Recent GARLIC development

Daniel Jeans, ECAL mtg@U.Tokyo, Sept 2014

Previous version (untouched for last 2-3 years)

- rather basic electron finding,
  seeded by tracks

- remove hits near track extrapolations

- Project first ~10 X0 of hits onto front face of ECAL
- look for peaks in this projection
  Require minimum energy, hits -> "seed"
- extend seed into calorimeter
  Width ~ a x (cell size) -> "core"
- add nearby hits to core
  If distance < b x Moliere radius -> "cluster"
- combine very nearby clusters
- add nearby unclustered hits
- decide if clusters look like photons
  using multi-variate analysis (Neural Network) -> "selected clusters"

東京大学
THE UNIVERSITY OF TOKYO

Recently been looking in detail at 2-photon separation

In ILD, and using CALICE testbeam data

Becomes clear that GARLIC identifies many fragments of photon and electron showers as photon-like clusters

There is a natural tension between

resolving nearby photons

and

collecting all a photon's energy into one cluster

Neural Network was trained to distinguish energy from photons and hadrons

and not to care if a cluster is the primary cluster or a fragment

- when calculating jet energy, we don't really care

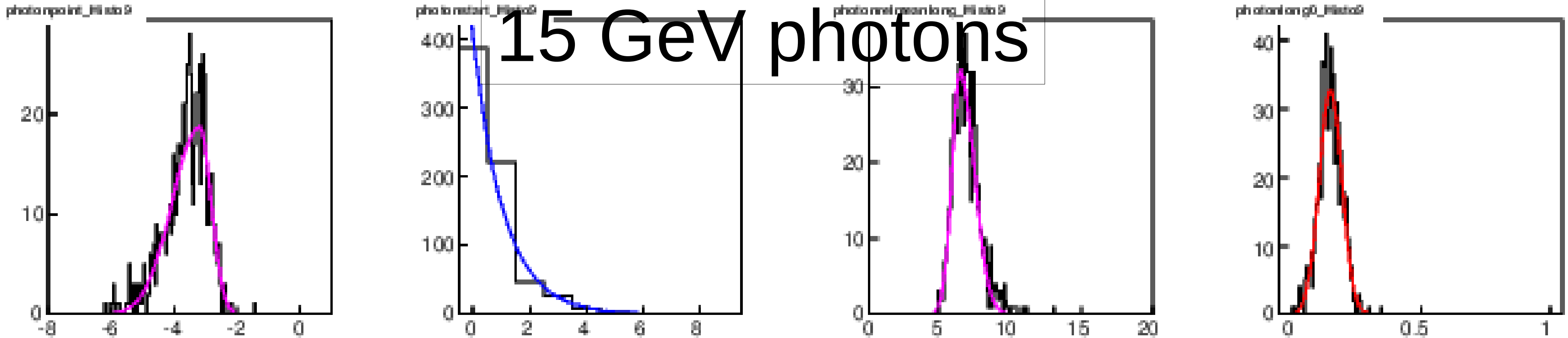
- not true when we study 2-photon separation, pi0 and tau reconstruction

I've been trying to improve this

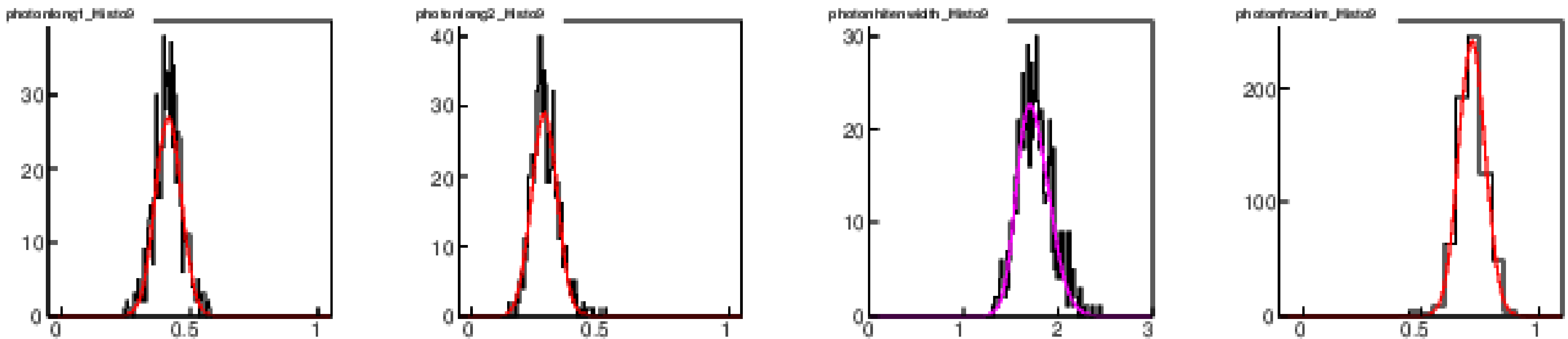
- parameterisation of photon and electron shower observables
  as function of energy
  considering central 90% of hits (remove far halo)

- these parameterisations can then be used as likelihood to decide if
  a cluster looks like an e-m shower

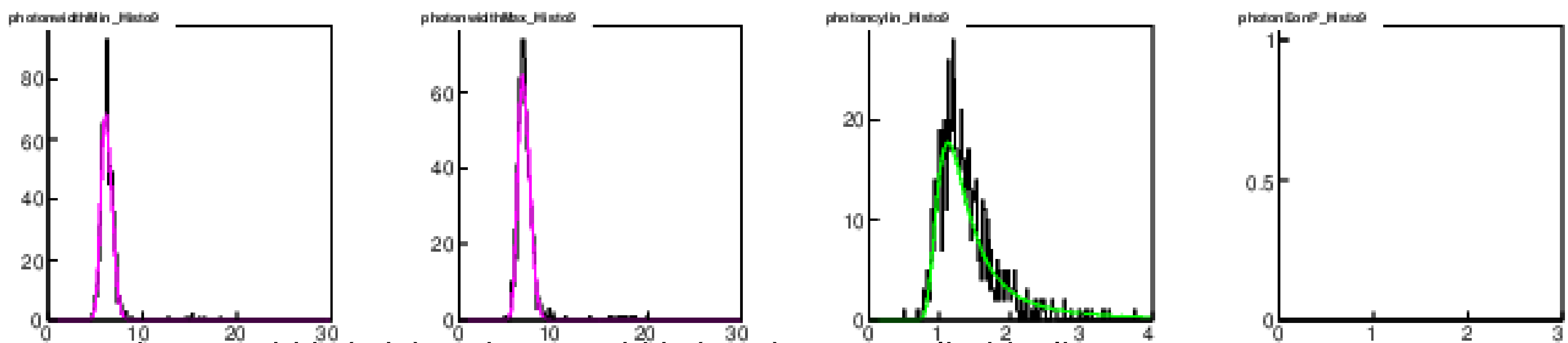
15 GeV photons



Pointing to IP shower start average depth fraction in 0-5 X0



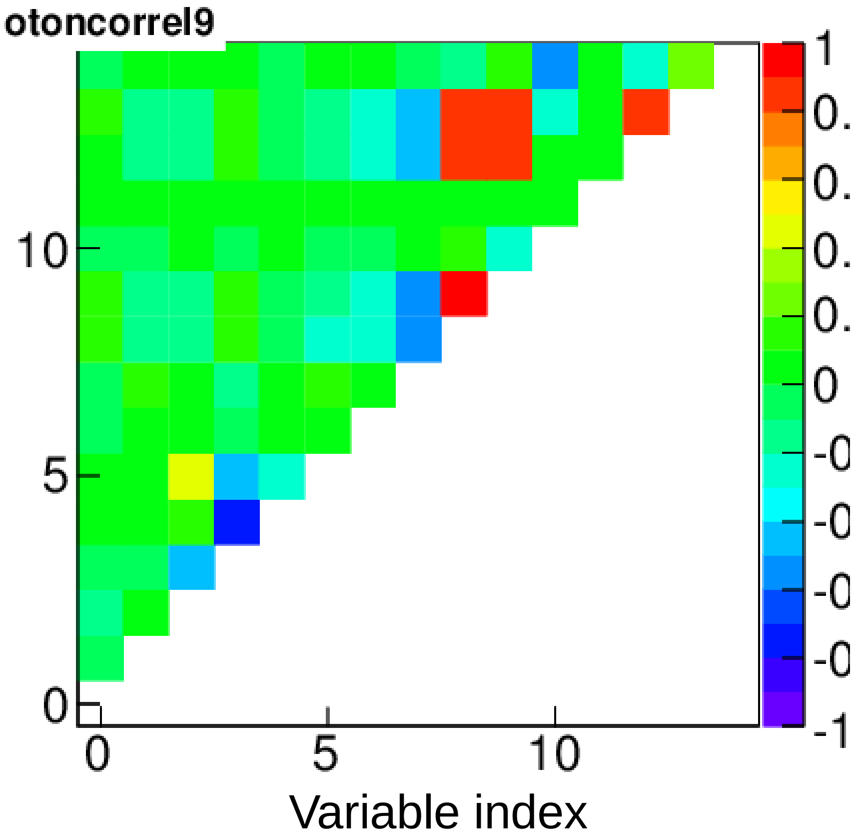
Frac in 5-10 X0 frac in 10-15 X0 width of hit en distr fractal dim.



Shower width (min) shower width (max) “cylindricality”

Can usually find a function which describes these distributions
Some observables not so easy to describe @ low energy
(and therefore not used at low energy <~1 GeV)

Some of these observables are (anti-)correlated

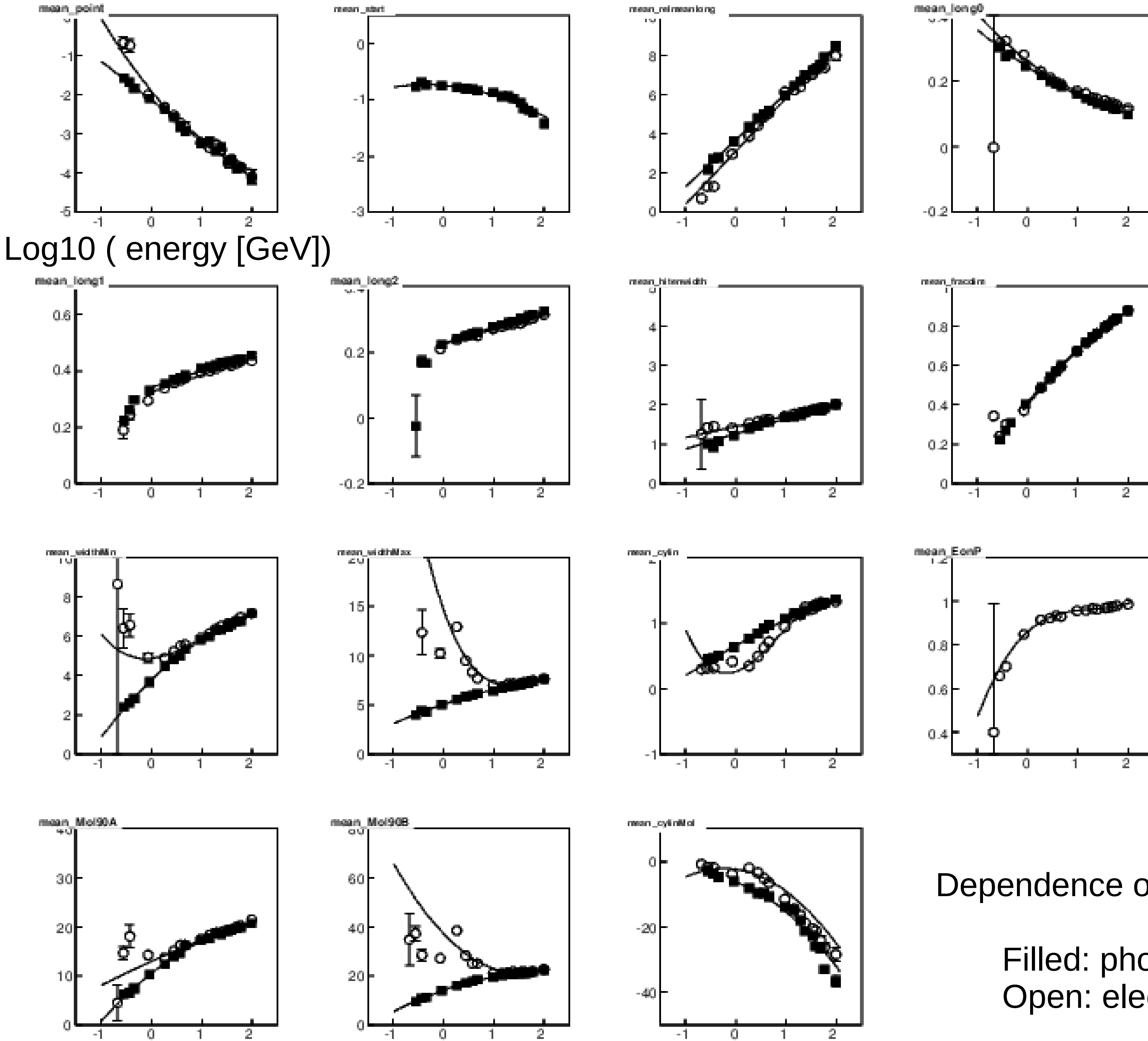


Perfectly correlated

un-correlated

Perfectly anti-correlated

When we combine single-variable PDFs to make a “photon-likelihood”
avoid using highly (anti-)correlated ones



Dependence of fit parameters:

Filled: photons
Open: electrons

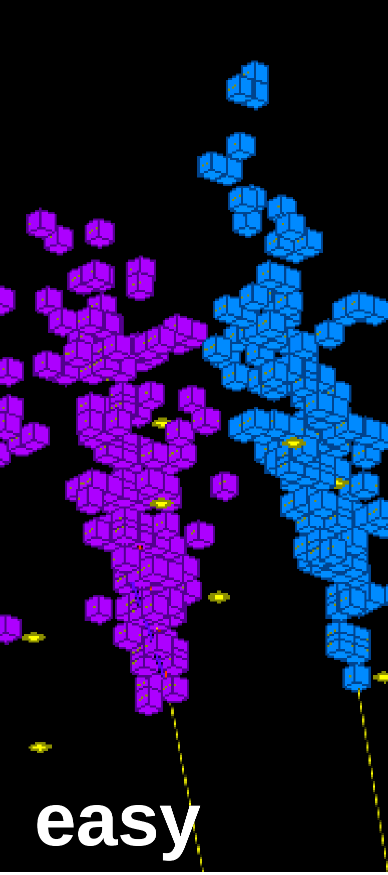
These PDFs are then used within GARLIC:

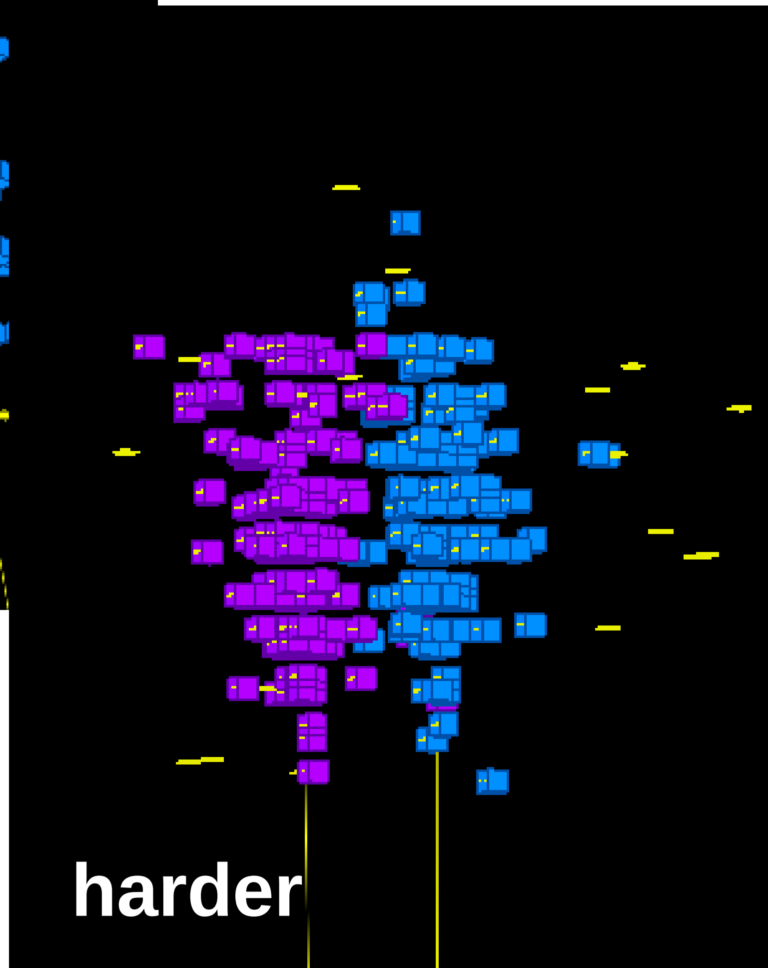
When deciding to

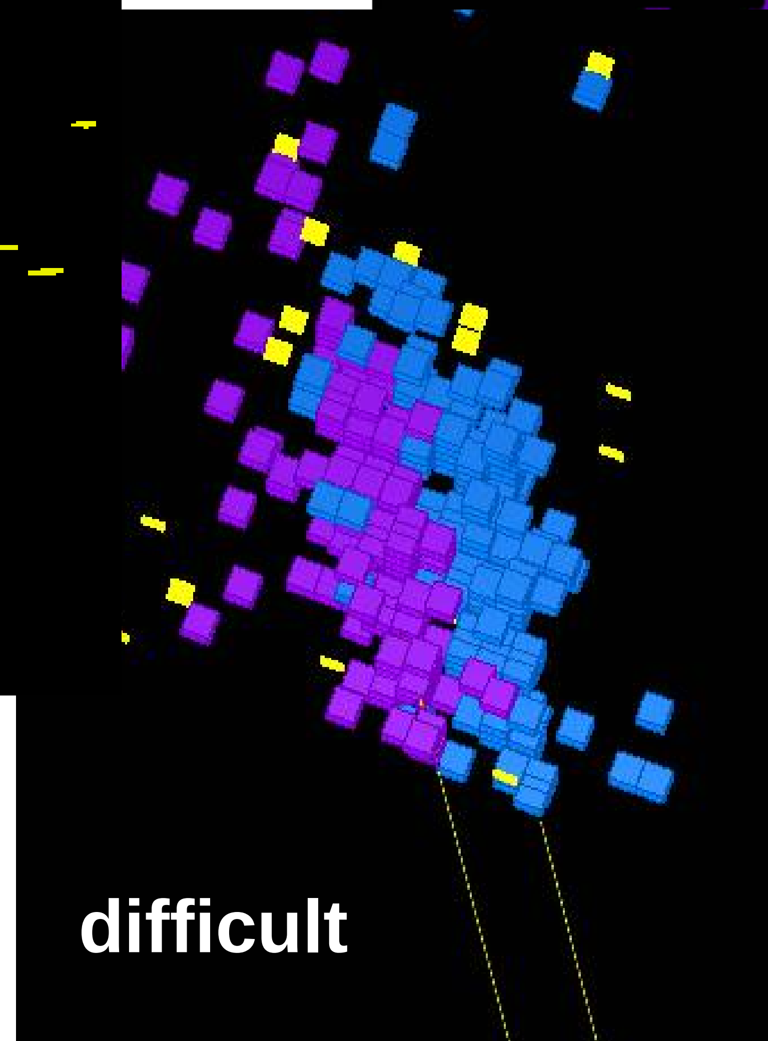
- combine two nearby clusters
- add unclustered hits to clusters

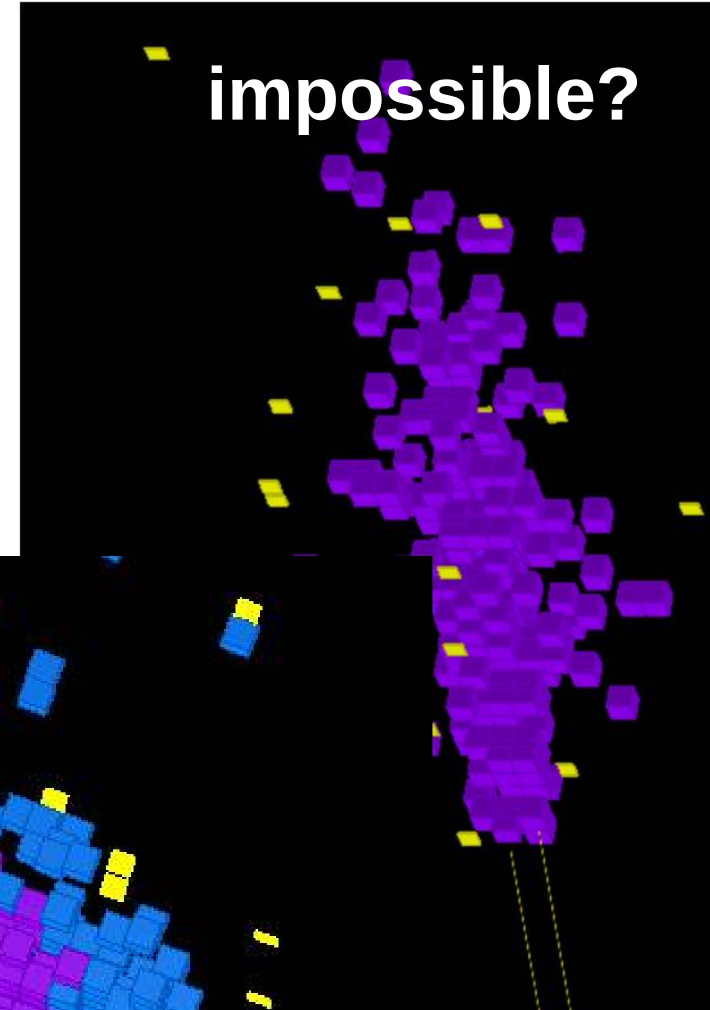
When deciding if a cluster looks like electron or photon

e.g. 2 x <u>4 GeV photons</u>,
at various distances



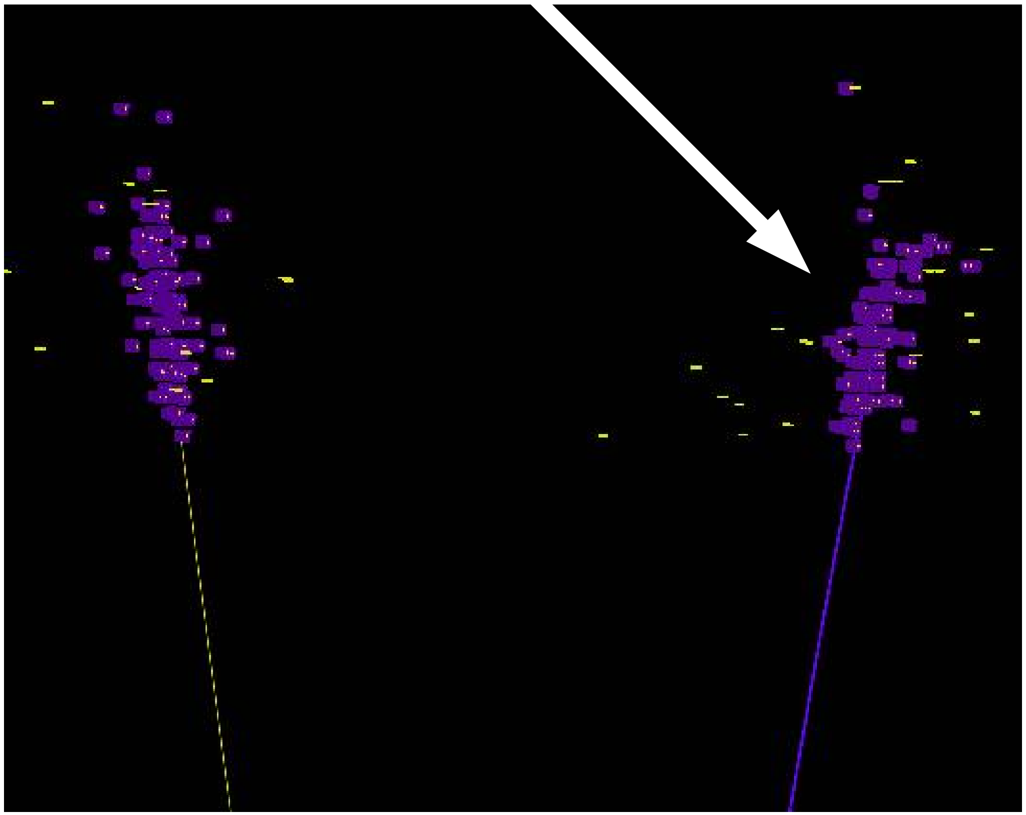






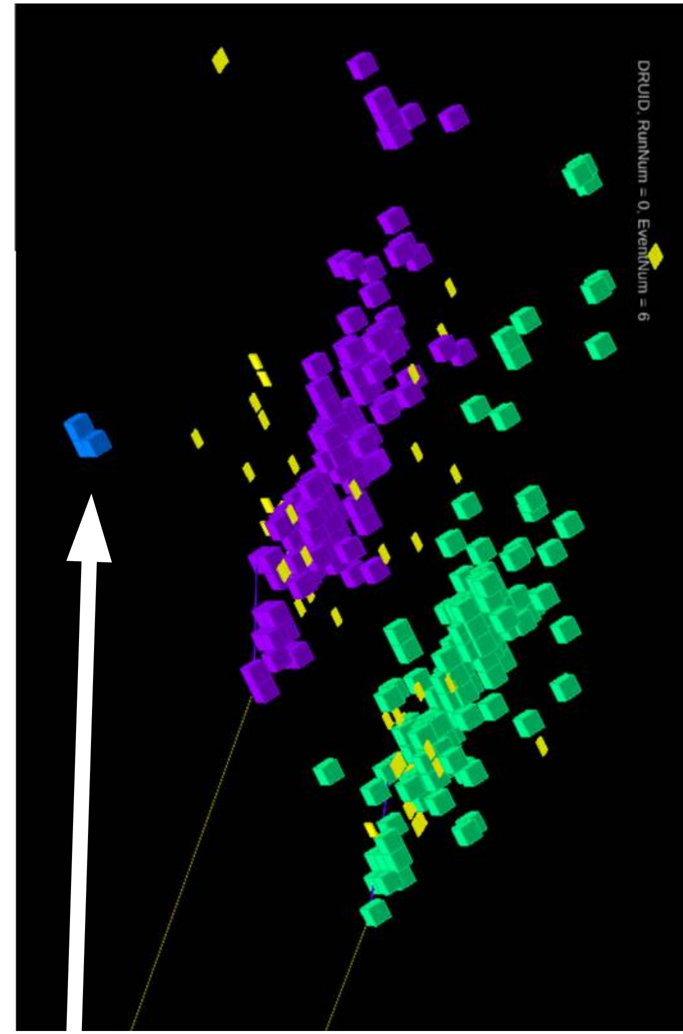
Very few “satellite” clusters
A few unclustered, isolated hits
Separation < n x cell size (~1,2,3...)
is very difficult

Electron clustering also works cleanly
Very little cluster fragmentation



Photon

electron
(from conversion)



Sometimes still get tiny,
~isolated satellite clusters
probably unavoidable...

Strategy:

Single photons:
- Parameterise EM cluster shapes
- Tune clustering to avoid fragments

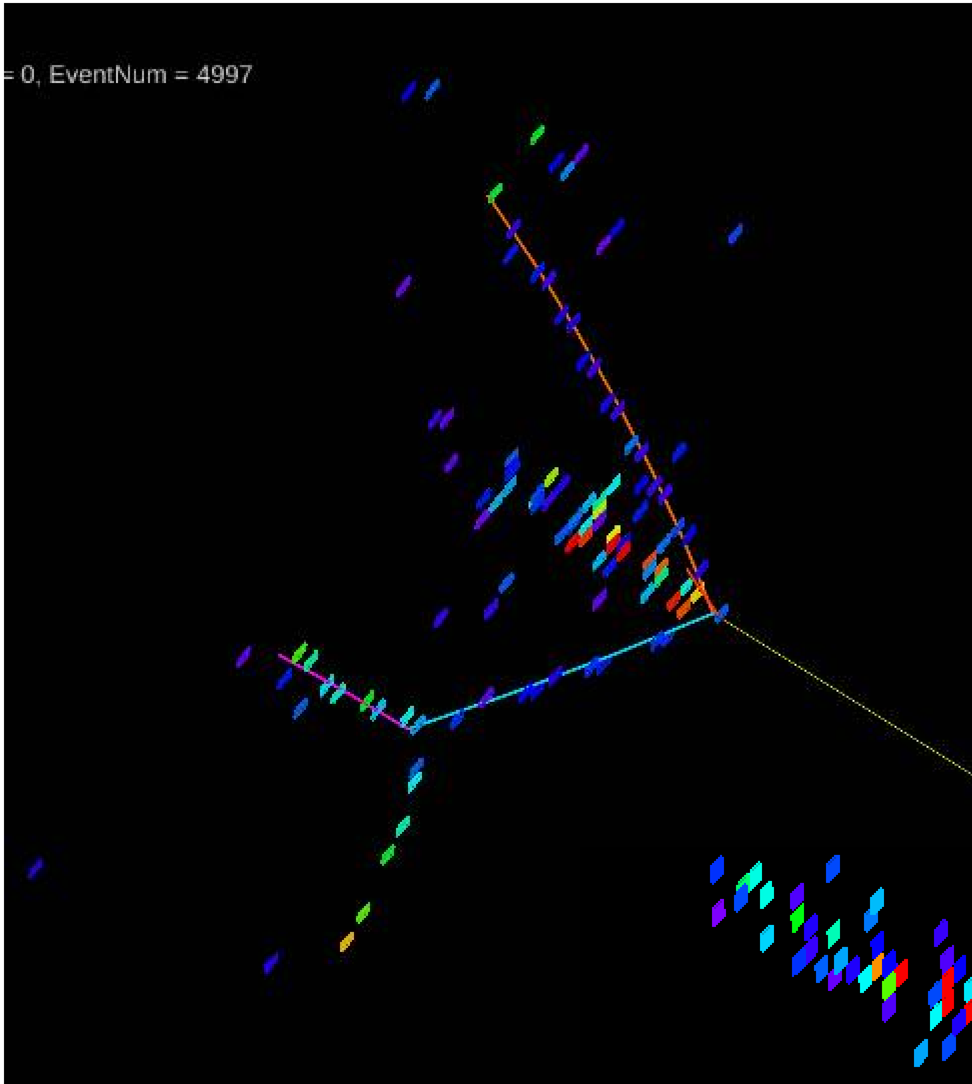
Double photons:
- Cluster separation (avoid over-combining clusters)

I am here now

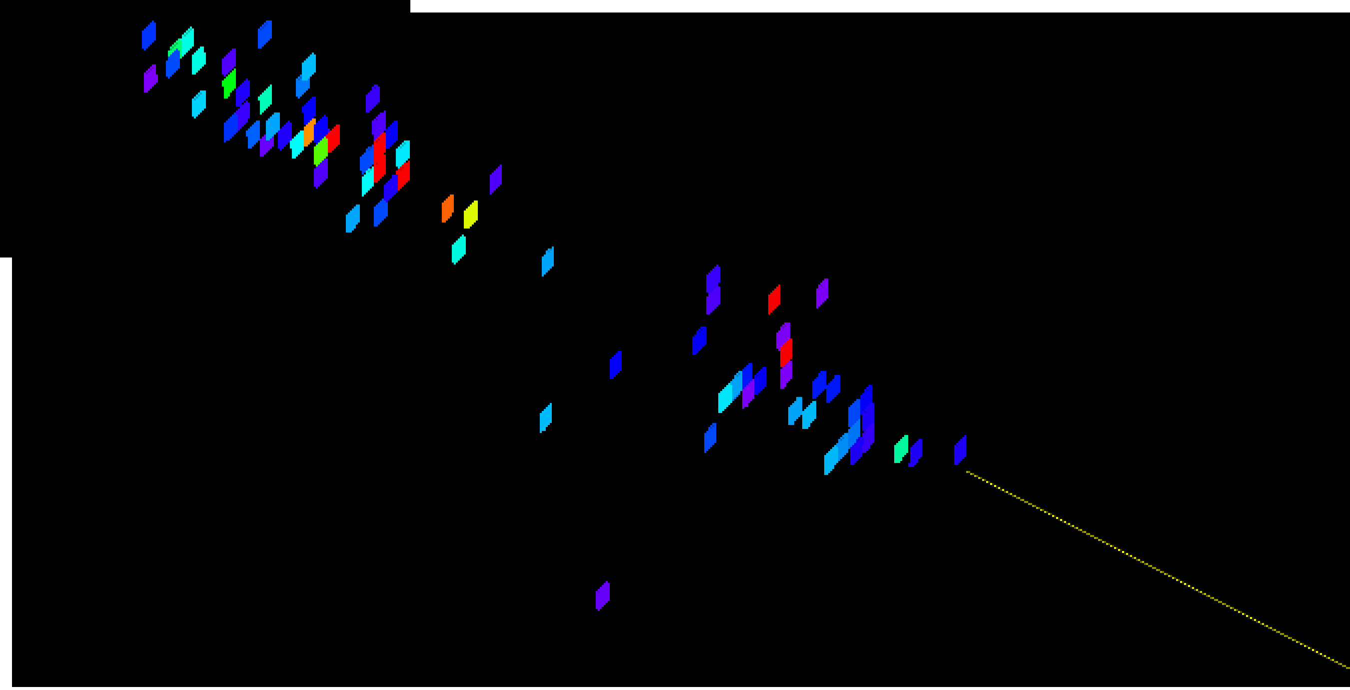
Single charged pions:
- Rejection of hadronic fragments

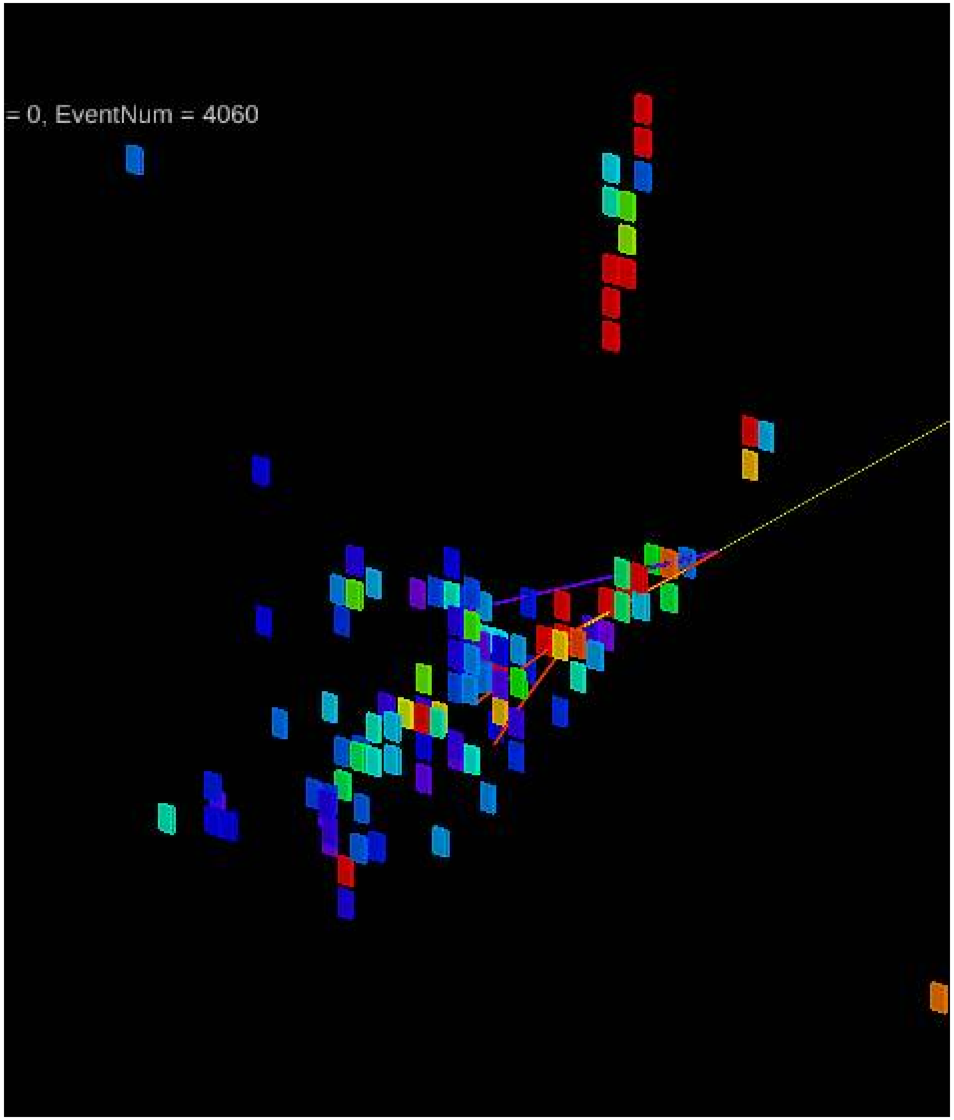
Single pi0 and tau:
- Quantify performance in “real” systems

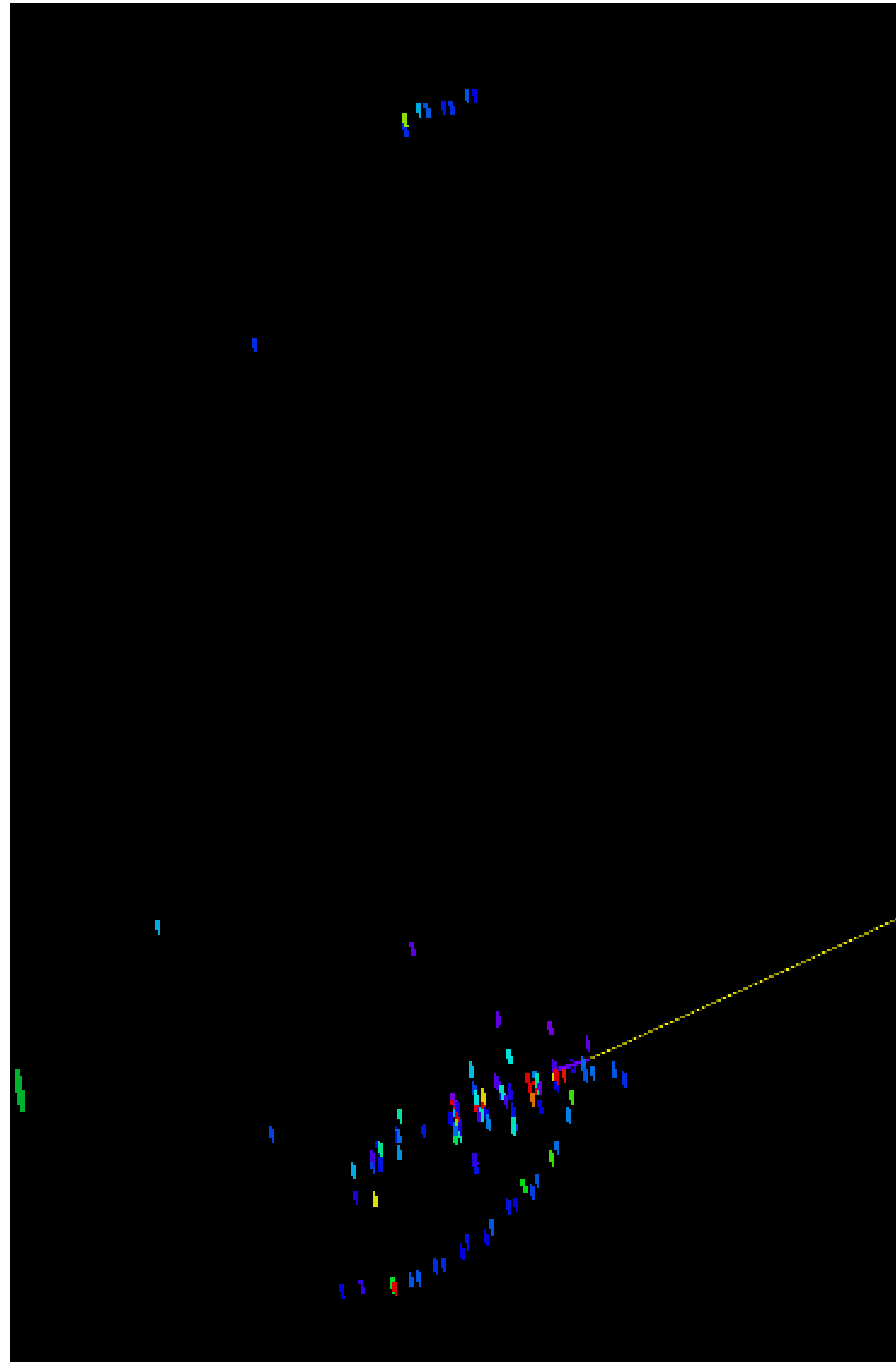
Compare performance of different
- ECAL & ILD geometries (ILD radius, Moliere radius)



When investigating why the photon likelihood sometimes doesn't select photon events, I found a few interesting events...




= 0, EventNum = 4060



Summary

GARLIC being improved (I hope...)

- Likelihood-based approach
- Seems OK, maybe some more work required for
  - low-energy photons < 1GeV

When ready, plan to apply GARLIC to

- pi0, tau events to compare
  - different ECAL sizes and layouts

I suspect that dependence in high energy tau may be stronger

- than for jet energy resolution