First results on nucleon resonance photocouplings from the $\gamma p \to \pi^+\pi^- p$ reaction

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Studies of the exclusive $\gamma p \to \pi^+\pi^- p$ reaction offer an effective tool for the exploration of excited nucleon states (N^*) in the mass range $W > 1.6$ GeV. Many of these states decay preferentially to the $\pi\pi N$ final state. The cross sections of $\pi^+\pi^- p$ photoproduction are the largest among the $\pi\pi N$ photoproduction channels. The new $\pi^+\pi^- p$ photoproduction data were obtained with the CLAS detector for the first time in terms of nine independent 1-fold differential and fully integrated $\pi^+\pi^- p$ cross sections in the center of mass energies W from 1.6 GeV to 2.0 GeV. Overall, ≈400M $\pi^+\pi^- p$ events were selected, exceeding the statistics previously collected in this channel by a factor of ∼50. The fully integrated and the nine 1-fold differential $\pi^+\pi^- p$ photoproduction cross sections are shown in Fig. 1. A good description of these new data with $1.15 < \chi^2/d.p. < 1.3$ was achieved within the framework of the JM meson-baryon reaction model. The credible isolation of the resonant contributions obtained in the data fit allowed us to determine the resonance parameters. The resonance photocouplings extracted from this work are listed in Table I and compared with the resonance photocoupling ranges and the results of the multichannel analysis included in the PDG (2018).

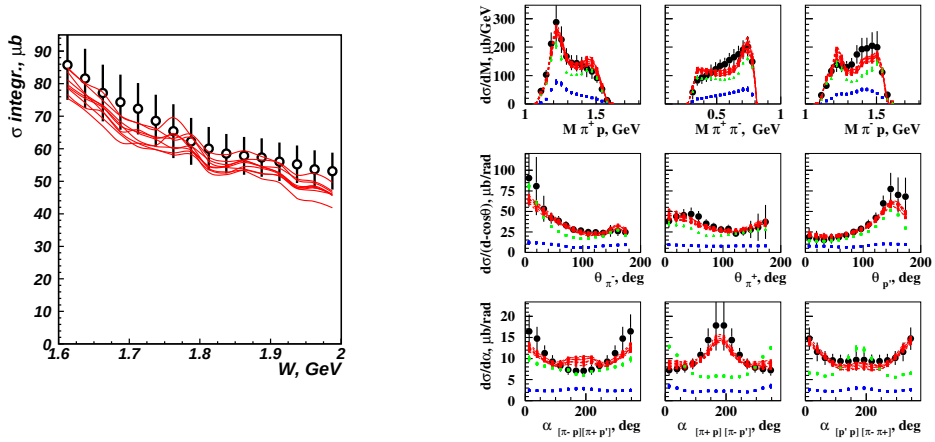

FIG. 1: (Left) Fully integrated cross sections computed from the fits of the nine 1-fold differential cross sections (red curves) in comparison with the measured integrated cross sections (points with error bars). The error bars include the combined statistical and point-to-point systematic uncertainties. (Right) Representative example of 1-fold differential cross sections (points with error bars) and the resonant/non-resonant contributions (blue/green bars) from the fits (red curves) of the CLAS $\pi^+\pi^- p$ photoproduction data at W from 1.73 GeV to 1.75 GeV.

There is good agreement in the magnitude and sign of the photocouplings between our results and the photocoupling ranges in the PDG listings. On the other hand, for several resonances, the photocouplings determined from the multichannel analysis are different from ours. Implementation of our $\pi^+\pi^- p$ photoproduction data into the global multichannel analyses will essentially improve our knowledge on the photocouplings and hadronic decay parameters of the resonances in the mass range of $W > 1.6$ GeV. For a successful description of the $\pi^+\pi^- p$ photo- and electroproduction CLAS data with Q^2-independent resonance hadronic decay parameters, a new baryon N'(1720)$3/2^+$ state is needed. Evidence for this new N'(1720)$3/2^+$ resonance will be published soon.

Resonances	$A_{1/2} \times 10^3$ from $\pi^+\pi^- p$ GeV$^{-1/2}$	$A_{1/2} \times 10^3$ PDG ranges GeV$^{-1/2}$	$A_{1/2} \times 10^3$ multichannel analysis GeV$^{-1/2}$	$A_{3/2} \times 10^3$ from $\pi^+\pi^- p$ GeV$^{-1/2}$	$A_{3/2} \times 10^3$ PDG ranges GeV$^{-1/2}$	$A_{3/2} \times 10^3$ multichannel analysis GeV$^{-1/2}$
$\Delta(1620)1/2^-$	29.0±6.2	30 – 60	55±7			
$N(1650)1/2^-$	60.5±7.7	35 – 55	32±6			
$N(1680)5/2^+$	−27.8±3.6	−18 – −5	−15±2	128±11	130 – 140	136±5
$N(1720)3/2^+$	80.9±11.5	80 – 120	115±45	−34.0±7.6	−48 – 135	135±40
$\Delta(1700)3/2^-$	87.2±18.9	100 – 160	165±20	87.2±16.4	90 – 170	170±25
$\Delta(1905)5/2^+$	19.0±7.6	17 – 27	25±5	−43.2±17.3	−55 – −35	−50±5
$\Delta(1950)7/2^+$	−69.8±14.1	−75 – −65	−67±5	−118.1±19.3	−100 – −80	−94±4

TABLE I: Resonance photocouplings determined from analysis of the $\pi^+\pi^- p$ photoproduction data from this work in comparison with the previous results from the PDG average and from multichannel analysis.