Jet Studies with ePIC

J. Kevin Adkins for the ePIC Collaboration

Morehead State University

RHIC Annual Users Meeting 2023 – Brookhaven National Laboratory
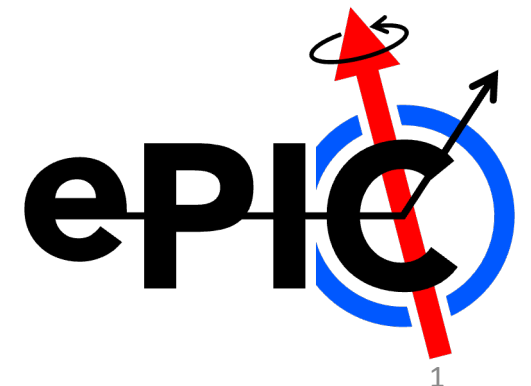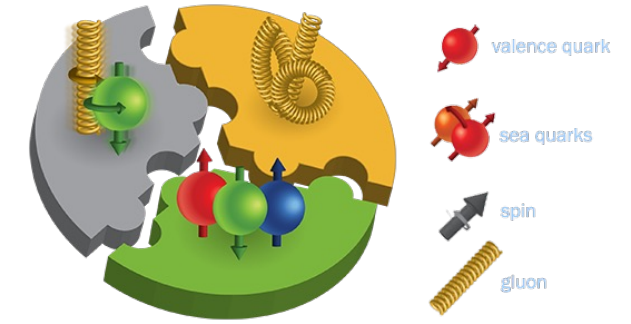
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Stepping Back: EIC Physics Goals

- The EIC aims to provide precision results over a broad kinematic range
  - The origin of mass and spin of the nucleon
  - The spin structure of the proton and atomic nuclei
  - Color confinement
  - Distribution of partons inside of nucleons in momentum and position space
  - How the dense nuclear environment inside of nuclei affects parton dynamics and correlations
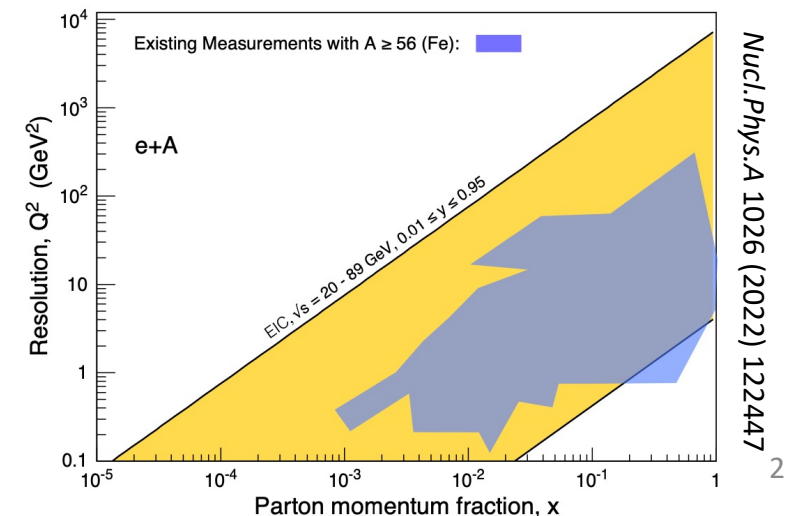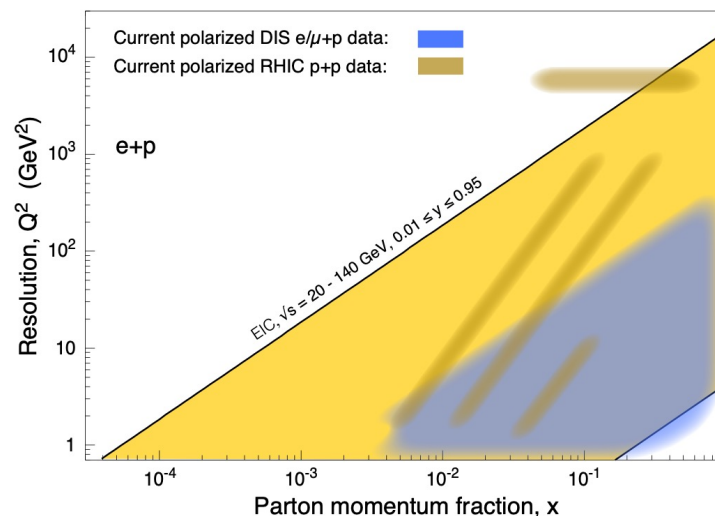
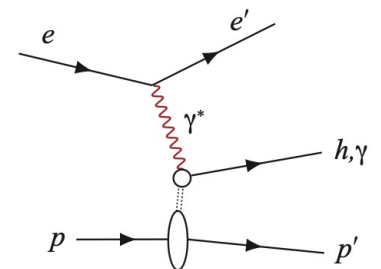# Physics Goals: Common Processes

- The most common processes that probe channels to reach these goals are
  - Neutral current inclusive DIS
  - Charged current inclusive DIS
  - Semi-inclusive DIS (SIDIS)
  - Exclusive DIS

Nucl.Phys.A 1026 (2022) 122447
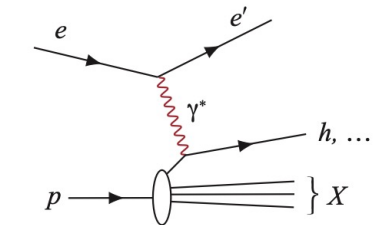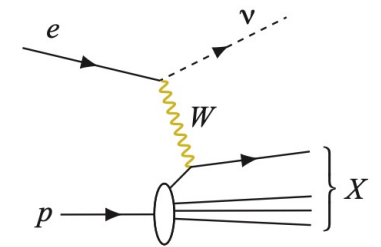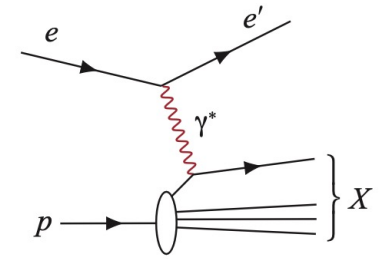
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- Jets are excellent probes to study partons
  - They offer many other channels that provide useful input on the EIC physics goals!
  - Jet measurements will be an important complement to other analyses

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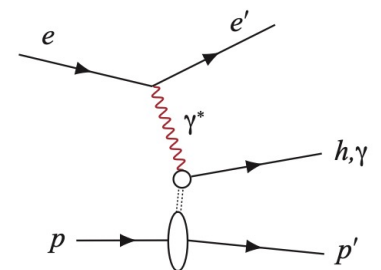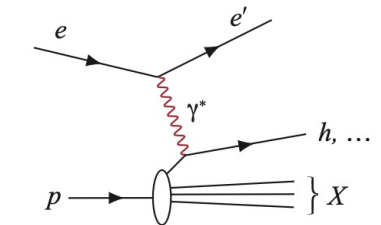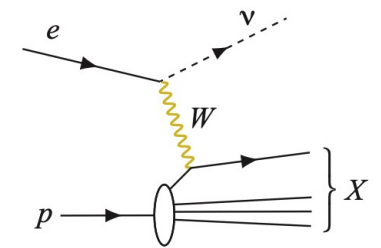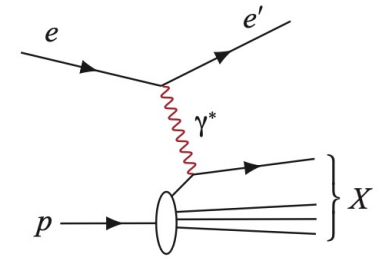
Electron Ion Collider

- Overlay onto existing RHIC site

- ePIC will be placed at IP6

- Ions travel counterclockwise

- Electrons travel clockwise

ePIC Detector

Ions → Electrons ←

hadronic calorimeters

Solenoidal Magnet

e/m calorimeters
(ECal)

Time.of.Flight,
DIRC,
RICH detectors

MPGD trackers

MAPS tracker

9.5m
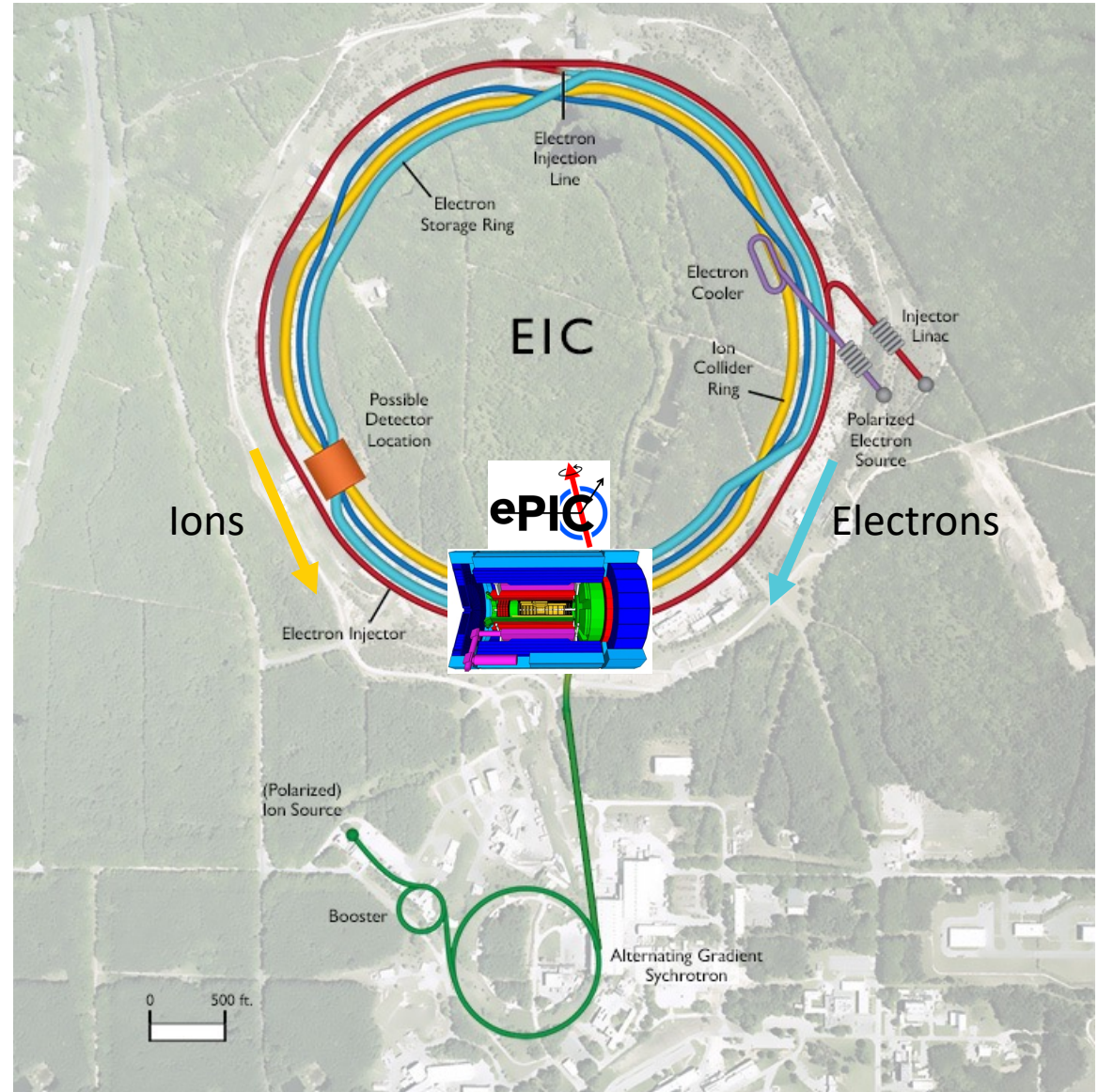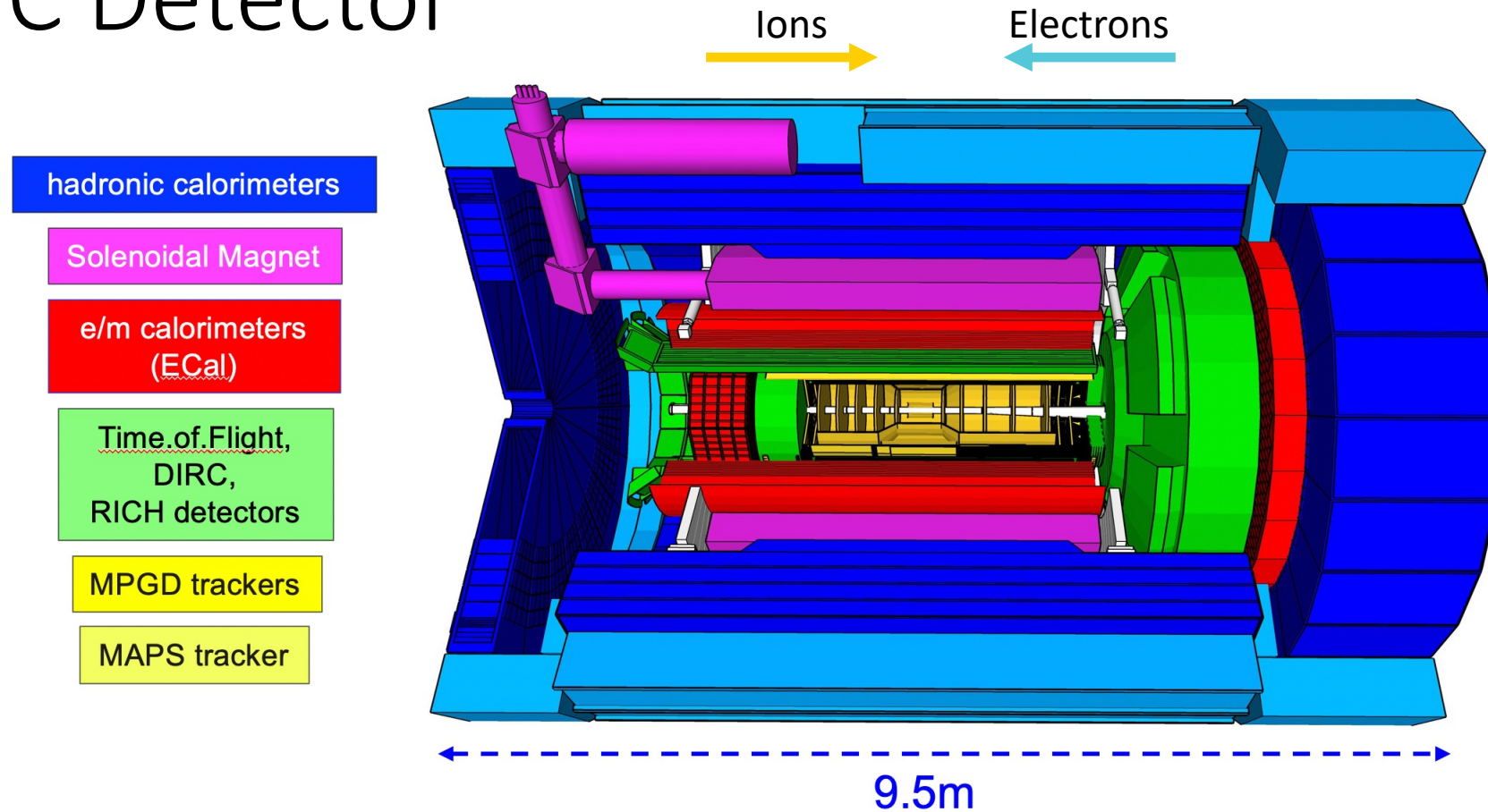
- Excellent tracking and calorimetry coverage lends itself to jet reconstruction and analyses

Opportunities with Jets in e-p Collisions

- 3D imaging of nucleons
  - Hadron-in-jet measurements (e.g. transversity and Collins FF)
    - Continue explorations of TMD evolution and universality
  - Azimuthal correlation between jet and scattered electron is sensitive to TMD PDFs
- Studies of hadronization and fragmentation via jet substructure
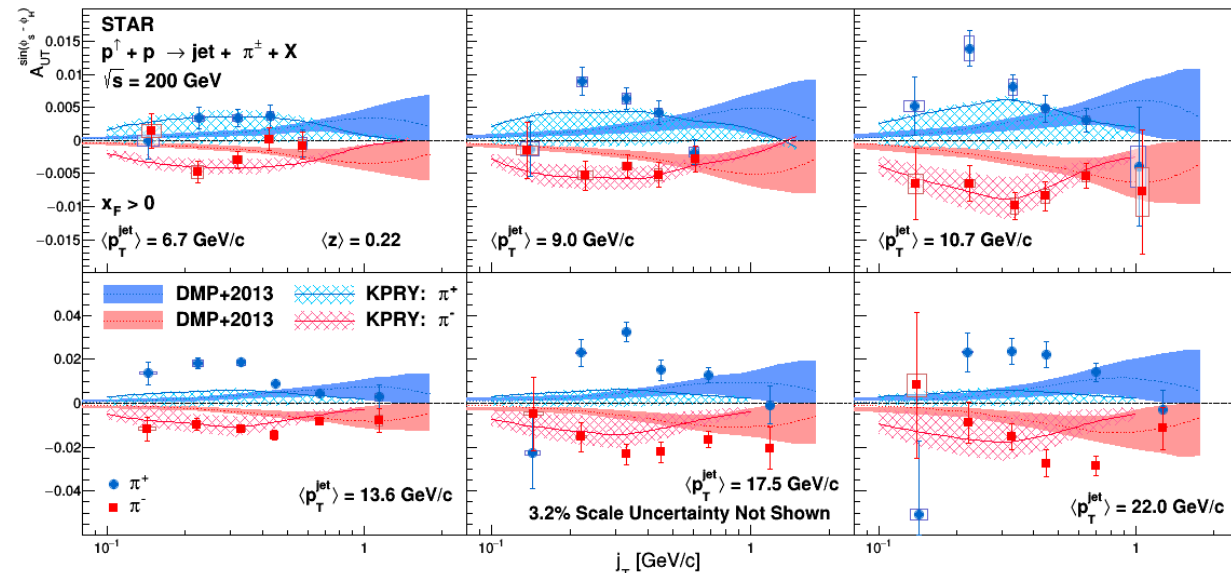
Phys.Rev.D 106 (2022)

Opportunities with Jets in e-A Collisions

- e-A collisions give a look at how dense nuclear medium affects hadronization and fragmentation
  - Comparison to e-p will give insight into differences between vacuum and nuclear medium
  - Projections give high statistical precision on nuclear modification factor, R_{eA}
- Heavy flavor jet analyses will help constrain nuclear PDFs (nPDFs)
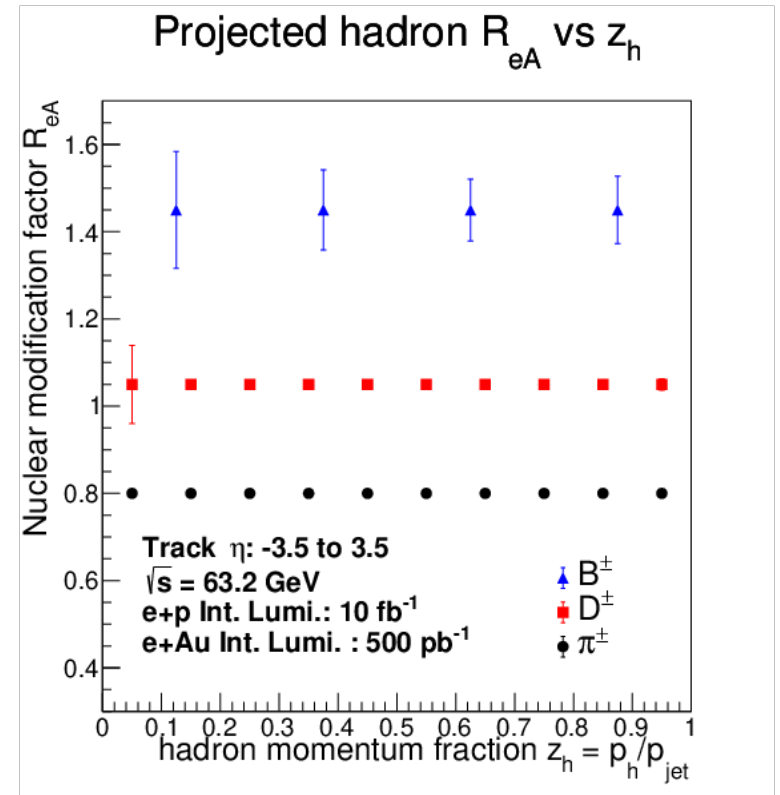
SciPost Phys.Proc. 8 (2022) 076

Jet & Heavy Flavor Working Group Goals

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- Validation of the detector design to ensure it will meet physics goals

- Develop jet-related benchmarks to be used for validation of software updates (reconstructed vs. generated quantities)

Recent Accomplishments

Parameter	Name	Value
Jet algorithm	m_jetAlgo	anti-kT
Jet recombination Scheme	m_recombScheme	E-scheme
Jet resolution parameter	m_rJet	1
Min. constituent pT	m_minCstPt	0.2 GeV/c
Max. constituent pT	m_maxCstPt	100 GeV/c
Min. jet pT	m_minJetPt	1 GeV/c
Area type	m_areaType	active
Max ghost rapidity	m_ghostMaxRap	3.5
No. of repeated ghost	m_numGhostRepeat	1
Area per ghost	m_ghostArea	0.001

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  - Successful outcome from EICrecon Jet Taskforce
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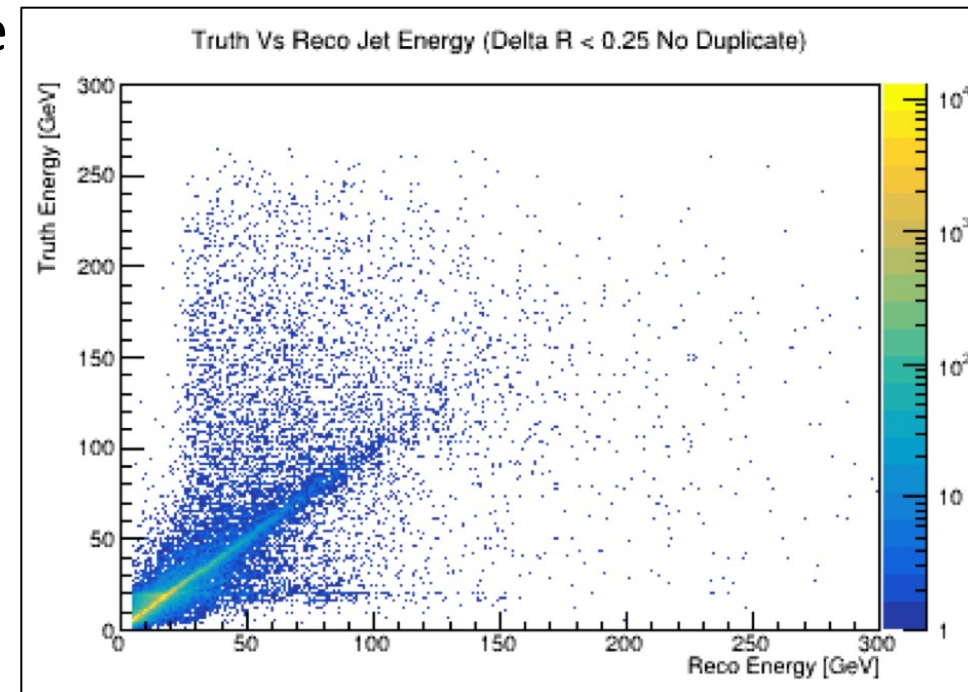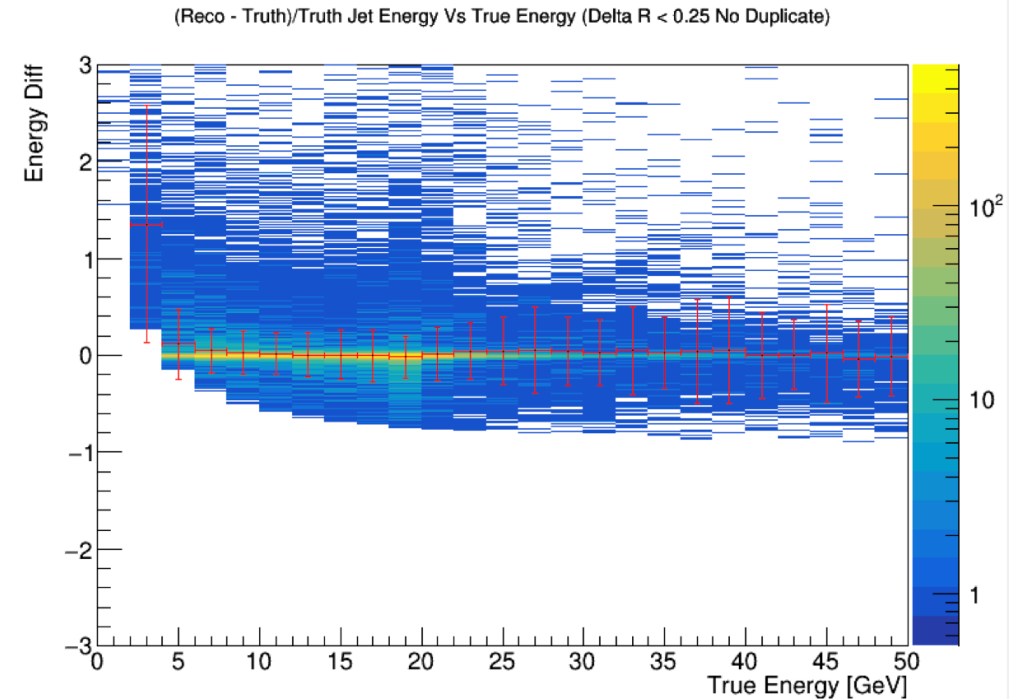| Parameter	Name	Value
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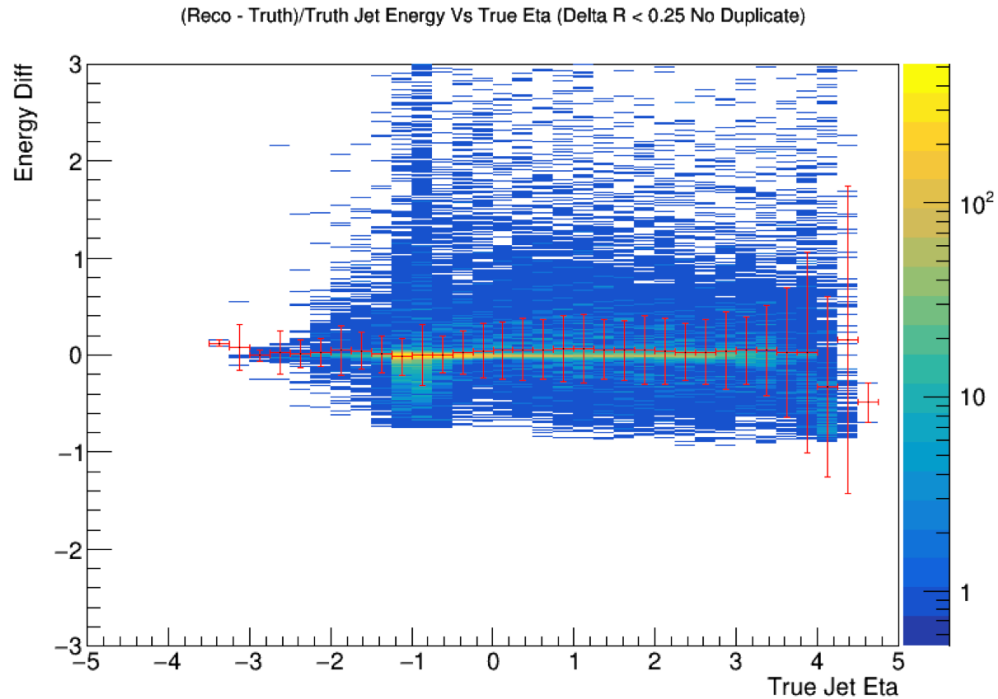- Jets are now reconstructed as part of the simulated data reconstruction package (EICrecon)
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- A first set of benchmarks using reconstructed simulation output
  - NC DIS 18x275 GeV ($Q^2 > 100$ GeV^2)

Truth Vs Reco Jet Energy (Delta R < 0.25 No Duplicate)

Benchmark Plots

(Reco - Truth)/Truth Jet Energy Vs True Eta (Delta R < 0.25 No Duplicate)

(Reco - Truth)/Truth Jet Energy Vs True Energy (Delta R < 0.25 No Duplicate)

- Plots of the energy difference ratio against other kinematic variables give the jet energy scale and resolution
  - Mean and width of each bin define the jet energy scale and resolution, respectively

Future Directions

- Modifications to the jet reconstruction from simulation output
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  - Reconstruction approach that focuses on physics objects rather than detector objects
    - Match tracks to calorimeter clusters and subtract track energy from the cluster energy

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- Improve jet reconstruction with the implementation of a particle flow algorithm
  - Reconstruction approach that focuses on physics objects rather than detector objects
    - Match tracks to calorimeter clusters and subtract track energy from the cluster energy
  - Avoids double counting energy in the jet
  - This simplifies backend analyses as it returns jets with properties closer to simulated jets, but adds frontend reconstruction complexity
  - Major area of research and focus for ePIC moving forward!

Summary/Conclusion

- Jets are a unique probe to provide input on the EIC physics goals
    - 3D imaging of nucleons
    - TMD FFs and PDFs
    - Dense nuclear medium effects
- ePIC's design lends itself very well to jet analyses
    - Excellent tracking and calorimetry coverage
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- If you are interested in joining this effort, email our convenors
  - There are plenty of tasks that need attention!

Olga Evdokimov: evdolga@uic.edu
Brian Page: bpage@bnl.gov