Current Status of the Electro-magnetic Calorimeter Complex FOREST

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A new electro-magnetic (EM) calorimeter complex FOREST with a solid angle of about 4π in total has been planned, and has been partly constructed [1, 2]. FOREST consists of three EM calorimters SCISSORS III, the LEPS Backward Gamma detector (BG), and Rafflesia II. A plastic scintillator hodoscope is placed in front of each EM calorimeter. In this year, the hodoscopes in front of BG have been replaced, and Rafflesia II has been constructed. A high speed data taking [3] and a solid hydrogen/deuterium target [4] systems have been also prepared for elementary meson photo-production experiments with FOREST. A beam test for FOREST has been performed, and the π^0 and η peaks are clearly observed in the $\gamma\gamma$ invariant mass distributions. We are now ready to carry out long term experiments.

§1. Replacement of the BG Plastic Scintillator Hodoscopes

Since the LEPS Backward Gamma detector (BG) was originally used at the Laser Electron Photon beam facility at SPring-8 (LEPS), the plastic scintillator hodoscope prepared for BG does not fit to FOREST. The space for Rafflesia II has been already occupied by the light guides and photo-multiplier tubes (PMT) of these scintillators. Figure 1 shows photos and a schematic view of BG. As shown in Fig. 1, a space exists between the polar angle of 100 degrees and an upstream plate for supporting lead scintillating fiber (Lead/SciFi) modules of BG. We planned to put all the light guides and PMTs of the plastic scintillators in front of BG into this space. The number of plastic scintillators has been enlarged from 12 to 18. Each plastic scintillator is connected to a small and light metal-packaged single-anode PMT Hamamatsu R8900U through a fish-tail light guide. This type of PMTs are also used for plastic scintillators in front of SCISSORS III [2]. The room for Rafflesia II has been obtained upstream of the supporting plate of BG after the hodoscopes were replaced.

§2. Construction of Rafflesia II

Rafflesia II consisted of 36 SF-5 lead glass Čerenkov counters [5] in the original design of FOREST [1]. The size of the SF-5 counter is 150 mm (W) $\times$ 150 mm (H) $\times$ 300 mm (T), and its density is 4.07 g/cm^3. Its performance has been investigated [6] by using the positron beams at LNS [7]. Since we failed many times in making a solid hydrogen target fitted to FOREST, we decided to make a distance shorter between a target holder and a vacuum chamber for a refrigerator of the target system. The
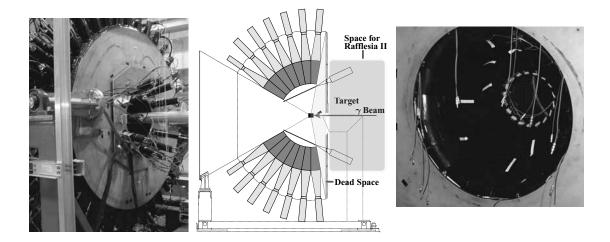
Fig.1. Photos and schematic view of the LEPS Backward Gamma detector (BG). The left and middle panels show a photo and a schematic view of BG before the plastic scintillator hodoscopes were replaced, respectively. The space of Rafflesia II was occupied with the light guides and photomultiplier tubes of the hodoscope. The right panel shows a photo of BG after the hodoscopes were replaced.

chamber occupied some space reserved for the SF-5 counters.

The SF-6 lead glass Čerenkov counters were adopted for a large part of Rafflesia II instead of SF-5 ones to keep the large solid angle of FOREST. The size of SF-6 counter is 75 mm (W) × 75 mm (H) × 250 mm, and its density is 5.18 g/cm^3. Since the density of SF-6 is higher than that of SF-5, both have the same lengths in a radiation length unit ($11.8X_0$). The higher position resolution will be obtained by adopting the smaller module. We constructed Rafflesia II with the 52 SF-6 and 10 SF-5 counters on the 11th June in 2008. Figure 2 shows the schematic view and photo of Rafflesia II.
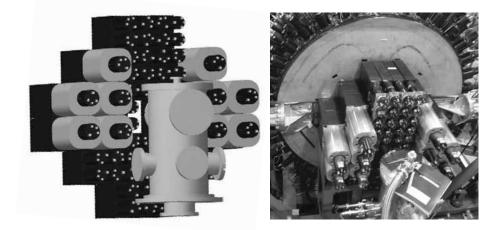

Fig.2. Schematic view and photo of Rafflesia II. The left panel shows the schematic view of Rafflesia II. Two types of lead glass Čerenkov counters are used. The right panel shows the photo of Rafflesia II.

§3. Beam Test

A beam test of the FOREST was performed from 16th June to 7th July in 2008. A high speed data taking system [3] had been newly developed and ones for SCISSORS III and LEPS Backward Gamma detector had been unified. Energies and timings of detectors were taken by ADC and TDC modules in 5 subsystems, one Tristan KEK Online (TKO), three VME, and one Fast Encoding Readout ADC (FERA) on CAMAC systems. The digitized data were collected in each subsystem. All the digitized data were finally collected with a personal computer (PC), and the data associating with the same trigger were built to one event. Event tags generated with an FPGA module developed at LNS [8] were used to confirm the trigger identification.

The trigger condition for the data taking system was described as

$$\sum_i \left([\text{SigmaTagger } i] \otimes [N_{\text{EMC}} \geq 2] \right). \tag{1}$$

Channels of STB-Tagger II were divided into 16 groups so that the counting rate of each group should be the same, and SigmaTagger i ($i = 1 \ldots 16$) denotes an OR signal of each group. Crystal signals of SCISSORS III were divided into 10 groups, and Lead/SciFi signals of BG were divided into 18 groups. An output signal was generated in a SCISSORS III group when a linear sum of signals belong to it exceeded the threshold. An output signal of a BG group was an OR signal of ones belong to it. The $N_{\text{EMC}} \geq 2$ stands for the signal which was generated when more than two output signals of SCISSORS III and BG groups were generated.

A neutral cluster was selected as a γ particle. The energy of the cluster was reconstructed as a sum of the modules which joins it, and the unit vector of the momentum was reconstructed from an energy weighted average of the position vectors of the modules from the target center. The energy calibration was made so that the π^0 peaks in the $\gamma\gamma$ invariant mass distribution should be π^0 mass. Figure 3 shows $\gamma\gamma$ invariant mass distributions measured with FOREST. The π^0 peaks are clearly observed. About 2,000,000 π^0 and 40,000 η produced events are measured a day.
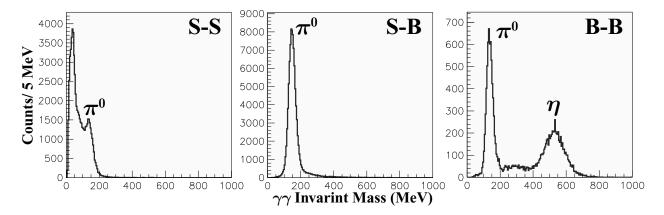

Fig.3. The $\gamma\gamma$ invariant mass distributions measured with FOREST. The left panel shows that for the events two photons are detected by SCISSORS III. The middle one shows that for the events one photons is detected by SCISSORS III and another is detected by BG. The right one shows that for the events two photons are detected by BG.

References

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