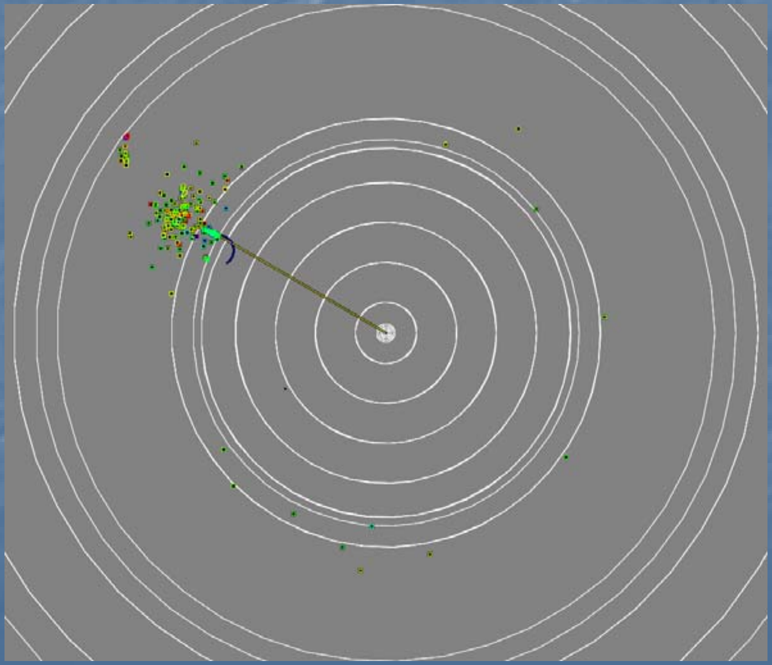
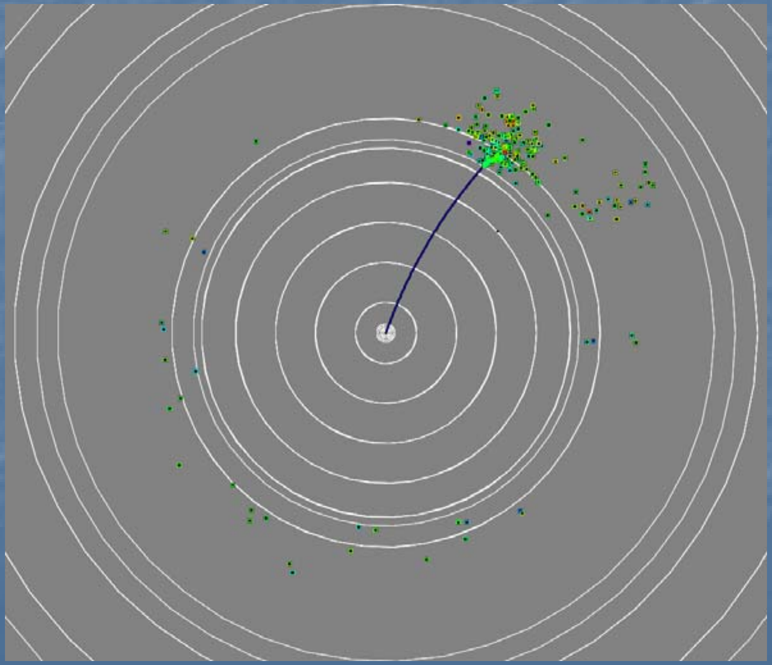
(How) Can Test Beams be used for PFA Validation?

What does PFA do?

Major advantage/biggest problem – separation of charged and neutral hadrons
(photon/photon, photon/hadron separation easier)





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What affects PFA performance?

-> number of particles in shower
-> angular distribution of particles in the shower
-> fragment particle density and angular distribution
-> transverse/longitudinal extent of shower (particle densities at shower edge)

Whatever we do to reconstruct particles, however numbers of cluster algorithms, hit matching procedures, density fits, etc. we devise, the performance of the PFA depends on having good hadron shower particle density distributions.

So, from test beam, we need to measure full particle shower density distributions (angle, energy) – we need differential cross sections in number and type of particles, angle and energy that can be used as inputs to the various hadron shower models.

Everything else is best done in simulations – change in pixel size, IR of calorimeter, longitudinal segmentation, layer absorber thickness, B-field, etc.

Hadron Showers in ILC CAL Prototype tests

1) Analog ECAL (Si) (0.25 cm**2 pixels)
E in small pixels, but weak neutral response - partial shower density distribution in small pixels is useful for PFA if neutral response is OK - very good shower edge resolution.

2) Analog ECAL (Scin) (1 cm strips x,y)
E in small regions and good neutral response - get shower density distribution from analog signal and good? shower edge resolution.

3) Analog TileHCal (Scint) (3X3 transverse)
E in 9 cm**2 tiles sees both charged and neutral particles -> full shower particle density distribution (limited? by area). Could be useful for PFA, but would be better if pixels were smaller - not as good shower edge resolution.

4) DHCALs (Gas) (1X1 transverse)
Limit of core shower shape defined by efficiency/threshold - no/small response to neutrals -> no full shower particle densities since digital and no neutral response - very limited usefulness for PFA since no particle densities and no neutral response

Summary

1) A test beam program for ILC CAL prototypes can verify or determine

-> depth of the combined E/HCAL for ILC (absorber type and thickness, layer thickness

-> shower sizes (transverse, long.) subject to efficiencies, threshold cuts, pixel size

-> limited shower particle density distributions - best is with analog tilecal, worst is gas DHCAL

Almost NONE of this can be used to tune hadron shower models - maybe the longitudinal/transverse extent of a shower and some very sketchy particle density distributions.

-> Can only compare different hadron shower simulation models for tested prototype configurations.

2) For PFAs, also need to know :

-> full shower particle densities FAR from shower core

- can vary this in simulation - see effect on PFA
- test beam? need fine grained readout away from core?

3) No "Fake" jets - fragment from particle A in fake jet associated with particle B – how do you know which particle it goes with?