CLUSTER-FINDING IN CALICE CALORIMETERS

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A tracker-like algorithm for cluster reconstruction in a highly granular calorimeter is presented and its application to the CALICE calorimeters is demonstrated.

1 Introduction

Excellent jet energy resolution is a mandatory requirement of the detector for a future linear collider [1]. To achieve this, studies have demonstrated that the calorimeter must be highly granular so that the individual particles within jets can themselves be resolved. Such tracker-like behaviour in the calorimetry is unprecedented and warrants the investigation of novel clustering techniques. One potential algorithm, currently under development, is explored here.

2 Method

In order to exploit the high granularity of the active cells, clusters are formed by tracking closely-related hits layer-by-layer outwards through the calorimeters. The procedure is illustrated in Fig. 1 and described in the steps below.

1. For each hit, j, in a given layer, l, the angle β is minimized with respect to all hits in layer $l-1$. For the hit, k, that yields the minimum:
   - if $\beta < \beta_{\mathrm{max}}$, hit j is assigned to the cluster already containing hit k;
   - if $\beta \geq \beta_{\mathrm{max}}$, the procedure is repeated with all hits in layer $l-2$, then, if necessary, those in layer $l-3$, and so on until $\beta < \beta_{\mathrm{max}}$ is satisfied.
2. New clusters seeds are formed from groups of nearby hits in layer l not associated with clusters in previous layers by step (1).
3. The mean position of the hits belonging to each cluster in layer l is calculated and used to assign a direction cosine to these hits, aligned along the displacement of the cluster's mean position in layer l from either its mean position in its seed layer, or (0,0,0) if l is the seed layer.
4. Steps (1)–(3) are propagated working forwards through each layer of the electromagnetic calorimeter and then, in turn, through each layer of the hadronic calorimeter.

5. To contend with occasional backward-spiralling track-like clusters that reconstruct as two forward-going clusters broken at the apex, such cluster fragments are retrospectively merged into the same cluster using their directional and proximity information in the layer of the break.

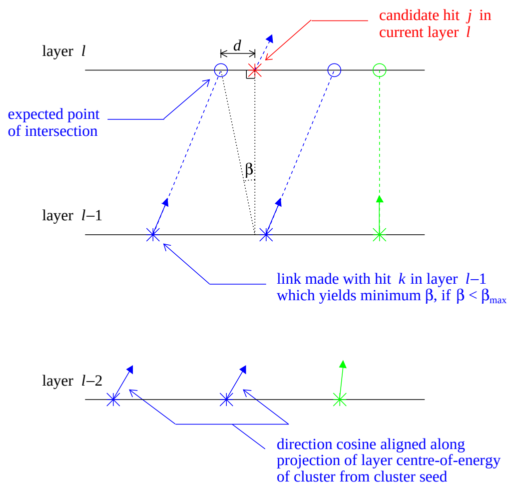

Figure 1: 2-D schematic of cluster-tracking through the third of three successive layers of the calorimeter. The asterisks mark the positions of hits in the calorimeter cells and, in the two lowest layers, are colour-coded according to the reconstructed cluster to which they belong (blue or green); the arrow associated with each indicates the inferred local direction of propagation of that cluster. An attempt is made first to link the (red) hit in the top layer, l, to a hit in the previous layer, $l-1$, by minimizing the distance, d, between this hit and the expected points of intersection of clusters projected from layer $l-1$ into this layer (marked by circles). In this example, if d is sufficiently small, the red hit would be linked to the left-most hit in layer $l-1$ and thus associated to the blue cluster in the reconstruction.

3 An Example

Fig. 2 shows, as an example, the application of the algorithm to reconstruct the clusters of a hadronic decay of a Z boson at 91 GeV in the proposed CALICE [2] barrel calorimeters, based on the TESLA TDR [1] design, simulated by MOKKA [3]. The high degree of correlation between groups of hits assigned to the same reconstructed cluster and groups of hits belonging to the same true cluster (*i.e.* those hits attributable to the same incident particle) is a sign of encouragement that the algorithm is performing effectively.

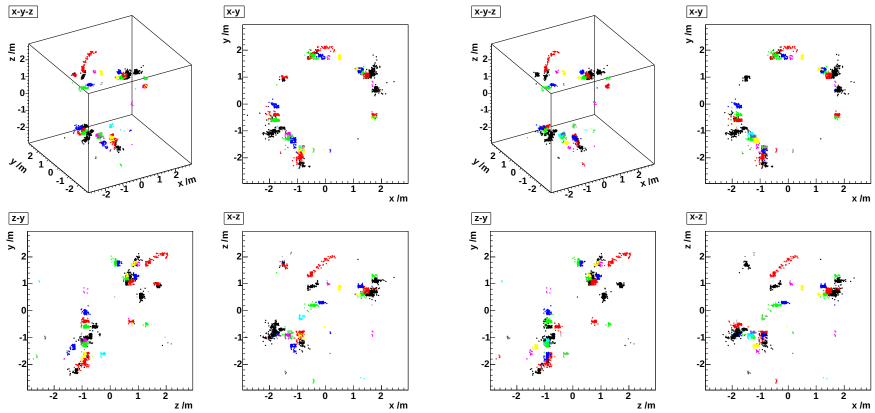

Figure 2: Reconstructed (left) and true clusters (right) from the MOKKA simulation of a hadronic Z event at 91 GeV in the barrel of the CALICE calorimeters. Clusters are ranked within each octant of the barrel according to the energy-sum of their hits and colour-coded in descending order: black, red, green, blue, yellow, magenta, cyan, and so on.

4 Conclusion

The basis has been presented for a cluster-finding algorithm honed for the highly granular calorimeters envisaged for a detector at the future linear collider. Tests with the CALICE barrel calorimeters suggest that the approach has future potential. The extension of the algorithm to be widely applicable to any detector configuration will be the subject of further study: this should be conducted within the LCIO [4] framework, enabling straightforward comparisons to be made with both alternative geometries and alternative algorithms.

References

1. TESLA Technical Design Report, Part IV: A Detector for TESLA, DESY 2001-011, ECFA 2001-209 (March 2001).
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`http://www-it.desy.de/physics/projects/simsoft/lcio/index.html`.