

Hall B Run Group Addition

Volker D. Burkert
Jefferson Lab



JLab PAC46 Meeting 07/18/2018

PAC46 – Hall B proposals/LOI

<u>Proposals</u>		<u>Contact</u>	<u>Days</u>
<u>New RG Proposal RG-M</u>			
C12-17-006	Electrons for Neutrinos	Hen	25.5
PR12-18-003	Exclusive Studies of SRC in Nuclei using CLAS12	Hen	35
Total Beam Time requested when run as RG		Hen	46.5
<u>RG-B Addition</u>			
P12-12-003B	J/Psi Photoproduction off the Deuteron	Ilieva	(80)
Total RG-B beam time remains unchanged		Niccolai	90
LOI12–18-004	Physics with Positron Beams at JLab 12 GeV	Grames	
(Hall A, B, C)	Hall B: DVCS & 2 γ -physics in e ⁺ p/e ⁻ p elastic	Voutier	N/A
<u>New beam time requested for Hall B Proposals:</u>			46.5

Run Groups A & B

Proposal	Physics	Contact	Rating	Days	Group	Equipment	Energy	Run Group	Target
E12-06-108	Hard exclusive electro-production of π^0, η	Stoler	B	80	139	RICH (1 sector) Forward tagger	11	A L. Elouadrhiri F. Sabatié	liquid H ₂
E12-06-108A	Exclusive N*->KY Studies with CLAS12	Carman		(60)					
E12-06-108B	Transition Form Factor of the η' Meson with CLAS12	Kunkel		(80)					
E12-06-112	Proton's quark dynamics in SIDIS pion production	Avakian	A	60					
E12-06-112A	SIDIS Λ production in target fragmentation region	Mirazita		(60)					
E12-06-112B	Colinear nucleon structure at twist-3	Pisano		(60)					
E12-06-119(a)	Deeply Virtual Compton Scattering	Sabatie	A	80					
E12-09-003	Excitation of nucleon resonances at high Q ²	Gothe	B+	40					
E12-11-005	Hadron spectroscopy with forward tagger	Battaglieri	A-	119					
E12-11-005A	Photoproduction of the very strangest baryon	Guo		(120)					
E12-12-001	Timelike Compton Scatt. & J/ ψ production in e+e	Nadel-Turonski	A-	120					
E12-12-001A	J/ ψ Photoproduction & study of LHCb pentaquarks	Stepanyan		(120)					
E12-12-007	Exclusive ϕ meson electroproduction with CLAS12	Girod	B+	60					
E12-07-104	Neutron magnetic form factor	Gilfoyle	A-	30	90	Neutron detector RICH (1 sector) Forward tagger	11	B S. Niccolai	liquid D ₂ target
E12-09-007(a)	Study of partonic distributions in SIDIS kaon production	Hafidi	A-	30					
E12-09-008	Boer-Mulders asymmetry in K SIDIS w/ H and D targets	Contalbrigo	A-	56					
E12-09-008A	Hadron production in target fragmentation region	Mirazita		(60)					
E12-09-008B	Colinear nucleon structure at twist-3	Pisano		(60)					
E12-11-003	DVCS on neutron target	Niccolai	A	90					
E12-11-003A	In medium structure functions, SRC, and the EMC effect	Hen		(90)					
E12-11-003B	J/Psi Photoproduction off the Deuteron	Ilieva		(80)					
Beam time partial sum				765 (1555)					

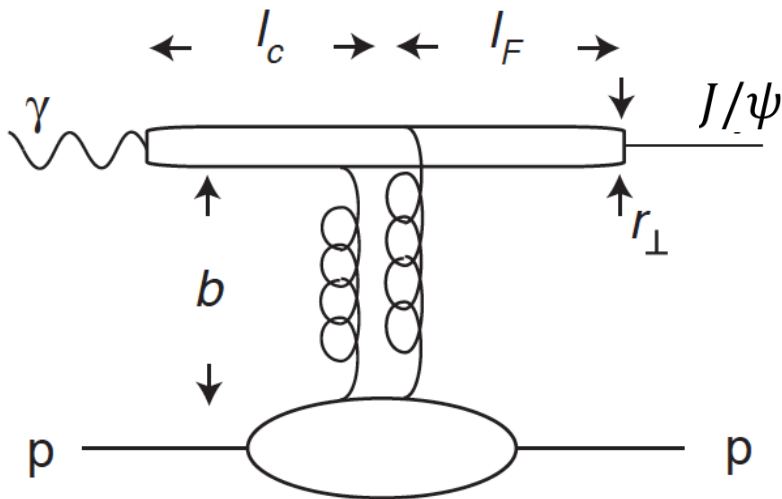
Study of J/ψ Photoproduction off Deuteron

PR12-11-003B

M.D. Baker, A. Freese, L. Guo, Ch. Hyde, Y. Ilieva, B. McKinnon, P. Nadel-Turonski, M. Sargsian, V. Kubarovsky, S. Stepanyan, N. Zachariou, Zh.W. Zhao

Near Threshold J/ψ Production off Deuteron

Why J/ψ ?



S.J. Brodsky, E. Chudakov, P. Hoyer, J.M. Laget, Phys. Lett. B 498, 23 (2001).

- Small transverse size: $r_{\perp} \sim 1/m_c = 0.13$ fm
- $E_{\text{thr}} = 8.2$ GeV, $l_c \approx 2E_{\gamma}^{\text{lab}}/4m_c^2 = 0.36$ fm
- At threshold, large $|t_{\text{min}}| = 2.2$ (GeV/c)²
- At threshold, small $b \sim 1/|t|^{1/2} = 0.2$ fm
- The $c\bar{c}$ couples to the gluon field in the target. Process dominated by multi-gluon exchange. Concept of gluonic Van der Waals potential in QCD.
- J/ψ production probes the short-range, gluon structure of the target.

Near-Threshold J/ψ Production off Deuteron

Incoherent Photoproduction: $J/\psi N$ FSI

Features of the QCD Van Der Waals Potential:

- dominates low-energy $J/\psi N$ scattering
- attractive (possible J/ψ -nuclear bound states)

$\sigma_{J/\psi N}$ is a relevant quantity to test first-principle predictions for the QCD Van Der Waals interaction and J/ψ -nuclear bound states

Incoherent Photoproduction provides **direct access (no VMD)** to $J/\psi N \rightarrow J/\psi N$ and the elementary $J/\psi N$ total cross section. **Low-energy $\sigma_{J/\psi N}$ is poorly known:**

- High-energy data only (large uncertainties for low-energy extrapolations)
 $\sigma_{J/\psi N} < 1$ mb (from VMD to inclusive J/ψ off Be, $E_\gamma = 80 - 230$ GeV)
 $\sigma_{J/\psi N} \sim 3.5$ mb (from A dependence of nuclear absorption, $E_\gamma = 20$ GeV).
- Theoretical predictions (first-principle calculations)
 $\sigma_{J/\psi N} \geq 17$ mb (multiple expansion and low-energy theorems in QCD).
 $\sigma_{J/\psi N} \sim 7$ mb (two-gluon exchange QCD calculation of interaction potential)
 $\sigma_{J/\psi N} \ll 1$ mb (lattice gauge theory and Born-Oppenheimer adiabatic expansion)

Near-Threshold J/ψ Production off Deuteron

Quasi-Free Photoproduction off the Neutron

Search for a neutral hidden-charm pentaquark signal, P_c^0 , (isospin partner of P_c^+).

- To confirm (or not) the existence of the LHCb charm pentaquarks
- If P_c observed, study the nature of the state (hadronic molecule, baryocharmonium, kinematic singularity, ...)

Evaluate the ratio $\frac{\sigma_{\gamma(p) \rightarrow J/\psi p}}{\sigma_{\gamma(n) \rightarrow J/\psi n}}$ to probe the two-gluon exchange mechanism, which is flavor-blind.

Evaluate the ratio $\frac{\sigma_{\gamma(p) \rightarrow J/\psi p}}{\sigma_{\gamma p \rightarrow J/\psi p}}$ to probe for nuclear effects on the elementary amplitude or the bound nucleon.

Near-Threshold J/ψ Production off Deuteron

Coherent Photoproduction

The t -dependence of the cross section can provide access to the deuteron gluonic structure (gluon form factor)

$$E_{\text{thr}} = 5.66 \text{ GeV} \rightarrow |t_{\text{min}}| = 3.31 \text{ (GeV/c)}^2$$

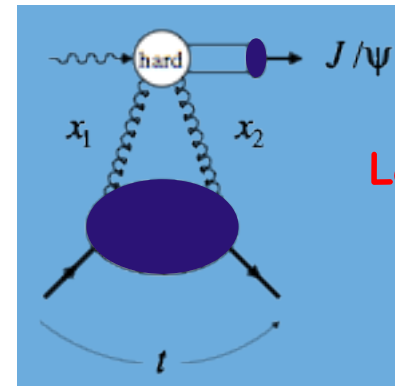
$$E = 11 \text{ GeV} \rightarrow |t_{\text{min}}| = 0.26 \text{ (GeV/c)}^2$$

GPD Based Description, $|t| \leq 1\text{--}2 \text{ GeV}^2$

$$\frac{d\sigma}{dt} \sim |F_{gg}(x_1, x_2, t, \mu^2)|^2 = \frac{1}{(1 - t/m_{2g}^2)^4}$$

Universal F_{gg} expected,
independent of μ^2 ; $m_{2g}^2 \sim 1 \text{ GeV}^2$

L. Frankfurt and M. Strikman, Phys. Rev. D 66, 031502(R) (2002).



$$\zeta = x_1 - x_2$$

Large skewness

Hard scale set by the $c\bar{c}$ distance $r_{\perp} \sim 1/m_c = 0.13 \text{ fm}$. Probe is hard for all Q^2 .

Unique opportunity for first glimpse at nuclear gluon distributions prior to EIC.

Near-Threshold J/ψ Production off Deuteron with CLAS12

The Experimental Configuration is Compatible with Run Group B

- Unpolarized LD2 target and 11-GeV electron beam, $L=10^{35} \text{ s}^{-1}\text{cm}^{-2}$.
- Standard CLAS electron trigger and a Muon trigger (new, established during RGA).
- Charged-hadron detection in the Forward and Central Detectors.
- Neutron detection in the Forward Detector.
- Forward Tagger On (not needed in trigger).
- Full torus field, electrons in-bending.

Expected Yields

- Quasi-free production off neutron: ~ 30 J/ψ per day (including both, $e+e-$ and $\mu+\mu-$ decays).
- Pentaquark total yields: 31 - 975 ($P_c(4380)$), 45 - 1430 ($P_c(4450)$)
- Incoherent production: < 3 J/ψ per day (including both, $e+e-$ and $\mu+\mu-$ decays).
- Coherent production: $\sim 0.3 - 1$ J/ψ per day (including both, $e+e-$ and $\mu+\mu-$ decays).

Near-Threshold J/ψ Deuteron Photoproduction with CLAS12

Experimental Method

Exclusive Incoherent Quasi-Real Photoproduction

Detected: both scattered nucleons, J/ψ decay products

Undetected: scattered electron

Reaction identified by reconstructing the beam photon from final state particles

Exclusive Quasi-Free Quasi-Real Photoproduction off Neutron (Proton)

Detected: strike neutron (proton), J/ψ decay products

Undetected: scattered electron, spectator proton (neutron)

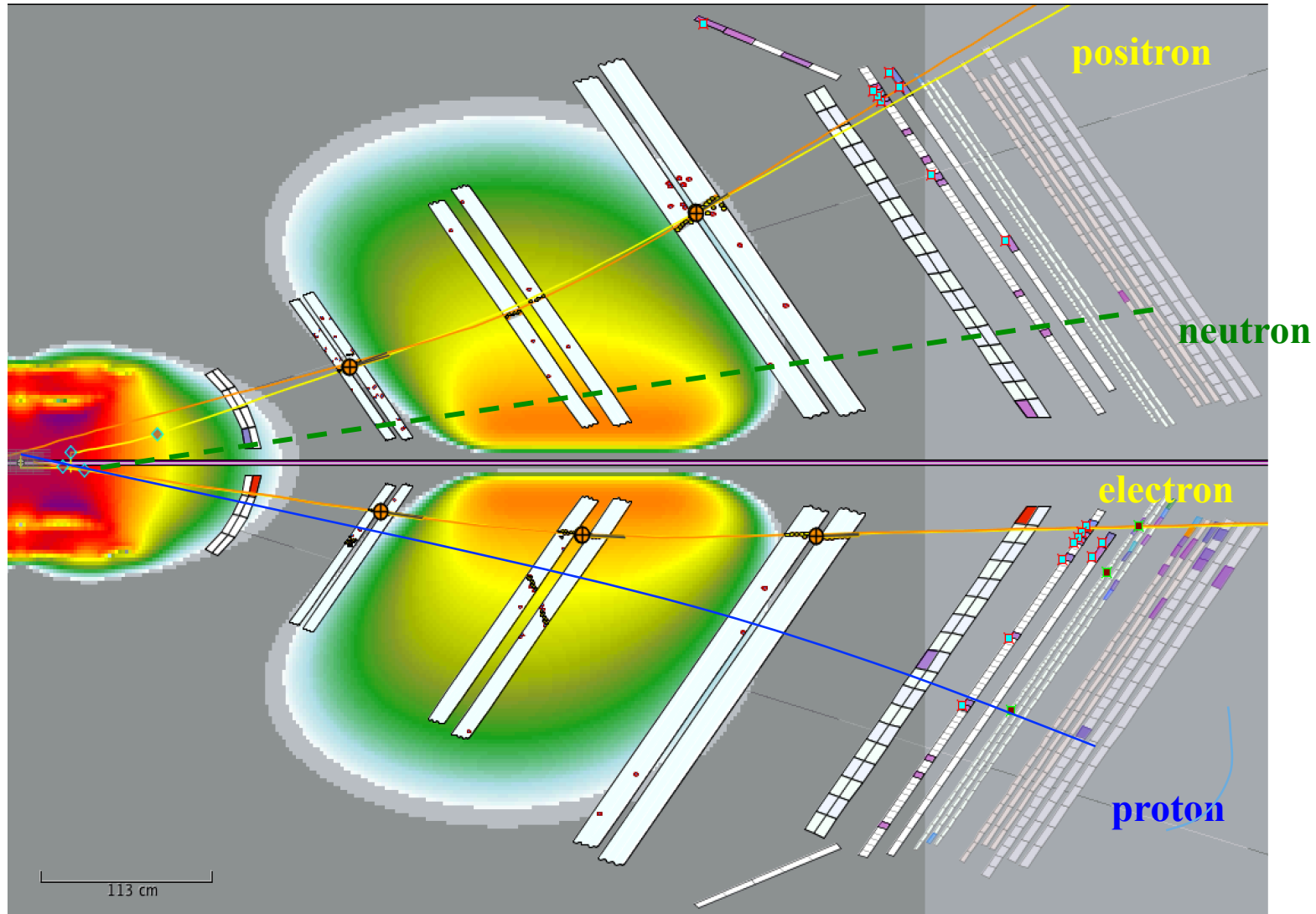
Reaction identified by reconstructing missing scattered electron assuming target nucleon was at rest.

Exclusive Coherent Quasi-Real Photoproduction

Detected: scattered deuteron, J/ψ decay products

Undetected: scattered electron

Reaction identified by reconstructing the beam photon from final state particles



Run Group Review Procedure



- *Experiment will use already approved beam time*
- *Run conditions are identical to the already approved experiment (beam & target conditions, magnetic fields, detector settings, etc.)*
- *Chair of PWG assigns review committee*
- *Committee reviews the proposal, communicates with proponents and with contact person of possibly affected approved experiment*
- *If committee is satisfied it issues report to the working group chair*
- *Working group chair informs CLAS chair about result of the review*

Internal CLAS review aims to address the subject with same rigor as a PAC review would, both in terms of science and feasibility

Report from Review Committee

Collaboration Review Committee Report for the Run Group B Proposal “Study of J/ψ Photoproduction off Deuteron ”

Review Committee: L. Guo and A. Celentano

The proposal (by Y. Ilieva et al.) aims to join Run Group B (RGB), and study exclusive, near-threshold J/ψ production using both real and quasi-real photons off deuteron. In addition to the cross section measurements of both coherent and incoherent processes, this experiment also has the potential to produce the first ever measurements of final-state interactions that could allow a direct access to the elementary J/ψ N interaction. In addition to probing gluonic form factors of bound nucleons using the incoherent reaction, the bound neutron data is particularly interesting since it allows the search for possible isospin partners of the LHCb pentaquark states. This is also complementary to similar searches at Jefferson Lab at both Hall B and others using free proton targets. Although the coherent production does not seem to be too promising in terms of statistics, such a cross section measurement (or the limit of which) would be a first time result that can provide valuable information for future experiments.

The proposal plans to use both untagged real photon events, thanks to the capabilities of CLAS12 detecting multiparticles in the final states, and the quasi-real photons tagged by the Forward Tagger (FT) which has performed extremely well during the spring 2018 run. The feasibility of these complimentary approaches has already been established. The running conditions of the proposed experiment are consistent with the current Run Group B plan and is what is used in the simulation. The additional trigger required for charged particles in opposite sectors have been tested in the Spring 2018 run and does not present a big logistic problem.

Based on the strength of the physics, the potential of multiple first time measurements or discoveries, and the compatibility with Run Group B, the committee therefore enthusiastically endorses the proposal on behalf of the collaboration.

Hall B Run schedule

Schedule	Run Group	Energy (GeV)	Polarization	PAC Days	PAC days used	Remaining PAC days
2/05 -5/06/18	RG-A	2.2 - 10.6	0.85	21.7		
10/22 – 11/15/18	RG-A	10.6	0.85	42	63.7	75.3
11/19 – 12/19/18	RG-K	7.5/6.5	0.85	14	14	86
2019						
01/30 – 03/10/19	RG-B	10.6	0.85	20		
06/10 – 08/04/19	HPS	4.55	-	28	43	137
10/01 – 11/24/19	RG-B	10.6	0.85	27	47	43
11/24 – 12/20/19	Installation					