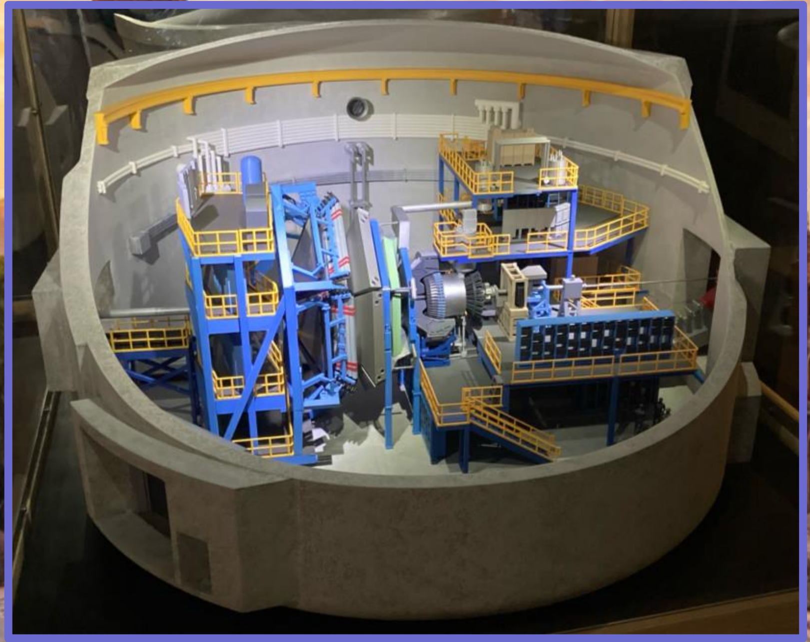
Nucleon Resonance Studies from KY Photo- and Electroproduction



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clas
CEBAF Large Acceptance Spectrometer

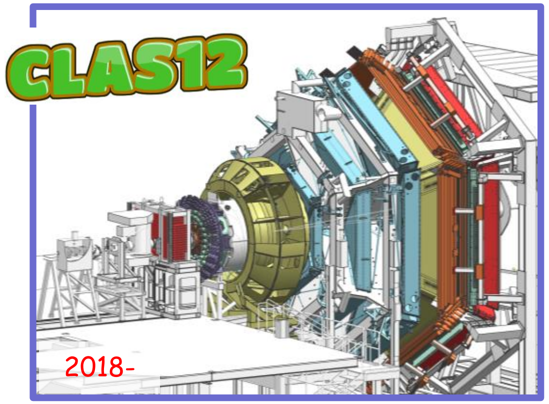
NSTAR 2026

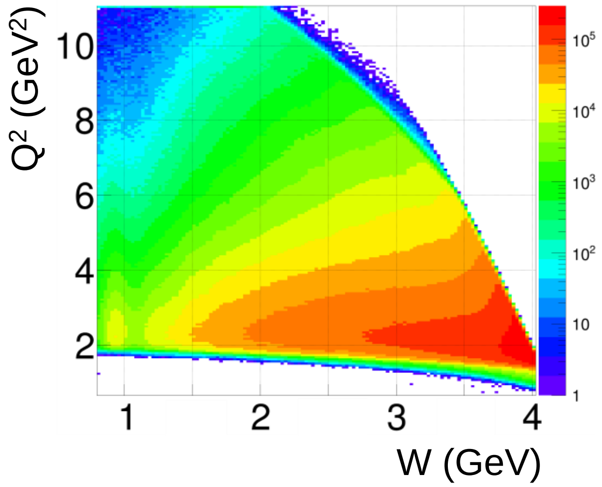
Outline

- Hall B N* Program Overview
- Spectrum/Structure Studies via N*→KY
- Latest Results
- Work in Progress / Upcoming Plans
- Concluding Remarks

Excited Nucleon State Studies

- Nucleons and their excited states are the Nature's most fundamental three-body systems. If we don't understand how QCD builds each state in the spectrum, then our understanding of QCD is incomplete





1. Studies of photo- and electroproduction of nucleon resonances allow for insight to understand the degrees of freedom underlying the N* spectrum
2. Understanding the dynamics of the strong interaction that governs hadron generation from the non-perturbative to perturbative regimes is a challenging open problem in the Standard Model
3. Comparisons of hadron structure parameters deduced from data to QCD-connected predictions are essential

The N* program is one of the physics foundations of Hall B

The large acceptance CLAS & CLAS12 spectrometers were designed to study $\gamma^{(*)}N$ over a broad kinematic range

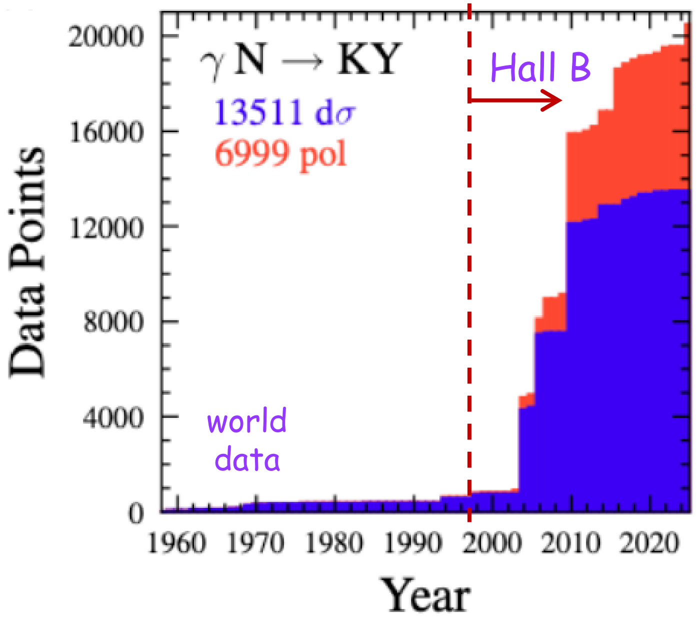
CLAS KY Photoproduction Overview

CLAS
γp → KY

Observable	Final State(s)	W (GeV)	$\cos\theta_K^{c.m.}$	N_{bin}	Year
$d\sigma$	$K^+\Lambda$, $K^+\Sigma^0$	[1.6 : 2.3]	[−0.9 : 0.9]	1140 Λ, 1020 Σ^0	2004
	$K^+\Lambda$, $K^+\Sigma^0$	[1.6 : 2.5]	[−0.9 : 0.9]	1494 Λ, 1386 Σ^0	2006
	$K^+\Lambda$	[1.6 : 2.84]	[−0.9 : 0.9]	2076	2010
	$K^+\Sigma^0$	[1.7 : 2.5]	[−0.9 : 0.9]	2089	2010
P	$K^+\Lambda$, $K^+\Sigma^0$	[1.6 : 2.3]	[−0.9 : 0.9]	220 Λ, 70 Σ^0	2004
	$K^+\Lambda$	[1.6 : 2.84]	[−0.9 : 0.9]	1707	2010
	$K^+\Sigma^0$	[1.7 : 2.5]	[−0.9 : 0.9]	455	2010
	$K^0_S\Sigma^+$	[1.75 : 2.73]	[−0.9 : 0.7]	113	2013
	$K^0_S\Sigma^+$	[1.8 : 2.1]	[−0.8 : 0.7]	21	2025
C_x, C_z	$K^+\Lambda$, $K^+\Sigma^0$	[1.6 : 2.5]	[−0.9 : 0.9]	196 Λ, 81 Σ^0	2006
	$K^+\Lambda$	[1.7 : 3.3]	[−0.85 : 0.95]	410	2025
O_x, O_z	$K^+\Lambda$, $K^+\Sigma^0$	[1.7 : 2.2]	[−0.75 : 0.85]	323 Λ, 120 Σ^0	2016
	$K^0_S\Sigma^+$	[1.8 : 2.1]	[−0.8 : 0.7]	21	2025
Σ	$K^+\Lambda$, $K^+\Sigma^0$	[1.7 : 2.2]	[−0.75 : 0.85]	323 Λ, 120 Σ^0	2016
	$K^0_S\Sigma^+$	[1.8 : 2.1]	[−0.8 : 0.7]	21	2025
T	$K^+\Lambda$, $K^+\Sigma^0$	[1.7 : 2.2]	[−0.75 : 0.85]	323 Λ, 120 Σ^0	2016
	$K^0_S\Sigma^+$	[1.8 : 2.1]	[−0.8 : 0.7]	21	2025

CLAS
γn → KY

$d\sigma$	$K^+\Sigma^-$	[1.67 : 2.75]	[−0.85 : 0.85]	396	2010
	$K^0\Lambda$	[1.64 : 2.34]	[−0.7 : 0.8]	225	2017
Σ	$K^+\Sigma^-$	[1.7 : 2.3]	[−0.8 : 0.8]	246	2022
E	$K^0\Lambda$, $K^0\Sigma^0$	[1.7 : 2.34]	[−0.7 : 0.7]	6 Λ, 6 Σ^0	2018
	$K^+\Sigma^-$	[1.7 : 2.3]	[−0.6 : 0.6]	24	2020

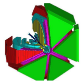


CLAS
γp → K(*)Y(*)

Observable	Final State	W (GeV)	$\cos\theta_K^{c.m.}$	N_{bin}	Year
$d\sigma$	$K^{0*}\Sigma^+$	[2.0 : 2.5]	[−0.75 : 0.8]	54	2007
	$K^{*+}\Lambda$, $K^{*+}\Sigma^0$	[2.0 : 2.9]	[−0.9 : 0.9]	191 Λ, 177 Σ	2013
	$K^+\Sigma^0(1385)$	[2.0 : 2.9]	[−0.8 : 0.8]	144	2013
	$K^+\Lambda(1405)$	[2.0 : 2.9]	[−0.8 : 0.8]	144	2013
	$K^+\Lambda(1520)$	[2.0 : 2.9]	[−0.8 : 0.8]	144	2013
	$K^{*+}\Lambda$	[2.0 : 2.8]	[−0.9 : 0.9]	38	2017
	$K^+\Lambda(1520)$	[2.25 : 3.25]	[−0.8 : 0.8]	63	2021
P	$K^{*+}\Lambda$	[2.0 : 2.8]	[−0.17 : 0.84]	21	2017

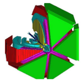
CLAS KY Electroproduction Overview

CLAS
$\gamma^* p \to K^+\Lambda$

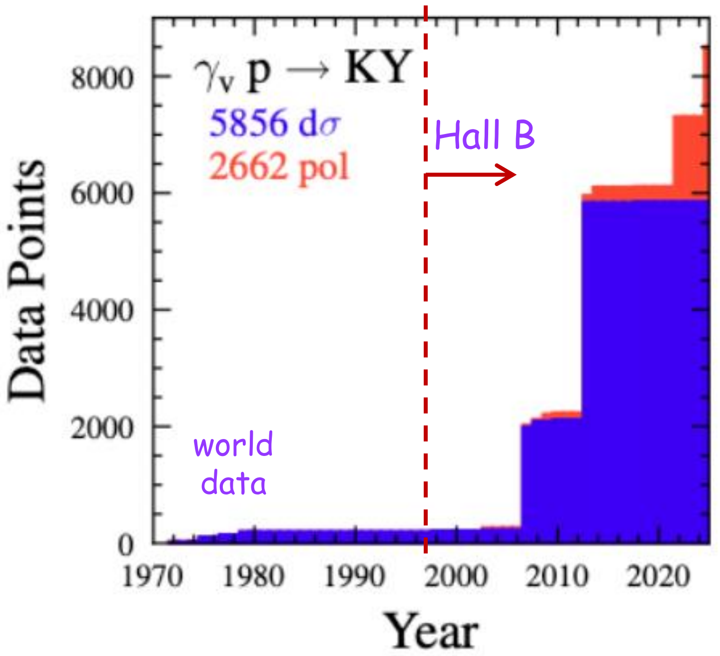


Observables	Q^2 (GeV^2)	W (GeV)	$\cos\theta_K^{c.m.}$	N_{bin}	Year
$\sigma_U, \sigma_{LT}, \sigma_{TT}$	[0.65 : 2.55]	[1.65 : 2.35]	[−0.80 : 1.0]	318	2007
σ_L, σ_T	1.0	[1.65 : 1.95]	[−0.80 : 1.0]	24	2007
$\sigma_{LT'}$	0.65, 1.00	[1.60 : 2.10]	[−0.80 : 1.0]	96	2008
$\sigma_U, \sigma_{LT}, \sigma_{TT}, \sigma_{LT'}$	[1.80 : 3.45]	[1.63 : 2.575]	[−0.9 : 1.0]	480	2013
σ_L/σ_T	[0.3 : 1.5]	[1.6 : 2.15]	1.0	3	2005
	1.5, 2.5	[1.7 : 2.2]		6	2009
$\mathcal{P}^0_{y'}$	1.9	[1.6 : 2.7]	[−1.0 : 1.0]	224	2014
$\mathcal{P}'_x, \mathcal{P}'_z,$	[0.3 : 1.5]	[1.6 : 1.25]	[−1.0 : 1.0]	38	2003
$\mathcal{P}'_{x'}, \mathcal{P}'_{z'}$	2.5	[1.75 : 2.31]	[−0.8 : 0.9]	76	2009

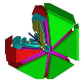
CLAS
$\gamma^* p \to K^+\Sigma^0$



$\sigma_U, \sigma_{LT}, \sigma_{TT}$	[0.65 : 2.55]	[1.725 : 2.35]	[−0.80 : 1.0]	240	2007
σ_L, σ_T	1.0	[1.75 : 1.95]	[−0.80 : 1.0]	18	2007
$\sigma_U, \sigma_{LT}, \sigma_{TT}, \sigma_{LT'}$	[1.80 : 3.45]	[1.695 : 2.575]	[−0.9 : 1.0]	450	2013
$\mathcal{P}'_x, \mathcal{P}'_z, \mathcal{P}'_{x'}, \mathcal{P}'_{z'}$	2.5	2.1	[−0.4 : 0.9]	15	2009



CLAS
$\gamma^* p \to K^+\Lambda^*$



Observable	Final State	Q^2 (GeV^2)	W (GeV)	$\cos\theta_K^{c.m.}$	N_{bin}	Year
Lineshape	$K^+\Lambda(1405)$	[1.0 : 3.0]	[1.5 : 3.5]	[−1.0 : 1.0]	-	2013
$d\sigma$	$K^+\Lambda(1520)$	[0.9 : 2.4]	[1.95 : 2.65]	[−1.0 : 1.0]	96	2001

CLAS12 N* Program

- Measure exclusive electroproduction of Nπ, Nη, N$\pi\pi$, KY final states from unpolarized proton target with longitudinally polarized electron beam

E_b = 6.6, 8.8, 11 GeV, Q^2 = 0.05 → 12 GeV^2, W → 3.0 GeV, cos θ_m^* = [-1:1]

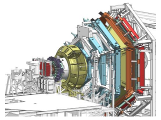
E12-09-003	Nucleon Resonance Studies with CLAS12
E12-06-108A	KY Electroproduction with CLAS12
E12-16-010A	N* Studies Via KY Electroproduction at 6.6 and 8.8 GeV
E12-16-010	A Search for Hybrid Baryons in Hall B with CLAS12

RG-A	Spr. 18 126 mC	10.2 GeV, 10.6 GeV 50% of total
	Fall 18 99 mC	
	Spr. 19 58 mC	
RG-K	Fall 18 28 mC	6.5 GeV, 7.5 GeV
	Spr24 173 mC	6.4 GeV, 8.5 GeV 50% of total

RG-K continues in 2027

1. Study higher-lying N* states:
   - confirm signals of new baryon states seen in $\gamma p \to KY$
   - explore full regime of "missing" quark model states
2. Understand active d.o.f. that account for N* structure vs. distance scale:
   - explore dynamical structure of N* states from low to high Q^2 – evolution of M-B cloud to quark d.o.f.
   - search for predicted qqqg hybrid baryons
3. Insight into emergence of hadron mass

CLAS12
$\gamma^* p \to K^+ Y$



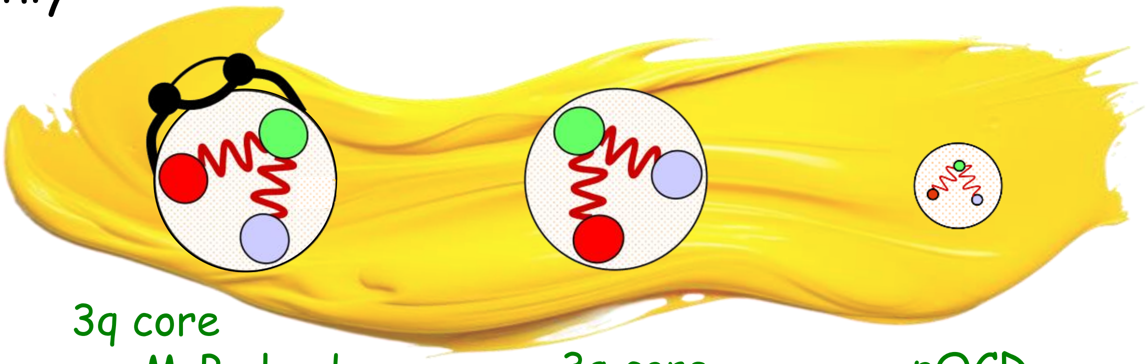
Observables	Q^2 (GeV^2)	W (GeV)	$\cos\theta_K^{c.m.}$	N_{bin}	Year
$\mathcal{P}^0_y$, $\mathcal{P}^0_{y'}$	[0.3 : 4.5]	[1.6 : 2.4]	[−1.0 : 1.0]	312 Λ, 312 Σ^0	2025
$\mathcal{P}'_x$, $\mathcal{P}'_z$, $\mathcal{P}'_{x'}$, $\mathcal{P}'_{z'}$	[0.3 : 4.5]	[1.6 : 2.4]	[−1.0 : 1.0]	312 Λ, 312 Σ^0	2022

Excited Nucleon Structure

- N* structure is more complex than what can be described accounting for dressed quark degrees of freedom only

meson-baryon cloud
surrounding inner quark core

($Q^2 < 1$ GeV^2)



quark core dominates; transition from strongly coupled to pQCD regime

($Q^2 > 5$ GeV^2)

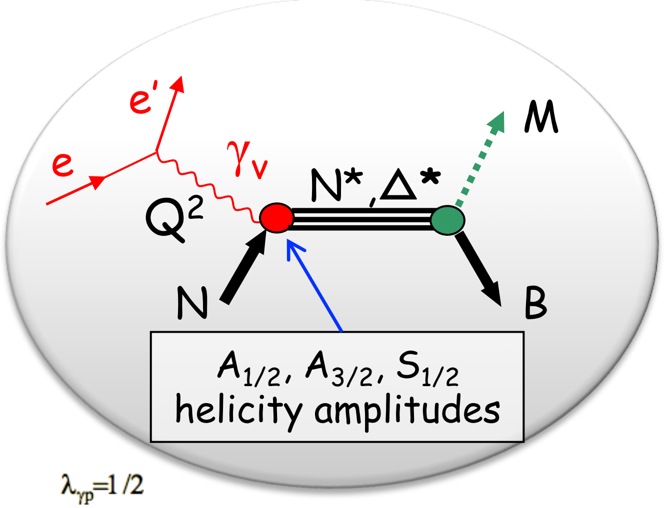
3q core
+ M-B cloud

3q core

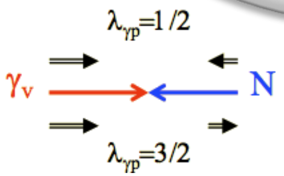
pQCD

low Q^2 ⟶ high Q^2

- Fits to the measured cross sections and polarization observables using reaction models provide access to the $\gamma_v pN^*$ electrocouplings

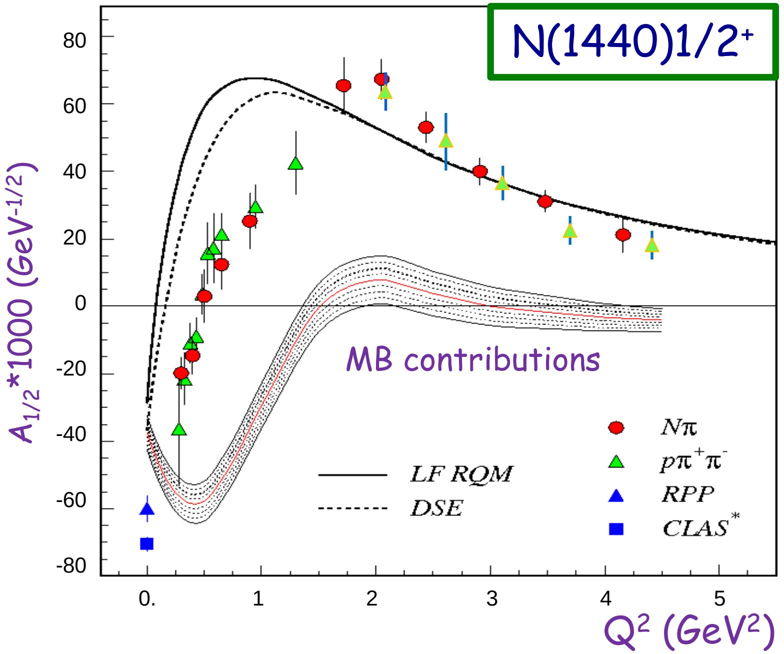


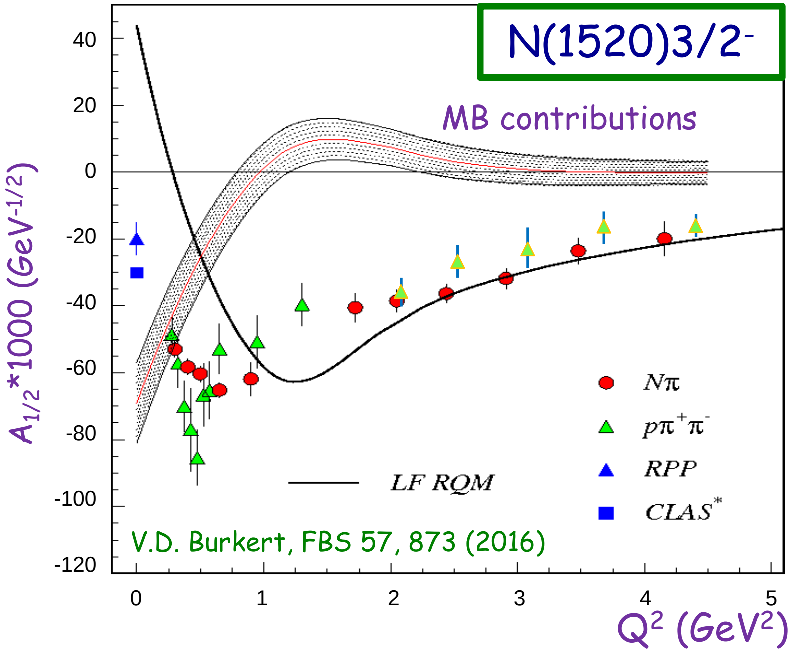
The momentum dependence of the underlying degrees of freedom shapes the structure of N* states and the Q^2 evolution of the electrocouplings



$A_{1/2}$, $A_{3/2}$ – transverse
$S_{1/2}$ - longitudinal

N* Photo-/Electrocouplings from CLAS





CLAS Electrocoupling Extraction

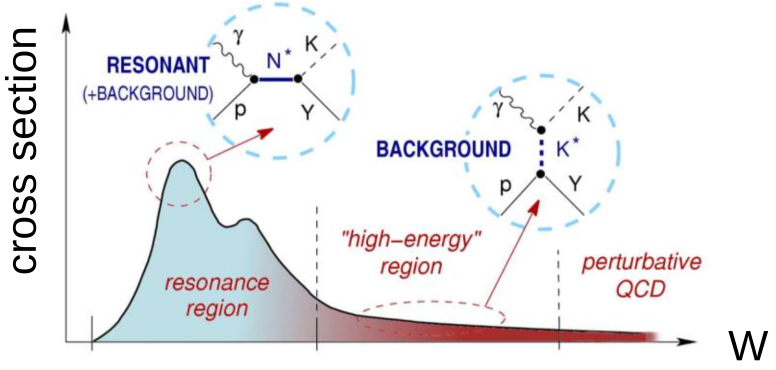
Channel	N*, Δ* States
$\pi^0 p$ $\pi^+ n$	Δ(1232)3/2+, N(1440)1/2+, N(1520)3/2-, N(1535)1/2-
$\pi^+ n$	N(1675)5/2+, N(1680)5/2+, N(1710)1/2+
ηp	N(1535)1/2-
$\pi^+\pi^- p$	N(1440)1/2+, N(1520)3/2-, Δ(1600)3/2+, Δ(1620)1/2-, N(1675)5/2-, N(1680)5/2+, Δ(1700)3/2-, N(1720)3/2+, N'(1720)3/2+

http://userweb.jlab.org/~mokeev/resonance_electrocouplings23

- Good agreement from independent extractions using πN and $\pi\pi$N:
  - Compelling evidence for the reliability of the results
  - Channels have very different mechanisms for the non-resonant background
- Electromagnetic couplings reveal different interplay between meson-baryon cloud and quark core:
  - Important to study for N* states of different quantum numbers
- Data from the KY channels is critical:
  - Provides independent extraction of the photo-/electrocouplings for higher-lying N* states where coupling to πN is small

KY Reaction Models

- A model that describes the KY data is necessary to extract the $\gamma_v pN^*$ electrocouplings from the existing lower Q^2 CLAS data and the higher Q^2 CLAS12 data
- No single channel (isobar type) model has yet been shown to adequately describe the KY electroproduction data in the resonance region



Single Channel:

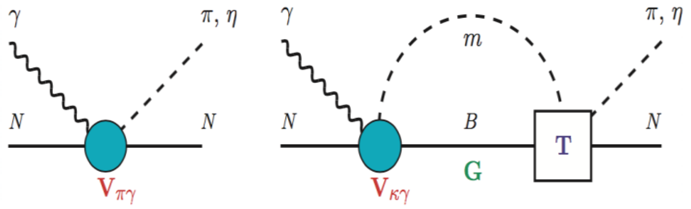
- Unitary Isobar Model and Fixed-t Dispersion relation approaches (Kaon-MAID)
- Regge + Resonance model (Ghent)
- Isobar models (T. Mart, O. Maxwell, P. Bydžovský)

Multi-Channel:

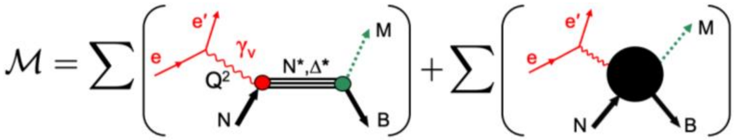
- Bonn-Gatchina
- GWU/SAID

multi-channel PWA

- Dubna-Mainz-Taipei dynamical model
- Argonne-Osaka dynamically coupled channel model
- Jülich-Bonn-GWU coupled-channel framework

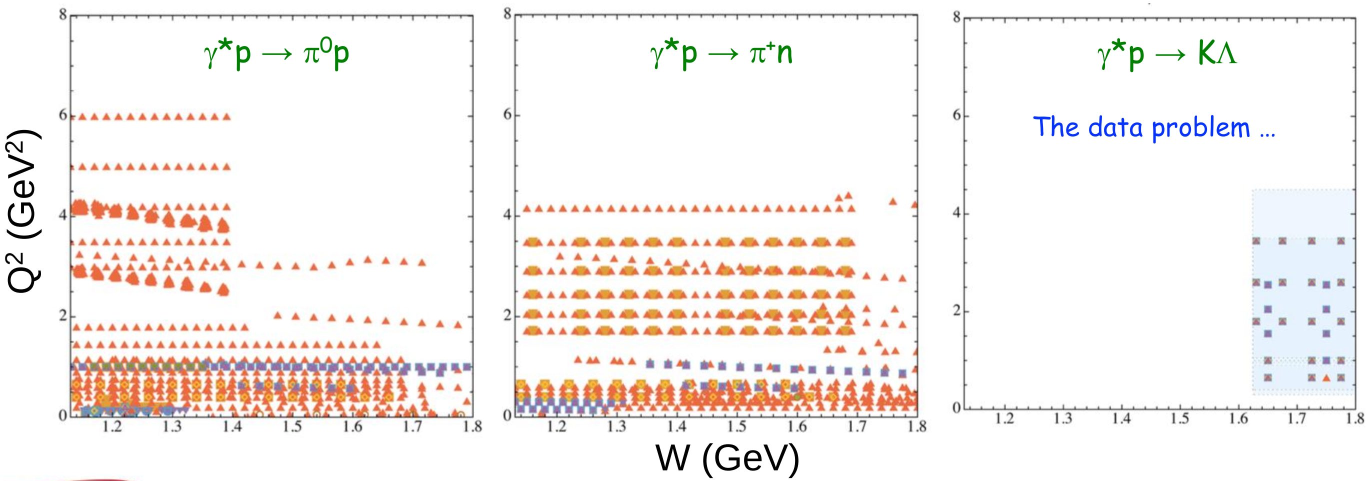


Resonant Amplitudes Non-Resonant Amplitudes



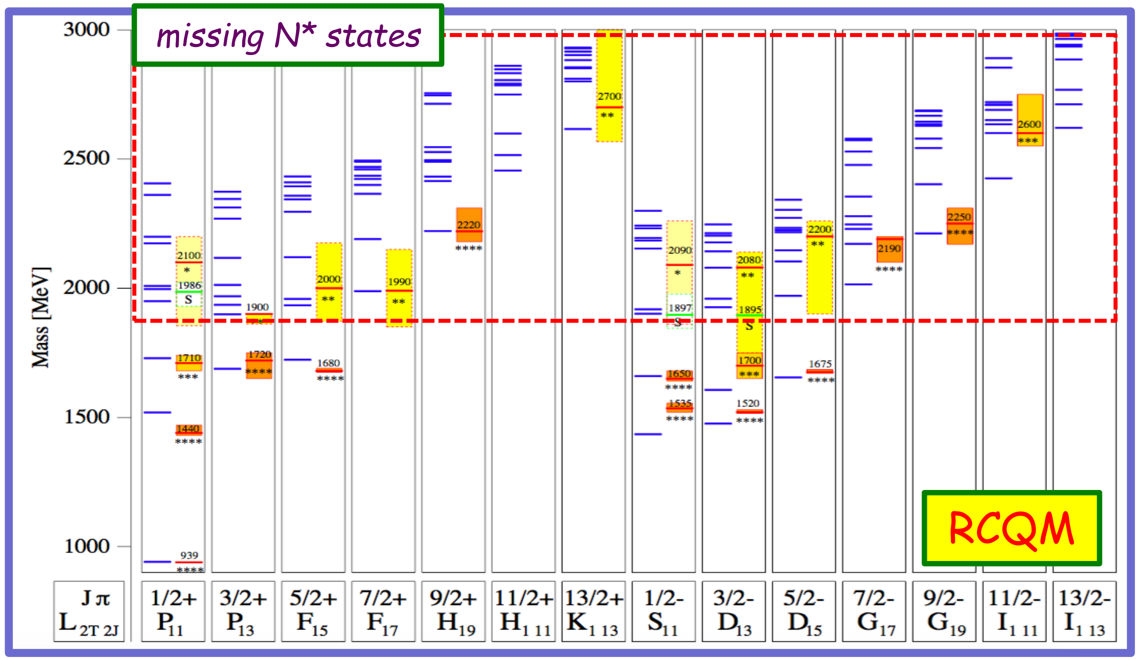
But there has been some recent progress!

D.S. Carman, K. Joo, V.I. Mokeev, FBS 61, 29 (2020)
M. Mai, Eur. Phys. J. A 59, 286 (2023)
Y.-F. Wang et al, PRL 133, 101901 (2024)



Evidence for New N* in KY Channels

State N(mass)J^P	PDG 2010	PDG 2024	πN	KΛ	KΣ	γN
N(1710)1/2$^+$	***	****	****	**	*	****
N(1875)3/2$^-$		***	**	*	*	**
N(1880)1/2$^+$		***	*	**	**	**
N(1895)1/2$^-$		****	*	**	**	****
N(1900)3/2$^+$	**	****	**	**	**	****
N(2000)5/2$^+$	*	**	*			**
N(2060)5/2$^-$		***	**	*	*	***
N(2100)1/2$^+$	*	***	***	*		**
N(2120)3/2$^-$		***	**	**	*	***
Δ(1600)3/2$^+$	***	****	***			****
Δ(1900)1/2$^-$	**	***	***		**	***
Δ(2200)7/2$^-$	*	***	**		**	***



U. Löring, B. Metsch, H.R. Petry, Eur. Phys. J. A 10, 395 (2001)

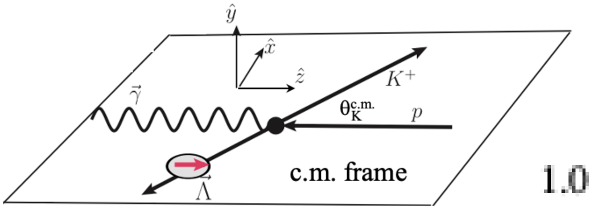
LQCD predictions support CQM

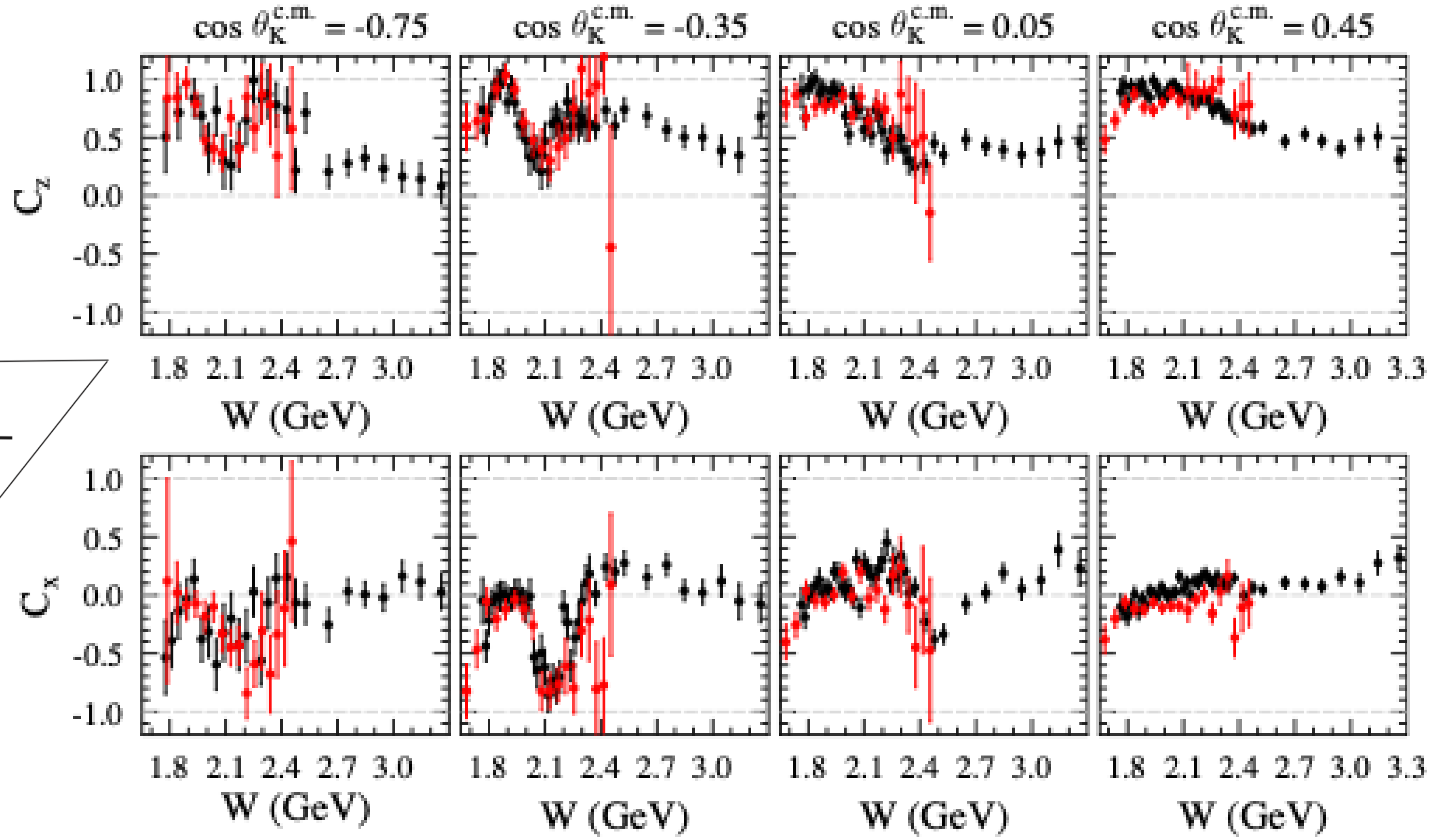
J. Dudek, R. Edwards, PRD 85, 054016 (2012)

Decisive impact from CLAS KY photoproduction data

- Extend studies to KY electroproduction and to higher masses

CLAS KΛ Transferred Polarization (γp)





g1c
g12

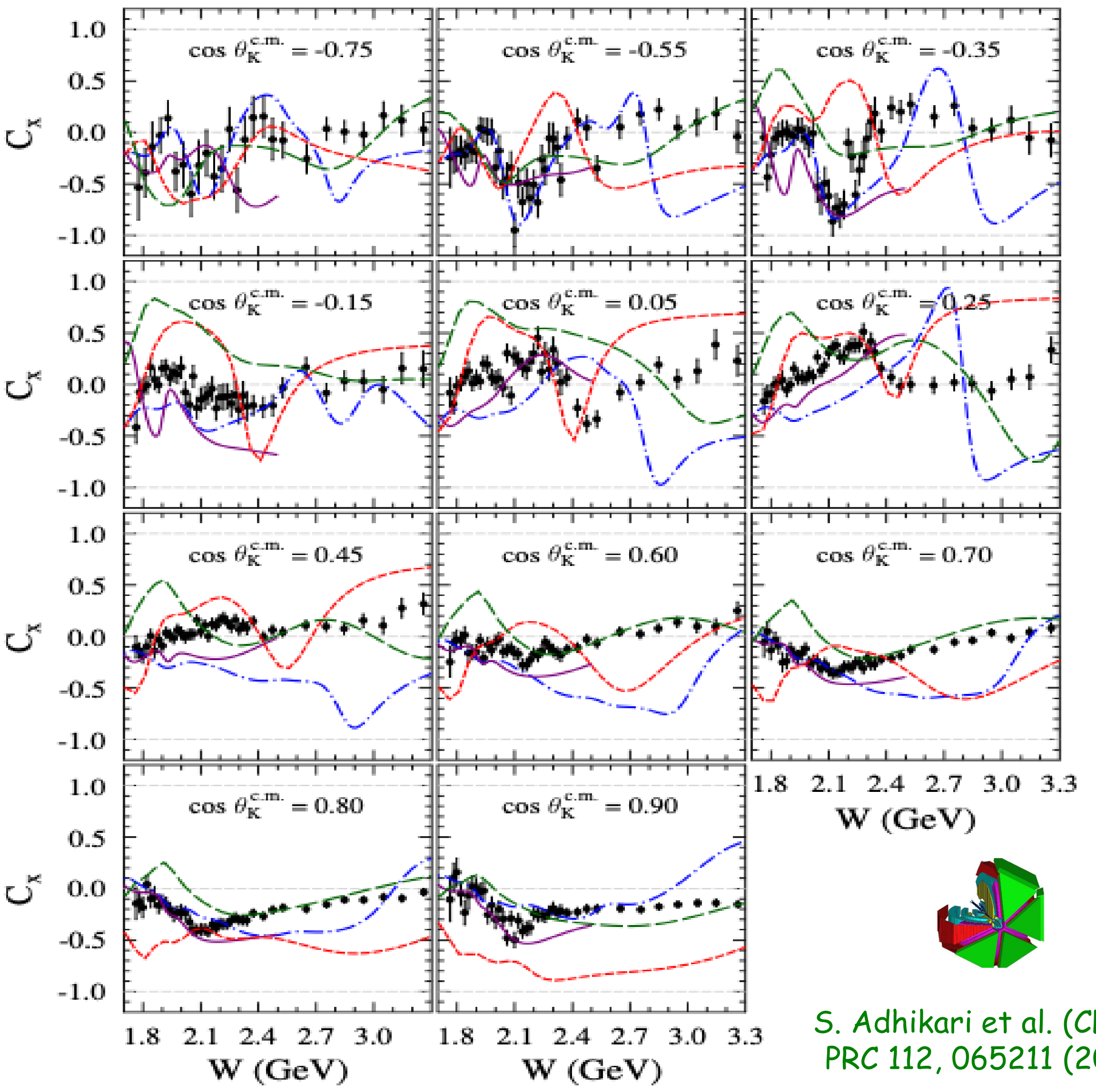
1ST GEN

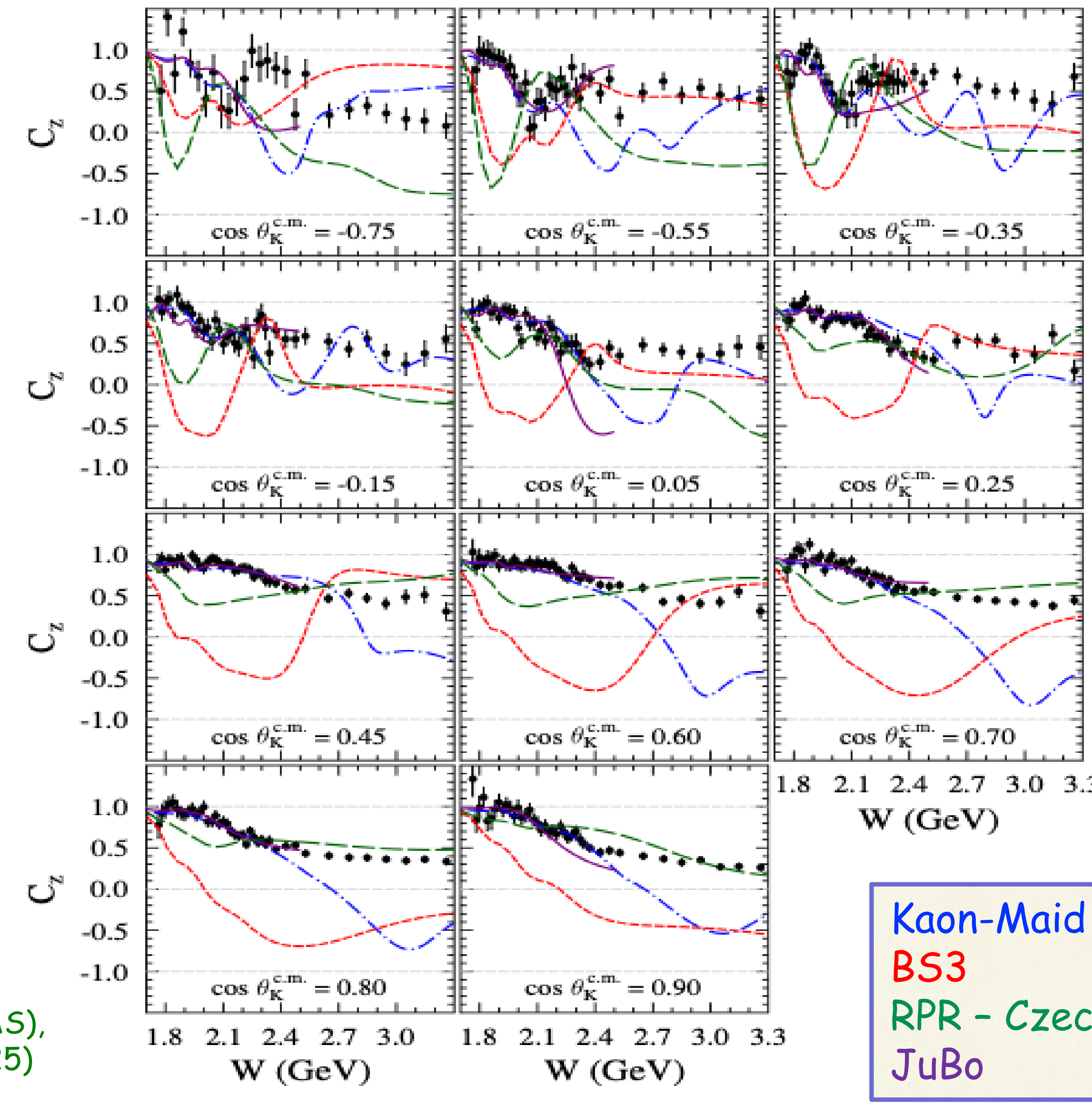
R.K. Bradford et al. (CLAS), PRC 75, 035205 (2007)

S. Adhikari et al. (CLAS), PRC 112, 065211 (2025)

2ND GEN

CLAS KΛ Transferred Polarization (γp)



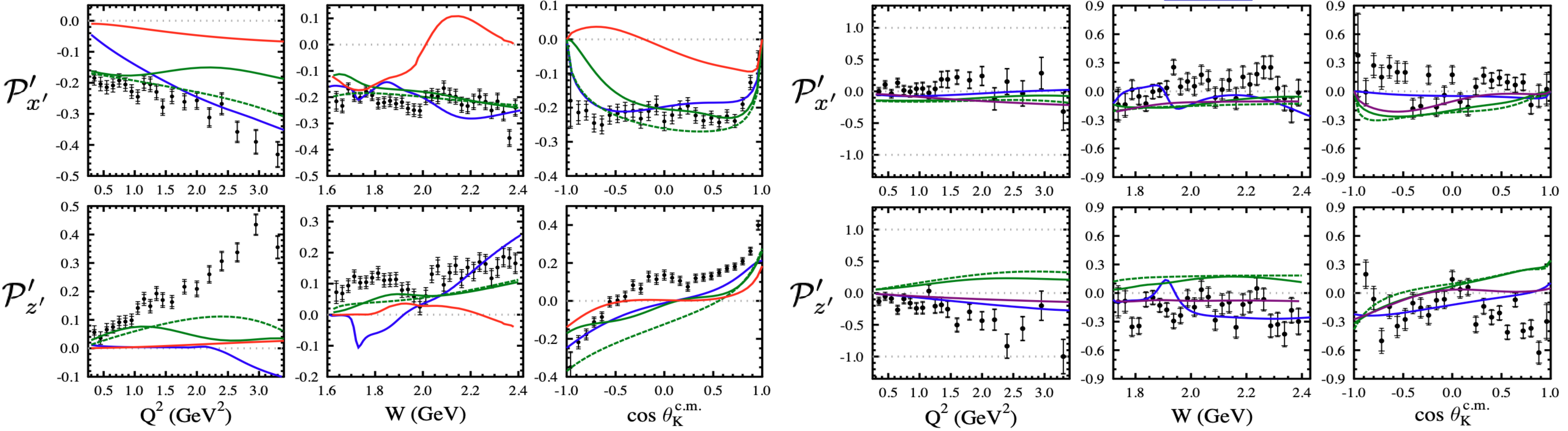


S. Adhikari et al. (CLAS), PRC 112, 065211 (2025)

Kaon-Maid
BS3
RPR – Czech
JuBo

CLAS12 KY Transferred Polarization (ep)

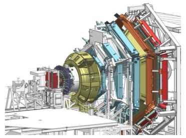
$K^+\Lambda$ $K^+\Sigma^0$

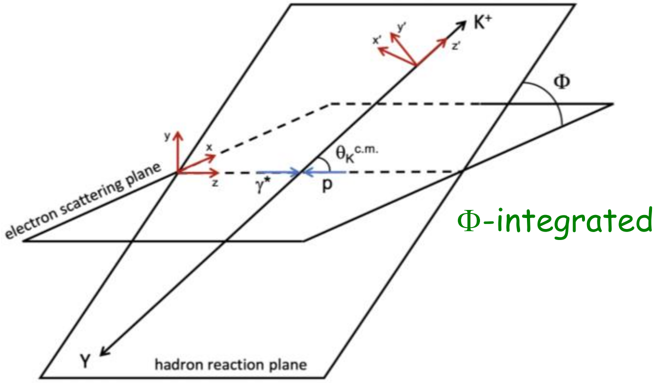


D.S. Carman et al. (CLAS), PRC 105, 065201 (2022)

Model	Year	Type	Fit Data	N* States
SL	1996	Isobar	none	1/2, 3/2
Kaon-MAID	2000	Isobar	none	1/2, 3/2, 5/2
RPR	2011	Isobar+Regge	CLAS γp	1/2, 3/2, 5/2
BS3	2018	Isobar	CLAS γp + ep	1/2, 3/2, 5/2

RG-K - W18
6.5 GeV





Φ-integrated

CLAS12 L/T from Transferred Polarization (ep)

At $\cos\theta_K^{c.m.} = 1, \quad R_{TT'}^{z'0} = R_T^{00}$

$$\mathcal{P}'_{z'} = \mathcal{P}'_z = \frac{c_0 R_{TT'}^{z'0}}{R_T^{00} + \epsilon R_L^{00}} = \frac{c_0 \sigma_T}{\sigma_T + \epsilon \sigma_L}$$

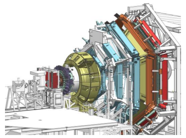
$$\Rightarrow \boxed{R = \frac{\sigma_L}{\sigma_T} = \frac{1}{\epsilon}\left(\frac{c_0}{\mathcal{P}'_{z,z'}} - 1\right)}$$

Use both z′ and z components:

$$\mathrm{R}_{\mathrm{sum}} = \frac{(\mathcal{P}'_{z'} + \mathcal{P}'_z)\sigma_U}{c_0}$$

$$\boxed{R(\theta_K^{c.m.} = 0^\circ) = \frac{2\sigma_U}{\mathrm{R}_{\mathrm{sum}}} - 1}$$

Fit function: $\mathrm{R}_{\mathrm{sum}} = a_0 + a_1 x + a_2 x^2 + a_3 x^3$

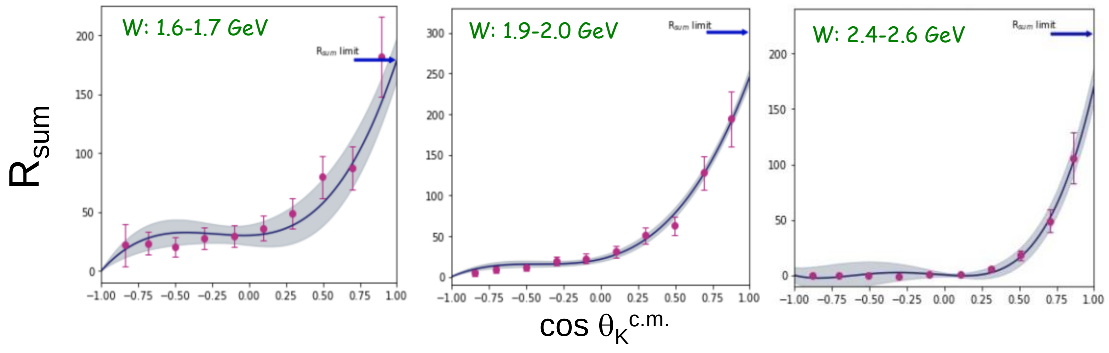


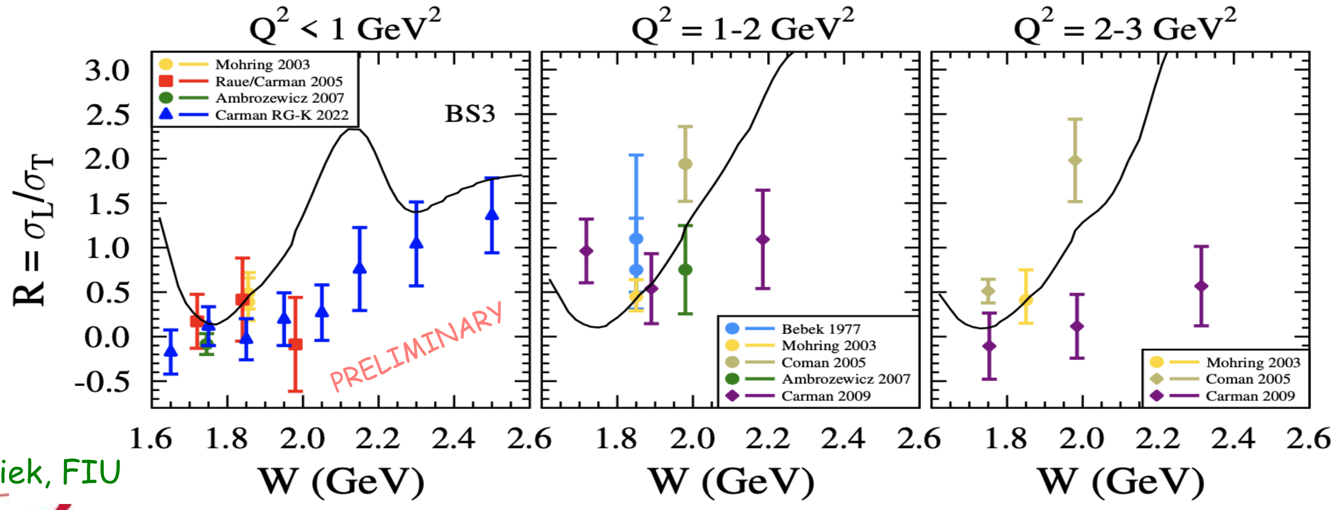
B.A. Raue and D.S. Carman, PRC 71, 065209 (2005)
D.S. Carman et al. (CLAS), PRC 79, 065205 (2009)

R provides stringent tests of:

- Meson pole dominance and meson FF
- Onset of QCD factorization and handbag dynamics
- N* transverse vs. longitudinal electrocouplings

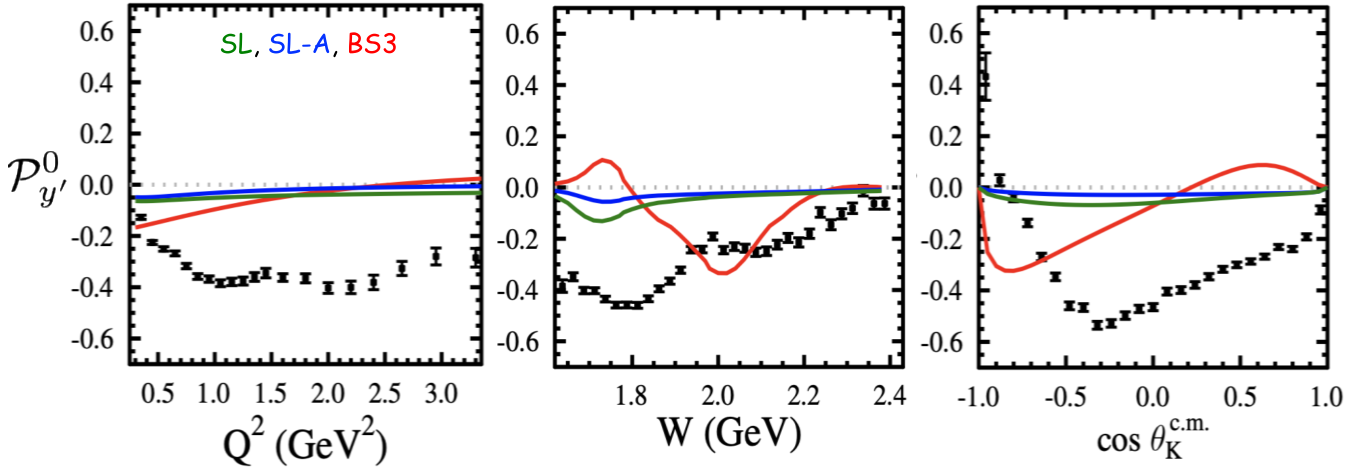
Representative fits

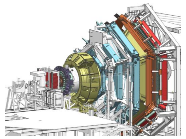




J. Landwersiek, FIU

CLAS12 Recoil Λ Polarization (ep)

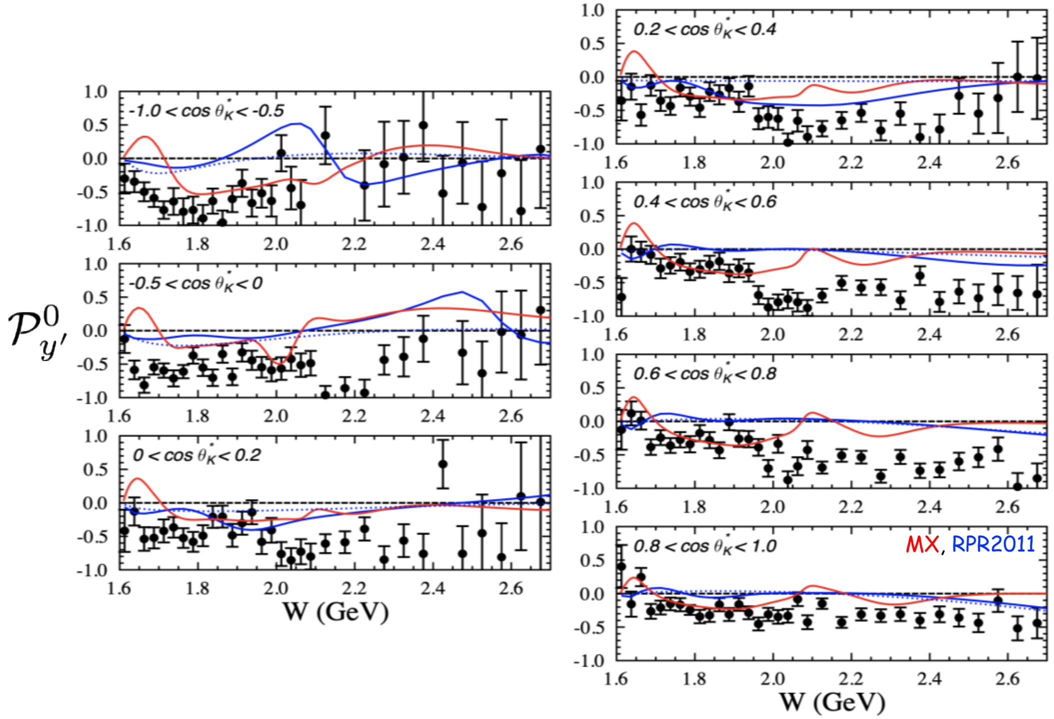




*Summed over Q^2 : [0.3-3.5] GeV^2

CLAS12 data @ 6.535 GeV

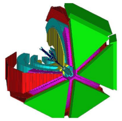
D.S. Carman et al. (CLAS), PRC 112, 035206 (2025)



*Summed over Q^2 : [0.8-3.5] GeV^2

CLAS data @ 5.5 GeV

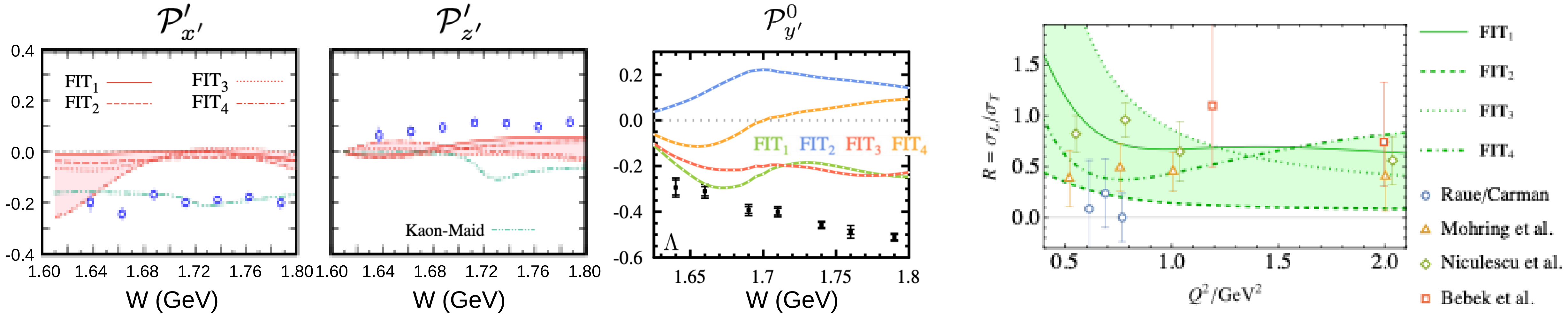
M. Gabrielyan et al. (CLAS), PRC 90, 035202 (2014)



- CLAS12 data from 2018 test run – 10% of PAC approved beam time – amounts to 5x existing CLAS data
- New 6.4 GeV/8.5 GeV data from Jan. – Mar. 2024 amounts to another 5x increase in statistics

Multi-dimensional analysis are required for these observables to have an essential impact!

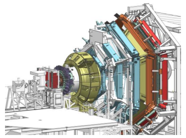
CLAS12 KΛ Polarization (ep) in JBW Model



- "Postdictions" of $K^+\Lambda$ polarization observables from Jülich-Bonn-Washington model show clear mismatch with the data
- As JBW model fits well the $K^+\Lambda$ photoproduction data, it is expected that these new data can impact the constraints on the longitudinal multipoles most directly.
- Data from CLAS12 are "highly" integrated making direct inclusion in fitting difficult
- New data from CLAS12 in fine binning of Q^2, W, cos $\theta_K^{c.m.}$ forthcoming!

Jülich-Bonn-Washington Model

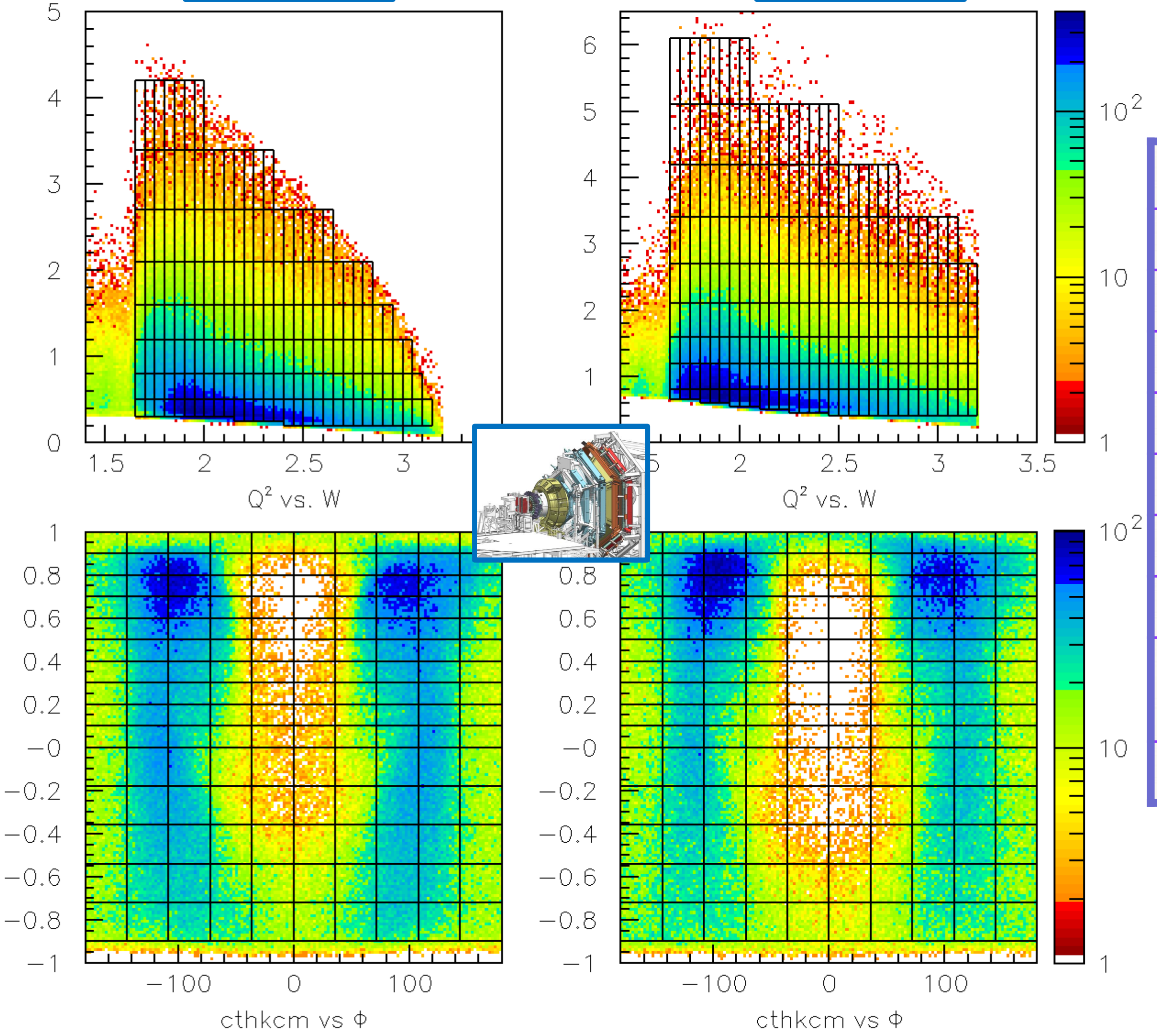
M. Mai et al., EPJA 59 (12), 286 (2023)

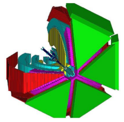


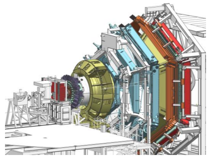
CLAS vs CLAS12 KY Datasets

6.4 GeV

8.5 GeV







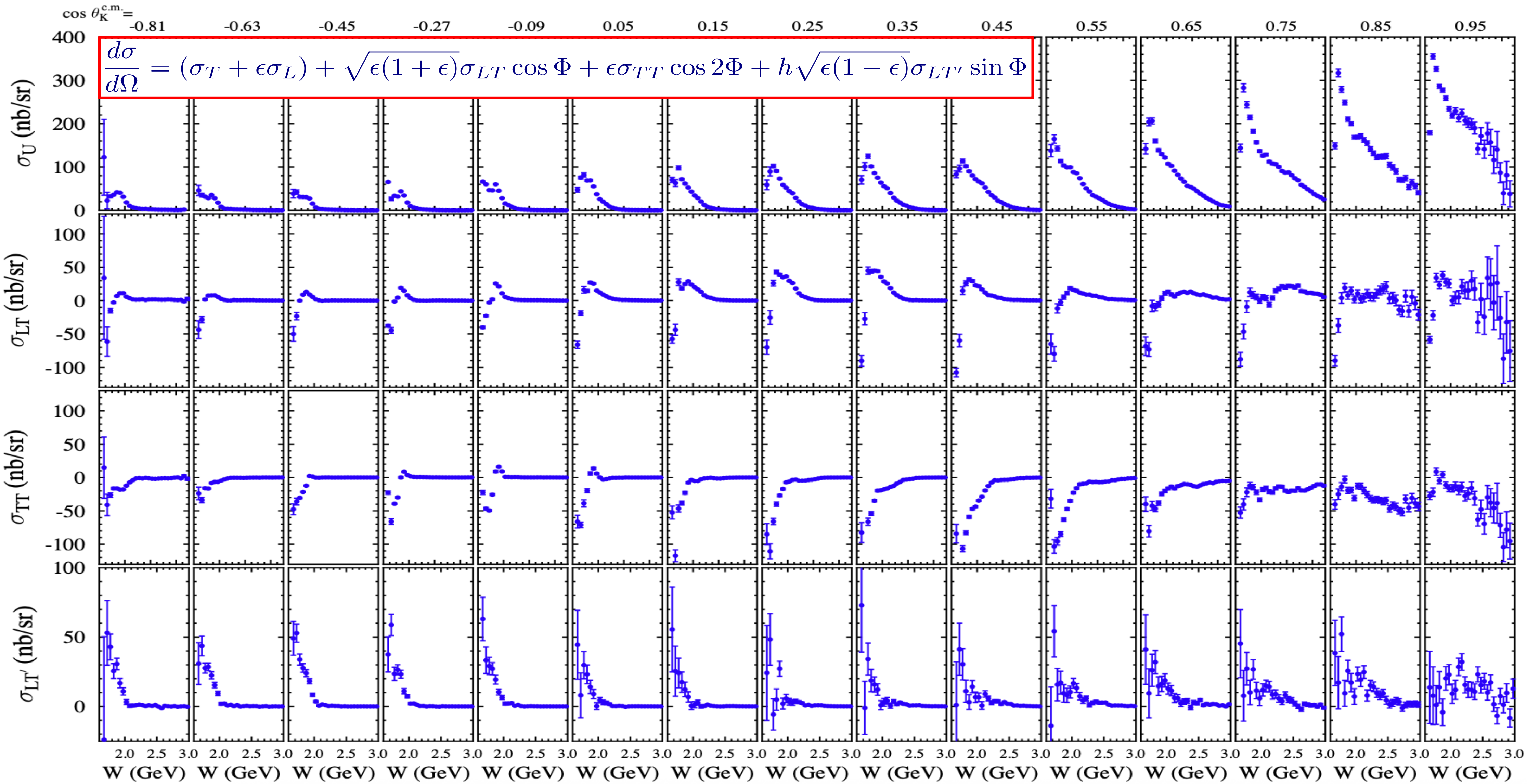
Quantity	e1f (CLAS)	RG-K (CLAS12)	
E_{beam}	5.5 GeV	6.4 GeV	8.5 GeV
Q^2	[1.4:3.9] GeV^2	[0.2:4.2] GeV^2	[0.4:6.1] GeV^2
W	[1.6:2.6] GeV	[1.6:3.2] GeV	[1.6:3.4] GeV
$\cos\theta_K^{c.m.}$	[-1.0:1.0]	[-1.0:1.0]	
Φ (deg)	[-180°:180°]	[-180°:180°]	
Lumin ($\mathcal{L}$)	1e^{34} cm^{-2}s^{-1}	1e^{35} cm^{-2}s^{-1}	
Q_{tot}	16 mC	90 mC	80 mC
N_{bins} $Q^2/W/\cos\theta_K^{c.m.}/\Phi$	3/20/10/8	8/30/15/10	9/35/15/10
N_Λ/N_Σ	3.64e^5 / 1.56e^5	1.64e^7 / 6.13e^6	1.02e^7 / 3.42e^6

New RG-K data from Jan.-Mar. 2024 – calibration and data processing complete … data analysis underway

Very Preliminary

CLAS12 $K^+\Lambda$ Structure Functions (ep)

$$\frac{d\sigma}{d\Omega} = (\sigma_T + \epsilon\sigma_L) + \sqrt{\epsilon(1+\epsilon)}\sigma_{LT}\cos\Phi + \epsilon\sigma_{TT}\cos 2\Phi + h\sqrt{\epsilon(1-\epsilon)}\sigma_{LT'}\sin\Phi$$

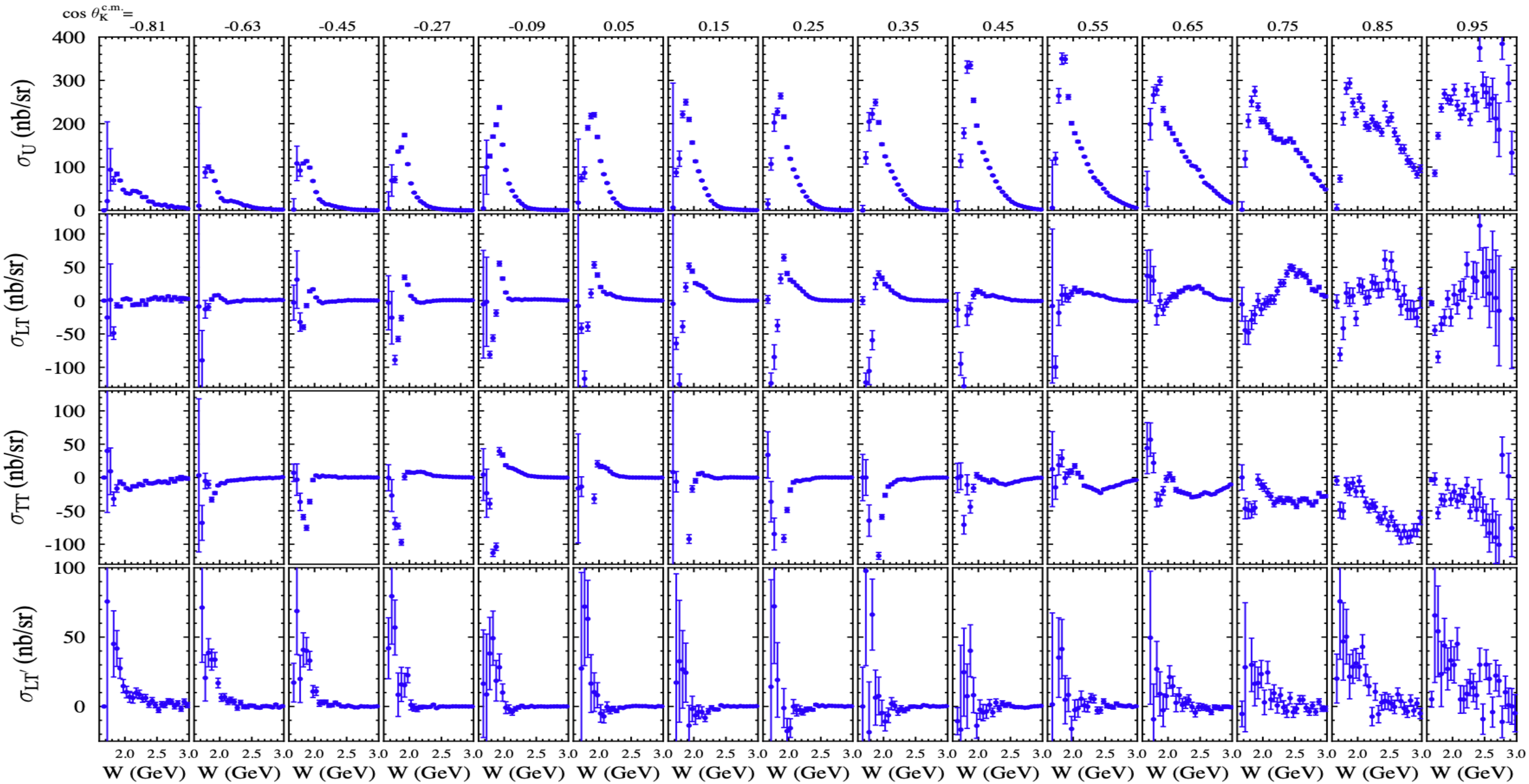


No background subtraction

RG-K 6.395 GeV
Q^2 [0.2:0.5] GeV^2

Very Preliminary

CLAS12 $K^+\Sigma^0$ Structure Functions (ep)

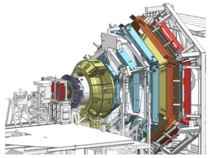


No background subtraction

RG-K 6.395 GeV
Q^2 [0.2:0.5] GeV^2

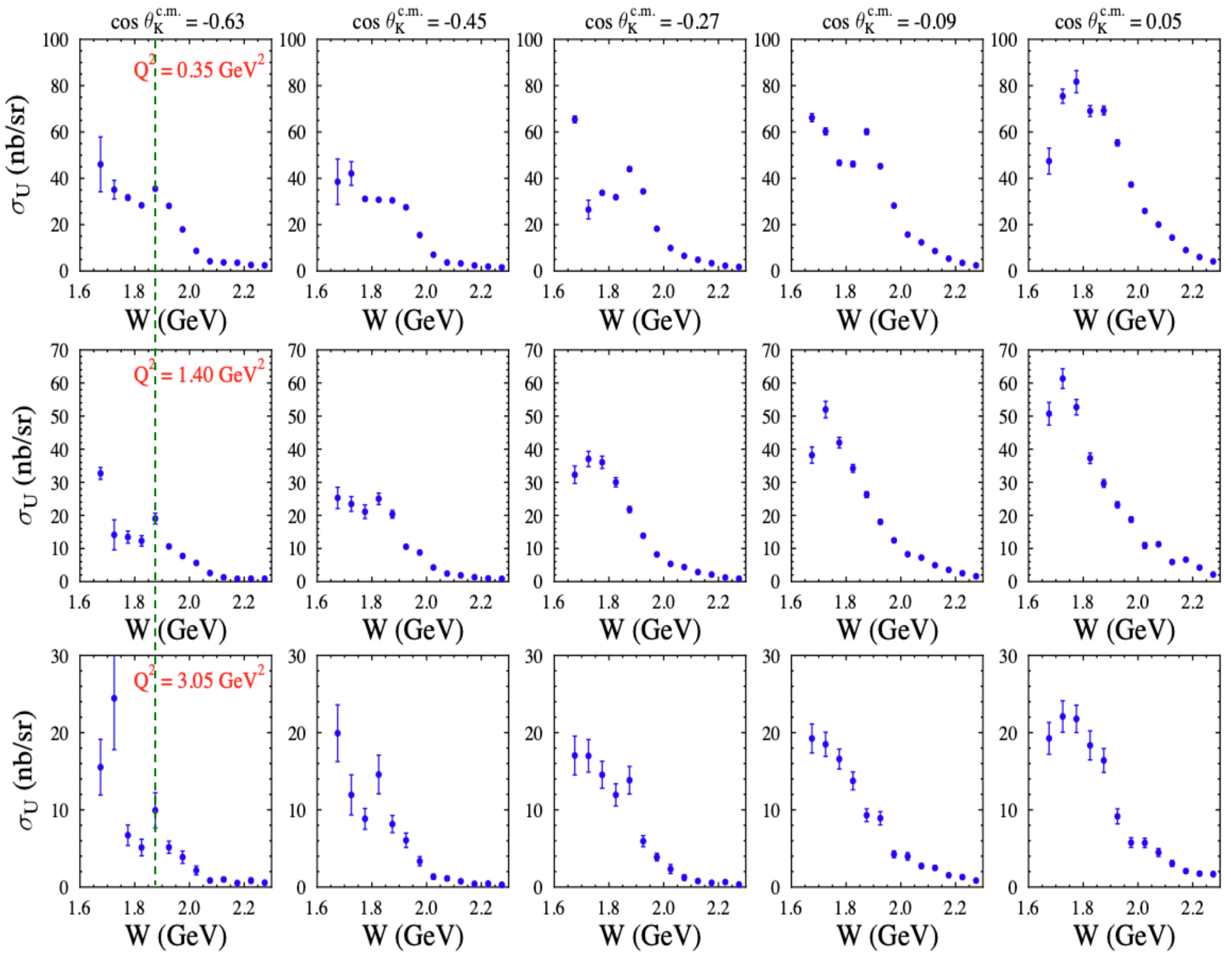
Very Preliminary

CLAS12 K^+Y Structure Functions

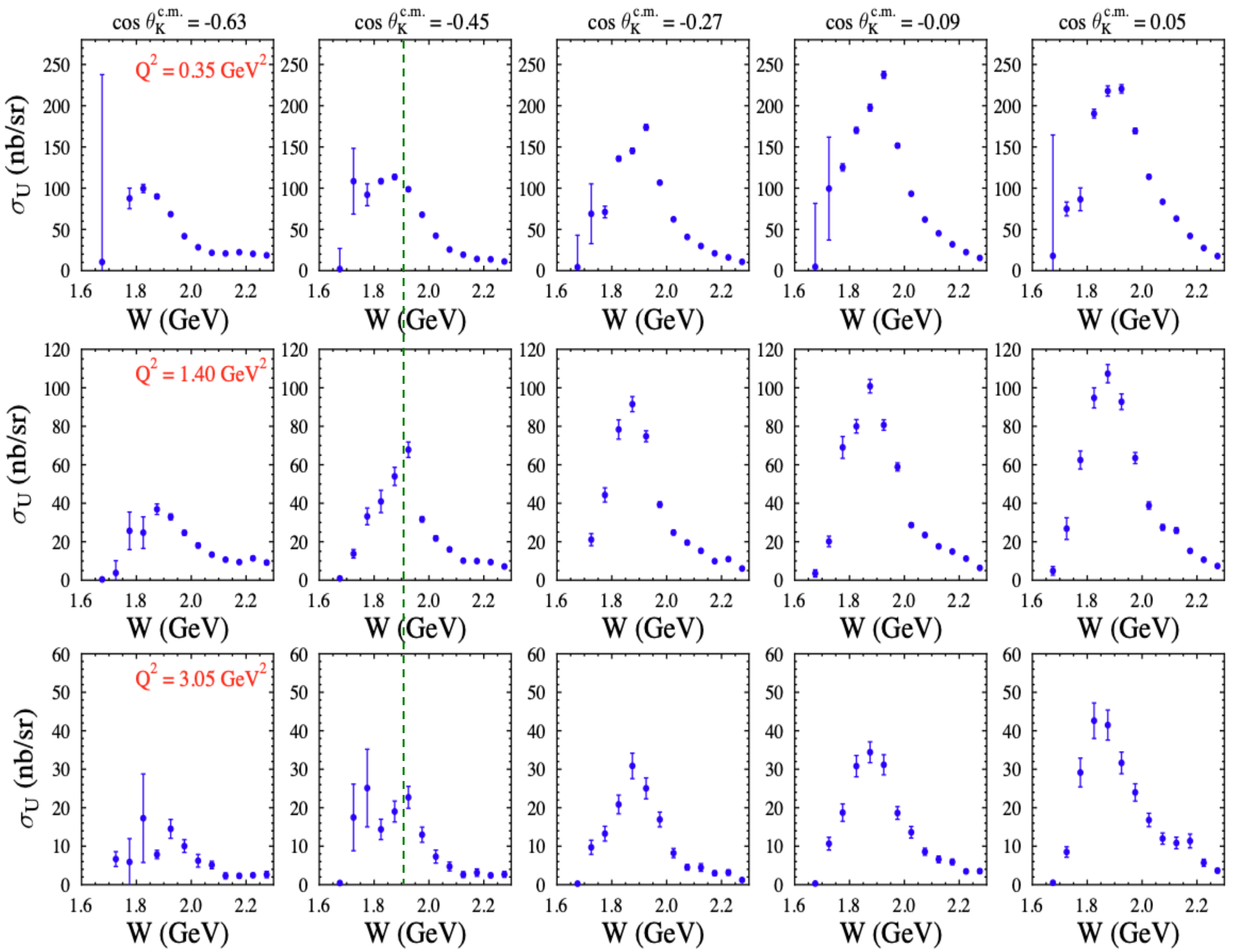


RG-K 6.395 GeV

$K^+\Lambda$



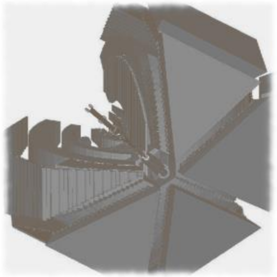
$K^+\Sigma^0$



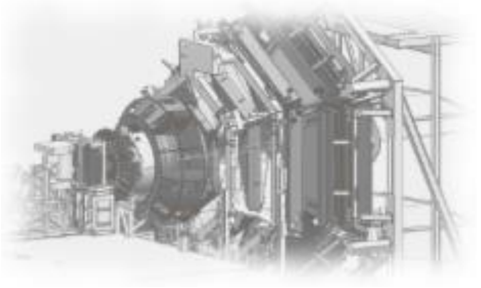
Peaks from $N^* \rightarrow KY$, interference effects, FSI contributions

No background subtraction

Concluding Remarks



- The study of N* states is one of the key foundations of the CLAS physics program:
  - CLAS cross section and polarization data have allowed detailed understanding of both the spectrum and structure of most N* states up to 1.8 GeV
  - Explorations of photo- and electroproduction over Q^2 up to 5 GeV^2 – the KY channels are important for W > 1.6 GeV



- The CLAS12 N* program is extending these studies for Q^2 up to 12 GeV^2:
  - Analysis of the collected data is underway – this talk has focused on KY
  - These data will be important input to address the challenging problems of the Standard Model on the nature of hadron mass and the emergence of N* states in the transition from the sQCD to pQCD regimes
  - These studies are complementary to studies of the structure of pions and kaons

- New KY review article: Electromagnetic Production of Kaons on the Nucleon
  - T. Mart, J.A. Djaja, D.S. Carman, Prog. Part. Nucl Phys. 150, 104252 (2026)

Backup Slides

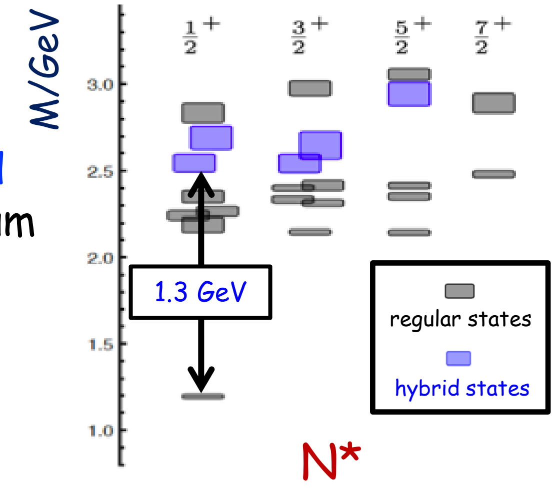
Hunting for Glue in Excited Baryons

Can glue be a structural component of excited baryon states?

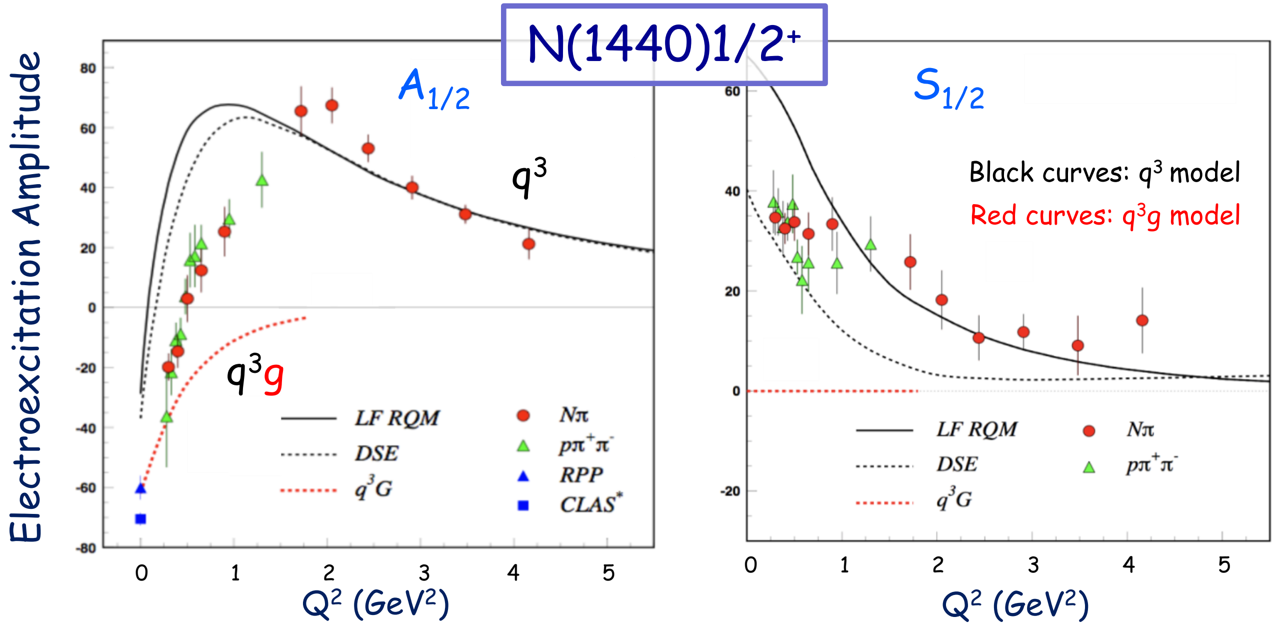
LQCD predicts hybrid baryons in N* spectrum

JLab LQCD group results

m_π=396 MeV



The hybrid nature of baryons appears in the Q^2 evolution of their transition amplitudes



The signatures for hybrid baryons include:

- Extra resonances with $J^\pi=1/2^+$, $3/2^+$ in mass range 2.0-2.5 GeV and decays into N□□ or KY final states
- Drop of $A_{1/2}(Q^2)$ and $A_{3/2}(Q^2)$ faster than for ordinary 3q states due to extra glue-component in valence structure
- Suppressed $S_{1/2}(Q^2)$ relative to $A_{1/2}(Q^2)$ transverse amplitude

Quark model predictions on the Q^2 evolution of the electrocouplings are necessary for hybrid identification

Z.P. Li, V. Burkert, Z.J Li, PRD 46, 70 (1992)

Pseudoscalar Meson Electroproduction Formalism

$$\frac{d\sigma_v}{d\Omega_K^{c.m.}} = \mathcal{K}\sum_{\alpha,\beta} S_\alpha S_\beta \Big[R_T^{\beta\alpha} + \epsilon R_L^{\beta\alpha} + c_+({}^cR_{LT}^{\beta\alpha}\cos\Phi + {}^sR_{LT}^{\beta\alpha}\sin\Phi)$$
$$+ \quad \epsilon({}^cR_{TT}^{\beta\alpha}\cos 2\Phi + {}^sR_{TT}^{\beta\alpha}\sin 2\Phi) + hc_-({}^cR_{LT'}^{\beta\alpha}\cos\Phi + {}^sR_{LT'}^{\beta\alpha}\sin\Phi) + hc_0 R_{TT'}^{\beta\alpha}\Big]$$

TABLE I. Polarization observables in pseudoscalar meson electroproduction. A star denotes a response function which does not vanish but is identical to another response function via a relation in App. A.

	Target				Recoil			Target + Recoil									
β	–	–	–	–	x'	y'	z'	x'	x'	x'	y'	y'	y'	z'	z'	z'
α	–	x	y	z	–	–	–	x	y	z	x	y	z	x	y	z
T	$\boxed{R_T^{00}}$	0	R_T^{0y}	0	0	$\boxed{R_T^{y'0}}$	0	$R_T^{x'x}$	0	$R_T^{x'z}$	0	$*$	0	$R_T^{z'x}$	0	$R_T^{z'z}$
L	$\boxed{R_L}$	0	$\boxed{R_L^{0y}}$	0	0	$*$	0	$R_L^{x'x}$	0	$R_L^{x'z}$	0	$*$	0	$*$	0	$*$
${}^cTL$	$\boxed{{}^cR_{TL}^{00}}$	0	${}^cR_{TL}^{0y}$	0	0	$*$	0	${}^cR_{TL}^{x'x}$	0	$*$	0	$*$	0	${}^cR_{TL}^{z'x}$	0	$*$
${}^sTL$	0	${}^sR_{TL}^{0x}$	0	${}^sR_{TL}^{0z}$	$\boxed{{}^sR_{TL}^{x'0}}$	0	$\boxed{{}^sR_{TL}^{z'0}}$	0	$*$	0	$*$	0	$*$	0	$*$	0
${}^cTT$	$\boxed{{}^cR_{TT}^{00}}$	0	$*$	0	0	$*$	0	$*$	0	$*$	0	$*$	0	$*$	0	$*$
${}^sTT$	0	${}^sR_{TT}^{0x}$	0	${}^sR_{TT}^{0z}$	${}^sR_{TT}^{x'0}$	0	${}^sR_{TT}^{z'0}$	0	$*$	0	$*$	0	$*$	0	$*$	0
${}^cTL'$	0	${}^cR_{TL'}^{0x}$	0	${}^cR_{TL'}^{0z}$	$\boxed{{}^cR_{TL'}^{x'0}}$	0	$\boxed{{}^cR_{TL'}^{z'0}}$	0	$*$	0	$*$	0	$*$	0	$*$	0
${}^sTL'$	$\boxed{{}^sR_{TL'}^{00}}$	0	$\boxed{{}^sR_{TL'}^{0y}}$	0	0	$*$	0	${}^sR_{TL'}^{x'x}$	0	$*$	0	$*$	0	${}^sR_{TL'}^{z'x}$	0	$*$
TT'	0	$R_{TT'}^{0x}$	0	$R_{TT'}^{0z}$	$\boxed{R_{TT'}^{x'0}}$	0	$\boxed{R_{TT'}^{z'0}}$	0	$*$	0	$*$	0	$*$	0	$*$	0

G. Knöchlein, D. Drechsel, L. Tiator, Z. Phys. A 352, 327 (1995)

Response functions

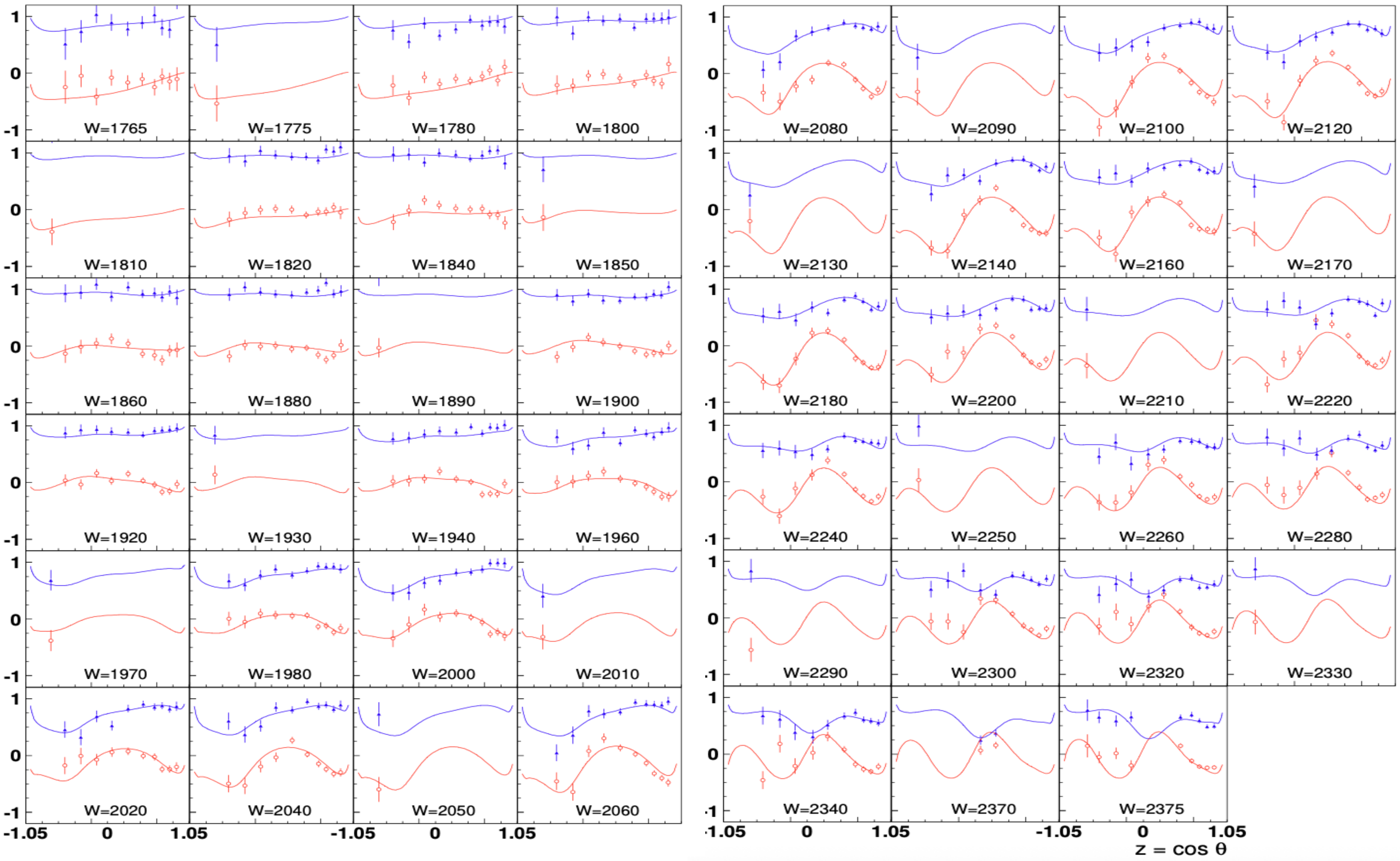
$R(Q^2, W, \cos\theta_K^{c.m.})$

CLAS/CLAS12 KY Program

- Differential cross sections
  - $\sigma_L, \sigma_T, \sigma_{LT}, \sigma_{TT}, \sigma_{LT'}$
- KY recoil polarization
- KY transferred polarization

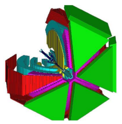
First Fits of New KΛ Recoil Polarization from Bn-Ga Model

C_x
C_z

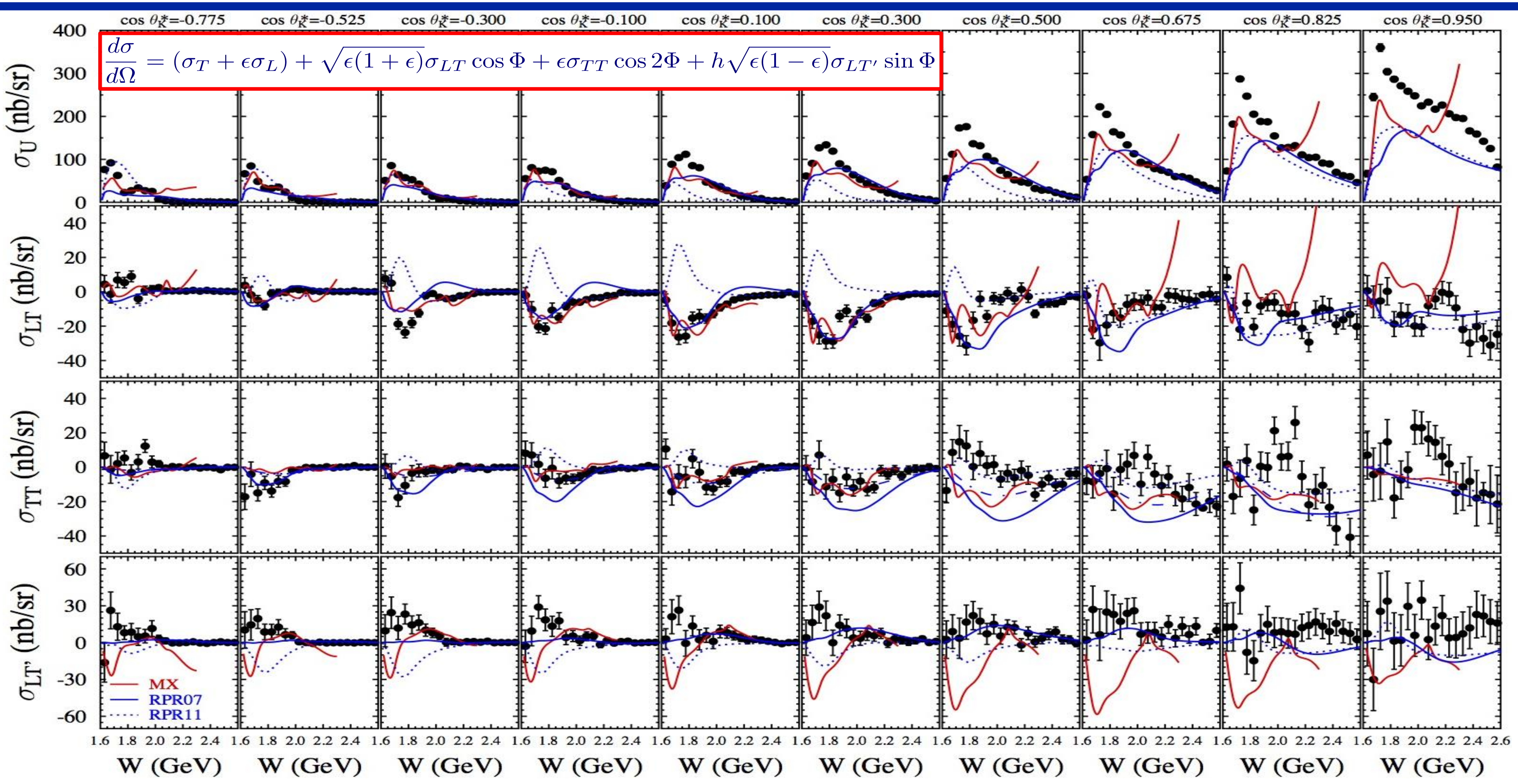


First fits from Bonn-Gatchina coupled-channels model from Eberhard Klempt

New paper with these data upcoming to see impact on N* spectrum and properties



CLAS $K^+\Lambda$ Structure Functions



E = 5.5 GeV

W: thr – 2.6 GeV

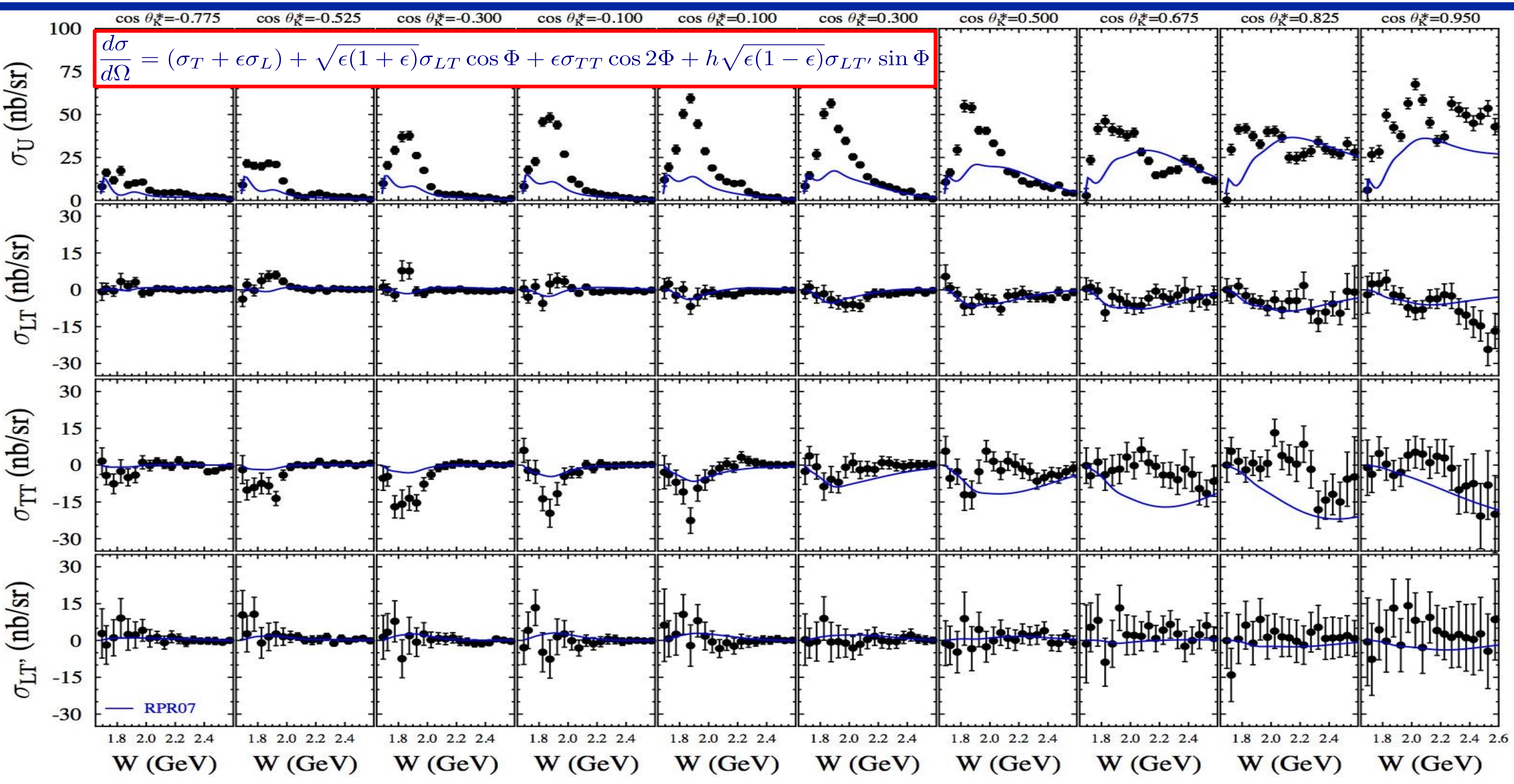
Q^2 = $\boxed{1.80\ GeV^2}$

2.60 GeV^2

3.45 GeV^2

D.S. Carman et al. (CLAS), PRC 87, 025204 (2013)

CLAS $K^+\Sigma^0$ Structure Functions



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D.S. Carman et al. (CLAS), PRC 87, 025204 (2013)