Studying Gluon GPDs at ePIC via Deeply Virtual Meson Production

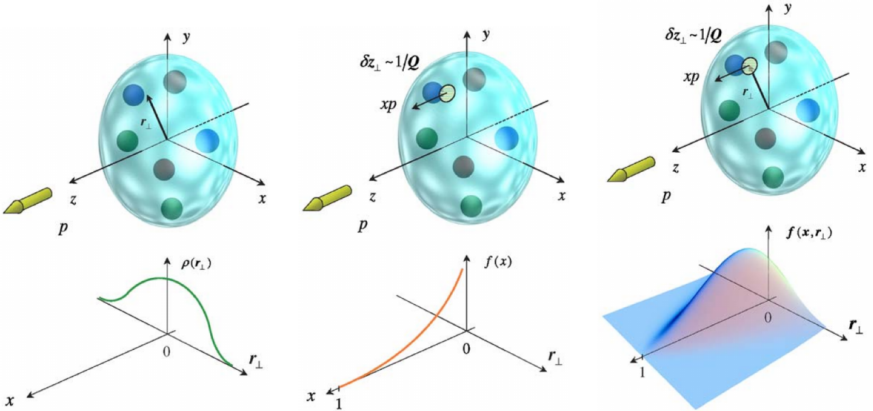
UK EIC Meeting, Birmingham

Stuart Fegan

University of York

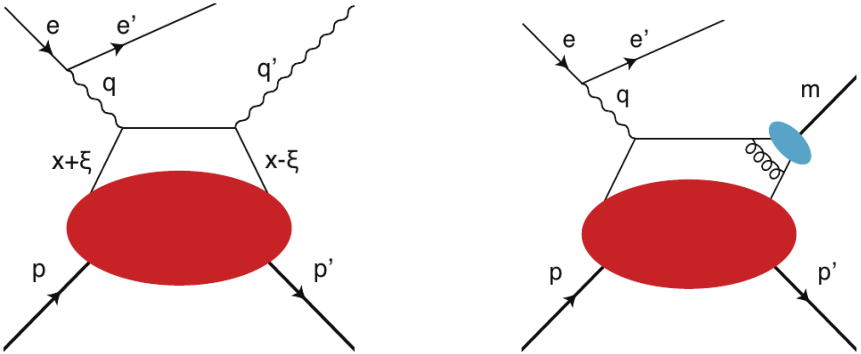
November 18th, 2024

Motivation



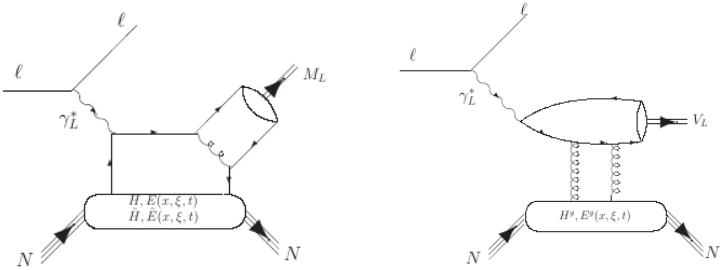
Uncovering Hadron Structure With Generalised Parton Distributions, A.V. Belitsky and A.V. Radyushkin

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.

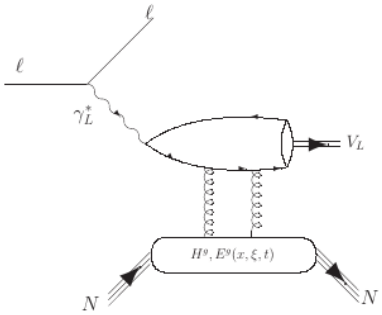
DVMP



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 at the EIC



- Exclusive vector meson channel $J/\Psi \to e^+e^-$ was previously studied in ECCE
- Overall goal of evaluating detector performance against VM event generators and show feasibility of measurement of DVMP events
- More details of this study in NIM A 1052, 168238 (2023)

arXiv:1511.04535

Both the ECCE and ATHENA studies provide useful benchmarks for our continuing work in ePIC

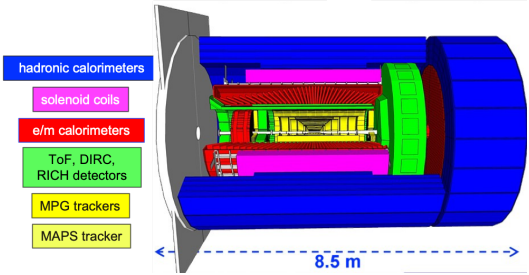
DVMP Generators

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

$J/\Psi \to e^+e^-$

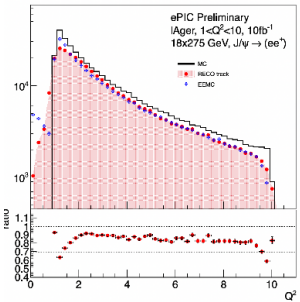
- Plots for $J/\Psi \to e^+e^-$ produced by N. Santiesteban and O. Olokunboyo (New Hampshire)

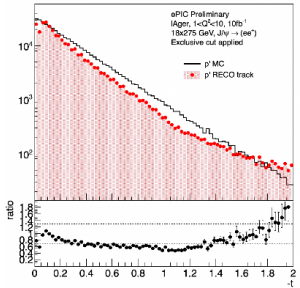


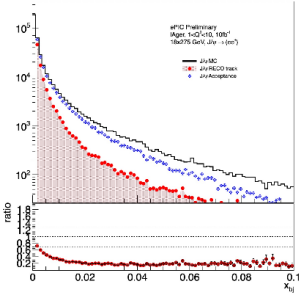
- 10 fb^{-1} of $J/\Psi \to e^+e^-$ events from eP collisions, generated in lAger at 18×275 GeV
- Evaluating feasibility of reconstructing J/Ψ for DVMP

Kinematics and Resolutions

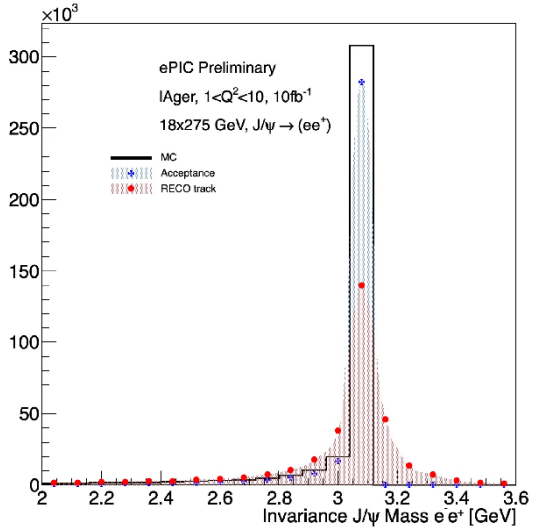
$J/\Psi \rightarrow e^+e^-$ event samples on eP collisions, 10 fb^{-1} at 18×275 GeV





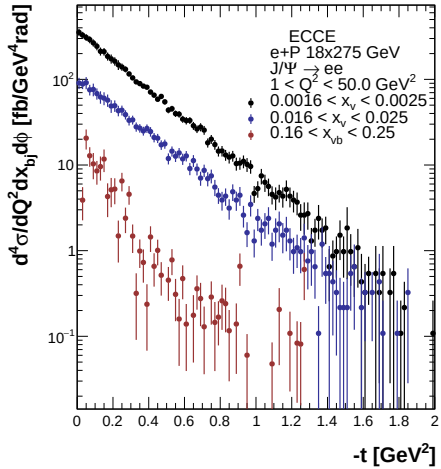


J/Ψ Reconstruction



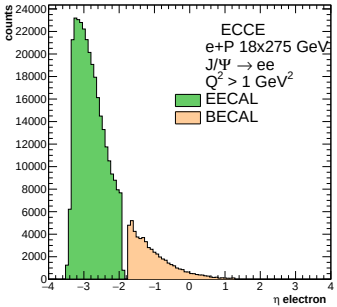
J/Ψ Cross Sections

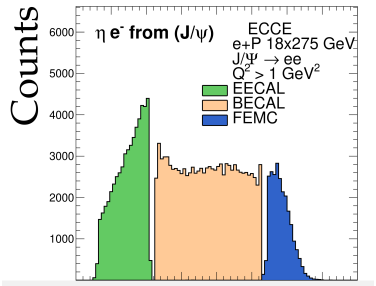
- J/Ψ Differential cross section from ECCE study
- Physics interest will come from the evolution over $-t$
- Q^2 dependence will be useful for multi-dimensional binning



$J/\Psi \to \mu^+\mu^-$

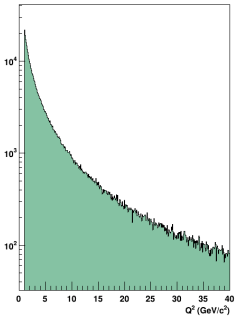
- In the ECCE study it was noted that adequately separating scattered electron from J/Ψ decay electron in the real world might be an issue
- Could avoid this by looking at other decay channels, like $J/\Psi \to \mu^+\mu^-$

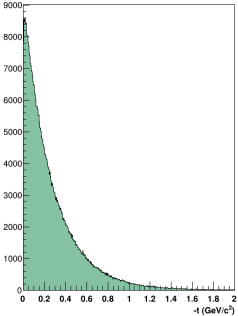


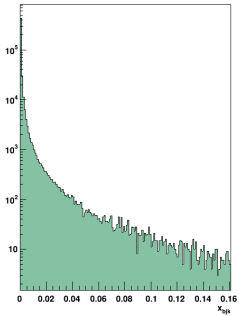


$J/\Psi \to \mu^+\mu^-$

- Parallel study of $J/\Psi \to \mu^+\mu^-$ will allow assessment of muon detection in ePIC
- 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)

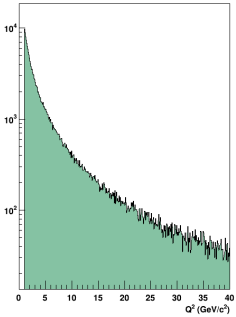


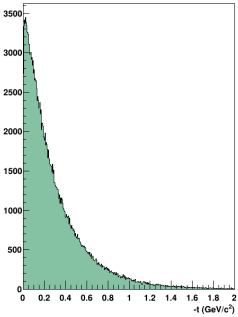


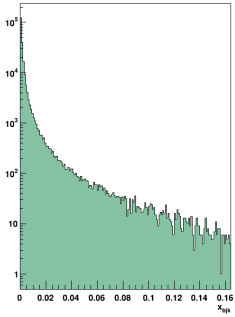


$J/\Psi \to \mu^+\mu^-$

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

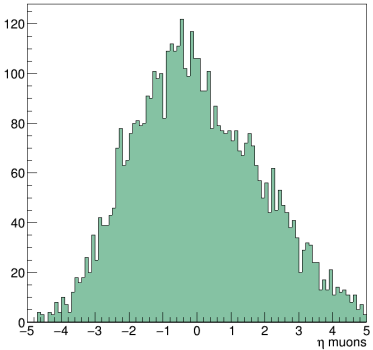


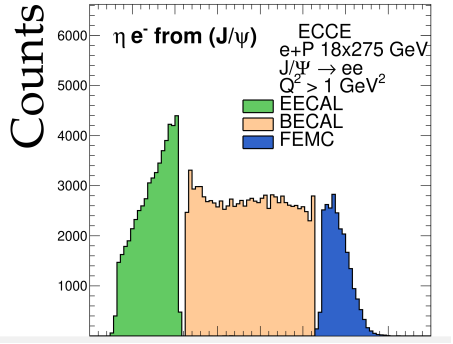




$J/\Psi \to \mu^+\mu^-$

- $J/\Psi \to \mu^+\mu^-$ at 18 on 275 GeV eP collisions
- No analysis yet, just a handful of reconstructed events to test process



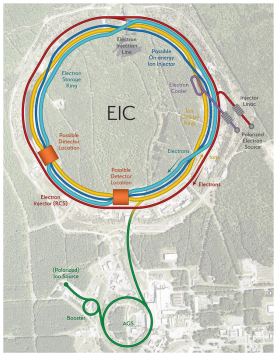


Next Steps for Other Vector Mesons

- Could also generate and repeat studies for other Vector Mesons of interest
- New collaborators looking at Υ channels
- ϕ is also of potential interest, although no suitable generator currently identified for a DVMP study in ePIC
- Heavier charmonium states, e.g. $\psi(2S)$?

Summary and Outlook

ePIC is coming...



- DVMP with Vector Mesons is feasible in an EIC detector design
- Studies in ePIC gathering pace
- Focus on complimentary J/Ψ leptonic decay channels
- Expanding to other vector meson channels with new collaborators

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
- Thanks to all my collaborators, particularly those at the University of New Hampshire, who have kept this ticking over with their efforts on $J/\Psi \to e^+e^-$
- Special thanks to Stephen Kay, and everyone else who set up and delivered the software tutorials, which has enabled me to look like I know what I'm doing by quickly processing events during the first session today, `https://eic.github.io/documentation/tutorials.html`

This work is supported in part by STFC grants ST/V001035/1 and ST/W004852/1