



Progress and Plans

Justin Stevens

S&T Review: July 29, 2015

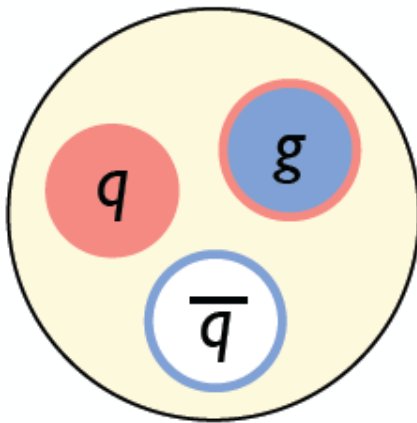
Introduction

- **Background information:**
 - Ph.D. at Indiana University with STAR (BNL)
 - Postdoc at MIT with GlueX
 - Joined JLab as a Hall D Staff Scientist in March 2015
- **What is my role in Hall D?**
 - Coordinator for DIRC-based Cherenkov project
 - Capital Equipment funds (talk by P. Rossi)
 - Physics Analysis Co-coordinator
 - Ongoing analysis of early commissioning data
 - Preparations for first physics data and analysis

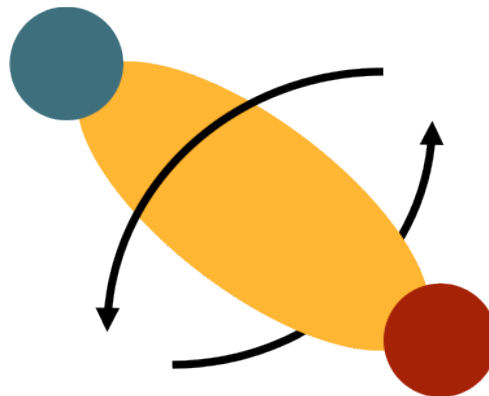
Hybrid mesons and gluonic excitations

- Excited gluonic field coupled to $q\bar{q}$ pair
- Rich spectrum of hybrid mesons predicted by Lattice QCD
- “Constituent gluon” with $J^{PC} = 1^{+-}$ and mass = 1-1.5 GeV
- Some have “exotic” J^{PC} which cannot be formed by $q\bar{q}$:

$$J^{PC} = 0^{+-}, 1^{-+}, 2^{+-} \dots$$

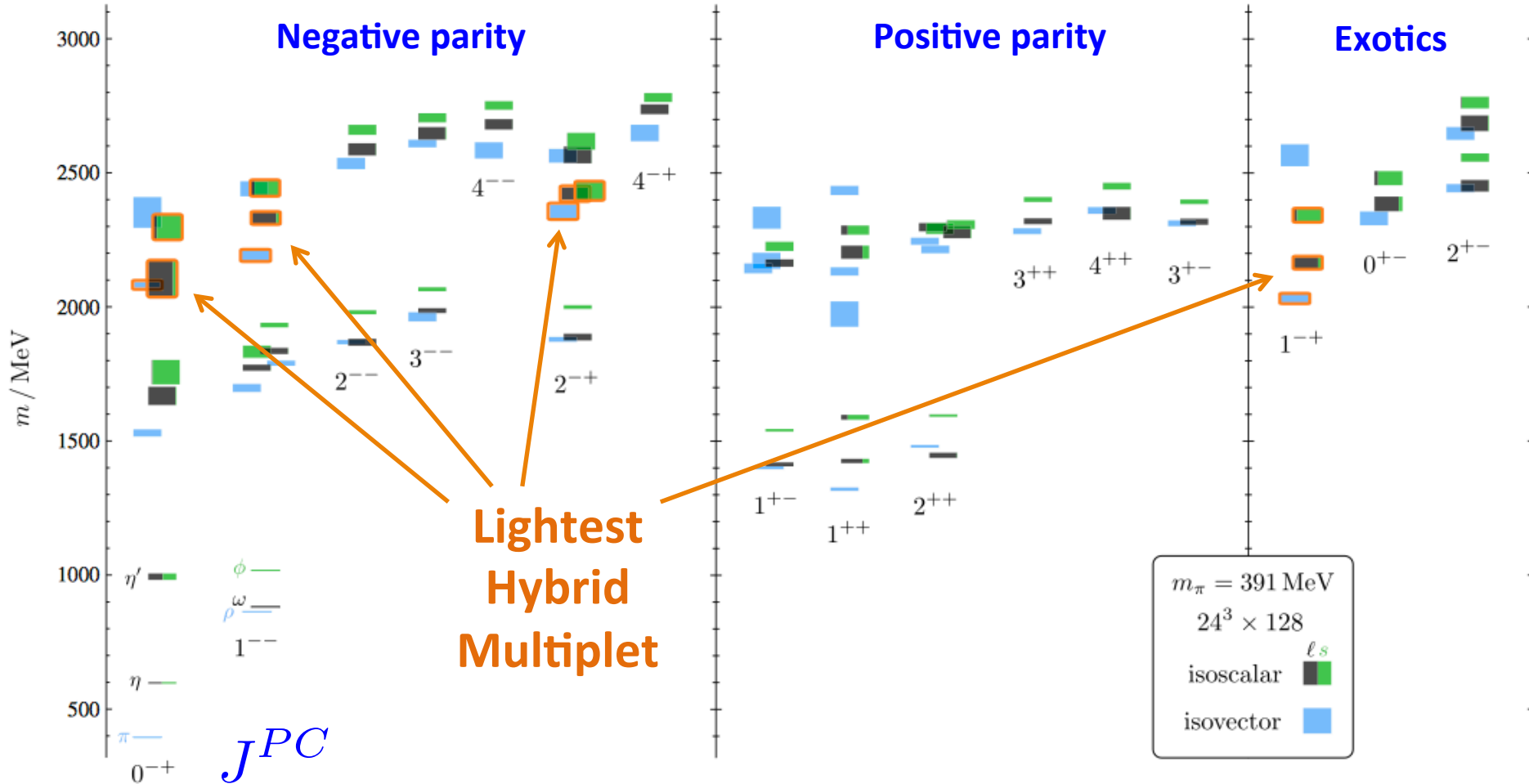


Hybrid Meson



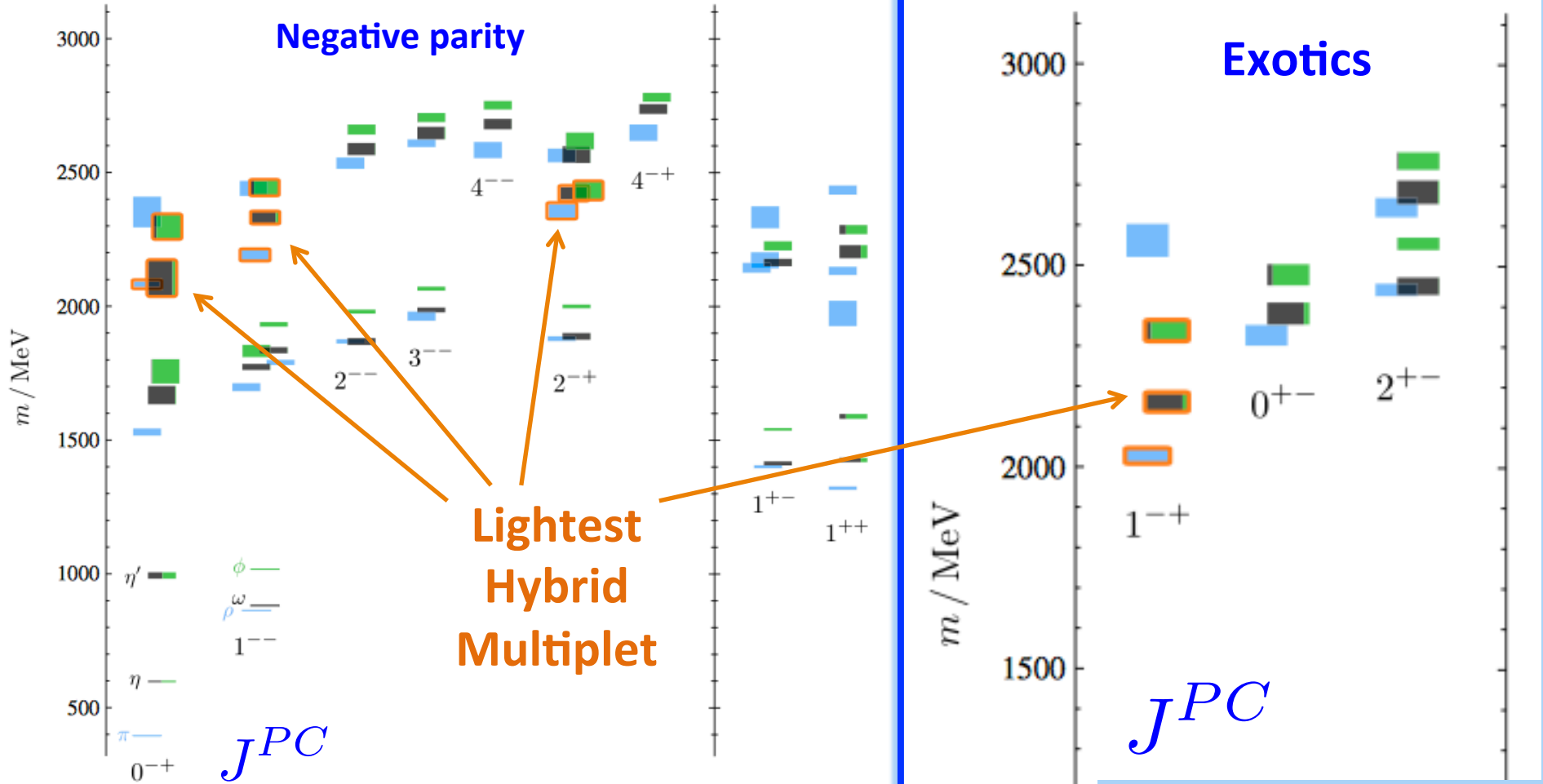
$$\begin{aligned} \vec{J} &= \vec{L} + \vec{S} \\ P &= (-1)^{L+1} \\ C &= (-1)^{L+S} \end{aligned}$$

Lattice QCD predictions



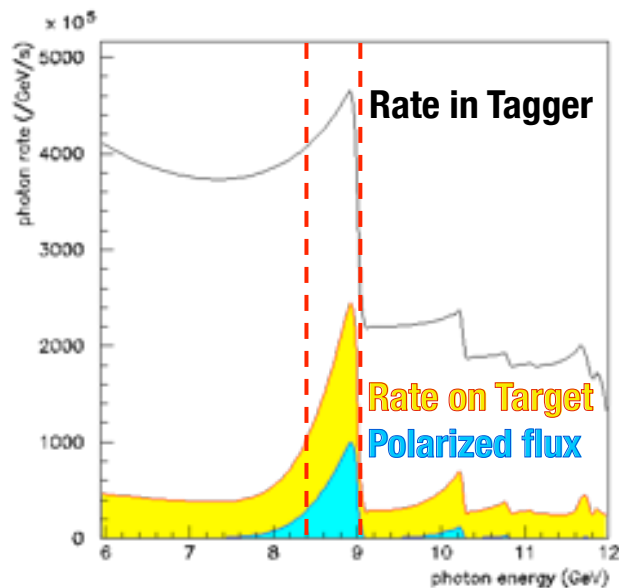
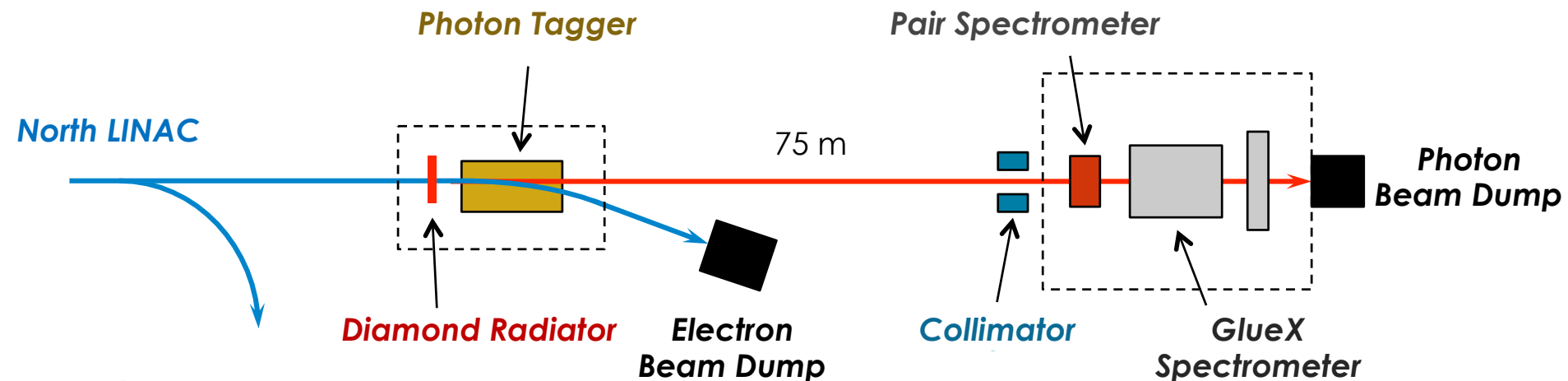
- The primary goal of the GlueX experiment is to search for and ultimately map out the spectrum of light quark hybrid mesons

Lattice QCD predictions



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GLUEX overview

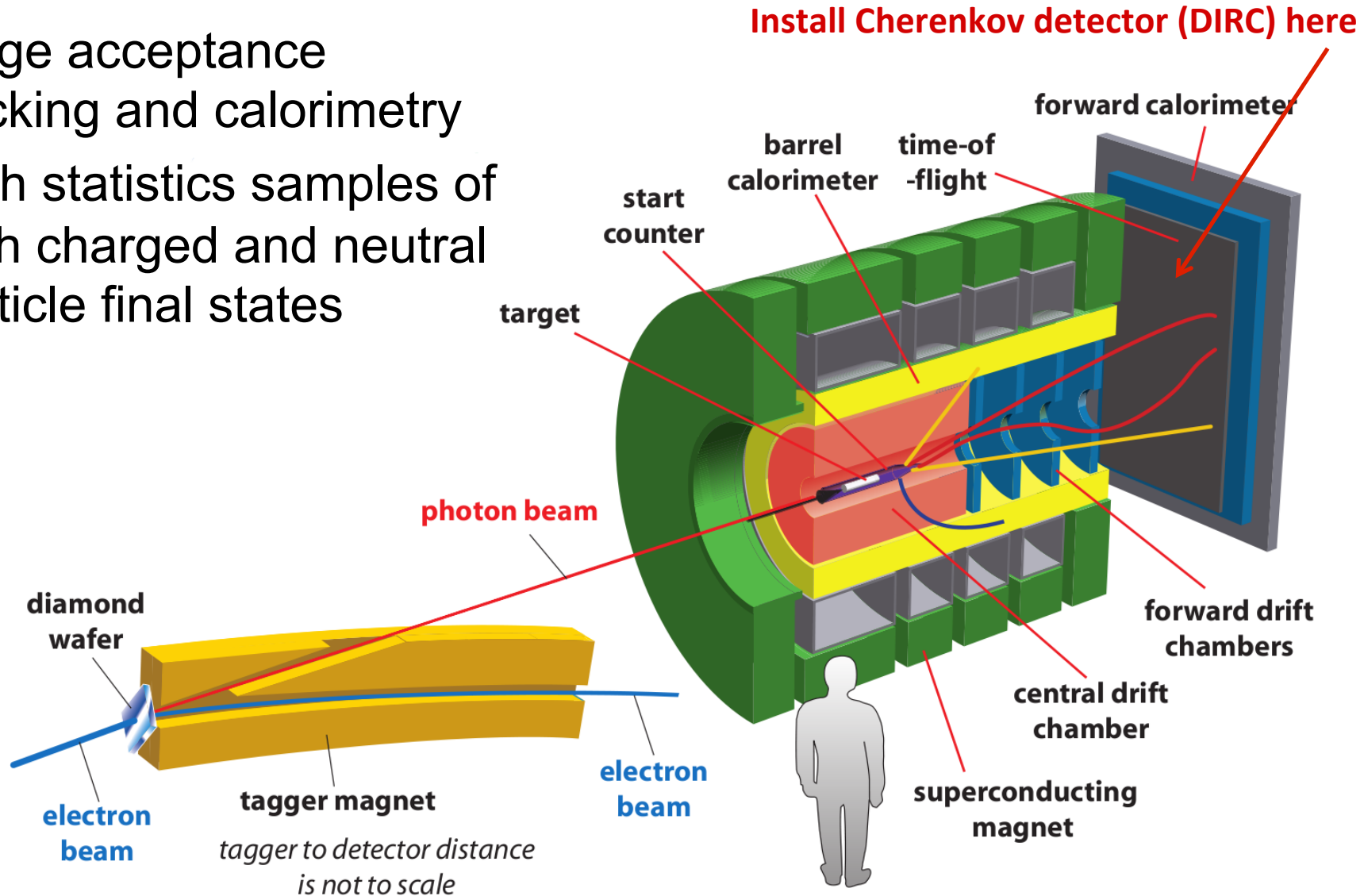


- 12 GeV e^- beam up to 2.2 μA
- Linearly polarized photon beam ($P_y \approx 40\%$) from coherent bremsstrahlung on **diamond radiator**
- Design intensity of 10^8 γ/s in coherent peak ($E_\gamma = 8.4\text{-}9$ GeV)

12 GeV Upgrade Driver

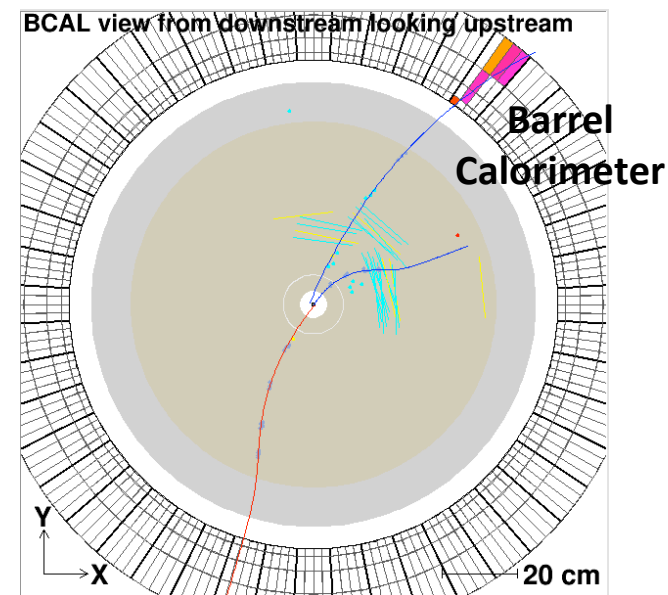
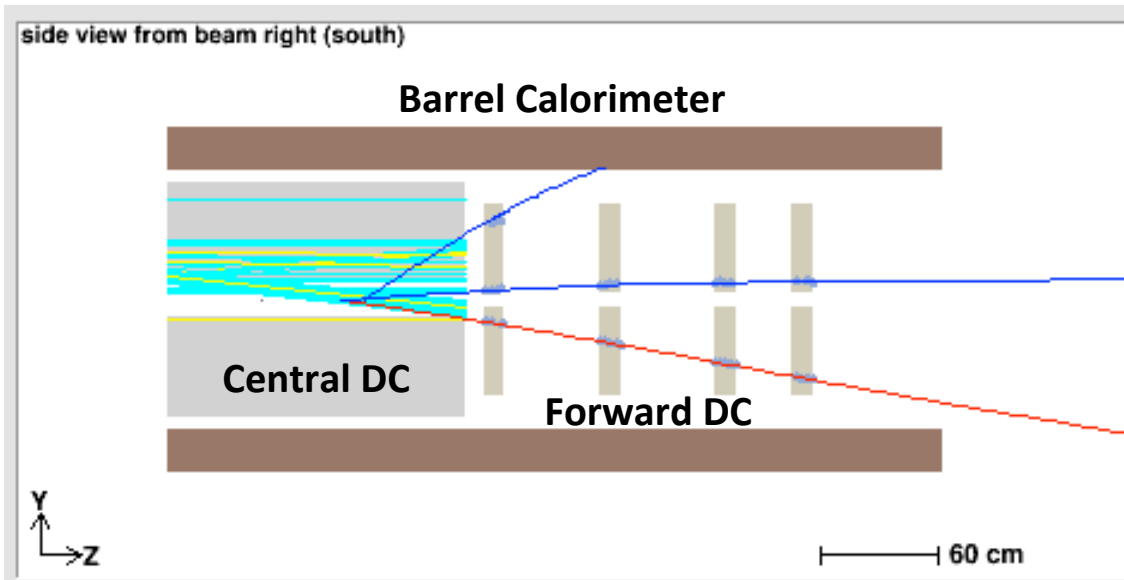
GLUEX overview

- Large acceptance tracking and calorimetry
- High statistics samples of both charged and neutral particle final states



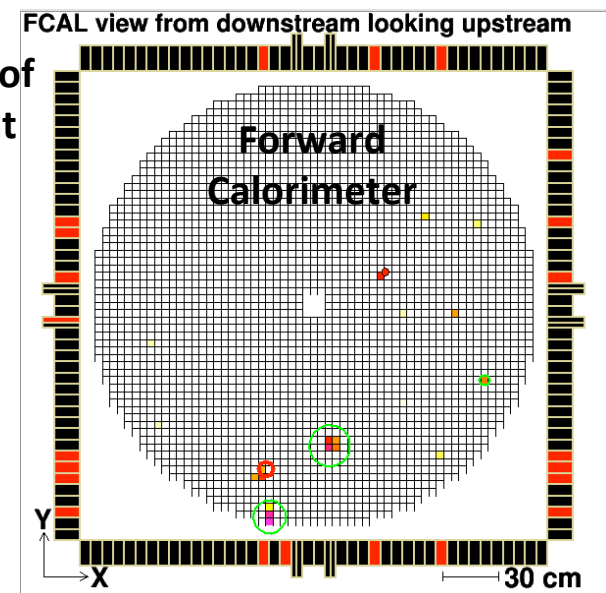
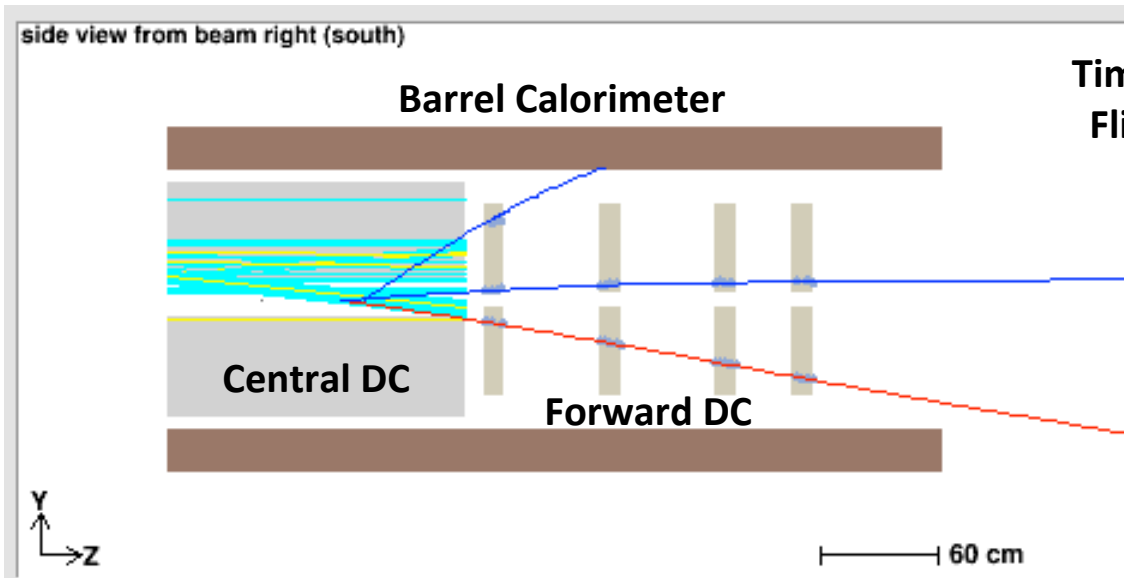
Fall 2014 commissioning

- After accelerator tuning: ~19 days of beam available
 - Electron beam: 10.1 GeV, 50 – 200 nA
 - Hall D: **amorphous radiator**, CH₂ target, solenoid 1200 A
- Primary goals:
 - Beamline commissioning: ✓
 - Checkout detectors, Trigger, DAQ & record data ✓
 - Collect data for preliminary detector calibration & alignment
- 12 GeV Key Performance Parameter for Hall D (approved Dec. 11, 2014)



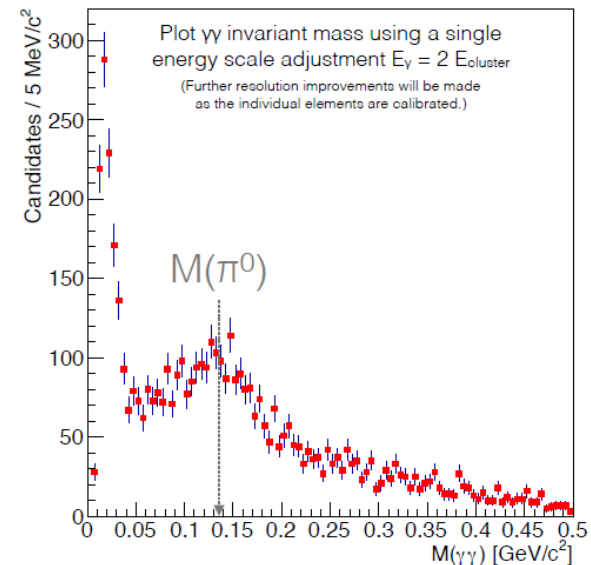
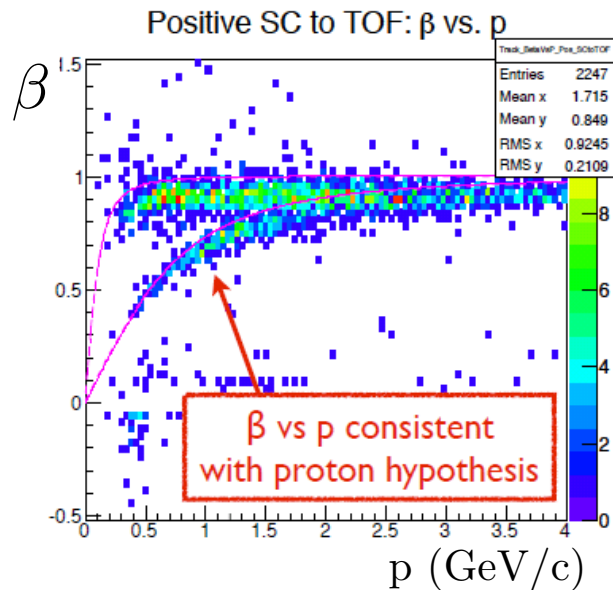
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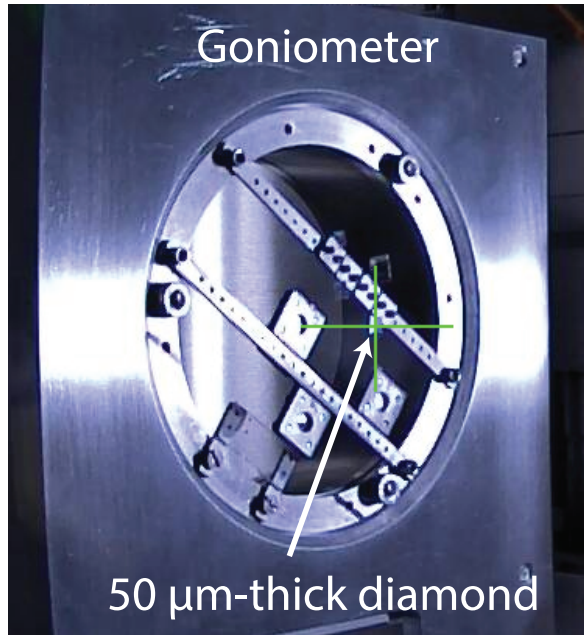


Spring 2015 commissioning

- **Original run plan:**
 - 2 months of 10.5 GeV e- beam: 1 opportunistic, 1 dedicated
- **Revised run plan:**
 - 10 days of beamtime with 5.5 GeV e- beam
- **Primary goals:**
 - Commission goniometer, **diamonds**, beamline detectors ✓
 - Commission LH₂ target ✓
 - Initial DAQ & Trigger optimization ✓
 - Commission accelerator RF timing ✓
 - Active collimator Fast Feedback 
 - Detector calibrations:
 - Field off data for drift chamber alignment 
 - Calorimeter dataset for π^0 calibration 
 - Establish solenoid running at 1300 A subject of recent review (talk by J. Gomez)

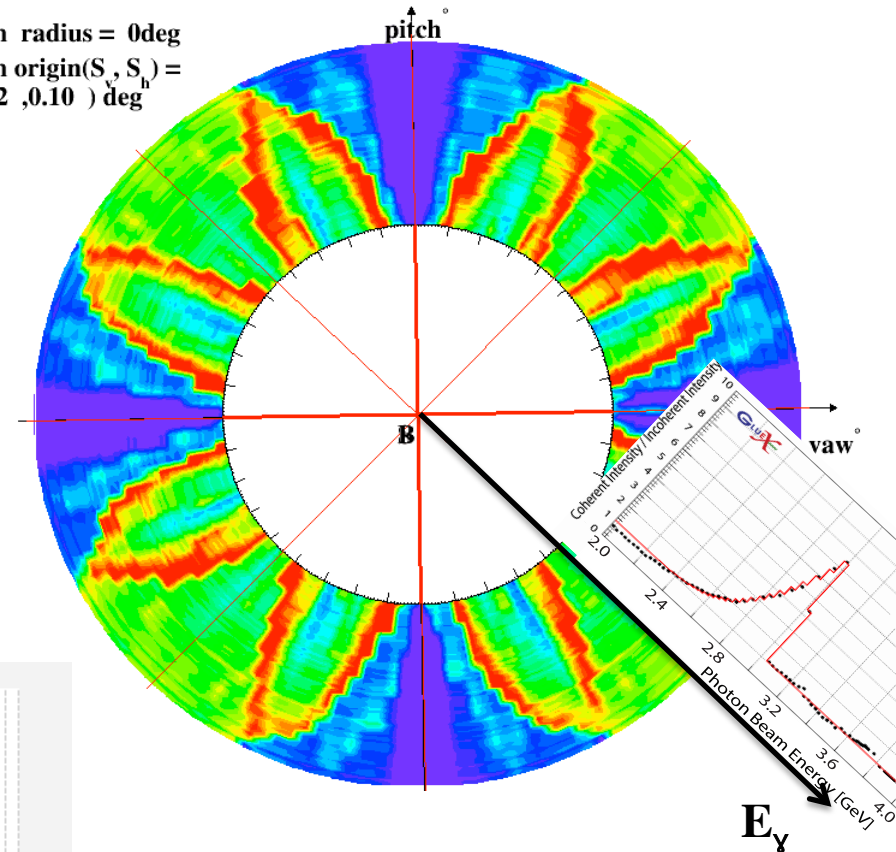
 Complete
 In progress

Diamond radiator commissioning

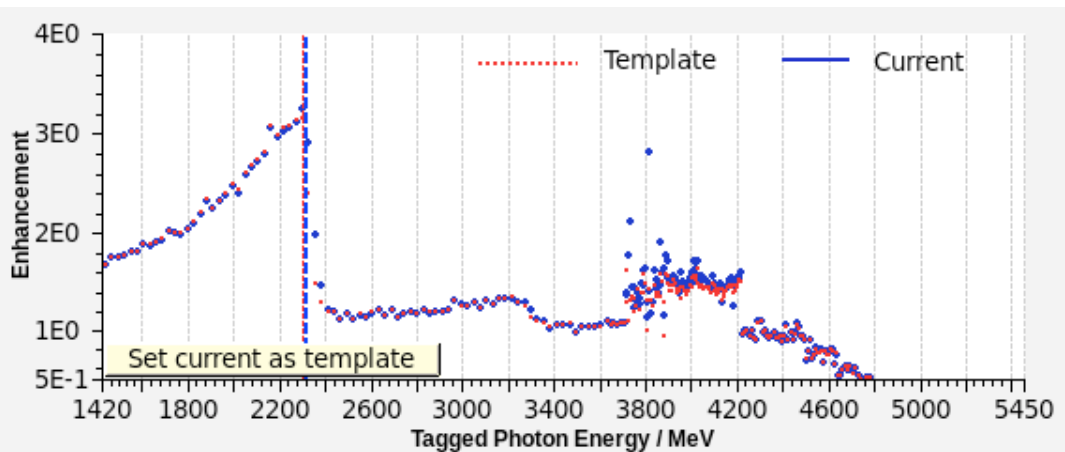


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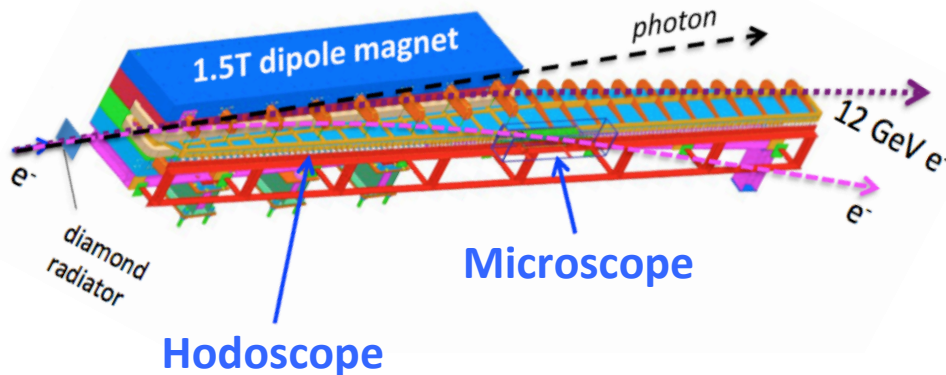
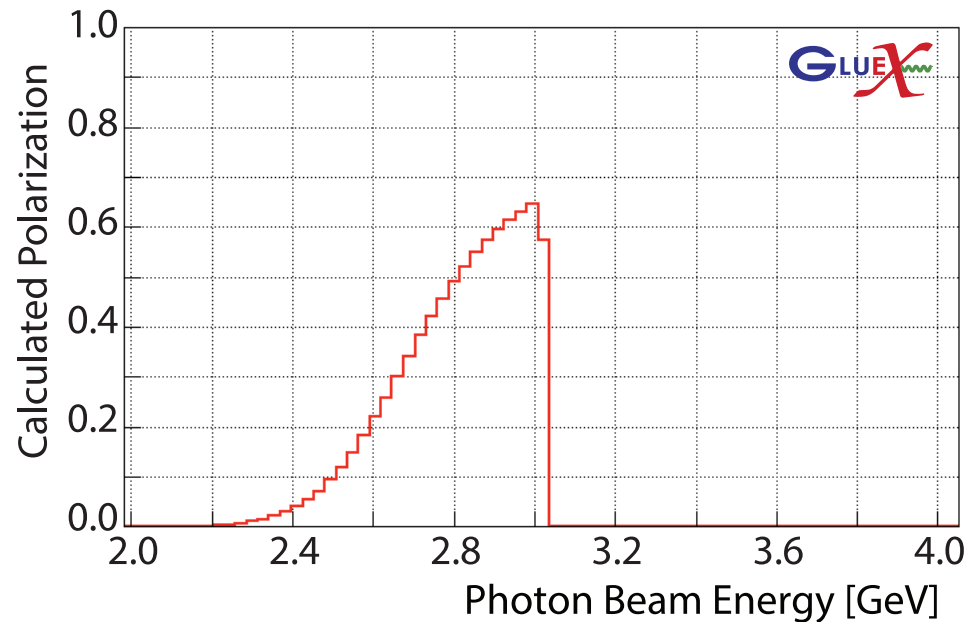
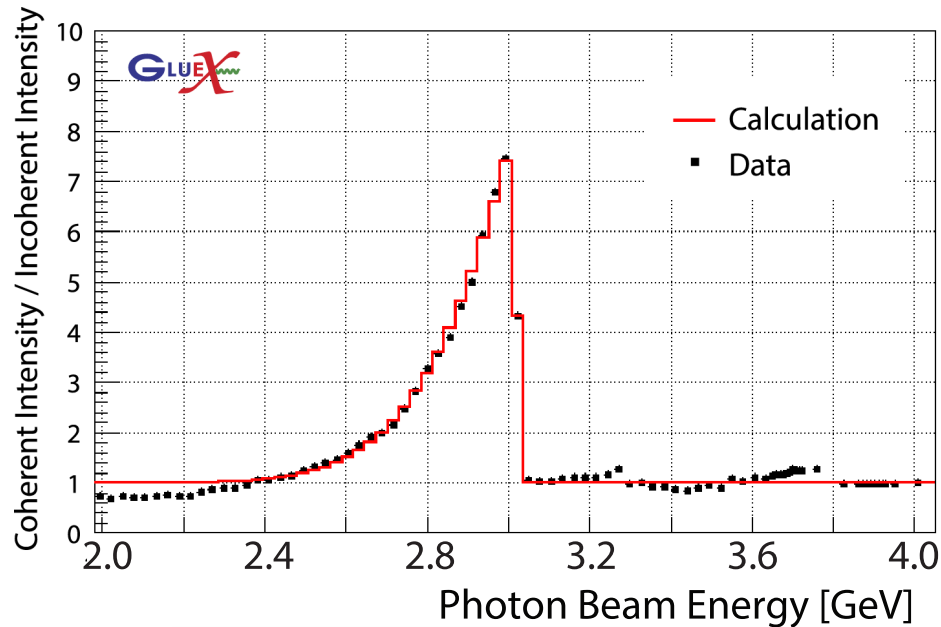
Scan radius = 0deg
 Scan origin(S_v, S_h) =
 (0.42, 0.10) deg



- Coherent bremsstrahlung observed with multiple diamonds in goniometer!

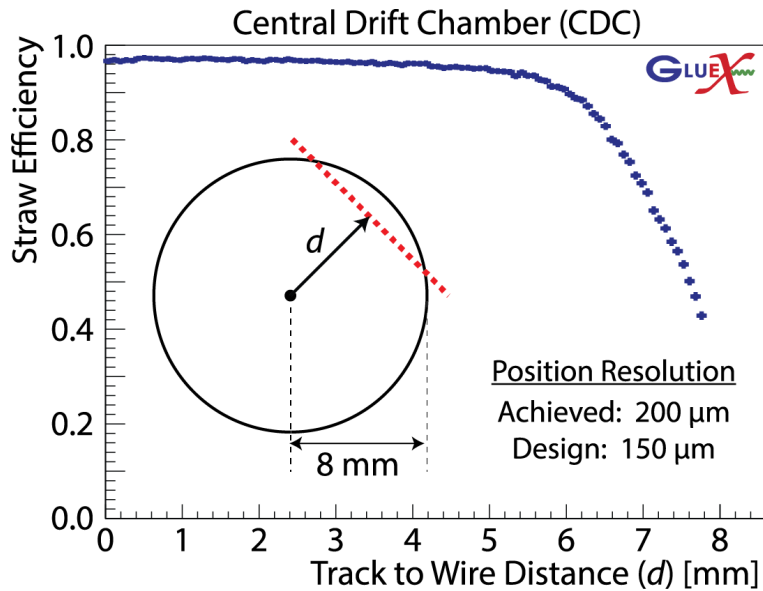


Coherent Bremsstrahlung

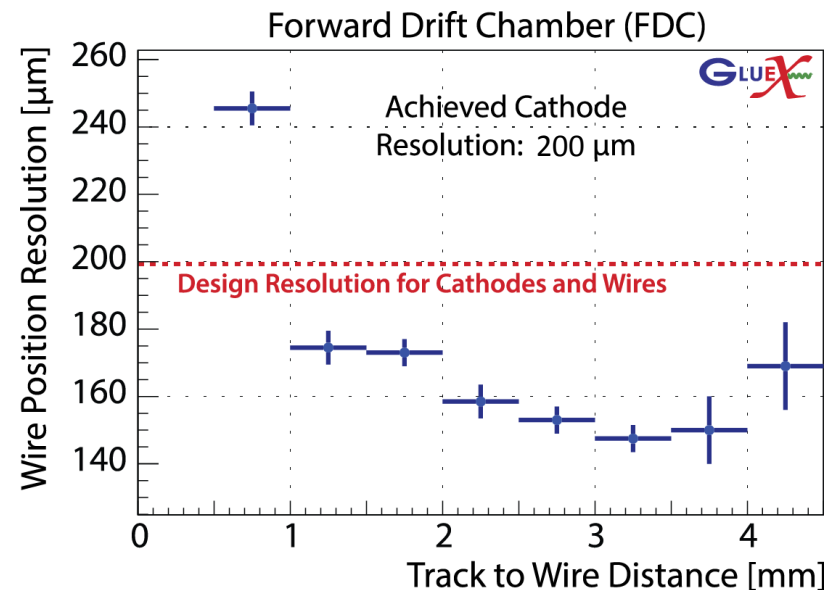
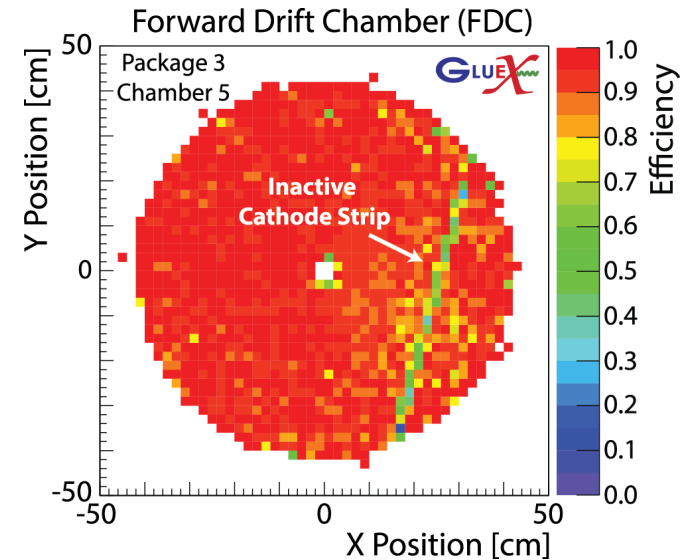


- Coherent peak at $E_\gamma \sim 3$ GeV observed on tagger hodoscope
- Fit to coherent peak yields a peak polarization of $\sim 65\%$

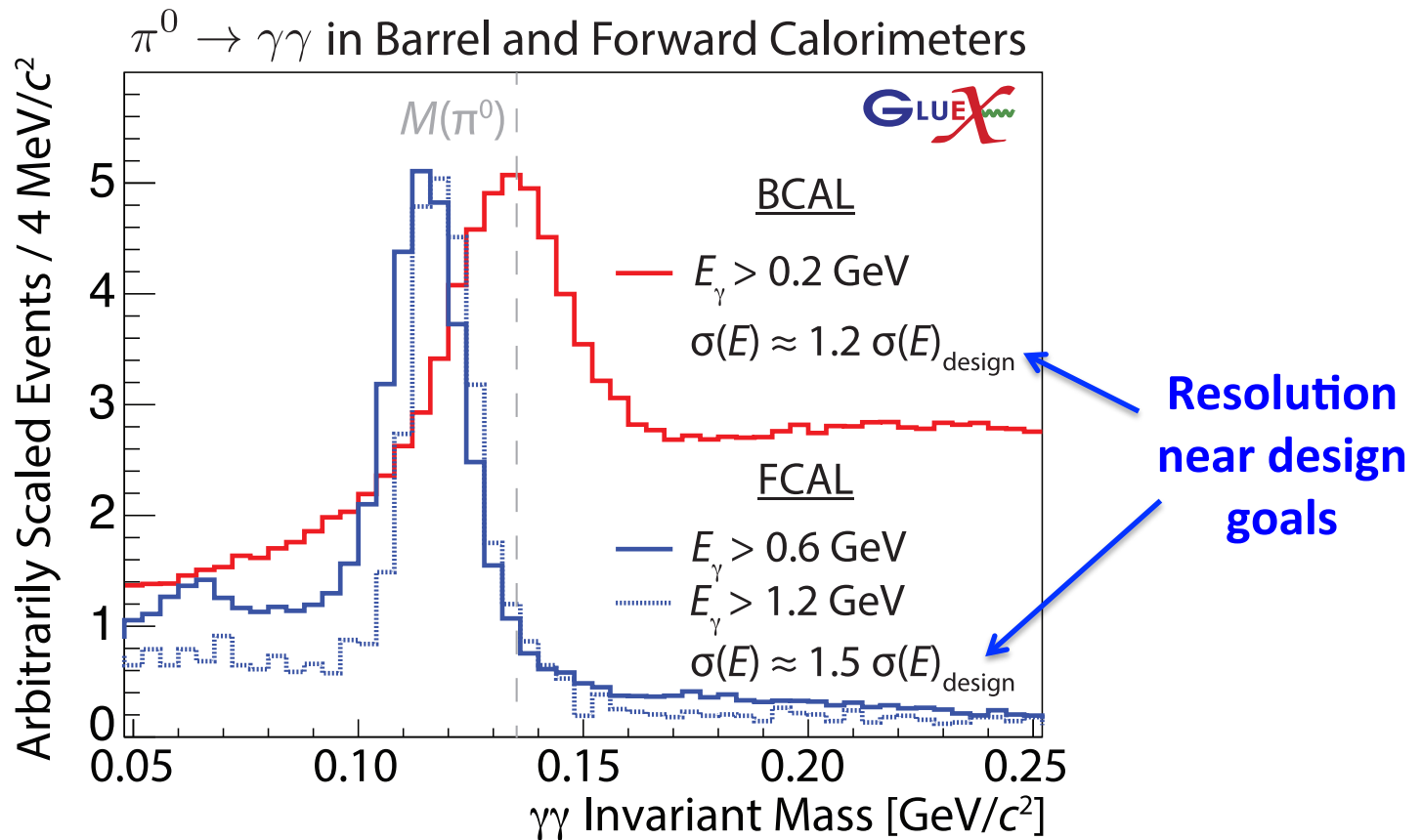
Drift chamber performance



- Drift chamber alignment in progress with solenoid field off
 - CDC: Cosmic rays
 - FDC: dedicated beam data with LH_2 target
- **Resolution near design goals**

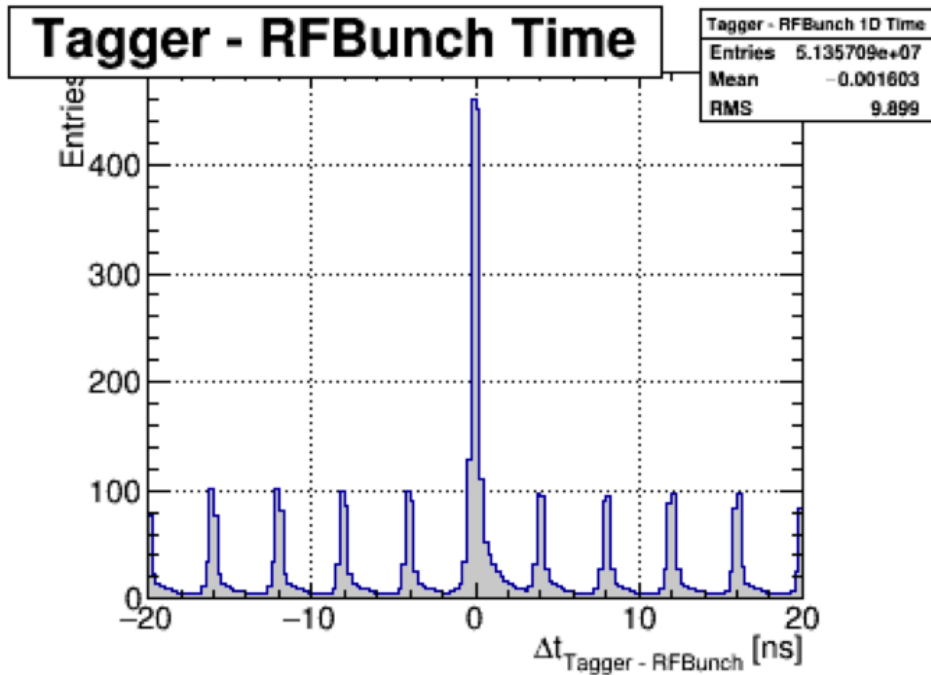


Calorimeter performance

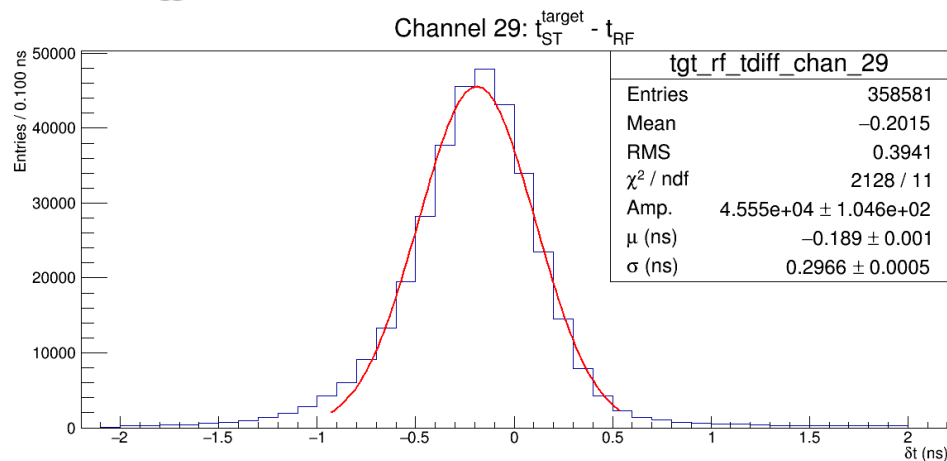


- Advanced calibration with sizable π^0 datasets collected
- Increased statistics needed to complete calibration, study systematics and meet design resolutions

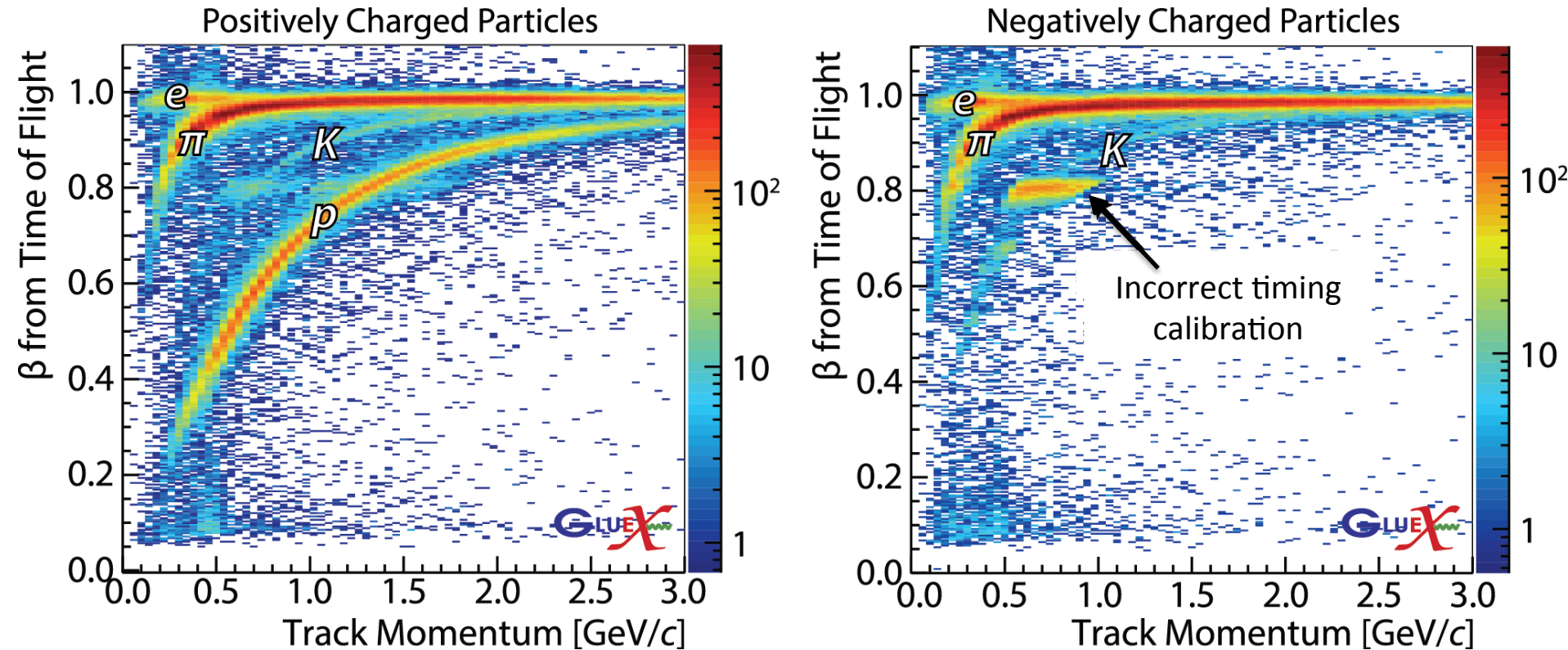
Timing calibrations



- Electron bunches every ~ 4 ns
 - Accelerator provides RF time
 - Select “correct” RF bunch using tracks matched fast timing detectors
 - Start Counter $\sigma_t \approx 300$ ps
- better than design goal!**

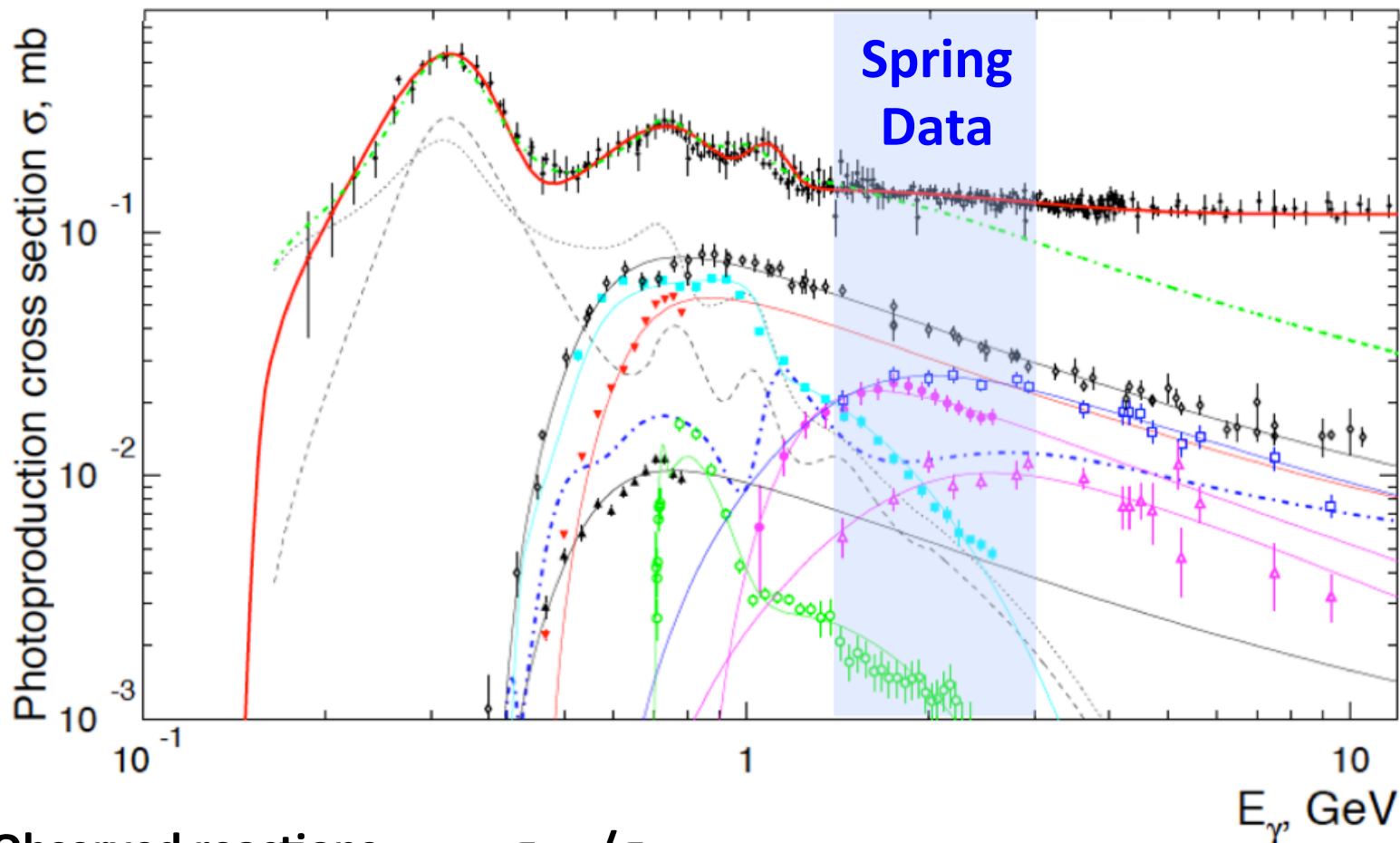


Particle identification



- Additional PID with other detector systems:
 - Proton identification via dE/dx in CDC and Start Counter
 - Electron identification via E/p in FCAL

Physics signals



Observed reactions

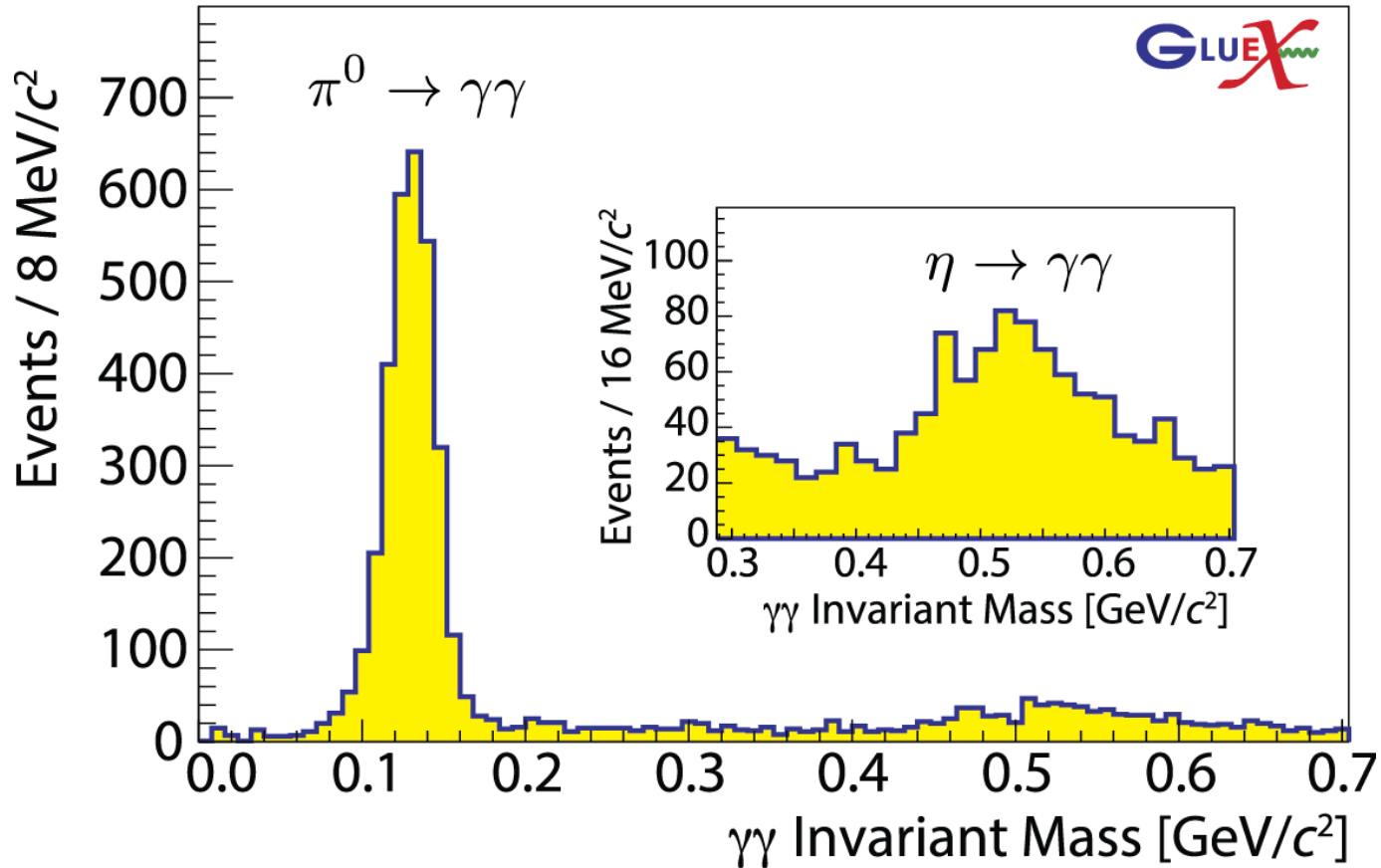
- ————— $\gamma p \rightarrow p \rho^0$ $\sim 10\%$
- ▲ ————— $\gamma p \rightarrow p \pi^0 \pi^0$ $\sim 5\%$

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

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

Physics signals

$$\gamma p \rightarrow \gamma \gamma p$$



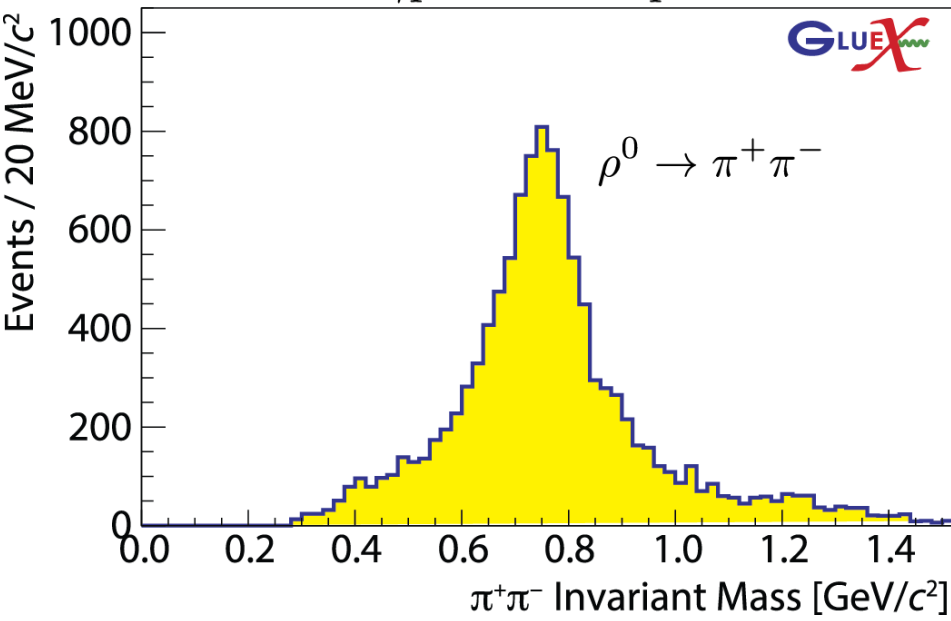
- $\gamma p \rightarrow p\pi^0$ ~5%
- ——— $\gamma p \rightarrow p\eta$ ~1%

Physics signals

$$\gamma p \rightarrow \pi^+ \pi^- p$$



$$\rho^0 \rightarrow \pi^+ \pi^-$$

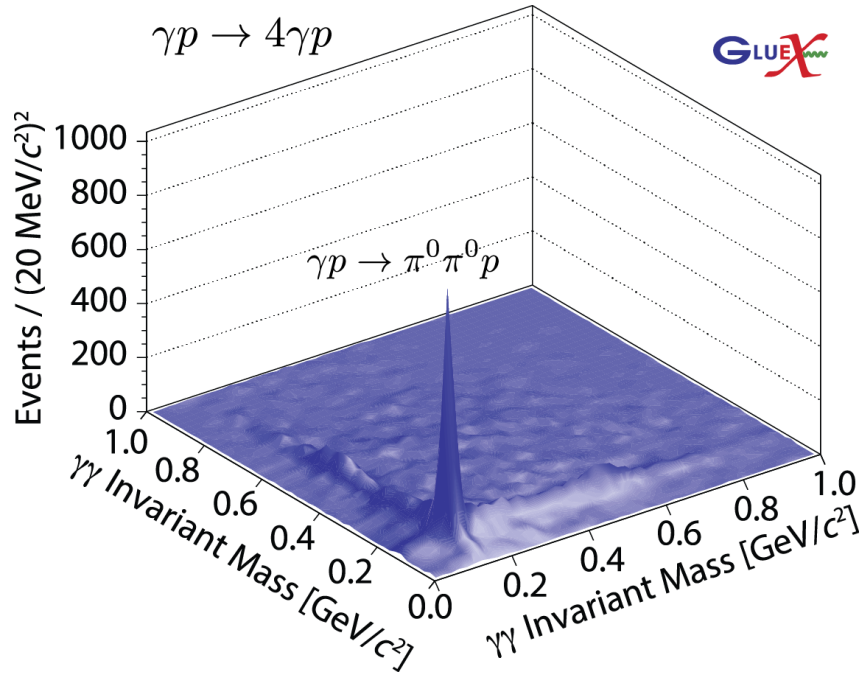


● ————— $\gamma p \rightarrow p \rho^0$ ~10%

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

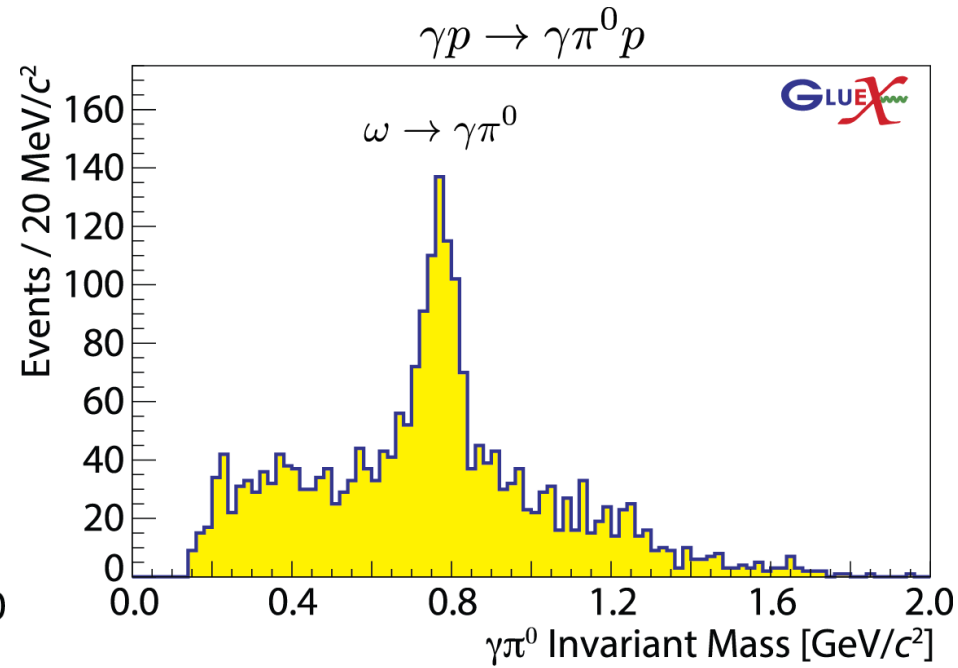
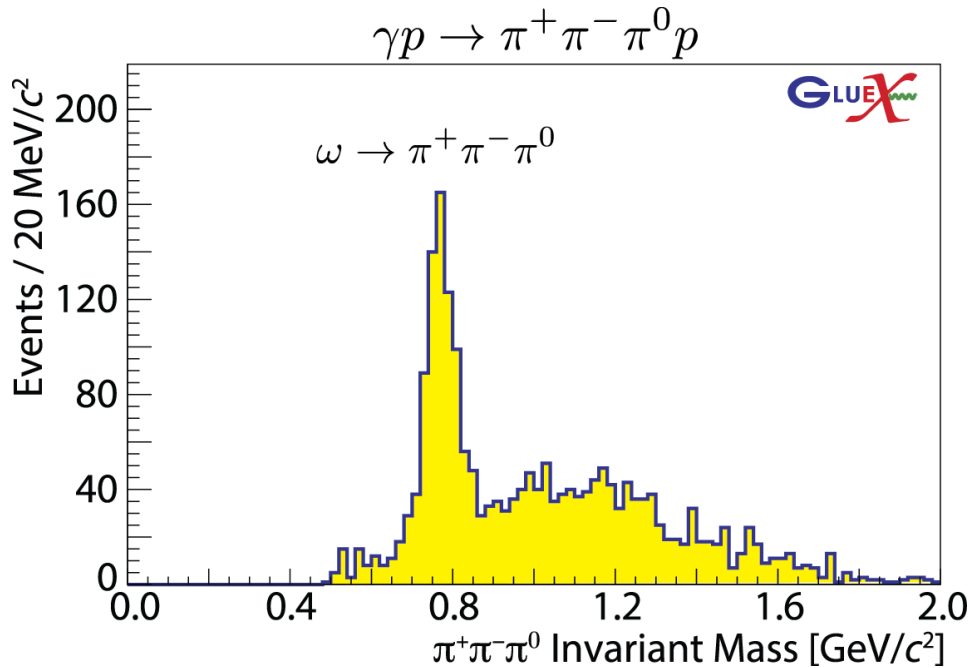


$$\gamma p \rightarrow \pi^0 \pi^0 p$$



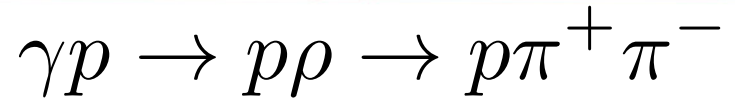
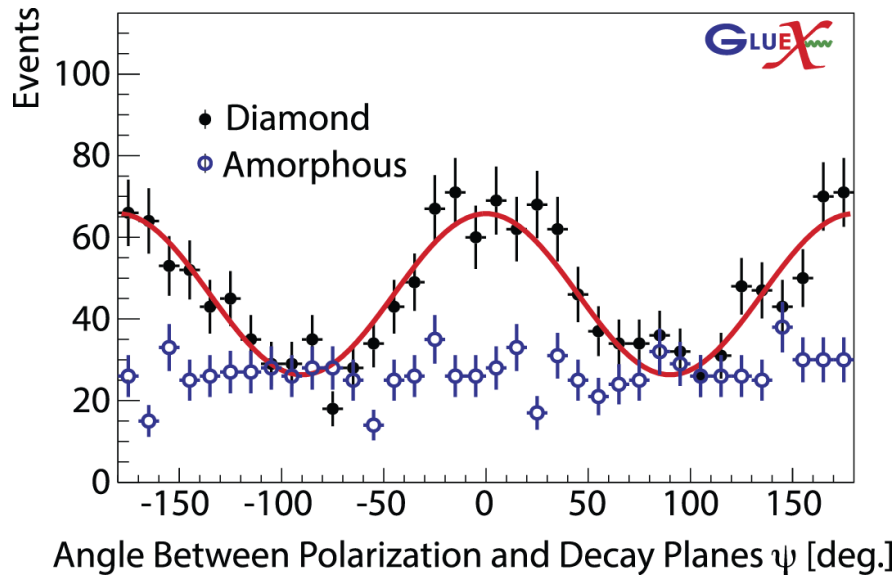
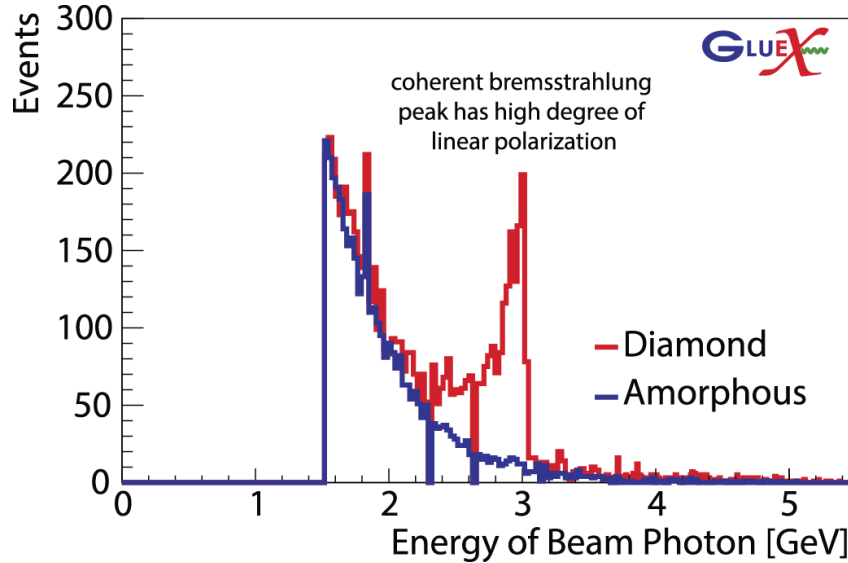
▲ ————— $\gamma p \rightarrow p \pi^0 \pi^0$ ~5%

Physics signals

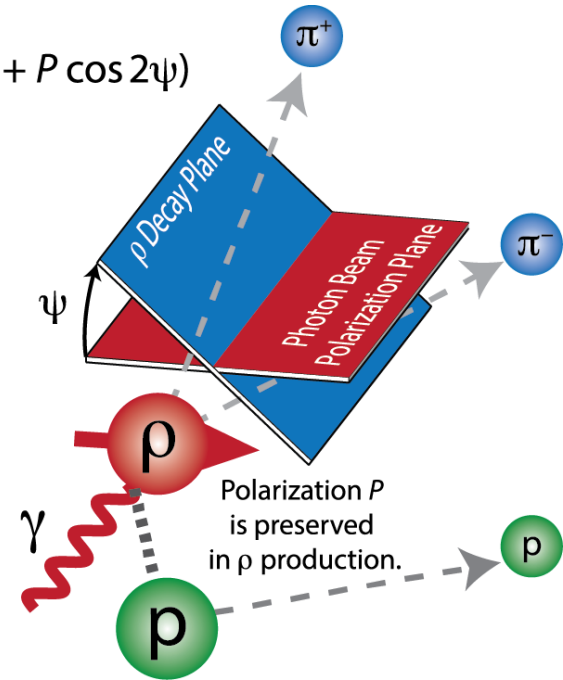


$\gamma p \rightarrow p \omega$ ~5%

Polarized ρ production



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



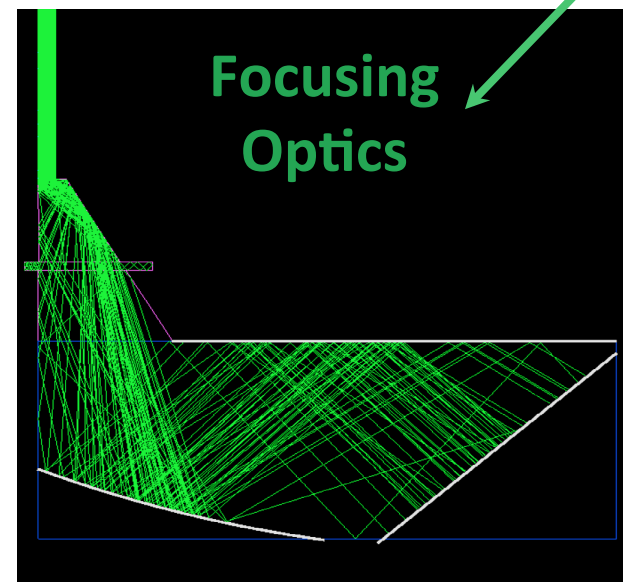
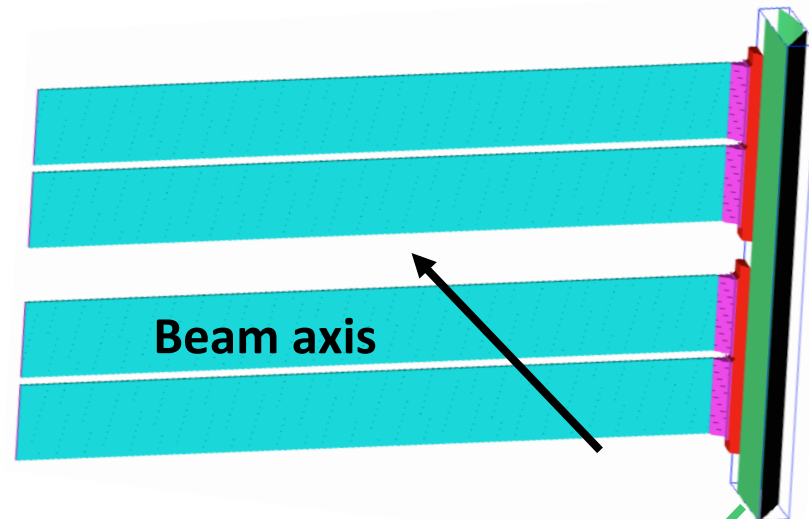
- Only a few hours of beamtime
- Fast turnaround: 2 days after run!
- Comparable to previous world data
- Preparing analysis towards paper

Future plans


- Complete baseline detector commissioning (next run):
 - Additional statistics for calorimeter calibration
 - Build, install and commission 20 μm diamonds
 - Complete commissioning of Fast Feedback system with accelerator to improve beam stability
 - Commission triplet polarimeter and total absorption counter (photon flux determination)
 - Continue trigger and DAQ optimization
- Implement high-level software trigger to minimize data footprint for future high intensity running


DIRC Cherenkov detector

- Improved π/K separation extends the physics program to study mesons and baryons containing strange quarks
- Received approval from SLAC to use BaBar DIRC components
- Implementing a compact, focusing optics system
- Synergy with CLAS12 RICH MaPMT readout and electronics
- Planning for installation in 2018



Summary

-  was designed to search for light quark hybrid mesons in a broad range of final states
- Successful commissioning runs in Fall 2014 and Spring 2015 to commission photon beamline and detector
- Many detectors near design resolutions, but additional commissioning time required
 - eg. π^0 statistics for calorimeter calibration
- Signals observed in several exclusive reactions with commissioning data
- Possible first physics data in Spring 2016
- Planned enhancements over the next few years to maximize impact of the physics program

-  Collaboration: 21 institutes, about 110 collaborators
- Hall D scientific staff: 13 staff scientists, 1 postdoctoral fellow

- Arizona State University
- University of Athens
- Carnegie Mellon University
- Catholic University
- University of Connecticut
- Florida International University
- Florida State University
- U. of Glasgow
- Indiana University
- ITEP Moscow
- Jefferson Lab

- U. of Massachusetts, Amherst
- Massachusetts Inst. of Tech.
- MEPHI
- Norfolk State University
- North Carolina A&T State
- U. of North Carolina, Wilmington
- Northwestern University
- Santa Maria University
- University of Regina
- Yerevan Physics Institute