POLARIZATION OBSERVABLES IN K^+-MESON PHOTO-PRODUCTION AT LEPS

High-energy γ-rays, called "Inverse Compton γ-rays," are generated from collisions between 8 GeV electrons and laser photons at beamline **BL33LEP**. The γ-ray can attain a maximum energy of 2.4 GeV at maximum. These γ-rays have excellent properties regarding directivity and polarization, and provide a good means to study the behavior of quark movements inside nucleons and nuclei since one of the best way to investigate the inside of hadrons is to use electromagnetic probes. This is thanks to the reduced theoretical complexity of the photonuclear reaction with real-photons. For this purpose, we constructed a detector system called the LEPS spectrometer to analyze charged particles. The LEPS spectrometer shown in Fig. 1 mainly consists of one dipole magnet with a large aperture, three drift chambers, and TOF (Time of Flight) scintillation counters. The dipole magnet is used to bend the charged particles produced by photonuclear reactions. One of the three drift chambers is located between the target and the dipole magnet. All the drift chambers are used to determine the particle trajectories. The ray-tracing technique is fully employed to determine the trajectories of charged particles, and the TOF scintillation counters serve to identify the particle mass through

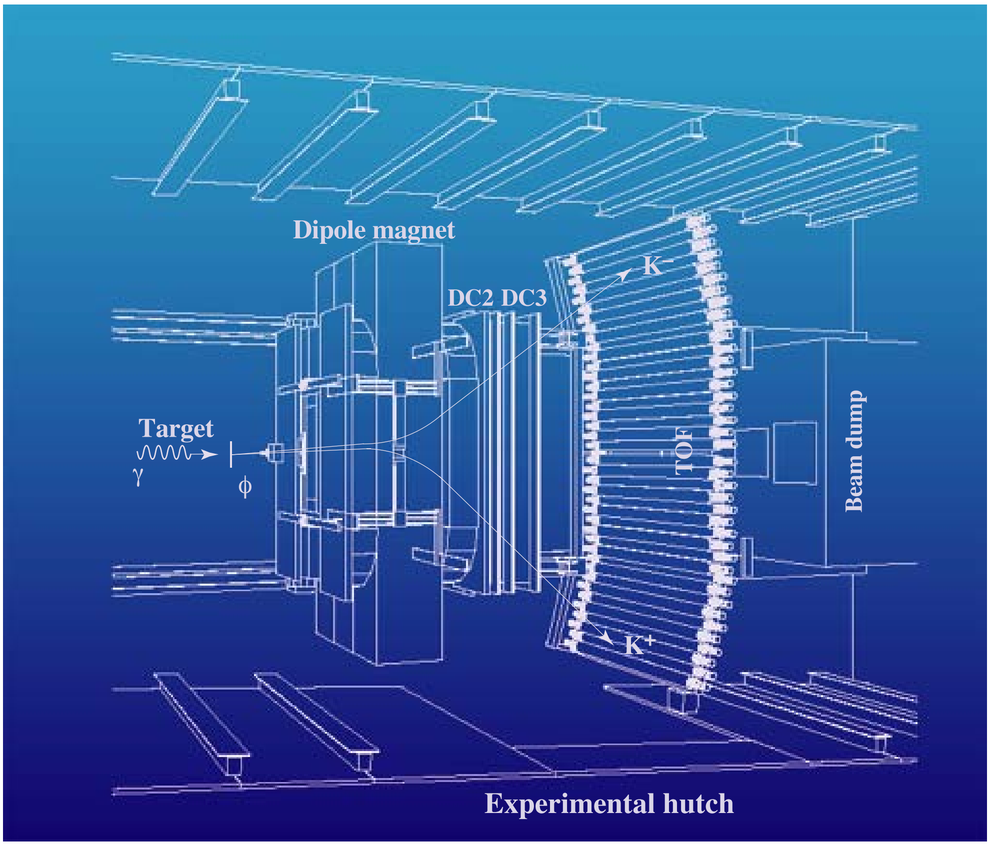

Fig. 1. Top view of the spectrometer system (LEPS) in the experimental hutch. The spectrometer mainly consists of a dipole magnet, drift-chambers, and scintillation counters for TOF measurement. High-energy γ-rays coming from the left side are stopped at the beam dump (on the right side of the figure). A typical event of $K^+ + K^-$ pairs for ϕ meson production is shown.

the measurement of the time-of-flight (TOF). In the case of ϕ meson photo-production, a ϕ-meson decays into $K^+ + K^-$ pairs when it is generated from the $\gamma + p \rightarrow p + \phi$ reaction, for example. Information on the measured magnetic fields is employed in the Runge-Kutta method to obtain the particle trajectories for the ray tracing.

In this short report, we show a typical experiment using polarized γ-rays. It is well known that a proton consists of quarks with a "*uud* " configuration, exchanging gluons (the origin of "strong force") to combine them. When a proton absorbs a high-energy γ-ray in the photo-reaction, a K^+-meson (a pair of an *u*-quark and an anti-strange s-quark) is created, leaving three quarks with a configuration of "*uds*." This system of hadrons is expected to provide us with an new aspect of studying the quark behavior, since it contains "strange quarks," which does not appear in the normal world at low temperature.

Figure 2 shows a mass identification spectrum from photonuclear reactions on protons, which demonstrates that various kinds of baryons are created with an "*uds*" quark configuration coupled to various spins and isospins. This spectrum has been obtained by measuring a K^+ meson with the LEPS magnetic spectrometer (see Fig. 1). A K^+ meson has a mass of 493.7 MeV, and mainly consists of a *u*-quark and an anti-strange $\bar{s}$-quark. When a high-energy γ-ray creates an s-$\bar{s}$ quark pair by interacting with proton, an anti-strange quark picks up the *u*-quark from the proton with a uud configuration, making a K^+ meson and leaving the Λ and Σ particles with an uds configuration. These are naive explanations for the reason why we can observe various kinds of Λ and Σ^0 particles in high-energy photoreaction. Figure 2 shows the missing mass spectrum for Λ and Σ particles produced via the processes of $\gamma + p \rightarrow K^+ + \Lambda$, $K^+ + \Sigma^0$. The Λ and Σ^0 baryons with masses of 1116, 1192, 1405, 1385, 1520 MeV are clearly identified in the spectrum.

When polarized high-energy γ-rays create the s-$\bar{s}$ quark pair as a result of the interaction with the quark-gluon field from the nucleon, the created particles tend to keep to the polarized axis and are emitted along the polarization axis of the γ-rays. This is physically natural. The quark anti-quark pair is mostly generated in the vacuum breaking process through a gluon exchange process. The distribution of created K^+ mesons have a basic pattern with respect to the linear polarization axis of γ-rays, which is predicted on the basis of quantum physics and given as

$$(d\sigma/d\Omega)_{pol} = (d\sigma/d\Omega)_{unpol}\ (\ 1 + P \bullet \Sigma \cos(2\phi)\ ),$$

where P is the polarization of the γ-ray beam, Σ is the asymmetry parameter commonly called Σ parameter, and ϕ is the deviation angle from the polarization direction of the γ-ray. We have succeeded in observing such patterns. Figure 3

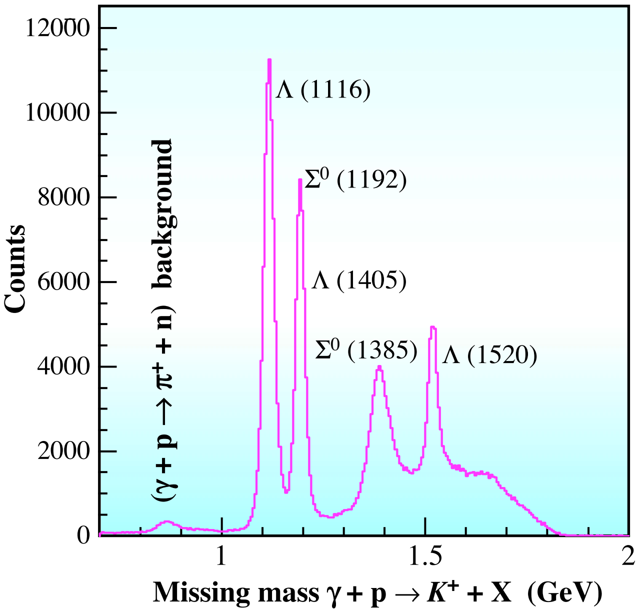

Fig. 2. Missing mass spectrum for the $\gamma + p \rightarrow K^+ + \Lambda(\Sigma^0)$ reaction. Narrow peaks for $\Lambda(1116)$, $\Sigma^0(1192)$, $\Lambda(1520)$ particles and the rather broad peaks for $\Lambda(1405)$ and $\Sigma^0(1385)$ particles can be distinguished. A small contamination for the $\gamma + p \rightarrow \pi^+ + n$ reaction is also present.

shows the measured asymmetry for the Λ(1116) and Σ^0(1192) productions. The K^+ meson production is found to be spatially asymmetric and is well described using a "cosine" curve. Its amplitude depends slightly on the type of particle production and incidence energy of the γ-rays. The amplitude of the obtained "cosine" curve depends on the interaction strengths associated with the K^+ meson creation and on the details of reaction mechanisms (*i.e.*, resonance states involved in the reaction process). These experimental results raise a somewhat controversial question, calling for theoretical challenges to describe asymmetries for Λ and Σ^0 productions.

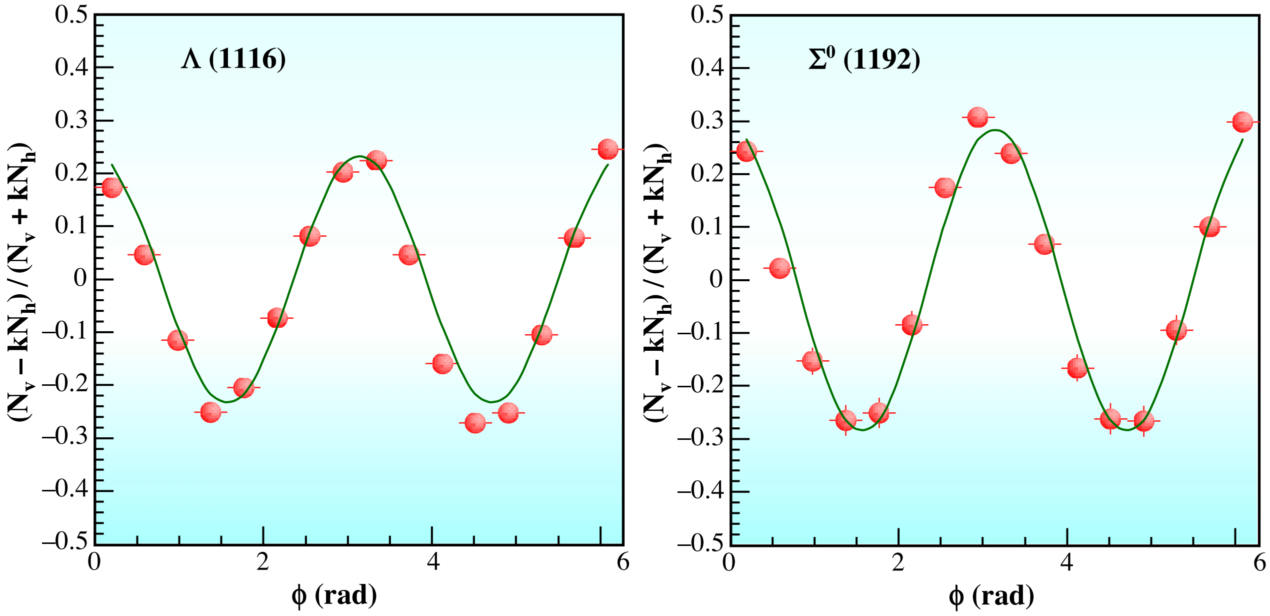

Fig. 3. Angle and energy-integrated asymmetry plots for the $\gamma + p \rightarrow K^+ + \Lambda(1116)$ reaction (left) and $\gamma + p \rightarrow K^+ + \Sigma^0(1192)$ reaction (right).

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