

Hyperon Resonance Photoproduction at CLAS

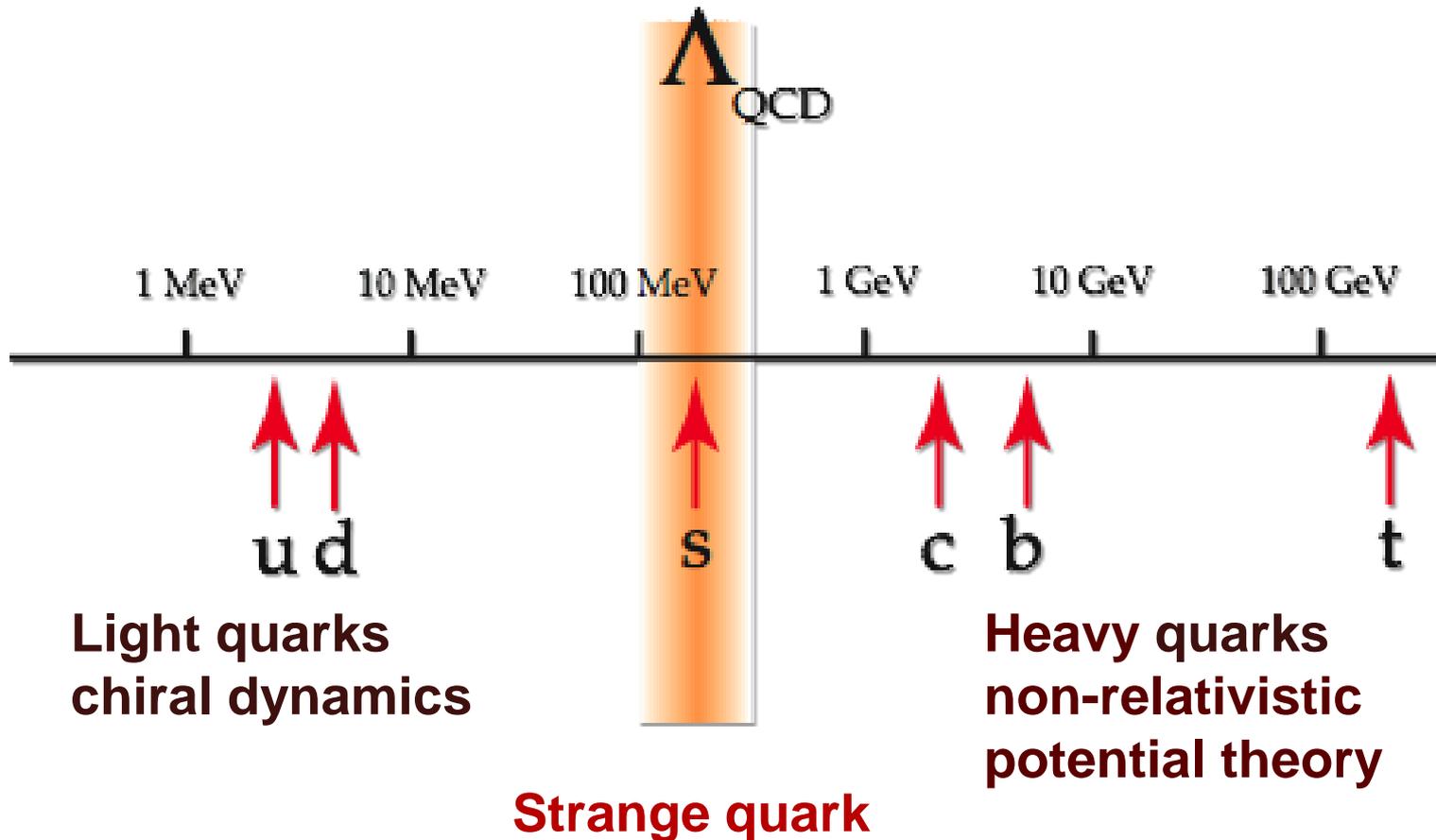
Ken Hicks (Ohio U.)
BEACH2010 Meeting
June 22, 2010

Outline

- Motivation: why study the strange baryons?
- Data on Λ and Σ photoproduction
 - New N^* resonances required
- $K^+\Sigma^{*-}$ photoproduction from the neutron
- Other KY^* resonance photoproduction
- Radiative decay of the $\Sigma^0(1385)$ resonance
- $K^{*+}\Lambda$ photoproduction

Theory and the s-quark

Ref.: R. Jaffe, NP08 talk

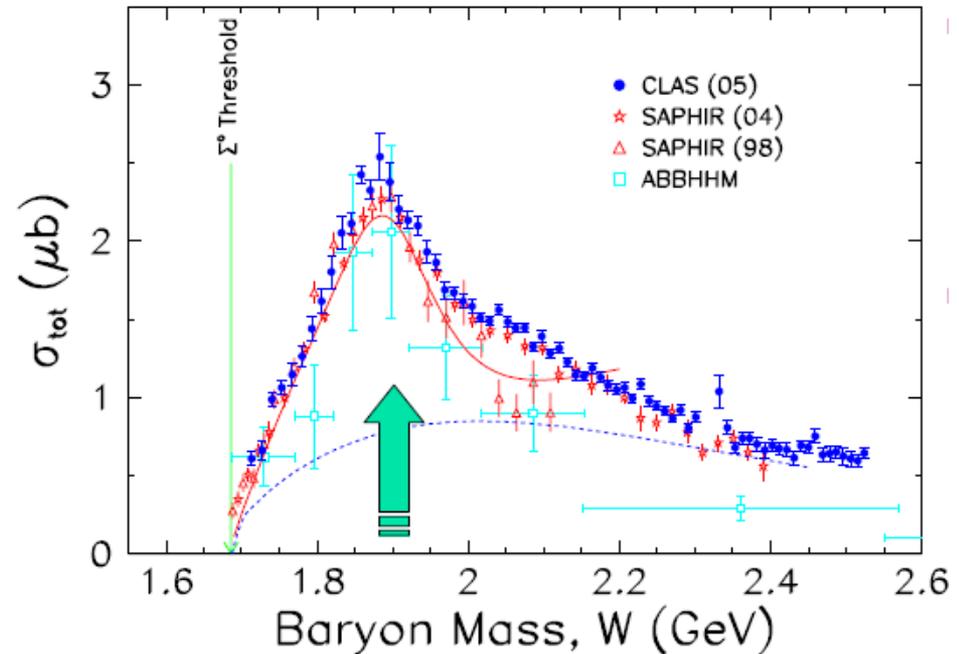
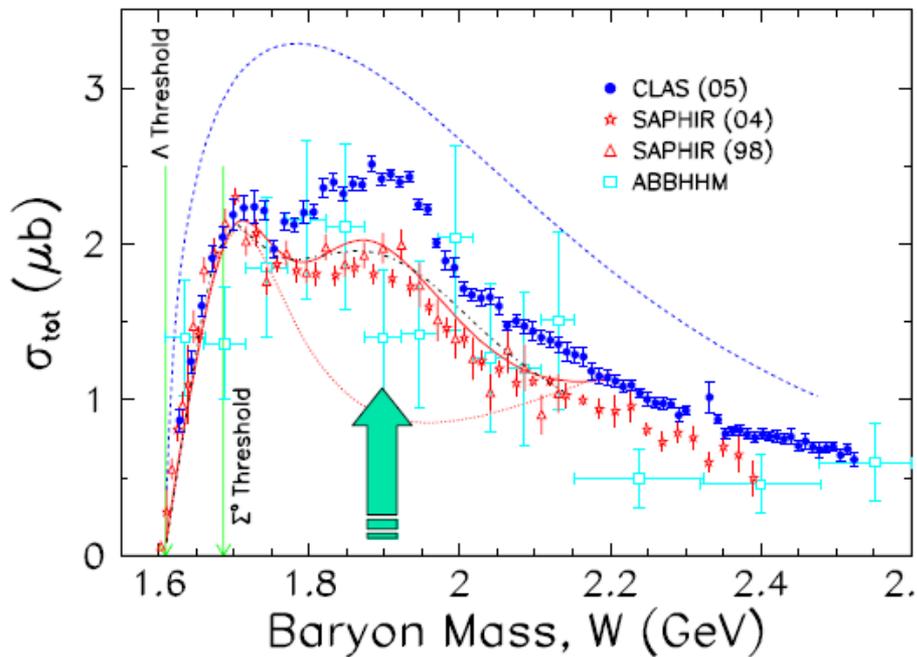


Why Strange Resonances?

- Standard theoretical models methods fail
 - Need experimental data to guide theory.
- Experimentally, Y^* widths are smaller
 - N^* and Δ^* widths typically ~ 200 MeV.
 - Y^* widths typically $\sim 15-50$ MeV.
 - Ξ^* widths typically $\sim 10-20$ MeV.

K⁺Y Photoproduction at CLAS

Bradford et al., PRC 73, 035202 (2006).



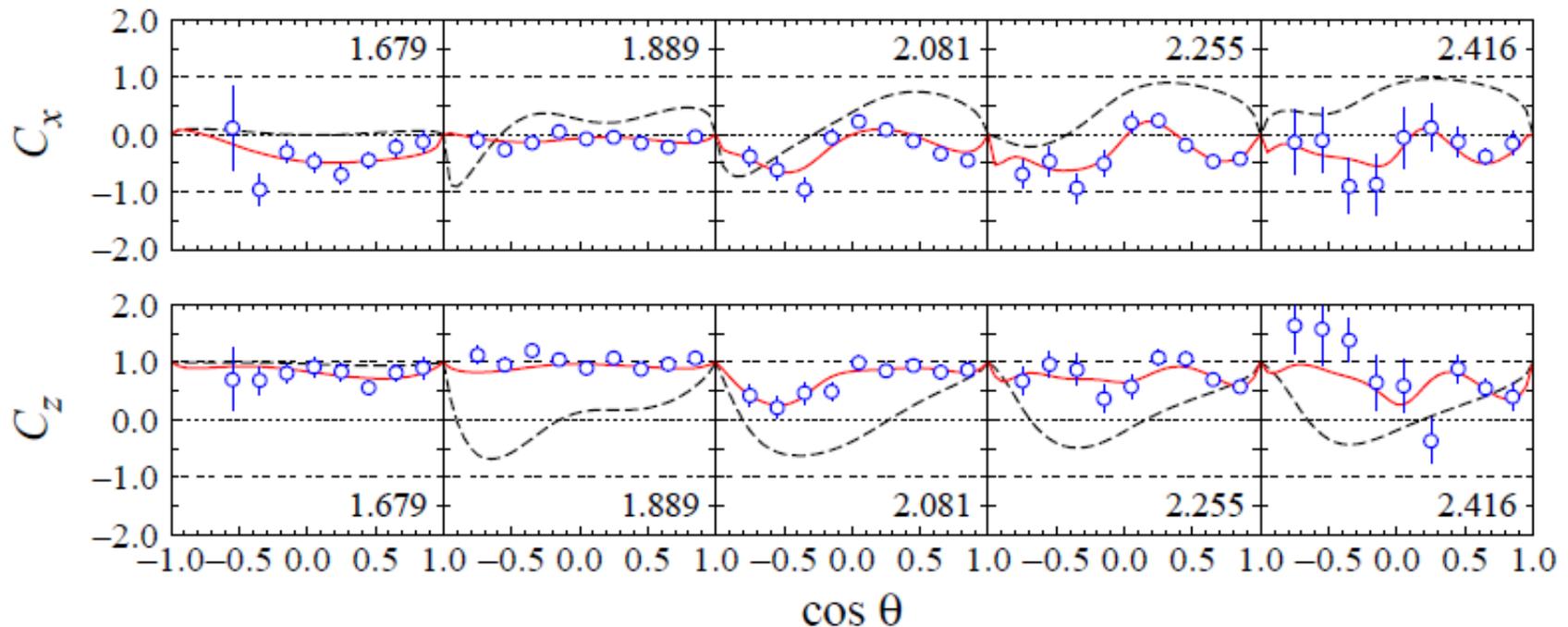
Resonance-like structure near 1.90 GeV:

Is it a new N^* state? Bennhold & Mart: $D_{13}(1900)$?? (new N^*).

Or perhaps a KKN bound state?? arXiv:0902:3633 [nucl-th].

Polarization Transfer in $K^+\Lambda$.

Data: Bradford et al., PRC 75, 035205 (2007), Curves: T. Mart, arXiv:0808.0771.



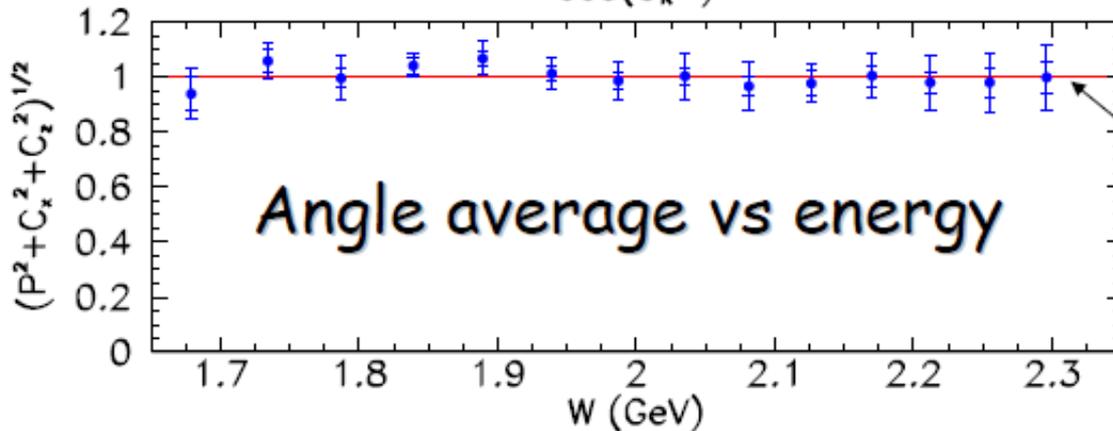
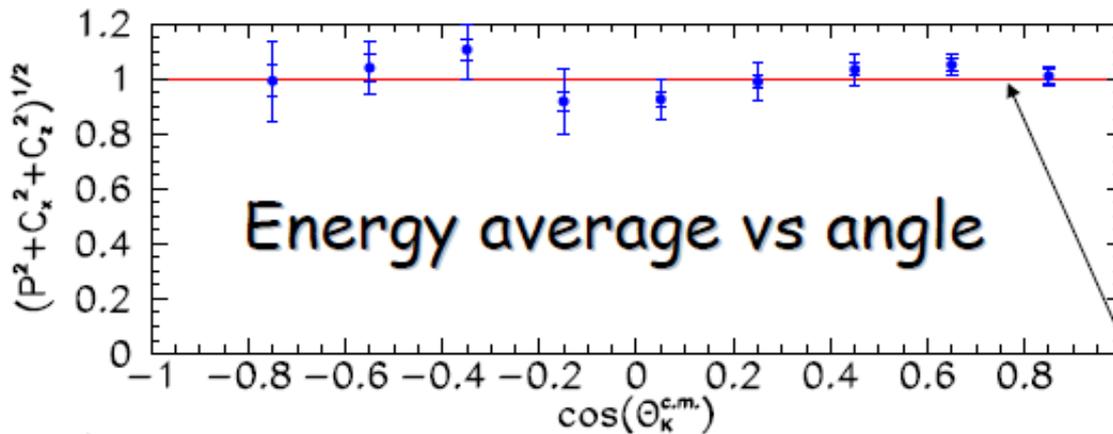
C_x and C_z are for transfer of circular beam polarization to the Λ .

Curves include: S_{11} (1650), P_{11} (1710), P_{13} (1720), P_{13} (1900).

Polarization is a powerful tool to sort out model dependence!

Surprising $K\Lambda$ Polarization Data

From: R. Schumacher, MENU Conference (2010).



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

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

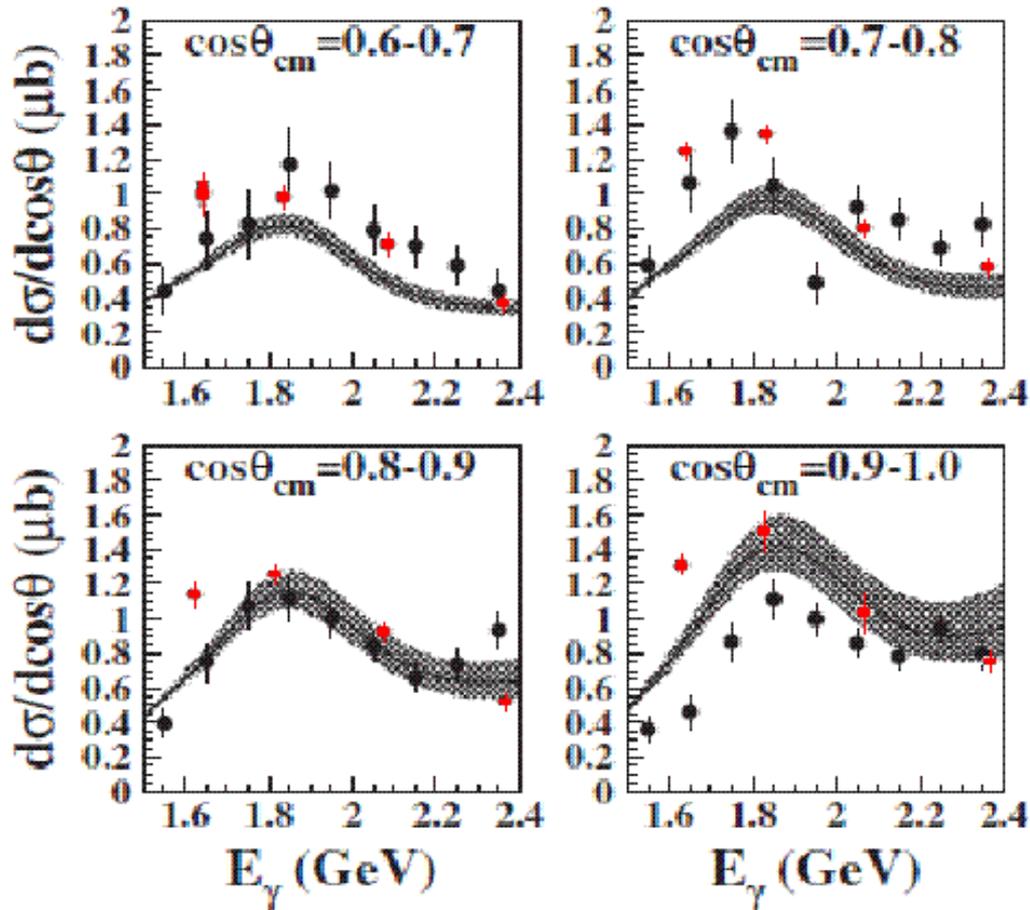
"Fully Polarized Λ "

Energy and angle averages are consistent with unity.

No model predicted this simple result!

$\gamma n \rightarrow K^+ \Sigma^{*-}$ cross sections

K. Hicks et al. (LEPS Collaboration), PRL 102, 012501 (2009)



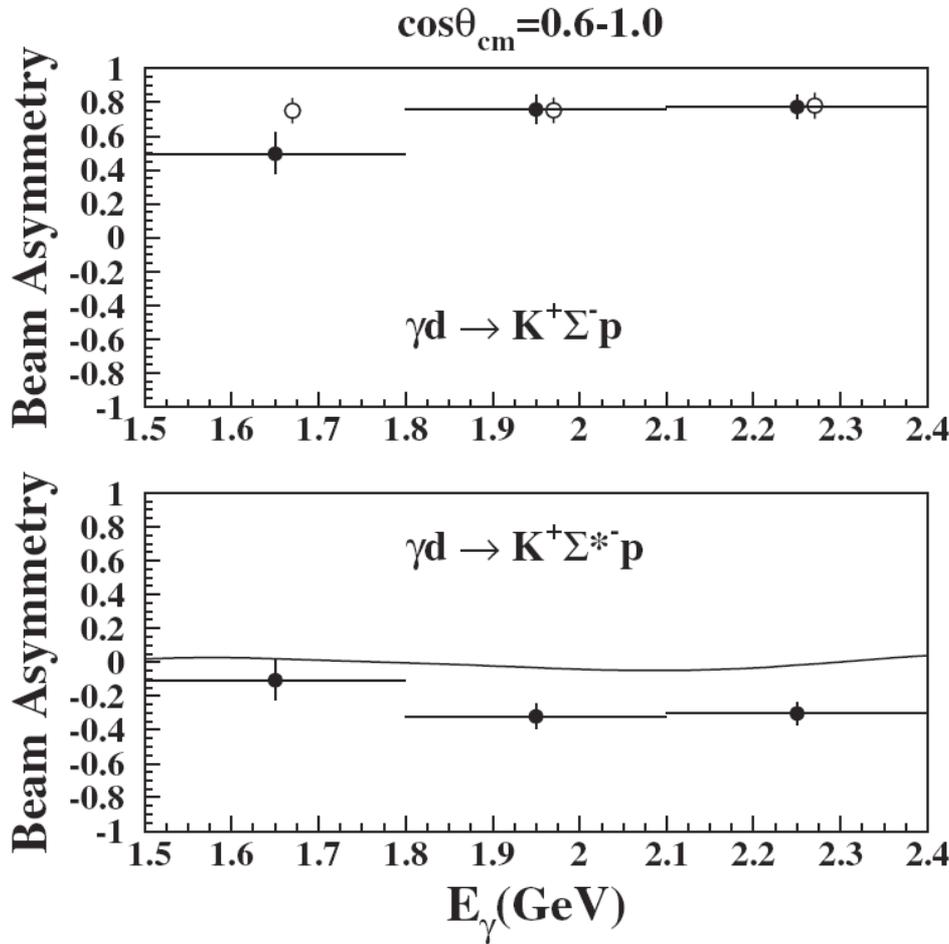
Calculations are from Oh, Ko & Nakayama, averaged over the bin size shown.

- Cross sections are only measured at forward angles: larger angles also available in CLAS data.

- Preliminary CLAS data shown by red points.

Σ^{*-} beam asymmetries

K. Hicks et al. (LEPS Collaboration), PRL 102, 012501 (2009)

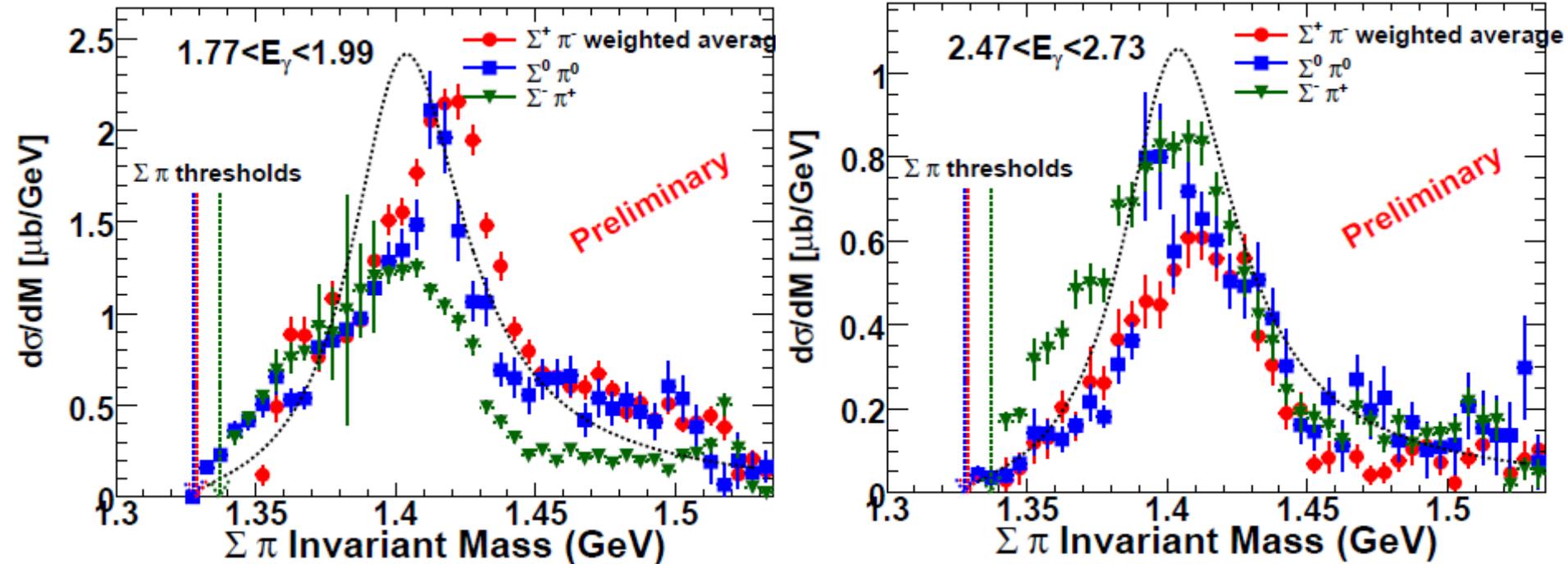


Present results (solid points) compared with previously published data (open points) from Kohri *et al.* (PRL, 2006)

Curve (Oh, Ko, Nakanyama) assumes 3-quark structure to the Σ^* . A 5-quark component would have asymmetry of -1 (model of B.-S. Zou).

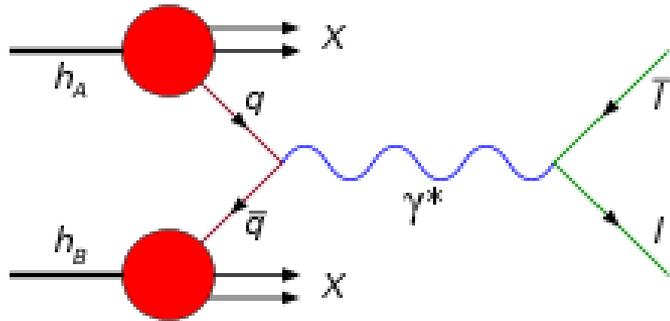
$K^+\Lambda(1405)$ Photoproduction

NOTE: STILL PRELIMINARY. From K. Moriya, talk at MENU Conference (2010).



Using isospin, the $\Sigma^+\pi^-$ and $\Sigma^-\pi^+$ decays should be symmetric. If the $\Lambda(1405)$ has 2 poles, these decays can be different. Is this a hint of $qqq(qq^*)$ structure for strange baryons?

Drell-Yan: nucleon has pion cloud

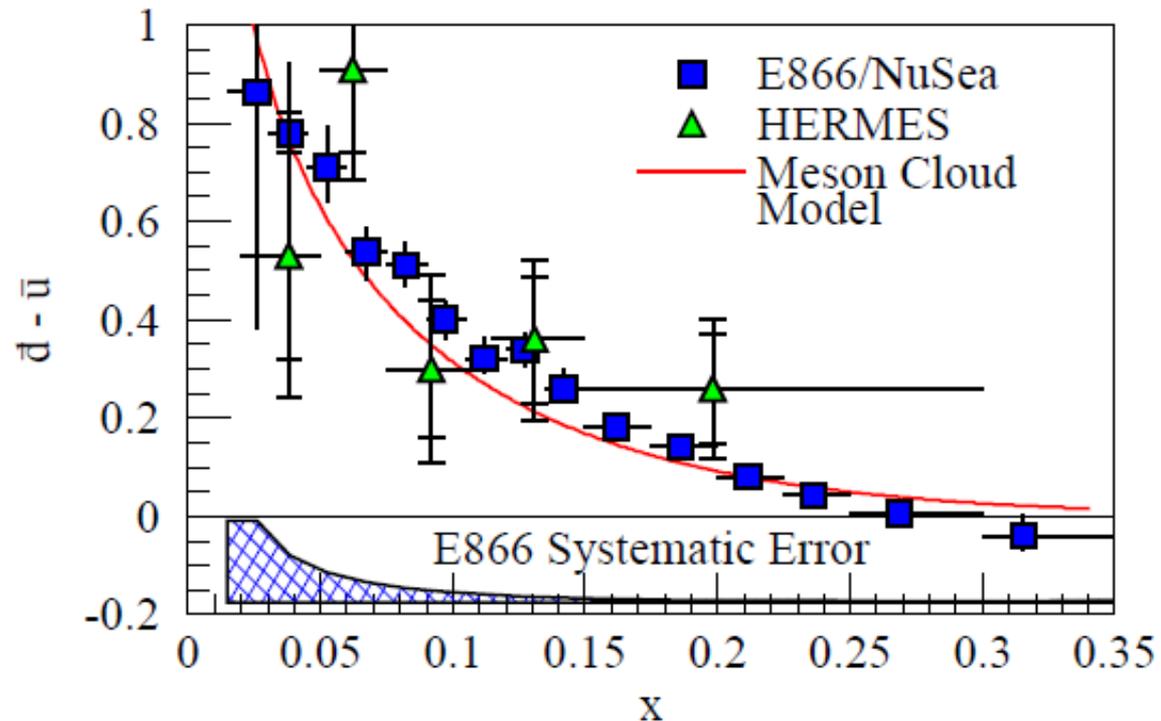


The Drell-Yan process measures the antiquark sea in the nucleon.

The results show that there is an asymmetry to the u^* and d^* sea in the proton.

The nucleon has an admixture of $qqq(qq^{\text{bar}})$.

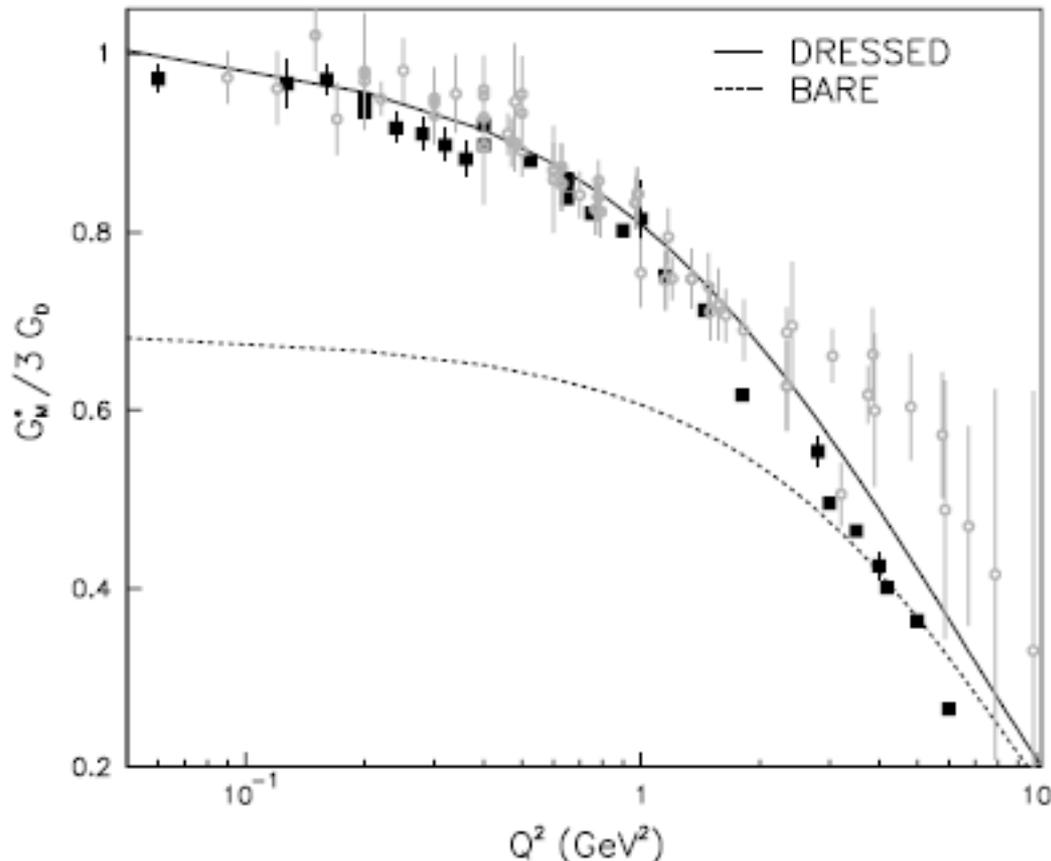
From: P. Reimer, arXiv:0704.3621.



The $N\Delta$ magnetic form factor

Data from Bates, MAMI, and JLab.

Curves from Julia-Diaz et al. PRC 75, 015205 (2007).



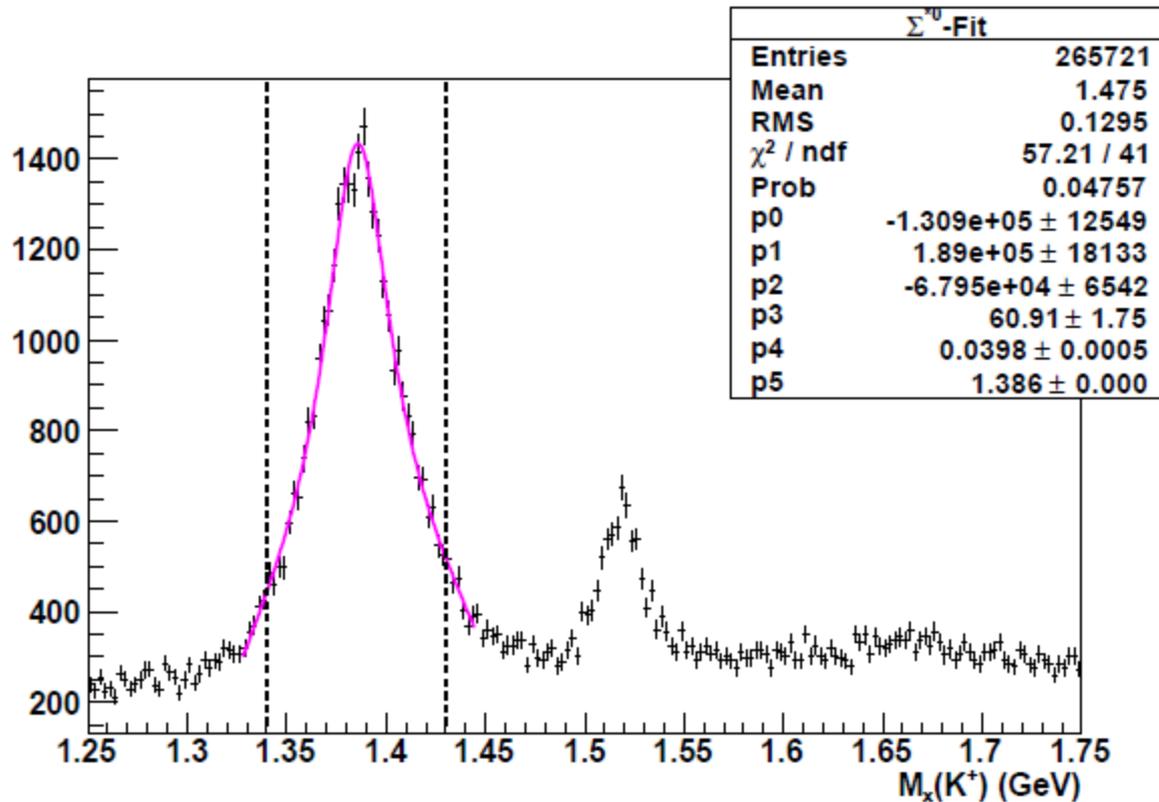
Quark model for $\gamma N \rightarrow \Delta$
does not fit the data.

Dressed with a meson
cloud, theory fits the data.
The effect is not small.

What about $\Sigma^* \rightarrow \Sigma\gamma$?
This is being measured
now using JLab data.
(Thesis of D. Keller)



Preliminary CLAS analysis by Dustin Keller (Ohio U.)



Preliminary results (ratio)

CLAS analysis (under review) by D. Keller (Ohio U.)

$$R_{\Lambda\pi}^{\Lambda\gamma} = \frac{\Gamma[\Sigma^0(1385) \rightarrow \Lambda\gamma]}{\Gamma[\Sigma^0(1385) \rightarrow \Lambda\pi^0]} = 1.42 \pm 0.11(stat)_{-0.13}^{0.14}(sys).$$

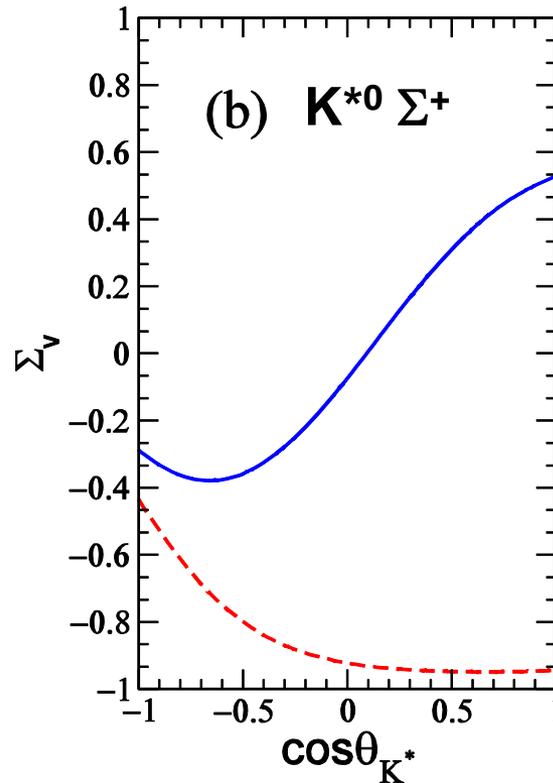
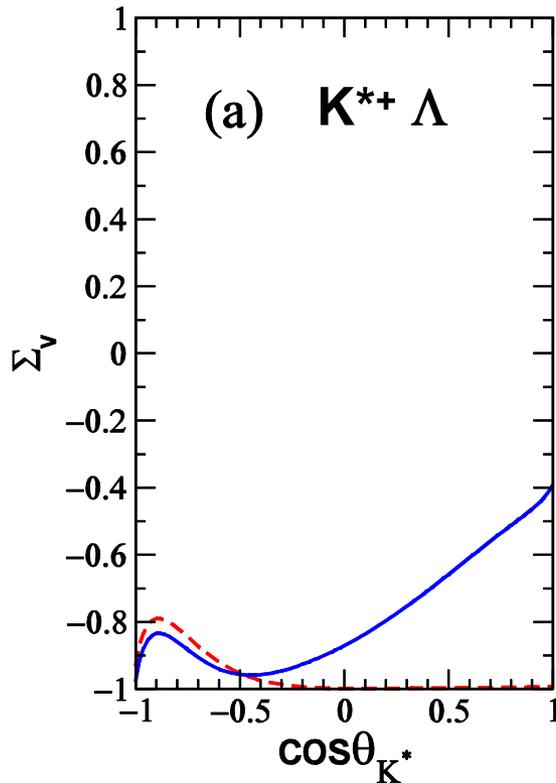
Preliminary systematic studies of cut points on the confidence level (%).

$P_{\pi^0}(\%)$	$P_{\gamma}(\%)$	R(%)
1	1	1.38 ± 0.11
5	5	1.39 ± 0.11
10	10	1.42 ± 0.11
15	15	1.43 ± 0.11
10	1	1.40 ± 0.11
1	10	1.42 ± 0.12
1	15	1.44 ± 0.11
1	20	1.44 ± 0.13
1	25	1.44 ± 0.14

K* Photoproduction: Theory

Y. Oh and H. Kim, Phys. Rev. C74, 015208 (2006).

Beam Polarization



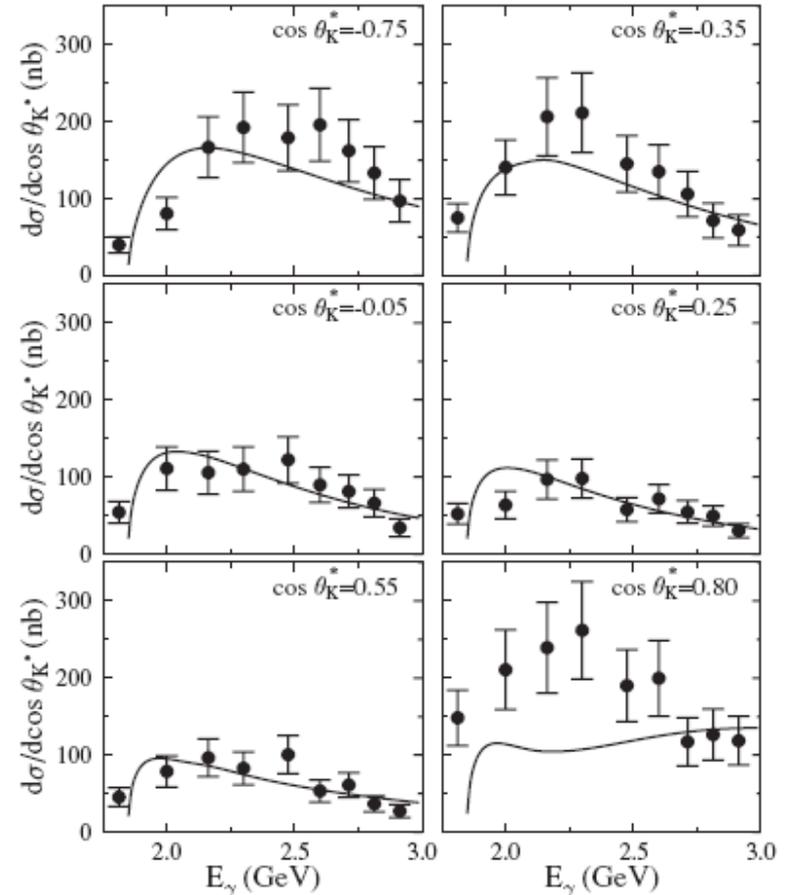
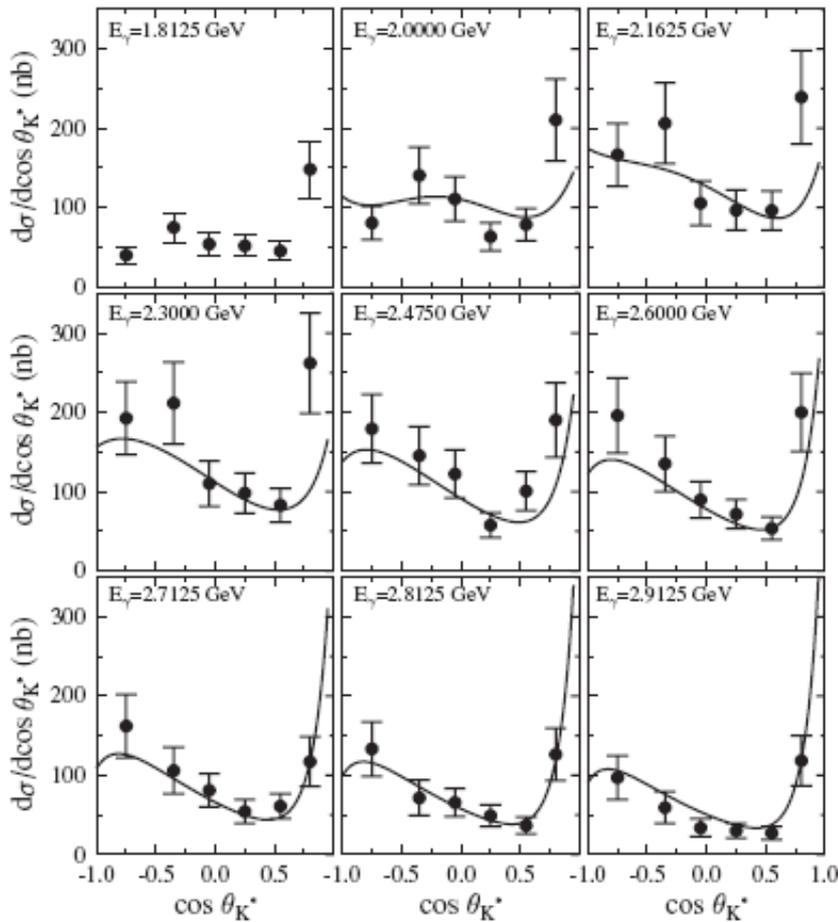
Solid line: with Kappa meson exchange.

Dashed line: no Kappa exchange diagrams

There is a large effect on the beam polarization when the $K_0(700)$ meson (0^{++}) is included. This could be definitive evidence for the existence of the $K_0(700)$, which cannot be seen directly due to its wide width

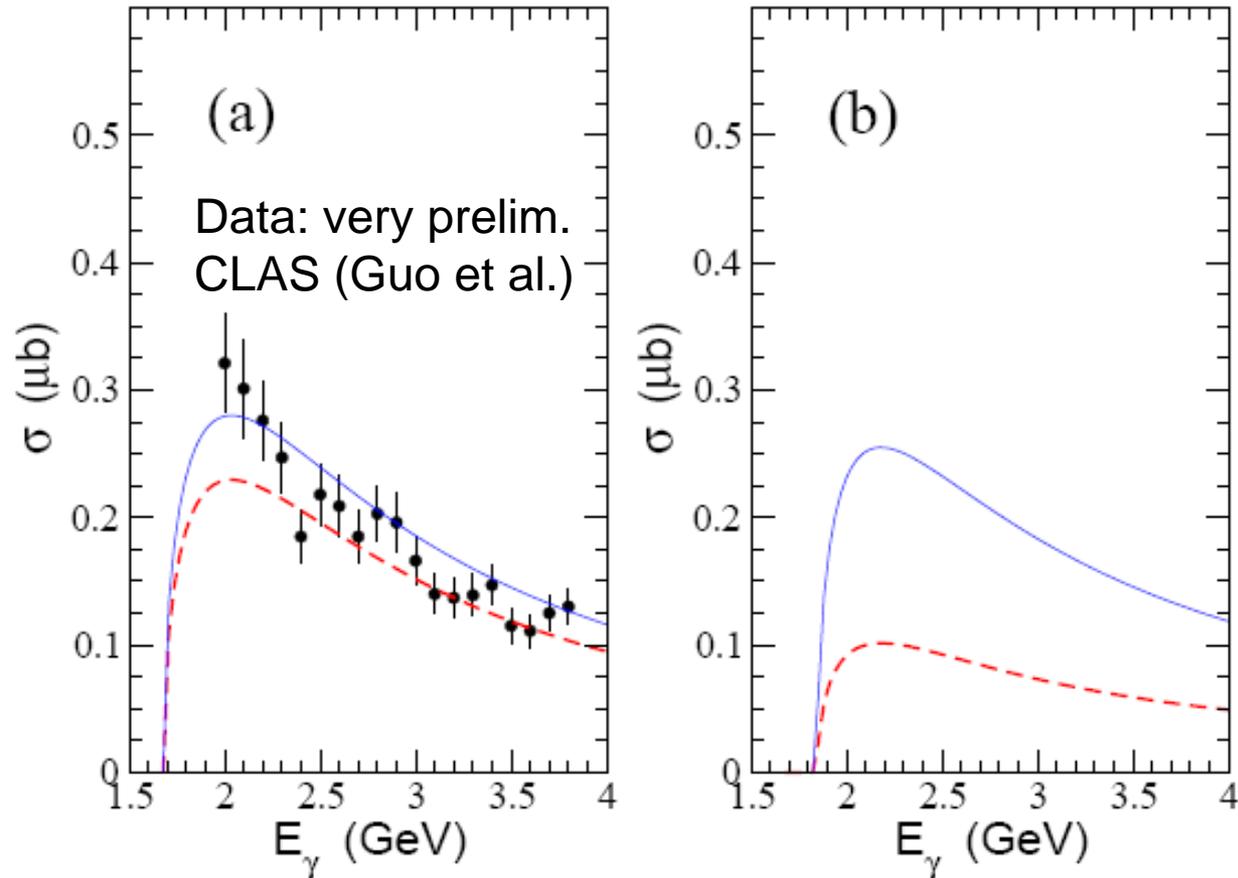
CLAS: $K^{*0}\Sigma^+$ data (2007)

I. Hleiqawi et al., Phys. Rev. C 76 (2007) 039905E.



Theory: a) $K^{*+}\Lambda$, b) $K^{*0}\Sigma^+$

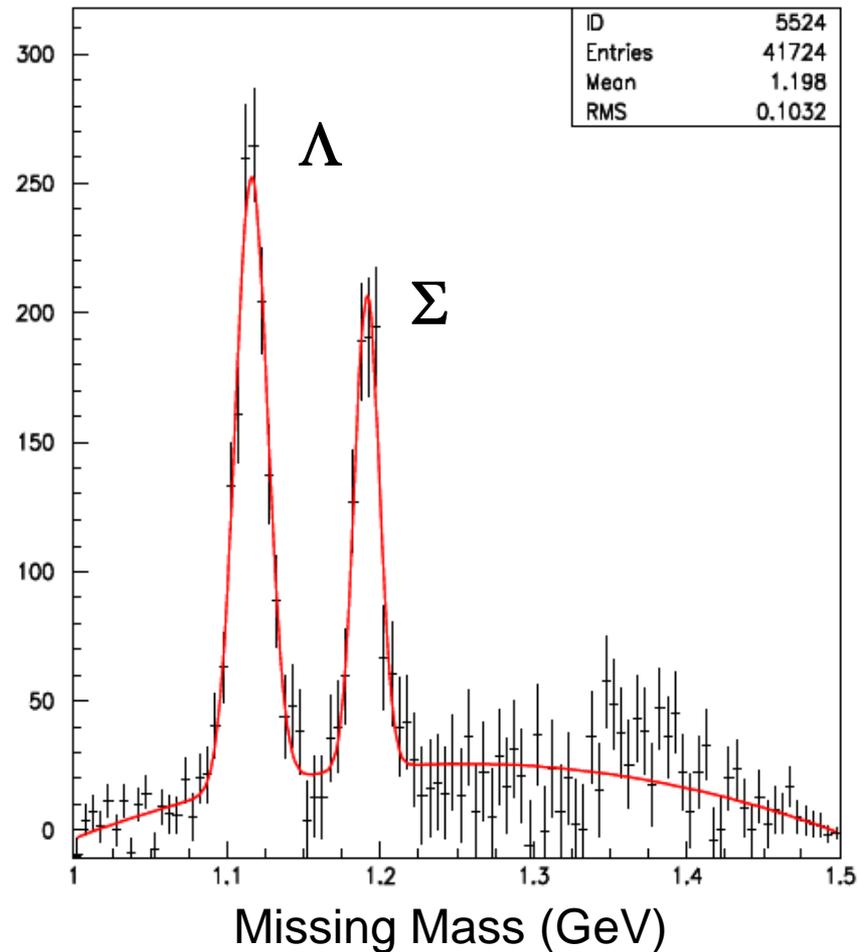
Y. Oh and H. Kim, hep-ph/0605105.



SOLID BLUE: no kappa form factor; DASHED RED: with kappa form factor

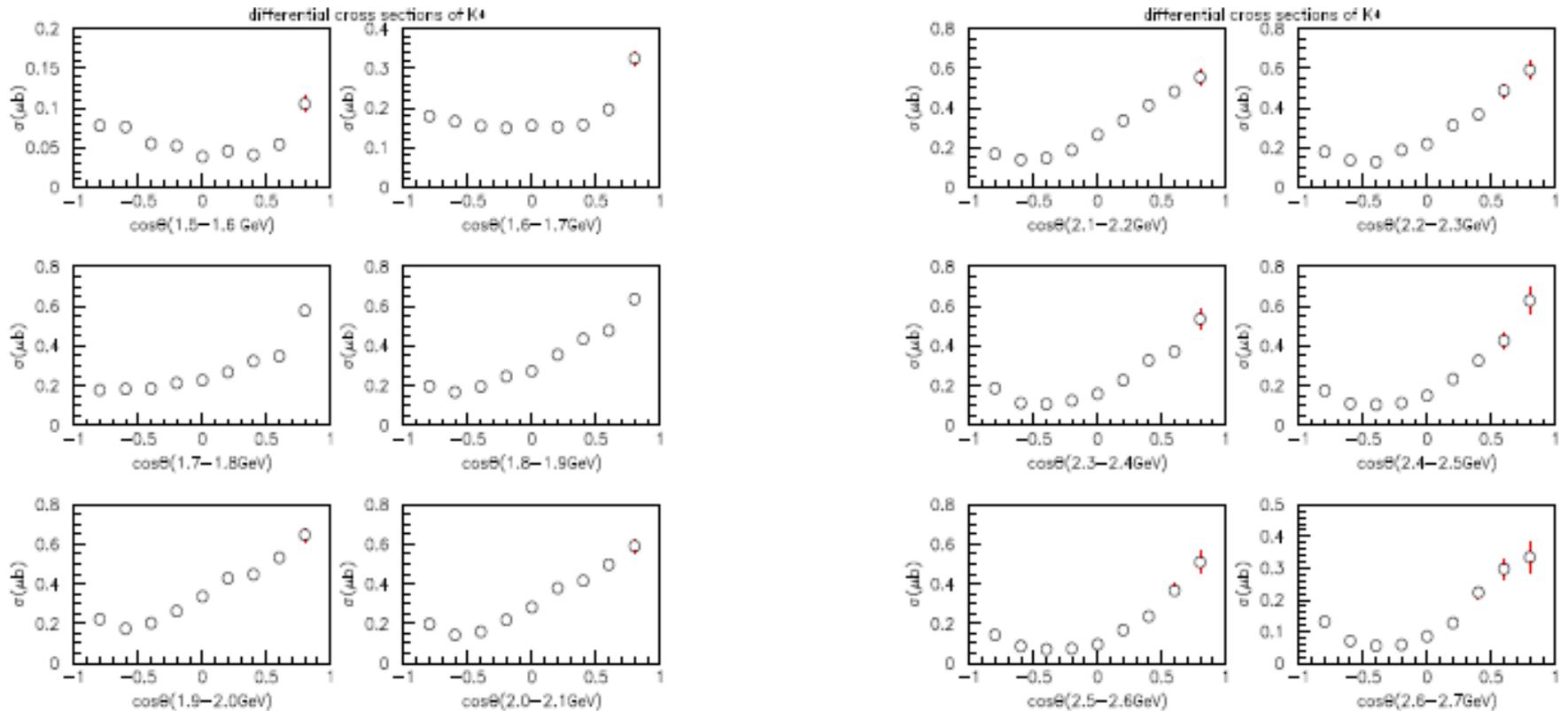


Preliminary CLAS analysis by Wei Tang (Ohio U.)



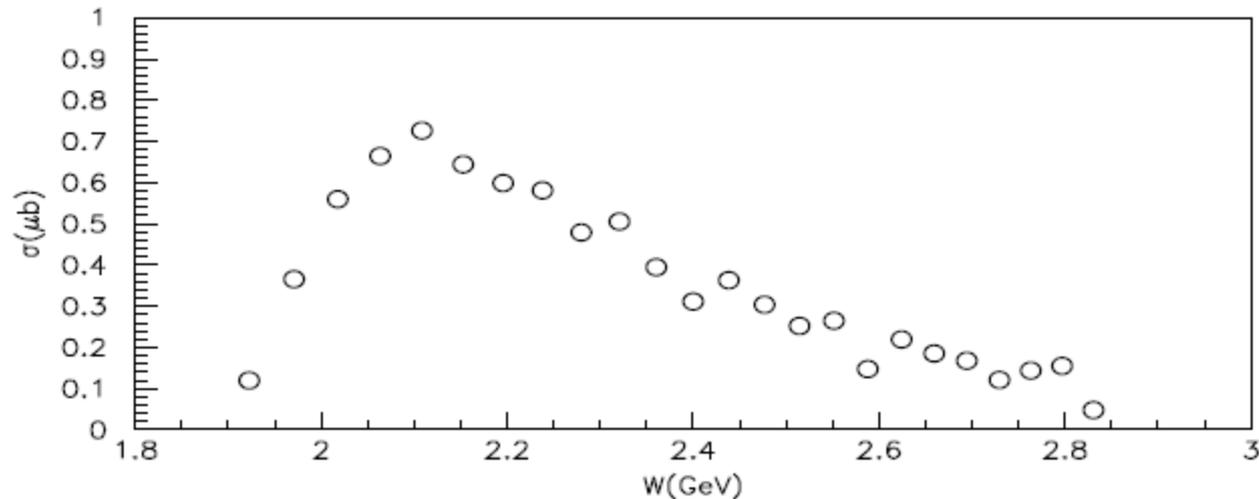
Differential Cross Sections

Preliminary CLAS analysis by Wei Tang (Ohio U.)



Total Cross Sections

Preliminary CLAS analysis by Wei Tang (Ohio U.)

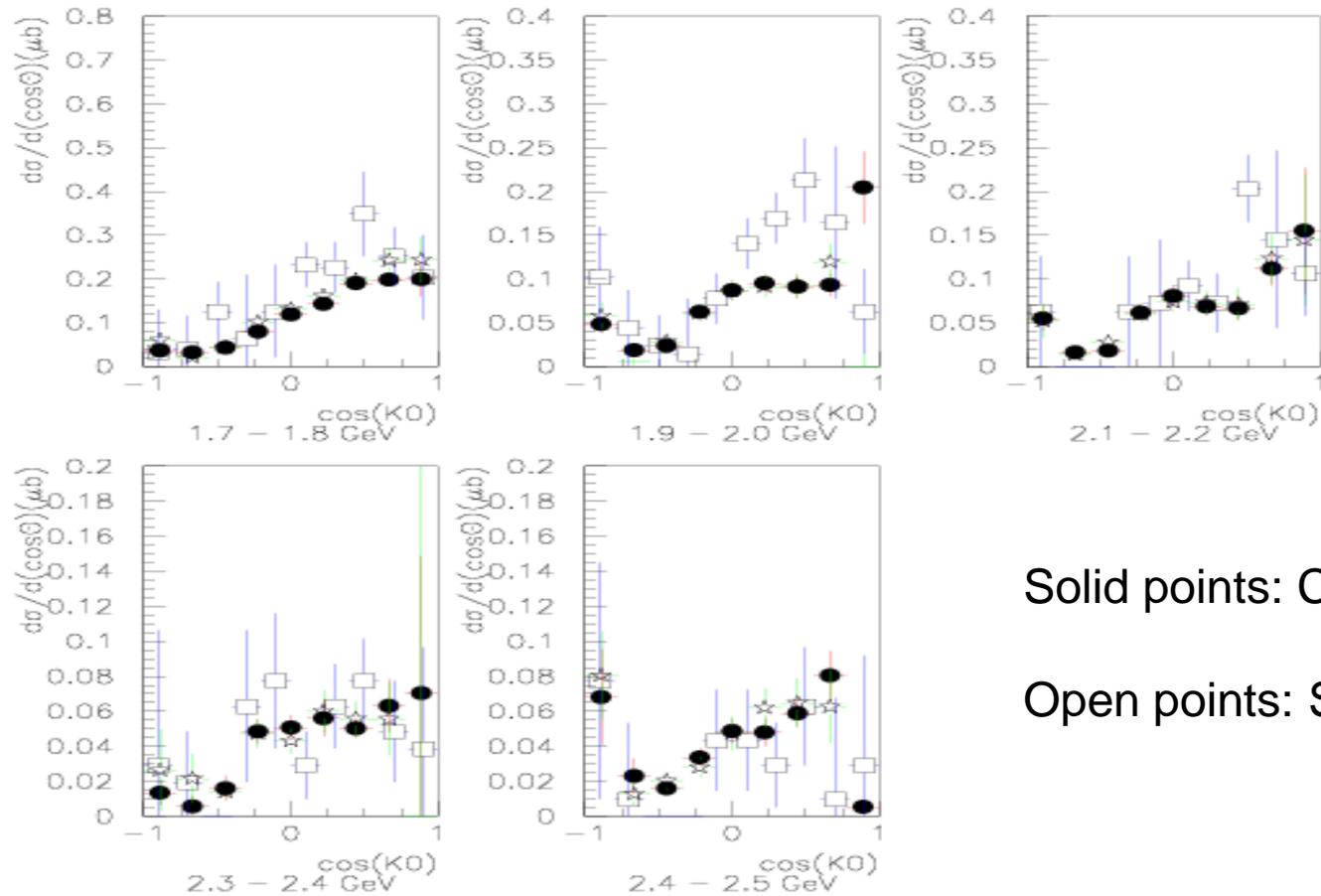


Although still preliminary, the total cross sections appear to be 2x larger than Guo's analysis.

The procedures used here can be checked using the $K^0\Sigma^+$ cross sections that should agree with world data.

Cross-check: $\gamma p \rightarrow K^0 \Sigma^+$

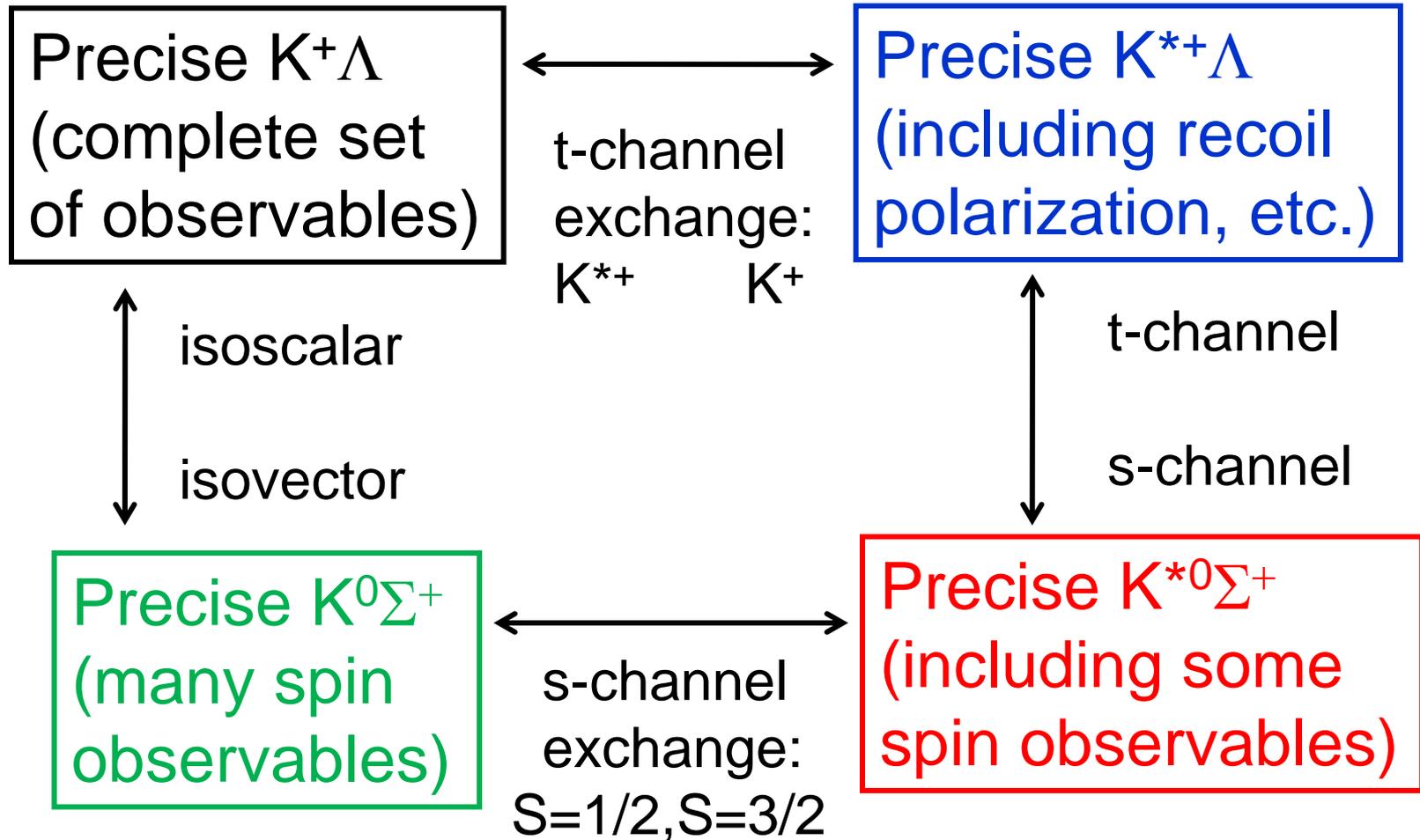
Preliminary CLAS analysis by Wei Tang (Ohio U.)



Solid points: CLAS

Open points: SAPHIR

Future of strangeness analysis

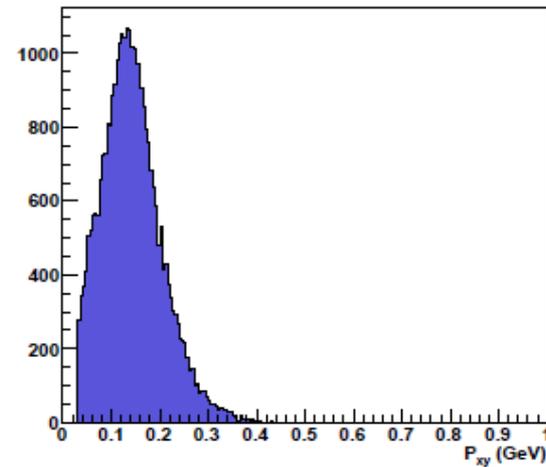
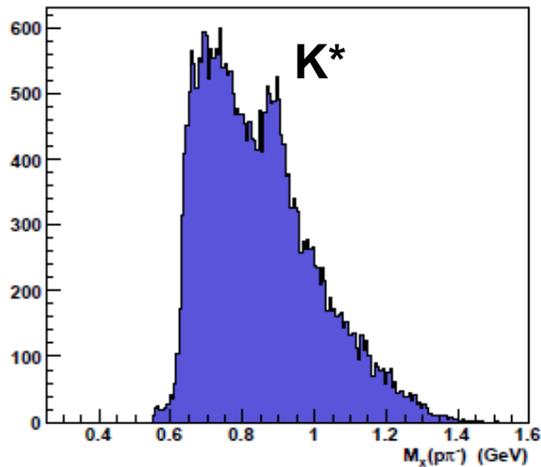
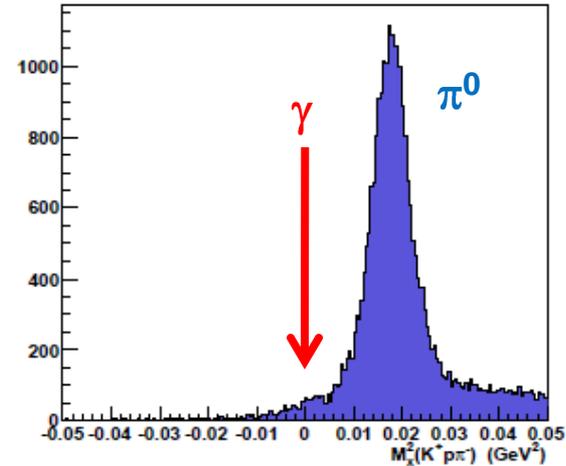
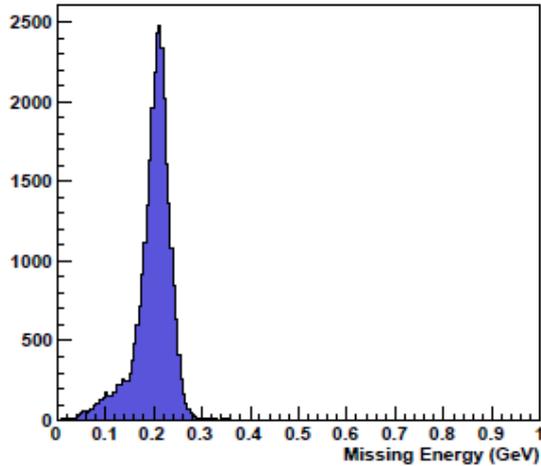


Summary

- The s-quark mass is difficult theoretically.
 - Too heavy for ChPT, too light for HQET
 - Need experimental data to guide theory
- New KY, KY* data: meson cloud effects!
 - $K\Lambda$ data show strong s-quark polarization
 - L(1405) photoproduction: isospin asymmetry!!
 - Other KY* cross sections: huge improvement.
 - Δ & Σ^* Radiative decays: need meson cloud?
 - K^*Y : lots of new, high-quality data: $K_0(700)$?

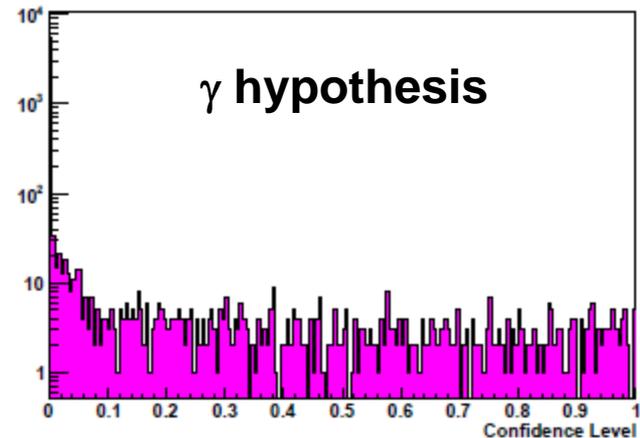
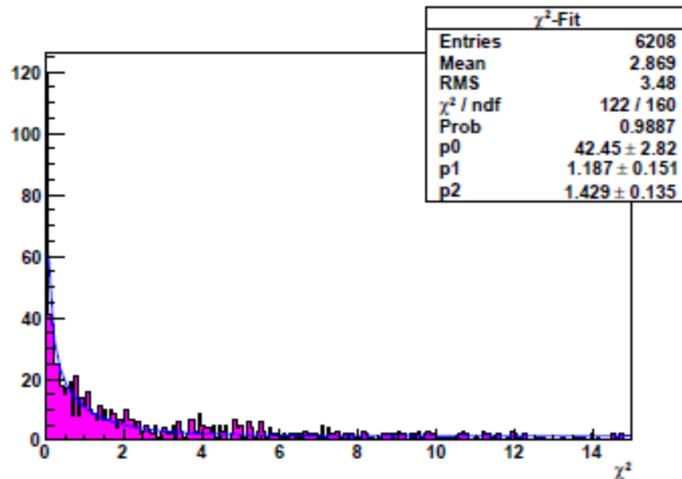
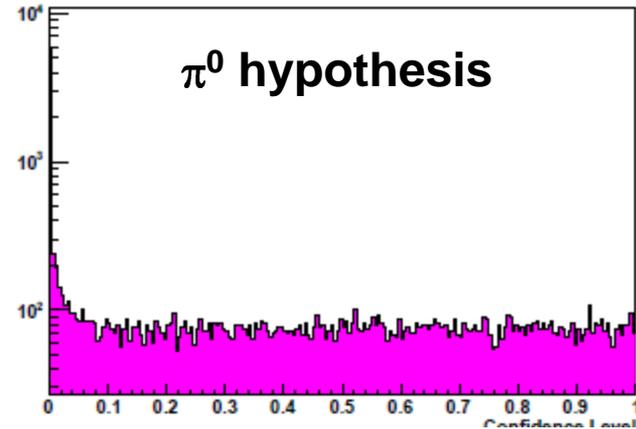
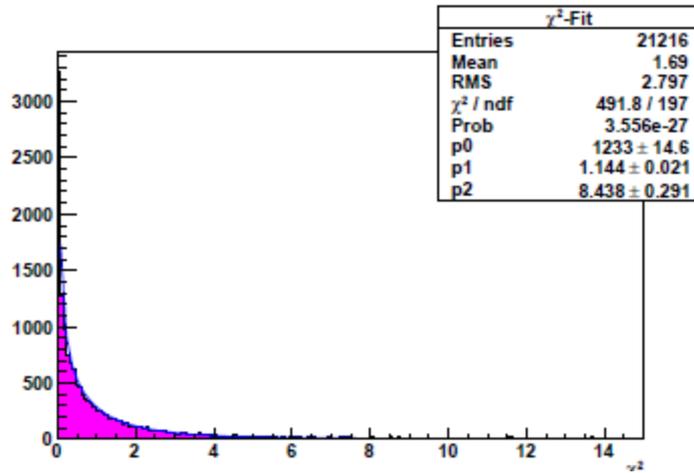
Need Kinematic Fitting

CLAS preliminary: mass spectra after cut on Σ^* peak.



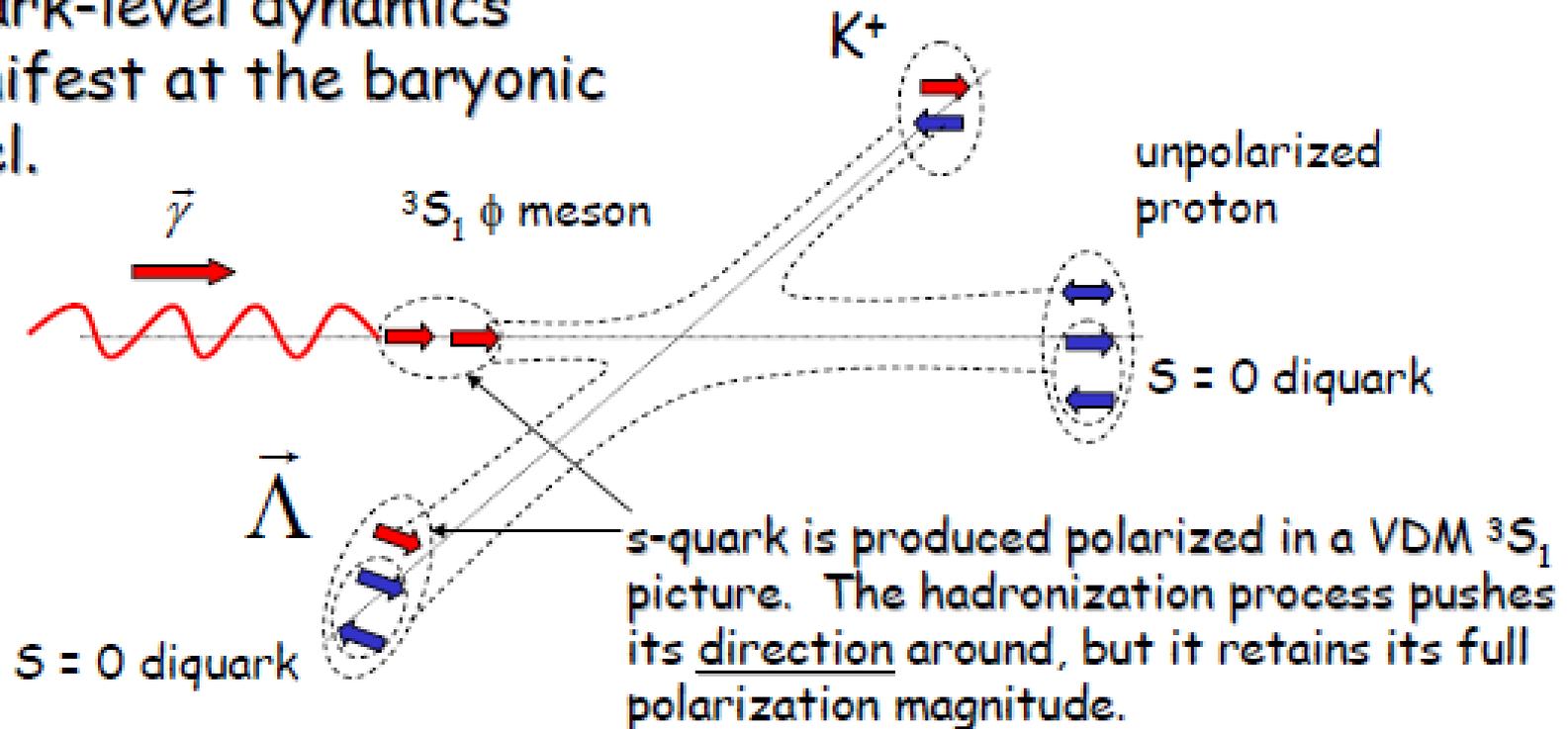
Confidence Level Plots

CLAS preliminary: analysis by Dustin Keller (Ohio U.)



Schumacher's "toy model"

Quark-level dynamics manifest at the baryonic level.



R. S., Eur.Phys.J. A35 299-305 (2008)