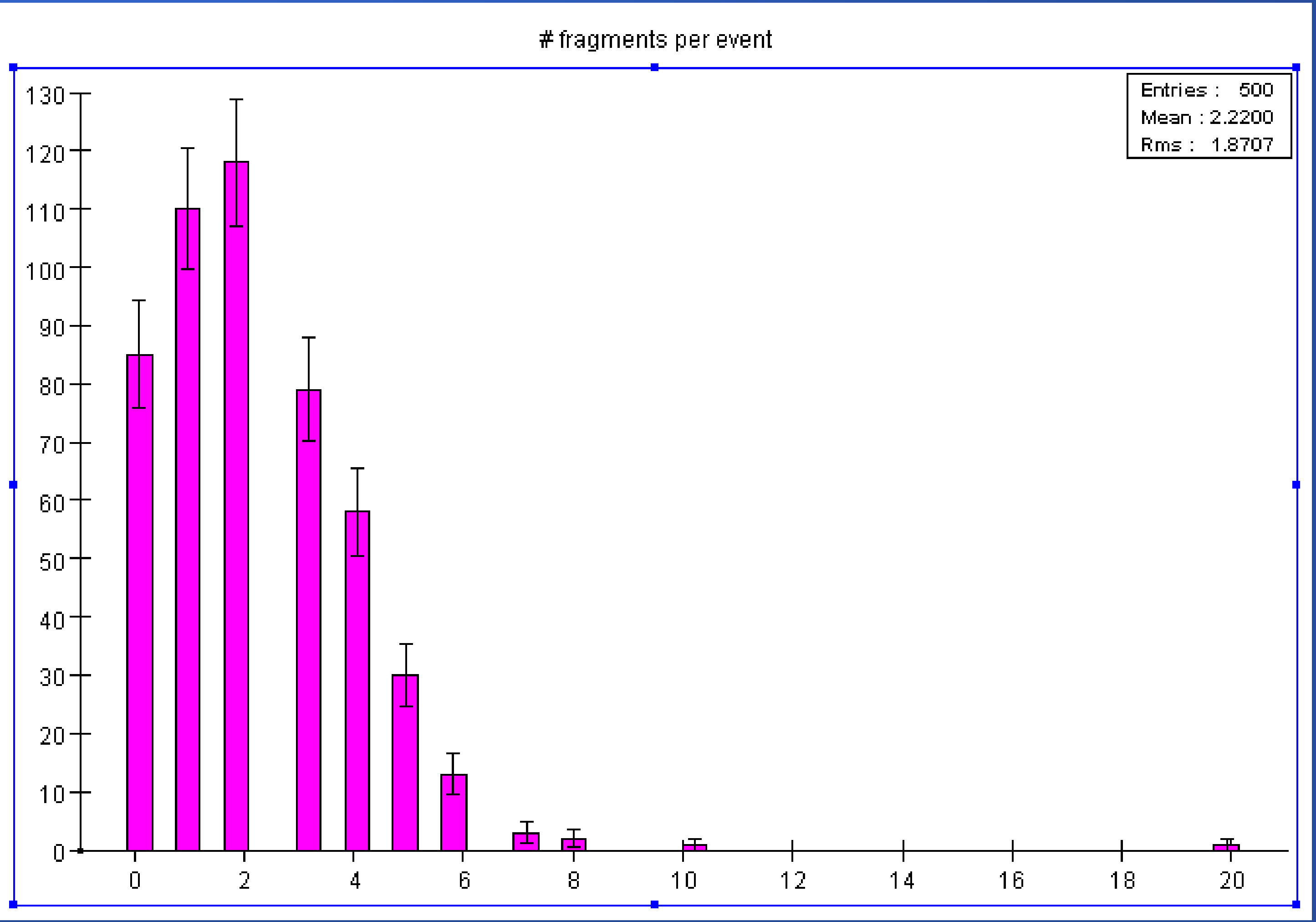
First looks at HMatrix and ClusterID are promising

Finish conversion to org.lcsim and PFA implementation

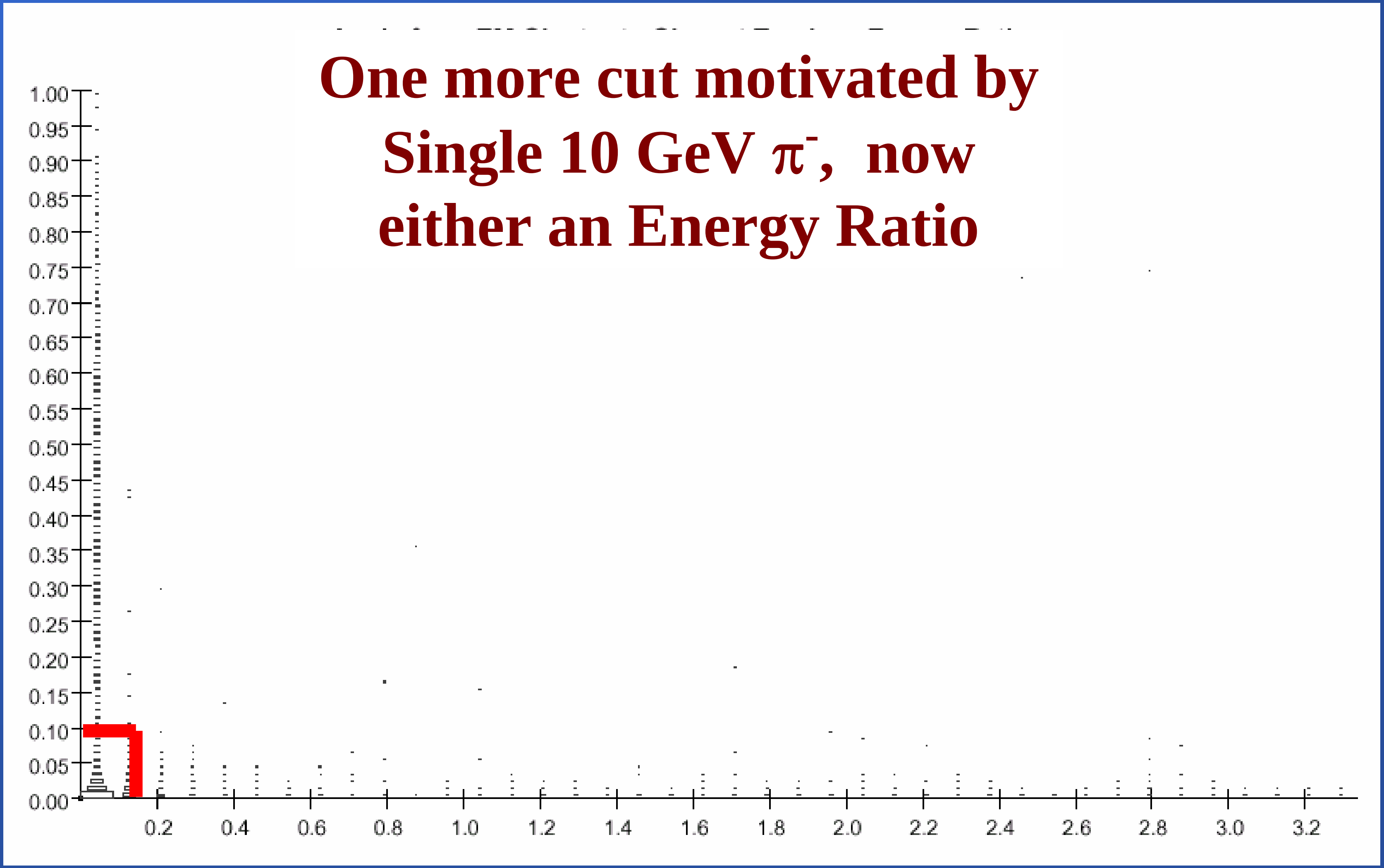
Backup Slides…

5 GeV single charged pions

Note: fragment is different than Fragment!



One more cut motivated by Single 10 GeV π^-, now either an Energy Ratio

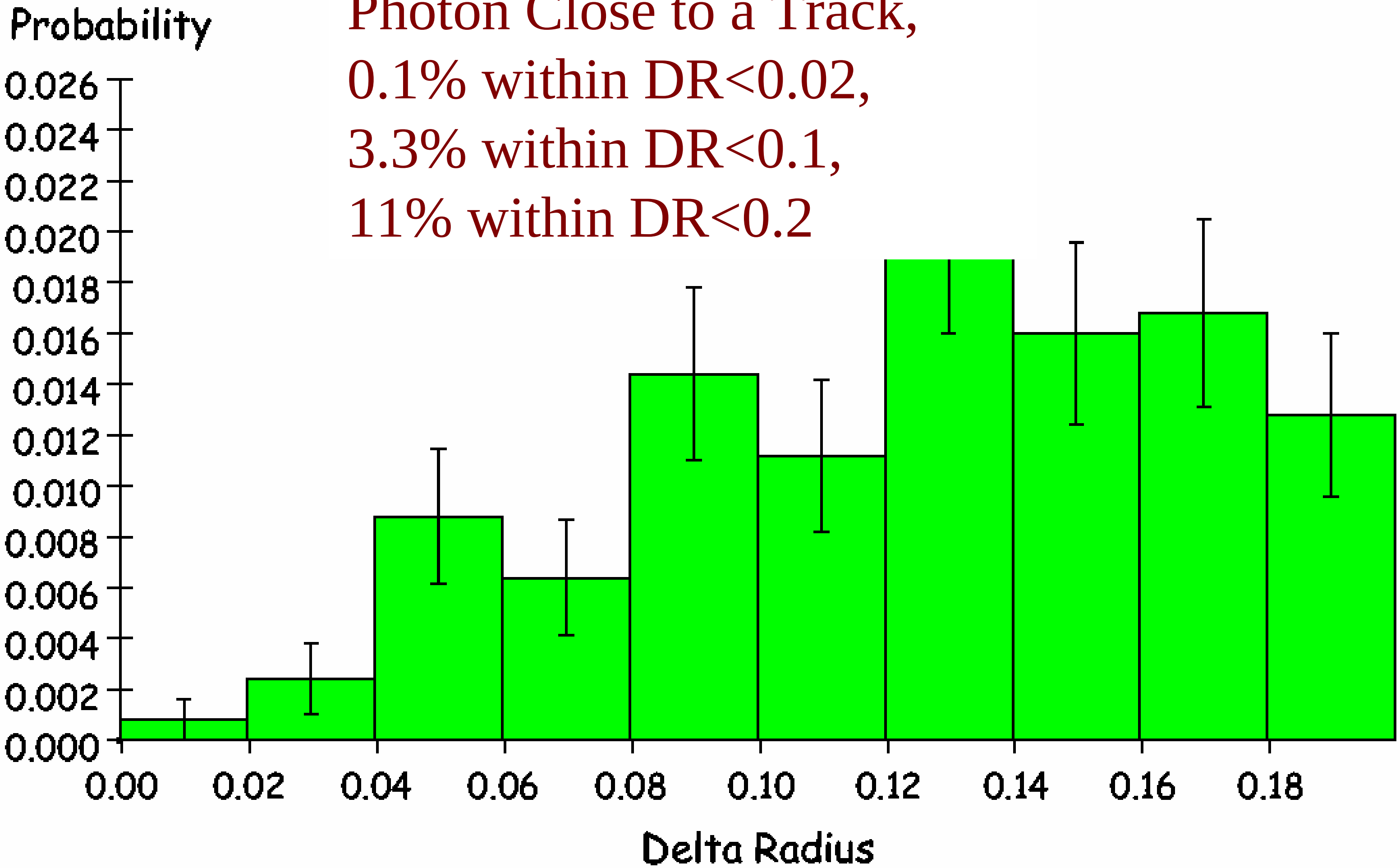


EM Cluster Energy/Track E

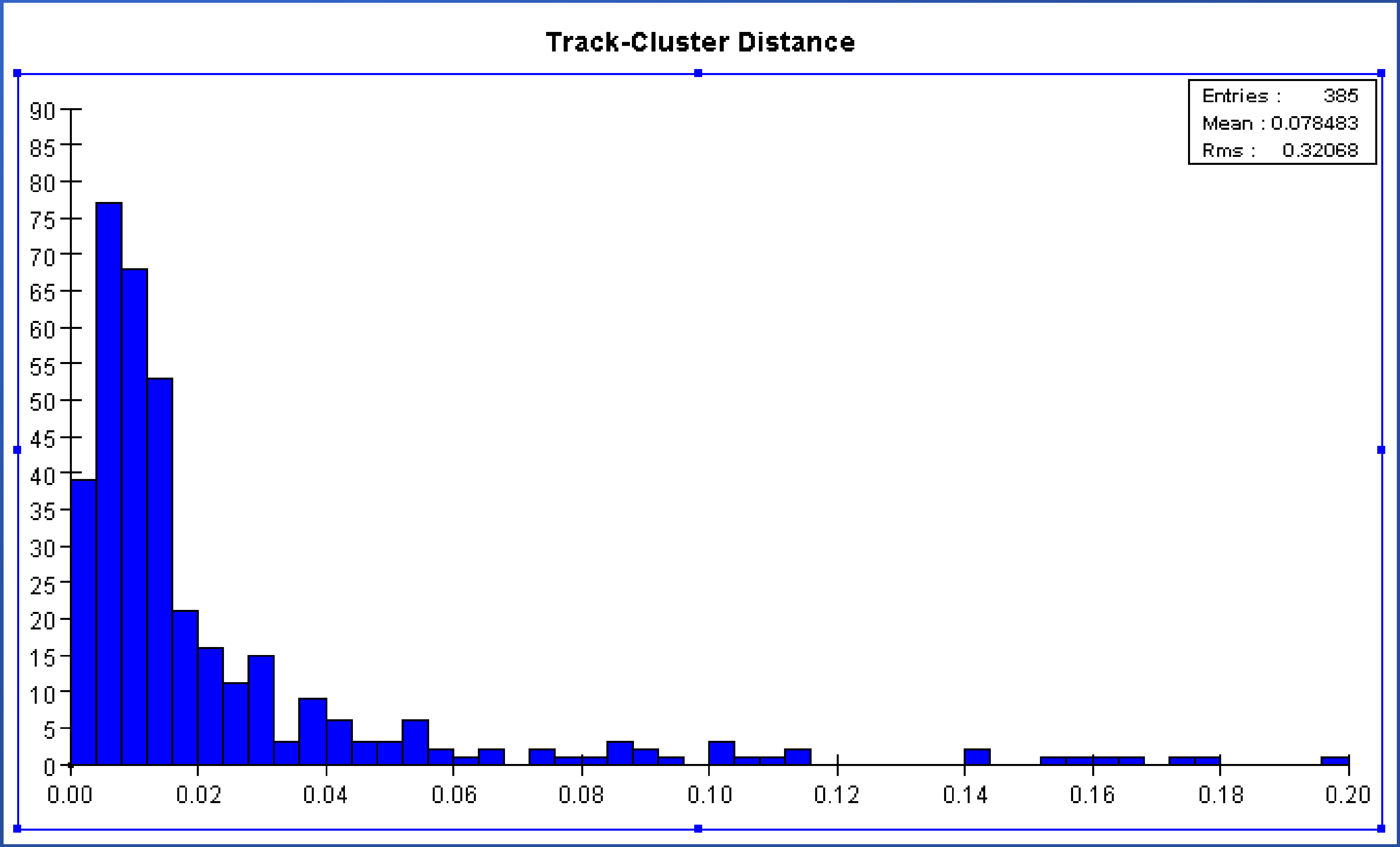
Delta-R from EM Cluster to Track

Hadronic Z Decays at $\sqrt{s}$ = 91 GeV

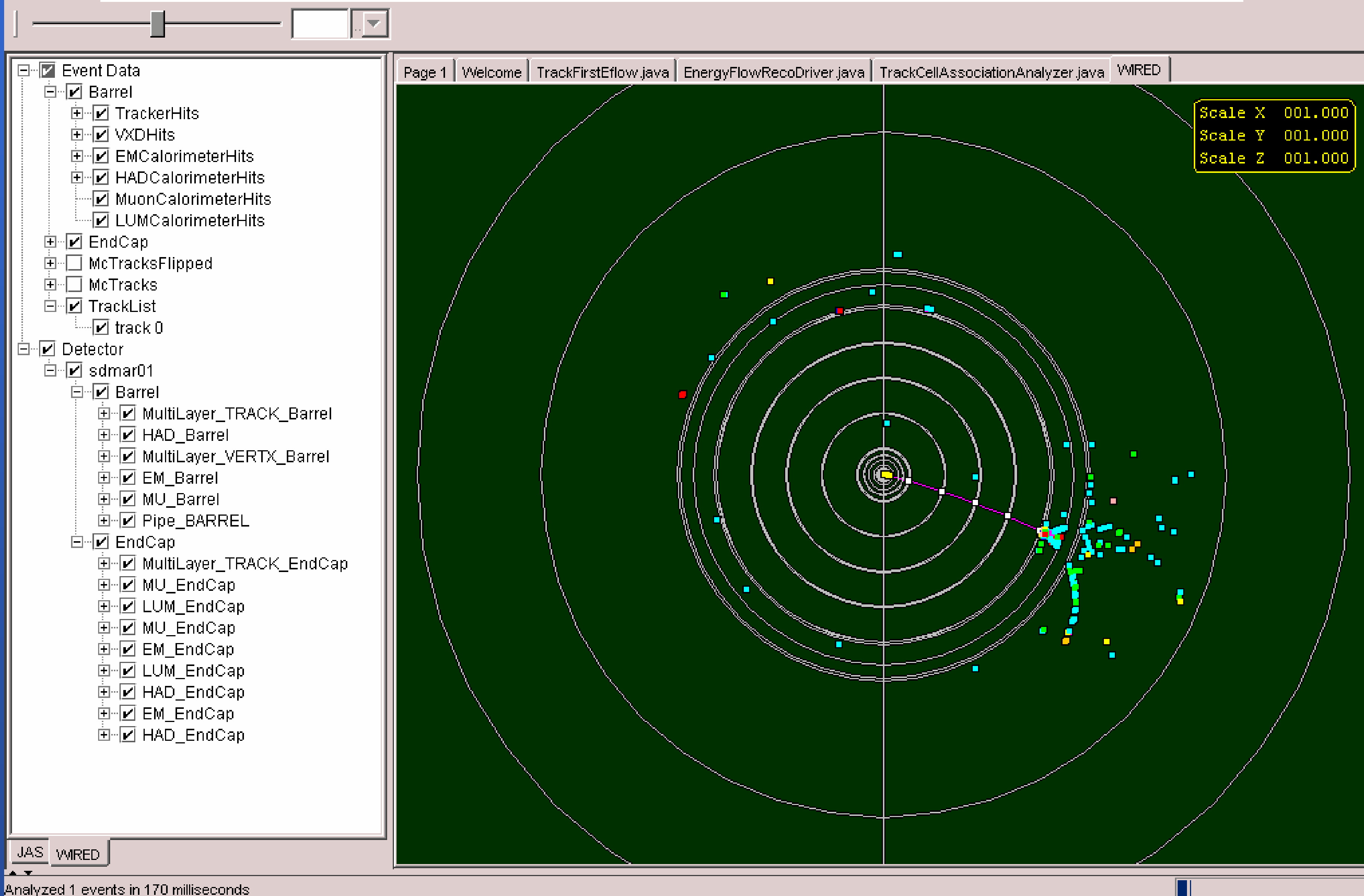
Probability of Overlapping Photon Close to a Track, 0.1% within DR<0.02, 3.3% within DR<0.1, 11% within DR<0.2



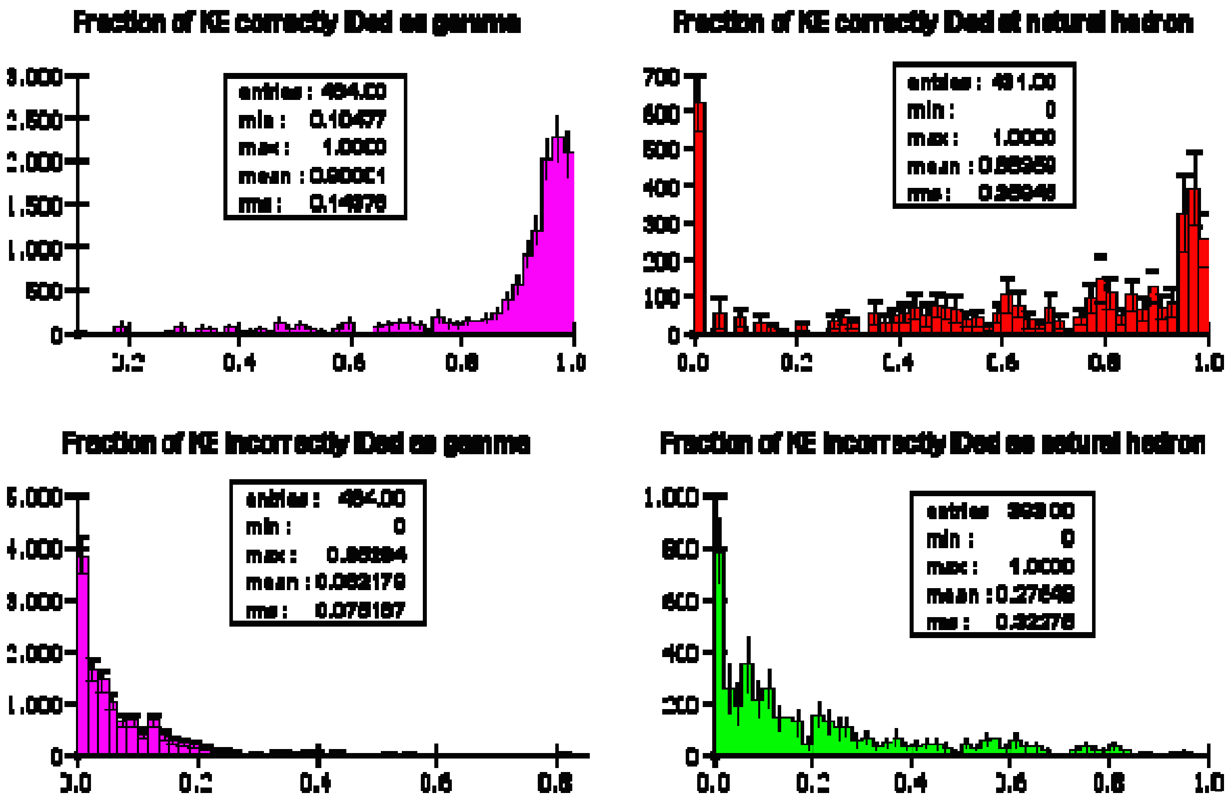
5 GeV Pion Fragments after MIP clusters are made



Energy Fragments from a Single 10 GeV π^-

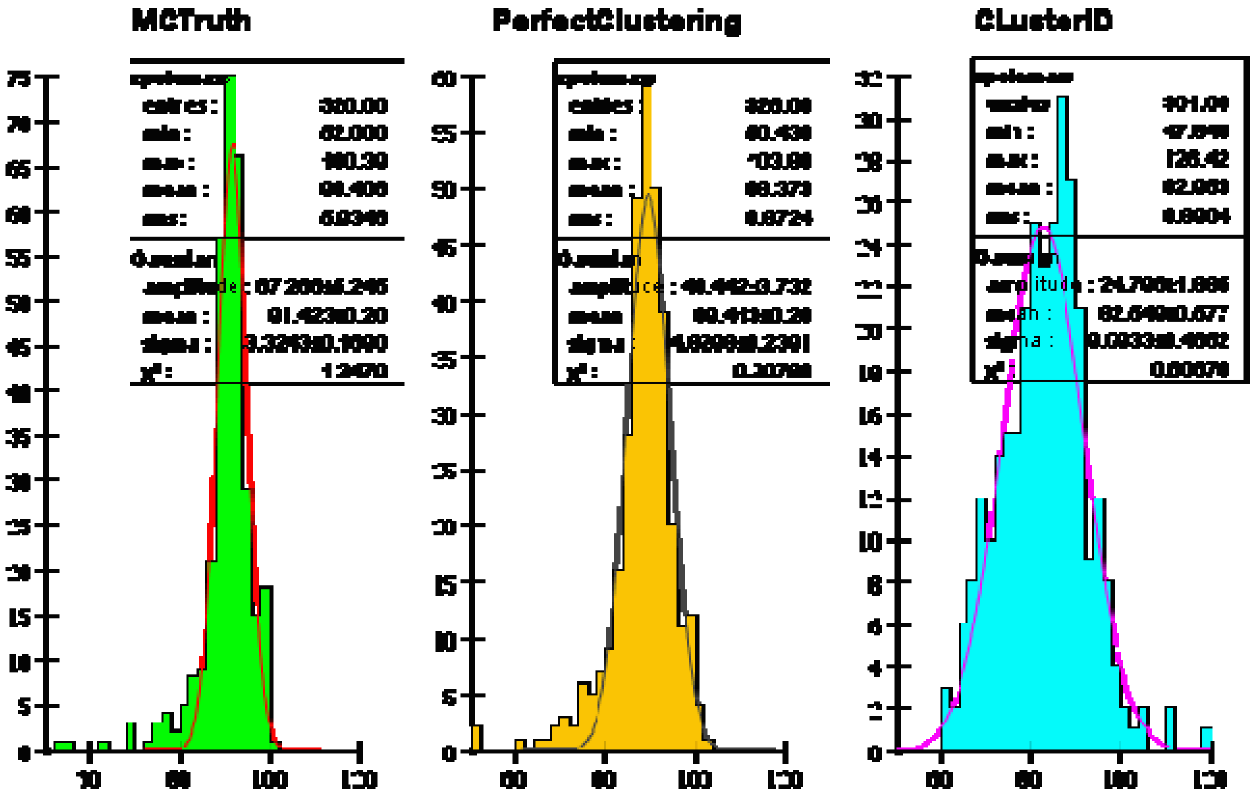


ClusterID recon efficiency



SD detector with no gap between EM and Had cals.

Zmass at Zpole



Refined Cluster Identification

- What limits efficiencies and purities of ClusterID?
- Using tools like Cluster Analysis (Ron's talk) can identify which cases are IDed wrong.
- Then think up new methods for those cases.
- Eg, fragments
  - Point fragments back to their origin.
- Eg, overlapping clusters
  - Raise hit E level to separate clusters.
  - Shape algorithm to see two gamma bulges.

The essential elements

- Calorimeter hits (digital or analog).
- A cluster builder technique
- A cluster identification technique (can use tracking information).
- To reconstruct events:
  - Make a reconstructed particle for each cluster and track.
- To study efficiency (& purity):
  - Make a clusterlist (& reconstructed particles).