



Hadron Spectroscopy with GlueX: Exotic States, Spin Dynamics, and Hadronization

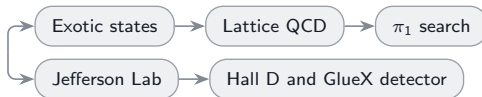
MENU 2026, 17th International Conference on Meson–Nucleon Physics and the
Structure of the Nucleon

Hao Li (for the GlueX Collaboration) William & Mary
Stony Brook University, October 19–23, 2026



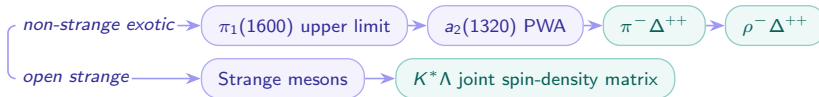
1

Introduction



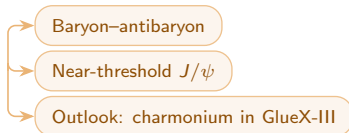
2

Exotic states and spin dynamics



3

Hadronization, gluonic structure and GlueX-III



Introduction



Exotic states

conventional hadrons



meson $q\bar{q}$



baryon qqq

allowed by QCD, beyond $q\bar{q}$ and qqq



hybrid
 $q\bar{q}g$



glueball
 gg



tetraquark
 $qq\bar{q}\bar{q}$



pentaquark
 $qqqq\bar{q}$

Do gluonic degrees of freedom manifest themselves in the hadronic states we observe in nature?

NON-STRANGE

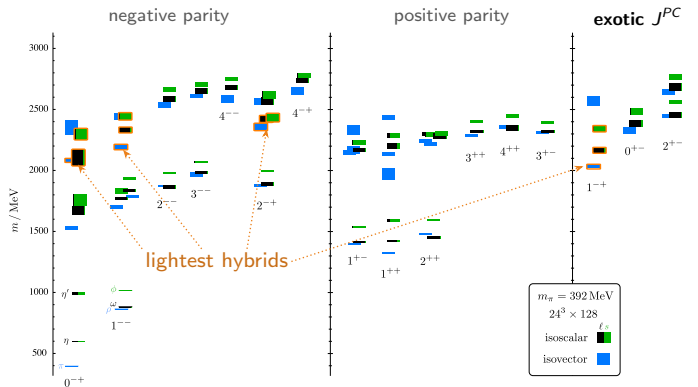


e.g. $\pi_1(1600)$, 1^{-+}

OPEN STRANGE



e.g. supernumerary K^*



Caveat: $m_\pi = 392 \text{ MeV}$, masses above physical

$\blacksquare$ $u\bar{d}$ $\blacksquare$ $u\bar{u} + d\bar{d}$ $\blacksquare$ $s\bar{s}$

Exotic J^{PC}

$0^{--}, 0^{+-}, 1^{-+}, 2^{+-}, \dots$:
impossible for $q\bar{q}$; needs gluonic or
multiquark content

$q\bar{q}$ glue hybrid

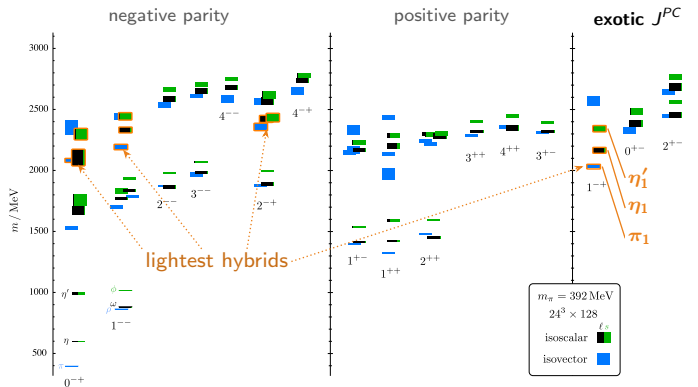
S-wave

$$0^{-+} \otimes 1^{+-} \rightarrow 1^{--}$$

$$1^{--} \otimes 1^{+-} \rightarrow 0^{-+}, 1^{-+}, 2^{-+}$$

P-wave

$$1^{++} \otimes 1^{+-} \rightarrow 0^{+-}, 1^{+-}, 2^{+-}$$



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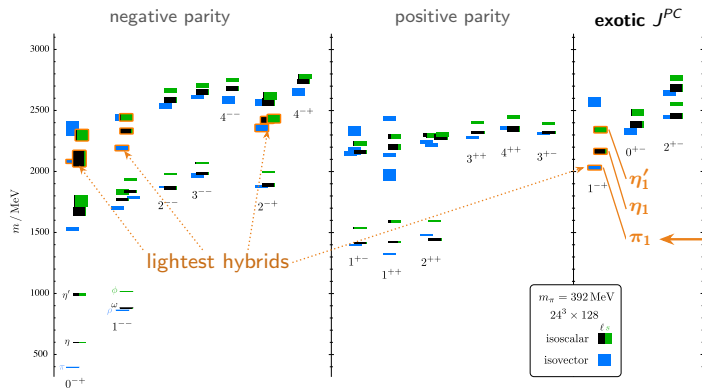
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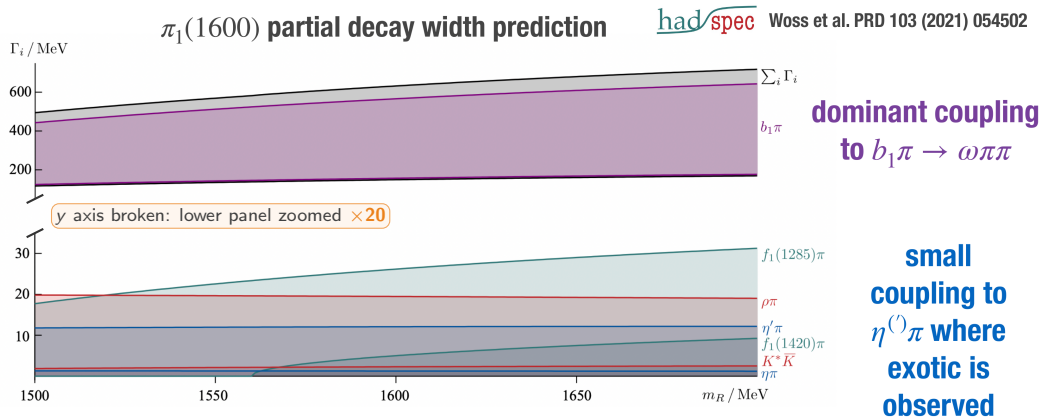
$$1^{--} \otimes 1^{+-} \rightarrow 0^{+-}, \boxed{1^{+-}}, 2^{+-}$$

P-wave

$$1^{++} \otimes 1^{+-} \rightarrow 0^{+-}, 1^{+-}, 2^{+-}$$

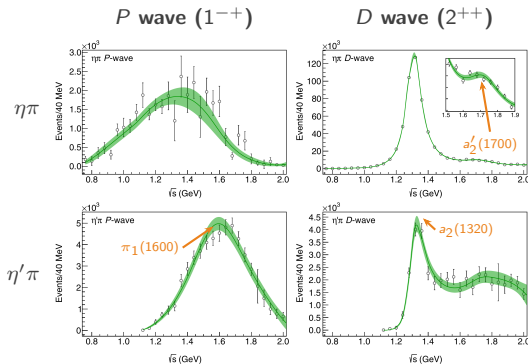
Where to search for $\pi_1(1600)$? Lattice QCD

HadSpec, PRD 103, 054502 (2021)



Where to search for $\pi_1(1600)$? Coupled-channel fit

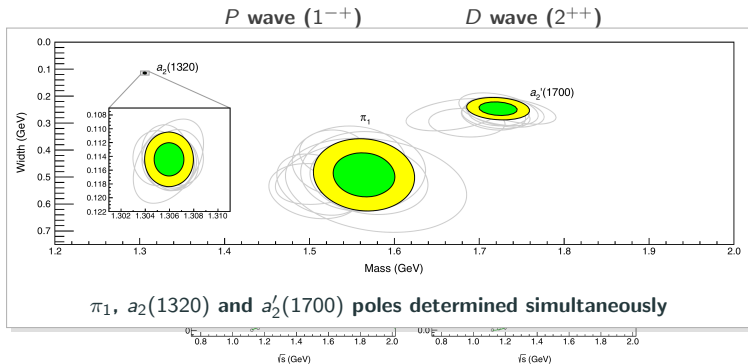
JPAC coupled-channel fit: COMPASS $\eta^{(\prime)}\pi$



- ▶ JPAC fit of COMPASS data: **one π_1 pole at ~ 1600 MeV**
- ▶ Independent coupled-channel analysis of $\bar{p}p$, $\pi^- p$, $\pi\pi$ (EPJC 81, 1056 (2021))
- ▶ Photoproduction: barely explored $\Rightarrow$ **unique opportunity for GlueX**

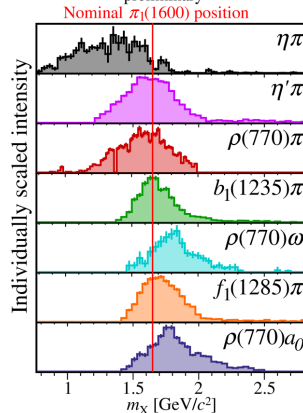
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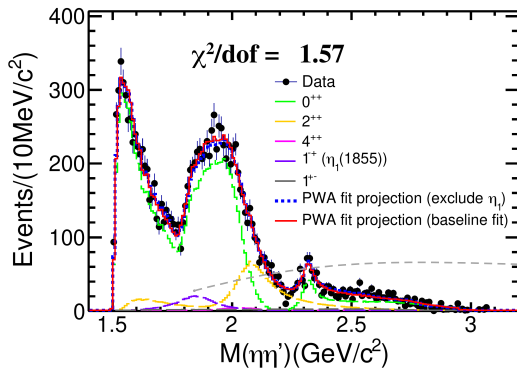
Spin-exotic $J^{PC}=1^{+-}$ waves at COMPASS
preliminary



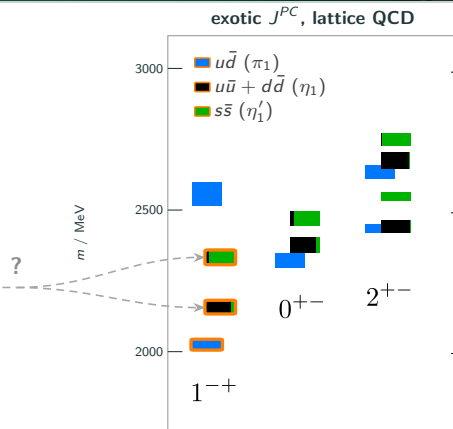
COMPASS: spin-exotic waves
seen in many decay channels

Isoscalar partner: $\eta_1(1855)$ at BESIII

Left: BESIII, PRL 129, 192002 (2022)
Right: HadSpec, PRD 88, 094505 (2013)



$J/\psi \rightarrow \gamma\eta\eta'$: $M(\eta\eta')$ with the partial-wave fit



Caveat: $m_\pi = 392$ MeV, masses above physical

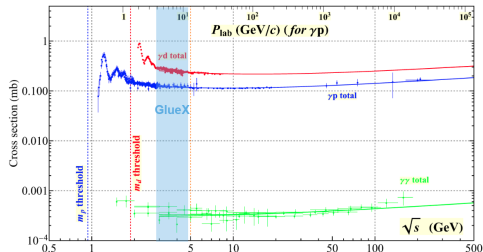
- ▶ BESIII candidate for the isoscalar partner $\eta_1(1855)$ in $J/\psi \rightarrow \gamma\eta'\eta$
- ▶ GlueX: opportunity to study the isoscalar partner in photoproduction

GlueX at Jefferson Lab



Hall D photon beam: t -channel dominance

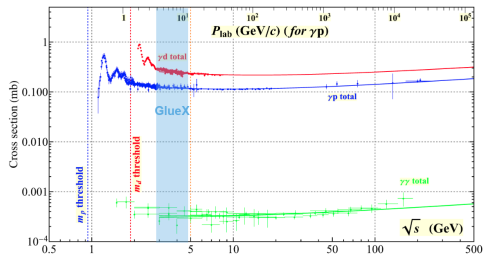
Total γp cross section (PDG 2022); band: GlueX,
 $6 < E_\gamma < 11.4$ GeV



- ▶ s -channel resonances fade: **t -channel exchange dominates**
- ▶ Top-vertex meson, recoiling off the target: near-threshold reach

Hall D photon beam: t -channel dominance

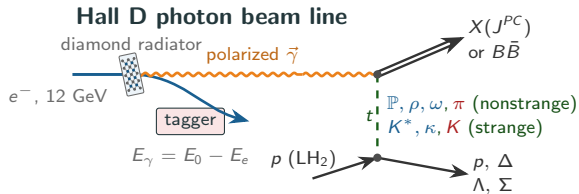
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- ▶ s -channel resonances fade: **t -channel exchange dominates**
- ▶ Top-vertex meson, recoiling off the target: near-threshold reach

t -channel exchange	natural $P(-1)^J = +1$	unnatural $P(-1)^J = -1$
nonstrange	$\mathbb{P}$ (vacuum); ρ , ω	π
strange	K^* , κ	K

Linear polarization probes naturality, which helps pin down J^{PC}



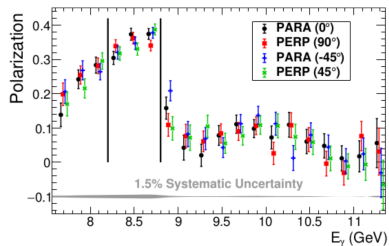
Coherent bremsstrahlung: $\sim 35\%$ linear polarization at 8.2–8.8 GeV, tagged to 11.6 GeV

GlueX data collected so far:

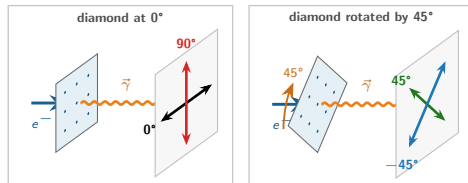
$\sim 10^{12}$ events and ~ 12 PB of data

Approximate yields

$\rho(770)$	800M	$\eta\pi$	8M
$\omega(782)$	160M	$\omega\pi$	40M
$\phi(1020)$	8M		



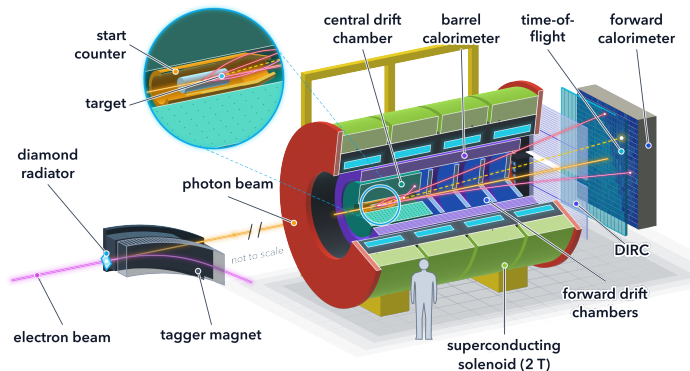
- ▶ World's largest polarized photoproduction data set
- ▶ Diamond radiator: $\sim 35\%$ polarization at 8.2–8.8 GeV; **diamond orientation sets the polarization angle**
- ▶ Key to the production mechanism and spin-parity
- ▶ $0^\circ/90^\circ$ and $-45^\circ/45^\circ$ pairs cancel the azimuthal acceptance (e.g. up-down asymmetry from detector sag)



The GlueX detector

Left: adapted from GlueX, NIM A 987, 164807 (2021)

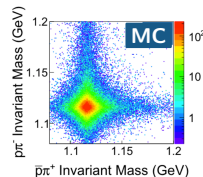
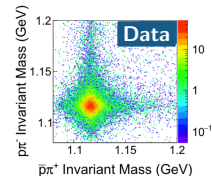
Right: $\gamma p \rightarrow \Lambda \bar{\Lambda} p$, GlueX, PRC 113, 045207 (2026)



► Large acceptance, nearly hermetic

► Precise exclusive final states

Reconstructed Λ vs $\bar{\Lambda}$ mass

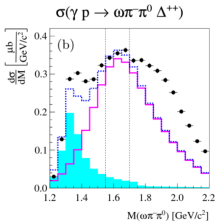
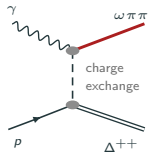
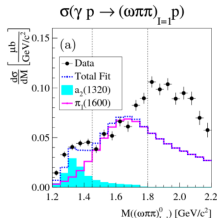
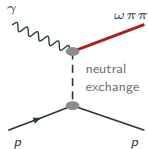


► Multistage detached-vertex reconstruction

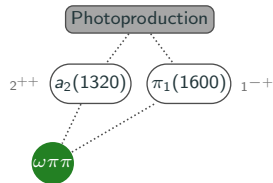
Exotic states and spin dynamics



$\pi_1(1600)$ photoproduction upper limit

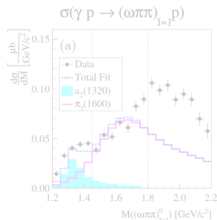
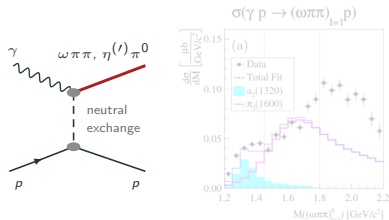


Fit $\sigma(\omega\pi\pi)_{I=1}$ with fixed BW shapes:
 $a_2(1320)$ (PDG), $\pi_1(1600)$ (JPAC)

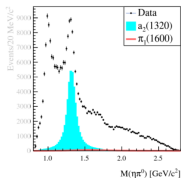


- **Upper limit on**
 $\gamma p \rightarrow p \pi_1^0(1600)$ and
 $\gamma p \rightarrow \Delta^{++} \pi_1^-(1600)$, using
 $\pi_1(1600) \rightarrow b_1 \pi \rightarrow \omega \pi \pi$

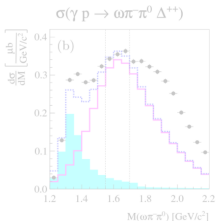
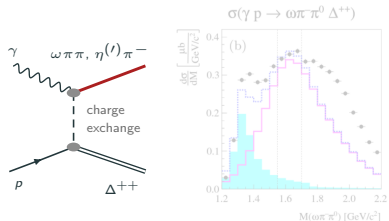
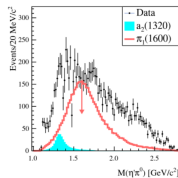
$\pi_1(1600)$ photoproduction upper limit



$\eta \pi$ projection

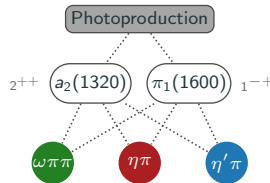


$\eta' \pi$ projection

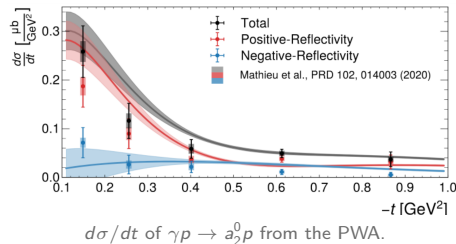
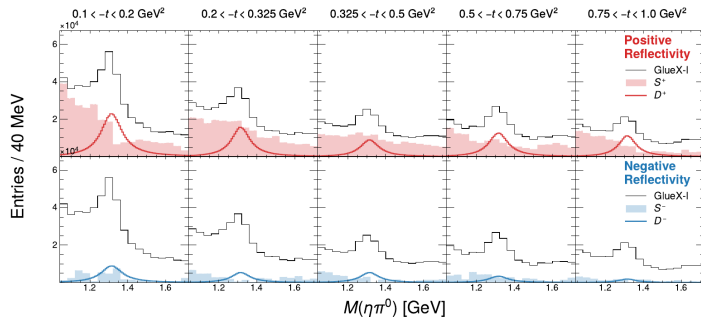


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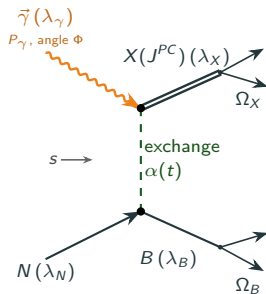
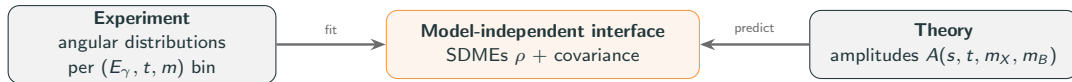
Lattice-QCD branching ratios $\Rightarrow \eta^{(\prime)} \pi$ projections:
 a $\pi_1(1600)$ could be significant in $\eta' \pi$



► Upper limit on
 $\gamma p \rightarrow p \pi_1^0(1600)$ and
 $\gamma p \rightarrow \Delta^{++} \pi_1^-(1600)$, using
 $\pi_1(1600) \rightarrow b_1 \pi \rightarrow \omega \pi \pi$



- ▶ $a_2(1320)$: reference for the amplitude analysis in the π_1 final states $\eta\pi$, $\eta'\pi$, $\omega\pi\pi$
- ▶ Wave reflectivity $\varepsilon \rightarrow$ naturality of the exchange:
 $\varepsilon = + \Leftrightarrow \text{natural } (P(-1)^J = +1)$; $\varepsilon = - \Leftrightarrow \text{unnatural } (P(-1)^J = -1)$
- ▶ Semi-mass-dependent PWA with an a_2 Breit–Wigner: dominantly natural-parity exchange, in agreement with tensor-meson dominance



1 production amplitude

$$A_{\lambda_\gamma \lambda_X; \lambda_N \lambda_B}(s, t, m_X, m_B) = \sum_\ell \underbrace{V_{\lambda_\gamma \lambda_X; \lambda_N \lambda_B}^\ell(s, t)}_{\text{production mechanism}} \underbrace{F_{\lambda_X}^\ell(m_X)}_{\text{meson resonance}} \underbrace{F_{\lambda_B}(m_B)}_{\text{baryon resonance}}$$

2 spin-density matrix

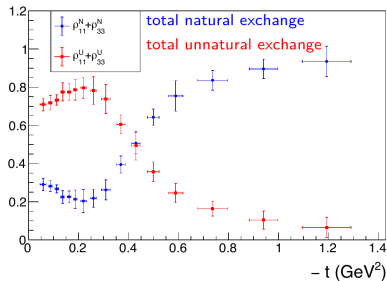
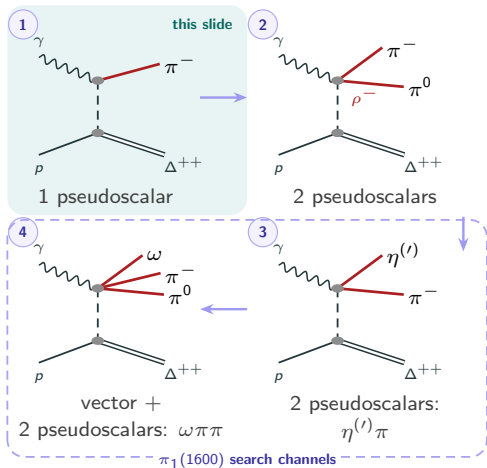
$$\rho_{\lambda_X \lambda_B; \lambda'_X \lambda'_B}(\Phi) = \frac{1}{N} \sum_{\lambda_\gamma \lambda'_\gamma \lambda_N} A_{\lambda_\gamma \lambda_X; \lambda_N \lambda_B} \rho_{\lambda_\gamma \lambda'_\gamma}(\Phi) A_{\lambda'_\gamma \lambda'_X; \lambda_N \lambda'_B}^*$$

3 intensity function of the joint angular distribution

$$W(\Omega_X, \Omega_B, \Phi) = \sum_{\lambda_X \lambda'_X \lambda_B \lambda'_B} \rho_{\lambda_X \lambda_B; \lambda'_X \lambda'_B}(\Phi) D_{\lambda_X \mu_X}^{J_X*}(\Omega_X) D_{\lambda'_X \mu_X}^{J_X}(\Omega_X) D_{\lambda_B \mu_B}^{J_B*}(\Omega_B) D_{\lambda'_B \mu_B}^{J_B}(\Omega_B)$$

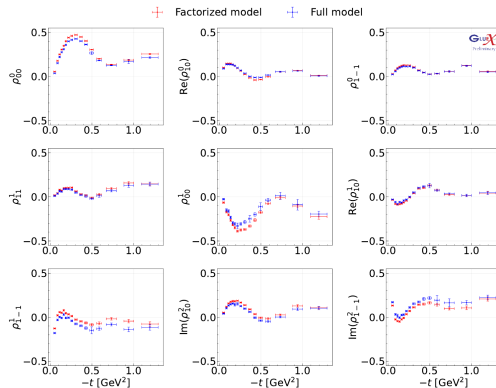
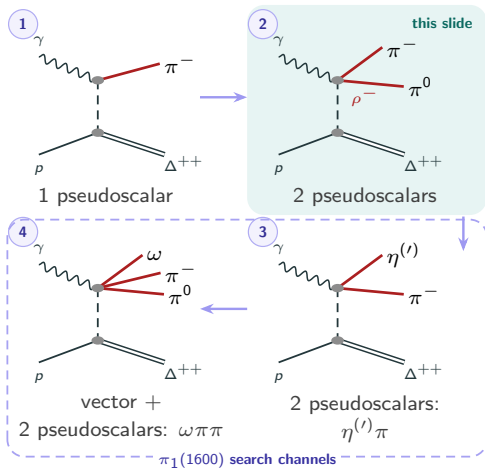
► A good interface between experimentalists and theorists, with the full covariance preserved

Spin-density matrix of Δ^{++} in $\gamma p \rightarrow \pi^- \Delta^{++}$



- Unnatural (π) exchange dominates at small $-t$, natural (ρ , a_2) at larger $-t$
- $N\Delta$ exchange couplings (JPAC): input for the charge-exchange π_1 channels

See also: M. Scott (GWU), *Beam asymmetry Σ of the $a_0(980)^0$ photoproduced in GlueX*, Parallel V, Thu Oct 22, 3:50 PM



- ▶ The Δ^{++} decay could give access to the joint spin-density matrix of vector meson–baryon
- ▶ Could test whether the t -channel Regge amplitude factorizes, to reduce the computational complexity of the model fit

Open strange



Extending the search to strange hybrids

Conventional decays: PDG; LHCb, PRD 89, 112004 (2014); PRD 104, 072002 (2021)
arXiv:2609.30850 (MESON 2026)

Complete the hybrid multiplet

the 1^{-+} hybrids appear in $\eta'\pi$ and $\eta'\eta$; their strange 1^{-} partner can be searched for in $\eta'K$ and other strange systems

No exotic signature

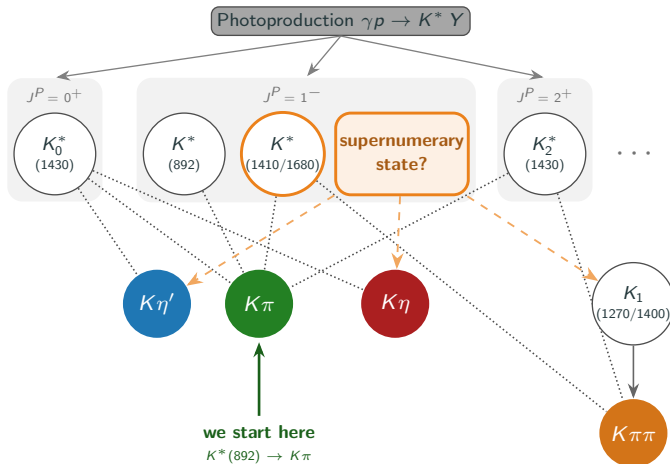
strange mesons have no C parity, so a strange hybrid has ordinary J^P and would appear as an extra, supernumerary K^*

Spectrum still open

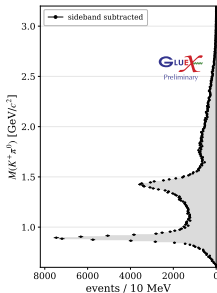
many excited K^* unestablished; GlueX $K\pi$, $K\eta^{(\prime)}$, $K\pi\pi$ data can map them

Extra handle in photoproduction

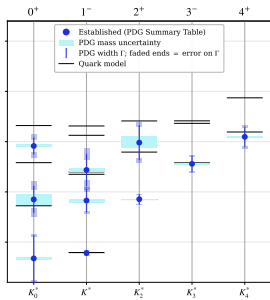
strangeness exchange (K , K^* , κ) and the self-analyzing Λ recoil give extra spin information



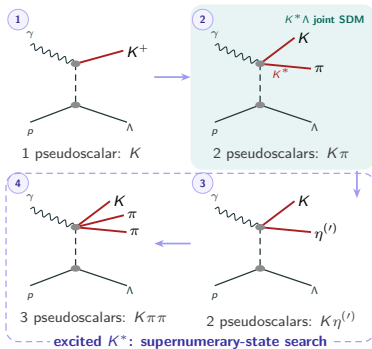
GlueX $K\pi$ mass



K_J^* : PDG vs. quark model

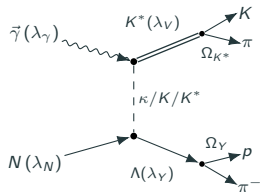


- ▶ Many K_J^* states unestablished; GlueX $K\pi$ data provide a unique opportunity to map them
- ▶ Strange hybrids: same J^P as ordinary K_J^* , found only by amplitude analysis



Roadmap

1. $K^*(892)$ as **standard candle**: spin observables
2. PWA of the excited K^* region
3. $K\pi\pi$ and multi-body systems



formalism	obs.
-----------	------

complete matrix	35
Schilling (K^* only)	9
spin correlation $K^* \otimes \Lambda$	26
hyperon polarization	5

$2 \times 3 \times 2 = 12$ helicity states;
linearly polarized beam,
unpolarized target.



1 production, photon polarization P_γ at angle Φ ; $i, j = (\lambda_V, \lambda_Y)$

$$\rho_{ij}(\Phi) = \frac{1}{N} \sum_{\lambda_\gamma \lambda'_\gamma \lambda_N} A_{i;\lambda_\gamma} \rho_{\lambda_\gamma \lambda'_\gamma}^\gamma(\Phi) A_{j;\lambda'_\gamma}^*$$

$$= \rho_{ij}^{(0)} - P_\gamma \cos 2\Phi \rho_{ij}^{(1)} - P_\gamma \sin 2\Phi \rho_{ij}^{(2)}$$

2 joint angular intensity function from the trace of ρ with the decay amplitudes

$$W(\Omega_{K^*}, \Omega_Y, \Phi) \propto \text{Tr} \left[\rho^{(0)} \left(\mathcal{D}(\Omega_{K^*}) \otimes \frac{1}{2} (\mathbb{I} + \alpha \boldsymbol{\sigma} \cdot \hat{n}(\Omega_Y)) \right) \right]$$

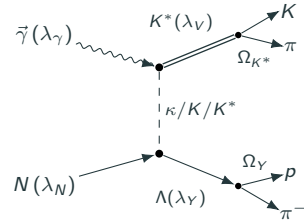
$$- P_\gamma \cos 2\Phi \text{Tr} \left[\rho^{(1)} \left(\mathcal{D}(\Omega_{K^*}) \otimes \frac{1}{2} (\mathbb{I} + \alpha \boldsymbol{\sigma} \cdot \hat{n}(\Omega_Y)) \right) \right]$$

$$- P_\gamma \sin 2\Phi \text{Tr} \left[\rho^{(2)} \left(\mathcal{D}(\Omega_{K^*}) \otimes \frac{1}{2} (\mathbb{I} + \alpha \boldsymbol{\sigma} \cdot \hat{n}(\Omega_Y)) \right) \right]$$

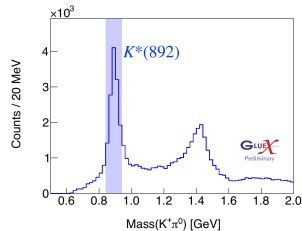
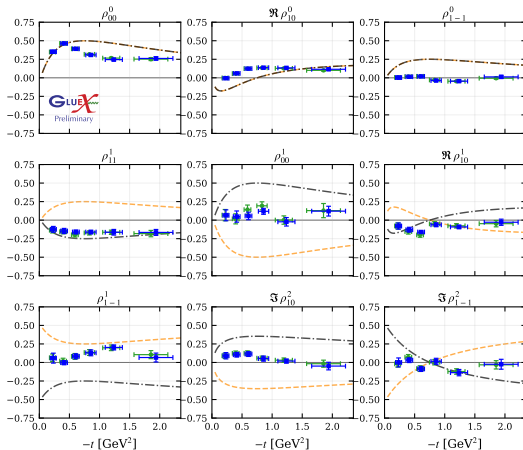
Joint angular intensity function: 35 terms

1: Schilling (9)			$\alpha_\Lambda n_x$ (8)			$\alpha_\Lambda n_y$ (10)			$\alpha_\Lambda n_z$ (8)		
lin. γ pol.	coeff.	Ω_K * function	lin. γ pol.	coeff.	Ω_K * function	lin. γ pol.	coeff.	Ω_K * function	lin. γ pol.	coeff.	Ω_K * function
1	ρ_{00}^0	$3 \cos^2 \theta - 1$	1	$\sqrt{2}A_{10s}^{(0,x)}$	$\sin 2\theta \sin \phi$	1	$P^{(0,y)}$	1	1	$\sqrt{2}A_{10s}^{(0,z)}$	$\sin 2\theta \sin \phi$
	$\sqrt{2}\Re \rho_{10}^0$	$\sin 2\theta \cos \phi$		$A_{1-1s}^{(0,x)}$	$\sin^2 \theta \sin 2\phi$		$A_{00}^{(0,y)}$	$\cos^2 \theta$		$A_{1-1s}^{(0,z)}$	$\sin^2 \theta \sin 2\phi$
	ρ_{1-1}^0	$\sin^2 \theta \cos 2\phi$		$\sqrt{2}A_{10s}^{(1,x)}$	$\sin 2\theta \sin \phi$		$\sqrt{2}A_{00}^{(0,y)}$	$\sin 2\theta \cos \phi$		$\sqrt{2}A_{10s}^{(1,z)}$	$\sin 2\theta \sin \phi$
$-P_\gamma \cos 2\Phi$	ρ_{11}^1	$\sin^2 \theta$	$-P_\gamma \cos 2\Phi$	$A_{1-1s}^{(1,x)}$	$\sin^2 \theta \sin 2\phi$		$A_{1-1c}^{(0,y)}$	$\sin^2 \theta \cos 2\phi$	$-P_\gamma \cos 2\Phi$	$A_{1-1s}^{(1,z)}$	$\sin^2 \theta \sin 2\phi$
	ρ_{00}^1	$\cos^2 \theta$	$-P_\gamma \sin 2\Phi$	$P^{(2,x)}$	1	$-P_\gamma \cos 2\Phi$	$P^{(1,y)}$	1	$-P_\gamma \sin 2\Phi$	$P^{(2,z)}$	1
	$\sqrt{2}\Re \rho_{10}^1$	$\sin 2\theta \cos \phi$		$A_{00}^{(2,x)}$	$\cos^2 \theta$		$A_{00}^{(1,y)}$	$\cos^2 \theta$		$A_{00}^{(2,z)}$	$\cos^2 \theta$
	ρ_{1-1}^1	$\sin^2 \theta \cos 2\phi$		$\sqrt{2}A_{10c}^{(2,x)}$	$\sin 2\theta \cos \phi$		$\sqrt{2}A_{10c}^{(1,y)}$	$\sin 2\theta \cos \phi$		$\sqrt{2}A_{10c}^{(2,z)}$	$\sin 2\theta \cos \phi$
$-P_\gamma \sin 2\Phi$	$\sqrt{2}\Im \rho_{10}^2$	$\sin 2\theta \sin \phi$		$A_{1-1c}^{(2,x)}$	$\sin^2 \theta \cos 2\phi$		$A_{1-1c}^{(1,y)}$	$\sin^2 \theta \cos 2\phi$		$A_{1-1c}^{(2,z)}$	$\sin^2 \theta \cos 2\phi$
	$\Im \rho_{1-1}^2$	$\sin^2 \theta \sin 2\phi$				$-P_\gamma \sin 2\Phi$	$\sqrt{2}A_{10s}^{(2,y)}$	$\sin 2\theta \sin \phi$			
							$A_{1-1s}^{(2,y)}$	$\sin^2 \theta \sin 2\phi$			

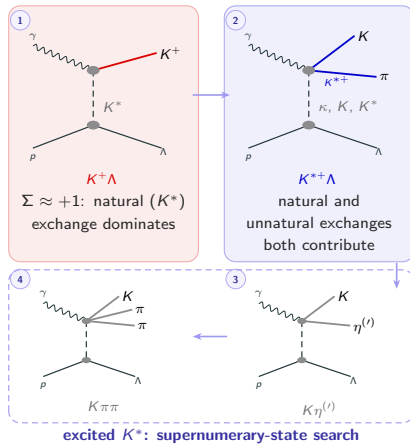
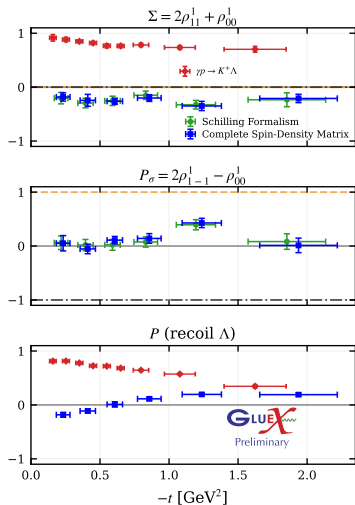
- As shown in the table, the full joint angular intensity function has 35 coefficients as free model parameters, fitted over a large range of t
- Each term is an angular response function of the polarization angle Φ , the K^* decay angle Ω_{K^*} and the Λ decay angle Ω_γ



◆ Schilling fit ■ complete-matrix fit
- - - κ (natural) - - - K (unnatural) theory: Wang *et al.*, PRC **102**, 015203 (2020); Wei *et al.*, PRC **101**, 014003 (2020)



- First precise $K^*(892)$ SDMEs measurement beyond Schilling formalism over large range of momentum transfer variable t
- Measurements consistent between intensity function fitting with Schilling formalism and the full spin-density matrix formalism

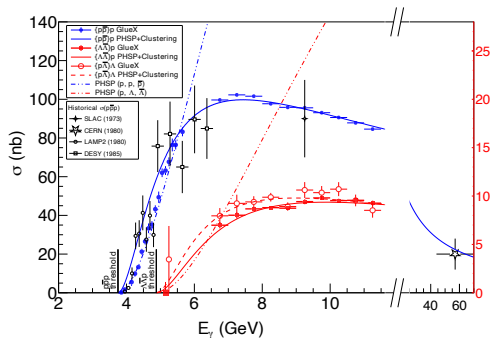


- Testbed for the amplitude formalism and machinery, preparing for channels 3 and 4 toward the strange-hybrid search

Hadronization, gluonic structure and GlueX-III



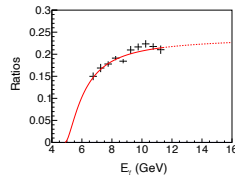
- $p\bar{p}$, and the first $\Lambda\bar{\Lambda}$ and $p\bar{\Lambda}$ photoproduction



Total cross-section model (Eq. 16): single exchange integrated over t' , m_{12} ; two parameters per channel

$$\sigma_{\text{tot}}(s) = \frac{N_{B\bar{B}}}{(4\pi)^3} \int_{m_{12}^{\min}}^{m_{12}^{\max}(s)} \text{Phsp}(s, m_{12}) \text{Exp}\left(-\frac{m_{12} - m_{12}^{\min}}{c_{\text{tot}}}\right) dm_{12}$$

Strange-to-nonstrange ratio vs. E_γ



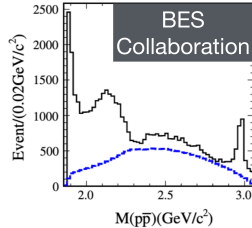
red: cross-section model, extrapolated

- Levels off at $P(s\bar{s})/P(u\bar{u}) \approx 0.23$: strangeness suppression

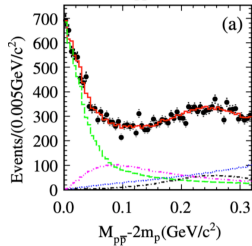
- Consistent with the Lund model, $u:d:s:c = 1:1:\frac{1}{3}:10^{-11}$ (PYTHIA 8 default $\lambda_s \approx 0.22$)

Outlook

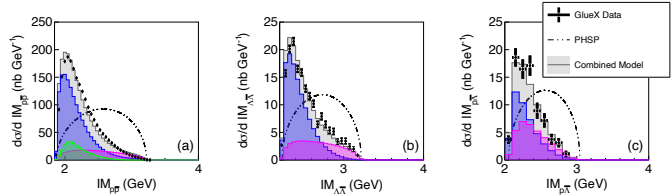
- Extending to the full hyperon–antihyperon family: $\Lambda\bar{\Lambda}$, $\Sigma\bar{\Sigma}$, $\Xi\bar{\Xi}$: mapping hadronization with one and two $s\bar{s}$ pairs
- BESIII sees the $X(2370)$ (0^{-+}) near the $\Sigma\bar{\Sigma}$ threshold (PRL 132, 181901 (2024))
- A $\Sigma\bar{\Sigma}$ molecule? ([arXiv:2609.01342](#)) $\Rightarrow \Sigma\bar{\Sigma}$ and $\Xi\bar{\Xi}$ are interesting channels to be explored at GlueX



[1]



[2]



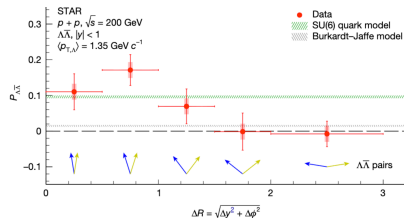
- Pairs cluster toward threshold in all three channels: a **broad** enhancement, no narrow $X(1835)$ -like structure as seen by BES/BESIII in J/ψ radiative decays [1, 2]
- Clustering model: one mass parameter c_m on top of phase space

$$\frac{d\sigma}{dm_{12}} \propto \text{Phsp}(m_{12}) \text{Exp}\left(-\frac{m_{12} - m_{12}^{\min}}{c_m}\right)$$
- Interpretations with theorists: $B\bar{B}$ final-state interactions [3–5]; sub-threshold scalar mesons with glueball content [6]

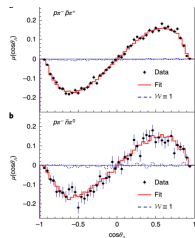
 [1] BES: Phys. Rev. Lett. **91**, 022001 (2003) [2] BESIII: Phys. Rev. Lett. **108**, 112003 (2012) [3] Phys. Rev. C **69**, 055205 (2004)

 [4] Eur. Phys. J. A **59**, 136 (2023) [5] Eur. Phys. J. A **60**, 119 (2024) [6] Phys. Rev. D **96**, 054024 (2017)

Hyperon–antihyperon spin observables



STAR, pp at $\sqrt{s} = 200 \text{ GeV}$: $\Lambda\bar{\Lambda}$ spin correlation vs. ΔR . Nature 650, 65 (2026).



BESIII, $J/\psi \rightarrow \Lambda\bar{\Lambda}$: Λ polarization $\mu(\cos\theta_\Lambda)$. Nature Phys. 15, 631 (2019).

Spin observables from self-analyzing decays

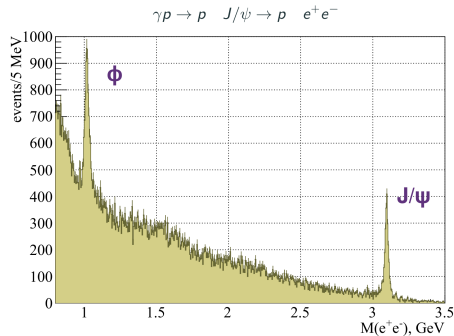
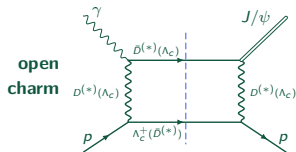
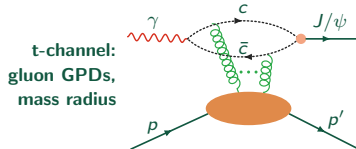
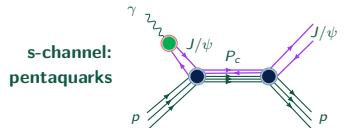
- ▶ STAR: $\Lambda\bar{\Lambda}$ spin correlation probes $s\bar{s}$ decoherence in hadronization
- ▶ BESIII: transverse Λ polarization, α_Λ revised, CP test
- ▶ GlueX: first measurable $\Lambda\bar{\Lambda}$ spin-correlation pattern in the photoproduced baryon–antibaryon system; precise interpretation ongoing with theoretical development

Future directions

- ▶ $\Lambda\bar{\Lambda}, \Sigma\bar{\Sigma}, \Xi\bar{\Xi}$ spin observables; $p\bar{p}$ beam asymmetries
- ▶ Same amplitude-level tools as in the strange-meson analyses
- ▶ Expands GlueX strangeness program to frontier baryon-pair entanglement studies recently highlighted by BESIII and STAR

Near-threshold charmonium

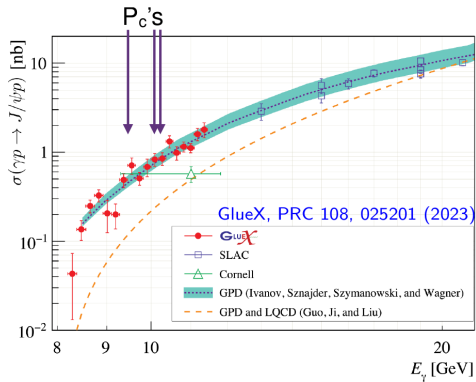




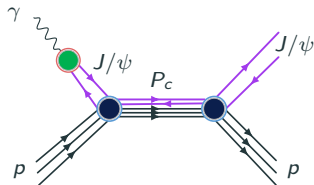
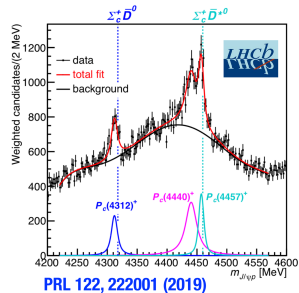
- ▶ Experimentally clean and rare probe: $\approx 2300 \ J/\psi$ in GlueX-I
- ▶ Broad physics program driven by different production mechanisms

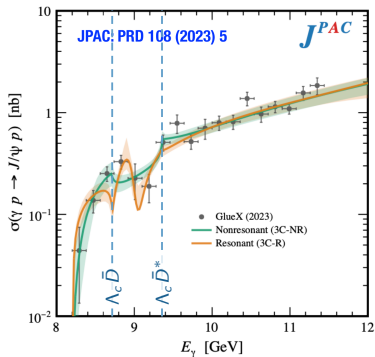
Search for LHCb P_c pentaquarks

LHCb, PRL 122, 222001 (2019)
GlueX, PRC 108, 025201 (2023)

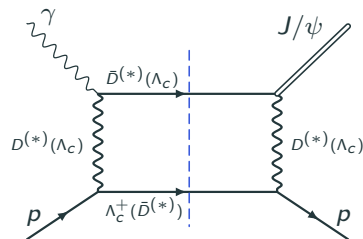


GlueX-I cross section across the LHCb P_c masses: no narrow peak, but a structure around 9 GeV

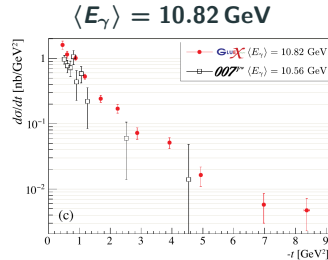
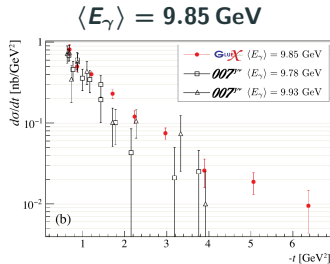
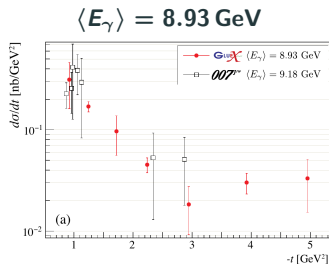




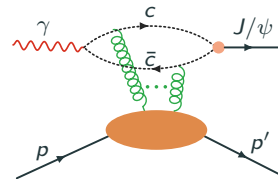
Open-charm intermediate states



- ▶ Total cross section sensitive to “cusps” near open-charm thresholds (dashed)
- ▶ Models with both resonant pentaquark and purely non-resonant effects can adequately describe the data
- ▶ Improved precision required to differentiate production mechanisms



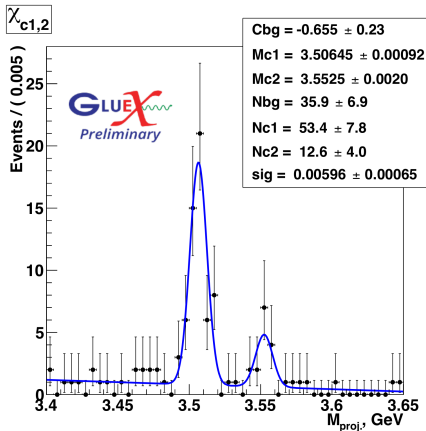
- ▶ Potentially sensitive to J/ψ - p scattering: proton “mass radius”, GPDs, etc.
- ▶ Consistent results between GlueX and J/ψ -007 (Hall C)
- ▶ **Interesting enhancement at large $-t$ for low energy:** hints at alternative production mechanisms



χ_{cJ} photoproduction near threshold

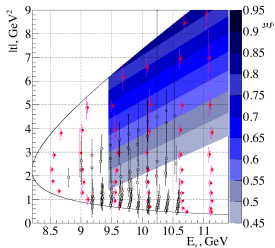


$$\gamma p \rightarrow \chi_{cJ} p \rightarrow (J/\psi \gamma) p \rightarrow (e^+ e^- \gamma) p$$



- ▶ χ_{c1} and χ_{c2} seen in $J/\psi \gamma$
- ▶ First evidence for photoproduction of C -even charmonium
- ▶ Tests the production mechanism beyond J/ψ ; χ_{c1} shares the J^{PC} of the $X(3872)$
- ▶ GlueX-III at 12 GeV: several times the χ_{c1} yield

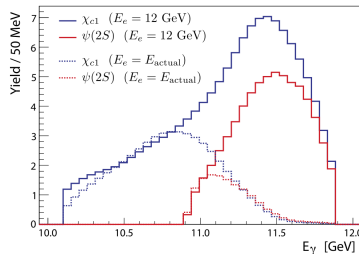
J/ψ : projected $d\sigma/dt$ coverage



● projected GlueX-III ○ GlueX ○ J/ψ -007
colour: skewness ξ (GPD)

Phase	Years	$\int L \text{ (pb}^{-1}\text{)}$	Status
I	2017–18	125	analyzed
II	2020–27	~ 400	90% taken
III	2028–	800	approved

χ_{c1} , $\psi(2S)$: projected yields at 12 GeV



Same luminosity: 12 GeV (solid) vs. GlueX-I/II beam (dotted)

- ▶ I+II+III: $\sim 10\times$ the GlueX-I J/ψ sample
- ▶ 12 GeV beam: 5–10 $\times$ yields

- ▶ **Exotic states and spin dynamics:** search for and map out hybrid mesons with polarized photons
 - ✓ World's largest polarized photoproduction data set
 - ✓ Amplitude analysis benchmarked on the conventional $a_2(1320)$
 - ✓ Exotic-state searches across sectors: non-strange and open strange
 - ✓ Spin-density matrices to understand the production mechanism
- ▶ **Hadronization and gluonic structure:** a unique photoproduction data set
 - ✓ Baryon–antibaryon photoproduction
 - ✓ Near-threshold J/ψ and χ_{cJ}
- ▶ **Outlook:** GlueX-III charmonium at 12 GeV

