Scaling Behaviour of the Multiplicity Distribution of Shower Particles at 3.7 A GeV

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Introduction

The use of nuclear emulsion both as a target and a detector can be used to study the properties of charged secondary particles.

The aim of present work is to investigate the validity of well-established KNO type scaling behavior of multiplicity distribution of shower particles produced in ^{28}Si-emulsion at 3.7 A GeV interactions with different emulsion target groups. The number of interacting projectile protons and multiplicity characteristics of different charged secondary particles can be determined accurately for each collision event. Various other useful consequences of multiparticle production such as variation of the ratio of D/< ns > as a function of n_g at 3.7 A GeV energy have also been analyzed.

Experimental Details

In the present experiment stacks of NIKFI BR2 nuclear emulsion of dimension 16.9 x 9.6 x 0.06 cm^3 have been exposed horizontally to a ^{28}Si beam of 3.7 A GeV per nucleon at JINR Dubna. Each primary ^{28}Si track has been followed using along the track scanning technique on an OLYMPUS BH2 microscope under a magnification of 2250 in order to search for inelastic collision events. Classification of different charged secondaries can be seen from our previous publications [1].

Results

KNO Scaling

According to this law, at the asymptotic energies, the probability P(n) to produce n charged particles in the final state is related to a scaling function (n/ < n >) according to the following relation:

$$< n > P(n) = (n/ < n >) \qquad (1)$$

This behavior of multiplicity distribution as a function of variable z' is referred as KNO scaling [2] and given as

$$P(n_s) = \sigma_n/\sigma_{inel} = 1/ < n_s > (z') \qquad (2)$$

KNO behavior is independent of energy of incident hadron and atomic mass of A_T of target nucleus, σ_n denotes the partial cross section of producing n charged particles and σ_{inel} denotes the total inelastic cross section.

Fig. 1 (a), (b) & (c) we plot (z') vs z' for ^{28}Si interaction with emulsion at 3.7 A GeV for H-events, CNO-events and AgBr-events respectively. From this figure we can see that the KNO scaling behavior of multiplicity distributions is well satisfied by shower particles produced in ^{28}Si-emulsion interactions with different emulsion targets (H, CNO & AgBr) at 3.7 A GeV. In Table 1, we present the experimental values of Dispersion $D = [< n_s >^2 - < n^2_s >]^2$ of shower particles in ^{28}Si-emulsion interactions. A consistent trend is seen in the data using different projectile. The ratio < ns > /D for hadron-nucleus and nucleus-nucleus collision is similar, indicating essential similarity in the production mechanism of two types of collision. In case of nucleus-nucleus collision, D increases as the mass number of projectile increases.

Table 1: Variation of < ns >, dispersion D and < ns > /D as a function different emulsion target groups.

Interaction	$< n_s >$	D	$< n_s >/D$
^{28}Si- CNO	10.40±0.54	6.030.32	1.72±0.15
^{28}Si -AgBr	24.44±1.26	13.850.71	1.76±0.18
^{28}Si-em	15.32±0.22	10.080.22	1.52±0.02

Number of Interacting Nucleons

The number projectile nucleons interacting with target (N_{int}) is one of the basic parameter of superposition model [2], in which we consider that the nucleons from the incoming nucleus interact independently of one another i.e. a nucleus-nucleus (A-A) collision is a superposition of nucleon-nucleus (N-A)

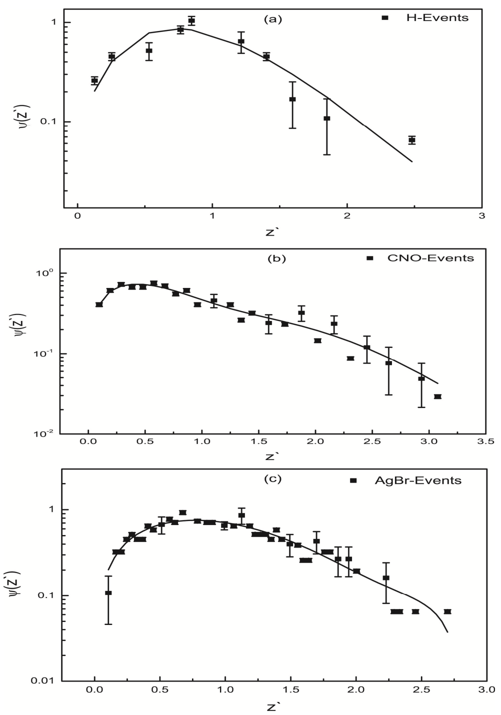

Fig.1 Variation of $\psi(z')$ as a function of z' for H-Events (a), CNO-Events (b) and AgBr-Events (c).

collisions[3]. The number of interacting nucleons is determined by the relation

$$< N_{int} > = A - (A/Z)\, Q = A - 2Q \qquad (3)$$

Where A and Z are the mass and charge of number respectively of projectile nucleus and Q is the average total charge of projectile spectator fragments (non-interacting PFs) which can be determined on event by event basis as

$$Q = \Sigma\, n_i Z_i \qquad (4)$$

Where ni is the number of projectile fragments with charge Zi and summation is made to include all fragments. Using relation (3) and (4), the average number of interacting nucleons is estimated to be~ (13.74 ± 0.45). The average number of interacting nucleons of projectile can also be calculated by

$$< N_{int} >= 0.73 A^{0.72} \qquad (5)$$

The experimental value of $< N_{int} >$ using (3) is higher than that of phenomenological value (8.04). This may be due to angular restriction imposed ($\leq 5^o$) in defining the $Z \geq 2$ projectile fragments. The average number of interacting nucleons of projectile determined by equation (3), for colliding with targets (i.e. H, CNO and AgBr) is found to be (6.86 ± 0.51), (12.38 ± 0.77) and (17.82 ± 0.81) respectively.

Fig. 2 shows the dependence of $D/ < n_s >$ as a function of n_g. We can see that the variation of D/< ns > with ng. follows the relation

$$D/ < ns >= c(n_g)^d, \qquad (6)$$

Where c = 1.75 ± 0.06 and d = -0.55 ± 0.02 for the present data.

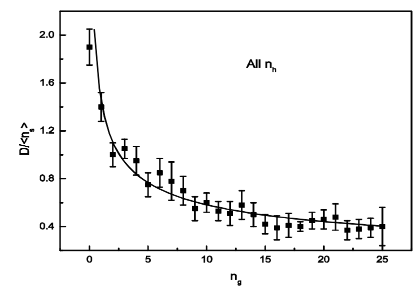

Fig. 2 Variation of $D/<n_s>$ as a function of grey particles (n_g) in ^{28}Si-emulsion interactions at 3.7 A GeV.

From Figure, we can observe that the ratio D / $< n_s >$ decreases with increasing value of n_g according to the relation given by equation (6). This decrease in the value of $D/<n_s>$ is in contradiction with the collective tube according to which $D/<n_s>$ should remain constant with n_g and it favours model which include repeated collisions [3].

Conclusion

The KNO type scaling behavior of the multiplicity distribution is well satisfied by shower particles produced in ^{28}Si-emulsion interactions at 3 A GeV for CNO and AgBr events. D /$< n_s >$ decreases with increasing value of n_g as predicted by the theoretical equation.

References

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