Light Nuclei (d, t) Production in Au + Au Collisions at $\sqrt{s_{NN}}$ = 54.4 GeV at STAR

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Abstract

In relativistic heavy-ion collisions, the light nuclei production is sensitive to the baryon density fluctuations and can be used to probe the QCD phase transition. Based on the coalescence production of light nuclei, we can extract the neutron density fluctuation from the yield ratio of proton, deuteron and triton, $N_t \cdot N_p / N_d^2$, which may provide a method to study critical phenomena in relativistic heavy-ion collisions. In this poster, we present measurements of (anti-)deuteron and triton production in Au + Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV. These results are obtained from the large data samples collected by the STAR experiment in the year of 2017. We show the centrality dependence of the particle ratios (d/p, t/p, and t/d), and the yield ratio of $N_t \cdot N_p / N_d^2$. Their physical implications are discussed.

Introduction

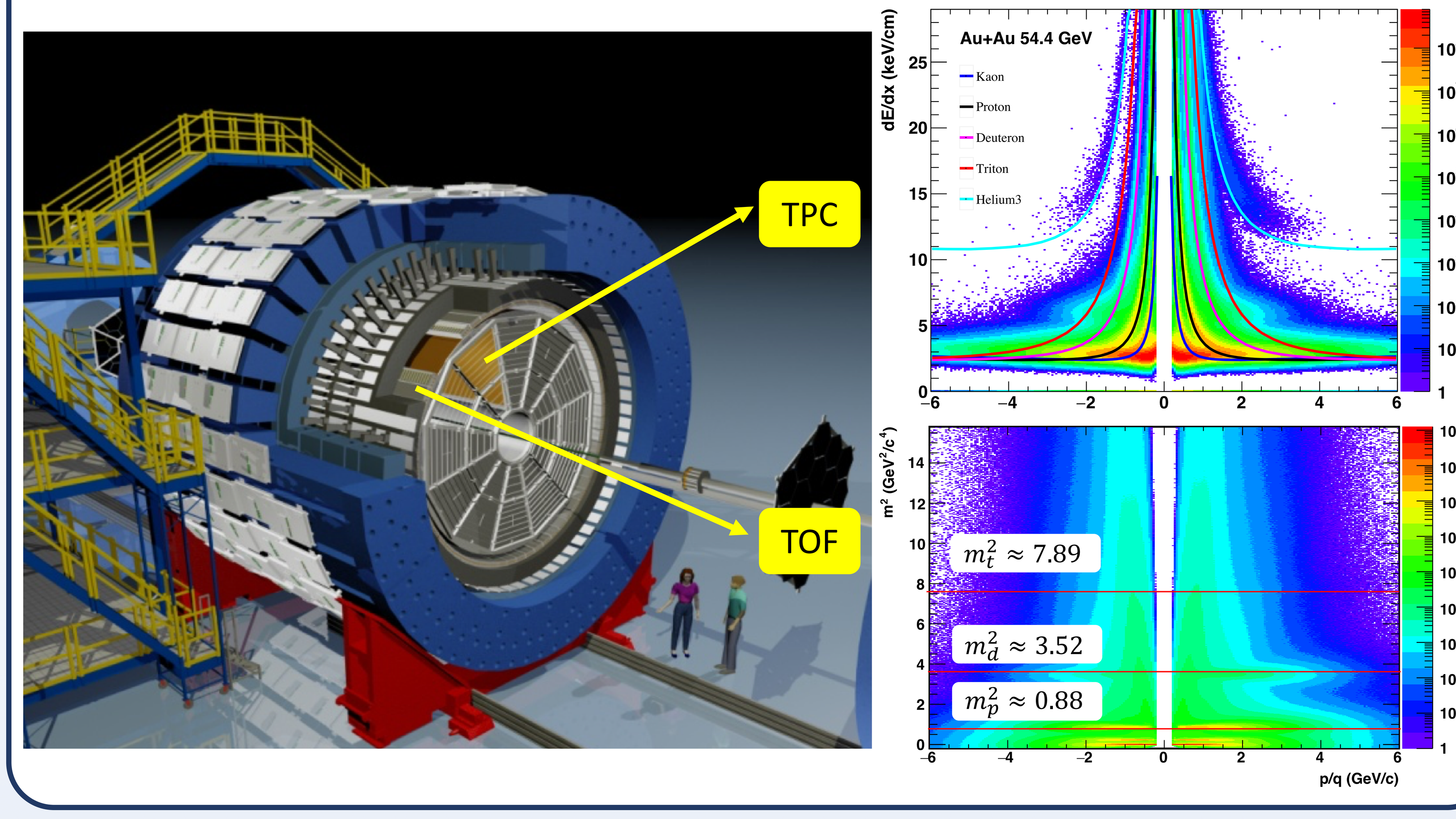
- Phase transition
  - High temperature : QGP properties
  - High baryon density : critical point and 1st order phase boundary
- Light nuclei, such as deuteron and triton, are loosely bound objects with small binding energies (d with 2.2 MeV and t with 8.4 MeV). Those are formed via coalescence of nucleons [1, 2].

$$E_A \frac{d^3N_A}{d^3p_A} = B_A (E_p \frac{d^3N_p}{d^3p_p})^Z (E_n \frac{d^3N_n}{d^3p_n})^{A-Z} = B_A (E_{p,n} \frac{d^3N_{p,n}}{d^3p_{p,n}})^A |_{\vec{p}_p=\vec{p}_n=\frac{\vec{p}_A}{A}}$$

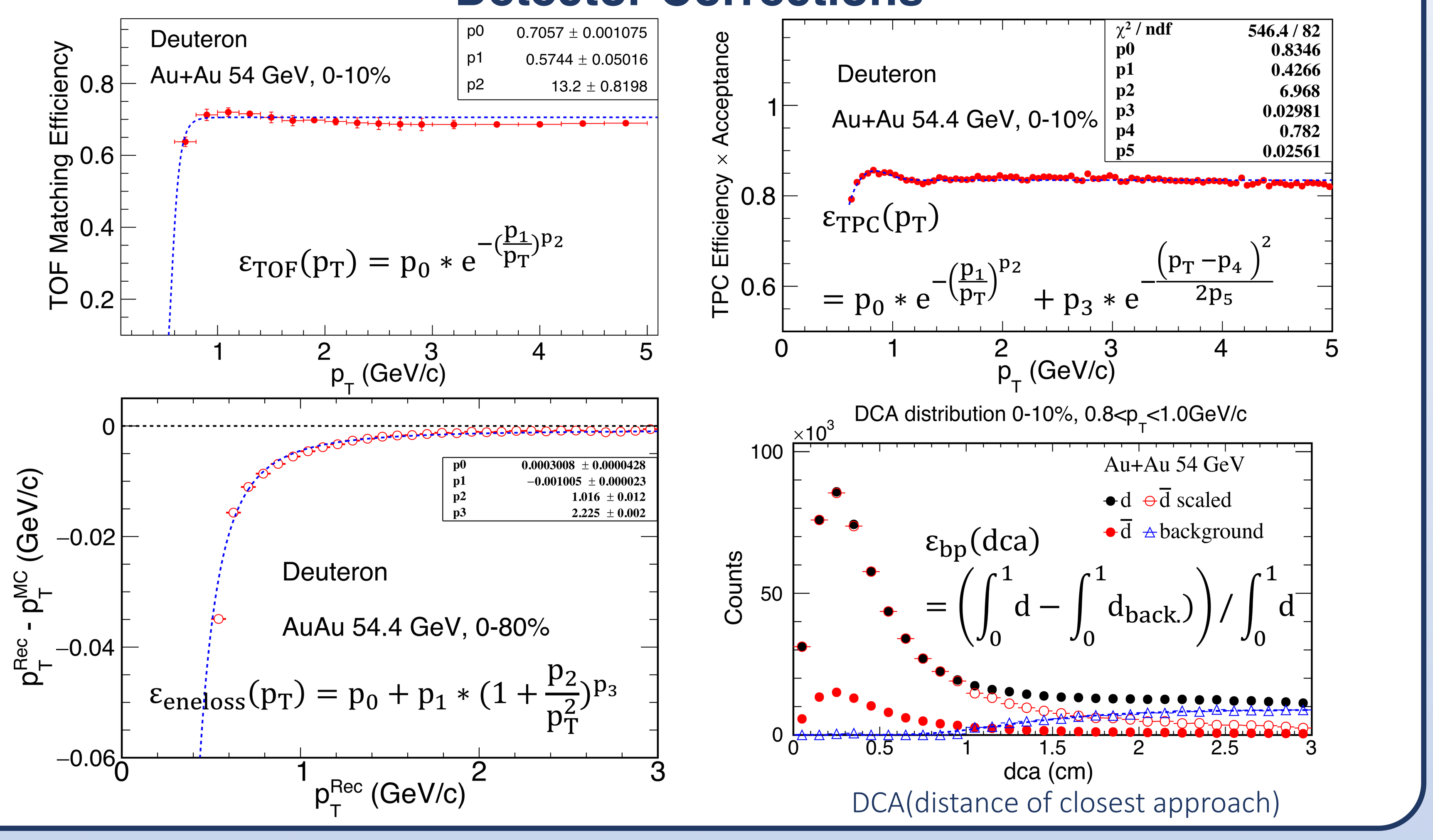
- Due to the increasing correlation length and a formation of an instability in the spinodal domain, both the critical fluctuations and first order phase transition can induce large baryon density fluctuations [3].
- The neutron density fluctuation ($\Delta n = \langle(\delta n)^2\rangle / \langle n \rangle^2$) at kinetic freeze out can be encoded in the yield ratio of light nuclei.

$$\Delta n = \langle(\delta n)^2\rangle / \langle n \rangle^2, \qquad N_p \cdot N_t / N_d^2 = g(1 + \Delta n)$$

STAR Detector and Particle Identification

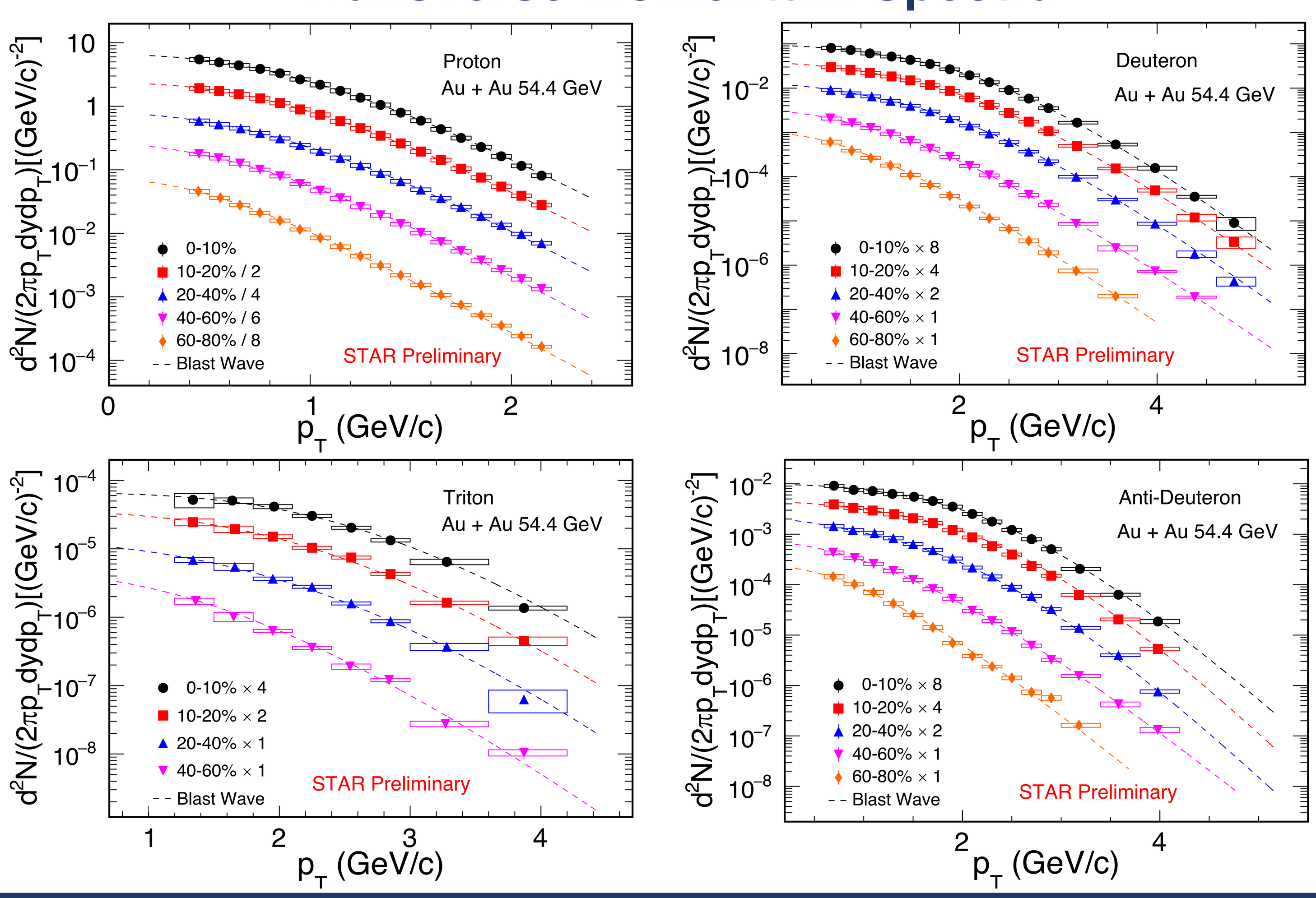


Detector Corrections

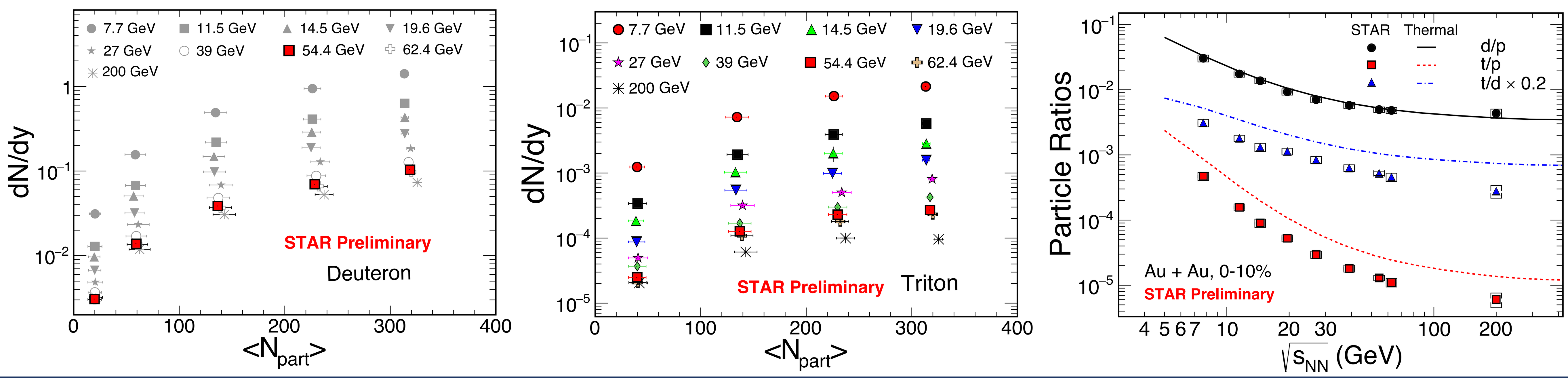


DCA(distance of closest approach)

Transverse Momentum Spectra

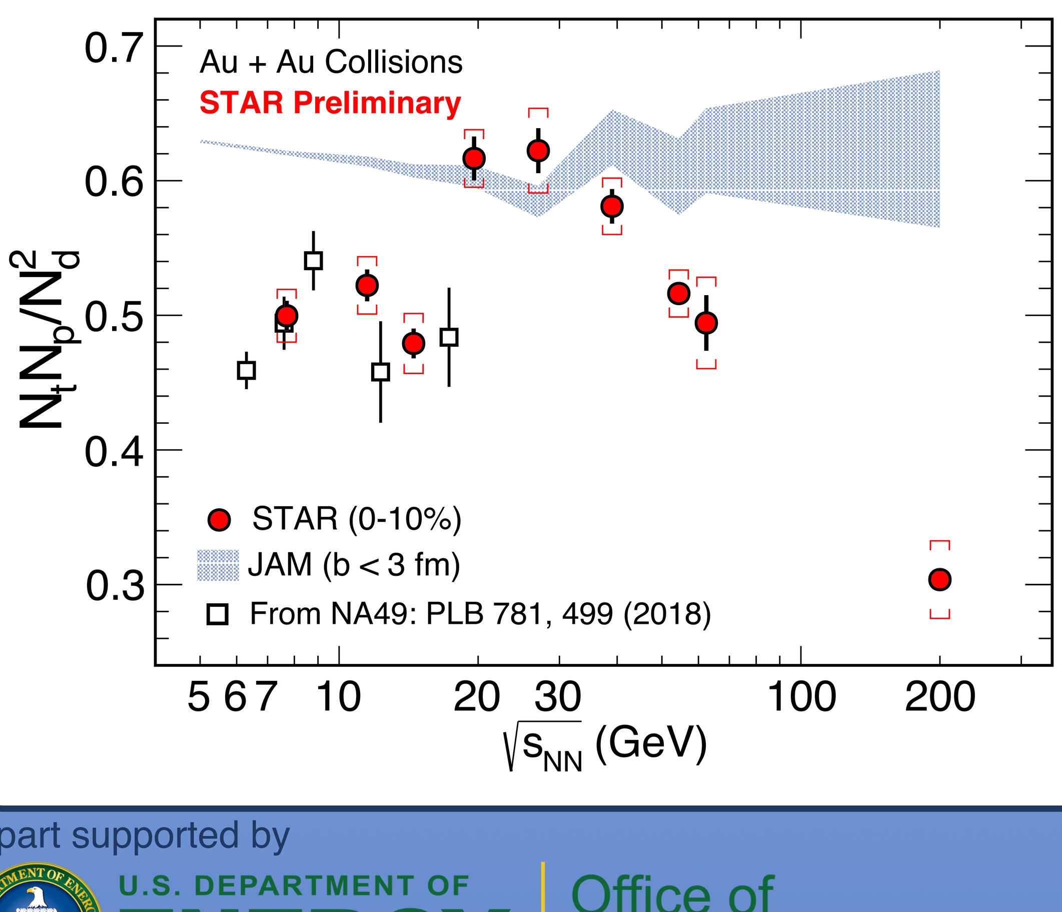


dN/dy and Particle Ratios



- dN/dy for deuteron and triton decrease with increasing energy, and increase from peripheral to central collisions.
- The particle ratios show a monotonic decrease with collision energy; d/p ratio [2] can be described well by a thermal model [4], but the model over-predicts t/p and t/d.

Yield Ratio



- The yield ratio $N_t \cdot N_p / N_d^2$ calculated from the experimental data, shows a clear non-monotonic energy dependence with a peak around $\sqrt{s_{NN}}$ = 20 GeV.
- JAM Model [5] result is flat with collision energy.

Summary

- We report the centrality dependence of deuteron, triton, proton and anti-deuteron productions in Au + Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV from STAR.
- The particle ratios d/p, t/p, and t/d have been calculated for Au + Au collisions at $\sqrt{s_{NN}}$ = 7.7 – 200 GeV.
- The yield ratio $N_t \cdot N_p / N_d^2$ shows a non-monotonic behavior as a function of collision energy in the most central Au + Au collisions, and the new results at $\sqrt{s_{NN}}$ = 14.5 and 54.4 GeV also follow this trend.

References

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In part supported by U.S. DEPARTMENT OF ENERGY Office of Science