EXPLORING THE SOFT-HARD TRANSITION AND JET ACTIVITY IN PROTON-PROTON COLLISIONS.

Aldo Zetina L.

INTRODUCTION

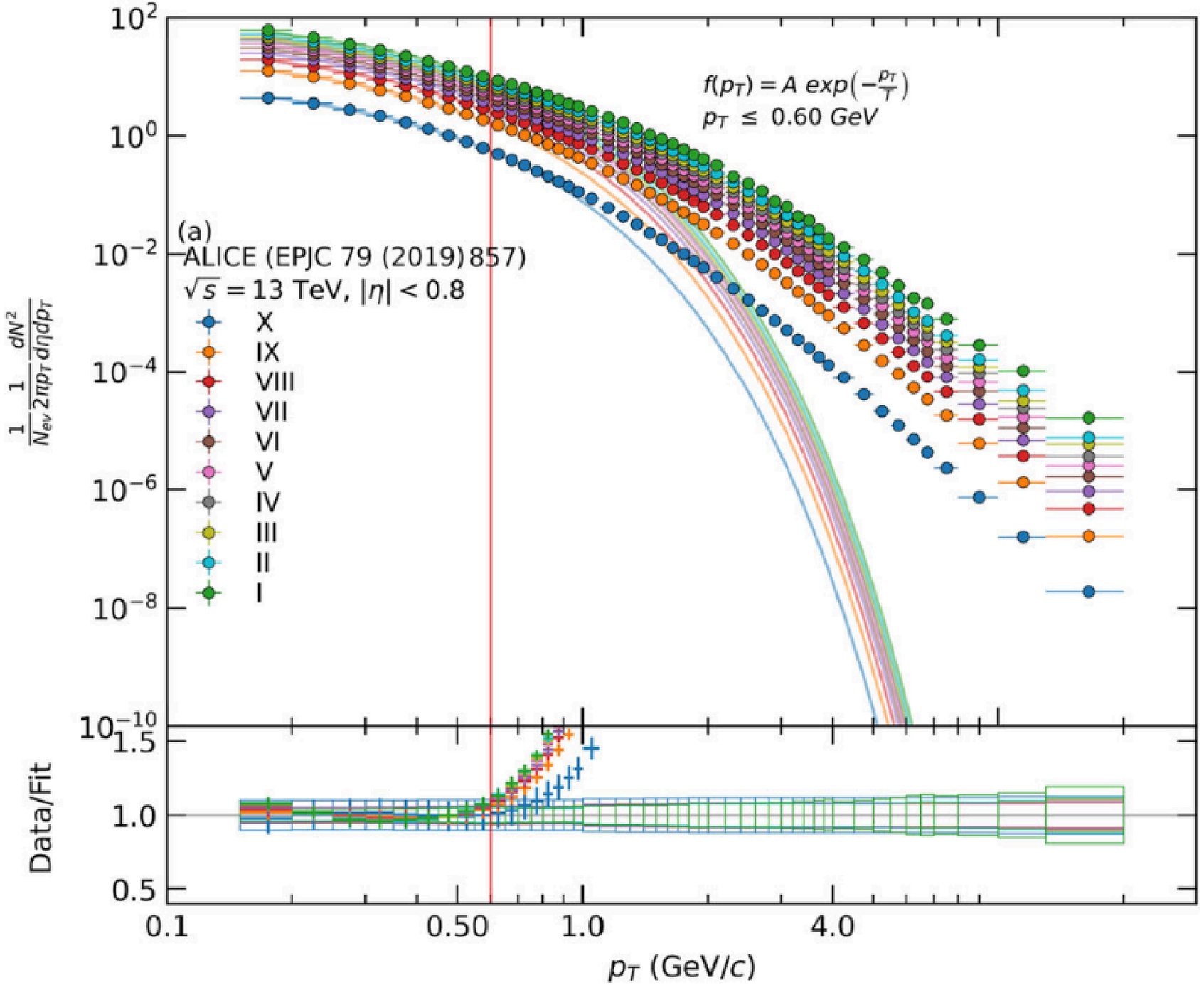
The data come from the ALICE experiment at the LHC. It shows the transverse momentum pT spectra for charged particles in inelastic proton-proton collisions at a center-of-mass energy of 13 TeV.

It is assumed that particle production at low pT is almost exclusively dominated by soft interactions. In this regime, classical thermodynamics governs, and the spectrum acquires an approximately exponential shape which is essentially a **Boltzmann distribution** [1].

The Roman numerals (I to X) represent event multiplicity classes, determined by the charged-particle pseudorapidity density.

- Class X (10): Corresponds to the lowest multiplicity class.
- Class I (1): Corresponds to the highest multiplicity class.

SOFT & HARD TRANSITION



[1]

JET CONTRIBUTION

What is a Jet?

- A cascade of partons, generated by the strong interaction with high momentum transfer and forced to confine.

Contamination of the Soft Spectrum

- A significant fraction of the particles produced during jet fragmentation have low transverse momentum, falling directly into the soft region of the spectrum.

- The presence of jet-derived particles in the low pT regime introduces an overlapping background, complicating the isolation of purely soft interactions and requiring careful consideration when applying the Boltzmann fit.

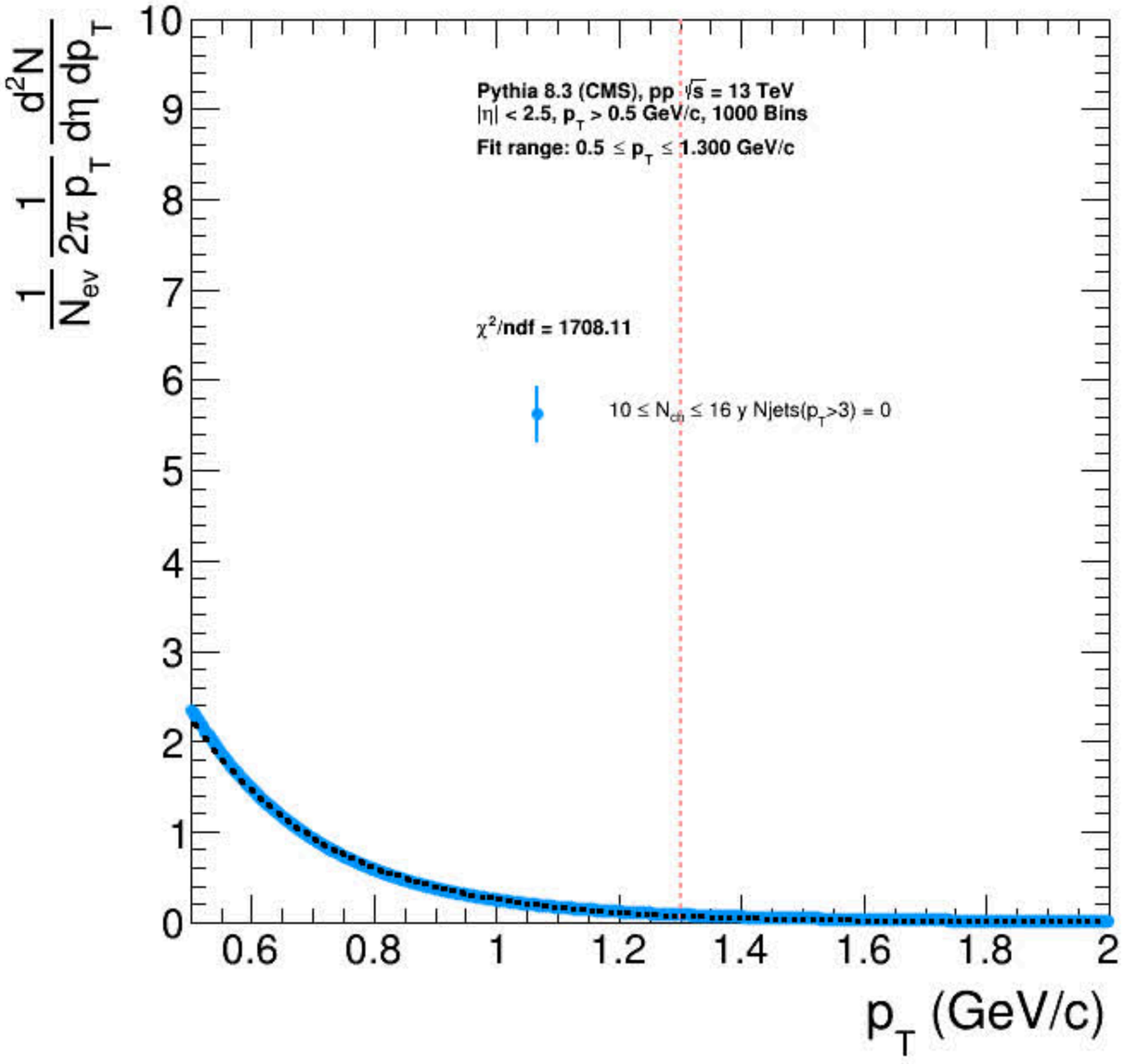
MULTIPLICITY CLASS SELECTION

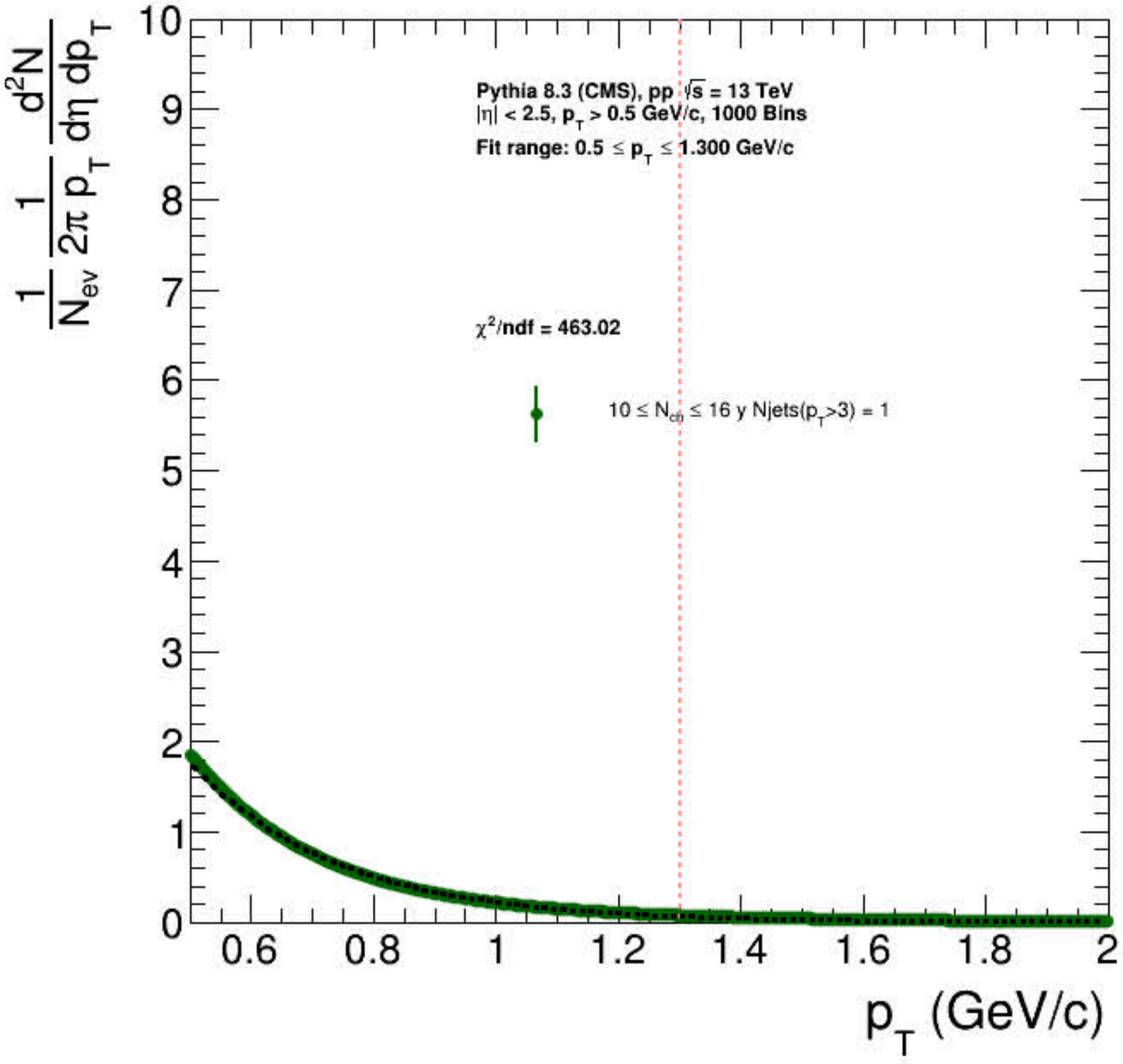
Table 1: ALICE Collaboration multiplicity classes vs. multiplicity cuts (N_{ch}) based on equivalence, assuming constant η.

Class	**ALICE** $\langle \mathrm{d}N_{ch}/\mathrm{d}\eta \rangle$ $(\lvert\eta\rvert < 0.5)$	**Equivalence** $(\Delta\eta = 5.0)$	**New Cut** (N_{ch} **for** $\lvert\eta\rvert < 2.5$)
I	26.02 ± 0.35	130.1	$N_{ch} \geq 130$
II	20.02 ± 0.27	100.1	$N_{ch} \approx 100$
III	16.17 ± 0.22	80.8	$N_{ch} \approx 81$
IV	13.77 ± 0.19	68.8	$N_{ch} \approx 69$
V	12.04 ± 0.17	60.2	$N_{ch} \approx 60$
VI	10.02 ± 0.14	50.1	$N_{ch} \approx 50$
VII	7.95 ± 0.11	39.7	$N_{ch} \approx 40$
VIII	6.32 ± 0.09	31.6	$N_{ch} \approx 32$
IX	4.50 ± 0.07	22.5	$N_{ch} \approx 23$
X	2.55 ± 0.04	12.7	$N_{ch} \approx 13$

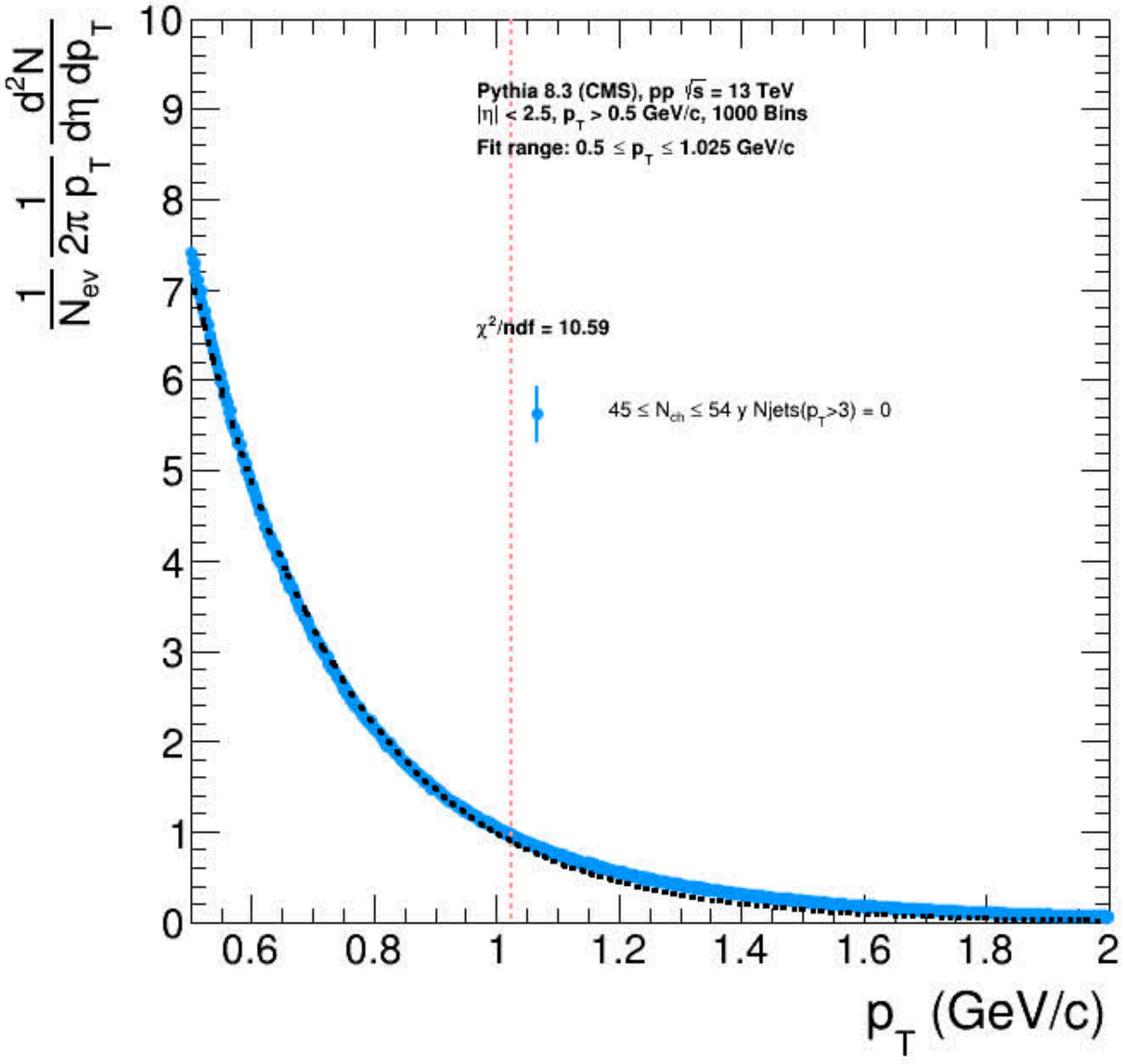
[3]

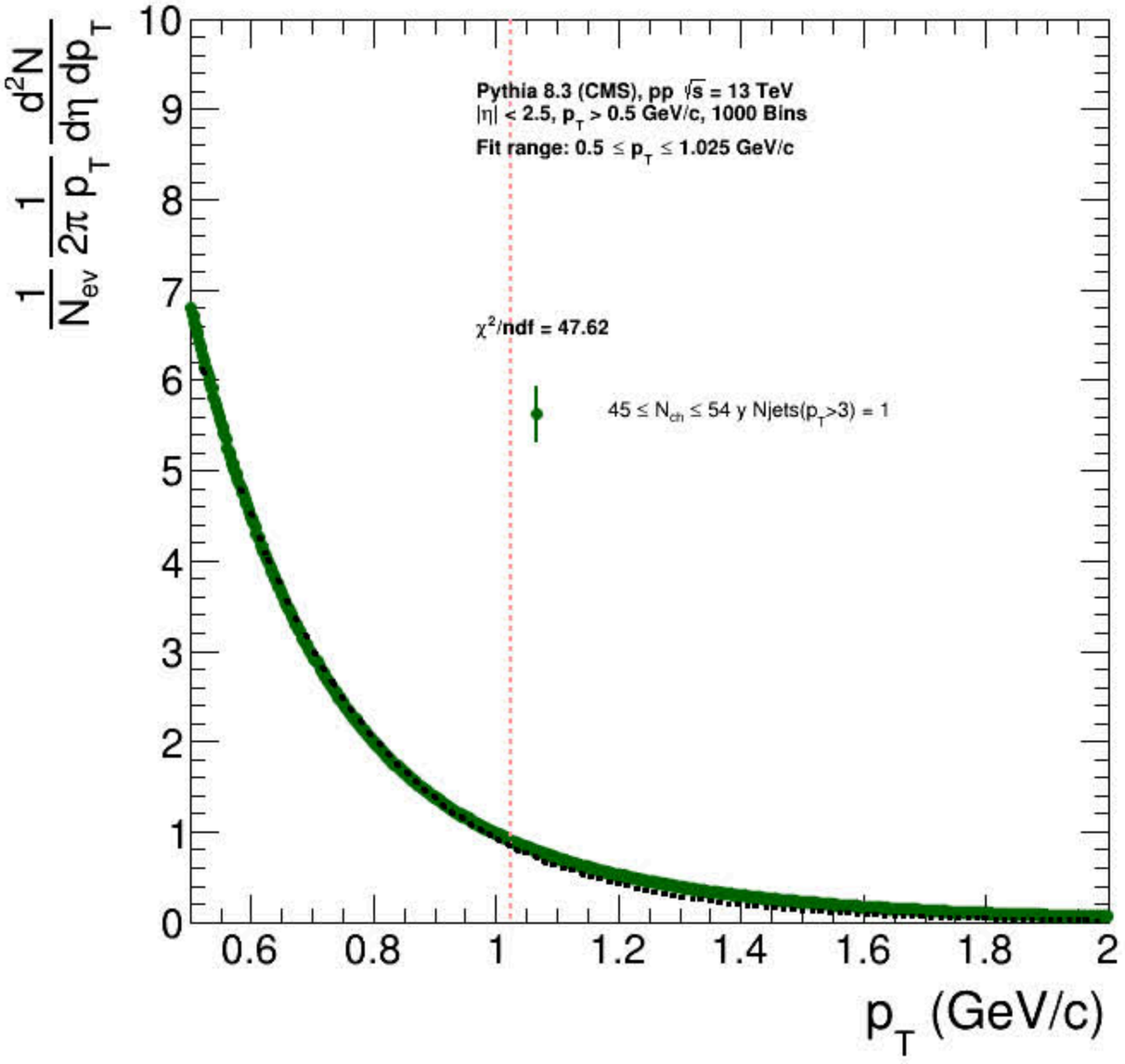
0 JET RAW & 1 JET CORRECTED \ NCH LOWER



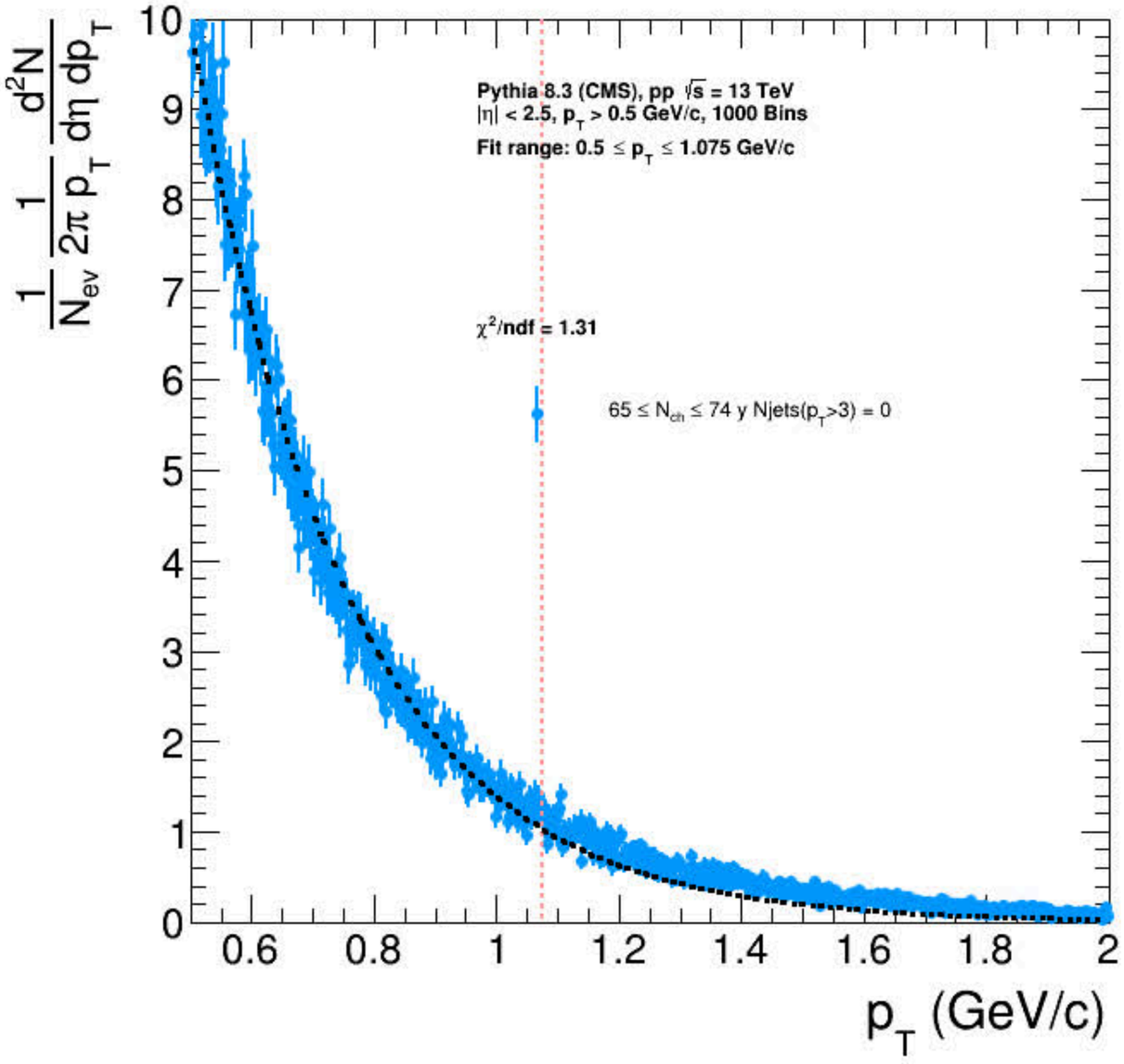


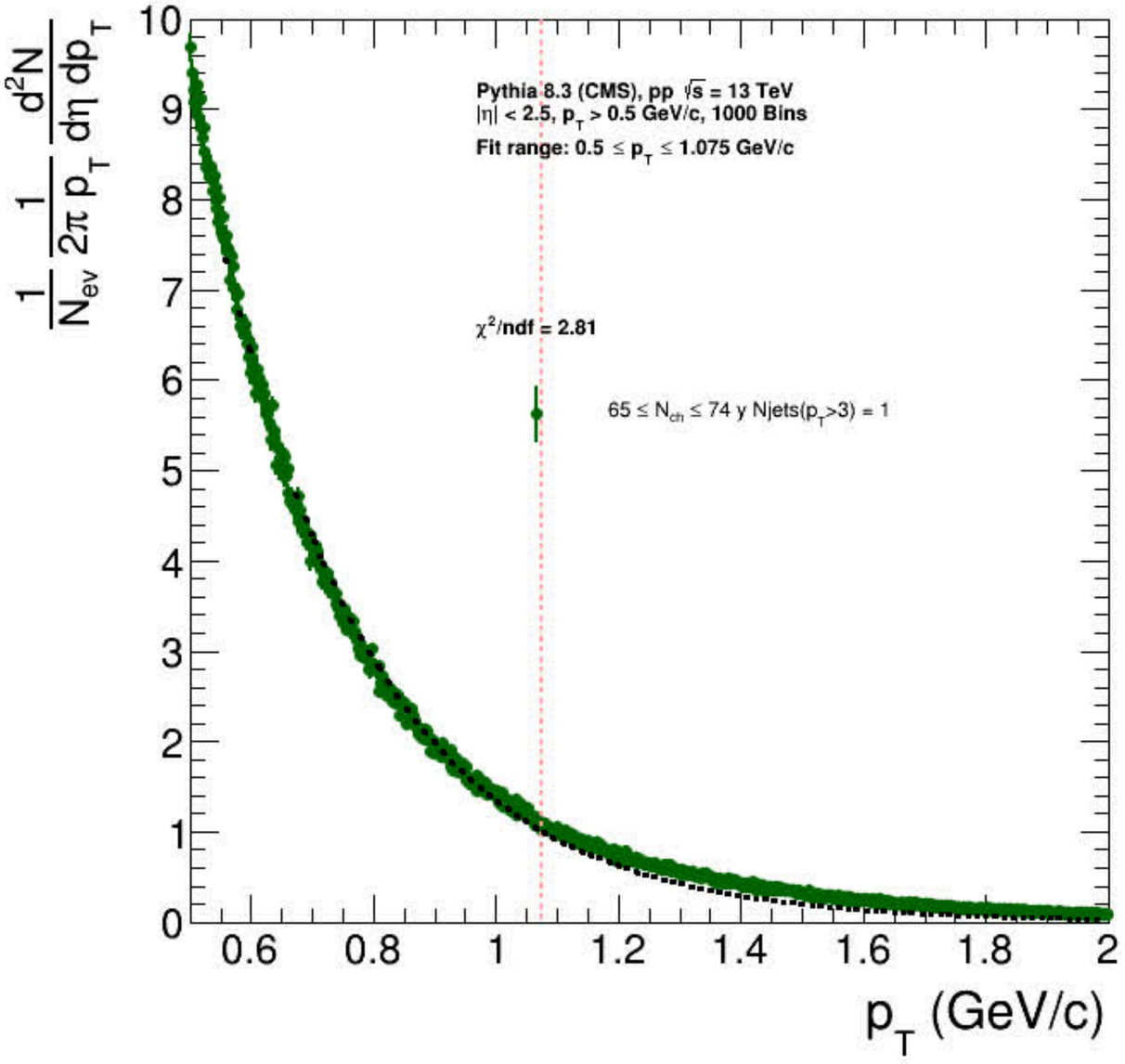
0 JET RAW & 1 JET CORRECTED \ NCH INTERMEDIATE



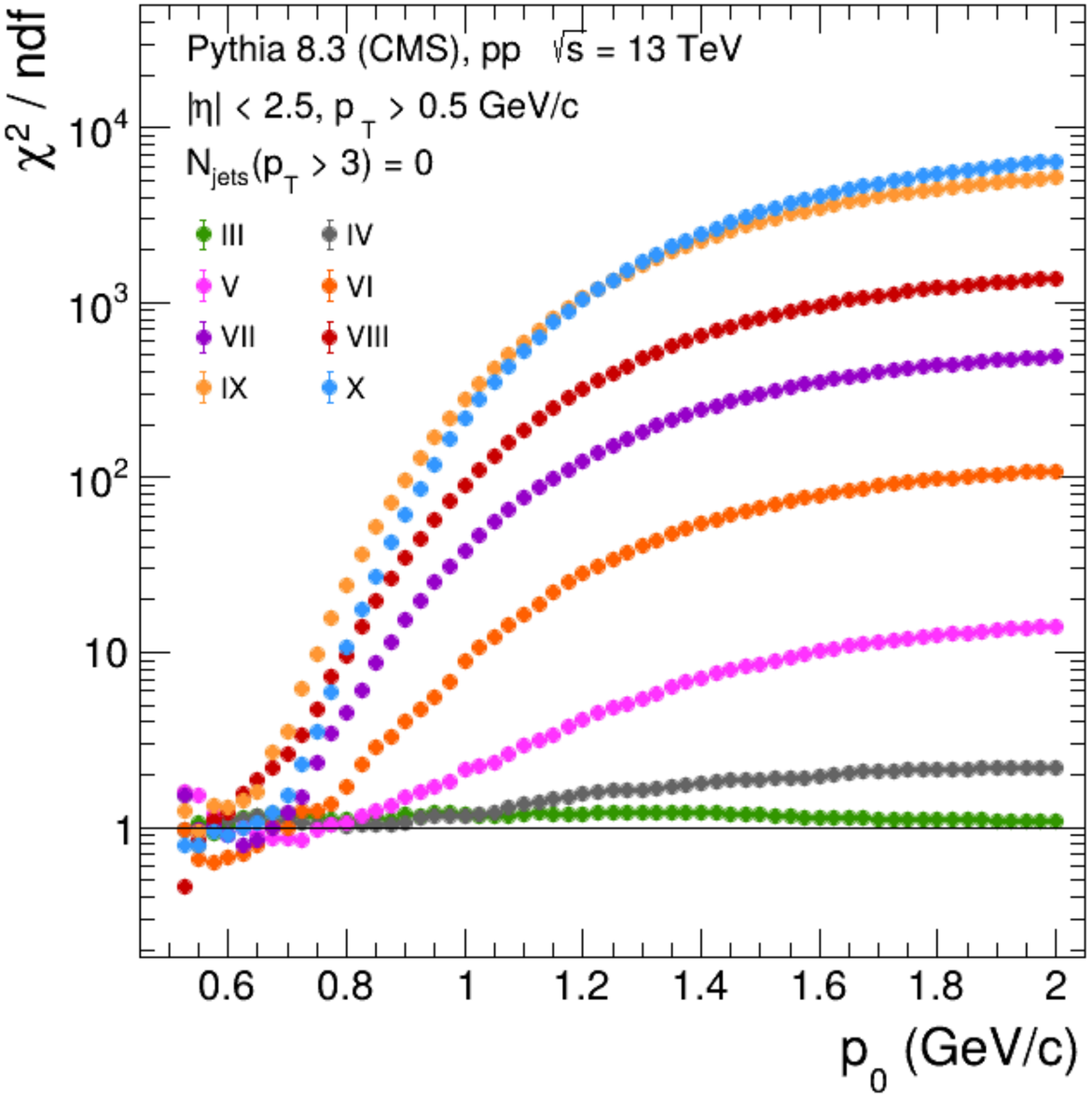


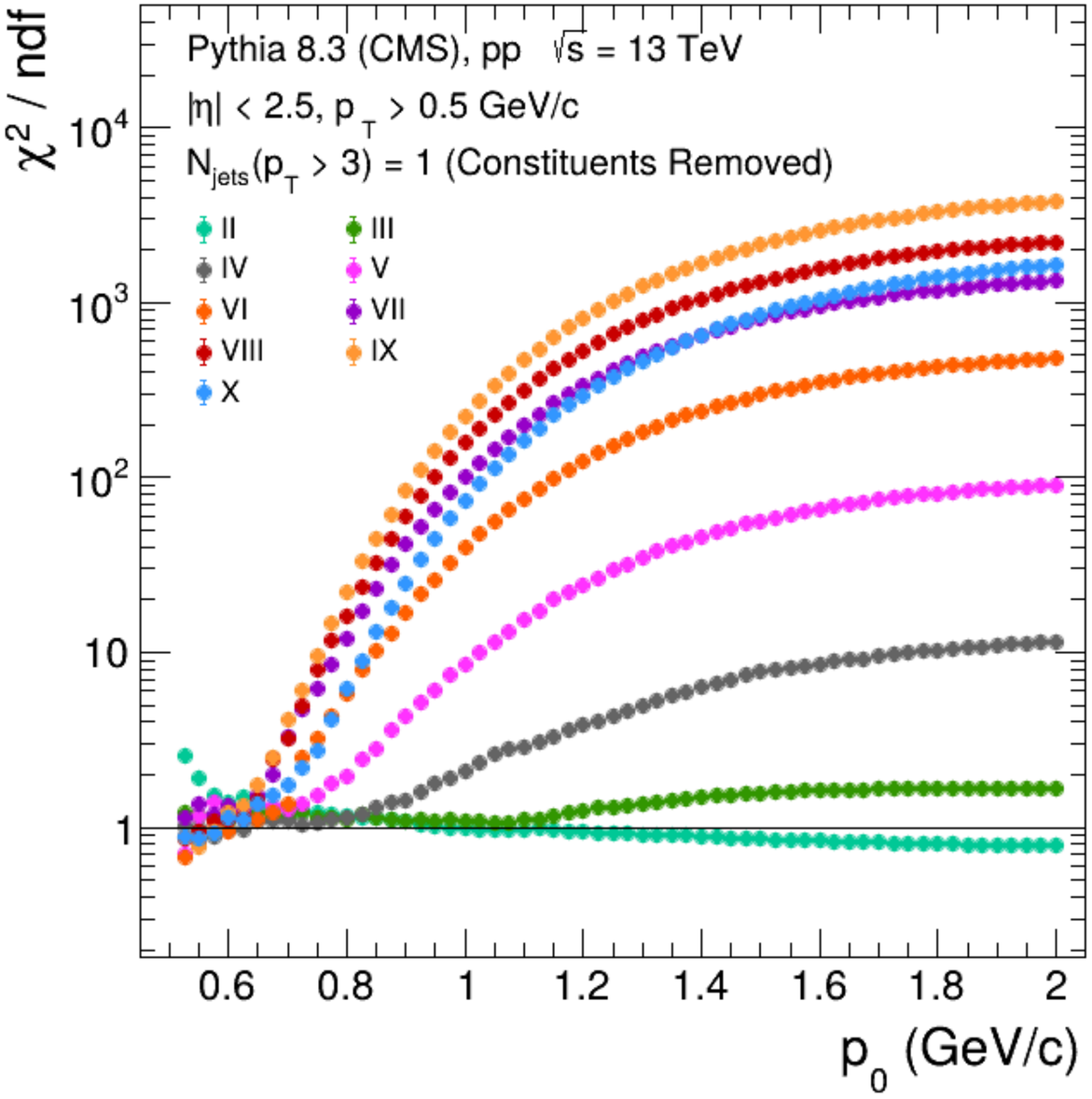
0 JET RAW & 1 JET CORRECTED \ NCH HIGHEST



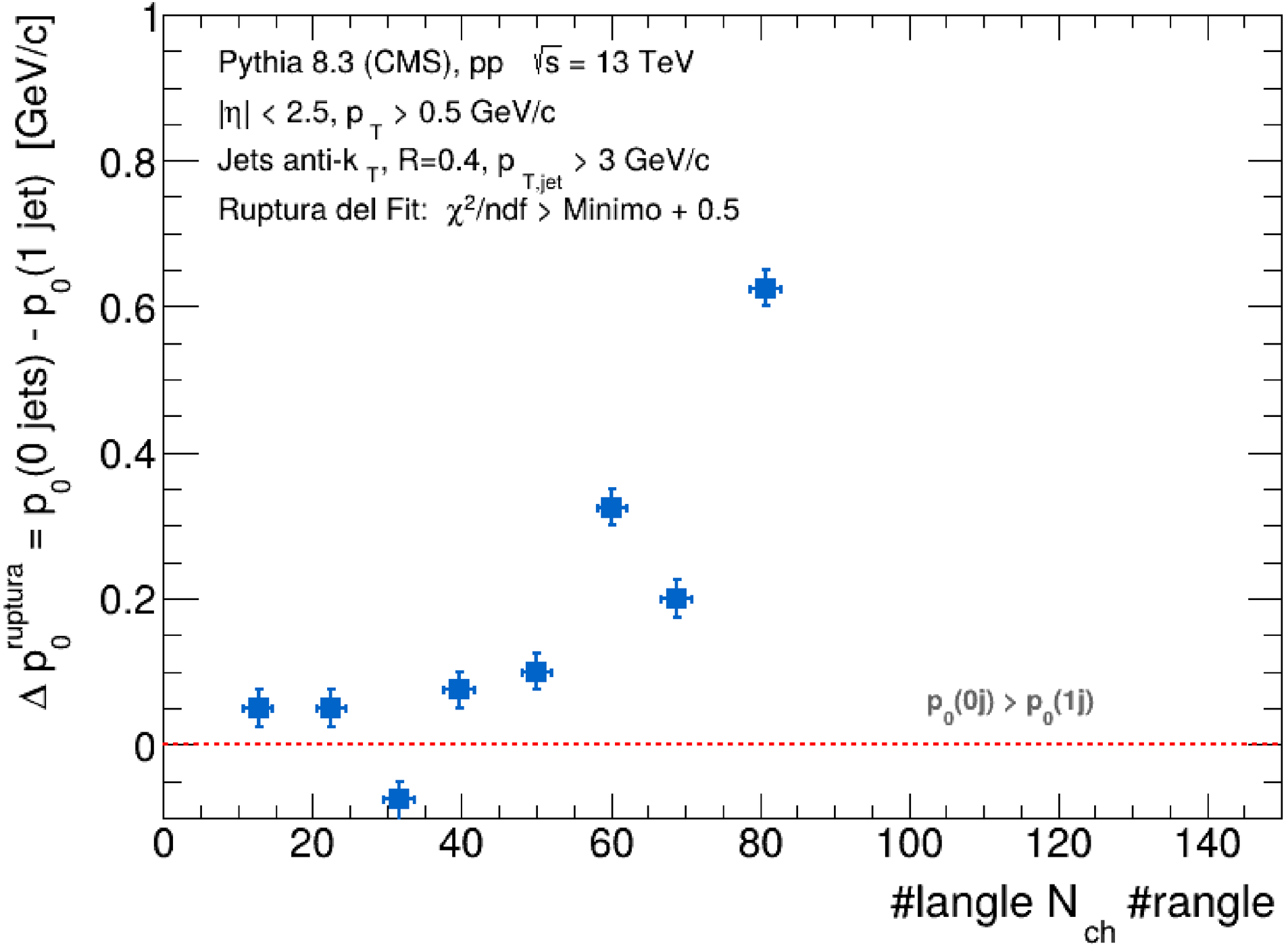


0 JET RAW & 1 JET CORRECTED

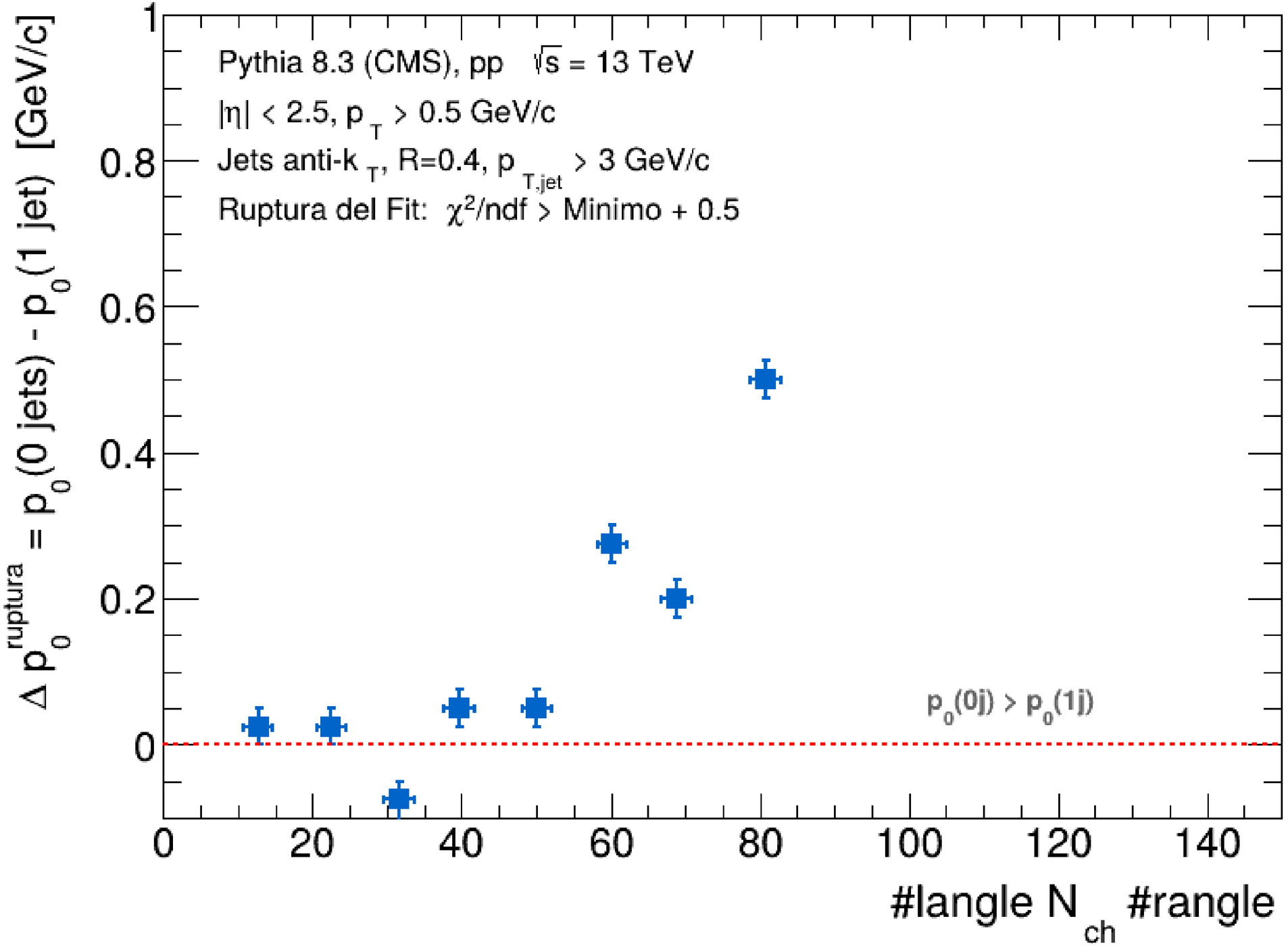




DELTAPO RAW VS NCH



DELTAPO CORRECTED VS NCH



CONCLUSION

We observe a stabilization in the lower and intermediate multiplicity, this confirms that subtracting the hard jet fragmentation successfully mitigates the background contamination, given us a much clener measurement of the soft component.

REFERENCES

[1] G. Bíró, L. Serkin, G. Paić, and G. G. Barnaföldi, “Investigating the soft and hard limits in transverse momentum spectra in pp collisions,” Eur. Phys. J. Spec. Top. (2025).

[2] G. Bíró, G. Paić, L. Serkin, and G. G. Barnaföldi, “Revisiting the soft-hard separation in the transverse momentum spectra of pp collisions,” Eur. Phys. J. C 86, 810 (2026).

[3]Collaboration, Alice. “Multiplicity dependence of $pi, K, and p production in pp collisions at \sqrt{s} = 13 TeV.” (2020).