RECENT STUDIES OF HIGH LYING N^* IN DOUBLE CHARGED PION ELECTRO PRODUCTION

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Physics analysis of recent CLAS data on double pion production by virtual photons is presented

1. Introduction

We report results on the physics analysis of recent CLAS data of double charged pion electro production [1, 2]. Photocouplings for several nucleon states with masses > 1.6 GeV have been extracted. We also discuss interpretation of some of the results in terms of "missing" baryon states.

2. The approach and results of analysis

A phenomenological approach [3, 4, 5] has been developed to describe double charged pion production, relating the electromagnetic and strong couplings of excited baryons (N^*) to the measured cross-sections and allowing extraction of N^* parameters from fits to the data. For the resonant part, all well established states with masses below 2.0 GeV are included based on a Breit-Wigner ansatz.

The data base is composed of sets of $(\pi^+\pi^-)$, (π^+p) invariant mass and π^- angular distributions, measured for invariant hadronic center-of-mass energy W from 1.4 to 1.9 GeV and for photon four-momenta-squared from 0.5 to 1.5 GeV^2 .

First, we calculated the above mentioned cross-sections using $A_{1/2}$ and $A_{3/2}$ electromagnetic couplings for the states taken from parameterizations of existing data [7]. The hadronic couplings are taken from analyses of hadronic data [8, 9]. In reference [2], a broader comparison to the differential cross sections is reported, showing that we are able to reproduce the main features of the data for $W < 1.65$ GeV and for $W > 1.8$ GeV. In order to further improve the description of the data, the N^* photocouplings and poorly known hadronic couplings are varied within uncertainties reported in [7, 8].

Figure 1. Total cross-sections for $\gamma_{\text{virt}} p \rightarrow p\pi^+\pi^-$ as a function of W from CLAS at 3 Q^2 intervals. The dashed-dotted lines represent best fit results assuming the contribution of well established states with photo and hadronic couplings varied inside uncertainties of [8,9]. The solid, dashed and dotted lines represent the result of fit performed for different assumptions on the nature of structure at 1.7 GeV (see text).

Fit results for the total cross-sections are shown on Fig. 1. We achieve good reproduction of the measured differential cross-sections in complete

kinematics [2] except for the structure at 1.7 GeV, where the data exhibit resonance-like behavior for all Q^2 bins. This feature makes it rather unlikely that the structure is the result of interference between resonant and non-resonant amplitudes. Assuming the resonance properties given by the PDG [6], the $D_{13}(1700)$, $P_{11}(1710)$ and $P_{13}(1720)$ states are the most likely candidates that could contribute to the structure in the data near 1.7 GeV. Enhancing the $D_{13}(1700)$ photocouplings allowed us to reproduce observed peaks in the total cross-sections (solid curves on Fig. 1), however, as reported in [1, 2], the calculated π^- angular distributions are far from the data ($\chi^2 = 5.2$), indicating a different spin-parity of the state responsible for the structure. We also investigated the possibility to describe this structure, by varying the poorly known hadronic couplings of the $D_{13}(1700)$ and $P_{11}(1710)$ states as well as the electromagnetic couplings of all states, that may contribute to the peak at 1.7 GeV. The best fit is presented in Fig. 1 by the dotted lines, while differential cross-sections can be found in [1, 2]. The fit gives a better reproduction of the data ($\chi^2 = 4.2$), however sizable discrepancies in the π^- angular distributions and $(\pi^+\pi^-)$ invariant mass distributions remain [1,2]. In a final step we allowed for large deviations of the N^* hadronic couplings from published values. We found, that differential cross-sections in complete kinematics, including 1.7 GeV structure, could be reproduced reasonably well [1, 2] with hadronic and photocouplings of $P_{13}(1720)$ as presented in the Table 1 and in [1, 2] respectively ($\chi^2 = 3.4$). Total cross-sections are presented on Fig. 1 by dashed lines.

Table 1. PDG $P_{13}(1720)$ parameters from fit (B) and new state parameters from fit (C). Errors are statistical.

	M (MeV)	Γ (MeV)	$\frac{\Gamma_{\pi\Delta}}{\Gamma}$ (%)	$\frac{\Gamma_{\rho N}}{\Gamma}$ (%)
PDG P_{13} (B)	1725 ± 20	114 ± 19	63 ± 12	19 ± 9
PDG [6]	1650-1750	100-200	N/A	70-85
new P_{13} (C)	1720 ± 20	88 ± 17	41 ± 13	17 ± 10

As it follows from the Table 1, the CLAS data were fitted best with hadronic couplings of the $P_{13}(1720)$ which are drastically different from the ones established in hadronic interactions. However, such modification can not be ruled out by the uncertainties in the hadronic data for high lying states. We also studied the alternative possibility to describe 1.7 GeV structure keeping hadronic couplings of N^* inside established uncertainties but assuming excitation of new (so-called "missing") baryon state.

The quantum numbers $S_{I1}, P_{I1}, P_{I3}, D_{I3}, D_{I5}, F_{I5}, F_{I7}$ were tested on an equal footing, where $I/2$ is the isospin, undetermined in our measurement. The best fit ($\chi^2/\nu=3.3$) was obtained for a P_{I3} state with a mass of 1.72 GeV. As reported in [1, 2] this assumption also provided reasonable description of the CLAS data.

Figure 2. The photocouplings for high lying N^* excitations extracted from CLAS data (the points at Q^2 0.65, 0.95 and 1.3 GeV^2) together with world data (the points at another Q^2). The $P_{13}(1720)$ is conventional state (see text).

In summary, we studied two possible interpretations of the structure at 1.7 GeV: an excitation of the conventional $P_{13}(1720)$ state with drastically different hadronic decay pattern with respect to the established one and alternatively as manifestation of new baryon state.

Finally, we extracted the photocouplings for all well established N^* 's with masses below 2.0 GeV in the Q^2 range from 0.5 to 1.5 GeV^2 , assuming

an excitation of new P_{13} baryon state [2, 11]. The results are shown on Fig. 2.

These data provided valuable input for the analysis of N^* excitation mechanisms at the level of constituent quarks, now in progress [10, 11].

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