

First Results of GLUEX

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GlueX Spokesperson



The GlueX Collaboration

Arizona State, Athens, Carnegie Mellon, Catholic University, Univ. of Connecticut, Florida International, Florida State, George Washington, Glasgow, Indiana University, ITEP, Jefferson Lab, U. Mass Amherst, MIT, MePhi, Norfolk State, North Carolina A&T, Univ. North Carolina Wilmington, Northwestern, Santa Maria, University of Regina and Yerevan Physics Institute.

Over 100 collaborators from 22 institutions. Others planning to join over the next 6 months and more are welcome.

Outline

- The GlueX Experiment and the Photon Beam.
- The physics program in GlueX
- Performance of GlueX during Commissioning.
- Initial Physics from GlueX
- Future Plans
- Summary

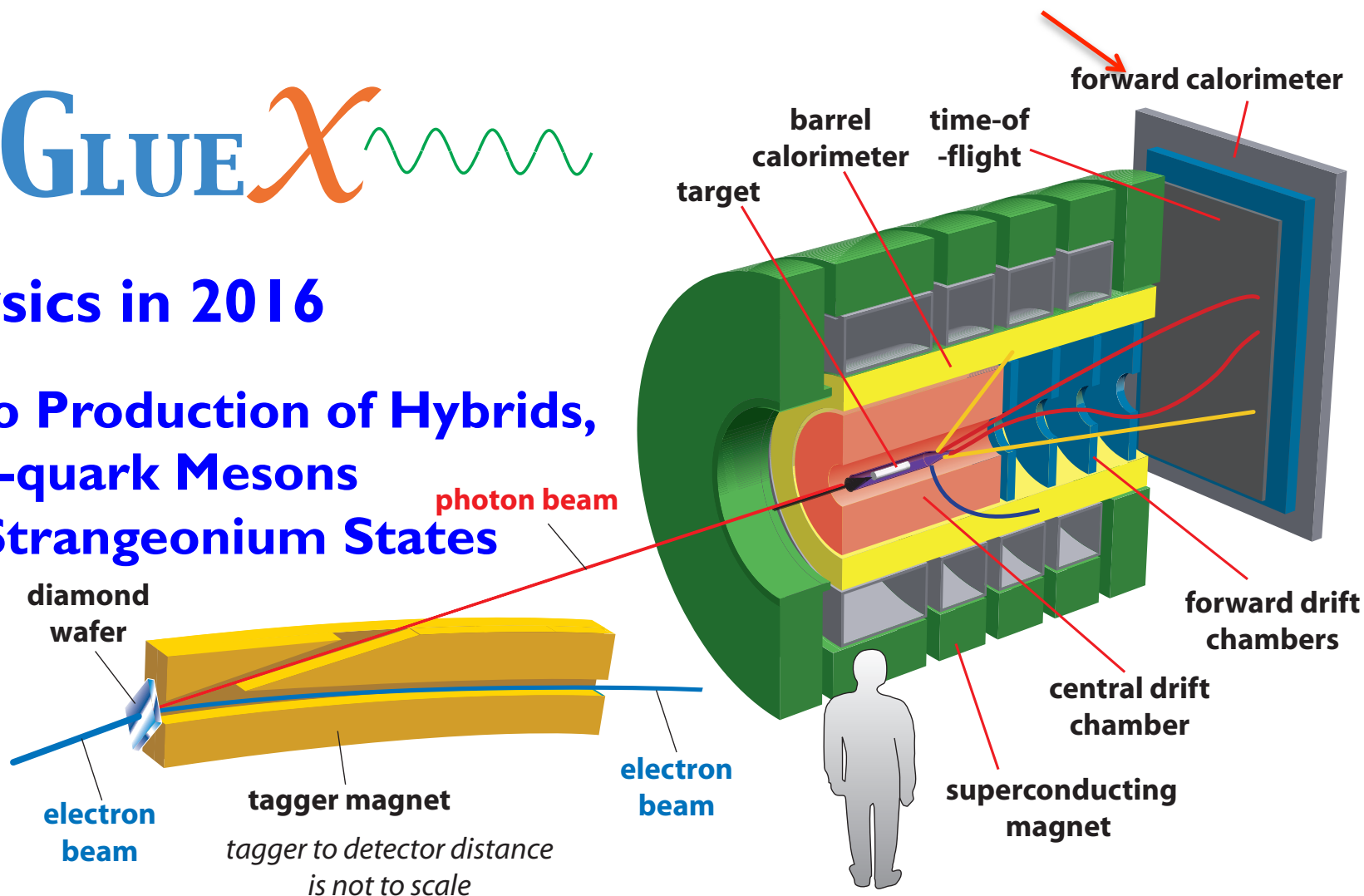
The GlueX Experiment

BaBar DIRC Bars

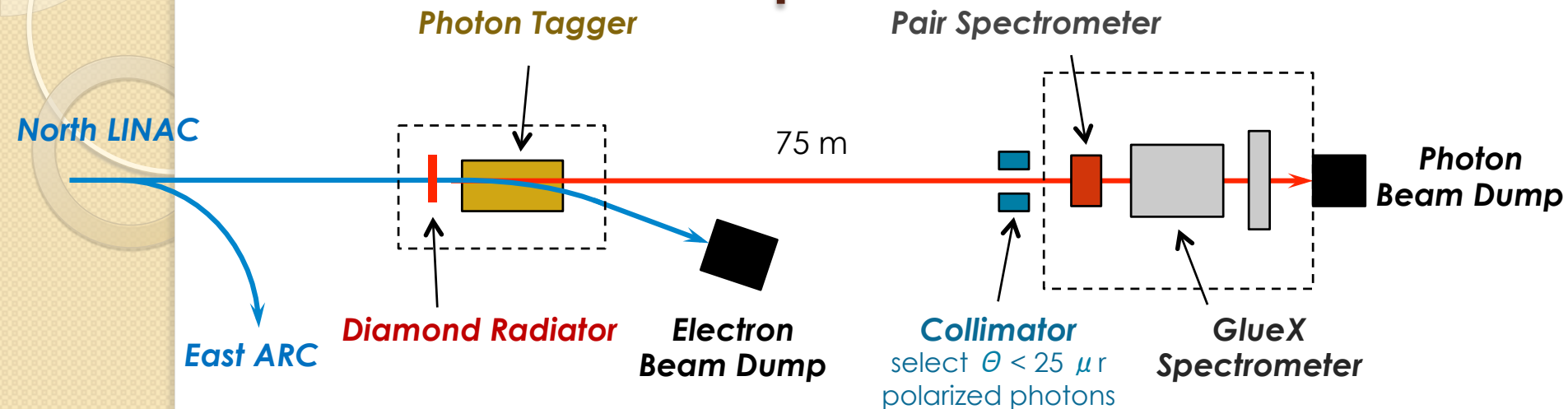
GLUEX 

Physics in 2016

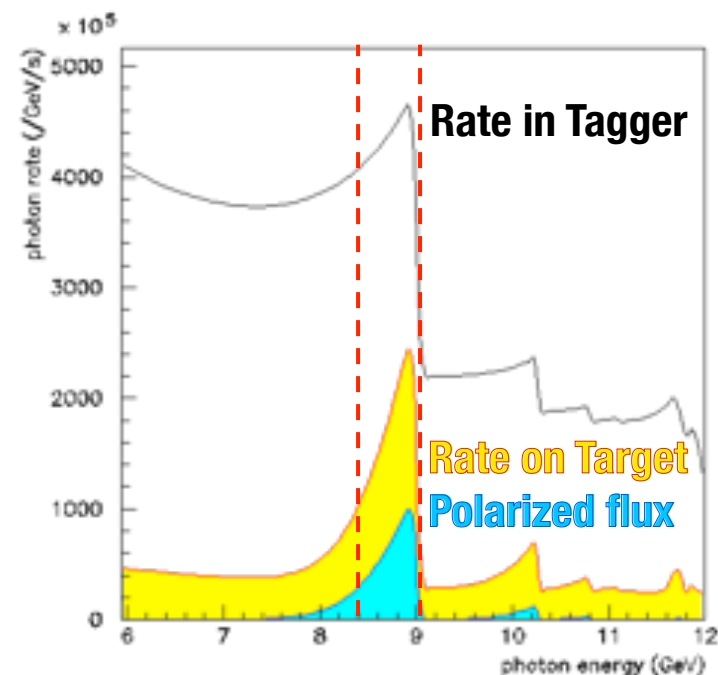
Photo Production of Hybrids,
Light-quark Mesons
and Strangeonium States



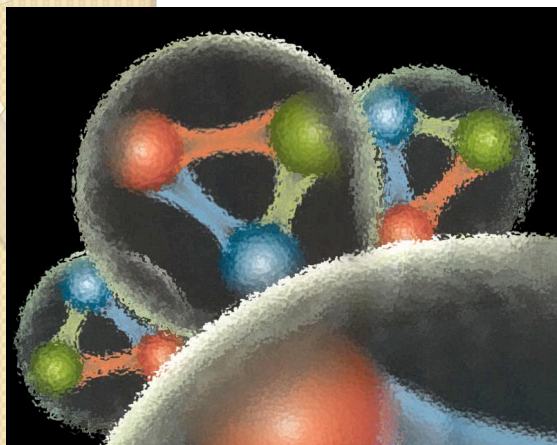
The GlueX Experiment



- 12 GeV e^- beam up to $2.2 \mu A$.
- Linearly polarized photons ($P_\gamma \approx 40\%$) from coherent bremsstrahlung on **diamond radiator**
- Design intensity of $10^8 \gamma/s$ in coherent peak ($E_\gamma = 8.4-9$ GeV)



Quantum Chromo Dynamics



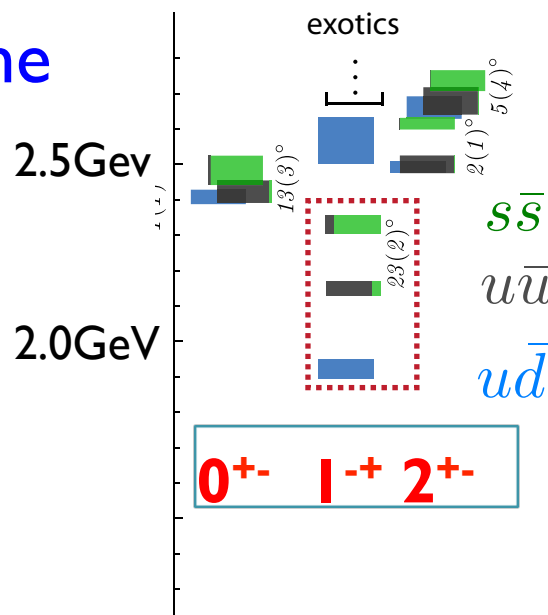
QCD describes the interactions of quarks and gluons and should predict the spectrum of bound-state baryons (qqq) and mesons ($q\bar{q}$).

There should also be mesons in which the gluonic field contributes directly to the J^{PC} quantum numbers of the states --- hybrid mesons. Some are expected to have ``exotic'' quantum numbers.

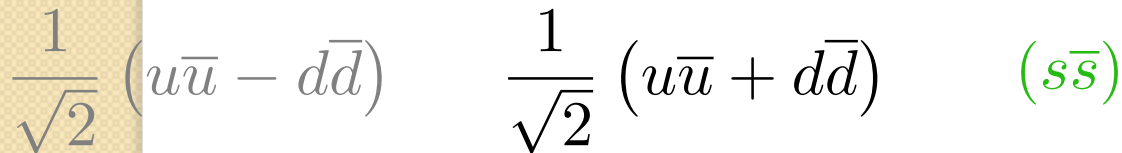
Lattice QCD calculation of the light-quark meson spectrum.

``Constituent gluon'': $J^{PC} = 1^{+-}$
mass of **1-1.5 GeV**.

The lightest hybrid nonets
 $1^{--}, (0^{-+}, 1^{-+}, 2^{-+})$

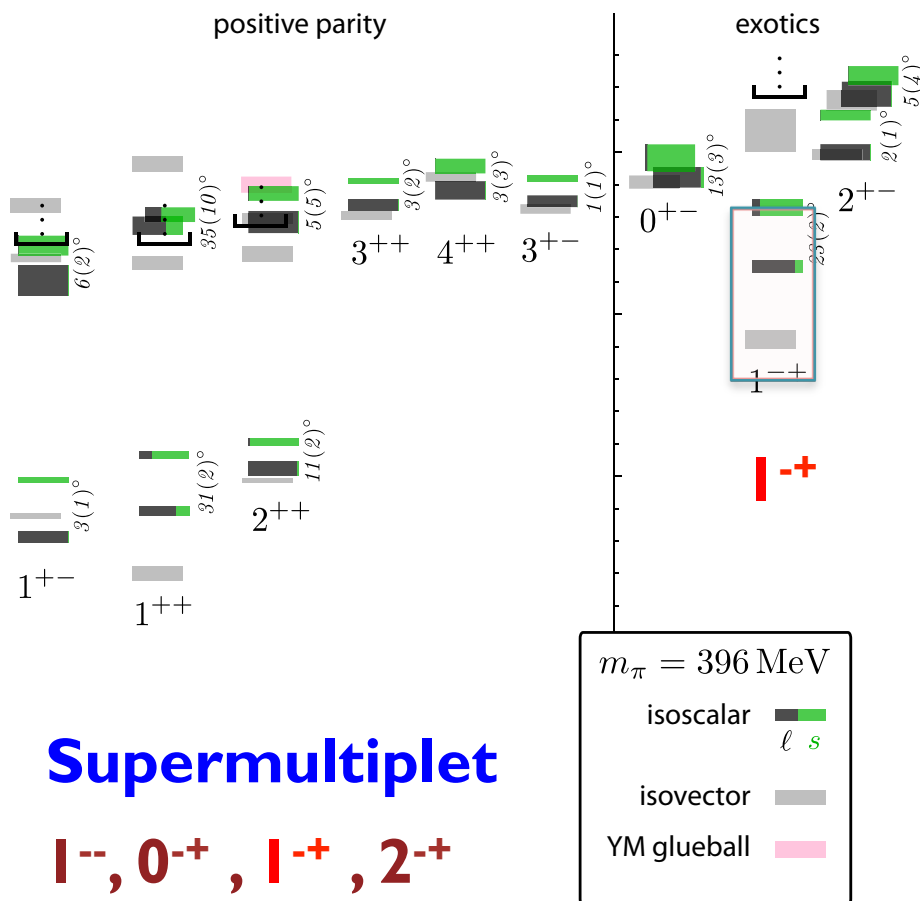
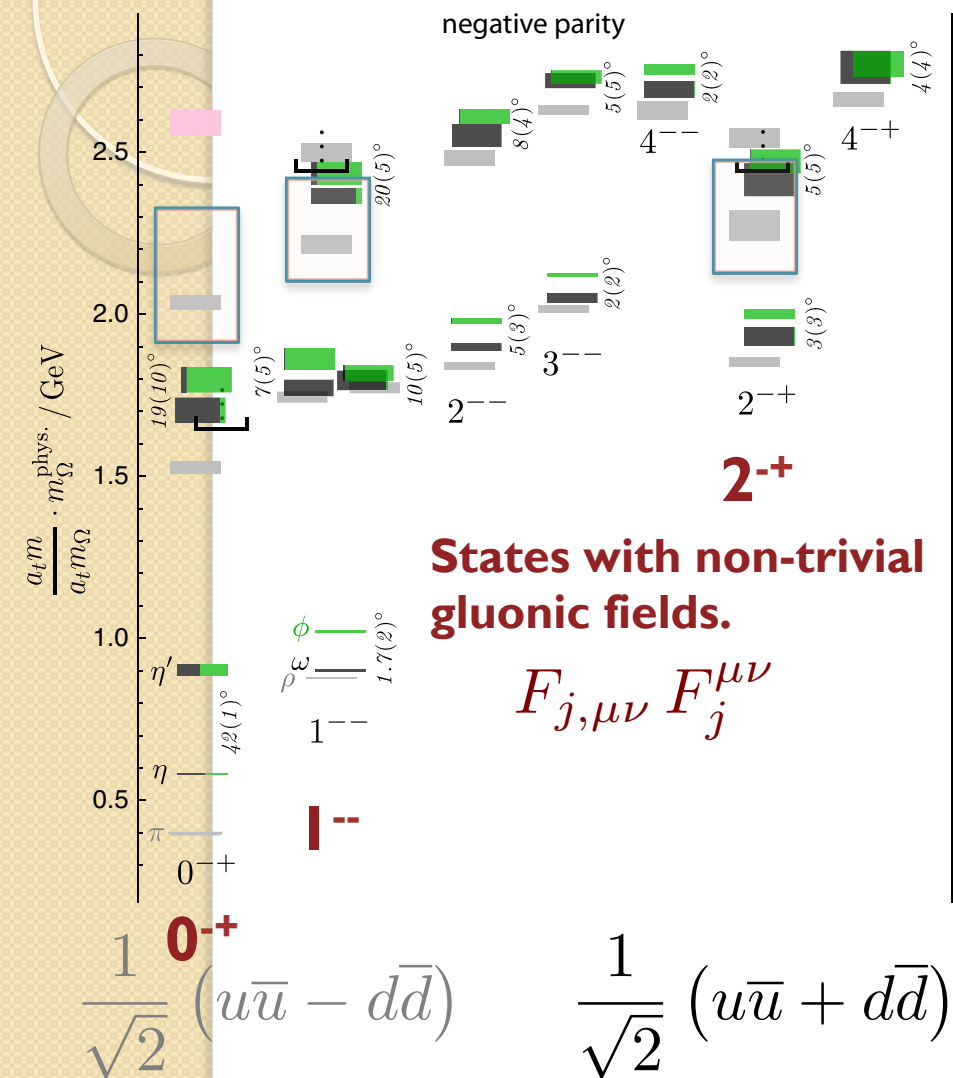


Light-quark Mesons (u,d,s)



Lattice QCD

Light-quark Mesons (u,d,s)

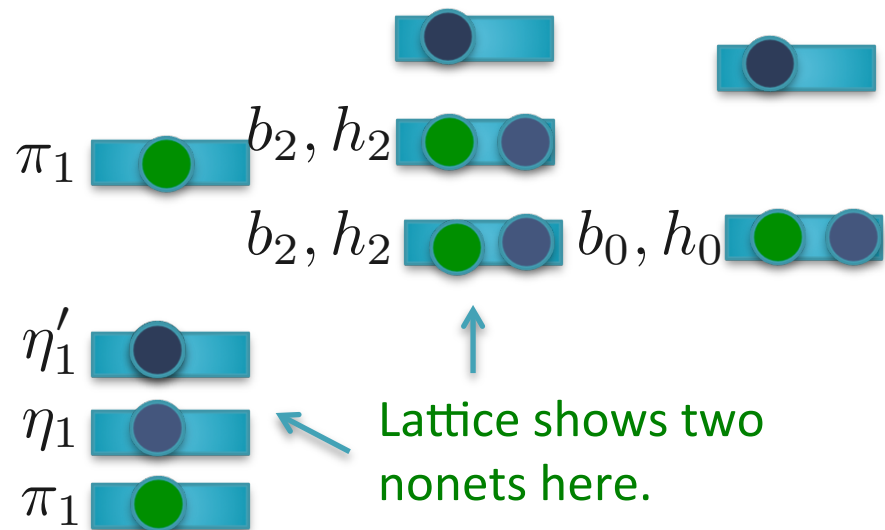


QCD Exotics

Lattice QCD suggests 5 nonets of mesons with exotic quantum number:

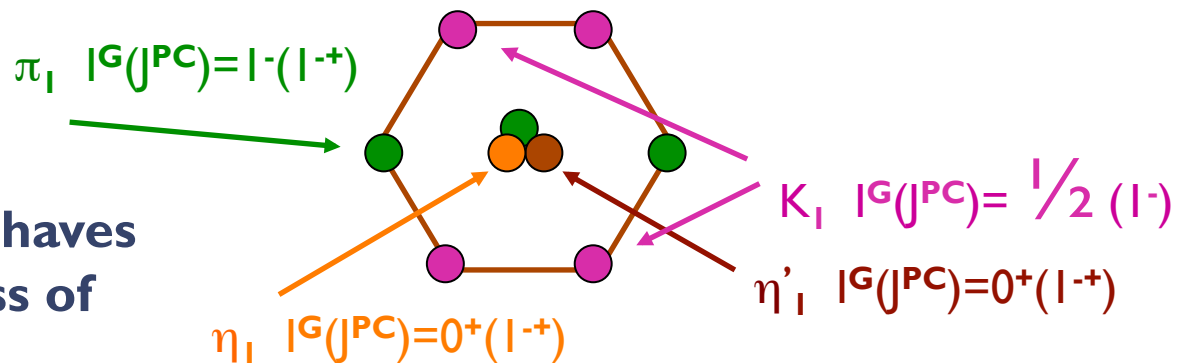
- 1 nonet of 0^{+-} exotic mesons
- 2 nonets of 1^{-+} exotic mesons
- 2 nonets of 2^{+-} exotic mesons

Experimental evidence exists for π_1 states.

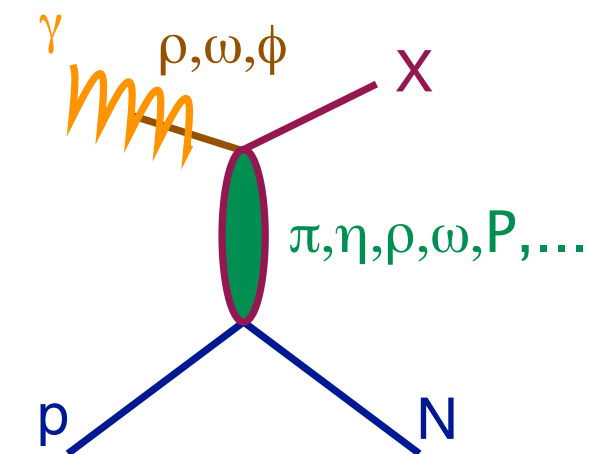


“Constituent gluon” behaves like $J^{PC} = 1^{+-}$ with a mass of 1-1.5 GeV

The lightest hybrid nonets:
 $1^{-}, (0^{-+}, 1^{-+}, 2^{-+})$



Photoproduction Mechanisms



Simple quantum number counting for production: $(I^G)J^{PC}$ up to $L=2$

P = Pomeron exchange

$\rho\pi, \rho\omega$	\rightarrow	π_1
$\omega\omega, \rho\rho$	\rightarrow	η_1
$\omega\omega, \rho\rho, \phi\omega$	\rightarrow	η'_1
ρP	\rightarrow	b_0
ωP	\rightarrow	h_0
$\omega P, \phi P$	\rightarrow	h'_0
$\omega\pi, \rho\eta, \rho P$	\rightarrow	b_2
$\rho\pi, \omega\eta, \omega P$	\rightarrow	h_2
$\rho\pi, \omega\eta, \phi P$	\rightarrow	h'_2

$\rho\pi$ is charge-exchange only

Can couple to all the lightest exotic hybrid nonets through photoproduction and VMD.

Linear polarization is a filter on the naturality of the exchanged particle.

Decay Modes of Exotic Hybrids

$$\begin{aligned}\pi_1 &\rightarrow \pi\rho, \pi b_1, \pi f_1, \pi\eta', \eta a_1 \\ \eta_1 &\rightarrow \eta f_2, a_2\pi, \eta f_1, \eta\eta', \pi(1300)\pi, a_1\pi, \\ \eta_1' &\rightarrow K^*K, K_1(1270)K, K_1(1410)K, \eta\eta'\end{aligned}$$

$$b_2 \rightarrow \omega\pi, a_2\pi, \rho\eta, f_1\rho, a_1\pi, h_1\pi, b_1\eta$$

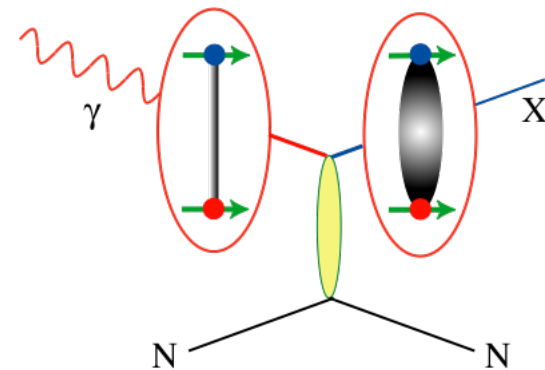
$$h_2 \rightarrow \rho\pi, b_1\pi, \omega\eta, f_1\omega$$

$$h_2' \rightarrow K_1(1270)K, K_1(1410)K, K_2^*K, \phi\eta, f_1\phi$$

$$b_0 \rightarrow \pi(1300)\pi, h_1\pi, f_1\rho, b_1\eta$$

$$h_0 \rightarrow b_1\pi, h_1\eta$$

$$h_0' \rightarrow K_1(1270)K, K(1460)K, h_1\eta$$



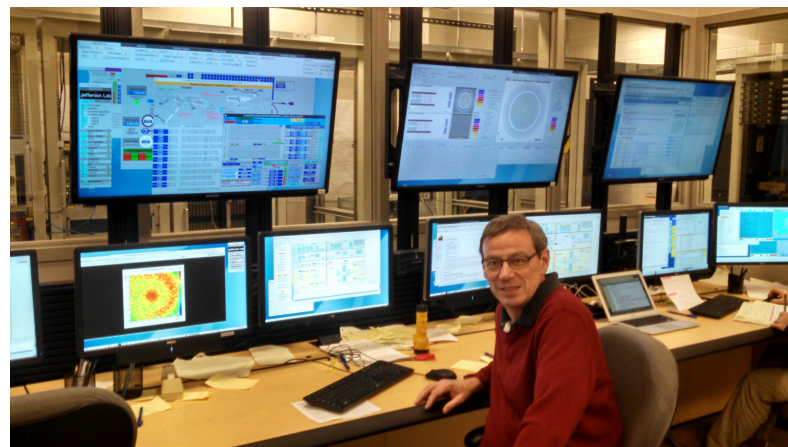
Early Reach **With Statistics** **Hard**

Hybrid kaons do not have exotic QN's

Models suggest narrower states are in the spin-1 and spin-2 nonets, while the spin-0 nonets are broad.

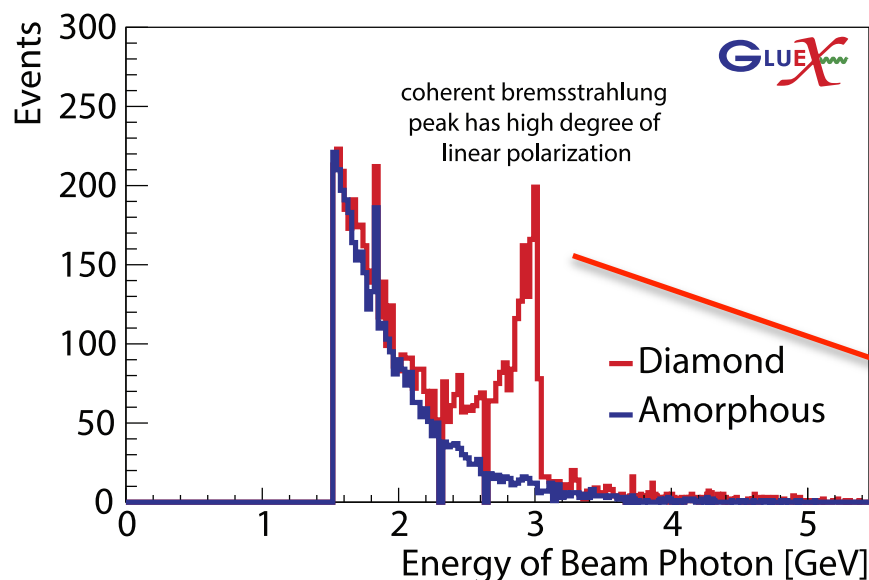
GlueX Commissioning Runs

- Late October to mid December 2014 with 10 GeV electrons. No polarized photons, and solid GlueX targets.
- All systems worked, all detectors recorded data using multiple triggers. 120TB of data collected, 930M events.
- April 2015 ran for a few days with 6GeV electrons producing linearly-polarized photons on the liquid-hydrogen GlueX target.
- Better DAQ and triggering led to higher-quality data. 74TB of data collected, 1285M events.
- Many detector systems at design specs, all detector systems are within 30% of design specs.
- Data are fully processed every two weeks. We are extracting physics from GlueX.

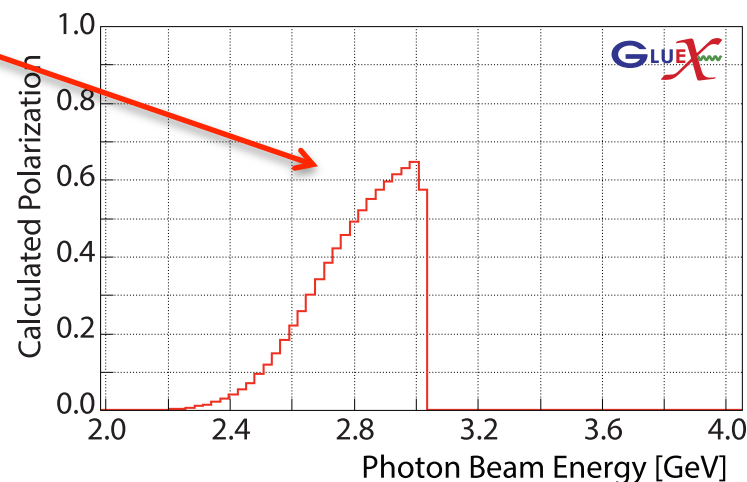


Coherent Bremsstrahlung

Spring 2015—6 GeV electron beam on diamond radiator
6 GeV electron beam on amorphous radiator

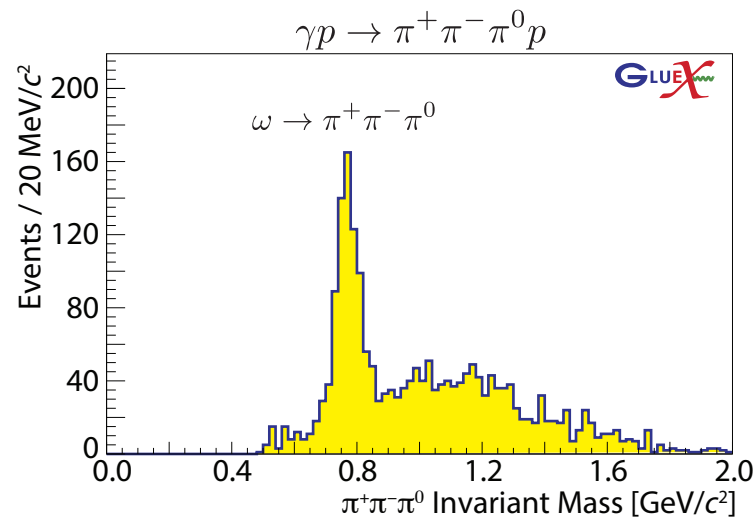
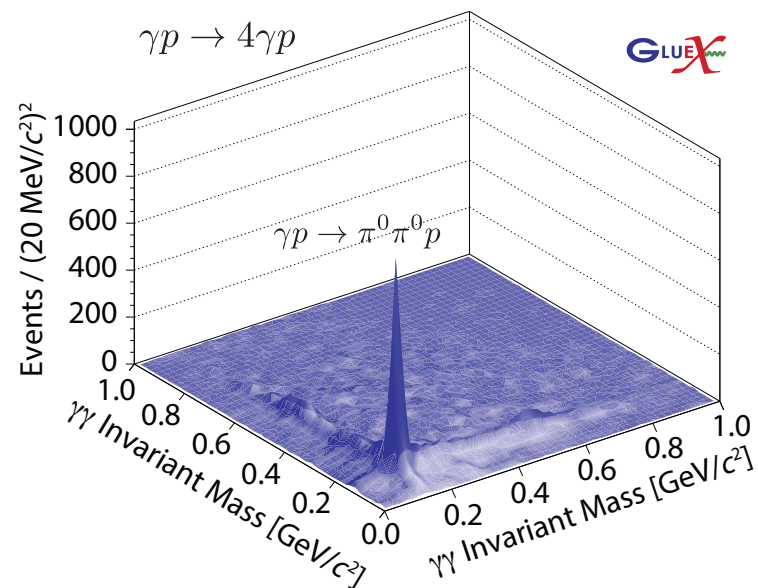
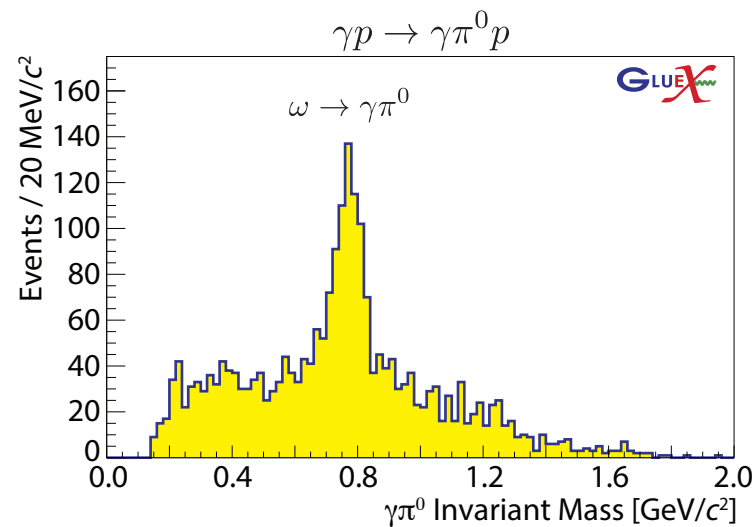
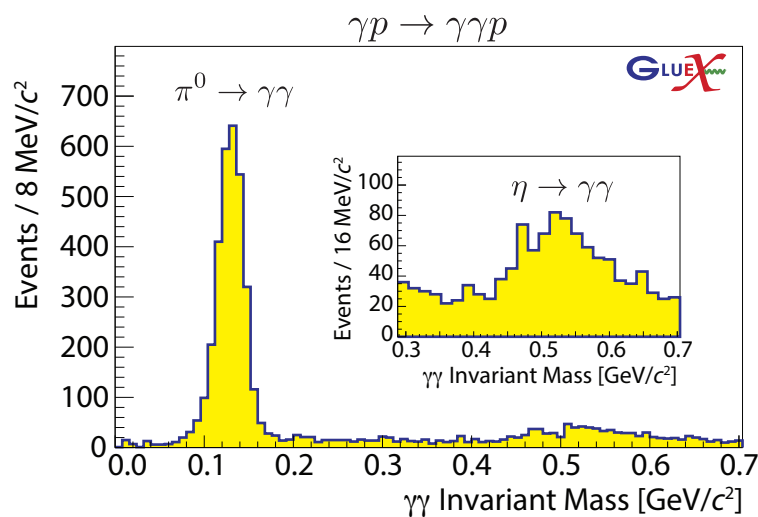


Linear Polarization



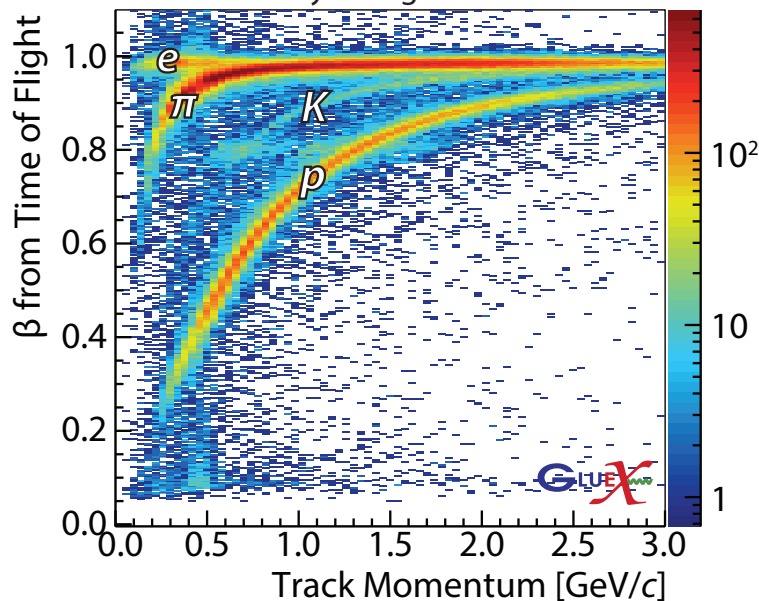
Polarized photon beam commissioning started.

Mass Peaks in GlueX

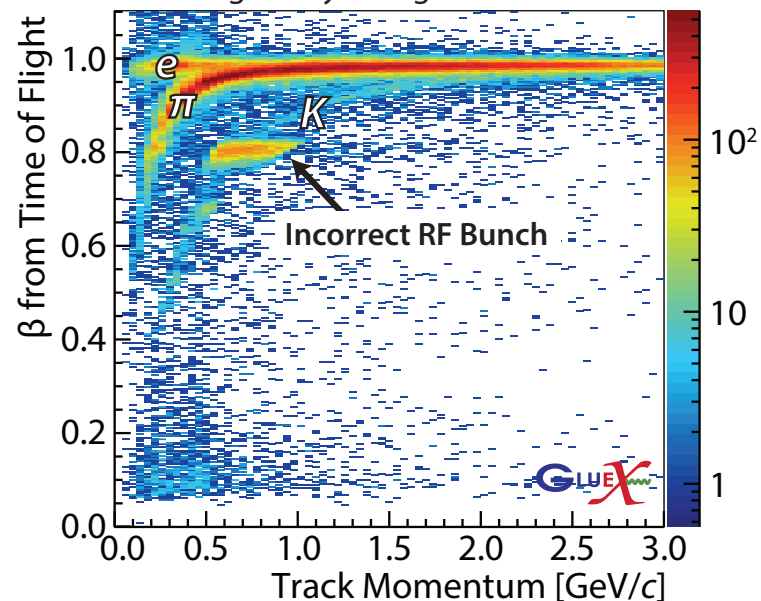


Particle Identification

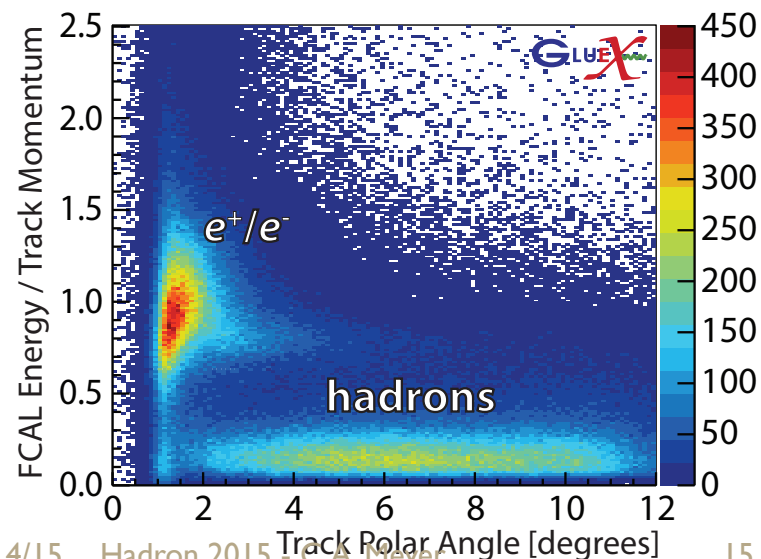
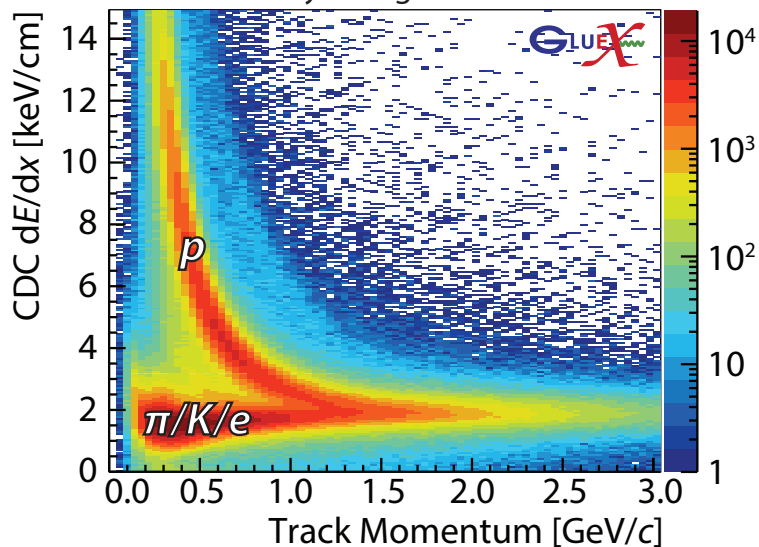
Positively Charged Particles



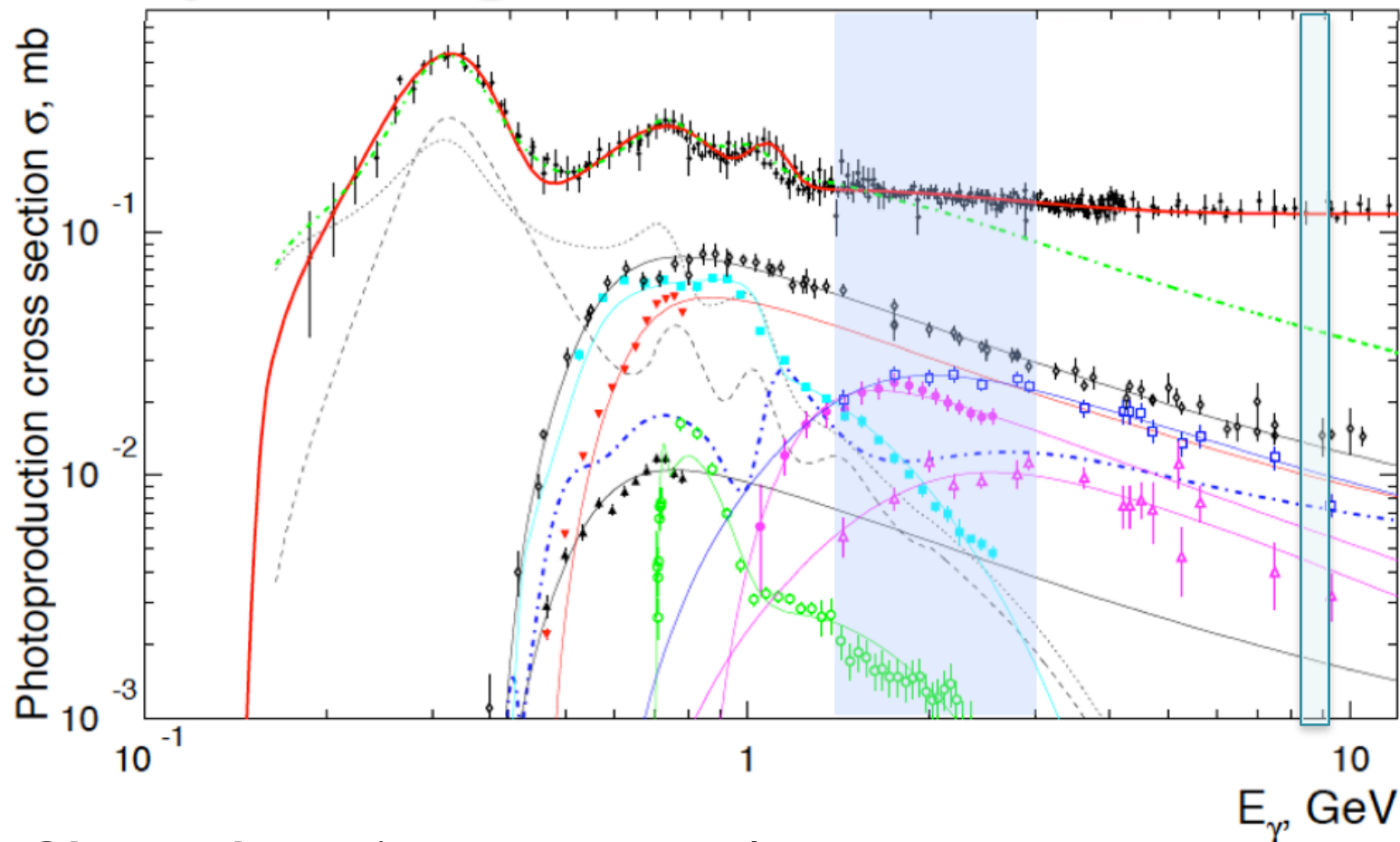
Negatively Charged Particles



Positively Charged Particles



Physics signals



Observed reactions

- — $\gamma p \rightarrow p \rho^0$ ~10%
- ▲ — $\gamma p \rightarrow p \pi^0 \pi^0$ ~5%

$\sigma_{\text{rect.}} / \sigma_{\text{tot}}$

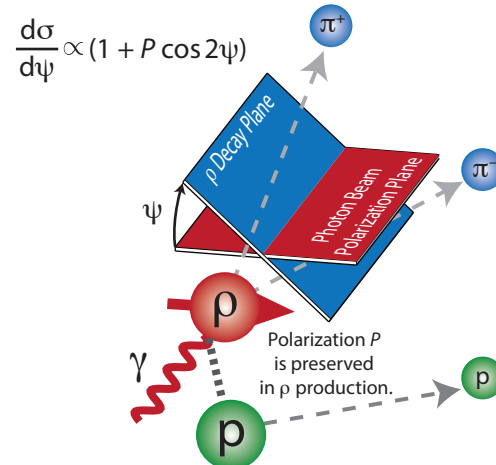
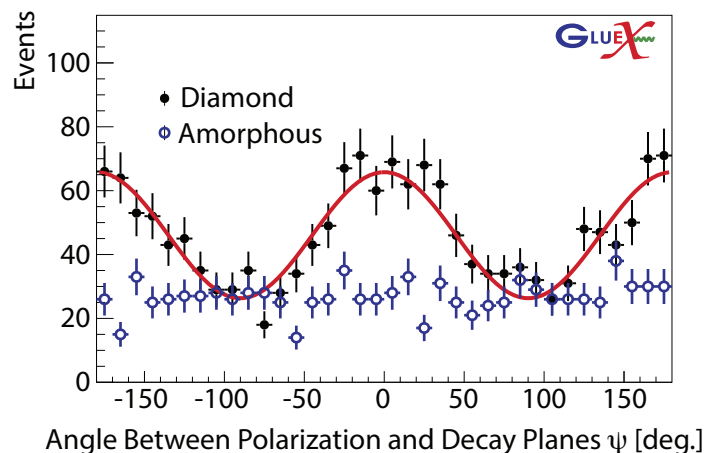
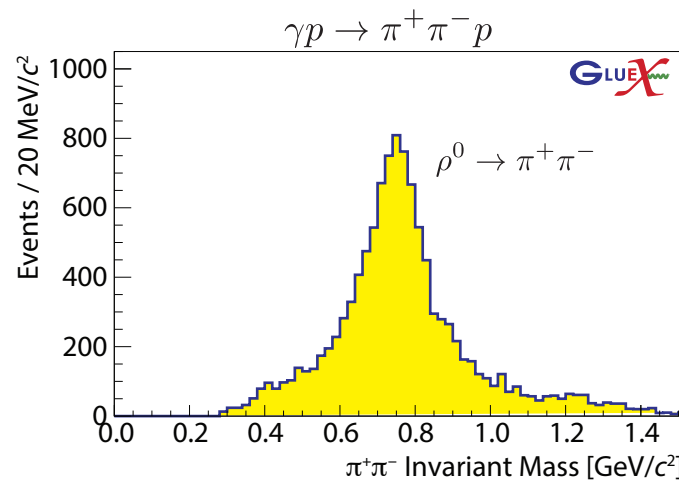
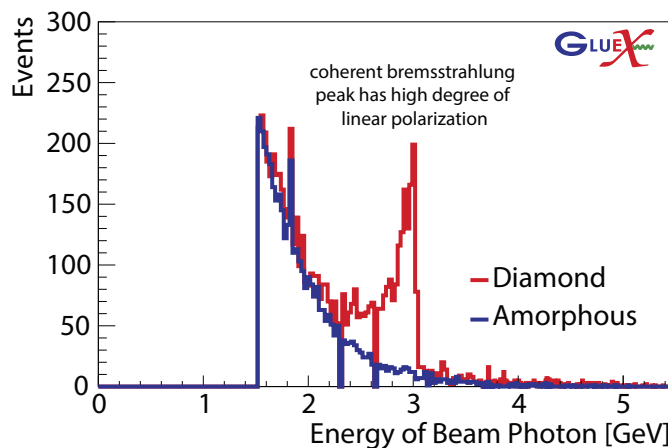
- $\gamma p \rightarrow p \pi^0$ ~5%
- — $\gamma p \rightarrow p \eta$ ~1%
- — $\gamma p \rightarrow p \pi^+ \pi^- \pi^0$ ~10%

Polarization transfer to the ρ

$$\frac{d\sigma}{d\psi} \propto (1 + P\Sigma \cos 2\psi)$$

P=Linear Polarization
 Σ =Beam Asymmetry ~ 1.0

A few hours of beam



Early Physics

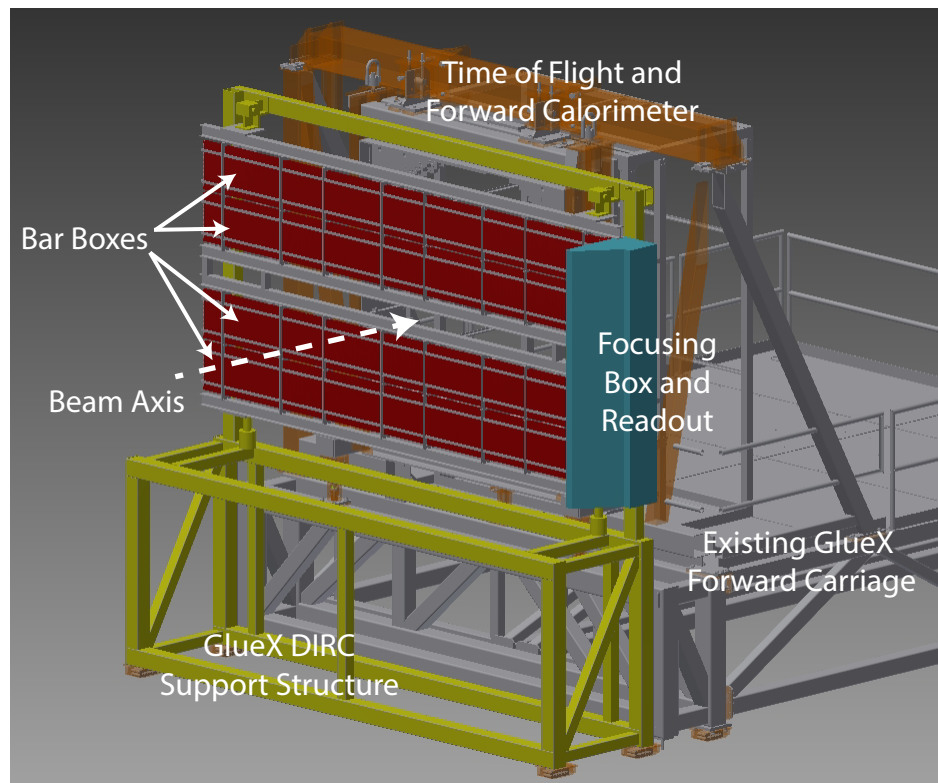
- Initial reactions will be polarization transfer and beam asymmetry measurements.

$$\gamma p \rightarrow \rho, \omega, \phi p \quad \gamma p \rightarrow \pi^0, \eta, \eta' p$$

- Cross section measurements.
- Spin-density matrix elements to understand production mechanisms.
- Identify known mesons in PWA.
- Move on to the search for exotic hybrids.

Forward Kaon Identification

- Four of the BaBar DIRC bar boxes will be installed in front of the TOF wall.
- This combined with the other PID systems in GlueX will allow us to fully study final states with strange quarks.
- Strangeonium mesons and hybrids can be studied.
- Hyperon and cascade baryons can be studied.



Expected late 2017/ 2018

Experiments using GlueX

GlueX—Hybrid mesons/spectroscopy
PR-06-102, PR-12-002 & PR-13-003

A rating
340-540 PAC days

GlueX—PrimEx-eta
PR-10-011
(calorimeter plug)

A- rating
79 PAC Days

GlueX—Pion polarizability
PR-13-008
(forward muon detector)

A- rating
25 PAC Days

GlueX—JEF: Rare eta decays
PR-14-004
(calorimeter upgrade)

Conditionally
Approved

Experiments using GlueX

GlueX—Study of ω photoproduction
on nuclei. LOI 2015

GlueX—Physics opportunities with a
secondary K_L beam LOI 2015

Workshop planned at JLab in February 2016
<https://www.jlab.org/conferences/kl2016/>

Summary

- GlueX is installed and well into its commissioning.
- All detector systems are approaching design specifications in performance, but additional data are needed for full calibration.
- The experiment is ready to do first physics measurements of simple reactions.
- The broader program of exotic mesons is in sight and an upgrade plan is in place to allow us to cover all parts of that program is moving forward.
- We have an extensive program beyond exotic hybrids and are excited to have new ideas and new collaborators.