System size and energy dependence of resonance production in ALICE

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Outline:

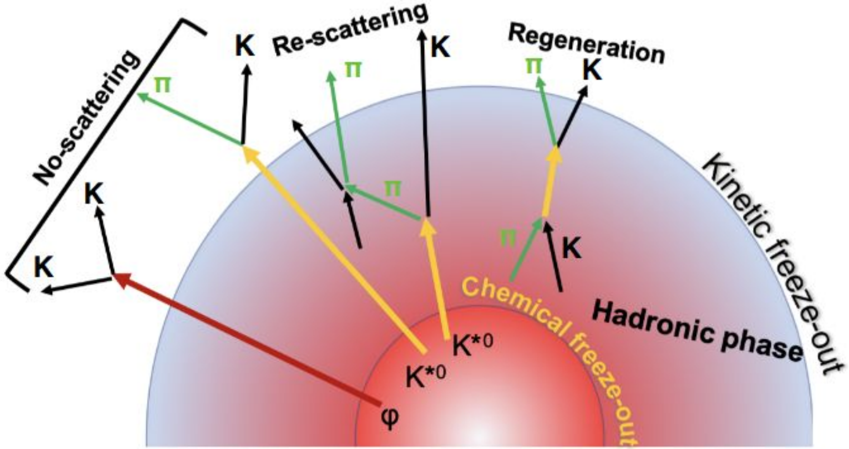
- Motivation
- ALICE detector and analysis details
- Results
  - p_T spectra
  - Mean transverse momentum and yield (dN/dy)
  - Particle ratios
  - Nuclear modification factors
- Summary

Motivation

Resonances are short lived particles (few fm/*c*) which decay by strong interaction

Hadronic phase: time span between chemical and kinetic freeze-out

Resonance	Lifetime (fm/*c*)	Decay channel	Branching ratio (%)
$\rho(770)^0$	1.3	$\pi^+\pi^-$	100
$K^*(892)^\pm$	3.6	$\pi^\pm K_s^0$	33
$K^*(892)^0$	4.16	$\pi^- K^+$	66
$\Lambda(1520)$	12.56	pK^-	22.5
$\phi(1020)$	46.2	$K^- K^+$	49.2



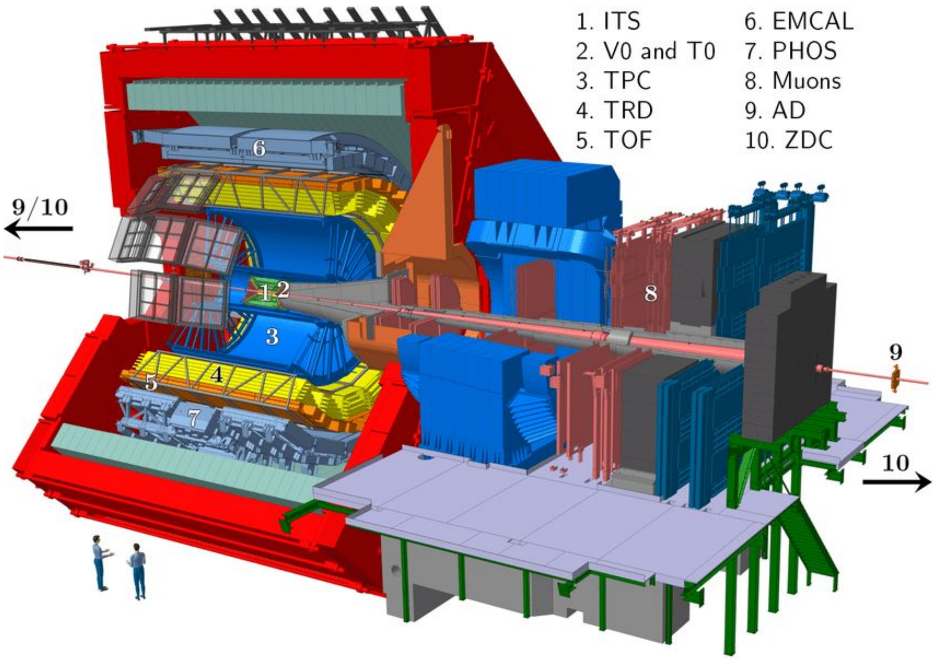
- **Modification of yields (re-scattering vs re-generation)**
- **Hint for finite lifetime of hadronic phase**
- **Hadrochemistry of particle production**
- **Study of in medium energy loss**

Λ(1520) resonance in p-Pb at 8.16 TeV is new and other resonances will be used as examples

ALICE detector

Forward detector (V0): V0A ($2.8<\eta<5.1$) and V0C ($-3.7<\eta<-1.7$)

- ❖ Trigger and centrality

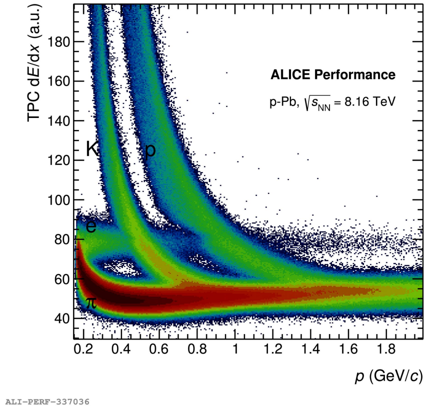


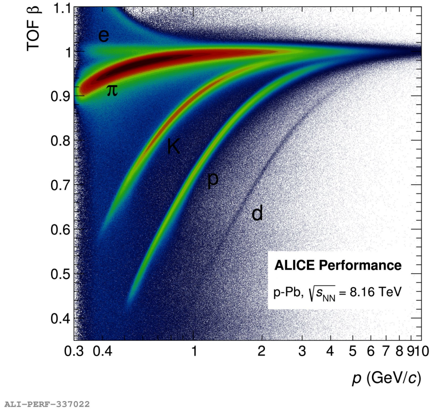
Time Projection Chamber (TPC): ($|\eta| < 0.9$)

- ❖ Primary vertex and tracking
- ❖ Measure momentum
- ❖ PID through dE/dx

Time-Of-Flight (TOF):($|\eta| < 0.9$)

- ❖ PID through time of flight





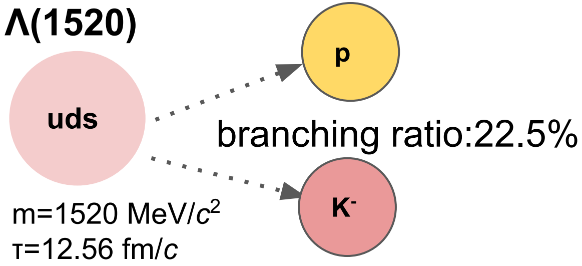
Analysis details: resonance reconstruction

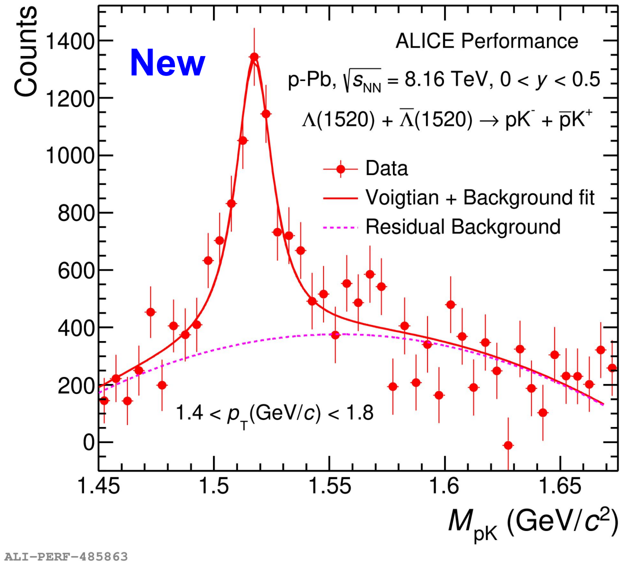
1. Invariant mass method: Resonances reconstructed by their decay products, adding their 4-momenta

2. Combinatorial background : Removed using mixed event or like-charge technique

3. Residual background : Correlated pairs or misidentified decay products removed by fitting with polynomial function

4. Signal : Fit with Breit-Wigner or Voigtian function, yield calculated by integrating the fitting function

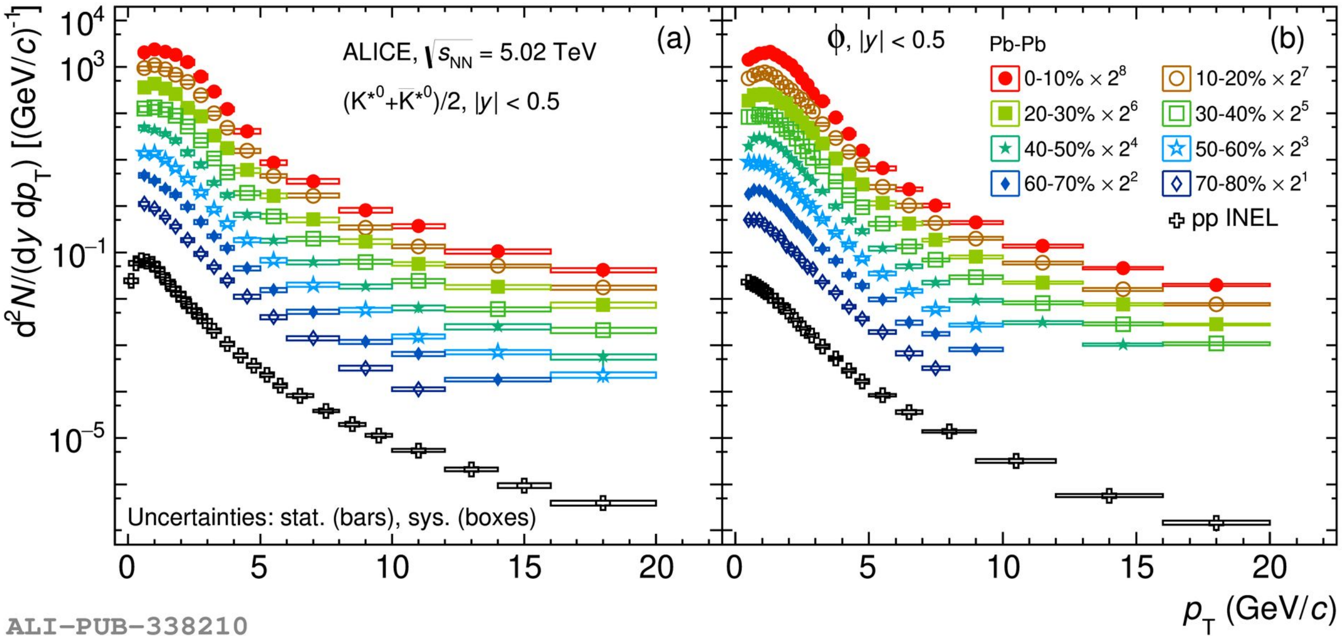




p_T spectra in heavy-ion collisions

Pb-Pb

PLB 802 (2020) 135225



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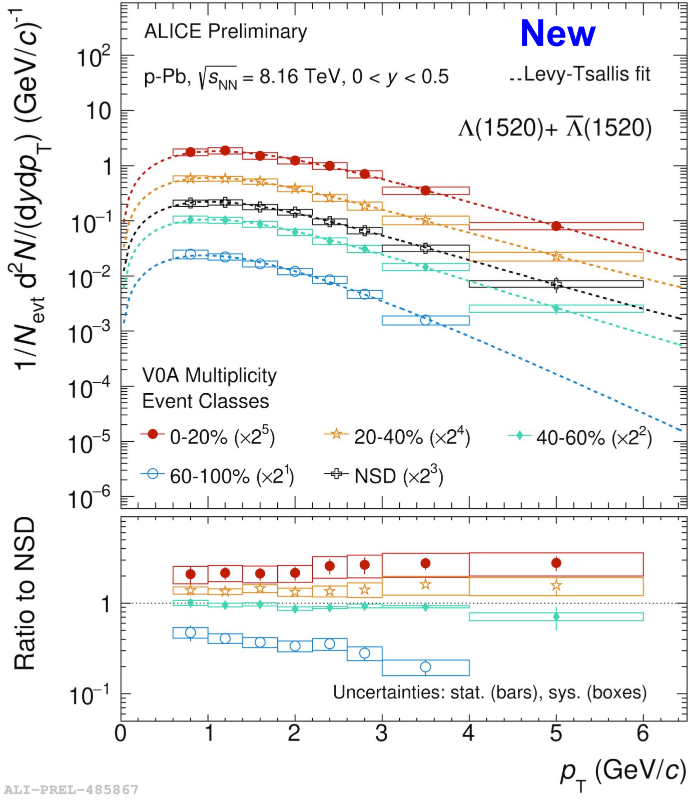
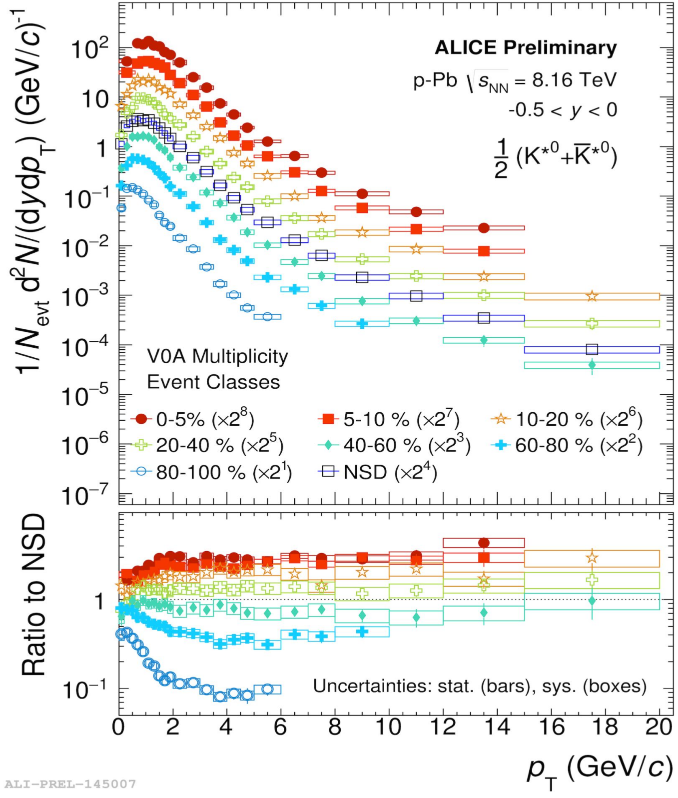
❖ p_T spectra get harder from peripheral to central collisions

Similar spectral shape also observed for K^{*0} and ϕ in Xe-Xe collisions and same behaviour is observed for other resonances

p_T spectra in p-Pb collisions





- The spectral shape changes with multiplicity
- The spectra get harder with multiplicity

p_T spectra in pp collisions

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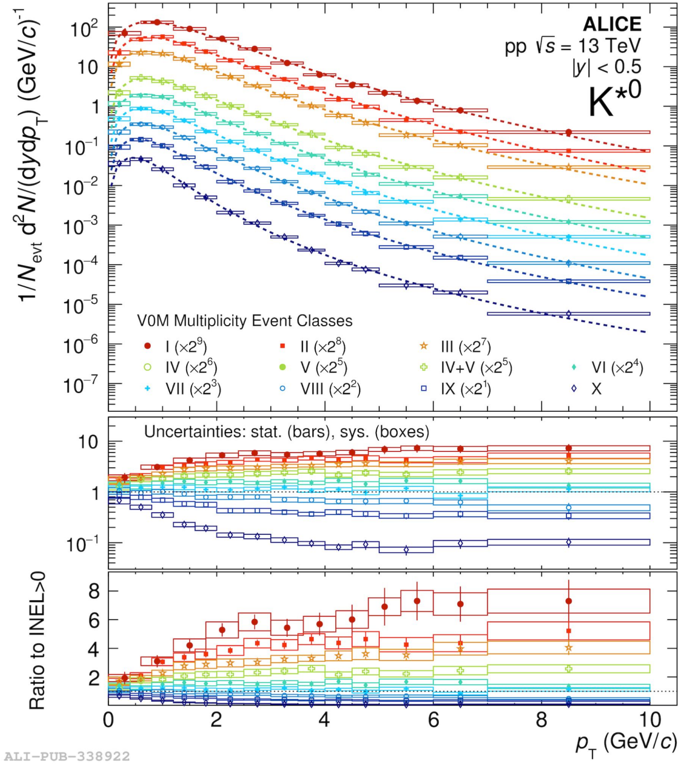
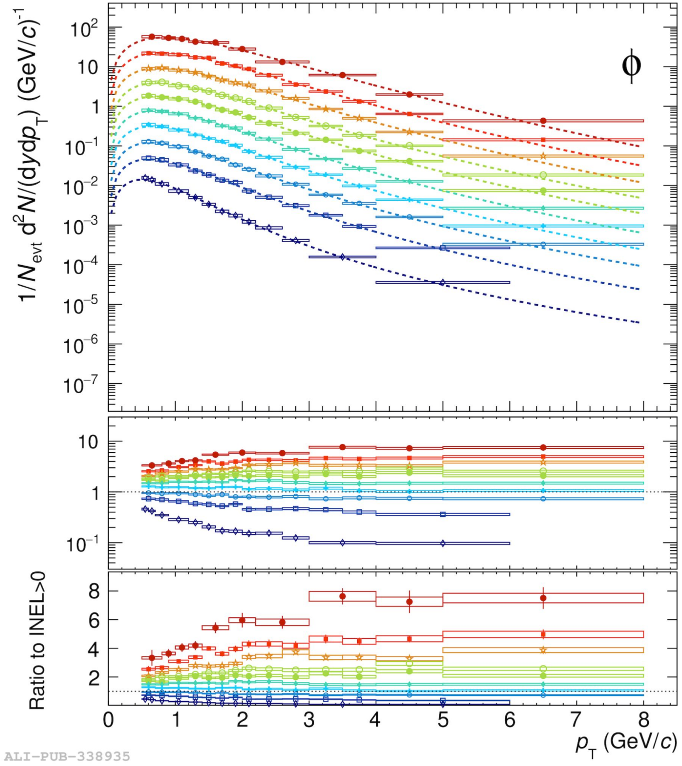
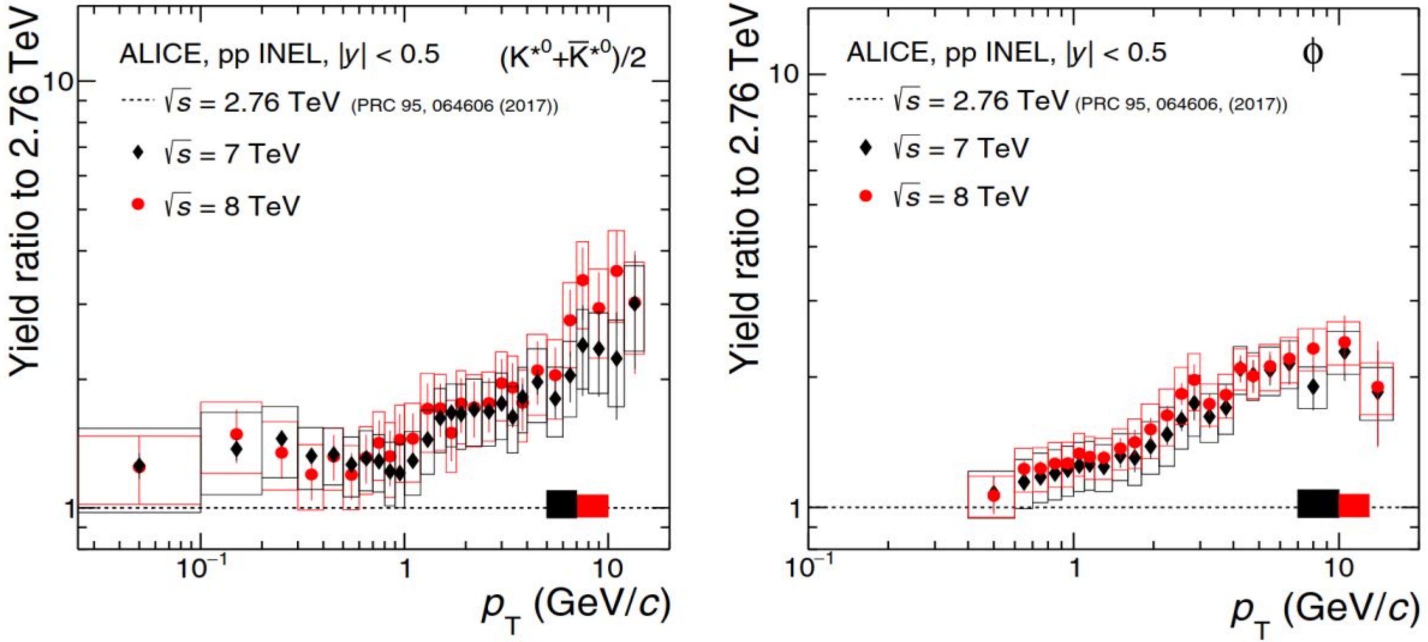




- The spectral shape changes with multiplicity
- The spectra get harder with multiplicity

Energy dependence of resonance production

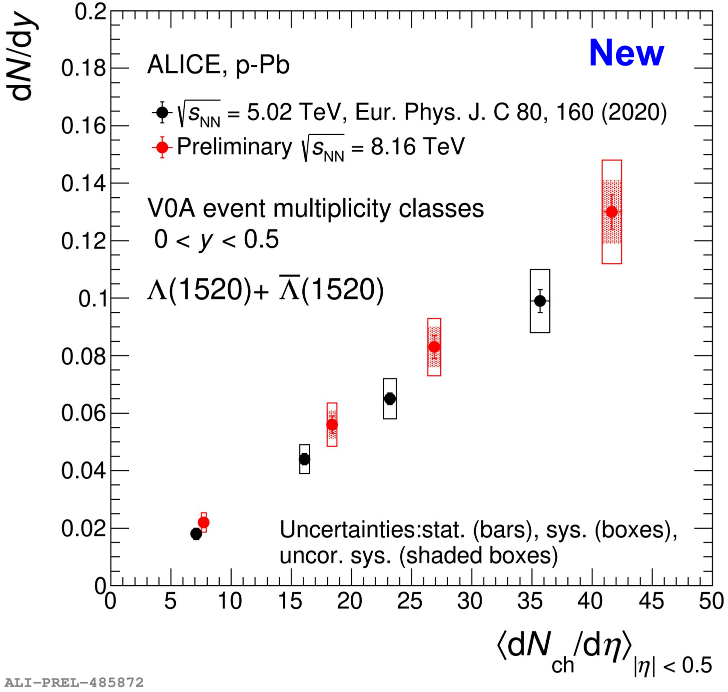
PRC 102, 024912 (2020)

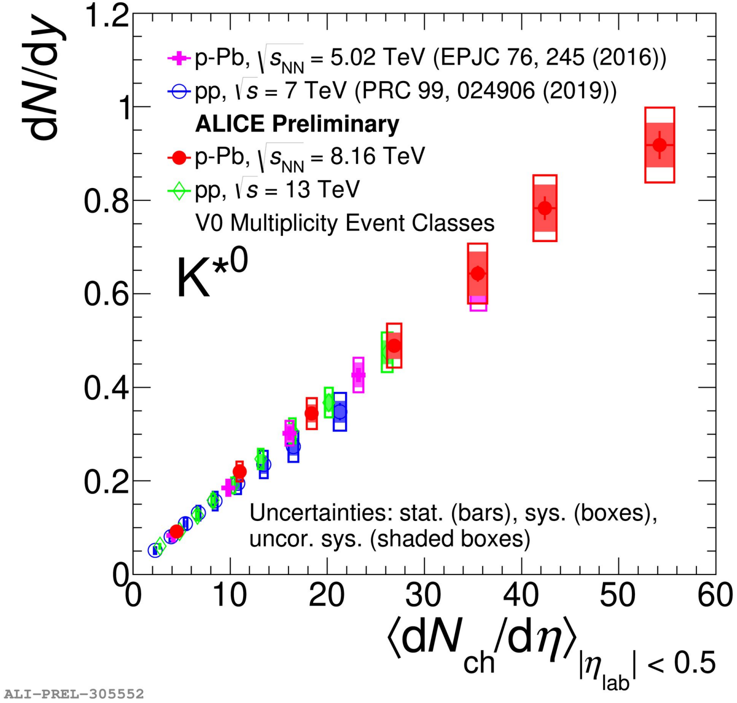


- ❖ Resonance yield increases with collision energy
- ❖ The increase is more for high p_T

Similar behaviour also observed in other collision systems

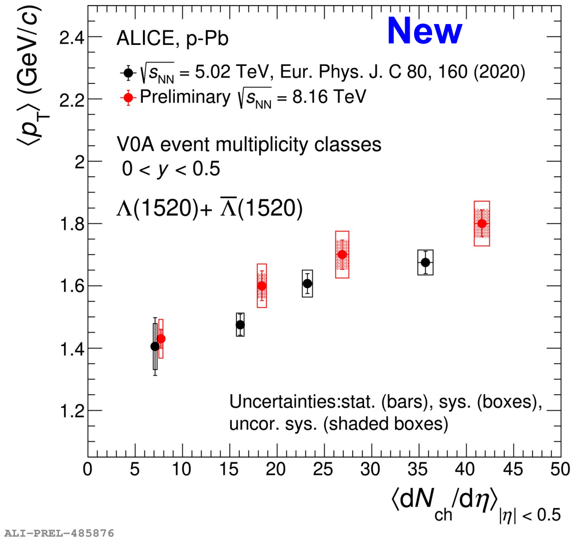
Integrated yield (dN/dy)

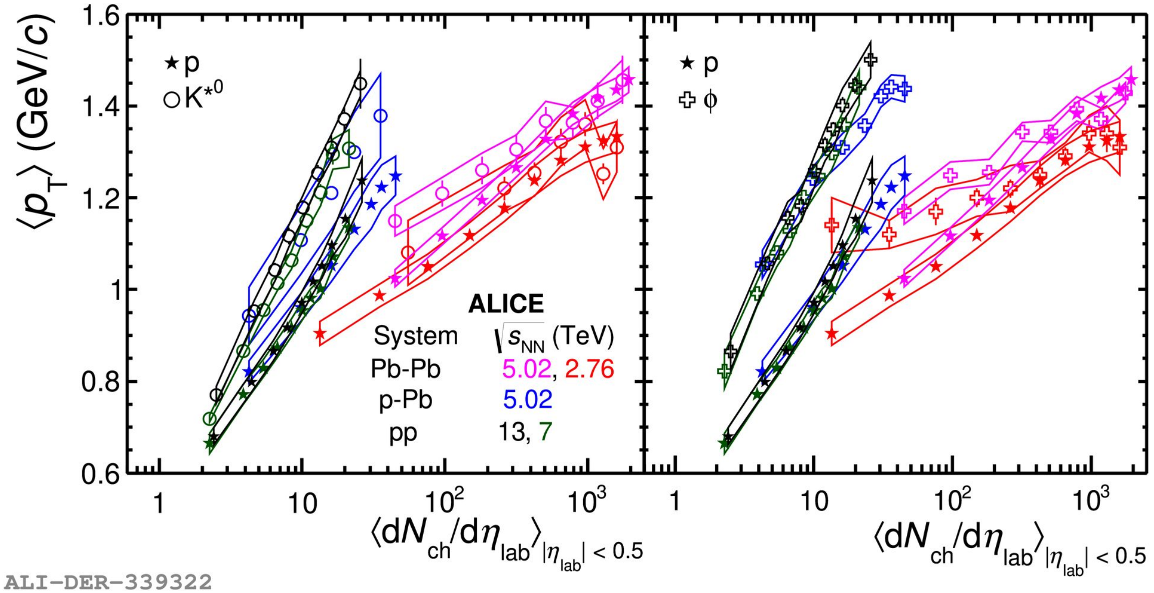




❖ Resonance production is independent of colliding system or energy for collisions with similar multiplicity
-> **Event multiplicity drives resonance yield**

Average p_T





❖ <p_T> of resonances increases with event multiplicity for all systems

❖ **Central Pb-Pb collisions:**

-- Mass ordering

❖ **Peripheral Pb-Pb and small collisions (pp, p-Pb):**

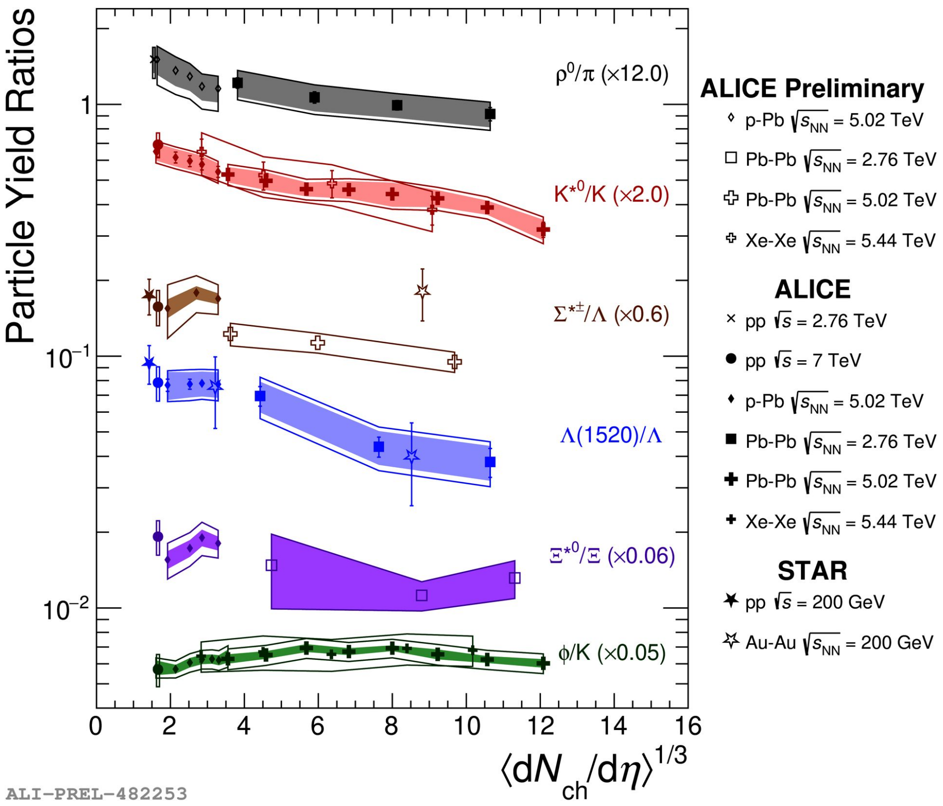
-- Mass ordering breaks down

❖ **Small systems (pp, p-Pb)**

-- <p_T> rises faster compared to Pb-Pb collisions

Particle ratios

Lifetime (fm/c): ρ^0 (1.3) < $K^{*\pm}$ (3.6) < K^{*0} (4.17) < $\Sigma^{*\pm}$ (5.0-5.5) < Λ^* (12.6) < Ξ^{*0} (21.7) < ϕ (46.2)



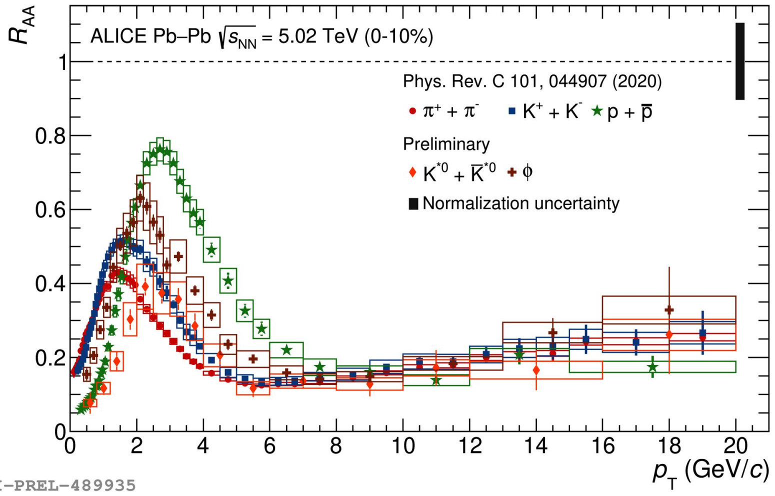
- **Pb-Pb collisions:**
  --Suppression of yields of resonances (ρ^0, K^{*0}, $\Sigma^{*\pm}$, $\Lambda(1520)$, Ξ^{*0}) with increasing multiplicity→ Re-scattering effect dominates over re-generation

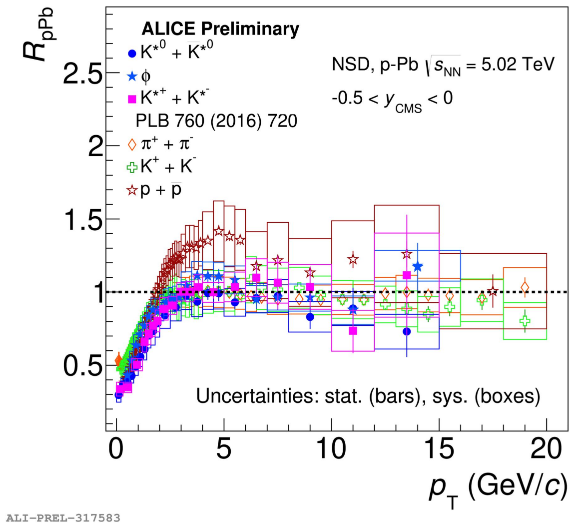
  --No suppression observed in ϕ resonance (could be a hint of finite or limited lifetime of hadronic phase)

- **Small systems (pp, p-Pb):**
  --Small decreasing trend for ρ^0 and K^{*0}
  --No significant suppression of yield for other resonances
  (could be a hint of the dependence of lifetime of hadronic phase on the collision system)

Nuclear modification factors (R_{AA} or R_{pA})

$$R_{AA,pA} = \frac{Yield_{AA,pA}}{< N_{coll} > \times Yield_{pp}}$$





R_{AA}:

- ❖ $R_{AA} < 1$, suppression (presence of in medium effects)
- ❖ No flavor (u,d,s) dependence for $p_T > 8$ GeV/c

R_{pA}:

- ❖ $p_T > 4$ GeV/c $\rightarrow R_{pA} = 1$, no suppression (absence of in medium effects)
- ❖ No flavor (u,d,s) dependence for $p_T > 6$ GeV/c

Summary

- **Hardening** of p_T spectra with multiplicity
- Resonance yield increases with energy
- Multiplicity drives resonance yield
- < p_T> mass ordering in central Pb-Pb collisions
- Limited lifetime of the hadronic phase
- Presence of in medium effects in Pb-Pb collisions
- At high p_T , no flavour dependence

Thanks for kind attention..