J/ψ production near threshold at EIC

Sayak Chatterjee

Department of Physics

University of Massachusetts, Amherst

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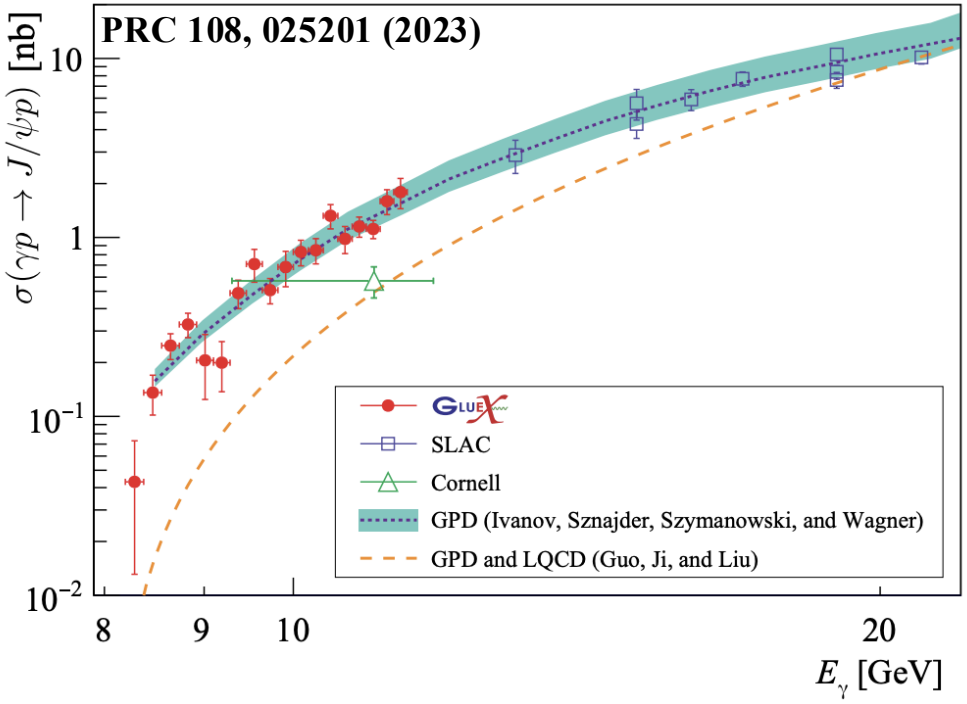
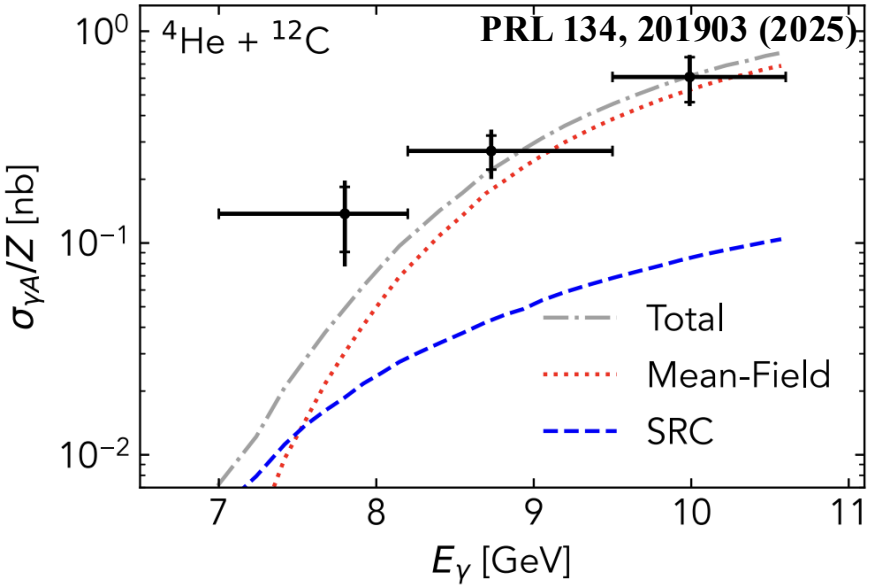
Why J/ψ production near threshold is interesting???

- **Near threshold exclusive production of heavy quarkonium such as J/ψ has emerged as a particularly promising channel for probing gluon distribution in nucleons**
  (PRL 123, 209; Nature 615, 7954 (2023); arXiv:2510.22076)
  - Uniquely sensitive to gluons
  - Differential cross-section measurement near threshold has a promising potential to directly probe gluons
  - Gives access to the valance quark region (Bjorken-x within $\sim 0.3 < x < 0.7$)
- **Better understanding of the J/ψ production mechanism near threshold (2-gluon exchange, 3-gluon exchange, SRC effects etc)**
  (EPJC 80, 1027 (2020); PLB 803, 10 (2020))
- **It could also be used to study the Proton mass and trace anomaly**
  (PLB 334, 155 (1994); EPJC 9, 459 (1999); PRD 98, 074003 (2018))
  - Gravitational Form Factors (GFFs) of the proton, which are related to the mass distribution
- **Exotic Hadron searches, such as Pentaquarks**
  (PRD 92, 031502 (2015); PLB 752, 329 (2016); PRD 94, 034002 (2016))

Existing data on the J/ψ production near threshold





- GlueX collaboration has measured the exclusive J/ψ photo-production cross-section ($\gamma p \to J/\psi p \to e^+e^-p$) over the photon beam energy of 8.2 GeV < E_γ < 11.4 GeV
- They have also measured the near threshold and sub-threshold J/ψ photo-production off nuclei for the very first time
  - Reaction (semi-inclusive) : $\gamma A \to e^+ e^- p(X)$, X is the undetected residual nuclear state
  - Nuclei : ^{2}H, ^{4}He, ^{12}C
  - Energy range : 7 GeV < E_γ < 10.6 GeV
- Excess production (as compared to the theoretical prediction) of J/ψ near threshold is observed

Interesting physics opportunity in the upcoming experiments to improve the understanding of the sub-threshold J/ψ production off nuclei (probing higher A region)

What is unique about EIC?

- State-of-the-art detector systems (large acceptance), high luminosity (10^{33} – 10^{34} $cm^{-2}s^{-1}$), wide center-of-mass energy ($\sqrt{S_{ep}} \sim 20 - 140\ GeV$), Polarization > 70%
  - Electron 5 - 18 GeV, Ion (p to Pb) 41, 100 – 275 GeV
  - Central detector : Hermetic detector
  - Far detector : Low-Q2 tagger, luminosity monitor, zero-degree calorimeters, off-momentum detectors
- Detailed report on the detector requirements for the EIC exclusive, diffractive and tagging physics is available using the ECCE detector concept (NIMA 1052 (2023) 168238)
  - Very promising performance
- Feasibility of spectator tagging at the EIC in the reaction channel $e + d \rightarrow e` + J/\psi + p` + n`$ has been studied and the results look promising (PLB 811 (2020) 135877)
- Upsilon (Y) production near threshold is another interesting physics process that would also be possible to measure at EIC

Proposal: Feasibility study of the detection of near threshold J/ψ ($\rightarrow e^+e^-/\mu^+\mu^-$) produced in eA collision using the EIC detector system

- **Physics aim:**
  - Gluon structure of the bound nucleons : Near threshold J/ψ production provides information on the large-x gluon distribution
  - Short Range Correlation (SRC) : Near threshold J/ψ production provides information about the SRC effect on the production mechanism
  - Connection to the Gluonic EMC effect
  - Investigation of the sensitivity of the mean-field versus SRC-dominated configurations on the near threshold J/ψ production and their Q^2 evolution (quasi-real photons, moderate virtuality, electroproduction).

- **Feasibility simulation:**
  - Reconstruction of the J/ψ generated using realistic nuclear momentum distribution for different targets
  - Investigate the feasibility of detecting the required particles to reconstruct the J/ψ events
  - Extraction of the physics observables (Q^2, W, t, $d\sigma/dt$ etc) for different A targets