Nucleon resonance studies from KY electroproduction at CLAS12

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e⁻ JLab12

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Outline

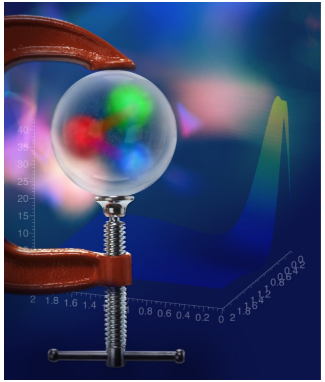
Physics Motivation: Study of the nucleon excitation spectrum to understand the dynamical properties of QCD in the non-perturbative regime.

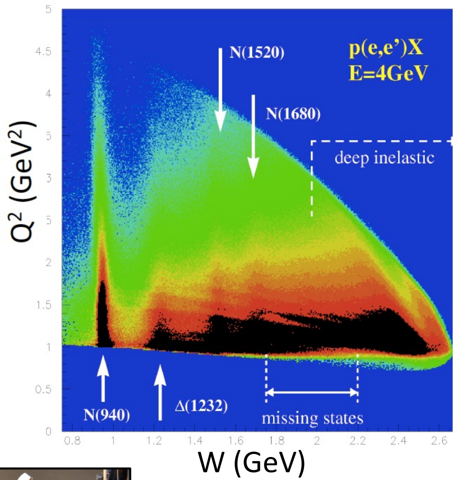
What is the role of glue?

- Search for new Baryon States → Hybrid States

How does the role of the active degrees of freedom in the nucleon spectrum evolve with distance scale?

- Probe underlying degrees of freedom and their emergence from QCD via studies of the Q^2 evolution of electroproduction amplitudes

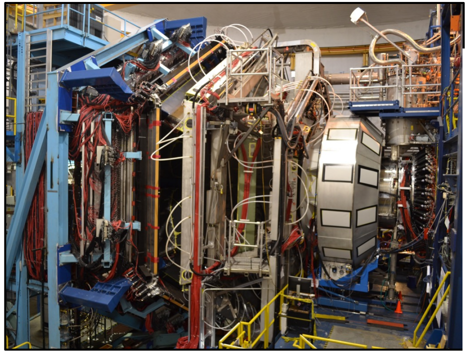




CLAS12 and Forward Tagger (FT) @ JLab: Experimental Setup description.

On-going Data Analysis:

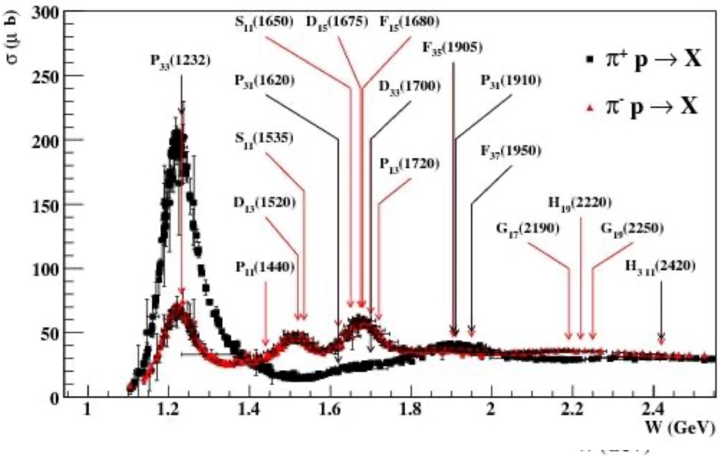
- **Results from Physics Runs**: ep -> e'KY channel studied exploiting data from Fall 2018 Physics Runs in Hall B at Jefferson Lab – new data available from 2024

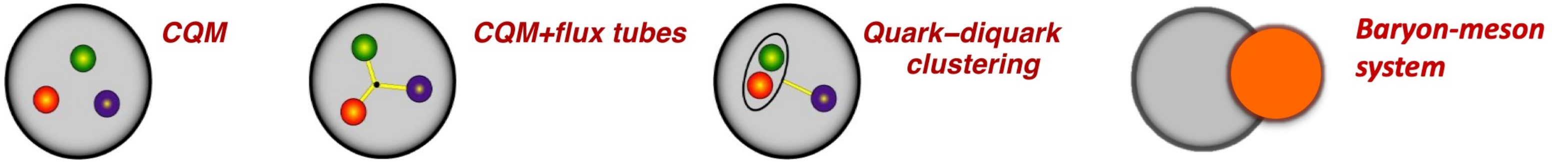


Why N*? From the N* Spectrum to QCD

- Understanding the proton's ground state requires understanding its excitation spectrum

- The N* spectrum reflects the effective degrees of freedom and the forces

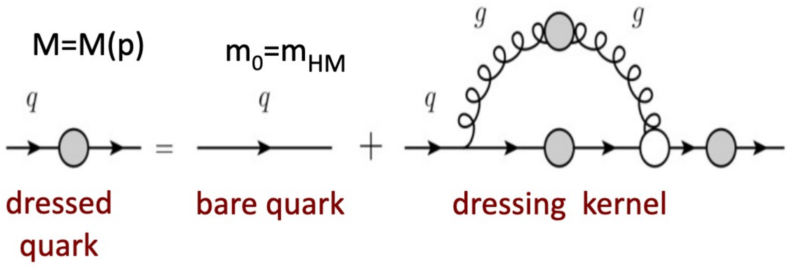




→ From the Constituent Quark model to QCD.

Mass Acquisition

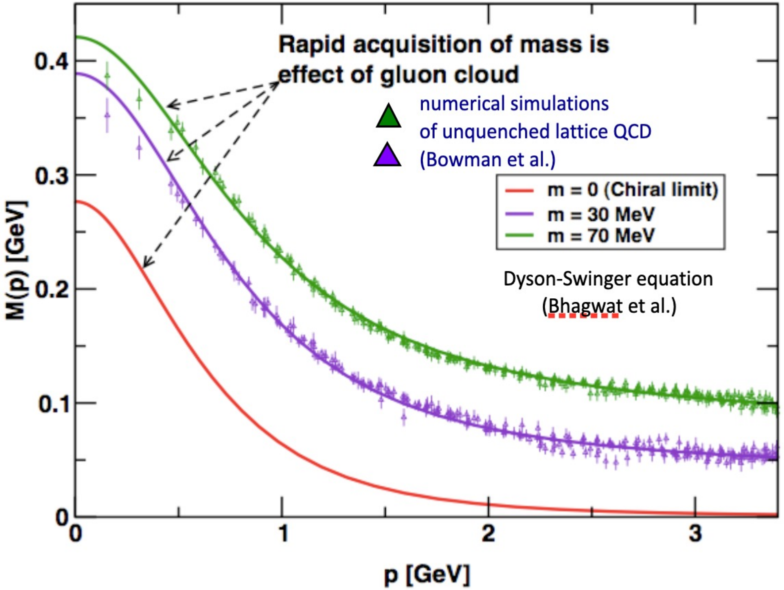
Effective quark mass depends on its momentum



mass composition

<2% Higgs mechanism

>98% non-perturbative strong interaction



We need more information about the working of QCD in the non-perturbative regime

Exotic Hadrons

Standard Hadrons come in two varieties: Baryons & Mesons

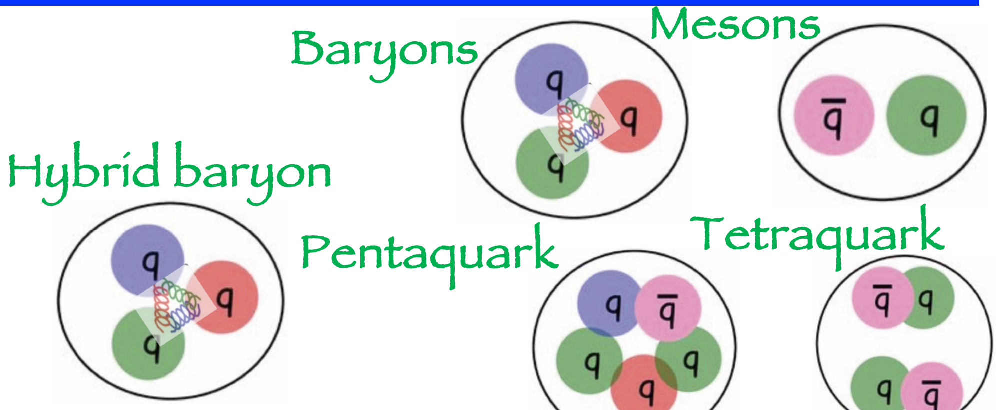
Exotic Hadrons ⇒ Meson and baryon states whose properties cannot be described in terms of q anti-q or qqq degrees of freedom only

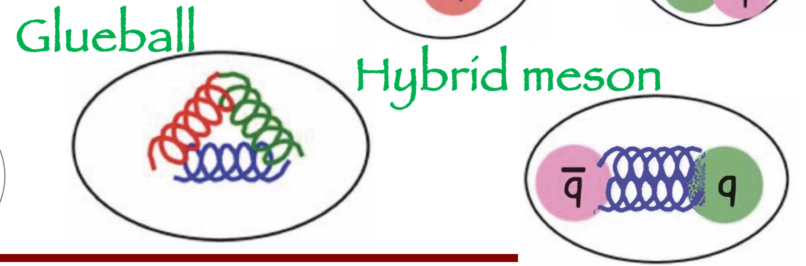
Hybrid mesons/baryons:
qqq or $q\bar{q}$ valence quarks plus a valence gluon

Multiquark states:
- Baryons with more than 3 valence quarks: **pentaquarks or di-baryons**
- Mesons with more than a quark-antiquark pair: **tetraquarks**

Glueballs:
Particles made up of gluonic degrees of freedom only

Molecules…





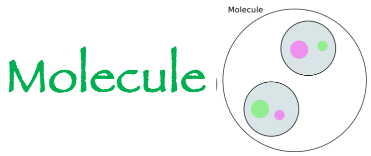


Photo- and Electro-Production of Mesons on Nucleon Targets

Meson photo- and electro-production reactions

for

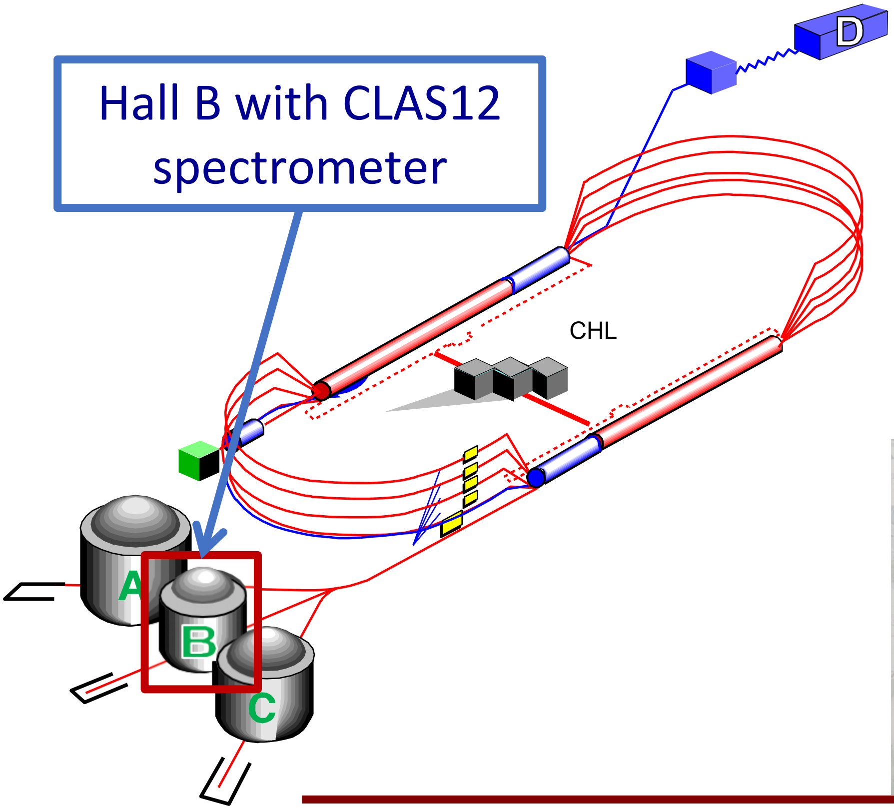
Light quark baryon spectroscopy

Two elements provided a crucial boost in the field:

- advent of large solid angle detectors
- polarized beam and targets → single and double polarization observables

Powerful tool to study the internal structure of the nucleon

CLAS N* Experimental Program



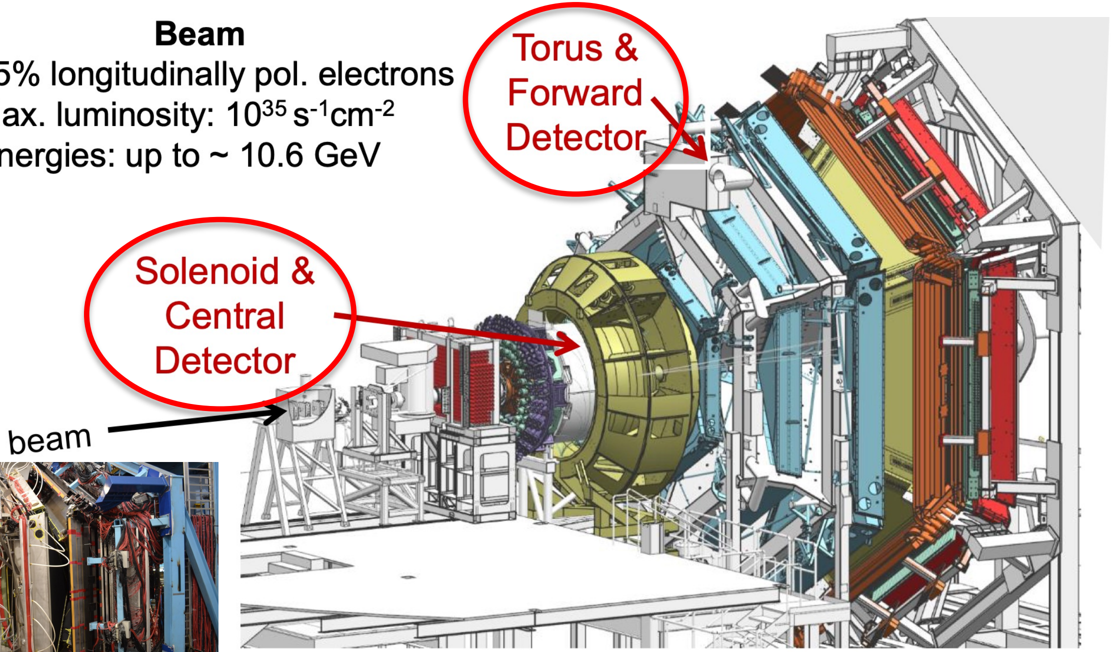
The N* program is one of the Hall B fundamental

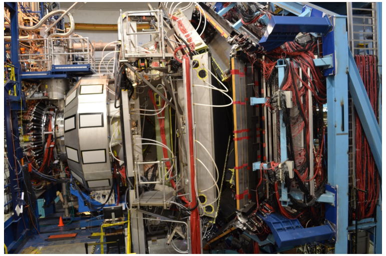
• CLAS & CLAS12 – optimized to study exclusive reaction channels over a broad kinematic range:

pN, ωN, φN, ηN, η'N, $\pi\pi$N, KY, K*Y, KY*

CLAS12

Beam
- 85% longitudinally pol. electrons
- Max. luminosity: $10^{35}\,s^{-1}cm^{-2}$
- Energies: up to ~ 10.6 GeV

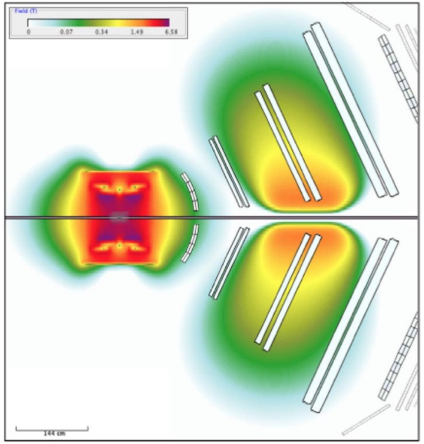




[V.D. Burkert et al., Nucl. Inst. and Meth. A 959, 163419 (2020)]

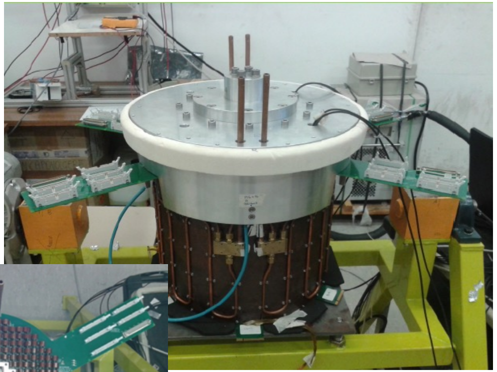
Targets (org. by Run Groups)
- Proton (RG-A/K)
- Deuteron (RG-B)
- Nuclei (RG-M/D/E)
- Long. pol. NH_3/ND_3 (RG-C)

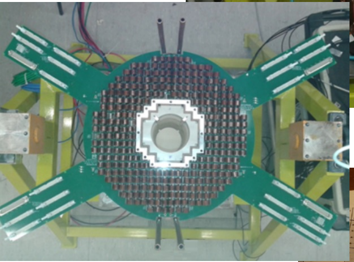
Magnetic Field

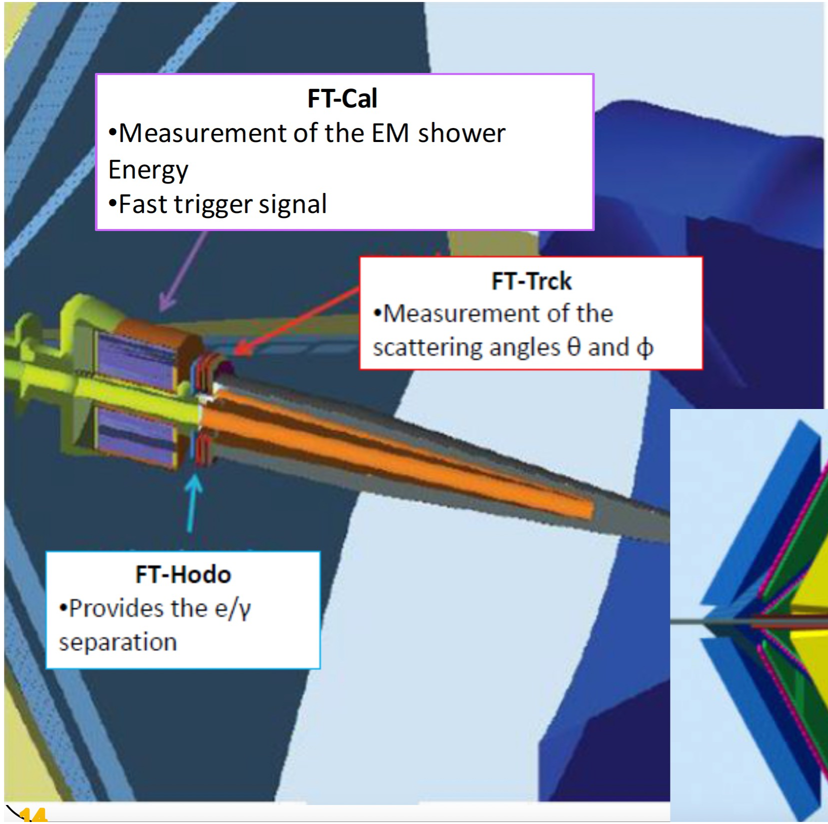


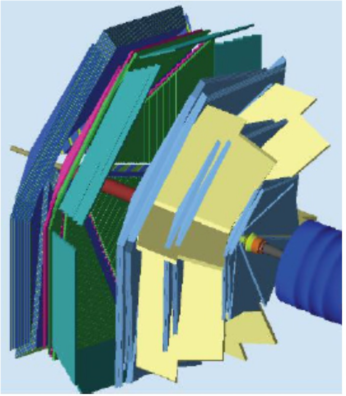
Ideal instrument to study exclusive meson electroproduction in the nucleon resonance region

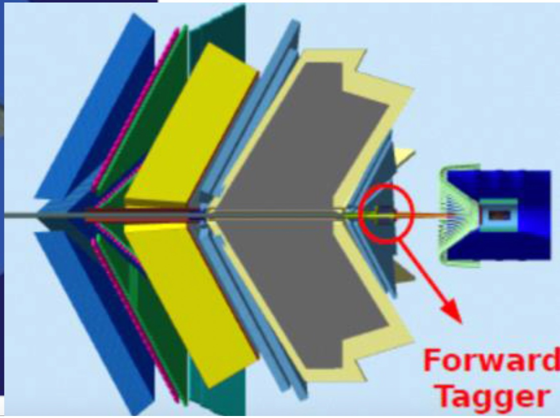
Experimental Setup: Forward Tagger











Electron Beam with CLAS12

Run Group Proposal (RG K) "Color Confinement and Strong QCD":

Search for Hybrid Baryons (qqqg)
KY Electroproduction for the N* study
DVCS
SIDIS

RUN CONDITIONS	
Torus Current	100% (3375 A) - negative out-bending
Solenoid	-100 %
FT	**ON @ 7.5 GeV -> OFF @ 6.5 GeV and 8.5 GeV**
Beam/Target	Polarized electrons, un-polarized LH_2 target
Luminosity	• ~ 5 10^{34} $cm^{-2}s^{-1}$ @ 7.5 GeV ~ 0.87 10^{34} $cm^{-2}s^{-1}$ @ 6.5 GeV 0.87 10^{35} $cm^{-2}s^{-1}$ @ 6.4 GeV 10^{35} $cm^{-2}s^{-1}$@8.5 GeV **FULL LUMINOSITY**

Fall 2018: EVENTS 15.6 G

Spring 2024: EVENTS 60 G (Statistics increased by a factor 4)

50% of the total

Hybrid Hadrons

Hybrid hadrons with dominant gluonic contributions are predicted to exist by QCD.

Experimentally:

- **Hybrid mesons** $|q\bar{q}g>$ states may have exotic quantum numbers J^{PC} not available to pure $|\ q\bar{q}>$ states
  GlueX, MesonEx, COMPASS, PANDA ….

- **Hybrid baryons** |qqqg> have the same quantum numbers J^P as |qqq> electroproduction with CLAS12 (Hall B).

Theoretical predictions:

✧ MIT bag model - T. Barnes and F. Close, Phys. Lett. 123B, 89 (1983).

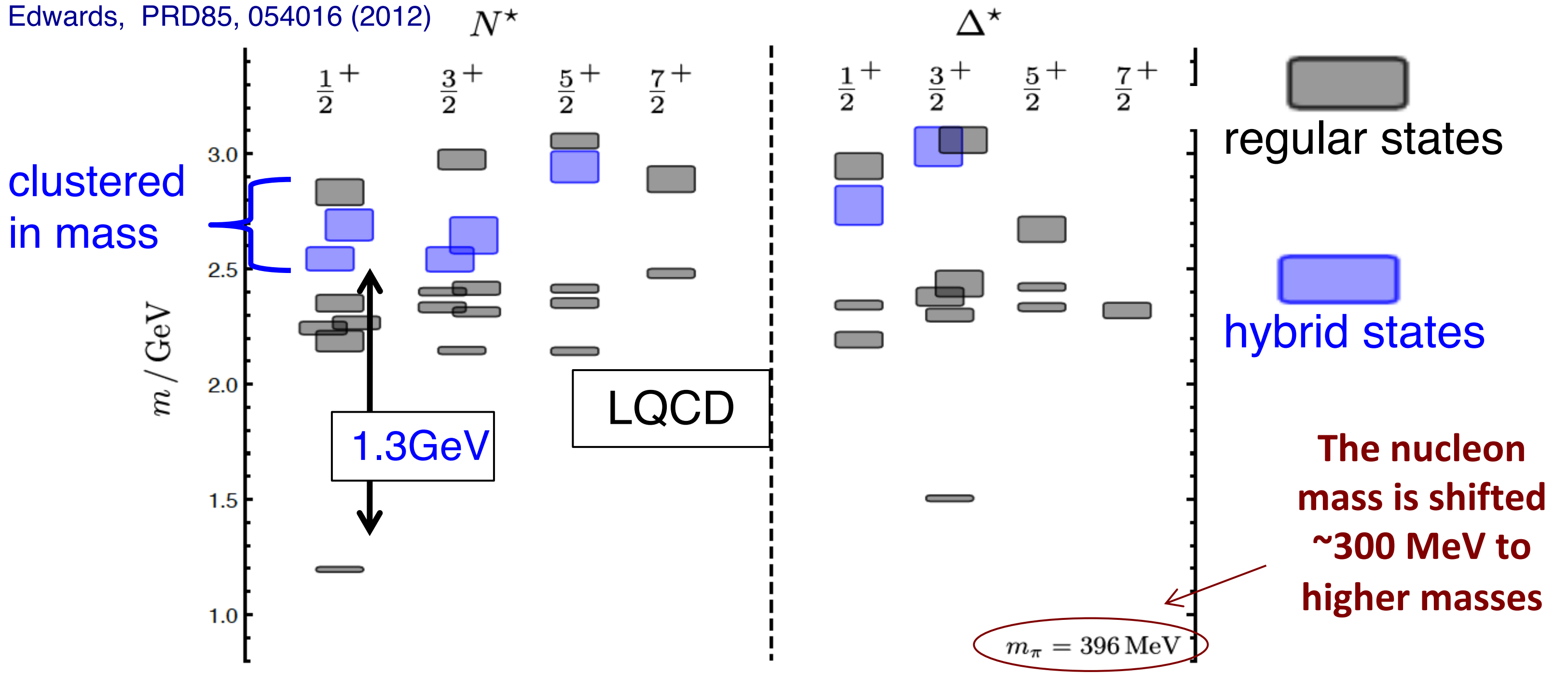
✧ QCD Sum Rule - L. Kisslinger and Z. Li, Phys. Rev. D 51, R5986 (1995).

✧ Flux Tube model - S. Capstick and P. R. Page, Phys. Rev. C 66, 065204 (2002).

✧ LQCD - J.J. Dudek and R.G. Edwards, PRD85, 054016 (2012).

Hybrid Baryons in LQCD

J.J. Dudek and R.G. Edwards, PRD85, 054016 (2012)



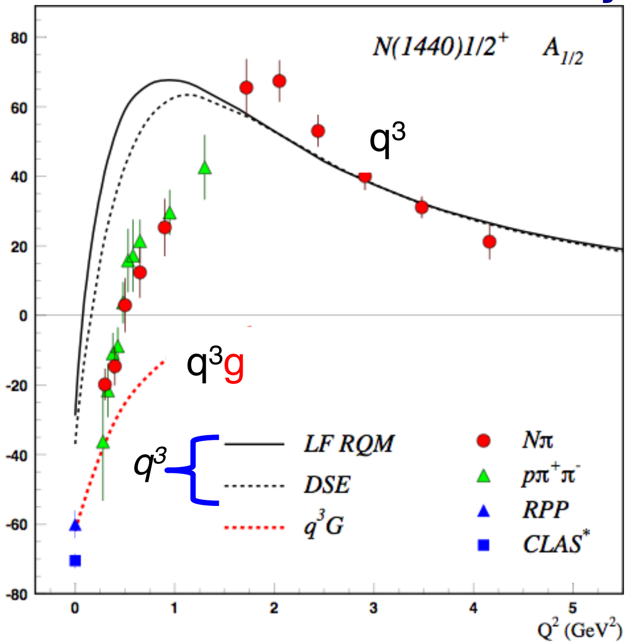
Hybrid states have same J^P values as qqq baryons. How to identify them?

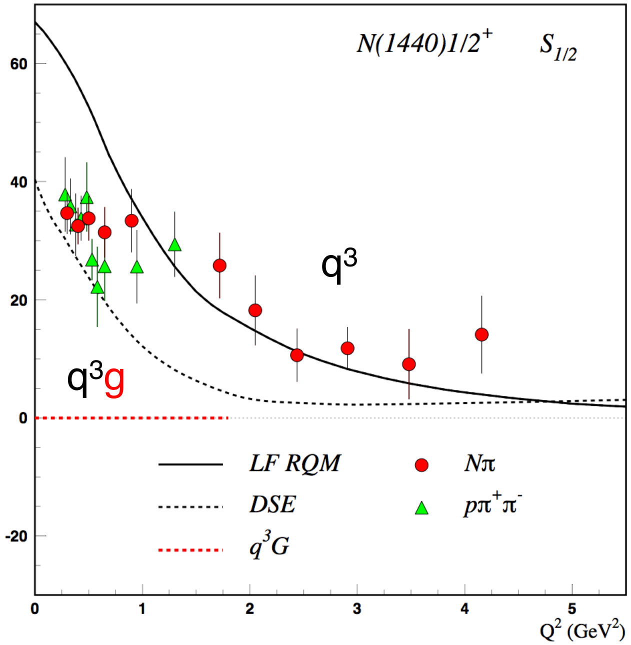
- Overpopulation of N $1/2^+$ and N $3/2^+$ states compared to QM projections.
- **$A_{1/2}$ ($A_{3/2}$) and $S_{1/2}$ show different Q^2 evolution.**

Separating q^3g from q^3 states?

CLAS results on electrocouplings clarified nature of the Roper.

Will CLAS12 data be able to identify gluonic contributions ?





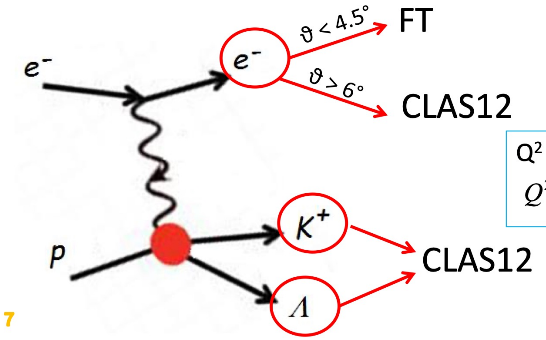
For hybrid "Roper", $A_{1/2}(Q^2)$ drops off faster with Q^2 and $S_{1/2}(Q^2) \sim 0$.

Hybrid Baryons

Data from KY are critical to provide the extraction of the electrocoupling amplitudes:

$$e\,p \rightarrow e'\,K^+\,\Lambda\,,\ \Lambda \rightarrow p\pi^-$$

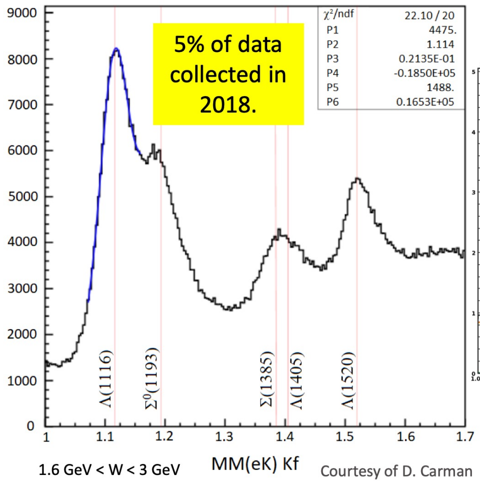
FT allows to probe the **crucial Q^2 range** where hybrid baryons may be identified due to their fast dropping $A_{1/2}(Q^2)$ amplitude and the suppression of the scalar $S_{1/2}$ (Q^2) amplitude.

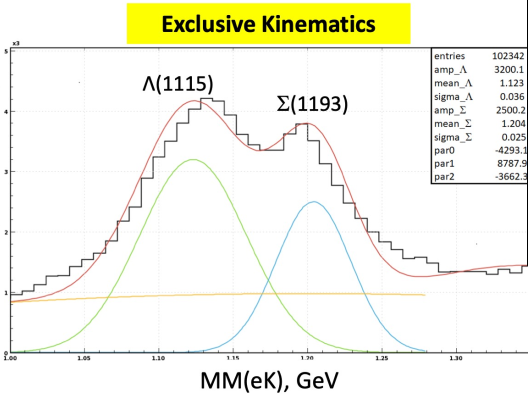


Q^2 range of interest: 0.05 - 2 GeV^2

$$Q^2 = 4E_{Beam}E_{e'}\sin^2\frac{\vartheta}{2} \Rightarrow \vartheta < 5°$$

Electron in the FD(CLAS)/FT





Preliminary results obtained with data collected in 2018

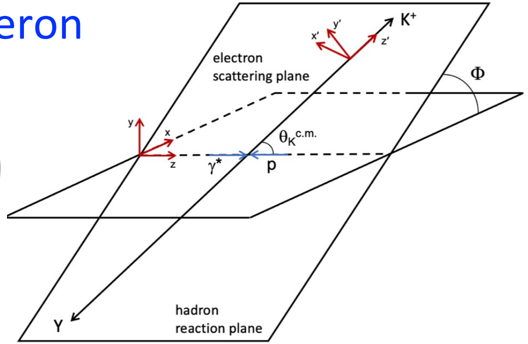
p(e,e'K⁺)X

E_{beam} = 7.546 GeV

Recoil and Transferred Polarization in K^+Y Electroproduction in the Nucleon Resonance Region with CLAS12

$$e + p \rightarrow e' + K^+ + Y \quad \text{where} \quad Y = \Lambda, \Sigma^0$$

Polarized-electron beam + unpolarized target → polarized recoil hyperon



$$\frac{d\sigma_v}{d\Omega_K^{c.m.}} = \sigma_0(1 + hA_{LT'} + P_{x'}\hat{x}' \cdot \hat{S}' + P_{y'}\hat{y}' \cdot \hat{S}' + P_{z'}\hat{z}' \cdot \hat{S}')$$

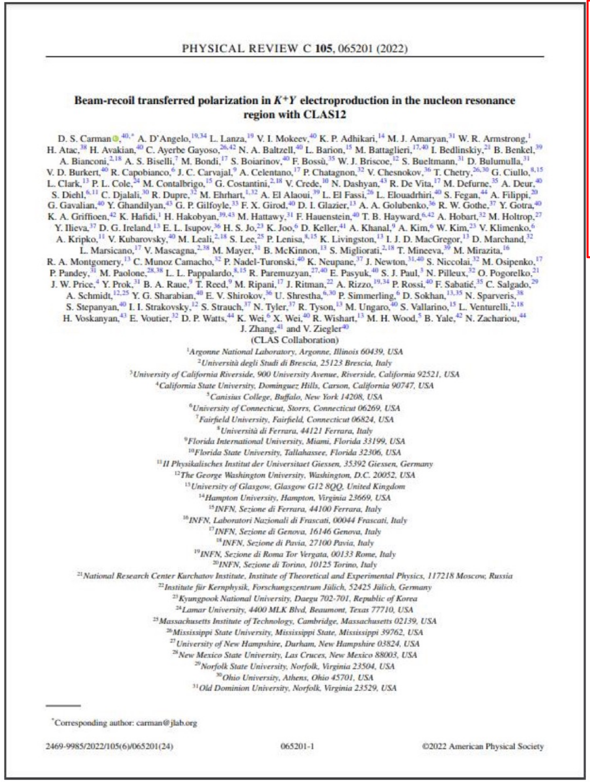
Hyperon polarization — **Beam helicity independent part: Recoil polarization** — **Beam helicity dependent part: Transferred polarization**

$$P_{i'} = P^0_{i'} + hP'_{i'}$$

Analysis of CLAS12 RG-K data from Fall 2018

- 6.535 GeV and 7.546 GeV electrons on LH_2 target
- Extract polarizations from longitudinally polarized electron beam to final state hyperon vs Q^2, W, cos $\vartheta_K^{c.m.}$

Recoil and Transferred Polarization in K⁺Y Electroproduction in the Nucleon Resonance Region with CLAS12



2022- RG-K KY P'

D. S. Carman, A. D'Angelo, L. Lanza, V. Mokeev (CLAS Collaboration):

- **Beam-Recoil Transferred Polarization in K⁺Y Electroproduction in the Nucleon Resonance Region with CLAS12**
- **Recoil Polarization in in K⁺Y Electroproduction in the Nucleon Resonance Region with CLAS12**

$ep \rightarrow e'K^+Y$

Hyperon polarization

Beam helicity independent part: Recoil polarization

Beam helicity dependent part: Transferred polarization

$$P_{i'} = P^0_{i'} + h P'_{i'}$$

Analysis of CLAS12 RG-K data from Fall 2018

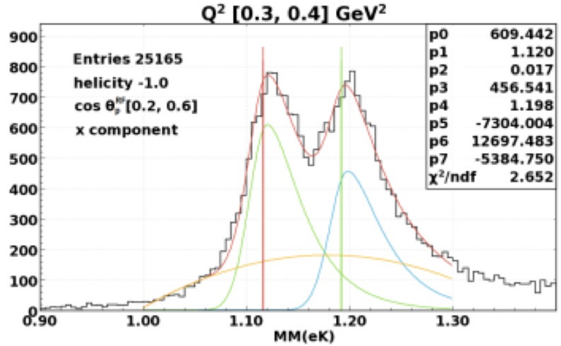
- 6.535 GeV and 7.546 GeV electrons on LH_2 target
- Extract polarizations from longitudinally polarized electron beam to final state hyperon vs Q^2, W, cos $\vartheta_K^{c.m.}$

17 Sept 2025- RG-K KY P⁰

Beam-Recoil Transferred Polarization in K⁺Y Electroproduction in the Nucleon Resonance Region with CLAS12

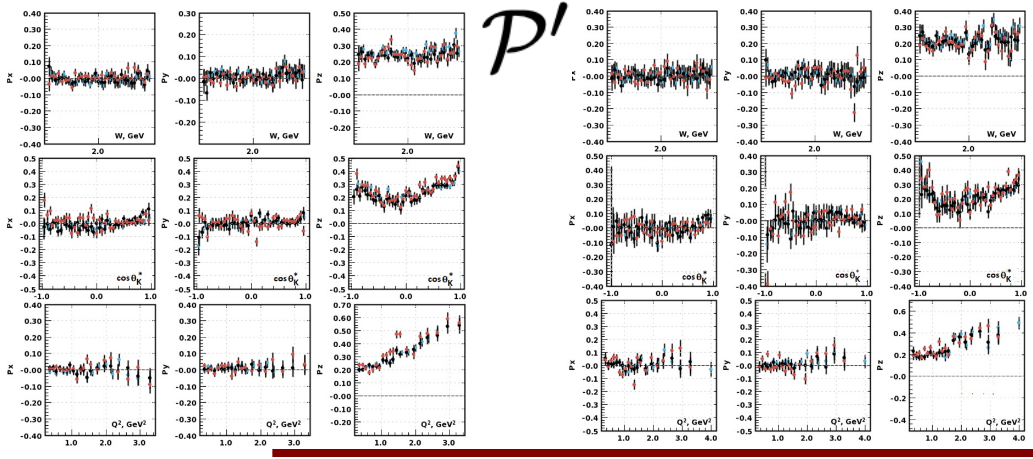
The **RM-ToV analysis** consists of the direct exploitation of equation

$$A = \frac{N^+ - N^-}{N^+ + N^-} = \nu_Y \alpha_\Lambda P_b \mathcal{P}'_Y \cos\theta_p^{RF}$$



The events in each kinematic bin of Q², W and cos ϑ_K^* were divided into 5 cos ϑ_p^{RF} bins for each beam helicity…

…and the number of Λ events was extracted using a fit of the MM(eK⁺) spectrum



Comparison between independent analyses results

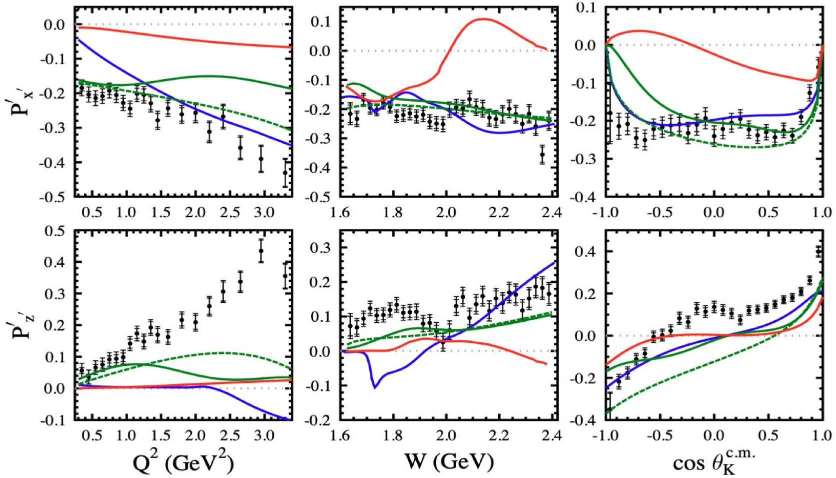
Blue dots : Approach 1
Red dots : Approach 2
Black dots : Approach 1 (different fitting procedure)

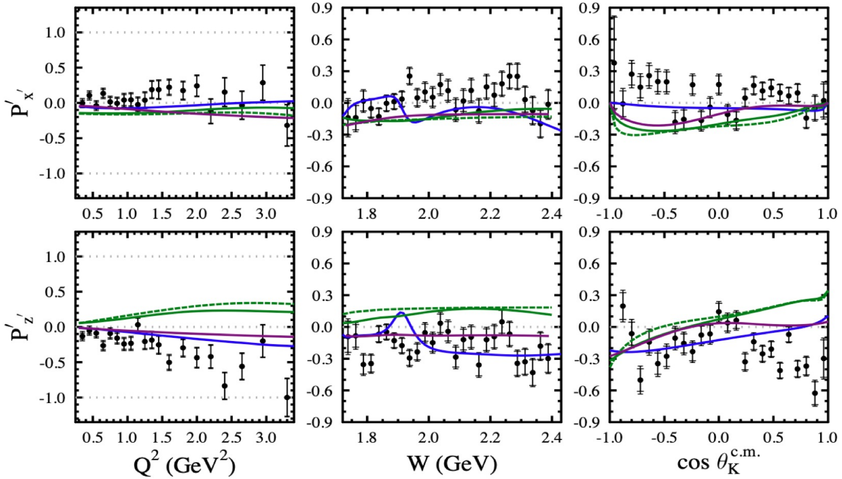
CLAS12 K^+Y Transferred Polarization

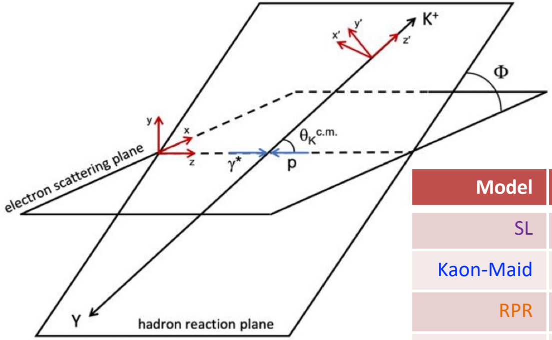
$K^+\Lambda$

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

$K^+\Sigma$



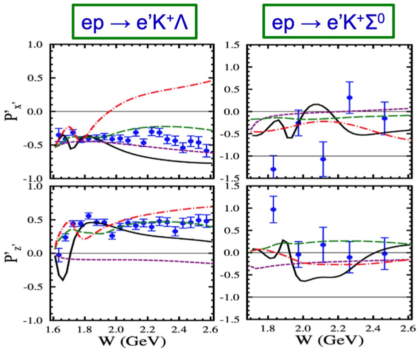




RG-K – Fall 2018 - 6.5 GeV

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 $\gamma p + ep$	1/2, 3/2, 5/2

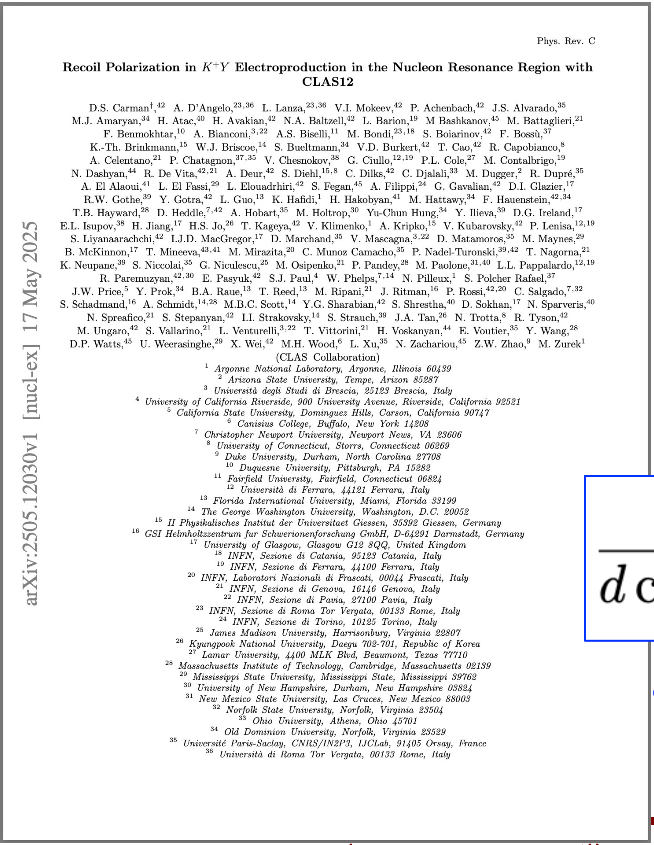
CLAS12 vs. CLAS (e1-6)



Mart/Bennhold RPR-2
RPR-1 Regge

[D.S. Carman et al., Phys. Rev. C 79, 065205 (2009)]

Recoil Polarization in K⁺Y Electroproduction in the Nucleon Resonance Region with CLAS12


Phys. Rev. C

Recoil Polarization in K^+Y Electroproduction in the Nucleon Resonance Region with CLAS12

D.S. Carman†,[42] A. D'Angelo,[23,36] L. Lanza,[23,36] V.I. Mokeev,[42] P. Achenbach,[42] J.S. Alvarado,[35] M.J. Amaryan,[34] H. Atac,[40] H. Avakian,[42] N.A. Baltzell,[42] L. Barion,[19] M Bashkanov,[45] M. Battaglieri,[21] F. Benmokhtar,[10] A. Bianconi,[3,22] A.S. Biselli,[11] M. Bondi,[23,18] S. Boiarinov,[42] F. Bossù,[37] K.-Th. Brinkmann,[15] W.J. Briscoe,[14] S. Bueltmann,[34] V.D. Burkert,[42] T. Cao,[42] R. Capobianco,[8] A. Celentano,[21] P. Chatagnon,[37,35] V. Chesnokov,[38] G. Ciullo,[12,19] P.L. Cole,[27] M. Contalbrigo,[19] N. Dashyan,[44] R. De Vita,[42,21] A. Deur,[42] S. Diehl,[15,8] C. Dilks,[42] C. Djalali,[33] M. Dugger,[2] R. Dupré,[35] A. El Alaoui,[41] L. El Fassi,[29] L. Elouadrhiri,[42] S. Fegan,[45] A. Filippi,[24] G. Gavalian,[42] D.I. Glazier,[17] R.W. Gothe,[39] Y. Gotra,[42] L. Guo,[13] K. Hafidi,[1] H. Hakobyan,[41] M. Hattawy,[34] F. Hauenstein,[42,34] T.B. Hayward,[28] D. Heddle,[7,42] A. Hobart,[35] M. Holtrop,[30] Yu-Chun Hung,[34] Y. Ilieva,[39] D.G. Ireland,[17] E.L. Isupov,[38] H. Jiang,[17] H.S. Jo,[26] T. Kageya,[42] V. Klimenko,[1] A. Kripko,[15] V. Kubarovsky,[42] P. Lenisa,[12,19] S. Liyanaarachchi,[42] I.J.D. MacGregor,[17] D. Marchand,[35] V. Mascagna,[3,22] D. Matamoros,[35] M. Maynes,[29] B. McKinnon,[17] T. Mineeva,[43,41] M. Mirazita,[20] C. Munoz Camacho,[35] P. Nadel-Turonski,[39,42] T. Nagorna,[21] K. Neupane,[39] S. Niccolai,[35] G. Niculescu,[25] M. Osipenko,[21] P. Pandey,[28] M. Paolone,[31,40] L.L. Pappalardo,[12,19] R. Paremuzyan,[42,30] E. Pasyuk,[42] S.J. Paul,[4] W. Phelps,[7,14] N. Pilleux,[1] S. Polcher Rafael,[37] J.W. Price,[5] Y. Prok,[34] B.A. Raue,[13] T. Reed,[13] M. Ripani,[21] J. Ritman,[16] P. Rossi,[42,20] C. Salgado,[7,32] S. Schadmand,[16] A. Schmidt,[14,28] M.B.C. Scott,[14] Y.G. Sharabian,[42] S. Shrestha,[40] D. Sokhan,[17] N. Sparveris,[40] N. Spreafico,[21] S. Stepanyan,[42] I.I. Strakovsky,[14] S. Strauch,[39] J.A. Tan,[26] N. Trotta,[8] R. Tyson,[42] M. Ungaro,[42] S. Vallarino,[21] L. Venturelli,[3,22] T. Vittorini,[21] H. Voskanyan,[44] E. Voutier,[35] Y. Wang,[28] D.P. Watts,[45] U. Weerasinghe,[29] X. Wei,[42] M.H. Wood,[6] L. Xu,[35] N. Zachariou,[45] Z.W. Zhao,[9] M. Zurek[1]
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- **RG-K Λ and Σ⁰ recoil polarization analysis by D. Carman, A. D'Angelo, L. Lanza, V. Mokeev**: **Paper published on PRC** on 17 September, 2025 (DOI: https://doi.org/10.1103/nhvq-7fv7)
- **This work aims at extending the available data** from CLAS to provide more complete input to available reaction models to **improve our understanding of strong QCD in the non-perturbative domain**.

KY channels: $e + p \rightarrow e' + K^+ + Y$ where $Y = \Lambda, \Sigma^0$

polarization of the parent Λ or Σ_0

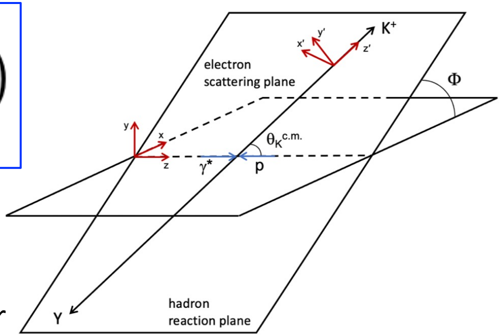
Yield Integral

$$\frac{dN}{d\cos\theta_p^{RF}} = N_0\left(1 + \nu_Y \alpha P_Y \cos\theta_p^{RF}\right)$$

angular distribution of the decay p in the Y decay frame

$\nu_Y = 1, -0.256\ (\Lambda, \Sigma^0)$
Dilution factor

$\alpha = 0.747 \pm 0.009$
Λ weak decay asymmetry parameter



Recoil Polarization in K⁺Y Electroproduction in the Nucleon Resonance Region with CLAS12

$$\frac{dN}{d\cos\theta_p^{RF}} = N_0\left(1 + \nu_Y \alpha P_Y \cos\theta_p^{RF}\right)$$

Recoil polarization for Λ and Σ^0

Yield in the forward angle range, i.e. cos $\theta_{RF}^{p} > 0$

$$N_F = \int_0^1 N_0(1 + \nu_Y \alpha P_Y cos\vartheta_p^{RF}) dcos\vartheta_p^{RF} = N_0 + N_0 \cdot \frac{\nu_Y \alpha P_Y}{2}$$

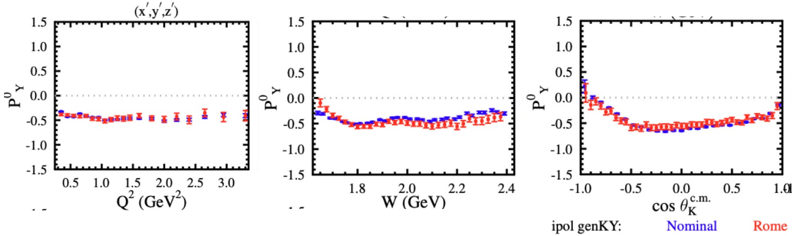
Yield in the backward angle range, i.e. cos $\theta_{RF}^{p} < 0$

$$N_B = \int_{-1}^0 N_0(1 + \nu_Y \alpha P_Y cos\vartheta_p^{RF}) dcos\vartheta_p^{RF} = N_0 - N_0 \cdot \frac{\nu_Y \alpha P_Y}{2}$$

Forward-backward yield asymmetry

$$A_{FB} = \frac{\frac{N_F}{A_F} - \frac{N_B}{A_B}}{\frac{N_F}{A_F} + \frac{N_B}{A_B}} = \frac{\nu_Y \alpha P_Y}{2}$$

Agreement between **independent** approaches supports final results



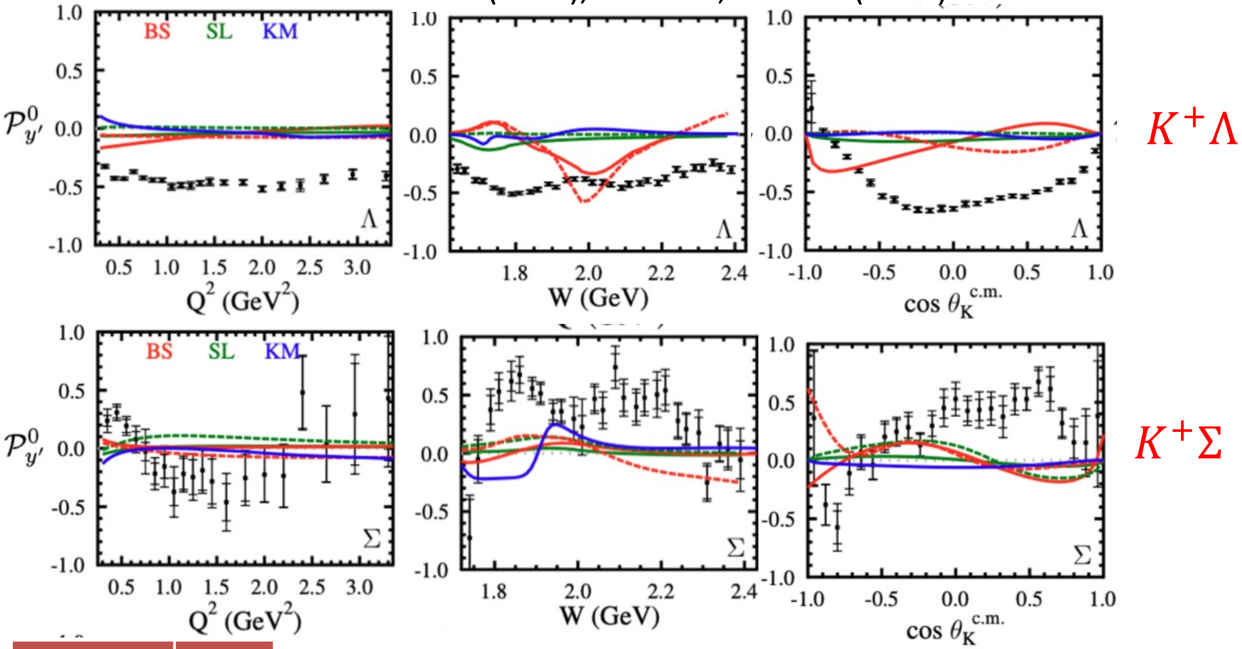
Sensitivity to the detector acceptance ⇨ **Acceptance Correction**

$$A_{F,B} = \frac{N_{F,B}^{REC}}{N_{F,B}^{MC}}$$

CLAS12 K^+Y Recoil Polarization

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

RG-K – Fall 2018 - 6.5 GeV



Model	Type
SL	Isobar
Kaon-Maid	Isobar
BS	Isobar

Full line: full model

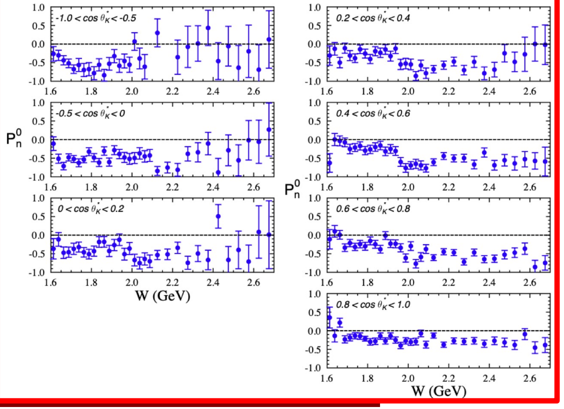
Dashed line: model with the non-resonant terms switched off

CLAS12 vs. CLAS (e1f)

5.479 GeV electron beam
Q^2: 0.8–3.5 GeV^2
W: 1.6–2.7 GeV.

Limited statistics => **coarse bins** in W and $cos\vartheta^K_{c.m.}$ - Q^2 integrated

RGK data have ~**5 times** the statistics compared to e1f



Summary and Outlook

Summarizing:

- The study of N* states is one of the crucial topics of the CLAS and CLAS12 physics programs:
  - -CLAS has produced a huge amount of data up to $Q^2 < 5$ GeV^2
  - -CLAS12 was designed to extend these studies for $0.05 < Q^2 < 12$ GeV^2
- The first results of the CLAS12 N* program have been obtained with the analysis of KY polarization transfer data from the RGK Fall 2018 Run
  - -The RGK dataset is 5x larger than the available KY world data in the resonance region
  - -Only 10% of expected statistics has been analyzed.
- On going analyses:
  - -Two papers on KY electroproduction have been published on PRC
  - -Other analyses based on the existing RG-K data are in progress
  - -More data have been collected in Spring 2024

And in the future…

- Future work with these data is expected to face up the most challenging problems of the Standard Model on the nature of hadron mass, confinement, and the emergence of N* states from quarks and gluons

Summary and Outlook

Summarizing:

- The study of N* states is one of the crucial topics of the CLAS and CLAS12 ...
  - -CLAS has produced a huge amount of data up to $Q^2 < 5$ GeV^2
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- On going analyses:
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  - -Other ana...
  - -More data ...

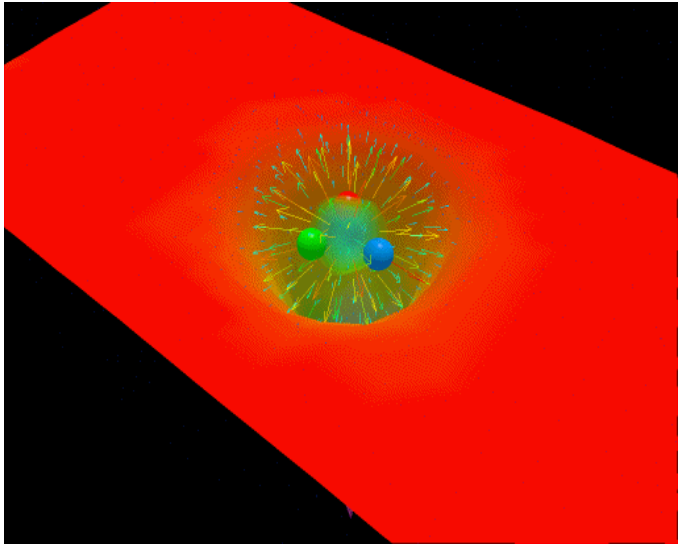
And in the f...

- Future work wit... ...ce up the most challenging problems of the Standard Model on the nature of hadron mass, c... ...e emergence of N* states from quarks and gluons

Thank you for the attention!

Critical QCD Questions Addressed

- The light N* spectrum: what is the role of glue?



Derek B. Leinweber – University of Adelaide

“Nucleons are the stuff of which our world is made.

As such they must be ***at the center of any discussion of why the world*** *we actually experience* ***has the character it does.****”*

Nathan Isgur, NStar2000, Newport News, Virginia

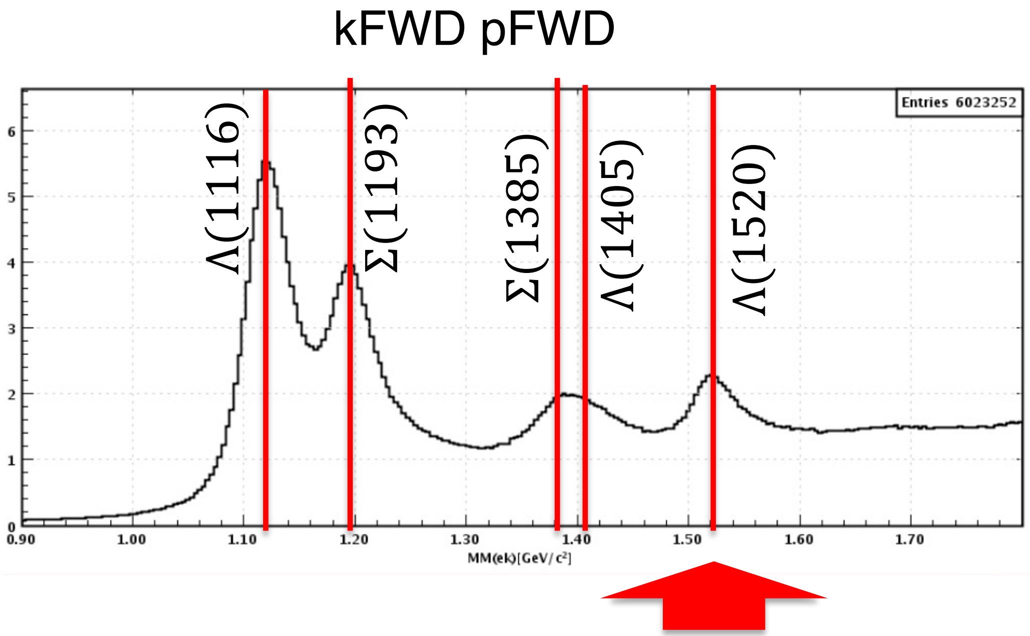
→ **Search for new baryon states**

$\Lambda(1520)$

Other channels could be exploited as final states for possible new resonances..

$$ep \rightarrow eK^{+}\Lambda(1520) \rightarrow eK^{+}\, K^{-}p$$

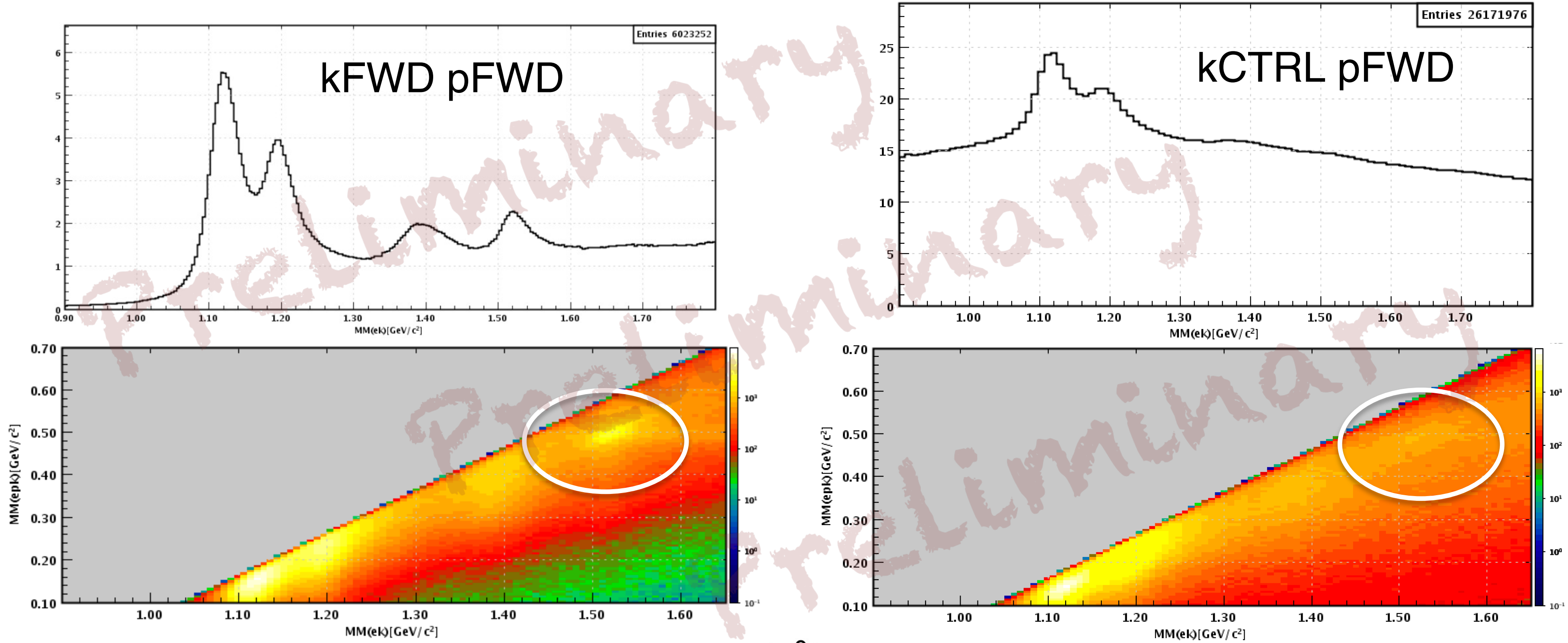
The existence of several nonstrange N* resonances with significant (~5%) branching ratios into the decay channel $K^{+}\Lambda(1520)$ has been predicted



$\Lambda(1520)$ arises as a separate structure

→ S. Barrow et al., CLAS Coll., Phys.Rev.C64:044601,2001
→ Simon Chapstick and W. Roberts, Phys. Rev. D **58** 074011

Λ(1520)

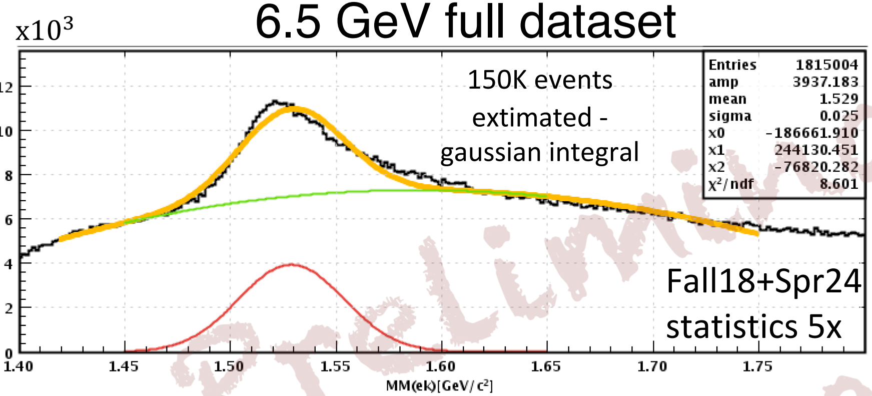


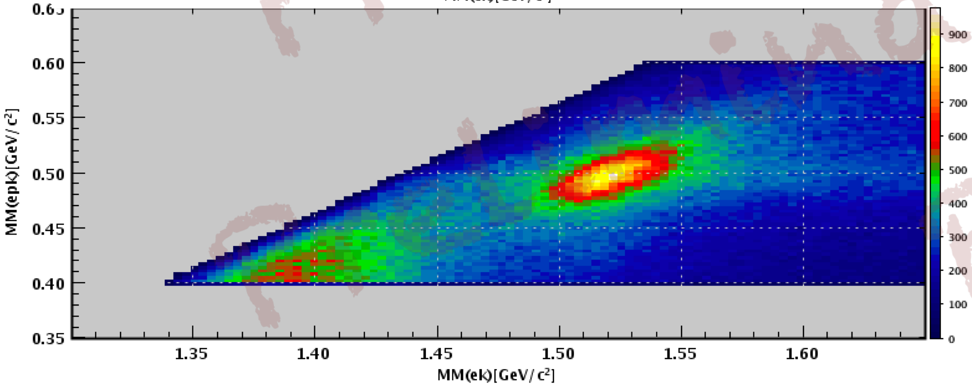
Five structures: Λ(1116), $\Sigma^0(1193)$, Σ(1385), Λ(1405), Λ(1520)

$$ep \rightarrow eK^+\Lambda(1520) \rightarrow eK^+\, K^- p$$

$\Lambda(1520)$

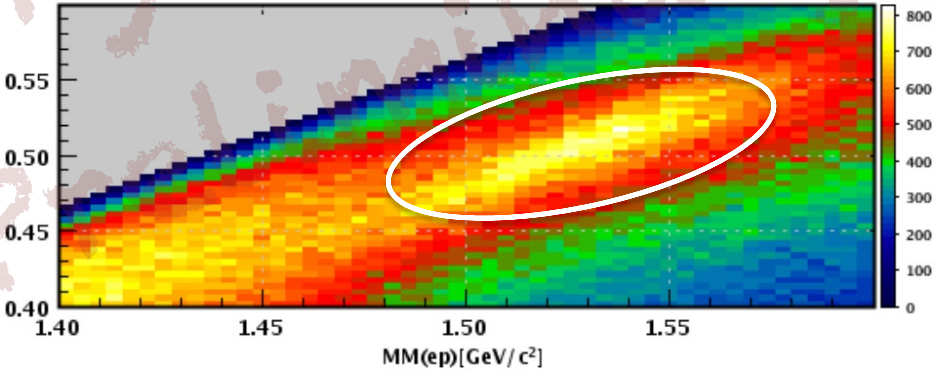
6.5 GeV full dataset





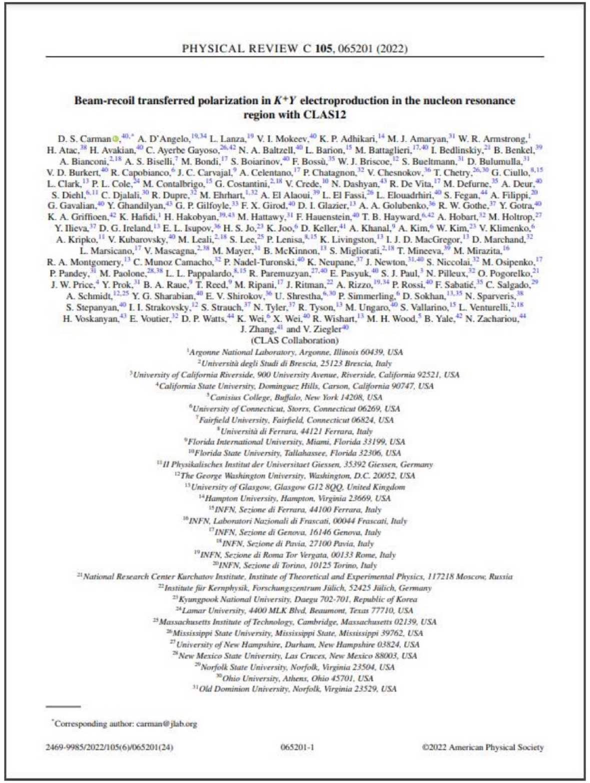
It is possible to isolate $\Lambda(1520)$ also in events with an electron detected in the FT

7.5 GeV dataset



$$ep \rightarrow eK^{+}\Lambda(1520) \rightarrow eK^{+}\,K^{-}p$$

Beam-Recoil Transferred Polarization in K^+Y Electroproduction in the Nucleon Resonance Region with CLAS12



PHYSICAL REVIEW C **105**, 065201 (2022)

Beam-recoil transferred polarization in K^+Y electroproduction in the nucleon resonance region with CLAS12

D. S. Carman,[40,*] A. D'Angelo,[19,34] L. Lanza,[19] V. I. Mokeev,[40] K. P. Adhikari,[14] M. J. Amaryan,[31] W. R. Armstrong,[1] H. Atac,[38] H. Avakian,[40] C. Ayerbe Gayoso,[26,42] N. A. Baltzell,[40] L. Barion,[15] M. Battaglieri,[17,40] I. Bedlinskiy,[21] B. Benkel,[39] A. Bianconi,[2,18] A. S. Biselli,[7] M. Bondi,[17] S. Boiarinov,[40] F. Bossù,[35] W. J. Briscoe,[12] S. Bueltmann,[31] D. Bulumulla,[31] V. D. Burkert,[40] R. Capobianco,[6] J. C. Carvajal,[9] A. Celentano,[17] P. Chatagnon,[32] V. Chesnokov,[36] T. Chetry,[26,30] G. Ciullo,[8,15] L. Clark,[13] P. L. Cole,[24] M. Contalbrigo,[15] G. Costantini,[2,18] V. Crede,[10] N. Dashyan,[43] R. De Vita,[17] M. Defurne,[35] A. Deur,[40] S. Diehl,[6,11] C. Djalali,[30] R. Dupre,[32] M. Ehrhart,[1,32] A. El Alaoui,[39] L. El Fassi,[26] L. Elouadrhiri,[40] S. Fegan,[44] A. Filippi,[20] G. Gavalian,[40] Y. Ghandilyan,[43] G. P. Gilfoyle,[33] F. X. Girod,[40] D. I. Glazier,[13] A. A. Golubenko,[36] R. W. Gothe,[37] Y. Gotra,[40] K. A. Griffioen,[42] K. Hafidi,[1] H. Hakobyan,[39,43] M. Hattawy,[31] F. Hauenstein,[40] T. B. Hayward,[6,42] A. Hobart,[32] M. Holtrop,[27] Y. Ilieva,[37] D. G. Ireland,[13] E. L. Isupov,[36] H. S. Jo,[23] K. Joo,[6] D. Keller,[41] A. Khanal,[9] A. Kim,[6] W. Kim,[23] V. Klimenko,[6] A. Kripko,[11] V. Kubarovsky,[40] M. Leali,[2,18] S. Lee,[25] P. Lenisa,[8,15] K. Livingston,[13] I. J. D. MacGregor,[13] D. Marchand,[32] L. Marsicano,[17] V. Mascagna,[2,38] M. Mayer,[31] B. McKinnon,[13] S. Migliorati,[2,18] T. Mineeva,[39] M. Mirazita,[16] R. A. Montgomery,[13] C. Munoz Camacho,[32] P. Nadel-Turonski,[40] K. Neupane,[37] J. Newton,[31,40] S. Niccolai,[32] M. Osipenko,[17] P. Pandey,[31] M. Paolone,[28,38] L. L. Pappalardo,[8,15] R. Paremuzyan,[27,40] E. Pasyuk,[40] S. J. Paul,[3] N. Pilleux,[32] O. Pogorelko,[21] J. W. Price,[4] Y. Prok,[31] B. A. Raue,[9] T. Reed,[9] M. Ripani,[17] J. Ritman,[22] A. Rizzo,[19,34] P. Rossi,[40] F. Sabatié,[35] C. Salgado,[29] A. Schmidt,[12,25] Y. G. Sharabian,[40] E. V. Shirokov,[36] U. Shrestha,[6,30] P. Simmerling,[6] D. Sokhan,[13,35] N. Sparveris,[38] S. Stepanyan,[40] I. I. Strakovsky,[12] S. Strauch,[37] N. Tyler,[37] R. Tyson,[13] M. Ungaro,[40] S. Vallarino,[15] L. Venturelli,[2,18] H. Voskanyan,[43] E. Voutier,[32] D. P. Watts,[44] K. Wei,[6] X. Wei,[40] R. Wishart,[13] M. H. Wood,[5] B. Yale,[42] N. Zachariou,[44] J. Zhang,[41] and V. Ziegler[40]

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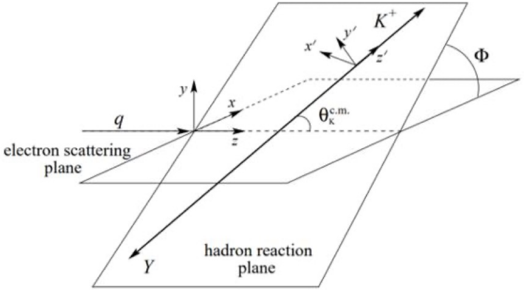
2469-9985/2022/105(6)/065201(24) 065201-1

D.S. Carman, A. D'Angelo, L. Lanza, V. Mokeev (CLAS Collaboration)), "Beam-Recoil Transferred Polarization in K^+Y Electroproduction in the Nucleon Resonance Region with CLAS12", Phys. Rev. C 105, 065201 (2022)



Analysis of CLAS12 RG-K data from Fall 2018

- 6.535 GeV and 7.546 GeV electrons on LH_2 target
- Extract beam-recoil transferred polarization from longitudinally polarized beam electron to final state hyperon vs. Q^2, W, $\cos\theta_K^{c.m.}$

$$A = \frac{N^+ - N^-}{N^+ + N^-} = \nu_Y \alpha_\Lambda P_b \mathcal{P}'_Y \cos\theta_p^{RF}$$

$\mathcal{P}'$ = transferred polarization

(x′,y′,z′)

$\mathcal{P}^0$ = recoil polarization

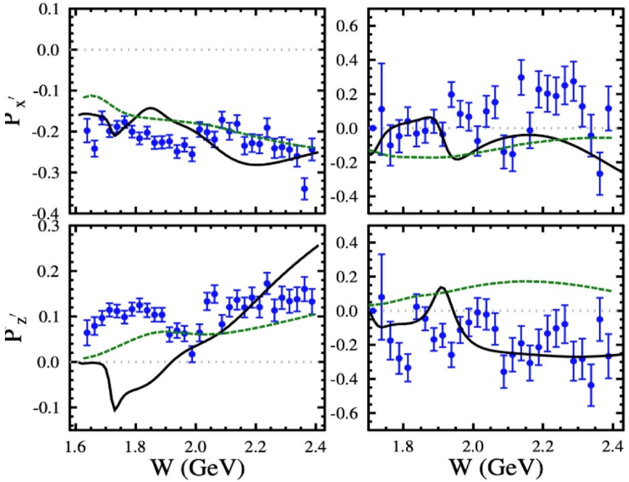
$$\mathcal{P}'_{x'} = K_I\sqrt{1-\epsilon^2}R_{TT'}^{x'0}$$
$$\mathcal{P}'_{y'} = 0$$
$$\mathcal{P}'_{z'} = K_I\sqrt{1-\epsilon^2}R_{TT'}^{z'0}$$

$\mathcal{P}^0_{x'}$	0
$\mathcal{P}^0_{y'}$	$K_I(R_T^{y'0} + \epsilon R_L^{y'0})$
$\mathcal{P}^0_{z'}$	0

K^+Y Transferred Polarization CLAS12 vs. CLAS

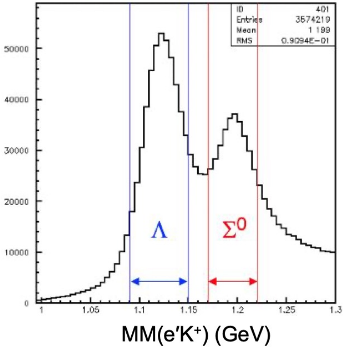
CLAS12 (RG-K)

$ep \rightarrow e'K^+\Lambda$ $ep \rightarrow e'K^+\Sigma^0$



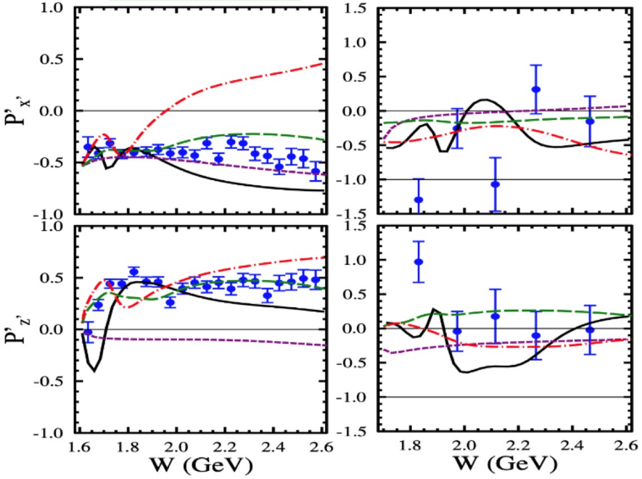
[D.S. Carman et al., Phys. Rev. C 105, 065201 (2022)]

$ep \rightarrow e'K^+Y$



CLAS (e1-6)

$ep \rightarrow e'K^+\Lambda$ $ep \rightarrow e'K^+\Sigma^0$



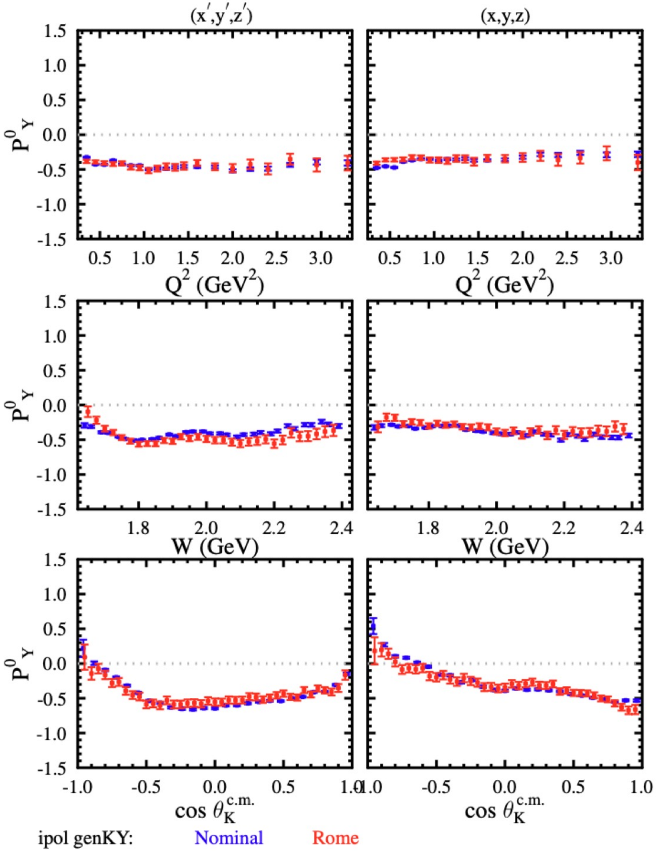
[D.S. Carman et al., Phys. Rev. C 79, 065205 (2009)]

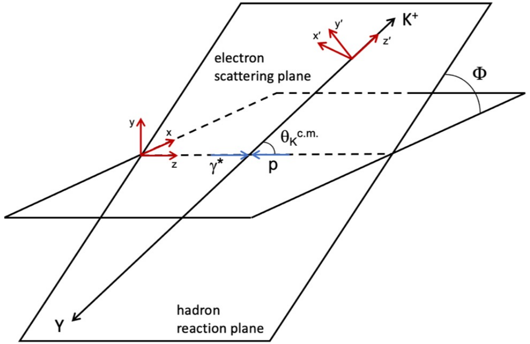
KAON-MAID
RPR

World data set will get extended by orders of magnitude

Mart/Bennhold RPR-2
RPR-1 Regge

K$^+$Y Induced Polarization CLAS12: Independent Analyses Match



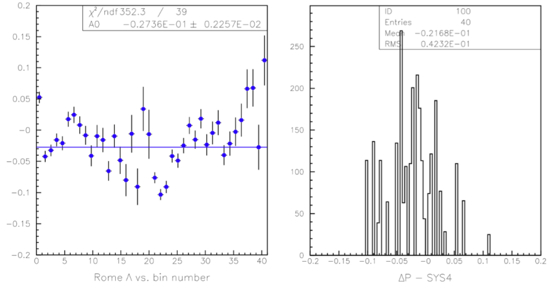


(x′,y′,z′)

$\mathcal{P}^U$ = recoil polarization

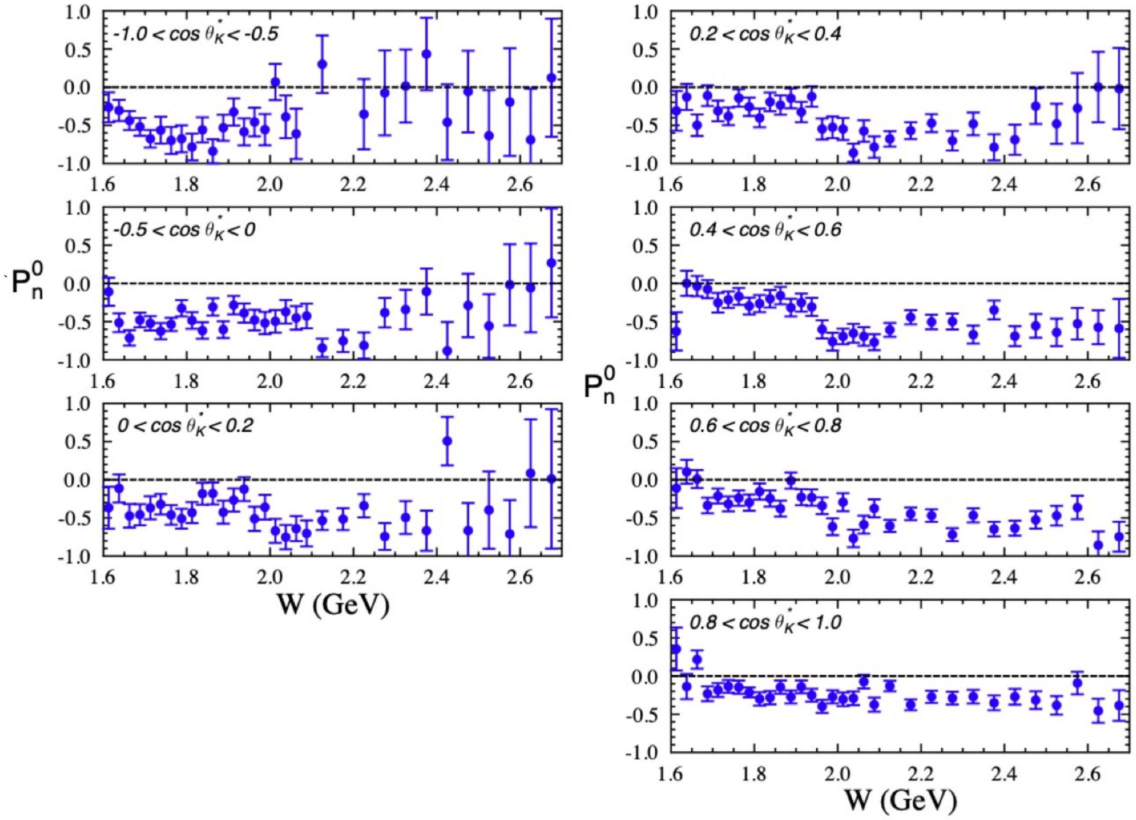
$\mathcal{P}^0_{x'}$	0
$\mathcal{P}^0_{y'}$	$K_I(R_T^{y'0} + \epsilon R_L^{y'0})$
$\mathcal{P}^0_{z'}$	0

Agreement between **independent** approaches support final results



$\Delta P^0 = -0.027$, RMS = 0.042

K+Y Induced Polarization: Previous Results from CLAS e1f



Λ recoil polarization in the ep reaction was **first measured from the CLAS e1f** experiment using a 5.479 GeV electron beam

Kinematic range:
Q^2: 0.8–3.5 GeV^2
W: 1.6–2.7 GeV.

Due to limited statistics the polarization was provided in **coarse bins** in W and $cos\vartheta^{K}_{c.m.}$ integrated over Q^2

RGK data have ∼5 times the statistics compared to e1f