Study of quark-gluons in nuclei at EicC

The 11th Workshop on Hadron Physics in China and Opportunities Worldwide
Nankai University, Tianjin
August 22-28, 2019

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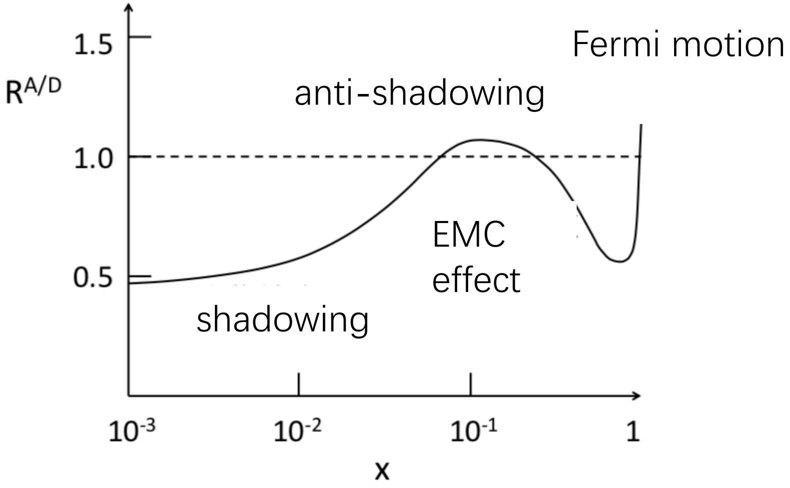
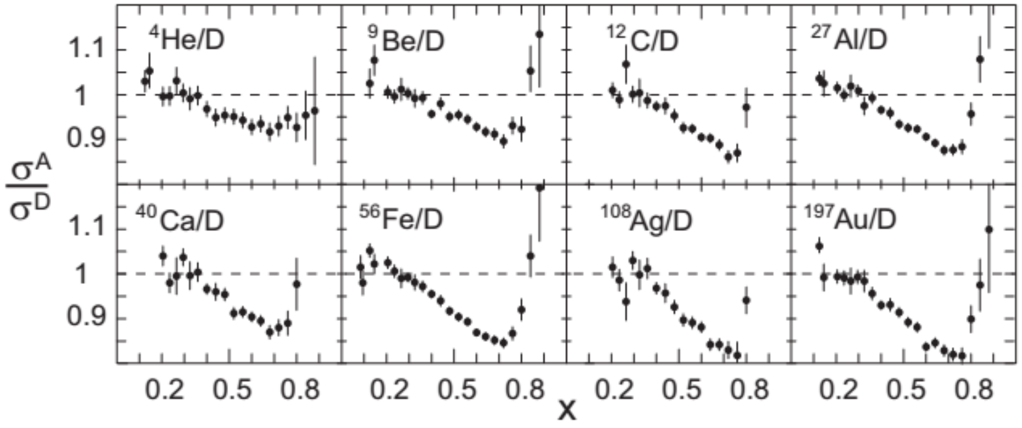
Nuclear medium modifications



$$R^{A/D}(x, Q^2) = \frac{F_2^A(x, Q^2)}{F_2^N(x, Q^2)}$$

Nuclear medium effects:

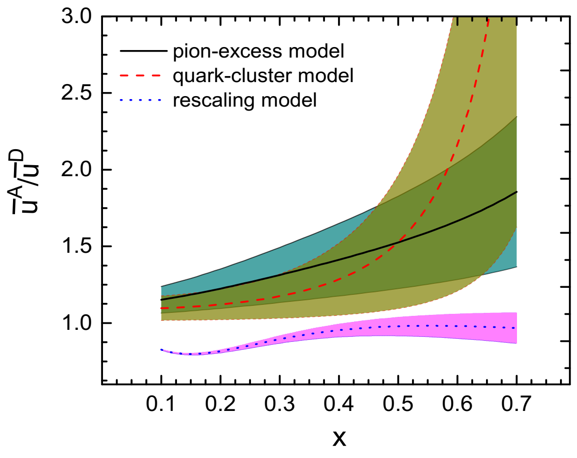
- x~0.01 shadowing region
- x ~0.1 anti-shadowing region
- 0.3<x<0.7 the EMC effect
- x>0.7 Fermi motion

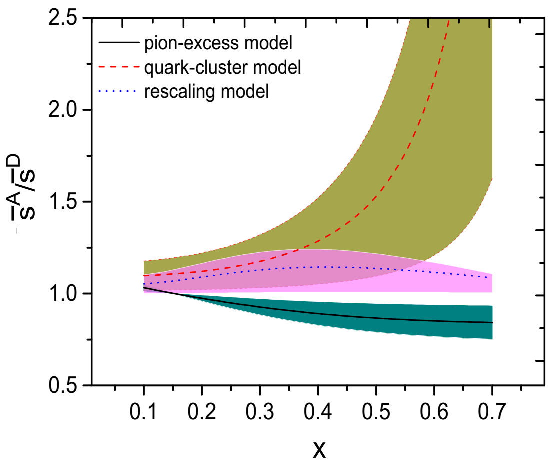


SLAC Data

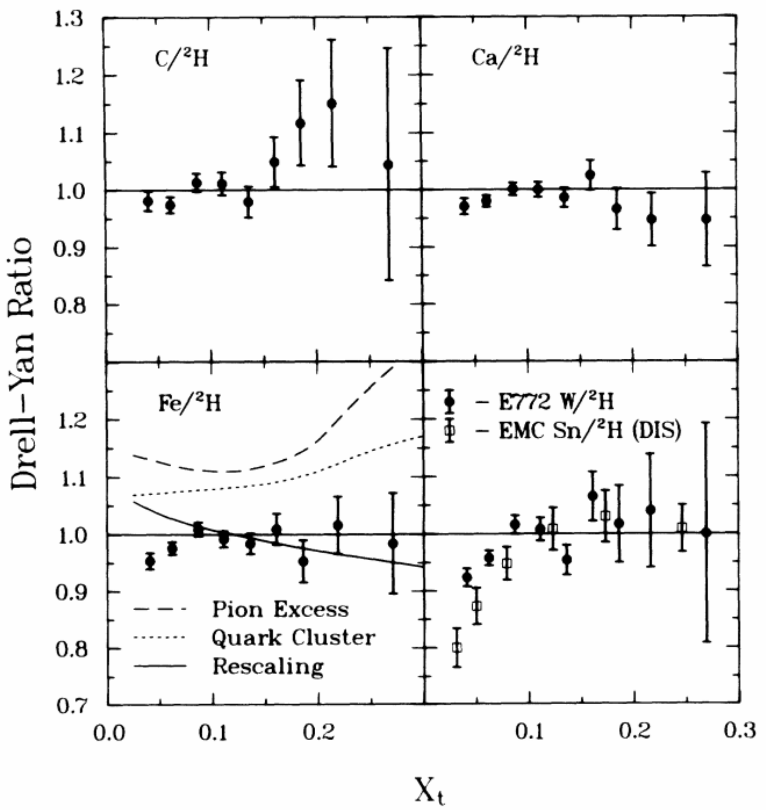
- The EMC effect: in the intermediate x region, the structure function of bound nuclei is smaller than that of free nucleons.
- In the QCD level, it can be understood that the valence quark distributions in nuclei are suppressed than those in free nucleons.
- Actually, the EMC effect reflects the nuclear medium modifications from both the valence quark and the sea quark.

Nuclear modification of sea quark distributions





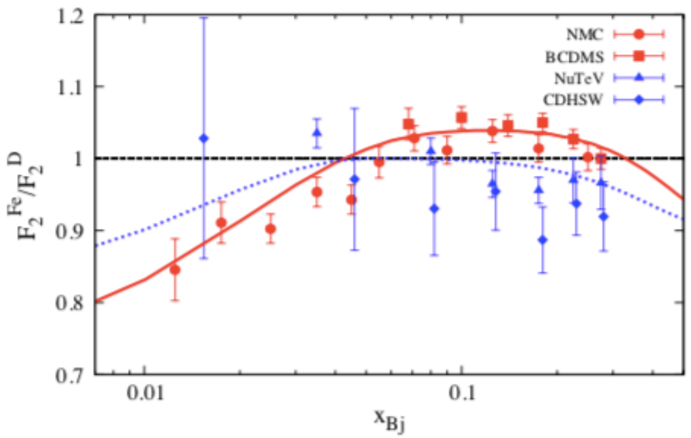
C. Gong and Bo-Qiang Ma. Phys. Rev. C 97, no. 6, 065207 (2018)



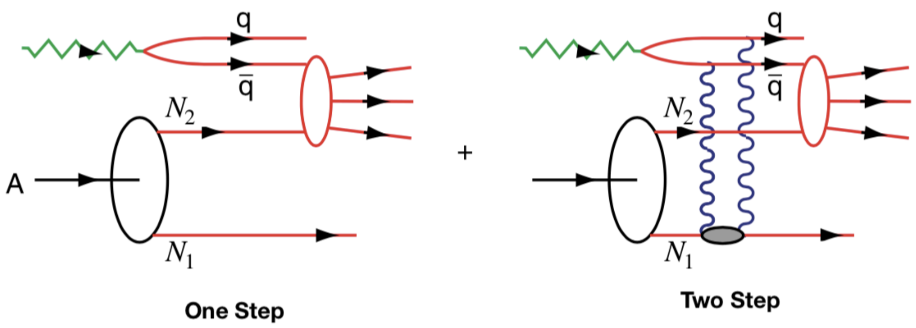
- In eA scatterings, there is little data about SIDIS processes and Drell-Yan processes, which are sensitive to the sea quark distributions in nuclei.
- The EicC facility can provide precision data in elestron-ion scattering processes at small x region. Combining measurements of final state production of several mesons or typical hadrons through SIDIS process in nuclei, we can accurately observe the nuclear modification effect of sea quarks in nuclei.

Anti-shadowing & shadowing

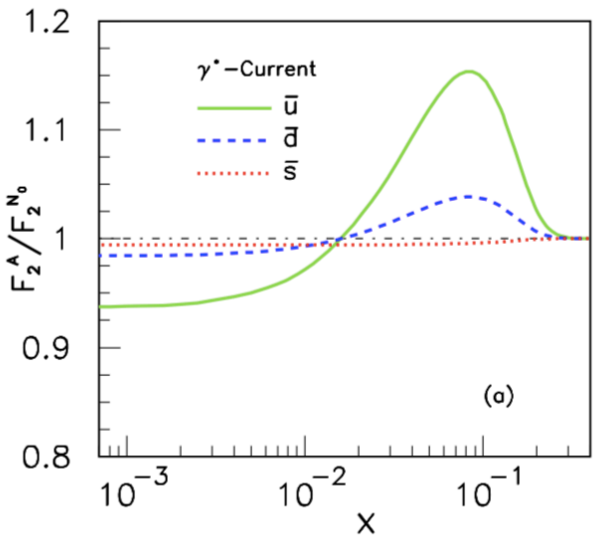
- In the Gribov-Glauber multiple scattering picture, the diffractive deep inelastic scattering (DDIS) lead to the anti-shadowing and shadowing of nuclear structure functions at small x region.
- Shadowing is greater for decreasing x and with increasing nuclear size



- The shadowing and anti-shadowing of nuclear cross section can be understood as a result of the constructive and destructive interference between two-step and one-step amplitudes in DDIS process

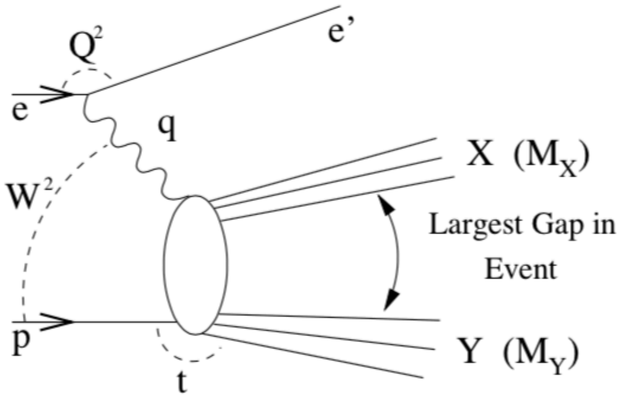


Stanley J. Brodsky et al. arXiv:1908.06317
Stanley J. Brodsky et al. Phys. Rev. Lett. 64,1342 (1990)



Stanley J. Brodsky, Ivan Schmidt, Jian-Jun Yang, Phys.Rev. D70, 116003(2004)

Diffractive deep inelastic scattering (DDIS)



- Diffractive deep inelastic scattering (DDIS) generally refers to the deep inelastic scattering process where the nucleon remains intact producing a large rapidity gap between the hard final state and the target
- Diffractive processes are generally understood to proceed through the exchange of a colourless object within the nucleon, generically called the pomeron
- The pomeron momentum is much smaller than the nucleon momentum
- x_P is the momentum fraction of the pomeron in the proton
- β is the momentum fraction of the struck quark within the pomeron

$$\frac{d\sigma^{ep}}{dydQ^2dtdM^2d\mathbf{k}^2} = \frac{\alpha_{em}}{yQ^2\pi}\left[\frac{1+(1-y)^2}{2}\frac{d\sigma_T^{\gamma^*p}}{dtdM^2d\mathbf{k}^2} + (1-y)\frac{d\sigma_L^{\gamma^*p}}{dtdM^2d\mathbf{k}^2}\right]$$

$$\frac{d^4\sigma_{diff}}{d\beta dQ^2dx_pdt} = \frac{2\pi\alpha^2}{\beta Q^4}\left[\left(1+(1-y)^2\right)F_2^{D(4)} - y^2F_L^{D(4)}\right]$$

$$\beta = \frac{Q^2}{Q^2+M^2} \qquad M^2 = (q + x_P P)^2$$

$$x_P = x_{Bj}/\beta \qquad x_{Bj} = Q^2/2P\cdot q$$

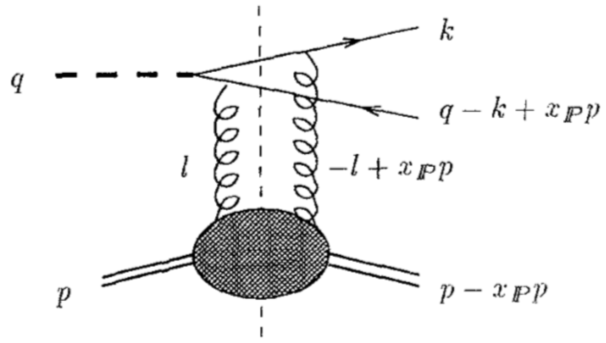
$$F_2^{D(3)}(\beta, Q^2, x_P) = \int F_2^{D(4)}(\beta, Q^2, x_P, t)dt$$

$$\frac{d^3\sigma_{diff}}{d\beta dQ^2dx_p} = \frac{2\pi\alpha^2}{\beta Q^4}\left(1+(1-y)^2\right)F_2^{D(3)}\left(\beta, Q^2, x_p\right)$$

Diffractive deep inelastic scattering (DDIS)

- At HERA, DDIS in $\gamma^{*}N \rightarrow NX$ reactions has been observed to be approximately 10% of DIS events

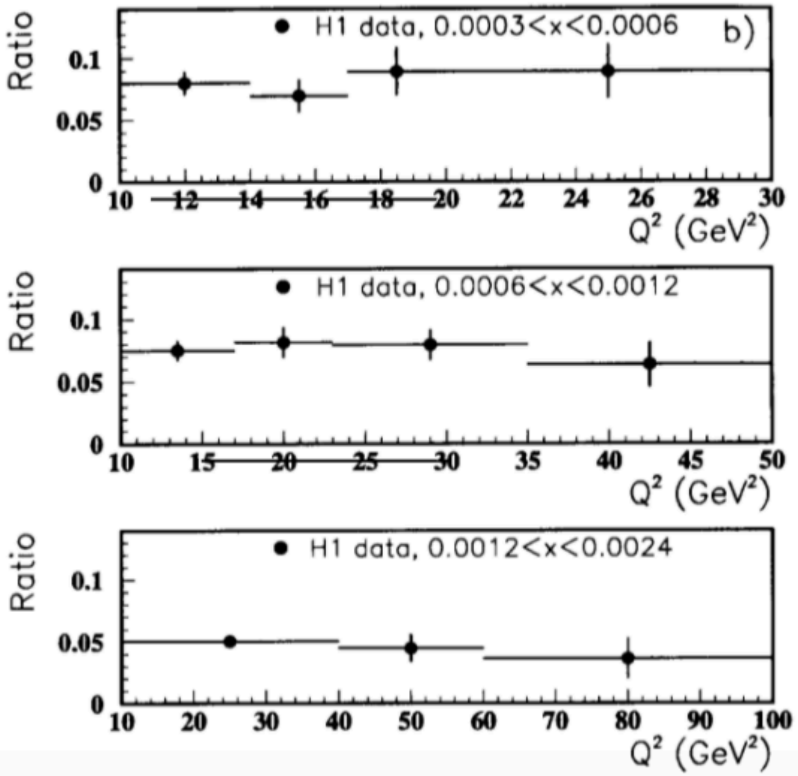
  -H1 Collaboration. Nucl. Phys. B 429, (1994) 477



L. Stodolsky Phys. Lett. B325. 505 (1994)

$$\frac{d^4\sigma_{eA\to eXA}}{dx_B dQ^2 dx_p dt} = A \cdot \frac{4\pi\alpha_{em}^2}{xQ^4}\left\{1 - y + \frac{y^2}{2\left[1 + R_A^{D(4)}\left(\beta, Q^2, x_p, t\right)\right]}\right\} \times F_{2,A}^{D(4)}\left(\beta, Q^2, x_p, t\right)$$

- The A-dependence of the diffractive structure function will give very useful information about the universality of the structure of the Pomeron.

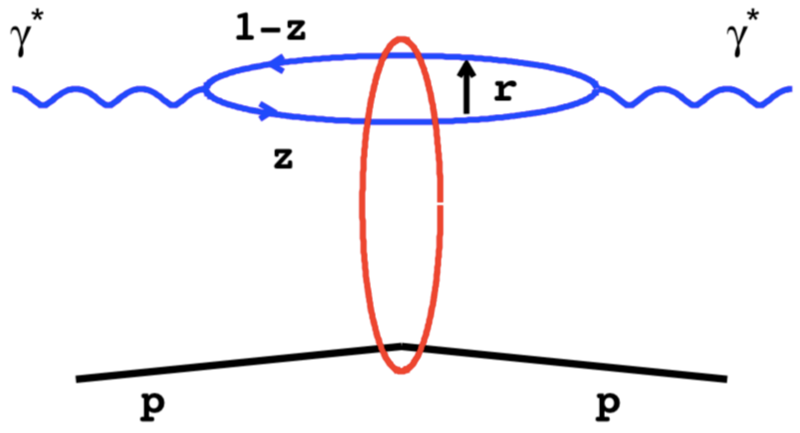


-H1 Collaboration. Nucl. Phys. B 429, (1994) 477

Exclusive vector meson production in DDIS

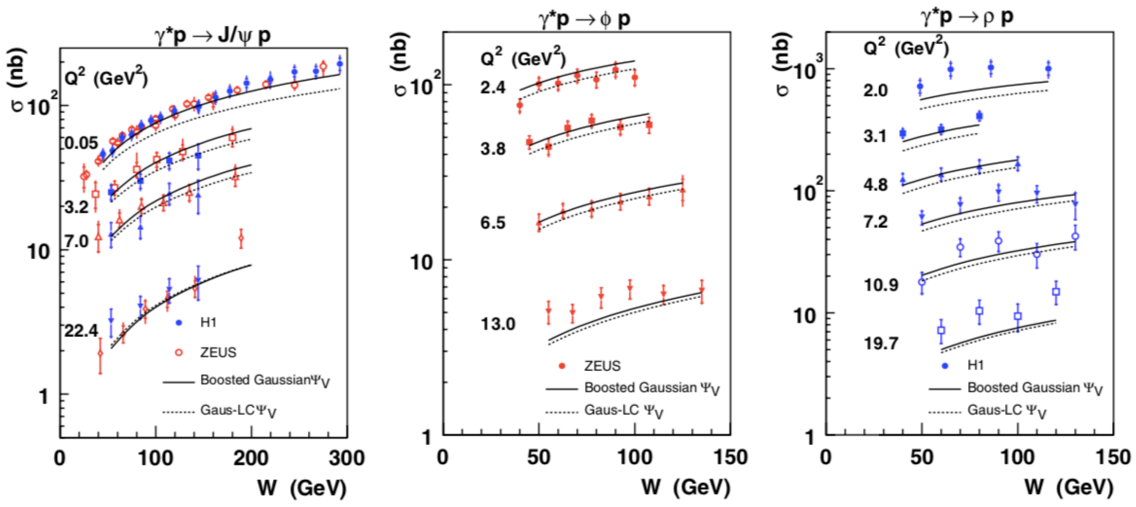
$$\gamma^* p \to Vp$$

- This process can be well described within a QCD dipole approach. In the dipole picture, deep-inelastic scattering is viewed as the interaction of a color dipole, that is mostly a quark-antiquark pair, with the proton.



Henri Kowalski, Phys. Rev. D68. 114005 (2003)

- First, the incoming virtual photon fluctuates into a quark-antiquark pair, then the quark-antiquark pair elastically scatters on the proton, and finally the quark-antiquark pair recombines to form a virtual photon.



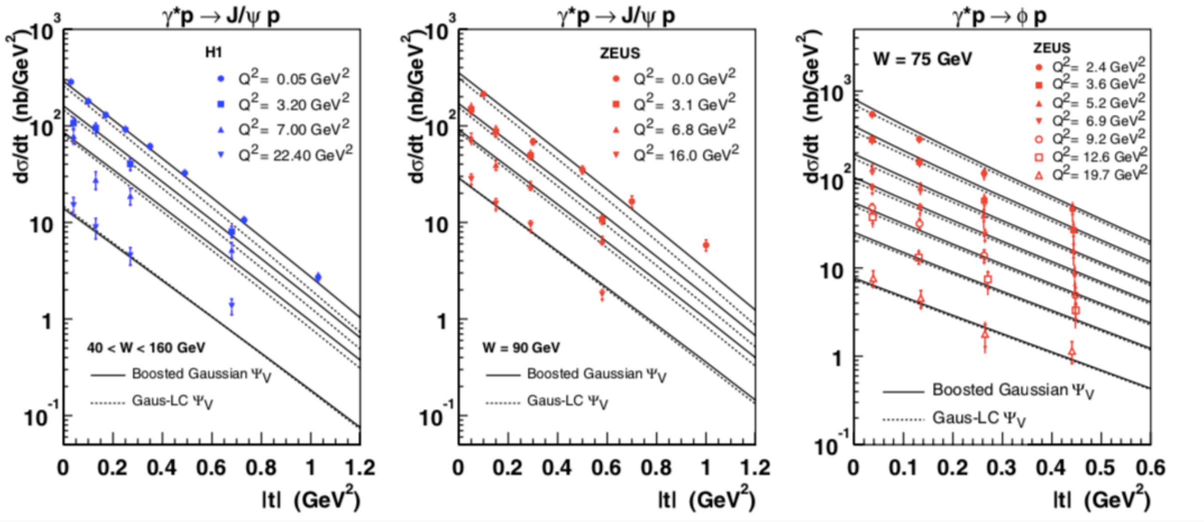
H. Kowalski, L. Motyka, and G. Watt, Phys.Rev.D74.074016

- The wave function that the virtual photon fluctuates into a quark-antiquark pair
- The scattering amplitude of the quark-antiquark pair on the target (the dipole cross section)
- The wave function give the amplitude for the scattered quark-antiquark pair with flavor f to become a vector meson

- Diffractive vector meson leptoproduction can provide basic information of the gluon distribution in nuclei.

Exclusive vector meson production in DDIS

$$\gamma^* p \to V p$$



H. Kowalski, L. Motyka, and G. Watt，Phys.Rev.D74.074016

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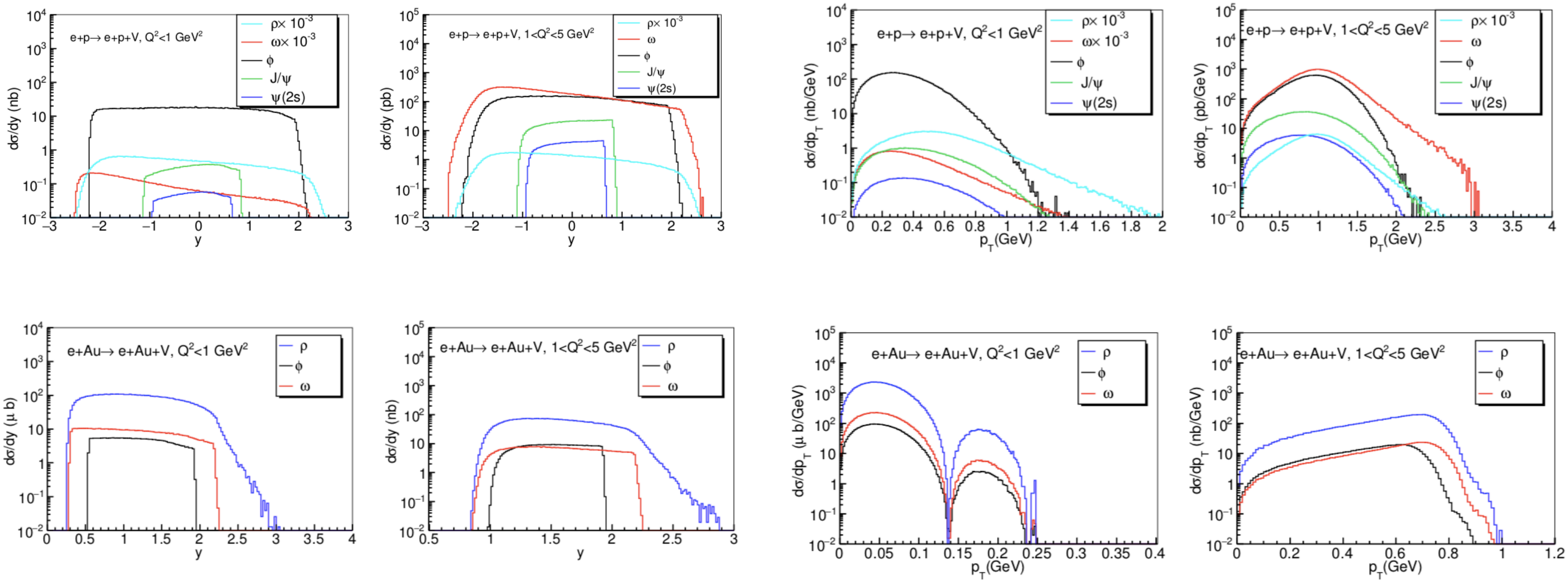
Simulations of diffractive vector production in ep and eA collision at EicC



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The eP/eA scattering at EicC

- The high luminosity of the EicC will increase magnitude of final states in DIS scattering off nuclei at high energies. The measurements of final state production of several mesons through SIDIS process can help us for investigating the nuclear modification effect of sea quarks in nuclei.
- The advantage of large cross sections at x~0.1 region can help us exploring the nuclear anti-shadowing

Thanks !