Individual Particle Reconstruction

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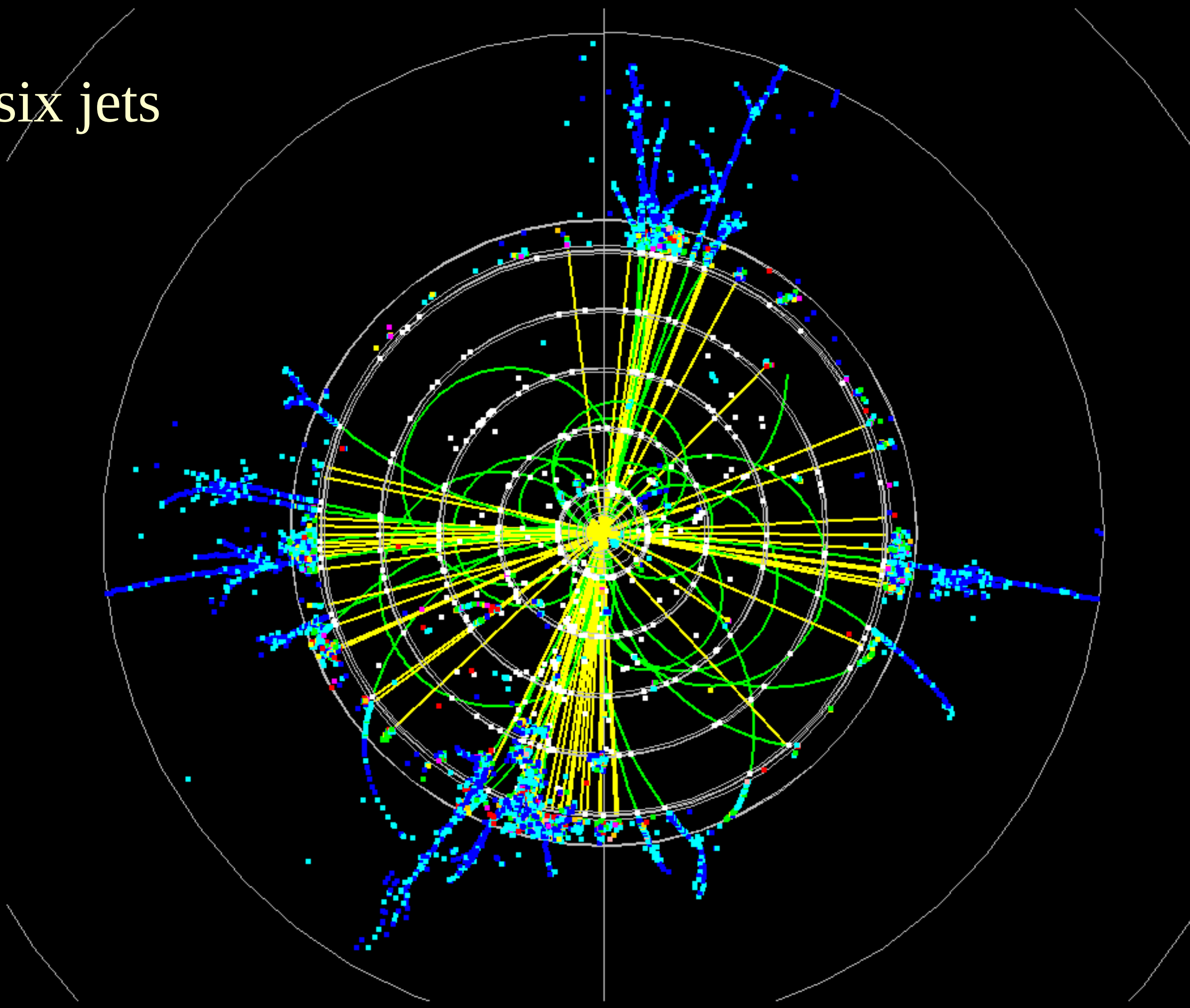
Individual Particle Reconstruction

- 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.

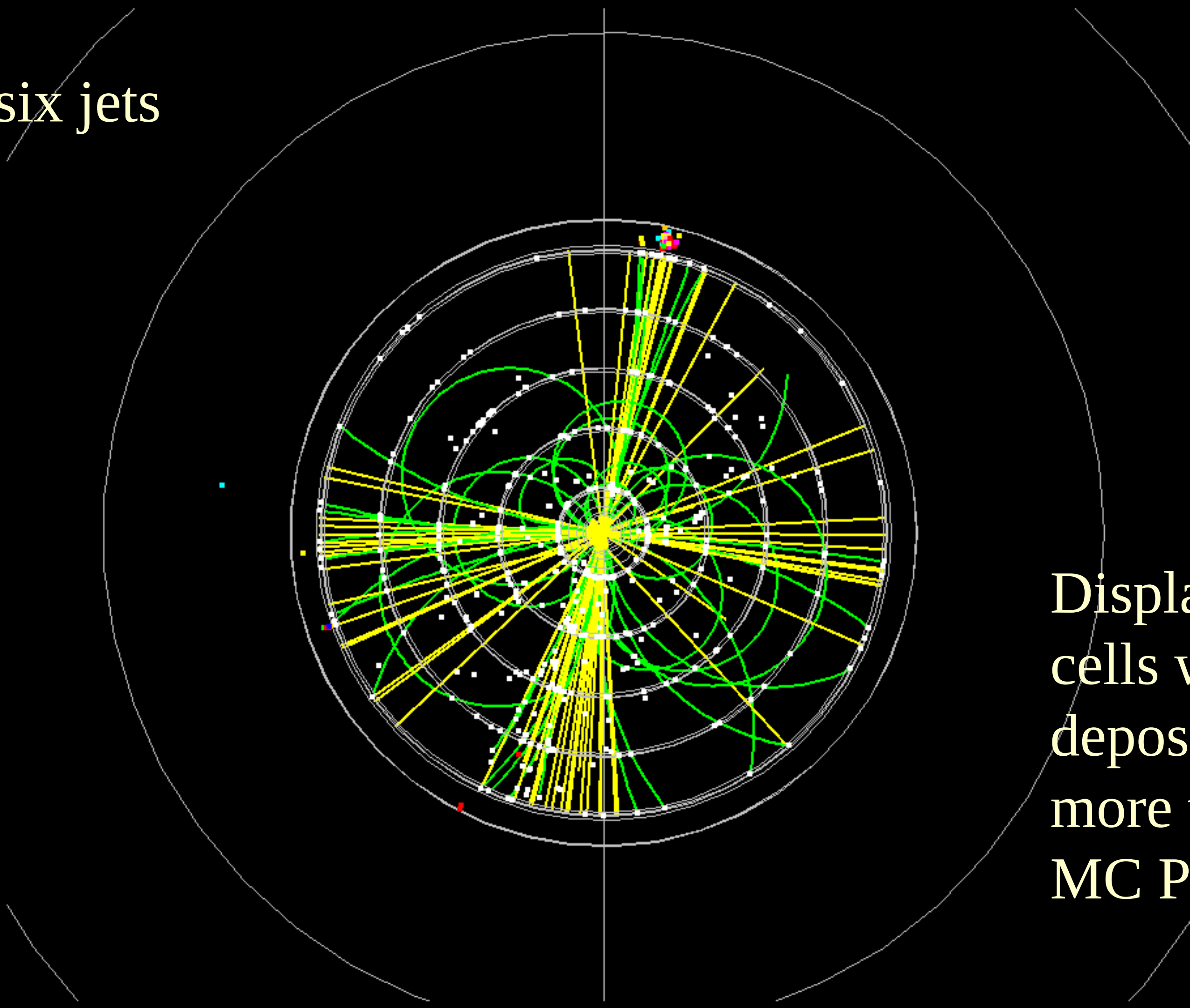
Occupancy Event Display

ttbar → six jets



Occupancy Event Display

ttbar → six jets

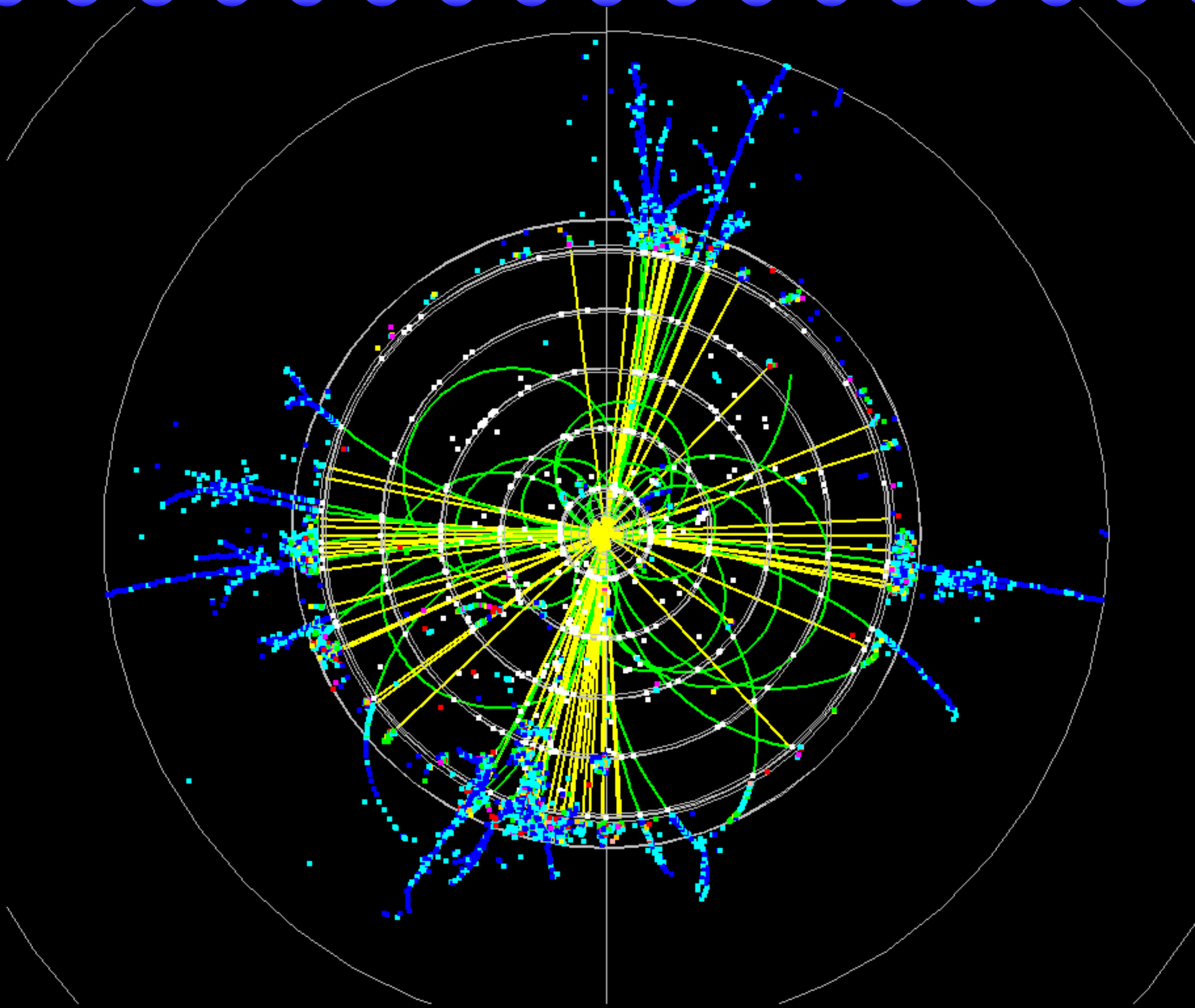


Display only cells with energy depositions from more than one MC Particle.

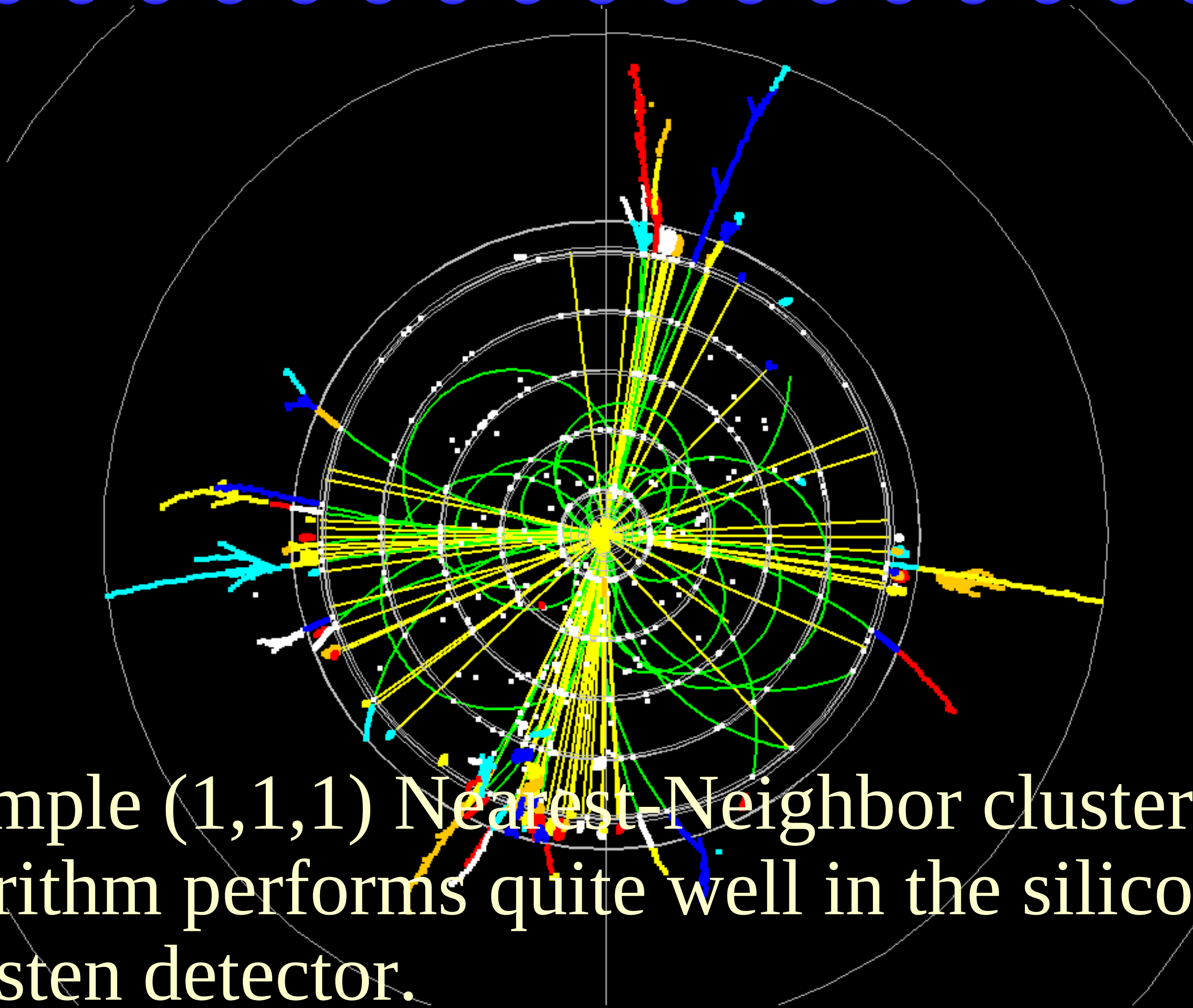
Clustering

- 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.

SimpleClusterBuilder



SimpleClusterBuilder



- 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 φ 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 $\rightarrow$ photons & electrons + muon MIPs + others
  - HAD $\rightarrow$ hadrons + muon MIPS
  - MUON $\rightarrow$ 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.

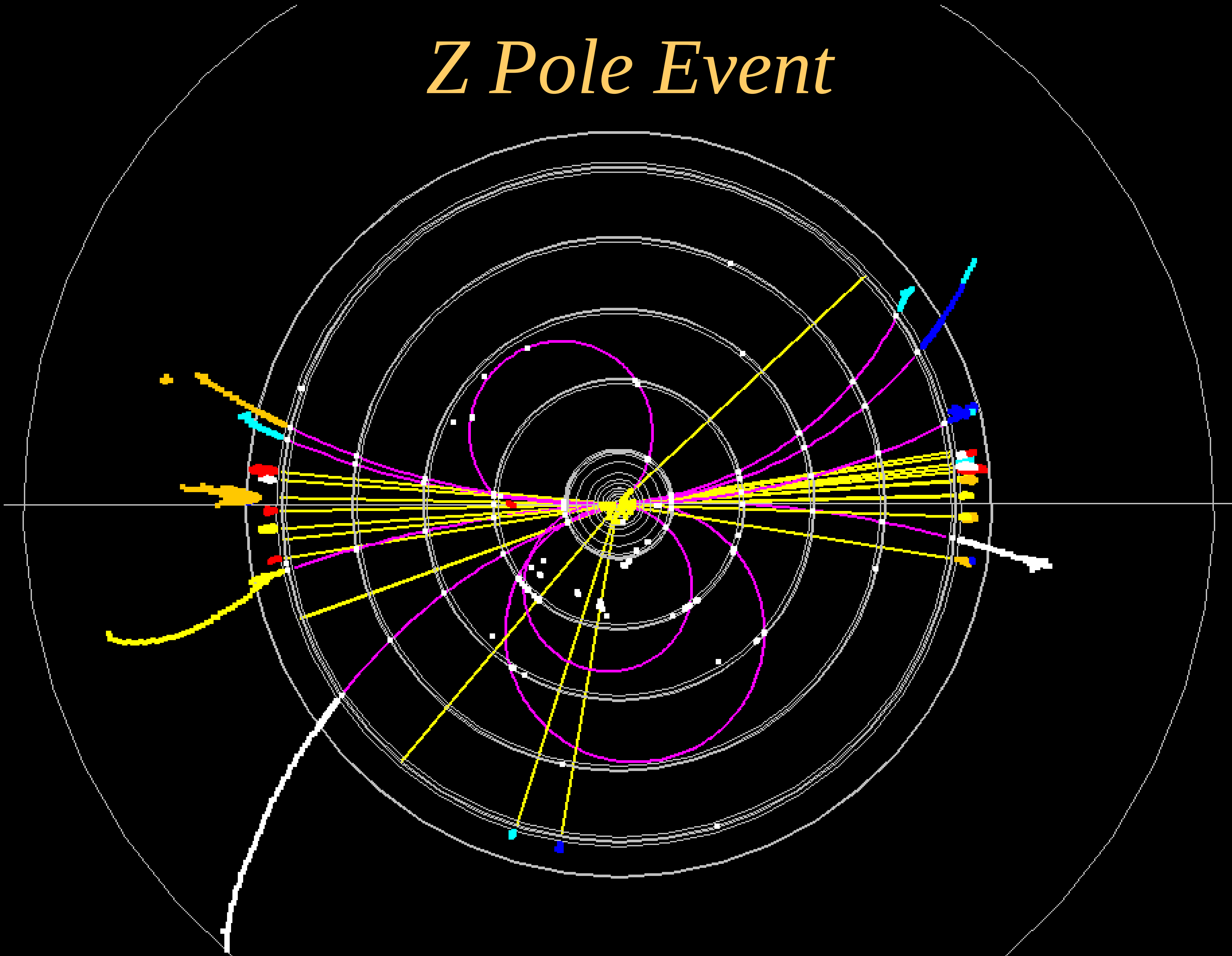
ReconstructedParticles

- These ReconstructedParticles (electron, photon, pion, muon, neutron) are added back to the event.
- Tracks and Clusters form ReconstructedParticles.
- Goal is 1:1 ReconstructedParticle ⇔ MCParticle

Z Pole Analysis

- Generate Z→ 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.

Z Pole Event



Reconstruction Example

```
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

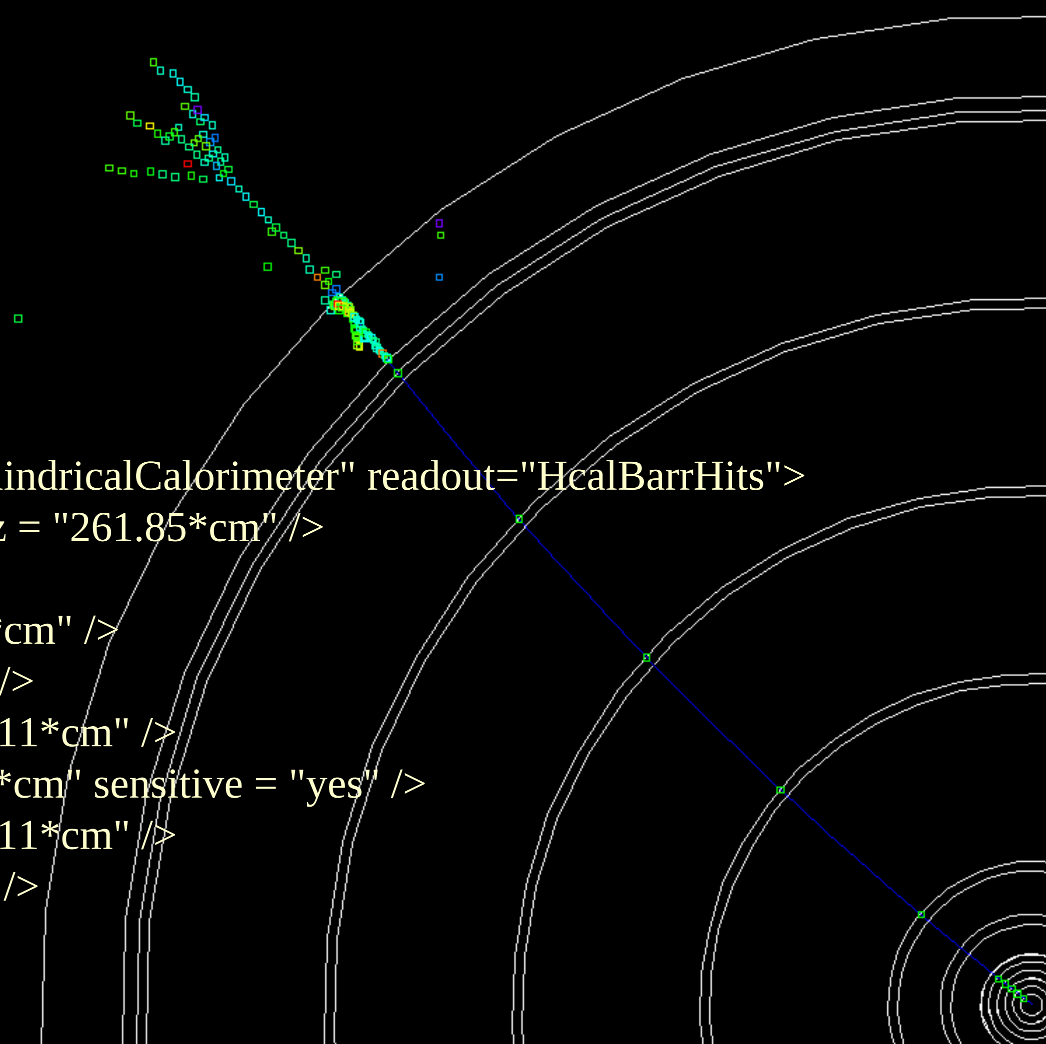
www.lcsim.org/datasamples/

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.) Sampling
- Barrel+Endcap Disks



```
<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>
```