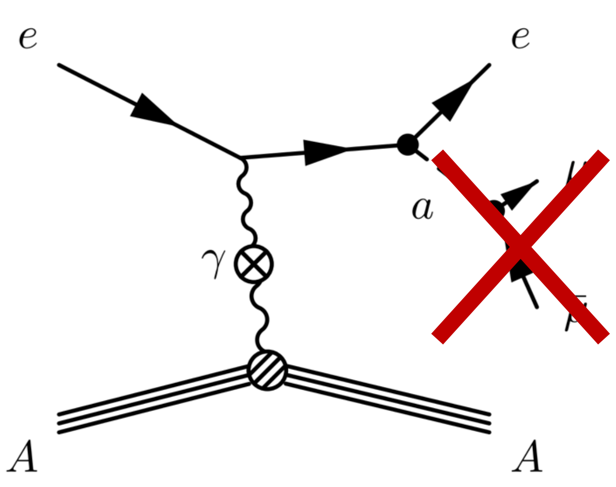
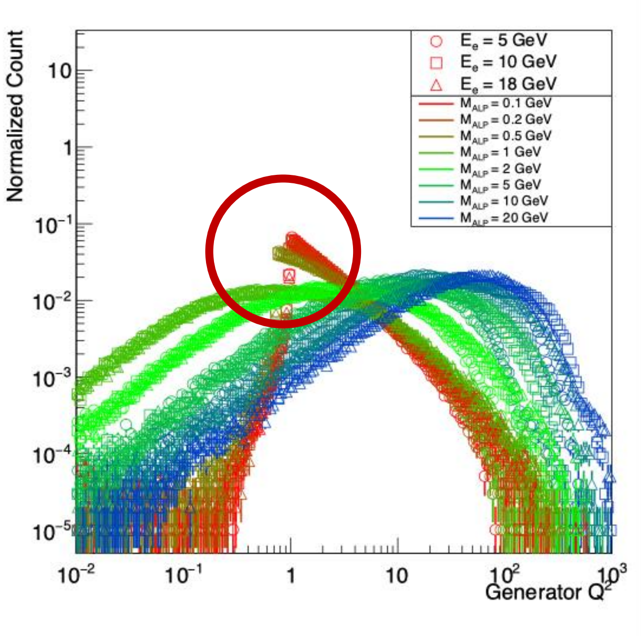
ALP@ePIC Update

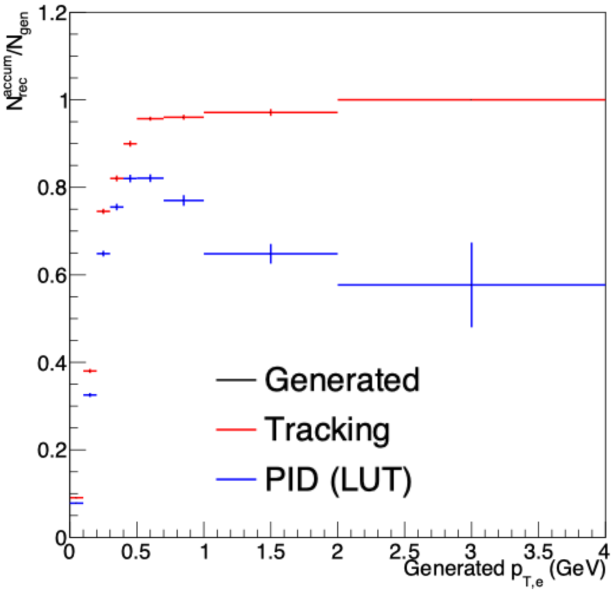
Alyssa Wheeler, Ganesh Parida, Jae Nam, Alessandro Tricoli

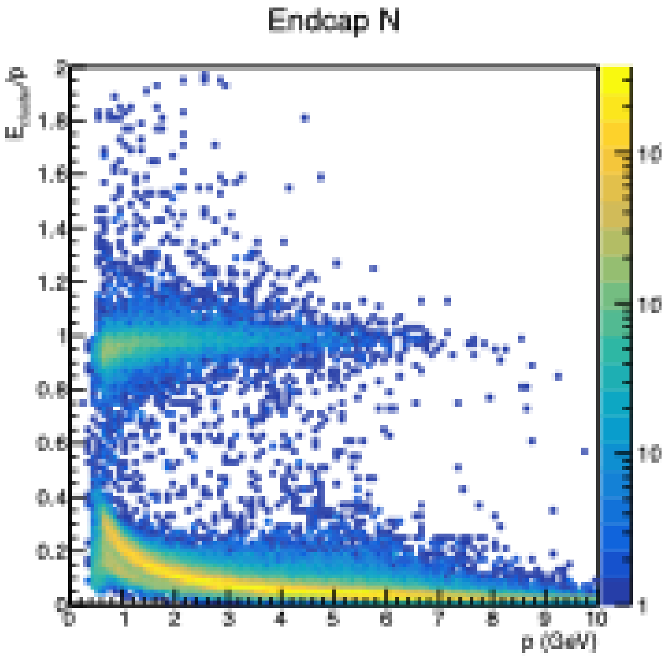
Jul 22, 2026

Recap



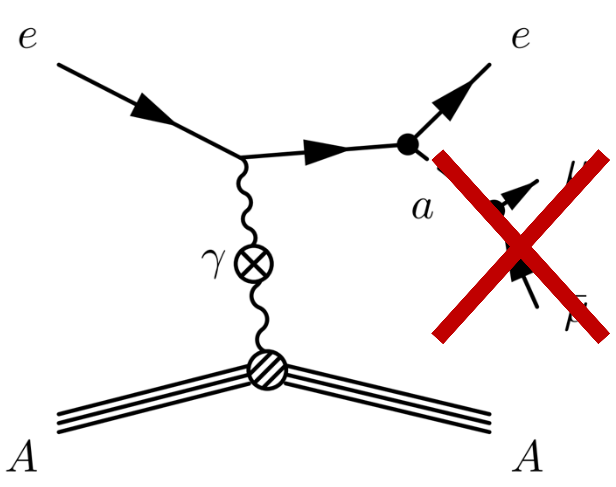


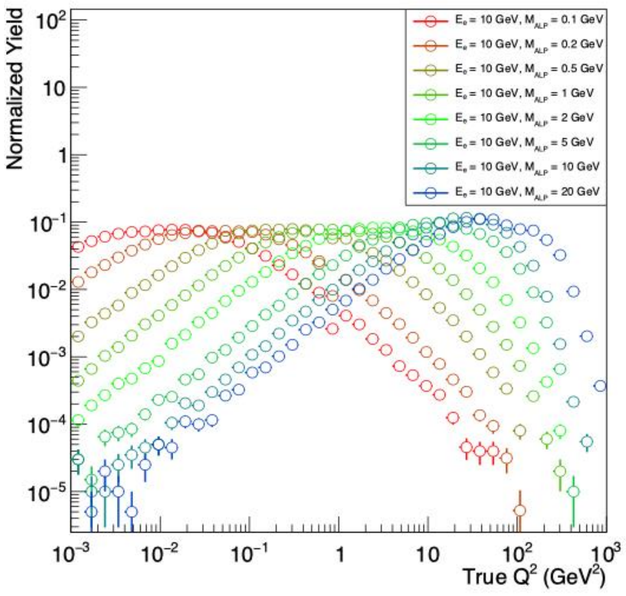


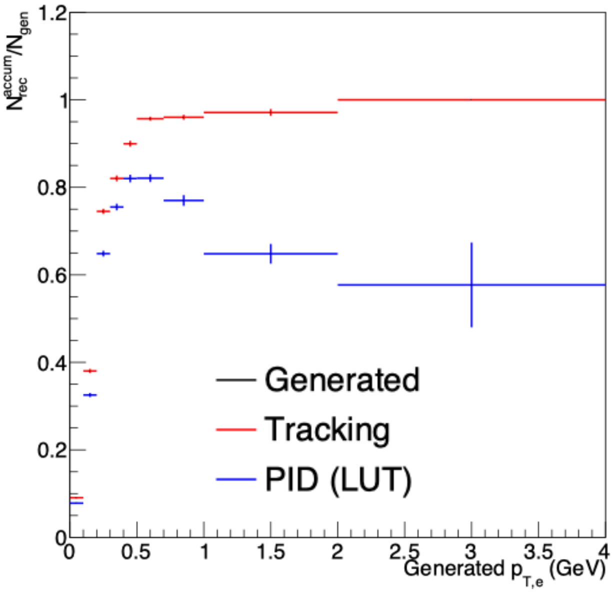


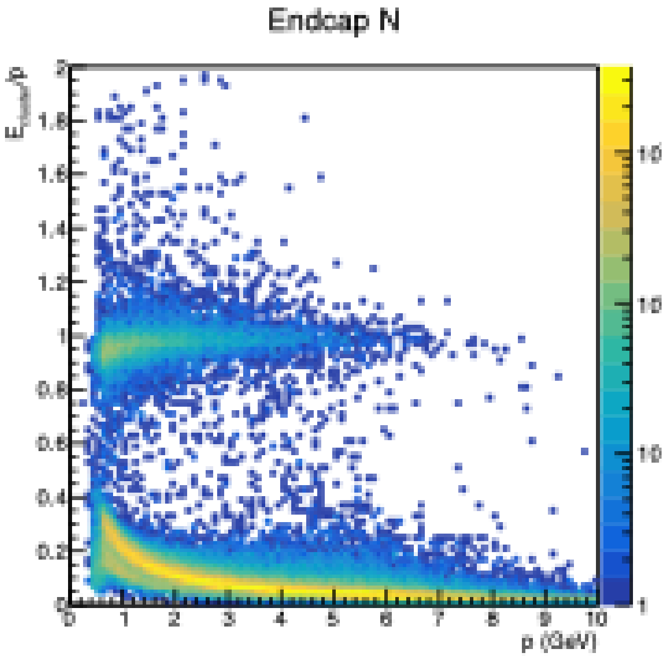
- Last update on Apr 21
- Focus: Non-decaying/ Invisibly-decaying ALP
- Event kinematics entirely defined by electron within central ePIC
- Bug with MadGraph5 event generation → has been addressed
- Strong ALP mass (m_a) dependence found in observed Q^2 (purely phenom. quantity)
- eID cannot entirely rely on PID systems?
- First look at ECal response

Recap









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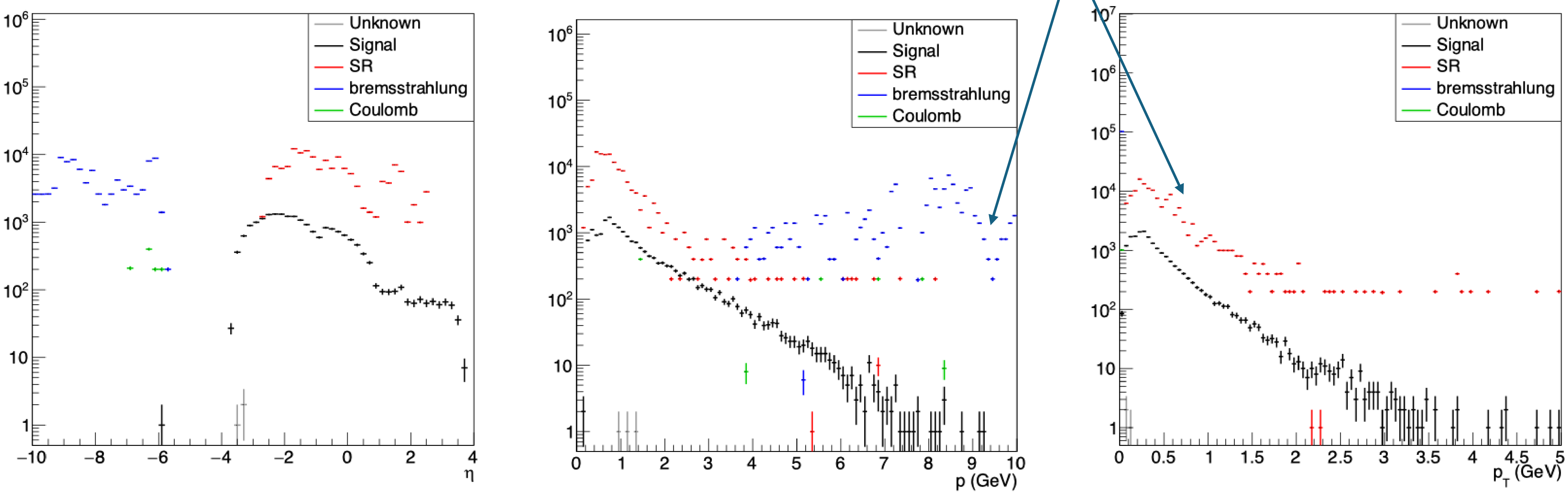
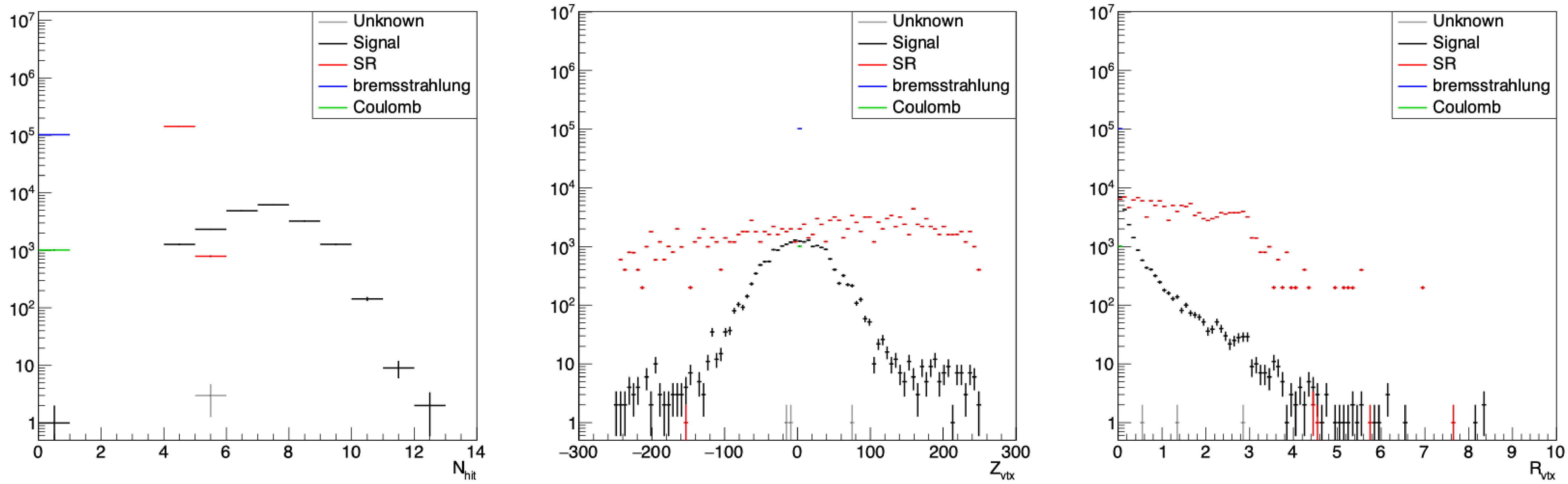
Rejecting machine backgrounds

Correlated BG, should be resolved in July campaign



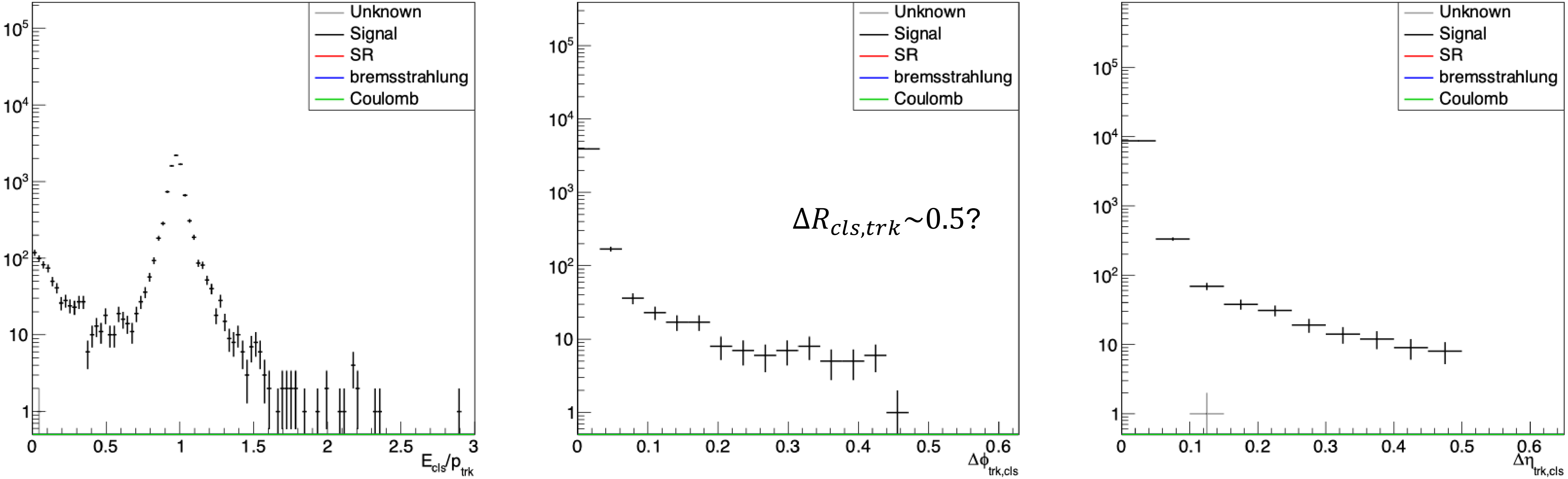
- Signal (ALP) tracks compared to machine backgrounds in June production
- brems and Coulomb tracks in low-Q^2 tagger
  → reject tracks in low-Q^2 tagger for now
- High-rate SR photons (~50k hits within $2\mu s$ window) → combinatoric fake tracks

Rejecting machine backgrounds



- N_{hits} cut at ≥ 5 (default) should reject most of the SR tracks
- Further beamline constraints should reject the remaining $\sim 50\%$

Rejecting machine backgrounds



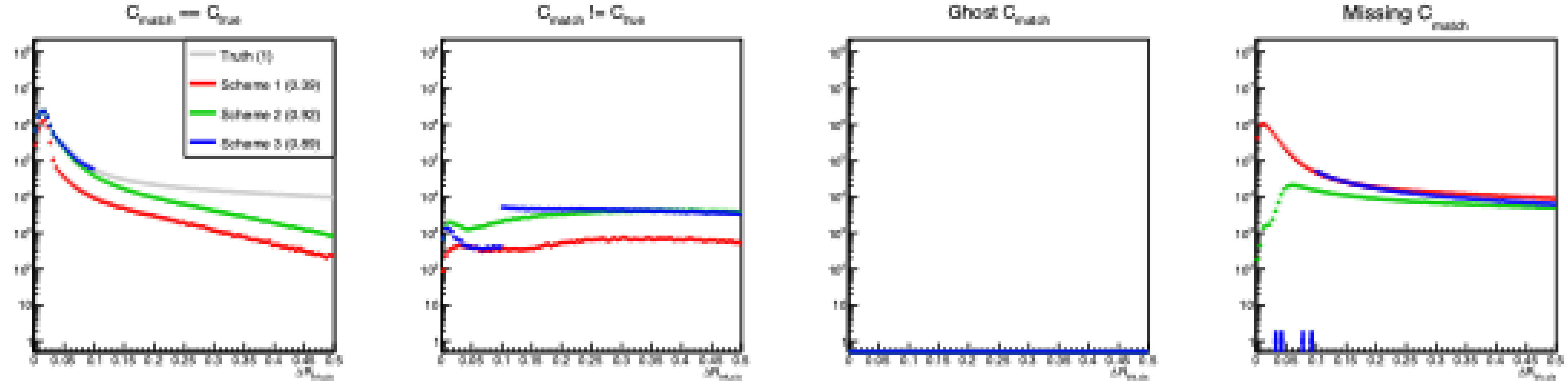
- Geometric matching ("TrackClusterMatch") to an ECal cluster, effectively requiring 6th hit, removes all of the SR fake tracks

➢ This effectively imposes a lower limit on momentum (e.g., $p_T > 0.5\ GeV$ in barrel)

- Current simulation infrastructure is limited in statistics, this study needs to be revisited with either more SR simulation or real data

Cluster matching tests

* Based on DIS $1 < Q^2(GeV^2) < 10$ sample



Truth-matched track-cluster

- Test of track-cluster matching algo
  - Scheme 1: “TrackClusterMatch” (nearest cluster within 0.5 in $\Delta\eta \times \Delta\phi$)
  - Scheme 2: Most energetic cluster within R = cluster radius + 1 cell size
  - Scheme 3: Most energetic cluster within R = 0.1 in $\Delta\eta \times \Delta\phi$ space
- No clear “winner”, will revisit this topic with cluster splitting
- Further studies (for now) using truth matches

Cluster matching tests

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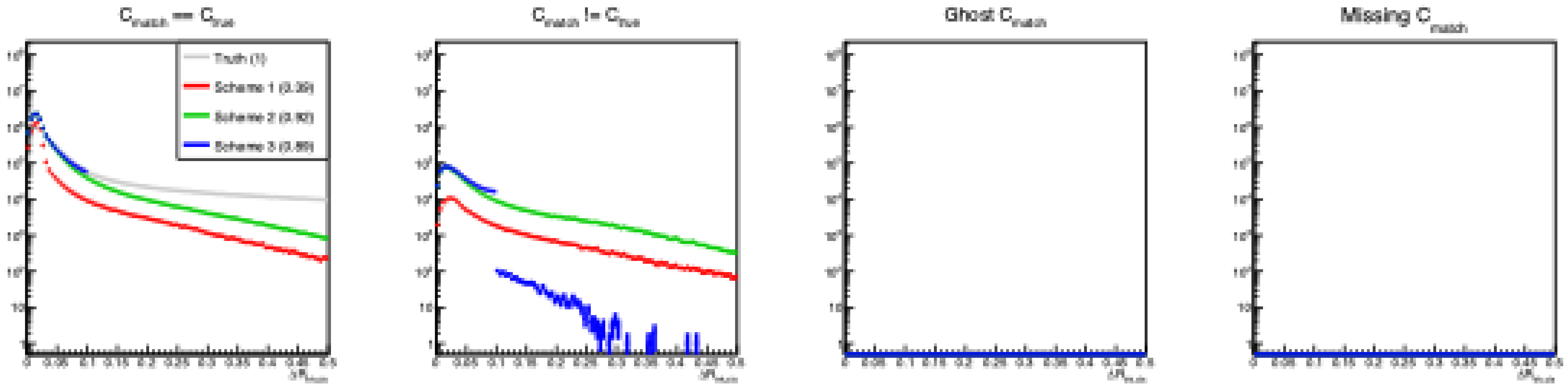

Algo-matched track-cluster

- Test of track-cluster matching algo
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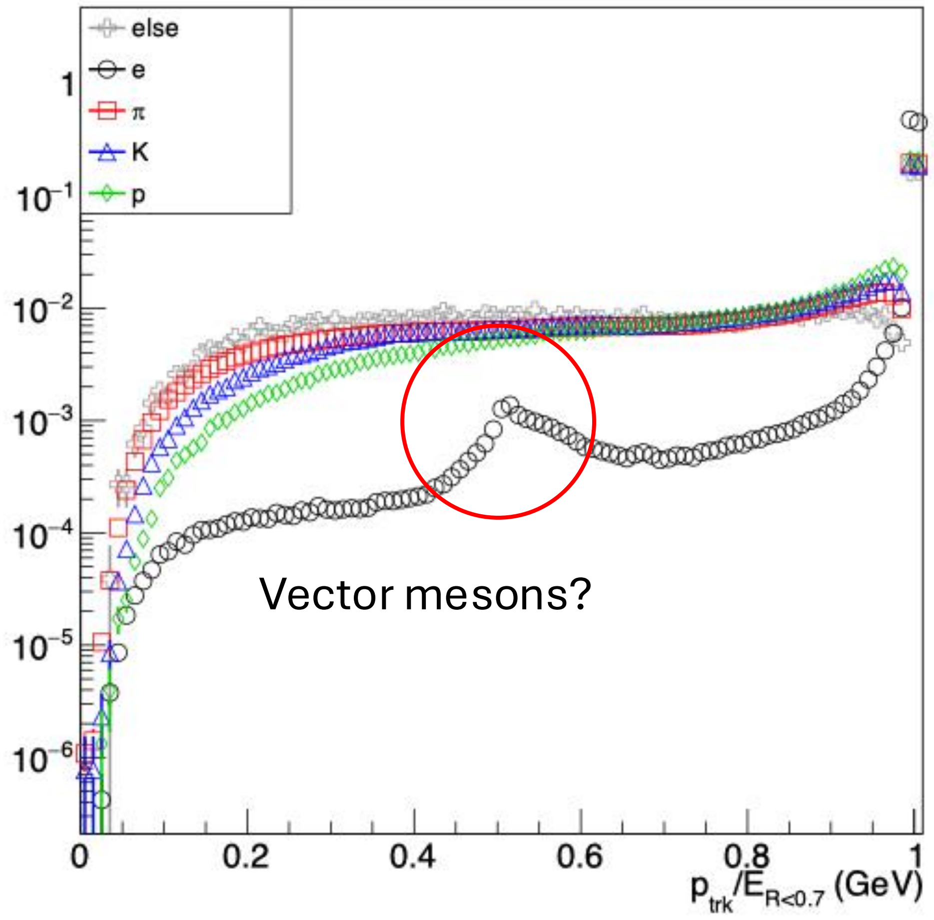
Electron identification

* Based on DIS $1 < Q^2(GeV^2) < 10$ sample

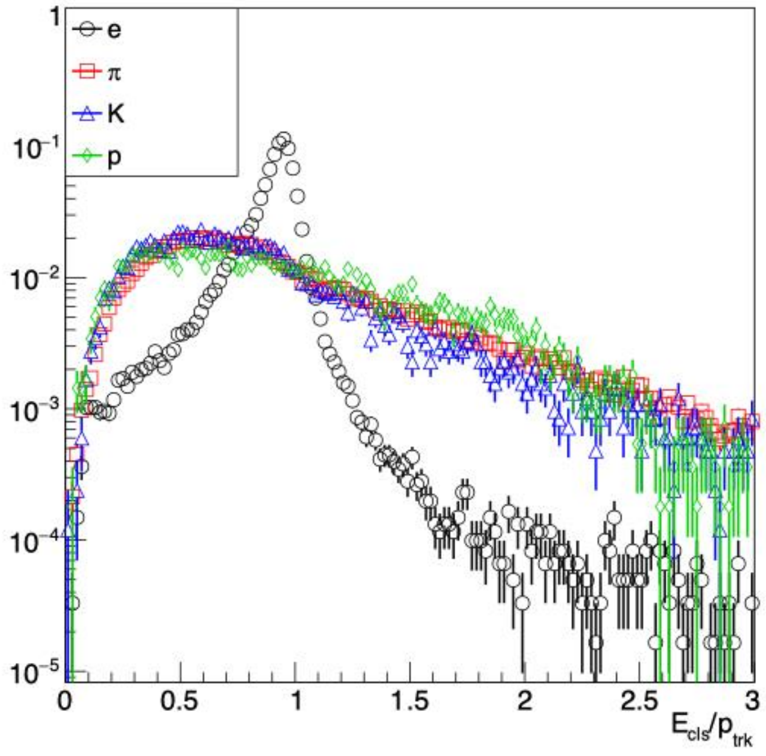


- Using inclusive DIS at $1 < Q^2(GeV^2) < 10$ sample for eID study
- The current strategy follows Inclusive PWG:
  - Track-cluster matching
  - Isolated cluster ($E/E_{\Delta R<0.7} > 0.9$)
  - $0.8 < E_{cls}/p_{trk} < 1.2$
  - Highest p_T track
- Isolation seems to work well for the most part, but perhaps some tuning required for non-primary electron ID.
- Also, requires cluster matching, which effectively imposes a lower momentum cut

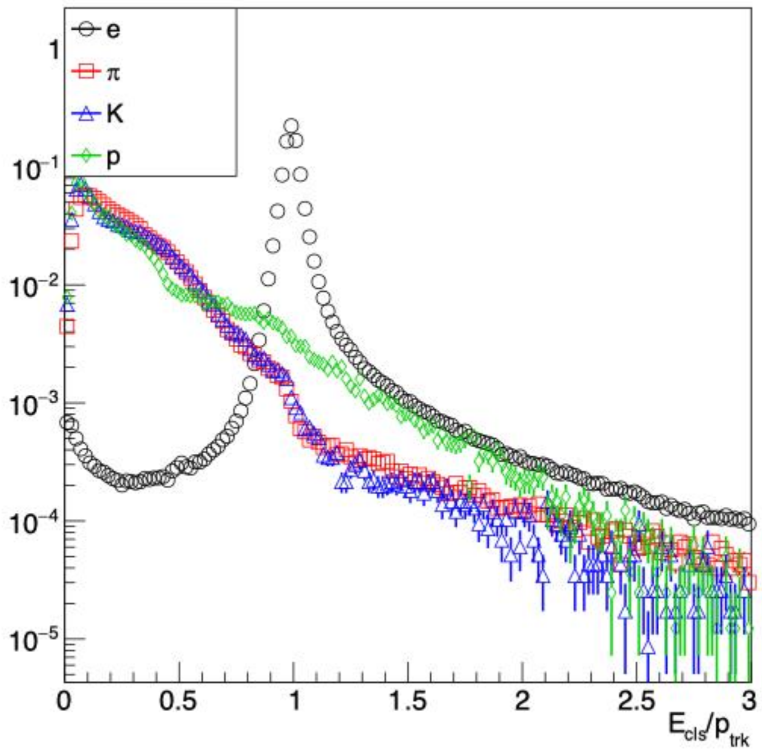
Electron identification

* Based on DIS $1 < Q^2(GeV^2) < 10$ sample

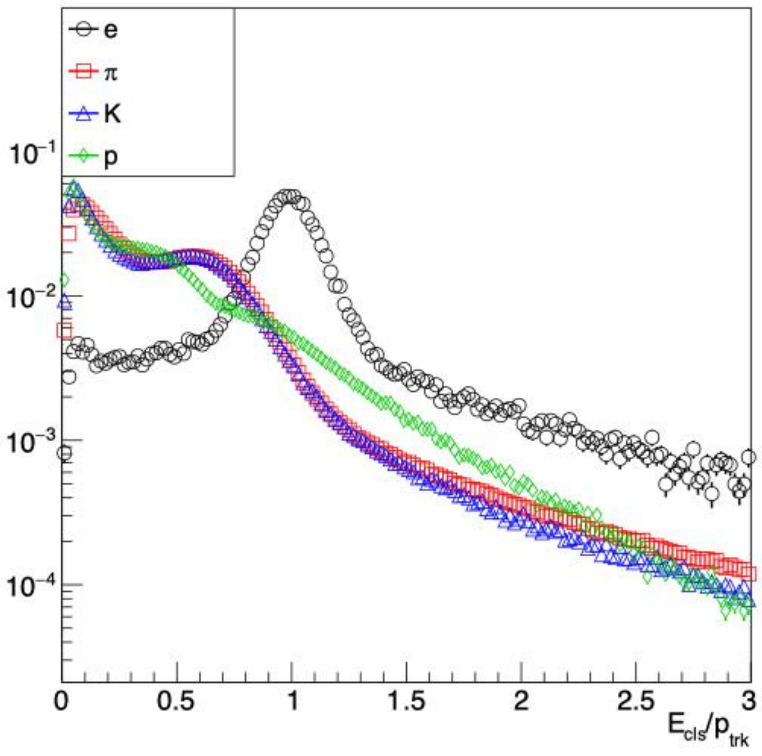
BEMC



N-Endcap EMC

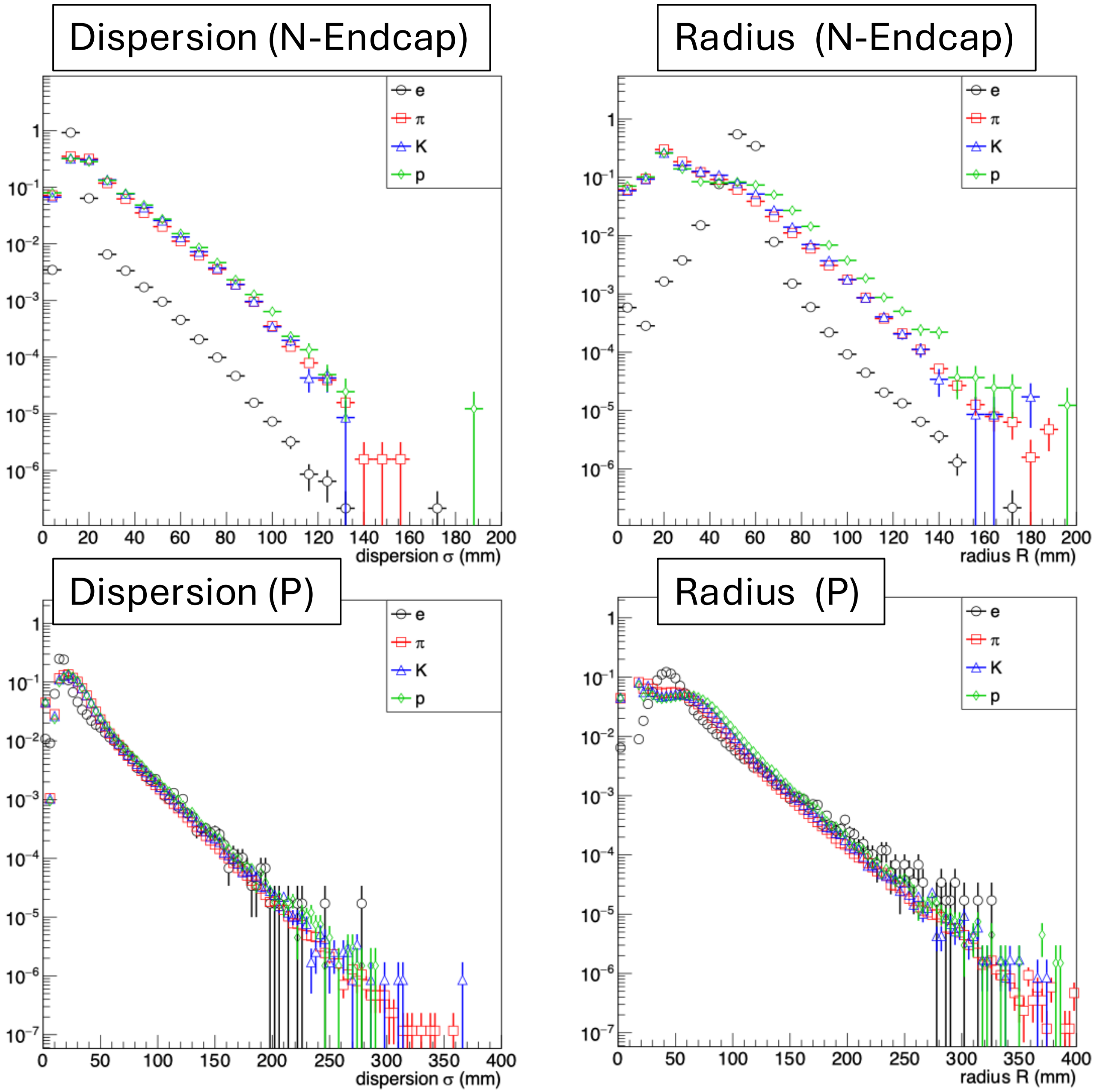


P-Endcap EMC



- E/p performs fairly well with varying degrees of success

Electron identification



- Cluster energy deposit pattern explored for additional eID performance

- Radius and dispersion have…

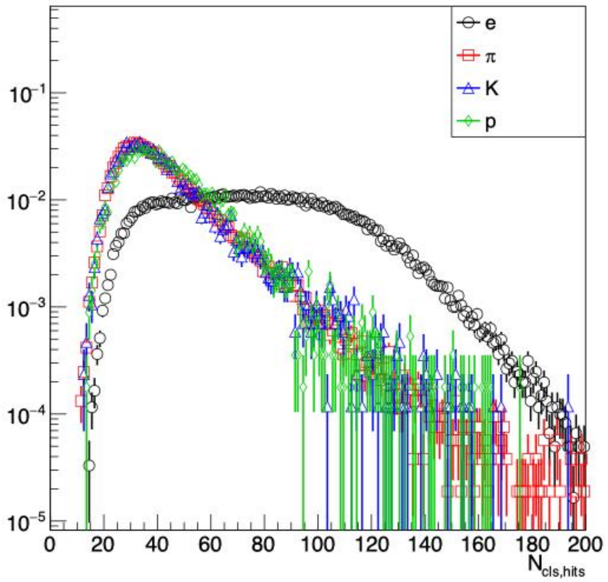
➢**Some biasing** in **N**-Endcap;

➢**No biasing** in **P**-Endcap;

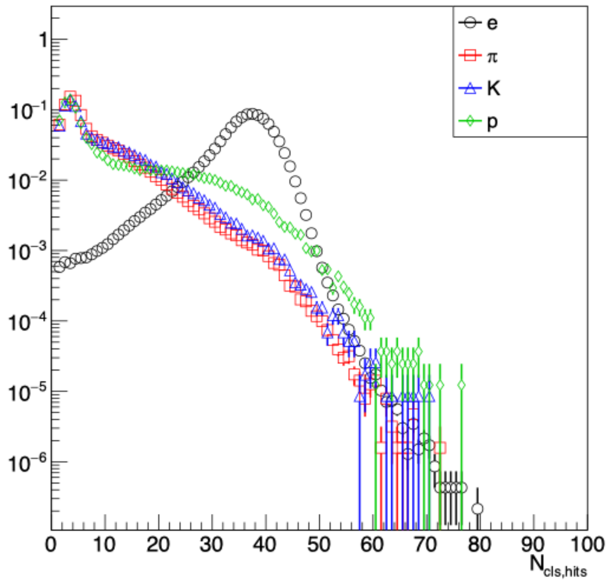
➢**Empty** (at the moment) in **B**arrel

Electron identification

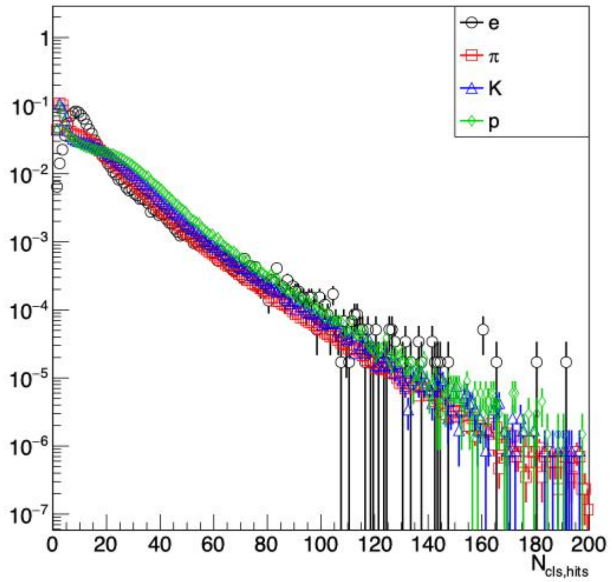
$N_{cls,hits}$ (Barrel)



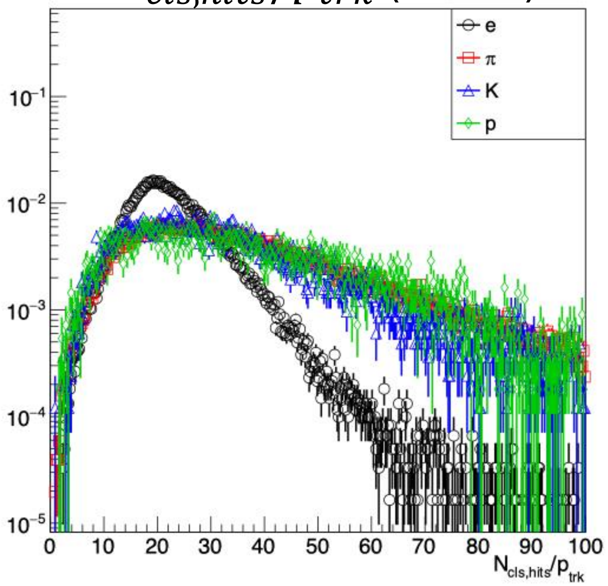
$N_{cls,hits}$ (N-Endcap)



$N_{cls,hits}$ (P-Endcap)



$N_{cls,hits}/p_{trk}$ (Barrel)



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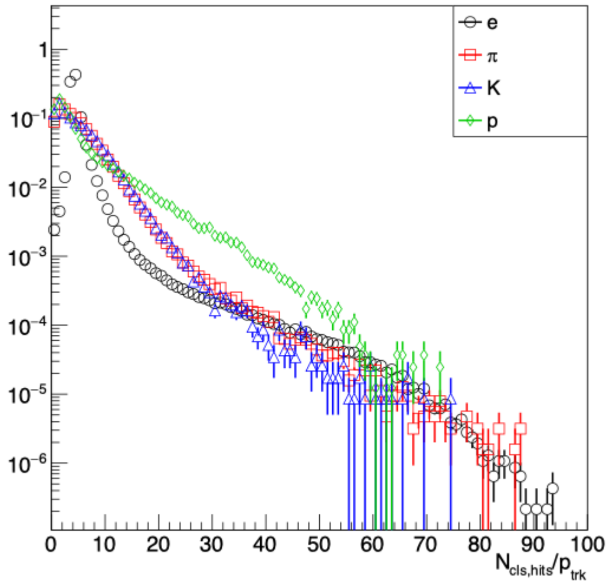

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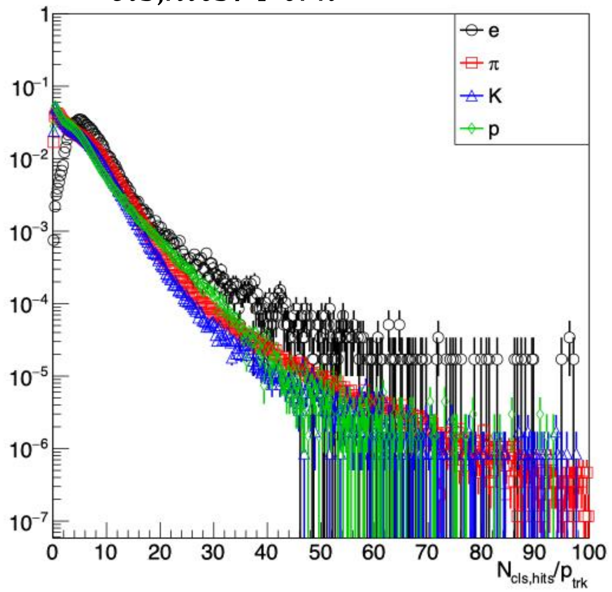
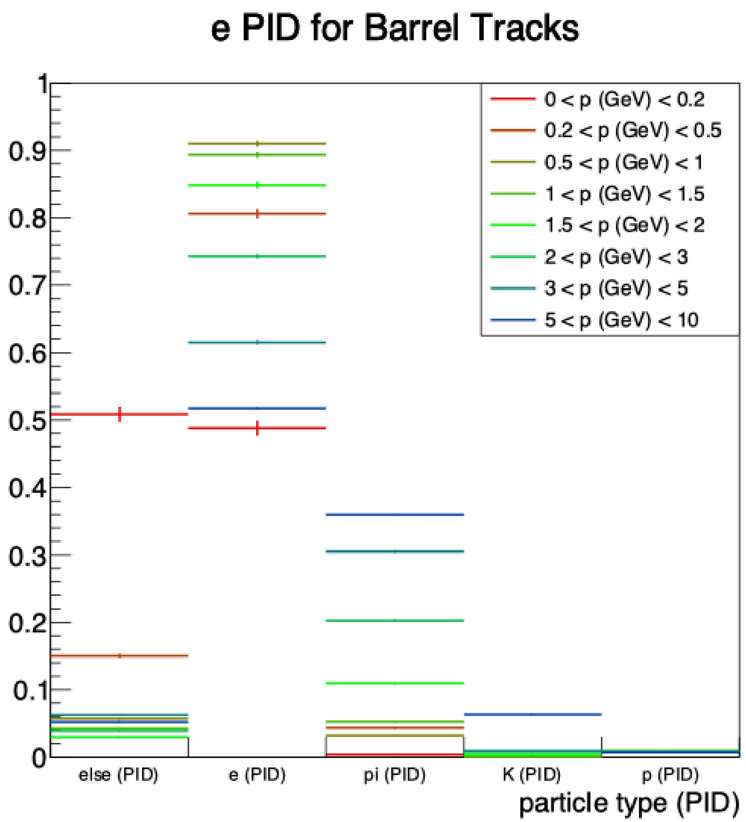
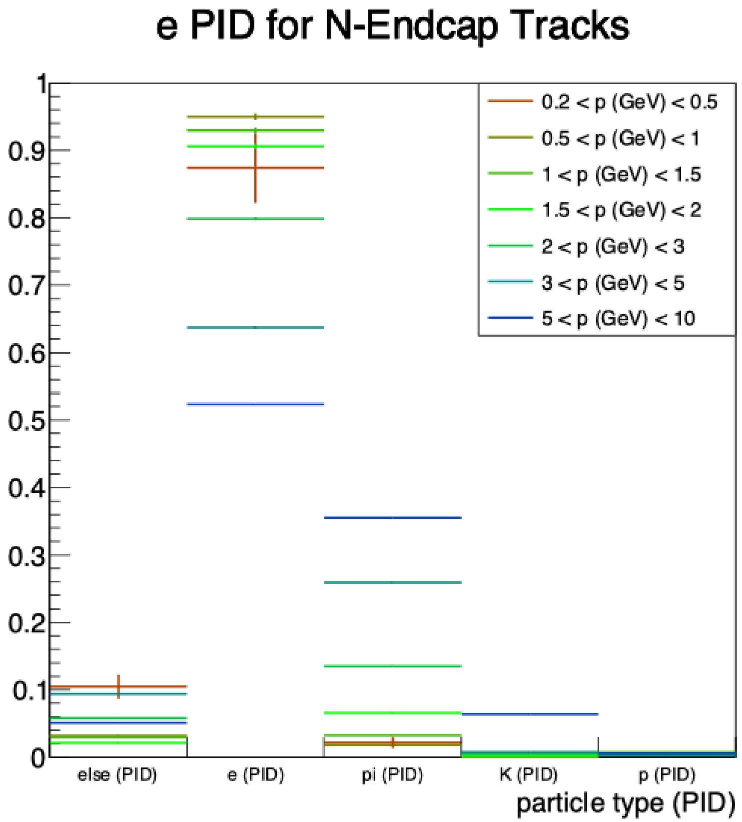
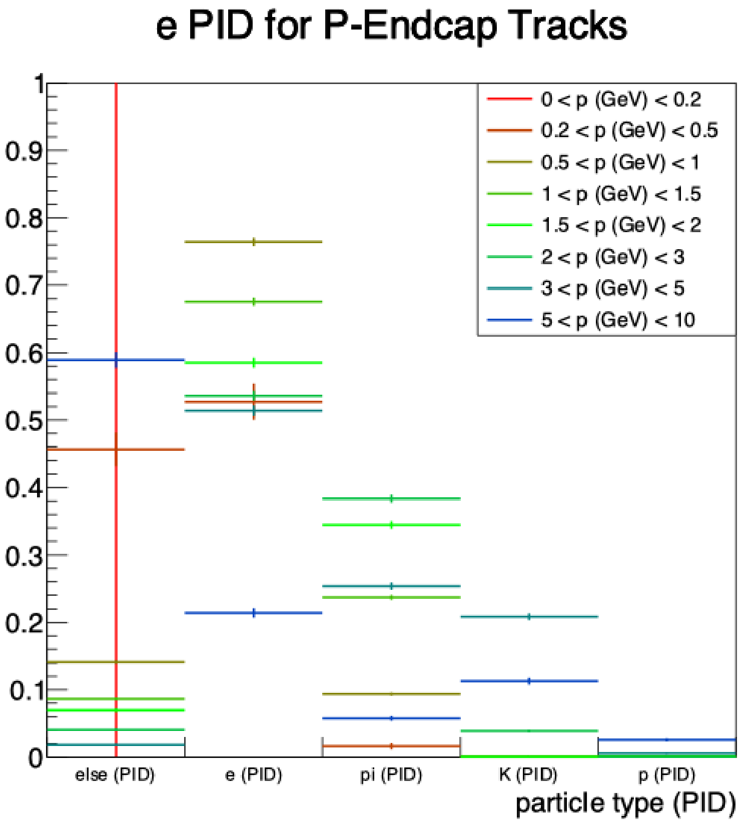


- N_{hits} naively looks usable;
- But more strongly correlated with momentum

Electron Identification

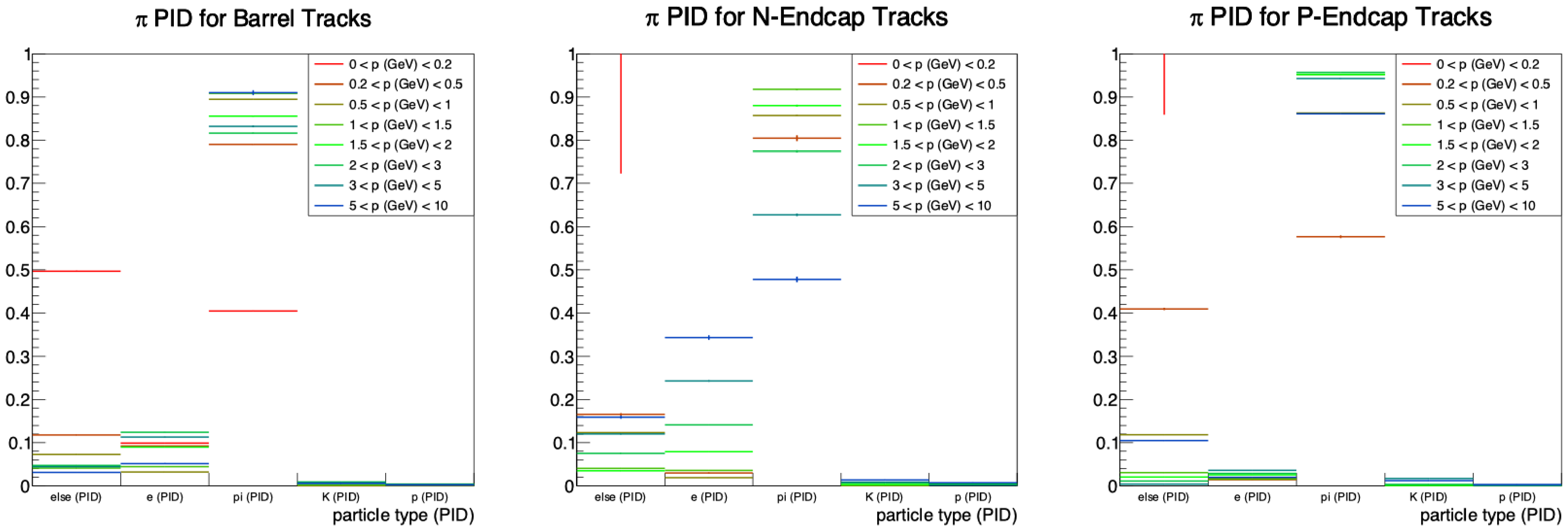






- PID detector perform well for low momentum electrons
  - $\sim 90\%$ up to $0.2 < p < 1.0$ GeV in Barrel, and $p < 2.0$ GeV in N-Endcap
- Will consider PID detectors for eID for tracks without a matched ECal cluster

Electron Identification



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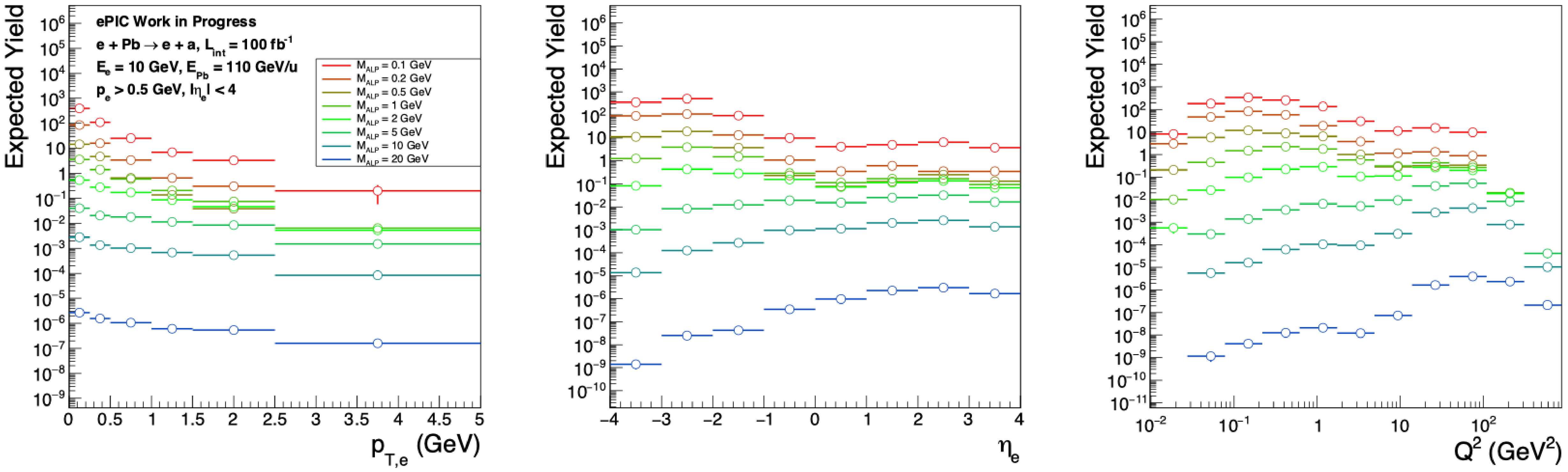
Selection cuts

Tracks	$\boldsymbol{p > 0.5\ GeV}$
	$\lvert\eta\rvert < 4$
	$\lvert Z_{vtx}\rvert < 100\ mm$
	$\lvert R_{XY,vtx}\rvert < 3\ mm$
	$\boldsymbol{N_{hits} \geq 5}$
	(Truth-)matched cluster
	Reject Low-Q2 tagger
Electron	$0.8 < E_{cls}/p_{trk} < 1.4$
	$\boldsymbol{E/E_{R<0.7} > 0.9}$
Event	$N_{trk} = 1$
	$E - P_Z < 10\ GeV$
	$p_{T,miss}/E_T > 0.9$
	Has ele candidate

- These were the selection cuts considered for NIM-A
- Will consider relaxing **these** cuts related to eID, while including PID measurements
- Will consider tightening **these** cuts, to reject SR fake tracks without requiring ECal matching

Will be discussed by **Ganesh & Alyssa**

Expected signal

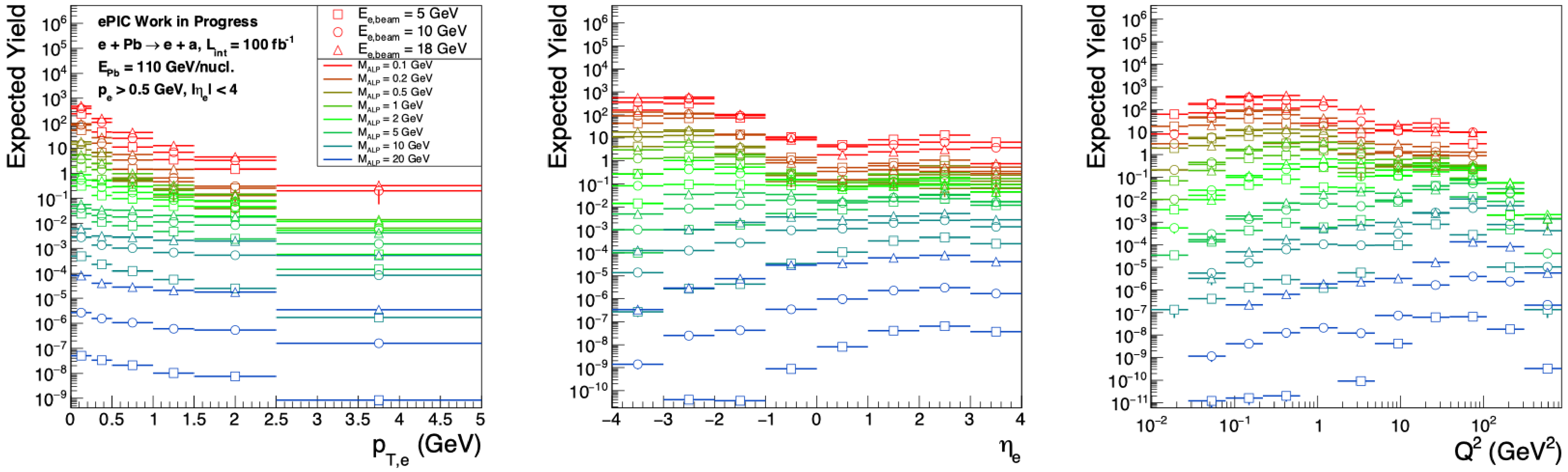


- Presented in EIC Asia Workshop
- Expected signal yield using “Tracking” cuts only

➢Searches possible for low-mass ($M_{ALP} < 1$ GeV) ALPs with $L_{int} = 100\ \text{fb}^{-1}$

➢Limit-setting for high-mass ALPs

Expected signal



- Expected signal yield based on the tracking and clustering performance

➢Significant beam-energy dependence with high-mass ALP

➢Motivates $E_{e,beam} = 18\ \mathrm{GeV}$ collisions

Conclusion

- Machine background rejection
  - Coulomb and bremsstralung most entirely fall in to low Q2 tagger
  - $N_{trk,hits} \geq 5$ rejects most of the SR
  - Requiring track-cluster matching rejects the rest
  - Some rejection provided by quality cuts
- Track-cluster matching
  - Several ideas have been tested
  - Without the presence of cluster splitting algo, the matching schemes tested here have their own limitations
  - Truth matching for now
- Electron Identification
  - The current scheme based on isolation and E/p performs well for cluster-matched tracks
  - Will investigate improvements from PID detectors for low momentum tracks