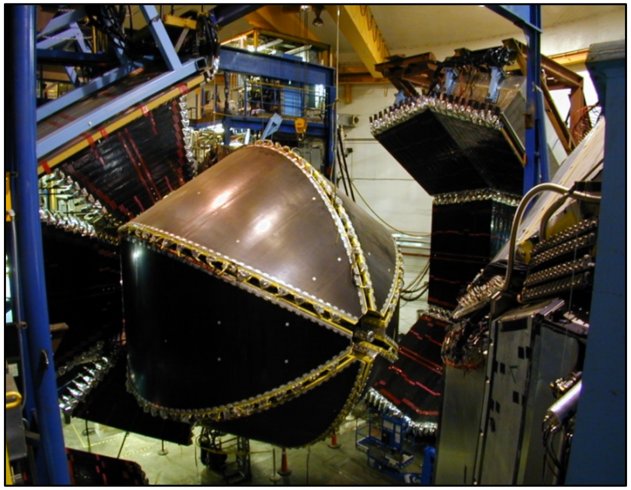
May 31, 2010
Williamsburg, VA



Electromagnetic Strangeness Production

Reinhard Schumacher

"MENU":

- Motivation for K Y study in N* resonance physics
- $\gamma\, p \rightarrow K^+ \Lambda$ & $\gamma\, p \rightarrow K^+ \Sigma^0$ Cross Sections: old and new
- Spin Observables
  - P_y , Σ – single spin results: older and new
  - O_x, O_z – beam-recoil: preliminary results
  - C_x, C_z – beam-recoil: CLAS measurements
  - Electroproduction extension…
- $\Lambda(1405)$ mass distribution ← Recent New Result
  - Likely signature of non-qqq structure
- $\Xi^{0,-(*)}$ production: search for resonances
- Future prospects
  - CLAS g13 data set, $\gamma\, n \rightarrow K^0\, \Lambda,\Sigma^0$ cross sections
  - FROST & HD Ice targets

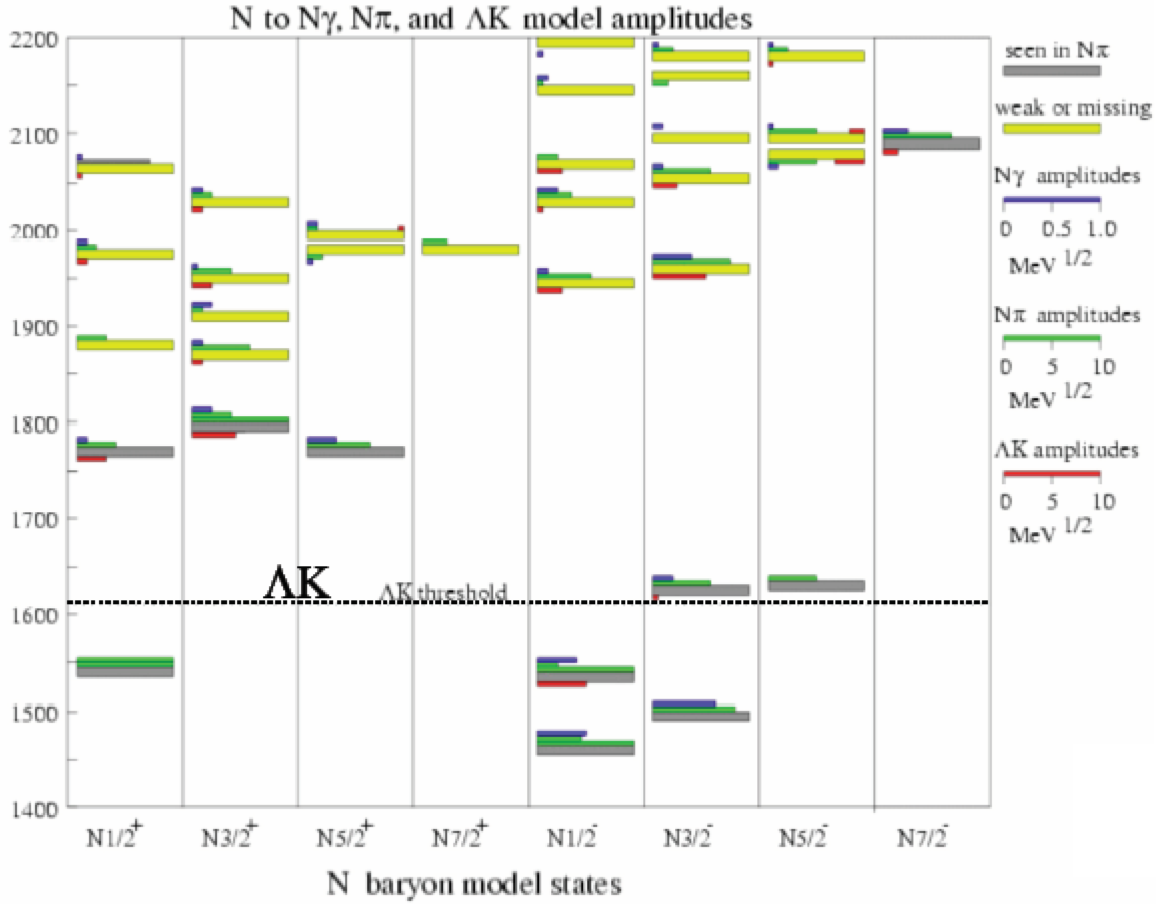
N* Physics via KY Channels

- N*→KY decays are significant two-body decay channels in the mass range of the "missing" resonances (few μb near 1.6 to 2 GeV).
- Hyperons have PV weak decays, "self-analyzing", induced and transferred polarization are measured easily
- Full experimental decomposition of reaction amplitudes → models can divine the N* content of the reactions.

The "Missing Baryon" (N*) Problem

Center of mass energy of baryonic system

E_γ		W
2.3	⇔	2.28
1.5	⇔	1.92
0.7	⇔	1.48



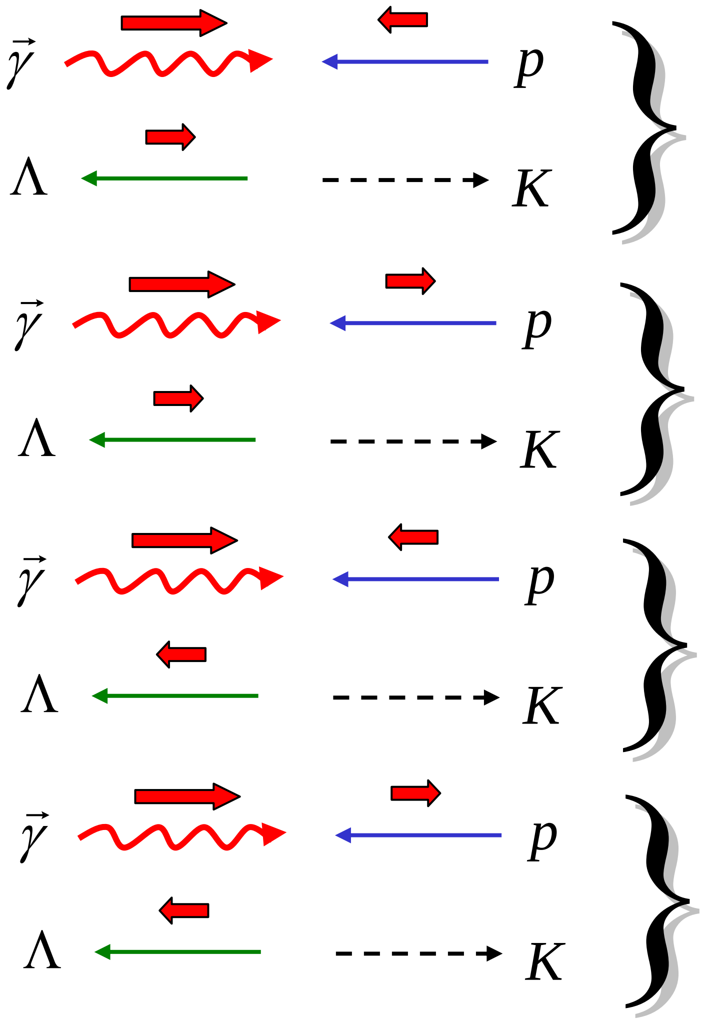
S. Capstick and W. Roberts, Phys. Rev. D **58**, 074011 (1998).

The Observables: 0^- mesons

- Photoproduction described by 4 complex amplitudes
- Bilinear combinations define 16 observables
- 8 measurements* needed to separate amplitudes at any given energy, W
  - differential cross section: $d\sigma/d\Omega$
  - 3 single polarization observables: P, T, Σ
  - 4 double polarization observables…

* W-T. Chiang and F. Tabakin Phys Rev. C 55 2054 (1997)

4 Helicity Amplitudes



N — No overall helicity flip $= |\gamma - (p - \Lambda)|$

S_1 — Single helicity flip

S_2 — Single helicity flip

D — Double helicity flip

16 Pseudoscalar Meson Photoproduction Observables

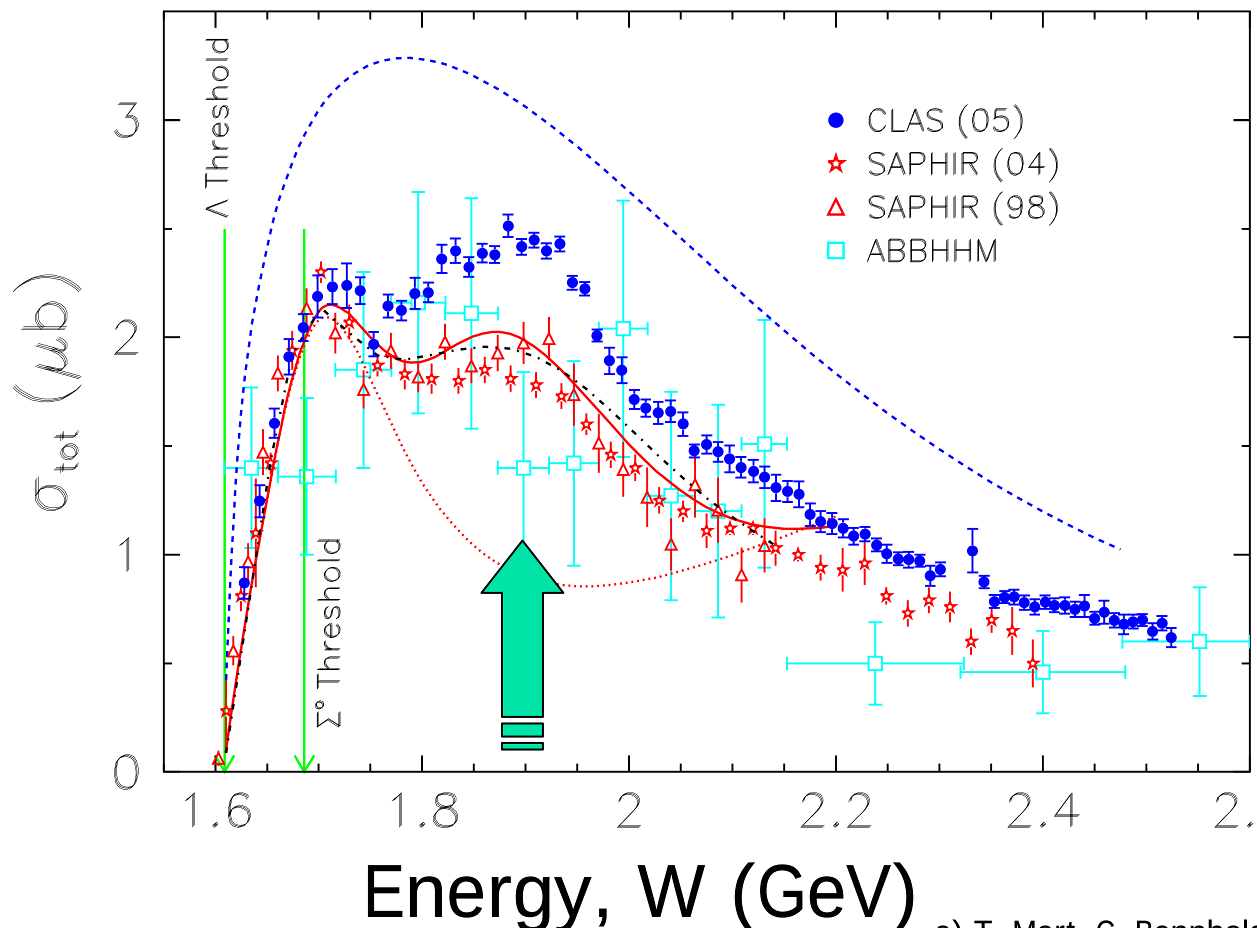
For $\gamma + p \rightarrow K^+ \Lambda$:

Table 1
Observables

Group	Usual symbol	Helicity representation	Experiment required a)	Status
Single Polarization	$d\sigma/dt$	$\lvert N\rvert^2+\lvert S_1\rvert^2+\lvert S_2\rvert^2+\lvert D\rvert^2$	$\{-;-;-\}$	R. Bradford *et al.* PRC **73** 035202 (2006), M. McCracken et al, PRC **81**, 025201 (2010).
	$\Sigma\, d\sigma/dt$	$2\mathrm{Re}(S_1^* S_2 - ND^*)$	$\{L(\frac{1}{2}\pi,0);-;-\}$ $\{-;y;y\}$	C. Paterson *et al.* (Glasgow), to be published
	$T\, d\sigma/dt$	$2\mathrm{Im}(S_1 N^* - S_2 D^*)$	$\{-;y;-\}$ $\{L(\frac{1}{2}\pi,0);0;y\}$	
	$P\, d\sigma/dt$	$2\mathrm{Im}(S_2 N^* - S_1 D^*)$	$\{-;-;y\}$ $\{L(\frac{1}{2}\pi,0);y;-\}$	J. McNabb *et al.* PRC **69** 042201 (2004), M. McCracken et al, PR C **81**, 025201 (2010).
Beam & Target	$G\, d\sigma/dt$	$-2\mathrm{Im}(S_1 S_2^* + ND^*)$	$\{L(\pm\frac{1}{4}\pi);z;-\}$	
	$H\, d\sigma/dt$	$-2\mathrm{Im}(S_1 D^* + S_2 N^*)$	$\{L(\pm\frac{1}{4}\pi);x;-\}$	FroST (g9a) under analysis
	$E\, d\sigma/dt$	$\lvert S_2\rvert^2-\lvert S_1\rvert^2-\lvert D\rvert^2+\lvert N\rvert^2$	$\{c;z;-\}$	
	$F\, d\sigma/dt$	$2\mathrm{Re}(S_2 D^* + S_1 N^*)$	$\{c;x;-\}$	FroST (g9b) data in 2010
Beam & Recoil	$O_x\, d\sigma/dt$	$-2\mathrm{Im}(S_2 D^* + S_1 N^*)$	$\{L(\pm\frac{1}{4}\pi);-;x'\}$	C. Paterson *et al.* (Glasgow),
	$O_z\, d\sigma/dt$	$-2\mathrm{Im}(S_2 S_1^* + ND^*)$	$\{L(\pm\frac{1}{4}\pi);-;z'\}$	to be published
	$C_x\, d\sigma/dt$	$-2\mathrm{Re}(S_2 N^* + S_1 D^*)$	$\{c;-;x'\}$	R. Bradford *et al.* Phys. Rev. C **75**
	$C_z\, d\sigma/dt$	$\lvert S_2\rvert^2-\lvert S_1\rvert^2-\lvert N\rvert^2+\lvert D\rvert^2$	$\{c;-;z'\}$	035205 (2007)
Target & Recoil	$T_x\, d\sigma/dt$	$2\mathrm{Re}(S_1 S_2^* + ND^*)$	$\{-;x;x'\}$	FroST (g9b) data in 2010
	$T_z\, d\sigma/dt$	$2\mathrm{Re}(S_1 N^* - S_2 D^*)$	$\{-;x;z'\}$	
	$L_x\, d\sigma/dt$	$2\mathrm{Re}(S_2 N^* - S_1 D^*)$	$\{-;z;x'\}$	FroST (g9a) under analysis
	$L_z\, d\sigma/dt$	$\lvert S_1\rvert^2+\lvert S_2\rvert^2-\lvert N\rvert^2-\lvert D\rvert^2$	$\{-;z;z'\}$	

I. S. Barker, A. Donnachie, J. K. Storrow, Nucl. Phys. B95 347 (1975).

γp→K⁺Λ Cross Sections



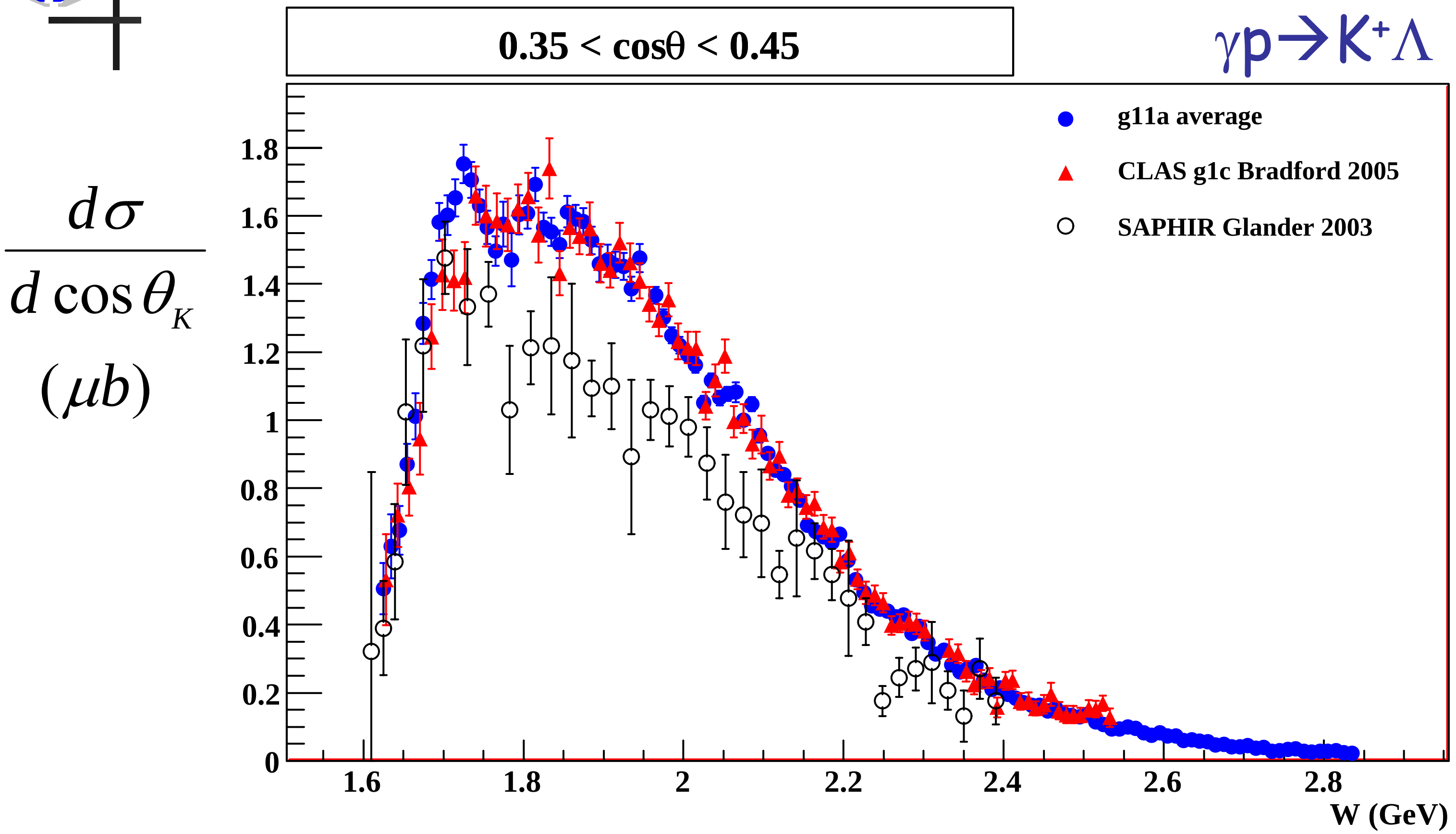
- Two-bump structure seen
- Resonance-like structure at 1.9 GeV:
  - D_{13} (Bennhold & Mart)[a]
  - P_{13} (Bonn-Gachina)[b]
  - P_{11} (Ghent "RPR" model)[c]
  - $\overline{K}KN$ bound state (Valencia model)[d]
  - Coupled-channel effects (Giessen)[e]

R. Bradford *et al*. Phys. Rev. C**73** 035202 (2006)
K. H. Glander *et al*. Eur. Phys. J. A**19** 251 (2004)

a) T, Mart, C. Bennhold, Phys Rev C **61**, 012201(R) (1999).
b) V. Nikanov et al, Phys Lett B **662**, 245 (2008).
c) T. Corthals, et al., PRC **73**, 045207 (2006).
d) A. MartinezTorres, et al., Eur. Phys J. A 41, **361** (2009).
e) R. Shyam, O.Scholten & H.Lenske, PRC **81**, 015204 (2010).

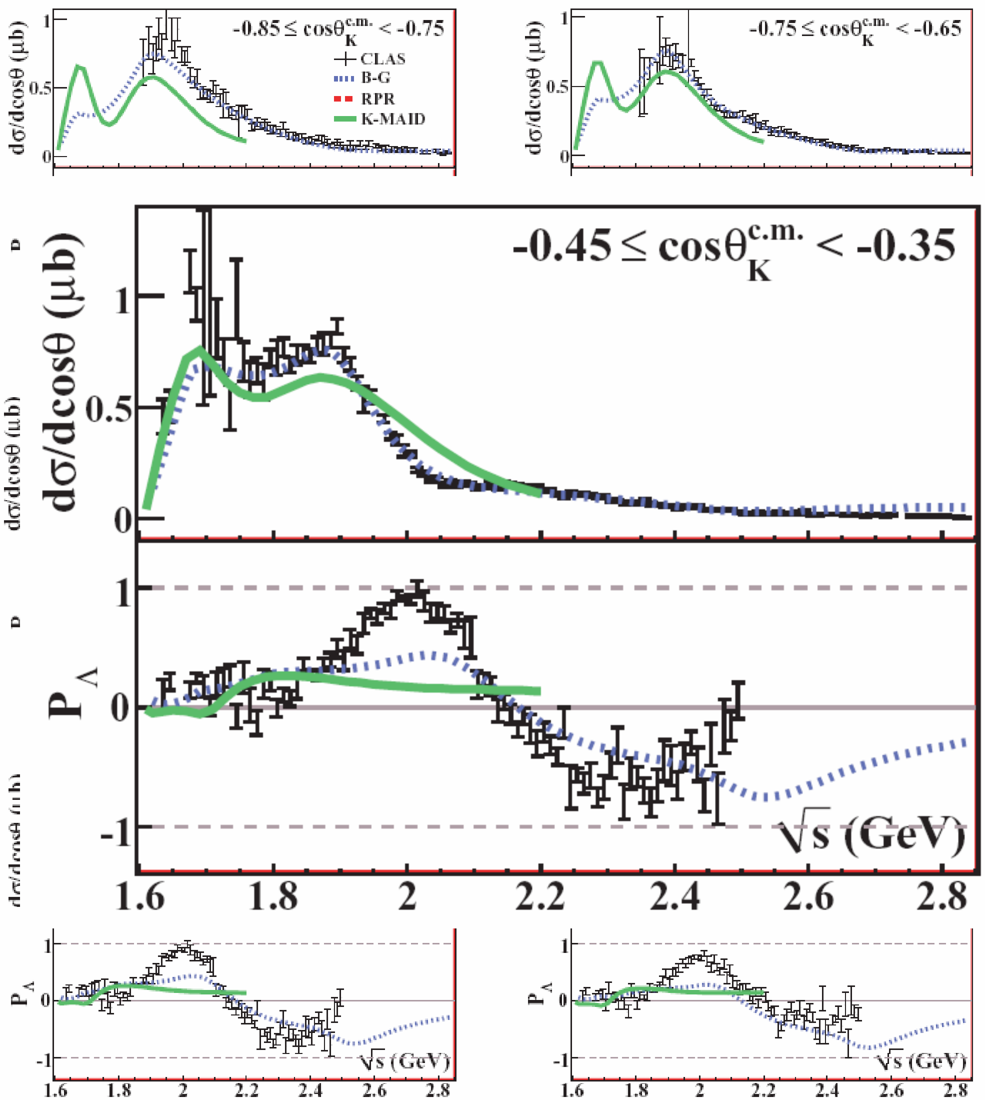
Compare CLAS'05, CLAS'09, SAPHIR

$\gamma p \rightarrow K^+ \Lambda$



- CLAS 'g11' data: broader energy range, better statistics, good agreement with 'g1c' (Bradford *et al.*)
  - Different data set, different trigger, different analysis chain
  - M. McCracken et al. Phys. Rev. C **81**, 025201 (2010).
  - PWA analysis underway

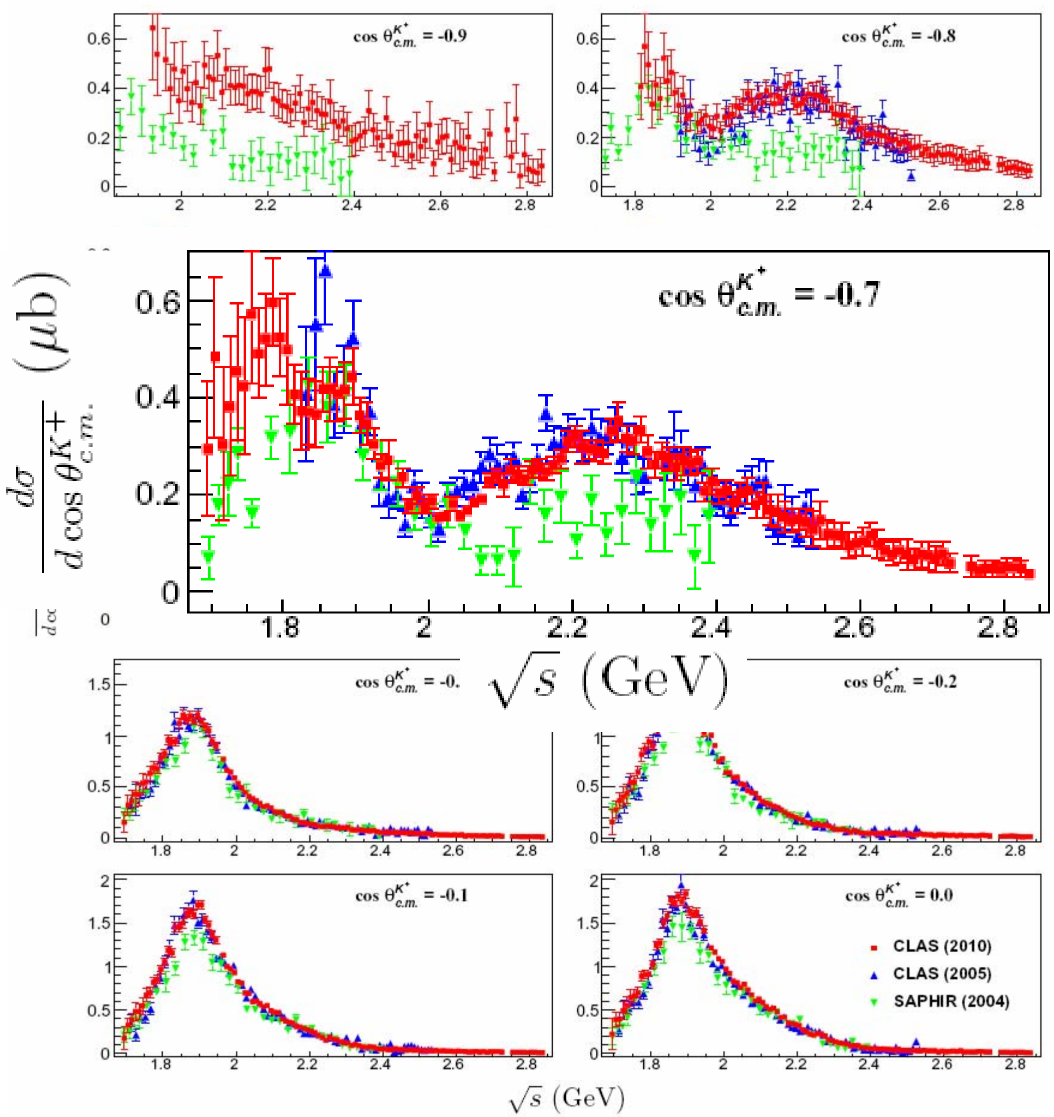
$\gamma p \rightarrow K^+\Lambda$ Cross Sections



- Kaon-MAID model (green)
  - F.X.Lee et al., Nucl. Phys. **A695**, 237 (2001).
  - Single-channel BW resonance fits
  - No longer up-to-date
- Bonn-Gachina model (blue)
  - A.V. Sarantsev et al., Eur. Phys. J., A **25**, 441 (2005).
  - Multi-channel, unitary, BW resonance fit
  - Large suite of N* contributions
  - Was not predictive for recoil polarization

M. McCracken et al, (CLAS) Phys. Rev. C **81**, 025201 (2010).

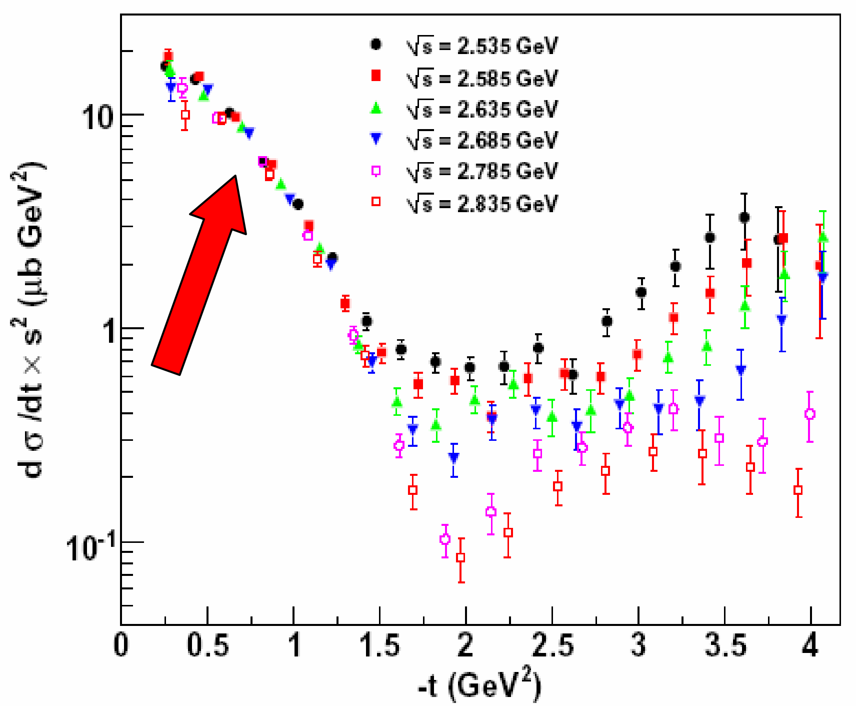
γp→K⁺Σ⁰ Cross Sections

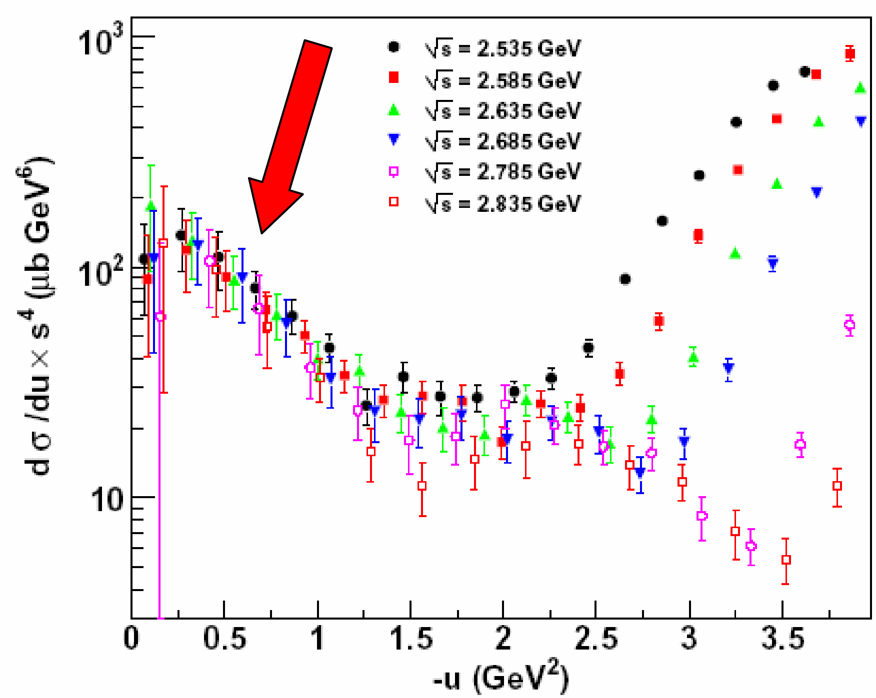


- New results from CLAS
- Unbinned maximum likelihood method
- Excellent agreement with previous CLAS publication (Bradford etal.)
- Resonance-like structure at 2.3 GeV at back angles
- PWA analysis underway

B. Dey *et al.* (CLAS) to be submitted (2010)

Regge-scaling in t and u in γp→K⁺Σ⁰





$$d\sigma / dt \sim s^{2\alpha_{eff}(t)-2}$$

$$\alpha_{eff} = \alpha_{K^+} + \alpha_{K*(892)} \approx 0, t \to 0$$

- Cross section scales as $\sim s^2$

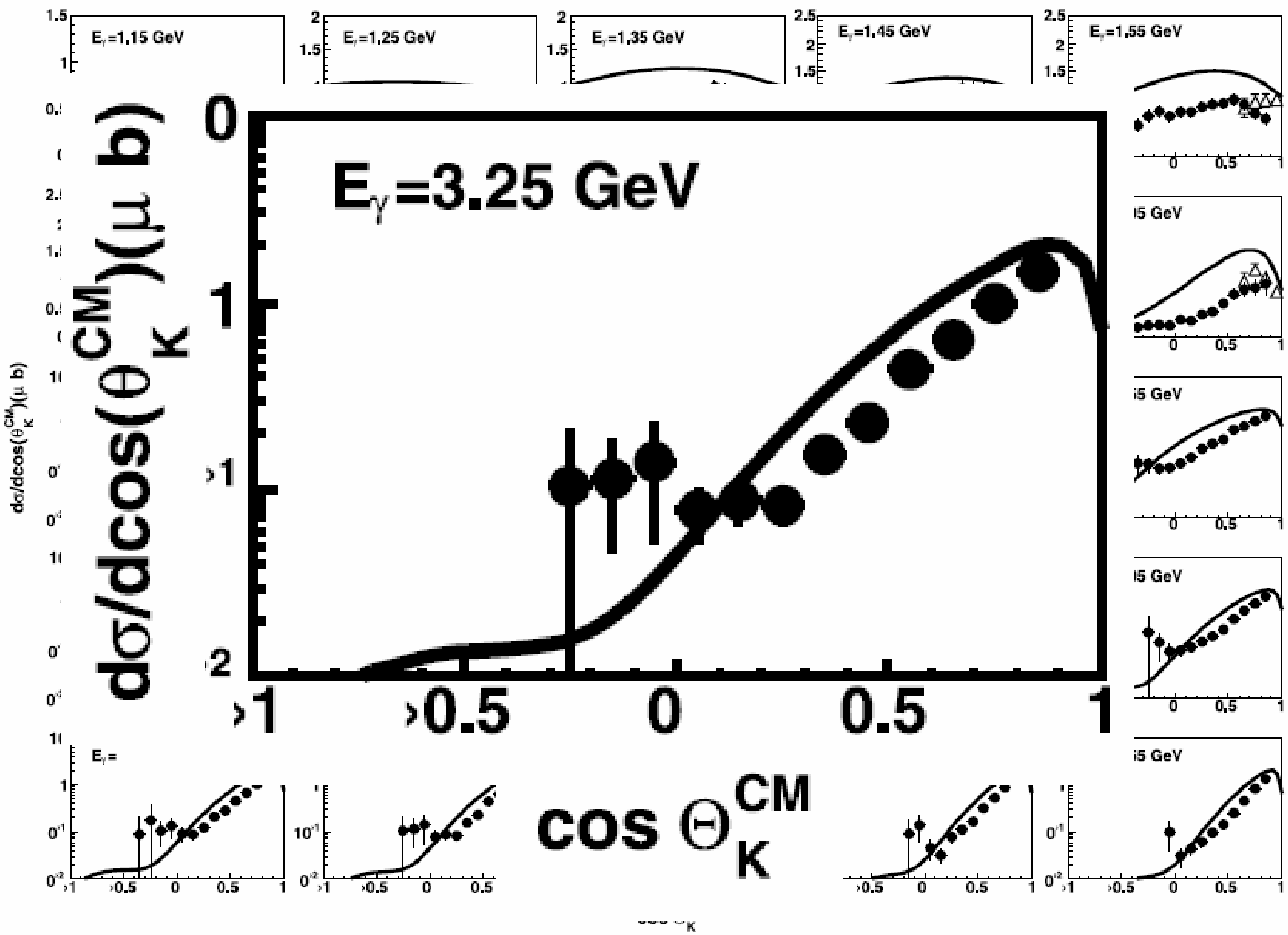
$$d\sigma / du \sim s^{2\alpha_{eff}(u)-2}$$

$$\alpha_{eff} = \alpha_{\Lambda} + \alpha_{\Sigma} \approx -1.4, u \to 0$$

- Cross section scales as $\sim s^4$

B. Dey *et al.* (CLAS) to be submitted (2010)

$\gamma n \rightarrow K^+\Sigma^-$ on bound neutrons



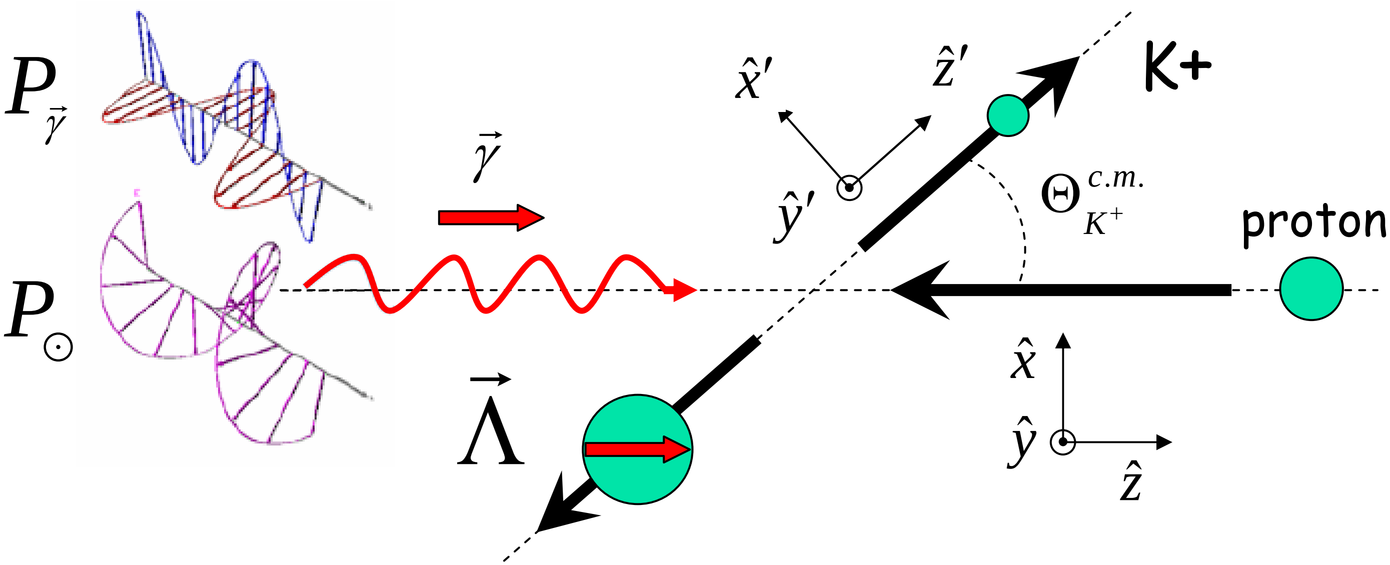
- First "complete" look at Y production off neutron
- Deuteron target, proton spectator, FSI ~ 10%
- Modeled with K^+ and $K^*(892)$ in Regge trajectories (no resonances)
  - Ghent model, Ryckebusch *et al.*
- Hint of back-angle rise → u-channel contribution

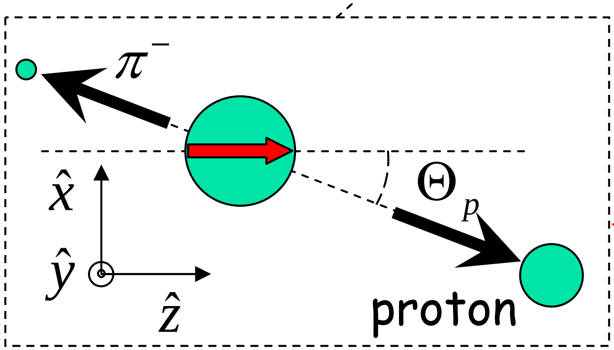
Related talk: P. Vancraeyveld: Session 2E

S. Anefalos Pereira *et al.,* (CLAS) PhysLett B **688**, 289 (2010)

Define the Spin Observables

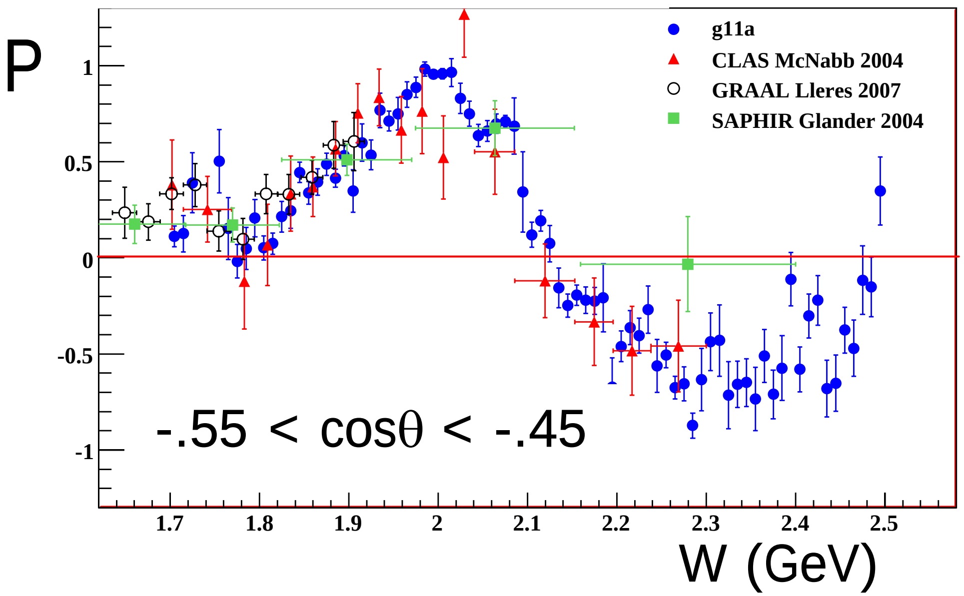
(for target polarization zero)

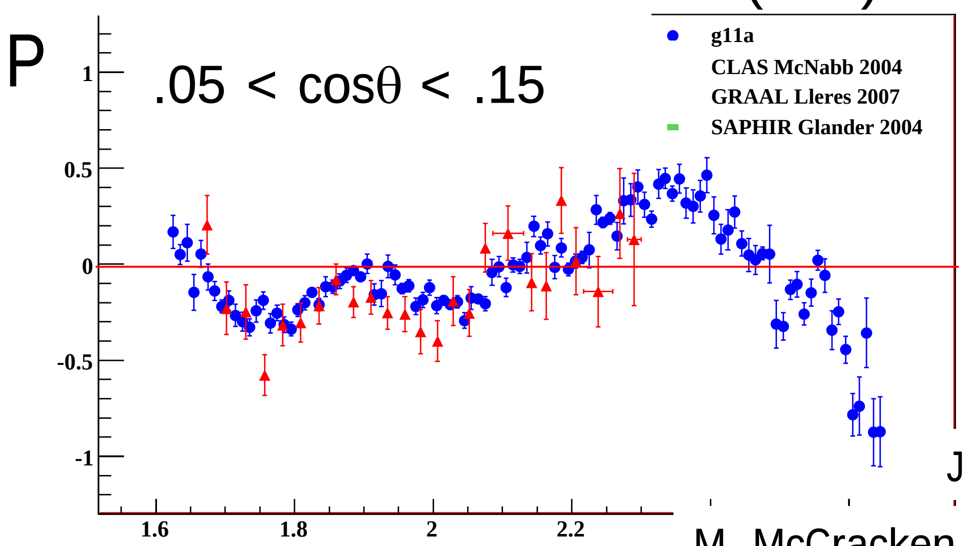




$$\frac{d\sigma}{d\Omega} = \sigma_0 \left\{ \begin{array}{l} 1 - P_{\vec{\gamma}} \Sigma \cos 2\phi \\ \quad - \alpha \cos\theta_{x'} \sin 2\phi P_{\vec{\gamma}} O_{x'} - \alpha \cos\theta_{x'} P_{\odot} C_{x'} \\ \quad - \alpha \cos\theta_{z'} \sin 2\phi P_{\vec{\gamma}} O_{z'} - \alpha \cos\theta_{z'} P_{\odot} C_{z'} \\ \quad + \alpha \cos\theta_{y'} P - \alpha \cos\theta_{y'} P_{\vec{\gamma}} T \cos 2\phi \end{array} \right\}$$

$\gamma p \rightarrow K^+\Lambda$ Hyperon Recoil Polarization



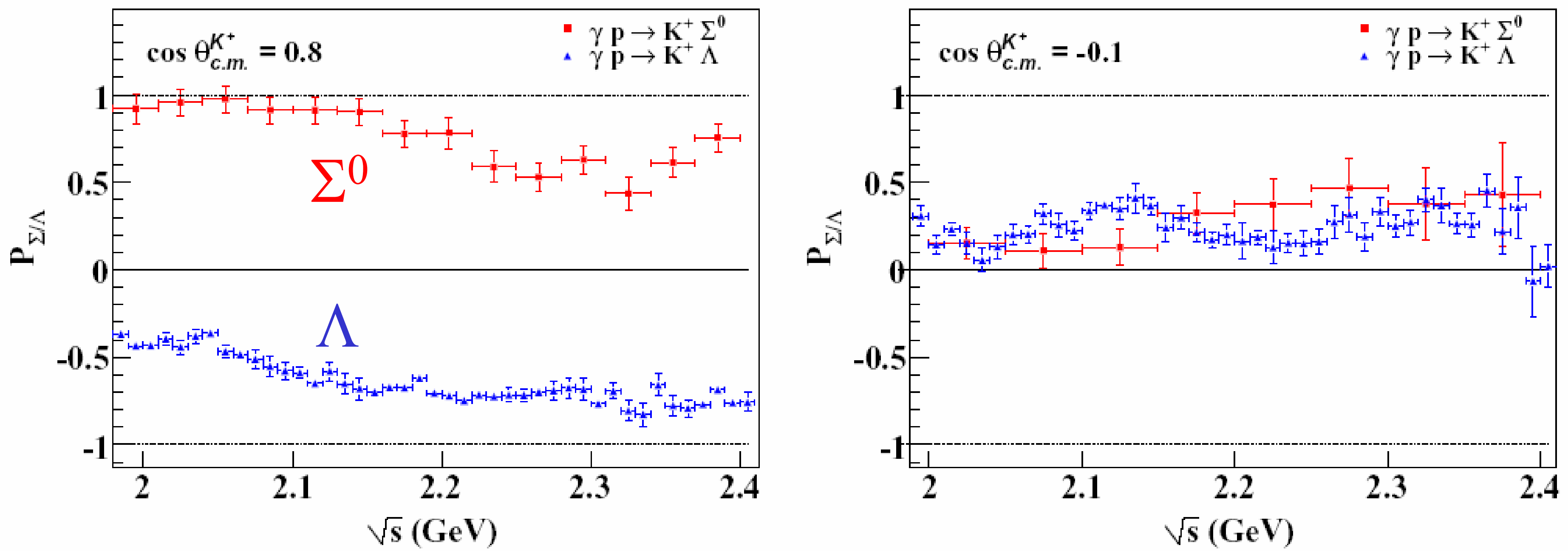


- New CLAS results show new structure in P_Λ
- Good agreement among older CLAS results (McNabb g1c, Paterson g8b), and GRAAL
- PWA analysis underway

J. McNabb *et al.* Phys Rev C **69** 042201 (2004)

M. McCracken et al, (CLAS) Phys. Rev. C **81**, 025201 (2010)

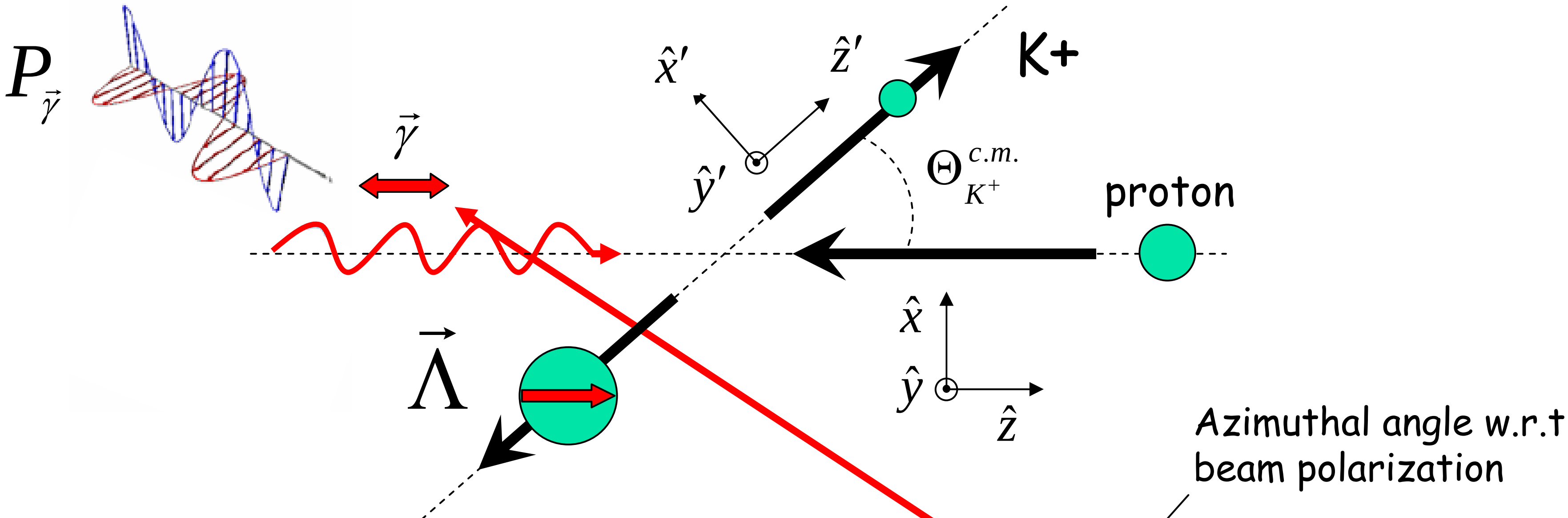
Polarization comparison

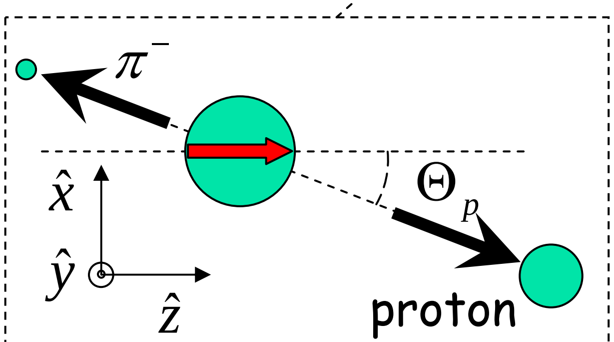


- Naïve SU(6) expectation: $P_\Lambda \simeq -P_{\Sigma^0}$
- True in forward direction
- False in backward direction

B. Dey *et al.* (CLAS) to be submitted (2010)

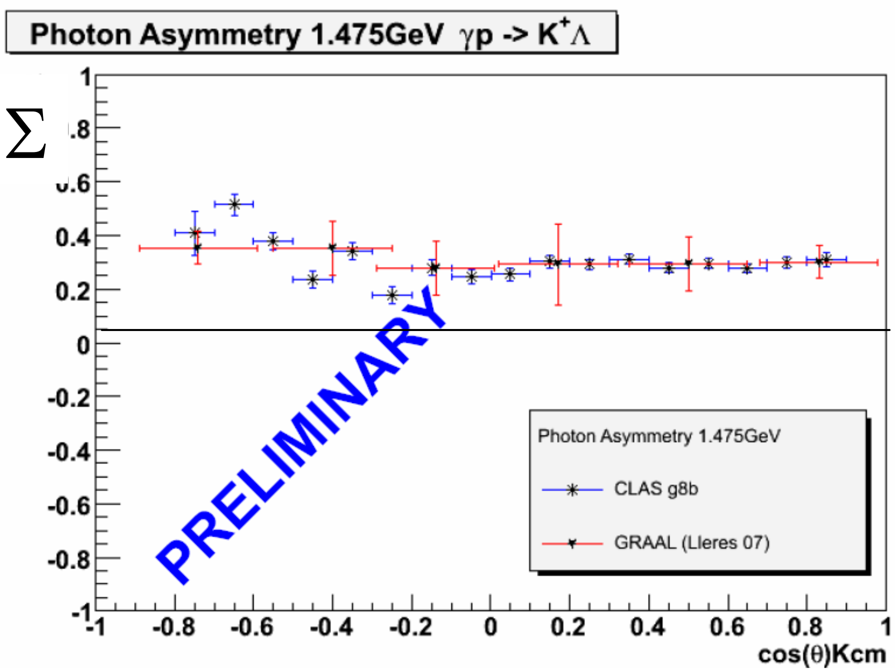
Beam Asymmetry

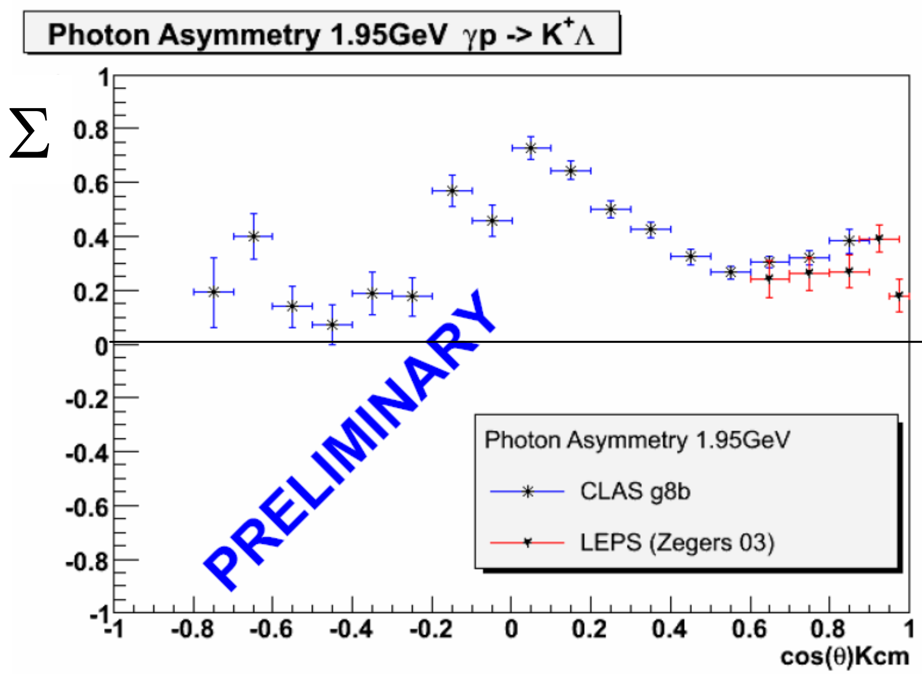




$$\frac{d\sigma}{d\Omega} = \sigma_0 \left\{ \begin{aligned} &1 - P_{\vec{\gamma}} \Sigma \cos 2\phi \\ &- \alpha \cos\theta_{x'} \sin 2\phi P_{\vec{\gamma}} O_{x'} - \alpha \cos\theta_{x'} P_{\odot} C_{x'} \\ &- \alpha \cos\theta_{z'} \sin 2\phi P_{\vec{\gamma}} O_{z'} - \alpha \cos\theta_{z'} P_{\odot} C_{z'} \\ &+ \alpha \cos\theta_{y'} P - \alpha \cos\theta_{y'} P_{\vec{\gamma}} T \cos 2\phi \end{aligned} \right\}$$

γp→K⁺Λ Photon Beam Asymmetry

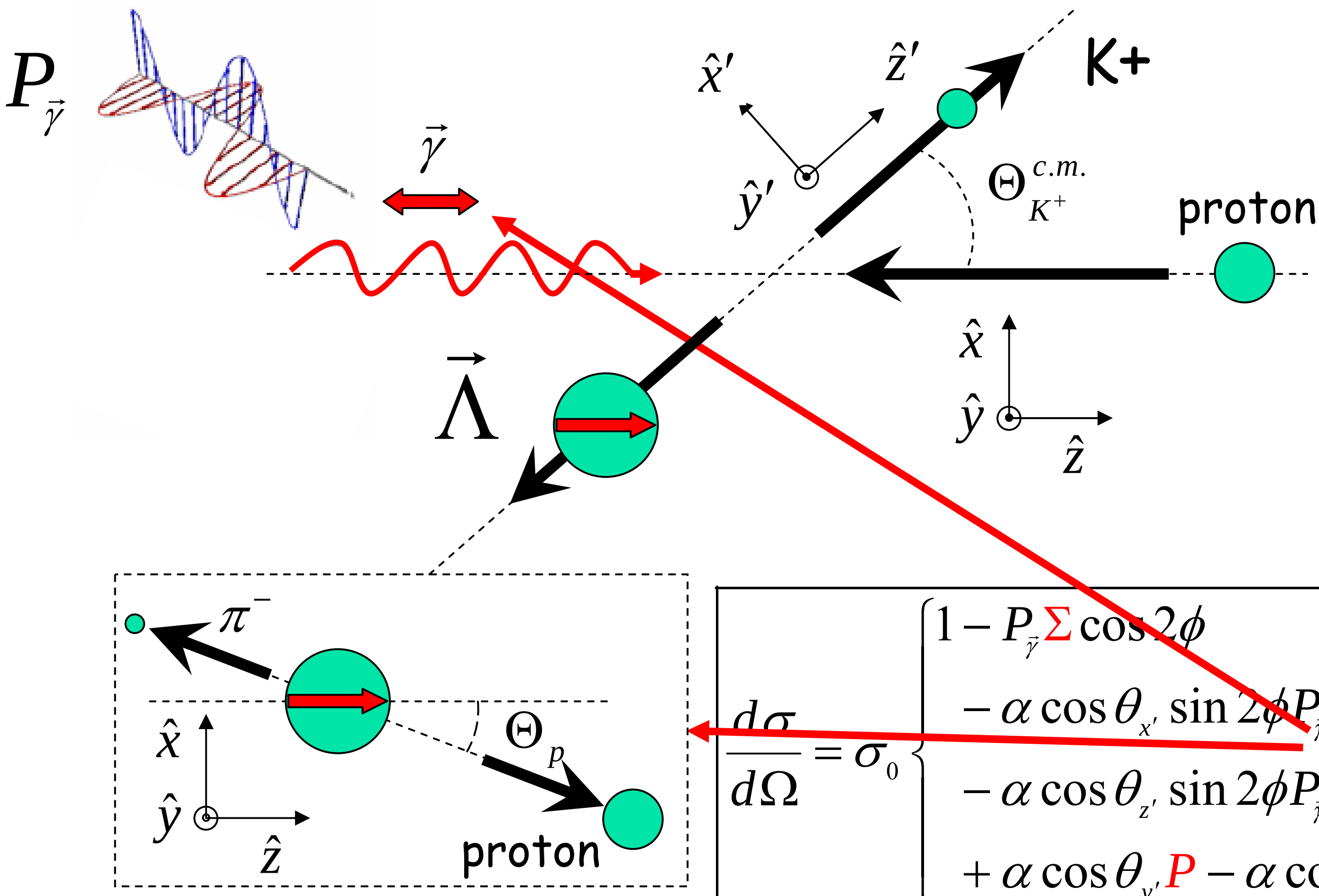




- Good agreement among CLAS, GRAAL and LEPS
- Results for $\gamma p \rightarrow K^+\Sigma^0$ coming as well

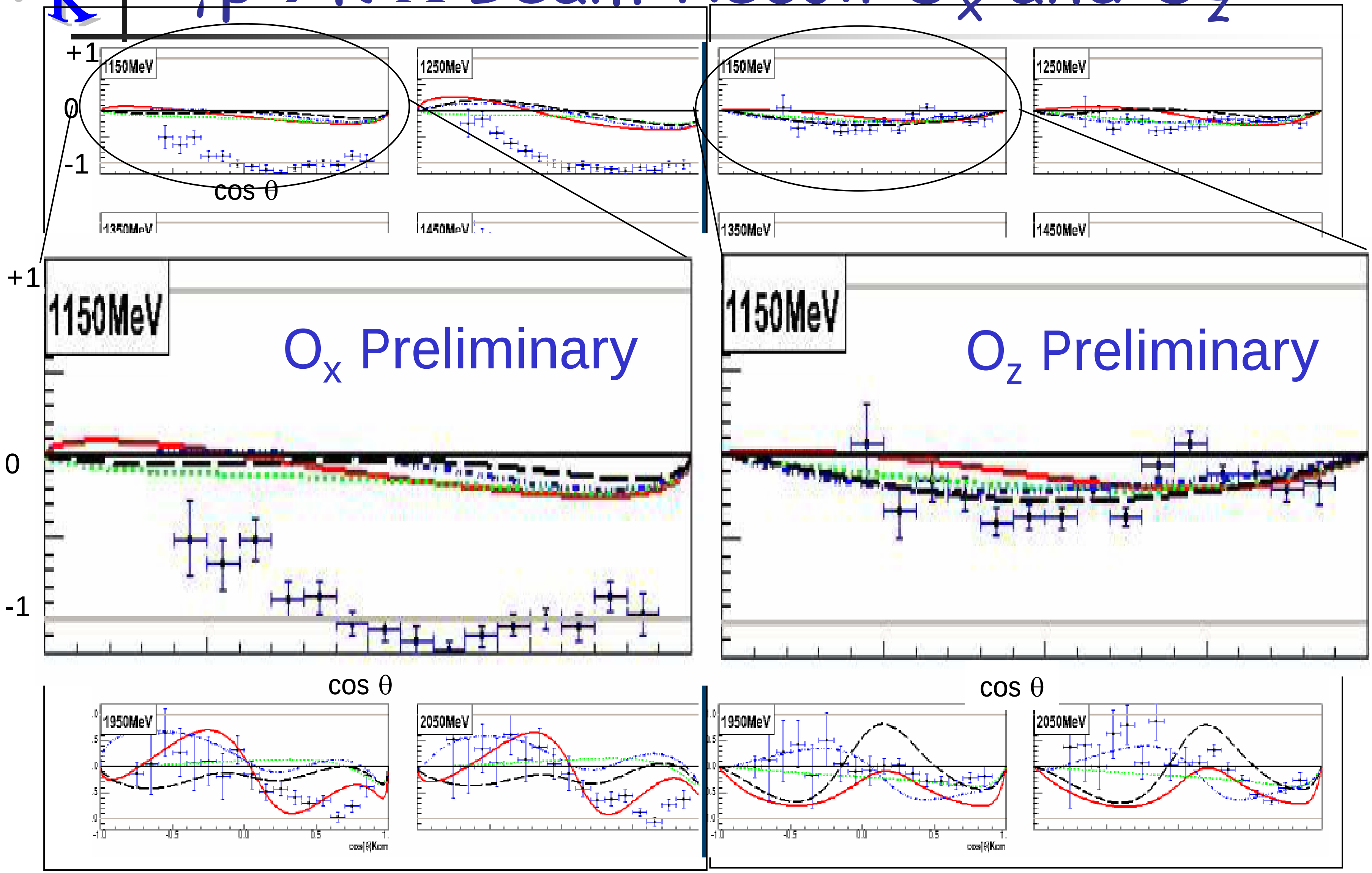
Craig Paterson (Glasgow)

Polarization Transfer for Linear Beam Polarization



$$\frac{d\sigma}{d\Omega} = \sigma_0 \left\{ \begin{array}{l} 1 - P_{\vec{\gamma}} \Sigma \cos 2\phi \\ -\alpha \cos\theta_{x'} \sin 2\phi P_{\vec{\gamma}} O_{x'} - \alpha \cos\theta_{x'} P_{\odot} C_{x'} \\ -\alpha \cos\theta_{z'} \sin 2\phi P_{\vec{\gamma}} O_{z'} - \alpha \cos\theta_{z'} P_{\odot} C_{z'} \\ +\alpha \cos\theta_{y'} P - \alpha \cos\theta_{y'} P_{\vec{\gamma}} T \cos 2\phi \end{array} \right\}$$

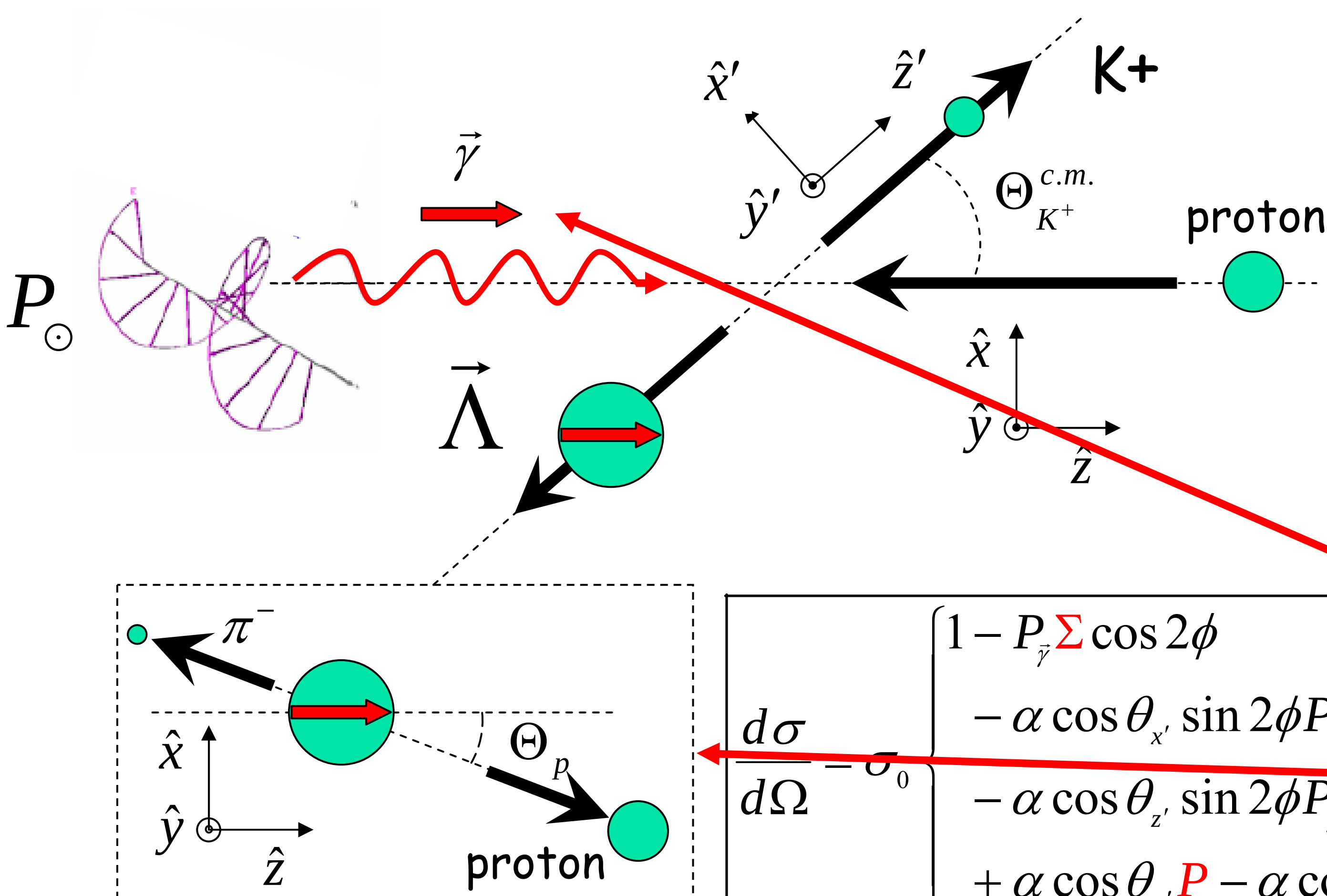
$\gamma p \rightarrow K^+ \Lambda$ Beam-Recoil O_x and O_z



KaonMAID; RPR2-Regge only; RPR2-core; RPR2-w/D13

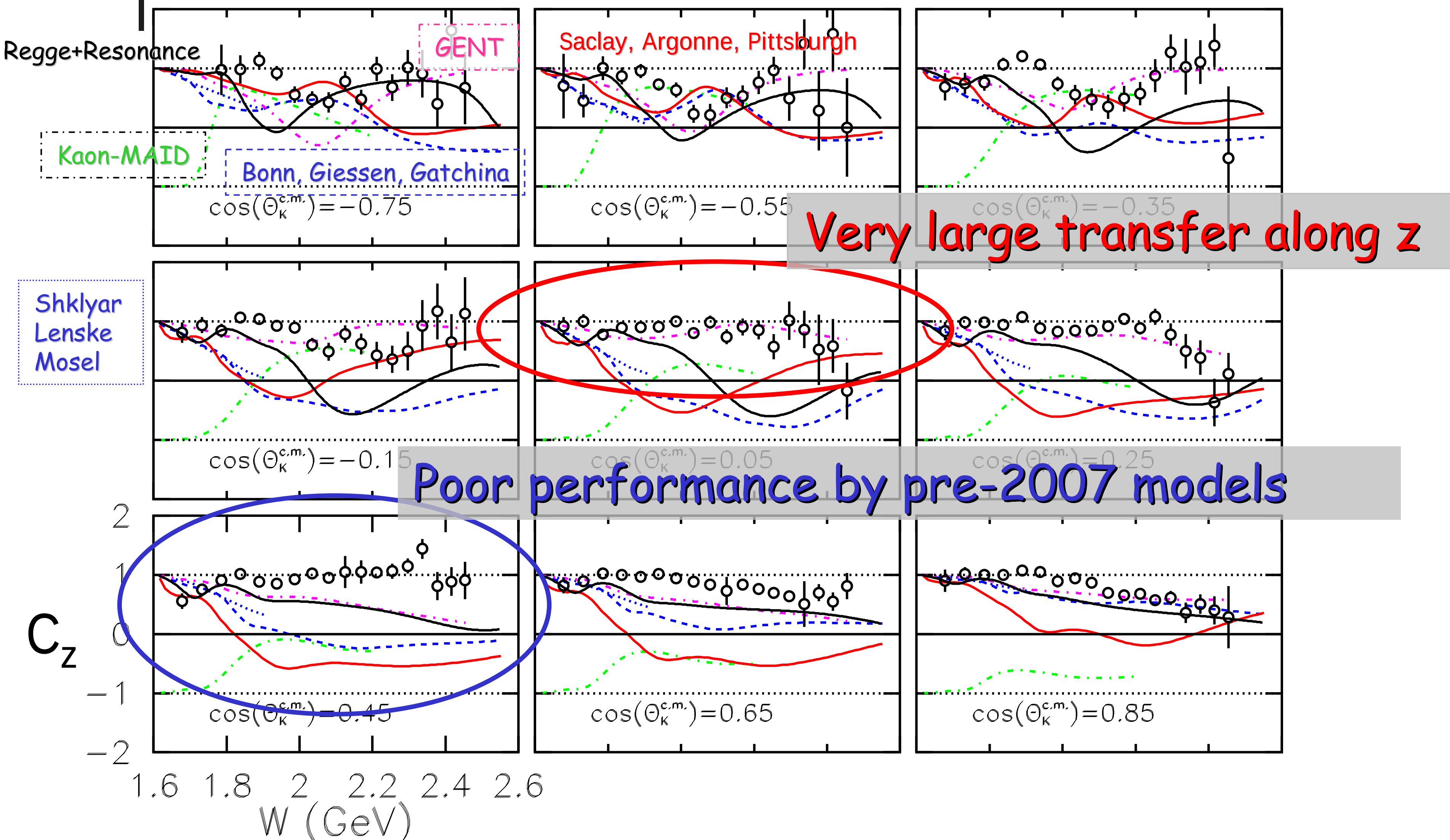
Craig Paterson (Glasgow)

Polarization Transfer for Circular Beam Polarization



$$\frac{d\sigma}{d\Omega} = \sigma_0 \left\{ \begin{aligned} & 1 - P_{\vec{\gamma}} \Sigma \cos 2\phi \\ & - \alpha \cos\theta_{x'} \sin 2\phi P_{\vec{\gamma}} O_{x'} - \alpha \cos\theta_{x'} P_{\odot} C_{x'} \\ & - \alpha \cos\theta_{z'} \sin 2\phi P_{\vec{\gamma}} O_{z'} - \alpha \cos\theta_{z'} P_{\odot} C_{z'} \\ & + \alpha \cos\theta_{y'} P - \alpha \cos\theta_{y'} P_{\vec{\gamma}} T \cos 2\phi \end{aligned} \right\}$$

C_z vs. W: Results for Λ

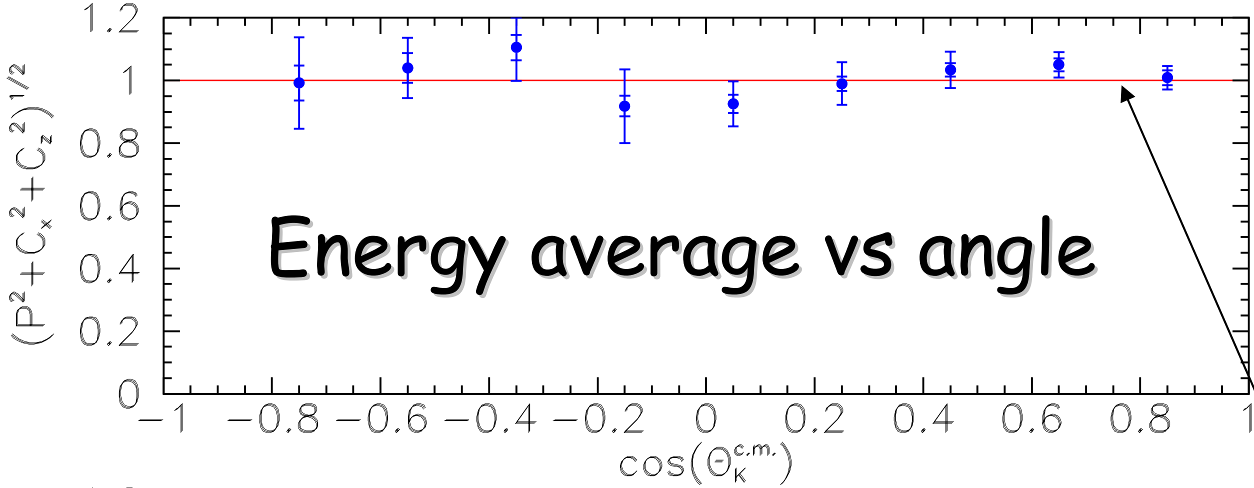


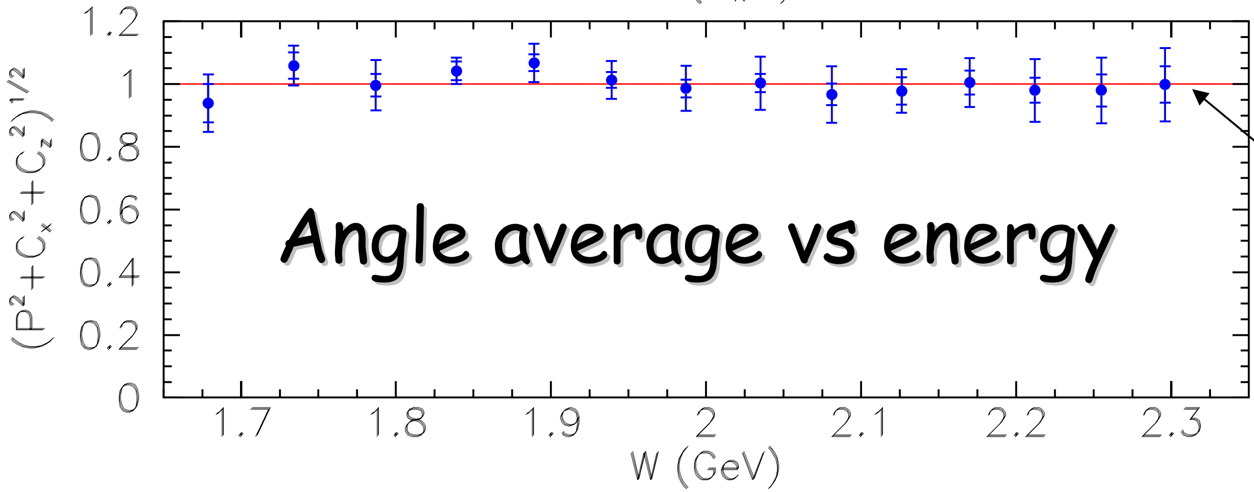
R. Bradford *et al.*, Phys. Rev. C **75**, 035205 (2007).

Average R Values for the Λ

$$R \equiv \sqrt{P^2 + C_x^2 + C_z^2}$$

$$\bar{R} = 1.01 \pm 0.01$$





"Fully Polarized Λ"

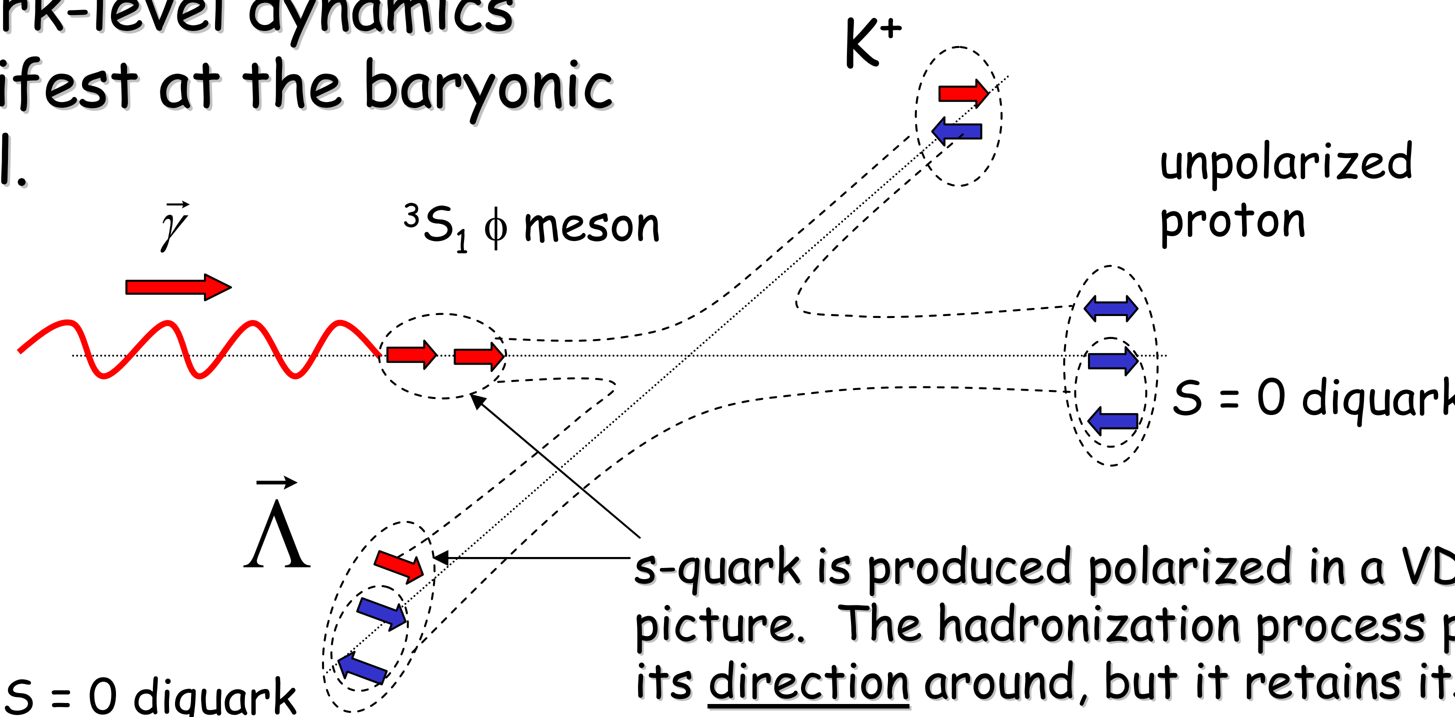
Energy and angle averages are consistent with unity.

No model predicted this CLAS result.

Confirmed by GRAAL:
A. Lleres *et al.* Eur. Phys. J. **A 39**, 149 (2009).

Quark-Picture Explanation

Quark-level dynamics manifest at the baryonic level.

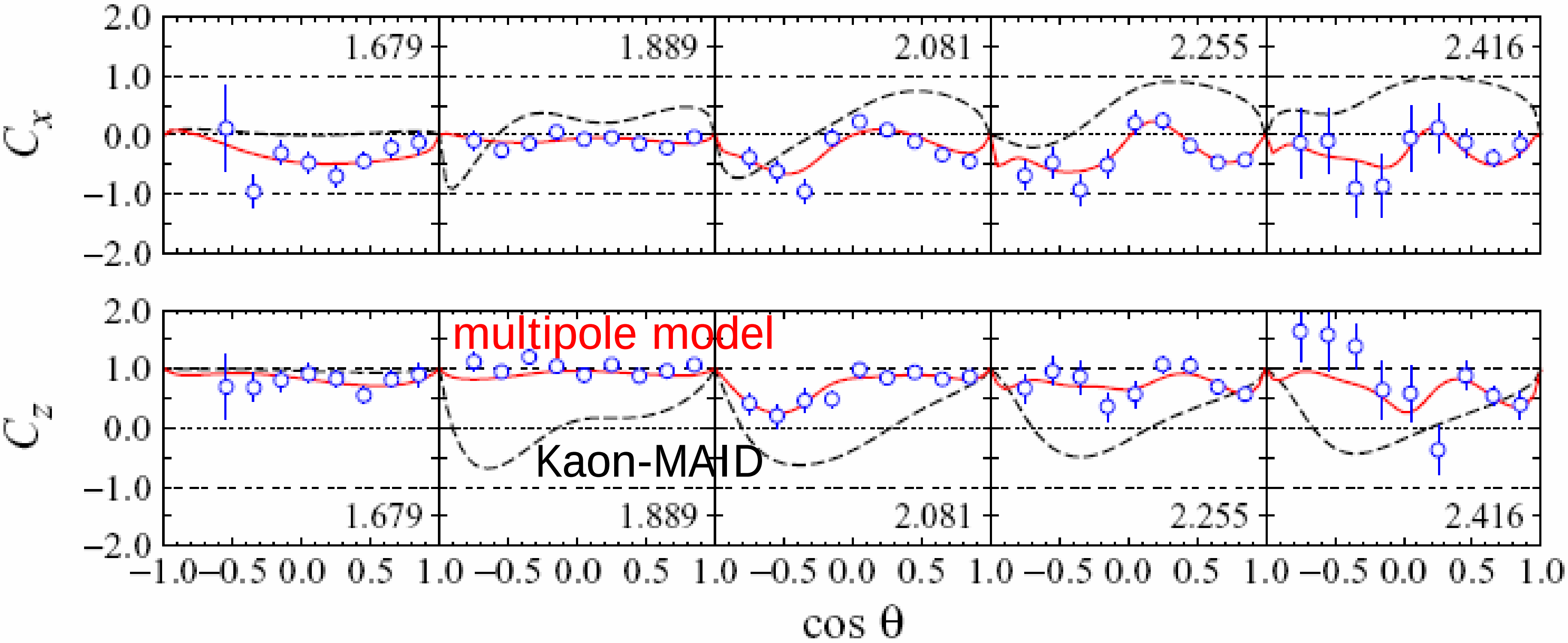


s-quark is produced polarized in a VDM $^3S_1$ picture. The hadronization process pushes its direction around, but it retains its full polarization magnitude.

R. S., Eur.Phys.J. A**35** 299-305 (2008)

Alternative quark-level S=0 (spin singlet) scenario:
D. Carman *et al.*, Phys Rev. Lett 90 131804 (2003).

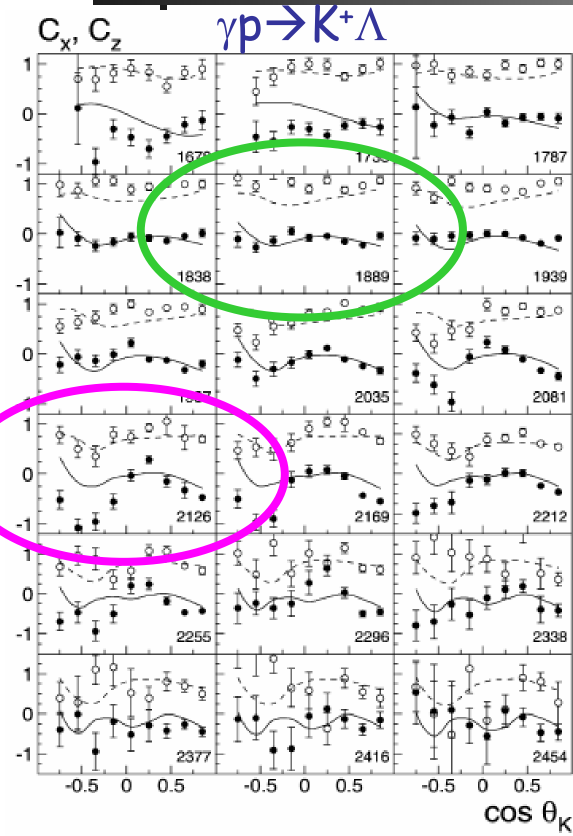
Hadronic-Model Explanation



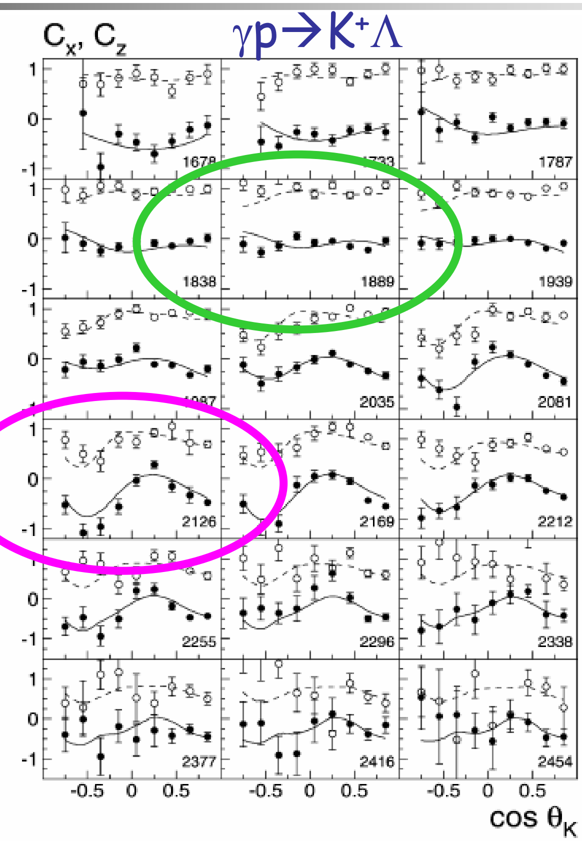
- Mart *et al.*'s refit of isobar and multipole models
- mix includes: $S_{11}(1650)$, $P_{11}(1710)$, $P_{13}(1720)$, $P_{13}(1900)$
- second resonance "bump" no longer consistent with a $D_{13}(2080)$

T. Mart, nucl-th 0808.0771 (Aug 2008)

Effect of including C_x C_z in Models



C_xC_z without N*(1900)P_{13}



C_xC_z with N*(1900)P_{13}

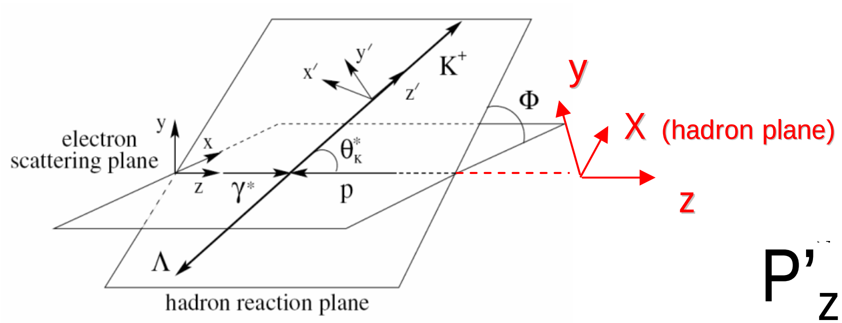
- Nikanov *et al.*'s refit of Bonn-Gachina coupled-channel isobar model
- mix includes: S_{11}-wave, $P_{13}(1720)$, $P_{13}(1900)$, $P_{11}(1840)$
- $K^+\Sigma^0$ cross sections also better described with $P_{13}(1900)$
- Promote this "missing" resonance from ** to **** status.
- $P_{13}(1900)$ is not found in quark-diquark models.

Related talk: A. Sarantsev: Session 5B

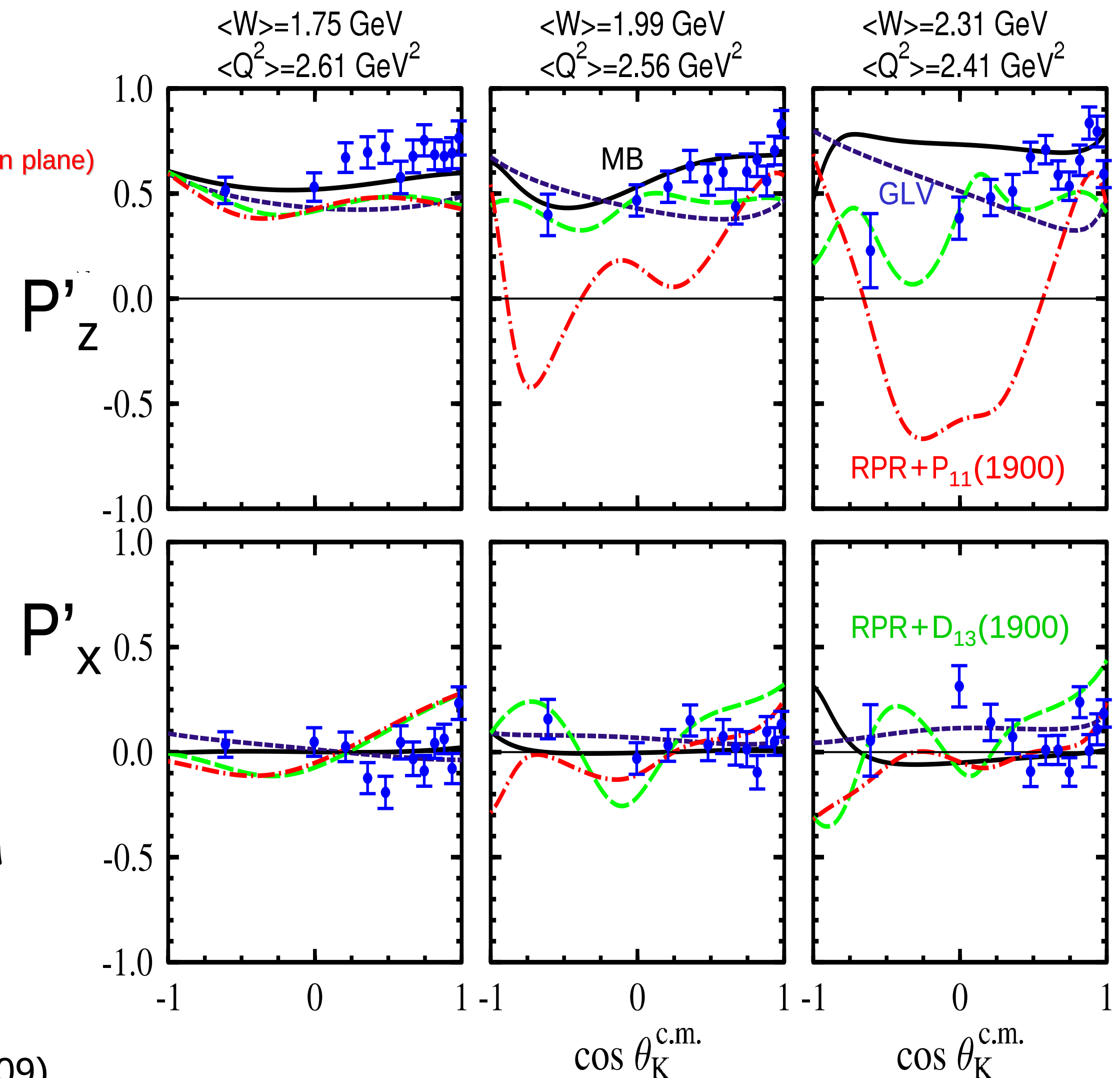
V. A. Nikanov *et al.*, Phys Lett. B **662**, 246 (2008).
see also: A.V. Anisovich *et al.*, Eur. Phys J. A **25** 427 (2005).

E. Santopinto Phys Rev. C **72**, 02201(R), (2005).

CLAS $p(\vec{e},e'K^+)\vec{\Lambda}$ Transferred Polarization



- Electro-production analog $C_x \rightarrow P_x'$ and $C_z \rightarrow P_z'$
- Large polarization transfer *along virtual photon direction* (not the z′ helicity axis)
- Beam depolarization (~0.6) is not divided out in figures.
- Qualitatively consistent with photoproduction: hints at "simple" reaction mechanism

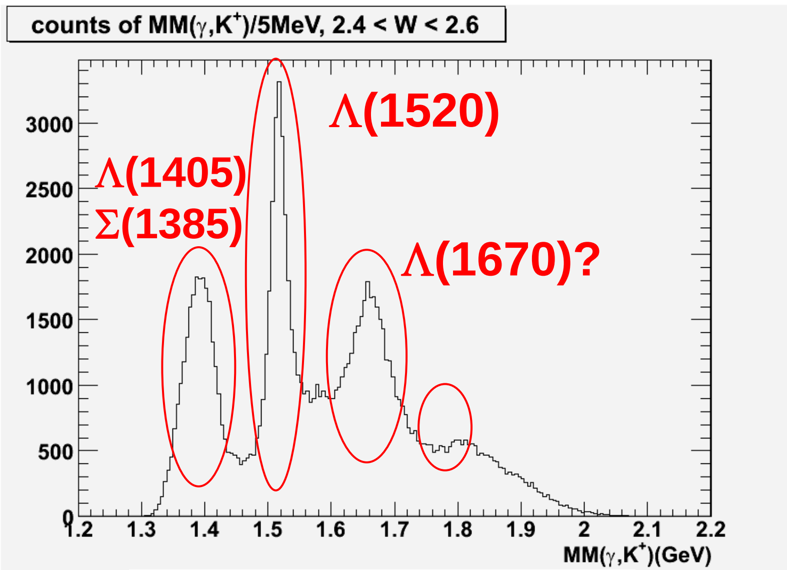


D. Carman *et al.*, Phys Rev. C **79** 065205 (2009).

D. Carman *et al.*, Phys Rev. Lett. **90** 131804 (2003).

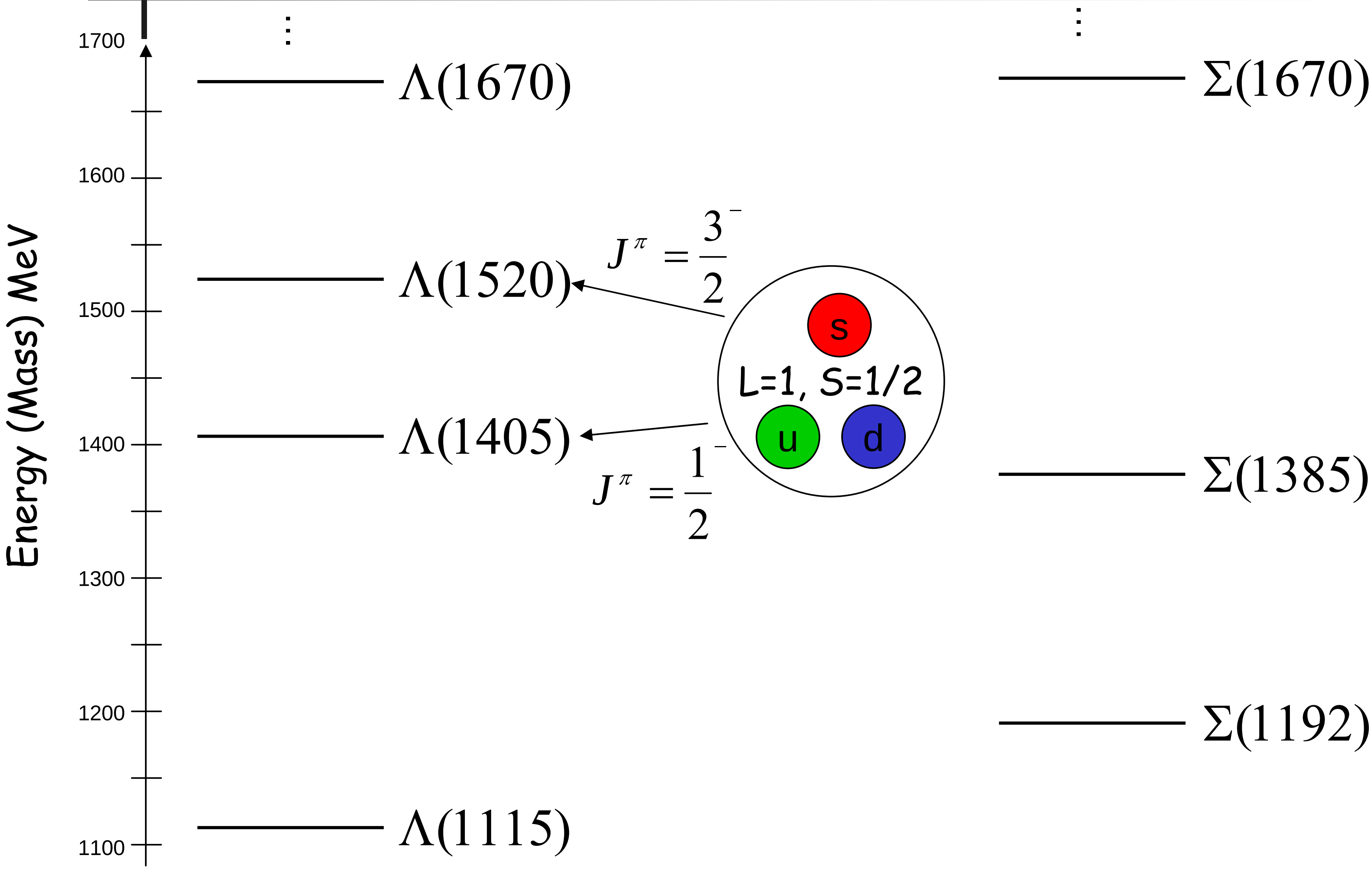
What "is" the $\Lambda(1405)$?

- Structure – an issue since its discovery
  - SU(3) singlet 3q state
    I=0, $J^\pi = \frac{1}{2}^-$
  - $\bar{K}N$ sub-threshold bound state
  - Gluonic (udsg) hybrid $J^\pi = \frac{1}{2}^+$
    - O. Kittel & G.R.Farrar hep-ph/0010186
  - Dynamically generated resonance, via unitary meson-baryon channel coupling
    - R. Dalitz & S.F.Tuan, Phys. Rev. Lett. **2**, 425 (1959), Ann. Phys. **10**, 307 (1960).
    - J. C. Nacher, E. Oset, H. Toki, A. Ramos, Phys. Lett. B **455**, 55 (1999).

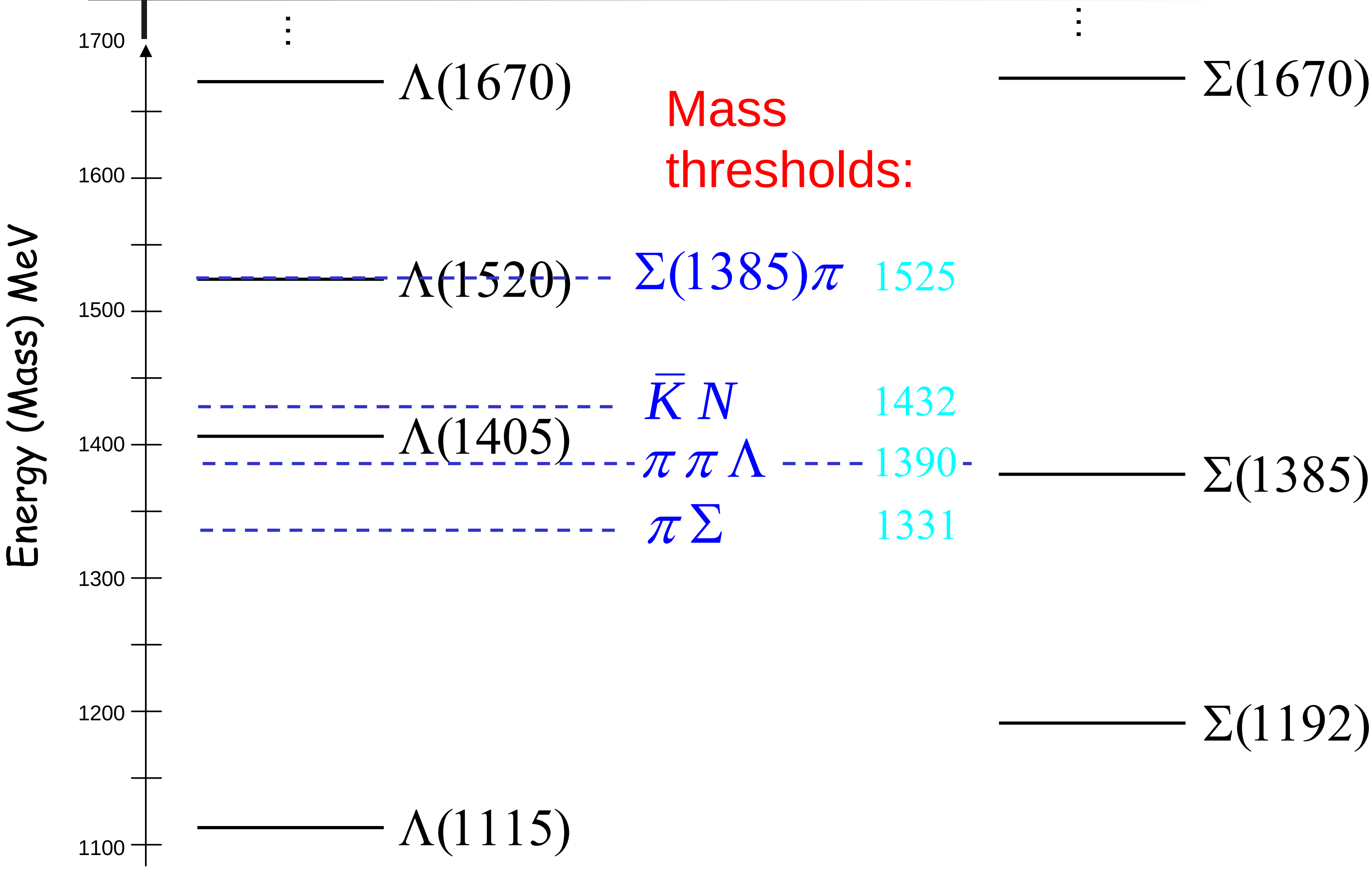


(γ,K) Missing Mass (GeV)

The Low-Mass S=-1 Hyperons

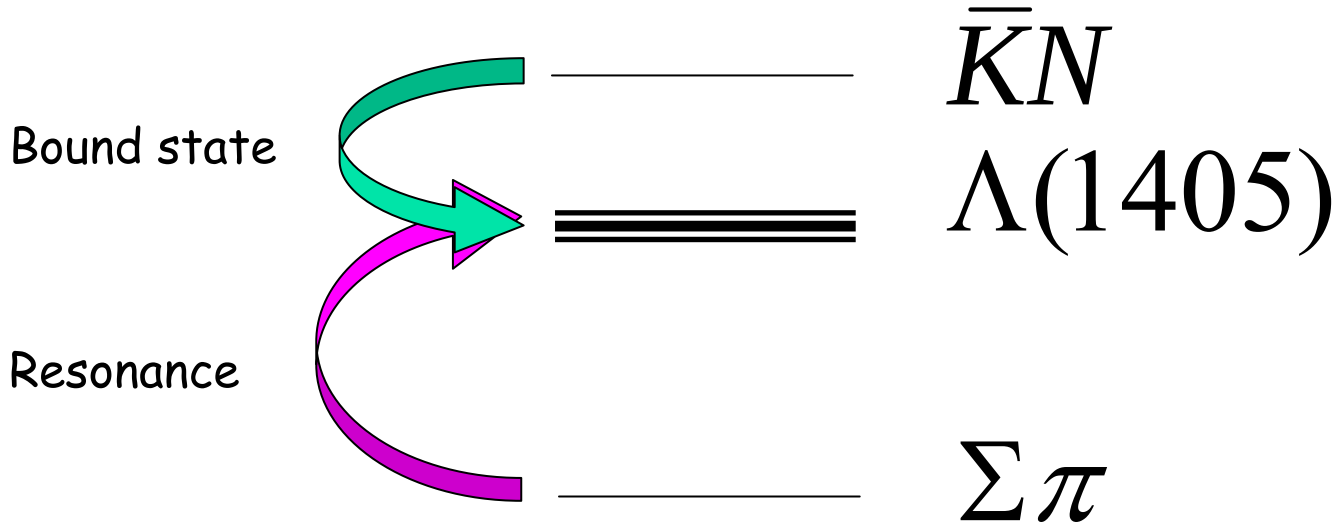


The Low-Mass S=-1 Hyperons



Dynamical State Generation

Do the "ground state" mesons and baryons attract strongly enough to form mB "molecular" bound states or unbound resonances?



Unitary channel coupling via Bethe-Salpeter equation formalism

"Weinberg-Tomozawa" driving term… + higher chiral orders…

Chiral Unitary Model (example)

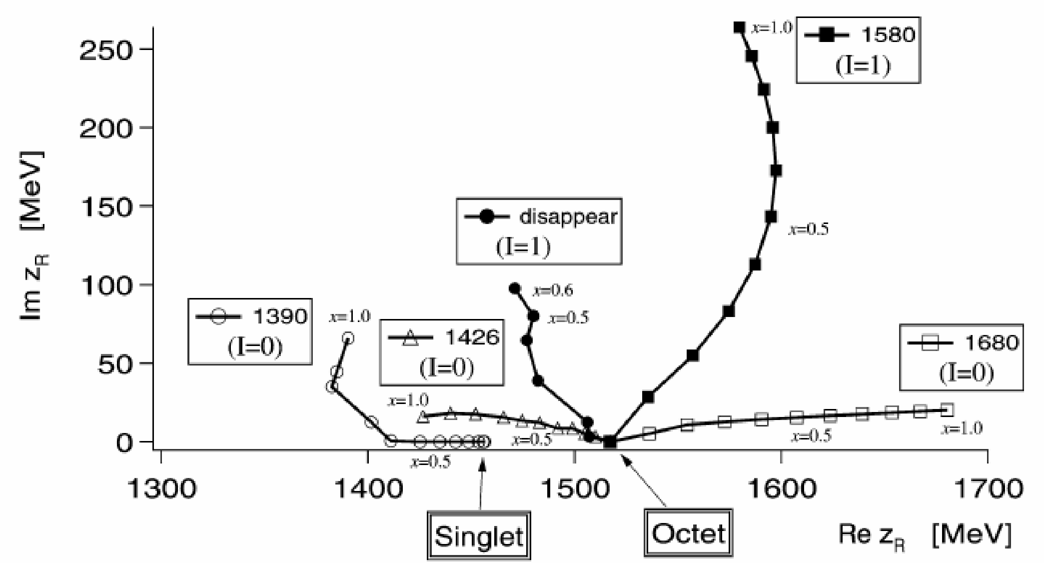
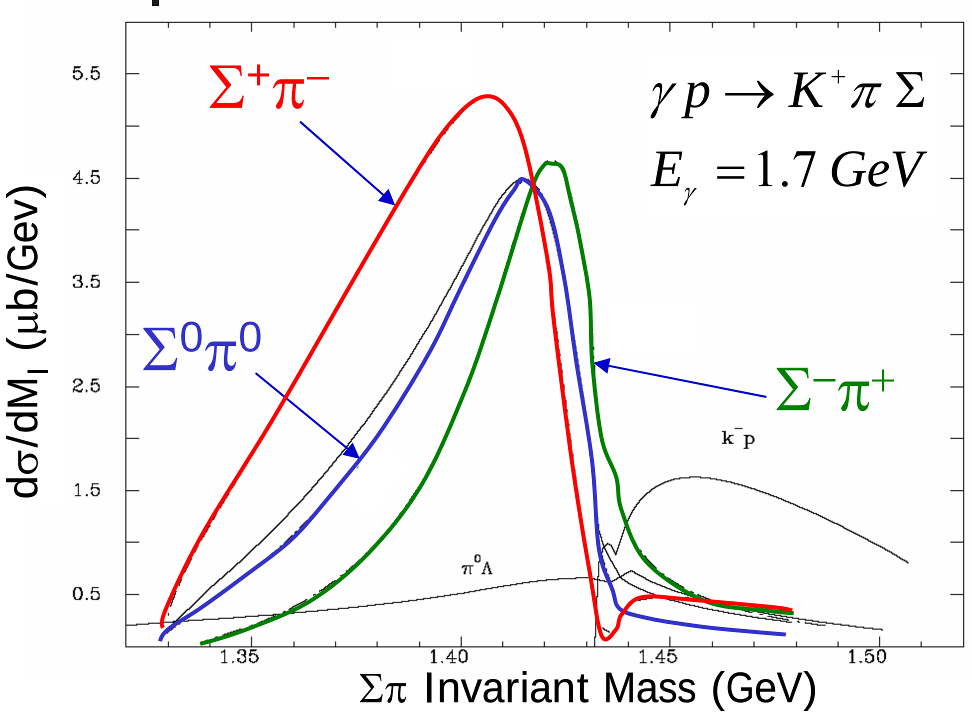


Fig. 1. Trajectories of the poles in the scattering amplitudes obtained by changing the SU(3) breaking parameter x gradually. At the SU(3) symmetric limit ($x = 0$), only two poles appear, one is for the singlet and the other for the octets. The symbols correspond to the step size $\delta x = 0.1$.

- SU(3) baryons irreps $1+8_s+8_a$ combine with 0^- Goldstone bosons to generate:
- Two octets and a singlet of $\frac{1}{2}^-$ baryons generated dynamically in SU(3) limit
- SU(3) breaking leads to two S=-1 I=0 poles near 1405 MeV
  - ~1420 mostly $\bar{K}N$
  - ~1390 mostly $\pi\Sigma$
- Possible weak I=1 pole also predicted

D. Jido, J.A Oller, E. Oset, A. Ramos, U-G Meissner Nucl. Phys. A 725 181 (2003)

Chiral Unitary Model (different example)



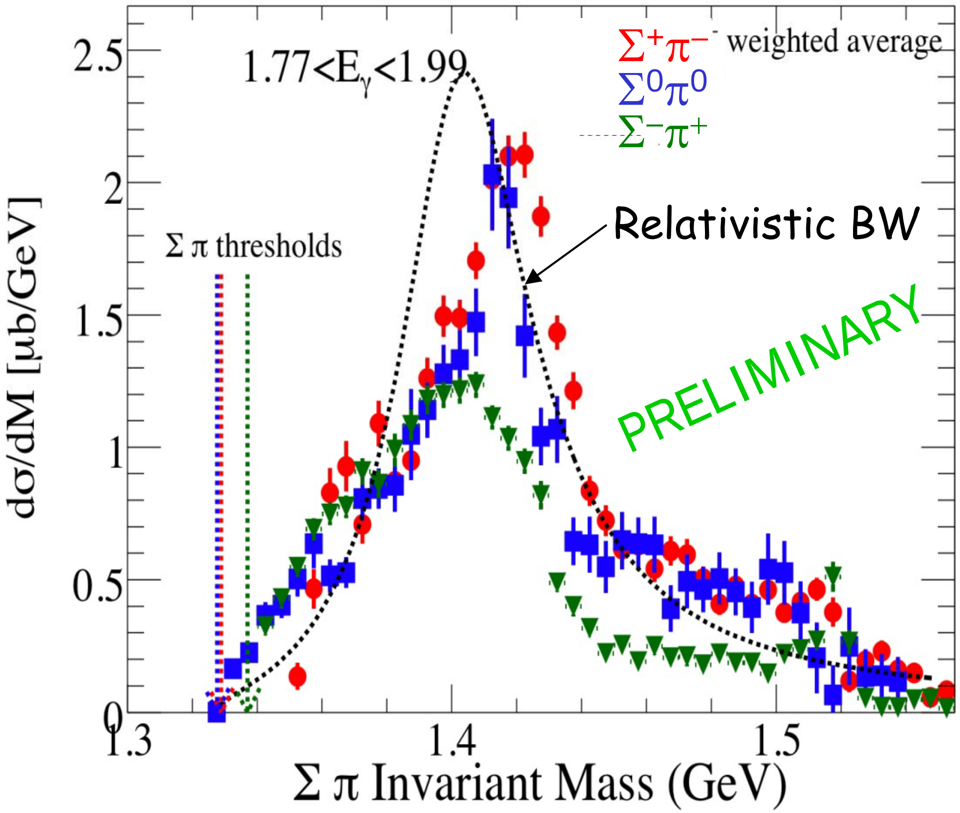
$$\frac{d\sigma(\pi^+\Sigma^-)}{dM_I} \propto \frac{1}{2}\left|T^{(1)}\right|^2 + \frac{1}{3}\left|T^{(0)}\right|^2 + \frac{2}{\sqrt{6}}\mathrm{Re}\left(T^{(0)}T^{(1)*}\right) + O\left(T^{(2)}\right)$$

$$\frac{d\sigma(\pi^-\Sigma^+)}{dM_I} \propto \frac{1}{2}\left|T^{(1)}\right|^2 + \frac{1}{3}\left|T^{(0)}\right|^2 - \frac{2}{\sqrt{6}}\mathrm{Re}\left(T^{(0)}T^{(1)*}\right) + O\left(T^{(2)}\right)$$

$$\frac{d\sigma(\pi^0\Sigma^0)}{dM_I} \propto \frac{1}{3}\left|T^{(0)}\right|^2 + O\left(T^{(2)}\right)$$

- Mass distribution of the "Λ(1405)" predicted to depend on $\pi\Sigma$ decay channel
- J. C. Nacher, E. Oset, H. Toki, A. Ramos, Phys. Lett. B **455**, 55 (1999).
  - Chiral Lagrangian + mB FSI + Channel Coupling
  - I(π Σ) = {0,1,2} – not in an isospin eigenstate
  - I=2 contributions negligible
  - Interference between I=0 and I=1 amplitudes modifies mass distributions

CLAS result for $\Lambda(1405)$

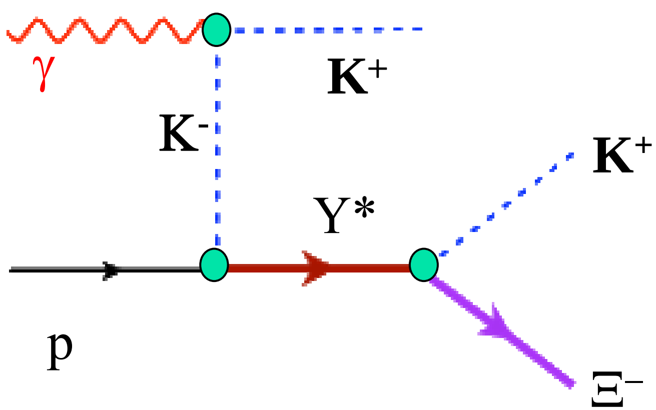


Note that "sign" of the charge asymmetry is opposite to Nacher *et al* prediction

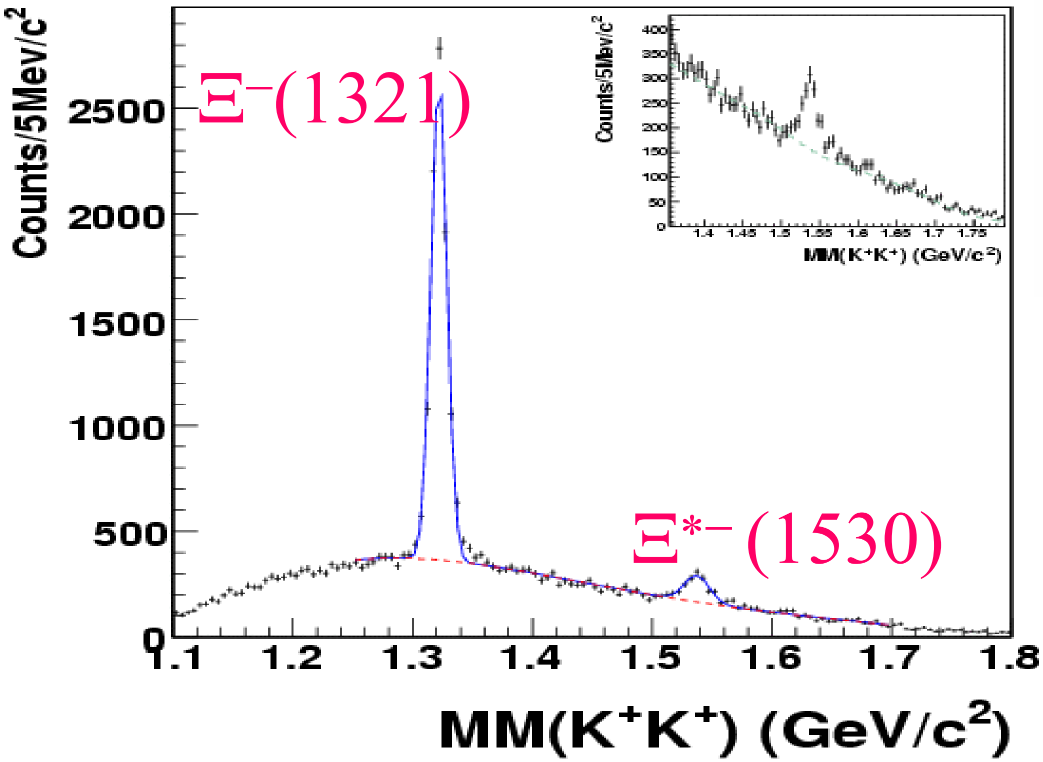
- Decay-channel asymmetry of $\Lambda(1405)$ lineshape confirmed
- Asymmetric among the three charge states → not a pure isospin I=0 decay (decomposition in progress…)
- Subtracted back-grounds: $\Sigma(1385)$, $\Lambda(1520)$, $K^*(892)$
- Direct Spin-parity measurement: $J^\pi = \frac{1}{2}^-$
- Details:
  - Kei Moriya Session 3B

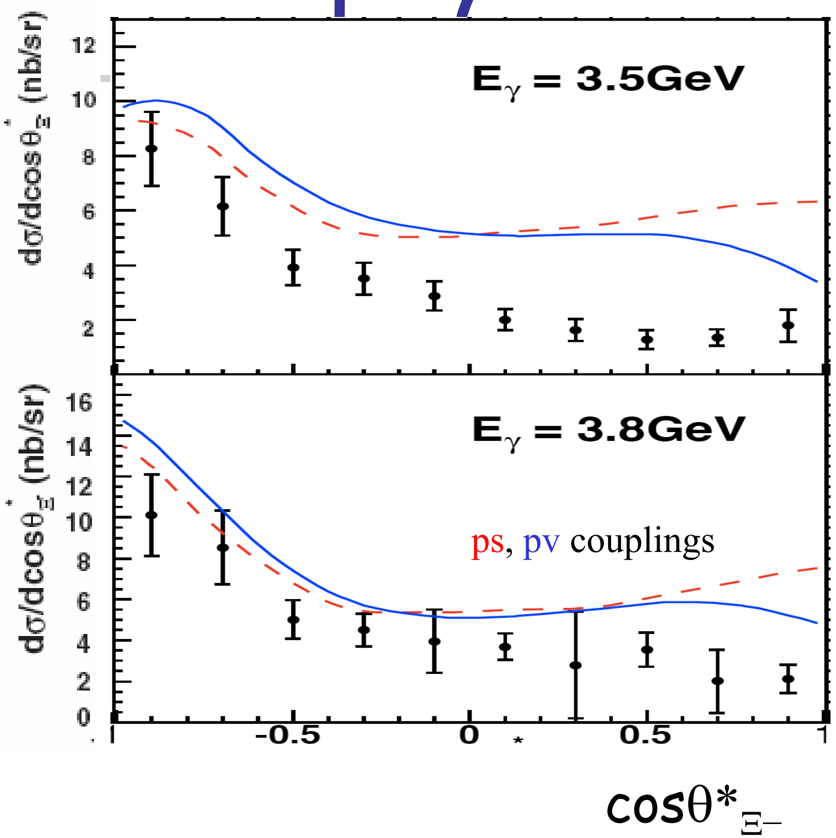
$\Xi^{0,-(*)}$ Production: S=-2 physics

- Cascade physics under-explored
  - Only 6 states with 3 or 4 stars in PDG, most without spin-parity
  - Cross sections very small (few nb)
  - Narrower than S=-1 hyperons and N*
- Measured mass differences of Ξ's
- Model: effective Lagrangian approach:
  - K. Nakayama, Y. Oh, H. Haberzettl, PRC74 (2006) 035205
  - H. Lee GlueX Workshop http://conferences.jlab.org/php2008



$\Xi^{-(*)}$ Production: S=-2 physics





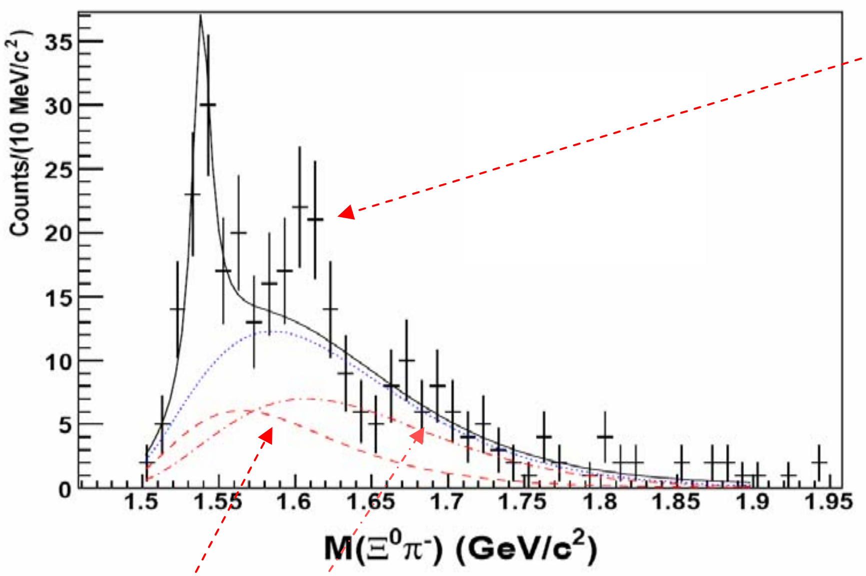
- Detect via $\gamma p \rightarrow K^+K^+(X^-)$
- Possible production through decay of excited hyperons
- High spin hyperon resonances needed ($J \geq 3/2$)

L. Guo *et al.* Phys Rev C **76** 025208 (2007)

$\pi^- \Xi^0$ Search for excited Ξ states

PDG

Excited cascades	Mass (GeV)	Width (MeV)	BR to $\Xi\pi$
$\Xi^{-0}(1530)$	1.535	9.1	100%
$\Xi^{0}(1620)$ (*)	1.6-1.63	~22	$\Xi\pi$
$\Xi^{-0}(1690)$ (***)	1.69	<30	seen



K* background

Non-Ξ events background

Ξ^-(1620) plausible, but not significant

Interest: Dynamical generation of J^π=1/2$^-$ meson-baryon resonances à la Ramos, Oset, Bennhold: PRL **89** 252001 (2002).

Further study of excited Ξ states:

- Higher energy/statistics CLAS 'g12' data under analysis now
- CLAS12 and Hall D in the 12 GeV era

Future prospects: n*'s

- CLAS "g13" data set – analysis in progress…
  - 40cm LD_2 DEUTERON target
  - Circular polarized beam, 20G two-sector triggers
    - E_γ up to 2.6 GeV (2006)
  - Linear polarized beam, 30G one-track triggers
    - E_γ in 6 bins between 1.1 and 2.3 GeV (2007)

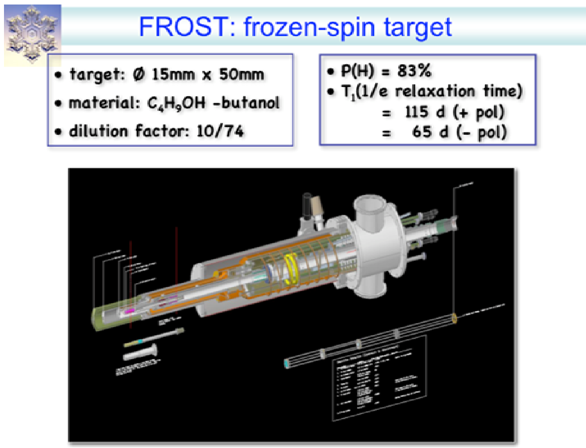
- γ n (p)→K^0 $\{\Lambda,\Sigma^0\}$ (p) neutron cross sections, spin observables
  - Completes the set of isospin channels (P. Nadel-Turonski)

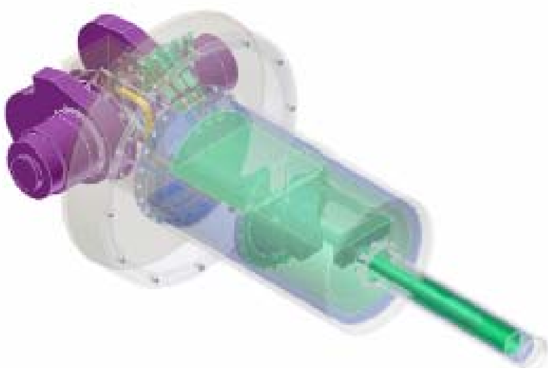
- γ n (p) → K^{0*} Λ, K^{+*} $\Sigma^{-*}(1385)$ (p) neutron target cross sections

- γ p (n)→K^+ $\{\Lambda,\Sigma^0\}$ (n) quasi-free proton cross sections, spin obs.
  - Raw linear polarization asymmetries seen (R. Johnstone PhD work)
  - ΛN potential from rescattering: high missing momentum

Further future prospects

- FroST (g9b)
  - Polarized target (C_4H_9OH)
  - Polarized photon beams: $\vec{\gamma}\ \vec{p}$
  - "complete" experiments
  - Runs 3-10 to 7-10 (now…)
- HD-ice (g14)
  - New polarized target ($\vec{H}\vec{D}$)
  - Neutron target: $\vec{\gamma}\ \vec{n}$
  - Runs 10-10 to 5-11
- CLAS12
  - RICH detector in discussion stage





Seeking New S=0 Baryons via Mesons off the Proton:

published, acquired, FroST(g9b)

	σ	Σ	T	P	E	F	G	H	T_x	T_z	L_x	L_z	O_x	O_z	C_x	C_z	CLAS run Period
$p\pi^0$	✓	✓	✓		✓	✓	✓	✓									g1, g8, g9
$n\pi^+$	✓	✓	✓		✓	✓	✓	✓									g1, g8, g9
$p\eta$	✓	✓	✓		✓	✓	✓	✓									g1, g11, g8, g9
$p\eta'$	✓	✓	✓		✓	✓	✓	✓									g1, g11, g8, g9
$p\omega$	✓	✓	✓		✓	✓	✓	✓									g11, g8, g9
$K^+\Lambda$	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	g1, g8, g11
$K^+\Sigma^0$	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	g1, g8, g11
$K^{0*}\Sigma^+$	✓										✓	✓			✓	✓	g1, g8, g11

Source: V. D. Burkert

Seeking New S=0 Baryons via Mesons off the Neutron:

published, acquired, HD-ice

	σ	Σ	T	P	E	F	G	H	T_x	T_z	L_x	L_z	O_x	O_z	C_x	C_z	CLAS run Period
$p\pi^-$	✓	✓	✓		✓	✓	✓	✓									g2, g10, g13, g14
$p\rho^-$	✓	✓	✓		✓	✓	✓	✓									g2, g10, g13, g14
$K^0\Lambda$	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	g13, g14
$K^0\Sigma^0$	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	g13, g14
$K^+\Sigma^-$	✓	✓	✓		✓	✓	✓	✓									g10, g13, g14
$K^{0*}\Sigma^0$	✓	✓															g10, g13

The combination of all of these measurements on proton and neutron targets represents an extremely powerful tool in the search for new baryon states.

Source: V. D. Burkert

Other (Omitted) topics

- Y* electromagnetic production
  - K. Hicks : talk: Session 1B
  - Y. Oh : talk: Session 1B
- Λ(1520) Electroproduction cross sections (Hall A)
  - I. Strakovsky: talk: Session 1B
- φ η Stangeonia search
- Λ(1116) Electroproduction:
  - 5^{th} structure function
    - R. Nasseripour *et al.* Phys. Rev C **77**, 065208 (2008).
  - Induced polarization
- K* Photoproduction measurements
  - I. Hleiqawi *et al.*], Phys. Rev. *C* **75**, 042201 (2007).
- Pentaquark searches

Summary: CLAS Hyperons

- KY photo- and electro-production offer kinematic and analysis benefits in N* searches
- Published CLAS KY results on proton (σ, P, C_x, C_z) have favored a $P_{13}(1900)$ (not $P_{11}(1900)$ or $D_{13}(2080)$)
- More observables to be published soon (more σ, P; Σ, O_x, O_z); others (G, E, L_x, L_z) are in the analysis pipeline (FroST)
- $\Lambda(1405) \rightarrow \Sigma\pi$ shows non-Breit-Wigner shape & non-pure I=0 structure; $J^\pi = \frac{1}{2}^-$ is confirmed
- Known Ξ hyperons measured in photoproduction
- Results on the neutron (D) coming in 1-2 years (g13, HD-ice…)

Supplemental Slides