Individual Particle Reconstruction

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Individual Particle Reconstruction

• The aim is to reconstruct individual particles in the detector with high efficiency and purity.
• Recognizing individual showers in the calorimeter is the key to achieving high di-jet mass resolution.
• High segmentation is favored over compensation.
• Loss of intrinsic calorimeter energy resolution is more than offset by the gain in measuring charged particle momenta.
Occupancy Event Display

ttbar $\rightarrow$ six jets
Occupancy Event Display

ttbar → six jets

Display only cells with energy depositions from more than one MC Particle.
Clustering

- Two clustering algorithms available in current code release
  - “Nearest”-Neighbor, with user-defined domains available in longitudinal and two transverse dimensions.
    - (1,0,0) is simplest MIP-cluster finder.
  - Fixed-Cone algorithm (θ,φ)
    - fast, seed-based, but iterative centering
    - cluster splitting for overlapping cones.
- Cluster interface defined, so additional clustering algorithms are easily accommodated.
A simple \((1,1,1)\) Nearest-Neighbor clustering algorithm performs quite well in the silicon-tungsten detector.
Track Finding and Fitting

- Nick Sinev has released standalone pattern recognition code for the 2D Barrel VXD hits.
  - High efficiency, even in presence of backgrounds.
  - Efficient at low momentum.
  - Propagates tracks into Central Tracker to pick up $\varphi$ hits.
- Conformal-mapping pattern recognition also available. Fast, but not yet tuned (97% vs 99+%).
- Work also ongoing to find MIP stubs in Cal and propagate inwards (Kansas State, Iowa).
Strategy I

• Begin by finding and fitting tracks.
• (Optionally) Cluster the calorimeter cells in EM, HAD & MUON independently using SimpleClusterBuilder.
  – EM → photons & electrons + muon MIPs + others
  – HAD → hadrons + muon MIPS
  – MUON → muon MIPS (+ punchthrough)
Strategy II

- Propagate tracks through the calorimeters and associate cells/clusters to the track if trajectory intersects calorimeter cell (or cell in cluster).
  - Tracks associated to EM cells/clusters and good match between cluster energy & track momentum become electron candidates.
  - Tracks associated with cells/clusters in EM, HAD and MUON become muon candidates.
  - Remainder become pion candidates.
- Remove cells/clusters from the event list.
Neutral Clusters

• EM Clusters unassociated with a track are photon candidates.
  – Calculate chi-squared for longitudinal shower shape.
  – Calculate shower width.
  – Clusters passing cuts become photon candidates.
  – Remove photon candidate clusters.

• Unassociated EM neutral clusters failing photon cut + HAD clusters are clustered using fixed cone algorithm.

• These become neutron ($K^0_L$) candidates.
ReconstructedParticles

• These ReconstructedParticles (electron, photon, pion, muon, neutron) are added back to the event.
• Tracks and Clusters form ReconstructedParticles.
• Goal is 1:1 ReconstructedParticle $\Leftrightarrow$ MCParticle
Z Pole Analysis

- Generate $Z \rightarrow \text{qqbar}$ events at 91GeV.
- Simple events, easy to analyze.
- Can easily sum up event energy in ZPole events.
  - Width of resulting distribution is direct measure of resolution, since events generated at 91GeV.
- Run jet-finder on RP four vectors, calculate dijet invariant mass.
- Can compare analysis results with SLC/LEP.
final public class ExampleReconstruction extends Driver {

    add( new SmearDriver() );
    add( new VXDBasedReco() );
    add( new SimpleClusterBuilder(1,1,1) );
    add( new IndividualParticleReconstruction() );
    add( new EMClusterAnalyzer(task, eMin, chisqMax) );
    add( new NeutralHadronFinder(radius, seedNhitMin, nHitMin) );
    add( new ReconstructedParticleEventAnalyzer() );

} 

fetch and return information from the event via the
process( EventHeader event ) method.
IPR Analysis Status

- Simple example of individual particle reconstruction is available within hep.lcd framework, expect org.lcsim version soon.
- Few (if any) hardcoded values for either geometries, algorithms, or cuts. These are all determined from the event detector (geometry) or arguments to object constructors (algorithm and cut values).
- Many places along the analysis chain for improvement.
Data Samples

• Have generated canonical data samples and are processing them through full detector simulation.
• Variants include HCal sampling material & readout, field strength, adding tracker layers, changing EMCal radius,…
• single particles of various species
• Z Pole events
• WW, ZZ, ttbar, qqbar, tau pairs, mu pairs, Zγ, Zh

www.lcsim.org/datasamples/
Detector Variants

• XML format allows variations in detector geometries to be easily set up and studied:
  – Stainless Steel vs. Tungsten HCal sampling material
  – RPC vs. Scintillator readout
  – Layering (radii, number, composition)
  – Readout segmentation
  – Tracking detector topologies
    • “Wedding Cake” Nested Tracker vs. Barrel + Cap
  – Field strength
Hadronic Calorimeter

- W(SS)+RPC (Scint.)
- Barrel+Endcap Disks

```xml
<detector id="3" name="HADBarrel" type="CylindricalCalorimeter" readout="HcalBarrHits">
  <dimensions inner_r = "138.26*cm" outer_z = "261.85*cm" />
  <layer repeat="55">
    <slice material = "Tungsten" width = "0.7*cm" />
    <slice material = "G10" width = "0.3*cm" />
    <slice material = "PyrexGlass" width = "0.11*cm" />
    <slice material = "RPCGas" width = "0.12*cm" sensitive = "yes" />
    <slice material = "PyrexGlass" width = "0.11*cm" />
    <slice material = "Air" width = "0.16*cm" />
  </layer>
</detector>
```