





Strangeness production in jets and underlying events in pp, p-Pb and Pb-Pb collisions with ALICE

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Motivation



- Enhancement of Λ/K_S^0 ratio observed at intermediate p_T at high multiplicity in pp, p-Pb and Pb-Pb collisions w. r. t that at low multiplicity
- Production of multi-strange particles increases with multiplicity
 - Similar behavior among different systems



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This analysis

Jets provide a nature reference to separate particles produced in hard processes and underlying events→further constraints on particle production mechanisms in different systems

> pp

- ✓ Study the jet fragmentation properties in vacuum
- ✓ Provide reference for p-Pb and Pb-Pb systems

> p-Pb

 A new insight into understanding the origin of flow-like behavior observed at high multiplicity in small systems

> Pb-Pb

 ✓ Study medium modified jet fragmentation and potential constraint on jet-medium interactions



• Underlying event

- PC: cone in perpendicular direction of jet axis
- OC: outside the jet cone
- > NJ : events without jet with p_T larger than a given threshold

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Strangeness production in jets and the UE

ALICE setup and data samples



Data samples

ALICE

- > pp collisions at $\sqrt{s} = 13 \text{ TeV}$
- ▶ p-Pb collisions at $\sqrt{s_{NN}} = 5.02 \text{ TeV}$
- > Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76 \text{ TeV}$

Strangeness reconstruction

- $\succ K_{\rm S}^0 \rightarrow \pi^+ + \pi^- ({\rm BR}\ 69.2\%)$
- $\succ \Lambda \rightarrow p + \pi^- (BR 63.9\%)$
- $\succ \Xi^- \rightarrow \Lambda + \pi^- \rightarrow p + \pi^- + \pi^- (BR 63.9\%)$

• TPC(Time Projection Chamber)

- \blacktriangleright $|\eta| < 0.9$
- Charged particle tracking
- Particle identification

• ITS(Inner Tracking System)

- \blacktriangleright $|\eta| < 0.9$
- Vertex reconstruction
- Event trigger

• **V0A** + **V0C**

- ▶ $2.8 < \eta < 5.1$ and $-3.7 < \eta < -1.7$
- Event multiplicity class determination
- Event trigger

• Jet reconstruction:

- > Charged track selection: $|\eta| < 0.9$, $p_{\rm T} > 0.15 \text{ GeV}/c$
- > Jet finder: anti- $k_{\rm T}$, R = 0.4, $|\eta_{\rm jet}| < 0.35$

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Strangeness production in jets and the UE

Results of pp collisions





$$\frac{d\rho}{dp_{\rm T}} = \frac{1}{N_{ev}} \times \frac{1}{\langle \text{Area} \rangle} \times \frac{dN}{dp_{\rm T}}$$

- The production density of strange hadrons in jets (JE) is harder than in the underlying event (UE)
- UE distributions harder than inclusive bias in events with the presence of jets

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Strangeness production in jets and the UE



- The Λ/K_S^0 ratio in UE is consistent with the inclusive one
- The ratio in jets is clearly different from the inclusive one at low and intermediate $p_{\rm T}$
- Ξ/Λ -- further exploration of production mechanisms in jets and UE with multi-strange particles
- Ξ/Λ is almost p_T independent in JE



- The Λ/K_S^0 in UE is consistent with the inclusive ratio
- The ratio in jets is clearly different from the inclusive ratio at low and intermediate $p_{\rm T}$
- Results at $\sqrt{s} = 7$ TeV are consistent with that at $\sqrt{s} = 13$ TeV within uncertainties
- Measurements at $\sqrt{s} = 7$ TeV: a hint of R_{jet} (V⁰, jet) dependence
 - Caveat: the potential residual UE background effect (?)

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- Results at $\sqrt{s} = 7$ TeV are consistent with that at $\sqrt{s} = 13$ TeV within uncertainties
- Measurements at $\sqrt{s} = 7$ TeV: a hint of R_{jet} (V⁰, jet) dependence
- The Λ/K_S^0 in JE in pp consistent with p-Pb within uncertainties in R = 0.4

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Results of p-Pb collisions



- The ratios depend only slightly on the jet resolution parameter R and do not vary with $p_{\rm T}^{\rm jet,ch}$
- The Λ/K_S^0 in JE are compatible with PYTHIA8 predictions in pp collisions

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Results of Pb-Pb collisions



- The different behavior from PYTHIA is seen in both K_S^0 and Λ at low p_T in Pb-Pb central
- The ratio in jets is far below the inclusive one in Pb–Pb collisions
- The ratio in jets is compatible within systematical and statistical errors to that in pp collisions

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Summary

- ▶ Production of V⁰s (K⁰_S and Λ) and Ξ has been investigated in jets and the UE in pp collisions at $\sqrt{s} = 13$ TeV
- > The Ξ/Λ ratio has been investigated in jet and the UE in pp collisions with ALICE
- > Λ/K_S^0 ratio enhancement is not present when the particles are within an energetic jet in pp, p-Pb and Pb-Pb collision systems
- \succ These measurements provide a new constrain on Ξ production mechanism

Thanks



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Backup

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V⁰s and E reconstruction

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• Channels

- $\succ K_{\rm S}^0 \rightarrow \pi^+ + \pi^- ({\rm BR}\ 69.2\%)$
- $\succ \Lambda \rightarrow p + \pi^- (BR 63.9\%)$

 $\succ \Xi^- \rightarrow \Lambda + \pi^- \rightarrow p + \pi^- + \pi^- (BR 63.9\%)$

•Strategy: based on decay topology selections

•Acceptance: $|\eta| < 0.75$



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Bin counting method

- Raw yield of the $V^0(\Xi^{\pm})$ is extracted by using bin counting method
 - > Fit Inv. Mass distribution with Gaussian plus a linear function in each $p_{\rm T}$ bin
 - \blacktriangleright Extract the mean value(μ) and the σ of the Gaussian function
 - Define side bands and the signal region
 - > Fit with linear function from side bands and interpolate into signal region
 - Subtract the background in the signal region





V⁰(E) jets matching

- Jet reconstruction:
 - > Charged track selection: $|\eta| < 0.9$, $p_{\rm T} > 0.15 \,{\rm GeV}/c$
 - > Jet finder: anti $-k_{\rm T}$, R = 0.4, $|\eta_{\rm jet}| < 0.35$, $p_{\rm T}^{\rm jet} > 10 \,{\rm GeV}/c$
- $V^0(\Xi^{\pm})$ -jets matching
 - ≻ $R(V^0/\Xi, jet) < 0.4$
- Normalization

$$\ge \frac{d\rho}{dp_{\rm T}} = \frac{1}{N_{ev}} \times \frac{1}{\langle \text{Area} \rangle} \times \frac{dN}{dp_{\rm T}}$$

- UE estimators
 - ➢ PC : perpendicular cone
 - ► OC : $R(V^0/\Xi, jet) > 0.6$
 - > NJ : events w/o jet in $p_{\rm T} > 5 \text{ GeV/c}$

$\mathbf{JE} = \mathbf{JC} - \mathbf{UE}$



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Systematic uncertainty

• Uncertainty on signal extract

- > Single V^0s/Ξ analysis: varying the correlated selection cuts
- > Feed-down correction: obtained from the spectra of Ξ
- Uncertainty on jet *p*_T scale and UE
 - \succ Jet $p_{\rm T}$ threshold:
 - Estimated from jet background fluctuations and detector response
 - > Variation of the jet $p_{\rm T}$ threshold within 1 GeV/*c*
 - > **UE background subtraction** (to be further studied and updated):
 - Central value: estimated from the PC background
 - Lower/upper limits: given by the OC/NJ backgrounds
- Other sources of uncertainties: material budget 4%

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Results of p-Pb collisions





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