Study of freeze-out parameters in Beam Energy Scan Program of STAR at RHIC

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Abstract

Statistical thermal model of grand canonical approach was used to extract the chemical freeze-out parameters by using the particle yields in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 11.5, 19.6, 27 and 39 GeV . We show the centrality dependence of extracted chemical freeze-out parameters for all the energies studied. We found as collision energy increases the chemical freeze-out temperature increases whereas baryon chemical potential decreases. We also found the strangeness saturation factor increases from peripheral to central for all the energies studied. The kinetic freeze-out parameters have been extracted using blastwave model through transverse momentum (p_T) spectra. Lower kinetic temperature corresponds to larger collectivity.

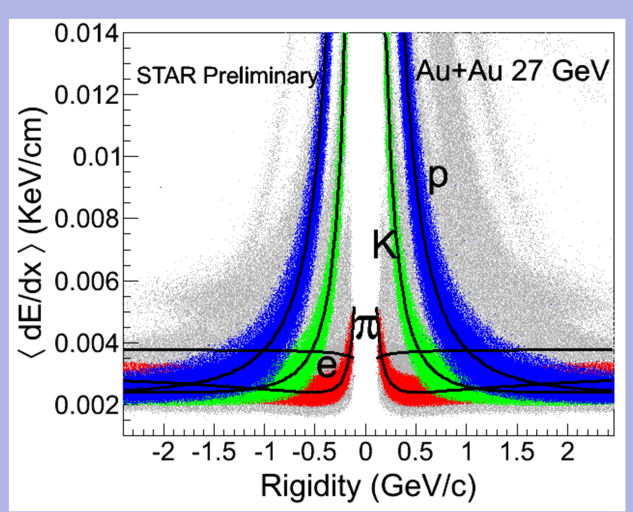
1. Introduction

➢ One of the main goal of Beam Energy Scan (BES) program is to search for the critical point and QCD phase boundary.

➢ Grand-canonical ensemble (GCE) approach of statistical THERMUS [1] model is used for fitting the experimental RHIC data at BES energies $\sqrt{s_{NN}}$ = 7.7, 11.5, 19.6, 27 and 39 GeV to extract chemical freeze-out Temperature T_{ch} and baryon chemical potential μ_B.

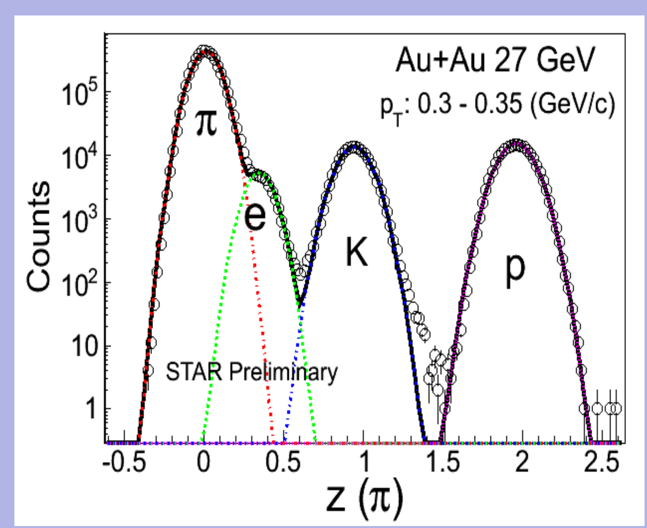
➢ Blast wave model [2] is used to extract kinetic freeze-out temperature (T_{kin}) and flow velocity (β) through p_T spectra [3].

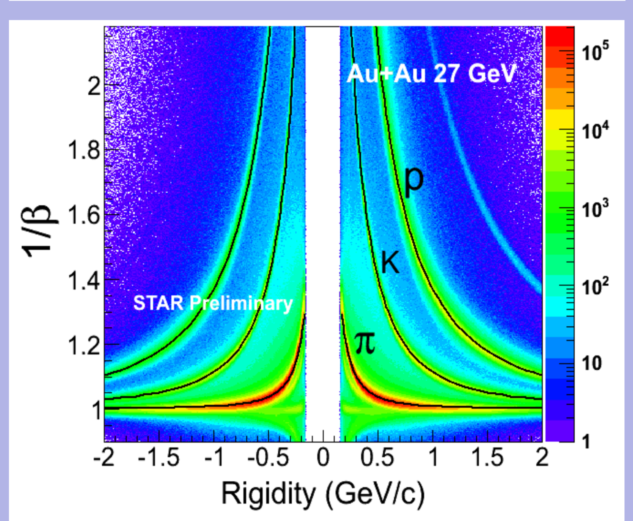
Particle Identification



TPC

$$z = \log\left(\frac{(dE/dx)_{meas.}}{(dE/dx)_{theory}}\right)$$

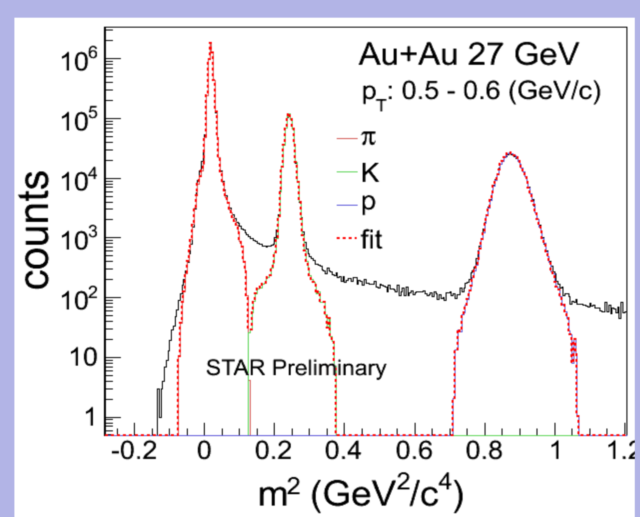




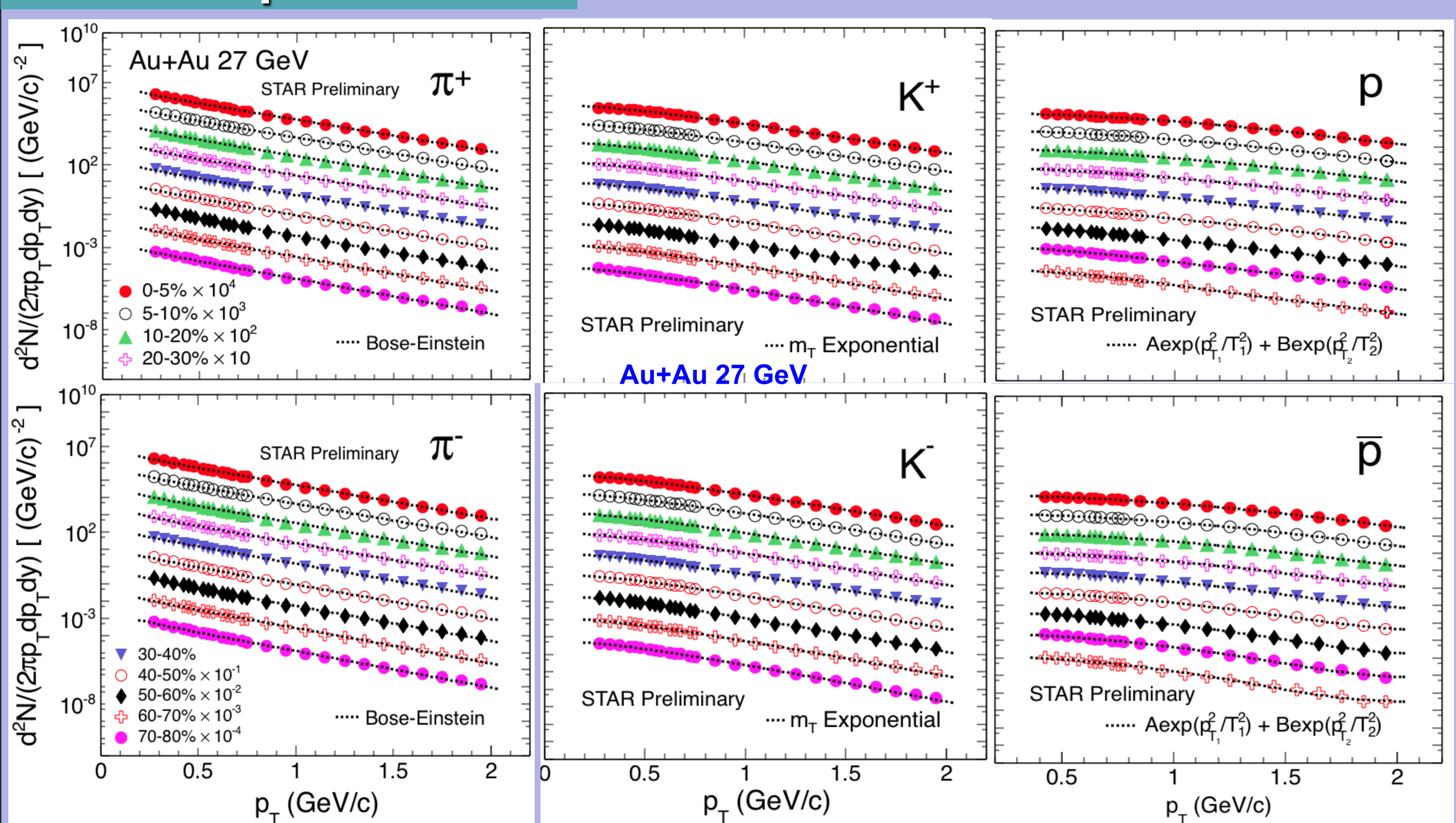
TPC+TOF

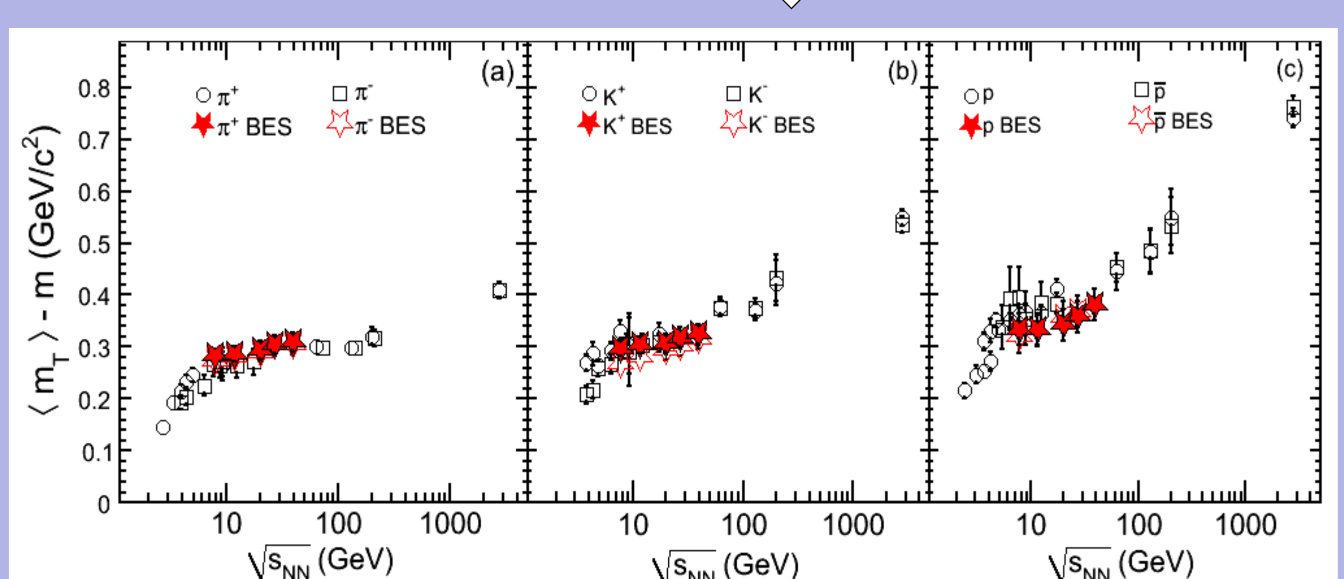
$$m^2 = p^2\left(\frac{c^2t^2}{L^2} - 1\right)$$

p = momentum
t = time-of-flight
c = velocity of light
L = path length



Particle Spectra





➢ $\langle m_T\rangle - m \sim T$ and Entropy ~ dN/dy α log($\sqrt{s_{NN}}$)

➢ The saturation of $\langle m_T\rangle$ - m around BES energies

↓

Indication for a 1st order phase transition region

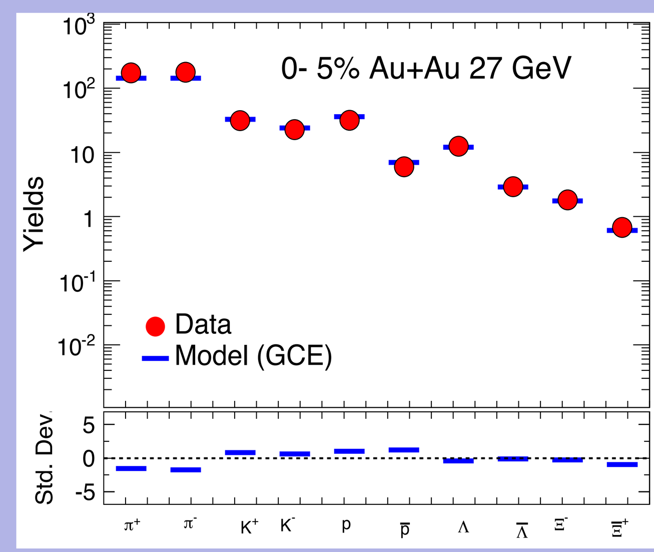
Chemical Freeze-out

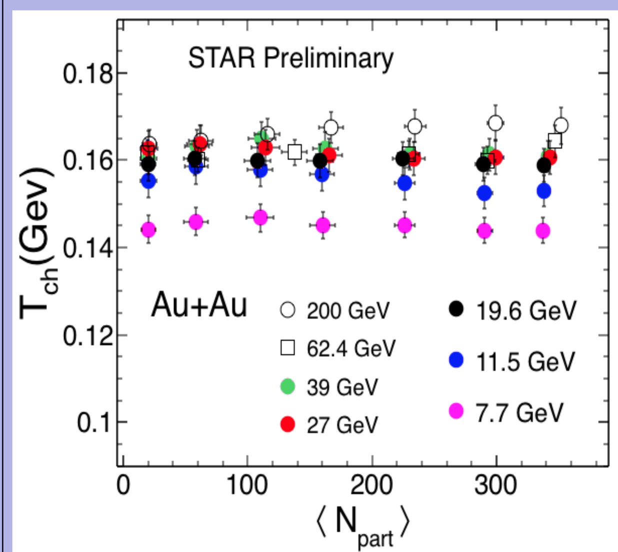
$$n_i = \frac{T m_i^2 g_i}{2\pi^2}\sum_{k=1}^{\infty}\frac{(\pm 1)^{k+1}}{k}\left(e^{\frac{k\mu_i}{T}}\right)K_2\left(\frac{k m_i}{T}\right) \Rightarrow n_i \to n_i \gamma_S^{|S_i|}$$

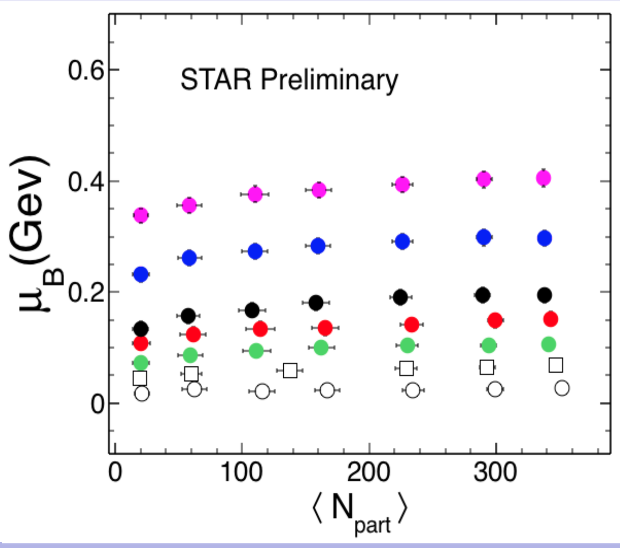
✓ Particles used : π, K, p, Λ , Ξ

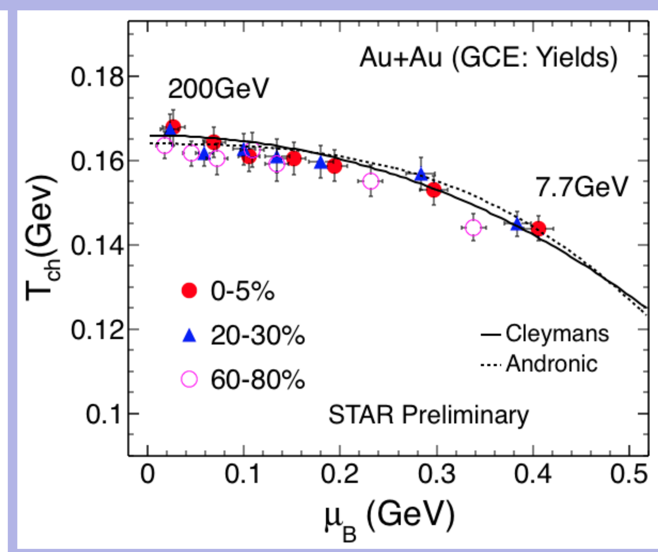
✓ Ensemble used: Grand canonical

✓ Fit parameters: T_{ch}, μ_B, μ_S, R and γ_S







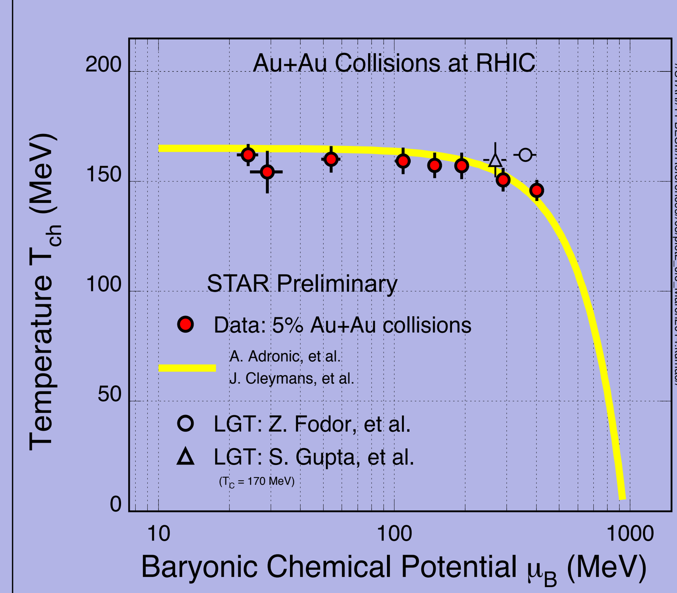


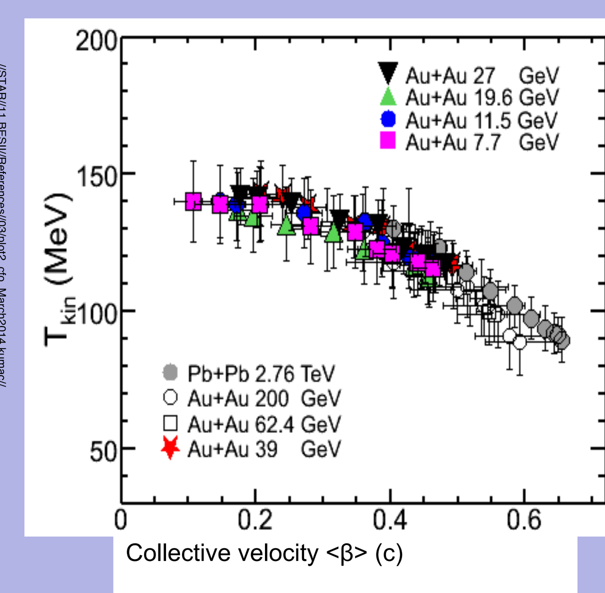
➢ As collision energy increases chemical freeze-out temperature increases

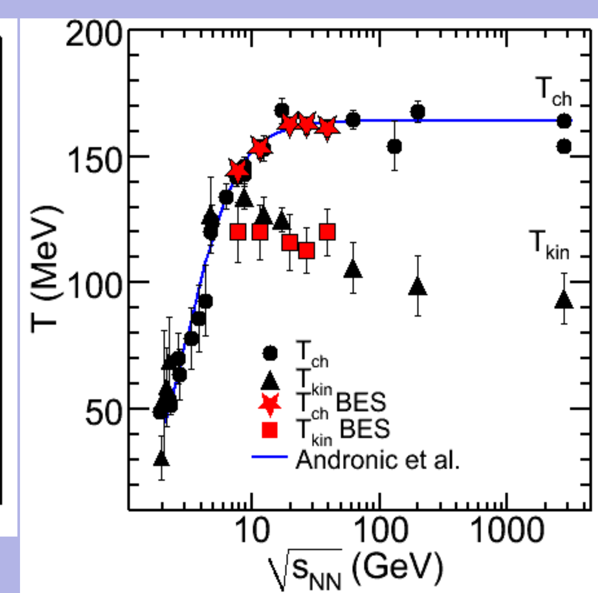
➢ Baryon chemical potential decreases with increase in collision energy.

➢ We observe a centrality dependence of chemical freeze-out parameters (T_{ch}, μ_B) at lower energies [4,5].

Chemical and KineticFreeze-out







Chemical Freeze-out: (GCE)
Central collisions.

Kinetic Freeze-out:

➢ Lower value of T_{kin} corresponds to larger collectivity β

➢ Stronger collectivity at higher energy

8. Summary

✓ Spectra are characterized through $\langle m_T\rangle$ -m which Indicates the first order phase transition

✓ Chemical Freeze-out: statistical Thermus Model calculation has been done for Au+Au collisions at 7.7, 11.5, 19.6, 27 and 39 GeV and particle yields are used to extract T_{ch} and μ_B : Study the QCD phase diagram

✓ Centrality dependence of chemical freeze-out parameters are discussed.

✓ Kinetic freeze-out: Higher kinetic temperature corresponds to lower collectiivity and stronger collectivity at higher energies.

9. References

[1] J. Cleymans *et al.*, PRC 71, 054901 (2005).

[2] E. Schnedermann, J. Sollfrank, and U. W. Heinz, Phys. Rev. C 48, 2462 (1993).

[3] B. I. Abelev *et al.* (STAR Collaboration), Phys. Rev. C 81, 024911 (2010).

[4] S. Das (STAR Collaboration), Nucl. Phys. A 904-905 (2013) 891C, J. Phys.: Conf. Ser. 509 012066 (2014)

[5] L. Kumar (STAR Collaboration), Nucl. Phys. A 862-863, 125 (2011), Nucl. Phys. A 904-905, 256c (2013), arXiv:1408.4209arXiv:1408.4209

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