Wounded nucleon model for charged particle production in ^{84}Kr-Em interaction at ~1GeV/n

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Introduction

Nuclear multifragmentation process is a consequential experimental phenomenon in nucleus–nucleus (A-A) and hadron-nucleus (h-A) collisions at high energies. These nuclear collisions at high energies are keeping arousing with considerable interest because of the unorthodox properties of the nuclear matter and under conditions of the high pressure and temperature [1]. As the kind of detector and target, nuclear emulsions have been utilized for investigation nuclear fragmentations from the birth of nuclear physics. It is a 4π detector and provide the high position resolution (<1μm) [2]. In the relativistic nucleus–nucleus (A-A) collisions, the notions of the participants and spectators are very utilizable in the study of the geometrical concept of nuclear collisions. After the collisions, the nuclei overlapping portions are called the participant regions and rest regions are called the spectators. Various new and participants particles produced in the participant region through the various nuclear reactions / disintegration, where the velocity of the projectile is zero. On the other hand, the unchanged velocities with fly off components are called the projectile spectators. The target nucleons received small momentum transfer from the projectile; therefore, it is either recoiled or evaporated from the nucleus. The “Wounded” nucleon model is used to study the multi-particle production at high energies. The present work is the study of the dependence of average number of produced charged particles in ^{84}Kr-Emulsion interaction at ~1GeV/n and compared with the calculated value for the same using wounded nucleon model.

Wounded Nucleon Model

According to the “wounded” nucleon model, the number of produced relativistic charged multiplicities (n_{AA}) is scalable to the average number of participant or wounded nucleons (W) with the proton-proton multiplicity (n_{PP}) [1, 3].

$$n_{AA}(E) = \tfrac{1}{2}\, W\, n_{PP}(E) \qquad (1)$$

Another convenient quantity is M = n / W, here the wounded nucleon W have all quantity of geometrical effects and M depends on the interaction dynamics of the collisions. The number of wounded nucleon is from the projectile and target nuclei and the nuclear interactions are given in terms of interaction cross section.

$$W = W_P + W_T = \frac{A_P \sigma_{PA_T}}{\sigma_{A_P A_T}} + \frac{A_T \sigma_{PA_P}}{\sigma_{A_P A_T}}. \qquad (2)$$

The total number of interactions is

$$\nu = W_P \nu_T = W_T \nu_P. \qquad (3)$$

Where

$$\nu_T = \frac{A_T \sigma_{NN}}{\sigma_{PA_T}} \qquad (4)$$

Here W_P and W_T are wounded projectile and target nucleons and ν_P and ν_T are the average number of the projectile and target collisions.

Result and Discussions

The calculated number of wound nucleons (W) and their average number of observed values of shower <Ns> and pions <Nπ> particles for inelastic collision of different projectiles with emulsion target at different energy regions has been tabulated in the table 1. From table 1, one can observed that, the numbers of wound nucleons (W) are substantially increases with increasing the different target nuclei. In addition, it is clear that, the wounded nucleons are also increases with increasing colliding nuclei. It shows that the produced number of wounded participants is not only depending on the mass of the target nuclei but also depend on the mass number of the projectile nuclei.

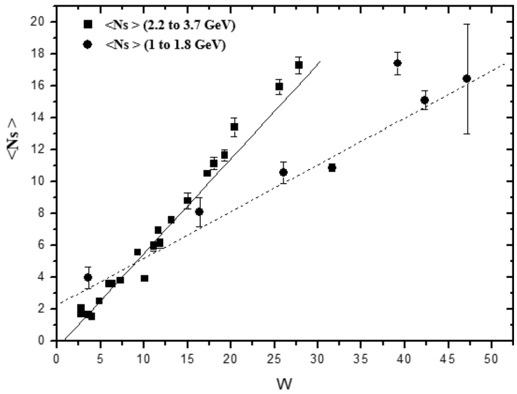

Fig. 1 The relation between average numbers of produced shower particles <Ns> and wounded nucleons (W) at different energy.

Figure 1 represents that, the linear relationship between <Ns> and W for inclusive interactions of the different energy system i.e. 1 to 1.8 A GeV. It i.e. calculated W values and <Ns> is compared with the results obtained at 3.7 A GeV [1]. From the graphs, one can understand that the average number of shower particles <Ns> is linearly increases with increasing the number of wounded nucleons W. Present data points are fitted with the linear function.

$$\langle Ns \rangle = (0.29\pm0.02)\, W + (2.25\pm0.063) \qquad (5)$$

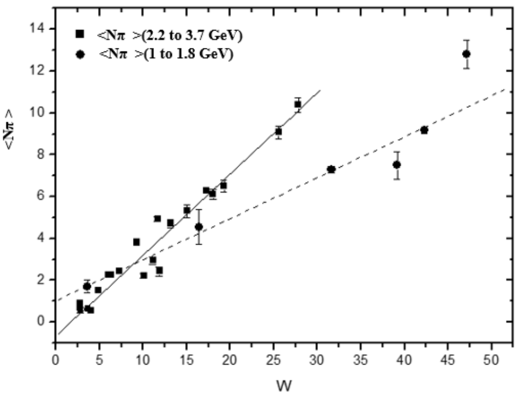

Fig. 2 The relation between average numbers of produced pions <Nπ> and wounded nucleons W at different energy.

Fig. 2 shows that the correlation between the produced pions <Nπ> and the calculated number of wound nucleons W. It may see from Fig. 2 that the average number of produced pion <Nπ> is increases with increasing the number of wounded nucleons or participants. Present data points of pions interactions and wounded nucleons (W) are fitted with linear function.

$$\langle N\pi \rangle = (0.19\pm0.008)\, W - (1.02\pm0.30) \qquad (6)$$

Table 1: The present calculated number of wounded nucleons and their average measured multiplicities <Ns> and <Nπ> for different projectiles with emulsion target at (1-1.8)A GeV.

System	W	<Ns>	<Nπ>	Ref.
^{84}Kr-H	2.38	3.99±0.67	1.7±0.3	PW
^{84}Kr-CNO	16.42	8.1±0.9	3.55±0.32	PW
^{84}Kr-AgBr	42.33	15.09±0.60	9.17±0.15	PW
^{56}Fe-Em[a]	26.04	10.53±0.68	7.5±0.7	PW
^{84}Kr-Em[b]	31.63	10.86±0.23	7.31±0.16	PW
^{132}Xe-Em[b]	39.15	17.4±0.7	12.8±0.7	PW
^{197}Au-Em[b]	47.16	16.43±3.43	-	PW

[a]1.8 A GeV, [b]1 A GeV

It can be understand from the above plots that the participating nucleons and geometry of nucleus-nucleus collisions are still playing prominent role in the high-energy interactions. Here the numbers of wounded nucleons (W) contains all geometrical effect of nucleus-nucleus collisions.

Conclusions

The emission rate of mean multiplicities of the produced charged particles <Ns> and <Nπ> are strongly dependent on the number of the wounded nucleons (W). The produced wounded nucleons are not only depending on the colliding nuclei but also depend on the mass number of the target nuclei.

References

[1] M.A.Jilany J.Phys.G: Nucl.Part. Phy **29**, 2263-2280, 2003

[2] N.Marimuthu, V.Singh et al, *Indian J. Phys,* **91** 431 (2017)

[3] N.Marimuthu, V.Singh et al., AHEP in Press: airxiv:**1706.10155** (2017)