# Jets and Heavy Flavor WG: Overview and Benchmarks

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# Jets and HF in the Yellow Report

## Global properties and parton structure of hadrons

- Unpolarized parton structure of the proton and neutron
- Spin structure of the proton and neutron
- Inclusive and hard diffraction
- Global event shapes and the strong coupling constant

## Multi-dimensional imaging of nucleons, nuclei and mesons

- Imaging of quarks and gluons in momentum space
- Wigner functions

## The nucleus: a laboratory for QCD

- High parton densities and saturation
- Particle propagation in matter and transport properties
- Special opportunities with jets and heavy quarks

## Understanding hadronization

- Hadronization in the vacuum
- Hadronization in the nuclear environment

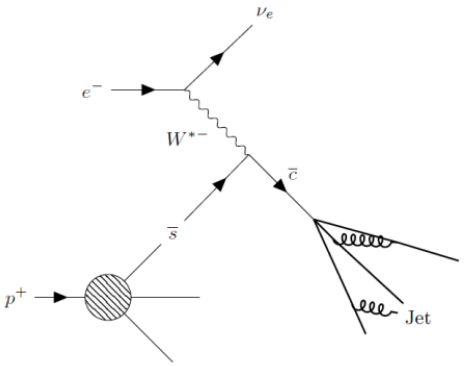
# Jet and HF Physics at the EIC

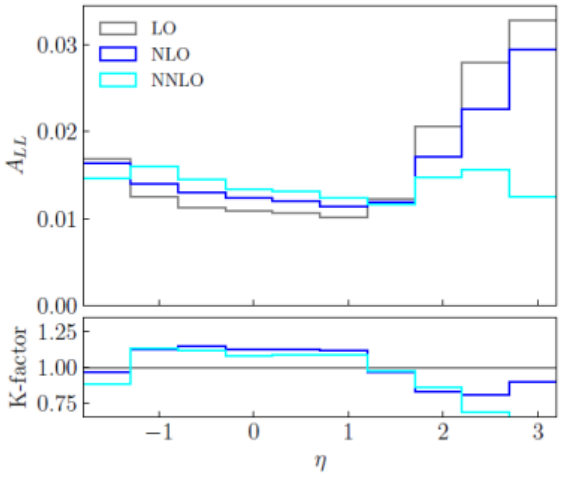
Global properties and parton structure of hadrons

Multi-dimensional imaging of nucleons, nuclei and mesons

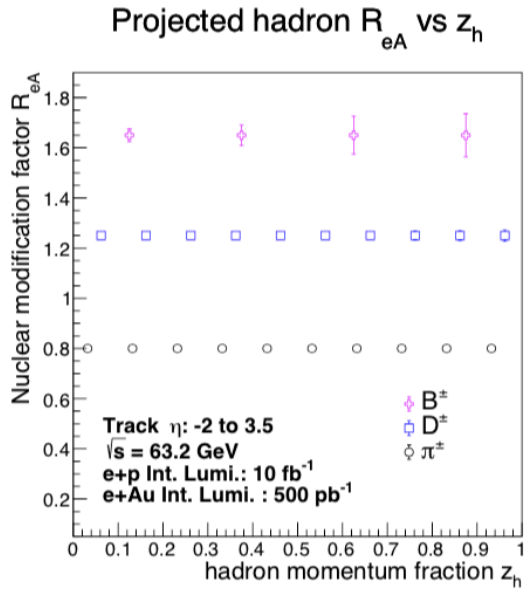
The nucleus: a laboratory for QCD

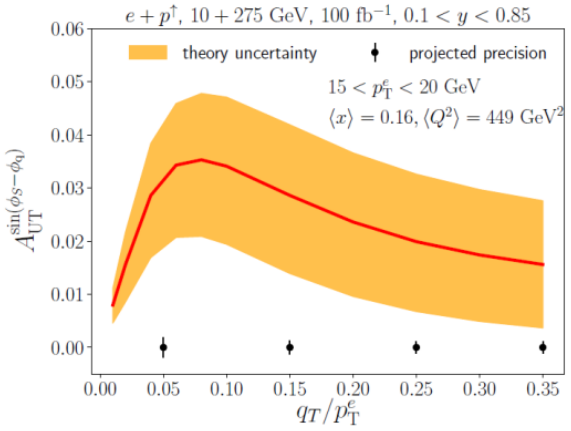
Understanding hadronization



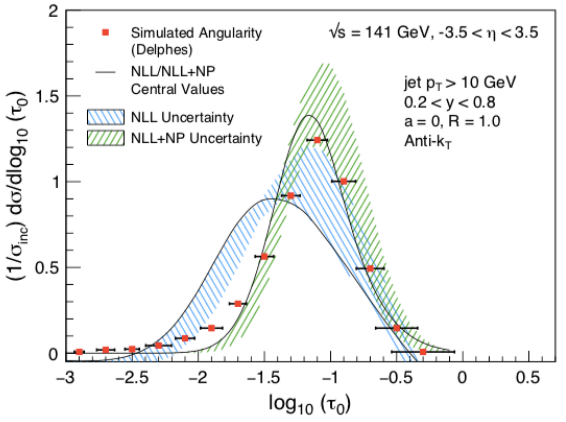




Borsa, de Florian, Pedron `20




Arratia, Kang, Prokudin, Ringer `20



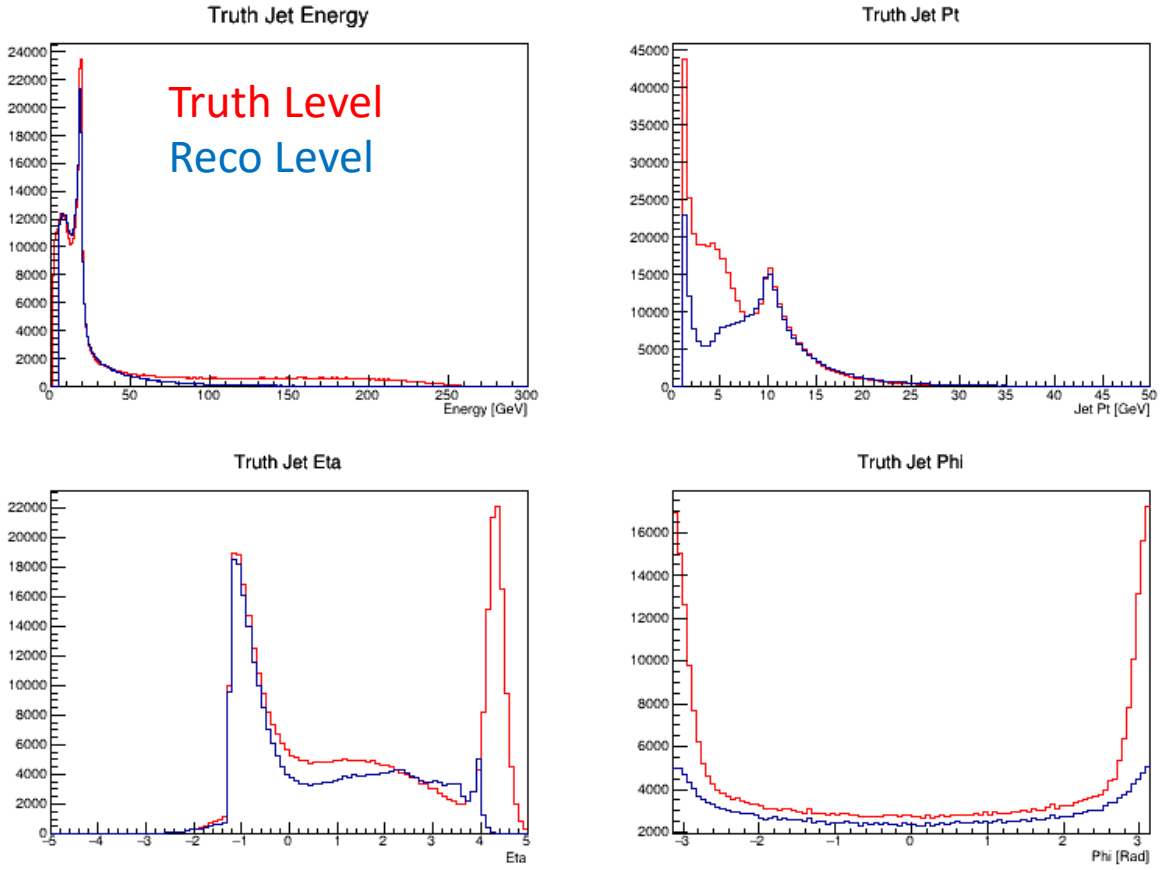

J. Adam *et al* 2022 *JINST* 17 P10019

Jets and HF will be complementary probes to the standard SIDIS program while providing while providing unique capabilities

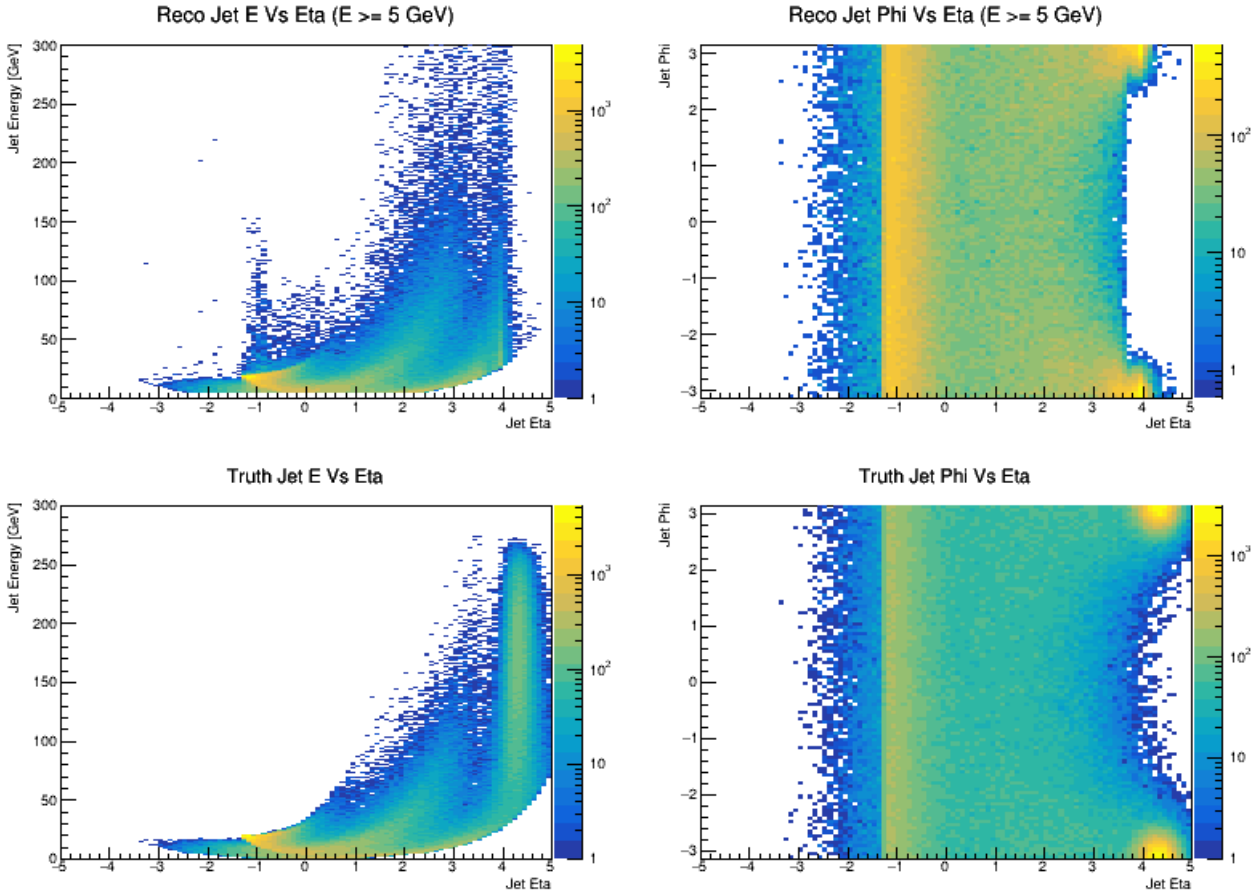
# Initial Jet Benchmarks

- Initial set of jet benchmarks
  - Kinematic Distributions (Jet pT, Eta, Phi, E, correlations)
  - Reconstructed / Generator Jet Delta R
  - Duplicate Track Plots
  - Jet Energy Resolution / Scale (Vs Eta and E)
- Root macro(s) for generating these quantities and plots using RDataFrames exists
- Based on ReconstructedJets and GeneratedJets branches of EICrecon output
  - Currently track-only
  - Should change GeneratedJets factory to only include charged truth particles
- Results shown derive from:
  - NC DIS (Pythia8) 18x275 with Q2 > 100 GeV2
  - 125000 events

# Jet Kinematic Plots



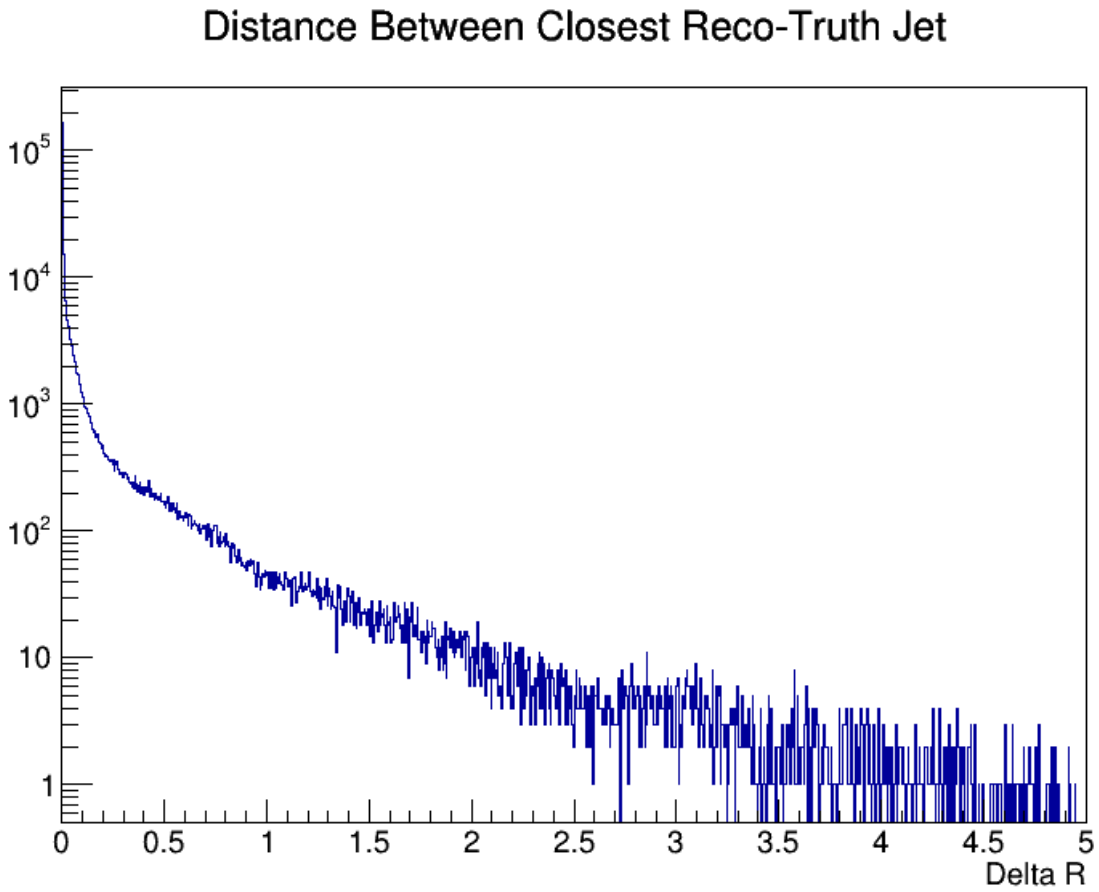

- See energy (pT) / eta peaks associated with clustering the scattered lepton
- See the hotspot associated with the crossing angle in generated and (somewhat less) in reco jets

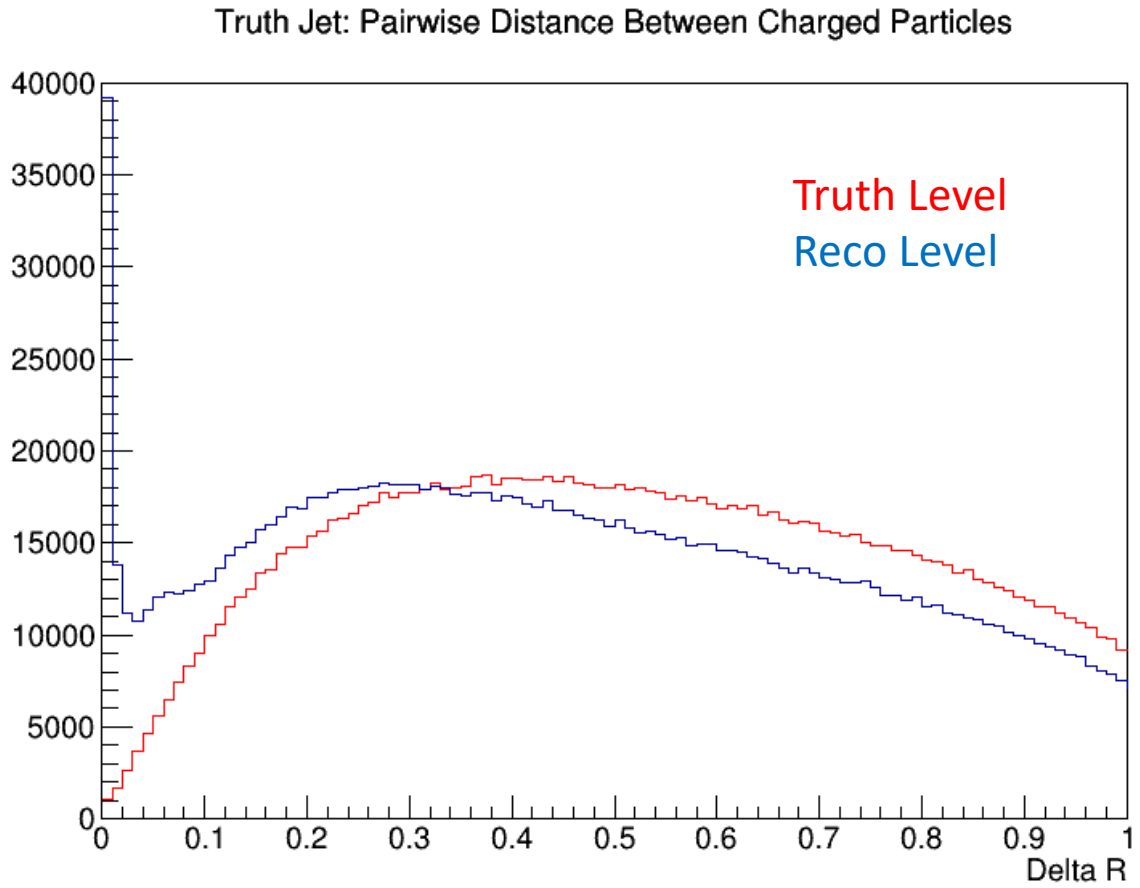



- Jets (therefore tracks) out to eta – 4?
- Access to track quantities for QA cuts may help here

# Jet Matching and other QA

- Find closest (ΔR) Truth jet for each Reco jet
- Require distance between jets to be less than 0.25 in order to calculate resolution

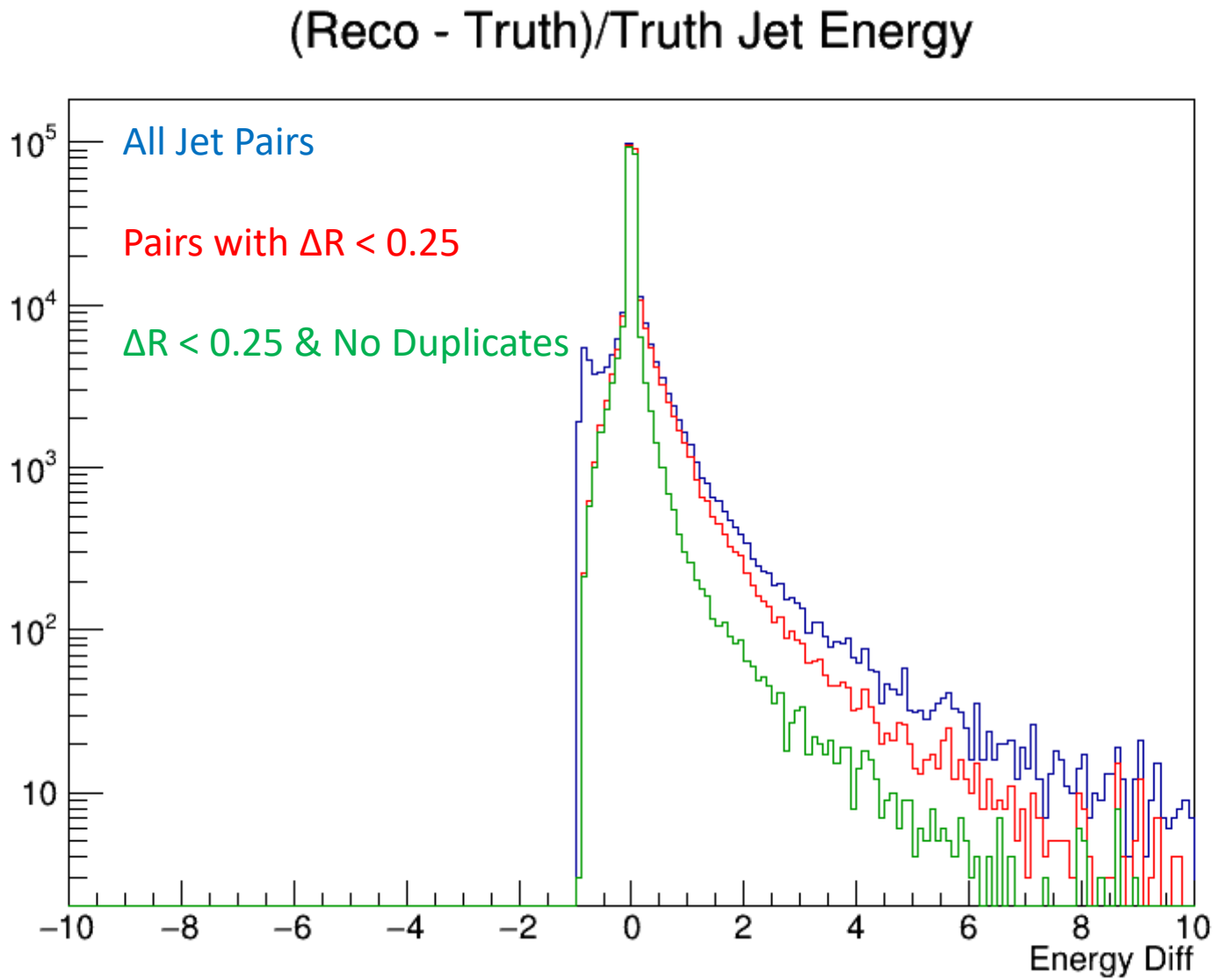


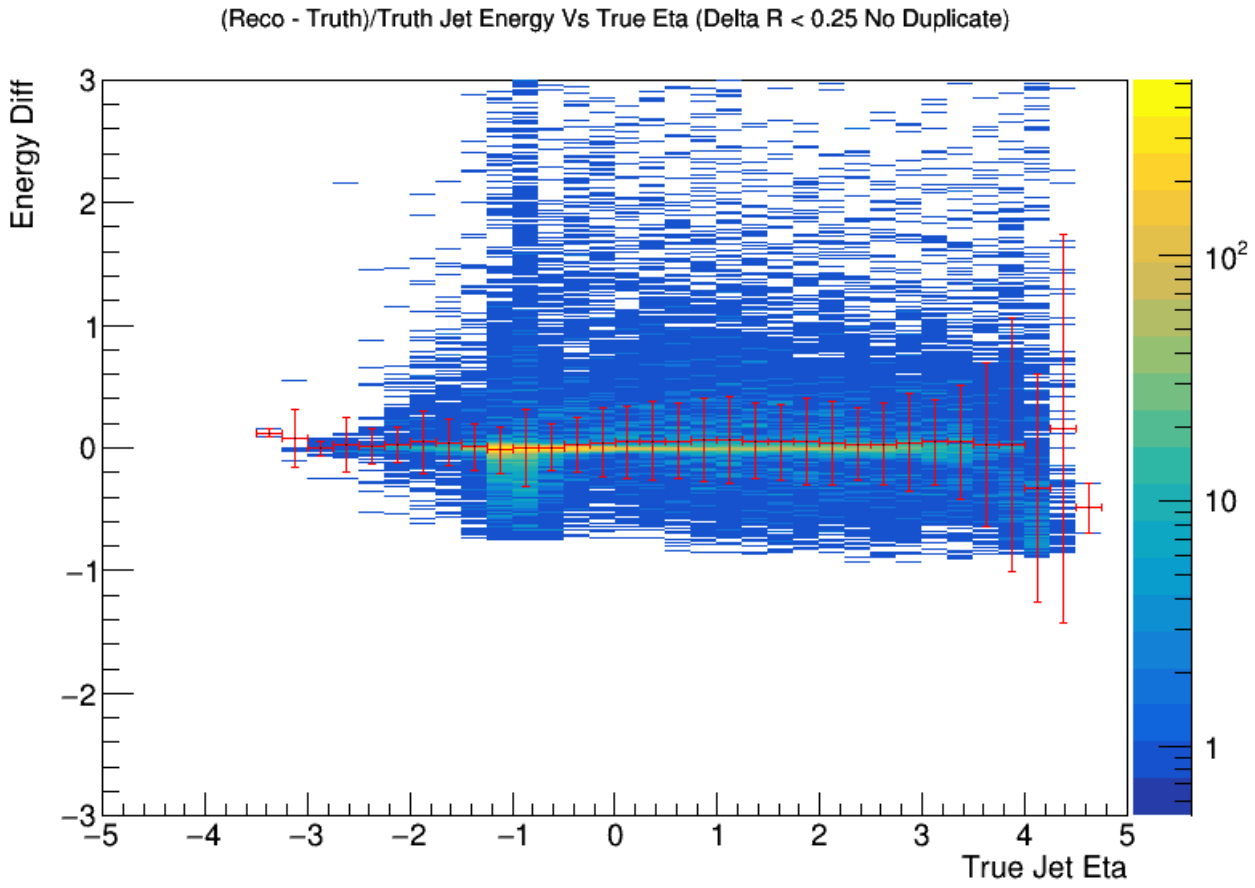

- Plot ΔR between all pairs of tracks within a jet – see 'duplicate' tracks with ΔR < 0.05
- Remove jets that contain duplicate tracks

# Impact of Cuts on Jet Resolution

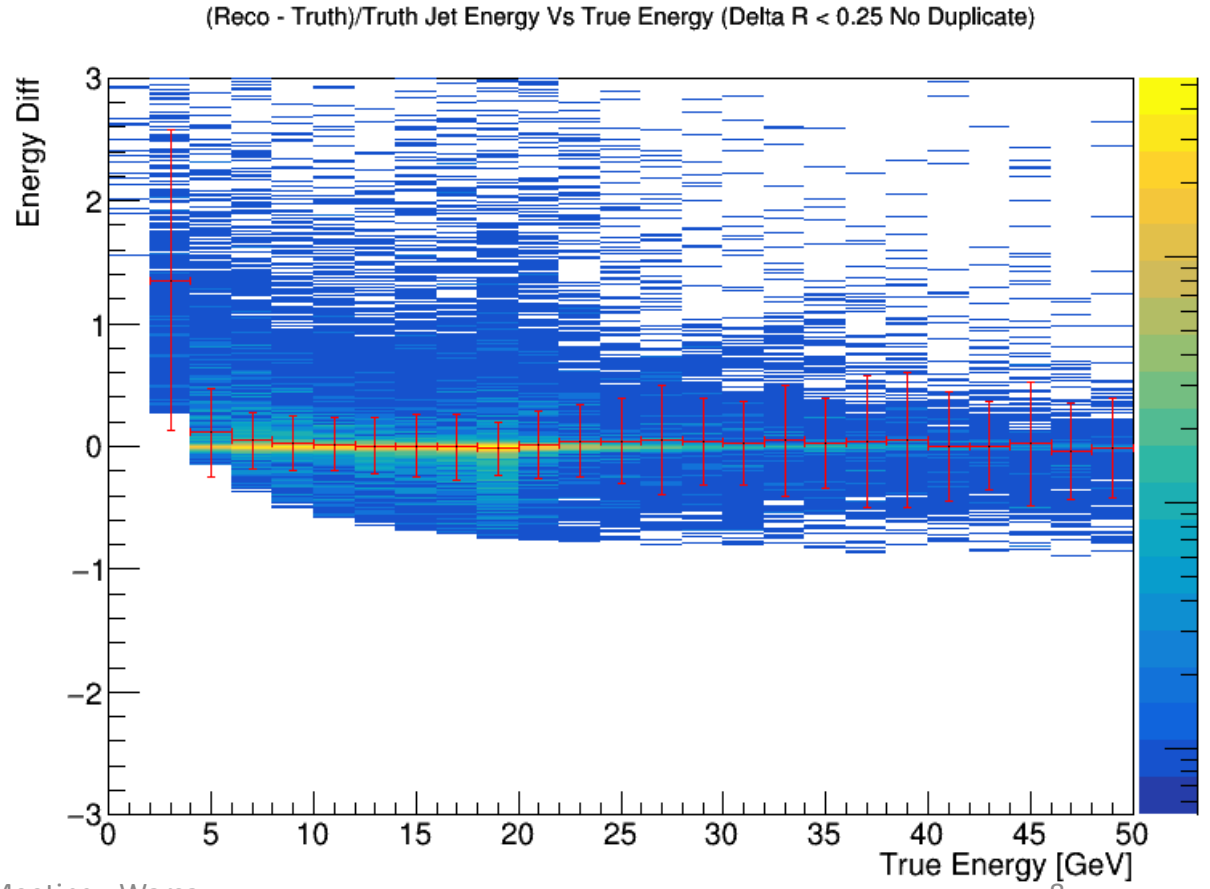
- When calculating jet scale / resolution, don't look at Reco – Truth pairs which are not geometrically correlated, or which have duplicate tracks and therefore inflated energies
- Cut on ΔR primarily removes events at negative values of the Energy Difference
- Additional cut to remove pairs where the reco jet contains duplicate tracks lessens tail at high values of the Energy Difference
- As expected, see improvement in resolution after cuts are applied



# Jet Energy Scale/Resolution Vs Eta and E



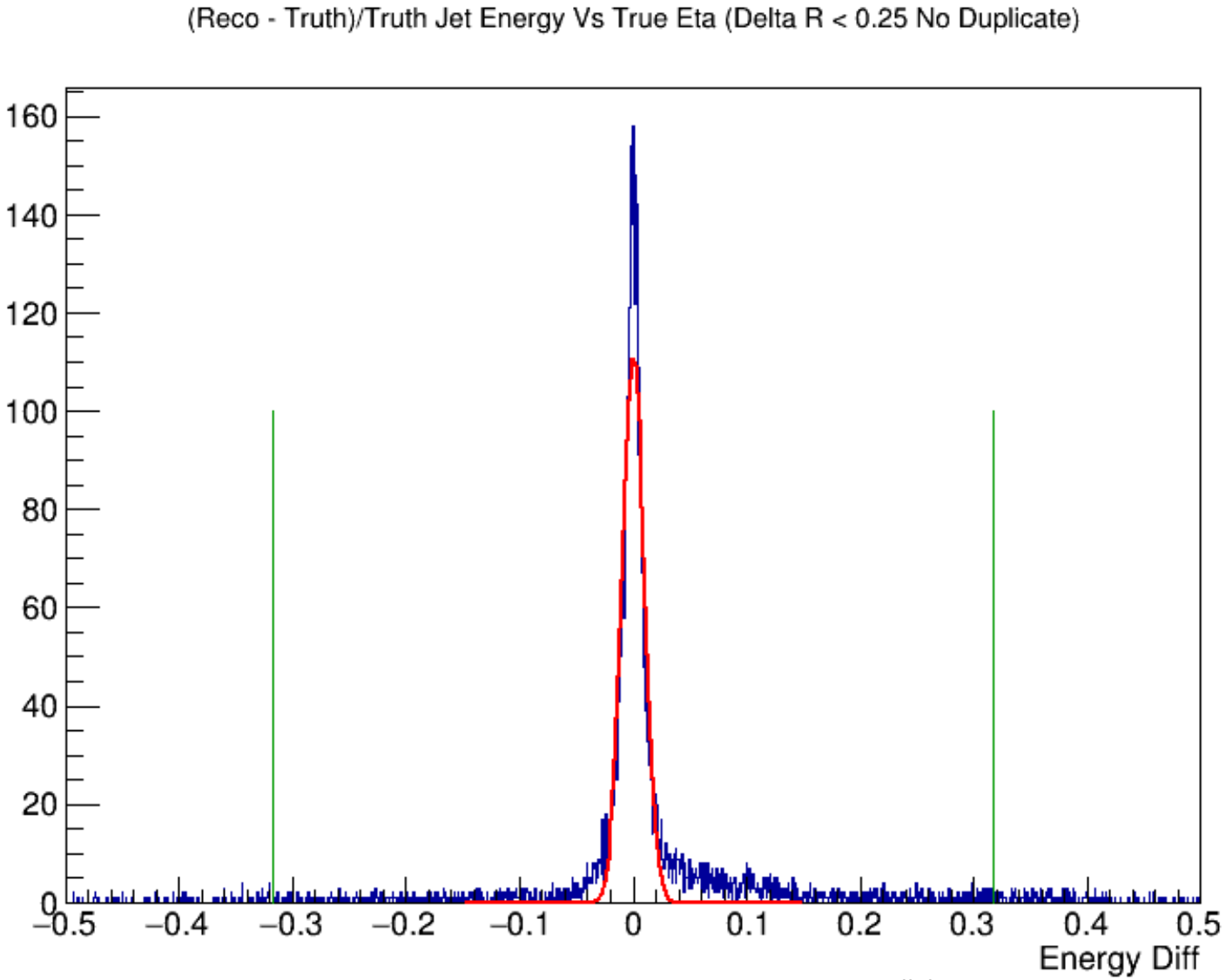

- Plot energy difference ratio vs eta, energy, etc to derive JES and JER as a function of kinematic variables of interest




- JES and JER are mean and width of distribution in each bin

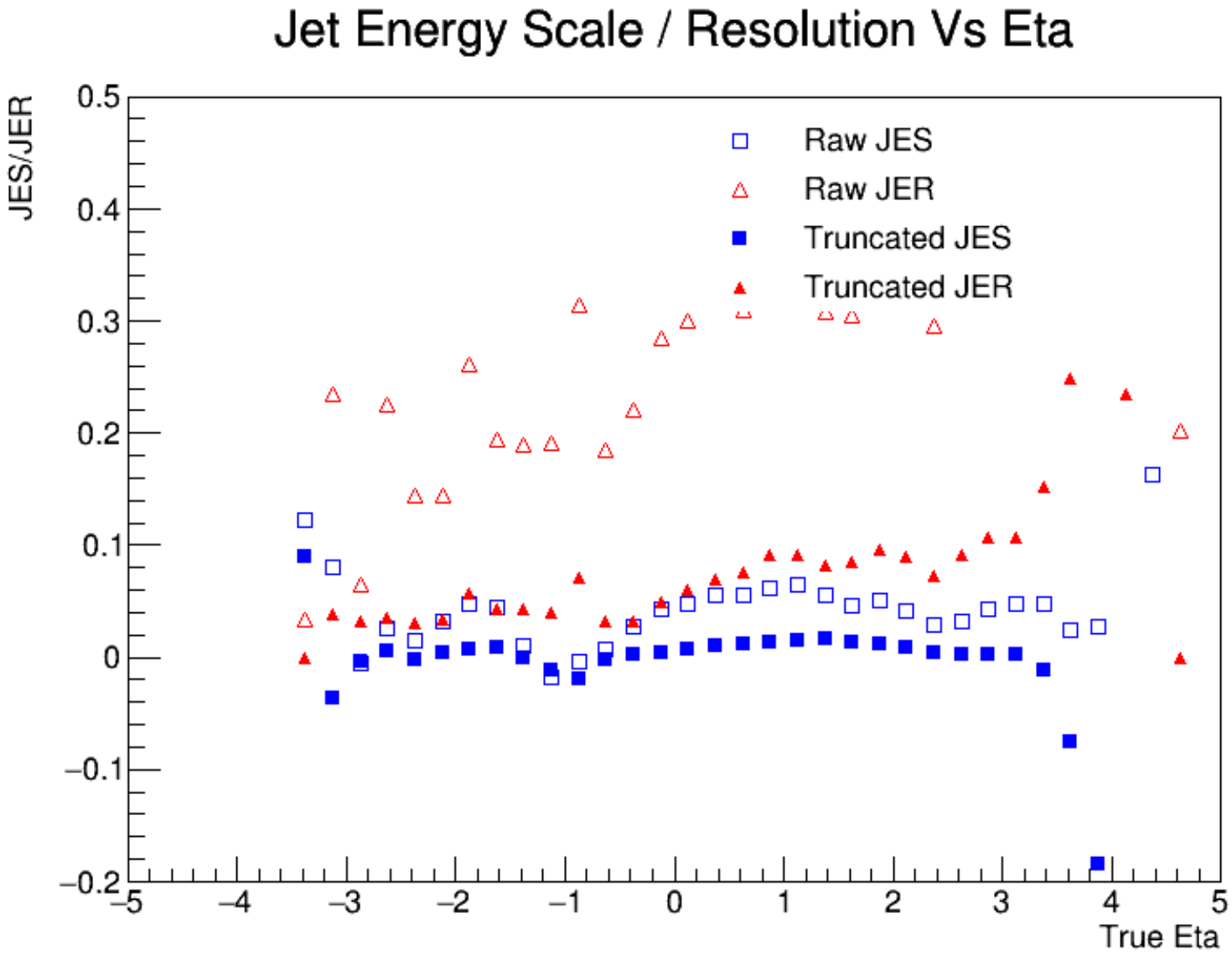
- But how do we characterize the distribution?

# Extracting the Mean and Width

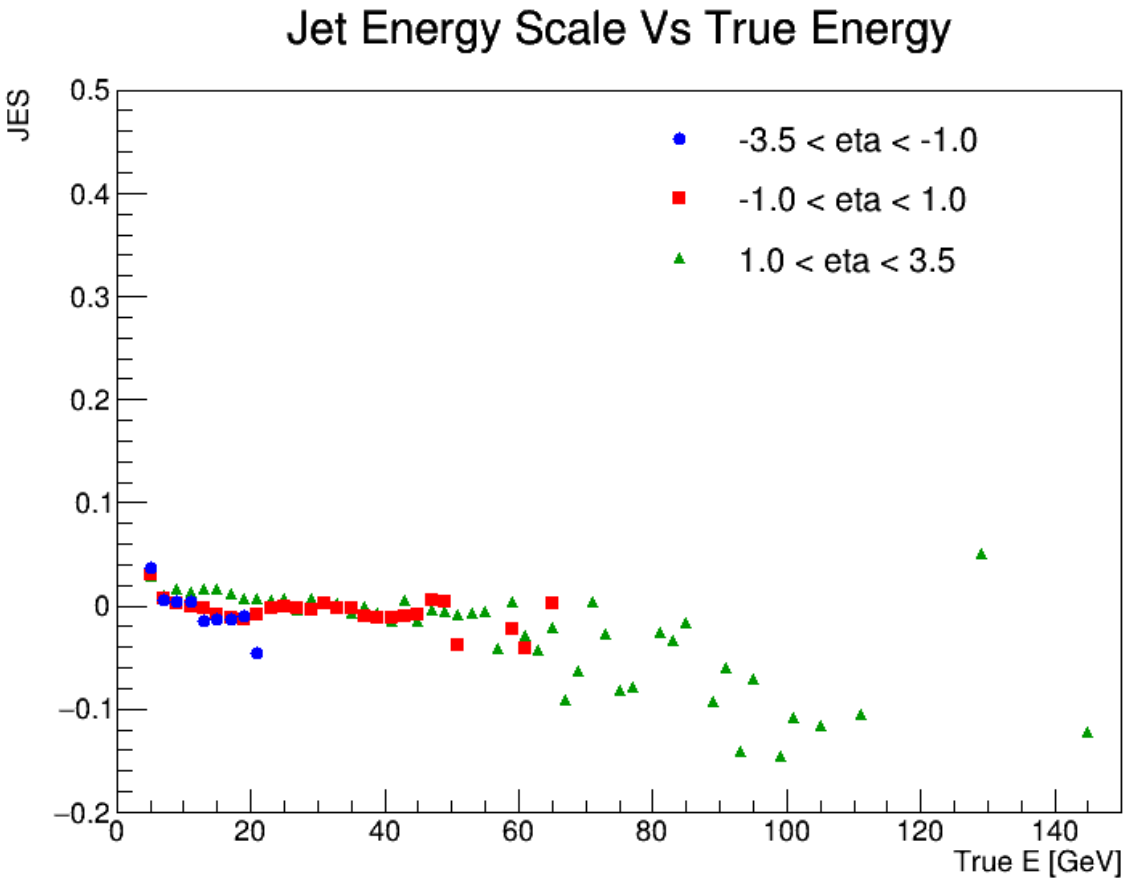



- Project out energy difference ratio for a single eta bin to demonstrate extraction of mean and width
- Raw distribution has a mean of 0.06 and a standard dev of 0.32
- Consider truncating the distribution to ± 1 sigma around peak value to get a mean of 0.01 and a standard dev of 0.07
- Can also fit the distribution with a function (gaussian) to extract a mean of 0.0001 and a sigma of 0.01
- Need to be very explicit how scales and resolutions are extracted from raw distributions – standard collaboration method(s)?

# Raw Vs Truncated JES and JER



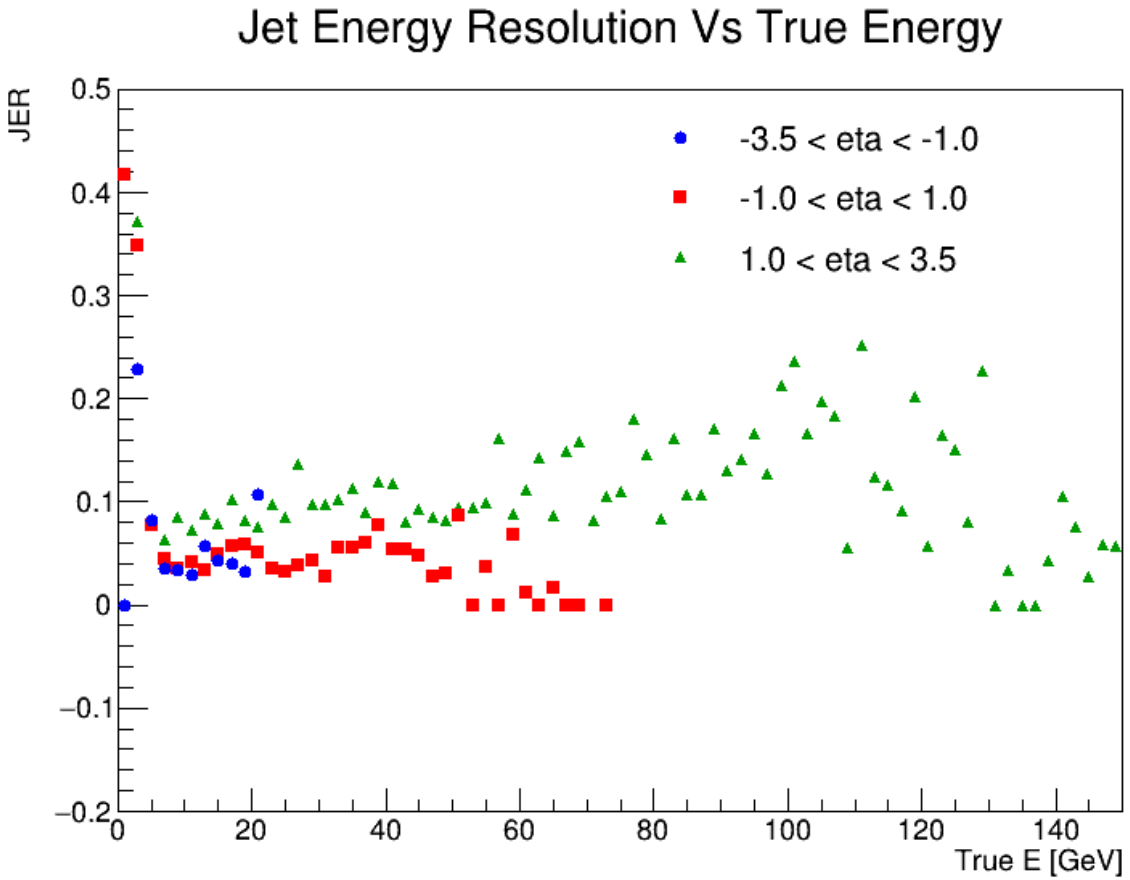
# JES and JER Differential in E and Eta




- Plot vs true jet energy for back, mid, and forward rapidities

- Statistics are ~adequate to get a feeling for performance over the energy range

- JES and JER extracted using the truncated distributions described above

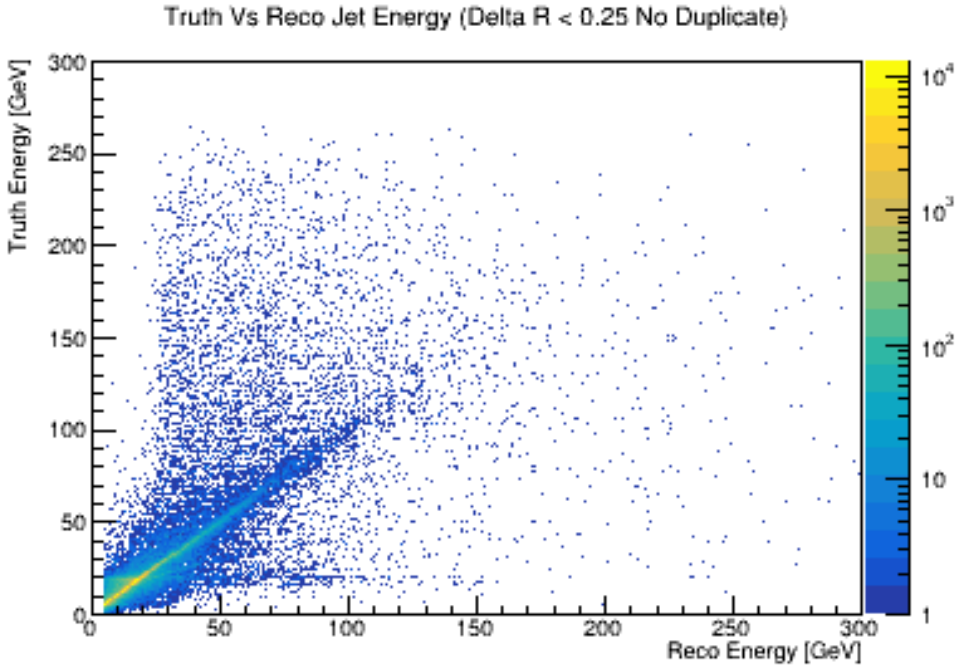


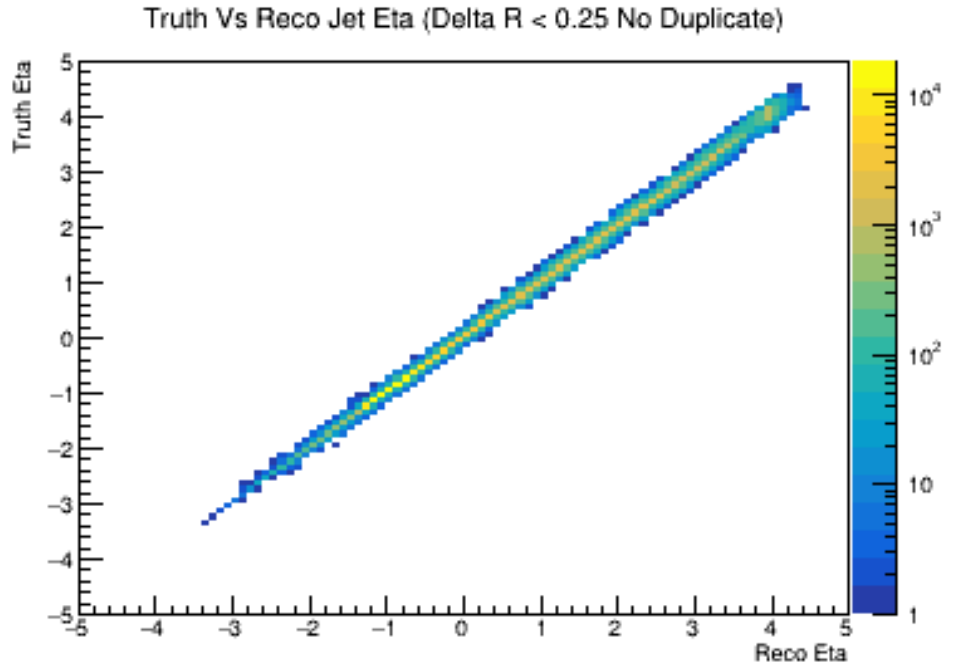
# Benchmark Discussion

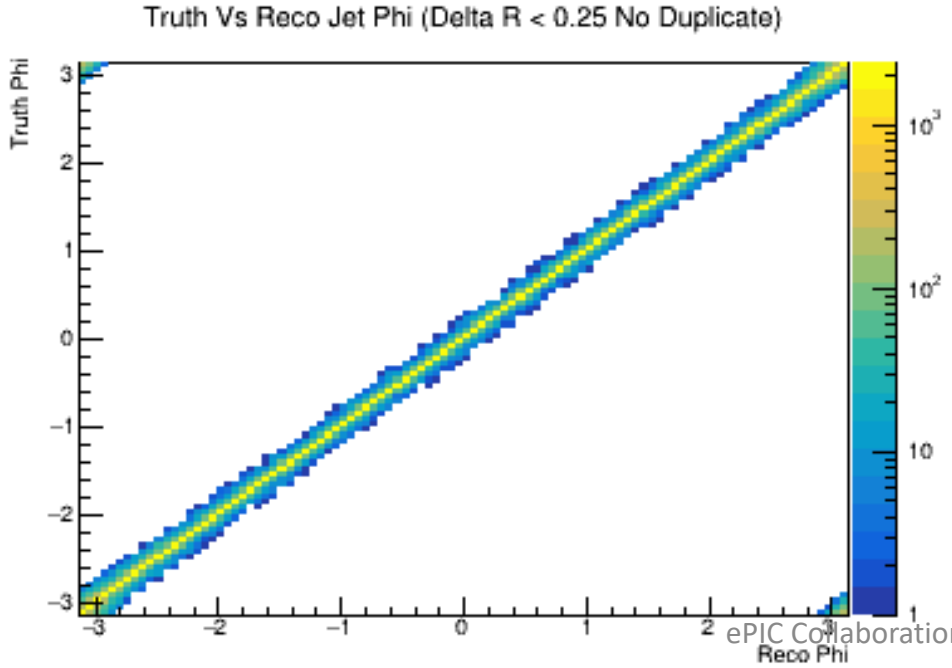
- Validation and benchmarking is a multiheaded beast – have identified three general benchmark categories
  - Detector Benchmarks
  - Reconstruction Benchmarks
  - Physics Benchmarks

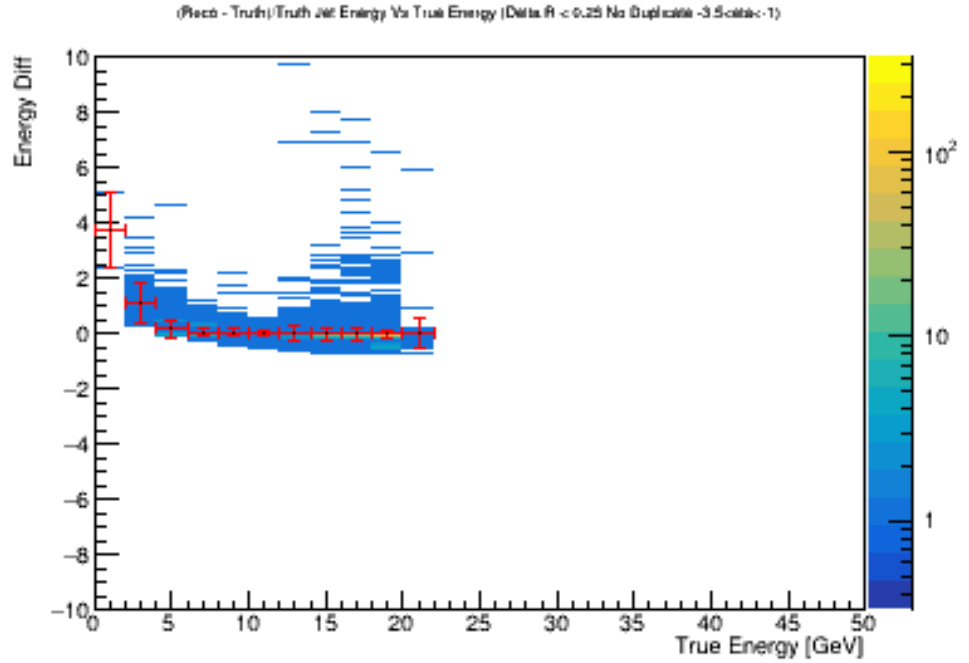
- Need to be aware of what our benchmarks are testing
  - Jet Benchmarks = detector geometry ⊗ track reconstruction ⊗ jet reconstruction
  - Need to have benchmarks at all levels to analyze and understand any performance changes
  - Well organized and easy access to output plots will be essential

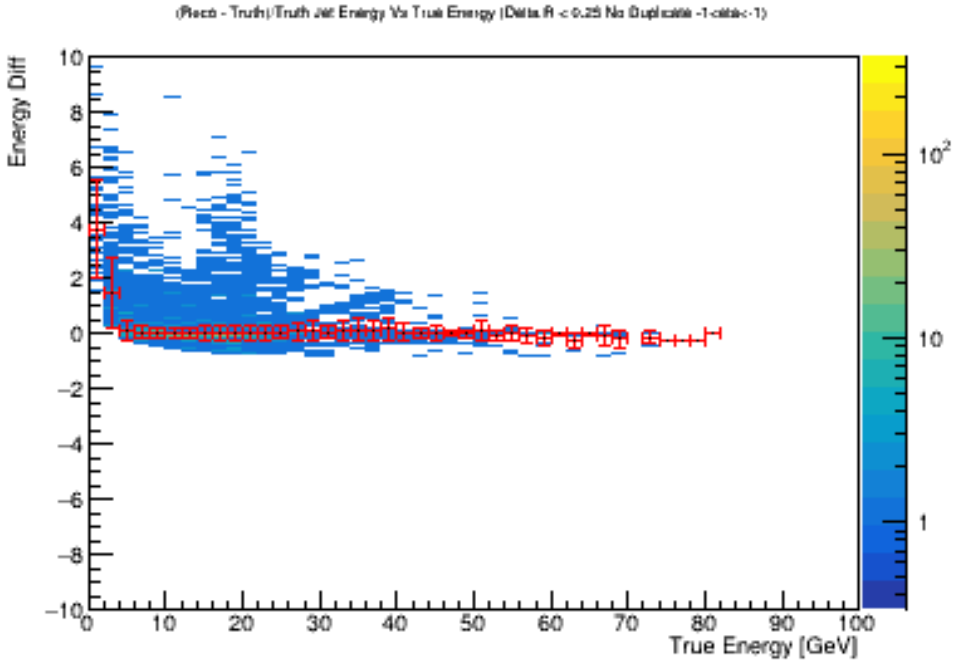
- Need to think about what triggers such benchmarks and how many events need to be run
  - 125K events seems to be roughly adequate to see resolutions – more is of course better
  - Probably can't run this much for every change in geometry or recon – maybe use a smaller number of events and look at things like kinematic distributions
  - Certainly the official 'train' productions will provide ample stats for inspection

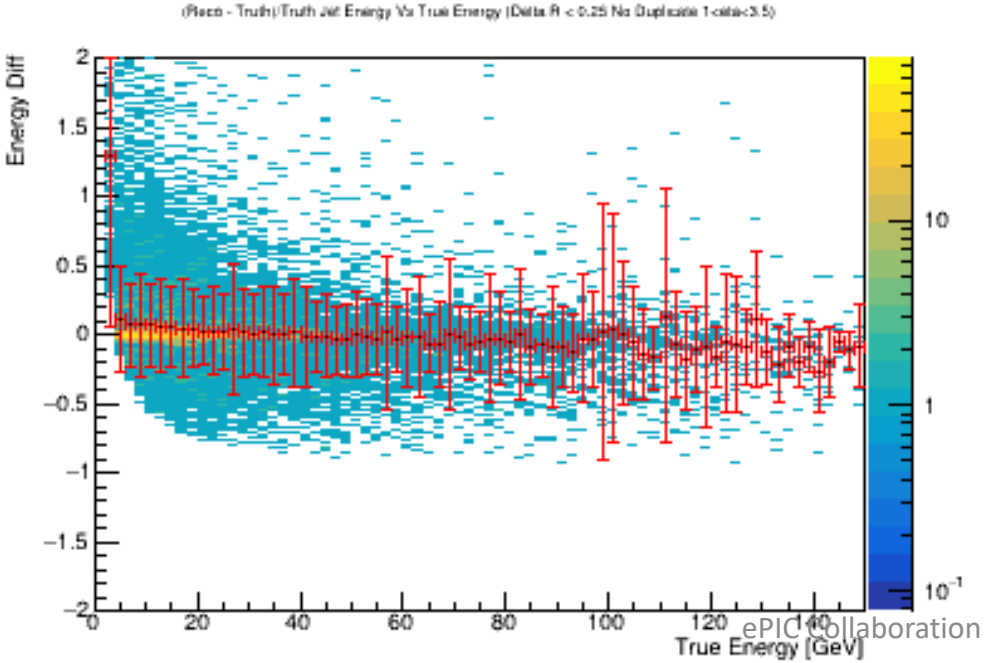

Truth Vs Reco Jet Energy (Delta R < 0.25 No Duplicate)
Truth Energy [GeV]
Reco Energy [GeV]


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


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


(Reco - Truth)/Truth Jet Energy Vs True Energy (Delta R < 0.25 No Duplicate -3.5<eta<-1)
Energy Diff
True Energy [GeV]


(Reco - Truth)/Truth Jet Energy Vs True Energy (Delta R < 0.25 No Duplicate -1<eta<-1)
Energy Diff
True Energy [GeV]


(Reco - Truth)/Truth Jet Energy Vs True Energy (Delta R < 0.25 No Duplicate 1<eta<3.5)
Energy Diff
True Energy [GeV]