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Energy Resolution of an SF-5 Lead Glass Čerenkov Counter

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A new electro-magnetic (EM) calorimeter complex FOREST consists of three independent calorimeters [1], covering a solid angle of about 4π sr in total. An SF-5 lead glass Čerenkov counter array Rafflesia II is employed to cover backward angles from 110 to 170 degrees of FOREST. The energy resolution of the SF-5 counter has been measured using a positron beam with energies up to 800 MeV.

§1. Experimental setup

The energy resolution of the SF-5 lead glass Čerenkov counter was measured at the electron/positron beamline dedicated to testing detectors at LNS. It consists of an SF-5 lead glass with a size of 150 mm (W) $\times$ 150 mm (H) $\times$ 300 mm and a 5 inch photo-multiplier tube (Hamamatsu R1250) directly connected to the lead glass, and it was manufactured by Ohara Optical Company [2]. The SF-5 lead glass is a mixture of 55% PbO_2 and 45% SiO_2 by weight, its density is 4.07 g/cm^3, and its radiation length (X_0) is 25.4 mm. The thickness of the counter corresponds to $11.8X_0$.

Momentum-analyzed positrons were used as an incident beam with the energy ranging from 100 to 800 MeV . A beam profile monitor (BPM) was used to specify the position of the incident positrons. BPM consists of two layers of scintillating fiber (SciFi) hodoscopes. Each hodoscope is composed of 16 SciFis with a cross section of 3×3 mm^2. The upstream and downstream layers determine the x and y positions of the incident positron, respectively. Figure 1 shows the experimental setup for measuring the energy resolution of the SF-5 counter.

The trigger condition for the data acquisition system is described as

$$[x \text{ fiber OR}] \otimes [y \text{ fiber OR}], \tag{1}$$

where $\otimes$ means coincidence of signals. The maximum singles rate of the SF-5 counter was 4 kHz and a fraction of accidental coincidence events was negligibly small. The energy resolution was measured by using positrons bent with a $\mathcal{R}$TAGX current from 50 to 450 A (about 100–800 MeV/c) [3] injected on to the central region (9$\times$9 mm^2).

§2. Energy Response

The measured energy E is determined by subtracting the mean of the pedestal distribution $A_{\rm ped}$ from the ADC value A as

$$E = A - A_{\rm ped}. \tag{2}$$

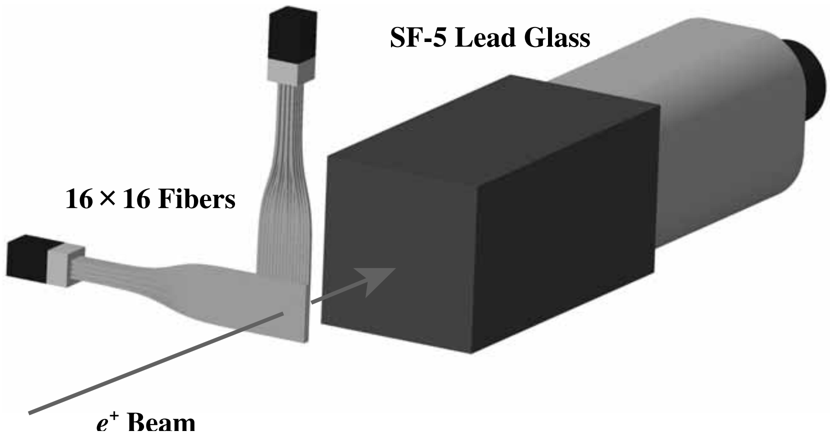

Fig.1. Experimental setup for measuring the energy resolution of the SF-5 counter. The 16 × 16 scintillating fiber hodoscopes are placed in front of the calorimeter to determine the position of incident positions.

The unit of the measured energy E is arbitrary. The positrons injected on to the central region ($9{\times}9$ mm^2) were selected in the energy measurement to suppress the energy leakage out of the SF-5 counter in the lateral direction. The linearity of the energy response was checked with the ratio of the mean of the measured energy distribution to the incident positron energy E_{e^+}. Figure 2 shows the ratio as a function of the incident energy. The difference of the ratio is less than 1% for $E_{e^+} < 0.6$ GeV and 5% for all the data.

The measured energy distribution for each incident positron energy was fitted with a Gaussian function, and the mean (μ) and width (σ) of the distribution was determined. The energy resolution is obtained as

$$\frac{\sigma_E}{E} = \frac{\sigma}{\mu}. \tag{3}$$

The energy spread of the positron beam and the smearing of the pedestal distribution is much smaller than the energy resolution of the SF-5 counter, and they do not affect the obtained resolution. Figure 2 shows the energy resolution as a function of the incident positron energy.

The energy resolution σ_E/E may be expressed as

$$\frac{\sigma_E}{E} = \left\{ \left(\frac{a_2}{E}\right)^2 + \left(\frac{a_1}{\sqrt{E}}\right)^2 + a_0^2 \right\}^{1/2}. \tag{4}$$

The function (4) is fitted to the data to give the result,

$$\frac{\sigma_E}{E}(E_{e^+}) = \left\{ \left(\frac{0.51 \pm 0.07}{E_{e^+}}\right)^2 + \left(\frac{4.06 \pm 0.01}{\sqrt{E_{e^+}}}\right)^2 + (2.70 \pm 0.14)^2 \right\}^{1/2}, \tag{5}$$

where the energy resolution and E_{e^+} are given in % and in GeV, respectively. The energy resolution for 1 GeV positrons corresponds to 4.9%. The energy resolution of the SF-5 counter is much higher than that of lead scintillating fibers (7.2%) [4]. The details of the analysis are described elsewhere [5].

Rafflesia II was constructed on the 11th June in 2008, and 10 SF-5 counter are used in it. The details of construction of Rafflesia II are reported [6].

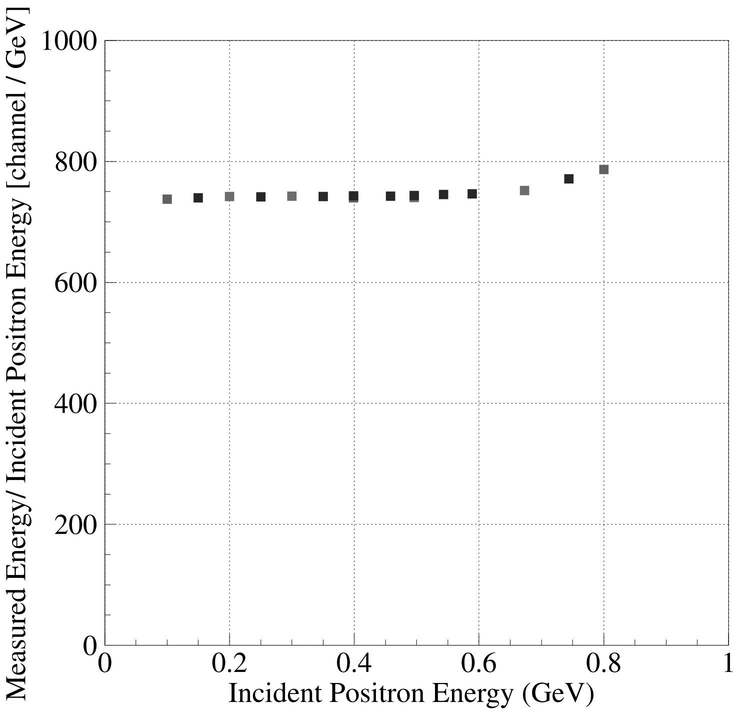

Fig.2. Ratio of the mean of the measured energy distribution to the incident positron energy. The measured energy is given by subtracting the mean of the pedestal distribution from the ADC value, and its unit is arbitrary.

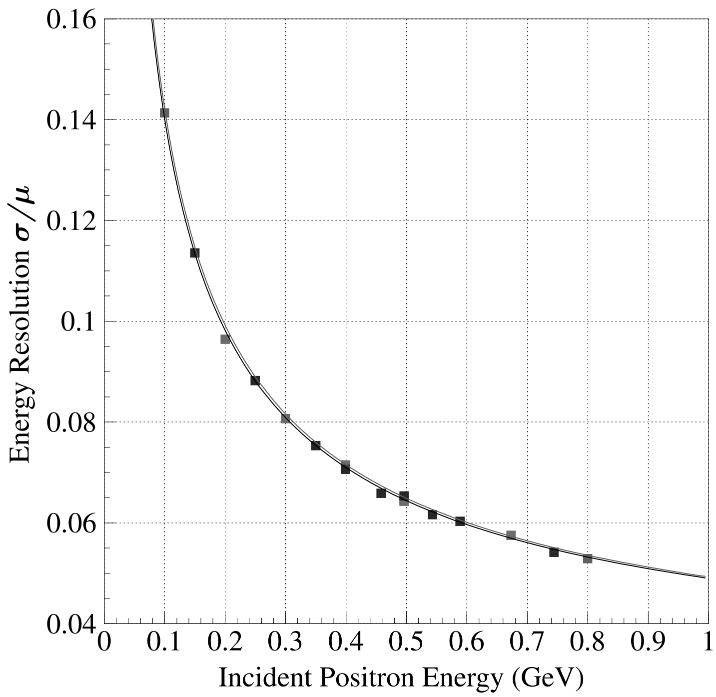

Fig.3. The energy resolution as a function of the incident positron energy. The resolution is given by the width (σ) divided by the mean (μ) of the measured energy distributions. The solid curve shows the fitted function by the equation (4).

References

[1] T. Ishikawa *et al.*: Research Report of LNS, Tohoku University **39** (2006) 35.

[2] A. Ando *et al.*: KEK Report, KEK-79-21 (1979).

[3] T. Ishikawa *et al.*: Research Report of LNS, Tohoku University **40** (2007) 6.

[4] K. Mochizuki and T. Ishikawa *et al.*: Research Report of LNS, Tohoku University **40** (2007) 15.
K. Mochizuki: Internal GeV-γ analysis note No.**44** (2007).

[5] M. Sato: Internal GeV-γ analysis note No. **86** (2008).

[6] T. Ishikawa *et al.*: in this Research Report of LNS, **41** (2008) 7.