Photon Finding Procedure for GLD-PFA

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We present the photon reconstruction method for future Linear Collider (LC) experiment. In our study, we used $Z \rightarrow q\bar{q}$ 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. 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.

In the PFA procedure, we classify particles into 4 types: charged hadron (CHD), neutral hadron (NHD), electron and photon (EM) and muon. After classifying the clusters, we use tracker information for CHD and muon instead of calorimeter hits information since tracker resolution is much better than that of calorimeter.

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 CHD 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. PHOTON FINDING

2.1. Clustering

As a first step of the photon finding, we perform the clustering of calorimeter hits.

Our calorimeter hits clustering method for EM particles has 2 steps, small clustering and tube based clustering. At the stage of small clustering, fired cells are simply merged with its neighboring fired cells while the cluster doesn't exceed the upper limit of energy deposition ($\simeq$50MeV).

After the small clustering, we look for the largest small cluster, which has the largest number of hits, in ECAL region (it is called as mother small cluster) and collect small clusters within the small tube region (R = 5cm, Half H = 15cm). We regard it as one cluster, and non photon-like clusters are rejected below.

2.2. Charged Particles Rejection

The tracking information is very helpful to remove the large number of CHD clusters. Fig. 1 shows the distribution of distance from the mother small cluster to the nearest track in $Z \rightarrow q\bar{q}$ event ($E_{cm} = 91.2GeV$). The histogram

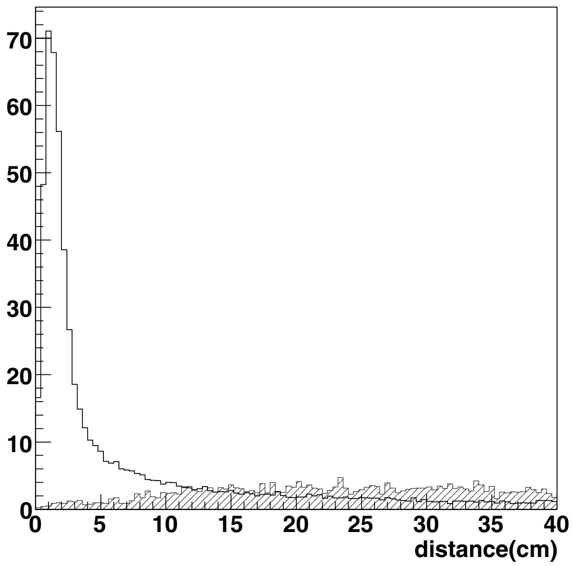

Figure 1: The distance from the nearest track.

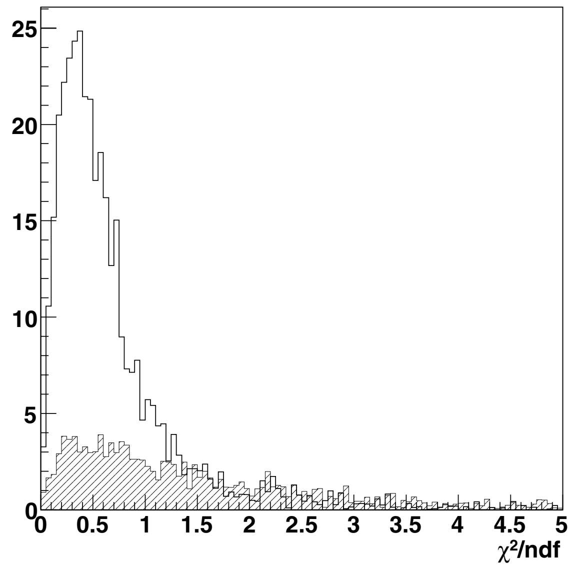

Figure 2: χ^2/ndf (Fitted by Gamma-distribution function).

filled by slash shows the result of photon clusters, and blank one shows the result of the others. This result indicates that we can obviously use this information to distinguish photon clusters from the others, especially from the charged pions. Our current cut value is 7cm for each cluster (tentative). We can remove about 80% of CHD origin mother small clusters while we lose about 4% photon origin mothers.

2.3. Longitudinal Shower Profile

In general, hadrons make shower in HCAL region and EM particles make shower in ECAL region. In addition, EM shower has some characteristics, for example, longitudinal shower profile is well described by Gamma-distribution, the size of transverse shower spread is approximated by Moliere radius etc.

But in our detector conditions, it is difficult to use the transverse shower profile to distinguish photon clusters from the others, because Moliere radius is about 2cm while cell size is 4cm. So, we only use longitudinal shower profile to choose photon clusters.

We check several information which related to the longitudinal shower profile. For example, 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 etc. Fig. 2 shows one of the result of our longitudinal shower profile search. We fit the cluster energy longitudinal shower profile by Gamma-distribution function [2]. This figure shows the result of χ^2/ndf of $Z \rightarrow q\bar{q}$ event at 91.2GeV (track distance cut which described above is already performed). The blank histogram shows the result of photons and the histogram filled by slash shows the result of the others. We regard the clusters as non photon-like one if χ^2/ndf larger than 1.8 (tentative).

3. RESULTS

Current performance of our photon finding efficiency is 78.4% with about 5% CHD and with about 5% NHD contamination. (About 0.6% CHD origin hits and about 8% NHD origin hits are included in reconstructed photon clusters.) We achieved about $40\%/\sqrt{E}$ resolution of energy sum in $Z \to q\bar{q}$ event at 91.2GeV, but if we use cheated photon finding method without any changes in other part of PFA, we can achieve about $37\%/\sqrt{E}$ resolution. These performance, both of the photon finding efficiency/purity and the resolution of energy sum, should be improved.

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] E.Longo and I. Sestili, Nucl. Instrum. Methods 128, 283 (1975).