Projectile fragmentation characteristics in peripheral collision at relativistic energy

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Introduction

Nuclear emulsion detector is one of the oldest detector technologies and has been in use from the birth of the experimental nuclear and astroparticle physics [1, 2]. It is a unique and simple detector till today, due to very high position resolution ($\sim$1 μm) along with several unique features. Nuclear emulsion detector has 4π detection capability with hit density of 300 - 500 grains per mm, compactness of the size and large range of ionization sensitivity depends upon the nature and need of the experiment [1, 2]. The high resolution allows easy detection of short-lived particles such as τ lepton and mesons.

The projectile fragmentation is a relatively well isolated process in the complex scheme of high-energy heavy-ion reactions with multi-baryon system [1, 2]. The results of our systematic studies on projectile fragmentation of inelastic events in the peripheral interaction of $^{84}Kr_{36}$ with the emulsions targets at around 1 GeV per nucleon and emission properties of projectile fragments are presented in this article.

Experimental Details

The nuclear emulsion detector used in present study was composed of silver halide crystals immersed in a gelatin matrix consisting mostly of hydrogen, carbon, nitrogen, oxygen, silver and bromine with a small percentage of sulfur and iodine [2]. In the present experiment, we had employed a stack of high sensitive NIKFI BR-2 nuclear emulsion pellicles of dimensions $9.8\times9.8\times0.06\ cm^3$, exposed horizontally to ^{84}Kr ion at a kinetic energy of around 1 GeV per nucleon [2]. The exposure has been performed at Gesellschaft fur Schwerionenforschung (GSI) Darmstadt, Germany. The interactions were found by along-the-track scanning technique using an oil immersion objective of 100×magnification. The beam tracks were picked up at a distance of 5mm from the edge of the plate and carefully followed until they either interacted with emulsion nuclei or escaped from any surface of the emulsion. These events have been examined and analyzed with the help of an OLYMPUS, binocular optical microscope, having total magnification of 2250× and measuring accuracy of 1μm. In this analysis the nuclear emulsion plate are scaned by the two standard methods. One of them is the line scanning and second is volume scanning [2]. In line scanning method the tracks are followed along their length until they interact with one of the photographic emulsion material or escape the plate, while in volume scanning method the emulsion plates are scanned strip by strip and event information are collected. The present analysis is based on the events coming from the peripheral collision only. In this analysis we have used 100 peripheral events out of 700 inelastic events.

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Classification of Secondary Charged Particles

According to the Participant Spectator Model (PS Model) the interacting system are divided into three main regions, (i) projectile spectator, (ii) target spectator and (iii) participant region [2]. All the secondary charged particles produced in an interaction of ^{84}Kr with nuclear emulsion are classified according to their ionization in terms of normalized grain density, range and velocity in three main categories, (i) *Shower Particle (N_s)*: These particles have normalized grain density $g^* < 1.4$ and relative velocity $\beta > 0.7$, (ii) *Black Particle (N_b)*: These particles have normalized grain density $g^* > 6.8$, range L < 3 mm and relative velocity $\beta < 0.3$, (iii) *Grey Particle (N_g)*: These particles having normalized grain density $1.4 < g^* < 6.8$, range L > 3 mm and relative velocity $0.3 > \beta < 0.7$. The number of heavily ionizing charged particles ($N_h = N_b + N_g$) depends upon the target breakup. The black particles and grey particles are mainly coming from the target spectator regions, while shower particles are coming from the participant region. The projectile fragments are coming from the projectile spectator region having charge Z ≥ 1. These projectile fragments are classified into three main categories, (i) *single charge projectile fragments* ($N_{z=1}$) (ii) *double charge projectile fragments* ($N_{z=2}$) and (iii) *multicharge projectile fragments* ($N_{z>2}$) respectively [1, 2].

Results and Discussion

In this report we focus our study on the emission characteristics of the multicharged projectile fragments of the inelastic events coming from the peripheral collisions only. In the present study all the collisions are classified according to the collision geometry in three main regions, (i) central collision, (ii) quasi-central collision, (iii) peripheral collision. In peripheral collision the target and projectile nuclei are far apart nearly equal to the sum of the their radii. Due to which only a small percentage of momentum are transferred in these collision. The variation of the average multiplicity of multicharged projectile fragments with mass number of the projectile beam (A_p) are shown in figure 1. From figure 1 we can see that the average multiplicity of multi-charged projectile fragments are linearly increasing with increasing the mass of projectile beam in peripheral collision.

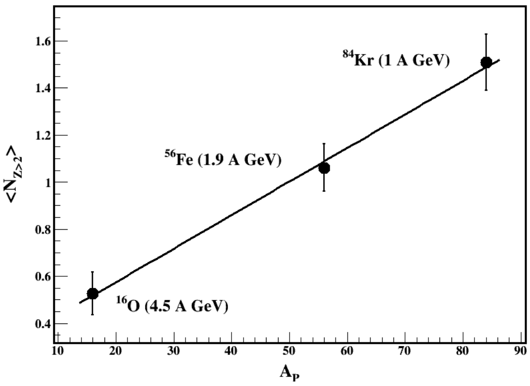

FIG. 1: The average multiplicity variation of the multicharged projectile fragments with the mass of the projectile beam for ^{16}O (4.5 AGeV) [3], ^{56}Fe (1.9 AGeV) [4], ^{84}Kr (1 AGeV)[present work]

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