

BNL BSM/EW Physics Program at ePIC

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At the ePIC and EIC Physics Workshop (2nd Edition)

Mar 18, 2026

BNL LDRD-A: EW and BSM Physics at EIC

- **PI:** Alessandro Tricoli
- **Co-PI:** S. Dawson, H. Davoudiasl, R. Szafron, Y. Hatta, P. Steinberg, Z. Tu
- **Collaborators:**
 - Theory: Hongkai Liu, Keping Xie
 - Experiment: Alex Jentsh
- **Postdocs:**
 - Theory: Zhite Yu
 - Experiment: Jae Nam, Ganesh Parida
- **Student:**
 - Experiment: Alyssa Wheeler

BNL LDRD-A: EW and BSM Physics at EIC

- Objectives

- Consortium of experimentalists and theorists in **HEP** and **NP** to study precision of **EW** measurements and **BSM** reach with the *ePIC detector* and *2nd Detector* at the EIC

- Methodologies

- Phenomenological Studies:

- Identification and simulation of benchmark signals of new physics at the EIC in the EW sector
- Complementarity between EIC and LHC discovery potential

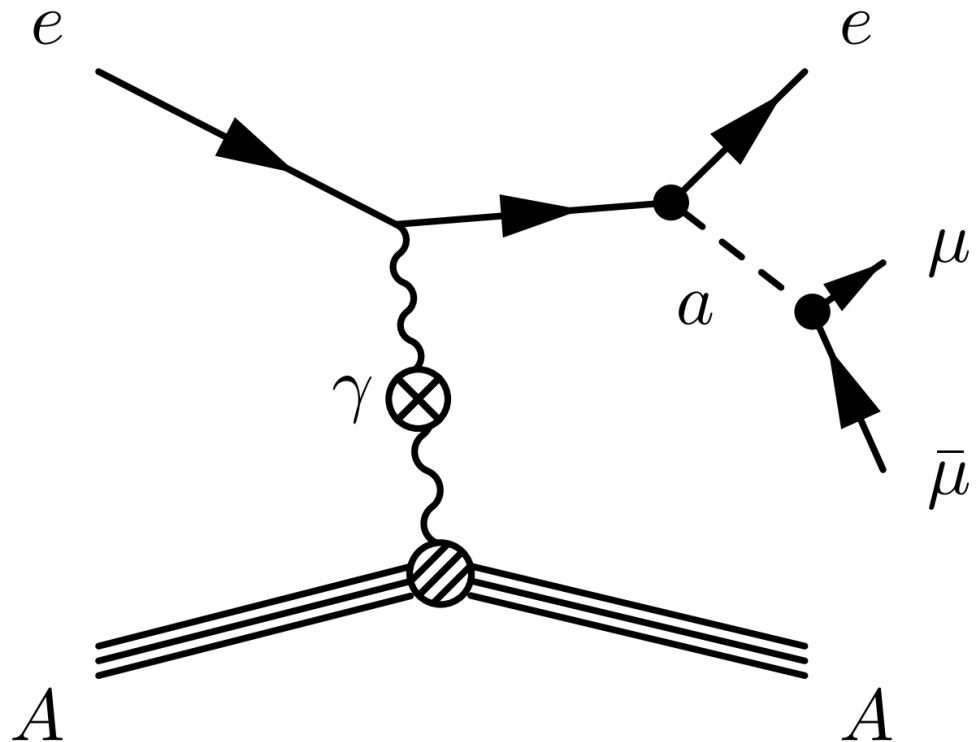
- Experimental Studies:

- Detector/software development and optimization to enhance BSM detection capabilities in EW processes, utilizing ML/AI techniques
- Provide benchmarks based on similar signatures in ultra-peripheral heavy-ion collisions as well as forward proton-proton physics using LHC Run-3 dataset

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Channels under investigation (so far)

- Fermion-coupled ALP
 - Compton-like scattering
 - Long-lived decay signal at low ALP mass+coupling



*coherent scattering, scaling as Z^2

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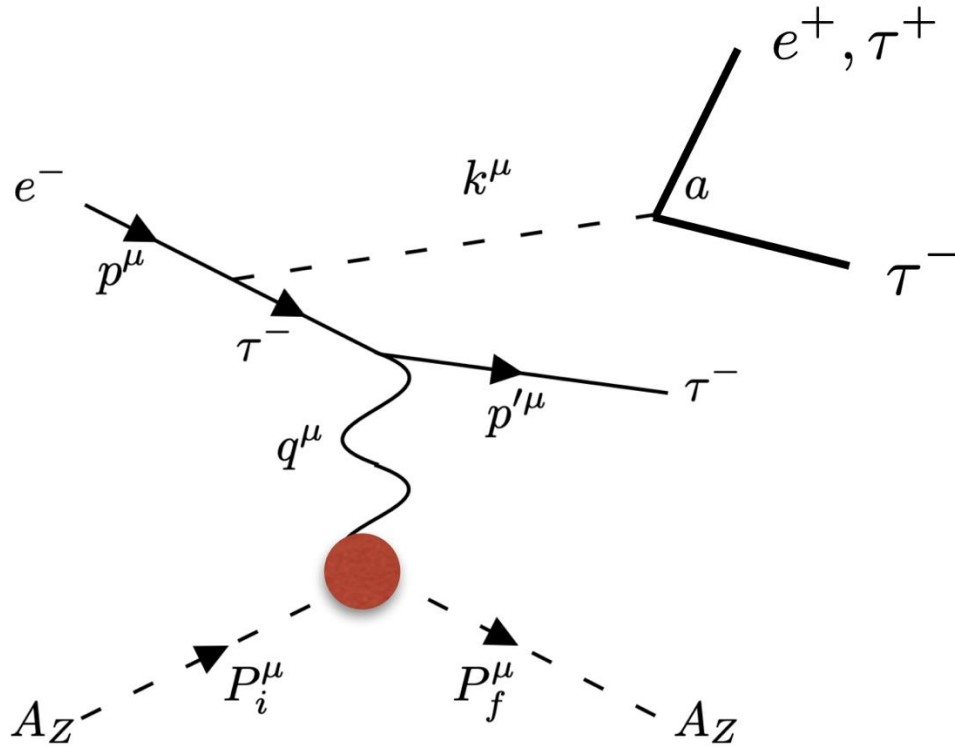
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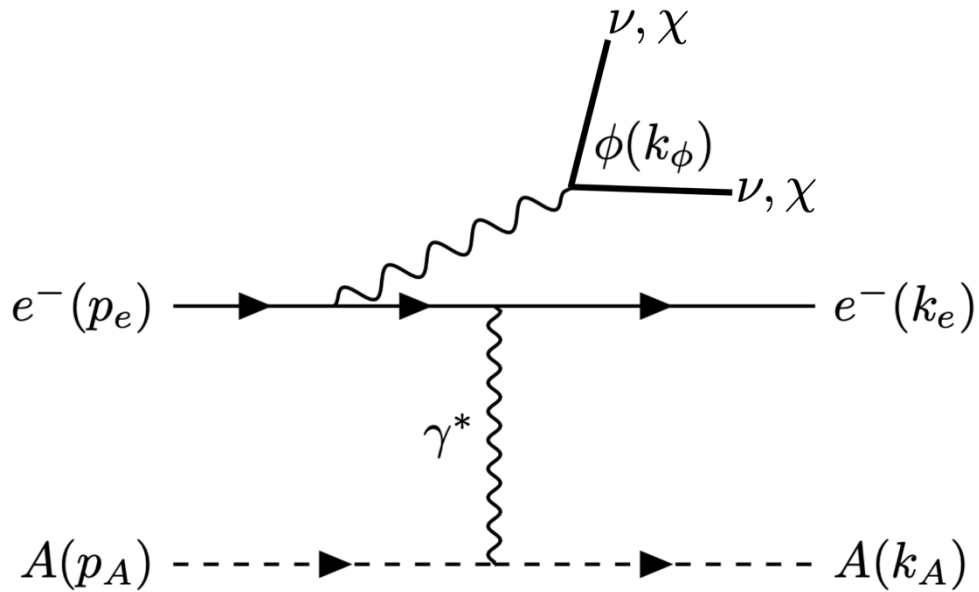
- Lepton Flavor Violating ALP

- $e^- + A$ into $\tau^- + e^+ + \tau^-$ final state
- $e + \tau$ mass and missing momentum reconstruction via ML/AI



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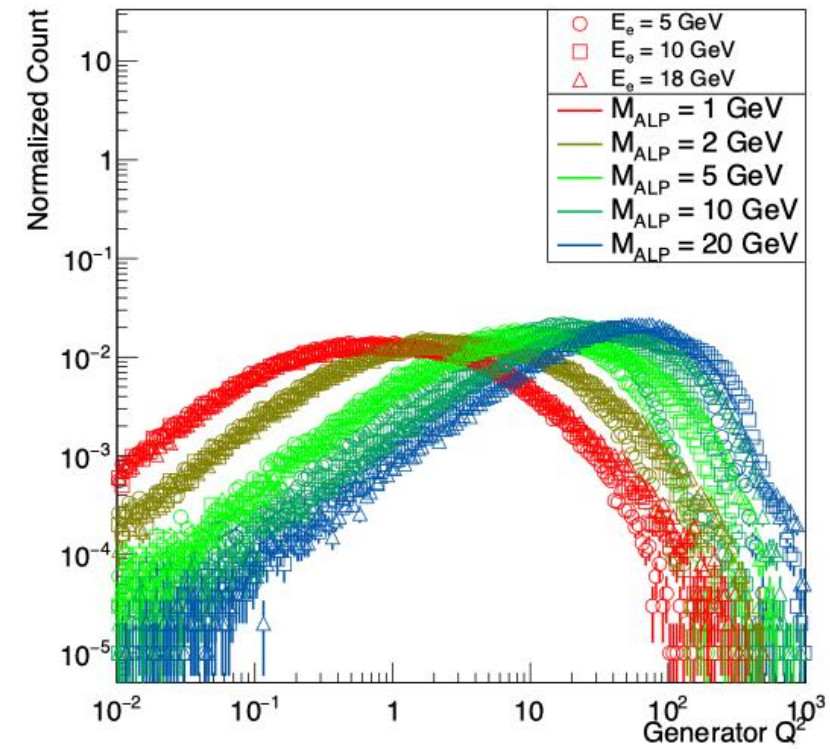
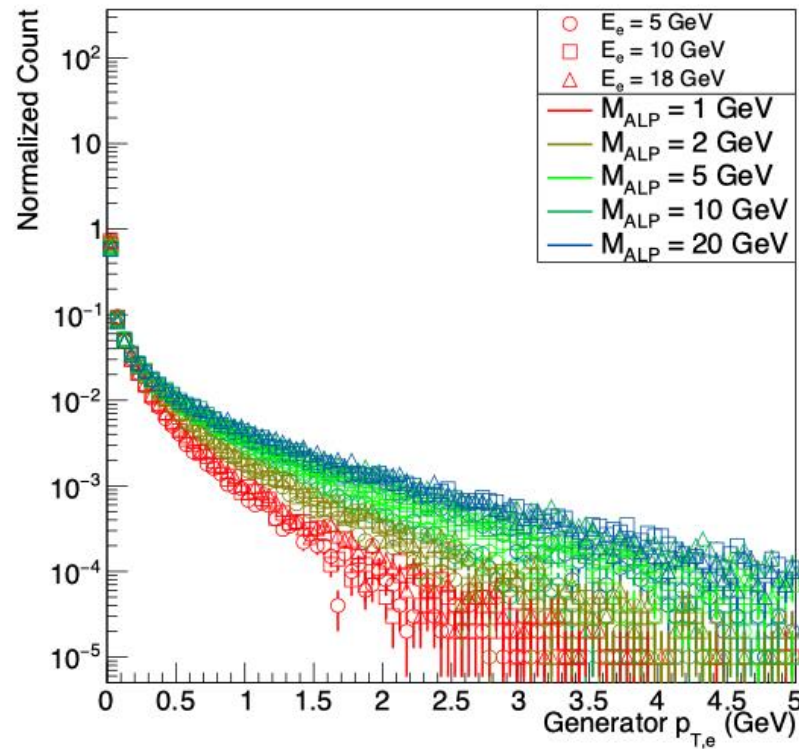
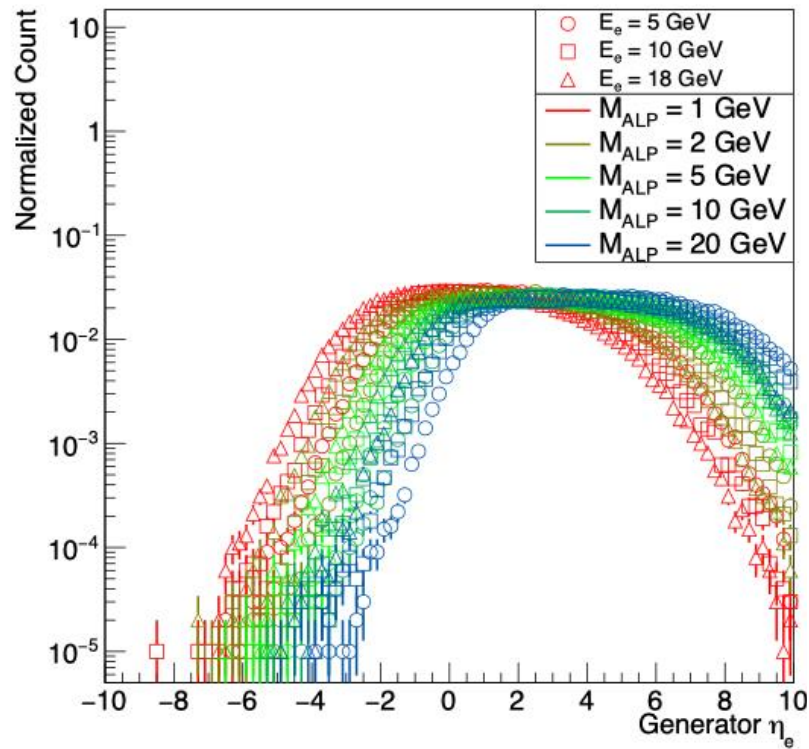
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- U(1) gauge extension

- Anomaly free U(1) gauge extensions involving electrons: $B - L, B - 3L_e, L_e - L_\mu, L_e - L_\tau$
- Depleted and central electrons + missing momentum

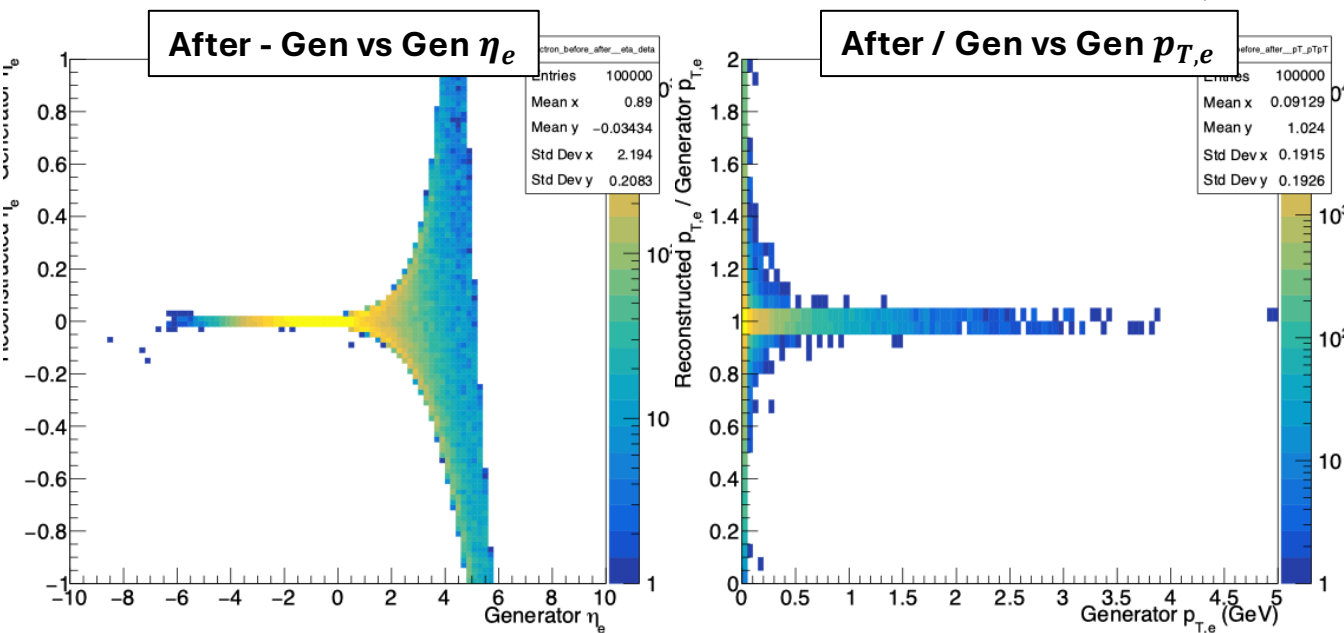
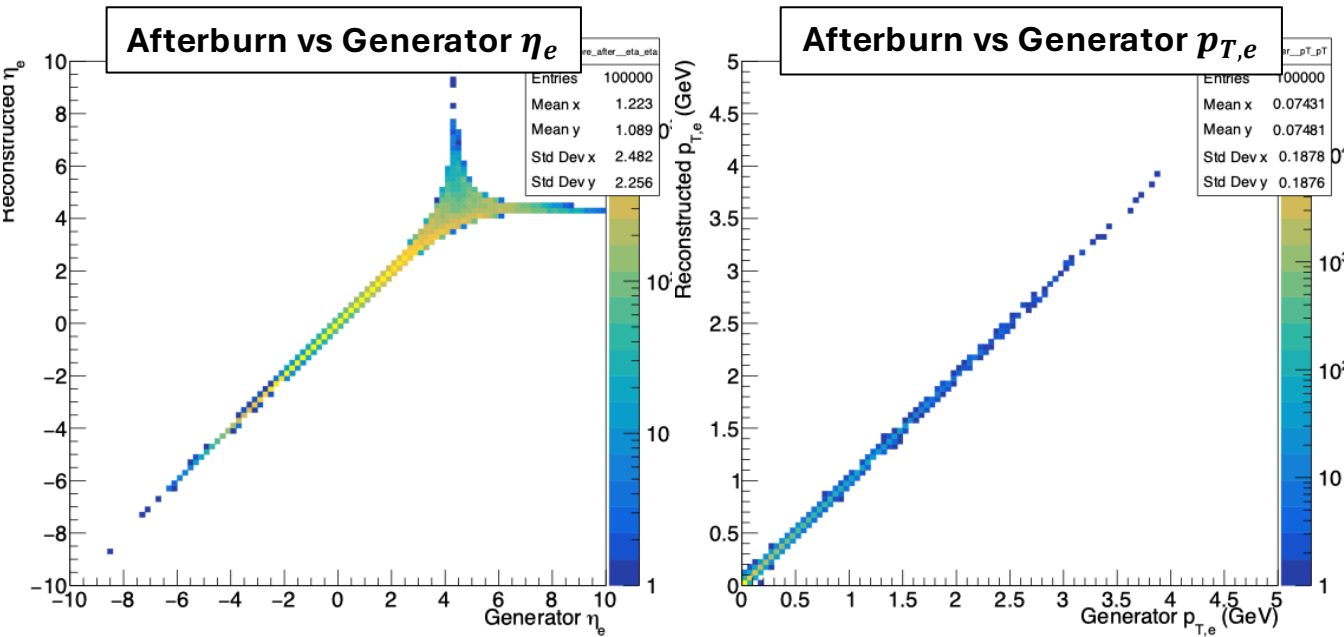
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Event Kinematics for long-lived ALP



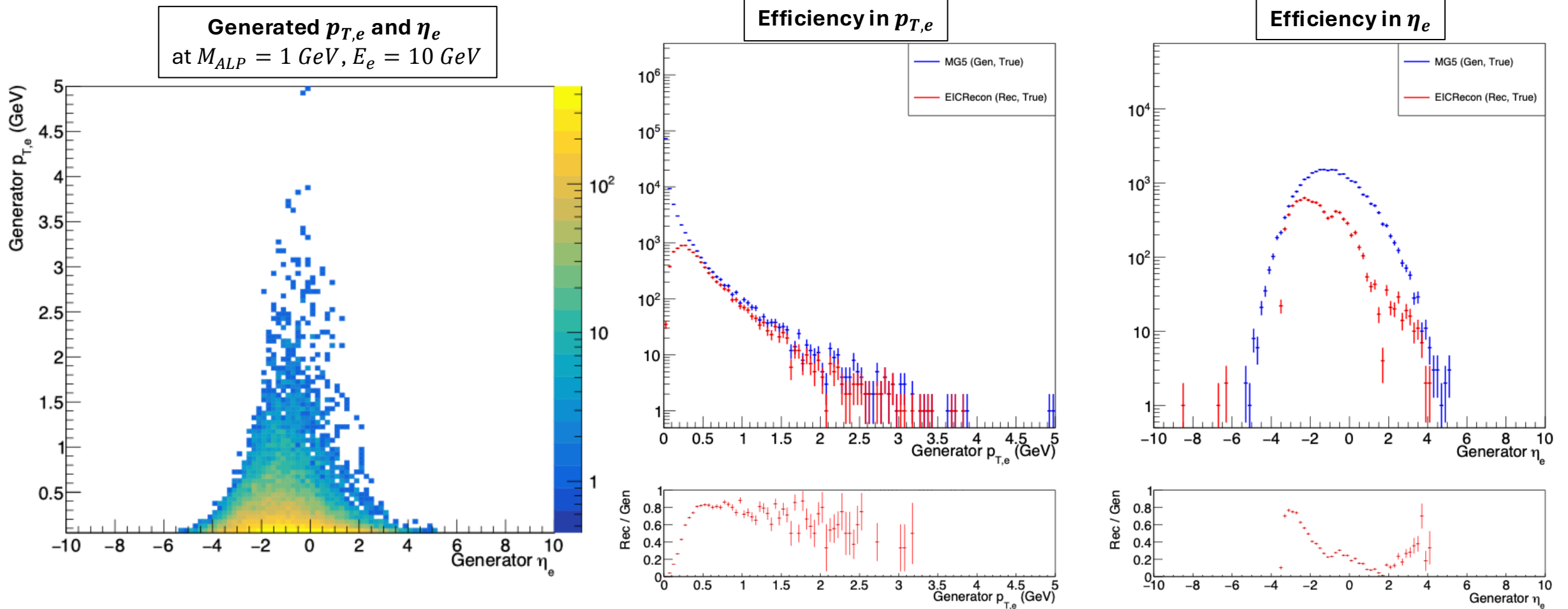
- **Fermion-coupled ALP** with long-lived particle that escapes detector
- **Low-multiplicity** environment with **central** and **soft** electron
- Opportunities for **low- Q^2 tagger** with low mass ALPs (< 1 GeV)

Beam-related effects



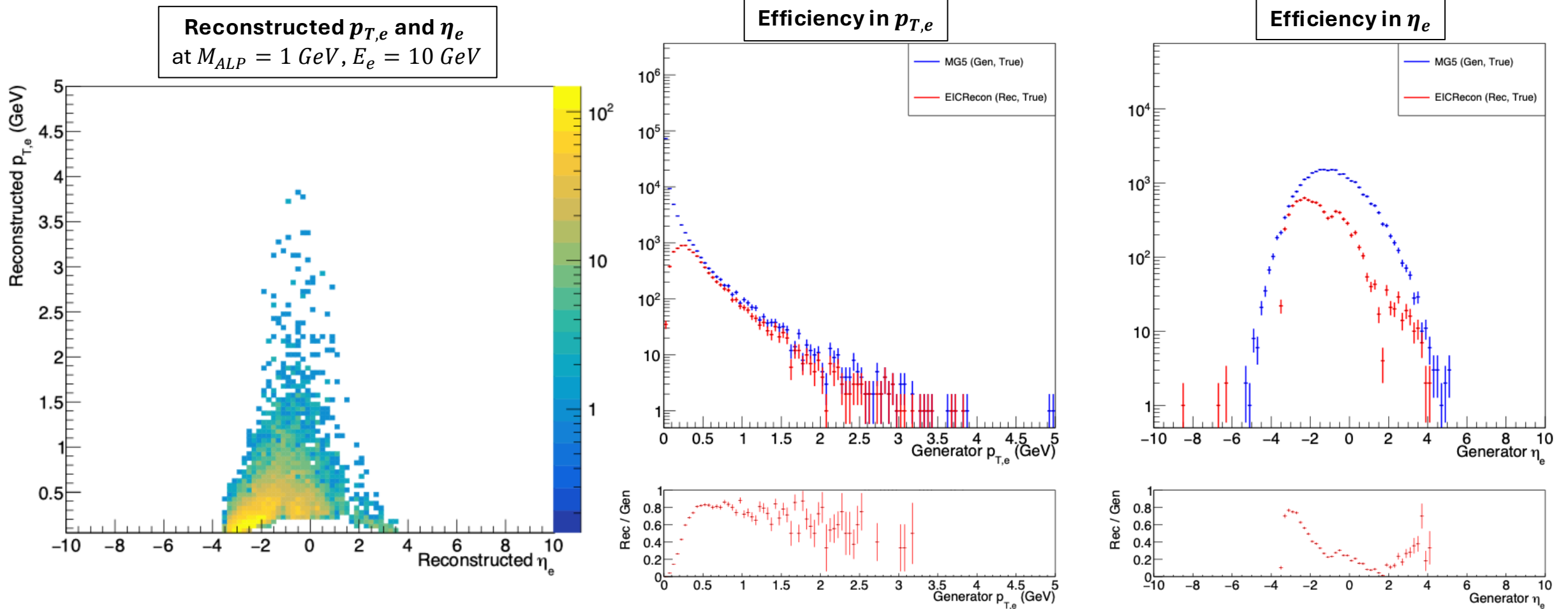
- Introduction of beam **crossing angle**, **angular divergence**, and **momentum spread** via *IP6 afterburner*
- **Asymptotic beam divergence** starting at $\eta \sim 4$
- Only a **small divergence** effects in the **backward** direction
- **Small p_T smearing** at low p_T ($< 0.5 \text{ GeV}$)

Event reconstruction with EICRecon



- Event reconstruction using tracking and PID (LUT) in EICRecon
- Optimal electron identification $p_T > 0.5 \text{ GeV}$ (w/ efficiency ~ 0.8)
- Higher efficiency in the **backward** direction \leftarrow This needs to be understood

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Summary

- **ALP** studies at ePIC initiated, aiming to bridge **HEP** and **NP** community and to provide case for **BSM/EW** physics at **EIC**
- Low-mass ($0.1 < M_{ALP} < 20 \text{ GeV}$) ALP channels under investigation
- ML/AI application for background rejection and mass/missing-momentum reconstruction
- Contribution to NIM-A Special Issue in October
- Updates in the inclusive PWG meeting on a regular basis