Updates on the Studies of N* Spectrum and Structure with the CLAS Detector

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Hall-B Staff Meeting, September 21, 2015

Major Directions in the Studies of N*-Spectrum and Structure with CLAS

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

- $\gamma_v NN^*$ electrocouplings at photon virtualities up to 5.0 GeV^2 for most of the excited proton states through analyzing major meson electroproduction channels
- extend knowledge on N*-spectrum and on resonance hadronic decays from the data for photo- and electroproduction reactions with multiple mesons in the final state.

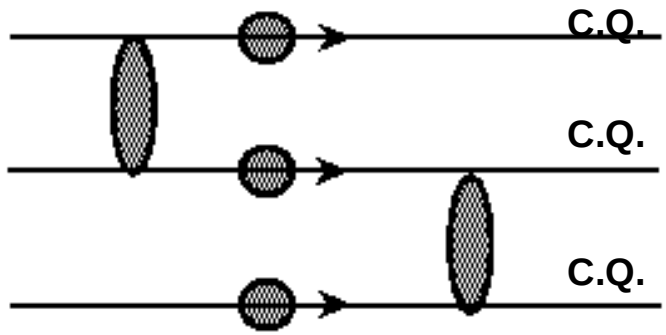
A unique source of information on different manifestations of the non-perturbative strong interaction in generating different excited nucleon states as relativistic bound systems of quarks and gluons.

Review papers:

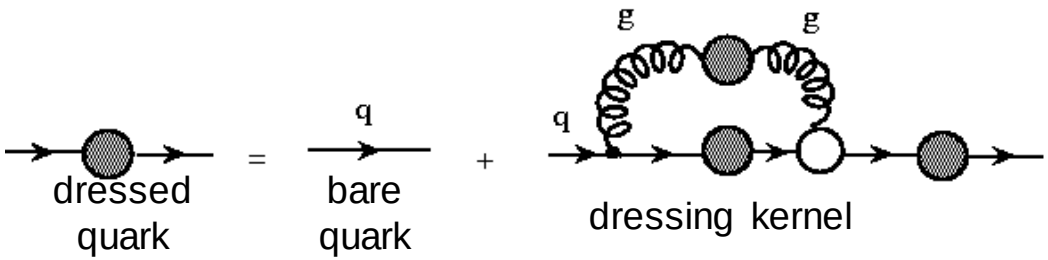
1. **I.G. Aznauryan and V.D.Burkert, Progr. Part. Nucl. Phys. 67, 1 (2012).**
2. **I.G. Aznauryan et al., Int. J. Mod. Phys. E22, 133015 (2013).**
3. **I.C. Cloët and C.D. Roberts, Prog. Part. Nucl. Phys. 77, 1 (2014).**

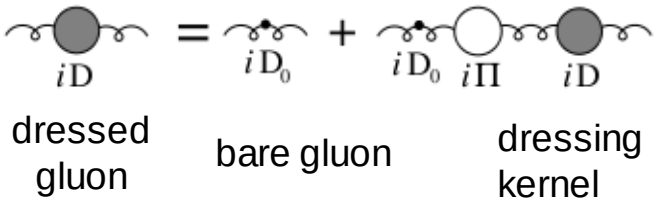
Excited Nucleon States and Insight to Non-Perturbative Strong Interaction

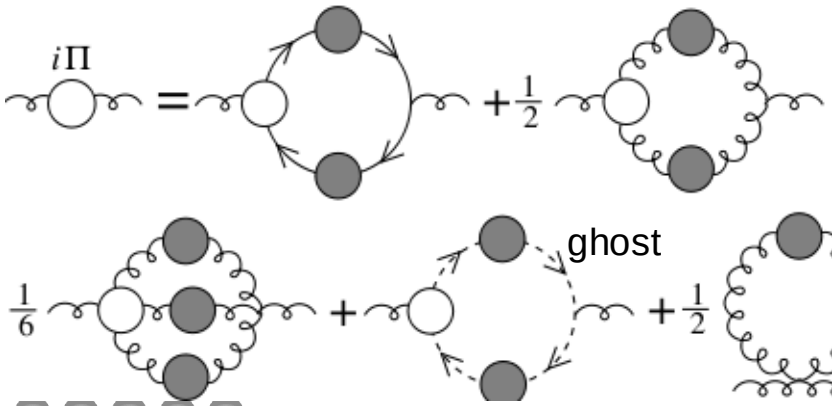
Studies of N* spectrum/structure suggest that ground and excited nucleon states consist of three dressed (constituent) quarks (C.Q.) coupled by non-perturbative strong interaction (ovals in the plot).



Emergence of dressed quarks and gluons

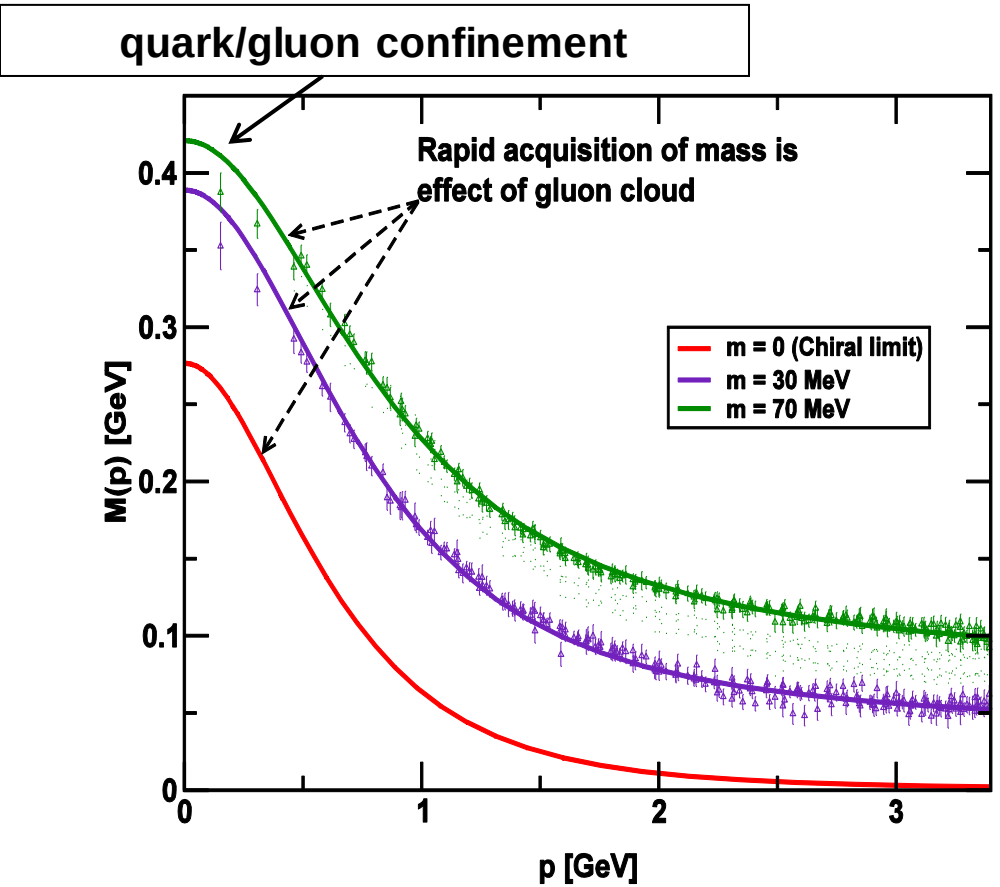






In the regime of large α_s that is relevant for N* formation, dressed quarks and gluons are substantially different with respect to the bare quarks and gauge gluons. They acquire dynamical structure and momentum-dependent mass.

Dressed Quark Evolution from pQCD to Confinement Regimes



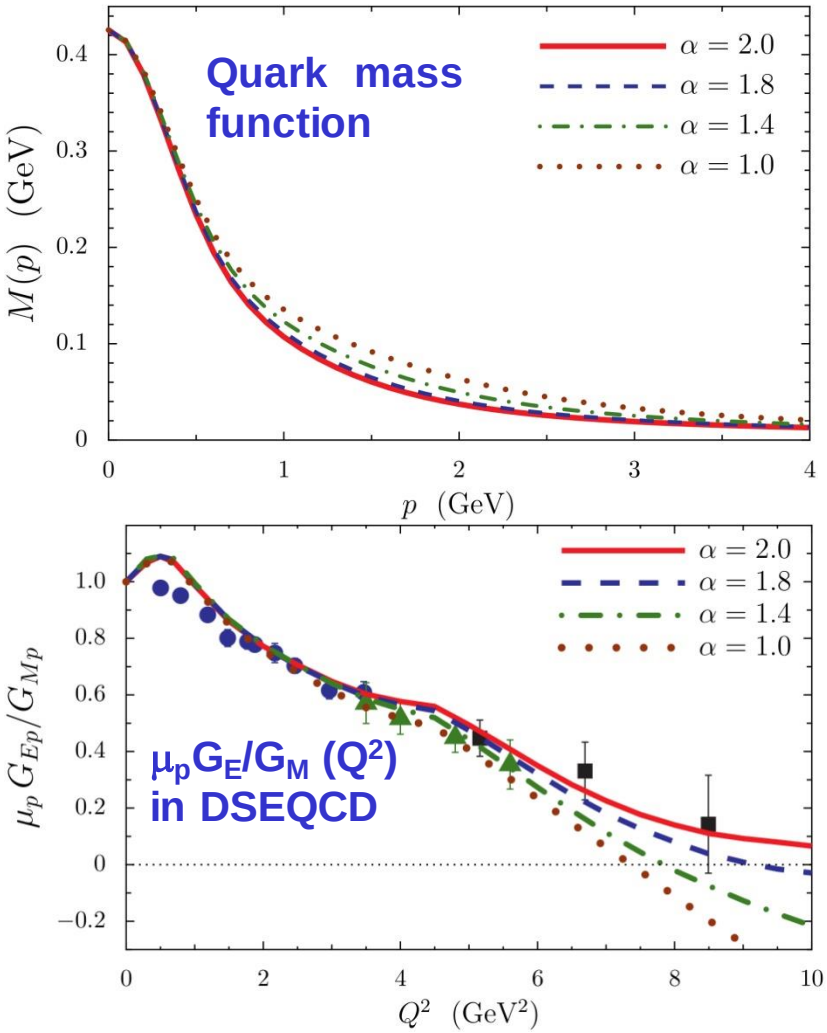
Consistent results from two different based on QCD approaches:

- LQCD - P.O.Bowman, et al., PRD **71**, 054505 (2005) (points with error bars).
- DSEQCD – C.D.Roberts, Prog. Part. Nucl. Phys. **61,** 50 (2008) (lines).

• more than 98% of dressed quark (N/N*) masses as well as their dynamical structure are generated non-perturbatively through dynamical chiral symmetry breaking (DCSB). The Higgs mechanism accounts for less than 2% of the nucleon & N* mass.

•the momentum dependence of the dressed quark mass reflects the transition from quark/gluon confinement to asymptotic freedom.

Mapping –out Quark Mass Function



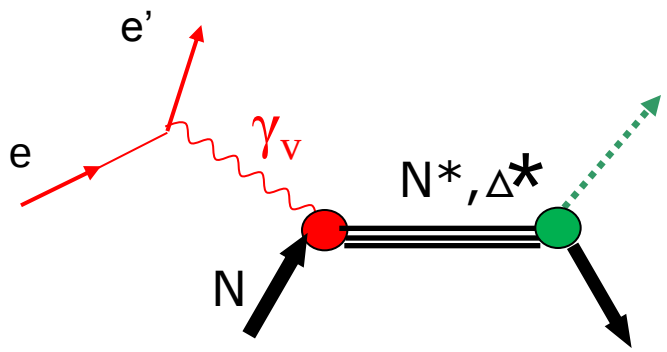
I.C.Cloët, C.D.Roberts, A.W.Thomas, Phys. Rev. Lett. 111, 101803 (2013).

- **elastic form factors are sensitive to momentum dependence of quark mass function.**
- **mass function should be the same for dressed quarks in the ground and excited nucleon states.**
- **consistent results on dressed quark mass function determined from the data on elastic form factors and transition γ_vNN* electrocouplings are critical for reliable extraction of this quantity.**
- **results on transition γ_vNN* electrocouplings offer an access to dynamics of quark-gluon vertex dressing beyond simplified rainbow-ladder truncation.**

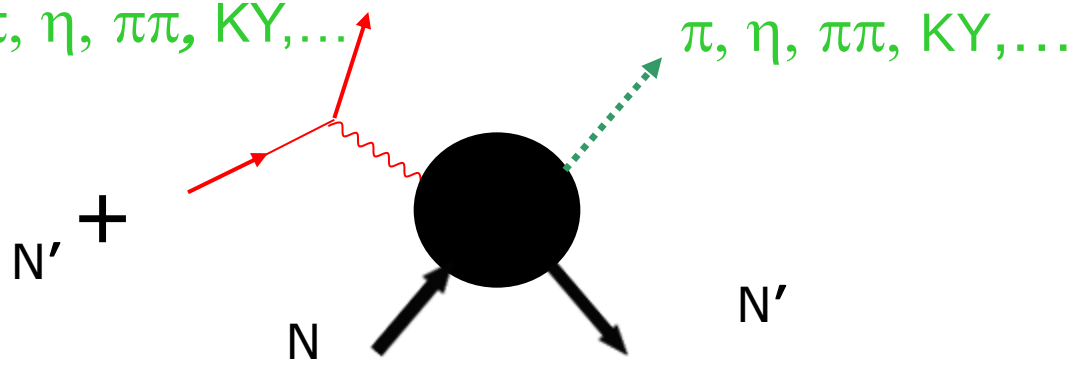
Studies of γ_vNN* electrocouplings (transition N→N* form factors) represents the central direction in the exploration of strong interaction in non-perturbative regime.

Extraction of γ_vNN* Electrocouplings from the Exclusive Meson Electroproduction off Nucleons

Resonant amplitudes



Non-resonant amplitudes



- Real $A_{1/2}(Q^2)$, $A_{3/2}(Q^2)$, $S_{1/2}(Q^2)$
  or
- $G_1(Q^2)$, $G_2(Q^2)$, $G_3(Q^2)$
  or
- $G_M(Q^2)$, $G_E(Q^2)$, $G_C(Q^2)$

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

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

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

Γ_γ stands for N* electro-magnetic decay widths at $W=M_{N^*}$ on the real energy axis.

- **Consistent results on γ_vNN* electrocouplings from different meson electroproduction channels and different analysis approaches demonstrate reliable extraction of these quantities.**

Summary of the 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 thresh-2.6	1.40-3.90 0.70-5.40	$d\sigma/d\Omega$ P'
$\pi^+\pi^-p$	1.3-1.6 1.4-2.1	0.2-0.6 0.5-1.5	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 asymmetries
- P^0 P' –recoil and transferred polarization of strange baryon

Almost full coverage of the final hadron phase space in πN, $\pi^+\pi^-p$, ηp, and KY electroproduction.

The data on exclusive electroproduction for all listed final states are available from CLAS and stored in the CLAS Physics Data Base http://clas.sinp.msu.ru/cgi-bin/jlab/db.cgi.

Approaches for Extraction of γ_vNN* Electrocouplings from the CLAS Exclusive Meson Electroproduction Data

- **Analyses of different pion electroproduction channels independently:**

➢ π^+n and π^0p 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 Coll., Phys Rev. C80, 055203 (2009).
I.G.Aznauryan et al., CLAS Coll., 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 S_{11}(1535) dominance

H.Denizli et al., CLAS Coll., 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 Coll., Phys. Rev. C86, 035203 (2012).

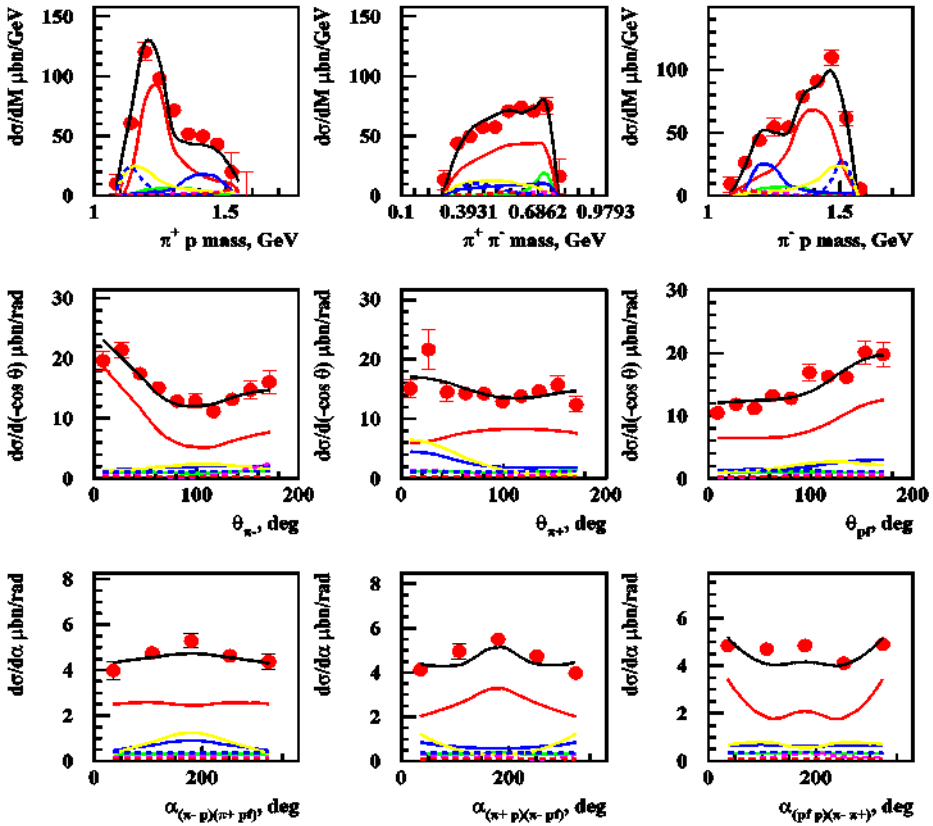
Global coupled-channel analyses of the CLAS/world data of $\pi N, \gamma_{r,v} N \to \pi N, \eta N, \pi\pi N, K\Lambda, K\Sigma$ exclusive channels:

T.-S. H. Lee , AIP Conf. Proc. 1560, 413 (2013).
H. Kamano et al., Phys. Rev. C88, 035209 (2013).

Fits to Differential Cross Sections

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

M.Ripani et al., PRL 91, 022002 (2003),
1.40<W<2.30 GeV; 0.5<Q^2<1.5 GeV^2
W=1.71 GeV, Q^2=0.65 GeV^2

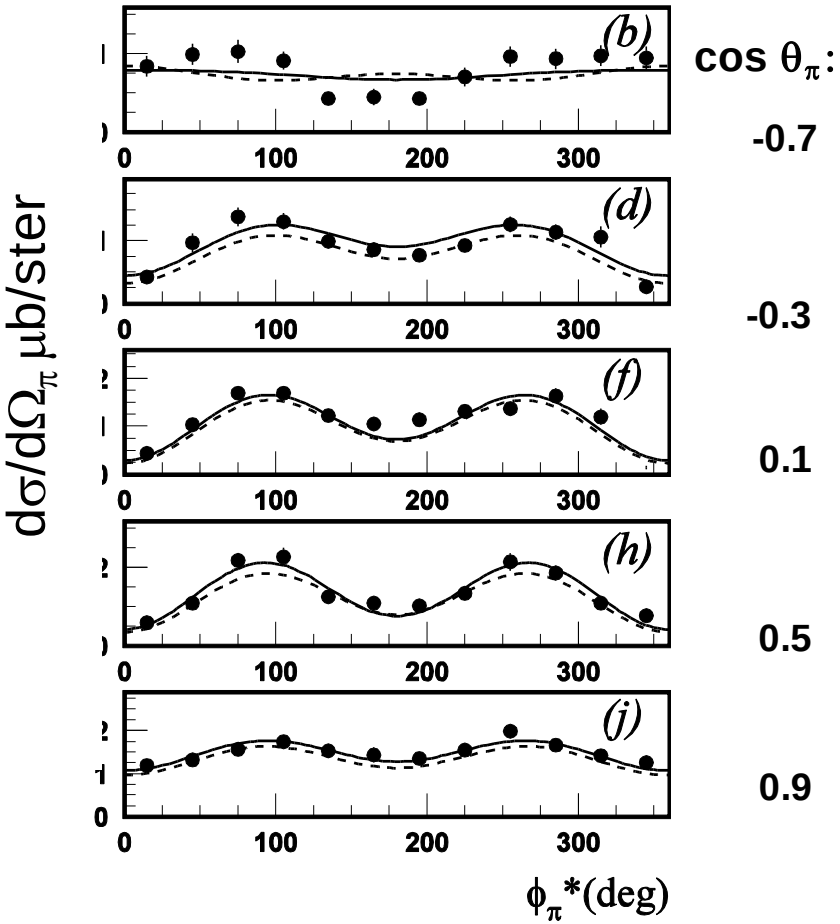


$\gamma_v p \rightarrow \pi^+ n$

K.Park et al., Phys. Rev. C91, 052014 (2015).

W=1.68 GeV
Q^2=1.8 GeV^2

——— DR
---------- UIM

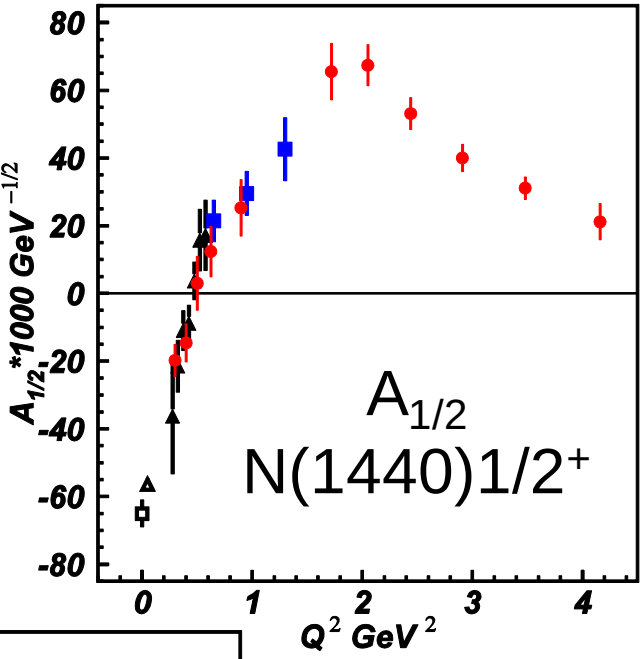


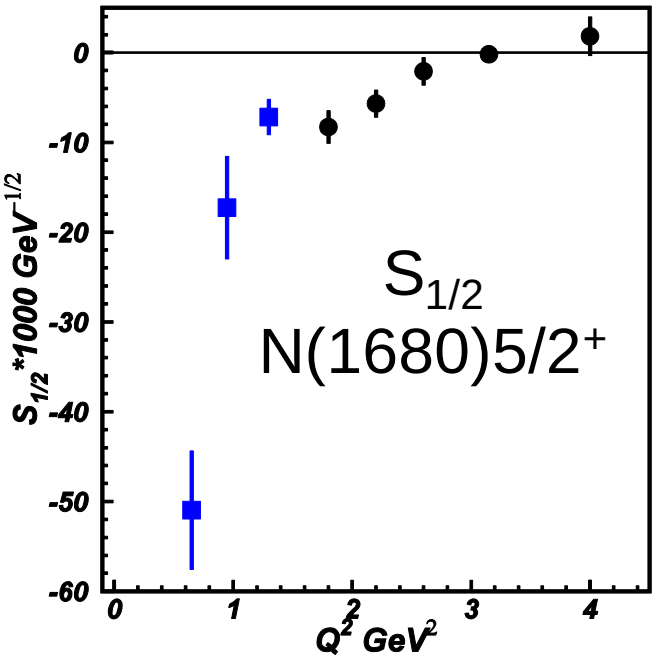
γ_vNN* Electrocouplings from Nπ and $\pi^+\pi^-$p Electroproduction

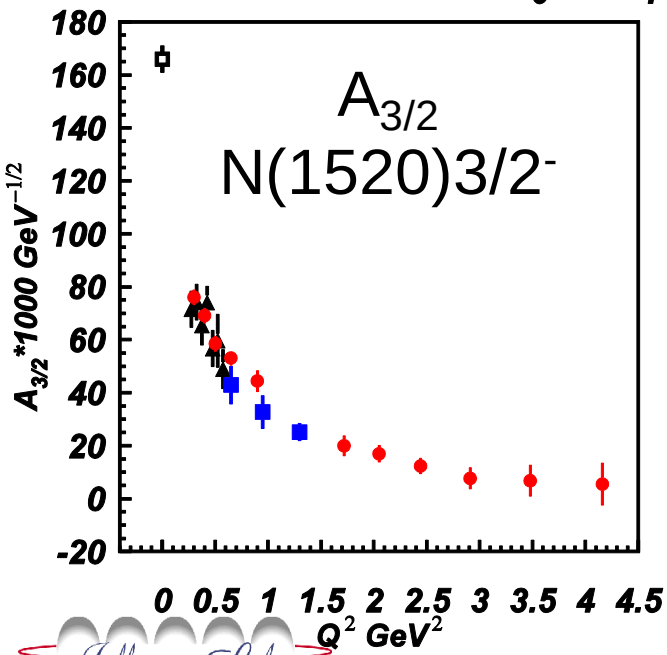
CLAS data:

- Nπ 2009
- $\pi^+\pi^-$p 2012
- $\pi^+\pi^-$p submitted to PRC
- Nπ 2015

I.G.Aznauryan et al., Phys. Rev. C80, 055203 (2009).
V.I.Mokeev et al., Phys. Rev . C86, 035203 (2012).
K.Park et al., Phys. Rev. C91, 052014 (2015).



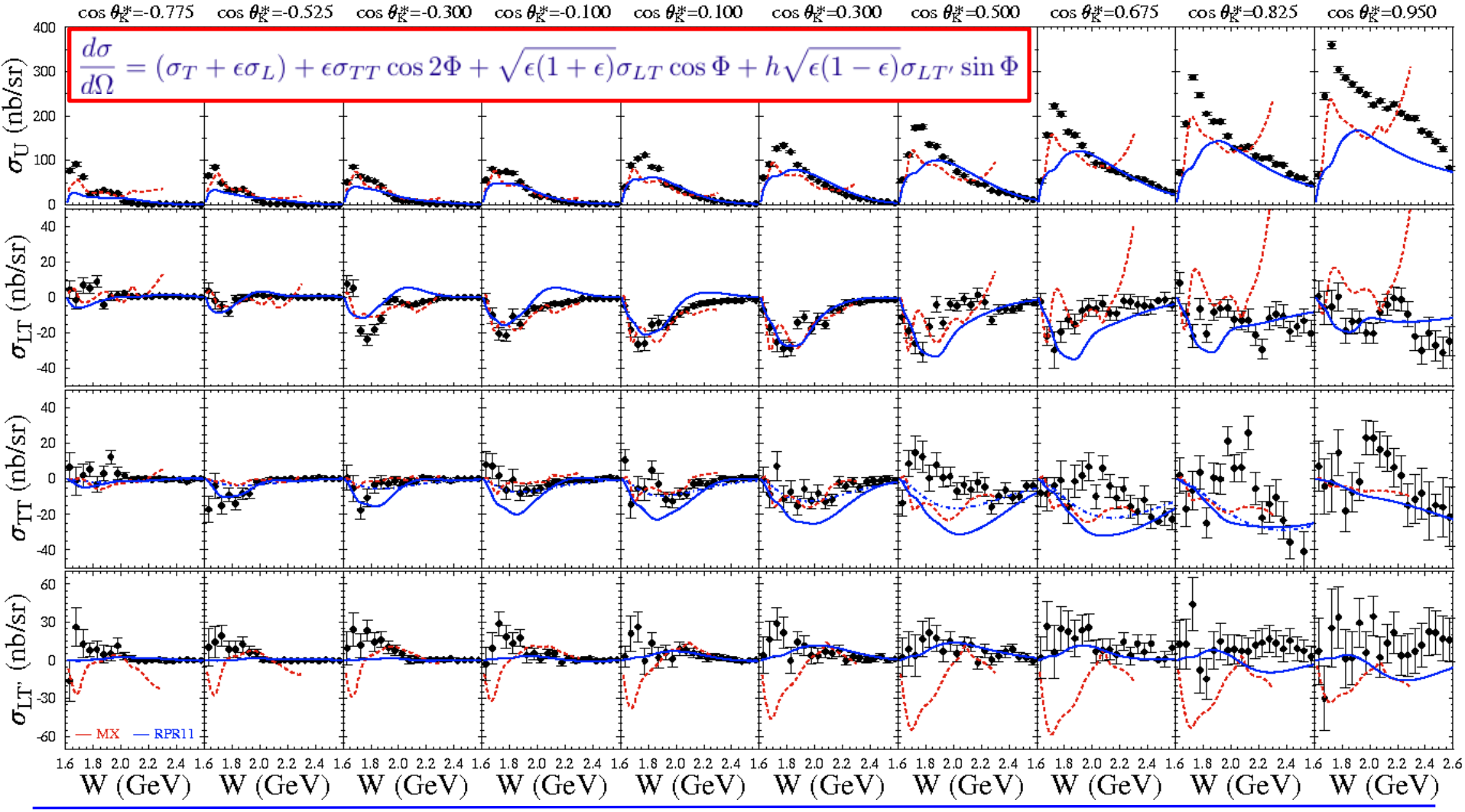




Consistent values of resonance electrocouplings from analyses of Nπ and $\pi^+\pi^-$p exclusive channels strongly support:

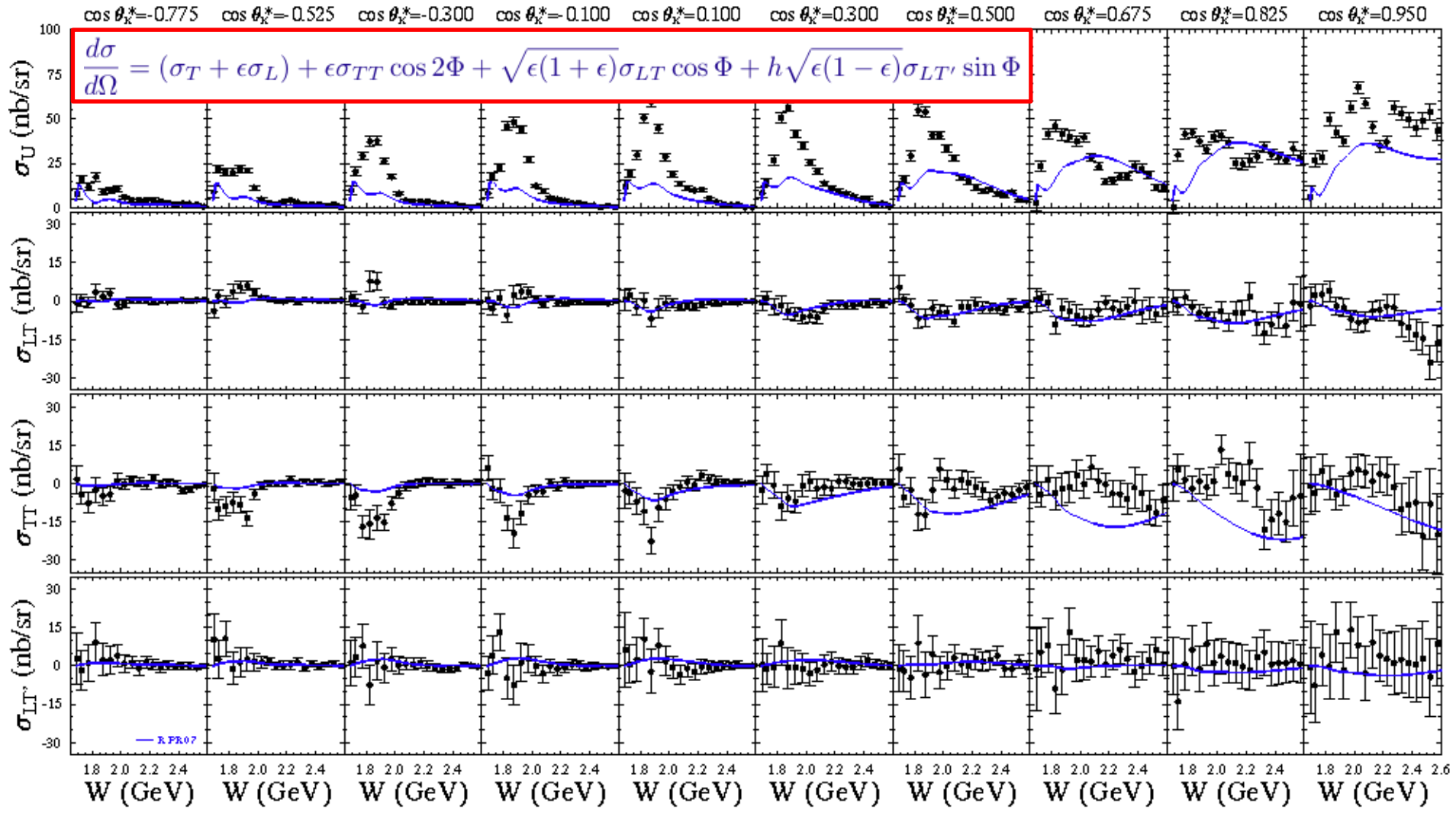
- **reliable electrocoupling extraction;**
- **capabilities of the reaction models to obtain resonance electrocouplings in independent analyses of these channels.**

$K^+\Lambda$ Structure Functions



E = 5.5 GeV, W: thr – 2.6 GeV, Q^2 = 1.80, 2.60, 3.45 GeV² *[Carman et al., PRC 87, 025204 (2013)]*

$K^+\Sigma^0$ Structure Functions

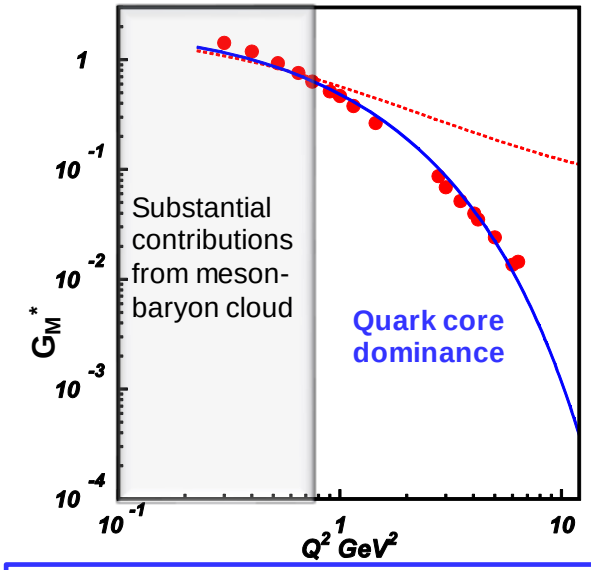


E = 5.5 GeV, W: thr – 2.6 GeV, Q^2 = 1.80, 2.60, 3.45 GeV² *[Carman et al., PRC 87, 025204 (2013)]*

Access to the Dressed Quark Mass Function from the Data on the Transition $N \to N^*$ Form Factors

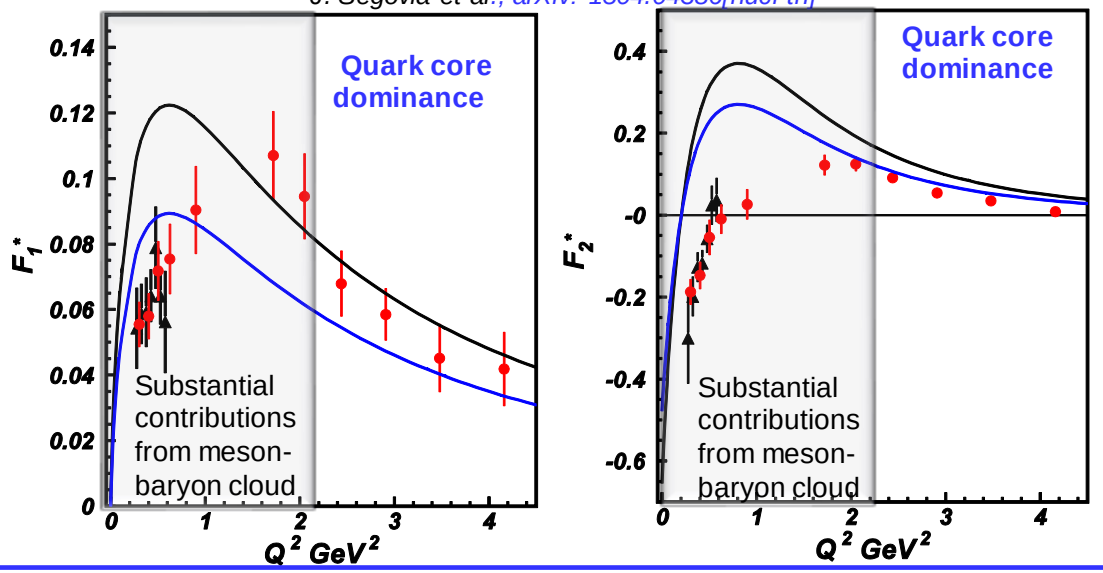
$\Delta(1232)3/2^+$
Jones-Scadron convention

J. Segovia et al., Few Body Syst. 55,1185 (2014).



$N(1440)1/2^+$
Dirac F_1^* and Pauli F_2^*
$N \to N(1440)1/2^+$ transition form factors

J. Segovia et al., arXiv: 1504.04386[nucl-th]



The quark core contributions to transition form factors computed in a common DSEQCD framework starting from the QCD Lagrangian:

- **Contact qq interaction, frozen constituent quark mass.**
- **Realistic qq interaction, running quark mass.**
- **Realistic qq interaction, running quark mass,**
- **the same but multiplied by the common factor fit to the data at Q^2>3.0 GeV^2 , which accounts for the product of the quark core fractions in ground and $N(1440)1/2^+$ states**

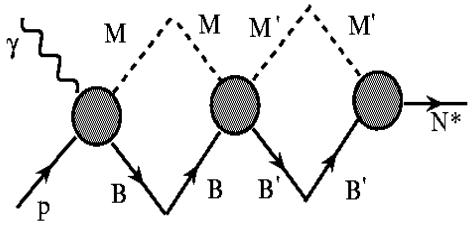
Good data description at Q^2>2.0 GeV^2 achieved with <u>the same dressed quark mass function</u> for the ground and excited nucleon states of distinctively different structure provides the strong evidence for:

- **the relevance of dressed quark predicted by DSEQCD**
- **promising prospect to map out dressed quark mass function from combined analyses of the data on nucleon elastic and transition form factors with available and future CLAS12 data at Q^2 < 12 GeV^2**

Quark Core and Meson-Baryon Cloud in the Structure of N(1440)1/2$^+$ Resonance

Quark core from DSEQCD

The mechanisms of meson-baryon dressing :

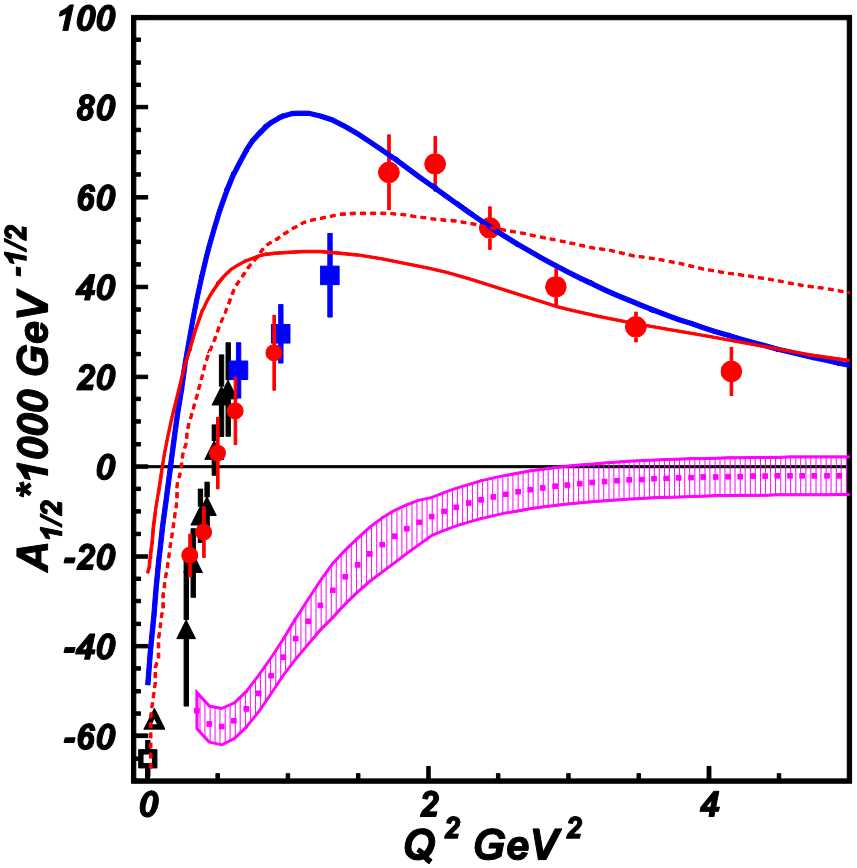


Description of the N(1440)1/2$^+$ $A_{1/2}$ electrocoupling by the light front quark models that incorporate the inner core and outer meson-baryon (MB) cloud:

Nπ loops MB cloud; running quark mass.
I.G.Aznauryan, V.D.Burkert, Phys. Rev. C85, 055202 (2012).

Nσ loops for MB cloud; frozen constituent quark mass.
I.T. Obukhovsky, et al., Phys. Rev. D89, 014032 (2014).

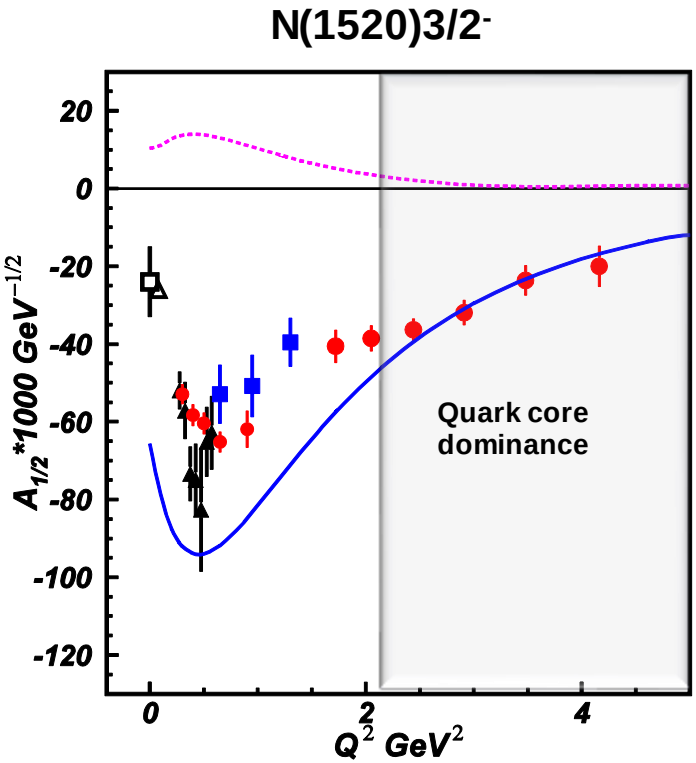
MB cloud inferred from the CLAS data as the difference between the data fit and evaluated within DSEQCD quark core

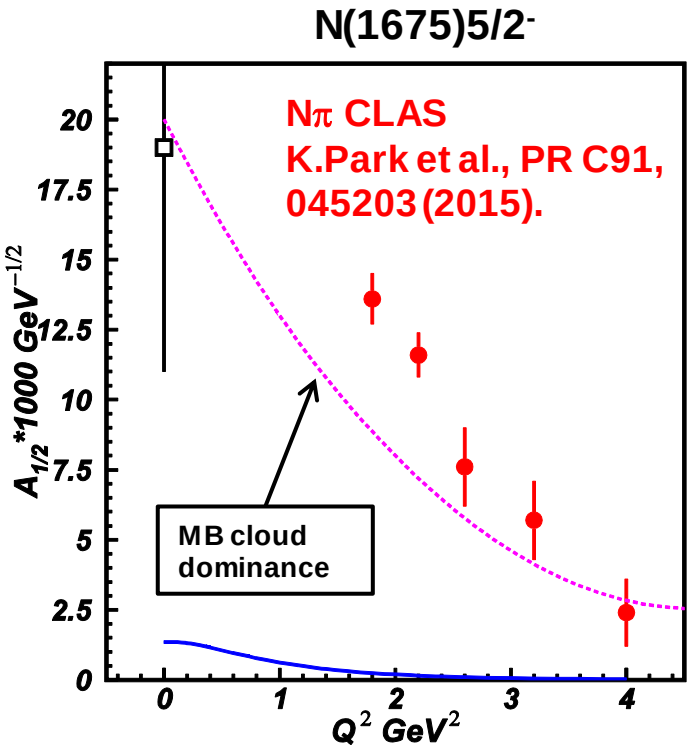


Successful description of the N(1440)1/2$^+$ quark core from the QCD Lagrangian has been achieved for the first time with the framework of DSEQCD!

The structure of N(1440)1/2$^+$ resonance is determined by complex interplay between inner core of three dressed quarks in the first radial excitation and external meson-baryon cloud.

Interplay Between Quark Core and Meson-Baryon Cloud in the Structure of Different Excited Nucleon States





MB dressing abs. values (Argonne-Osaka).

E. Santopinto and M. M. Giannini, PRC 86, 065202 (2012).

Almost direct access to:

- **quark core from the data on N(1520)3/2$^-$: prospect to explore dressed quark mass function and qqG vertex;**
- **meson-baryon cloud from the data on N(1675)5/2$^-$: shed light on the transition from confined quarks in inner core to colorless mesons and baryons in N* exterior**

First Interpretation of the Structure at W~1.7 GeV in $\pi^+\pi^-$p Electroproduction

The JM03 analysis of <u>three of nine</u> one-fold differential cross sections (*M.Ripani et al., Phys. Rev. Lett. 91, 022002 (2003)).* ..... *conventional states only, consistent with PDG 02.*

implementing 3/2⁺(1720) candidate or conventional states only with different than in PDG 02 N(1720)3/2⁺ Nππ decays.

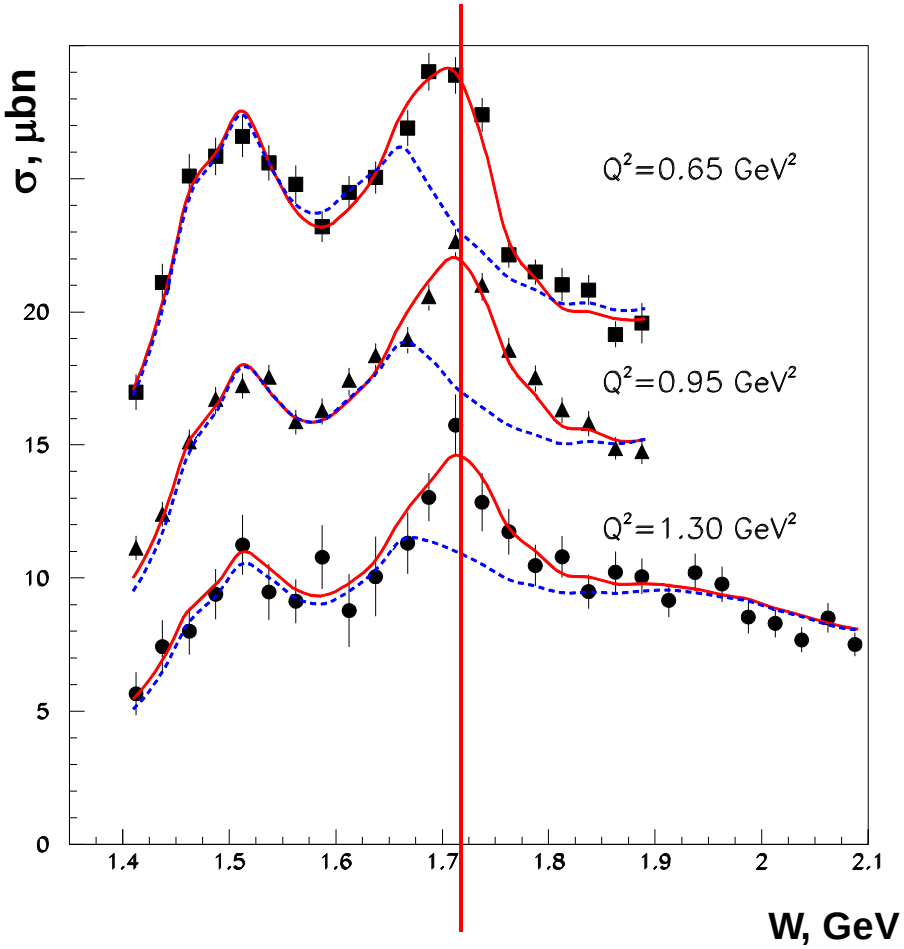
<u>Two equally successful ways for the data description:</u>

different than in PDG 02' N(1720)3/2⁺ Nππ hadronic decay widths:

	Γ_{tot}, MeV	BF(πΔ) %	BF(ρp) %
N(1720)3/2⁺ decays fit to the CLAS Nππ data	**114±19**	**63±12** **75±12 (BnGa12)**	**19±9**
N(1720)3/2⁺ PDG 02'	**150-300**	**<20**	**70-85**

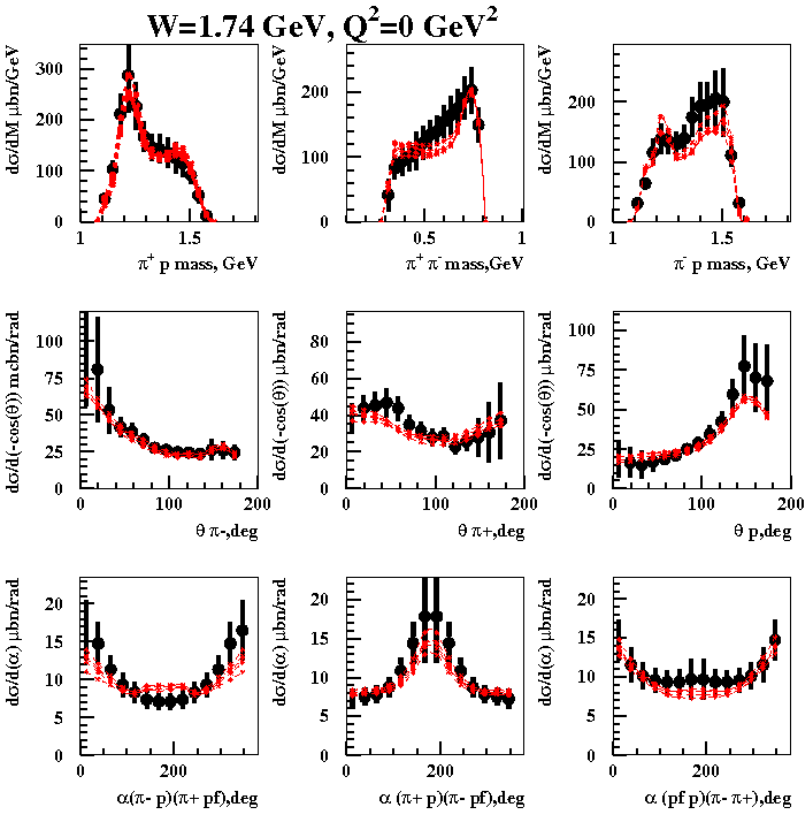
new 3/2⁺(1720) state and consistent with PDG 02' Nππ hadronic decays of N(1720)3/2⁺:

	Γ_{tot}, MeV	BF(πΔ) %	BF(ρp) %
3/2⁺(1720) candidate	**88±17**	**41±13**	**17±10.**
N1720)3/2⁺ conventional	**161±31**	**<20**	**60-100**



Resonance Photocouplings from the Preliminary $\pi^+\pi^-p$ Photoproduction Cross Sections

Fit of the CLAS data within the framework of the JM15:

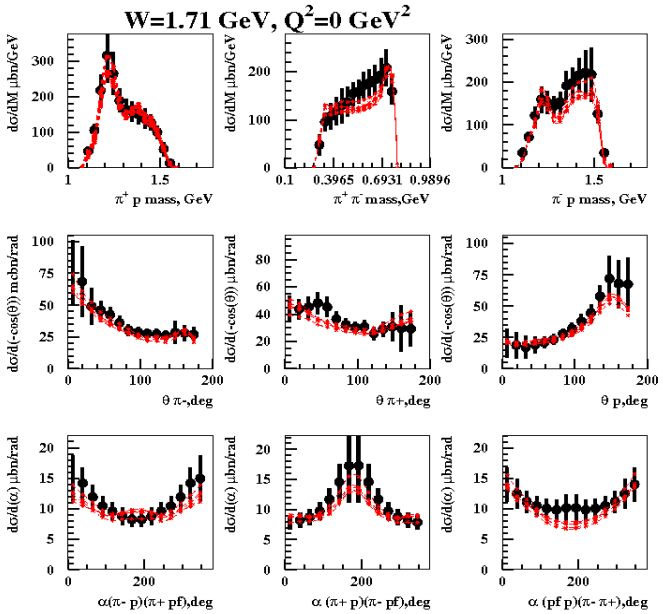


Resonance	$A_{1/2}$, $GeV^{-1/2}$ *1000, JM15/RPP12	$A_{3/2}$, $GeV^{-1/2}$ *1000 JM15/RPP12
N(1650)1/2⁻	63±6 53±16	
N(1680)5/2⁺	-29±3 -15±6	133±14 133±12
N(1700)3/2⁻	-5±4 -18±13	30±22 -2±24
N'(1720)3/2⁺	40±3 N/A	-43±8 N/A
N(1720)3/2⁺	89±16 97±3 (*)	-35±13 -39±3(*)
Δ(1600)3/2⁺	-26±10 -23±20	-19±9 -9±21
Δ(1620)1/2⁻	33±4 27±11	
Δ(1700)3/2⁻	97±19 104±15	84±11 85±22
Δ(1905)5/2⁺	25±4 26±11	-57±10 -45±20
Δ(1950)7/2⁺	-68±16 -76±12	-123±20 -97±10

(*)M. Dugger et al., Phys. Rev. C76, 025211 (2007).

Consistent results on photocouplings of resonances with masses above 1.6 GeV from analyses of $N\pi$ and $\pi^+\pi^-p$ channels demonstrate reliable extraction of these fundamental quantities.

Further Evidence for the Existence of the New State N'(1720)3/2$^+$ from Combined $\pi^+\pi^-$p Analyses in both Photo- and Electroproduction



N(1720)3/2$^+$ hadronic decays from the CLAS data fit with conventional resonances only

	BF($\pi\Delta$), %	BF(ρp), %
electroproduction	64-100	<5
photoproduction	14-60	19-69

The contradictory BF values for N(1720)3/2$^+$ decays to the $\pi\Delta$ and ρp final states deduced from photo- and electroproduction data make it impossible to describe the data with conventional states only.

Almost the same quality of the photoproduction data fit at 1.66 GeV <W<1.76 GeV and Q^2=0, 0,65, 0.95, 1.30 GeV^2 was achieved with and without N'(1720)3/2$^+$ new states

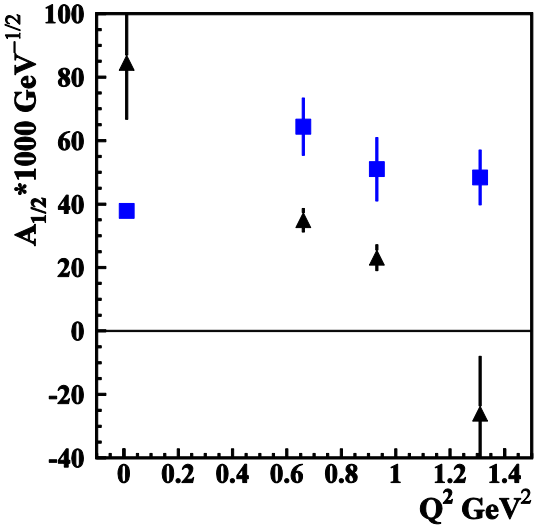
N* hadronic decays from the data fit that incorporates the new N'(1720)3/2$^+$ state

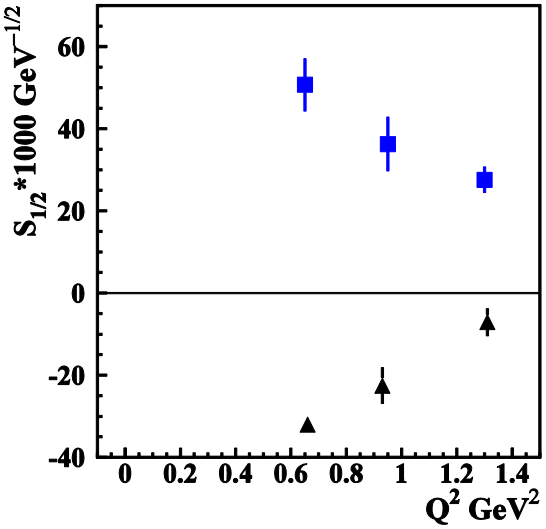
Resonance	BF($\pi\Delta$), %	BF(ρp), %
N'(1720)3/2$^+$		
electroproduction	47-64	3-10
photoproduction	46-62	4-13
N(1720)3/2$^+$		
electroproduction	39-55	23-49
photoproduction	38-53	31-46
Δ(1700)3/2$^-$		
electroproduction	77-95	3-5
photoproduction	78-93	3-6

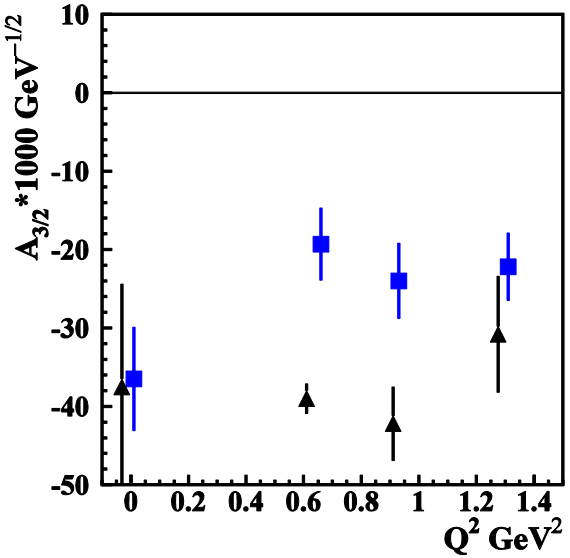
Successful description of $\pi^+\pi^-$p photo- and electroproduction data achieved by implementing new N'(1720)3/2$^+$ state with Q^2-independent hadronic decay widths of all resonances contributing at W~1.7 GeV provides strong evidence for the existence of new N'(1720)3/2$^+$ state.

The Parameters of N'(1720)3/2$^+$ New State from the CLAS Data Fit

The photo-/electrocouplings of N'(1720)3/2$^+$ and conventional N(1720)3/2$^+$ states:







N'(1720)3/2$^+$

N(1720)3/2$^+$

Resonance	Mass, GeV	Total width, MeV
N'(1720)3/2$^+$	1.715-1.735	120±6
N (1720)3/2$^+$	1.743-1.753	112±8

N'(1720)3/2$^+$ is the only candidate state for which the results on Q^2-evolution of transition electrocouplings have become available offering the insight to the structure of the new baryon state.

CLAS12 N* Program

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

- 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, cos θ_m^* = [-1:1]

- Key Motivations:
  - *Study spectrum and structure of all prominent N* states vs. Q^2 up to 12 GeV^2.*

    A unique opportunity to explore the nature of confinement that is responsible for >98% of resonance masses and the emergence of N states from QCD*
  - *KY data complement the $N\pi\pi$ data as independent information for high-mass states inaccessible with $N\pi$ final states*

    Urgent need: Develop reaction models to extract electrocouplings that incorporate the transition from M-B to q-G degrees of freedom

Contact person:
Volker D. Burkert

A Letter of Intent to the Jefferson Lab PAC43

Search for Hybrid Baryons with CLAS12 in Hall B

Annalisa D'Angelo,[1,2] Ilaria Balossino,[11] Luca Barion,[11] Marco Battaglieri,[3] Vincento Bellini,[12] Volker Burkert,[4] Simon Capstick,[5] Daniel Carman,[4] Andrea Celentano,[3] G. Ciullo,[11] Marco Contalbrigo,[11] Volker Credé,[5] Raffaella De Vita,[3] E. Fanchini,[3] Gleb Fedotov,[6] A. Filippi,[10] Evgeny Golovach,[6] Ralf Gothe,[7] Boris S. Ishkhanov,[6,13] Evgeny L. Isupov,[6] Valeri P. Koubarovski,[4] Lucilla Lanza,[2] P. Lenisa,[11] Francesco Mammoliti,[12] Victor Mokeev,[4,6] A. Movsisyan,[11] Mikhail Osipenko,[3] Luciano Pappalardo,[11] Marco Ripani,[3] Allesando Rizzo,[2] Jan Ryckebusch,[8] Iuliia Skorodumina,[7,13] Concetta Sutera,[12] Adam Szczepaniak,[9,4] Mauro Taiuti,[3] M. Turisini,[11] Maurizio Ungaro,[4] and Veronique Ziegler[4]

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(Dated: May 17, 2015)

Recommendation:

The PAC encourages the preparation of a full proposal. However, we emphasize that the 11 GeV running should be put forward as a **Run Group Proposal**, if it is indeed to run in parallel with other approved experiments. Further, the additional beam time at 6.6 and 8.8 GeV must be considered as a **separate proposal** that may include other measurements that could be carried out with the additional beam time.

Conclusions

- **High quality meson electroproduction data from CLAS allowed us to determine the electrocouplings of most well-established resonances in mass range up to 1.8 GeV from analyses of π^+n, π^0p, ηp and $\pi^+\pi^-p$ electroproduction channels. Consistent electrocoupling values for the transitions to N(1440)1/2$^+$ and N(1520)3/2$^-$ states obtained independently from $N\pi/N\pi\pi$ exclusive channels demonstrated capabilities of the developed reaction models for reliable extraction of N*-parameters.**

- **To describe both the $\pi^+\pi^-p$ photo- and electroproduction data demands including the new baryon state N'(1720)3/2$^+$. Successful description of these data with Q^2-independent hadronic decay widths to the $\pi\Delta$ and ρp final states of all contributing resonances provides strong evidence for the existence of N'(1720)3/2$^+$ new baryon state.**

- **Physics analyses of the CLAS results on resonance electrocouplings revealed the structure of N*-states at $Q^2<5.0$ GeV^2 as complex interplay between meson-baryon and quark degrees of freedom. The studies of N*-states with different quantum numbers are essential in order to disentangle different components in the N* structure.**

- **Successful description of elastic and transition form factors to different low-lying resonances achieved at $Q^2>2.5$ GeV^2 within the framework of DSEQCD demonstrated promising opportunity to map out dressed quark mass function from the data on elastic and transition form factors.**

Outlook

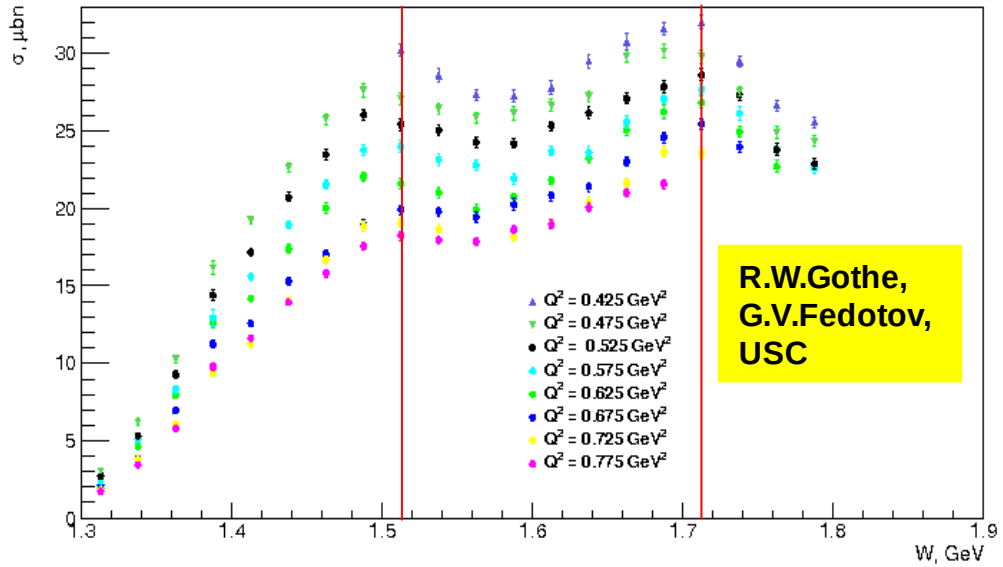
- **After 12 GeV Upgrade CLAS12 will be only available worldwide facility capable to obtained electrocouplings of all prominent N* states at still unexplored ranges of low photon virtualities down to 0.05 GeV^2 and highest photo virtialities ever achieved for exclusive reactions from 5.0 GeV^2 to 12 GeV^2 from the measurements of exclusive $N\pi$,$\pi^+\pi^-p$, and KY electroproduction.**

- **The expected results will allow us:**
  a) search for hybrid-baryons;
  b) explore the emergence of meson-baryon cloud from quark-gluon confinement;
  c) access quark distribution amplitudes in N* states;
  d) to map out the dressed quark mass function at the distance scales 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 quark-gluon confinement.

- **Success of N* Program with the CLAS12 will be very beneficial for Jefferson Lab and hadron physics community worldwide.**

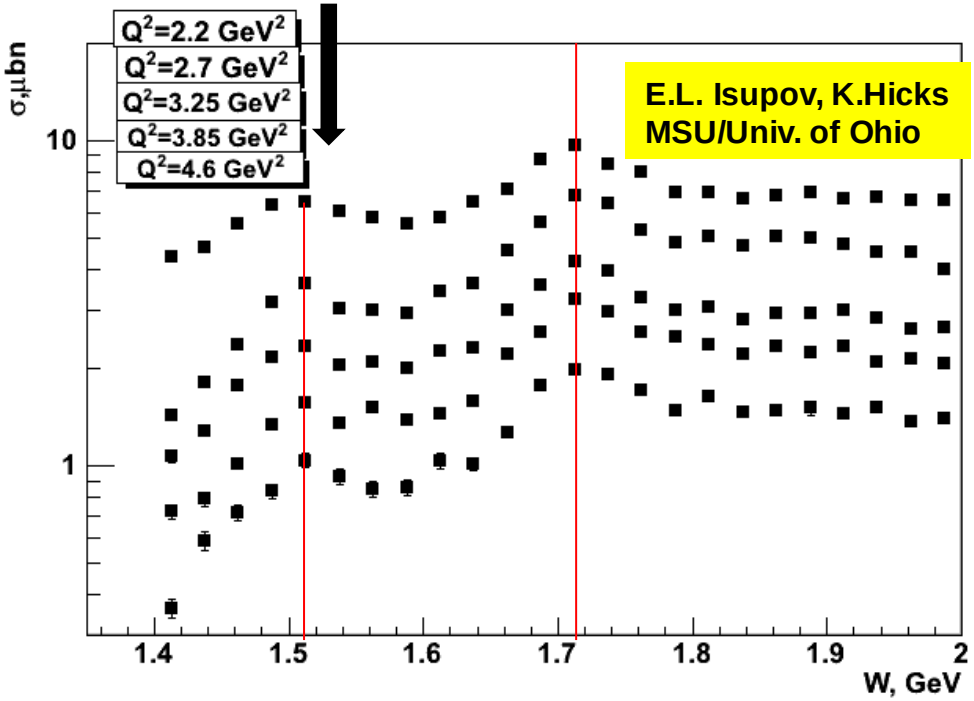
Back up

Extension of the CLAS $\pi^+\pi^-p$ Electroproduction Data



Fully integrated $\pi^+\pi^-p$ electroproduction cross sections off protons

- **Nine 1-fold differential cross sections are available In each bin of W and Q^2 shown in the plots.**
- **Resonance structures are clearly seen at W ~1.5 GeV and ~1.7 GeV at $0.4 < Q^2 < 5.0$ GeV^2 (red lines) .**



Analysis objectives:

- **Extraction of $\gamma_v NN^*$ electrocouplings and $\pi\Delta$, ρp decay widths for most N*s in mass range up to 2.0 GeV and $0.4 < Q^2 < 5.0$ GeV^2 within the framework of JM-model.**
- **Exploration of the signals from $3/2^+(1720)$ candidate-state (M.Ripani et al., Phys. Rev. Lett 91, 022002 (2003)) with a goal to achieve decisive conclusion on the state existence and structure.**
- **First results on electrocouplings of high-lying ($M_{N^*} > 1.6$ GeV) orbital nucleon excitations and high-lying parity partners.**

Signals from N* states in the CLAS KY electroproduction data

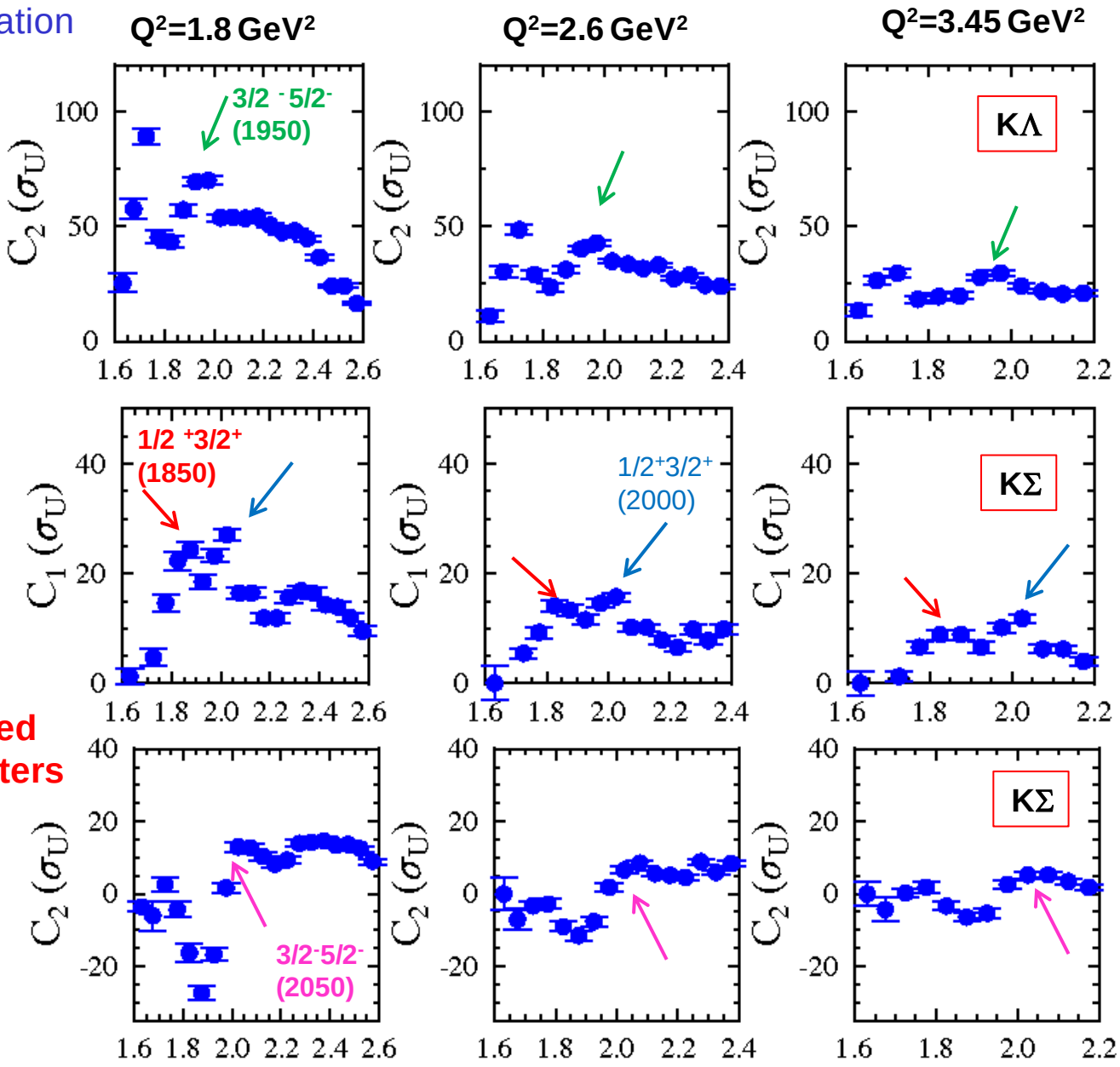
D.Carman, private communication

$$C_l = \int \{ \frac{d\sigma}{d\theta_{K_T}} + \varepsilon \frac{d\sigma}{d\theta_{K_L}} \} P_l(z) d(-z)$$

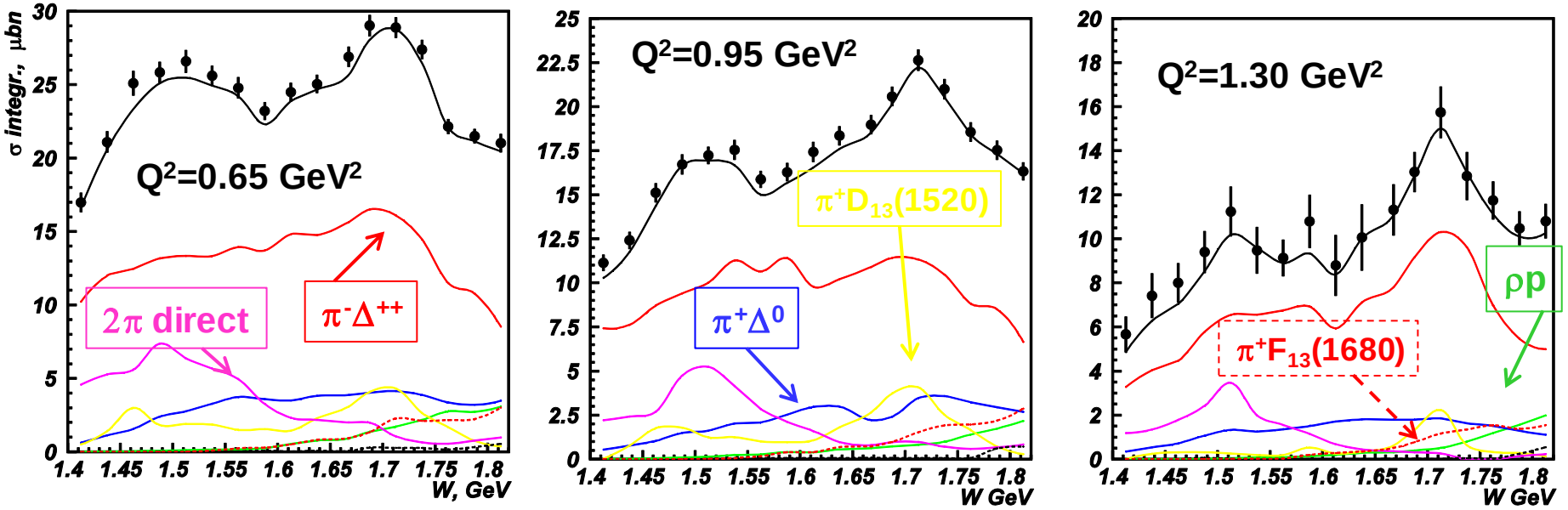
$$z = \cos(\theta_K)$$

the structures in W-dependencies of C_l – moments at the same W-values in all Q^2-bins are consistent with the contributions from resonances of spin-parities listed in the plots

reaction model(s) are needed for extraction of N* parameters from KY electroproduction



Charting Meson-Baryon Mechanisms of the JM Model

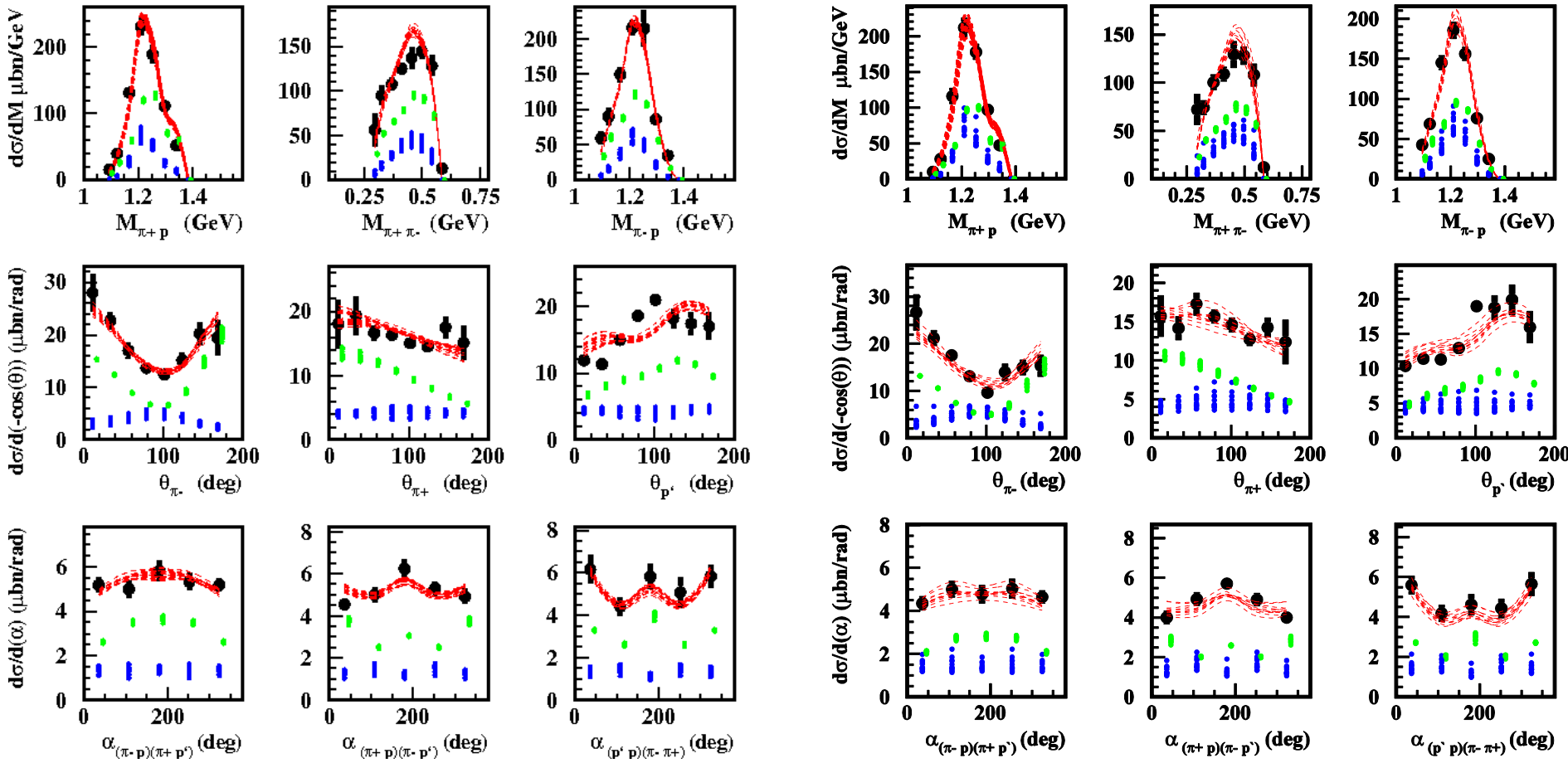


- $\pi^-\Delta^{++}$ meson-baryon channel accounts for the major part of $\pi^+\pi^-p$ electroproduction cross section. Relative resonant contribution to $\pi^-\Delta^{++}$ channel increases with Q^2.
- 2π direct production decreases substantially at W from 1.5 to 1.7 GeV offering an indication for sizable final hadronic interactions between the $\pi^+\pi^-p$ final state and others open meson-baryon channels.
- $\pi\Delta$, ρp-amplitudes decomposed over PW's of angular momenta J can be provided from the data fit.
- **The request for reaction theory: guidance for the development of analytical continuation of $\pi\Delta$, ρp-amplitudes allowing us to extract resonance electrocouplings from residues at the resonance pole positions.**

Resonant /Non-Resonant Contributions from the Fit of $\pi^+\pi^-p$ Electroproduction Cross Sections within the JM Model

W=1.51 GeV, Q^2=0.38 GeV^2

W=1.51 GeV, Q^2=0.43 GeV^2



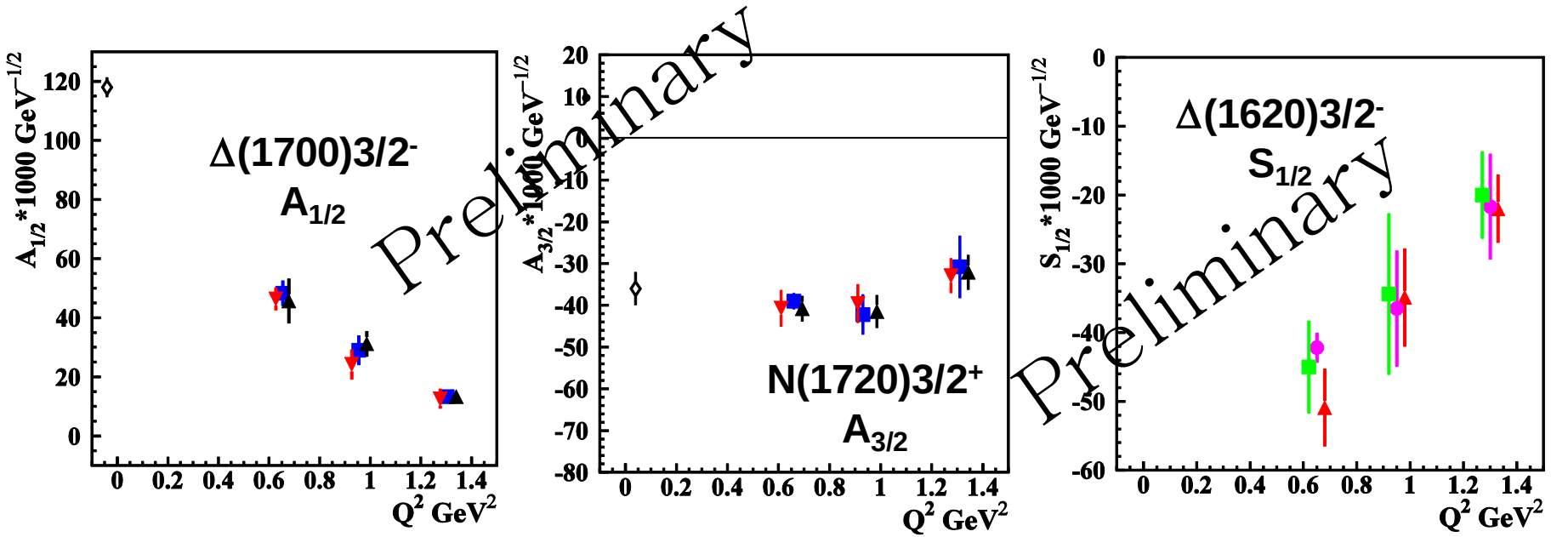
Reliable isolation of the resonant cross sections is achieved

full cross sections within the JM model

resonant part

non-resonant part

Status and Prospects on Extraction of High-Lying N* Electrocouplings from CLAS Data



Independent fits in different W-intervals:

green: 1.46<W<1.56 GeV
magenta: 1.56<W<1.66 GeV
red: 1.61<W<1.71 GeV
blue: 1.66<W<1.76 GeV
black: 1.71<W<1.81 GeV

consistent electrocoupling values offer sound evidence for their reliable extraction.

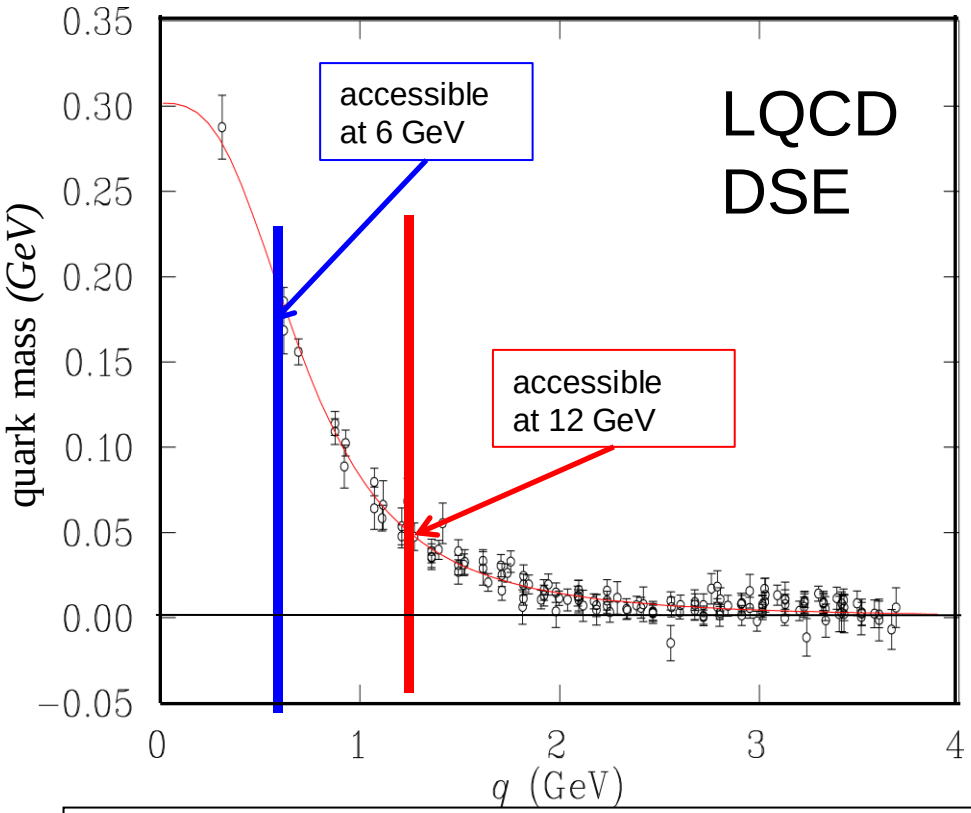
$\pi^+\pi^-$p electroproduction channel provided first preliminary results on $\Delta(1620)1/2^-$, $N(1650)1/2^-$, $N(1680)5/2^+$, $\Delta(1700)3/2^-$, and $N(1720)3/2^+$ electrocouplings with good accuracy.

Prospect: evaluation of high-mass N* electrocouplings from independent analyses of KY channels. Reaction models capable of extracting resonance electrocouplings from the fit of unpolarized cross sections and polarization asymmetries measured in KY electroproduction are needed!

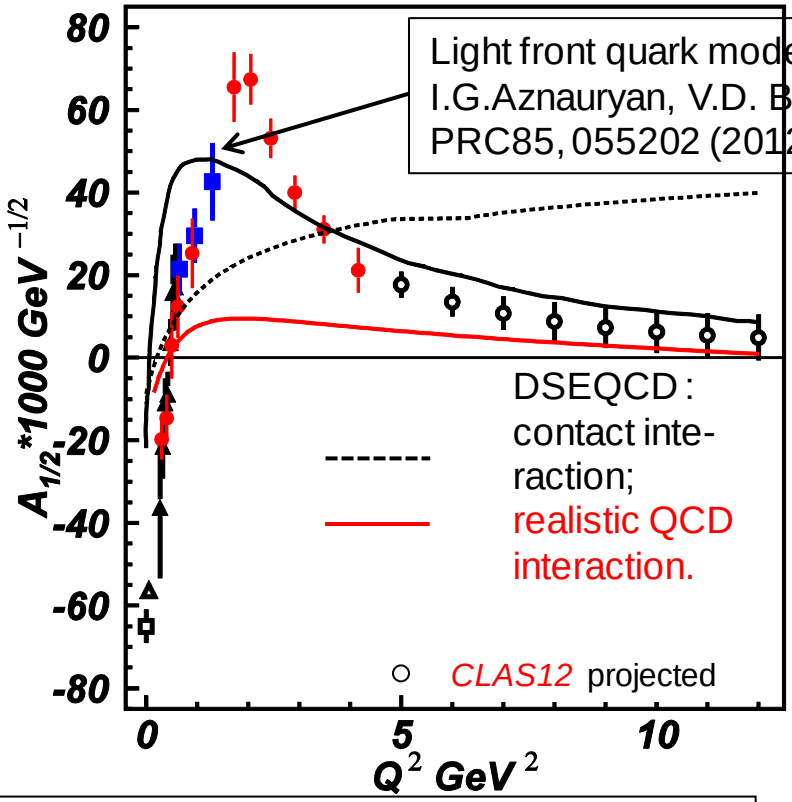
Resonance Transitions with the CLAS12

Resonance electrocouplings in regime of quark core dominance can be related to the running quark masses and their dynamical structure.

12 GeV experiment E12-09-003 will extend access to electrocouplings for all prominent N* states in the range up to Q^2=12GeV^2.



$P_{11}(1440)$ $A_{1/2}$



Probe the transition from confinement to pQCD regimes, allowing us to explore how confinement in baryons emerge from QCD and how >98 % of baryon masses are generated non-perturbatively via dynamical chiral symmetry breaking.