Calibration Factors

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In this proceeding, I aim to summarise the status of the study of calibration factors in GLD simulation group, including standalone and full detector setup.

1. INTRODUCTION

The work can be separated into two categories: standalone related and full detector related. This document follows this categorization.

Selections of electromagnetic (EM) and hadronic (HD) shower models are based on the models which could duplicate energy resolution results as close as our prototype data [1]. Details of the selected shower models are reported in another proceeding [2].

2. STANDALONE RELATED

The setup is a sandwiched calorimeter in the compose of 8-mm-thick lead plates and 2-mm-thick scintillator plates with a transverse size of 1 m $\times$ 1 m and total layers of 136. The 1st to 18th layers are treated as ECAL (EM calorimeter) and the 19th to 136th layers are HCAL (HD calorimeter). A 50-mm-thick iron block is placed in front of the ECAL to reject electrons while the π^- beam energy higher than 10 GeV. This special treatment is because of rebuilding the setup of the real data taking envirnment [1].

Calibration factor of e^- beam is obtained by scaling the mean value of total energy deposited in ECAL (dE/dx) to its incident beam energy. The deviation from linearity is given in the left of Figure 1 which shows a good agreement between data and MC. In addition, the better linearity is for those higher than 2 GeV e^- beams. One may need to study the calibration factors for those e^- energy below 2 GeV cases in another way.

Different from the e^- beam case, the calibration method for π^- beam is in two steps as follows. We first separately sum up the absorbed energy in ECAL ($\mathbf{E_{ECAL}}$) and HCAL ($\mathbf{E_{HCAL}}$). Multiplying a weighting factor, $\mathbf{b}$, on $\mathbf{E_{HCAL}}$, we then use the Gaussian function to fit this energy distribution, $\mathbf{E_{ECAL}} + \mathbf{b} \times \mathbf{E_{HCAL}}$. The minimum energy resolution is then obtained by the minimum fitting value of energy resolution in the function of $\mathbf{b}$, as the 2nd order of polynomial function (Left of Figure 2).

Second step is to scale the energy, $\mathbf{a} \times (\mathbf{E_{ECAL}} + \mathbf{b} \times \mathbf{E_{HCAL}})$, back to its incident energy by the other factor, $\mathbf{a}$. The factor $\mathbf{a}$ is fitted as the 1st order of polynomial function of the incident beam energy (Right of Figure 2). In the 10 GeV case, it can't be fitted well by the fitting function. We wonder something wrong in the HD shower models.

The calibrated π^- beam energy shows a good agreement of linearity between data and MC, except 10 GeV case. The deviation from linearity is given in the right of Figure 1. The calibration factors are listed in Table I.

3. FULL DETECTOR RELATED

We use the **GEANT4**-based [3] simulation tool named **Jupiter** to simulate the full detector of GLD. The schematic of the GLD calorimeter can be found in another proceeding [4]. The calorimeter is in cylindrical shape, including endcap and barrel part. In addition, it uses the scintillator tiles and tower structure. In one tower, it consists a

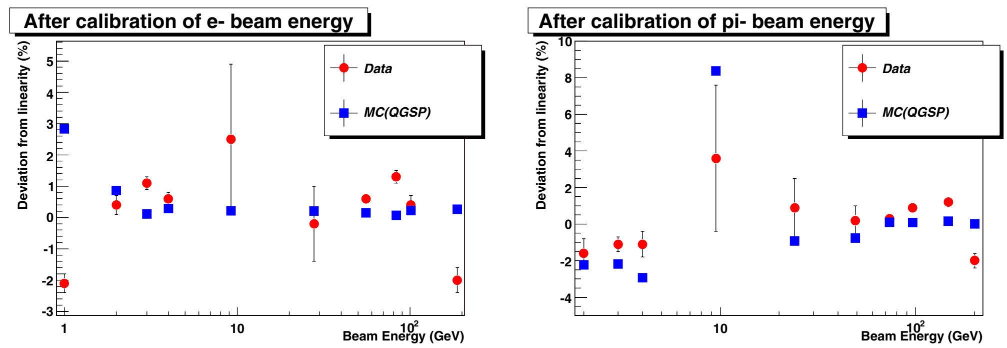

Figure 1: Deviation from linearity of e^- (left) and π^- (right) between data and MC.

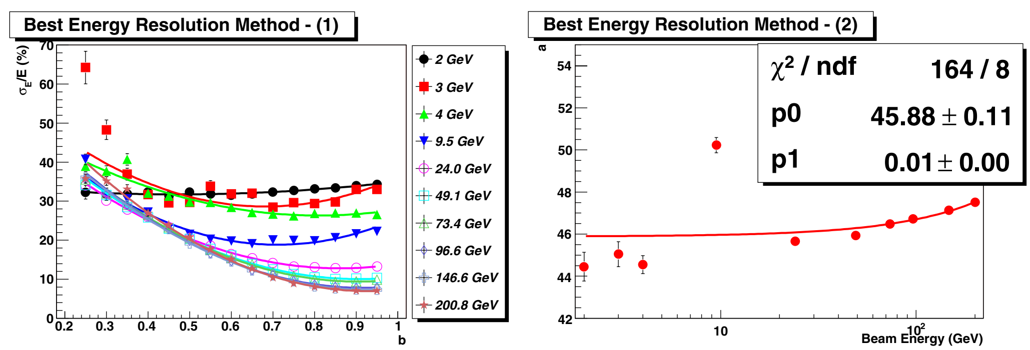

Figure 2: Calibration factors of π^- beam test. (Left) The energy resolutions in the function of weighting factor, **b**, are fitted by 2nd order of polynomial function. (Right) The scaling factor **a** is in the function of the incident beam energy, fitted by 1st order of polynomial function.

sandwiched calorimeter in the compose of 4-mm-thick lead plates and 1-mm-thick scintillator tiles with total layers of 38 (ECAL) and of 8-mm-thick lead plates and 2-mm-thick scintillator tiles with total layers of 130 (HCAL). Each tile size in ECAL is 4 cm × 4 cm and in HCAL is 12 cm × 12 cm.

We apply the same method as mensioned in the standalone setup to calibrate the energy in the Jupiter. Due to the low energy charged particles (below 2 GeV) make turns before they reach the calorimeter (Figure 3). We average 4 calibration factors from the single e^- beam test: 2 GeV, 3 GeV, 10 GeV, and 30 GeV. The deviation from linearlity is within 1%. The energy resolution of e^- is then obtained: $\sigma_E/E = (16.8 \pm 0.4)\%/\sqrt{E} \oplus (-0.2 \pm 0.1)\%$. Similarly, the energy resolution of π^- is obtained: $\sigma_E/E = (38.9 \pm 1.5)\%/\sqrt{E} \oplus (3.7 \pm 0.4)\%$. Again, the scaling factor **a** can't fit well in the 10 GeV case. Moreover, the constant term of the fitting energy is too large which is the same as we found in the standalone case [2]. This means the best HD shower model, **QGSP**, is not good enough to describe the low energy showers but good for high energies. While comparing the π^- with K_L and Neutron particles, we expect the same energy resolution for them, however, it is much worse in the Neutron case. The treatment of Neutron in the shower models maybe not correct.

The calibration factors are listed in Table I.

4. DISCUSSION

Since the e^- energy lower than 2 GeV cases can't be calibrated, we may use gamma for replacement. The EM showers for e^- and gamma are very close, it is possible to get the scaling factor in this way. However, we still have no idea of calibrating the low energy hadron showers.

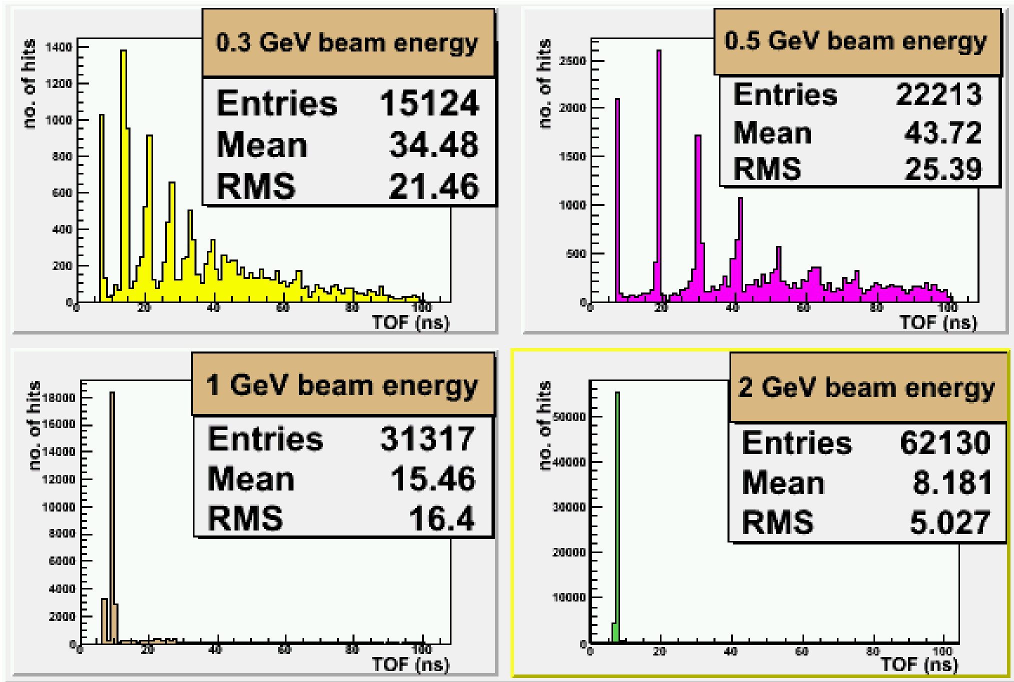

Figure 3: The Time-of-Fly information for the low e^- beam energy cases. Those energy lower than 2 GeV cases can't be used for calibration.

Table I: Summary of calibration factors in both standalone and full GLD detector (Jupiter). The **a** is the scaling factor, **b** is minimuming energy resolution factor, and E_{beam} is the incident beam energy.

	a	**b**
Standalone e^-	50.9 ± 0.1	
Standalone π^-	$(45.88 \pm 0.11)E_{beam} + (0.01 \pm 0.00)$	0.7 (E_{beam}=2 GeV)
		0.75 (E_{beam}=3 GeV)
		0.8 (E_{beam}=4-10 GeV)
		0.9 (E_{beam}=20-200 GeV)
Jupiter e^-	25.6 ± 0.1	
Jupiter π^-	$(20.08 \pm 0.13)E_{beam} + (0.07 \pm 0.01)$	0.7 (E_{beam}=2 GeV)
		0.9 (E_{beam}=3-30 GeV)

References

[1] S. Uozumi, et al., Nucl. Instr. and Meth. A 487 (2002) 291-307.

[2] M.-C. Chang, "Shower Models for Calorimeter", ALCPG0802.

[3] http://geant4.web.cern.ch/geant4/. The version 7.0.p1 is used in both standalone and full detector setup.

[4] T. Yoshioka, "Particle Flow Algorithm for GLD", ALCPG1102.