Transverse momentum distributions of relativistic charged fragments in heavy ion collisions

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Introduction

Nuclear fragmentation is an important phenomenon in high energy heavy ion interactions [1]. Nuclear emulsion detectors have been widely used in the investigations of nuclear fragmentation [2]. This detector provides 4π geometrical coverage therefore allows an exclusive type of analysis on an event by event basis with detailed information about the fragmentation mechanism of nucleus-nucleus interaction. In this paper, the transverse momentum distribution of ^{84}Kr-emulsion interaction at around 1 GeV per nucleon has been described with the help of two sources of fragments emission model.

It is generally believed that the nuclear geometry plays important role in analyzing data in high energy nucleus-nucleus collisions [3]. According to the participant-spectator model, overlapping part of two nuclei in collision is called the participant region where multiple productions of new particles occur and the other part called spectator as shown in Figure 1. In collision, due to the existence of the relative motion between the participant and the spectator, the friction is assumed to be caused on the contact layer. Both the participant and spectator obtain the heat of friction. It takes some time when the contact layer transmits the heat to the residual part of the spectator. This could not lead the whole spectator to local equilibrium state. The contact layer and the other part of the spectator are two sources to emit light fragments with two different temperatures.

Let d denote the thickness of the projectile spectator and D represent the thickness of the hot spectator. Then there are three major cases for projectile fragments emission i) if $d = 0$ there is only emission source that is the projectile participant region, ii) if $0 < d < D$, then there are two emission sources such as projectile participant as well as hot spectator regions and iii) if $D < d < 2R_P$, then there are three emission sources such as the projectile participant and the hot spectator and the cold spectator regions.

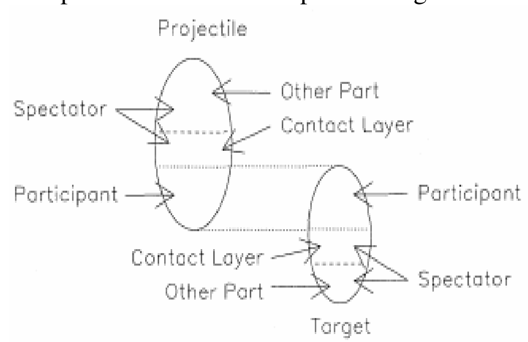

Fig. 1: Schematic diagram of participant-spectator model in case of heavy ion interactions.

Transverse Momentum Distribution

In an emulsion detector based experiment it is not possible to make direct measurement of momentum of high energy projectile fragments. However the transverse momentum can indirectly be measured by using the fact that the fragments have nearly the same momentum per nucleon as that of the projectile/beam because when a projectile nucleus with relativistic energy collide with a target nucleus the projectile fragment emitted retain more or less the same momentum per nucleon as that of the incident projectile. Thus, the transverse momentum of the fragment of charge Z can be calculated by using the relation $P_T = A_F P_o \sin \Theta$, where P_o is the momentum of the projectile and A_F is the mass number of the fragments and Θ is the emission angle of the fragments with respect to the projectile direction. Therefore in nuclear emulsion experiment the pseudotransverse momentum can be obtained from the measurements of the emission angle of the fragments. It is expected that a thermalised cylinder is formed in high energy nucleus-nucleus collisions along the incoming direction of the projectile. Many emission sources exist in the thermalised cylinder. The emission sources stay at different rapidities in the range from y_{min} to y_{max} [4]. As in the ideal gas model, in the rest frame of the emission source n, we assume that three components of particle momentum obey a Gaussian distribution and have the same standard deviation (σ_n). The Transverse momentum P_T obeys the Rayleigh distribution; f_{PT} (P_T, σ_n) = [P_T/σ_n^2] exp ($-P_T^2/2\sigma_n^2$).

Results

In order to test the two source emission picture, we compared the two transverse momentum distributions of single and double charge fragments for different target groups with Rayleigh distribution function. The transverse momentum distribution for Ag(Br) target with single and double charge projectile fragments (PFs) are shown in figure 2 & 3, respectively. The histogram is the experimental distribution of transverse momentum of PFs, measured for ^{84}Kr -Em interactions at around 1 A GeV and solid curve is the Rayleigh distribution function as described in last equation. These PFs are only in the projectile fragmentation region due to their high energies.

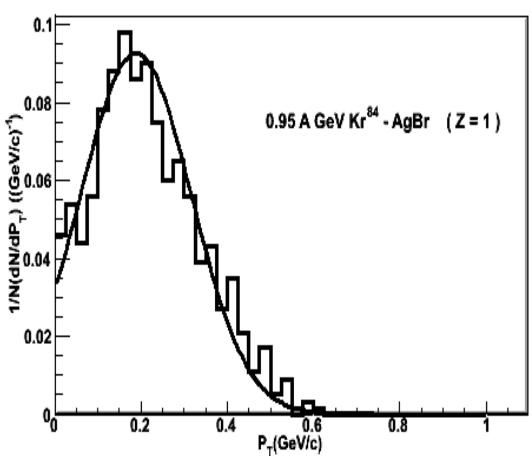

Fig. 2: Pseudotransverse momentum distribution of singly charged relativistic projectile fragments for ^{84}Kr-Ag(Br) interactions at around 1 A GeV. The histograms are the experimental data and the curve is the calculated result for Rayleigh scattering.

The relativistic fragments produced in high energy nucleus emulsion collisions can be regarded as the result of a two-source emission. The two sources are the hot spectator with high temperature and cold spectator with low temperature respectively. From the figures 2 & 3, we can see that the two source model gives a reasonable description of the transverse momentum distributions in case of single and double charge projectile fragments emitted in ^{84}Kr-Em collisions at around 1 A GeV.

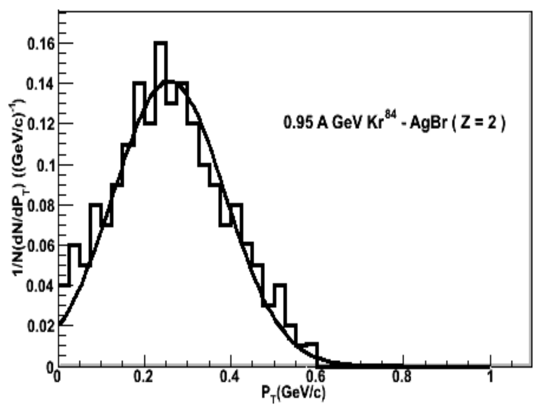

Fig. 3: Pseudotransverse momentum distribution of alpha projectile fragments emitted in ^{84}Kr-Ag(Br) interactions at around 1 A GeV. The histograms are the experimental data and the curve is the calculated result for Rayleigh scattering.

We will present pseudotransverse momentum distribution dependence on different type of target groups such as H, CNO and Ag(Br) and check the two source hypothesis. Our results must be compared with others recent and similar results [4, 5].

References

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