Convener report from Jets & HF working group

Rongrong Ma, Shyam Kumar

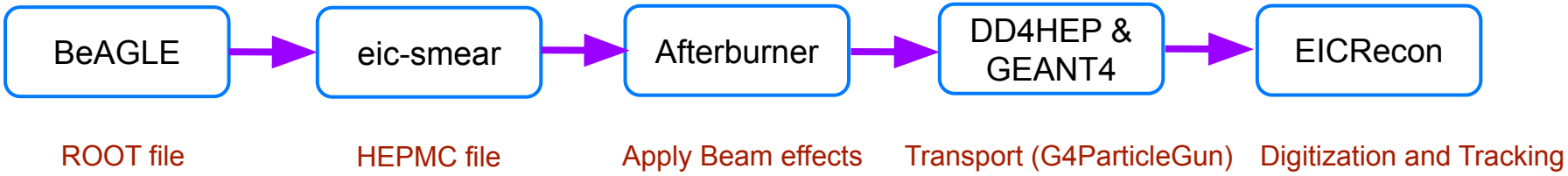
ePIC Collaboration Meeting

Jan. 2026

Introduction

- Contact and administrative info
  - Mailing list: eic-projdet-jethf-l@lists.bnl.gov
  - To subscribe, visit: https://lists.bnl.gov/sympa/info/eic-projdet-jethf-l
  - Indico: https://indico.bnl.gov/category/420/
  - Mattermost: https://chat.epic-eic.org/landing#/main/channels/phys-jets-hf
  - Webpage: https://www.epic-eic.org/physics/jets_hf.html
- Conveners
  - Rongrong Ma (marr@bnl.gov)
  - Shyam Kumar (shyam.kumar@ba.infn.it)
- Working group meetings
  - Tuesdays at 11:30 am ET (bi-weekly)
  - Zoom link: see Indico
- **Analysis codes**: https://github.com/eic/snippets/tree/main/JetsAndHF/

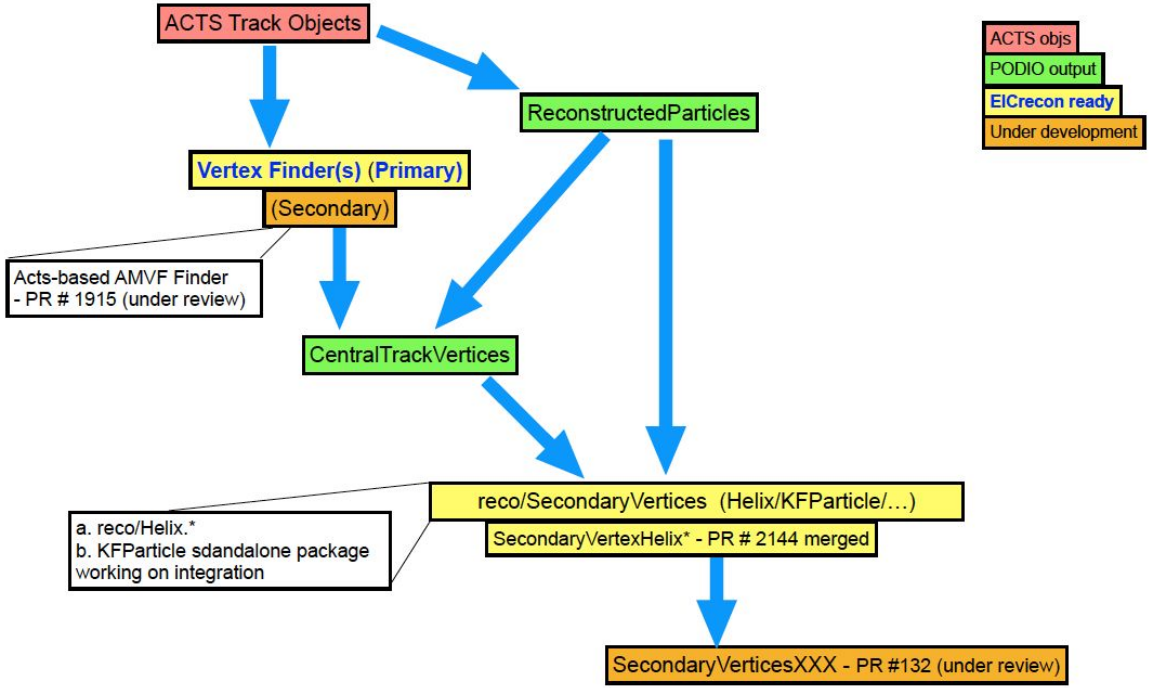
Software update: eic-smear



- Can be used to convert root files into HEPMC files
- Two fixes
  - Use mm instead of cm as the default unit, as is expected by afterburner for beam effects
  - Add decay time to secondary vertices, which is used by GEANT4. Otherwise, secondary vertices are set to primary vertex location during ePIC simulation
- Fixes are included since 1.1.14
  - https://github.com/eic/eic-smear/releases/tag/1.1.14

Software update: Secondary Vertex finders

X. Dong (LBNL)
B. Dongwi (SBU)



AMVF - under review (PR #1915)

Helix - merged (PR #2144)

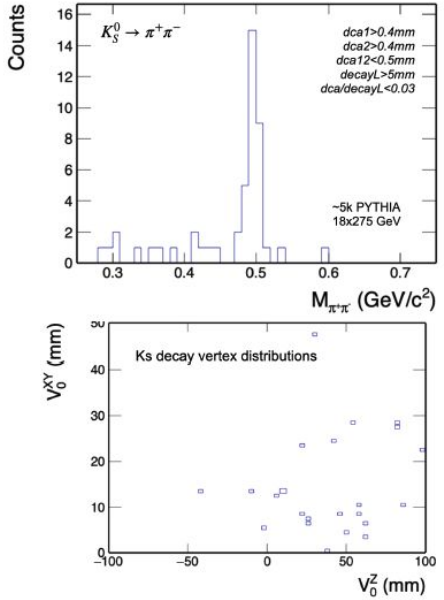
KFParticle - under development

Software update: SV data structure

X. Dong (LBNL)

- Current vertex data structure does not contain topological variables
- Propose new SV structure to facilitate offline analysis (PR #132)

```
edm4eic::SecondaryVertex:
  Description: "EIC secondary vertex"
  Author: "X. Dong"
  Members:
    - int32_t             type          // Type flag, to identify what type of vertex it is (e.g. p
    - float               chi2          // Chi-squared of the vertex fit
    - int                 ndf           // NDF of the vertex fit
    - edm4hep::Vector4f   position      // position [mm] + time t0 [ns] of the vertex. Time is 4th c
    - edm4eic::Cov4f      positionError // Covariance matrix of the position+time. Time is 4th compo
    - edm4hep::Vector3f   parentMomentum             // parent momentum
    - float               parentInvariantMass        // parent invariant mass
    - float               parentInvariantMassError   // parent invariant mass error
    - float               parentDecayLength          // parent decay length
    - float               parentDecayLengthError     // parent decay length error
    - float               parentDca2PV               // parent dca to primary vertex
    - float               parentDca2PVError          // parent dca_error to primary vertex
  VectorMembers:
    - edm4hep::Vector3f   daughterMomentum           // daughter track momentum at the decay vertex
    - int                 daughterPDG                // daughter PDG
    - float               daughterDca2PV             // daughter dca to primary vertex
    - float               daughterDca2PVError        // daughter dca_error to primary vertex
    - int                 daughterPairIndices        // track indices for any pair
    - float               daughterPairDca            // dca between any pair of tracks
    - float               daughterPairDcaError       // dca_error between any pair of tracks
  OneToOneRelations:
    - edm4eic::Vertex     primaryVertex              // associated primary vertex
  OneToManyRelations:
    - edm4eic::ReconstructedParticle associatedParticles // particles associated to this vertex.
```



preTDR efforts: Jets

D. Lemos (BNL)

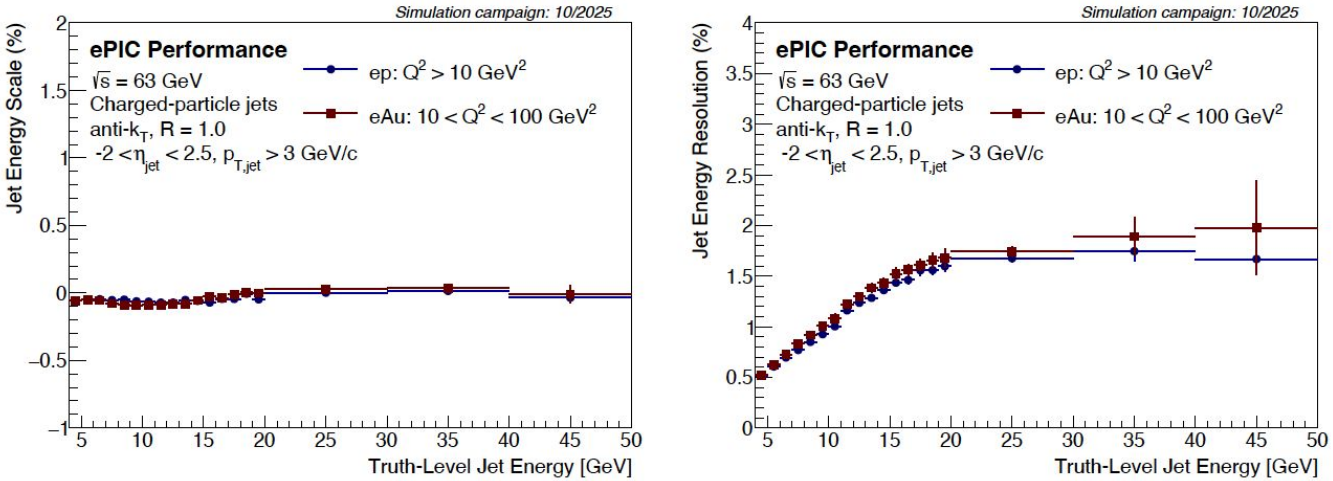


Figure 2: Jet energy scale (left) and jet energy resolution (right) in percentage as a function of truth-level jet energy for charged jets of $R = 1.0$ and $-2 < \eta_{\text{jet}} < 2.5$ in e+p and e+Au collisions at $\sqrt{s} = 63$ GeV.

preTDR efforts: Jets

D. Lemos (BNL)

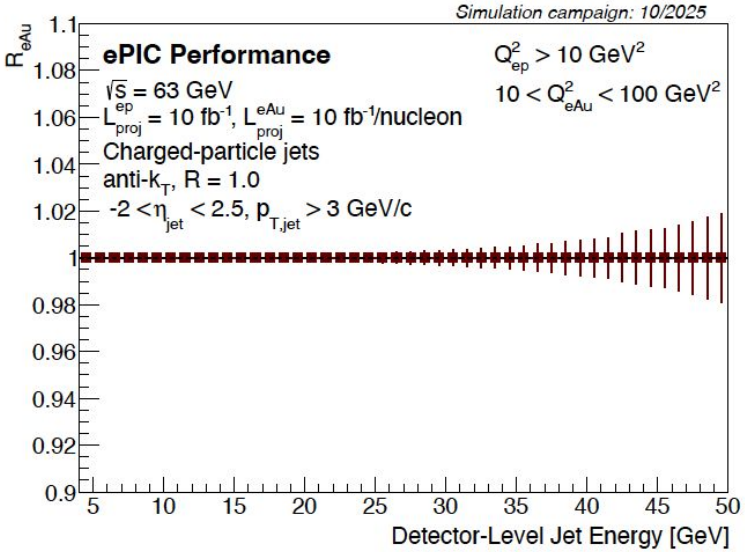
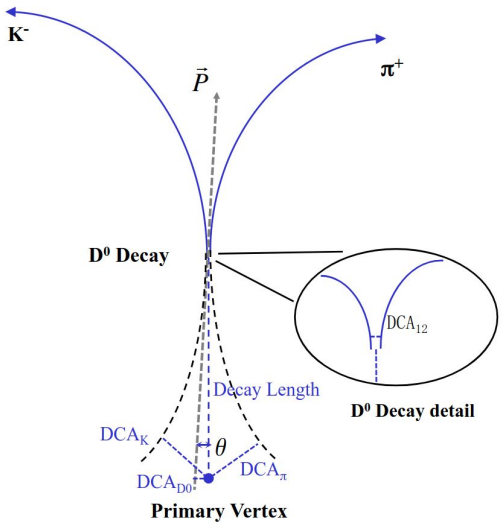


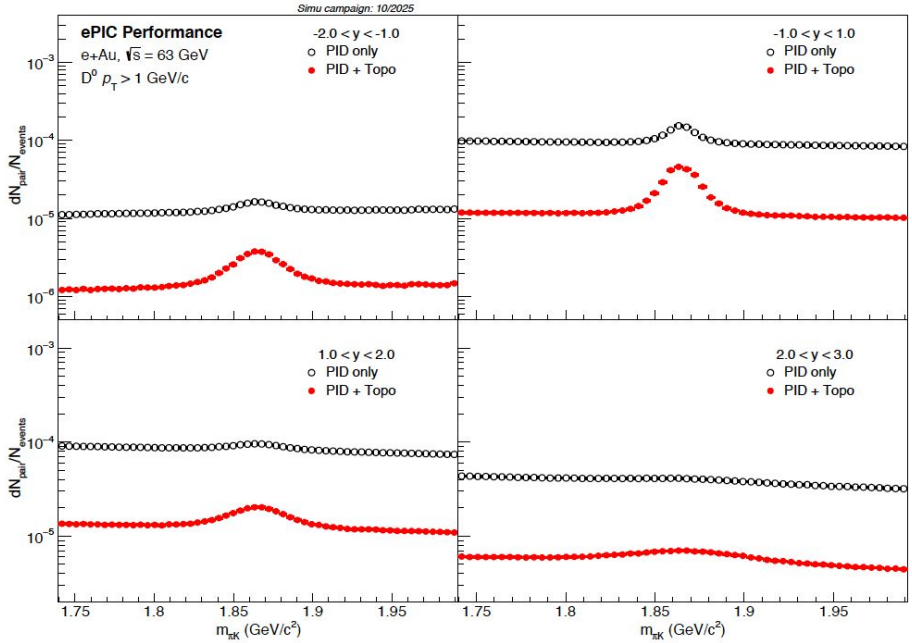
Figure 2: Statistical precision projection, indicated by vertical bars around data points at unity, for charged inclusive jet $R_{e\mathrm{Au}}$ as a function of jet energy for e+p and e+Au collisions at $\sqrt{s}$ = 63 GeV. In case the vertical bars are invisible, they are smaller than the marker size.

preTDR efforts: D^0

S. Kumar (INFN)

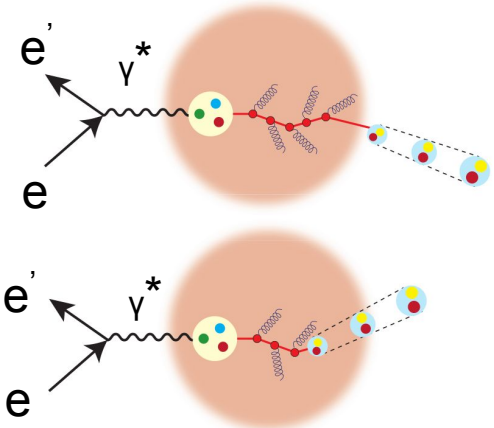
ML Framework





preTDR efforts: D^0

S. Kumar (INFN)



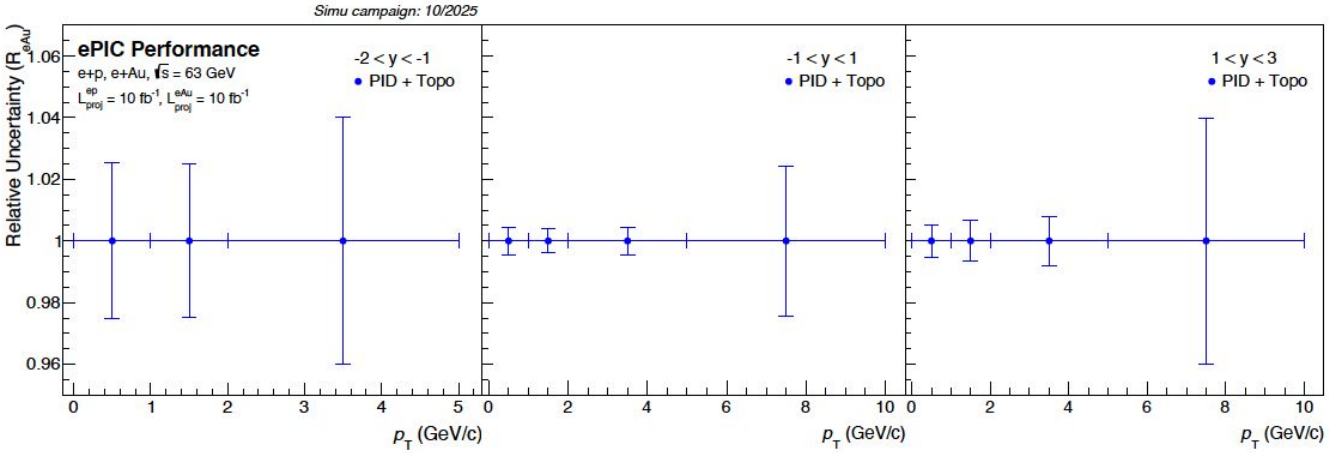


Figure 7: Projection of relative statistical uncertainties on D^0 yield ratios between 10×100 GeV e+Au and e+p collisions as a function of p_T of the D^0 meson for three different D^0 rapidity intervals within $-2 < y < 3$.

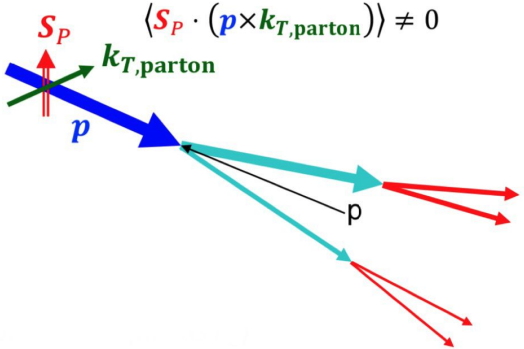
preTDR studies: next

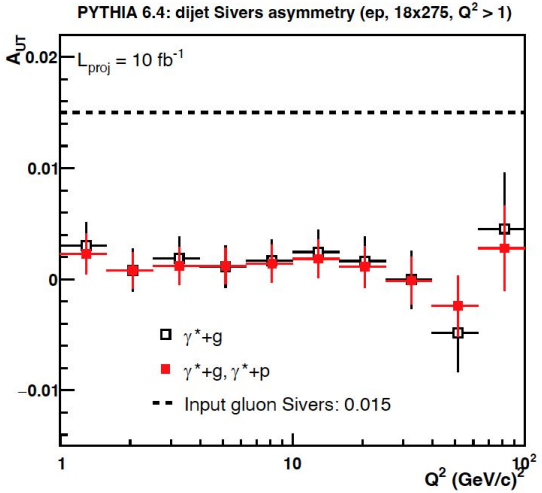
- Prepare analysis code and notes
- Get approval from PWG
- Present at Physics Forum

Dijets to probe gluon Sivers function

R. Ma (BNL)
SLIDES

- Use charged dijets to measure gluon Sivers function



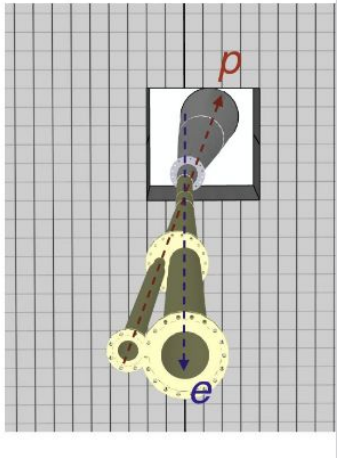


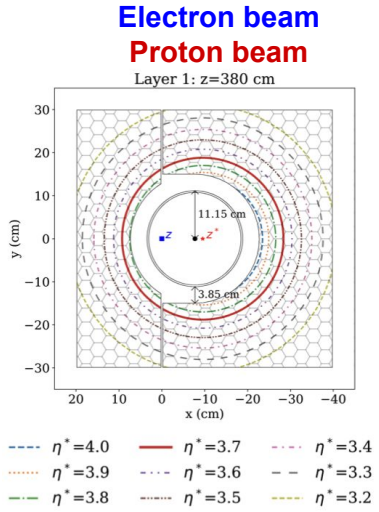
- About ~10 reduction in signal; re-visit with full jets once available

Forward jets

S. Preins (UCR)
SLIDES

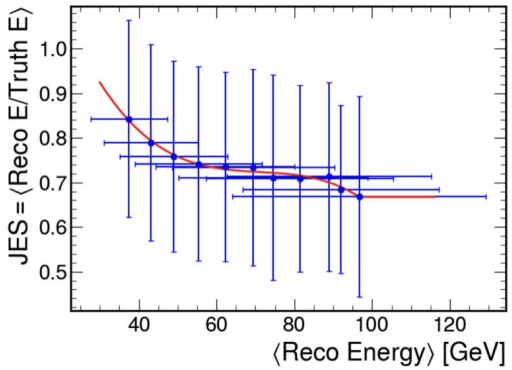
- Jet studies with insert
  - Insert covers 3 < eta < 4
  - Combines clusters from the LFHCAL, ECal endcap, and ECal + HCal insert

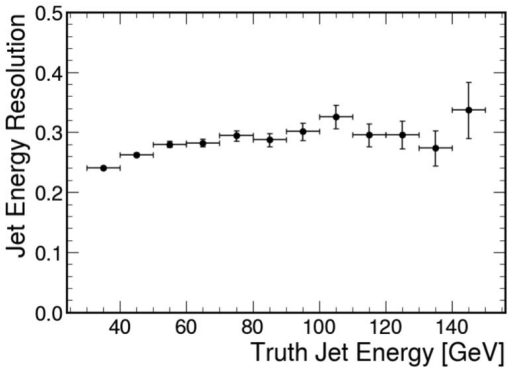




M. Arratia et al, Nucl. Instr. Meth. 1047, (2023), 167866

JES: 70-80%; JER: 25-30%

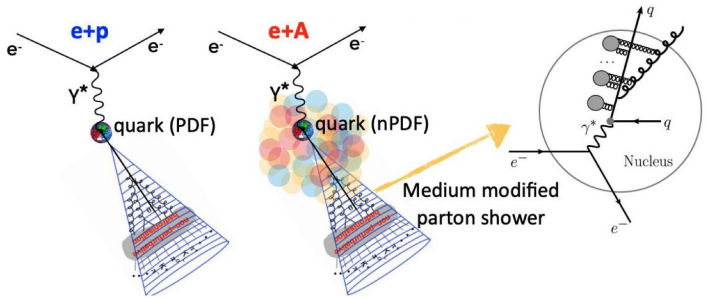




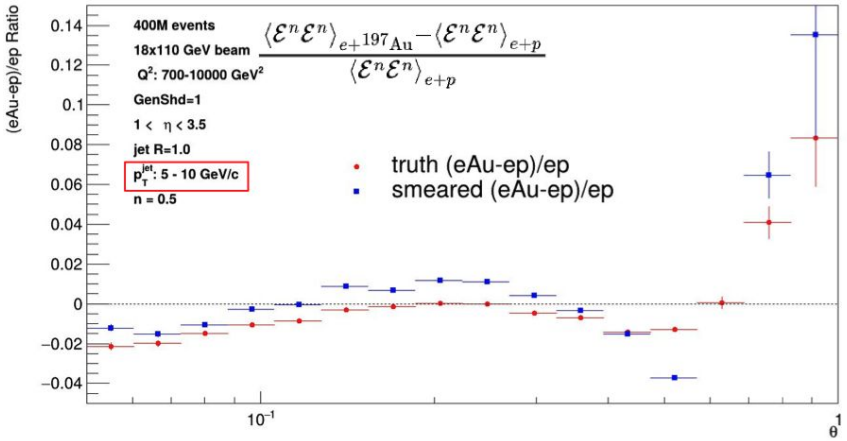
Inclusive jet EEC

S. Gu (UMich)
SLIDES

- Energy-energy correlator (E2C)
  - Sensitive to the timescales of hadronization
- Nuclear modification of EEC



BeAGLE + smearing of charged hadrons

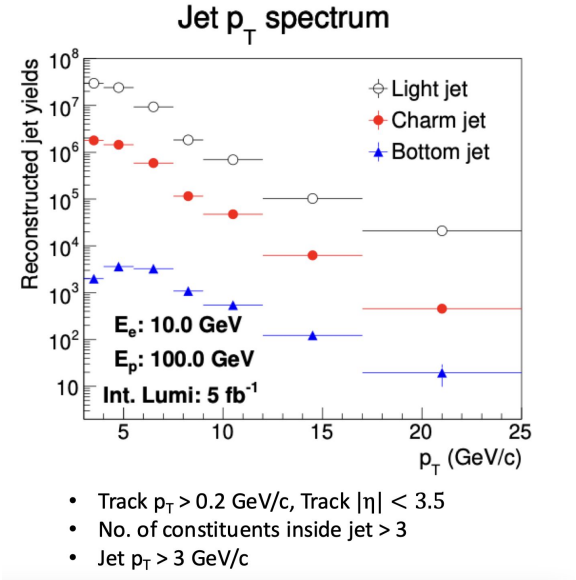


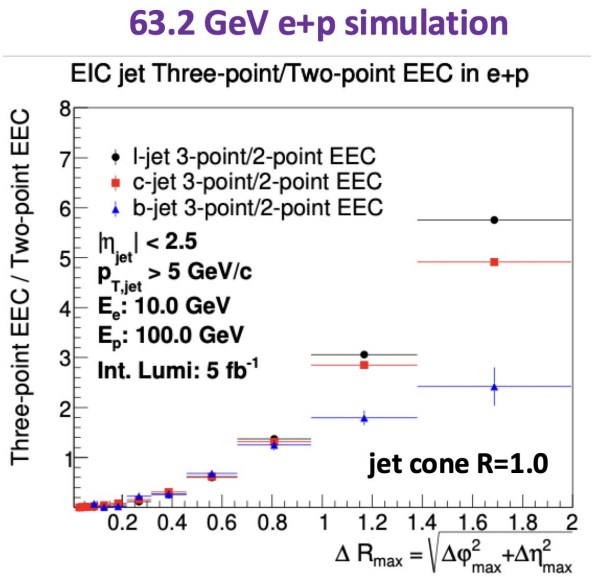
- Looks promising; repeat with full ePIC simulation (E2C)
- Further explore three-point energy correlators (E3C)

HF jet EEC

X. Li (LANL)
SLIDES

- Study dead-cone and flavor-dependent energy loss





Smearing based on performance parameterization

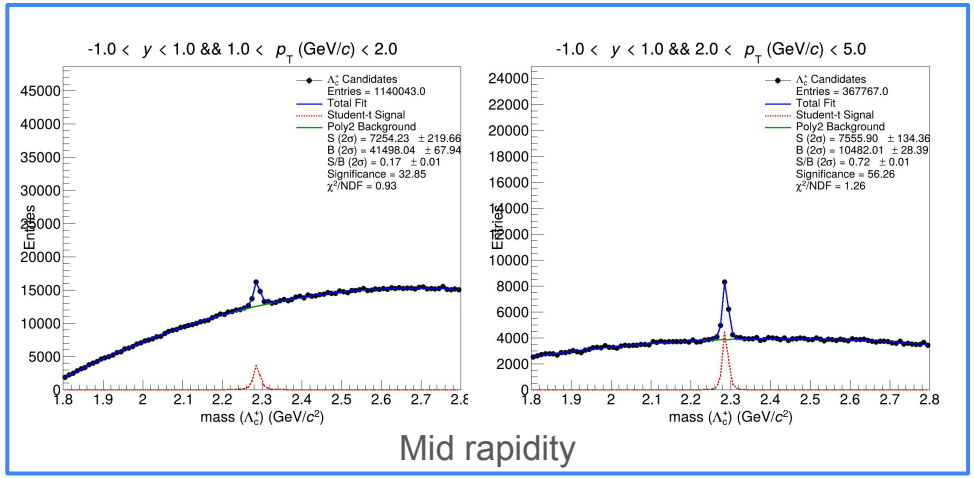
- Use official ep and eA simulations

Λ_c reconstruction

S. Kumar (INFN)

SLIDES

- Charm baryon-to-meson ratio (Λ_c/D^0): explore hadronization
  - Reconstruction of Λ_c baryon (Real PID)
  - Scale up branching ratio in PYTHIA8 simulation (factor ~9)



- Further explore ML models to optimize the performance

ML Framework

Machine background impact

- HF (C. Yang, D. Thomas, SLIDES)
  - Much wider DCA_{xy} distribution for pions from D^0 decay, likely caused by worse primary vertex resolution
  - Probably need to apply nhits > 3 cut on tracks used for primary vertex finding
  - Repeat the study after primary vertexing with nhits > 3

- Jets
  - ep 18x275: minimal impact on jets when using tracks with nhits > 3
    - J. Gupta, B. Schmooker, SLIDES
  - ep 10x100: need nhits > 4 cut (double check with single hadrons)
    - D. De Souza Lemos, SLIDES

Early Science studies

- Focus on physics analyses that can be achieved with ES running plan
  - Jet R_{eA} with different radii
  - D^0 R_{eA}
  - Λ_c/D^0 ratio
  - Others …

- Simulation samples
  - ep 10x130: need DIS and Λ_c /D^0 Sample
  - eAu 10x100: available
  - How to deal with mismatched energies? Bin in (x, Q^2)?

Other topics that could use more help

- Charm structure function
- D^+ and D_s performance study
- Jet performance and physics studies, such as angular resolution, FF, EEC, etc.
- *Further physics studies are highly encouraged!*

- **Feel free to talk to us if you would like join the efforts**

Backup

preTDR efforts: Jets

D. Lemos (BNL)

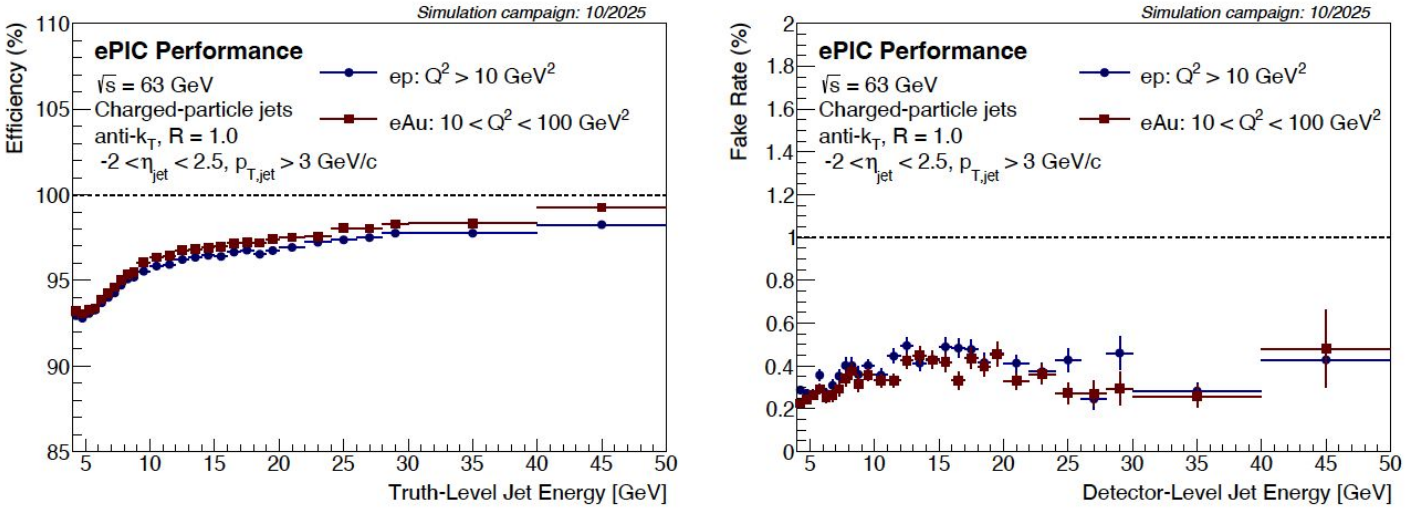


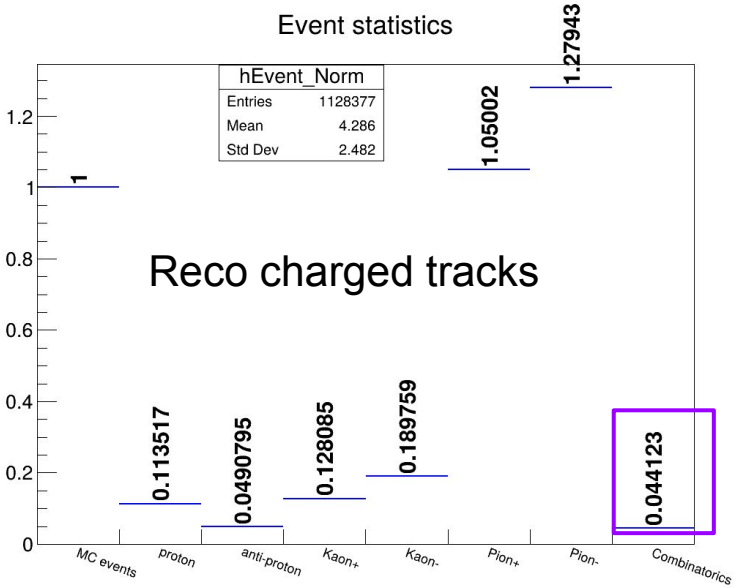
Figure 1: Jet finding efficiency (left) and fake jet rate (right) in percentage as a function of jet energy for charged jets of $R = 1.0$ and $-2 < \eta_{\text{jet}} < 2.5$ in e+p and e+Au collisions at $\sqrt{s} = 63$ GeV.

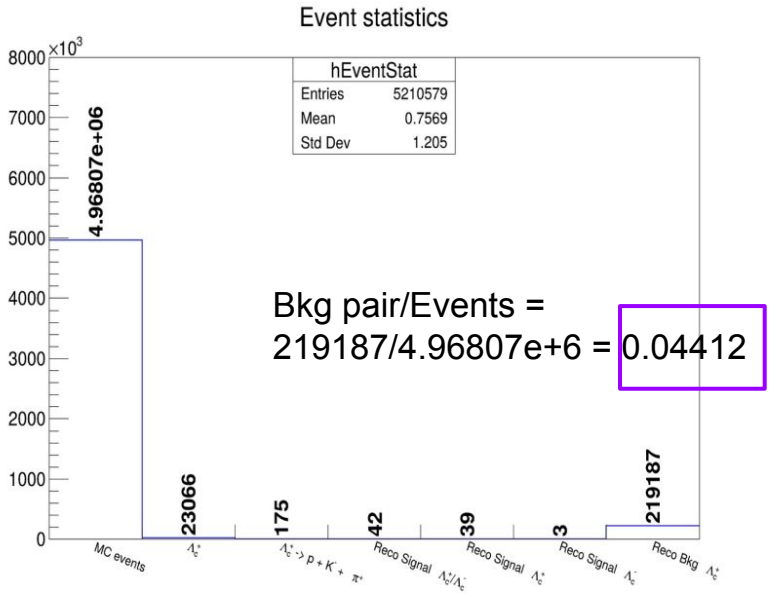
Λ_c: Studies (using Realistic PID)

DIS Sample (October 2025)

```
for (int i = 0; i < rcCharge.GetSize(); ++i) {

  if      (rcPdg[i] ==  2212) { hEventStat->Fill(1.5); nP++;    } // p
  else if (rcPdg[i] == -2212) { hEventStat->Fill(2.5); nPbar++; } // pbar
  else if (rcPdg[i] ==   321) { hEventStat->Fill(3.5); nKp++;   } // K+
  else if (rcPdg[i] ==  -321) { hEventStat->Fill(4.5); nKm++;   } // K-
  else if (rcPdg[i] ==   211) { hEventStat->Fill(5.5); nPip++;  } // pi+
  else if (rcPdg[i] ==  -211) { hEventStat->Fill(6.5); nPim++;  } // pi-
}
```



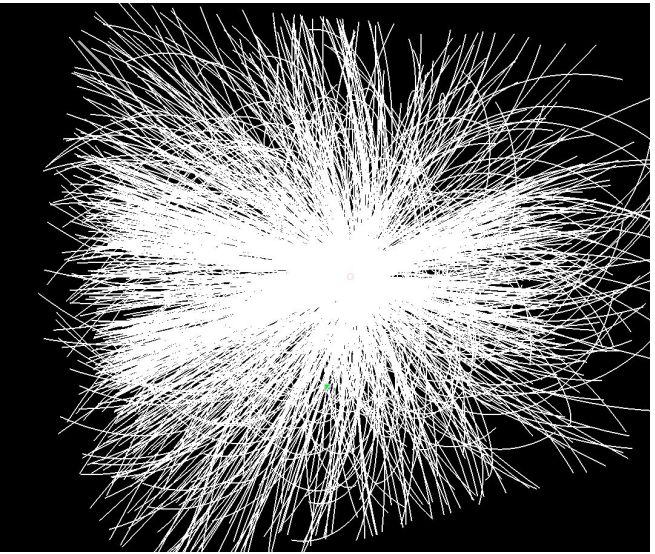


Bkg pair/Events =
219187/4.96807e+6 = 0.04412

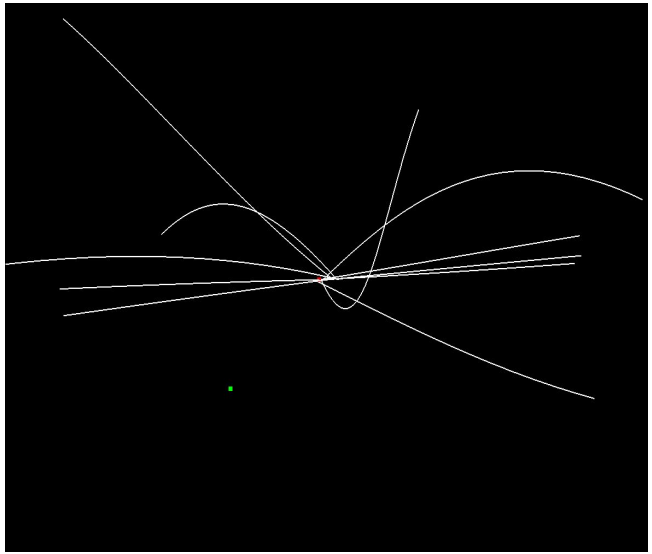
Event visualization

ep (10x100, Q^2> 1 GeV^2) (Oct Campaign with machine background)

No nhits cut

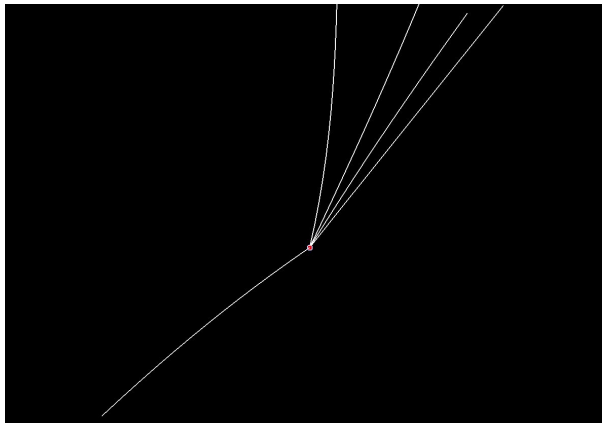


nhits>3



MC Vertex, Reco vertex failed

ep (10x100, Q^2> 1 GeV^2) DIS event w/o bkg



Average multiplicity ~4

Systematic uncertainties

- Heavy flavor
  - Uncertainty on tracking efficiency
  - Particle identification efficiency uncertainty
  - Luminosity uncertainty (1.5%)

- Jets
  - Uncertainty on tracking efficiency
  - Luminosity uncertainty (1.5%)