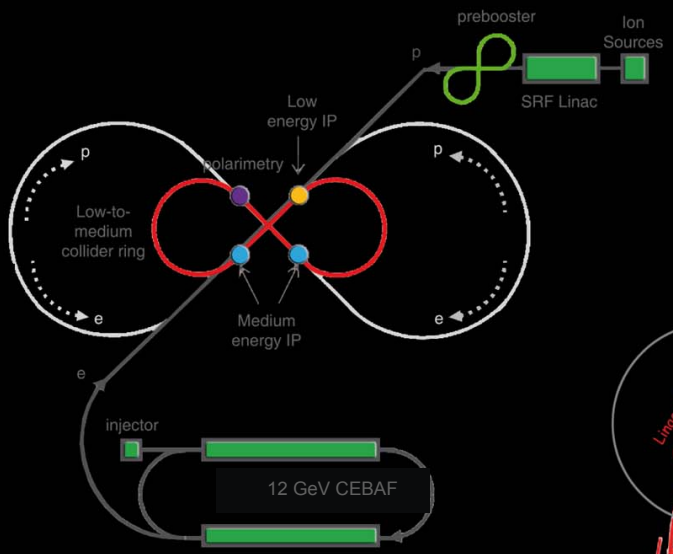
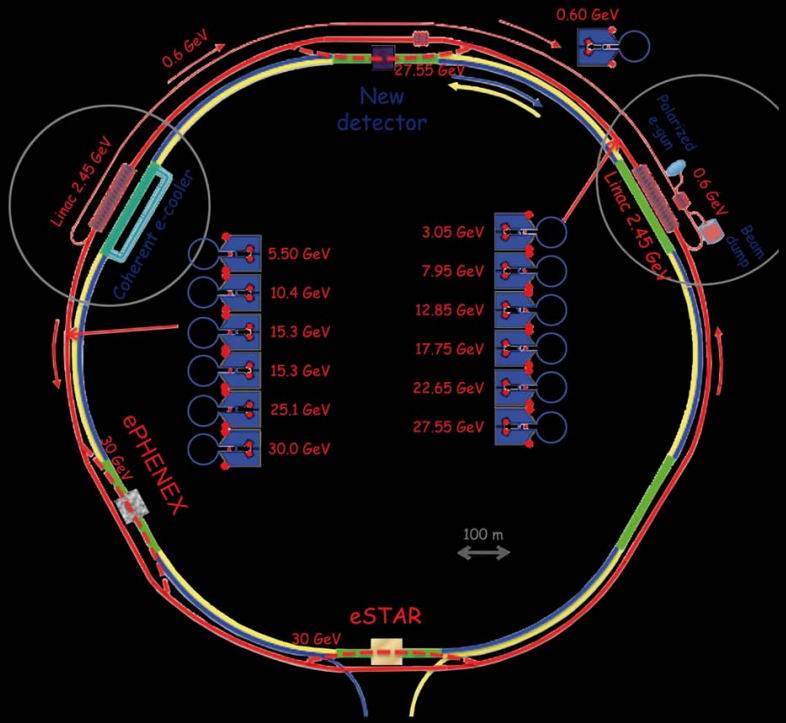
From JLab12 to EIC



From: Nuclear physics with a medium-energy Electron-Ion Collider
by A. Accardi et al.



R. D. McKeown

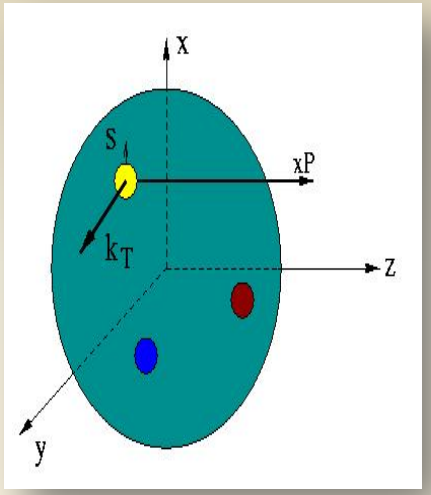
POETIC 2012
Indiana University

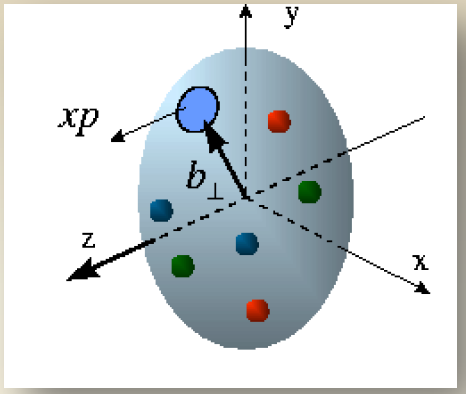
Jefferson Lab
Thomas Jefferson National Accelerator Facility

Unified View of Nucleon Structure

$W_p^u(x,k_T,\boldsymbol{r})$ Wigner distributions

6D Dist.





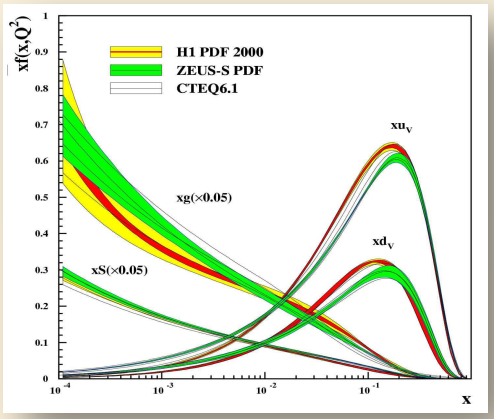
$d^3\boldsymbol{r}$ $d^2k_T\,dr_z$

TMD PDFs
$f_1^u(x,k_T)$, .. $h_1^u(x,k_T)$

GPDs/IPDs

3D imaging

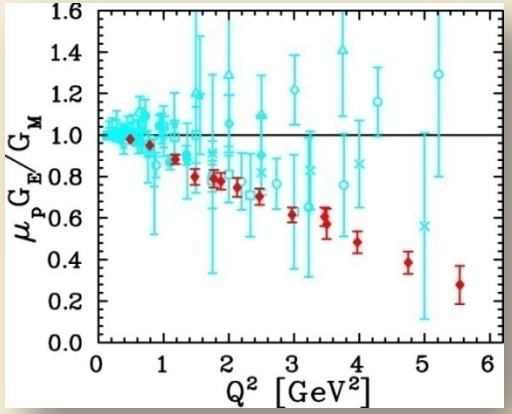
d^2k_T d^2r_T dx & Fourier Transformation



PDFs
$f_1^u(x)$, .. $h_1^u(x)$

1D

Form Factors
$G_E(Q^2)$, $G_M(Q^2)$

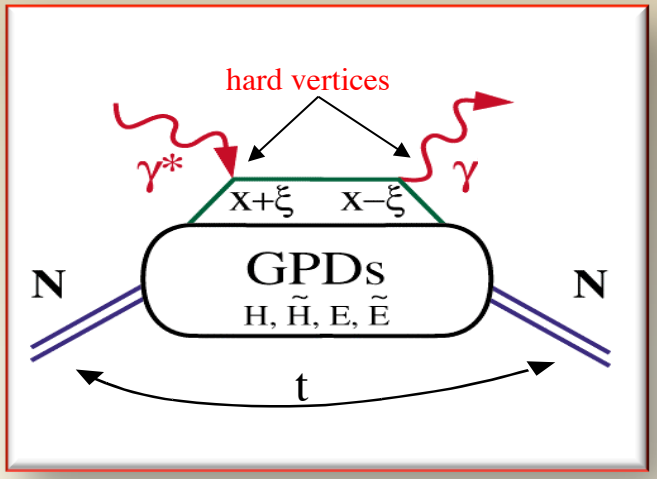


Extraction of GPD's

Cleanest process: Deeply Virtual Compton Scattering

$$A = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-} = \frac{\Delta\sigma}{2\sigma}$$

$\xi = x_B/(2-x_B)$



Polarized beam, unpolarized target:

$$\Delta\sigma_{LU} \sim \sin\phi\{F_1 H + \xi (F_1+F_2)\tilde{H} + kF_2 E\}d\phi$$

⇒ $H(\xi,t)$

Unpolarized beam, longitudinal target:

$$\Delta\sigma_{UL} \sim \sin\phi\{F_1 \tilde{H} + \xi (F_1+F_2)(H + \xi/(1+\xi)E)\}d\phi$$

⇒ $\tilde{H}(\xi,t)$

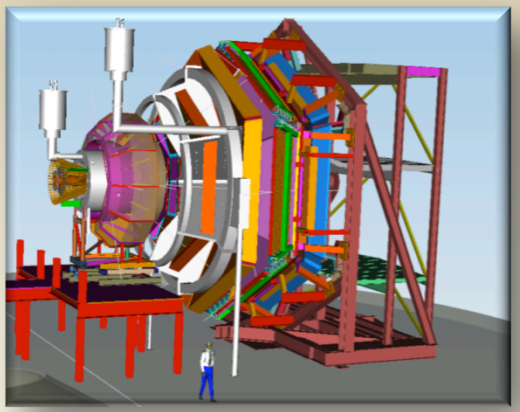
Unpolarized beam, transverse target:

$$\Delta\sigma_{UT} \sim \sin\phi\{k(F_2 H - F_1 E)\}d\phi$$

⇒ $E(\xi,t)$

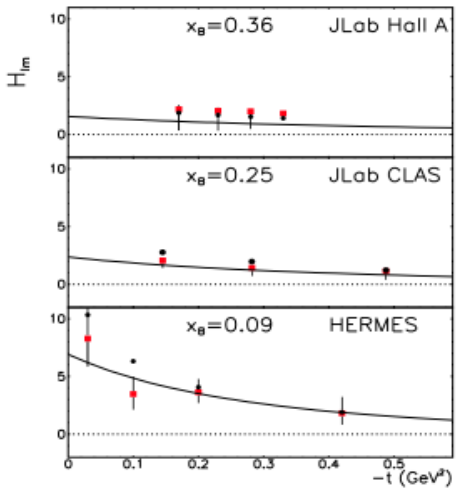
DVCS beam asymmetry at 12 GeV

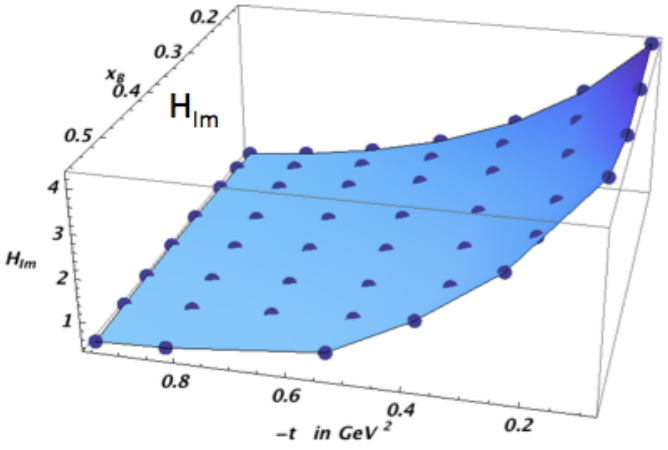
CLAS12

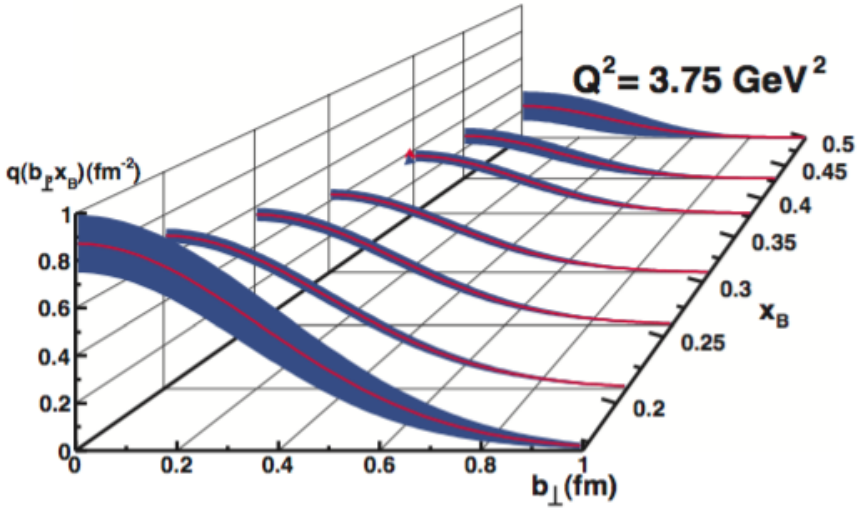


$\vec{e}p \longrightarrow epγ$

High luminosity and large acceptance allows wide coverage in $Q^2 < 8$ GeV^2, $x_B < 0.65$, and $t < 1.5$GeV^2



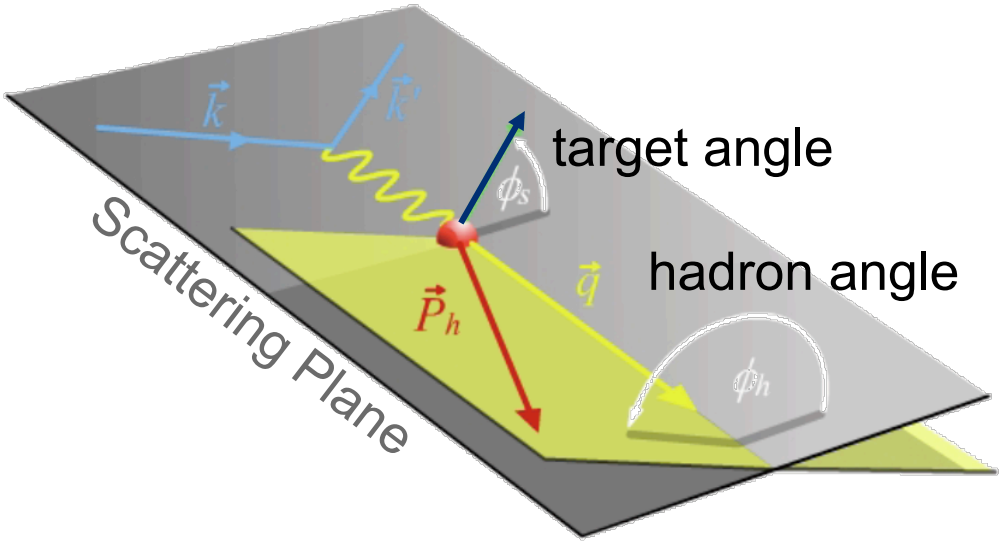




Jefferson Lab

SIDIS Electroproduction of Pions

- Separate Sivers and Collins effects

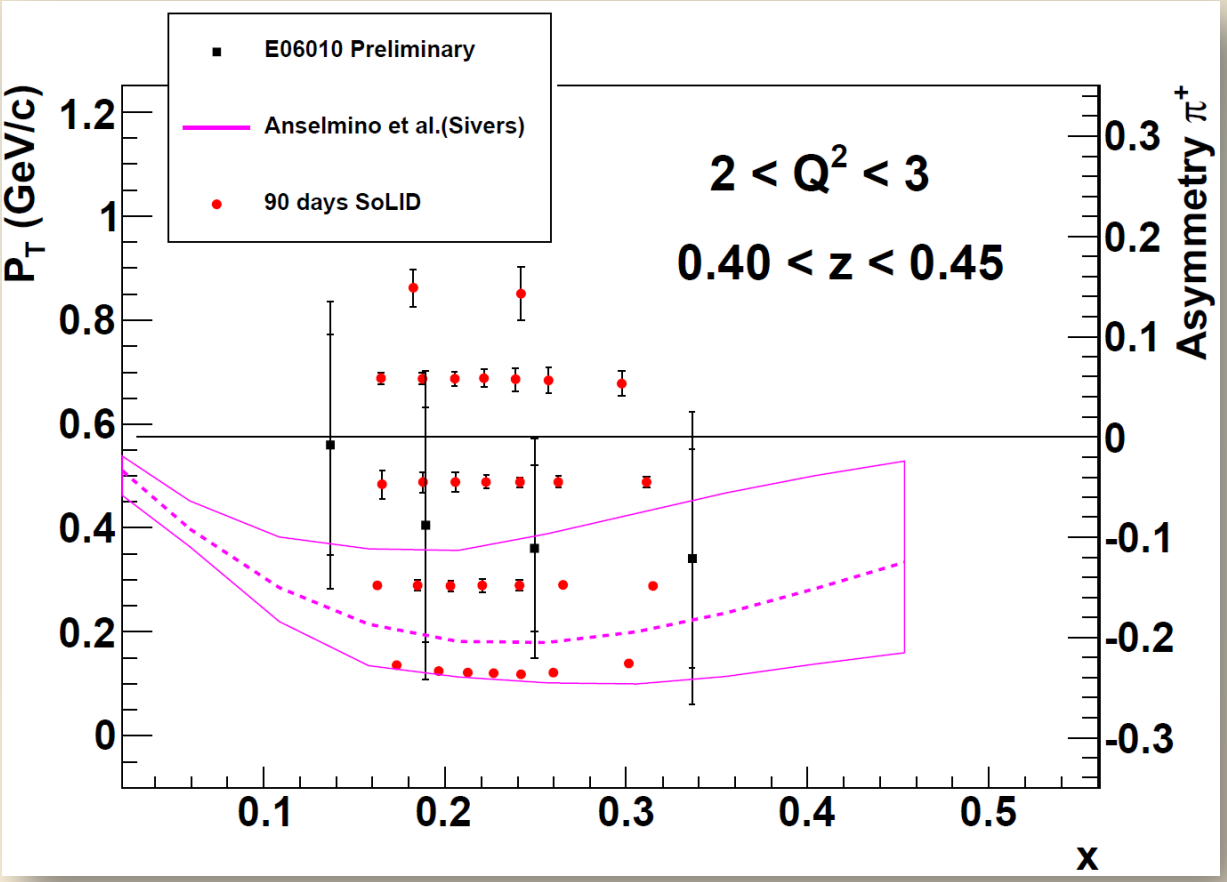


- Previous data from HERMES,COMPASS
- New landscape of TMD distributions
- Access to orbital angular momentum

- **Sivers** angle, effect in distribution function: $(\phi_h - \phi_s)$
- **Collins** angle, effect in fragmentation function: $(\phi_h + \phi_s)$

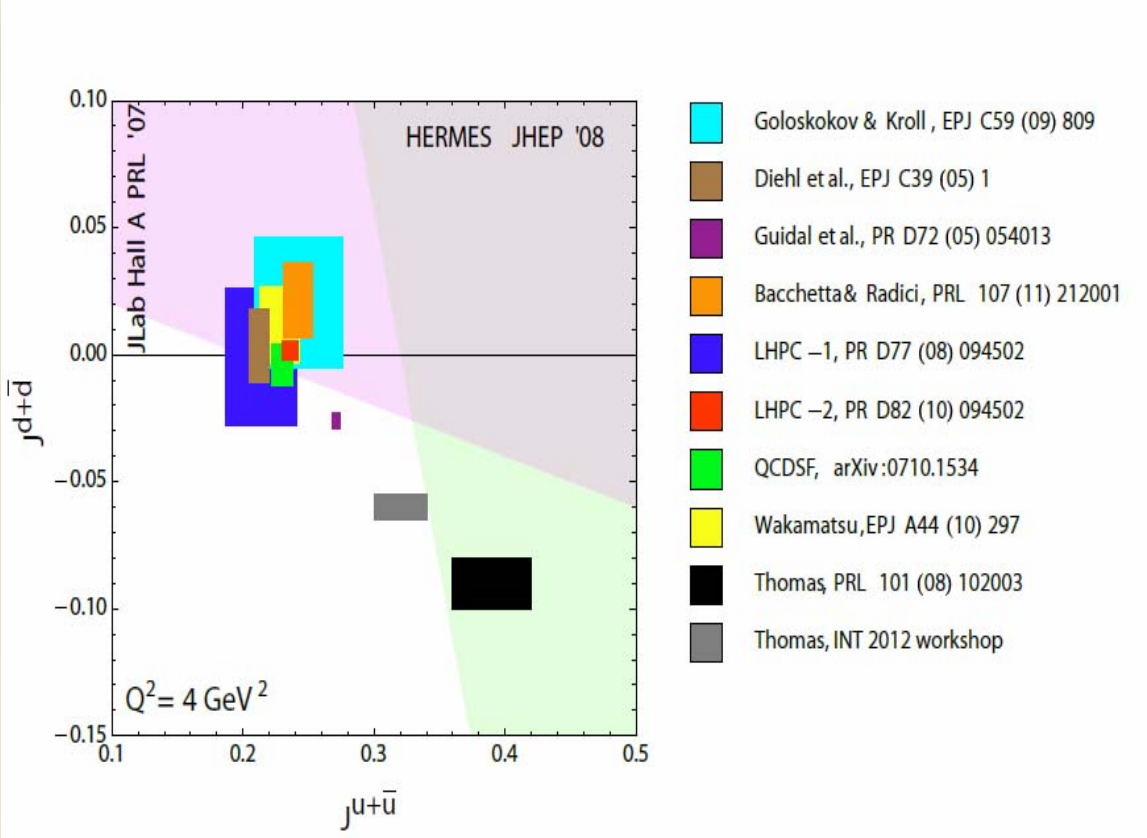
SoLID Transversity Projected Data

- Total 1400 bins in x, Q^2, P_T and z for 11/8.8 GeV beam.
- z ranges from 0.3 ~ 0.7, only one z and Q^2 bin of 11/8.8 GeV is shown here. π^+ projections are shown, similar to the π^- .



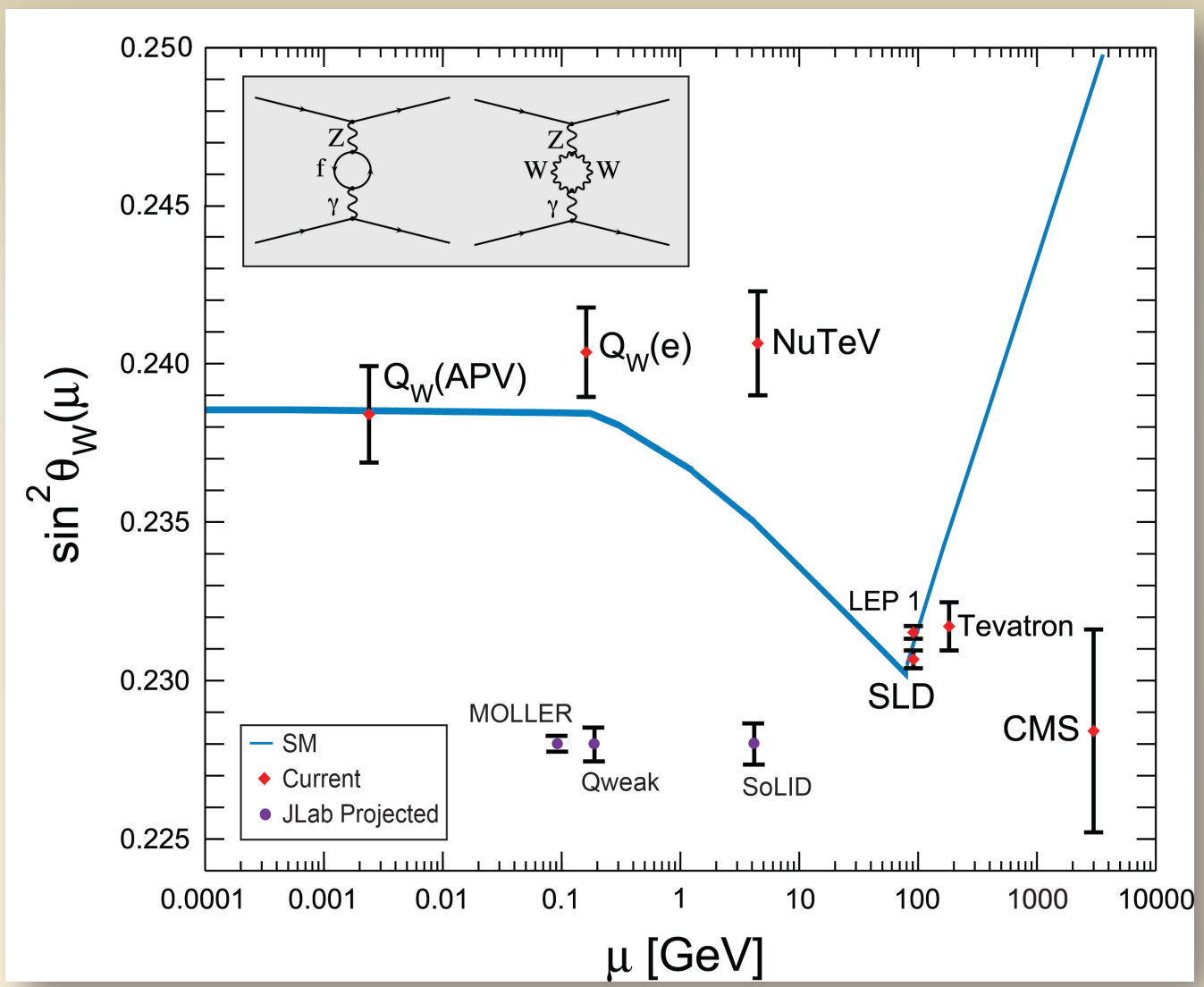
Quark Angular Momentum

$$J^q = \frac{1}{2}\int_{-1}^{+1} dx\, x\,[H^q(x,\xi,t) + E^q(x,\xi,t)] = \Delta\Sigma^q / 2 + L^q$$



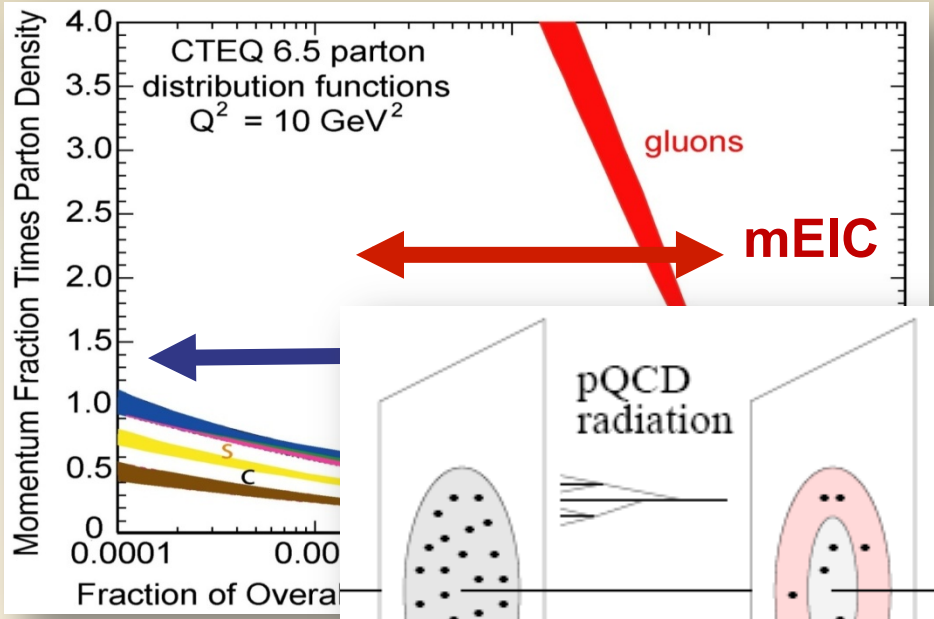
→ **Access to quark orbital angular momentum**

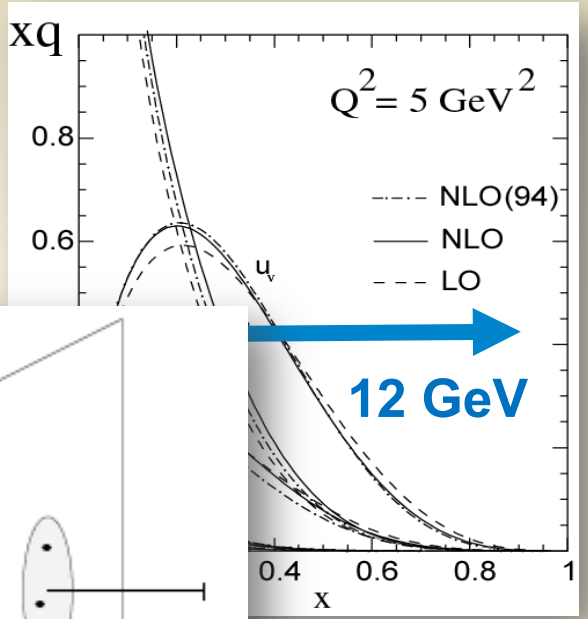
Parity Violating Electron Scattering

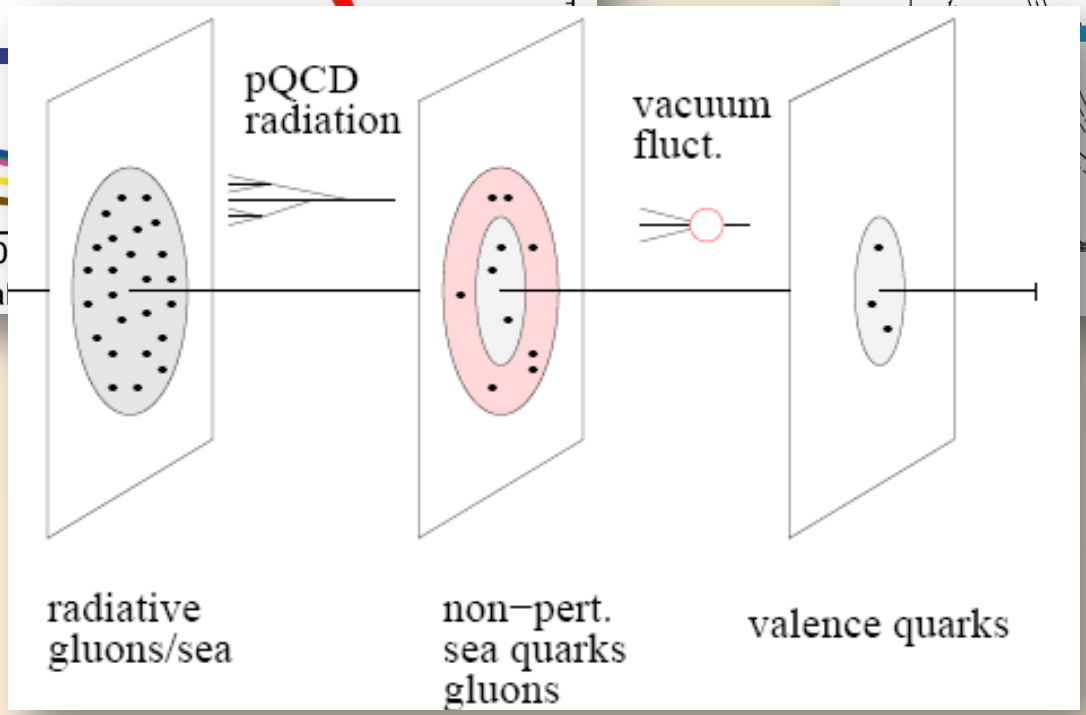


Into the "sea": EIC

- An EIC aims to study gluon dominated matter.
- With 12 GeV we study mostly the valence quark component



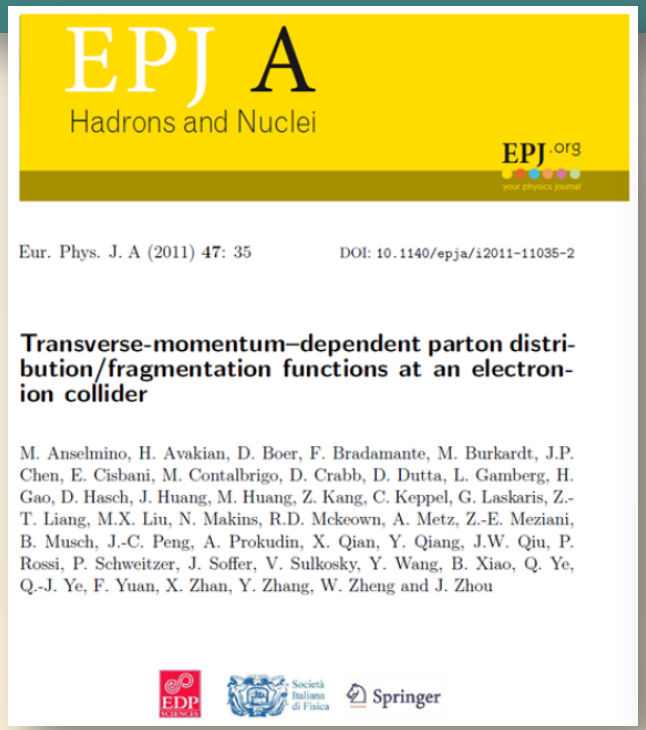


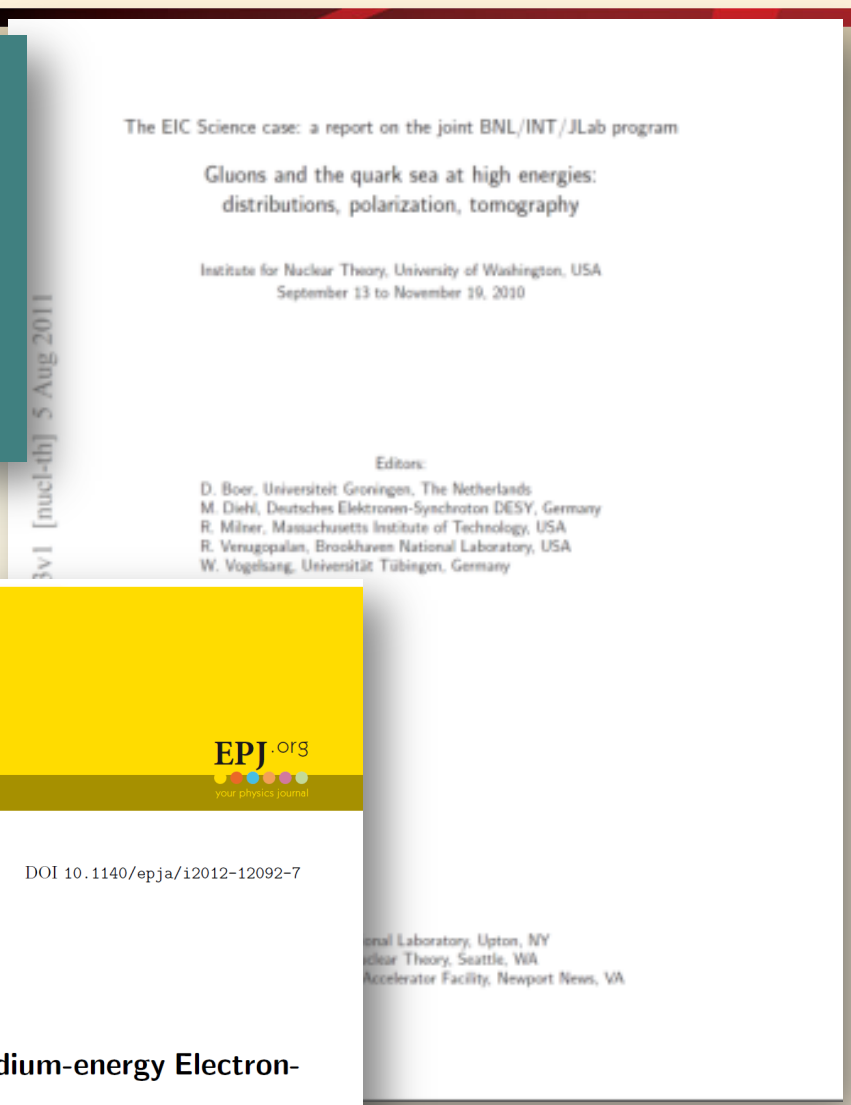


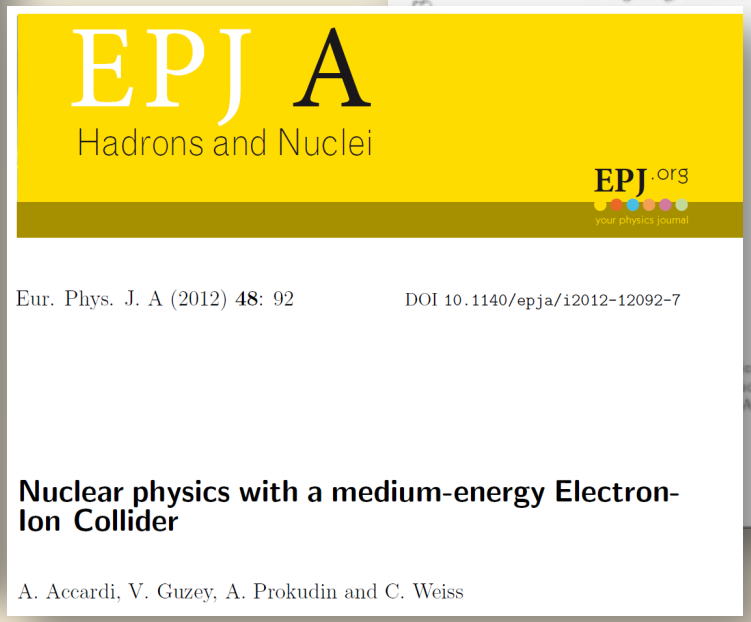
The Electron Ion Collider:

A Next QCD Frontier

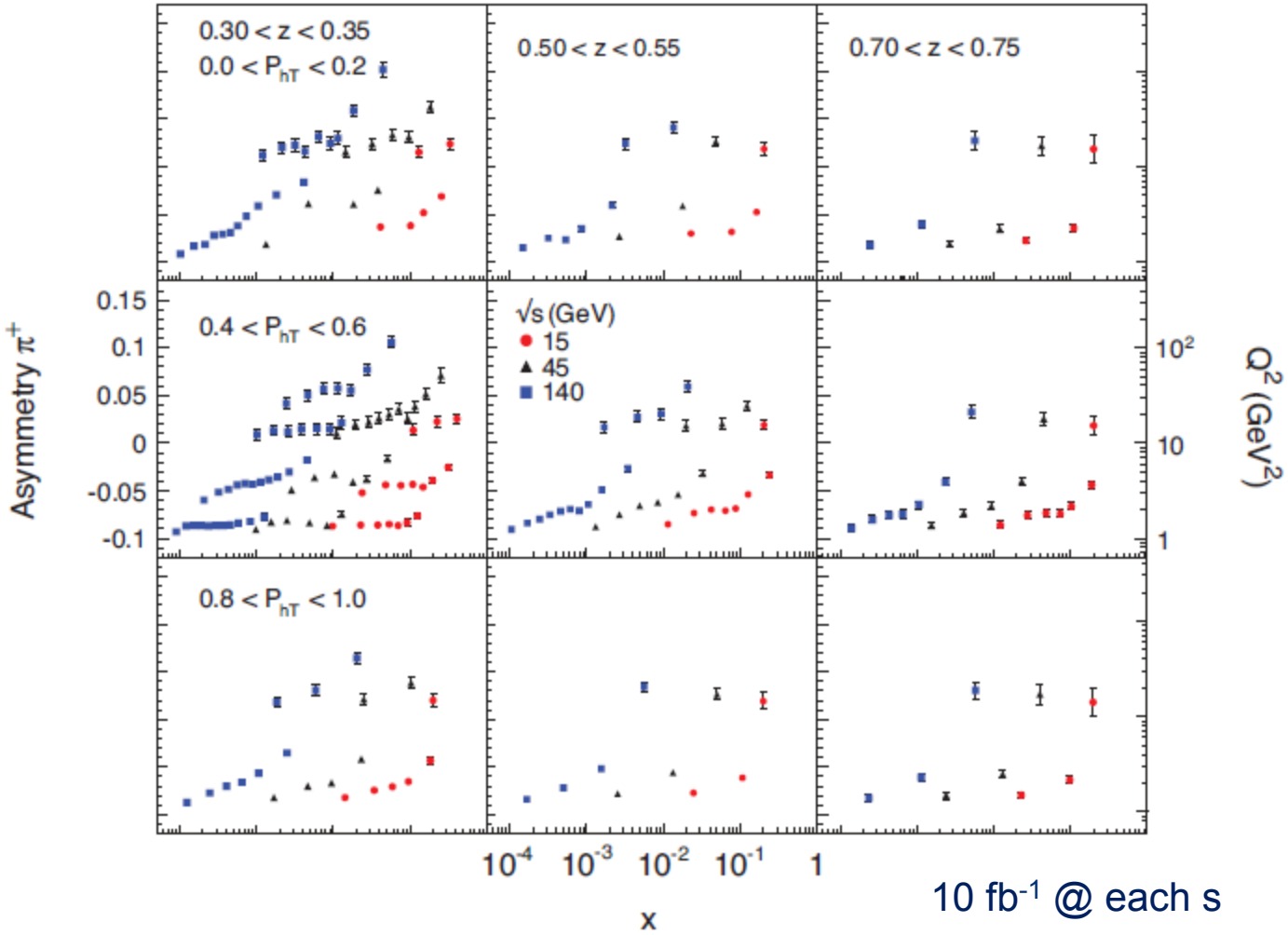
Understanding the Glue that Binds us all





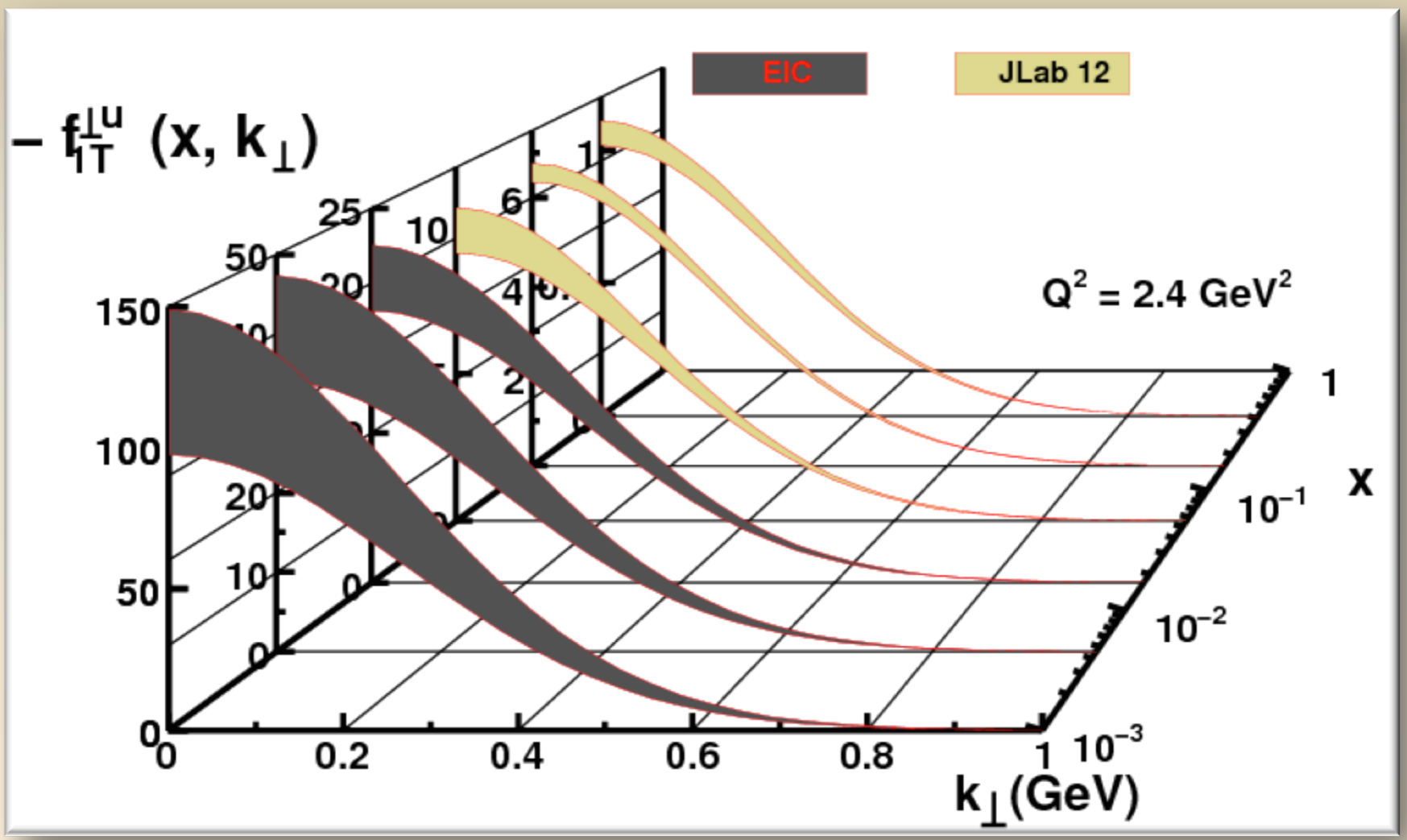


TMD studies at EIC



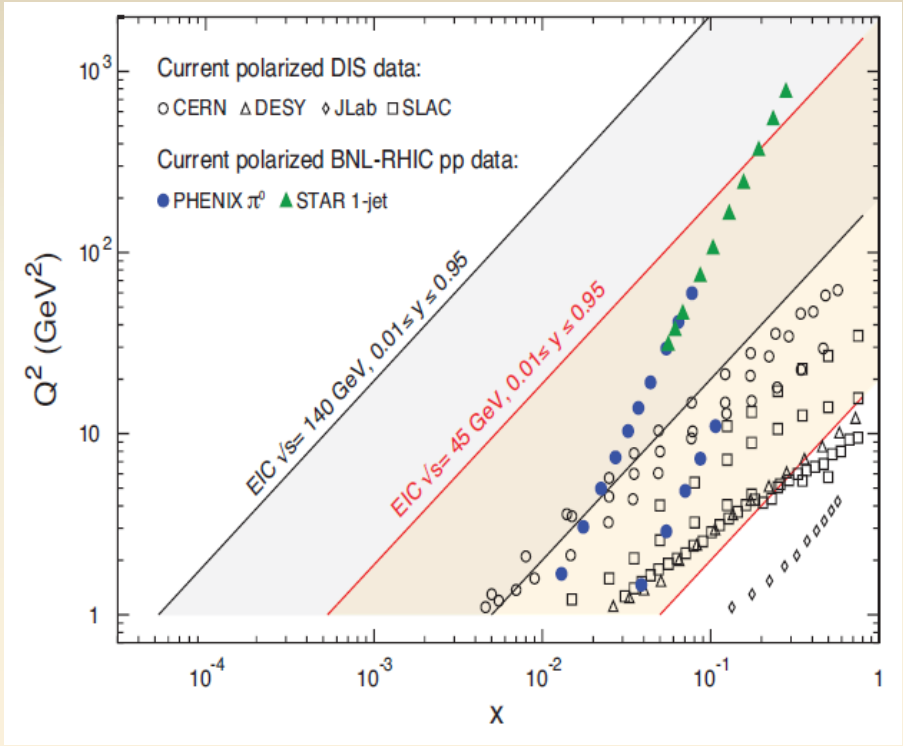
(from EIC White Paper)

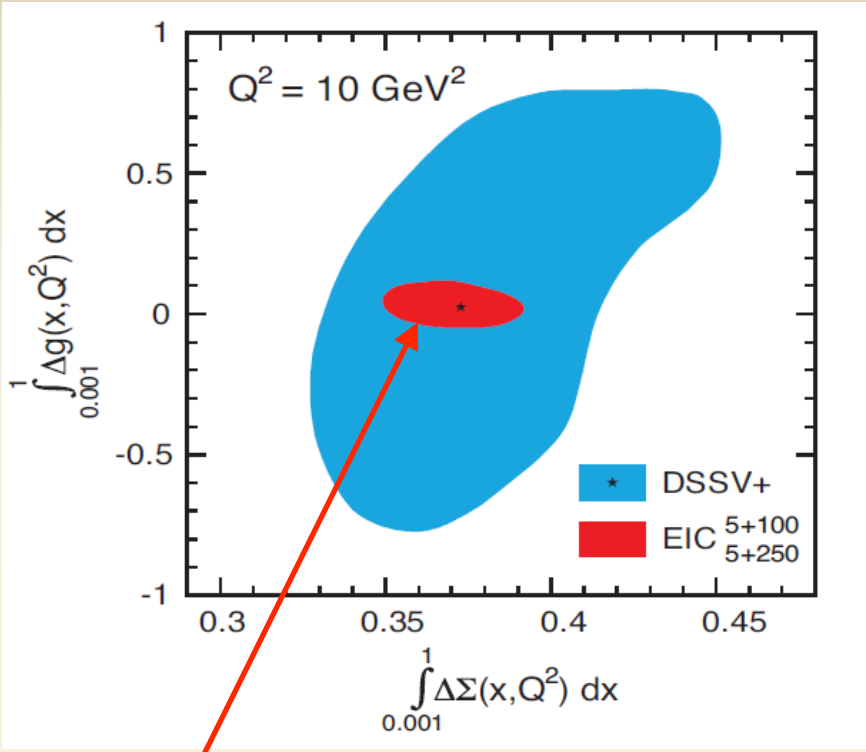
Extending Sivers Tomography



A. Prokudin

Longitudinal Spin - ΔG

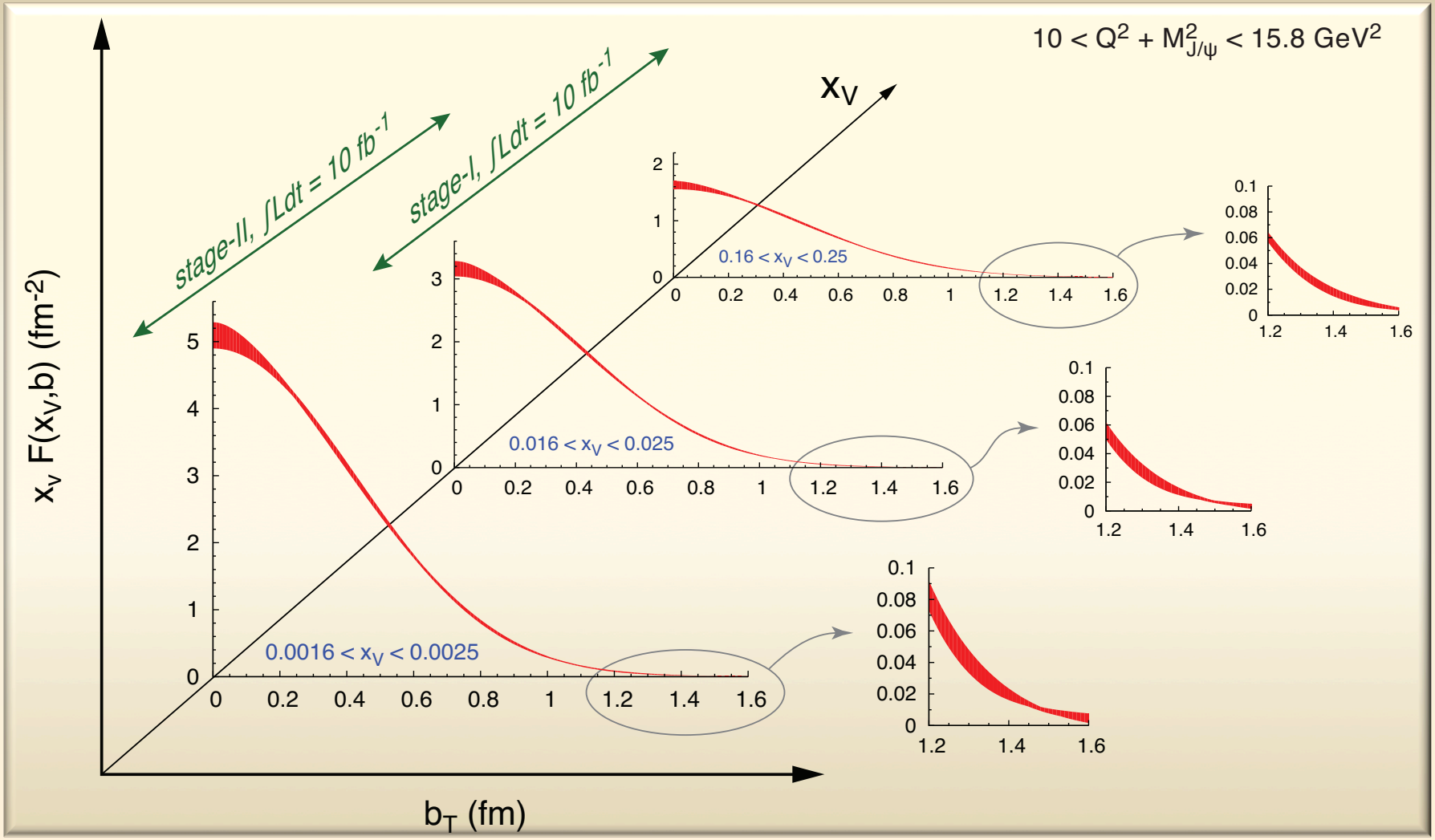




10 fb^{-1} – Stage 1

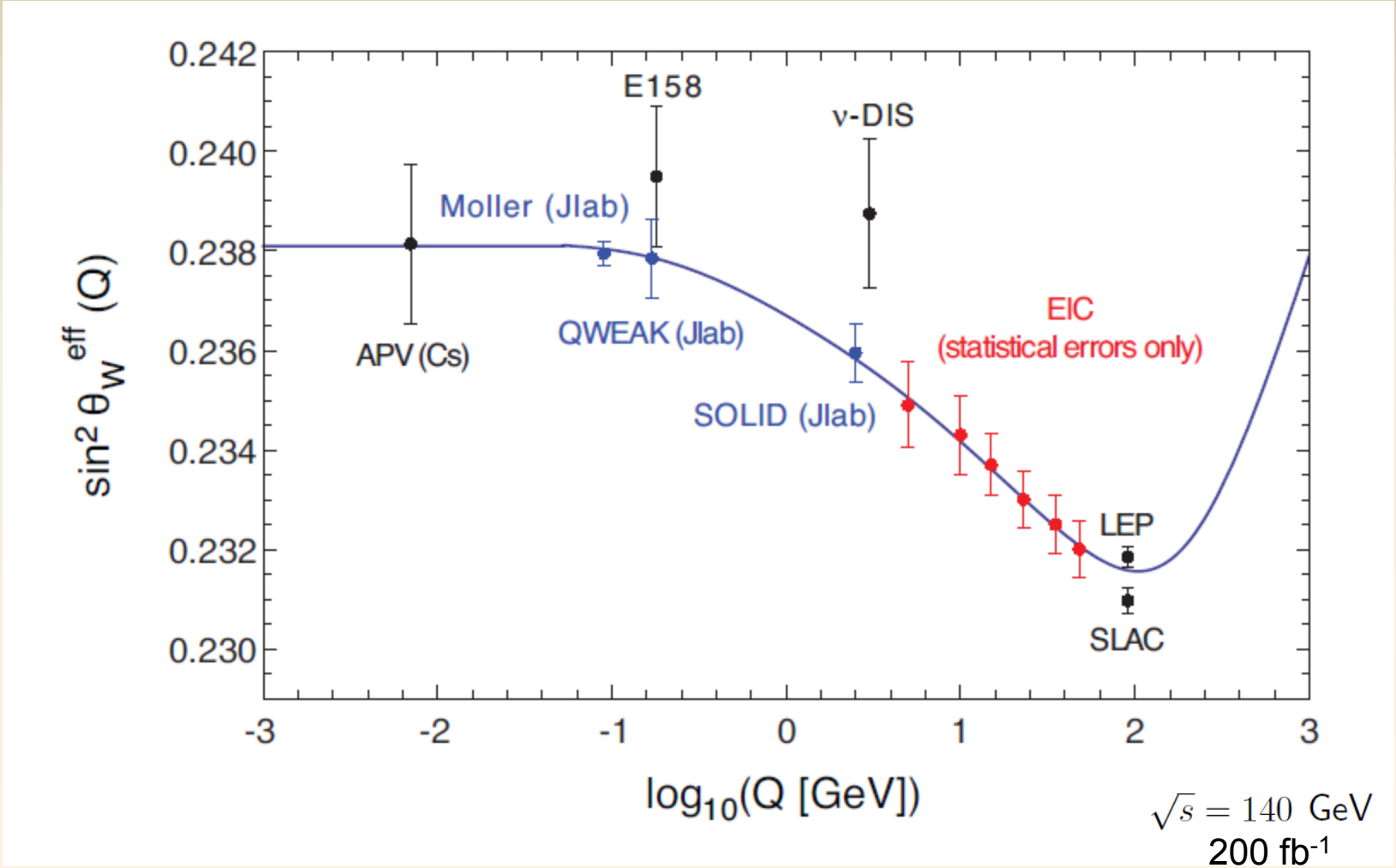
(from EIC White Paper)

Gluon Tomography



DV J/Ψ Production (from EIC White Paper)

Precision Tests of the Standard Model



MEIC Design Report

- Web posting imminent
- Stable design for 3 years

Science Requirements and Conceptual Design for a Polarized Medium Energy Electron-Ion Collider at Jefferson Lab

S. Abeyratne[8], A. Accardi[1], S. Ahmed[1], D. Barber[5], J. Bisognano[15], A. Bogacz[1], P. Chevtsov[12], S. Corneliussen, J. Delayen[11], W. Deconinck[4], Ya. Derbenev[1], S. DeSilva[11], D. Douglas[1], V. Dudnikov[9], R. Ent[1], B. Erdelyi[10], Yu. Filatov[7,8], D. Gaskell[1], V. Guzey[1], T. Horn[3], A. Hutton[1], C. Hyde[11], R. Johnson[9], Y. Kim[6], F. Klein[2], A. Kondratenko[14], M. Kondratenko[14], P. Nadel-Turonski[1], E. Li[1], F. Lin[1], S. Manikonda[2], F. Marhauser[9], R. McKeown[1], V. Morozov[1], P. Nadel-Turonski[1], G. Krafft[1,11], R. Nissen[1], P. Ostroumov[2], F. Pilat[1], M. Poelker[1], A. Prokudin[1], R. Rimmer[1], T. Satogata[1], M. Spata[1], H. Sayed[12], M. Sullivan[13], C. Tennant[1], B. Terzic[1], M. Tiefenback[1], H. Wang[1], S. Wang[1], C. Weiss[1], B. Yunn[1], Y. Zhang[1]

[1] Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, USA
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[7] Joint Institute for Nuclear Research, Dubna, Russia
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[10] Northern Illinois University, De Kalb, IL 60115, USA
[11] Old Dominion University, Norfolk, VA 23529, USA
[12] Paul Scherrer Institute, 5232 Villigen PSI, Switzerland
[13] SLAC National Accelerator Laboratory, Menlo Park, CA 94305, USA
[14] Science and Technique Laboratory Zaryad, Novosibirsk, Russia
[15] University of Wisconsin-Madison, Madison, WI 53706, USA

Editors: Y. Zhang and J. Bisognano

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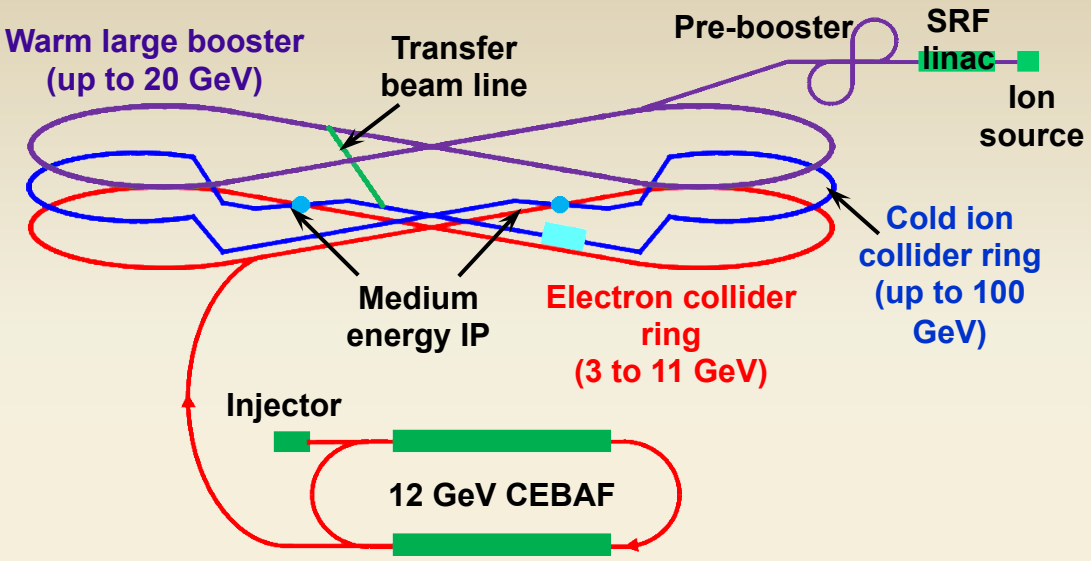
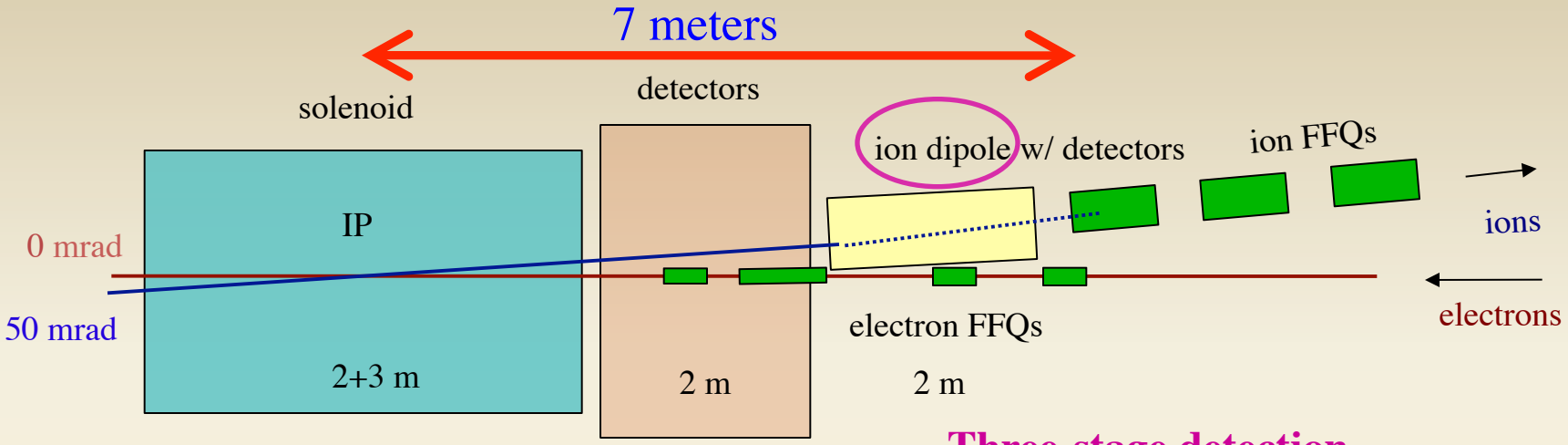
Medium Energy EIC@JLab



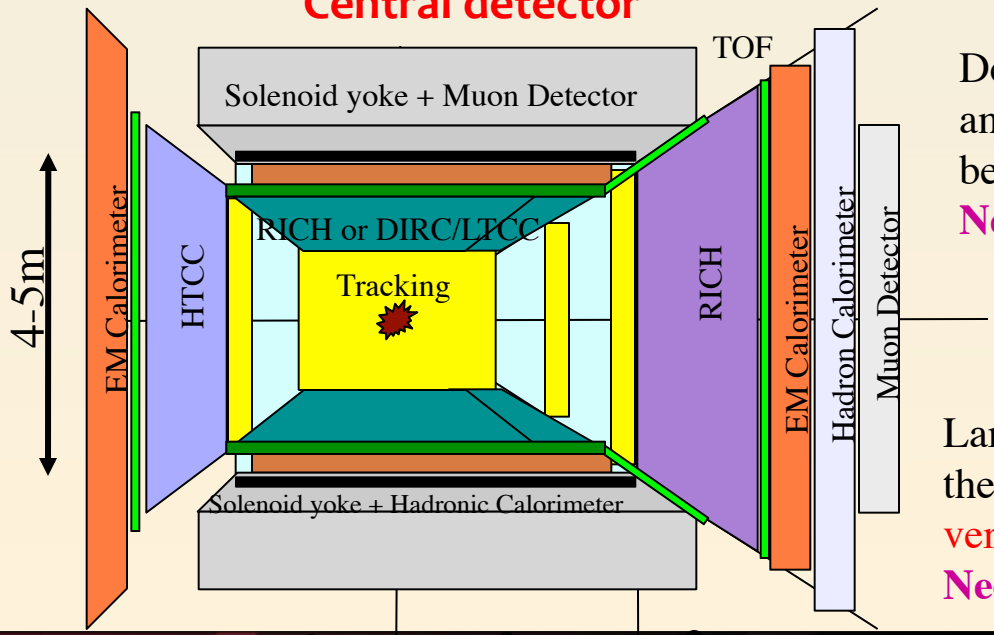
JLab Concept

- Initial configuration (MEIC):
  - 3-11 GeV on 20-100 GeV ep/eA collider
  - fully-polarized, longitudinal and transverse
  - luminosity: up to few x 10^{34} e-nucleons cm^{-2} s^{-1}
- Upgradable to higher energies (250 GeV protons)

MEIC: Full Acceptance Detector



Central detector



Three-stage detection

Detect particles with angles down to 0.5° before ion FFQs.
Need 1-2 Tm dipole.

Detect particles with angles below 0.5° beyond ion FFQs and in arcs.
Need 4 m machine element free region

Very-forward detector

Large dipole bend @ 20 meter from IP (to correct the 50 mr ion horizontal crossing angle) allows for very-small angle detection (<0.3°).
Need 20 m machine element free region

My View Going Forward

- There has been excellent progress on developing the EIC science case over the last 2 years, and even more since the INT program.
- There have been important contributions from both the BNL and JLab communities.
- I continue to believe that it is essential that these two communities work together to realize the recommendation of an EIC by the broader nuclear physics community.
- Completing the White Paper is a crucial next step in this process.
- Many thanks to the WP writers/editors.