Study of photoproduction of vector mesons

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- Introduction
- Vector meson photoproduction at large $|t|$
  - existing data and interpretations
  - theoretical predictions
- Prospects for LEPS2

Introduction

- **LEPS experiment**
  - **Backward Compton photon beam = low-background beam**
    → Forward spectrometer.
  - **Polarized photon.**

  forward ϕ photoproduction, K^+ photoproduction
  u-channel meson production.

- **LEPS → LEPS2**
  - **Higher photon intensity.**
  - **Higher photon energy (~ 7 GeV /w X-ray injection).**
  - **Large acceptance detector (BNL-E949 magnet).**

strong competitor: CLAS@JLAB

Comparison of Detector Acceptance

(numbers are not very precise)

detector	Magnet Type	θ^{lab} coverage (deg.)	Comment
LEPS	Dipole	2 ~ 20	
LEPS + TPC	Dipole + Solenoid	2 ~ 4 (*) 30 ~ 100	(*) depending on target position
CLAS @JLAB	Toroidal	10 ~ 100	For positive particles
LEPS2 (E949)	Solenoid	10(5) ~ 90	*p* resolution is high for θ>10deg.

Advantage of LEPS2 (solenoid)

- **Same acceptance for positively and negatively charged particles.**

  → suitable for detecting multi-particle final states.

- **CLAS has small acceptance for negative particles because they are bended inside by the toroidal field.**

(example)

- **γ p → ϕ p → $K^+ K^-$ p**

  K^+K^-, K^+ p, K^-p, KKp at LEPS2 (and LEPS)

  K^+ p only at CLAS

  → limits the kinematical coverage.

- **γ p → ω p → $\pi^+ \pi^- \pi^0$ p**

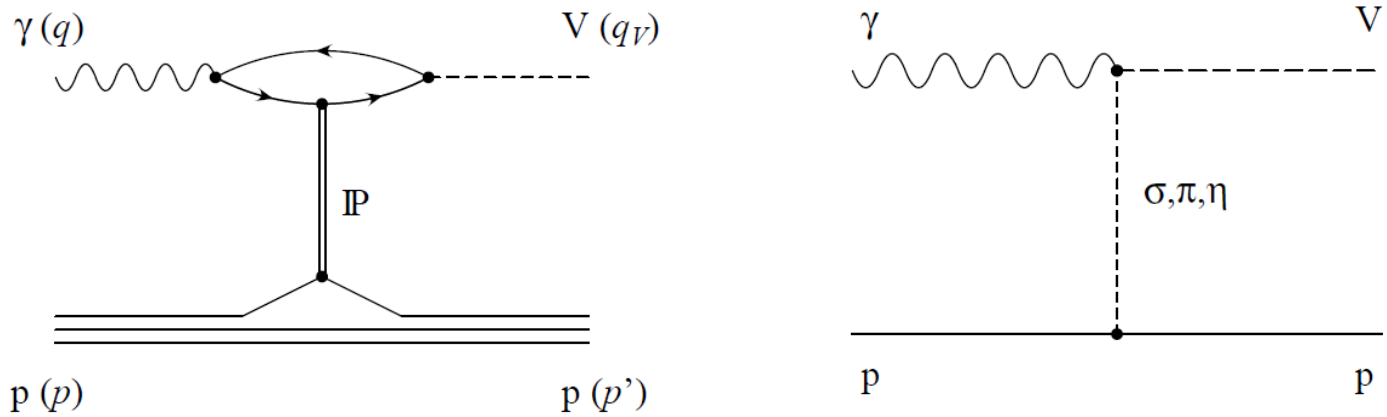
Overview of vector meson photoproduction mechanism

- **Forward angles (small momentum transfer $|t|$)**

  VDM picture, diffractive production.

  Pomeron (multi-gluon) exchange

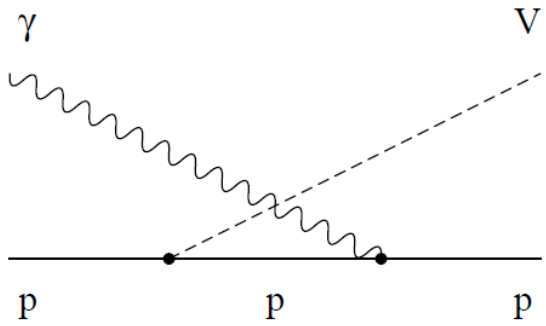
  & meson exchange



meson exchange is suppressed for ϕ.

Overview of vector meson photoproduction mechanism

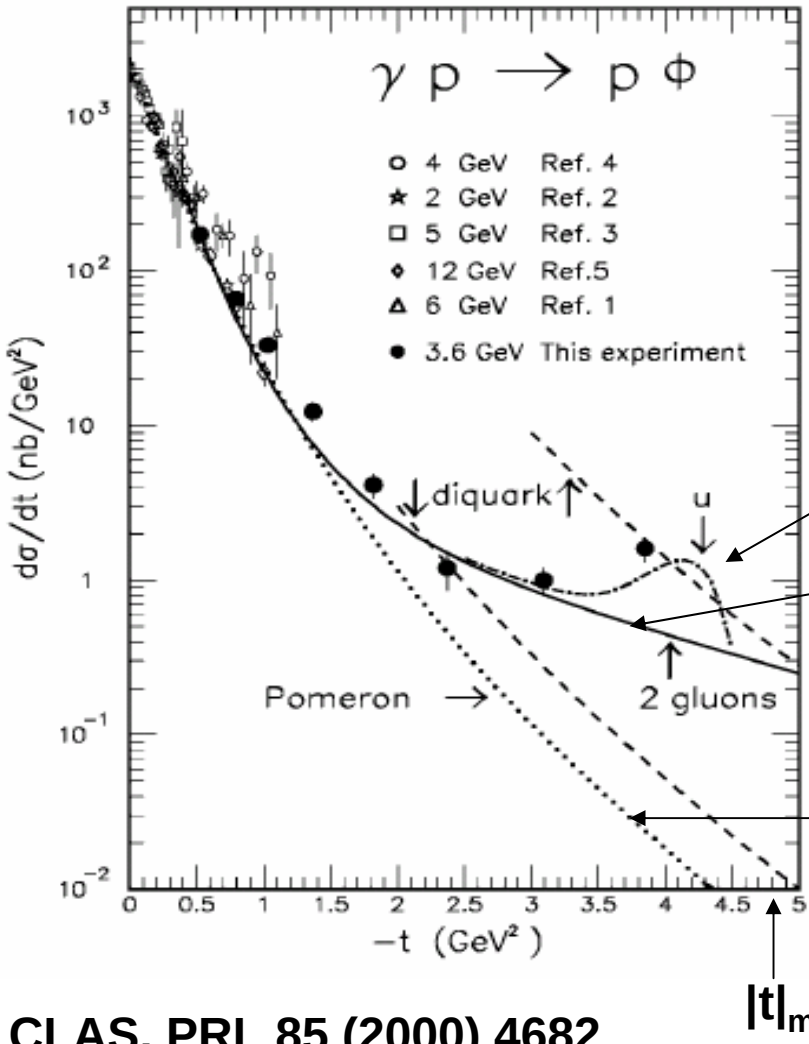
- **Backward (~ $|t|_{max}$, small $|u|$)**
  u-channel nucleon exchange.



- **Intermediate angles (both |t| and |u| are large)**
  Production mechanism is energy dependent & not very clear.
  - **s-channel resonance excitation**
  - **quark exchange**
  - **2 gluon exchange with quark correlations in N.**

Existing data: ϕ photoproduction at CLAS

E_γ=3.6 GeV (above resonance region)

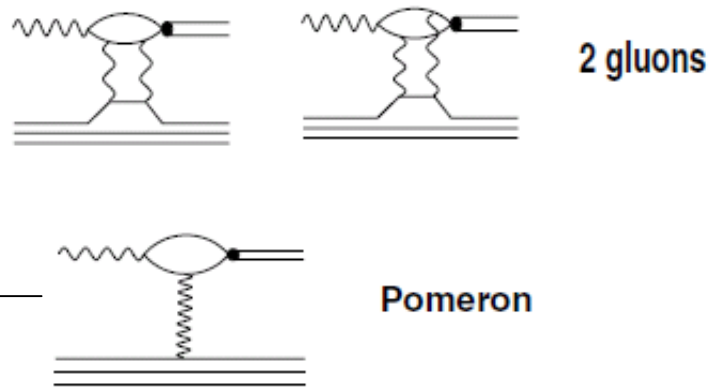


(J.M. Laget, PLB 489 (2000) 313)

***u*-channel contribution**

with the choice $g_{\phi NN} = 3$

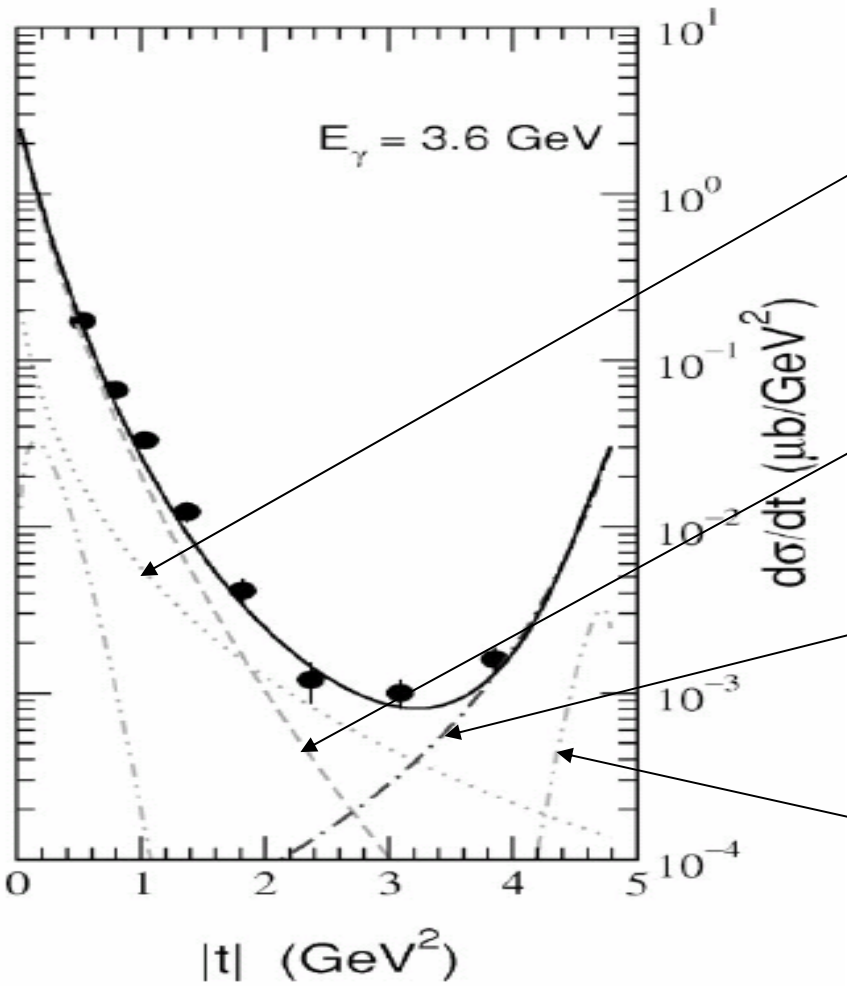
(3 times larger than OZI)

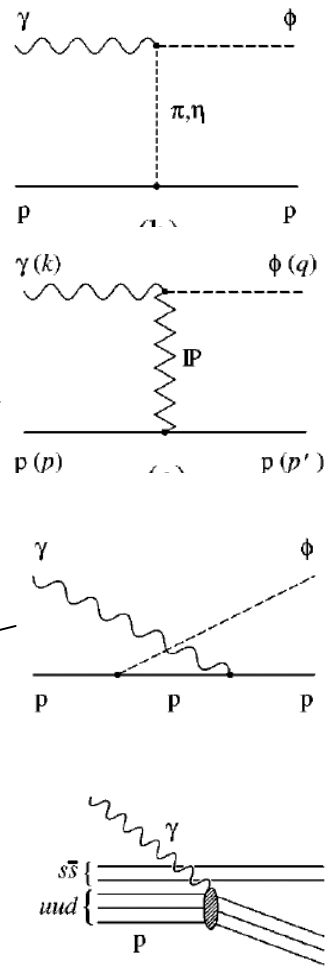


CLAS, PRL 85 (2000) 4682

Existing data: ϕ photoproduction at CLAS

E_γ=3.6 GeV (above resonance region)





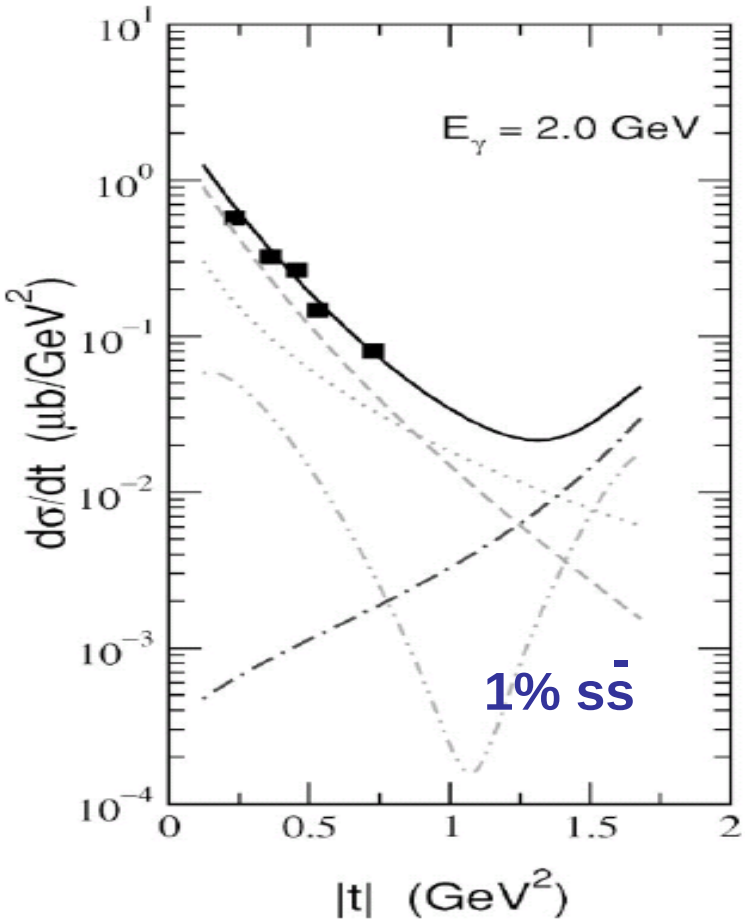
$g_{\phi NN}$ = -3
(fitted to data)

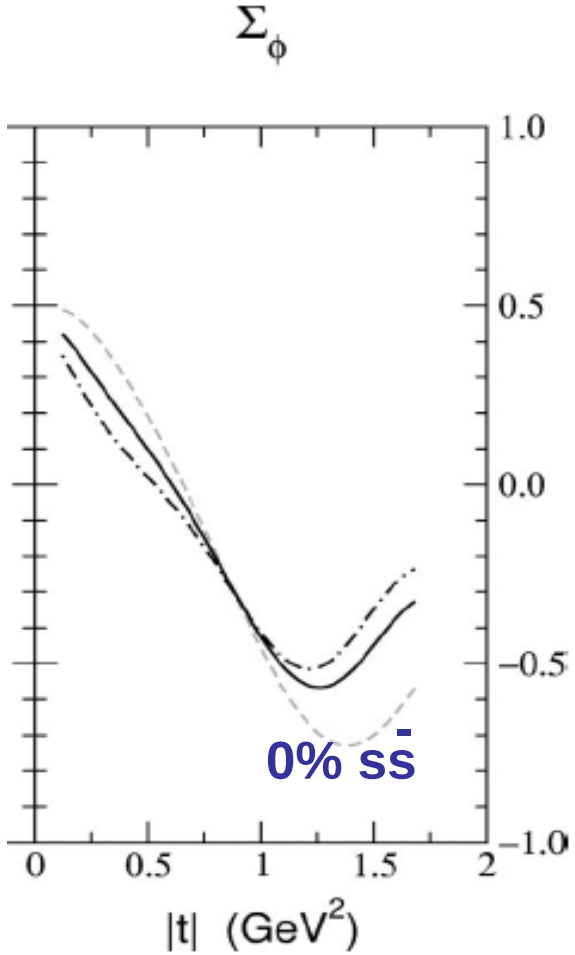
1% $s\bar{s}$

(Y. Oh and H.C. Bang, PRC 64 (2001) 055207)

Theoretical prediction for E_γ=2 GeV

May be possible at LEPS2 (high intensity beam & large acceptance detector)

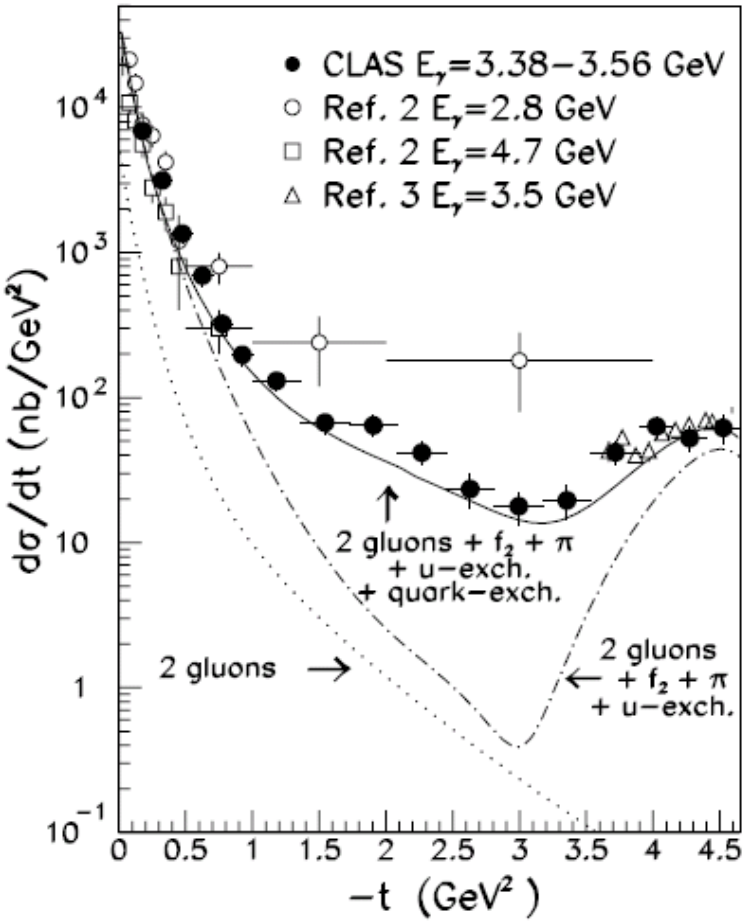




(Y. Oh and H.C. Bang, PRC 64 (2001) 055207)

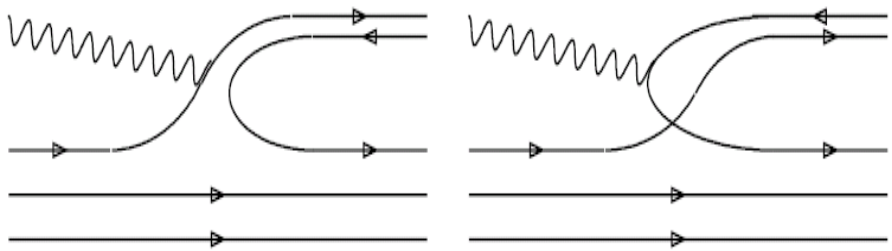
Existing data: ω photoproduction at CLAS

(above resonance region)



CLAS, PRL 90 (2003) 022002-1

(J.M. Laget, PLB 489 (2000) 313)



quark exchange contribution

u-channel: Nucleon Regge traj.

t-channel: $f_2(1270)$ + π exchange

Different theoretical approach

w/o quark exchange

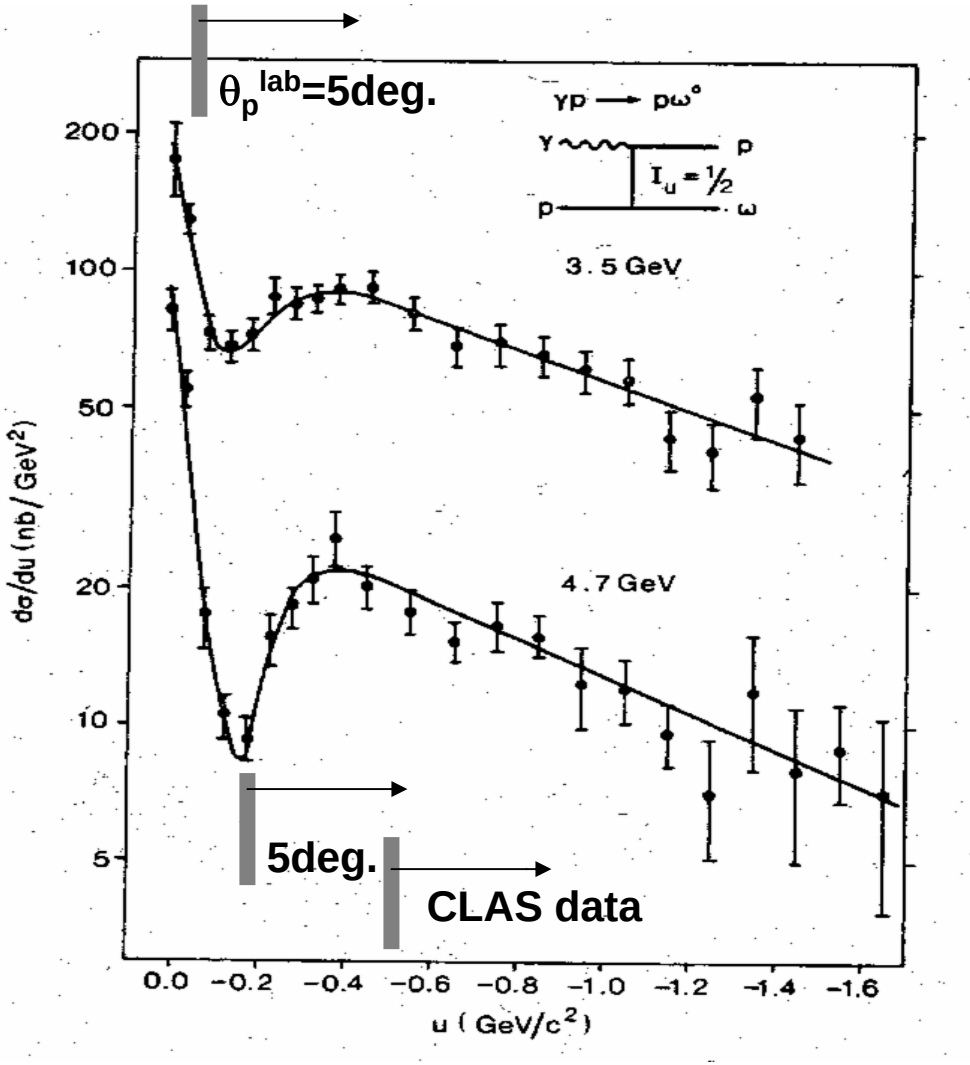
ωNN coupling

(Sibirtsev, Tsushima, & Krewald, nucl-th/0202083)

5.3

$|t|_{max}$

Existing data: u-channel ω photoproduction



NINA, PL 72B (1977) 144

γ p → p X (missing X = ω)

u-channel: Nucleon Regge traj.

+

quark exchange contribution

Question?

Prominent dip structure at

u ~ - 0.1 GeV²

? Not seen for ρ^0 photoproduction with same setup.

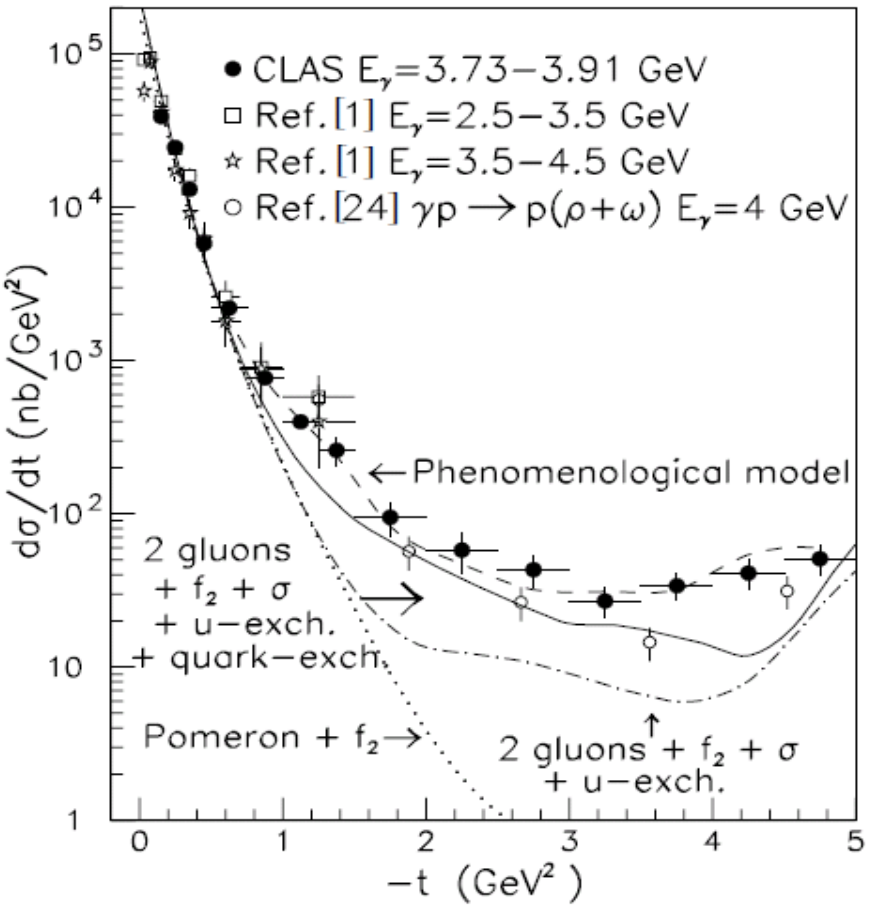
(PL 64B (1976) 213)

? Difficult to reproduce theoretically

(nucl-th/0202083)

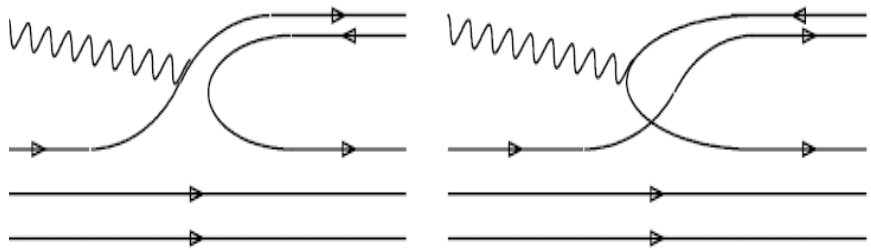
Existing data: ρ^0 photoproduction at CLAS

(above resonance region)



CLAS, PRL 90 (2003) 022002-1

(J.M. Laget, PLB 489 (2000) 313)



quark exchange contribution

u-channel: N & Δ Regge traj.

t-channel: $f_2(1270)$ + σ exchange

Different theoretical approach

2π, σ, f_2 exchange.

ρNN coupling ← πN scat. data

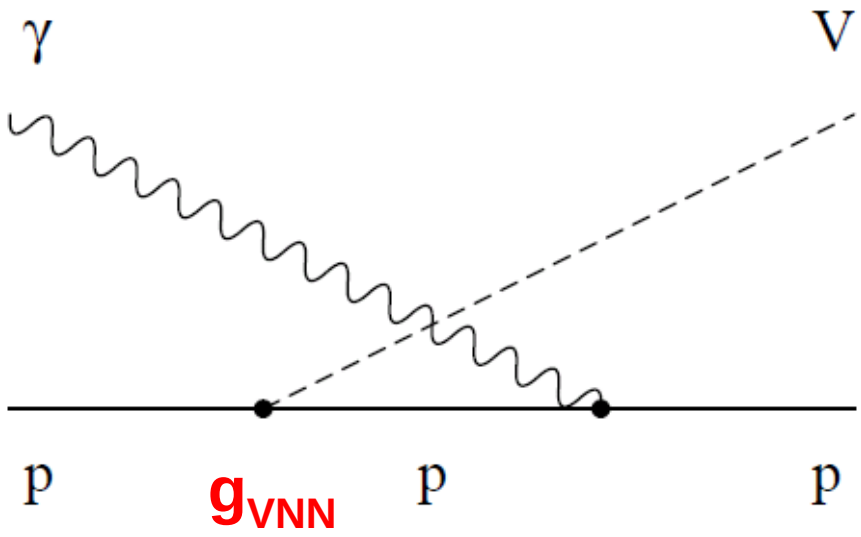
(Oh & Lee, PRC 69 (2004) 25201)

5.9

↑

$|t|_{max}$

u-channel meson production



direct probe for multi-quark component

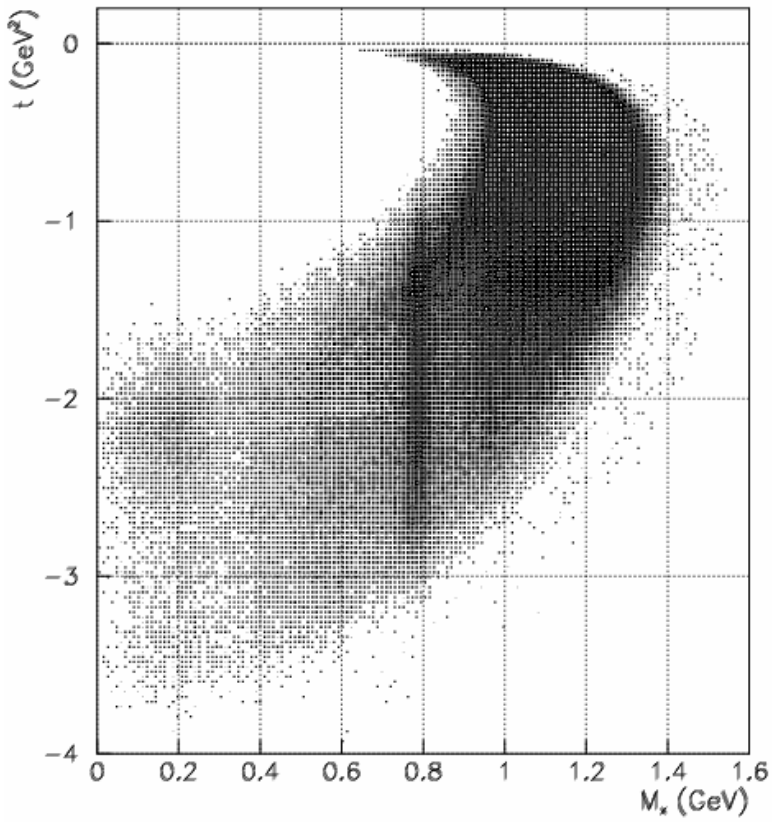
To see u-channel process clearly…

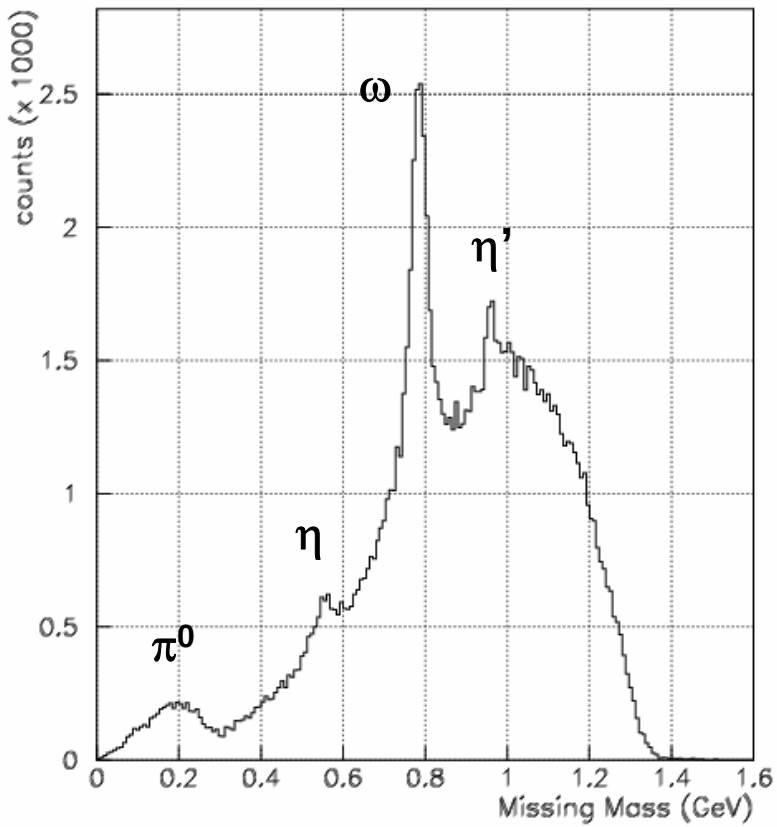
- **Measurement of N at extremely forward angle.**
- **Choice of energy to reduce “background” process.**
  - **s-channel resonance contribution**
  - **hard process**
- **Polarization observables**

γ p → p X reaction at LEPS

Eγ = 1.5 ~ 2.4 GeV

$t < -1.2$ GeV^2





γ p → p X reaction at LEPS

- **LEPS data of backward (π^0, η, ω, η') production on proton will be reported soon.**

  cross section & photon beam asym.

- **ρ^0 is not seen in the missing mass spectra.**
  - **large width and background in γp → pX mode: …can be seen by detecting decay particles.**
- **ϕ is not seen**
  - **background in γp → pX mode: …can be seen by detecting decay particles.**
  - **small cross section? : …with high intensity beam.**

Summary and Prospects for LEPS2

- **Photoproduction of vector meson at large angles.**
  - **u-channel production → NNV coupling.**

- **LEPS and LEPS2 experiments can give us new information**
  - **different kinematics (extremely forward or backward angles)**
  - **measurement of decay particles.**
  - **polarization observables.**
  - **LEPS2 (E949) + forward spectrometer combination may be important for this subject.**