Photoproductions of hyperons and resonances

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Role of symmetries in reaction

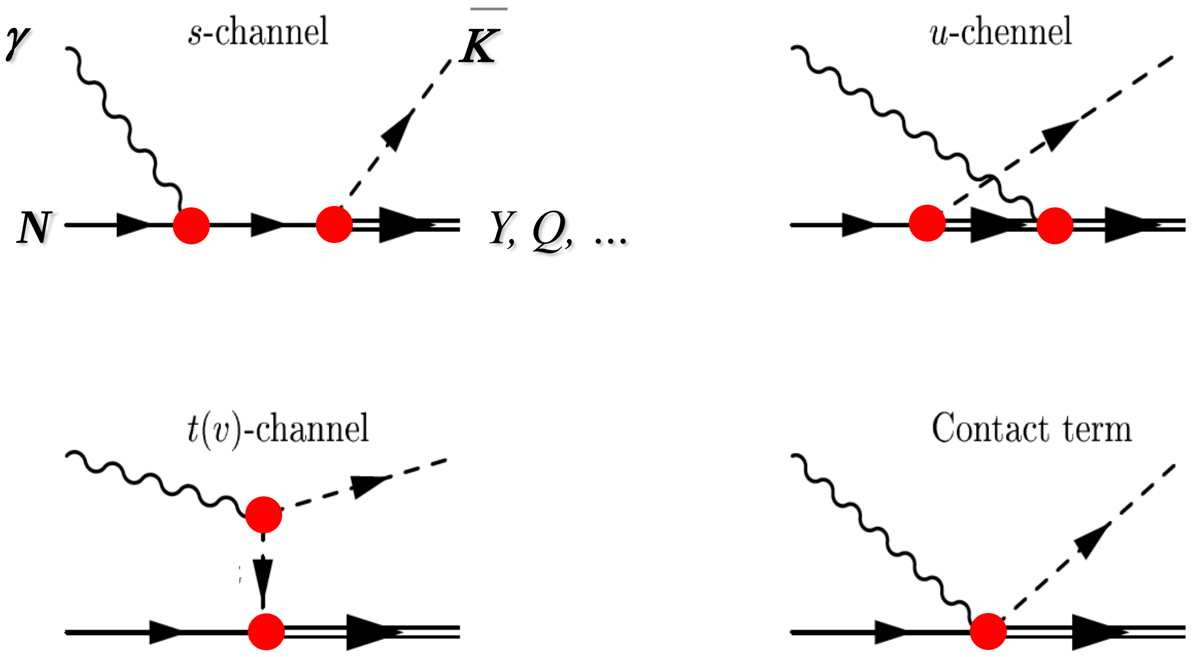
1. **Chiral symmetry: Kroll-Ruderman term**
   γN –> KΛ(1520)

2. **Charge and U-spin**
   γN –> N*

3. **SU(3) symmetry violation?**
   γN –> KΛg.s. and the use of polarization

Effective Lagrangian approach

Respecting symmetry
Flavor, chiral, • • •
➡ ***Application to strangeness productions***



Various parameters

$g_{KN\Lambda}$

$g_{K^*N\Lambda}$

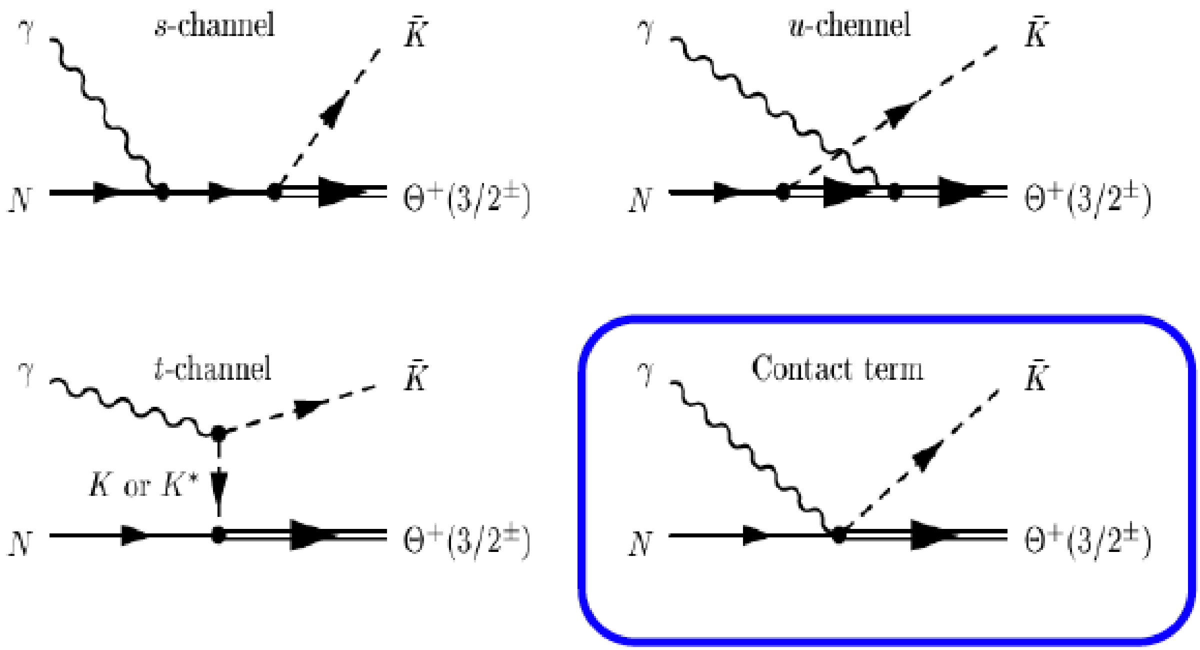
...

1. Chiral symmetry: Kroll-Ruderman term

$\gamma N \to K\Lambda(1520)$

Nam-Hosaka-Kim
Phys.Lett.B579:43-51,2004
Phys.Rev.D71:114012,2005
Phys.Lett.B633:483-487,2006

γN –> KΛ(1520)



present only for charge-exchange reactions

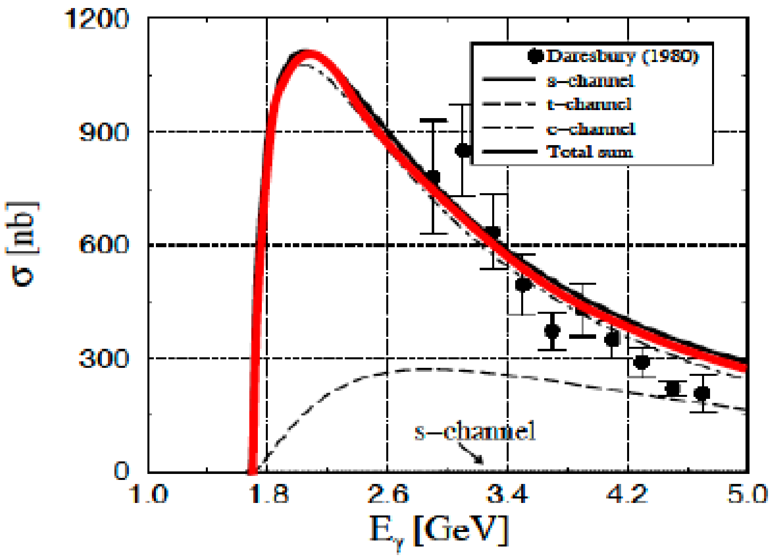
Particularly important for *J* = 3/2

γp –> K⁻Λ(1520): allowed
γn –> K⁰Λ(1520): forbidded

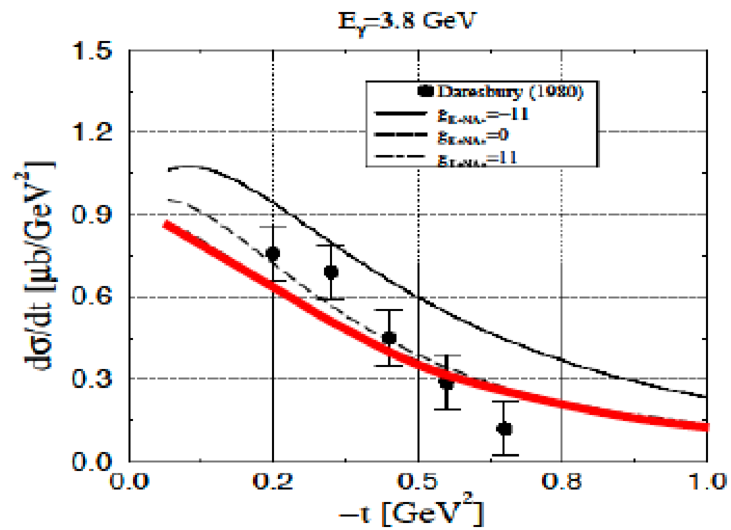
γp –> K Λ(1520) *J* = 3/2⁻

Λ = 700 MeV <=> *r* ~ 0.8 fm

Energy dependence



***t* or *θ* dependence**



Nam-Hosaka-Kim, PRD 71:114012,2005

$\Lambda(1520)\ J^P = 3/2^-$

Reactions	$\gamma p \to K^+\Lambda^*$	$\gamma n \to K^0\Lambda^*$
σ	$\sim 900\, nb$	$\sim 30\, nb$
$d\sigma/d(\cos\theta)$	Forward peak	Peak at $\sim 45°$

Contact term

- $\sigma(p) >> \sigma(n)$
- Strong forward peak

⇨ To be checked by experiments

For Θ: we expect $\sigma(p) << \sigma(n)$

Comparison with new LEPS data will be made soon

2. Charge and U-spin

$\gamma N \rightarrow N^* \rightarrow \eta N$

Ki-Seok Choi, Seung-il Nam , Atsushi Hosaka, Hyun-Chul Kim. Phys.Lett.B636:253-258,2006.

Photon

Charge

$$Q = t_3 + \frac{1}{\sqrt{3}} t_8$$

$$= \begin{pmatrix} 2/3 & & \\ & -1/3 & \\ & & -1/3 \end{pmatrix} \Longleftrightarrow \begin{pmatrix} 0 & \\ & \vec{\tau} \end{pmatrix}$$

U-spin

Photon behaves as ***singlet*** in U-spin space

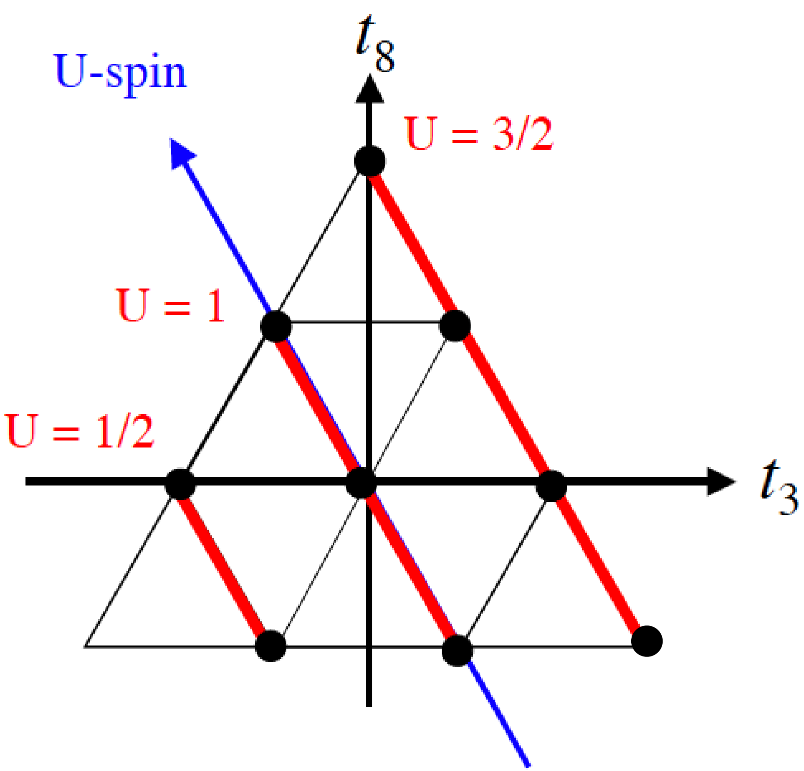
=>

U-spin of the photon is 0

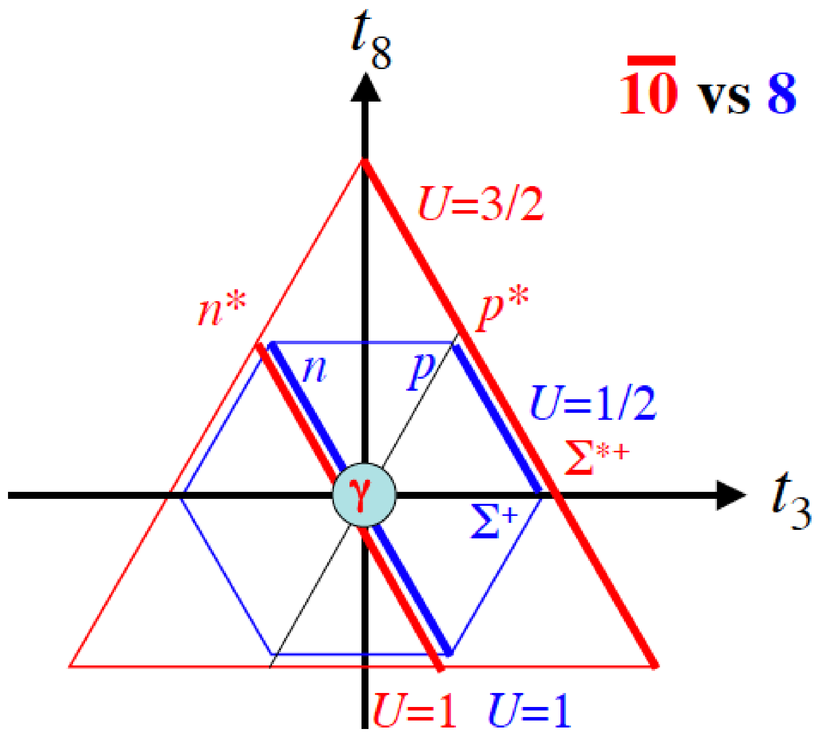
U-spin of antidecuplet

SU(3) weight diagram

U-spin multiplets



Selection rule



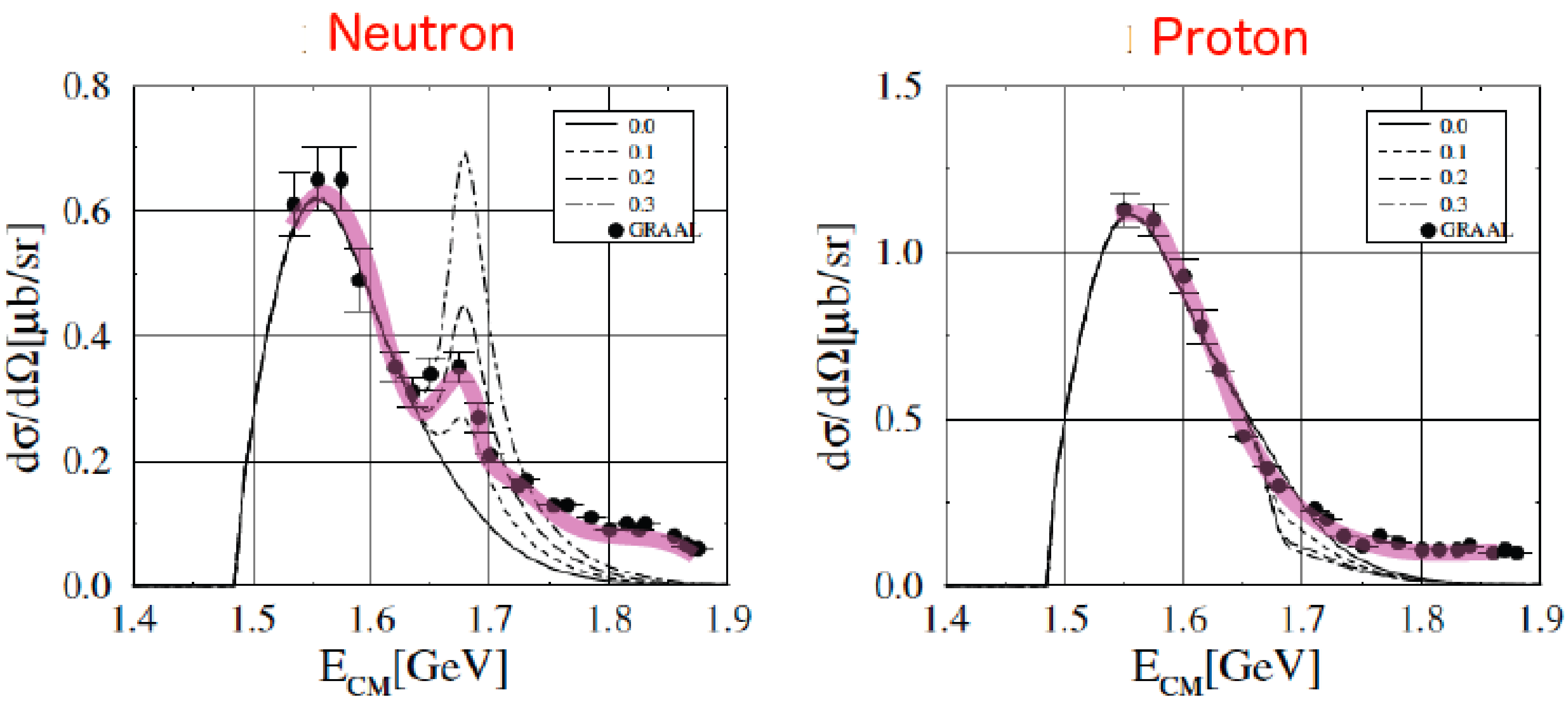
$$U(p^*) = 3/2 \neq U(p) = 1/2$$
$$U(n^*) = U(n) = 1$$

$p^* \rightarrow p\gamma$ is forbidden
$n^* \rightarrow n\gamma$ is allowed

New resonance N*(1675)?

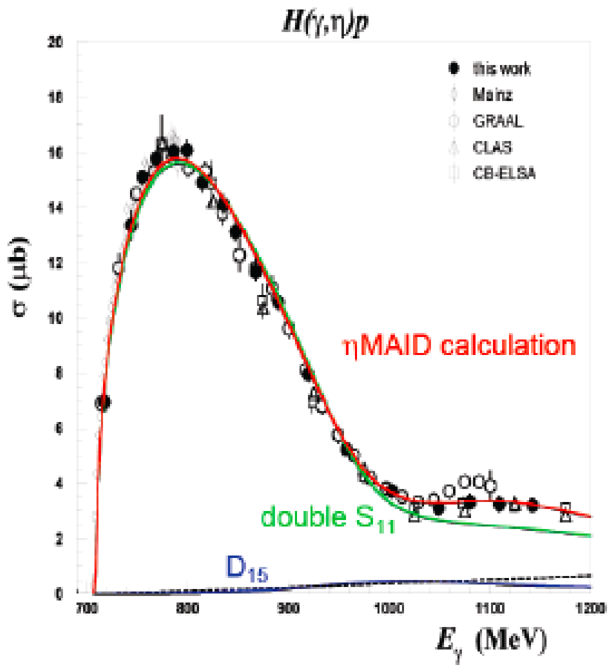
$\gamma N \to N^* \to \eta N$

Data from GRAAL

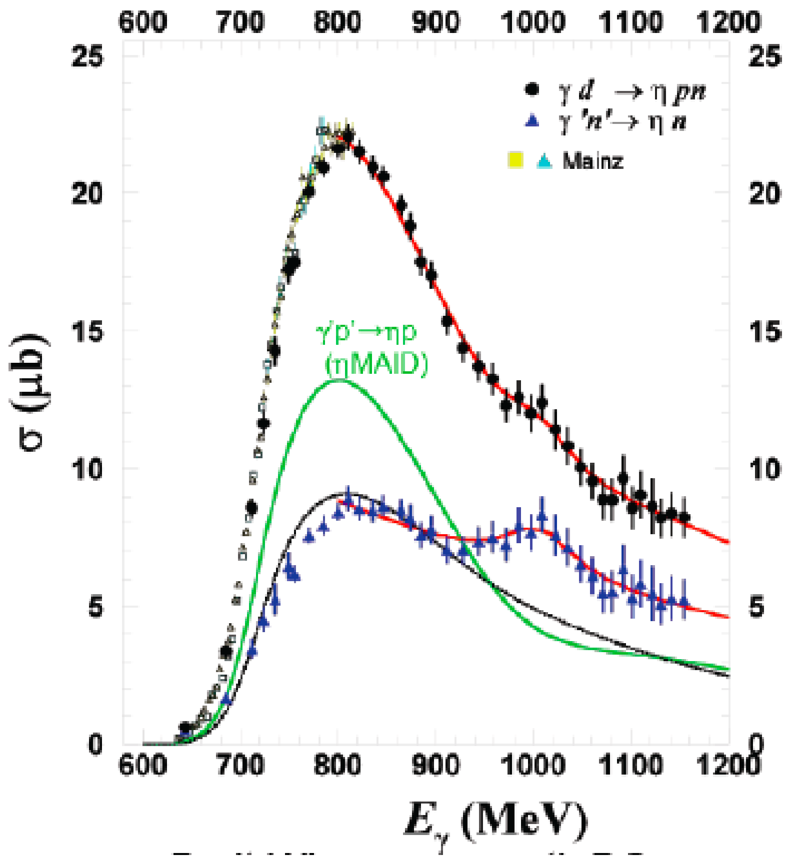


Kasagi et al

Proton



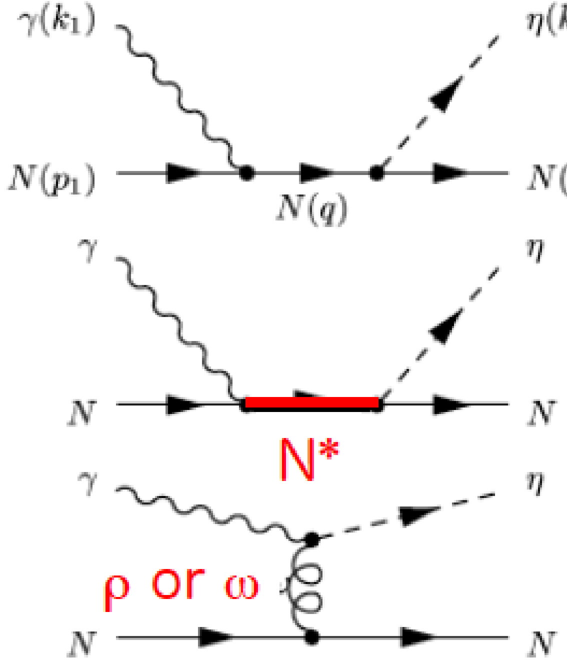
Neutron

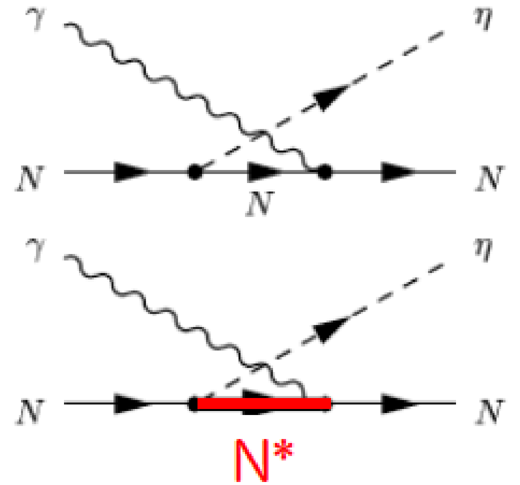


Model calculation

Choi-Nam-Hosaka-Kim, Phys.Lett.B636:253-258,2006

Effective lagrangian method



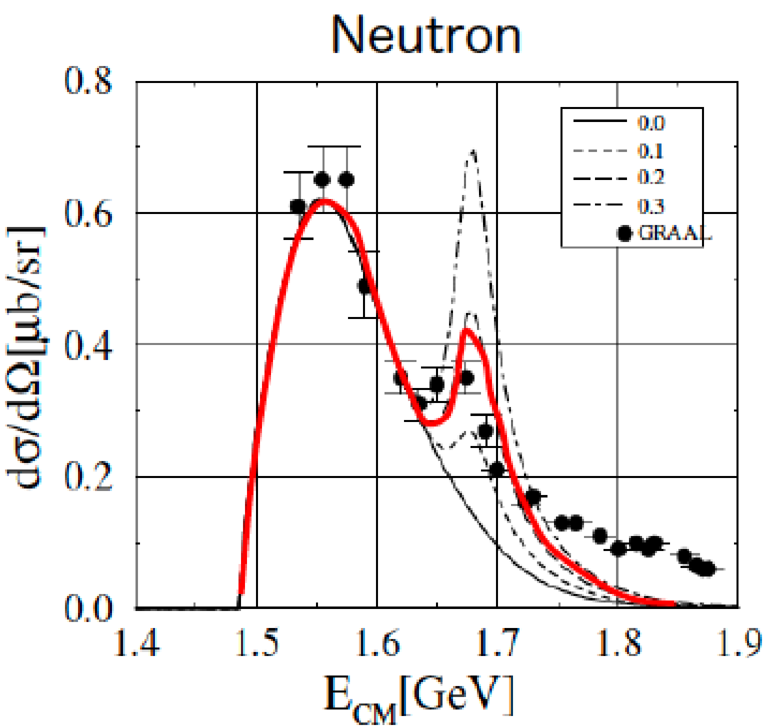


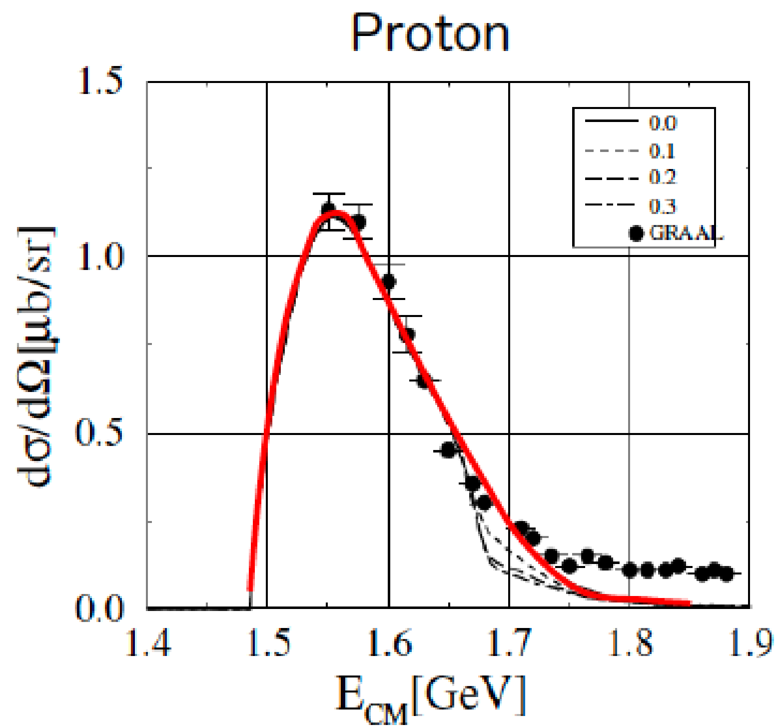
N* = 1535, 1650, 1710

N*(10bar): 1/2+-

Results

N* $J^P = 1/2^+$





$\kappa = +0.2$ <= This value is consistent with the chiral soliton prediction

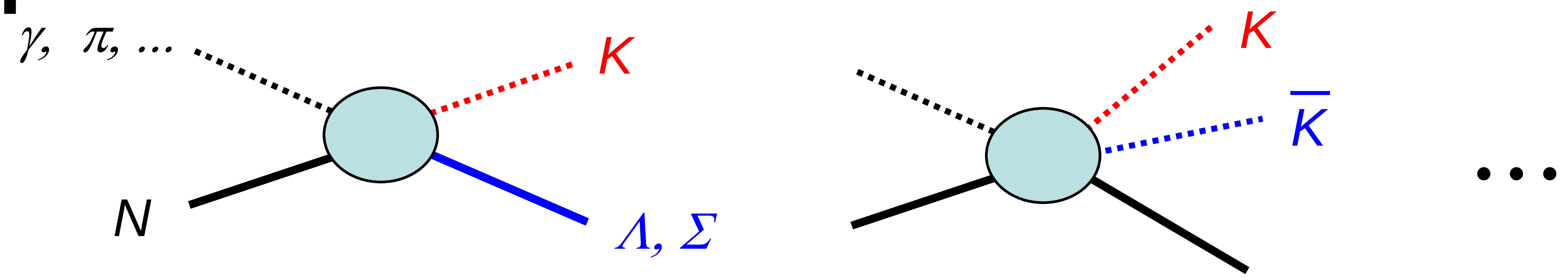
H.-Ch. Kim et al, Phys. Rev. D71, 094023(2005)

3. SU(3) symmetry violation?

$\gamma N \rightarrow K\Lambda$g.s. and the use of polarization

Ozaki-Nagahiro-Hosaka

Basic process of strangeness production



Important for: Hyper nuclei, hadronic matter, exotics, • • •

BUT: The nature of interactions are not well understood

Strong or weak K*

	Bennhold et al. NPA695 (2001) 237	SU(3)
$g_{K\Lambda N}/\sqrt{4\pi}$	–3.80	–4.09
$g_{K\Sigma N}/\sqrt{4\pi}$	1.20	0.78
$g_{KK^*\gamma}\underline{g^V_{K^*\Lambda N}}/4\pi$	–0.51	–0.07
$g_{K^*K\gamma}\underline{g^T_{K^*\Lambda N}}/4\pi$	0.67	0.16
$g_{K^*K\gamma}\underline{g^V_{K^*\Sigma N}}/4\pi$	–0.31	–0.11
$g_{K^*K\gamma}\underline{g^T_{K^*\Sigma N}}/4\pi$	–0.61	–0.37

Strong

Weak

Is SU(3) broken?

Also discussed by Guidal et al. NPA627 (1997) 645

Evidence of strong K* ~ *Magnetic*

Use of *polarized gamma*

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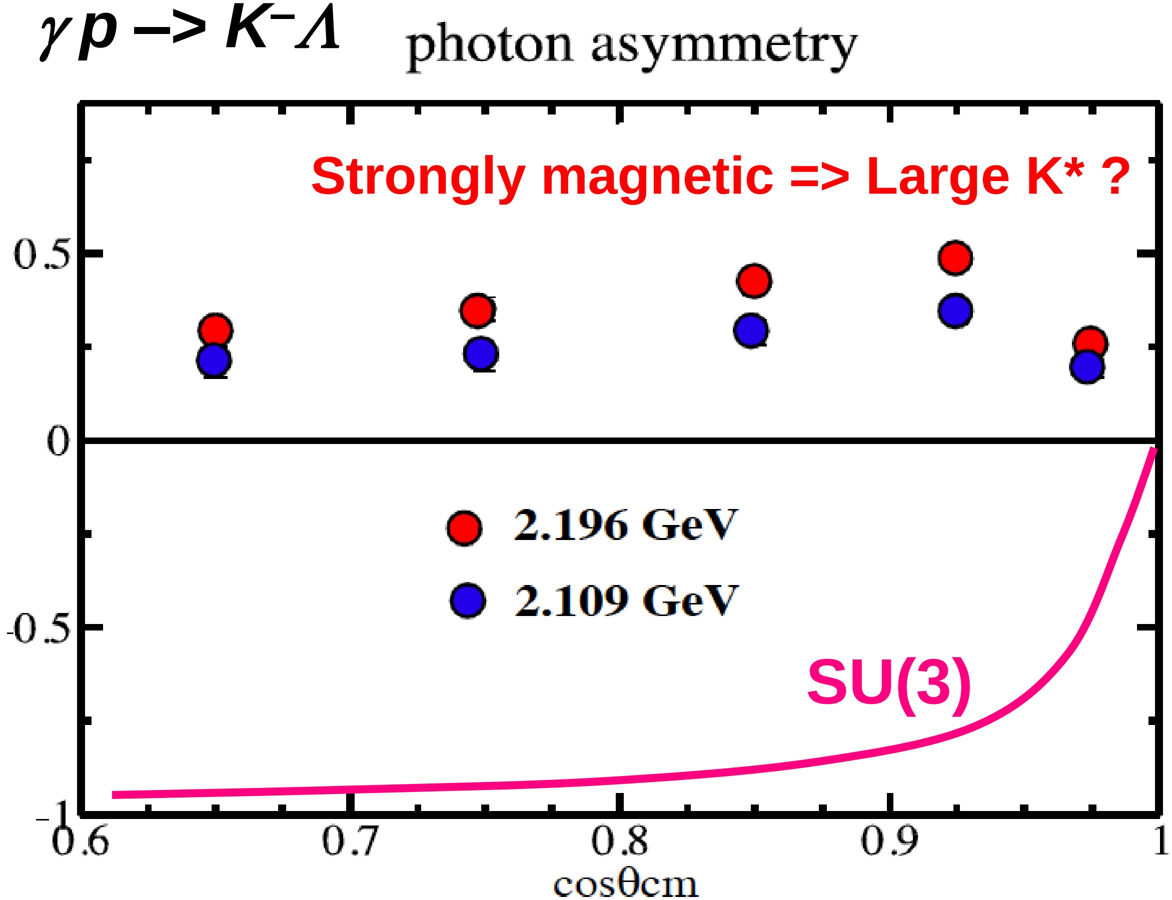
Asymmetry

$$A = \frac{\sigma_{\perp} - \sigma_{\|}}{\sigma_{\perp} + \sigma_{\|}} = \begin{cases} +\ \textbf{Magnetic} \\ -\ \textbf{Electric} \end{cases}$$

Asymmetry

$$A = \frac{\sigma_{\perp} - \sigma_{\parallel}}{\sigma_{\perp} + \sigma_{\parallel}} = \begin{cases} + \text{ Magnetic} \\ - \text{ Electric} \end{cases}$$

$\gamma\, p \to K^{-} \Lambda$

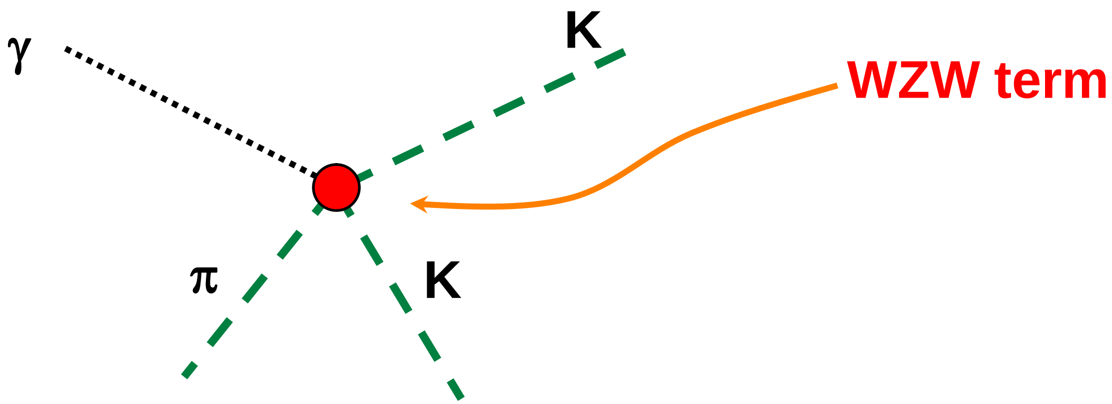


LEPS data
Sumihama et al.
PRC73,035214 (2006)

Is SU(3) broken?

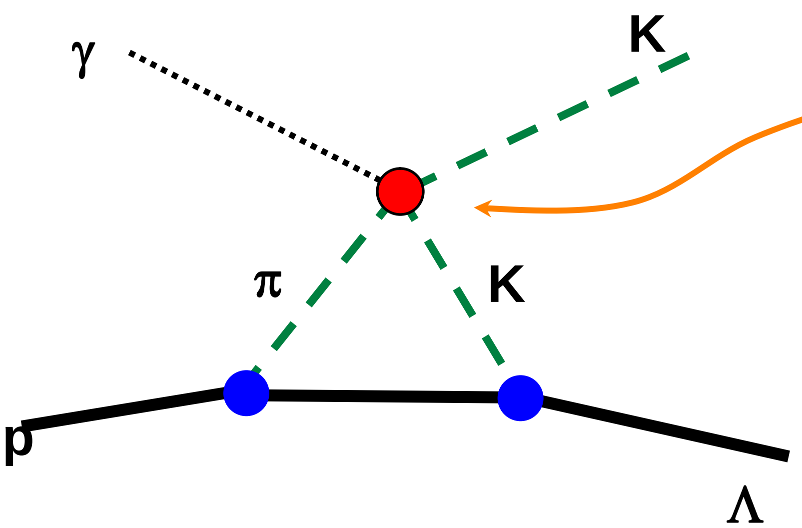
WZW induced process

A higher order contribution to be added to Born diagrams



WZW induced process

A higher order contribution to be added to Born diagrams



WZW term

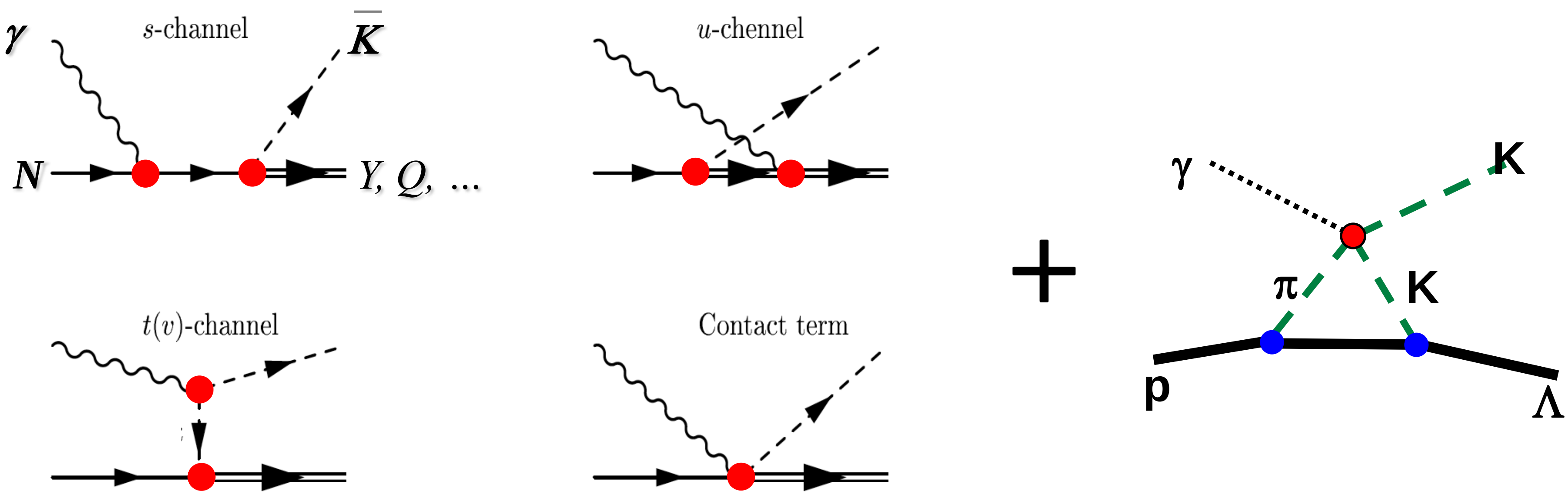
- **Strength is determined by QCD**
- **Contains** $\varepsilon_{\mu\nu\alpha\beta}$ **=> Magnetic**
- **Triangle can not be K***
- **Energy dependent, raising**

Actual computation (Ozaki, M2 student)

Covariant loop integral

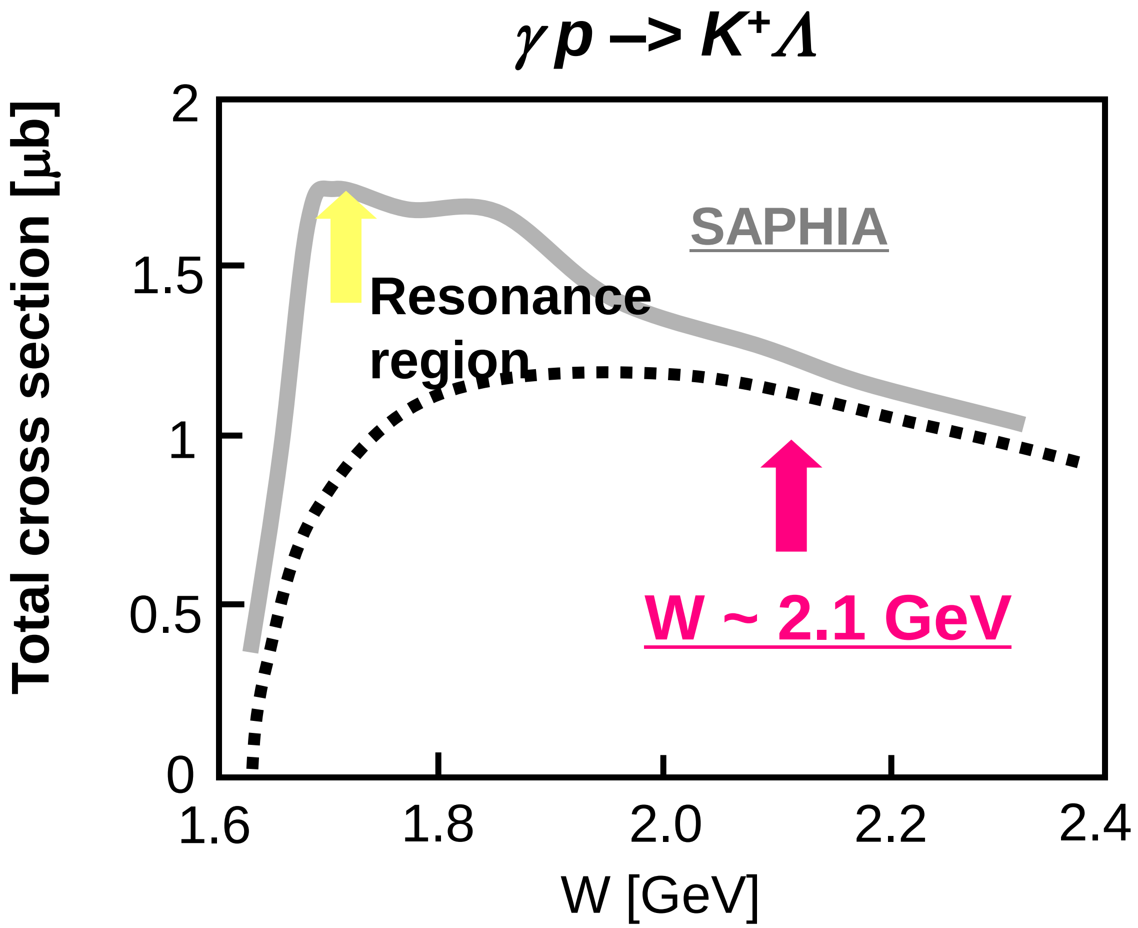
Cutoff ~ 1 GeV

We consider

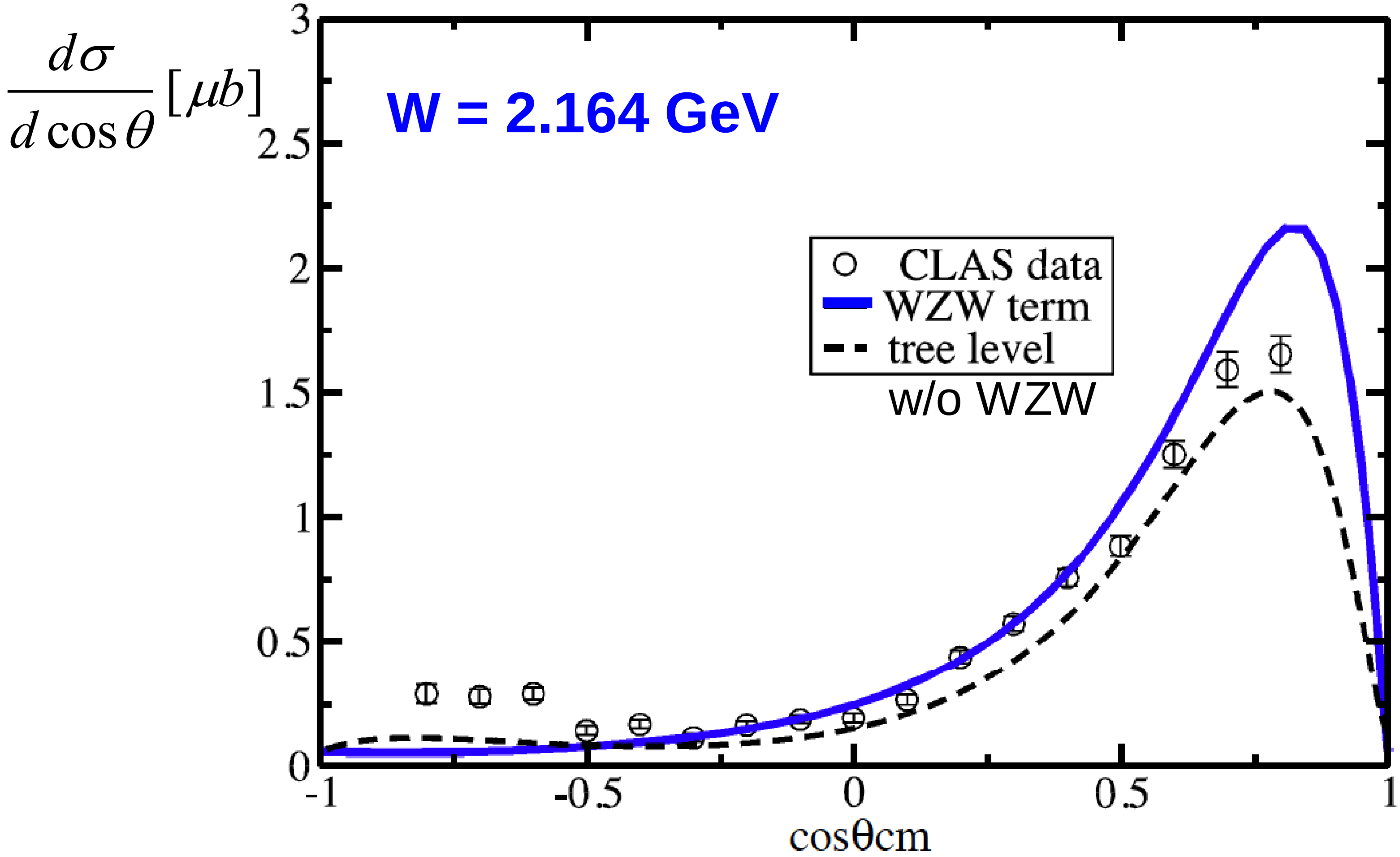


Using SU(3) parameters

Where to study

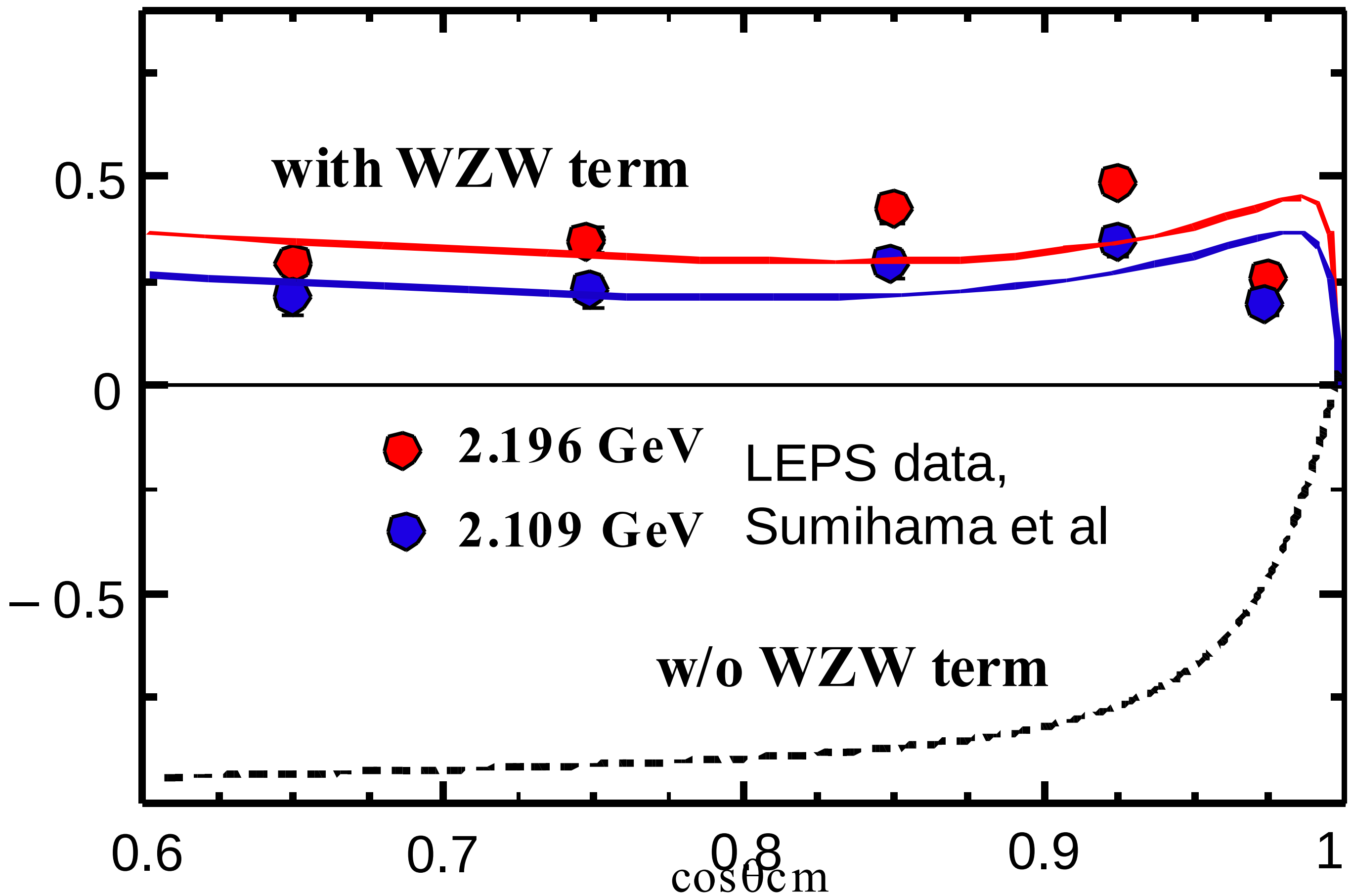


$\gamma p \to K^+\Lambda$



Asymmetry

$$A = \frac{\sigma_\perp - \sigma_\parallel}{\sigma_\perp + \sigma_\parallel}$$



Summary

- **We have performed s-productions in an**
  effective lagrangian approach

- **Some *symmetry related predictions* are made**
  To be tested further experiments, J-Lab, LEPS, etc

- **Applicability to variety phenomena including *exotics***

Summary

• We have investigated SU(3) flavor symmetry

• Strong magnetic force may be explained by
meson clouds induced by the WZW anomaly

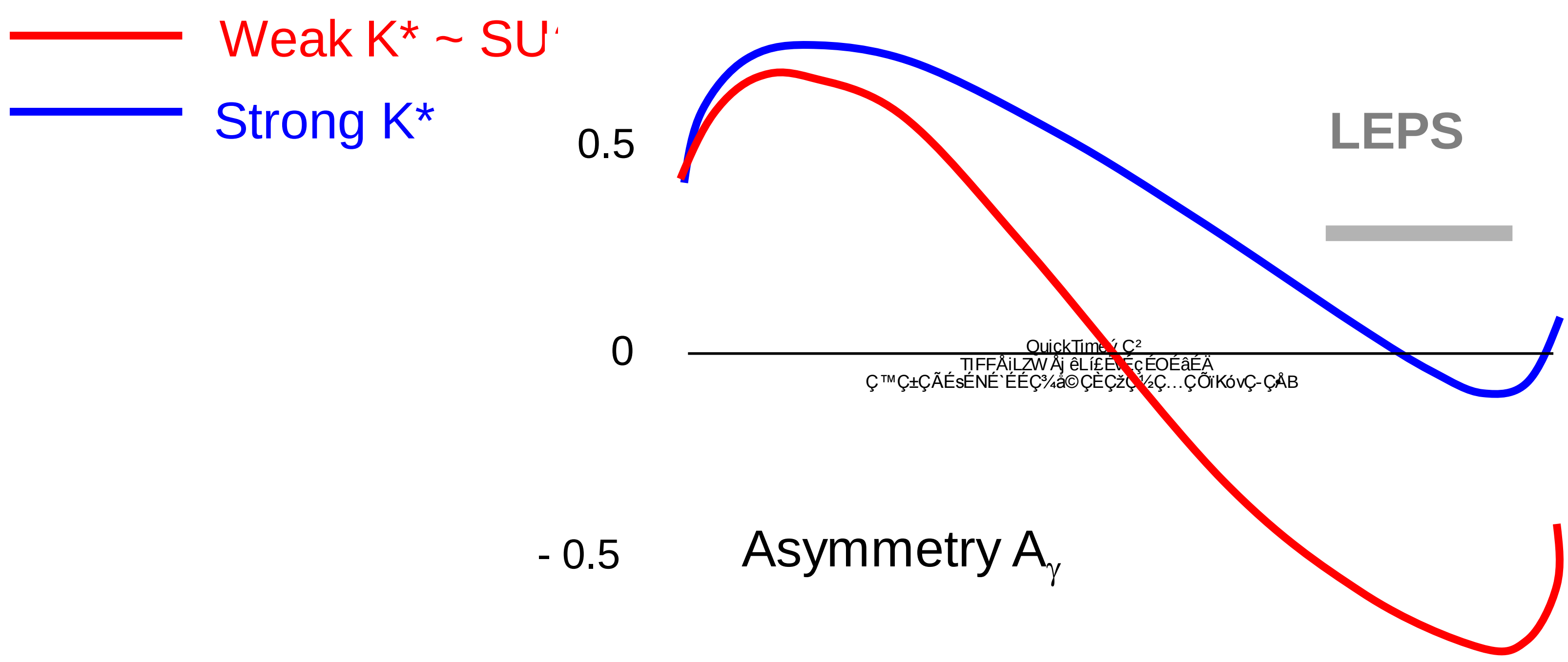
• Flavor symmetry should be respected

• Higher order processes may be relevant
for some processes

~ ***near threshold of new***

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

E_γ = 1.9 GeV, W ~ 2.1 GeV



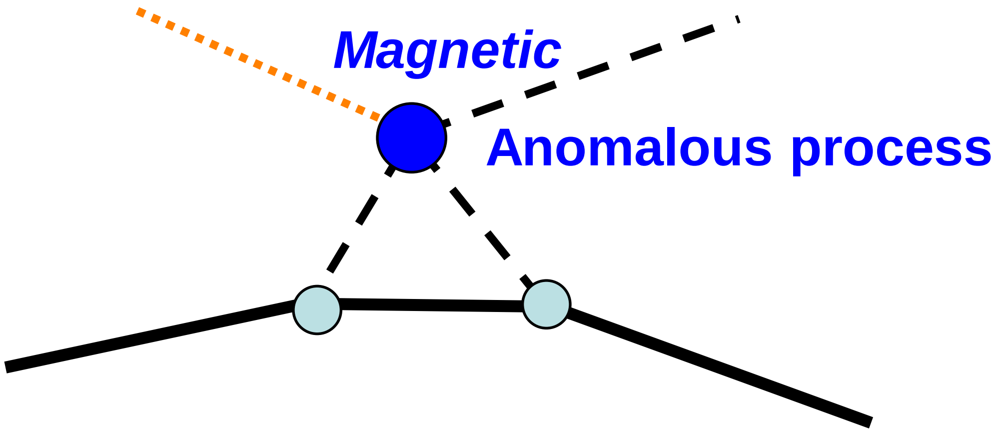
Role of K*

Strong K* => pn asymmetry is not so large
Weak   =>   could be large due to ***contact term***

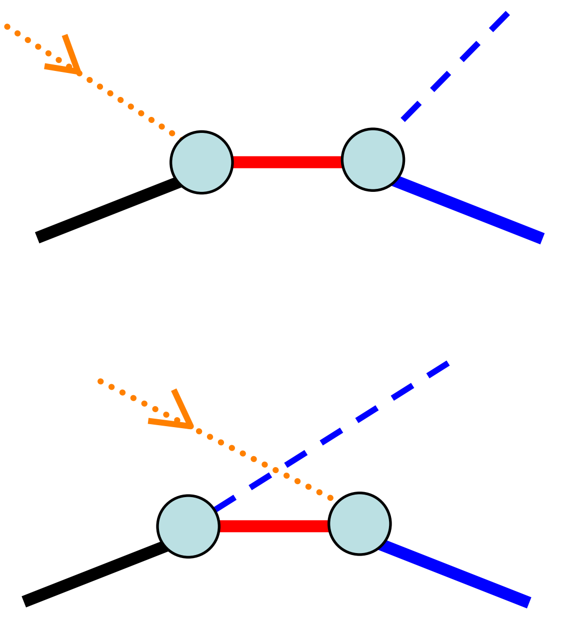
Information of n-target is very important

Something is missing?

Meson clouds



Spin 3/2



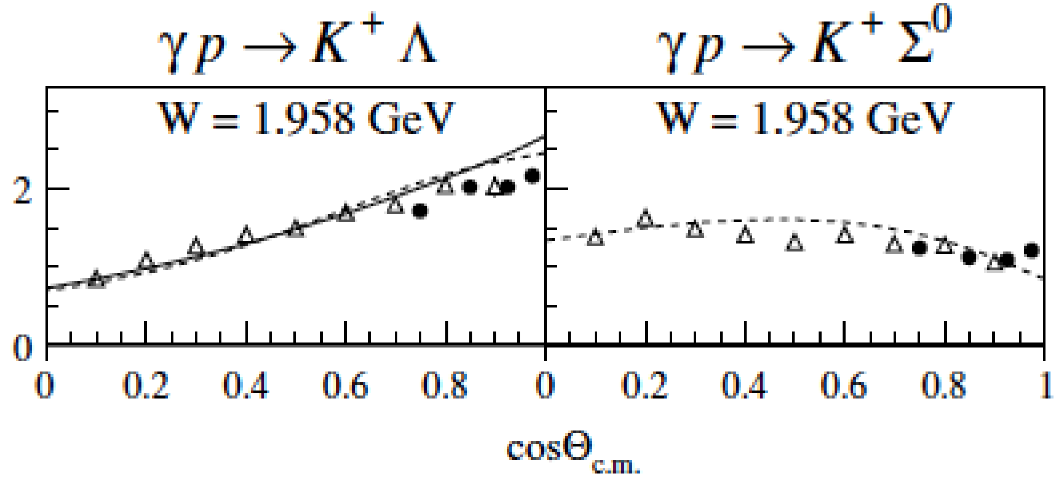
Summary

There are many important but not yet well understood physics

- Test of chiral symmetry: KR- and TW terms
- SU(3) relations holds? Vector meson couplings

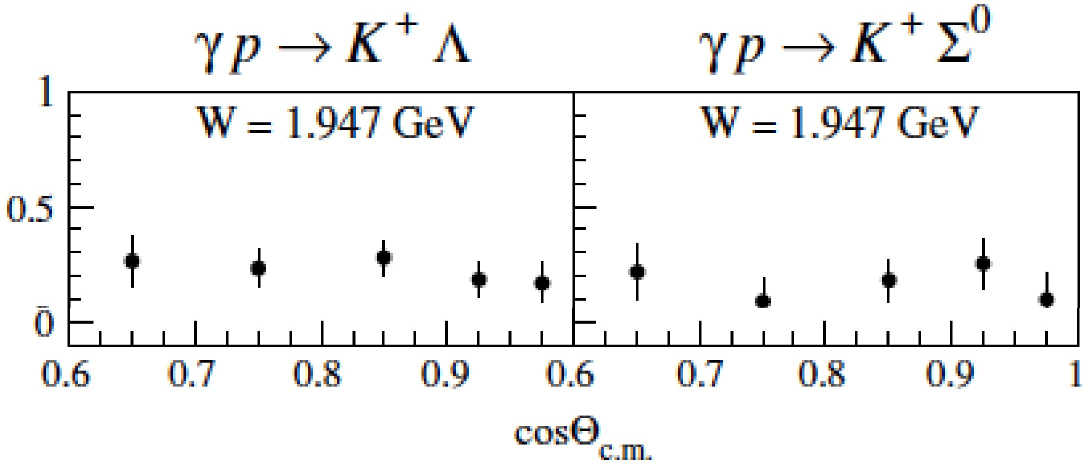
LEPS data

θ-dependence



Asymmetry

+ : K* dominant
– : K dominant

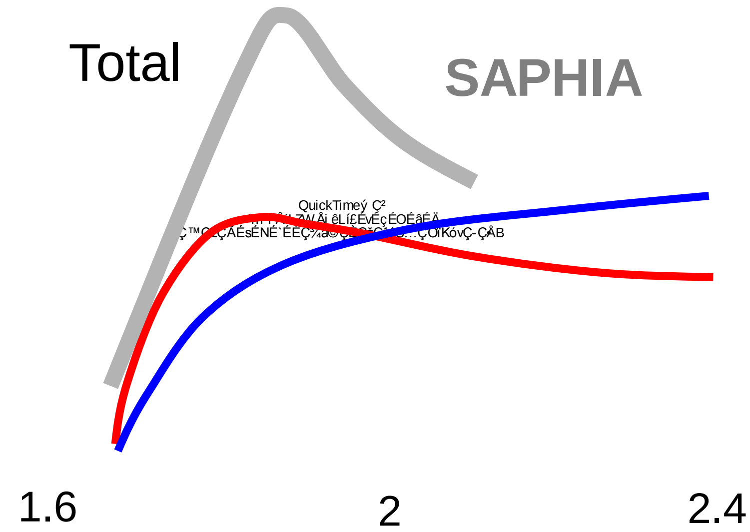


$\gamma p \rightarrow K^+\Sigma^0$

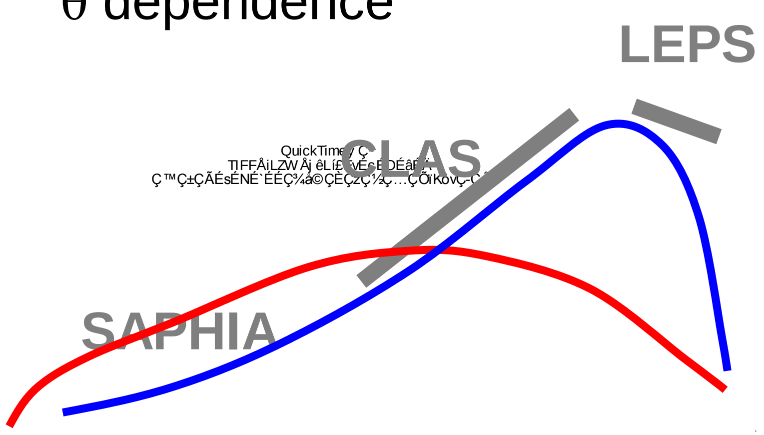
$E\gamma$ = 1.9 GeV, W ~ 2.1 GeV

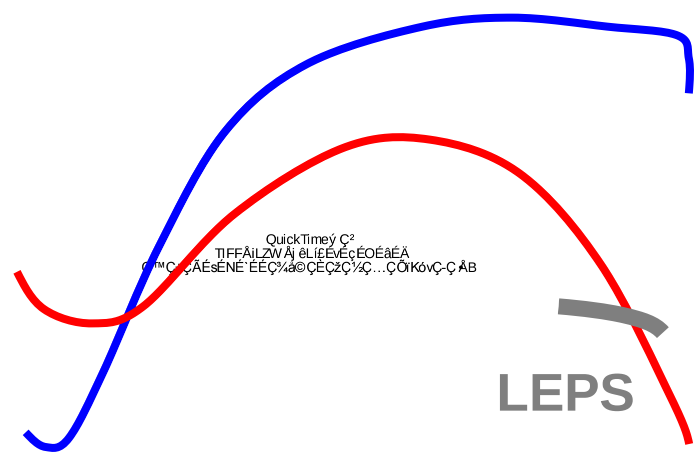
Weak K* ~ SU(3)

Strong K*



θ dependence





Strangeness/KK productions

Many reasons that we believe it important

- ***Hyper nuclei***

  New era of nuclear physics
- ***Strange nuclear/quark matter***

  Hadronic matter, astrophysics-nuclear physics
- ***Exotic hadrons***

  Θ^+, D_s, heavy quark systems
- ***Strange contents of hadrons***

  Strong vacuum structure
- . . .