An insight into strangeness with $\phi(1020)$ production from small to large collision systems with ALICE at the LHC

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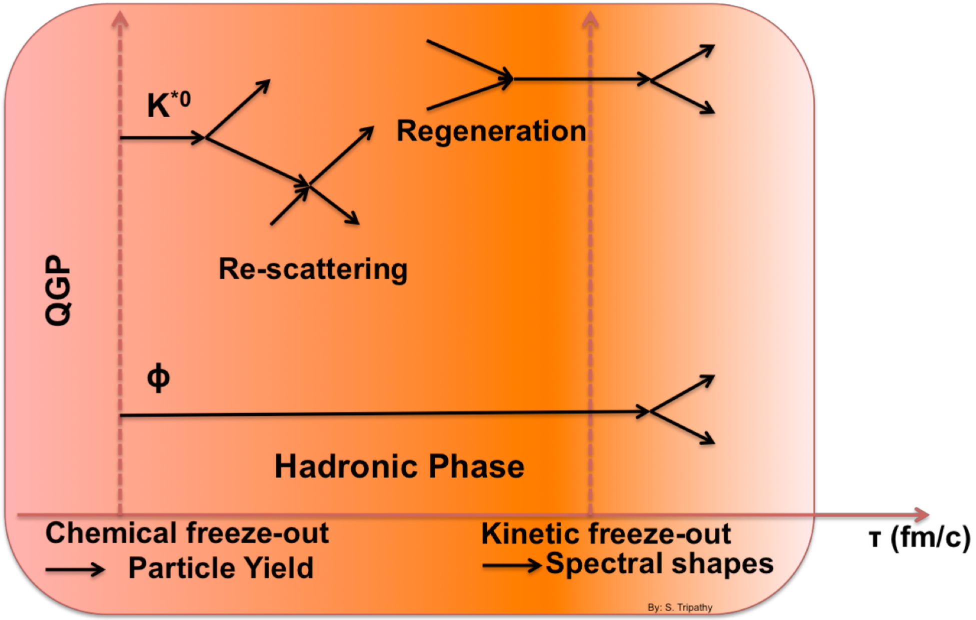
XXIII DAE-BRNS HIGH ENERGY PHYSICS SYMPOSIUM 2018
December 10 - 14, 2018

Outline

- ***Introduction***
- ***Signal Extraction***
- ***Transverse momentum (p_T) spectra and mean-p_T***
- ***ϕ vs. other resonances***
- ***Strangeness enhancement***
- ***Effective strangeness of ϕ***
- ***Conclusion***

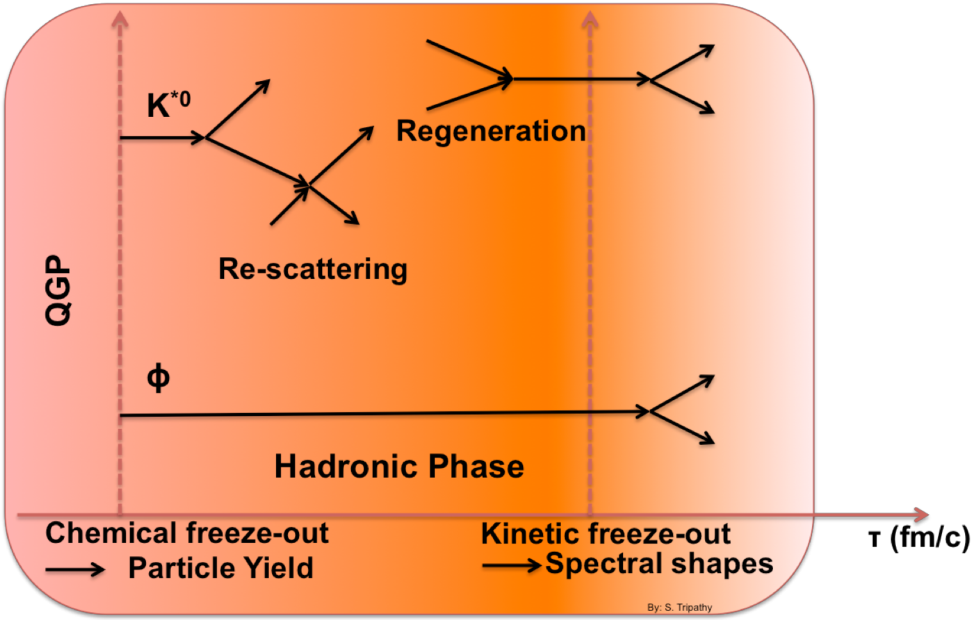
Introduction

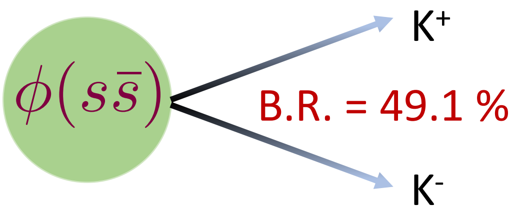


- ***Resonances are sensitive to evolution dynamics and are important to probe the hadronic phase due to their short lifetimes***
- ***Re-scattering of decay daughters results in signal loss and regeneration of resonance results in signal gain***

More on Resonances → Stay tuned for S. Dudi's talk at 15:15 today

Introduction

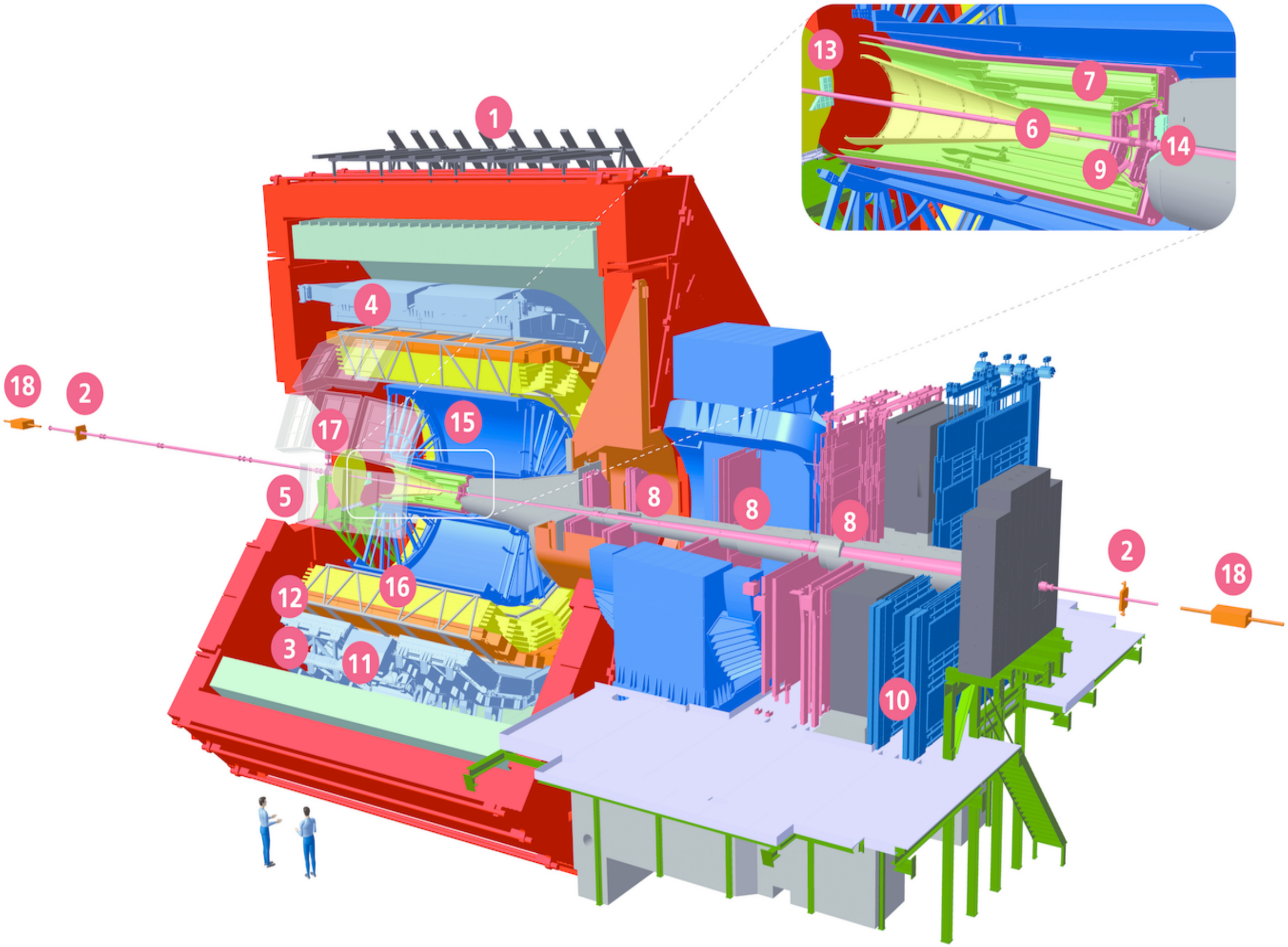




- ***Mass =*** 1.019 GeV/c^2
- ***Width =*** 4.25 MeV/c^2
- ***Lifetime =*** 46.4 fm/c

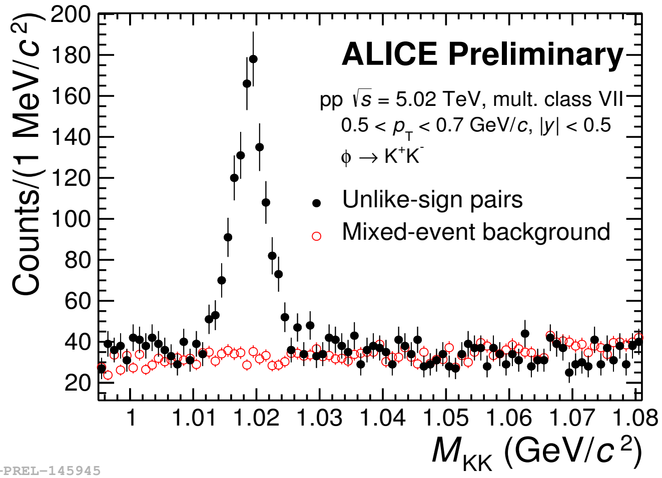
- *Resonances are sensitive to evolution dynamics and are important to probe the hadronic phase due to their short lifetimes*
- *Re-scattering of decay daughters results in signal loss and regeneration of resonance results in signal gain*
- *As ϕ consists of strange valence quarks, it can shed light into strangeness production*
- *Effective strangeness of ϕ?*

ALICE Detector



1. **ACORDE** | ALICE Cosmic Rays Detector
2. **AD** | ALICE Diffractive Detector
3. **DCal** | Di-jet Calorimeter
4. **EMCal** | Electromagnetic Calorimeter
5. **HMPID** | High Momentum Particle Identification Detector
6. **ITS-IB** | Inner Tracking System - Inner Barrel
7. **ITS-OB** | Inner Tracking System - Outer Barrel
8. **MCH** | Muon Tracking Chambers
9. **MFT** | Muon Forward Tracker
10. **MID** | Muon Identifier
11. **PHOS / CPV** | Photon Spectrometer
12. **TOF** | Time Of Flight
13. **T0+A** | Tzero + A
14. **T0+C** | Tzero + C
15. **TPC** | Time Projection Chamber
16. **TRD** | Transition Radiation Detector
17. **V0+** | Vzero + Detector
18. **ZDC** | Zero Degree Calorimeter

Signal Extraction



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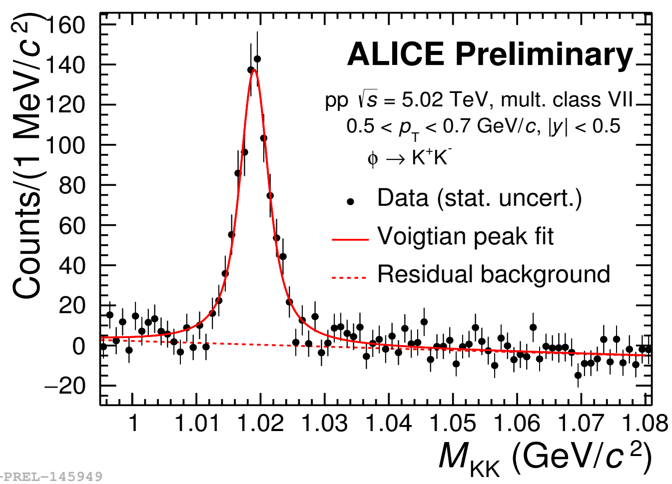


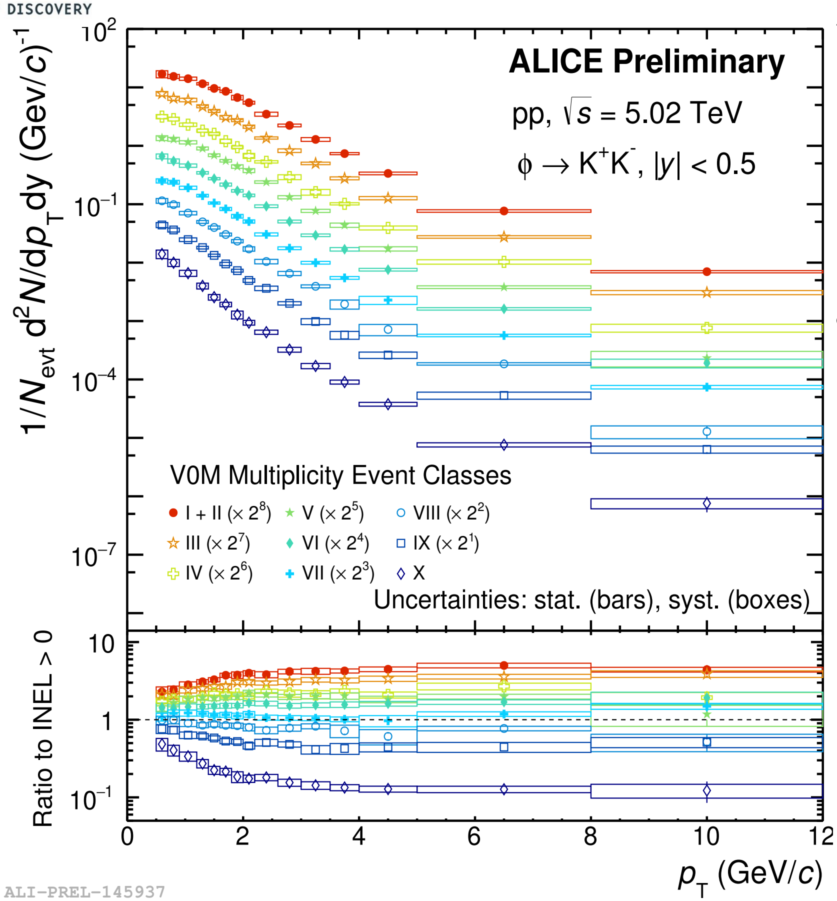
ALI-PREL-145949

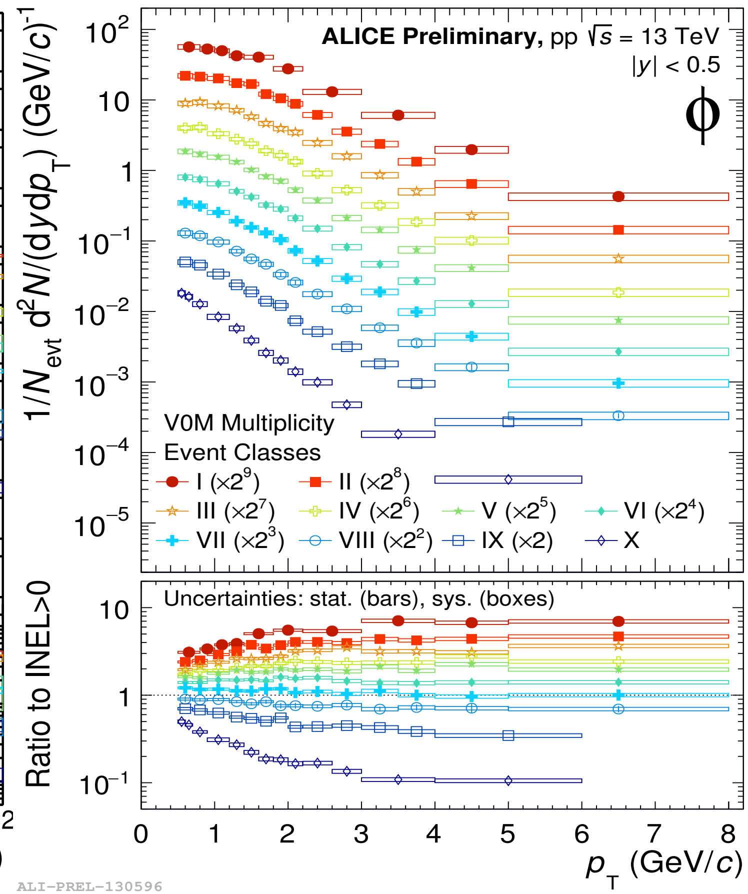
- ***ϕ(1020) is reconstructed via invariant mass technique***
- ***The uncorrelated background is estimated using event-mixing and like-sign technique.***
- ***In different p_T intervals, raw yields are obtained from the combinatorial background subtracted signal distributions***
- ***ϕ(1020) peak is fitted with a Voigtian function and residual background is fitted with 2nd order polynomial***

$$\frac{\mathrm{d}N}{\mathrm{d}m_{\mathrm{KK}}} = \frac{A\Gamma}{(2\pi)^{3/2}\sigma}\int_{-\infty}^{\infty}\exp\left[-\frac{(m_{\mathrm{KK}}-m')^2}{2\sigma^2}\right]\frac{1}{(m'-M)^2+\Gamma^2/4}\mathrm{d}m'$$

- ***A Voigtian function is used due to the fact that the mass resolution and width of ϕ have similar magnitudes***

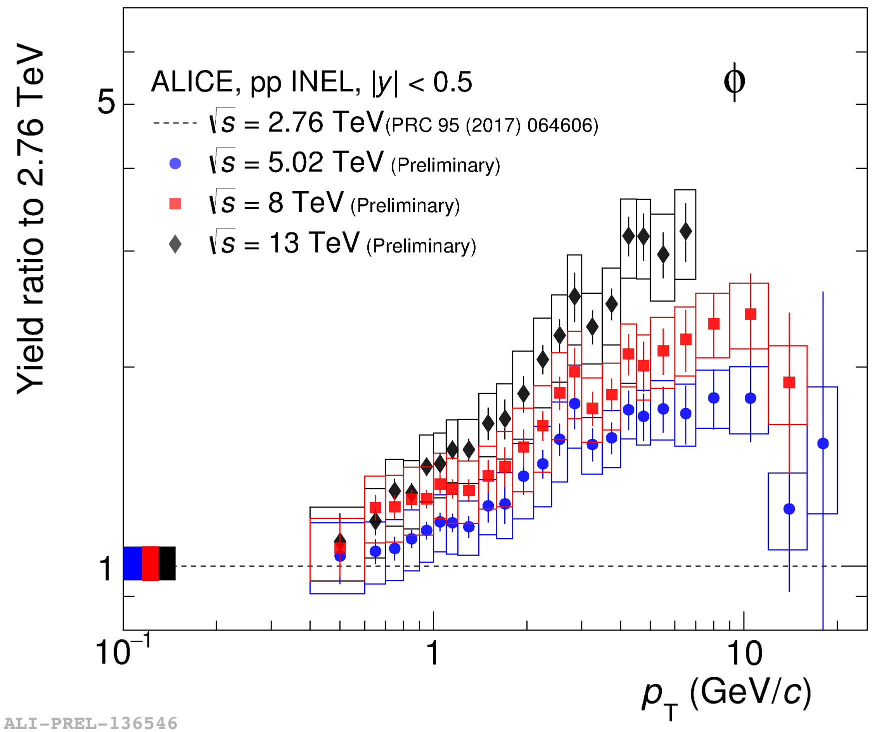
Transverse momentum (p_T) Spectra

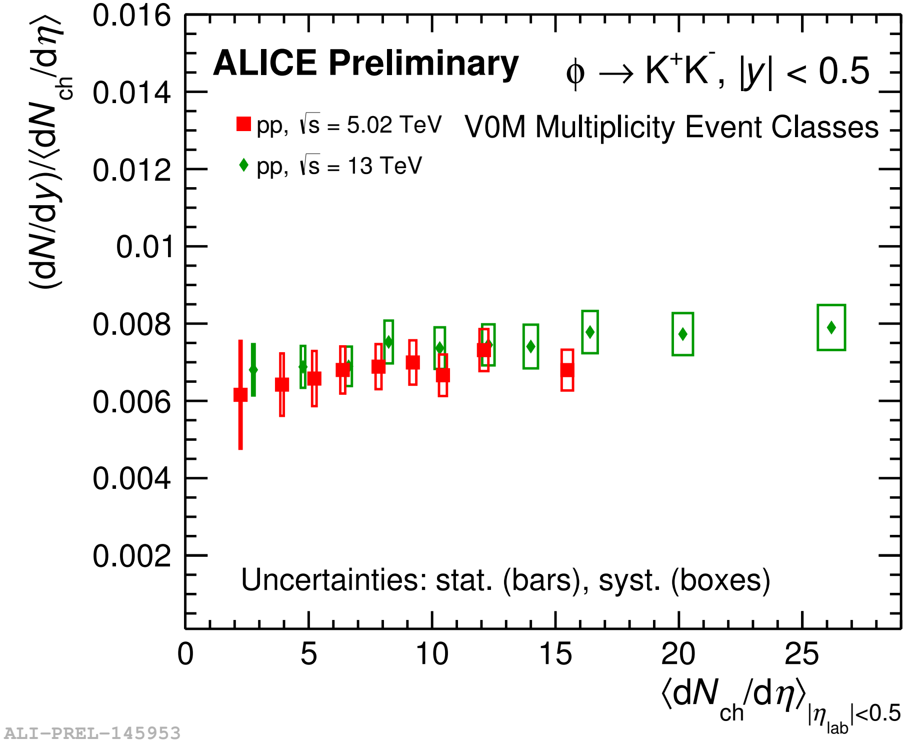




- ***p_T-spectra measured in fine multiplicity bins at three collision energies in pp***
- ***Ratio to INEL>0 increases at low p_T → hardens with increasing multiplicity***
- ***For p_T > 4 GeV/c, spectral shape is independent of multiplicity***
- ***Similar behavior observed for other light flavored particles***

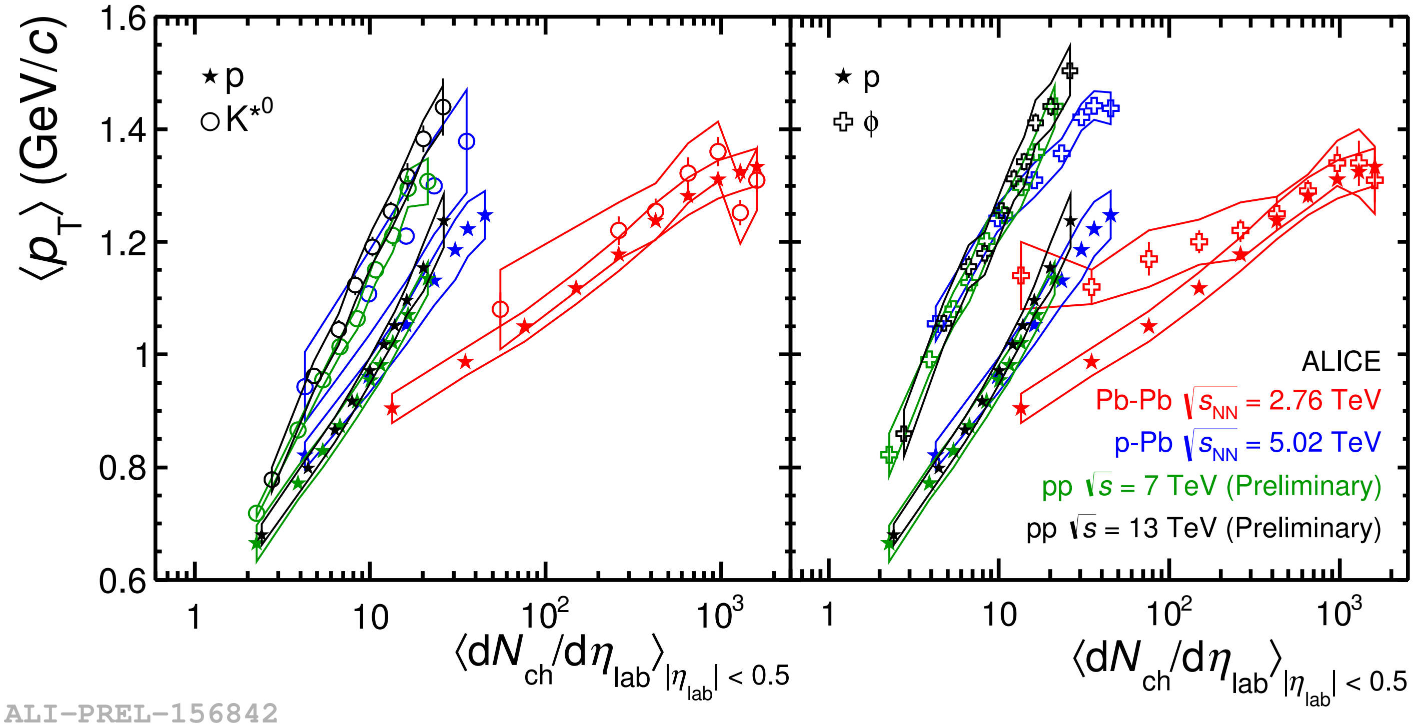
p_T-differential yield Ratio and Integrated yields





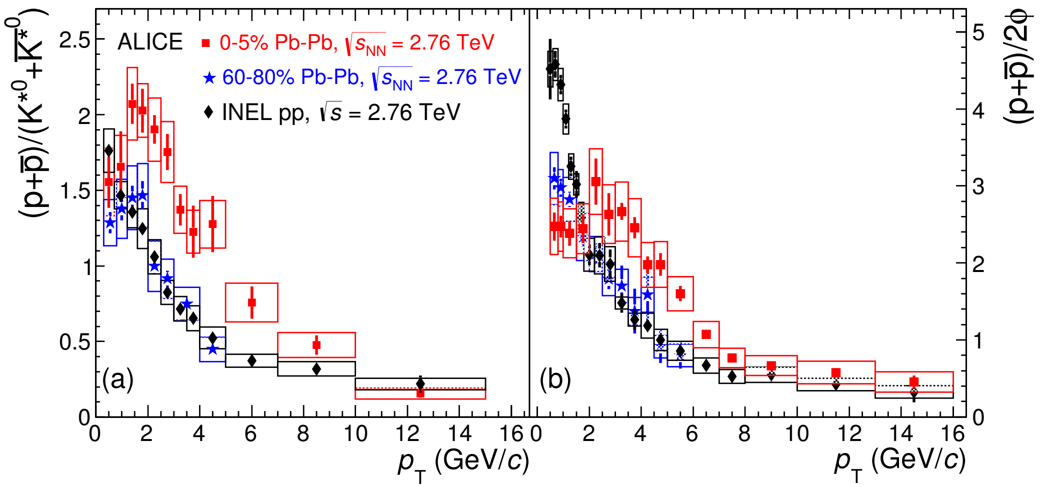
- ***High-p_T yields increase as a function of collision energy***
- ***Bulk production at low-p_T is independent of collision energy***
- ***Event multiplicity drives the particle production, irrespective of collision energy***

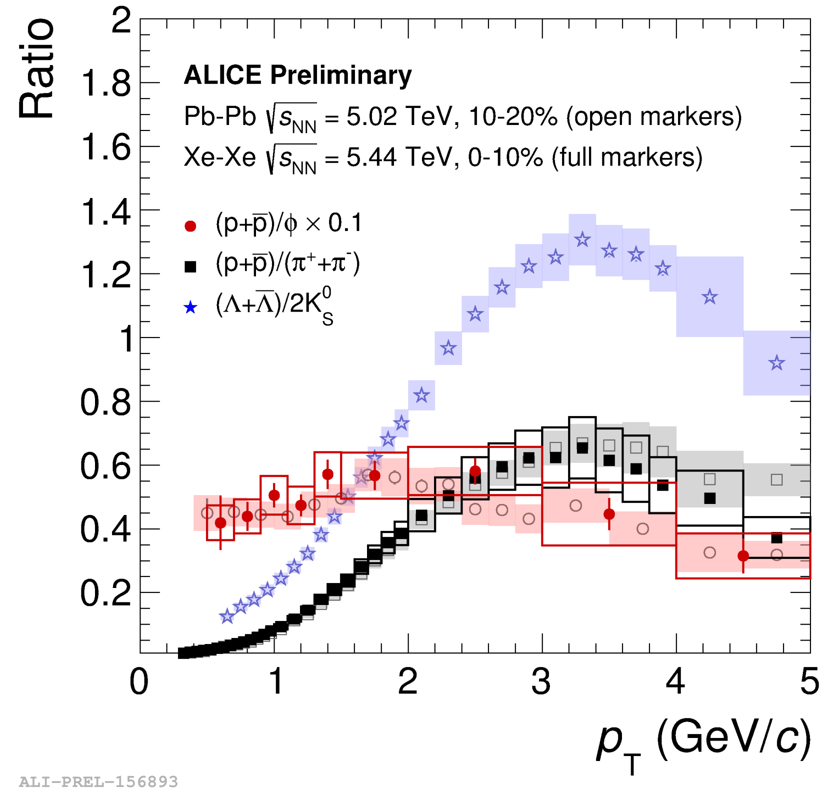
Mean Transverse Momentum



- *Similar $<p_T>$ for K^{*0}, p and ϕ in central Pb-Pb collisions → expected from hydrodynamical models (similar mass)*
- *pp and p-Pb follow same trend as a function of multiplicity while the trend is different for Pb-Pb collisions*
- *Exceed central Pb-Pb values in high multiplicity pp and p-Pb collisions*

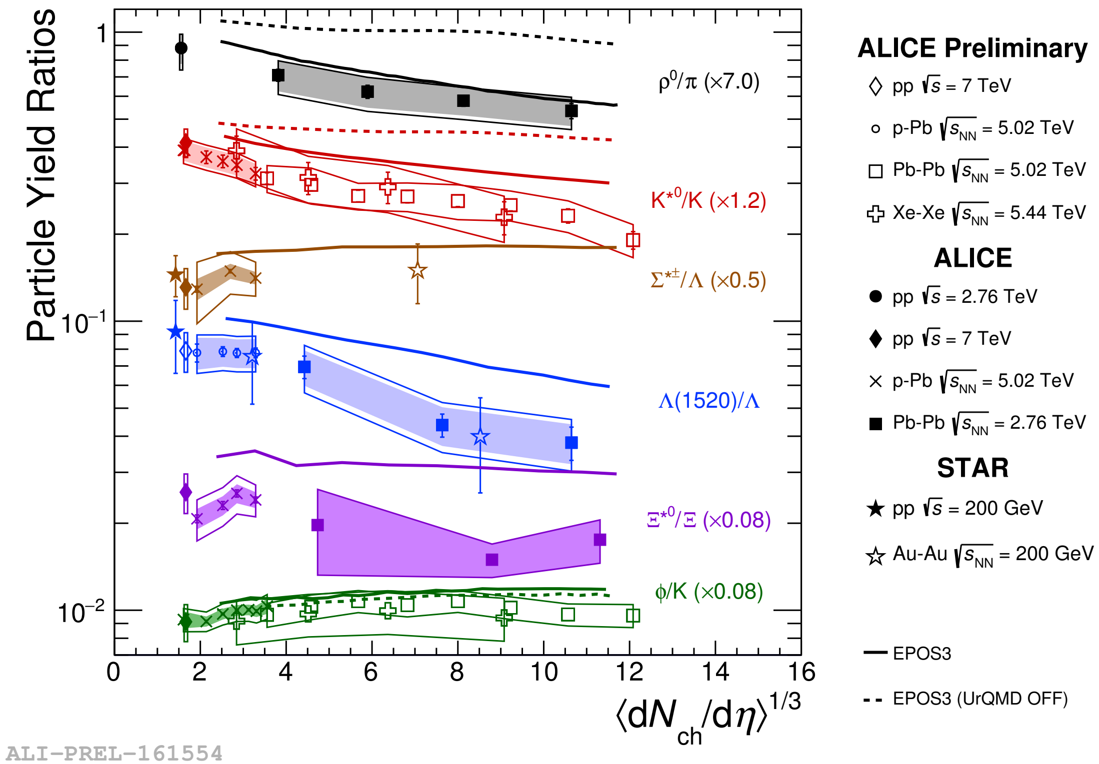
Particle Ratios





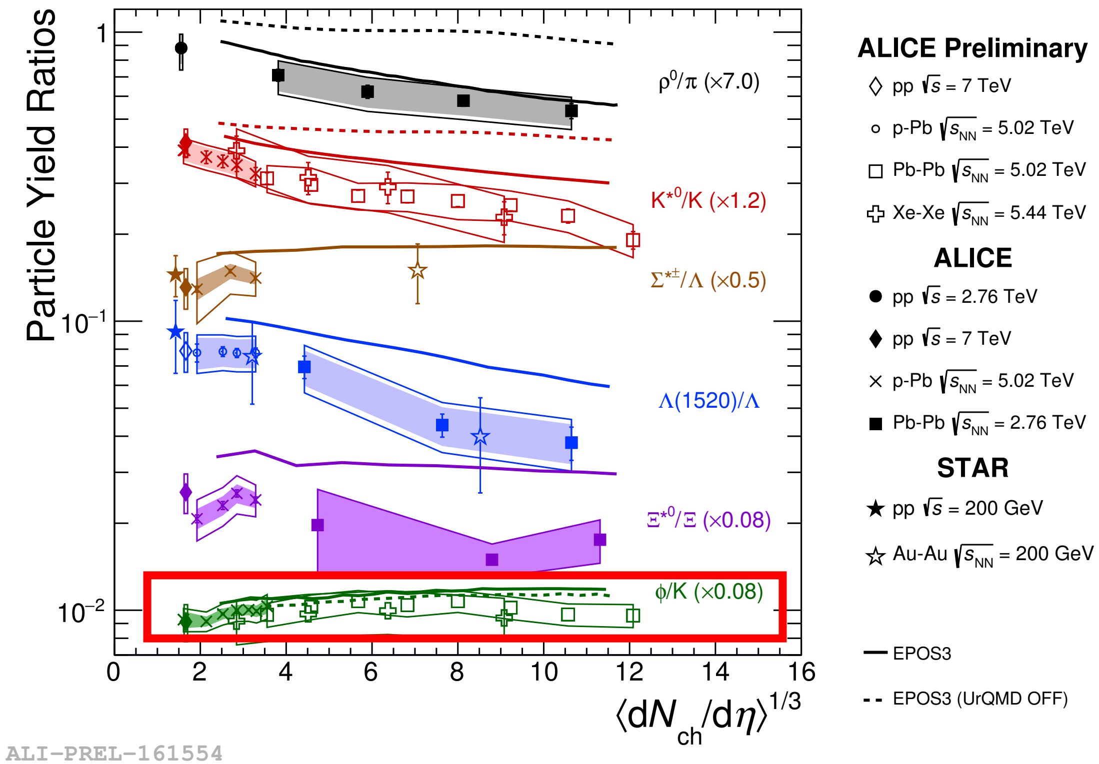
- ***p/ϕ ratio is almost flat at low-p_T for central Pb-Pb and Xe-Xe collisions → expected from hydrodynamical (similar mass) but can be described with latest recombination models.***
- ***p/ϕ ratio drops at high-p_T and becomes similar to peripheral Pb-Pb and inelastic pp collisions.***

ϕ vs other Resonances



- ***Short-lived resonances are suppressed in large collision systems with respect to thermal model prediction and with respect to pp and peripheral Pb-Pb collisions***
- ***EPOS (with UrQMD) seems to describe the resonance suppression qualitatively while without modeling the hadronic phase via UrQMD, does not describe the suppression.***

ϕ vs other Resonances



- ***Short-lived resonances are suppressed in large collision systems with respect to thermal model prediction and with respect to pp and peripheral Pb-Pb collisions***
- ***EPOS (with UrQMD) seems to describe the resonance suppression qualitatively while without modeling the hadronic phase via UrQMD, does not describe the suppression.***

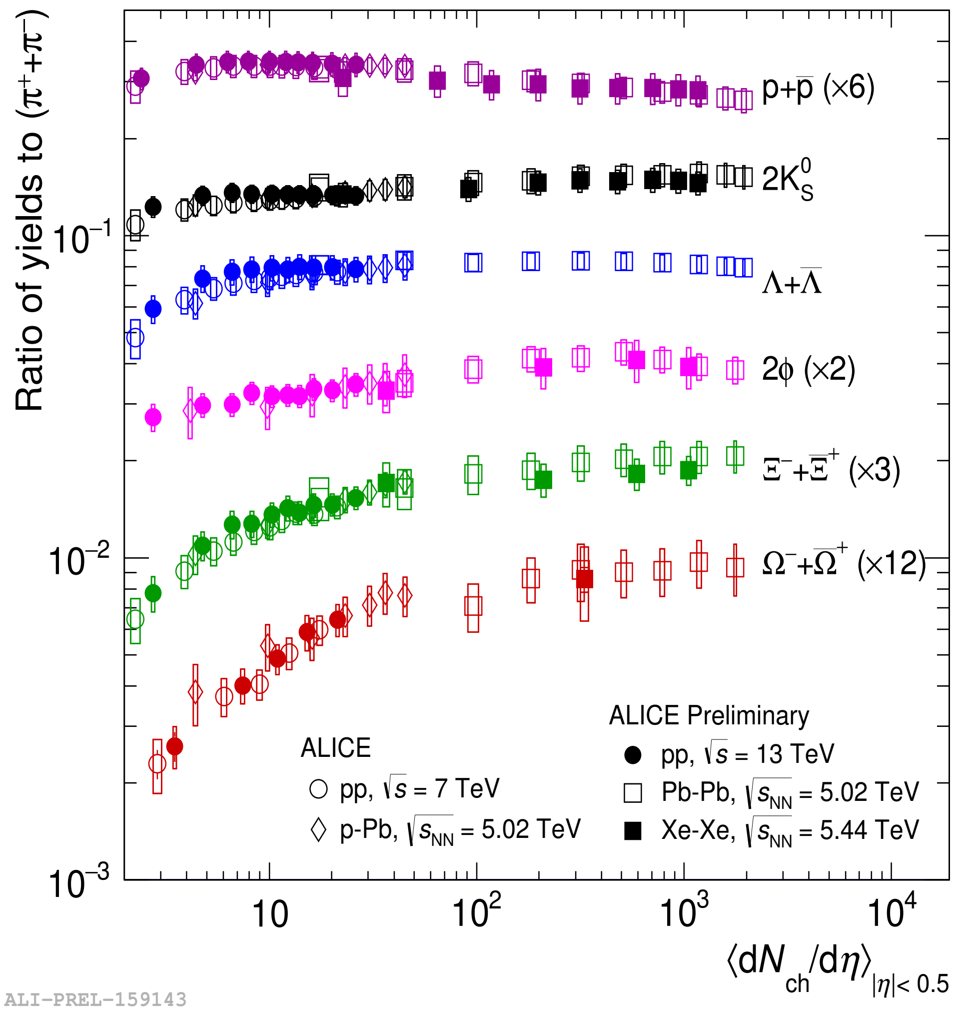
- ***The modelling of hadronic phase via UrQMD doesn't affect ϕ production.***
- ***ϕ is not suppressed due to its long lifetime compared to the lifetime of fireball.***

Small fraction of ϕ decays in the hadronic phase

Strangeness Enhancement

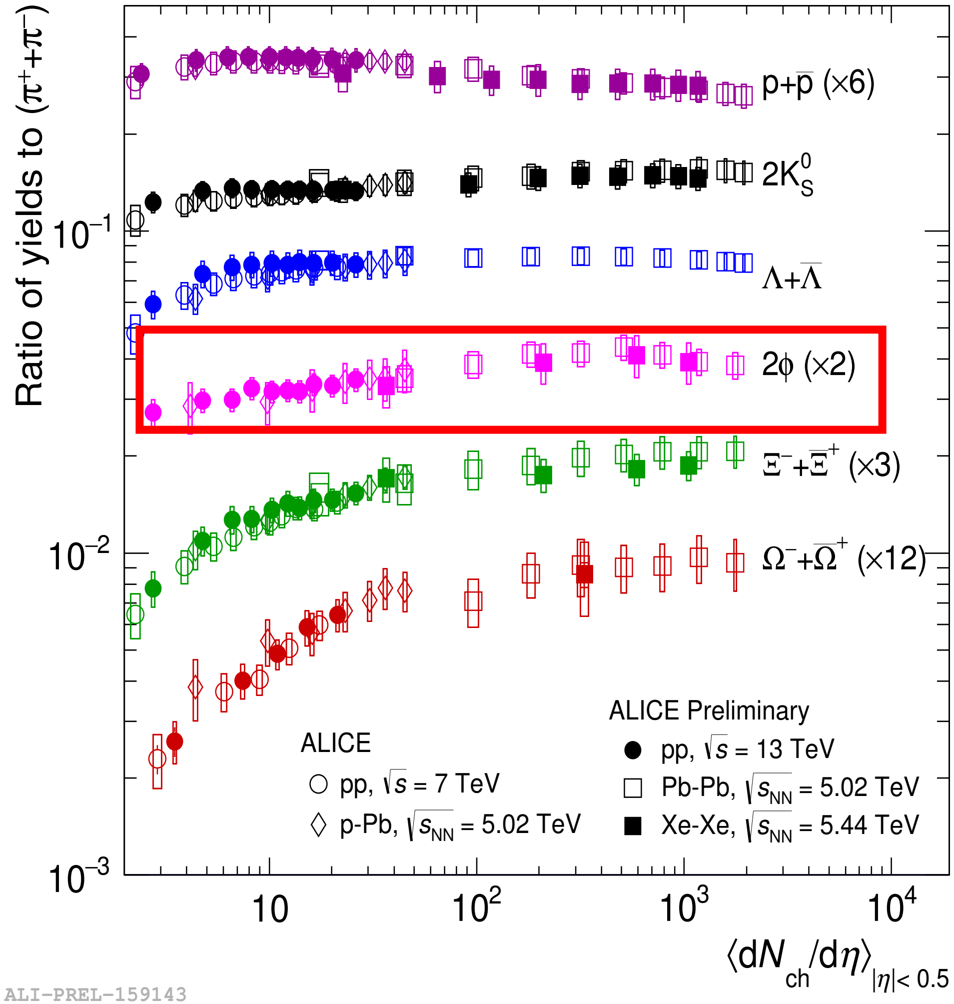
- ***ALICE for the first time observed the strange particle enhancement in high multiplicity collisions of small system, pp and p-Pb.***

- ***The strangeness enhancement increases with particle strangeness content***



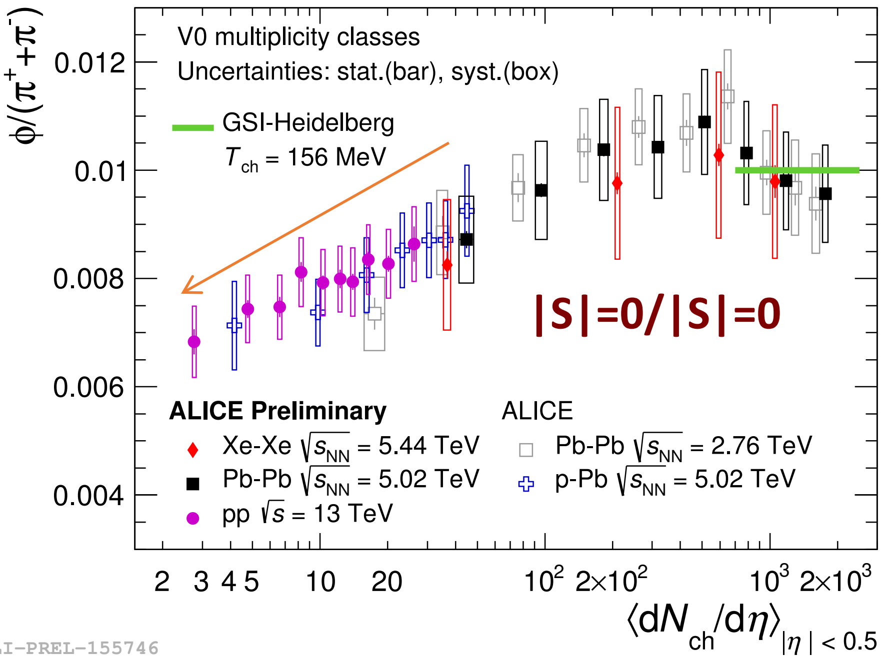
Strangeness Enhancement

- *ALICE for the first time observed the strange particle enhancement in high multiplicity collisions of small system, pp and p-Pb.*
- *The strangeness enhancement increases with particle strangeness content*
- ***ϕ/π shows the same trend as K/π.***
- ***Possible stronger increase for Λ/π compared to K/π and ϕ/π in very low multiplicity pp collisions.***



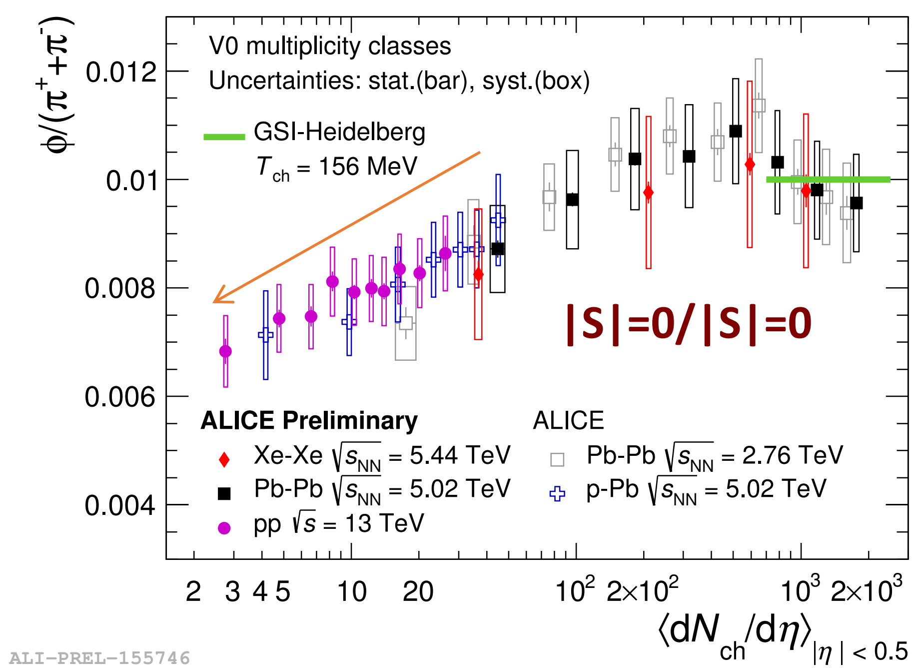
What is the effective strangeness of ϕ?

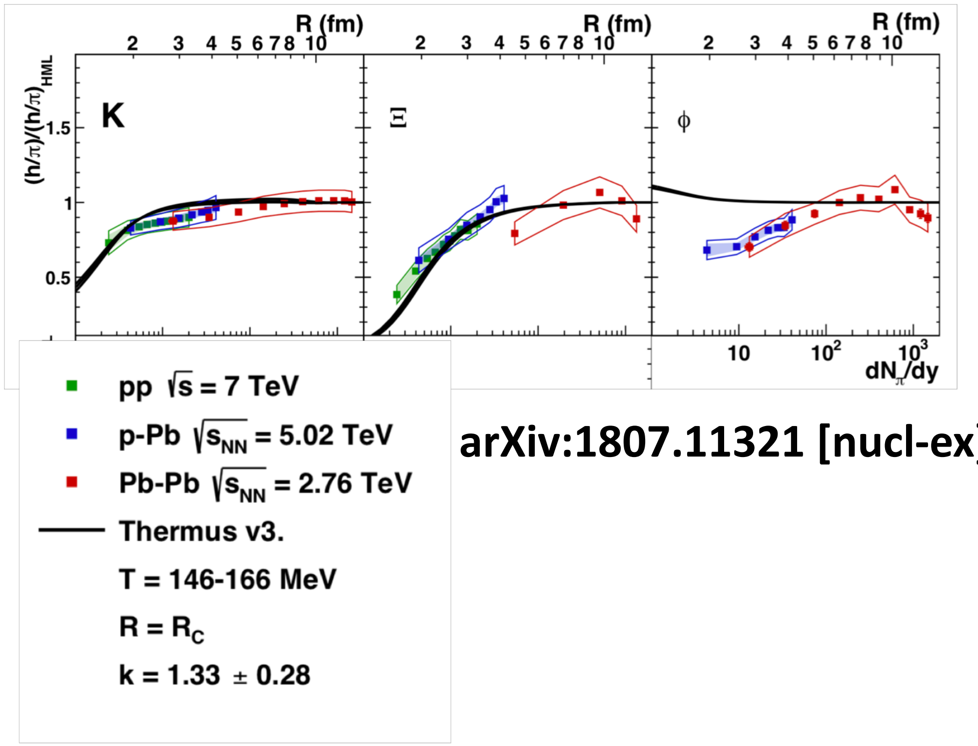
Effective strangeness of ϕ



➢ ***ϕ(S=0) yield in agreement with thermal model expectation in central Pb-Pb collisions***

Effective strangeness of ϕ

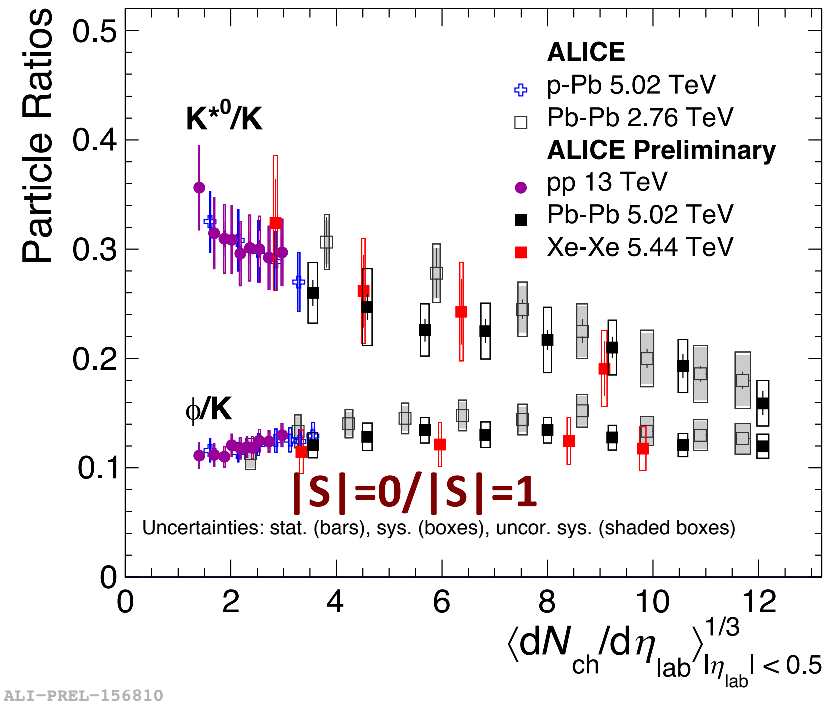




arXiv:1807.11321 [nucl-ex]

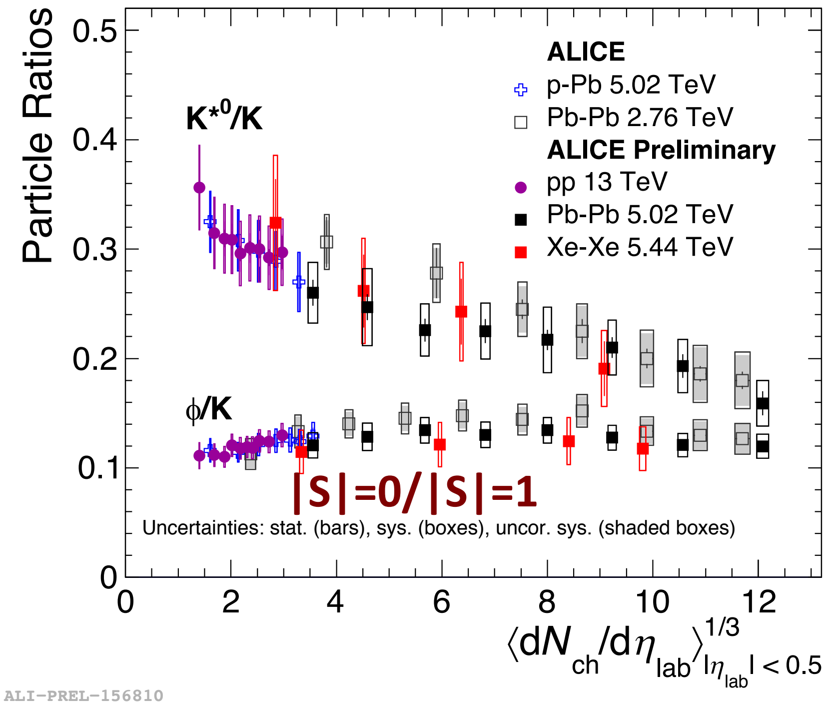
- ***ϕ(S=0) yield in agreement with thermal model expectation in central Pb-Pb collisions***
- ***But decreases towards smaller multiplicity in contrast to the expectation from strangeness canonical suppression***
- ***Favors non-equilibrium production (γ_s<1) of ϕ or all strange particles.***

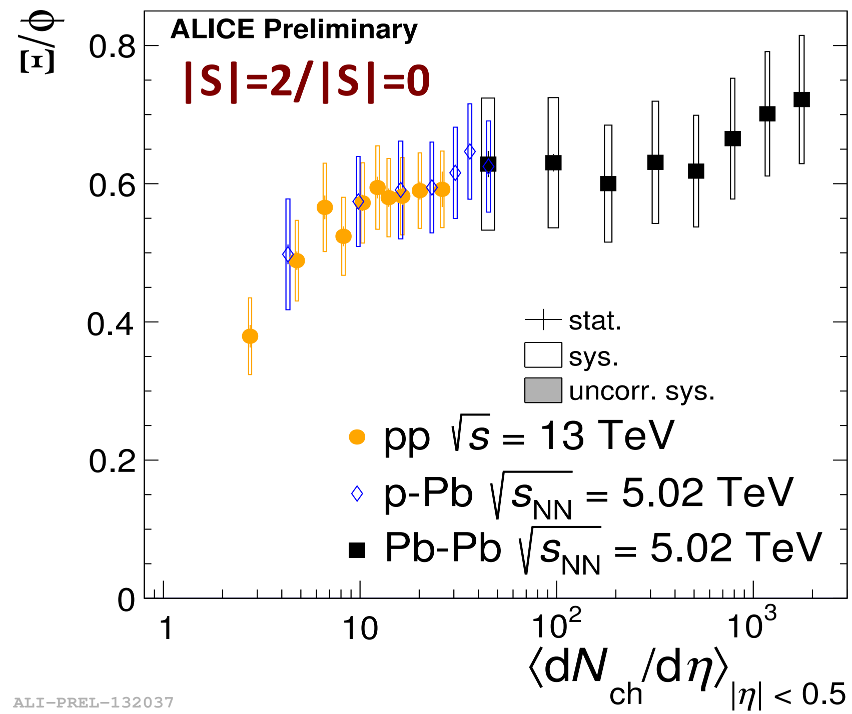
Effective strangeness of ϕ



➢ ***ϕ(S=0)/K(S=1) fairly flat as a function of multiplicity → The ϕ has effective strangeness of 1-2 units***

Effective strangeness of φ





- ***φ(S=0)/K(S=1) fairly flat as a function of multiplicity → The φ has effective strangeness of 1-2 units***
- ***Ξ(S=2)/φ(S=0) fairly flat as a function of multiplicity →***
  - ***The φ has effective strangeness of 1-2 units***
  - ***Hint of different evolution Ξ and φ in very low multiplicity pp collisions.***
  - ***In contrast to expectation from non-equilibrium production as quantified with strangeness suppression factor.***

φ(S=0) production in small systems remains to be understood!

Conclusions

- ***At low p_T, transverse momentum spectra harden with increasing multiplicity***
- ***For $p_T > 4$ GeV/c, spectral shape is independent of multiplicity***
- ***Bulk production at low-p_T is independent of collision energy for minimum bias pp collisions***
- ***Event multiplicity drives the particle production, irrespective of collision energy for pp collisions***
- **Small fraction of ϕ decays in the hadronic phase and not affected by re-scattering and/or regeneration**
- ***Thermal production of ϕ in Pb-Pb collisions***
- ***Effective strangeness of ϕ and production in small systems is still a puzzle.***

Conclusions

- *At low p_T, transverse momentum spectra harden with increasing multiplicity*
- *F*
- *E ... as*
  p
- *E ... rgy*
  f
- *S*
  s
- *T*

- *Effective strangeness of ϕ and production in small systems is still a puzzle.*