Experimental overview on recent measurements of Resonances and Exotics

Junlee Kim[1]

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Asian **T**riangle **H**eavy-**I**on **C**onference
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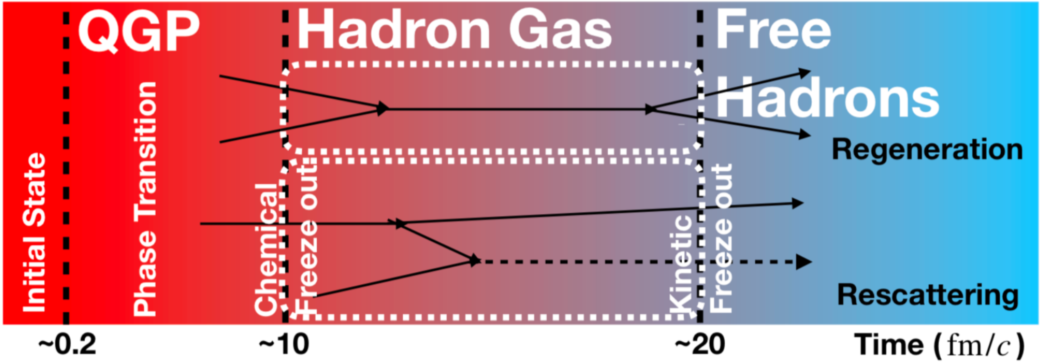
1. CERN

Highlighting a very limited selection of topics for exotic particle measurements at LHC energy

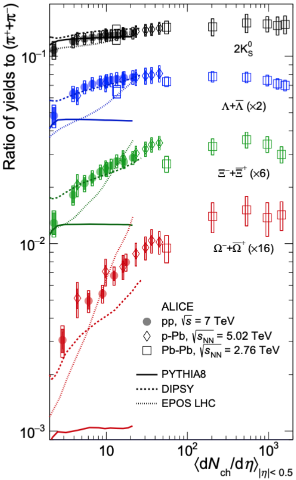


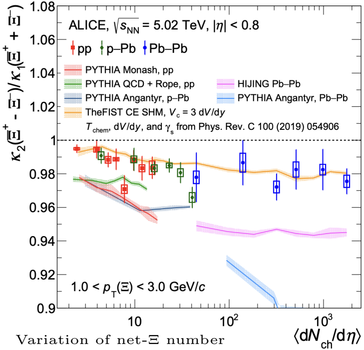
- Modifications of resonance yields to study late hadronic phase
- Dependent on:
  1) Particle composition at chemical freeze-out. 2) Lifetime of hadronic phase.
  3) Lifetime of resonances. 4) Scattering cross sections of decay products.

Strangeness enhancement in small collision systems

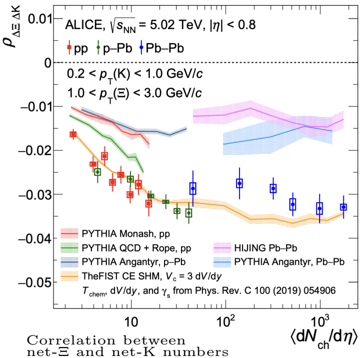
Nature Phys. 13 (2017) 535-539

arXiv:2405.19890





Variation of net-Ξ number



Correlation between net-Ξ and net-K numbers

- Strangeness enhancement only in small collision systems due to undersaturation of strangeness
- Thermal model is more favored than string fragmentation by experimental data.
- Useful tool to investigate quark contents

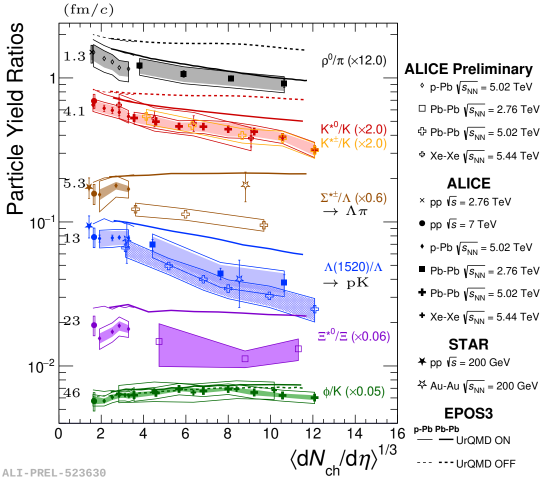
Several short-lived resonances are suppressed with increasing multiplicity

- Suppression trend is continuous from small to large collisions systems for mesons
- Suppression is rarely observed in small collision systems for baryons but becomes sizable in large collision systems.
- Resonances having longer lifetime are not suppressed.

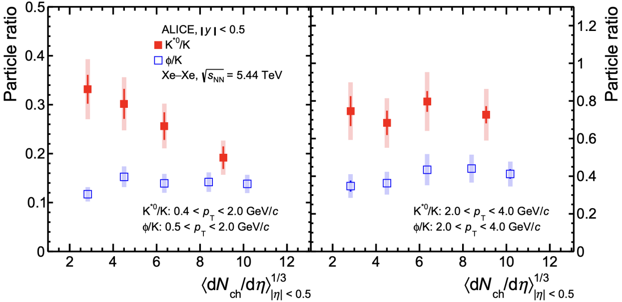
EPOS with UrQMA qualitatively describes trend with multiplicity.

Suppression is not observed nor expected for $\Sigma^{*\pm}$. $\leftrightarrow$ $\Lambda(1520)$

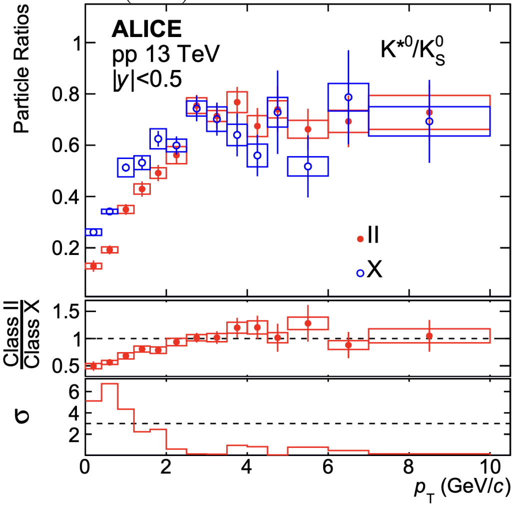
- Inelastic cross sections?
- Regeneration?



PRC 109 (2024) 014911



PLB 807 (2020) 135501



Suppression only dominant at low $p_{\mathrm{T}} < 3$ GeV/c

Lifetime of hadronic phase

Lower limit hadronic phase lifetime from modification of resonance yields

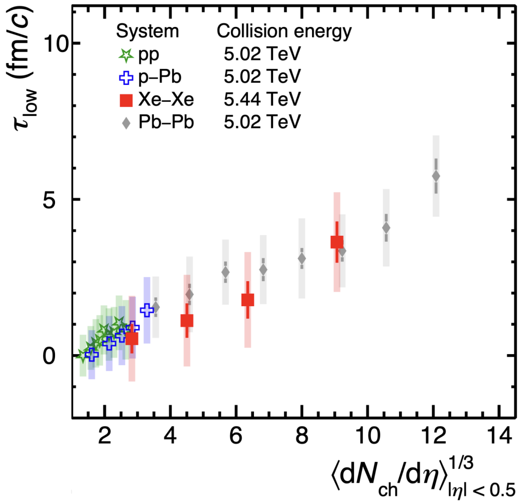
$$\left(\frac{\mathrm{K}^*}{\mathrm{K}}\right)_{\mathrm{kin}} = \left(\frac{\mathrm{K}^*}{\mathrm{K}}\right)_{\mathrm{chem}} \times \exp(-\tau_{\mathrm{low}}/\tau_{\mathrm{K}^*}),$$

where no regenerations were assumed.

$\left(\frac{\mathrm{K}^*}{\mathrm{K}}\right)_{\mathrm{chem}}$: particle yield ratio at low-multiplicity events

Smooth evolution with increasing multiplicity

PRC 109 (2024) 014911

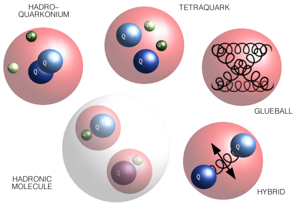


The understanding of exotic hadrons can provide better insight into the non-perturbative regime of Quantum Chromodynamics.

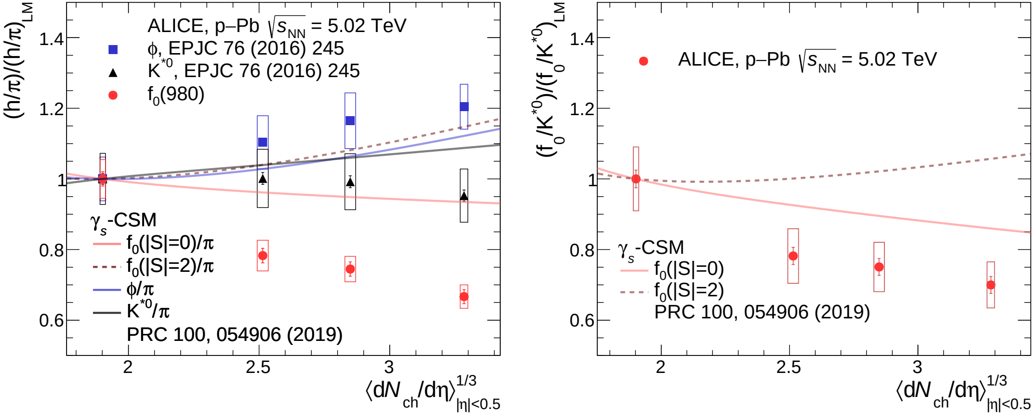
Powerful tool to study partial restoration of chiral symmetry

Exploration of internal structures of exotic particles based on observed phenomena at LHC energies

- Strangeness enhancement
- Modification of resonance yields
- Number of constituent quarks scaling
- Cronin-like enhancement

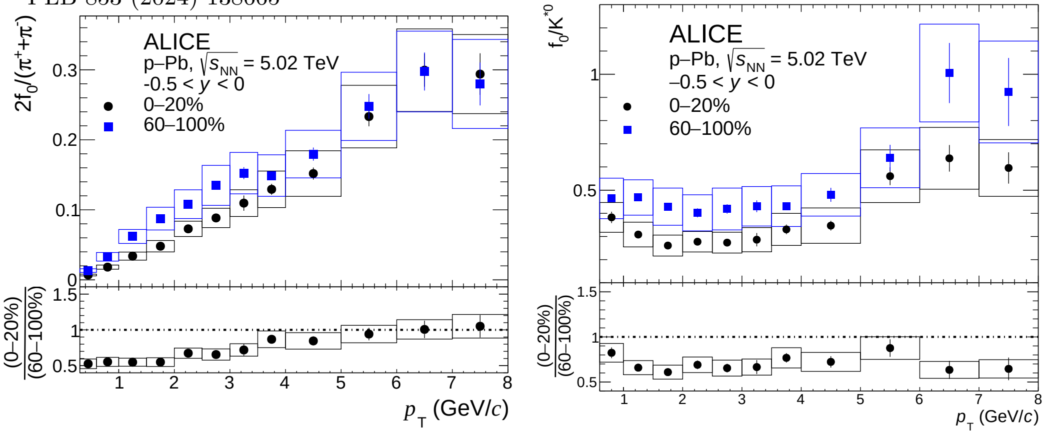


PLB 853 (2024) 138665



- No (anti-)strange quarks inside $f_0(980)$ favored from both results
- What about in large collision systems?

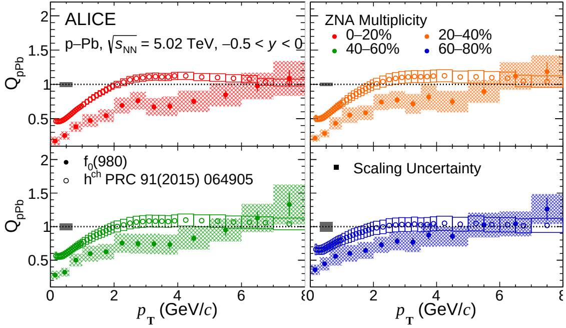
PLB 853 (2024) 138665



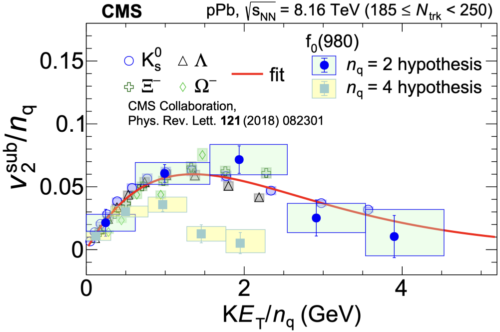
- p_T dependence of f_0/π similar to K^*/K: Exhibition of rescatterings?
- p_T dependence of f_0/K^* not compatible with f_0/π nor K^*/K

$f_0(980)$ resonances

PLB 853 (2024) 138665



arXiv:2312.17092



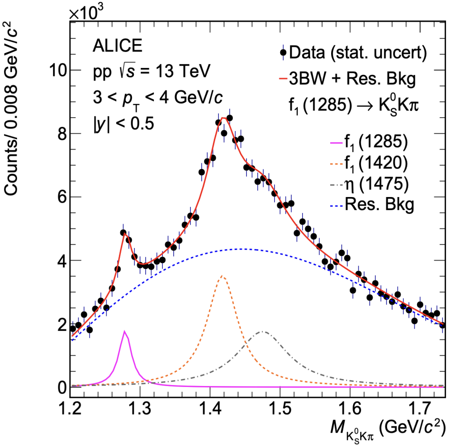
No Cronin-like enhancement for $f_0(980)$ R_{pPb}: Not a baryonic state?

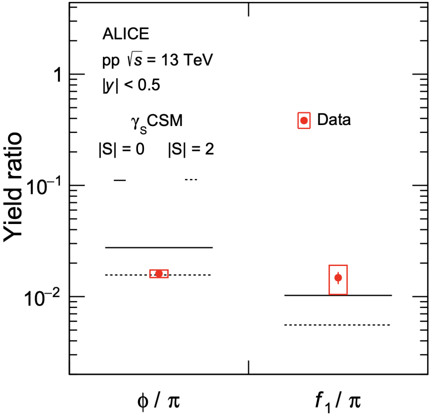
- Further enhancement for tetraquark state: PLB 645 (2007) 138

The origin of flow from constituent quarks → $f_0(980)$ flow aligned with conventional meson

- Disclaimer: Definition of event plane in p–Pb collisions to be clarified

Important input into the chiral symmetry for the lightest pseudoscalar mesons arXiv:2409.11936



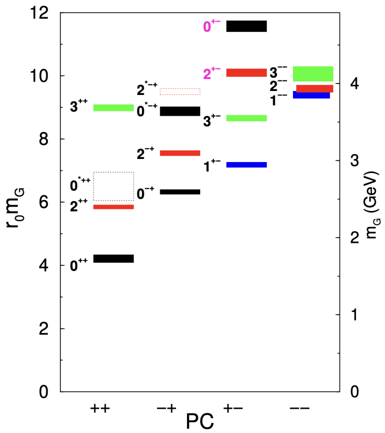


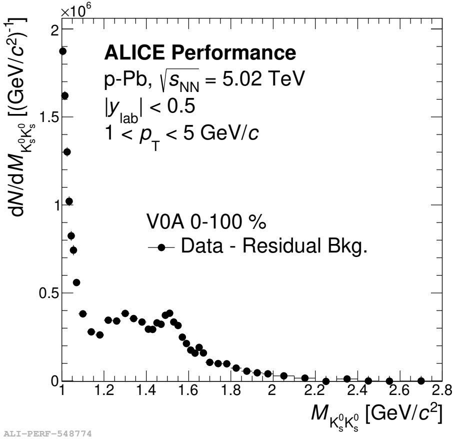
Chiral partner of ω meson: good probes to observe partial restoration of chiral symmetry

- Thermal model favors no (anti-)strange quarks inside $f_1(1285)$.
- Baseline measurement for the first time at LHC energy

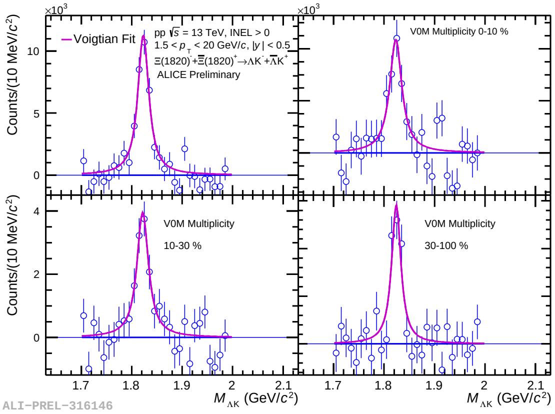
Search for Glueball candidates via KK channels

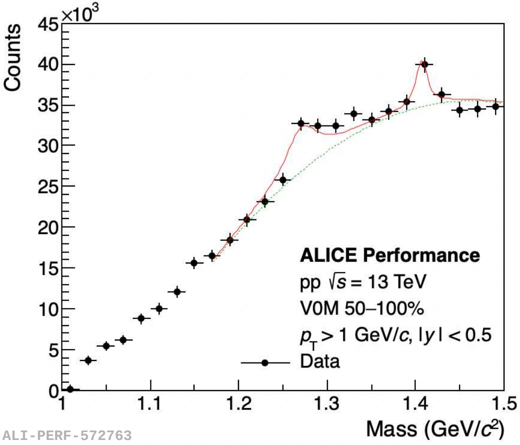
PRD 60 (1999) 034509





- $K^0_s K^0_s$ channel for lower combinatorial backgrounds
- New perspectives on how hadron structure influences R_{AA} and flow

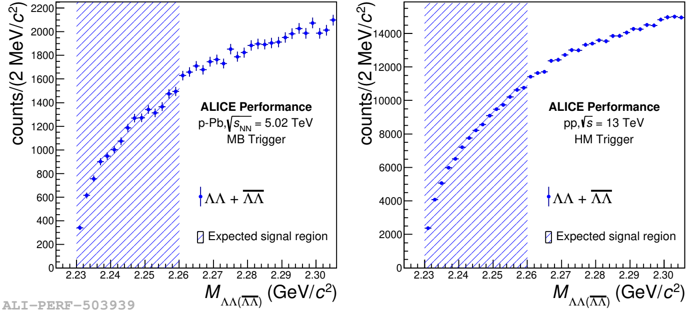




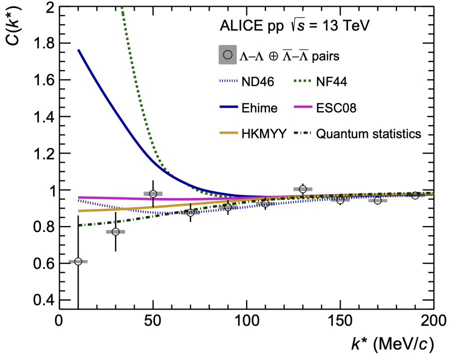
Convergence of invariant mass (PRD 7 (2019) 074503), evolution of particle yield ratio (PLB 819 (2021) 136388)

→ important inputs for partial restoration of chiral symmetry

Promising exotic candidates?



PLB 797 (2019) 134822



- H-dibaryon to be resonant state? PRC 75 (2007) 022201
- Little bump: statistical fluctuation?
- Replusive interaction?

A new results with high statistics in Run 3?

Conclusions

Multi-dimensional measurements of resonances to understand hadronic phase between chemical and kinetic freeze out

- Better understanding of strangeness enhancement providing more precise particle composition at chemical freeze-out
- Modifications of resonance yields from small to large collision systems not simple
- Also useful to understand light-flavored resonances, which posses broad particle width

Differential measurements on exotic states

- Formation of exotic state: Better understanding of non-perturbative QCD regime.
- Strong proves to observe partial restoration of chiral symmetry

PRD 96 (2017) 3, 034029

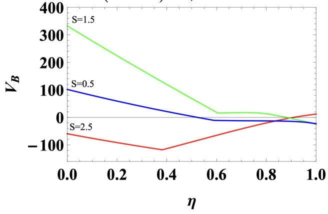


FIG. 10: V_B of $s^3q^2\bar{Q}^2$ with $I=0$(unit: MeV).

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