Vector-Meson-Nucleon Scattering Length from Omega to Upsilon

Igor Strakovsky & William Briscoe

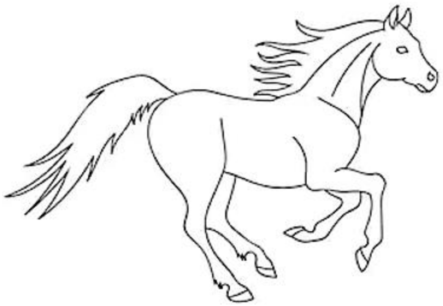
The George Washington University

J/ψ photoproduction is sample of hard processes corresponding to relatively large scale $\mu_c \sim (0.5 - 1)M_{J/\psi}$

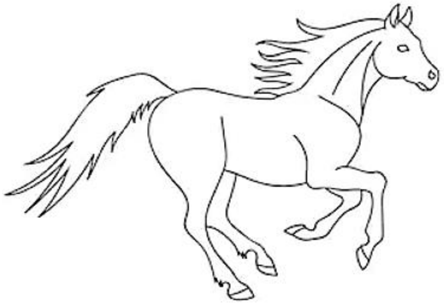
J/ψ is 'small size' object which can be used to study internal structure of proton (hadron), like in DIS case but now J/ψ feels not electric charge but gluon distribution

Supported by DE-SC0016583

Outline



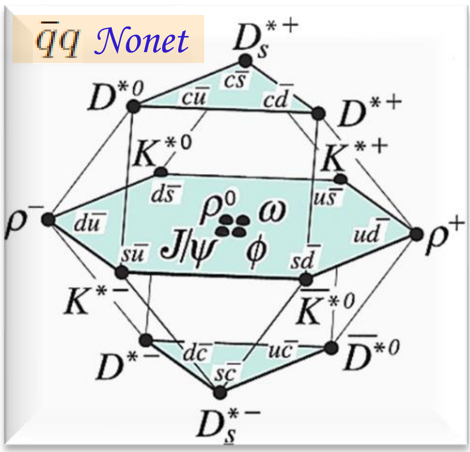
- Vector-Meson domestic Zoo.
- Vector-Meson – Nucleon *SL*.
- Brief tour through experiments.
- Total cross section fits.
- Brief tour through *SLs*.
- Expectation from EIC
- Summary.



Vector-Meson Domestic Zoo

- 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***.

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

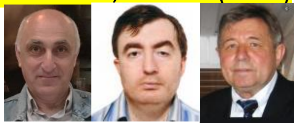


Name (PDG)	Quark Content	Γ (MeV)	
$\rho^+(770)$	$u\bar{d}$	148	
$\rho^0(770)$	$\frac{1}{\sqrt{2}}(u\bar{u} - d\bar{d})$	149	
$\omega(782)$	$\frac{1}{\sqrt{2}}(u\bar{u} + d\bar{d})$	8.5	
$K^{*+}(892)$	$u\bar{s}$	51	
$K^{*0}(892)$	$d\bar{s}$	47	
$\phi(1020)$	$s\bar{s}$	4.3	
$D^{*+}(2010)$	$c\bar{d}$	0.083	*Open Charm*
$D^{*0}(2007)$	$c\bar{u}$	< 2.1	
$J/\psi(1S)(3097)$	$c\bar{c}$	0.093	*Charmonium*
$\Upsilon(1S)(9460)$	$b\bar{b}$	0.052	*Quarkonium*

- We will focus on **4** vector-mesons from $\bar{q}q$ ***Nonet*** which widths are **narrow** enough to study meson photoproduction @ threshold & where data are available.

Vector-Meson – Nucleon Scattering Length Determination

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



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

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

k is photon CM momentum $k = (s - M^2) / 2\, s^{1/2}$

q is *vector-meson* CM momentum

$T^{\gamma p\to Vp}$ is the invariant amplitude of *vector-meson* photoproduction

α is fine-structure constant

g_V is VMD coupling constant, related to *vector-meson* ***EM*** decay width $\Gamma_{V\to e+e-}$

$$g_V^2 = \pi\alpha^2 m_V / 3\Gamma_{V\to e^+e^-}$$

- Finally, one can express absolute value of *SL* as product of pure ***EM*** VMD-motivated kinematic factor

$R_V^2 = \alpha m_V k / 12\pi\Gamma_{V\to e^+e^-}$ & $h_{Vp}^2 = b_1$ where b_1 came from best fit $\sigma_t = b_1 q + b_3 q^3 + b_5 q^5$

that is determined by interplay of strong (hadronic) & ***EM*** dynamics as

$$|\alpha_{Vp}| = R_V h_{Vp}$$

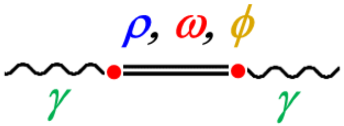
- To ***avoid*** theoretical uncertainties, we did not
  - determine sign of ***SL***,
  - separate Re & Im parts of ***SL***,
  - extract *spin* **1/2** & **3/2** contributions.

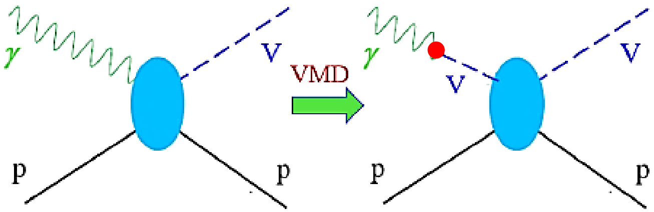
VMD Approach


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

M. Gell-Mann & F. Zachariasen, Phys Rev **124**, 953 (1961)
J.J. Sakurai, *Currents and Mesons* (The University of Chicago Press, Chicago, 1969)
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.

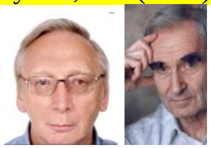
VMD for $J/\psi N$ Interaction

- There is no alternative VMD to get ***J/ψ p SL*** from meson photoproduction.

Courtesy of Arkady Vainshtein & Michael Ryskin, July 2020

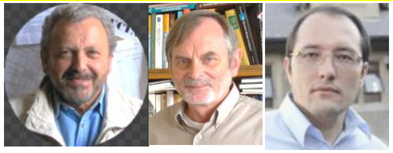
- To estimate theoretical uncertainty related to VMD model, one refer to estimation of cross section of ***J/ψ*** photoproduction in *peripheral model* & found strong energy dependence close to threshold because non-diagonal ***$\gamma p \rightarrow Vp$*** & elastic *$Vp \rightarrow Vp$* must have larger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

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

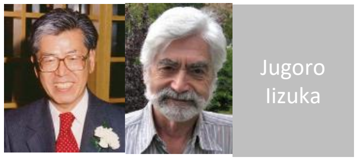


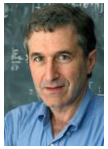
- **Color** factor for *charmonium* is **1**/**9** while for *open charm* is **8**/**9**.

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



- Additional suppression factor for $J/\psi N$ interaction @ threshold is **OZI** rule. **OZI** suppressed processes have larger number of independent fermion loops compared with non-suppressed processes.





Courtesy of Boris Kopeliovich & Bob Jaffe, June 2020

VMD Approach: EM Factor

VMD coupling constant

$g_V^2 = \pi\alpha^2 m_V / 3\Gamma_{V\to e^+e^-}$

EM factor

$R_V^2 = \alpha m_V k / 12\pi\Gamma_{V\to e^+e^-}$

PDG particle data group	V	m_V	$\Gamma_{V\to e^+e^-}$	g_V	R_V
		(MeV)	(keV)		(MeV$^{1/2}$)
	ω	782.65	0.60±0.02	8.53±0.14	390.5±6.4
	ϕ	1019.461	1.27±0.04	6.69±0.10	342.5±5.3
	J/ψ	3096.916	5.55±0.11	5.58±0.07	454.9±4.1
	Υ	9460.30	1.340±0.018	19.84±0.14	2655.0±162.2

- *EM* factor R_V for each vector-meson are close to each other.

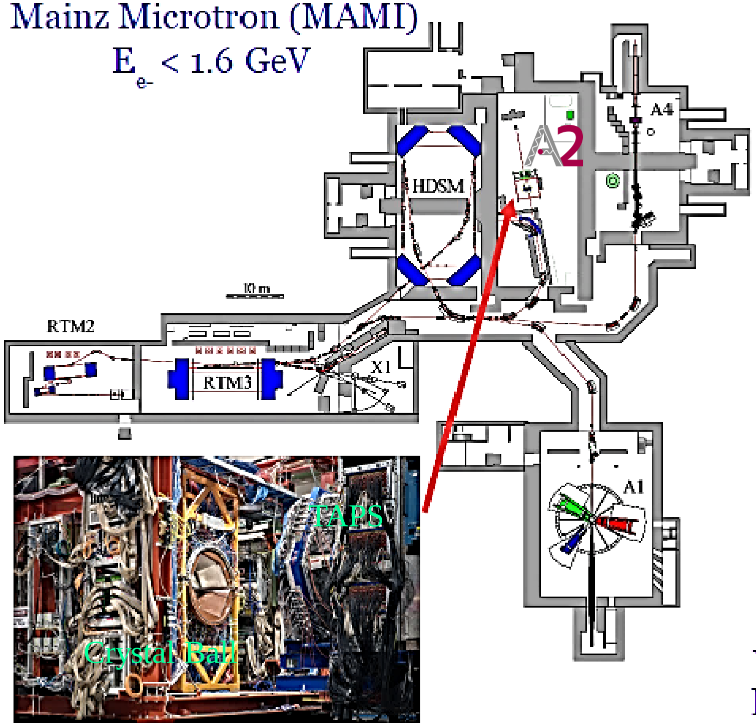
A2

MAMI in 2021

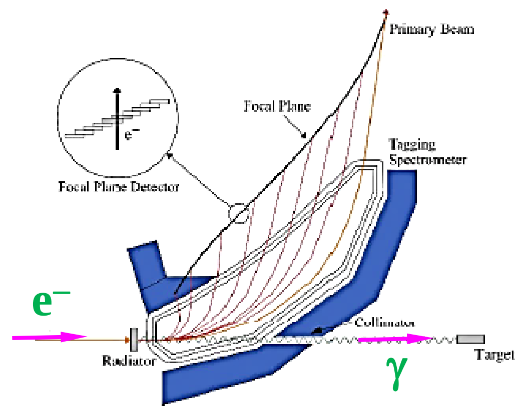
- ● [Crystal Ball] was build @ SLAC & used in *J*/*ψ* measurements @ SPEAR3 & *b* quark physics @ DESY.

  Then [Crystal Ball] worked @ BROOKHAVEN NATIONAL LABORATORY for physics of *hadrons* & it is @ MAMI now.

Mainz Microtron (MAMI)
$E_{e-} < 1.6$ GeV



Tagger/End point tagger



$$E_\gamma = E_{e-} - E_{tagg}$$

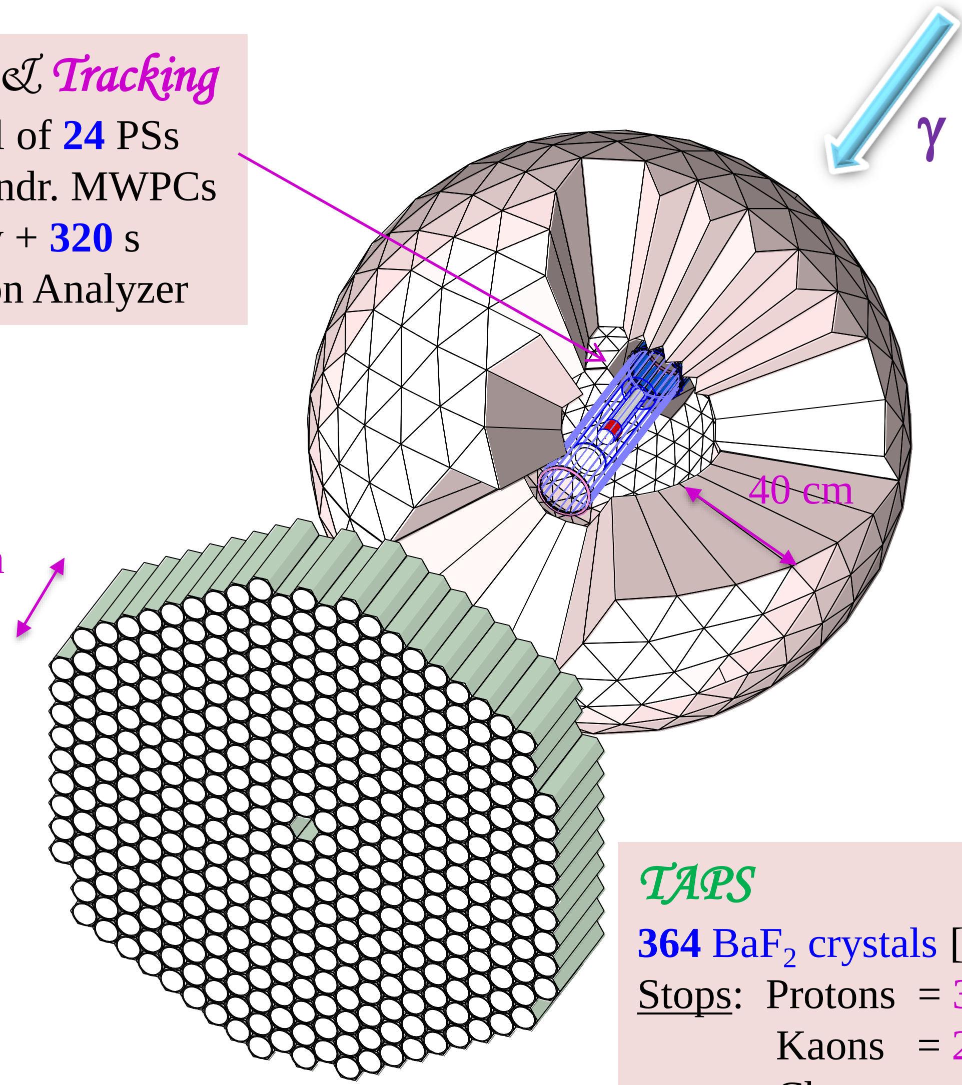
Upgrade → experiments with ~4 times higher rates ~~will be~~ possible!

- High-Flux, Tagged, Bremsstrahlung Photon Beam: Unpolarized, Linear, and Circular
- Polarized and Unpolarized Targets
- Recoil polarimeter

Crystal Ball, TAPS, & Tracking

PID & Tracking

Barrel of **24** PSs
2 cylindr. MWPCs
480 w + **320** s
Carbon Analyzer



Crystal Ball

672 NaI(Tl) crystals [20–160°]
Stops: Protons = 420 MeV
Kaons = 340 MeV
Chrg. p = 240 MeV
Chrg. m = 230 MeV

$\sigma(E) = 2$ MeV
$\sigma(\theta) = 2.5^{o}$
$\sigma(\phi) = 2^{o}/\sin\theta$

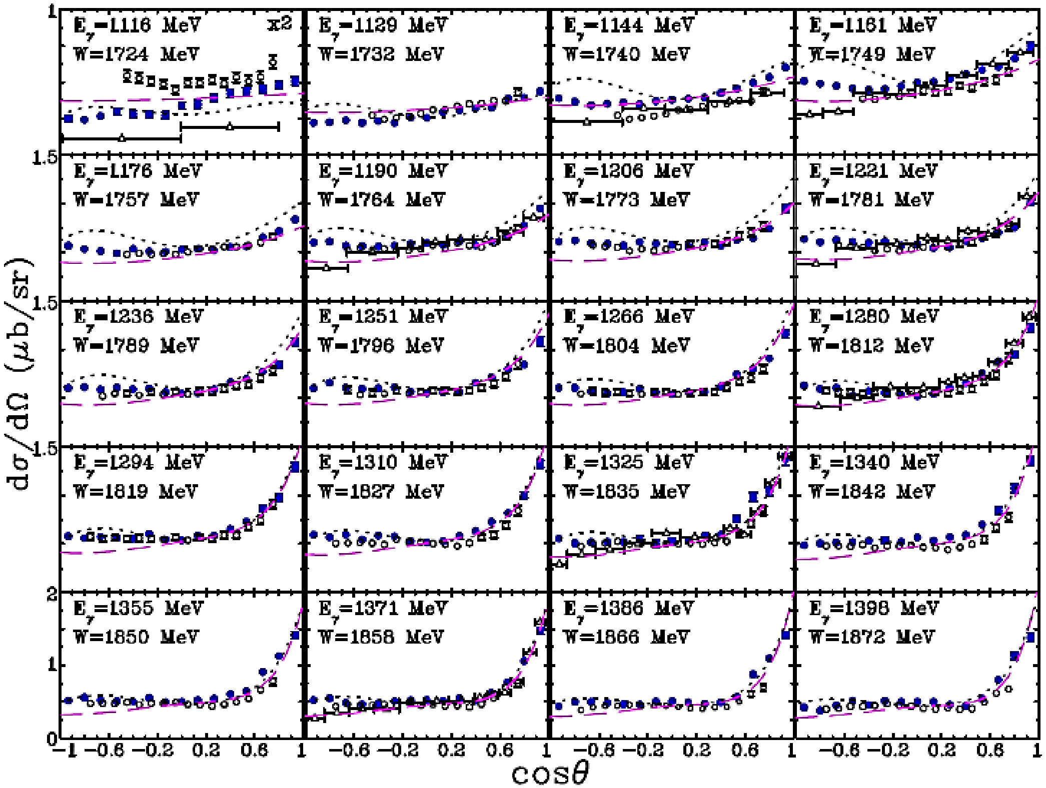
TAPS

364 BaF_2 crystals [0–20°]
Stops: Protons = 360 MeV
Kaons = 280 MeV
Chrg. p = 180 MeV

$\gamma p \rightarrow \omega p \rightarrow \pi^0 \gamma p \rightarrow 3\gamma p$ Measurements

BR=8.4%

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

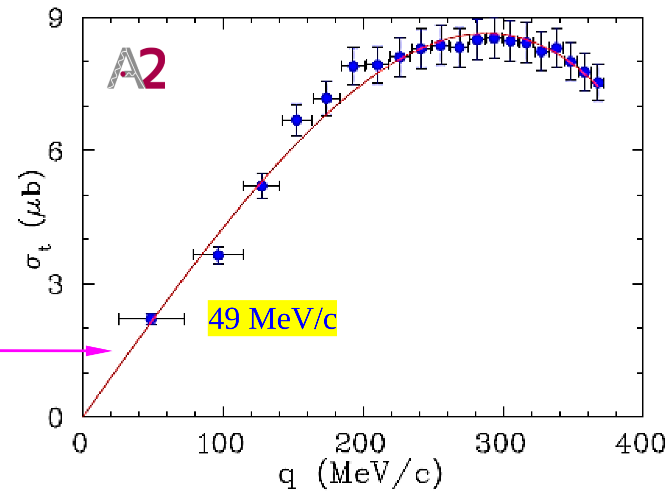


- Full production-angle coverage allows to determine σ_t.
- Legendre polynomial extension

$$d\sigma/d\Omega(E_\gamma, \cos\theta) = \sum_{j=0} A_j(E_\gamma) P_j(\cos\theta)$$

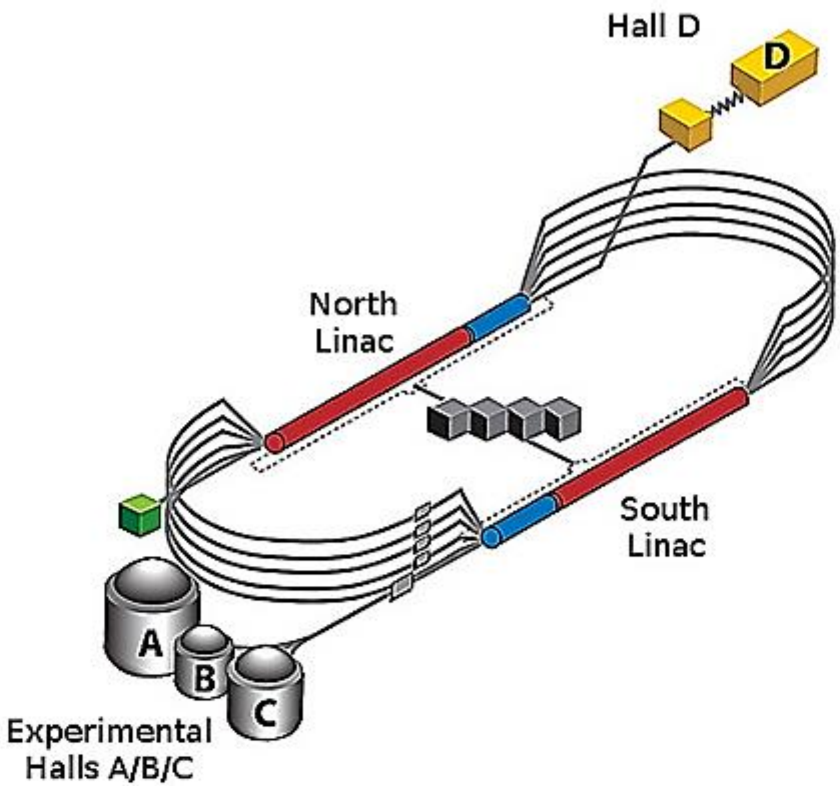
confirms σ_t determination

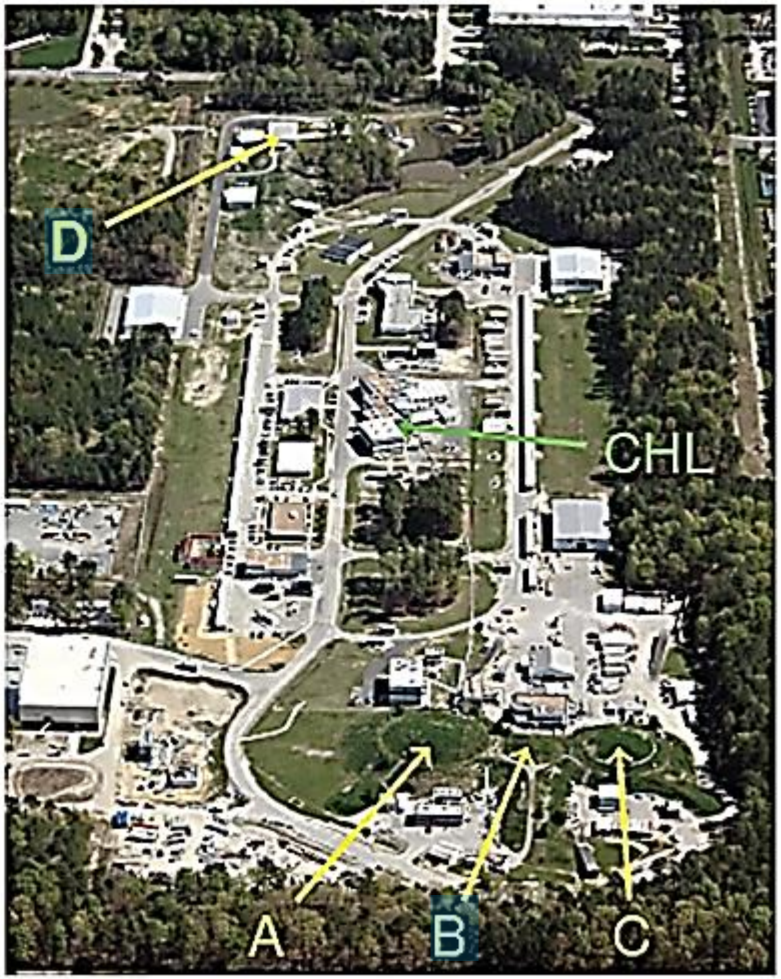
$$\sigma_t = 4\pi A_0(E_\gamma)$$



$$\sigma_t = b_1 q + b_3 q^3 + b_5 q^5$$

Jefferson Lab *in 2021*

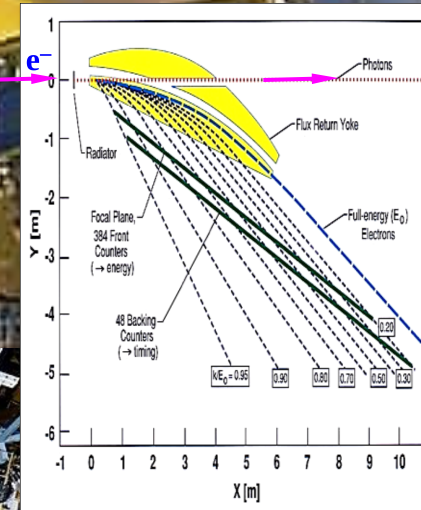




- Accelerator: 2.2 GeV/pass
- Halls A,B,C: e^- 1-5 passes $\leq$11 GeV
- Hall D: e^- 5.5 passes 12 GeV $\Rightarrow$ γ-beam
- Runs 2017-2018: 5.5 passes 11.7 GeV

CEBAF Large Acceptance Spectrometer 1997-2012

Bremsstrahlung Photon Tagger
384 E & 61 T Counters

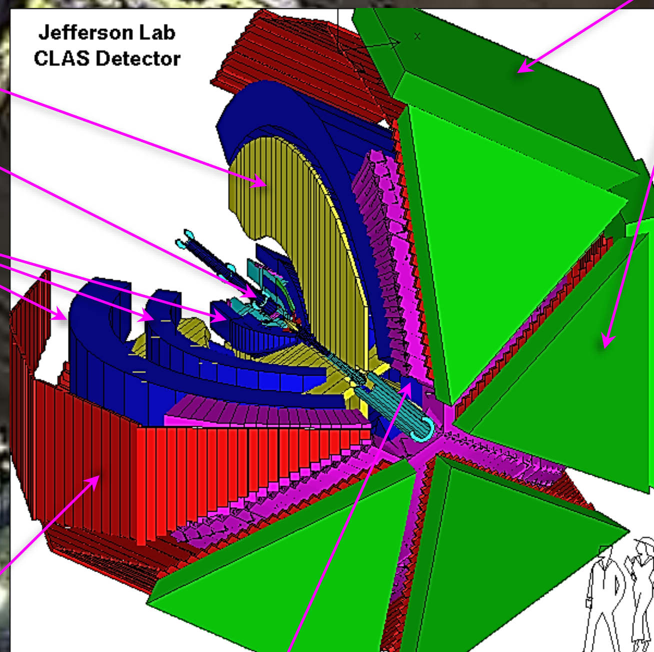


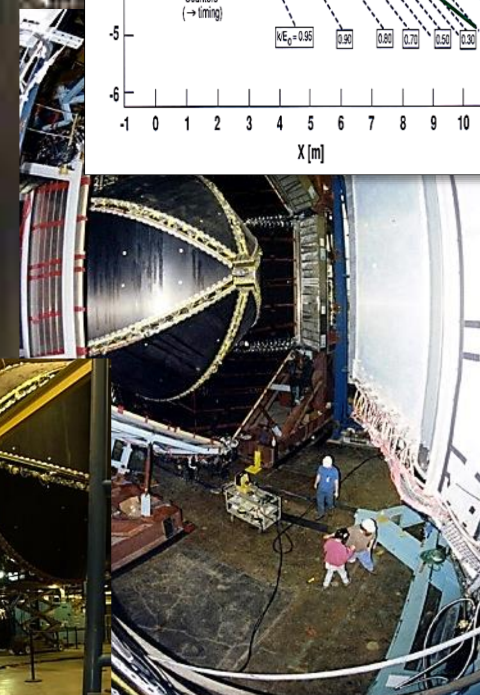
Electromagnetic Calorimeters
Lead/Scintillator, 1296 PMTs

Torus Magnet
6 Superconducting Coils

Target + Start Counter

Drift Chambers
35,000 cells





Time-of-Flight Counters
Plastic Scintillators, 684 PMTs

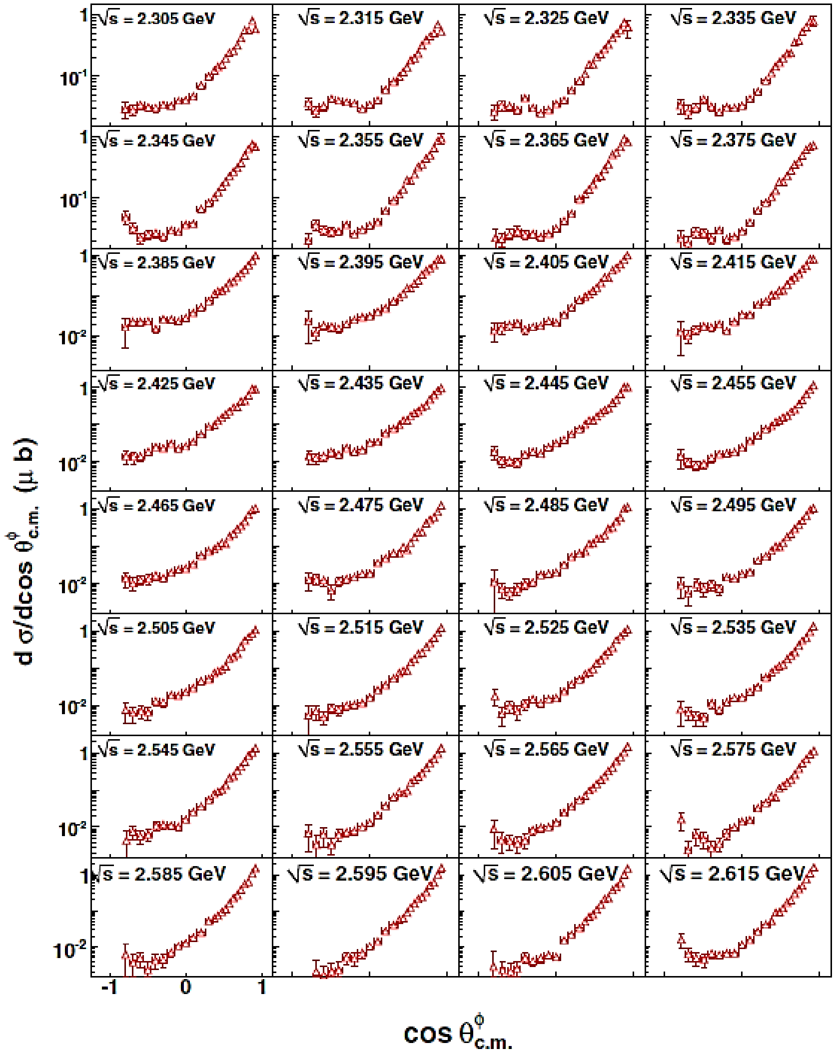
Gas Cherenkov Counters
e/π separation, 256 PMTs

B.A. Mecking *et al*. Nucl Inst Meth A **503**, 513 (2003)

$\gamma p \to \phi p \to K^+K^- p$ Measurements

BR=49.2%

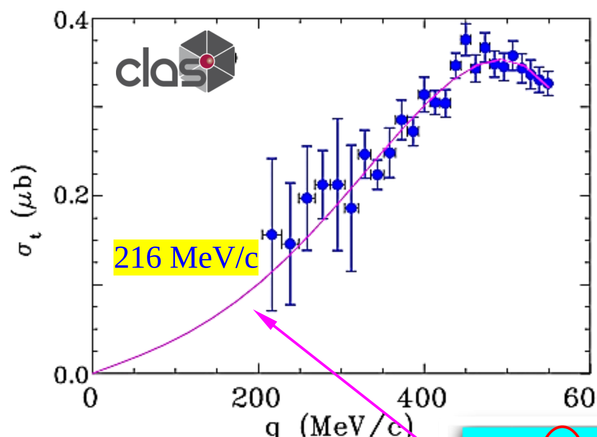
B. Dey *et al*, Phys Rev C **89**, 055208 (2014)



- *$\cos\theta$* of CLAS spans from -0.80 to 0.93.
- Legendre polynomial extension

$$d\sigma/d\Omega(E_\gamma, \cos\theta) = \sum_{j=0} A_j(E_\gamma) P_j(\cos\theta)$$

is way to determine σ_t $\quad \sigma_t = 4\pi A_0(E_\gamma)$



$$\sigma_t = b_1 q + b_3 q^3 + b_5 q^5$$

IS, L. Pentchev, & A.I. Titov, Phys Rev C **101**, 045201 (2020)

2nd paper

PHYSICAL REVIEW LETTERS **123**, 072001 (2019)

Editors' Suggestion

First Measurement of Near-Threshold J/ψ Exclusive Photoproduction off the Proton

(GlueX Collaboration)

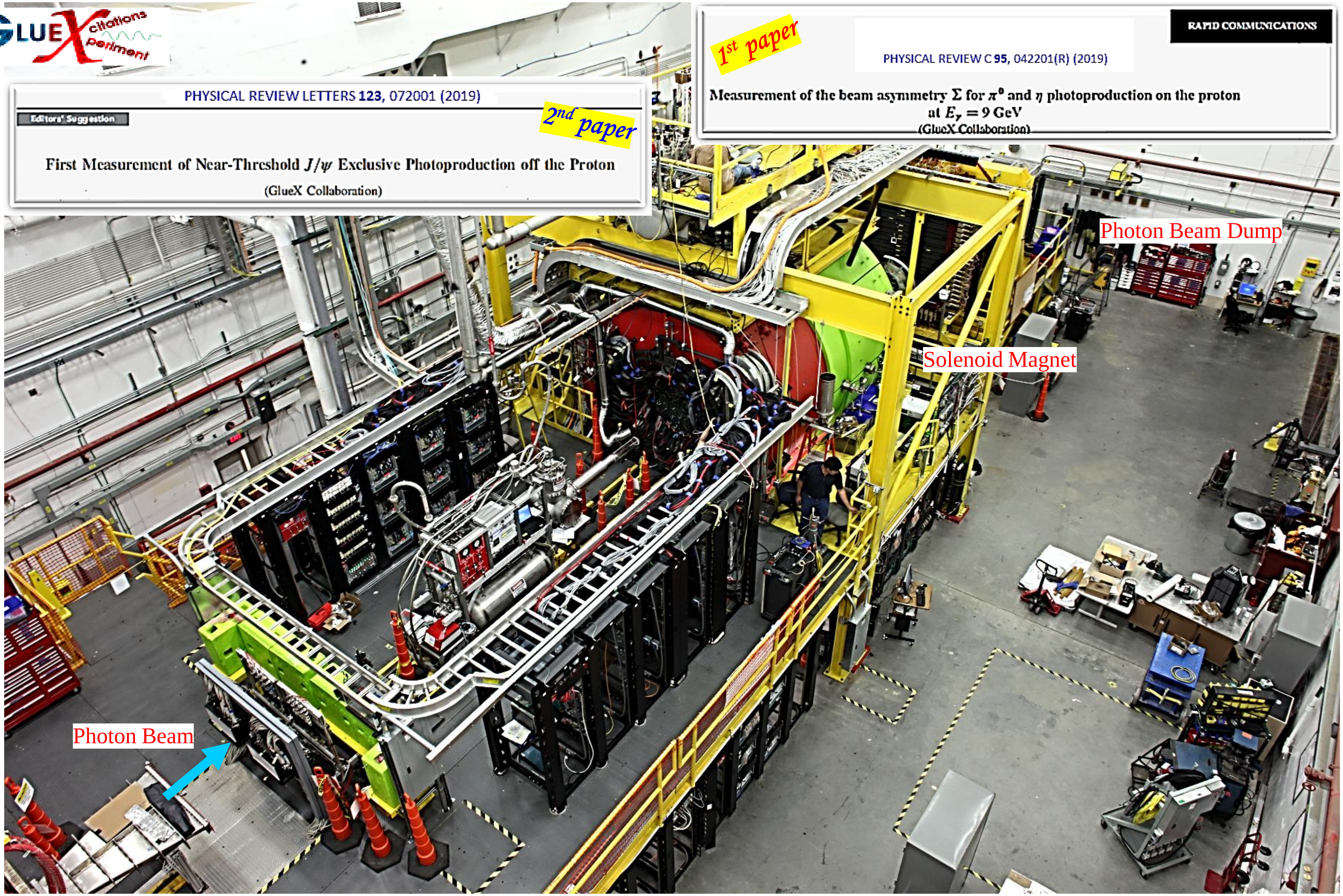
1st paper

RAPID COMMUNICATIONS

PHYSICAL REVIEW C **95**, 042201(R) (2019)

Measurement of the beam asymmetry Σ for π^0 and η photoproduction on the proton at $E_\gamma = 9$ GeV

(GlueX Collaboration)



GlueX Statistics: above 8.2 GeV

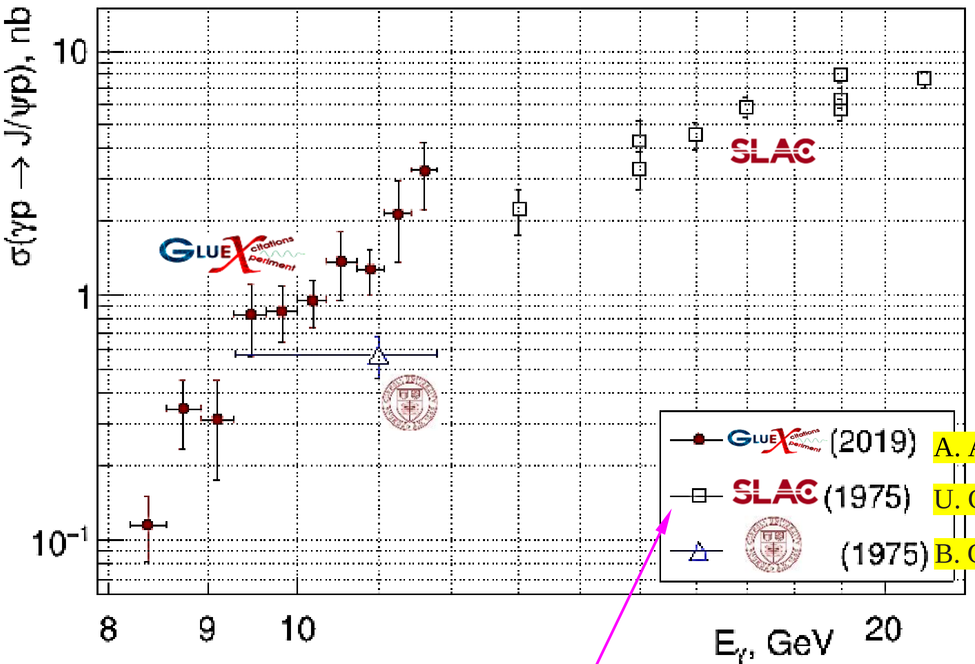
Spring 2016: 10 pb^{-1}
Spring 2017: 58 pb^{-1}

25% of total statistics (2016-2018) up to date.

Total Xsection for $\gamma p \to J/\psi p \to e^+e^- p$ @ J/ψ Threshold

BR=5.97%   A. Ali *et al*, Phys Rev Lett **123**, 072001 (2019)

$$\sigma_{J/\psi}(E_\gamma) = \frac{N_{J/\psi}(E_\gamma)}{N_{BH}(E_\gamma)} \frac{\sigma_{BH}(E_\gamma)}{\mathcal{B}_{J/\psi}} \frac{\varepsilon_{BH}(E_\gamma)}{\varepsilon_{J/\psi}(E_\gamma)}$$



A. Ali *et al*, Phys Rev Lett **123**, 072001 (2019)

U. Camerini *et al*, Phys Rev Lett **35**, 483 (1975)

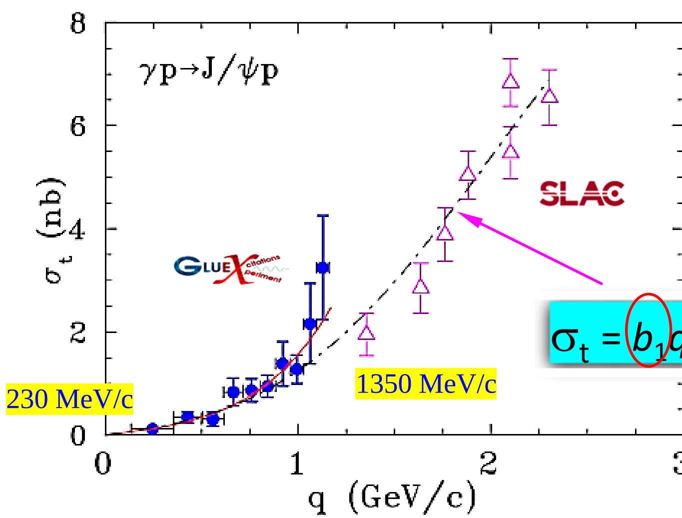
B. Gittelman *et al*, Phys Rev Lett **35**, 1616 (1975)

- Yields [$N(J/\psi)$ & N(BH)] extracted from fits of $M(e^+e^-)$ & E/p in bins of energy.
- σ(BH) calculated using analytical & numerical results of *EM* tree level diagrams.
- Syst errors of individual data points assigned to max deviation when varying fitting methods.
- Errors dominated by statistics.

- SLAC experiment measured $d\sigma/dt$ at $t = t_{min}$ as function of E_γ.
- To determine σ_t from SLAC data, GlueX used dipole t-dependence.

New J/ψ-p Scattering Length

- All previous *theoretical* results (including *potential* approaches & *LQCD* calculations) gave much-much larger *SL*.



$\sigma_t = b_1 q + b_3 q^3 + b_5 q^5$

- There is *no discrepancy* between
  GlueX A. Ali *et al*, Phys Rev Lett **123**, 072001 (2019)
  &
  SLAC U. Camerini *et al*, Phys Rev Lett **35**, 483 (1975)
  data.

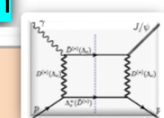
a_i	GlueX	GlueX & SLAC
a_1 [nb/(GeV/c)]	0.46 ± 0.16	0.53 ± 0.12
a_3 [nb/(GeV/c)^3]	0.83 ± 0.91	0.78 ± 0.16
a_5 [nb/(GeV/c)^5]	0.28 ± 0.87	-0.06 ± 0.03
χ^2/dof	0.67	0.98

IS, D. Epifanov, & L. Pentchev, Phys Rev C **101**, 042201 (2020) — Input: σ_t from GlueX — $|\alpha_{J/\psi p}|$ = (**3.08**$\pm$**0.55**(stat)$\pm$**0.42**(syst)) am

L. Pentchev & IS, Eur Phys J A **57**, 56 (2021) — Input: $d\sigma/dt$ from GlueX — $|\alpha_{J/\psi p}|$ = (**3.64...24.5**) am depends on treatment

O. Gryniuk & M. Vanderhaeghen, Phys Rev D **94**, 074001 (2016) — Input: $d\sigma/dt$ & σ_t from SLAC — $|\alpha_{J/\psi p}|$ = (**46**$\pm$**5**) am

Meng-Lin Du, V. Baru, Feng-Kun Guo, Ch. Hanhart, U.-G. Meissner, A. Nefediev, & IS, Eur Phys J C 80, 1053 (2020) — $|\alpha_{J/\psi p}|$ = (**0.28...4.38**) am



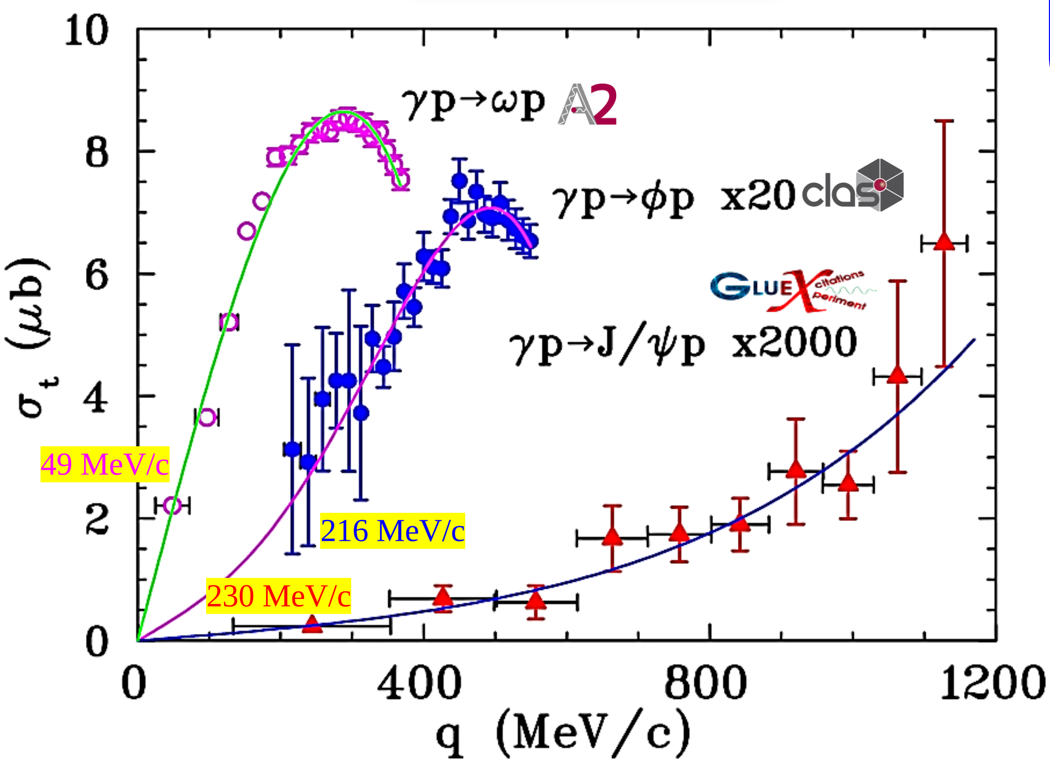
- Using *VMD* (replacing *photon* by *J/ψ*), they determined *J/ψ-p scattering length.*
- There is NO 'young' effect (in other words, this effect is included into $g_{\psi-DD}$, $g_{\psi-DD^*}$... couplings).
- Fact that *scattering length* is of order of *phenomenological* value means that *interference* between two mechanisms may *not be negligible*.

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*).

$$\sigma_t = b_1 q + b_3 q^3 + b_5 q^5$$

- ***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.



A2 — b_1 = (**4.42**±0.14) x 10^{-2} μb/(MeV/c)
IS, S. Prakhov, Ya. Azimov *et al*, Phys Rev C **91**, 045207 (2015)

clas — b_1 = (**3.40**±1.15) x 10^{-4} μb/(MeV/c)
IS, L. Pentchev, & A.I. Titov, Phys Rev C **101**, 045201 (2020)

GlueX — b_1 = (**0.46**±0.16) x 10^{-6} μb/(MeV/c)
IS, D. Epifanov, & L. Pentchev, Phys Rev C **101**, 042201 (2020)

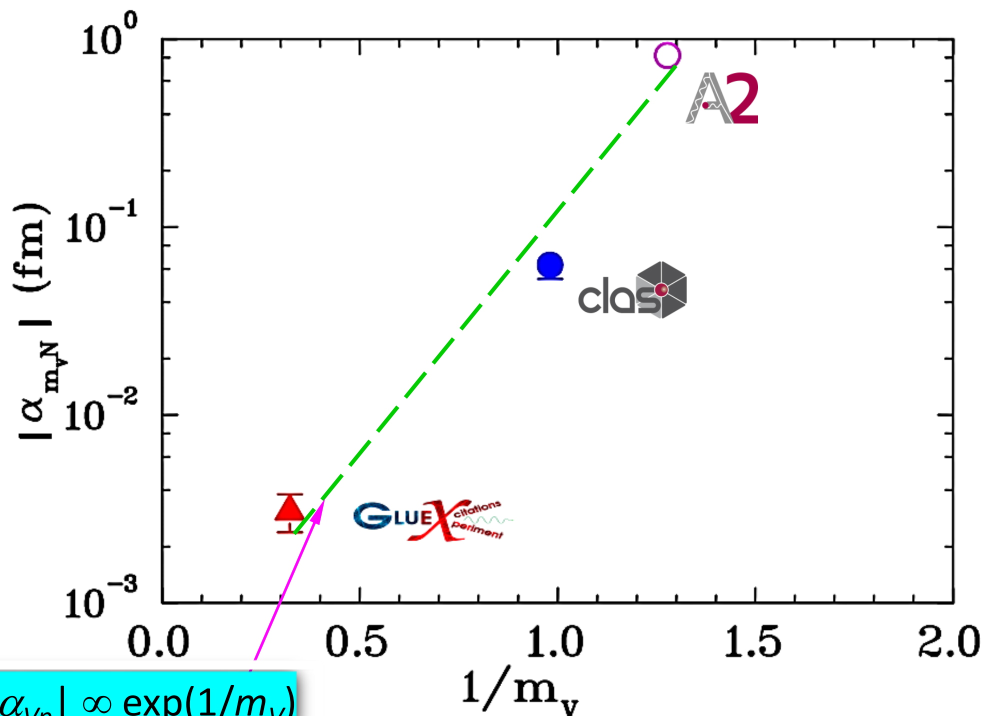
- Dramatic differences in hadronic factors $h_{Vp}^2 = b_1$, as slopes (b_1) of σ_t @ threshold as function of q varies significantly from ω to ϕ to J/ψ.

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

Vector-Meson – Nucleon SL

- ***EM*** factor R_V for each vector-meson are close to each other.
- Therefore, such big difference in *SL* is determined mainly by **hadronic** factor h_{Vp}.

$|\alpha_{Vp}| = R_V h_{Vp}$

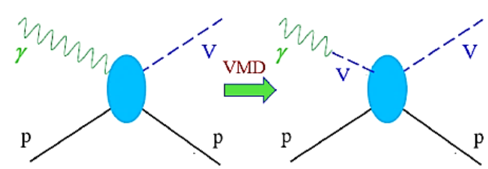


$|\alpha_{Vp}| \propto \exp(1/m_V)$

- Such small value of ϕp SL 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 for J/ψ -meson.

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

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



Courtesy of Michael Ryskin, July 2020

BROOKHAVEN NATIONAL LABORATORY

in 2021

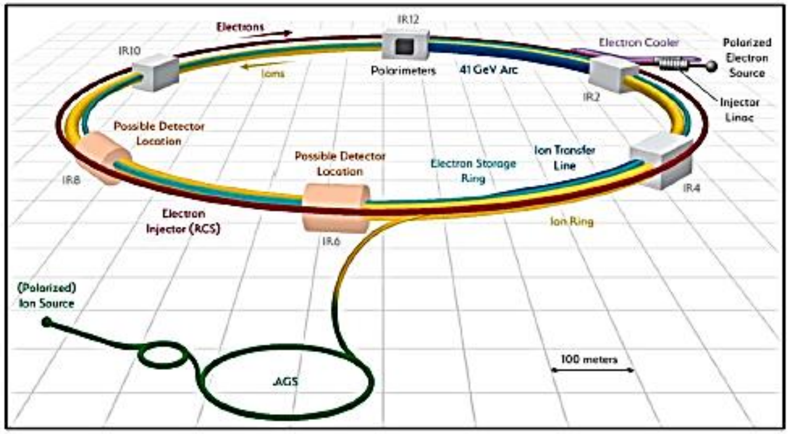
Electron Ion Collider Receives CD-0 Approval

- EIC Panel evaluated proposals from JLAB and BNL (Aug – Oct, 2019)
- CD-0 approved Dec. 19, 2019
- DOE announced selection of Brookhaven National Lab to host EIC Jan. 9, 2020

U.S. Department of Energy Selects Brookhaven National Laboratory to Host Major New Nuclear Physics Facility

January 9, 2020

The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory will provide crucial infrastructure for the new Electron Ion Collider.

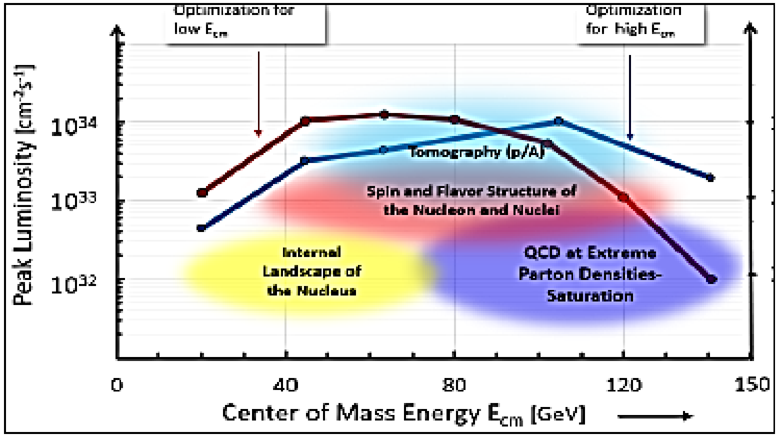


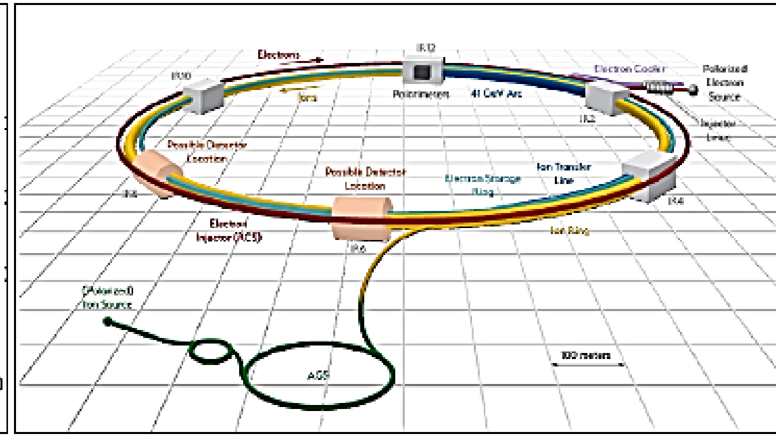
Courtesy of Stuart Henderson, JLUO, June 2020

11

Jefferson Lab

EIC Machine Parameters



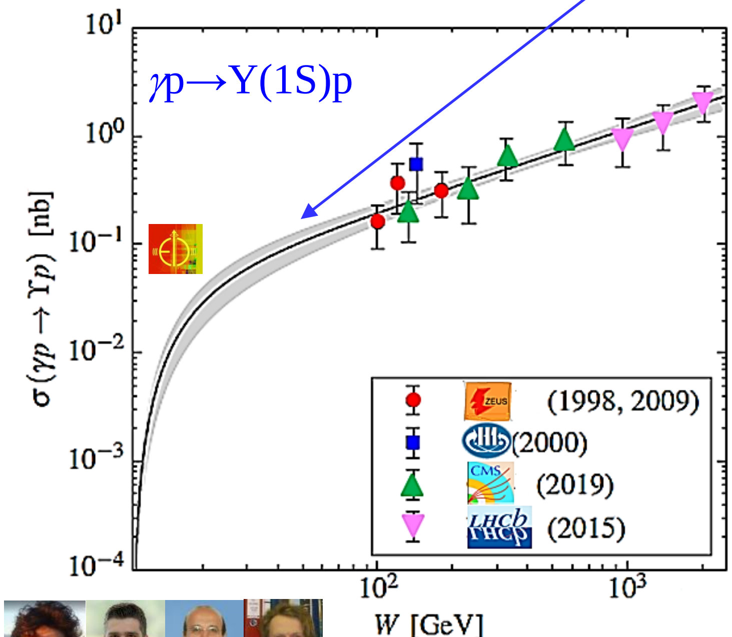


Double Ring Design Based on Existing RHIC Facilities	
Hadron Storage Ring: 40 - 275 GeV	**Electron Storage Ring: 2.5 - 18 GeV**
• RHIC Yellow Ring and Injector Complex	• Many Bunches, Large Beam Current - 2.5 A
• Many Bunches, 1160 @ 1A Beam Current	• 9 MW Synchrotron Radiation
• Bright Beam Emittance ε_{xp}= 9 nm	• Superconducting RF Cavities , 10MW Power
• Flat Beam, Requires Strong Cooling	
High Luminosity Interaction Region(s)	**Electron Rapid Cycling Synchrotron**
• 25 mrad Crossing Angle with Crab Cavities	• Spin Transparent Due to High Periodicity

Courtesy of Jim Yeck, EIC@IP6, March 2021

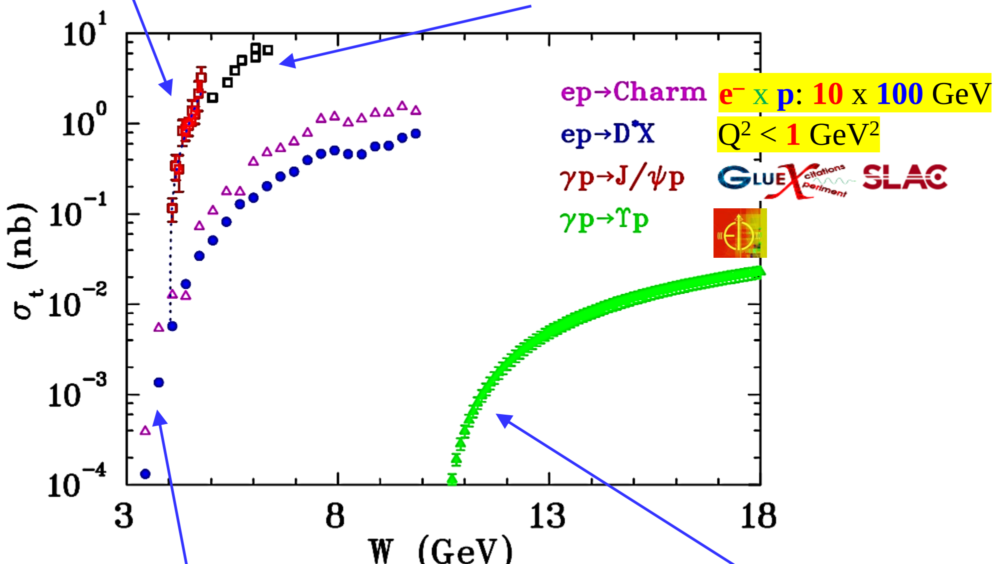
Expectation from

- For simulations:
  - One assumed total integrated luminosity of **100 fb^{-1}** for , which corresponds to **116 days @ 10^{34} cm^{-2} s^{-1}**.
  - Extrapolation goes down from **100 GeV**.



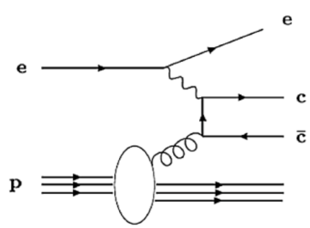
A. Ali *et al*, Phys Rev Lett **123**, 072001 (2019)

U. Camerini *et al*, Phys Rev Lett **35**, 483 (1975)



Courtesy of Sylvester Joosten, Sept 2020

O. Gryniuk *et al*, Phys Rev D **102**, 014016 (2020)

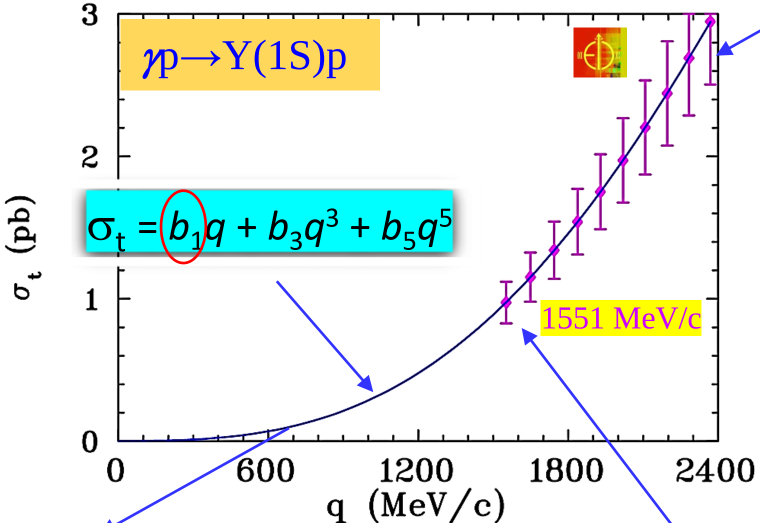


Courtesy of Sergey Furletov, July 2020

For Electroproduction - HVQDIS: B.W. Harris & J. Smith, Phys Rev D **57**, 2806 (1998)

For Photoproduction - FMNR: S. Frixione P. Nason, & G. Ridolfi, Nucl Phys B **454**, 3 (1995)

Expectation from



$\sigma_t = b_1 q + b_3 q^3 + b_5 q^5$

15% errs for quasi-data

b_1 = (**1.66**±0.36) x 10^{-8} μb/(MeV/c)

O. Gryniuk *et al*, Phys Rev D **102**, 014016 (2020)

- ***EM*** factor R_V for each ***VM*** are close to each other.

$|\alpha_{Vp}| = R_V h_{Vp}$

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

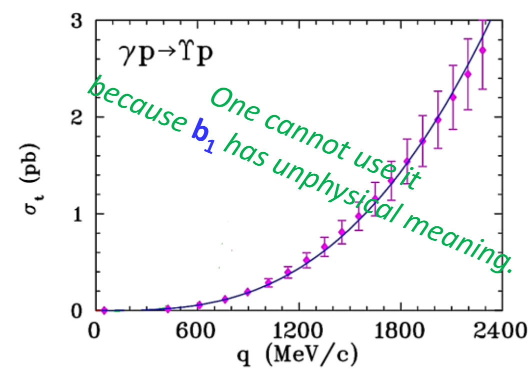
$|\alpha_{\Upsilon p}|$ = **0.000108**±0.000011 fm

$|\alpha_{\Upsilon p}|$ = **0.066**±0.001 fm

or

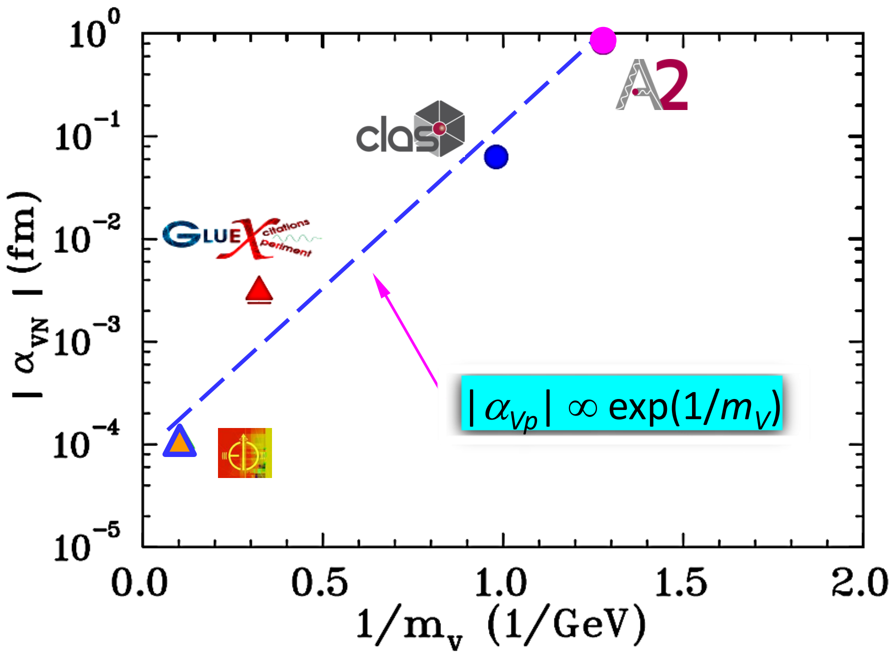
$|\alpha_{\Upsilon p}|$ = **0.016**±0.001 fm

Factor of difference is 600 or 150



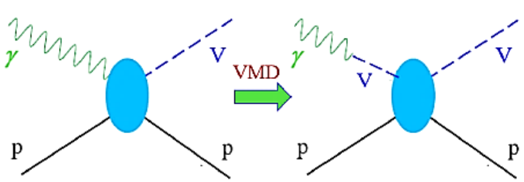
One cannot use it because b_1 has unphysical meaning.

$\mathcal{VM}$–$\mathcal{N}$ SL



- Such small value of ϕp *SL* 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 for J/ψ -meson.

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



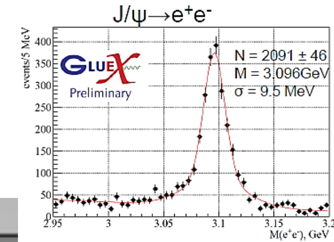
- *p→V* coupling is proportional to α_s & *separation* of corresponding quarks.
- This *separation* (in zero approximation) is proportional to $1/m_V$.

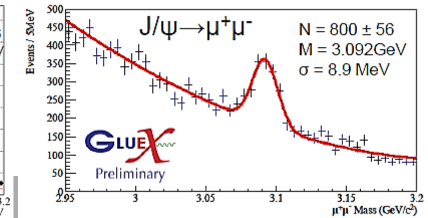
Courtesy of Michael Ryskin, July 2020

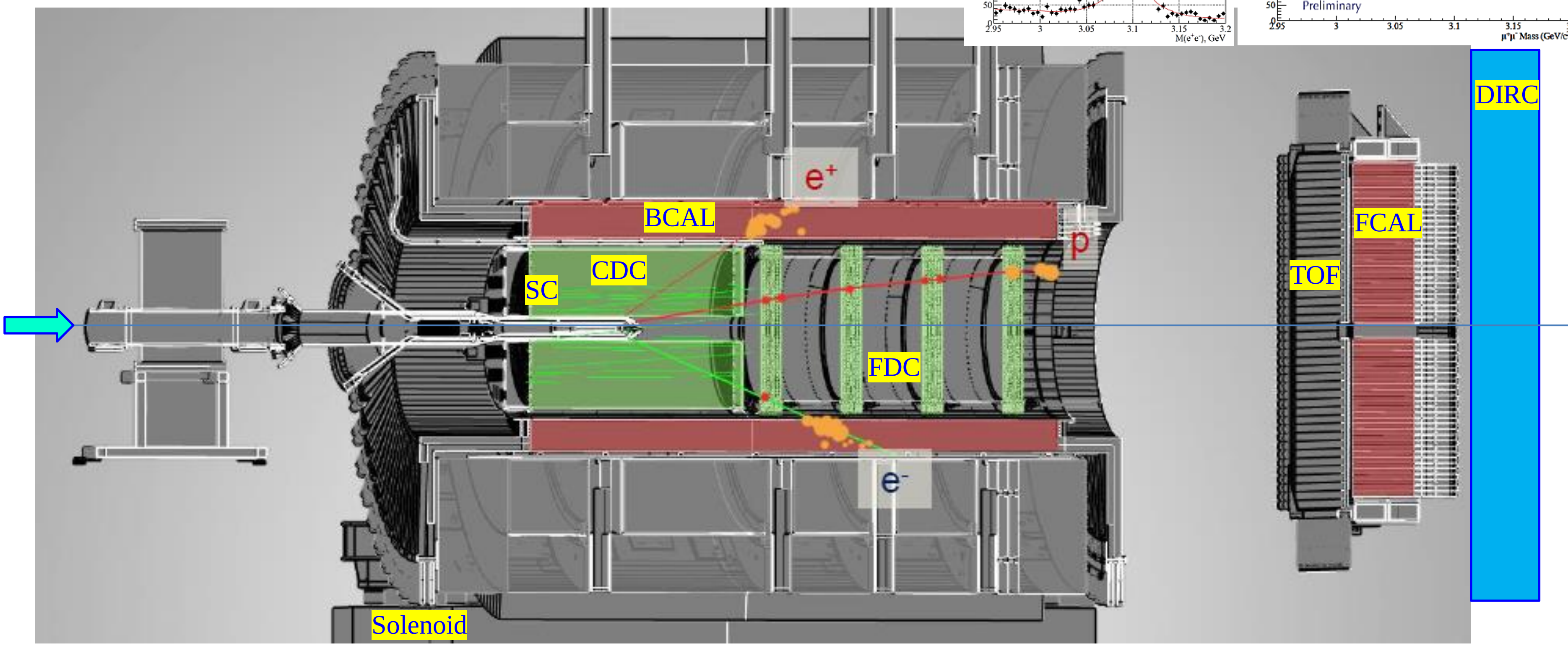
Exclusive Reaction $\gamma p \longrightarrow J/\psi p \longrightarrow e^+e^- p$ @ J/ψ *Threshold*

A. Ali *et al*, Phys Rev Lett **123**, 072001 (2019)

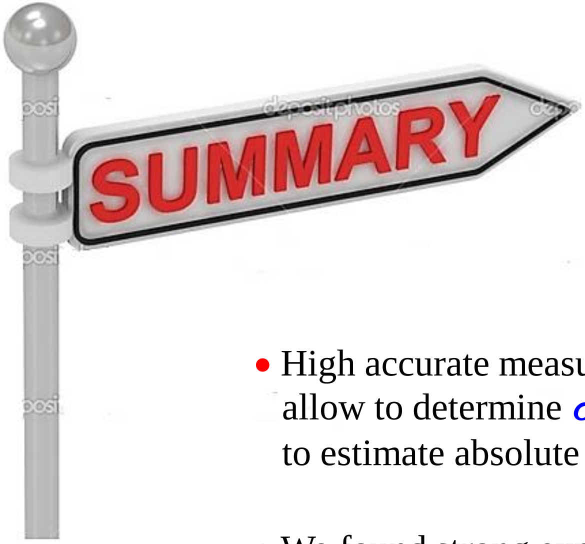
BR($J/\psi \to e^+e^-$) = (5.971±0.032)%	BR($Y \to e^+e^-$) = (2.38±0.11)%
BR($J/\psi \to \mu^+\mu^-$) = (5.961±0.033)%	BR($Y \to \mu^+\mu^-$) = (2.48±0.05)%







- *Electrons* separated from *pions* by **E/p** – energy deposition in calorimeters over measured momentum (*pions* >10^3 times more than *electrons*) .



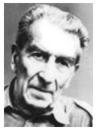
- High accurate measurements near-threshold by A2, clas, & GlueX allow to determine σ_t of reactions $\gamma p \to VMp$ & to estimate absolute value of ***VM-p SL***s within *VMD* model.

  IS, S. Prakhov, Ya. Azimov *et al*, Phys Rev C **91**, 045207 (2015)
  IS, L. Pentchev, & A.I. Titov, Phys Rev C **101**, 045201 (2020)
  IS, D. Epifanov, & L. Pentchev, Phys Rev C **101**, 042201 (2020)

- We found strong exponential increase of ***VM-p SL*** with inverse mass of ***VM***s $|\alpha_{Vp}| \propto \exp(1/m_V)$

- It is remarkable that proton is quite so *transparent* to J/ψ, though general progression from ω to ϕ to J/ψ to probably Υ is perhaps qualitatively reasonable on account of *OZI* rule $|\alpha_{J/\psi p}| << |\alpha_{\phi p}| << |\alpha_{\omega p}|$

- Due to ***small size*** of '***young***' ***VM*** vs '***old***' ***VM***, measured ***SL*** is very small. ***VM*** crated by photon @ threshold then most probably ***VM*** is not formed completely & its radius is smaller than that for normal ('***old***') ***VM***. Therefore, one observe stronger suppression for ***VM-p*** interaction.



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

- **Light** *VM*s can be '***young***' as well. This depends on particular kinematics. $|\alpha_{J/\psi p}| << |\alpha_{\phi p}| << |\alpha_{\omega p}|$
  Another point is that for slow ***heavy*** quark, one need more time to reach *equilibrium*, i.e., to form final (long-living/static) *VM*.

- Obviously, facility will open new window in solving the ***VM*-*N* *SL*** puzzle.
  It will allow to make deal with `***young***' ***Υ***-meson as well.

- It was observed that ***J/ψ*-*N*** cross section measured via ***J/ψ*** re-scattering/absorption inside nucleus is anomaly small in case of low energy photoproduction.
  This can be explained by fact that we dealt with `***young***' ***J/ψ*** of too small radius.
  Υ-photoproduction on both proton & ***nucleus*** will extend our ***J/ψ*** study.

- In case of ***J/ψ*** (even ***Υ***) ***electroproduction***, we deal with the `***young***' ***J/ψ*** (***Υ***) for larger ***Q^2***
  & we will have smaller formation time & correspondingly smaller radius of heavy *Charmonium* & *Quarkonium*.