Deuteron production in $Au + Au$ collisions at RHIC energies

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Introduction

In relativistic heavy-ion collisions, the mechanism for light nuclei production is not well understood. One possible approach is through coalescence of nucleons. Since the binding energies of light nuclei are small (2.2 MeV for deuteron, these light nuclei cannot survive when the temperature is much higher than the binding energy. The typical kinetic freeze-out temperature for light hadrons is around 100 MeV, hence they might break apart and be formed again by final-state coalescence after nucleons are de-coupled from the hot and dense system. Therefore the production of these light nuclei can be used to extract important information of nucleon distributions at freeze-out.

The transverse momentum (p_{T}) distribution of particles produced in hadronic collisions can be described by the Hagedorn function which is a QCD-inspired summed power law [1] given as

$$E\,\frac{d^3N}{dp^3} = A\left(1+\frac{m_{\mathrm{T}}}{p_0}\right)^{-n} \qquad (1)$$

Here A, p_0 and n are fit parameters. The transverse mass m_{T} is related to the p_{T} by the relation $m_{\mathrm{T}} = \sqrt{p_{\mathrm{T}}^2 + m^2}$, where m is the mass of the prodeuced particle. This function describes both the bulk spectra in the low p_{T} region and the particles produced in QCD hard scatterings reflected in the high p_{T} region.

At low p_{T} , it becomes a exponetial law

$$\left(1+\frac{m_{\mathrm{T}}}{p_0}\right)^{-n} \simeq \exp\left(\frac{-nm_{\mathrm{T}}}{p_0}\right), \qquad (2)$$

At high p_{T} , it becomes a power law

$$\left(1+\frac{m_{\mathrm{T}}}{p_0}\right)^{-n} \simeq \left(\frac{m_{\mathrm{T}}}{p_0}\right)^{-n}, \qquad (3)$$

In this paper, we present a systematic study of deuteron production at mid-rapidity region for $Au + Au$ collisions at $\sqrt{s}_{NN}$ =7.7, 11.5, 14.5, 19.6, 27, 39, 62.4, and 200 GeV, measured by STAR at RHIC. The deuteron spectra in $Au+Au$ collisions are described by Tsallis distribution [2] which is given by Eq.2.

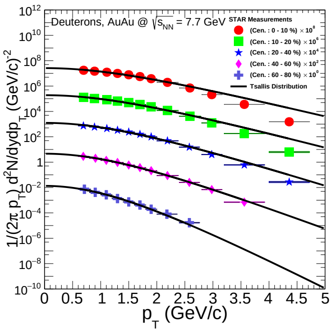

FIG. 1: The invariant yields of the deuteron particles as a function of transverse momentum p_{T} for $Au + Au$ collisions at $\sqrt{s_{\mathrm{NN}}} = 7.7$ GeV measured by the STAR experiment [3]. The solid curve is the fitted Tsallis distributions.

Results and Discussions

Figure 1 shows the invariant yields of the deuteron particles as a function of transverse momentum p_{T} for $Au+Au$ collisions at $\sqrt{s_{\mathrm{NN}}}$ = 7.7 GeV measured by the STAR experiment [3]. The solid curve is the fitted Tsallis distributions.

Figure 2 shows the invariant yields of the deuteron particles as a function of transverse

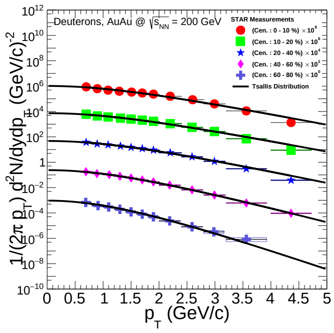

FIG. 2: The invariant yields of the deuteron particles as a function of transverse momentum p_T for $Au + Au$ collisions at $\sqrt{s_{NN}} = 200$ GeV measured by the STAR experiment [3]. The solid curve is the fitted Tsallis distributions.

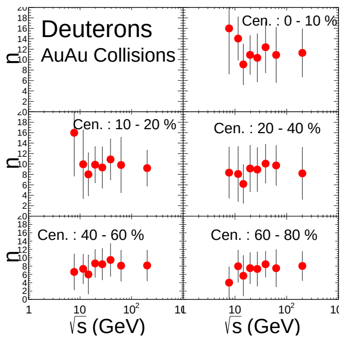

FIG. 3: The Tsallis parameter n for the deuteron particle as a function of the centre of mass energy $\sqrt{s}$ of $Au + Au$ collisions.

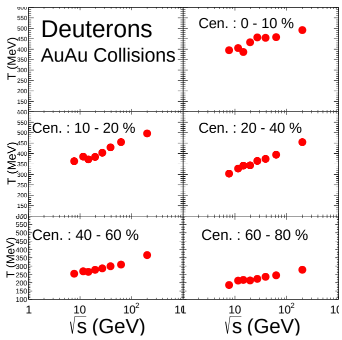

FIG. 4: The Tsallis temperature parameter T for the deuteron particle as a function of the centre of mass energy $\sqrt{s}$ of $Au + Au$ collisions.

TABLE I: The χ^2/NDF of the Tsallis function obtained by fitting the deuteron particle spectra in $Au + Au$ collisions at $\sqrt{s_{NN}} = 200$ GeV.

Centrality (%)	$< N_{part} >$	$\frac{\chi^2}{NDF}$
0 - 10	325.0 ± 4.0	1.147
10 - 20	237.0 ± 9.0	0.633
20 - 40	143.0 ± 11.0	0.307
40 - 60	62.0 ± 10.0	0.105
60 - 80	21.0 ± 6.0	0.481

momentum p_T for $Au+Au$ collisions at $\sqrt{s_{NN}}$ = 200 GeV measured by the STAR experiment [3]. The solid curve is the fitted Tsallis distributions.

Figure 3 shows the Tsallis parameter n for the deuteron particle as a function of the centre of mass energy $\sqrt{s}$ of $Au + Au$ collisions.

Figure 4 shows the Tsallis temperature parameter T for the deuteron particle as a function of the centre of mass energy $\sqrt{s}$ of $Au+Au$ collisions.

We observe that the Tsallis temperature T has a increasing trend with center-of-mass energy as well as with centrality. The parameter n approaching stability towards higher center of mass energy and is fluctuating in lower center of mass energy. The fluctuation rate of n is decreasing from central to peripheral collisions. So here we can say that deuterons are produced as a result of bulk scattering among hadrons.

References

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