Electromagnetic Showers with the MST Algorithm

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The University of Iowa
Matthew Charles, Wolfgang Mader, Usha Mallik

ILC Workshop, Snowmass
August 17, 2005

- The MST algorithm
- Classifying photons
- Status on efficiency & purity

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The Minimum Spanning Tree Algorithm

- Recursive algorithm
- Any two hits with distance below a threshold end up in the same cluster
- User has to define distance definition and a threshold

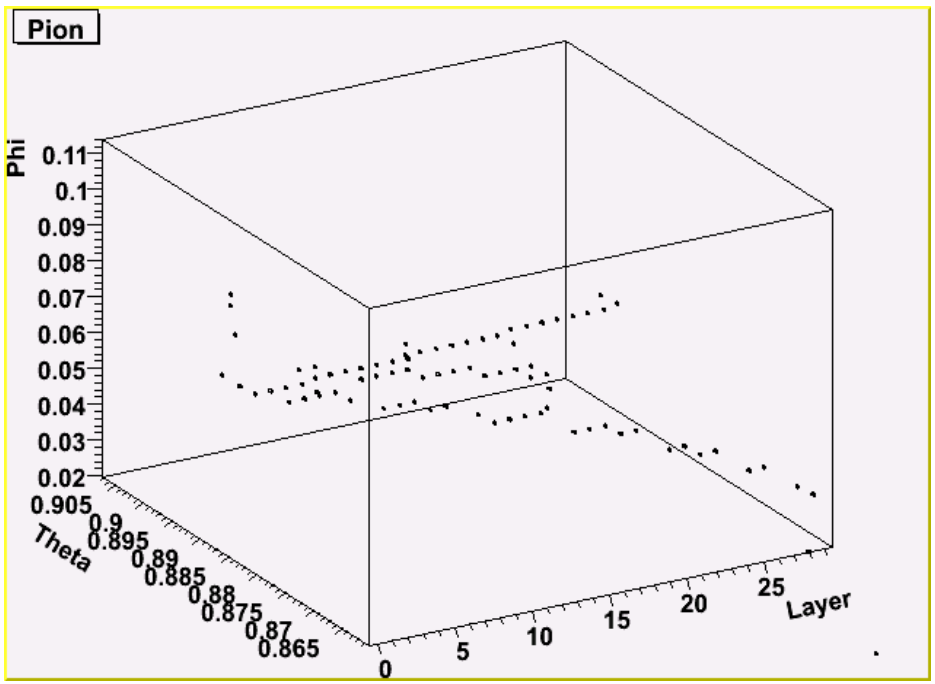
Implementation for hep.lcd available in CVS
(Matthew Charles, Wolfgang Mader, N.M.)

More details:
"Calorimeter algorithms" sessions
(Friday afternoon / Saturday morning)

The Minimum Spanning Tree Algorithm

- Recursive algorithm
- Any two hits with distance below a threshold end up in the same cluster
- User has to define distance definition and a threshold

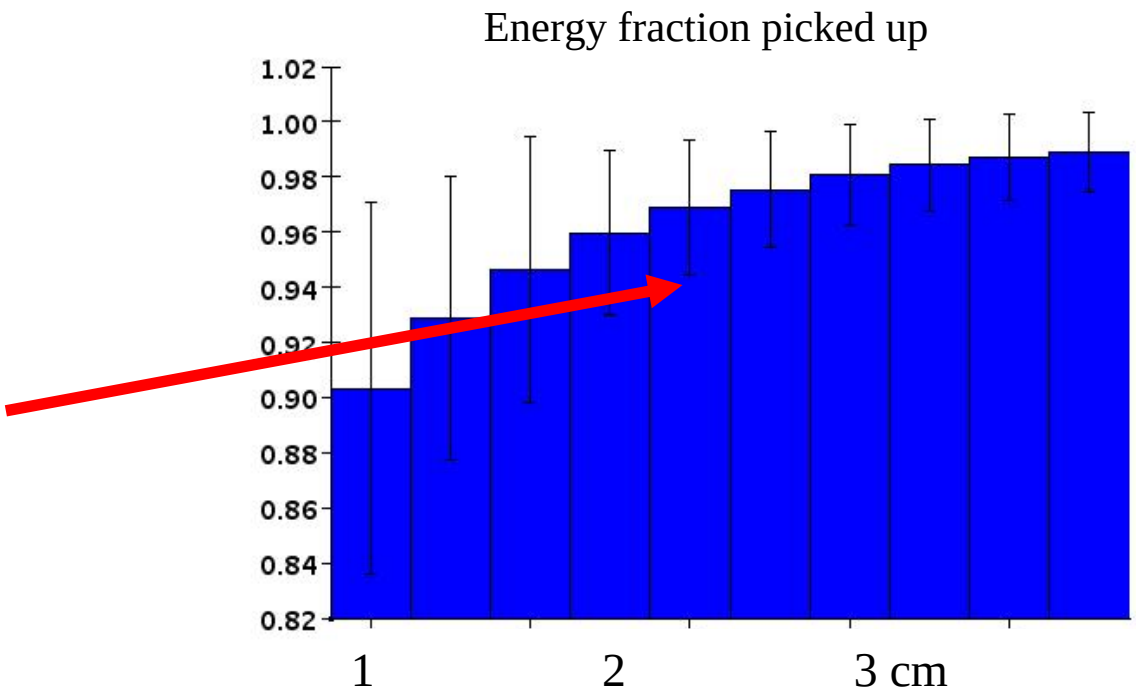
Example:
pion with ~4 GeV
use 3D distance
threshold = 0.75cm



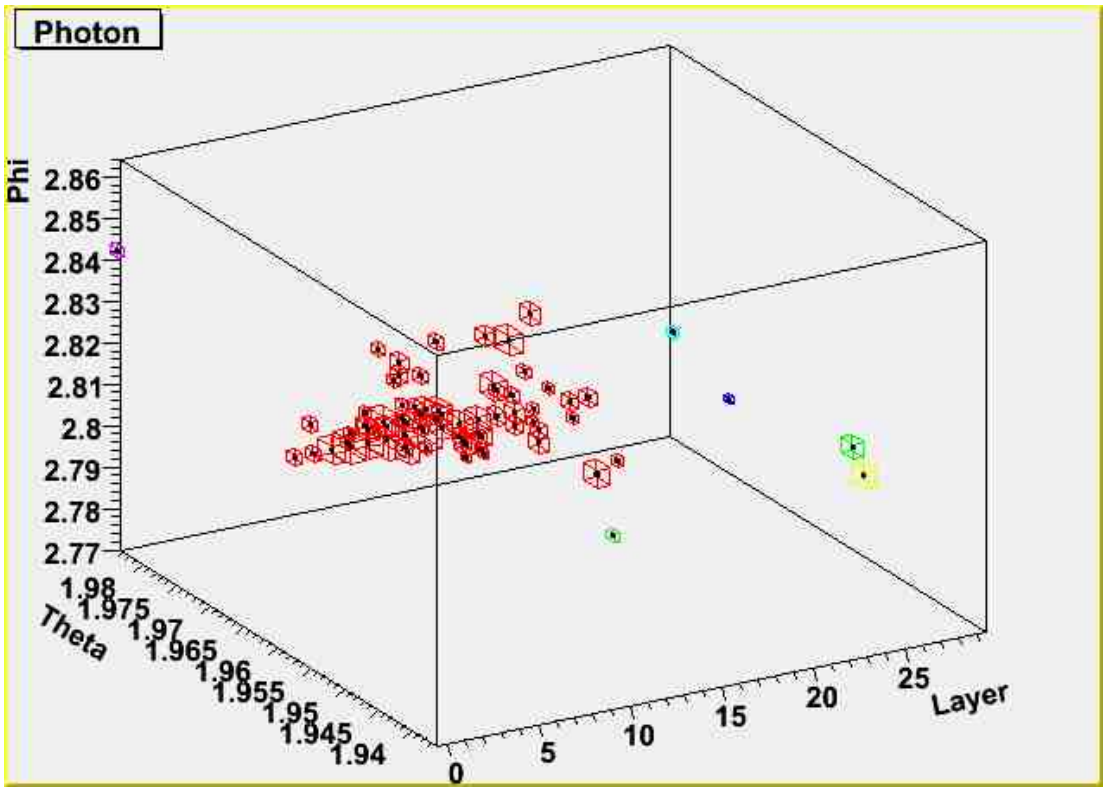
Finding Photons – Optimizing the MST

- Let's start simple, use 3D distance (no energy, angle, ...)
  Control sample: single particles (~1000 each)
  1-10GeV in ECal barrel, SDFeb05 detector
- Find MIP tracks first, don't use these hits
- Optimize threshold
  by energy collected

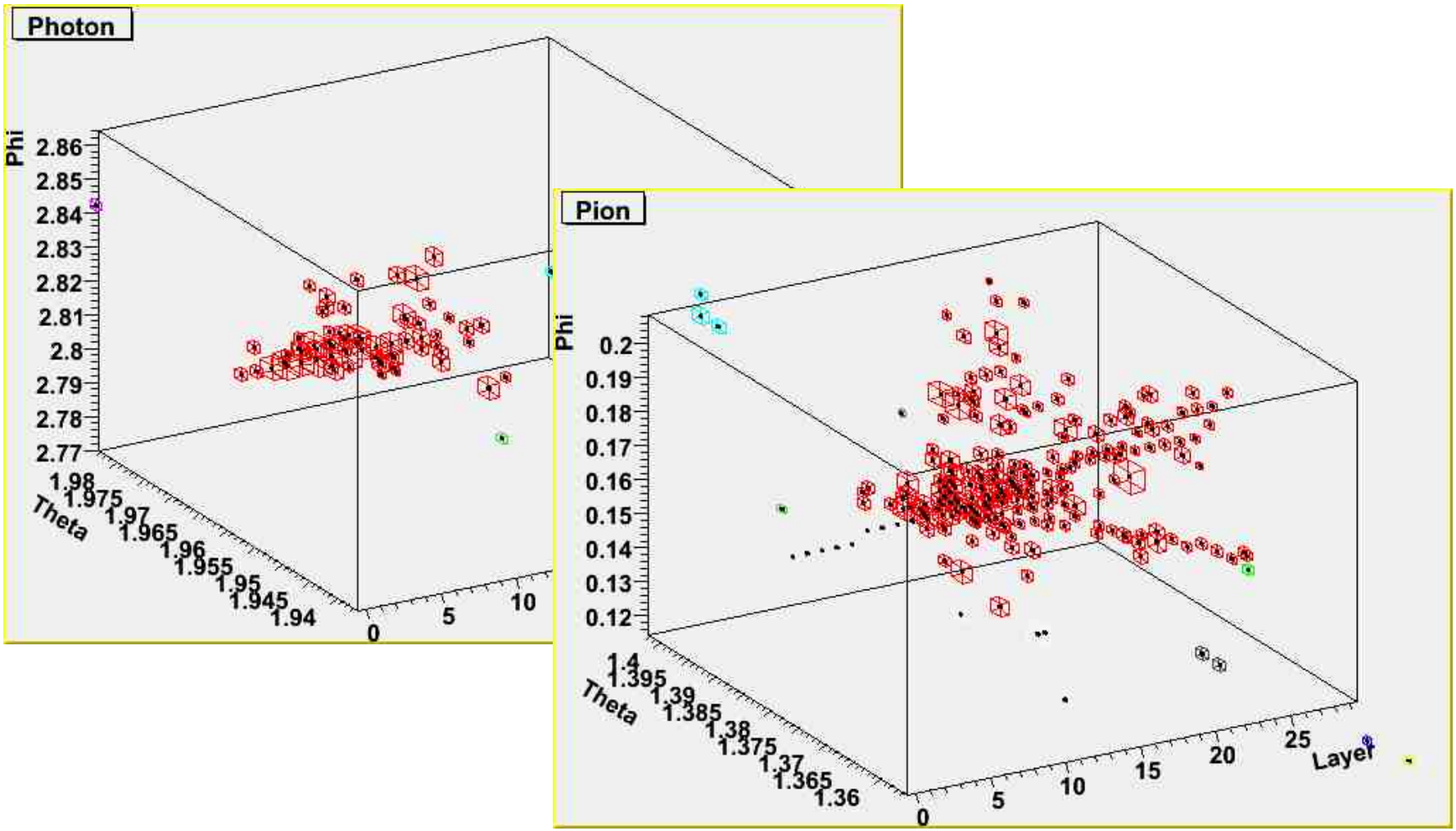
2cm threshold
~97% energy



MST Output


Photon
Phi
2.86
2.85
2.84
2.83
2.82
2.81
2.8
2.79
2.78
2.77
1.98
1.975
1.97
1.965
1.96
1.955
1.95
1.945
1.94
Theta
0
5
10
15
20
25
Layer

MST Output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Theta
0
5
10
Pion
Phi
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
1.4
1.395
1.39
1.385
1.38
1.375
1.37
1.365
1.36
Theta
0
5
10
15
20
25
Layer

Identify Photons

- Look at cluster properties, try to find simple cuts
  Goal: keep it simple for now!

Size
Content
Shape
Position

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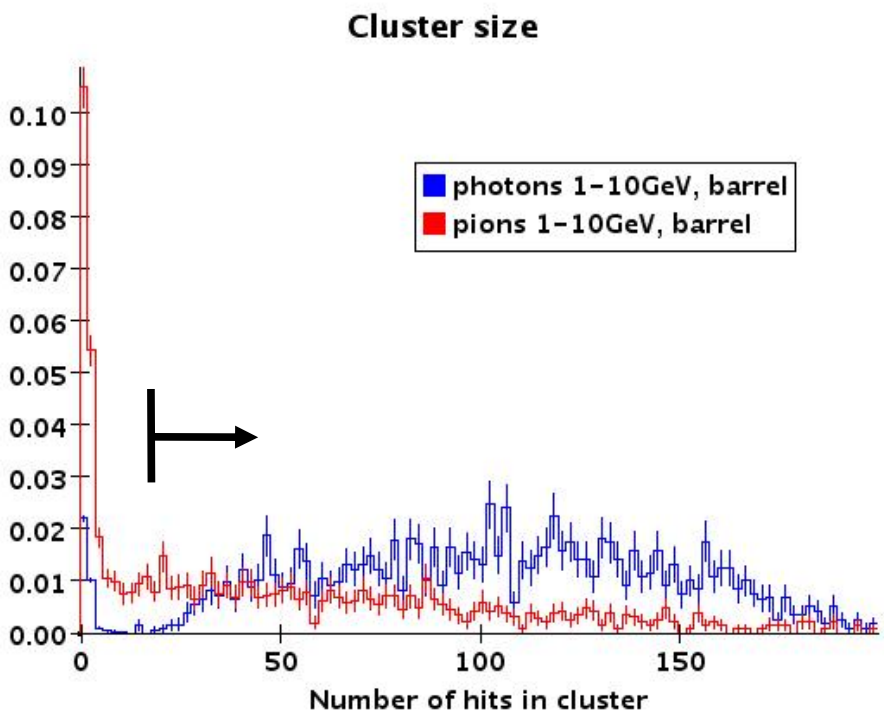

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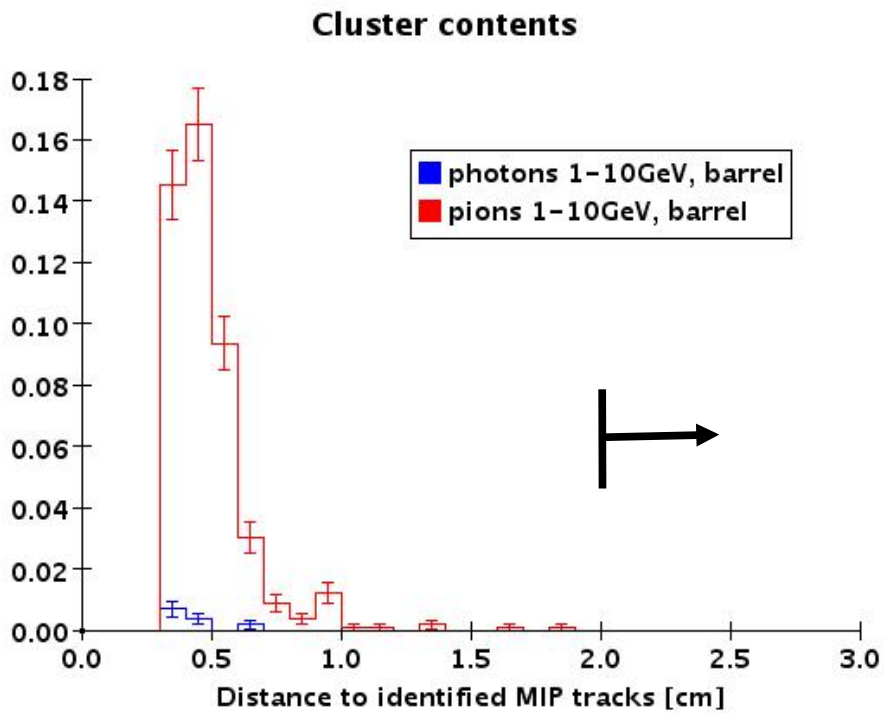

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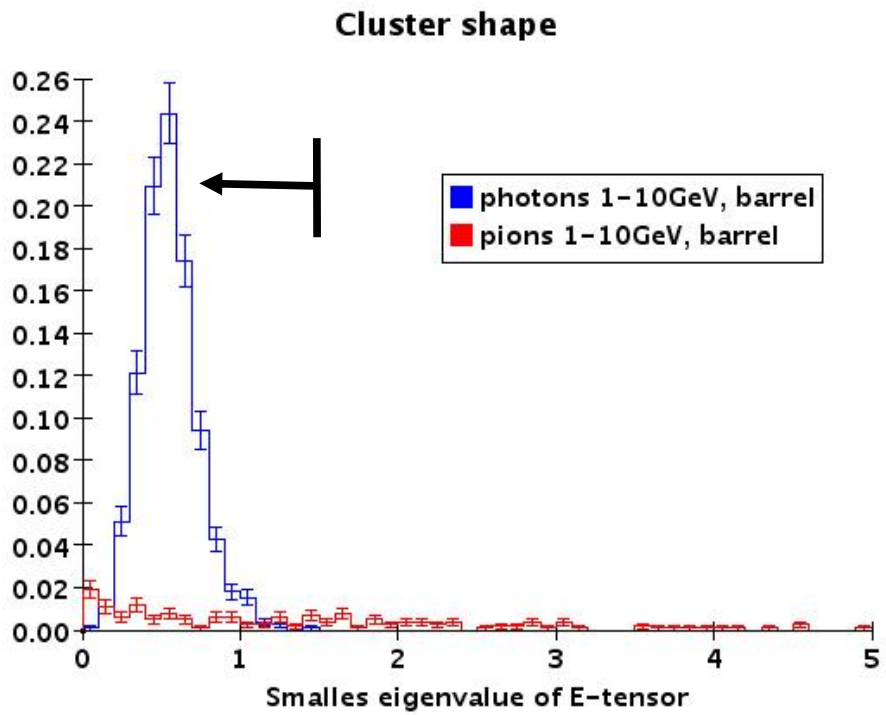

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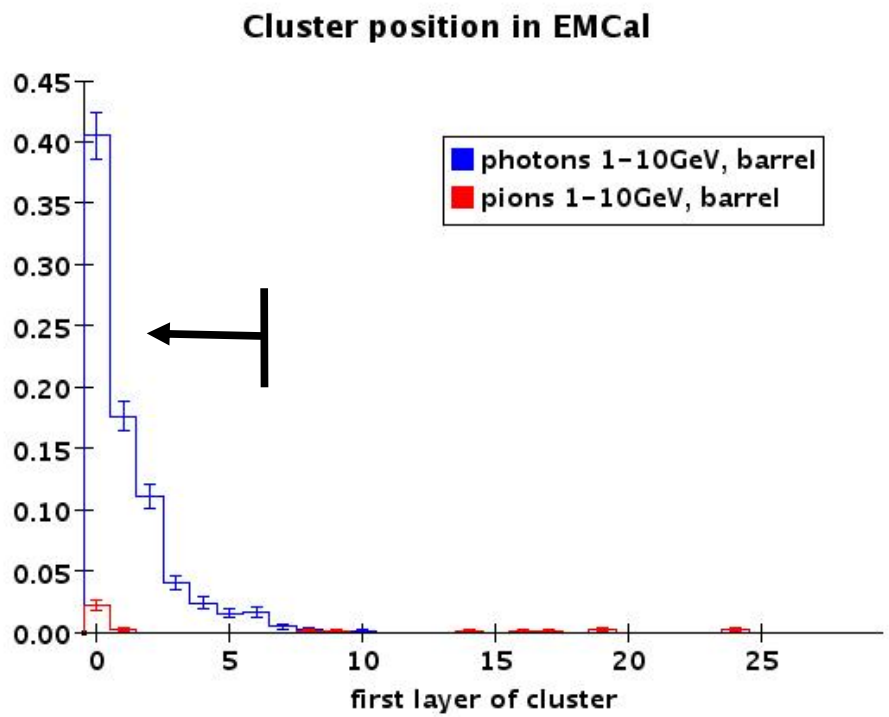
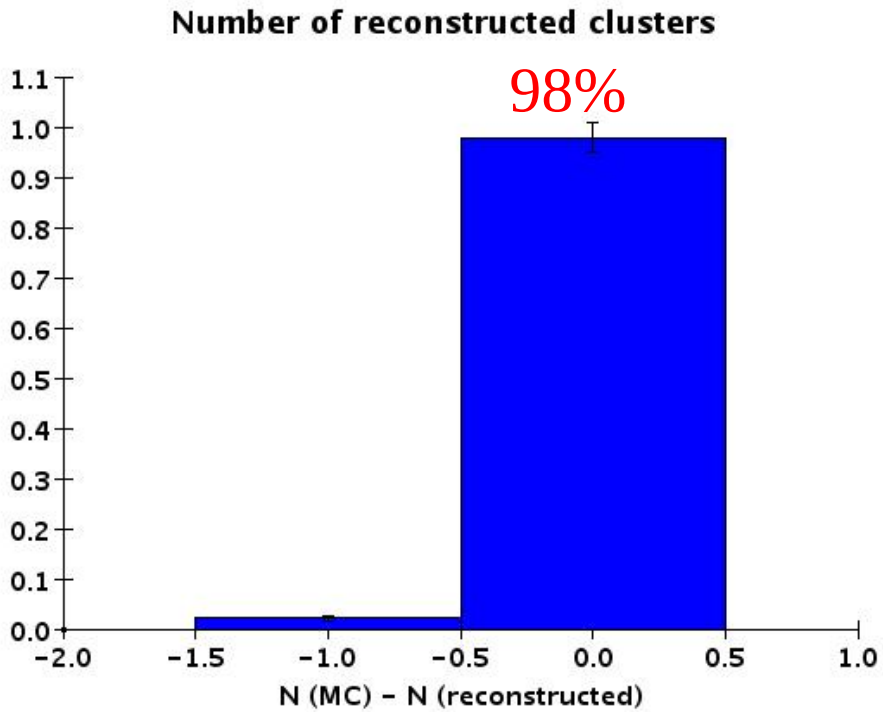
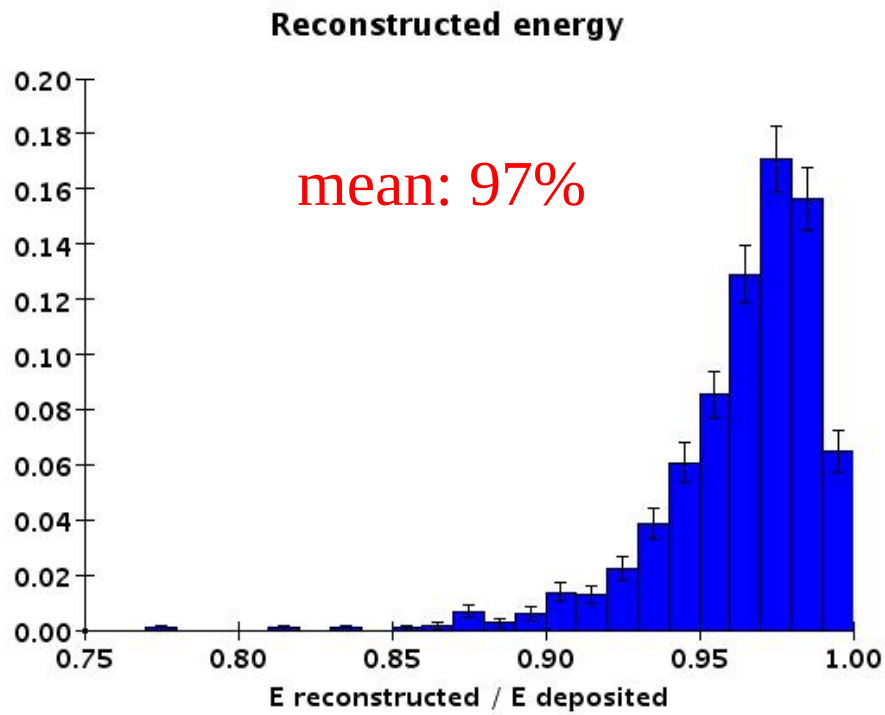


Performance – Single Particles

- Photon efficiency:

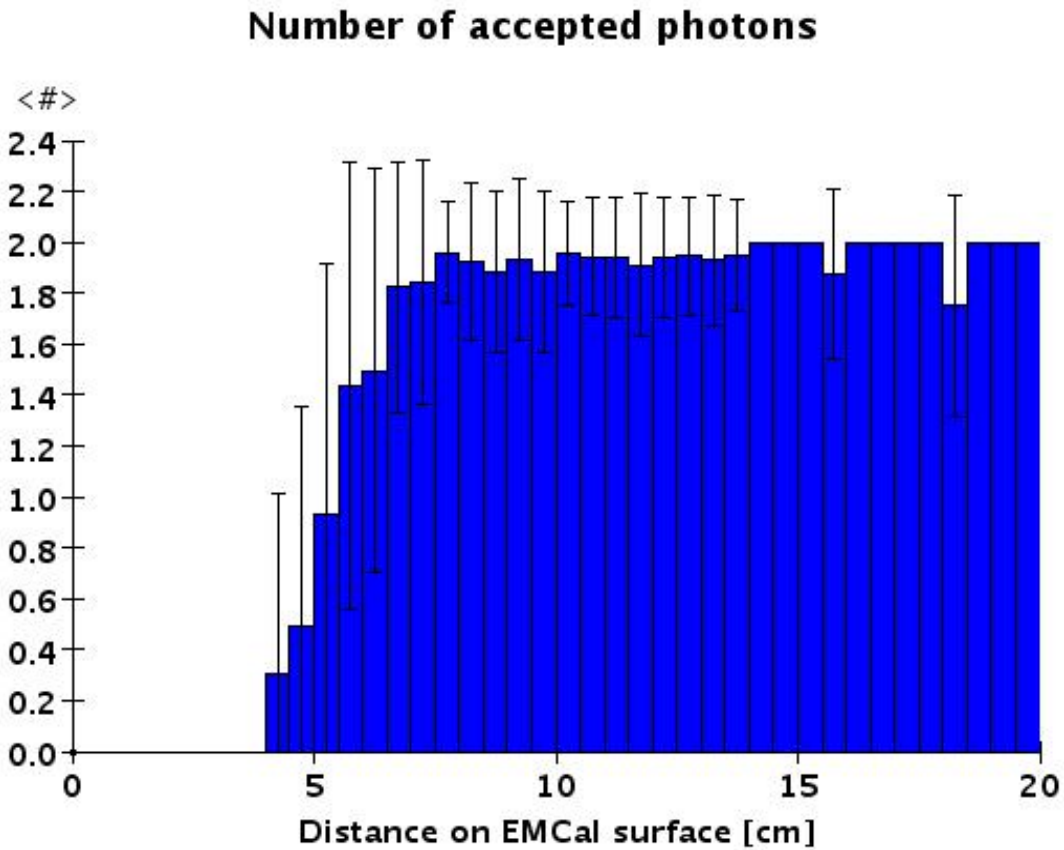




- Accepts 5% pions, 10% neutrons, 10% K^0_L

First Look at Overlap

- Life is always easy with single particles
- Try pi0 (two close-by photons)



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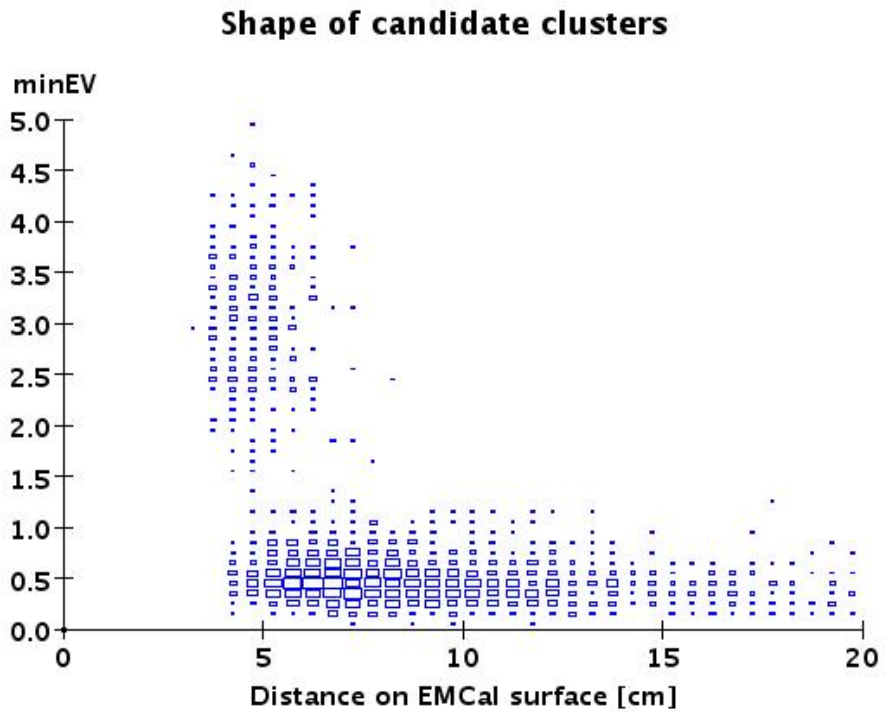

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- High energy efficiency is simple with single particles
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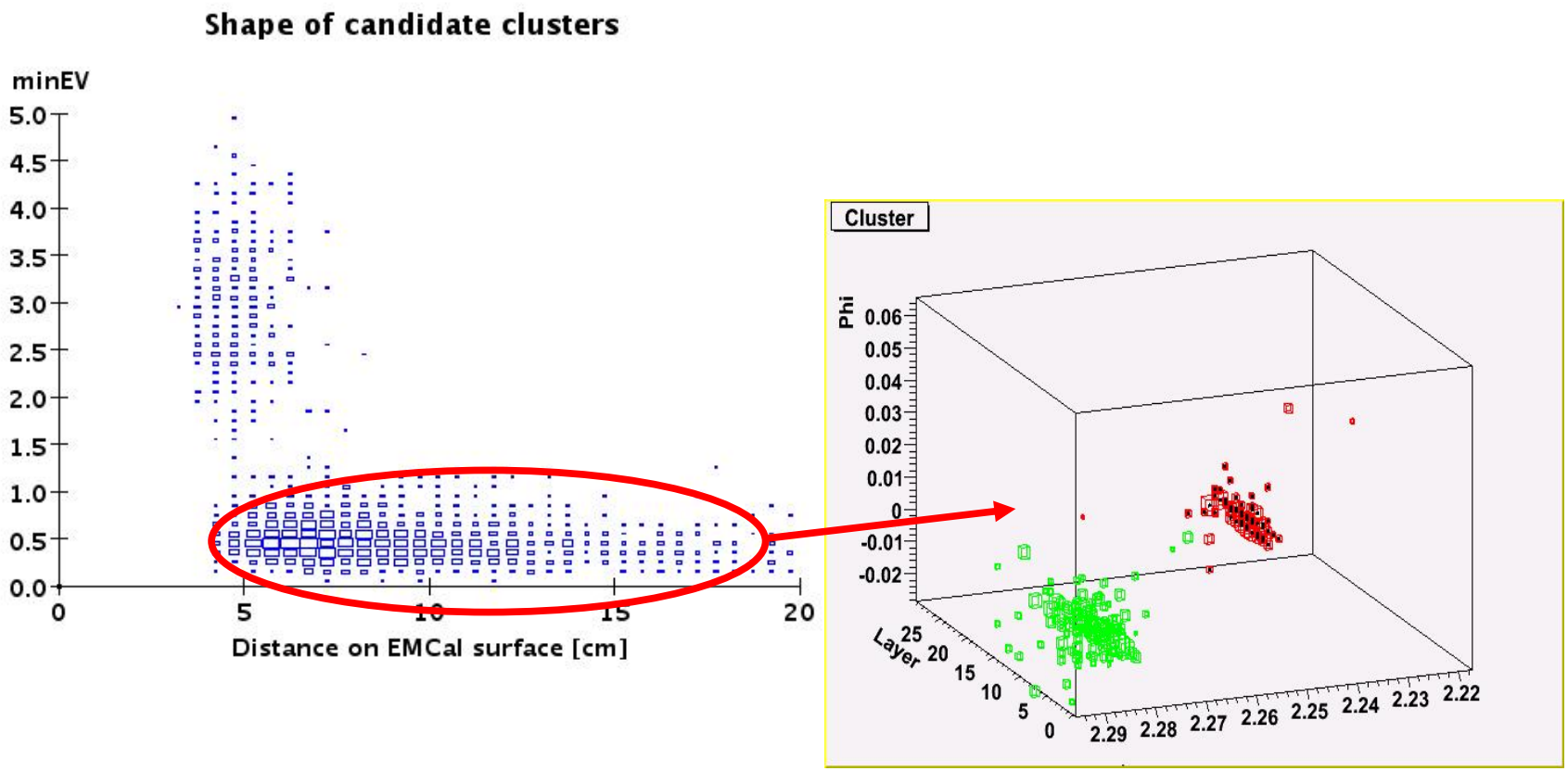

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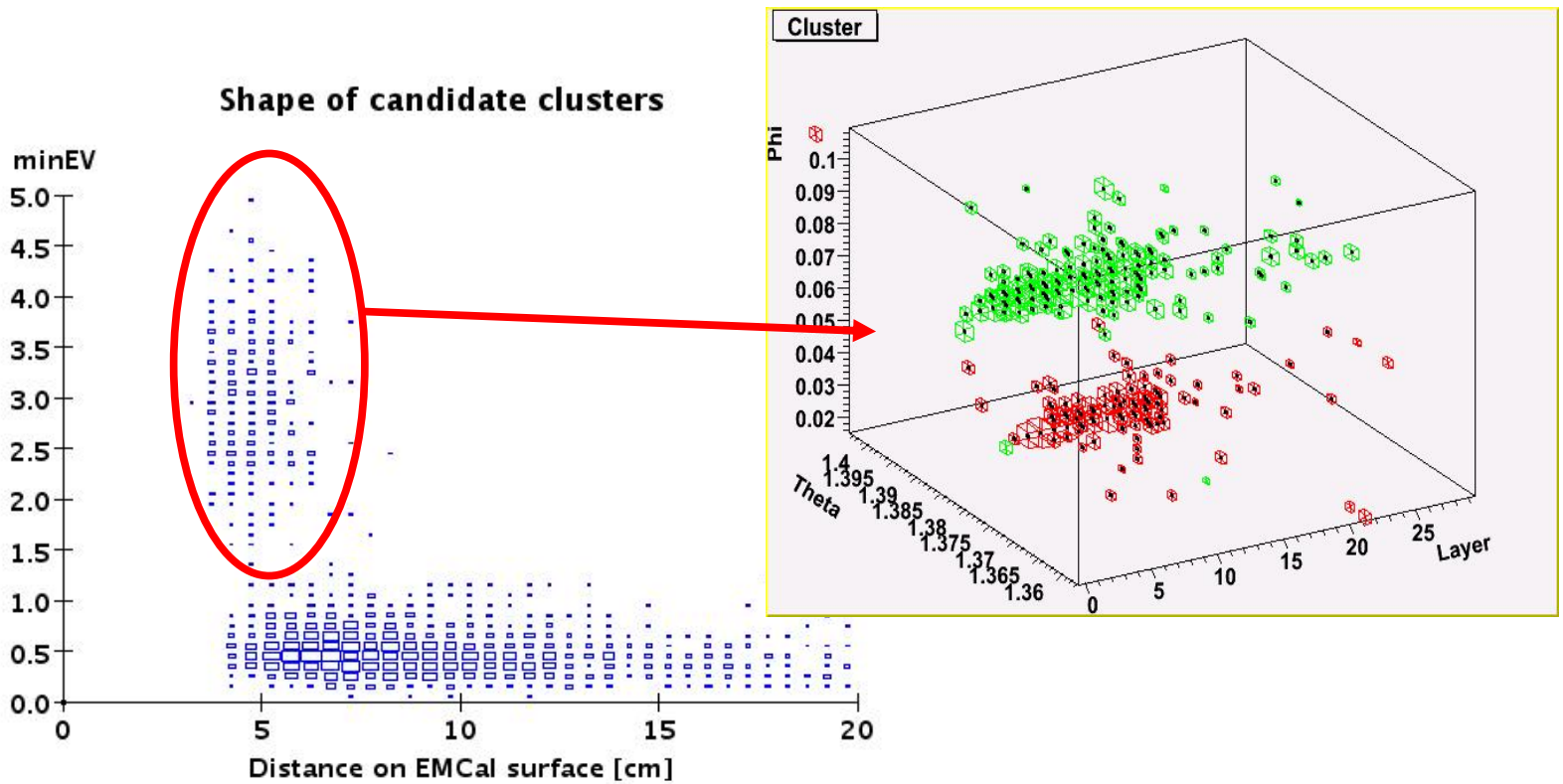
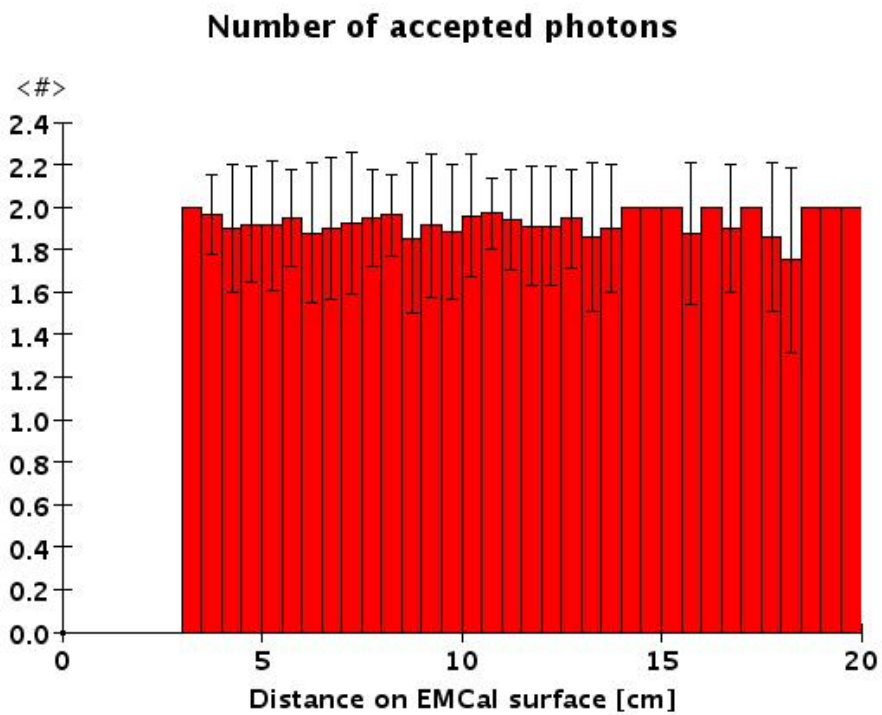
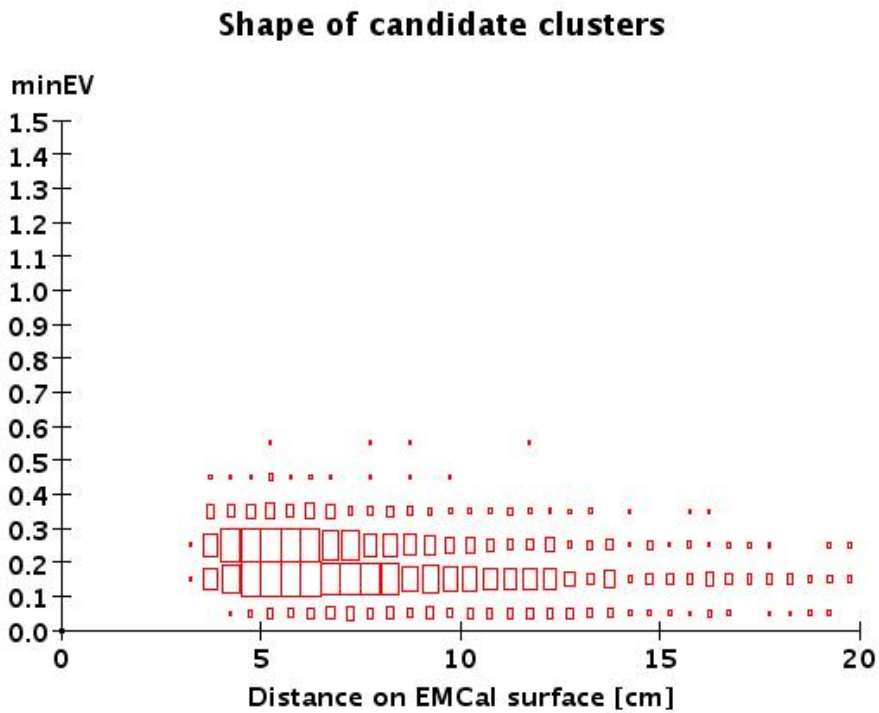


Test: Tighter Threshold

- Try threshold=0.75cm (continuous cluster)





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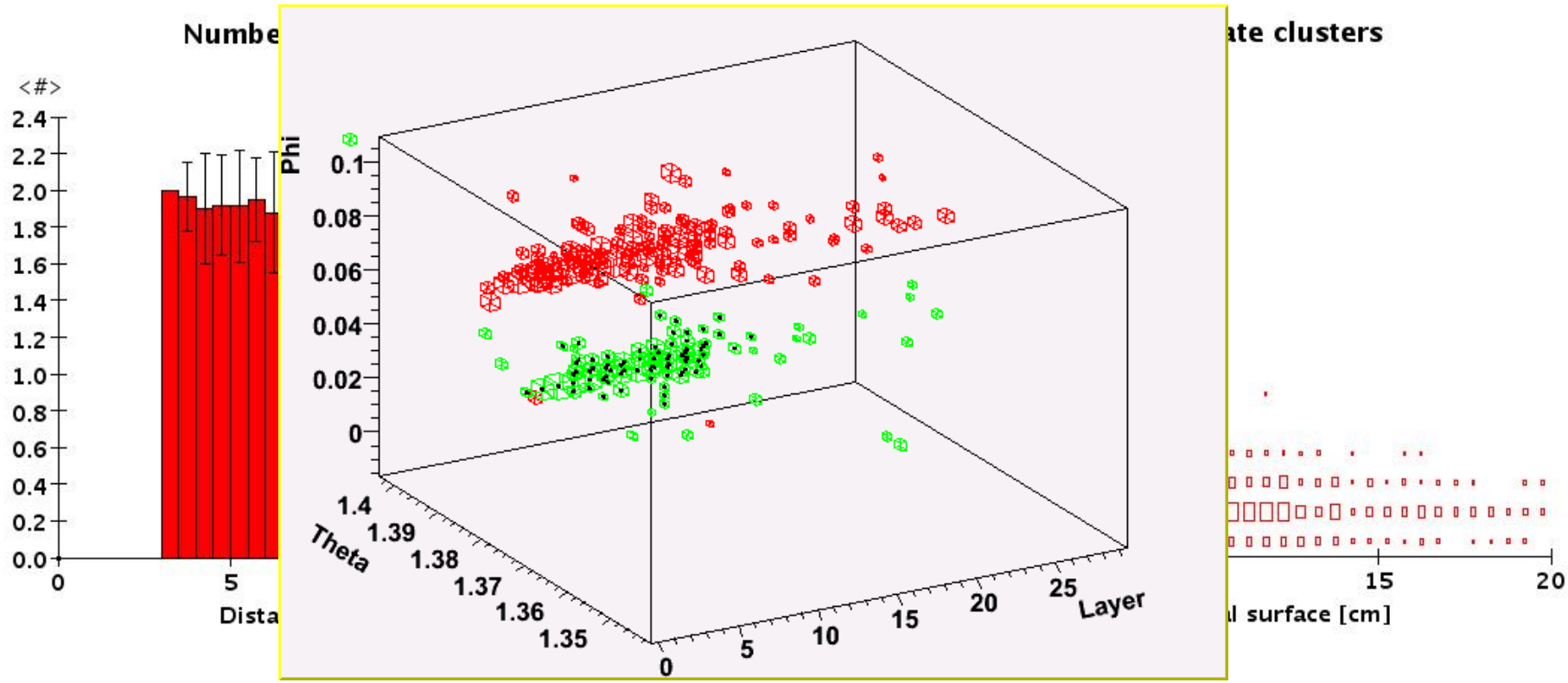

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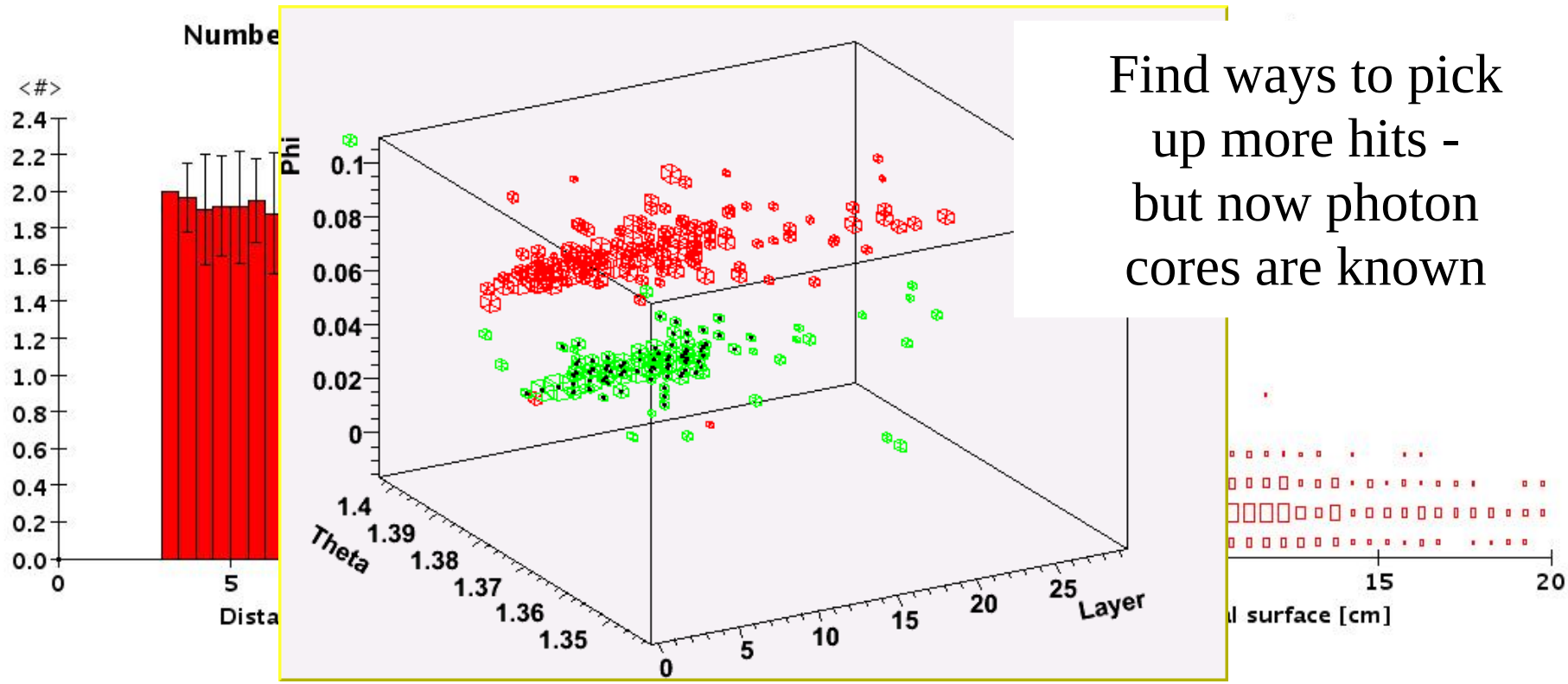

Find ways to pick up more hits - but now photon cores are known

Summary and Outlook

- Use MST algorithm to find electromagnetic showers
- Promising results on single particles and pi0
- Work in progress:
    - Optimize energy collection efficiency
    - Find criteria for low-E photons
    - Study overlap with pions, neutral hadrons
    - ...
    - Put together a 'photon finder'
- Stay tuned...