Prospects for multiplicity-dependent studies of $K^*(892)^\pm$ production in pp collisions at $\sqrt{s}$ = 13 TeV with ALICE

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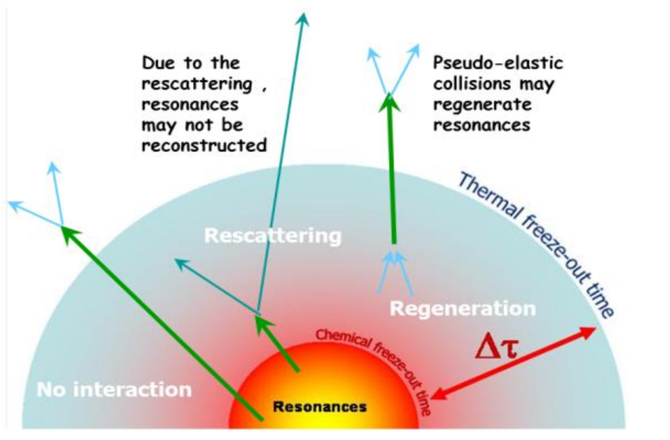
Introduction



Resonance lifetimes comparable with fireball lifetime $\Delta\tau$ (about 10 fm/c at LHC energies)

Hadronic resonances reconstructed in **ultra-relativistic heavy-ion collisions** provide information on:

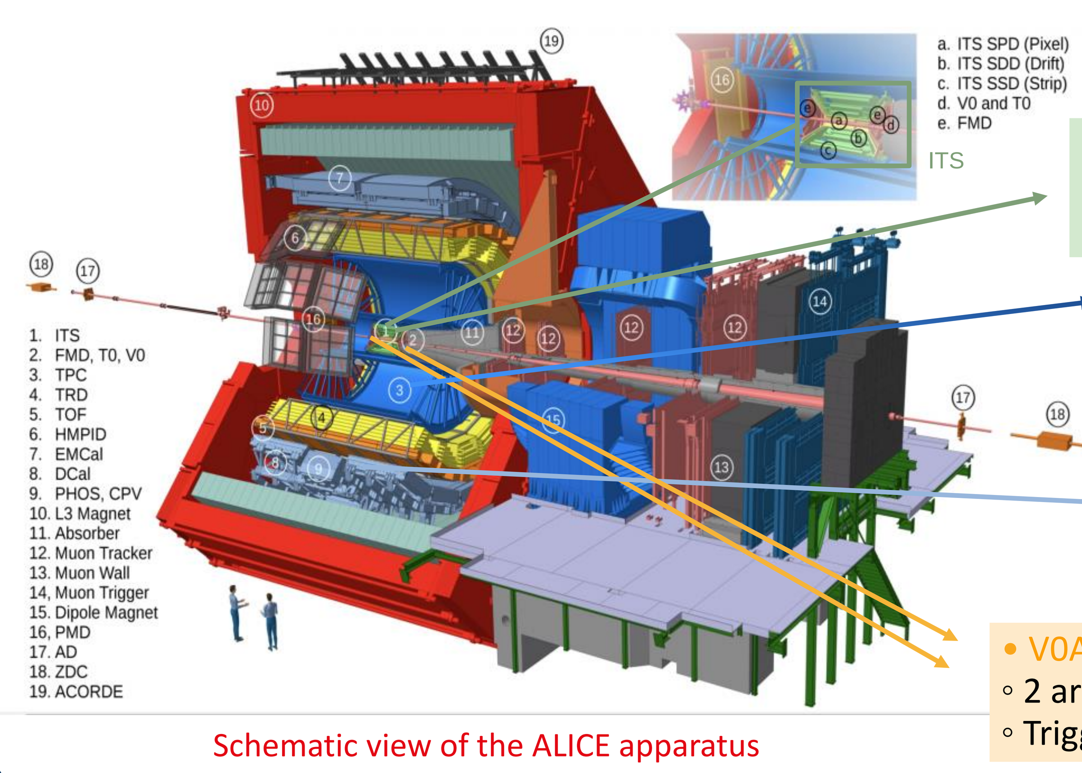
- Dynamical evolution and lifetime of the **hadronic phase**, highlighting resonance **regeneration** and **re-scattering** effects
- Strangeness production and processes that determine the shape of p_T spectra

Hadronic resonances measured in **proton-proton collisions**:

- Are used as a baseline for ion-ion collisions
- Studied as a function of multiplicity highlight possible onset of collective effects and/or features typical of heavy-ion collisions even in small systems

Resonance	$\rho(770)^0$	$\Delta(1232)$	$K^*(892)^\pm$	$K^*(892)^0$	$\Sigma(1385)^\pm$	$\Lambda(1520)$	$\Xi(1530)^0$	$\phi(1020)$
τ (fm/c)	1.3	1.7	3.6	4.2	5.0 - 5.5	12.6	21.7	46.4
Quark composition	$\frac{u\bar{u}+d\bar{d}}{\sqrt{2}}$	uuu, uud, udd, ddd	$u\bar{s}, \bar{u}s$	$d\bar{s}, \bar{d}s$	uus, dds	uds	uss	$s\bar{s}$
Decay BR (%)	ππ (100)	Nπ (99.4)	$K^0_S\pi$ (33.3)	Kπ (66.6)	Λπ (87)	pK (22.5)	Ξπ (66.7)	KK (48.9)

The ALICE detector at LHC



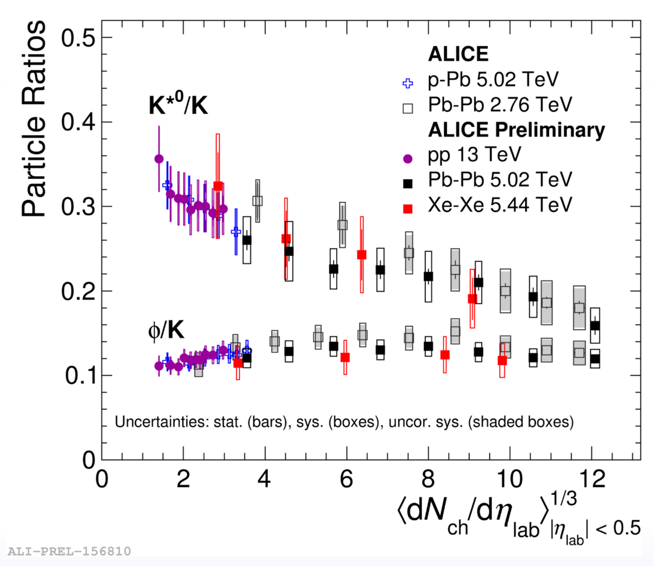
Schematic view of the ALICE apparatus

Main detectors [1] used in $K^*(892)^\pm$ analysis:

- Inner Tracking System (ITS)
  - 6 layers of silicon detectors
  - Trigger, tracking, vertex, PID (dE/dx)
- Time Projection Chamber (TPC)
  - Gas-filled ionization detector
  - Tracking, vertex, PID (dE/dx)
- Time Of Flight (TOF)
  - large MRPC (Multi-gap Resistive Plate Chamber) array
  - PID through particle time of flight
- V0A and V0C
  - 2 arrays of plastic scintillator counters
  - Trigger, multiplicity (centrality) estimator

Resonance production in pp collisions as a function of multiplicity: motivation

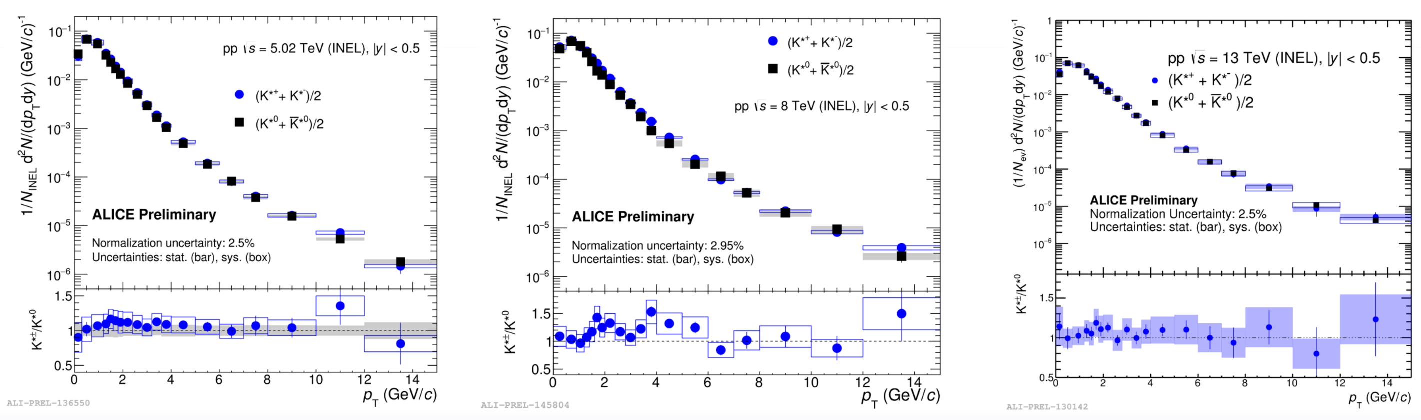
- $\mathbf{K^{*0}/K}$ **suppression** in central heavy-ion collisions w.r.t. peripheral ones, p-Pb and pp collisions [2] → suggests K^{*0} **re-scattering dominance** over regeneration in hadronic medium
- Similar **suppression** also for ρ^0/π [3] and $\Lambda(1520)/\Lambda$ [4]
- ϕ/K **no suppression**: equilibrium between regeneration and re-scattering or no final-state effects at all because of longer ϕ life (manily decays outside the fireball)
- **No suppression** even for $\Sigma^{*\pm}/\Lambda$ [5], despite $\Sigma^{*\pm}$ short lifetime → suppression is not just a lifetime effect
- $\mathbf{K^{*0}/K}$ **decreasing trend** for increasing multiplicity also in **pp collisions** and p-Pb collisions → **hint of possible presence of hadronic phase even for small system at** (their) **high multiplicities**
- Independence of particle ratios from colliding systems and energies, dependence only on charged-particle multiplicity



- K^{*0}/K and ϕ/K p_T-integrated yield ratios as a function of cubic root of charged-particle multiplicity at mid-rapidity (proxy for system size)

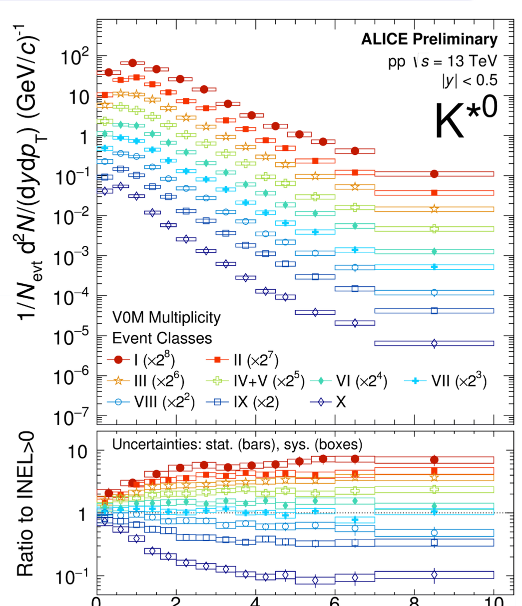
Motivation for studying $K^*(892)^\pm$

- $\mathbf{K^{*\pm}}$ and $\mathbf{K^{*0}}$ multiplicity-integrated yields equal within uncertainties at 5.02, 8 and 13 TeV in pp collisions



- $K^{*\pm}$ vs K^{*0} p_T spectra in pp collisions at 5.02, 8 and 13 TeV

- Study of $\mathbf{K^{*\pm}}$ **as a function of multiplicity in pp collisions at 13 TeV** is **complementary** to multiplicity dependent study of $\mathbf{K^{*0}}$. Systematic uncertainties for the two measurements are largely uncorrelated.
- $\mathbf{K^{*\pm}}$ **analysis as a function of multiplicity in pp collisions at 13 TeV is currently in progress**



- $\mathbf{K^{*0}}$ $\mathbf{p_T}$ **spectra** and ratio to multiplicity-integrated yield in **pp collisions at 13 TeV for different multiplicities**
- p_T spectra hardening with increasing multiplicity
  - In small systems mechanism such as colour reconnection can mimic flow-like effects
- Same spectral shape across multiplicity for p_T > 5 GeV/c
  - suggests dominance at low p_T of processes that change the shape of p_T spectra

Summary

- Due to their lifetimes, comparable to the time scale of the collision, hadronic resonances have been shown to be **good probes of the late-stage evolution** of ultra-relativistic heavy-ion collisions
- Recent measurements of resonance production in high-multiplicity proton-proton and proton-lead collisions have shown the **onset in small systems of phenomena typical of heavy ions**
- In particular, there are hints of suppression of the $K^*(892)^0/K$ ratio with increasing charged-particle multiplicity
- The study of $\mathbf{K^*(892)^\pm}$ production **can provide further evidence** to confirm the observed trend

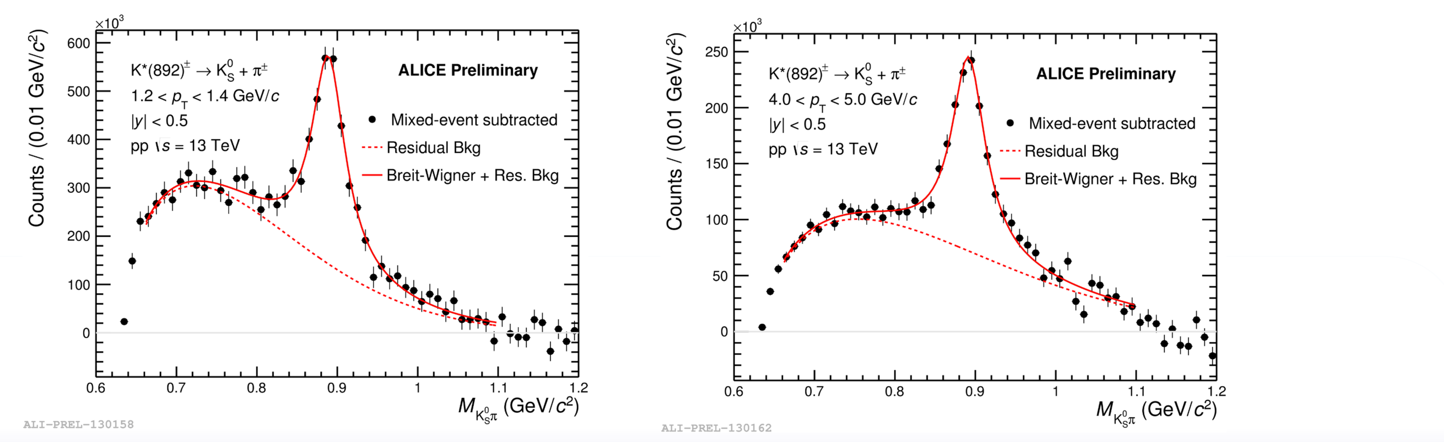
$K^{*\pm}$ resonance reconstruction

Resonances reconstructed via **invariant mass distribution** of their decay daughters

- $K^*(892)^\pm$ identified via: $K^{*\pm} \rightarrow \pi^\pm + K^0_S$ ◦ $\pi^\pm$ detected, K^0_S identified via $K^0_S \rightarrow \pi^+ + \pi^-$
- Data Set: pp √s = 13 TeV
  - Data: 415.52 M. evts; MC: PYTHIA 8 (Monash 2013 tune) - 102.15 M. evts
- Event selection via minimum bias trigger; possibility of using high-multiplicity trigger
- **Combinatorial background** estimated via event mixing technique
- **Signal + residual background** fit with suitable functions: in this case Non-Relativistic Breit-Wigner + F_{BG} function
  - Modeling the residual background is the main source of systematic uncertainties and the limiting aspect of this analysis. F_{BG} function has proven to be a better choice than 2nd and 3rd order polynomials

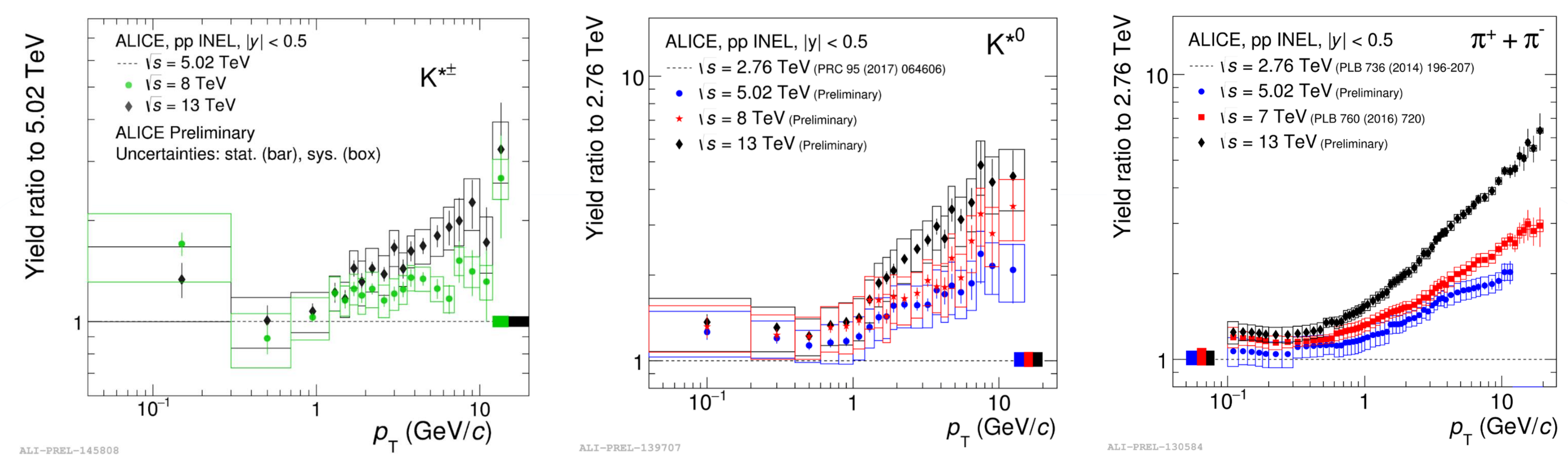
$$NRBW(M_{K\pi}) + F_{BG}(M_{K\pi}) = \frac{A}{2\pi}\frac{\Gamma_0}{(M_{K\pi}-M_0)^2+\frac{\Gamma_0^2}{4}} + F_{BG}(M_{K\pi}) \quad [6]$$

$$F_{BG}(M_{K\pi}) = [M_{K\pi} - (m_\pi + m_K)]^n exp(A + BM_{K\pi} + CM_{K\pi}^2)$$



- $K^{*\pm}$ resonance reconstruction in pp collisions at 13 TeV in the 1.2 < p_T < 1.4 GeV/c and the 4.0 < p_T < 5.0 GeV/c bins

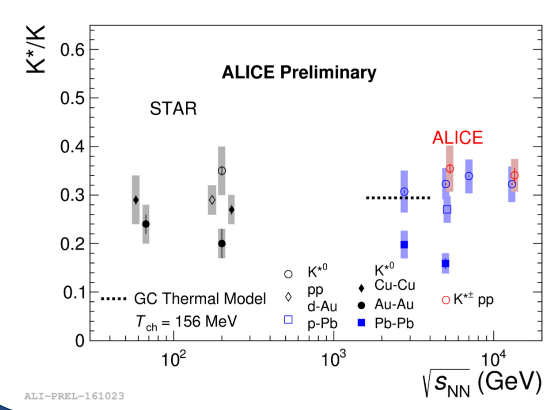
Energy dependence of $K^{*\pm}$ production in pp collisions



Ratio of $K^{*\pm}$, K^{*0} and $\pi^\pm$ yields in pp collisions at different energies as a function of p_T

- Independent of p_T up to ~ 1 GeV/c → production mechanism at low momentum is independent of collision energy
- Increase in slope for p_T > 1-2 GeV/c; p_T spectra get harder with increasing collision energy

Similar behaviour observed for other resonances and for stable hadrons (like reported $\pi^\pm$)



K^*/K yield ratios as a function of center-of-mass energy [2, 7, 8]

- Independent of collision energy and system, except for central nucleus–nucleus collisions, due to final state effects in the late hadronic stage
- Ratios in pp collisions consistent with thermal model estimations in the grand-canonical limit

References

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