Source Shape Parameters in Central Ru + Ru Collisions at 400 AMeV

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Collective flow effects in heavy ion collisions are of interest since they are expected to provide insight into the properties of hot and dense nuclear matter and its Equation of State (EoS). They are not uniquely sensitive to the stiffness of the EoS but also to other effects such as the momentum dependent interaction (MDI) and the in-medium modification of the nucleon-nucleon cross section (σ_{nn}).

In this context a complete study of the nuclear collective flow has been performed with a method which can be used in a restricted region of momentum space where the spectator contribution is believed to be negligible. In this procedure, applied successfully to DIOGENE data [1], the two-dimensional momentum distributions (p_z^{cm}/m, p_x/m), (p_z^{cm}/m, p_y/m) are fitted with anisotropic Gaussian distributions in and out of the reaction plane, respectively. The emission pattern is then approximated by an ellipsoid whose orientation and shape are defined by the flow angle, θ_F, and the in-plane and out-of-plane aspect ratios, $\lambda_{31} = \sigma_3/\sigma_1$ and $\lambda_{21} = \sigma_2/\sigma_1$, respectively. σ_i are the standard deviations, σ_3 is oriented along the flow axis.

Studied were Ru + Ru collisions at 400 AMeV measured with the FOPI detector. We focus on central events ($< b_{geo} > = 1.1$ fm) selected by means of the energy ratio criterion Erat [2]. The reaction plane is reconstructed according to the transverse momentum analysis method [3]. The observables are corrected for autocorrelation and momentum conservation effects [4] and for reaction plane fluctuations as described in [5, 1]. The shape parameters are determined with the data measured in the central part of FOPI and they are shown for proton-like fragments. We emphasise on the possibility to constrain σ_{nn} on the basis of the present data. In this purpose the shape parameters are compared in fig.1 to the predictions of the Isospin Quantum Molecular (IQMD) model [7] for a hard EoS including MDI (HM parametrisation) and different values of σ_{nn}. The shape parameters exhibit important sensitivities to this quantity. Both the flow angle and the aspect ratios rise strongly as σ_{nn} increases from $0.5\sigma_{nn}^{free}$ to $2\sigma_{nn}^{free}$ and a saturation of the shape parameters seems to be reached for $\sigma_{nn} > 2\sigma_{nn}^{free}$. It is obvious that the data cannot be reproduced by the IQMD model for $\sigma_{nn} \geq 2\sigma_{nn}^{free}$. A significant reduction of σ_{nn} seems to be excluded as well. This is consistent with results on the nuclear stopping obtained from isospin tracer observables [6].

The present work shows that the source shape parameters extracted from gaussian fits to double differential momentum distributions offer the possibility to constrain the range of the nucleon-nucleon cross section in the nuclear medium. This constitutes an important step towards the determination of the Equation of State.

References

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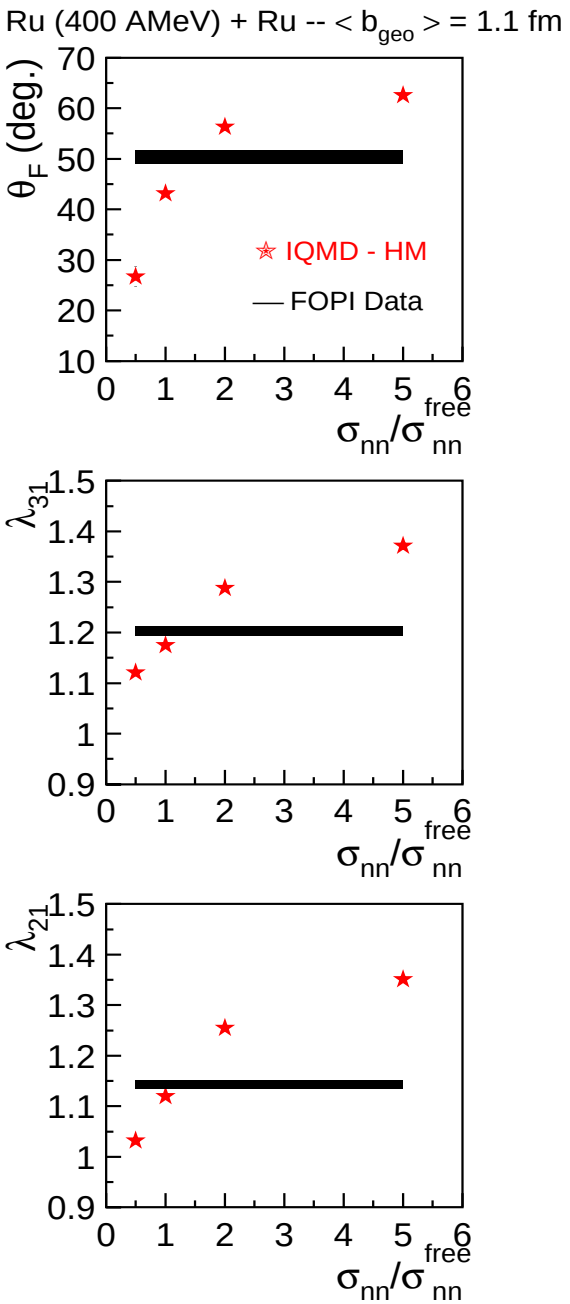

Figure 1: Flow angle and aspect ratios of proton-likes measured in central Ru + Ru reactions at 400 AMeV. The data are compared to the IQMD predictions (HM version) for different values of σ_{nn}. The stars correspond to the model calculations. The solid line represents the experimental data and includes the statistical uncertainties.