Measurement of the (γ, K_S) reaction at SPring-8/LEPS

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Preparation of the measurement of the K_S photoproduction reaction is proceeding at the LEPS facility in SPring-8. The details of the experimental setup of the K_S measurement and preliminary results from a short test experiment are presented.

1. KAON PHOTOPRODUCTION REACTIONS

Experimental studies on the kaon photoproduction reactions off hydrogen had a considerable progress in recent years. Several experimental groups in new facilities published new experimental data. The SAPHIR collaboration reported on the $p(\gamma, K^+)\Lambda$ and $p(\gamma, K^+)\Sigma^0$ reactions in a photon energy range up to 2 GeV[1]. It was the first precise measurement on the cross section of the kaon photoproduction reactions in the photon energy range well over the kaon production threshold. The photon energy dependence of the total cross section showed a bump structure around 1.5 GeV, and a possibility of contribution of a nucleon resonance, $D_{13}(1895)$, which was one of candidates of the missing resonances, was proposed[2]. The new data motivated many theoretical works, and the importance of inclusion of baryon resonances, choice of hadronic form factors and coupling constants, effect of u-channel contributions was realized. Another experimental data of the reaction cross section from the CLAS collaboration basically supported the SAPHIR data, and also suggested a possibility of contributions of several nucleon resonances with masses around 1.9 GeV[3].

Other categories of data also became available. The SAPHIR and the CLAS collaborations provided the recoil polarization data for the kaon photoproduction reactions[1,3,4]. The LEPS and the GRAAL collaborations provided the beam polarization asymmetry data[5,6]. The new category of data were quite sensitive to interference between various amplitudes contribute to the kaon photoproduction reactions, and thus quite important to understand the reaction mechanism.

Since only experimental data can fix various parameters in the phenomenological models, new experimental data are still awaited. Kaon photoproduction data other than the well studied $p(\gamma, K^+)\Lambda, \Sigma^0$ reaction are quite useful because these can provide information complementary with that from the (γ, K^+) reaction. New analyses of the kaon photoproduction reaction off neutron and estimation of the $p(\gamma, K^0)\Sigma^+$ reaction cross section are in progress[7].

In this paper, we present a layout of an ongoing experiment for the $(\vec{\gamma}, K_S)$ reaction measurement with a linearly polarized photon beam at LEPS. We also present preliminary results of a test experiment.

2. EXPERIMENTAL SETUP FOR K_S DETECTION

In the Laser-Electron Photon facility (LEPS) at the electron storage ring of SPring-8, a laser light was injected into the storage ring to produce high energy photon beams by the backward Compton scattering with the circulating 8 GeV electrons. An Ar laser light of 351 nm in wavelength produced photon beams up to 2.4 GeV. A linearly polarized laser light was used in the LEPS experiment, and about 90% (50%) linearly polarized photon beam was obtained at 2.4 GeV (1.5 GeV). A photon energy tagging system measured the recoil electrons and determined photon energies in event-by-event basis. Typical tagged beam intensity was 10^6 photon/s.

The photon beam was transported to experimental hutch through a vacuum pipe, collimated with lead blocks, and injected into a liquid hydrogen target of 15 cm in length. Particles produced in the liquid hydrogen target were detected by a magnetic spectrometer system. Fig.1 shows the LEPS spectrometer system and Fig.2 is a closeup view of the target area. A Gas Čerenkov veto detector (GC) filled with isobutane gas radiator was newly installed just behind the target vacuum chamber for the K_S measurement. A plastic scintillation counter (Start Counter) was also newly installed in behind of GC, and the counter had a small hole in the center to make the photon beams to pass through. The combination of GC and Start Counter triggered hadron events efficiently and eliminated the background from the electron-positron pair creation events. A silicon strip detector (SSD) and three drift chambers (DC1, DC2 and DC3) were used to track charged particle trajectories in a dipole magnet and analyze momenta of particles. SSD was used also to determine reaction vertices precisely. A wall made of 40 modules of plastic scintillation counters was placed at the end of the spectrometer system for the time-of-flight (TOF)

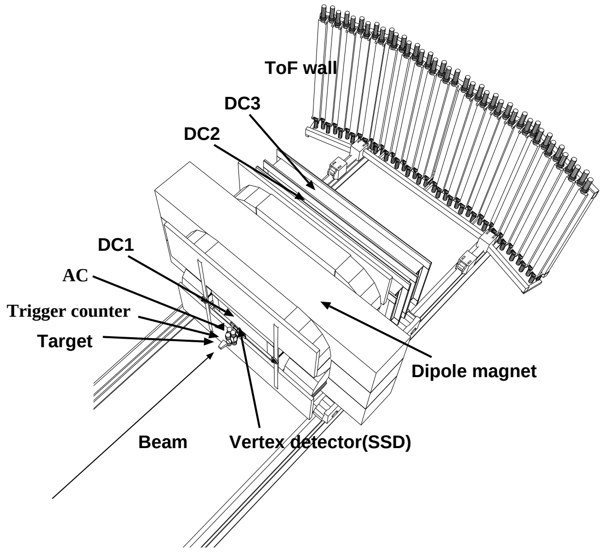

Figure 1. A schematic view of the LEPS magnetic spectrometer system.

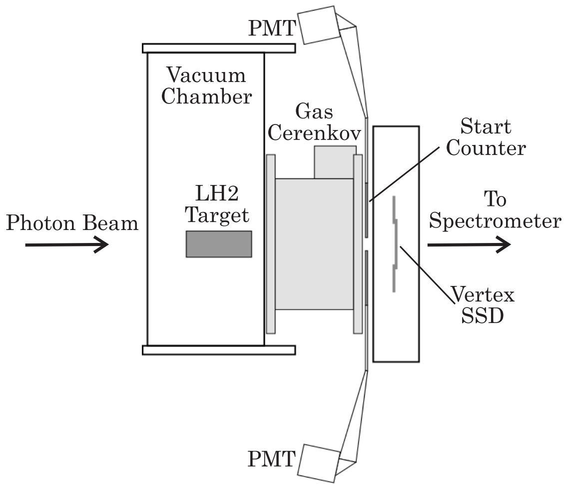

Figure 2. Schematic view of the detector setup around the liquid hydrogen target.

measurement. To determine TOF, the Start Counter and also the RF signal from the SPring-8 electron storage ring were used.

3. RESULTS OF TEST EXPERIMENT AND FUTURE PROSPECTS

The performance of the new trigger system for the K_S detection and feasibility of the K_S identification by the spectrometer were tested in June, 2003. The trigger rate was reduced to reasonable level with the new trigger system, and the DAQ dead time was 10% level. Produced K_S particles were measured in the $K_S \to \pi^+\pi^-$ decay mode (68.6% branching) and identified by the invariant mass of the $\pi^+\pi^-$ system.

Since the background from the multi-pion production reaction ($p\gamma \to N\pi^+\pi^-X$) was huge, we needed several event selections to see the K_S events clearly. One of useful informations for the event selections was the distance between the creation and the decay vertices of K_S. The K_S decay vertex was reconstructed from two pion trajectories in the spectrometer, and the unmeasured K_S trajectory also could be reconstructed. The creation vertex position was defined as the point of closest approach of the K_S trajectory to the beam axis. The feasibility of a cut on the distance between the two vertices was tested by using the $\Lambda \to p\pi^-$ decay events. The average flight distances before decays were similar for the $K_S \to \pi^+\pi^-$ and the $\Lambda \to p\pi^-$ events, about 100 mm and 150 mm, respectively, in our kinematical condition. Fig.3 shows distributions of the distance of the two vertices projected to the beam axis. The solid histogram corresponds to the Λ events, and the dashed one corresponds to background events. We could see clear difference of the two distributions, and could make efficient discrimination of the Λ decay events from the background events. This type of background reduction was feasible also in the selection of the K_S decay events.

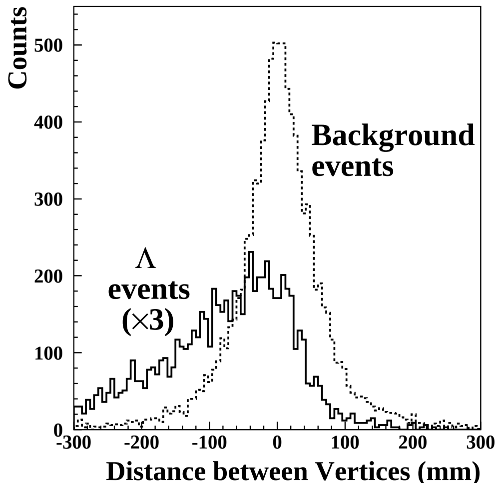

Figure 3. Distribution of the distance between the creation and the decay vertices of Λ particle projected to the beam axis.

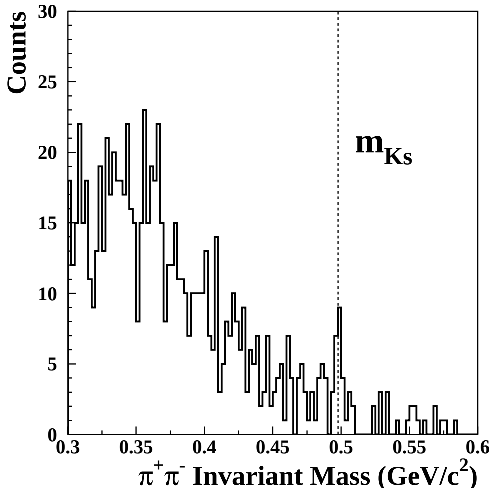

Figure 4. K_S invariant mass spectrum after several K_S enhancement cuts. See text for more details.

Another information could be used for the K_S event selection was the decay vertex position. The cleanest cut was to select events which had the decay vertices out of the liquid hydrogen target. Practically, more moderate cut was applied because the cleanest cut reduced also the K_S events to about 50 %. Fig.4 shows the $\pi^+\pi^-$ invariant mass spectrum after the event selections mentioned above and a cut on the missing mass calculated by assuming the $p\gamma \to \pi^+\pi^- X$ reaction kinematics. In the missing mass cut, we selected $\Sigma^+(1189)$ and $\Sigma^+(1385)$ mass region. We could see a peak at the K_S rest mass (indicated by dashed line) in the spectrum.

A longer period of beamtime is scheduled from the end of November, 2003. We expect about 500 events of yield of K_S from the $p(\gamma, K^0)\Sigma^+$ reaction, and expect to measure the beam polarization asymmetry of the reaction for the first time.

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