# Jets and Calorimetry: First Look

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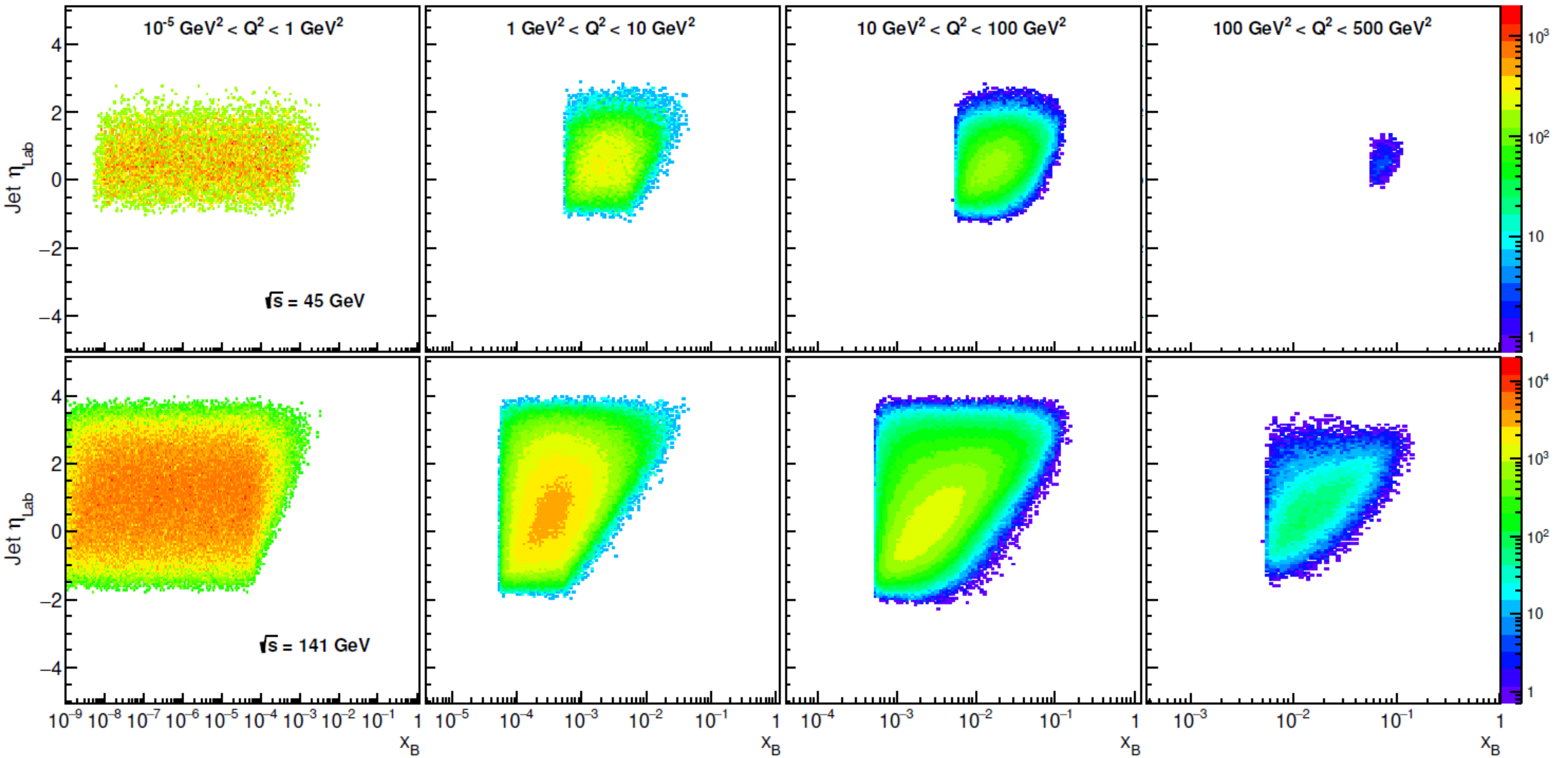
Calorimeter WG Parallel Session

3/19/2020

# Jet Kinematics




- Jet production extends quite far forward (proton going direction), especially at higher energies – forward tracking and calorimetry will be as important as mid-rapidity

arXiv:1911.00657

# Jet η Vs Energy

arxiv:1912.05931

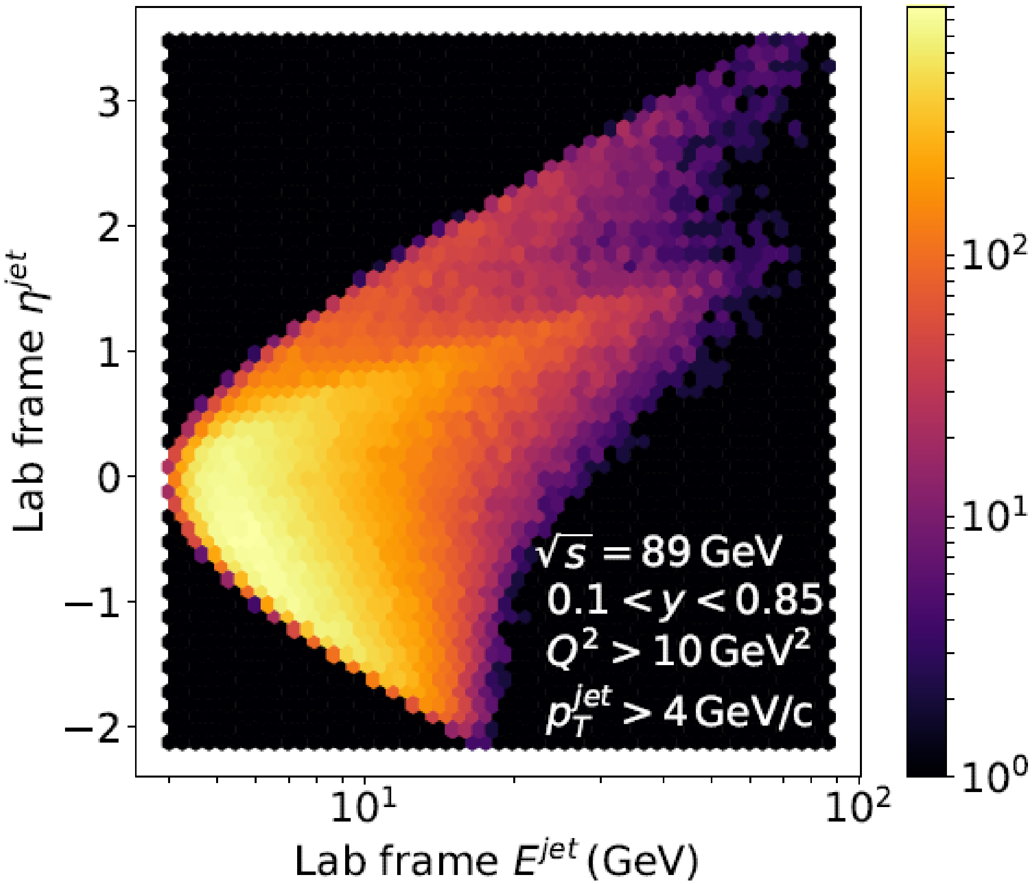
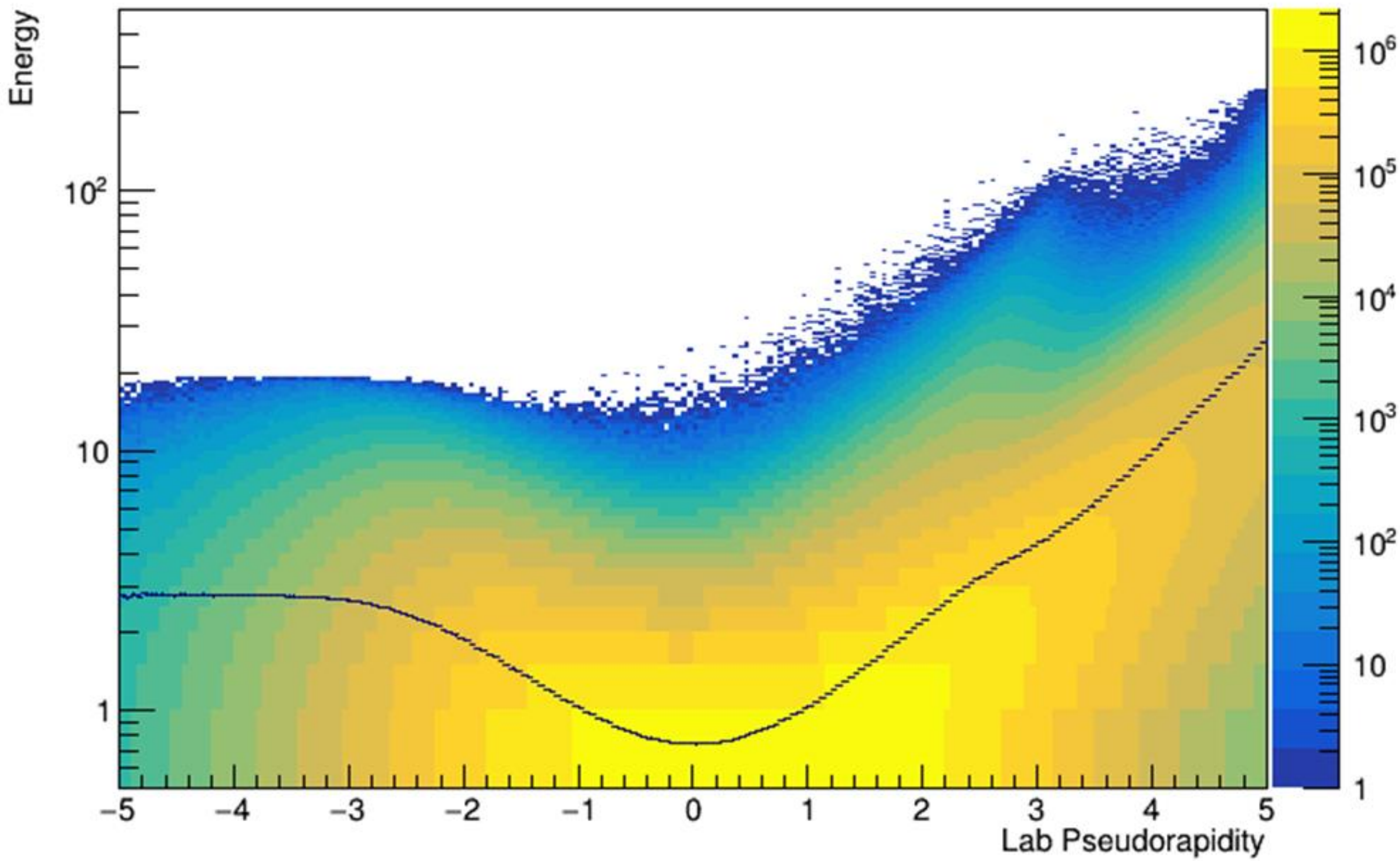
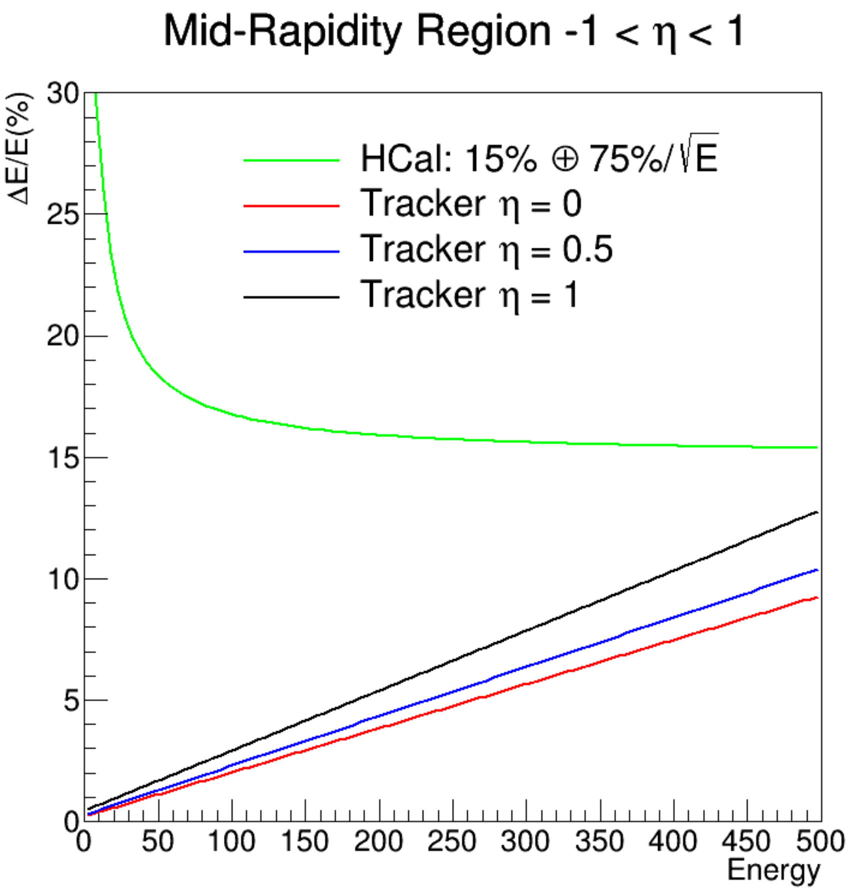


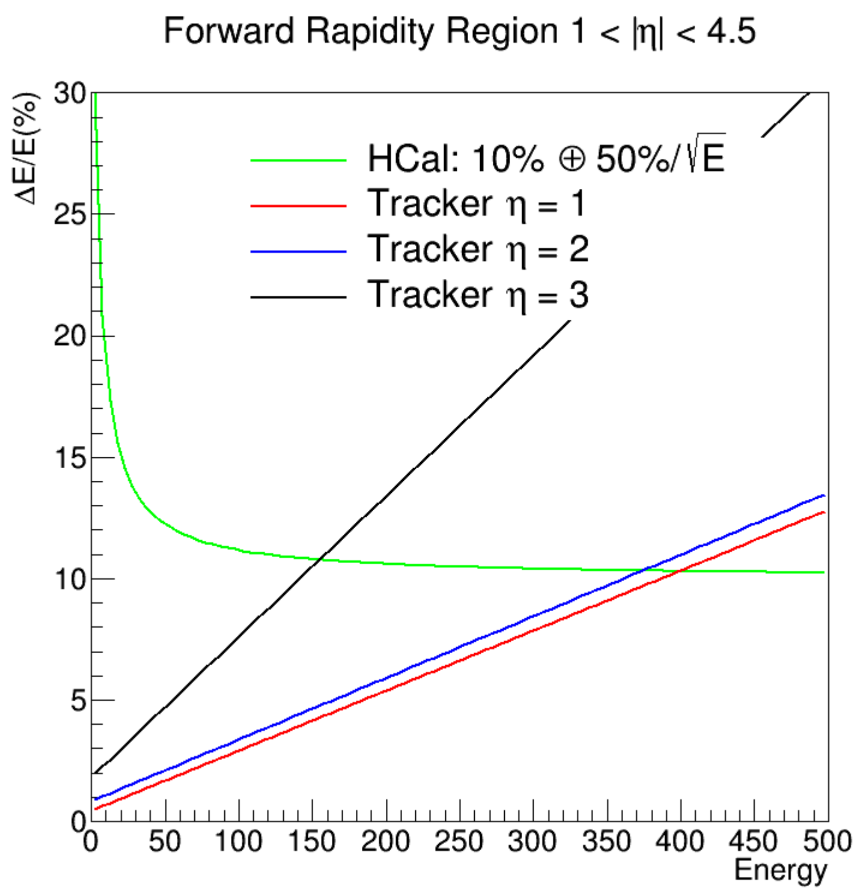

Figure 4. Jet energy vs jet pseudorapidity (in the lab frame). $\eta^{jet}$ is defined as positive in the proton (ion)-going direction. The jets are defined with radius $R = 1.0$ and the anti-$k_{\mathrm{T}}$ algorithm. The beam energies of the simulation are 20 GeV for the electron and 100 GeV for the proton.

# Particle Energy Vs η



# Tracker Vs HCal Resolution

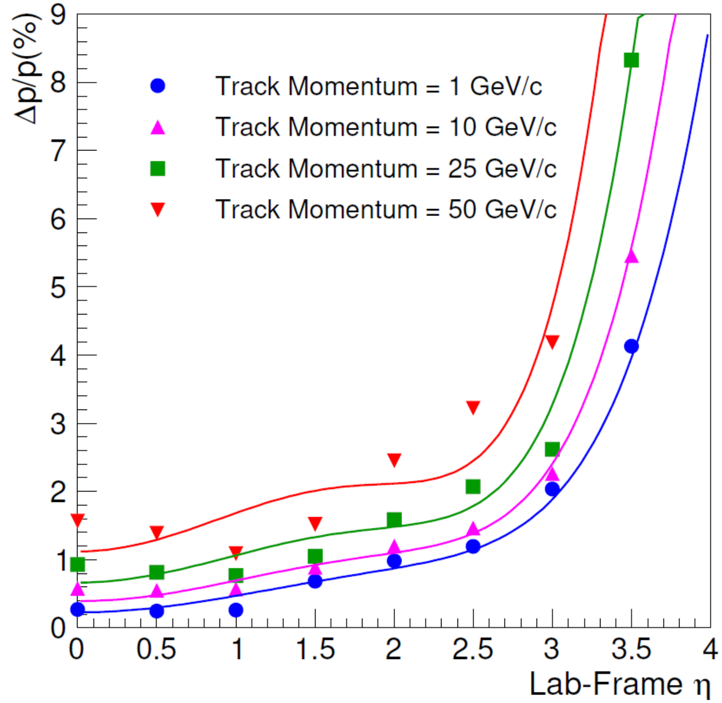



- Tracker provides better resolutions for nearly all energies and pseudorapidities

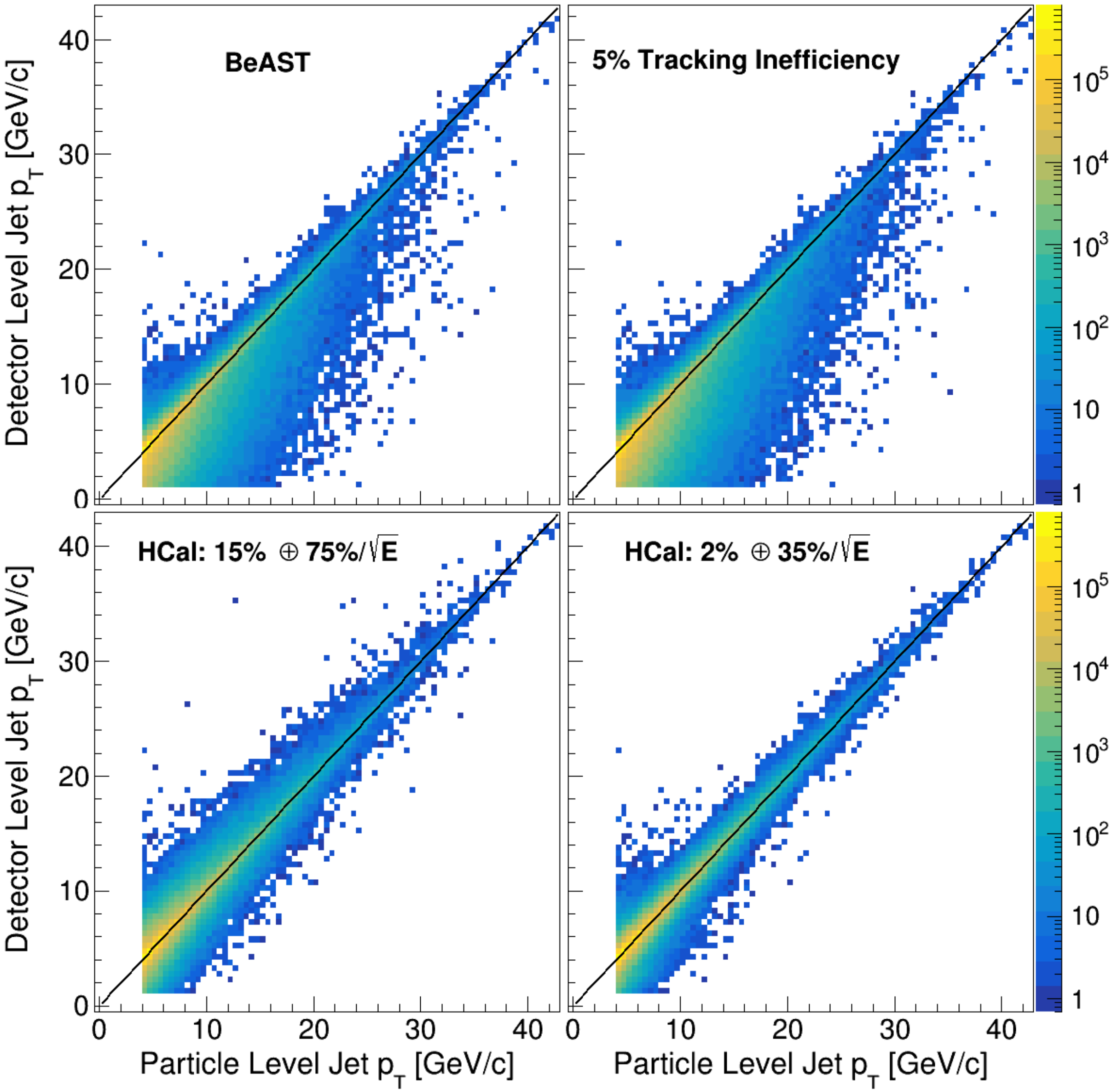
- Assumption: use tracker for all hadrons except long lived neutrals such as neutrons and $K^0_L$s

# Assumed Resolutions




| Component | Pseudorapidity Range | Resolution |
|---|---|---|
| Back EMCal | $-4.0 < \eta < -2$ | $\frac{1.5\%}{\sqrt{E}} \oplus 1\%$ |
| Mid-Back EMCal | $-2 < \eta < -1$ | $\frac{7\%}{\sqrt{E}} \oplus 1\%$ |
| Mid EMCal | $-1 < \eta < 1$ | $\frac{10\%}{\sqrt{E}} \oplus 1\%$ |
| Fwd EMCal | $1 < \eta < 4.0$ | $\frac{10\%}{\sqrt{E}} \oplus 1\%$ |
| Fwd/Back HCal | $1 < \lvert\eta\rvert < 4.0$ | $\frac{50\%}{\sqrt{E}} \oplus 10.0\%$ |
| Lo Res Mid Hcal | $-1 < \eta < 1$ | $\frac{75\%}{\sqrt{E}} \oplus 15\%$ |
| Hi Res Mid Hcal | $-1 < \eta < 1$ | $\frac{35\%}{\sqrt{E}} \oplus 2\%$ |

# Jet $p_T$ Smearing




- Study jet $p_T$ resolutions using smearing generator
- Smear particle momenta and energies based on detector characteristics
- Use BeAST detector parameters (baseline design does not include mid-rapidity hadron calorimeter)
- Also look at effects of track finding inefficiency, and mid-rapidity HCals – assume SPHENIX and ZEUS resolutions

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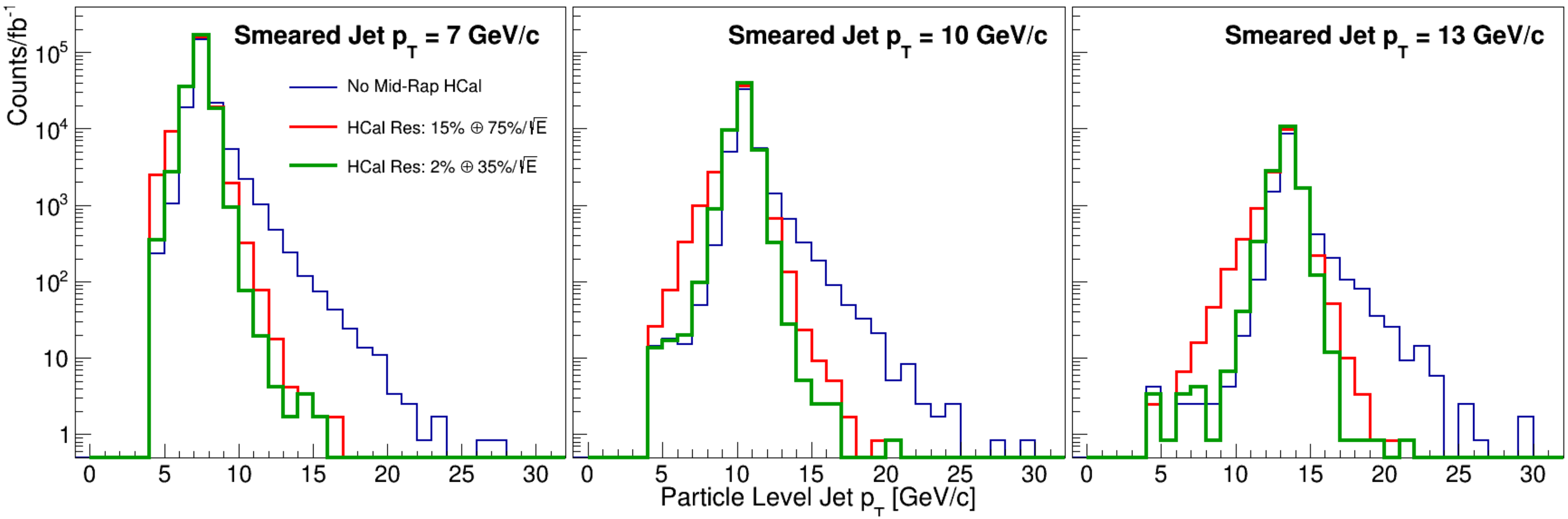
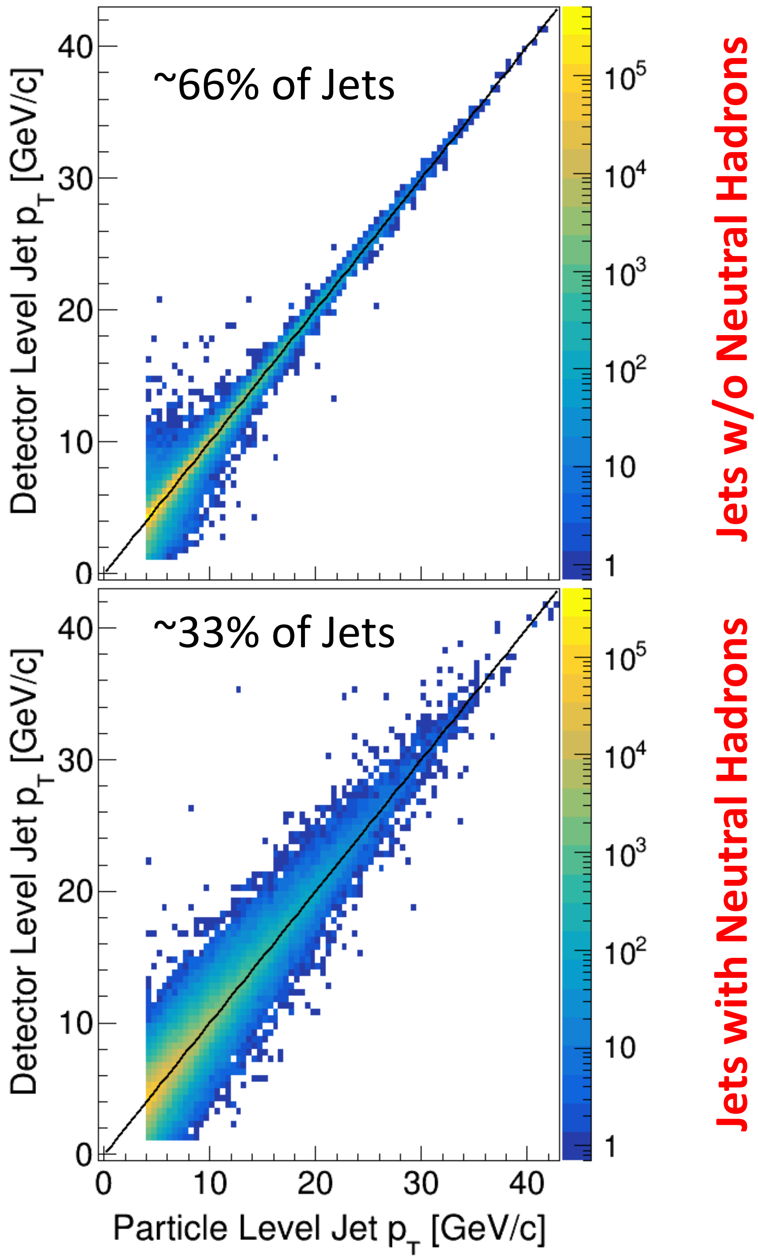
# Particle Level Projections




- Look at the true jet $p_T$s which contribute to three specific detector level jet $p_T$s
- Assume no mid-rapidity HCal, or the SPHENIX or ZEUS HCal resolutions
- The no Hcal case has a large tail of high pT particle level jets which contribute to lower pT detector jets due to the loss of neutral hadrons
- Lo Res Hcal reduces this high energy tail, but has a significant low energy tail

arXiv:1911.00657

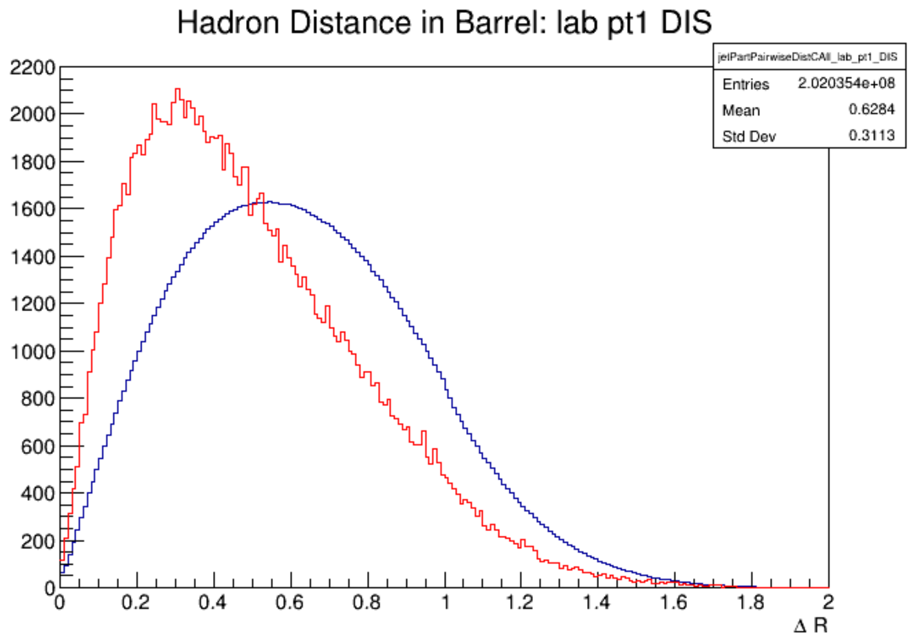
# Neutral Hadron Veto




arXiv:1911.00657

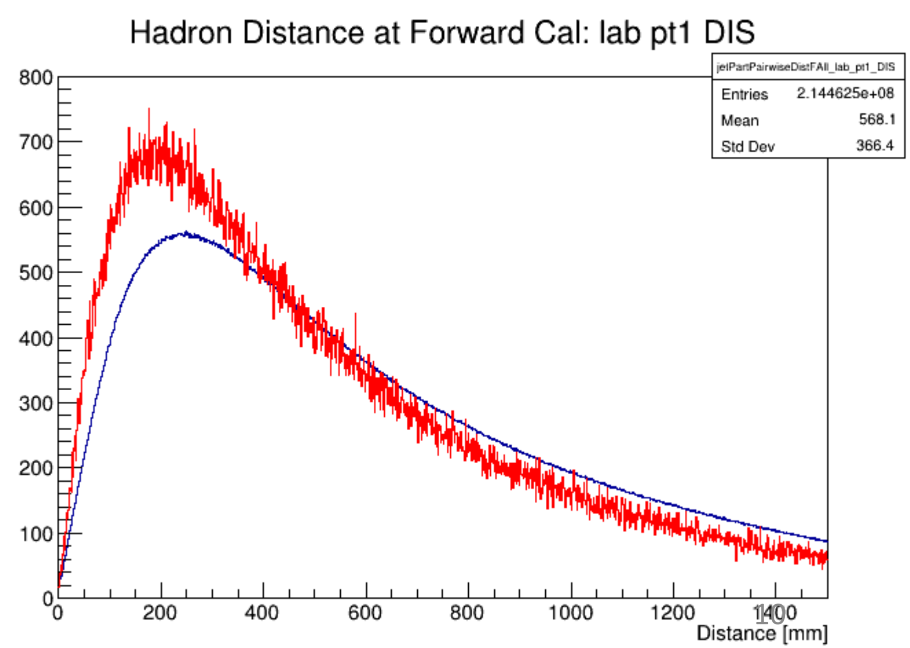
- A low energy resolution HCal may not improve jet energy resolution much, but may be useful as a neutral hadron veto
- Identify jets which contain neutral hadrons by finding energy clusters which do not have tracks pointing to them
- The roughly 66% of jets which do not contain neutral hadrons will have energy resolutions defined by the tracker and can have a very small correction
- Only apply a large correction to the 33% of jets which have neutrals

# Particle Separation




- Look at distance between each pair of charged or neutral hadrons inside jet (EM particles)
- In Barrel region ($-1 < \eta < 1$), report distance in eta-phi space
- In forward region ($1 < \eta < 4$) report absolute distance in millimeters

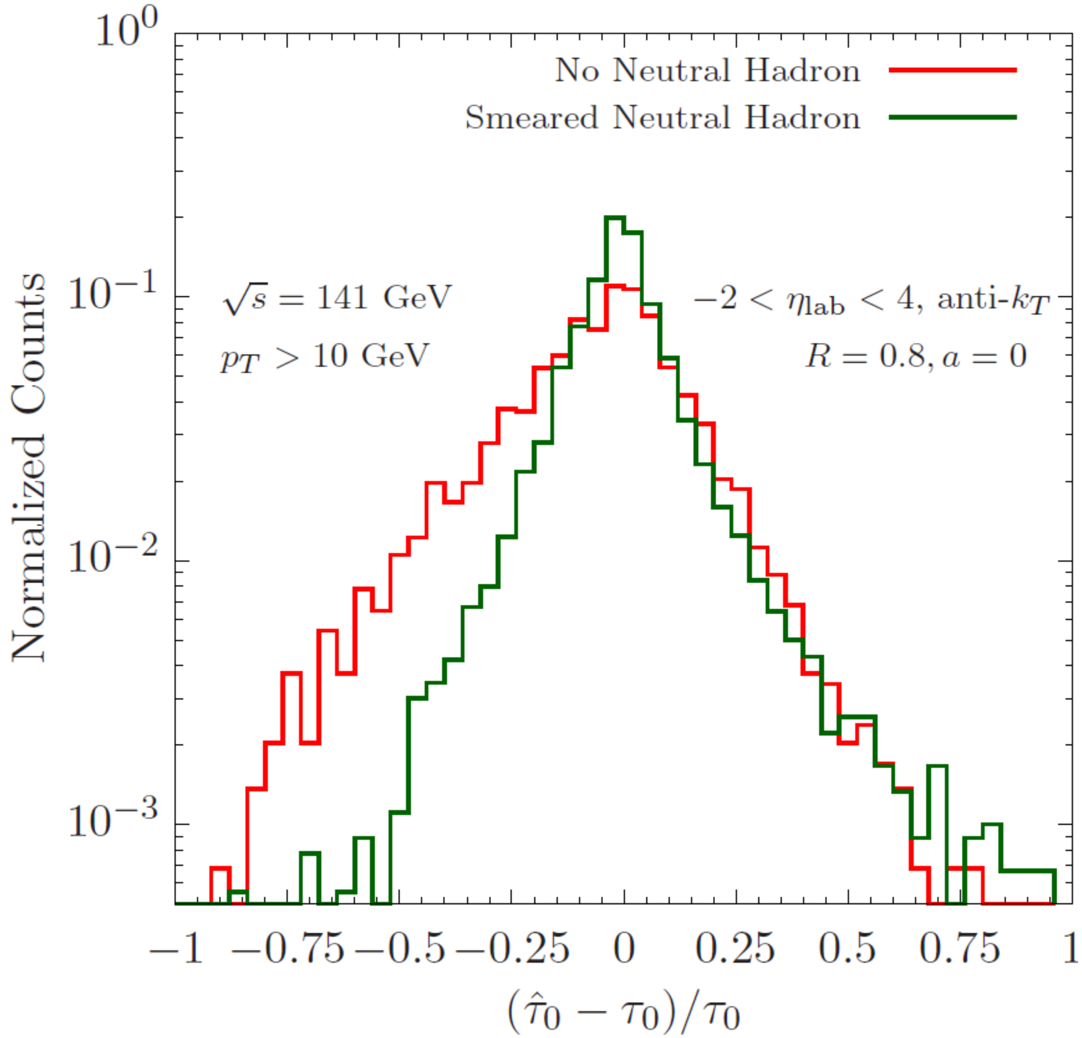
- $Q^2$ = 10 – 100 GeV$^2$, R = 1.0
- In forward region, find distance at plane with z = 3400 mm (potential front face of HCal)




**Jet $p_T$ > 5 GeV**

**Jet $p_T$ > 10 GeV**

# HCal and Substructure




- Assess distortions to angularity spectrum caused by smearing of neutral hadrons in the Hcal
- On a jet-by-jet basis, either smear energies and positions of neutrals using realistic detector response, or drop neutrals completely and recalculate angularity
- Compare altered angularity with true for those jets which had neutral
- Narrower green curve means Hcal benefits measurement

arXiv:1910.11460

$$\frac{\sigma_E}{E} = \frac{75\%}{\sqrt{E}} \oplus 15\% \qquad \frac{\sigma_E}{E} = \frac{50\%}{\sqrt{E}} \oplus 10\% \qquad \sigma_{xy} = \frac{10\ \text{cm}}{\sqrt{E}} \oplus 0.6\ \text{cm}$$

# Summary

- The above is a generic overview of some issues regarding calorimetry (mostly hadron) for jet physics – conclusions will be refined as YR work progresses
- For now, assume full calorimeter coverage ($-4 < \eta < 4$) with energy resolution at midrapidity poorer than in endcaps
- Particle / Jet energies will be low – tracker will almost certainly provide better resolution for charged particles
- Depending on extent and efficiency of tracker, calorimeters may be only detecting elements at forward angles ($\eta > \sim 3.5$)
- EIC jets are sparse objects, however, more work on required granularity and position resolution will be needed

# Particle Separation