Insert Jet Studies Update

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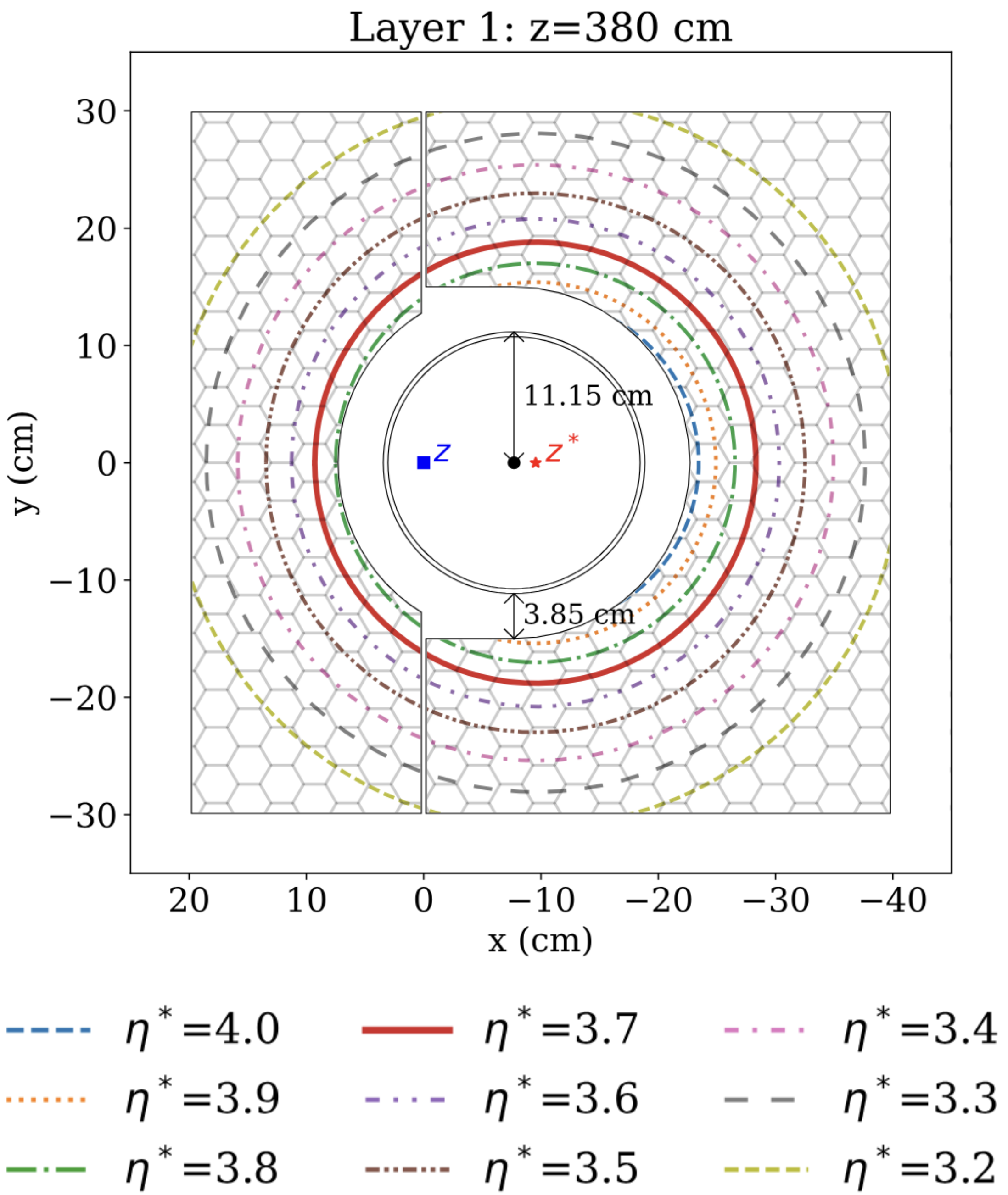
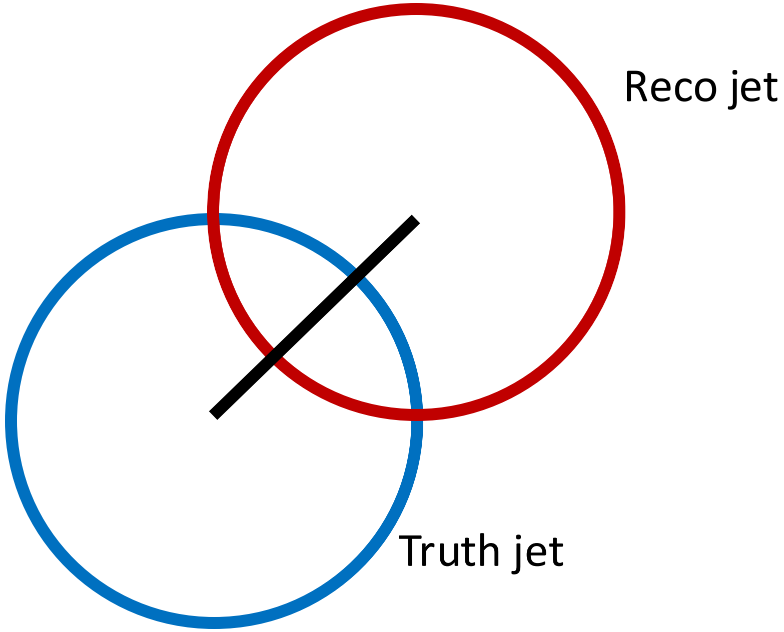
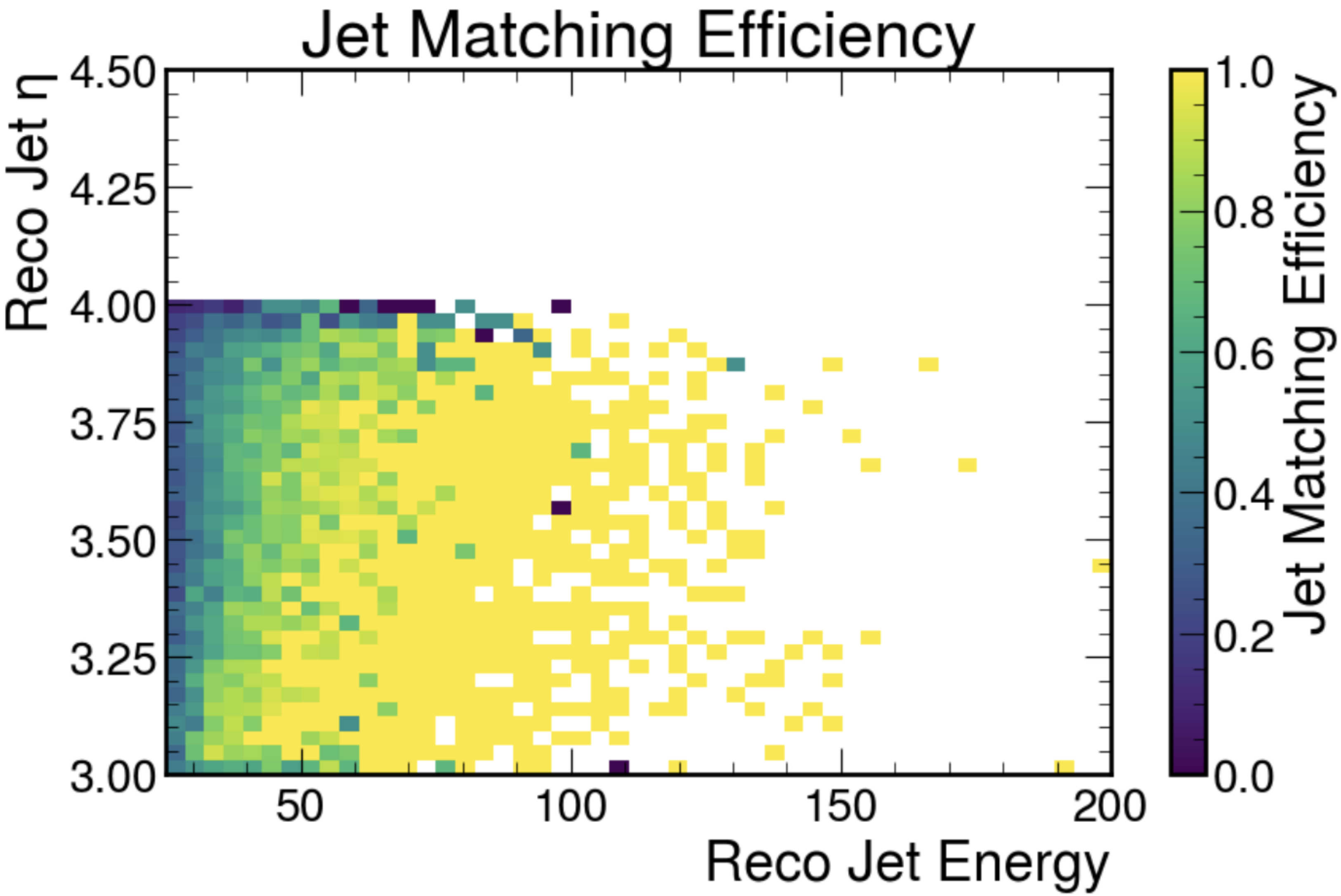
- Insert covers eta range of 3 – 4
- Analyzed 1M events with min Q2 = 1
- Combines clusters from the LFHCAL, ECal endcap, and ECal + HCal insert
- Jets are defined using anti-kt algorithm with R = 0.4
- Reco level cuts:
  - Min cluster E = 1.5 GeV
  - 3 < eta < 4
  - Min jet E = 25 GeV
- Truth level cuts:
  - 3 < eta < 4
  - Min jet E = 30 GeV

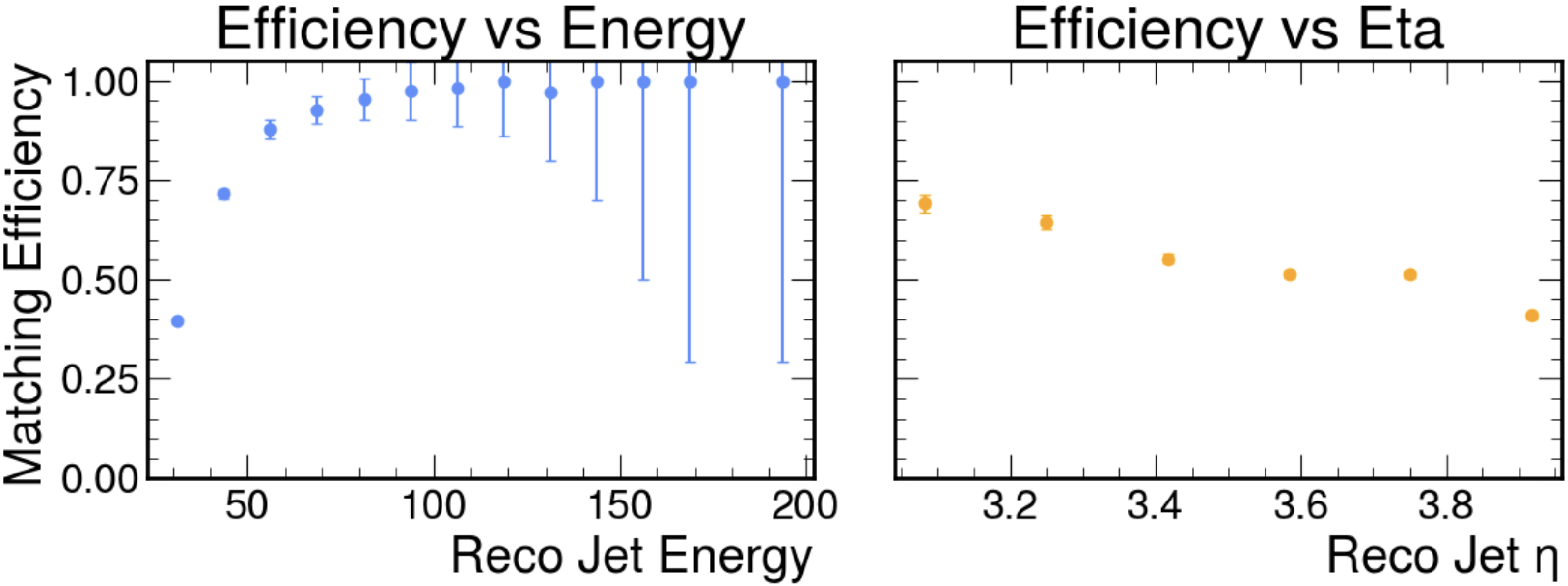


- Truth and reco jets are paired by their proximity in eta-phi space
- Max dR = 0.4 (one jet radius)
- 1-to-1 jet matching is enforced
- Total truth jets: 30,757
- Total reco jets: 26,212
- Total matched jets: 13,547
- Jet matching efficiency: 51.7%



dR = $\sqrt{d\varphi^2 + d\eta^2}$


Jet Matching Efficiency
Reco Jet η
4.50
4.25
4.00
3.75
3.50
3.25
3.00
50
100
150
200
Reco Jet Energy
1.0
0.8
0.6
0.4
0.2
0.0
Jet Matching Efficiency


Efficiency vs Energy
Matching Efficiency
1.00
0.75
0.50
0.25
0.00
50
100
150
200
Reco Jet Energy
Efficiency vs Eta
3.2
3.4
3.6
3.8
Reco Jet η

Numerical Inversion Overview

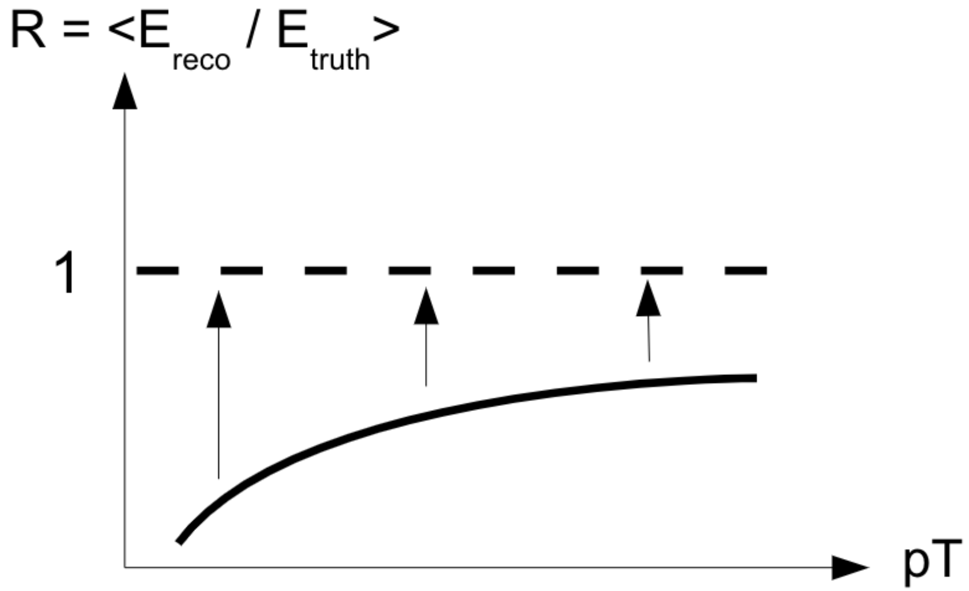
The insert is a non-compensating calorimeter, meaning the same amount of EM or hadronic energy will be reconstructed differently

As jets are composed of a mix of EM and hadronic energy, we need to apply a jet-specific calibration scheme to accurately reconstruct jets

Simply creating a correction factor from

$$\widetilde{R}(E) = \mathbb{E}\left(\frac{E}{E_{truth}} \middle| E_{reco} = E\right)$$

would be biased from the underlying truth distribution, so numerical inversion is needed to remove this bias



Numerical Inversion Overview

Mathematical properties of numerical inversion for jet calibrations, https://doi.org/10.1016/j.nima.2017.03.038.

1 Compute the jet response function:

$$f(E) = \mathbb{E}(E_{reco}|E_{truth} = E)$$

2 Compute the jet scaling function:

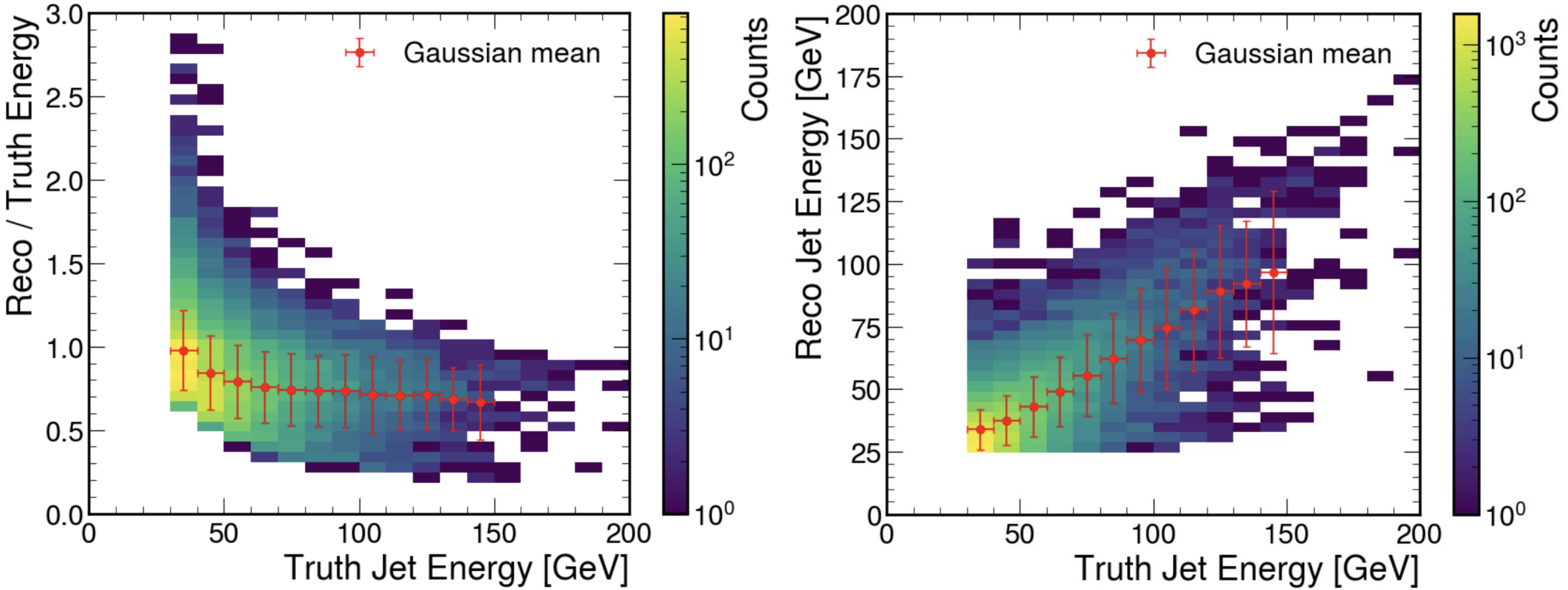
$$R(E) = \mathbb{E}(\frac{E_{reco}}{E}|E_{truth} = E)$$

3 From these, let

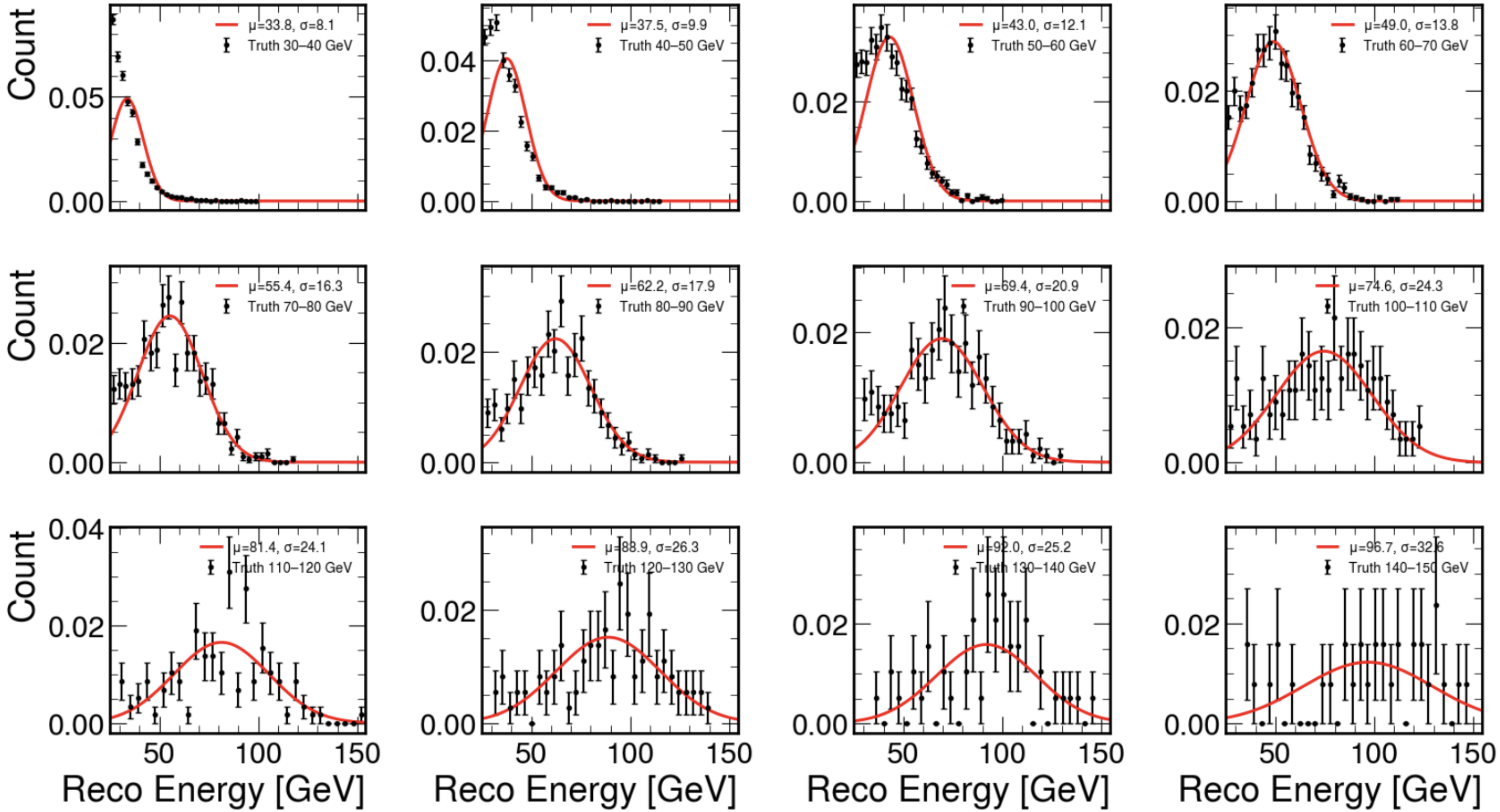
$$\widetilde{R}(E) = R(f^{-1}(E))$$

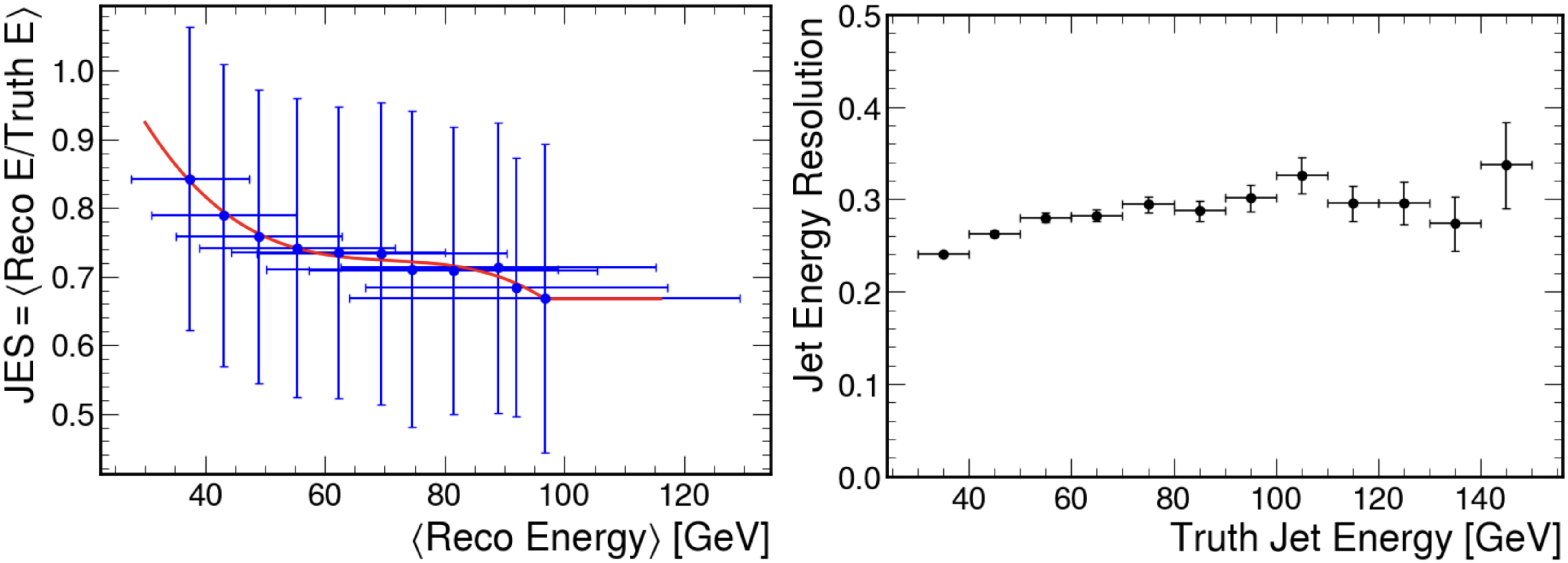
4 Finally, apply this as a correction jet-by-jet as

$$E_{reco} \mapsto E_{reco}/\widetilde{R}(E_{reco})$$

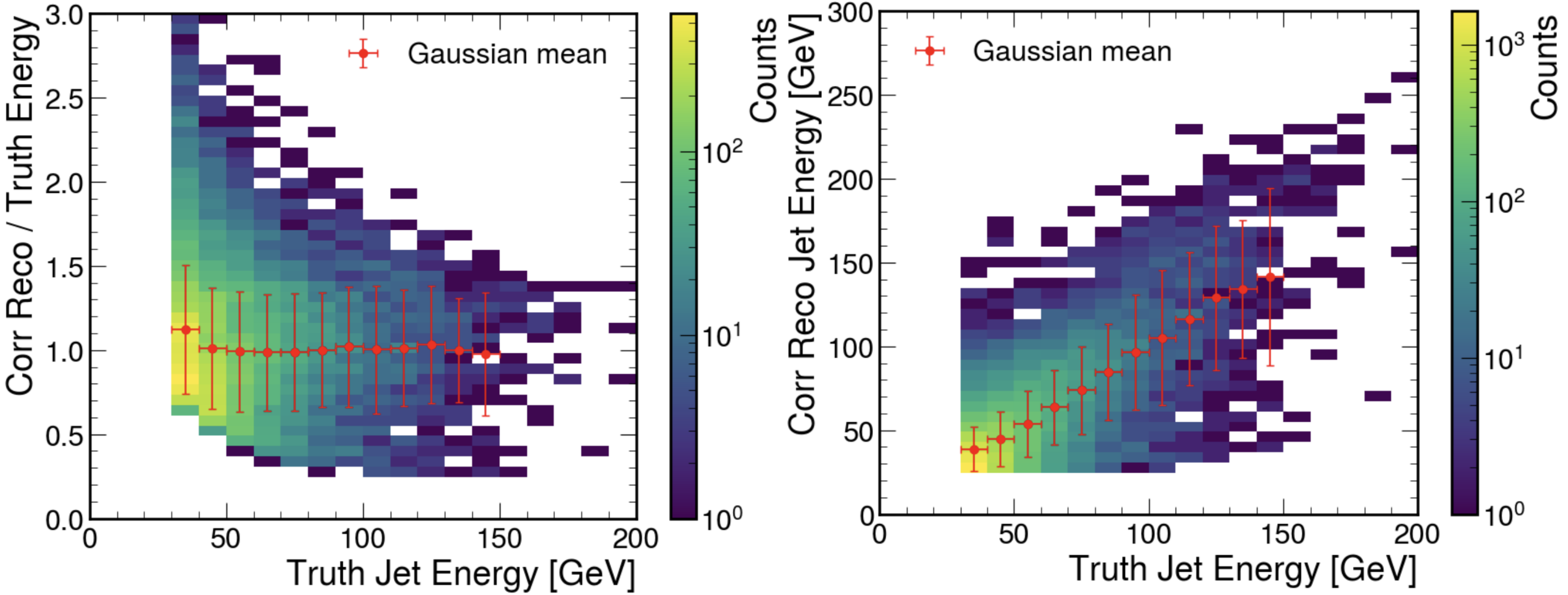


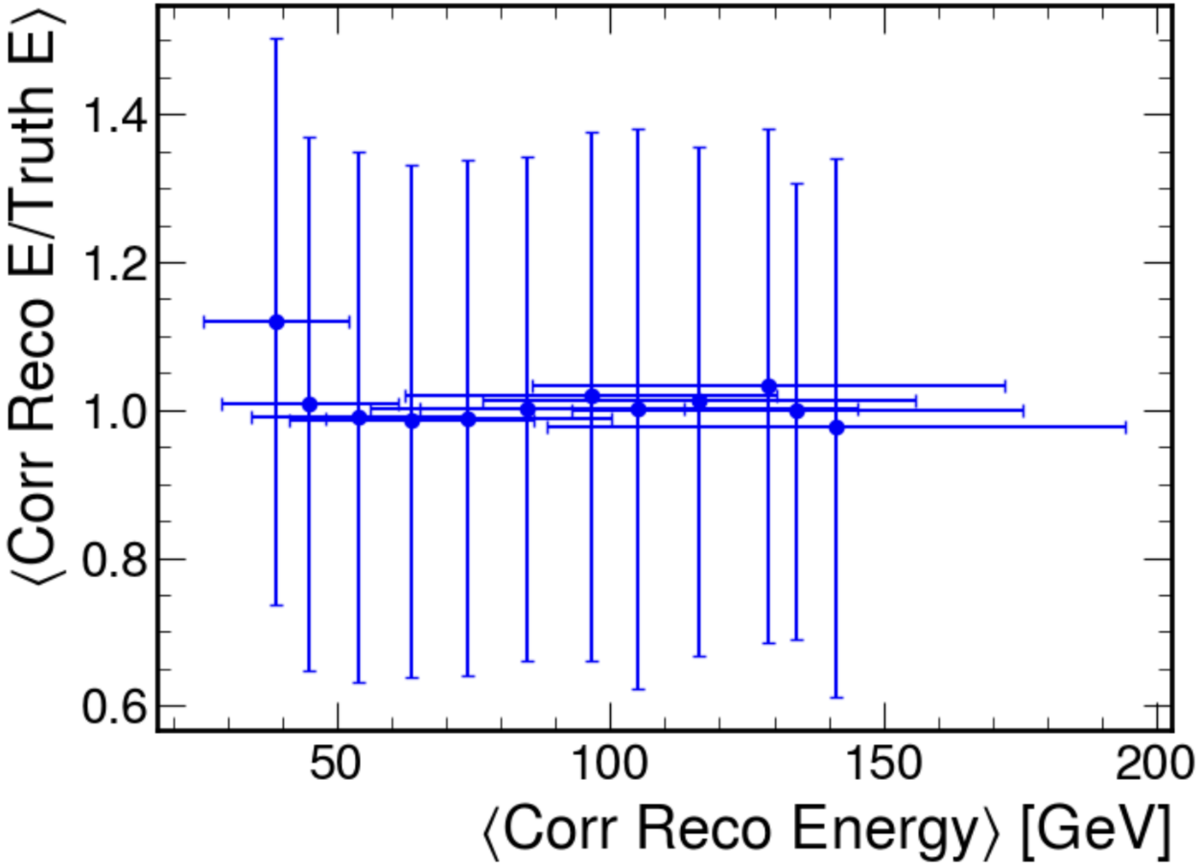
Gaussian mean
Reco / Truth Energy
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
50
100
150
200
Truth Jet Energy [GeV]
Counts
10^0
10^1
10^2
Gaussian mean
Reco Jet Energy [GeV]
0
25
50
75
100
125
150
175
200
Truth Jet Energy [GeV]
Counts
10^0
10^1
10^2
10^3


μ=33.8, σ=8.1
Truth 30–40 GeV
μ=37.5, σ=9.9
Truth 40–50 GeV
μ=43.0, σ=12.1
Truth 50–60 GeV
μ=49.0, σ=13.8
Truth 60–70 GeV
μ=55.4, σ=16.3
Truth 70–80 GeV
μ=62.2, σ=17.9
Truth 80–90 GeV
μ=69.4, σ=20.9
Truth 90–100 GeV
μ=74.6, σ=24.3
Truth 100–110 GeV
μ=81.4, σ=24.1
Truth 110–120 GeV
μ=88.9, σ=26.3
Truth 120–130 GeV
μ=92.0, σ=25.2
Truth 130–140 GeV
μ=96.7, σ=32.6
Truth 140–150 GeV
Count
Reco Energy [GeV]
0.00
0.02
0.04
0.05
50
100
150

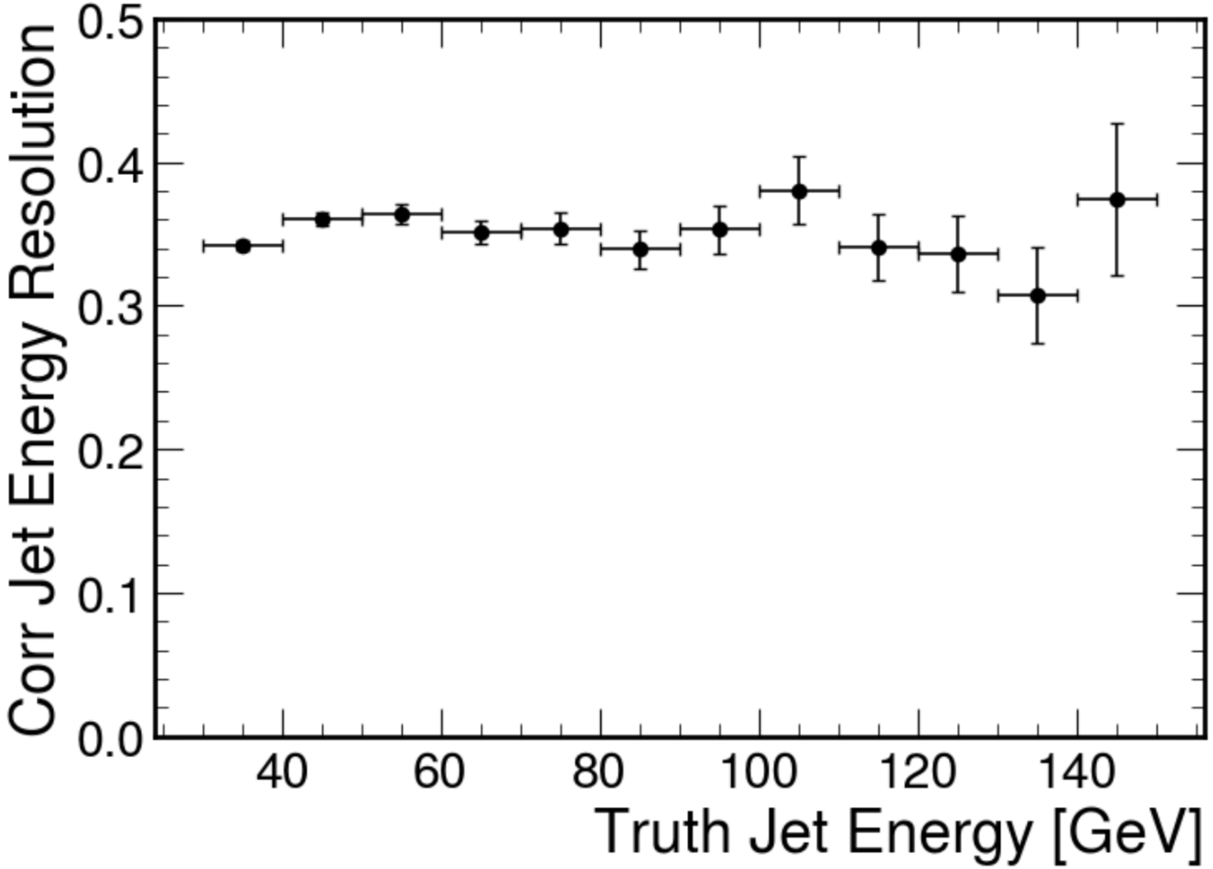

JES = ⟨Reco E/Truth E⟩
1.0
0.9
0.8
0.7
0.6
0.5
40
60
80
100
120
⟨Reco Energy⟩ [GeV]
Jet Energy Resolution
0.5
0.4
0.3
0.2
0.1
0.0
40
60
80
100
120
140
Truth Jet Energy [GeV]

Apply JES calibration back on the data, closure tests





⟨Corr Reco E/Truth E⟩
1.4
1.2
1.0
0.8
0.6
50
100
150
200
⟨Corr Reco Energy⟩ [GeV]



Corr Jet Energy Resolution
0.5
0.4
0.3
0.2
0.1
0.0
40
60
80
100
120
140
Truth Jet Energy [GeV]