Reconstruction of showers in the GlueX barrel calorimeter

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Physics
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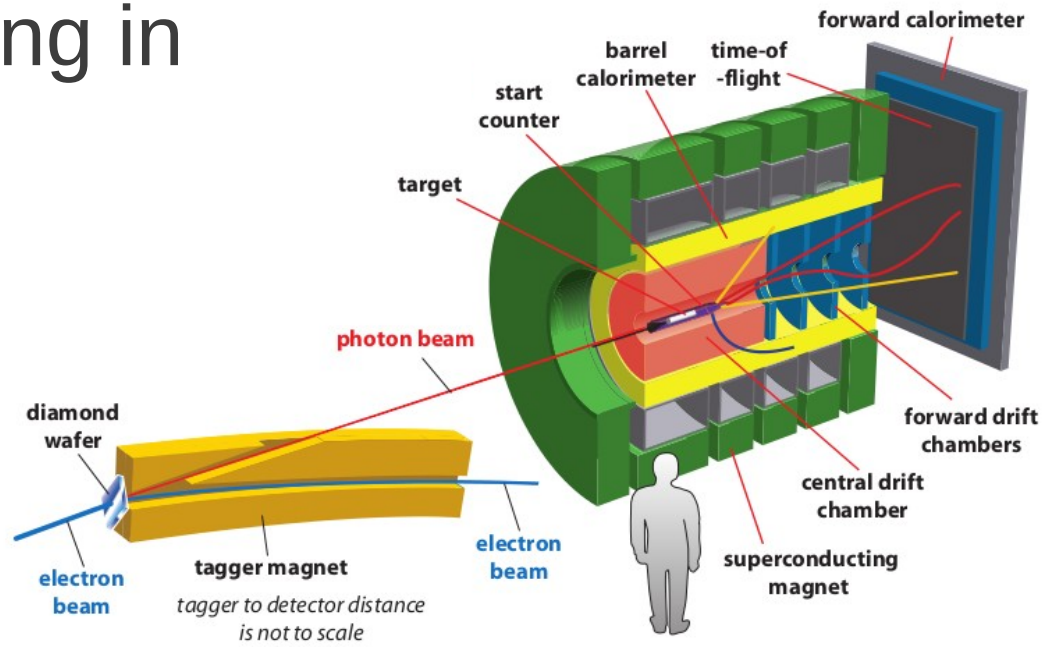
GLUEXcitations
periment

The GlueX Experiment

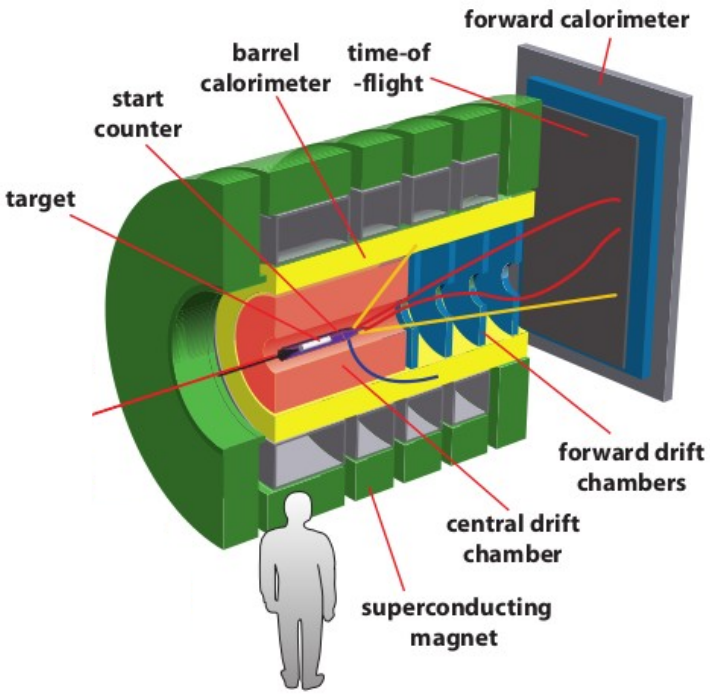
- (Exotic) meson spectroscopy
- Linearly polarized photon beam (~9 GeV) on liquid H2 target
- Beam commissioning in 2014

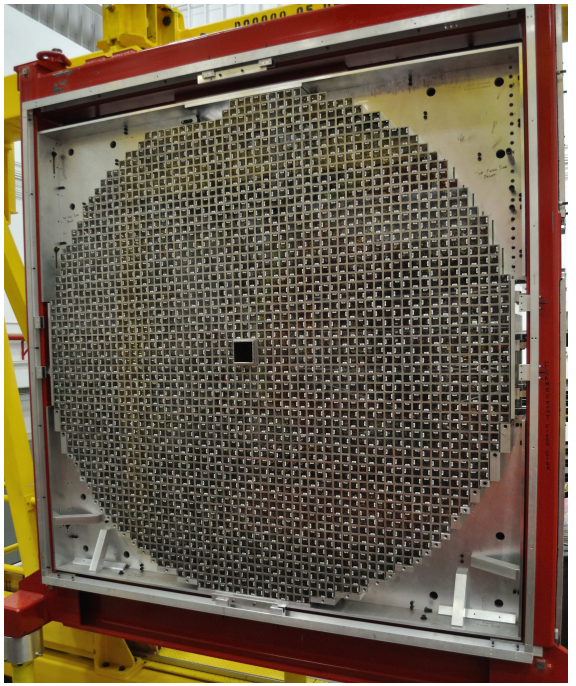


Calorimetry in GlueX

- Excited mesons decay into neutral and charged ground state mesons
  - $\gamma p \rightarrow \pi_1(1600)^0 p \rightarrow \pi^+\pi^-\pi^0 p$

$\pi^0 \rightarrow \gamma\gamma$
$\eta \rightarrow \gamma\gamma, \pi^+\pi^-\pi^0$
$\eta' \rightarrow \pi^+\pi^-\eta, \pi^+\pi^-\gamma, \gamma\gamma$



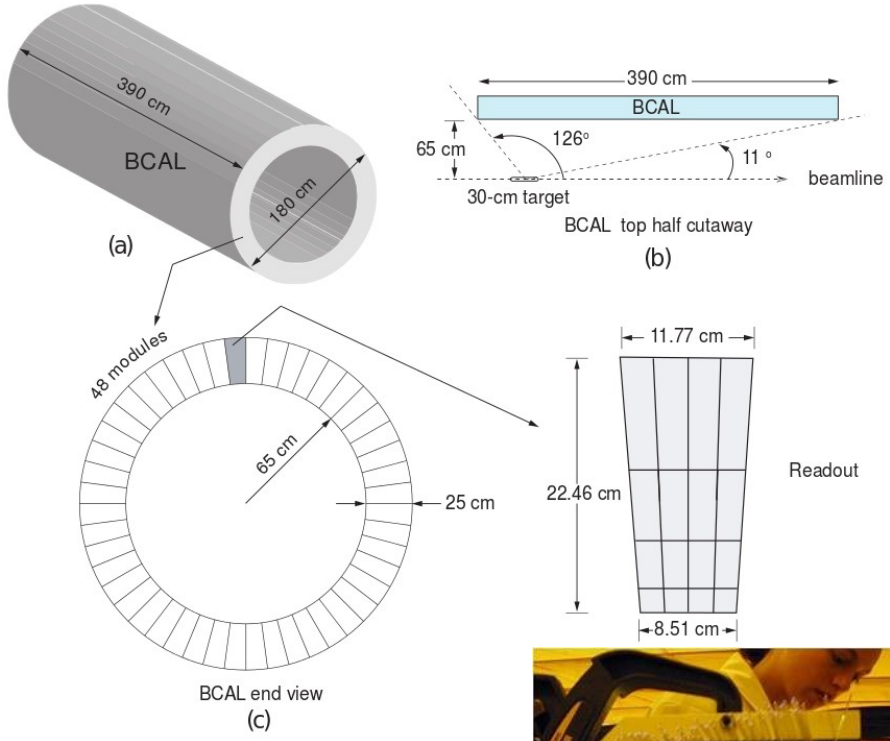


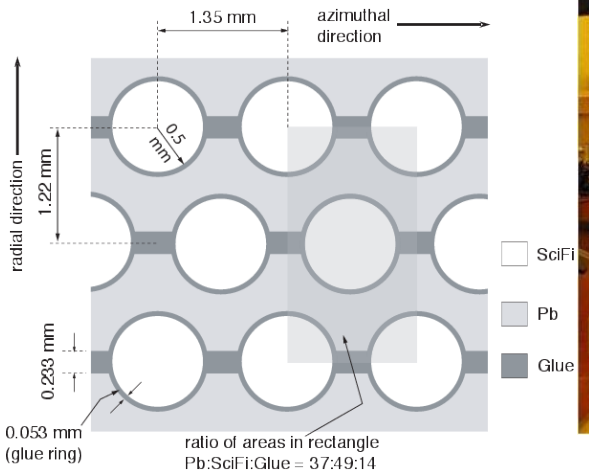
Forward calorimeter (FCAL)
$1° < \theta < 11°$

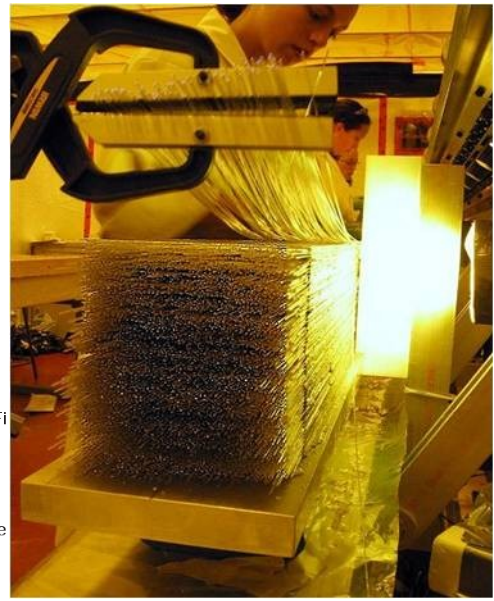
Barrel calorimeter (BCAL)
$11° < \theta < 125°$

Barrel Calorimeter

- Lead/scintillating fiber matrix
- Segmentation
  - 48 modules
  - Segmented readout: 16 channels/module
- Double-ended readout
  - Time difference allows determination of z position
    - $z = \Delta t * c_{eff}$
  - Flash ADC + TDC for precise time- and z- resolution
    - $\sigma_z = 1.1\ cm/\sqrt{E}$
  - Silicon photomultiplier instead of PMT due to B field

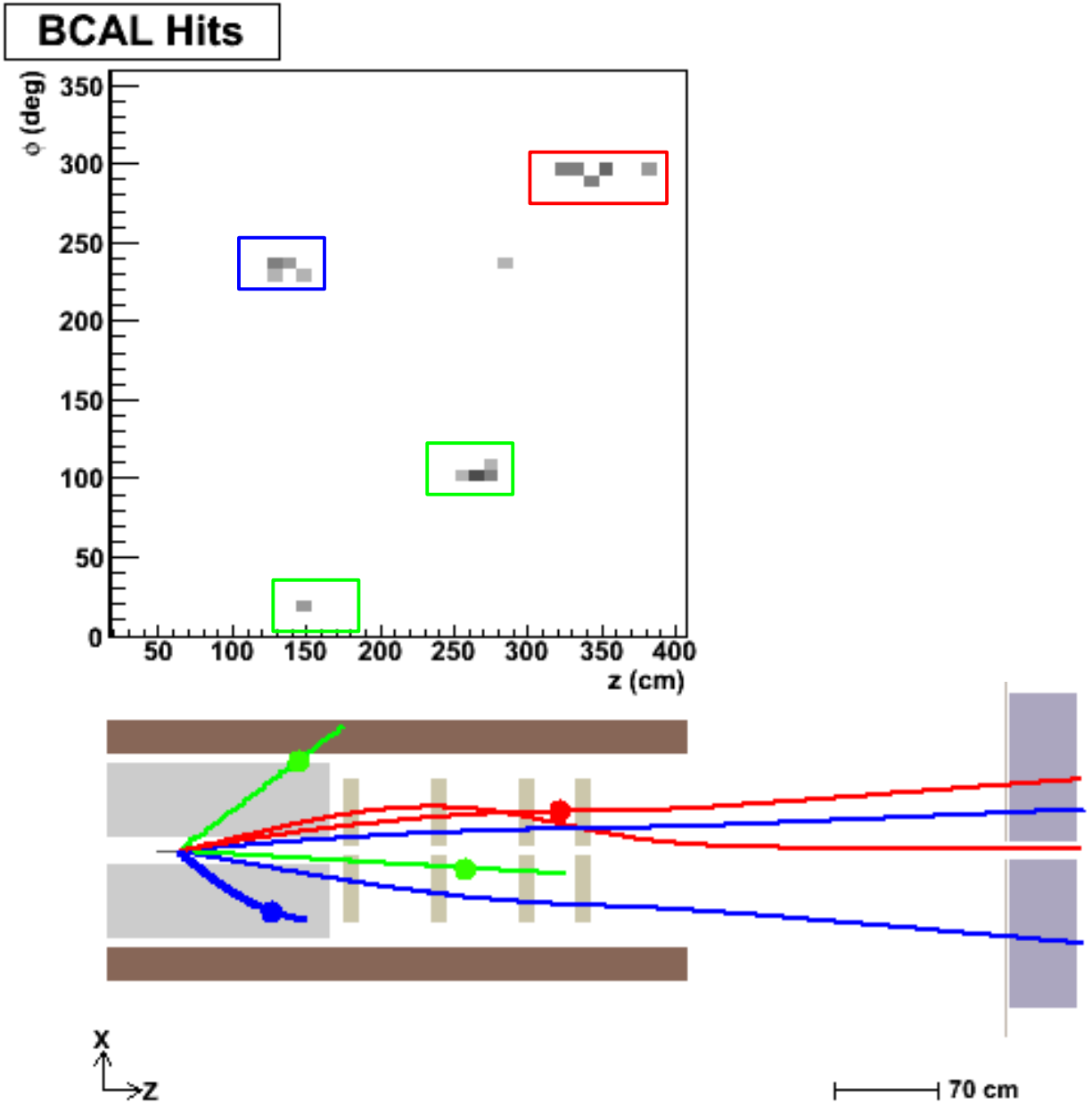






BCAL Reconstruction

- Accurately cluster hits in high multiplicity events
  - Avoid splitting or merging showers
- Distinguish hadronic showers from photons



Clustering Procedure

1. Start with the highest energy hit as a **seed** for cluster
2. Group nearby hits together with seed to form a cluster
3. Next seed is highest energy hit not yet part of a cluster
4. Sum hit energies, average hit positions to get cluster properties

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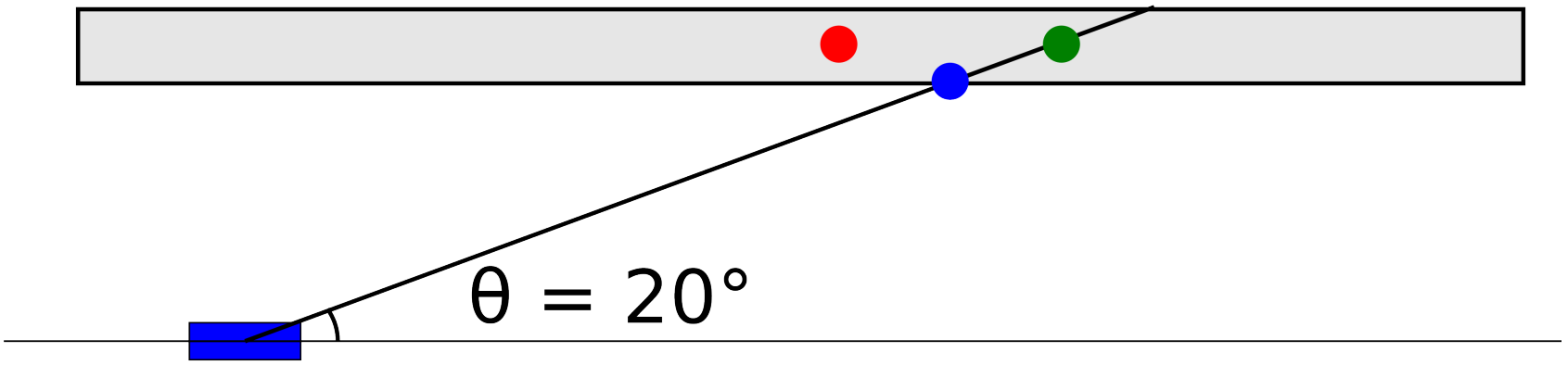
Clustering Procedure: What is "nearby"?

2. Group nearby hits together with seed to form a cluster

Nearby by distance in φ-z space?



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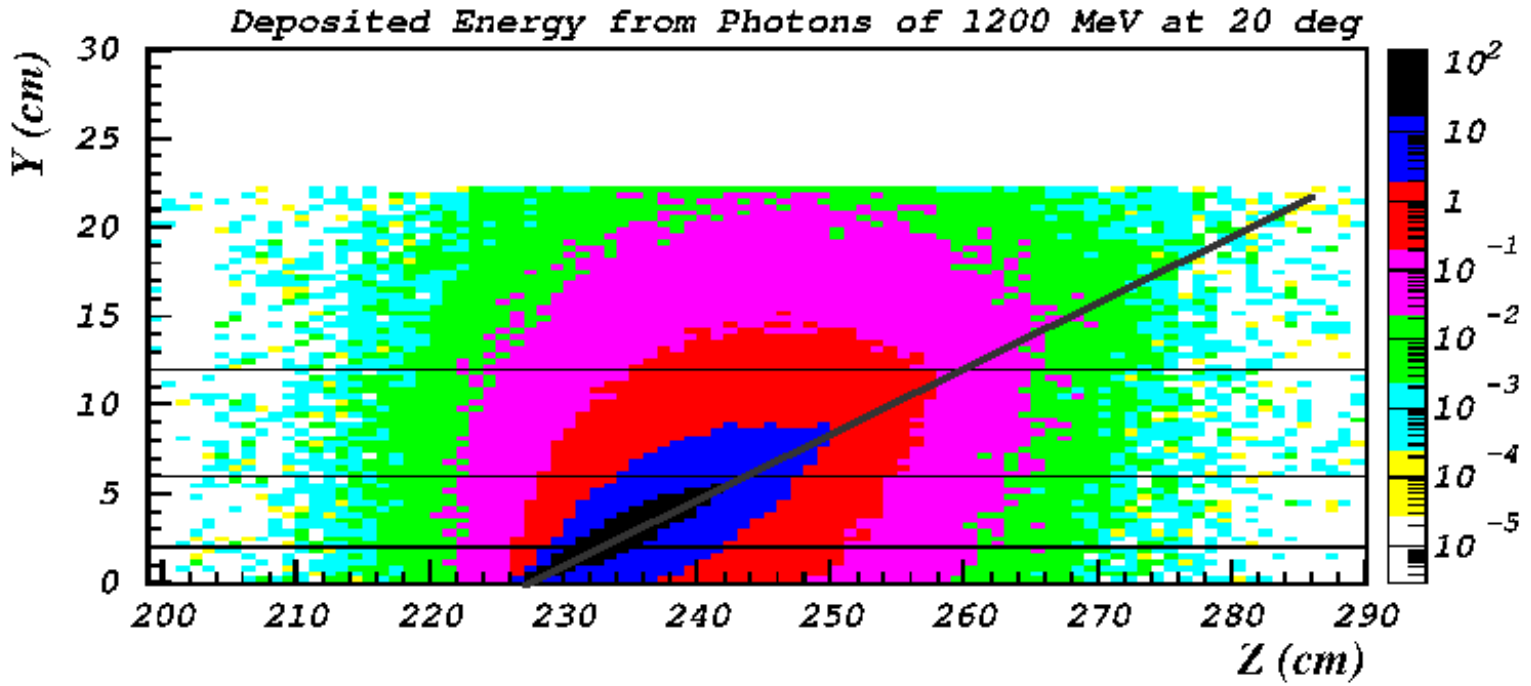
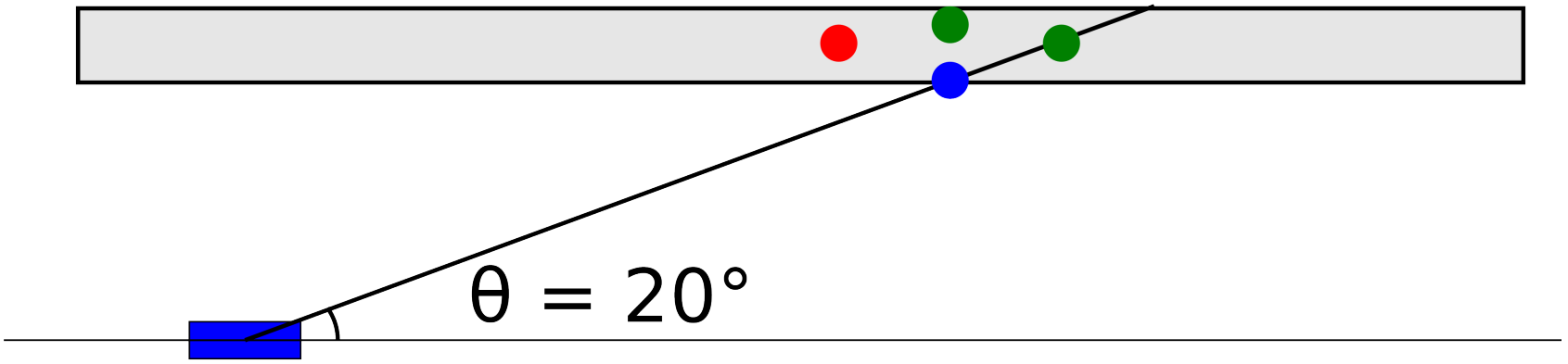


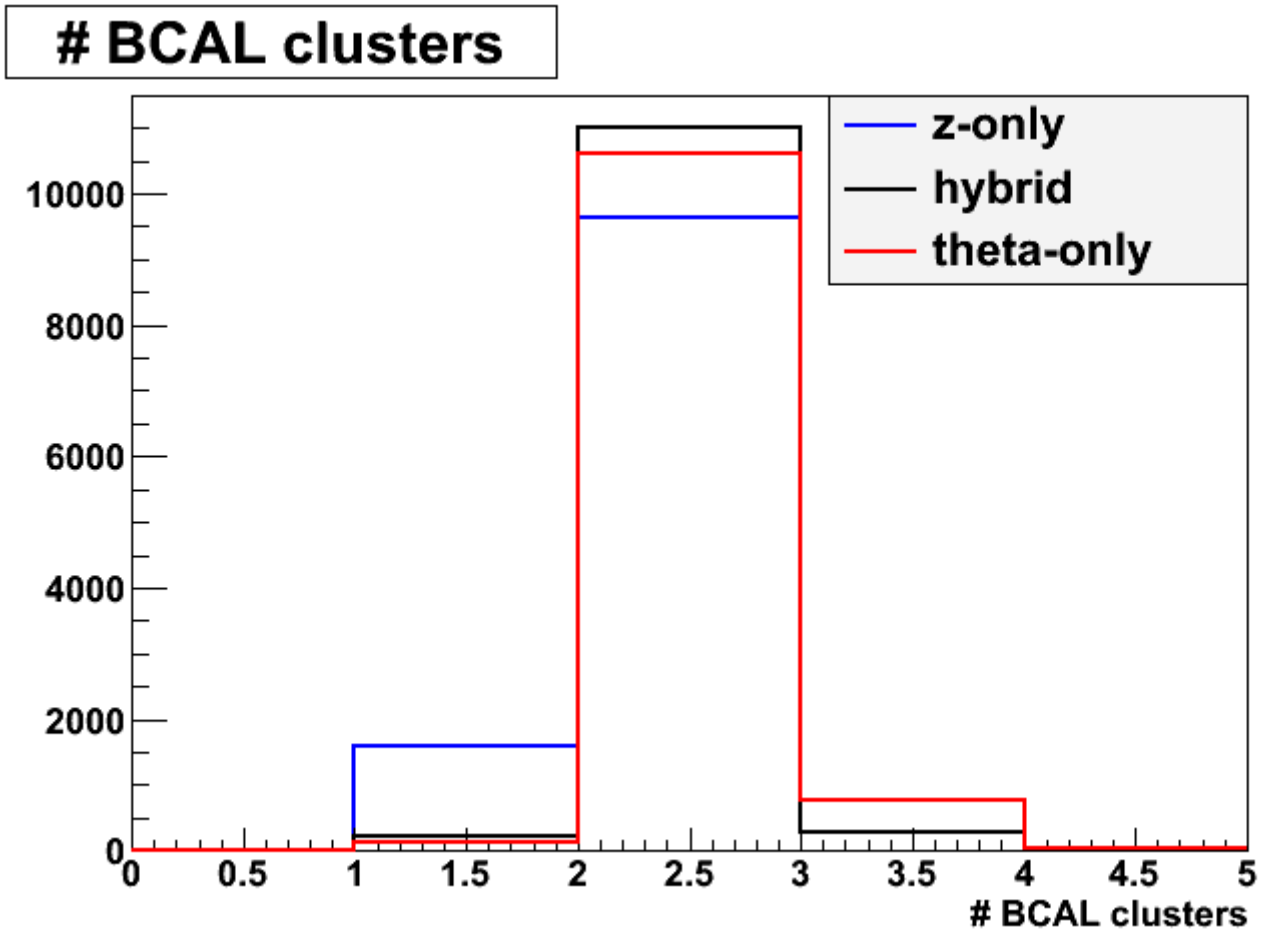
Clustering Procedure: What is “nearby”?

- Hybrid method
  - Require hits nearby in φ
  - Require hits nearby in θ or nearby in z
  - “nearby” depends on energy, depth of hit



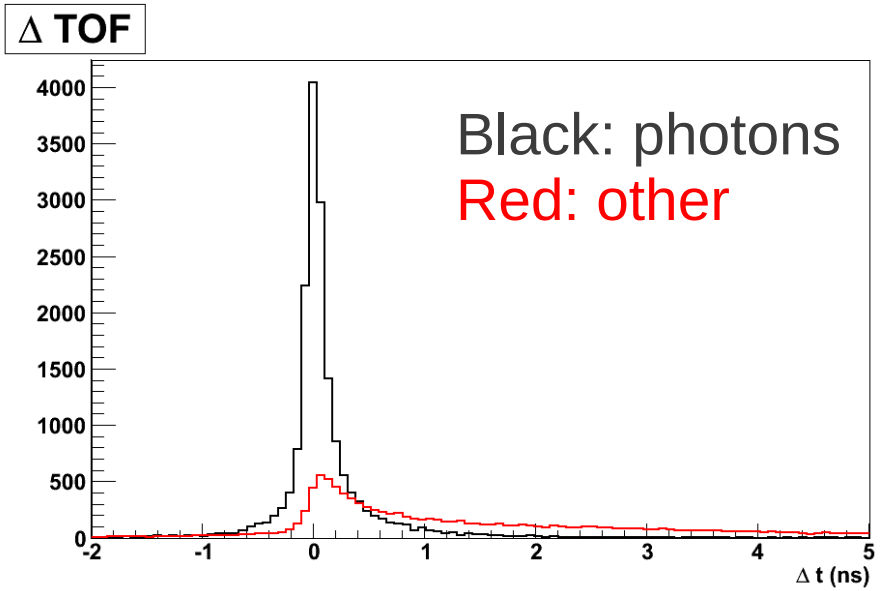
Evaluating clustering algorithms

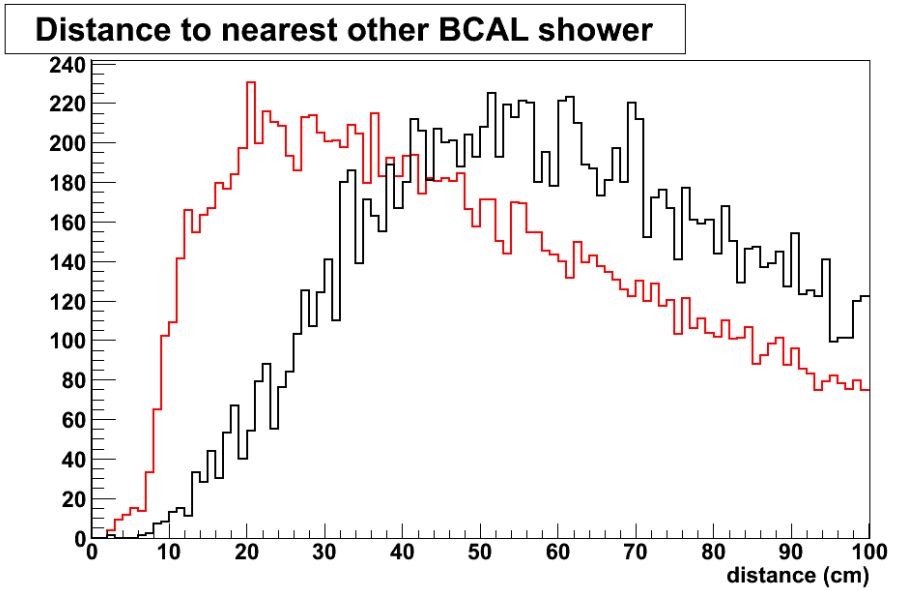
- Compare 3 algorithms
- π^0 sample
  - Both decay photons in BCAL
  - Both photons have sufficient energy to be reconstructed
  - Should get exactly 2 clusters/event



Distinguishing hadronic showers from EM showers

- Hadronic showers are background for photon reconstruction
- Spatial matching between reconstructed track and reconstructed cluster
  - Only eliminates 50% of clusters due to hadrons
- Discriminating variables
  - Time-of-flight relative to expected photon TOF
  - Depth profile in calorimeter
  - Distance to nearest other cluster





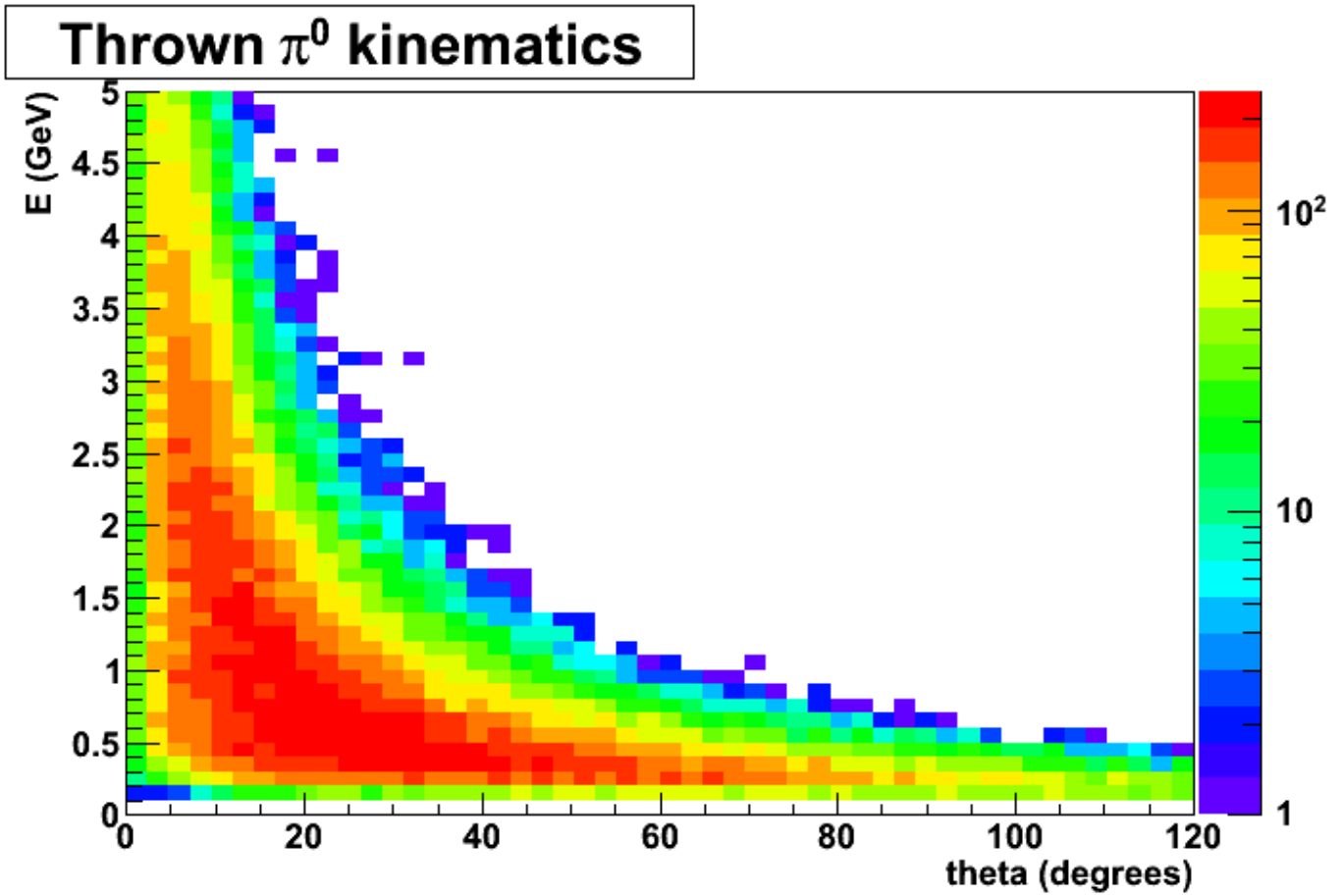
Distinguishing hadronic showers from EM showers

- Simple cuts on discriminating variables
  - Eliminate 80% of non-photon clusters
- Multivariate classifier (boosted decision tree)
- Global analysis (kinematic fit)

Summary

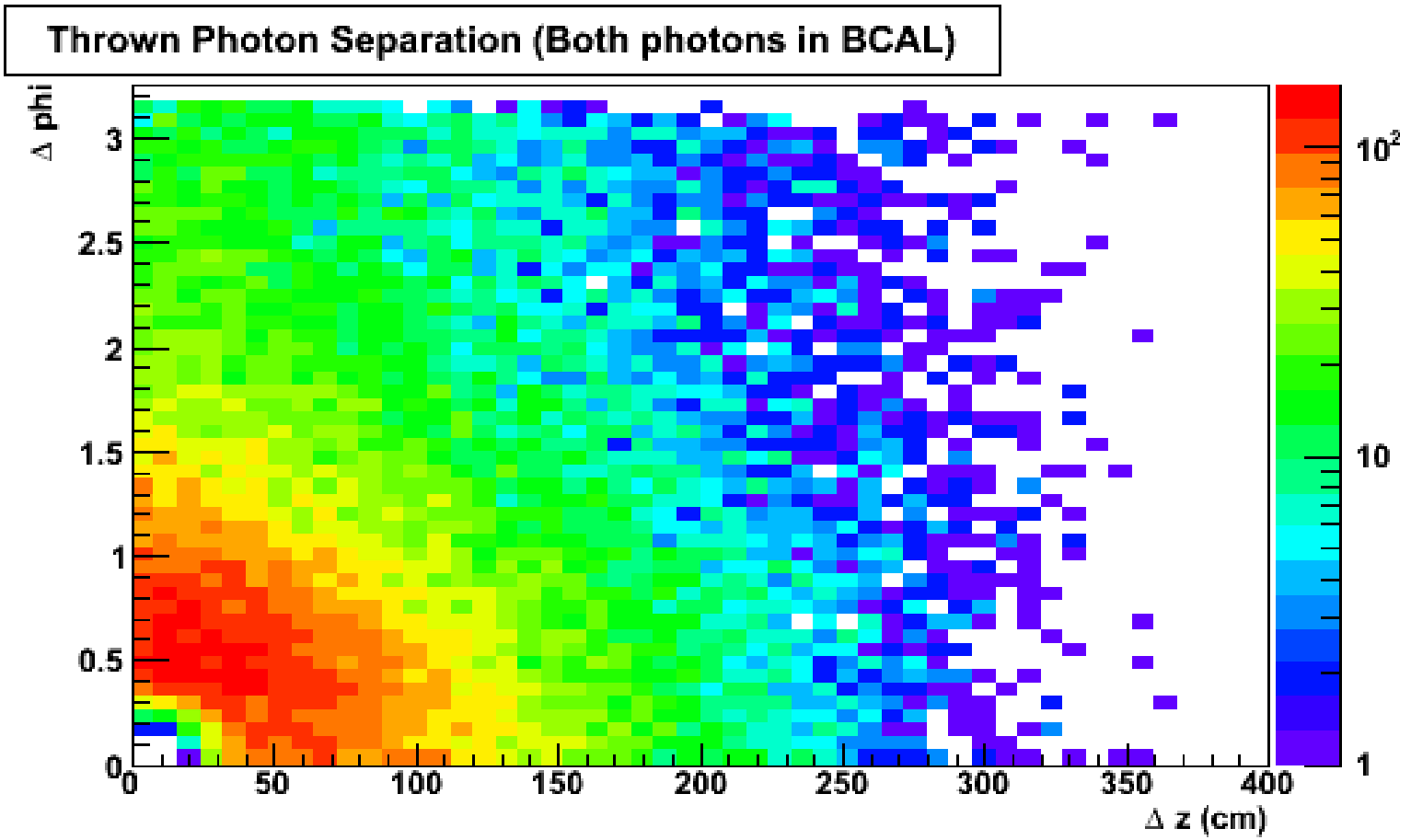
- Clustering algorithm
  - Cluster hits around seed
  - Hybrid method uses z-position and θ
- Identifying hadronic showers
  - Matching with reconstructed tracks
  - Analysis of discriminating variables (timing, shape)
  - Kinematic fit

π^0 kinematics

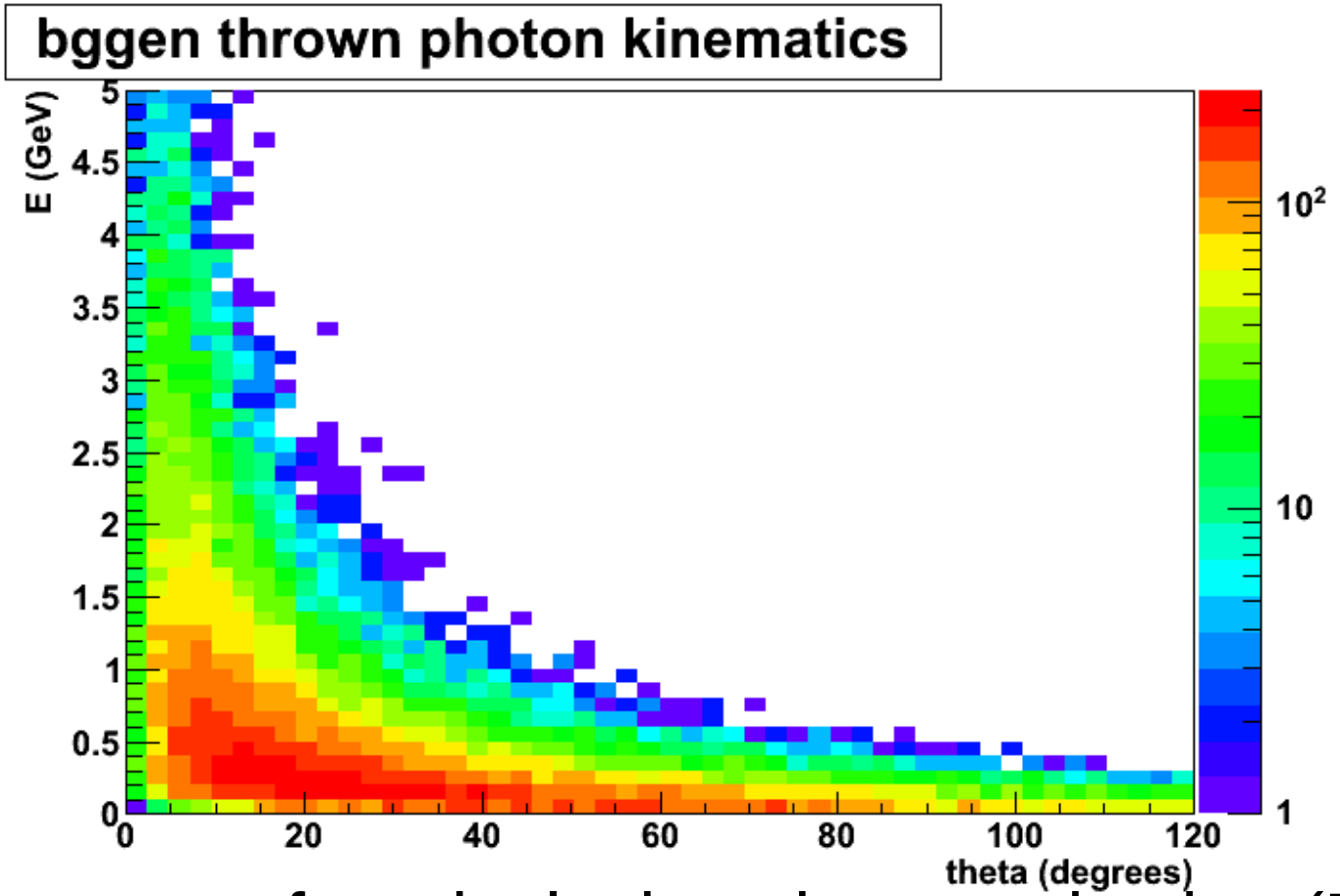


π^0 spectrum from inclusive photoproduction (E_γ = 8.4-9 GeV), modeled by pythia

π^0 decay photon separation

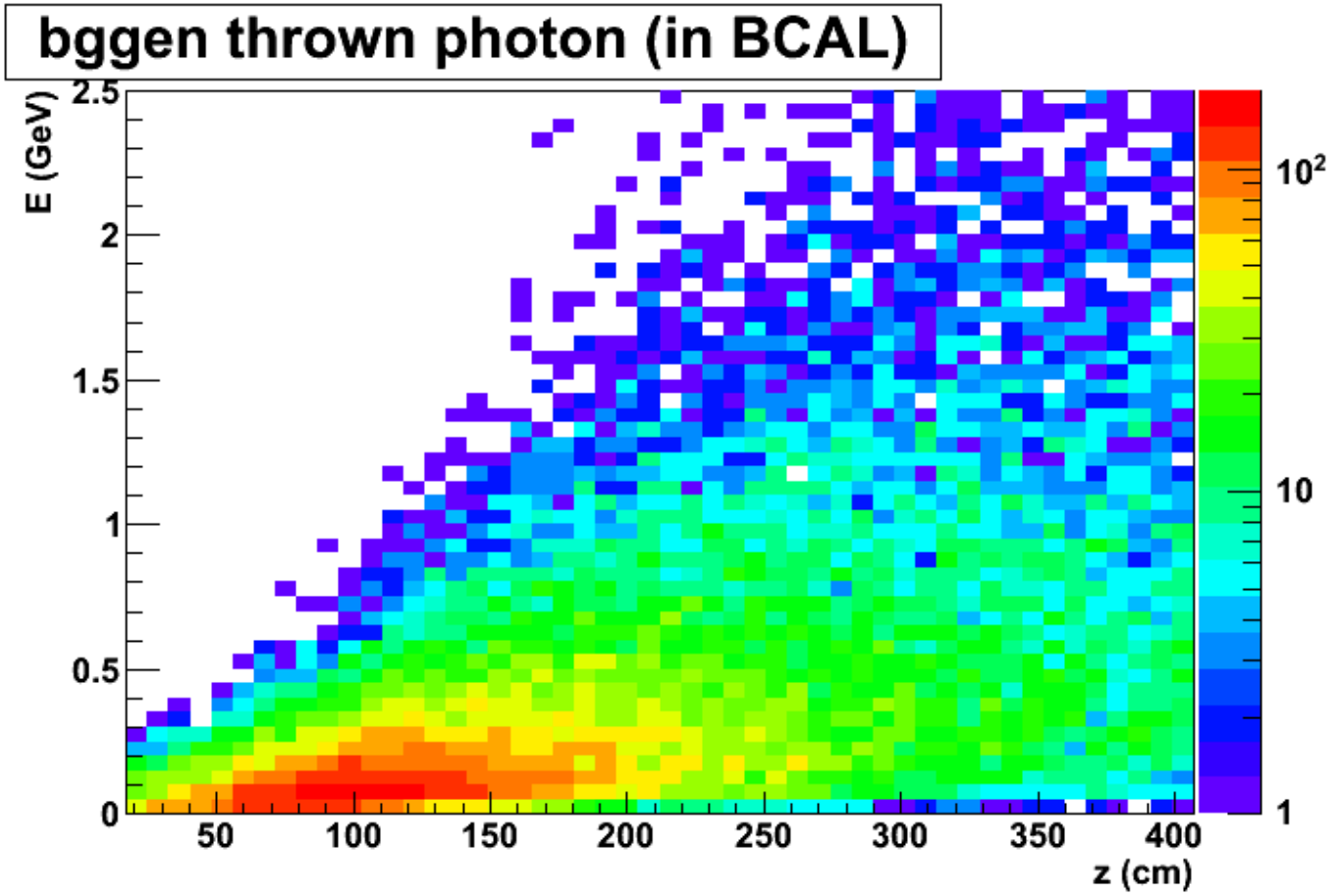


BCAL photons in full event reconstruction



γ spectrum from inclusive photoproduction (E_γ = 8.4-9 GeV), modeled by pythia

BCAL photons in full event reconstruction



- 2.3 BCAL photons/event

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