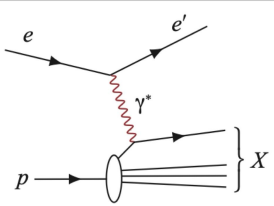


eID Update

Stephen Maple (U. Birmingham), Win Lin (SBU)

Joint ePIC/EICUG Meeting, 07/16/2026

UNIVERSITY OF BIRMINGHAM

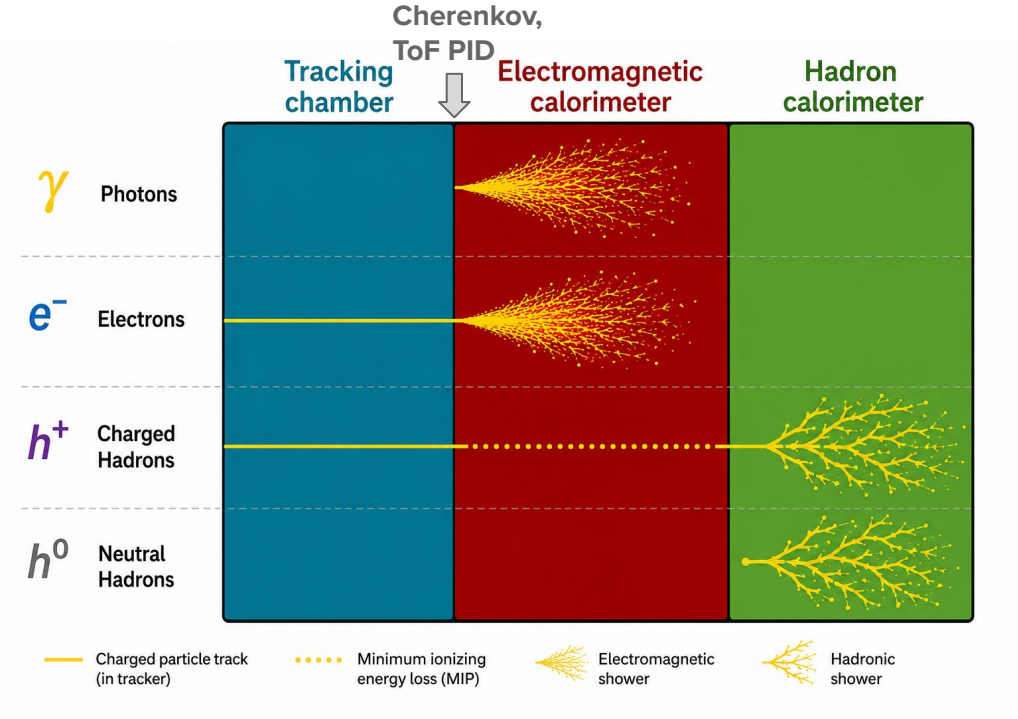
Stony Brook University

Center for Frontiers in Nuclear Science

General Concepts

Finding electrons

Electrons aren't reliably identified by e.g. Cherenkov/ToF-based PID systems -> instead we distinguish them by the properties of their signal in each detector subsystem

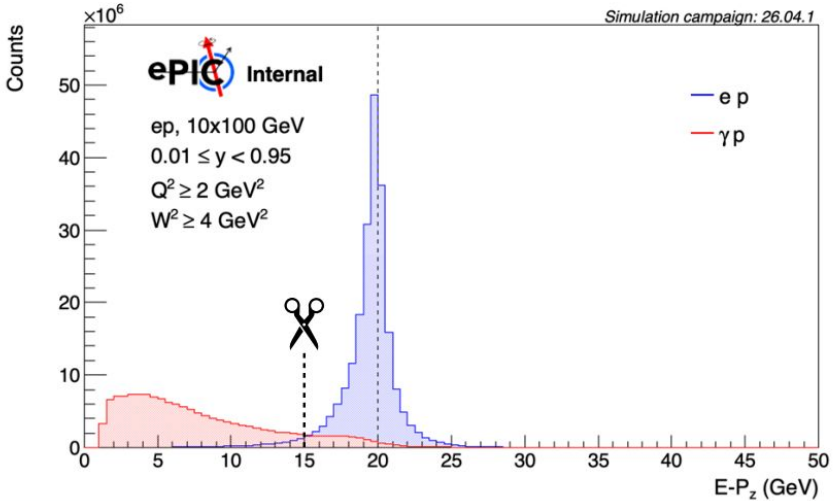


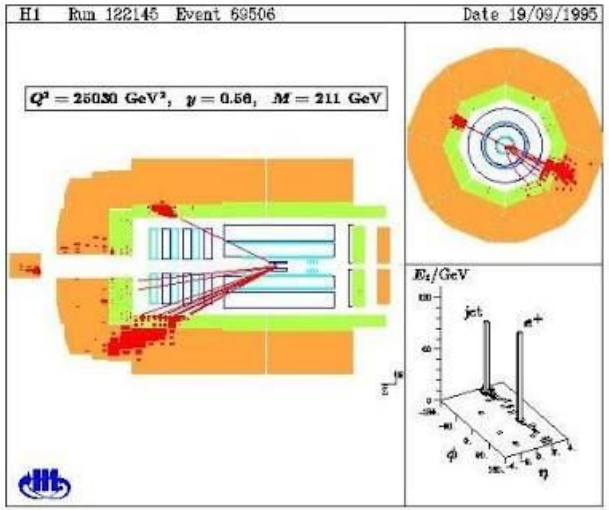
Electrons

- Produce a track
- Highly relativistic $\beta \approx 1$
  - Shorter t.o.f., wider cherenkov angle (only see at very low p)
- Deposit vast majority of their energy in ECAL
  Compared to hadrons:
  - Short shower length
  - Narrow shower width
- Deposit little to no energy in HCAL

Finding scattered electrons

- Need to separate DIS electrons from candidates arising from e.g. photoproduction background, real electrons produced in decays etc
- Consider further distinguishing quantities such as
  - Event longitudinal energy-momentum balance $\Sigma(E-p_z)$
  - Isolation of candidate
  - p_T of candidate



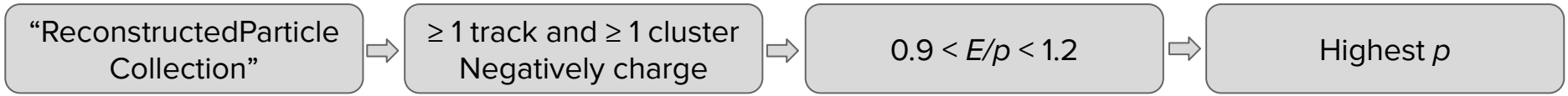


Note: e^- from heavy boson decays likely also isolated

What’s currently available?

Review of current status (ElCrecon)

- Electron finding development starts from code in [snippets repository]
  - Still uses a simple cut-based approach for now
- We also have a basic cut-based selection in ElCrecon:



- This is accessed by the “ScatteredElectronsEMinusPz” branch

Intended workflow

1. Snippets code used for fast benchmarking of electron-finding code
2. Results of studies to update electron-finding in ElCrecon

Review of current status (snippets)

"ReconstructedParticle Collection"

↓

≥ 1 track & ≥ 1 cluster
Negatively charge

↓

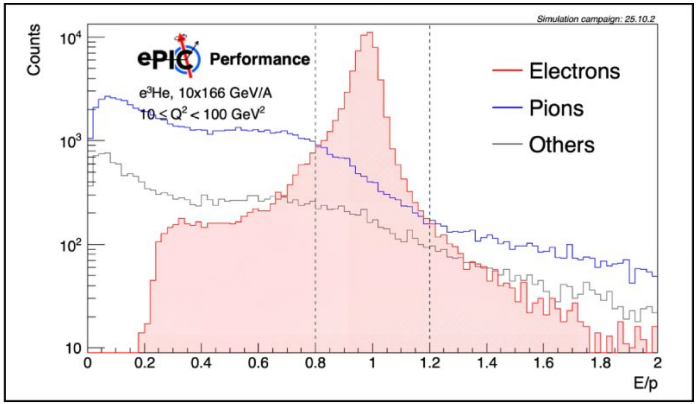
Isolated cluster:
$E_0/\Sigma E_{\delta R<0.7} > 0.9$

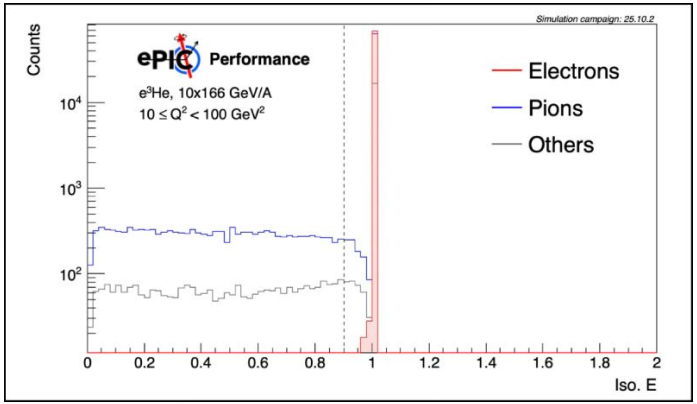
↓

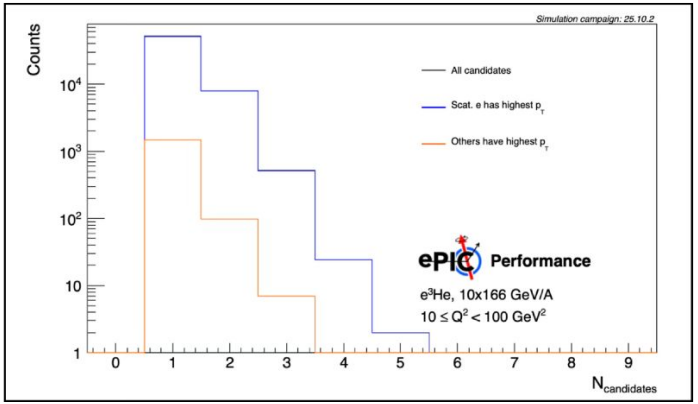
$0.8 < E/p < 1.2$

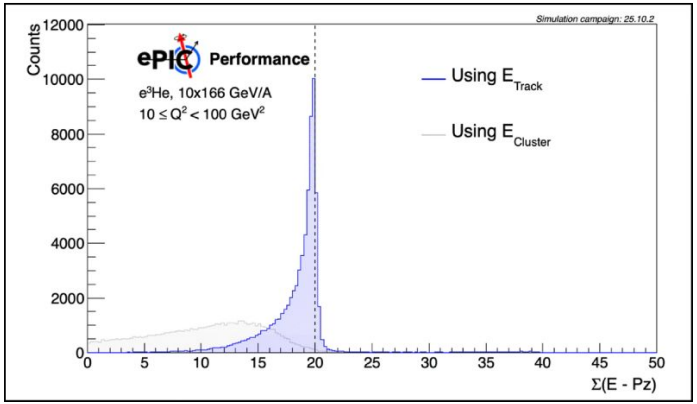
↓

Highest p_T

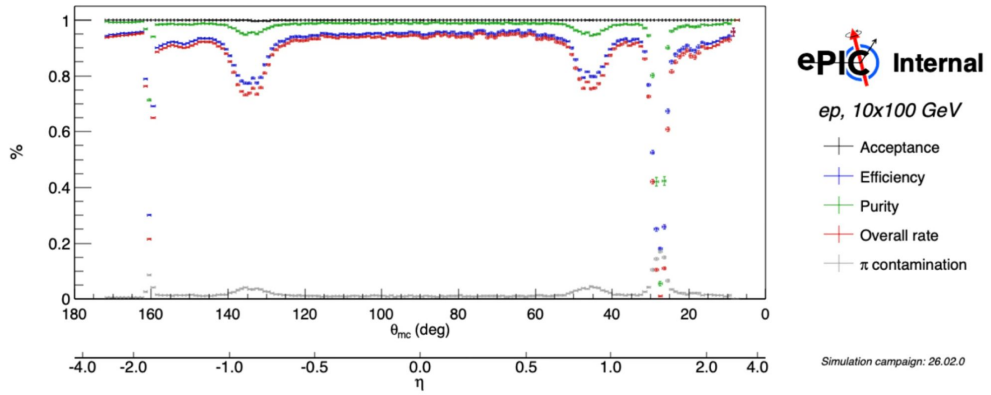


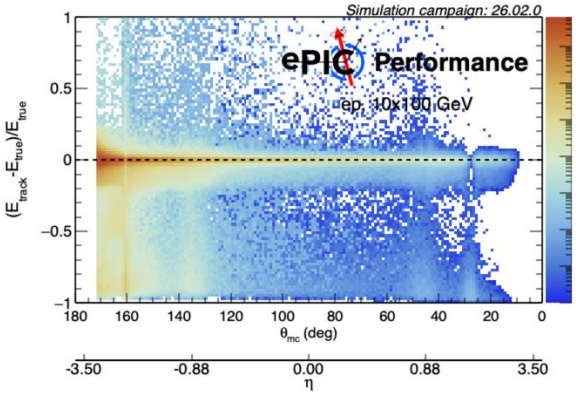


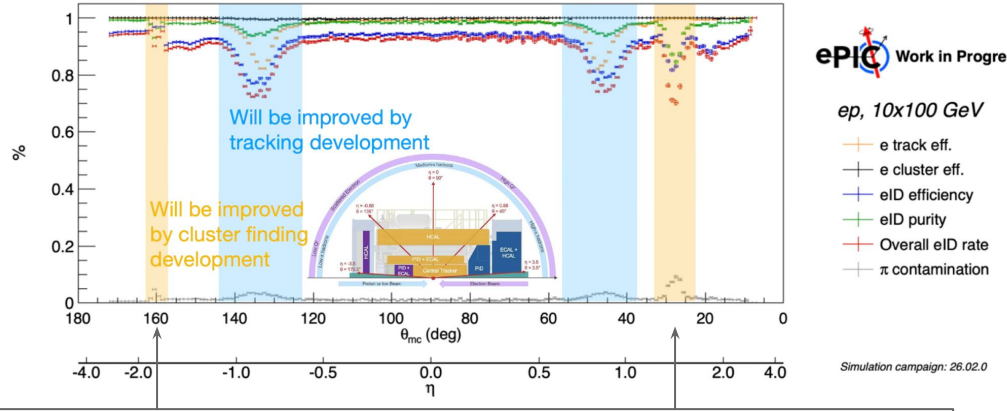


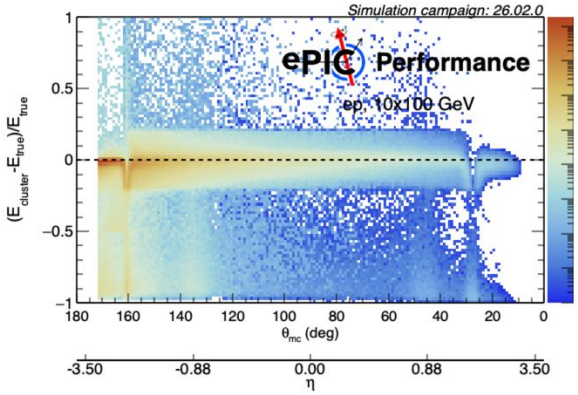


Performance and limitation of current method



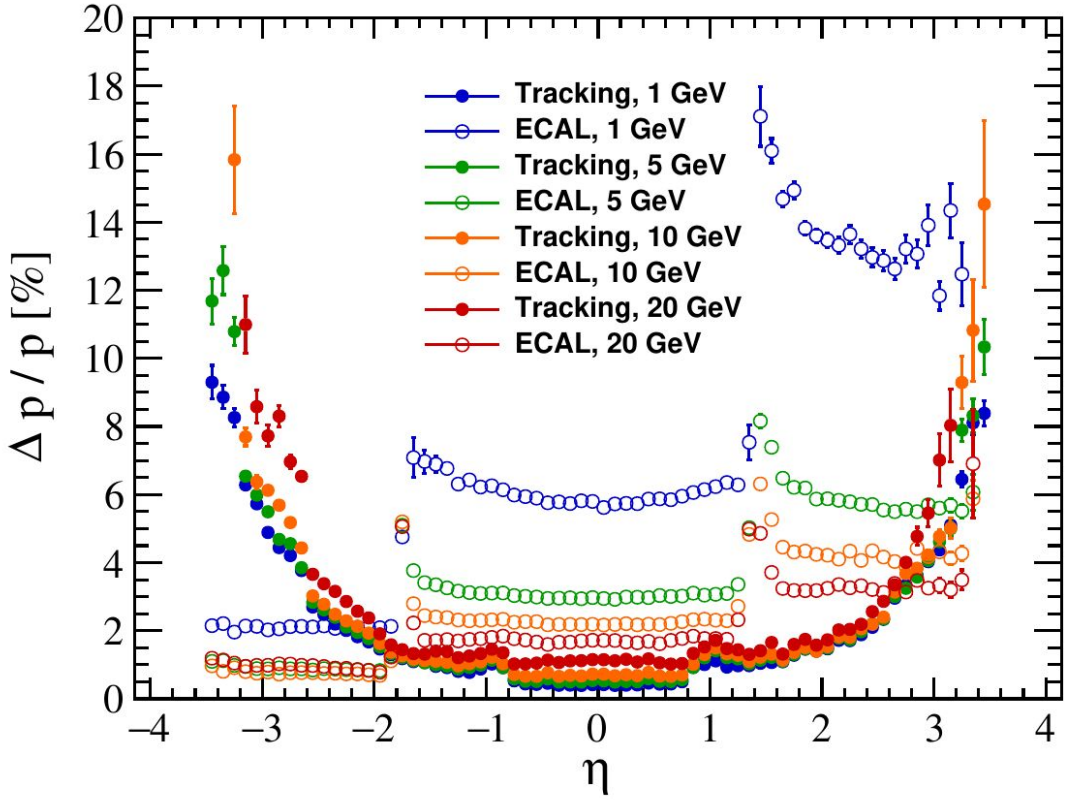






If found tracks in these regions, but no particles passed E/P cut for this event, then add these to candidate list

Tracker vs Calorimeter Energy Resolution

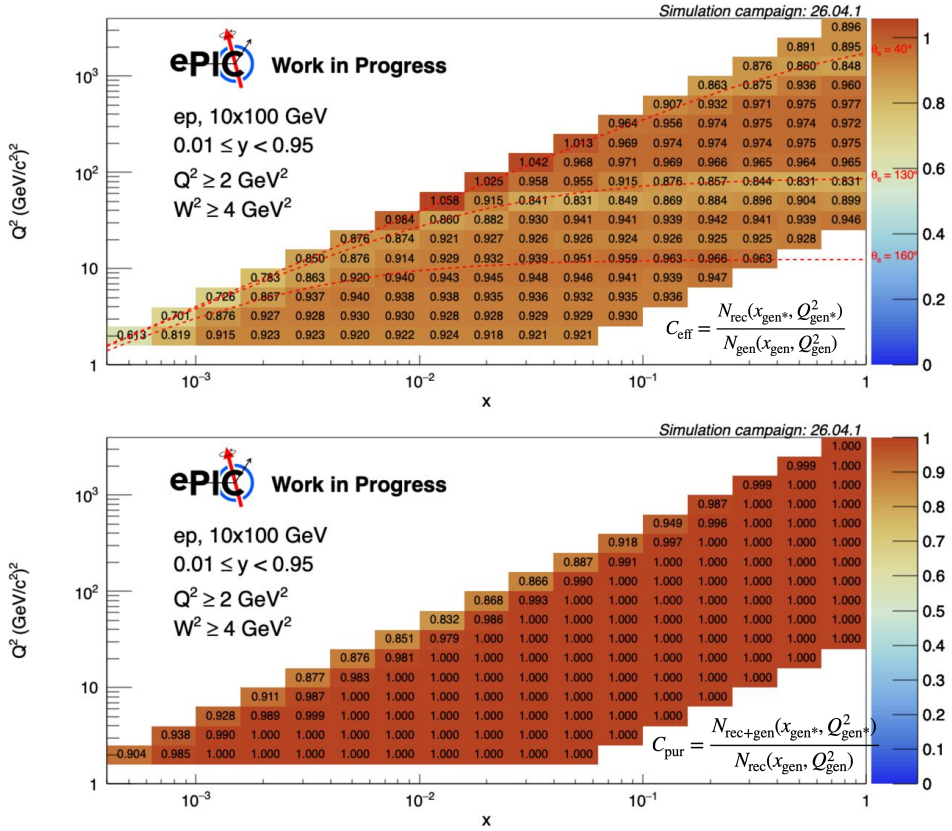


Resolution on E and p, and hence E/p varies with energy

- Tracking “energy” resolution degrades with increasing energy and |η|
- ECAL resolution shows weaker dependence on η, but strong dependence on energy
- Could use an η dependent E/p cut!

Generally: E_e better reconstructed by ECAL for η<-2.5, and tracker everywhere else

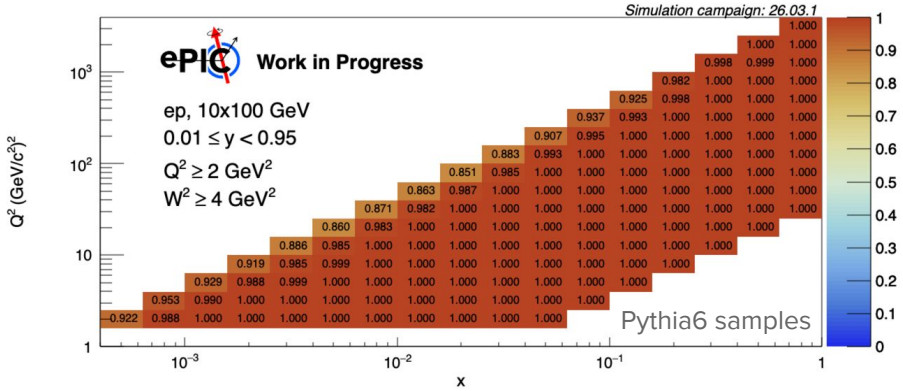
Performance and limitations of snippets eID

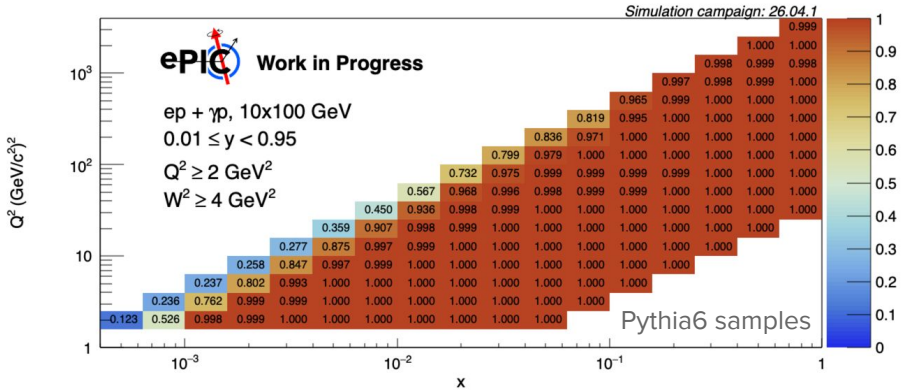


- Current algorithm largely driven by E/p and highest p_t selection
  - Requires efficient reconstruction of tracks and ECAL clusters
  - Also requires good resolution of for tracks and clusters in order to pass E/p cut
- Limited in that:
  - No E-H ratio
  - No PID detector info
  - No shower shape
- Also use pure cut-based approach -> aim to move to likelihood based (and for ML methods something like a BDT score)

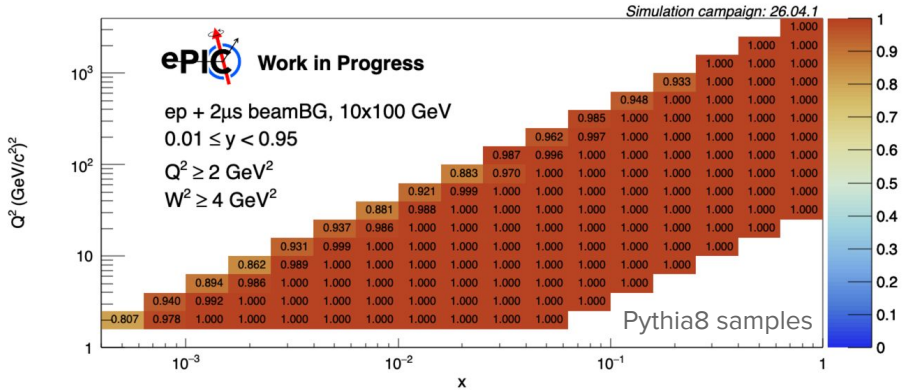
$x_{\text{gen}*}, Q^2_{\text{gen}*}$ - for the scattered electron, this is calculated using MC info of the electron
- for the mis-identified particle, this is calculated by assuming it is the scattered electron and using its MC momentum

Impact of backgrounds





- **Shown**: changes in purity when low Q^2 events and beam background are added to DIS signal sample
- Impact mostly in the high y, low x region
- Corresponds to low energy electrons -> PID detectors may help here



Ongoing developments

Recent studies

Matilda Donlan (U. Birmingham) Details

"ReconstructedParticle Collection"

↓

≥ 1 track & ≥ 1 cluster
Negatively charge

↓

Isolated cluster:
$E_0/\Sigma E_{\delta R<0.7} > 0.9$

Basic

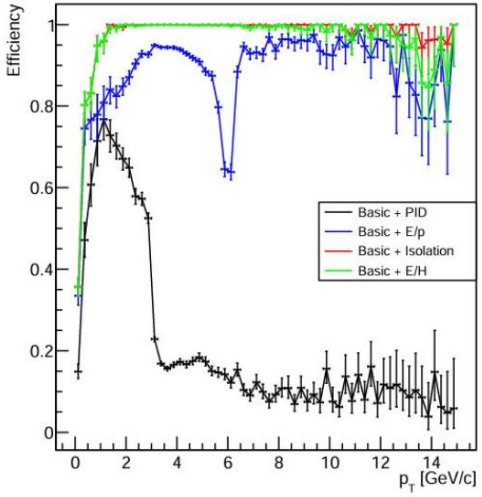
↓

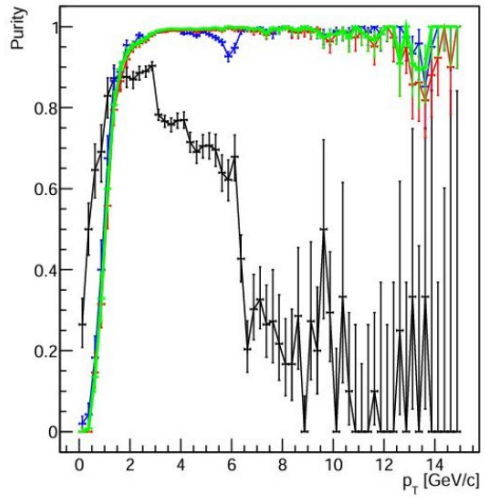
$0.8 < E/p < 1.2$

Other options?

↓

Highest p_T





Q^2>10GeV^2
DIS only

- Promising initial results when considering PID -> low efficiency, but does increase purity at low p_t
  - Not ideal for cut based selection, but could prove valuable when moving to likelihood-based approach
- Improvement hard to see for ECAL-HCAL energy ratio -> test with other samples and as function of other variables

Recent studies

Arthur Guest (U. Birmingham) Details

- Scattered electron identification using BDT (XGBoost)
- Trained on DIS samples, different model for each beam energy config
  - Promising results -> high purity and efficiency
- Helpful tool to study feature importance -> informs conventional algorithm development

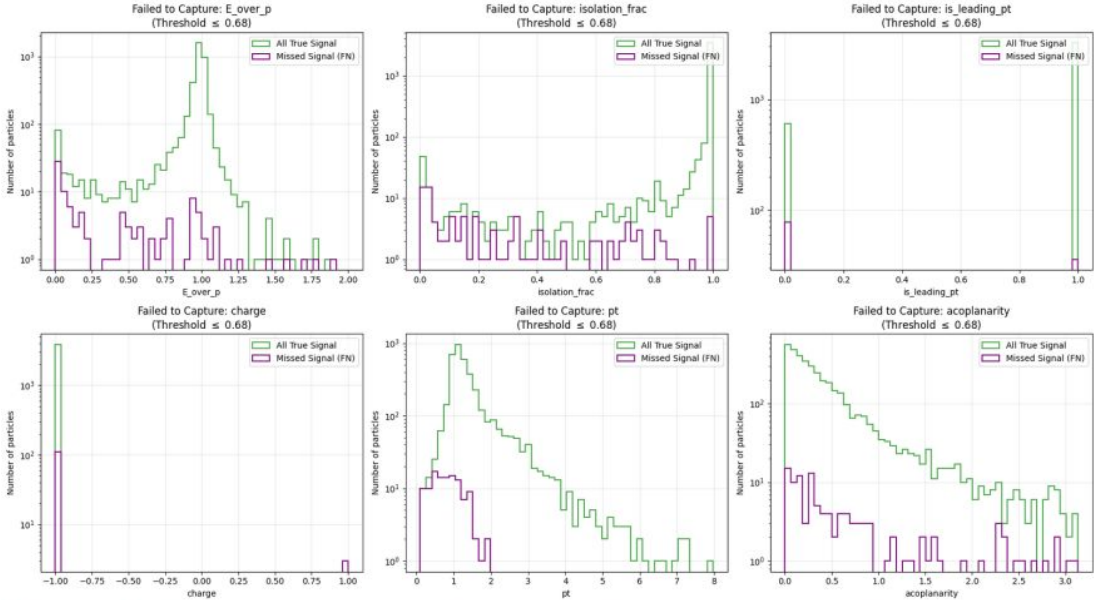
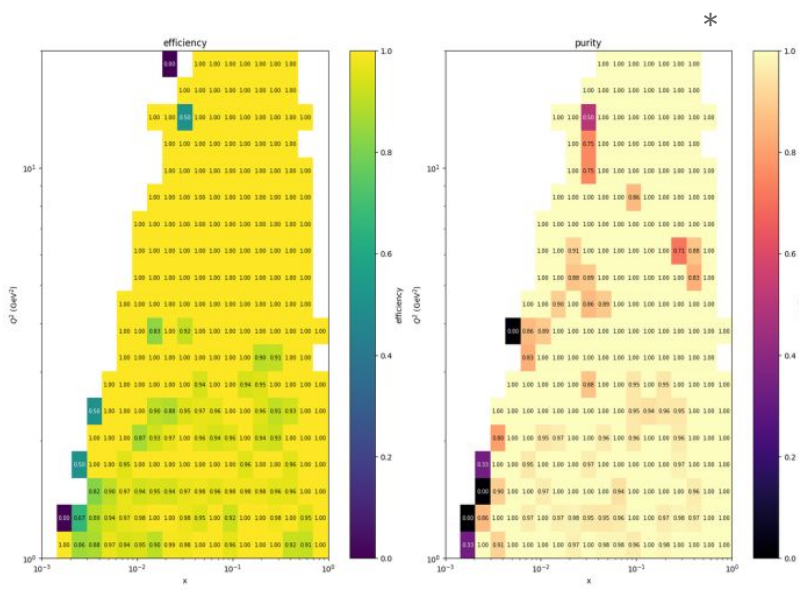


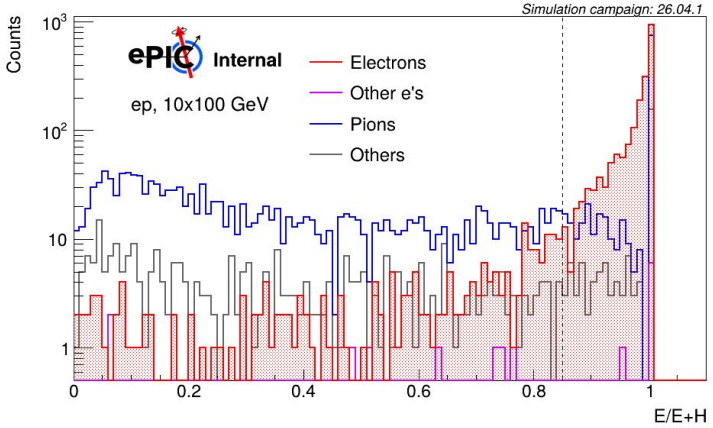
Figure 13: The input variable distributions for false negatives and the true signal, for the 5x41 GeV datasets.

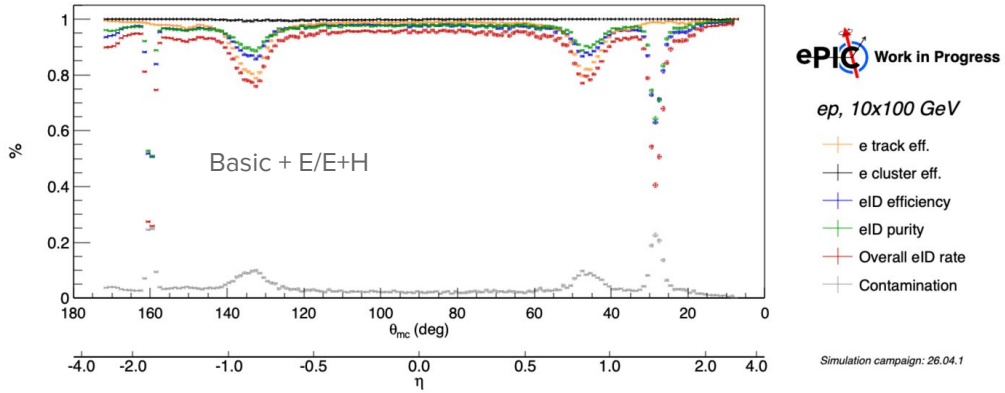


efficiency purity

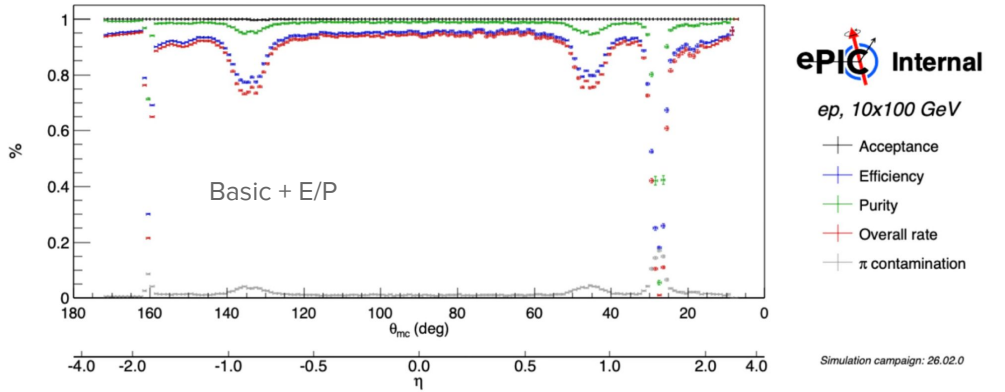
*low statistics

Cluster ratio E/E+H

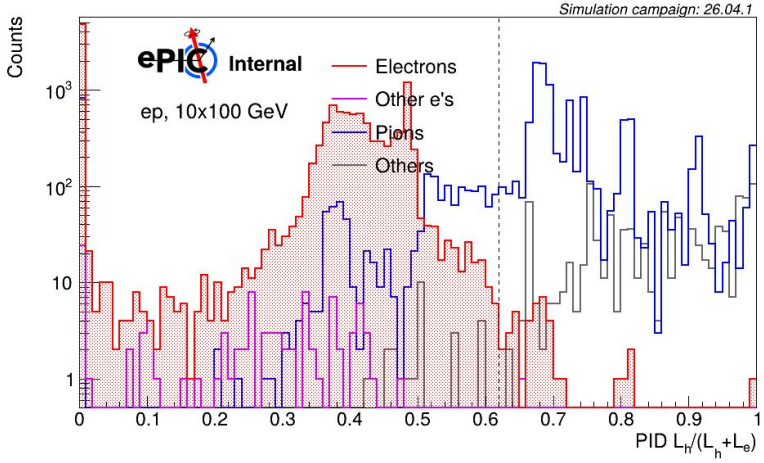




- Gives higher eID efficiency while keeping purity similar to Basic + E/P
- Has better performance than Basic + E/P at small θ
- Does not help with the detector gap regions



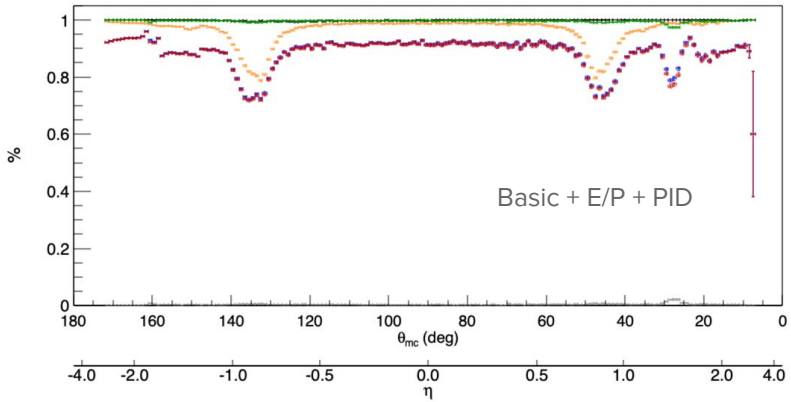
PID lookup table

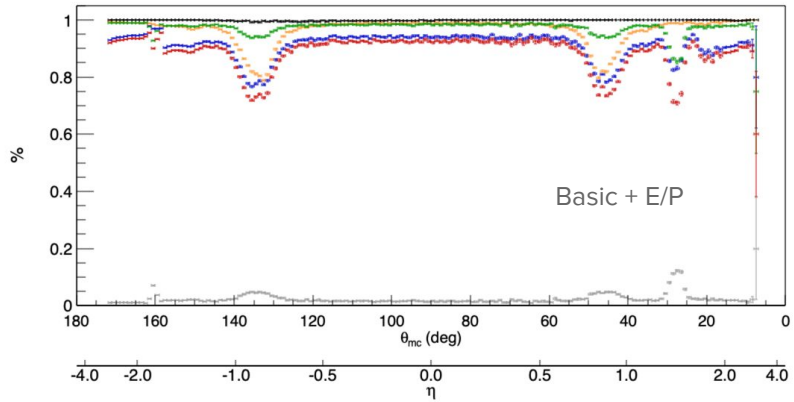


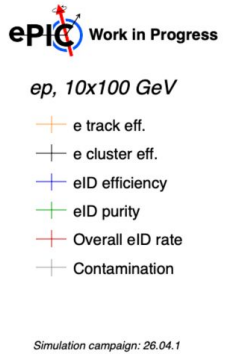
Lh: Max likelihood of being h+

Le: Max Likelihood of being e-

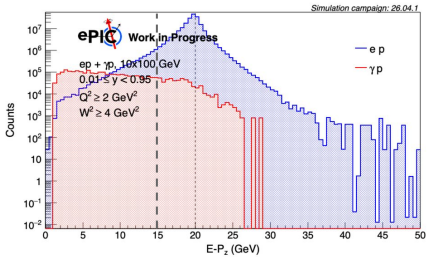
- Rate of success is low if we only consider the first prediction from PID LUT
- Calculate likelihood ratio from PID LUT accessed through “Reconstructed Particle” list
- Veto if $L_h / (L_h+L_e) > 0.6$



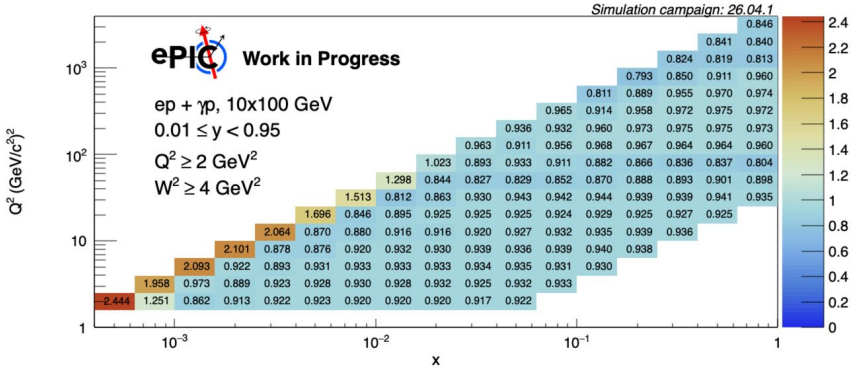




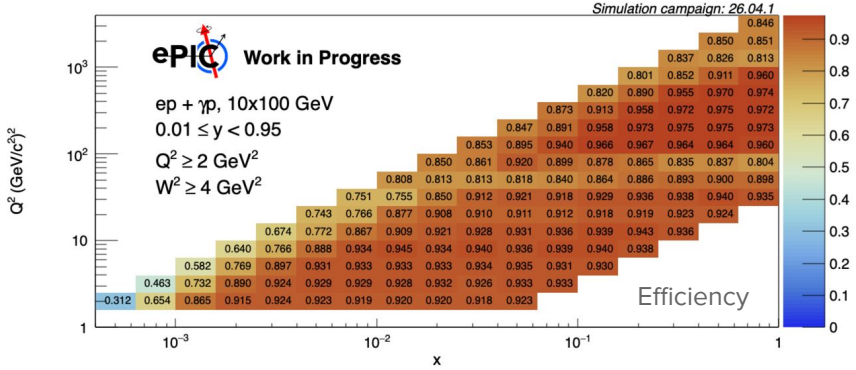
PID lookup table

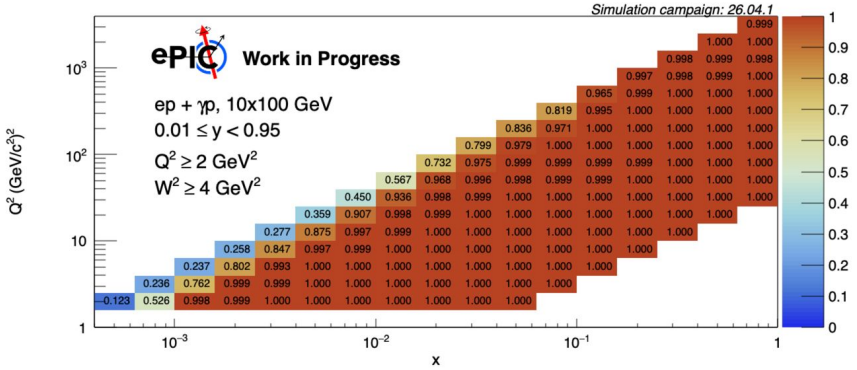


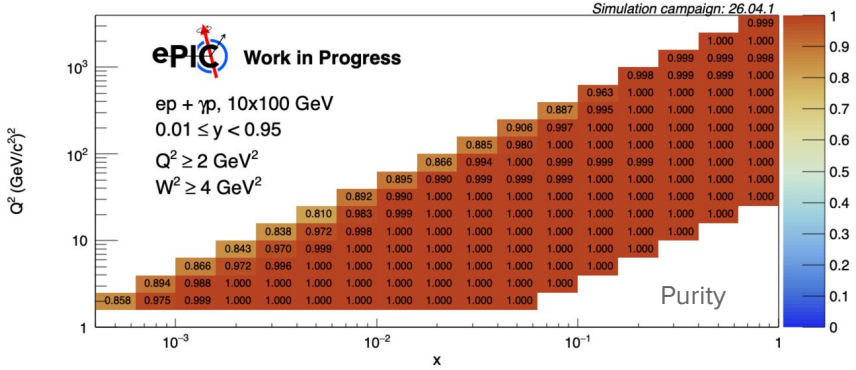
Basic + E/P + E-Pz



Basic + E/P + PID + E-Pz







Conclusions

- Efficient and high resolution of E/p is crucial for electron finding
- Development ongoing to make use of all detector subsystems in eID
  - First attempts to use PID LUTs for eID, result is promising.
  - E/E+H is also effective for eID. Will also consider Basic + E/E+H + PID.
- Will decide new set of DIS eID selection criteria in 2-3 weeks.

Thank you!

Join us at our biweekly meeting on Wednesday 11 AM ET :)

The 17th edition of the "International Conference on Meson-Nucleon Physics and the Structure of the Nucleon" (MENU 2026) is organized by the Center for Frontiers in Nuclear Physics and the Physics and Astronomy Department of Stony Brook University. It will be held at the Charles B. Wang Center.

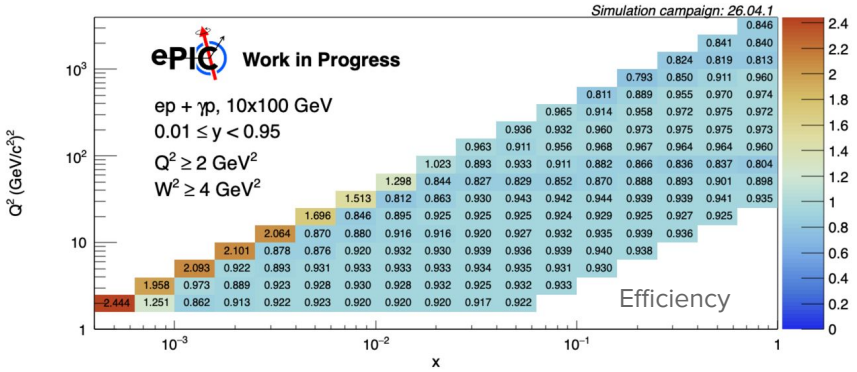
October 19th - 23rd, 2026

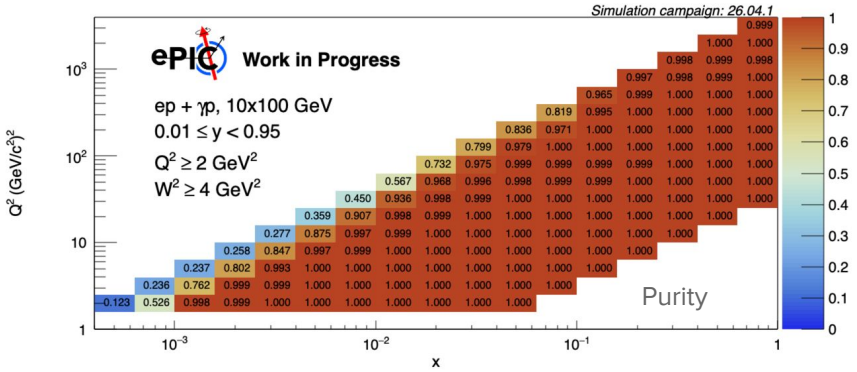
https://indico.cfnssbu.physics.sunysb.edu/event/668/overview

Backup

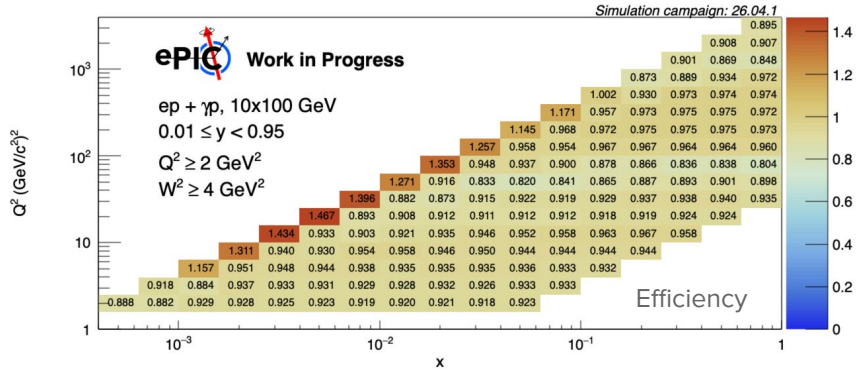
PID lookup table

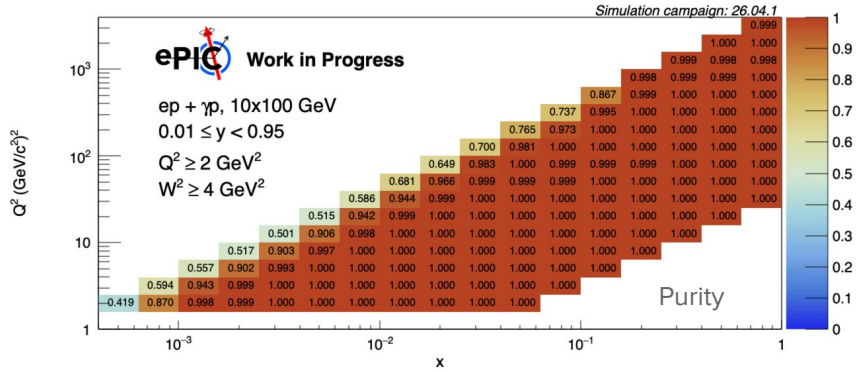
Basic + E/P + E-Pz



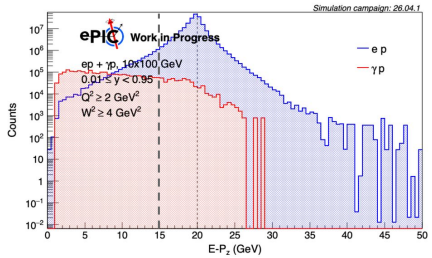


Basic + E/P + PID

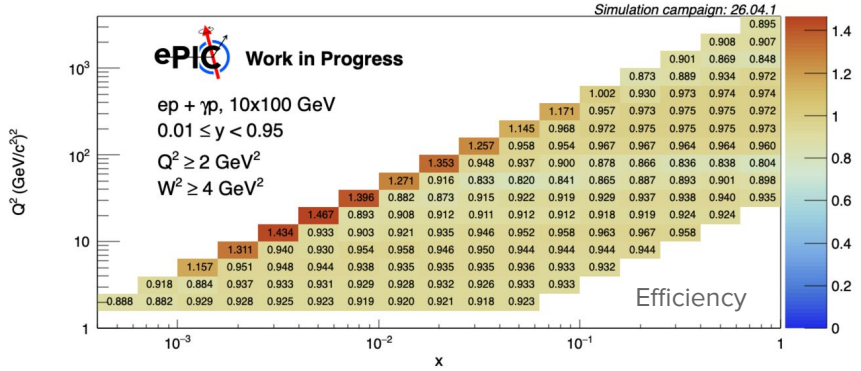


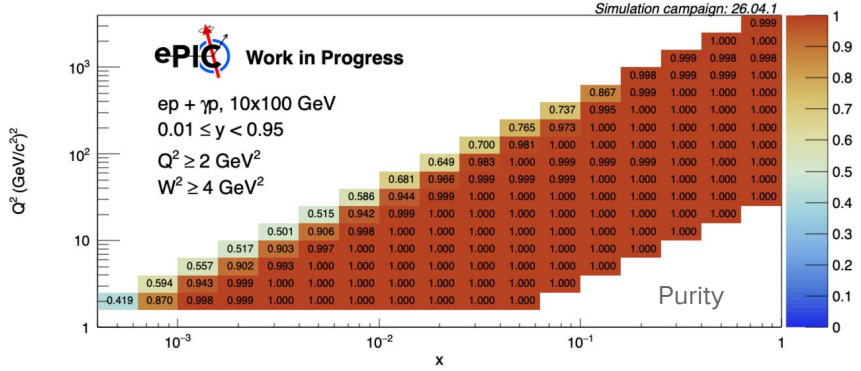


PID lookup table



Basic + E/P + PID





Basic + E/P + PID + E-Pz