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.

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

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

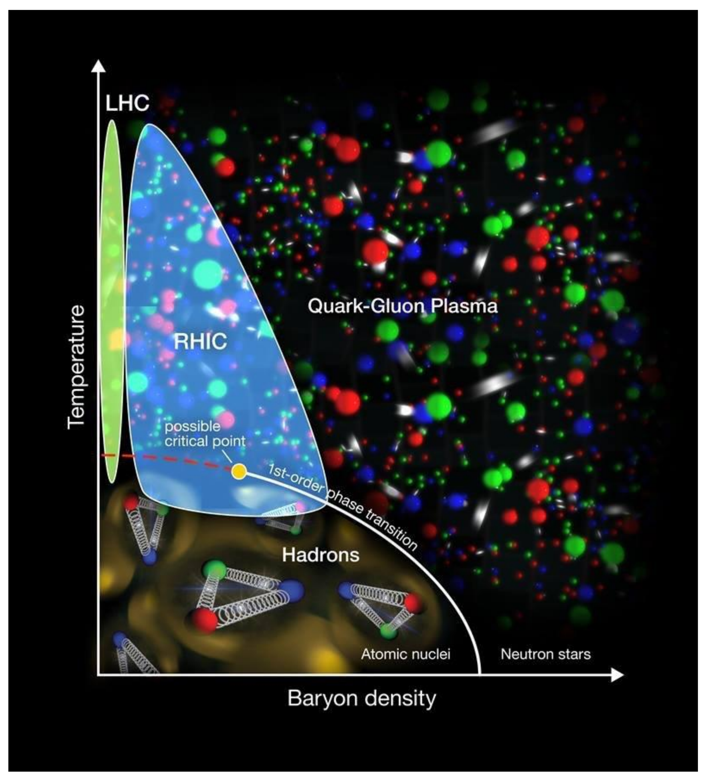

Figure 1: The QGP phase diagram [1]

•The thermal production of s-$\bar{s}$ quark pairs is favorable in the QGP since the s-$\bar{s}$ masses are lower than the predicted QGP temperature, with the QGP -> hadron gras transition temperature ~157 MeV.

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

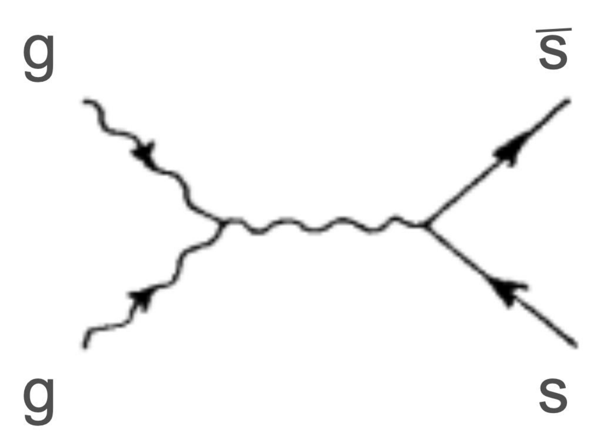

Figure 2: Lowest Order Feynman diagram for $s\bar{s}$ production [2]

•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[3].

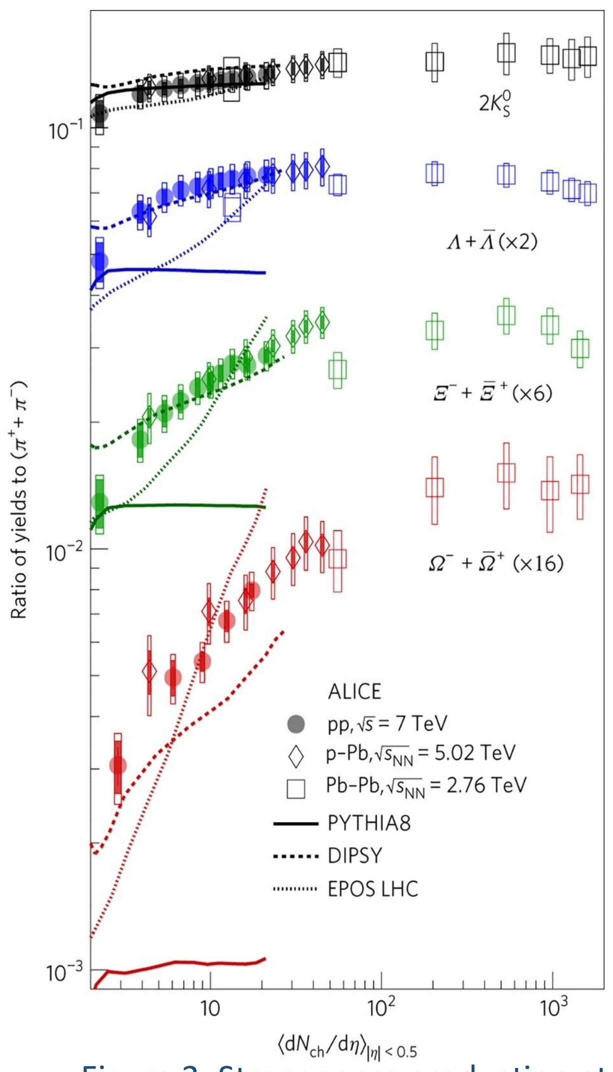

Figure 3: Strangeness production at ALICE[3]

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

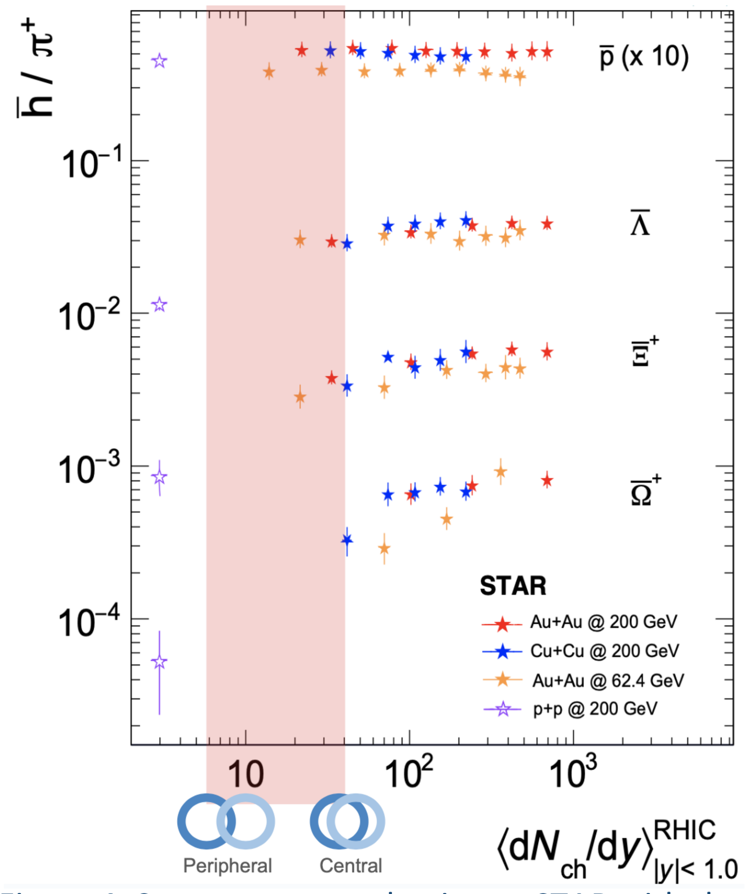

Figure 4: Strangeness production at STAR with the O+O multiplicity are to be filled-in highlighted in red

2) STAR Detector

Figure 6: Diagram of the STAR detector [4]

•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

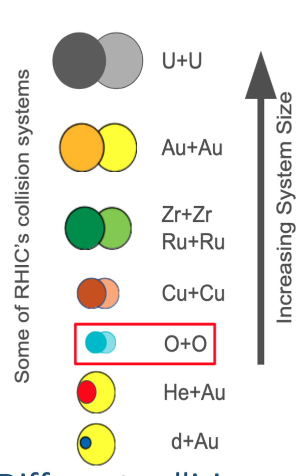

Figure 5: Different collision systems at RHIC

•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

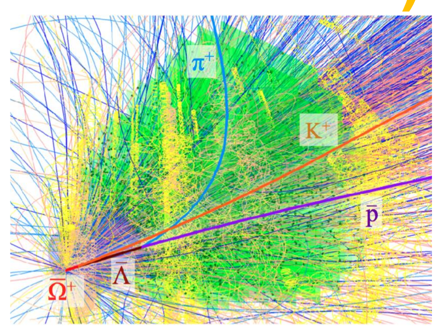

Figure 7: Simulated anti-**Ω** decay[5]

•Using Kalman Filter Particle (KF Particle) reconstruction algorithm will allow us to measure **Λ**, Ξ, Ω and K^0_s and their anti-particles.

•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/c²] (**μ** = m_Λ).
•Fitting function: 2nd poly (for background) + double Gauss function (signal).

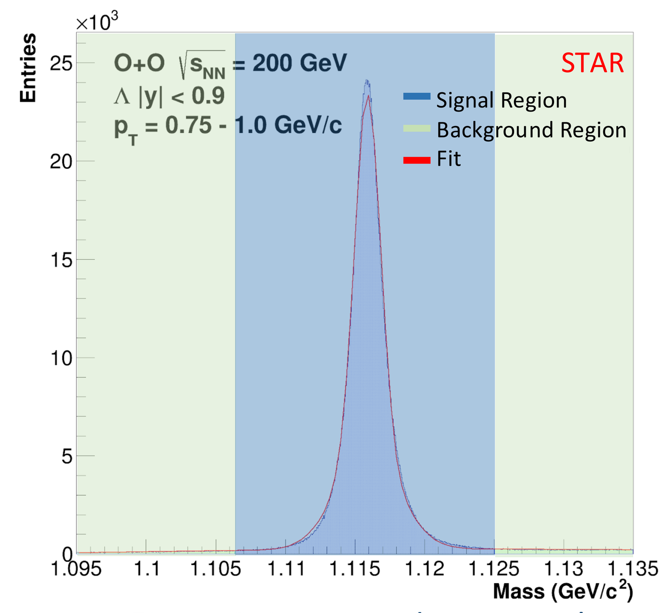

Figure 8: Invariant Λ mass peak

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

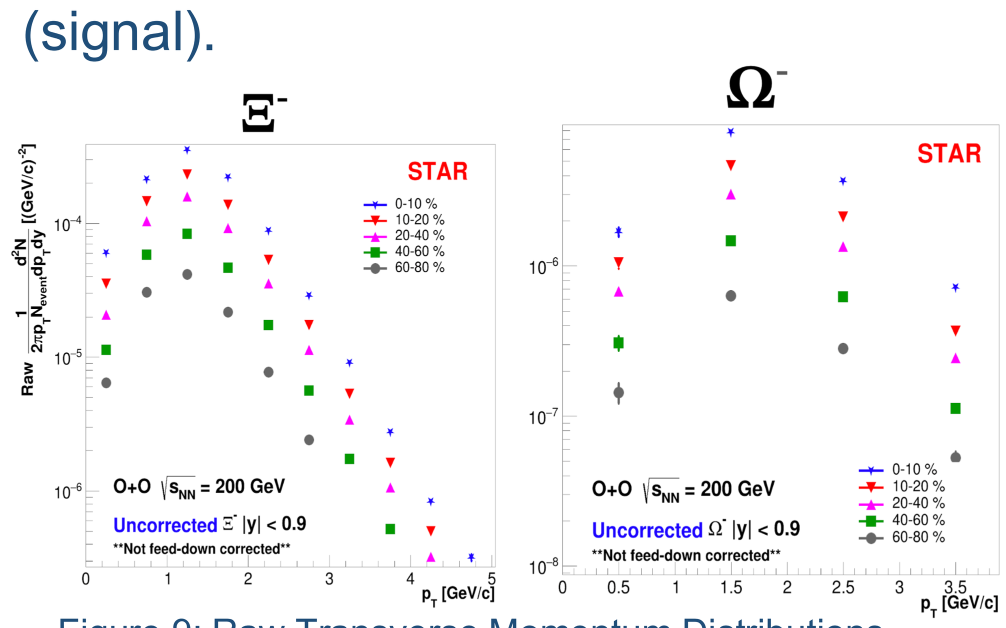

Figure 9: Raw Transverse Momentum Distributions for O+O at $\sqrt{s_{NN}}$ = 200 GeV

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

4) p_T Spectrum and Particle Yields

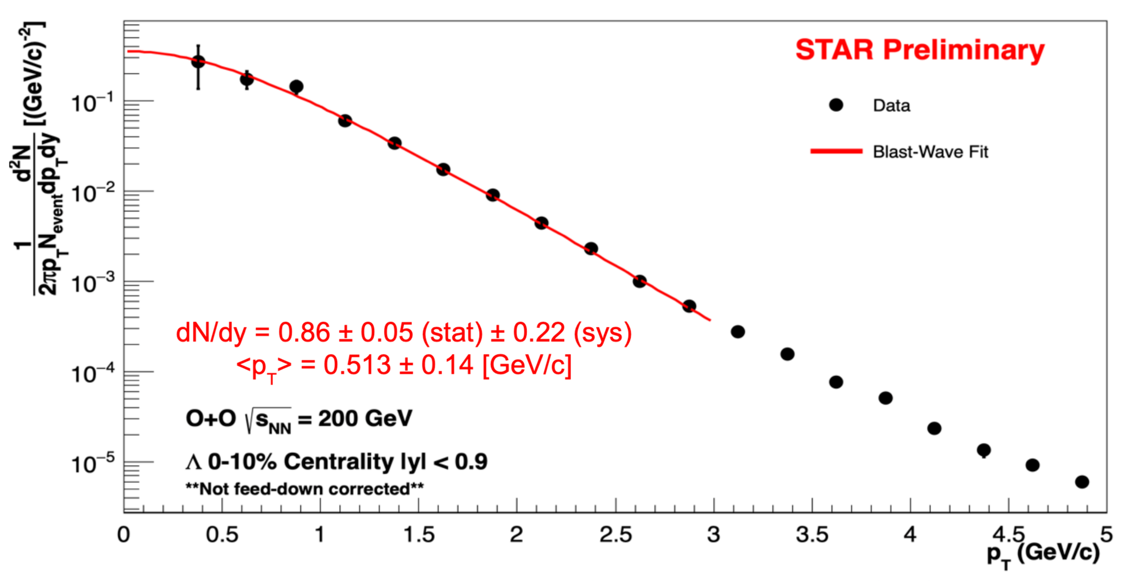

Figure 10: Corrected p_T spectrum for **Λ**'s in Central O+O Collisions

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.

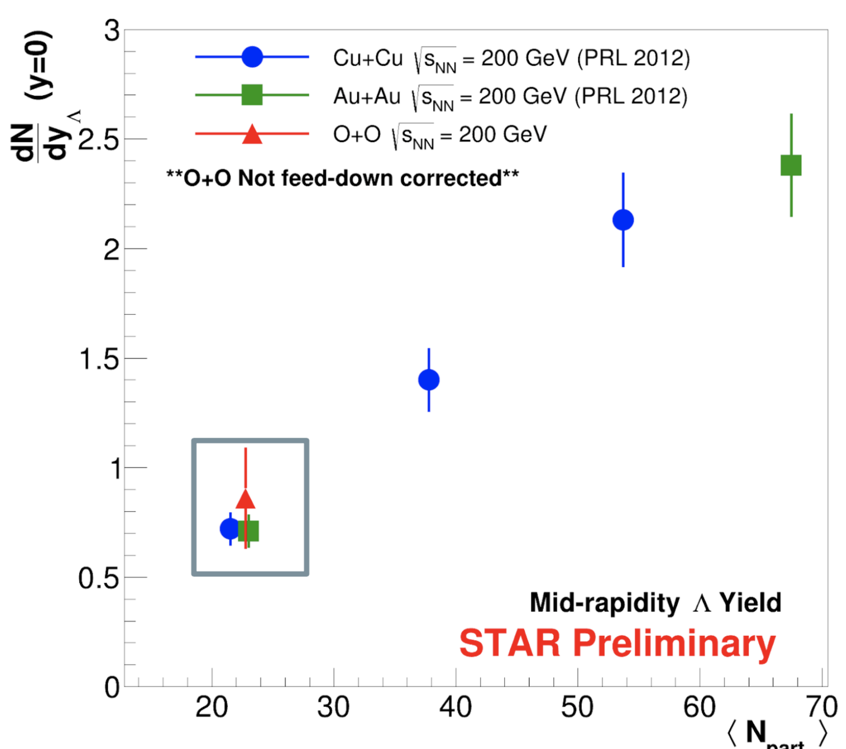

Figure 11: Yields as a function of average N_{part}

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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