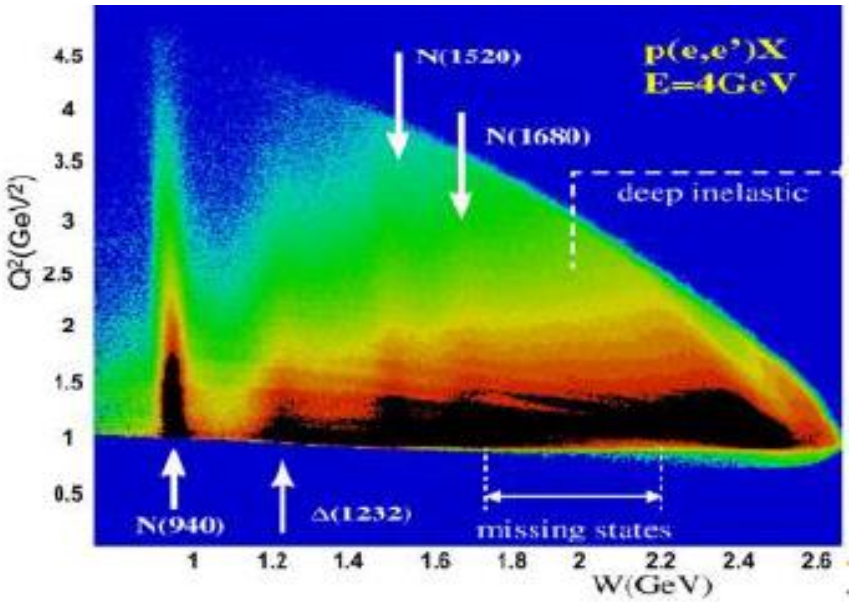
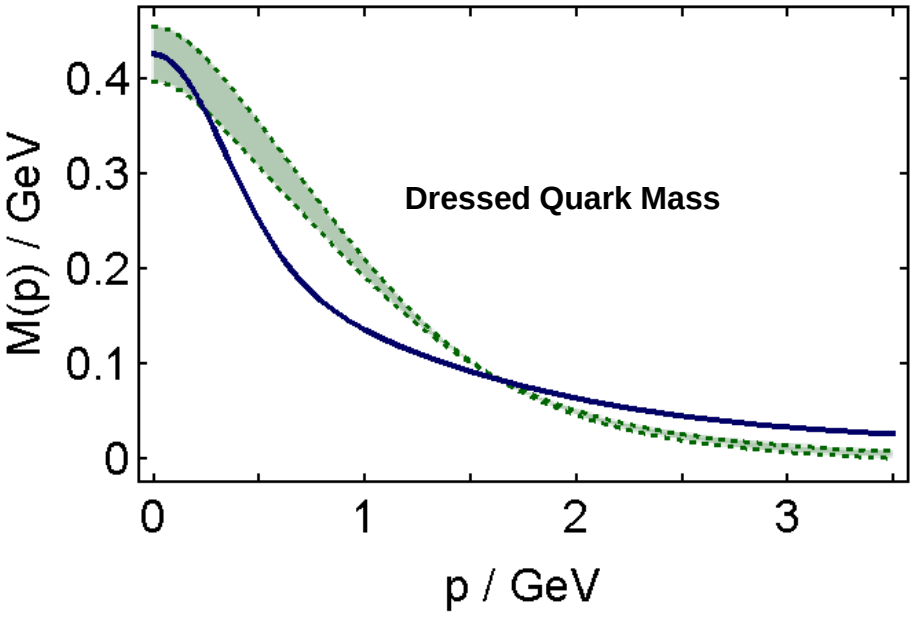
Insight to Hadron Mass Generation from N* Electroexcitation





Talk outline:

- **Resonance electrocouplings and hadron mass generation, N*/DIS synergistic efforts**
- **γ_vpN* electrocouplings from CLAS data**
- **From γ_vpN* electrocouplings to quark dynamical mass**
- **N* studies at high Q^2 with the CLAS12 and emergence of hadron mass from QCD**

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Jefferson Laboratory

Office of Science

ECT* Workshop Emergent Mass and its Consequences in the Standard Model, 17-21 September 2018, ECT* - Villa Tambosi, Italy

N* Structure and Hadron Mass Generation in Experiments with CLAS/CLAS12

The experimental program on the studies of N* structure in exclusive meson electroproduction with CLAS/CLAS12 seeks to determine:

- $\gamma_v pN^*$ electrocouplings at photon virtualities up to 5.0 GeV^2 for most of the excited proton states through analyzing major meson electroproduction channels from the CLAS data
- extend accessible Q^2 range up to 12 GeV^2 from the CLAS12 data and explore N* structure evolution in the transition from the strong and pQCD regimes
- explore hadron mass emergence by mapping out dynamical quark mass in the transition from almost massless pQCD quark to fully dressed constituent quark

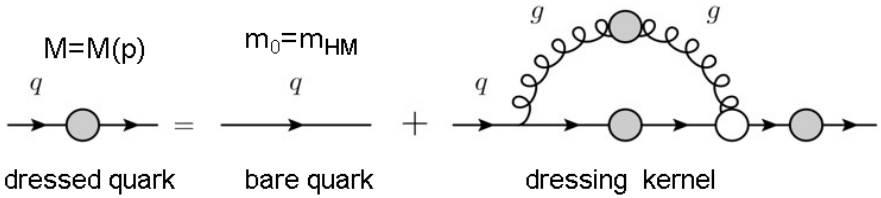
A unique source of information on many facets of strong QCD in generating excited nucleon states with different structural features

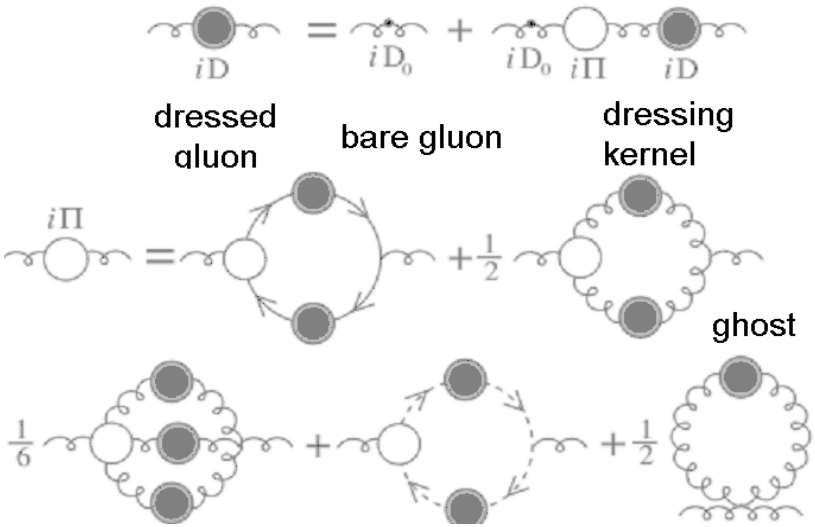
Review papers:

1. I.G. Aznauryan and V.D. Burkert, Prog. Part. Nucl. Phys. 67, 1 (2012).
2. V.D. Burkert and C.D. Roberts, arXiv:1710.02549 [nucl-ex].
3. C.D. Roberts, Few Body Syst. 59, 72 (2018).
4. C.D. Roberts, Few Body Syst. 58, 5 (2017).

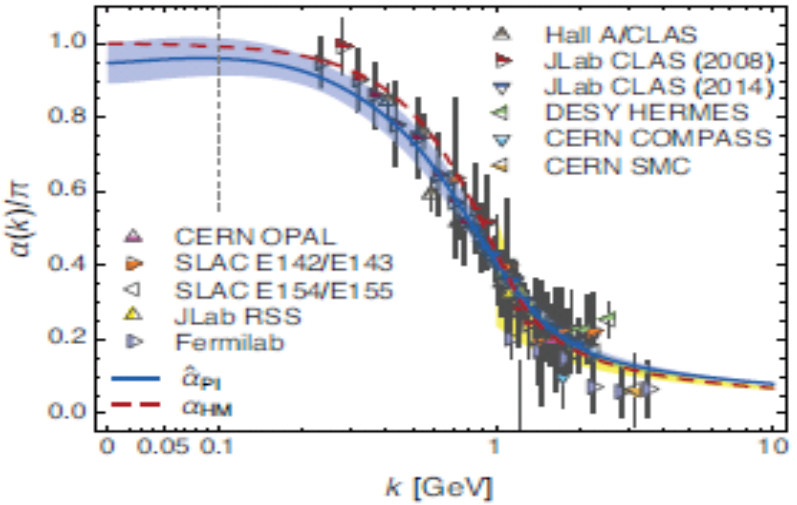
Insight into Hadron Mass Generation from N* and DIS Experiments

Emergence of Dressed Quarks and Gluons
D. Binosi et al, Phys. Rev. D95, 031501 (2017)

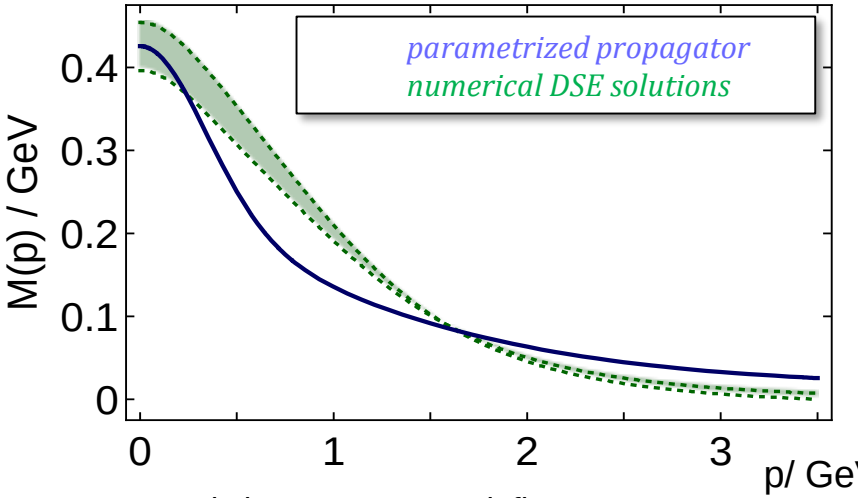




Process independent running QCD-coupling
D. Binosi et al, Phys. Rev. D 96, 054026 (2017)



Dressed Quark Mass Function
C.D. Roberts, Few Body Syst. 58, 5 (2017)

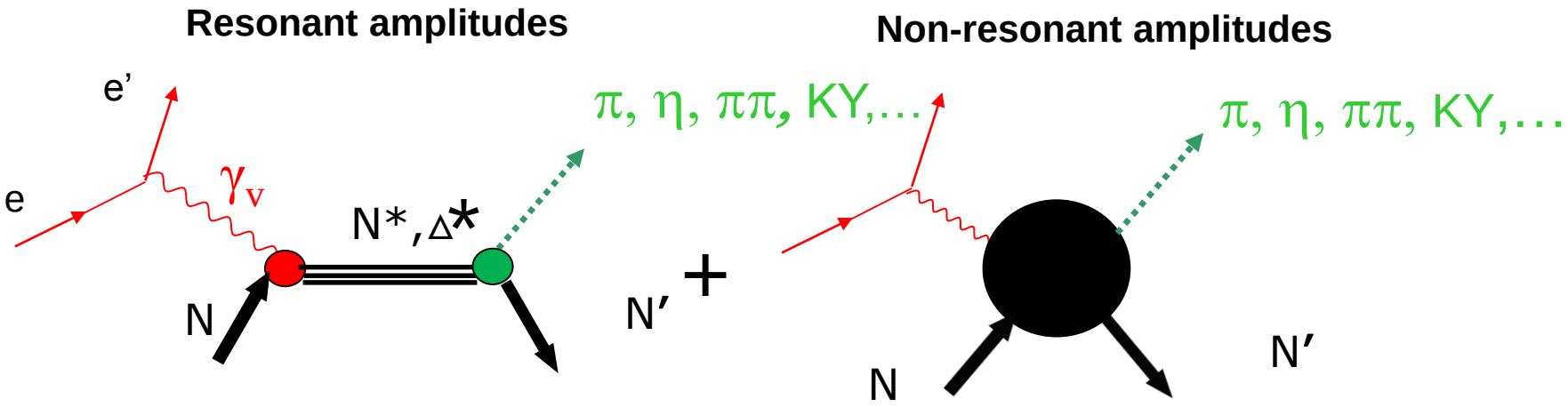


Dressed gluon propagator defines momentum dependencies of quark mass and running QCD-coupling

Success in describing electrocouplings of different N* with common quark mass function validates the insight into the mass generation dynamics, allows to predict the running QCD coupling, and compare the expectation with the wealth of the data from DIS

DSEQCD offers the framework to explore hadron mass generation and the momentum dependence of the QCD coupling both from the data of experiments on the N* structure and on the DIS processes

Extraction of γ_vNN* Electrocouplings from Exclusive Meson Electroproduction off Nucleons



Definition of N* photo-/electrocouplings employed in the CLAS data analyses:

- **Real $A_{1/2}(Q^2)$, $A_{3/2}(Q^2)$, $S_{1/2}(Q^2)$**

I.G. Aznauryan and V.D. Burkert, Prog. Part. Nucl. Phys. 67, 1 (2012).

$$\Gamma_\gamma = \frac{k^2_{\gamma_{N^*}}}{\pi}\frac{2M_N}{(2J_r+1)M_{N^*}}\left[|A_{1/2}|^2+|A_{3/2}|^2\right]$$

- **Consistent results on γ_vpN* electrocouplings from different meson electroproduction channels are critical in order to validate reliable extraction of these quantities.**

Summary of Published/Submitted CLAS Data on Exclusive Meson Electroproduction off Protons in N* Excitation Region

Hadronic final state	Covered W-range, GeV	Covered Q^2-range, GeV^2	Measured observables
π^+n	**1.1-1.38** **1.1-1.55** **1.1-1.7** **1.6-2.0**	**0.16-0.36** **0.3-0.6** **1.7-4.5** **1.8-4.5**	**$d\sigma/d\Omega$** **$d\sigma/d\Omega$** **$d\sigma/d\Omega$, A_b** **$d\sigma/d\Omega$**
π^0p	**1.1-1.38** **1.1-1.68** **1.1-1.39**	**0.16-0.36** **0.4-1.8** **3.0-6.0**	**$d\sigma/d\Omega$** **$d\sigma/d\Omega$, A_b,A_t,A_{bt}** **$d\sigma/d\Omega$**
ηp	**1.5-2.3**	**0.2-3.1**	**$d\sigma/d\Omega$**
$K^+\Lambda$	**thresh-2.6**	**1.40-3.90** **0.70-5.40**	**$d\sigma/d\Omega$** **P^0, P'**
$K^+\Sigma^0$	**thresh-2.6**	**1.40-3.90** **0.70-5.40**	**$d\sigma/d\Omega$** **P'**
$\pi^+\pi^-p$	**1.3-1.60** **1.4-2.10** **1.4-2.00** **1.3-1.83** **1.6-2.00**	**0.2-0.6** **0.5-1.5** **2.0-5.0** **0.4-1.0** **0.**	**Nine 1-fold differential cross sections**

- $d\sigma/d\Omega$–CM angular distributions
- A_b,A_t,A_{bt}-longitudinal beam, target, and beam-target asym-metries
- P^0, P' –recoil and transferred polarization of strange baryon

Over 140,000 data points!

Almost full coverage of the final hadron phase space

The measured observables from CLAS are stored in the CLAS Physics Data Base: http://clas.sinp.msu.ru/cgi-bin/jlab/db.cgi

Approaches for Extraction of $\gamma_v pN^*$ Electrocouplings

Analyses of different meson electroproduction channels independently:

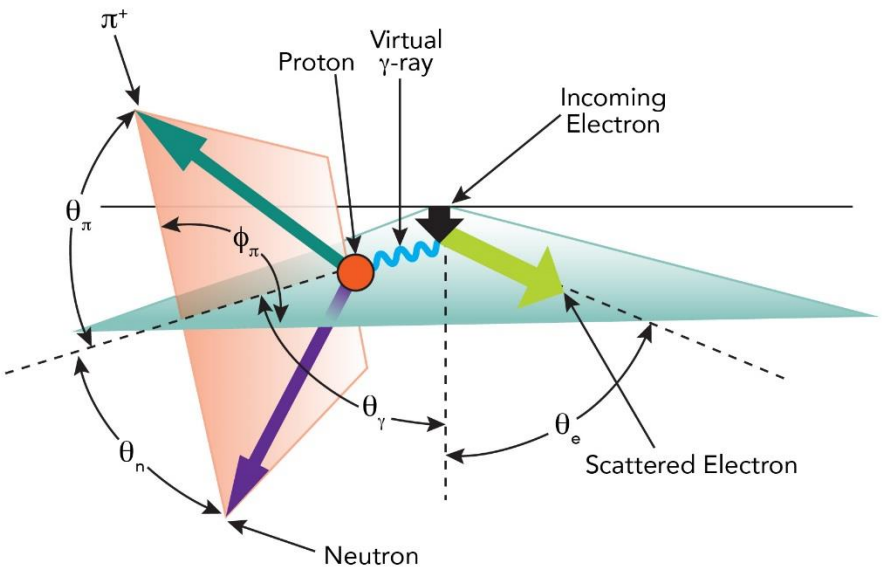
- **$\pi^+ n$ and $\pi^0 p$ channels:**
  Unitary Isobar Model (UIM) and Fixed-t Dispersion Relations (DR)
  I.G. Aznauryan, Phys. Rev. C67, 015209 (2003)
  I.G. Aznauryan et al. (CLAS), Phys. Rev. C80, 055203 (2009)
  I.G. Aznauryan et al. (CLAS), Phys. Rev. C91, 045203 (2015)
- **ηp channel:**
  Extension of UIM and DR
  I.G. Aznauryan, Phys. Rev. C68, 065204 (2003)
  Data fit at W<1.6 GeV, assuming $N(1535)1/2^-$ dominance
  H. Denizli et al. (CLAS), Phys. Rev. C76, 015204 (2007)
- **$\pi^+\pi^- p$ channel:**
  Data driven JLab-MSU meson-baryon model (JM)
  V.I. Mokeev, V.D. Burkert et al., Phys. Rev. C80, 045212 (2009)
  V.I. Mokeev et al. (CLAS), Phys. Rev. C86, 035203 (2012)
  V.I. Mokeev, V.D. Burkert et al., Phys. Rev. C93, 054016 (2016)
  E. Golovatch et al., arXiv:1806.01767 [nucl-ex]

Global coupled-channel analysis of $\gamma_{r,v}N$, πN, ηN, $\pi\pi N$, $K\Lambda$, $K\Sigma$ exclusive channels:

H. Kamano, Few Body Syst. 59, 24 (2018)
H. Kamano, JPS Conf. Proc. 13, 010012 (2017)
H. Kamano, arXiv:1610.01710 [nucl-th]

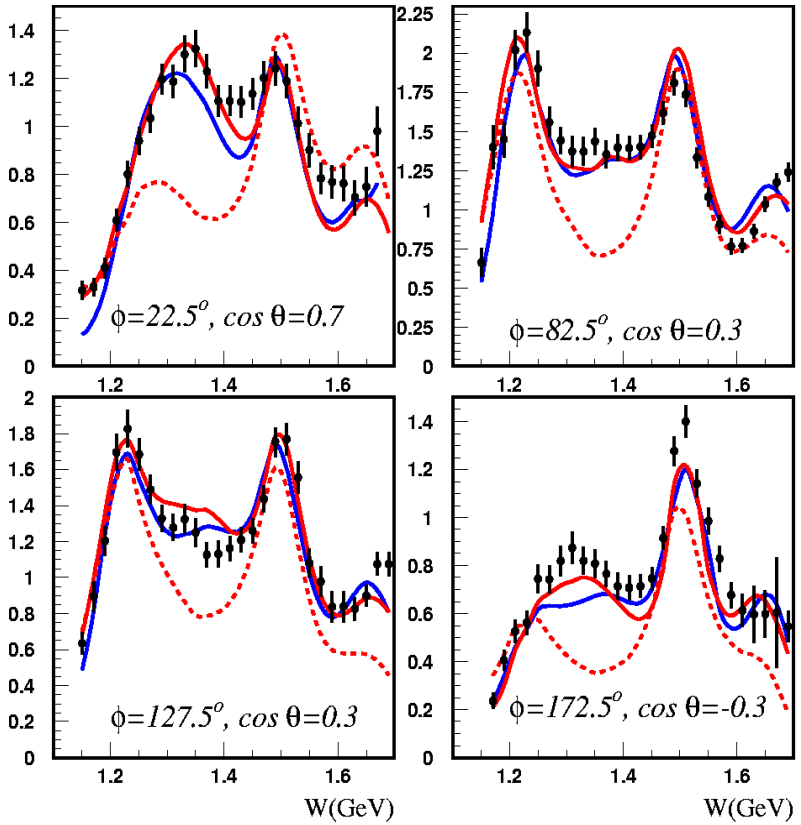
Accessing Resonance Electrocouplings from the π^+n Differential Electroproduction Cross Sections off Protons

Kinematics of exclusive π^+n electroproduction off protons (lab frame)



Q^2=2.05 GeV^2

DR
DR w/o P11
UIM

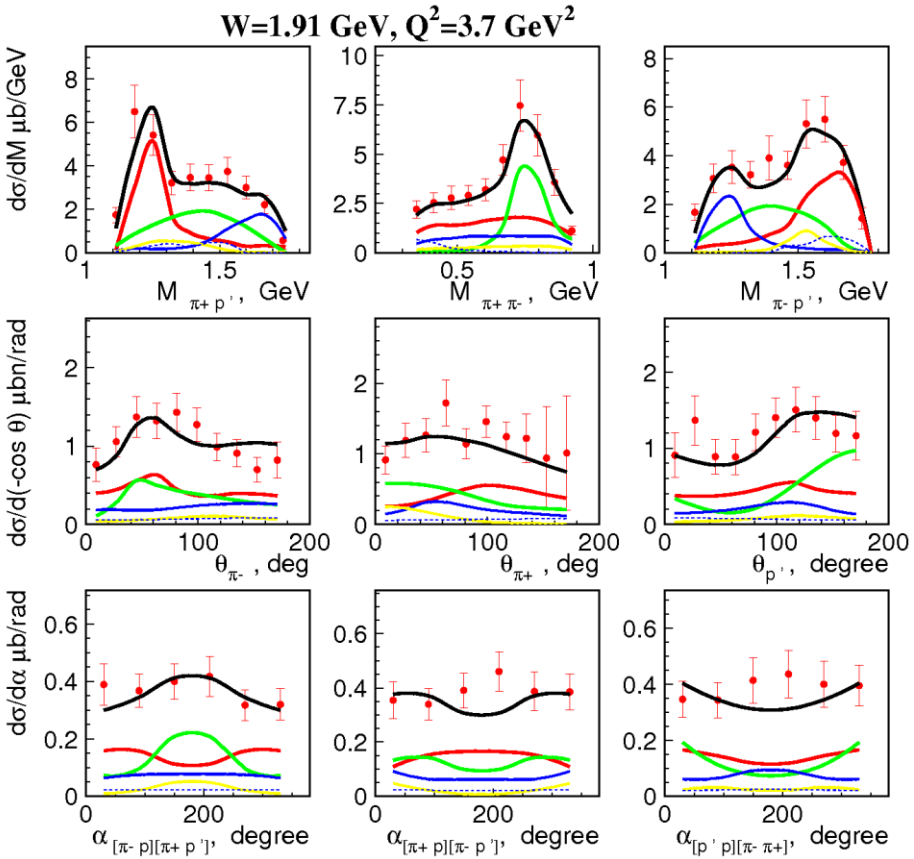


The final pion angles are in the CM-frame of the final hadrons

Accessing Resonance Electrocouplings from the $\pi^+\pi^-p$ Differential Electroproduction Cross Sections off Protons

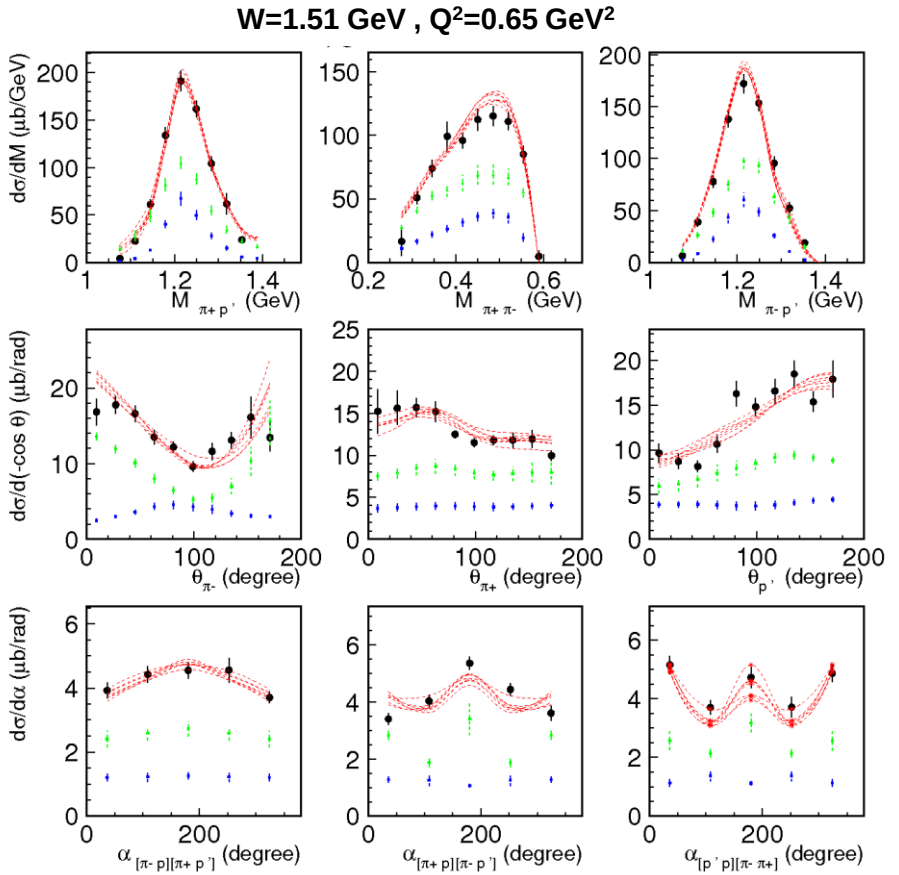
Contributing mechanisms seen in the data

E. Isupov et al. (CLAS), Phys. Rev. C96, 025209 (2017)



Resonant and non-resonant contributions

V.I. Mokeev et al., Phys. Rev. C93, 054016 (2016)



full JM — ρp — π^+ N(1520)3/2$^-$ — data fit within JM under variations of both resonant and background parameters

$\pi^-\Delta^{++}$ — $\pi^+\Delta^0$ — π^+ N(1680)5/2$^+$ — background cross sections

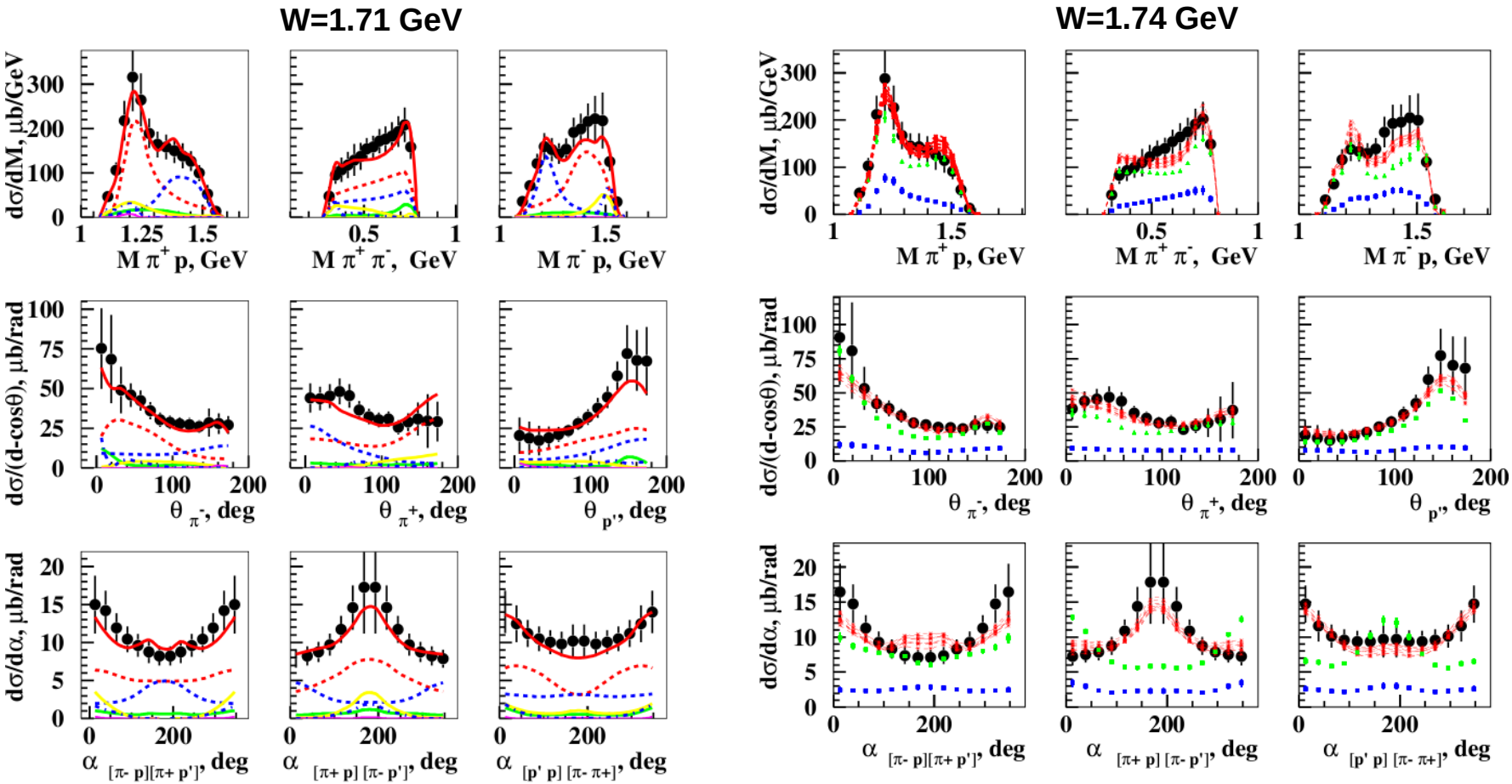
resonant cross sections

$\pi^+\pi^-p$ Differential Photoproduction Cross Sections off Protons in the Resonance Region

Contributing mechanisms seen in the data

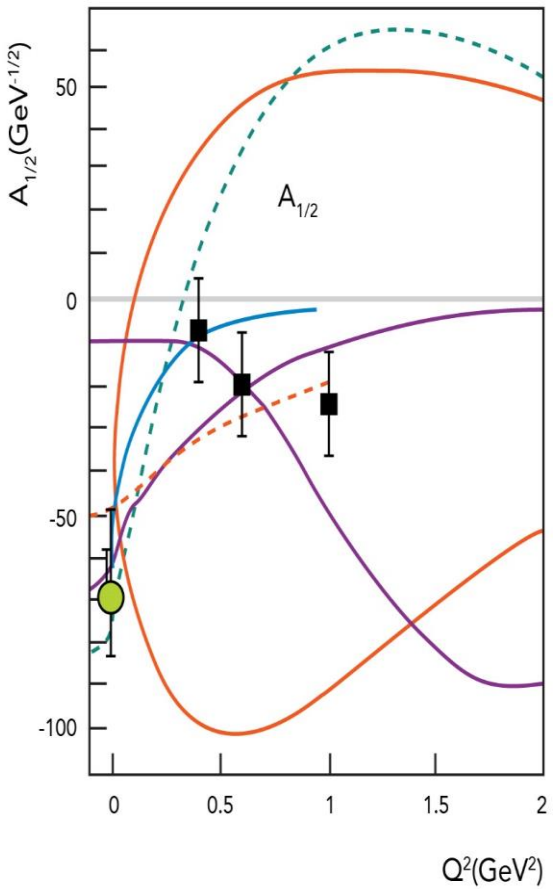
Resonant and non-resonant contributions

E. Golovatch et al. (CLAS), arXiv:1806.01767 [nucl-ex]



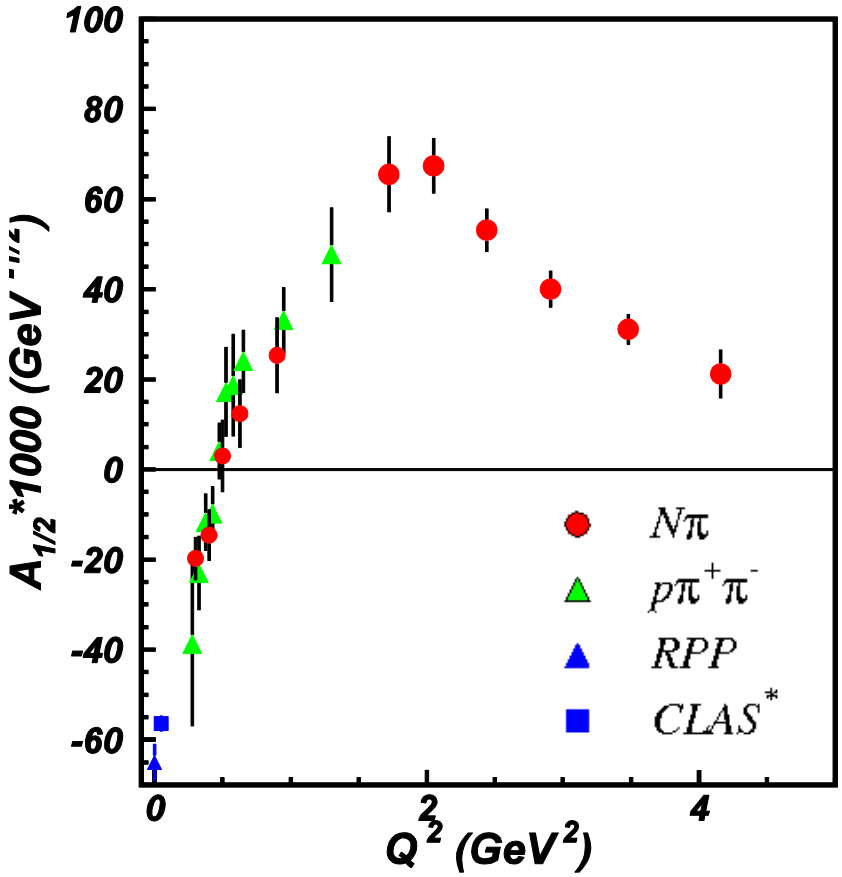
Roper Resonance in 2002 & 2018

2002



V. D. Burkert, Baryons 2002

2018



V. D. Burkert, Baryons 2016

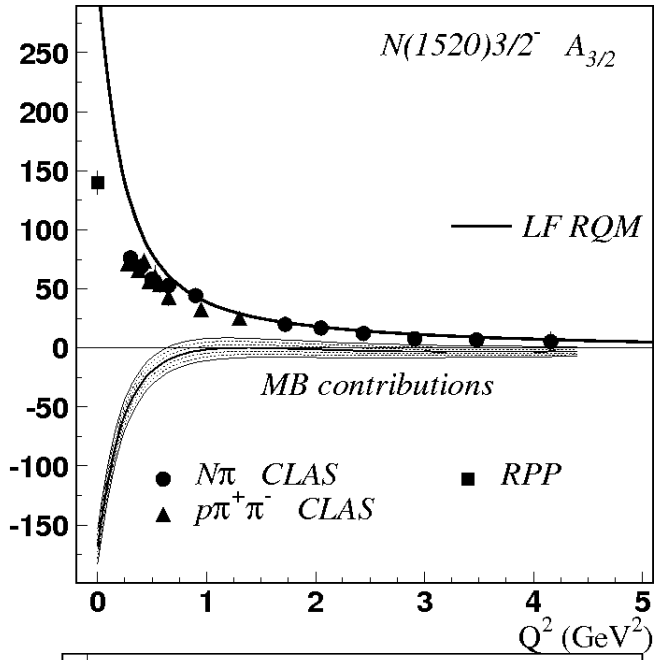
Summary of Results on $\gamma_v pN^*$ Photo-/Electrocouplings from CLAS

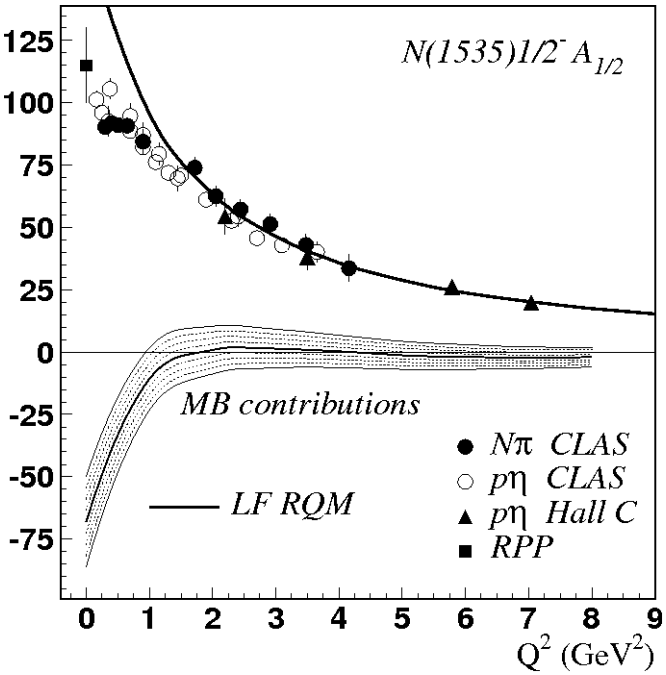
Exclusive meson electroproduction channels	Excited proton states	Q^2-ranges for extracted $\gamma_v pN^*$ electrocouplings, GeV^2
$\pi^0 p$, $\pi^+ n$	$\Delta(1232)3/2^+$ $N(1440)1/2^+$,$N(1520)3/2^-$, $N(1535)1/2^-$	0.16-6.0 0.30-4.16
$\pi^+ n$	$N(1675)5/2^-$, $N(1680)5/2^+$ $N(1710)1/2^+$	1.6-4.5
ηp	$N(1535)1/2^-$	0.2-2.9
$\pi^+\pi^- p$	$N(1440)1/2^+$, $N(1520)3/2^-$ $\Delta(1620)1/2^-$, $N(1650)1/2^-$, $N(1680)5/2^+$, $\Delta(1700)3/2^-$, $N(1720)3/2^+$, $N'(1720)3/2^+$ $\Delta(1620)1/2^-$, $N(1650)1/2^-$, $N(1680)5/2^+$, $\Delta(1700)3/2^-$, $N(1720)3/2^+$, $N'(1720)3/2^+$, $\Delta(1905)5/2^+$, $\Delta(1950)7/2+$	0.25-1.50 0.5-1.5 photoproduction

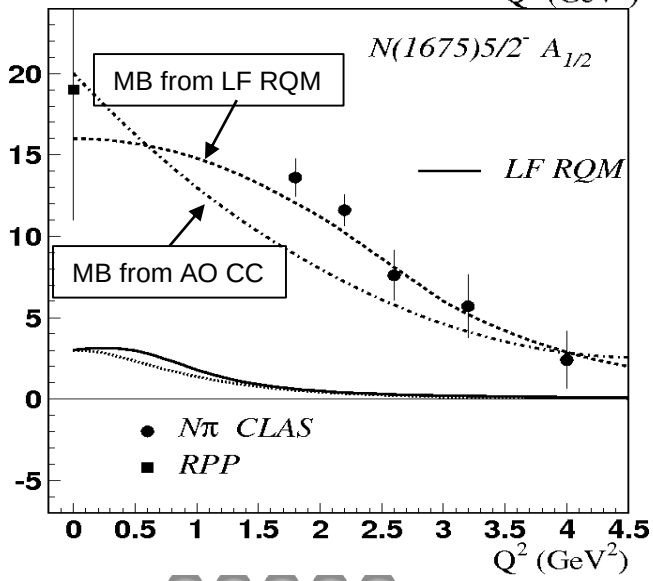
The website with numerical results and references: userweb.jlab.org/ ~mokeev/resonance_ electrocouplings/

The interpolated/extrapolated CLAS results on $\gamma_v pN^*$ electrocouplings in the mass range <1.8 GeV and Q^2<5.0 GeV^2: userweb.jlab.org/~isupov/couplings/

$\gamma_v pN^*$ Electrocouplings from $N\pi$, $N\eta$, and $\pi^+\pi^- p$ Electroproduction







CLAS data points from:
I.G. Aznauryan et al., Phys. Rev. C80, 055203 (2009).
K. Park et al., Phys. Rev. C91, 045203 (2015).
V.I. Mokeev et al., Phys. Rev . C86, 035203 (2012).
V.I. Mokeev et al., Phys. Rev.. C93, 025206 (2016).

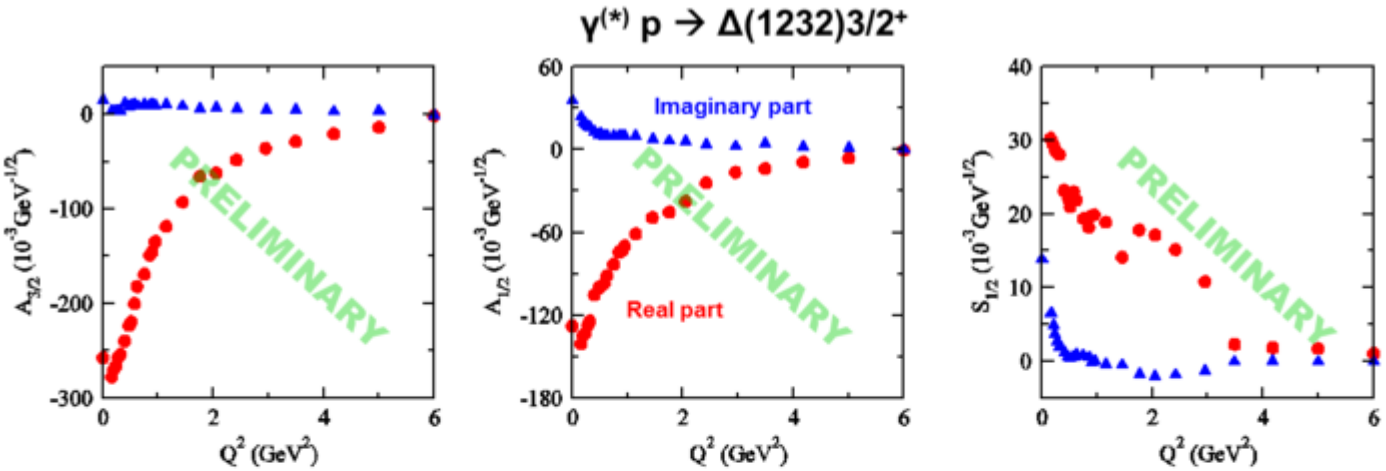
LF RQM:
I.G. Aznauryan and V.D. Burkert, Phys. Rev. C95, 065207 (2017).
AO CC:
B. Julia-Diaz et al., Phys. Rev. C77, 045205 (2008).

Consistent values of resonance electrocouplings from $N\pi$, $N\eta$, and $\pi^+\pi^- p$ electroproduction strongly support their reliable extraction

The structure of all resonances studied with CLAS represents a complex interplay between the inner quark core and external meson-baryon cloud.

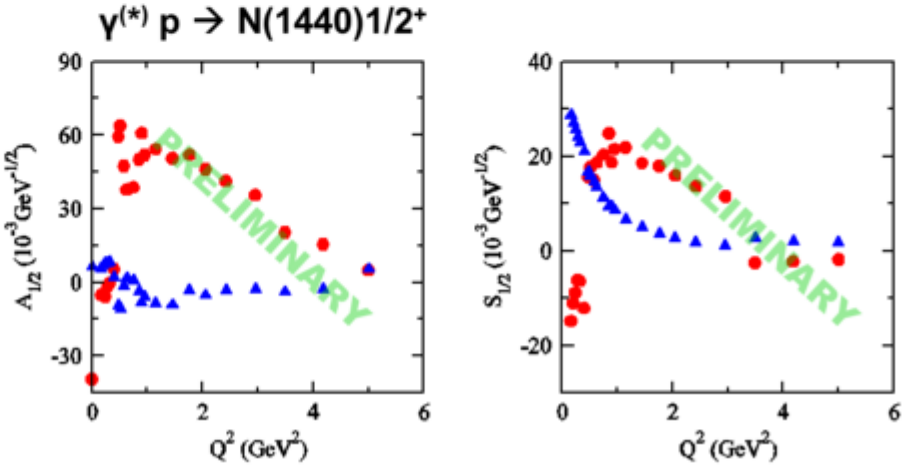
Resonance Electrocouplings from Global Multi-Channel Analysis

Argonne-Osaka (AO) eight-channel coupled channel approach
H. Kamano, Few Body Syst. 59, 24 (2018)



Channel included:

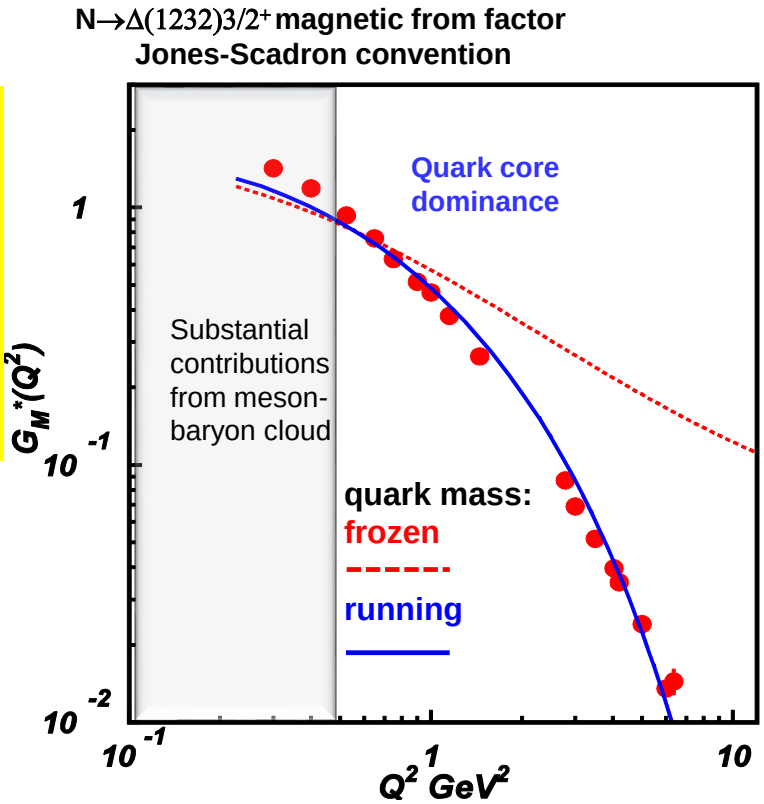
$\gamma_v p \rightarrow$ πN, ηN, $K\Lambda$, $K\Sigma$, $\pi\Delta$, ρN, σN

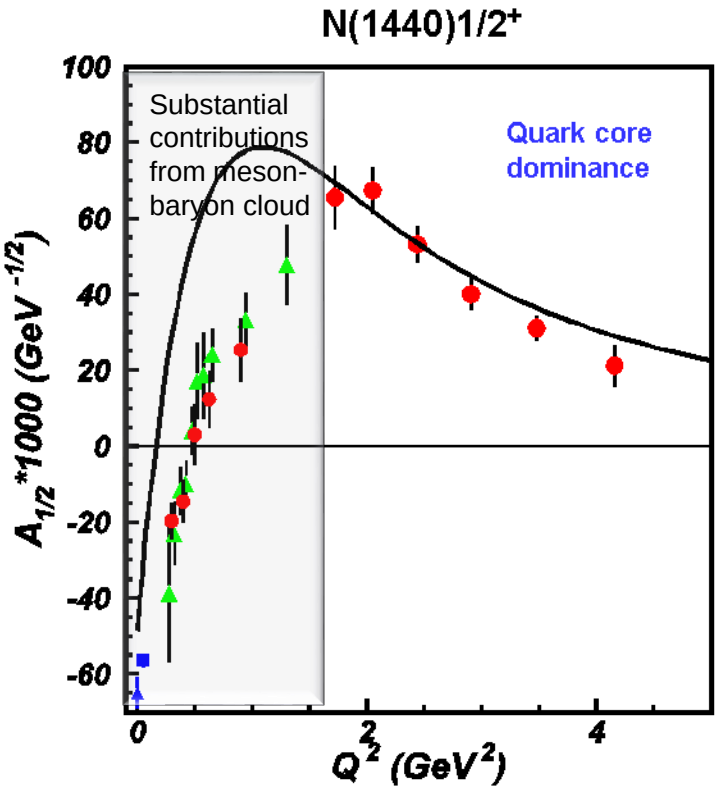


From Resonance Electrocouplings to Hadron Mass Generation

Dyson-Schwinger Equations (DSE):

- J. Segovia et al., Phys. Rev. Lett. 115, 171801 (2015).
- J. Segovia et al., Few Body Syst. 55, 1185 (2014).

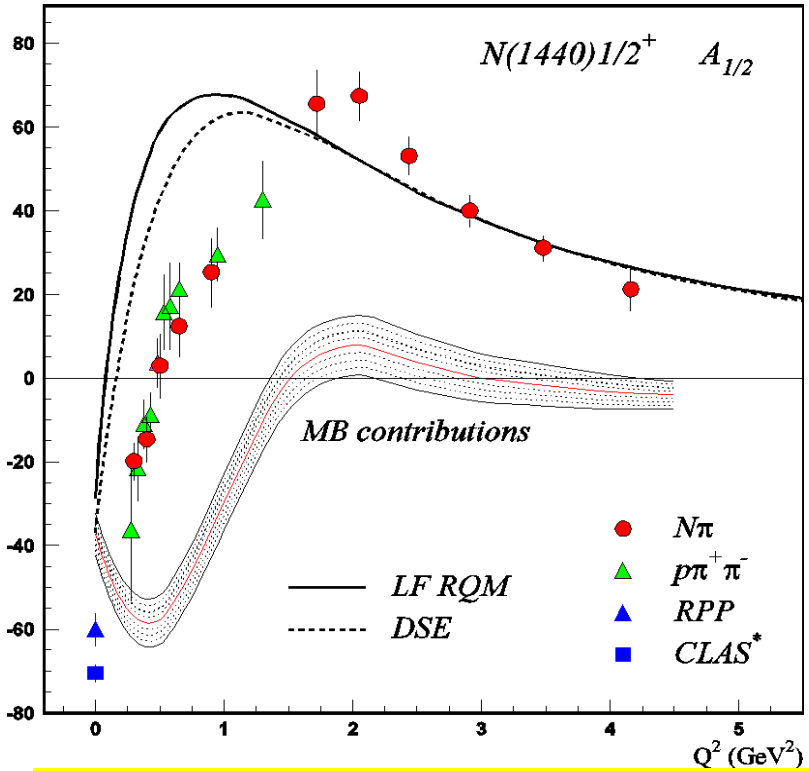


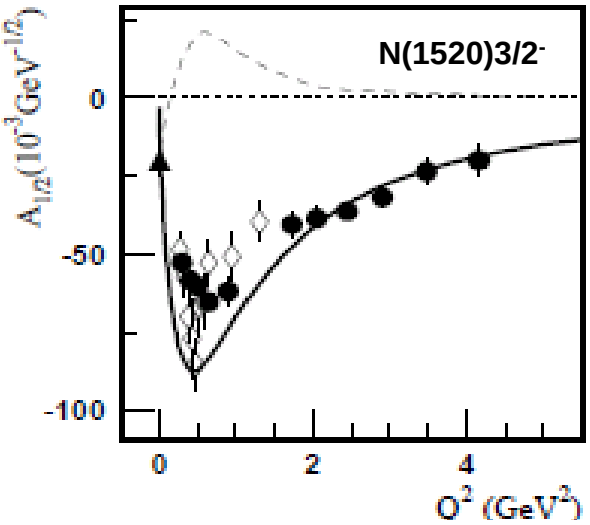


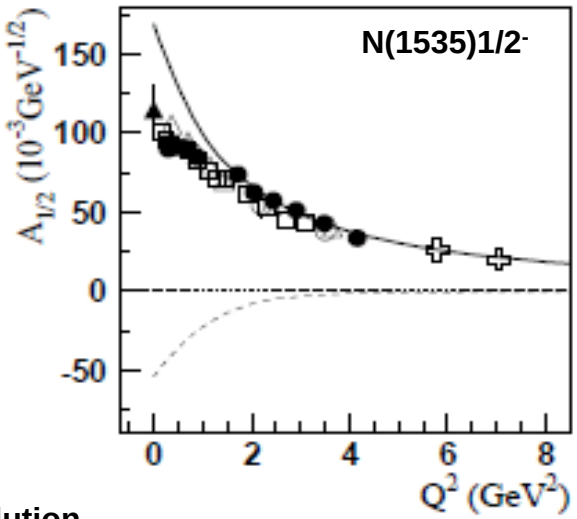
- ***Dressed quark mass is running with momentum***
- **Good data description at Q^2>2.0 GeV^2 with the same dressed quark mass function for the ground and different excited nucleon states validate the DSE results on generation of dressed quarks as the relevant degree of freedom in the structure of the ground and excited nucleons.**
- **γ_vpN* electrocoupling data are needed in order to map-out dressed quark mass function**

One of the most important achievements in hadron physics of the last decade in synergistic efforts between experimentalists and theorists.

Running Quark Mass from the Light Front Quark Model







Common momentum dependence of constituent quark mass fit to elastic nucleon form factor data.

Successful description of $\gamma_v pN^*$ electrocouplings of different resonances was achieved within LF RQM at $Q^2>2.0$ GeV^2 with the common running constituent quark mass

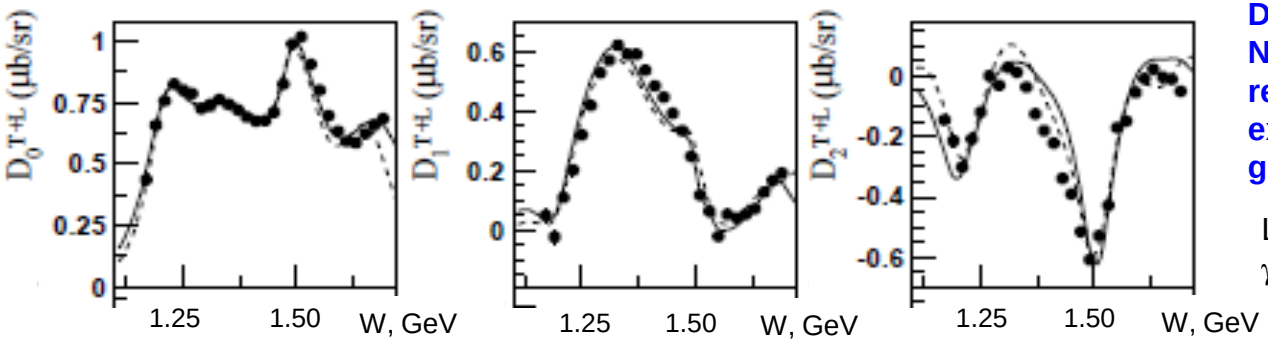
LF RQM-Light Front relativistic quark model: V.D. Burkert, I.G. Aznauryan, Phys . Rev. C85, 055202 (2012); Phys. Rev. C95, 065207 (2017).

Quark core descriptions within LF RQM and DSE are consistent.

For more details see:

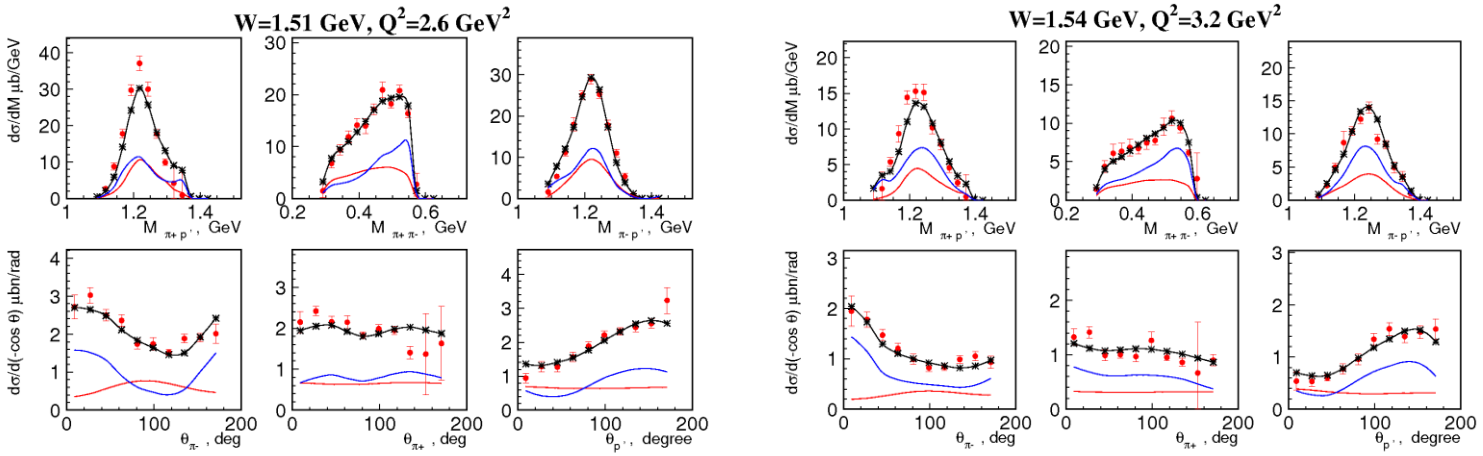
V. D. Burkert and C.D. Roberts ``Roper resonance-solution to the fifty year puzzle", arXiv:1710.02549 [nucl-ex].

Dressed Quark Mass Function from Exclusive Meson Electroproduction off Protons Data



DSE evaluations of N(1520)3/2$^-$ and N(1535)1/2$^-$ electrocouplings represent the next step needed for exploration of the hadron mass generation

Legendre moments of unpolarized $\gamma_v p \to \pi^+ n$ cross sections at Q^2=2.44 GeV^2



$\gamma_v p \to \pi^+ \pi^- p$

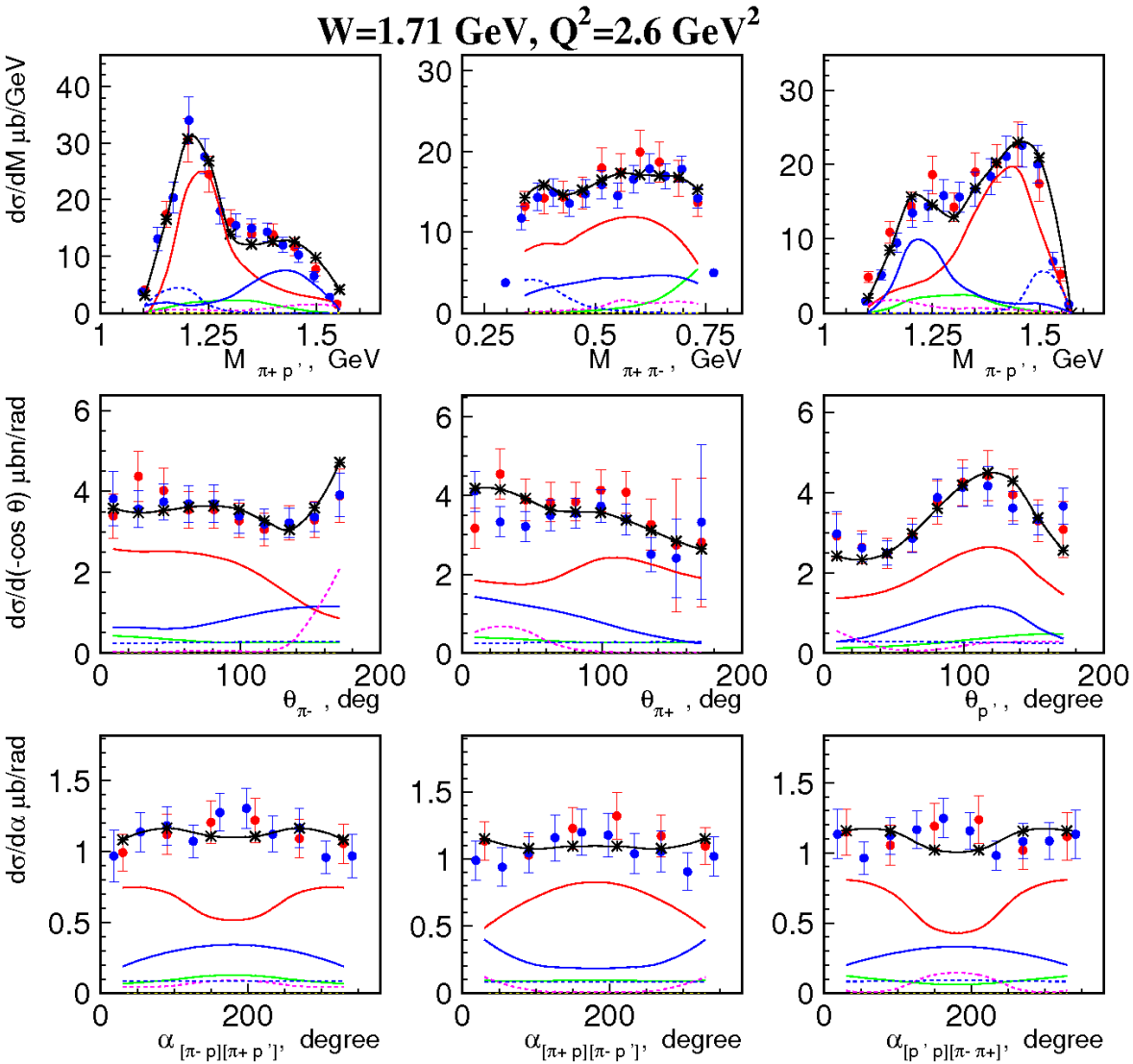
Resonant contributions

Non-resonant contributions

- **The observables of Nπ and $\pi^+\pi^-$p exclusive channels at W<1.55 GeV and 2.0 GeV^2<Q^2< 5.0 GeV^2 will be computed with electrocouplings of four relevant Δ(1232)3/2$^+$, N(1440)1/2$^+$, N(1520)3/2$^-$, and N(1535)1/2$^-$ resonances obtained within DSE by employing the common dressed quark mass function. Mass function parameters will be fit to the data.**

- **Insight to the dressed quark mass function from the Nπ and and $\pi^+\pi^-$p electroproduction observables. The correlations between different resonance electrocouplings imposed by the common quark mass function will be checked against the data for the first time. Successful data description will validate unambiguously credible access to the quark mass function.**

Extending the Kinematical Coverage of $\pi^+\pi^-$p Electroproduction off Proton Data



Two data sets at
1.40 GeV <W<2.0 GeV and
2.0 GeV² < Q² < 5.0 GeV² :

red - E. Isupov et al., CLAS Coll., Phys. Rev. C96, 025209 (2017), Mosc. State U., Jlab, Ohio U.

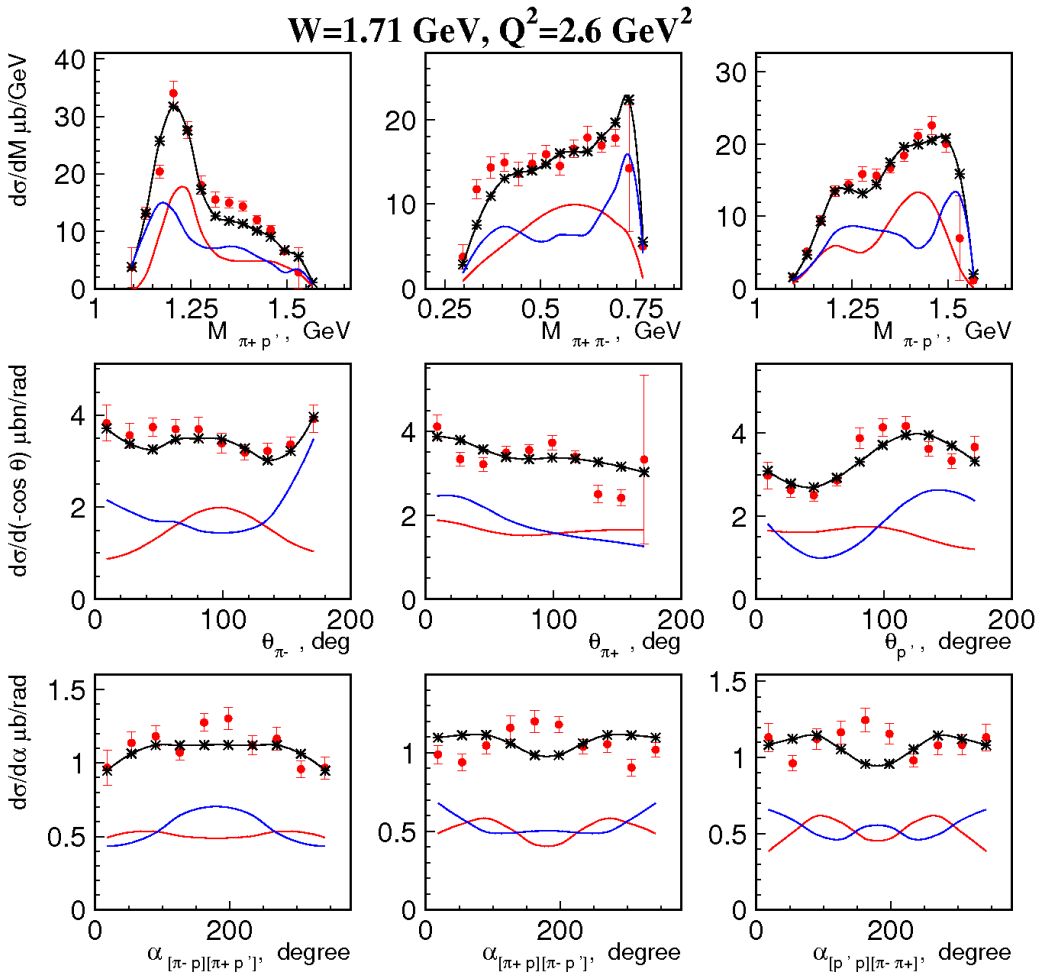
blue - preliminary, A.Trivedi, R.W. Gothe, USC.

JM18 results:

- full JM
- ρp
- $\pi^-\Delta^{++}$
- $\pi^+\Delta^0$
- π^+ N(1520)3/2⁻
- π^+ N(1680)5/2⁺

The JM18 model offers a good description of both $\pi^+\pi^-$p electroproduction off protons data sets

Prospects for $\gamma_v pN^*$ Electrocoupling Extraction



JM18 model version adjusted to the preliminary A.Trivedi & R.W. Gothe data

Resonant contributions

Non-resonant contributions

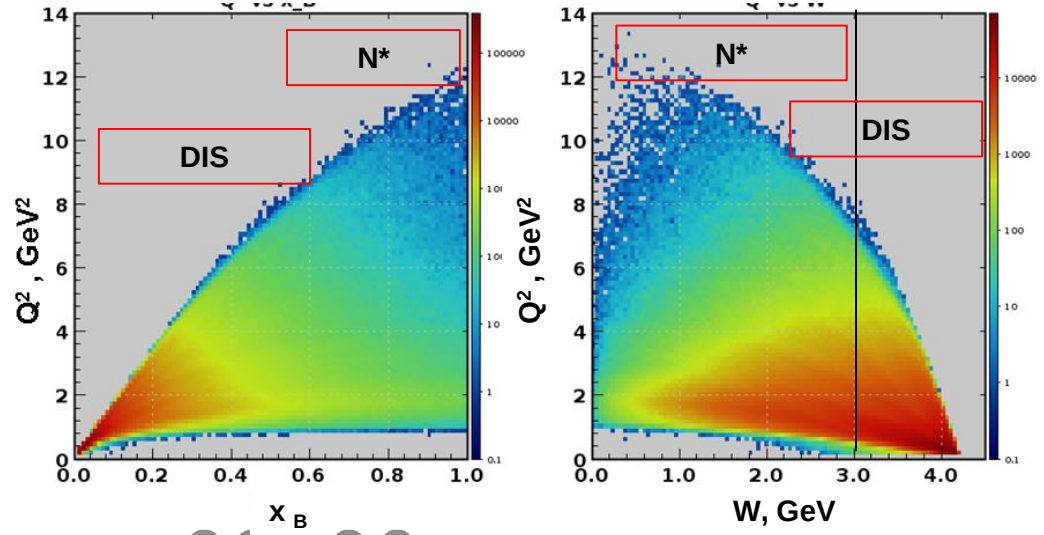
Significant resonant contributions and pronounced differences in the shapes of the resonant /non-resonant contributions were seen in all nine one-fold differential cross sections. The relative growth of the resonant contributions with Q^2 was observed.

In the near term future electrocouplings of most excited nucleon states in the mass range up to 2.0 GeV will become available from these data sets at 2.0 GeV^2<Q^2<5.0 GeV^2

Impact of the Extended CLAS Results on $\gamma_v pN^*$ Electrocouplings on the Exploration of Hadron Mass Generation

- **The $\gamma_v pN^*$ electrocouplings of most resonances in the mass range of W<2.0 GeV will become available in the near term future at Q^2<5.0 GeV^2 from the Nπ and $\pi^+\pi^-$p electro-production off protons data.**
- **First results on electrocouplings of the resonances in the mass range of W<1.6 GeV will become available at 2.0 GeV^2<Q^2<5.0 GeV^2 from independent studies of the Nπ and $\pi^+\pi^-$p electroproduction off proton data.**
- **Electrocouplings of many resonances in the mass range of W >1.6 GeV which decay preferentially to the N$\pi\pi$ final states will be obtained for the first time at 2.0 GeV^2 < Q^2<5.0 GeV^2.**
- **New opportunities to explore Dynamical Chiral Symmetry Breaking (DSCB) from the data on the parity partner electrocouplings: $\Delta(1232)3/2^+$ vs $\Delta(1700)3/2^-$, $N(1520)3/2^-$ vs $N(1720)3/2^+$ shedding light on connection between the hadron mass generation and DCSB.**
- **Exploration of different types of di-quark correlations from the $\gamma_v pN^*$ electrocouplings obtained over full N*-spectrum within the mass range of W <2.0 GeV.**
- **New N* electrocouplings results from CLAS pave a way for exploration of universality or environmental sensitivity of dressed quark mass function. Observation of the dressed quark mass sensitivity to the resonance quantum numbers will open a new avenue in the exploration of hadron mass generation.**

12 GeV Era with the CLAS12 Detector



CLAS12 kinematic coverage from the first inclusive electron scattering events

CLAS12 N* Program at High Q^2

E12-09-003	E12-06-108A
Nucleon Resonance Studies with CLAS12	KY Electroproduction with CLAS12
Gothe, Mokeev, Burkert, Cole, Joo, Stoler	*Carman, Gothe, Mokeev*

- Measure exclusive electroproduction cross sections from an unpolarized proton target with polarized electron beam for $N\pi$, $N\eta$, $N\pi\pi$, KY:

  E_b = 11. GeV, Q^2 = 3 → 12 GeV^2, W → 3.0 GeV with nearly complete coverage of the final state phase space

- Key Motivation

  Study the structure of all prominent N states in the mass range up to 2.0 GeV vs. Q^2 up to 12 GeV^2.*

  CLAS12 is the only facility to map-out the N quark with minimal meson-baryon cloud contributions.*

The experiments already started in February 2018!

Emergence of Hadron Mass and Quark-Gluon Confinement

N* electroexcitation studies at JLab will address the critical open questions:

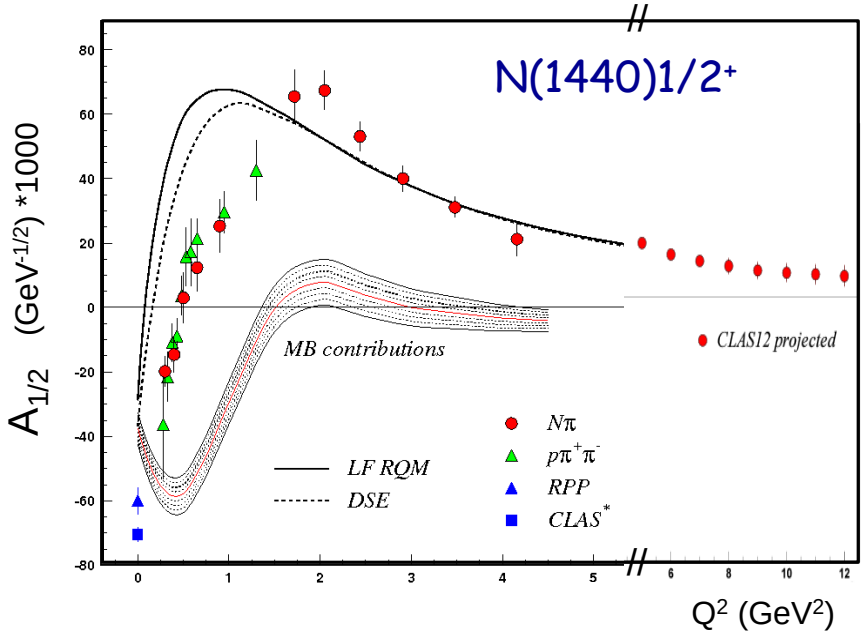
How is >98% of visible mass generated?

How does confinement emerge from QCD and how is it related to Dynamical Chiral Symmetry Breaking?

What is the behavior of QCD's running coupling at infrared momenta?

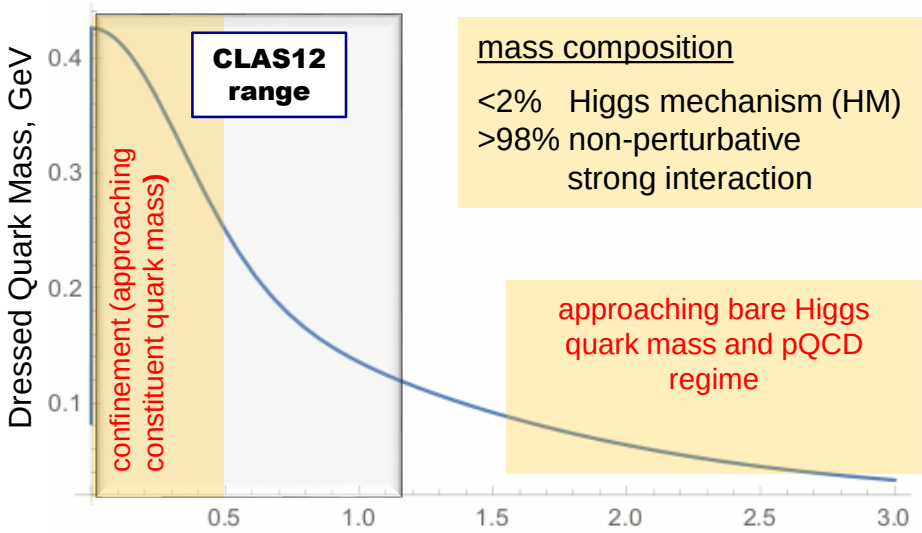
(D. Binosi et al., Phys. Rev. D96, 054026 (2017))

Mapping-out quark mass function from the CLAS12 results on $\gamma_v pN^*$ electrocouplings of spin-isospin flip, radial, and orbital excited nucleon resonances at $5<Q^2<12$ GeV^2 will allow us to explore the transition from strong QCD to pQCD regimes.



CLAS results versus theory expectations with running quark mass

Access to the dressed quark/hadron mass generation



mass composition

<2% Higgs mechanism (HM)
>98% non-perturbative strong interaction

Conclusions and Outlook

- **High quality meson electroproduction data from CLAS have allowed us to determine the electrocouplings of most resonances in the mass range up to 1.8 GeV with consistent results from analyses of π^+n, π^0p, ηp, and $\pi^+\pi^-p$ electroproduction channels.**

- **<u>Profound impact on the exploration of strong QCD dynamics underlying the hadron mass generation:</u>**
  a) first DSE evaluations of $\Delta(1232)3/2^+$ and $N(1440)1/2^+$ electroexcitation amplitudes with a traceable connection to the QCD Lagrangian;
  b) synergistic efforts between the experimental studies of $\gamma_v pN^*$ electrocouplings in Hall B at JLab and the continuum QCD theory at ANL have demonstrated the capability for reliable access to the dressed quark mass function at the distances corresponded to the strong QCD regime.

- **Electrocouplings of most resonances in the mass range up to 2.0 GeV will become available at $2.0\ GeV^2<Q^2<5.0\ GeV^2$ from the new CLAS data on $\pi^+\pi^-p$ electroproduction in the near term future.**

- **New opportunities to explore the connection between the hadron mass generation and DCSB through comparative studies of electrocouplings of the chiral parity partner pairs, in particular, electrocouplings of $\Delta(1232)3/2^+$ vs $\Delta(1700)3/2^-$, $N(1520)3/2^-$ vs $N(1720)3/2^+$ resonances.**

- **Exploration of universality or environmental sensitivity of dressed quark mass function from electrocouplings of most resonances in the mass range of W <2.0 GeV.**

Conclusions and Outlook

- **CLAS12 is the only facility in the world capable of obtaining electrocouplings of all prominent N* states at still unexplored ranges of highest photon virtualities for exclusive reactions from 5.0 GeV^2 to 12 GeV^2 from measurements of Nπ, $\pi^+\pi^-$p, and KY electroproduction.**

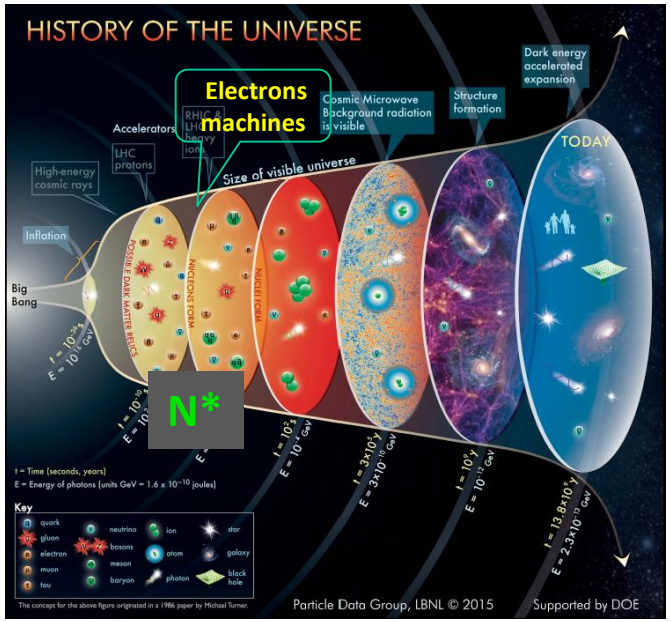
- **The expected results will allow us to map out the dressed quark mass function at the distances where the transition from quark-gluon confinement to pQCD regime is expected, addressing the most challenging problems of the Standard Model on the nature of >98% of hadron mass and of quark-gluon confinement.**

- **Success of the N* program will be very beneficial for the hadron physics community fostering the synergistic efforts between the resonance structure and DIS process studies aimed to get insight into the strong QCD dynamics underlying the hadron mass generation and behavior of the QCD running coupling.**

- **The QCD-rooted theory framework for the unified description of the ground and excited nucleon state structure offering a description and predictions of the parameters extracted from experiment is of particular importance.**

Back up

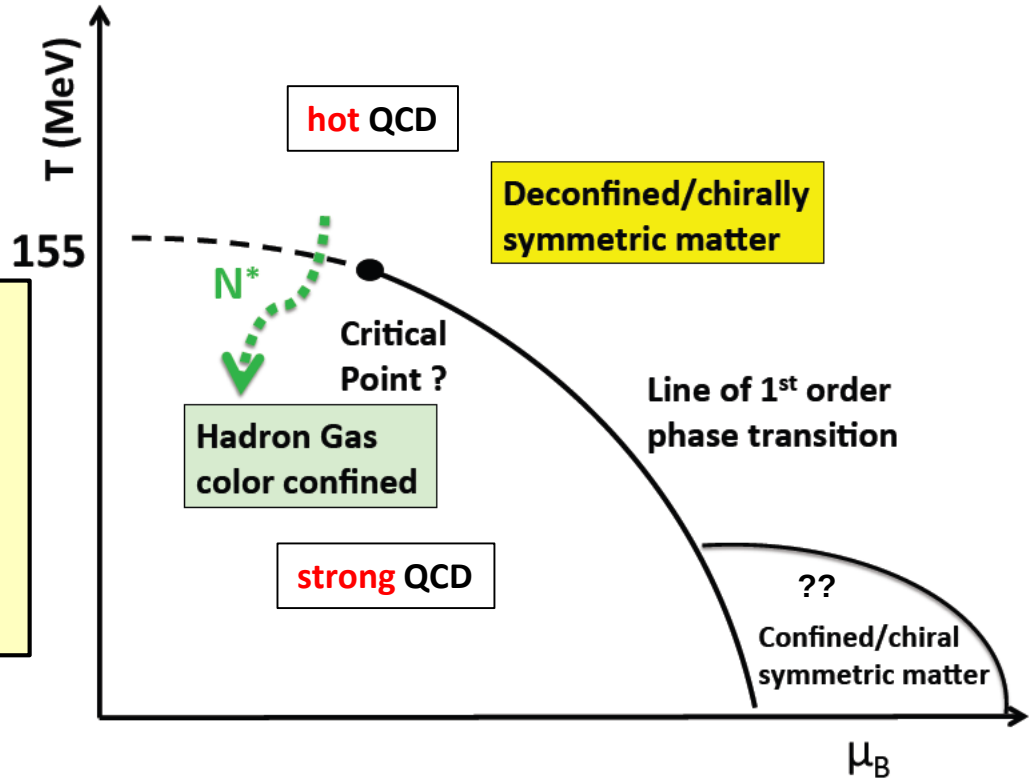
Nucleon Resonances in the History of the Universe



- Chiral symmetry is broken
- Quarks acquire mass
- Baryon resonances occur
- Quark-gluon confinement emerges

Full baryon spectrum shaped this transition

Dramatic events occur in the micro-second old universe during the transition from the QGP phase to hadron phase.



N* studies at 0.05 GeV^2 < Q^2 < 7.0 GeV^2 with CLAS12

Hybrid Baryons E12-16-010	Search for hybrid baryons (qqqg) focusing on 0.05 GeV^2 < Q^2 < 2.0 GeV^2 in mass range from 1.8 to 3 GeV in KΛ, Nππ, Nπ *(A. D'Angelo, et al.)*
KY Electroproduction E12-16-010A	Study N* structure for states that couple to KY through measurements of cross sections and polarization observables that will yield Q^2 evolution of electrocoupling amplitudes at Q^2<7.0 GeV^2 *(D. Carman, et al.)*

Approved by PAC44

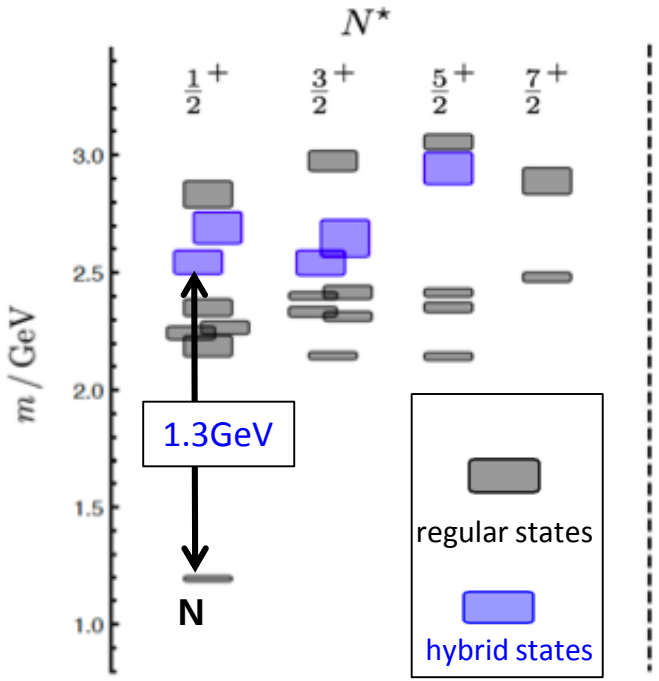
Run Group conditions:
E_b = 6.6 GeV, 50 days
E_b = 8.8 GeV, 50 days

- Polarized electrons, unpolarized LH_2 target
- L = 1x10^{35} cm^{-2}s^{-1}

Hunting for Glue in Excited Baryons with CLAS12

Can glue be a structural component to generate hybrid q^3g baryon states?

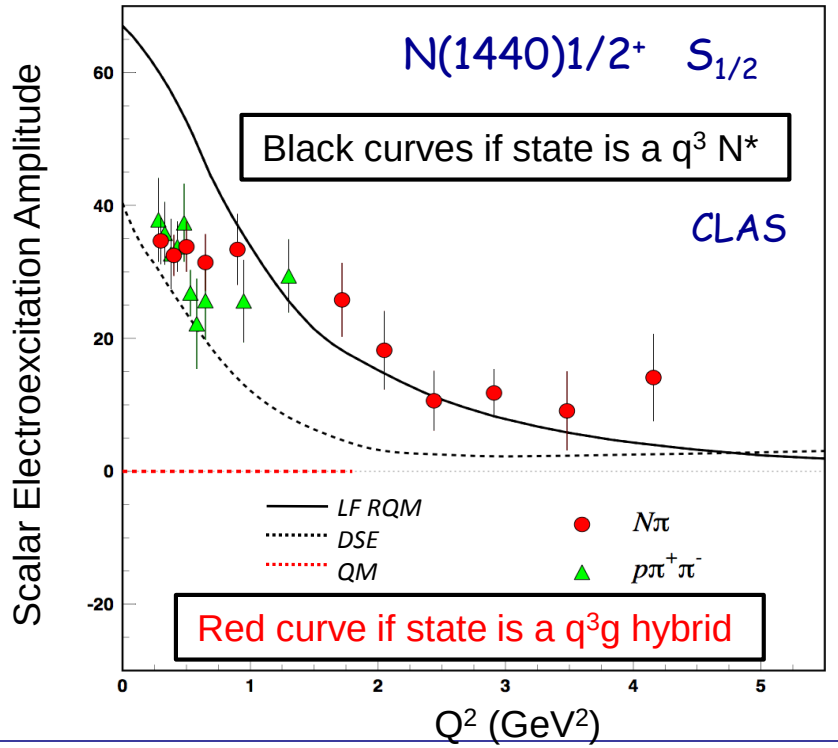
Predictions of the N* spectrum from QCD show both regular q^3 *and* hybrid q^3g states



JLab LQCD group results

Search for hybrid baryons with CLAS12 in exclusive KY and $\pi^+\pi^-$p electroproduction

LQCD and/or QM predictions on Q^2 evolution of the hybrid-baryon electroexcitation amplitudes are critical in order to establish the nature of a baryon state



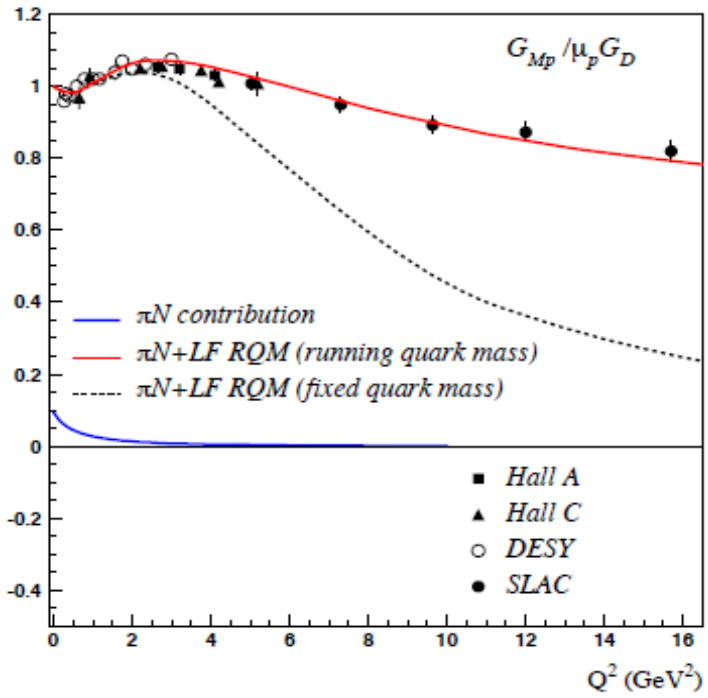
Quark Model with Input from QCD-based Approaches

Light Front QM by I.G. Aznauryan and V.D. Burkert: PRC 85, 055202 (2012).

The approach discussed here is purely phenomenological, and addresses a few topics that have some importance for the direction of the field, in particular:

- obtain a better understanding of the expected meson-baryon contributions
- study the sensitivity of the resonance transition amplitudes to the running quark mass, which is a result of the DSE approach and of LQCD calculations.

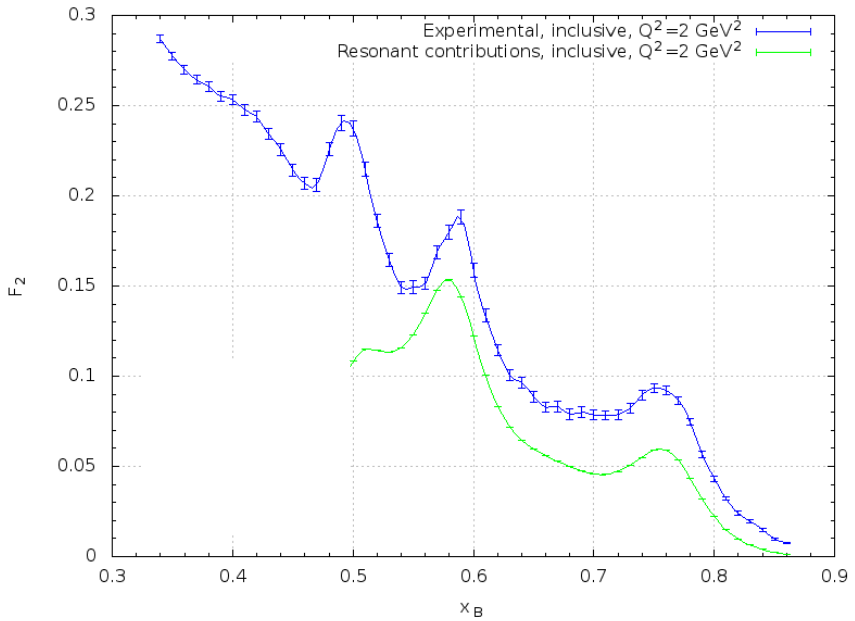
Proton Magnetic Form Factor

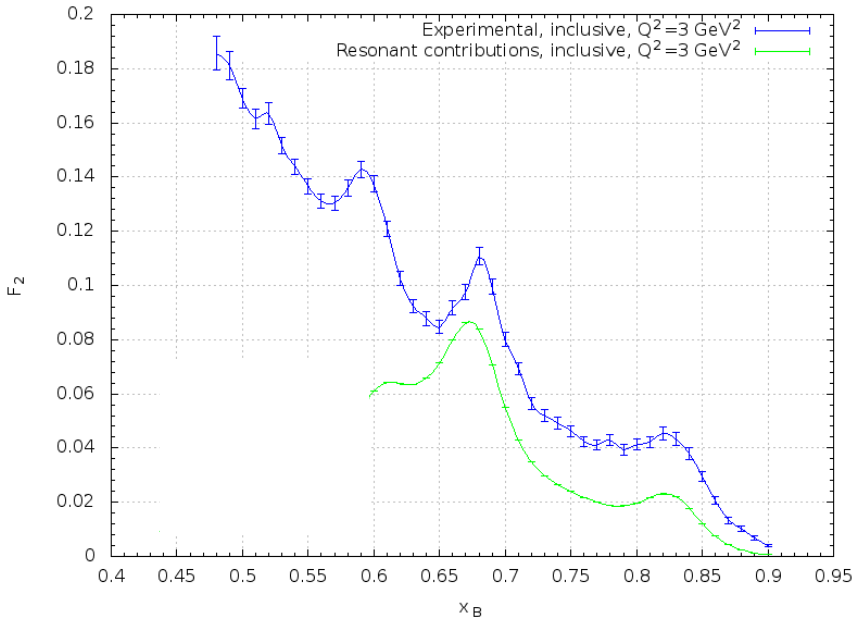


- Nucleon electromagnetic form factors
  → $q^3 + \pi N$ loops contributions in light-front dynamics
  → running quark mass
- Electroexcitation of $\Delta(1232)\frac{3}{2}^+$, $N(1440)\frac{1}{2}^+$, $N(1520)\frac{3}{2}^-$, and $N(1535)\frac{1}{2}^-$
  → q^3 contribution in a LF RQM with running quark mass
  → inferred MB contributions

Implementation of momentum-dependent quark mass is needed in order to reproduce elastic magnetic form factor of proton at Q^2>3.0 GeV^2

Accessing Parton Distributions in the Resonance Region





Interpolation of the CLAS data on $F_2(x,Q2)$ structure function, M.Osipenko et al. (CLAS Coll), Phys. Rev. D67, 092001 (2003).

Resonant contributions from the CLAS results on $\gamma_v pN^*$ electrocouplings stored in: userweb.jlab.org/~mokeev/resonance_electrocouplings, userweb.jlab.org/~isupov/couplings/

The CLAS results on electrocouplings of most N* in the mass range of W <1.8 GeV and at Q^2<5.0 GeV^2 makes it possible to evaluate the resonant contributions to the inclusive electron scattering offering access to the parton distributions at large x_B in the resonance region

See details in the talk: A.N. Hiller Blin ``Constraints from Finite-Energy Sum Rules on Inclusive Electron and Virtual Compton Scattering"