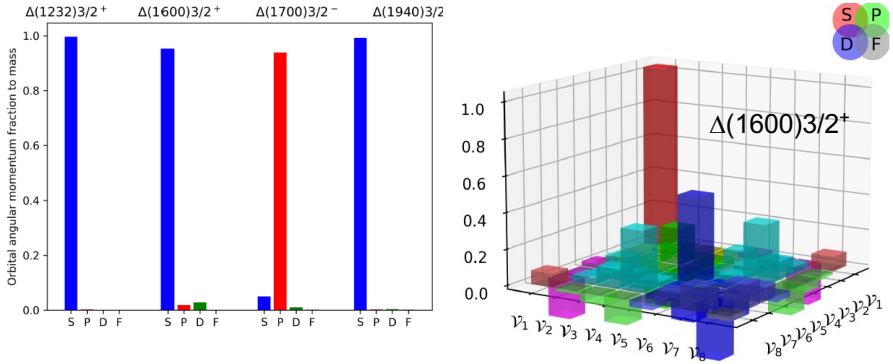
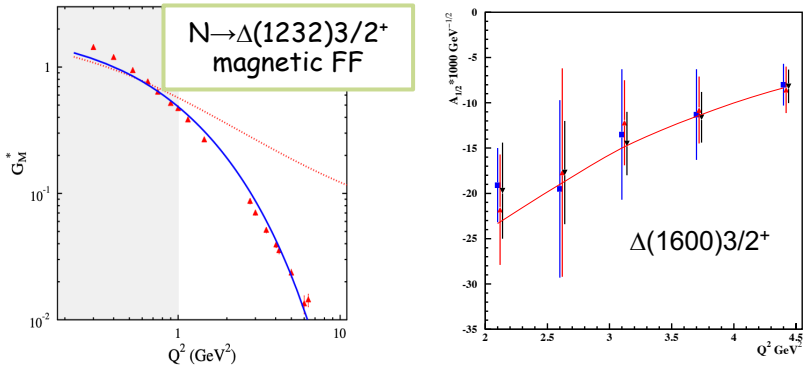
Resonance Electroexcitation Amplitudes and Understanding of Strong QCD

Nucleons and their resonances are the most fundamental three-body systems in Nature. If we don't understand how QCD builds each state in the complete spectrum, then our understanding of the sQCD regime remains incomplete.

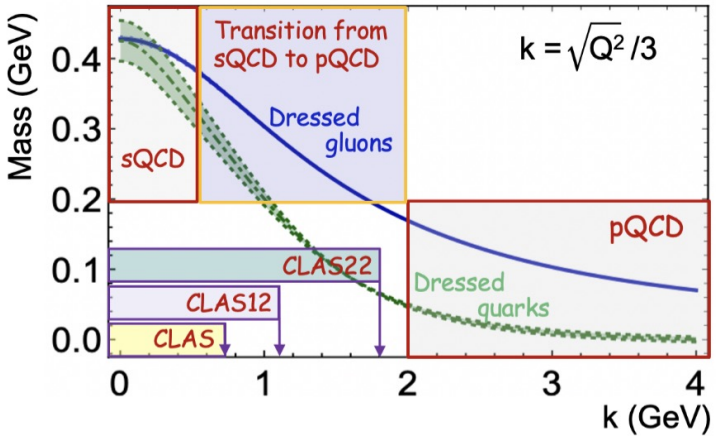
L. Liu et al., PRD 105, 114047 (2022)



V. I. Mokeev et al., PRC 108, 025204 (2023), D.S. Carman et al., Particles 6, 416 (2023).



- N* photocouplings are sensitive to the long-range components of the N* wavefunction, which are consistent with the expectations of quark models based on SU(6) spin-flavor symmetry (left)
- Results on the Q^2-evolution of the $\gamma_v pN^*$ electrocouplings provide insight into the full complexity of the N* wavefunction (right)



- Successful description of the $\gamma_v pN^*$ electrocouplings for N*'s of different structure for $Q^2<30$ GeV^2 will allow us to explore the emergence of N* mass and structure from QCD

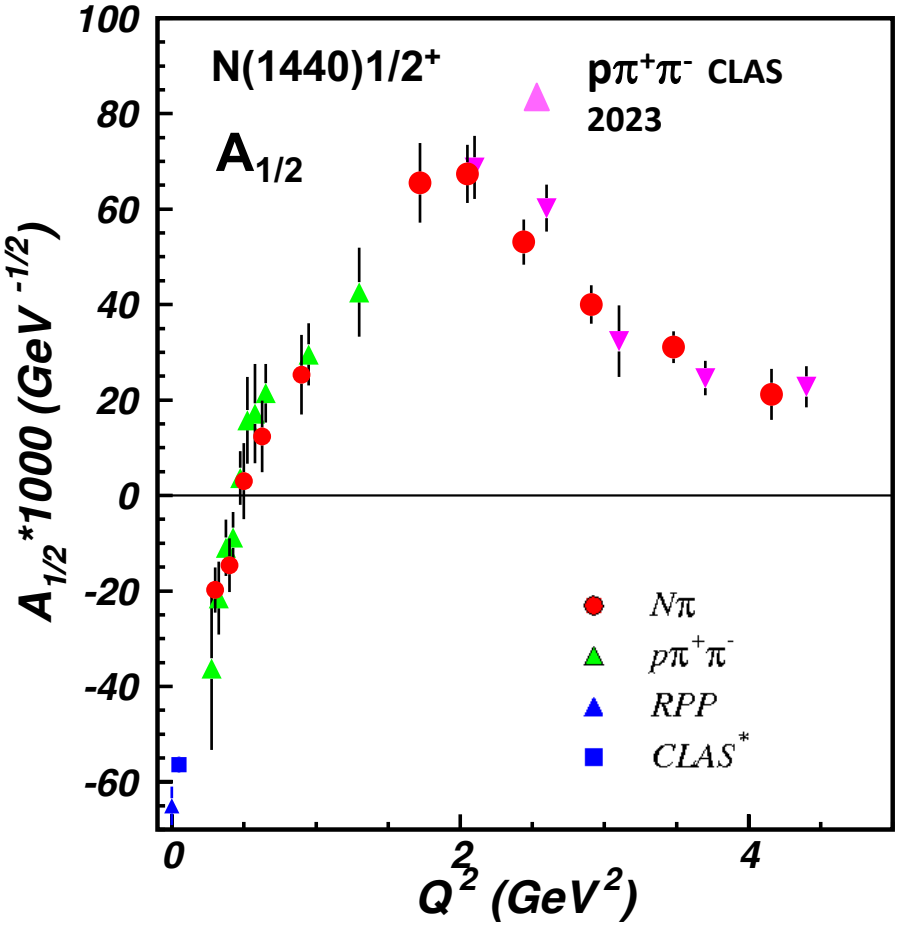
A unique source of information on many facets of sQCD in generating excited nucleon states with different structural features

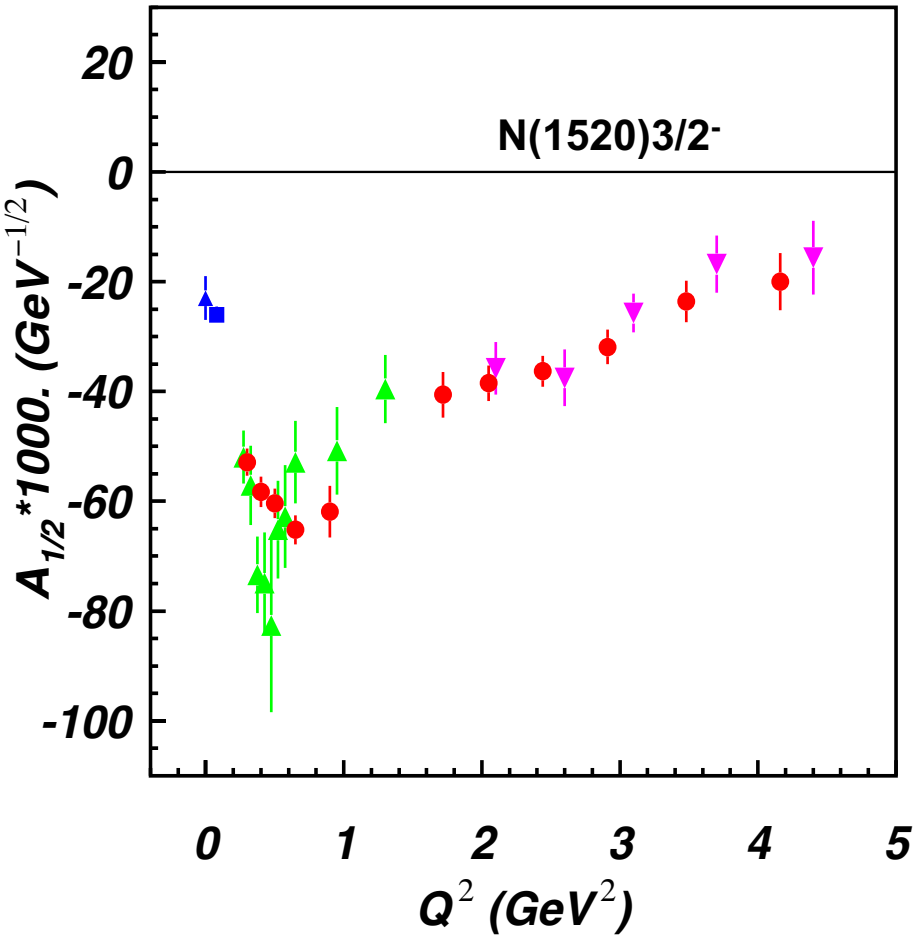
Nucleon Resonance Electrocouplings from Data on Exclusive Meson Electroproduction of 6 GeV Era with CLAS

Exclusive meson electroproduction channels	Excited proton states	Q^2-ranges for extracted $\gamma_v pN^*$ electrocouplings, GeV^2
$\pi^0 p$, $\pi^+ n$	$\Delta(1232)3/2^+$ $N(1440)1/2^+$,$N(1520)3/2^-$, $N(1535)1/2^-$	0.16-6.0 0.30-4.16
$\pi^+ n$	$N(1675)5/2^-$, $N(1680)5/2^+$,$N(1710)1/2^+$	1.6-4.5
ηp	$N(1535)1/2^-$	0.2-2.9
$\pi^+\pi^- p$	$N(1440)1/2^+$, $N(1520)3/2^-$ $N(1440)1/2^+$, $N(1520)3/2^-$, $\Delta(1600)3/2^+$ $\Delta(1620)1/2^-$, $N(1650)1/2^-$, $N(1680)5/2^+$, $\Delta(1700)3/2^-$, $N(1720)3/2^+$, $N'(1720)3/2^+$	0.25-1.50 2.0-5.0 0.5-1.5

- The $\gamma_v pN^*$ electrocouplings have become available from analysis of CLAS data for most N* states in the mass range <1.8 GeV and in a broad range of $Q^2 < 5$ GeV^2.
- Numerical results can be found in: https://userweb.jlab.org/~mokeev/resonance_electrocouplings23 and A.N. Hiller Blin et al, PRC100, 035201 (2019)
- Recently, electroexcitation amplitudes for N* within the mass range up to 1.8 GeV were determined for $Q^2<5$ GeV^2 at the pole positions within a coupled channel analysis of $N\pi$ $N\eta$, KY photo-/electro- and hadroproduction data in *Y-F. Wang et al., arXiv:2404v2 [nucl-th] (see the talk by M. Doering).*

Electrocouplings of N(1440)1/2$^+$ and N(1520)3/2$^-$ Resonances from πN and $\pi^+\pi^-$p Electroproduction off Proton Data





Consistent results on the N(1440)1/2$^+$ and N(1520)3/2$^-$ electrocouplings from independent studies of the two major πN and $\pi^+\pi^-$p electroproduction channels with different non-resonant contributions demonstrated the capabilities of the reaction models for their reliable extraction and allow us to evaluate their systematic uncertainties in a nearly model-independent way.

Resonance Electrocouplings from Meson Electroproduction Channels
Items for Discussion

1. Prospects for extension of reaction models for extraction of the $\gamma_v pN^*$ electrocouplings from the $\pi^+ n$ and $\pi^0 p$ channels to provide results on the Q^2 evolution of the electrocouplings from 5−10 GeV^2.

   Expected data: two-fold differential cross sections and beam asymmetry of quality comparable with the data for $Q^2<5$ GeV^2.

2. Prospects for developing reaction models aimed to determine the $\gamma_v nN^*$ electrocouplings from $\pi^- p$ electroproduction off bound neutron data.

   Available/*expected data*: two-fold differential cross sections with data quality highlighted by R.W. Gothe.

3. Development of the reaction models for extraction of the $\gamma_v pN^*$ electrocouplings from $K\Lambda$ and $K\Sigma$ electroproduction off protons data for 0.5 $GeV^2<Q^2<7.0$ GeV^2.

   Expected data: Data availability/quality discussed by D.S. Carman.

4. How useful are the results on the contributions from the $\pi\Delta$ and ρp electroproduction channels into the nine one-fold differential $\pi^+\pi^- p$ cross sections deduced from the data fit for the coupled-channel analyses of meson photo-/electro- and hadroproduction?

5. What are the prospects to predict π, K, and ground state nucleon 1D and 3D structure functions within approaches under connection to QCD with the basic ingredients checked against the data on π, K, ground state nucleon elastic form factors and transition $\gamma_v pN^*/\gamma_v nN^*$ electrocouplings?