

Heavy quarkonium production near threshold at EIC

C. Weiss (JLab), ECT* Workshop “Spectroscopy at EIC,” 20-Dec-18



- Exclusive heavy quarkonium production kinematics

Near threshold $\leftrightarrow$ high energies

HQ and nucleon momenta — can they be “slow”?

- Near-threshold heavy quarkonium production at EIC

Physics: Nucleon gluonic form factor, pentaquark baryon resonance

Physics: Tetraquark charmonium $Z_c^+(3900)$

Momentum and angle distributions

Discussion: Detection capabilities

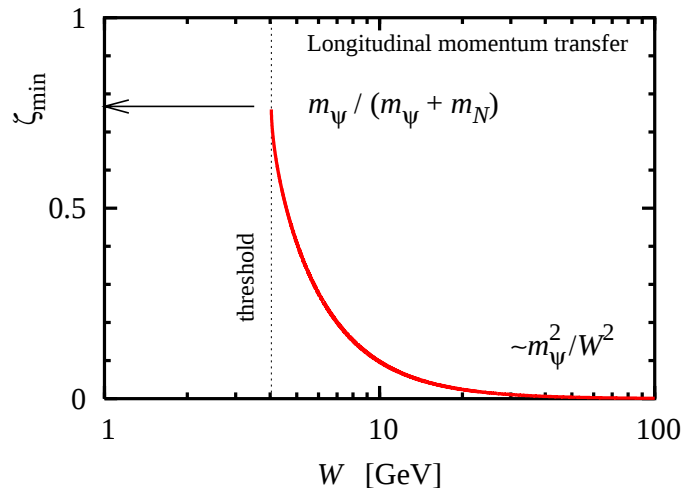
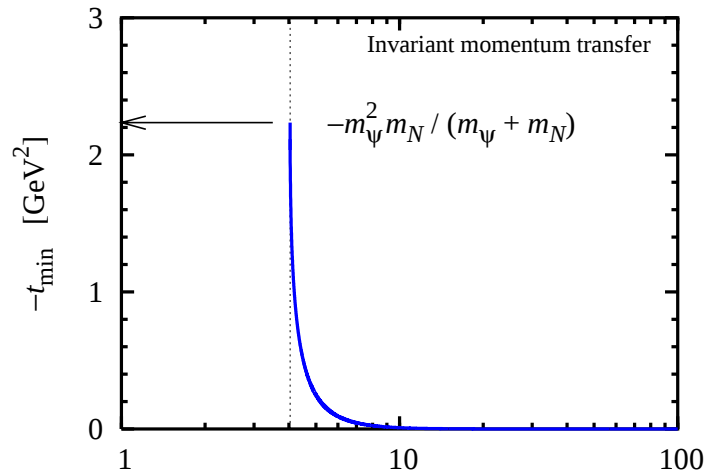
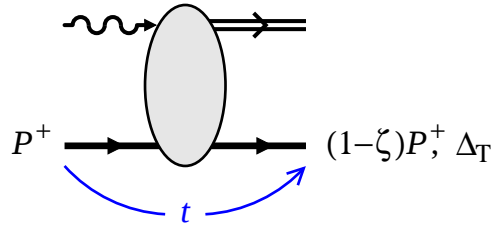
- Low- Q^2 electron tagger for photoproduction

[Discussion points, not formal presentation.]

Based on ideas/materials from M. Strikman, J. Stevens, A. Camsonne, Ch. Hyde]

Exclusive HQ production: Kinematics

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- Light-cone variables

ζ “Plus” momentum transfer, cf. x_B

Δ_T Transverse momentum transfer

$t = -(\zeta^2 m_N^2 + \Delta_T^2) / (1 - \zeta)$
invariant momentum transfer

- Near-threshold region $W \approx W_{\text{th}}$

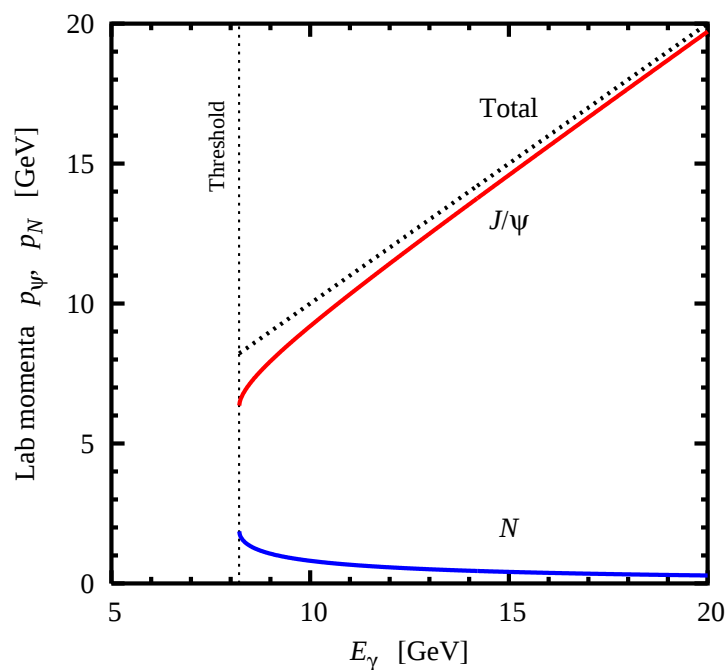
ζ large, at threshold = 0.78 (J/ψ)

$|t_{\text{min}}|$ large, at threshold = 2.2 GeV^2

- High-energy region $W \gg W_{\text{th}}$

$\zeta \ll 1$, $|t_{\text{min}}| \ll m_N$

Exclusive HQ production: Momenta in final state 3



- J/ψ and N momenta in target rest frame
(consider $\Delta_T = 0$)

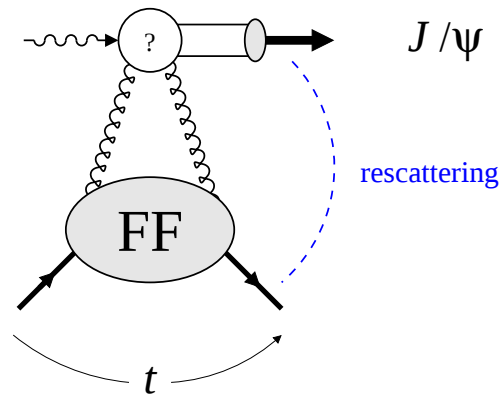
J/ψ and N momenta add up to photon momentum, sharing determined by masses

$$\frac{p_\psi}{m_\psi} \approx \frac{m_\psi}{2m_N} \quad \text{at threshold}$$

- HQ carries almost all of photon momentum in target rest frame, is never “slow”, not even at threshold
→ Implications for in-medium studies using nuclei
- Final-state nucleon carries large momentum at threshold, but becomes slow at high energies (diffractive process)
- Near threshold the produced HQ and final-state nucleon move collinearly with almost the same velocity and can interact for a long time

HQ production near threshold: Physics

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- Physics interest

Production mechanism: High- t gluonic form factor of nucleon

Various ideas about gluonic operator

Collinear gluon GPDs: Frankfurt, Strikman 02

Local operator related to EM tensor: Kharzeev et al 99; Hatta, Yang 18

pQCD hard scattering mechanism: Brodsky, Chudakov, Hoyer, Laget 01

Rescattering of HQ with nucleon in final state, pentaquark resonance $P_c(4450)$ [LHCb]

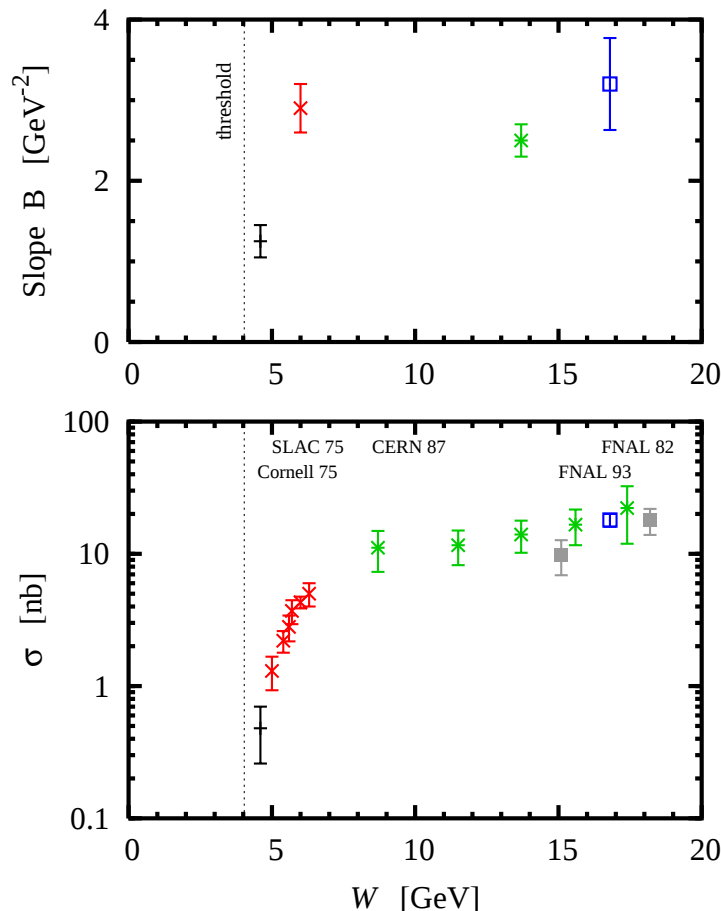
- Fixed-target measurements near threshold

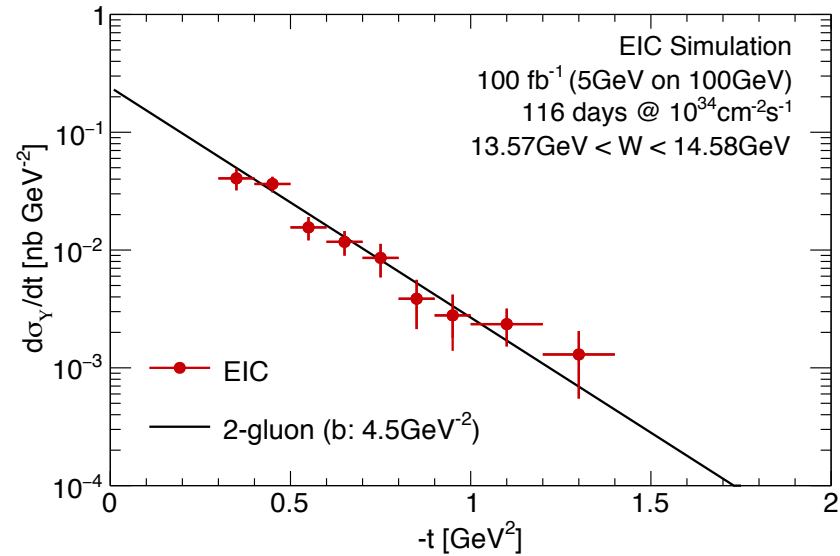
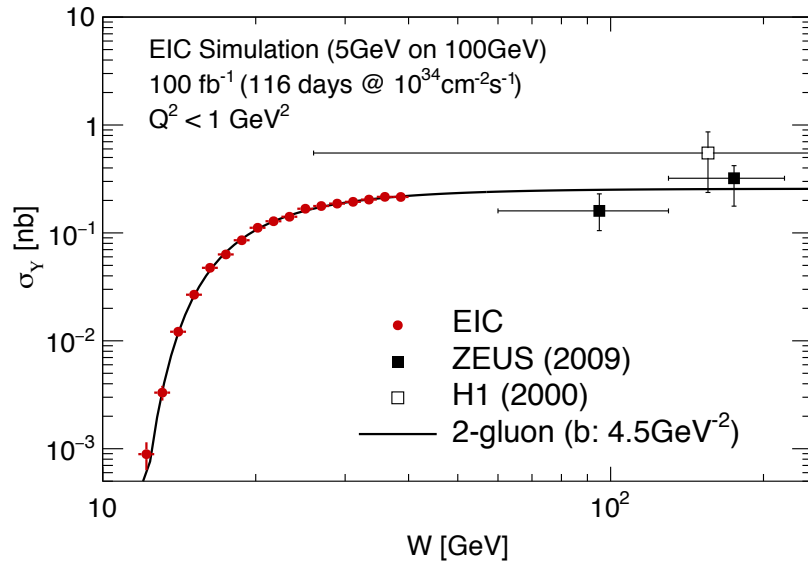
SLAC75, CORNELL75

JLab12 GlueX results to be published

CLAS12 photo/electroproduction, Hall C

SoLID planned



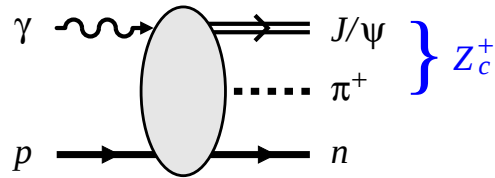


[Joosten, Meziani 18. Simulation parameters available in arXiv:1802.02616v2]

- Near-threshold Υ production feasible with $L_{\text{int}} = 100\text{ fb}^{-1}$
- Test QCD description, nature of gluonic operator

HQ production near threshold: $Z(3900)$ with EIC

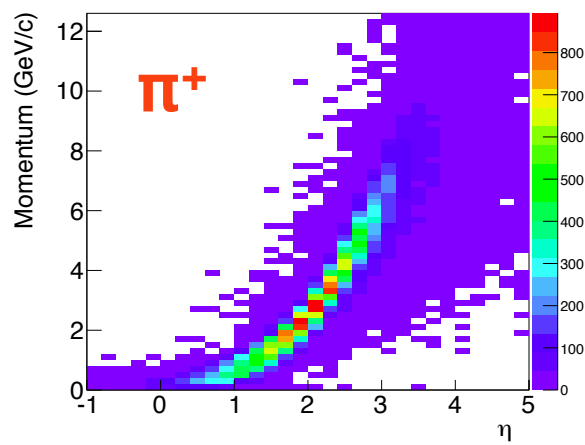
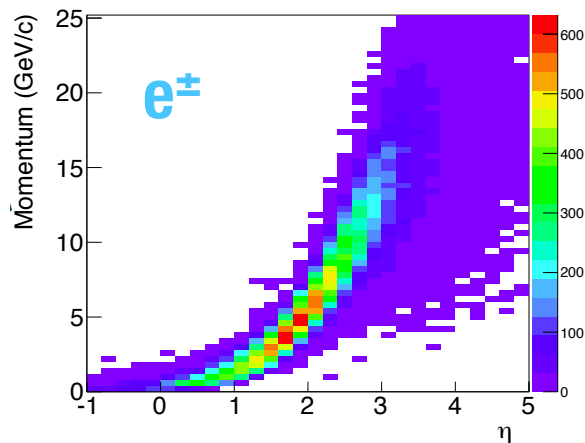
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- Photoproduction of XYZ states

Charged charmonium structure $Z_c^+(3900)$ observed in $\pi^\pm J/\psi$ mass distributions in decay of $Y(4260)$

Can it be confirmed/studies in photo/electroproduction on nucleon?



- EIC simulations [\[Materials from J. Stevens 15/18\]](#)

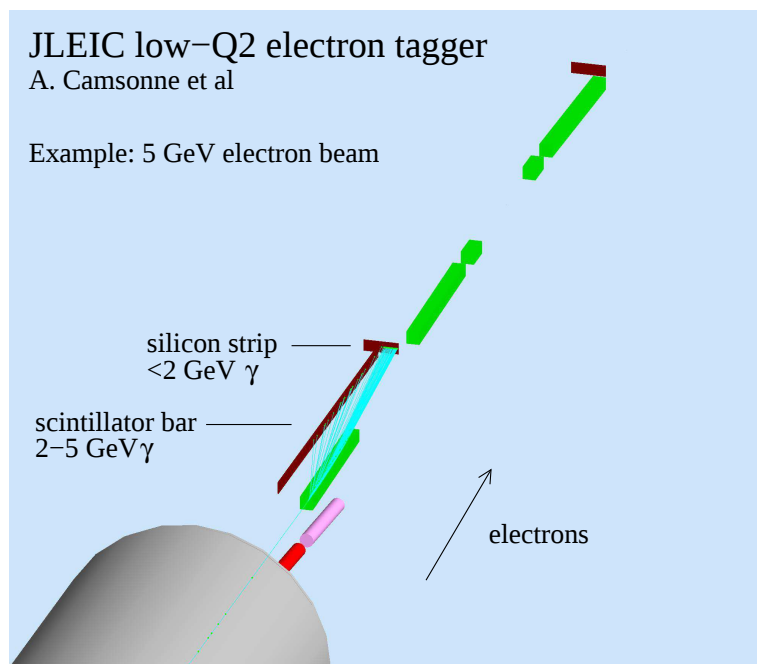
Beam energies 5×50 GeV
quasi-real photoproduction

Decay $e^\pm$ and π^+ boosted in proton direction

Need good hadron and $e^\pm$ PID
and momentum resolution $\rightarrow$ Discussion

Low- Q^2 electron tagger for photoproduction

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- Low- Q^2 electron tagger

Integrated in IR design

Uses same chicane as
Compton polarimeter

Coverage down to $Q^2 \sim m_e^2$

- Effective photon flux

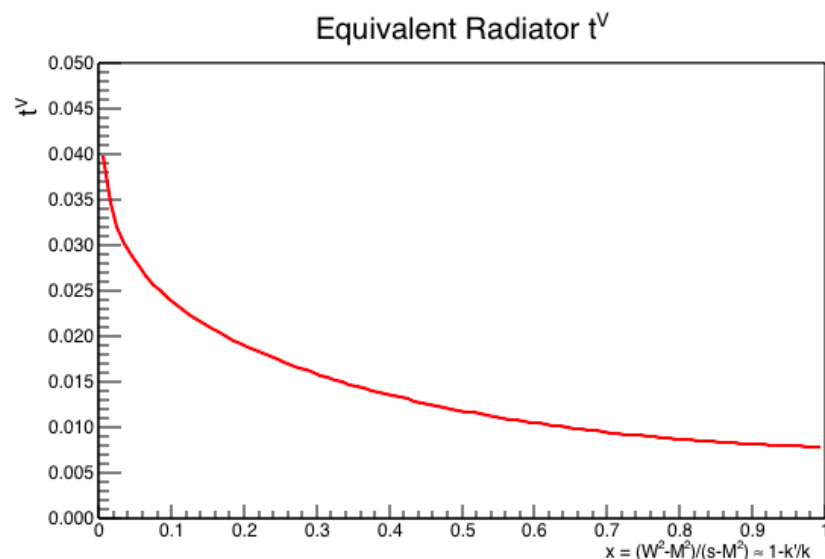
$$d\Phi_\gamma = L_{ep} t^V \frac{dW^2}{W^2}$$

t^V “equivalent radiator”

Integrated flux $\sim 10^4 - 10^5 \text{ s}^{-1}$
for $L_{ep} = 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$

Energy resolution $\sim 10^{-3}$

[Materials from A. Camsonne, Ch. Hyde]



HQ production near threshold: Discussion

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- What PID and resolution are needed for near-threshold HQ production at EIC?

e^+e^- resolution? $e-\pi$ separation?

Is muon detection needed?

- What capabilities can be provided in EIC detector?

Central detector and hadron endcap → [Talk Deshpande](#)

- [• What capabilities are needed for high-energy HQ production?]

→ [Talk Glazier](#)