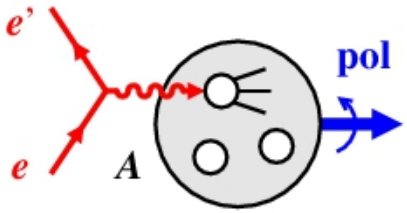
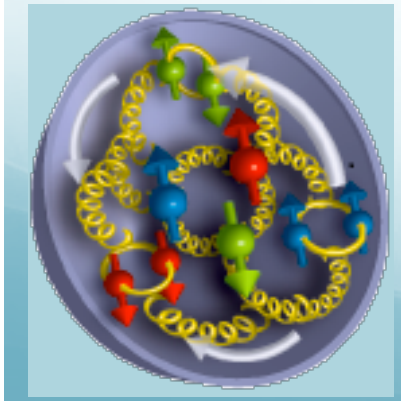


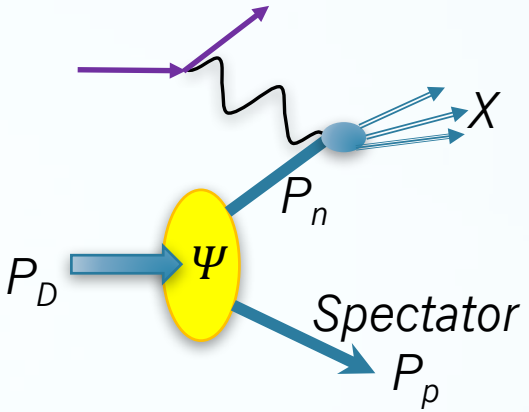
Polarized Light Ion Physics with EIC
5–9 Feb 2018, Ghent, Belgium

Spectator Tagging with the Electron Ion Collider

Charles Hyde
Old Dominion University



Light-Cone Variables



$$P_D^{[+,-,\perp]} = \left[P_D^+, \frac{M_D^2}{2P_D^+}, \mathbf{0}_\perp\right], \qquad P_D^+ \gg M_D = 2M_N - B;$$

$$p_S = p_p^{[+,-,\perp]} = \left[\frac{\alpha}{A}P_D^+, \frac{M_N^2 + \mathbf{p}_\perp^2}{2\alpha P_D^+/A}, \mathbf{p}_\perp\right], \qquad 0 < \alpha < A = 2;$$

$$p_n^2 = (P_D - p_p)^2 \equiv t$$

$$M^2 - t = M_N^2 \frac{2}{\alpha}(1-\alpha)^2 + \mathbf{p}_\perp^2 \frac{2}{\alpha} + (2-\alpha)\left(2M_N B - \frac{B^2}{2}\right) > 0$$

$$\rightarrow \left(2M_N B - \frac{B^2}{2}\right) = 0.004 \text{ GeV}^2 \text{ as } \mathbf{p}^2 \rightarrow 0,\ \alpha \rightarrow 1.$$

$$\alpha \approx 1 + \frac{p_z^{\text{Rest-frame}}}{M}$$

$$|\alpha - 1| \lesssim p_F$$

Collider Kinematics

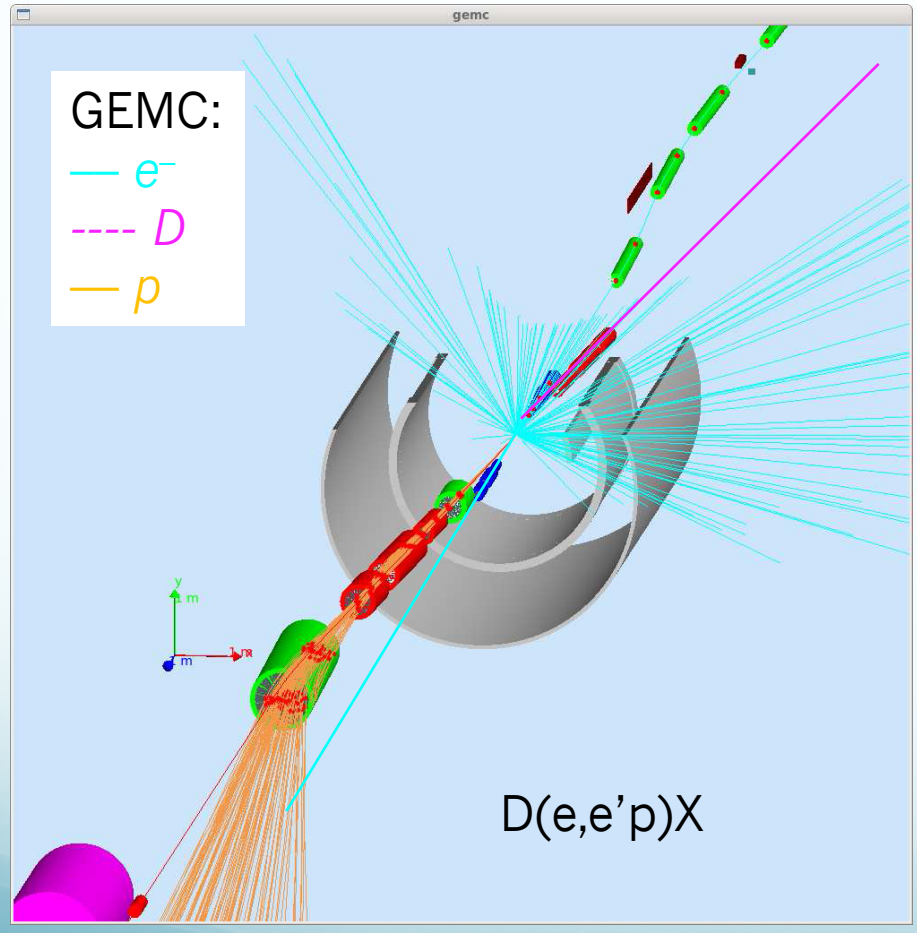
- Natural light-cone direction is event-by-event frame with **q** and $\mathbf{P}_D$ anti-collinear.
  - Spectator proton (or neutron) emitted in forward direction with ~ 50% of beam momentum
- Beam emittance envelope is comparable to Far-Forward tracking resolution of spectator proton
- Both effects (and crossing angle) included in *e D* → *e´ p X* Monte-Carlo (Jlab LDRD 2014).

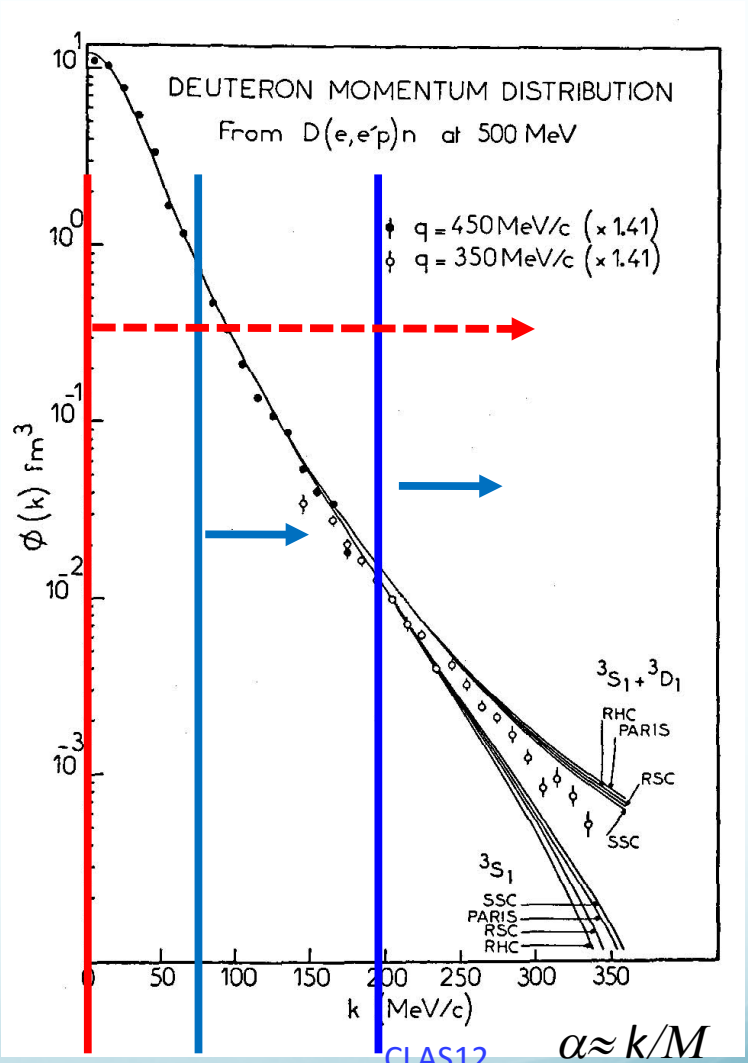
Beam Emittance & Detector Resolution

- Beam emittance envelope
  - $\sigma(P_D)/P_D \approx 3 \cdot 10^{-4}$, $\sigma(P_\perp)/P_D \approx 2 \cdot 10^{-4}$
- Spectator tracking resolution
  - $\sigma(x) \approx 100\mu m$, Dispersion $\approx 1m$
  - $\sigma(P_{||}, P_\perp)/P_p \leq 2 \cdot 10^{-4}$
  - Lower $\sqrt{s}$ gives better spectator resolution
    - $P_D = 100$ GeV/c
      - $\sigma(p_\perp) \approx 15$ MeV/c
      - $\sigma(\alpha) \approx 0.0002$

Detector implementation

- JLEIC example

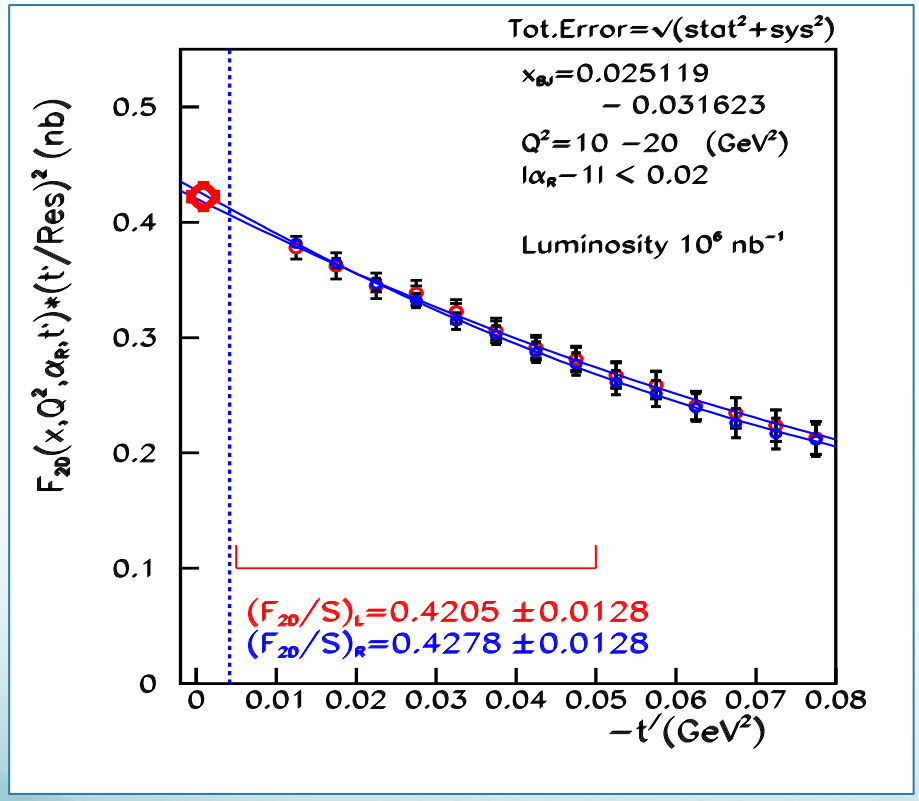


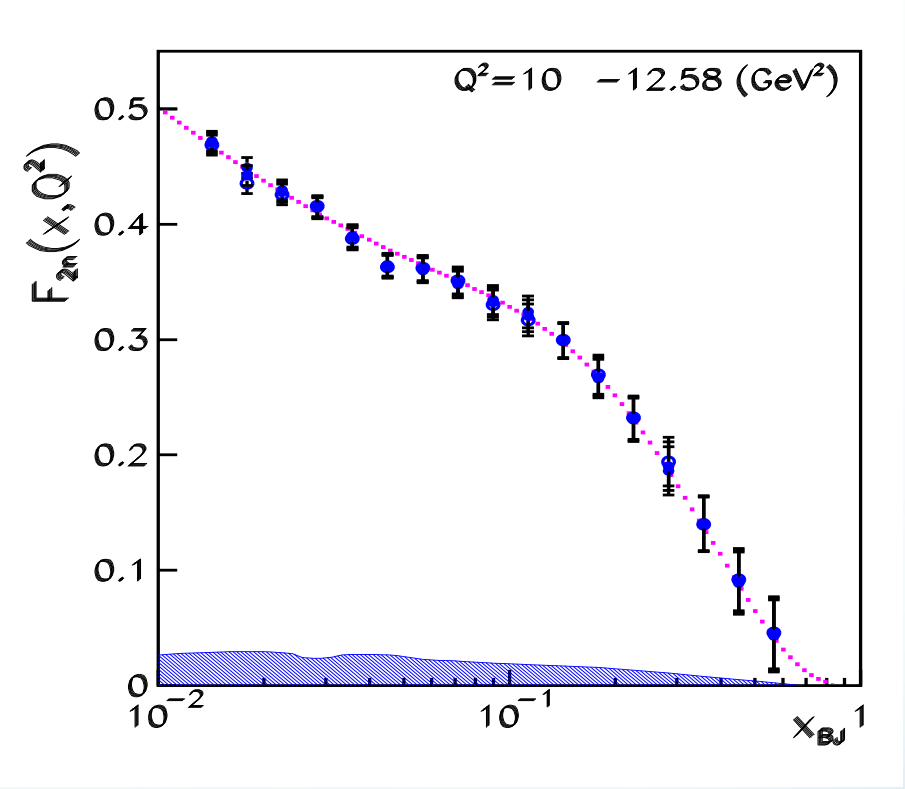


EIC CLAS12 + BoNuS12/ ALERT

Neutron F2

- On-shell extrapolation

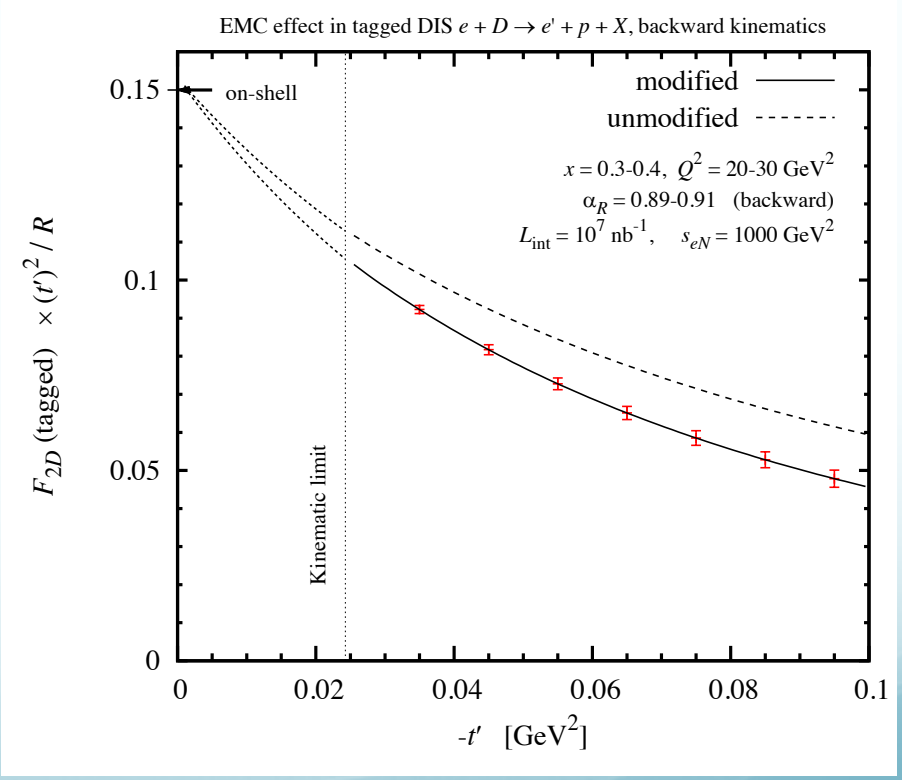




One (small) bin in Q^2

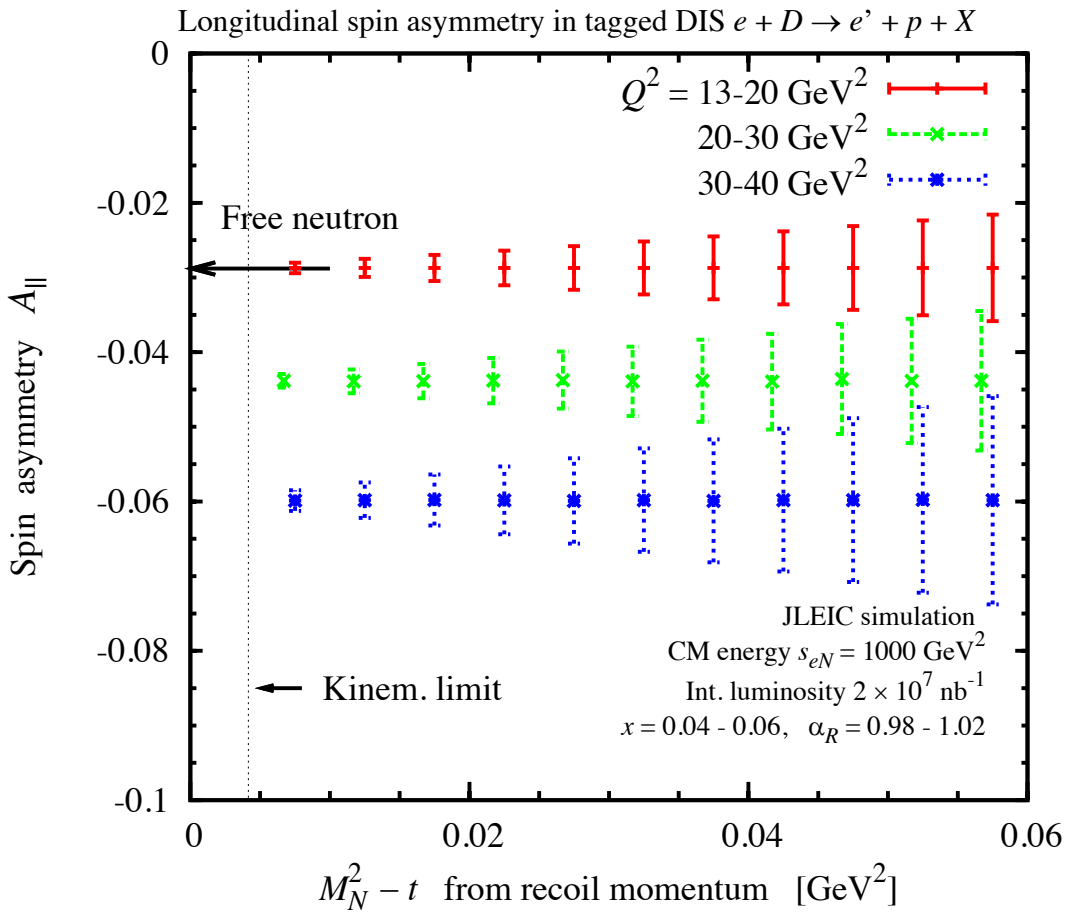
The EMC Effect in the Deuteron

- Concept: EMC effect arises from short range fluctuations in D wave-function
- Extract on-shell point for $|\alpha-1|<0.02$
- Dashed line is IA for $\alpha = 0.9$
- Pseudo-data shows possible magnitude of EMC effect



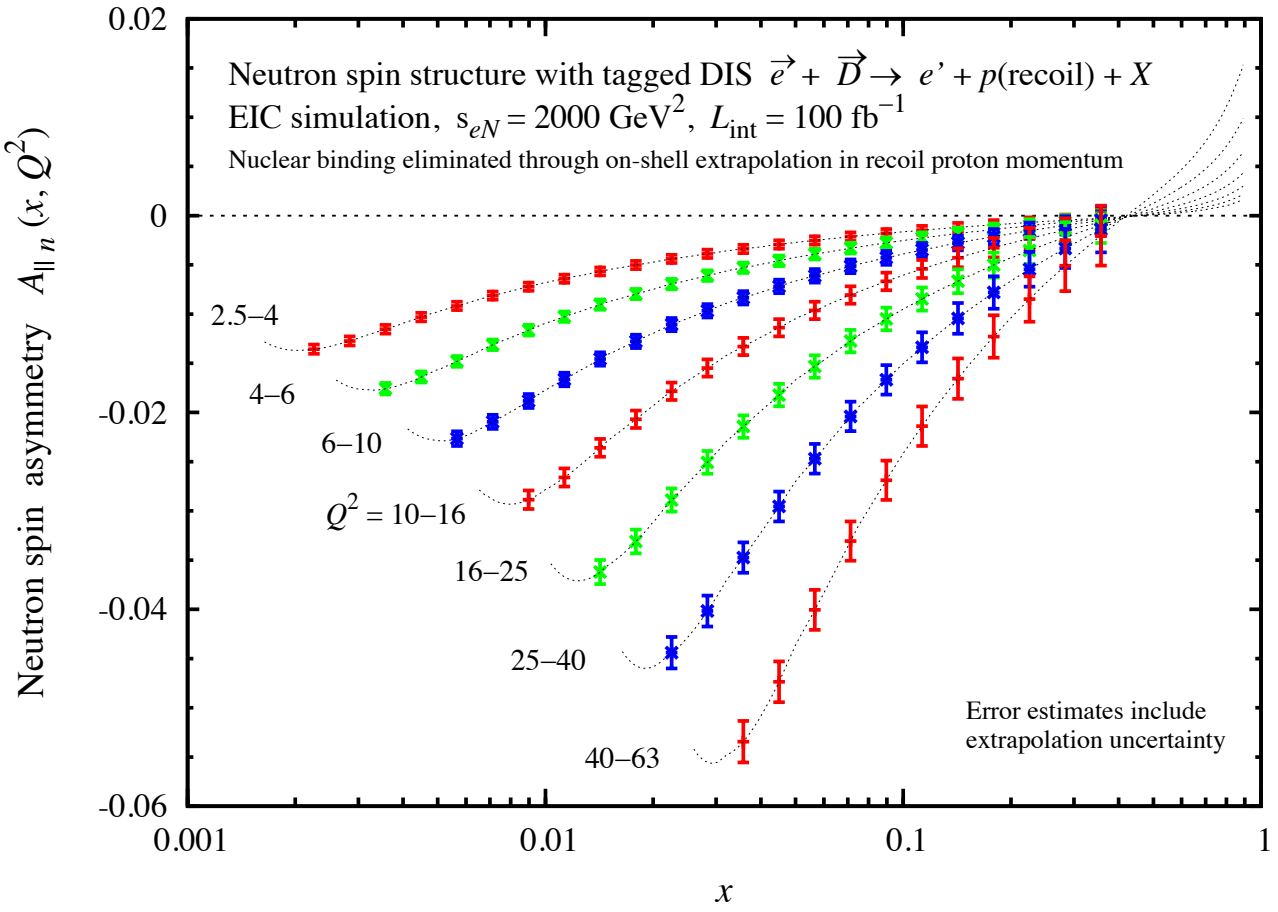
Polarization: On-Shell Extrapolation

- S-state only
  - Asymmetry independent of *t*.
- D-state coming soon (MS, CW)



Polarization

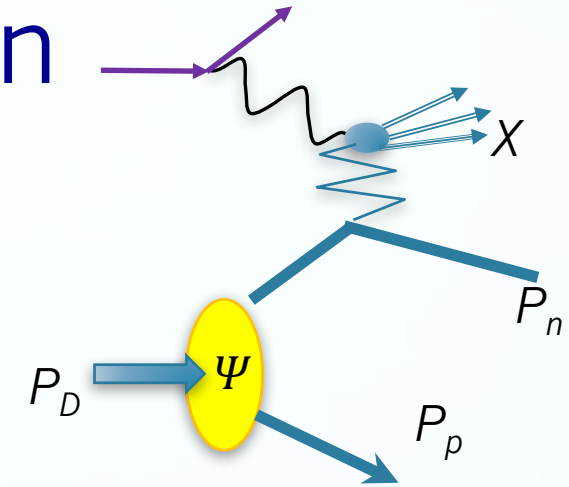
- 1 year @ $10^{34}/cm^2/s$
- Depolarization favors lower energy:
  $D = y(2-y)/(2-2y+y^2)$
- $p \pm n$
  - flavor
  - Bjorken Sum Rule
  - $\alpha_S(Q^2)$



(A.D.)^2

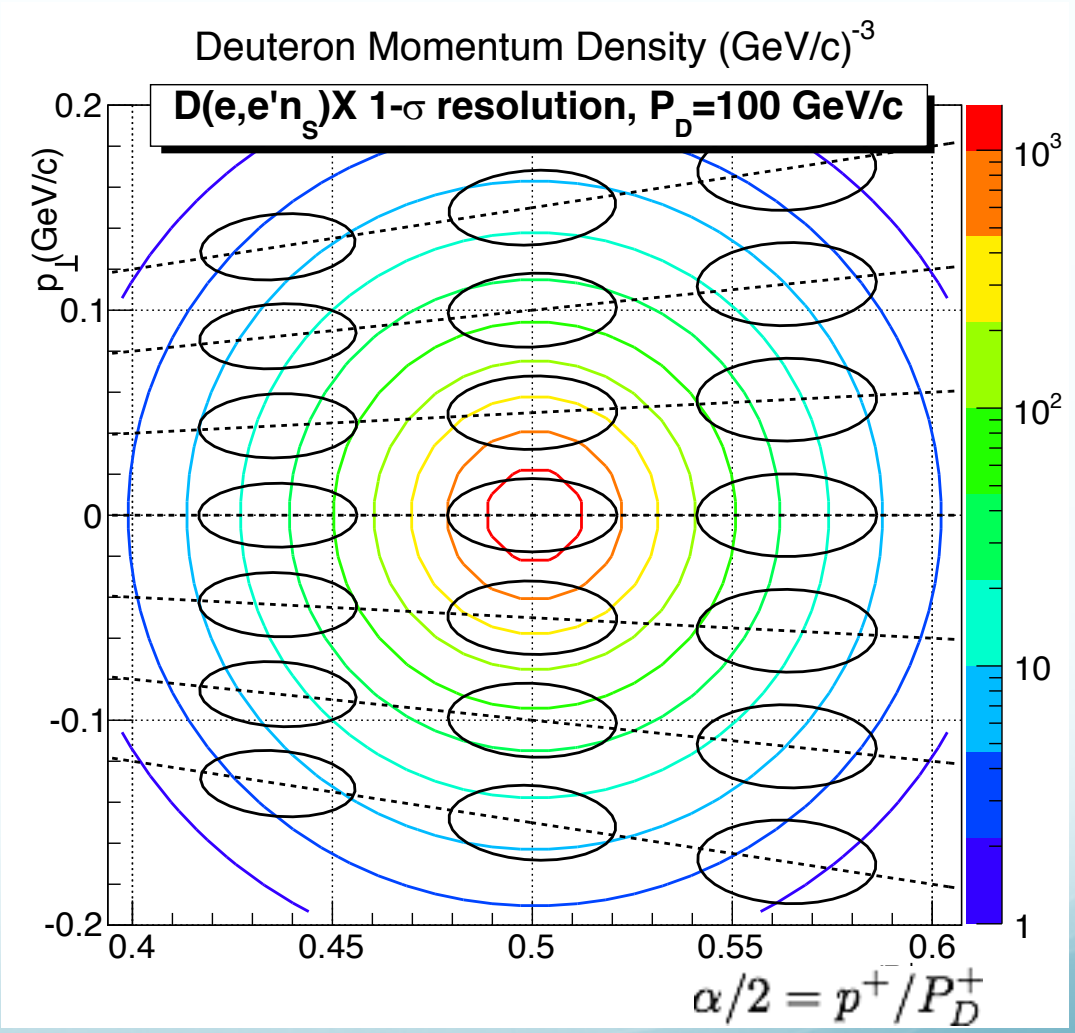
Diffraction, (Anti-)Shadowing, NN interaction

- D(e,e' pn)X, D(e,e'Vpn)
- Detect final state neutron in ZDC
- V. Guzey, next talk



DIS from Bound Proton

- Tag spectator neutron
  - D(e,e'n) X
  - State-of-the-art HCal $\sigma(E)/E \gtrsim 30\%/\sqrt{E}$ NIM A 866 (2017) 76.
- 3 contours/decade in D momentum distribution.
- Ovals are 1-σ envelope of tagged neutron resolution.



Conclusions

- EIC can study deuteron with unprecedented precision
  - Polarization without target dilution
  - Spectator tagging to $p_S = 0$
  - Tensor Polarization
  - EMC effect
    - Exotic components
  - Coherent D imaging: eD→ eDV (over-complete exclusivity).

Deuteron: NIJM-II, NN-Online.org