Parity doubling as a signature for chiral symmetry restoration: Experimental possibilities

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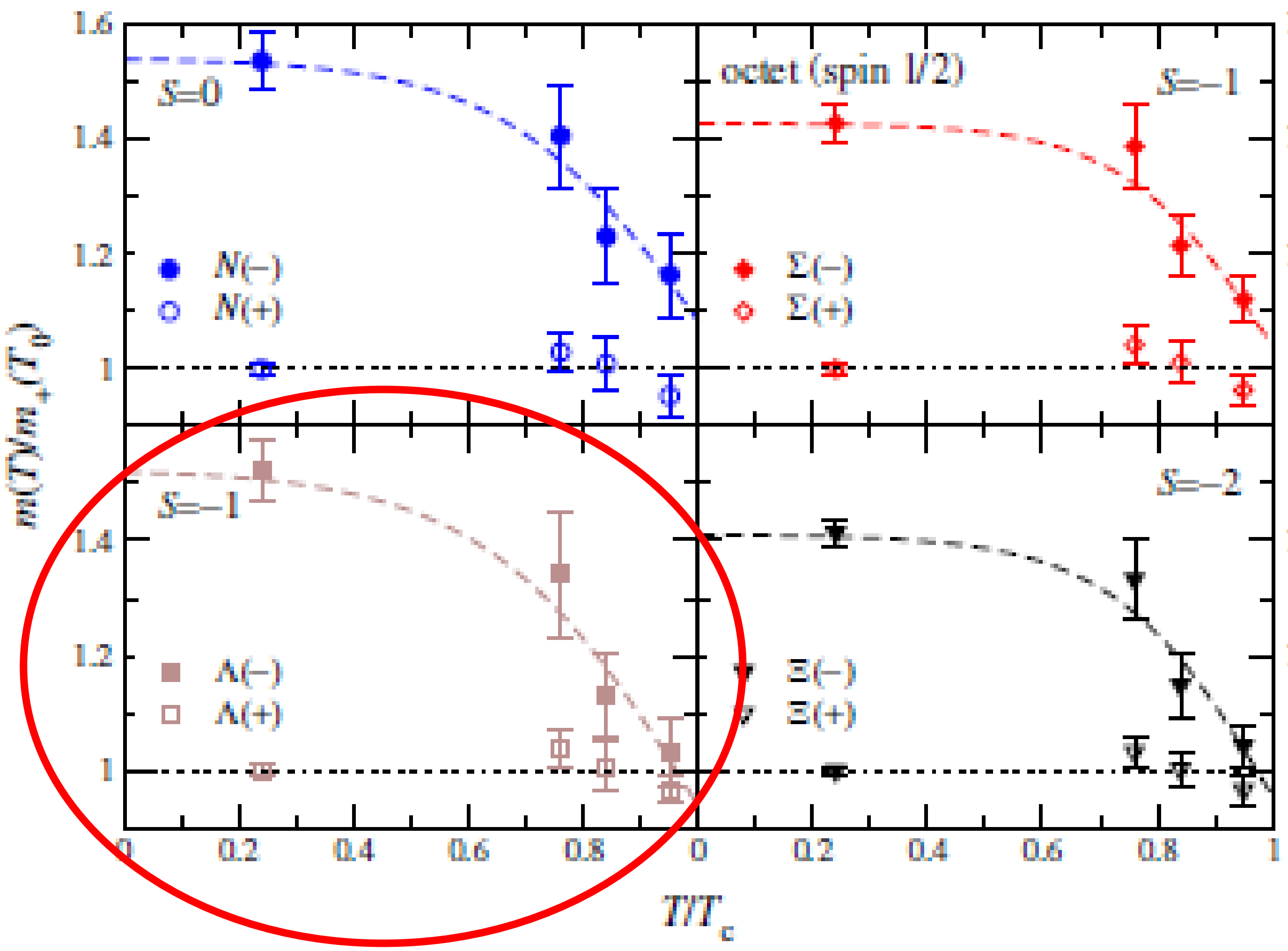
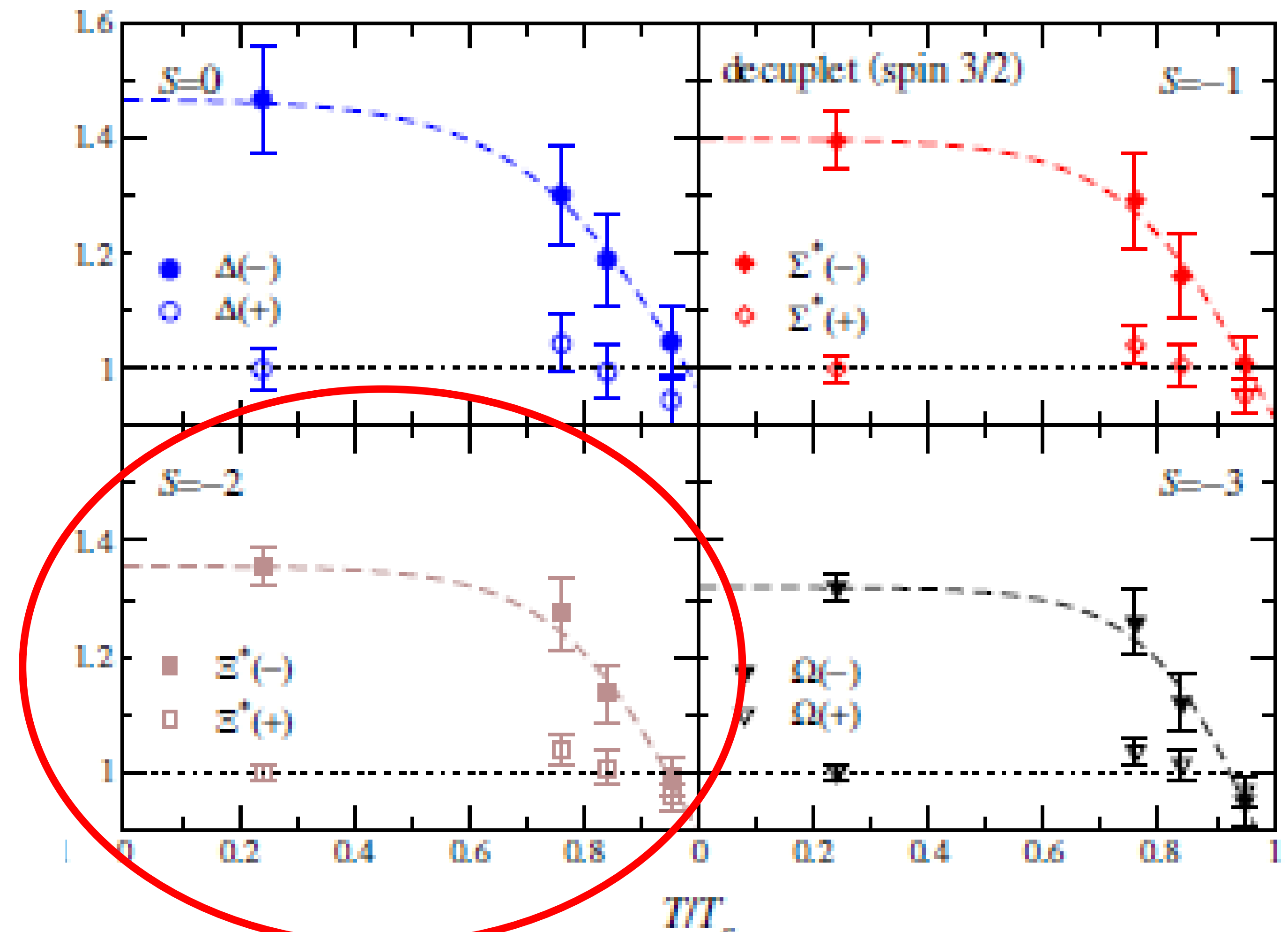
The theory development

Lattice QCD calculations of baryon spectral functions as a function of temperature

FASTSUM Collaboration (Swansea and Co.): Baryons in the plasma

PRD 92 (2015) 014503 (arXiv:1502.03603)
JHEP 06 (2017) 034 (arXiv:1703.09246)
EPJ WoC 171 (2018) 14005 (arXiv:1710.00566)





Theoretical findings

- Emerging degeneracy around T_c for chiral partners
- Positive parity masses nearly temperature independent
- Negative parity masses drop as temperature increases
- Experiment: find appropriate chiral partners.
- In this talk focus on the strange sector

Theoretical findings

Integrate the $R(\tau)$ ratio

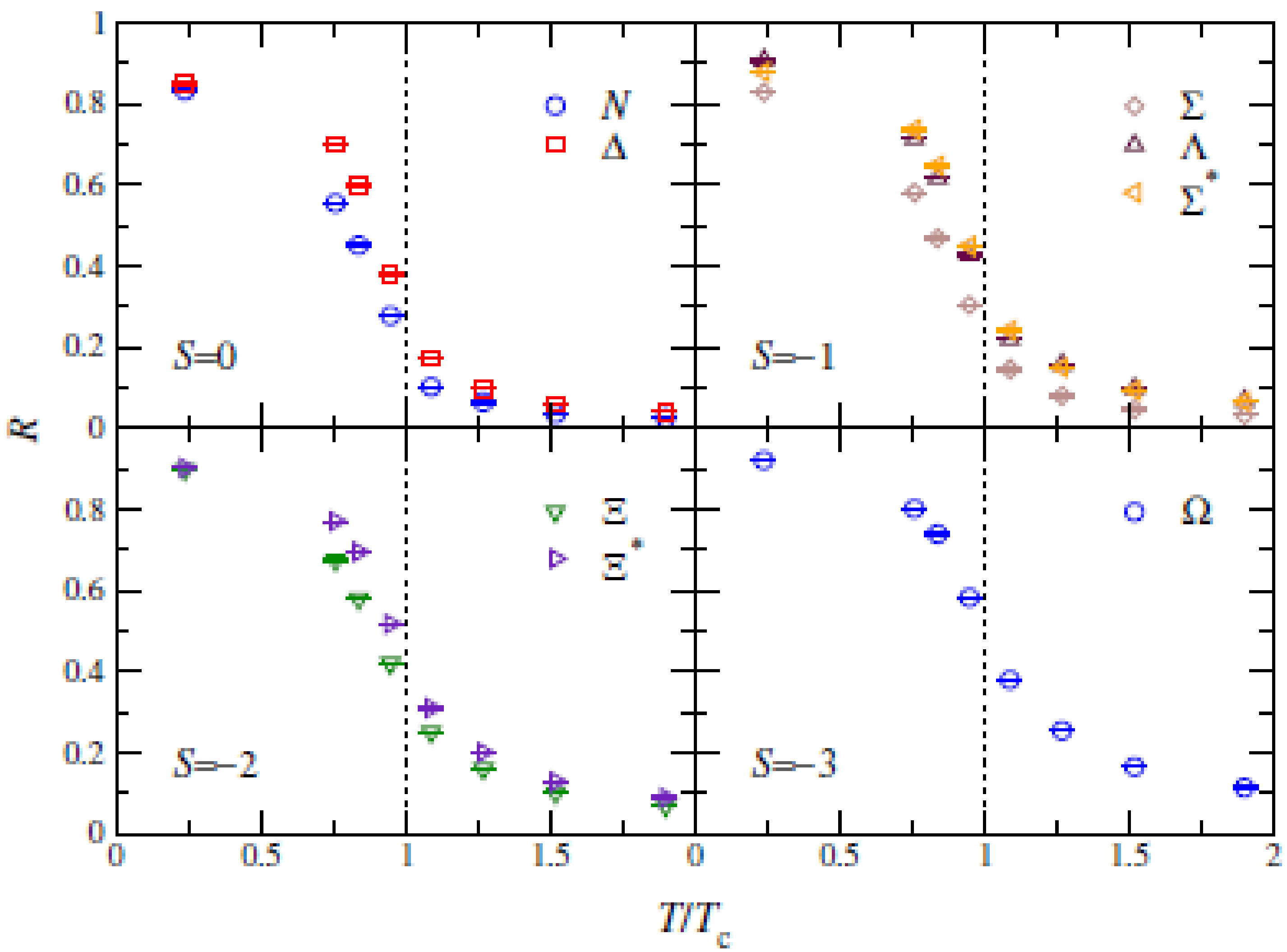
$$R(\tau) = \frac{G_+(\tau) - G_-(\tau)}{G_+(\tau) + G_-(\tau)}$$

$\Rightarrow$ quasi-order parameter

$$R = \frac{\sum_n R(\tau_n)/\sigma^2(\tau_n)}{\sum_n 1/\sigma^2(\tau_n)}$$

Interesting new pseudo-order parameter for the phase transition:

Parity doubling Ratio R



- Seems to indicate slight quark mass dependence in the chiral transition

Possible experimental verificiation
(in the strange sector)

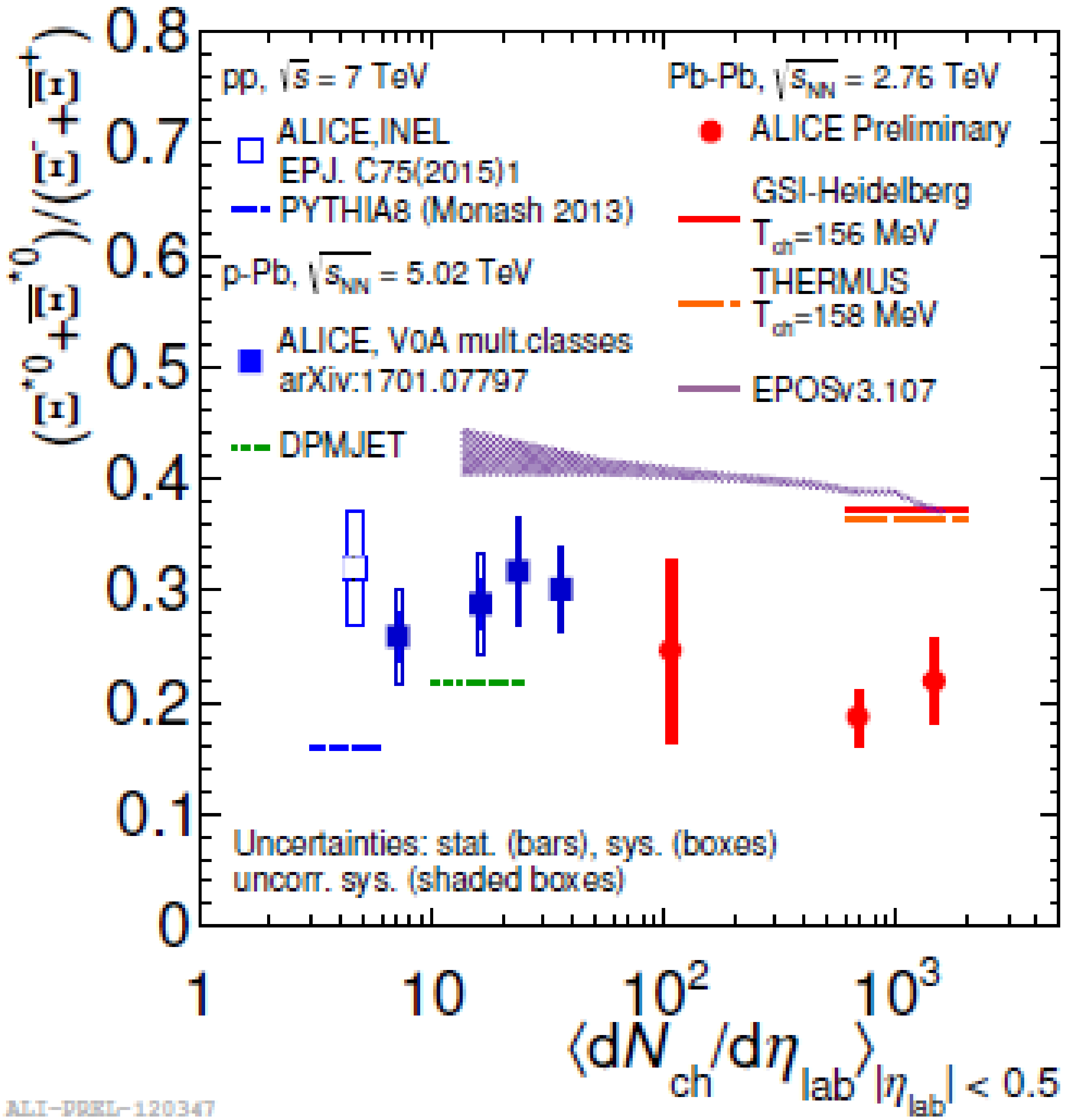
Difficult to find appropriate chiral partners that are experimentally accessible:

In the octet sector: ½ states for the Λ : positive parity $\Lambda(1115)$,
negative parity $\Lambda(1405)$

In the decuplet sector: 3/2 states for the Ξ: positive parity $\Xi(1530)$
negative parity $\Xi(1820)$

The Ξ sector

The Ξ(1530) is well established (Jihye's work)



τ = 21.7 fm/c

The Ξ(1820) in pp was just found (Corey Myers' work)

See updates in resonance PAG

τ = 8.2 fm/c

Experimental Caveats

- Typical resonance analyses.

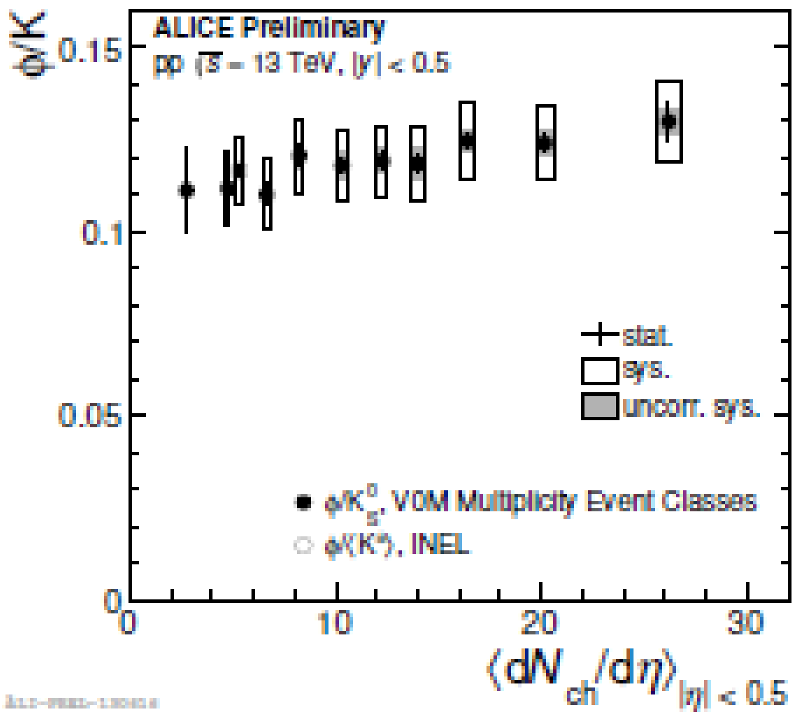
- The $\Xi(1530)$ is not expected to show a mass shift. There is also little evidence of rescattering/regeneration. Maybe due to the rather long lifetime (t = 21.7 fm/c)

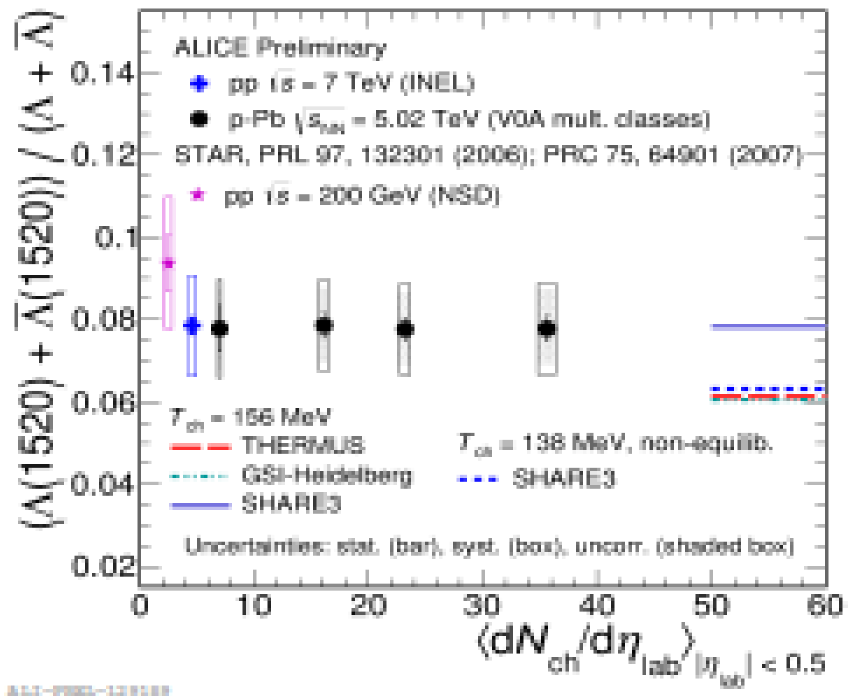
- The $\Xi(1820)$ mass should drop, which could either be measured through a width broadening as a function of system size or simply a change in the relative yield ($\Xi(1820)/\Xi(1530)$).

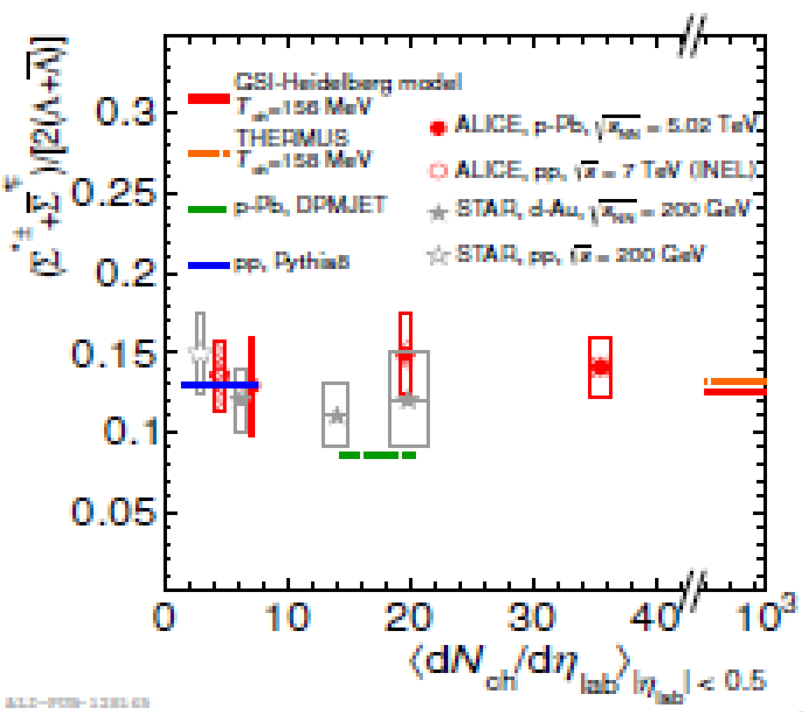
- Any yield or ratio measurement needs to take into account the trivial rescattering/regeneration effects that should occur for a t=9.1 fm/c resonance (comparable to the lifetime of the $\Lambda(1520)$)

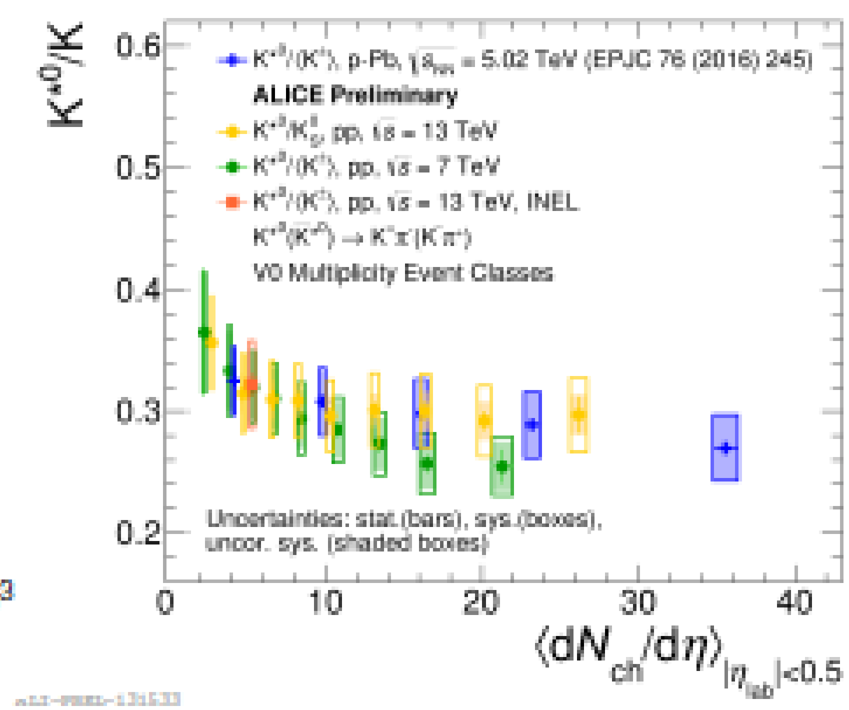
pp or AA ?

- Can the Ξ(1820) be isolated in AA collisions ?
- A study of the effect in pp as a function of multiplicity ?









- Resonant/ground state ratios have been measured successfully in small systems and show some sensitivity
- A double-resonance ratio is challenging but possible ?

Summary

- Finding experimentally suitable chiral partners in the baryon sector is not easy.

- There are options in the octet non-strange and S=-1 sector, but pairing the proton with the N(1535) or the Lambda with the Λ(1405) is difficult because of the background prone measurements in the resonance sector.

- There is an intriguing option the in decuplet S=-2 sector. Both the Ξ(1530) and the Ξ(1820) have been found in pp collisions in ALICE.

- Their lifetimes make them suitable for studying the effect as a function of system size/multiplicity. Caveats such as rescattering/regeneration need to be taken into account.