



APCTP
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Imaging protons, neutrons, and nuclei with an Electron Ion Collider

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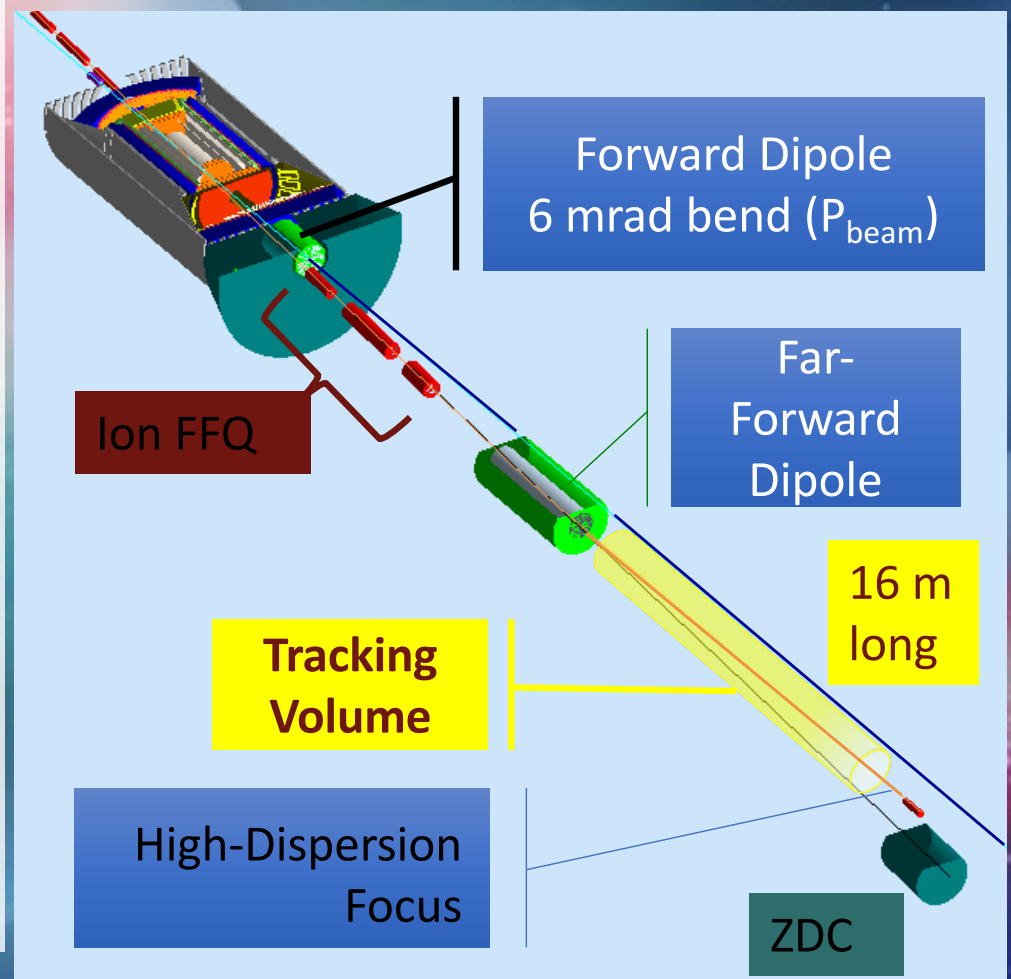
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Spatial Imaging with the EIC

- Improved neutron DVES via tagging of spectator proton over full range of Deuteron wave-function
- Precision DVES measurements with transverse polarized targets
- Exclusive DVES on nuclei
- Low- x_B , high Q^2 : Imaging gluons and the quark-sea in the nucleon and in nuclei
 - n-p density differences in $N>Z$ nuclei \cong u-d differences in GPDs of $N>Z$ nuclei
 - Equation of State of nuclear matter and neutron stars

Exclusive $ep \rightarrow e p \gamma$

- Detect final proton, with momentum $\sim (1-x_B)p_{\text{Beam}}$ (almost lost in beam).
- Ion FFQ acceptance
 - $\Delta p_{\parallel} / p \sim \pm 50\%$
 - $\Delta p_{\perp} / p \leq 8 \text{ mrad}$
- “Beam Stay Clear” (BSC) = detection limit
 - Secondary focus $z = 40 \text{ m}$
 - BSC
 - $|\delta p_{\parallel, \perp}| / p > 0.003$



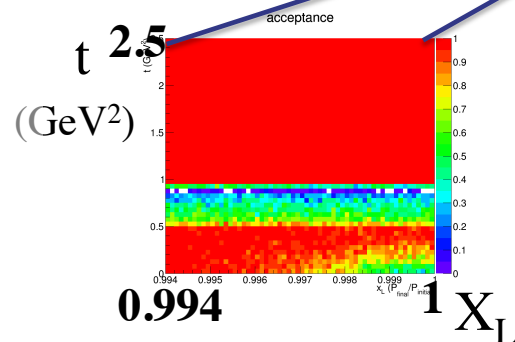
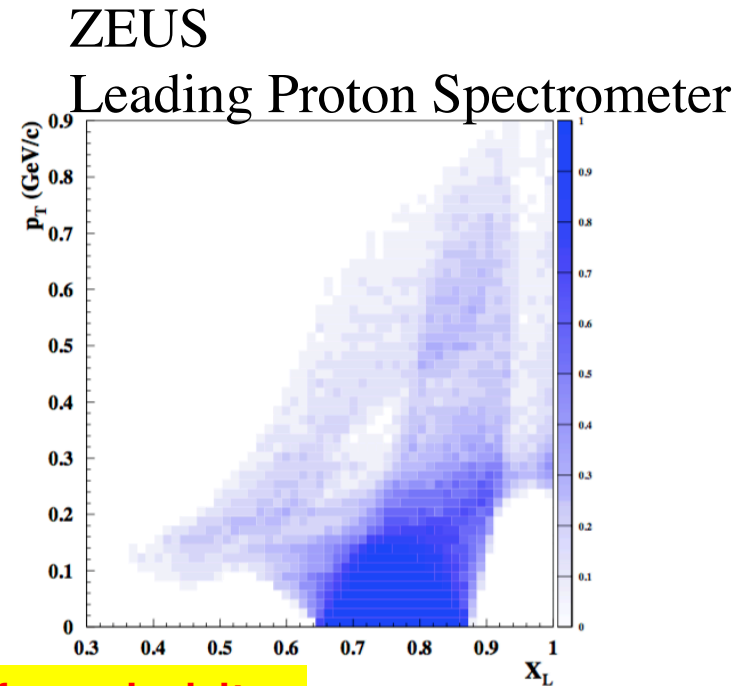
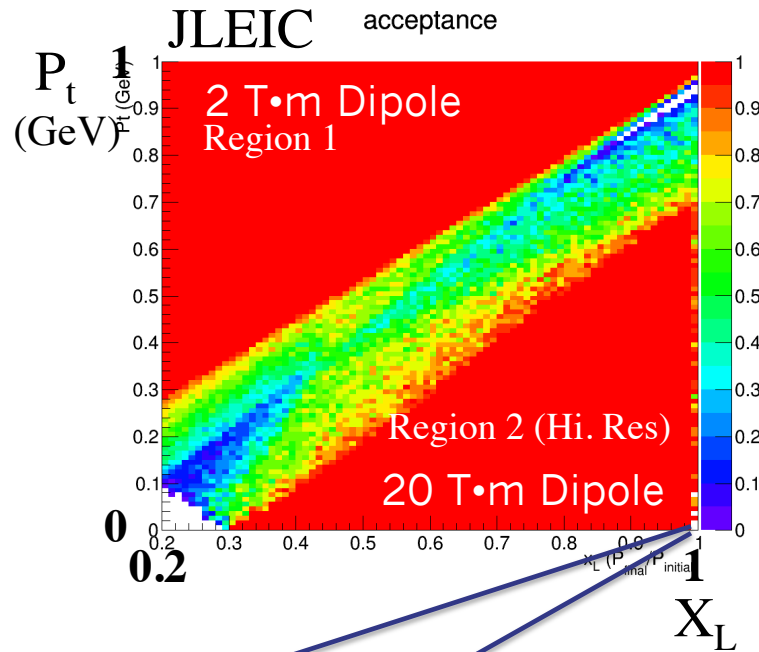
Diffractive DIS and DVES: gaining a factor 5000.

- EIC Luminosity \otimes Acceptance = HERA \times (100x50)

- Full proton detection acceptance to “Beam-Stay-Clear (BSC)” limit of $\sim 10 \times$ rms emittance:

- JLEIC:
 $\theta_p > 3$ mrad
 OR
 $|\Delta p_L/p_0| \approx x_{Bj} > 0.003$

Acceptance for p' in DDIS/DVES



Tagging essential for exclusivity

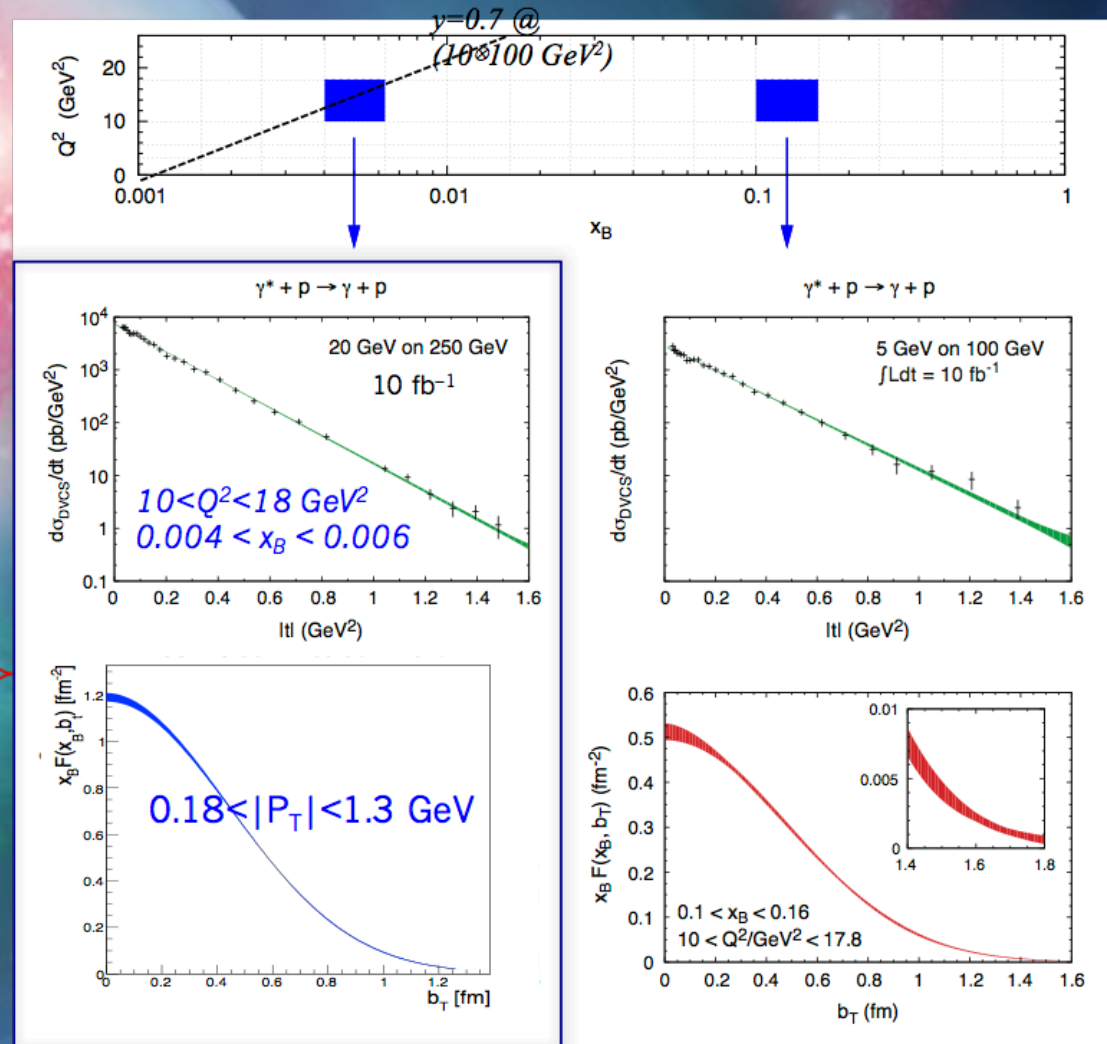
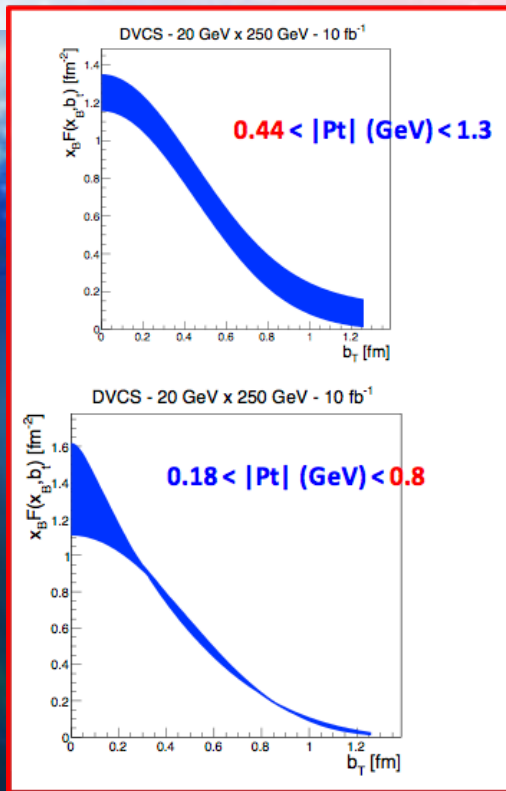
Acceptance in diffractive peak ($X_L > \sim .98$)

ZEUS: $\sim 2\%$

JLEIC: $\sim 100\%$

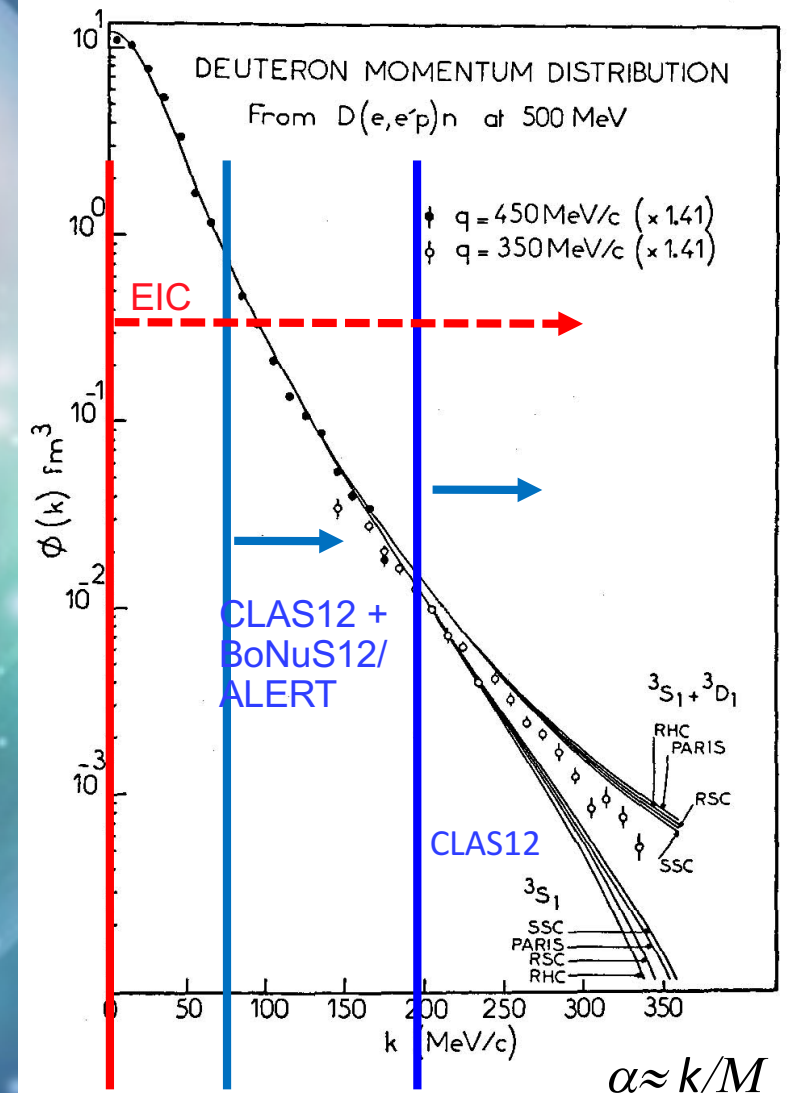
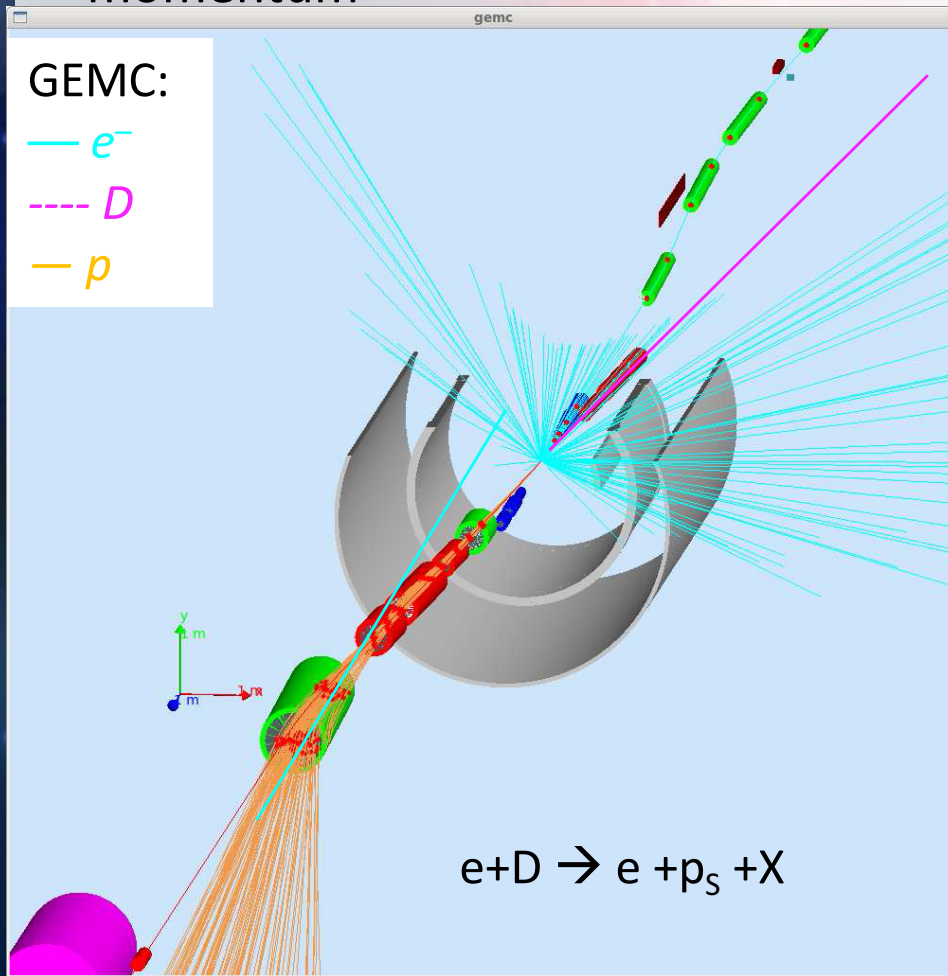
DVCS on the Proton at the EIC: Transverse Imaging vs x_B

- Tagging the recoil protons over the full momentum range is essential for precision imaging
- Repeat with L & T polarized beam




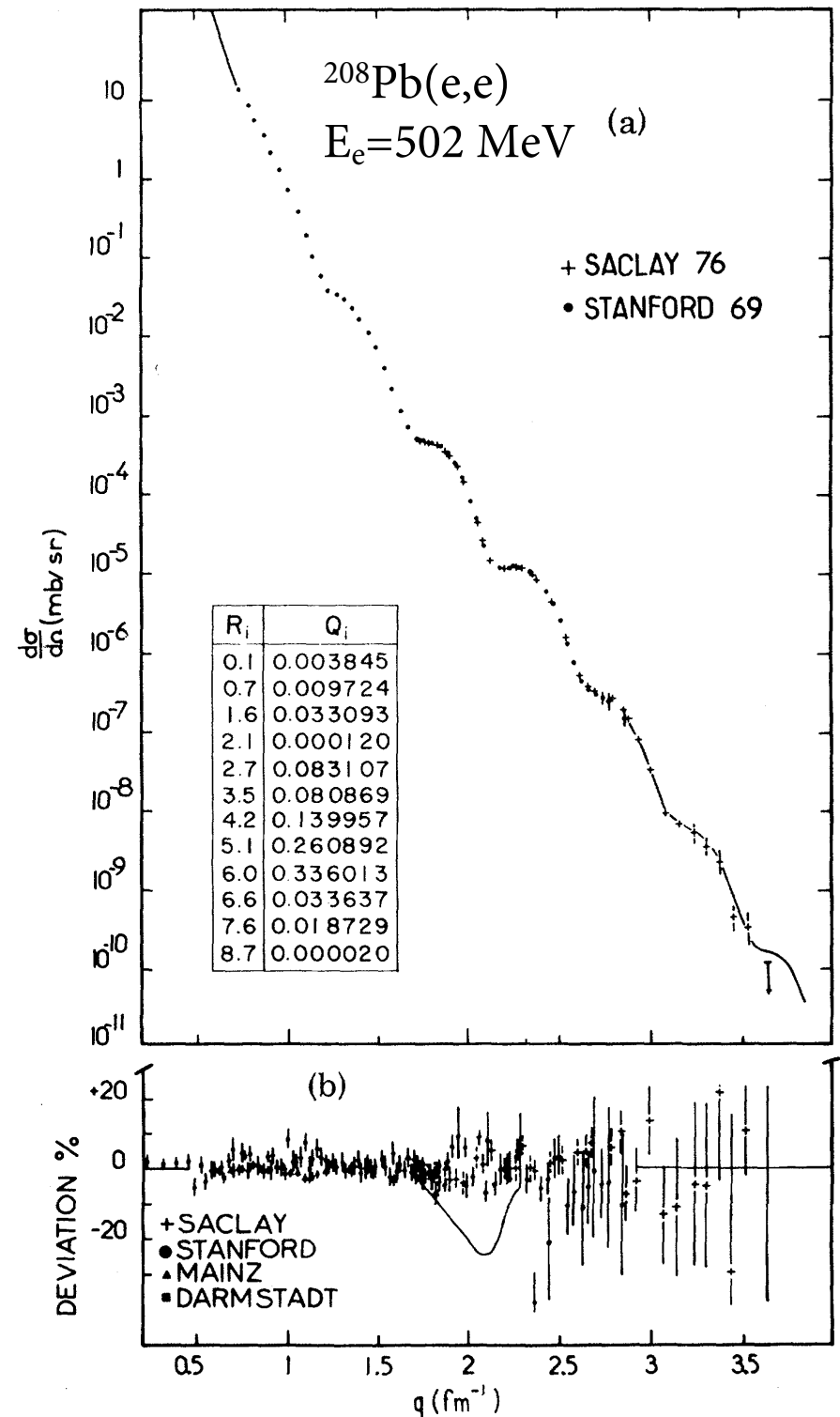
Deep Exclusive Scattering on the neutron $e+D \rightarrow e + p_s + V$

- Spectator proton has $\sim 50\%$ of beam momentum



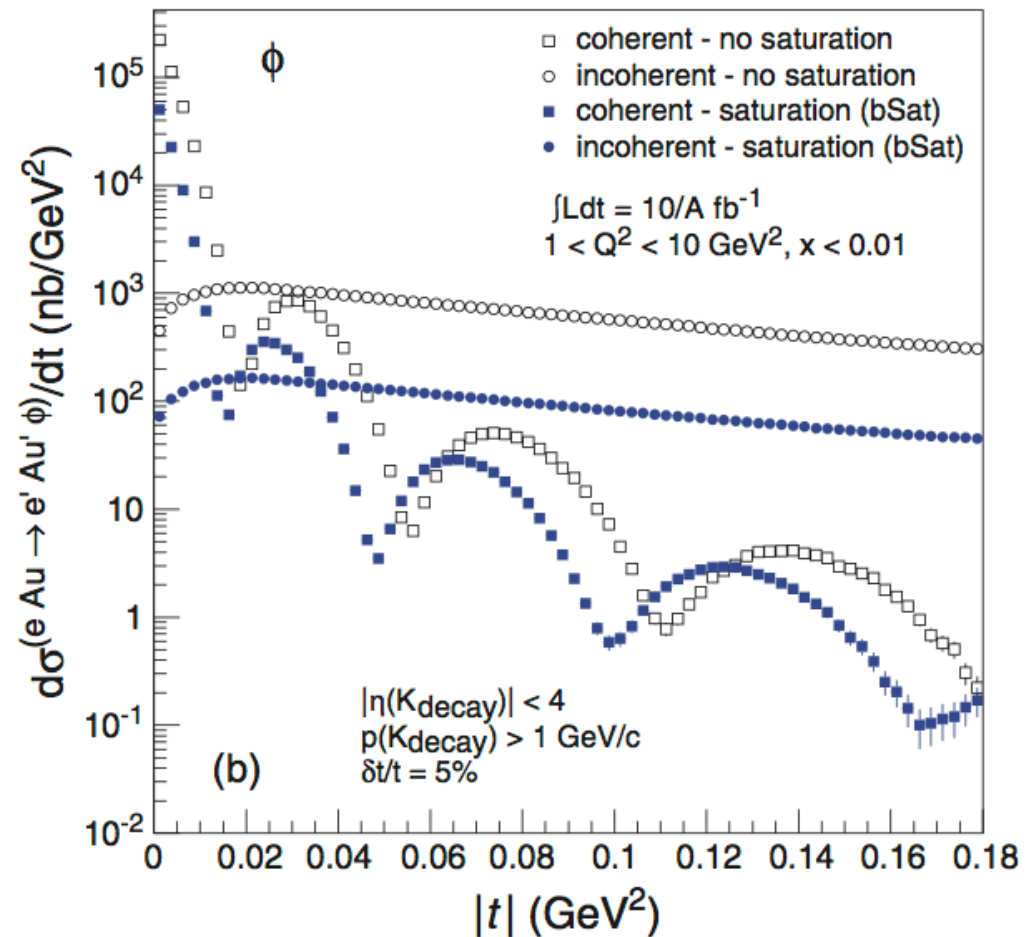
DVES on Nuclei

- Precision charge densities measured in 1970s 
- “Neutron Skin” of heavy nuclei has implications for nuclear equation of state & neutron star structure.
 - $p-n \cong u\text{-quark} - d\text{-quark}$
 - ρ, ω : DVES amplitude has charge weight $e_u \mp e_d$.
 - $q + q\text{-bar}$
- Gluon profiles of nuclei from $e+\text{Pb} \rightarrow e+\text{Pb} + V$:
 - $V = J/\Psi$ or ϕ



Gluon Imaging of Nuclei: Deep- ϕ

- Luminosity per nucleus $\sim 1/A$.
- $d\sigma/dt(t=0) \sim A^2$
- $|t| \approx \Delta_{\perp}^2$ resolved by ${}^A Z(e, e' K^+ K^-) X$ kinematics
- Recoil nucleus lost in 10σ Beam envelope
 - Break-up channels vetoed by ZDC & forward trackers



EIC Users Group: www.eicug.org

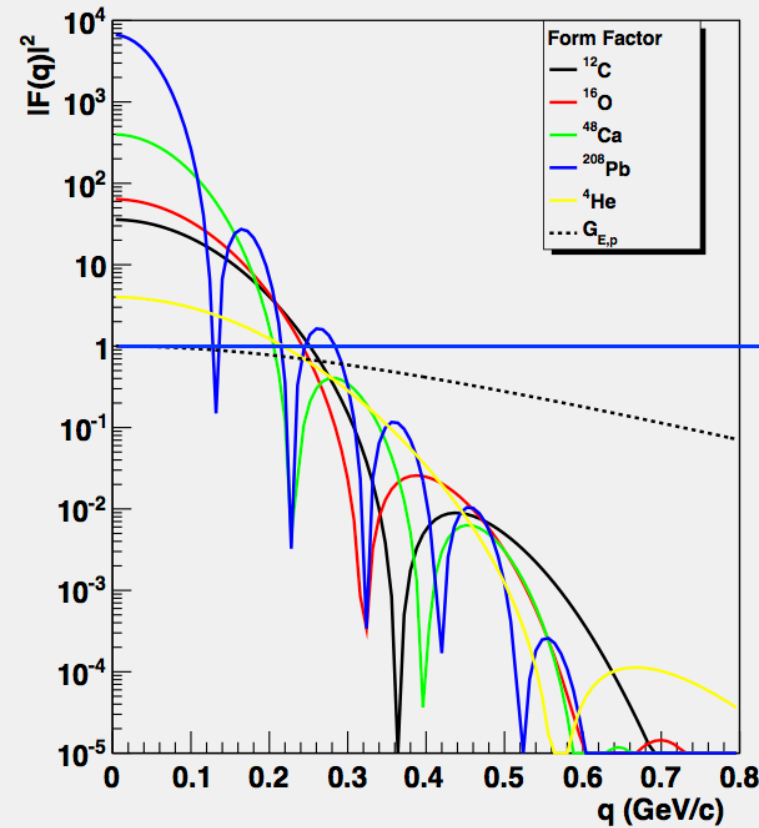


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Nuclear DVES and Exclusivity: ^{208}Pb

- Unresolved bound-excited states smooth out diffraction pattern.
 - $3^-(2.6\text{MeV})$,
 - $5^-(3.2\text{ MeV})$,
 - $2^+(4.1\text{MeV})$,
 - $4^+(4.3\text{MeV})$
- In DVES@EIC, γ -cascade boosted ($\times 40$ JLEIC, $\times 100$ eRHIC)
- High Resolution (PbWO_4) forward EMCAL can veto ($\sim 50\%$) $E_\gamma > 100\text{ MeV}$

Fourier-Bessel Charge Form Factors



- Doubly Magic nuclei, bound-state decay-energies are large

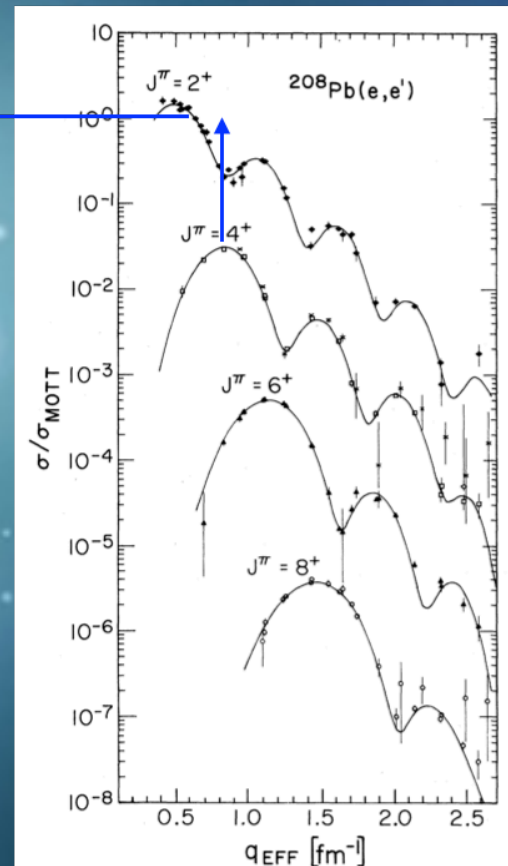


FIG. 3. Cross section for the even spin natural parity states in $^{208}\text{Pb}(e,e')$ divided by (the cross section for a unit-point charge). Data and best fit for the 4^+ level are scaled down a factor of 0.03, for the 6^+ level a factor of 0.001, and for the 8^+ level a factor of 0.00003.