Calorimeter Clustering

• The basic concept of the “Energy Flow” algorithm for jet-finding is to use the tracking detector for the measurement of charged particle momenta and the calorimeter for neutrals.

• We therefore have to subtract the charged particle’s energy deposition in the calorimeter before reconstructing neutrals.
- We also need pattern recognition algorithms to associate energy deposition in calorimeter cells with particles.
- EM showers are energetic, very localized and highly correlated.
  - Clustering works well.
- Muons deposit only minimum ionization, but do so along their trajectory
  - Tracking in calorimeter.
- Hadron showers are broad and unconnected.
  - More difficult to handle.
• In complex events and within jets multiple particles will deposit energy in the same calorimeter cell, and showers will overlap
  – Good clustering is essential to resolve showers
  – A splitting/merging strategy is essential.

• Many cells are hit
  – An efficient algorithm is essential
• A fast, efficient, generic clustering algorithm has been developed to solve the problem.
  – Requires only one pass through the data to establish the clusters.
  – Based on a Nearest-Neighbor approach, but can be generalized.
  – Works for arbitrary dimensions.
• Basic unit for clustering is a Cell.
• Cell contains an Index by which it is referenced.
  – E.g. Cell2D contains integer indices i,j.
• Cell also contains a value, for energy deposited.
• A Neighborhood encapsulates the topology of the detector. Given an Index, it is able to return a list of neighboring Indices.
  – Current implementation is Nearest-Neighbor.
• One begins with each Cell pointing to itself as a proto-cluster.
• One then loops through all the neighboring Cells and establishes a pointer to the highest-valued neighbor.
• Linked lists of Cells comprise a Cluster.
Cluster Splitting

• Nearby clusters, although identified as separate, will contaminate leak into each other.
  – Important to be able to remove background from nearby clusters.
    • Requires knowledge of shower shapes.
    • OK for EM showers and muons.
    • Not as obvious for hadronic showers.
Cluster Fitting

- General Non-linear multidimensional fitter has been written to allow n-dimensional Gaussian, or exponential, to be fit to identified clusters.
- Fit each cluster separately to establish initial estimate, then perform global fit to all clusters.
- Can then subtract contributions from neighboring clusters.
Cluster Merging

- Clusters can also be incorrectly identified as separate, especially in hadronic showers.
- Will need to establish criteria for merging nearby clusters.
To Do

- Need to incorporate code into LCD framework.
- Generate single particles of e, μ, π, n, etc. to create catalogs of shower shapes.
- Recognize and eliminate EM showers and μ traces.
- Extrapolate tracks into calorimeter to eliminate charged hadron showers.
- Try to understand neutral hadron showers.
- Look at real events.