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The Ideas for Photon Finding Method

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We present the problems in our current photon finding method for future Linear Collider (LC) experiment and the ideas to solve it. In our study, we used $Z \to q\bar{q}$ event at 91.2GeV which generated by PYTHIA generator. Our current performance of photon finding efficiency is about 78% with about 5% charged hadron contamination. The problems, especially, occur in the low momentum charged hadron rejection and in the overlapping clusters. We may be able to solve those problems by modifying our small clustering method and by using the information of cluster direction. This study is based on the full simulator for GLD detector named Jupiter, and its reconstruction package named Satellites.

1. INTRODUCTION

Since precise jet energy measurement is necessary in future LC experiment, the jet reconstruction method (Particle Flow Algorithm, PFA) is quite important.

The photon finding method which is applied before charged hadron finding is quite important part in PFA, because the expected photon energy contribution in LC experiment is about 20% and good photon finding method allow us to use the simple charged hadron finding method.

In our study, we used $Z \to q\bar{q}$ event at 91.2GeV which generated by PYTHIA generator. Our current performance of photon finding efficiency is about 78% with about 5% charged hadron contamination. However, because of this performance is not sufficient for future LC experiment, we should improve our current photon finding method.

Our study is based on the full simulator for GLD detector (Jupiter) [1]. The calorimeter which implemented in current Jupiter has tower type geometry with 4cm×4cm tile size for ECAL and 12cm×12cm for HCAL as default value. It has scintillator/Pb sandwich construction and those thickness are 1mm/4mm for ECAL and 2mm/8mm for HCAL, and the number of layers of ECAL is 38 and those of HCAL is 130. The inner radius of barrel part is 210cm, half length for z direction is 270cm.

Basically, our study is based on this default geometry, but we can change these parameters by modifying the input file.

2. CURRENT PHOTON FINDING METHOD

2.1. Flow of the Photon Finding

The flow of our current photon finding method is as follows [2];

1. Clustering
2. Charged particles rejection
3. Longitudinal shower profile check

We perform the clustering for photon at first. Our clustering method for photon is based on the nearest neighbor clustering (Small Clustering) method and on the tube based clustering.

After making the clusters, we check the distance from the nearest track. If cluster is close to the track ($\leq$7cm) it is regarded as charged particle cluster. We can remove the large number of charged hadron clusters by this cut.

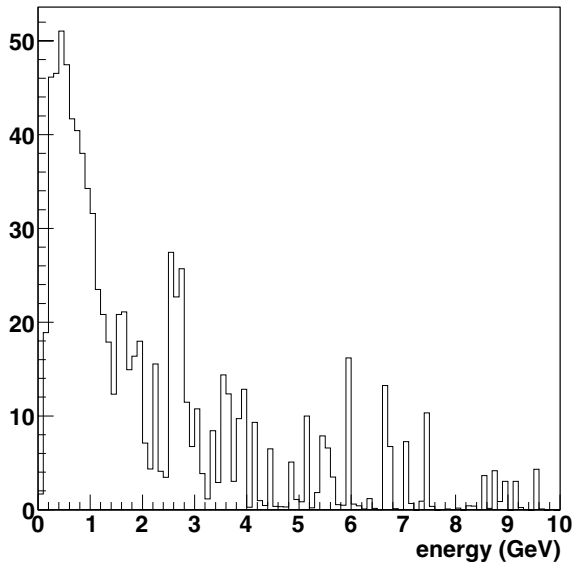

Figure 1: Energy distribution of charged hadron clusters which is in reconstructed photon clusters.

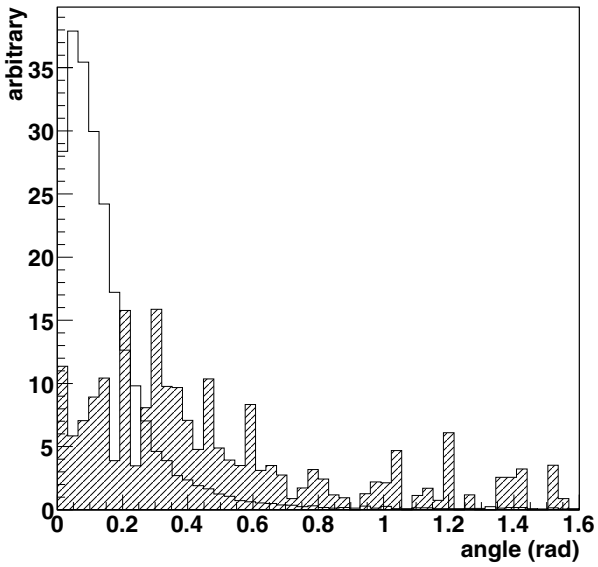

Figure 2: Angle distribution of reconstructed photon clusters.

As a last step of photon finding, we check longitudinal shower profile of the clusters. We check following information: energy weighted cluster mean depth from the calorimeter inner surface, maximum layer ID of the cluster (layer ID is counted from the inner surface), layer ID which has maximum energy deposition. In addition, we fit the cluster energy longitudinal shower profile by Gamma-distribution function [3] and the result of χ^2/ndf is used to distinguish the photon (and electron) clusters from the others.

2.2. Problems in Current Photon Finding Method

Current performance of our photon finding efficiency is 78.4% with about 5% charged hadron and with about 5% neutral hadron contamination. (About 0.6% charged hadron origin hits and about 8% neutral hadron origin hits are included in reconstructed photon clusters.)

Because of this performance is not sufficient for LC experiment, we investigated the problems in our photon finding method. Fig. 1 shows the energy distribution of the charged hadron clusters which included in the reconstructed photon clusters. As this figure shows, low momentum charged hadrons can not be removed in our current photon finding method. In addition, we checked event display and found the fact that overlapped photon clusters are removed even if it is photon cluster.

3. HOW TO SOLVE THE PROBLEMS

3.1. Cluster Direction

To find low momentum charged hadron clusters, we may be able to use the information of cluster direction.

We defined cluster direction by similor way to the thrust calculation; cluster direction vector $\overrightarrow{n}$ is defined such as it minimize $\sum_i |\overrightarrow{X_i} \cdot \overrightarrow{n}| E_i / (E_{total} \sum_i |\overrightarrow{X_i}|)$, where $\overrightarrow{X_i}$ and E_i is position vector and energy deposition of i-th hit in a cluster.

Fig. 2 shows the angle distribution between cluster direction and cluster position vector with 1cm×1cm ECAL tile size configuration. The histogram filled by slash shows the distribution of charged hadron clusters which included in the reconstructed photon clusters, and blank one shows the result of photon clusters. This plot shows that we can use this information to remove low momentum charged hadrons. But in case we used 4cm×4cm tile size configuration, it seemed to be difficult to use this information.

3.2. New Small Clustering

To reduce the merging of overlapped clusters, it is necessary to improve the clustering method. So, we considered new nearest neighbor clustering (we call it as small clustering) method. In this method, we start from the high energy threshold and perform the nearest neighbor clustering, then set threshold lower and continue the nearest neighbor clustering. By lowering energy threshold gradually, we may be able to find the core of clusters at first and to distinguish overlapping clusters.

4. CONCLUSION

Low momentum charged hadrons tend to be regarded as photon clusters, and overlapping photon clusters tend to be removed in our current photon finding method. We may be able to use the information of cluster direction and to use new nearest neighbor clustering method. But both of them have not been implemented in the Satellites yet. We should implement them and study by using full simulator.

References

[1] The package of GLD simulation tools can be downloaded at (http://acfahep.kek.jp/subg/sim/simtools/index.html) and detailed information can be obtained at (http://acfahep.kek.jp/subg/sim/).
[2] The detail of our current photon finding method is described in ALCPG1109.
[3] E.Longo and I. Sestili, Nucl. Instrum. Methods 128, 283 (1975).