Low Q^2 Jet Smearing: Kinematics and Angularity

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EIC WG Meeting

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Simu Details

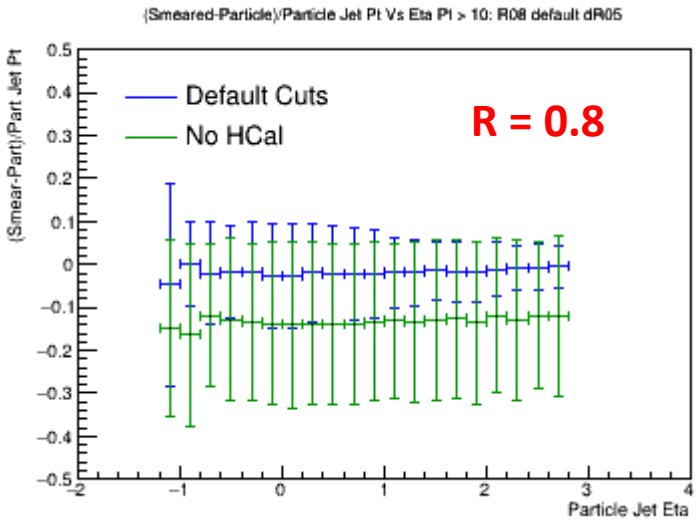
- Simulation
  - PYTHIA-6 (BNL Instance)
  - E_e = 18 GeV E_p = 275 GeV
  - $10^{-5} < Q^2 < 1.0$ GeV^2
- Jet Finder
  - Anti-k_T
  - Lab frame
  - R = 0.8, 0.4
  - Min Jet p_T = 10 GeV (unless specified)
  - Particle Level Input: All stable particles with |eta| < 3.5 (not scattered electron)
- Smearing
  - Eic-smear: Handbook detector (v1.2)
  - Charged hadron p_T > 250 (500) MeV, Photon Energy > 200 MeV, Hcal Energy > 500 MeV (or infinite to simulate no Hcal)
  - Charged hadrons detected by tracker, photons detected by Emcal, Neutrons, KLongs and untracked charged hadrons detected by Hcal
  - No position smearing!

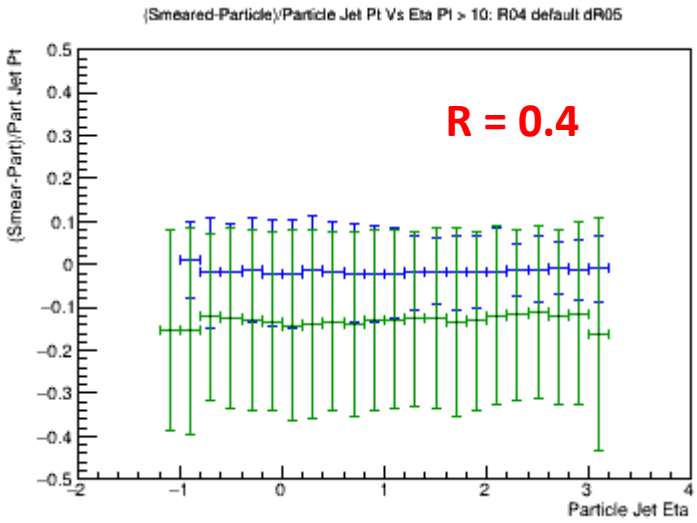
Particle – Smear Correlations

- For each particle (smeared) jet which has p_T and eta within acceptance, loop over all smeared (particle) jets and find the one closest in deltaR
- Require deltaR < 0.5
- Select particle and loop over smear – show how a given particle level jet will be modified
- Select smeared and loop over particle – show potential biases introduced by the detector / selection criteria
- Will show several plots of 'Sigma A vs B' – Sigma is defined as (Smeared quantity – Particle quantity) / Particle quantity; error bars are RMS of sigma distribution

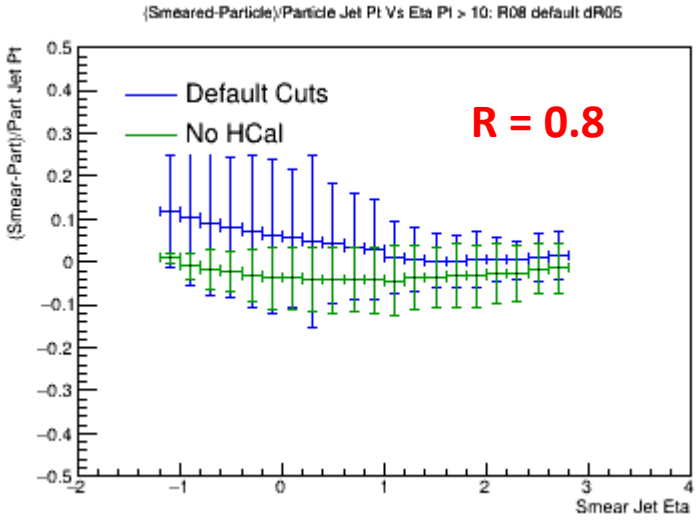
Sigma p_T vs Eta

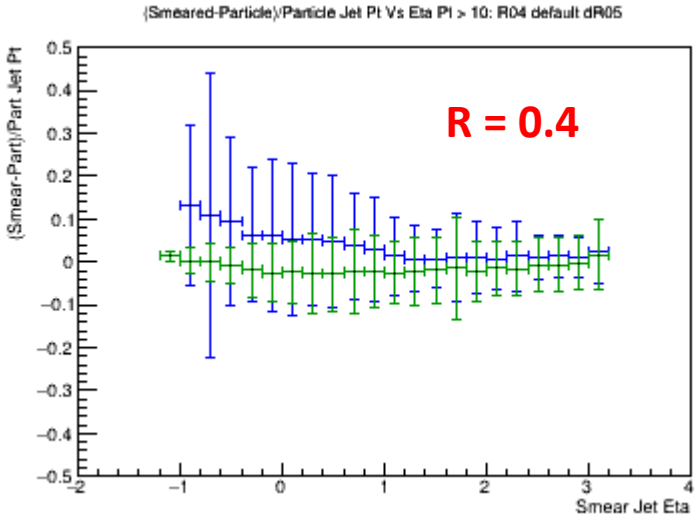
Select Particle



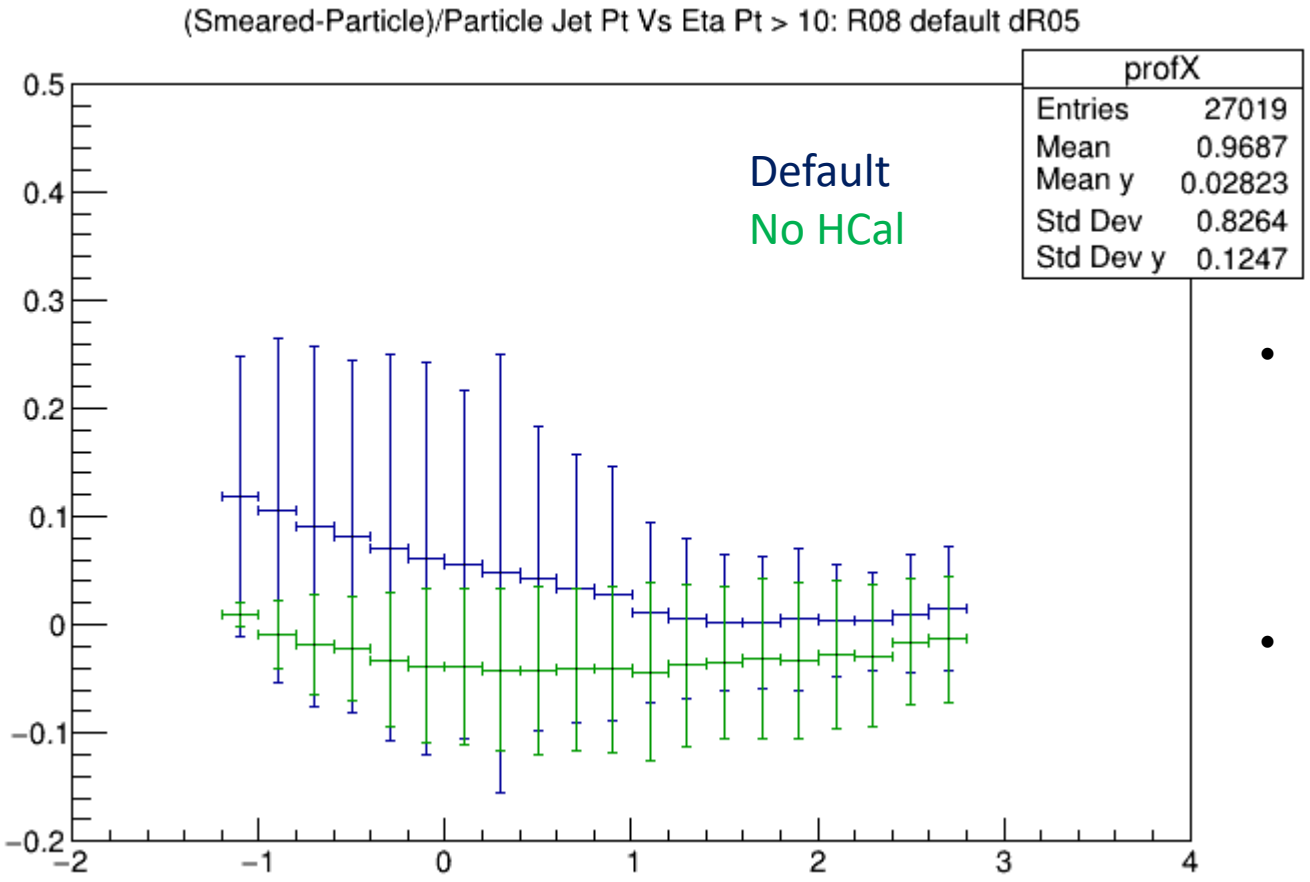


Select Smear



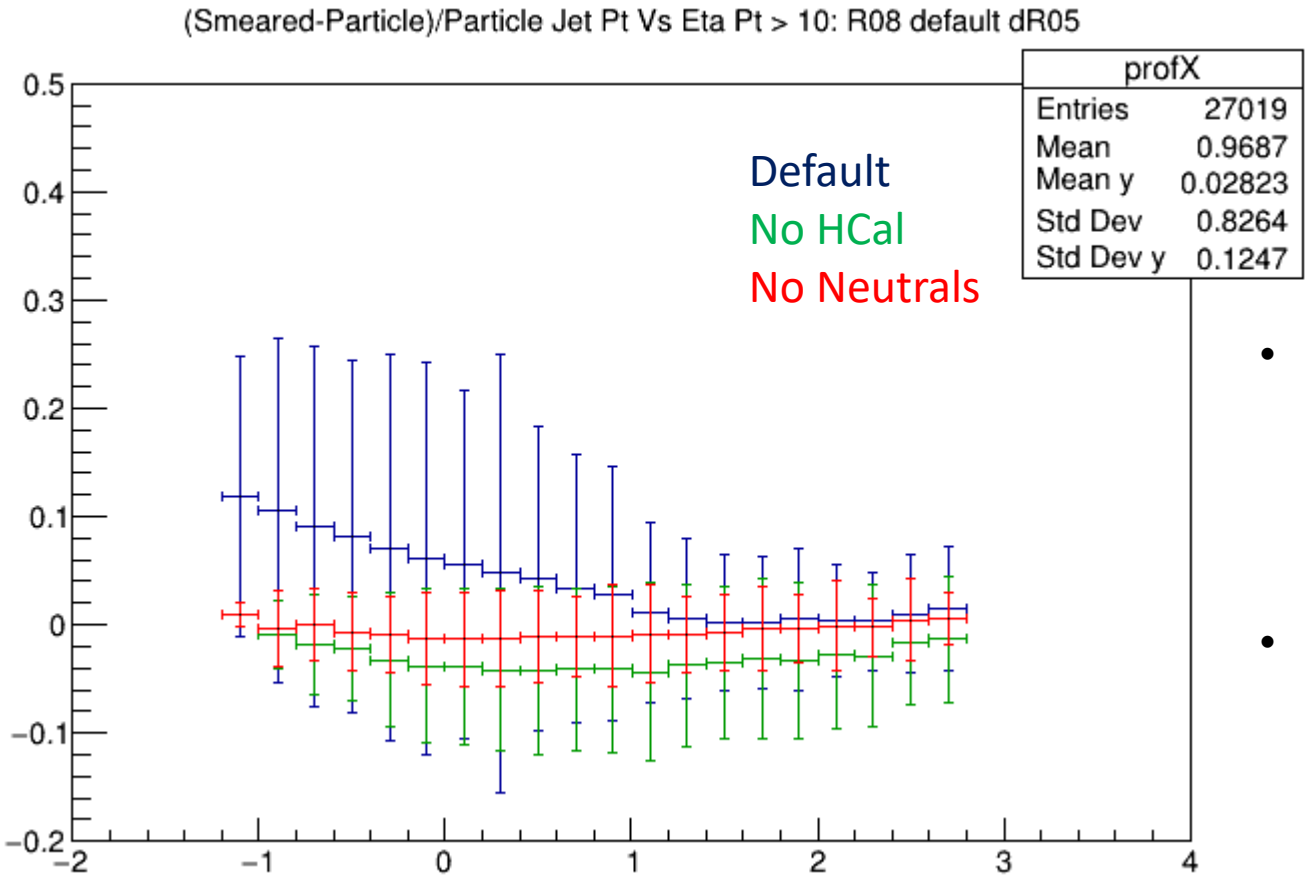


Reconstruction Bias



- When selecting smeared jets, we see a bias toward lower p_T particle level jets at low eta for default cuts
- Sample for which HCal info is ignored shows much less bias and smaller RMS

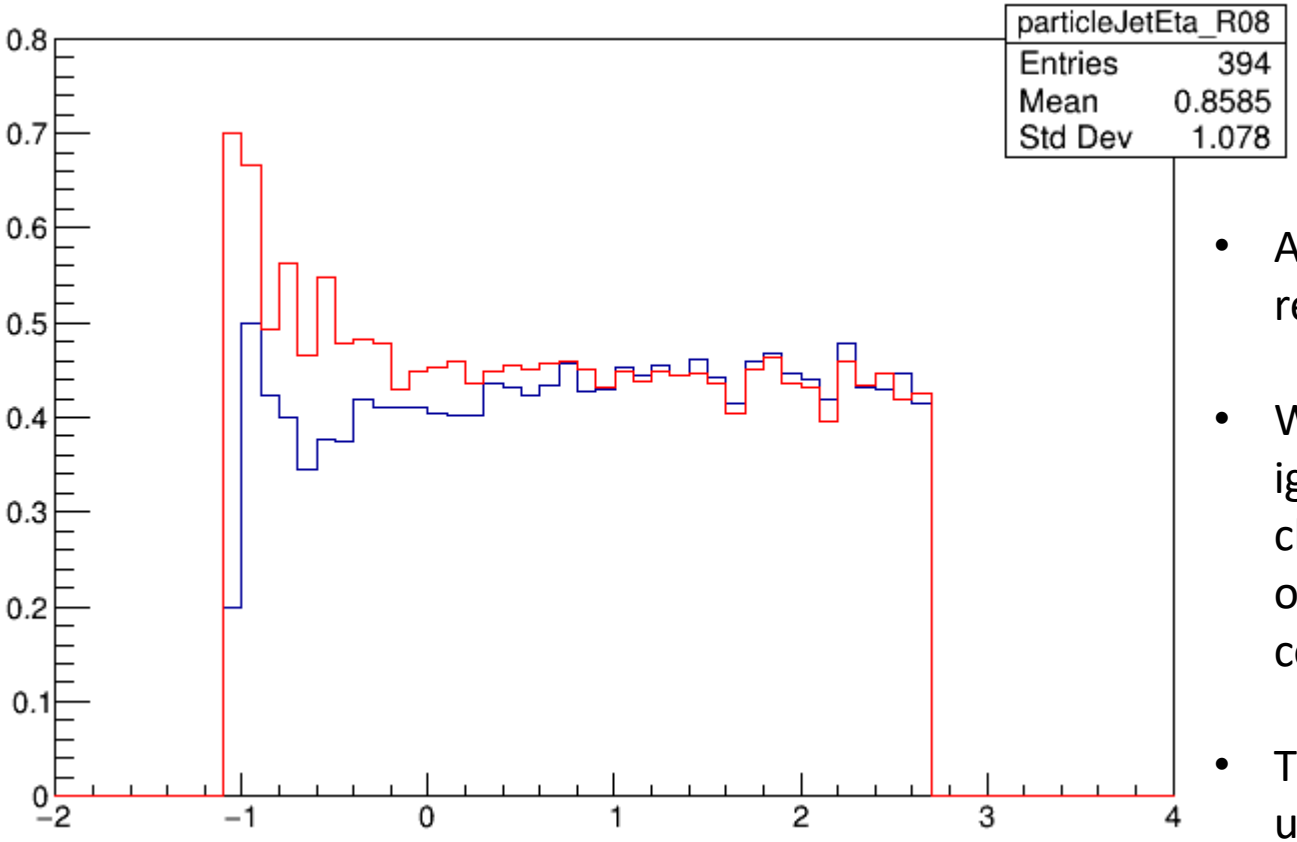
Reconstruction Bias



- When selecting smeared jets, we see a bias toward lower pT particle level jets at low eta for default cuts
- Sample for which HCal info is ignored shows much less bias and smaller RMS

- Selecting only those smeared jets which do not have a neutral hadron basically eliminates bias and substantially reduces RMS
- Hypothesis – default cuts impose bias toward sub threshold particle jets containing neutral hadrons that get smeared to higher energy

Selection Bias

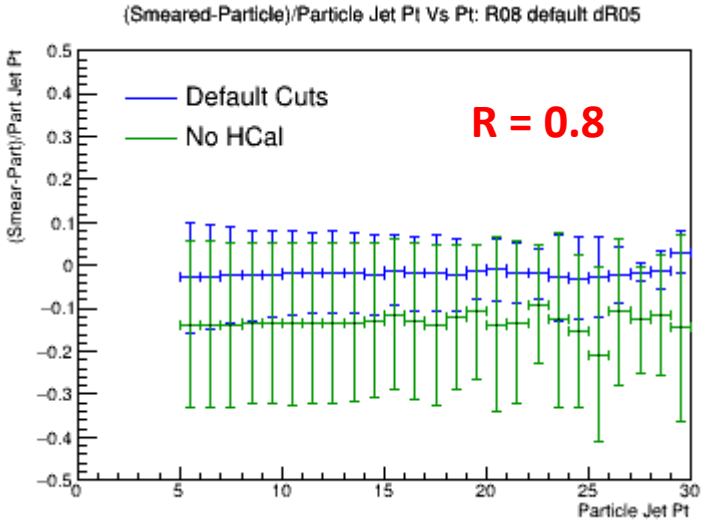


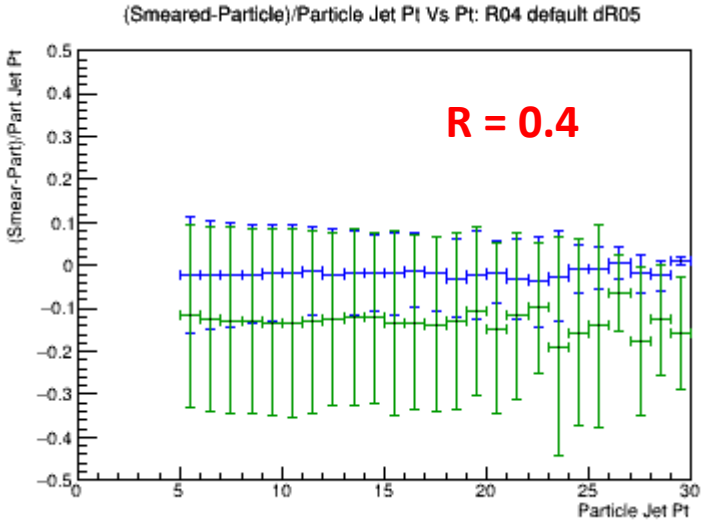
- Blue curve shows the fraction of particle level jets with p_T > 10 GeV that contain at least 1 neutral hadron (no matching required)
- Red curve is same for smeared jets

- Above plots showed bias in reconstructed vs 'true' p_T
- We can reduce this bias by ignoring HCal info when clustering, or by selecting only jets which do not contain a neutral hadron
- This however, biases the underlying particle level sample
- Still need to determine how much the noHCal option biases

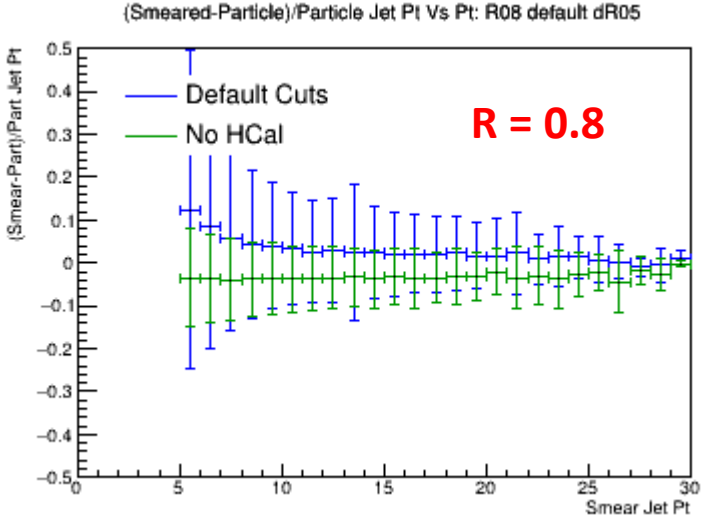
Sigma p_T vs p_T

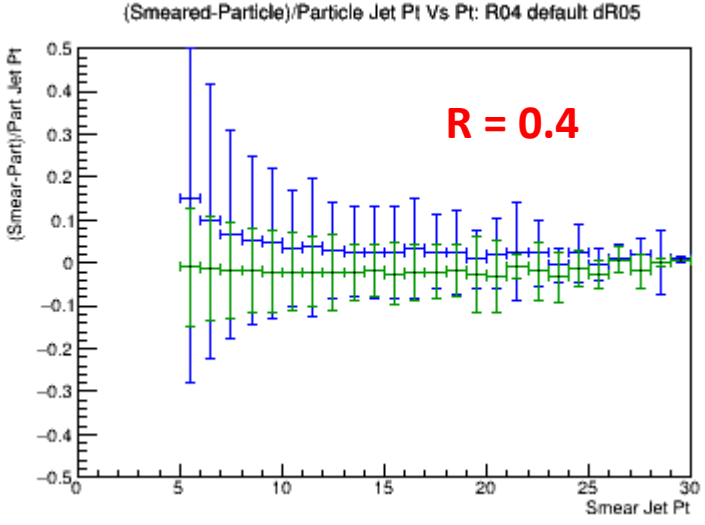
Select Particle



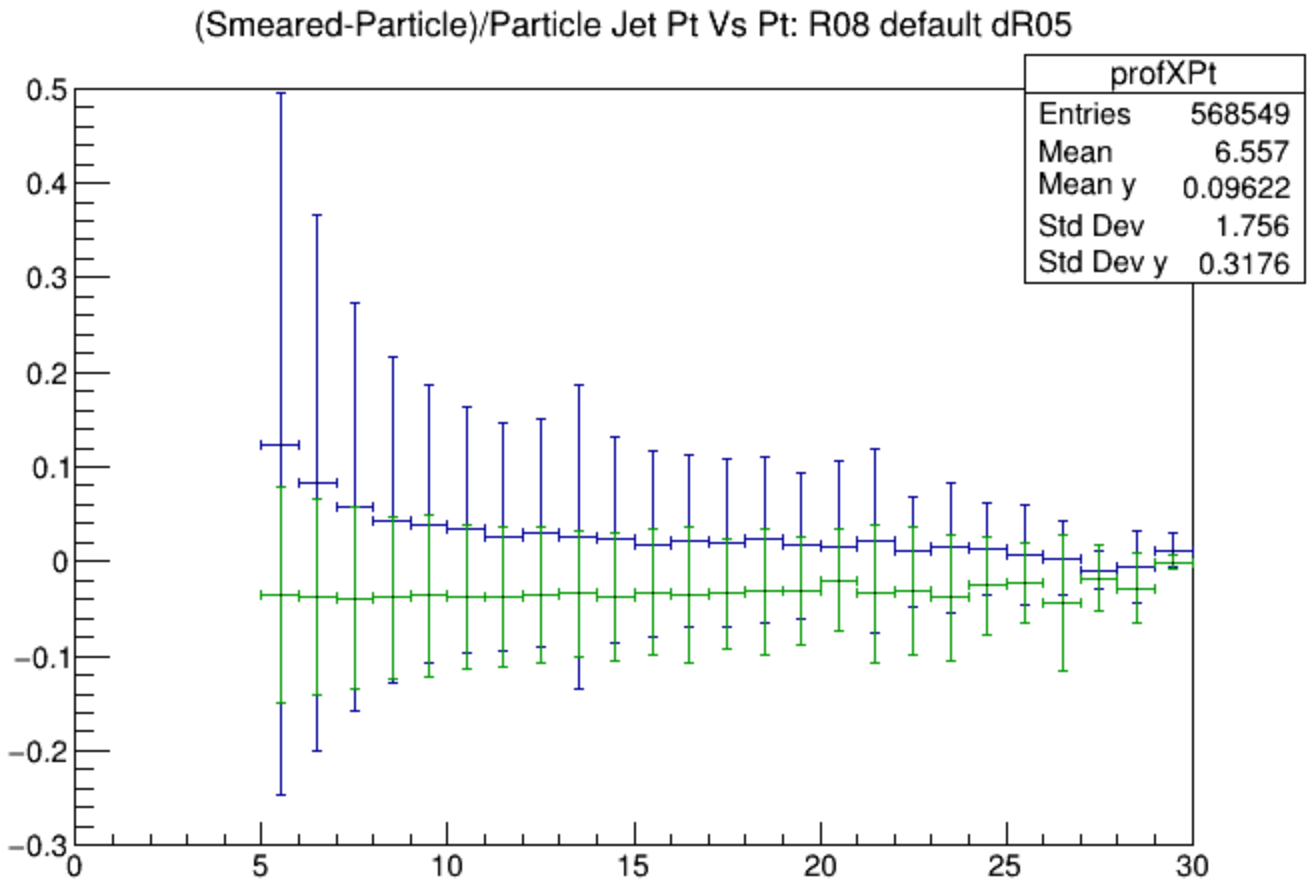


Select Smear

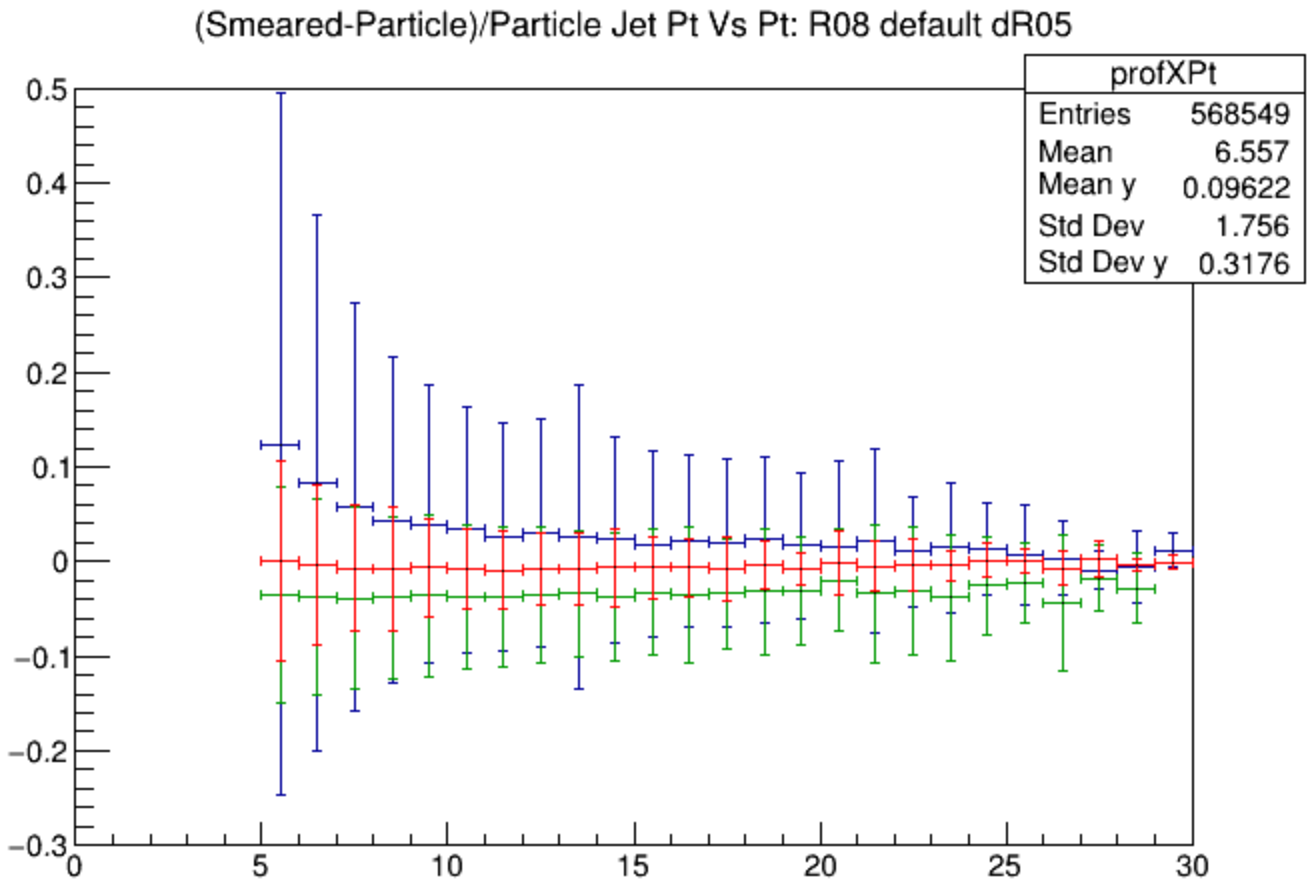




Reconstruction Bias

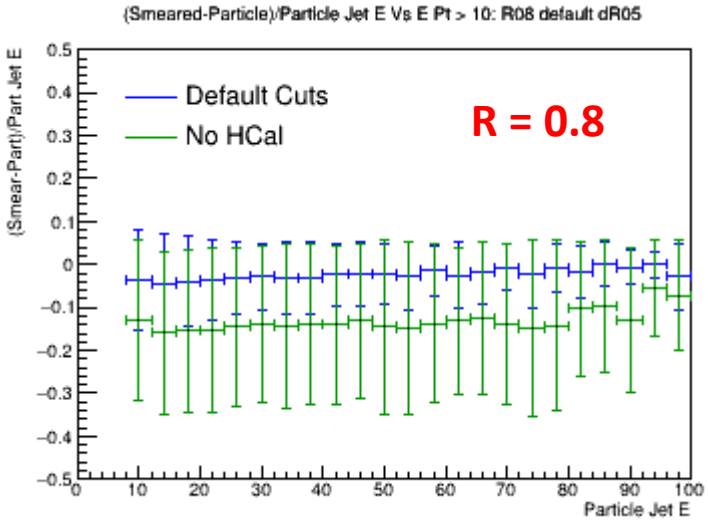


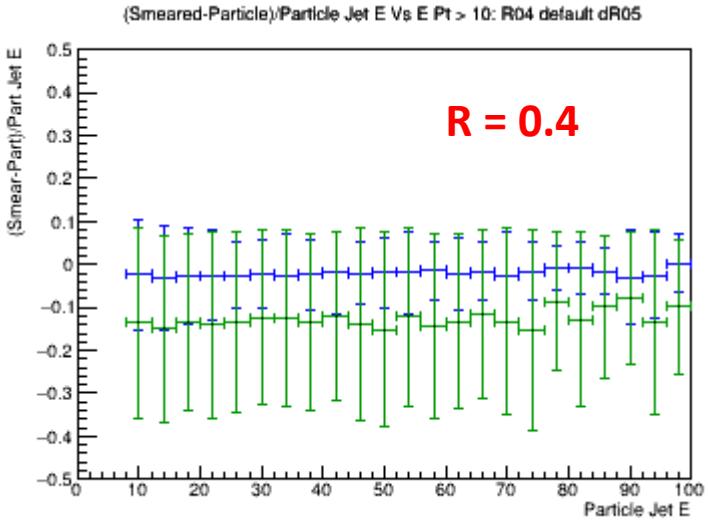
Reconstruction Bias



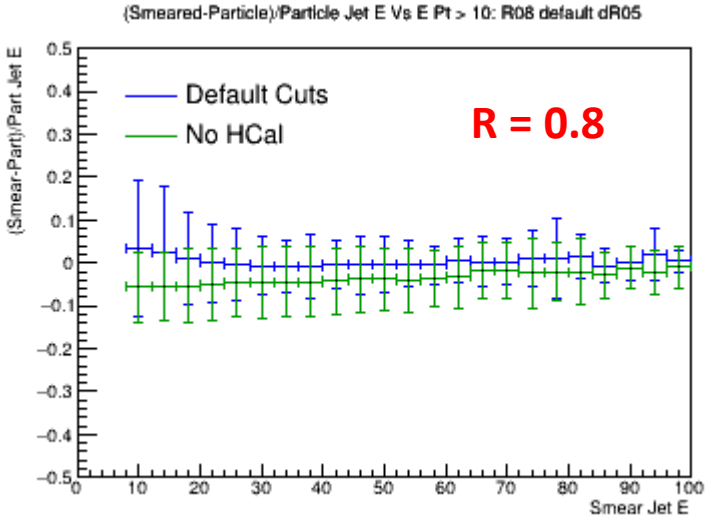
Sigma E vs E

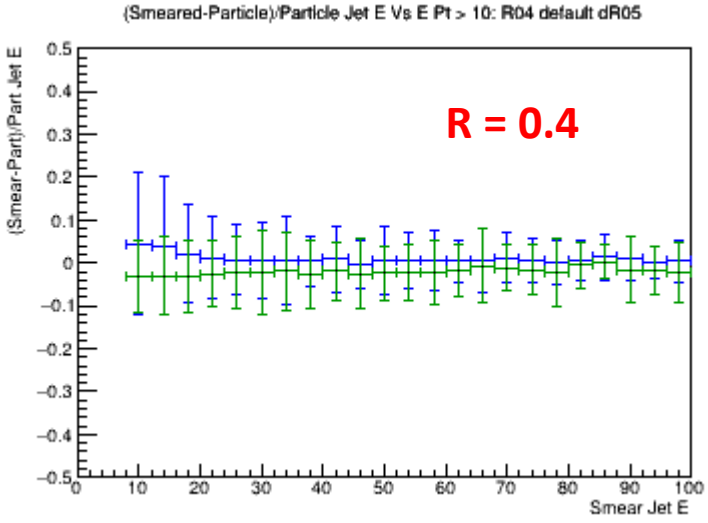
Select Particle





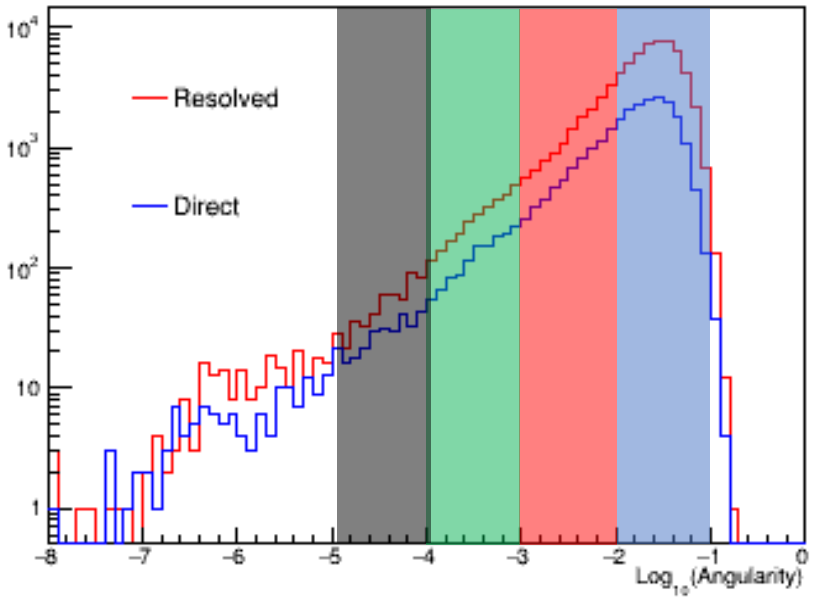
Select Smear





Angularity Overview

Angularity: R = 0.8; a = -2.0

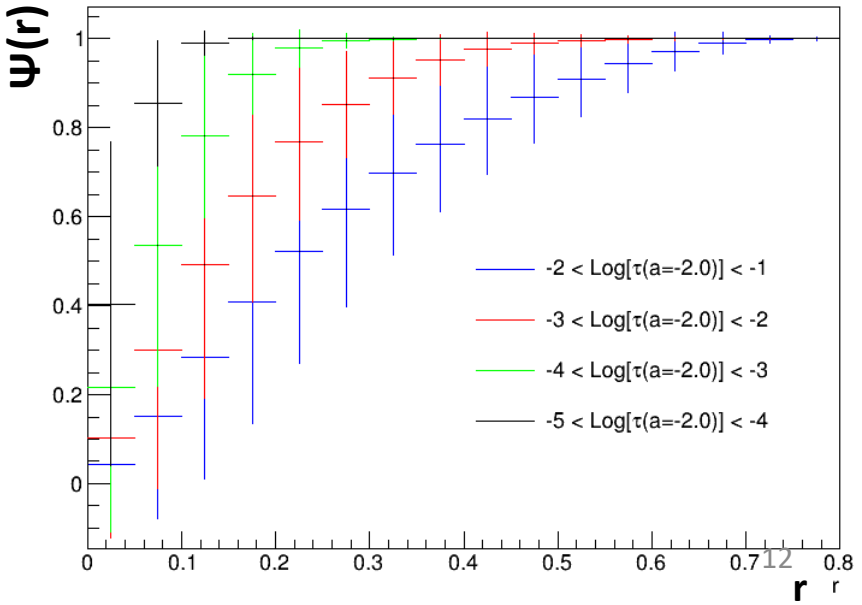


$$\tau_a \equiv \frac{1}{p_T} \sum_{i \in J} p_T^i \left(\Delta R_{iJ}\right)^{2-a}$$

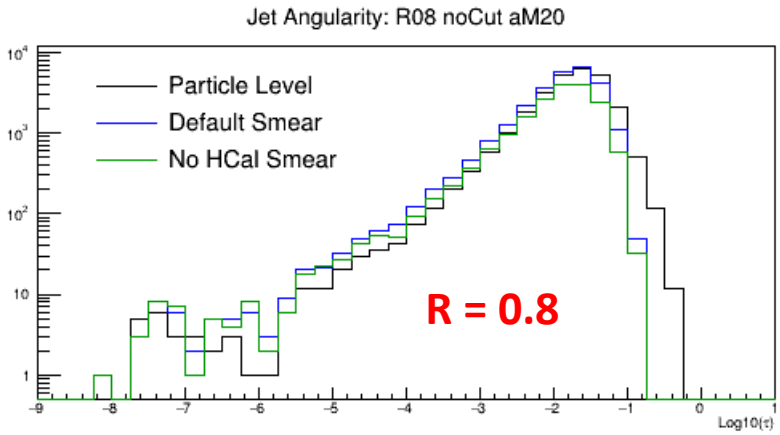
- Angularity sums over each p_T of the particles in the jet weighted by the distance of the particle from the jet thrust axis
- The ‘a’ parameter controls how heavily the distance is weighted

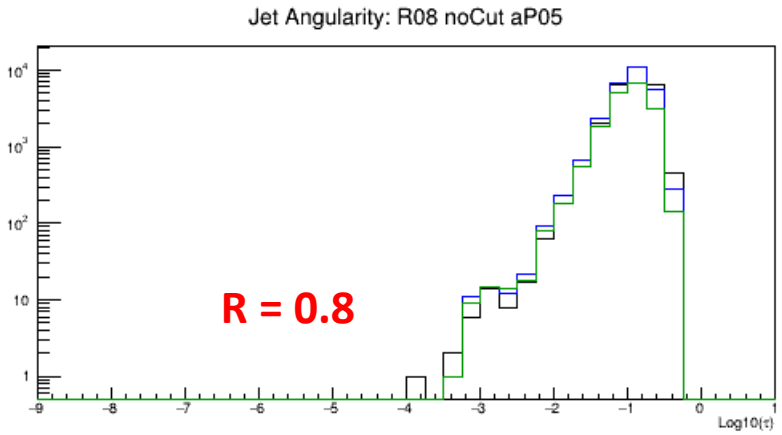
- Log of the angularity spectrum with ‘a’ = -2.0 is shown above for resolved and direct jets with R = 0.8
- The jet profiles of the jets in the 4 colored regions are shown to the right
- Jet Profile is the fraction of p_T contained in a radius ‘r’ from the center of the jet
- For a given ‘R’ and ‘a’, jets with lower angularity are more collimated

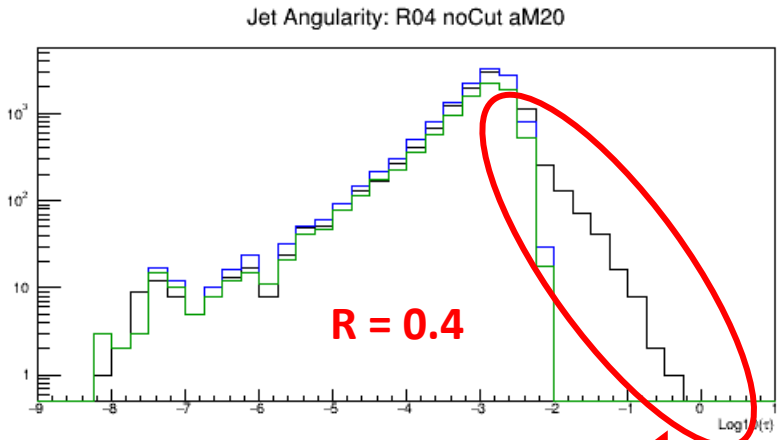
Jet Profile

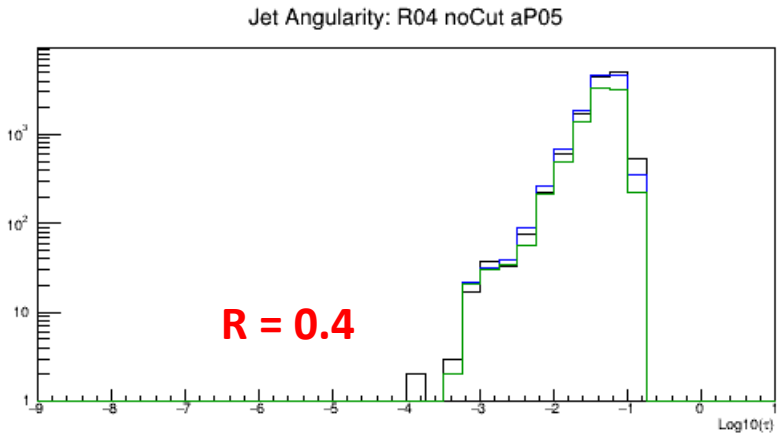


Angularity Spectra







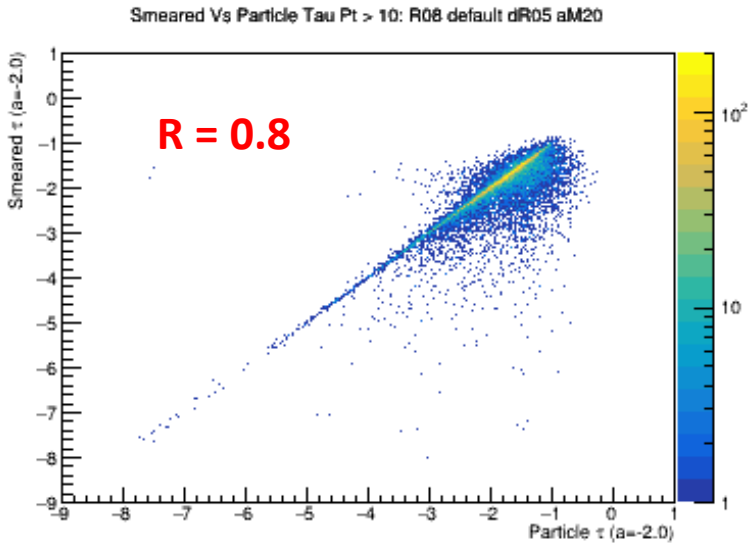


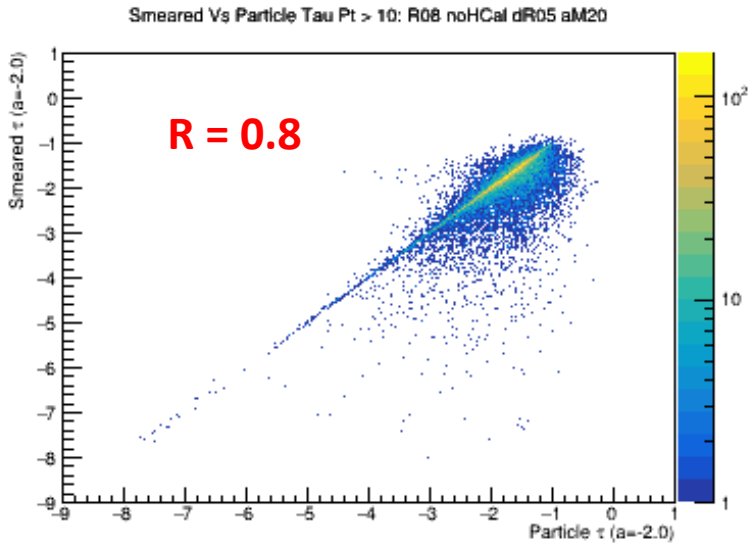
a = -2.0

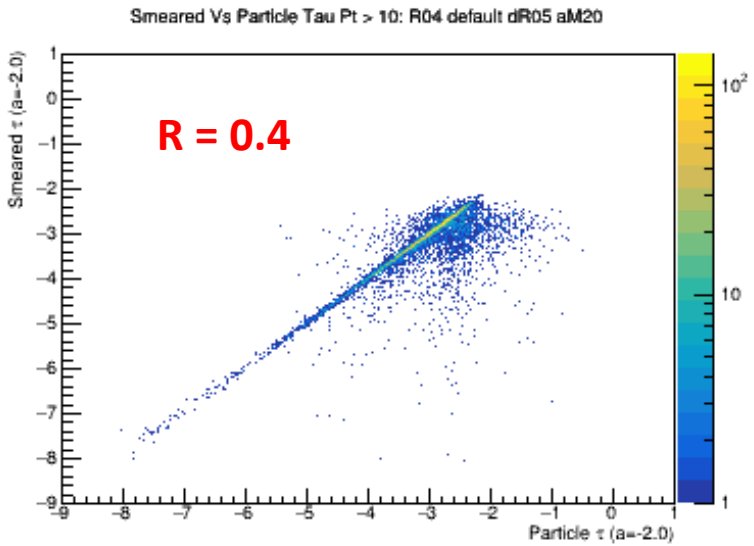
a = 0.5

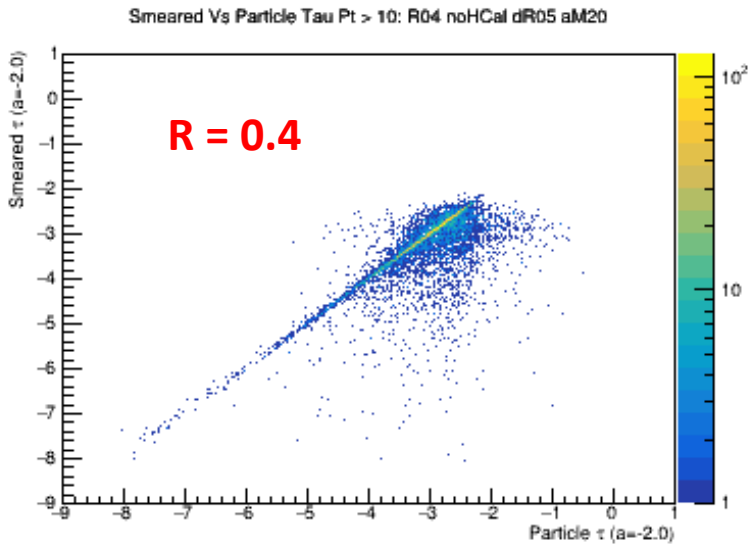
- More investigation needed – my guess is this is coming from soft, wide angle particles – look into grooming

Angularity Correlations: a = -2.0



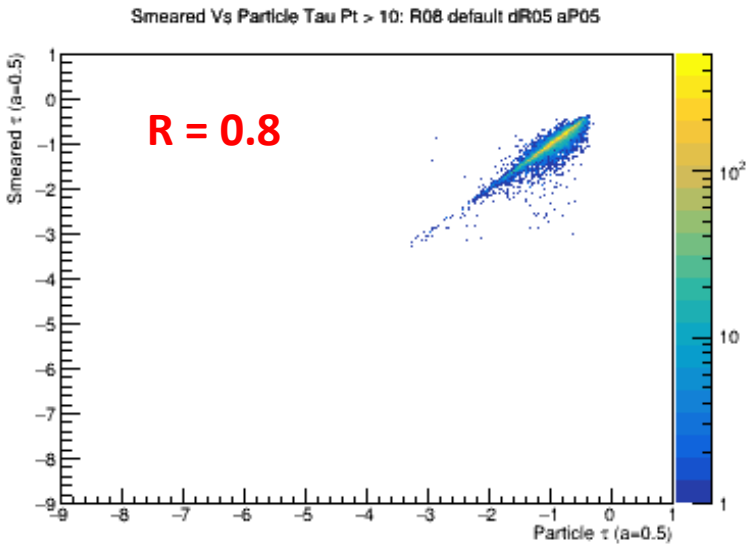


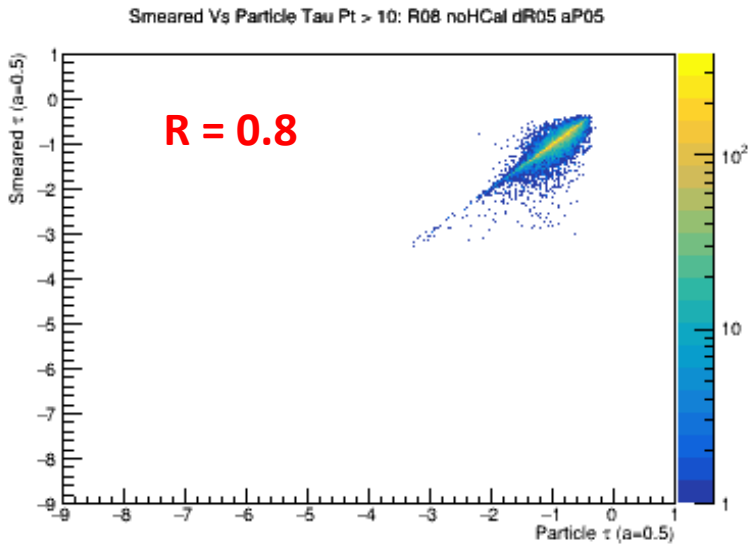


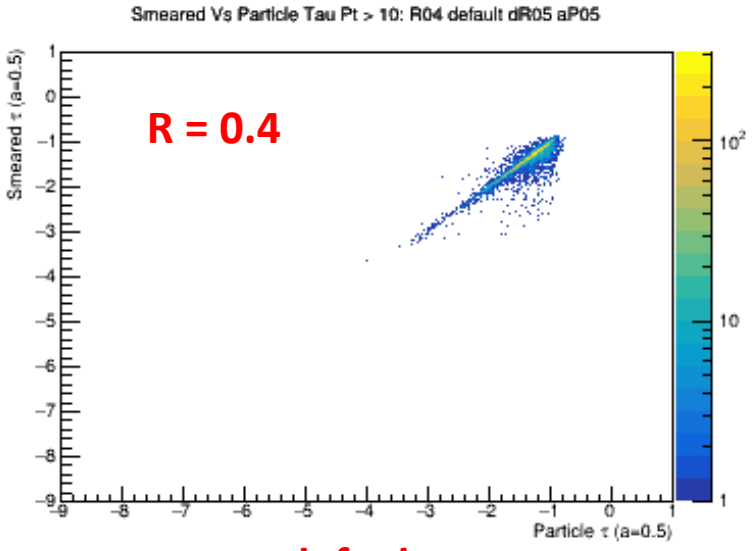


default **No HCal**

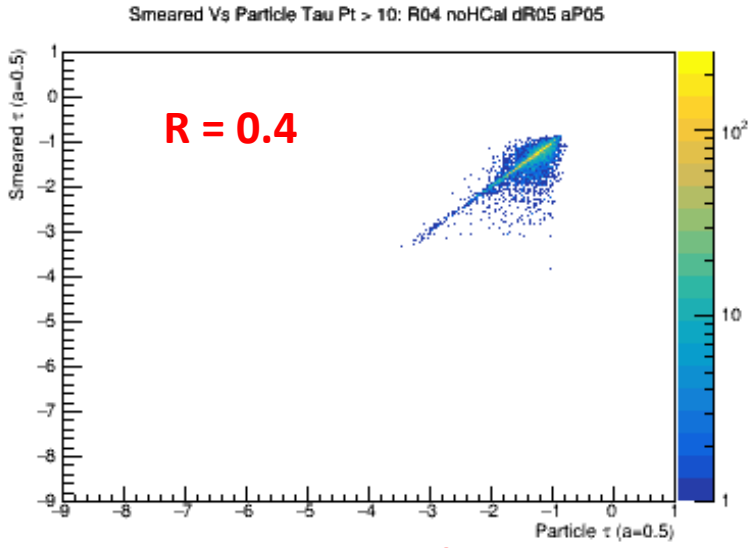
Angularity Correlations: a = 0.5







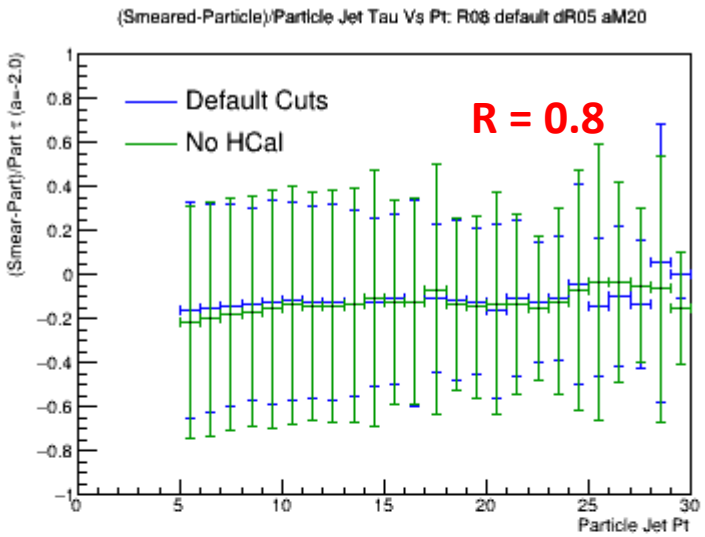
default

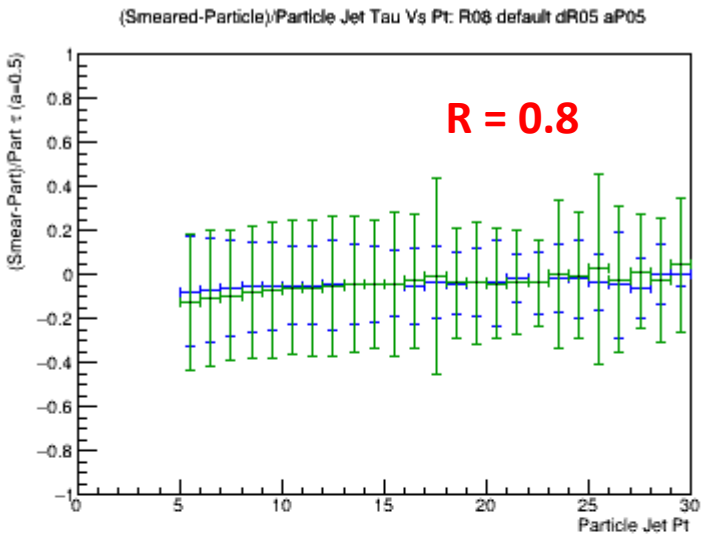


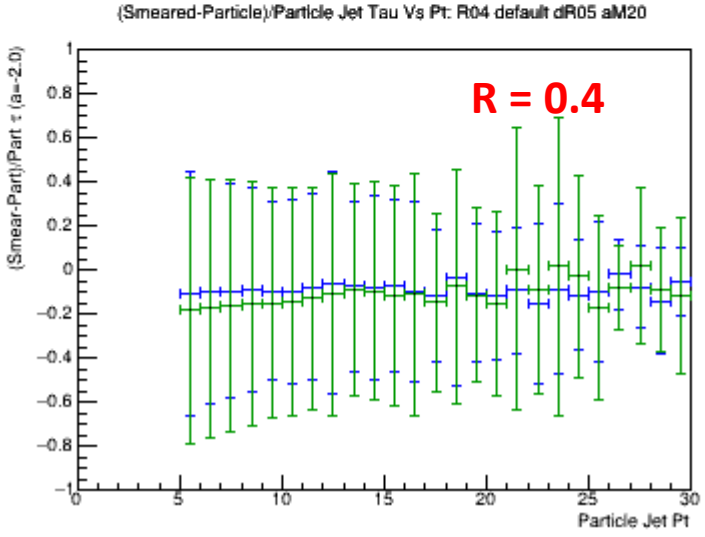
No HCal

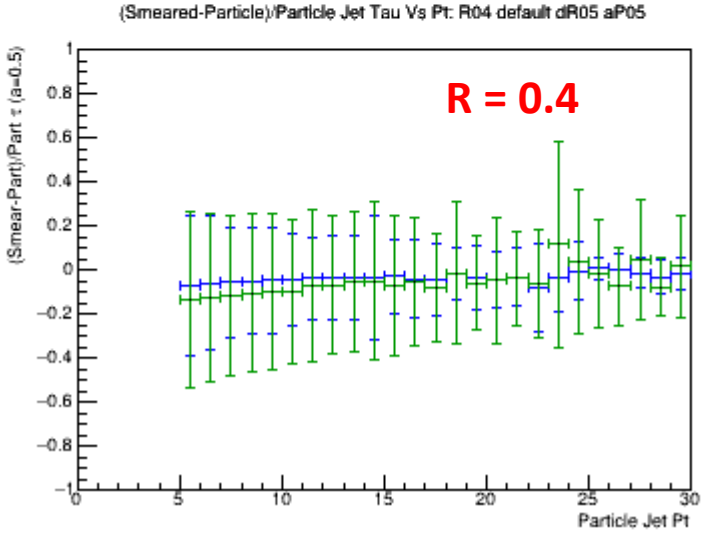
Sigma τ Vs p_T: Select Particle

Select Particle







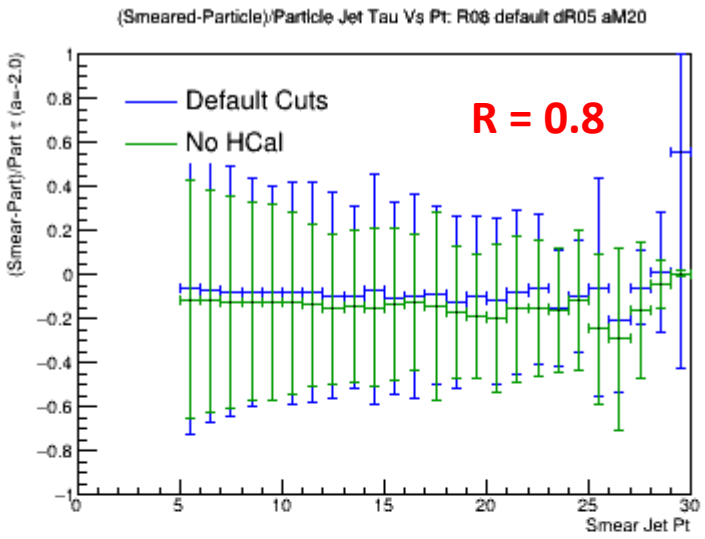


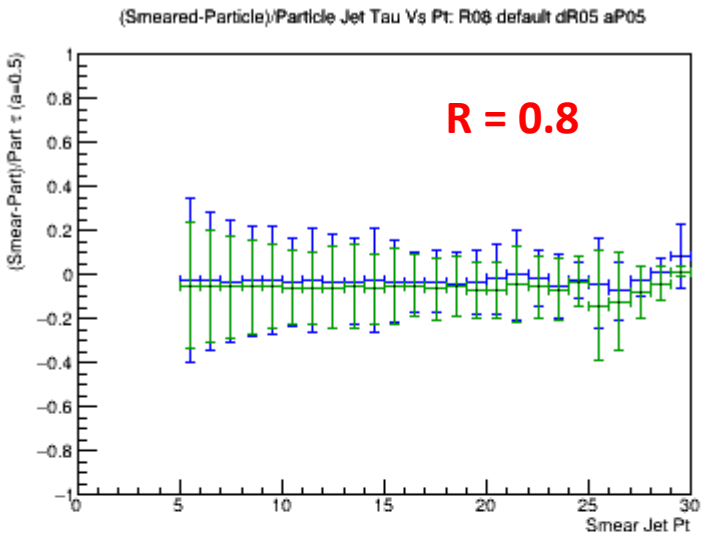
a = -2.0

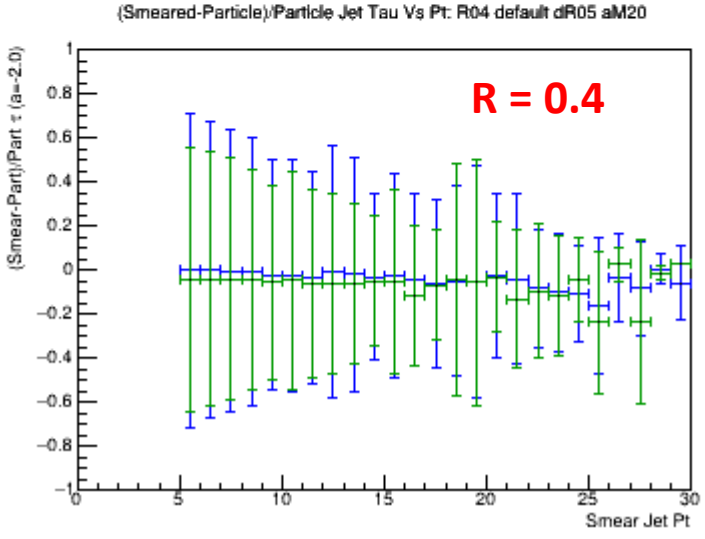
a = 0.5

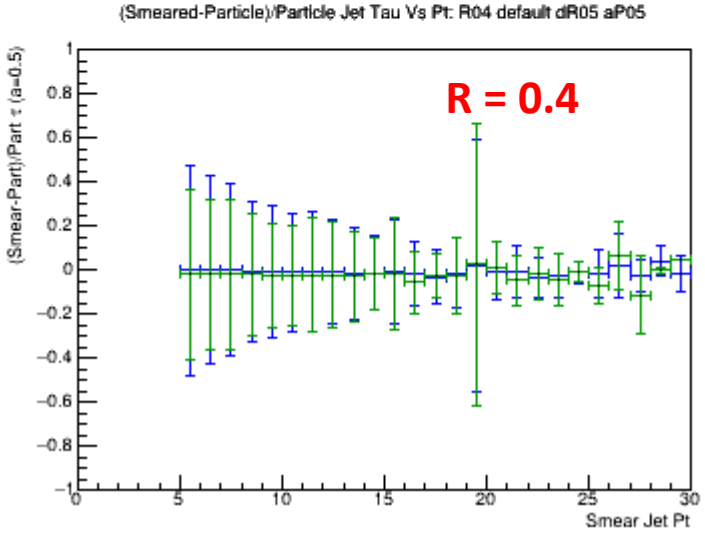
Sigma τ Vs p_T: Select Smear

Select Smear







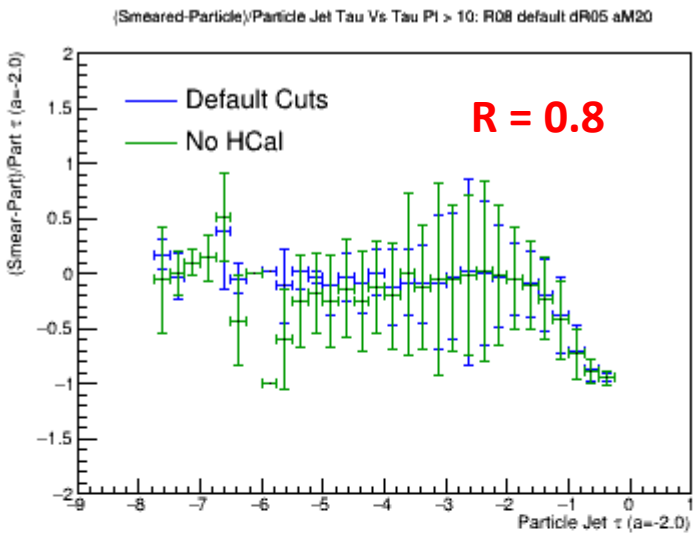


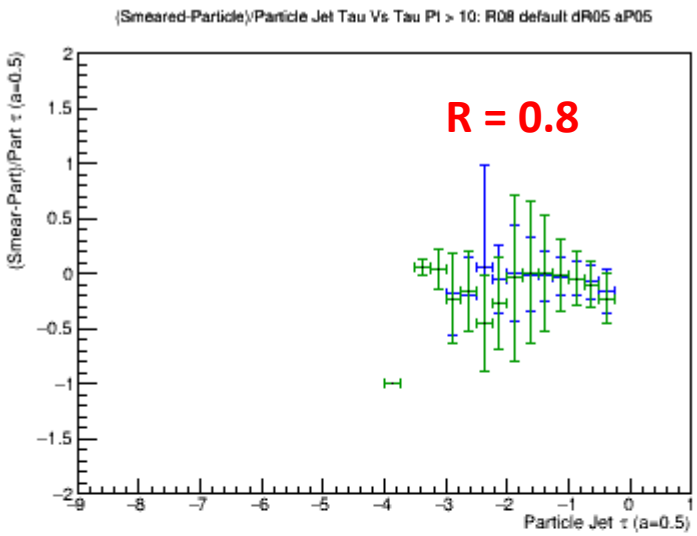
a = -2.0

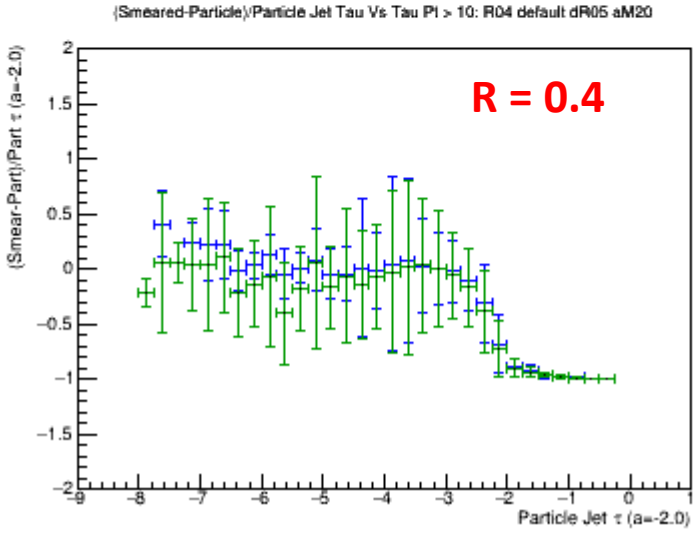
a = 0.5

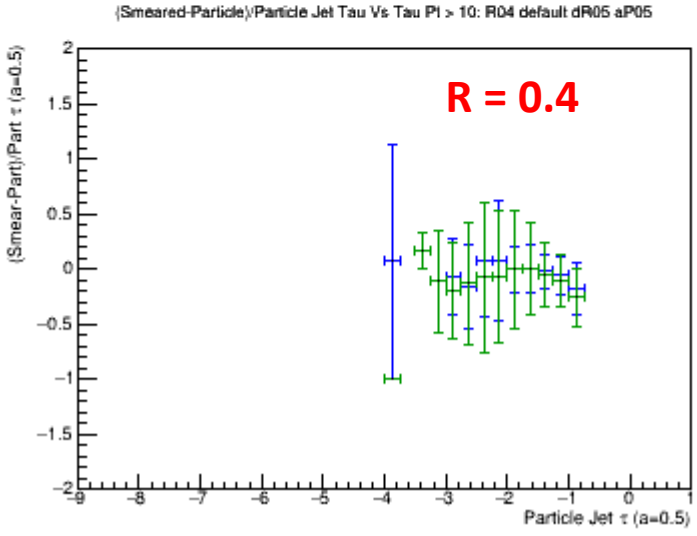
Sigma τ Vs τ: Select Particle

Select Particle







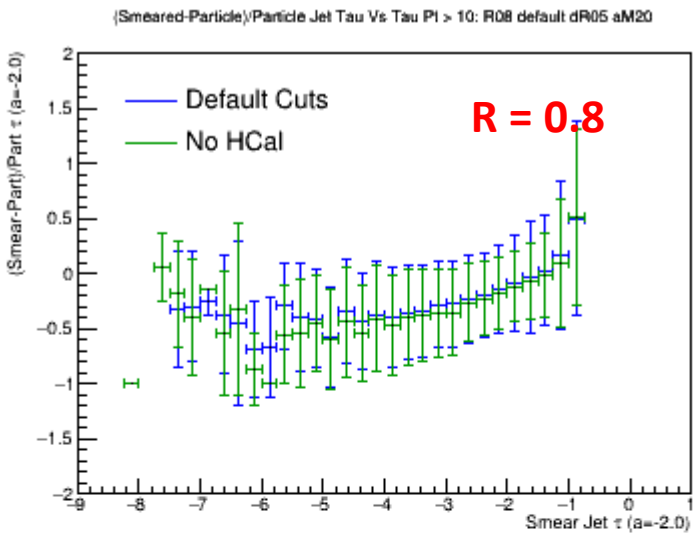


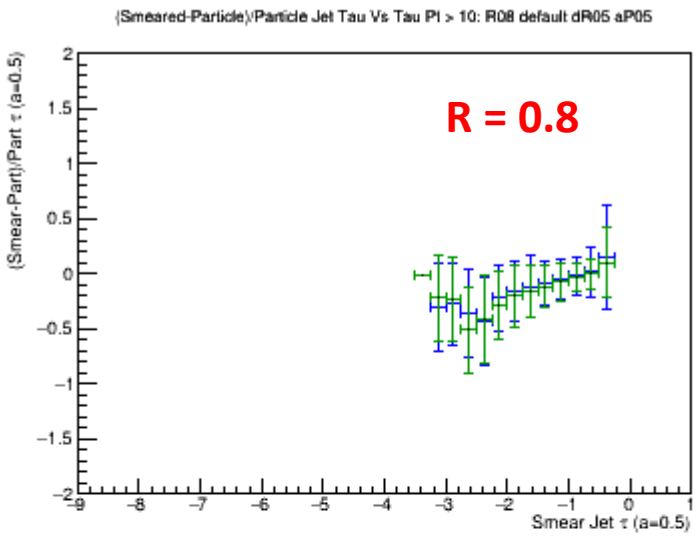
a = -2.0

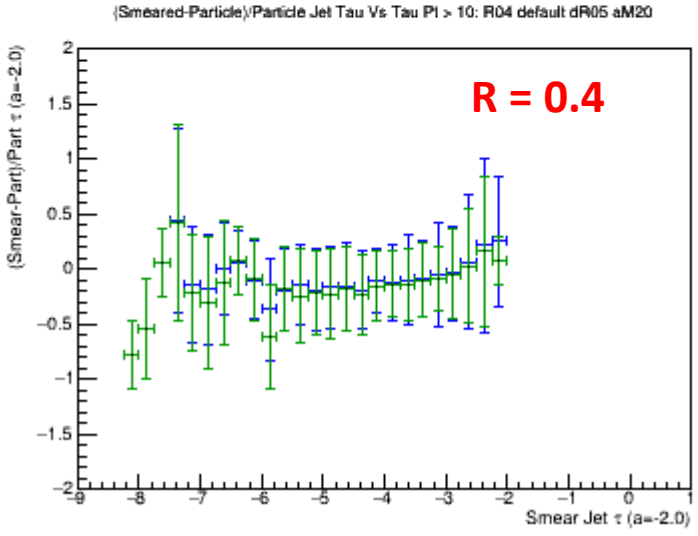
a = 0.5

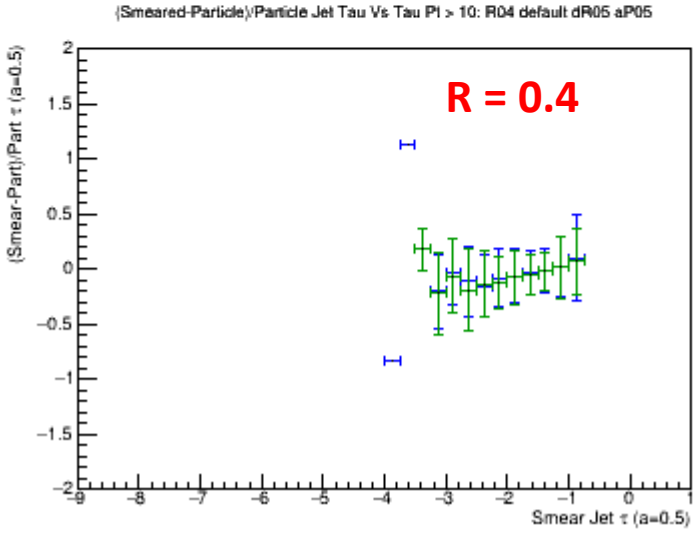
Sigma τ Vs τ: Select Smear

Select Smear









a = -2.0

a = 0.5

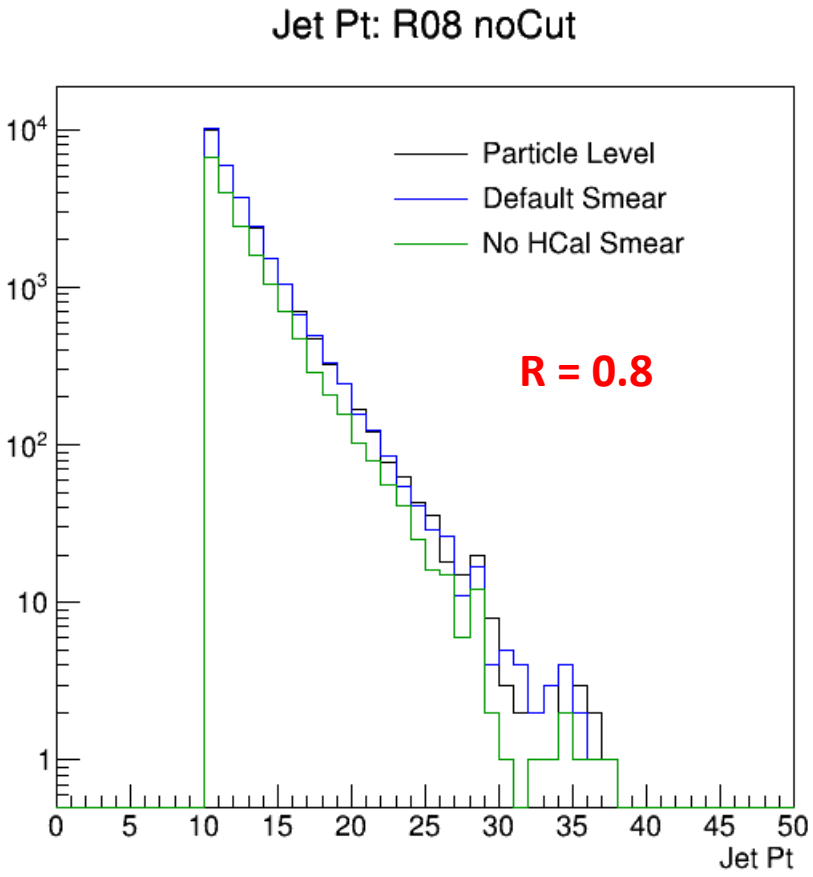
Conclusions

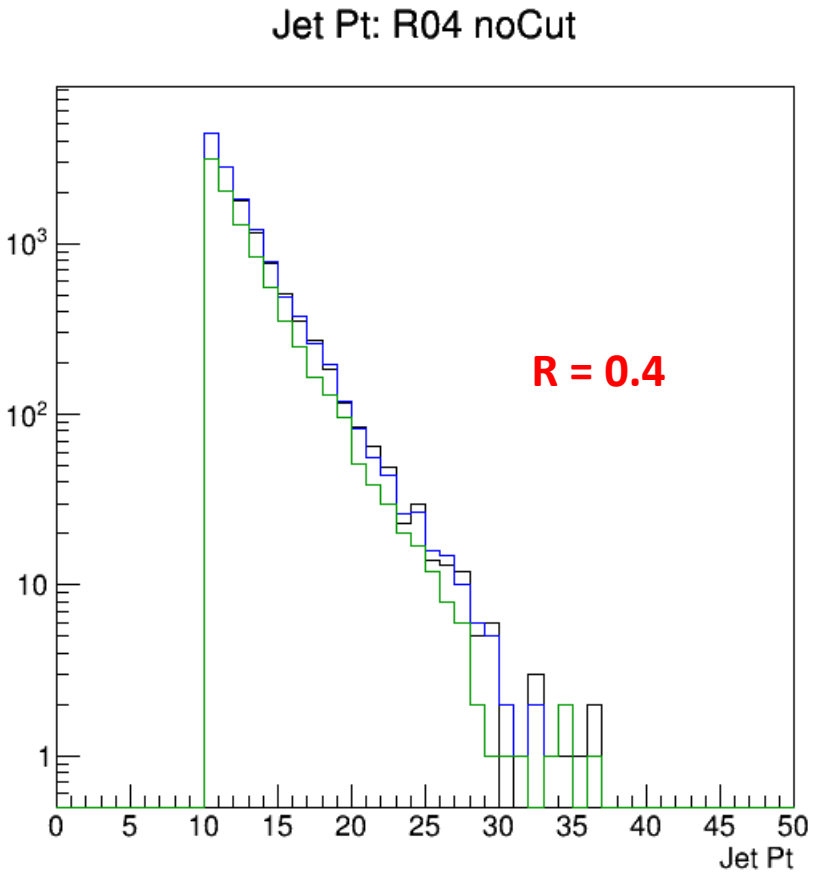
- First look at jet smearing in the photoproduction region using eic-smear and 'Handbook detector' for basic kinematics and angularity observable (caveat – no position smearing implemented yet)
- Smearing of particle level jets looks largely as one would expect
- Need to be aware of non-intuitive biases that can be introduced when selecting smeared jets as one would do in a detector – need to study further
- Can see quite large particle – smeared deviations for jet angularity, although overall particle and smeared spectra are in pretty good agreement
- Deviations more pronounced for a = -2.0 and less for a = 0.5
- See excess at large values of tau in particle level spectra (especially for a = -2.0 and R = 0.4) – need to study further

Next Steps

- Study biases in more detail and look at different Q^2 ranges
- Try to get reasonable position dependence for calorimeter systems included in eic-smear
- Investigate alternate detector resolutions in order to better understand limiting behavior (look at new detector releases as they become available)
- Look at theory predictions for angularity to better understand needed precision

Basic Kinematics: Jet p_T

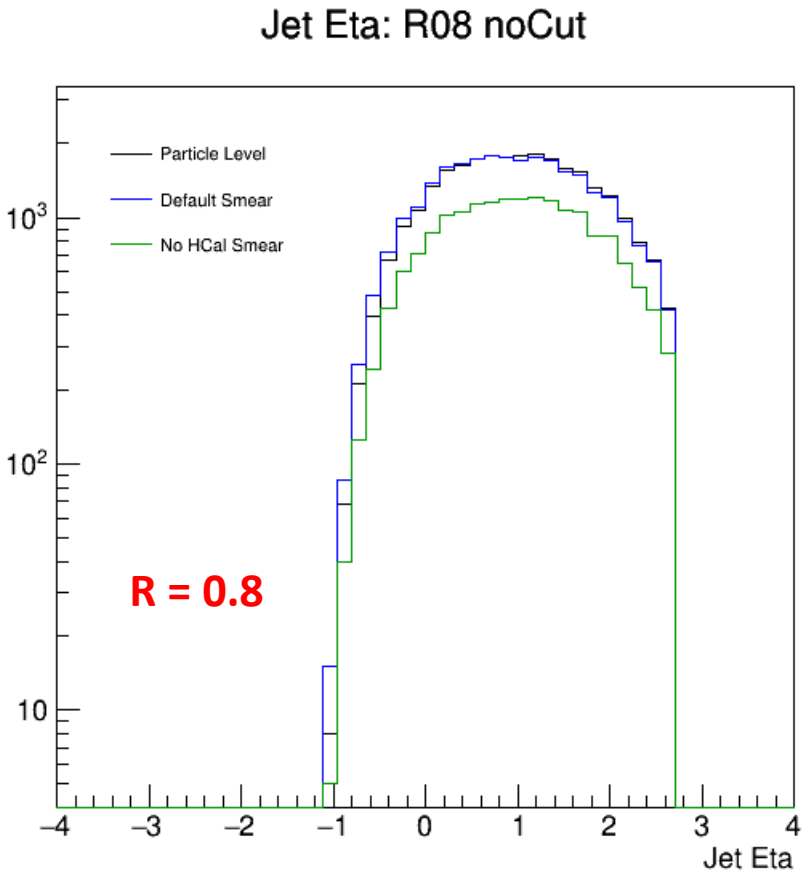


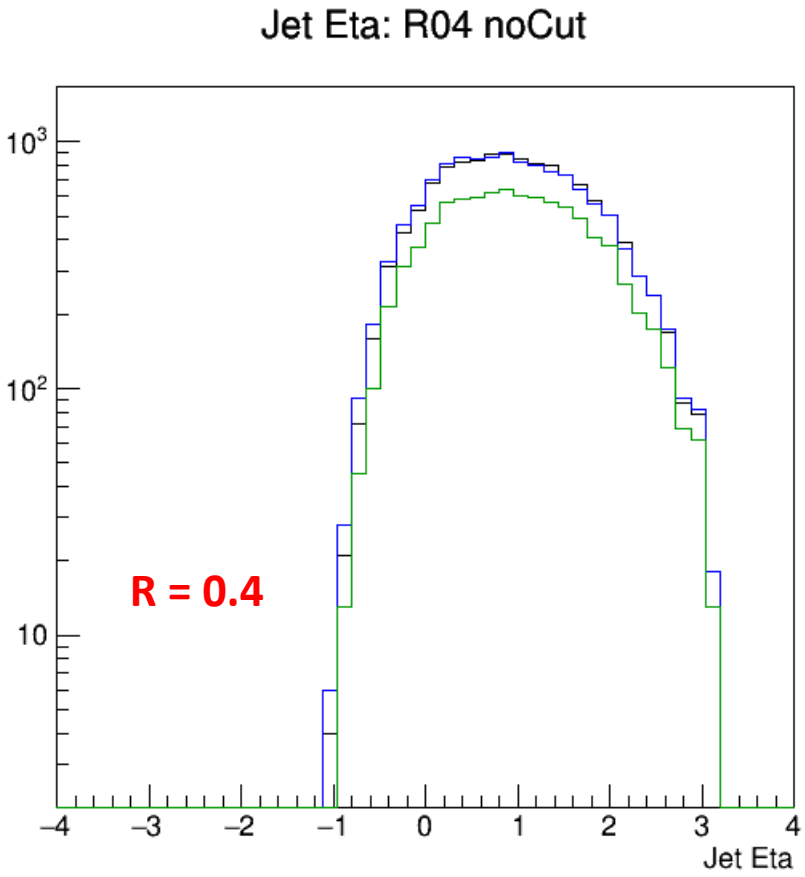


Smearing Scenarios: Default = Charged Hadron pT > 250 MeV, Photon E > 200 MeV, Neutral Hadron E > 500 MeV

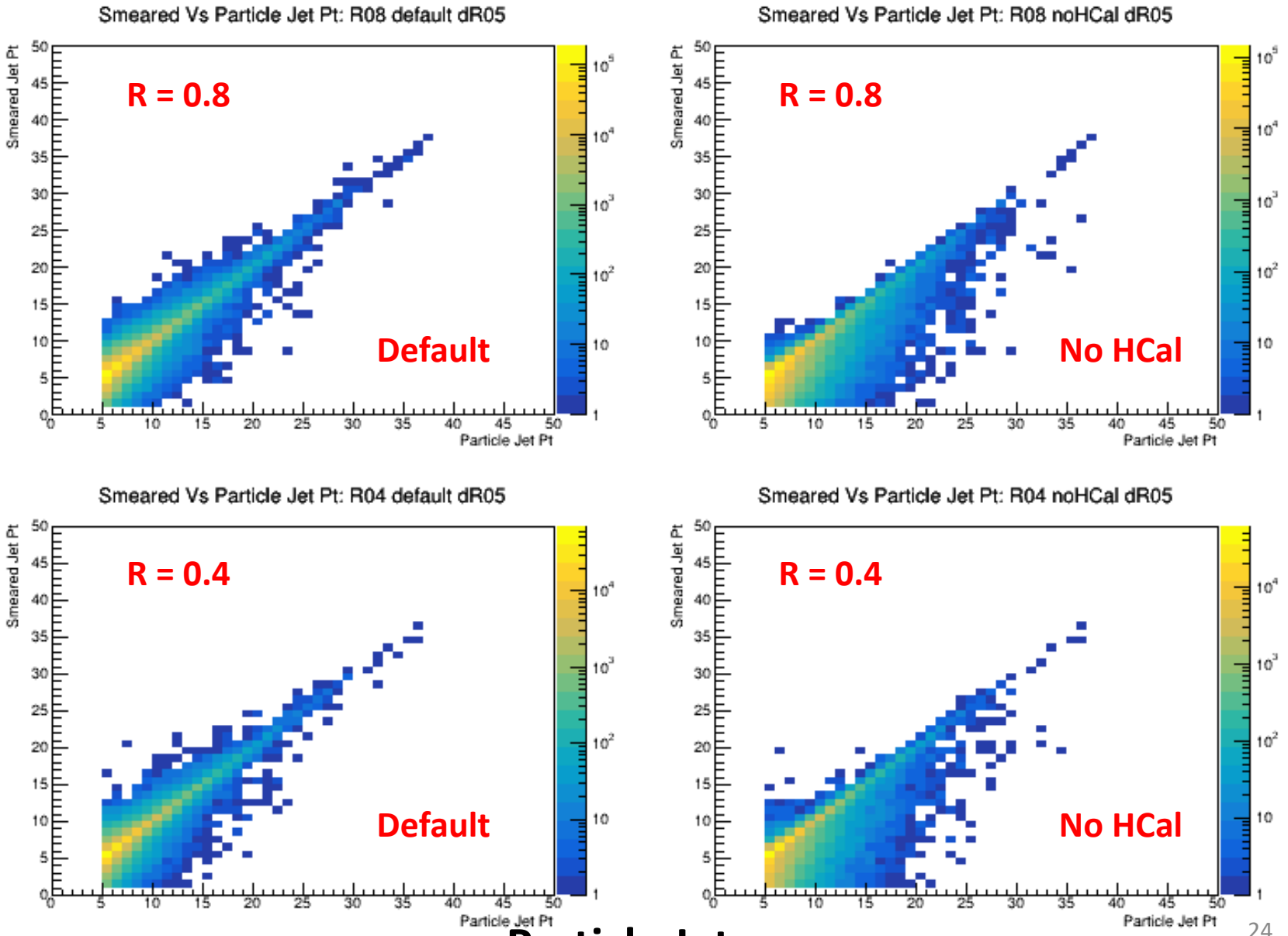
No Hcal = Energy deposits in Hcal ignored in jet finding

Basic Kinematics: Jet Eta

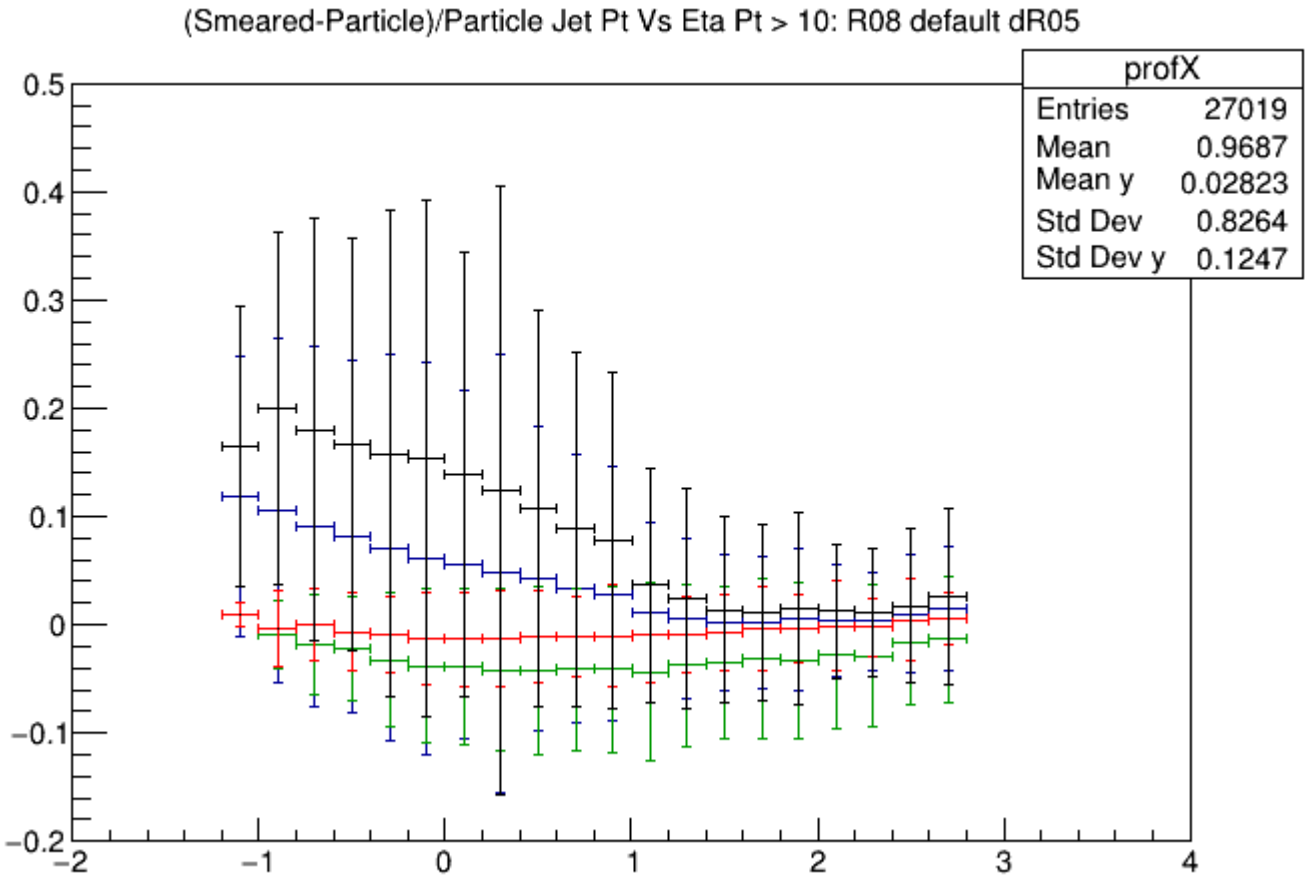




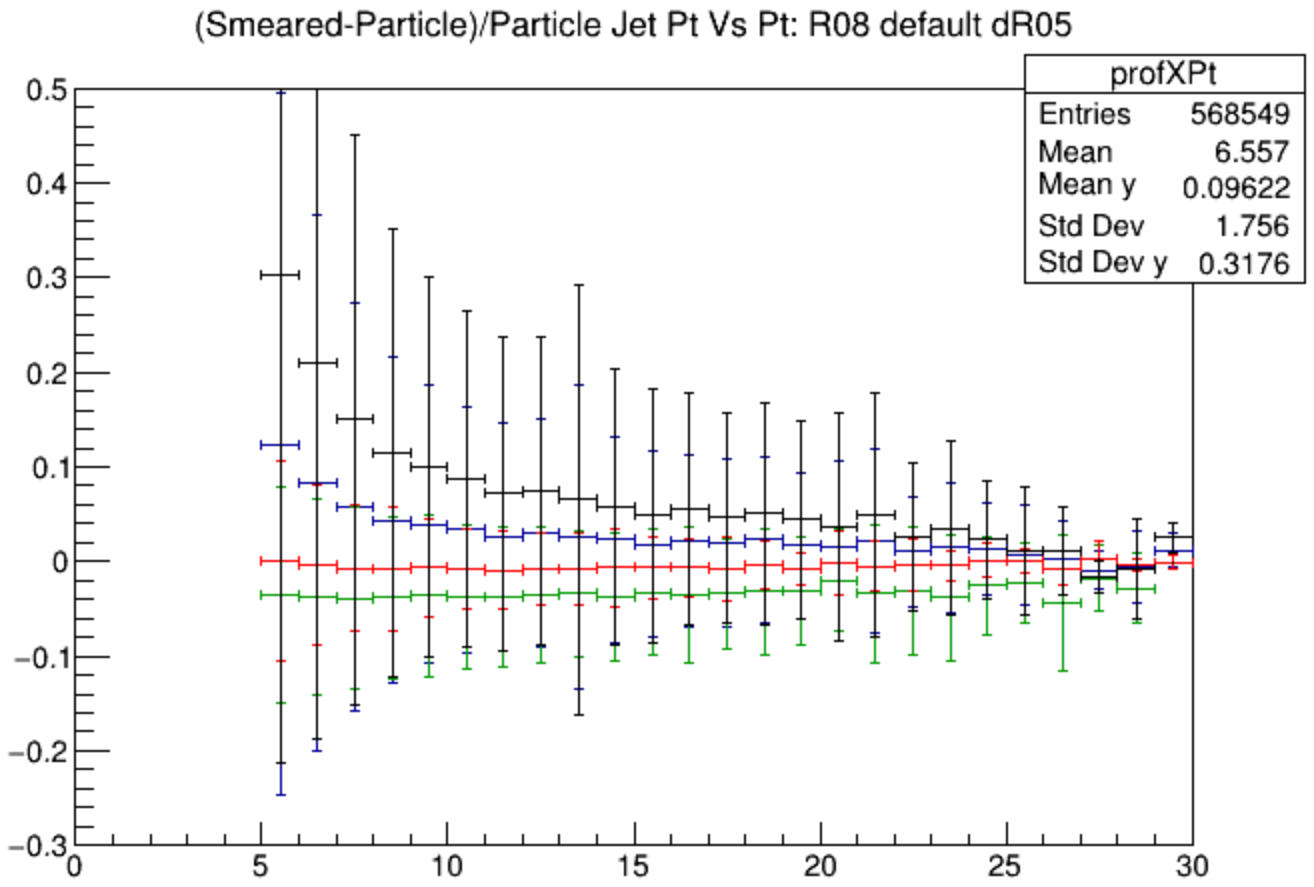
Particle – Smear Correlations



Reonstruction Bias



Reconstruction Bias



Handbook Parameters

Tracker	Eta Range	Resolution
	-3.5 to -2.5	2%/Sqrt{P} + .1%
	-2.5 to -1.0	1%/Sqrt{P} + .05%
	-1.0 to 1.0	.05%/Sqrt{P} + .05%
	1.0 to 2.5	1%/Sqrt{P} + .05%
	2.5 to 3.5	2%/Sqrt{P} + .1%

EM Cal	Eta Range	Resolution
	-4.5 to -2.0	1%/Sqrt{E} + 1%
	-2.0 to -1.0	8%/Sqrt{E} + 2%
	-1.0 to 4.5	12%/Sqrt{E} + 2%

HCal	Eta Range	Resolution
	-3.5 to -1.0	45%/Sqrt{E} + 6%
	-1.0 to 1.0	85%/Sqrt{E} + 7%
	1.0 to 3.5	45%/Sqrt{E} + 6%