

Hall D Report

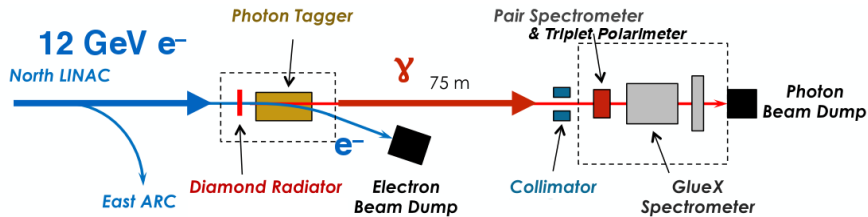
E.Chudakov

Hall D Group Leader

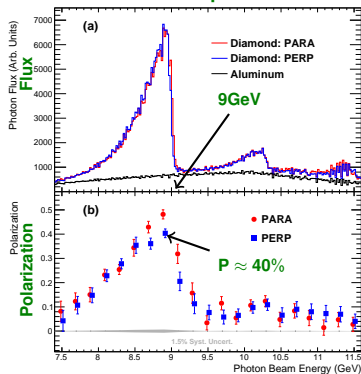
JLab PAC49, Jul 2021



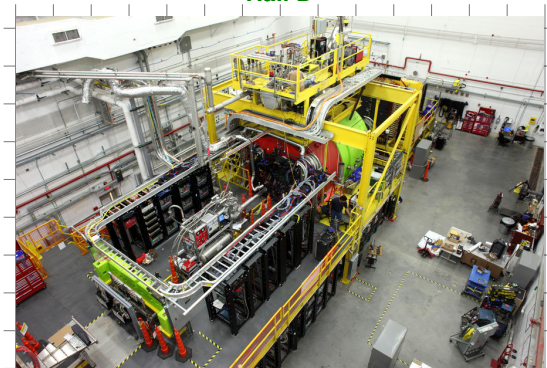
Hall D Apparatus



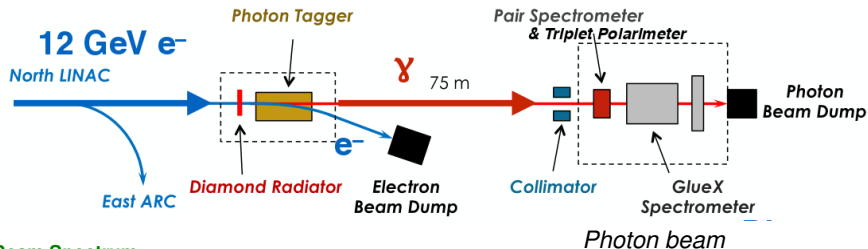
Photon Beam Spectrum



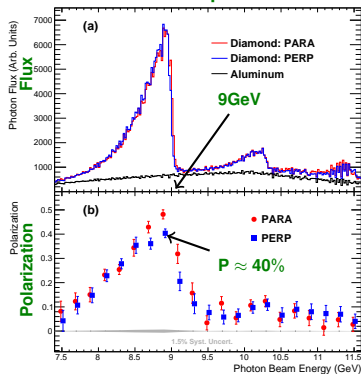
Hall D



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: all photoproduction at $E_{BEAM} > 7 \text{ GeV}$
DAQ in 2021: 85 kHz (photoproduction + EM background)

Physics Program

Experiment	Title	PAC rating	PAC days	PAC #	data taken
E12-06-102	Mapping the Spectrum of Light Quark Mesons and Gluonic Excitations with Linearly Polarized Photons	A	120	30	100%
E12-12-002	A study of meson and baryon decays to strange final states with GlueX in Hall D	A	220	42	33%
E12-13-003	An initial study of hadron decays to strange final states with GlueX in Hall D	Grp	200	40	0%
A	Eta Decays with Emphasis on Rare Neutral Modes: The JLab Eta Factory(JEF) Experiment	Grp	100	45	
E12-10-011	A Precision Measurement of the eta Radiative Decay Width via the Primakoff Effect	A-	79	35	30%
E12-13-008	Measuring the Charged Pion Polarizability in the $\gamma\gamma \rightarrow \pi^+\pi^-$ Reaction	A-	25	40	
A	Measuring the neutral pion polarizability	Grp		48	
E12-19-003	Studying Short-Range Correlations with Real Photon Beams at GlueX	B+	15	47	
E12-19-001	Strange Hadron Spectroscopy with Secondary KL Beam in Hall D	A-	200	48	
E12-20-011	Measurement of the high-energy contribution to the Gerasimov-Drell-Hearn sum rule	A-	33	48	

+ started
 ✓ complete

Accelerator schedule and runs for 2016-2022

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	01/10-05/06	11.40	75	38	63%	E12-12-002	Production start
2020	07/27-09/21	11.40	56	21	46%	E12-12-002	Production
<i>Future, established</i>							
2021	08/23-10/16	10.10	54			E12-10-011	Production
2021	10/20-12/13	10.90	52			E12-19-003	Production to finish
2022	05/02-06/20	11.70	50			E12-13-008	Production to finish
2022	06/28-08/22	11.70	55			E12-10-011	Production to finish
2022	08/27-11/26	11.70	<93			E12-12-002	Production up to 92 days
2023							<i>Plan: FCAL2 installation</i>

GlueX Collaboration

- 140 participants from 30 institutions from 12 countries
- Currently 16 graduate students
- 17 PhDs since 2016

KLF Collaboration

- 200 participants from 68 institutions from 19 countries
- Partly overlapping with GlueX

SRC group

- 30 post-bachelor researchers + a part of the GlueX collaboration
- 3 graduate students + 1 postdoc (dedicated to Hall D SRC)

Hall D staff

- 12 staff scientists + 1 hiring
- 2 postdocs
- 8 engineering and technical group

Data taking

- GlueX-I (E12-06-102) 100% complete
- PrimeX- η (E12-10-011) 30% of total
- GlueX-II (E12-12-002) 33% of total

Data processing

- ▶ E12-06-102 100%
- ▶ E12-10-011 2019 data 100%
- ▶ E12-12-002 2020 spring data 100%, 2019 fall data started

Data analysis and results

- Physics analysis of E12-06-102 data:
 - J/ψ : 1 PRL paper (2019, 25% of data): 90 citations - Plenty of interest
 - Beam asymmetries: 4 PRC papers, 1 close to submission
 - Talks since PAC48: 37 at APS DNP meetings, 11 at other conferences and workshops
 - Step by step analysis strategy: asymmetries, SDME, cross sections, PWA
- Technical papers: 24 NIMA publications in total; 2021 - NIMA General Paper on the GlueX spectrometer

Reviews

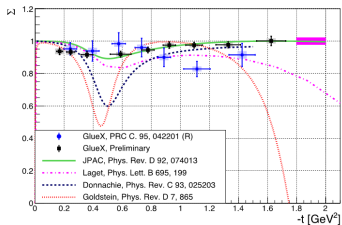
- 2021 March 25-26: Review of GlueX progress in search for hybrids
- 2021 May 18 : DOE Science and technology review

GlueX E12-06-102 Published results: Beam Asymmetries

PRC 95 (2017) 4, 042201

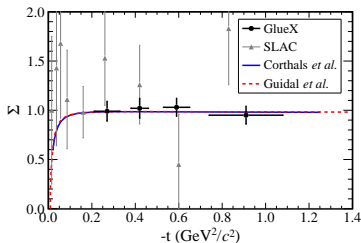
$$\gamma p \rightarrow \pi^0 p$$

$$\pi^0 \rightarrow 2\gamma$$



PRC 101 (2020) 6, 065206

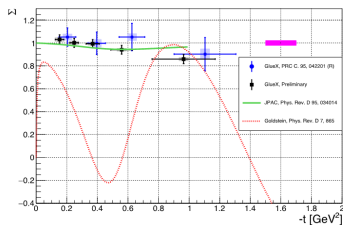
$$\gamma p \rightarrow K^+ \Sigma^0$$



PRC 100 (2019) 5, 052201

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

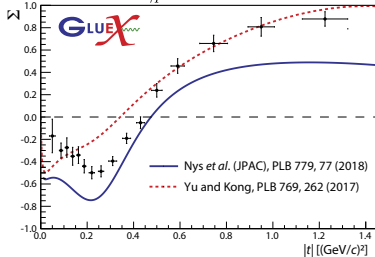
$$\eta \rightarrow 2\gamma$$



PRC 103 (2021) 5, L02201

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

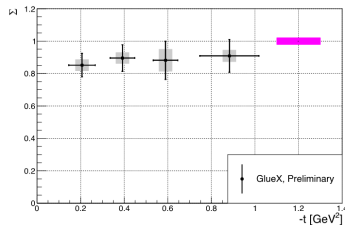
$$\tilde{\gamma} p \rightarrow \pi^- \Delta^{++}$$



PRC 100 (2019) 5, 052201

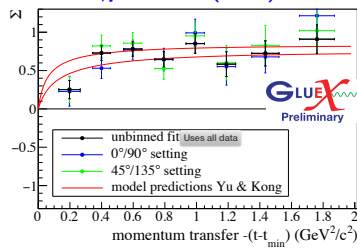
$$\gamma p \rightarrow \eta' p$$

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



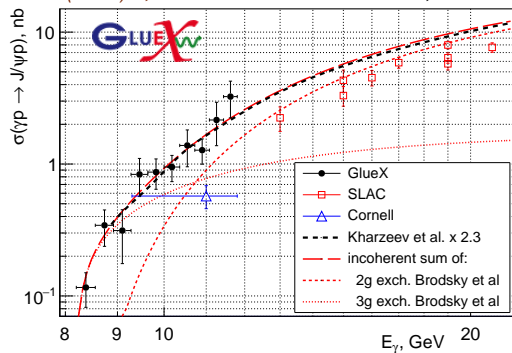
In preparation $\Sigma + \text{SDME}$

$$\gamma p \rightarrow K^+ \Lambda(1520)$$

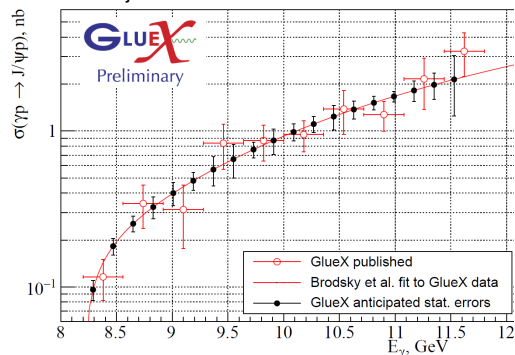


GlueX E12-06-102: J/ψ production

PRL 123 (2019) 7, 072001 25% of GlueX-I data, 90 citations

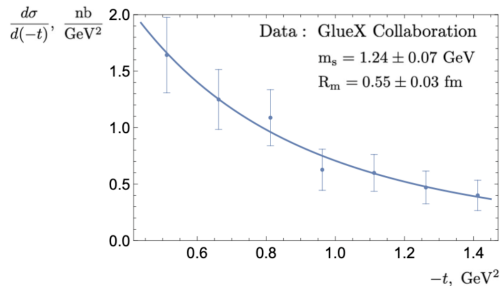


Projection to 100% of GlueX-I data

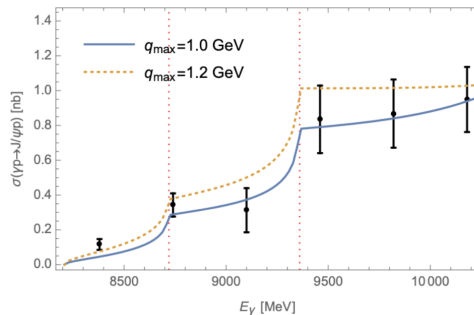


Theoretical interest to the cross section close to threshold

Kharzeev arXiv:2102.00110 (2021)



Du et al EPJC 80, 1053 (2020)



Mass radius: $R_M = 0.55 \pm 0.03 \text{ fm}$
 Charge radius: $R_C = 0.8409 \pm 0.0004 \text{ fm}$
 More data close to threshold is needed

Calculated cross section energy dependence
 including open charm loops
 Higher precision data are needed

First measurements often cause a considerable interest!

Review GlueX: review the progress in the search for hybrids

March 25-26

Presentations

- 1 Introduction to GlueX (*M. Shepherd*)
- 2 The GlueX Data Analysis Framework (*S. Dobbs*)
- 3 Measurement of Vector Meson SDMEs (*A. Austregesilo*)
- 4 Analysis of $\eta\pi$ and $\eta'\pi$ (*M. Albrecht*)
- 5 Analysis of $\omega\pi$ (*J. Stevens*)
- 6 Summary and Other Opportunities (*C. Meyer*)

Review

Jim Napolitano (chair) + 6 reviewers

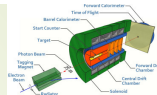
Curtis Meyer



Search for π_1 in $\eta\pi$ and $\eta'\pi$

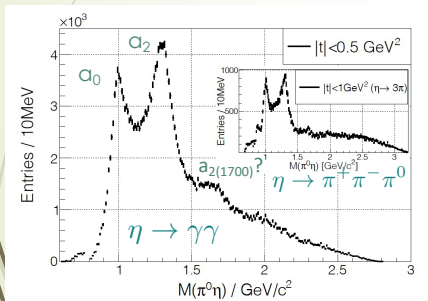
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Theory collaboration on amplitudes: $Z_l^m(\Omega, \Phi) = Y_l^m(\Omega) e^{-i\Phi}$

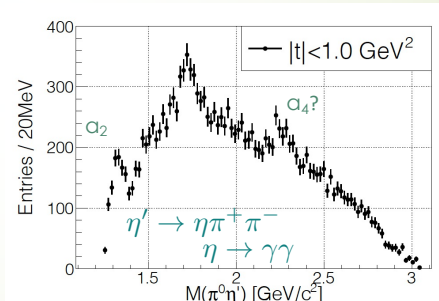


- Basis for all two-pseudoscalar work.
- Amplitude analysis in progress.
- Also doing moment analysis.

$$I(\Omega, \Phi) = 2\kappa \sum_k \left\{ (1 - P_\gamma) \left| \sum_{\ell, m} [\ell]_{m; k}^{(-)} \text{Re}[Z_\ell^m(\Omega, \Phi)] \right|^2 + (1 - P_\gamma) \left| \sum_{\ell, m} [\ell]_{m; k}^{(+)} \text{Im}[Z_\ell^m(\Omega, \Phi)] \right|^2 + (1 + P_\gamma) \left| \sum_{\ell, m} [\ell]_{m; k}^{(+)} \text{Re}[Z_\ell^m(\Omega, \Phi)] \right|^2 + (1 + P_\gamma) \left| \sum_{\ell, m} [\ell]_{m; k}^{(-)} \text{Im}[Z_\ell^m(\Omega, \Phi)] \right|^2 \right\}$$



Exotic Review

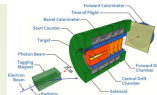


3/26/21

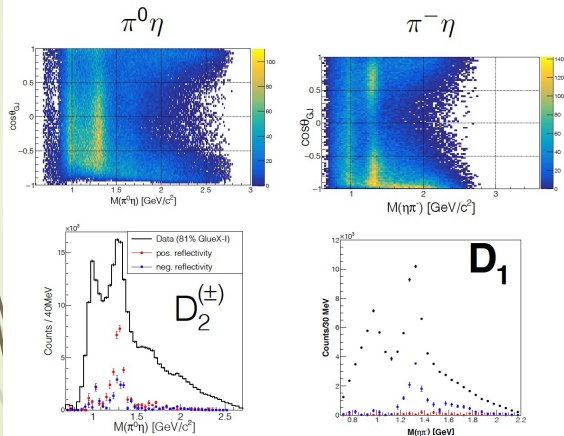
Curtis Meyer



The $a_2(1320)$ in $\eta\pi^0$ and $\eta\pi^-$



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- Neutral $a_2(1320)$ is produced dominantly in the $m=2$ wave in mostly positive reflectivity.
 - Consistent with $\gamma\gamma$ production.
- Charged $a_2(1320)$ is produced dominantly in the negative reflectivity, $m=1$ wave.
 - Expected from π exchange.

3/26/21

Charge Questions

1. Has the collaboration completed adequate data reconstruction with sufficient quality checks to produce event distributions that are ready for a higher level analysis relevant to the search for exotic hybrid mesons? **Yes**
2. Does the collaboration have a sufficient understanding of the properties of the GlueX detector? **Yes**
3. Does the collaboration have an adequate plan to complete the higher level analysis of the data for exotic hybrid mesons in a timely fashion? What is the realistic time scale?
The contributions of non-resonant processes are not presently understood, which makes the time scale uncertain.
4. Has the collaboration efficiently organized their efforts to produce timely results?
The collaboration has plans for producing a series of publications over the next 1-2 years.
5. Can you identify opportunities for improvement in the analysis effort to facilitate the production of publishable results? **It would help to add additional experienced research staff with analysis skills and software expertise to the PWA effort.**

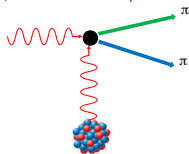
A number of comments, generally positive, and a recommendation to have annual reviews.

S&T Review: Particular concern with the theoretical support

ERR for CPP/NPP E12-13-008: Polarizability of π^+ and π^0

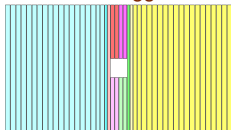
Primakoff

$$\gamma Z \rightarrow \pi^+ \pi^- / \pi^0 \pi^0$$



BG: $e^+e^- \mu^+\mu^-$

New TOF trigger: Hai

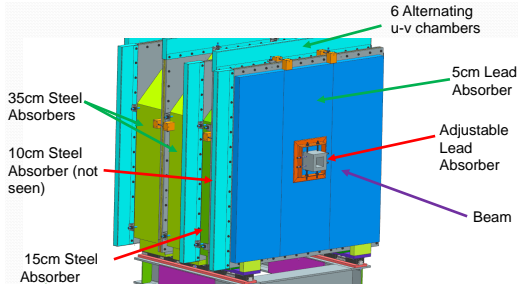


UMass MWPC delivered



June 2021: to be tested in EEL

Muon detector Fe/MWPC



Recommendations

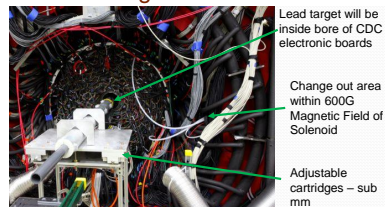
- **MWPC:** HV plateau; efficiency (cosmics);
 - **Trigger:** Details for the rate (30 kHz)
 - **Analysis:** μ/π separation; softw.; timeline for results
- Response from the experiment submitted*

Still active recommendations

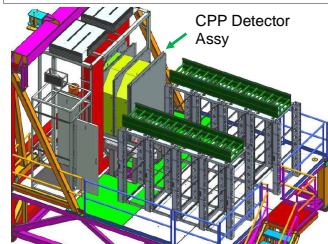
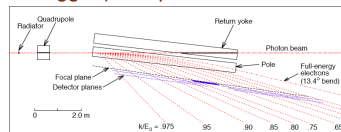
- **MWPC:** Demonstrate the accuracy of the efficiency evaluation and its impact on the physics results

Manufacturing/installation in progress

Pb target from PRIMEX



Tagger μ -scope shift to 6 GeV

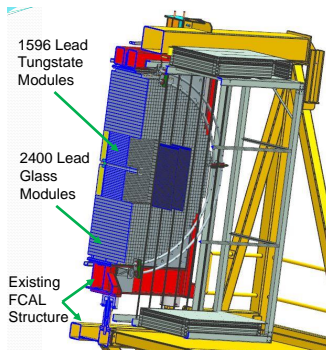
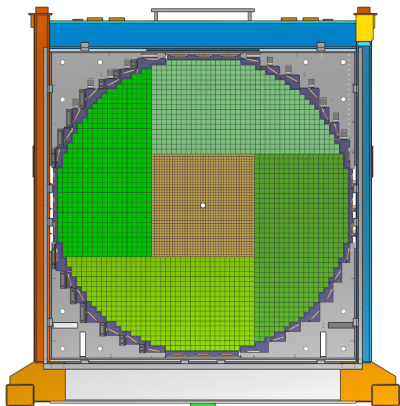


JEF E12-12-002A: status of PbWO₄ FCAL insert

item	#	ordered	delivered	completion budget
crystals	1600	1004	64+132+160=356	FY21 + ?
PMT	1600	500	500	FY21 + ?
FADC, crates	1200	1200	about all	
HV channels	1600	1600	0	
module components	1600	part	part	FY21-22
signal cables	1200	1200 part	part	building
HV cables	1200	1200 ?	0	building

VXS Crates

Signal Cable



- Borrowed Designer from Engineering – Keith Harding
- 40x40 (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.

- Installation in 2023: 0.8 - 1.0 year

Scheduling Outlook

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Activity, experiment running	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	scheduled									
Run PRIMEX- η	■	■								
Run SRC		■								
Installation CPP		■								
Run CPP-NPP		■								
Run GlueX-II			■							
Installation FCAL2			■	■						
Run GlueX-II+JEF				■	■					
Installation KLF (K_L beam)					■	■				
Commissioning, Run KLF						■	■	■		
Back to photon beam								■	■	
Installation of REGGE									■	
Commissioning, Run REGGE										■

- Assumed 25 weeks/year for Hall D running
- Assumed timely budgeting for KLF and REGGE
- Assumed timely construction of JEF,KLF,GDH

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