Hall D Report

E.Chudakov

Hall D Group Leader

JLab PAC47, July 2019

Highlights Since July 2017

Data taking

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

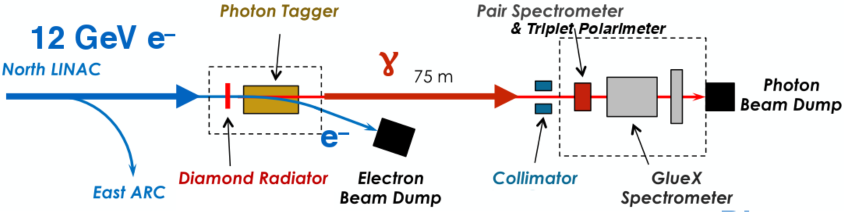
Data processing

- E12-06-102 70%
- E12-10-011 not started, doing calibration

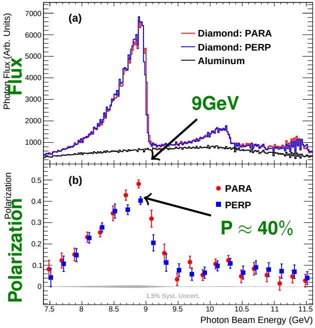
Physics analysis

- E12-06-102 25% of all data
  - J/ψ paper accepted by PRL *arXiv:1905.10811 May 2019*
  - 3 papers on beam asymmetries are in progress
  - Progress in understanding efficiencies and acceptance
  - Technical papers: *Start Counter, NIMA 297 (2019)*

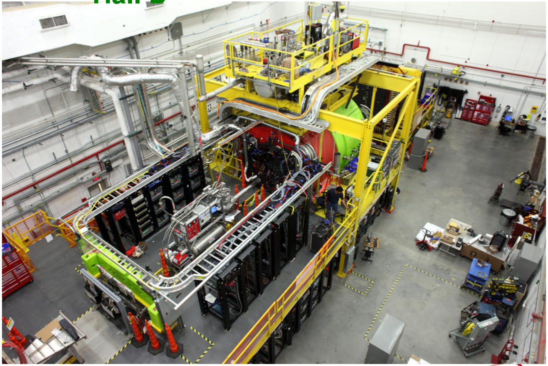
Hall D Apparatus



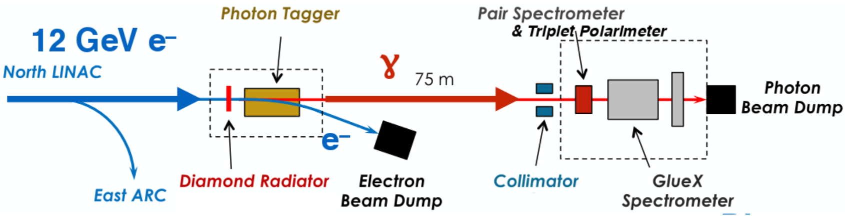
Photon Beam Spectrum



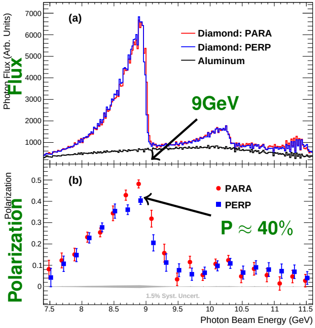
Hall D



Hall D Apparatus



Photon Beam Spectrum



Photon beam

- 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 $E_{BEAM} > 7$ GeV
  in 2017: 55 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 (3 PhDs in 2018-2019)

Hall D group: 12 (+1 in 2019) scientists; 2 postdocs
Hall D tech group: 7 (+1 in 2019)

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

Physics Program

Established schedule

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 $\gamma\gamma \to \pi^+\pi^-$ 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

Physics Program

Established schedule

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 2019 Spring – of the eta Radia- tiv makoff 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 $\gamma\gamma \to \pi^+\pi^-$ 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

Physics Program

Established schedule

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 … of the eta Radia- tiv … makoff Effect	79	35
E12-13-003	A	An initial study of hadron decays to strange fin…	200	40
E12-13-008	A-	Measuring the Charged Pion Polarizability in the $\gamma\gamma \to \pi^+\pi^-$ 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

2019 Spring –

2019 Fall, 2020 Spring –

Physics Program

Established schedule

Intention

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 … of the eta Radia- tiv… makoff Effect	79	35
E12-13-003	A	An initial study of hadron decays to strange fin…	200	40
E12-13-008	A-	Measuring the Charged Pion Polarizability in th…	25	40
E12-12-002	A	A … aryon 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

2019 Spring –

2019 Fall, 2020 Spring –

2021 Spring ?

Accelerator schedule and runs for 2016-2020

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
					Past		
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
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
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
2019	03/08-04/15	11.17	38	16	73%	E12-10-011	Production

Accelerator schedule and runs for 2016-2020

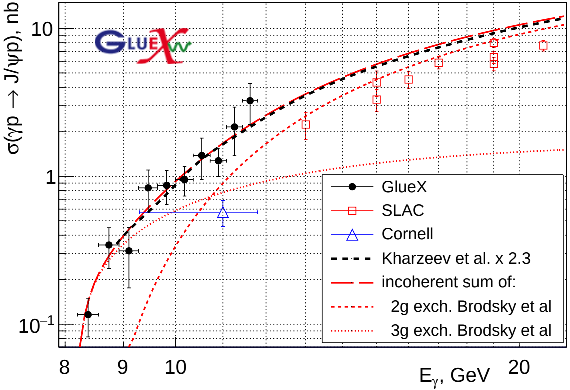
Note: *the current scale used by the ENP: 1 PAC day = 2 calendar days*

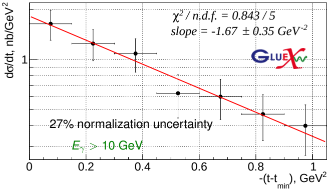
Year	start-end mm/dd	E_e GeV	days cal.	days PAC	ABU+ BANU	exper	Comments
					Past		
2016	02/03-03/23	12.00	49	28	?	E12-06-102	Engineering run
2017	01/30-03/09	11.67	40	20	58%	E12-06-102	Production
2018	01/12-03/05	11.62	52	26	52%	E12-06-102	Production
2018	03/29-05/06	11.62	38	19	58%	E12-06-102	Production
2018	09/21-11/26	11.62	66	33	53%	E12-06-102	Production
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
2019	03/08-04/15	11.17	38	16	73%	E12-10-011	Production
					Future		
2019	11/01-12/19	11.60	49			E12-12-002	DIRC com./Production
2020	02/12-05/01	11.60	79			E12-12-002	Production

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

GlueX E12-06-102 Early Results: J/ψ

GlueX Collaboration A. Ali et al,arXiv:1905.10811 May 2019 (6 cit.), accepted by PRL





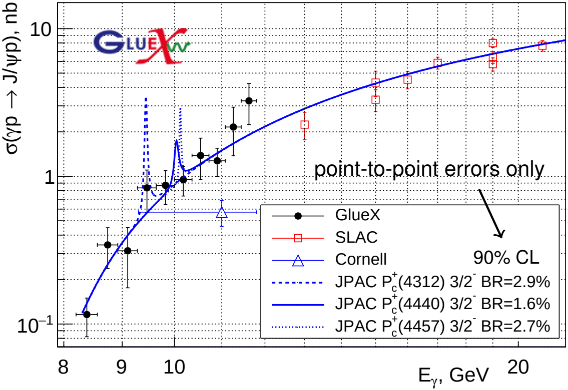
1-st measurement close to threshold
Cross section larger than expected from earlier results

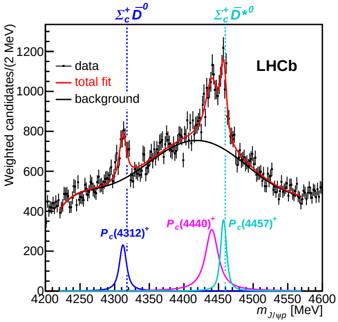
Interpretation of the results

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

GlueX E12-06-102 Early Results: J/ψ

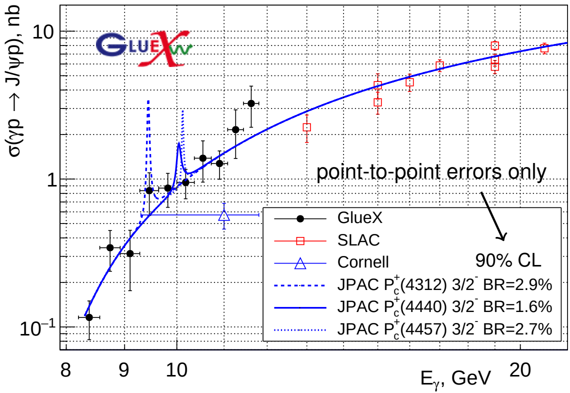
GlueX Collaboration A. Ali et al,arXiv:1905.10811 May 2019 (6 cit.), accepted by PRL





GlueX E12-06-102 Early Results: J/ψ

GlueX Collaboration A. Ali et al,arXiv:1905.10811 May 2019 (6 cit.), accepted by PRL



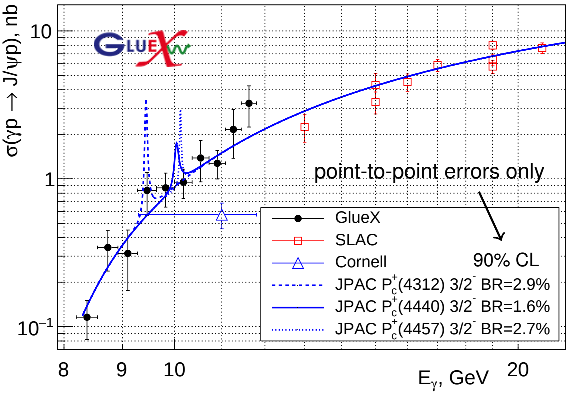
Evaluation of $BR(P_c^+ \to J/\psi p)$

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	$< 3.8\%$

GlueX Collaboration A. Ali et al,arXiv:1905.10811 May 2019 (6 cit.), accepted by PRL



model	Ref.	$BR(J/\psi p)$
hadrocharm.	*Eides 1904.11616*	25-70%
molecule	*Guo PLB 793*	50-80%
molecule	*Eides PRD 98*	0.1%
diquarks	*Ali PLB 793*	small

Evaluation of $BR(P_c^+ \to J/\psi p)$

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

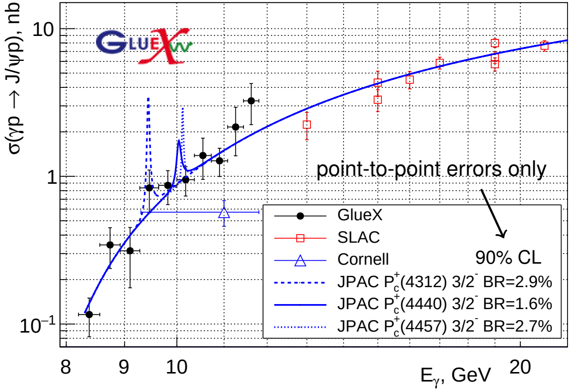
all the uncertainties are included
Limits at 90% CL

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!

GlueX E12-06-102 Early Results: J/ψ

GlueX Collaboration A. Ali et al,arXiv:1905.10811 May 2019 (6 cit.), accepted by PRL



model	Ref.	$BR(J/\psi p)$
hadrocharm.	*Eides 1904.11616*	25-70%
molecule	*Guo PLB 793*	50-80%
molecule	*Eides PRD 98*	0.1%
diquarks	*Ali PLB 793*	small

Evaluation of $BR(P_c^+ \rightarrow J/\psi p)$

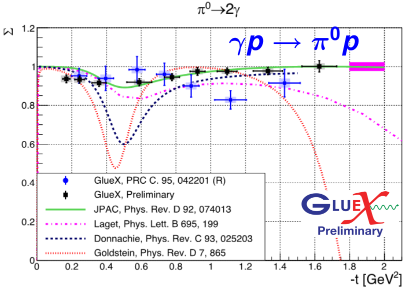
JPAC model *PRD 94, 034002*
for $J = 3/2$, $\Gamma \Leftarrow$ LHCb
all the uncertainties are included
Limits at 90% CL

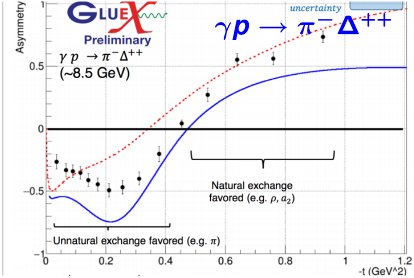
P_c	Γ,MeV	BR
$P_c(4312)$	10 ± 3	$< 4.6\%$
$P_c(4440)$	20 ± 5	$< 2.3\%$
$P_c(4457)$	6 ± 2	$< 3.8\%$

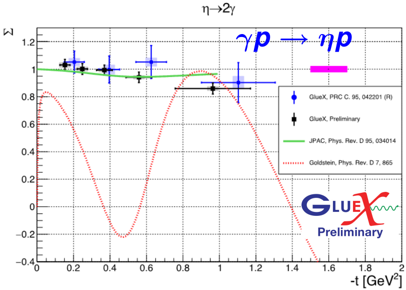
Interpretation

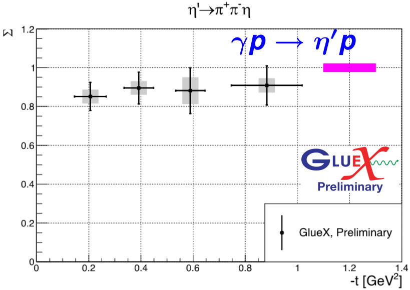
- *Wang 1906.04044* suppress photoproduction
- Diquarks?
- Triangular diagrams

GlueX E12-06-102 in progress: Beam Asymmetries









GlueX E12-06-102 analysis: Path Forward

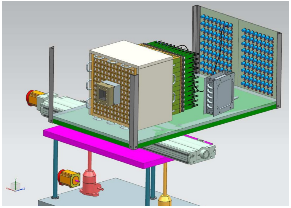
- Beam asymmetries of various reactions
- Understanding of the acceptance and efficiencies: in progress
- PWA application: in progress
- Search for hybrids
  - Starting at 70% of the full statistics
  - Start with looking for the lowest predicted multiplet
    $1^{-+}: \ \pi_1, \ \eta_1, \ \eta_1'$
  - Try 2-body decays first ($\eta\pi, \eta'\pi$)

PRIMEX-η E12-10-011 Status

New equipment:

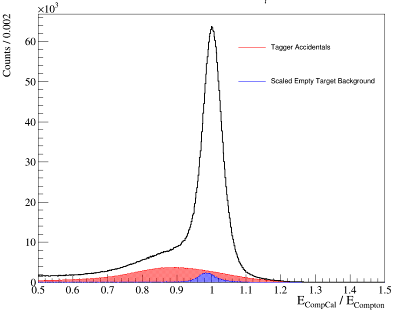
- ComCal to detect Compton scattering
  140 PbWO crystals
- Liquid He target, Be target

30% of data taking complete

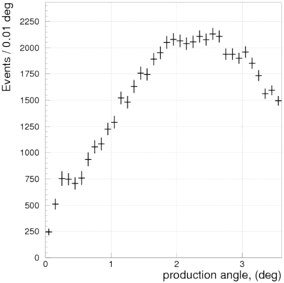


Very preliminary

Compton scattering



Primakoff η

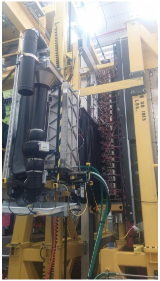


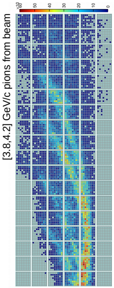
Jefferson Lab

Hardware for next experiments

DIRC

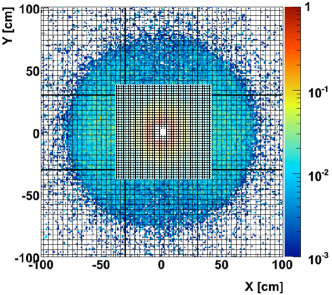
- Required for GlueX-II
- 4 “bar-boxes” from BaBar + new readout
- Readiness: 1/2 commissioned
  full commissioning in Nov 2019





FCAL insert

- Required by JEF experiment
- Central area $\sim 80\times80$ cm^2
  1200-1600 crystals PbWO (700 ordered)
- Expected improvement:
  - Radiation hardness
  - Resolution - twice better
- Timescale: 3 years



Jefferson Lab