Study of $\eta\pi^+\pi^-$ States in the $\rho'(1600)$ Mass Region Photoproduced in the Reaction $\gamma p \rightarrow \eta\pi^+\pi^- p$ at Photon Energies of 20 to 70 GeV

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Abstract. In diffractive photoproduction of $\eta\pi^+\pi^-$, the two-body substates $\eta\rho^0$ and $A_2\pi$ are found to contribute significantly to the cross-section for $\eta\pi^+\pi^-$ masses below 2.4 GeV. From a spin-parity analysis the branching ratio, $\rho'(1600)\rightarrow \eta\rho/\rho'(1600)\rightarrow \text{all}$, is determined to be <0.02 at the 68.3 % confidence level. The $A_2\pi$ component shows an enhancement around 1.7 GeV. The spin-parity analysis indicates a probable contribution to this signal from exclusive photoproduction of the $g(1690)$.

1. Introduction

The $\rho'(1600)$ is the best established candidate for a radial excitation of a vector meson composed of light quarks. It has been observed in the decay modes $\rho^0\pi^+\pi^-$ [1, 2], $\rho^0\pi^+\pi^0$ [3, 4] and $\pi^+\pi^-\pi^0$ [5]. In both an earlier photoproduction experiment [6] and $e^+e^-$ annihilation [7] there is some evidence for an enhancement in the $\eta\pi^+\pi^-$ mass spectrum in the $\rho'(1600)$ mass range but no detailed analysis has yet been done due mainly to poor statistics.

In this paper a detailed study of the reaction

$$\gamma p \rightarrow \eta\pi^+\pi^- p$$

(1)

is presented allowing a search for the decay modes $\rho'(1600)\rightarrow \eta\pi^+\pi^-$ via the substates $\pi\rho^0$, $A_2\pi$, and $\delta\pi$. The data come from a general study of photoproduction of hadrons by photons of energy 20–70 GeV. The experiment (WA57) was performed using the Omega Spectrometer at the CERN SPS. A previous analysis of reaction (1) from this experiment has studied $\eta\pi^+\pi^-$ masses below 1.4 GeV [8]. The analysis presented here extends the mass range up to 2.4 GeV.

2. Experiment and Data Selection

A description of the experiment and details of the trigger and the data selection can be found in the
previous publication on reaction (1) [8] and are therefore not reported here. The final data sample for the present analysis of reaction (1) was obtained by requiring that the events had a $\gamma\gamma$ pair with effective mass between 0.50 and 0.59 GeV (see Fig. 1) and that the missing energy, $\Delta E$, to the incident photon and $\eta\pi^+\pi^-$ system was within the range $-1.5$ to $+2.5$ GeV (see Fig. 2). With these selections a final sample of 1871 events corresponding to reaction (1) was obtained. In order to calculate the acceptance of the events in the experimental set-up, reaction (1) was simulated by a Monte-Carlo program [9]. The photon bremsstrahlung spectrum was generated according to the experimental spectrum. The production cross-section was taken to be independent of photon energy and the differential cross-section $d\sigma/dt$ was taken as exponential with a slope of 5 GeV$^{-2}$. The $\eta\pi^+\pi^-$ mass distribution was generated with a shape similar to the experimental one and the $\eta\pi^+\pi^-$ system was allowed to decay according to Lorentz-invariant phase space. The normal to the $\eta\pi^+\pi^-$ decay plane was distributed isotropically. The events were passed through an acceptance program [10] which simulated the experimental conditions including the multiplicity requirement of the trigger, the geometrical cuts imposed by the apparatus and the inefficiencies of the chambers. In addition this program included a full simulation of showering in the photon detector and reconstruction of $\gamma$ rays. A bin-by-bin division of the spectra for accepted events by those for generated events then yielded the acceptance as a function of all relevant kinematical variables for the analysis described below.

3. Results

3.1. Reaction Cross-Sections and Mass Spectra

The $\gamma\gamma$ mass spectrum was fitted to a Gaussian distribution plus a second-order polynomial back-