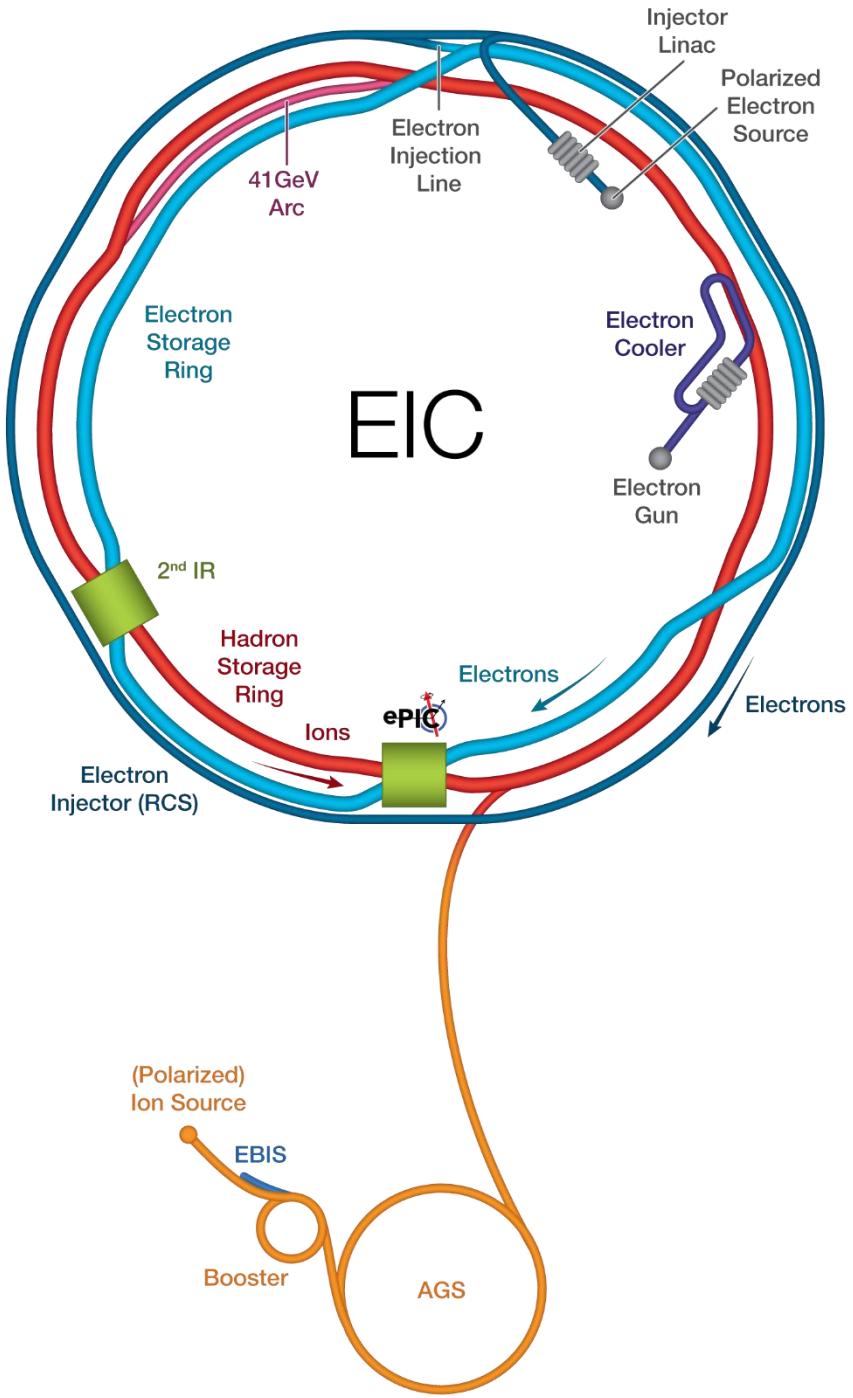


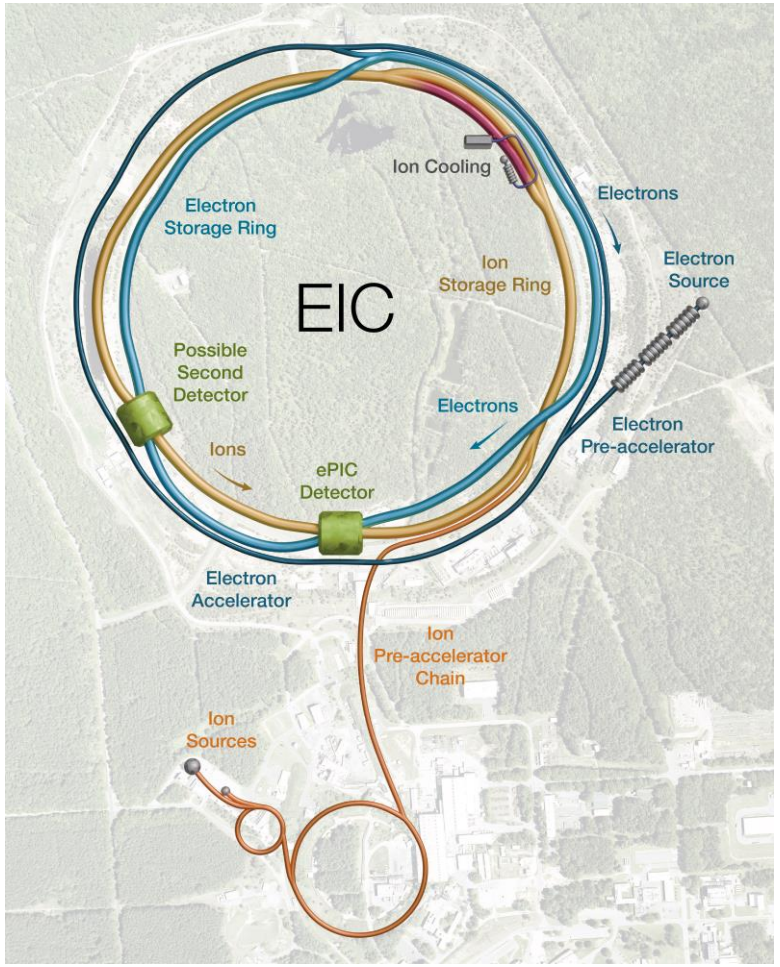
Exclusive processes at EIC at high x (x>0.05)

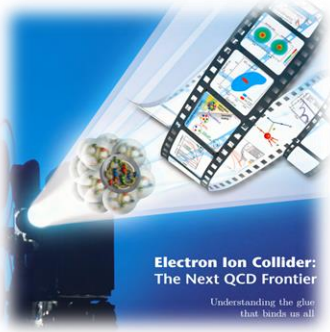
Carlos Muñoz Camacho
IJCLab – Orsay (CNRS/IN2P3, France)

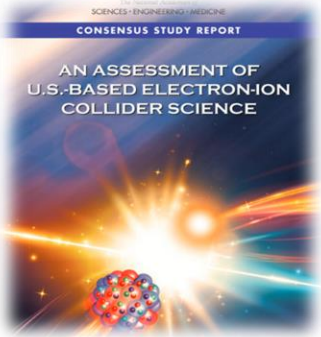
Science at the Luminosity Frontier: Jefferson Lab at 22 GeV

Frascati, Dec 9-13 (2024)

The EIC facility





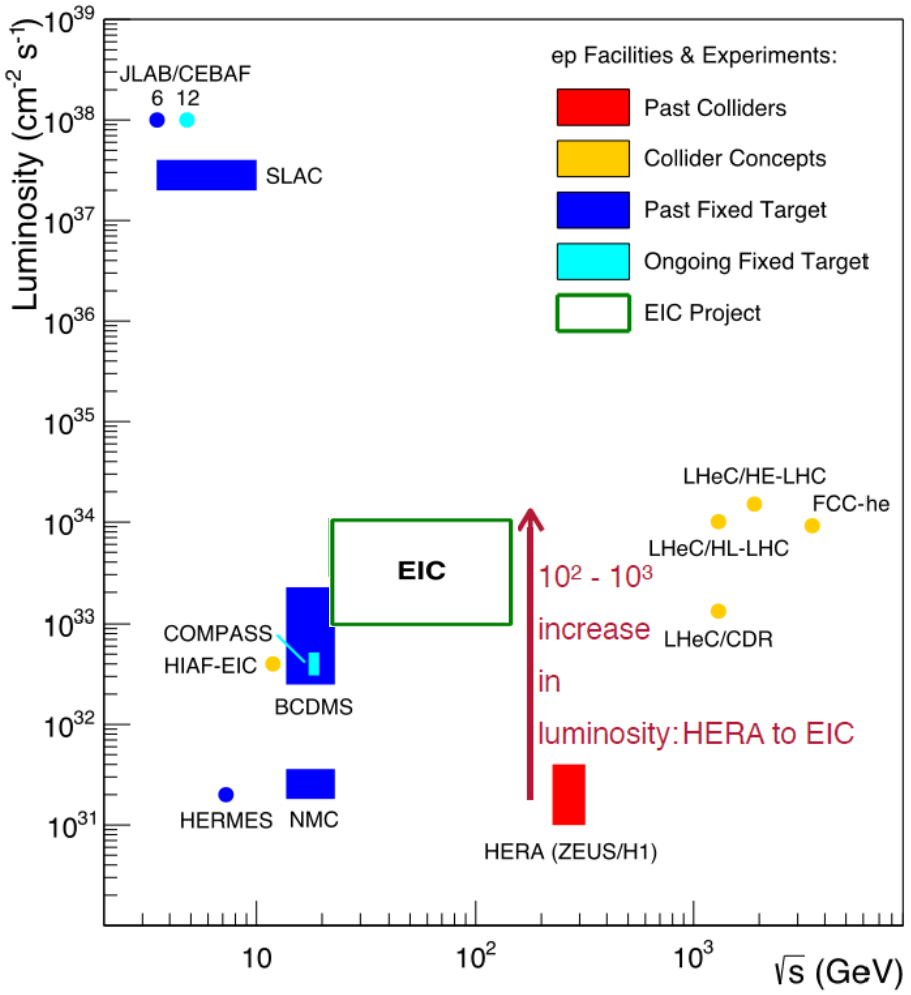


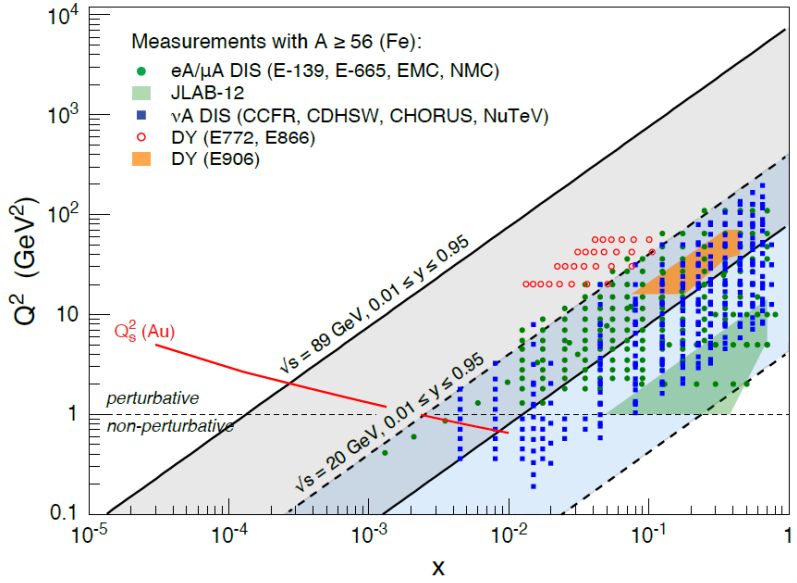
Project Design Goals

- High Luminosity: L= 10^{33} – 10^{34}cm^{-2}sec^{-1}, 10 – 100 fb^{-1}/year
- Highly Polarized Beams: 70%
- Large Center of Mass Energy Range: E_{cm} = 29 – 140 GeV
- Large Ion Species Range: protons – Uranium
- Large Detector Acceptance and Good Background Conditions
- Accommodate a Second Interaction Region (IR)

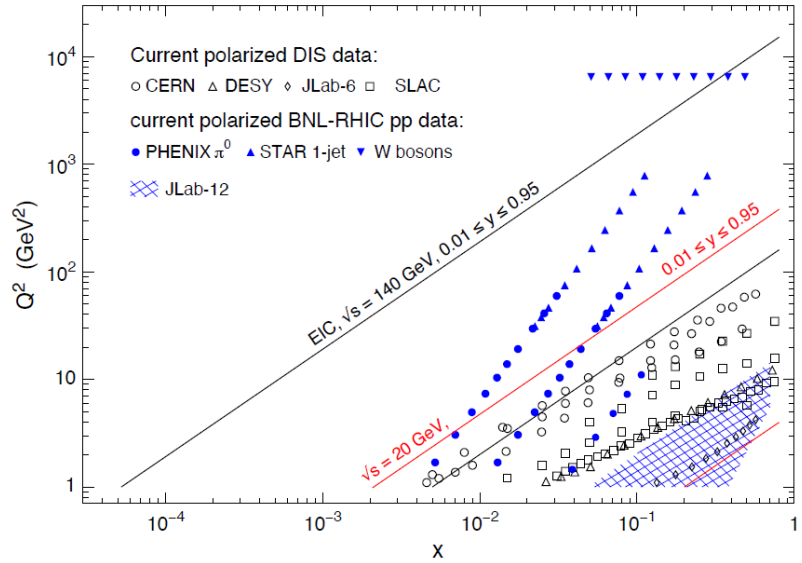
p: 41 GeV, 100 to 275 GeV → p/A beam ← e beam **e: 5 GeV to 18 GeV**

Luminosity and kinematic coverage



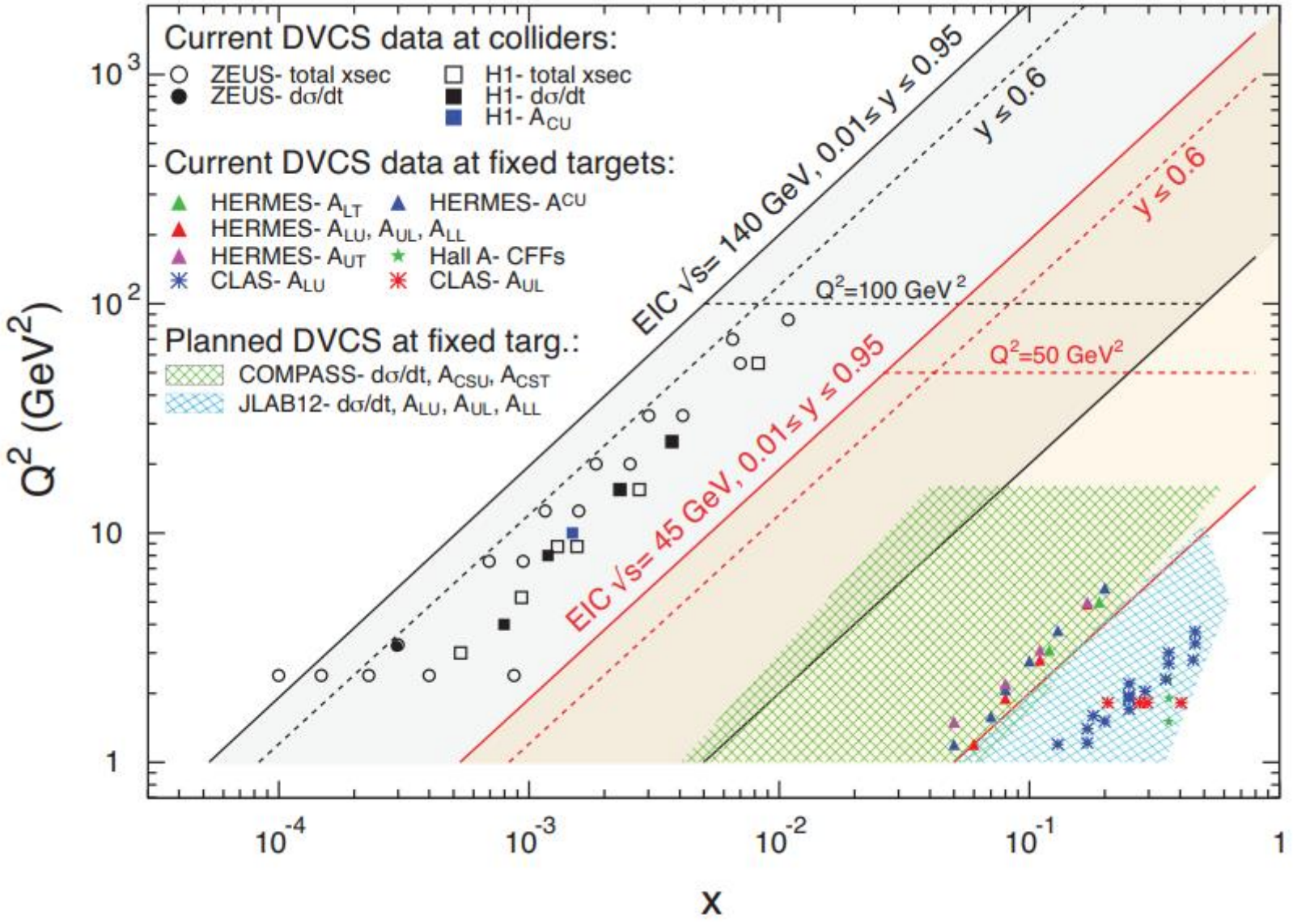


eA



ep

Complementarity with JLab and other facilities



The EIC project detector: ePIC

Tracking:

- New 1.7T solenoid
- Si MAPS Tracker
- MPGDs (μRWELL/μMegas)

PID:

- Backward pfRICH
- Barrel hpDIRC
- Forward dRICH
- Barrel & Forward TOF (AC-LGAD)

Calorimetry:

- Backward HCal (Steel+scint)
- $PbWO_4$ EMCal in backward direction
- Sampling & Imaging Barrel EMCal
- Outer HCal (sPHENIX re-use)
- Finely segmented EMCal +HCal in forward direction

hadronic calorimeters

Solenoidal Magnet

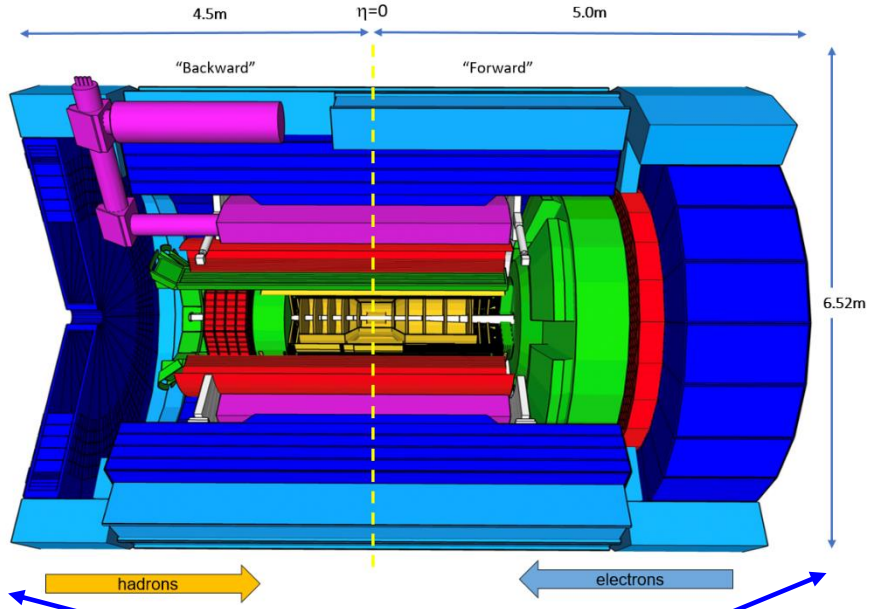
e/m calorimeters

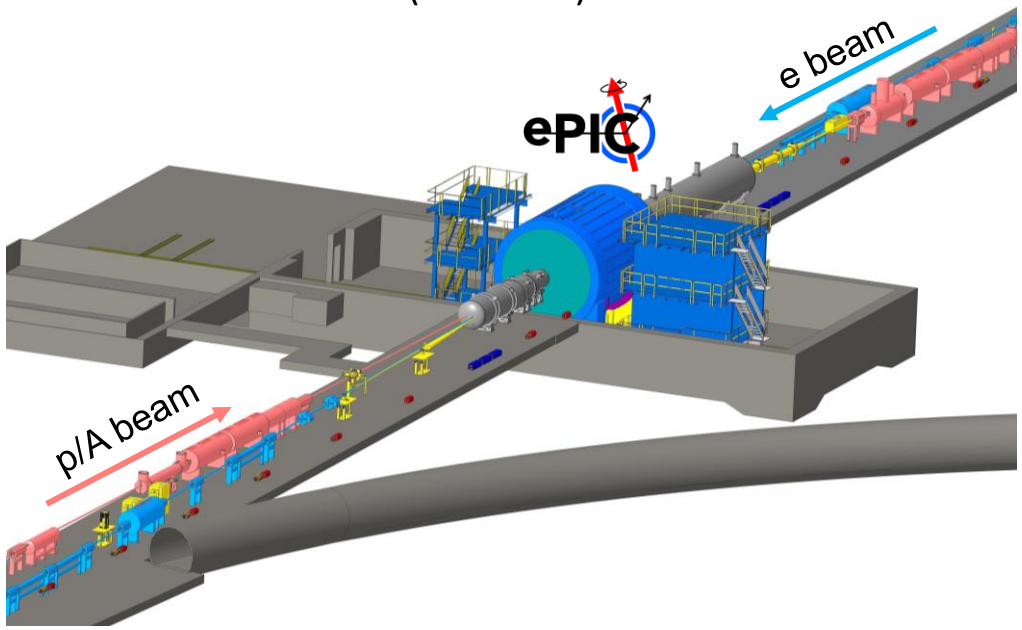
ToF, DIRC, RICH detectors

MPG trackers

MAPS tracker

25 subdetectors incl. polarimeters



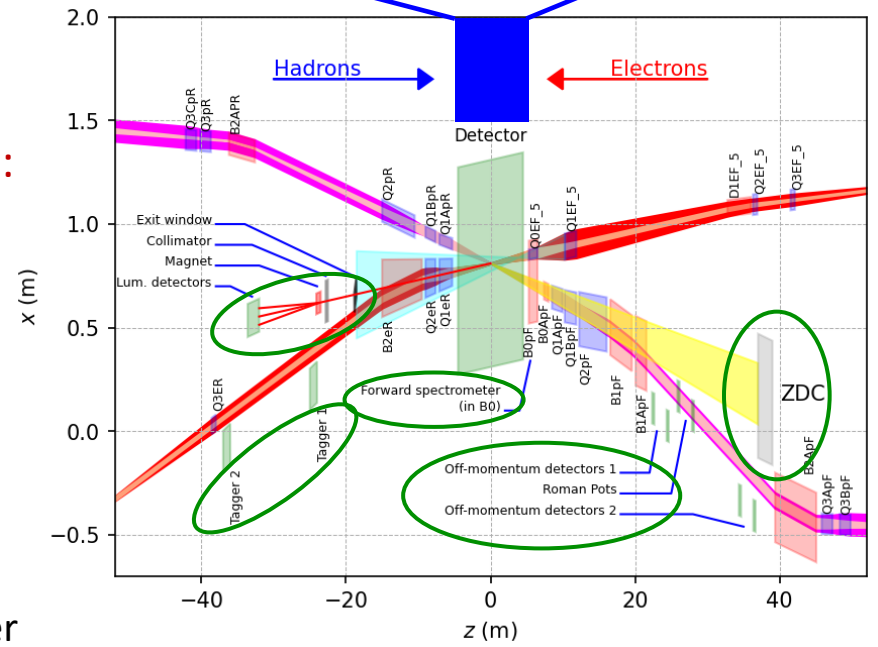


Far-Backward Detectors:

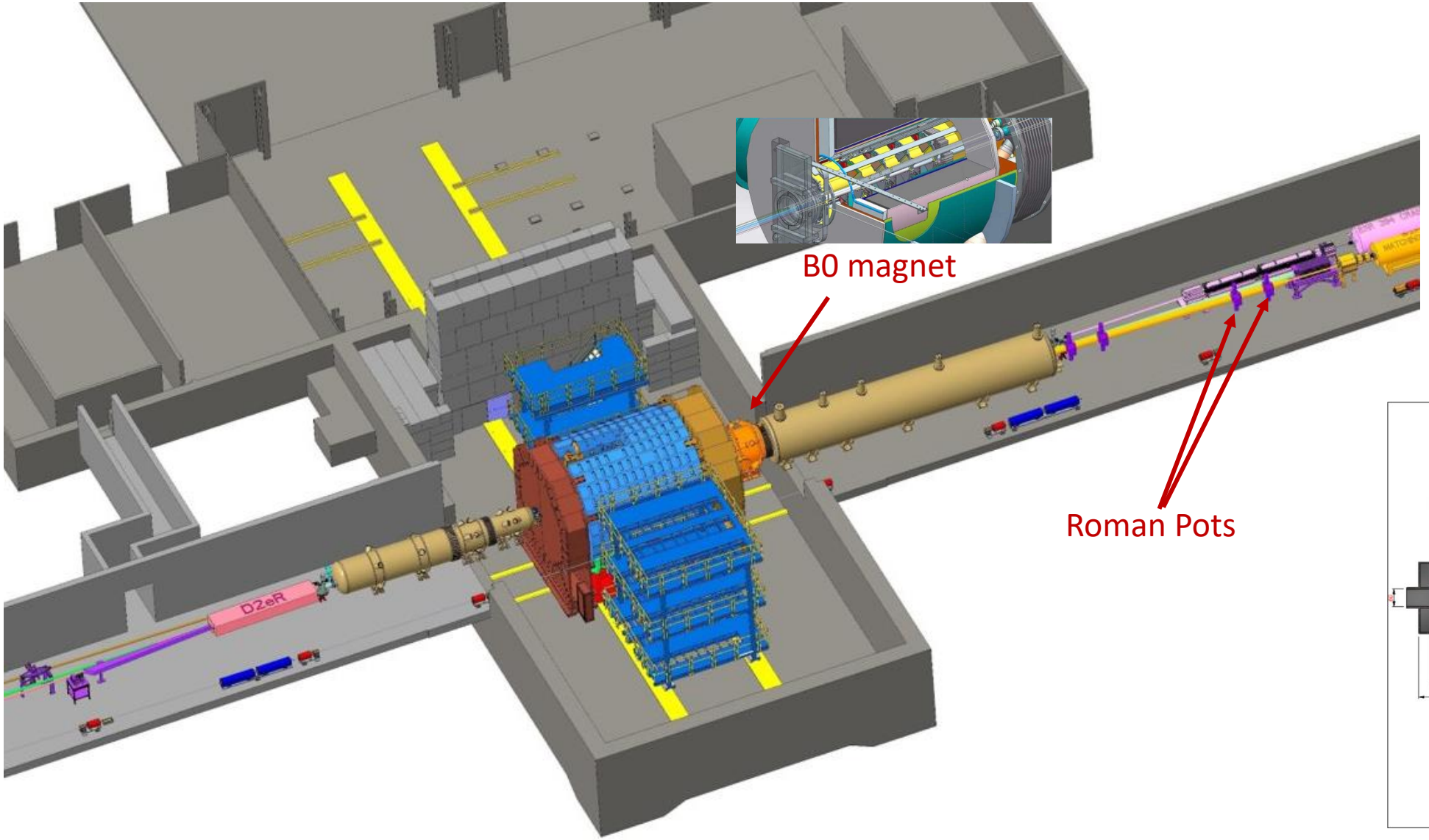
- Luminosity monitor.
- Low-Q^2 Tagger

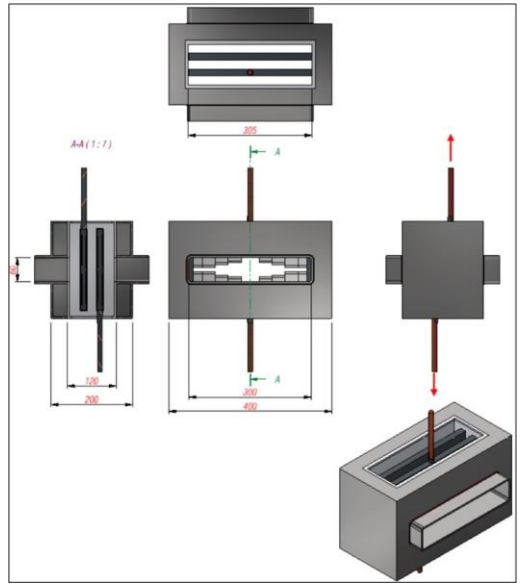
Far-Forward Detectors:

- B0 Tracking and Photon Detection
- Roman Pots and Off-Momentum Detectors.
- Zero-Degree Calorimeter



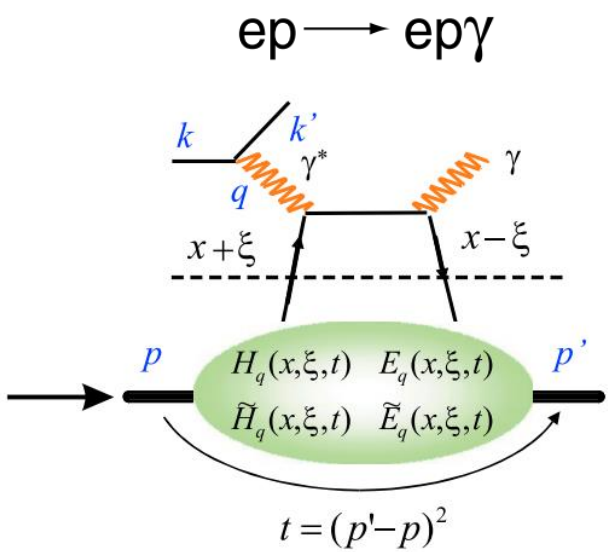
Far-forward detection region





Exclusive processes and nucleon 3D imaging

3D imaging of the nucleon and nuclei
through Generalized Parton Distributions (GPDs)

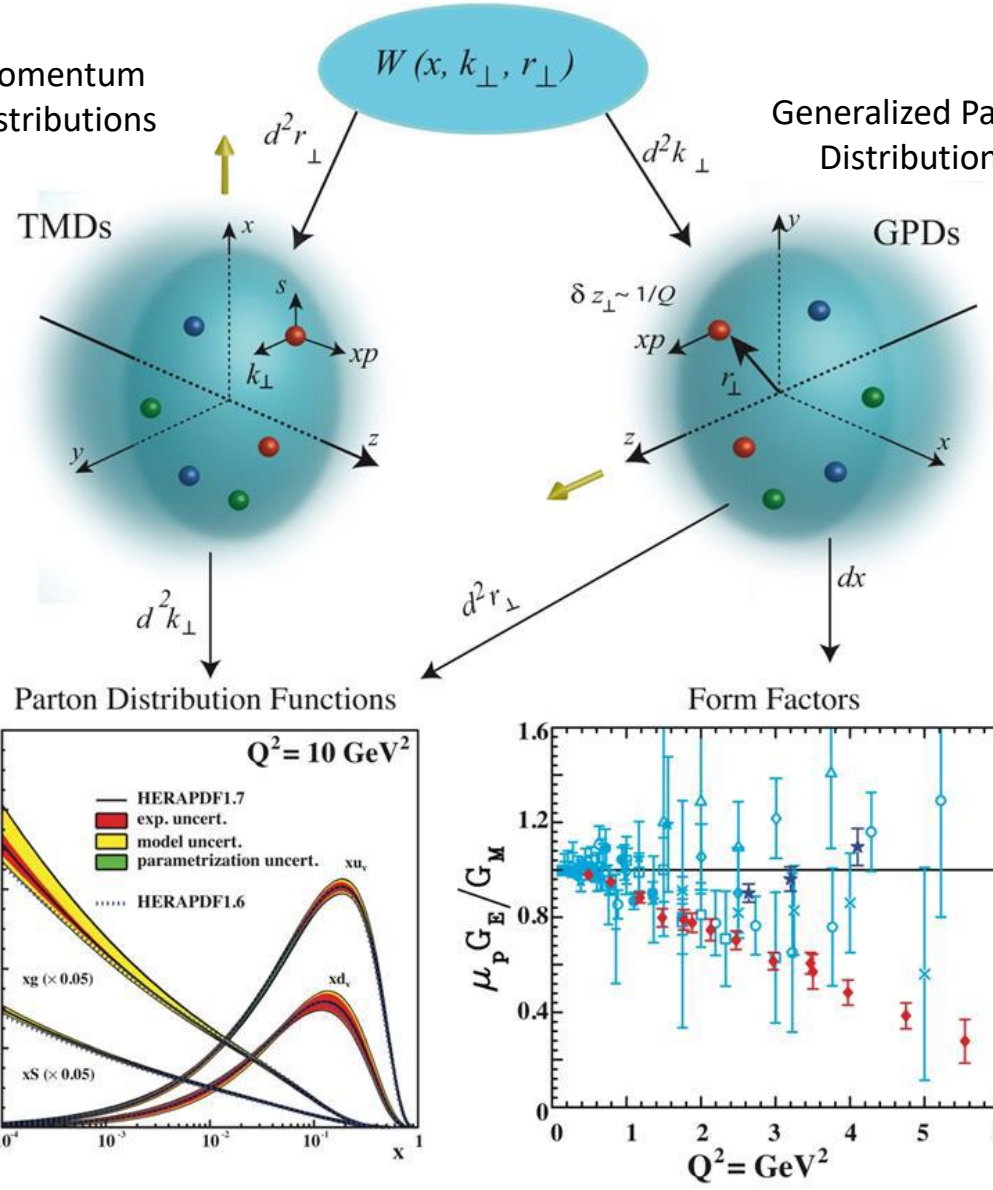


Experimentally accessible with exclusive reactions:

- Deeply Virtual Compton Scattering (DVCS)
- Deeply Virtual Meson Production (DVMP)

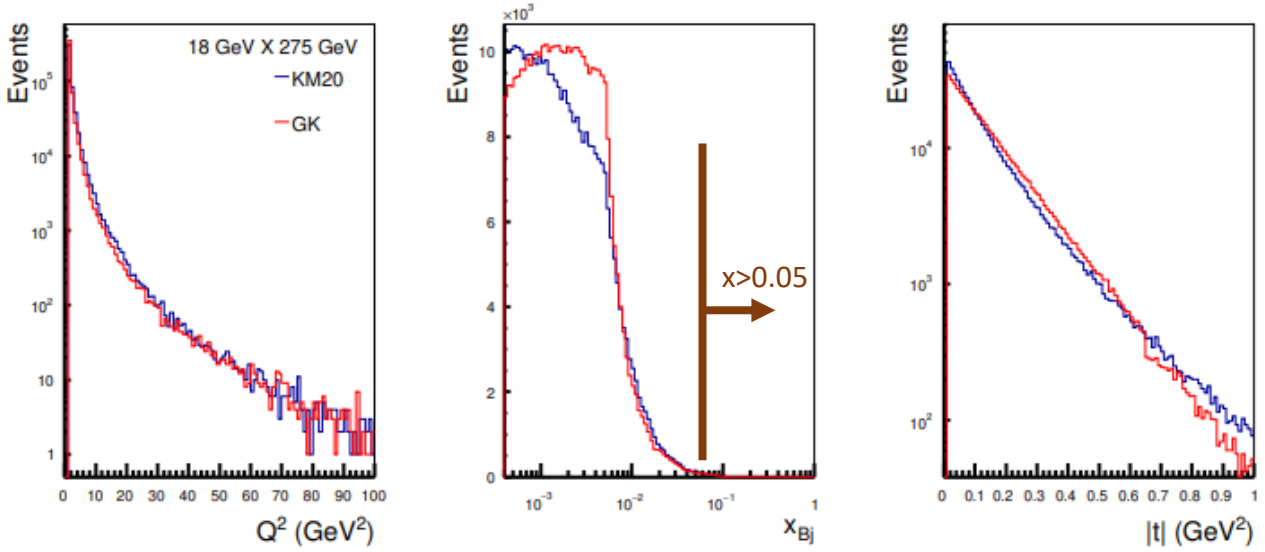
Transverse Momentum Dependent Distributions

Generalized Parton Distributions

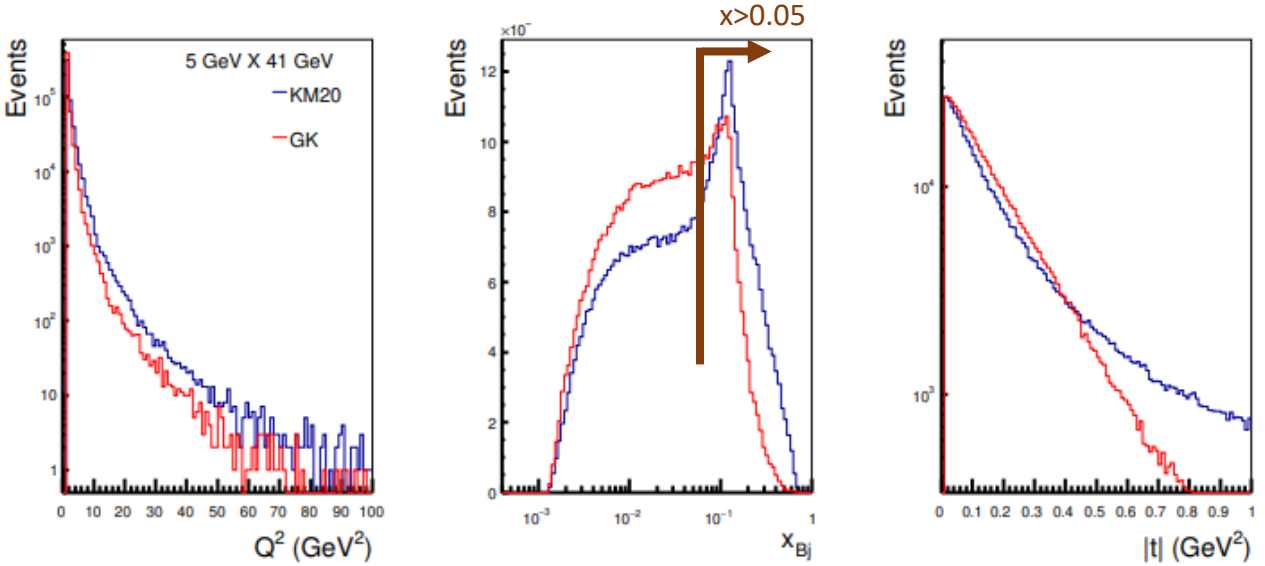


DVCS at EIC: kinematic coverage

18 GeV x 275 GeV



5 GeV x 41 GeV

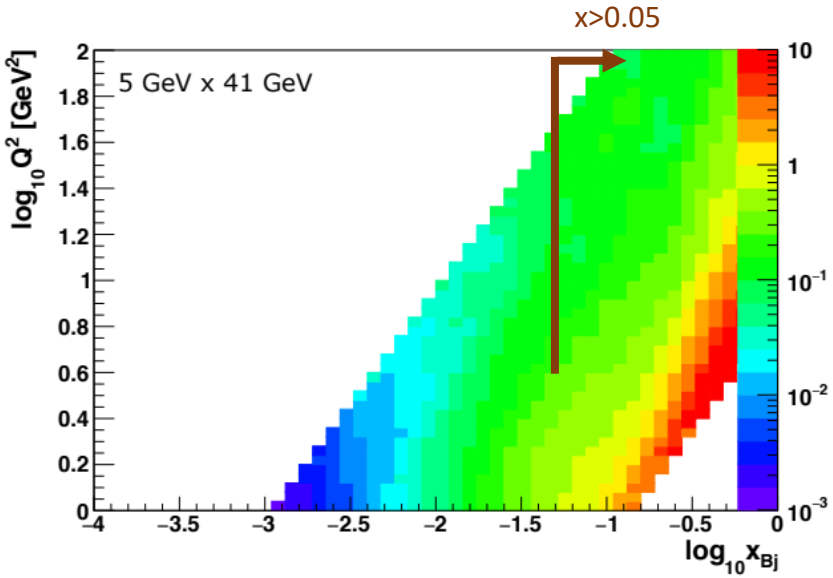


EIC Yellow Report

Projections using 2 different models:

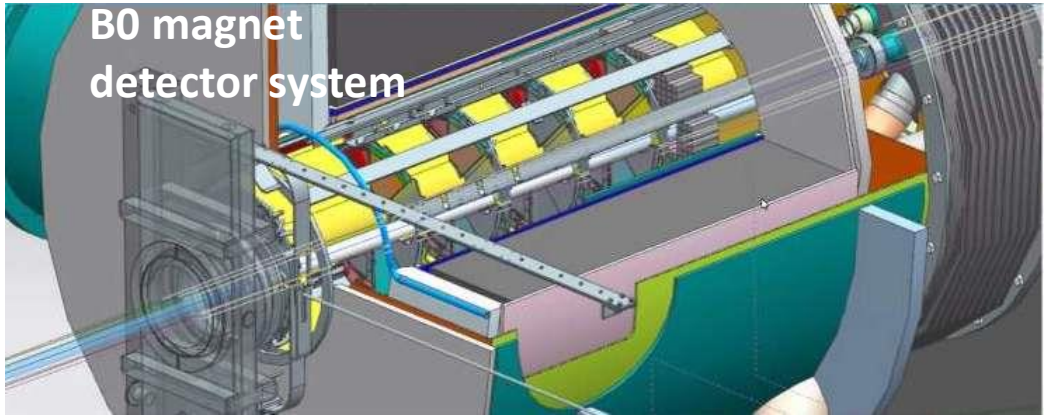
- KM20
- GK

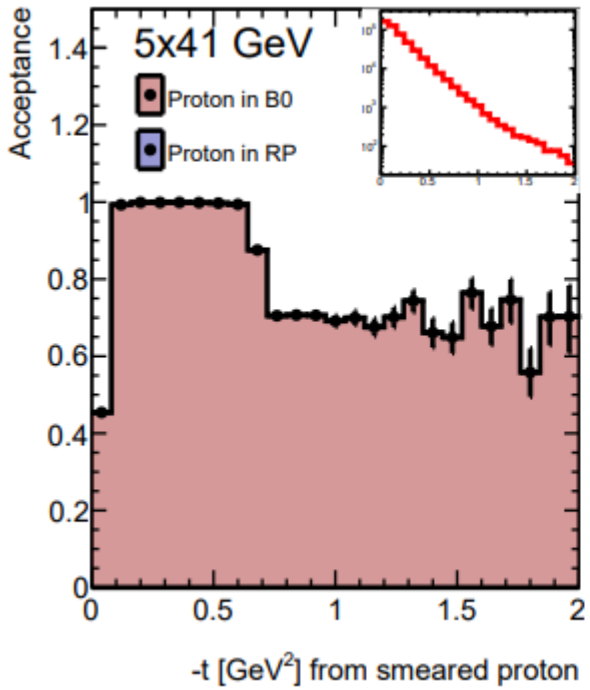
At the lowest COM energy, most of the events will be 0.05<x<0.5

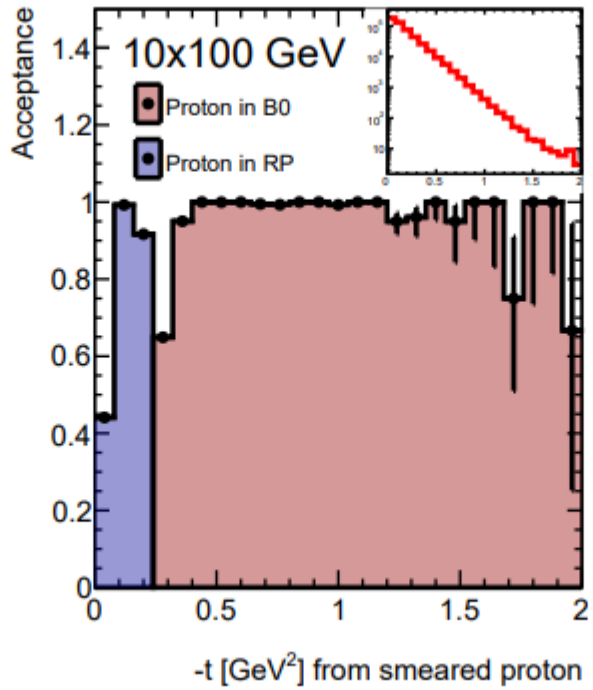


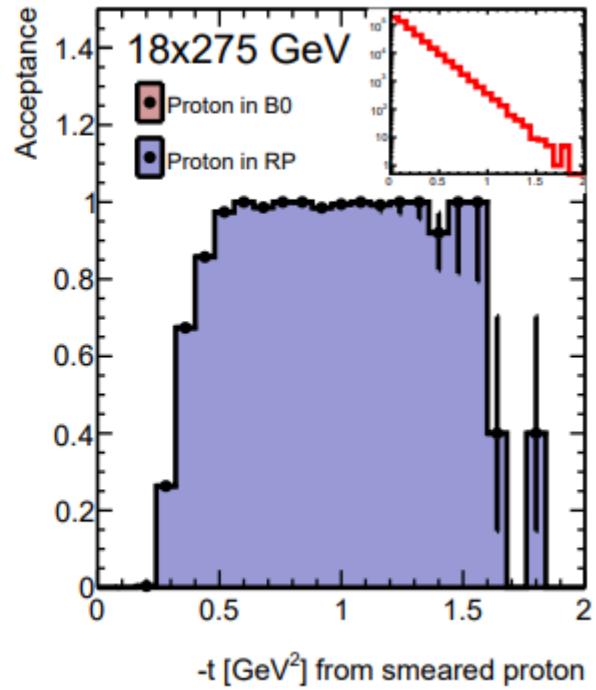
DVCS: acceptance

- Continuous coverage in t in a single detector (B0) at low energy
- Important for Fourier transform and 3D imaging



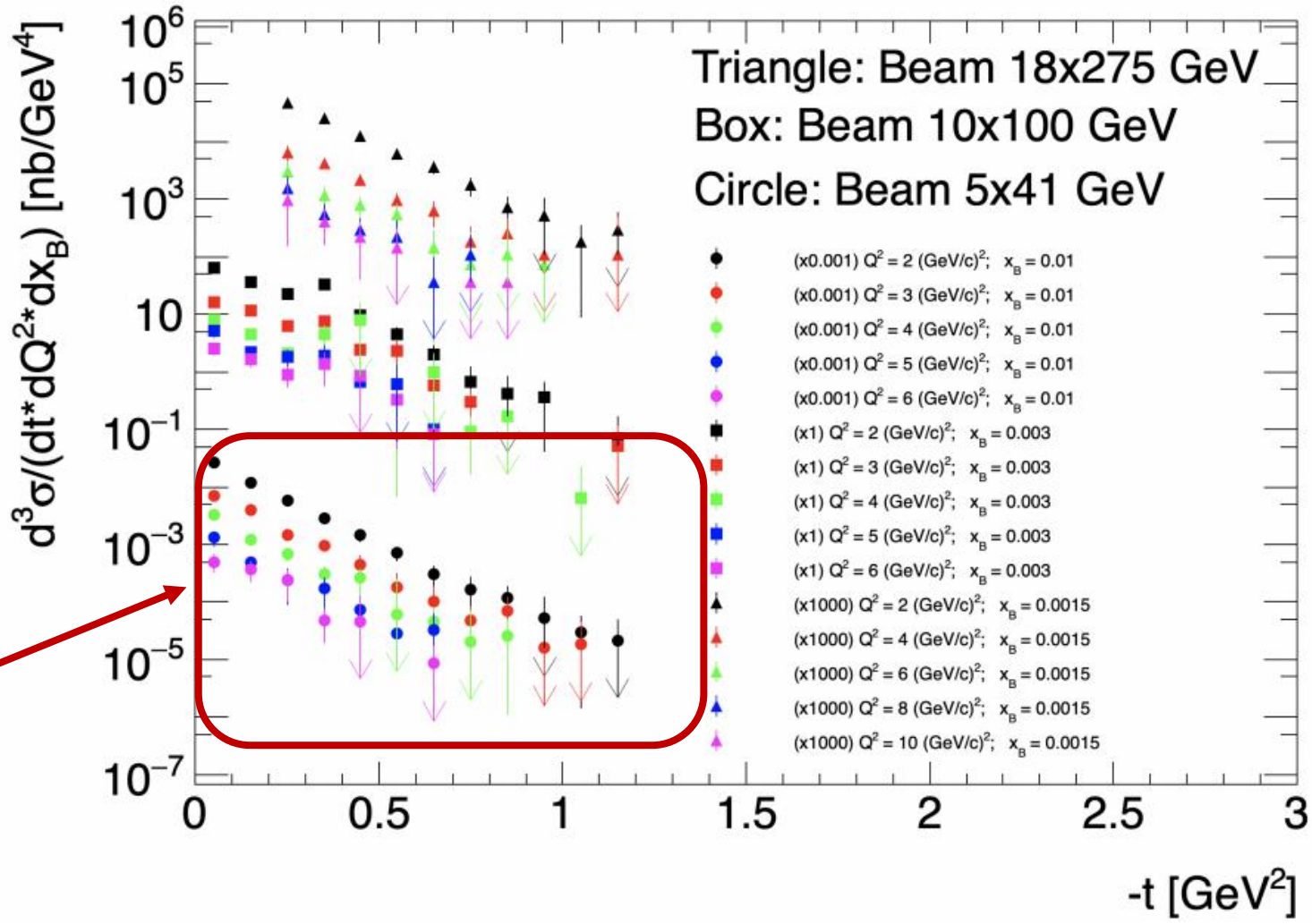






DVCS: cross section measurements

Projections for 1 year of running at highest luminosity (10_{34} $cm^{-2}s^{-1}$)

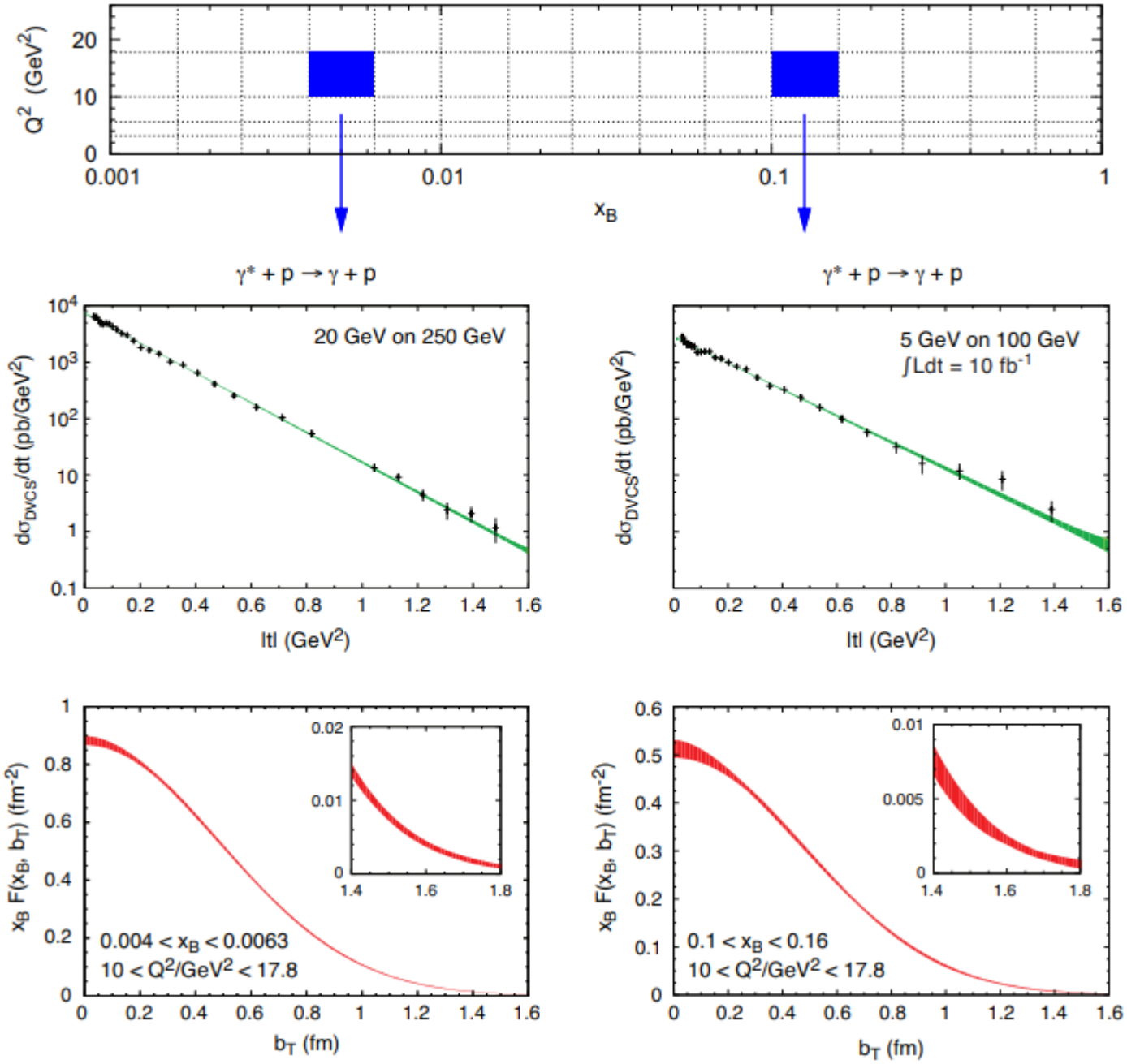


High *x* data

DVCS: nucleon 3D imaging

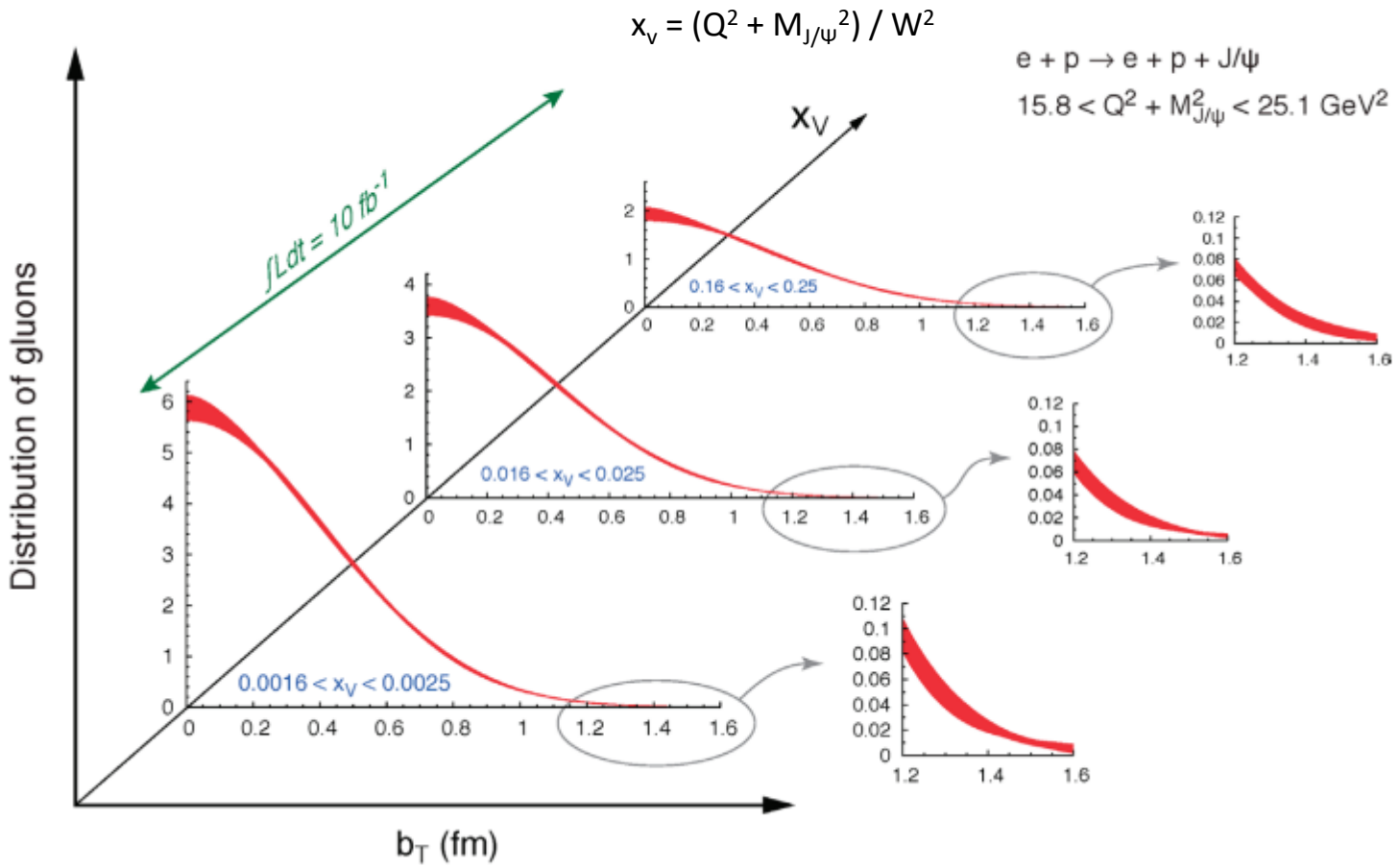
- Projections for 10 fb^{-1} (≈1 year)
- Very good statistical precision, even at large t and high x

  (for 5 GeV x 100 GeV)

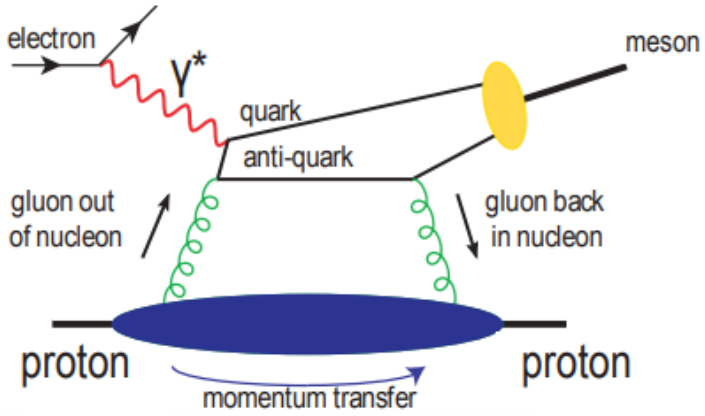


EIC White Paper

Exclusive J/Ψ production: 3D imaging of gluons

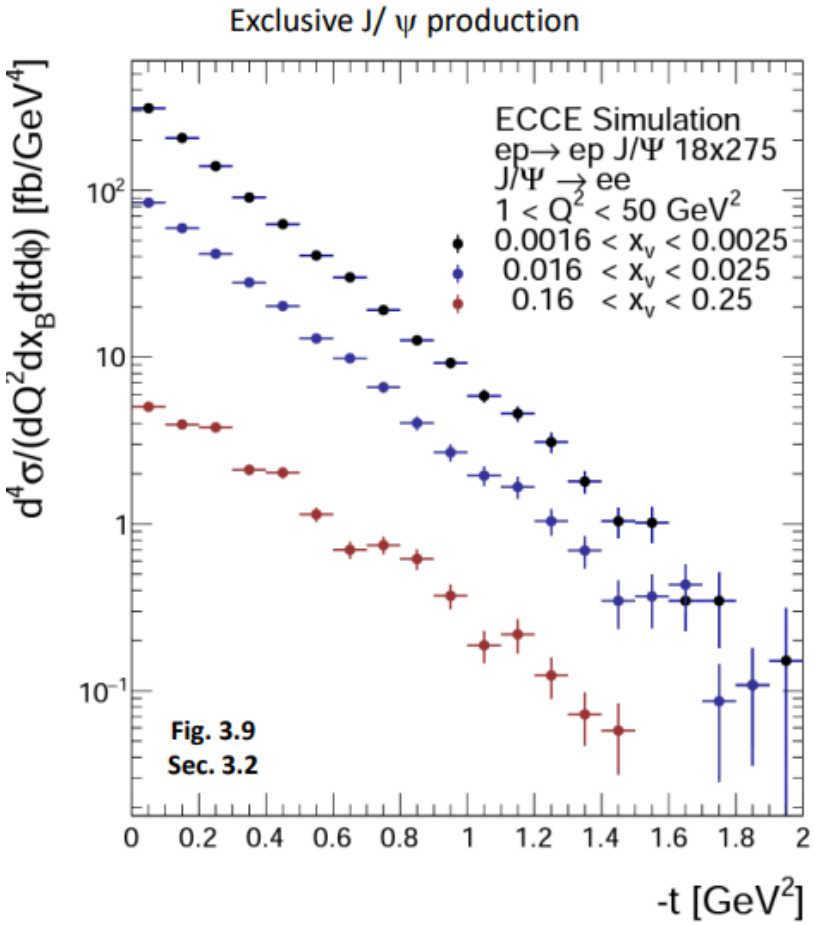


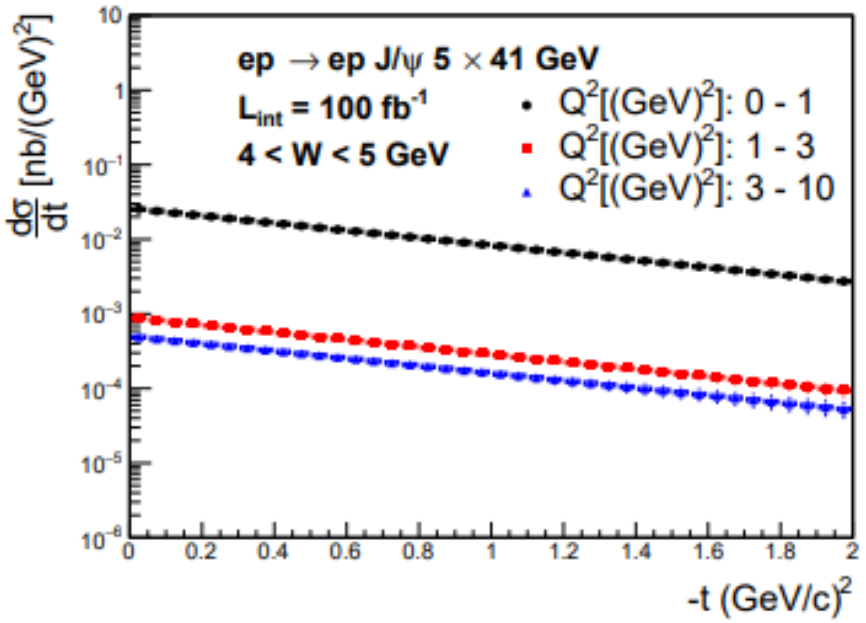
EIC White Paper

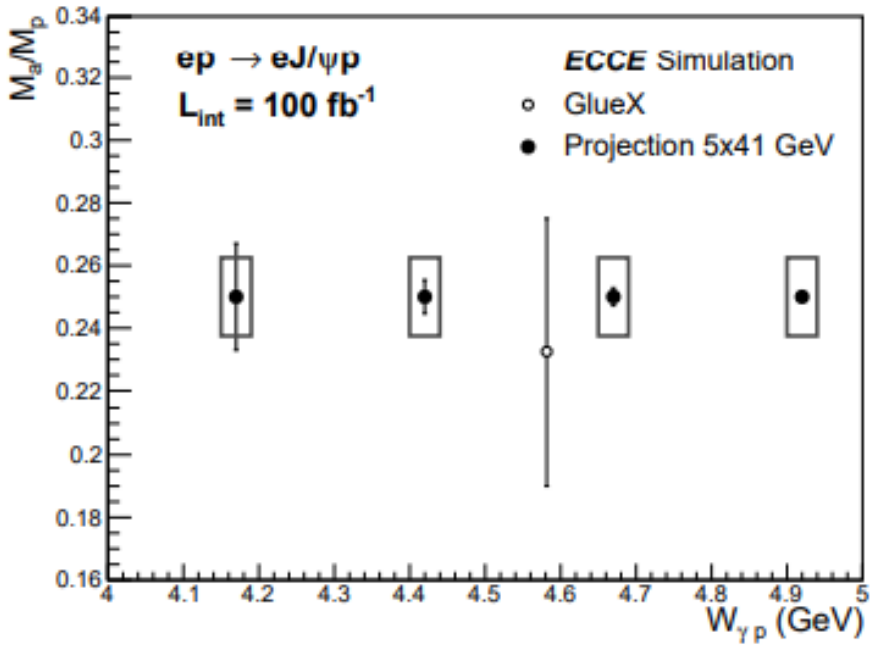


- Exclusive J/Ψ production access gluon distributions inside the nucleon
- Very high precision expected with one year of data (10 fb^{-1}), even at high b_T

Origin of mass







Threshold J/Ψ production as a function of Q2 is sensitive to the trace anomaly contribution to the proton mass

Other exclusive channels

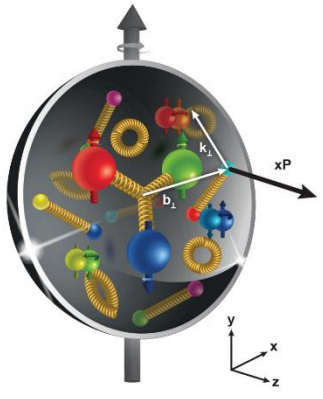
- Other meson channels (π^0, Υ, etc)
- Time-like Compton scattering
- DVCS off nuclei
- Backward DVCS

Studies ongoing

No projections for high *x* (that I could find), but could be done

Summary

- The EIC facility will address fundamental questions on the structure and dynamics of nucleons and nuclei in terms of quarks and gluons.



- Exclusive reactions are an essential tool to address one of the key deliveries of EIC: 3D imaging, gluon content of the nucleon and nuclei
  - 3D imaging
  - Gluon content of the nucleon and nuclei
  - Origin of nucleon mass
- EIC will mostly cover the low-*x* kinematic region, dominated by gluons and sea quarks, and complement measurements performed at JLab (at 12 and 22 GeV)
- A significant overlap with JLab in the region of $x>0.05$ will allow cross-checks and shed light into the transition region between the gluon-dominated kinematics and the valence-quark kinematics

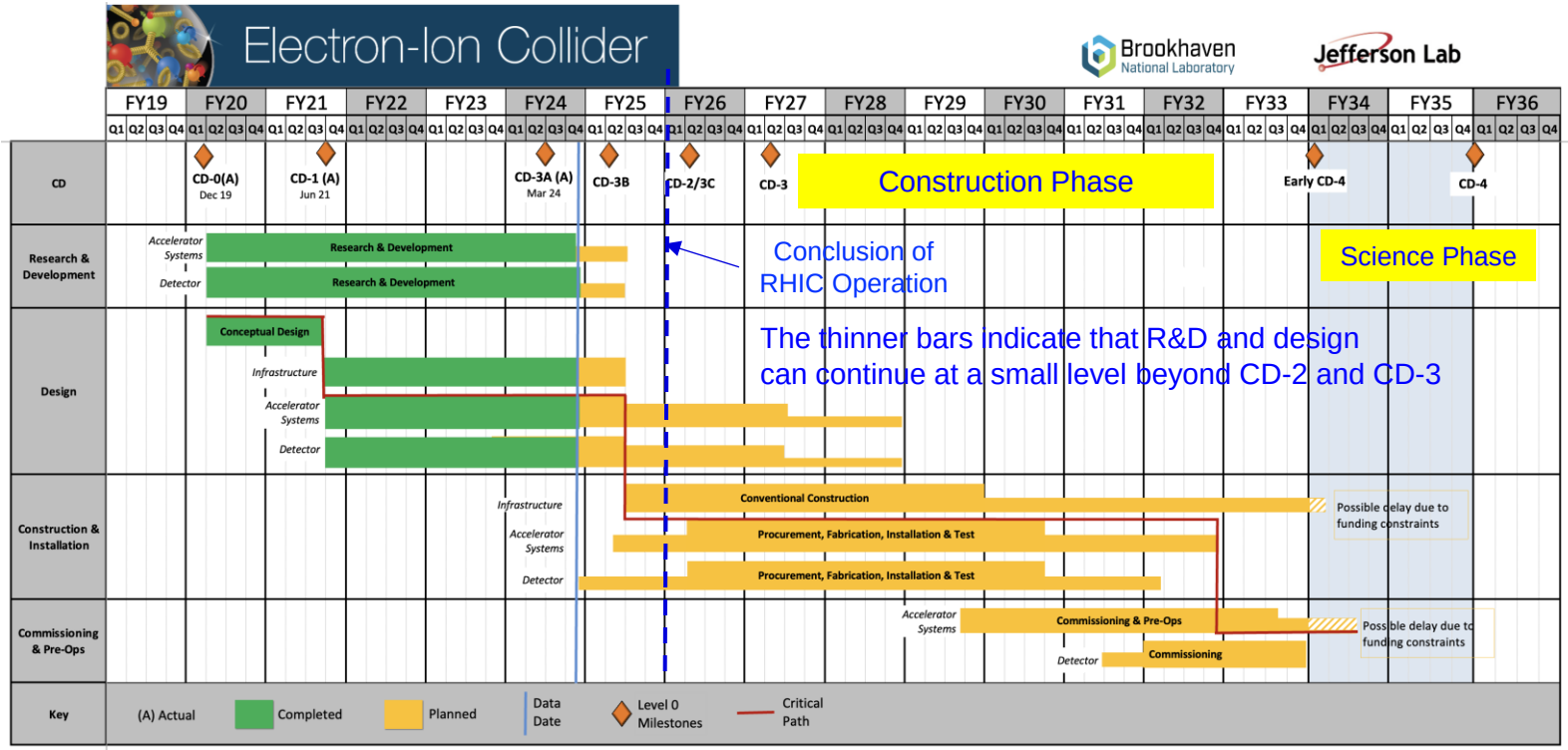
Back-up

EIC schedule

CD-3A:
Approve start of long-lead procurements
CD-3A items passed final design review
All interfaces related to them are frozen
Authorization received March 28, 2024.

CD-2:
Approve prelim. design for all subdetectors
Design Maturity: >60%
Need “pre-”TDR (or draft TDR)
Baseline project in scope, cost, schedule

CD-3:
Approve final design for all subdetectors
Design Maturity: ~90%
Need full TDR



As presented by the EIC project on Oct 9, 2024

EIC project timeline

- **Dec 2021 (CD-1):** Start of detector design (through CD-3)
- Dec 2025: R&D completed (expected CD-2)
- 2027: Start of construction (expected CD-3),
- 2034: Start of early physics program (expected CD-4A)
- 2036: Project completion (expected CD4) and start of operations

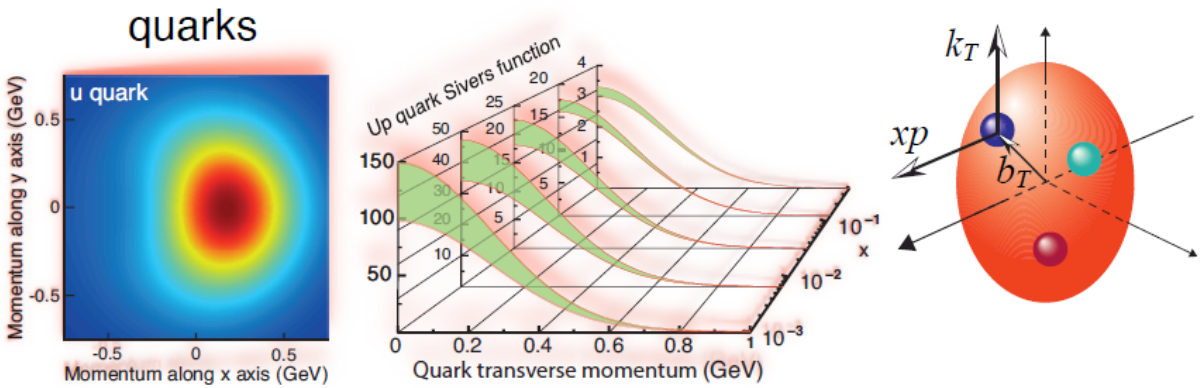
Updated EIC Critical Decision Plan	
CD-0/Site Selection	December 2019 ✓
CD-1	June 2021 ✓
CD-3A	March 2024 ✓
CD-3B Review	**January 7-9 2025**
CD-2/3C Review	End of 2025?
CD-3 Review	End of 2026?
early CD-4	December 2034?
CD-4	December 2036?

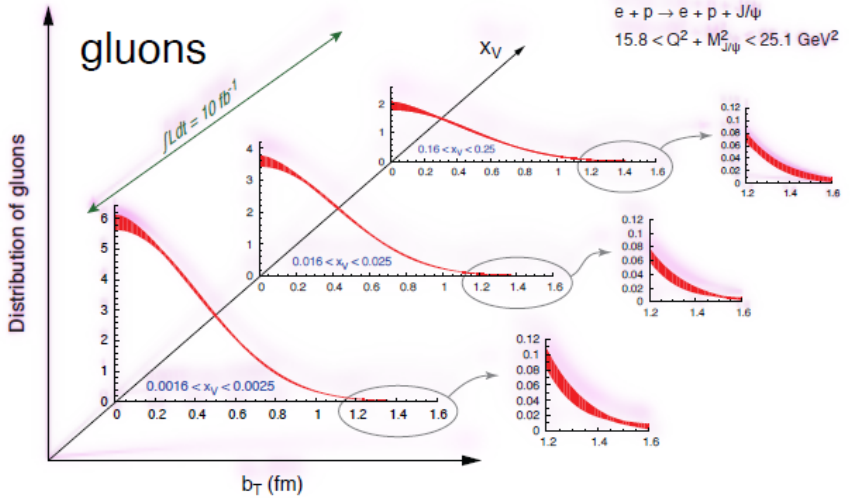
TMDs and GPDs at EIC

- Transverse Momentum Distribution and Spatial Imaging

$f(x, k_T)$ 1+2D $\quad \int d^2 b_T \quad W(x, b_T, k_T) \quad \int d^2 k_T \quad f(x, b_T)$ 1+2D

Transverse Momentum Distribution (TMD) ⟵ Wigner Distribution ⟶ Impact Parameter Distribution





- Spin-dependent 1+2D momentum space (transverse) images from semi-inclusive scattering
- Spin-dependent 1+2D impact parameter (transverse) images from exclusive scattering

Fourier transf.
$b_T \longleftrightarrow \Delta$: $t = -\Delta^2$

$H(x, 0, t)$

$\xi = 0$

$H(x, \xi, t)$

Generalized Parton Distribution (GPD)

EIC White Paper
Eur. Phys. J. A (2016) 52