Measurements of $ep \to e'\pi^+\pi^-p'$ Cross Sections with CLAS at 1.40 GeV $< W < 2.0$ GeV and 2.0 GeV$^2 < Q^2 < 5.0$ GeV^2

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Studies of the exclusive $ep \to e'\pi^+\pi^-p'$ reaction represent an important direction in the exploration of the excited nucleon state (N^*) spectrum and structure. Many high-lying N^* states in the mass range above 1.6 GeV decay preferentially to the $\pi\pi N$ final state, making charged double pion electroproduction off the proton the major source of information on the photo- and electrocouplings of these resonances. Combined analyses of the CLAS $\pi^+\pi^-p$ photo- and electroproduction data have already revealed strong evidence for the existence of the new $N'(1720)3/2^+$ state.

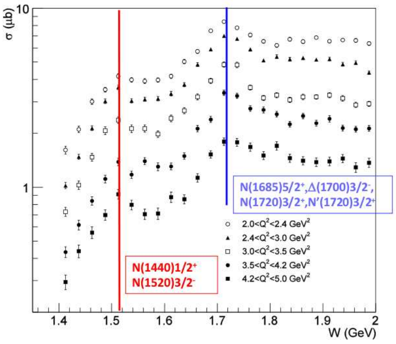

Figure 1: Fully integrated cross sections for $\pi^+\pi^-p$ electroproduction as a function of W at Q^2=2.2, 2.6, 3.2, 3.8, and 4.6 GeV^2. The error bars represent the statistical uncertainties.

The new exclusive cross sections for $\pi^+\pi^-p$ electroproduction off protons were obtained for the first time at Q^2 from 2.0 GeV^2 to 5.0 GeV^2 for center-of-mass energies W from 1.4 GeV to 2.0 GeV in terms of nine independent 1-fold differential and fully integrated cross sections. These data considerably extend the kinematic reach of previous measurements. The fully integrated $\pi^+\pi^-p$ electroproduction cross sections are shown in Fig. 1. Two structures located at W=1.5 GeV and 1.7 GeV produced by the resonances of the second and third resonance regions are the major features in the W evolution of the integrated cross sections observed in the entire range of Q^2 covered by the CLAS measurements. Using the JM reaction model successfully employed for the extraction of the $\gamma_v pN^*$ electrocouplings from the $\pi^+\pi^-p$ electroproduction channel, we see strong indications that the relative contributions from the resonant cross sections at $W < 1.74$ GeV increase with Q^2 as shown in Fig. 2.

This offers encouraging prospects for the extraction of resonance electrocouplings in the full Q^2 range covered by the measurements. A reasonable description of the nine 1-fold differential cross sections was achieved within the framework of the updated JM reaction model in the entire area of W and Q^2 with $\chi^2/d.p. < 1.2$. A representative example of the fit quality in the description of the 1-fold differential cross sections is shown in Fig. 3, together with the resonant and non-resonant contributions, which show distinctively different shapes in all 1-fold cross sections allowing for their credible isolation.

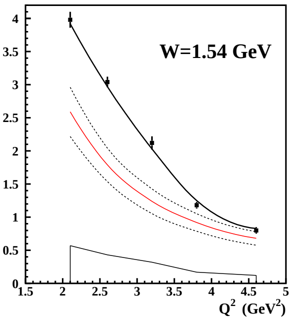

Figure 2: Resonant contributions from the JM model (red solid lines with black dashed lines showing the uncertainties) compared with the CLAS results on the fully integrated $\pi^+\pi^-p$ electroproduction cross sections (points with statistical error bars).

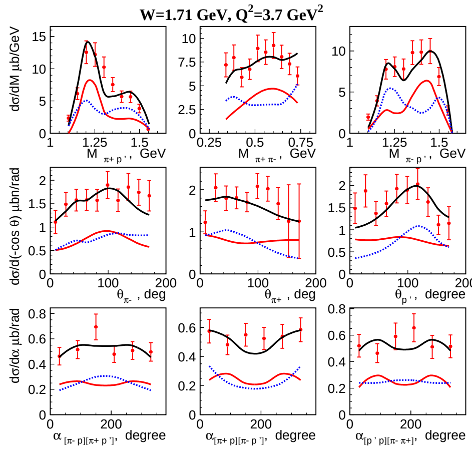

Figure 3: Description of the nine 1-fold differential cross sections from the JM model. The resonant and non-resonant contributions are shown by the red solid and blue dotted lines, respectively.

This success will allow us in the near-term future to obtained electrocouplings of most resonances in the mass range $W < 2.0$ GeV and at photon virtualities 2.0 GeV$^2 < Q^2 < 5.0$ GeV^2 from exclusive $\pi^+\pi^-p$ electroproduction data for the first time. The expected results are of particular importance in order to conclude on the existence of the new $N'(1720)3/2^+$ resonance. These results will provide a profound impact on the development of hadron structure theory with a traceable connection to the QCD Lagrangian and will stimulate further development of quark models for the description of the resonance structure over the full spectrum of excited nucleon states.