# Experiments with the forward gamma detector at the SPring-8/LEPS

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We constructed a forward gamma detector(FG) at SPring-8/LEPS beam line to detect decay gamma-rays from neutral mesons in the photo reaction. Of a physical motivation is a measurement of $2\pi^0$s generated by the Primakov effect. This reaction is related to the polarizability of $\pi^0$. Only one experimental data has been obtained previously[1] but with limited statistics. This reaction could also give a unique approach for the $\sigma$ meson study as the process of $\gamma + \gamma^* \rightarrow \sigma \rightarrow 2\pi^0$. One would expect the detection of $\eta$, $\eta'$, $\omega$, and $K^0$ by combining FG and the backward gamma detector(BG)[2] covering the polar angle from 30 to 100 deg. Measurements of these mesons are expected to be helpful in searching for "missing resonances" since ever observed states through $\pi N$ scattering and $\pi$ decay channels have not satisfied the predictions given by constituent quark models. The measurement of photon beam asymmetry is expected for further information.

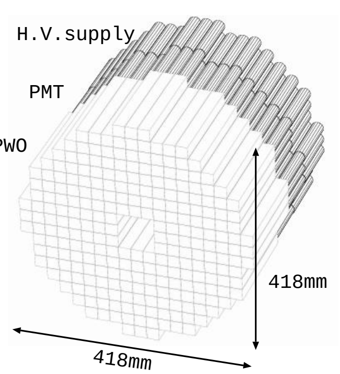


Figure 1: Inside of the detector box of the forward gamma detector.

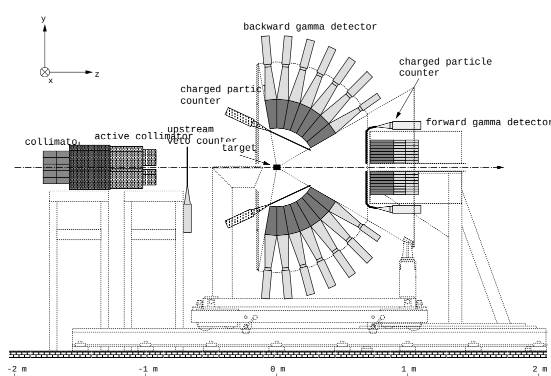


Figure 2: Detector setup. The distances from the target to the forward and backward detectors are 710 and 300 mm, respectively.

FG consists of 252 sets of a $PbWO_4$ crystal, a photomultiplier tube, and a high-voltage supplier. The size of each crystal is $22\times22\times180$ mm$^3$. The length for the direction that the electromagnetic shower proceeds corresponds to 19.5 radiation lengths. Figure 1 shows the inside of the detector box. There is a hole which corresponds to nine crystals at the center of the detector in order that the incident gamma beam can go through the detector after passing the target. We used $PbWO_4$ crystals because of their superior properties. One radiation length of the crystal is 0.92 cm and this is smaller than other common crystals. The Moliere radius is small(22 mm) and this is suitable for a precise position measurement. The fast decay time($\sim$10 nsec) is good for high count rate experiments like a forward angle measurement. One disadvantage is its relatively small light output but it was not a problem for our experiment in which gamma-rays with higher energy dominate due to the measurement at a forward angle. A 3/4-in. HAMAMATSU R4125G photomultiplier tube was attached to the end of each crystal with a spring. We adopted the Cockcroft-Walton type (HAMAMATSU E974-19CWDP) high voltage supplier which can provide up to $-1800$ V. This equipment requires only two low voltage DC inputs and can make the high voltage system simple.

The experiment was performed with the setup shown in Fig. 2. The gamma beam with an energy of 1.5-2.4 GeV and an intensity of 5-6$\times 10^5$ photons/s was bombarded on targets. We used a tungsten target for the Primakov reaction and polyethylene and carbon targets for nucleon resonances. The thickness of all these targets corresponds to 0.1 radiation lengths. FG and BG covered the polar angle of 5-15 deg and 30-100 deg with the full azimuthal angles, respectively.

The energy calibration of each crystal of FG was done using cosmic-ray data in a preliminary analysis. The energy deposition of each electromagnetic shower in FG was basically obtained by nine crystals of the 3$\times$3 matrix. The position reconstruction was performed by a center of gravity method. An example of the position distribution for detected gammas is shown in Fig. 3. Many events are concentrating around the beam line and most of them are thought to be $e^+$, $e^-$, and $\gamma$ particles coming from the electromagnetic shower at the target. Figure 4 shows the invariant mass distribution of 2 gamma events in which both of gammas were detected by FG. A peak corresponding to $\pi^0$ is seen at 0.135 GeV/c$^2$. The obtained mass resolution($\sigma_{m_{\pi^0}}/m_{\pi^0}$) is currently 6.1 % and 1.5 times broader than that of the GEANT4 simulation(dotted line). We are attempting a precise energy calibration by the iteration method using 2 gammas from $\pi^0$ to improve the invariant mass resolution. Analyses of physical channels mentioned above are in progress.

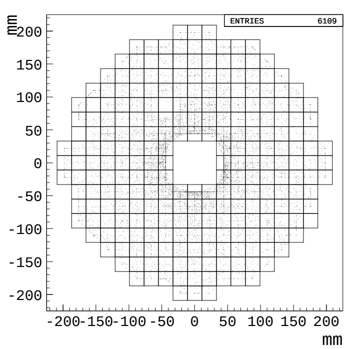


Figure 3: Position distribution of detected particles by the forward gamma detector. The squares in the figure represent the positions of 252 $PbWO_4$ crystals.

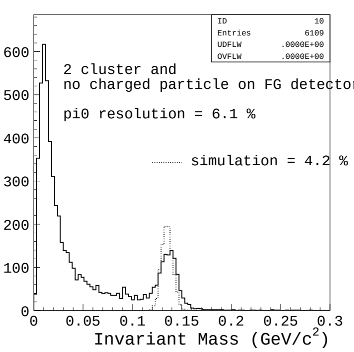


Figure 4: Invariant mass distribution of 2$\gamma$ events. The dotted line is the result of the GEANT4 simulation.

## References


[1] H. Marsiske *et al*, Phys. Rev. D **41** (1990) 3324.

[2] T. Matsumura *et al*, Nuclear Physics in Different Degrees of Freedom, edited by H.Bhang, S.W.Hong, and H.Shimizu, Proc. 41,(Institute of Basic Science, 2002).