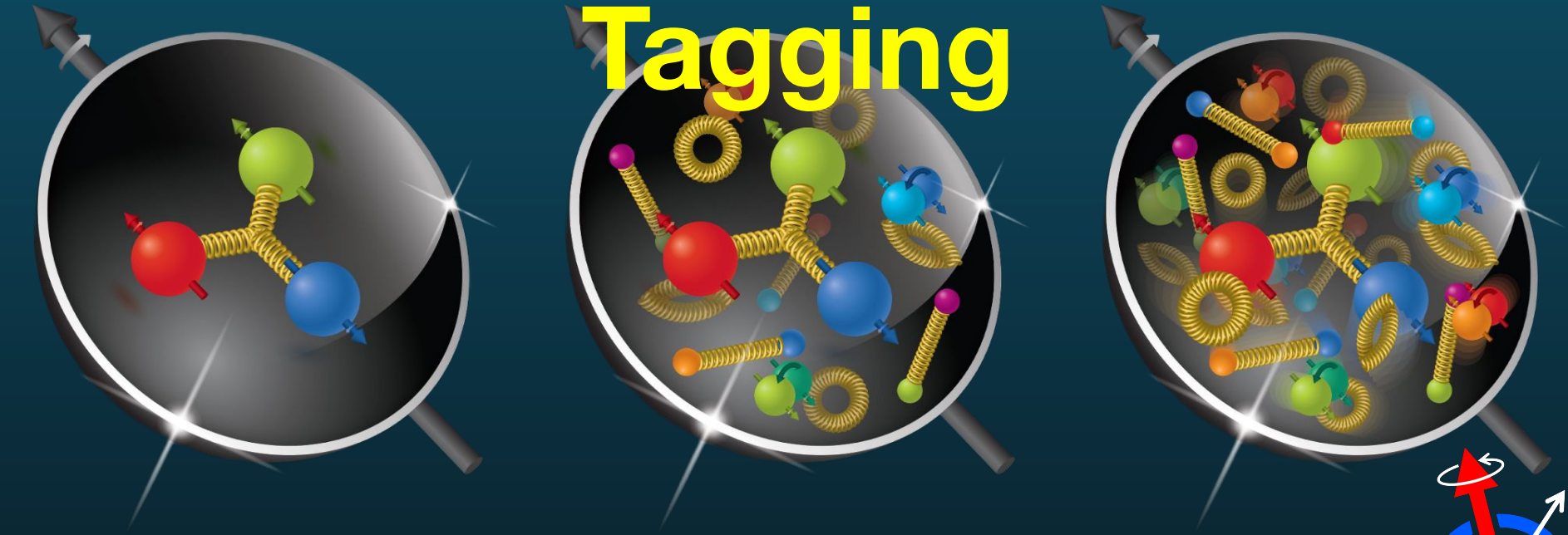
Exclusive Diffractive & Tagging



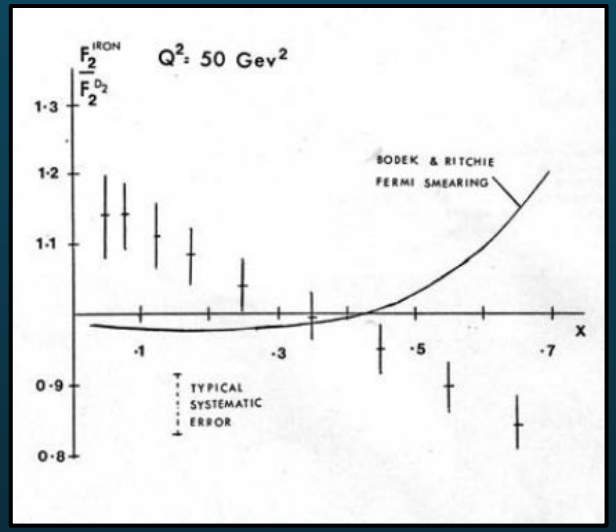
University of Glasgow

Gary Penman
23.07.23

ePIC

History of DVCS and DIS

- Measurements of F_2^{Fe}/F_2^{D2} in DIS at CERN, 1982
- Binding Energy of Nucleus << Typical momentum transfer
- Expect almost constant plot with minor corrections
- Instead, see clear downward gradient!
- Dubbed: ‘EMC Effect’

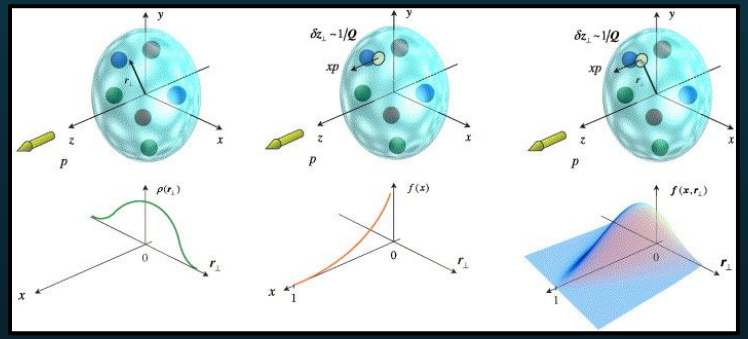


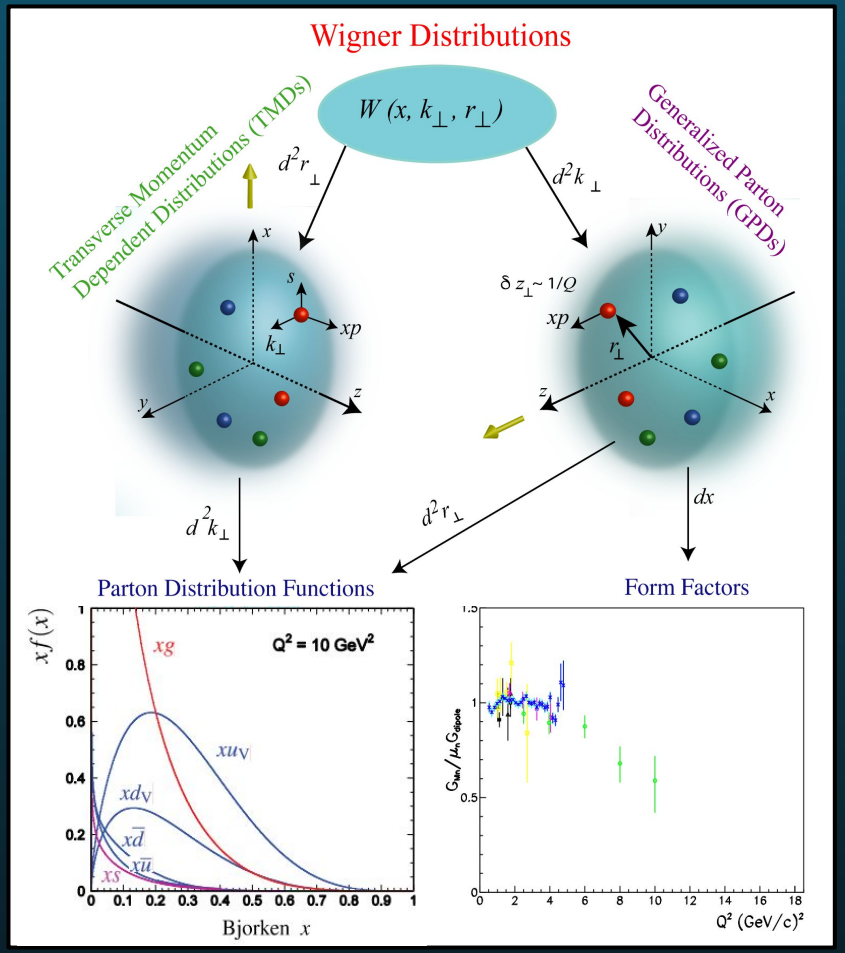
EMC Data, CERN Courier 1982.

https://cds.cern.ch/record/1734943/files/vol53-issue4-p035-e.pdf

Hard Exclusive Processes and 3D Imaging

- FFs describe 1D transverse distribution, PDFs describe 1D longitudinal momentum, but no correlation!
- GPDs directly correlate longitudinal momentum and transverse position of partons.





Exclusive Diffractive and Tagging (EDT) Working Group

Channel	Generator	Kinematics
DVCS ep	EpiC	5x41, 10x100, 18x275
DVCS eA (e-He4)	Topeg	5x41/u
TCS	EpiC	5x41, 18x275
DVMP ep	LAGER	18x275
DVMP eA (e-Pb)	Sartre + BeAGLE	18x108.4/u
Diffractive J/Psi (e-Zr90)	Sartre + BeAGLE	18x108.4/u + 18x122/u (Bg)
Pion FF* & SF	DEMP + EIC_mesonMC	5x41, 5x100*, 10x100, 18x275
Double Tagged e-He3	DJANGOH	5x41/u, 18x166/u
XYZ Spectroscopy	elspectro	5x41, 5x100, 10x100, 18x275
Y Photo and Electroproduction	eSTARlight	5x41, 10x100, 18x275
u-Channel DVCS	eSTARlight	5x41, 10x100, 18x275

←Zachery after this talk

Recent EDT publications from ECCE detector proposal work:
https://arxiv.org/abs/2208.14575

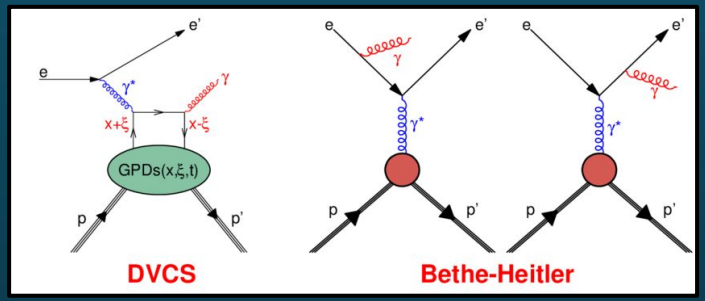
Work is ongoing to develop benchmark scripts + plots for ePIC detector.

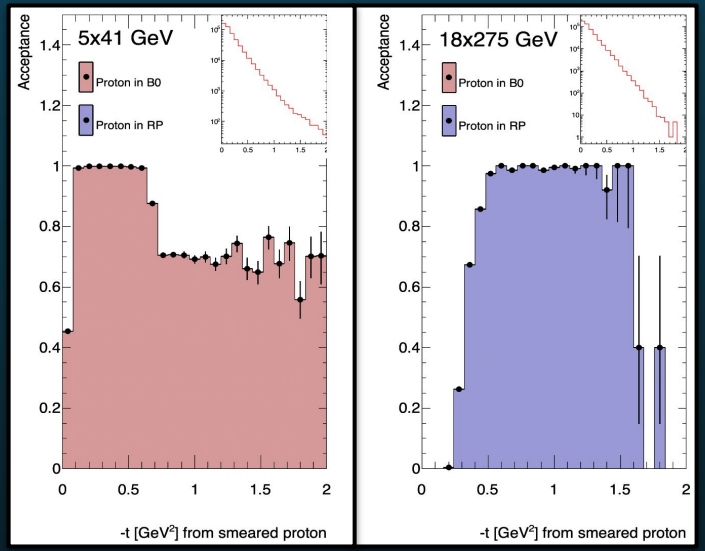
DVCS ep

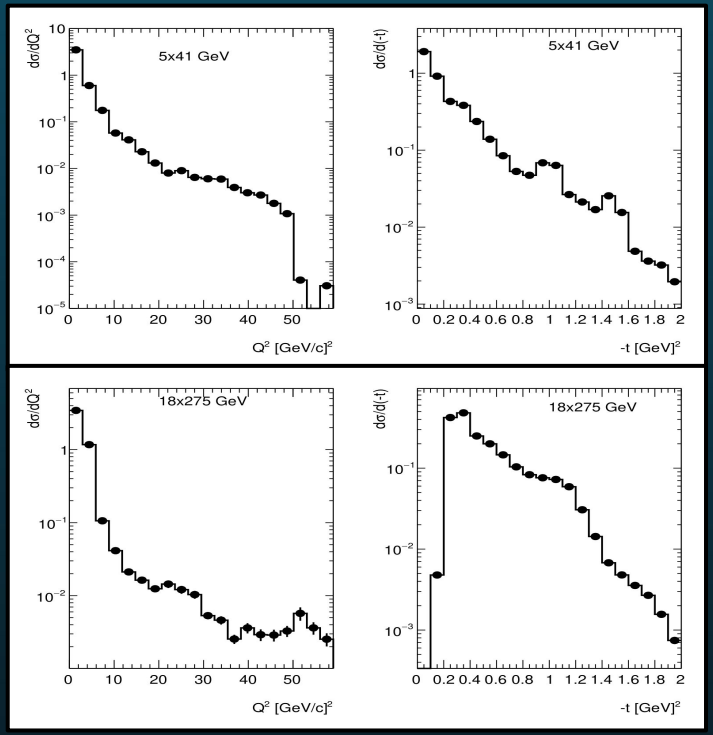
Allows probe of EMC effect as well as tomography.

Described by “Handbag mechanism” + Bethe Heitler diagrams.

Detection shifts from B0 to RP with increasing energy due to decreasing transverse deflection.







Credit: Igor Korovor

DVCS ep

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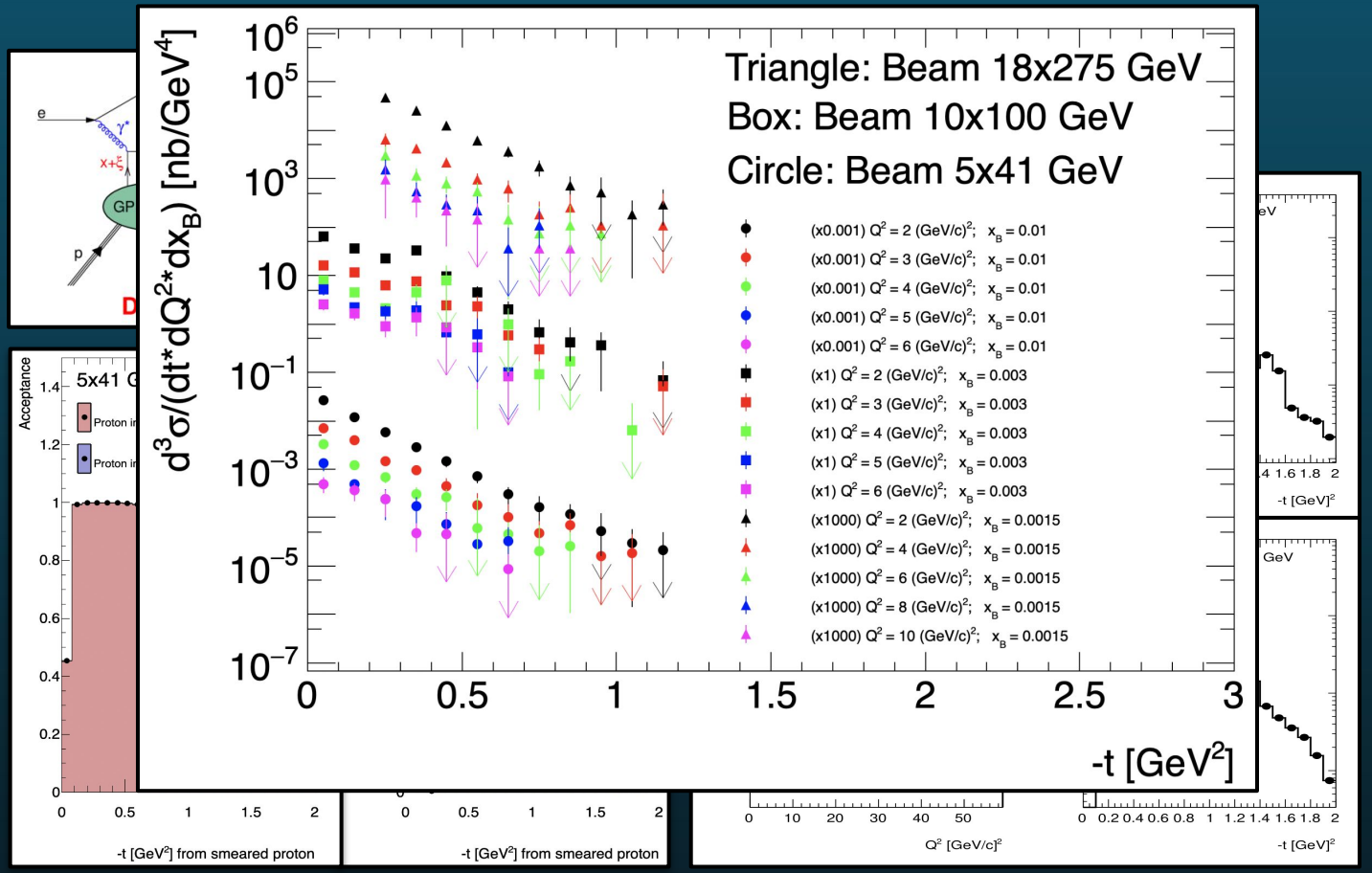


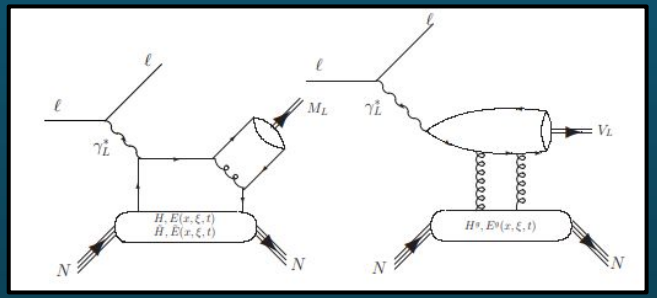
Credit: Igor Korovor

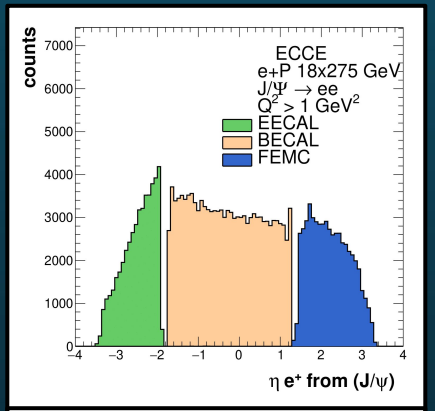
DVMP ep (J/ψ->e^-e^+)

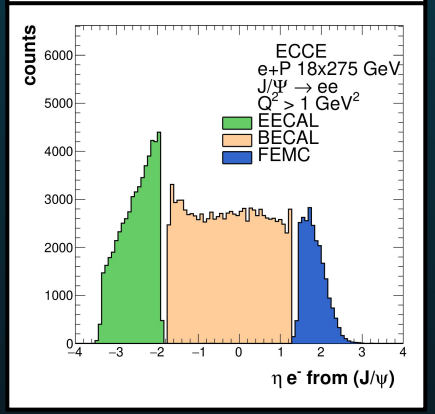
Access to gluon 2D spatial and 1D longitudinal momentum in nucleon.

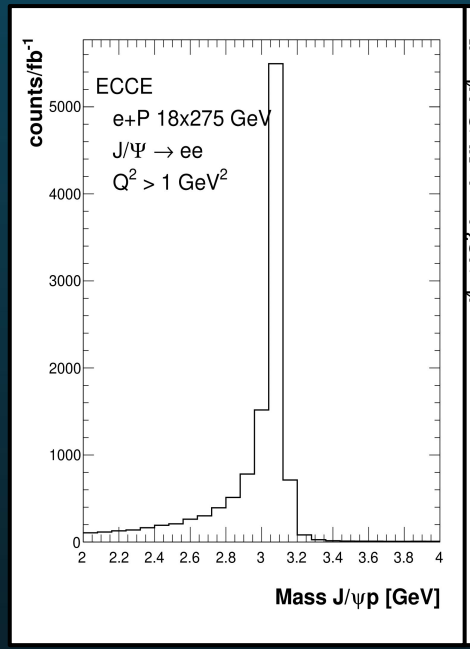
Lepton pair detected across η spectrum by multiple calorimeters.

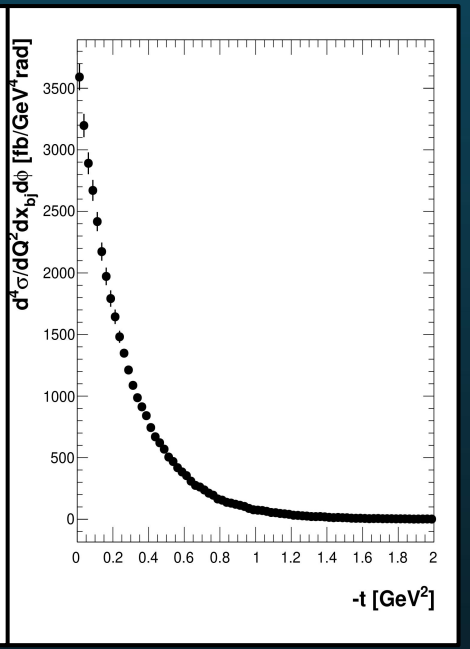
- Can reconstruct J/psi invariant mass spectrum











Credit: Stuart Fegan & Nathaly Santiesteban

DVMP e-Pb^{207} (ϕ->K^-K^+)

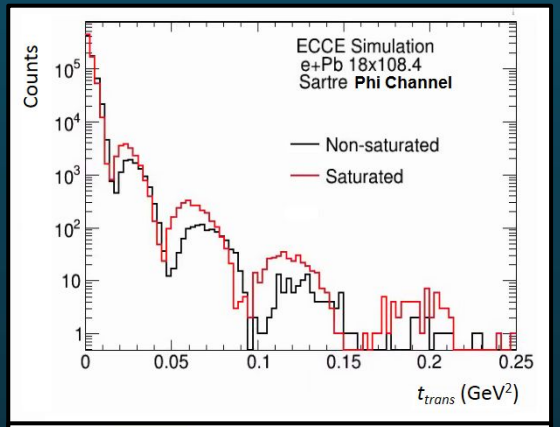
Study of vector meson final states allows exploration of saturation

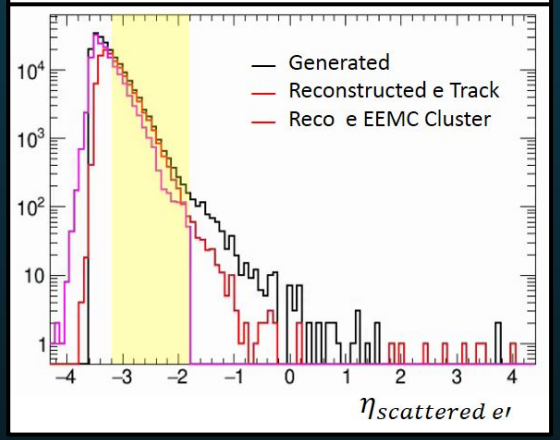
Larger mesons like ϕ more sensitive to saturation effects

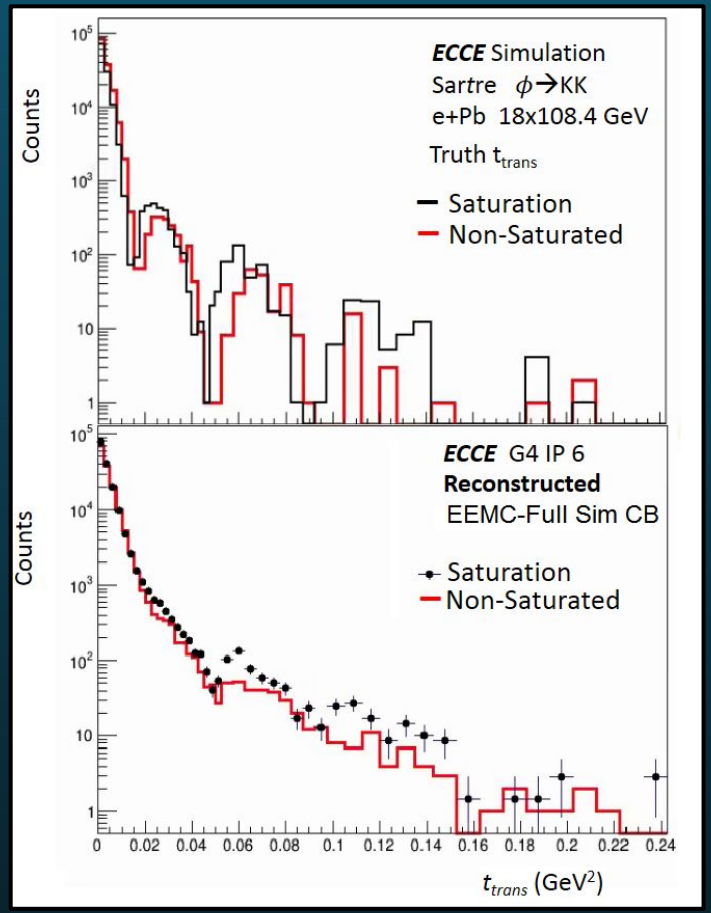
Expect shift in -t with saturation included.

Background Rejection + Calorimetry (CB Func)

➢ Begin to resolve diffractive minima in saturated spectrum







Credit: Justin Frantz, Peter Steinberg, Spencer Klein

DVCS He^4 with ePIC

DVCS of ^{4}He

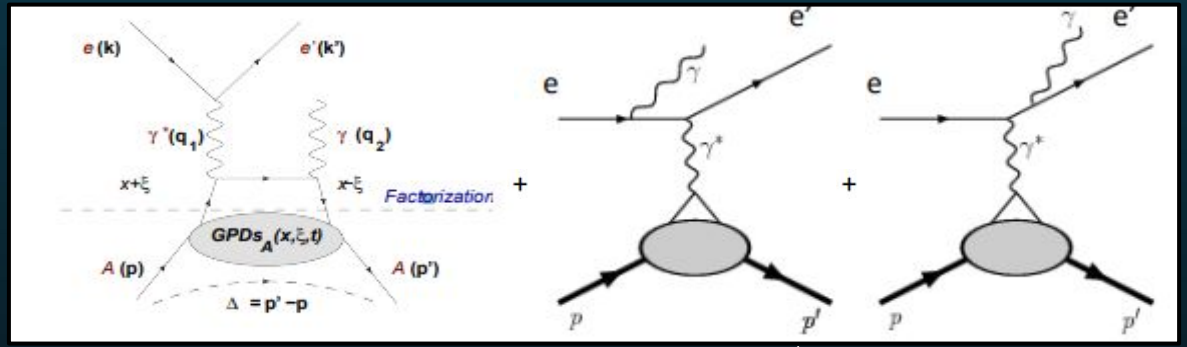
- Process which can give understanding of EMC effect, and tomographic view of nucleons.
- Pure DVCS reaction illustrated by ‘Handbag Mechanism’.
- At leading twist order full picture DVCS + Bethe-Heitler:

$Q^2 = -q^2 = -(k'- k)^2$, the virtuality of γ^*

$x_B = Q^2/2M\nu$

$t = -\Delta = -(p-p')^2$

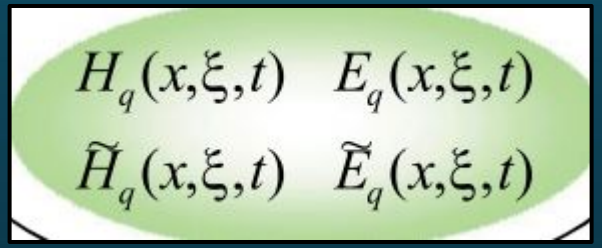
ϕ_h = angle between leptonic and hadronic scattering planes.



Handbag approximation of coherent DVCS of ^{4}He
https://arxiv.org/pdf/1910.07458.pdf

Generalized Parton Distributions

- DVCS / TCS allow access to 1+2D GPDs through CFFS.
- Many ep studies and experiments so far.
- Recent publication of 12 GeV e-p results, en (e`,d) approved at PAC50
- However only current e-^{4}He data from CLAS6!
  M. Hattaway, R. Dupre et al.
  https://arxiv.org/abs/2102.07419



Combine differently depending on polarization of beam and target (BSA, ITSA, BITSA, tTSA).

Only 1 Chiral even GPD needed to parameterize structure of spinless nuclei:

$$H_A(x,\xi,t)$$

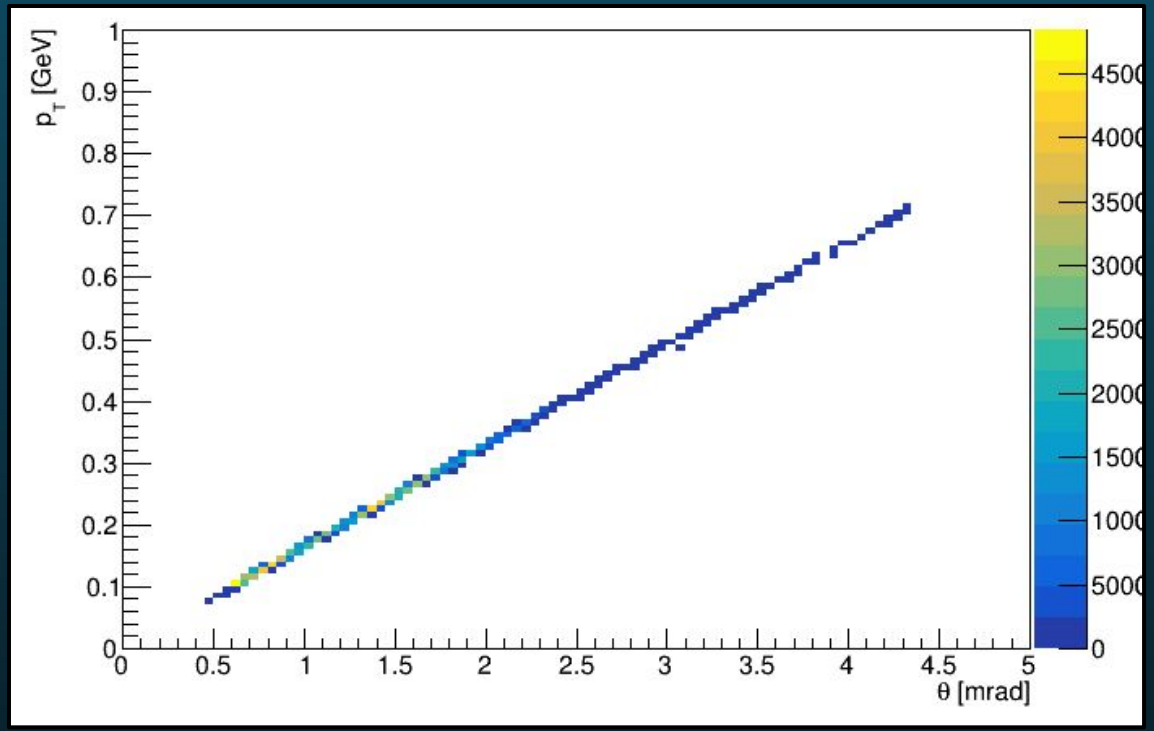
Setup

- Topeg Generator

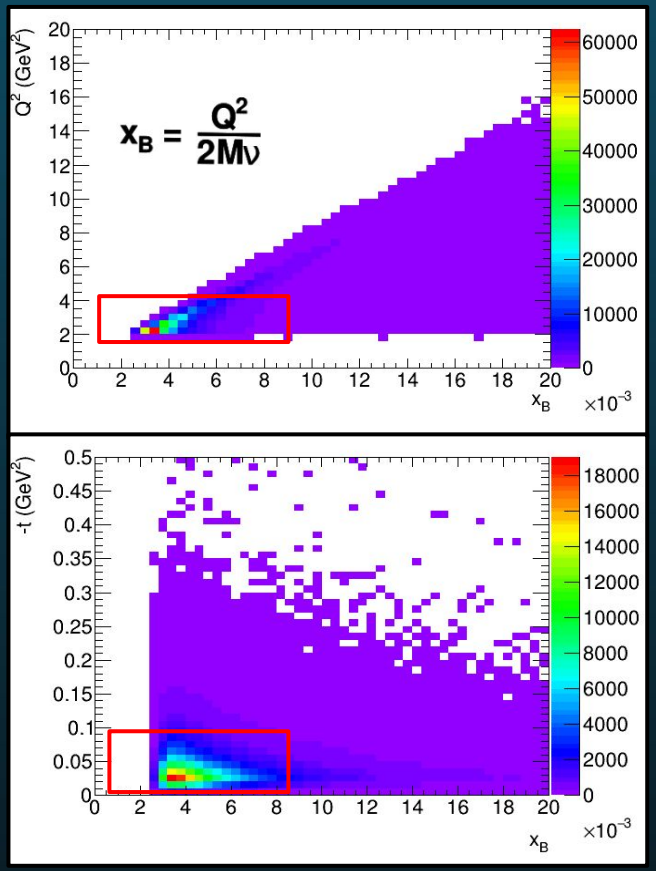
  https://gitlab.in2p3.fr/dupre/nopeg

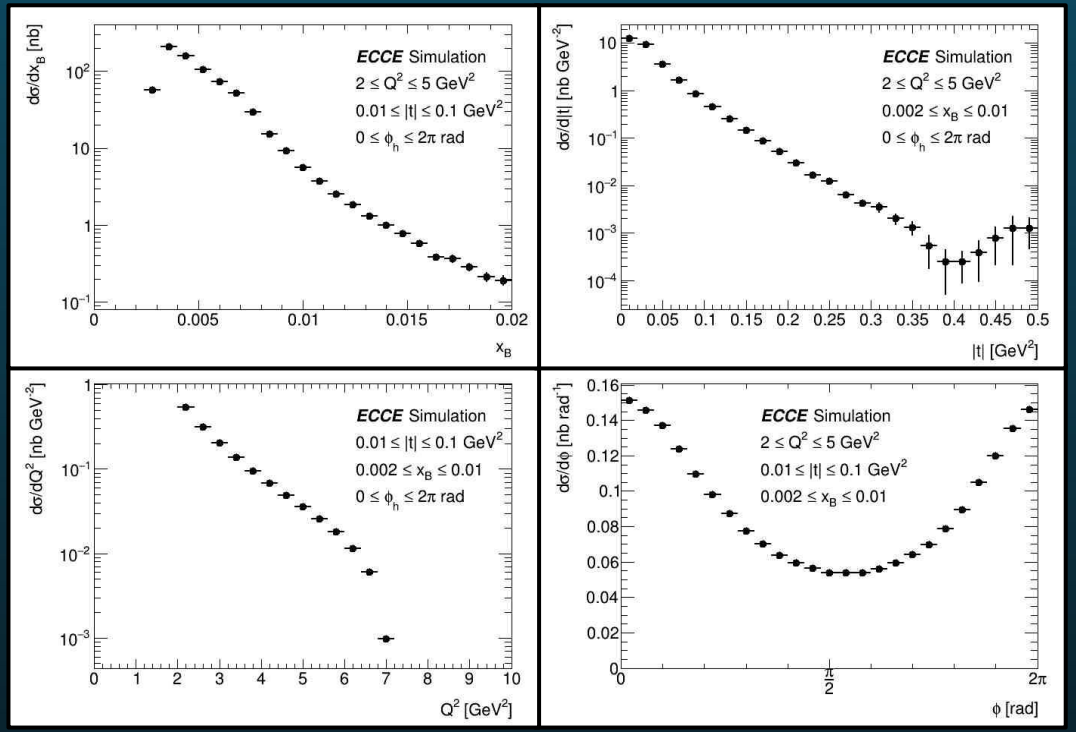
- 5 GeV e^-
- 41 GeV/u = 164 GeV He^4
- 1M events generated

Right: MC pt vs polar theta



ECCE Results





Scaling Forward Magnets to 41GeV/u He4

Need to correctly steer the ion beam through the beam pipe and centre of forward detectors (B0 Calorimeter, Roman Pots).

“Effective” scaling of 82 GeV required - 2 protons in He4!

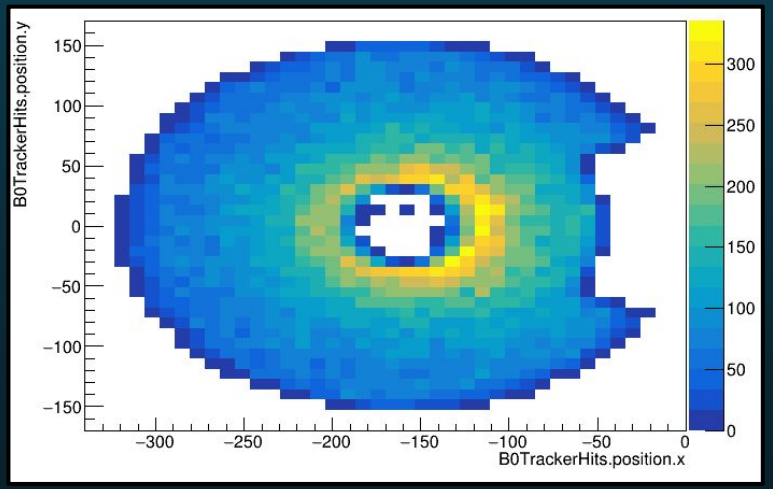
Initial attempts were unsuccessful, but recent attempt looks to be working.

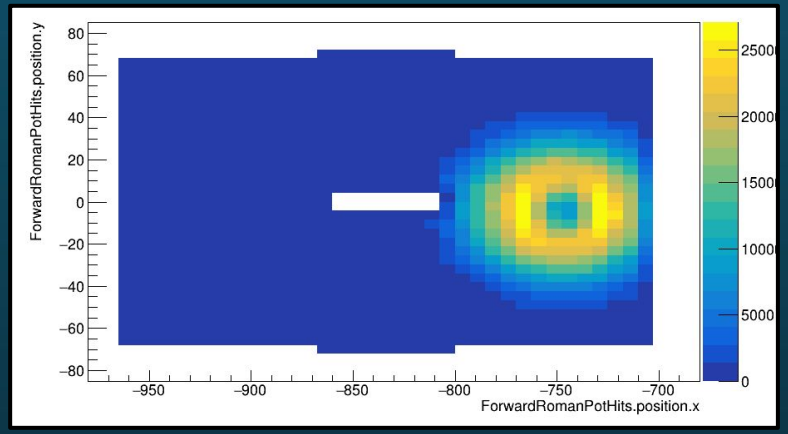
ePIC 41GeV Steering He4

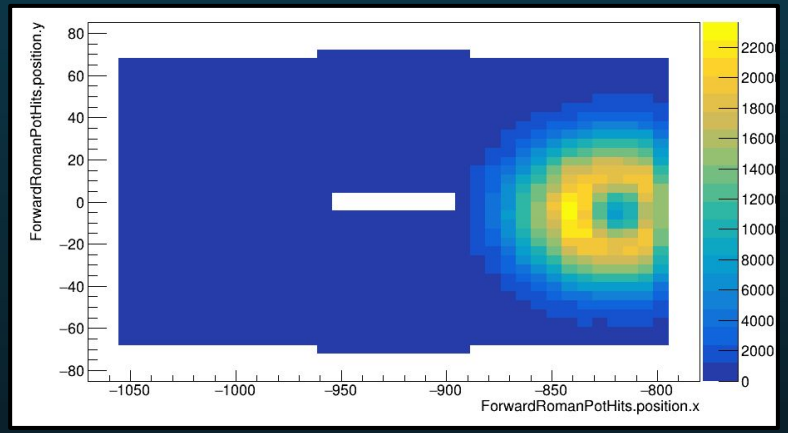
Config: epic_5x41 (default)

Version: epic-nightly

Build date: June 28-30 2023





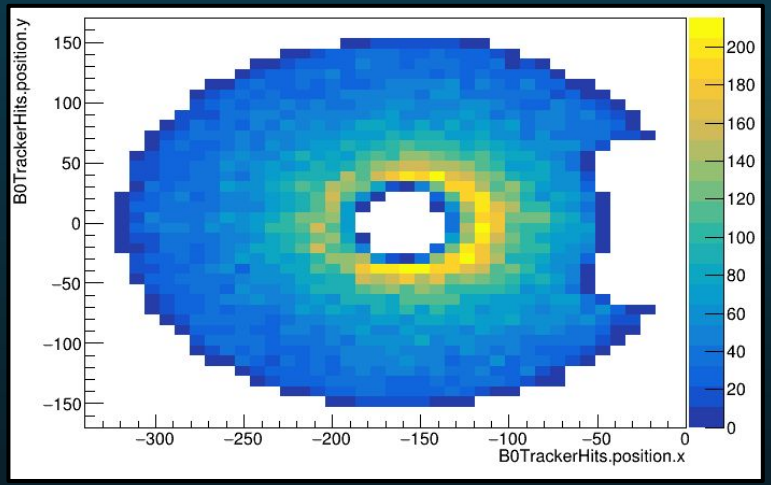


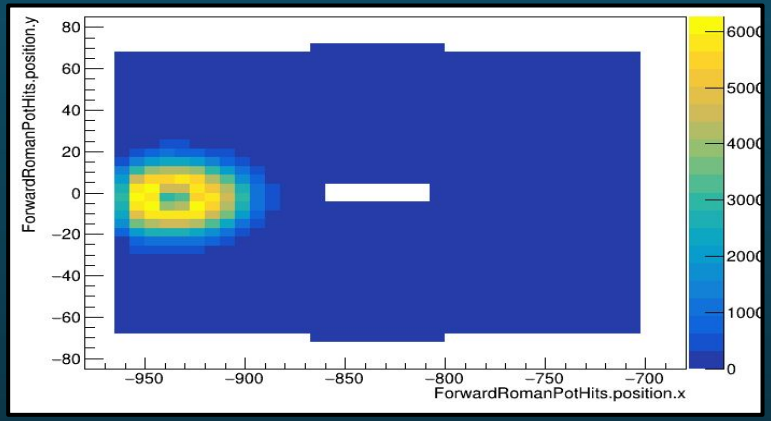
ePIC 82GeV Steering He4

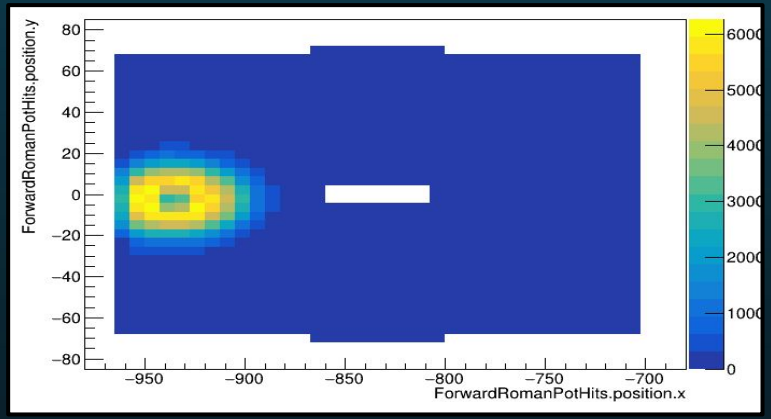
Config: epic_5x164 (custom - 5x100 with forward magnets scaled by 0.82)

Version: epic-nightly

Build date: June 15/16 2023





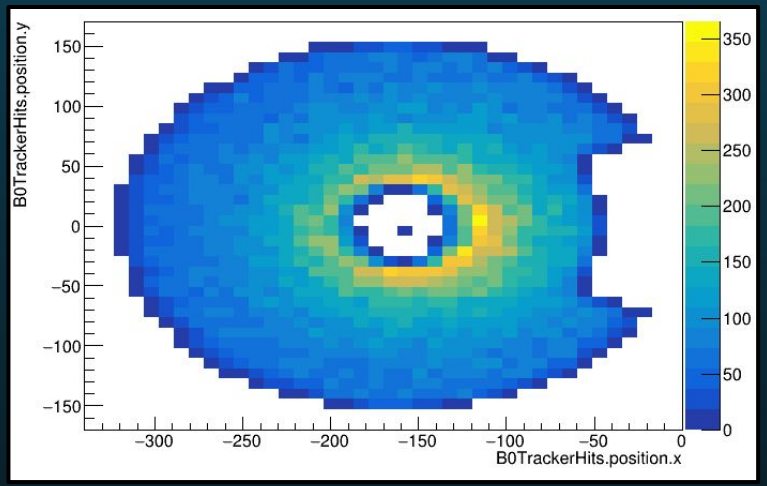


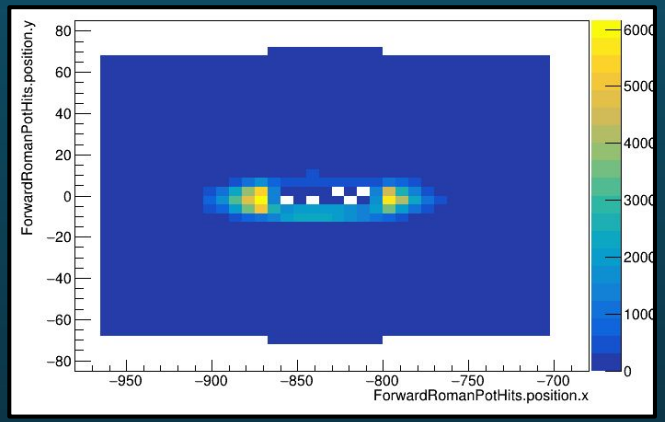
New 82GeV Steering He4

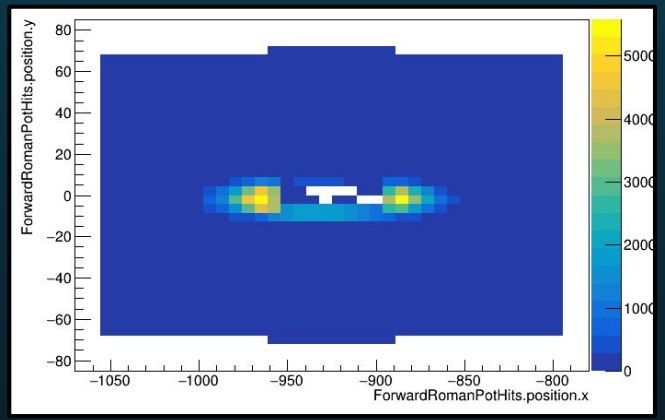
Config: epic_5x164 (custom - 18x275 with forward magnets scaled by 82/275)

Version: epic-nightly

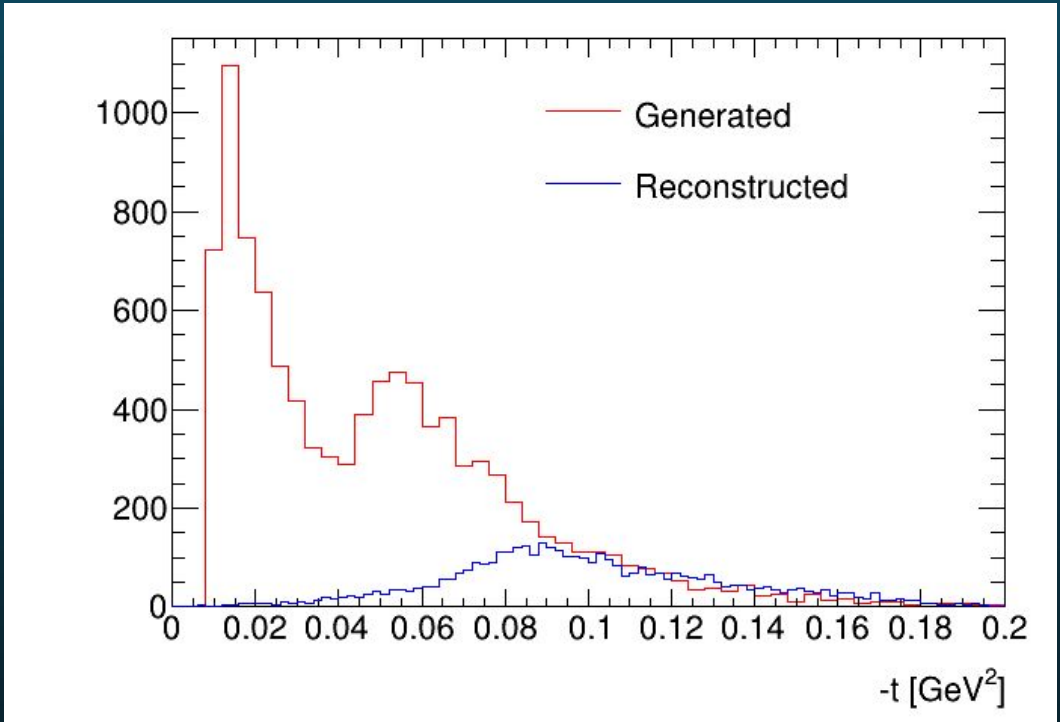
Build date: July 3rd/4th 2023







Initial Look at ePIC acceptance



Very early look at ePIC reconstruction (10K events).

Current efforts focused on developing correct optics model for He4.

Reconstruction currently performed with proton model.

Next Steps + Ongoing Work

- Pass simulation output through eic-recon
  - Full statistics reconstruction
- Determine correct forward optics model for He4.
- Benchmark Script for EDT Processes
  - Overlapping benchmarks with working group.
  - Forward acceptance / t reconstruction / other observables
- ePIC Physics comparison plots
- Background studies

THANKS!

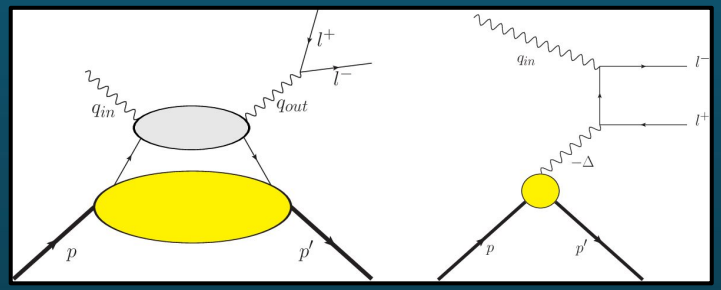
Backup

TCS ep

Inverse process of DVCS. Both sensitive to quark GPDs

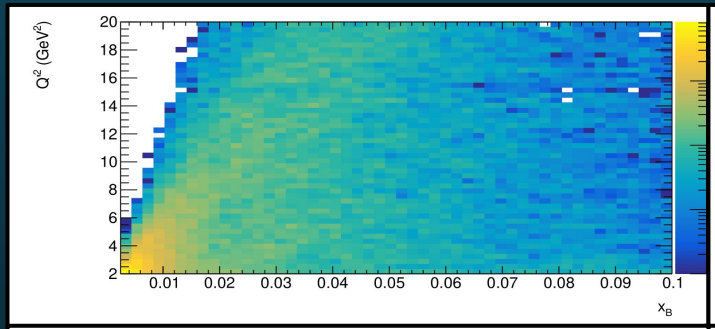
Also allows access to compton form factors (CFF) -> Each CFF related to a GPD.

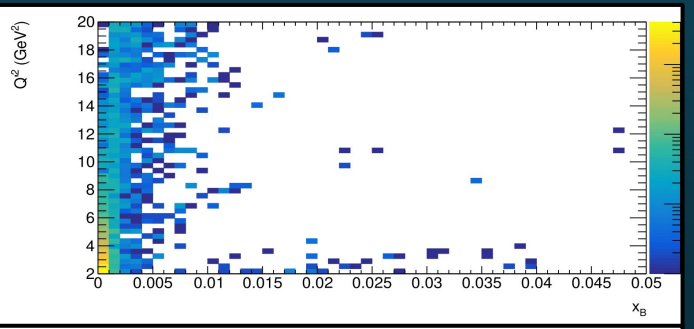
Reconstruction in higher energy kinematic yields less statistics (in this beam parameterisation) Due to lower RP occupancy

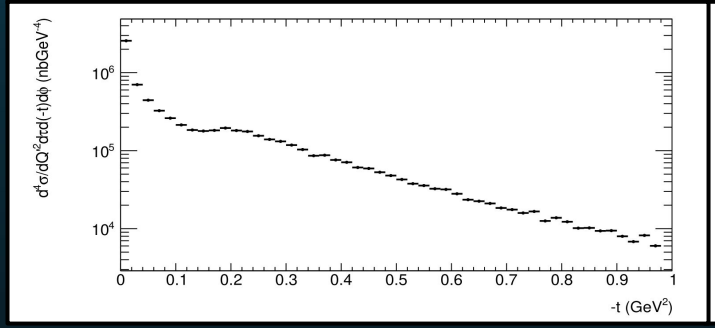


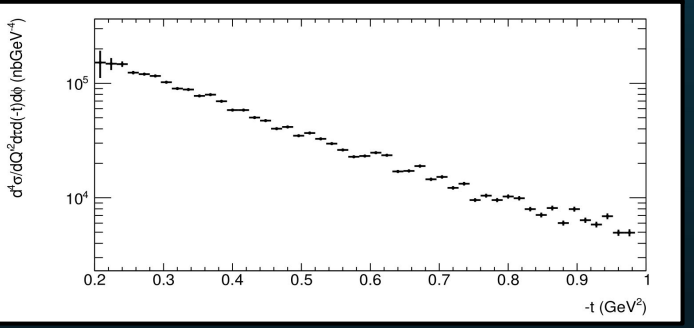
5x41

18x275



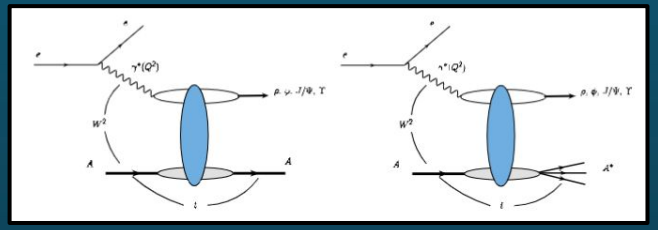






Credit: Kayleigh Gates

Diffractive J/ψ (e-Pb^{207})

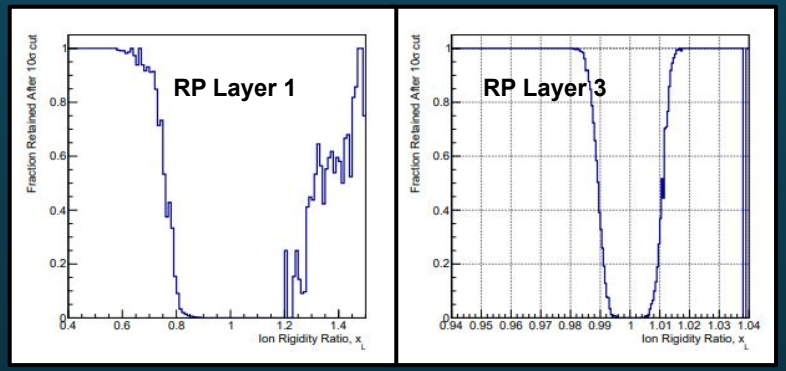


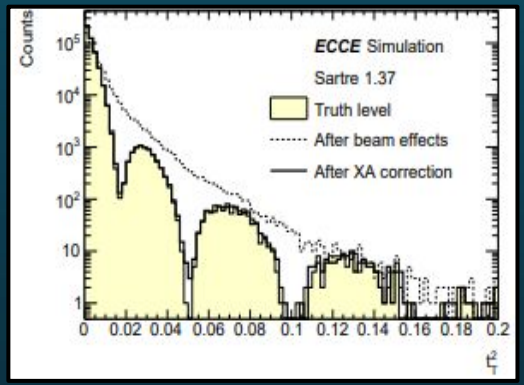
Less sensitive to saturation effects due to smaller wavefunction.

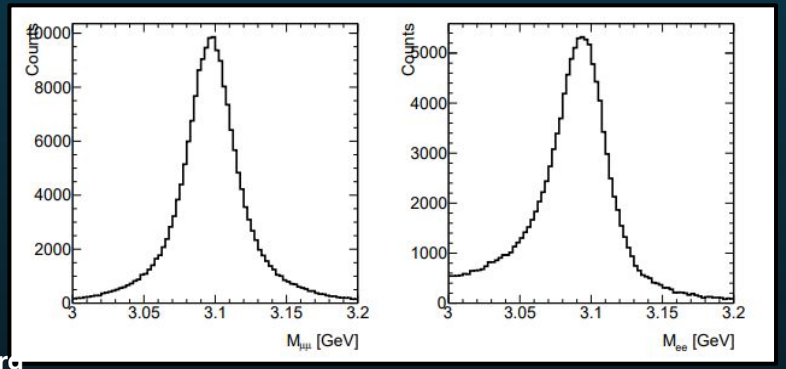
Detection of Rigid Ions highly improved with second interaction region.

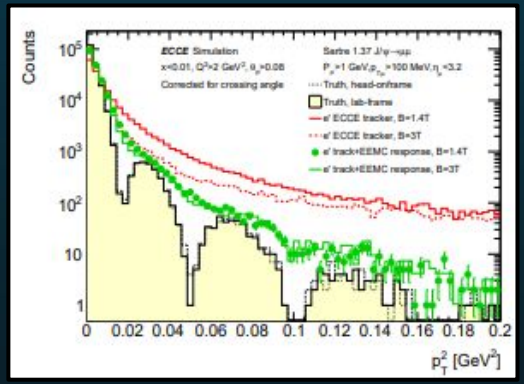
Invariant mass reconstruction using different lepton pairs in fair agreement.

➢ Begin to resolve diffractive minima when moving from tracker to calorimeter.



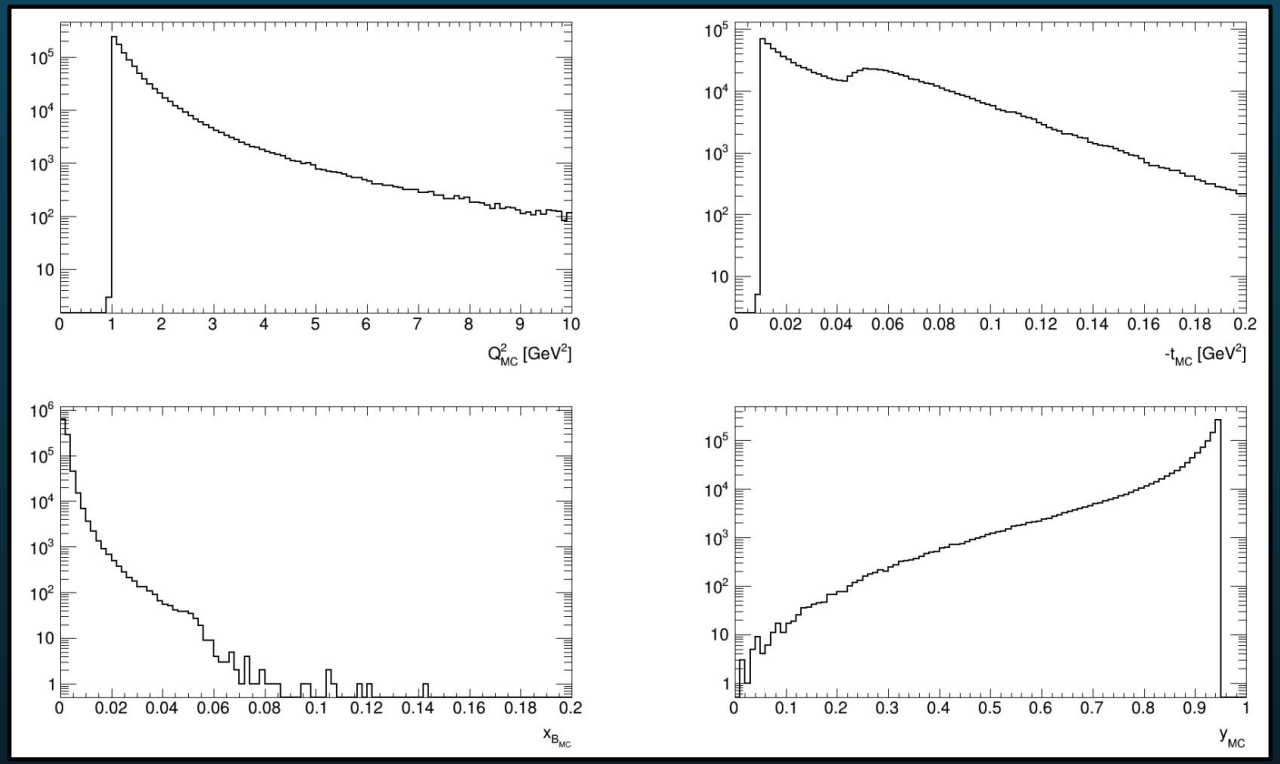




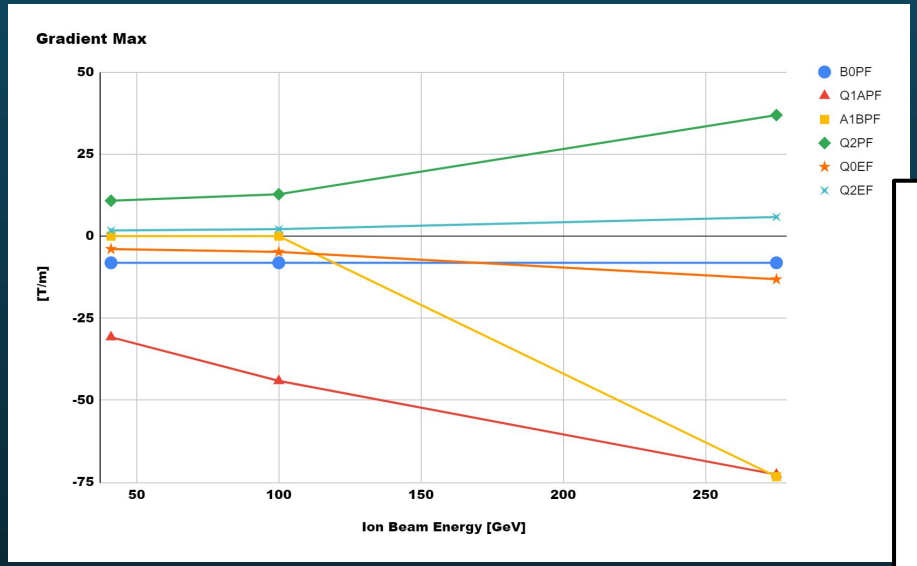


Credit: Justin Frantz, Peter Steinberg
Spencer Klein, Kong Tu

eHe4 DIS MC Kinematics



Default Far Forward Field Gradient and BMax values



Forward steering values show near linear interpolation between kinematic settings.