Particle Flow Algorithm for GLD

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A Particle Flow Algorithm (PFA) for the GLD detector has been developed in order to get better jet energy resolution. We studied the PFA using the GEANT4-based full simulator named Jupiter. In this paper, the general scheme and performance of the GLD-PFA are presented.

1. INTRODUCTION

Most of the important physics processes studied in the future linear collider experiment have multi-jets in the final state and precise jet reconstruction is therefore essential. Since momentum resolution of a charged particle measured by trackers is much better than energy resolution measured by a calorimeter, we use trackers for charged particle measurement and calorimeters for only neutral particles in the event reconstruction. This is so-called Particle Flow Algorithm (PFA) and the best energy resolution is obtained by using the PFA. In order to get better energy resolution by PFA, it is important to spatially separate charged particles from neutral particles at the calorimeter surface. A large detector which has large inner radius of calorimeter is advantageous for the PFA because that a charged particle is bended by a magnetic field while a neutral particle is not. One of the detector currently being proposed, the GLD detector, is such a large detector. In this paper, the general scheme and performance of a PFA using a full simulator of the GLD detector named Jupiter is presented.

Left most figure in Figure 1 shows a schematic cross section of the GLD calorimeter that is currently implemented in the Jupiter. The calorimeter is cylindrical shape with a half length of 270 cm in the beam direction and a inner radius of 210 cm. The calorimeter consists of tower structure (see middle part of Figure 1): One tower consists of electromagnetic calorimeter (ECAL) and hadron calorimeter (HCAL). The ECAL is a sandwich-type calorimeter made of 38 layers of 1 mm-thick plastic scintillator and 4 mm-thick lead. The length in the radial direction is 27

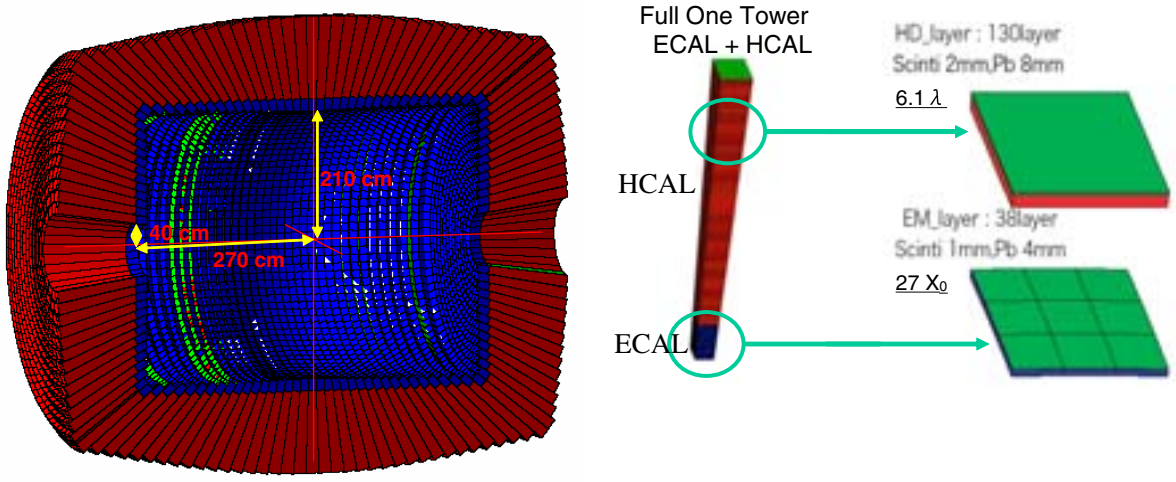

Figure 1: Schematic cross section of the GLD calorimeter implemented in the Jupiter (left). The calorimeter consists of tower structure (middle) and one tower consists of electromagnetic calorimeter and hadron calorimeter (right). See text for more details.

radiation lengths in total. The HCAL is a sandwich-type calorimeter, as well as the ECAL, made of 130 layers of 2 mm-thick plastic scintillator and 8 mm-thick lead. The length in the radial direction is 6.1 interaction lengths in total. The size of plastic scintillator sheet (called "cell") can be changed easily in the Jupiter and current cell size is 4 cm × 4 cm and 12 cm × 12 cm for the ECAL and HCAL, respectively. One layer in a tower containers 9 ECAL cells (3 × 3) as shown in the right most figure of Figure 1.

2. PROCEDURE OF GLD-PFA

The procedure of GLD-PFA is as follows: First of all, the nearest neighbor clustering called "small clustering" is performed. First step of the clustering is to find a "starting cell" which has the highest energy deposit among "fired cell" in the calorimeter. Here the fired cell is defined as a cell whose energy deposit is greater than 50 keV. From the starting cell, its "fired neighbor cells" are then connected to form a "small cluster". The clustering is repeated until no fired neighbor cells are found or the cluster energy exceeds 50 MeV. In the next, in order to separate gammas to hadrons, the "gamma finding" is performed based on the small clusters. Details of the gamma finding method can be found in [1]. The energy-weighted efficiency and purity is obtained to be 78.4% and 95.2%, respectively. Note that contribution from the neutral hadrons are subtracted for the purity calculation. After the gamma finding, matching between a charged track and calorimeter hit cells are examined (called "track matching") in order to separate charged particles to neutral particles. Details of the track matching method can be found in [2]. Note that the track matching is based on the calorimeter hit and is not based on the small cluster. The energy-weighted efficiency and purity is obtained to be 84.2% and 91.2%, respectively. Finally, the remaining calorimeter hits after the track matching is assumed to be due to neutral hadrons.

3. RESULTS

In order to study the GLD-PFA performance, $Z \to q\bar{q}$ events are generated at the center of mass energy of 91.2 GeV. The results are shown in Figure 2. Left histogram shows the energy sum in the calorimeter and the energy

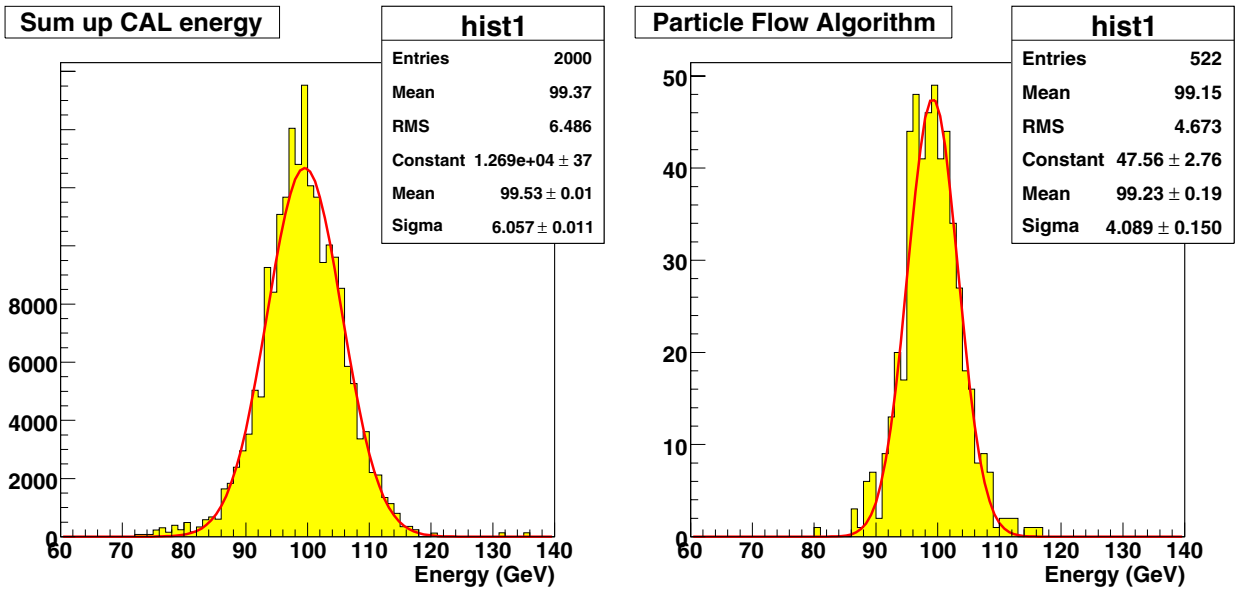

Figure 2: Energy sum in the calorimeter for $Z \to q\bar{q}$ events (right). The resolution is improved from $60\%/\sqrt{E}$ to $40\%/\sqrt{E}$ by using the PFA (left).

Table I: Gamma finding performance for various calorimeter granularity

ECAL cell size	**1 cm × 1 cm**	**2 cm × 2 cm**	**4 cm × 4 cm**
Efficiency	76.4%	78.8%	78.4%
Purity	95.1%	95.1%	95.2%

Table II: Track matching performance for various calorimeter granularity

ECAL cell size	**1 cm × 1 cm**	**2 cm × 2 cm**	**4 cm × 4 cm**
Efficiency	83.6%	84.1%	84.2%
Purity	90.9%	91.7%	91.2%

resolution is obtained to be $60\%/\sqrt{E}$. If the PFA is applied in the event reconstruction, the energy resolution is improved to $40\%/\sqrt{E}$ as shown in the right histogram. Note that the events in which most energy is deposited in the barrel region are selected.

The calorimeter granularity dependence is also studied. The results for various calorimeter granularity are summarized in Table I and Table II for the gamma finding and track matching, respectively. Note that the top row in the tables represents tile size for the ECAL. So far, no significant gain can be seen with finer segmentation against the expectation. The reason is currently under investigation.

4. SUMMARY

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 $60\%/\sqrt{E}$. First trial of study on different calorimeter granularity is performed. So far, no gain with finer segmentation is observed.

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References

[1] T. Fujikawa, "Photon Finding Procedure for GLD-PFA", in these Proceedings.
[2] T. Yoshioka, "PFA Algorithm", in these Proceedings.