ρ-Meson Nucleon Scattering Length from CLAS Threshold Photoproduction Measurements

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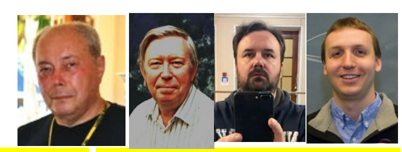
- Puzzle for Vector Meson Thr Photoprod.
- A bit of History for ρ & ω.
- VMD Model.
- Vector Meson Nucleon SL Puzzle.
- Extraction of $\gamma p \to \rho p$ Xsec from CLAS data.
- ρ & ω SLs.
- Vector Meson Nucleon Puzzle.
- Summary.



IIS, V. Mokeev, E. Isupov, A. Schmidt, arXiv:2509.04672 [nucl-th]

Supported by DE-SC0016583

Puzzle for Vector Meson Threshold Photoproduction with Phenomenology

PHYSICAL REVIEW C 91, 045207 (2015)

Photoproduction of the ω meson on the proton near threshold

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(A2 Collaboration at MAMI)

PHYSICAL REVIEW C 101, 042201(R) (2020)

***J/ψ p* scattering length from GlueX threshold measurements**

Igor I. Strakovsky,[1,*] Denis Epifanov,[2,3] and Lubomir Pentchev[4]

PHYSICAL REVIEW C 101, 045201 (2020)

Comparative analysis of ωp, ϕp, and $J/\psi p$ scattering lengths from A2, CLAS, and GlueX threshold measurements

Igor I. Strakovsky,[1,*] Lubomir Pentchev,[2] and Alexander I. Titov[3]

PHYSICAL REVIEW D 104, 074028 (2021)

Threshold Upsilon-meson photoproduction at the EIC and EicC

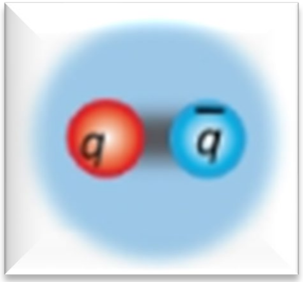
Igor I. Strakovsky,[1,*] William J. Briscoe,[1] Lubomir Pentchev,[2] and Axel Schmidt[1]

ρ-Meson Nucleon Scattering Length from CLAS Threshold Photoproduction Measurements

Igor I. Strakovsky,[1,*] Evgeny L. Isupov,[2,†] Victor Mokeev,[3,‡] and Axel Schmidt[1,§]

arXiv:2509.04672v1 [nucl-th] 4 Sep 2025

A Bit of History for ρ & ω



Short Introduction

- ρ meson is one of earliest vector mesons to be discovered, & its history is tied to development of VMD idea & study of *strong interaction*.

- Occasionally, ρ-meson is considered as gauge boson of *broken hidden local chiral symmetry*, which, however, is distinct from broken global ***Chiral Symmetry*** of which pion is respective Goldstone-Nambu boson.

- Moreover, non-strange vector mesons ρ, ω, & ϕ play central role in Sakurai's VMD model, where they account for (virtually admixed) hadronic part of photon by which photon couples to hadronic matter.

- There are no vector meson beams, so experiments using modern EM facilities attempt to access *vector meson* nucleon interactions via EM production reactions $e + p \rightarrow e' + V + p$ (V is vector meson).

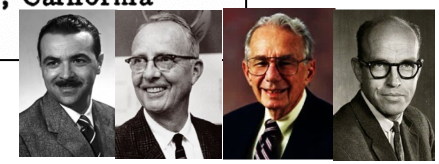
65 yrs Discovery of ω & ρ

VOLUME 7, NUMBER 5 PHYSICAL REVIEW LETTERS SEPTEMBER 1, 1961

EVIDENCE FOR A $T=0$ THREE-PION RESONANCE*

B. C. Maglić, L. W. Alvarez, A. H. Rosenfeld, and M. L. Stevenson
Lawrence Radiation Laboratory and Department of Physics, University of California, Berkeley, California

(Received August 14, 1961)



Citation: S. Navas *et al.* (Particle Data Group), Phys. Rev. D 110, 03000 2024 and 2025 update

$\omega(782)$

$I^G(J^{PC}) = 0^-(1^{--})$

$\omega(782)$ MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
782.66±0.13 OUR AVERAGE	Error includes scale factor of 2.0. See the ideogram below.				
777.9 ±2.2 $^{+4.3}_{-2.2}$	900k	ANDREEV	20	H1	$ep \to e\pi^+\pi^- p$
783.20±0.13±0.16	18680	AKHMETSHIN	05	CMD2	0.60–1.38 $e^+e^- \to \pi^0\gamma$
782.68±0.09±0.04	11200	[1] AKHMETSHIN	04	CMD2	$e^+e^- \to \pi^+\pi^-\pi^0$
782.79±0.08±0.09	1.2M	[2] ACHASOV	03D	RVUE	0.44–2.00 $e^+e^- \to \pi^+\pi^-\pi^0$
781.96±0.17±0.80	11k	[3] AMSLER	94C	CBAR	0.0 $\bar{p}p \to \omega\eta\pi^0$
782.08±0.36±0.82	3463	[4] AMSLER	94C	CBAR	0.0 $\bar{p}p \to \omega\eta\pi^0$
781.96±0.13±0.17	15k	AMSLER	93B	CBAR	0.0 $\bar{p}p \to \omega\pi^0\pi^0$
782.4 ±0.2	270k	WEIDENAUER	93	ASTE	$\bar{p}p \to 2\pi^+2\pi^-\pi^0$
782.4 ±0.5	7000	[5] KEYNE	76	CNTR	$\pi^- p \to \omega n$

Citation: S. Navas *et al.* (Particle Data Group), Phys. Rev. D 110, 03000 2024 and 2025 update

$\rho(770)$

$I^G(J^{PC}) = 1^+(1^{--})$

$\rho(770)$ MASS

We no longer list *S*-wave Breit-Wigner fits, or data with high combinatorial background.

NEUTRAL ONLY, e^+e^-

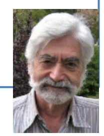
VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
775.26±0.23 OUR AVERAGE					
775.3 ±0.5 ±0.6		[1] ACHASOV	21	SND	$e^+e^- \to \pi^+\pi^-$
775.02±0.35		[2] LEES	12G	BABR	$e^+e^- \to \pi^+\pi^-\gamma$
775.97±0.46±0.70	900k	[3] AKHMETSHIN	07		$e^+e^- \to \pi^+\pi^-$
774.6 ±0.4 ±0.5	800k	[4,5] ACHASOV	06	SND	$e^+e^- \to \pi^+\pi^-$
775.65±0.64±0.50	114k	[6,7] AKHMETSHIN	04	CMD2	$e^+e^- \to \pi^+\pi^-$
775.9 ±0.5 ±0.5	1.98M	[8] ALOISIO	03	KLOE	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
775.8 ±0.9 ±2.0	500k	[8] ACHASOV	02	SND	1.02 $e^+e^- \to \pi^+\pi^-\pi^0$
775.9 ±1.1		[9] BARKOV	85	OLYA	$e^+e^- \to \pi^+\pi^-$

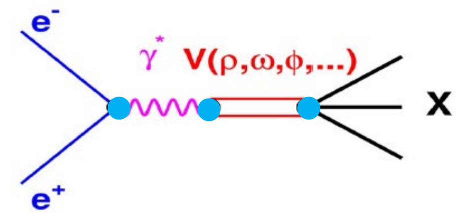
Interference from SND

Ya. Azimov, J Phys G **37**, 023001 (2010)

PDG $\Gamma(\rho^0)$ = 149.4 MeV; $\Gamma(\omega)$ = 8.5 MeV; $\Gamma(\phi)$ = 4.3 MeV

$\Gamma(\rho^0\to3\pi)$ = 0.015 MeV Isospin violated
$\Gamma(\omega\to3\pi)$ = 7.58 MeV
$\Gamma(\phi\to3\pi)$ = 0.65 MeV Zweig rule violated



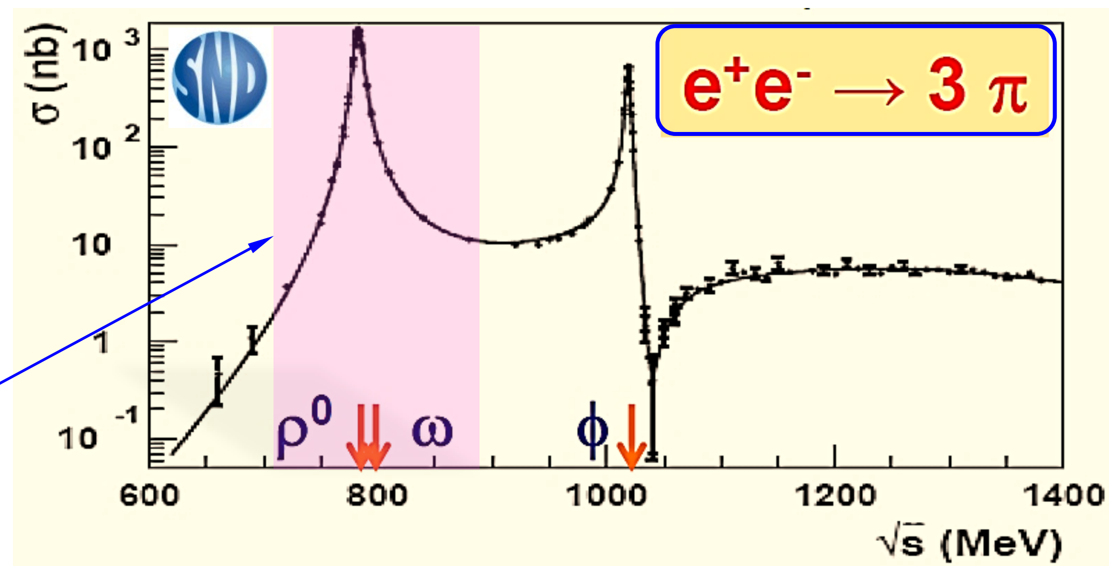


- Bkg near ϕ changes slowly

  ⇩

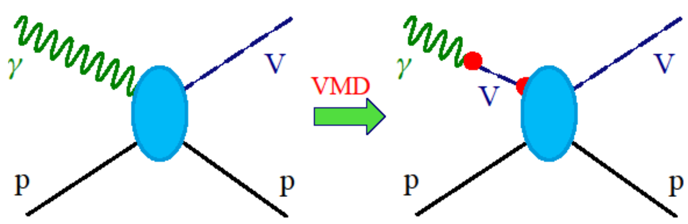
  nearly standard interference curve,
  instead of ϕ–peak:
  both bump & dip,
  each has form different from **BW**;
  max/min different from ϕ-*mass* ρ.

- ρ-contribution here deforms ω-*tails*.
- Curve is fit with ω, ϕ, ρ, ω', & ω''.



M. Achasov, Nucl Phys B Proc Suppl **162**, 114 (2006)

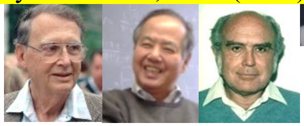
VMD Model



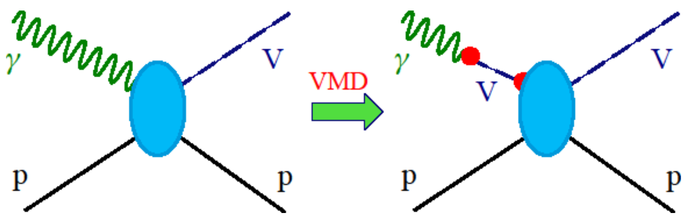
VMD Model

- *Vector Meson Dominance* model
  relying on transparent current-field identities

J.J. Sakurai, Annals Phys. 11, 1 (**1960**)
M. Gell-Mann & F. Zachariasen, Phys Rev **124**, 953 (**1961**)
N.M. Kroll, T.D. Lee, & B. Zumino, Phys. Rev. **157**, 1376 (**1967**)



- In *VMD*, ***real photon*** can *fluctuate* into virtual ***vector meson***,
  which subsequently scatters off target *proton*.



- *VMD* does not contain *free parameters* & can be used for variety of qualitative estimates of observables in ***vector meson*** photoproductions @ least as first step towards their more extended theoretical studies.

VMD for VN Interaction

- ρp & ωp **SL** were determined from photoproduction reactions $\gamma p \to Vp$ with *VDM*.
  Non-perturbative QCD-related approach employing dressed *quarks* & *gluons* as ingredients for $\gamma p \to Vp$ reaction model is under development in INP@Nanjing U.

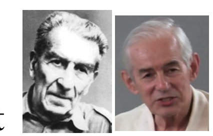
- To estimate theoretical uncertainty related to *VMD* model, one refers to estimation of Xsec of J/ψ photoproduction in *peripheral model* & found strong energy dependence close to threshold because non-diagonal $\gamma p \to Vp$ & elastic $Vp \to Vp$ must have larger transfer momenta *vs* elastic scattering.
  This results in violation of *VMD* by factor of **5**.

K.G. Boreskov & B.L. Ioffe, Sov J Nucl Phys **25**, 331 (**1977**)

- **Color** factor for *charmonium* is **1/9,** while for *open charm* is **8/9**.

B.Z. Kopeliovich, I. Schmidt, & M. Siddikov, Phys Rev C **95**, 065203 (**2017**)

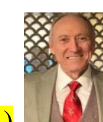
- Strong suppression in *VN* interaction close to threshold is observed because of $\bar{q}q$ pair in point-like configuration lacks sufficient time to form complete wave function of vector meson;
  that is, proton interacts with "*young*" (undressed quarks) *vector meson* whose size is smaller than that of "*old*" one participating in elastic $Vp \to Vp$ scattering.



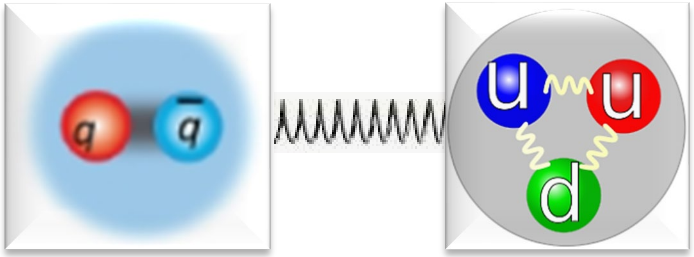
E.L. Feinberg, Sov Phys Usp, **23**, 629 (**1980**)
Courtesy of Misha Ryskin, July **2020**

- In recent study, effect of *VMD* assumption was studied in formalism of *Dyson-Schwinger equations,* which one can consider alternative interpretation of "*young age*" in connection to QCD.

Y.Z. Xu, S. Chen, Z.Q. Yao, D. Binosi, Z.F. Cui, & C.D. Roberts, Eur Phys J C **81**, 895 (**2021**)



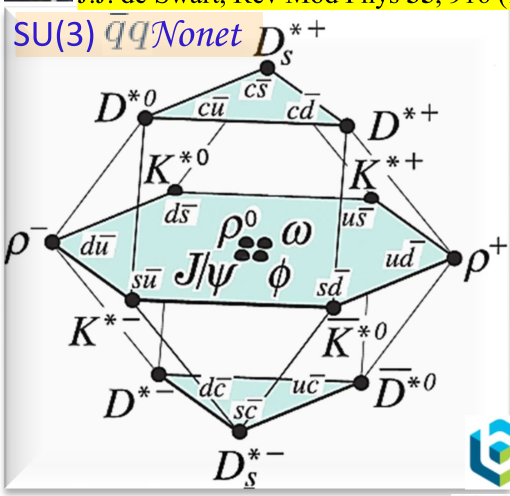
Vector Meson Nucleon Scattering Length Puzzle

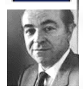


- Some *vector mesons* can, compared to other mesons, be measured to very high precision.
- This stems from fact that *vector mesons* have ***same*** quantum numbers as *photon*.

$(J^{PC}) = (1^{--})$

J.J. de Swart, Rev Mod Phys **35**, 916 (**1963**)





Name (PDG)	Quark Content	Γ (MeV)
$\rho^+(770)$	$u\bar{d}$	148
$\rho^0(770)$	$\frac{1}{\sqrt{2}}(u\bar{u} - d\bar{d})$	149
$\omega(782)$	$\frac{1}{\sqrt{2}}(u\bar{u} + d\bar{d})$	8.5
$K^{*+}(892)$	$u\bar{s}$	51
$K^{*0}(892)$	$d\bar{s}$	47
$\phi(1020)$	$s\bar{s}$	4.3
$D^{*+}(2010)$	$c\bar{d}$	0.083
$D^{*0}(2007)$	$c\bar{u}$	< 2.1
$J/\psi(1S)(3097)$	$c\bar{c}$	0.093
$\psi'(2S)(3686)$	$c\bar{c}$	0.284
$\Upsilon(1S)(9460)$	$b\bar{b}$	0.052
$T(1S)(?)$	$t\bar{t}$	?

~~To avoid broad ***width*** problem @ threshold, we are not considering this case to determine ρN SL.~~

Open Charm

Charmonium

There is difference between 1S & 2S states due to \`*zero*' in radial **WF**s.

Bottonium

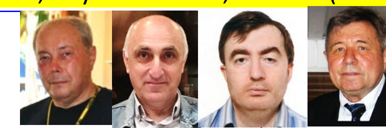
Toponium

It does not exist, due to large mass & t-quark decays faster than meson formation time..

- Let us focus on ~~4~~ **5** ***vector mesons*** from $\bar{q}q$ ***Nonet*** to study *meson photoproduction* @ threshold & where data are available.

Vector Meson – Nucleon SL Determination

IIS, D. Epifanov, & L. Pentchev, Phys Rev C **101**, 042201 (**2020**)
IIS, L. Pentchev, & A.I. Titov, Phys Rev C **101**, 045201 (**2020**)



- Small ***positive*** or ***negative*** *VN* ***SL*** may indicate weakly ***repulsive*** or ***attractive*** ***V**N* interaction if there is no *VN* bound state below experimental q_{min}.
- For evaluation of *absolute* value of *VN* ***SL***, we apply *VMD* approach that links near-threshold photoproduction *Xsections* of ***γp → Vp*** & elastic ***Vp → Vp***

$q \to 0$

$$\frac{d\sigma^{\gamma p\to Vp}}{d\Omega}\Big|_{thr} = \frac{q}{k}\frac{1}{64\pi}|T^{\gamma p\to Vp}|^2 = \frac{q}{k}\cdot\frac{\pi\alpha}{g_V^2}\frac{d\sigma^{Vp\to Vp}}{d\Omega}\Big|_{thr} = \frac{q}{k}\cdot\frac{\pi\alpha}{g_V^2}|\alpha_{Vp}|^2$$

V CM momentum

Photon CM momentum

k = (**s** – M²) / 2 **s**^1/2

Invariant amplitude of *V* photoproduction

$$g_V^2 = \frac{\pi\cdot\alpha^2\cdot m_V}{3\cdot\Gamma(V\to e^+e^-)}$$

Fine-structure constant

VMD coupling constant, related to ***V*** ***EM*** decay width ***Γ(V→ e⁺e⁻)***

- Absolute value *SL* is determined by interplay of *strong* (*hadronic*) & *EM* dynamics as:

$$\boxed{|\alpha_{Vp}| = h_{Vp}\, B_V}$$

where *hadronic* component is $\boxed{h_{Vp} = \sqrt{a}}$ & *linear term* **a** came from $\boxed{\sigma_t = a\,q + b\,q^3 + c\,q^5}$ ⇐ Experiment

pure *EM VMD*-motivated kinematic factor $\boxed{B_V^2 = \frac{\alpha\, m_V\, k}{12\,\pi\,\Gamma(V\to e^+e^-)}}$ ⇐ PDG

- For VN system, to avoid theor uncertainties, we do not
  - Determine *sign* of SL,
  - Separate Re & Im *parts* of **SL**,
  - Extract *total angular momentum* 1/2 & 3/2 contributions

Total Cross Sections for Vector Meson Photoproduction off Proton

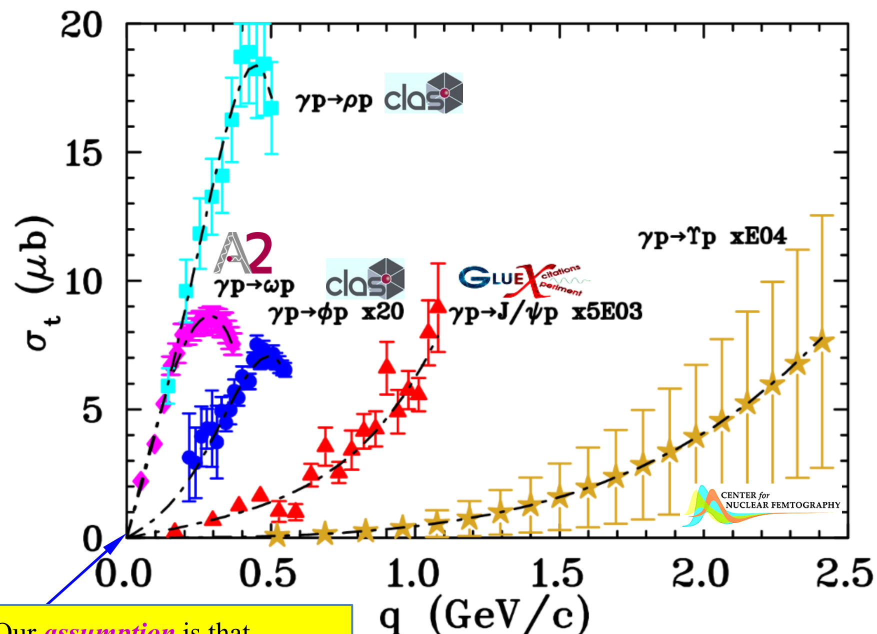
- Traditionally, σ_t behavior of near-threshold binary *inelastic* reaction

$$m_a + M_b < m_c + M_d$$

is described as series of ***odd*** powers in q
(*even* powers in case of *elastic*).

$$\boxed{\sigma_t = a\,q + b\,q^3 + c\,q^5}$$

- ***Linear*** term is determined by two independent ***S***-waves only with total spin *1/2* &/or *3/2*.
- Contributions to ***cubic*** term come from both ***P***-wave amplitudes & ***W*** dependence of ***S***-wave amplitudes,
- ***Fifth***-order term arises from ***D***-waves & ***W*** dependencies of ***S***- & ***P***-waves.



- Our *assumption* is that there are no *VN bound states* below experimental q_{min}.

a_ω = (4.42±0.14) x 10^{-2} μb/(MeV/c)
IIS, S. Prakhov, Ya. Azimov *et al*, Phys Rev C **91**, 045207 (2015)

a_ρ = (3.99±0.52) x 10^{-2} mb/(MeV/c)
IIS, V. Mokeev, E. Isupov, A. Schmidt, arXiv:2509.04672 [nucl-th]

a_ϕ = (0.34±0.12) x 10^{-3} μb/(MeV/c)
IIS, L. Pentchev, & A.I. Titov, Phys Rev C **101**, 045201 (2020)

$a_{J/\psi}$ = (0.43±0.12) x 10^{-6} μb/(MeV/c)
IIS, D. Epifanov, & L. Pentchev, Phys Rev C **101**, 042201 (2020)

a_Υ = (0.37±0.04) x 10^{-9} μb/(MeV/c)
IIS, W.J. Briscoe, L. Pentchev, & A. Schmidt, Phys Rev C **104**, 074028 (2021)

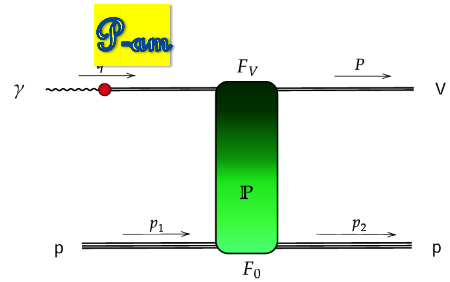
- Dramatic differences in hadronic factors $\boxed{h_{Vp} = \sqrt{a}}$, as slopes ($a$) of σ_t @ threshold as function of q varies significantly from ω to ϕ to J/ψ to Υ.

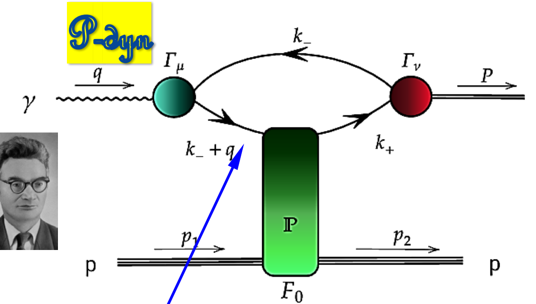
- Therefore, such big difference in *SL* is determined mainly by *hadronic* factor h_{Vp}.

for *VM Photoproduction*

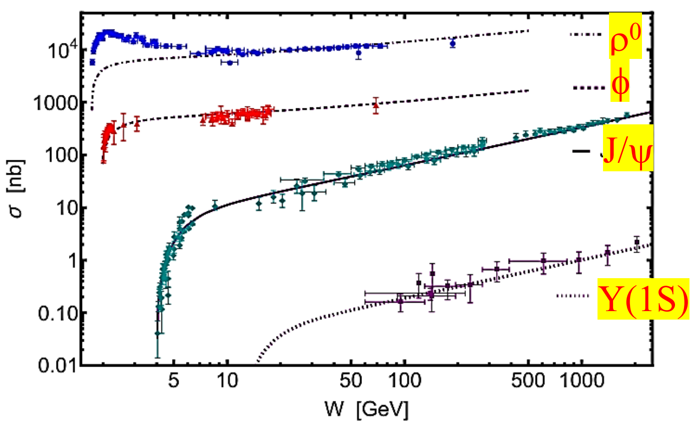
Lin Tang, Hui-Yu, Minghui Ding, & C.D. Roberts, arXiv:2510.08845 [hep-ph]

Abstract A reaction model for $\gamma + p \to V + p$, $V = \rho^0, \phi, J/\psi, \Upsilon$, which exposes the quark-antiquark content of the photon in making the transition $\gamma \to q\bar{q} + \mathbb{P} \to V$, where q depends on V, and couples the intermediate $q\bar{q}$ system to the proton's valence quarks via Pomeron ($\mathbb{P}$) exchange, is used to deliver a unified description of available data – both differential and total cross sections – from near threshold to very high energies, W, for all the V-mesons. For the Υ, this means $10 \lesssim W/\mathrm{GeV} \lesssim 2\,000$. Also provided are predictions for the power-law exponents that are empirically used to characterise the large-W behaviour of the total cross sections and slope parameters characterising the near-threshold differential cross sections. Appealing to notions of vector meson dominance, the latter have been interpreted as vector-meson–proton scattering lengths. The body of results indicate that it is premature to link any $\gamma + p \to V + p$ data with, for instance, in-proton gluon distributions, the quantum chromodynamics trace anomaly, or pentaquark production. Further developments in reaction theory and higher precision data are required before the validity of any such links can be assessed.





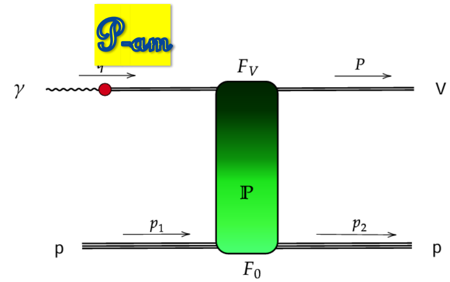
- Good description of data is mainly provided by explicit implementation of *upper quark loop*.
- Of course, there is NO reason for ***Pomeron*** dominance near thr.
- There is no fit to diff. & total Xsec & predictions are really good.
- For **ω** in such model, we have to expect (up to normalization) same results as that for **ρ**.

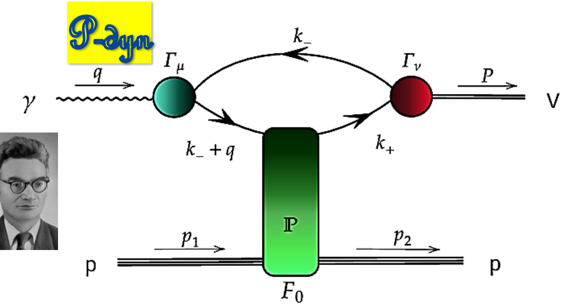


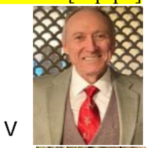
V	$\lvert\alpha^{\mathrm{dyn}}_{Vp}\rvert$/fm	$\lvert\alpha^{\mathrm{am}}_{Vp}\rvert$/fm	$\lvert\alpha^{\mathrm{VMD}}_{Vp}\rvert$/fm
ρ^0	0.136	0.072	0.23 ± 0.03
ϕ^0	0.087	0.048	0.063 ± 0.010
J/ψ	3.08×10^{-3}	1.88×10^{-3}	$3.08(55) \times 10^{-3}$
Υ	5.87×10^{-5}	1.86×10^{-5}	$0.51(3) \times 10^{-3}$

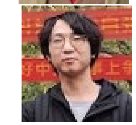
for *VM Photoproduction*

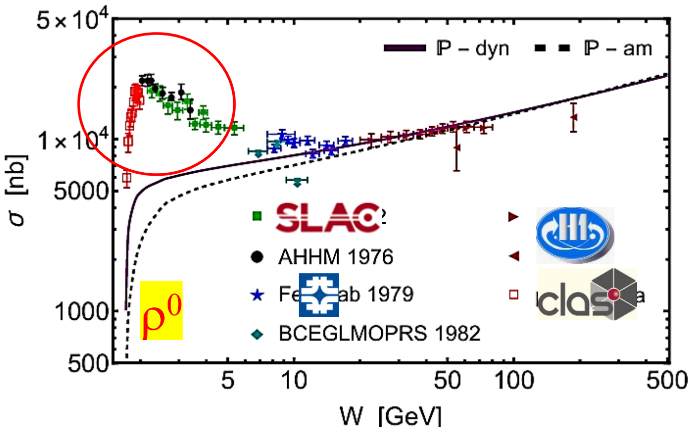
Lin Tang, Hui-Yu, Minghui Ding, & C.D. Roberts, arXiv:2510.08845 [hep-ph]

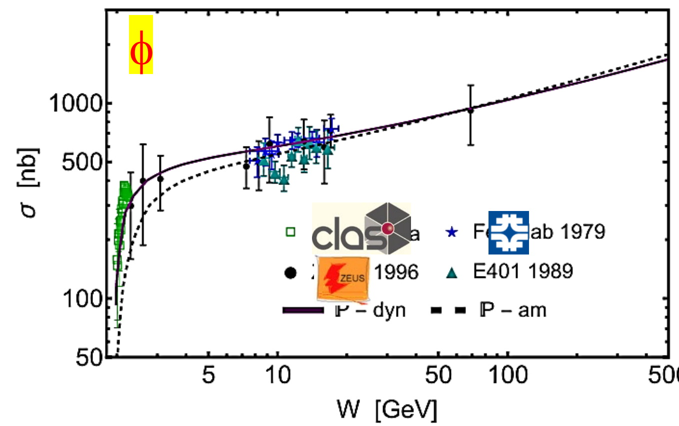


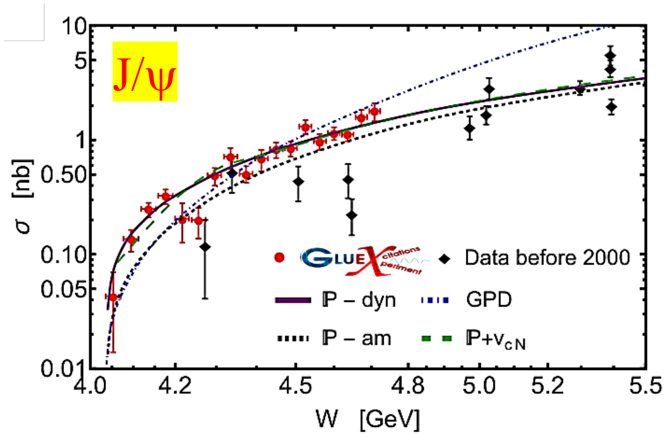


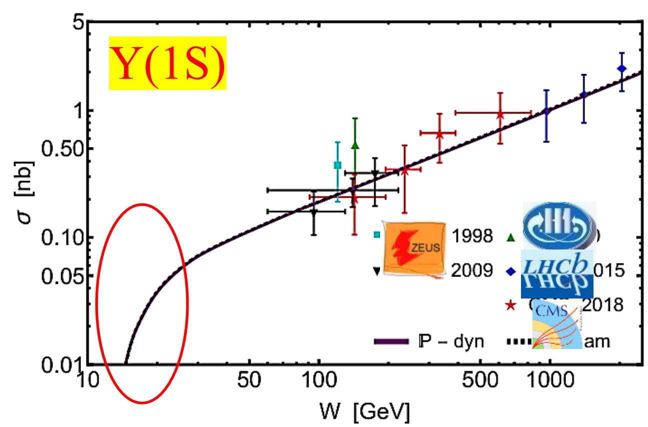








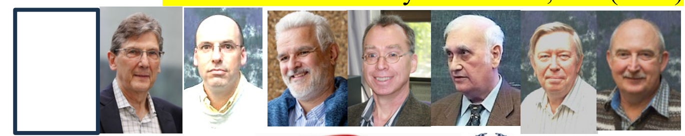




Extraction of Integrated $\gamma\, p \longrightarrow \rho\, p$ Xsec from CLAS Measurements

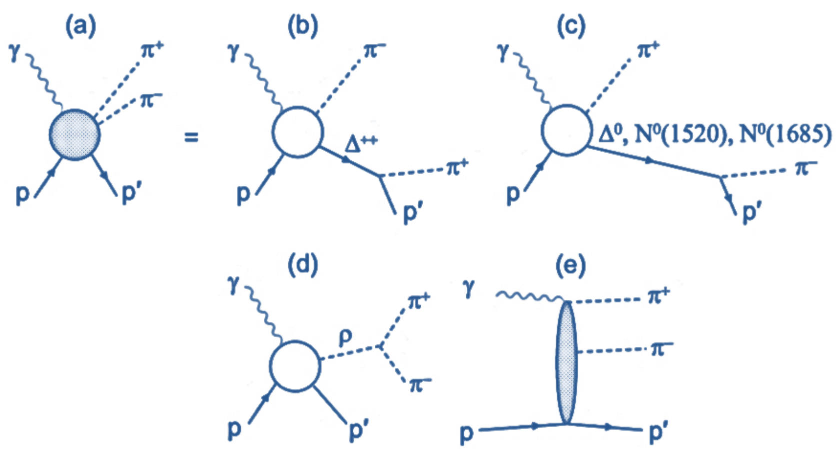
$\gamma p \to \rho p$ Xsec from CLAS

E. Golovatch *et al* Phys Let B **788**, 371 (**2019**)



Jefferson Lab

- Using *tree-level meson-baryon diagrams*, JM model allows us to extract total Xsec for reaction $\gamma p \to \rho p$ from CLAS data for $\gamma p \to \pi^+\pi^- p$.



- Analysis was carried out in bins of invariant mass of three-body final hadronic system, using 25 MeV bin widths & covering W=1.6-2.0 GeV.
- Each of **nine** one-fold differential $\pi^+\pi^- p$ Xsec was evaluated as integral of common five-fold differential Xsec, which fully determined kinematics of final $\pi^+\pi^- p$ state, over different sets of **four** variables.

- Nucleon resonances contribute through $\pi^-\Delta^{++}$, ρp, & $\pi^+\Delta^0$ channels.
- For evaluation of $\gamma p \to \rho p$ Xsec, we use resonance parameters determined from fits to CLAS $\pi^+\pi^- p$ photoproduction data.

$\gamma p \rightarrow \rho p$ Xsec from clas

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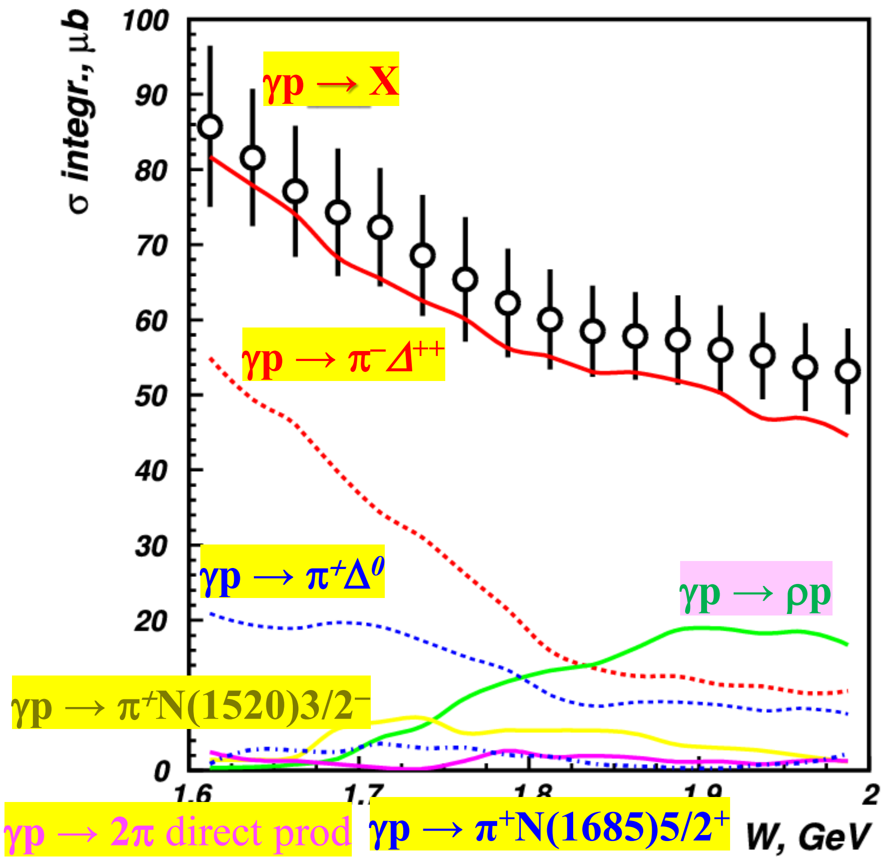
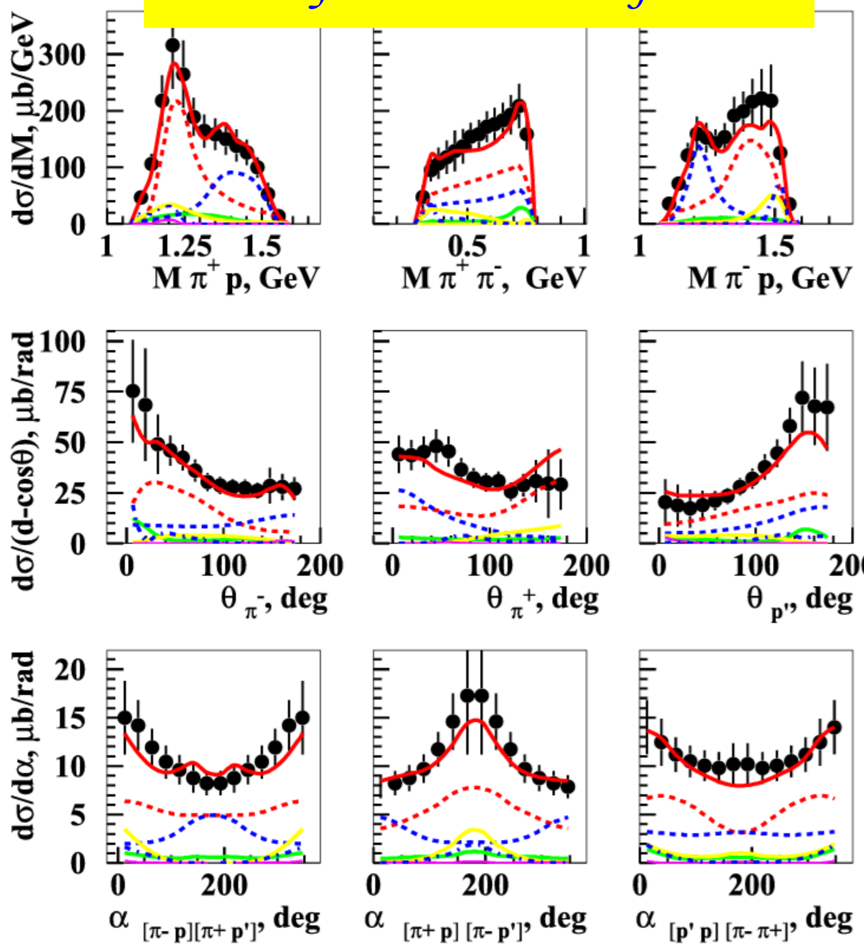
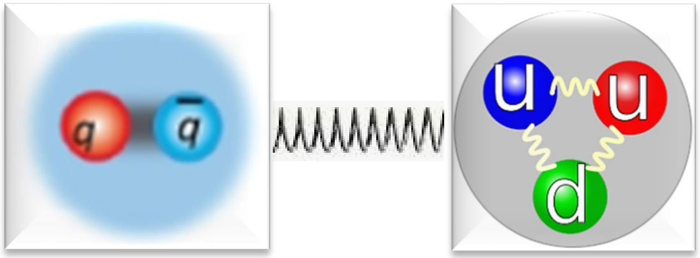
Example of ***nine*** *one-fold diff Xsec @ W from 1.70 to 1.73 GeV*

Fully integrated Xsec

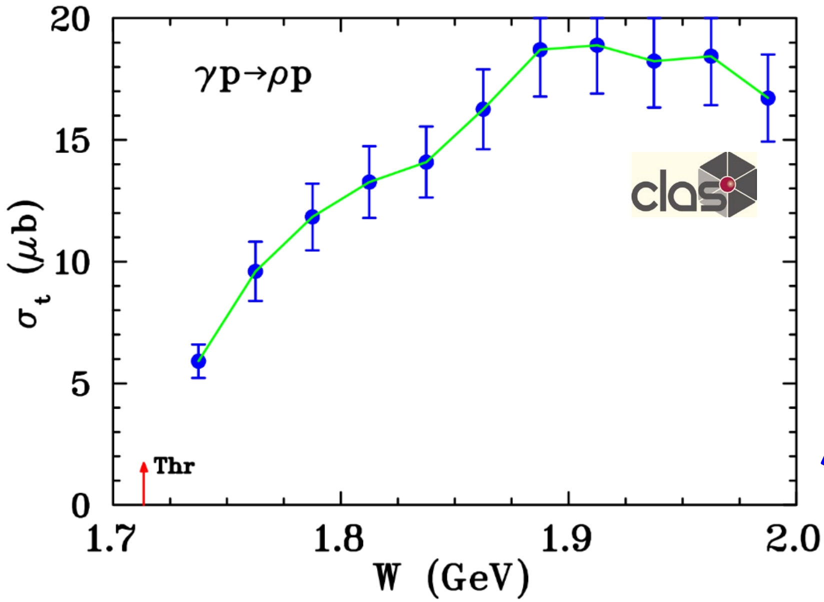




ρ & ω Proton SLs



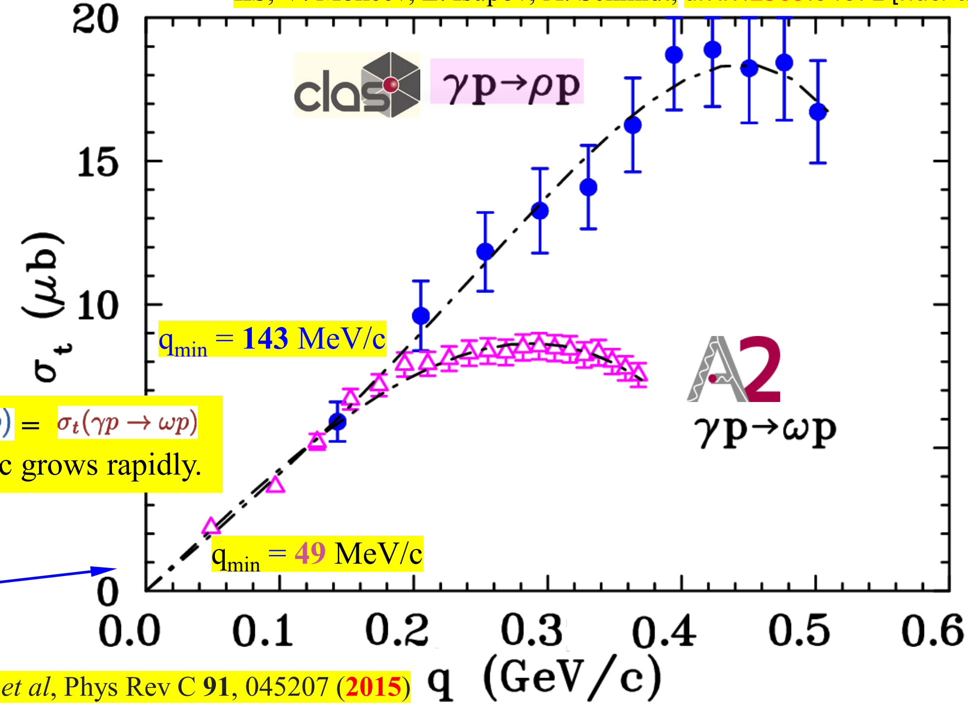
SLs of Light Vector Mesons from Photoproduction



E. Golovatch *et al* Phys Let B **788**, 371 (**2019**)

Meson	q_{min} (MeV/c)	$\Gamma(V \to e^+e^-)$ (keV)	$\|\alpha_{Vp}\|$ (fm)
$\rho(770)$	143	7.04±0.06	0.23±0.03
			0.24±0.02
$\omega(782)$	49	0.60±0.02	0.82±0.03
			0.97±0.16
			0.811±0.019

IIS, V. Mokeev, E. Isupov, A. Schmidt, arXiv:**2509**.04672 [nucl-th]



@ q < 200 MeV/c $\sigma_t(\gamma p \to \rho p)$ = $\sigma_t(\gamma p \to \omega p)$
Then ρp photoproduction Xsec grows rapidly.

- We assume that there are no ρN bound states below q_{min}, or that effect is minimal & consistent with Xsec errs.
- There is no evidence for manifestation of res-like structure in q-evolution of γp → ρp Xsec.

IIS, S. Prakhov, Ya. Azimov *et al*, Phys Rev C **91**, 045207 (**2015**)

Intermediate Summary

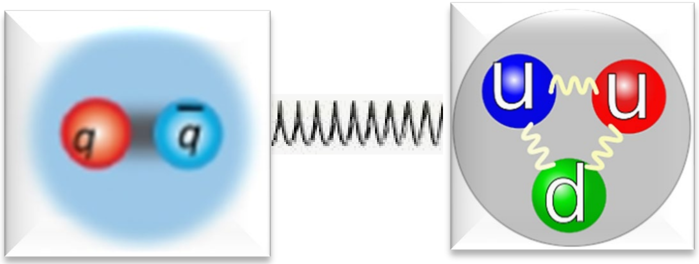
- We found that ρ-nucleon **SL** result is by factor of **4** smaller than size of hadron & phenomenological determination of ω-nucleon **SL** using *threshold* photoproduction Xsec.

IIS, V. Mokeev, E. Isupov, A. Schmidt, arXiv:2509.04672 [nucl-th]

- Dynamical coupled-channel approach addresses analysis of $\pi^- p \to \omega n$ was performed to determine $\alpha_{\omega p}$.
- Channel space of πN, $\pi\Delta$, σN, ρN, ηN, $K\Lambda$, & $K\Sigma$ is extended by adding ωN final state.
- This approach is free from VMD model contribution.
- Authors reported two best-fit results: $\boxed{\alpha_{\omega p} = -0.24 + i\ 0.05\ \mathrm{fm}}$ & $\boxed{\alpha_{\omega p} = -0.21 + i\ 0.05\ \mathrm{fm}}$.
- Let us point out that we obtained ReSL > ImSL, which is natural for threshold dynamics.

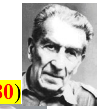
Y.F. Wang, D. Roenchen, U.G. Meißner, Y. Lu, C. W. Shen, J.J. Wu, Phys Rev D **106**, 094031 (2022)

Vector Meson Nucleon Scattering Puzzle



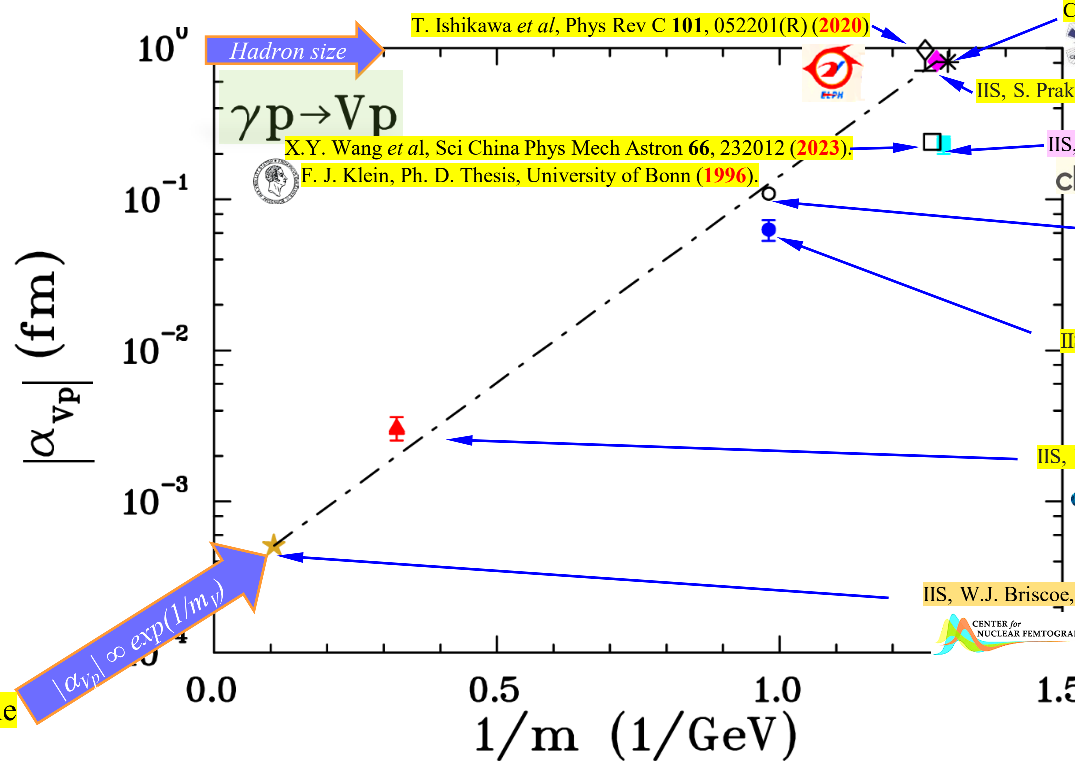
Can Young's Hypothesis Explain Vector Meson – Nucleon SL Puzzle?

- Due to ***small size*** of "*young*" *V* vs "*old*" *V*, measured & predicted ***SL*** is very small.
- *V* created by photon @ threshold, then most probably *V* is not *formed completely* & its radius is smaller than that for normal ("*old*") *V*.
- Therefore, one observes stronger suppression for ***Vp*** interaction.



E.L. Feinberg, Sov Phys Usp, **23**, 629 (**1980**)
Courtesy of Misha Ryskin, July **2020**

$|\alpha_{\Upsilon p}| \ll |\alpha_{J/\psi p}| \ll |\alpha_{\phi p}| \ll |\alpha_{\omega p}| < |\alpha_{\rho p}|$



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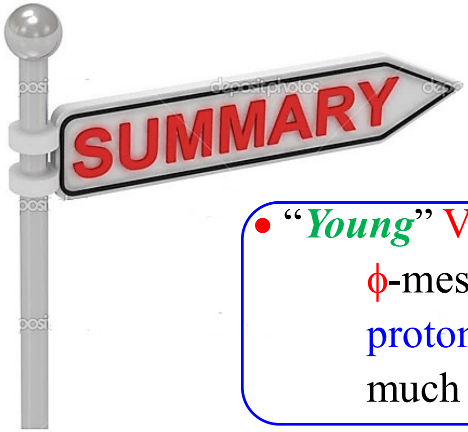
S. Adhikari *et al*, Phys Rev C **108**, 025201 (**2023**)
A. Ali *et al*, Phys Rev Lett **123**, 072001 (**2019**)
IIS, W.J. Briscoe, L. Pentchev, & A. Schmidt, Phys Rev C **104**, 074028 (**2021**)
Y. Guo, X. Ji, & Y. Liu, Phys Rev D **103**, 096010 (**2021**)

Hypothetical Line

- ***p→V*** coupling $\bar{q}q$ is proportional to α_s & *separation* of corresponding quarks.
- This *separation* (in *zero approximation*) is proportional to $1/m_V$.

Summary



- “*Young*” V hypothesis may explain fact that obtained SL value for ϕ-meson nucleon, compared to typical hadron size of 1 fm, indicates that proton is more transparent for ϕ-meson compared to ω-meson & is much less transparent than J/ψ-meson.

$|\alpha_{\Upsilon p}| << |\alpha_{J/\psi p}| << |\alpha_{\phi p}| << |\alpha_{\omega p}| < |\alpha_{\rho p}|$!

- Our result for ρN SL is factor of 4 smaller than phenomenological determination of ωN SL using threshold photoproduction Xsec.

- & ability allows us to understand dynamics of $s\bar{s}$ & $c\bar{c}$ & $b\bar{b}$ production @ threshold.

- Further studies on both *nucleons* & *nuclei* in *heavy* V photo- & electro-production will significantly extend our knowledge of gluonic structure of nuclear matter.

- J-PARC able to measure $\pi^- p \to \phi n$ & $\pi^- p \to J/\psi\ n$ @ thresholds, which are free from VMD, that is important input to phenomenology (PWA).

- *Polarized measurements* are important contribution to model-independent PWA.

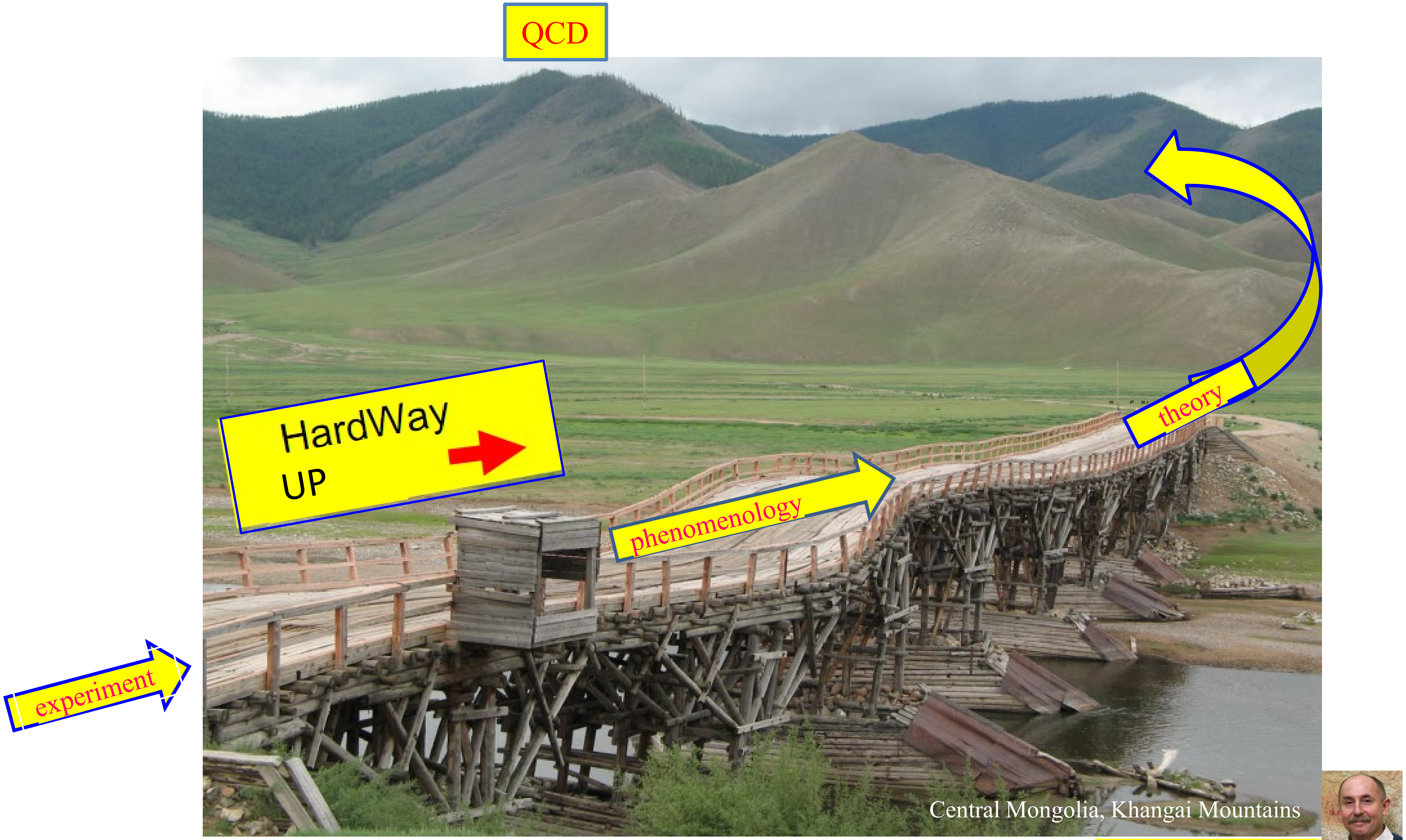


Photo of Pavel Azimov

Do you have any questions to speaker?

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