

Hall D Report

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Hall D Group Leader

JLab PAC48, Aug 2020

Highlights Since 2016

Data taking

- GlueX-I (E12-06-102) 100% complete
- PrimeX- η (E12-10-011) 30% of total
- GlueX-II (E12-12-002) 24% of total

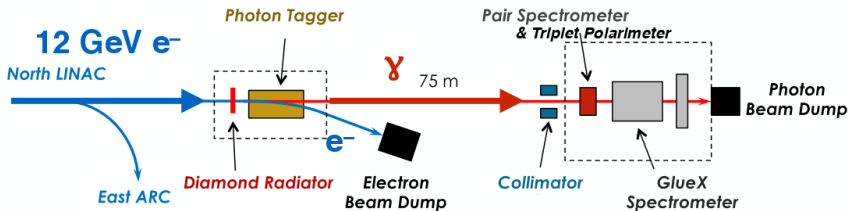
Data processing

- E12-06-102 100%
- E12-10-011 not started, doing calibration
- E12-12-002 not started, doing calibration

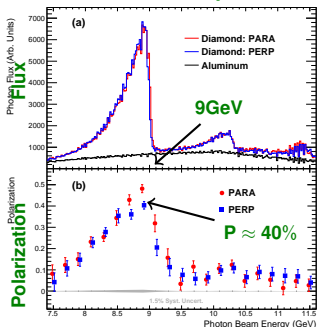
Data analysis and results

- Physics analysis of E12-06-102:
 - J/ψ : 1 PRL paper (25% of data)
 - Beam asymmetries: 3 PRC papers, 2 in preparation
 - Step by step analysis strategy: asymmetries, SDME, cross sections, PWA
- Technical papers 2016-2020: 11 in total, 5 NIMA papers, 1 submitted

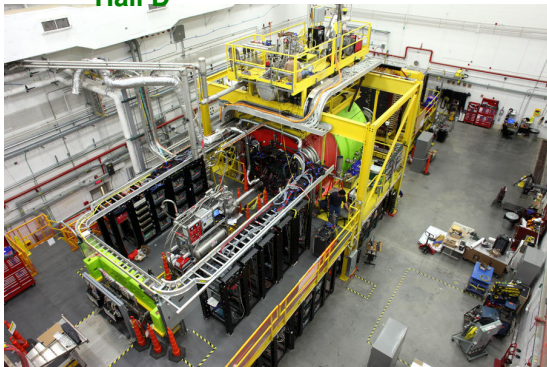
Hall D Apparatus



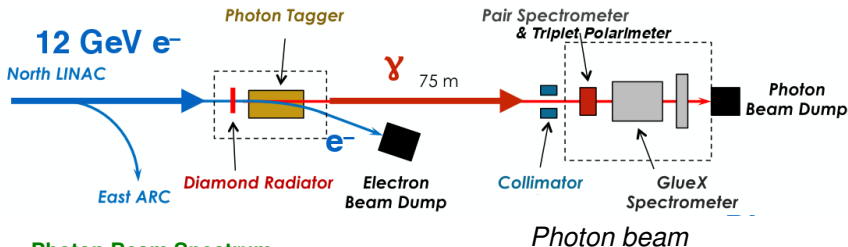
Photon Beam Spectrum



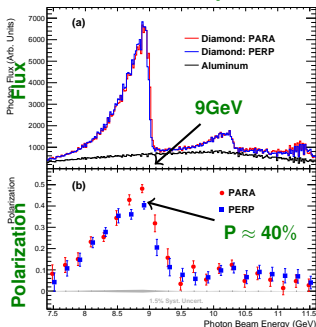
Hall D



Hall D Apparatus



Photon Beam Spectrum



- ▶ Linear polarization
- ▶ Tagging $\sigma E/E \sim 0.1\%$
- ▶ Pair Spectrometer & Triple Polarimeter

Spectrometer

- ▶ Acceptance: $1^\circ < \theta < 120^\circ$
- ▶ Resolutions: h^\pm : $\sigma_p/p \sim 1 - 3\%$
 γ : $\sigma_E/E \sim 6\%/\sqrt{E} + 2\%$
- ▶ Trigger: photoproduction at $E_{BEAM} > 7 \text{ GeV}$
In 2020: 85 kHz (signal + EM background)

The GlueX Collaboration

Arizona State, Athens, Carnegie Mellon, Catholic University, Univ. of Connecticut, Florida International, Florida State, Forschungszentrum Juelich, George Washington, Glasgow, GSI, IHEP Beijing, Indiana University, ITEP, Jefferson Lab, U. Mass. Amherst, MIT, MEPhi, Norfolk State, North Carolina A&T, Univ. North Carolina Wilmington, Northwestern, Old Dominion, Santa Maria, Tomsk, University of Regina, W&M, Wuhan, and Yerevan Physics Institute.

Over 120 collaborators from 29 institutions.

20 grad. students (10 PhDs in 2016-2020)

Hall D group: 12 staff scientists; 2 postdocs

Hall D tech group: 8

Physics Program

Proposal/ experiment	PAC rating	Title	PAC days	PAC #
✓ E12-06-102	A	Mapping the Spectrum of Light Quark Mesons and Gluonic Excitations with Linearly Polarized Photons	120	30
+ E12-10-011	A-	A Precision Measurement of the eta Radiative Decay Width via the Primakoff Effect	79	35
E12-13-003	A	An initial study of hadron decays to strange final states with GlueX in Hall D	200	40
E12-13-008	A-	Measuring the Charged Pion Polarizability in the $\gamma\gamma \rightarrow \pi^+\pi^-$ Reaction	25	40
+ E12-12-002	A	A study of meson and baryon decays to strange final states with GlueX in Hall D	220	42
E12-12-002A	A	Eta Decays with Emphasis on Rare Neutral Modes: The JLab Eta Factory(JEF) Experiment	Grp	45
E12-19-003	B+	Studying Short-Range Correlations with Real Photon Beams at GlueX	15	47

+ started

✓ complete

Accelerator schedule and runs for 2016-2021

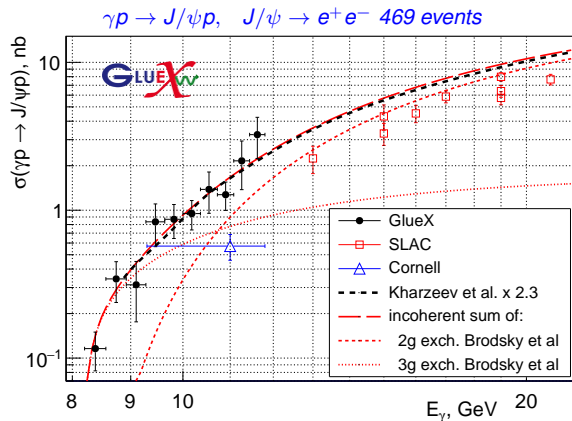
Note: the current scale used by the ENP: 1 PAC day = 2 calendar days

Year	start-end mm/dd	E_e GeV	days cal.	days PAC	ABU+ BANU	exper	Comments
<i>Past</i>							
2016	02/03-03/23	12.00	49	28	?	E12-06-102	Engineering run
2017	01/30-03/09	11.67	40	20	58%	E12-06-102	Production start
2018	01/12-03/05	11.62	52	26	52%	E12-06-102	Production
2018	03/29-05/06	11.62	38	19	58%	E12-06-102	Production
2018	09/21-11/26	11.62	66	33	53%	E12-06-102	Production to finish
2018	11/28-12/09	10.30	12	–	–	E12-10-011	Commissioning
2018	12/12-12/18	8.93	7	–	–	E12-10-011	Commissioning
2019	02/08-02/21	11.61	13	6	45%	E12-12-002	1/2 DIRC commis.
2019	02/21-03/05	11.61	15	8	52%	E12-10-011	Production start
2019	03/08-04/15	11.17	38	16	73%	E12-10-011	Production
2019	11/25-12/19	11.40	24	8	34%	E12-12-002	DIRC com.
2020	01/10-03/24	11.40	75	38	63%	E12-12-002	Production start
<i>Ongoing and Future</i>							
2020	07/27-09/06	11.40	42			E12-12-002	Production
2021	06/21-08/14	10.10	54			E12-10-011	Production
2021	08/18-10/11	10.90	54			E12-19-003	Production to finish

2020 Sep - 2021 May: *Scheduled replacement of a CHL-2K cold box*

GlueX E12-06-102 Early Results on 25% of data: J/ψ

GlueX Collaboration A. Ali et al, Phys.Rev.Lett. 123 (2019) 7, 072001 (55 cit.)



Search for LHCb pentaquarks
Evaluation of
 $BR(P_c^+ \rightarrow J/\psi p)$

JPAC model PRD 94, 034002
for $J = 3/2$, $\Gamma \leftarrow$ LHCb

all the uncertainties are included
Limits at 90% CL

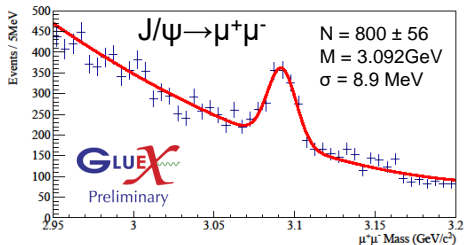
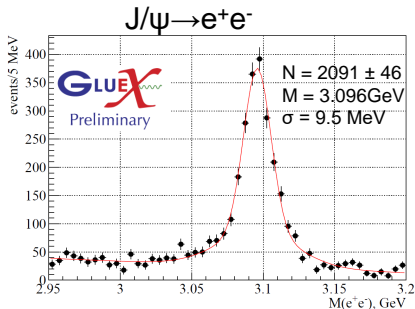
P_c	Γ, MeV	BR
$P_c(4312)$	10 ± 3	$< 4.6\%$
$P_c(4440)$	20 ± 5	$< 2.3\%$
$P_c(4457)$	6 ± 2	$< 3.8\%$

Lower than expected!

Interpretation of the results: cross section close to threshold

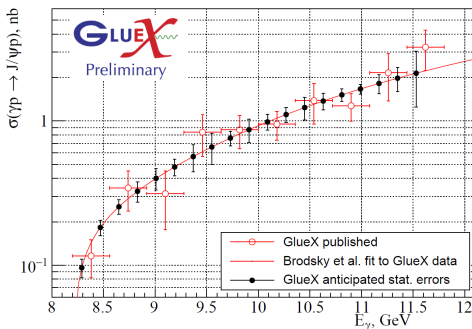
- 3-gluon exchange (no spectator in proton) dominates (*Brodsky et al PLB 498 (2002)*)
- Implies a large contribution from gluons to the proton mass via trace anomaly (*Kharzeev et al NPA 661 (1999)*, *Y.Hatta et al :1906.00894 (2019)*)

GlueX E12-06-102 full data set: J/ψ in progress



Update with full GlueX-I data set:

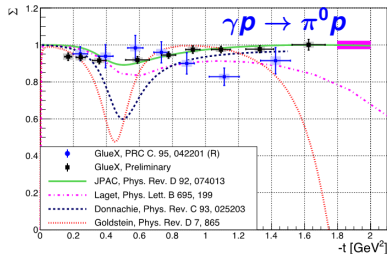
- More than 2000 events in e^+e^-
- Complementary decay to $\mu^+\mu^-$
- Detailed studies of differential cross section near threshold
- Continue search for Pentaquarks



GlueX E12-06-102: Beam Asymmetries

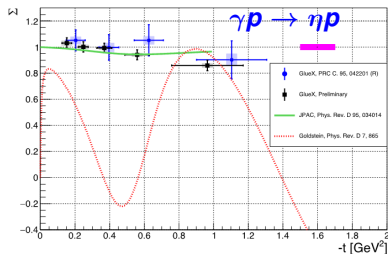
PRC 95 (2017) 4, 042201

$\pi^0 \rightarrow 2\gamma$

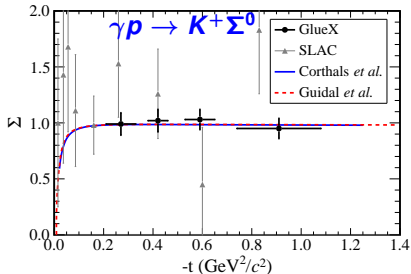


PRC 100 (2019) 5, 052201

$\eta \rightarrow 2\gamma$

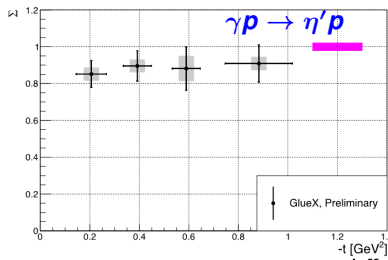


PRC 101 (2020) 6, 065206

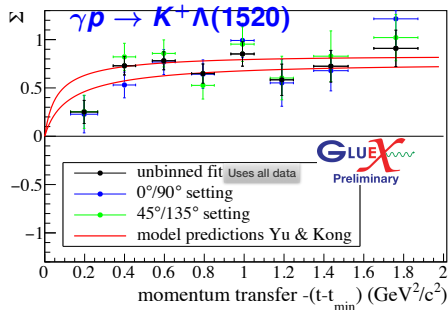
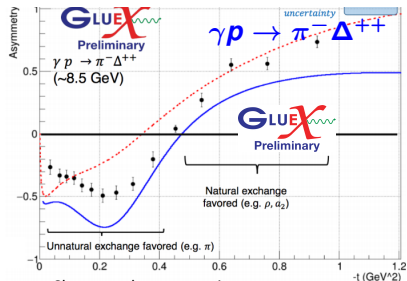


PRC 100 (2019) 5, 052201

$\eta' \rightarrow \pi^+ \pi^- \eta$



GlueX E12-06-102 in progress: Beam Asymmetries

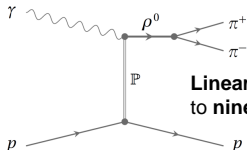


Presentation by A.Austregesilo at 2020 JLUO meeting

The Full Chain: Vector Meson SDMEs

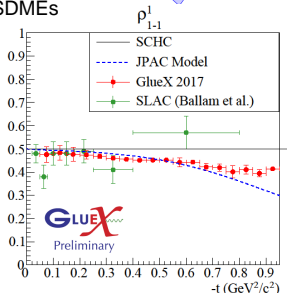
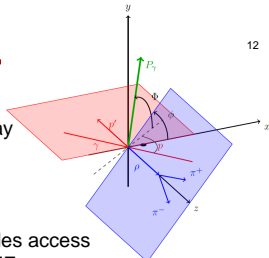
Spin-Density Matrix Elements ρ_{ij} :

Angular distribution of vector meson production and decay



Linear beam polarization provides access to **nine** linearly independent SDMEs

- High-statistics sample: orders of magnitude higher precision than previous measurements
- Good agreement with model predictions
- Used to study **acceptance** and to develop **tools** for modern amplitude analysis (GPU, machine learning)



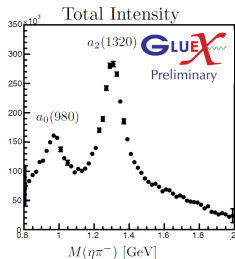
Next milestone: First Result with PWA tools

Jefferson Lab

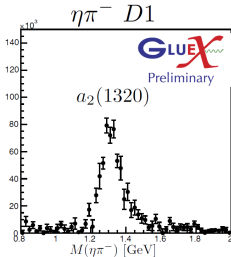
GlueX E12-06-102 in progress: first PWA probes

Presentation by A. Austregesilo at 2020 JLUO meeting

Partial-Wave Analysis of the $\eta \pi^-$ system: (C. Gleason)

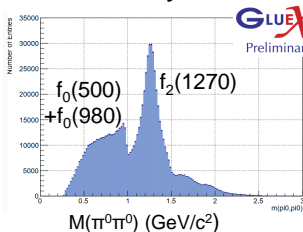


$\gamma p \rightarrow \eta \pi^- \Delta^{++}$
PWA

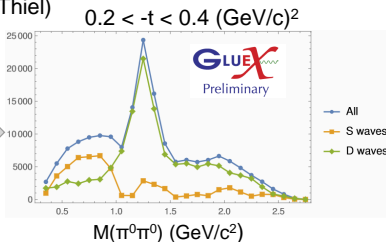


- Mass-independent
- Extraction of dominant signals
- Ongoing work

Moment Analysis of the $\pi^0\pi^0$ system: (A. Thiel)



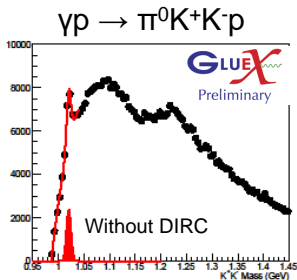
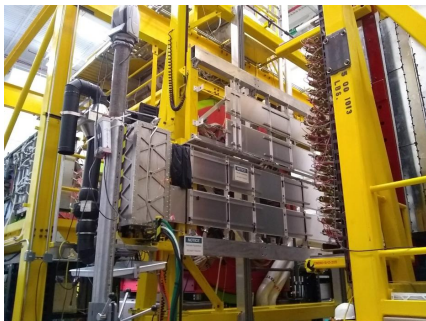
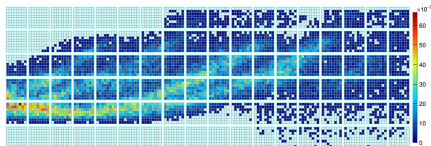
$\gamma p \rightarrow \pi^0\pi^0 p$
PWA



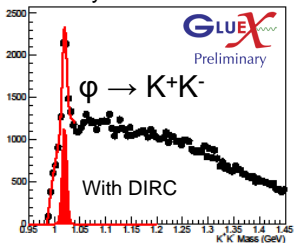
GlueX-II E12-12-002: DIRC operations

2019:

- DIRC installed and commissioned
- Cherenkov hit patterns match expectation from simulation



Preliminary DIRC Performance



2020:

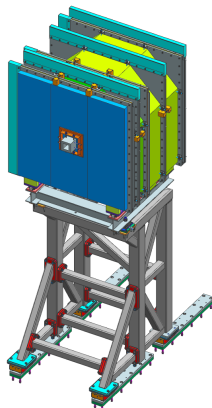
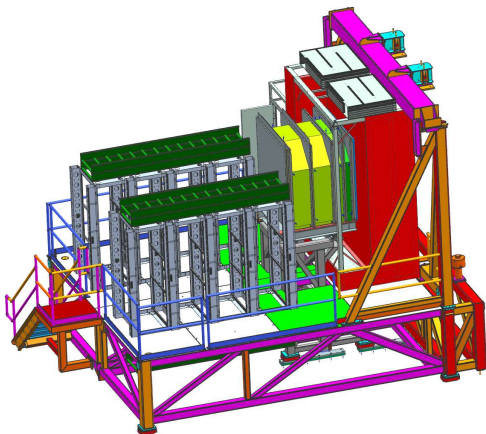
- GlueX-II with DIRC
- Completed 20% of allocated PAC days

CPP E12-13-008: preparations

Charged Pion Polarizability experiment requires a muon detector

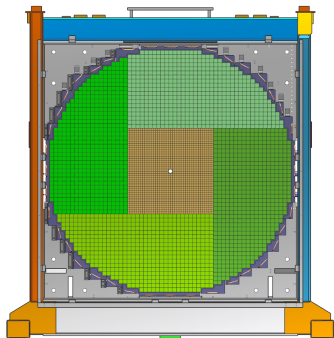
Intentions: run in 2022

- Muon detector wire chambers are been built by UMass
- Muon detector iron absorber and supporting frame designed at JLab
- Plans: build in 2021

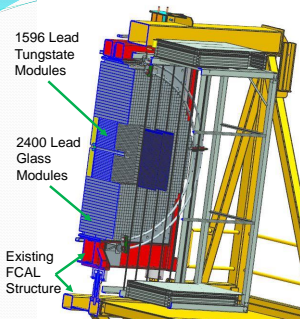


JLab Eta Factory experiment requires an upgrade of the Forward Calorimeter Insert of 40×40 PbWO₄ crystals

- Procurement of crystals, PMTs, HV, cables in progress
- Fast electronics has been procured or ordered
- Design of the frame etc. well advanced
- Design of the module done (similar to CompCal in Hall D, also NPS in Hall C)



FCAL Insert Design



- Borrowed Designer from Engineering – Keith Harding
- 40×40 (2cm) Lead Tungstate Insert
- Design of infrastructure and Modules complete
- Complete set of preliminary drawings have been produced
- All crystal module components on order
- FCAL Darkroom becomes a Refrigerator

Items needing decisions;

- Tungsten absorber size
- Monitoring Panel config.
- PMT Bases – Heat load may be 4KW.