New Results on the $\pi^+\pi^-$ Electroproduction Cross Sections off Protons

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Abstract. In these proceedings we present preliminary $\pi^+\pi^-$ electroproduction cross sections off protons in the kinematical area of $1.4 \text{ GeV} < W < 1.8 \text{ GeV}$ and $0.4 \text{ GeV}^2 < Q^2 < 1.1 \text{ GeV}^2$. Our results extend the kinematical coverage for this exclusive channel with respect to previous measurements. Furthermore, the $\pi^+\pi^-$ electroproduction cross sections were obtained for $Q^2$-bins of much smaller size. The future analysis of this data within the framework of the JLAB-MSU reaction model (JM) will considerably improve our knowledge on the $Q^2$ evolution of the transition $\gamma pN^*$ electrocouplings, in particular for the resonances with masses above 1.6 GeV.

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INTRODUCTION

Measurements of the $\pi^+\pi^-$ electroproduction cross sections represent an important part of the efforts in the $N^*$ program with CLAS [1, 2]. This program is focused on the evaluation of most excited proton electrocouplings at photon virtualities ($Q^2$) up to 5.0 GeV$^2$, which will allow us to pin down the active degrees of freedom in the $N^*$ structure at different distance scales, and to access the non-perturbative strong interaction mechanisms that are responsible for the formation of the ground and excited nucleon states [3, 4].

Single and charged double pion exclusive channels are two major contributors to the meson electroproduction in the $N^*$ excitation region with different non-resonant mechanisms. A successful description of all observables in these exclusive channels with consistent $N^*$ electrocouplings offers evidence for the reliable evaluation of these fundamental quantities. Moreover, the $\pi^+\pi^-$ exclusive channel is very promising for the studies of $N^*$'s with masses above 1.6 GeV [1, 5].

Our measurements of $\pi^+\pi^-$ electroproduction cross sections, described in these proceedings, continue the previous studies of this exclusive channel with the CLAS detector [6, 8]. Our preliminary data provide a complementary kinematical coverage: $1.4 \text{ GeV} < W < 1.8 \text{ GeV}$ and $0.4 \text{ GeV}^2 < Q^2 < 1.1 \text{ GeV}^2$ in comparison with the previously available measurements, and offer more than a factor six smaller binning over $Q^2$. This kinematical region is suitable to access the electrocouplings and the $\pi\Delta$, $p\rho$ hadronic decay widths for high-lying nucleon resonances as $S_{31}(1620)$, $S_{11}(1650)$, $F_{15}(1685)$, $D_{33}(1700)$, and $P_{13}(1720)$ that have substantial decay probabilities to the $N\pi\pi$ final states [5].
DATA ANALYSIS

Our analysis is focused on the evaluation of the fully integrated and nine one fold differential $\pi^+\pi^-$ electroproduction cross sections off the proton as defined in [6]. This information will allow us to determine $N^*$ electrocouplings within the framework of the reaction model JM [7, 5]. The analysis is based on the experimental data taken with the CLAS detector during the 2003 e1e run period with the electron beam energy 2.039 GeV. The procedure for the extraction of the above mentioned cross sections incorporates: a) the selection of $ep\pi^+\pi^-$ exclusive events, and b) the evaluation of detector efficiencies in the five dimensional reaction phase space through Monte-Carlo simulations. One fold differential cross sections were obtained by integrating the five fold differential $\pi^+\pi^-$ electroproduction cross section over all variables except of one of interest, as described in [6].

![Figure 1](image)

**FIGURE 1.** $Q^2$ versus $W$ distribution for the selected $ep \rightarrow e^\prime p^\prime \pi^+\pi^-$ exclusive events. Cross sections were determined inside the area shown by white borders. Hatched areas correspond to the kinematical regions, where the data on $\pi^+\pi^-p$ electroproduction cross sections are available from previous CLAS measurements [6, 8].

The scattered electron was identified by the coincidence of the electromagnetic calorimeter, Cherenkov counter, drift chambers, and time-of-flight detector signals. Positive hadrons (protons and $\pi^+$) were identified as particles leaving hits in the drift chambers and time-of-flight scintillators. Further particle identification procedures were similar to those described in [6]. The reaction events were selected in four different topologies. In the first one all final hadrons were detected, while in the remaining one of the final hadrons was reconstructed employing energy and momentum conservation. Maximal statistics is achieved in the missing $\pi^-$ topology. The distribution of the selected events over $W$ and $Q^2$ is shown in Fig. 1. Differential and fully integrated cross sections were obtained in the kinematical region depicted in Fig. 1 by the white polygon. A considerable extension of the covered kinematical region is achieved in comparison with the previous experiments [6, 8] (hatched areas in Fig. 1). The $\pi^-$ missing mass squared distribution of the selected events is shown in Fig. 2 and peaks at the $\pi^-$ mass squared.
FIGURE 2. Distribution of the events over the $\pi^-$ missing mass squared that were selected after particle identification and kinematical cuts.

FIGURE 3. Fully integrated $\pi^+\pi^-$ electroproduction cross sections obtained in our analysis (open circles) in comparison with the previously available data [6] (filled diamonds).

PRELIMINARY CROSS SECTIONS

Preliminary results on the fully integrated $\pi^+\pi^-$ electroproduction cross sections obtained in our analysis are shown in Fig. 3 in comparison, with the previously available data [6]. The cross sections obtained in the current analysis are in a good agreement with previously available results in the overlapping area of $Q^2$ and $W$. The $Q^2$-evolution of the $\pi^+\pi^-$ electroproduction cross section determined in the entire range of photon virtualities covered by our measurement is depicted in Fig. 4.
Conclusions

In our analysis of the CLAS e1e data obtained $\pi^+\pi^-p$ electroproduction cross sections extend considerably the kinematical range covered in previous measurements of this exclusive channel. Preliminary results on nine differential and integrated $\pi^+\pi^-p$ electroproduction cross sections were obtained in the kinematic region of $1.4 \text{ GeV} < W < 1.8 \text{ GeV}$ and $0.4 \text{ GeV}^2 < Q^2 < 1.1 \text{ GeV}^2$, and they are in a good agreement with previously available results. The cross sections show clear indication of resonance contributions to the second and third resonance regions, offering encouraging prospects for the extension of our knowledge on $N^*$ electrocouplings, in particular for the resonances with masses above 1.6 GeV.

References

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