Strange Hadron Production in O+O Collisions at $\sqrt{s_{NN}}$ = 200 GeV at STAR

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1) Introduction

•At high temperatures QCD matter becomes a new state of matter called the Quark-Gluon plasma (QGP). The QGP behaves as deconfined strongly coupled fluid.

•Its existence was predicted in 1975 and experimentally discovered in the early 2000s.

•The QGP is predicted to have existed in the early universe in the first μs after the Big Bang.

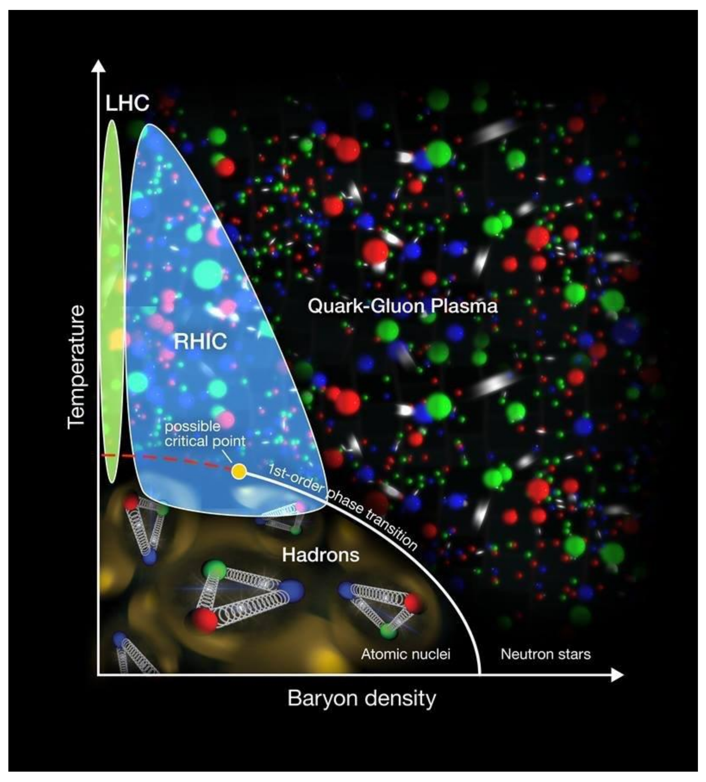

Figure 1: The QGP phase diagram [1]

•Strangeness enhancement was one of the first observables predicted as a signature of the QGP[2]

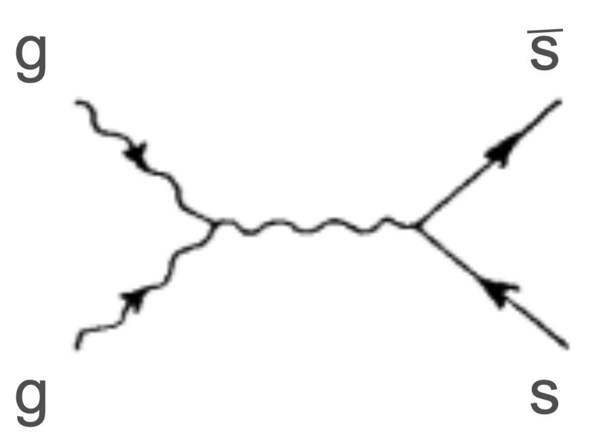

Figure 2: Lowest Order Feynman diagram for $s\bar{s}$ production [2]

•The thermal production of s-$\bar{s}$ quark pairs is favorable in the QGP since the $\bar{s}$-s masses are close to the QGP transition temperature ~157 MeV.

- 2 x m_s ~192 MeV
- There are abundant thermal gluons in the QGP medium.

2) Motivation

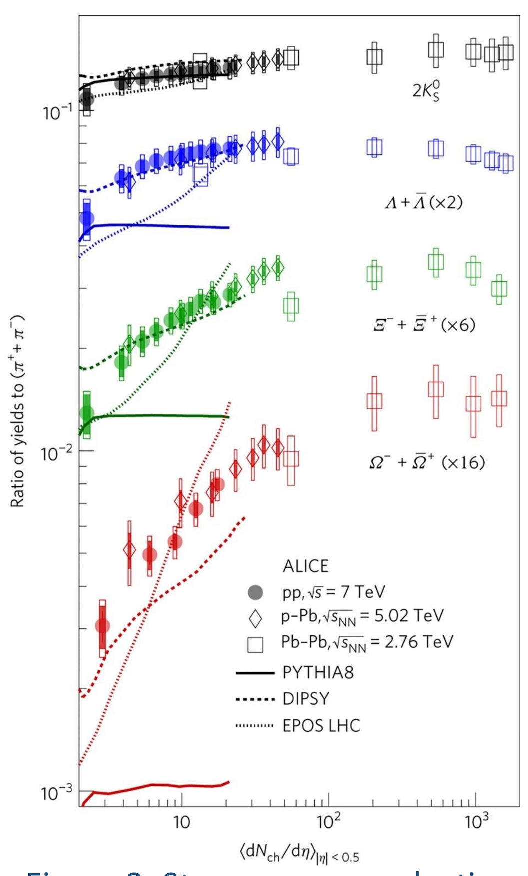
Figure 3: Strangeness production at ALICE[3]

•A smooth increase in the ratio of strange hadron production to the pion yield as a function of multiplicity has been found in various collision systems (p+p, p+A, A+A) at TeV collision energies.

- STAR potentially observes a similar trend at $\sqrt{s_{NN}}$ = 200 GeV, but needs more data at low multiplicity.

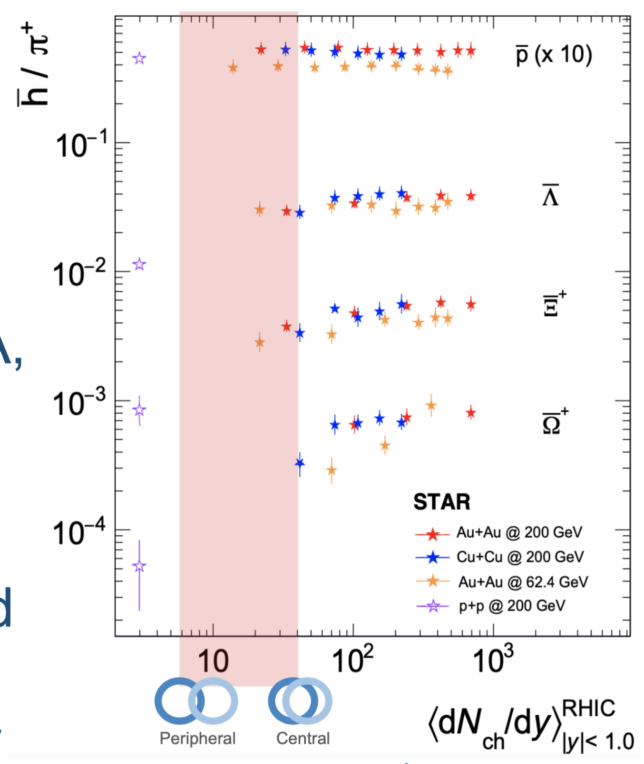

Figure 4: Strangeness production at STAR with the O+O multiplicity are to be filled-in highlighted in red

2a) STAR Detector

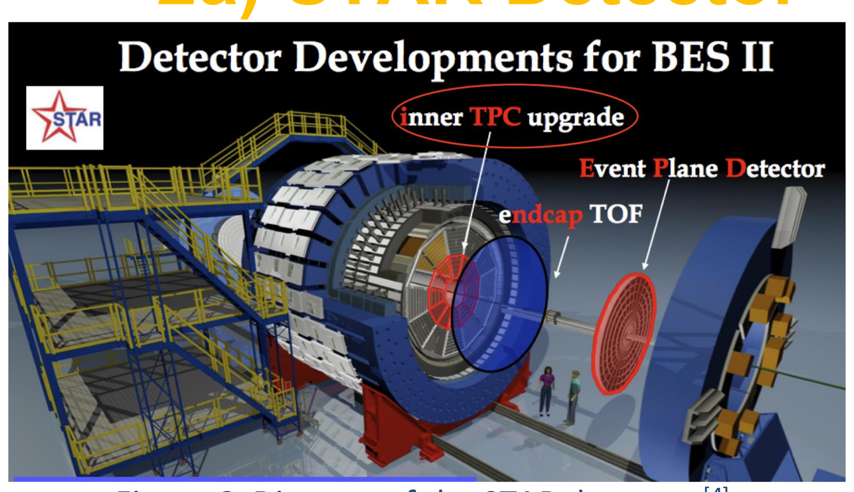

Figure 6: Diagram of the STAR detector [4]

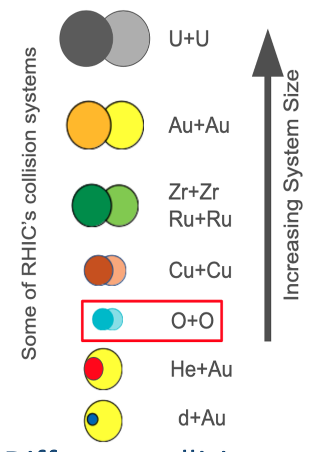

Figure 5: Different collision systems at RHIC

•From 2018 on, STAR had two detector upgrades: iTPC and eTOF

- Improved coverage: From |η| < 1.0 ⟶ |η| < 1.5
- Lower p_T coverage: 125 MeV/c ⟶ 60 MeV/c
- Extended PID with eTOF

•There are ~650M O+O minimum bias events total at $\sqrt{s_{NN}}$ = 200 GeV.

- ¼ of the O+O run was taken with the magnetic field reversed.
- Testing calibration and TPC distortions

3) Particle Reconstruction

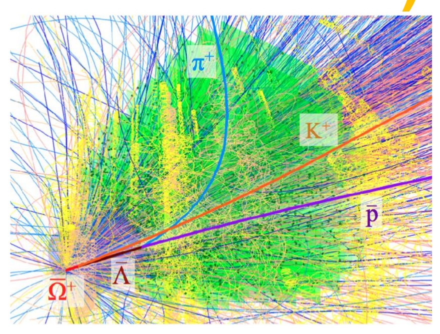
Figure 7: Simulated anti-Ω decay[5]

•Using Kalman Filter Particle (KF Particle) reconstruction algorithm.

•The signal (without background subtraction) region is [μ-3σ,μ+3σ], and the background region is [1.095 to μ-3σ, μ+3σ to 1.135 GeV/c^2].

•Fitting function: 2nd poly (for background) + double Gauss function (signal).

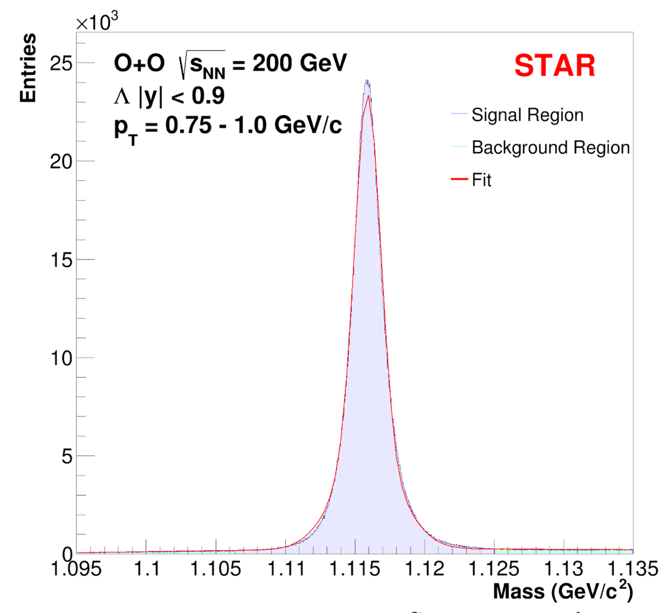

Figure 8: Invariant Λ mass peak

The blue region is the signal w.o background subtraction.
The green region is the background region (very small).

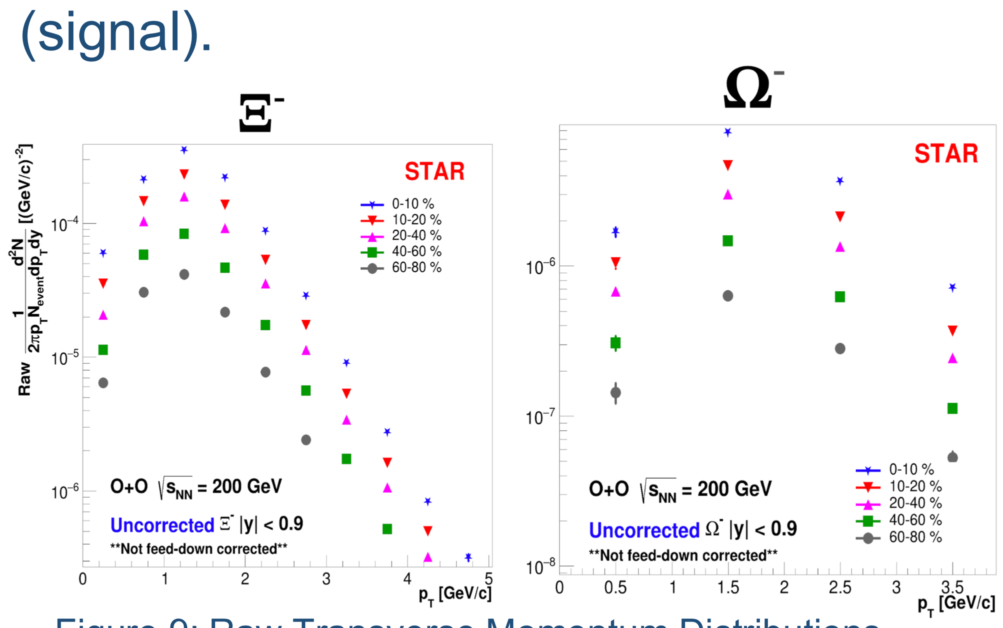

Figure 9: Raw Transverse Momentum Distributions for O+O at $\sqrt{s_{NN}}$ = 200 GeV

There is good coverage through 0 - 80% centralities for multi-strange hadrons.

4) p_T Spectrum and Particle Yields

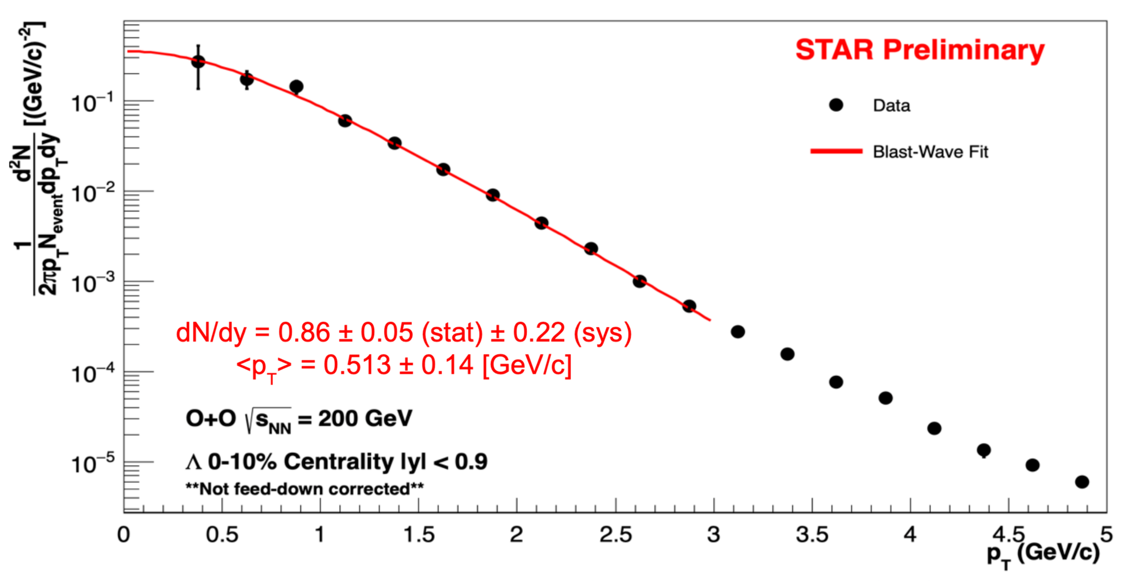

Figure 10: Corrected p_T spectrum for Λ's in Central O+O Collisions

The p_T spectrum is calculated from the Λ's invariant mass distributions in different momentum ranges.

The Λ p_T spectrum is the average of both magnetic field configurations.

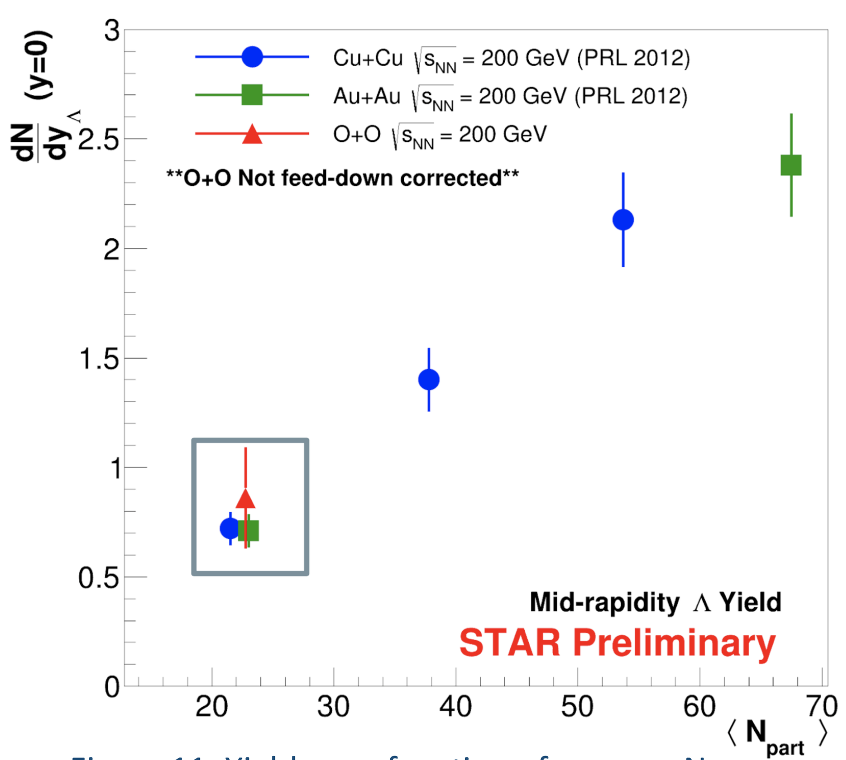

Figure 11: Yields as a function of average N_{part}

Most central O+O collisions have a similar < N_{part}> as peripheral Au+Au and Cu+Cu collisions.

$$\frac{dN}{dy} = \int_0^\infty p_t$$
$$\frac{dN}{dy} = 0.86 \pm 0.05 \ \pm 0.22$$

**O+O yield is not feed-down corrected.

5) Summary and Outlook

- The O+O dataset can fill in the gaps in the low-multiplicity regions of the ratio of strange hadron production to the pion yield for the STAR data.
- We presented the first yield calculation for Λ's in the 0-10% centrality region for O+O. The O+O yield agrees with previous published STAR Λ yields at similar N_{part} values.
- Extend the analysis to other hyperons.
  x) The raw p_T spectra are pending the corrections.
- Use thermal model for freeze-out parameter (e.g. μ_B , T_{ch}) extraction.

[1] Brookhaven National Laboratory. (2023, February 24). *Clear sign that QGP production 'turns off' at low energy.*
[2] P. Koch, et al. Phys. Rep. 142, 167 (1986).
[3] ALICE Collaboration. Nat. Phys., 13, 535 (2017)
[4] Picture: Alex & Maria Schmah
[5] Maksym Thesis (2016))

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