PFA Summary

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A Particle Flow Algorithm (PFA) for GLD detector has been developed in order to get better jet energy resolution. A lot of the GLD-PFA related talks were presented during the Snowmass workshop; This paper reviews and summarizes these talks.

1. INTRODUCTION

A lot of the GLD-PFA related talks were presented during the Snowmass workshop; general scheme and performance of the GLD-PFA were presented by T. Yoshioka at the PFA session and the GLD Concept Design session [1, 2]. Details of the gamma finding method in the GLD-PFA were presented by T. Fujikawa at the PFA session and the GLD Concept Design session [3, 4]. Calibration factor related topic was presented by J. Chang at the GLD Concept Design session [5].

2. GLD-PFA

A PFA for GLD detector has been developed by using the GEANT4-based full simulator named Jupiter. The energy-weighted efficiency and purity is obtained to be 78.4% and 95.2% for the gamma finding method. The nearest neighbor clustering, called small clustering, is performed in prior to the gamma finding. The energy-weighted efficiency and purity is obtained to be 84.2% and 91.2% for the track matching method. The PFA performance is studied by using $Z \to q\bar{q}$ events; $40\%/\sqrt{E}$ energy resolution is achieved by using the PFA while resolution of energy sum in the calorimeter is $60\%/\sqrt{E}$ as shown in Figure 1. There was a discussion about worse resolution of the calorimeter sum energy ($60\%/\sqrt{E}$). So far, a constant calibration factor was used in order to convert to actual energy from visible energy deposit. It was pointed out that energy dependent calibration factor should be applied. By looking at distribution of a small cluster energy subtracted by true cluster energy, it turned out that current small clustering method tends to merge two (or more) particles. In order to obtain the energy dependent calibration factor, we might therefore need to improve the small clustering method.

First trial of study on different calorimeter granularity is performed. So far, no gain with finer segmentation is observed. It was suggested that to try higher center of mass energy to see granularity dependence. In addition to that another algorithm (pattern recognition, etc.) might be used for finer segmentation.

There is also a discussion about the current track matching performance. It turned out that track matching purity for the endcap region is low. The track matching method should be improved for the endcap region, in particular for low momentum case.

There were a lot of discussions about future prospects in addition to the above: The material study should be performed as well as the granularity study. The MIP finding method and neutral finding method should be implemented in near future.

3. Gamma Finding

We got 78% efficiency and 95% purity by using the nearest track distance requirement and longitudinal shower profile search. It turned out that current gamma finding method has low purity at low energy region.

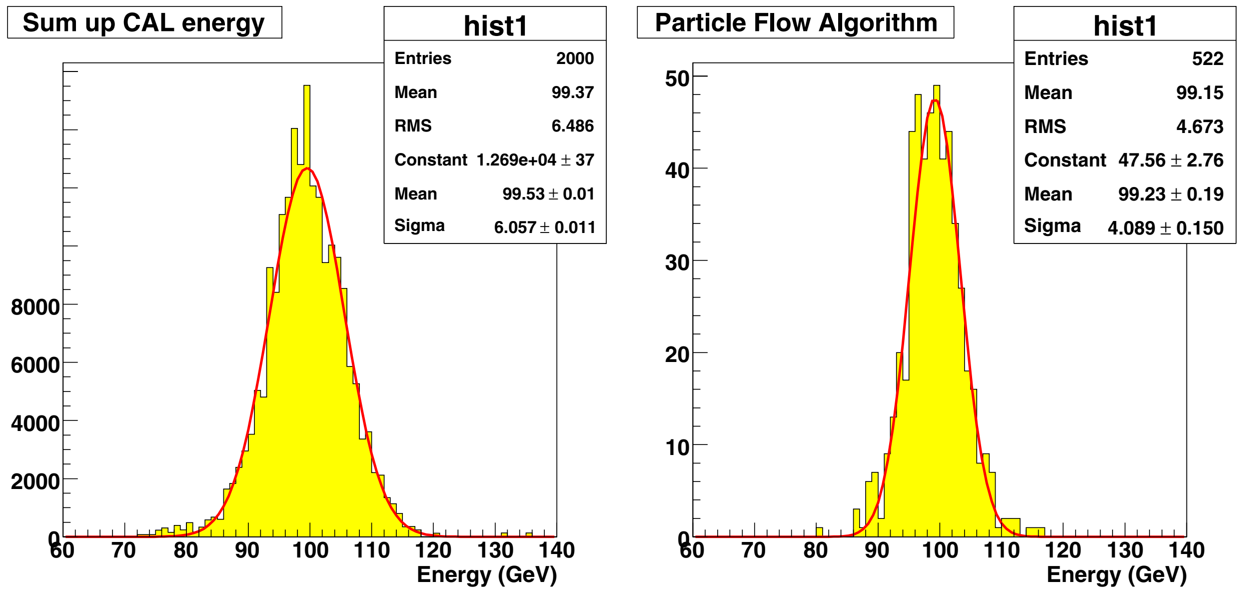

Figure 1: Energy sum in the calorimeter for $Z \to q\bar{q}$ events (right). The resolution is improved from $60\%/\sqrt{E}$ to $40\%/\sqrt{E}$ by using the PFA (left).

There were a lot of discussions to improve the gamma finding method: We need to study energy/angle dependent clustering method (change tube size depend on energy etc.) and re-consider current small clustering method. We have to reject low momentum hadrons (which related to low momentum track matching). We are going to study other cell size configuration and other physics event case. We are also going to try to use H-matrix method (SiD group proposal).

4. Calibration Factors

Calibration factors are studied in order to get the best energy resolution. Total energy deposit (E_{tot}) in the calorimeter is expressed as follows:

$$E_{tot} = a \times (E_{ECAL} + b \times E_{HCAL}), \tag{1}$$

where E_{ECAL} and E_{HCAL} are the energy deposit in the ECAL and HCAL, respectively. Factors a and b are the calibration factors.

For the GEANT4 standalone setup, factor a for hadron is obtained to be

$$a = (45.88 \pm 0.11) \times E_{beam} + 0.01 \pm 0.00, \tag{2}$$

where E_{beam} is the incident beam energy. Note that factor a is obtained to be 50.9 for electron. Results of factor b are summarized in Table I. The deviation from linearly is less than 3%. By using these calibration factors, the best energy resolution is achieved to be

$$\frac{\sigma}{E} = \frac{(45.2 \pm 1.0)\%}{\sqrt{E}} + (3.7 \pm 0.2)\% \tag{3}$$

for π^-.

For the Jupiter setup, factor a for hadron is obtained to be

$$a = (20.08 \pm 0.13) \times E_{beam} + 0.07 \pm 0.01. \tag{4}$$

Table I: Calibration factor b for hadrons obtained by the GEANT4 standalone setup.

Incident Beam Energy (GeV)	**b**
2	0.7
3	0.75
4 - 10	0.8
20 -200	0.9

Table II: Calibration factor b for hadrons obtained by the Jupiter setup.

Incident Beam Energy (GeV)	**b**
2	0.7
3-30	0.9

Note that factor a is obtained to be 25.6 for electron. Results of factor b are summarized in Table II. The deviation from linearly is less than 6%. By using these calibration factors, the best energy resolution is achieved to be

$$\frac{\sigma}{E} = \frac{(38.9 \pm 1.5)\%}{\sqrt{E}} + (3.7 \pm 0.4)\% \tag{5}$$

for π^-.

Plans after the Snowmass workshop were discussed; We have to calibrate the low energy gamma (0.1 GeV, 0.2 GeV ... 10 GeV) in the Jupiter setup. We also have to calibrate the charged hadrons in the low transverse momentum region (energy dependent and position dependent calibration factors).

Current GEANT4 version in the Jupiter is geant4.7.0.p1, but some bugs are fixed in the geant4.7.1. We need to compare the difference between them and update in Jupiter. SiD group said, it is no problem to use the LCHadron-Physics as their Hadronic Shower Model. We better try it in the geant4.7.1 again.

Acknowledgments

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References

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