



Study of J/ψ Photoproduction off Deuteron

LOI12-17-001

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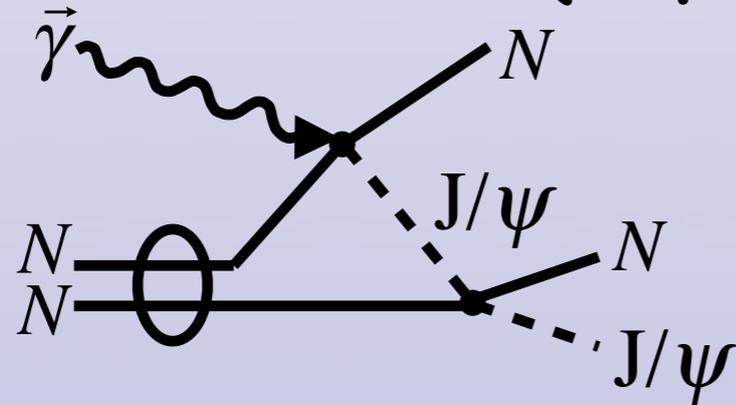
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Near Threshold J/ψ Production off Deuteron

The Program

- Incoherent photoproduction: $\gamma d \rightarrow J/\psi pn$
 - Quasi-free photoproduction off proton: $\gamma(p) \rightarrow J/\psi p$
 - Quasi-free photoproduction off neutron: $\gamma(n) \rightarrow J/\psi n$
 - Final-State Interactions ($J/\psi N$ rescattering)

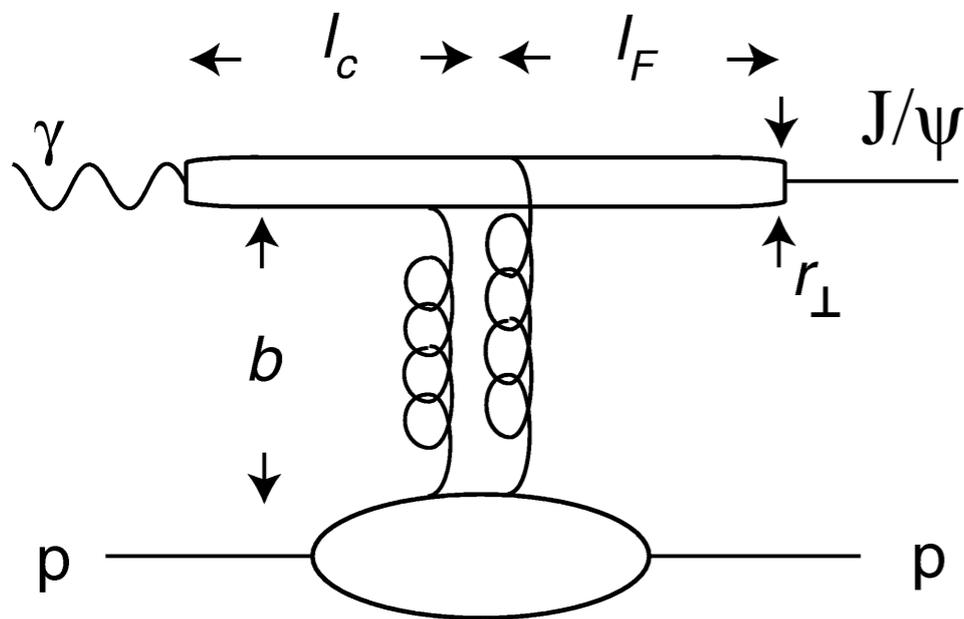


- Coherent photoproduction: $\gamma d \rightarrow J/\psi d$

Plan: To develop LOI into a run-group proposal for RG B and submit to PAC in Summer 2018. Standard CLAS12 configuration.

Near Threshold J/ψ Production off Deuteron

Why J/ψ ?



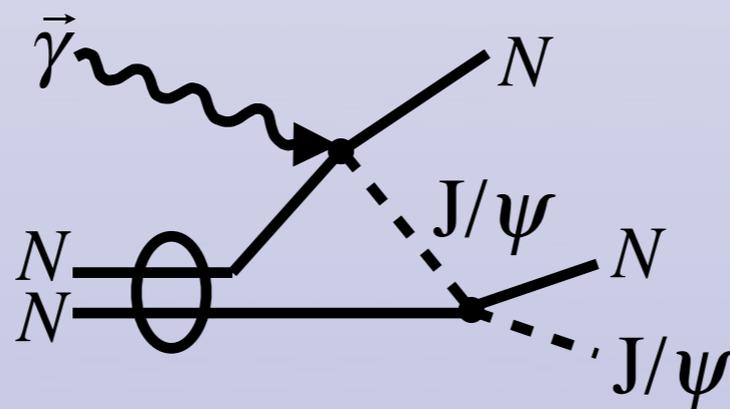
- Small transverse size: $r_\perp \sim 1/m_c = 0.13$ fm
- $E_{\text{thr}} = 8.2$ GeV, $l_c \approx 2E_\gamma^{\text{lab}}/4m_c^2 = 0.36$ fm
- At threshold, $|t_{\text{min}}| = 1.7$ (GeV/c)²
- $b \sim 1/|t|^{1/2} = 0.2$ fm
- The $c\bar{c}$ couples to gluon field in the target. Process dominated by multi-gluon exchange.
- Probes the short-range structure of the target.

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

Near-Threshold J/ψ Production off Deuteron

Incoherent Photoproduction: $J/\psi N$ FSI

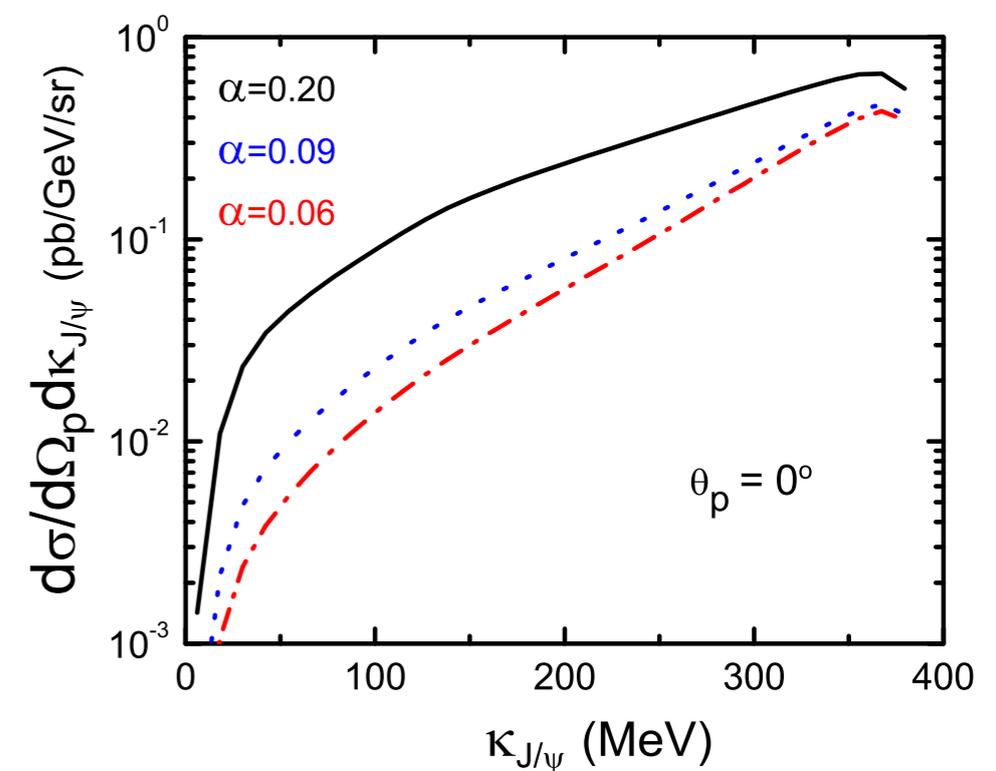
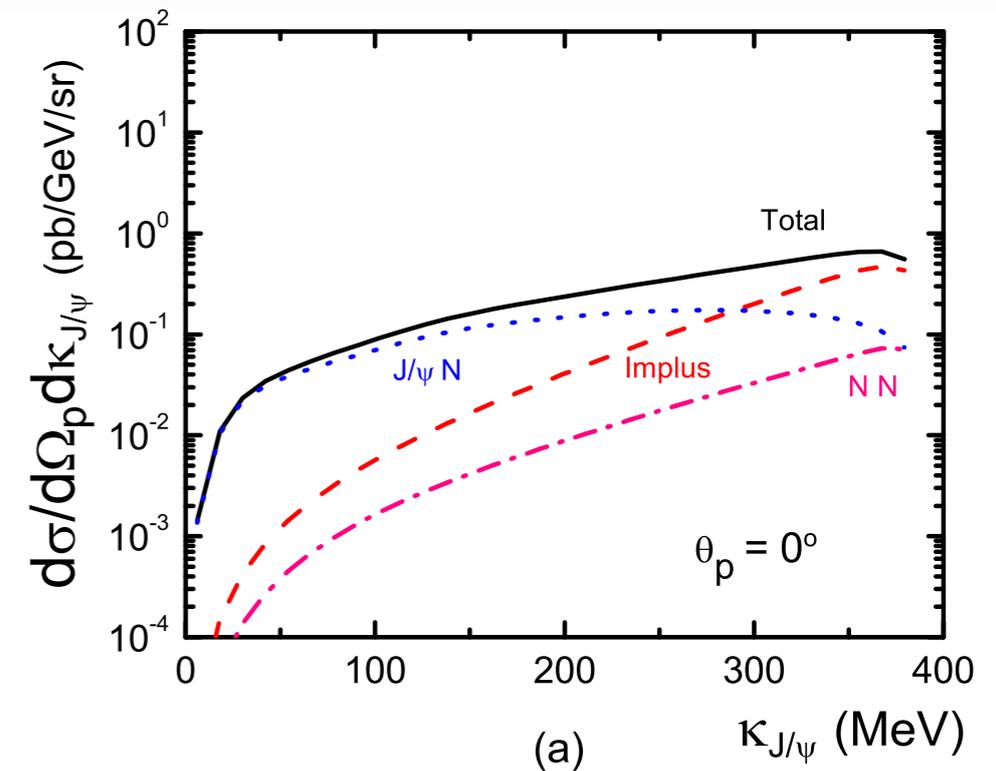
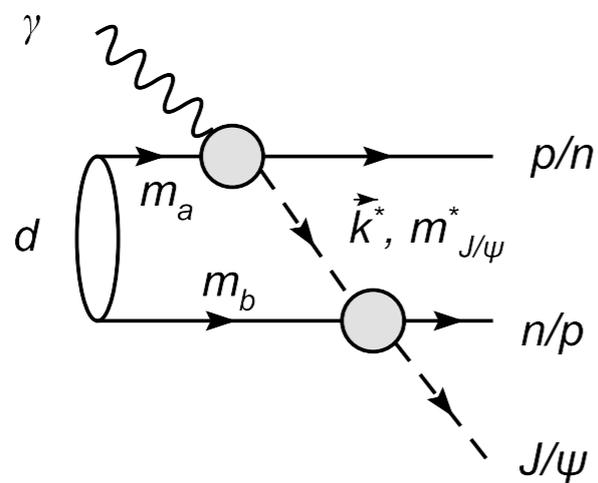
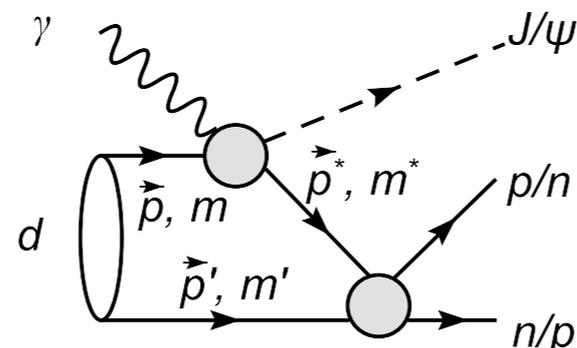
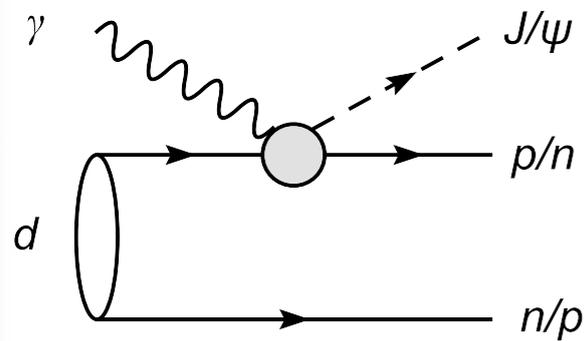
- Direct access to $J/\psi N \rightarrow J/\psi N$ and the elementary $J/\psi N$ total cross section ($l_F \sim 1 \text{ fm}$).
 - $\sigma_{J/\psi N} < 1 \text{ mb}$ (from J/ψ on N)
 - $\sigma_{J/\psi N} \sim 3.5 \text{ mb}$ (from A dependence of nuclear absorption).
 - $\sigma_{J/\psi N} \geq 17 \text{ mb}$ (multiple expansion and low-energy theorems in QCD).



- At $E_e = 11 \text{ GeV}$, $p_{J/\psi, \text{lab}} = 5 - 10 \text{ GeV}$, $W_{J/\psi N} = 4.6 - 5.7 \text{ GeV}$.

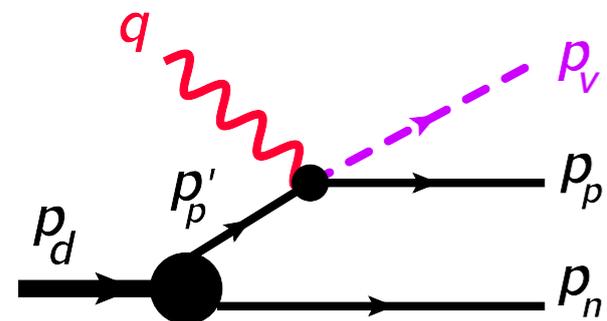
Near-Threshold J/ψ Production off Deuteron

Incoherent Photoproduction: $J/\psi N$ FSI

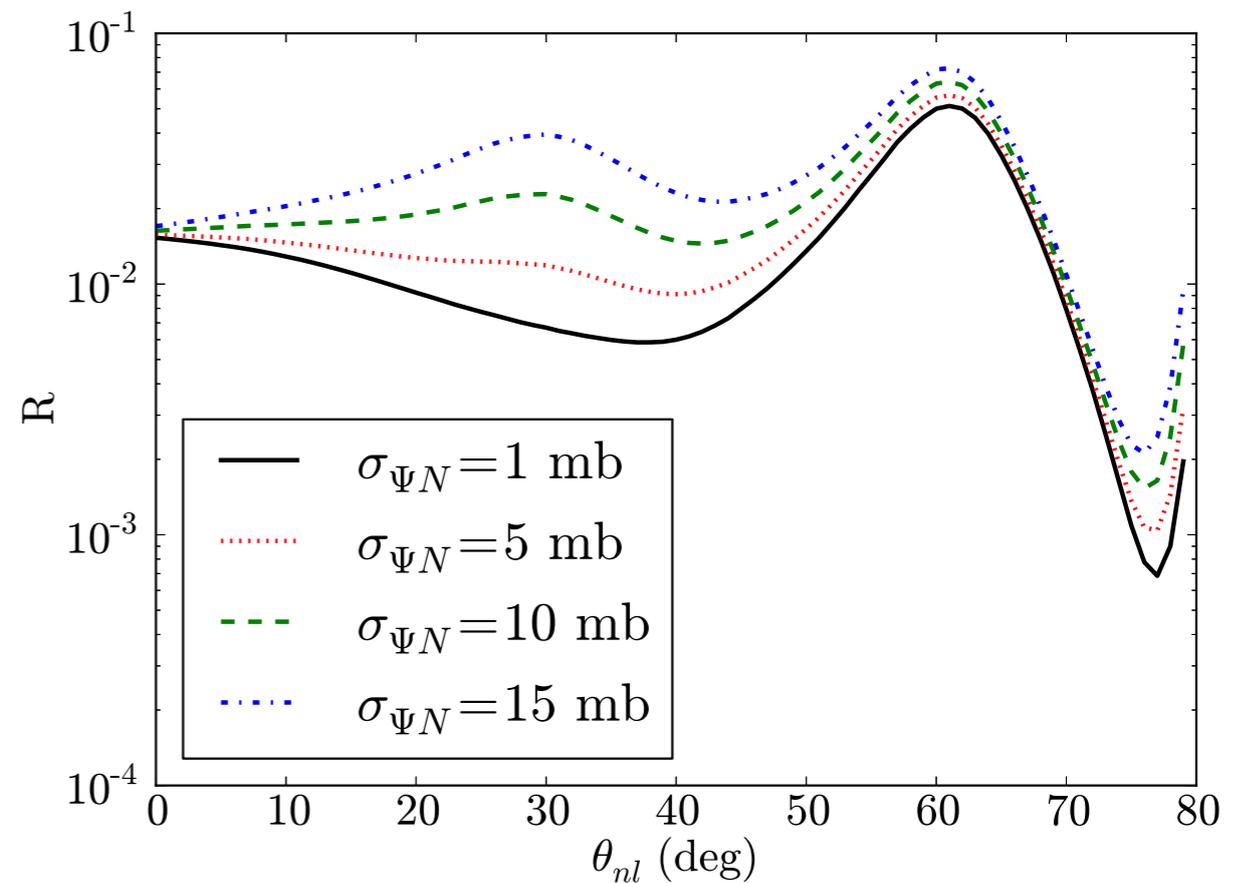
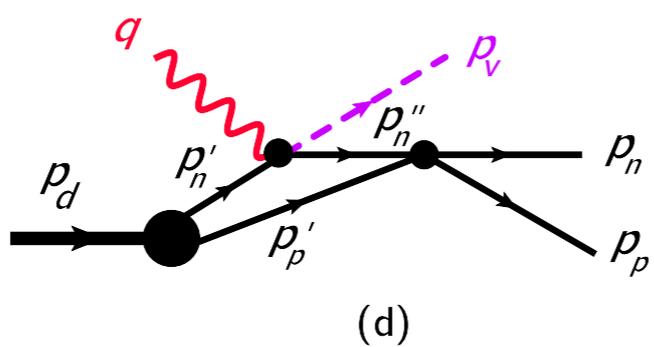
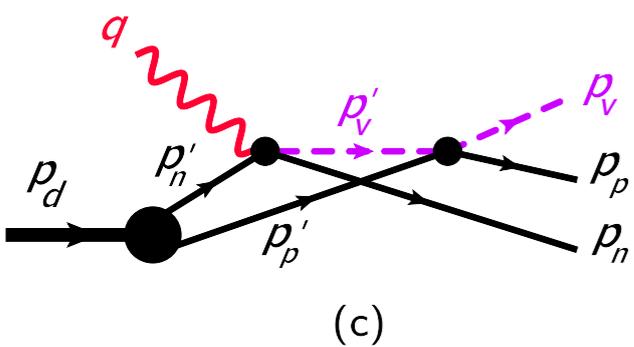
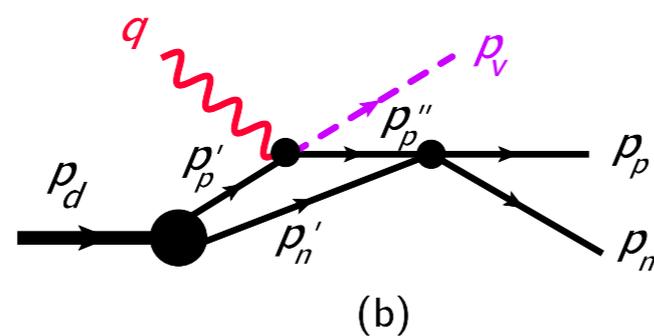
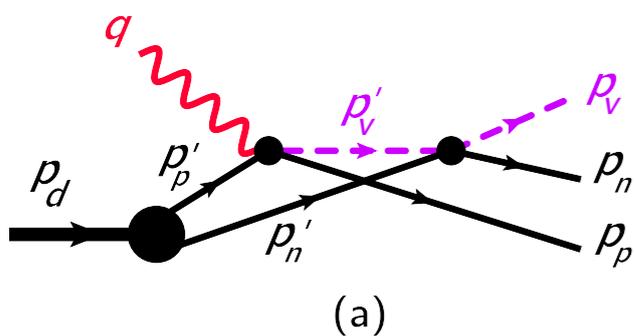


Near-Threshold J/ψ Production off Deuteron

Incoherent Photoproduction: $J/\psi N$ FSI



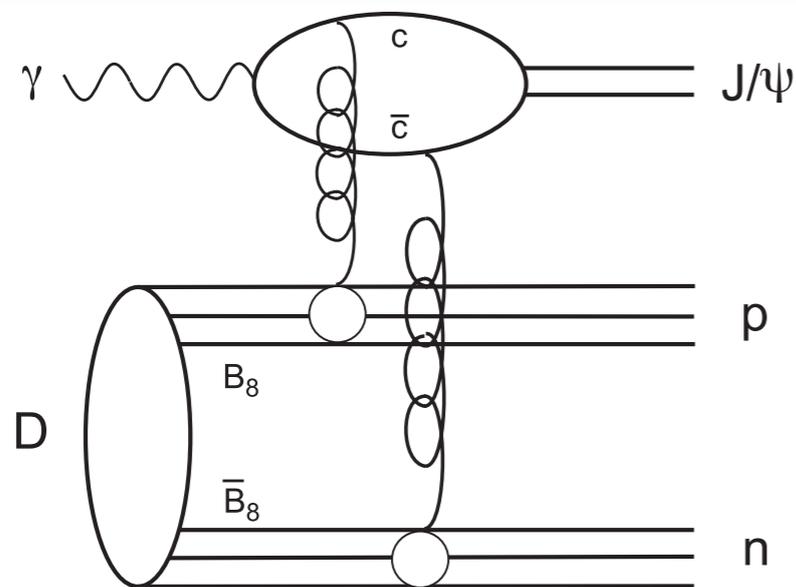
$$R = \frac{\sigma(p_n = 600 \text{ MeV})}{\sigma(p_n = 200 \text{ MeV})}$$



Near-Threshold J/ψ Production off Deuteron

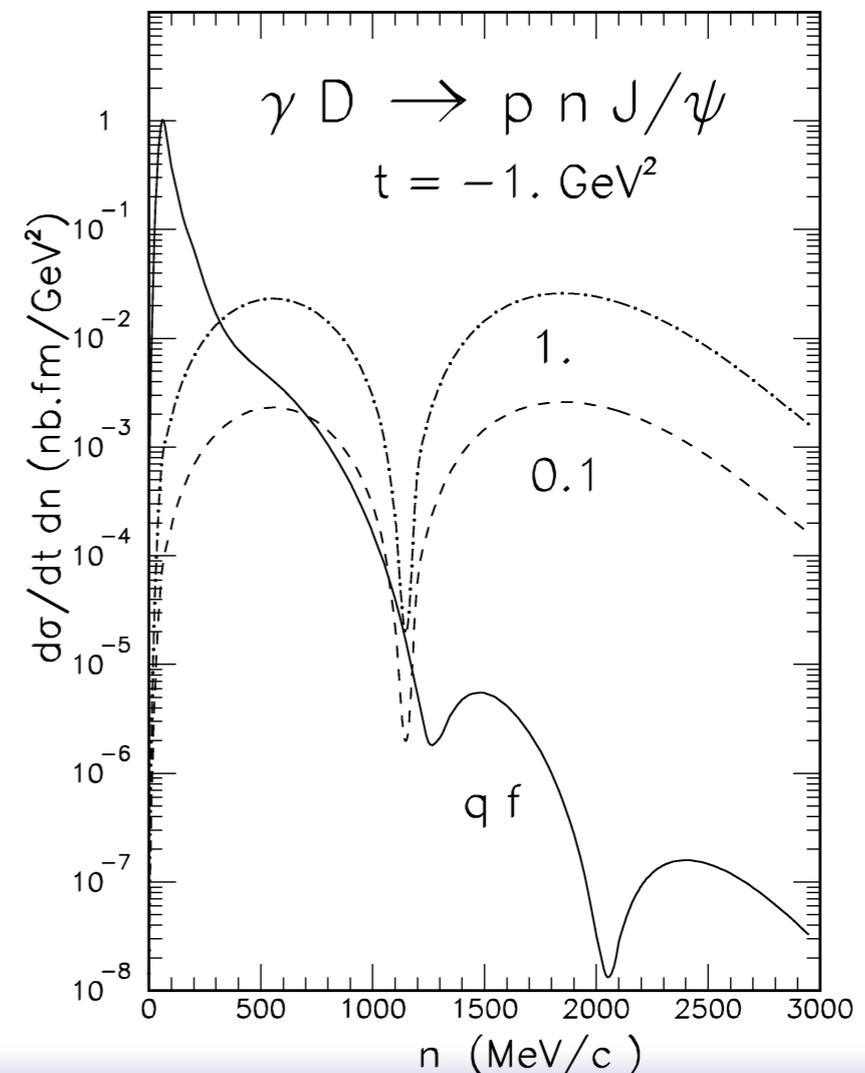
Incoherent Photoproduction: $J/\psi N$ FSI

- Sensitivity to hidden-color component of the deuteron wave function.



Hidden-color component contribution dominates the cross section above neutron momenta of 500 MeV/c.

May dominate subthreshold photoproduction (on deuteron: $E_{\text{thr}}=5.66$ GeV).



$$\frac{d\sigma}{dt d|\vec{n}|} = \frac{d\sigma}{dt} \Big|_{\gamma p \rightarrow J/\psi p} 4\pi \vec{n}^2 \left[\varphi_{cc} \left(\frac{\vec{n}}{2} \right) \right]^2 \frac{F_1^4(t/4)}{F_1^2(t)}$$

Near-Threshold J/ψ Production off Deuteron

More Physics

- Coherent photoproduction off Deuteron: access to the deuteron two-gluon form factor ($E_{\text{thr}}=5.66 \text{ GeV}$, $|t_{\text{min}}|=3.63 \text{ (GeV/c)}^2$).
- Quasi-free photoproduction off neutron.
 - Probe the two gluon-exchange mechanism, which is “flavor-blind”, via the ratio $\frac{\sigma_{\gamma n \rightarrow J/\psi n}}{\sigma_{\gamma p \rightarrow J/\psi p}}$.
- Search for neutral hidden-charm pentaquark signal, P_c^0 , (isospin partner of P_c^+).

Near-Threshold J/ψ Deuteron Photoproduction

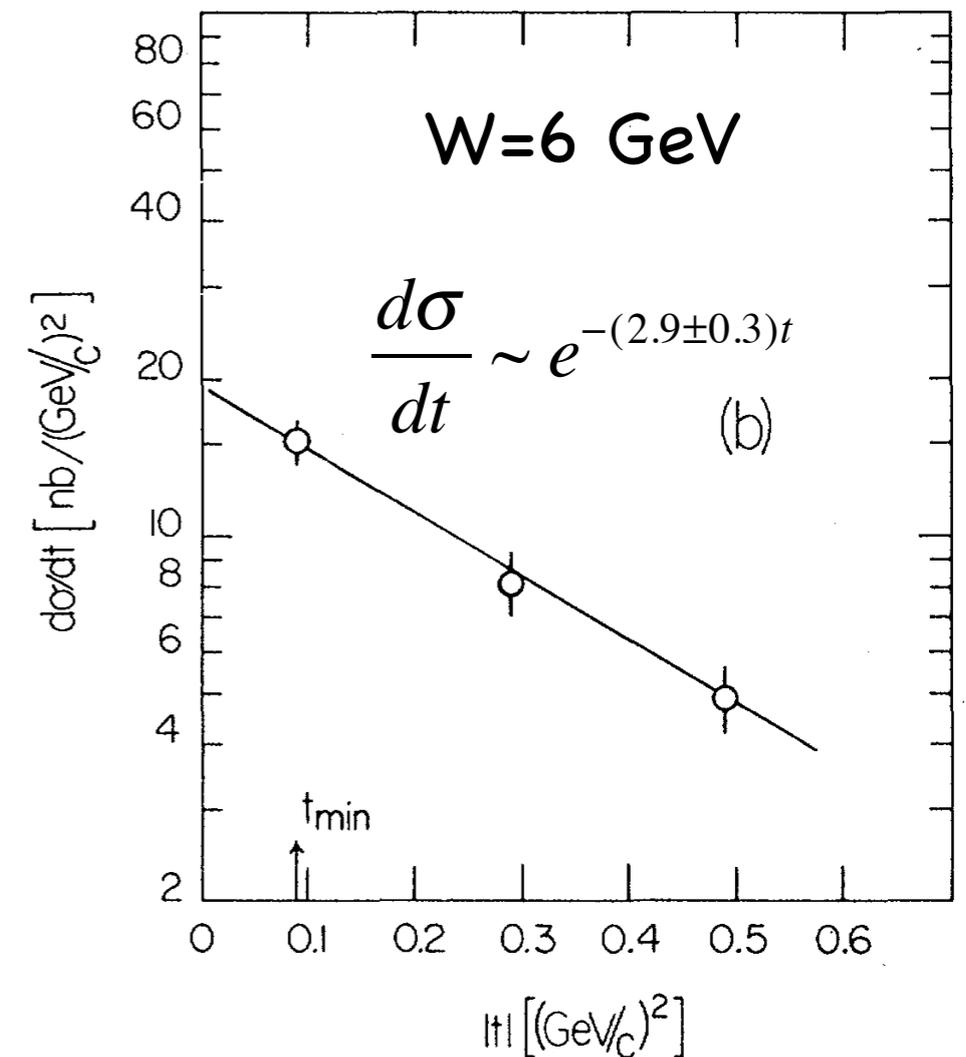
Previous Measurements

SLAC, untagged real photon beam, e^+e^- and $\mu^+\mu^-$ detected

$$\sigma_{tot}(J/\psi - N) \leq 0.8 \text{ mb}$$

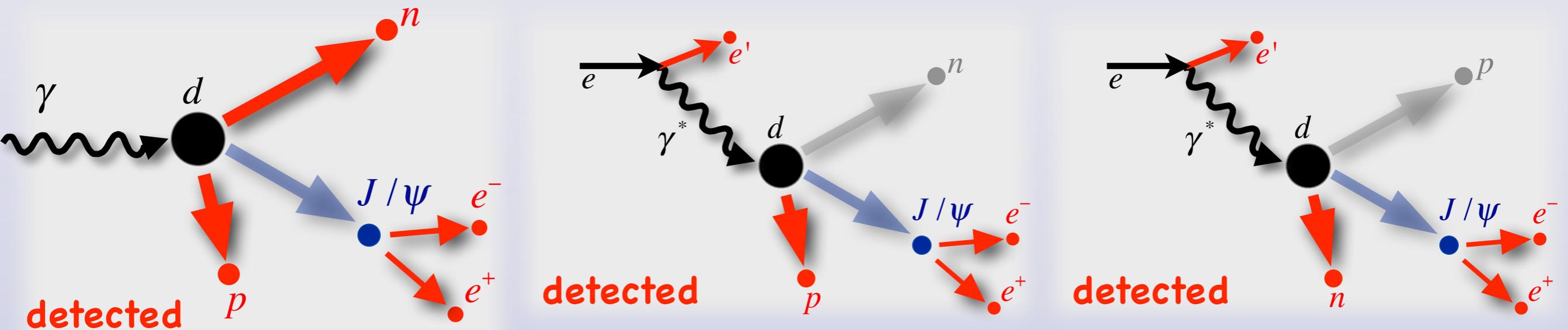
TABLE I. Differential cross sections and kinematic conditions for the data points of this experiment. $t' \equiv t - t_{\min}$.

k (GeV)	E_0 (GeV)	t_{\min} (GeV/c) ²	t' (GeV/c) ²	$d\sigma(t)/dt$ [nb/(GeV/c) ²]
$\psi(3100)$ from deuterium target				
21.0	21.5	0.069	0.0	14.6 ± 1.2
19.0	20.0	0.088	0.0	15.0 ± 1.0
19.0	19.5	0.088	0.0	12.0 ± 1.1
17.0	17.5	0.116	0.0	10.8 ± 1.0
16.0	16.5	0.135	0.0	8.2 ± 1.1
15.0	20.0	0.160	0.0	7.7 ± 1.5
15.0	16.0	0.160	0.0	5.9 ± 1.0
13.0	13.5	0.236	0.0	3.8 ± 0.8
19.0	20.0	0.088	0.20	8.2 ± 1.1
19.0	20.0	0.088	0.40	4.9 ± 0.7



Near-Threshold J/ψ Deuteron Photoproduction with CLAS12

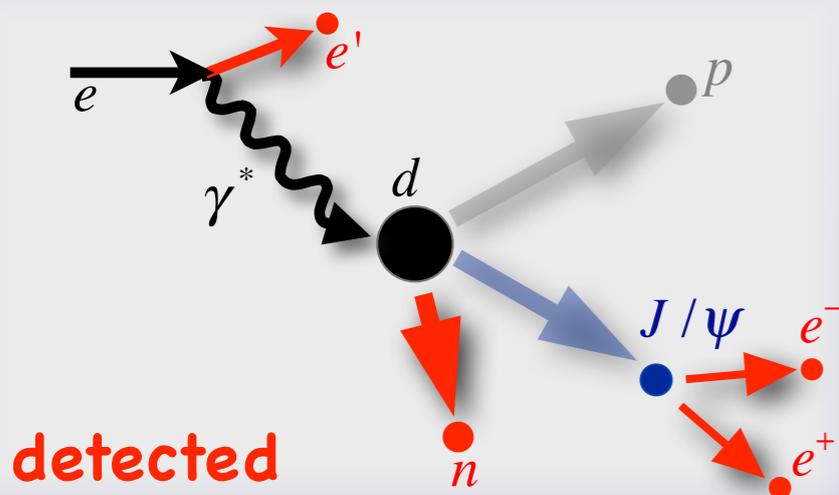
Fully Exclusive Measurements of Incoherent Photoproduction



- Will run together with RunGroup B: 11 GeV, unpolarized d target, forward tagger, central neutron detector.
- Standard CLAS12 electron trigger
- Acceptance, expected yields, and optimal CLAS settings to be estimated.

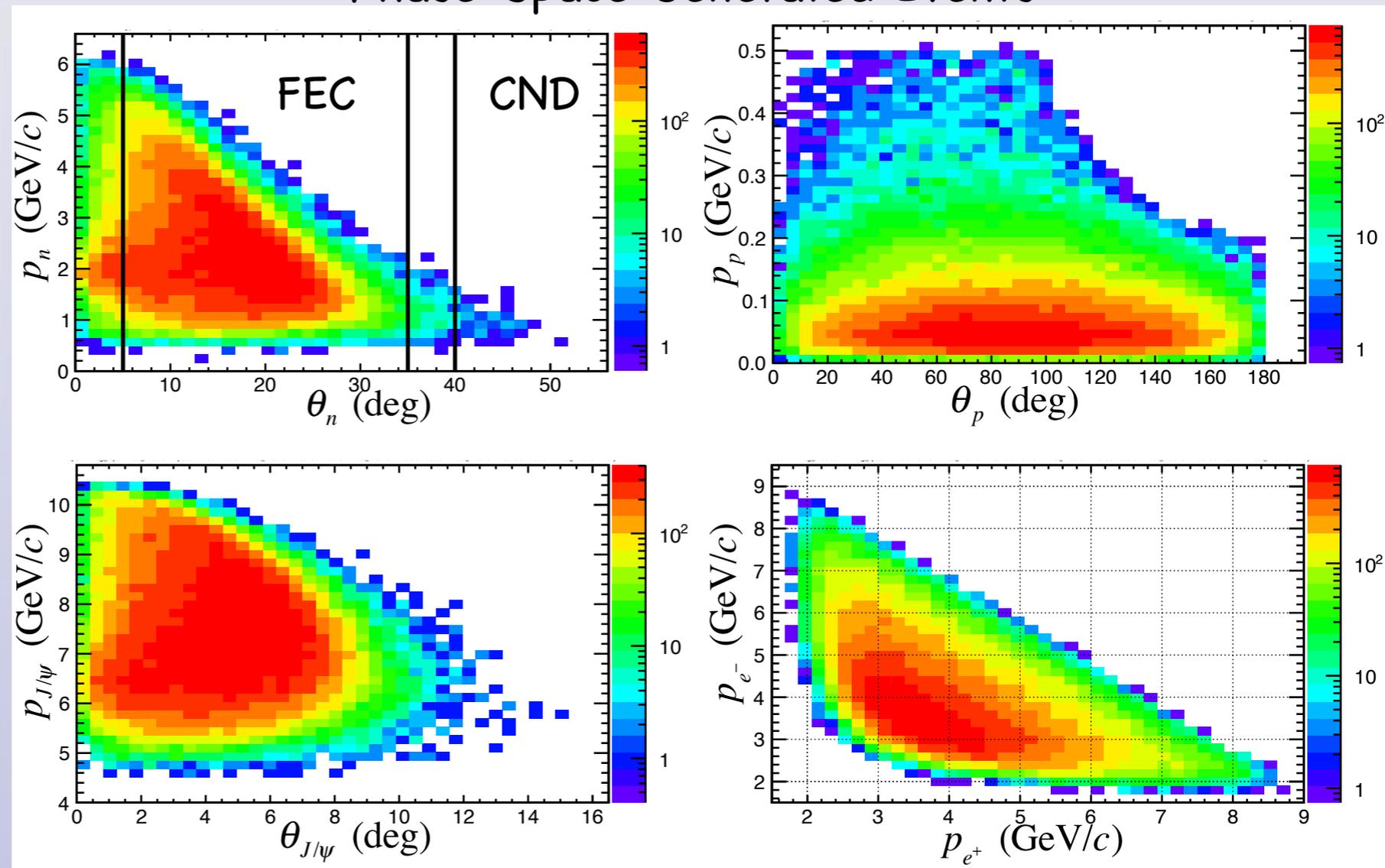
Near-Threshold J/ψ Deuteron Photoproduction with CLAS12

Fully Exclusive Measurements of Incoherent Photoproduction



- quasi-real, tagged photons
- n detection in Forward EC, possible CND
- J/ψ : from e^+e^- decay

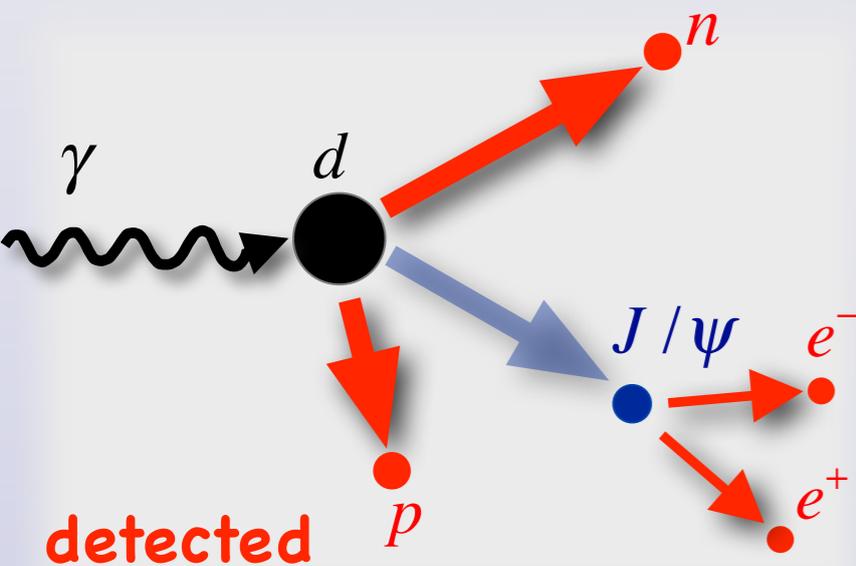
Phase-Space Generated Events



This topology yields primarily qf events off neutron.

Near-Threshold J/ψ Deuteron Photoproduction with CLAS12

Fully Exclusive Measurements of Incoherent Photoproduction



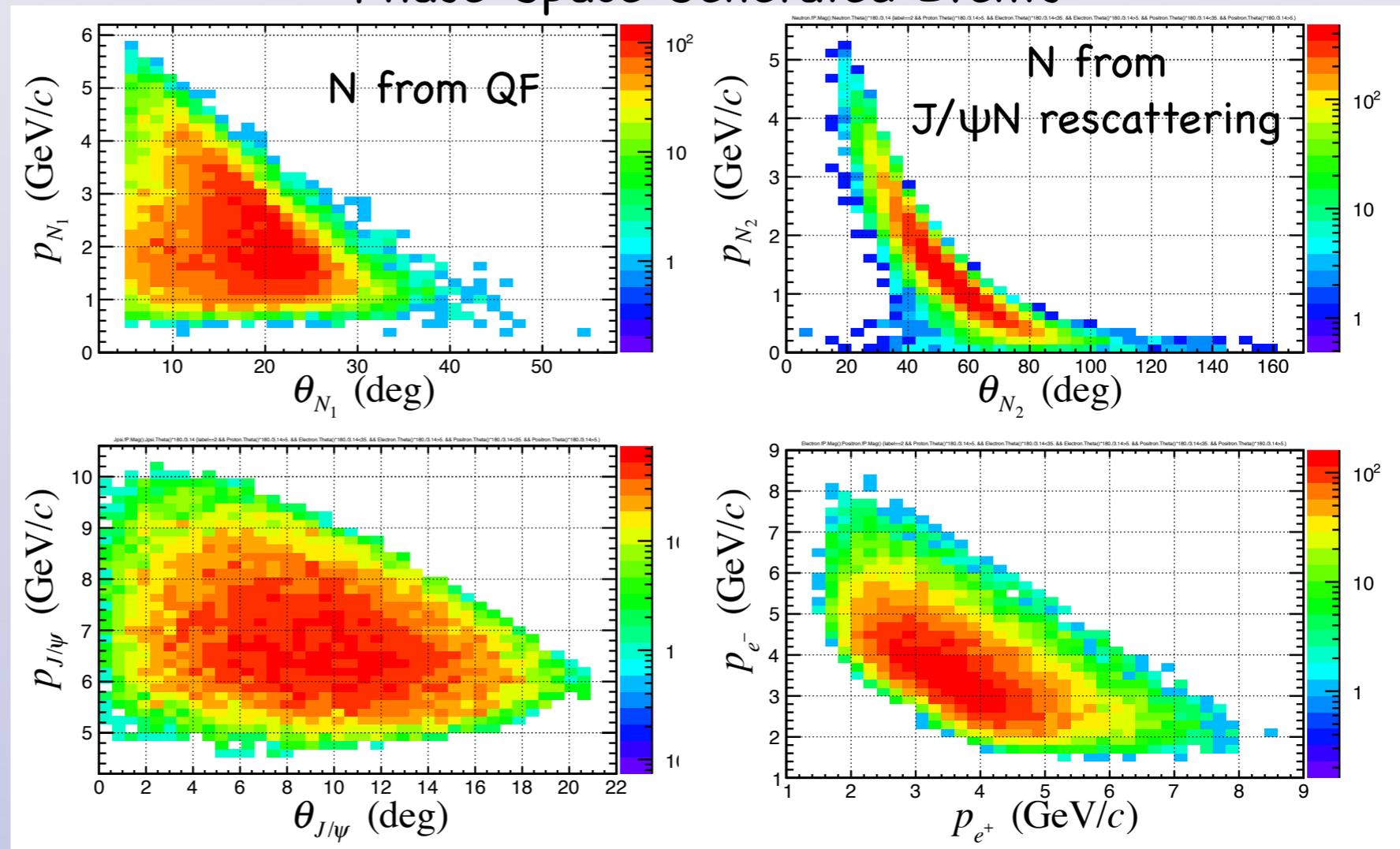
- untagged photons: all final-state particles detected; primarily $J/\psi p$ rescattering

- tagged photons: e' in FT

$$\gamma d \rightarrow p J/\psi X (X \equiv n)$$

$$\gamma d \rightarrow n J/\psi X (X \equiv p)$$

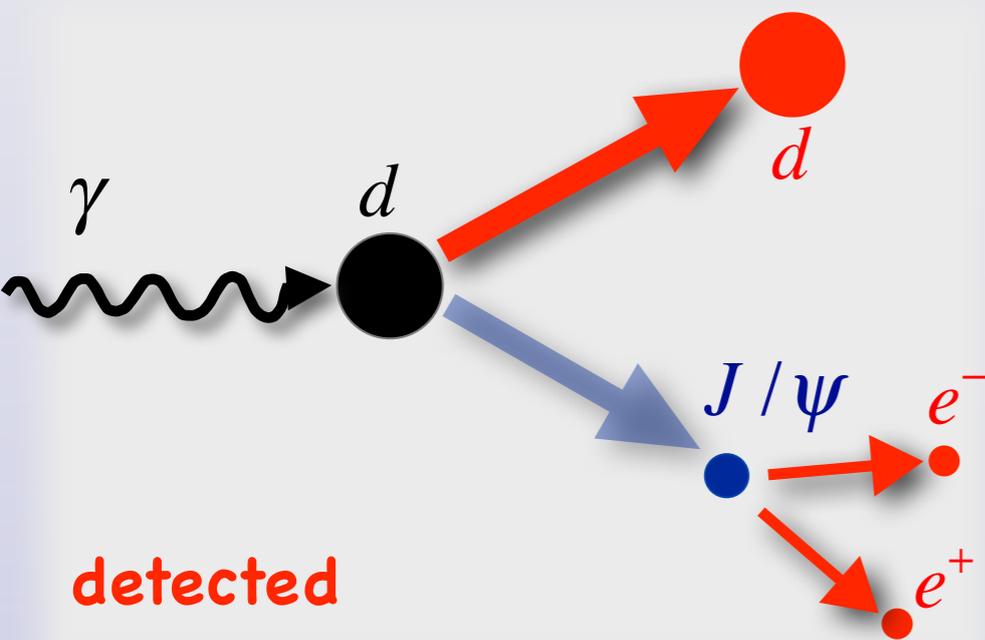
Phase-Space Generated Events



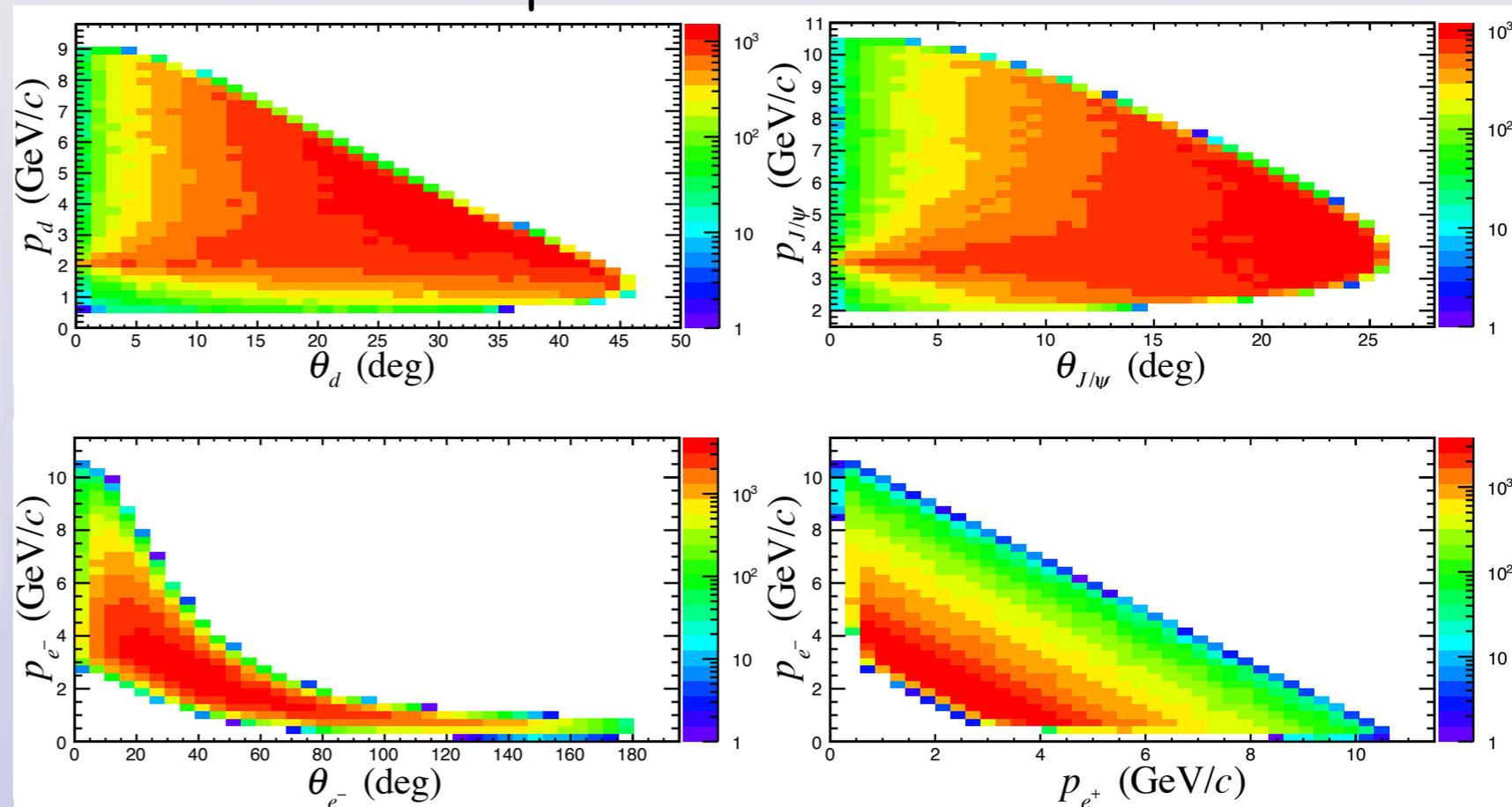
Several event topologies to obtain FSI-dominated yields.

Near-Threshold J/ψ Deuteron Photoproduction with CLAS12

Fully Exclusive Measurements of Coherent Photoproduction



Phase-Space Generated Events



- Deuteron must be detected.
- Smaller counting rates expected, compared to incoherent production.
- We will look for possible signal in various topologies (tagged and untagged) in data.

Summary and Outlook

- Window of opportunity to measure the cross section for photoproduction of J/ψ off the deuteron with CLAS12 and to study:
 - gluonic structure of deuteron
 - J/ψ -N interaction through rescattering
 - J/ψ -n photoproduction
- Will explore extracting polarization observables, such as beam-spin asymmetry.
- In preparation for a Run-Group Proposal to next PAC.

The End