

Pion Production in $^{96}\text{Ru}+^{96}\text{Ru}$ Collisions at 400A and 1528A MeV

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We examine the thermal model [1, 2] in order to reproduce the momentum spectra of charged pions in Ru + Ru collisions at 400A and 1528A MeV. The collision centrality is determined by the E_{rat} at 400A MeV and by the total multiplicity at 1528A MeV for the most central 10% of σ_{geom} . Consistent selection cuts of π^\pm with the p_t dependences are applied. The pion invariant spectra as a function of transverse mass can be described by one exponential function at 400A MeV and by the sum of two exponential functions at 1528A MeV. Therefore, decay pions from the $\Delta(1232)$ resonances are sufficient at 400A MeV, but additional thermal pions are necessary at 1528A MeV. For the phase-space distributions of $\Delta(1232)$ resonances at freeze-out, the isotropic expanding source with the temperatures of 30 and 84 MeV at 400A and 1528A MeV, respectively, are assumed with the same radial flow velocity (0.3) [3, 4]. Two different mass distributions of $\Delta(1232)$ are considered with and without including πN interactions in the thermal fireball [1]. The modified spectral function, which can be uniquely determined by the measured phase-shift δ_{33} , is shifted to lower masses in comparison with the free spectral function.

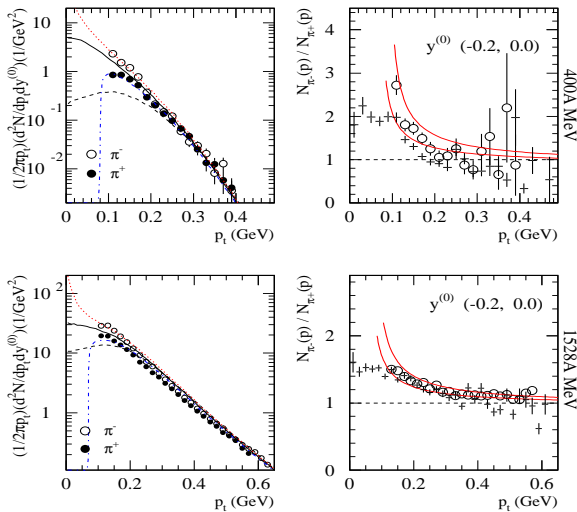


Figure 1: (Left) Invariant spectra of π^\pm at midrapidity in comparison with the thermal model calculations at 400A (top) and 1528A MeV (bottom). The dashed line is obtained for the free spectral function, whereas the solid line is for the modified spectral function (no Coulomb correction). The final results of the thermal model for π^- and π^+ are shown by dotted and dash-dotted lines, respectively, after the static Coulomb potential is taken into account. (Right) Ratios of π^- to π^+ yields at midrapidity. Two solid lines represent the upper and lower limits from the thermal model calculation, and the crosses are from the IQMD(HM) calculation.

The invariant spectra of π^\pm at midrapidity are compared with the thermal model calculations in Fig. 1 for both beam energies. It is clear that the free spectral func-

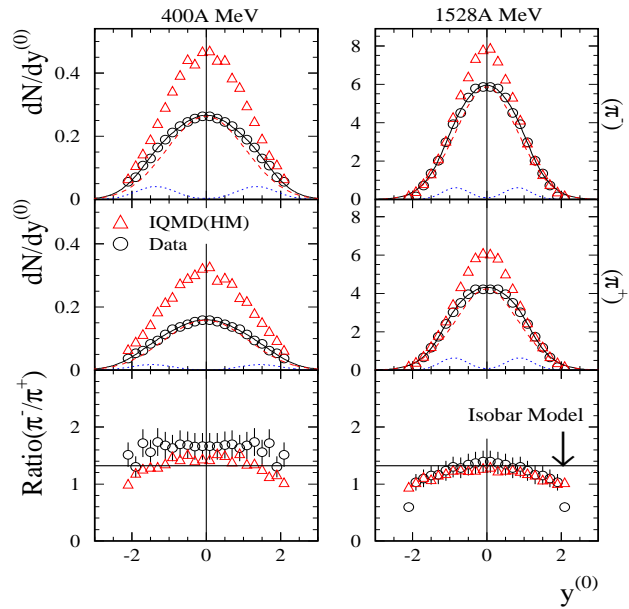


Figure 2: Rapidity distributions of π^- (top) and π^+ (middle) at 400A (left) and 1528A MeV (right). Dashed and dotted lines in top two panels are the isotropic thermal source at the center-of-mass and the estimated target/projectile components, respectively. Solid lines represent the sums of two contributions. Bottom panels show the ratio of the rapidity distributions of π^- and π^+ with the solid lines the isobar model predictions. The IQMD(HM) calculations are shown by triangles.

tion cannot reproduce data, especially in the low p_t region, and that the modified spectral function can enhance the yields at low p_t , which brings the model calculation much closer to the experimental data. The Coulomb potential is determined by the ratios of π^- and π^+ yields which are shown in the right panels of Fig. 1 ($V_C = 22 \pm 5$ and 15 ± 3 MeV at 400A and 1528A MeV, respectively). This yields the freeze-out radii $R_f = Z_{eff} \cdot e^2 / V_C \approx 4.4 \pm 1.0$ and 6.4 ± 1.3 fm, respectively. This result shows a larger freeze-out volume at higher beam energy.

The pion spectra are also compared with the IQMD model with hard EoS and momentum-dependent interaction, IQMD(HM) [5]. As shown in Fig. 2, pion yields by IQMD(HM) are higher than the measurements, especially at 400A MeV (the data has about 20% systematic error). But, the ratio of π^- and π^+ yields can be reproduced very well (right panels of Fig. 1).

References

- [1] W. Weinhold *et al.*, Phys. Lett. B **433**, 236 (1998).
- [2] B. Hong *et al.*, Phys. Lett. B **407**, 115 (1997).
- [3] B. Hong *et al.*, Phys. Rev. C **66**, 034901 (2002).
- [4] B. Hong *et al.*, Phys. Rev. C **57**, 244 (1998).
- [5] C. Hartnack *et al.*, Eur. Phys. J. A **1**, 151 (1998).