DEUTERON PRODUCTION AND SPACE-MOMENTUM CORRELATIONS AT RHIC

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We present predictions for the formation of (anti)nuclear bound states in Au+Au central collisions at $\sqrt{s} = 200A$ GeV. The coalescence afterburner was applied to the freeze-out phase space distributions of nucleons provided by the transport model, RQMD version 2.4. We study the sensitivity of the deuteron spectra to space-momentum correlations. It is found that the deuteron transverse momentum distributions are strongly affected by the nucleon space-momentum correlations

1 Introduction

Nuclear clusters have been a useful tool to establish collective effects throughout the history of heavy ion reactions: production rates have provided evidence for low temperature phase transitions,[1] the spectral distribution shows particular sensitivities to collective flow,[2,3,4] transverse expansion[5,6,7,9,8] and potential forces.[7,10] With planned commisioning of the Relativistic Heavy-Ion Collider (RHIC) the necessity of the predictions of the baryon distribution in general, and light clusters in particular, is evident. It should be mentioned that predictions of different transport models for RHIC energies already offer large differences in rather basic observables like total particle multiplicities, etc. In this paper we present some results of calculations based on the cascade model RQMD version 2.4[11] and a coalescence afterburner.[7,6,12] These results are part of the effort to formulate a physics program for the STAR collaboration. More details related to this study and extensive discussion of the sensitivity of the light nuclei to various properties of the colliding system at RHIC can be found elsewhere.[13,14]

2 Rapidity Distributions

One of the basic observables in nucleus-nucleus collisions is rapidity distributions of nucleons. It reflects the energy loss of the nucleons and as well as bulk properties of the particle production in a collision. Figure 1 shows predictions, based on RQMD calculations of rapidity distributions of protons and deuterons as well as antiprotons and antideuterons for central Au+Au collisions at full RHIC energy. As has been mentioned earlier, predictions for clusters were made in a coalescence framework. Vertical dashed lines on Figure 1 schematically show the expected acceptance of the STAR TPC. One can conclude from the figure that RQMD predicts 1 deuteron to be emmited into the STAR acceptance for about every 20 central events. The predicted rate of antideuteron production is about 1 per 100 events. With the expected trigger rate of STAR for Au+Au central collisions (∼1 Hz) these pedicted rates make deuteron and antideuteron measurements feasible and a good candidate for a "year one" physics.

3 Transverse Momentum Distributions

Another important basic observable of the heavy-ion collision is the transverse momentum distribution of baryons. It is sensitive to various physical properties of the collision. Transverse momentum distributions reflect the degree of thermalization reached in the heavy-ion collision as well as effects of the collective flow. Fig. 2(a) presents the rapidity dependence of the average transverse momentum of protons and deuterons for normal RQMD events. The average transverse momentum for deuteron is about a factor of two higher than for protons. For comparison, rapidity dependence of the mean transverse momentum of pions and kaons is shown as dashed and solid lines respectively. A clear "particle mass hierarchy" of the mean p_T is evident from Fig. 2(a), which is commonly[8] attributed to the presence of the transverse flow. The influence of the collective transverse flow component on the mean transverse momentum can be further demonstrated by comparing this result with calculations where the freeze-out correlation of positions and momenta of the nucleons have been deliberately altered. Panels labeled (b) and (c) in Fig. 2 show the result of such calculations. Fig. 2(b) shows the case where the angle between $\vec{p_T}$ and $\vec{r_T}$ has been randomized. This procedure produces a system with no collective flow. It can be seen from the figure that the dif-

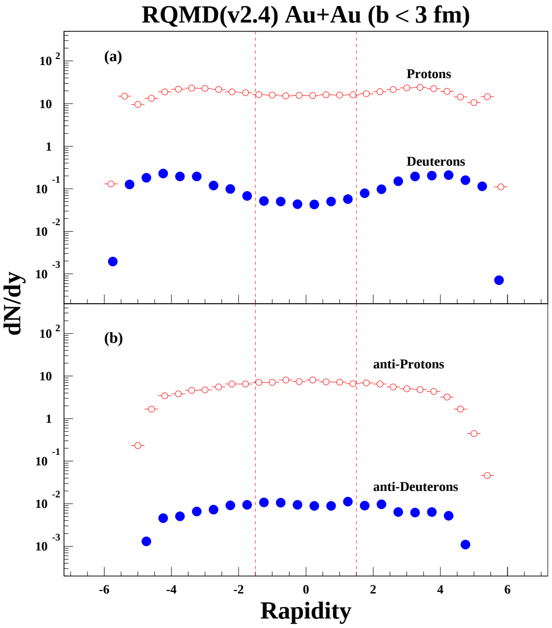

Figure 1. Rapidity distributions of (a) protons (open circles) and deuterons (filled circles); (b) anti-protons (open circles) and anti-deuterons (filled circles), from central Au+Au collisions. The STAR TPC acceptance is indicated by the dashed lines.

ference between the average transverse momenta of deuterons and protons is dramatically reduced. Fig. 2(c) shows the so called aligned case, where for each nucleon the transverse radius vector $\vec{r_T}$ is aligned with the transverse momentum vector $\vec{p_T}$. This case mimics a "maximum flow" scenario. Note that in the aligned and random cases only the relative orientation of $\vec{r_T}$ to $\vec{p_T}$ is modified: momentum distributions and projections onto either r_T or p_T are not touched. These figures illustrates high sensitivity of the deuteron spectra to the momentum position correlations. Figure 2 (d) is the result of a calculation without rescattering among baryons (rescattering here means interaction with produced particles). Similar to the random case, the results of calculations without baryon rescattering (Fig. 2(d)) show a constant, rapidity independent difference between deuteron and proton transverse momentum of about 150 MeV. This suggests that multiple rescattering among particles in

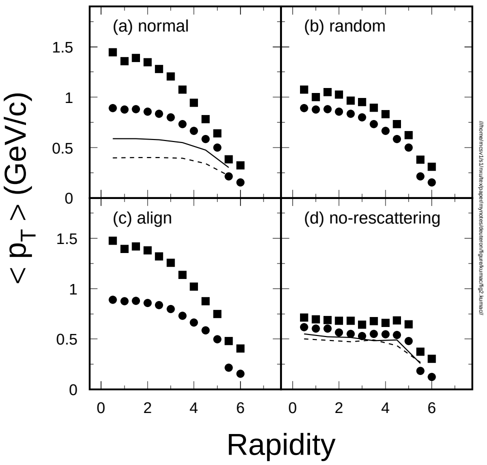

Figure 2. Deuteron (filled square), nucleon (filled circle), kaon (solid-line), and pion (dashed-line) mean transverse momentum as a function of rapidity.

RQMD leads to collective flow.[14]

In summary, using a microscopic transport model RQMD and a coalescence afterburner, we have calculated rapidity distributions of protons and deuterons as well as their antiparticles for central Au+Au collisions at $\sqrt{s} = 200A$ GeV. We studied the sensitivity of the deuteron transverse momentum distributions in different rapidity regions to the effects of the transverse collective flow. Should new physics occur at RHIC, a modification of the space-momentum structure will manifest itself in the deuteron yields and transverse momentum distributions. These distributions can be measured in the STAR TPC and other RHIC experiments.

† B. Monreal is at Lawrence Berkeley National Laboratory through the Center for Science and Engineering Education.

Acknowledgement

We are grateful for many enlightening discussions with Drs. S. Johnson, D. Keane, S. Pratt, H.G. Ritter, S. Voloshin, R. Witt. We especially thank Dr. J. Nagle for permission to use his coalescence code. This research used resources of the National Energy Research Scientific Computing Center. This work has been supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098 and W-7405-ENG-36, DOE grant DE-FG02-89ER40531 and the Energy Research Undergraduate Laboratory Fellowship and National Science Foundation.

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