ϕ and K^{*0} production in p-Pb and Pb-Pb collisions with ALICE at LHC

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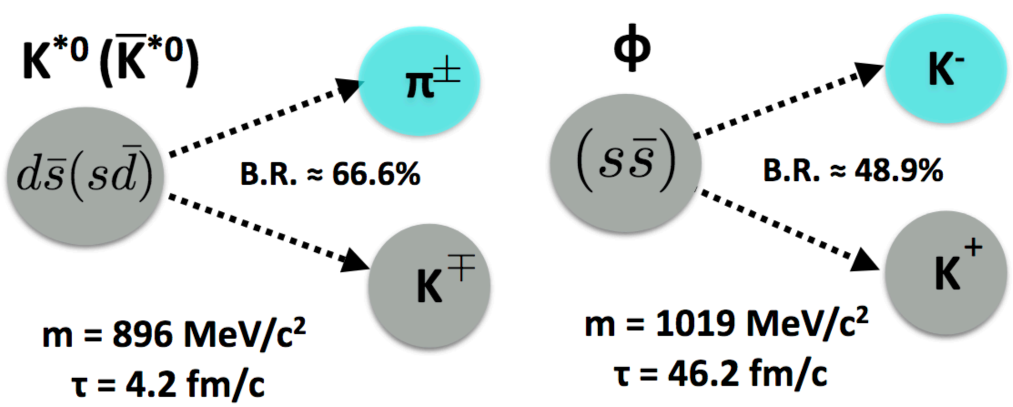
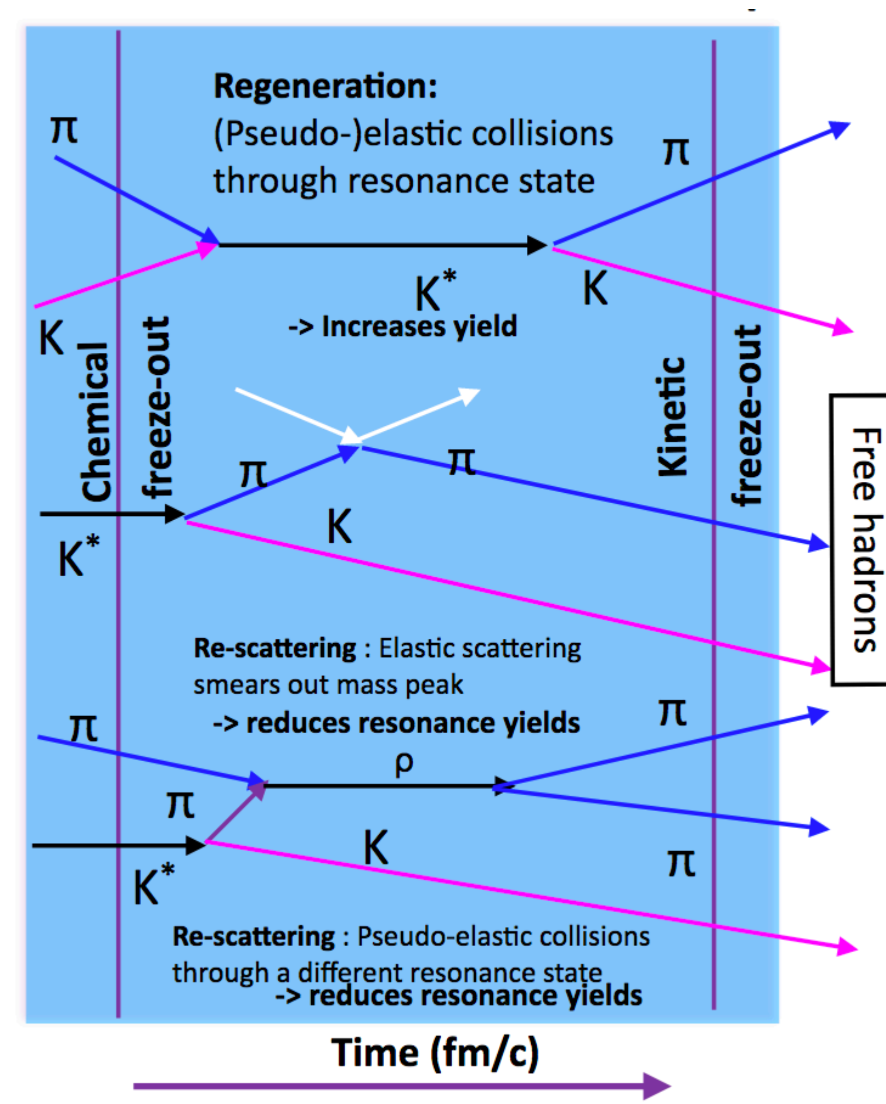
Outline

- Motivation
- ALICE detector
- Results
  - p_T spectra
  - Yield (dN/dy)
  - Mean transverse momentum ($\langle p_T \rangle$)
  - Particle ratios
  - Nuclear modification factor (R_{pPb} and R_{AA})
- Summary

Resonances having short lifetimes (few fm/*c*) comparable to that of fireball produced in heavy-ion collisions -> sensitive to the evolution dynamics



Interaction with in-medium hadronic phase



✦ Properties of hadronic phase (Re-scattering vs. Regeneration)

- - Modification of measured particle yields
- - Compare resonances with different lifetimes

✦ In-medium energy loss

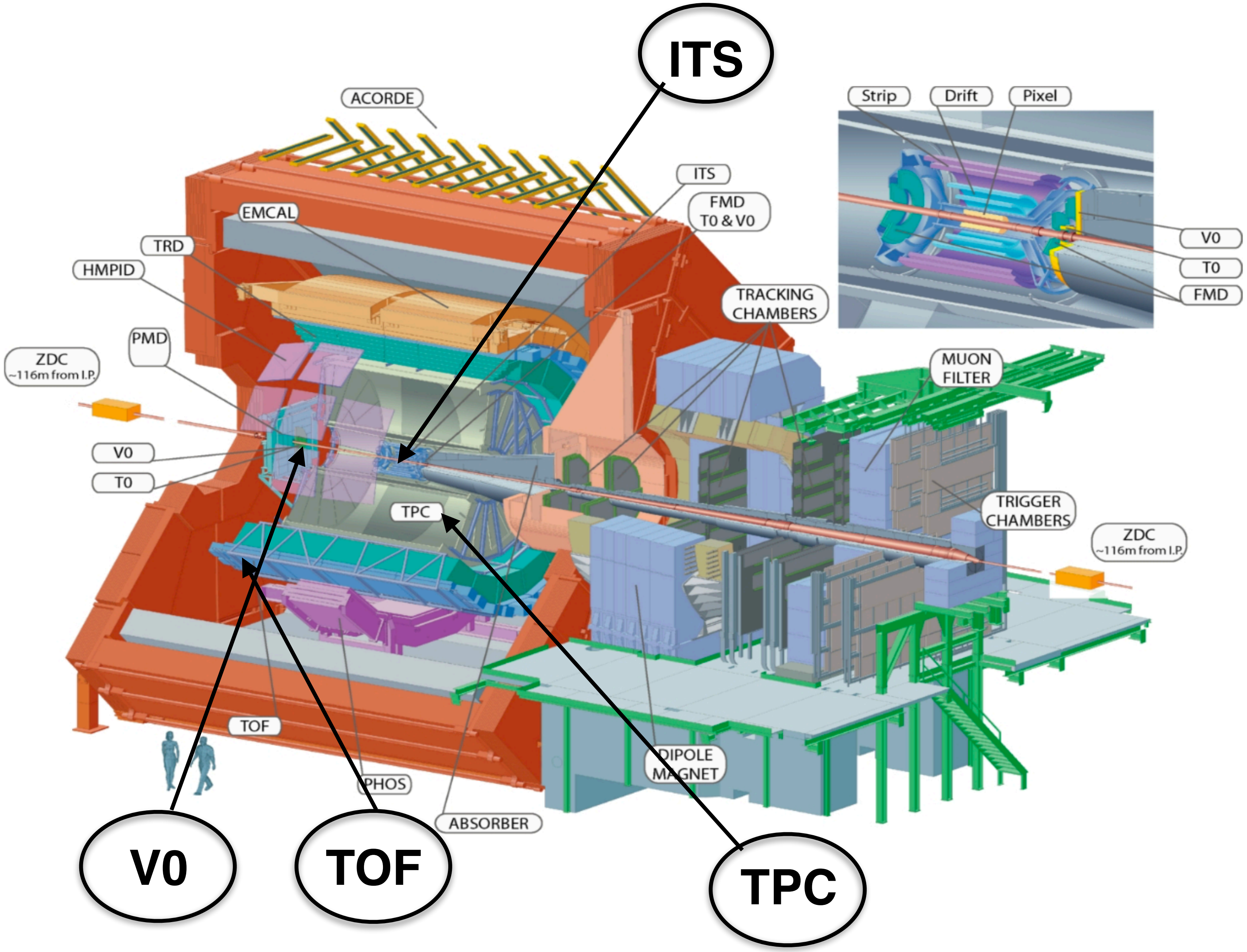
- - Suppression of nuclear modification factor (R_{AA})

✦ Nuclear Modification Factor in p-Pb (R_{pPb})

- - Disentangle initial and final state effect
- - Understanding the energy loss mechanism and Cronin effect

➔ p-Pb is suitable system to fill gap in size of system produced between pp and Pb-Pb, allowing investigation of dominant particle production mechanism

ALICE : A Large Ion Collider Experiment



Inner Tracking System(ITS): (Iηl < 2.0)

- ❖ Primary vertex
- ❖ Tracking

TimeProjectionChamber (TPC): (Iηl < 0.9)

- ❖ Tracking
- ❖ PID

Time-Of-Flight (TOF): (Iηl < 0.9)

- ❖ PID (time-of-flight measurement)

Forward detector (V0):
V0A (2.8< η < 5.1) & V0C (-3.7< η < -1.7)

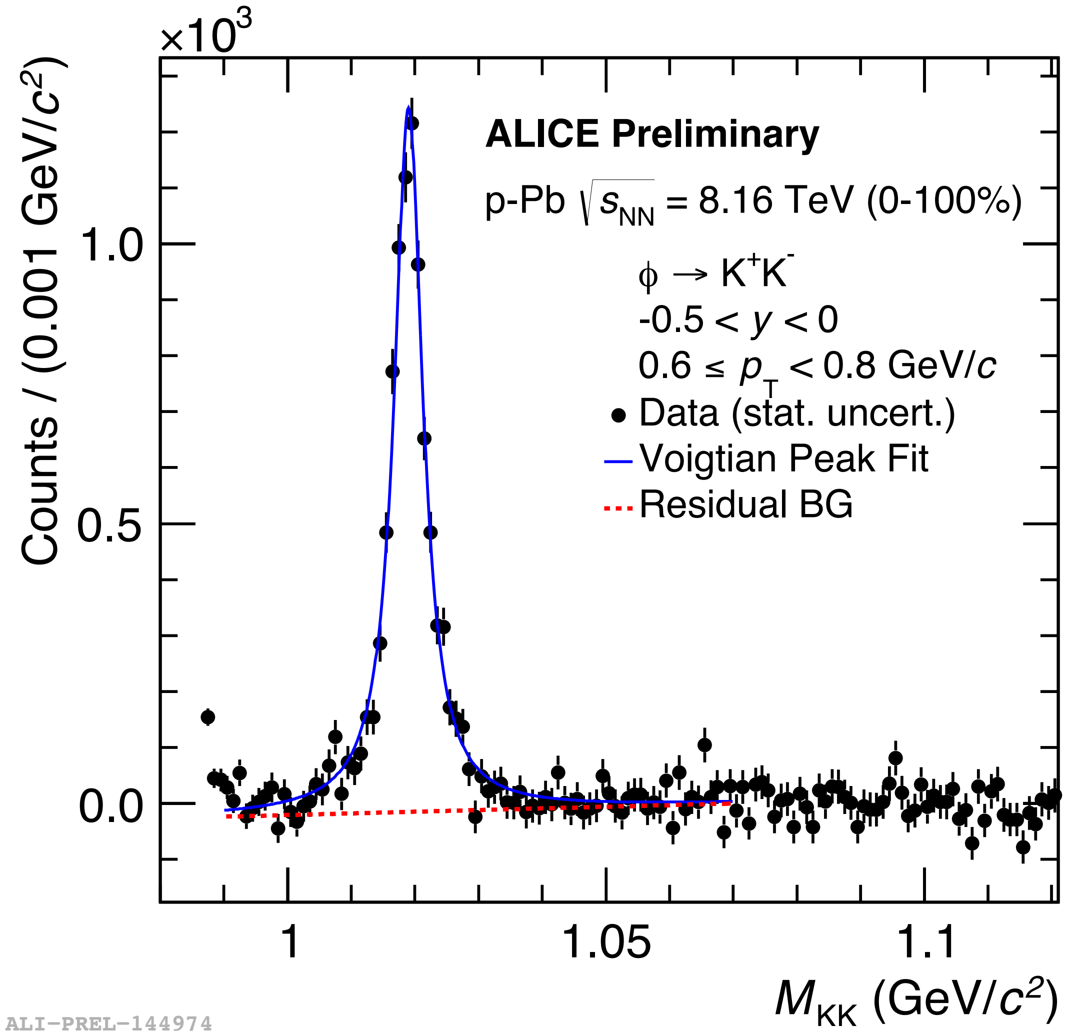
- ❖ Trigger, centrality estimator

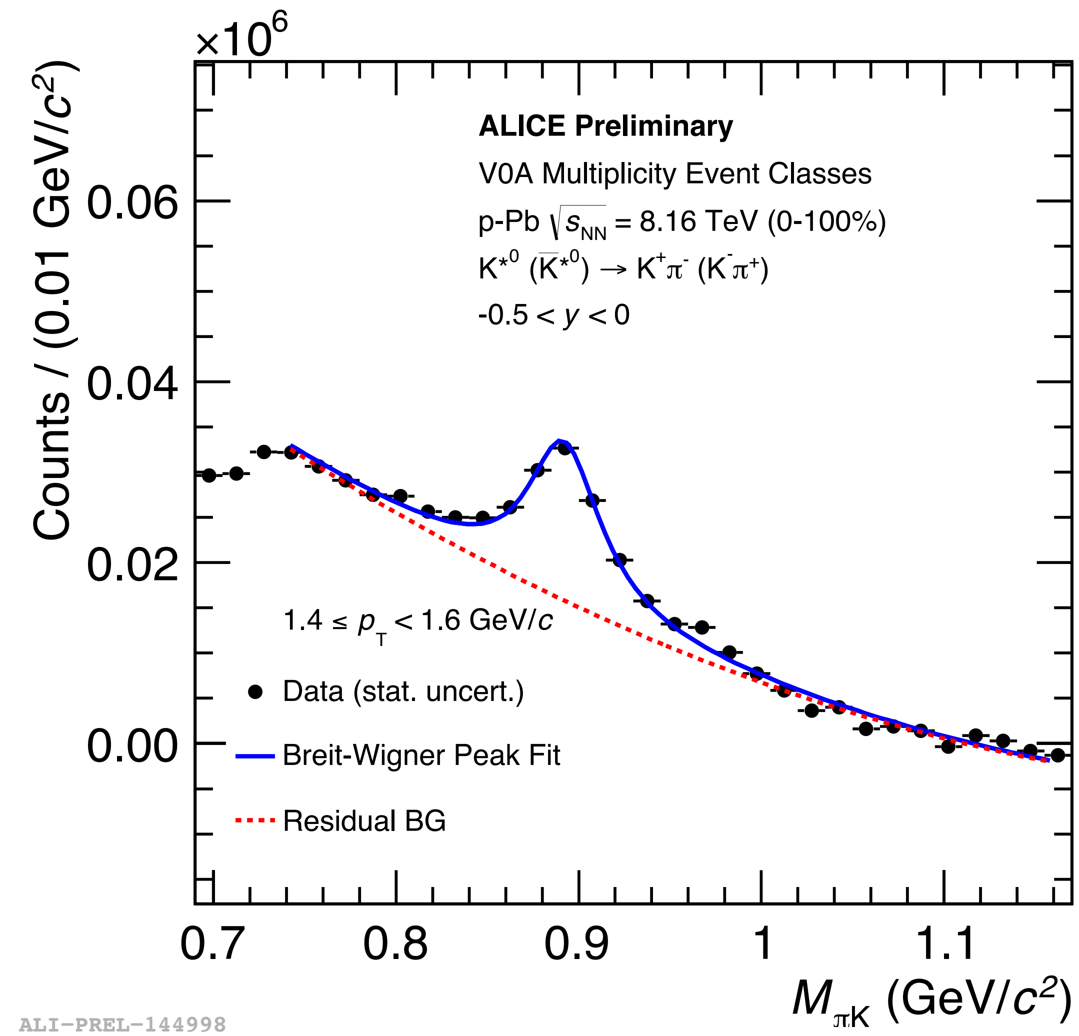
Multiplicity/centrality event classes definition

- ❖ In p-Pb (V0A) and in pp, Pb-Pb (V0M = V0A + V0C)

Signal Extraction

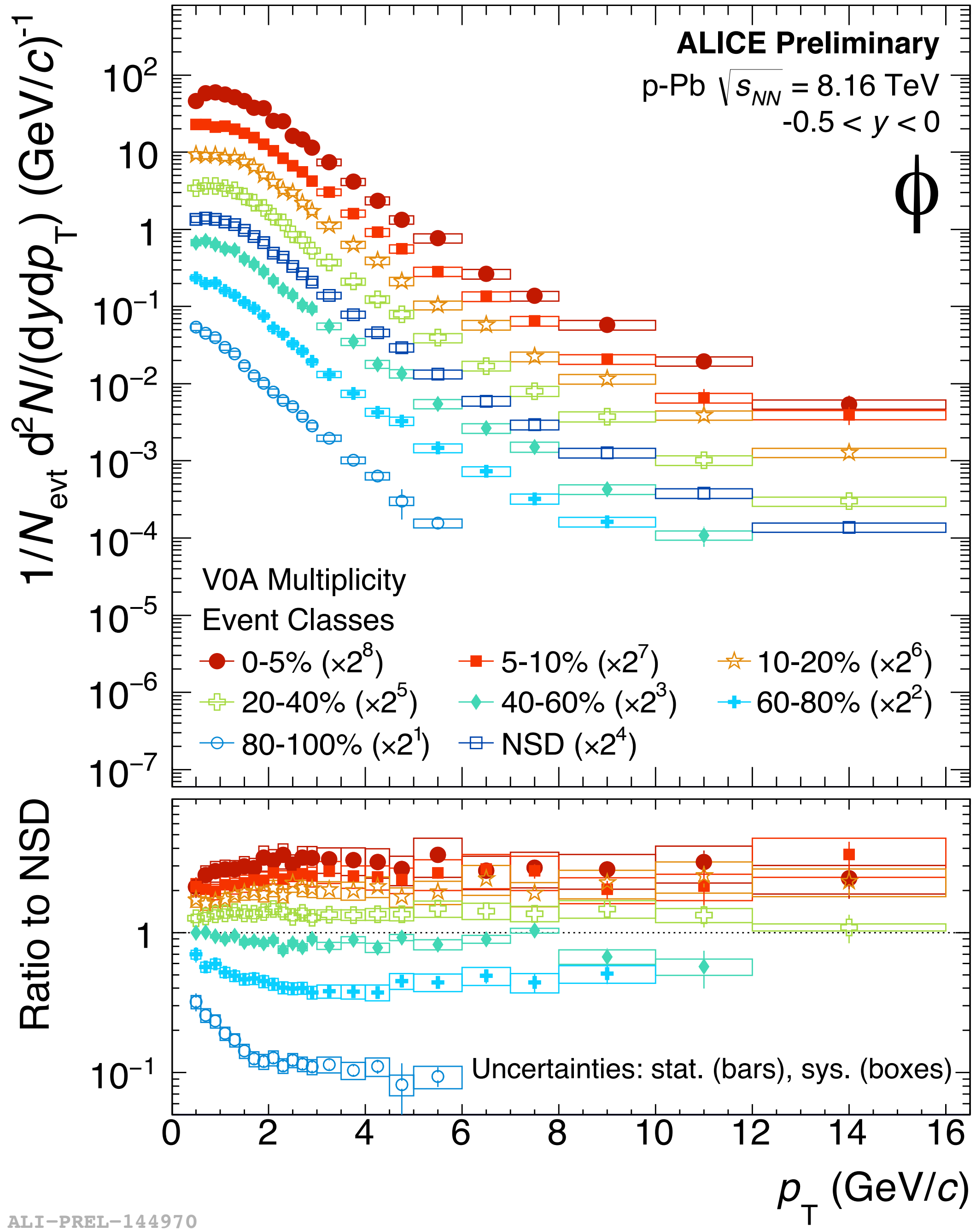
p-Pb 8.16 TeV

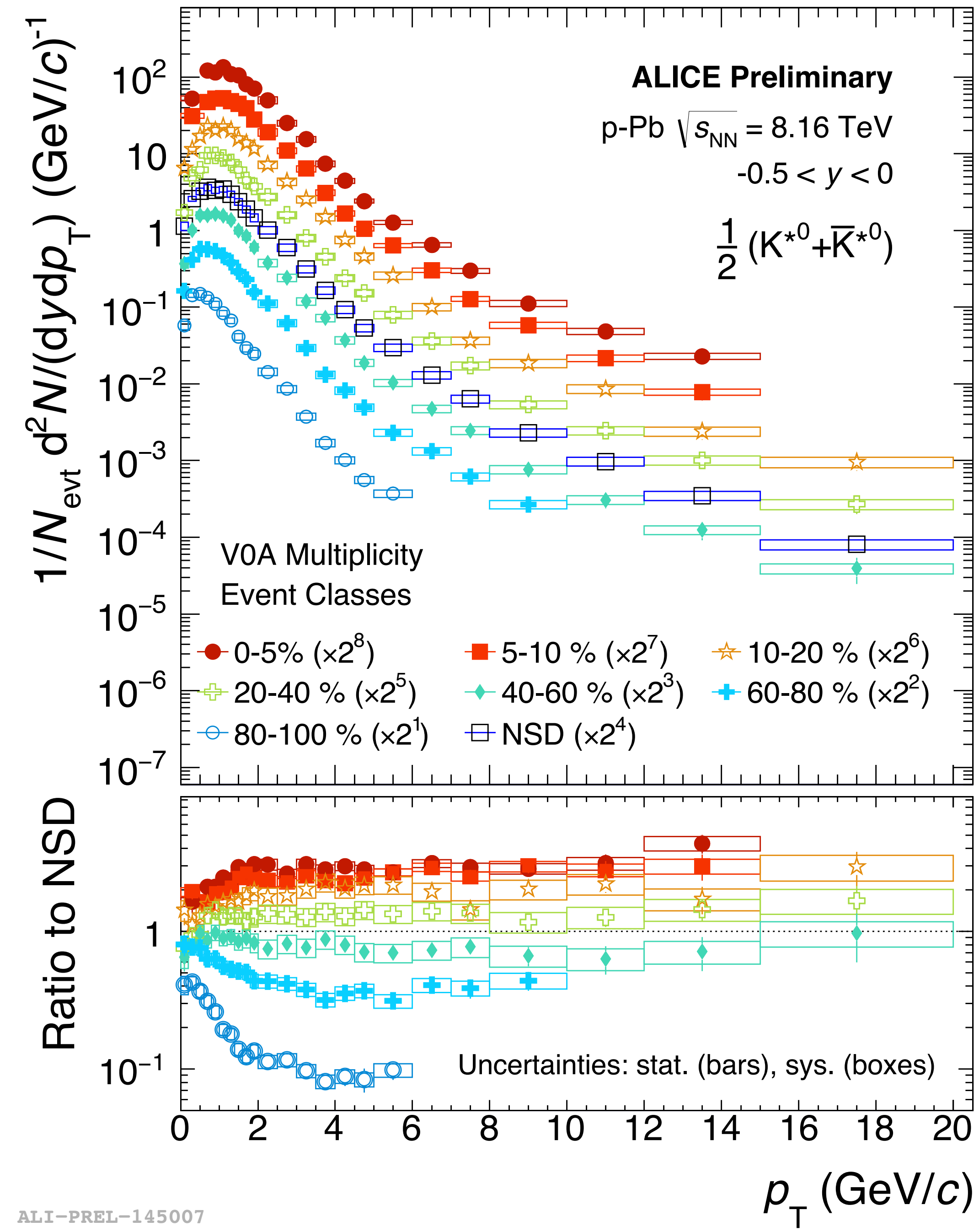




- ❖ ϕ and K^{*0} signal obtained by using invariant mass technique
- ❖ Combinatorial background : Event-mixing and like-sign technique
- ❖ Fit: Breit-Wigner (K^{*0}) or Voigtian (ϕ) + polynomial (residual background)

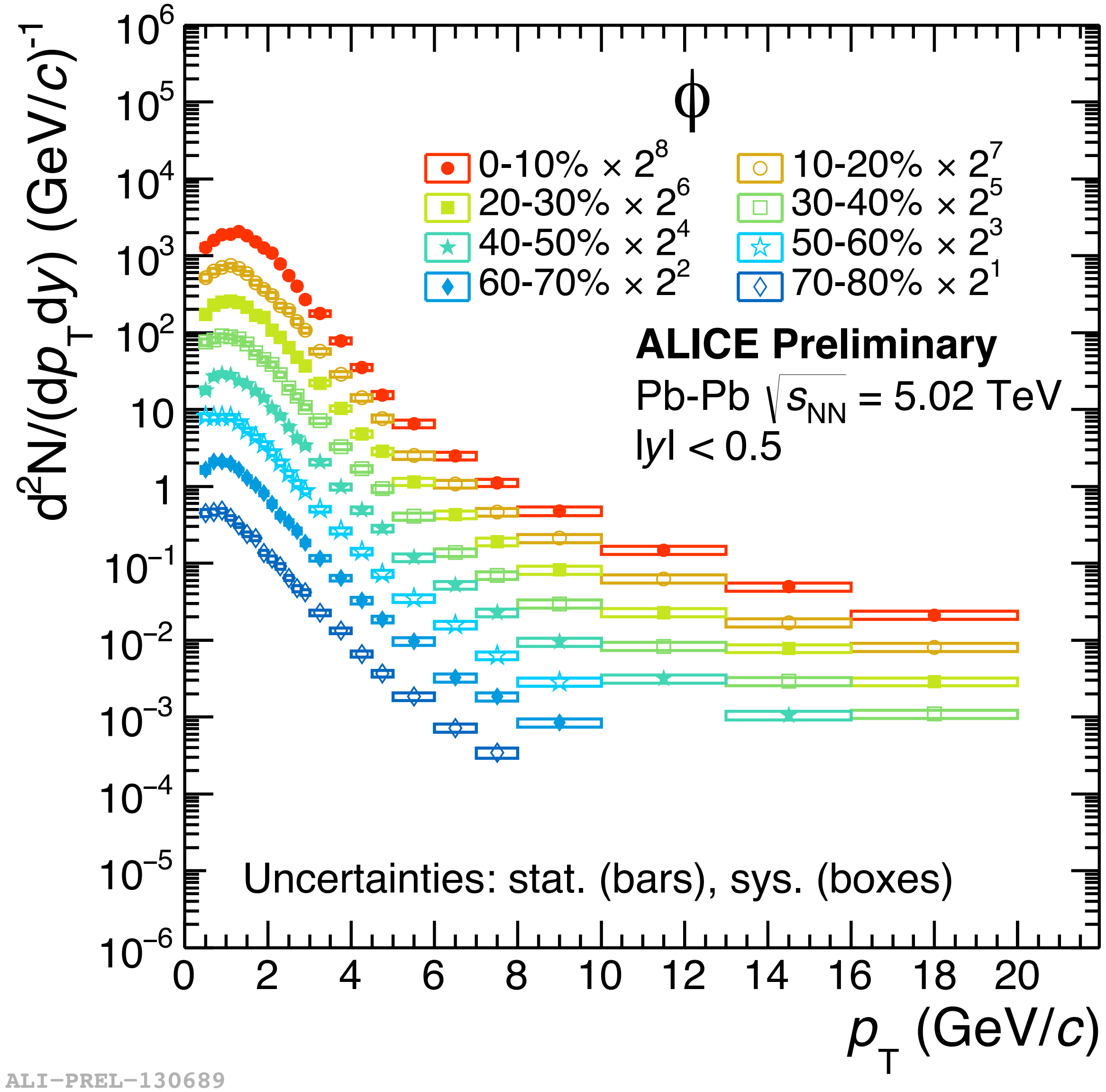
p_T Spectra in p-Pb

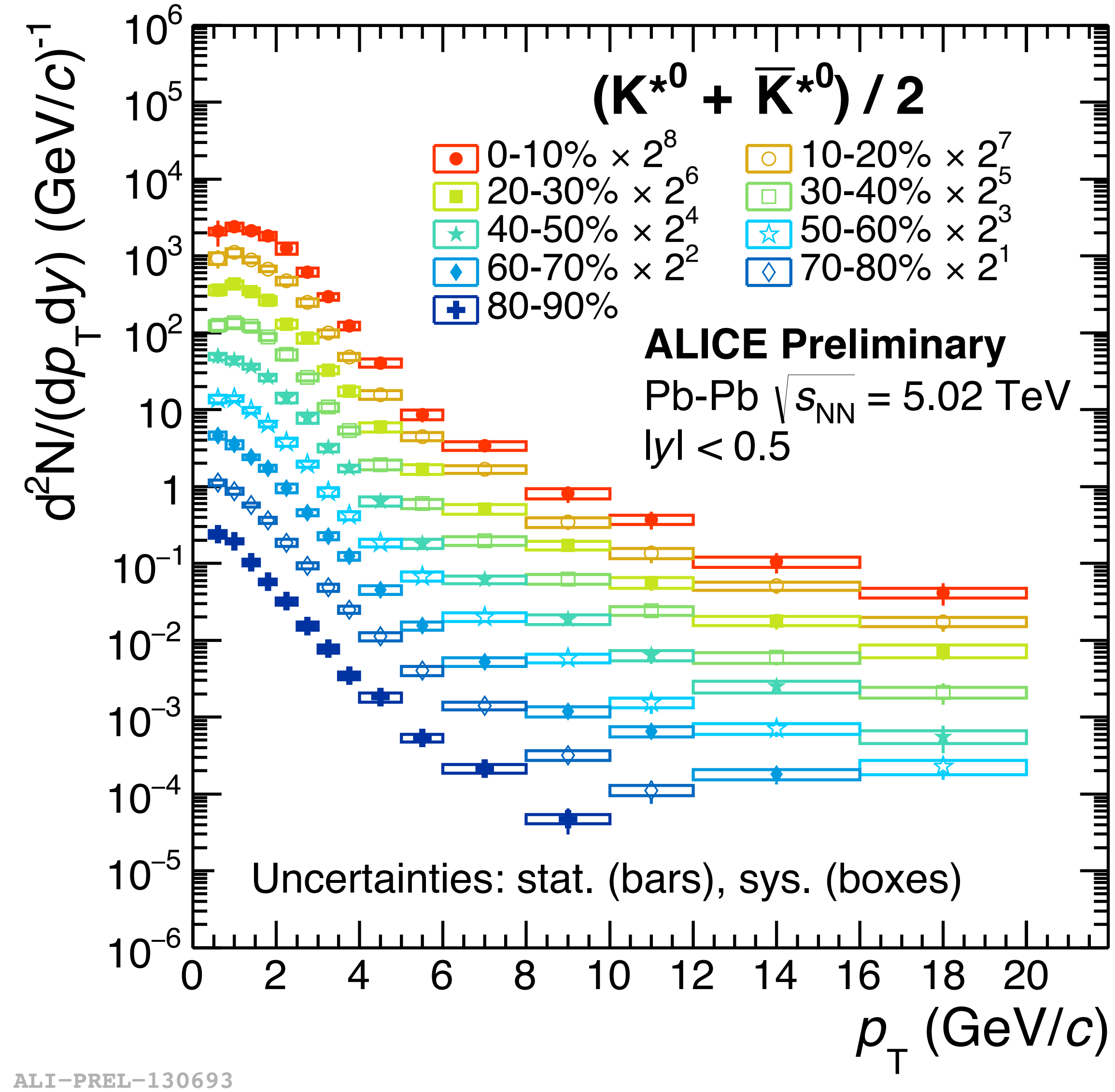




- ❖ Significant evolution of spectral shape with increasing multiplicity for p_T < 5 GeV/c
- ❖ The spectral shape is similar across multiplicity for p_T > 5 GeV/c

p_T Spectra in Pb-Pb

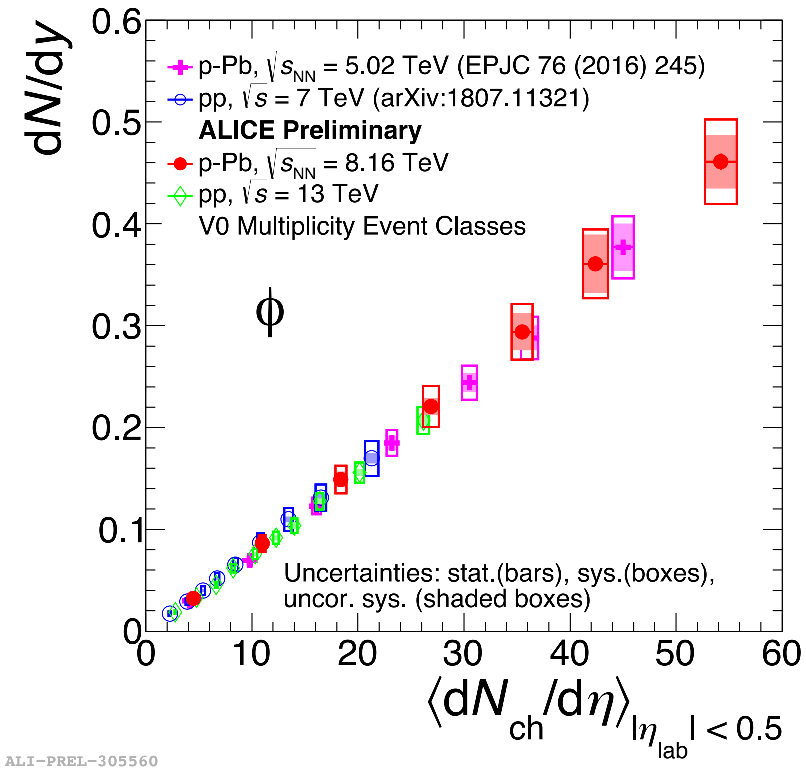


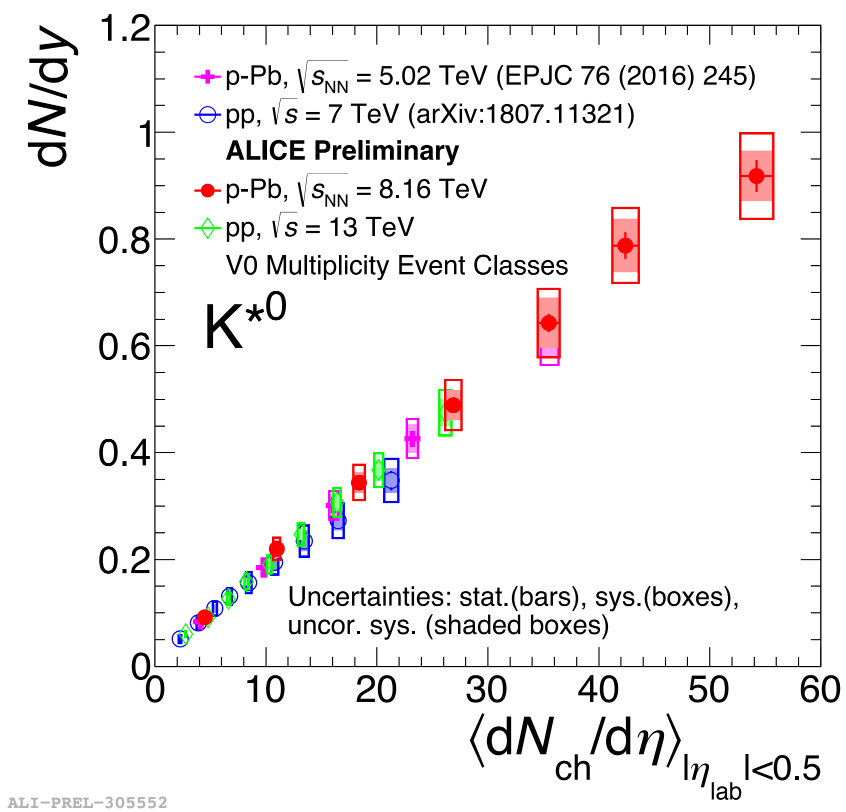


- ❖ Evolution of the spectral shape with increasing multiplicity for $p_T < 5$ GeV/c
- ❖ Similar behaviour of p_T spectra in Pb-Pb collisions with increasing multiplicities are observed as seen in p-Pb collisions

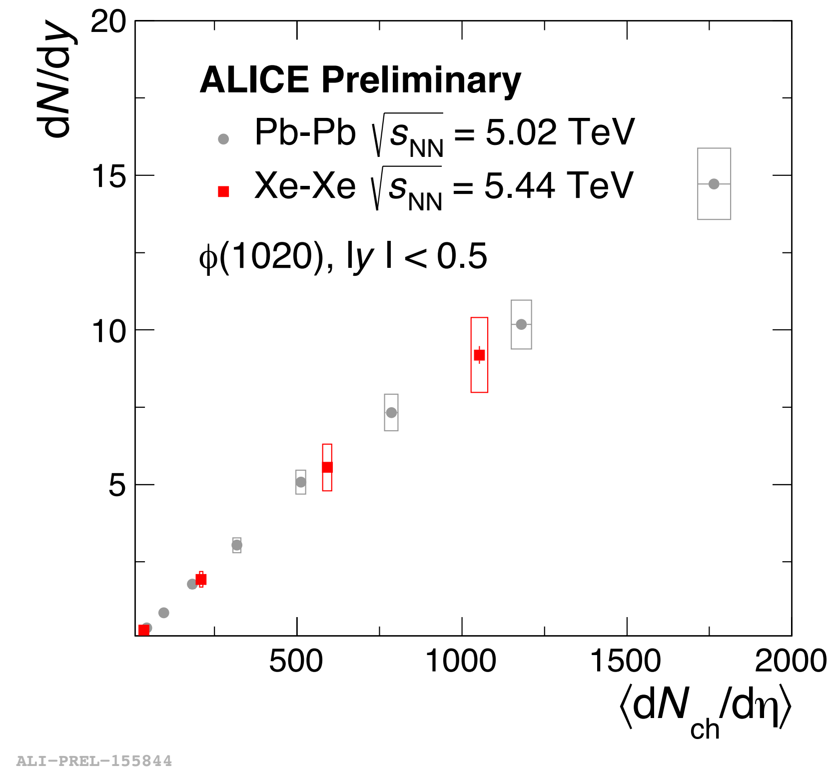
dN/dy vs multiplicity

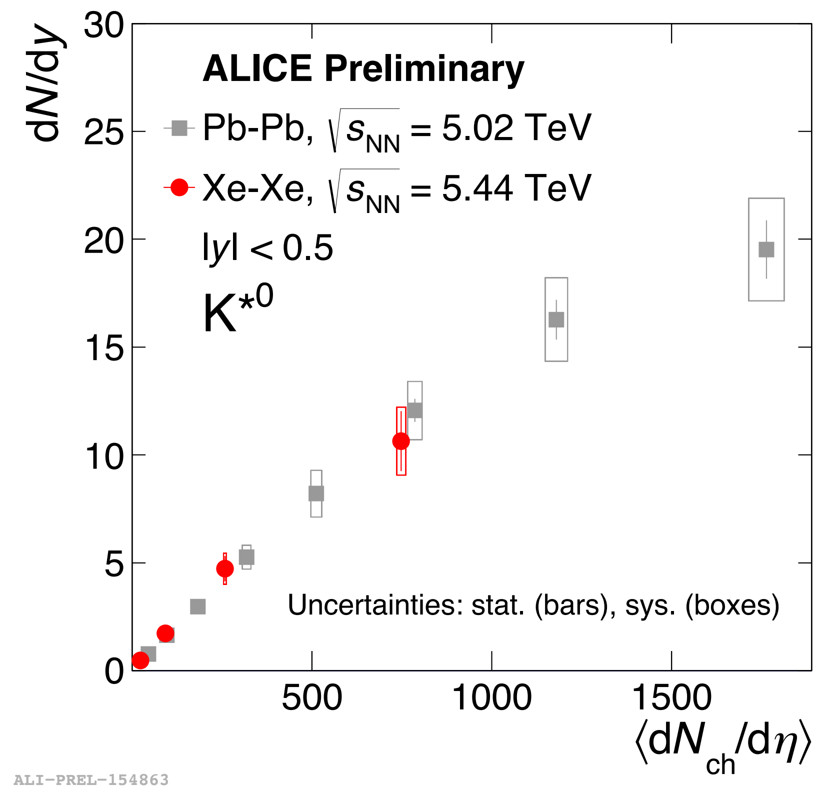
pp, p-Pb





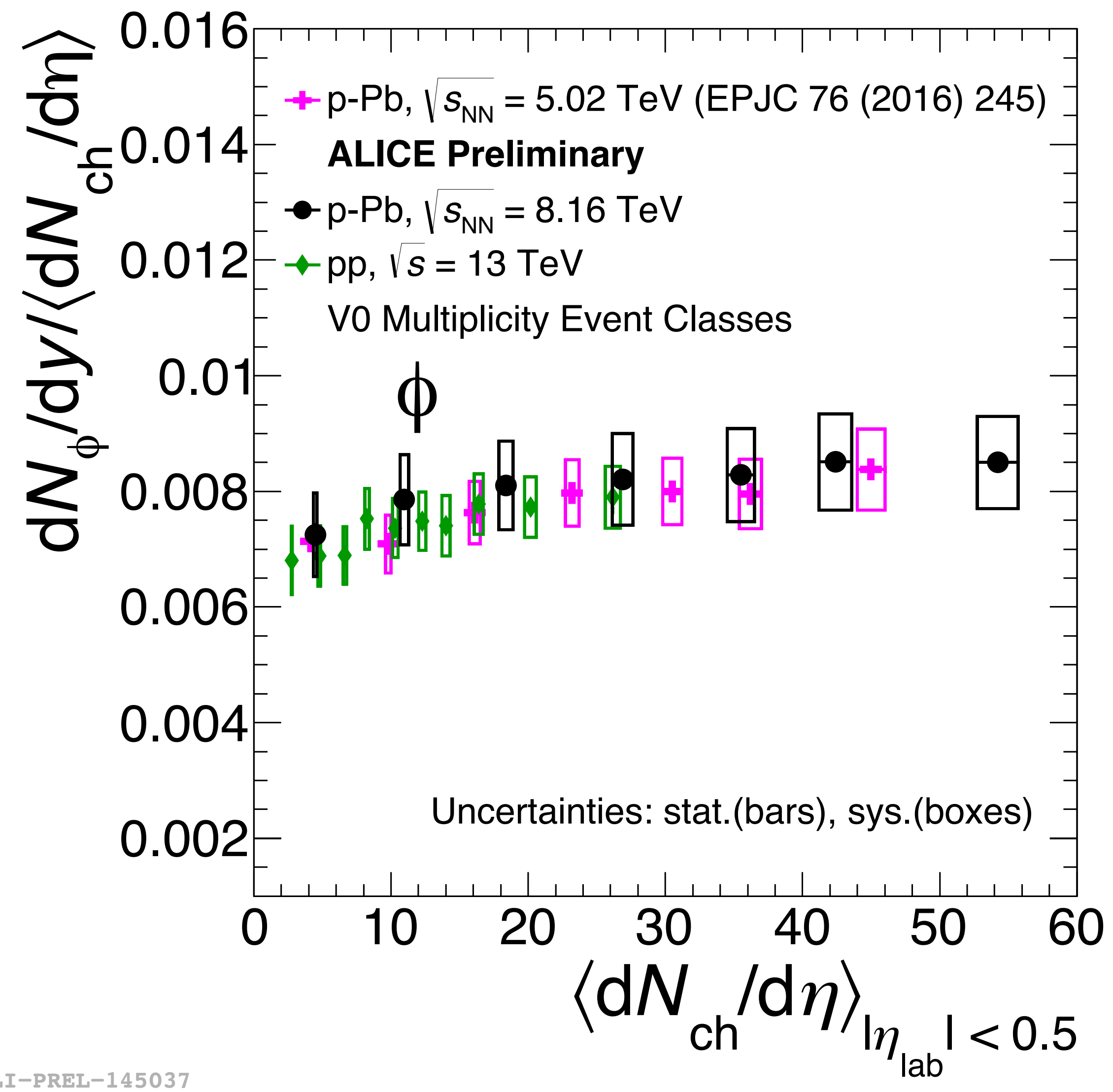
Xe-Xe, Pb-Pb

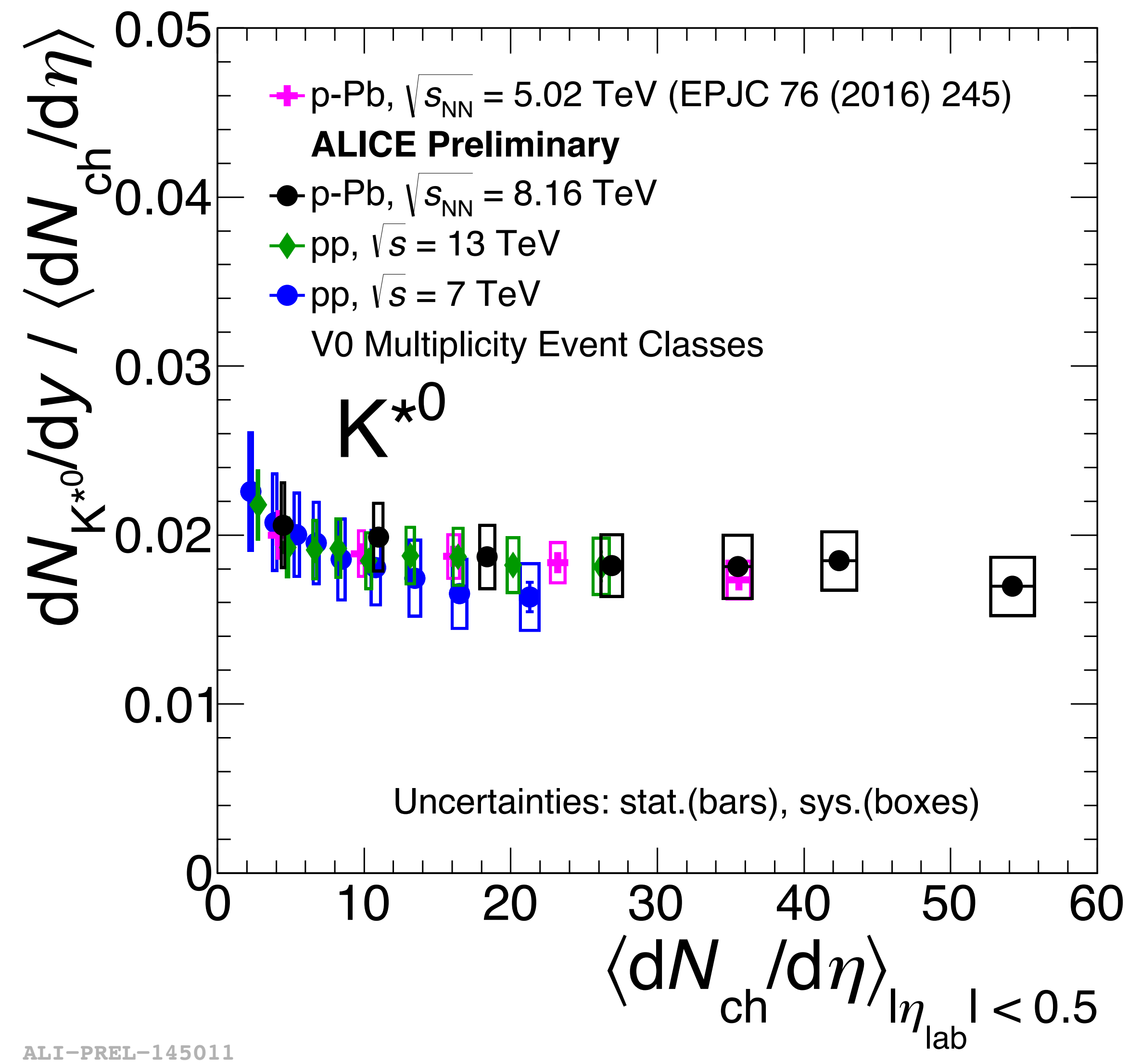




- ❖ dN/dy increases with increasing multiplicity
- ❖ dN/dy increases approximately linearly with multiplicity
- ❖ Independent of colliding systems and energies at similar charged particle multiplicity
- ❖ Event multiplicity drives the particle production irrespective of collision energy and system

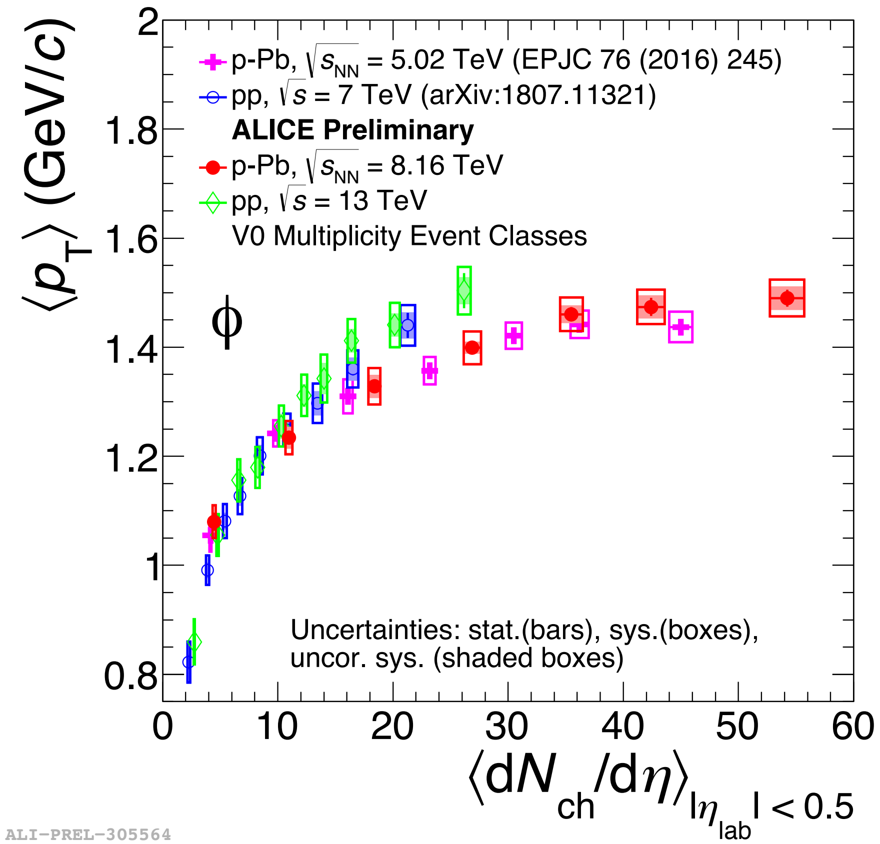
dN/dy vs multiplicity

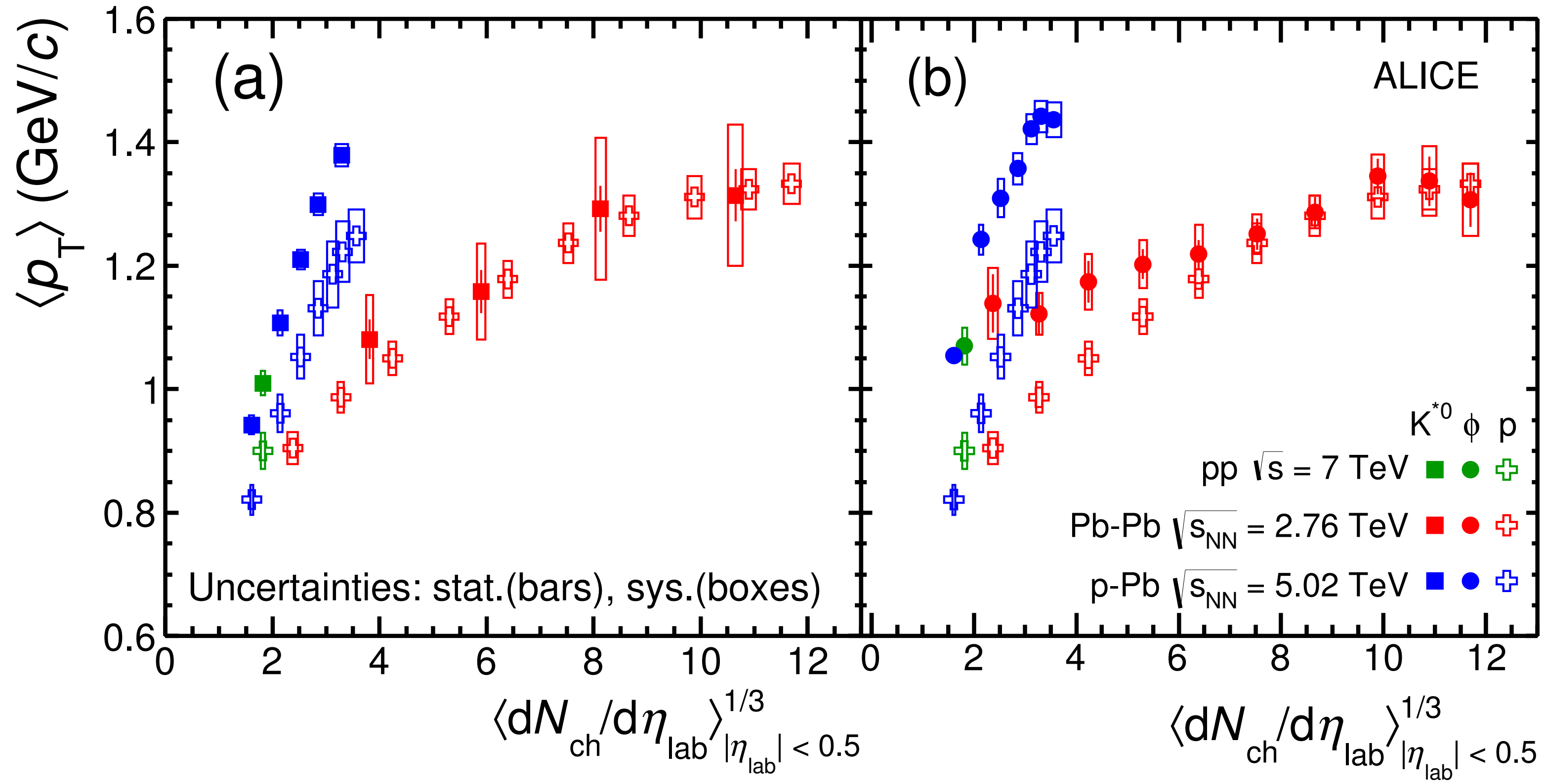


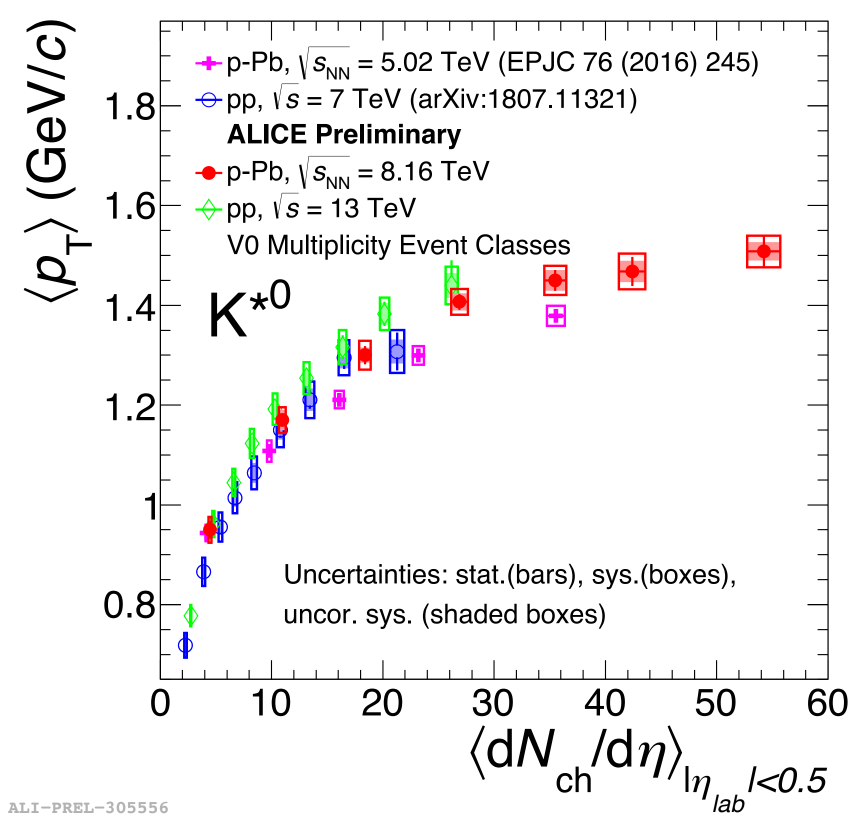


- ❖ $dN_{\phi}/dy / \langle dN_{ch}/d\eta \rangle$ slightly increasing with multiplicity (due to strangeness enhancement)
- ❖ $dN_{K^{*0}}/dy / \langle dN_{ch}/d\eta \rangle$ slightly decreasing with multiplicity (due to re-scattering)

Mean p_T vs multiplicity : mass ordering







- ❖ $\langle p_T \rangle$ increases with increasing multiplicity and seems to saturate for high multiplicity p-Pb collisions
- ❖ $\langle p_T \rangle$ follows different trends for different collision systems
- ❖ Mass ordering of $\langle p_T \rangle$ in central Pb-Pb
  ➔ as expected from hydrodynamics
- ❖ Mass ordering breaks down for small collision systems including peripheral Pb-Pb collisions
  ➔ $\langle p_T \rangle_\phi > \langle p_T \rangle_p$ though they have similar mass

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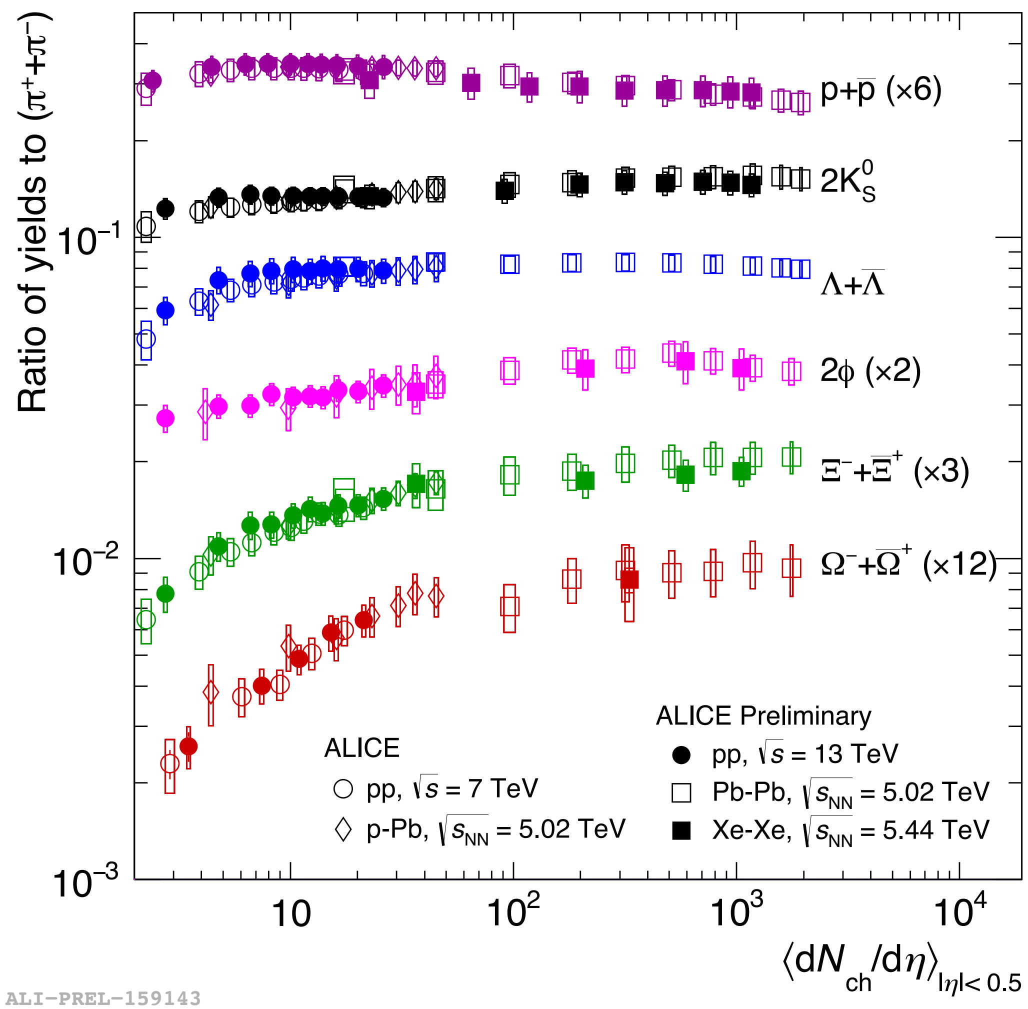
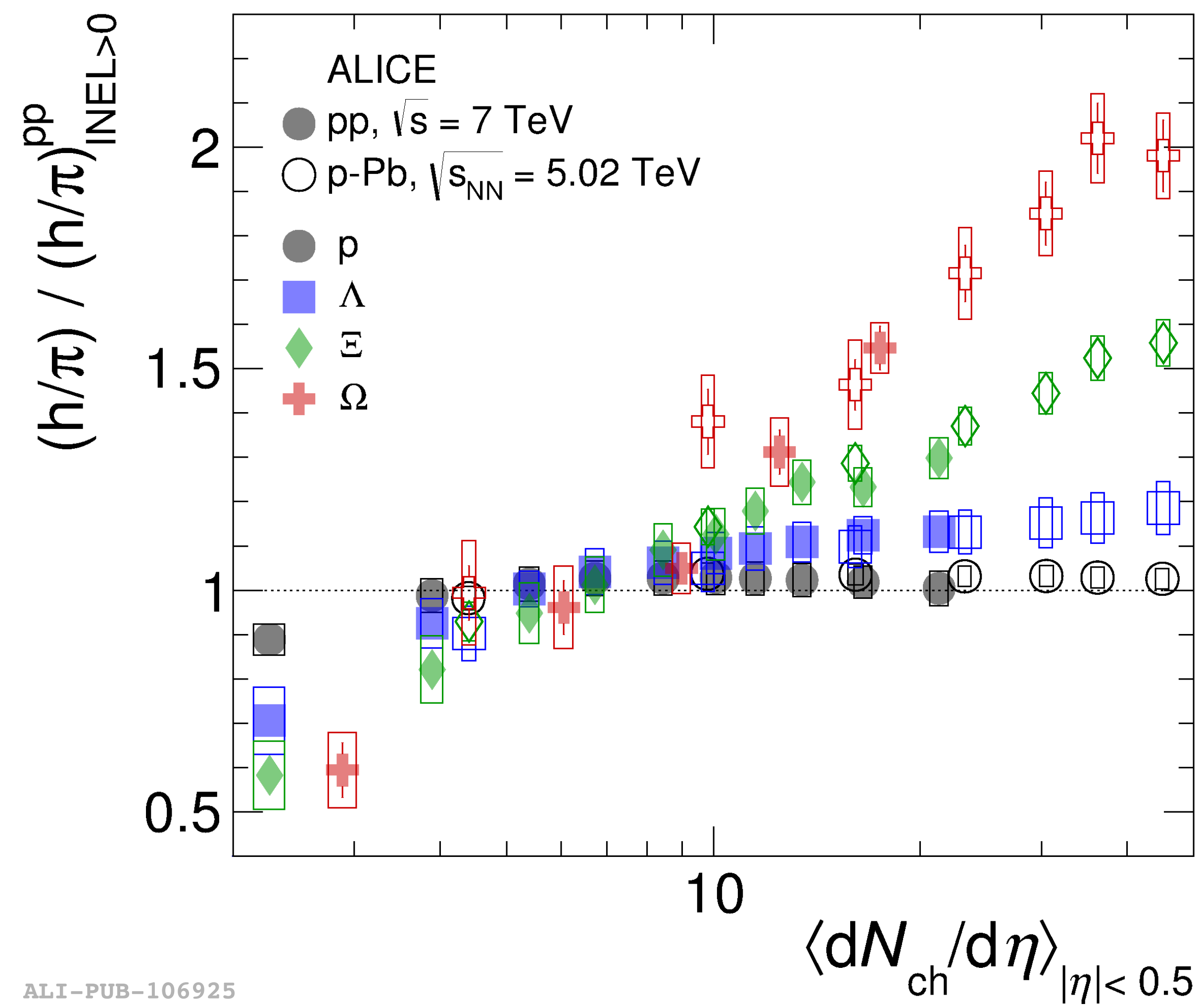
Relative Strangeness Production





- ❖ Hyperon production increases from low to high multiplicity in pp and p-Pb collisions
- ❖ The larger the valence strange quark content, the steeper the slope in the double ratio

  → the effect is due to strangeness and not due to baryon number or mass

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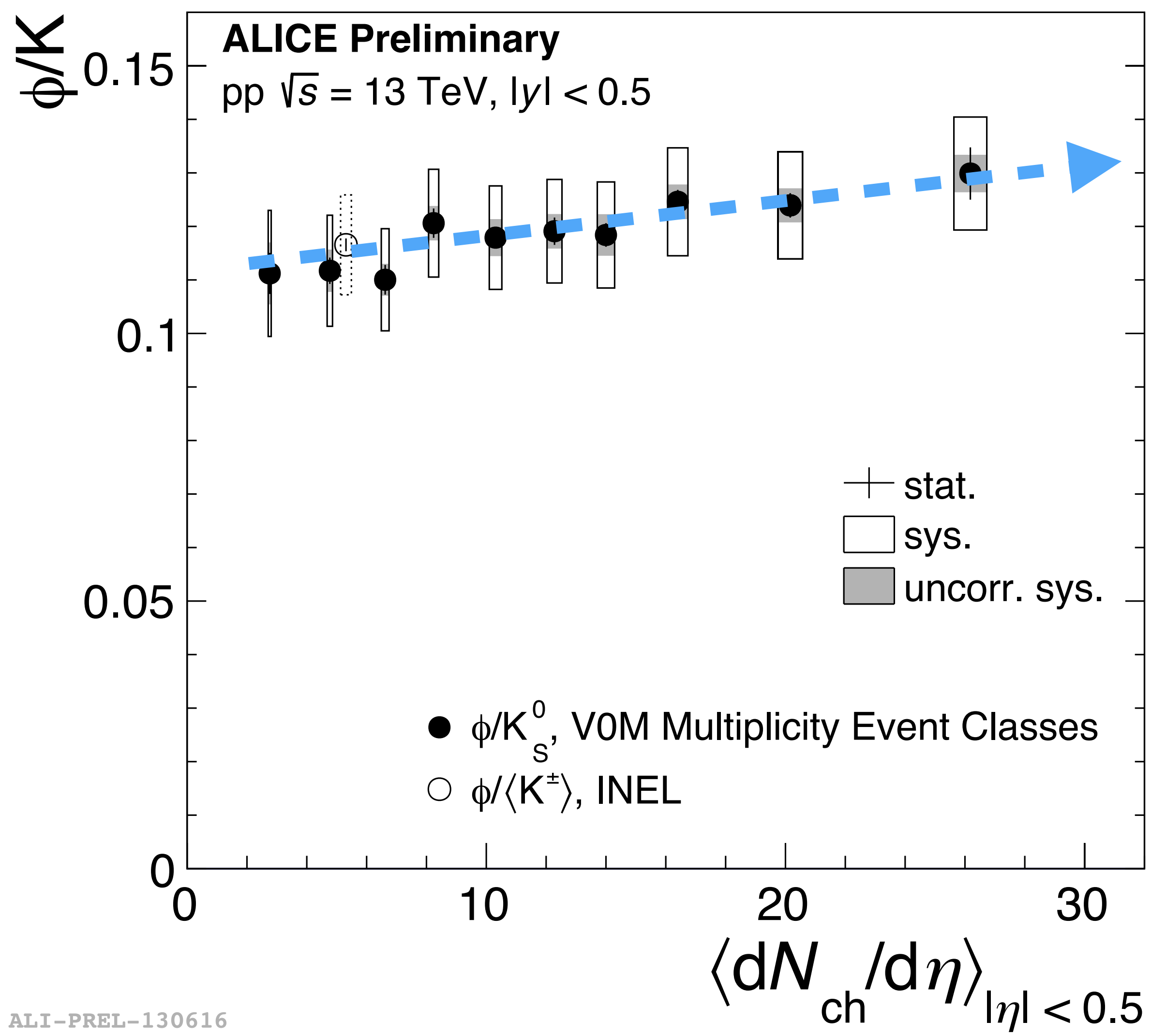
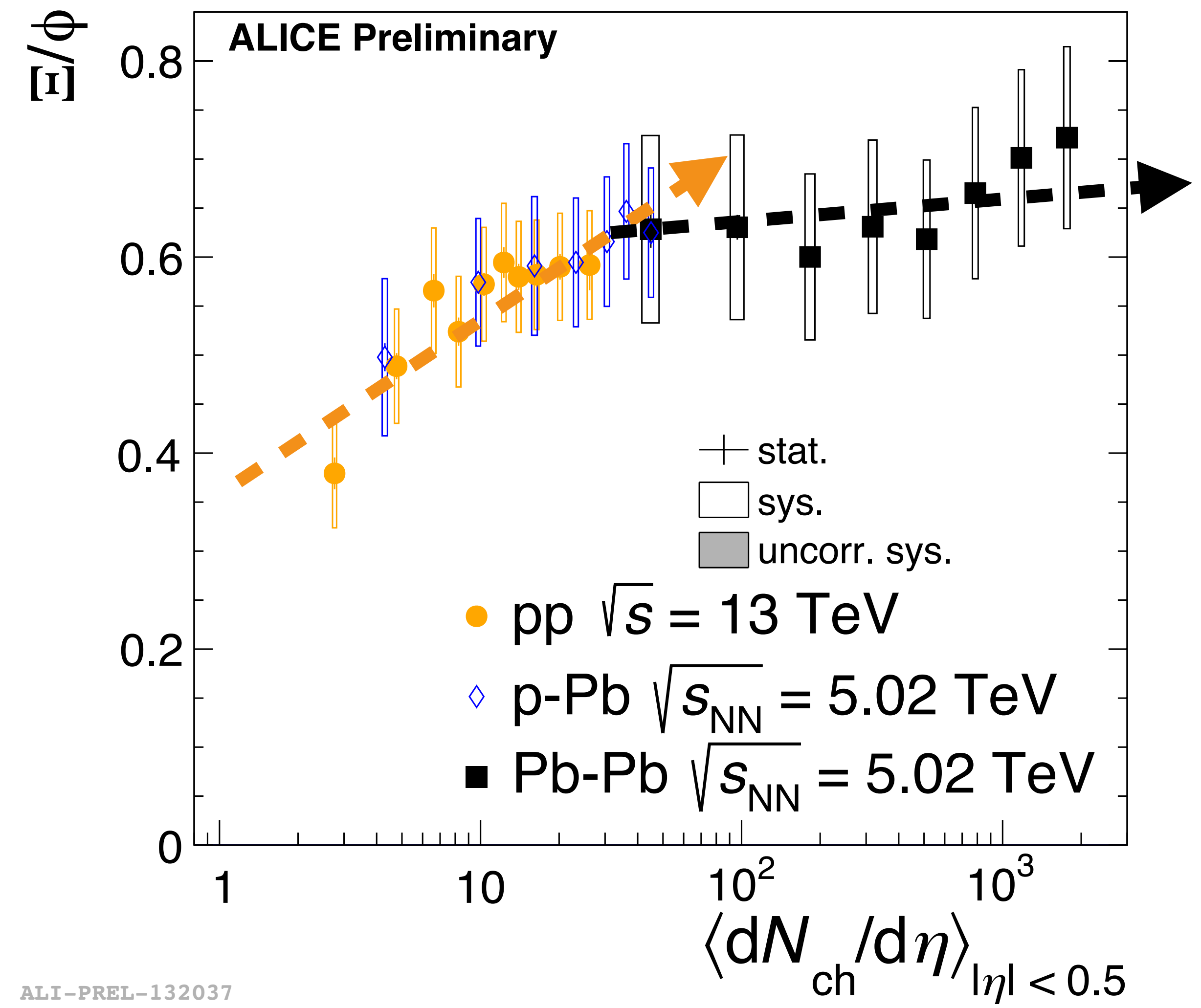
Special role of ϕ ($s\bar{s}$)



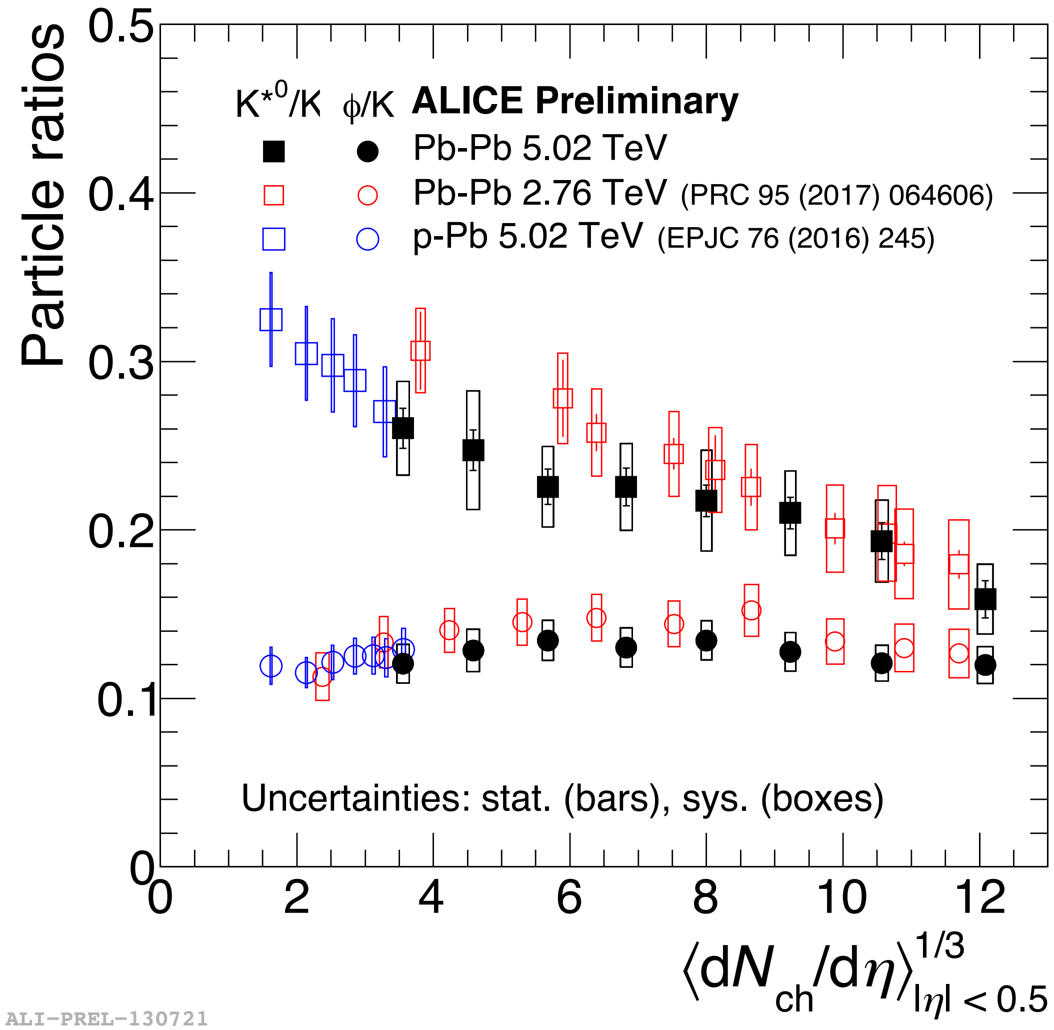


K and Ξ : Canonical suppression
ϕ : No canonical suppression

- ❖ Net strangeness of ϕ is zero (hidden strangeness), but it behaves like a particle with open strangeness
- ❖ S_ϕ : Effective strangeness of ϕ
- ❖ Flat or slightly increasing ϕ(|S|=0)/K(|S|=1) in pp
  -- suggesting $S_\phi \geq 1$
- ❖ Flat Ξ(|S|=2)/ϕ(|S|=0) for high multiplicities or slightly increasing in pp, p-Pb vs. multiplicity
  -- suggesting $S_\phi \sim 2$ or $S_\phi < 2$

ϕ behaves like a particle with strangeness between 1 and 2 ?

Particle ratio: Resonance to long lived particle



❖ **φ/K: shows no suppression**

- - From p-Pb and Pb-Pb collisions, almost constant behaviour with system size

→ No re-scattering or regeneration

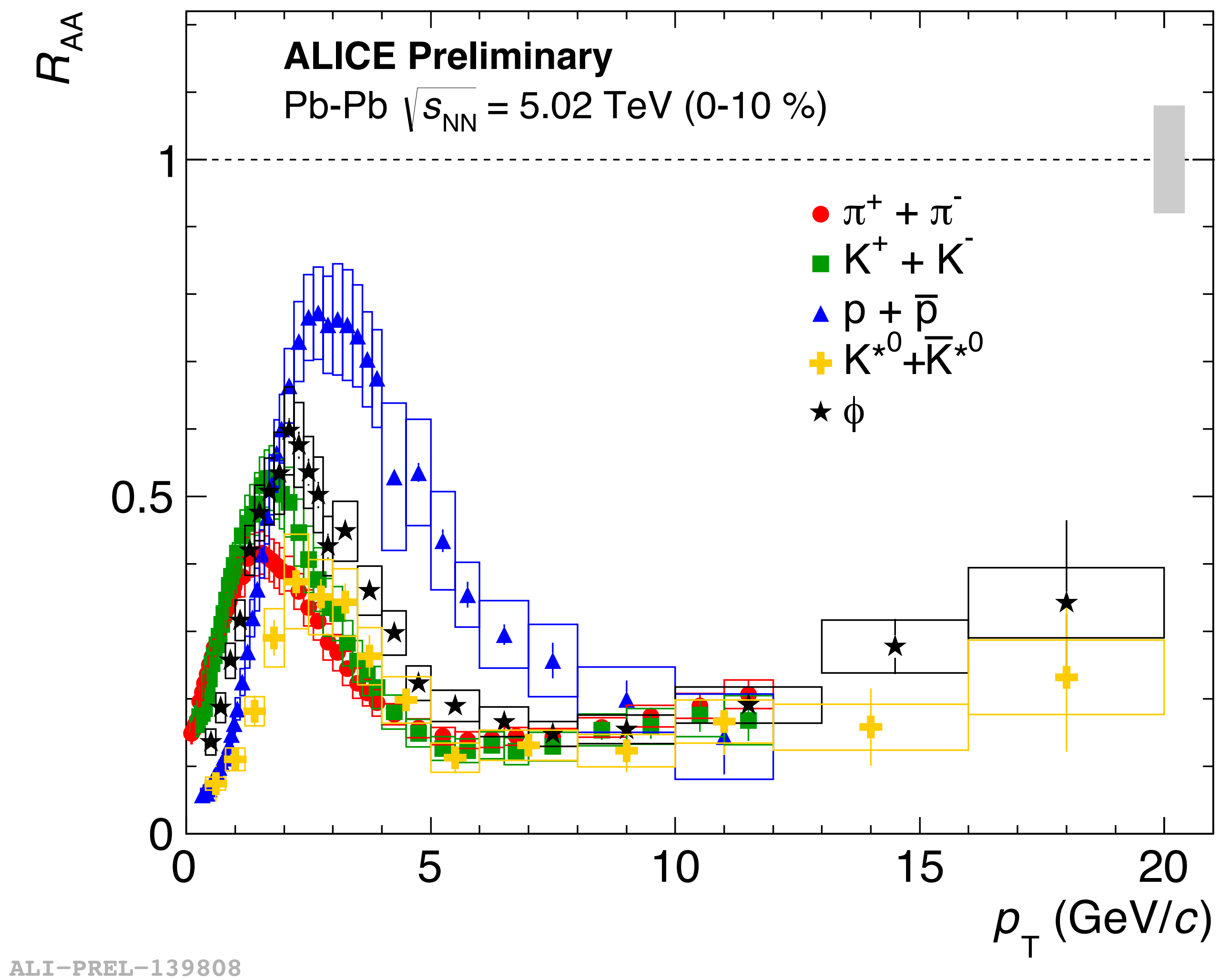
❖ **K^{*0}/K : shows clear suppression**

- - From p-Pb and peripheral Pb-Pb collisions to most central Pb-Pb collisions

→ Re-scattering dominates over regeneration

$\tau(\phi)$ = 46.2 fm/*c* >> $\tau(K^{*0})$ = 4.2 fm/*c*

Nuclear Modification Factor: R_{AA}



$$R_{AA}(p_T) = \frac{Yield_{AA}(p_T)}{Yield_{pp}(p_T)\times < N_{Coll} >}$$

✦ Low-p_T (< 2.0 GeV/c)

- - K^{*0} production is suppressed more than π, K and ϕ -> Re-scattering

✦ Intermediate-p_T (2< p_T < 8.0 GeV/c)

- - Difference between baryon and mesons, among the mesons (K^{*0},π, K and ϕ) -> Mass ordering

✦ Light flavoured hadrons shows similar suppression at high-p_T (> 8.0 GeV/c)

- - Flavour independence

Summary

❖ **p_T spectra**

- The shape of p_T spectra are different for different multiplicity classes ($p_T < 5.0$ GeV/c), spectra become harder with increasing multiplicity

❖ **Yields (d*N*/d*y*)**

- pp, p-Pb,Pb-Pb: Independent of colliding system, energy and driven by multiplicity

❖ **Mean p_T ($\langle p_T \rangle$)**

- In central Pb-Pb : Mass ordering as expected from hydrodynamics
- pp, p-Pb collisions : Mass ordering violated

❖ **Particle ratios**

- In p-Pb: hint of collective behaviour and strangeness enhancement ?
- ϕ has "effective strangeness" between 1-2 units ?
- K^{*0} show suppression whereas no suppression behaviour in ϕ

❖ **Nuclear modification factor**

- In Pb-Pb: Consistent with light-flavoured hadrons at $p_T > 8.0$ GeV/*c*
- Suppression in K*0 at lower p_T due to re-scattering

Thank you