Fragmentation function performance

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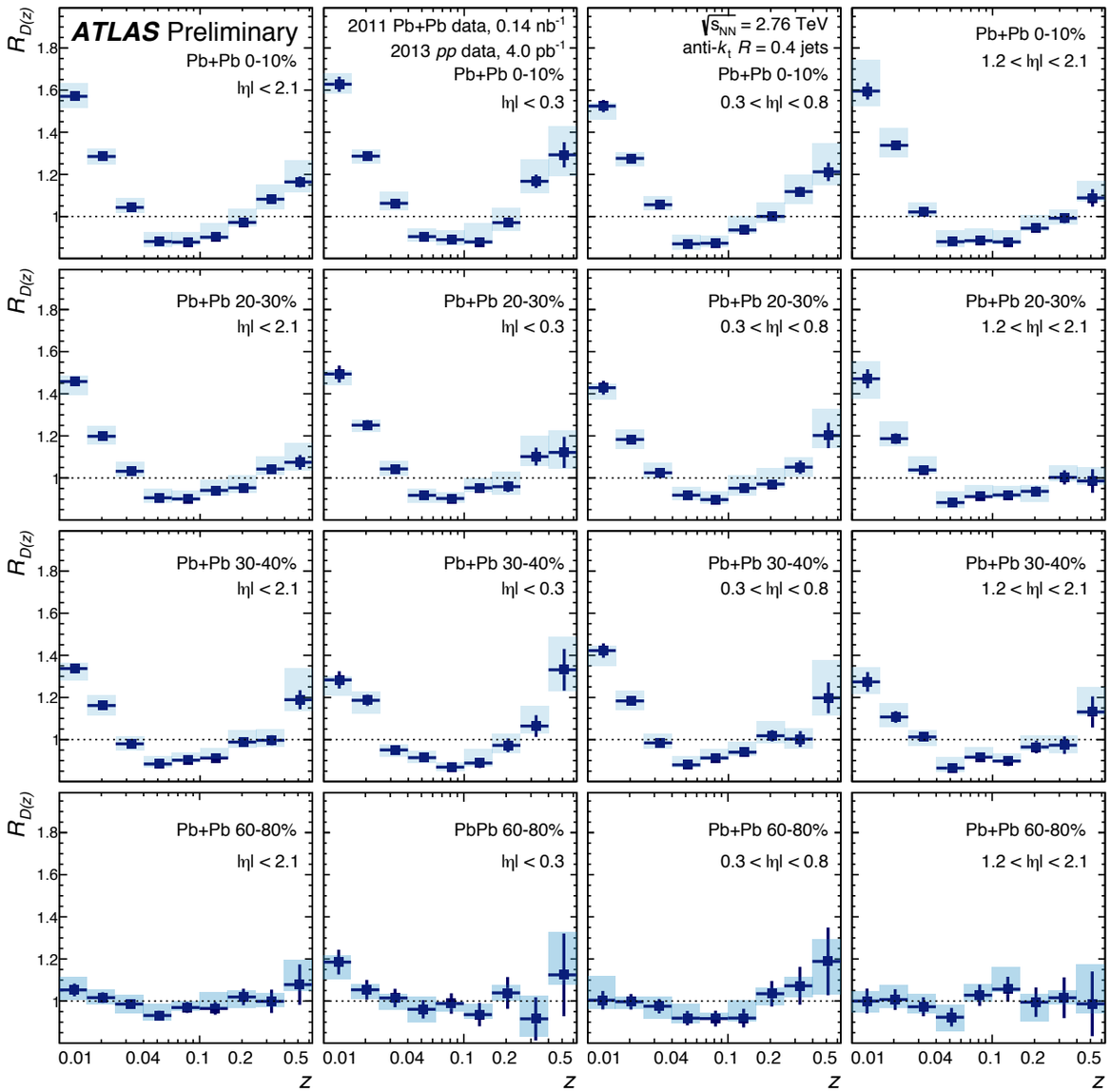
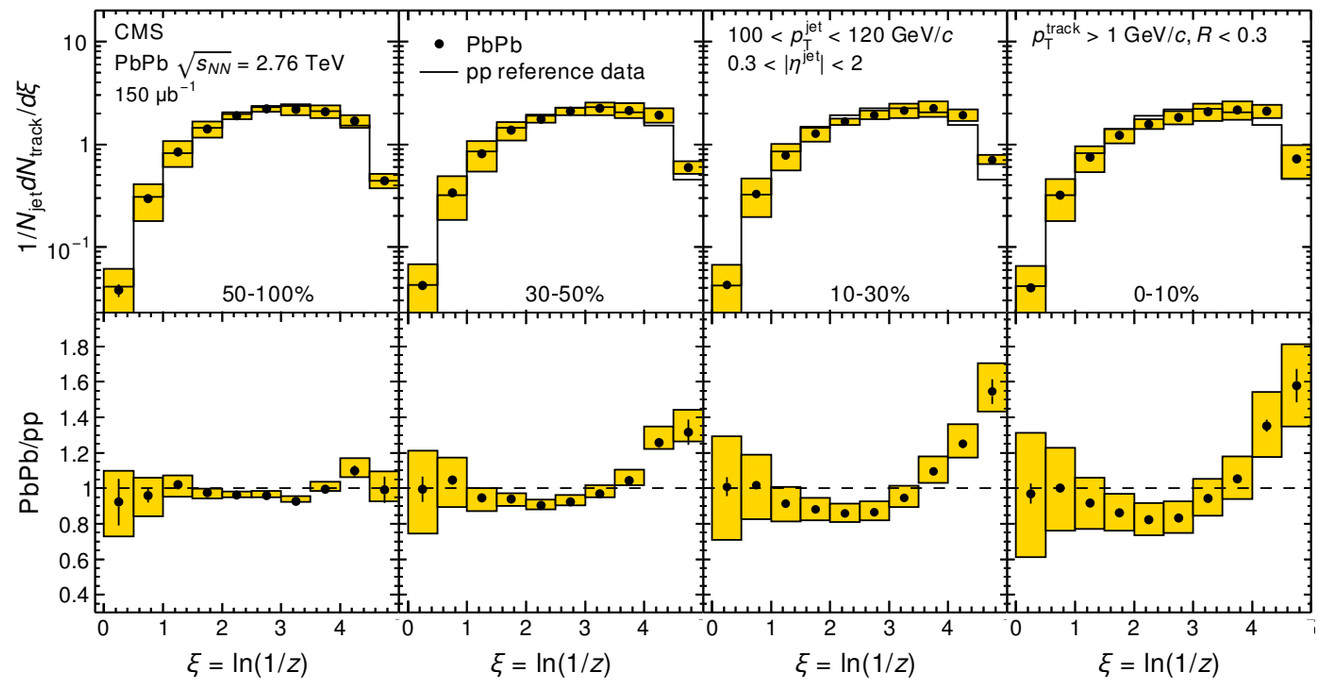
sPHENIX Simulations Meeting

Motivation





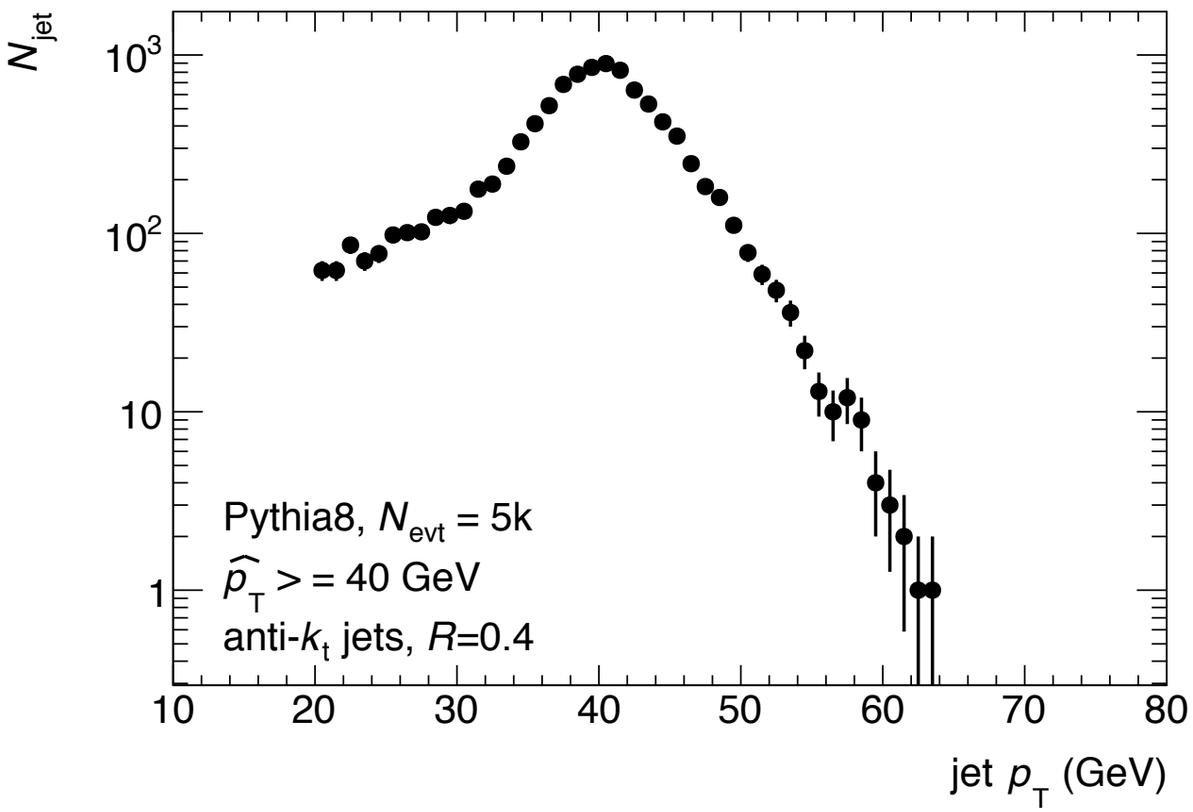
CMS PRC 90 (2014) 024908

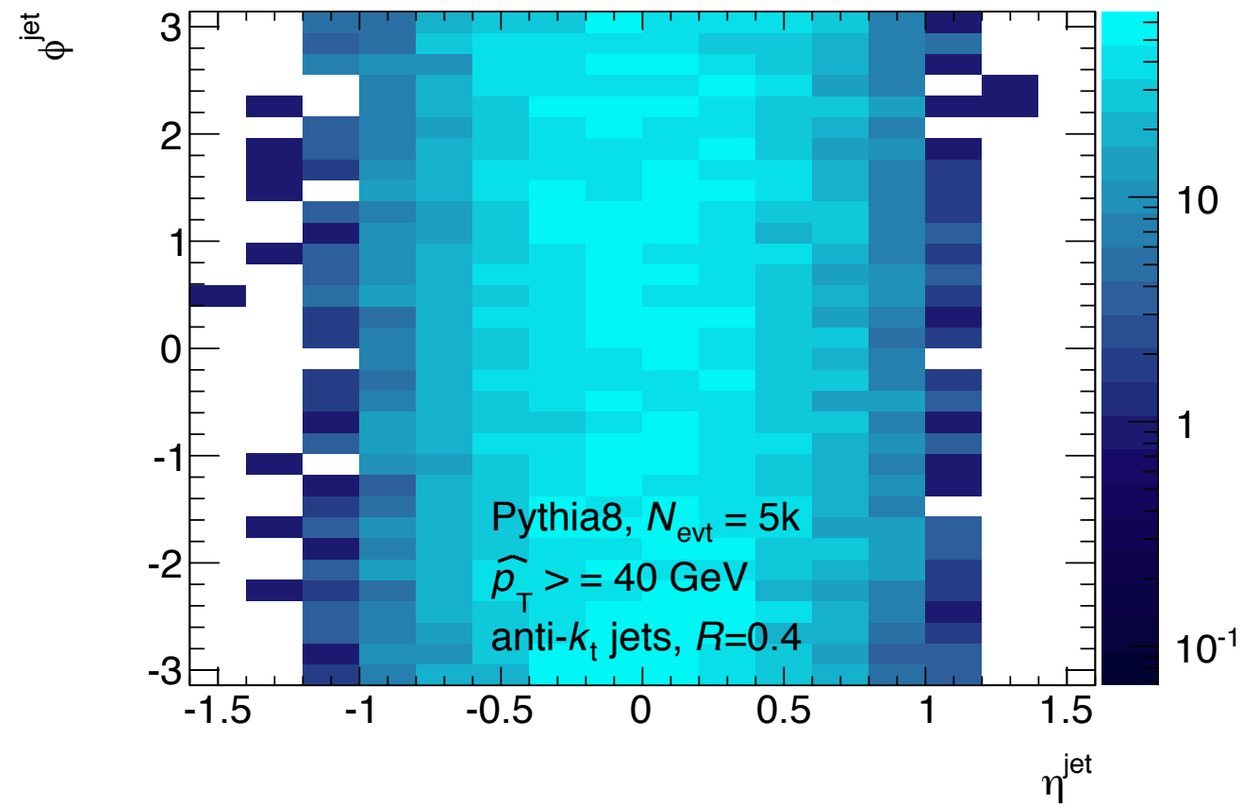
ATLAS-CONF-2015-022

- How well can sPHENIX measure fragmentation functions?
  - ➡ in *p*+*p*, Au+Au, and with different tracking options
  - ➡ physics insight from LHC: ~20% modifications for z=0.05-0.50, up to ~60% modification for z < 0.05

➡ This update: focus on *p*+*p* collisions, default tracking option to start

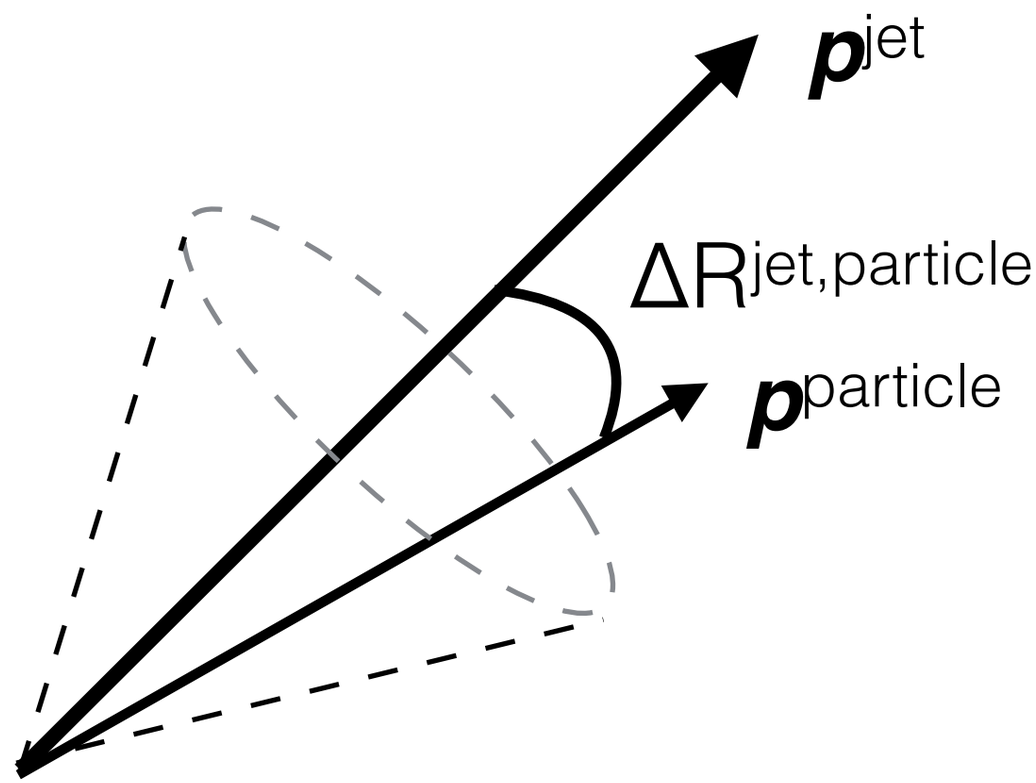
Simulated dataset



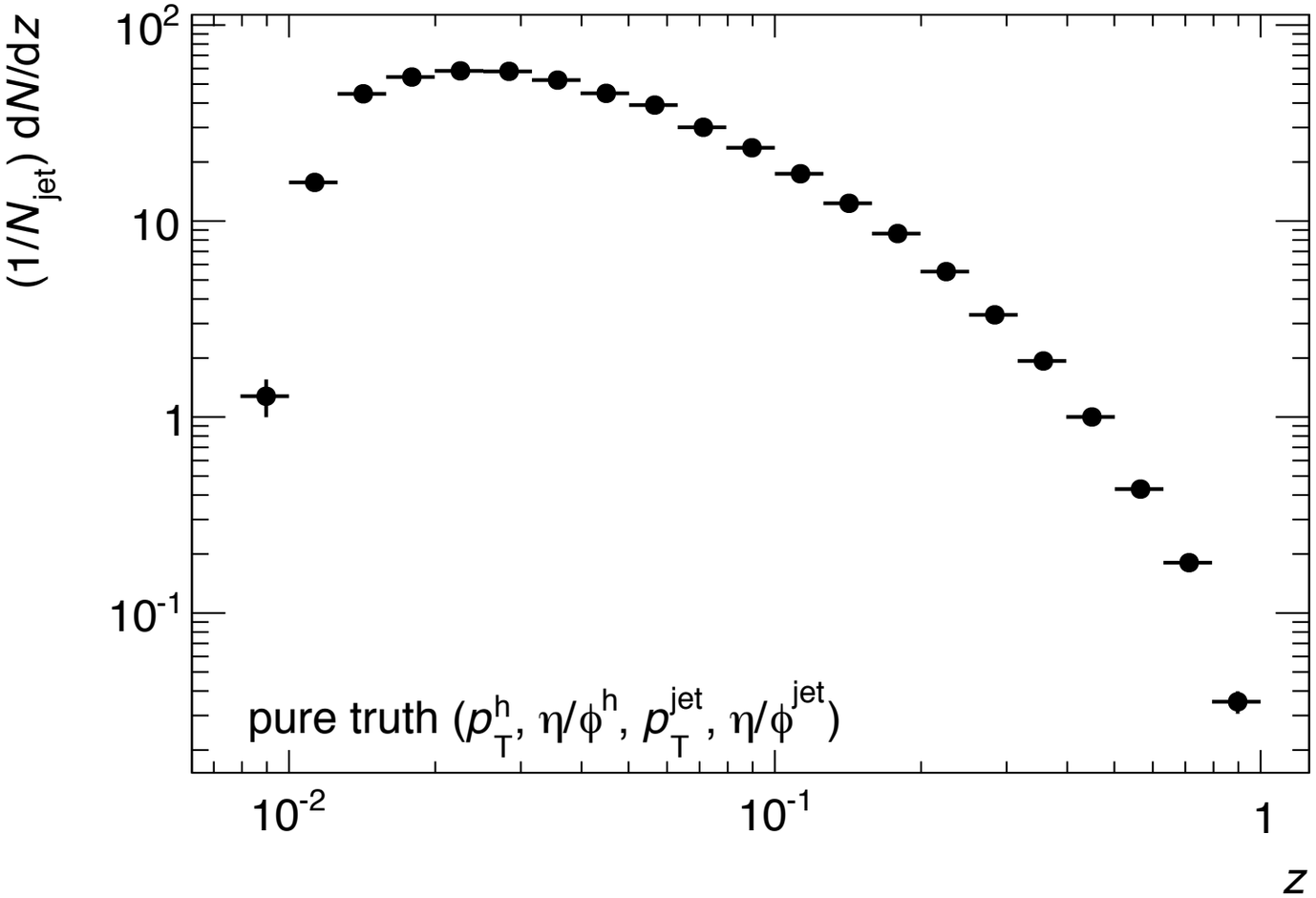


- Ran 5k Pythia8 dijet events, minimum $\widehat{p_T}$ > 40 GeV
  - ➡ only analyze R=0.4 truth jets with p_T > 20 GeV and $|\eta^{jet}|$ < 0.6 (so that $|\eta^{jet} \pm 0.4|$ < 1.0)
- <u>Full G4 simulation</u> with fully active 7 layer pixel+strip in cylindrical geometry form (“G4_Svtx.C”)
  - ➡ not yet simulating any calorimeter elements (so no reco jets)

Observable definition



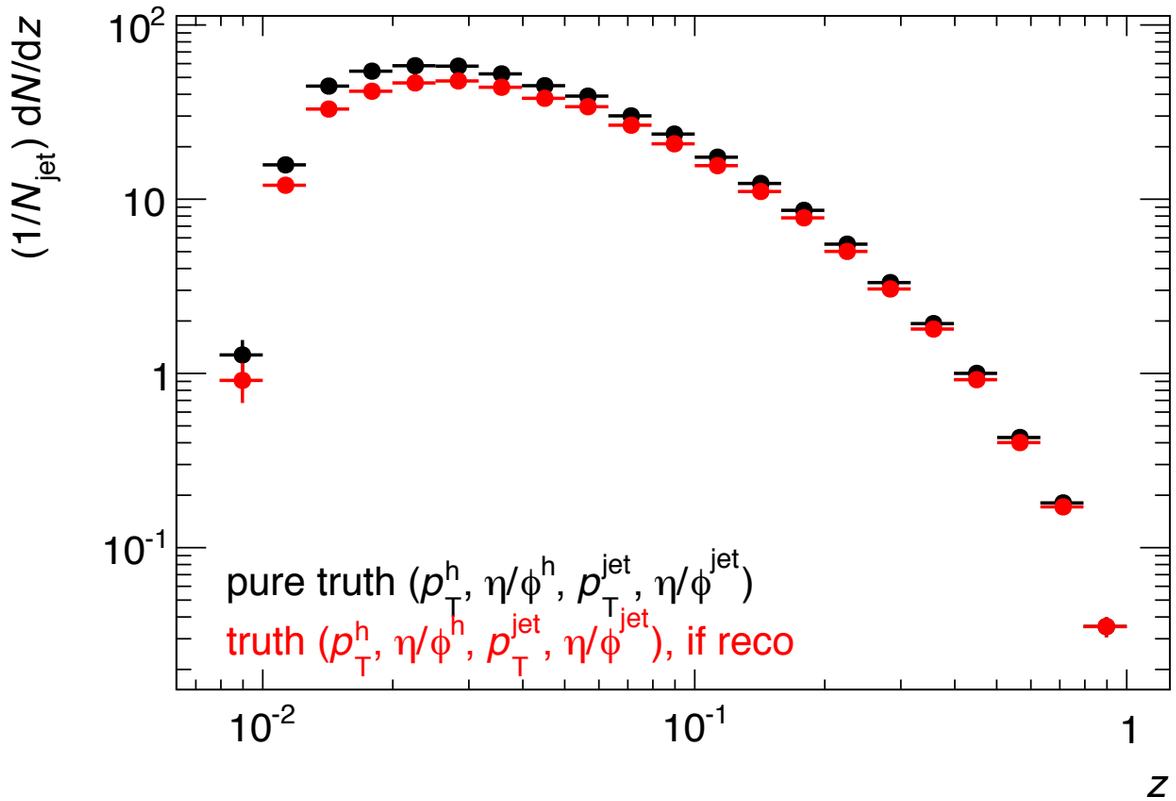
- Take all particles with $p_T^{\text{particle}} > 0.5$ GeV that are within $\Delta R^{\text{jet,particle}} < 0.4$ of the ($R_{\text{anti-kt}}$=0.4) jet axis
  - ➡ $(1/N_{\text{jet}})\mathrm{d}N/\mathrm{d}z$, where $z = (\boldsymbol{p}^{\text{particle}} \cdot \boldsymbol{p}^{\text{jet}}) \ / \ |\boldsymbol{p}^{\text{jet}}|^2$
  - ➡ $(1/N_{\text{jet}})\mathrm{d}N/\mathrm{d}p_T^{\text{rel}}$, where $p_T^{\text{rel}} = |\boldsymbol{p}^{\text{particle}} \times \boldsymbol{p}^{\text{jet}}| \ / \ |\boldsymbol{p}^{\text{jet}}|$ (GeV)
  - ➡ others possible, e.g. $(1/N_{\text{jet}})\ (1/\Delta R)\ \mathrm{d}(p_T^{\text{particle}})/\mathrm{d}(\Delta R)$

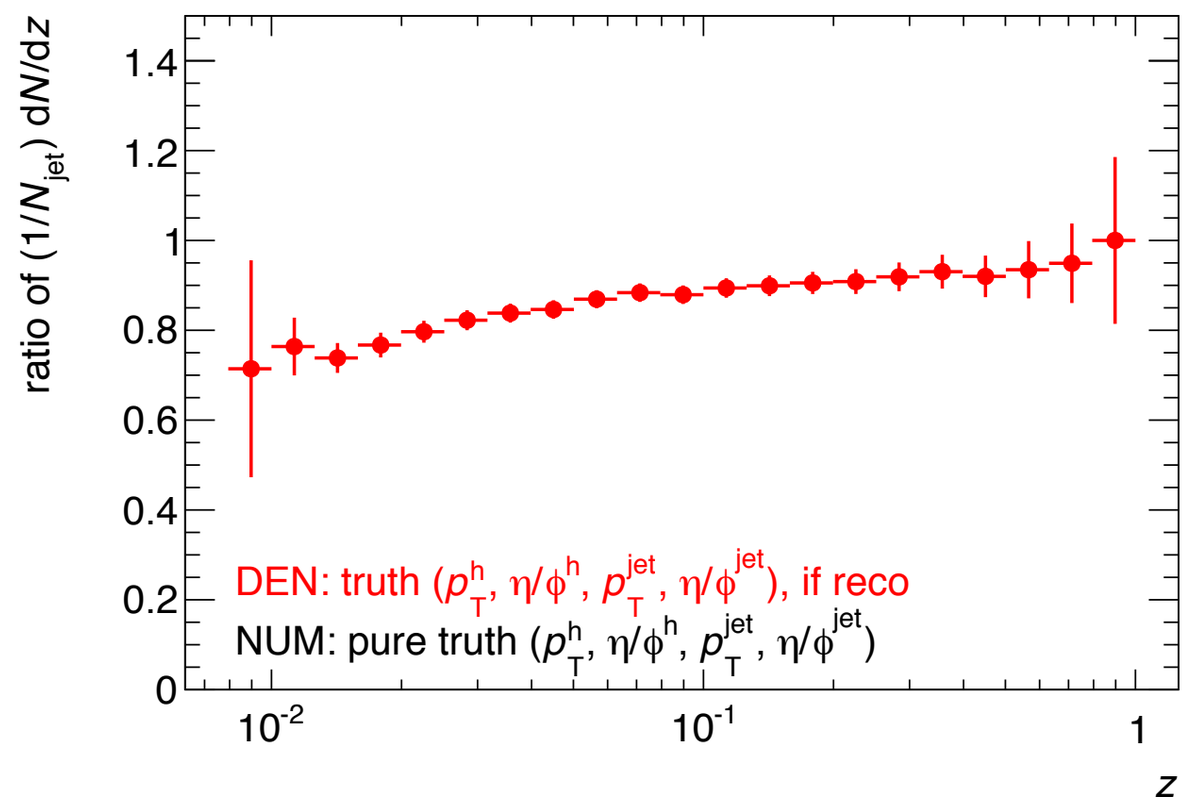


Detector effects on *z* distribution

- Generator-level distribution using final-state charged particles (π, K, p, e) in HepMC record
- Will explore detector effects on distribution differentially:
  1. finite reconstruction efficiency
  2. resolution on particle angle
  3. resolution on particle momentum
  4. resolution on jet angle
  5. resolution on jet momentum

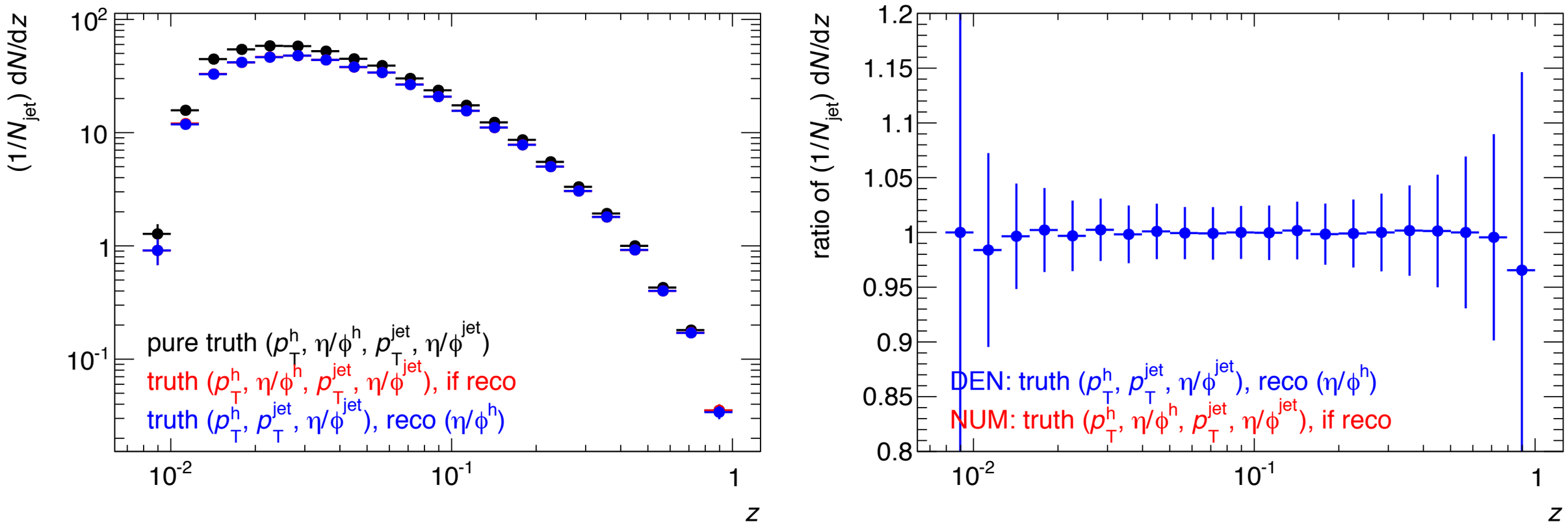
1. Finite reconstruction efficiency





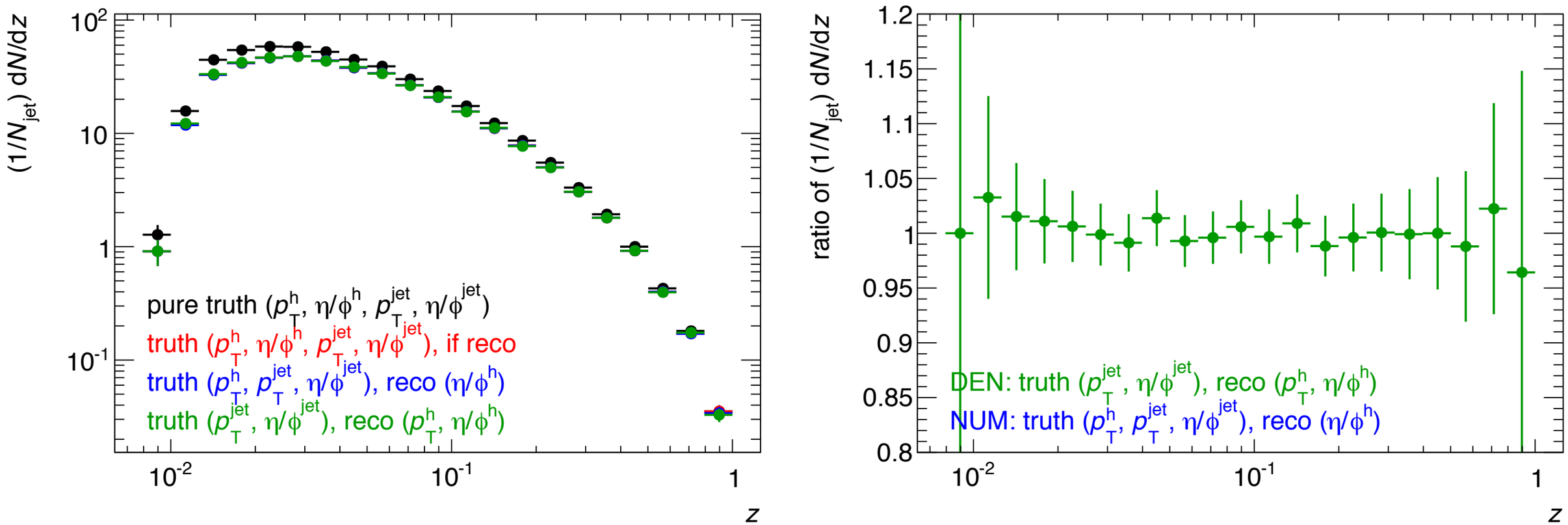
- Loop over all reconstructed tracks without quality cuts/selection
  - ➡ declare their “associated” truth particles (SvtxTrackEval::max_truth_particle_by_nclusters()) as having been successfully reconstructed
- Then, remake *z* distribution using the subset of truth particles which were successfully reconstructed
  - ➡ remember: no smearing in z, just drop in yield…

2. Resolution on particle angle



- As step #1, but use reconstructed track's (η, ϕ)
  - ➡ this can change dot product, and also push reconstructed particle angle out of jet cone
  - ➡ note: still using truth particle's p_T, and truth jet (p_T, η, ϕ)
  - ➡ resulting smearing in z is negligible except at very low-z

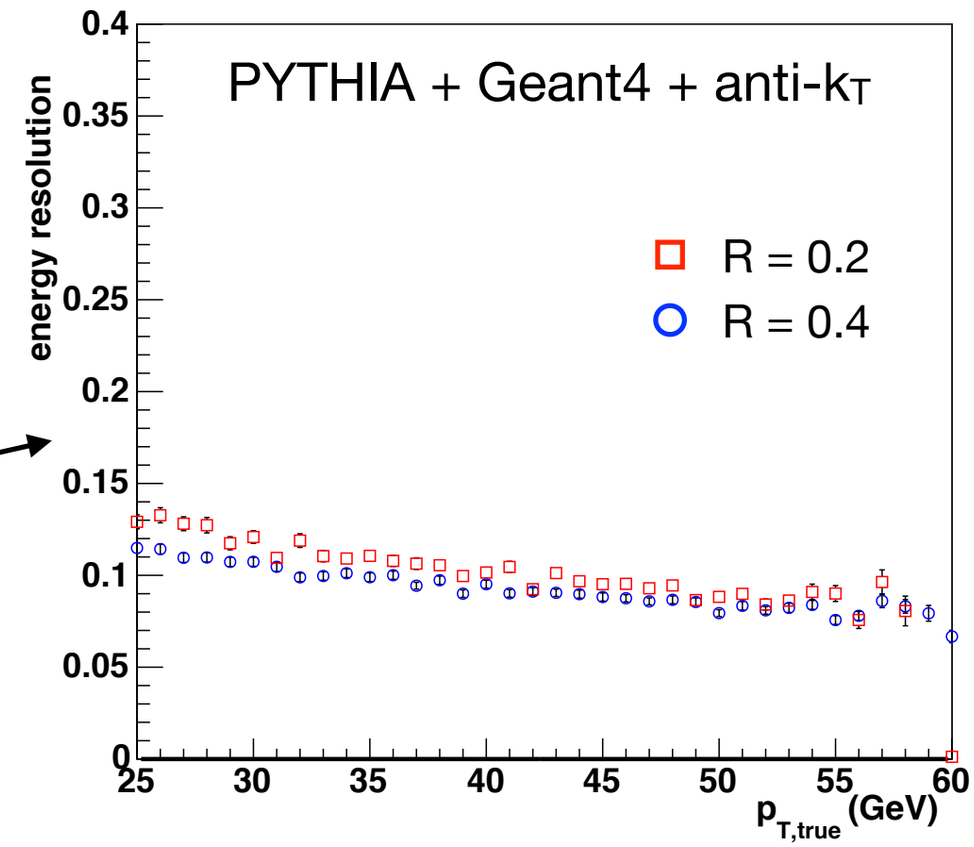
3. Resolution on particle momentum

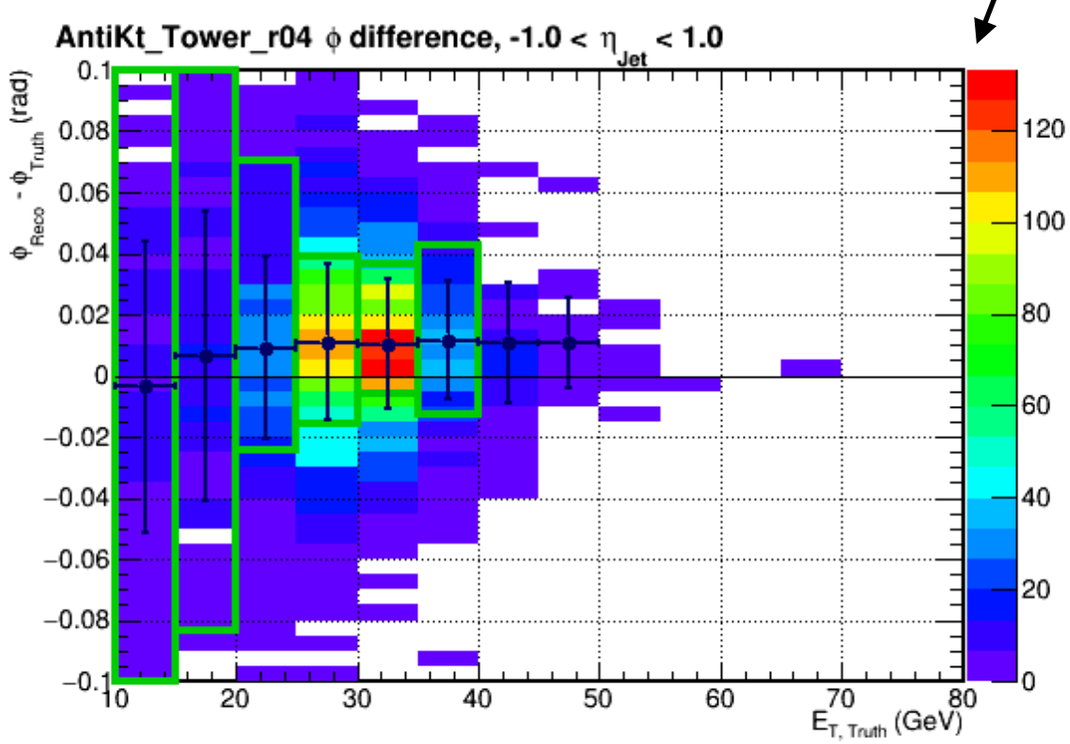


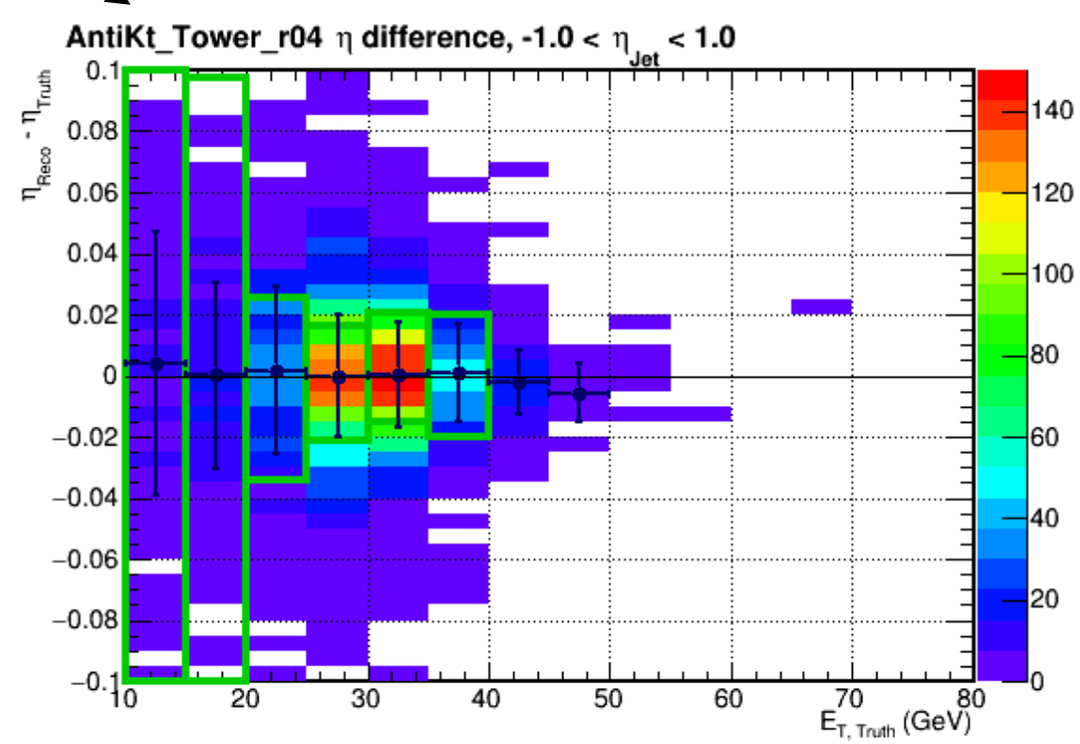
- As step #2, but using reconstructed track's p_T
  - ➡ note: still using truth jet kinematics
  - ➡ resulting smearing in z is at the 1%-level

Simulating jet angle & momentum resolution

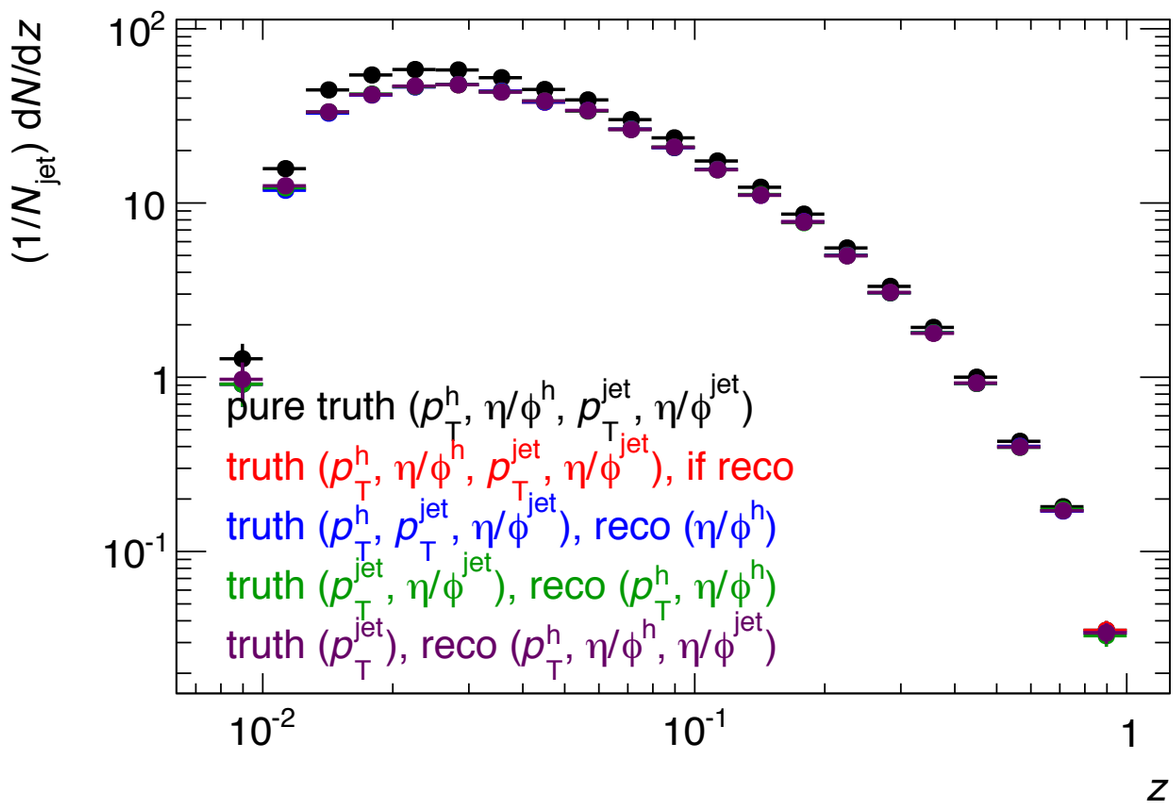
- At the moment, no full G4 or fast simulation of calorimeters
  - ➡ grab some numbers from previous studies just to test scale of the effect
  - ➡ 10% resolution in *p*+*p* collisions from sPHENIX MIE document
  - ➡ 0.02 angular resolution Jin Huang's jet performance studies

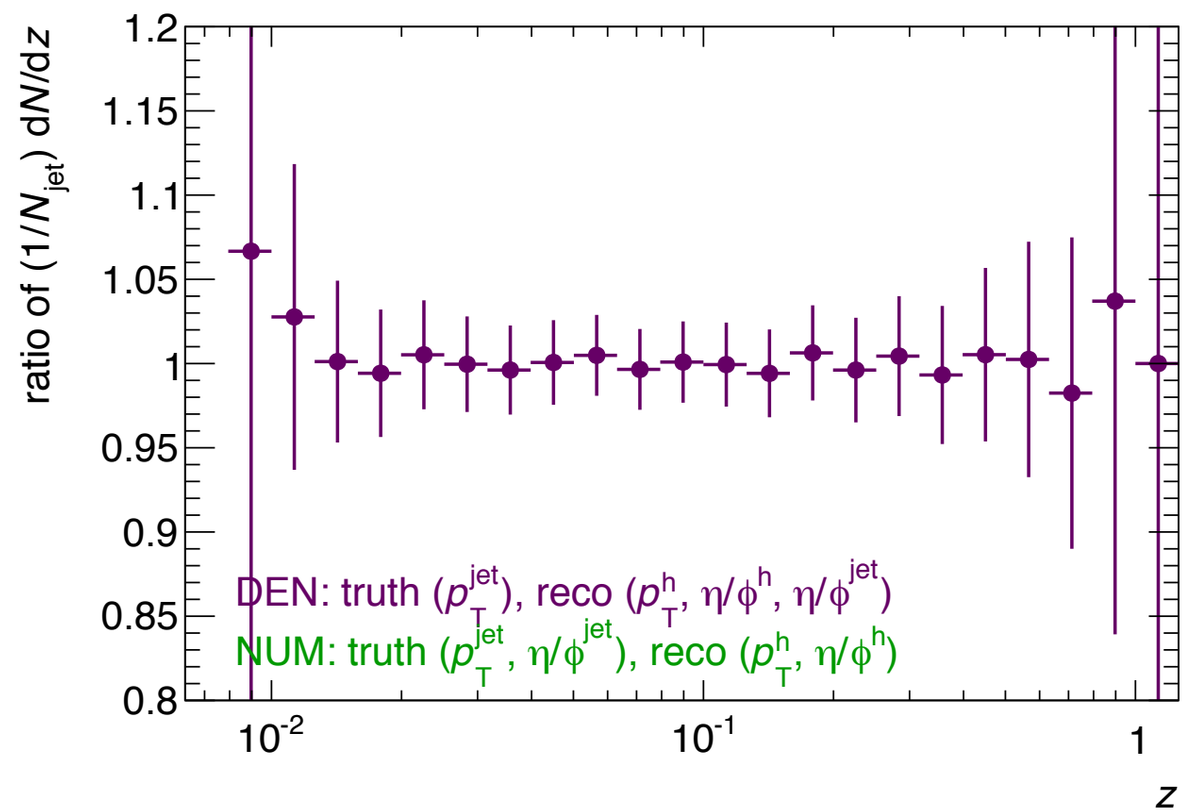






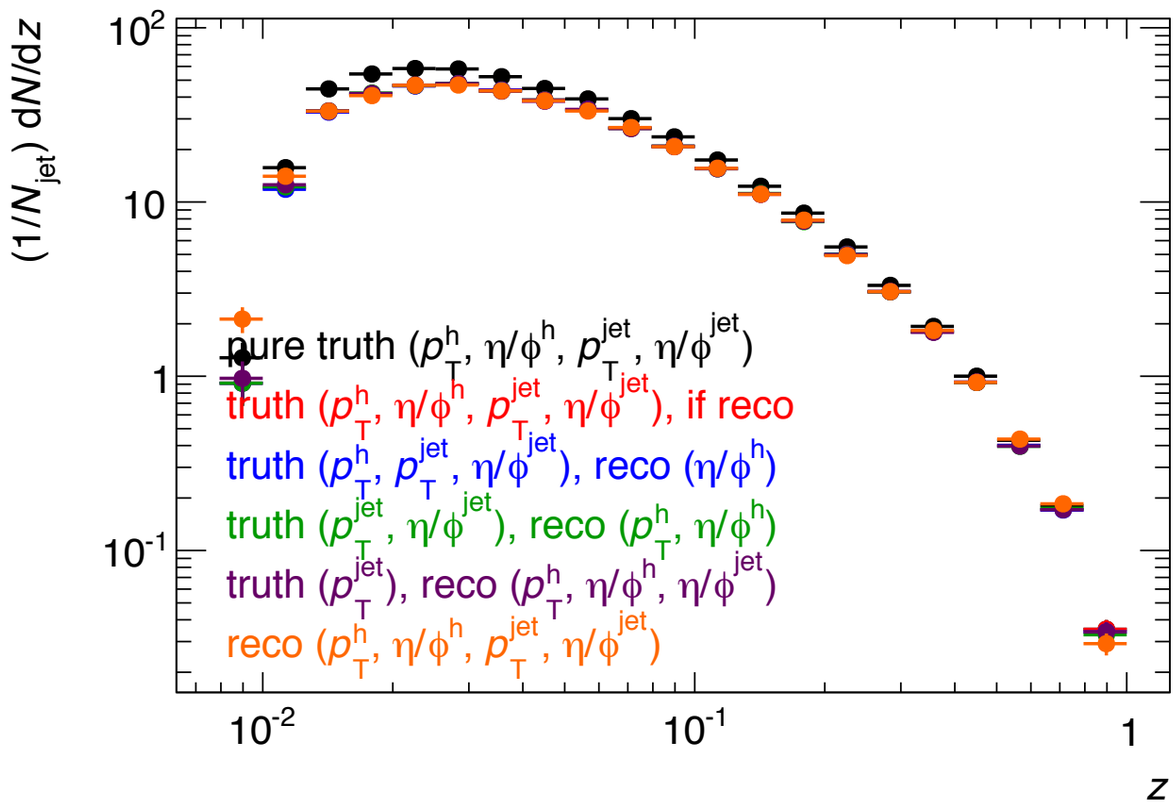
4. Resolution on jet angle

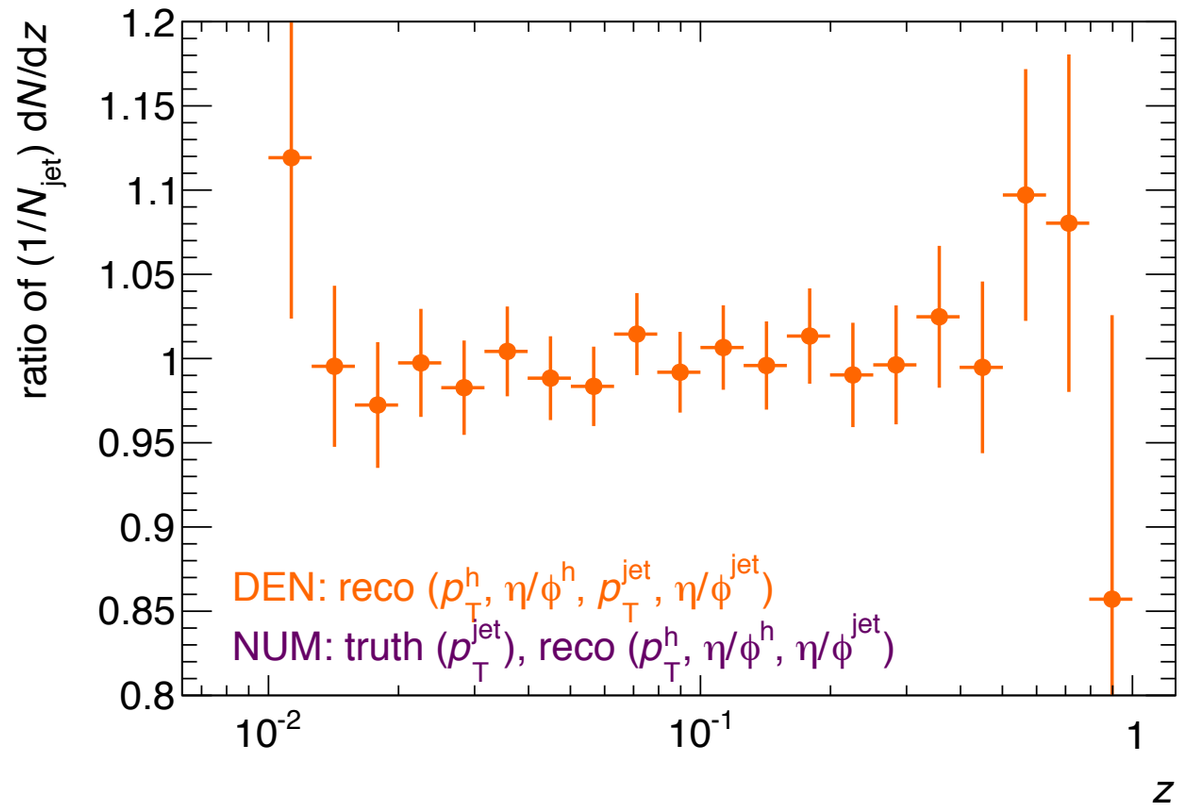




- No simulation of calorimeters, so no reconstructed jets
- Take step #3 and apply *ad hoc* Gaussian smearing of 0.02 radians to jet η and **ϕ**, independently
  - ➡ recalculate *z* with new jet angle (note: no change in jet p_T)
  - ➡ smearing in *z* at the %-level

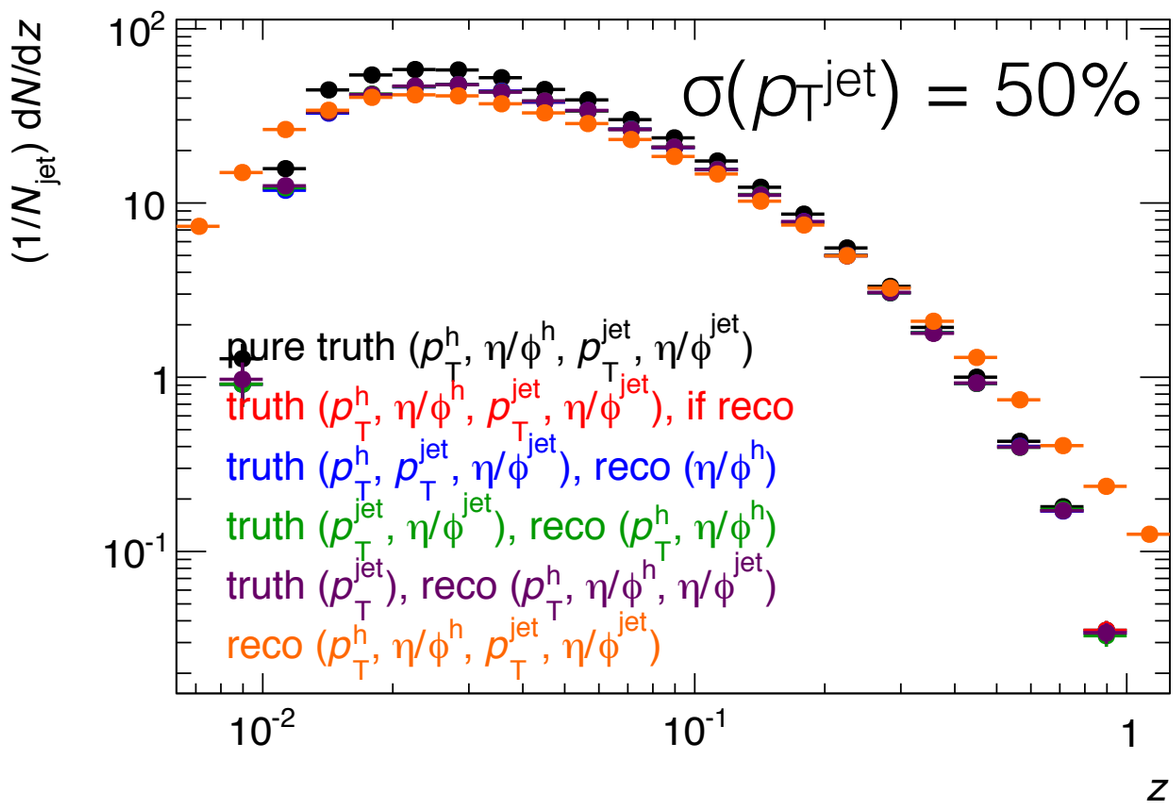
5. Resolution on jet momentum

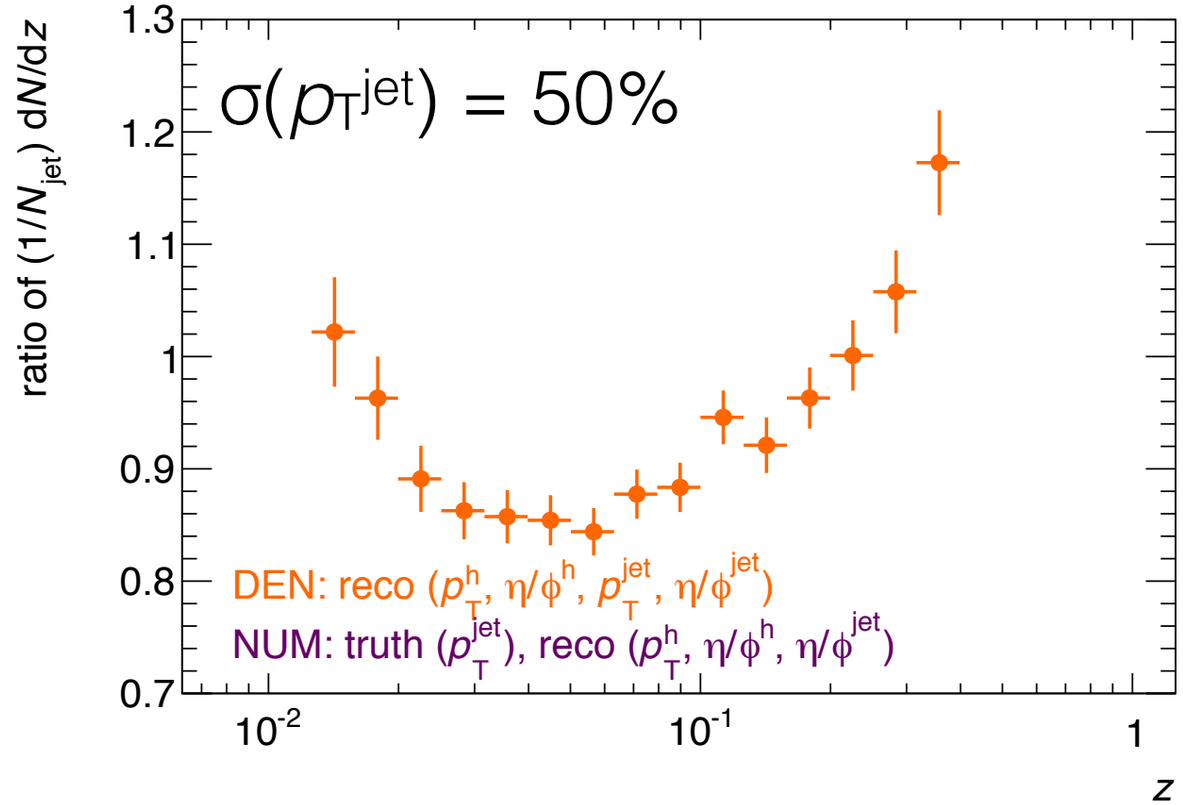




- Take step #4 and apply *ad hoc* 10% jet energy resolution, recalculate *z*
  - ➡ smearing in *z* at the few-% level, but noticeably larger at low-/high-*z*
  - ➡ naively expected this effect to be larger (see next slide)

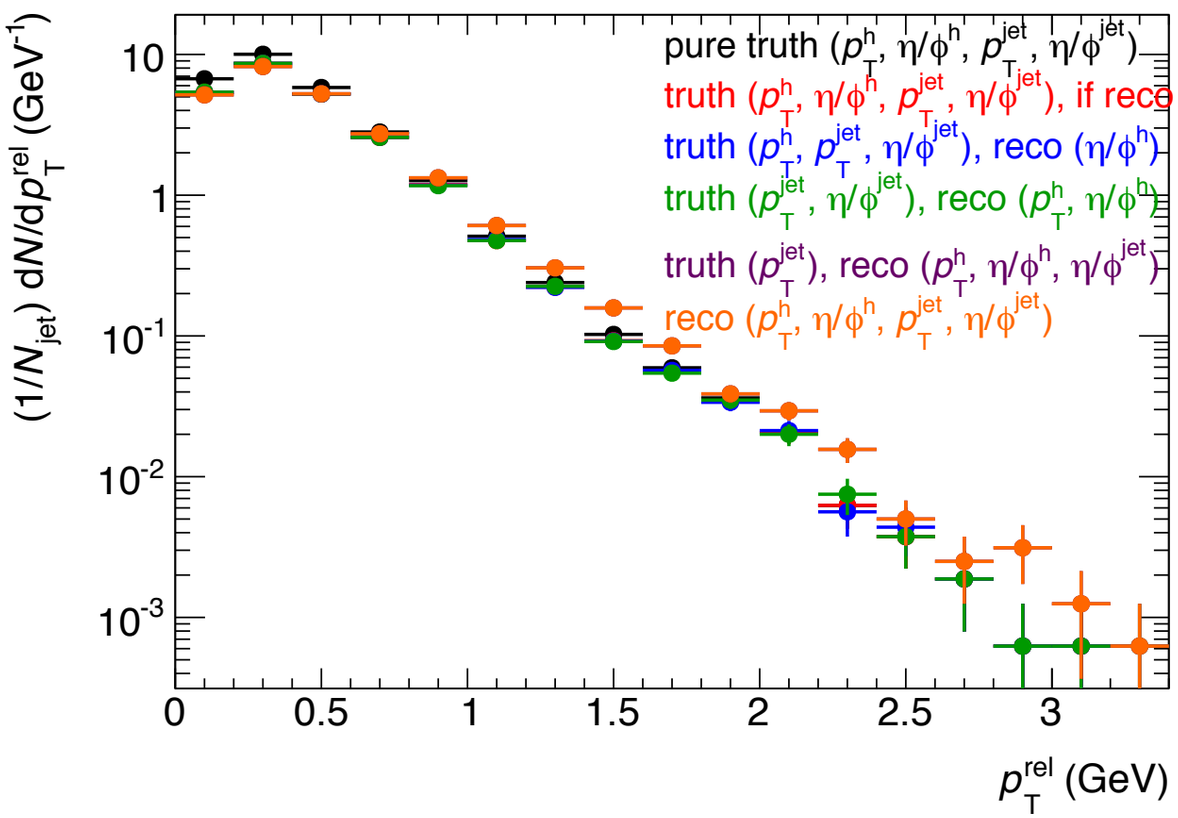
5. Resolution on jet momentum

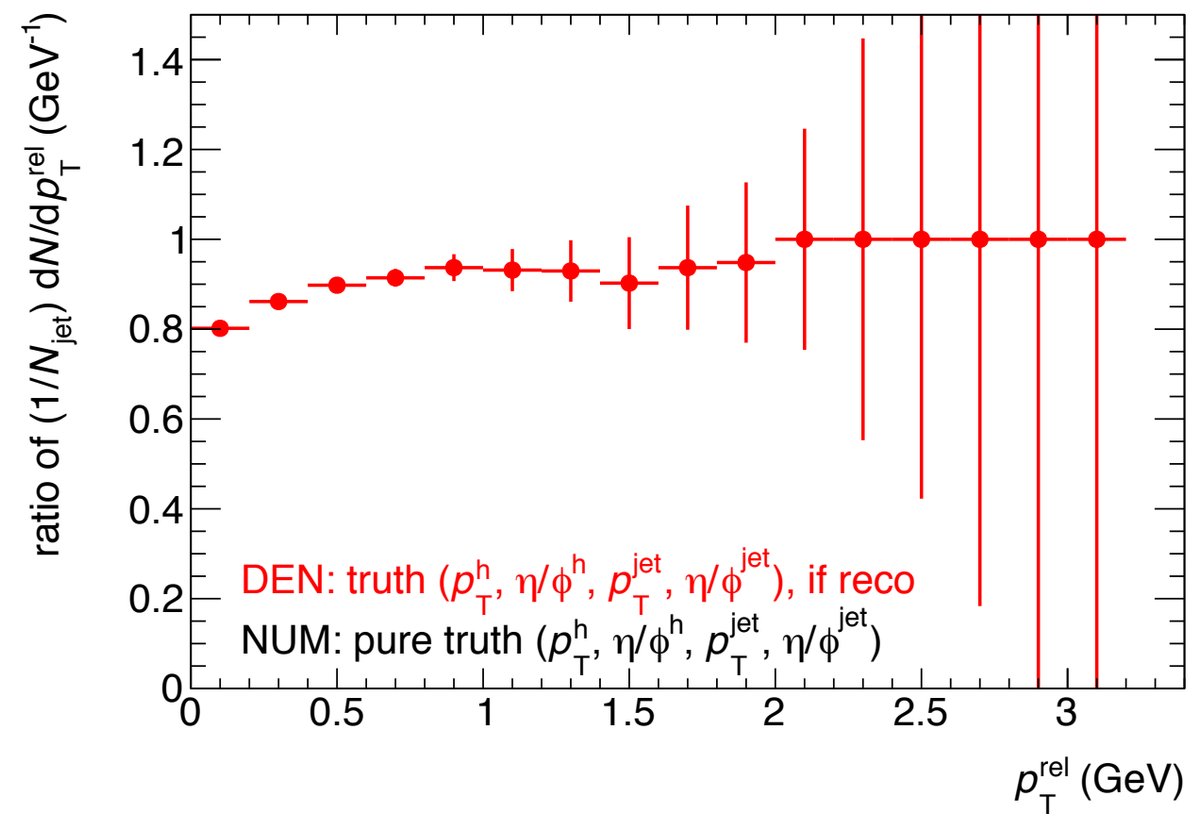




- Just to understand the effect, increase jet momentum resolution to 50%
  - ➡ as expected, “broadening” of measured z distribution
  - ➡ approximately 5x larger than effects of 10% resolution on previous slide
  - ➡ so, this effect is NOT important in *p*+*p* but will be important in Au+Au, where resolution is notably worse

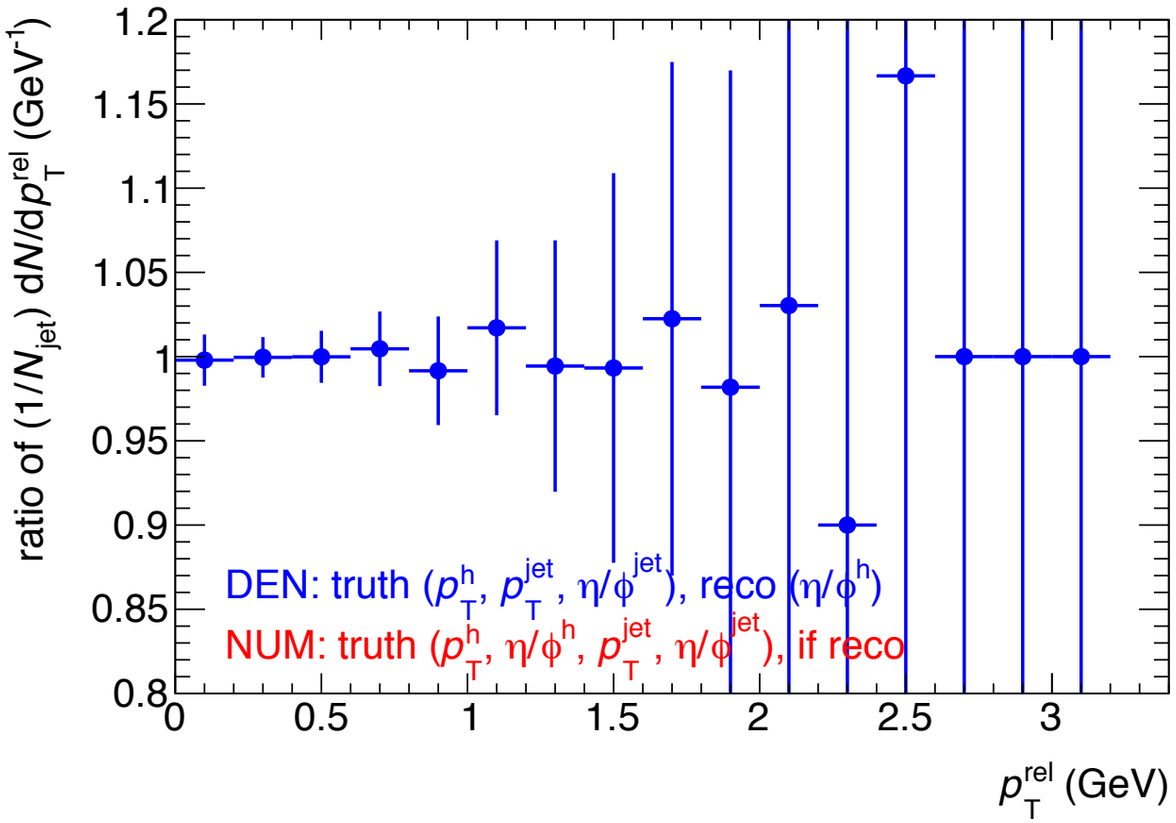
Detector effects on p_T^{rel} distribution

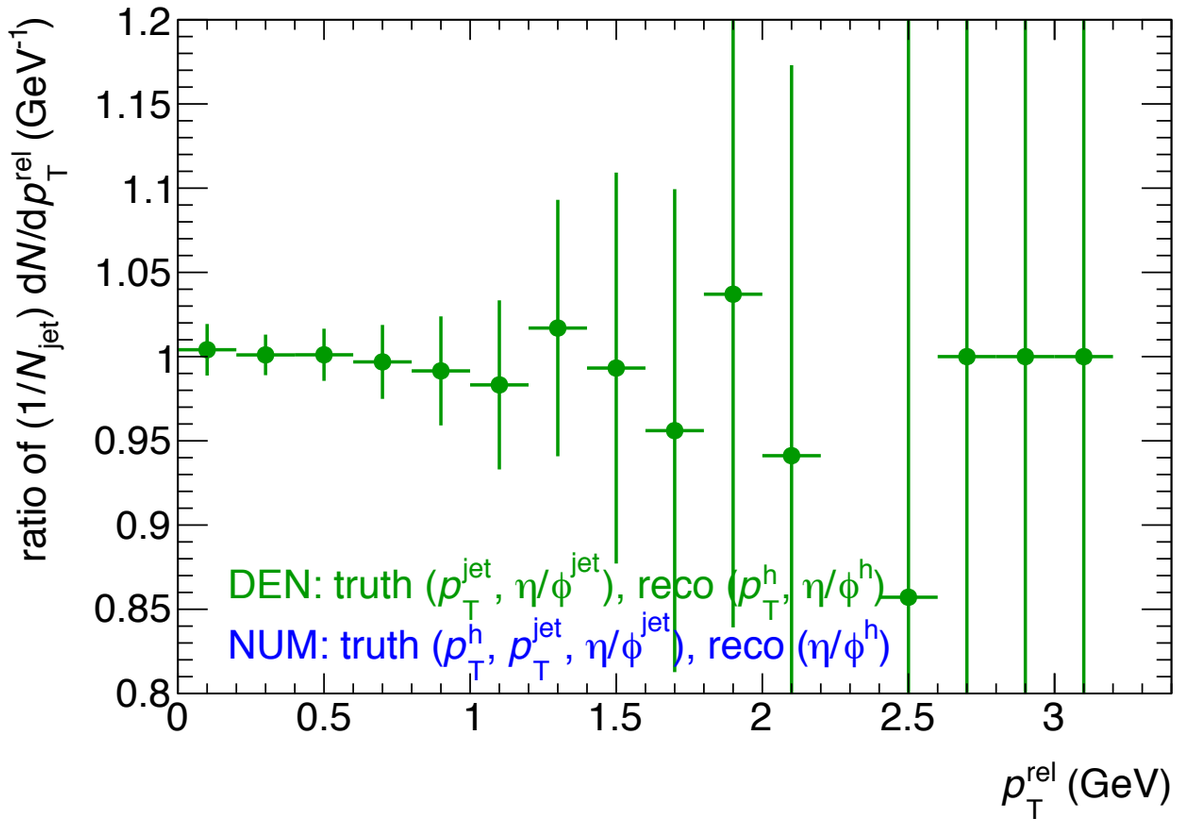




- Similar study with p_T^{rel} distribution
  - ➡ right plot: effect just of reconstruction efficiency (truth kinematics for particles and jets)

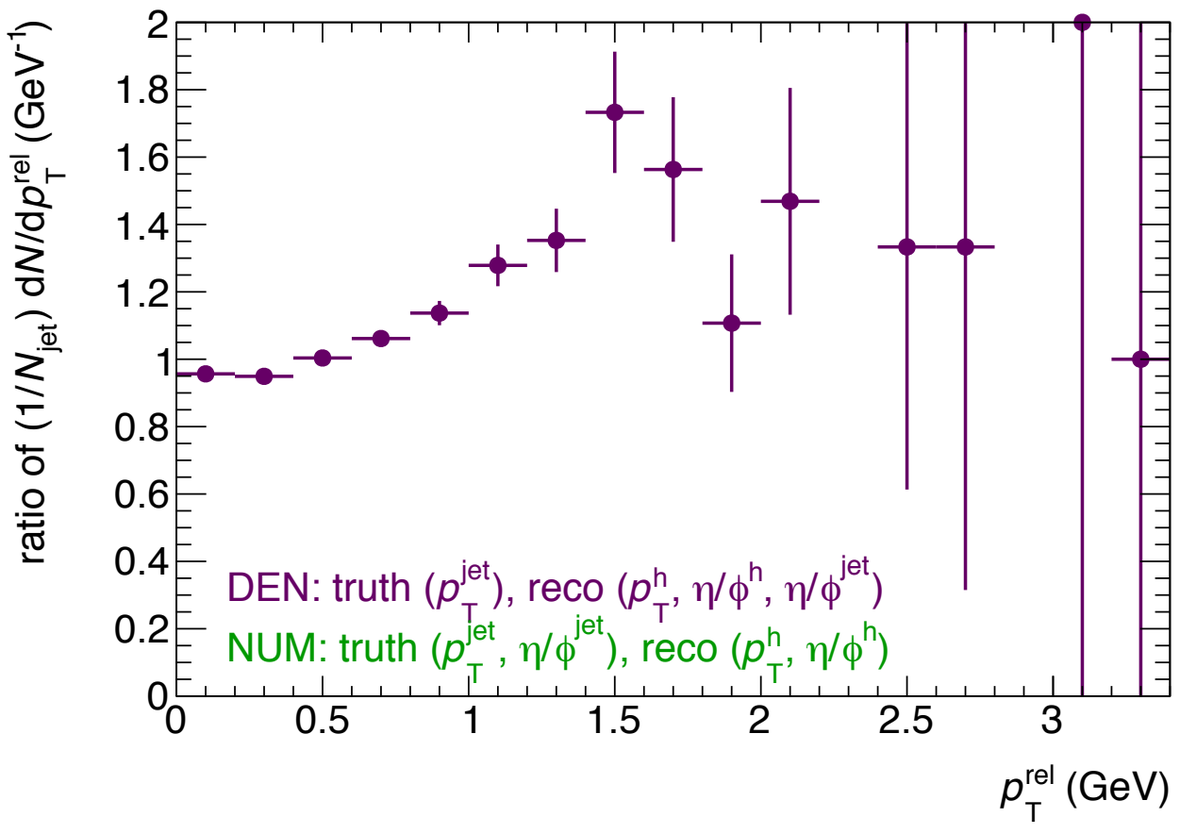
Detector effects on p_T^{rel} distribution

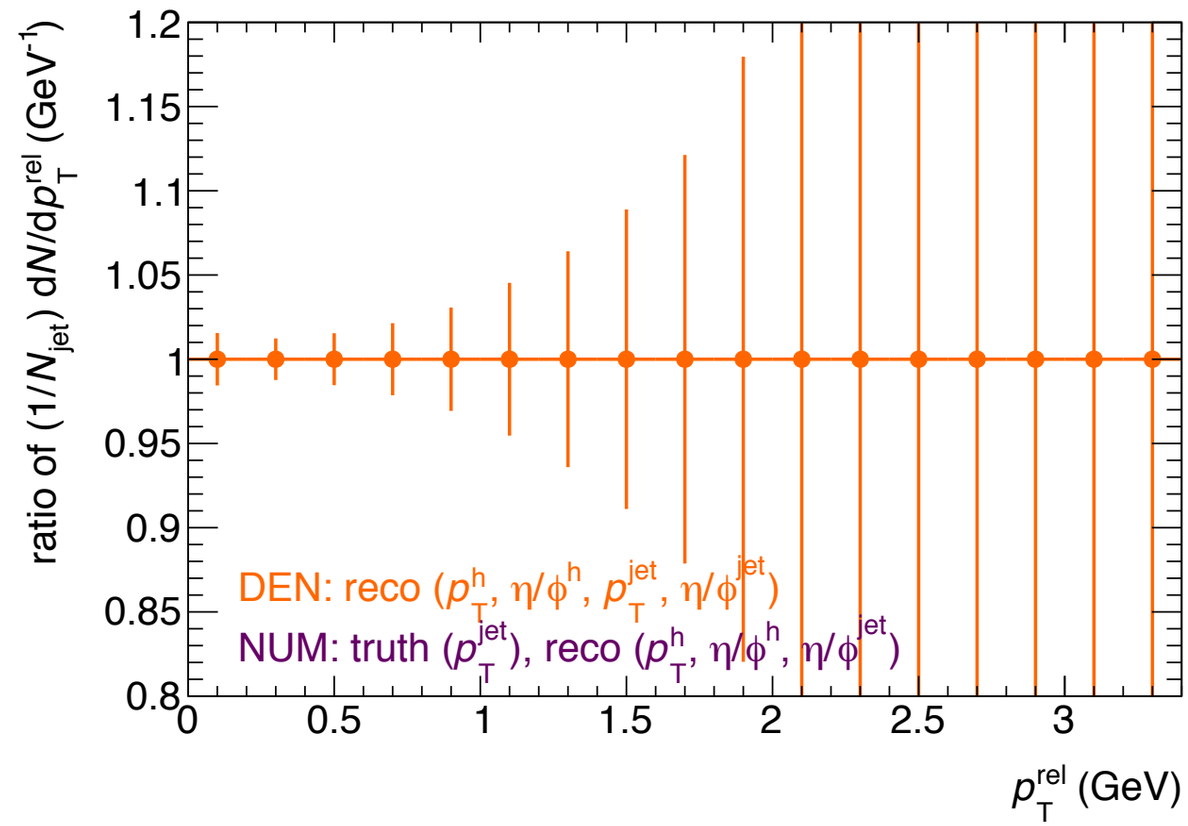




- Left: effect of particle angle resolution
  - ➡ %-level
- Right: effect of particle momentum resolution
  - ➡ few-% level, a specially at higher p_T^{rel}

Detector effects on p_T^{rel} distribution





- Left: effect of $\sigma_{\eta,\phi}$ = 0.02 jet angle resolution
  - ➡ very large effect within current (linear) binning
  - ➡ z goes as cos(ΔR) ~ 1- ΔR^2, p_T^{rel} goes as sin(ΔR) ~ ΔR, so more susceptible to small changes in ΔR?
- Right: effect of σ = 10% jet momentum resolution
  - ➡ nil by construction, since it cancels in observable definition

Next steps?

- Identify / quantify effect of fake tracks
- Analyze FF for Pythia8 jets embedded into HIJING Au+Au
  - ➡ large particle inefficiency & pT resolution, larger jet kinematics resolution, fake tracks?
  - ➡ would need to implement UE subtraction at low-z
- Compare & contrast other tracking options
  - ➡ which are ready to be used?
- Include calorimeters in simulation (full G4 or fast-sim with tails?)
  - ➡ to have more realistic handle on jet-part of the performance?
- <u>Proposal for “money” performance plot</u>:
  - ➡ train analysis procedure on Pythia8+HIJING (unmodifed FF)
  - ➡ see how well one can reconstruct modified FF’s (PYQUEN or JEWEL)