Probing the hadronic phase of large hadronizing system through the study of the Λ(1520) resonance with ALICE at the LHC

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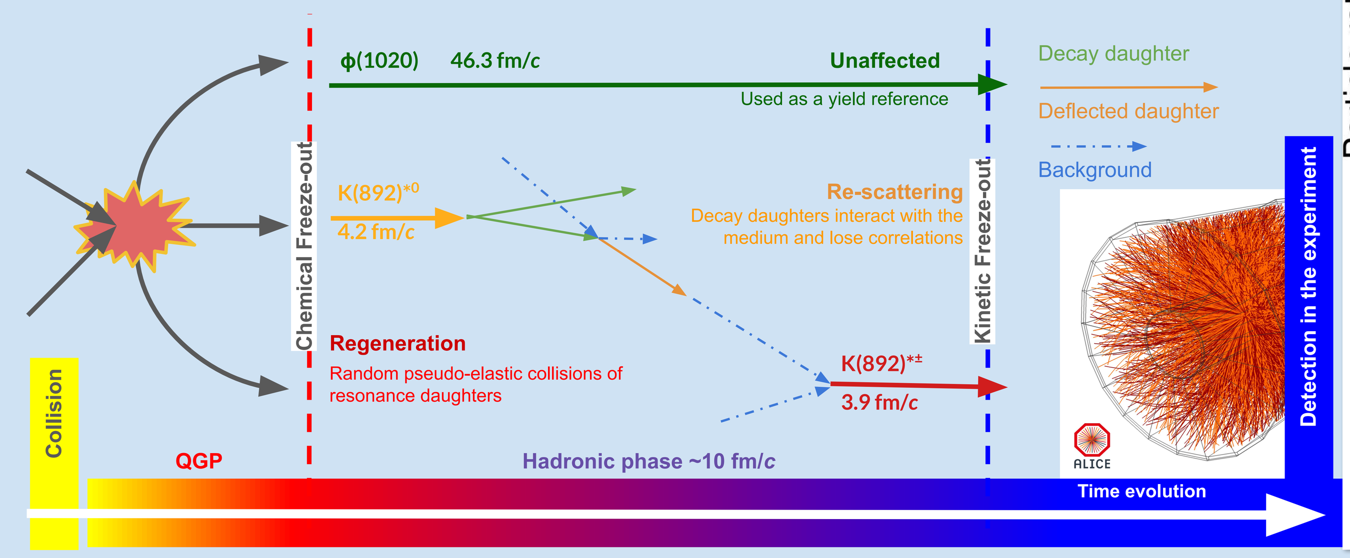
Motivation

1. A deconfined **Quark Gluon Plasma** (QGP) state is created in high energy heavy-ion collisions. As the initial hot and dense system expands and cools down, it eventually transitions back from QGP to hadronic gas phase. **After hadronisation, the system continues to expand** until all interactions cease (kinetic freeze-out).
2. **Due to their short lifetimes** (τ ~ few fm/c), resonances **can decay within the hadronic medium**. This can alter their final reconstructible yields by destroying the correlation of decay products due to interaction (re-scattering) with the surrounding hadrons (e.g. K*(892)[1] & ρ (770)[2] Figures 1 & 7).
3. The **relative abundances** of stable particles are successfully **described by statistical hadronisation models (SHMs)**. Resonances are expected to be produced with abundances consistent with the chemical equilibrium parameters (T_{ch}, μ_B).



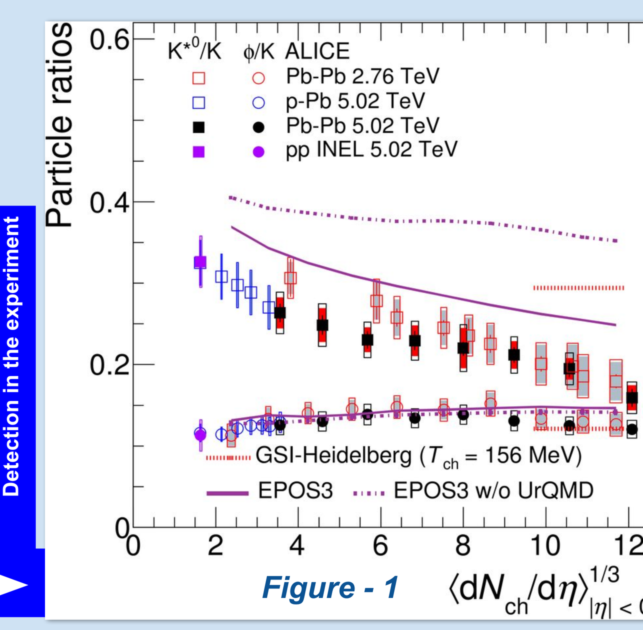


Figure - 1

Signal extraction

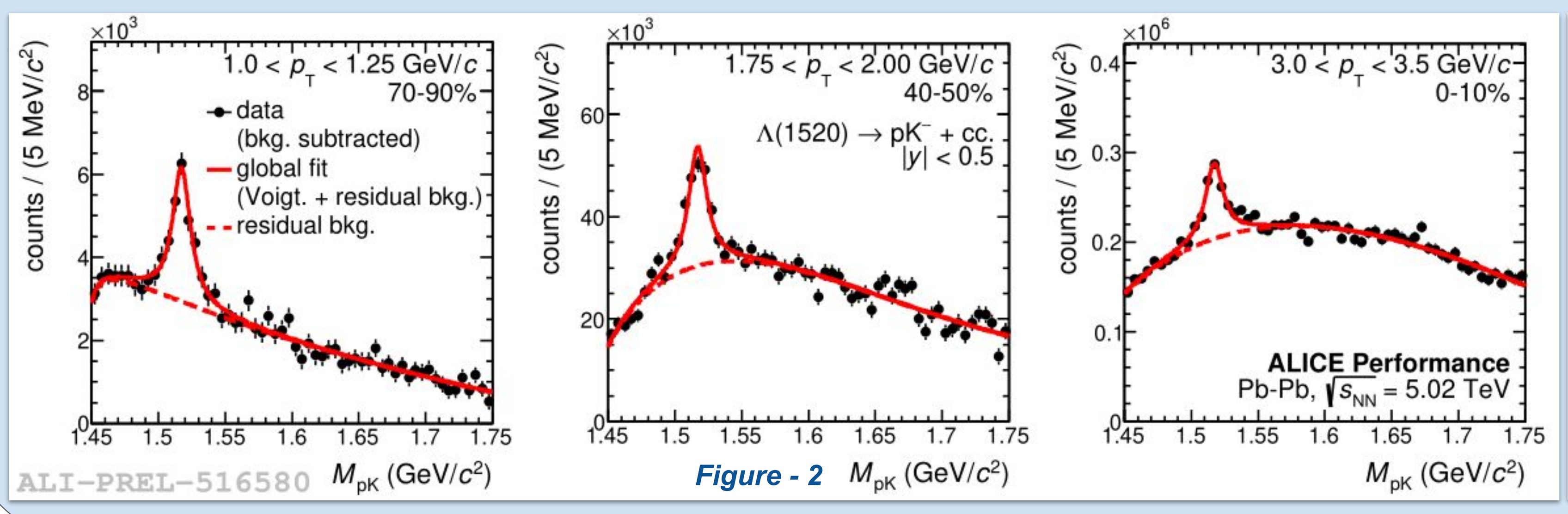


Figure - 2

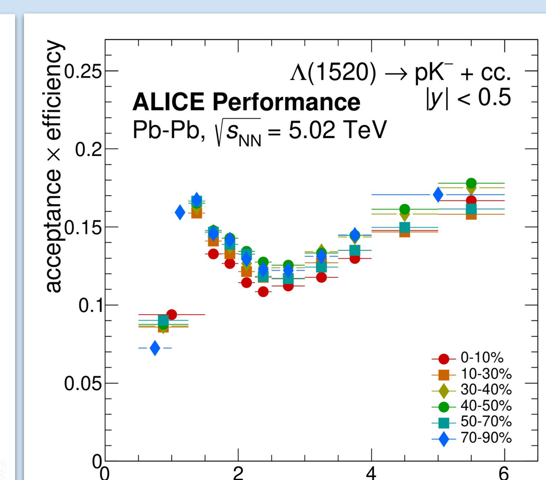


Figure - 3

Λ(1520) → p + K (B.R. = 22.5%± 0.05%)
Lifetime = 12.6 fm/c & Quark content = uds

1. The production yield of Λ(1520) measured in **Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with full Run-2 data sample**.
2. The resonance is reconstructed via **invariant-mass analysis in the Λ(1520) → pK⁻** and charge conjugate **decay channel** (Figure 2).
3. The p_T-differential yield is extracted with a **combined fit** (**voigtian** signal + **Maxwell Boltzmann** function to describe residual background) as shown in Figure 2 and corrected for the detector acceptance and reconstruction efficiency (Figure 3).

p_T spectra and comparison to model predictions

1. The fully corrected Λ(1520) + cc. **p_T-differential yield measured** in **Pb-Pb collisions** at $\sqrt{s_{NN}}$ = **5.02 TeV at midrapidity** (|y| < 0.5) in the six centrality classes is shown in Figure 4.
2. The spectral shapes are compared with **Blast-Wave model** [3] and **MUSIC hydrodynamic model** [4] with **SMASH afterburner** from 5.02 TeV Pb-Pb predictions.
3. The **spectral shapes show good agreement** with the **Blast-Wave** [3] (parameters obtained from π/K/p fits) and close to **MUSIC with SMASH afterburner** prediction [4] at low p_T, while they diverge at high p_T.
4. **MUSIC slightly underestimates the data** with possible explanation that this model underestimates overall strangeness production at midrapidity.

Particles:	π/K/Λ/Ξ	ϕ(1020)	Ξ(1530)^0	Λ(1520)	Σ(1385)$^{*\pm}$	K(892)^{*0}	K(892)$^{*\pm}$	ρ$_0$(770)
Lifetime:	>> 100 fm/c	46.3 fm/c	21.7 fm/c	12.6 fm/c	5-5.5 fm/c	4.2 fm/c	3.9 fm/c	1.3 fm/c

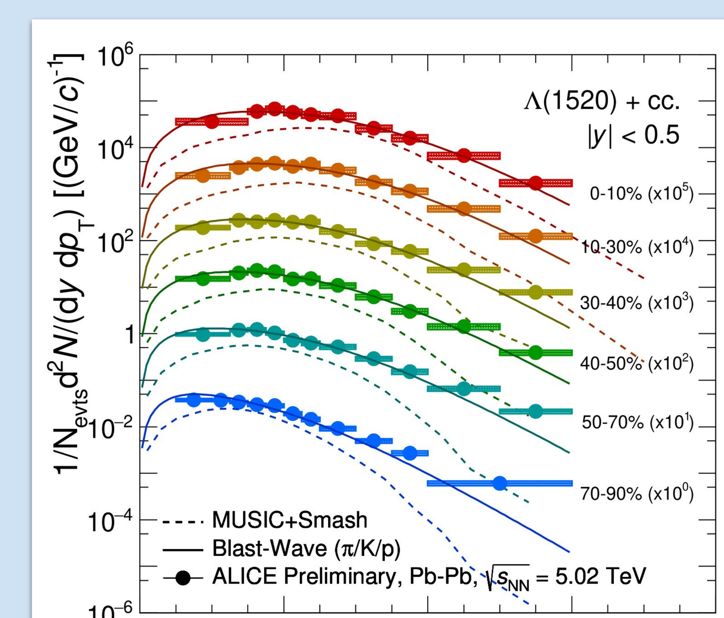


Figure - 4

$\langle p_T \rangle$ and particle ratios results: Λ(1520)/Λ

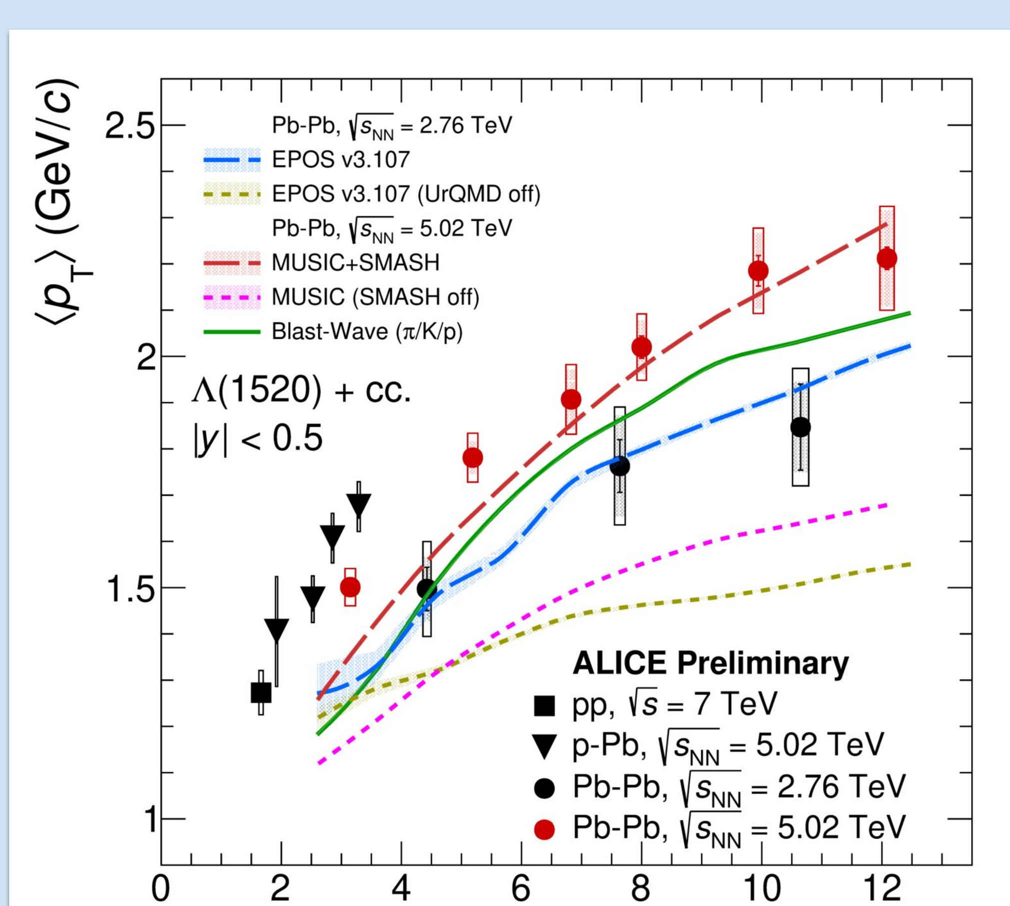


Figure - 5

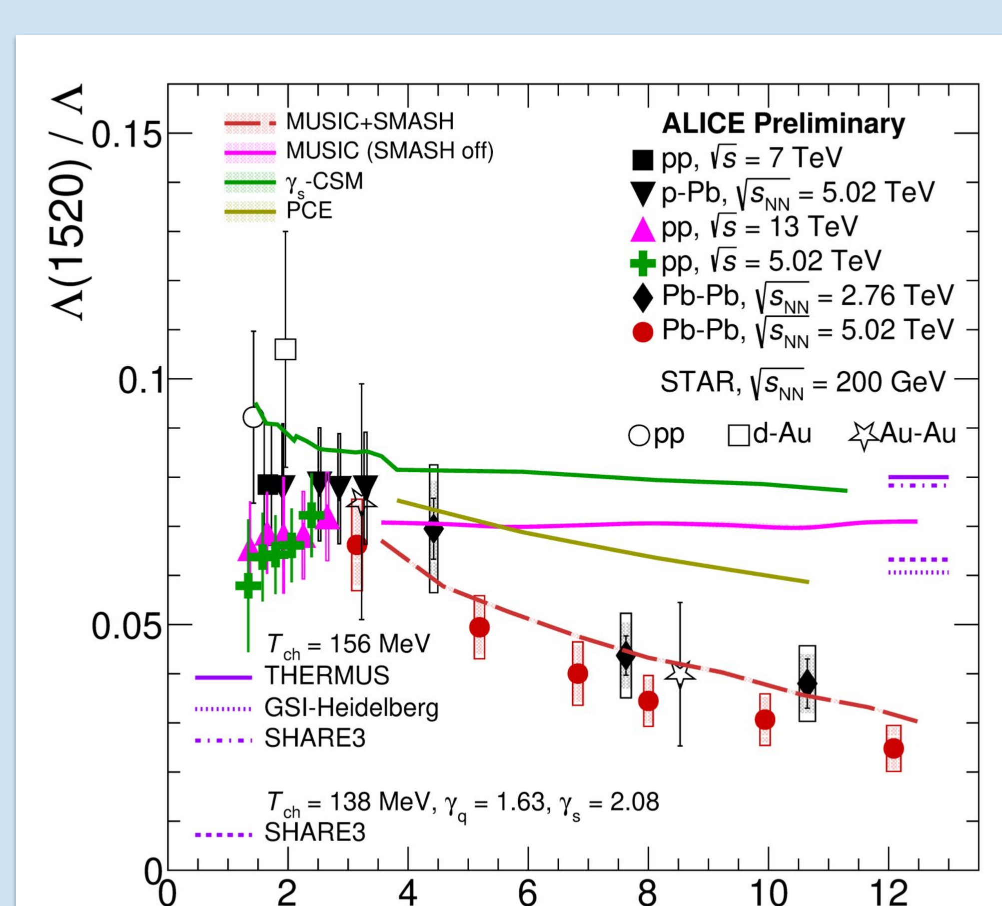


Figure - 6

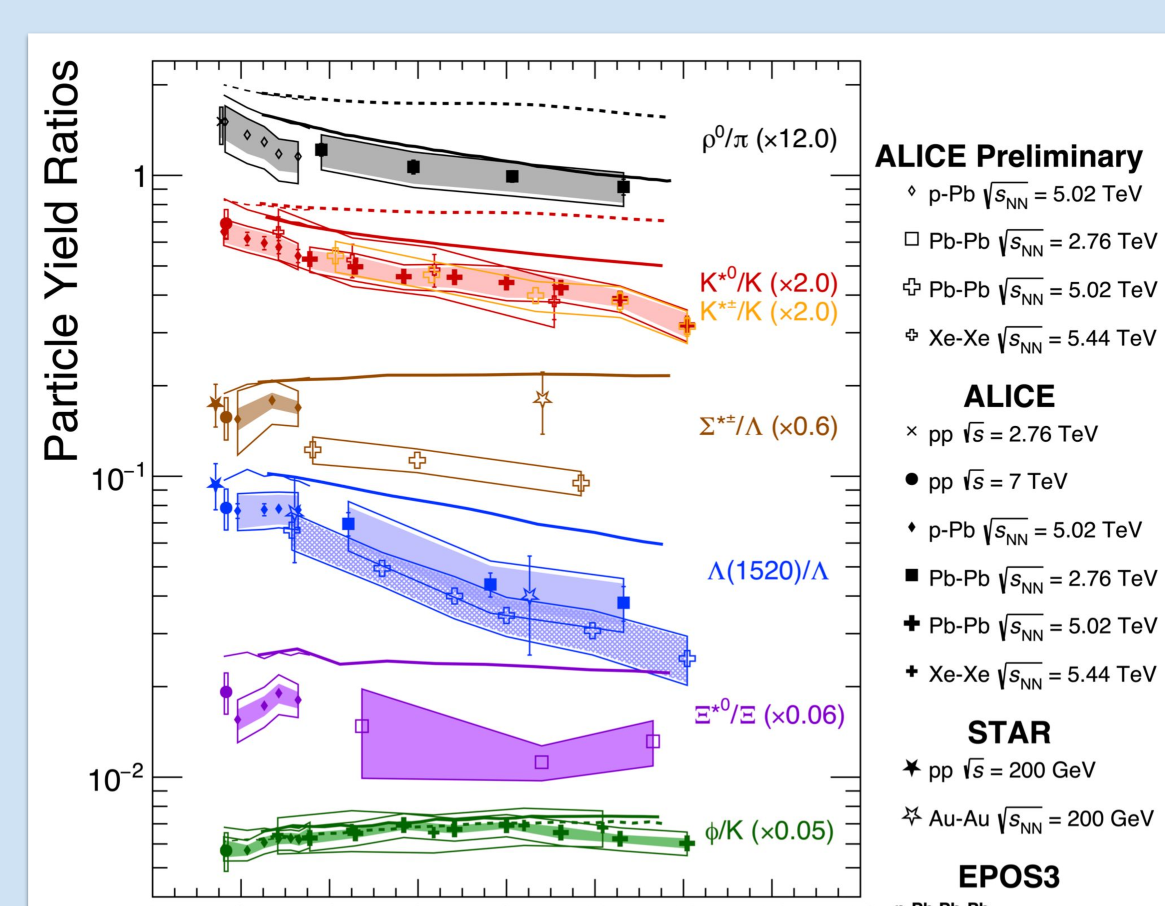


Figure - 7

1. The $\langle p_T \rangle$ of Λ(1520) as shown in Figure 5, **increases from peripheral to central collisions** (~47% higher in 0-10% than 70-90% centrality class), **increases faster than Pb-Pb** at $\sqrt{s_{NN}}$ = **2.76 TeV [5] values,** higher than Blast-Wave model (π/K/p) [3] and EPOS3 (with UrQMD) model [6] predictions at 2.76 TeV, but EPOS3 fails to predicts data if UrQMD is off.
2. This observation confirms the common hydrodynamic evolution picture. **Predictions from MUSIC+SMASH afterburner** [4] are consistent with data in central collisions but underestimate in peripheral collisions, overall **better agreement with the data.** When SMASH afterburner is turned off, the value of $\langle p_T \rangle$ is underestimated.
3. The **p_T-integrated Λ(1520)/Λ yield ratio** in **Pb-Pb collisions** at $\sqrt{s_{NN}}$ = **5.02 TeV** is shown in Figure 6. The ratio is **suppressed in central collisions (0-10%)** as compared to the values observed in peripheral collisions, p-Pb, pp collisions and predictions from statistical hadronisation models (SHMs).
4. The p_T-integrated Λ(1520)/Λ yield **ratio in central Pb-Pb collisions (0-10%) is 62.55% lower than 70-90% peripheral Pb-Pb collisions at 7.1σ level** and 60% lower than thermal model predictions [7,8,9,10,11] and **follows published Pb-Pb** at $\sqrt{s_{NN}}$ = **2.76 collisions suppression trend** [3] with wider multiplicity coverage and highest precision so far for any resonance measurements at LHC energies.
5. **MUSIC with SMASH afterburner** [4] **reproduces the multiplicity suppression trend** with a good agreement with data, showing the importance of a macroscopic description of the late hadronic interactions.
6. **MUSIC without SMASH** is the **first ever prediction without an afterburner**. It gives a **flat curve**, matches peripheral 70-90% Pb-Pb collisions, and is also near the results for pp.
7. This measurement with **highest multiplicity and improved accuracy** further confirms the formation of a **dense hadronic phase** in which a significant reduction of the observable yield of short-lived resonances is observed.

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