PROCEEDINGS OF SCIENCE

Photoproduction of $\pi^-\Delta^{++}$ and $\pi^+\Delta^0$ on the proton for the comparison of $\bar{u}u$ and $\bar{d}d$ productions

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We carry out photoproduction experiments using linearly polarized photon beams with energies of 1.5-3 GeV at SPring-8/LEPS. The photoproduction of various mesons and baryons is important to understand hadron production mechanisms. We took the data for the $\gamma p \to \pi^-\Delta^{++}$ and $\gamma p \to \pi^+\Delta^0$ reactions at the forward π angles of $0.7 < \cos\theta_\pi^{c.m.} < 1$ with the same acceptance for π^- and π^+. Precise comparison between the $\bar{u}u$ and $\bar{d}d$ productions in the final state is possible, which is expected to give important information on how hadrons are produced. Preliminary results of photon beam asymmetries, which are sensitive to reaction mechanisms, are reported.

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1. Introduction

The photoproduction of various meson and baryons is important to understand how hadrons are produced. We started LEPS experiments using a linearly polarized photon beams with energies of 1.5-2.4 GeV at SPring-8 in 2000. The LEPS spectrometer was designed to efficiently detect ϕ-mesons decaying to K^+ and K^- at forward angles [1, 2, 3, 4, 5]. Not only ϕ but also K^+ photoproduction reactions are extensively studied [6, 7, 8, 9, 10, 11, 12, 13].

In order to take clean K^+ and K^- data, an Aerogel cherenkov detector with a refractive index of 1.03 was used. The cherenkov detector removed not only e^+ and e^- but also high-momentum π^+ and π^- by the online trigger. We took high-momentum charged pion data with photon beam energies of 1.5-3 GeV for the first time in 2007. The data for the $\gamma p \to \pi^+ n$ reaction were analyzed, and the differential cross sections and photon beam asymmetries were obtained [14].

The production of an $\bar{s}s$ quark pair in the final state from the proton has been studied by the $\gamma p \to K^+ X$ reaction. That of a $\bar{d}d$ quark pair in the final state has been studied by the $\gamma p \to \pi^+ n$ reaction. However, the production of a $\bar{u}u$ production has not been well studied, yet. The $\gamma p \to \pi^- \Delta^{++}$ reaction is a unique channel to study the $\bar{u}u$ production in the final state from the proton.

The LEPS spectrometer has the same acceptance for π^+ and π^- at forward angles. Precise comparison with high statistics between the $\bar{u}u$ and $\bar{d}d$ productions in the final state is possible by the $\gamma p \to \pi^- \Delta^{++}$ and $\pi^+ \Delta^0$ reaction data taken simultaneously. We expect this comparison will give us important information to clarify how hadrons are produced.

2. Experiment

We carry out experiments using the LEPS beam line at the SPring-8 facility. Linearly polarized photon beams were produced by the laser backscattering technique using a deep-UV laser with a wavelength of 257 nm. The polarization of the tagged photon beams was 88% at 3 GeV and 28% at 1.5 GeV. The photon beams were incident on a LH_2 target with an effective length of 16 cm.

Charged particles produced at the target were detected by the LEPS spectrometer [15, 7]. The main purpose of the present experiment was to detect K^{*0} decaying to K^+ and π^- [16]. The aerogel cherenkov detector was not used for detecting high-momentum π^-. Electrons and positrons were effectively vetoed by installing a plastic scintillation counter at the downstream position of three drift chambers. The scintillation counter had a hole with the size of 20 mm in height and 50 mm in width for allowing the photon beams to pass through. For the details about the LEPS spectrometer, see Refs. [15, 7].

3. Preliminary Results

Figure 1 shows the missing mass of the $\gamma p \to \pi^- X$ and $\pi^+ X$ reactions. In the case of the π^- detection, a Δ^{++} peak is dominantly observed. In the case of the π^+ detection, a neutron peak is dominantly observed and a Δ^0 peak is clearly observed. The yields of the $\pi^- \Delta^{++}$ and $\pi^+ \Delta^0$ productions are obtained by fitting to the missing mass. A relativistic Breit-Wigner shape was used for the Δ peak. For background estimation, electron and positron curves, ρ production curve, 2π and 3π production curves estimated by using GEANT simulations were used.

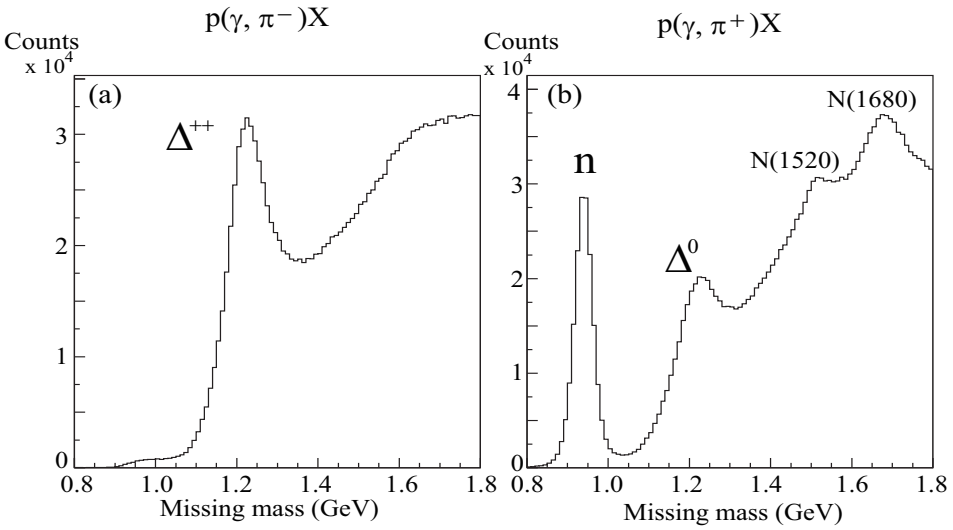

Figure 1: Missing mass for the (a) $\gamma p \to \pi^- X$ and (b) $\gamma p \to \pi^+ X$ reactions for E_γ=1.5-3 GeV.

Preliminay differential cross sections for the $\pi^-\Delta^{++}$ and $\pi^+\Delta^0$ reactions are obtained as a function of E_γ. As the photon beam energy increases, both the cross sections become smaller. There is no distinct peak or bump structure suggesting a nucleon or Δ resonance. As the pion angle becomes smaller, both the cross sections rapidly become larger. Strong forward peaking of the cross sections is observed for both the reactions.

Figure 2 shows the photon beam asymmetries for the $\pi^-\Delta^{++}$ and $\pi^+\Delta^0$ reactions. At small pion angles, the asymmetries are close to zero or slightly smaller than zero for both the reactions. As the pion angle becomes larger and the photon beam energy increases, the asymmetries are split to positive and negative sides. The $\pi^-\Delta^{++}$ reaction has negative asymmetries, while the $\pi^+\Delta^0$ reaction has positive asymmetries. The negative asymmetries suggest that π-meson exchange in the t-channel is strong. The positive asymmetries suggest that ρ-meson exchange in the t-channel is strong. Although these reactions seem to be similar to each other, the reaction mechanisms are found to be largely different.

Other charged meson photoproduction reactions from the proton, such as $\vec{\gamma}p \to \pi^+ n$ [14, 17] and $\vec{\gamma}p \to K^+\Lambda$ and $K^+\Sigma^0$ [6, 7, 8, 18, 13], have positive asymmetries. It is interesting that only the $\bar{u}u$ quark pair production in the final state from the proton has negative asymmetries. The π^- production seems to have a different reaction mechanism.

4. Summary

We obtained preliminary differential cross sections and photon beam asymmetries for the $\gamma p \to \pi^-\Delta^{++}$ and $\pi^+\Delta^0$ reactions. The $\pi^-\Delta^{++}$ reaction is a unique channel to study the $\bar{u}u$ quark pair production in the final state from the proton. The productions of the $\bar{u}u$ quark pair and $\bar{d}d$ quark pair in the final state from the proton are compared precisely. The present data are important to achieve unified understanding of the hadron photoproduction in the framework of the flavor SU(3) symmetry in the near future.

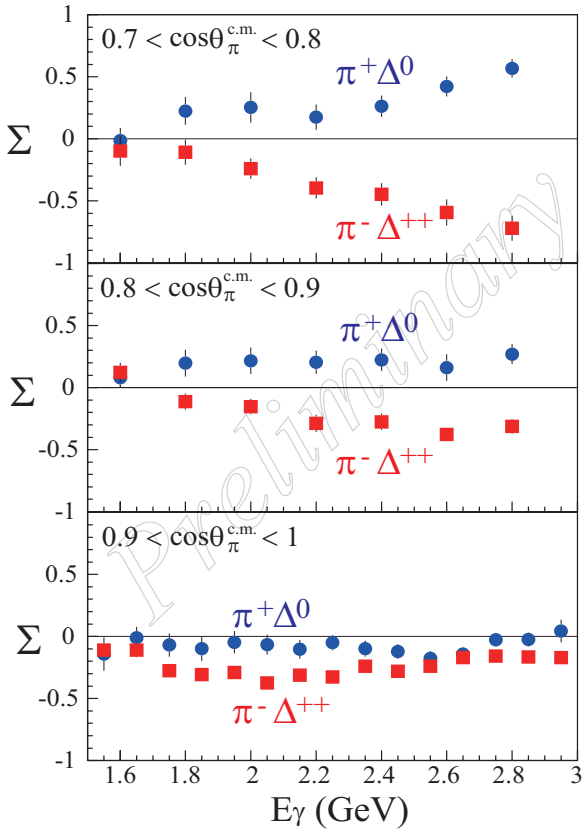

Figure 2: Photon beam asymmetries for the $\gamma p \to \pi^- \Delta^{++}$(squares) and $\gamma p \to \pi^+ \Delta^0$(circles) reactions for E_γ=1.5-2.9 GeV.

5. Acknowledgments

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