Cluster finding in CALICE

Chris Ainsley
University of Cambridge, UK
ainsley@hep.phy.cam.ac.uk

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Calorimeters
Cluster finding in CALICE
Motivation

• Desire for excellent jet energy resolution at future LC
  ⇒ calorimeter needs to be highly granular to resolve individual particles within jets;
  ⇒ calorimeter will have tracker-like behaviour: unprecedented;
  ⇒ novel approach to calorimeter clustering required.
• Aim to produce a flexible clustering algorithm, independent of ultimate detector configuration and not tied to a specific MC program.
• Develop within an LCIO-compatible framework
  ⇒ direct comparisons with alternative algorithms can be made straightforwardly.
• Test with CALICE calorimeters (TESLA TDR) simulated by Mokka.
Order of service

• Overview of CALICE geometry.
• Algorithm in outline.
• Application to single-particle cluster reconstruction.
• Application to multi-particle cluster reconstruction:
  – in the full barrel;
  – in selected segments
    • assessment of performance (how best to do this?).
• Summary and outlook.
Cross-section through the CALICE barrel calorimeters

- TESLA TDR barrel geometry:
  - 8 identical octants (number 1 at 12 o’clock, running anti-clockwise to number 8);
  - 40 layers of W-Si in Ecal (green);
  - 40 layers of Fe-Scintillator in Hcal (yellow);
  - 1x1 cm² sensitive cells in both Ecal & Hcal.
Algorithm in outline

- Sum energy deposits within each cell.
- Retain cells with total hit energy above some threshold (½ MIP).
- Form clusters by tracking closely related hits through calorimeters:
  - for a given hit $j$ in a given layer $l$, minimize the angle $\beta$ w.r.t all hits $k$ in layer $l-1$;
  - if $\beta < \beta_{\text{max}}$ for minimum $\beta$, assign hit $j$ to same cluster as hit $k$ which yields minimum;
  - if not, repeat with all hits in layer $l-2$, then, if necessary, layer $l-3$, etc.;
  - after iterating over all hits $j$, seed new clusters with those still unassigned;
  - calculate centre-of-energy of each cluster in layer $l$;
  - assign a direction cosine to each hit along the line joining its clusters’ seed (or $\{0,0,0\}$ if it’s a seed) to its clusters’ centre-of-energy in layer $l$;
  - propagate through Ecal, then Hcal;
  - do some retrospective tidying up.
Single-particle reconstruction

15 GeV $e^-$

15 GeV $\pi^-$
91 GeV Z event: Full barrel

Reconstructed clusters

True particle clusters
91 GeV Z event: Octant 1

Reconstructed clusters

True particle clusters
Octant 1: Performance

- 97.8 % of octant energy maps from true onto reconstructed clusters (2 clusters broken in reconstruction).
- 100 % of octant energy maps from reconstructed onto true clusters ⇒ no misassignments.
91 GeV Z event: Octant 8

Reconstructed clusters

True particle clusters
• 99.3 % of octant energy maps from true onto reconstructed clusters (3 clusters broken in reconstruction).
• 99.5 % of octant energy maps from reconstructed onto true clusters ⇒ almost no misassignments.
Summary & Outlook

• R&D on clustering algorithm for calorimeters at a future LC in progress.
• Approach mixes tracking and clustering aspects to utilize the high granularity of the calorimeter cells.
• Starts from calorimeter hits and builds up clusters – a “bottom up” approach (cf. “top down” approach of G. Mavromanolakis).
• Testing with CALICE geometry.
• Works well for single-particles events.
• Encouraging signs for multi-particle events:
  – Averaged over 100 Z events at 91 GeV
    • 91.1 ± 0.5 % of event energy maps from true onto reconstructed clusters;
    • 94.3 ± 0.3 % of event energy maps from reconstructed onto true clusters.
  – Any better ways of assessing performance?
• Adapt to LCIO framework for easy comparison with alternative (existing and new) algorithms and for application to alternative detector geometries.