Electromagnetic Showers with the MST Algorithm

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- Brief summary of Wed's talk
- Work done here at Snowmass
- Status on efficiency & purity

Some Words on My World...

- SiD detector 'SDFeb05_SciHcal', barrel only
- Single particle samples:

photons	1-10 GeV	efficiency studies
pi^0	1-10 GeV	overlap / purity studies
$K^0 \rightarrow pi^0 pi^0$	5-25 GeV	even more overlap

The **M**inimum **S**panning **T**ree Algorithm

- Recursive algorithm
- User has to define distance and a threshold.
  used here:
  distance = $|\mathbf{p}_1 - \mathbf{p}_2|$ (3D between cell centers)
  threshold of order cm
- Any two hits with distance < threshold get assigned to the same output cluster

Implementation for hep.lcd available in CVS
(Matthew Charles, Wolfgang Mader, N.M.)

Identify Photons

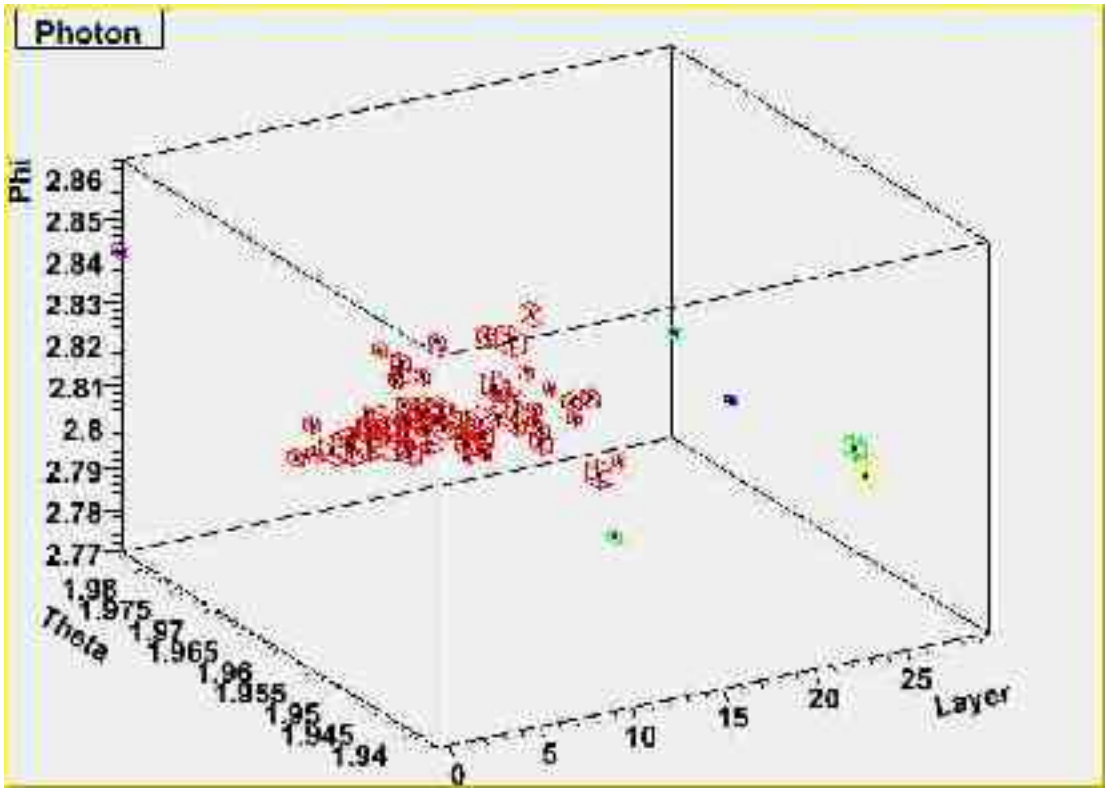
- There are several clusters per MC particle, and not all of them might be from photons...
- Use single particle sample to find simple criteria, tune cuts as function of threshold

size	reject small 'fragments'
position	EM showers start after few X_0
composition	no 'MIP' tracks expected
shape	'long' and 'thin'

- Accept ~98% EM, ~5% chrgd. had, ~10% ntr. had

Which Threshold ???

First try: threshold = 2cm



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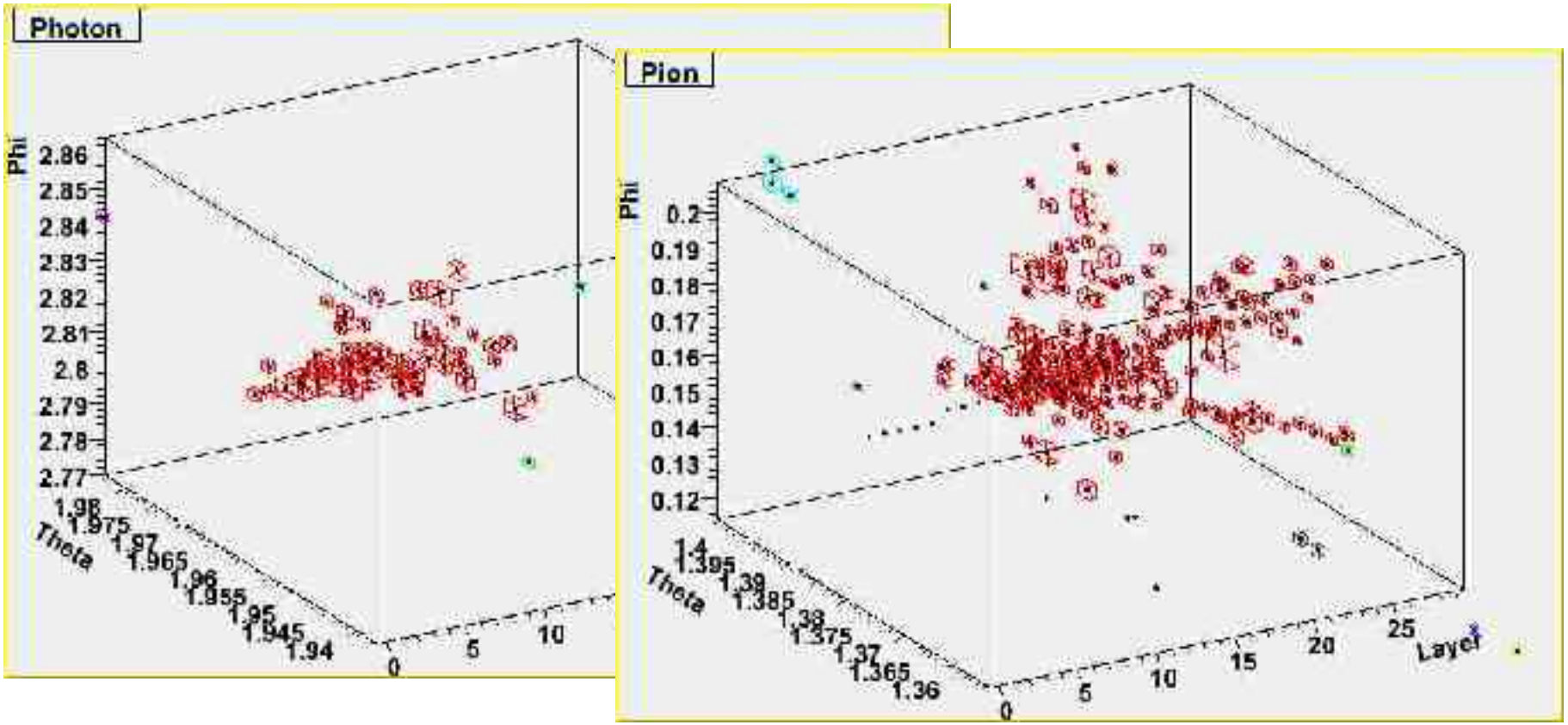
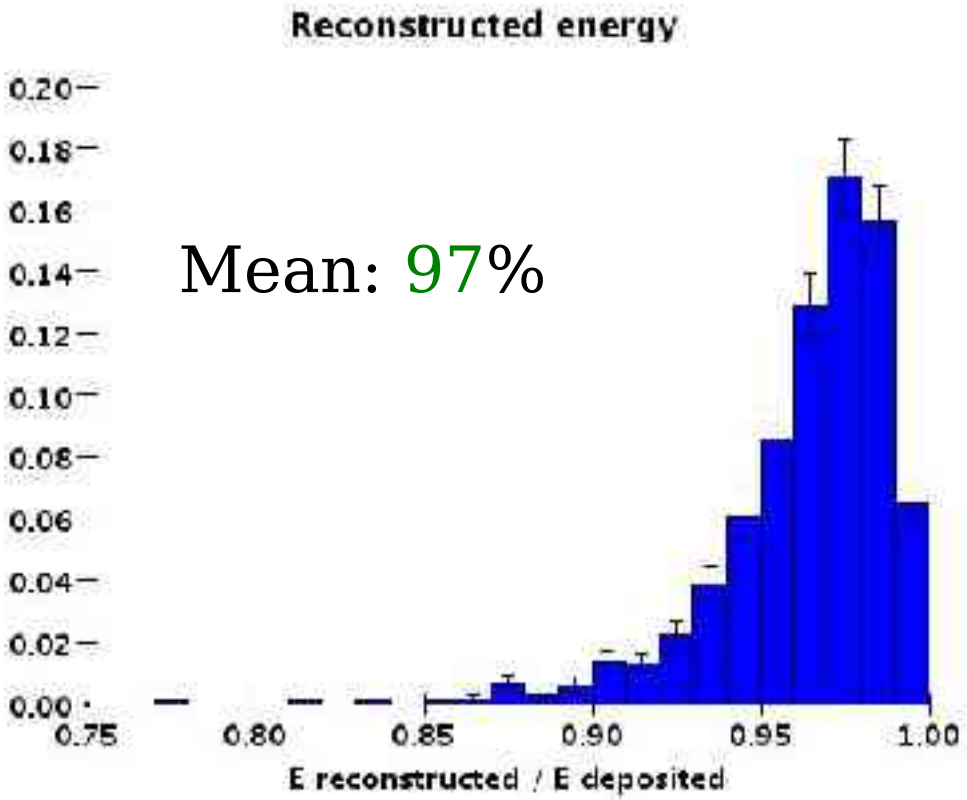


Which Threshold ???

First try: threshold = 2cm

- Advantage: collect large fraction of energy in single photon sample



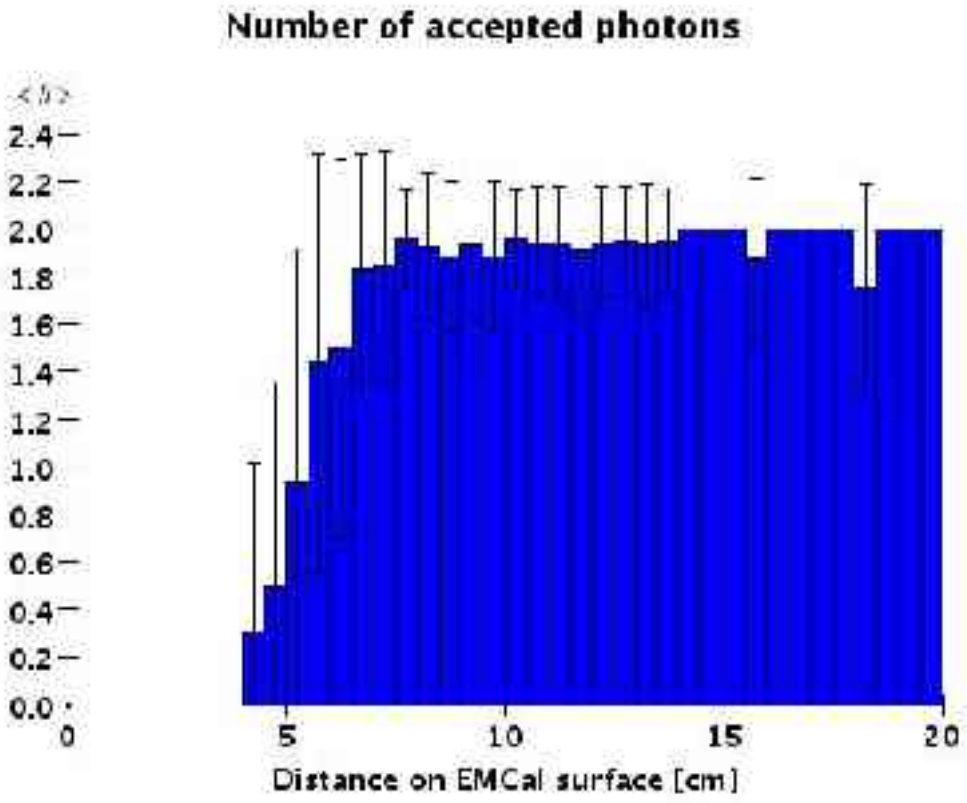
Mean: 97%

Which Threshold ???

First try: threshold = 2cm

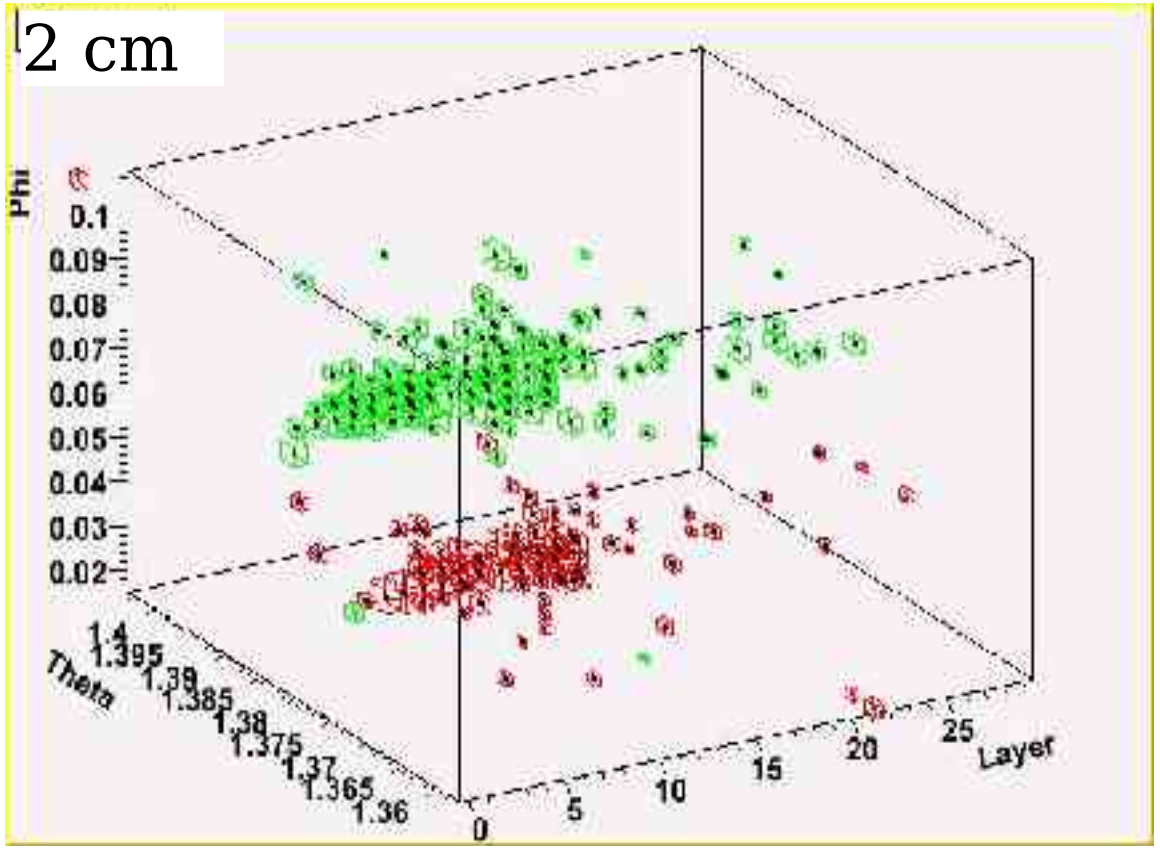
- Advantage:
  collect large
  fraction of energy
  in single photon
  sample

- Disadvantage:
  poor separation
  of close-by photons
  from pi^0 sample



Which Threshold ???

Next try: threshold = .75cm (contiguous clusters)



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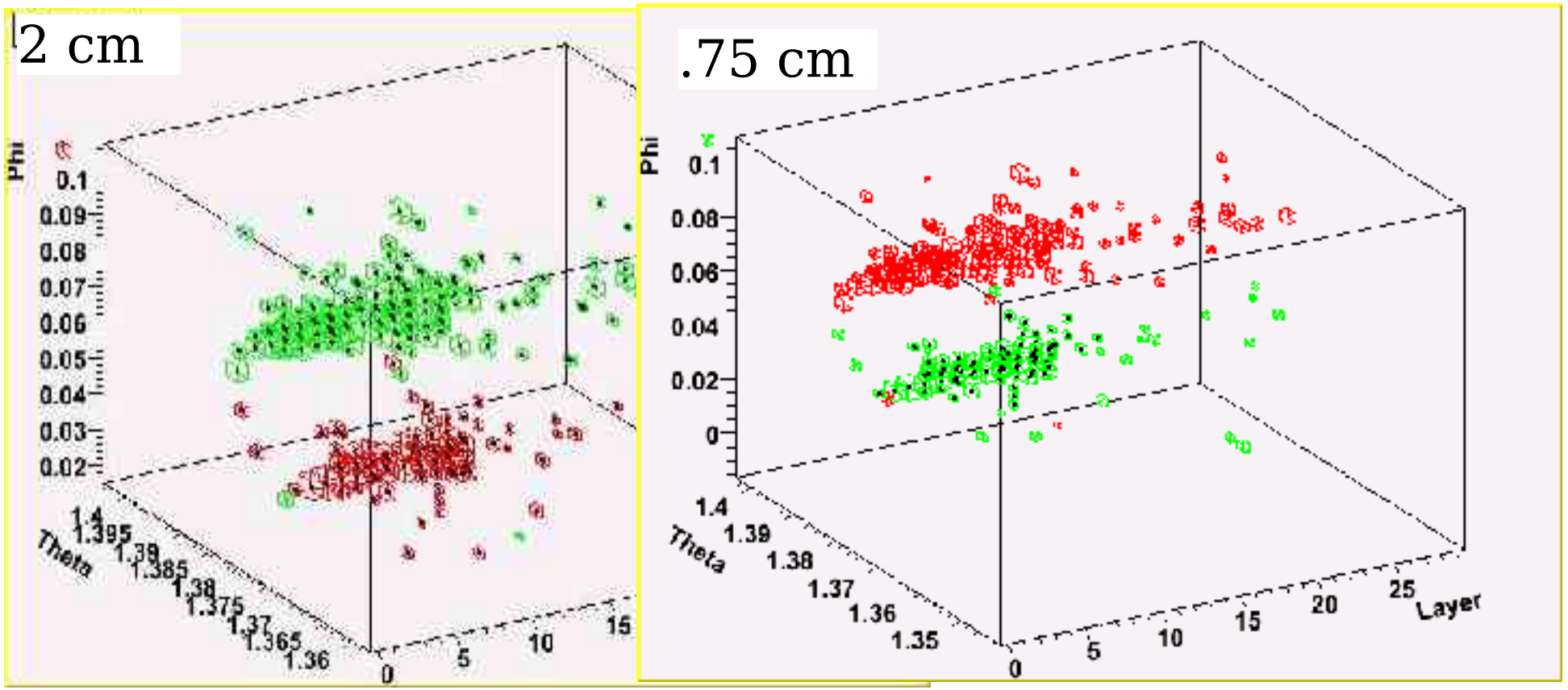
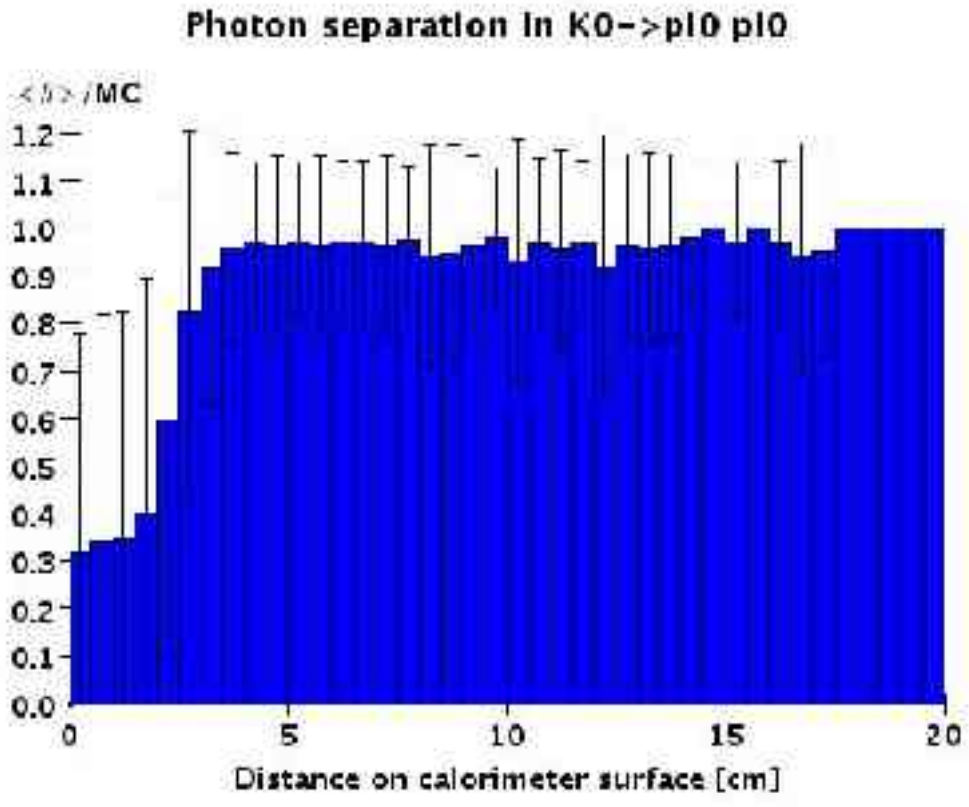


Which Threshold ???

Next try: threshold = .75cm (contiguous clusters)

- Advantage:
  good separation
  even in $K^0 \rightarrow pi^0 pi^0$
  sample

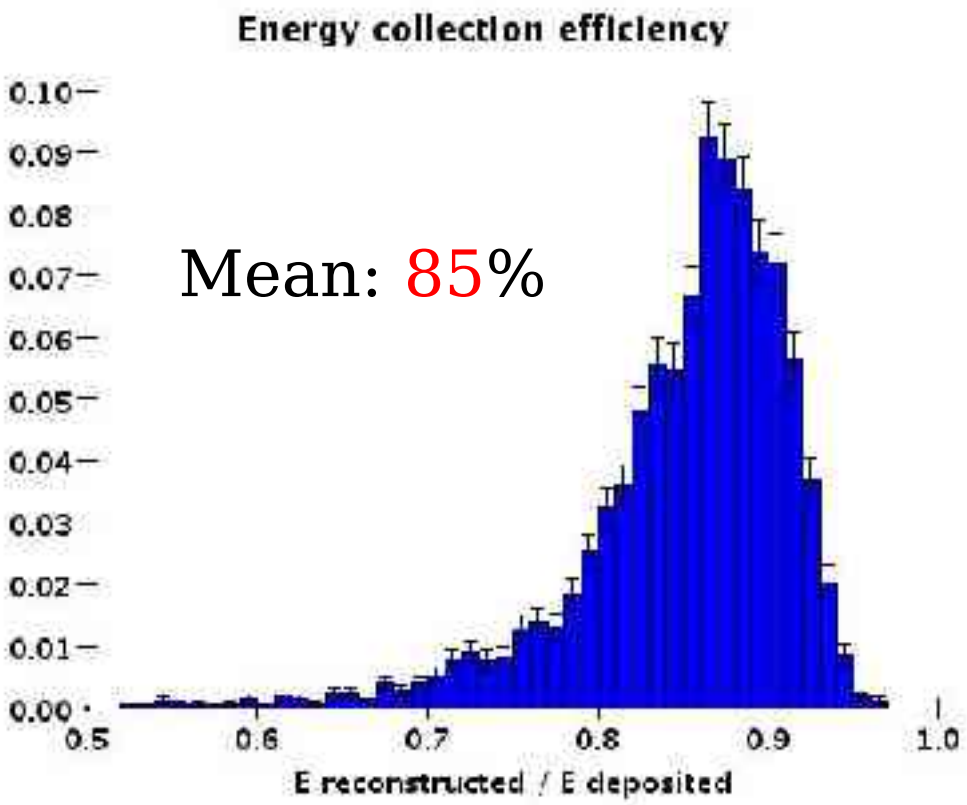


Which Threshold ???

Next try: threshold = .75cm (contiguous clusters)

- Advantage:
  good separation
  even in $K^0 \rightarrow pi^0 pi^0$
  sample

- Disadvantage:
  poor energy
  collection even
  in single photon
  sample



Mean: 85%

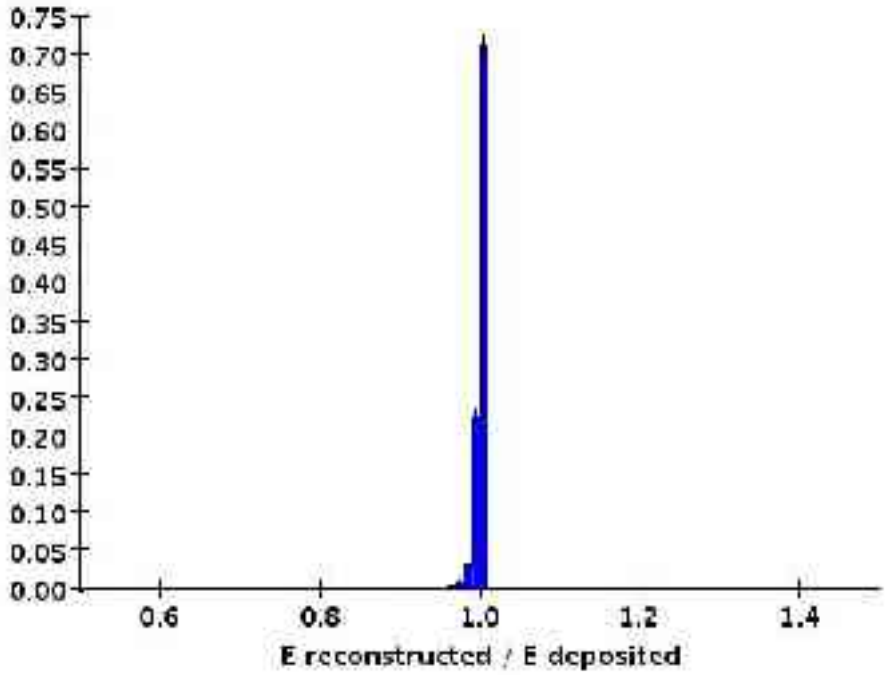
What About Two-Step Approach

- Find dense cores with MST algorithm
- Find criteria for one core per photon
  (as shown before, could be done better!)
- Collect energy around cores
  first idea (brand new!):
  cylinder around principle axis of cores,
  cut overlapping cylinders (simplest: symmetric)

Some Plots...

Reconstructed energy

- Single particles
  mean: 99.8%
  RMS: 1%

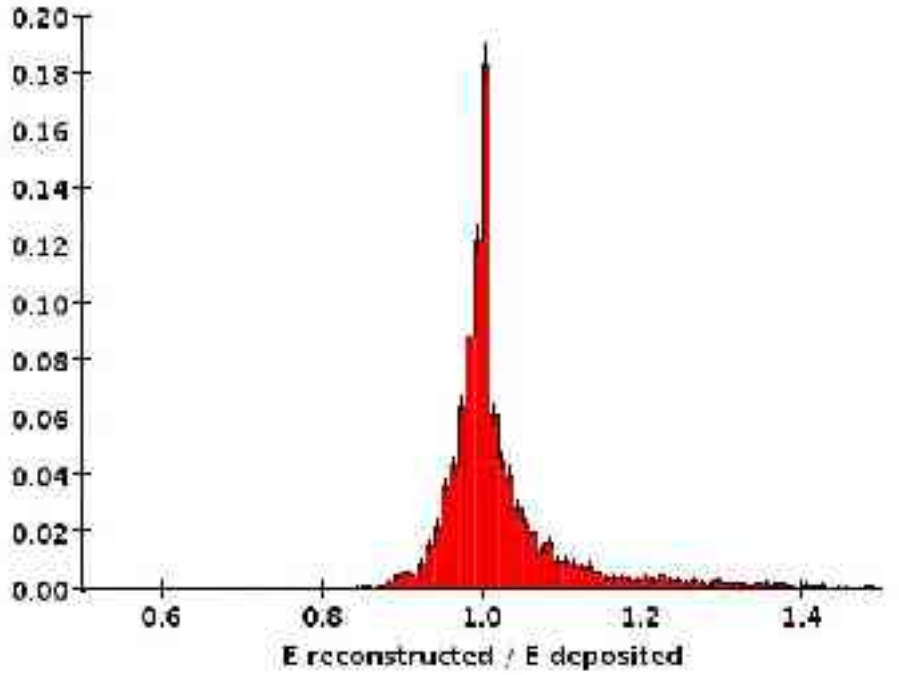


Some Plots...

Reconstructed energy

- Single particles
  mean: 99.8%
  RMS: 1%

- Photons in pi^0
  mean: 102%
  RMS: 8%



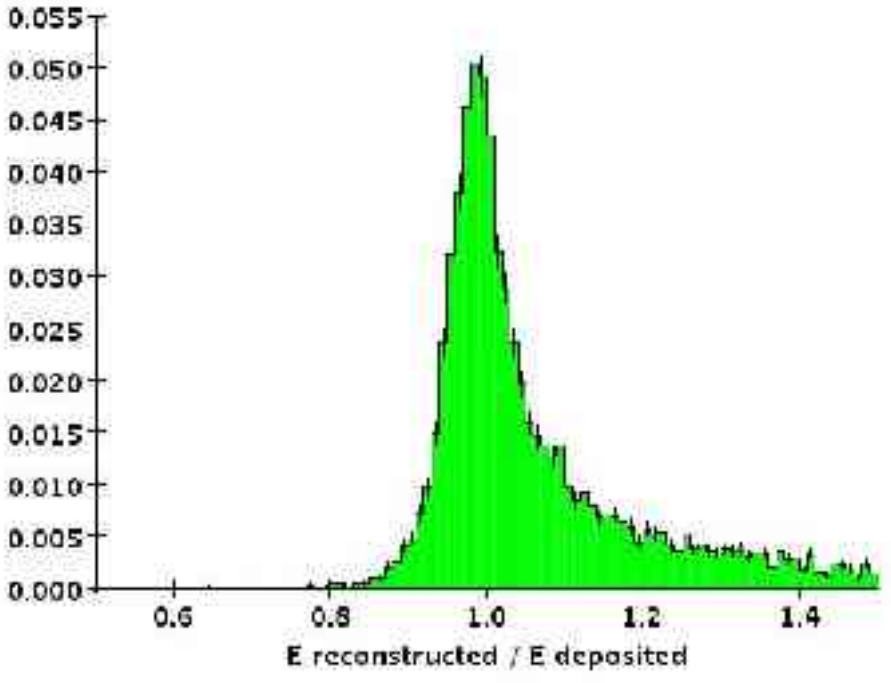
Some Plots...

Reconstructed energy

- Single particles
  mean: 99.8%
  RMS: 1%

- Photons in pi^0
  mean: 102%
  RMS: 8%

- Photons in K^0
  mean: 106%
  RMS: 13%



Some Conclusions...

- This is VERY preliminary
  - Just a week of work (bugs, bugs, bugs...)
  - The cylinder radius is just a guess
  - Even the choice of a 'cylinder' is arbitrary

- Trends observed:
  - Looks encouraging!
  - Algorithm tends to pick up too much energy for low-E photon next to high-E particle

Summary and Outlook

- Use MST algorithm to find electromagnetic showers
- Single photon resolution for D > 3 cm
- Work in progress:
    - Optimize energy collection strategy
    - Find criteria for low-E photons
    - Study overlap with pions, neutral hadrons
    - ...
    - Put together a 'photon finder'
- Stay tuned...