

Probing light-flavour particle production in small collision system through event topology with ALICE

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ALICE



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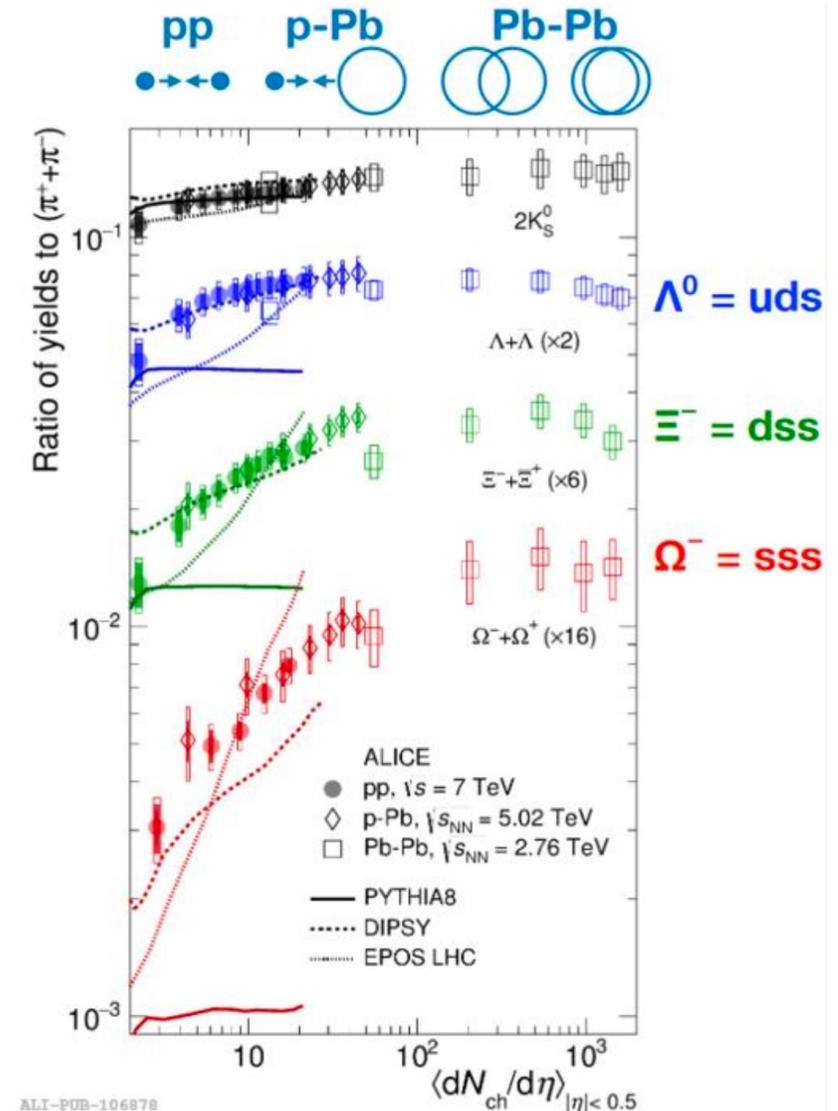
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(Series 3)**

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A closer look into strangeness enhancement

- ✓ Multiplicity-dependent study in small systems allows us to bridge the gap between minimum bias pp and peripheral heavy-ion collisions
- ✓ Light-flavor hadrons: the most abundant particles facilitate the study of the soft processes and non-perturbative regime
- ✓ In AA systems, strangeness enhancement could be interpreted as a signature of the formation of a quark–gluon plasma (QGP).
 - ✓ Unresolved if this also applies to pp collisions
- ✓ In such cases, we need other observables to characterize events. **So, what are the possible observables?**

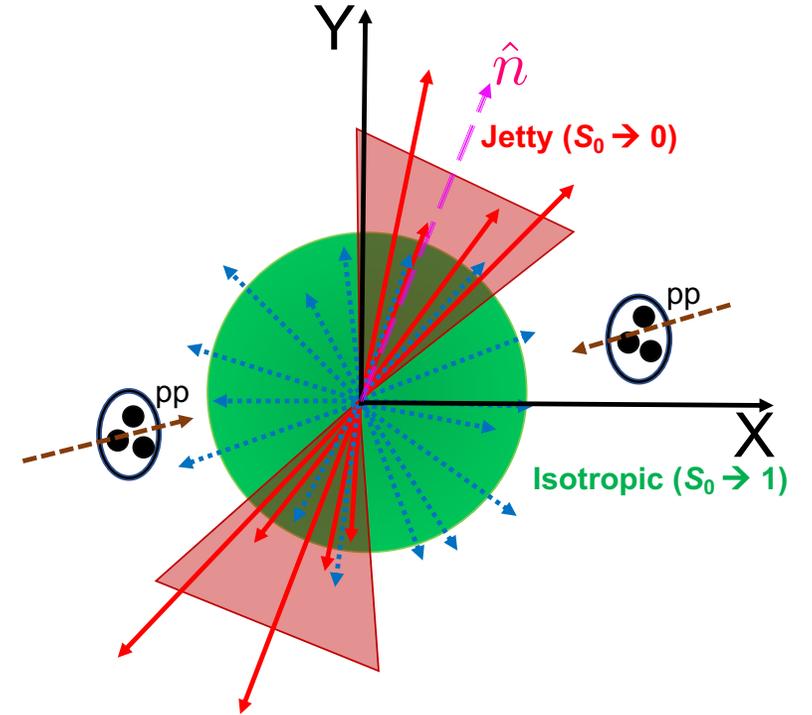
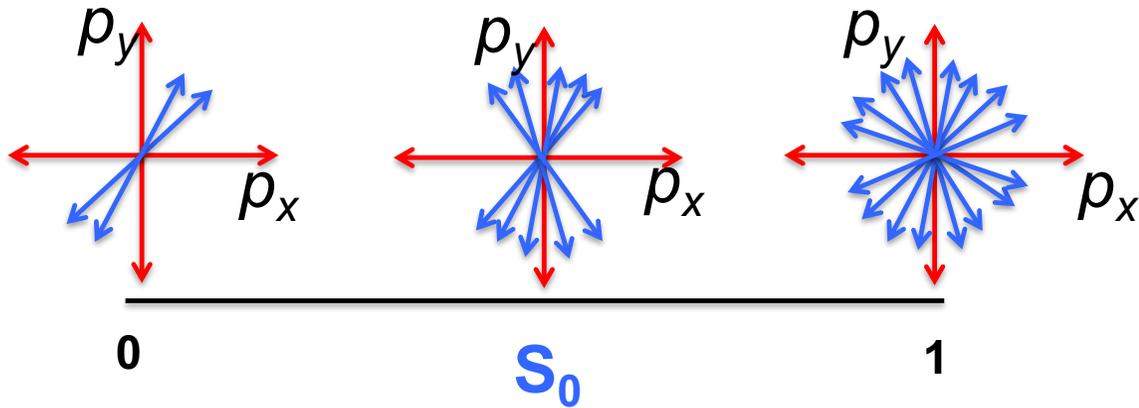


Transverse spherocity ($S_0^{p_T=1}$)

- ✓ S_0 is defined using a unit vector \hat{n} ($n_T, 0$) that minimizes

$$S_0^{p_T=1} = \frac{\pi^2}{4} \min_{\hat{n}} \left(\frac{\sum_i |\hat{p}_{T_i} \times \hat{n}|}{N_{trk}} \right)^2$$

- ✓ S_0 can be used to disentangle the soft and hard QCD dominated process in an event



$S_0 \rightarrow 0$ (jetty limit)

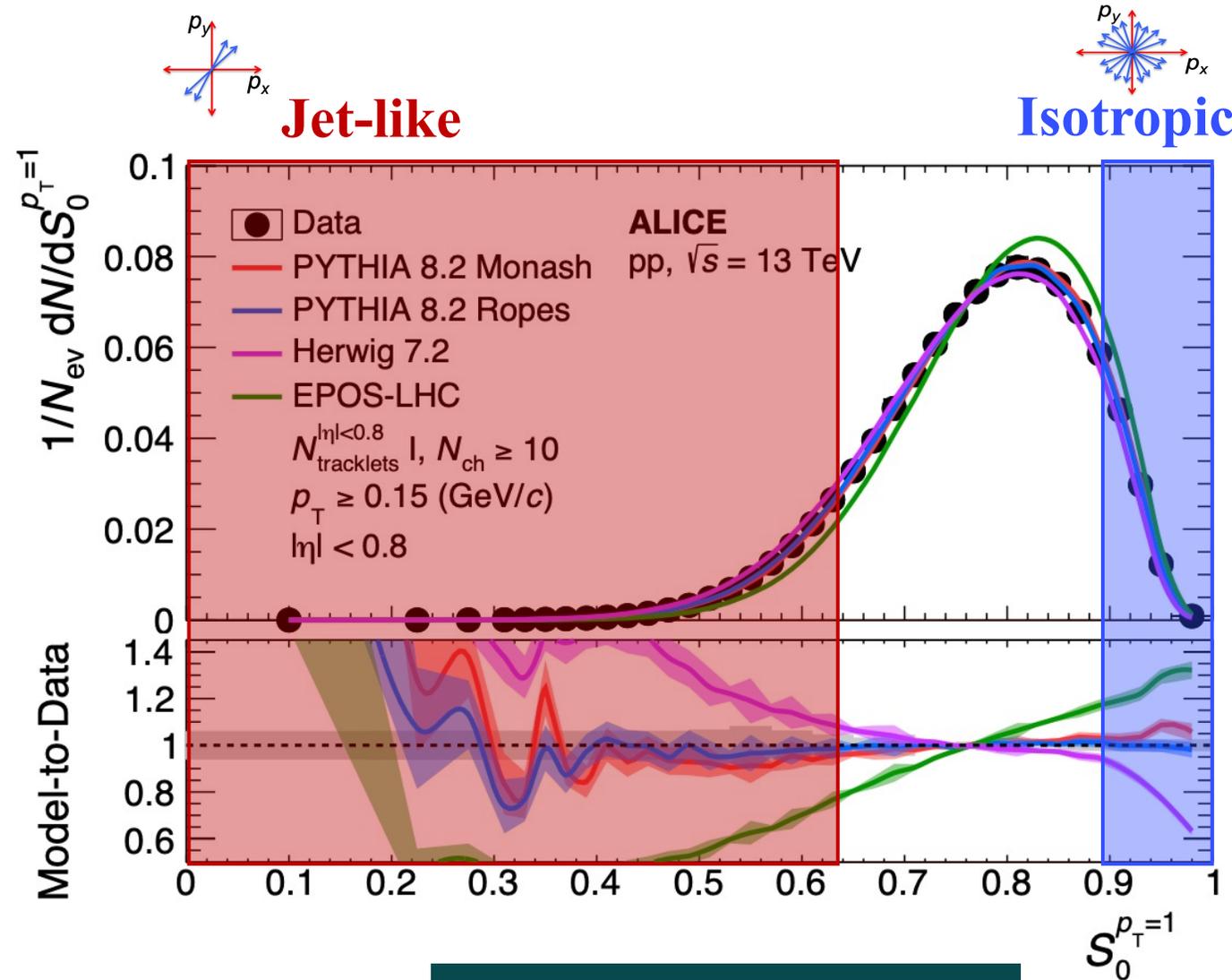
(Dominated by hard QCD processes)

$S_0 \rightarrow 1$ (isotropic limit)

(Dominated by soft QCD processes)

Transverse spherocity ($S_0^{p_T=1}$)

- ✓ Classify high-multiplicity events based on event topology
 - ✓ Focus on top 1% multiplicity ($N_{tracklets}^{\eta < 0.8}$), where QGP-like effects arise
- ✓ Events are selected for the top (isotropic) and bottom (jetty-like) 10% of the spherocity distribution
- ✓ PYTHIA8 better describes the data as compared to other MC generators

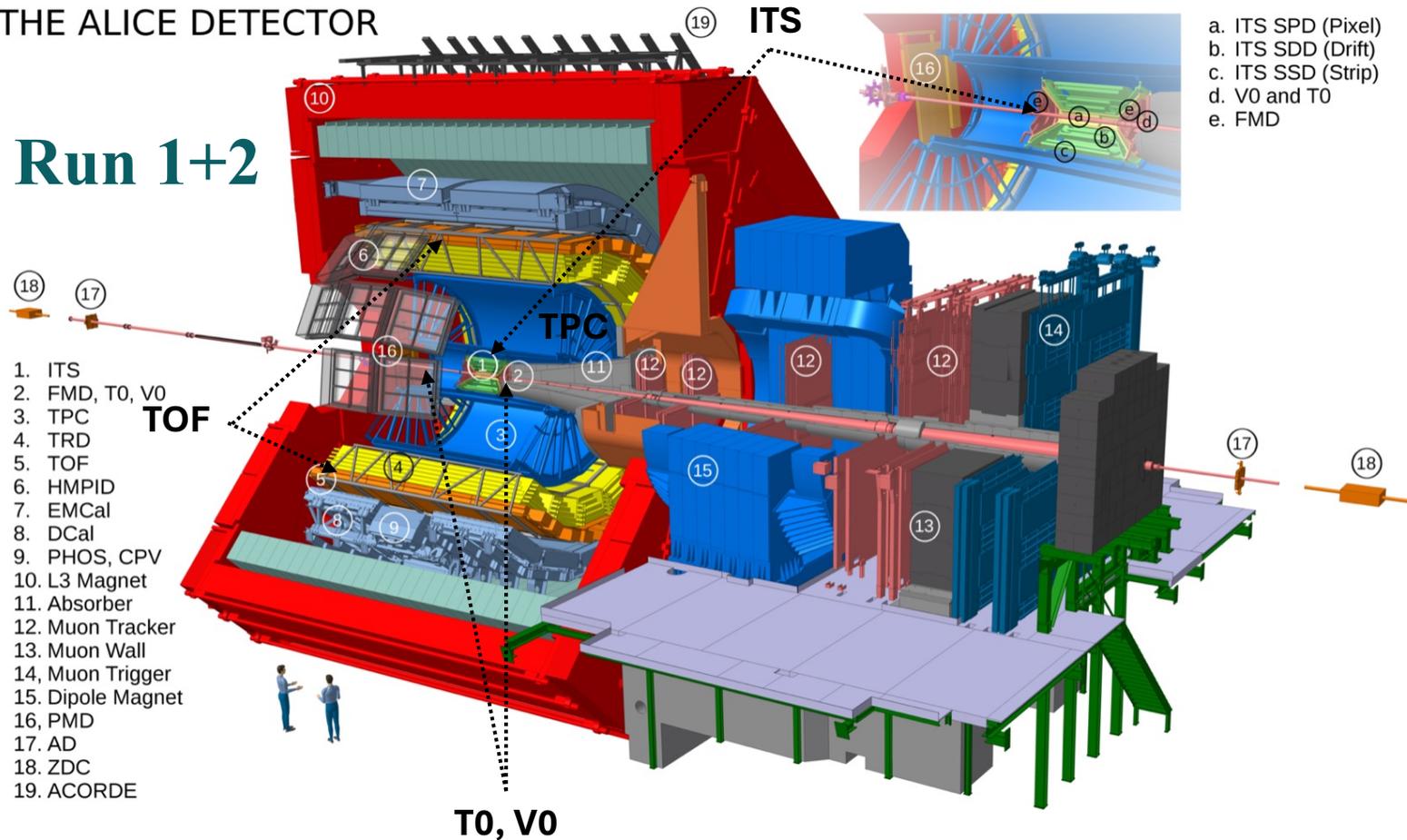


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The ALICE detector

THE ALICE DETECTOR

Run 1+2



ITS ($|\eta| < 0.9$)

Trigger, vertex, tracking, PID (dE/dx)

TPC ($|\eta| < 0.9$)

Tracking, PID (dE/dx)

$\sigma_{dE/dx} \sim 5.5\%$ for pp

$\sigma_{dE/dx} \sim 7\%$ for Pb–Pb

TOF ($|\eta| < 0.9$)

Multi-gap Resistive Plate Chambers

Time resolution ($\sigma_{TOF} \sim 80$ ps), PID (time-of-flight)

V0 (A&C)

trigger, multiplicity estimators

(Minimum Bias: 0 – 100%, High Multiplicity: 0 – 0.1%)

JINST 3, S08002 (2008)

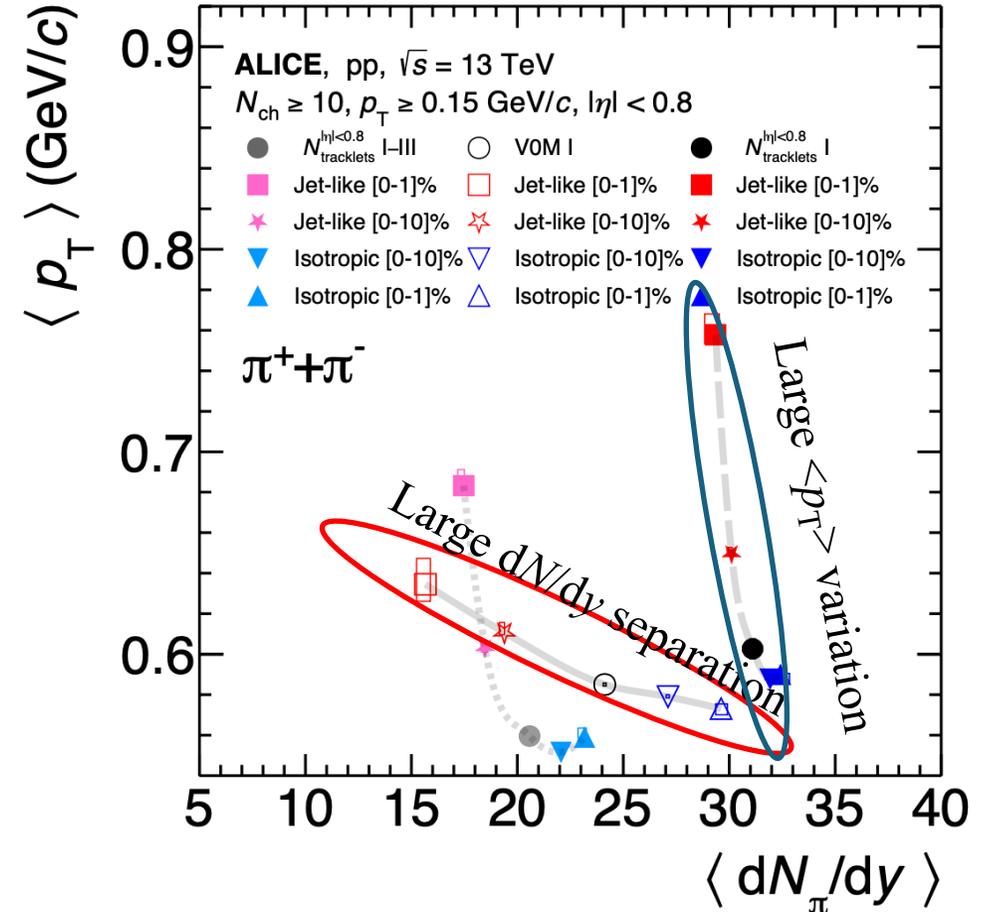
Multiplicity estimators for $S_0^{pT=1}$ analysis

$N_{tracklets}^{|\eta| < 0.8}$: Mid-rapidity multiplicity estimator
(SPD tracklets: $|\eta| < 0.8$)

V0M: Forward rapidity multiplicity estimator
(V0 amplitude: $2.8 < \eta < 5.1$ and $-3.7 < \eta < -1.7$)

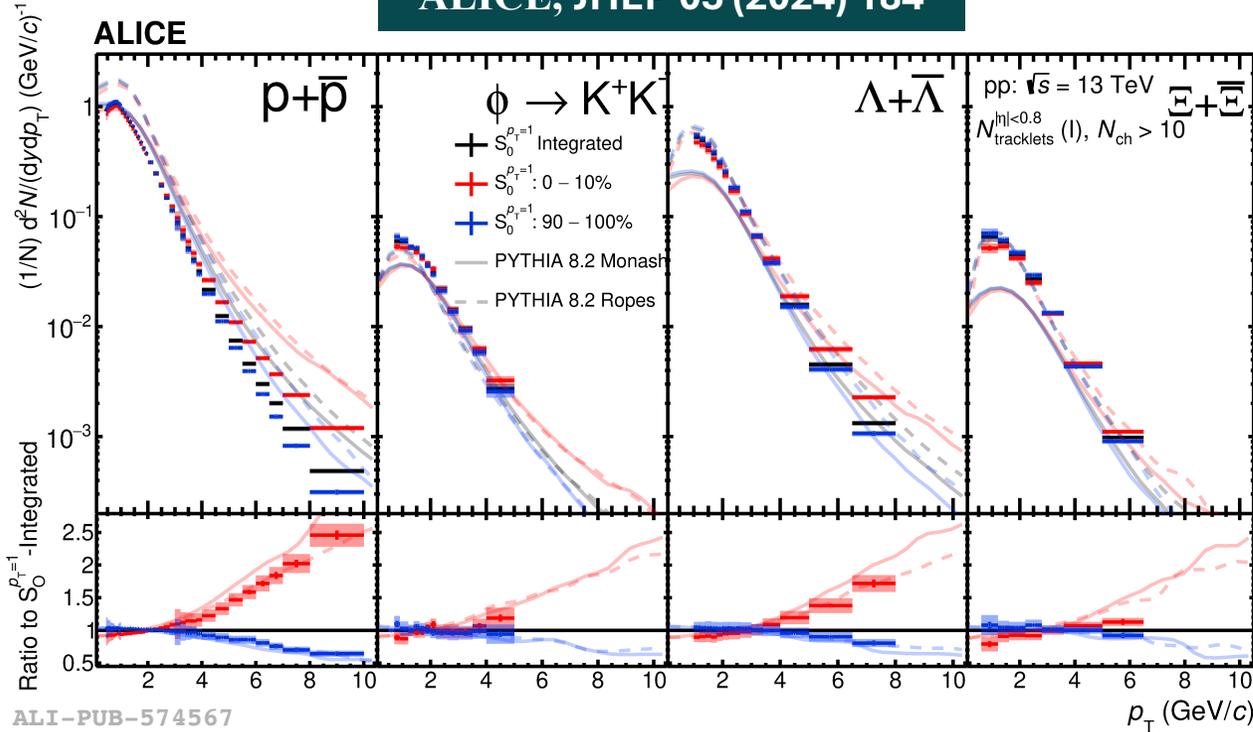
- ✓ V0M \rightarrow change in $\langle dN_{\pi}/dy \rangle$
- ✓ Broad $\langle dN_{\pi}/dy \rangle$ in V0M \rightarrow selection on pion multiplicity
- ✓ $N_{tracklets}^{|\eta| < 0.8} \rightarrow$ change in $\langle p_T \rangle$
- ✓ Primary focus is $N_{tracklets}^{|\eta| < 0.8}$, where we seem to capture the jet bias in our jet-like events

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Transverse momentum spectra

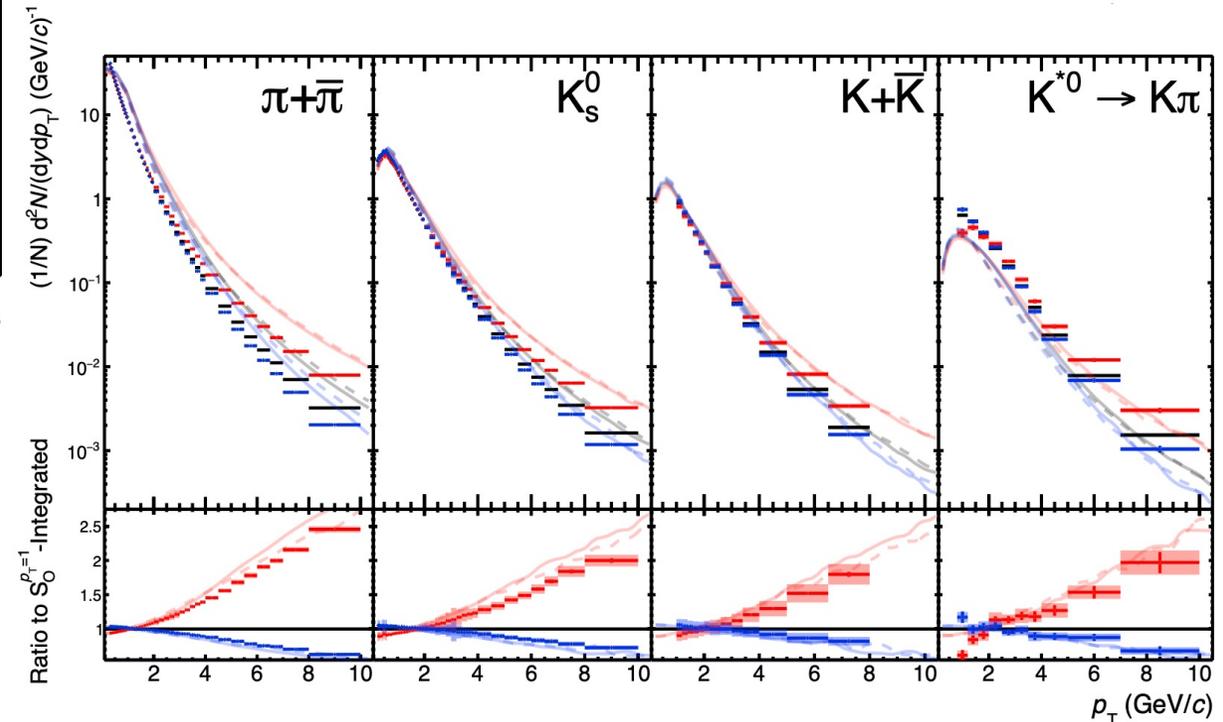
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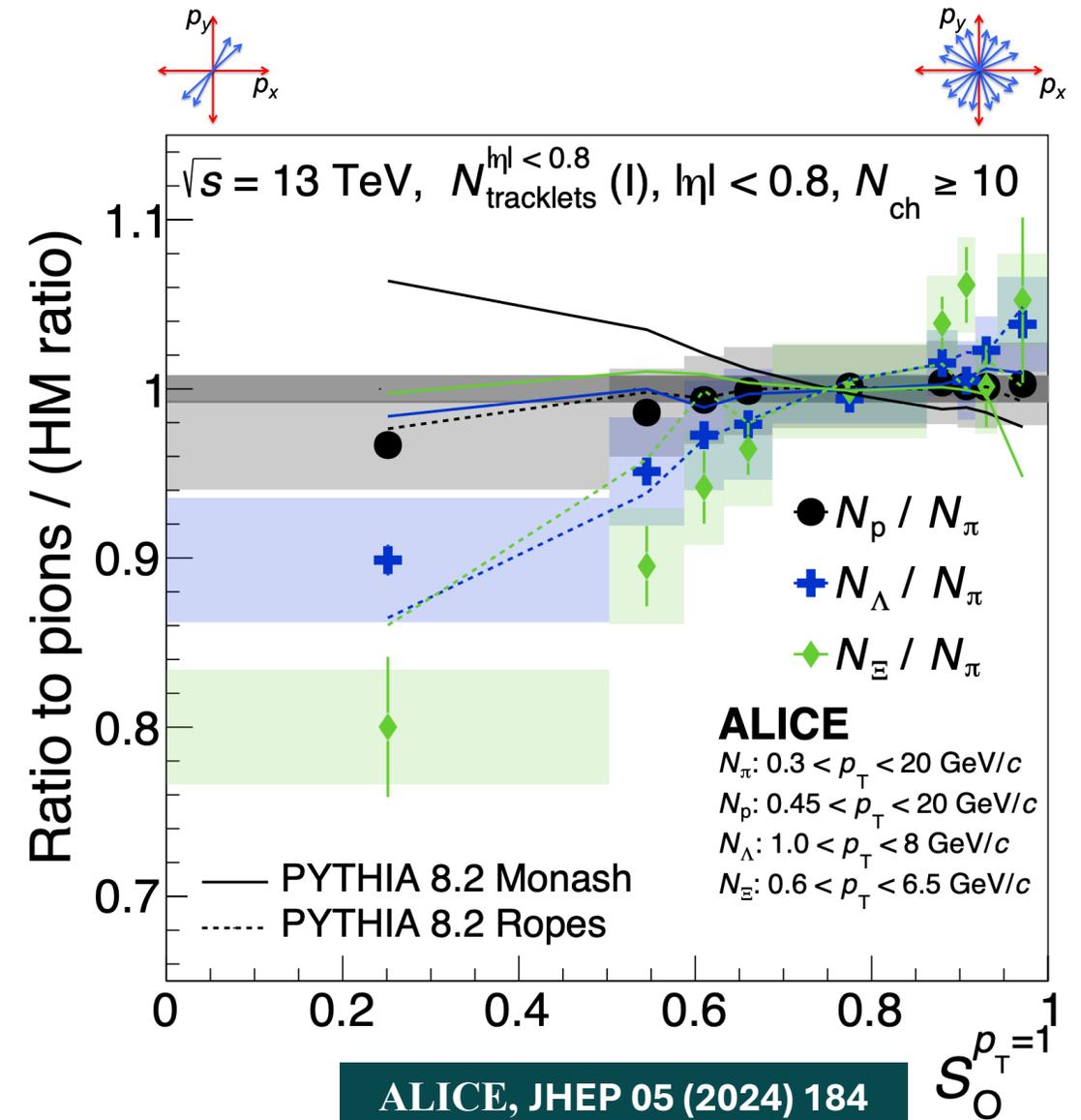
- ✓ PYTHIA8 reproduces the double ratio observed in data
- ✓ The same trends are seen for all measured particle species

- ✓ As a function of $S_0^{p_T=1}$ event classes, the low- p_T region is dominated by isotropic events, whereas, the high- p_T region is dominated by jet-like events
- ✓ Suggests hardening of the spectra in jet-like events



Strangeness with event topology

- Substantial reduction in strange production rates observed in jet-like events
 - ✓ Proton remains mostly unaffected ($S = 0$)
 - ✓ Around 20% decrease observed in Ξ
 - ✓ Strangeness-based ordering
 - HM events seem to be largely homogenous
 - ✓ Mostly driven by soft physics
 - ✓ Jet-like topologies seem to be the outliers
- MC predictions:
- ✓ PYTHIA Ropes predicts qualitative trend, but not the strangeness ordering

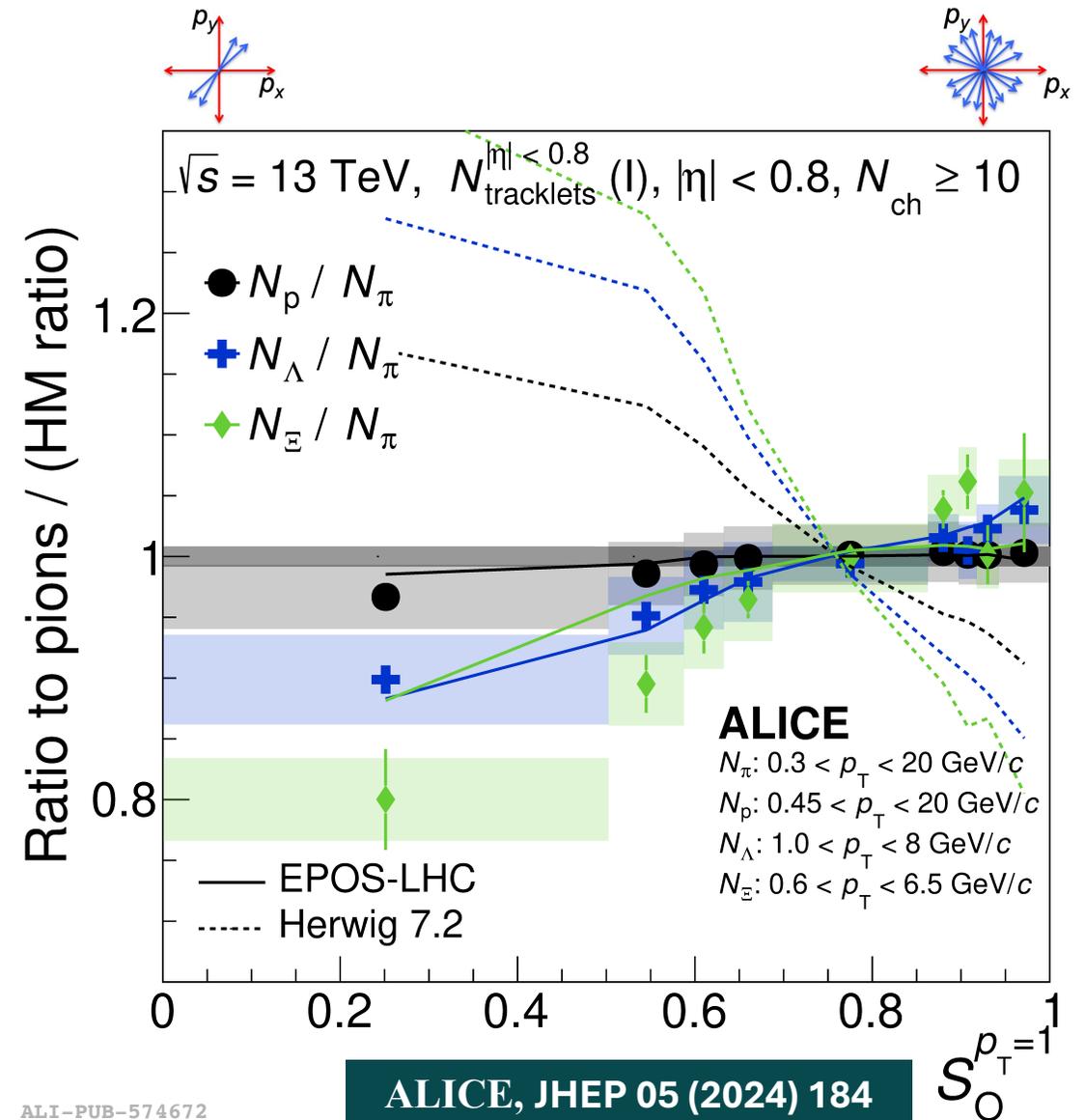


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MC predictions:

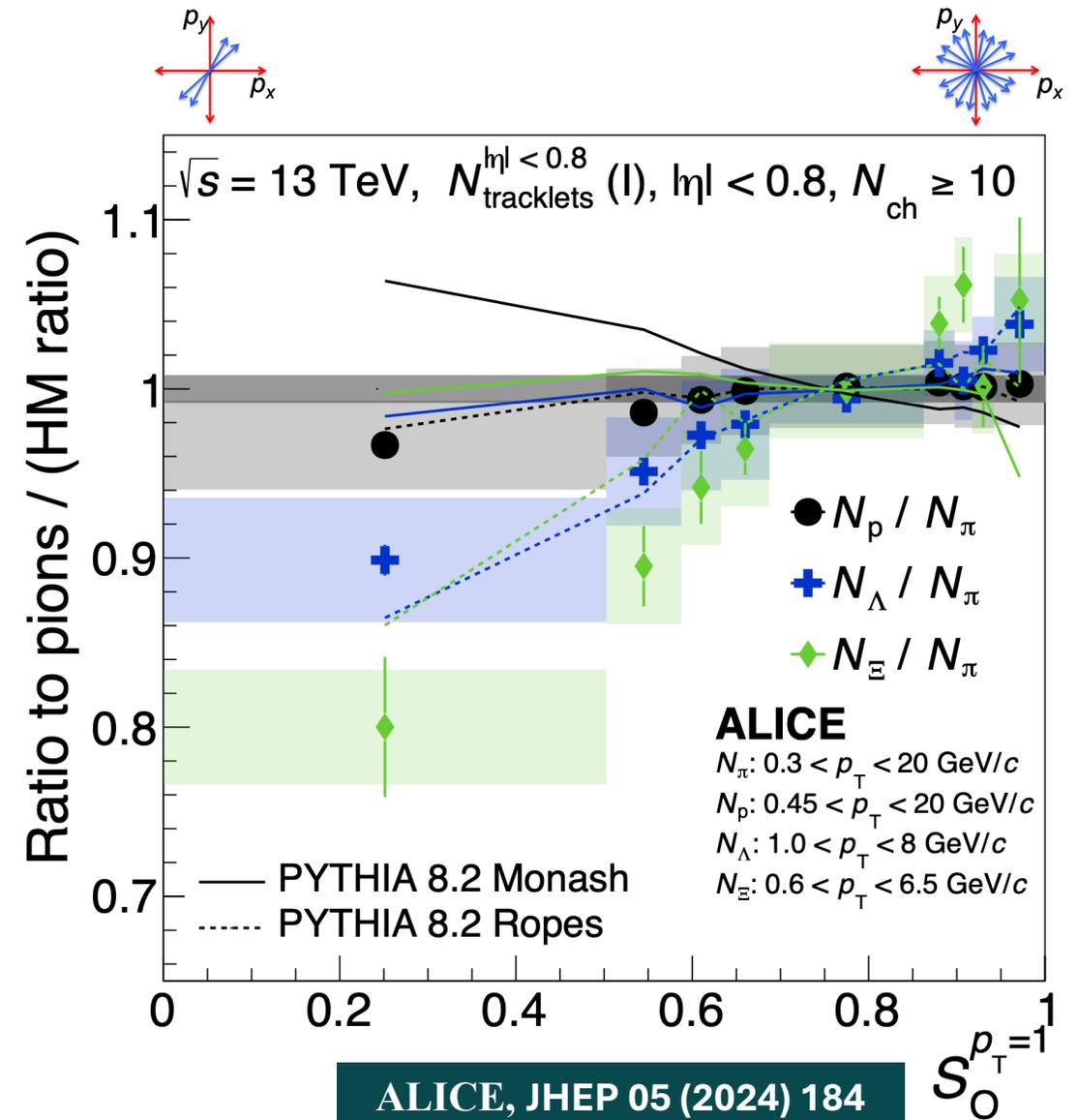
- ✓ PYTHIA Ropes predicts qualitative trend, but not the strangeness ordering
- ✓ Same applies for EPOS
- ✓ Herwig 7.2 and PYTHIA 8.2 Monash are unable to capture trends



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“Strangeness enhancement in pp seems to be the feature of the isotropic events”



Strangeness production as a function of relative transverse activity (R_T)

- In pp the underlying event (UE) is defined as the set of particles which do not originate from the primary hard parton-parton scattering

- ✓ MPIs, initial- and final-state radiation (ISR/FSR), beam remnants

- The UE activity is quantified as:

$$R_T = \frac{N_T}{\langle N_T \rangle}$$

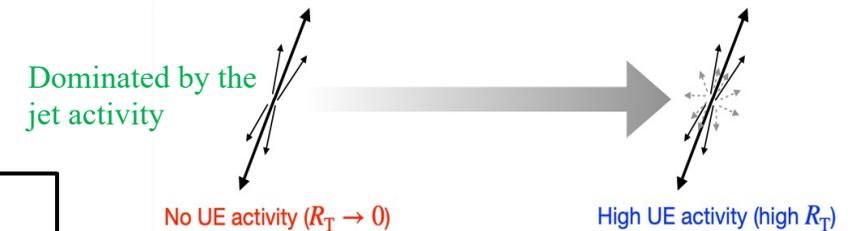
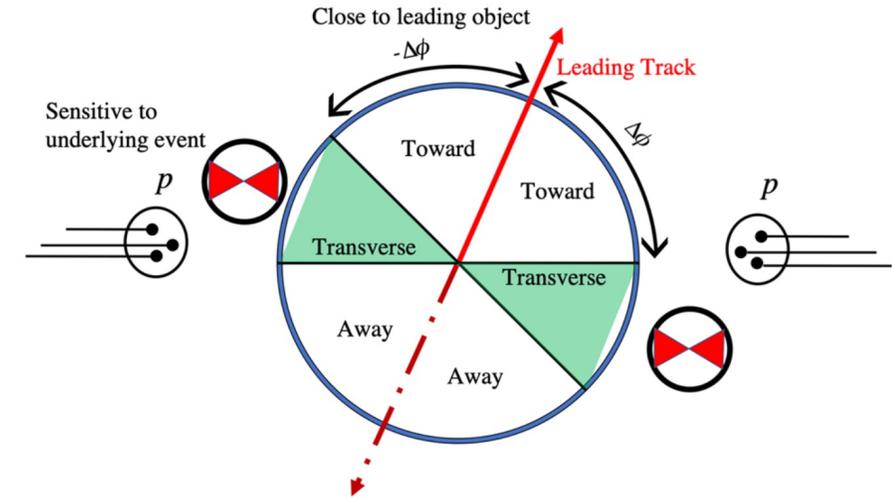
N_T : Charged-particle multiplicity in the transverse region per event

- R_T helps to control the UE contributions in an event

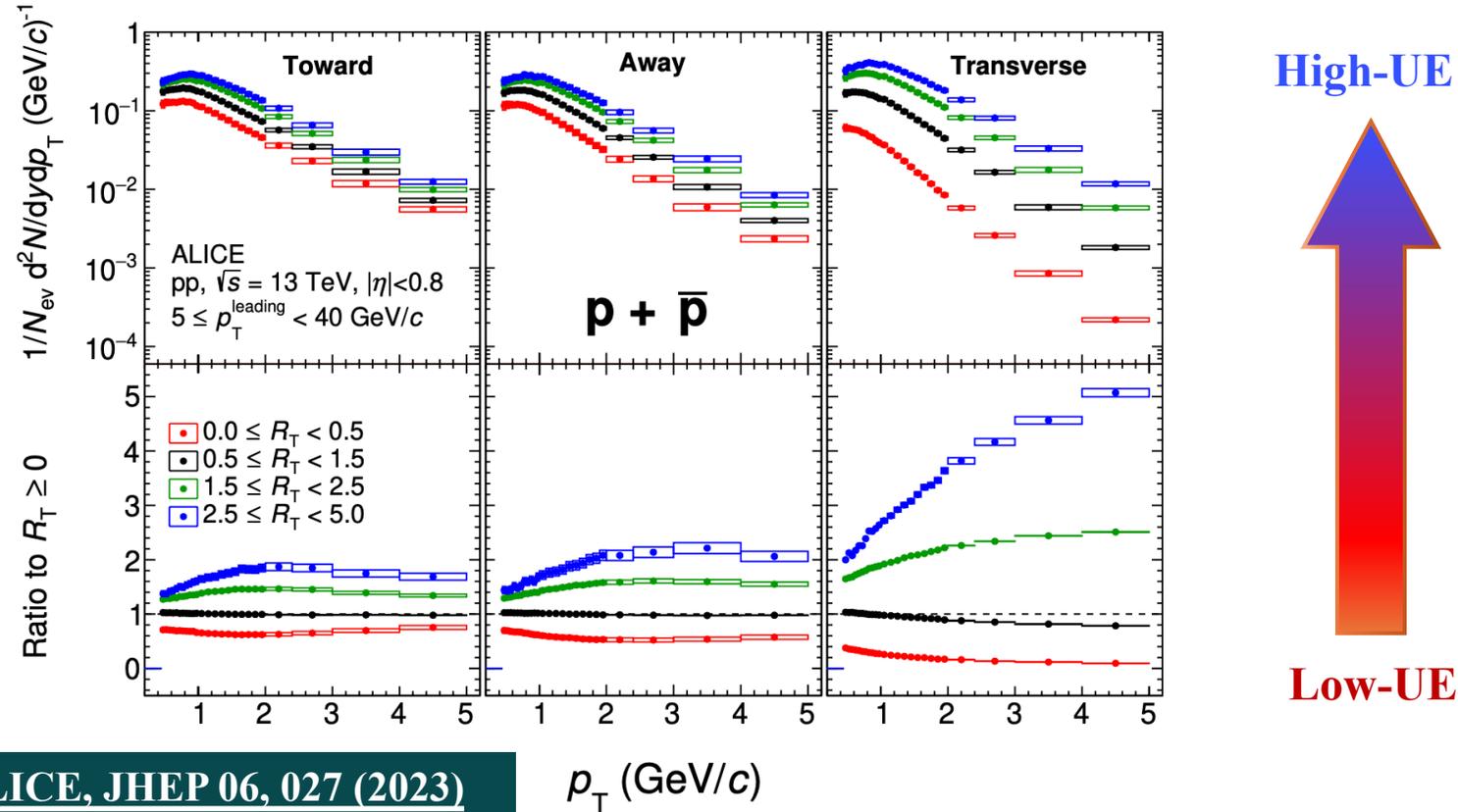
- The two components of N_T are $N_{T,\min}$ and $N_{T,\max}$:

$$N_T = N_{T,\min} + N_{T,\max}$$

- ✓ Transverse-max ($R_{T,\max}$): contains soft UE + ISR/FSR
 - ✓ Transverse-min ($R_{T,\min}$): contains only soft UE ($\propto n\text{MPI}$)



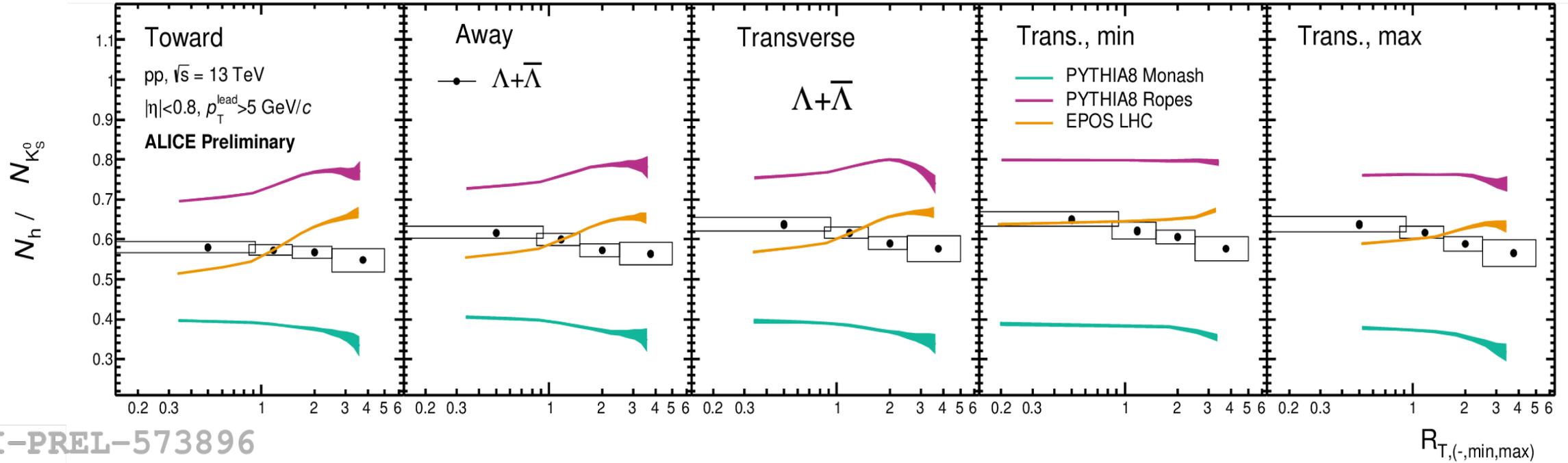
Relative Transverse Activity Classifier (R_T): p_T Spectra



ALICE, JHEP 06, 027 (2023)

- Depletion of low- p_T particles with increasing R_T and mild dependence at high p_T for **toward and away** regions \rightarrow Possibly a feature of radial flow
- The spectra harden with increasing UE activity at high p_T in the **transverse region** \rightarrow Possibly due to a selection bias (contribution from multi-jet topologies)

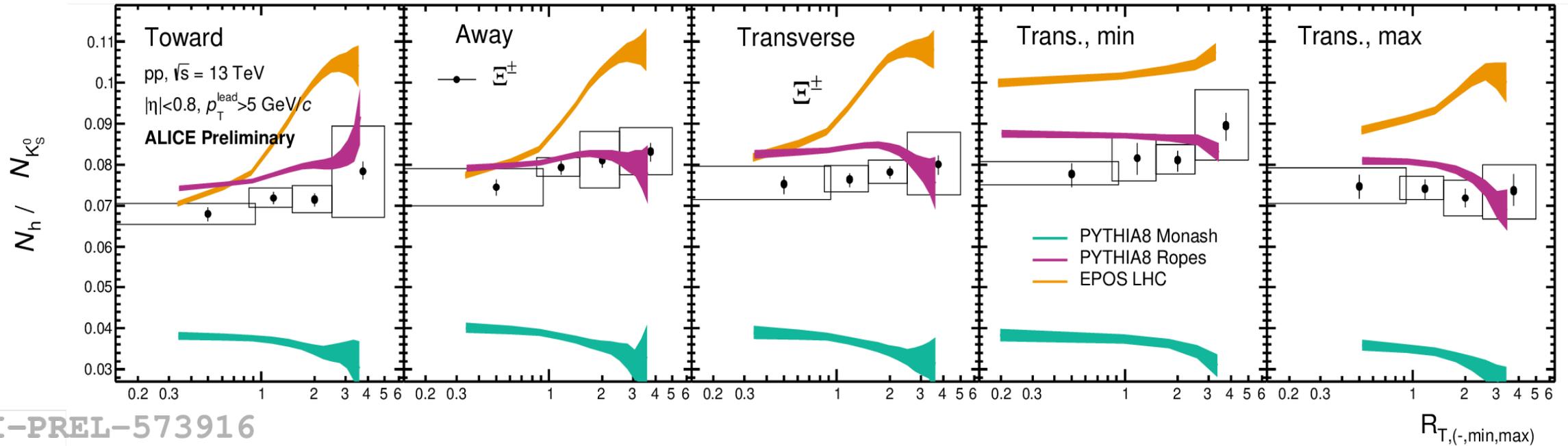
Strangeness production as a function of relative event classifier (R_T)



ALI-PREL-573896

- Λ : shows no apparent sensitivity on the R_T and region

Strangeness production as a function of relative event classifier (R_T)



ALI-PREL-573916

- Λ : shows no apparent sensitivity on the R_T and region
- Ξ : strangeness enhancement observed with increase in R_T

Strangeness enhancement is prominent in the MPI-sensitive transverse-min while not evident in the ISR/FSR-sensitive transverse-max region

Summary

- ✓ Transverse sphericity helps to study the events by separating the soft and hard physics processes in small collision systems
- ✓ $S_0^{p_T=1}$ can be used to select strangeness enhanced/suppressed events
- ✓ Hard, jet-like events seem to produce strange hadrons at a much lower rate than the average high-multiplicity event
- ✓ Strangeness enhancement in high multiplicity pp collisions is a feature of the isotropic events which is also prominent in the MPI-sensitive transverse-min region

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Outlook:

- ✓ ALICE is making effort to understand the charm production with event topology: Λ_c resonance and D-meson production as function of $S_0^{p_T=1}$

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Outlook:

- ✓ ALICE is making effort to understand the charm production with event topology: Λ_c resonance and D-meson production as function of $S_0^{p_T=1}$

Stay tuned for the new results

THANK YOU FOR YOUR ATTENTION.. 