Latest Results from GlueX

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for the GlueX Collaboration

PWA9 / ATHOS4
March 13th, 2017

Outline

Jefferson Lab
Thomas Jefferson National Accelerator Facility

1. Introduction
2. First Results
   - Beam Asymmetries
   - Prospects for Spectroscopy
   - Charmonium
3. Outlook

Spectroscopy Worldwide

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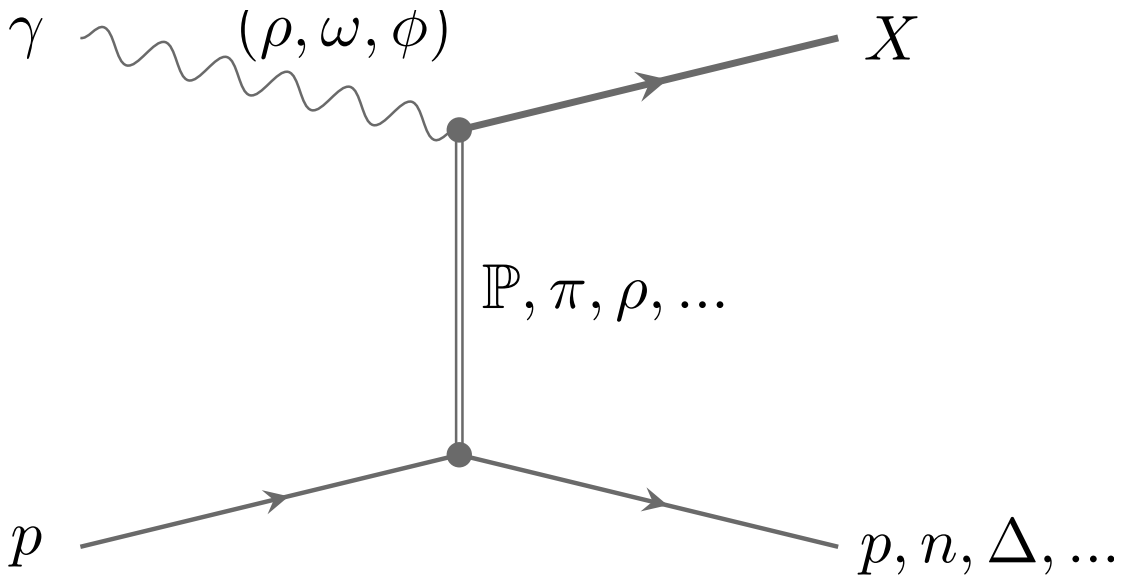
	hadron probes		electromagnetic probes	
colliding beam	CDF, DØ	ATLAS, CMS, LHCb	BESIII, Belle II	BaBar, Belle
	completed/analysis	ongoing/future	ongoing/future	completed/analysis
fixed target	COMPASS	PANDA	GlueX, CLAS12	CLAS

Photoproduction



Complementary Production Mechanism

- Photon coupling via vector meson dominance (VMD)
- Wide variety of $I^G J^{PC}$ states accessible
- Photon polarization provides additional constraints

Photon Beam Line

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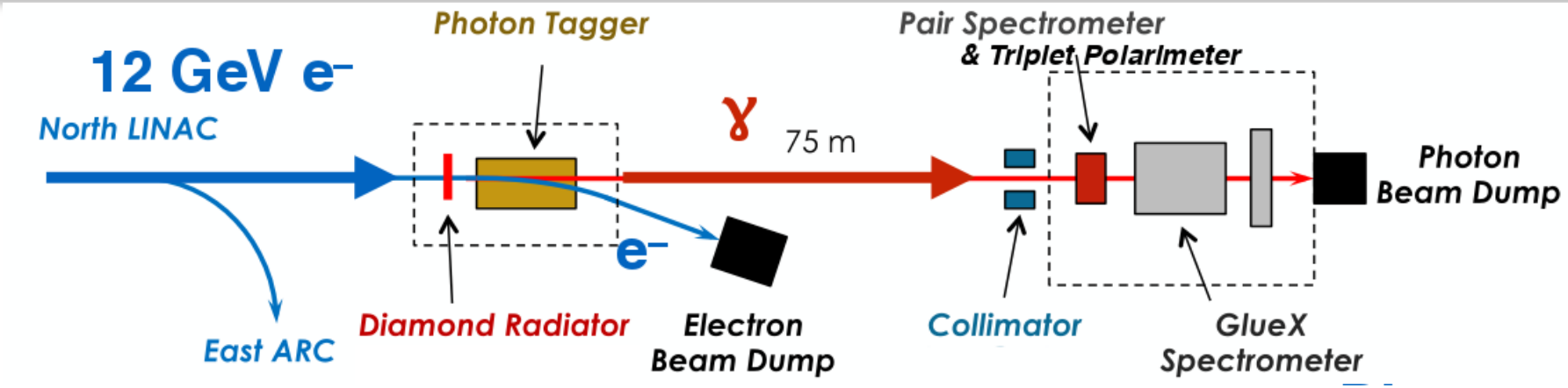

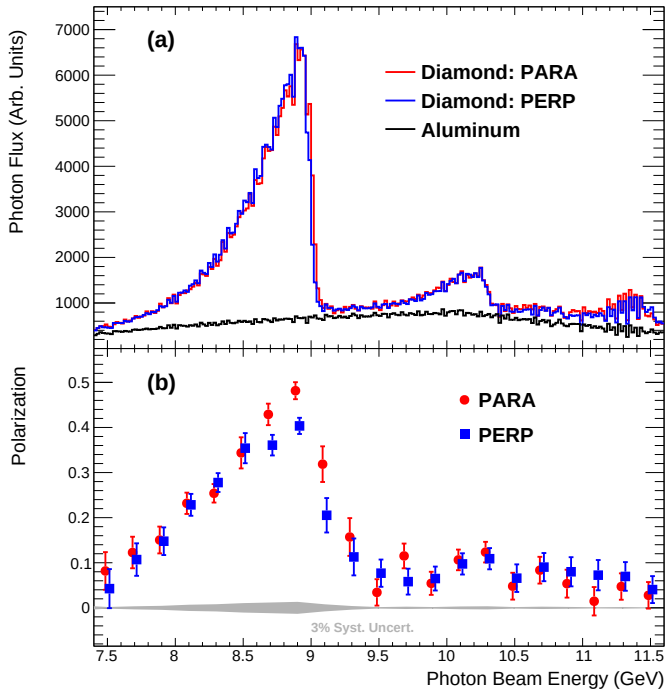

9 GeV Polarized Photon Beam

- Coherent Bremsstrahlung on thin diamond
- Energy tagged by scattered electrons
- Collimation to suppress incoherent part
- Linear polarization in peak $P_\gamma \approx 40\%$, measured by Triplet polarimeter: $\gamma e^- \rightarrow e^- e^+ e^-$
- Beam intensity: $10^7 - 10^8\,\gamma/\mathrm{s}$ in peak

GlueX Detector

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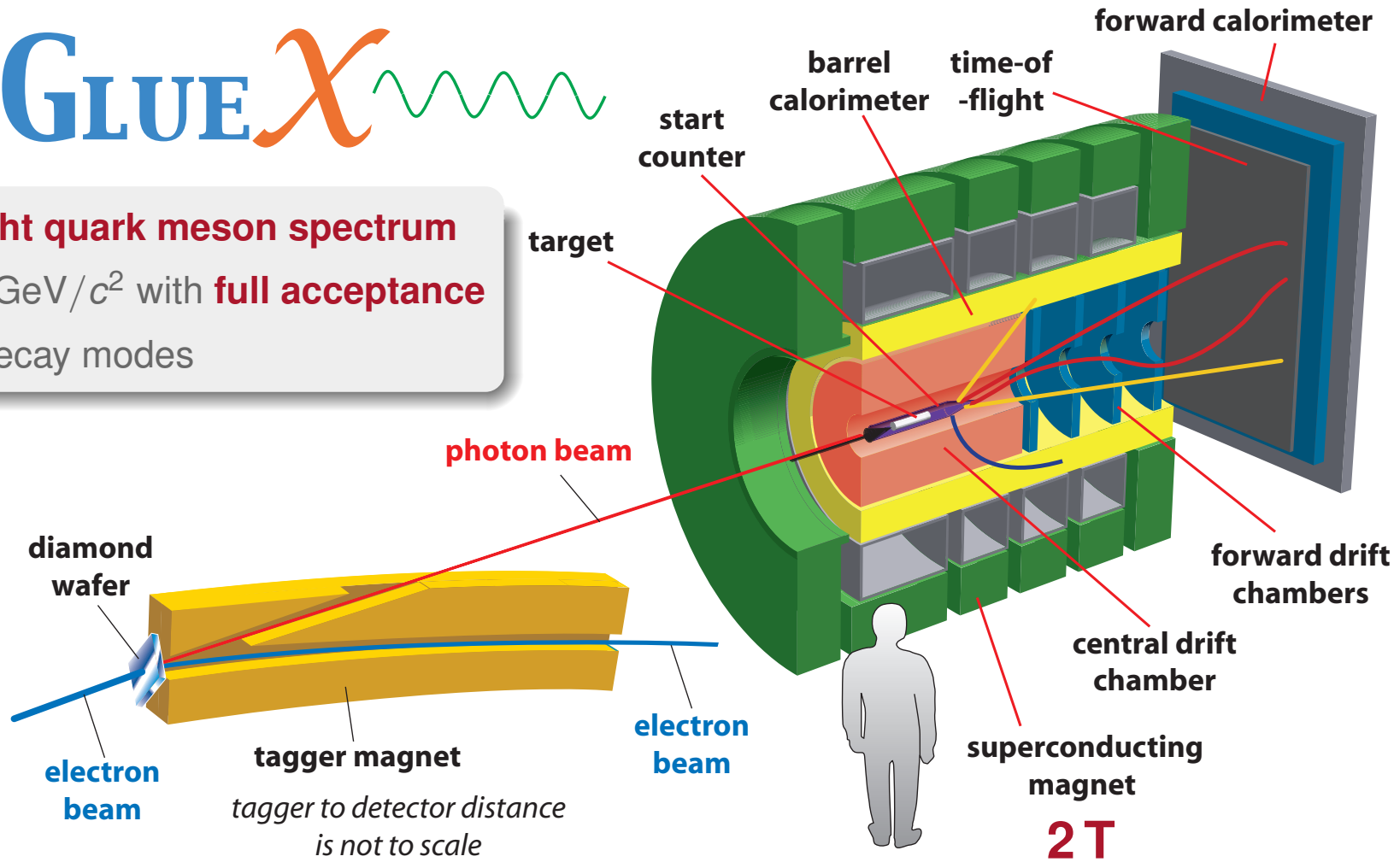
GLUEX

Map **light quark meson spectrum** up to 3 GeV/c^2 with **full acceptance** for all decay modes



GlueX Detector

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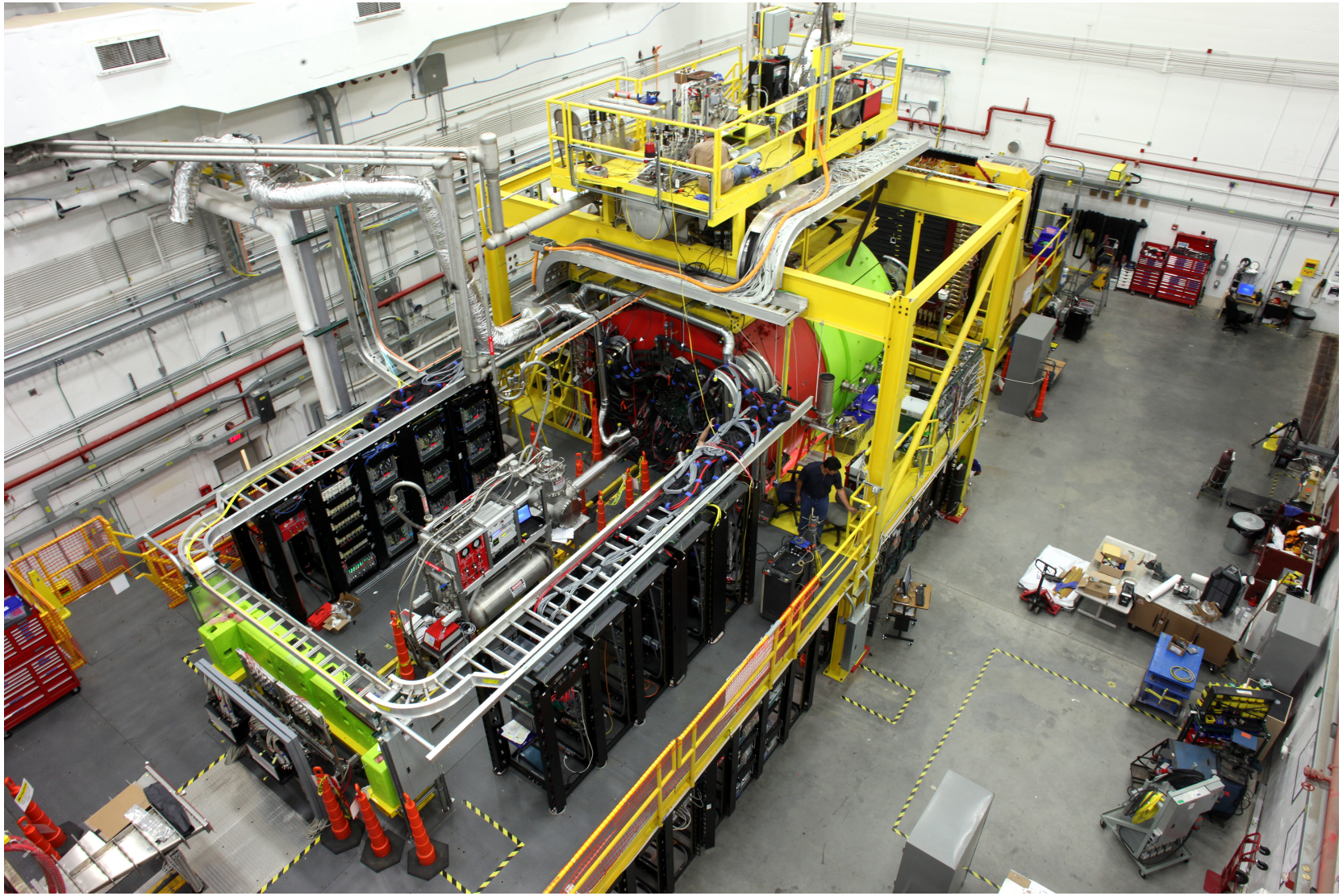

GlueX Runs

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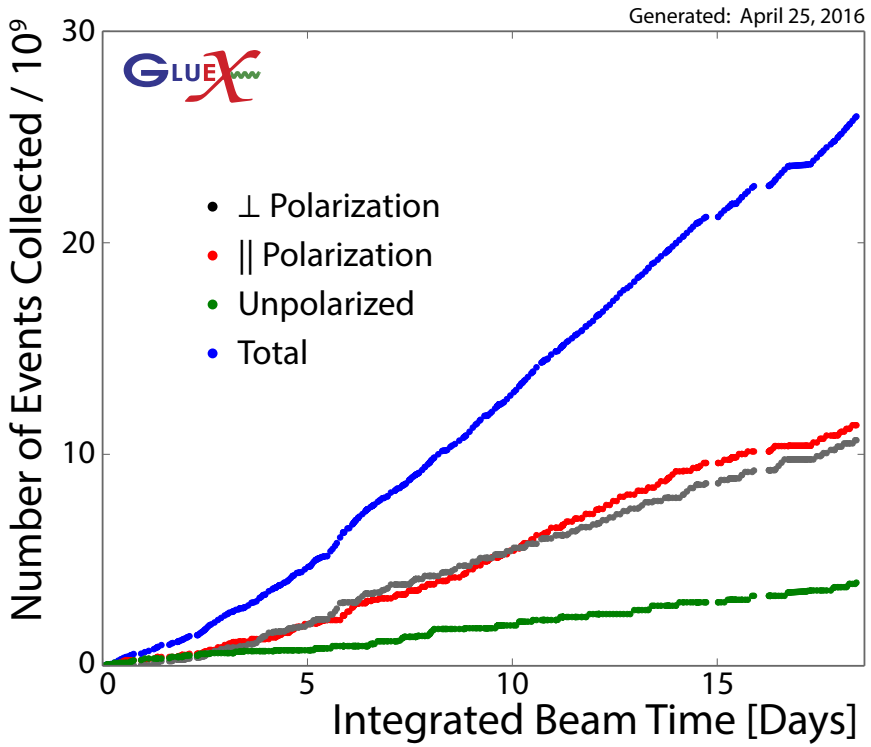
Thomas Jefferson National Accelerator Facility

Fall 2014 - Spring 2015

Detector and beamline commissioning

Spring 2016: GlueX Engineering Run

- Initial physics data ($\approx$ 80 h)
- First results presented here



GlueX Runs

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Fall 2014 - Spring 2015

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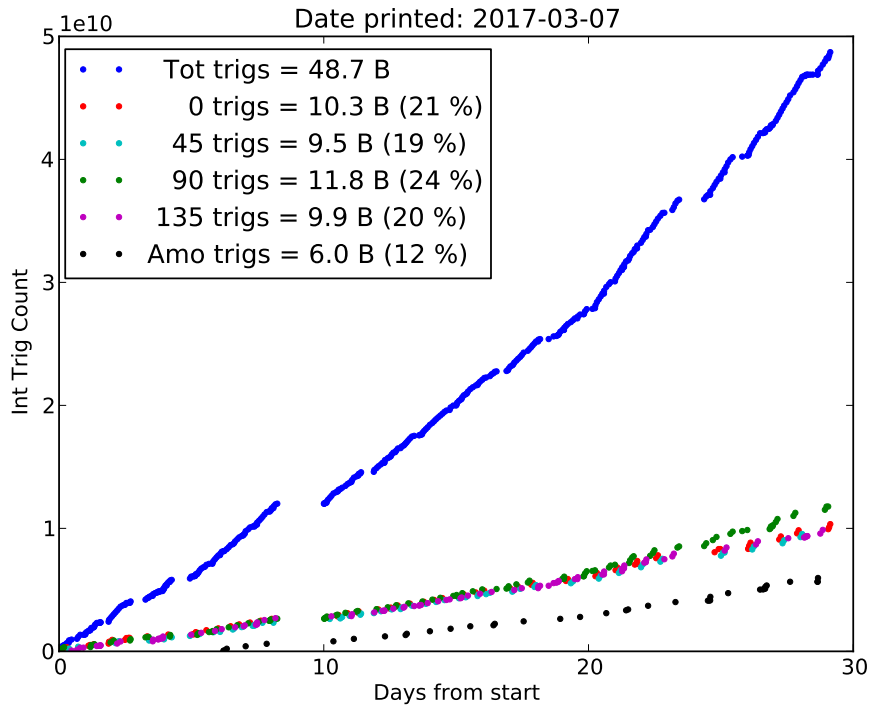
- Initial physics data ($\approx$ 80 h)
- First results presented here

GlueX-I: 2017 - 2018

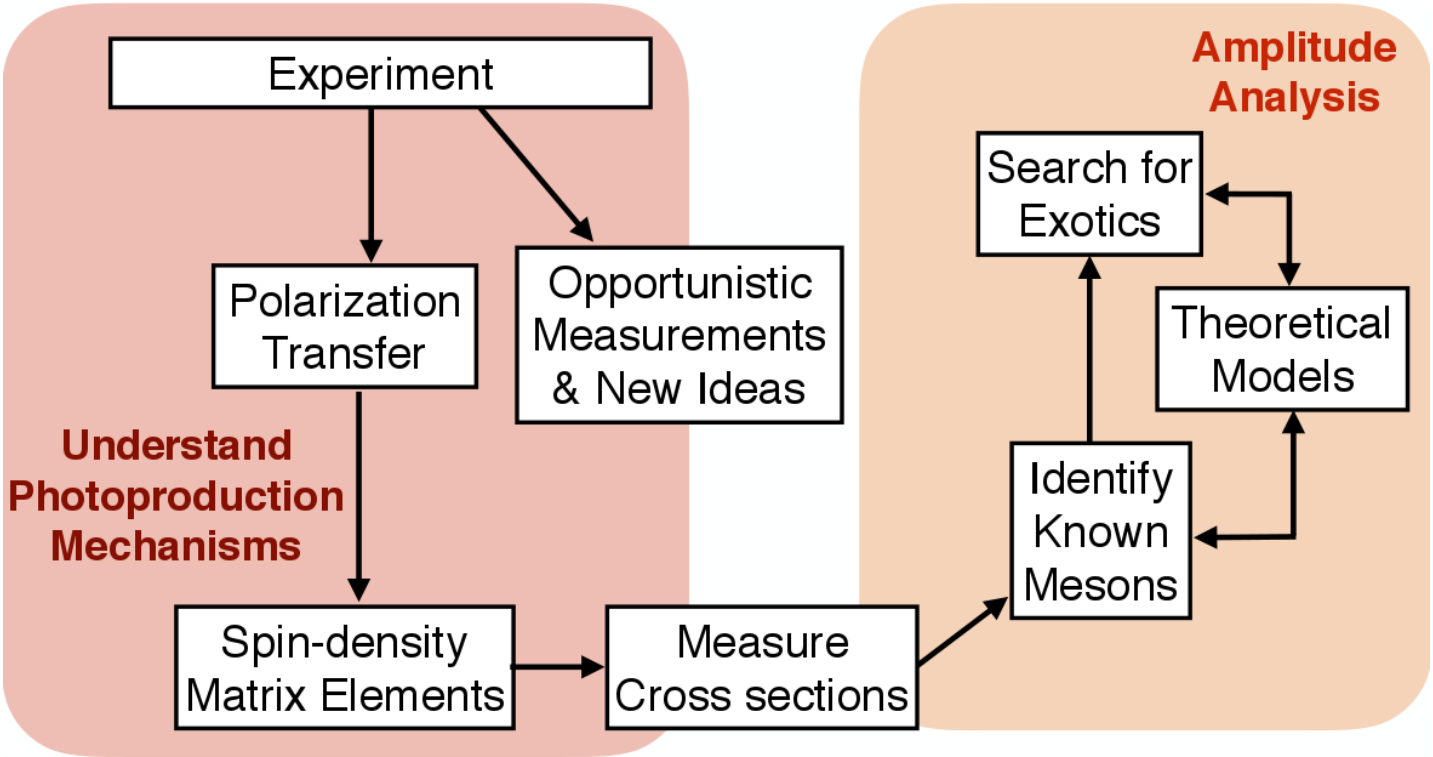
- Started in February
- $\approx 10\times$ more data than 2016 planned

GlueX-II: 2019+

- Upgraded detector (DIRC, ..)
- High luminosity



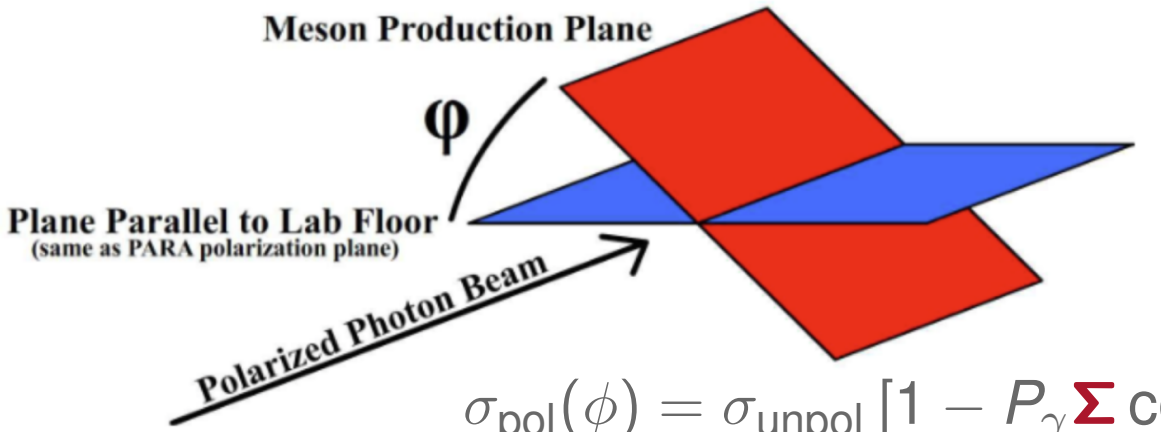
Analysis Strategy



GlueX + Joint Physics Analysis Center (JPAC)

- High statistical precision requires removing simplifying assumptions
- Robust theoretical models and capable analysis frameworks
- Collaboration: experiment and theory working together on analysis and interpretation

Pseudoscalar Beam Asymmetries



$$\sigma_{\text{pol}}(\phi) = \sigma_{\text{unpol}}\,[1 - P_\gamma \boldsymbol{\Sigma} \cos 2\phi]$$

- Understanding production mechanism necessary for amplitude analysis
- Beam asymmetry Σ yields and its t dependence yields information
- Cancel systematic effects by rotating polarization plane by 90°

π^0 Beam Asymmetry

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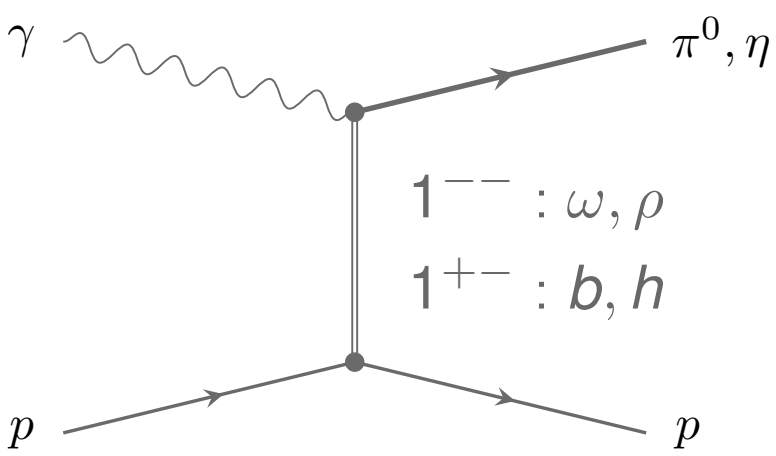
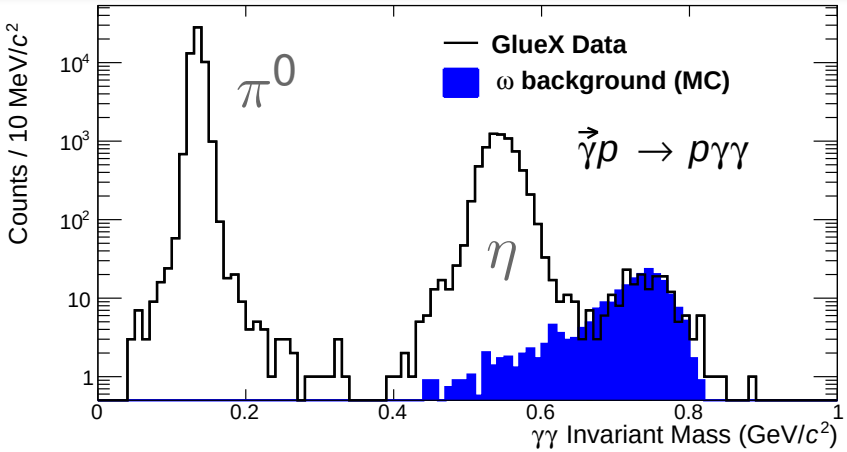
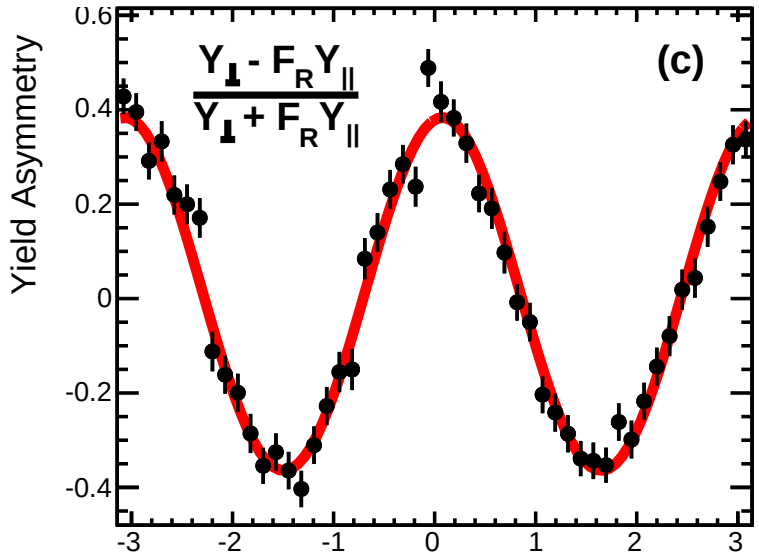




- P_γ measured with polarimeter
- Σ sensitive to exchanged J^{PC}

$$\Sigma = \frac{|\omega+\rho|^2 - |h+b|^2}{|\omega+\rho|^2 + |h+b|^2}$$

[PRD 92 (2015) 074013]



$$\propto P_\gamma \Sigma \cos 2\phi$$

π^0 and η Beam Asymmetries

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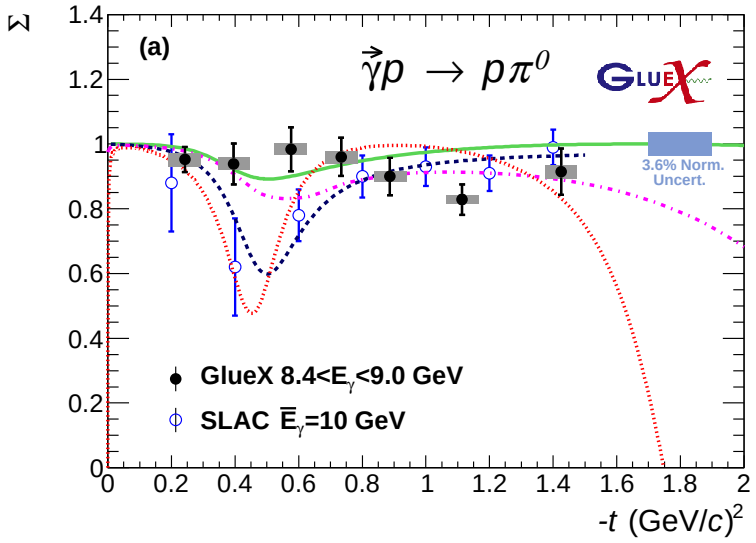

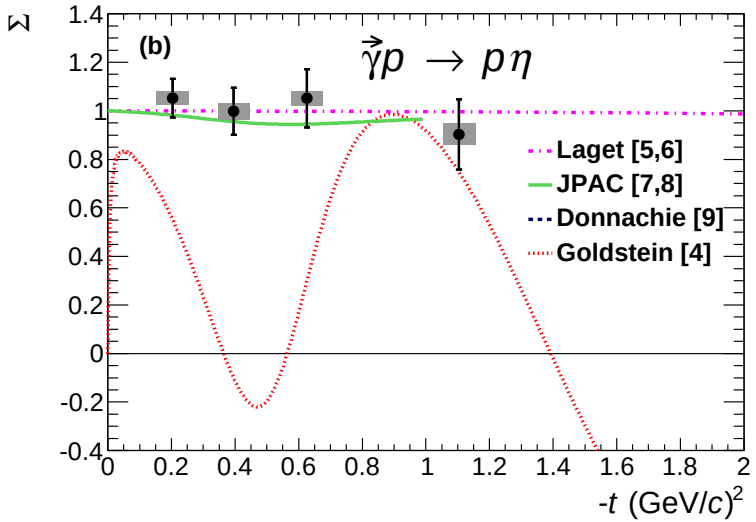

First GlueX Publication!

- No observed dip at $-t = 0.5$ (GeV/c)^2 $\Rightarrow$ Vector exchange dominates
- Comparison with several theory models
- Constrains background to baryon resonance production
- First measurement for η at this energy
- Submitted to PRL [arXiv:1701.08123]
- Measurement for η' with 2017 data

π^+/π^- Beam Asymmetry

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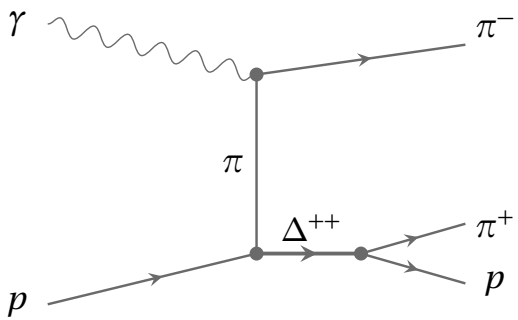
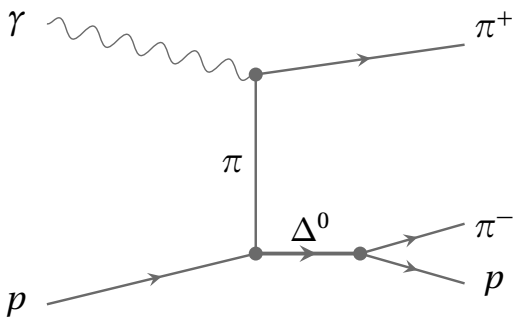
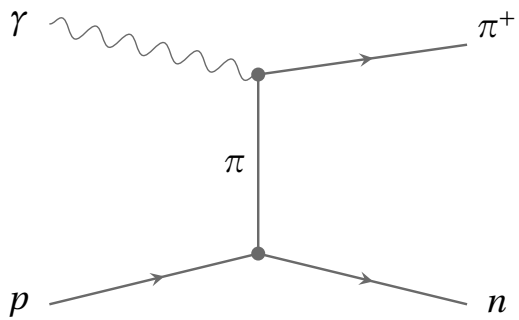
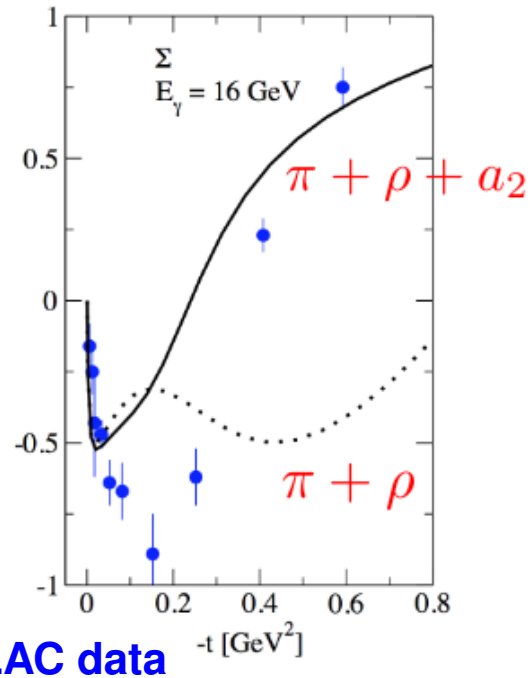




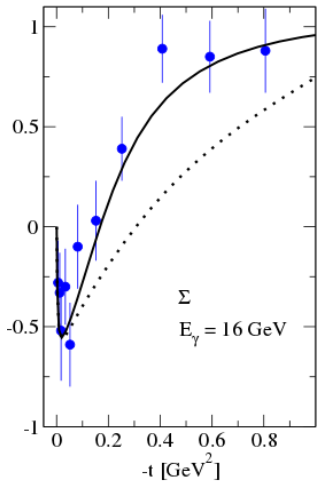


[arXiv:1611.09629]

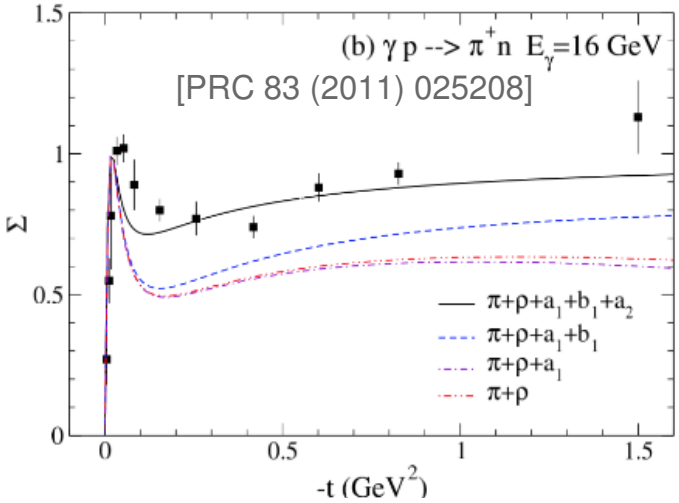


SLAC data

from [PRD 20 (1979) 1553]



[PRC 83 (2011) 025208]



- Recently revived interest in charge exchange
- $-t$ dependence sensitive to Regge contributions
- Important confirmation for theoretical models

π^+/π^- Beam Asymmetry

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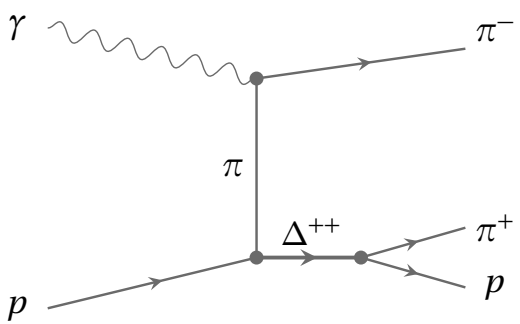
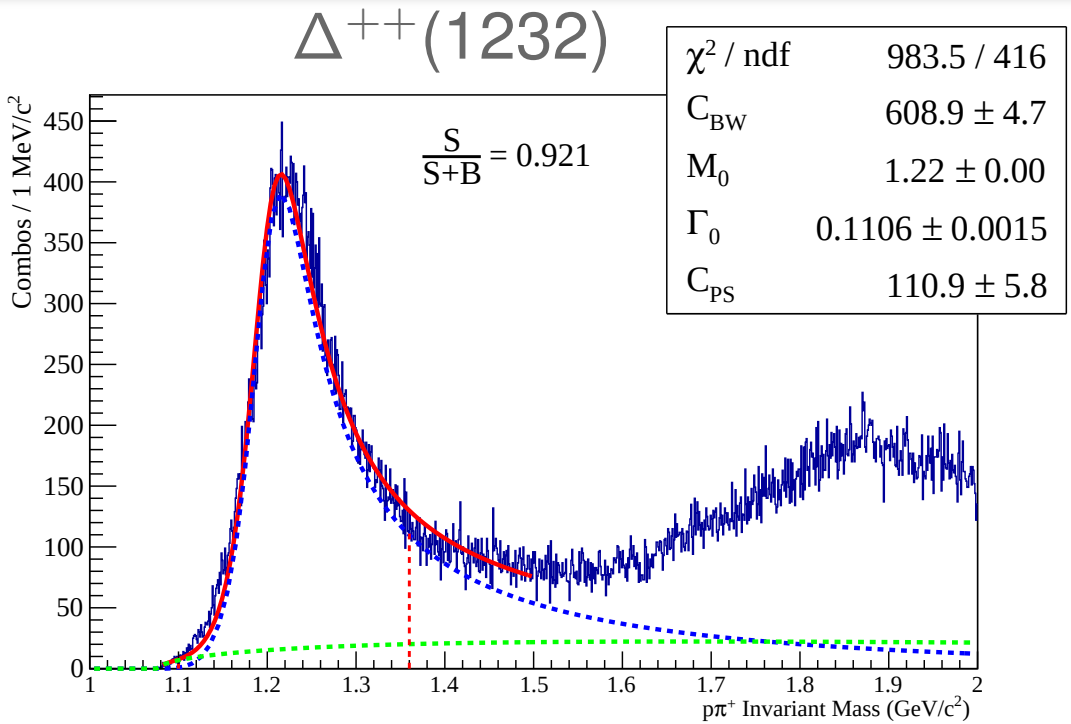
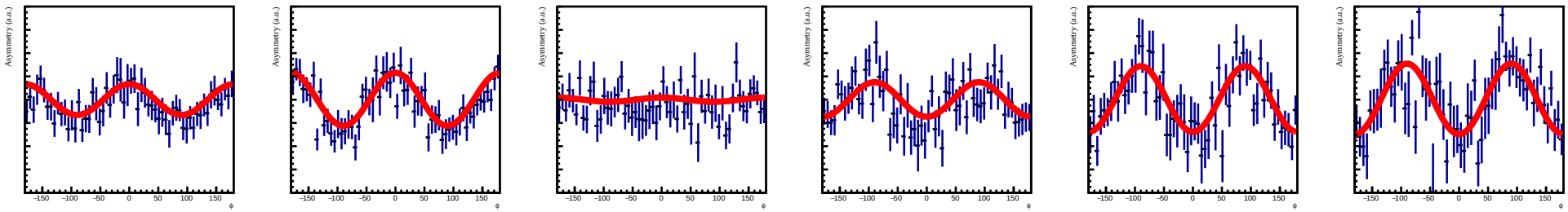


GlueX Preliminary





ρ Beam Asymmetry

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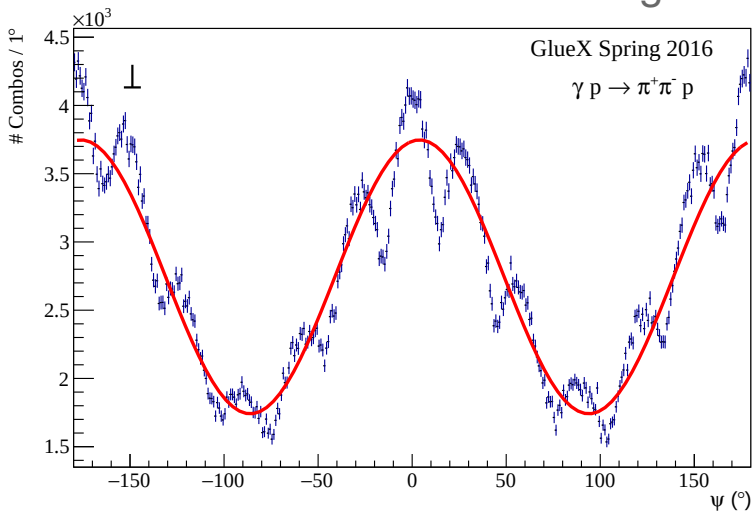
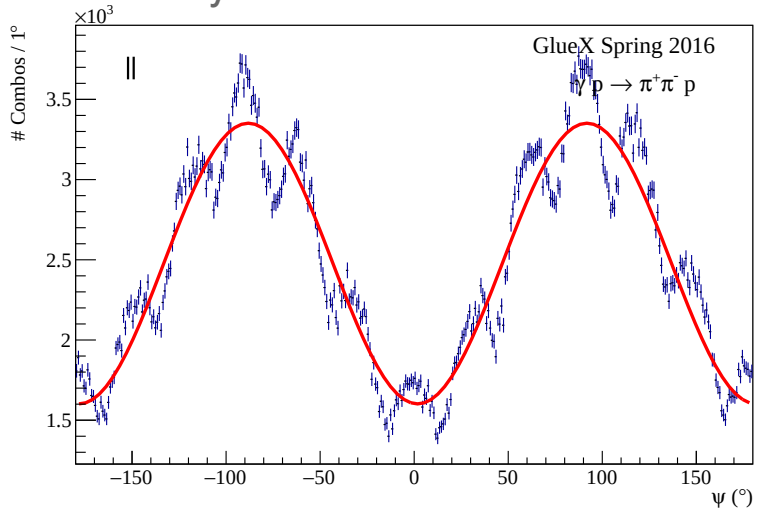
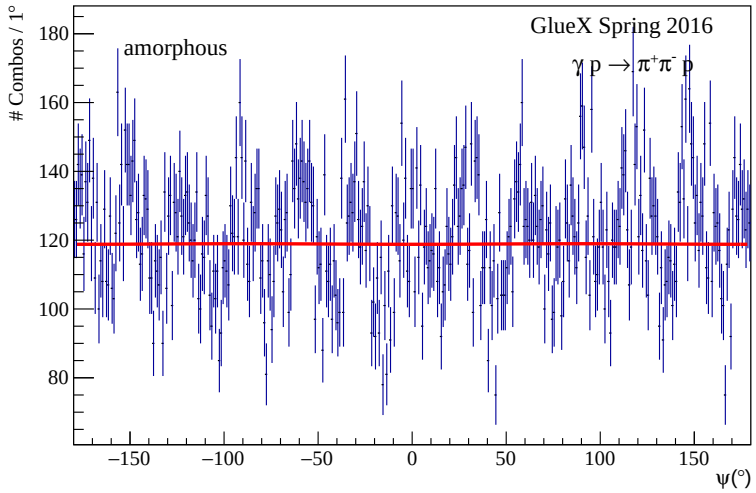
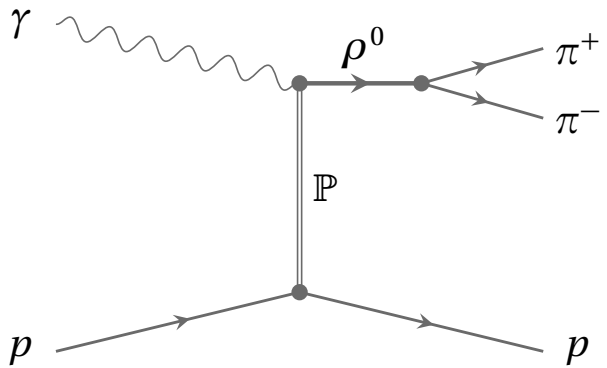
Artifacts of tracking detector alignment in early reconstruction









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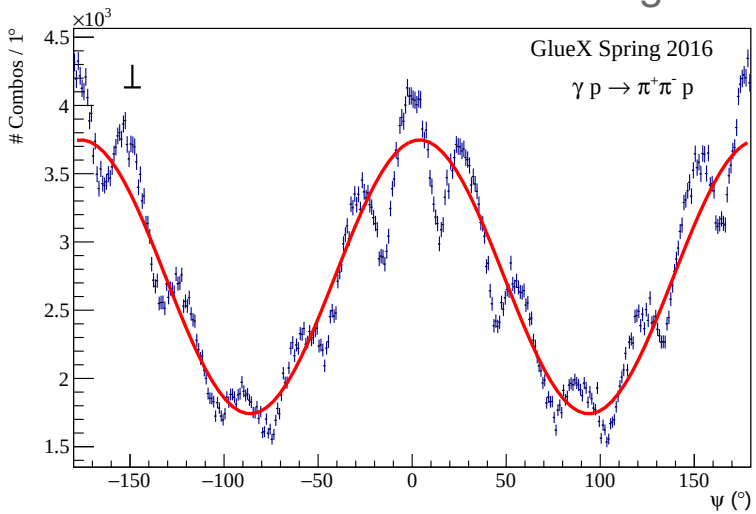
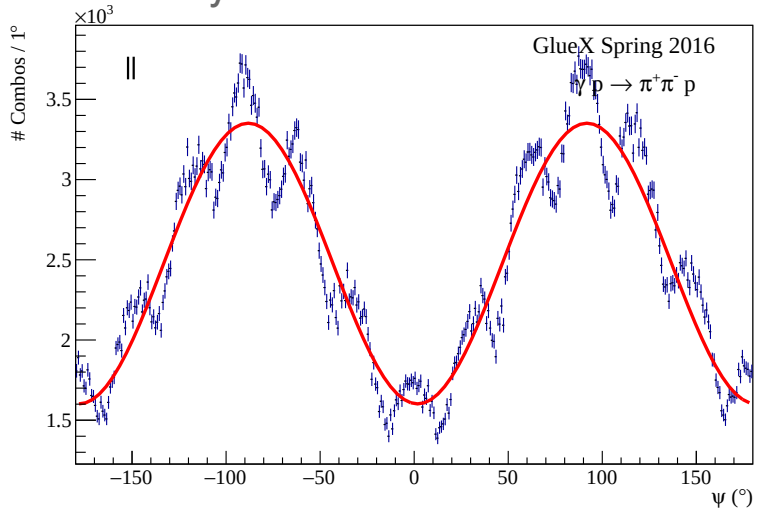
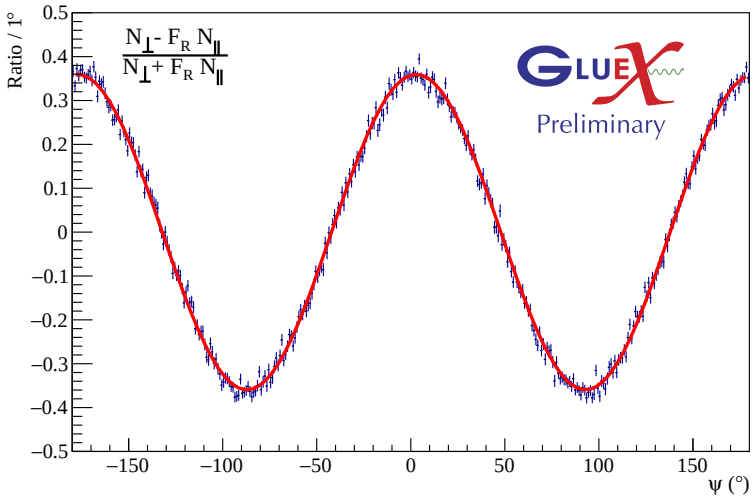
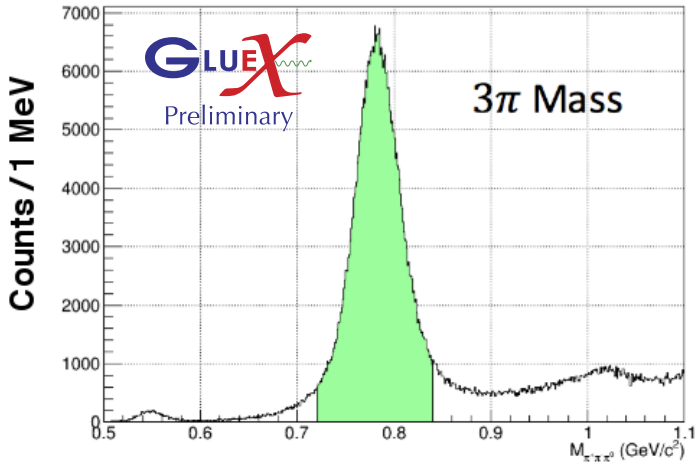


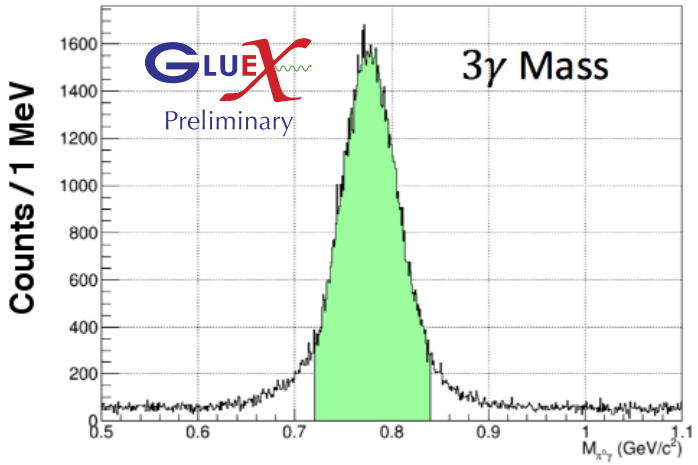


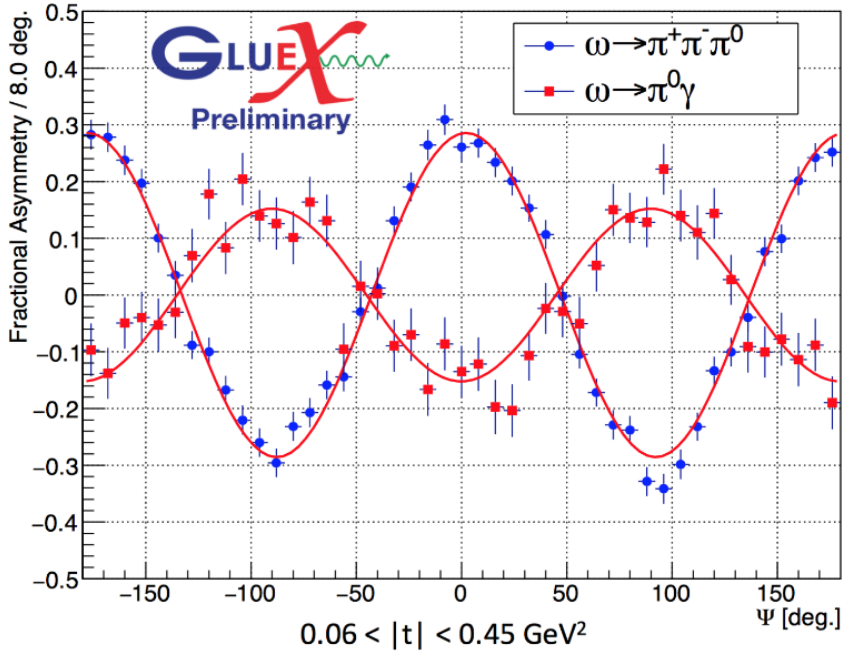
- Acceptance effects cancel
- Confirmation of polarization
- Analysis of angular distribution
  $\Rightarrow$ Spin Density Matrix Elements



ω Beam Asymmetry

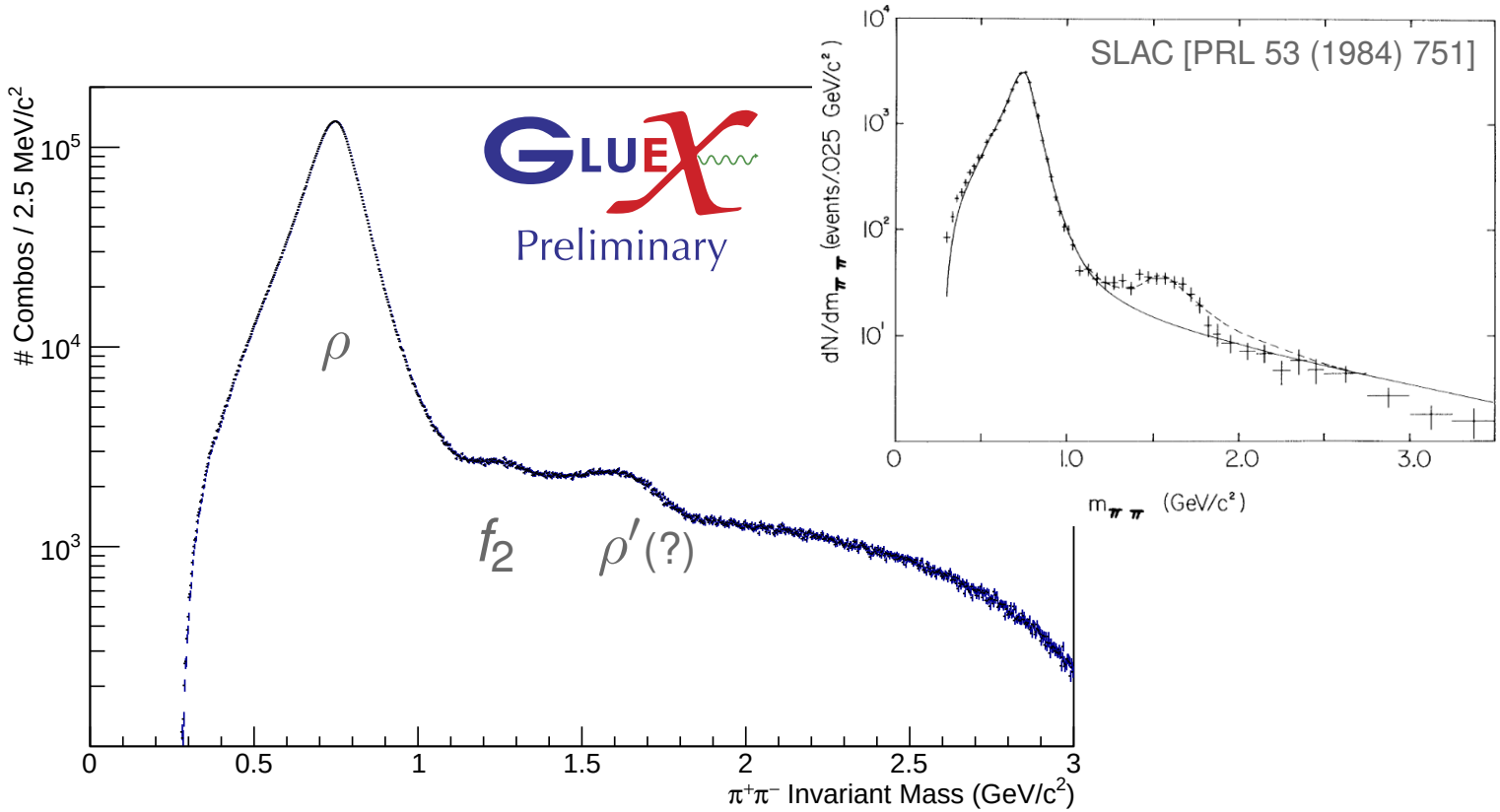






- Two different decays
- Expectation: $\Sigma_{3\pi}/\Sigma_{\pi^0\gamma} = -2$
- Measurement: $\Sigma_{3\pi}/\Sigma_{\pi^0\gamma} = -1.88 \pm 0.13$
- Goal: Measurement of SDMEs

$\pi\pi$ Spectroscopy



- $\approx 100\times$ more data than previous experiments
- Hints for excited ρ $\Rightarrow$ moment / amplitude analysis started

Multi-Photon Final States

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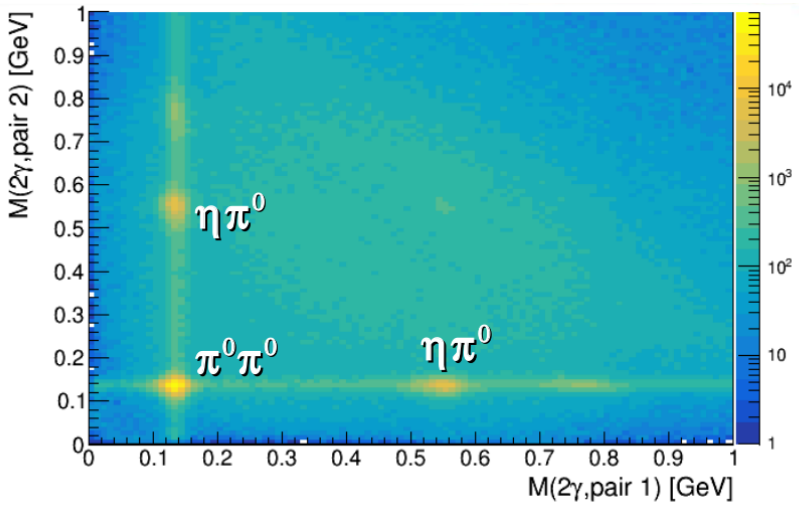
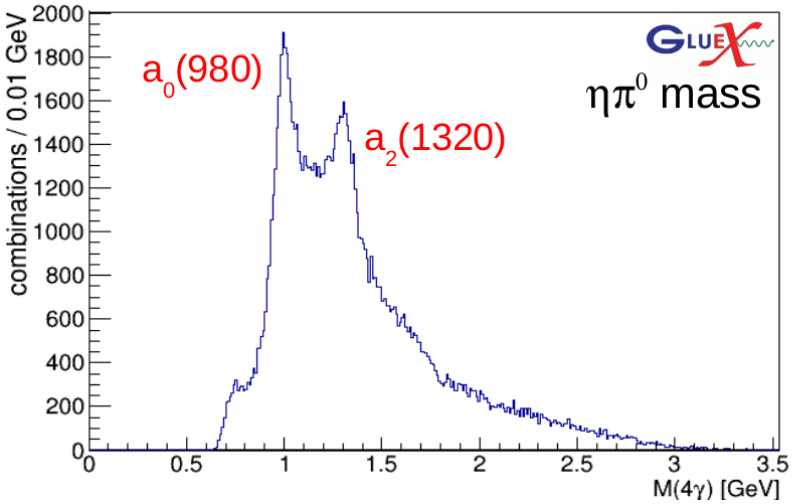
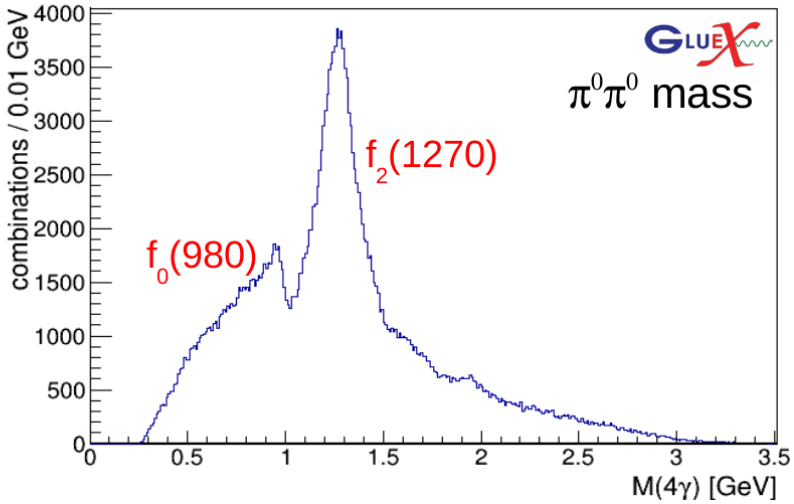
$$\gamma + p \rightarrow 4\gamma + p$$







Multi-Photon Final States

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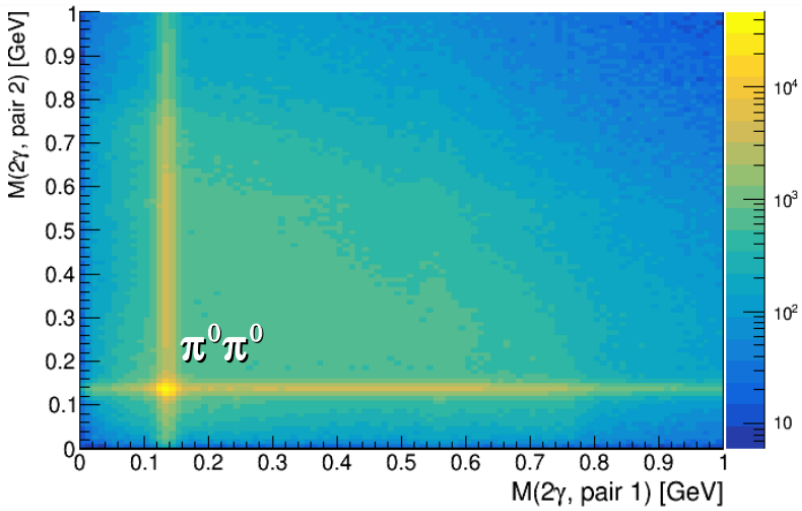
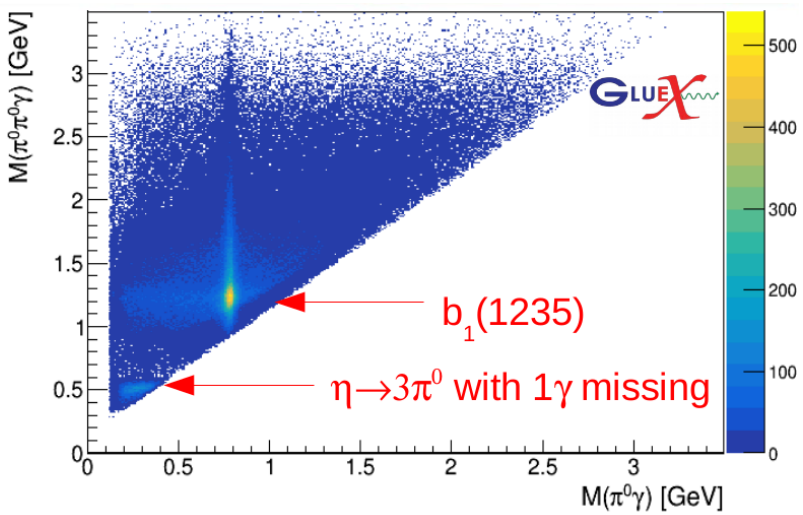
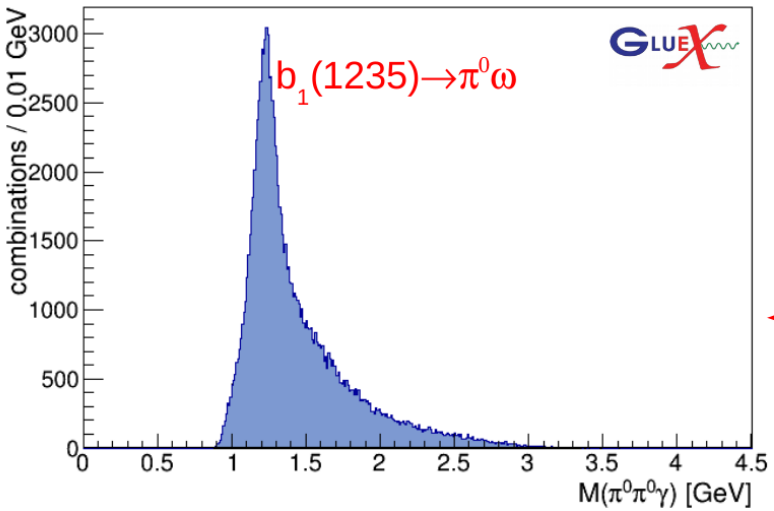
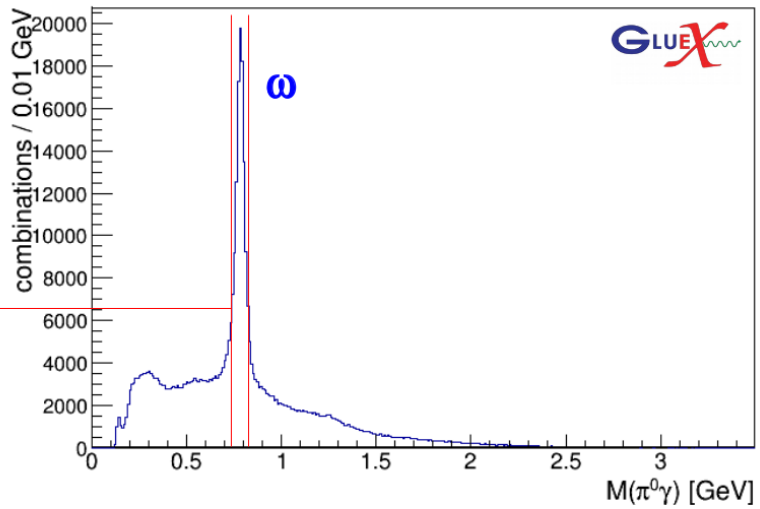
Thomas Jefferson National Accelerator Facility

$$\gamma + p \rightarrow 5\gamma + p$$









Multi-Photon Final States

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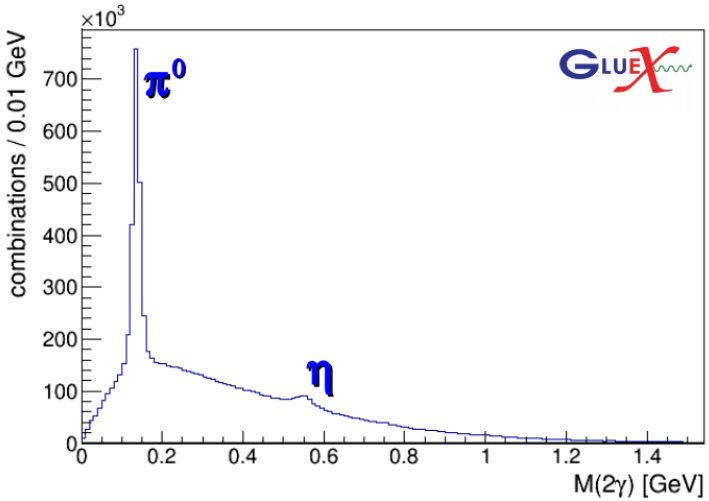
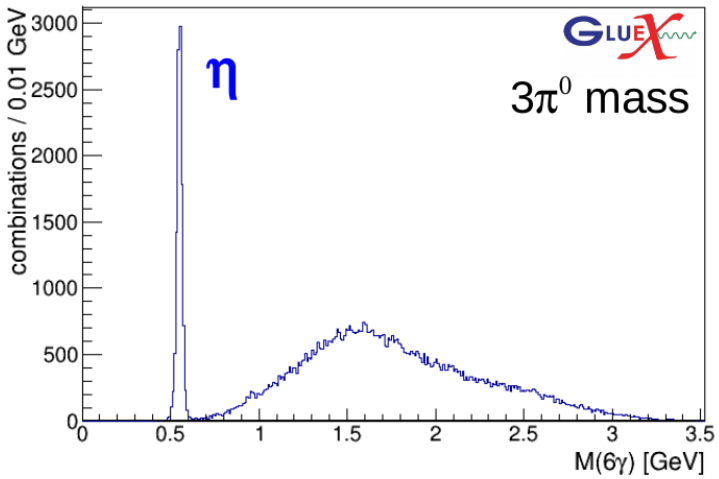
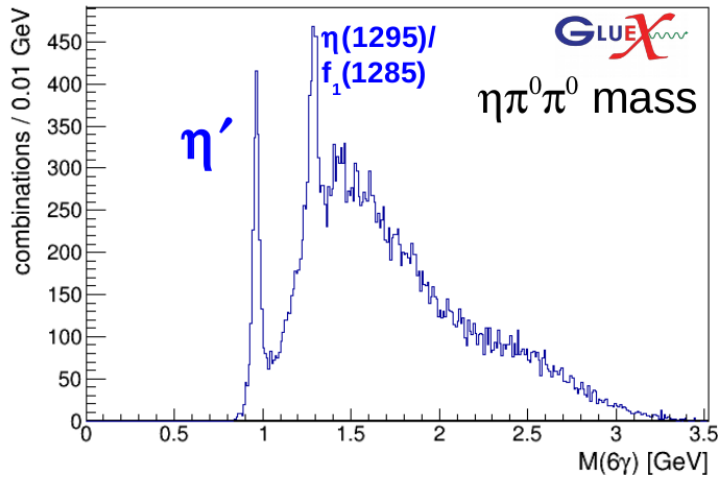
$$\gamma + p \rightarrow 6\gamma + p$$



- **GlueX** well equipped for the detection of **neutral particles**
- Excellent prospects for spectroscopy program





Mapping the Meson Spectrum

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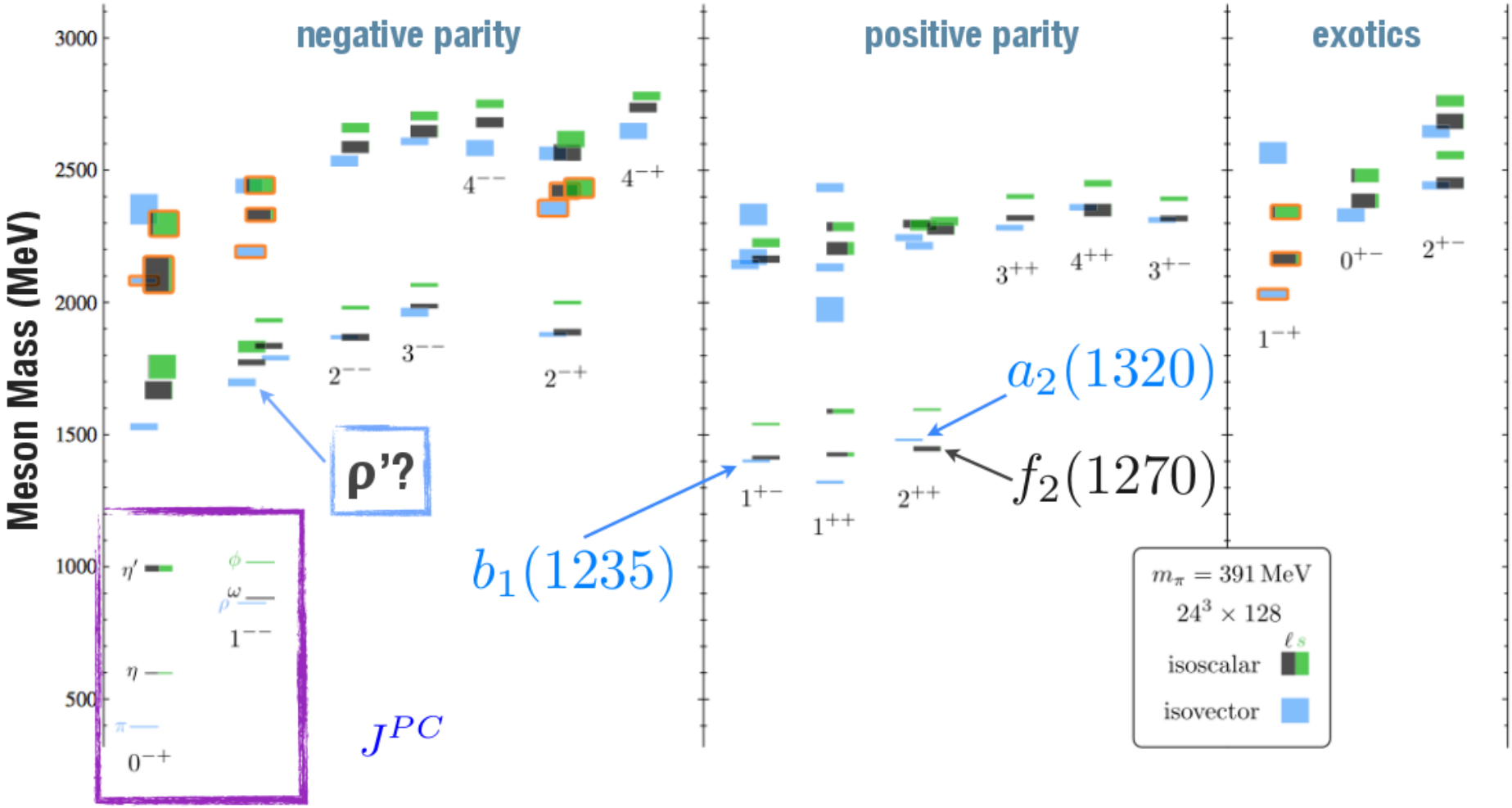

[PRD 88 (2013) 094505]

Charmonium Photoproduction

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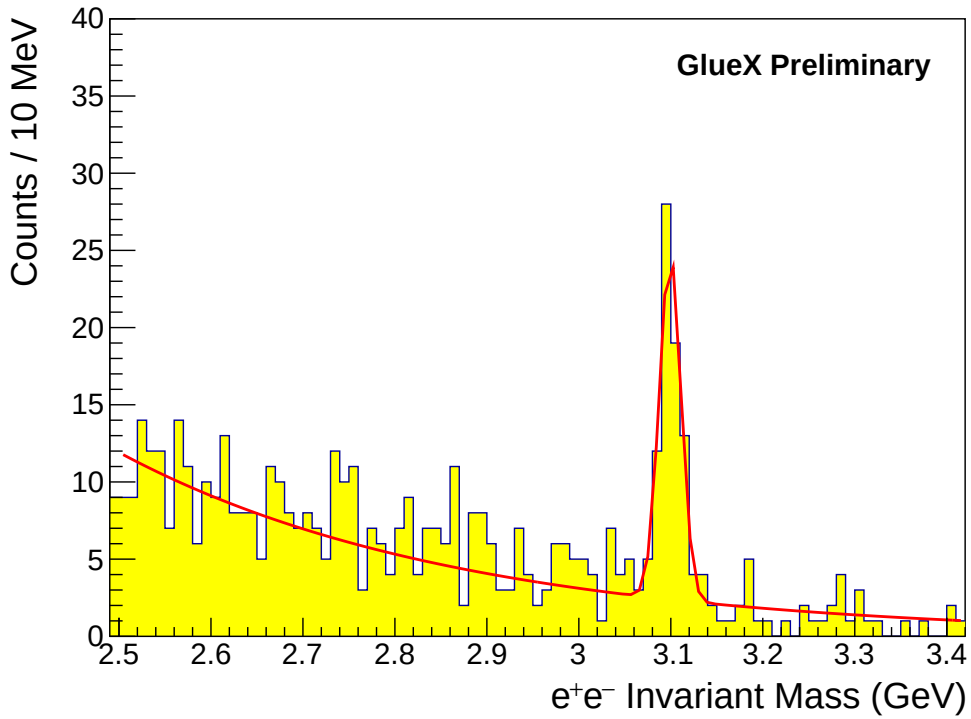
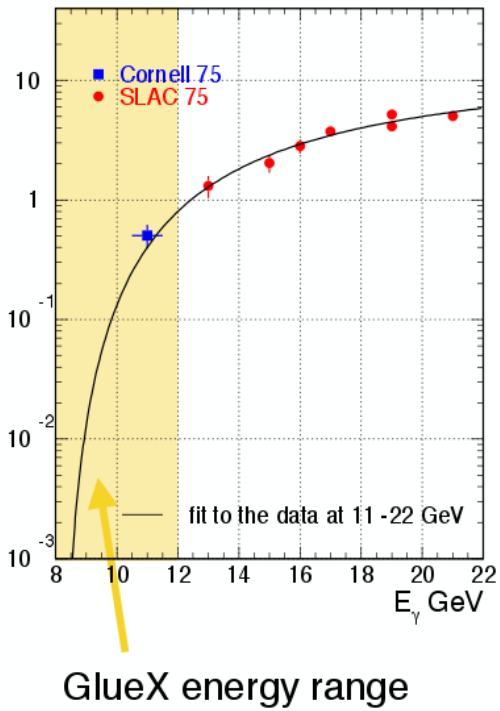
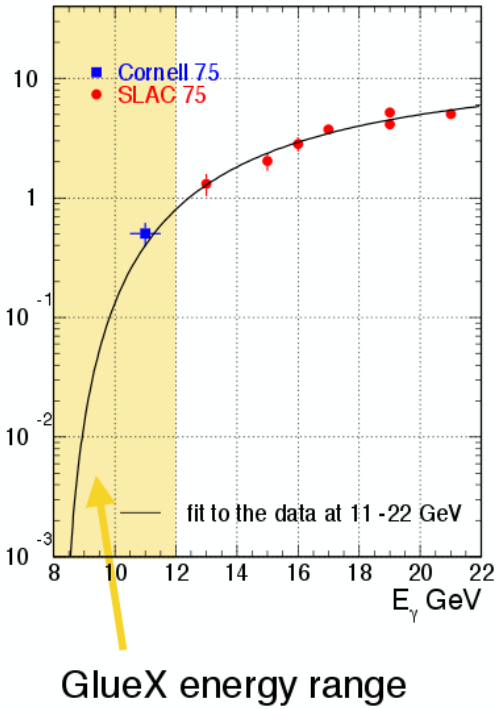




$\gamma + p \to p + J/\psi, \quad J/\psi \to e^+ e^-$

- Production at threshold is ideal for studying N + J/ψ interaction
- Very few existing measurements
- First observation of charmonium at CEBAF

Charmonium Photoproduction



$\gamma + p \to p + J/\psi, \quad J/\psi \to e^+e^-$

- Production at threshold is ideal for studying N + J/ψ interaction
- Very few existing measurements
- First observation of charmonium at CEBAF

Conclusion

Jefferson Lab
Thomas Jefferson National Accelerator Facility

Status

- Successful **commissioning** and **early physics** analyses
- First production run ongoing
- Understanding of detector acceptance and systematics
  $\Rightarrow$ Comparison with previous measurements and models
- Study production mechanism
  $\Rightarrow$ Cross sections, beam asymmetries and spin density matrix elements

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Outlook

- Spectroscopy: identification of known resonances and ultimately hybrid candidates
- Detector upgrade: improved π/K separation (DIRC), high-level trigger

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Thank you for your attention!