

# Nucleon resonance electrocouplings from CLAS data on pion electroproduction

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Studies of nucleon resonance electrocouplings for excited proton states at various photon virtualities  $Q^2$  represent an important part in the  $N^*$  Program with the CLAS detector [1]. The CLAS measurements extend the data on differential cross sections for  $N\pi$  and  $N\eta$  electroproduction channels, longitudinally polarized beam/beam-target asymmetries for  $\pi$  electroproduction off protons considerably, providing a nearly complete coverage of the final hadron phase space. Electrocouplings of the  $P_{11}(1440)$ ,  $D_{13}(1520)$ , and  $S_{11}(1535)$  resonances were determined from analyses within the framework of two conceptually different reaction models [2] at  $0.3 < Q^2 < 5.0 \text{ GeV}^2$ , and at  $0.3 < Q^2 < 6.0 \text{ GeV}^2$  for the  $P_{33}(1232)$  state.

Data were also collected on charged double pion electroproduction off protons leading to nine independent differential  $\pi^+\pi^-p$  cross sections [3]. Using a phenomenological approach [4] allowed us to establish all essential mechanisms contributing to this channel at invariant masses of final hadrons  $W < 1.8 \text{ GeV}$ , and  $Q^2 < 1.5 \text{ GeV}^2$ . The  $P_{11}(1440)$  and  $D_{13}(1520)$  electrocouplings were determined from the  $\pi^+\pi^-p$  electroproduction data for the first time. They are in a good agreement with the results of the independent  $N\pi$  electroproduction analyses [2], offering evidence for the reliable extraction of resonance electrocouplings. First results from the  $\pi^+\pi^-p$  electroproduction channel on electrocouplings of  $S_{11}(1650)$ ,  $D_{33}(1700)$ , and  $P_{13}(1720)$  resonances have also become available.

Analyses of these results in quark models and evaluation of the  $N^*$  meson-baryon dressing [5] strongly suggests two contributions to  $\gamma_v NN^*$  electrocouplings: a) an internal quark core, and b) an external meson-baryon cloud.

A further extension of the  $N^*$  Program with the CLAS12 detector after completion of JLAB 12 GeV Upgrade Project will be outlined.

## References

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