Backward-η meson photoproduction at BL33LEPS

In this study, new baryon resonances were investigated via η photoproduction. Baryons are composed of quarks, which are fundamental constituent particles of matter. Although various dynamical models (e.g., the constituent quark-model and the deformed oscillator quark model) have been developed to describe baryon resonances, the internal structure of baryons has not been fully understood yet.

The constituent-quark model, which describes a baryon as a three-quark state, predicts many baryon resonances. However, there are considerably many baryon resonances not observed experimentally [1]. Two possible explanations are given for understanding the missing baryon resonances. One possibility stems from oversimplifications of the model. Several pictures are proposed to describe the internal structure of baryons instead of the simple structure of three-quarks. For example, a picture of five-quark components (three constituent quarks and a large admixture of an extra quark-antiquark pair) explains the characteristic of the $S_{11}(1535)$ resonance, which is heavier than the $P_{11}(1440)$ and $\Lambda(1405)$ resonances [2]. In this model, the $S_{11}(1535)$, $P_{11}(1440)$, and $\Lambda^*(1405)$ particles are composed of uud[$s\bar{s}$], uud[$d\bar{d}$], and uds[$u\bar{u}$] quarks, respectively. This picture can also explain the strong coupling of $S_{11}(1535)$ to an ηN channel because the η meson is the lightest meson with an $s\bar{s}$ component.

The other explanation for the missing baryon resonances is that missing baryon resonances are still not observed in conventional experiments for measuring the pion induced or pion production reactions. Some of the missing baryon resonances may couple to other channels, like ηN, η'N, ωN, ρN, ϕN, KY, etc. and have higher masses of around 2 GeV, which have not been studied well experimentally. Therefore, experiments to study various meson-coupled resonances at around 2 GeV would give us a new insight into the internal structure of baryons.

We measured differential cross sections for η photoproduction ($\gamma p \rightarrow p\eta$) at **BL33LEPS** [3]. The LEPS beamline provides a laser-electron photon beam with an energy range from 1.5 to 2.4 GeV. The laser-electron photon beam was produced by backward-Compton scattering between Ar-ion laser photons with a 351nm wavelength and electrons with an 8 GeV energy. The beam intensity was typically 10^6 photons/s. The target was a liquid hydrogen target with a thickness of 15 cm. Scattered protons were detected by a magnetic spectrometer, which covers forward angles. Mass identification was made using momentum, path length, and time-of-flight. The proton mass resolution was 46 MeV/c^2 at 2 GeV/c momentum. Proton events were selected in the reconstructed mass spectrum within 4σ of the nominal value. Contaminations from pions and kaons were estimated to be less than 0.1%. The produced η mesons were identified by calculating the missing-mass of protons. Figure 1 shows the missing-mass spectrum for the reaction of $\gamma p \rightarrow pX$ ('X' is unknown particles). Peaks due to π^0, η, η', and ω mesons are

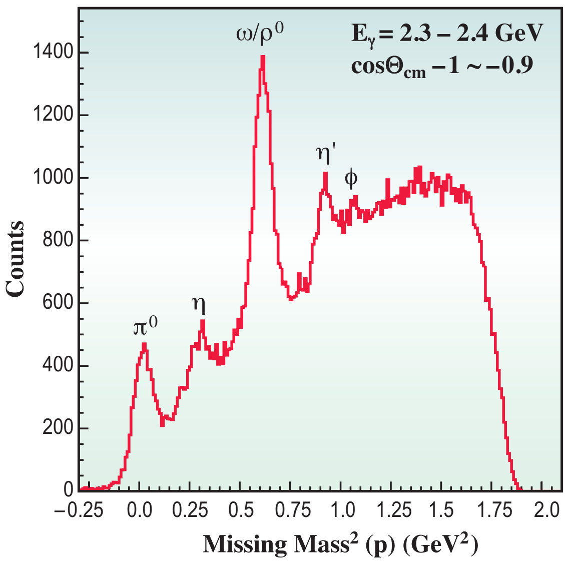

Fig. 1. Missing-mass spectrum of protons.

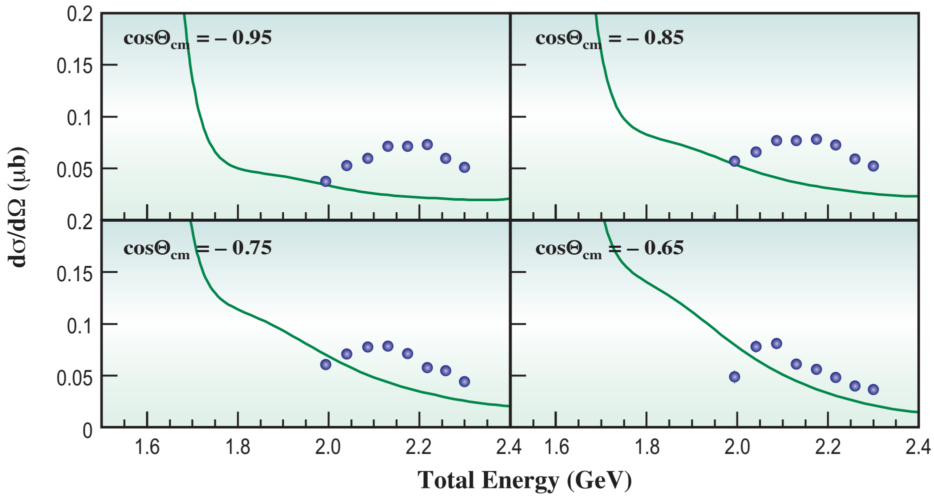

Fig. 2. Differential cross sections for η photoproduction.

clearly observed. There are background events of multipion photoproduction under signal peaks. The yield of η photoproduction was obtained by estimating the distributions of each reaction using Monte Carlo simulation. Differential cross sections were calculated by correcting for the acceptance and detection efficiency of the spectrometer and the numbers of beam photons and target protons.

Figure 2 shows differential cross sections as a function of the total energy for η photoproduction. The closed circles are the present data. The curves correspond to the theoretical model including non-resonant processes and known resonances with significant contributions. A wide bump structure has been observed above 2.0 GeV in total energy [4]. In order to explain such a large bump structure, the contribution of new resonances is required. The central position of the bump structure shifts to higher energies at backward angles. This may be attributed to the interference between resonances and diffractive processes that, in general, depends on the scattering angles. The other possibility is that the bump structure consists of more than one resonance, whose angular distributions are different. We measured differential cross sections for π^0, η', and ω photoproductions as well in the same kinematical range as that in the present study. No such structure was observed in the reaction channels. Therefore, it is inferred that this unique structure in η photoproduction is due to a baryon resonance with a large $s\bar{s}$ component, which strongly couples to the ηN channel. Detailed theoretical studies including the present data will reveal the hidden resonances contributing to the bump structure.

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