Studying Gluon GPDs at ePIC via Deeply Virtual Meson Production
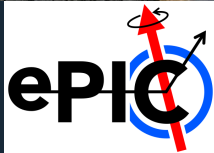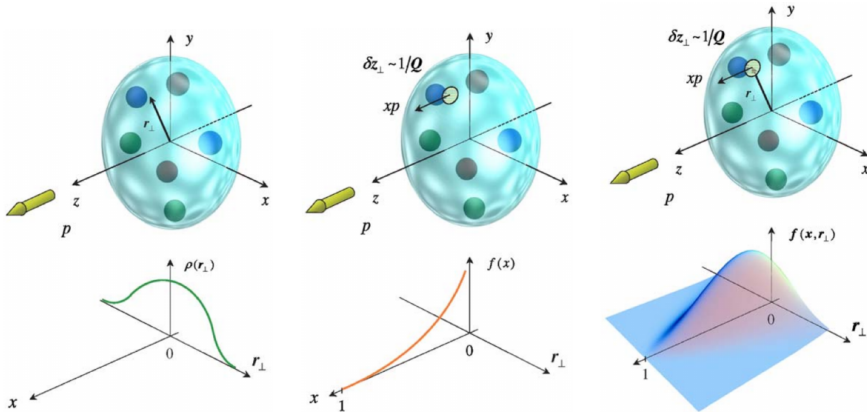
UK EIC Meeting, York

Stuart Fegan

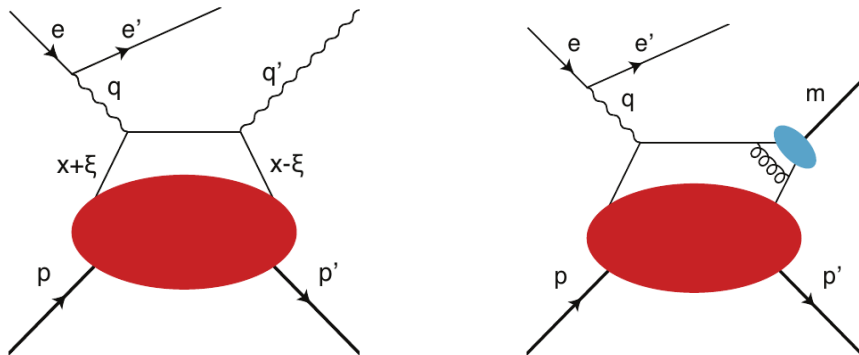University of York

March 1st, 2024

Motivation
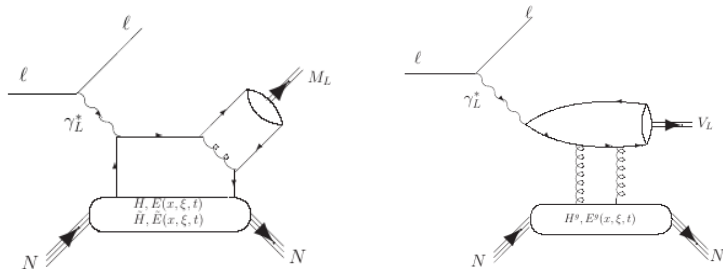

Uncovering Hadron Structure With Generalised Parton Distributions, A.V. Belitsky and A.V. Radyushkin

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Accessing GPDs

- GPDs are experimentally accessed via DVCS (left) and DVMP (right)
- DVMP, Deeply Virtual Meson Production, is an analogous process to DVCS, where a meson is produced in the final state instead of a photon.

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DVMP

arXiv:1511.04535

- Heavy vector mesons, such as J/Ψ and Υ, can probe gluon GPDs
- This can provide information about saturation by measuring the change in the spatial gluon distribution from low to high x_B
- However, this lies beyond kinematics of current facilities, e.g. Jefferson Lab

DVMP with Vector Mesons

Both the ATHENA and ECCE groups have published numerous aspects of their studies, providing useful benchmarks for our continuing work in ePIC
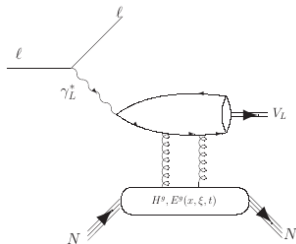
arXiv:1511.04535

- Exclusive vector meson channel J/Ψ, studied in ECCE
- Use heavy vector mesons to access gluon GPDs
- Study focussed on J/Ψ, but evaluated potential to expand to lower (ϕ) and higher mass vector mesons ($\psi(2s)$, Υ)
- Overall goal of evaluating ECCE performance against VM event generators and show feasibility of measurement

DVMP Generators

lAger - Argonne generic l/A-event generator (S. Joosten)

- The lAger generator was used to produce event samples for the ECCE studies presented
- Modular accept-reject generator, capable of simulating both fixed target and collider kinematics
- Significant recent developmental effort in support of DVMP studies, with a focus on J/Ψ and Υ
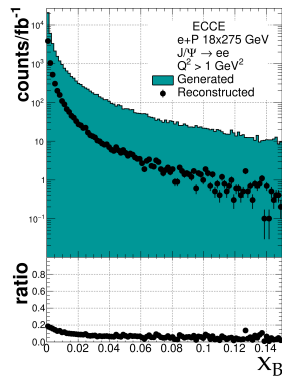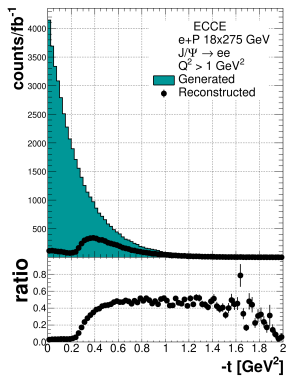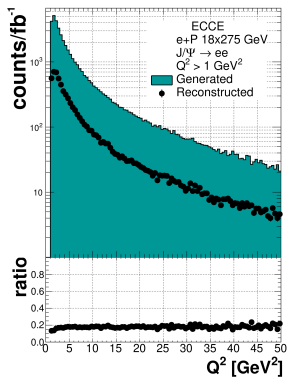
The ECCE Study

See NIM A 1052, 168238 (2023)

- Plots produced by N. Santiesteban (UNH)
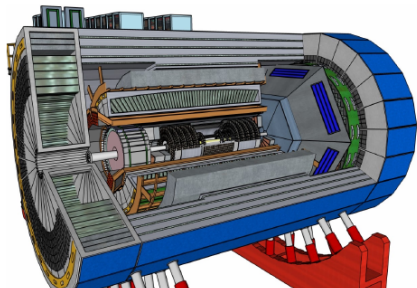
- 10 fb^{-1} of $J/\Psi \to e^+e^-$ events from eP collisions, generated in lAger at 18×275 GeV

- Smeared and passed through ECCE detector geometry
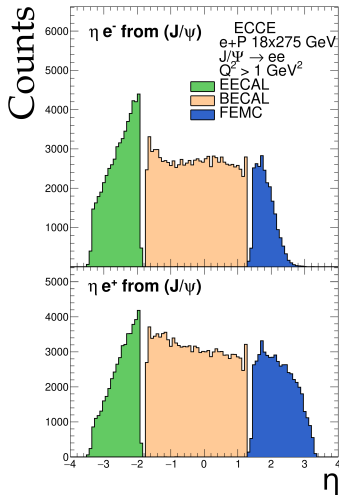
- Evaluating feasibility of reconstructing J/Ψ DVMP

Kinematics and Resolutions

$J/\Psi \to e^+ e^-$ event samples on eP collisions, 10 fb^{-1} at 18×275 GeV
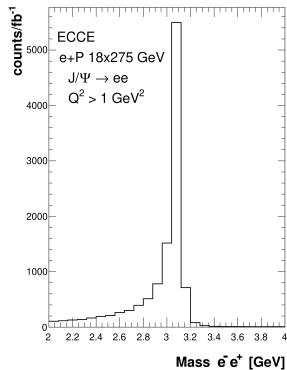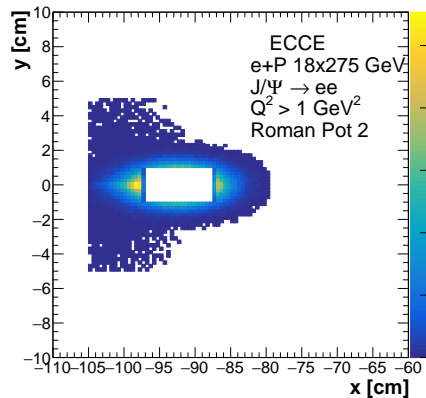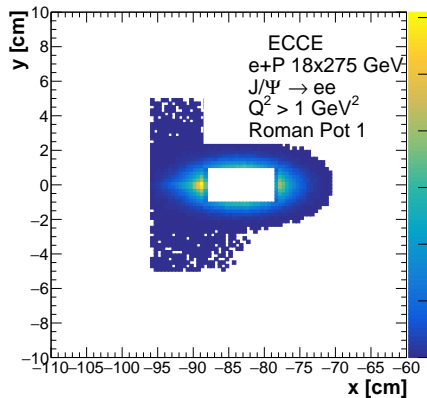
J/Ψ Detection

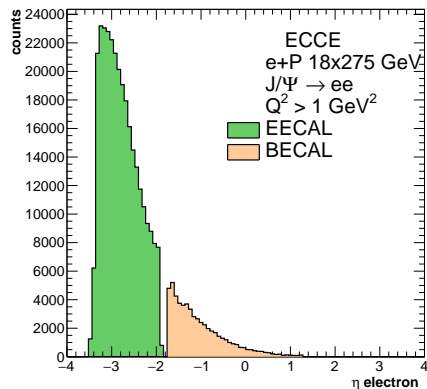- J/Psi decay products (Top: electron, Bottom: positron)

Scattered Proton Detection

Scattered proton detection in Roman Pots. B0 outside acceptance of kinematics studied

Scattered Electron Detection

- Scattered electron distribution
- Some J/Ψ decay electrons will be seen at negative η
- MC truth was used for this study
- Keenly aware of the need to be able to separate these experimentally

J/Ψ Cross Sections

- J/Ψ Differential cross section
- Physics interest will come from the evolution over $-t$
- Q^2 dependence will be useful for multi-dimensional binning

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Introduction
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DVMP Studies
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Summary and Outlook
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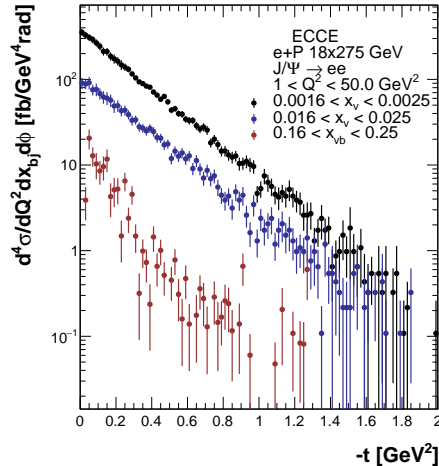
Next Steps for J/Ψ

- Studies shown from the ECCE detector model
- The ePIC design uses this as a starting point, but generated events have been processed through the latest geometry
- Investigations motivated by lessons learned so far (e.g. can we adequately separate scattered electron from J/Ψ decay electron in the real world?)
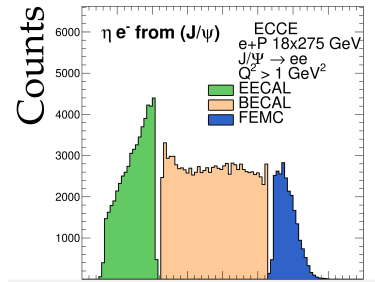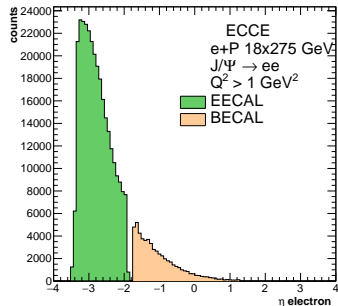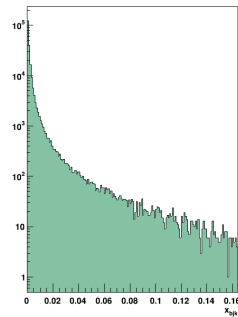
Next Steps for J/Ψ

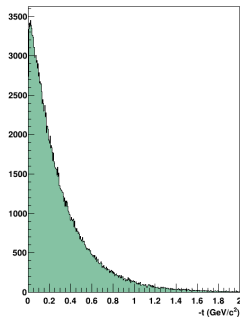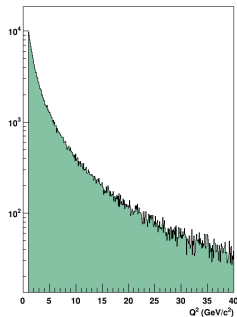- Parallel study of $J/\Psi \to \mu^+ \mu^-$ will allow assessment of muon detection in ePIC
- Also avoids separating the scattered electron from a J/Ψ decay electron
- Equivalent sample for this channel generated in lAger to match the $10\,fb^{-1}$ of $J/\Psi \to e^+ e^-$ (18 on 275 GeV eP)

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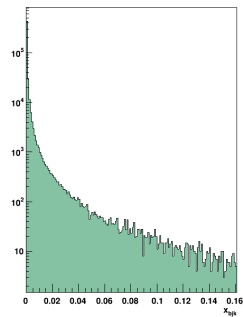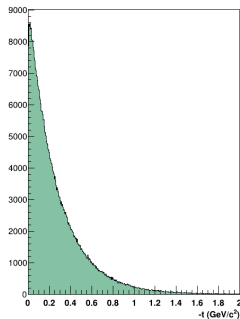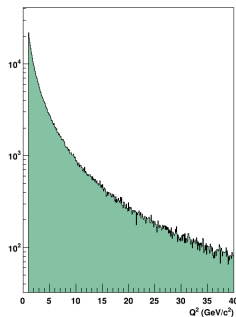
Next Steps for J/Ψ

- $10 fb^{-1}$ of $J/\Psi \to \mu^+\mu^-$ at 10 on 100 GeV eP collisions

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Next Steps for Other Vector Mesons

- Could also generate and repeat studies for other Vector Mesons of interest
- A limited event sample was produced for Υ, but was dropped from ECCE study
- ϕ is also of potential interest, although no suitable generator currently identified for a DVMP study in ePIC
- Heavier charmonium states, e.g. $\psi(2S)$?

The ePIC TDR is coming...
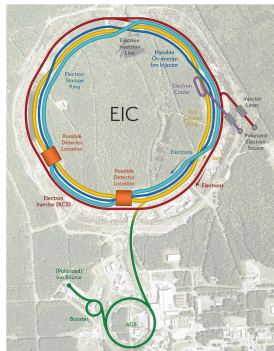
- DVMP with Vector Mesons is feasible in an EIC detector design
- Moving from our preliminary ECCE study to one grounded in ePIC
- Focus on complimentary J/Ψ leptonic decay channels for TDR
- Pick up other channels if time and personnel allow

Summary and Outlook

- This work is part of the Exclusive, Diffractive and Tagging working group, one of many physics working groups in the ePIC collaboration
- The ECCE simulation studies are from an earlier iteration of this group, published as NIM A1052, 168238 (2023)
- Thanks to all my collaborators, particularly Nathaly Santiesteban (UNH), whose analysis was at the heart of the J/Ψ studies in ECCE
- Additional thanks to the relevant software groups who provide the tools to realise this work, process events through the evolving detector concepts, and put up with a barrage of "How do I...?" questions