Production of light flavor particles as a function of the Underlying Event activity with ALICE

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Introduction

High-multiplicity pp and p–Pb collisions show signatures of collective phenomena, as well as strangeness enhancement.
To pin down the origins of these effects, particle production is studied as a function of the Underlying Event (UE) activity [1], namely in the "transverse" region (perpendicular to the direction of the event's leading particle).

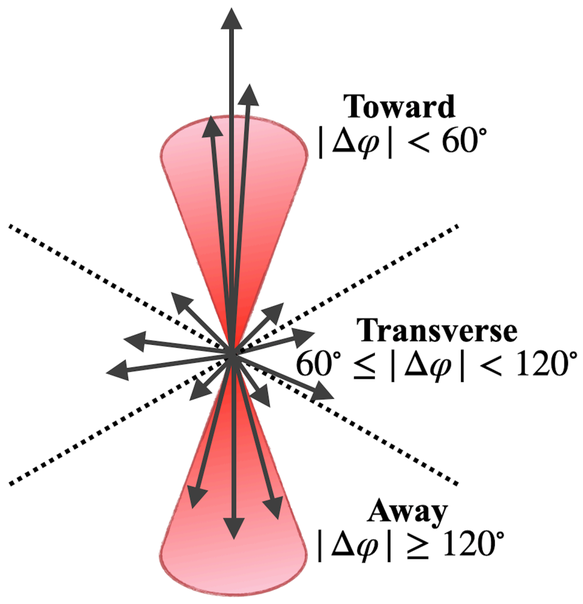

Figure 1: Definition of the topological regions in the azimuthal angle plane with respect to the direction of the leading particle (longest upright arrow). Figure taken from [2].

The UE activity is quantified using the relative transverse activity classifier, $\boldsymbol{R_{\mathrm{T}}} = \boldsymbol{N_{\mathrm{T}}}/\langle \boldsymbol{N_{\mathrm{T}}} \rangle$ [1], where N_{T} is the per event charged-particle multiplicity in the transverse region and $\langle N_{\mathrm{T}} \rangle$ is the average value over all the analyzed events.

- R_{T} separates events with "higher-than-average" UE from "lower-than-average".
- Investigate whether events with $R_{\mathrm{T}} \to 0$ (dominated by the jet activity) exhibit particle ratios and spectra consistent with fragmentation models tuned to $\mathrm{e^+e^-}$ data and whether events with $R_{\mathrm{T}} \to \infty$ exhibit any clear signs of collective phenomena.
- In the context of MPI models, this type of differential studies allow to measure event properties in an MPI-suppressed (-enhanced) environment.

Analysis procedure

This study presents the production of π, K, and p measured in pp collisions at $\sqrt{s} = 13$ TeV in different topological regions as a function of R_{T}.

- Uses events with trigger charged tracks in $|\eta| < 0.8$ and $5 \leq p_{\mathrm{T}}^{\mathrm{leading}} < 40$ GeV/c.
- The π, K, and p yield is measured in topological regions, and as function of R_{T}. Particle identification is performed exploiting the TPC and the TOF detectors.
- The $\mathrm{d}^2N(R_{\mathrm{T}})/\mathrm{d}y\mathrm{d}p_{\mathrm{T}}$ distributions are unfolded using an iterative Bayesian unfolding method. Moreover, the p_{T} distributions include a Feed-Down correction.

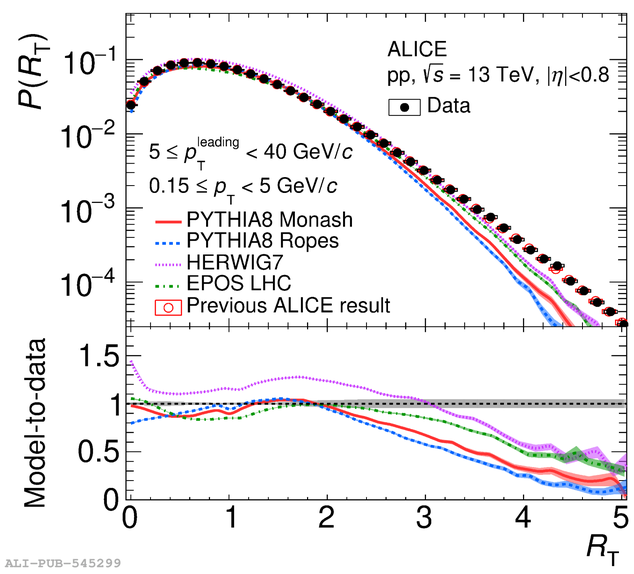

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Figure 2: Unfolded R_{T} probability distribution and model predictions in the transverse region in events with a leading charged particle. Figure taken from [2].

R_{T}	N_{T}
$0 - 0.5$	$0 - 3$
$0.5 - 1.5$	$4 - 11$
$1.5 - 2.5$	$12 - 18$
$2.5 - 5$	$19 - 30$
$0 - 5$	$0 - 30$

Table 1: Relation between R_{T} classes and N_{T} intervals.

Results

Toward and away regions:

- Particle production in the $0 \leq R_{\mathrm{T}} < 0.5$ interval is dominated by the leading and away-side jet fragmentation.
- Depletion (enhancement) of particles for $p_{\mathrm{T}} \lesssim 2$ GeV/c ($p_{\mathrm{T}} \approx 2.5$ GeV/c) with increasing UE activity. Possibly attributed to radial flow.
- The spectra soften with increasing UE activity for $p_{\mathrm{T}} \gtrsim 2$ GeV/c. The UE dominates at high R_{T}

Transverse region:

- The spectra harden with increasing UE activity. Possibly due to a selection bias.

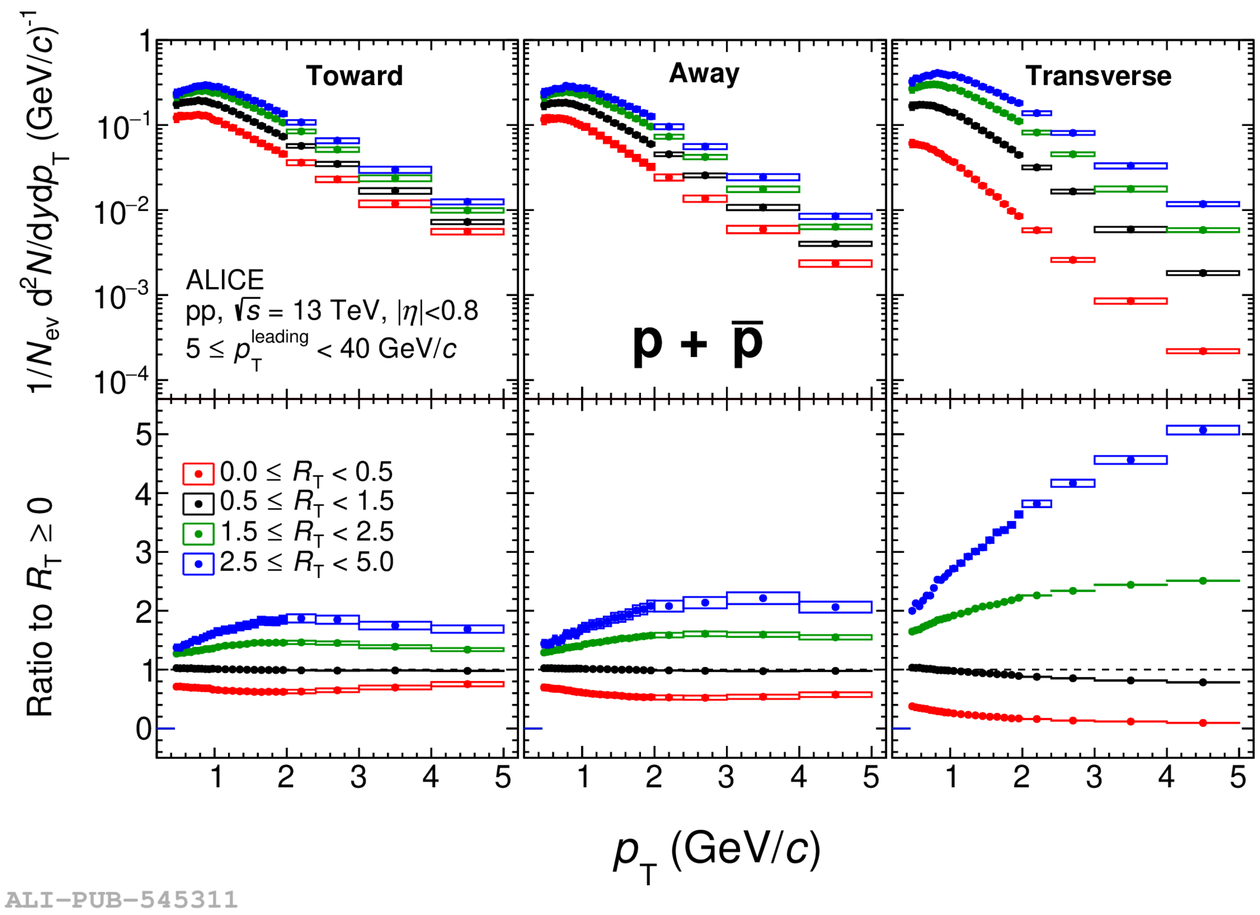

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Figure 3: p_{T} spectra (top panels) of protons as a function of R_{T} and ratios to the R_{T}-integrated spectrum (bottom panels). Figure taken from [2].

- The K/π and p/π ratios in the toward region increase with increasing UE activity for $p_{\mathrm{T}} \gtrsim 1$ GeV/c. This might be due to a gradual increase of radial flow.
- PYTHIA 8 can only describe qualitatively the particle ratios in the toward and away regions for $0 \leq R_{\mathrm{T}} < 0.5$. This is expected since it is tuned to reproduce jet-like $\mathrm{e^+e^-}$ measurements.
- PYTHIA 8 Monash predicts almost no evolution when the UE increases.

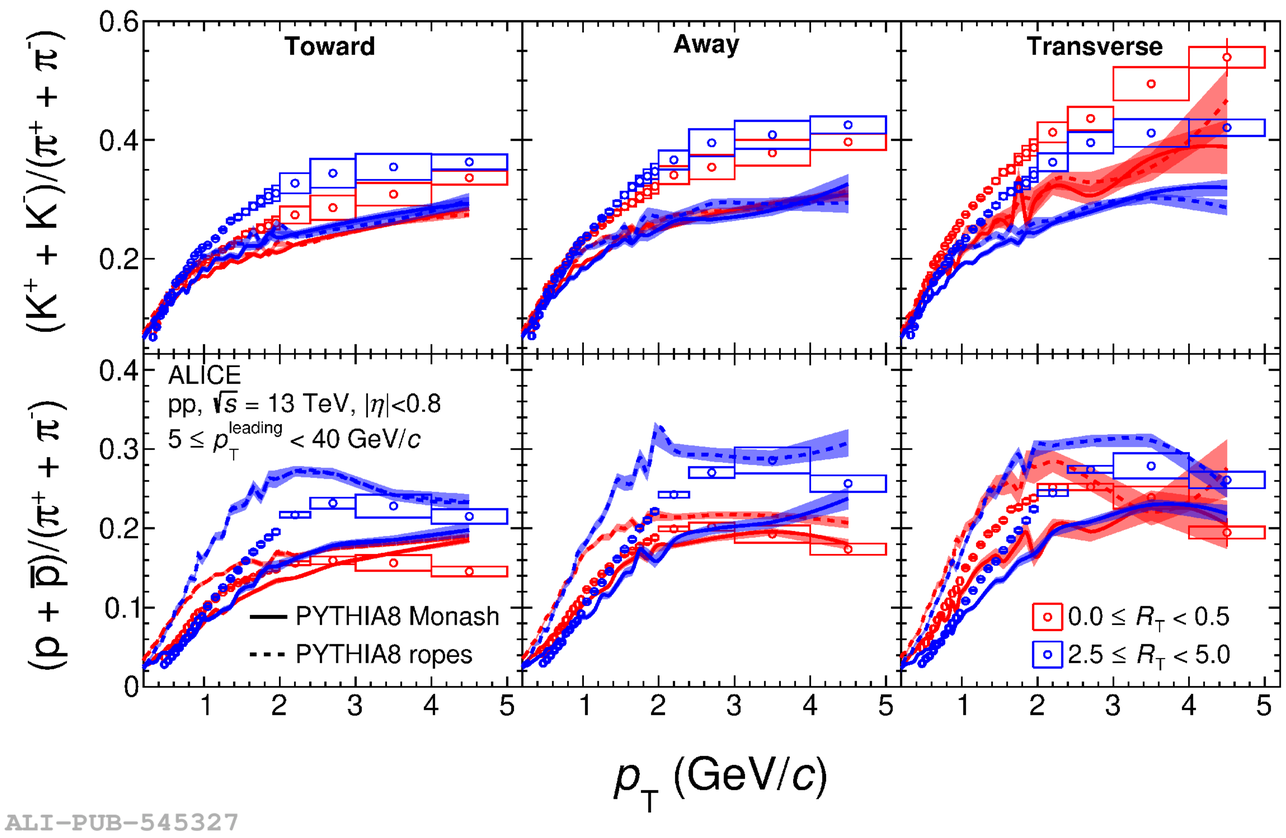

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Figure 4: p_{T}-differential particle ratios in the extremes of R_{T} and predictions from the PYTHIA model.

References

[1] T. Martin, P. Skands, and S. Farrington, "Probing Collective Effects in Hadronisation with the Extremes of the Underlying Event," *Eur. Phys. J. C* **76** no. 5, (2016) 299, arXiv:1603.05298 [hep-ph].

[2] **ALICE** Collaboration, S. Acharya *et al.*, "Production of pions, kaons, and protons as a function of the relative transverse activity classifier in pp collisions at $\sqrt{s} = 13$ TeV," *JHEP* **06** (2023) 027, arXiv:2301.10120 [nucl-ex].

Acknowledgment

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