



**BARYONS
2025**

Study of multiplicity-dependent resonance productions in small systems in the EPOS4

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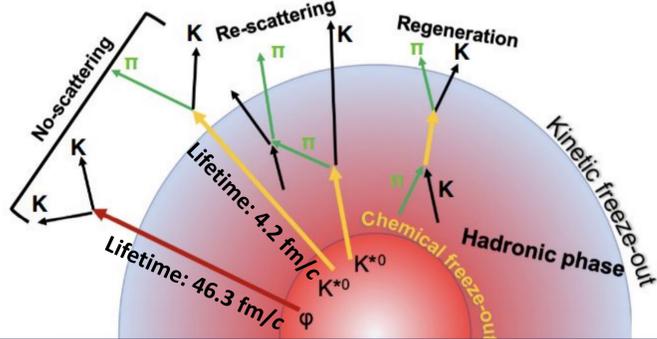
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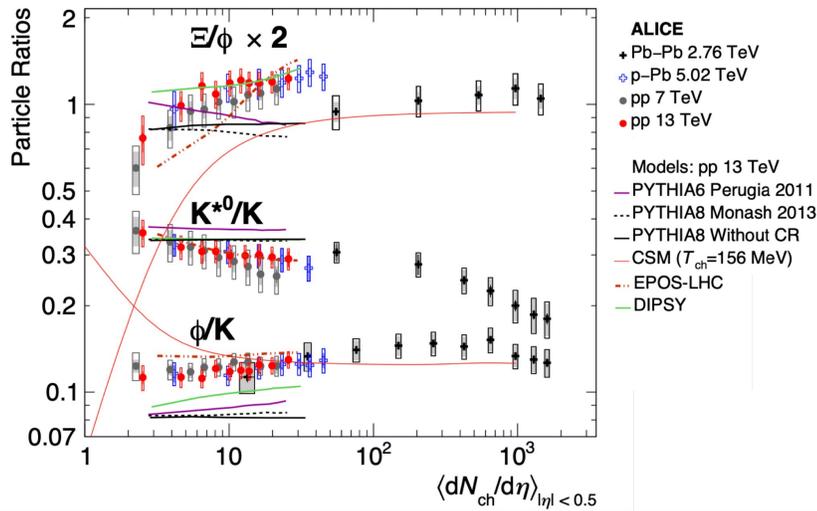
1. MOTIVATION

Probing the properties of the hadronic phase:

Resonances are ideal probes to study the properties of the hadronic phase. Since the lifetime of resonances is comparable to that of the hadronic phase, their yields can be affected by the **rescattering** and **regeneration** effects.



Hadronic interaction in small collision systems: [1]



The K^*/K ratio is reduced in high multiplicity pp collisions, while the ϕ/K ratio exhibits no significant multiplicity dependence. This reduction indicates the possible **existence of hadronic interactions**, such as the **rescattering effect**, even in small systems.

Therefore, it becomes crucial to consistently predict the **multiplicity-dependent trend of resonance productions** across various collision systems.

2. ANALYSIS METHOD

Model introduction:

► **EPOS**: [2]

Event generator based on 3+1D viscous hydrodynamical evolution

► **UrQMD**: [3]

UrQMD describes the full-phase space evolution based on its hadronic interactions

EPOS3+UrQMD has successfully described the resonance productions in Pb-Pb

→ **EPOS4+UrQMD** in small systems

Simulation settings:

► Version: AliGenerators::v20250601-1 & EPOS4 v.4.0.3

► Collision system: pp at $\sqrt{s} = 13.6$ TeV, Pb-Pb at $\sqrt{s_{NN}} = 5.36$ TeV

► Event selection: INEL > 0 events at pp 13.6 TeV (least charged π, K, p in the $|\eta| < 1.0$)

► Multiplicity: # of charged π, K, p in the VOM range ($-3.7 < \eta < -1.7$ & $2.8 < \eta < 5.1$)

Resonance	Shorthand	Quark Content	Decay Channel	Branching Ratio	Lifetime (fm/c)
$\rho(770)^0$	ρ^0	$(u\bar{u}/d\bar{d})/\sqrt{2}$	$\pi^+ + \pi^-$	1	1.335
$K^*(892)^0$	K^{*0}	$d\bar{s}$	$\pi^+ + K^-$	0.67	4.16
$\phi(1020)$	ϕ	$s\bar{s}$	$K^+ + K^-$	0.492	46.26
$\Delta(1232)^{++}$	Δ^{++}	uuu	$\pi^+ + p$	1	1.69
$\Sigma(1385)^+$	Σ^{*+}	uus	$\pi^+ + \Lambda$	0.870	5.48
$\Sigma(1385)^-$	Σ^{*-}	dds	$\pi^- + \Lambda$	0.870	5.01
$\Lambda(1520)$	Λ^*	uds	$K^- + p$	0.225	12.54
$\Xi(1530)^0$	Ξ^{*0}	uss	$\pi^+ + \Xi^-$	0.67	22

► Track selection:

Resonances and its ground state in the $|\eta| < 0.5$

pp Pb-Pb
■ ■ ■ UrQMD OFF

Results hadronic cascade was not activated

■ ■ ■ UrQMD reg+res

Decay into daughters which do not rescatter

→ Include **regeneration + rescattering**

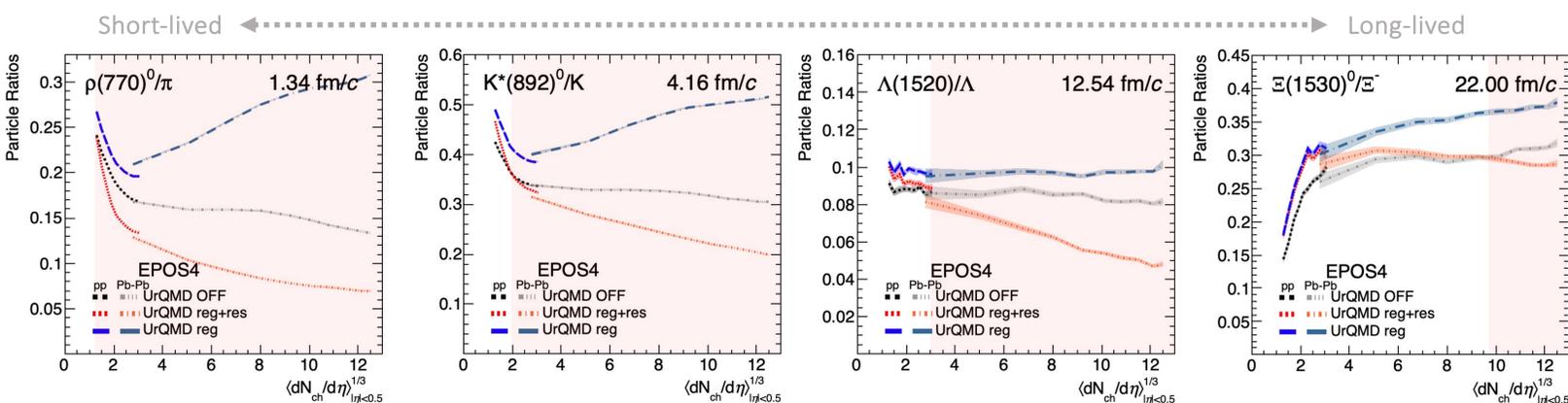
■ ■ ■ UrQMD reg

Decay into daughters which do & do not rescatter

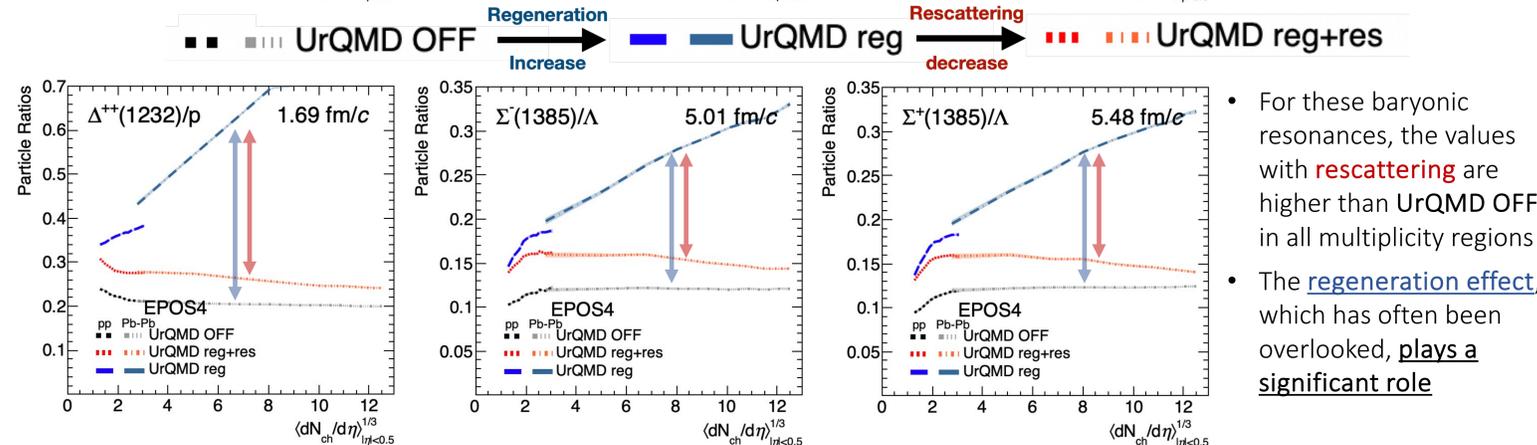
→ Include **regeneration**

3. ANALYSIS RESULTS

Particle ratio vs $\langle dN/d\eta \rangle$:



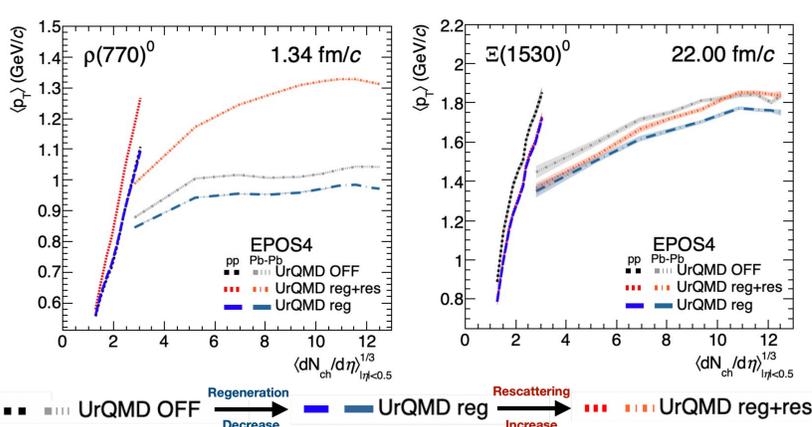
- The smaller the system size, the weaker the **rescattering** becomes
- This behavior is more pronounced for resonances with longer lifetimes
- In such cases, the yield increase from **regeneration** can exceed the reduction from **rescattering**



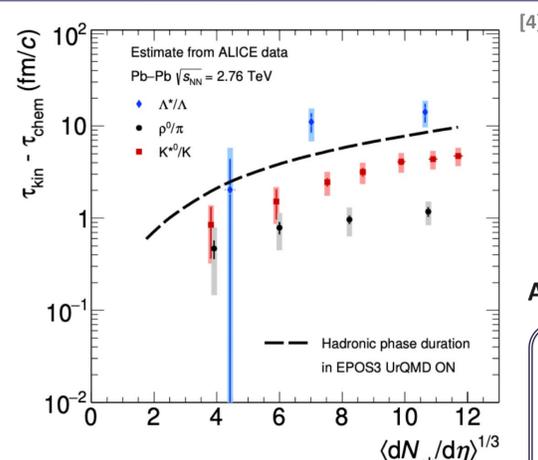
- For these baryonic resonances, the values with **rescattering** are higher than UrQMD OFF in all multiplicity regions
- The **regeneration effect**, which has often been overlooked, **plays a significant role**

- Particles can be lost during the hadronic cascade

$\langle p_T \rangle$ vs $\langle dN/d\eta \rangle$:



3. SUMMARY



[4]

$$[h^*/h]_{kinetic} = [h^*/h]_{chemical} \times e^{-\tau/\tau_{h^*}}$$

- In the estimation of the hadronic phase lifetime, **regeneration was not taken into account**
- Within the model, **regeneration** is confirmed to be **process-dependent** and **can become significant** depending on the particle species

A paper including in p-O and O-O results is in preparation!

[1] ALICE Collaboration. Physics Letters B 807, 135501 (2020)

[2] K. Werner. Physical Review C 108, 064903 (2023)

[3] S.A. Bass et al. Progress in Particle and Nuclear Physics 41 (1998) 225-370

[4] ALICE Collaboration. The European Physical Journal C 84 (2024) 813