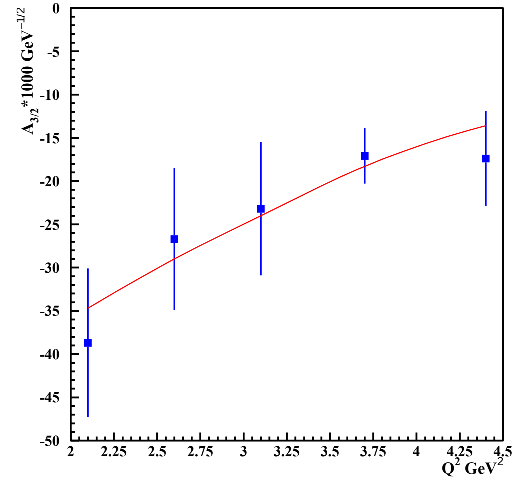


Insight into EHM from Results on Electroexcitation of $\Delta(1600)3/2^+$ Resonance

- CSM concept for EHM and predictions for hadron structure observables
- $\gamma_v pN^*$ electrocouplings from CLAS
- Connecting $\gamma_v pN^*$ electrocouplings to EHM within CSM
- Validation of the CSM concept for EHM from the $\gamma_v pN^*$ electrocoupling studies
- Gaining insight into EHM from the CLAS12 data and after increase of JLab energy/luminosity
- Conclusions and outlook

V.I. Mokeev
Jefferson Lab
(CLAS Collaboration)

Office of Science

How do the Ground/Excited State Nucleon Masses Emerge?

Composition of the Nucleon Mass:

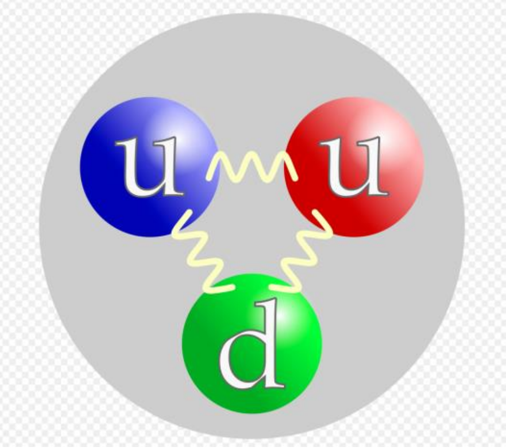
M_p, MeV (PDG20)

938.2720813
±0.0000058

Sum of bare quark masses, MeV

2.16+2.16+4.67
$=8.99^{+1.45}_{-0.65}$ or < 1.1%

proton



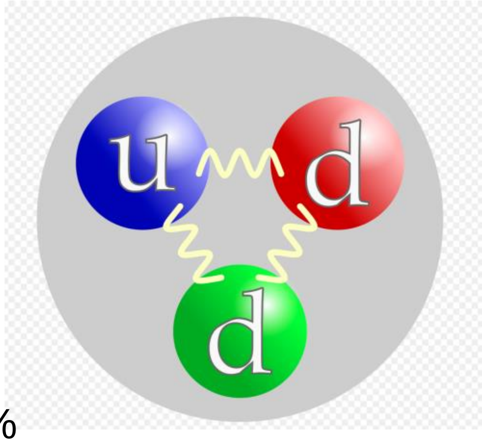
M_n, MeV (PDG20)

939.5654133
±0.0000058

Sum of bare quark masses, MeV

4.67+4.67+2.16
$= 11.50^{+1.45}_{-0.60}$ or < 1.4%

neutron

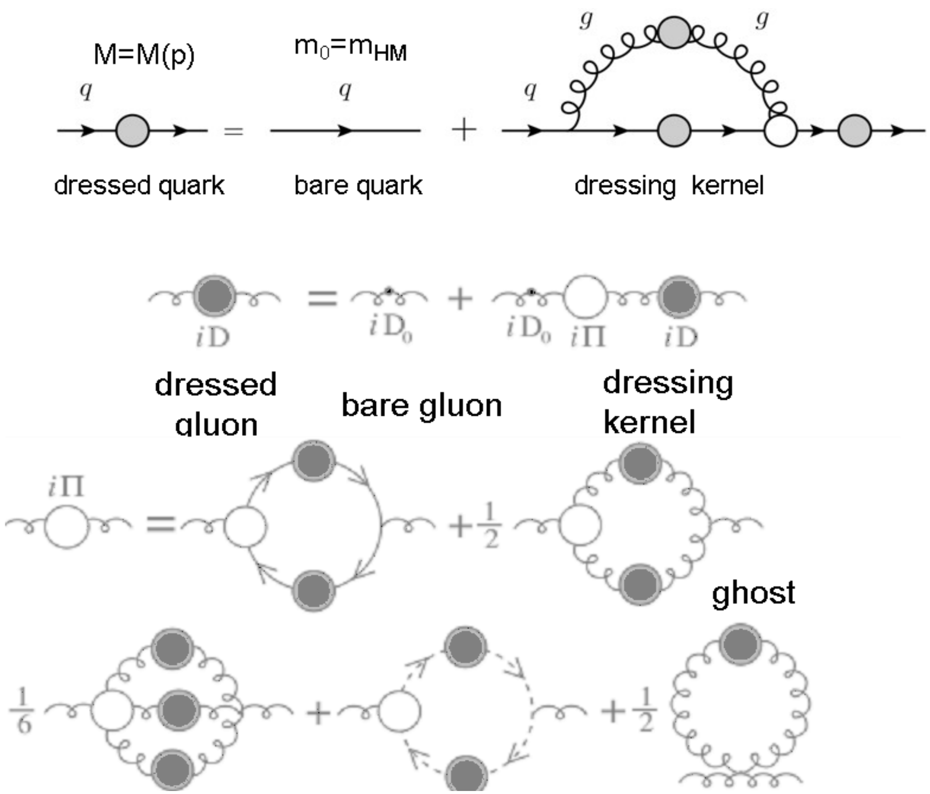


- **Higgs mechanism generates the masses of bare quarks**
- **Dominant part of nucleon mass is generated in processes other than the Higgs mechanism**

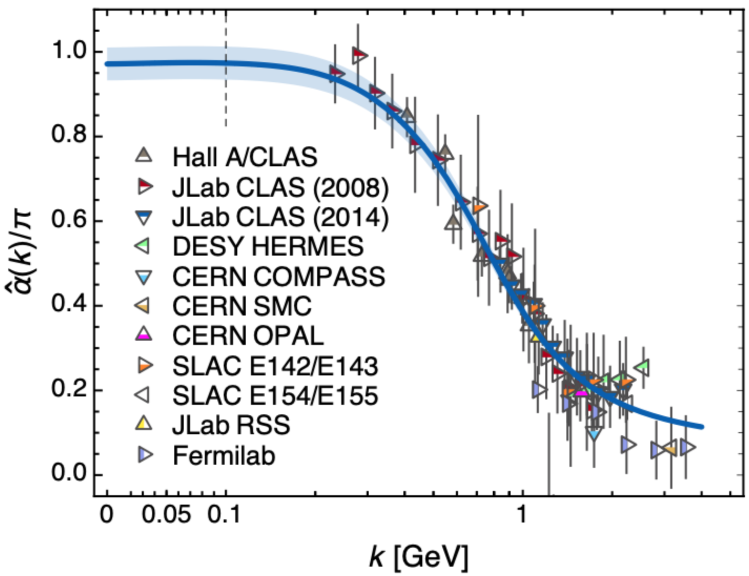
The Continuum Schwinger method (CSM) has conclusively demonstrated that the dominant part of hadron mass is generated by the strong interaction in the regime when the QCD running coupling becomes comparable with unity, the so-called strong QCD regime

Basics for Insight into EHM: Continuum Schwinger Methods (CSM)

Emergence of Dressed Quarks and Gluons
D. Binosi, Few Body Syst. 63, 2 (2022)



QCD Running Coupling α(k)
Zh-F. Cui et al., Chin. Phys. C44, 083102 (2020)

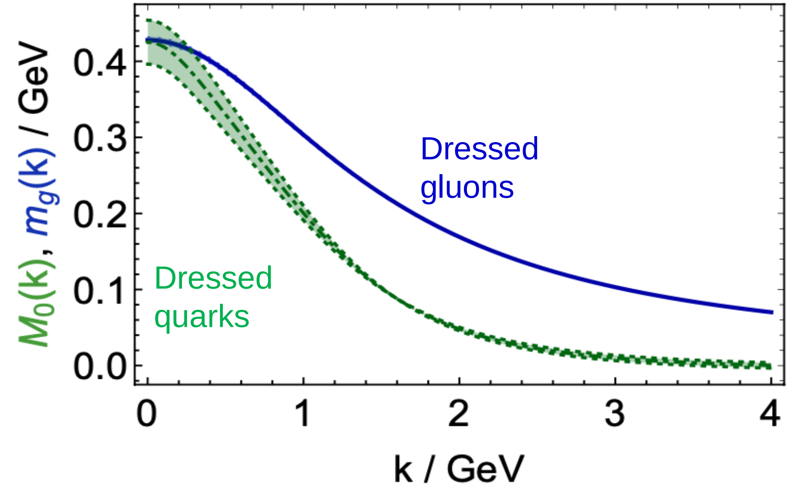


In the regime of the QCD running coupling comparable with unity, the dressed quarks and gluons with distance (momentum) dependent masses emerge from QCD, as follows from the equations of the motion for the QCD fields depicted above.

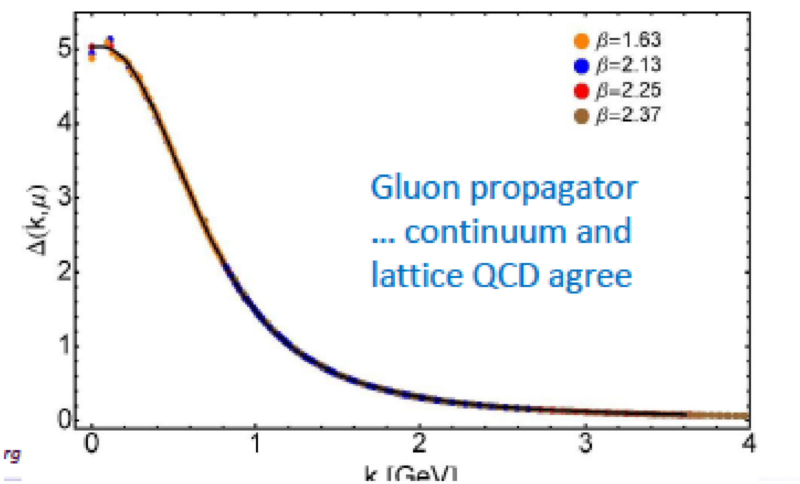
Basics for Insight into EHM: Continuum and Lattice QCD Synergy

- Express the fundamental feature: emergence of the quark and gluon masses even in the case of massless quarks in the chiral limit and massless QCD gluons
- Continuum QCD results get support from LQCD
- Insight into dressed quark mass function from data on hadron structure represents a challenge for experimental hadron physics

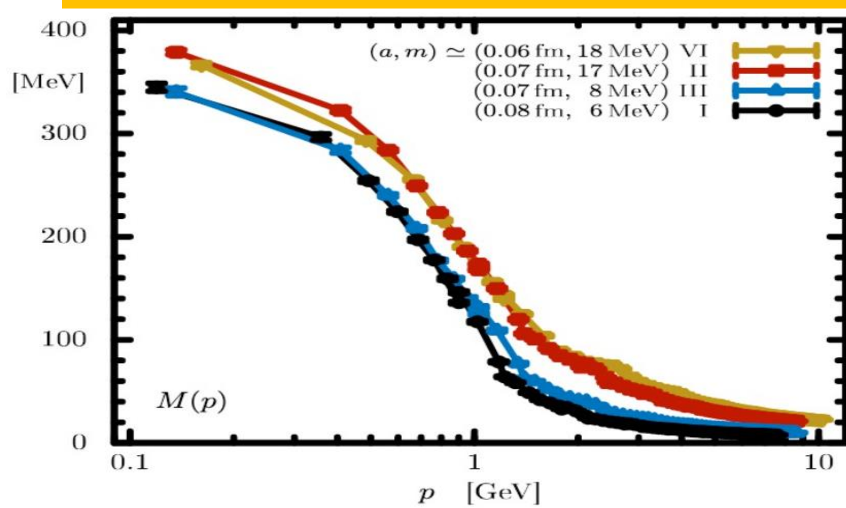
Dressed Quark/Gluon Masses (continuum QCD)
C.D. Roberts, Symmetry 12, 1468 (2020)



Inferred from QCD Lagrangian with only Λ_{QCD} parameter



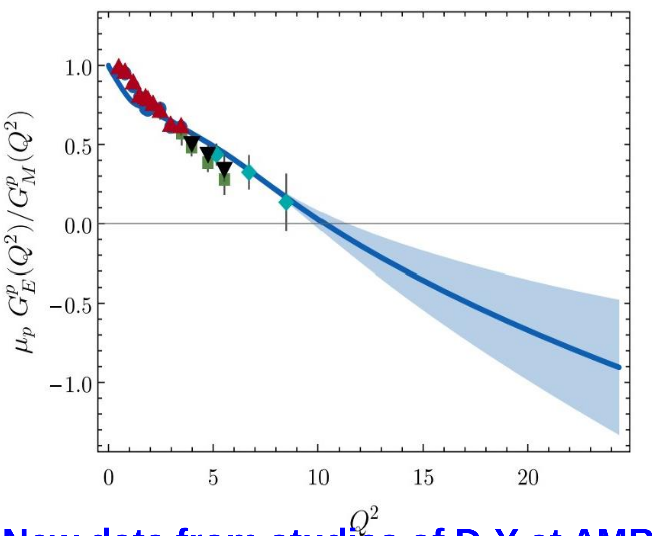
Dressed Quark Mass (lattice QCD)
O. Olivera et al., Phys. Rev. D 99, 094506 (2019)



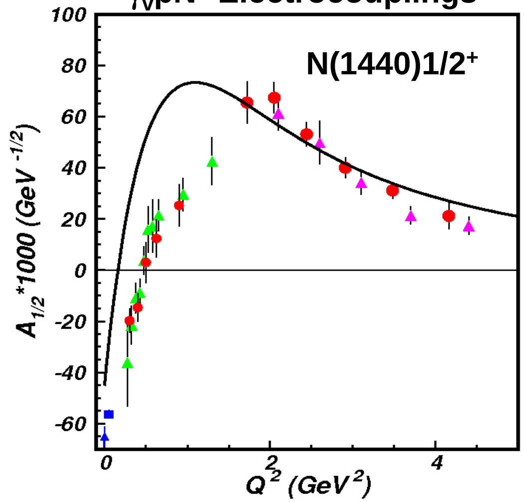
EHM from Global Hadron Structure Analysis

Will be extended by the future data from JLab in the 12 GeV era, AMBER@CERN, EIC, EicC

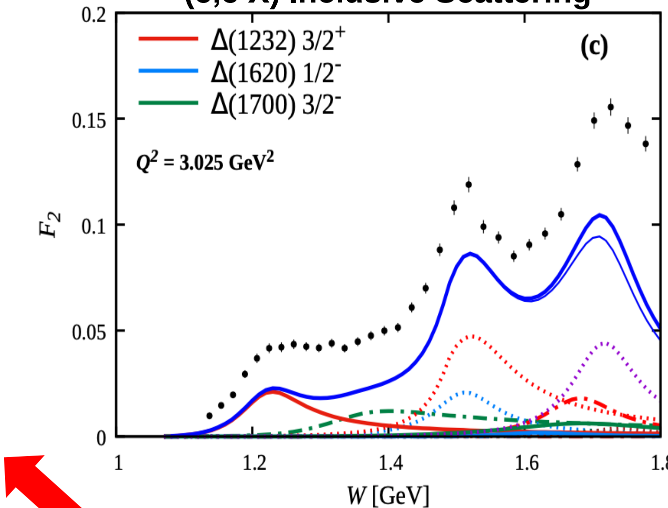
Nucleon Elastic FF



$\gamma_v pN^*$ Electrocouplings

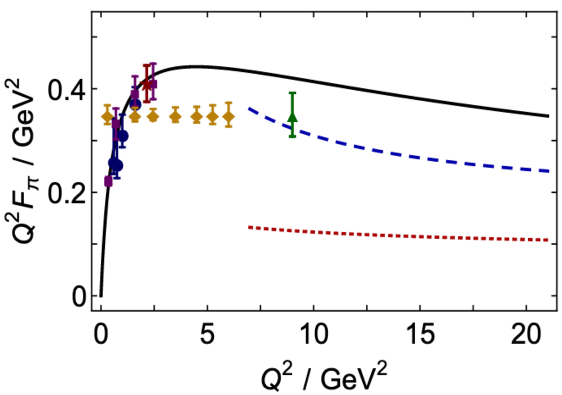


(e,e'X) Inclusive Scattering

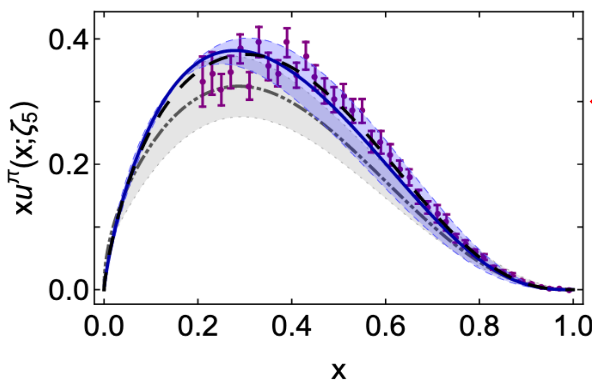


New data from studies of D-Y at AMBER + Sullivan processes at JLab

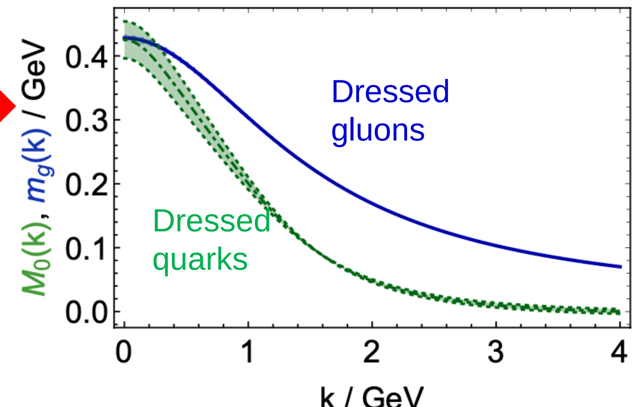
Pion Elastic FF



Pion PDF



Dressed Quark/Gluon Running Masses



- Insight into the dressed quark/gluon running masses from the experimental results within the continuum QCD approach

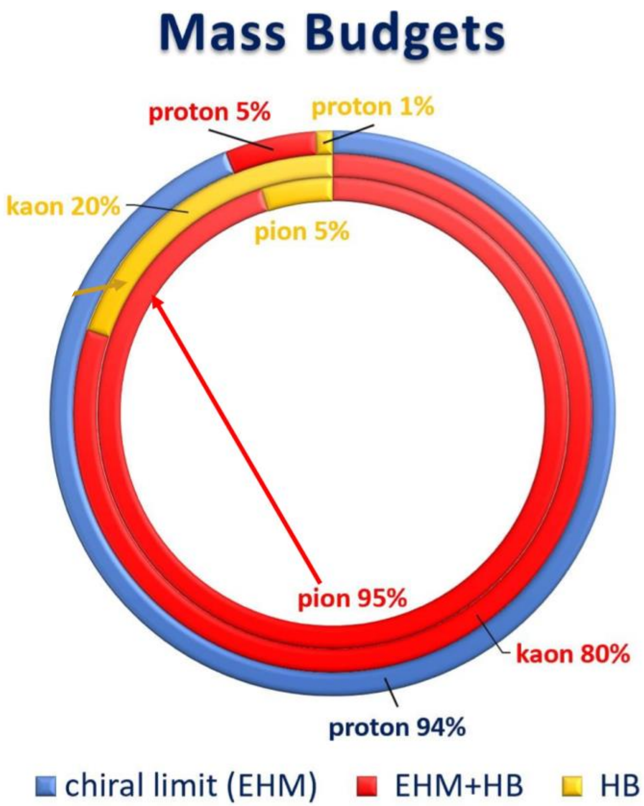
Insight into EHM from the Data on Pion/Kaon Structure

- The model and renormalization scheme/scale independent Goldberger-Treiman relations connect the momentum dependence of the dressed quark mass to the pion/kaon Bethe-Salpeter amplitudes, making the studies of pion and kaon structure a promising way to map out the momentum dependence of the dressed quark mass.

$$f_\pi E_\pi(p^2) = B(p^2)$$

- Pions and kaons are simultaneously $q\bar{q}$ bound states and Goldstone bosons in chiral symmetry breaking. Their masses should be reduced to zero in the chiral limit and, in the real world, down to small values in comparison with the hadron mass scale owing to DCSB.

Insight into EHM from the Data on N/N* Structure



- Studies of π/K structure elucidate the interference between emergent and Higgs mechanisms in EHM
- Studies of ground/excited state nucleon structure allow us to explore the dressed quark mass function in a different environment where the sum of dressed quark masses is the dominant contribution to the physical masses of these states, offering insight into emergent mechanisms

- Consistent results on the momentum dependence of the dressed quark mass function from independent studies of the pseudoscalar mesons and the ground and excited state nucleon structure are of particular importance for the validation of insight into EHM.

EHM in Particular Environments for Different Resonances

Borrowed from C.D. Roberts

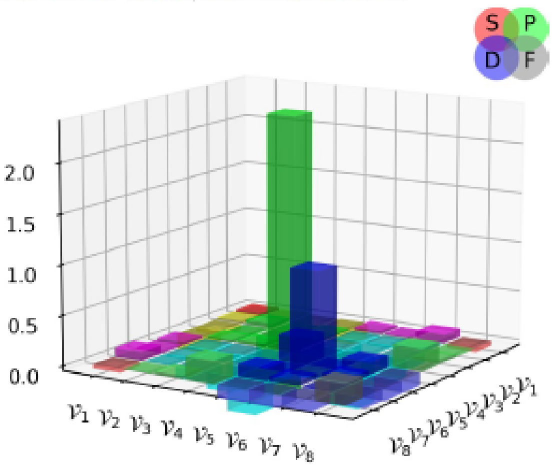
Composition of low-lying $\mathbf{J} = \frac{3}{2}^{\pm}$ $\mathbf{\Delta}$-baryons

Langtian Liu (Nanjing U.), Chen Chen (Hefei, CUST and PCFT, Hefei), Ya Lu (Nanjing U.), Craig D. Roberts (Nanjing U.), Jorge Segovia (Nanjing U. and Pablo de Olavide U., Seville)

Mar 22, 2022

13 pages
e-Print: 2203.12083 [hep-ph]
Report number: NJU-INP 057/22, USTC-ICTS/PCFT-22-11

Electroexcitation of baryon resonances



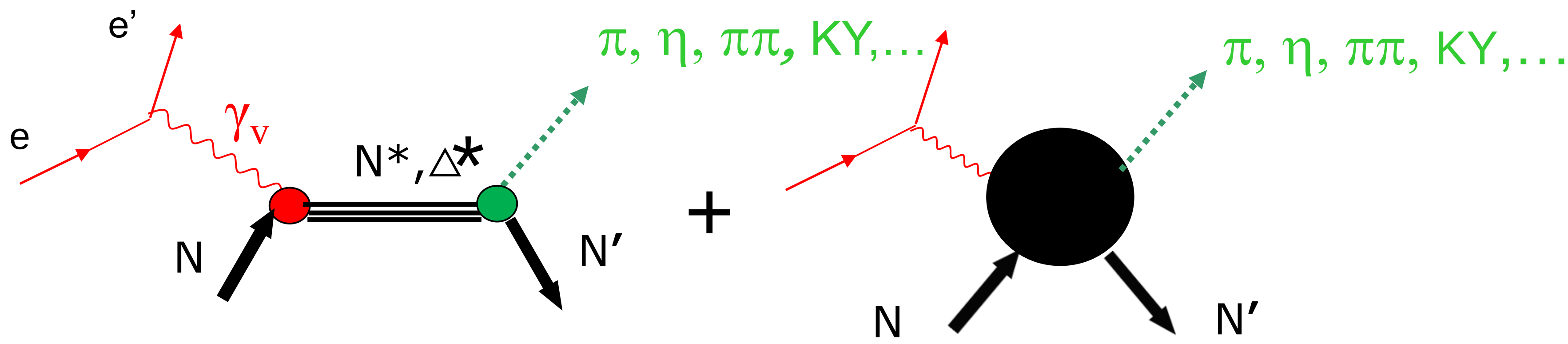
Exposing orbital angular momentum structure of, e.g., $\Delta(1700)\frac{3}{2}^{-}$ ... providing motivation and support for extensive baryon resonance programme at JLab

- *The ground state proton is not enough*
- Ground state of the hydrogen atom did not give us QED
- Studies of the proton alone cannot reveal all the wonders of QCD, if QCD is truly the theory of strong interactions in the Standard Model
- Modern and planned high-luminosity facilities provide unprecedented opportunities to move beyond the 100-year focus on the structure of just one (or two = neutron) hadron(s)
- How much richer will be our store of knowledge once insights into the full array of Nature's hadrons is in our hands!
- Poincaré-covariant Faddeev equation is shedding new light on the structure of ALL baryons

A unique opportunity to explore either universality or the environmental sensitivity of the dressed quark mass function

N* Photo-/Electroexcitation Amplitudes ($\gamma_{r,v}$pN* Photo-/Electrocouplings) and their Extraction from Exclusive Photo-/Electroproduction Data

Resonant amplitudes **Non-resonant amplitudes**



- **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)

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

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

- **Consistent results on the $\gamma_{r,v}$pN* photo-/electrocouplings from different meson photo-/electro-production channels allow us to validate reliable extraction of these quantities**

Summary of Published 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
$\pi^+ n$	**1.1-1.38** **1.1-1.55** **1.1-1.70** **1.6-2.00**	**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 $d\sigma/d\Omega$
$\pi^0 p$	**1.1-1.38** **1.1-1.68** **1.1-1.39** **1.1-1.80**	**0.16-0.36** **0.4-1.8** **3.0-6.0** **0.4-1.0**	$d\sigma/d\Omega$ $d\sigma/d\Omega$, A_b,A_t,A_{bt} $d\sigma/d\Omega$ $d\sigma/d\Omega$, A_b
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** **0.70-5.4**	$d\sigma/d\Omega$ P'
$\pi^+\pi^- p$	**1.3-1.6** **1.4-2.1** **1.4-2.0**	**0.2-0.6** **0.5-1.5** **2.0-5.0**	**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 asymmetries
- P^0, P' –recoil and transferred polarization of strange baryon

Over 150,000 data points!

Almost full coverage of the final state 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

Nucleon Resonance Electrocouplings from Data on Exclusive Meson Electroproduction with CLAS

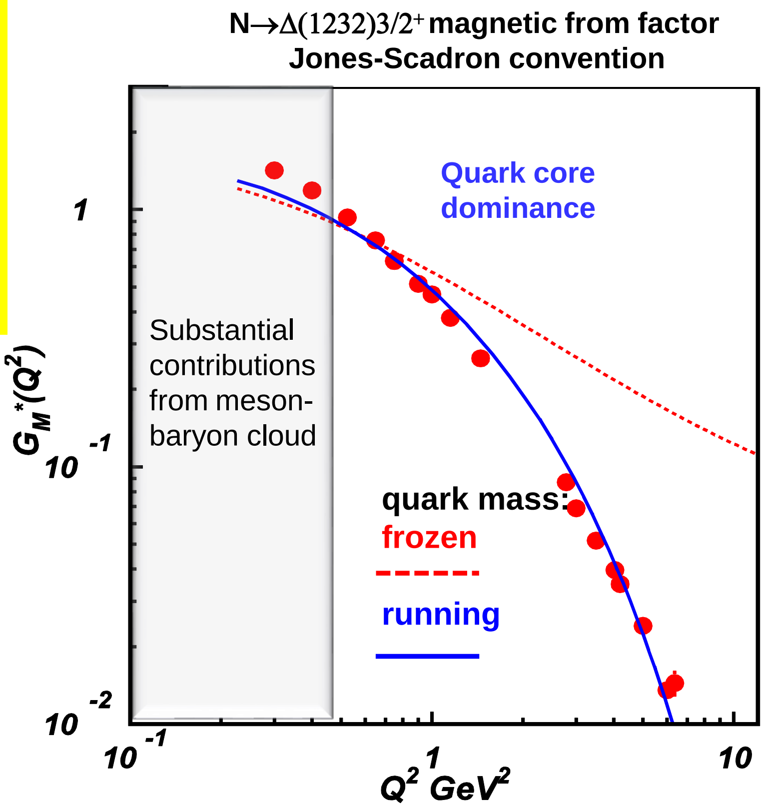
Exclusive meson electroproduction channels	Excited proton states	Q^2-ranges for extracted $\gamma_v pN^*$ electrocouplings, GeV^2
$\pi^0 p$, $\pi^+ n$	$\Delta(1232)3/2^+$ $N(1440)1/2^+$, $N(1520)3/2^-$, $N(1535)1/2^-$	0.16-6.0 0.30-4.16
$\pi^+ n$	$N(1675)5/2^-$, $N(1680)5/2^+$ $N(1710)1/2^+$	1.6-4.5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

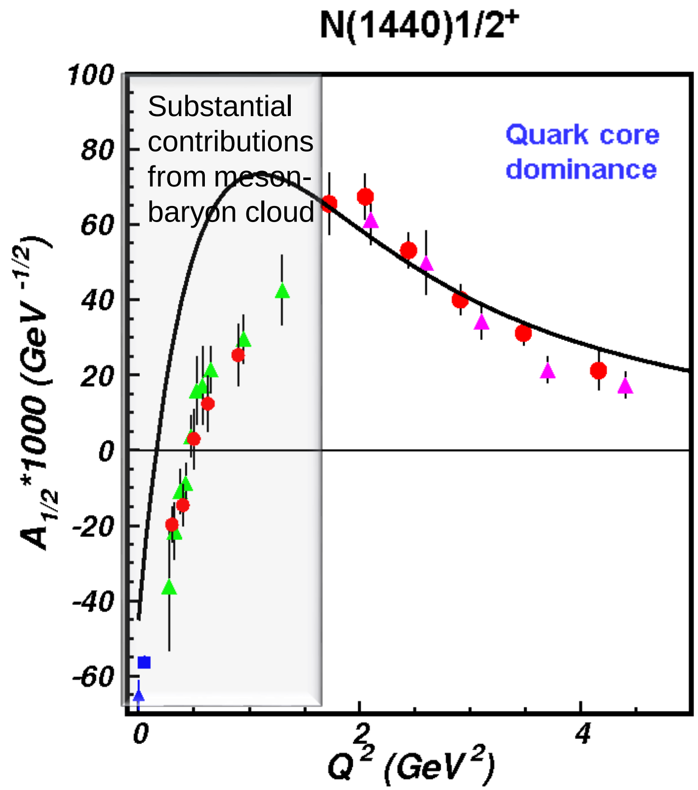
- **The N* electroexcitation amplitudes ($\gamma_v pN^*$ electrocouplings) have become available in a broad range of Q^2<5.0 GeV^2**
- **In the mass range W<1.6 GeV the $\gamma_v pN^*$ electrocoupling were obtained from independent studies of πN, ηp, and $\pi^+\pi^- p$ electroproduction**

Recent results can be found in: A.N. Hiller Blin et al, PRC100, 035201 (2019)

Insight to EHM From Resonance Electrocouplings

<u>Dyson-Schwinger Equations (DSE):</u>
- **J. Segovia et al., PRL 115, 171801 (2015)**
- **J. Segovia et al., Few Body Syst. 55, 1185 (2014)**

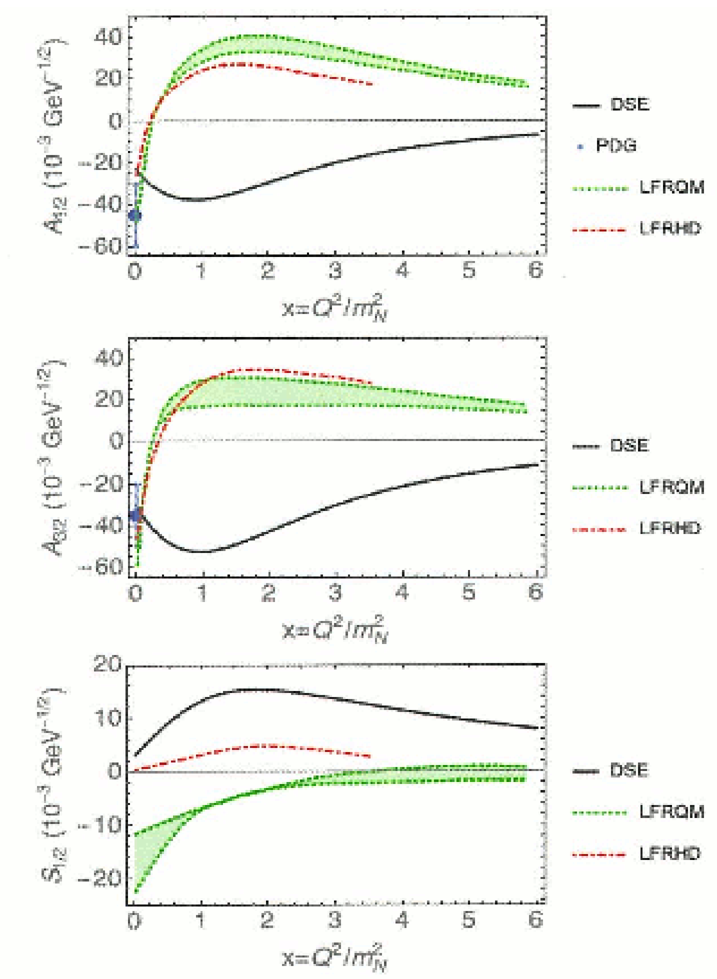




Good data description at Q^2>2 GeV^2 achieved with <u>the same dressed quark mass function</u> for the ground pion/nucleon and two excited nucleon states of distinctively different structure validates the Continuum Schwinger Method (CSM) results on the momentum dependence of the dressed quark mass. The $\gamma_v pN^*$ electrocoupling data shed light on the strong QCD dynamics underlying hadron mass generation.

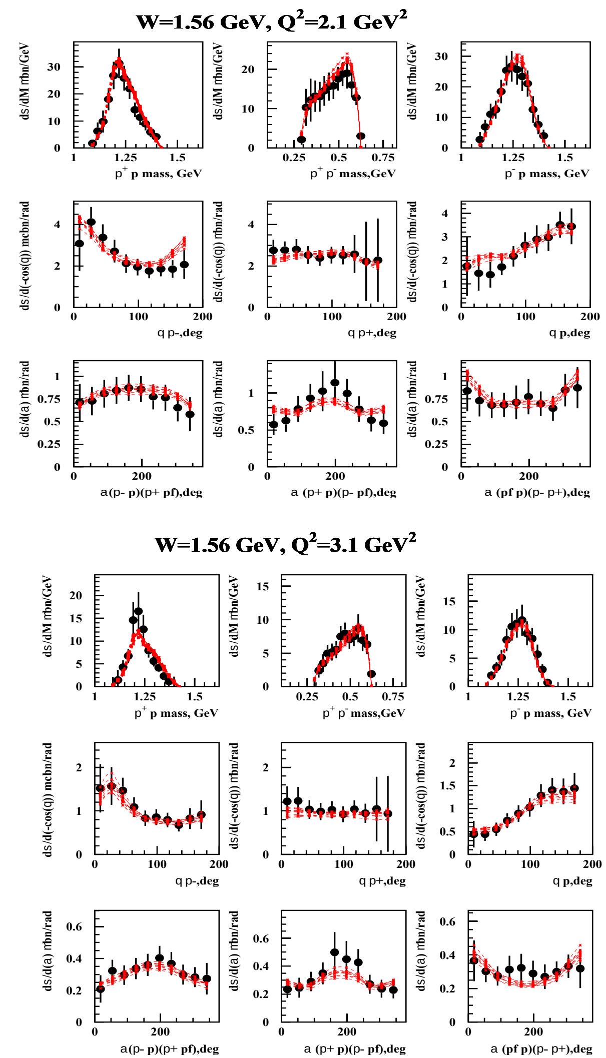
One of the most important achievements in hadron physics of the last decade in synergistic efforts between experimentalists, phenomenologists, and theorists.

Electrocouplings of the $\Delta(1600)3/2^+$: CSM prediction vs. Data Determination



Parameter-free CSM predictions for $\Delta(1600)3/2^+$ electrocouplings
Ya Lu et al., Phys. Rev. D 100, 034001 (2019)

Extraction of $\Delta(1600)3/2^+$ electrocouplings from the CLAS $\pi^+\pi^-p$ electroproduction data at 2 GeV^2<Q^2<5 GeV^2 within the JM reaction model, January-March, 2022

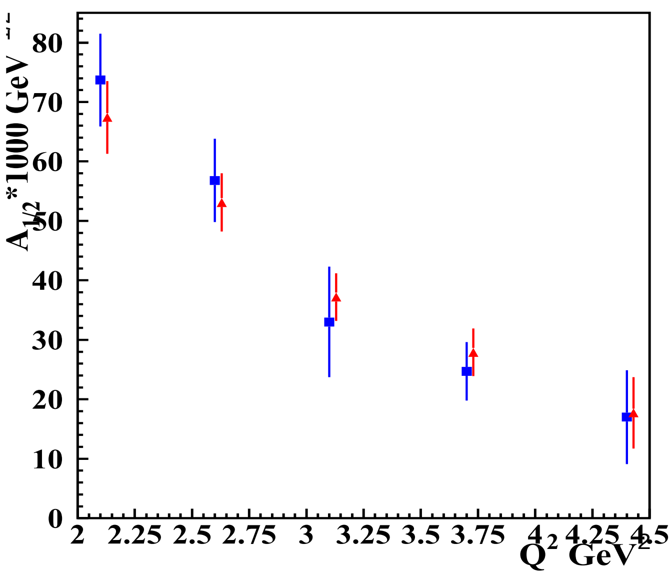


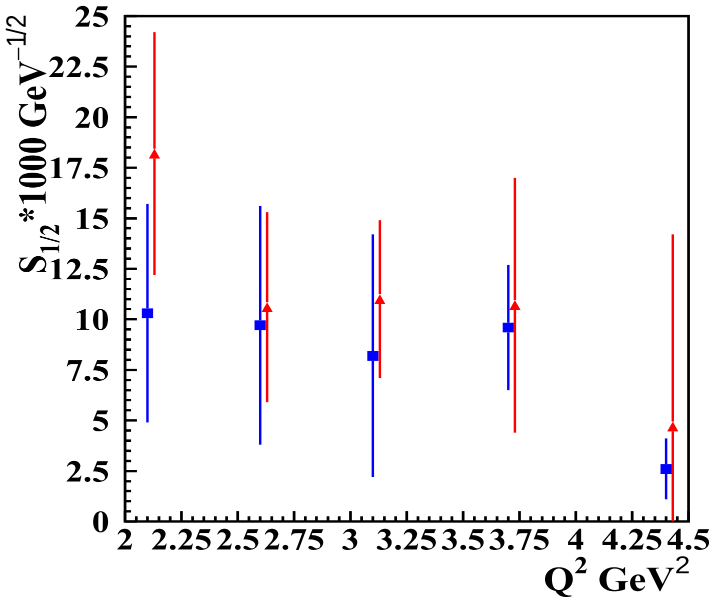
N(1440)1/2$^+$ Parameters from $\pi^+\pi^-p$ Data at $2<Q^2<5$ GeV^2

Γ_{tot}, MeV	$\Gamma\pi\Delta$, MeV	Γ ρp, MeV	Mass, GeV
331±50 343±40 352±37	129±48 142±39 120±41	5.6±1.9 5.6±1.0 4.9±2.2	1.45±0.010 1.45±0.015 1.45±0.011
BF, %	21-62 27-60 20-52	1.0-2.7 1.2-2.2 <2	

The data fit 1.51<W<1.61 GeV:
in black:
in red: $3.0<Q^2<5.0$ GeV^2
$2.0<Q^2<3.5$ GeV^2

$\pi^+\pi^-p$ at $0.5<Q^2<1.5$ GeV^2
V.I. Mokeev, et al., PRC 93, 025206 (2016)





Electrocouplings:

red: Nπ
I.G. Aznauryan et al., PRC 80, 055203 (2009)

blue: $\pi+\pi^-$p
JM21 preliminary

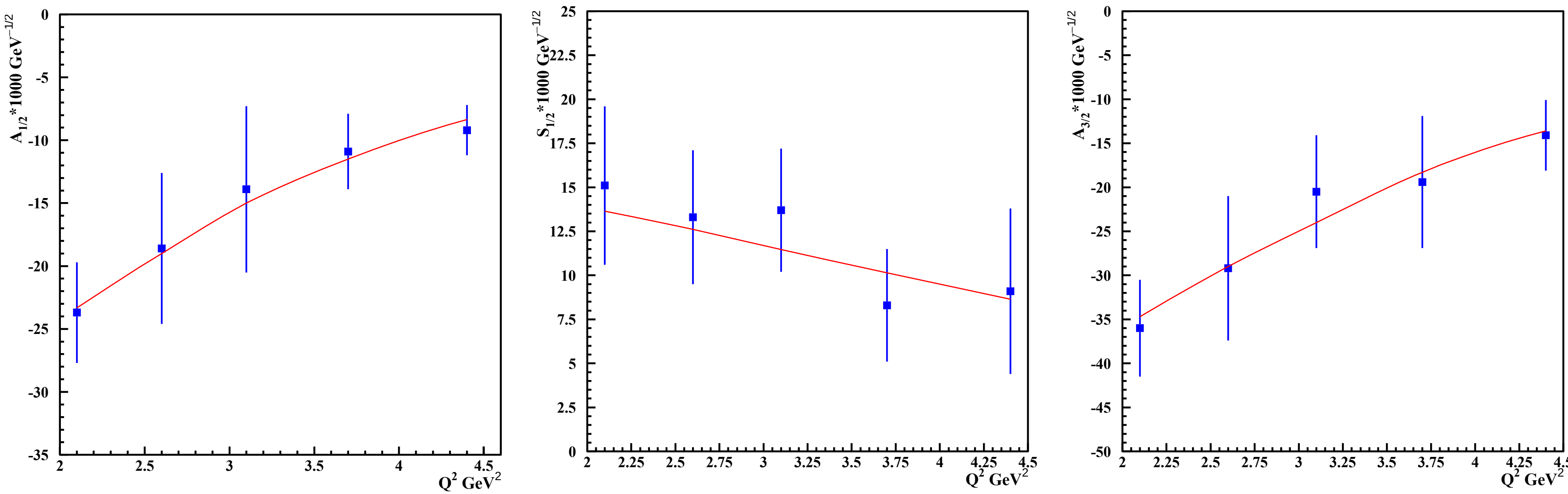
Consistent results on N(1440)1/2$^+$ electrocouplings from Nπ/$\pi^+\pi^-$p electroproduction and good description of the $\pi^+\pi^-$p data with Q^2 independent $\pi\Delta$ /ρp decay widths demonstrate credible extraction of these quantities and the capability of reaction models for reliable extraction tools

$\Delta(1600)3/2^+$ parameters from $\pi^+\pi^-p$ data fit

Γ_{tot}, MeV	Γ $\pi\Delta$, MeV	Γ ρp, MeV	Mass, GeV
248±25 259±21	158.±25. 169±22	0 0	1.564±0.026 1.57±0.018
BF, %	48-82 52-81	0 0	

The data fit at
1.51<W<1.61 GeV:
in black: $2.0<Q^2<3.5$ GeV^2
in red: $3.0<Q^2<5.0$ GeV^2

continuum QCD predictions, Ya Lu et al., Phys. Rev. D 100, 034001 (2019)



CLAS results on $\Delta(1600)3/2^+$ electrocouplings confirmed the CSM prediction solidifying evidence for insight into dressed quark mass function and, consequently, into EHM !

Emergence of Hadron Mass from the Data with CLAS12

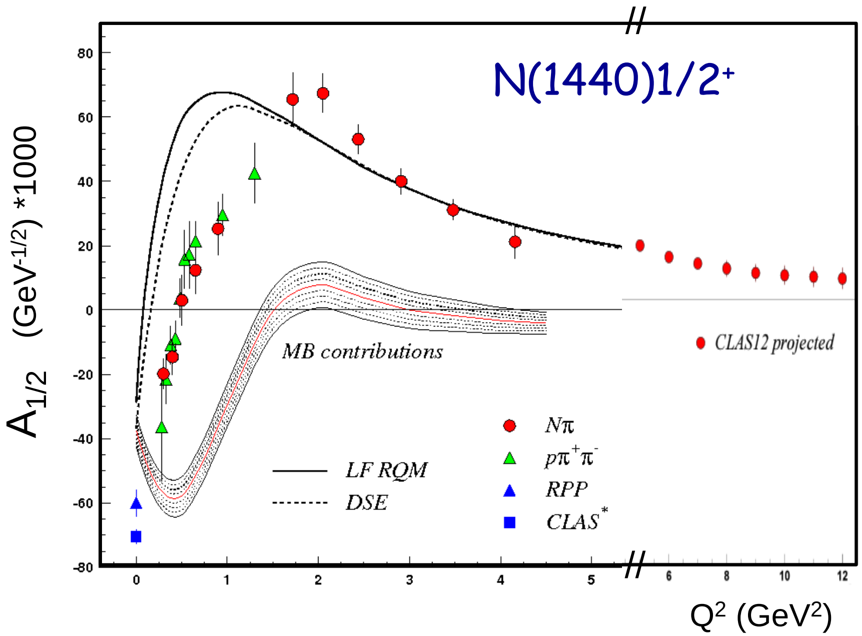
N* electroexcitation studies at JLab during and after 12 GeV era will address the critical questions:

How is >98% of visible mass generated?

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

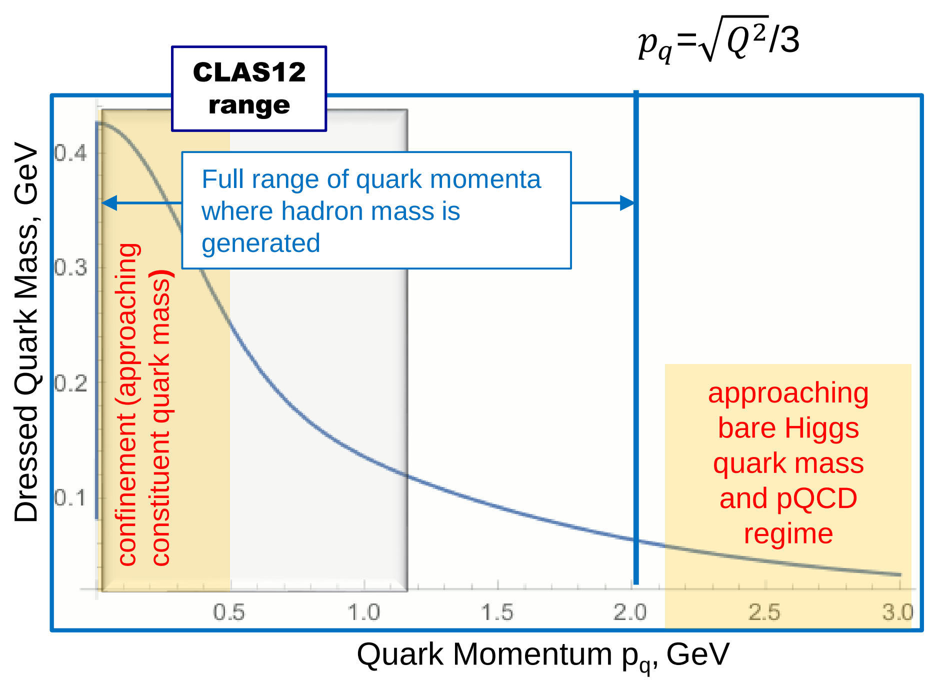
(S.J, Brodsky et al., Int. J. Mod. Phys. Rev. E29, 2030006 (2020))

Mapping-out quark mass function from the results on $\gamma_v pN^*$ electrocouplings of spin-isospin flip, radial, and orbital excited nucleon resonances at $5<Q^2<36$ GeV^2 is needed to explore the full range of distances where the dominant part of hadron mass is generated



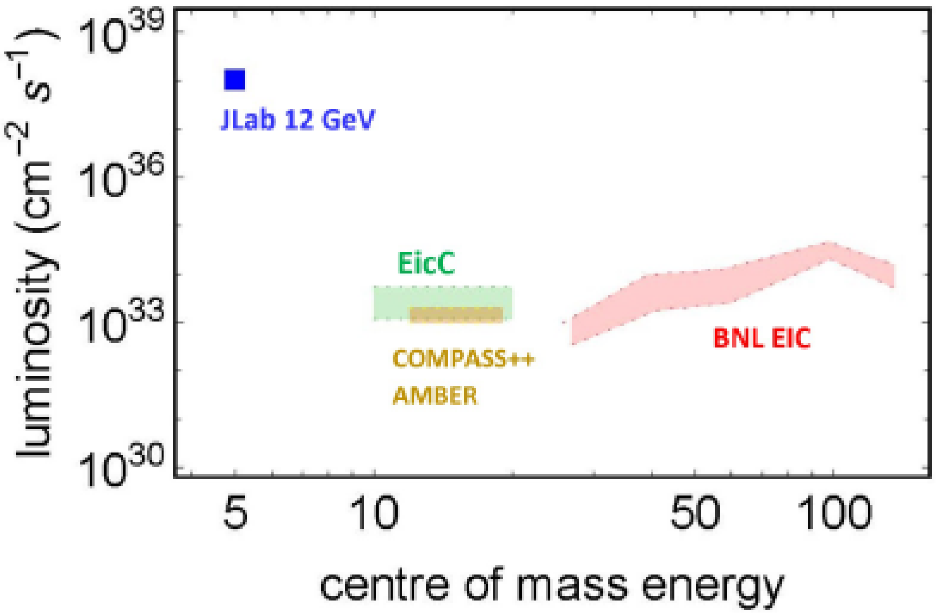
CLAS results vs. theory expectations with running quark mass

Access to the dressed quark/hadron mass generation



Studies of $\gamma_v pN^*$ Electrocouplings at $Q^2 > 10$ GeV^2

Energy and luminosity increase up to >10^{36} cm^{-2}s^{-1} are needed in order to obtain information on the $\gamma_v pN^*$ electrocouplings at Q^2>10 GeV^2, allowing us to map out the momentum dependence of the dressed quark mass within the entire range of distances where the dominant part of hadron mass is generated



Both EicC and EIC would need much higher, unlikely feasible luminosity

The exclusive electroproduction measurements foreseen at JLab after completion of the 12 GeV program:

- Beam energy at fixed target: 24 GeV
- Nearly 4π coverage
- High luminosity

Offer maximal achievable luminosity for extraction of $\gamma_v pN^*$ electrocouplings at Q^2>10 GeV^2

Conclusions and Outlook

- **EHM paradigm makes a broad array of predictions. Those for N/N* structure are worth testing to gain insight and understanding of hadron mass generation by mapping the momentum dependence of the dressed quark running masses.**

- **The CLAS detector provided the dominant part of the data on most exclusive meson electroproduction channels in the resonance region. These high-quality data 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 the π^+n, π^0p, ηp, and $\pi^+\pi^-p$ channels offering the experimental input needed for the validation of *all* available and foreseen approaches for the description of hadron mass.**

- **A good description of CLAS results on the $\Delta(1232)3/2^+$ and $N(1440)1/2^+$ electro-excitation amplitudes *achieved with the same dressed quark mass function* as used previously in the successful evaluations of the elastic ground nucleon and pion form factors, and the pion PDF validates insight into the dynamics that underlie the emergence of hadron mass.**

- **The CSM parameter-free predictions on the $\Delta(1600)3/2^+$ electrocouplings obtained within the same framework as for the above-mentioned resonances have been confirmed by the first preliminary results on the electrocouplings of this state from $\pi^+\pi^-p$ electroproduction data. Combined with the successful description of the hadron structure observables mentioned above, these results offer overwhelming evidence in support of the CSM concept for EHM.**

Conclusions and Outlook

- **CLAS12 is the only facility in the world capable of obtaining the electrocouplings of all prominent N* states at the still unexplored ranges of the highest Q^2 for exclusive reactions from 5 GeV^2 to 12 GeV^2 from measurements of $N\pi$, $\pi^+\pi^-p$, and KY electroproduction, allowing us to map out the dressed quark mass function at quark momenta < 1.3 GeV.**

- **Extension of the results on the $\gamma_v pN^*$ electrocouplings into the Q^2 range from 10 GeV^2 to 36 GeV^2 from the measurements of exclusive meson electroproduction after the future JLab upgrade with 24 GeV beam energy and luminosity $>10^{36}$ $cm^{-2}s^{-1}$ will provide information on the dressed quark mass function at the full range of distances where the dominant part of hadron mass is generated, addressing the most challenging problems of the Standard Model on the nature of >98% of hadron mass, quark-gluon confinement, and the emergence of the N* structure from QCD. It will make *the future JLab at high energy/luminosity the ultimate QCD machine.***

- **CSM approach is capable to predict the observables which describe the pion and kaon structure from the results on exploration of the ground and excited nucleon state structure and forge synergistic efforts between JLab and AMBER@CERN, EIC, EicC on gaining insight into the nature of hadron mass.**

Back up

N* Structure in Experiments with CLAS/CLAS12

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

- $\gamma_v pN^*$ electrocouplings at photon virtualities up to 10 GeV^2 for most of the excited proton states through analyzing the major meson electroproduction channels from CLAS/CLAS12 data
- Explore hadron mass emergence (EHM) and elucidate the trace anomaly by mapping out the dynamical quark mass in the transition from almost massless pQCD quarks to fully dressed constituent quarks

An important part of the efforts on the exploration of strong QCD from the data of the experiments with electromagnetic probes:

1. **S.J. Brodsky et al., Int. J. Mod. Phys. E29, 203006 (2020).**
2. **C.D. Roberts, Symmetry 12, 1468 (2020).**
3. **M. Barabanov et al., Prog. Part. Nucl. Phys. 103835 (2021).**

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

1. **I.G. Aznauryan and V.D. Burkert, Prog. Part. Nucl. Phys. 67, 1 (2012).**
2. **D.S. Carman, K. Joo, and V.I. Mokeev, Few Body Syst. 61, 29 (2020).**
3. **V.D. Burkert and C.D. Roberts, Rev. Mod. Phys. 91, 011003 (2019).**

Approaches for Extraction of $\gamma_v NN^*$ Electrocouplings from the CLAS Exclusive Meson Electroproduction Data

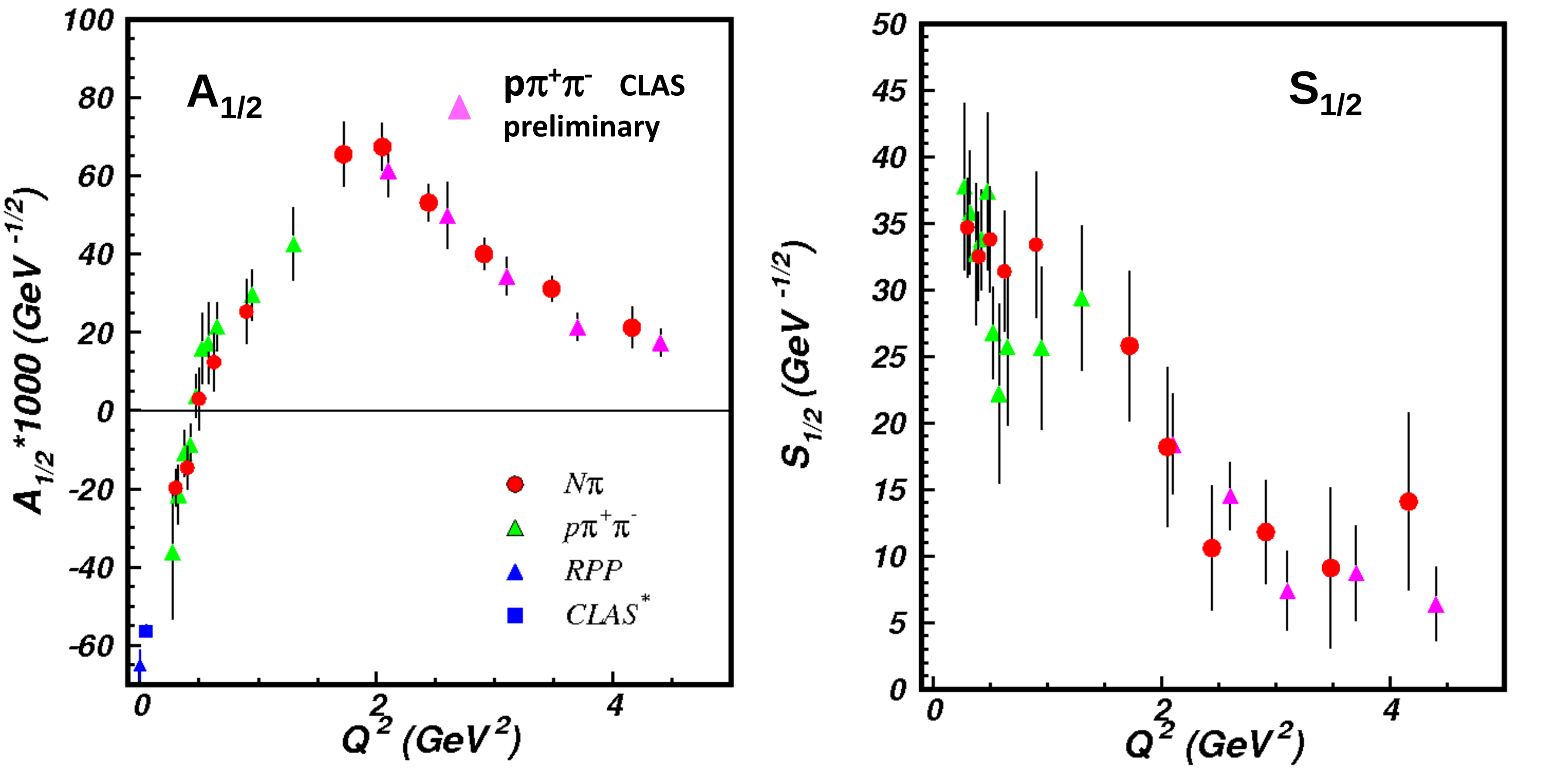
Independent analyses of different meson electroproduction channels:

- **$\pi^+ n$ 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)

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

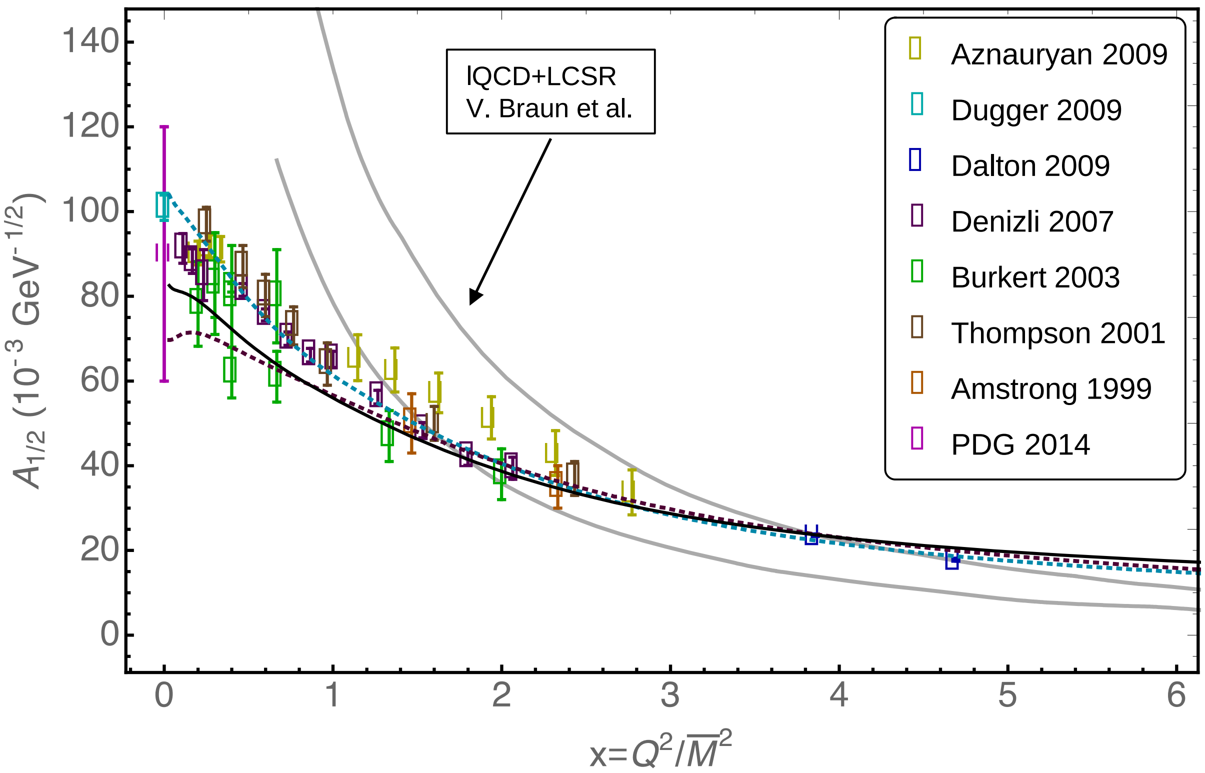
H. Kamano, Few Body Syst. 59, 24 (2018). Argonne-Osaka
H. Kamano, JPS Conf. Proc. 13, 010012 (2017). Argonne-Osaka
M. Mai et al., Phys. Rev. C103, 065204 (2021). Julich-Bonn-Washington
M. Mai et al., e-Print: 2111.04774 [nucl-th]

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



Consistent results on N(1440)1/2$^+$ electrocouplings from independent studies of two major πN and $\pi^+\pi^-$p electroproduction channels with different non-resonant contributions allow us to evaluate the systematic uncertainties of these quantities in a nearly model-independent way

Toward Exploration of EHM from Orbital Nucleon Excitations



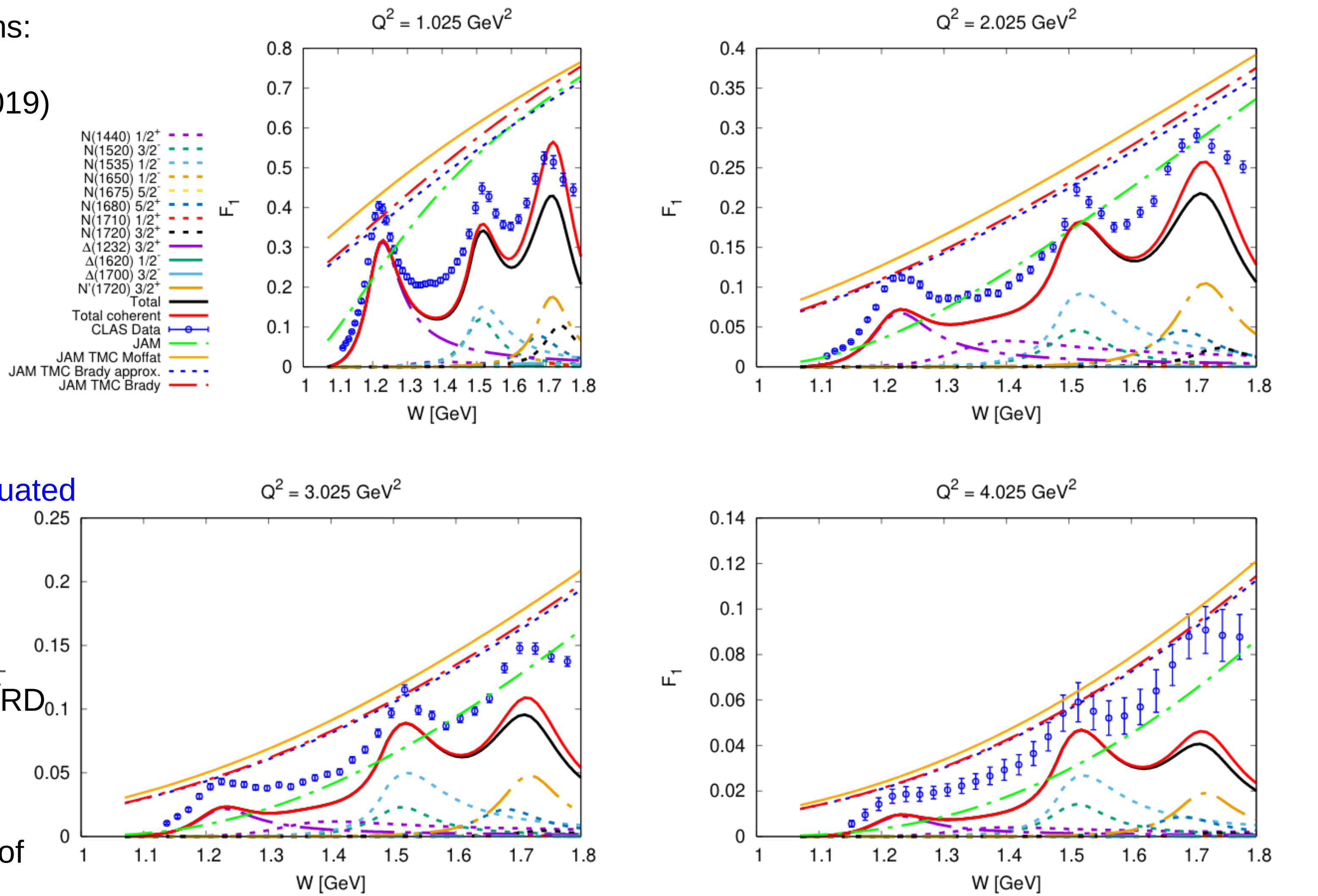
Continuum QCD Breakthrough: $N(1535)1/2^-$ electrocouplings computed under a traceable connection to the QCD Lagrangian (green area). C.D Roberts et al, private communication

The first preliminary continuum QCD evaluation of electro-excitation amplitudes of the $[70,1^-]$ supermultiplet resonances ($L_{3q}=1$) with the same dressed quark mass mass function as used for the resonances with $L_{3q}=0$

Studies of electroexcitation amplitudes for the resonances in the second region suggest the universality of the dressed quark mass function for the ground and different excited states of the nucleon, including the first spin-isospin flip, the first radial, and the first orbital ($L_{3q}=1$) excitations.

Resonant Contributions into Inclusive $F_1(W,Q^2)$ Structure Functions & the Contributions from the PDF in the Ground State of the Nucleon Evaluated from the Data in DIS Region

Resonant contributions:
A.N. Hiller Blin et al.,
PRC 100, 035201 (2019)



Data points are from interpolation of the CLAS results re-evaluated with the σ_L/σ_T ratio from Hall C data

<u>CLAS data:</u>
M. Osipenko et al., PRD 67, 092001 (2003)

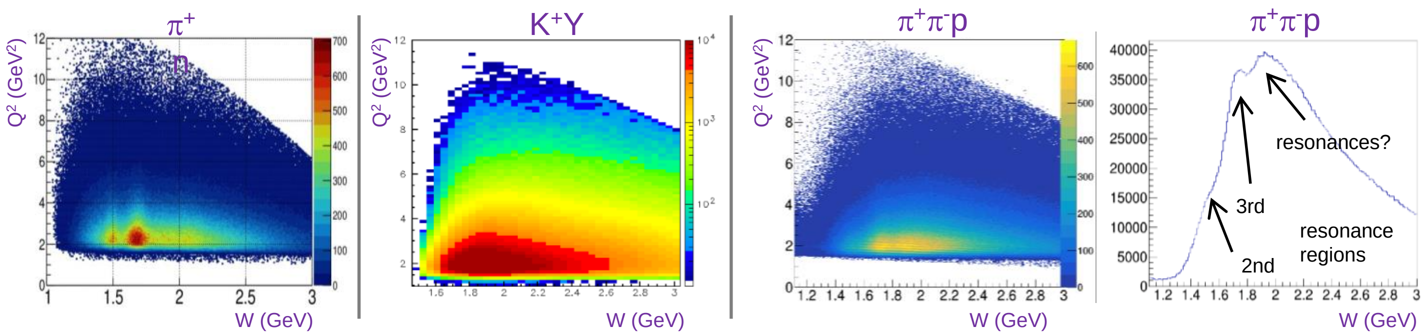
<u>Hall C data</u>:
Y. Liang, PhD thesis of American University (2003)

Green dot-dashed lines: F_1 from JAM PDF
Other smooth curves: F_1 from JAM PDF after target mass corrections within different prescriptions

N* Electroexcitation to high Q^2 with CLAS12

Expected outcome: The first results on the $\gamma_v pN^*$ electrocouplings of most N* states from data in the range W < 2.5 GeV and Q^2 > 5.0 GeV^2 for exclusive reaction channels: πN, $\pi\pi N$, KY, K*Y, KY*

kinematic coverage for RG-A data @ 10.6 GeV



Expected events per Q^2/W bin for full RG-A dataset

π^+n			$K^+\Lambda$ & $K^+\Sigma^0$					$\pi^+\pi^-p$		
Q^2 [GeV^2]	W [GeV] 1.5-1.55	W [GeV] 1.7-1.75	Q^2 [GeV^2]	W_Λ [GeV] 1.7-1.75	W_Σ [GeV] 1.7-1.75	W_Λ [GeV] 1.9-1.95	W_Σ [GeV] 1.9-1.95	Q^2 [GeV^2]	W [GeV] 1.7-1.75	W [GeV] 1.9-1.95
			1.4-2.2	63417	6012	66564	33170			
			2.2-3.0	72144	5364	77443	28720			
5.2-5.8	15272	4175	3.0-4.0	52358	3945	51991	18936	5.2-5.8	2813	2808
5.8-6.5	10737	2637	4.0-5.0	24833	3103	26690	5925	5.8-6.5	1822	1969
6.5-7.2	7367	1684	5.0-6.0	11203	1598	11160	2642	6.5-7.2	1159	1294
7.2-8.1	4567	1290	6.0-7.0	5566	648	6300	943	7.2-8.1	661	924
8.1-9.1	2742	540	7.0-8.0	2606	338	3276	633	8.1-9.1	364	414
9.1-10.5	1453	194	8.0-9.0	1440	244	936	86	9.1-10.5	118	179

Collecting the remainder of the approved RG-A beam time will give a factor of two more statistics

This will extend the Q^2 range of the $\gamma_v pN^*$ electrocouplings to 8-10 GeV^2 for each of these channels – *the data collected so far will limit us to 6-8 GeV^2*