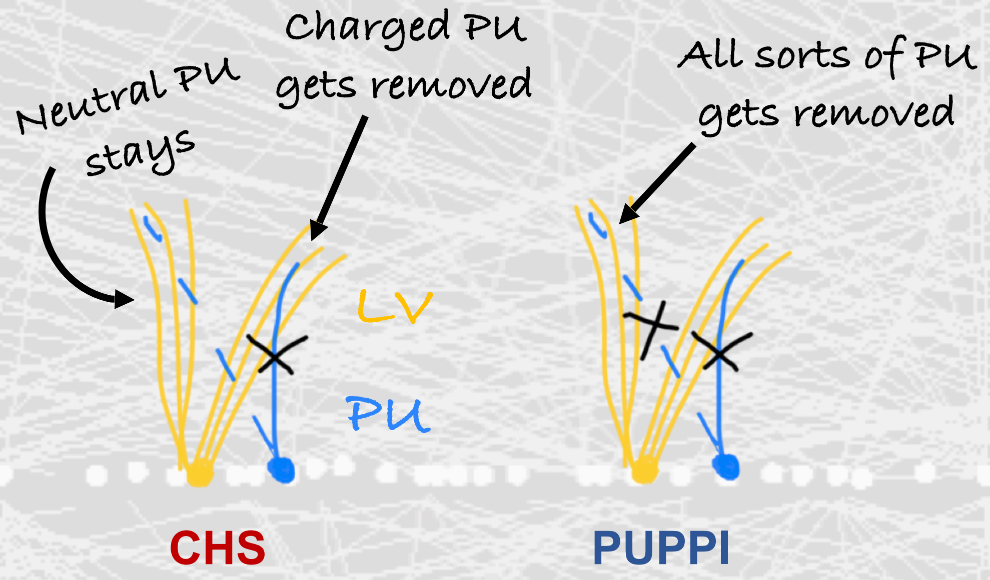
Jet performance and pileup mitigation in Run3 in CMS

Anna Benecke (UCLouvain)
on behalf of the CMS Collaboration



Outline

Event cleaning

[CMS-DP-2024-043]

Optimisation of the pileup mitigation technique for the τ_h identification → unified flavor identification

Jet energy performance

[CMS-DP-2024-028]
[CMS-DP-2024-039]
[CMS-DP-2024-064]

Jet scale and resolution in $|\eta|$<2.5 in promptly reconstructed data is as good as legacy reconstruction in Run2

First full calibration of regressed p_T for small-cone jets

New developments

[CMS-DP-2024-038]
[CMS-DP-2024-044]

New developments for variable-R jet clustering and charge identification

Outline

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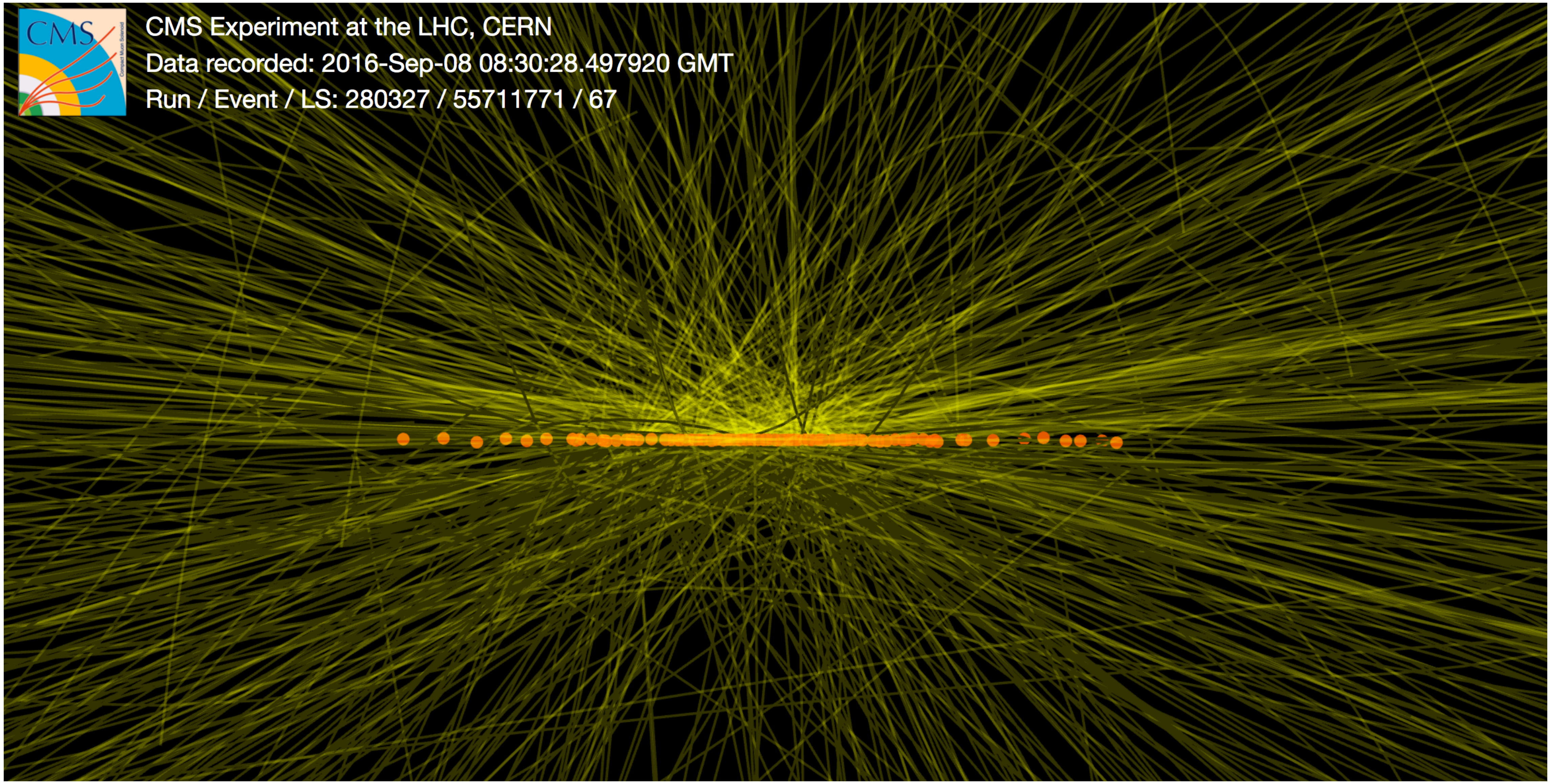
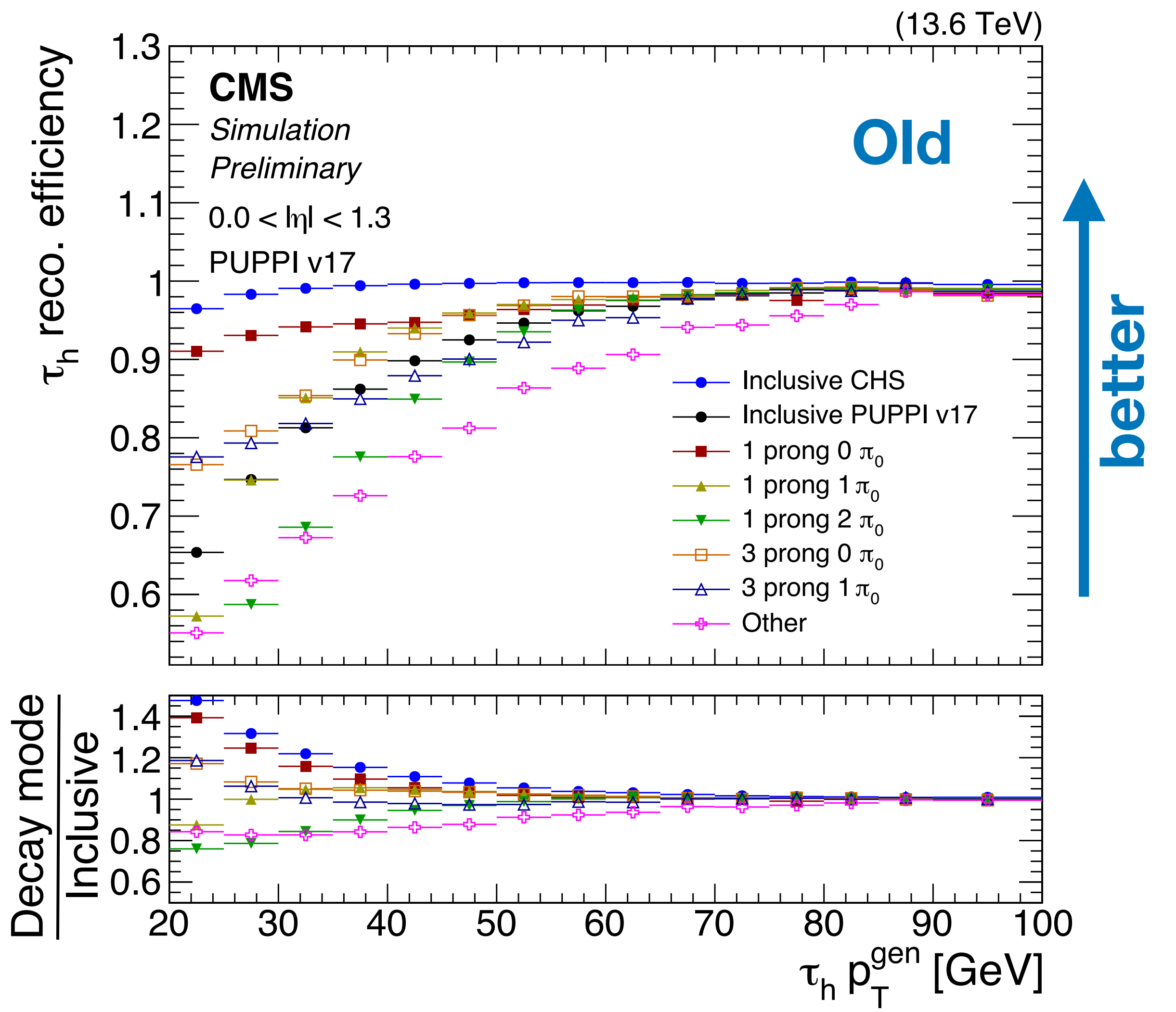
[CMS-DP-2024-043]

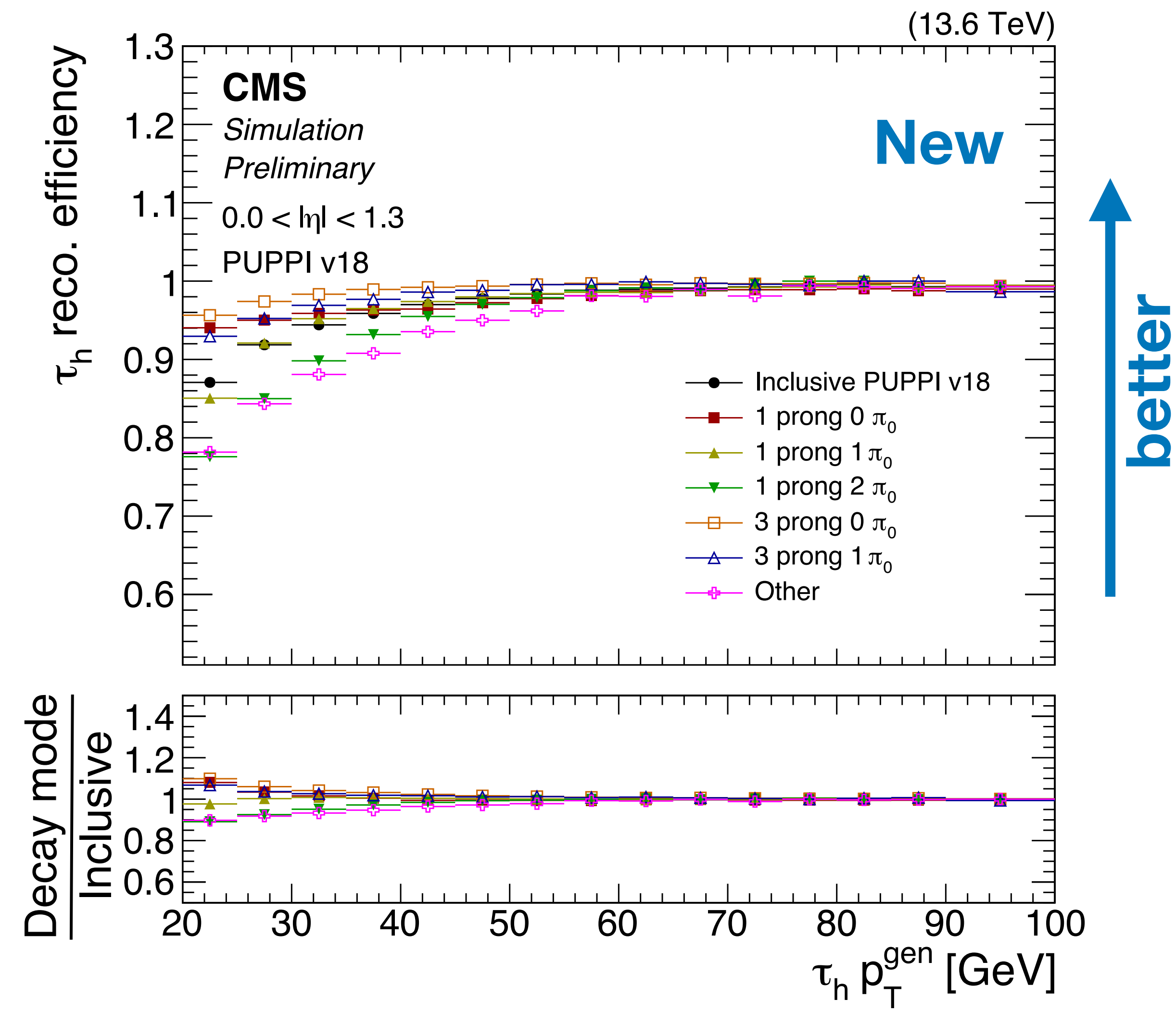
Optimisation of the pileup mitigation technique for the τ_h identification → unified flavor identification



Pileup mitigation in the context of τ_h identification

[CMS-DP-2024-043]



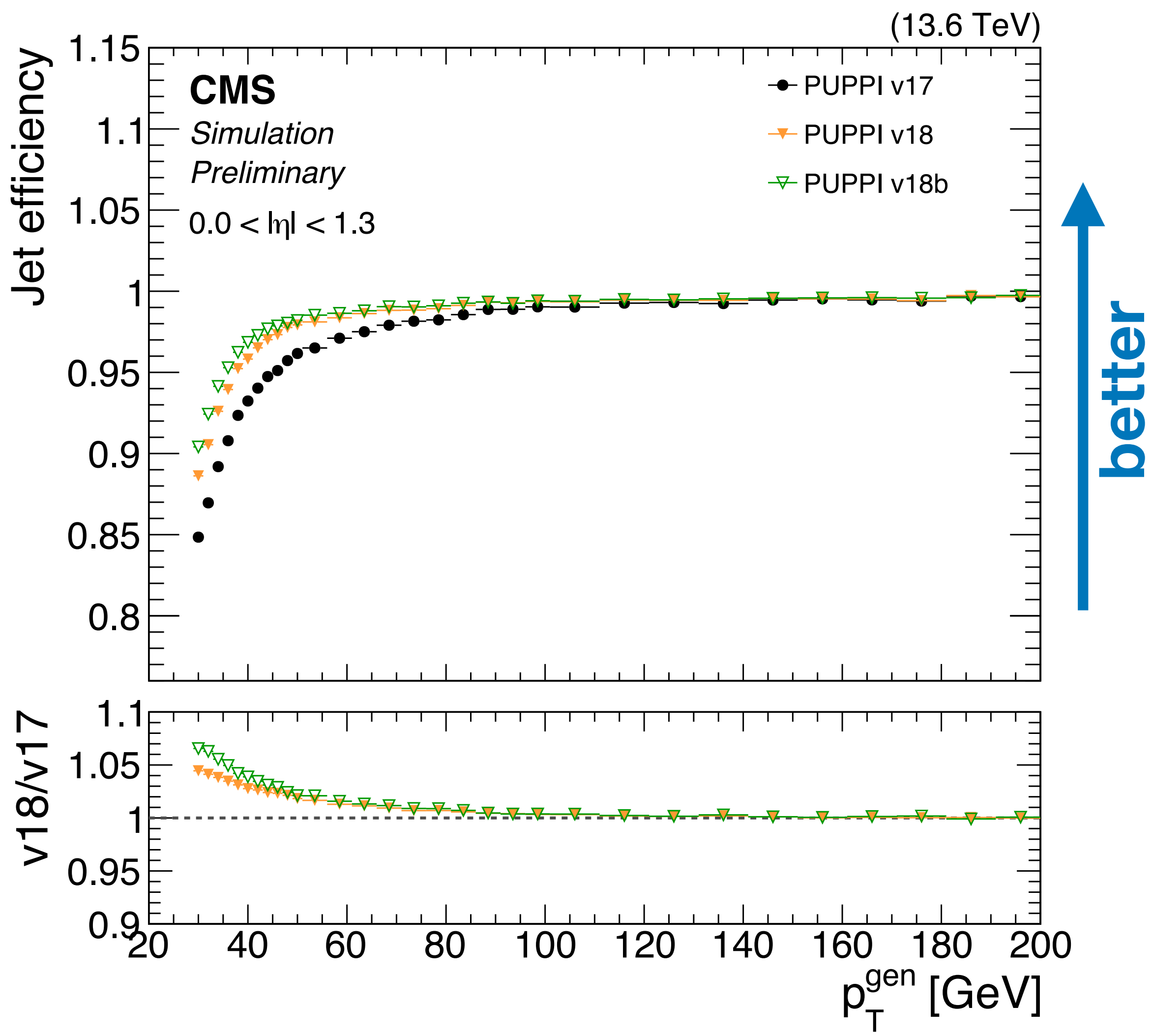


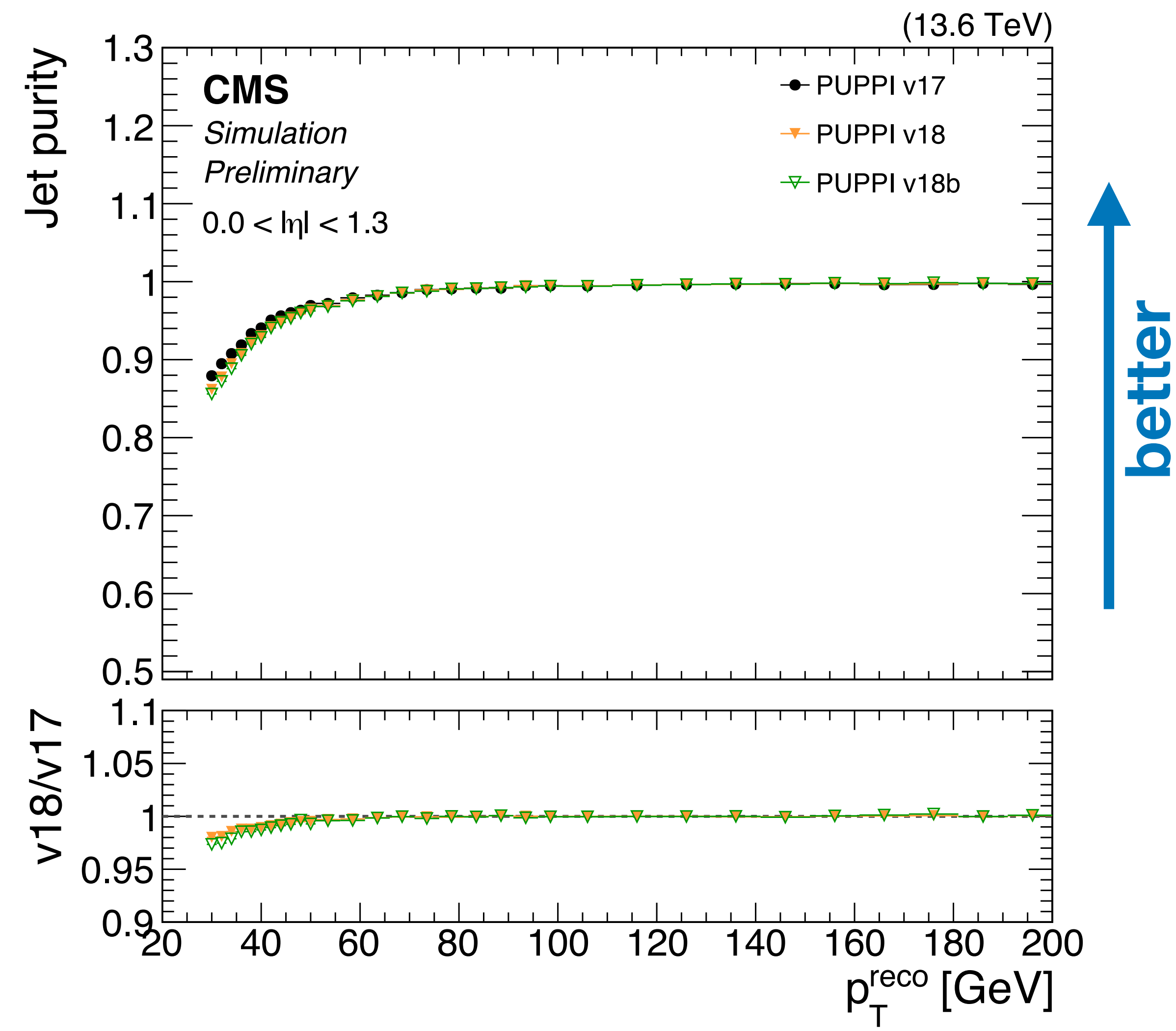
- Unified flavor identification for small-cone jets extended to hadronic τ
- **PUPPI** showed an inefficiency wrt to **CHS** at low p_T
  → optimized track-vertex association (PUPPI v18)

More about the unified flavor identification in the talk by Uttiya Sarkar

Pileup mitigation in the context of τ_h identification

[CMS-DP-2024-043]





Outline

Jet energy performance

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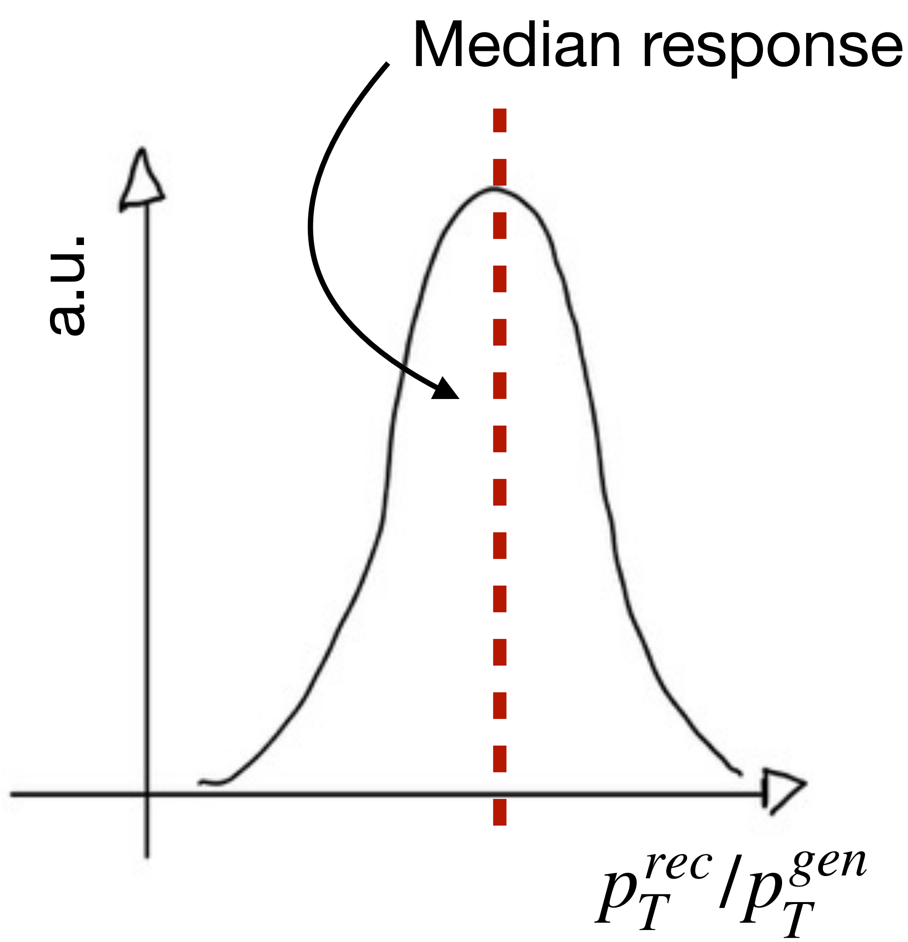
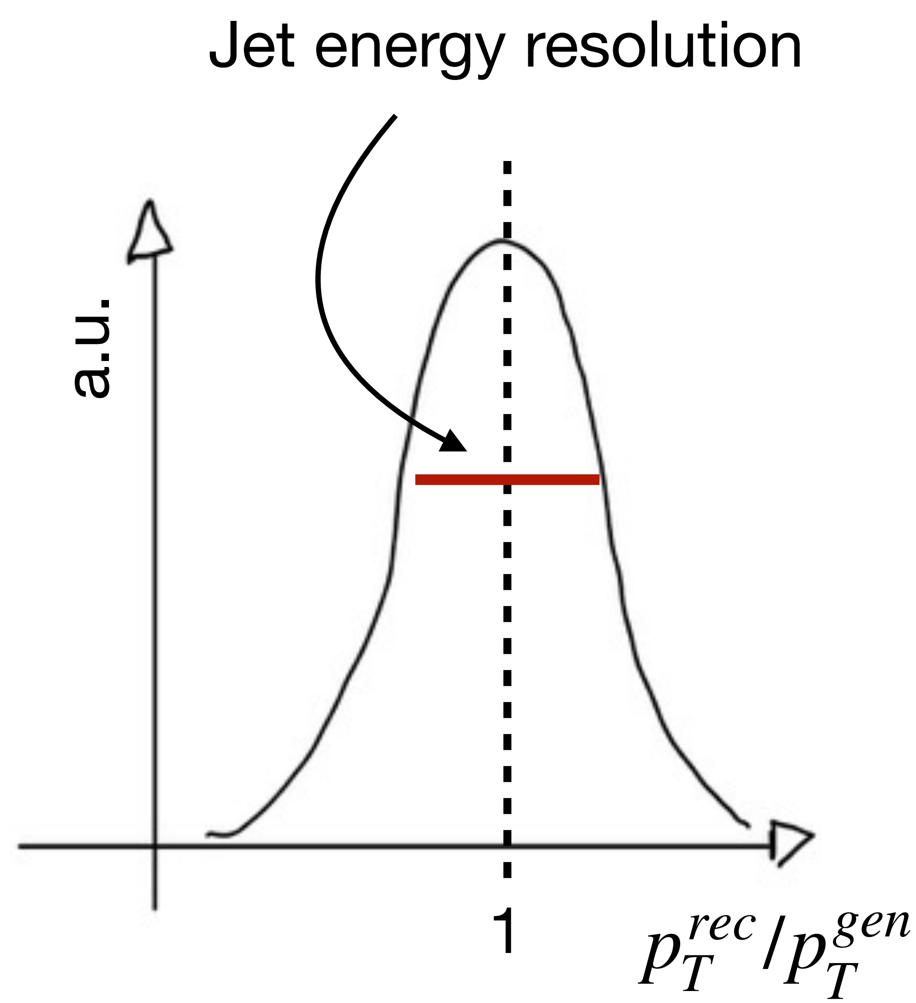
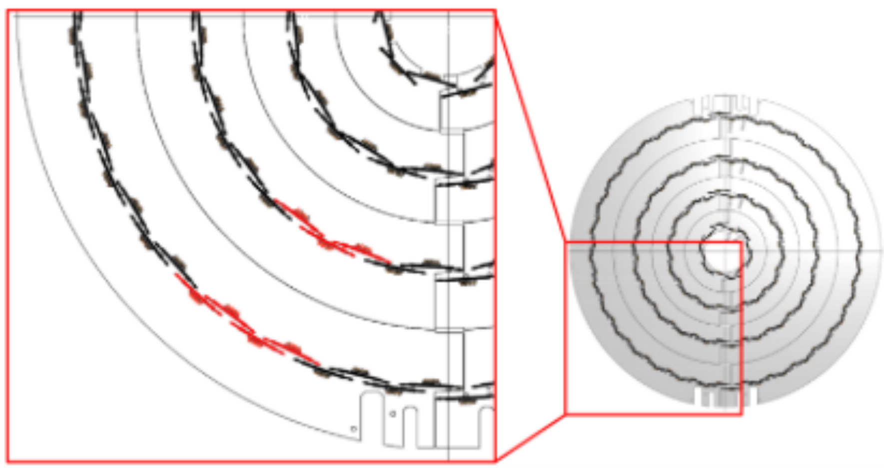


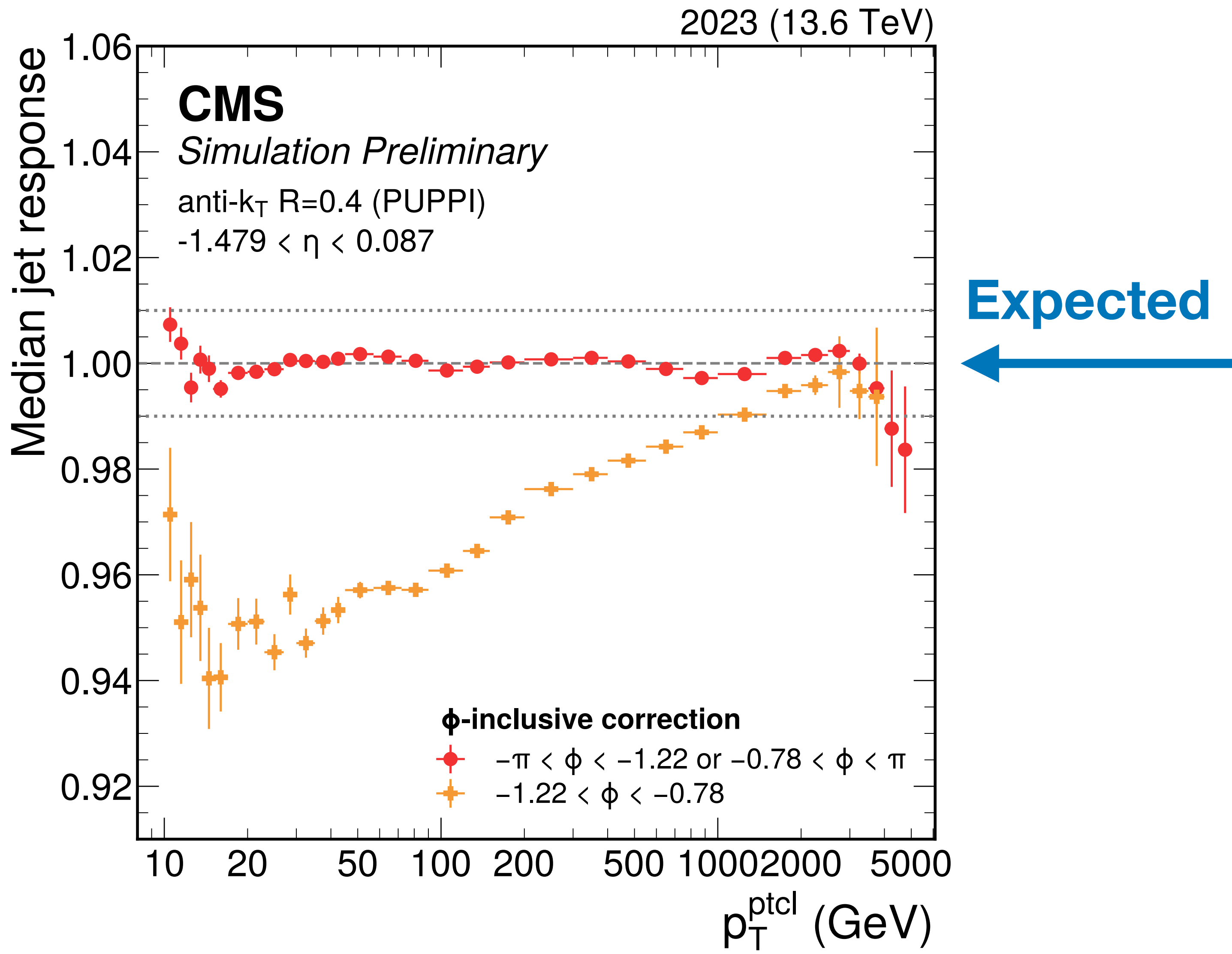


Barrel Pixel layer 3 & 4

After TS1 of 2023 (June 19-24): 27 modules* in the Barrel Pixel Layers 3 & 4 became inoperable (issue in distributing the LHC clock signals). They cover a sector spanning approximately 0.4 radians (~23 degrees) in ϕ at negative pseudorapidity.



A small region in the detector has reduced efficiency in tracking



* representing about 1.5 % of the total modules in the pixel detector

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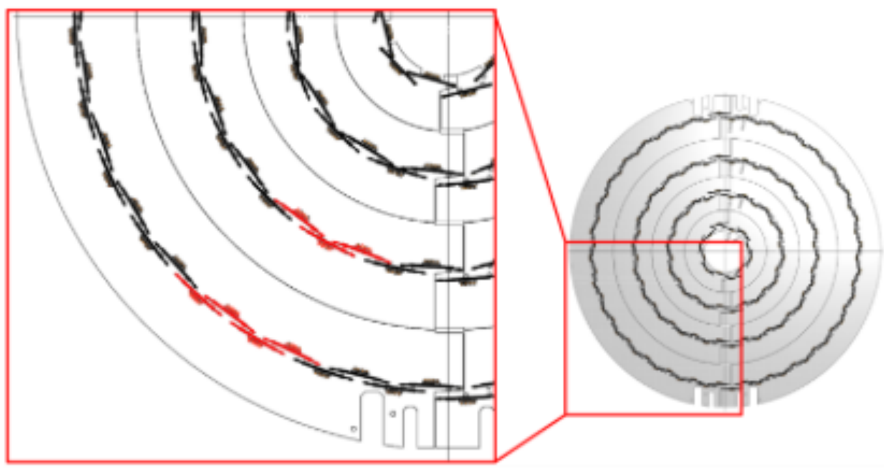

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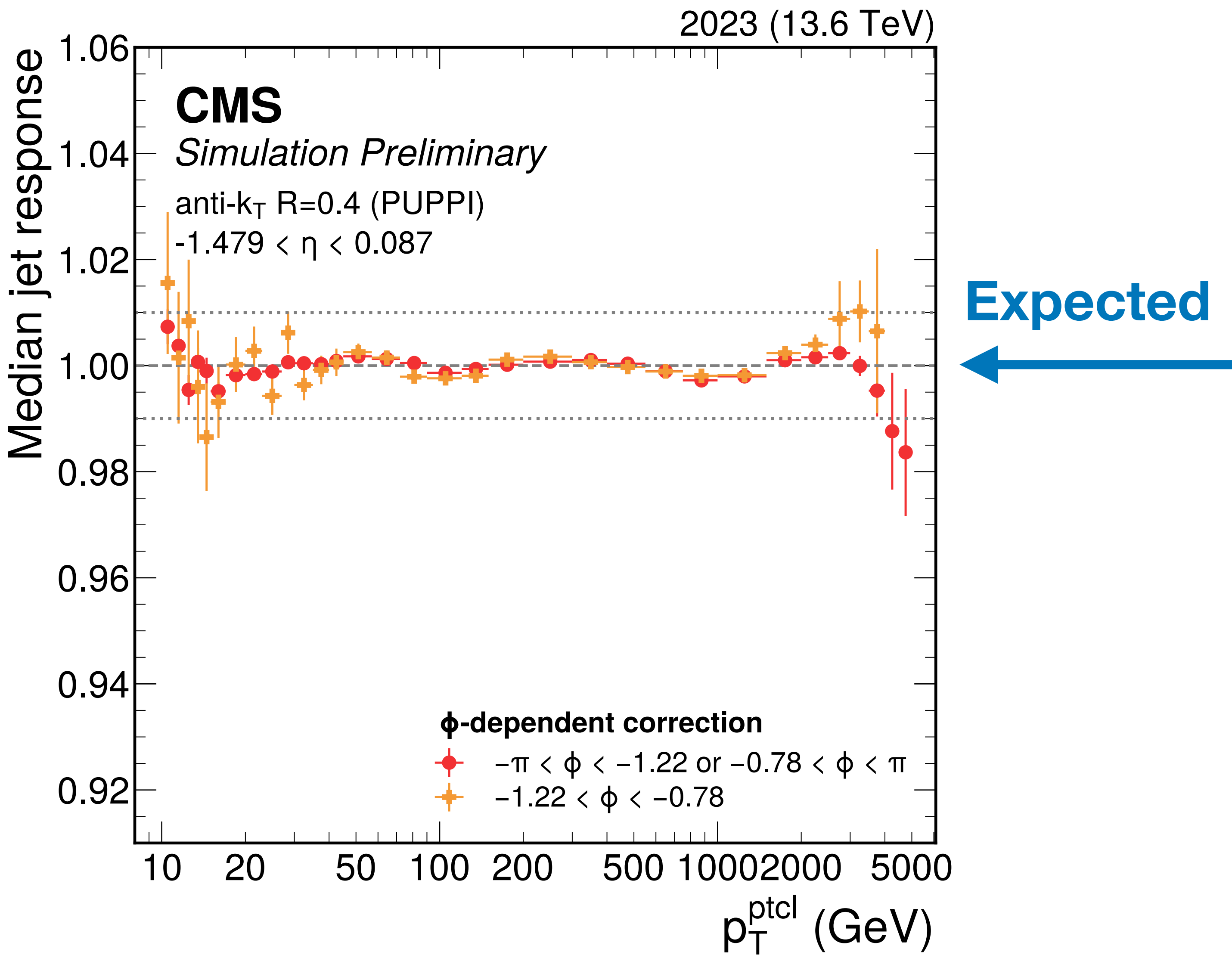

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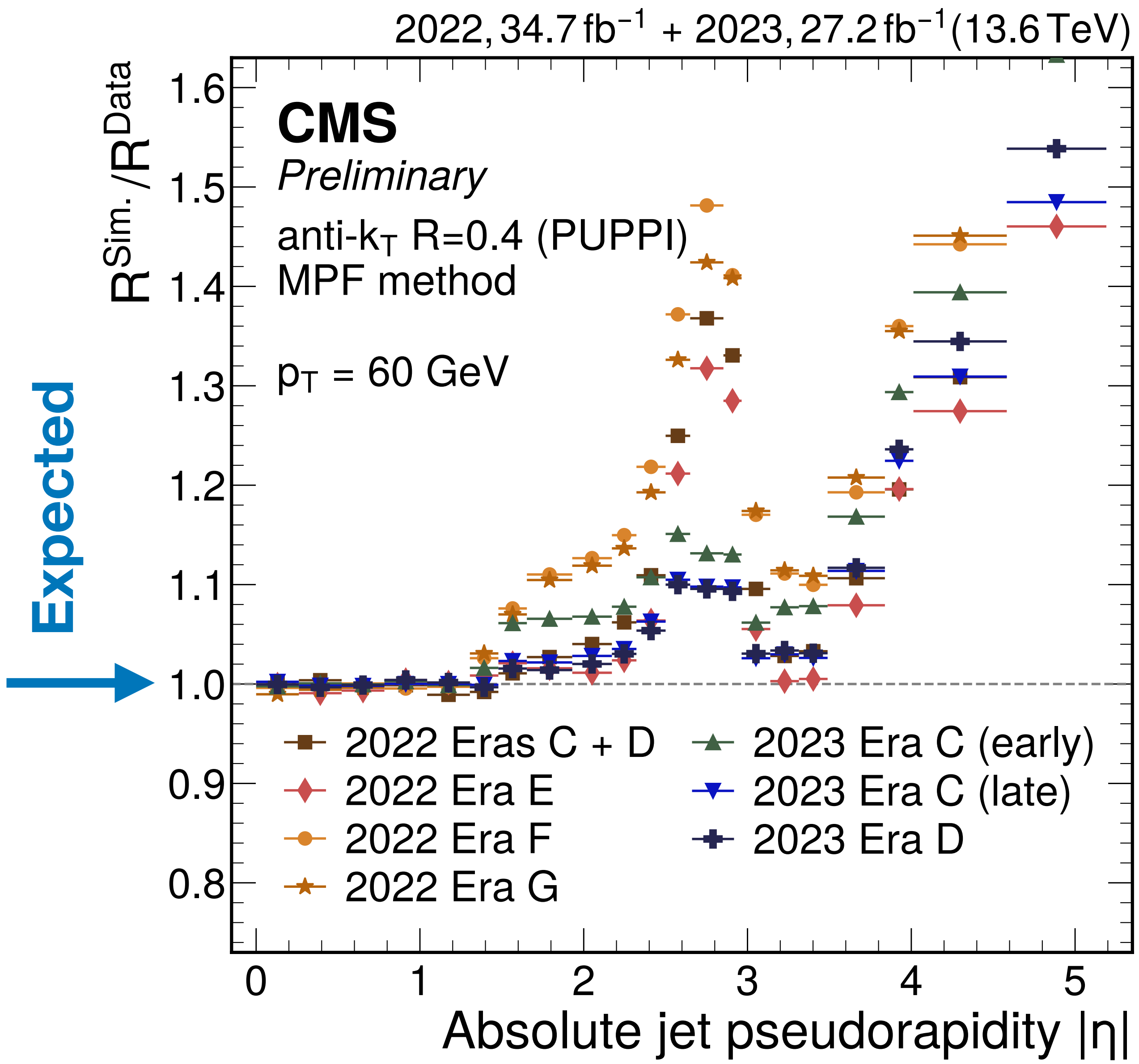
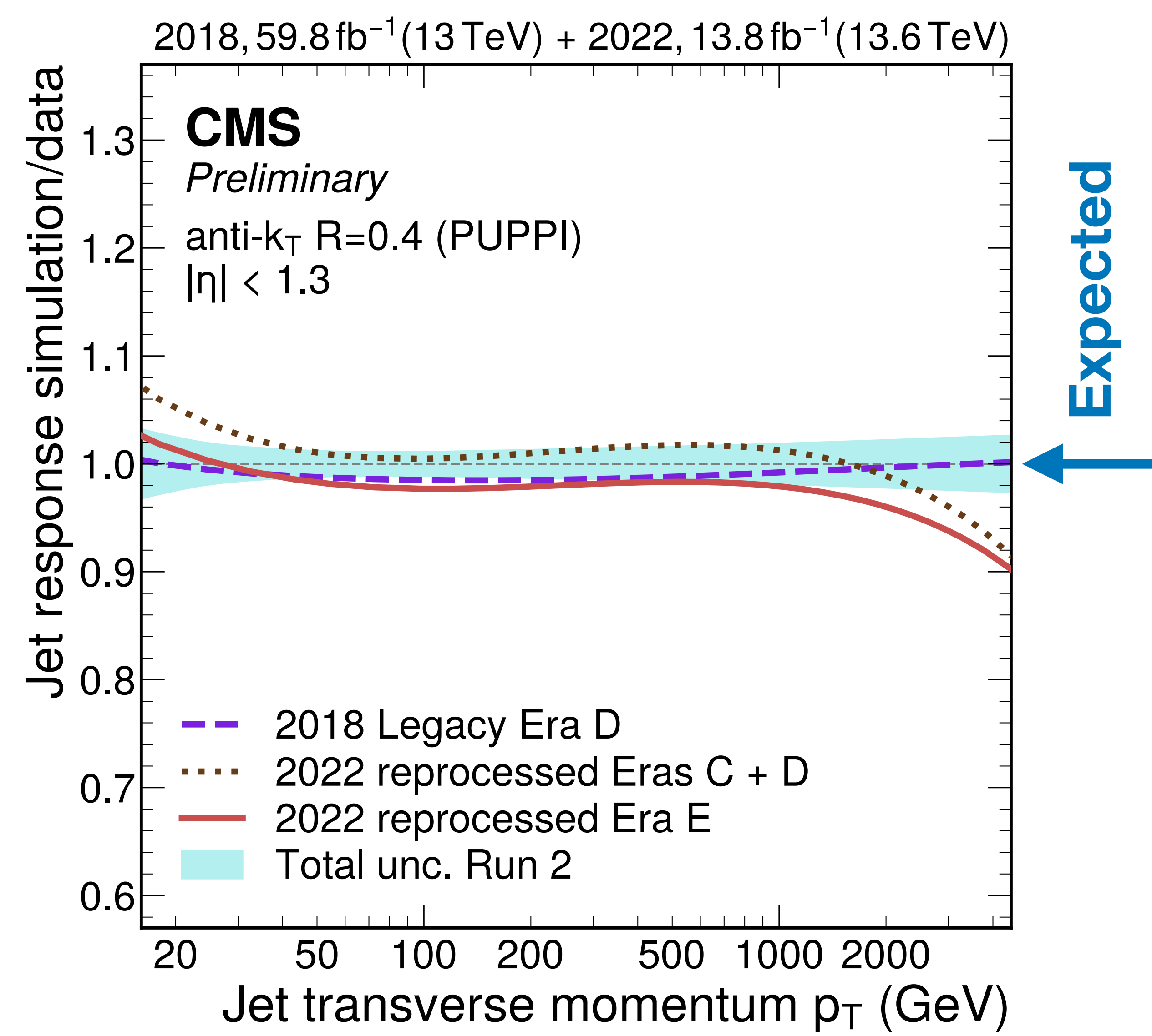
Jet energy scale – time evolution -

[CMS-DP-2024-039]

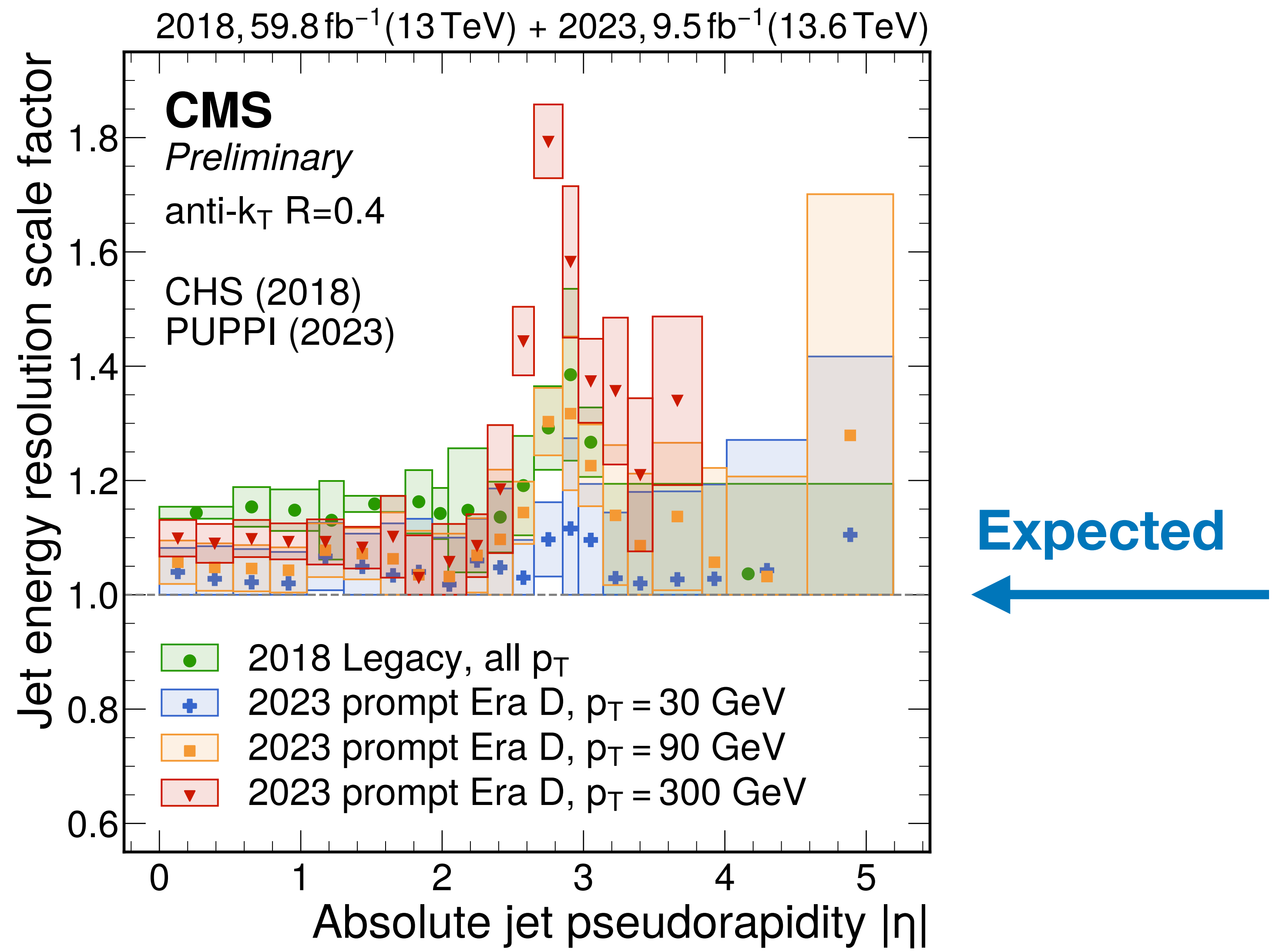




- Excellent performance in the barrel region for Run3
- The difference between data and simulation stable after the alignment in 2022

Jet energy resolution - time evolution -

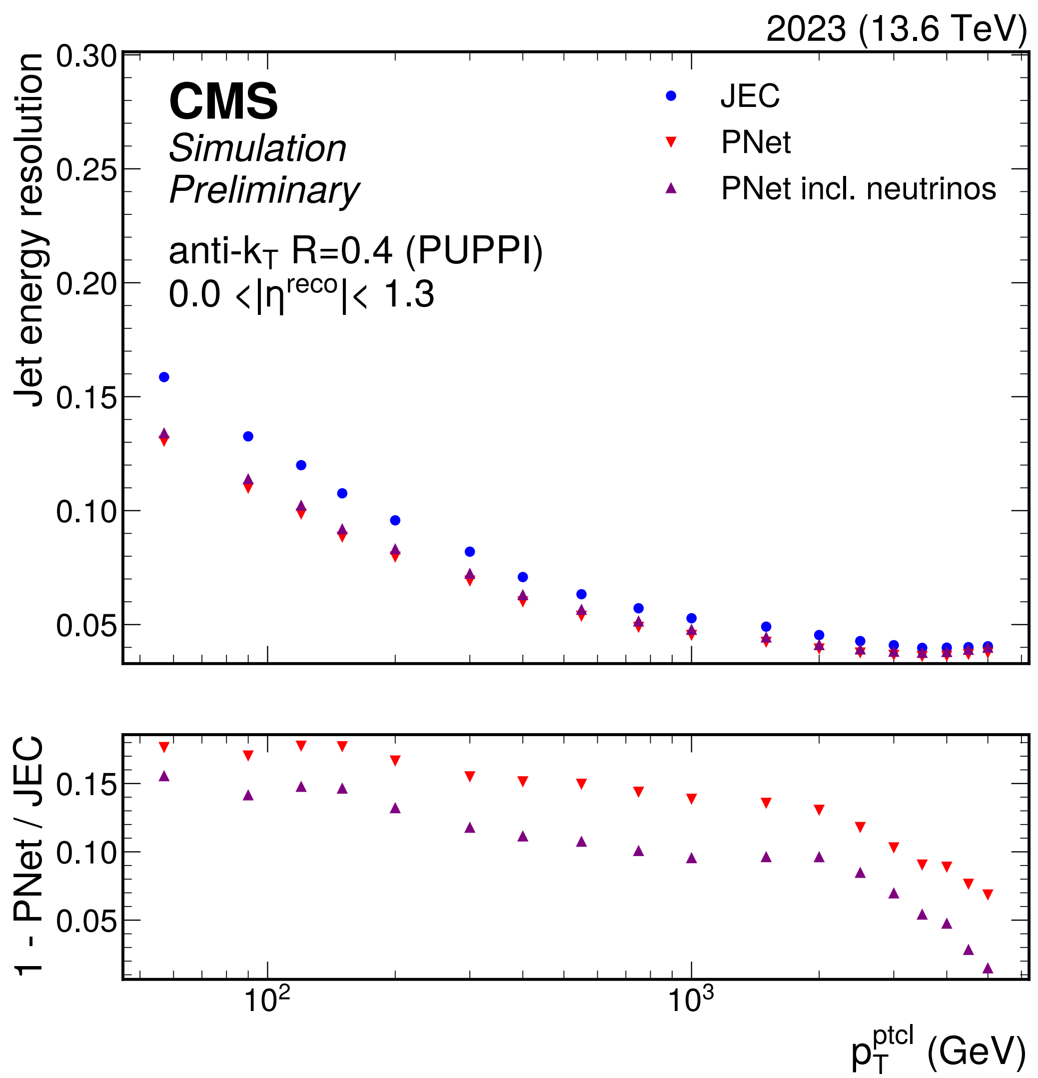
[CMS-DP-2024-039]

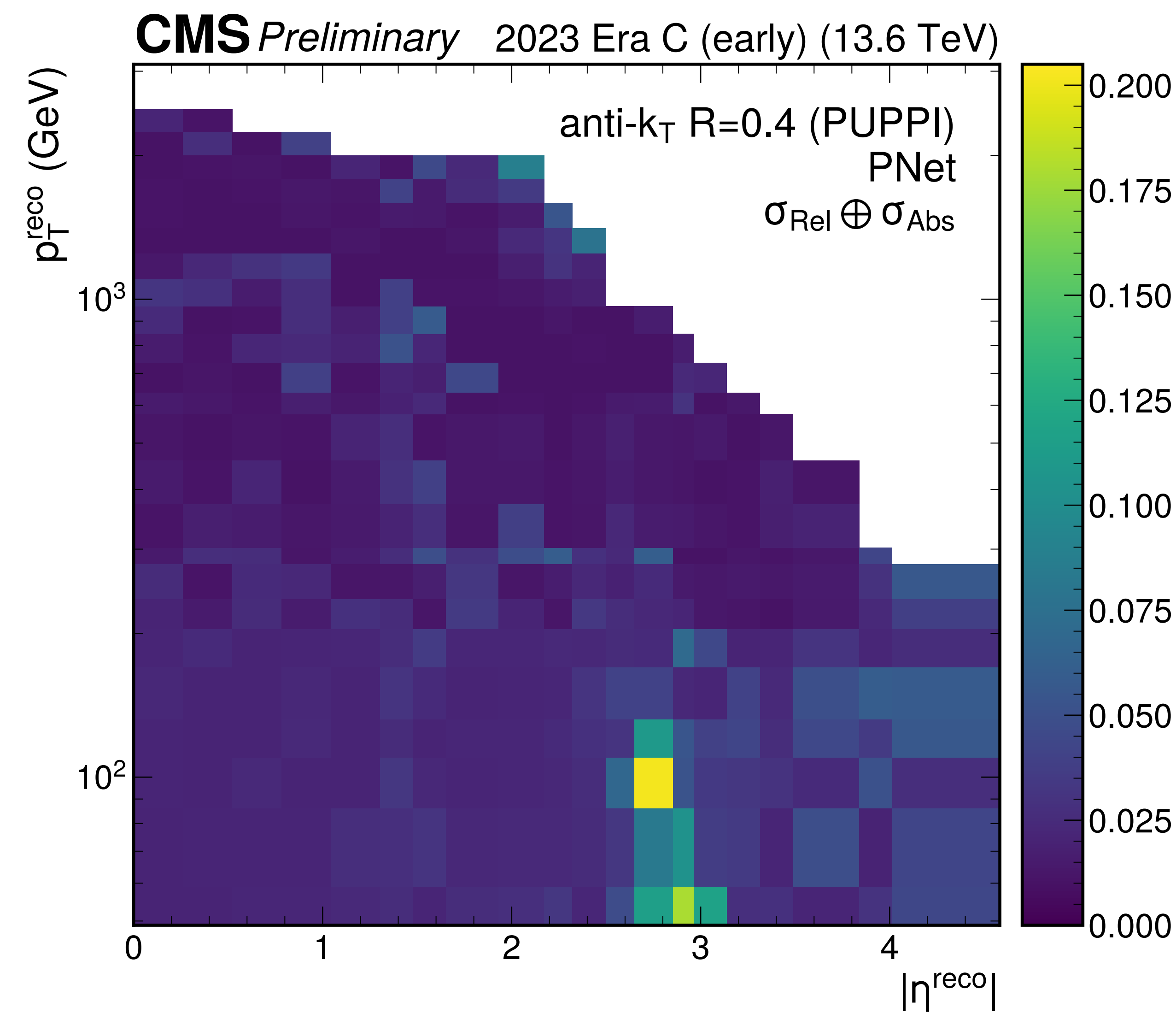


Outperforming legacy Run2 reconstruction in $|\eta| < 2.5$ with promptly reconstructed data!

p_T regression

[CMS-DP-2024-064]





First flavor-aware p_T regression for small cone jets:

- Significant resolution improvement of up to 17%!
- Complete calibration with data gives a non-closure of 2-5% in $|\eta| < 2.5$

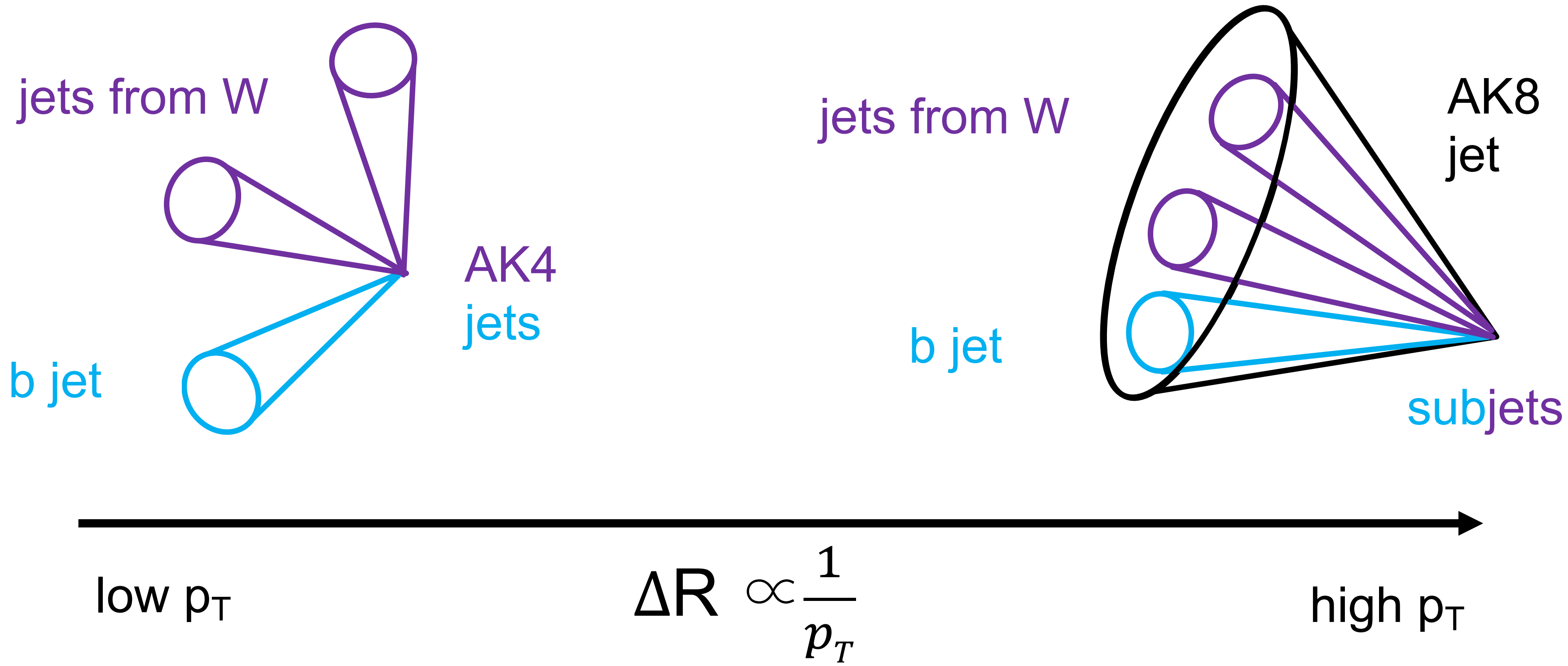
Outline

New developments

New developments for variable-R jet clustering and charge identification

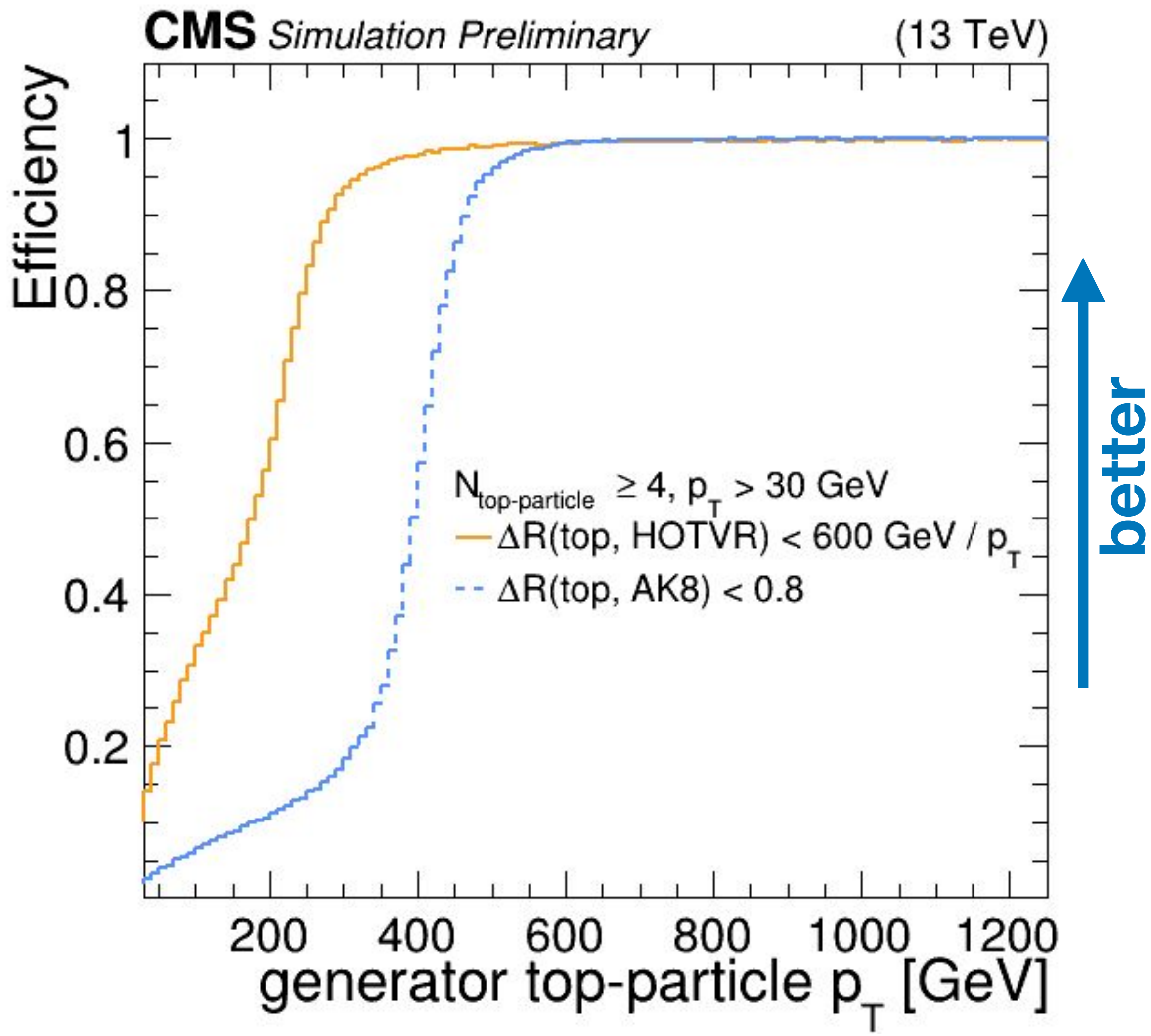
[CMS-DP-2024-038]

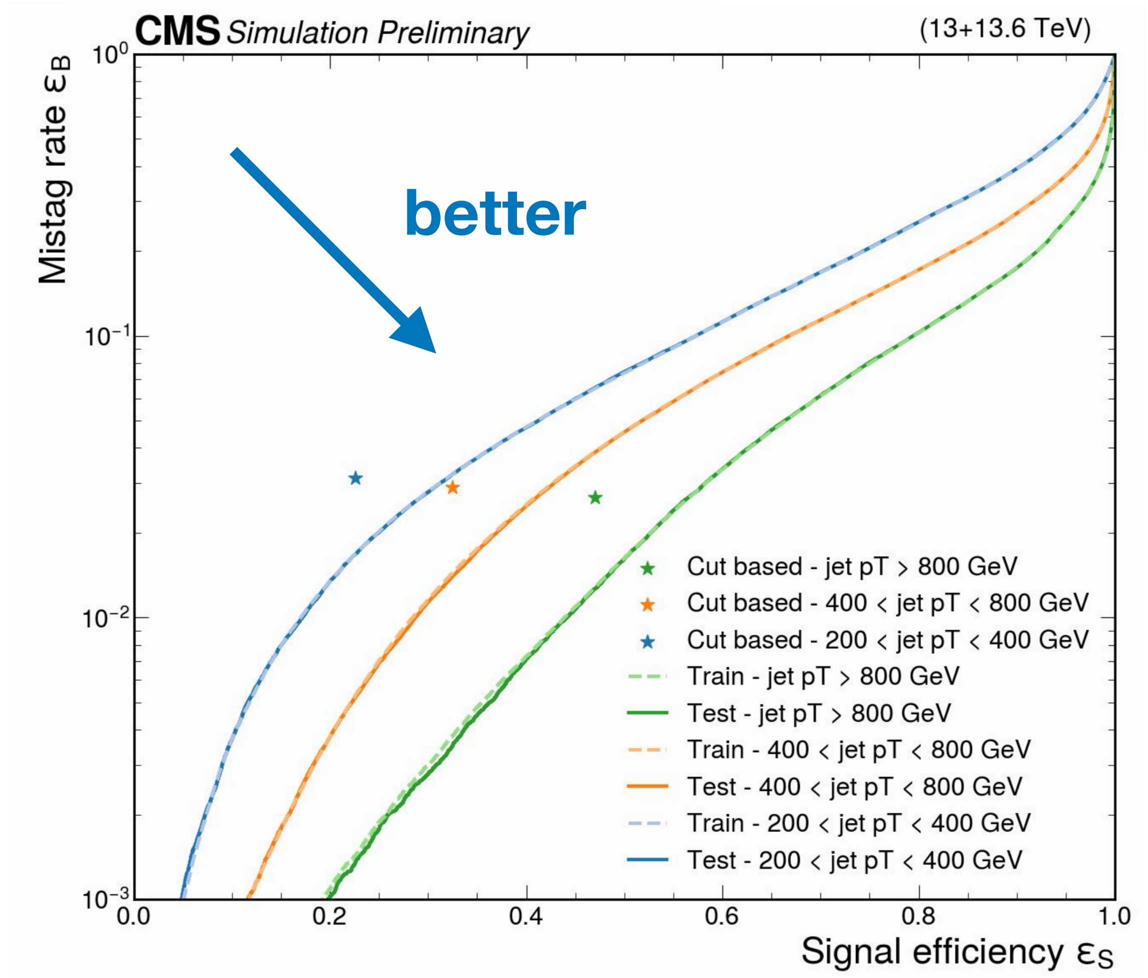
[CMS-DP-2024-044]



Multiscale problems with Variable-R jet clustering

[CMS-DP-2024-038]

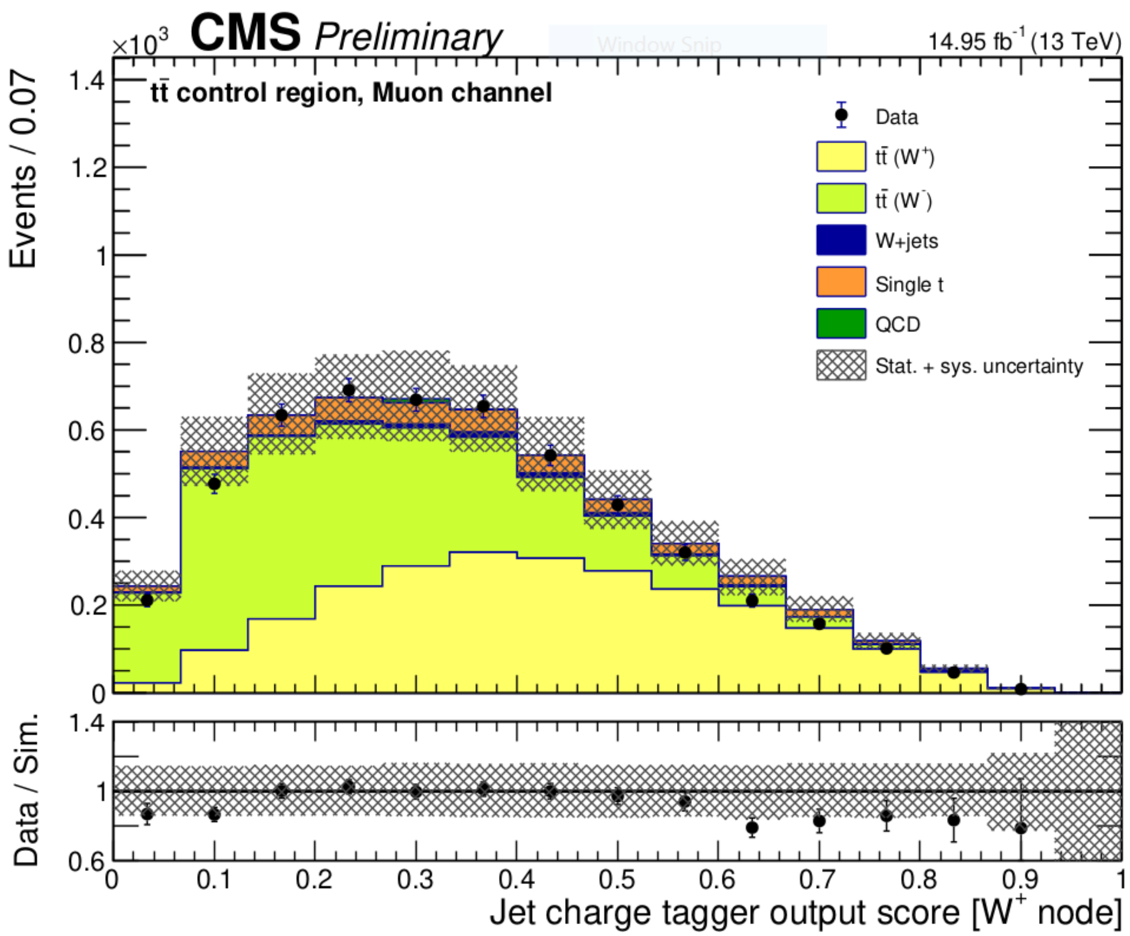


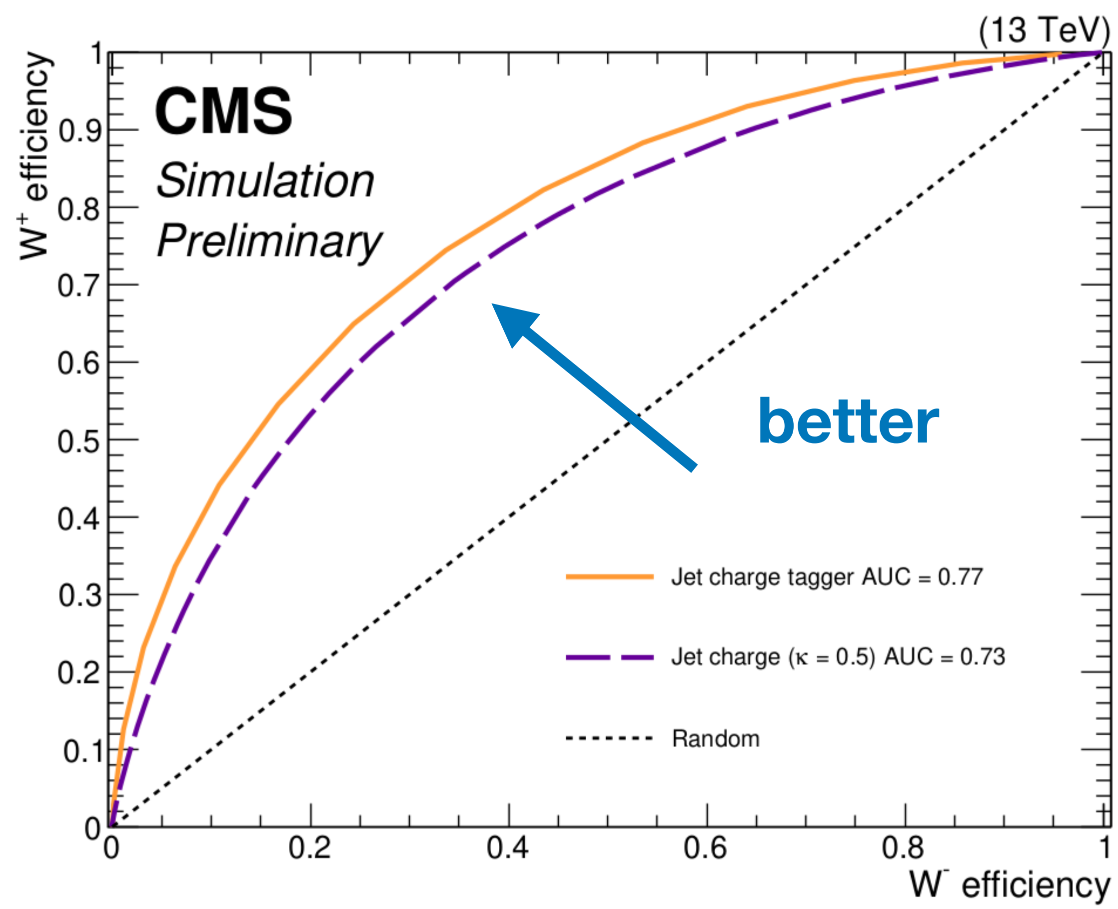


- Variable-R clustering especially useful for multiscale problems like 4 top final states
- Training a BDT improves the top tagging efficiency significantly over cut-based approach

Jet charge tagger

[CMS-DP-2024-044]

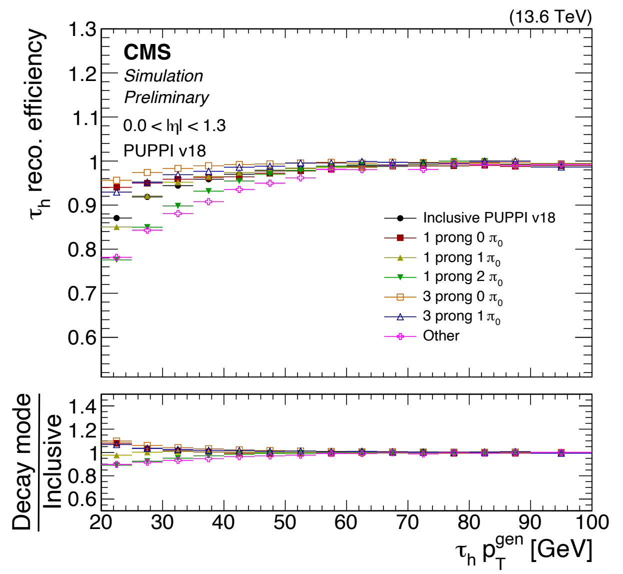




- Development of a charge jet tagger to differentiate W^+, W^-
- Using ParticleNet architecture trained on W's from $t\bar{t}$ production
- Very good agreement between data and simulation

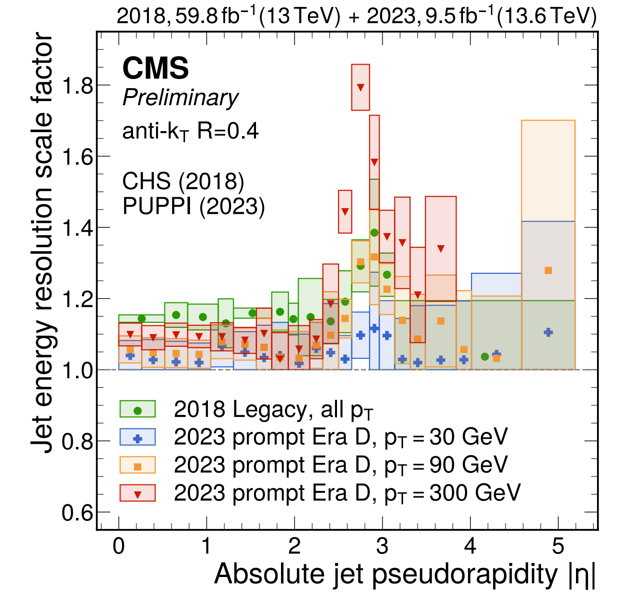
Summary

Optimisation of the pileup mitigation technique for the τ_h identification → unified flavor identification

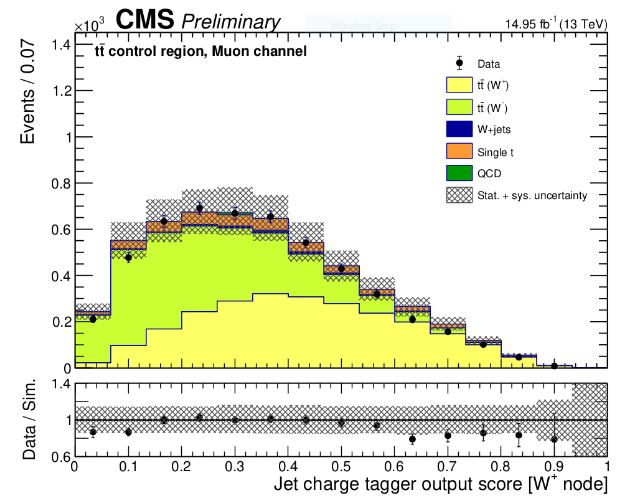


Jet scale and resolution in the barrel region in promptly reconstructed data is as good as legacy reconstruction in Run2

First full calibration of regressed p_T for small-cone jets

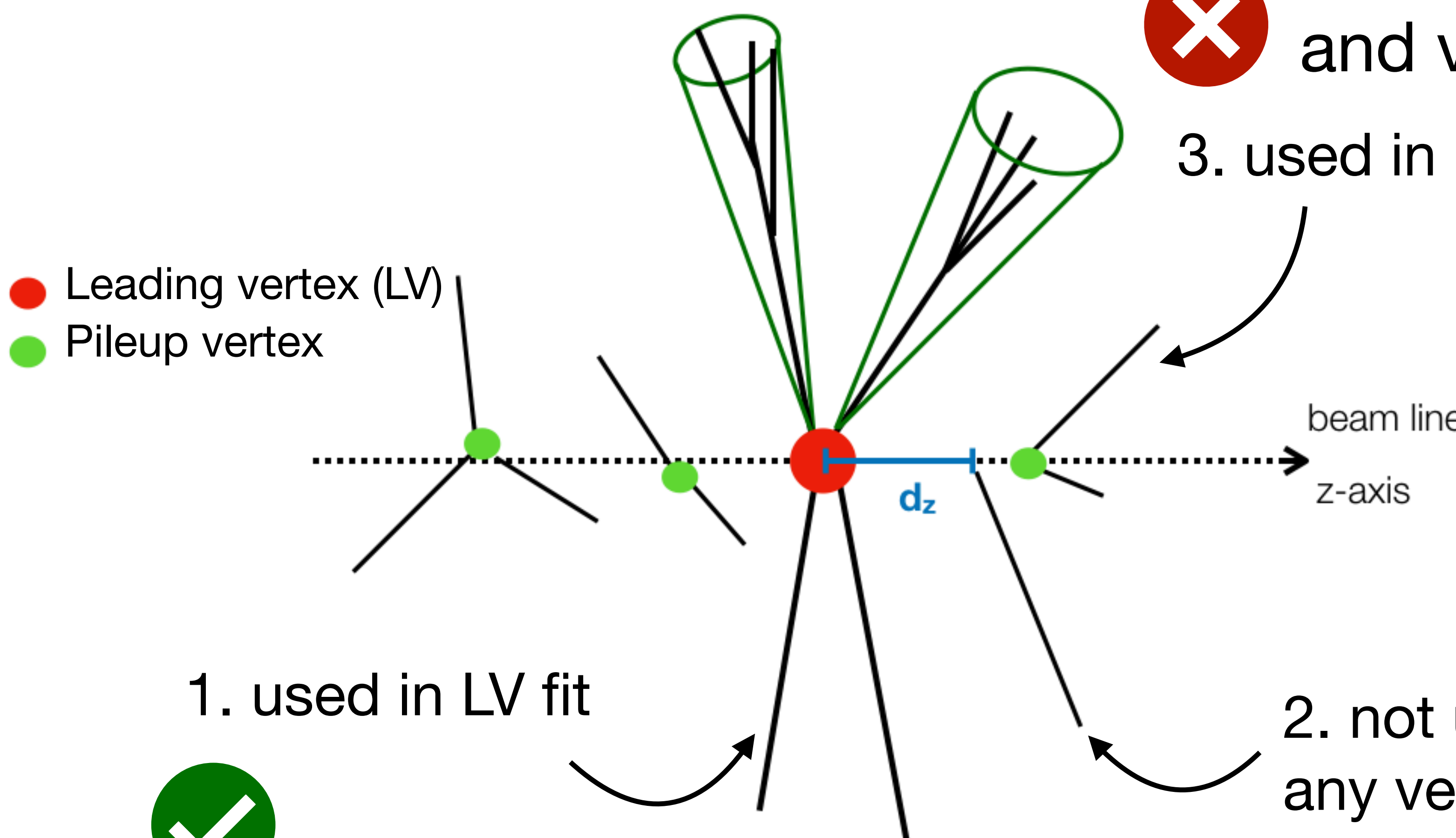


New developments for variable-R jet clustering and charge identification



Backup

Track-vertex association in PUPPI



✓ ✗ Recover tracks used in nearby vertice fits and vertex splitting

3. used in PU vertex fit

1. used in LV fit ✓

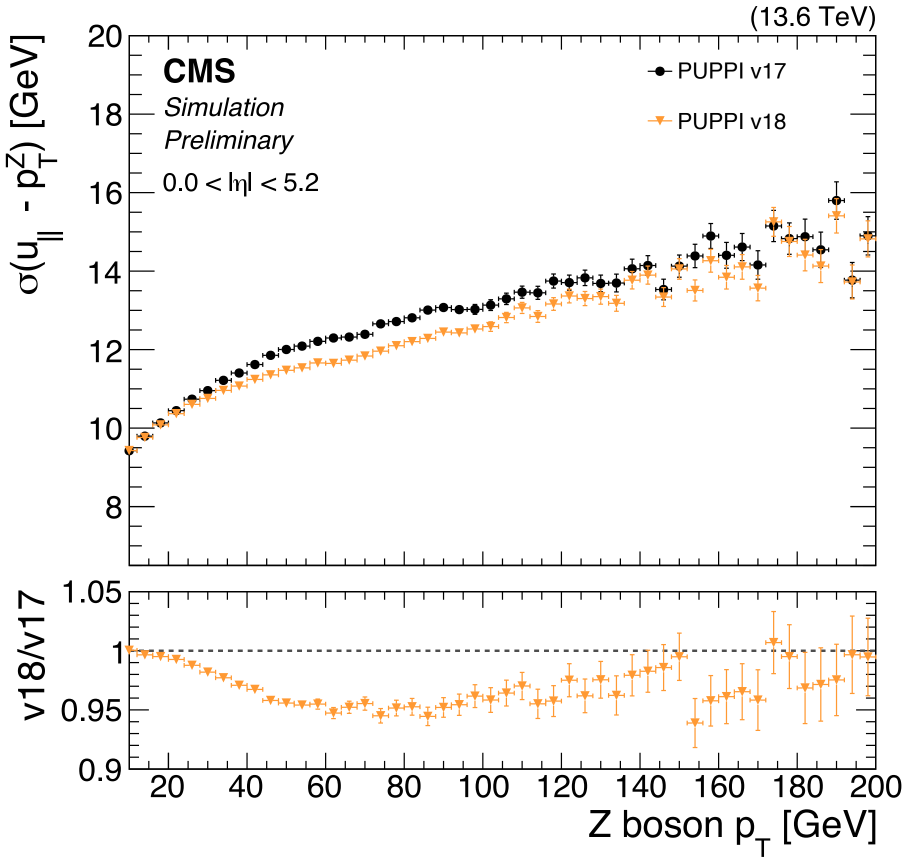
2. not used in any vertex fit

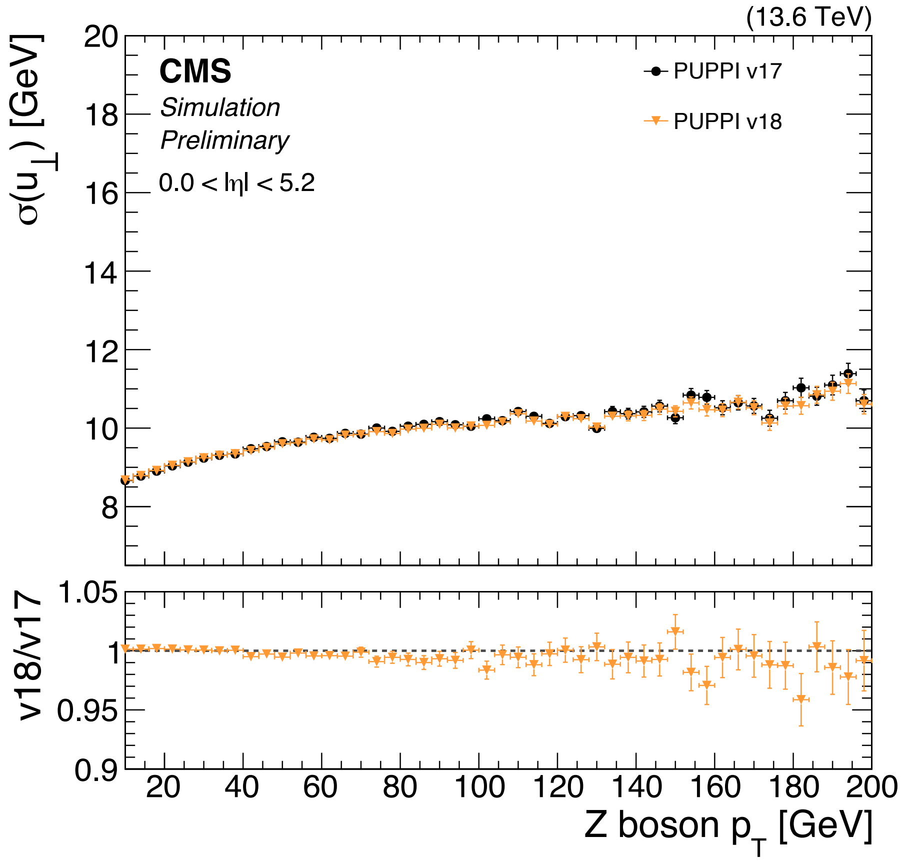
✓ ✗ Decide based on dz and p_T (for $|\eta| > 2.4$)

More information can be found in DP-21-001

CHS keeps LV (✓) and unassociated (✗) particles, PUPPI keeps LV (✓) but assigns a weight o unassociated particles (✗).

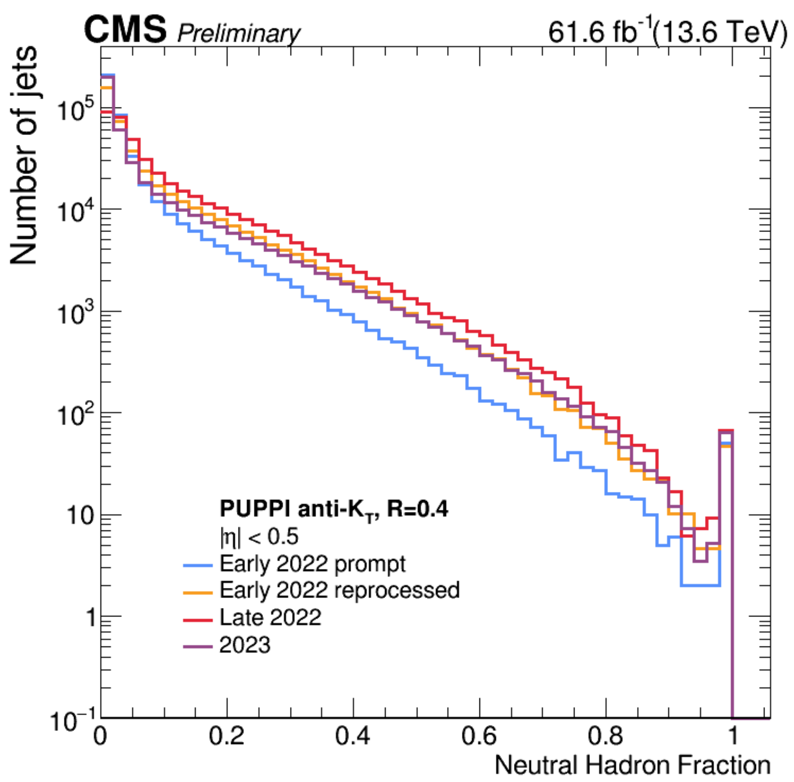
Pileup mitigation in the context of τ_h identification

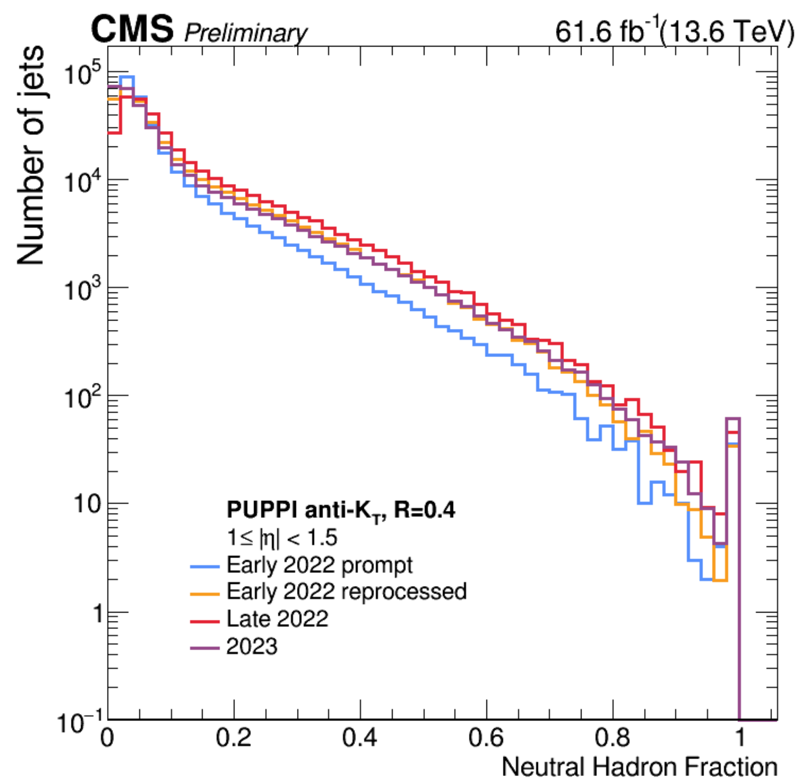


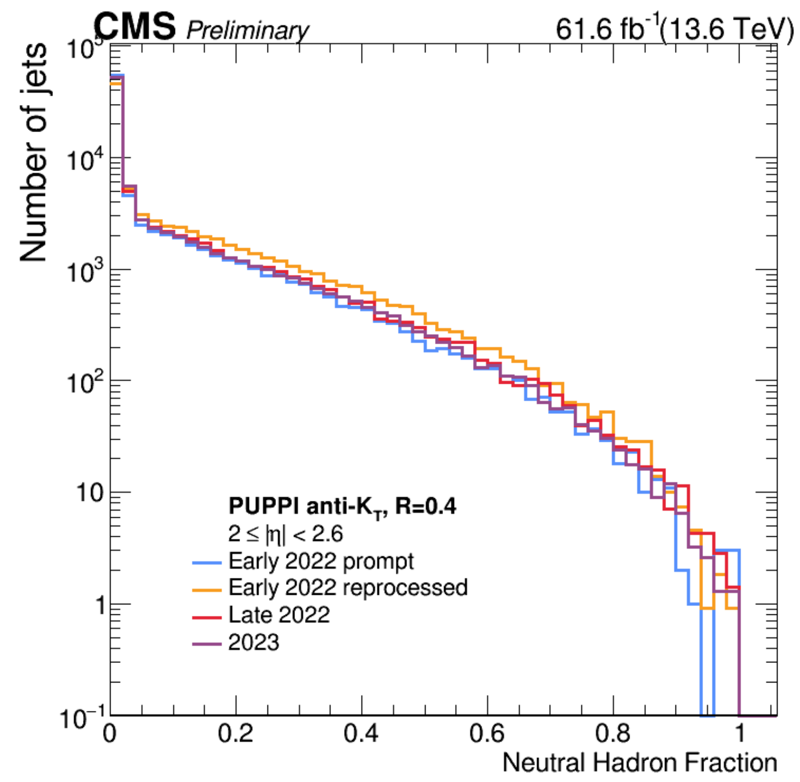


Time stability

[CMS-DP-2024-028]



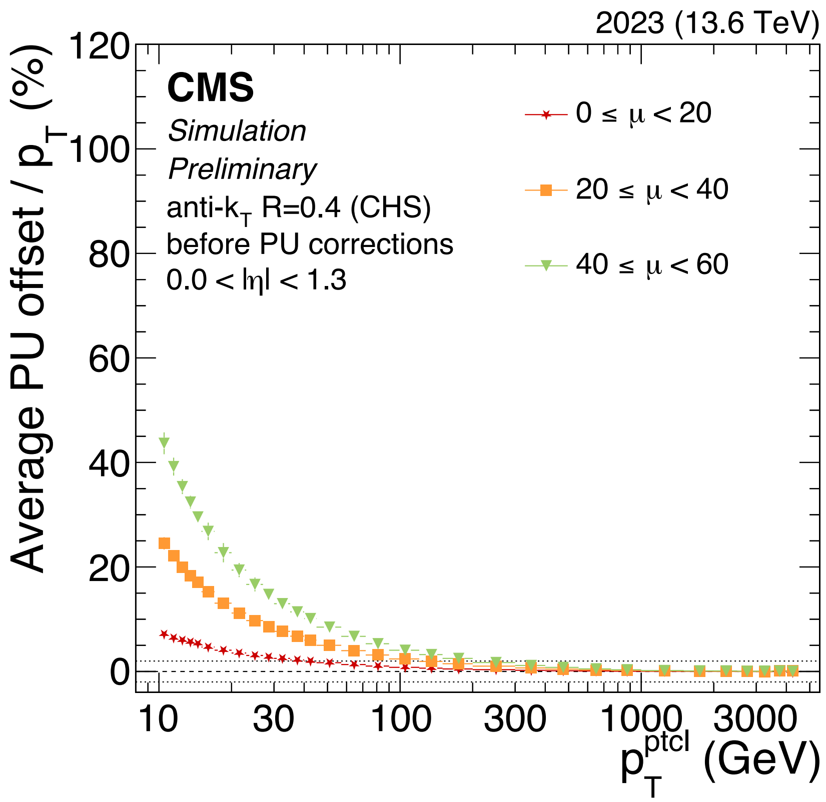


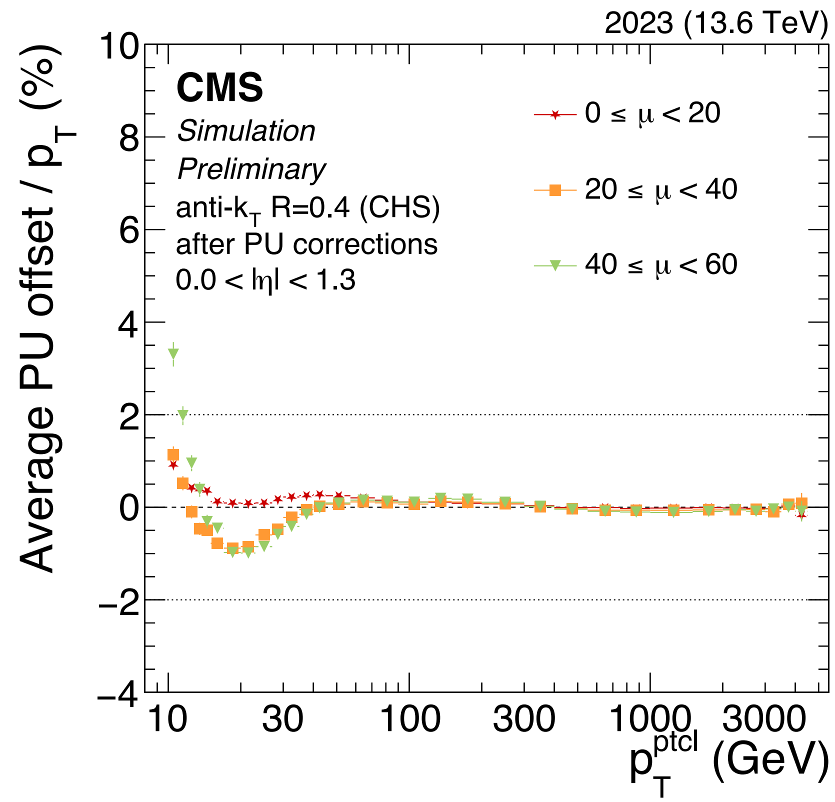


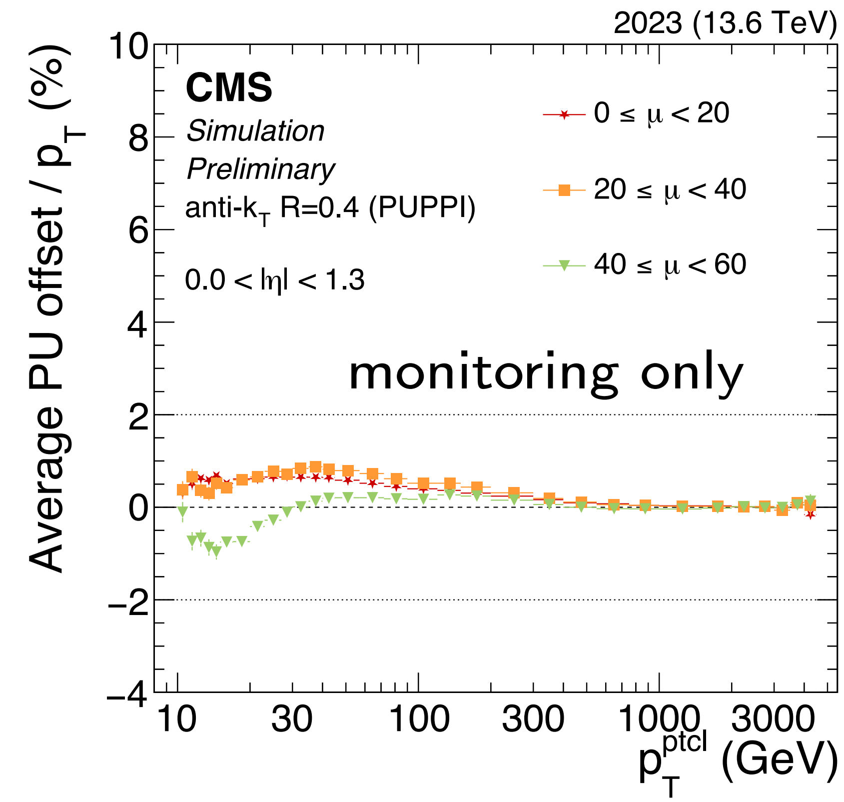
In general a very good time stability is observed!

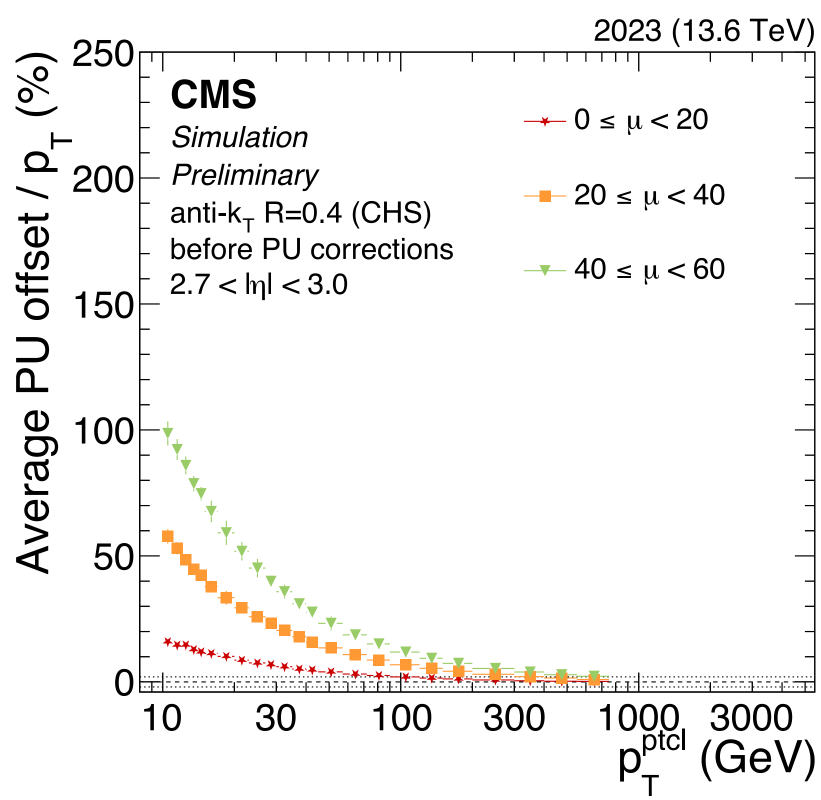
Average pileup offset

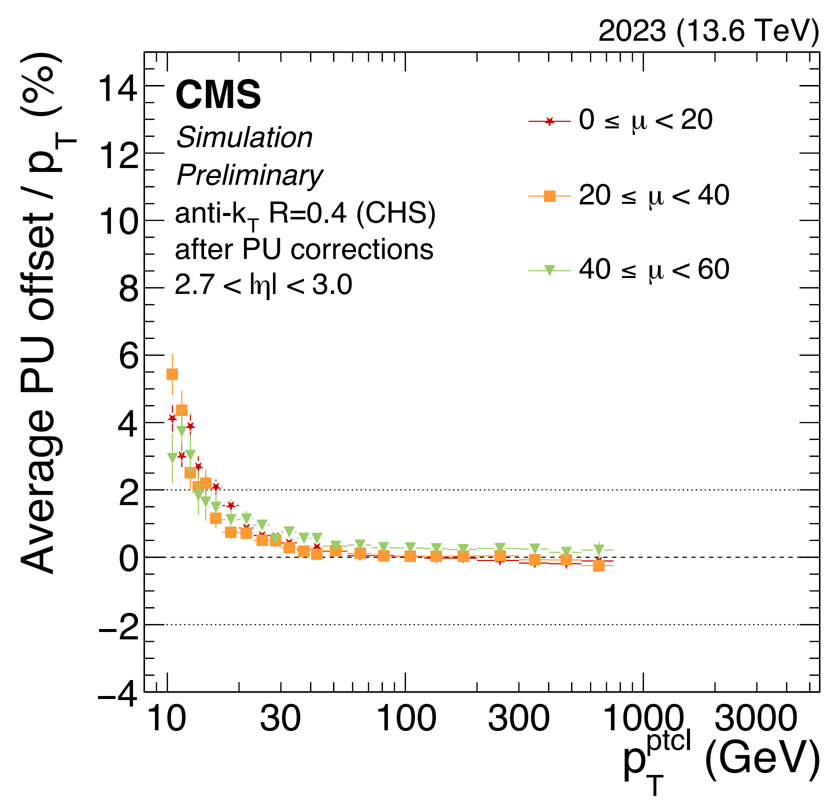
[CMS-DP-2024-039]

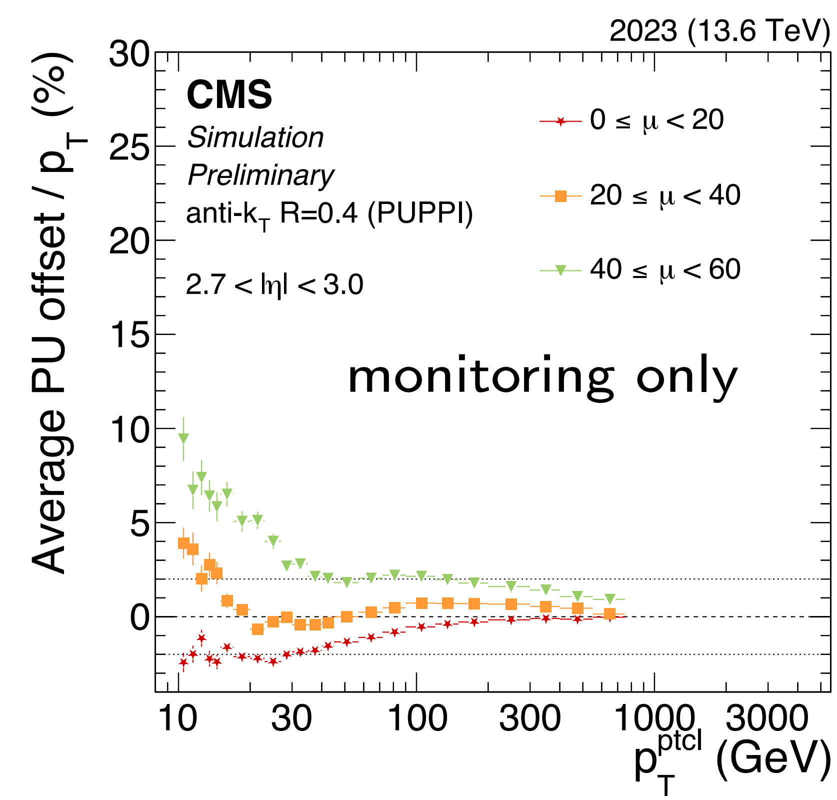






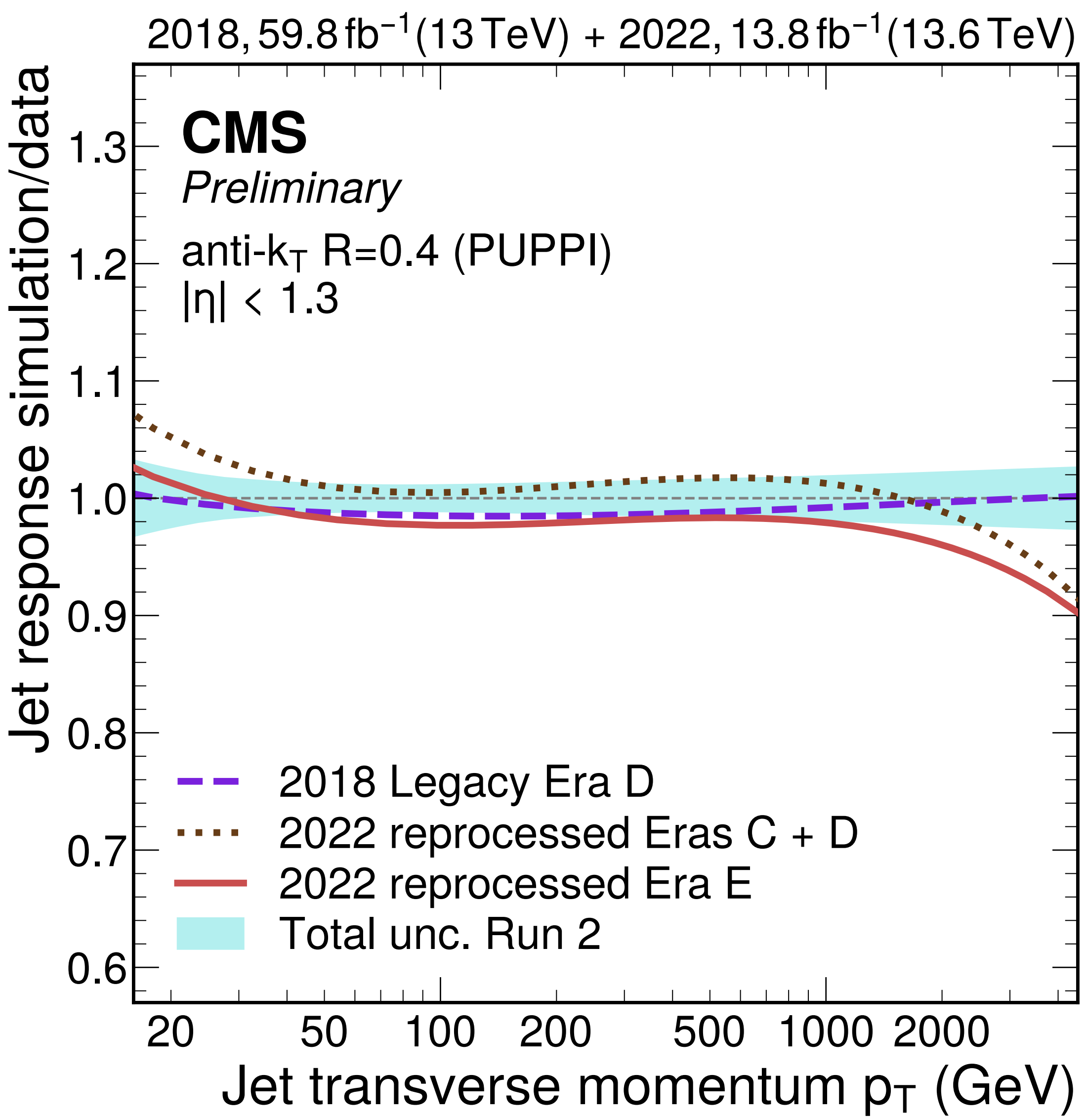


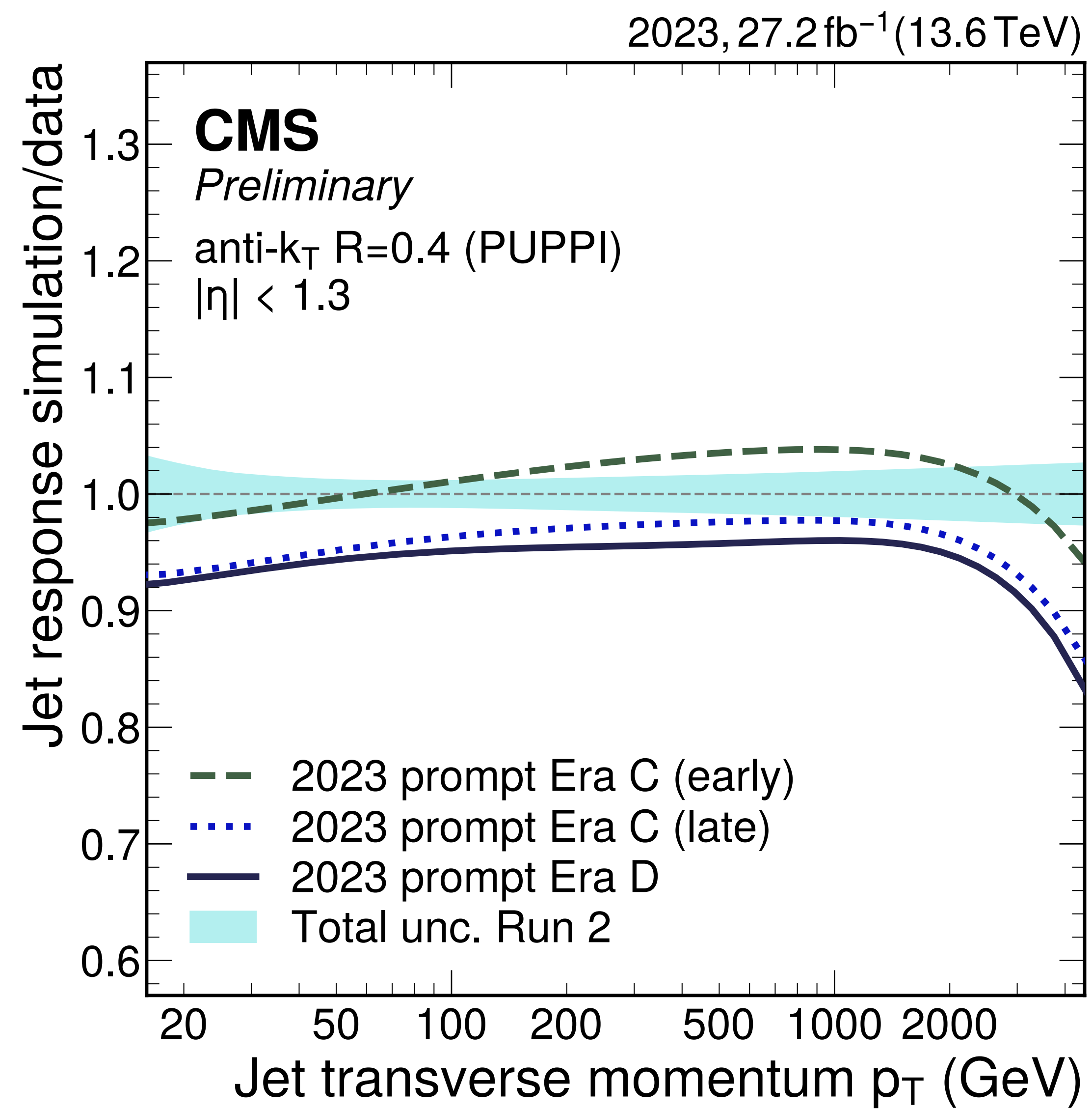




Absolute p_T-dependent residual correction

[CMS-DP-2024-039]

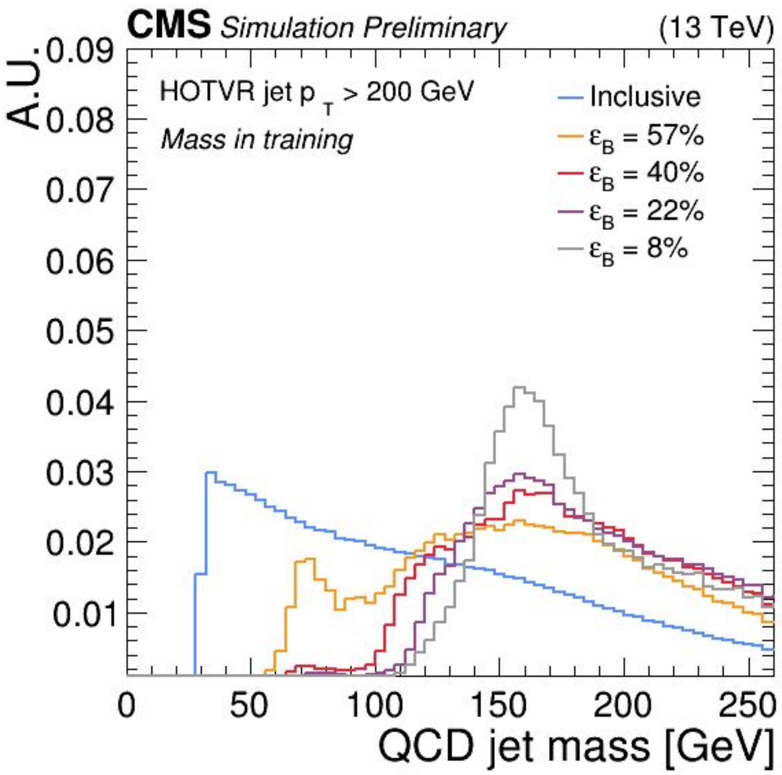


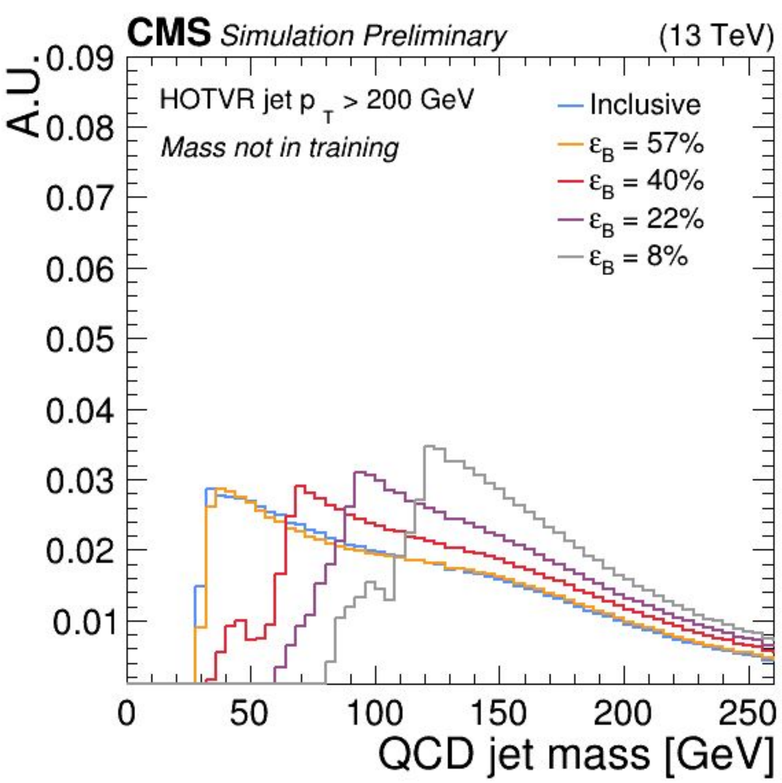


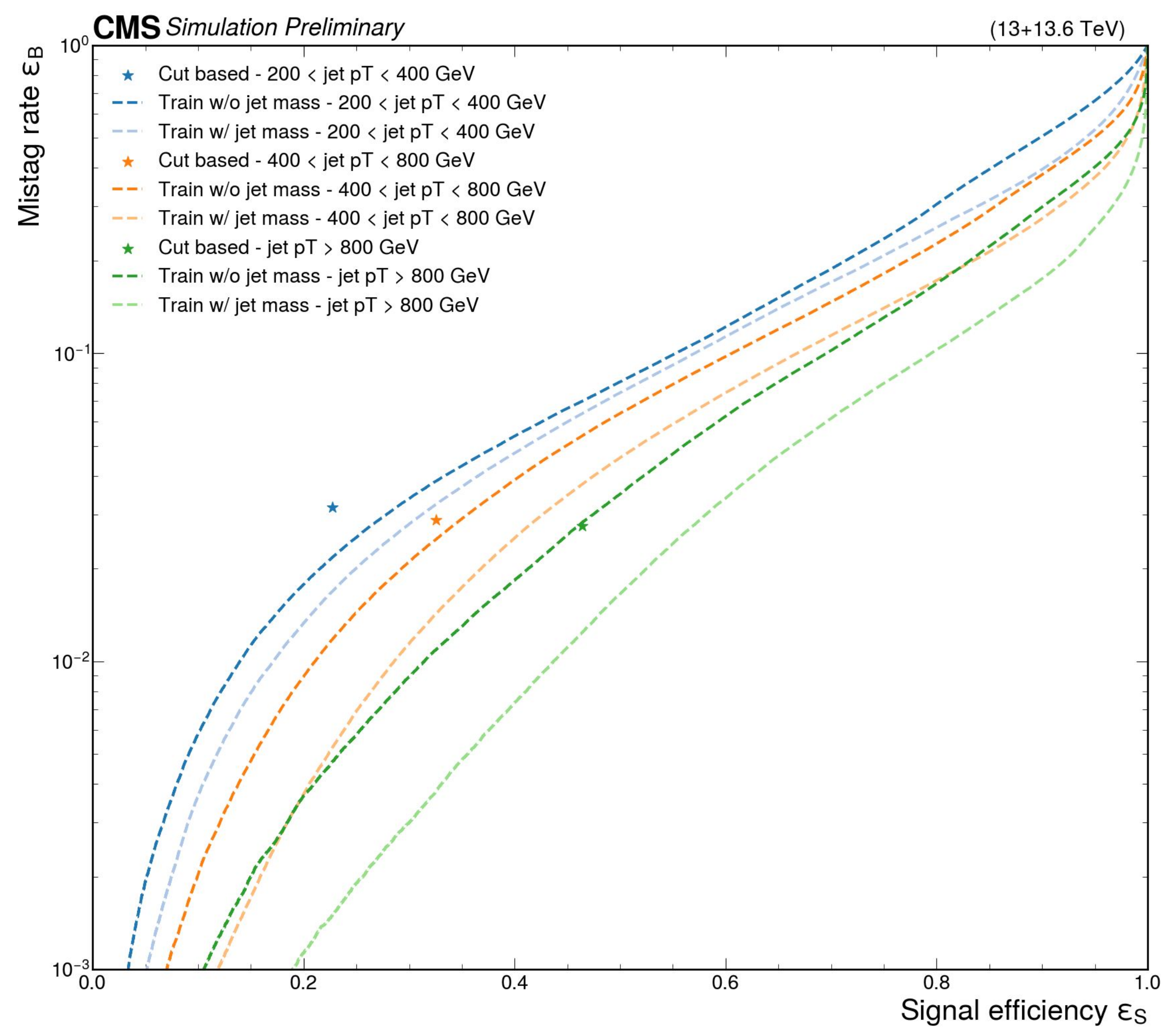
- Similar performance to legacy reconstruction of Run2 in $50 < p_T < 500$ GeV

HOTVR+BDT - mass sculpting

[CMS-DP-2024-038]

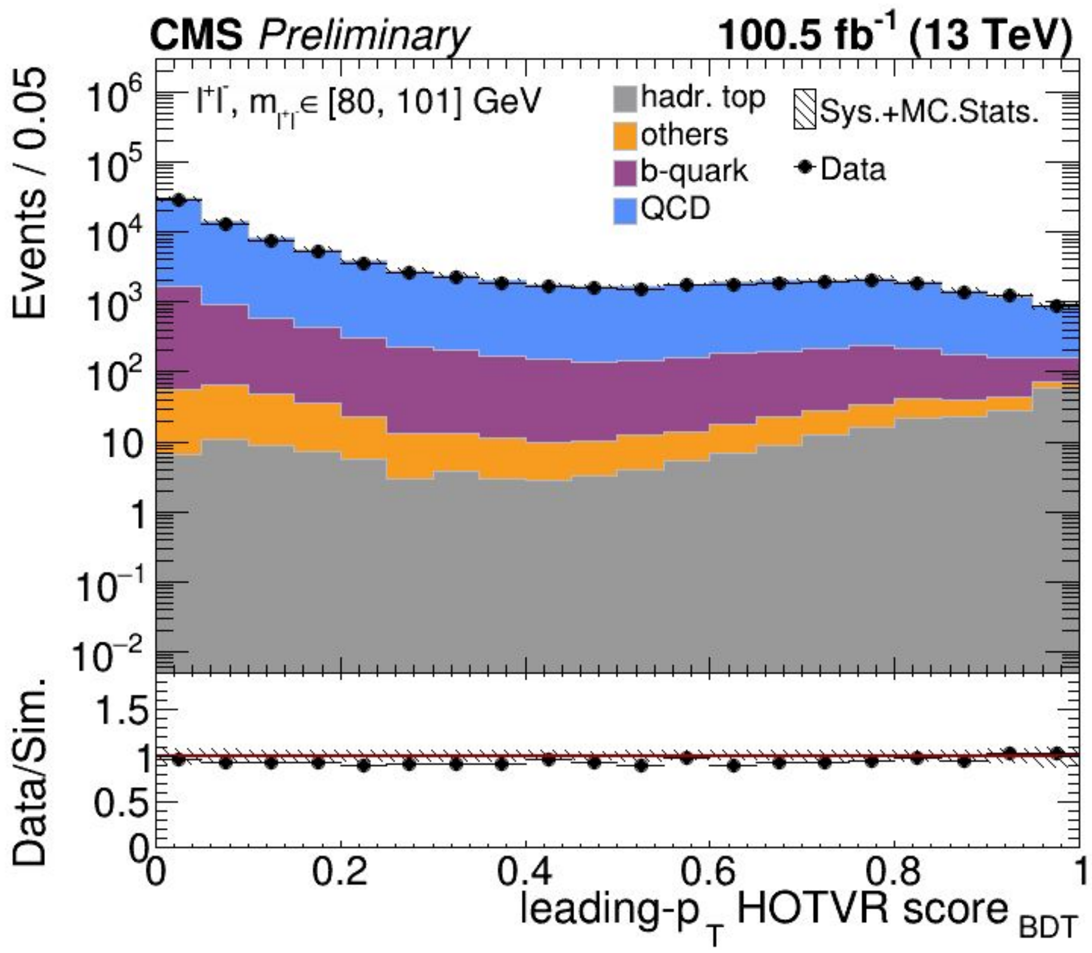


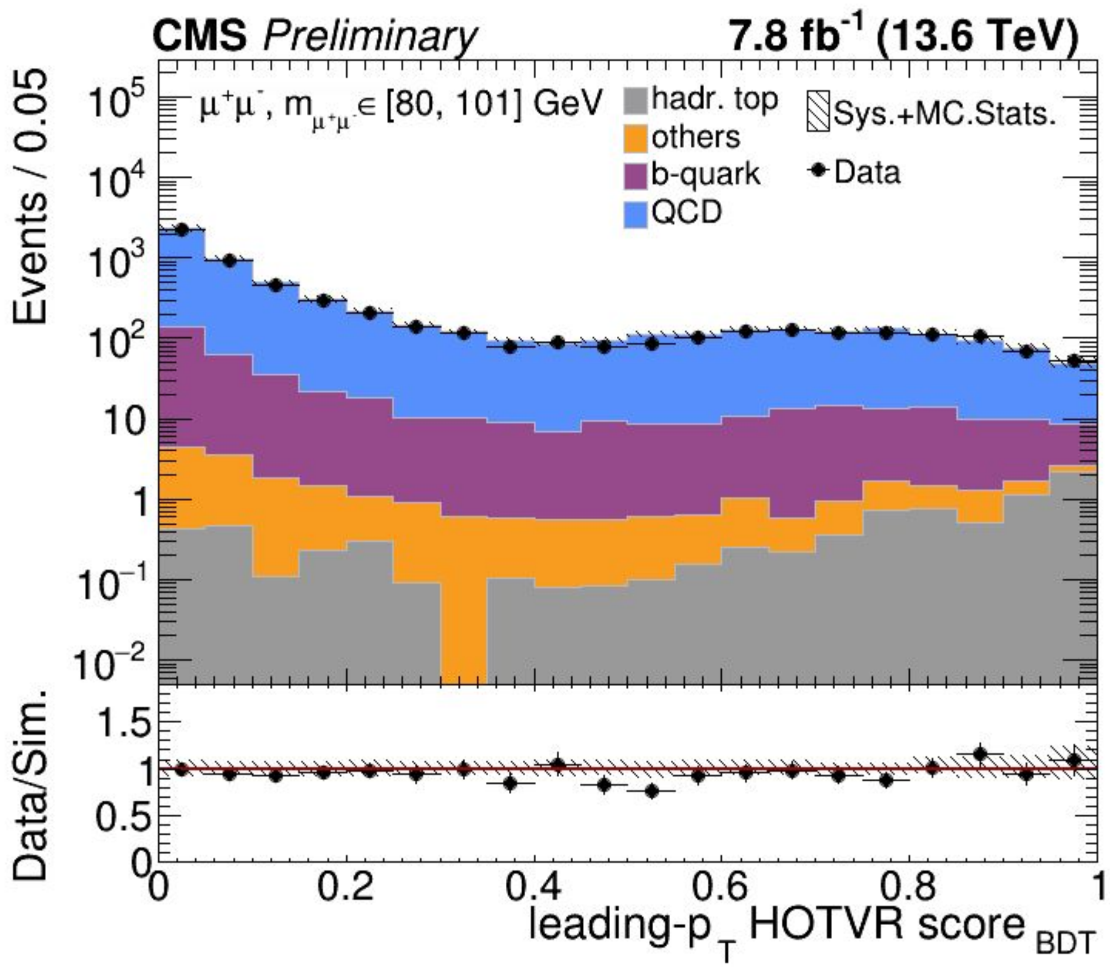




HOTVR+BDT - BDT output

[CMS-DP-2024-038]





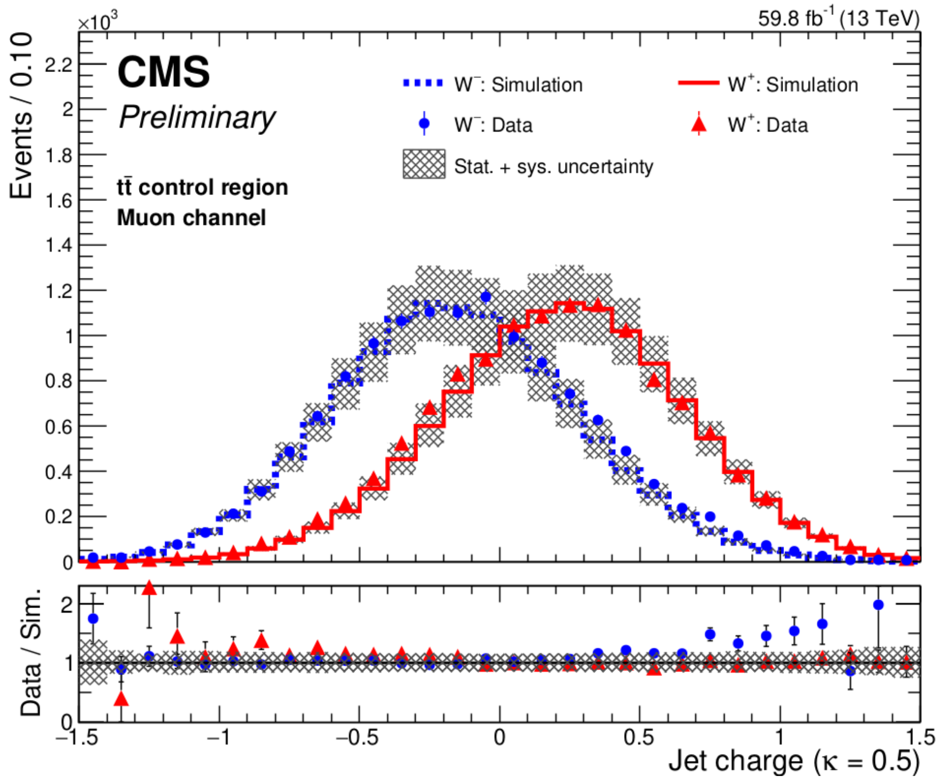
Jet charge tagger - input features

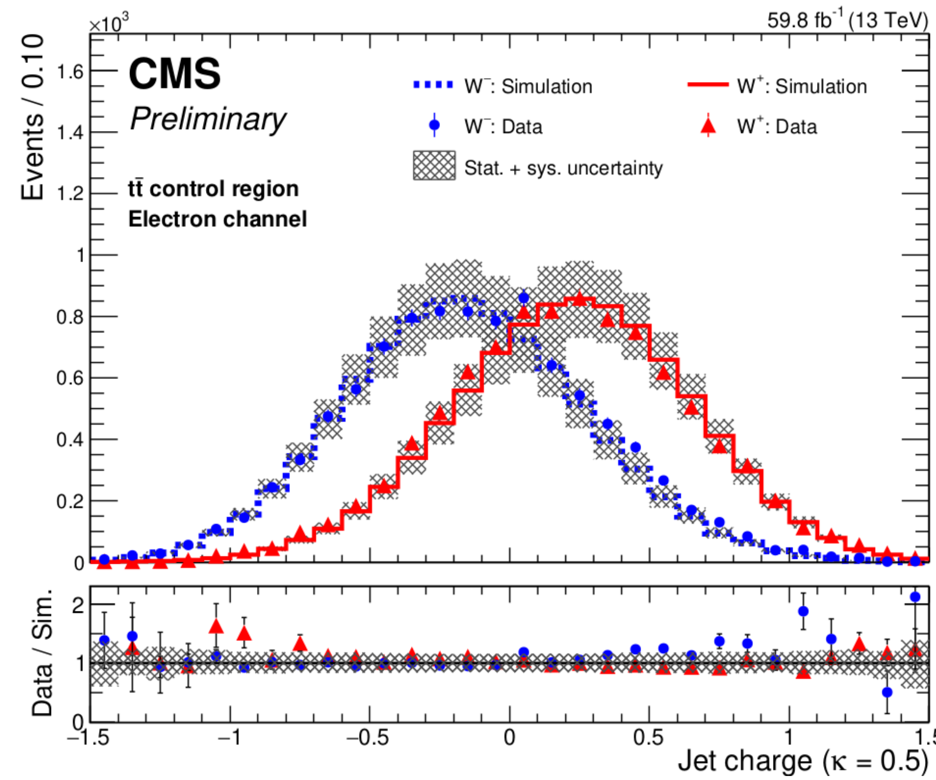
[CMS-DP-2024-044]

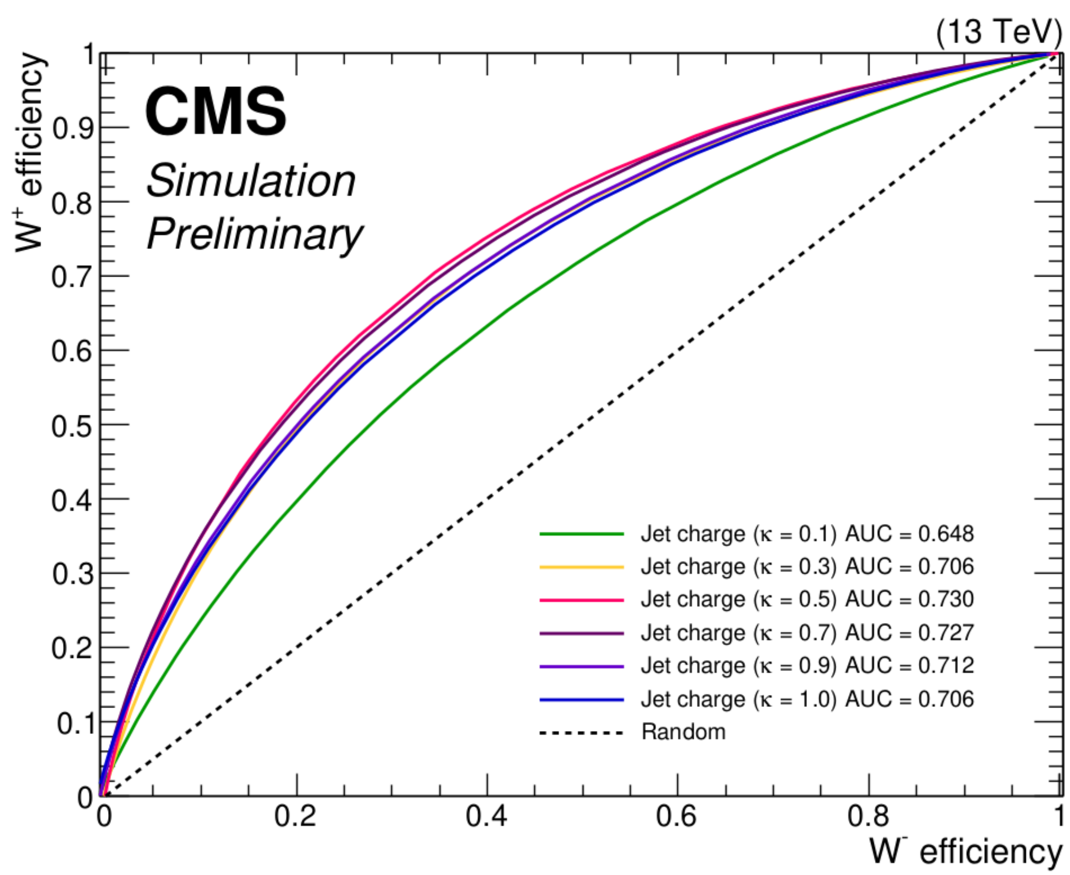
Variable	Description
ΔR	angular separation between the particle and the jet axis $\sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$
$\Delta\eta$	difference in the pseudorapidity between the particle and the jet axis
$\Delta\phi$	difference in the azimuthal angle between the particle and the jet axis
log E	logarithm of the particle's energy
log p_T	logarithm of the particle's p_T
log E/log E^{jet}	logarithm of the particle's energy relative to the jet energy
log p_T/log p_T^{jet}	logarithm of the particle's p_T relative to the jet p_T
Jet constituents charge	electric charge of the particle

Jet charge tagger - jet charge

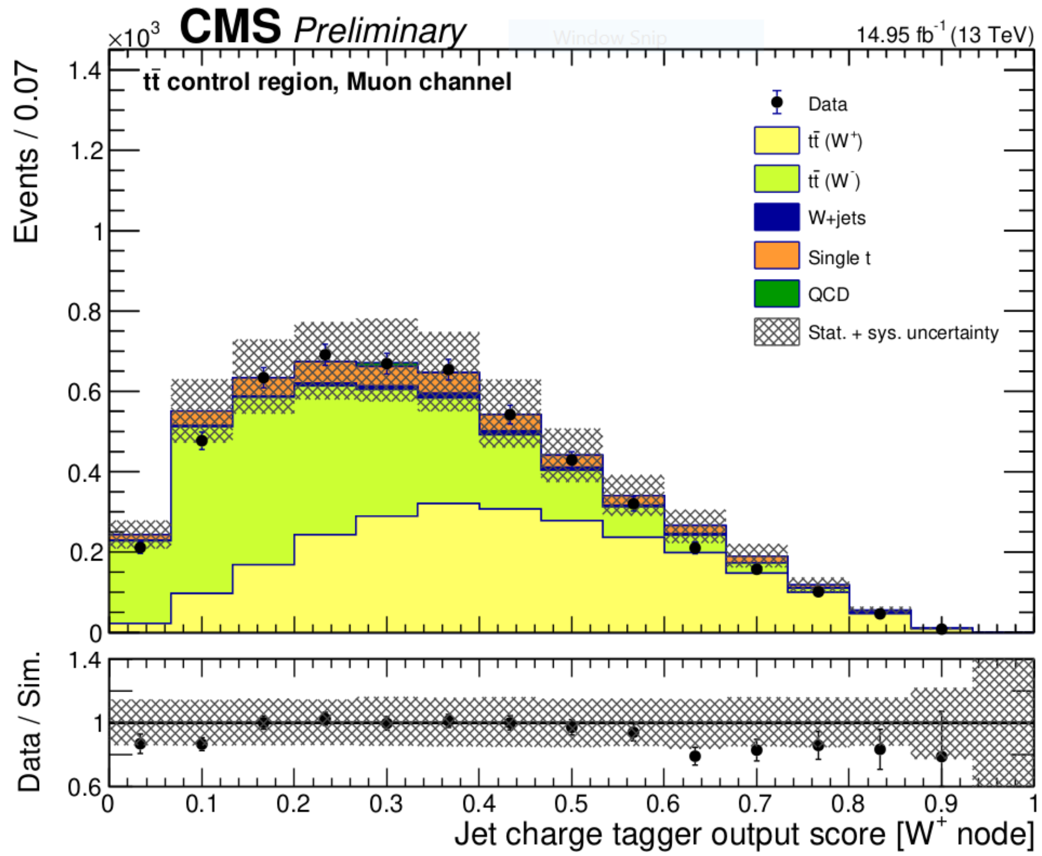
[CMS-DP-2024-044]

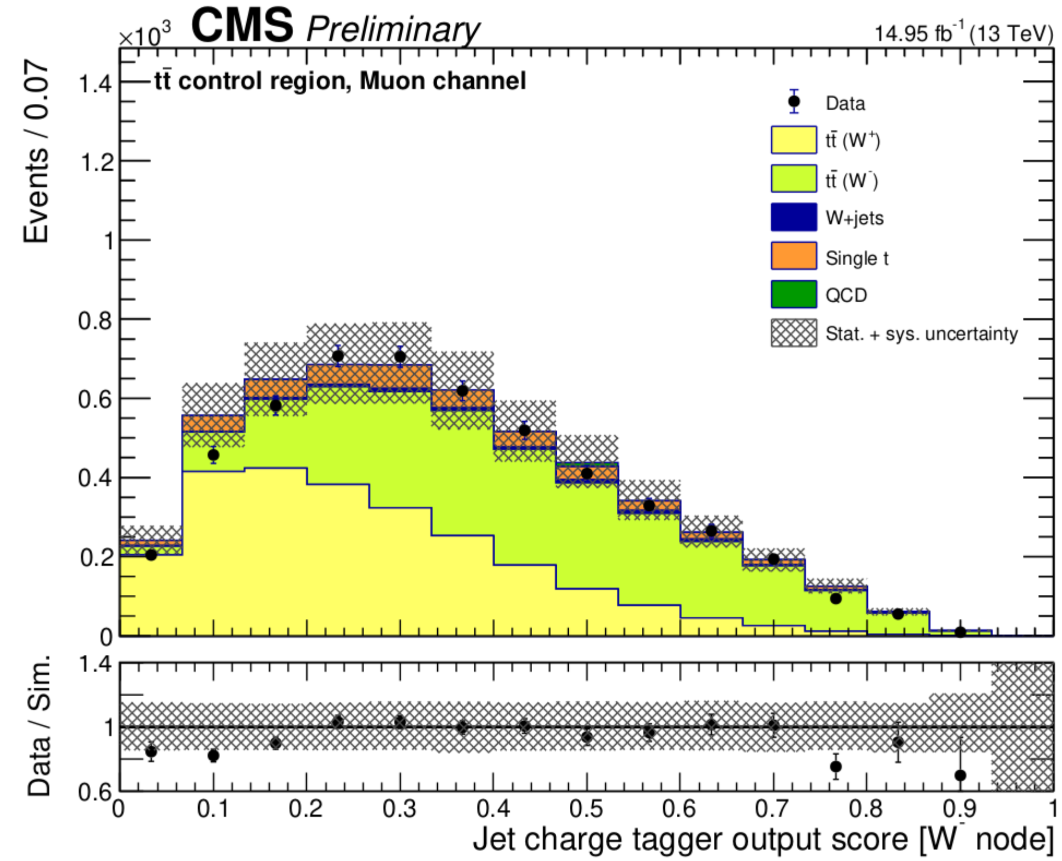


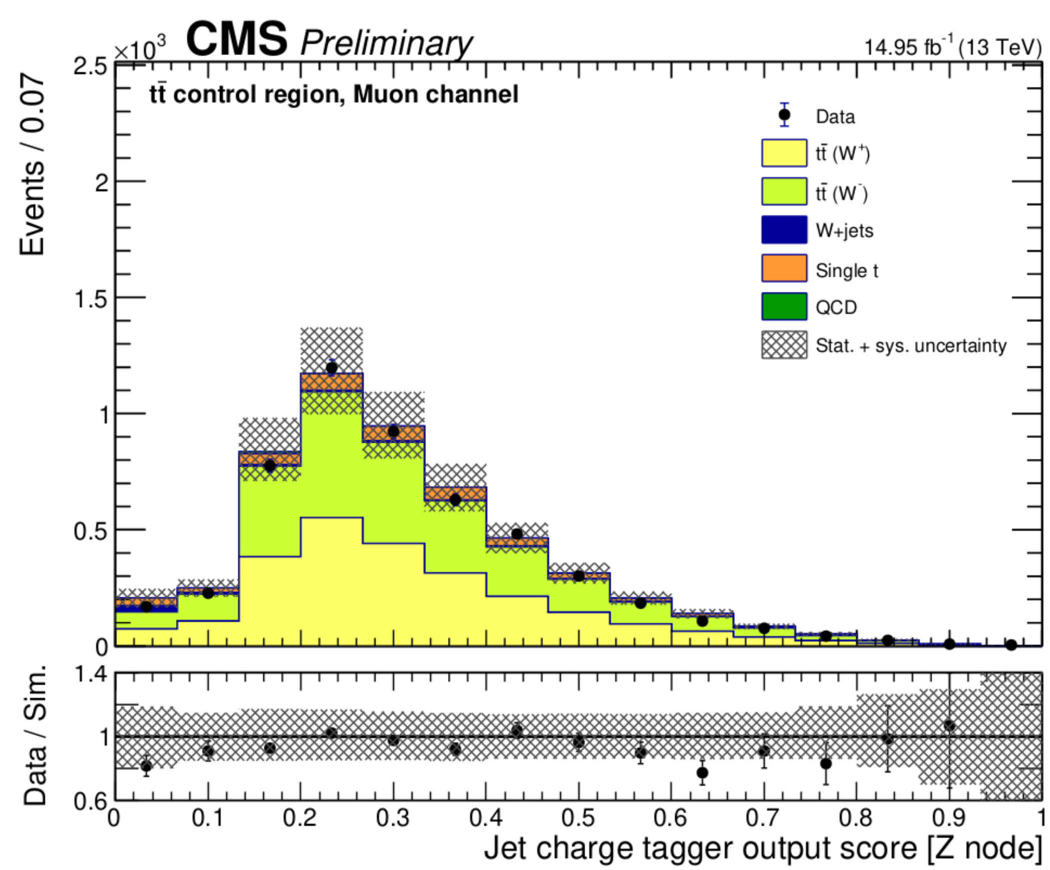




Jet charge tagger - output node







[CMS-DP-2024-044]