Study of shower particles production in $^{84}Kr_{36}$ emulsion by using wounded nucleon model

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Introduction

Relativistic heavy ion collisions provide as unique possibility to produce the hadronic matter at higher density and temperature [1]. In such a heavy ion collisions baryonic matter reaches up to few time's more than the normal nuclear matter. The variation of energy with density provides us platforms to extract the information of Equation of State (EOS) [1]. It is also believed that such heavy interactions may give some useful information about the dynamics of the multiparticles production. Nuclear Emulsion Detectors (NED) are widely used in the multiparticles detection [2]. When an energetic projectile collides on the nuclear emulsion targets, a large number of charged and uncharged particles are produced. According to the participant spectator model (PS), the overlapping region is called the participant region and other regions are called the spectators [3]. The PS model predicts that violent nucleon - nucleon (N-N) collisions takes place in the participant region and weak excitation and cascade collisions are takes place in the spectator parts. The large numbers of fresh particles i.e. pions, photons, lepton pairs etc., are produced in the participant regions. The wounded or participant nucleons are also produced from both projectile and target nuclei. The wounded nucleon model and its extension become useful tool for investigation of the heavy ion interactions. In the present work, the total number of projectile and target wounded nucleons are calculated for $^{84}Kr_{36}$-Em interactions at around 1GeV/n by using wounded nucleon model.

Wounded nucleons model calculation

Wounded nucleon model of hadronic interaction describes nucleus - nucleus (A-A) or hadron - nucleus (h-A) collisions as an incoherent superposition of collisions of individual nucleons. The total number of projectile and target wounded nucleon i.e. W_P and W_T are calculated from the nucleus - nucleus, nucleon - nucleus and nucleon - nucleon cross-sections as described in Refs. [2-3]. Calculated values of the wounded nucleon for both projectile and target nuclei are tabulated in table. From the table, we can observed that the calculated values of projectile and target wounded nucleons are increases with increasing the target mass number. In addition, it is found that the calculated values of projectile wounded nucleons are relatively higher than the target wounded nucleons. This implies that the projectile nucleus playing prominent role in production of wounded nucleons.

System	W_P	W_T	Ref.
^{84}Kr-H	2.82	0.81	PW
^{84}Kr-CNO	10.23	6.18	PW
^{84}Kr-AgBr	21.07	21.26	PW
^{56}Fe-Em$^{\mathbf{a}}$	13.27	12.77	PW
^{84}Kr-Em$^{\mathbf{b}}$	17.02	14.60	PW
^{132}Xe-Em$^{\mathbf{b}}$	22.29	16.85	PW
^{197}Au-Em$^{\mathbf{b}}$	28.15	19.01	PW

Table 1: The calculated values of projectile wounded nucleon (W_P) and target wounded nucleon (W_T) for different projectiles at different energy regions are tabulated. $^{\mathbf{a}}$1.8, $^{\mathbf{b}}$1 AGeV.

The calculated values of W_P and W_T for different projectiles such as ^{56}Fe-Em, ^{84}Kr-Em, ^{132}Xe-Em and ^{197}Au-Em at relativistic high energy are compared with other projectiles as shown in figure 1 and other projectiles data are taken from ref [2]. Figure 1 shows that a strong correlation between the W_P, W_T and projectile mass (A_P). We can notice from figure 1 that the calculated values of the wounded nucleons i.e. W_P and W_T are linearly increases with increasing the projectile mass number and independent from the incident kinetic energy. The calculated values are fitted with the linear function and the best fit parameters are

$W_P = (0.62 \pm 0.006)\ A_P + (0.02 \pm 0.008).$ (1)

$W_T = (0.41 \pm 0.03)\ A_P + (0.40 \pm 0.03).$ (2)

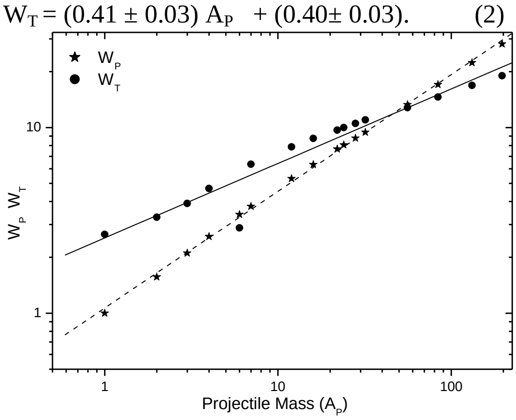

Fig. 1: The relation between projectile and target wounded nucleons (W_P and W_T) on the projectiles mass number (A_P) at different energy regions.

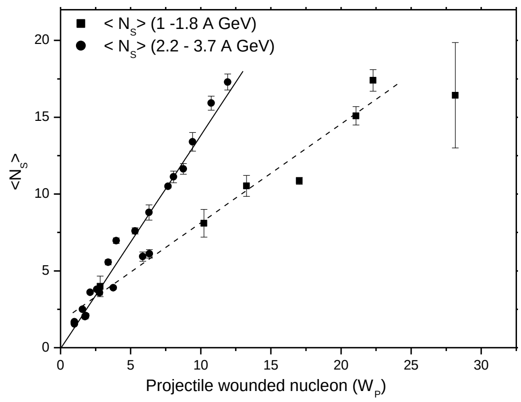

Fig. 2: Dependence of emitted shower particles ($<N_S>$) on the projectile wounded nucleons (W_P) at different energies.

Figure 2 depicts that the dependence of produced average number of shower particles ($<N_S>$) on the calculated projectile wounded nucleons (W_P). The present experimental values are compared with the other energy regions i.e. 2.2 - 3.7 A GeV [2]. Similarly, we have also plotted shower particle multiplicities on the target wounded nucleons (W_T) as shown in figure 3.

It is important to note here that all our experimental data's are fitted with linear function.

$<N_S> = (0.55 \pm 0.07)\ W_P + (2.74 \pm 1.33).$ (3)

$<N_S> = (0.51 \pm 0.04)\ W_T + (4.03 \pm 0.58).$ (4)

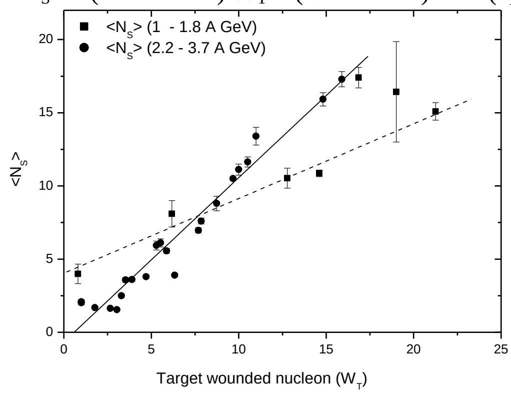

Fig. 3: The dependence of emitted mean shower particles ($<N_S>$) on the target wounded nucleons (W_T) at different energy regions

From figure 2 & 3, we can observe that the emitted average number of singly charged relativistic particles i.e. $<N_S>$ is linearly increases with increasing W_P and W_T in both energy regions. From above figures, we may also infer that the W_P and W_T with shower particles $<N_S>$ shows similar slope within the statistical error such as (0.55 ± 0.07) and (0.51 ± 0.04). The comparative study revealed that the mean number of singly charged particles emission is higher in higher energy regions 2.2-3.7 A GeV with wounded nucleons.

Conclusion

The calculated W_P and W_T are strongly depends on the projectile and target mass number and independent of incident kinetic energy. The emitted average number of relativistic charged particles i.e. $<N_S>$ depends on the projectile and target wounded nucleons.

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References

[1] P. Senger et al., J. Phys. G: Nucl. Part. Phys. **25,** R59 (1999).

[2] M. A. Jilany, J. Phys. G: Nucl. Part. Phys. **29**, 2263 (2003).

[3] N. Marimuthu et al., Indian J. Phys. **91,** 431 (2017); Advances in High Energy Phys (in Press) airxiv:**1808.01485** (2018).