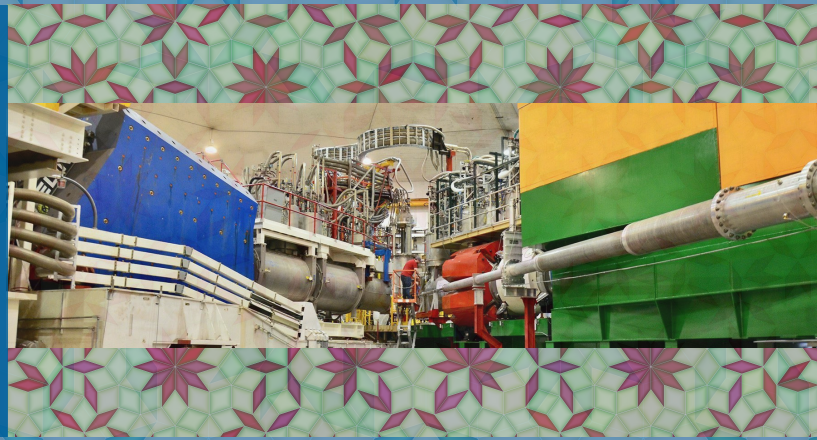
JUNE 18 2026

PR12-26-003:

EXCLUSIVE NEAR-THRESHOLD J/Ψ PHOTOPRODUCTION AT LARGE SKEWNESS IN HALL C AT JLAB

2026 Hall A/C Summer Meeting



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*On behalf of the **J/ψ-007-II Collaboration***

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U.S. DEPARTMENT of ENERGY

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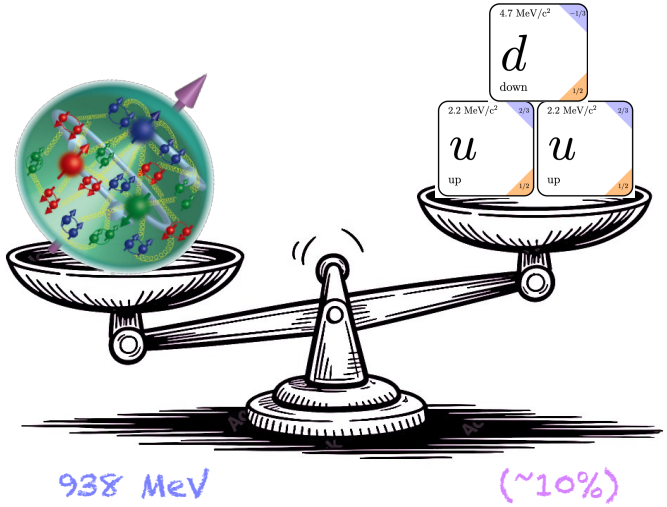
MECHANICAL STRUCTURE OF THE PROTON

A majority of the mass in the observable Universe is largely attributed to **protons**, **neutrons** and **combinations thereof** (i.e. **nuclei**)

Mass of the proton is simply not the sum of its bare quark masses

- Higgs mechanism alone seems irrelevant for *generating* “normal” confined matter

Whence does the majority of the 938 MeV mass of the proton emerge?



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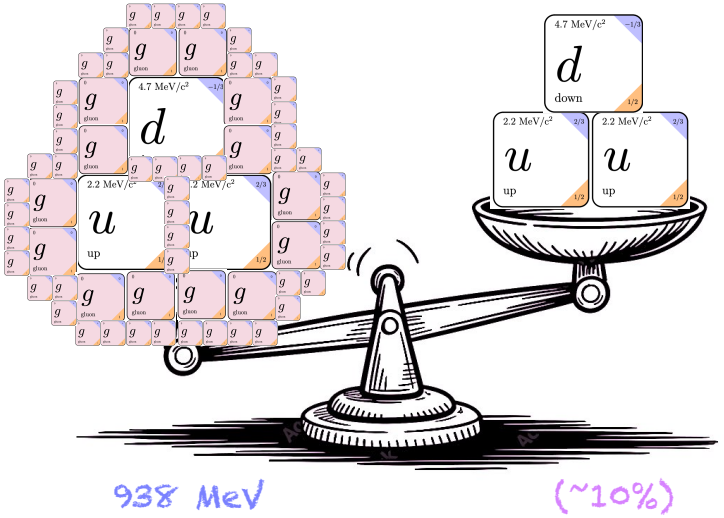

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Clöet and Roberts. *Prog. Part. Nucl. Phys.* **77** *[2014]*

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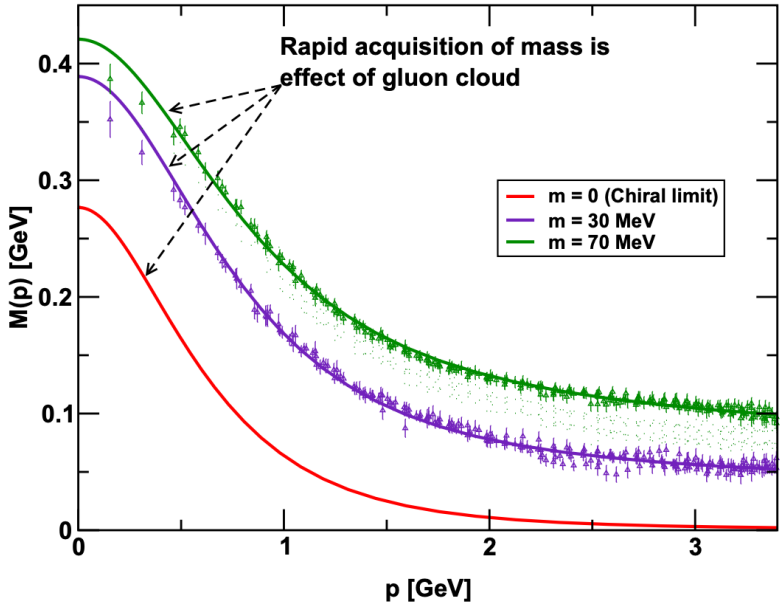


Whence does the majority of the 938 MeV mass of the proton emerge?

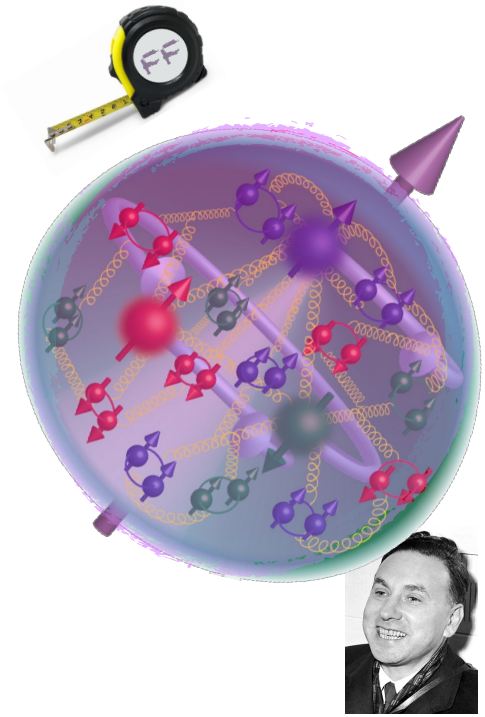
GLUONS!

- Mass dynamically originates from the energy within the QCD gluonic fields and their interactions
- Mass of constituent-quarks arises from cloud of low-momentum gluons attaching themselves to bare quarks
- Non-perturbative effect occurring even at the chiral limit

What about the *size of the proton? What role do the gluons play?*

MECHANICAL STRUCTURE OF THE PROTON

What do we know about the size of the proton? How is mass distributed within the proton? How are its internal forces spatially distributed? What quantitative role do the gluons play?



Charge radius can be experimentally probed via ***elastic ep scattering***

- Deviations from *point-like* structure provide insight into the proton's size
  - Encoded in the so-called electromagnetic **Form Factors (FFs)**
  - Defined as the *matrix elements* of the *electromagnetic current operator:*

$$\langle p', s' | J^{\mu}_{EM} | p, s \rangle = \bar{u}(p', s') \left[F_1(t) \gamma^{\mu} + \frac{i\sigma^{\mu\nu} q_{\nu}}{2M} F_2(t) \right] u(p, s)$$

For point-like particles, FFs would be constant

- Not the case: Found to be pronounced functions of *t*

$F_1(0)$: Electric charge of proton (in units of *e*)

$F_2(0)$: Anomalous magnetic moment (in terms of μ_N)

The t-dependence of the EM FFs allow information about the spatial distributions of the electric charge and magnetization to be directly inferred

Can we by way of (experimental) analogy extract information about the mechanical properties of the proton (e.g. mass, momentum current densities, etc.)?

MECHANICAL STRUCTURE OF THE PROTON

The mechanical structure of the proton is well-defined by analogy at the continuum through the **QCD Energy-Momentum Tensor (EMT)**

- Gravitational Form Factors (**GFFs**) are defined as the *matrix elements* of the *QCD EMT for both* ***quarks*** *and* ***gluons****:*

$$\langle p', s' | T^{\mu\nu}_{q,g} | p, s \rangle = \bar{u}(p', s') \left[A_{q,g}(t) \gamma^{(\mu} P^{\nu)} + B_{q,g}(t) \frac{i P^{(\mu} \sigma^{\nu)\rho} \Delta_\rho}{2M} + C_{q,g}(t) \frac{\Delta^\mu \Delta^\nu - g^{\mu\nu} \Delta^2}{M} + \bar{C}_{q,g}(t) M g^{\mu\nu} \right] u(p, s)$$

Role of the GFFs:

$A_{q,g}(t)$: Momentum/energy distribution component (2nd Mellin transform of the GPD ***H***)

- For *t = 0*, $A_q(0) = \langle x \rangle_q, \langle x \rangle_g \ni \sum A(0) = 1 \longrightarrow$ *Momentum Sum Rule*

$B_{q,g}(t)$: Spin component (2nd Mellin transform of the GPD ***E***)

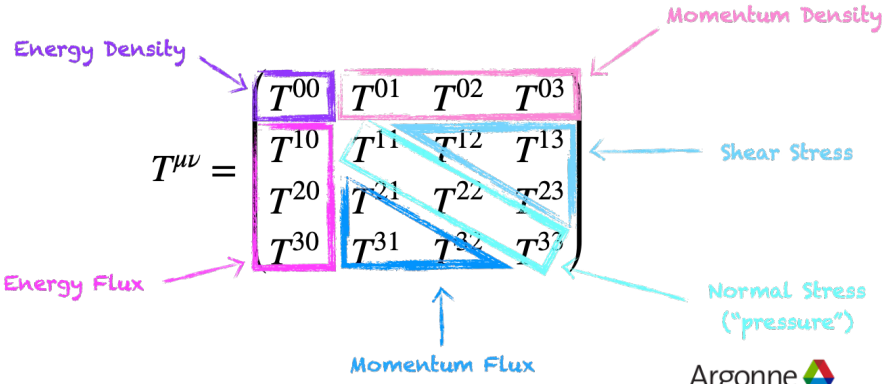
- For *t = 0*, $J_{q,g} = \frac{1}{2}[A_{q,g}(0) + B_{q,g}(0)] = \frac{1}{2} \longrightarrow$ *Spin Sum Rule*

$D_{q,g}(t)$: Internal forces component, where $D_{q,g}(t) = 4C_{q,g}(t)$

- For *t = 0*, $D(0) = \sum_q D_q(0) + D_g(0)$

$\bar{C}_{q,g}(t)$: Trace component

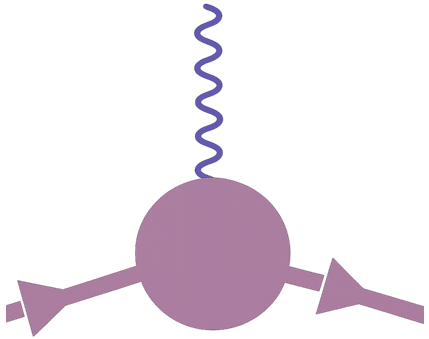
- For *t = 0*, $\bar{C}(0) = \sum_q \bar{C}_q(0) + \bar{C}_g(0) = 0$



GFF MEASUREMENTS

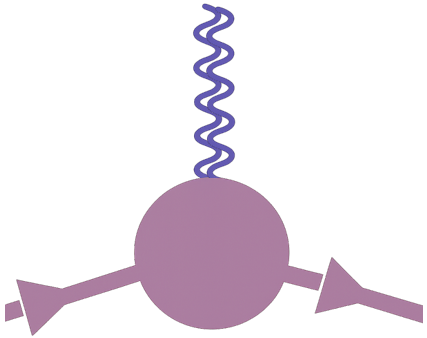
For the case of the **EM FFs**, we use a single spin-1 EM exchange via an EM probe on the electromagnetic current operator

- Routine measurement in lepton-proton scattering



GFFs Case: We need a (graviton-like) *spin-2* exchange as the probe on the EMT

- Not very trivial
  - Single graviton exchange cross section is *extremely small*
- Currently experimentally limited from direct access
- Indirectly, however, one can in principle emulate the exchange
  - Deeply Virtual Compton Scattering (DVCS)[†]
  - **Exclusive Vector Meson production**



GFF MEASUREMENTS: DVCS

DVCS mimics a spin-2 exchange via two spin-1 photons

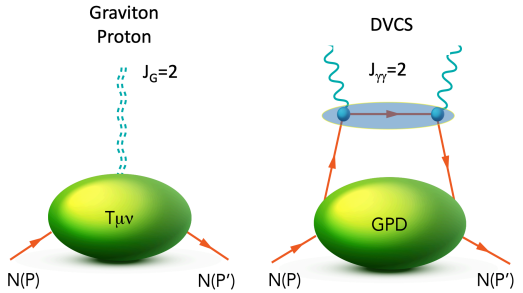
Quark component of the **total GFF *D-term*** can be probed through such process

$$D = D_u + D_d + D_s + \ldots + D_g$$

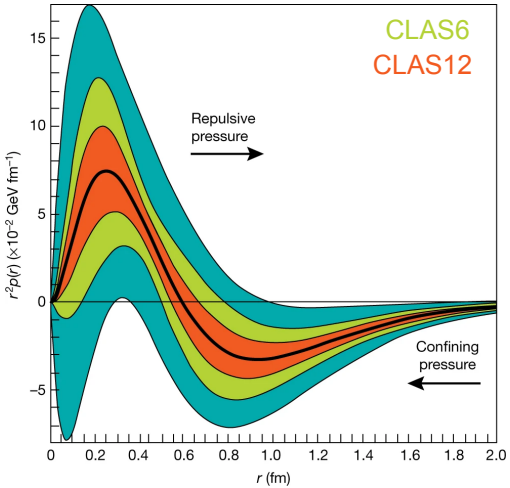
In the Breit-frame, the extracted *D-term* is related to "pressure profile" within the proton

- Analysis based on the fits to the DVCS cross-section and asymmetries from CLAS
- Repulsive "pressure" near center of proton with a confining "pressure" beyond 0.6 fm
  - Consistent with the notions of proton stability and QCD quark confinement

Burkert, Elouadrhiri and Girod. ***arXIv 2310.11568***



Burkert, Elouadrhiri and Girod. Nature. ***557*** *[2018]*



GFF MEASUREMENTS: HEAVY VECTOR MESONS

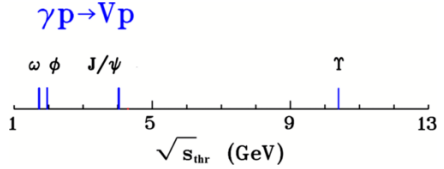
The gluonic components of the total **GFF *terms*** can also be probed by mimicking the spin-2 exchange as long as:

- Probe is not sensitive mostly to quarks/quark structure
  - ~~Electromagnetic~~
  - ~~Weak~~
  - ~~Light-flavor hadronic~~

Heavy flavor vector mesons, namely J/ψ and Υ, make the perfect tool for probing the gluon components of the GFFs

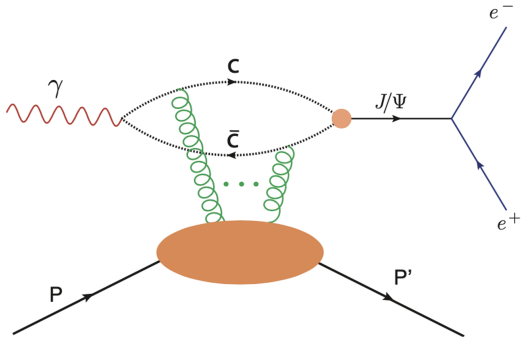
- J/ψ scattering used as a proxy for elastic quarkonium scattering
  - Ideal measurement in the 12 GeV JLab era!
- Gluonic GFFs constrained by exclusive near-threshold photoproduction
  - Particularly at **large** values of the **skewness** (ξ) and a **sizable momentum transfer** ($|t|$)

$$E_\gamma^{\text{thr}} = \frac{(M_{J/\psi} + M_p)^2 - M_p^2}{2M_p} \approx 8.2 \text{ GeV}, \qquad t = (p - p')^2 \leq 0, \qquad \xi = \frac{M_{J/\psi}^2 - t}{2(W^2 - M_p^2) - (M_{J/\psi}^2 - t)}$$



Vector-Meson	m_V (MeV)	$\sqrt{s_{\text{thr}}}$ (MeV)	E_{thr} (MeV)
~~$\omega(782)$~~	~~782.65~~	~~1720.9~~	~~1109.1~~
~~$\phi(1020)$~~	~~1019.461~~	~~1957.7~~	~~1573.3~~
$J/\psi(1S)$	3096.900	4035.2	8207.8
~~$\Upsilon(1S)$~~	~~9460.30~~	~~10398.6~~	~~57152.9~~

I.I. Strakovsky, W.J. Briscoe, L. Pentchev, A. Schmidt. Phys. Rev. D. ***104***



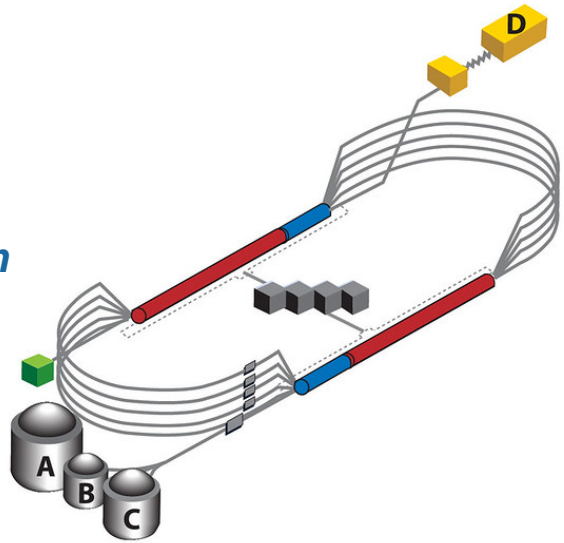
Duran et al (J/ψ-007). *Nature*. **615** [2023]

CEBAF AT JEFFERSON LAB

***Very* high luminosity ($10^{35} - 10^{39}\mathrm{cm}^{-2}\mathrm{s}^{-1}$) continuous electron beam on fixed target(s)**

- 4 Experimental Halls
  - ~11 GeV in Halls A, B and C
  - ~12 GeV in Hall D

JLab is the ideal laboratory for near threshold J/ψ given the large CEBAF luminosity, excellent detector resolution in each hall and the energy range in allowable kinematic region



12 GeV era J/ψ Experiments at JLab

- **Hall A:** Dedicated J/ψ electro/photoproduction Experiment (SoLID)
- **Hall B:** J/ψ Photoproduction Run Groups A and B (CLAS12)
- **Hall C:** LHCb Hidden Charm Pentaquarks Experiment (J/ψ-007)
- **Hall D:** First J/ψ at JLab 12 GeV (GlueX) and full phase space access

J/Ψ PHOTOPRODUCTION IN HALL D (GLUEX)

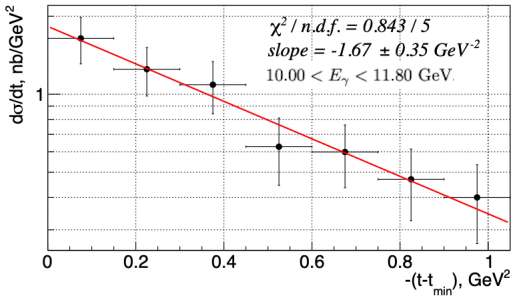
GlueX first measured the 1D cross section of J/ψ photoproduction at JLab

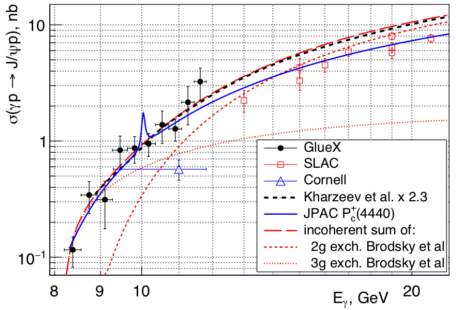
- Saw no evidence of hidden-charm pentaquarks
- Higher values than those previously measured
- Explicit t-dependence of differential cross-section

In 2023 GlueX results in the near-threshold region extract the 2D differential cross section in E_γ ~ 8.2 - 11.4 GeV

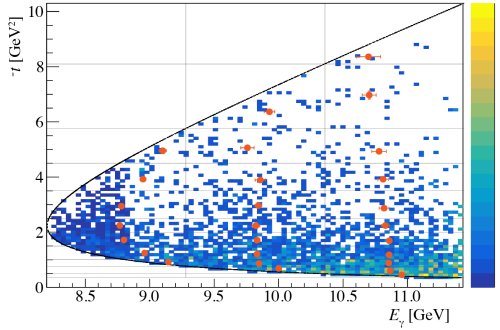
- Observed *enhancement* of the differential cross-section in the lowest E_γ region
- "*Can be interpreted as an s-channel or u-channel contribution*"
- Suggests contributions to fluctuations in the lowest E_γ bin (8.2 GeV to 9.28 GeV) from open-charm ($D^0\Lambda_C$)
- Total cross-section drops here as well

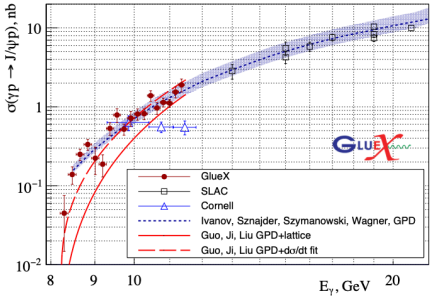
Ali et al. (GlueX). *Phys. Rev. Lett.* ***123*** **(2019)**

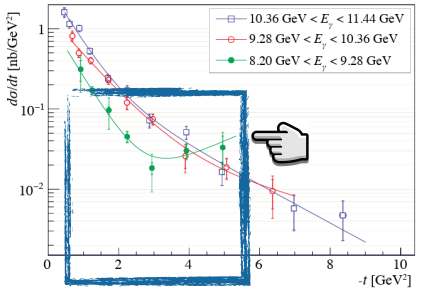




Adhikari et al. (GlueX). *Phys. Rev. C.* ***108*** **(2023)**



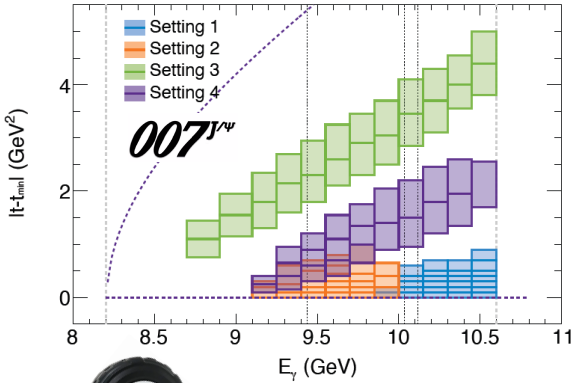


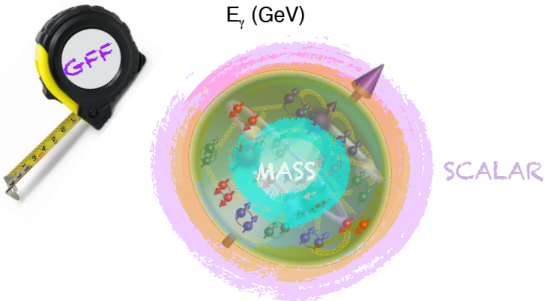


J/Ψ-007 EXPERIMENT IN HALL C

JLab Experiment **E12-16-007** (J/ψ-007) in Hall C measured the J/ψ photoproduction cross section in the e^+e^- channel

- Ten E_γ slices in 9.1 - 10.6 GeV range
- Found no evidence of hidden-charm pentaquarks in the phase space region
- Placed constrains on the gluon GFFs
  - Mass radius < charge radius
  - Scalar gluonic cloud surrounds charge region at around 1 fm





Duran et al (J/ψ-007). *Nature*. **615** [2023]

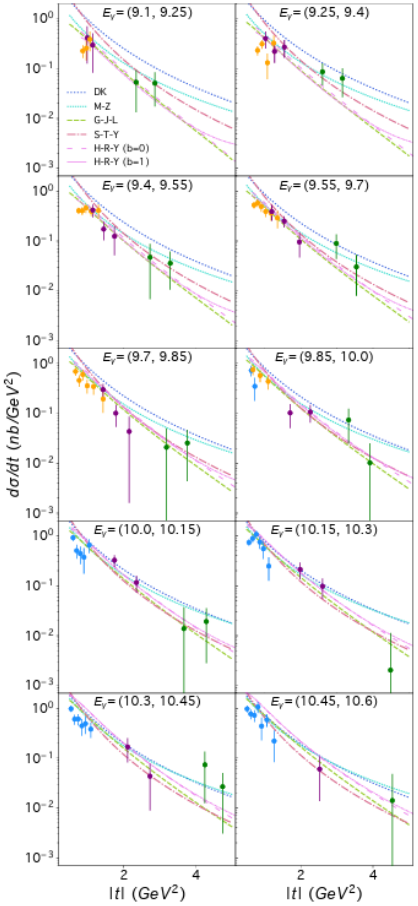


Table 1 | The gluonic GFF fit parameters, proton mass radius and scalar radius

Theoretical approach	χ^2/n.d.f.	m_A (GeV)	m_C (GeV)	$C_g(0)$	$\sqrt{\langle r_m^2\rangle}_g$ (fm)	$\sqrt{\langle r_3^2\rangle}_g$ (fm)
GFF functional form						
Holographic QCD	0.925	1.575±0.059	1.12±0.21	−0.45±0.132	0.755±0.035	1.069±0.056
Tripole–tripole						
GPD	0.924	2.71±0.19	1.28±0.5	−0.20±0.11	0.472±0.042	0.695±0.071
Tripole–tripole						
Lattice		1.641±0.043	1.07±0.12	−0.483±0.133	0.7464±0.025	1.073±0.066

MASS SCALAR

J/Ψ-007 EXPERIMENT IN HALL C

Muon-channel results for the two-dimensional cross-section from the J/ψ-007 Collaboration agree within uncertainties of the electron-channel

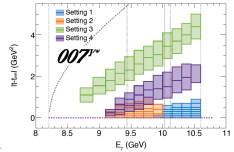
- Panels shows *t-dependence* within a single E_γ bin
- J/ψ-007 results consistent with those from GlueX; *do not* exhibit fluctuations reminiscent of contributions from open-charm production processes

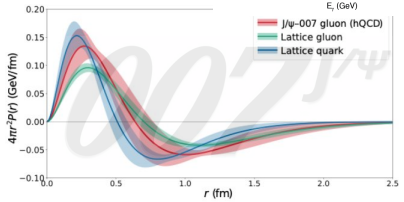
Combined analysis of both channels from J/ψ-007 gives a great constraint on the gluonic GFF D-*term*

Lowest E_γ bin lies above GlueX 8.2 GeV to 9.28 GeV bin

- Extraction of gluon GFFs not clear if contributions to the cross section beyond a pure *t-channel process*

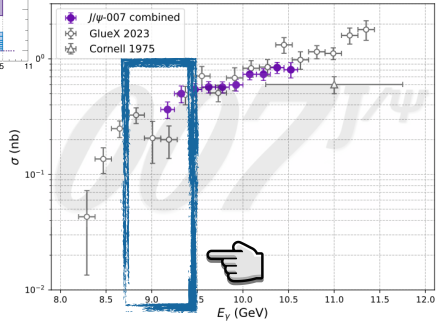
GPD model extraction of the GFFs currently discards all data below $\xi = 0.5$ from the J/ψ-007 dataset

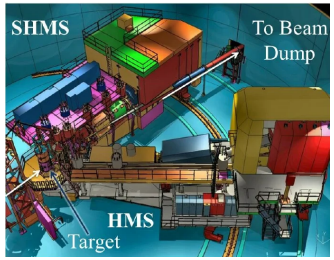




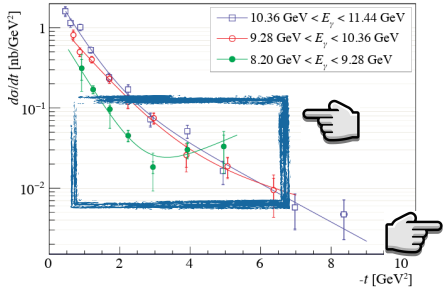
Duran et al (J/ψ-007). *Nature*. **615** [2023]

Joosten et al (J/ψ-007). **arXiv: 2602.14416**

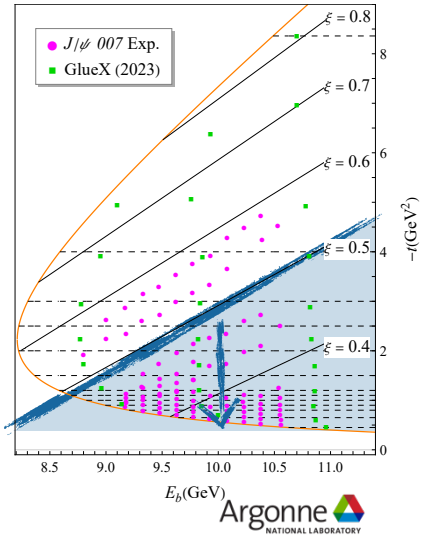




Adhikari et al. (GlueX). *Phys. Rev. C.* ***108*** **(2023)**



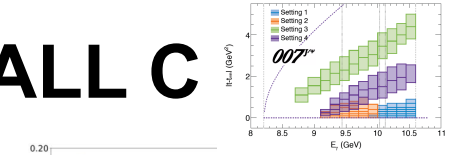
Y. Guo, X. Ji and F. Yuan. **arXiv: 2308.13006**

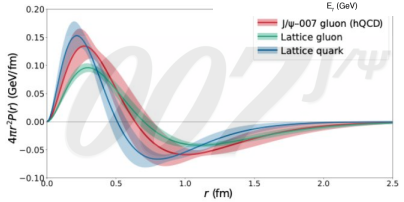


J/Ψ-007 EXPERIMENT IN HALL C

Given the impact of the first iterations of the J/ψ experiments at JLab both in experiment and theory, ***it is prudent to <u>now</u> plan for a new and complementary experiment to map out the* J/ψ photo*production cross-section***

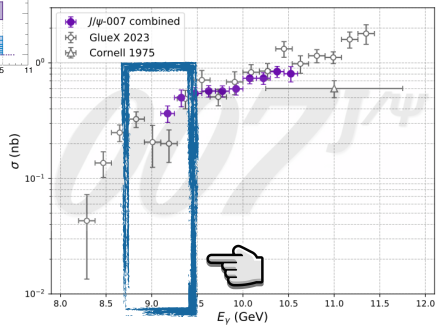
We propose a high current, high precision measurement of J/ψ photoproduction in Hall C near threshold that extends the kinematic coverage of the J/ψ-007 experiment in Hall C to the low E_γ, large-ξ and sizable *t regime*

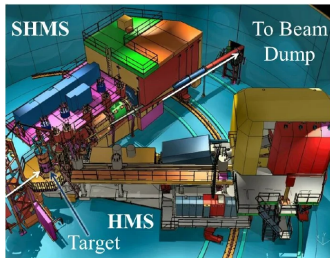




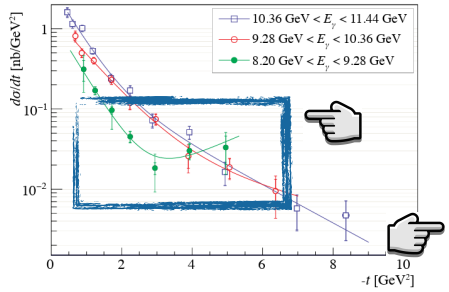
Duran et al (J/ψ-007). *Nature*. **615** [2023]

Joosten et al (J/ψ-007). **arXiv: 2602.14416**

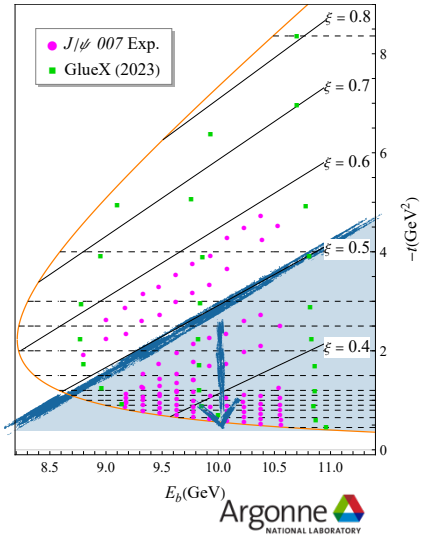




Adhikari et al. (GlueX). *Phys. Rev. C*. *108* (2023)



Y. Guo, X. Ji and F. Yuan. **arXiv: 2308.13006**

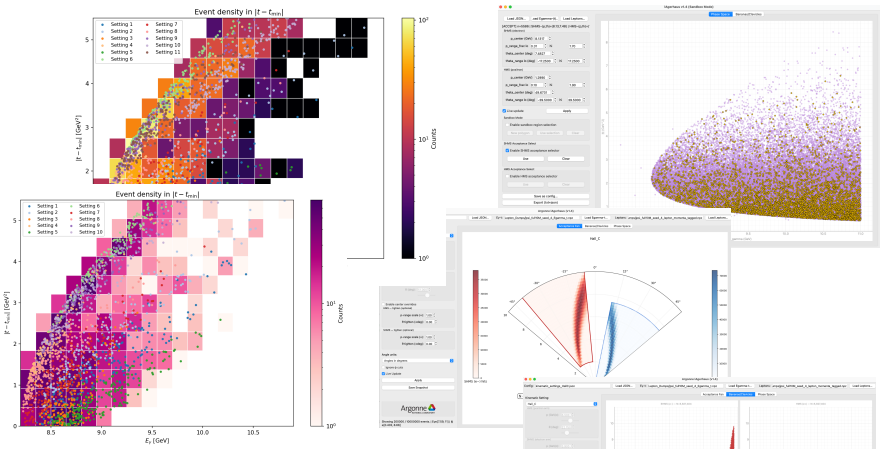


NEED FOR A COMPLEMENTARY MEASUREMENT IN HALL C

We decided to make some sort of *utility sandbox* for us to play with detector kinematic settings (HMS and SHMS) and optimize the number of projected J/ψ candidates in the kinematic region of interest

- Produces critical histograms on the fly from a `lAger` MC supersample for the $\gamma p \to J/\psi p$ process
- Avoids discretely going to-and-fro from one setting to another to produce phase space
- HMS and HMS configurations (WRT $|p|$ and θ) optimized in the region(s) of interest
  - Maximized number of E_γ and t bins in the large-ξ region where GFF sensitivity is enhanced

HISTOGRAMMING AND UTILITY SANDBOX (HAUS)

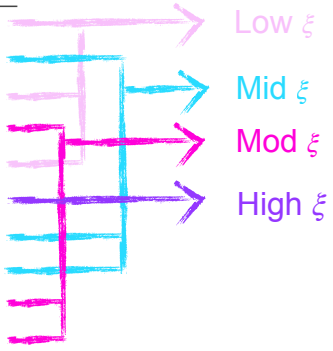


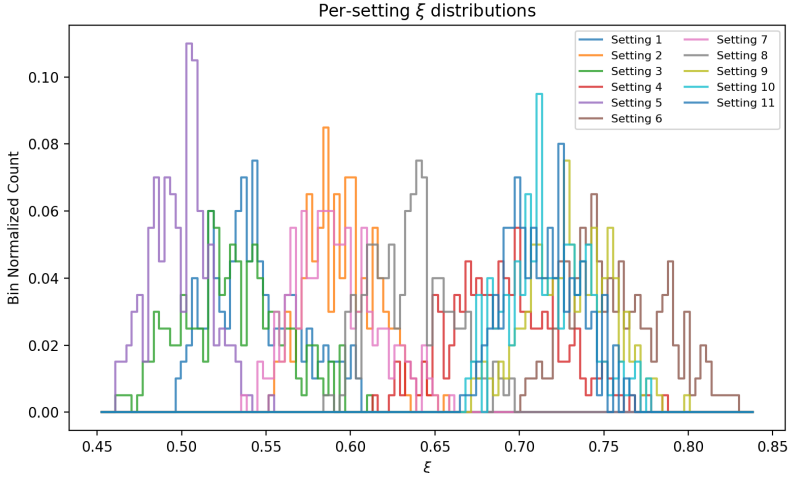
Hall C Configuration	SHMS (−) $\lvert p\rvert$ (GeV)	SHMS (−) θ (deg.)	HMS (+) $\lvert p\rvert$ (GeV)	HMS (+) θ (deg.)	Kinematic Ranges
J/ψ-007-II Setting 1	1.96	37.5	5.83	17.1	$E_\gamma \in [8.4, 10.5]$ GeV $\lvert t\rvert \in [1.4, 5.0]$ GeV^2 $0.5 \le \xi \le 0.6$
J/ψ-007-II Setting 2	3.79	28.6	3.60	21.0	$E_\gamma \in [8.3, 10.5]$ GeV $\lvert t\rvert \in [1.8, 5.7]$ GeV^2 $\xi = 0.6$
J/ψ-007-II Setting 3	4.74	16.2	2.97	33.0	$E_\gamma \in [8.4, 9.3]$ GeV $\lvert t\rvert \in [1.0, 3.4]$ GeV^2 $0.45 \le \xi \le 0.6$
J/ψ-007-II Setting 4	4.11	20.2	2.51	37.8	$E_\gamma \in [8.2, 9.1]$ GeV $\lvert t\rvert \in [2.4, 5.0]$ GeV^2 $0.6 \le \xi \le 0.8$
J/ψ-007-II Setting 5	4.44	22.4	3.66	23.0	$E_\gamma \in [8.5, 10.2]$ GeV $\lvert t\rvert \in [1.0, 3.1]$ GeV^2 $\xi = 0.5$
J/ψ-007-II Setting 6	3.07	30.1	3.27	28.5	$E_\gamma \in [8.4, 10.0]$ GeV $\lvert t\rvert \in [3.3, 7.3]$ GeV^2 $\xi \ge 0.7$
J/ψ-007-II Setting 7	2.55	32.0	4.80	21.0	$E_\gamma \in [8.2, 9.8]$ GeV $\lvert t\rvert \in [1.6, 4.6]$ GeV^2 $\xi = 0.6$
J/ψ-007-II Setting 8	4.25	22.9	2.76	31.4	$E_\gamma \in [8.2, 9.2]$ GeV $\lvert t\rvert \in [2.1, 4.0]$ GeV^2 $0.6 \le \xi \le 0.7$
J/ψ-007-II Setting 9	3.33	31.3	3.27	25.6	$E_\gamma \in [8.3, 10.5]$ GeV $\lvert t\rvert \in [3.0, 7.2]$ GeV^2 $\xi = 0.7$
J/ψ-007-II Setting 10	4.20	28.8	3.00	25.7	$E_\gamma \in [8.7, 10.5]$ GeV $\lvert t\rvert \in [2.0, 7.0]$ GeV^2 $\xi = 0.7$
J/ψ-007-II Setting 11	3.50	28.8	3.00	25.7	$E_\gamma \in [8.3, 10.4]$ GeV $\lvert t\rvert \in [1.7, 7.5]$ GeV^2 $\xi = 0.7$

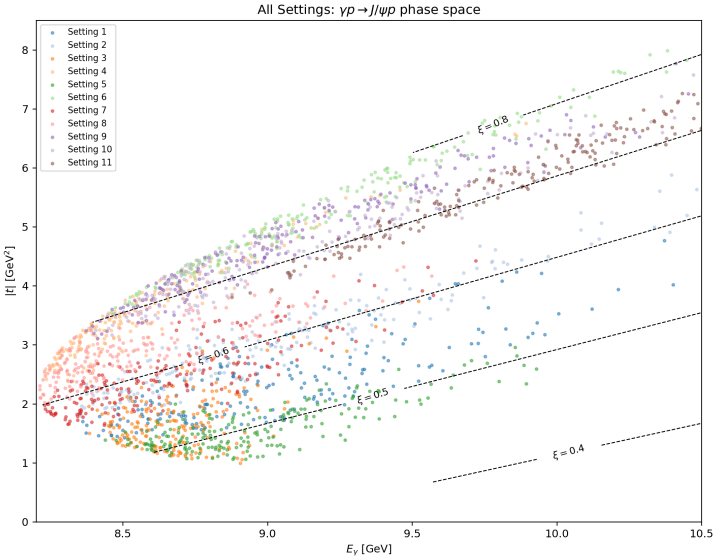
$$\xi = \frac{t - M_{J/\psi}^2}{2M_p^2 + M_{J/\psi}^2 - t - 2W^2}$$

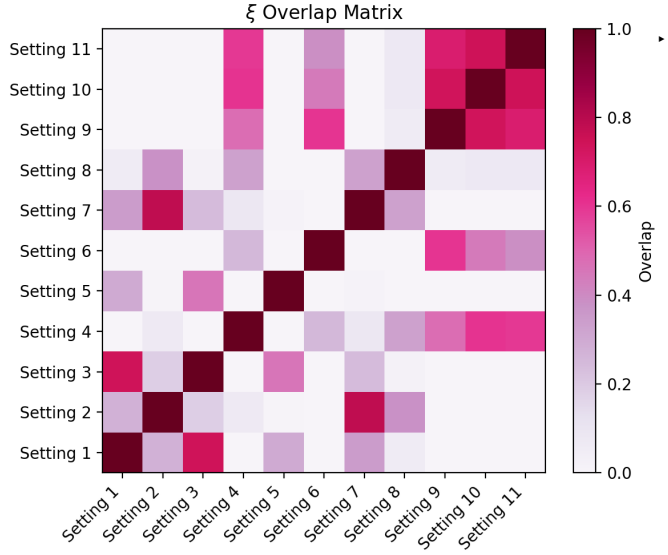
SETTING CONSOLIDATION

Setting	ξ range
1	[0.491, 0.613]
2	[0.545, 0.660]
3	[0.476, 0.606]
4	[0.618, 0.782]
5	[0.459, 0.542]
6	[0.708, 0.832]
7	[0.546, 0.657]
8	[0.590, 0.688]
9	[0.667, 0.791]
10	[0.668, 0.780]









- Grouped in terms of 4 subsets
  - 3 subsets each with 2 settings
  - Dedicated single setting for highest ξ
  - Narrowed the search down down to 7 *distinct* settings
- Dropped into cavalry list):
  - Setting 2
  - Setting 3
  - Setting 9
  - Setting 11

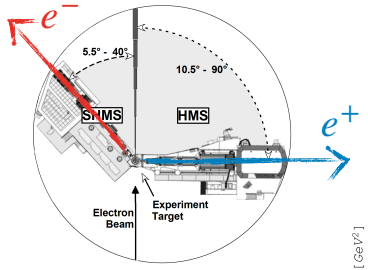
$$\xi = \frac{t - M_{J/\psi}^2}{2M_p^2 + M_{J/\psi}^2 - t - 2W^2}$$

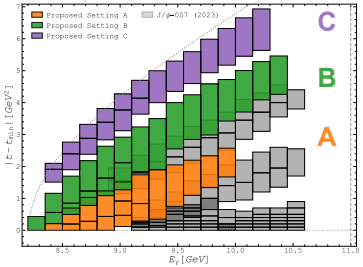
PROPOSED J/Ψ-007-II EXPERIMENT IN HALL C

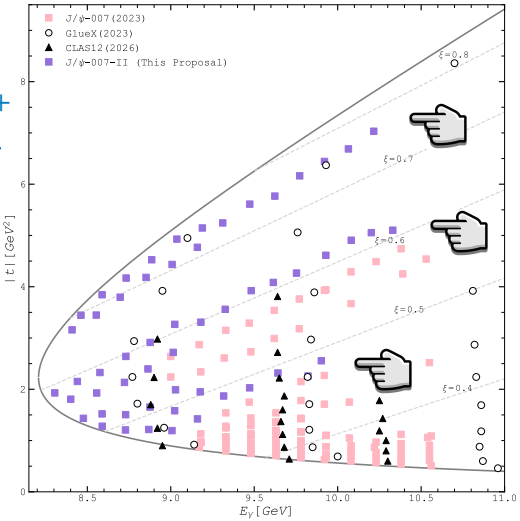
Spectrometer configurations of J/ψ-007 were explicitly determined through a maximization of the projected signal from the hidden-charm pentaquark channel

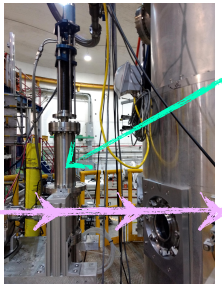
We propose a high current, high precision measurement of J/ψ photoproduction in Hall C near threshold that extends the kinematic coverage of J/ψ-007 to the low E_γ, large-ξ and sizable *t regime*

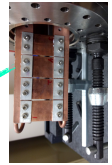
SHMS and HMS configurations optimized in region of interest





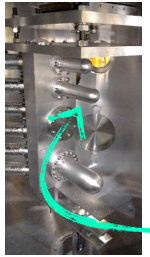




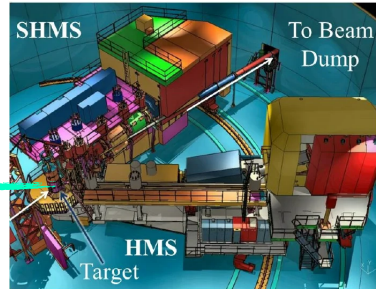


Copper radiator(s)

Beamline

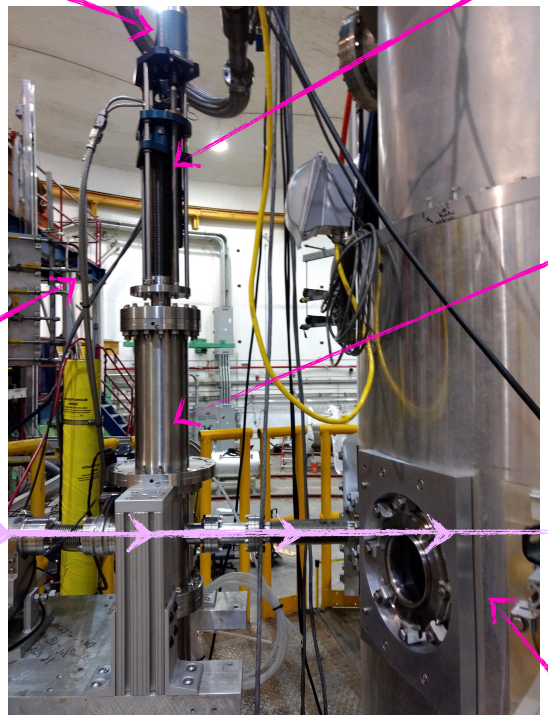


LH_2 target

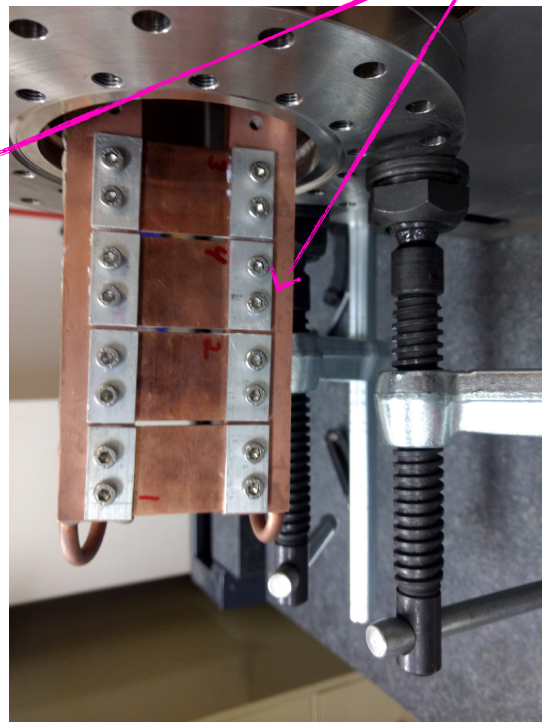


Hall C Configuration	SHMS (−) $\lvert p\rvert$ (GeV)	SHMS (−) θ (deg.)	HMS (+) $\lvert p\rvert$ (GeV)	HMS (+) θ (deg.)	Kinematic Ranges
J/ψ–007-II Setting A	4.44	22.4	3.66	23.0	$E_\gamma \in [8.4, 10.0]$ GeV $\lvert t\rvert \in [1.0, 2.8]$ GeV^2 $\xi \in [0.45, 0.55]$
J/ψ–007-II Setting B	3.79	28.6	3.60	21.0	$E_\gamma \in [8.2, 10.5]$ GeV $\lvert t\rvert \in [1.6, 6.0]$ GeV^2 $\xi \in [0.55, 0.65]$
J/ψ–007-II Setting C	3.11	31.3	3.44	25.6	$E_\gamma \in [8.35, 10.5]$ GeV $\lvert t\rvert \in [2.9, 7.6]$ GeV^2 $\xi \in [0.65, 0.80]$

HALL C COPPER RADIATOR SUBSYSTEM



Sealed/installed Hall C copper foil radiator radiator target(s) subsystem

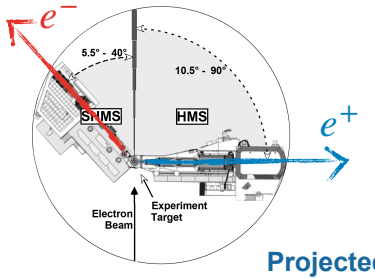


Unsealed/uninstalled Hall C copper foil radiator radiator targets

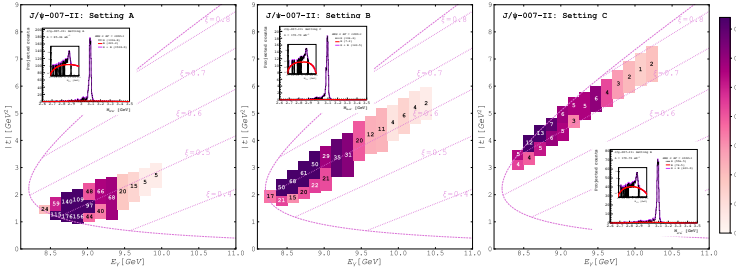
BEAMTIME REQUEST AND PROJECTED IMPACT

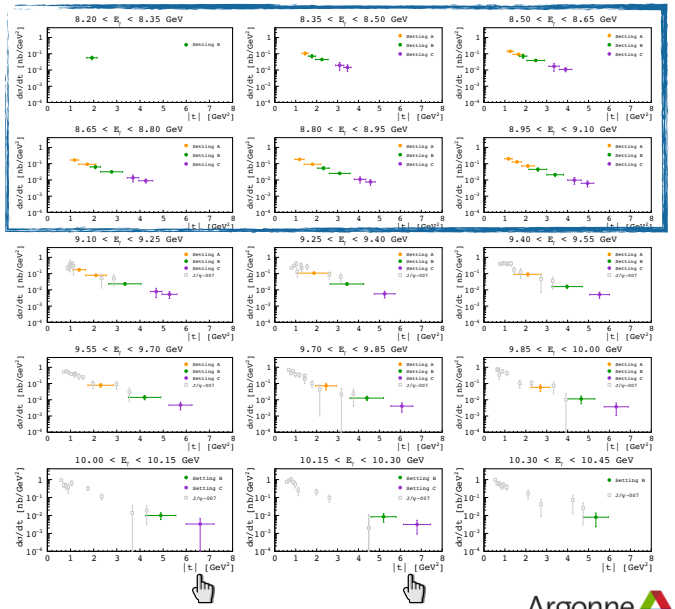
Hall C Configuration	SHMS (−) $\lvert p\rvert$ (GeV)	SHMS (−) θ (deg.)	HMS (+) $\lvert p\rvert$ (GeV)	HMS (+) θ (deg.)	Kinematic Ranges
J/ψ–007-II Setting A	4.44	22.4	3.66	23.0	$E_\gamma \in [8.4, 10.0]$ GeV $\lvert t\rvert \in [1.0, 2.8]$ GeV^2 $\xi \in [0.45, 0.55]$
J/ψ–007-II Setting B	3.79	28.6	3.60	21.0	$E_\gamma \in [8.2, 10.5]$ GeV $\lvert t\rvert \in [1.6, 6.0]$ GeV^2 $\xi \in [0.55, 0.65]$
J/ψ–007-II Setting C	3.11	31.3	3.44	25.6	$E_\gamma \in [8.35, 10.5]$ GeV $\lvert t\rvert \in [2.9, 7.6]$ GeV^2 $\xi \in [0.65, 0.80]$

Signal regions all projected to have minimal SIDIS pion background across all three settings — assuming a 1000:1 pion rejection factor



Description	Beam Energy (GeV)	Beam Current (μA)	Target	Days
Production Running				
J/ψ–007-II Setting A	SHMS(−) and HMS(+)	11.0	50	LH_2	5.0
J/ψ–007-II Setting B	SHMS(−) and HMS(+)	11.0	50	LH_2	10.0
J/ψ–007-II Setting C	SHMS(−) and HMS(+)	11.0	50	LH_2	10.0
Subtotal (Production)				**25.0**
Commissioning and Calibration				
Initial commissioning	Detector and DAQ setup			1.0
Optics/momentum calibration	Spectrometer tuning			0.5
Detector calibration	Tracking, PID, timing			0.5
Subtotal (Calibration)				**2.0**
Total Requested Time				**27.0**





Projected $dt/d\sigma$ counts address the low E_γ region of interest

We assume an 11.0 GeV, 50 μA unpolarized CEBAF beam on a 15 *cm* LH_2 target with a 9% Cu radiator placed upstream of the target cell

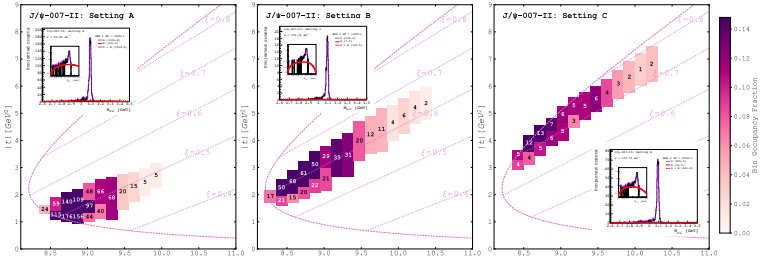
Requested production beam time totals 25 days — 1:2:2 split between settings A, B and C — totaling 426.8 ab^{-1}

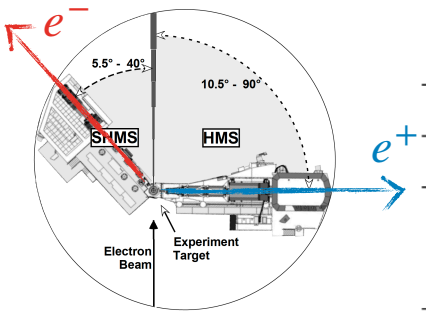
- Setting A covers the near-threshold E_γ *region*
- Setting B covers the $\xi = 0.6$ region from threshold to $E_\gamma^{\max}$
- Setting C covers the $\xi = 0.7$ region to values of |t| up to the kinematic limit

Projected $dt/d\sigma$ also expand the |*t*| coverage across wide E_γ range

BEAMTIME REQUEST AND PROJECTED IMPACT

Hall C Configuration	SHMS (−) $\lvert p\rvert$ (GeV)	SHMS (−) θ (deg.)	HMS (+) $\lvert p\rvert$ (GeV)	HMS (+) θ (deg.)	Kinematic Ranges
J/ψ–007-II Setting A	4.44	22.4	3.66	23.0	$E_\gamma \in [8.4, 10.0]$ GeV $\lvert t\rvert \in [1.0, 2.8]$ GeV^2 $\xi \in [0.45, 0.55]$
J/ψ–007-II Setting B	3.79	28.6	3.60	21.0	$E_\gamma \in [8.2, 10.5]$ GeV $\lvert t\rvert \in [1.6, 6.0]$ GeV^2 $\xi \in [0.55, 0.65]$
J/ψ–007-II Setting C	3.11	31.3	3.44	25.6	$E_\gamma \in [8.35, 10.5]$ GeV $\lvert t\rvert \in [2.9, 7.6]$ GeV^2 $\xi \in [0.65, 0.80]$



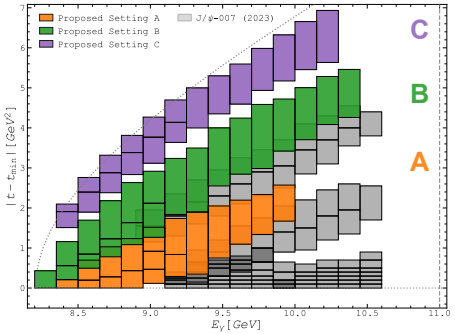


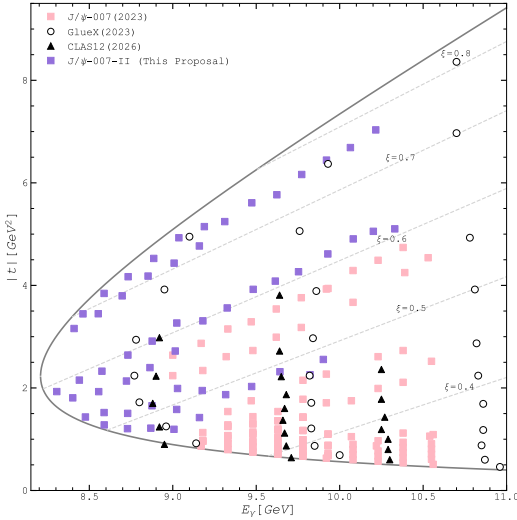
		Beam Energy (GeV)	Beam Current (μA)	Target	Days
Production Running					
J/ψ–007-II Setting A	SHMS(−) and HMS(+)	11.0	50	LH_2	5.0
J/ψ–007-II Setting B	SHMS(−) and HMS(+)	11.0	50	LH_2	10.0
J/ψ–007-II Setting C	SHMS(−) and HMS(+)	11.0	50	LH_2	10.0
Subtotal (Production)					**25.0**
Commissioning and Calibration					
Initial commissioning	Detector and DAQ setup				1.0
Optics/momentum calibration	Spectrometer tuning				0.5
Detector calibration	Tracking, PID, timing				0.5
Subtotal (Calibration)					**2.0**
Total Requested Time					**27.0**

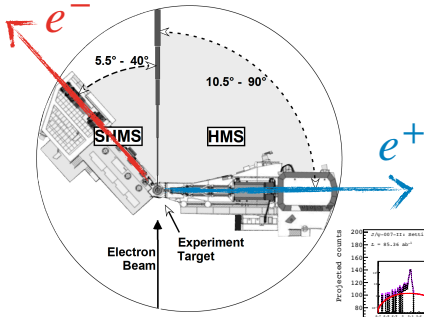
CLOSING REMARKS

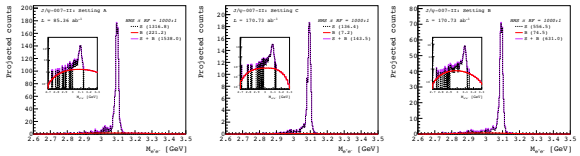
The JLab 12 GeV era J/ψ program(s) have established near-threshold J/ψ photoproduction as a powerful probe of the gluonic mechanical structure of the proton

- World data sparsely populated in the large skewness and large values of momentum transfer — particularly region of the phase space close to the production threshold (E_γ ~ 8.2 GeV)
- Theoretical developments indicate a controlled GPD-based extraction of the gluonic GFFs require direct access to the $\xi > 0.5$ kinematic region, which remains statistically limited in the existing J/ψ photoproduction JLab datasets









Our proposed measurement explicitly addresses the above limitations by extending the kinematic coverage of the pioneering J/ψ-007 experiment in Hall C to the large-|t|, large-ξ regime of the accessible phase space

Hall C Configuration	SHMS (−) |p| (GeV)	SHMS (−) θ (deg.)	HMS (+) |p| (GeV)	HMS (+) θ (deg.)	Kinematic Ranges
J/ψ–007-II Setting A	4.44	22.4	3.66	23.0	$E_\gamma \in [8.4, 10.0]$ GeV $\|t\| \in [1.0, 2.8]$ GeV^2 $\xi \in [0.45, 0.55]$
J/ψ–007-II Setting B	3.79	28.6	3.60	21.0	$E_\gamma \in [8.2, 10.5]$ GeV $\|t\| \in [1.6, 6.0]$ GeV^2 $\xi \in [0.55, 0.65]$
J/ψ–007-II Setting C	3.11	31.3	3.44	25.6	$E_\gamma \in [8.35, 10.5]$ GeV $\|t\| \in [2.9, 7.6]$ GeV^2 $\xi \in [0.65, 0.80]$

We welcome anyone interested in joining J/ψ-007-II !!!

Feel free to contact FAF: fflor@anl.gov (Link to proposal)

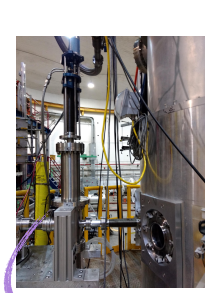
CAVALRY

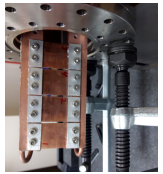
HALL C SPECTROMETER CONFIGURATION

Standard Hall C spectrometer configuration with HMS (+) and SHMS (-) in coincidence

Parameter	*HMS Performance*	*SHMS Specification*
Range of Central Momentum	0.4 to 7.4 GeV/c	2 to 11 GeV/c
Momentum Acceptance	±10%	-10% to +22%
Momentum Resolution	0.1% – 0.15%	0.03% – 0.08%
Scattering Angle Range	10.5° to 90°	5.5° to 40°
Target Length Accepted at 90°(HMS)/45° (SHMS)	10 cm	25 cm
Horizontal Angle Acceptance	±32 mrad	±18 mrad
Vertical Angle Acceptance	±85 mrad	±45 mrad
Solid Angle Acceptance	8.1 msr	4 msr
Horizontal Angle Resolution	0.8 mrad	0.5 – 1.2 mrad
Vertical Angle Resolution	1.0 mrad	0.3 – 1.1 mrad
Target resolution (y_{tar})	0.3 cm	0.1 - 0.3 cm
Maximum Event Rate	4–5 kHz	4–5 kHz
Max. Flux within Acceptance	∼ 5 MHz	∼ 5 MHz
e/h Discrimination	>1000:1 at 98% efficiency	>1000:1 at 98% efficiency
π/K Discrimination	100:1 at 95% efficiency	100:1 at 95% efficiency

Hall C Configuration	SHMS (–) |p| (GeV)	SHMS (–) θ (deg.)	HMS (+) |p| (GeV)	HMS (+) θ (deg.)	Kinematic Ranges
J/ψ–007-II Setting A	4.44	22.4	3.66	23.0	$E_\gamma \in [8.4, 10.0]$ GeV $\|t\| \in [1.0, 2.8]$ GeV^2 $\xi \in [0.45, 0.55]$
J/ψ–007-II Setting B	3.79	28.6	3.60	21.0	$E_\gamma \in [8.2, 10.5]$ GeV $\|t\| \in [1.6, 6.0]$ GeV^2 $\xi \in [0.55, 0.65]$
J/ψ–007-II Setting C	3.11	31.3	3.44	25.6	$E_\gamma \in [8.35, 10.5]$ GeV $\|t\| \in [2.9, 7.6]$ GeV^2 $\xi \in [0.65, 0.80]$





Detector Stacks:

Tracking/ Timing:

1. Drift Chambers
2. Hodoscopes

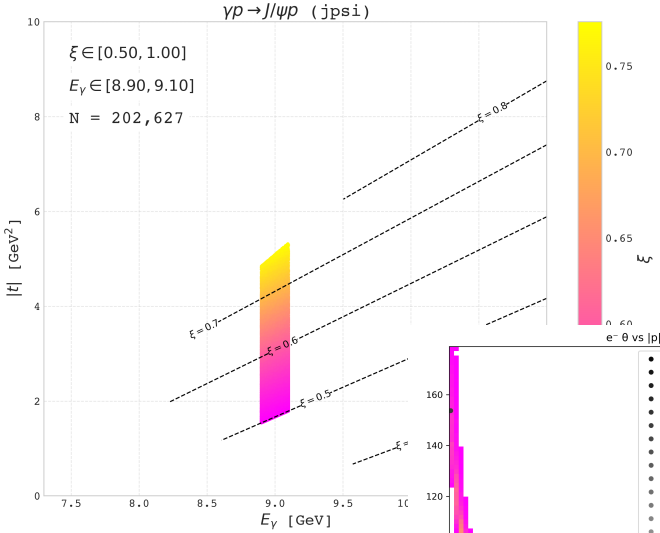
Particle ID:

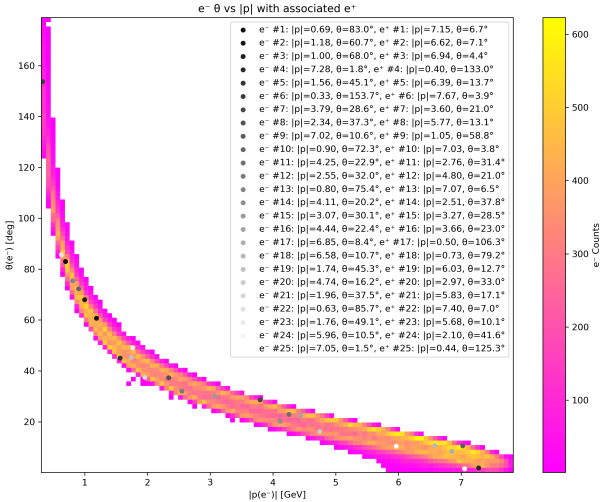
3. Gas Čerenkov
4. Lead Glass Calorimeter

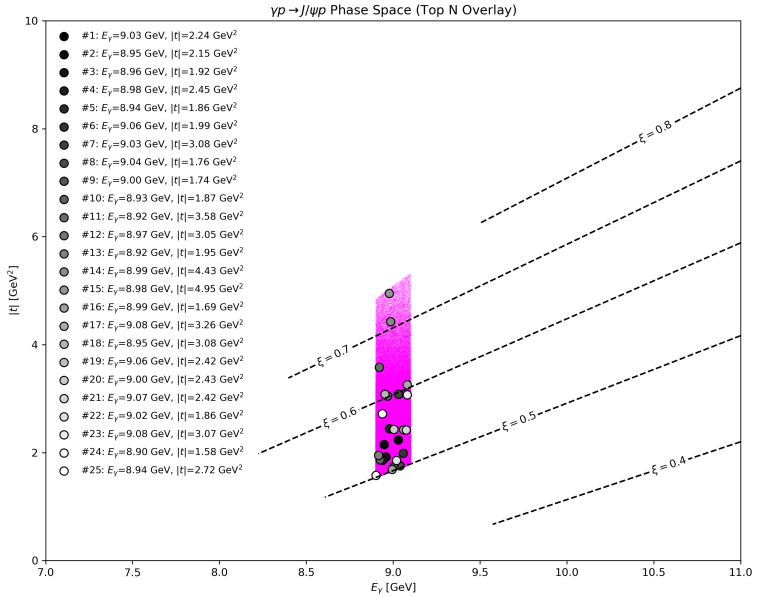
J/Ψ MC CAMPAIGN

$$\xi = \frac{t - M_{J/\psi}^2}{2M_p^2 + M_{J/\psi}^2 - t - 2W^2}$$

Hall C Parameters (1M Events): Strict xi and E_gamma cuts



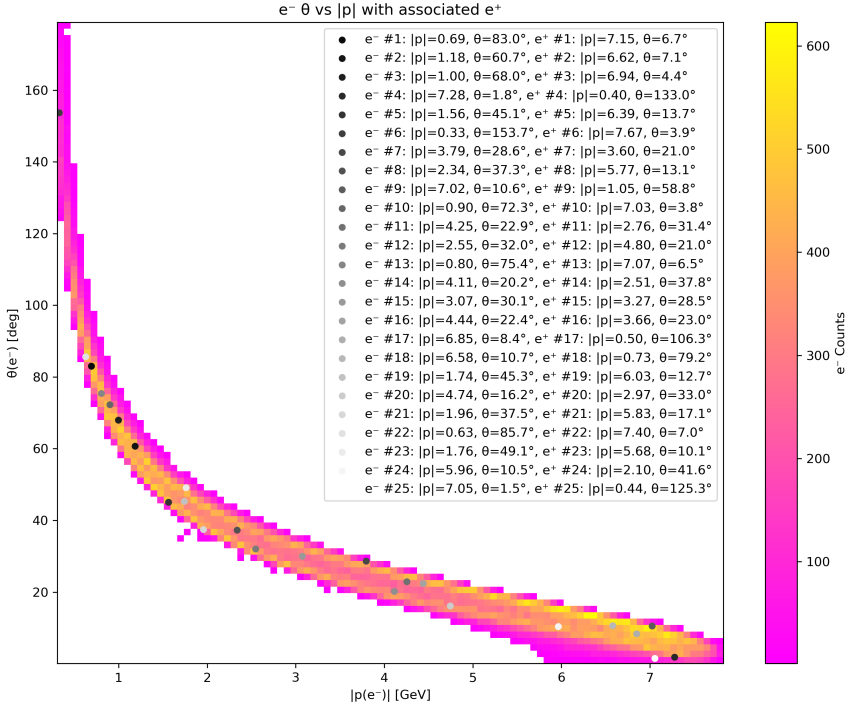


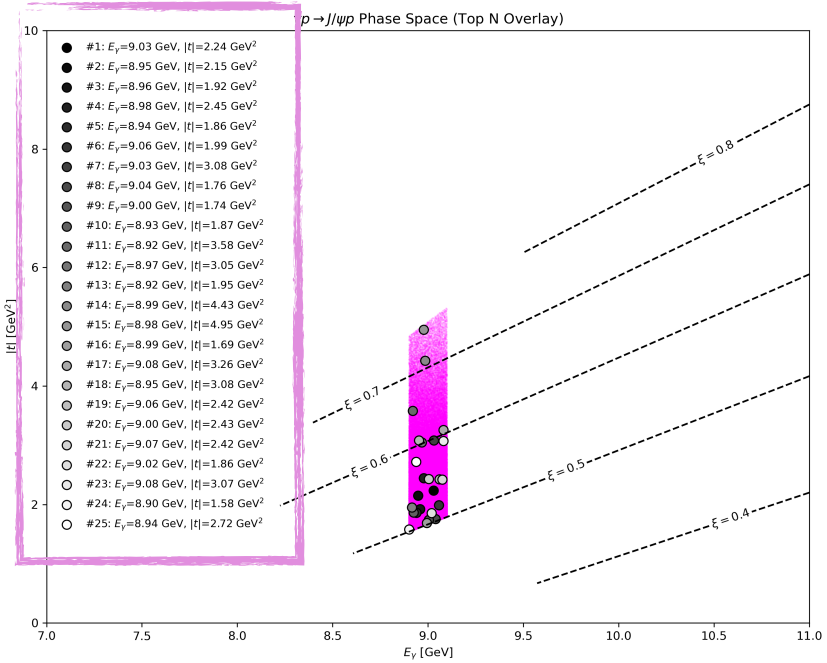


J/Ψ MC CAMPAIGN

$$\xi = \frac{P^+ - P'^+}{P^+ + P'^+} = \frac{t - M_{J/\psi}^2}{2M_p^2 + M_{J/\psi}^2 - t - 2W}$$

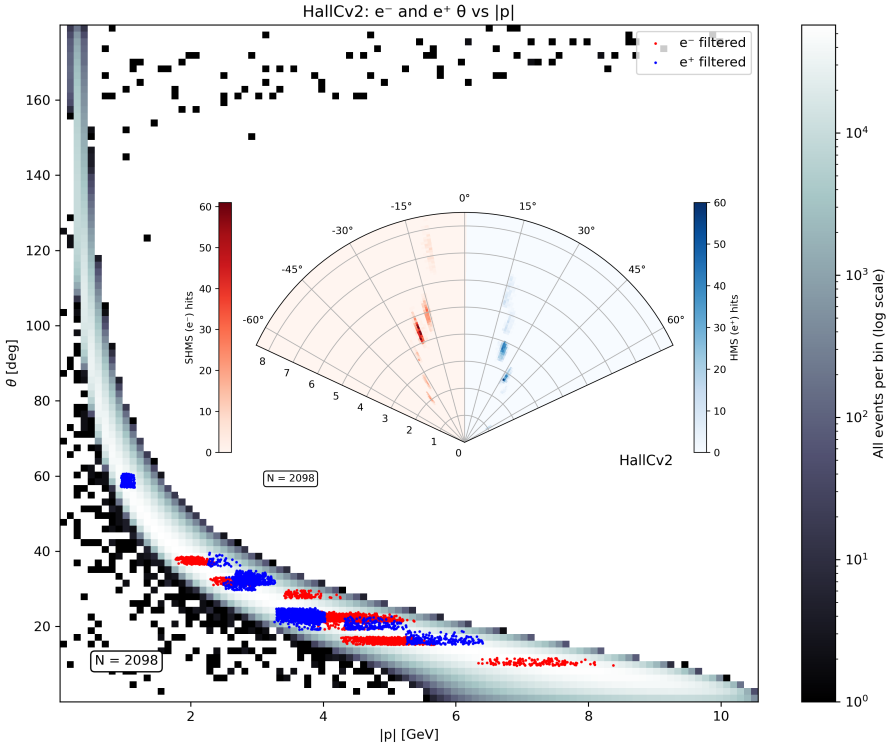
Hall C Parameters (1M Events): Top 25 “most likely” events

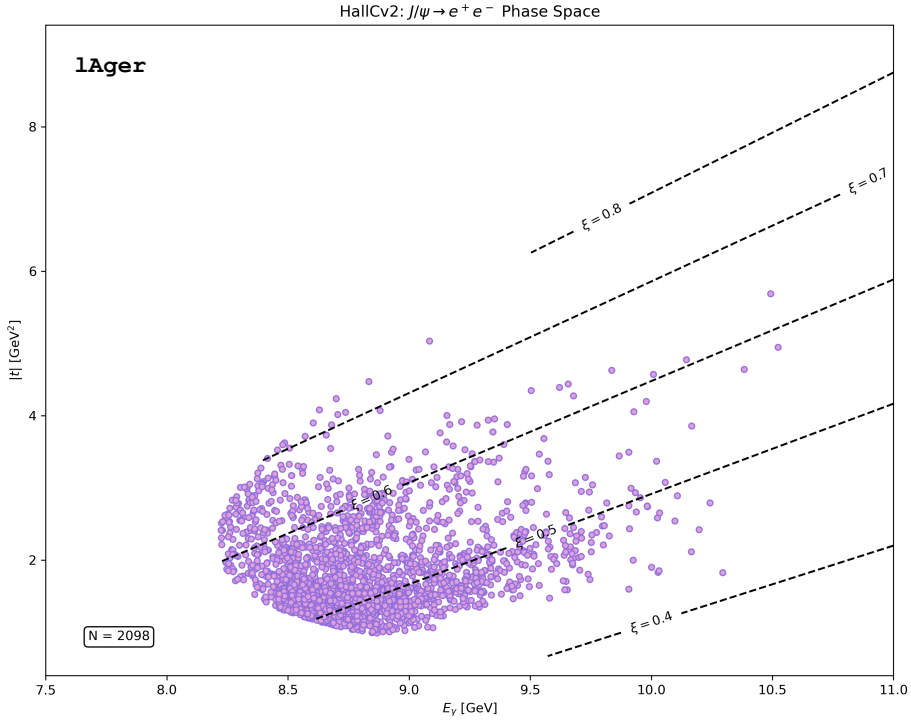




COMBINED PRELIMINARY SETTINGS

$$\xi = \frac{t - M_{J/\psi}^2}{2M_p^2 + M_{J/\psi}^2 - t - 2W}$$





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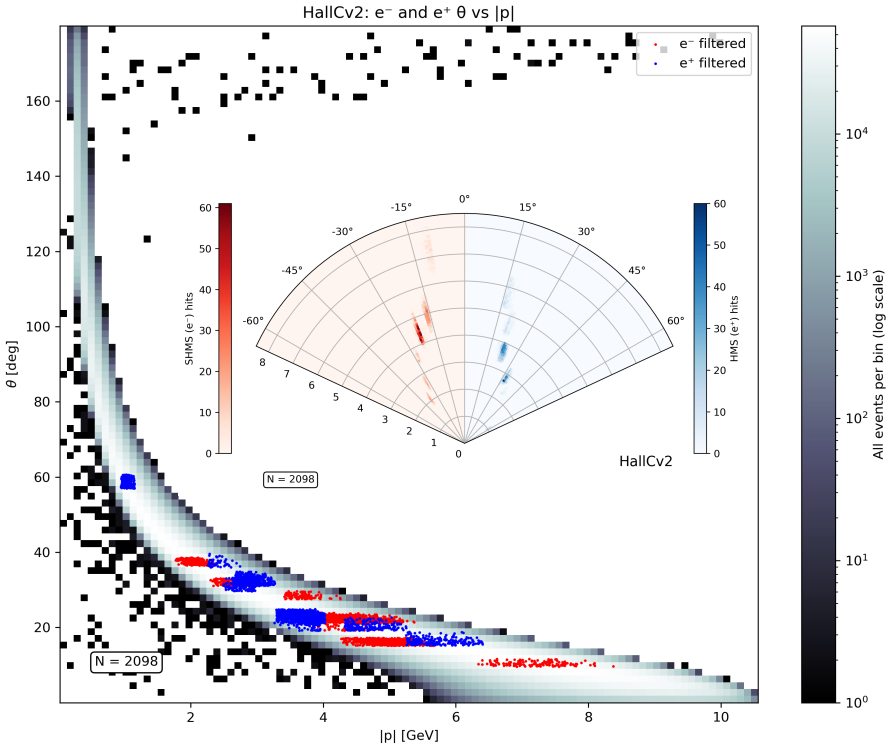
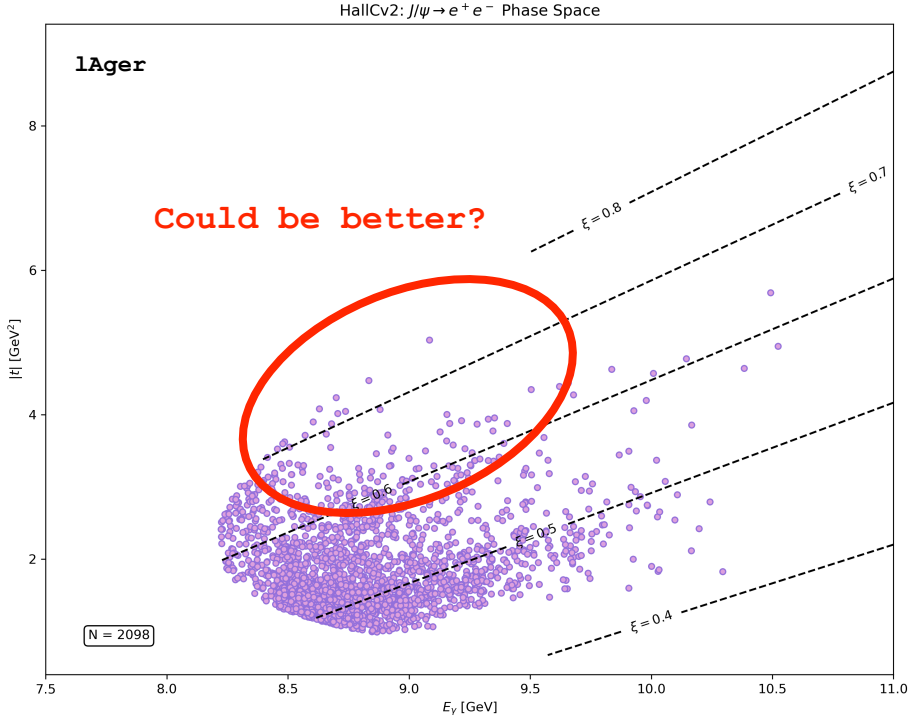
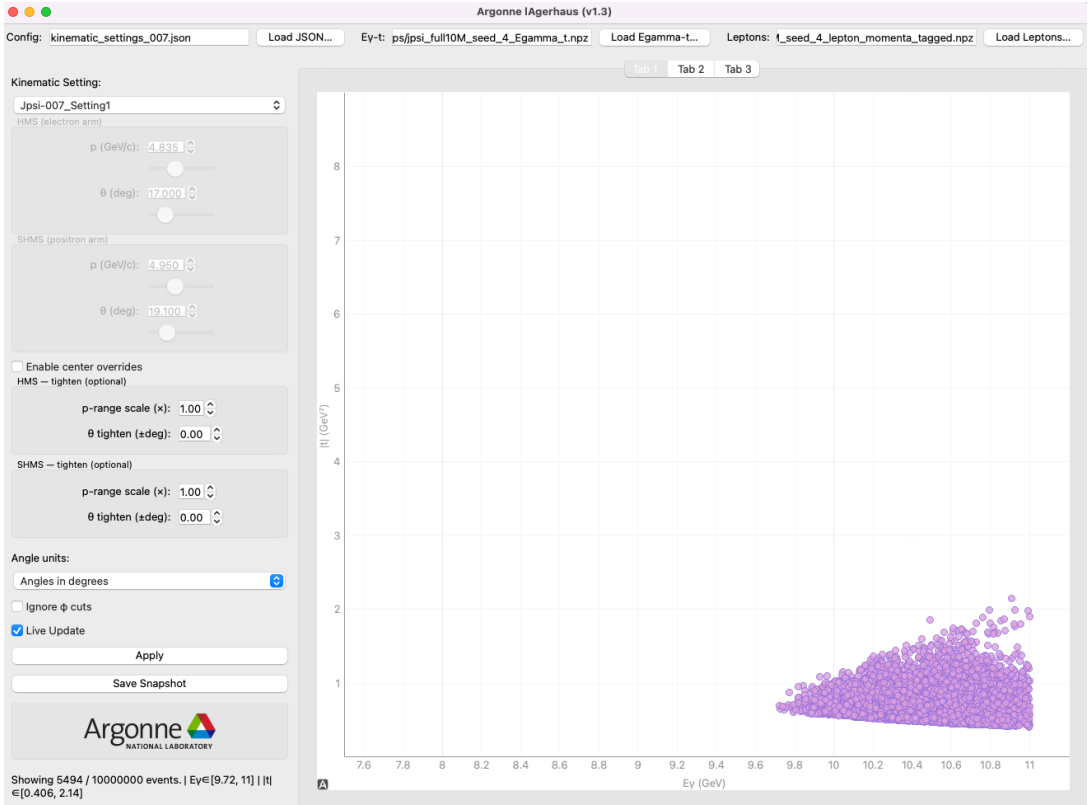




HISTOGRAMMING AND UTILITY SANDBOX (HAUS)

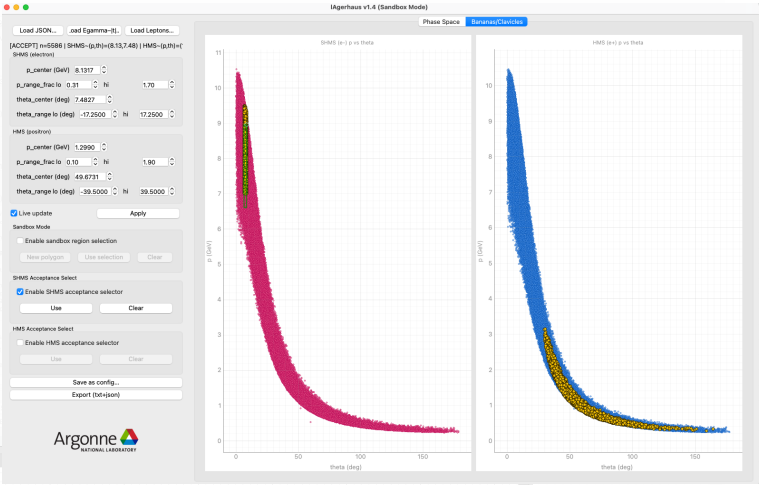
- Decided to make some sort of *utility sandbox* for me to play with detector kinematic settings (HMS and SHMS)
  - Mainly, to produce some critical *histograms* on the fly
  - Avoids discretely going to-and-fro from one setting to another to produce phase space
- Inputs:
  - Chopped version (as .npz) of the lAger output root file
    - Can also use take lAger .root files without the chopper step
  - Detector config file (as .json)
- In principle can be tailored to include any quantity and any detector

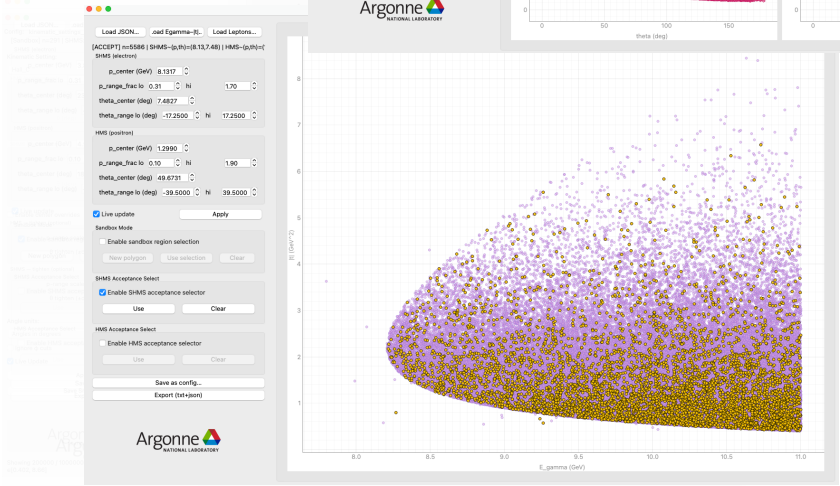


Ideally, you select (t,E_gamma) pairs in bunches and have lAgerhaus give me the HMS and SHMS settings on the fly…

HISTOGRAMMING AND UTILITY SANDBOX (HAUS)

- Modified GUI to fulfill the criteria we would like to fulfilhave in the :
  - Wanted the polar densities plots (fans) and the |p| vs. theta plots (bananas/ clavicles) to be shown on fly ✅
  - Wanted to be able to manually select points in the |t| vs. E_gamma phase space and output SHMS and HMS settings ✅
  - Wanted to be able to manually select points SHMS/HMS bananas and output HMS/SHMS settings AND (|t|, E_gamma) pairs ✅





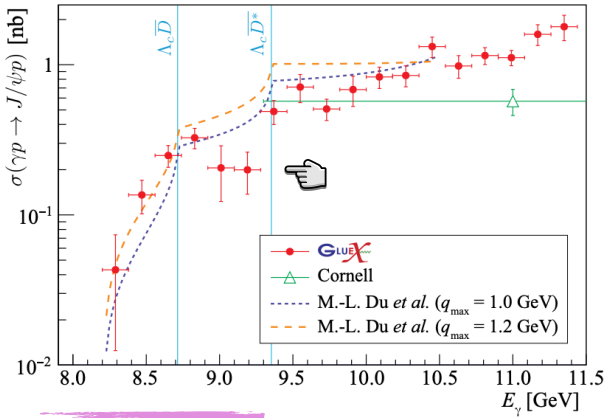
J/Ψ PHOTOPRODUCTION IN HALL D (GLUEX)

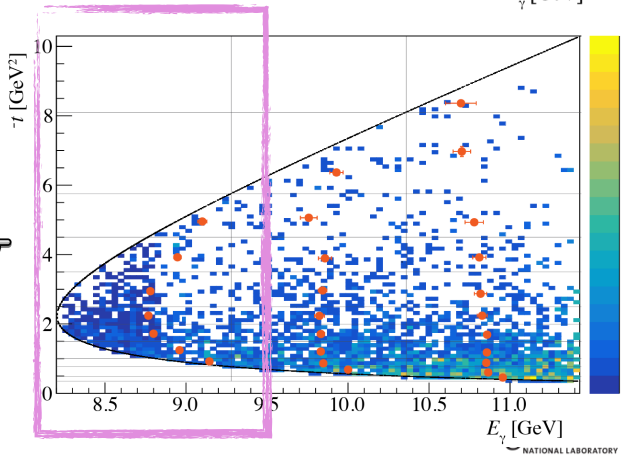
Alternative mechanism of J/ψ photoproduction from *Du et al.* suggests dominant contributions from open-charm exchanges (i.e. $\Lambda_c\bar{D}$ and $\Lambda_c\bar{D}^*$)

- Total cross-section of said model shows *good agreement* with the GlueX measurements
- Data *shows* structures peaking at both the $\Lambda_c\bar{D}$ and $\Lambda_c\bar{D}^*$ thresholds — interpreted as cusps expected with this reaction mechanism
- However, such heavy hadron exchange in this model implies a very *shallow t-dependence* in the differential cross-section
  - Not supported by steeply falling differential cross-sections
  - Differential cross-section measurements do not support dominant contribution from open-charm exchanges
    - Enhancement at ***high t*** in the lowest E_γ bin, maybe?
      - *High t* enhancement may be explained via *u-channel* contribution assuming factorization in terms of Transition Distribution Amplitudes

Challenge on the GFF extraction/interpretation as the *t-dependence* sees a dip

Adhikari et al. (GlueX). *Phys. Rev. C.* ***108*** **(2023)**

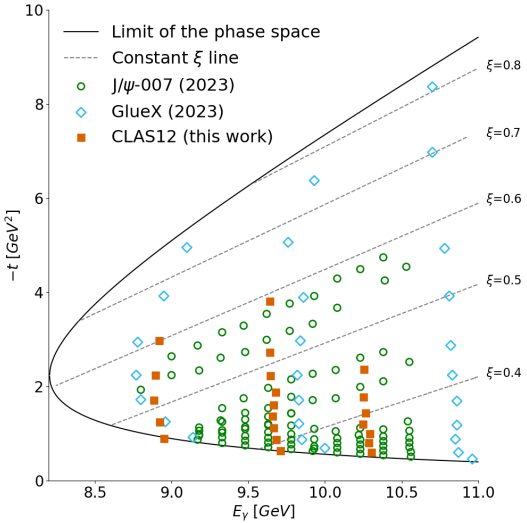




CLAS12 J/Ψ PHOTOPRODUCTION

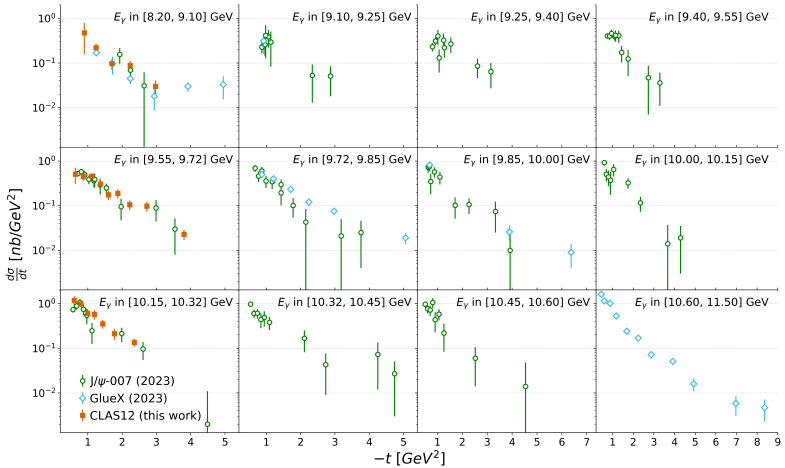
Chatagnon et al (CLAS12). *arXiv:2602.22128*

Recent CLAS12 measurement of near-threshold J/ψ photoproduction provides new data on the total and differential cross sections



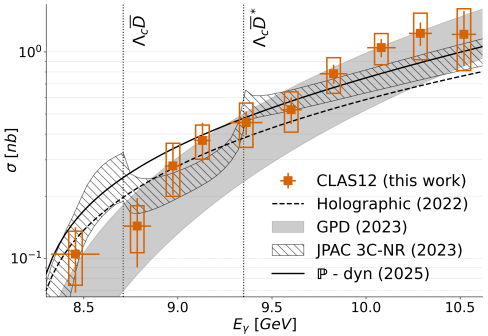
Consistent with existing world data across overlapping kinematics

- Smooth energy dependence near open-charm thresholds — threshold-induced distortions of the unpolarized cross section may be subtle



Lowest E_γ bin lies above GlueX 8.2 GeV to 9.28 GeV bin

Measured cross-section to moderately high values of |t| still limited



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