CLHCP 2024

13-17 Nov, 2024, Qingdao, Shandong

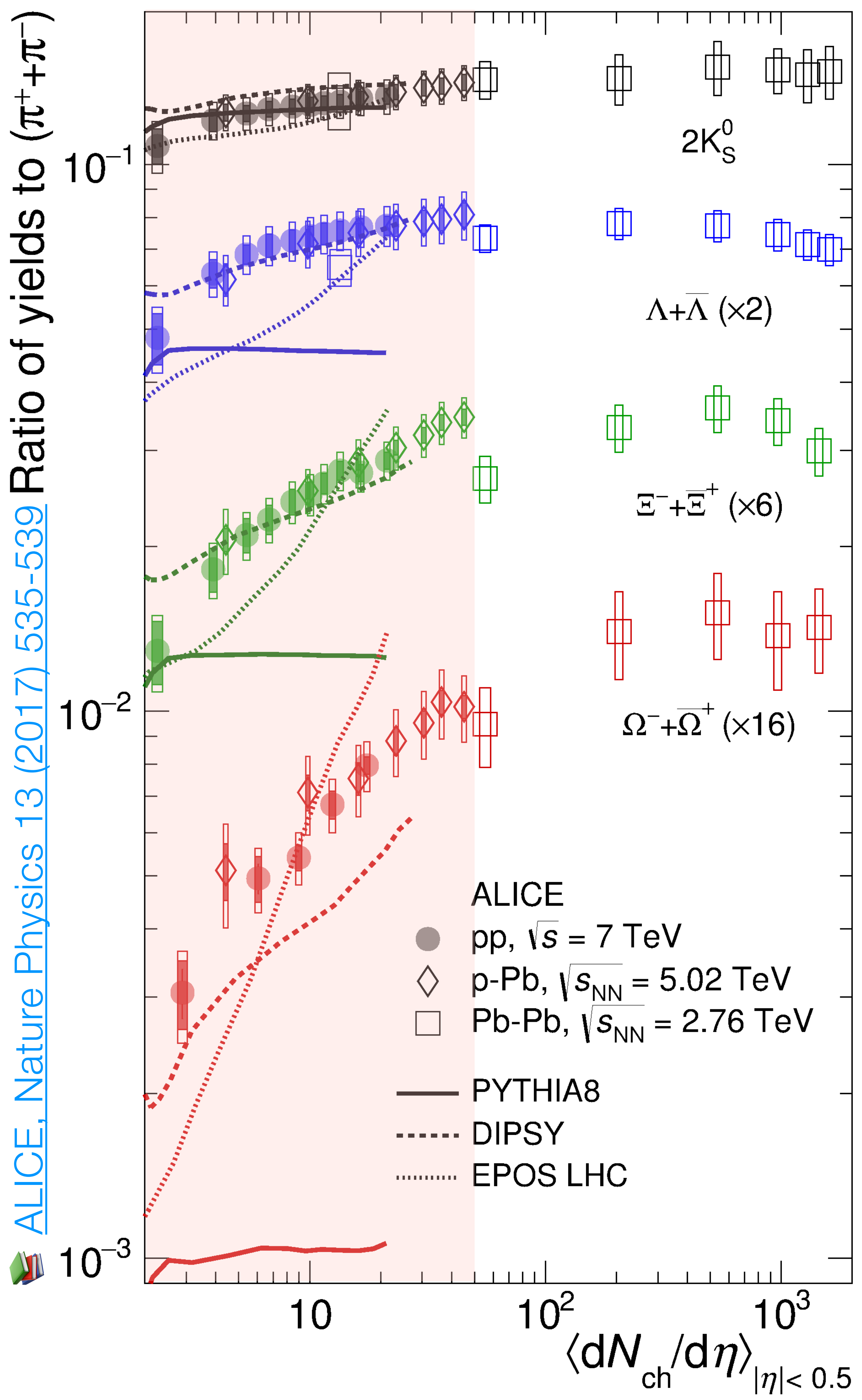
華中師範大學
CENTRAL CHINA NORMAL UNIVERSITY

ALICE

Particle production as a function of event shape classifiers in small collision systems with ALICE

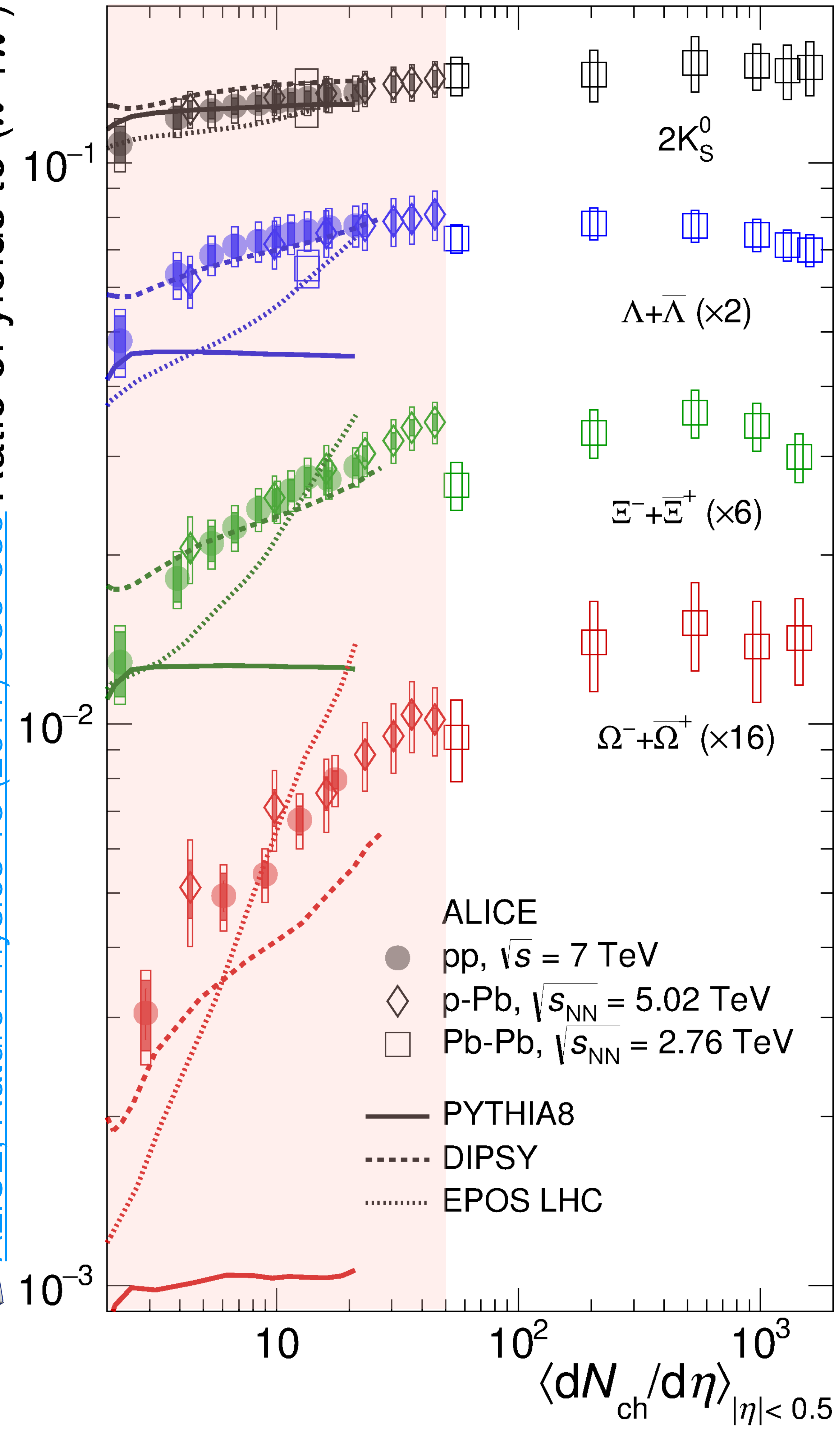
Feng Fan (for the ALICE Collaboration)
Central China Normal University

Strangeness enhancement



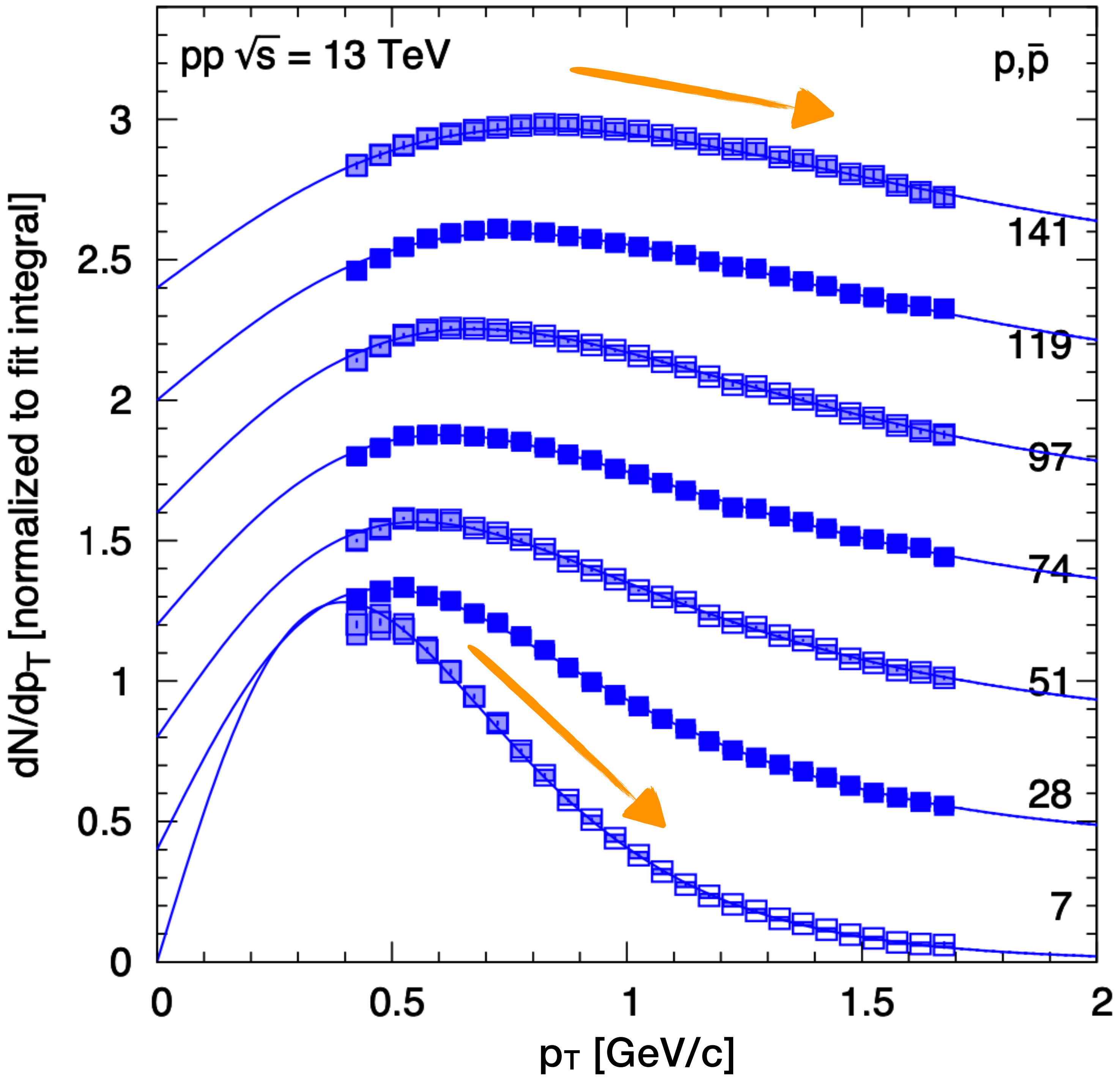
QGP-like effects in small systems

Strangeness enhancement



ALICE, Nature Physics 13 (2017) 535-539

radial flow



CMS, Phys. Rev. D 96, 112003 (2017)

QGP-like effects in small systems

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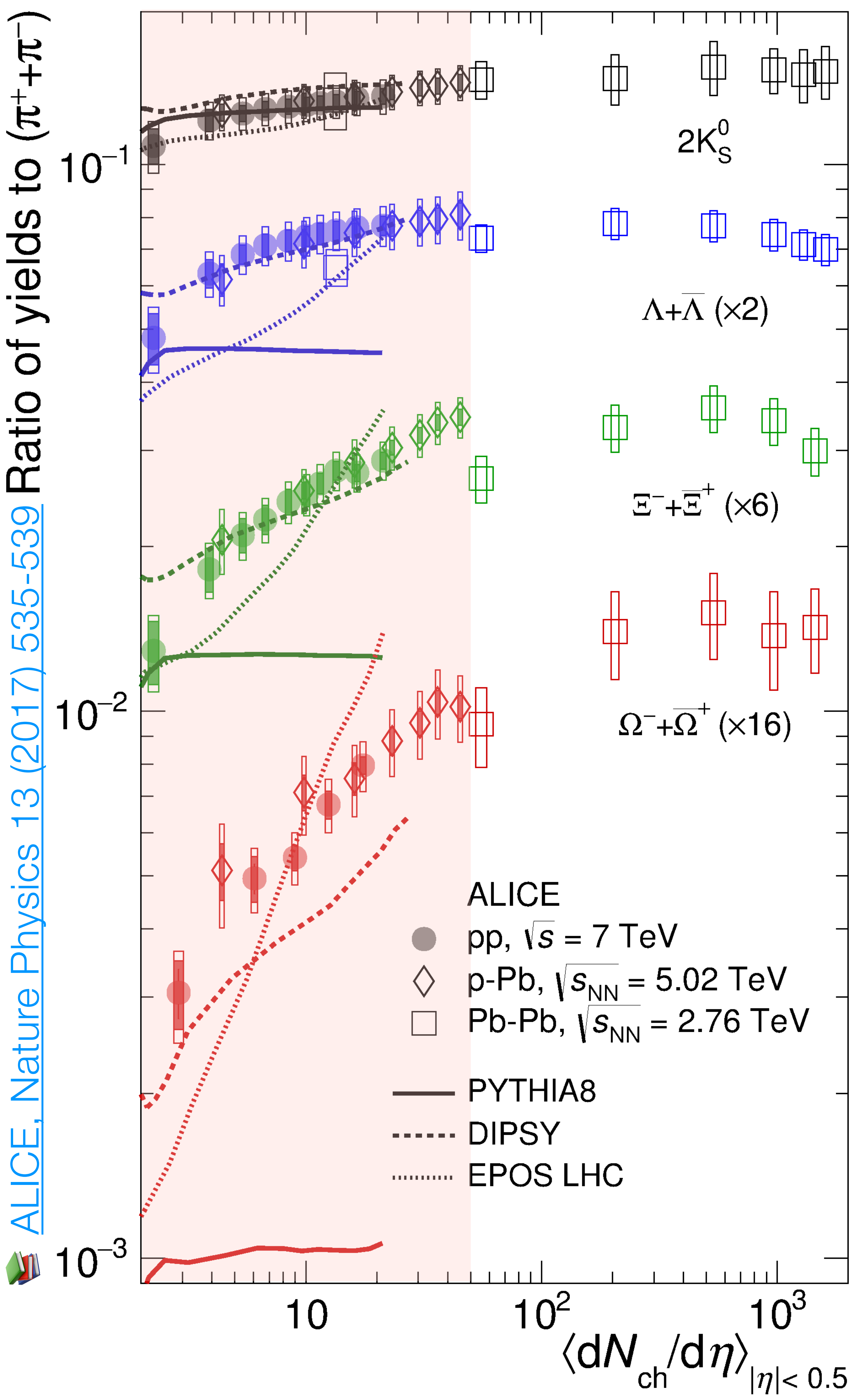

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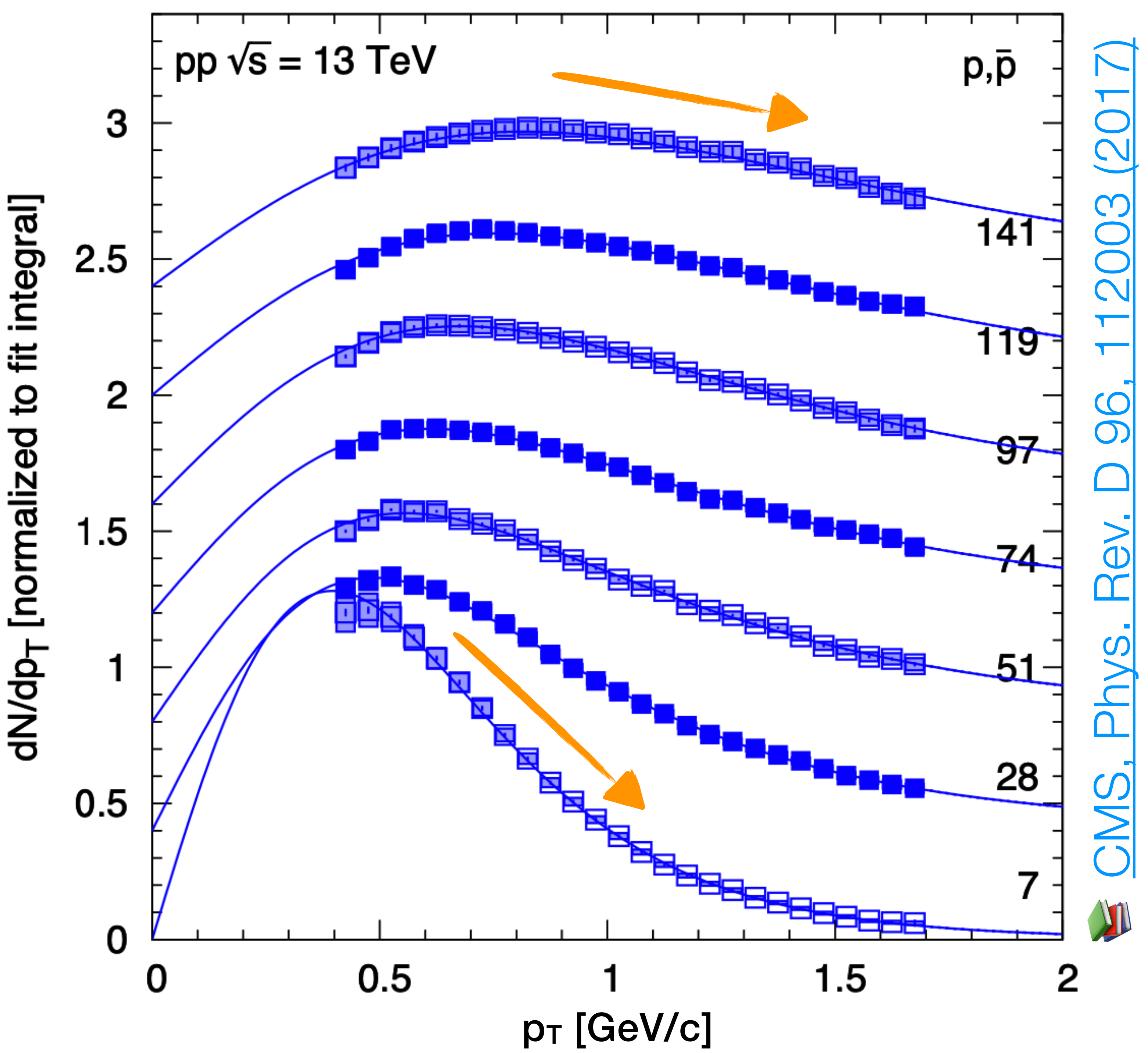
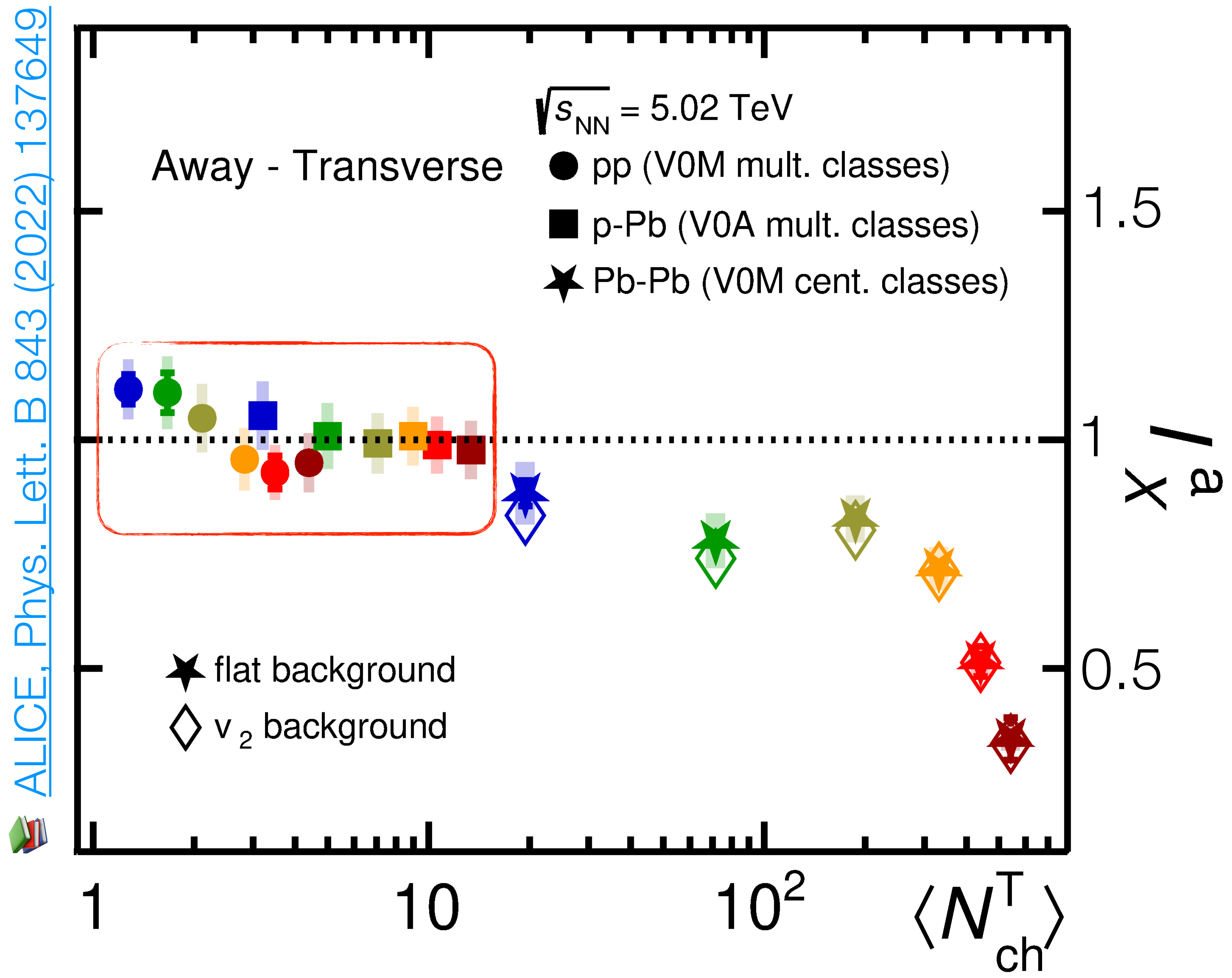
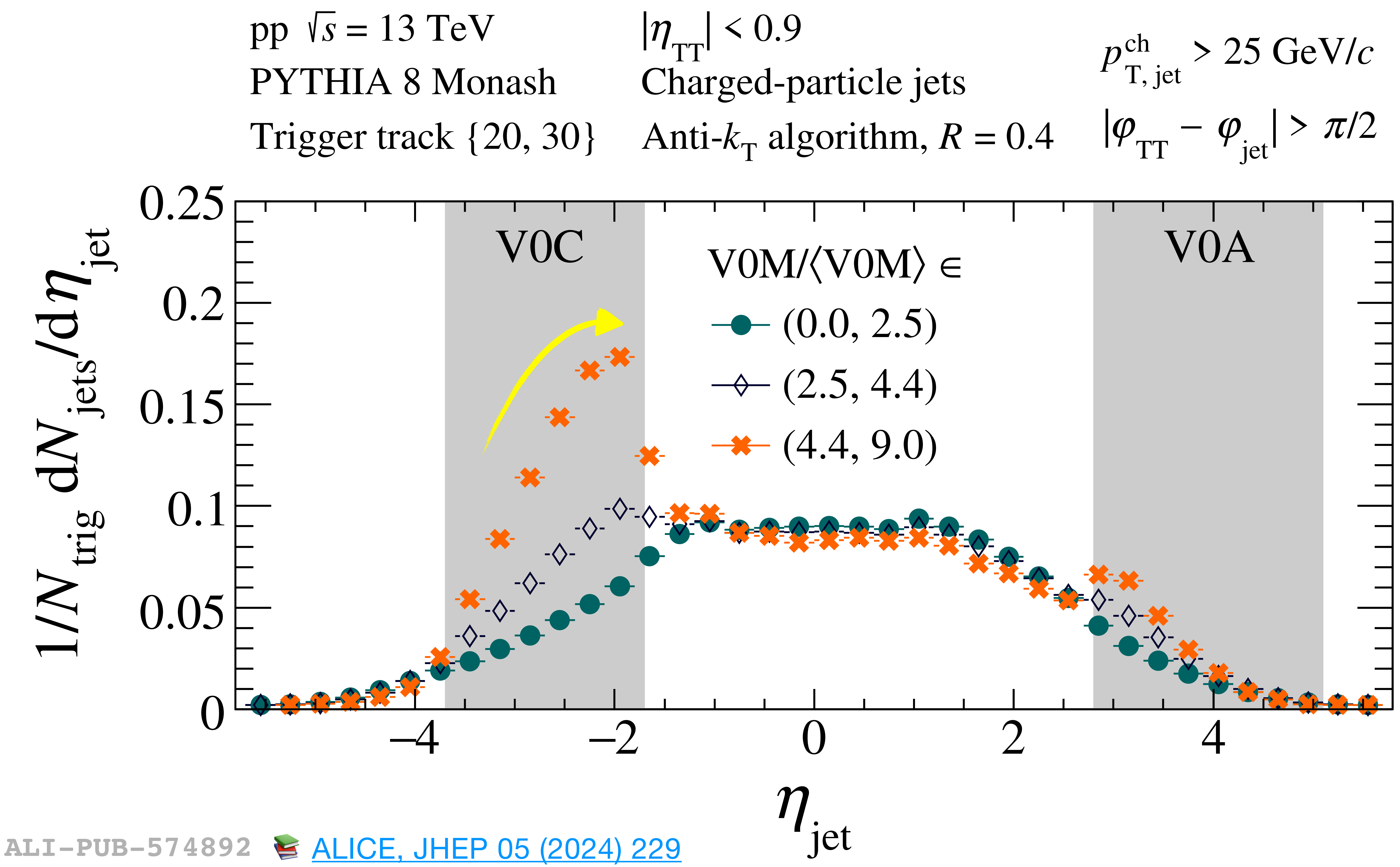


Jet quenching?



$$I_X^a = \frac{\left(dN_{ch}^{AS-TS}/dp_T\right)_{V0M}}{\left(dN_{ch}^{AS-TS}/dp_T\right)_{MB}}$$

Bias due to local multiplicity fluctuations



ALI-PUB-574892 ALICE, JHEP 05 (2024) 229

- The high-V0M multiplicity class selects pp collisions with jets in the forward detector

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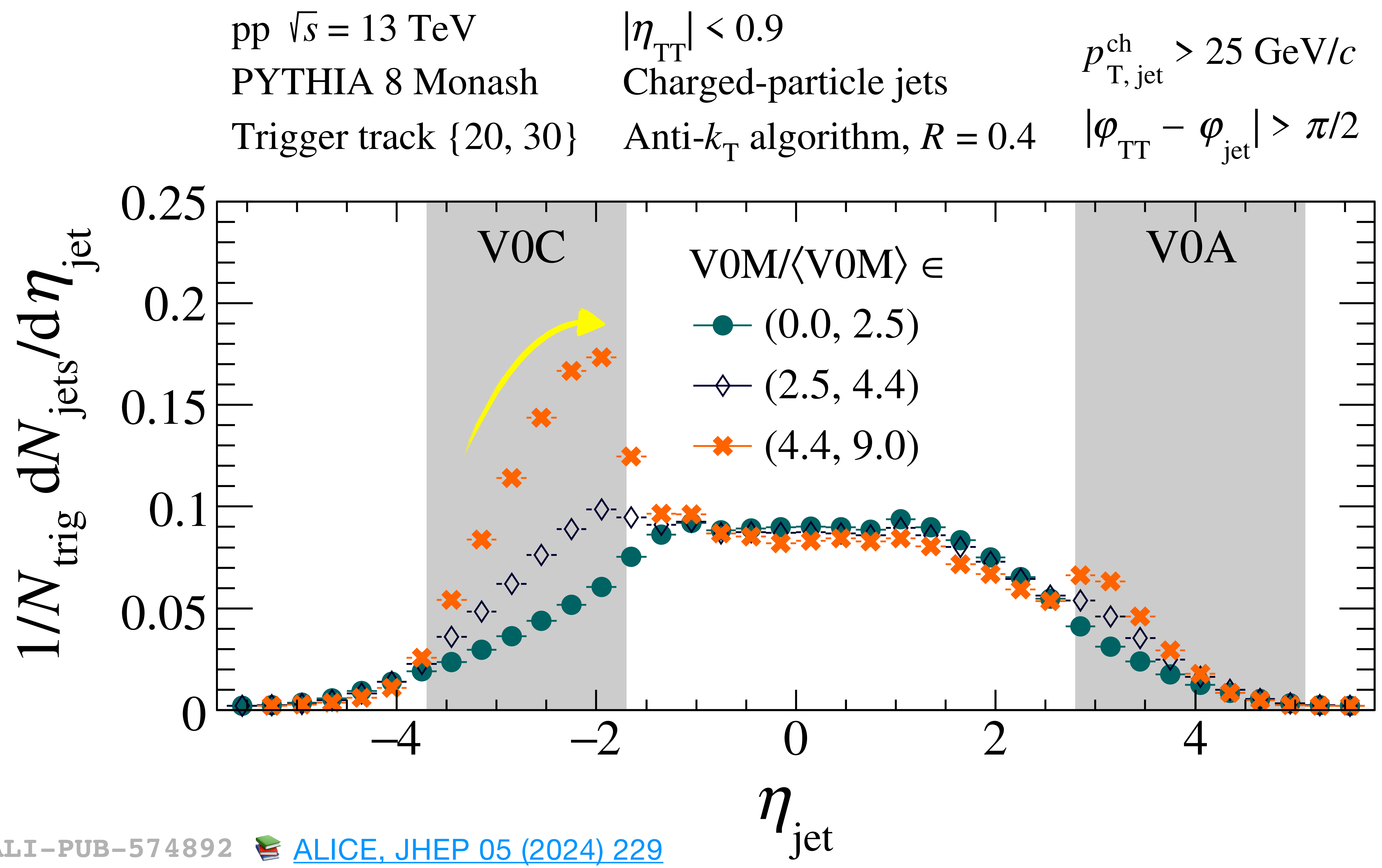


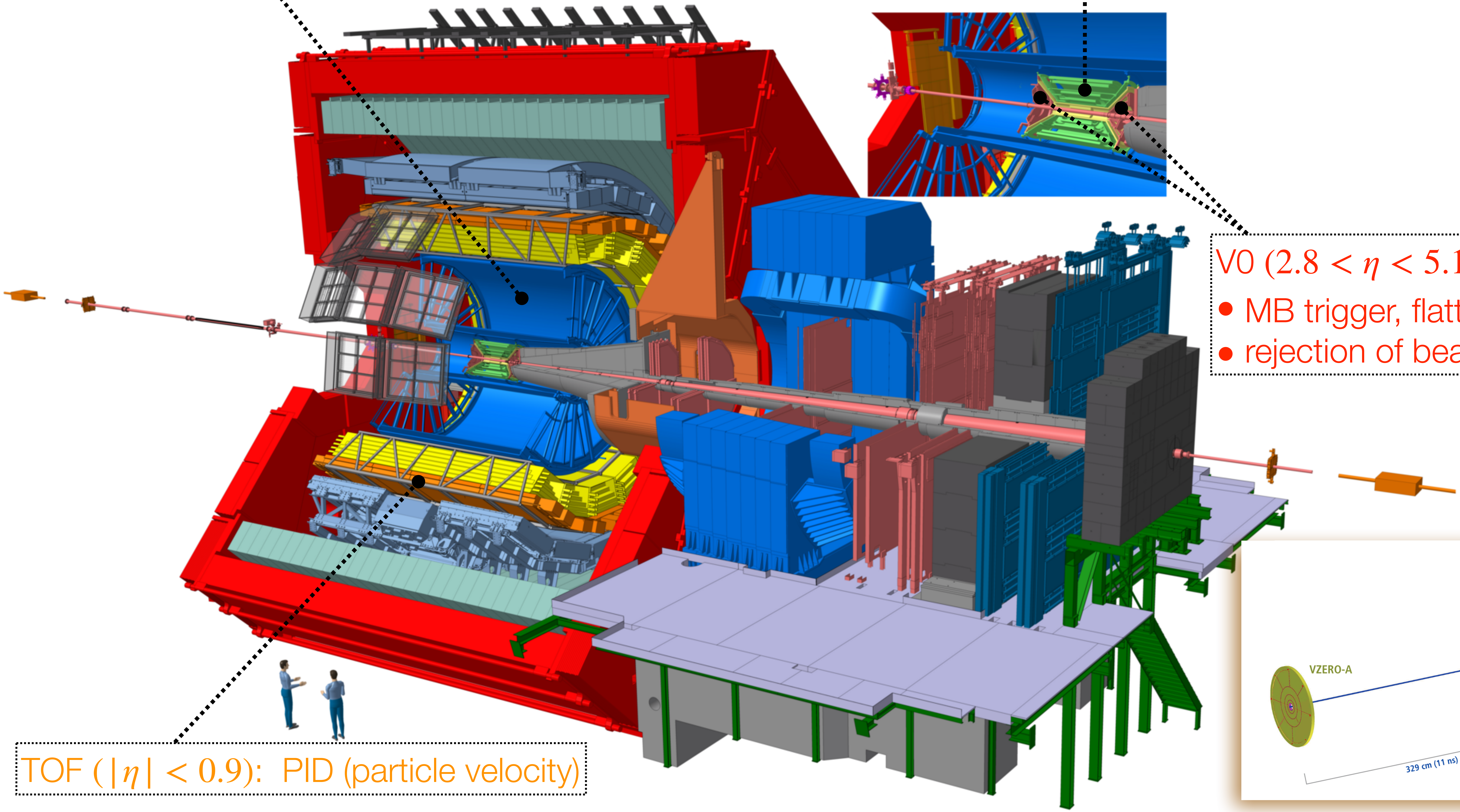
ALI-PUB-574892 ALICE, JHEP 05 (2024) 229

- The high-V0M multiplicity class selects pp collisions with jets in the forward detector
- New observables to reduce selection biases: ☑ Relative transverse activity R_T ☑ Charged-particle flattenicity $1-\rho$

The ALICE detector in Run 1 and Run 2

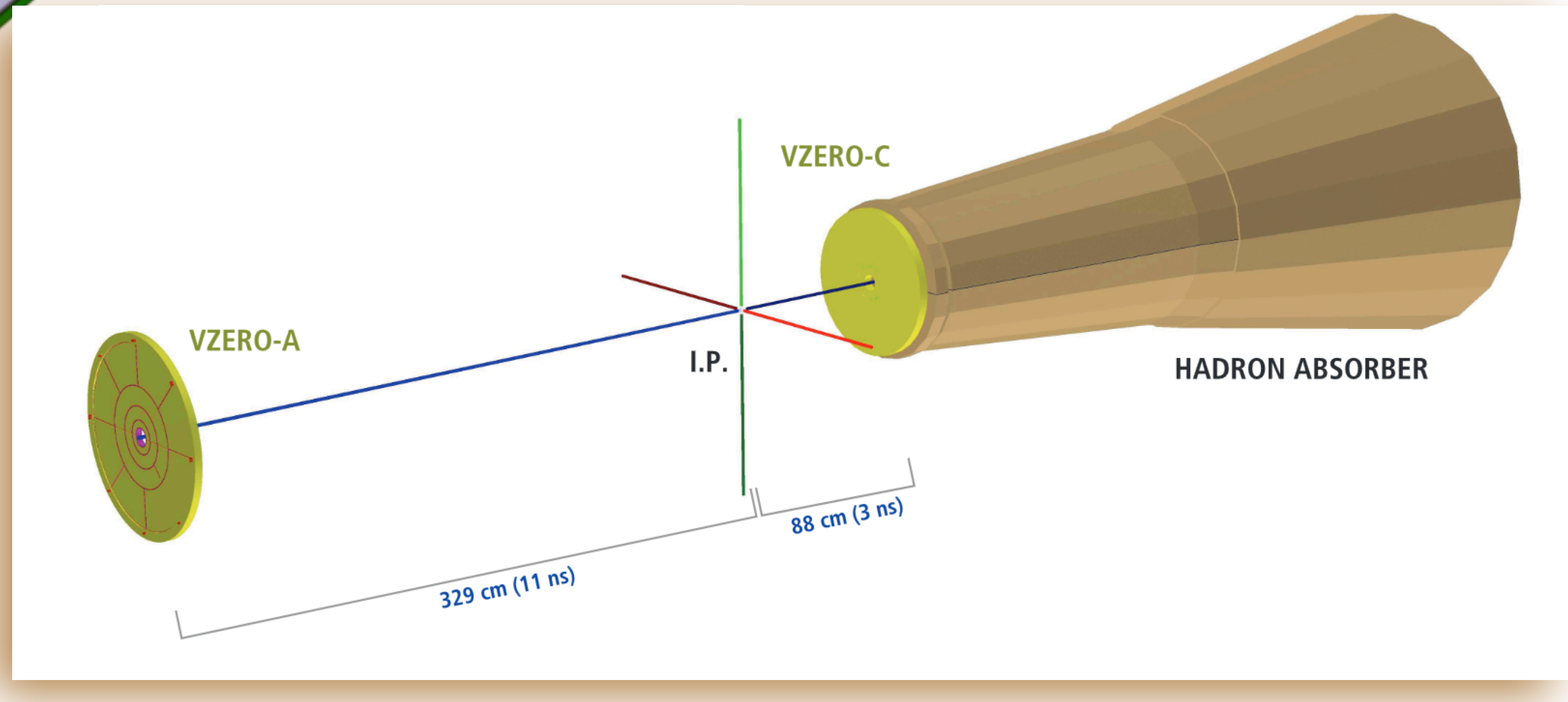
TPC ($|\eta| < 0.9$): tracking, PID ($\mathrm{d}E/\mathrm{d}x$)

ITS ($|\eta| < 0.9$): tracking, vertexing, pile up rejection



V0 ($2.8 < \eta < 5.1$ and $-3.7 < \eta < -1.7$)

- MB trigger, flattenicity
- rejection of beam induced background



TOF ($|\eta| < 0.9$): PID (particle velocity)

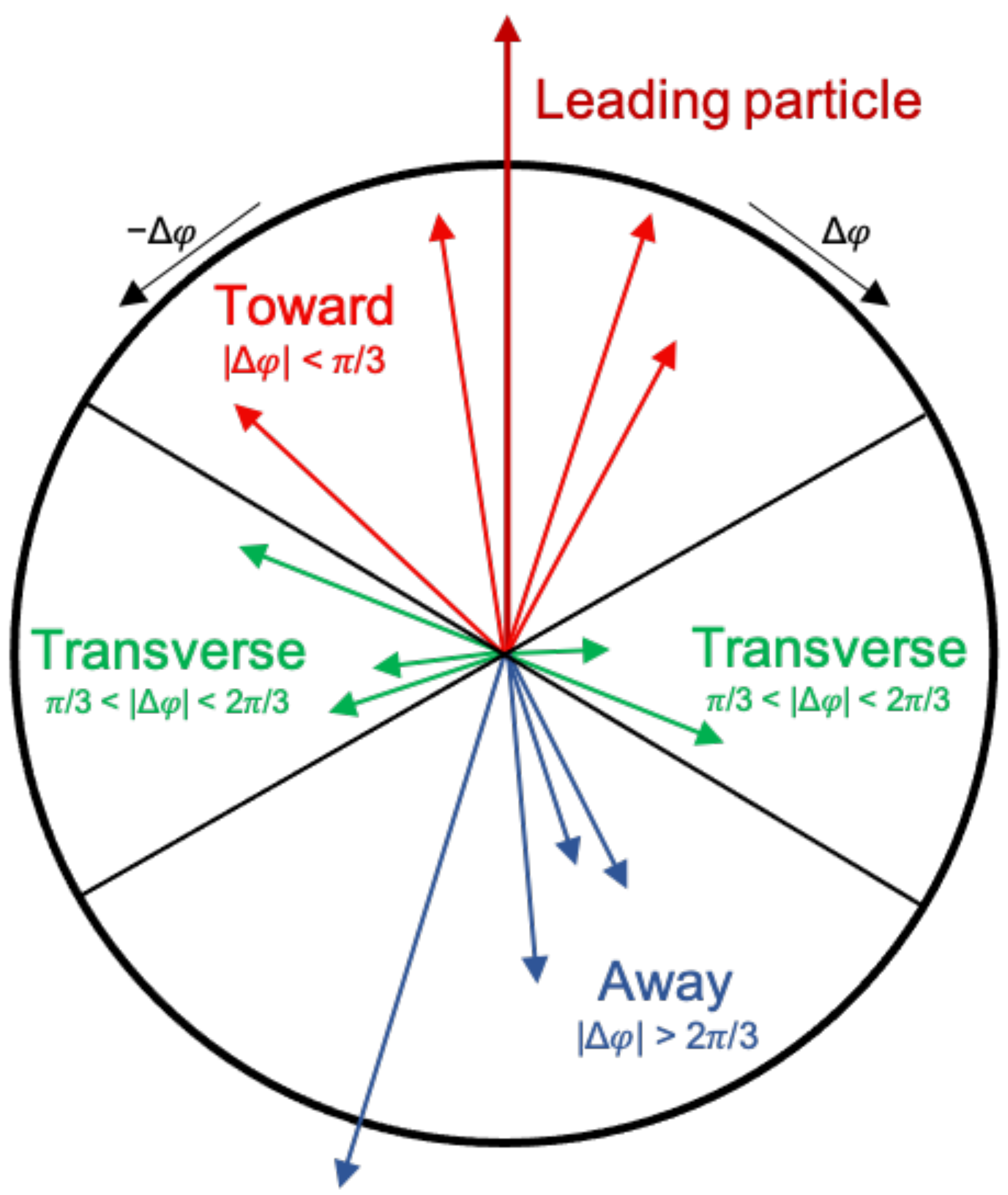
Relative transverse activity R_T measurement

Relative transverse activity R_{T}

Event-by-event selection based on the underlying-event (UE) activity in the midrapidity interval (UE refers to everything that does not come from the main hard partonic scattering)

$R_{\mathrm{T}} = N_{\mathrm{ch}}^{\mathrm{TS}} / \langle N_{\mathrm{ch}}^{\mathrm{TS}} \rangle$

- $N_{\mathrm{ch}}^{\mathrm{TS}}$ is the charged-particle multiplicity in the transverse region (TS)
- $\langle N_{\mathrm{ch}}^{\mathrm{TS}} \rangle$ is the average multiplicity over all events in TS



$\Delta\varphi = \varphi^{\mathrm{trig}} - \varphi^{\mathrm{assoc}}$

Relative transverse activity R_T

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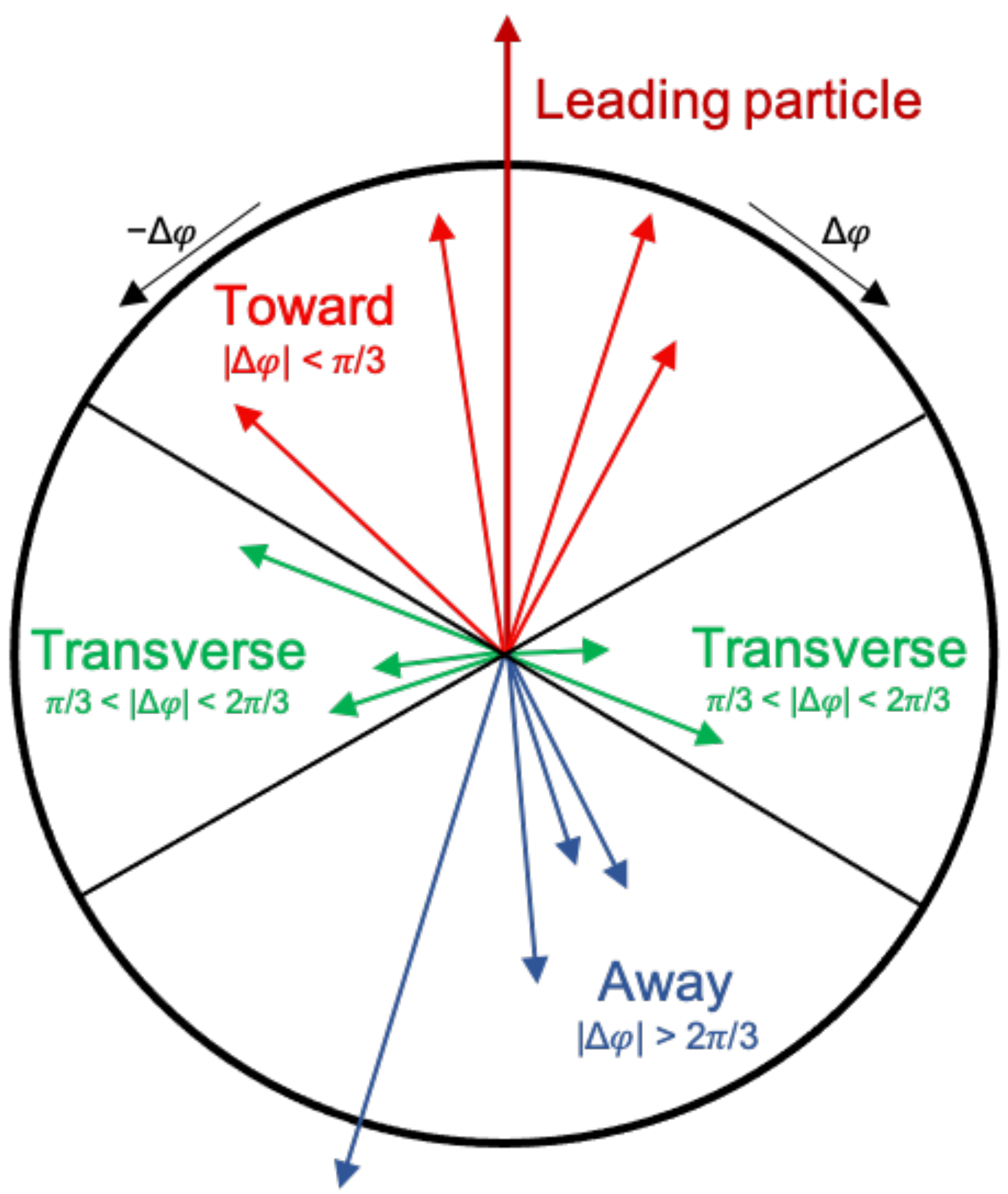

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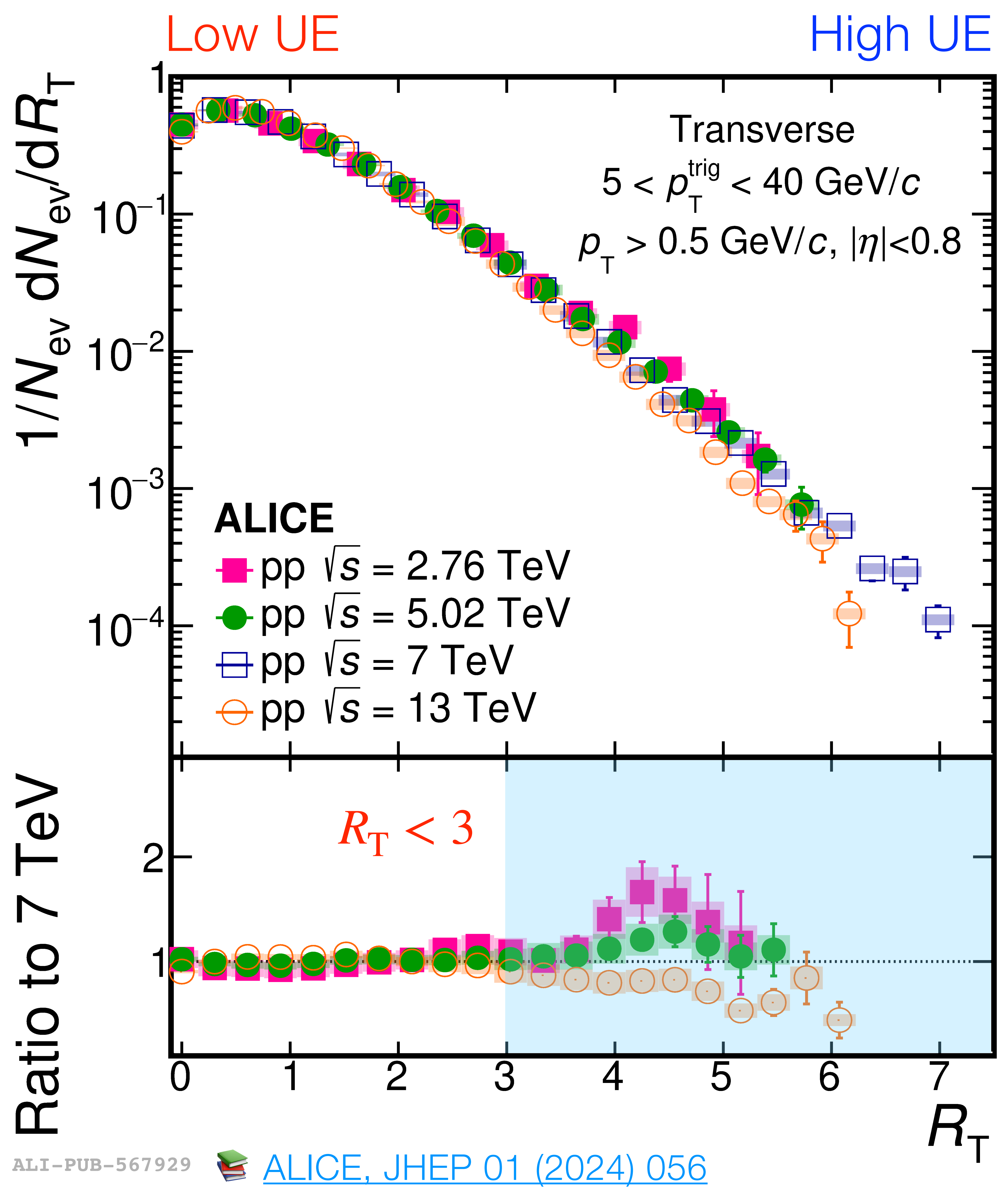
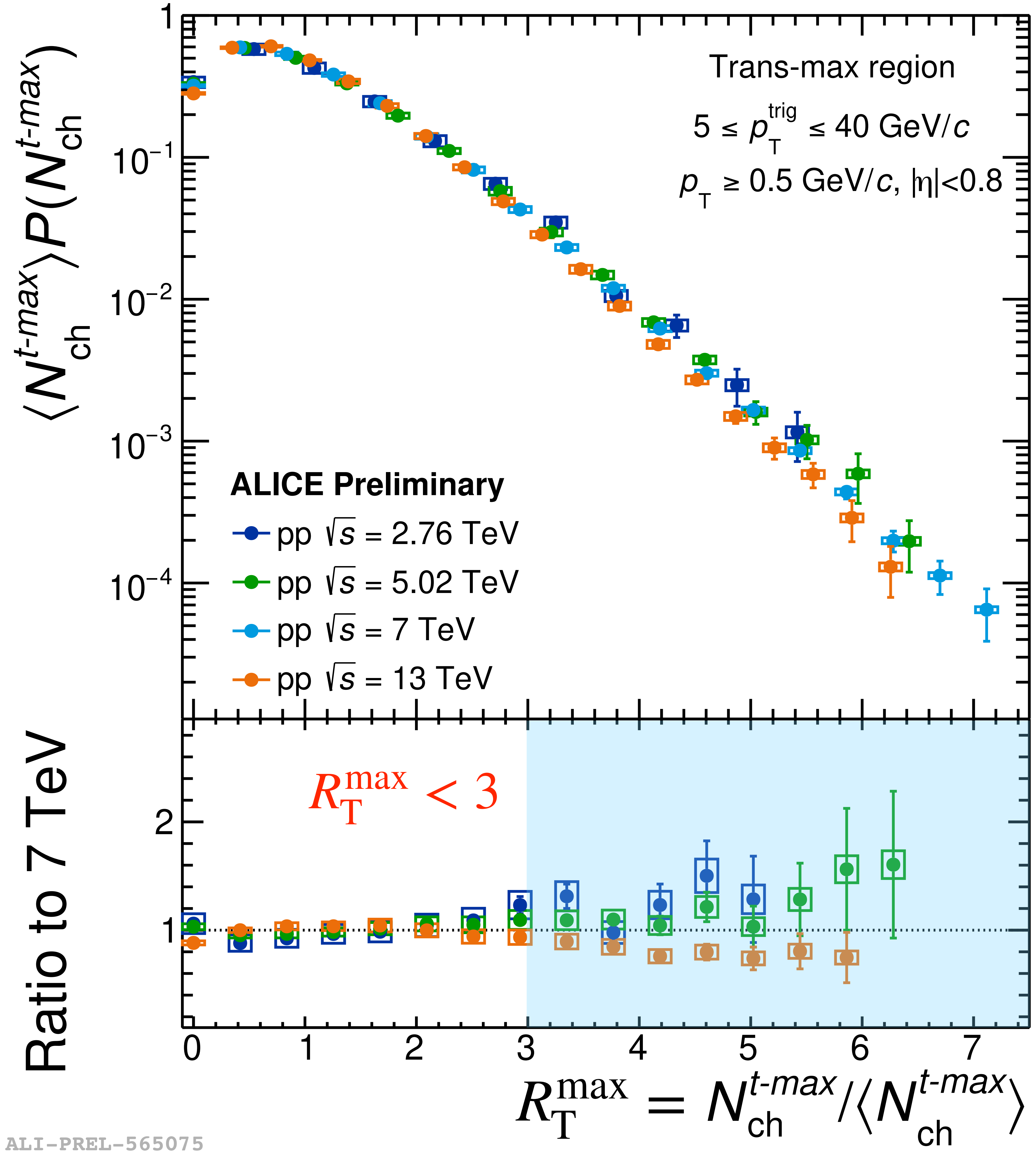


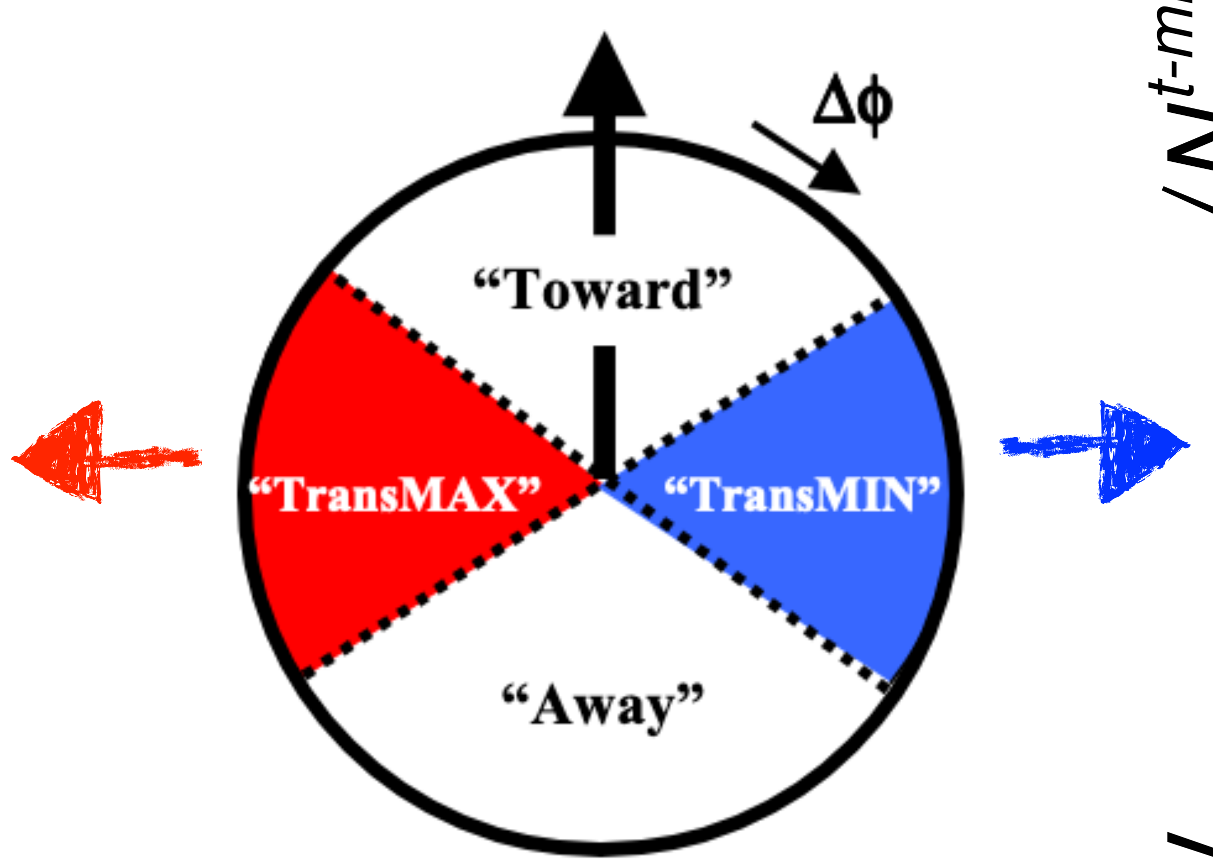
ALICE, JHEP 01 (2024) 056

Koba-Nielsen-Olesen-like scaling is broken for $R_T > 3$, which might be attributed to the local multiplicity fluctuations.

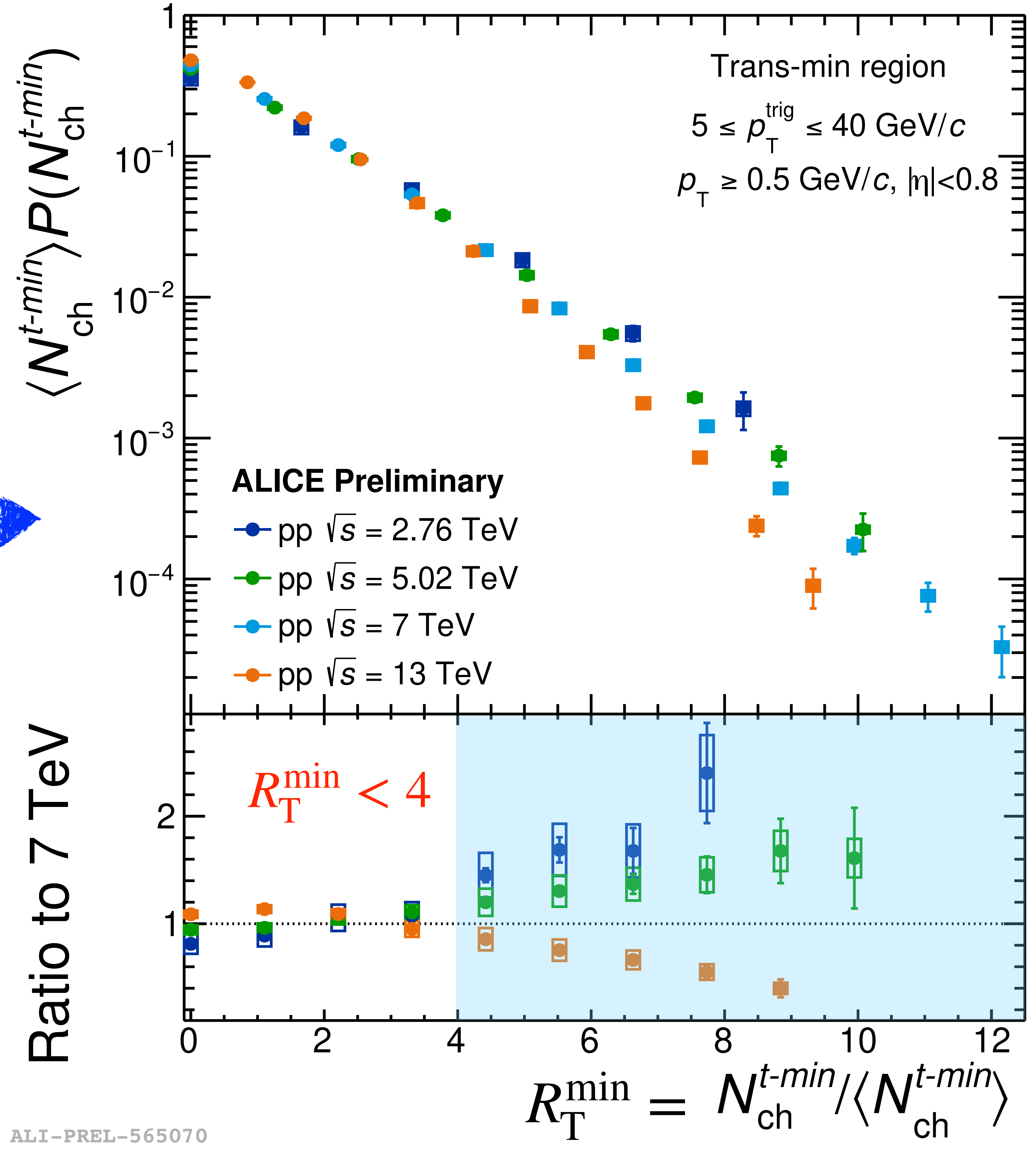
EyE separation into TransMAX / TransMIN region

TransMAX: larger sensitivity to ISR-FRS



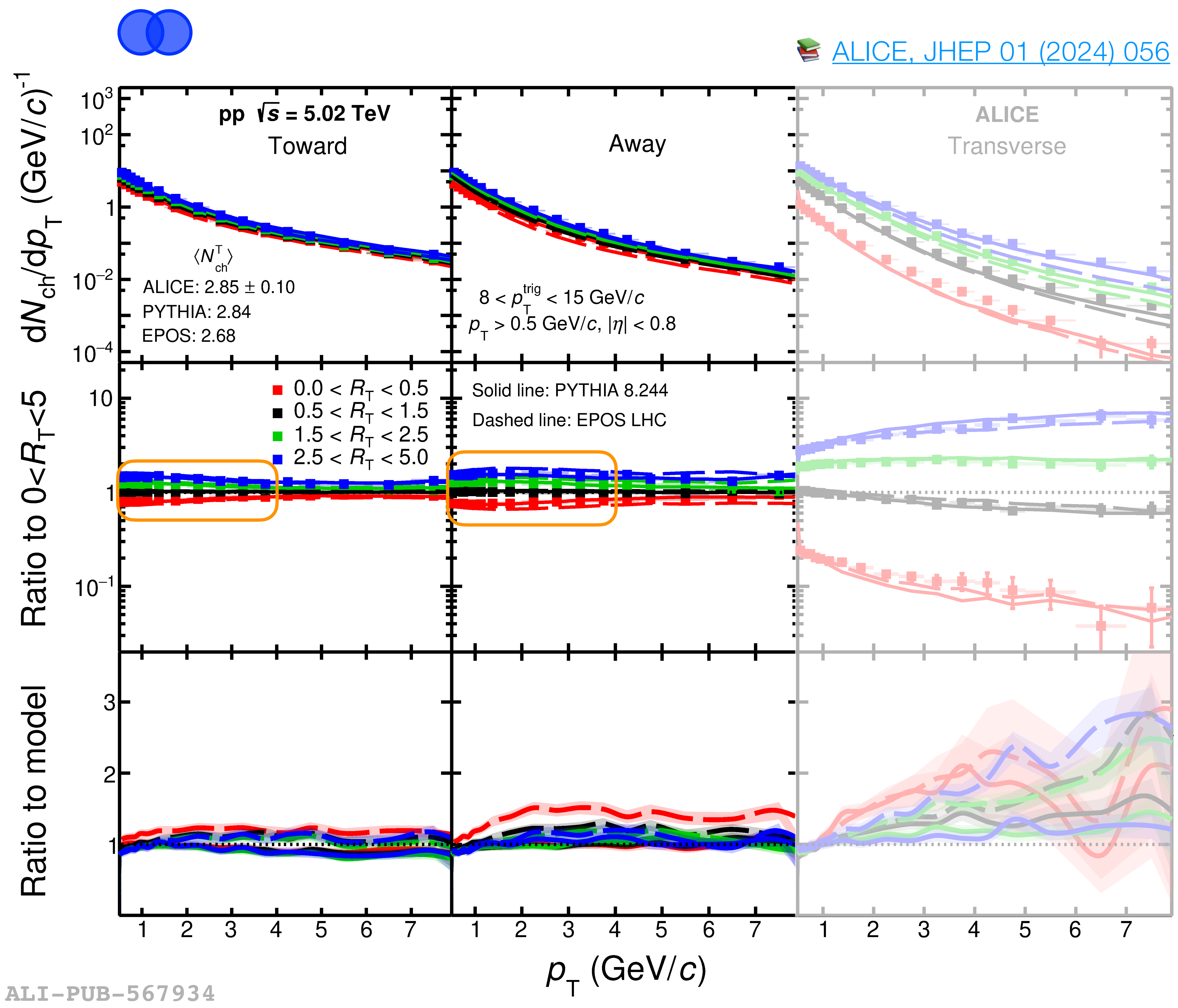


TransMIN: larger sensitivity to MPI



p_T-spectra as a function of R_T

ALICE, JHEP 01 (2024) 056



Toward and Away regions:

- $p_T < 4$ GeV/c, p_T spectra are dependent of R_T
- $p_T > 4$ GeV/c, ratios approach unit

p_{T}-spectra as a function of R_{T}

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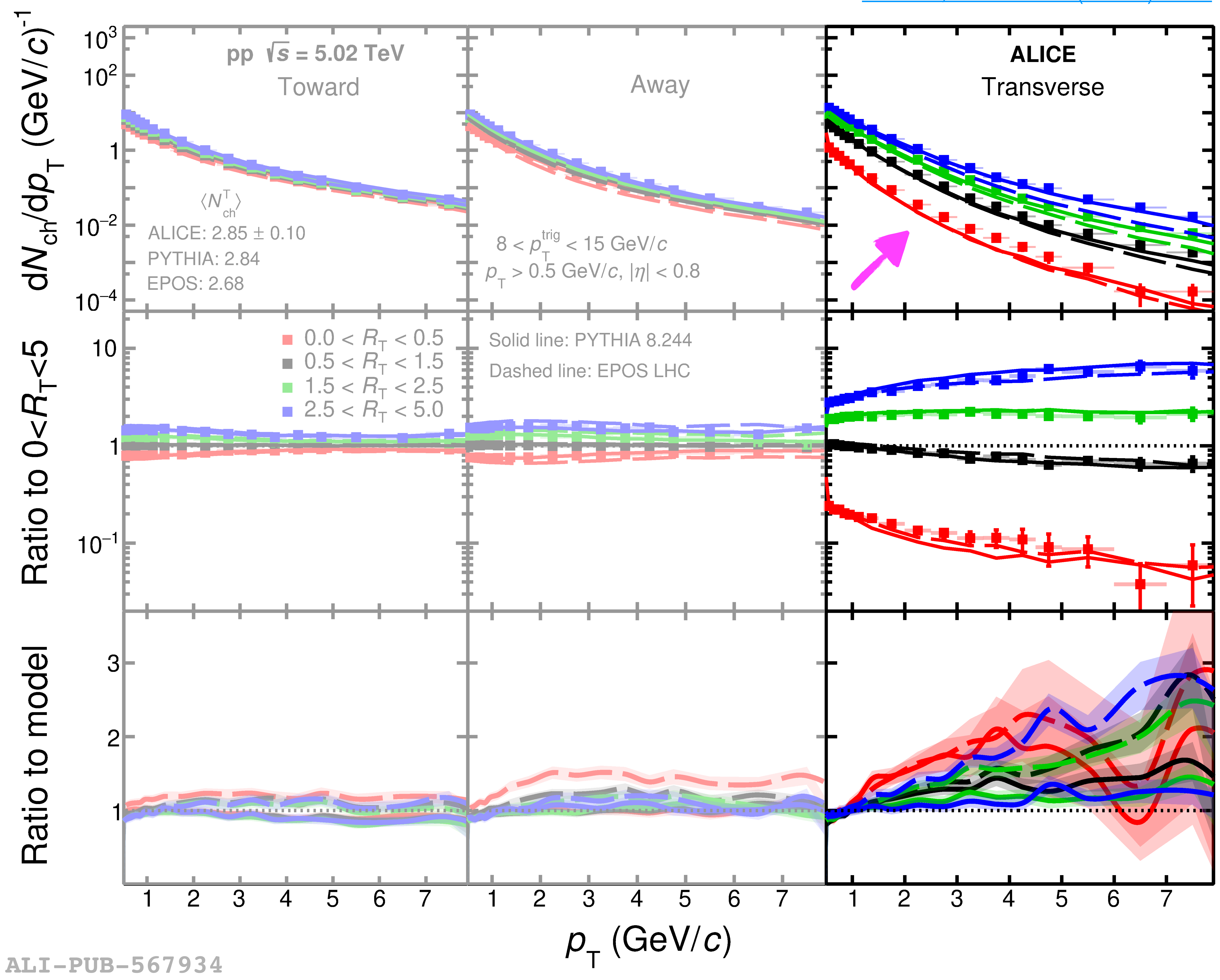

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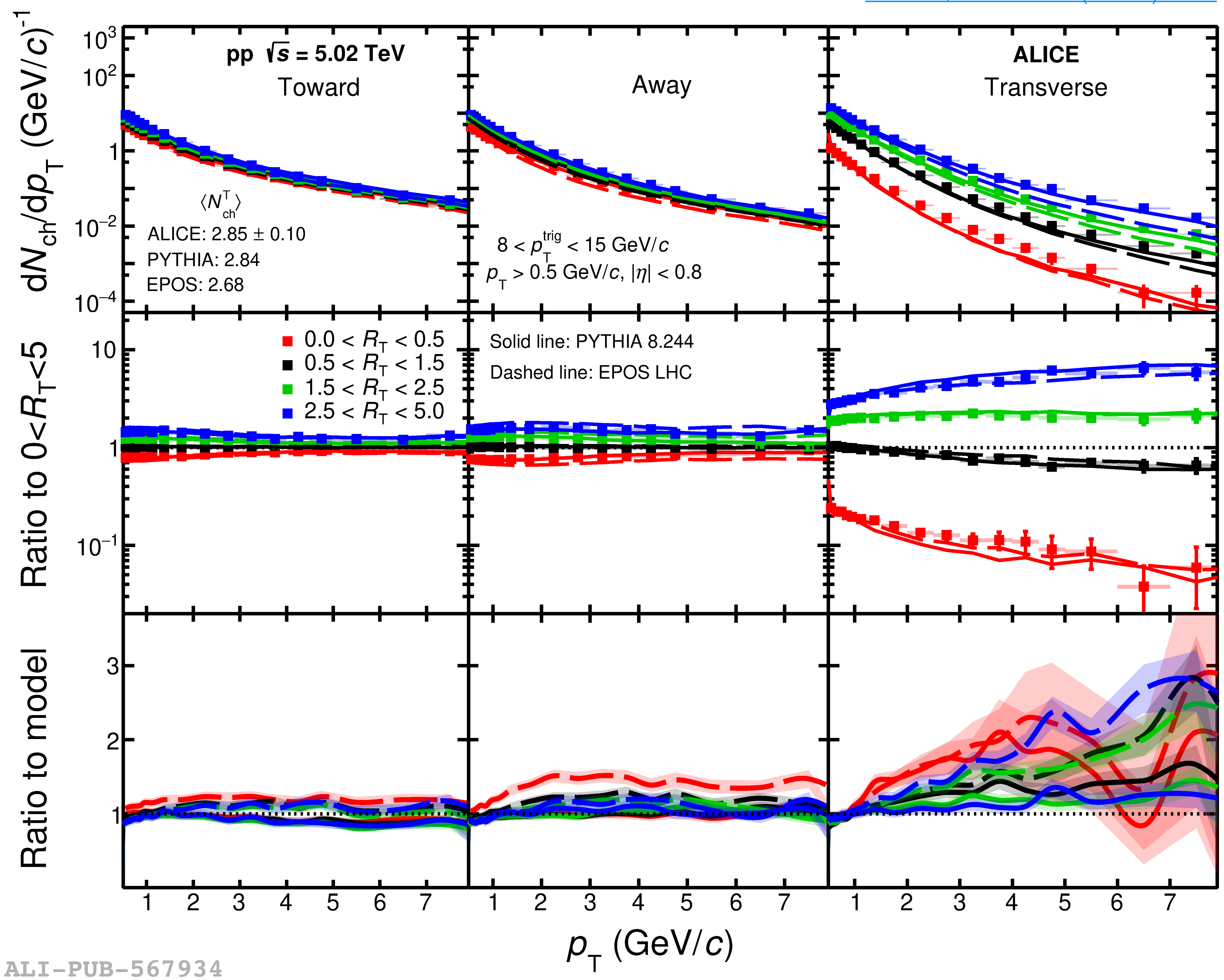
Transverse region:

- A p_{T}-hardening with increasing R_{T}, due to local multiplicity fluctuations Phys. Rev. D 104 (2021) 016017

p_T-spectra as a function of R_T

ALICE, JHEP 01 (2024) 056



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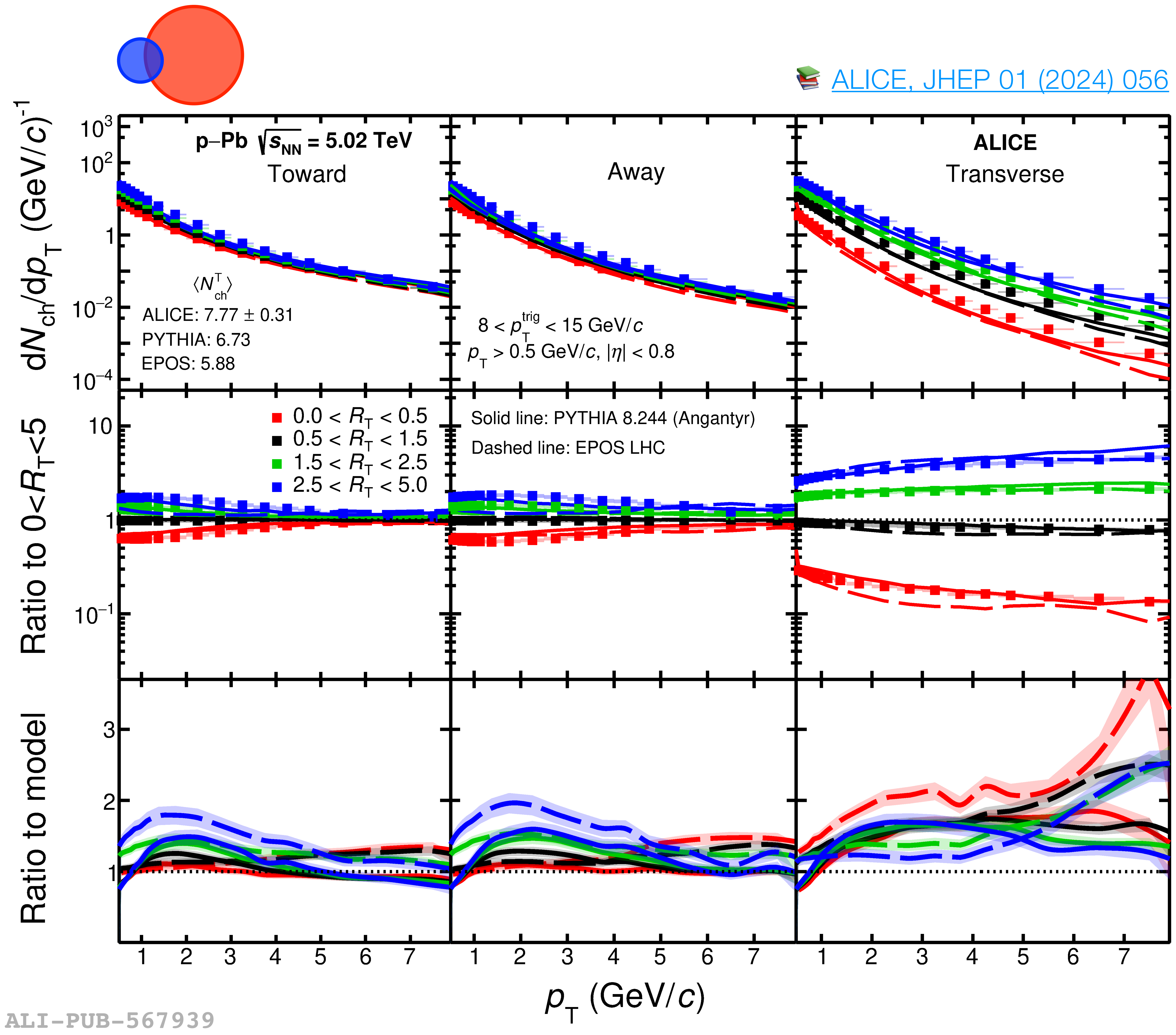
MC predictions:

- PYTHIA 8 describes data better than EPOS LHC

p_T-spectra as a function of R_T

ALICE, JHEP 01 (2024) 056



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MC predictions:

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p-Pb: similar behaviors as observed in pp collisions

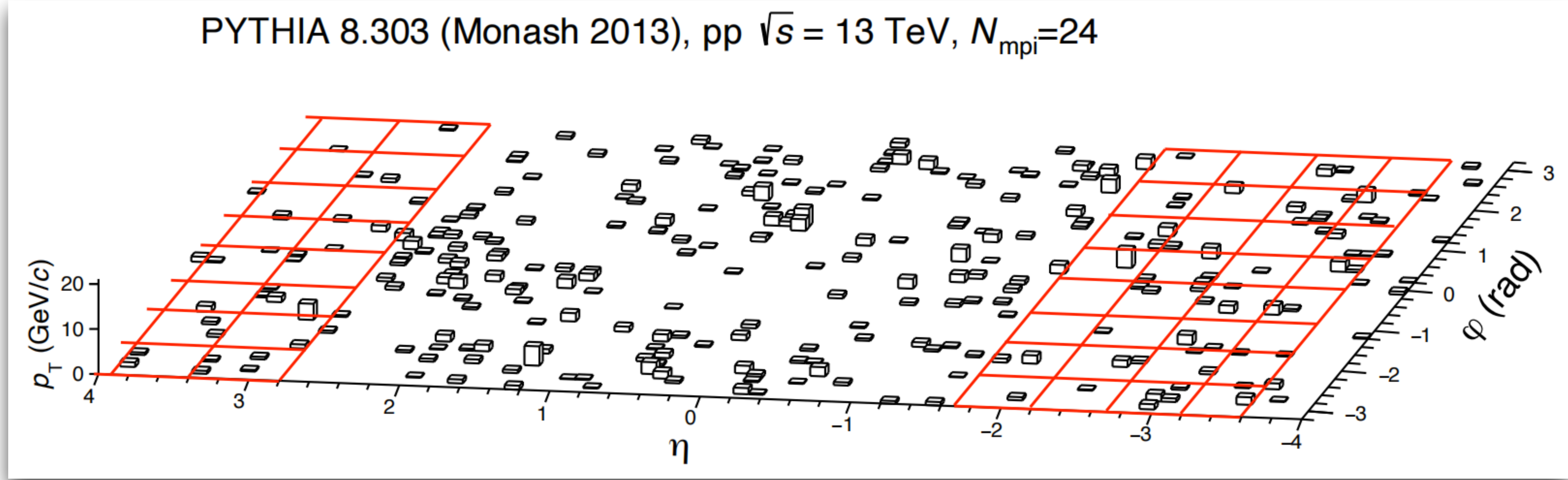
Charged-particle flattenicity 1-ρ measurement

Charged-particle flattenicity 1-ρ

Event-by-event selection based on the relative standard deviation of the multiplicity measured in the 64 V0 channels

$$\rho = \frac{\sqrt{\sum_{i=1}^{64}\left(N_{\rm ch}^{{\rm cell},i} - \langle N_{\rm ch}^{\rm cell}\rangle\right)/N_{\rm cell}^{2}}}{\langle N_{\rm ch}^{\rm cell}\rangle}$$

- $N_{\rm ch}^{{\rm cell},i}$ is the particle multiplicity in the *i*-th cell
- $\langle N_{\rm ch}^{\rm cell}\rangle$ is the average multiplicity over the all 64 cells per event



✓ small flattenicity $1-\rho \rightarrow 1$ (small local multiplicity fluctuations): isotropic events with large multiplicities

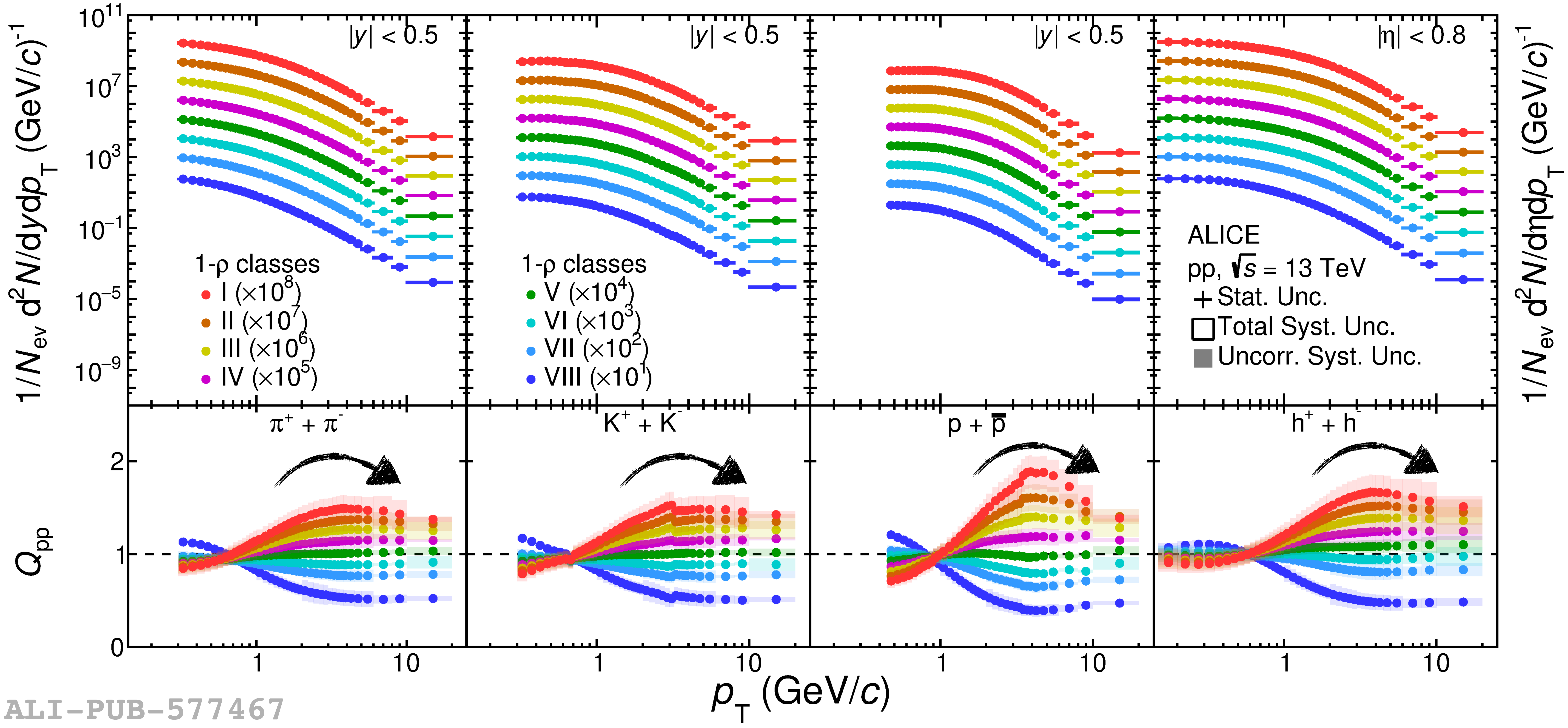
✓ large flattenicity $1-\rho \rightarrow 0$ (large local multiplicity fluctuations): jet-like events with small multiplicities

Q_{pp} as a function of p_T

NEW

arXiv:2407.20037

$$Q_{pp}(p_T) = \left(\frac{1}{N_{ev}}\frac{d^2N_{ch}}{dyd p_T}\frac{1}{\langle dN_{ch}/d\eta\rangle}\bigg|_{1-\rho}\right) \Bigg/ \left(\frac{1}{N_{ev}}\frac{d^2N_{ch}}{dyd p_T}\frac{1}{\langle dN_{ch}/d\eta\rangle}\bigg|_{MB}\right)$$



- Intermediate p_T: a bump structure develops with increasing multiplicity

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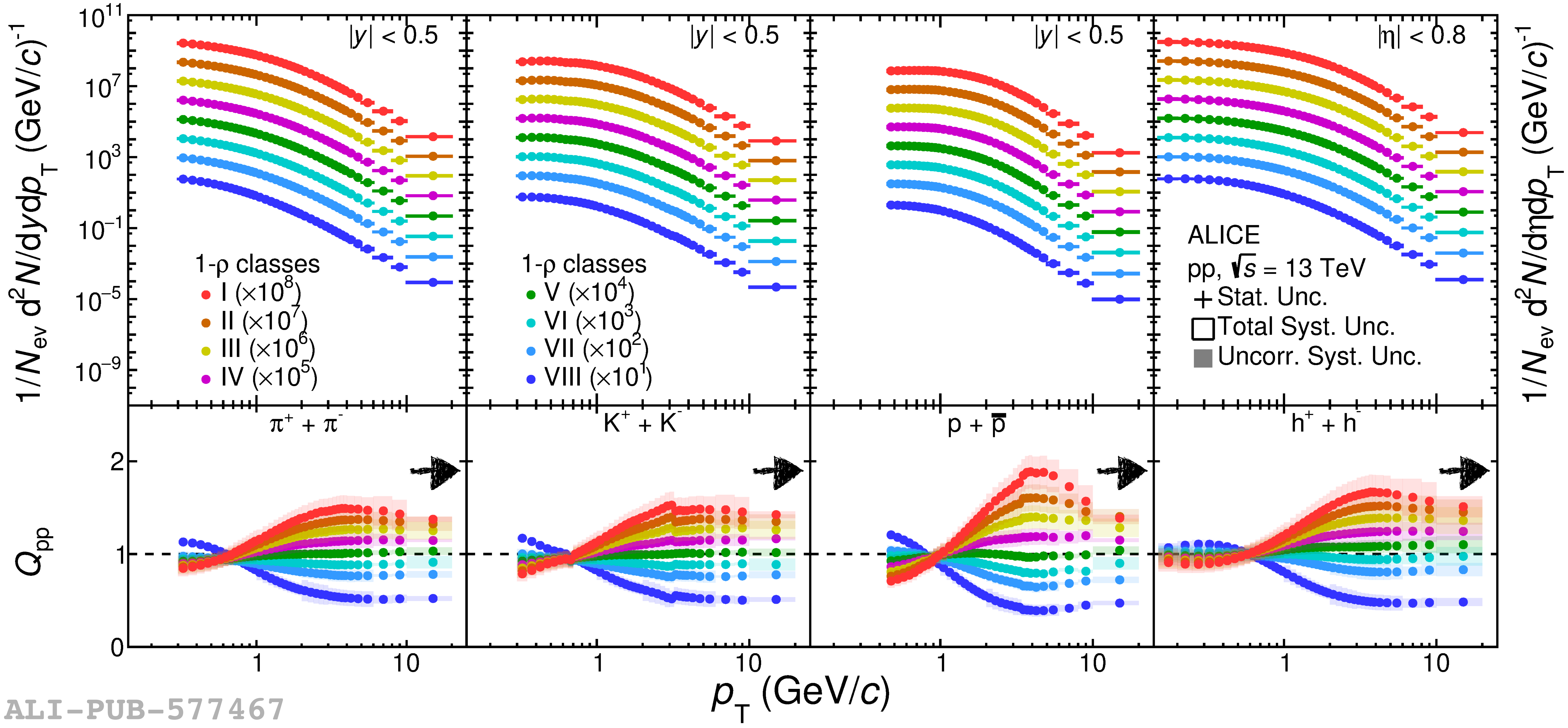

- Intermediate p_T: a bump structure develops with increasing multiplicity
- High p_T: Q_{pp} approaches unit

Q_{pp} as a function of p_T

NEW

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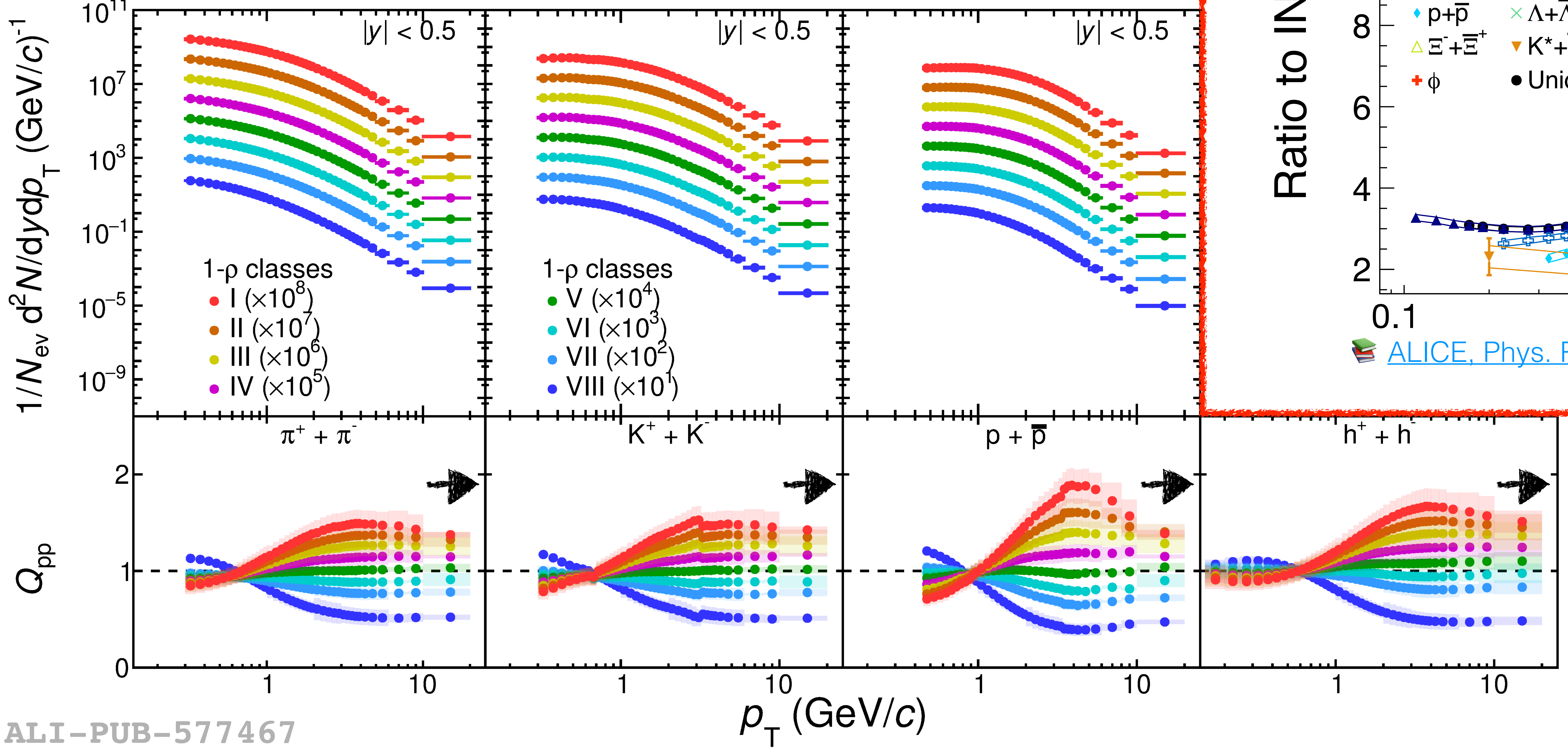
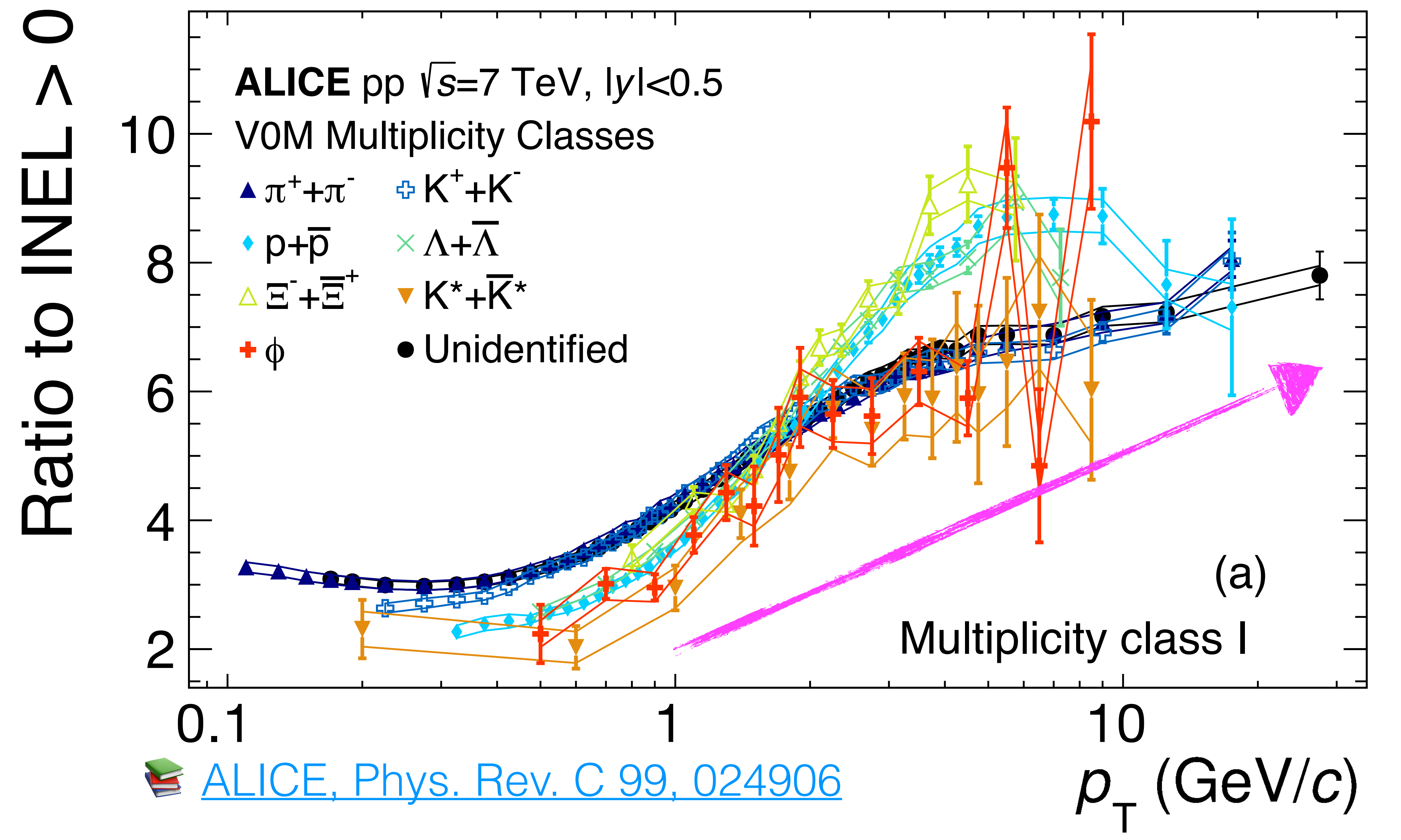




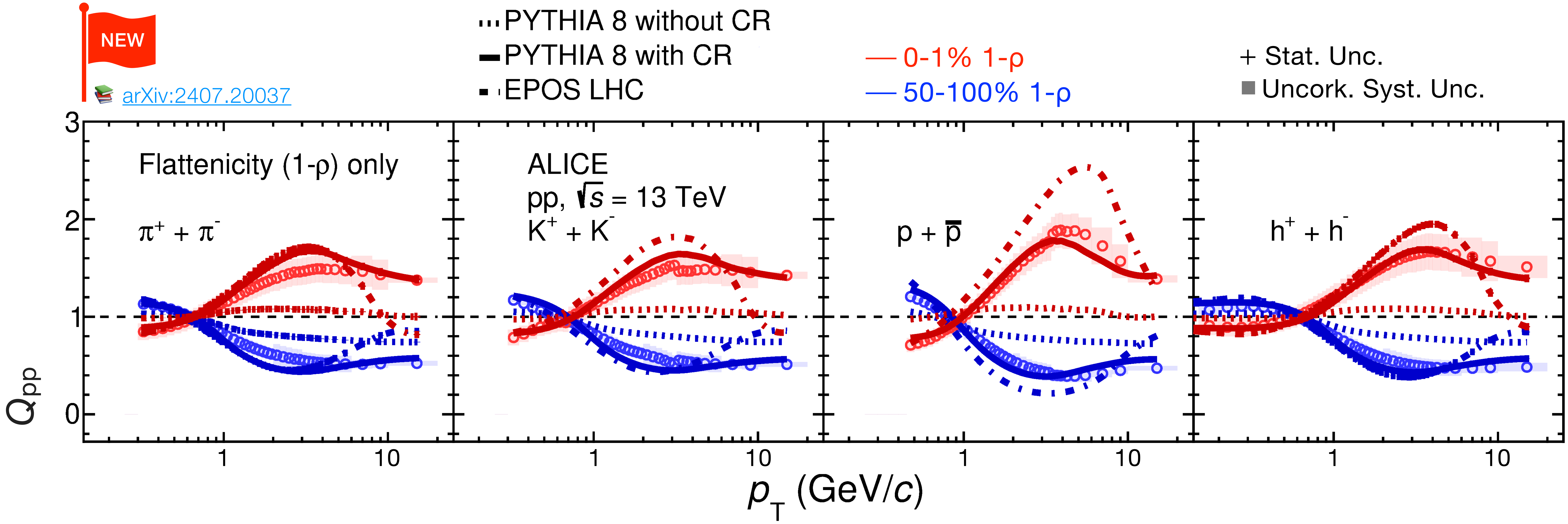
ALICE, Phys. Rev. C 99, 024906

The effect was not seen in the standalone multiplicity (V0M) analysis!

- Intermediate p_T: a bump structure develops with increasing multiplicity
- High p_T: Q_{pp} approaches unity

NEW

arXiv:2407.20037



- PYTHIA 8 w/o CR: a nearly flat Q_{pp} as a function of p_T
- PYTHIA 8 w CR: overall the best description of data
- EPOS LHC: overestimates and underestimates Q_{pp} at intermediate and high p_T values, respectively

Summary

1. R_T and flattenicity: reduce local multiplicity fluctuations
2. Promising tool to study particle production in small systems