π^0 reconstruction in the GLD calorimeter

Daniel Jeans, Kobe University
for the ACFA-SIM-J group

π^0 identification in a strip calorimeter

(π^0 γ–γ pairing in Z0 events)

π^0 finding

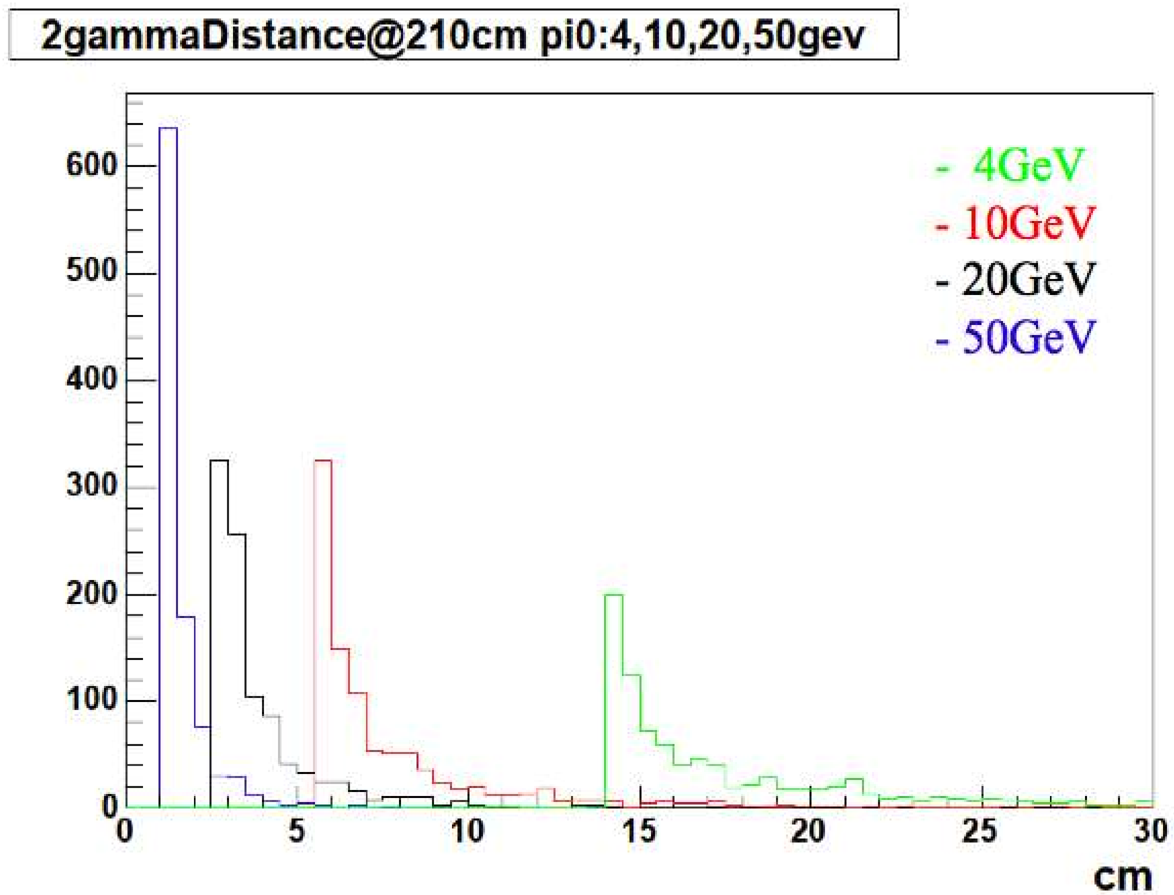
- significant fraction of neutral energy in jets are γ from π^0
- in PFA, neutral energy contributes most to the energy resolution
- hope to identify pairs of γ from π^0, perform kinematic fit, improve energy estimate

GLD strip calorimeter

- GLD baseline calorimeter has scintillator strips
  - 1x5 cm, perpendicular orientation in adjacent layers
- hope that a smart algorithm can get almost 1x1cm "effective granularity"
- how long can the strips be?
- study in single π^0 and single γ events
  - how well can these be distinguished?

π^0 -> $\gamma\gamma$ opening angle

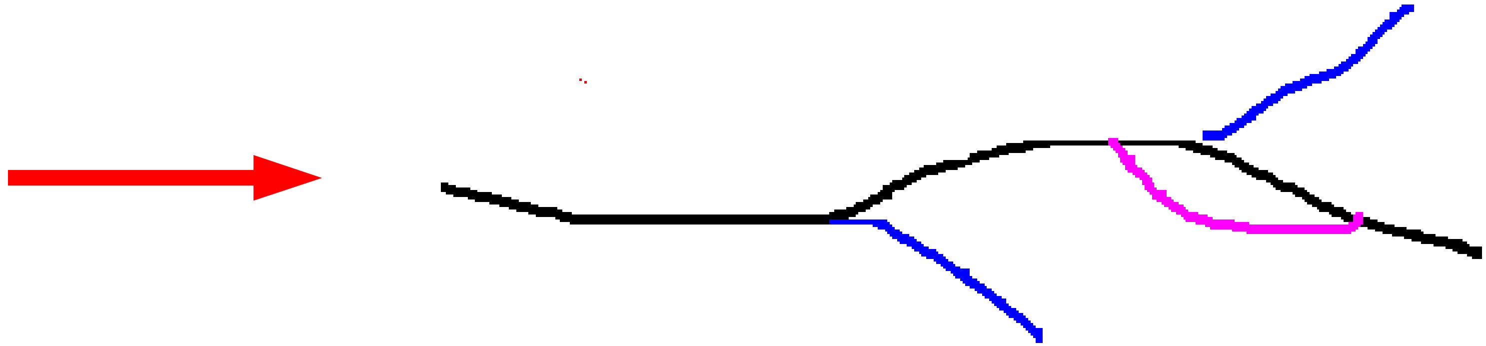
separation of photons at front face of EM calorimeter (210cm)



10 GeV ~ 6cm, 20 GeV ~ 3cm

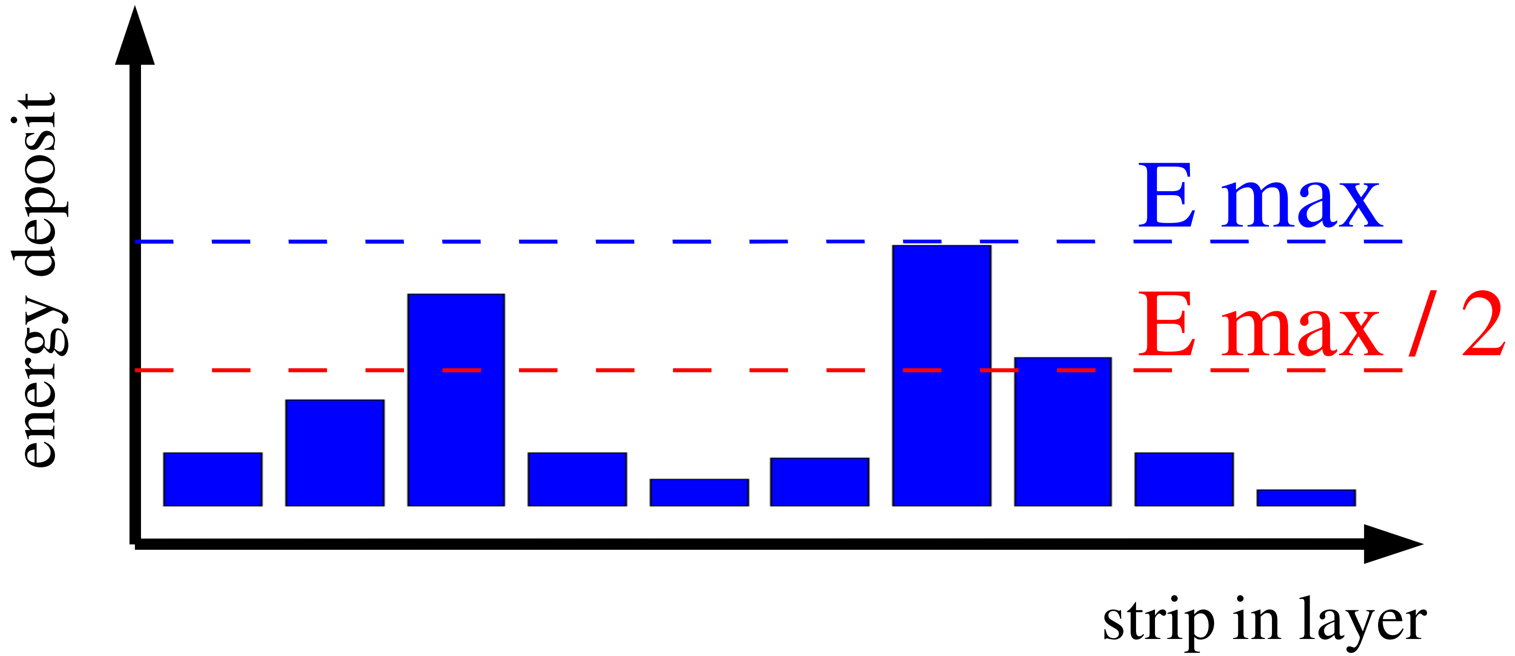
strip clustering

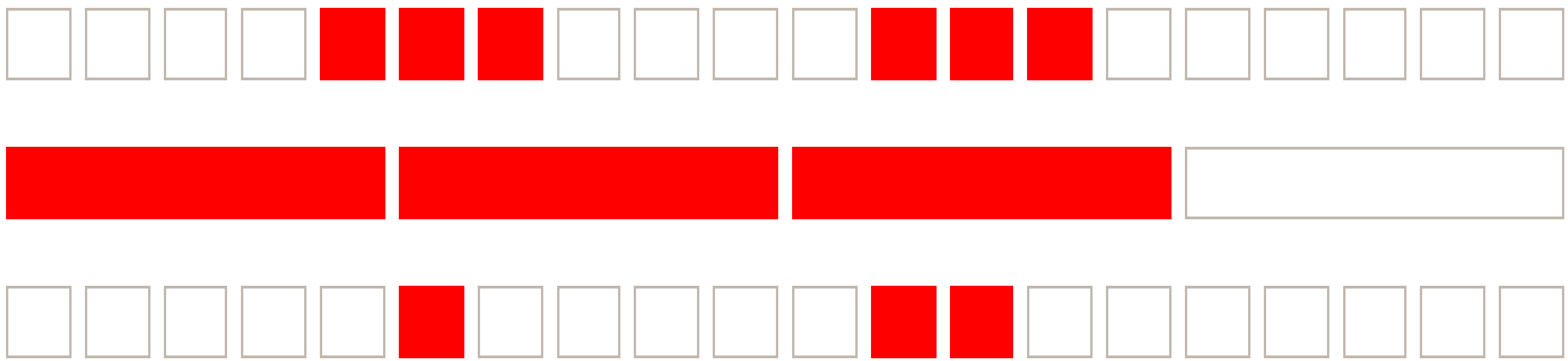
- 2 photons maybe resolved in only one strip
  "polarity"
- resolve as much information about shower shape

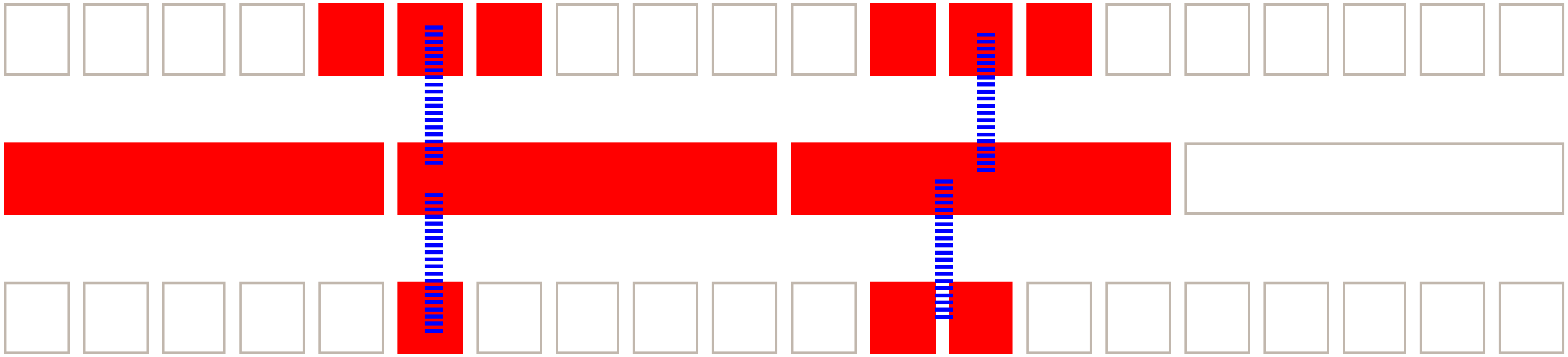


strip clustering algorithm

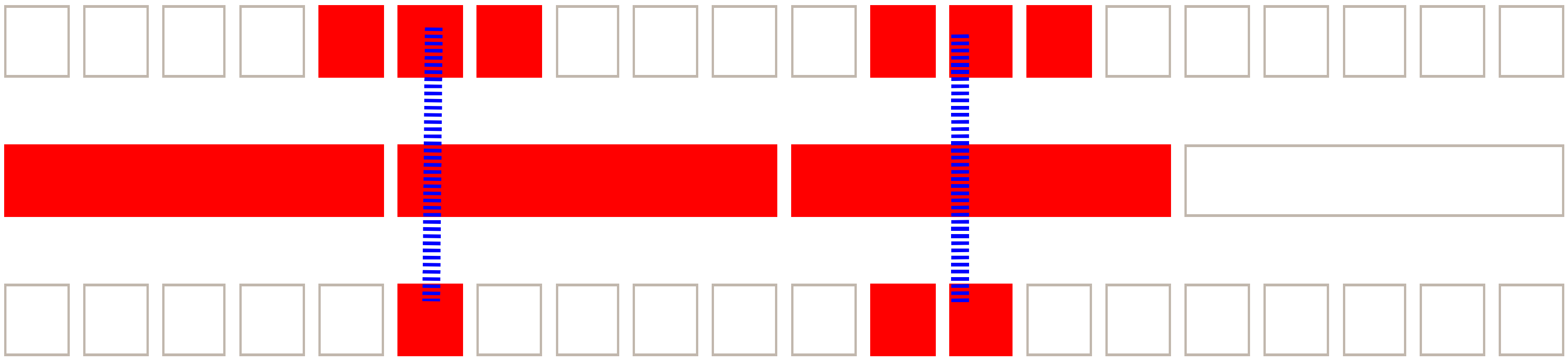
- first nearest-neighbor clustering in each layer.
- look for substructure in clusters,
  - recluster with higher energy threshold
- split if reclustering gives > 1 cluster
  - assign below threshold strips to closest cluster





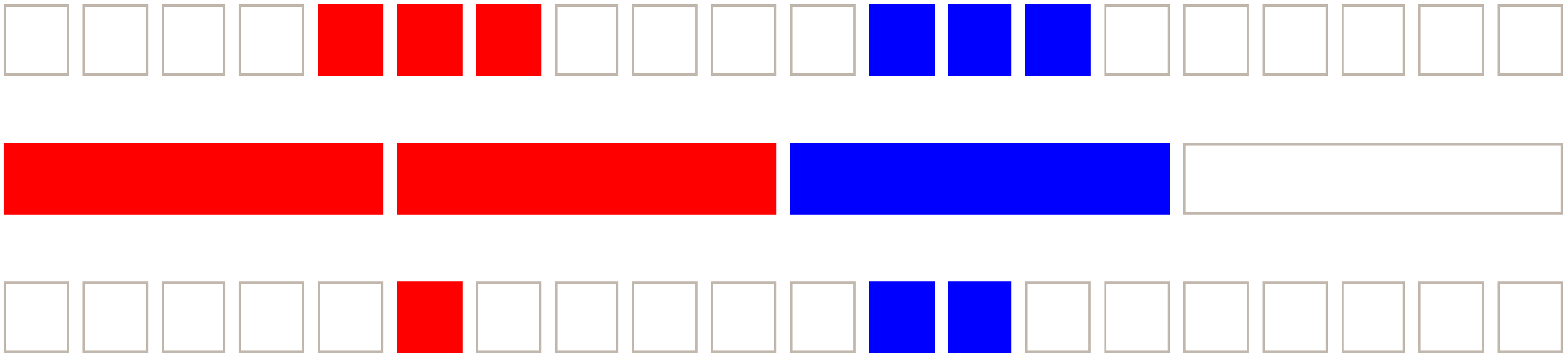


- look for neighboring clusters in the layers above and below
  - since these have different orientations, it's easy to be a neighbor

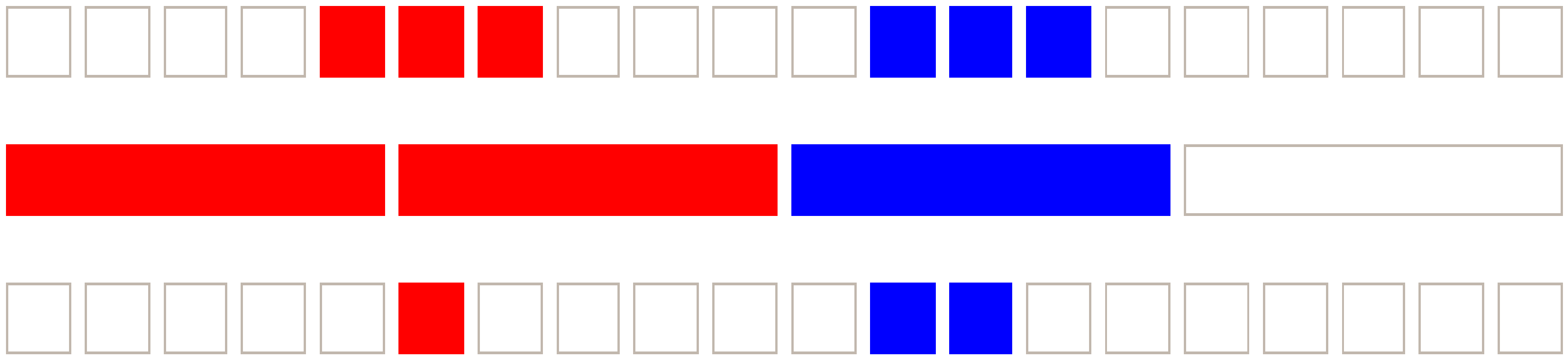


- look for neighboring clusters in the layers above and below
  - since these have different orientations, it's easy to be a neighbor

- if “above” and “below” are also each others' neighbors, make “triplet”
  - this is more stringent: “above” & “below” have same orientation

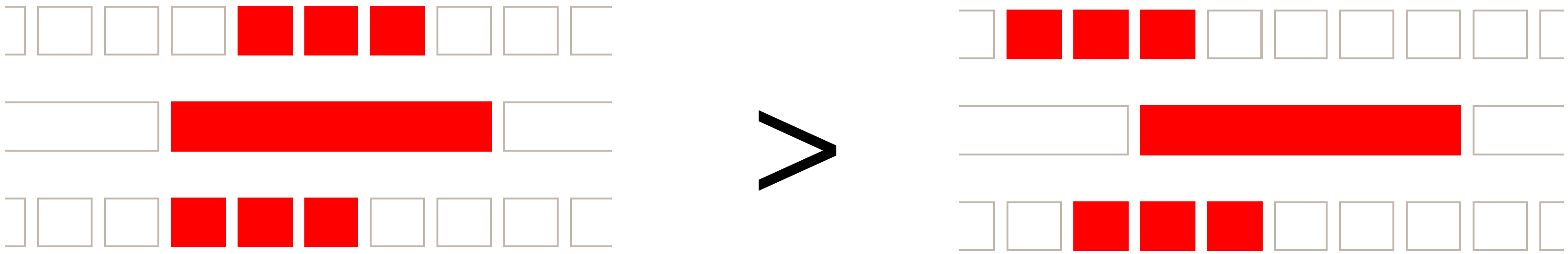


- if a cluster is central member of >1 triplet, split it cell-by-cell

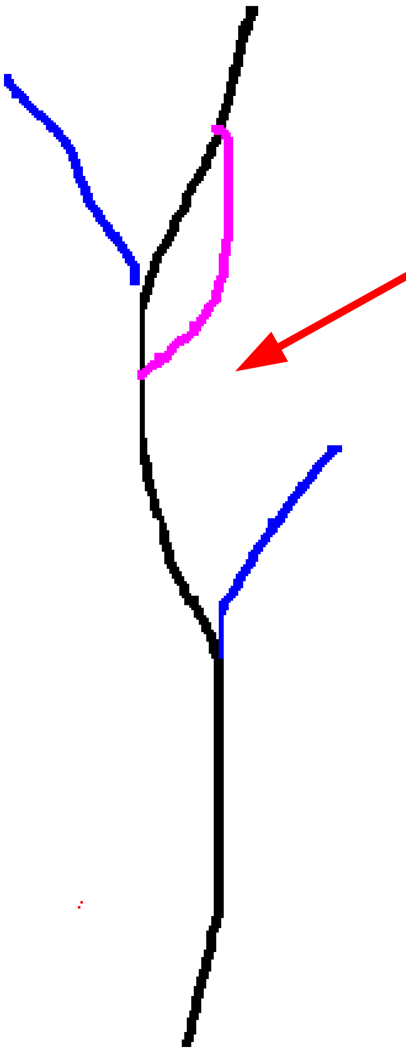


- if a cluster is central member of >1 triplet, split it cell-by-cell

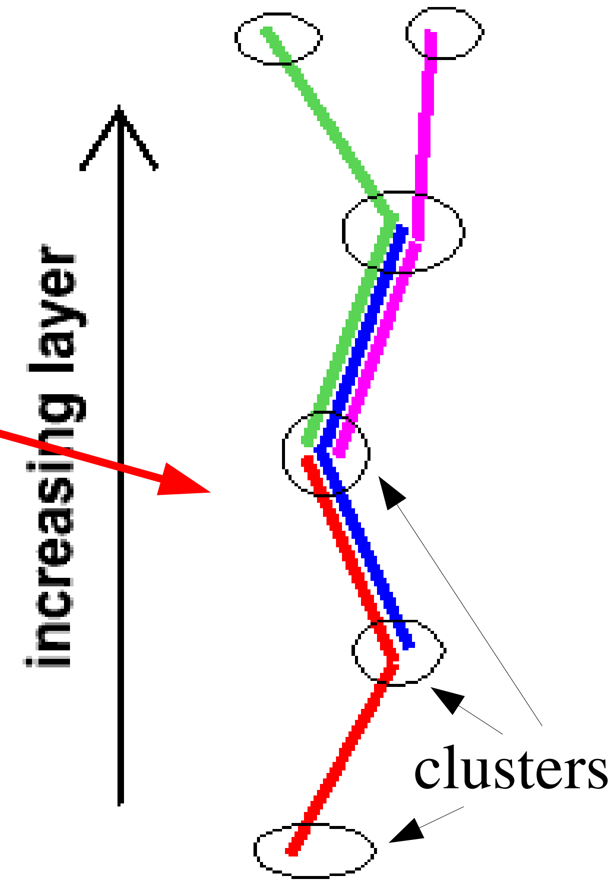
- define “overlap-quality” of triplet
  - energy-overlap of its clusters



calorimeter "tracking"

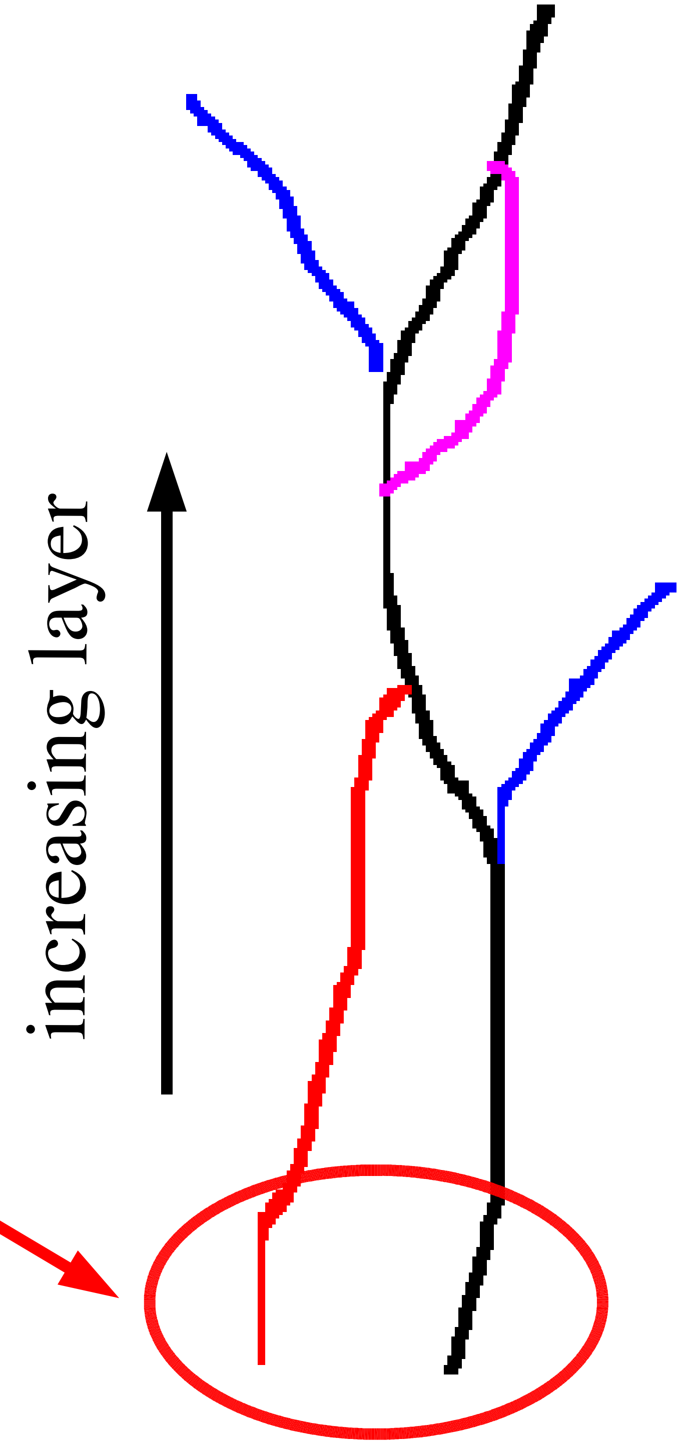


- ideally want to reconstruct as much detail about shower as possible
- do this by combining triplets which have 2 clusters in common, starting at inside of calorimeter, working out
- in case of ambiguities, use triplet "overlap-quality" to choose

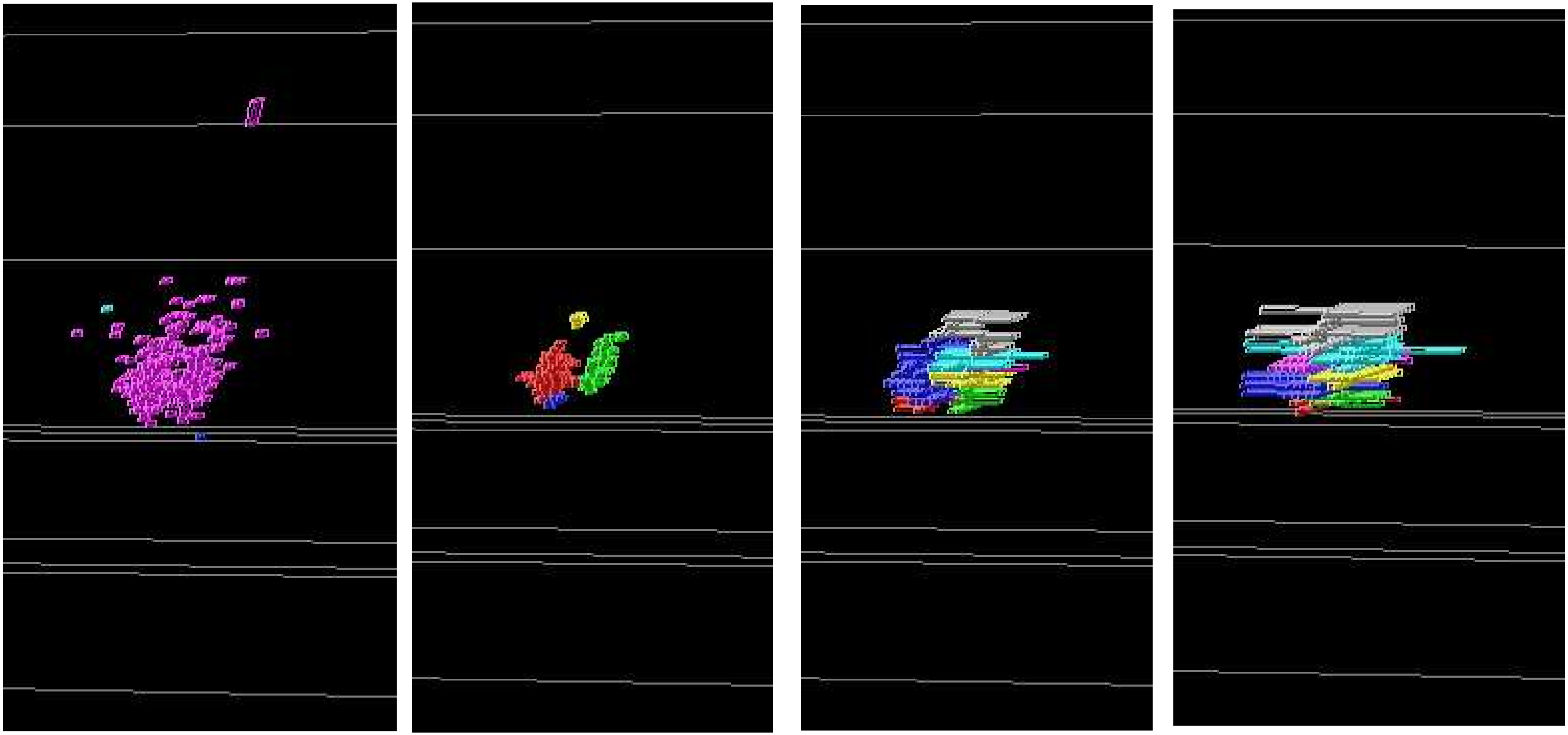


π^0-γ separation

- can we distinguish π^0 from γ?
- look at cases where separation is non-trivial: simple nearest neighbor clustering finds a single cluster
- look for cases where there are two “motherless tracks” early in the cluster development



events displays: same 10 GeV π^0 event



present clustering ------------“calorimeter tracking”-------------

1x1cm 1 x 1 cm 1 x 5 cm 1 x 10 cm

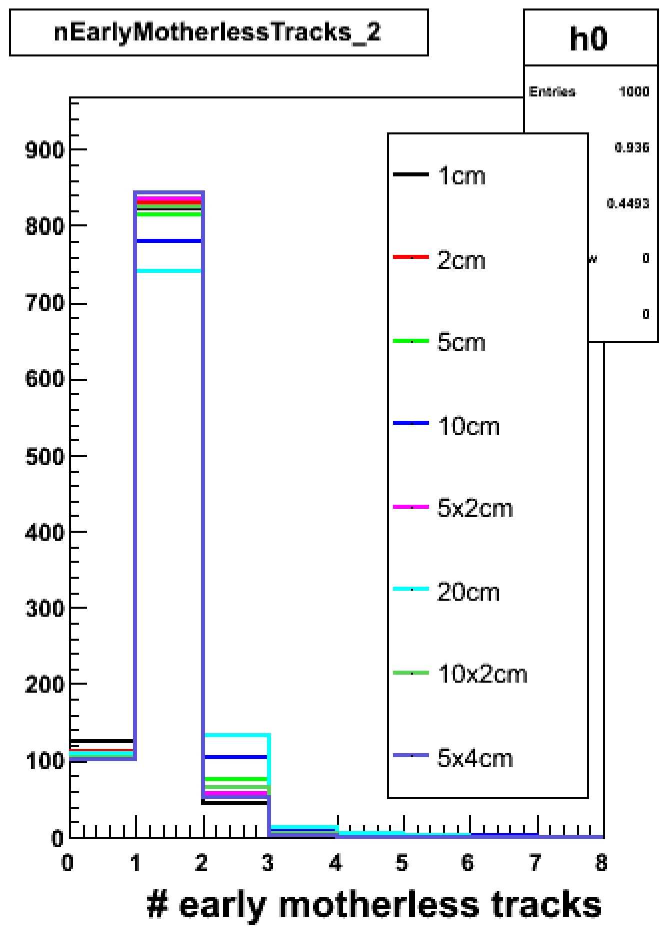
different colors = different reconstructed clusters or tracks

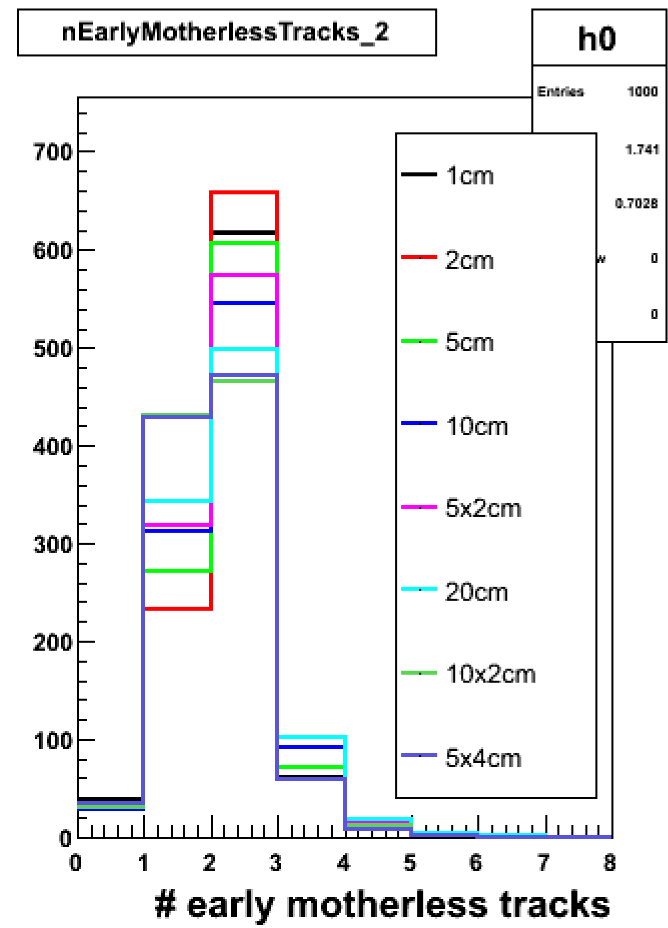
distinguish π^0-photon

- look at 10 GeV photons, π^0 (γ–γ separation ~ 6cm)
- look at strip lengths 1 – 20cm, different widths
- plot # "motherless tracks" starting in first 2 calorimeter layers

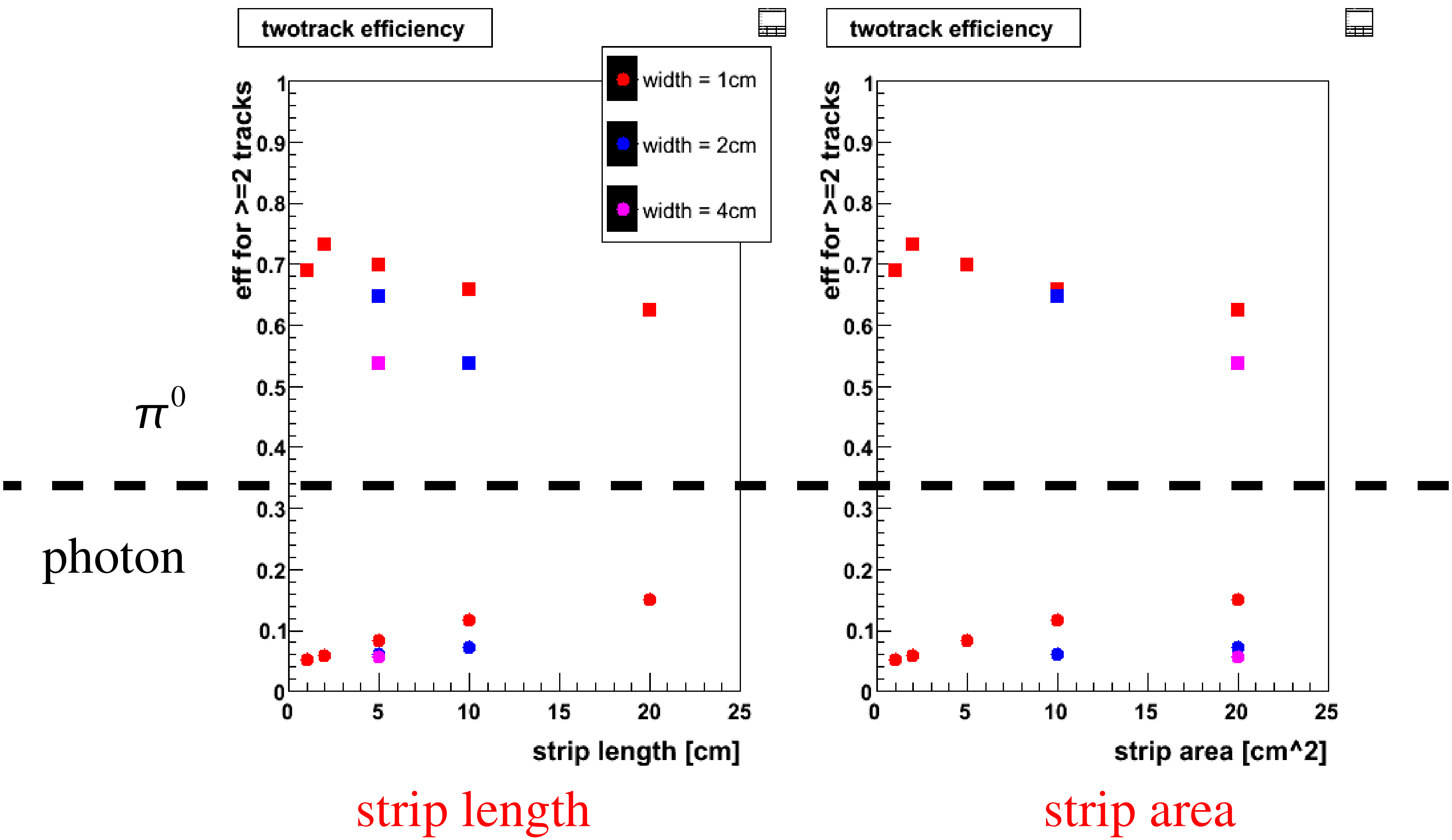
γ: 1 track
π^0: often 2 tracks

larger strips, more
difficult to resolve π^0





efficiency for resolving >=2 early motherless tracks in π^0,
prob of splitting a γ into >=2 early motherless tracks



algorithm with longer strips tends to split γ
longer strips give somewhat worse π^0 identification; dependence not so strong

strip clustering summary & plans

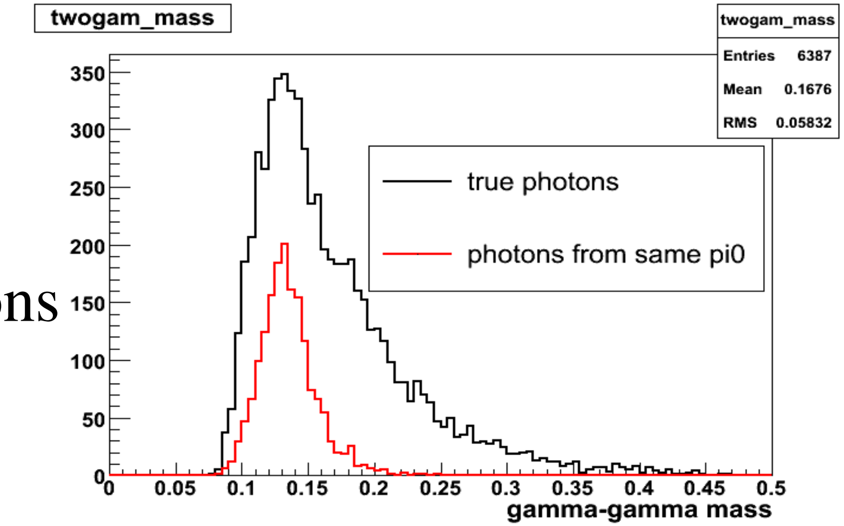
- developing algorithm to identify π^0 in strip calorimeter
  - preliminary results on strip length dependence
  - needs some more understanding
- try with π^0 in jets
- apply algorithm to hadrons; plug into (GLD) PFA

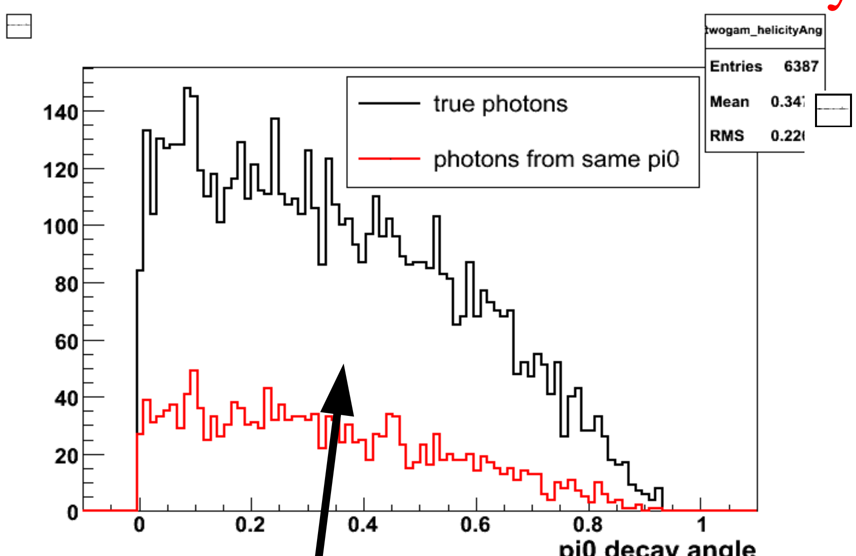
π^0 finding

- significant fraction of neutral energy in jets are gamma from π^0
- in PFA, neutral energy contributes most to the energy resolution
- hope to identify pairs of gamma from π^0, perform kinematic fit, improve energy estimate
- study in fully simulated hadronic Z^0 decays @ 91 GeV
- calorimeter segmented into 1x1cm scintillator cells

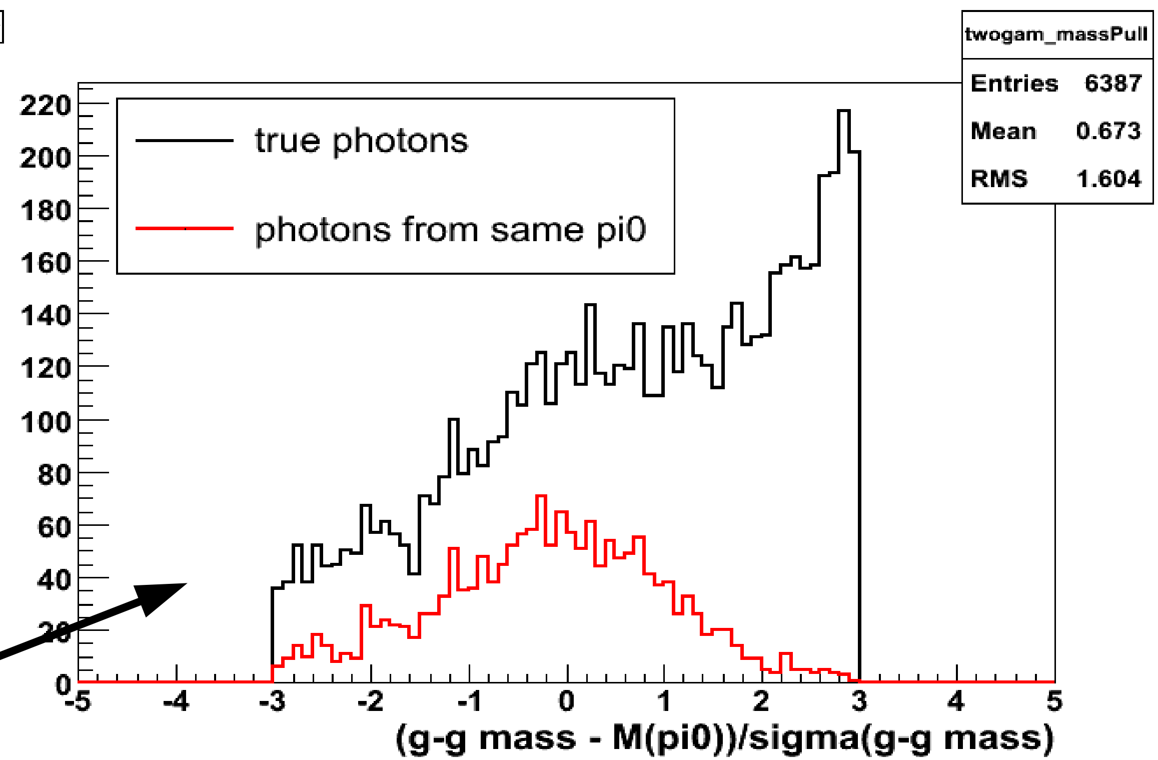
π^0 finding in Z->uds jets

- with respect to generic photon pairs, γ from π^0 have:
  - invariant mass consistent with π^0 mass
  - consistent with decay of spin-0 particle
- compare distributions for all γ–γ combinations and those from real π^0 decay





decay angle of π^0 not useful

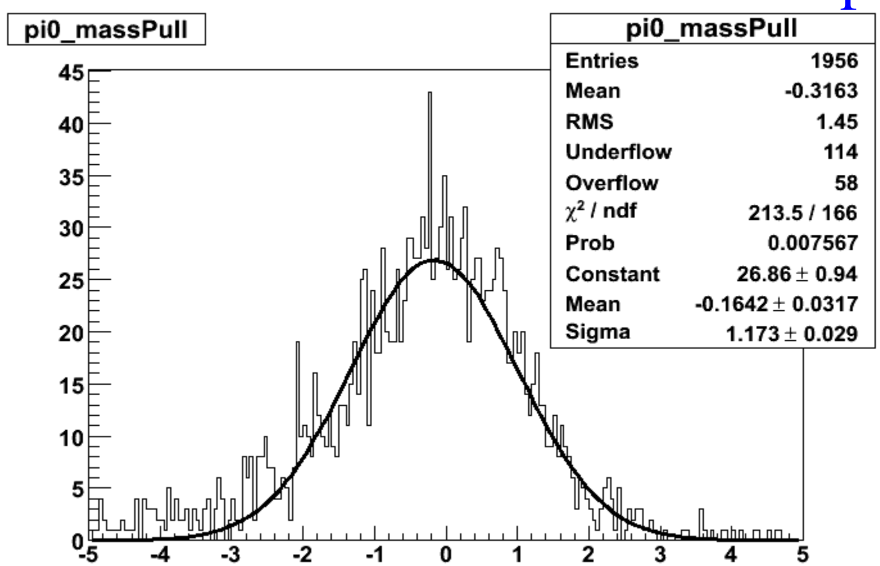


mass information is useful

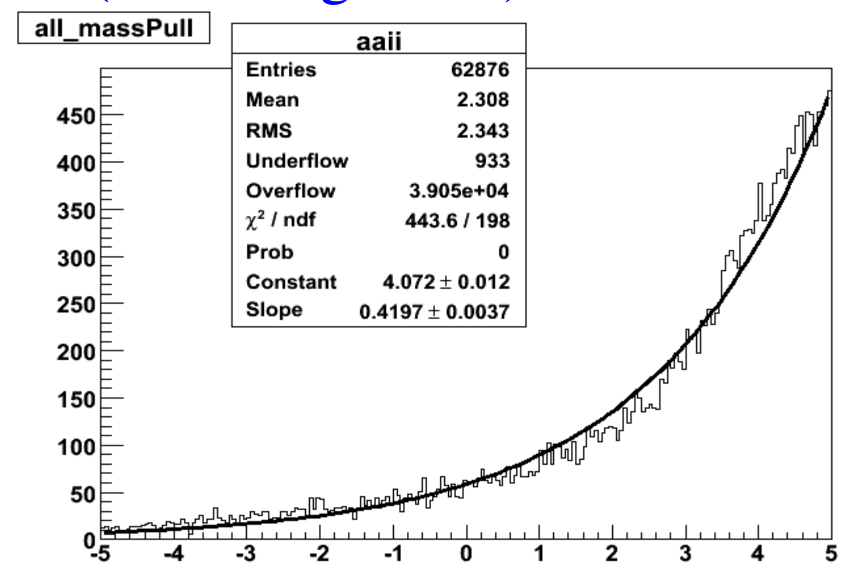
combining identified photons

- many photons per jet, also a number of fake photons
- only mass information is useful for identifying those from pi0
  - use "π^0 pull" = (m_γγ-m_π^0))/sigma(m_γγ)
  - use expected error on energy; ignore angular uncert. for now
- model this as a Gaussian for true π^0 pairs, Exponential for others
- define Likelihood Ratio Ls/Lb as function of "mass pull"

all reconstructed photons (including fakes)



"mass pull" for true π^0 pairs



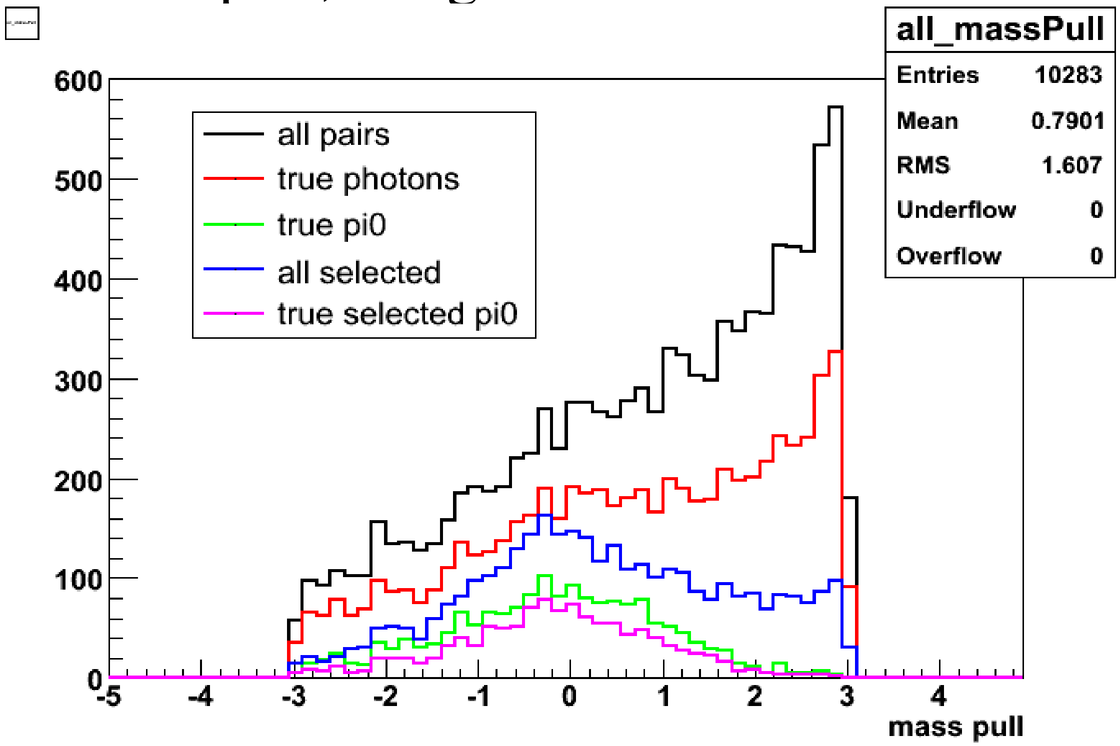
"mass pull" for non-π^0 pairs

combining photons

- consider all possible pairs of identified photons with

  |"mass pull"|<3, order in Ls/Lb

- Starting with the best pair, assign to π^0s

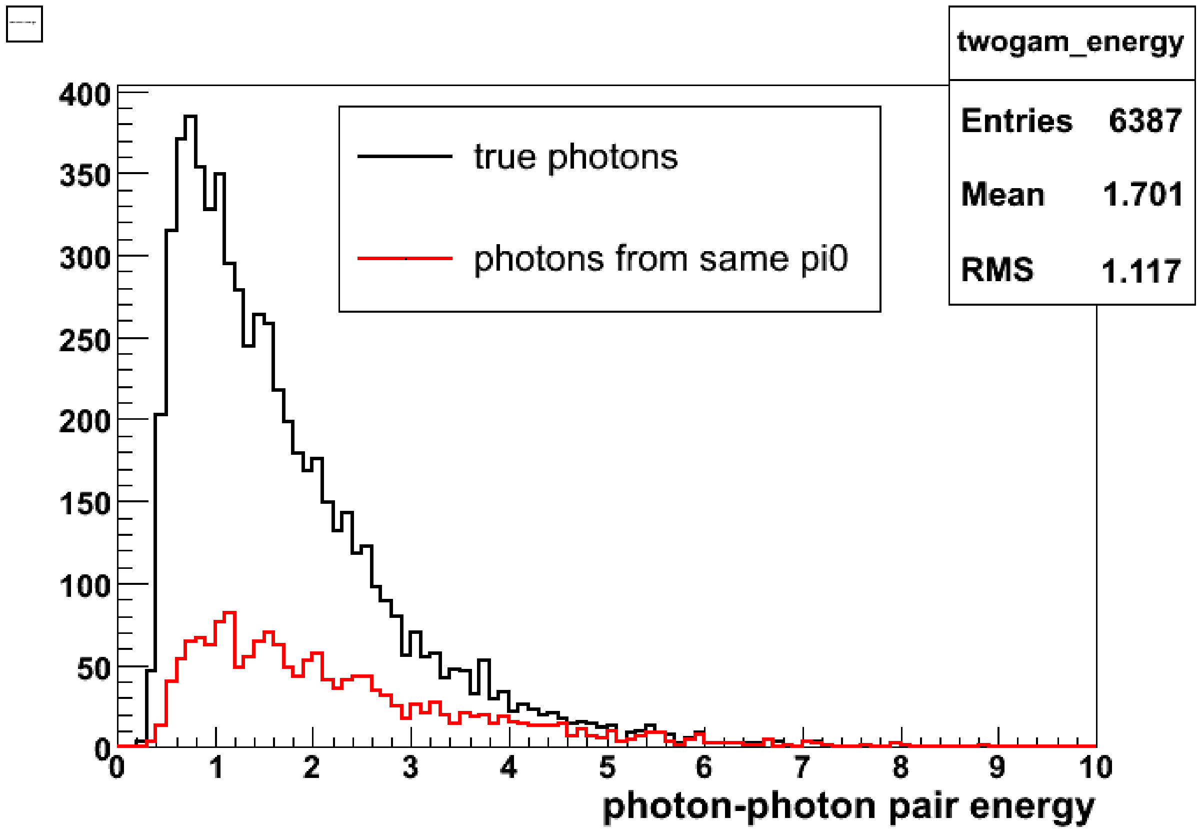


efficiency for true π^0 quite good: true selected π^0/all true π^0 ~ 68%

however purity is low: true selected π^0/all selected ~ 33%

energy distribution

- the energy of wrong combinations tends to be lower that true π^0



tried rather simple strategy to increase priority of high energy pairs,

no significant improvement in purity

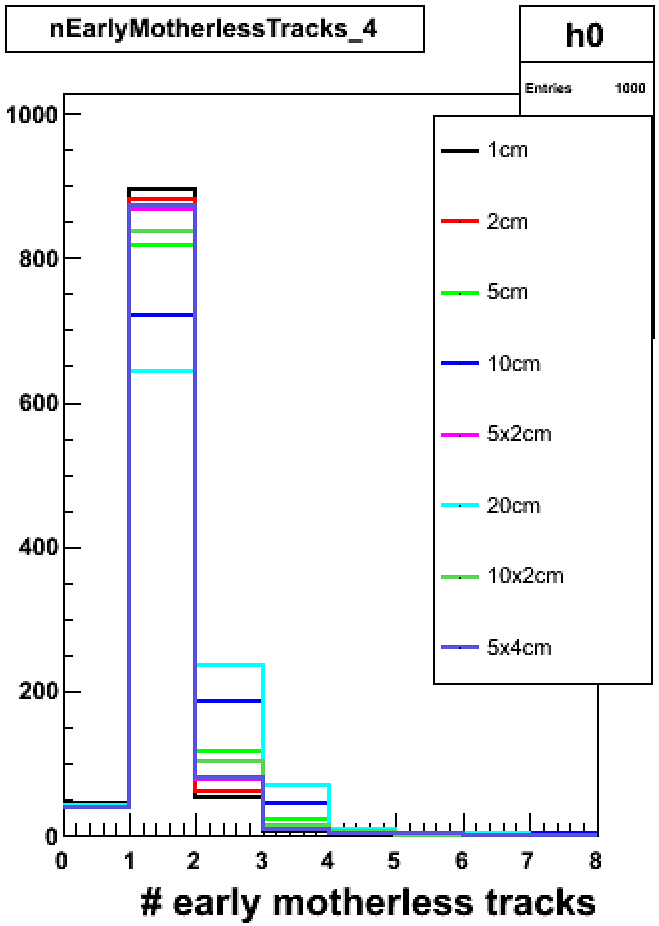
try more sophisticated approach

photon pairing summary

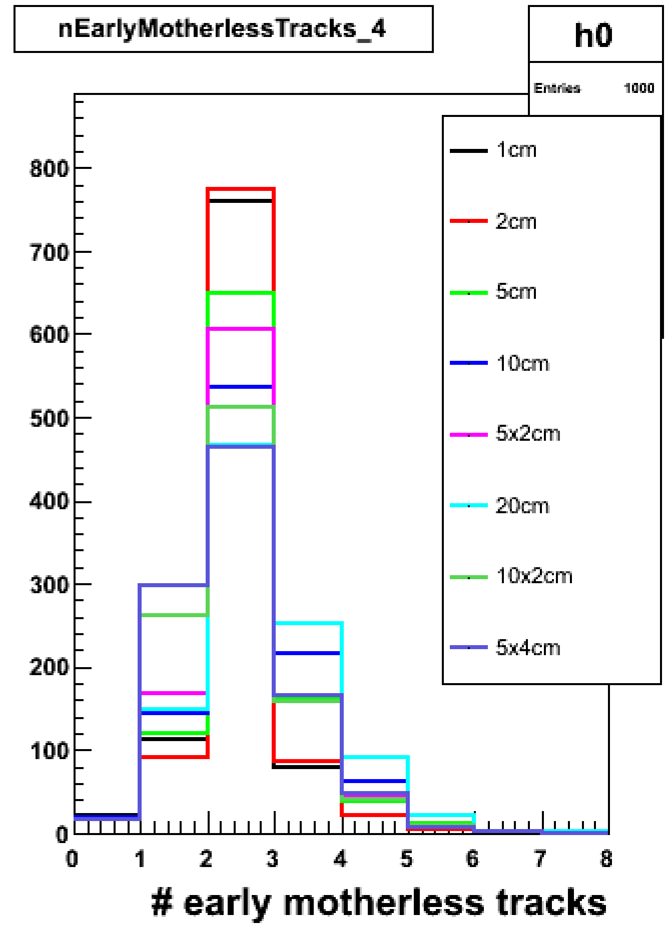
π^0 -> photons combinations:

get most of the correct π^0->$\gamma\gamma$ pairings ~68%
but also many false ones (purity ~ 33%)

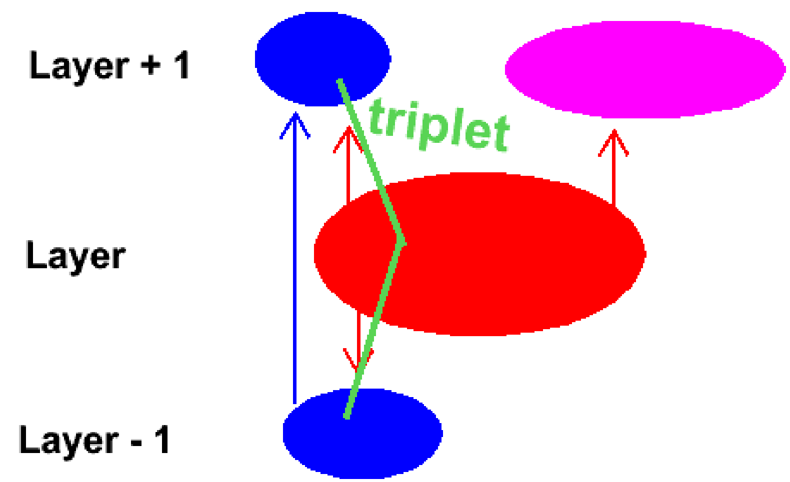
attempt better use of energy information



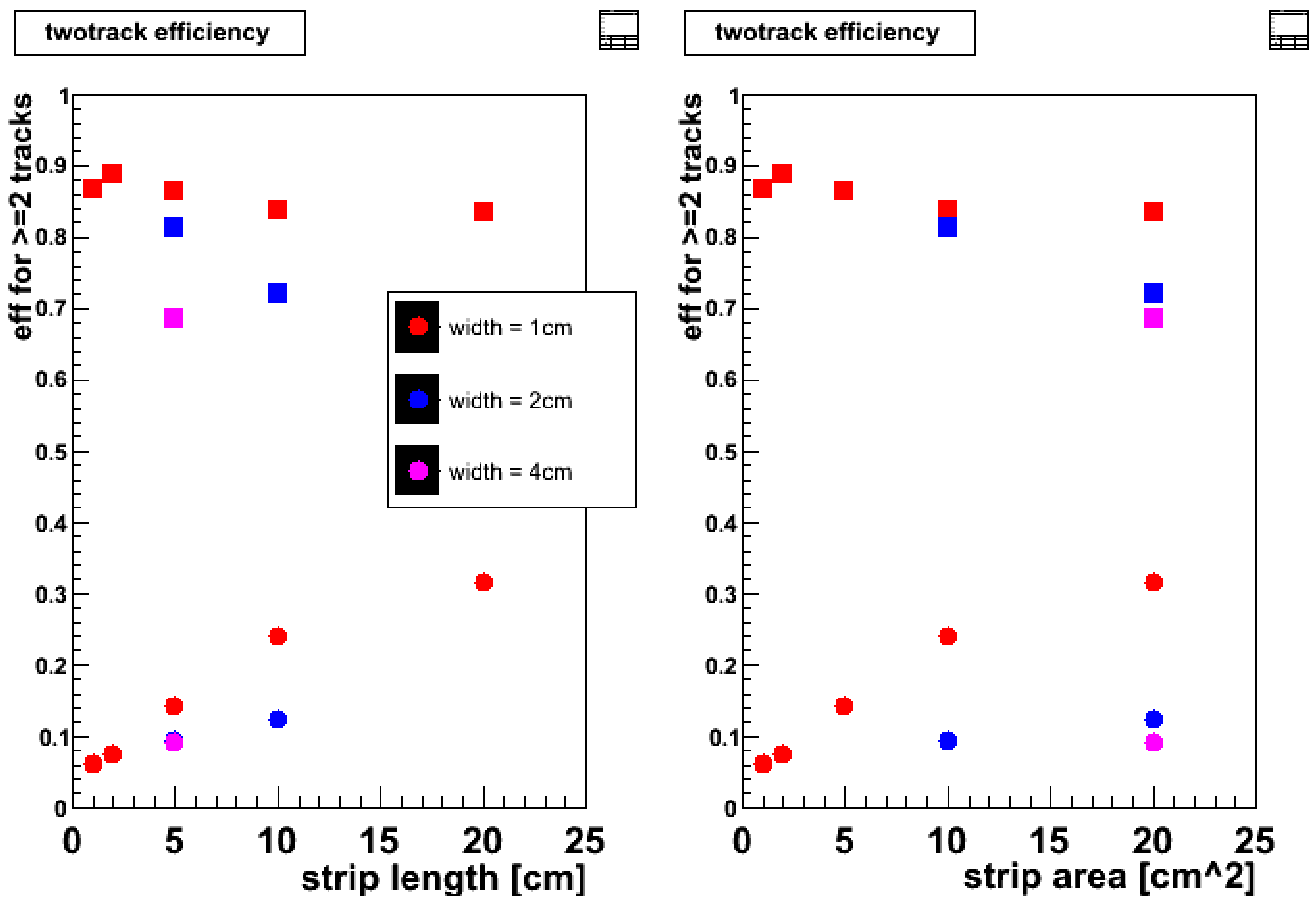
nEarlyMotherlessTracks_4
h0
Entries 1000
1cm
2cm
5cm
10cm
5x2cm
20cm
10x2cm
5x4cm
0
200
400
600
800
1000
0 1 2 3 4 5 6 7 8
early motherless tracks



nEarlyMotherlessTracks_4
h0
Entries 1000
1cm
2cm
5cm
10cm
5x2cm
20cm
10x2cm
5x4cm
0
100
200
300
400
500
600
700
800
0 1 2 3 4 5 6 7 8
early motherless tracks



Layer + 1
triplet
Layer
Layer - 1


twotrack efficiency
eff for >=2 tracks
strip length [cm]
width = 1cm
width = 2cm
width = 4cm
twotrack efficiency
eff for >=2 tracks
strip area [cm^2]