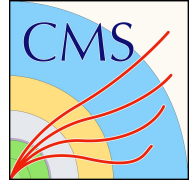
中國科學院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences



Jet and Missing Transverse Momentum Performance at CMS

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CLHCP – Xinxiang, Henan, October 29 to November 2, 2025

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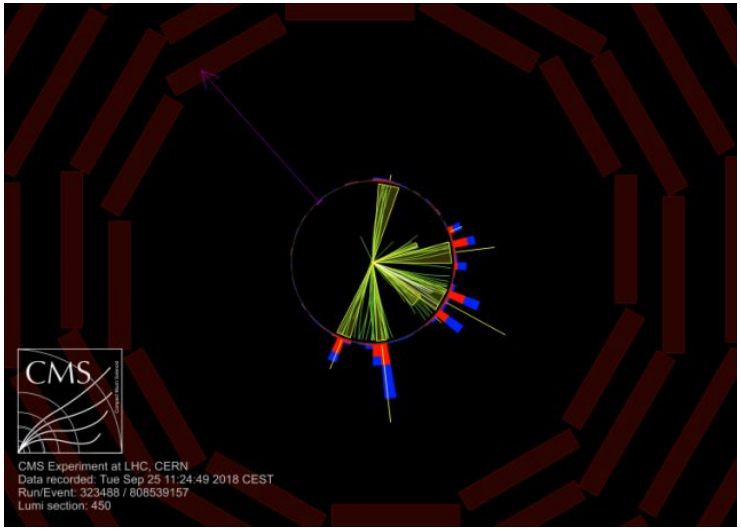
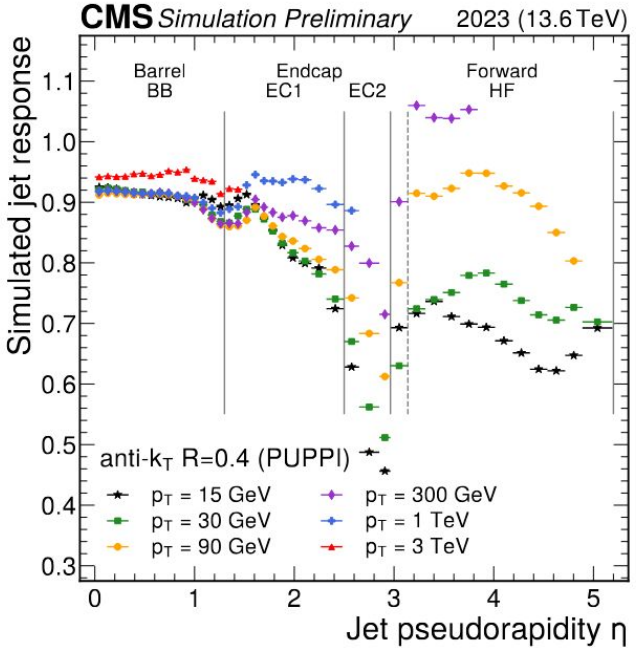
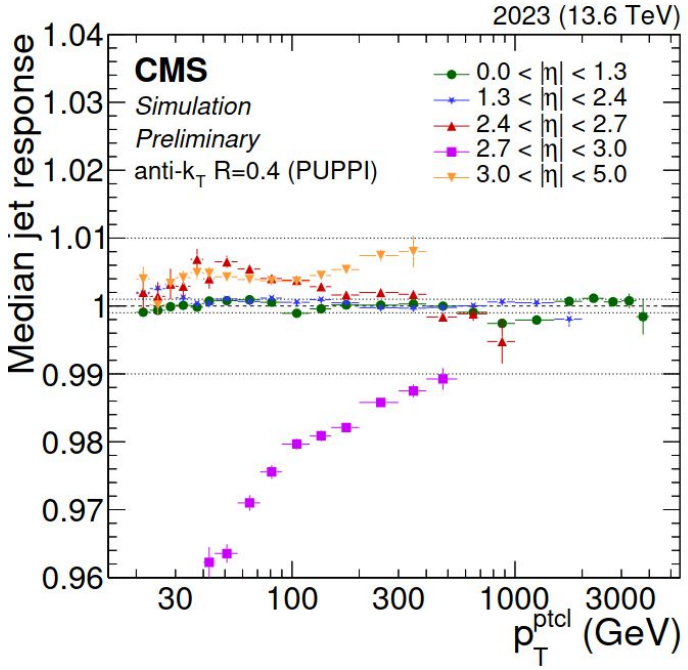
Introduction

- Jet Energy Scale: corrections and calibrations to align reconstructed jet energy with true energy
- Jet Energy Resolution: quantifies the distribution of the reconstructed energy around the true energy
- JES and JER impact invariant mass reconstruction where precise calibration sharpens resonances and reduces systematics
- Robust jet reconstruction mitigates QCD multi-jet backgrounds such as in H to bb decays
- p_T^{miss} identifies neutrino signatures (in τ, W, Z decays); essential for suppressing $t\bar{t}$ and W+jets backgrounds



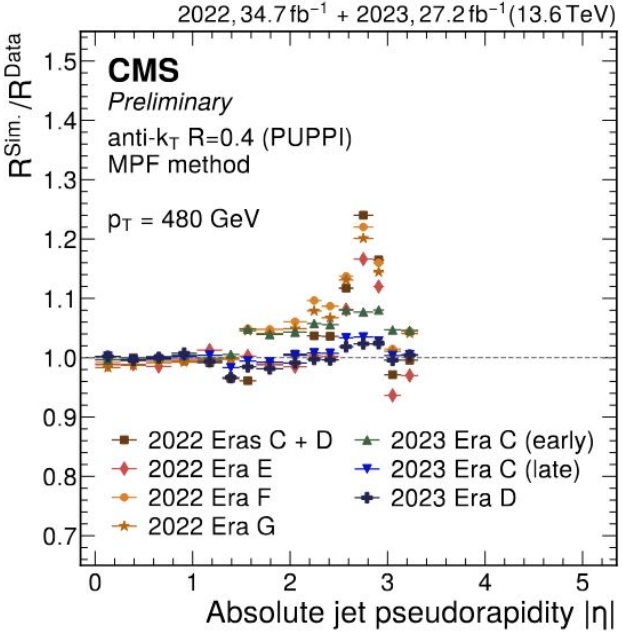
Jet Energy Scale and Resolution [CMS-DP-2024-039]

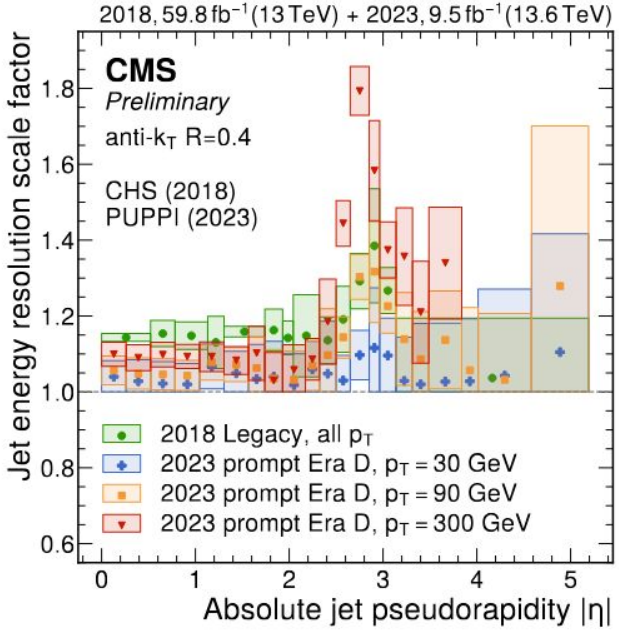




- Jet response defined as median of p_T(reco)/p_T(gen) in bins of gen-jet p_T,η
- Small p_T dependence other than in EC2 (outside of tracking acceptance)
- After correcting for JES, non- closure can go from 0.8% in |η|< 2.4 to at most 4% in 2.7 < |η| < 3.0

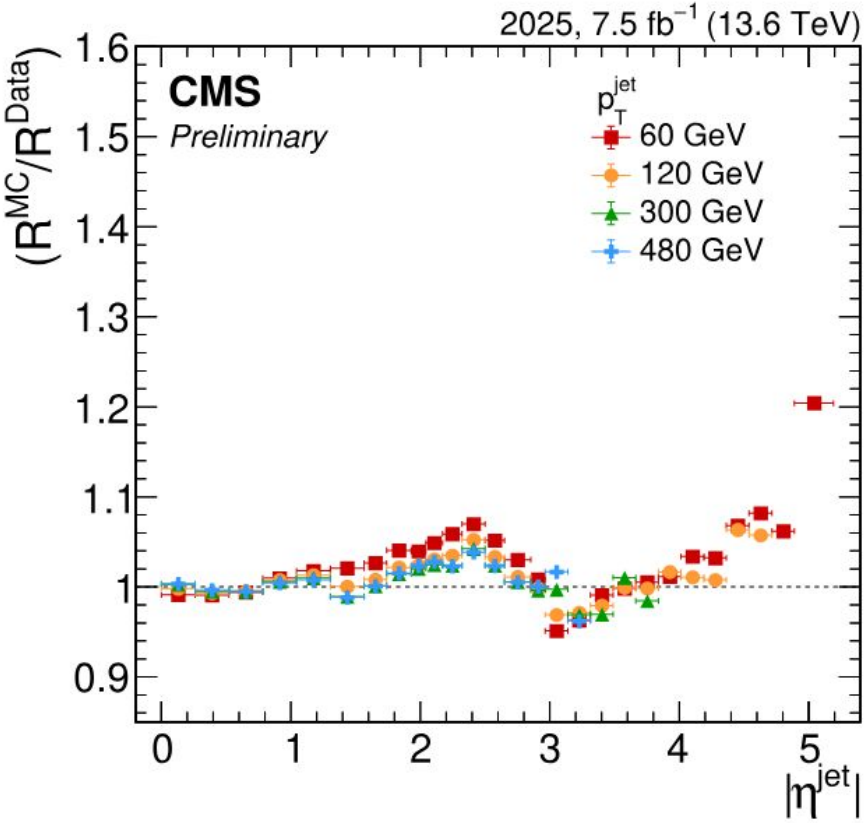
Jet Energy Scale and Resolution [CMS-DP-2024-039]





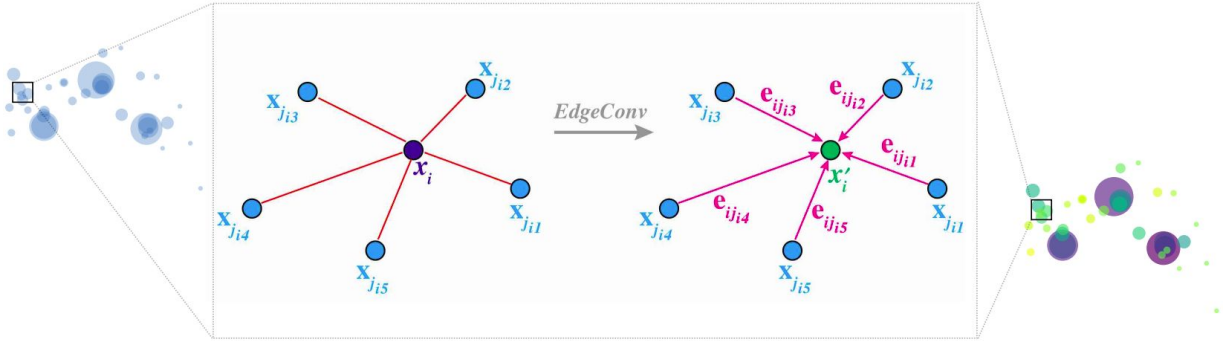
- Significant improvement in residual scale corrections for re-processing of 2022 data (CDE) and for prompt 2023 with respect to prompt 2022 reconstruction
- Good agreement between ‘22 re-reco and ‘23 prompt-reco within tracking acceptance
- Energy resolution SFs for ‘23 prompt-reco are closer to 1 than the 2018 Legacy ones

Jet Energy Scale and Resolution: 2025 [CMS-DP-25-044]



- Significant improvement observed in endcap region ($1.3 < |\eta| < 3$) compared to previous eras
  - Improved calorimeters calibration in this region
- Very quick turnaround time: first 2025 JERC results show in BOOST2025

ParticleNet Energy Regression [CMS-DP-24-064]



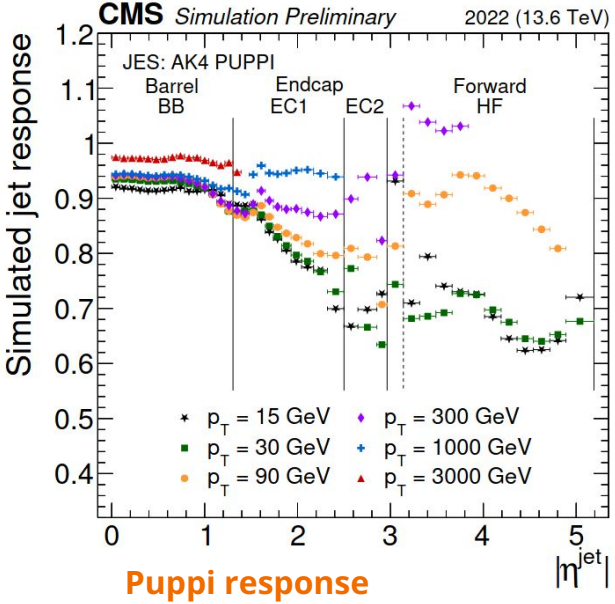
- Well-established ParticleNet architecture involving point clouds (PRD.101.056019)
- Historically used for tagging, now extended to accomplish “unified” flavor tagging (b, c, q/g, tau, …) and flavor-aware energy regression

$$L = \mathrm{CatEntropy}(x, x_{truth}) + \lambda \times \log(\cosh(y - y_{truth})) + \gamma \times [\rho_{0.16}(z - z_{truth}) + \rho_{0.84}(z - z_{truth})]$$

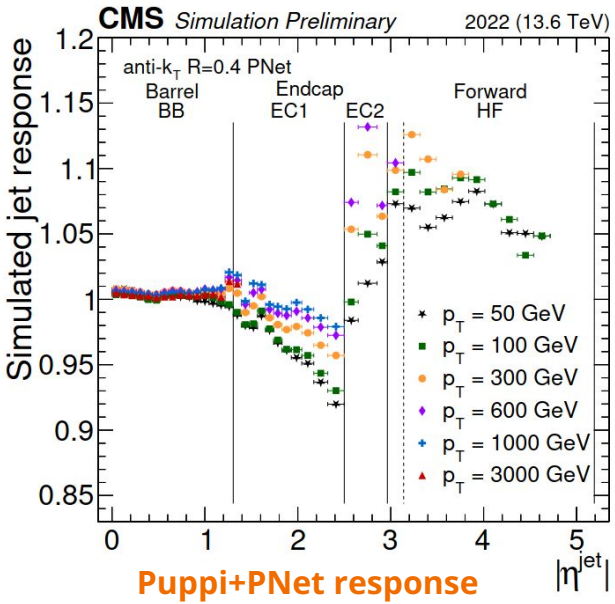
Classification — *Regression (p_T,m_X)* — *Quantile regression*

$$\rho_\tau(z) = \begin{cases} \tau z, & \text{if } z > 0; \\ (\tau - 1)z, & \text{otherwise,} \end{cases}$$

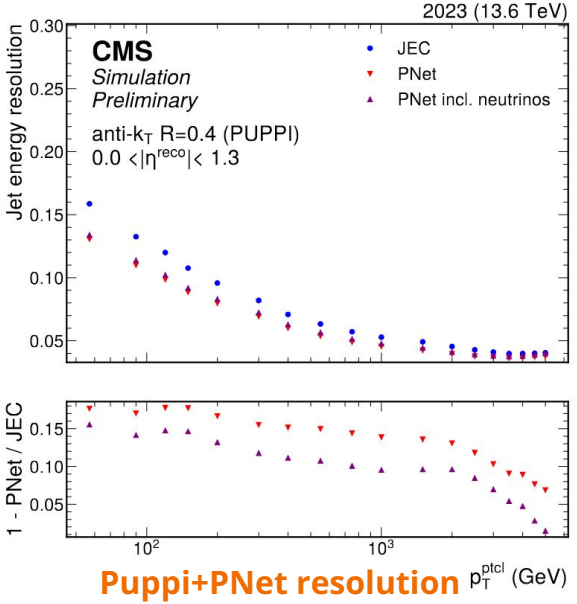
ParticleNet Energy Regression [CMS-DP-24-064]



Puppi response
(CMS-DP-2023-045)



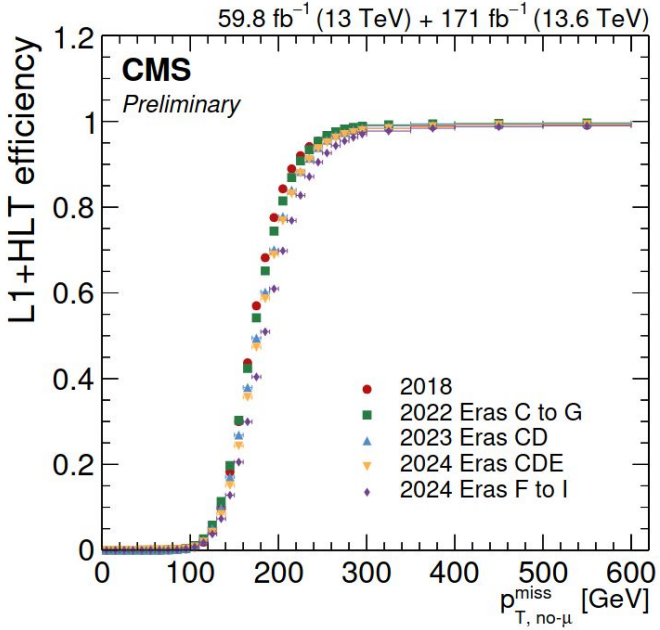
Puppi+PNet response

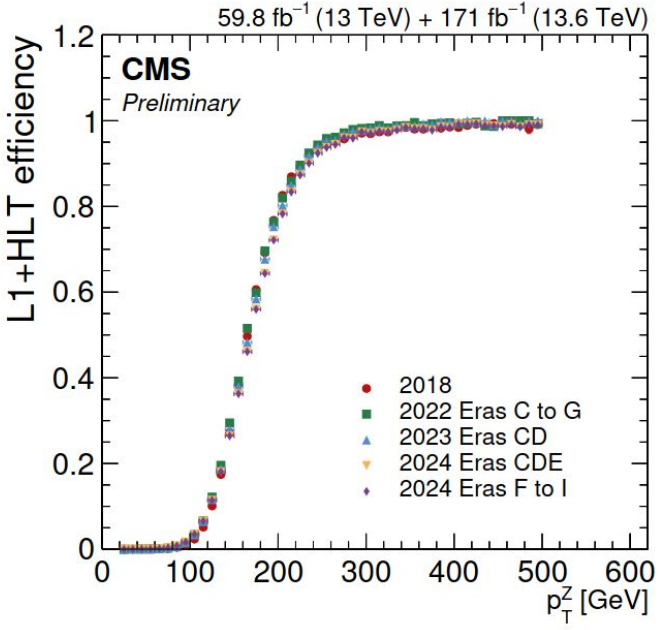


Puppi+PNet resolution

- Improved jet energy response and resolution when using Puppi+PNet energy regression

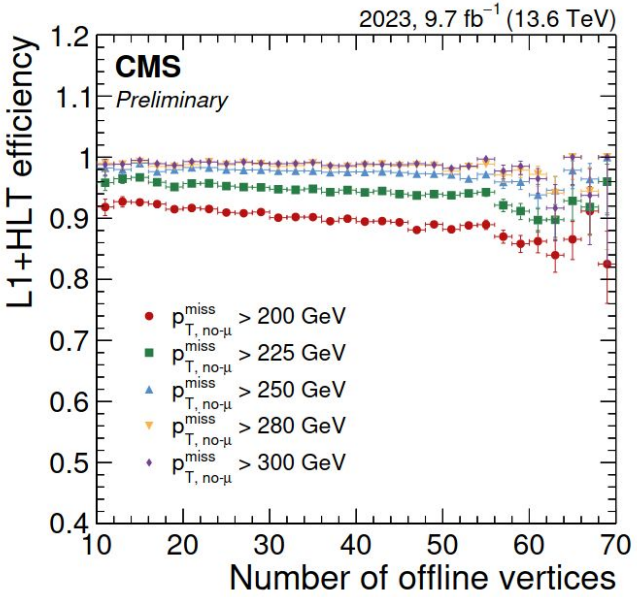
MET Triggers Performance [CMS-DP-2025-007]

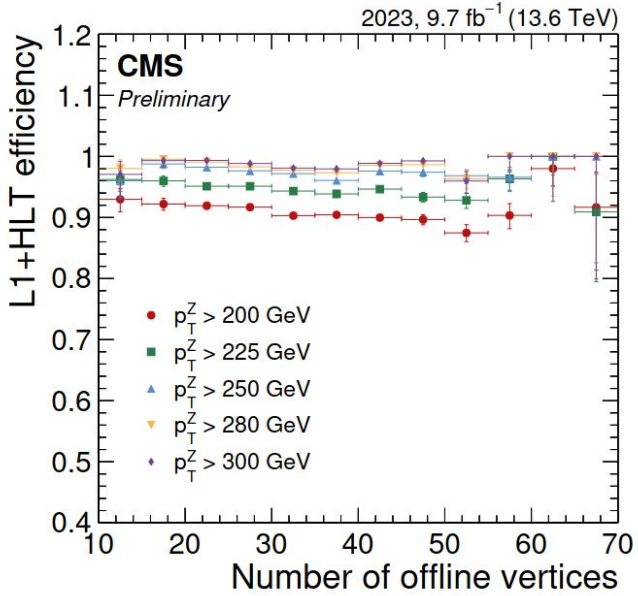




- Efficiency for the trigger requirement $MET_{no\text{-}\mu}$ > 120 GeV and $HT_{no\text{-}\mu}$ > 120 GeV
- Slower turn-on vs $MET_{no\text{-}\mu}$ for ‘24 FGHI due to small mis-calibration of offline JECs
- Stable performance of MET triggers over time otherwise (even when comparing with Run2)

MET Triggers Performance [CMS-DP-2025-007]

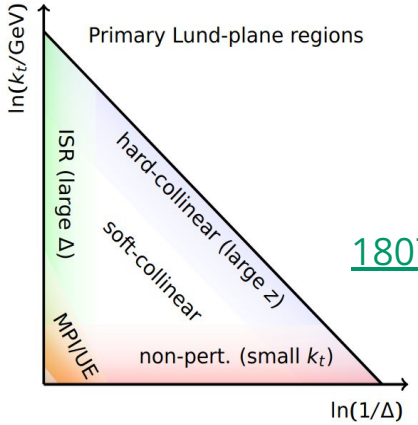




- Efficiency for the trigger requirement $MET_{no\text{-}\mu}$ > 120 GeV and $HT_{no\text{-}\mu}$ > 120 GeV as a function of number of vertices high and mostly constant
- Some small trend vs nVertices visible for low MET cuts, as expected

Lund Jet Plane (LJP) Reweighting

- A way to **calibrate jets with >3 prongs** (e.g., H(WW))
- **General idea:** derive LJP data/MC ratios for subjets of W-jets in ttbar semileptonic selection
  - **Key assumption**: method to be applied to quark-induced subjets
- **How to correct multi-pronged jets**:
  - Recluster constituents of AK8 jet to get exactly N subjets, using Ex-KT algorithm
  - For each subjet, recluster constituents with pt>1GeV to get clustering history (CA-algorithm)
  - For each splitting, pick the corresponding SF in LJP ratio
- SFs derived in 2-pronged (W) jets, validated in 3-pronged (top) jets
- Validation for > 3 subjets performed using Herwig as pseudo-data



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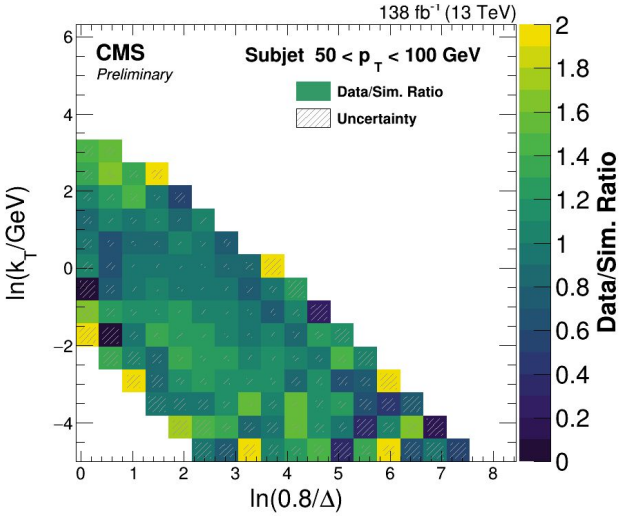
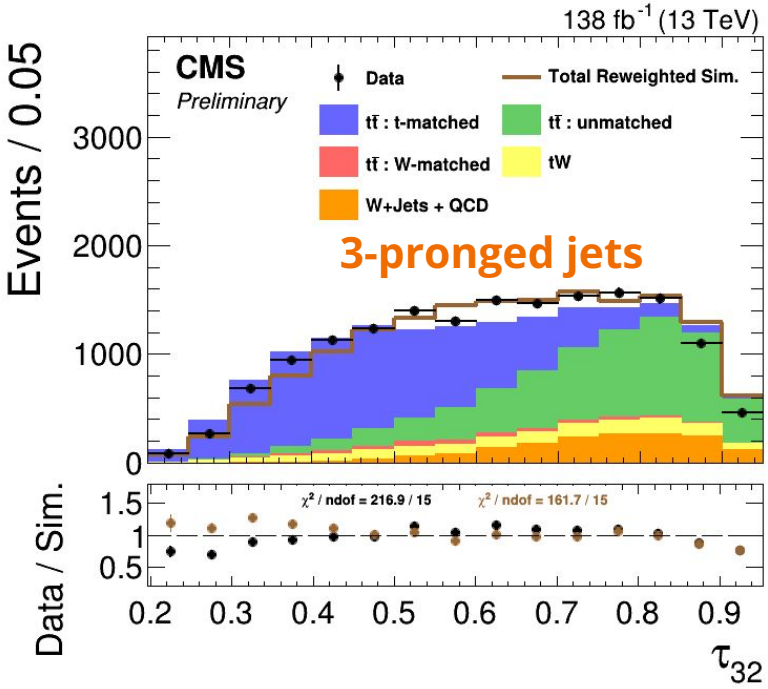
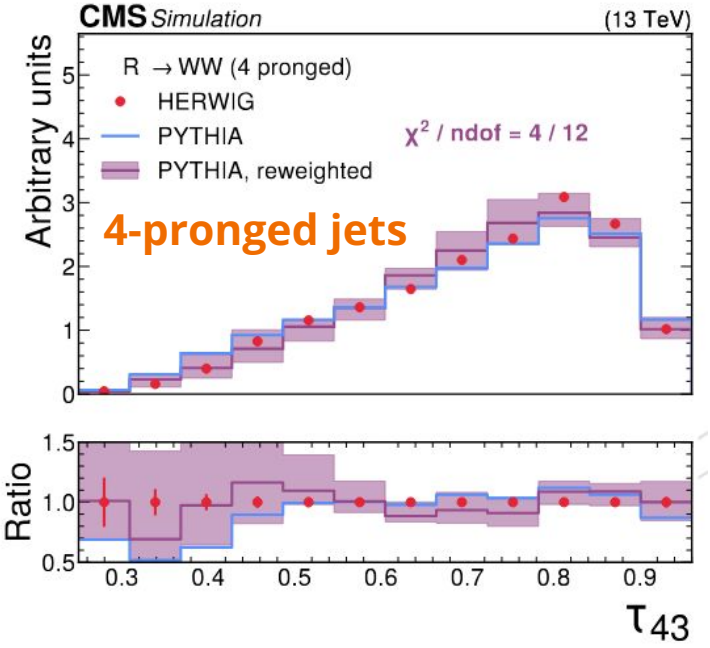


CMS-PAS-JME-23-001

Lund Jet Plane Reweighting





- Improved data/MC and pseudo-data/MC agreement

Conclusion

- Jet and MET performance are central to precision measurements and BSM sensitivity for many analyses
- Continued development of calibration and ML-based methods significantly improves resolution and systematic control in CMS
- MET is being monitored in Run3 and shows stable performance
- Novel calibration methods allow usage of boosted, multi-pronged signatures