

Updates on DV π^0 P Analysis

Exclusive π^0 production in ep collisions

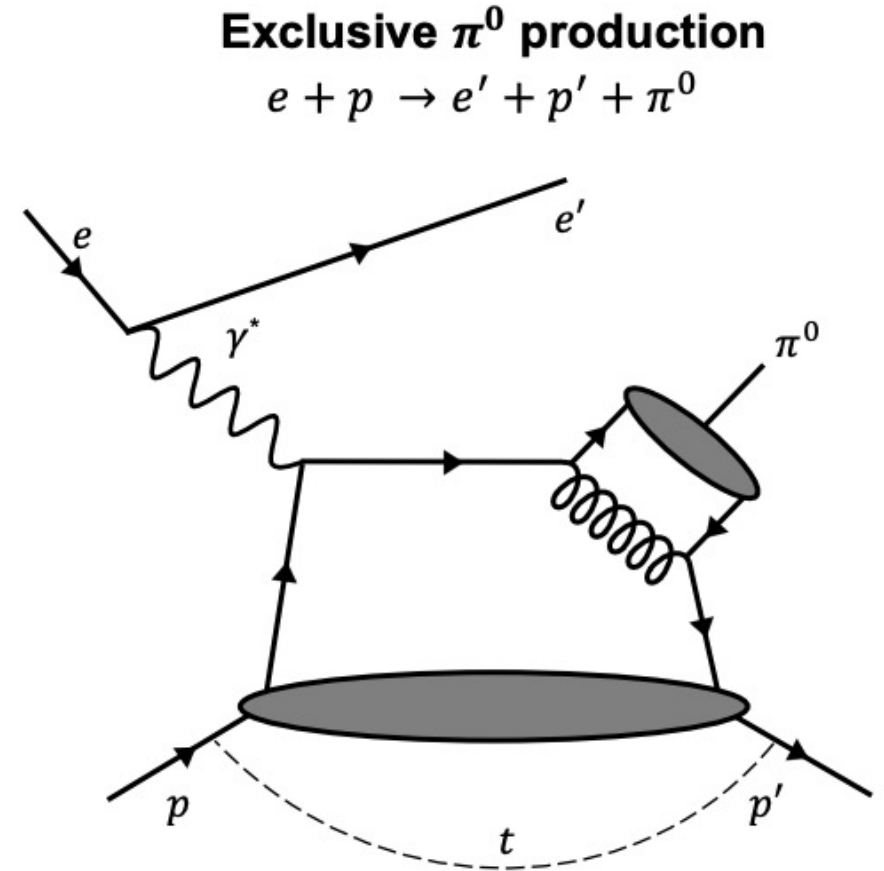
Li XU (BNL)
ePIC Meeting
July 15, 2026

DV π^0 P Analysis

- Previous status
 - Analysis performed by Jihee Kim based on ePIC October Simulation Campaign
 - The t -distribution has been extracted to access spatial distribution of quarks (25.10.2 sample $10 \times 130 \text{ GeV}^2$)
 - The DIS background ($10 \times 130 \text{ GeV}^2$ sample) and machine background ($18 \times 275 \text{ GeV}^2$ sample) have been studied
 - See Jihee's slides at the last Collaboration Meeting [[link](#)]
- Recent updates
 - Update the analysis results using the 26.03.1 sample ($10 \times 130 \text{ GeV}^2$)
 - Study the machine background using 26.02.0 sample ($10 \times 130 \text{ GeV}^2$)
 - $9 \times 130 \text{ GeV}^2$ samples are currently in production

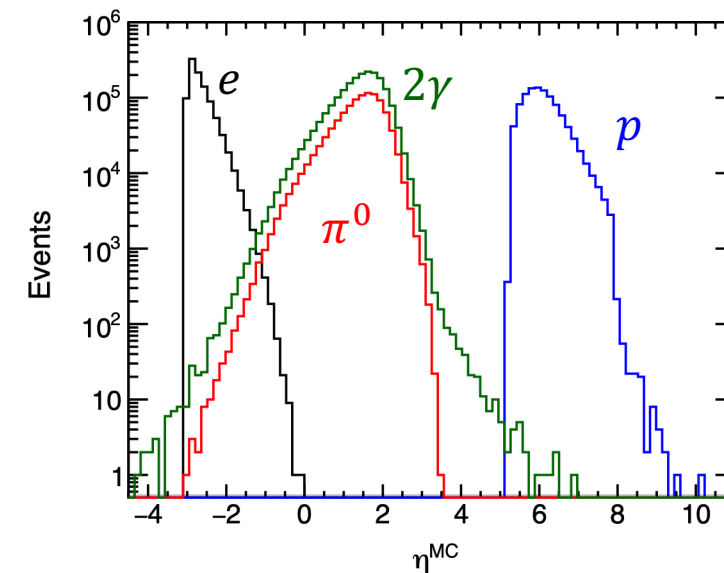
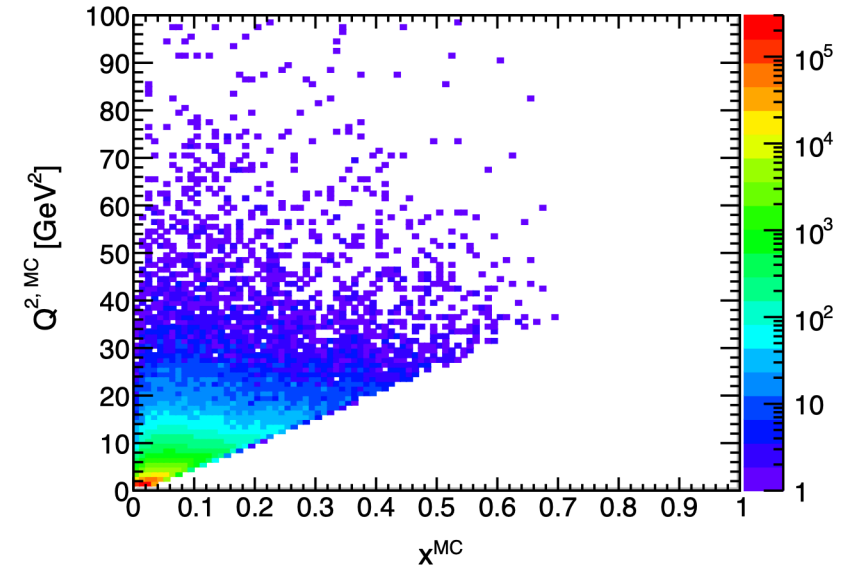
Motivation

- **3D Imaging: GPDs**
 - Probe chiral-odd GPDs (quark-helicity flip)
 - Complementary to DVCS (helicity flip processes are suppressed)
- **Spin: Quark orbital angular momentum**
 - Azimuthal asymmetries provide a sensitive probe for quark orbital angular momentum [PRL 133, 051901](#)



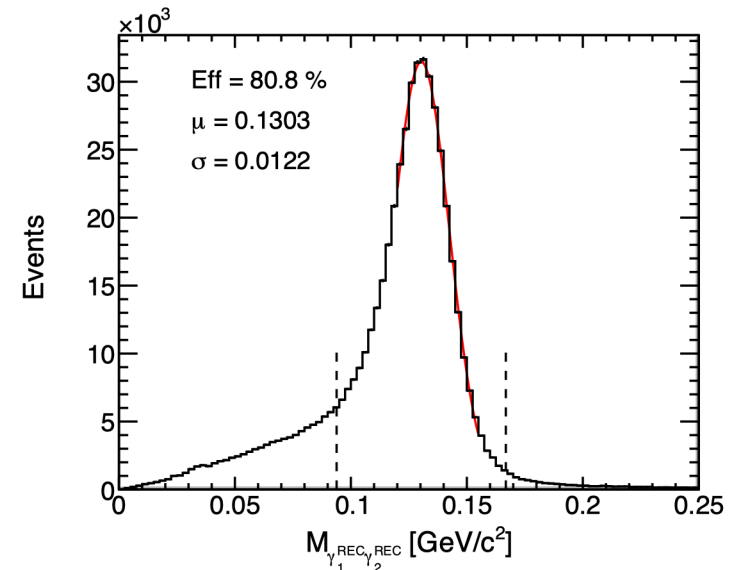
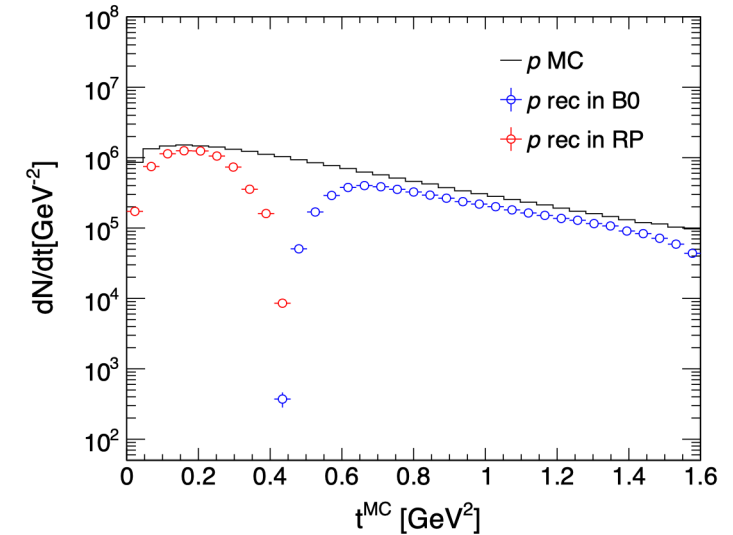
Simulation Sample and $DV\pi^0 p$ Kinematics

- Simulation sample
 - EpIC Monte Carlo Generator
 - 1M events: $10 \times 130 \text{ GeV}^2$
 - Event generation ranges:
 - $1 < Q^2 < 1000 \text{ GeV}^2$
 - $10^{-5} < x < 0.95$
 - $0.01 < |t| < 1.6 \text{ GeV}^2$
 - $0.01 < y < 0.85$
 - Official simulation campaign 26.03.1
 - $9 \times 130 \text{ GeV}^2$ samples are currently in production



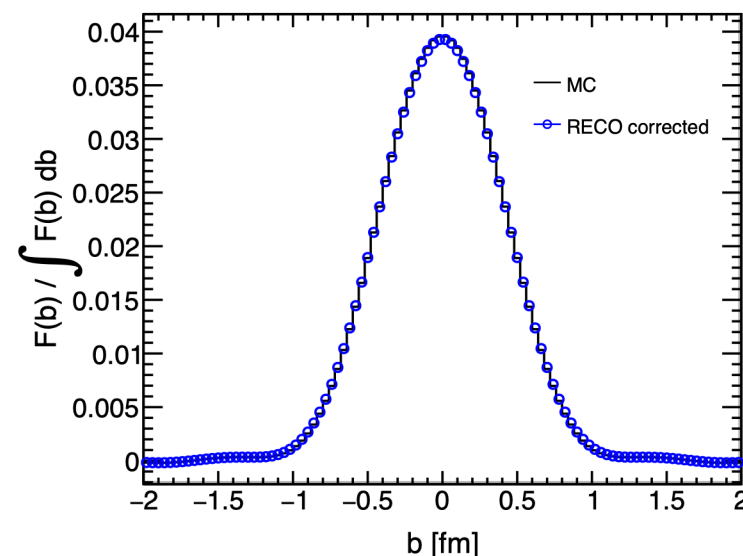
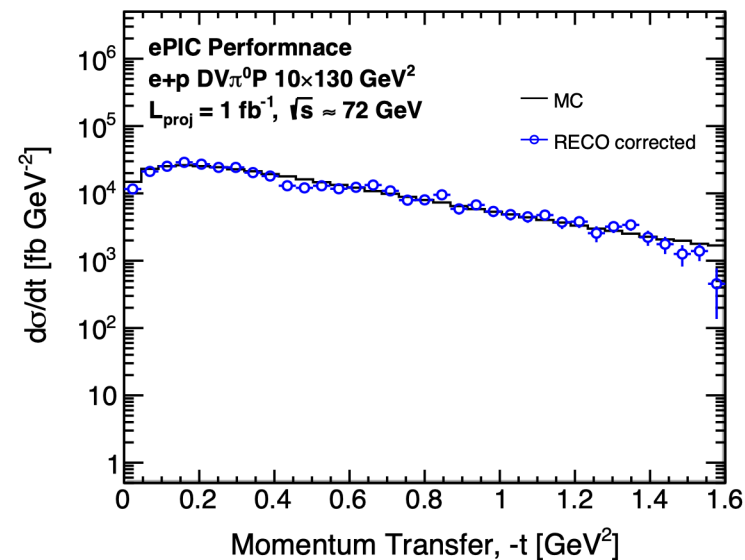
Event Reconstruction and Selection

- Scattered electron
 - Detected in backward region (Tracker + Calorimeter)
 - $0.8 < E/p < 1.2$
- Scattered proton
 - Detected in far-forward tracker (B0 + RP)
 - $5.5 < \theta_{B0} < 20 \text{ mrad}$ or $0 < \theta_{RP} < 5 \text{ mrad}$
- Neutral pion ($\pi^0 \rightarrow \gamma\gamma$)
 - Detected in mid-rapidity and forward calorimeters
 - $0.096 < m_{\gamma\gamma} < 0.172 \text{ GeV}$
- Selection on $DV\pi^0p$
 - $15 < E - P_z < 25 \text{ GeV}$
 - $|M_{miss}^2| < 1 \text{ GeV}^2$



$d\sigma/dt$ distribution

- t distribution with two sample combined
 - Events with p reconstructed
 - $t = (p_p - p'_p)^2$
 - Events without p reconstructed
 - $t = (p_p - p'_{corr})^2$ using the p'_e and p_{π^0}
- $d\sigma/dt$ distribution with 1 fb^{-1} projection
 - Acceptance and efficiency correction
 - Gaussian smearing for realistic fluctuation modeling
- Extract quark spatial distribution
 - Exponential fit is performed on the $d\sigma/dt$ distribution
 - Fourier transform is applied to the exponential function



Machine background study

- Simulation samples: 26.02.0 (10×130 GeV²)

- Signal-only sample (~ 1 M)

root://dtn-eic.jlab.org:1094//volatile/eic/EPIC//RECO/26.02.0/epic_craterlake/
EXCLUSIVE/DVMP/EpIC1.1.6-1.0/unpolarised/10x130/q2_1_1000/

- Mixed sample (~ 0.23 M)

- One signal embedded per background event

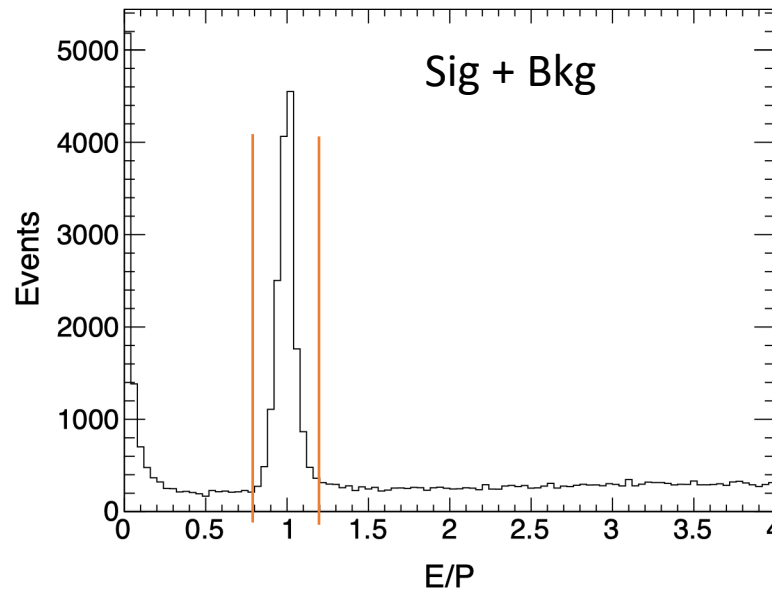
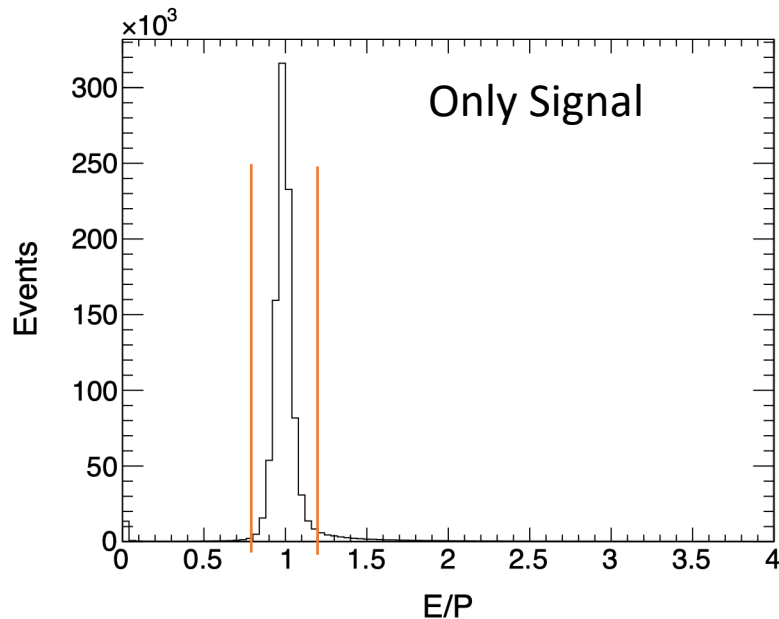
- Background contributions: [synchrotron radiation \(dominant\)](#),
electron Bremsstrahlung, electron Touschek scattering, electron Coulomb
scattering, and proton beam-gas interaction

root://dtn-eic.jlab.org:1094//volatile/eic/EPIC//RECO/26.02.0/epic_craterlake/
Bkg_Exact1S_2us/GoldCt/5um/EXCLUSIVE/DVMP/EpIC1.1.6-
1.0/unpolarised/10x130/q2_1_1000/

Machine background: Electron reconstruction

Sample	Only Signal	Sig + Bkg
Total events	998k (100%)	229k (100%)
Has truth-matched electron	994k (99.5%)	96.2k (42.1%)
Has truth-matched backward ECAL cluster	979k (98.1%)	95.2k (41.6%)
Cut: $0.8 < E/P < 1.2$	903k (90.4%)	15.4k (6.7%)

- Significant decrease in electron reconstruction efficiency after the background merging
- 58% events no truth-matched electron
 - 42% has electrons but not matched
 - 16% no reconstructed electrons
- 83% truth-matched electrons are removed by E/P cut



Machine background: Pion reconstruction

- Photon candidates:
 - Neutral particles from ReconstructedParticles collection
 - Clusters not matched to the electron track from EcalEndcapNClusters, EcalBarrelClusters, EcalEndcapPClusters collections

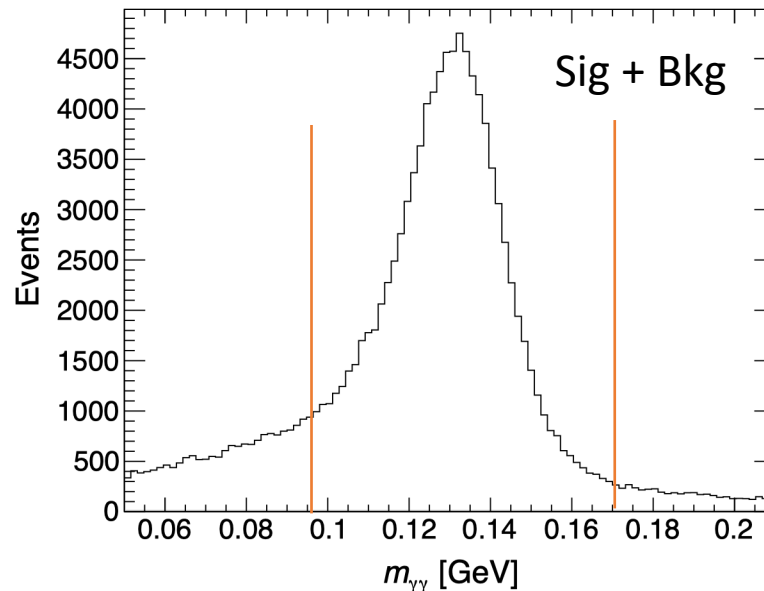
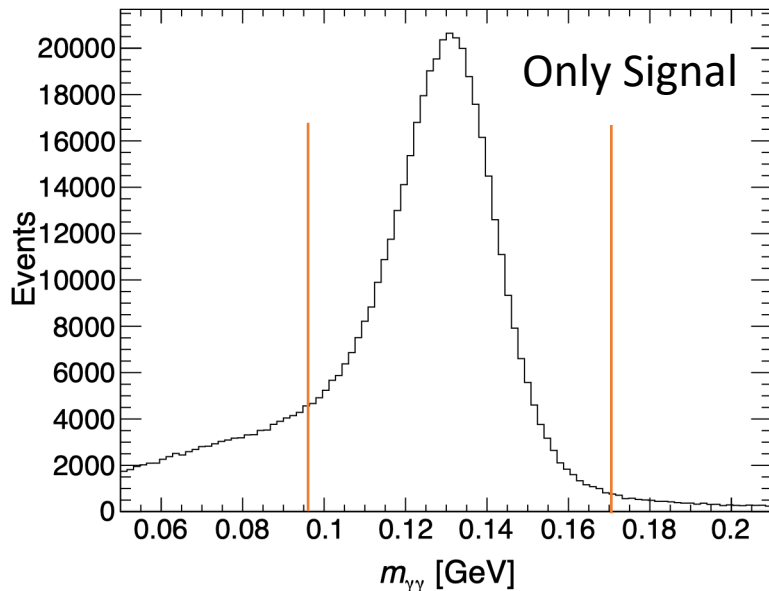
Sample	Only Signal	Sig + Bkg
Total events	998k (100%)	229k (100%)
No photon	19.7k (2.0%)	3.9k (1.7%)
One photon	35.5k (35.6%)	56.8k (24.9%)
Two photons	622k (62.3%)	118k (51.7%)
More than two	1.8k (0.2%)	49.7k (21.7%)

- More reconstructed photons after the background merging
- For events with more than two photons, the combination with an invariant mass closest to the π^0 mass is selected

Machine background: Pion reconstruction

Sample	Only Signal	Sig + Bkg
$N_\gamma \geq 2$	624k (100%)	168k (100%)
Both truth-matched	623k (99.8%)	3.9k (81.4%)
One truth-matched	1.1k (0.2%)	26.6k (15.9%)
No truth-matched	0	4.7k (2.8%)

Sample	Only Signal	Sig + Bkg
$N_\gamma \geq 2$ and $m_{\gamma\gamma}$ in [0.096, 0.172] GeV	441.2k (100%)	100.9k (100%)
Both truth-matched	441.2k (100%)	97.6k (96.7%)



- For events with at least two photons, the mass-window cut ensures high purity (96.7%) for the π^0 candidates

Summary

- Exclusive π^0 production in ep collisions
 - Extract $d\sigma/dt$ distribution
 - Fourier transform to access quark spatial distribution
- Machine background
 - 3.3% contamination from machine-background photons in reconstructed π^0 after the π^0 mass window cut
- Next to do
 - Update the results using the $9 \times 130 \text{ GeV}^2$ samples
 - Update the analysis note