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Current Status of the Electro-Magnetic Calorimeter SCISSORS III

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A new electro-magnetic calorimeter complex FOREST with a solid angle of about 4π in total is under construction. A forward calorimeter SCISSORS III, a part of FOREST, was constructed last year. We have installed plastic scintillator hodoscopes in front of SCISSORS III. A beam test has been performed for the forward detector assembly. The π^0 peak is clearly observed in the $\gamma\gamma$ invariant mass distribution.

§1. Plastic Scintillator Hodoscopes in Front of SCISSORS III

Nucleon resonances are experimentally studied via π^0 and η photo-production by using an electro-magnetic (EM) calorimeter in the GeV-γ experimental hall [1] at Laboratory of Nuclear Science (LNS), Tohoku University. These neutral mesons are identified in $\gamma\gamma$ invariant mass distributions. A new EM calorimeter complex called FOREST (Four-pi Omnidirectional Response Extended Spectrometer Trio) with a solid angle of about 4π in total is under construction [2] to reduce a fraction of undetected γ's. It consists of three calorimeters. A forward one made up of pure CsI crystals 'SCISSORS III' was constructed last year [3]. Since an EM calorimeter itself cannot distinguish whether an incident particle is neutral or charged, a thin plastic scintillator hodoscope is usually placed in front of it. We have designed and constructed a set of plastic scintillator hodoscopes named Spiral-shaped Particle Identification Detector for Elementary Reactions (SPIDER), which is capable of determining the incident position of charged particles precisely.

SPIDER consists of 3 layers, each of which is made up of 24 identical plastic scintillators. The side curve of each plastic scintillator has a shape of spiral as depicted in Fig. 1. The spiral curve may be represented as

$$r = \exp\left\{b(\theta + \theta_0)\right\}, \tag{1}$$

in the polar coordinate system, where r is a radius measured in mm, and b is a curvature parameter being chosen to be 1.1. The inside and outside radii r range from 57 to $425(1 - 0.15\sin 15^\circ)$ mm and to $425(1 + 0.35\sin 15^\circ)$ mm, respectively. The phase difference in θ between adjacent scintillators is 15°.

Two layers in SPIDER have different configurations in placing 24 spiral scintillators in a plane. One of them is a left-handed layer and the other is right-handed. A pair of these left-handed and right-handed layers can determine the position of charged particles going through SPIDER. The third layer is placed so as not to have inefficient area taking place at the boundary region of spiral in each scintillator.

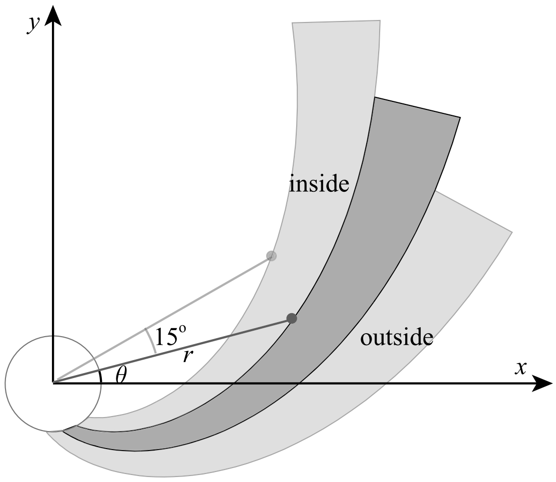
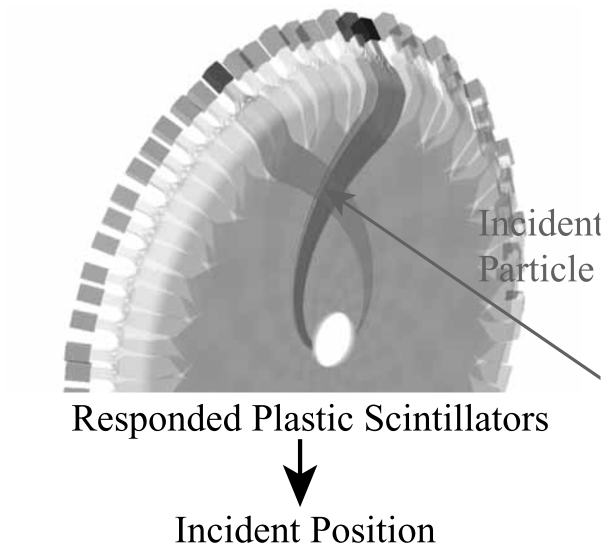


Fig.1. Spiral-shaped scintillators. The side curve of each plastic scintillator is represented as $r = \exp\{b(\theta + \theta_0)\}$ in the polar coordinate system. The phase difference between adjacent scintillators is 15°.

Figure 2 shows the schematic view and photo of SPIDER. The spiral-shaped scintillator is connected to a metal packaged photo-multiplier tube Hamamatsu R8900U through a twisted-type light guide.



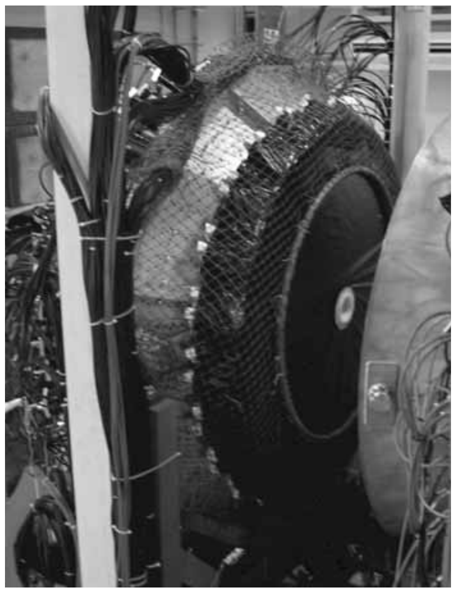
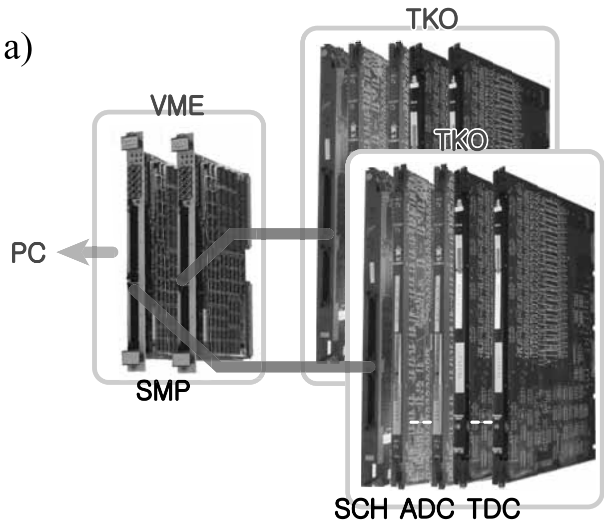


Fig.2. Schematic view and photo of SPIDER. The left panel illustrates how to reconstruct the incident position of charged particles. The right one shows the mounted SPIDER in front of SCISSORS III.

§2. Beam Test of SCISSORS III

A beam test of SCISSORS III with SPIDER was performed from 3rd to 5th Jul. in 2007. A data acquisition system for SCISSORS III was essentially the same as that for SCISSORS II. The energy and timing of each crystal were digitized by ADC and TDC modules in two TRISTAN/KEK Online (TKO) systems [4]. The digitized data were collected and stored with Super Memory Partner (SMP) modules in a VME system through Super Control Header (SCH) modules in the TKO systems. All the digitized data were finally accumulated in a personal computer (PC) through the VME-bus. Figure 3a) shows a dataflow of the data acquisition system for SCISSORS III.



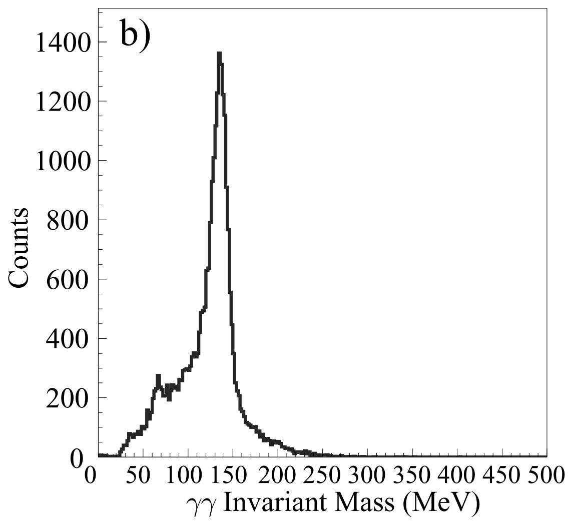


Fig.3. a) Dataflow of the data acquisition system for SCISSORS III. The digitized data of energies and timings are collected from ADC's and TDC's in a TKO system through SCH and SMP modules. b) The $\gamma\gamma$ invariant mass distribution measured with SCISSORS III. The π^0 peak is clearly observed.

The trigger condition was described as

$$\sum_i \left([\text{SigmaTagger } i] \otimes [N_{\text{S3}} \geq 2]\right), \tag{2}$$

where $\otimes$ means coincidence of signals. Channels of STB-Tagger II [5] were divided into 16 groups so that the counting rate of each group should be the same, and an OR signal of each group is denoted by SigmaTagger i ($i = 1 \dots 16$). Crystals of SCISSORS III were divided into 10 groups; a signal of each group was generated when an analogue sum signal of the group exceeded the threshold. The $N_{\text{S3}} \geq 2$ stands for the signal in which more than two groups generate signals. A coincidence signal between SigmaTagger i and $N_{\text{S3}} \geq 2$ signals is required for taking data. Data can be taken with a higher intensity tagged photon beam in this condition compared with the condition:

$$\left(\sum_i [\text{SigmaTagger } i]\right) \otimes [N_{\text{S3}} \geq 2]. \tag{3}$$

A neutral cluster was selected as a γ particle, and the incident position is reconstructed by an energy weighted average of the position vectors of the modules which joins the cluster. The energy calibration is made so that the π^0 peaks in the $\gamma\gamma$ invariant mass distribution should be π^0 mass, where the events are selected by the condition that both the cluster energies are larger than 200 MeV. Figure 3b) shows the $\gamma\gamma$ invariant mass distribution measured with SCISSORS III. The π^0 peak is clearly observed.

References

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[4] KEK Data Acquisition Development Working Group, KEK Report 85-10 (1985).

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