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A STUDY OF COMPOUND PARTICLES IN EMULSION

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ABSTRACT

An attempt is made to study the compound particles by taking black and shower particles together. Average compound particle multiplicity is found to vary linearly with heavily ionizing particle multiplicity but with black particle multiplicity it does not show a linear dependence. Dispersion of the compound multiplicity distribution has also been studied. The ratio of the mean number of compound particles to its dispersion for different target sizes has been calculated.

Keywords: Compound particle; relativistic charged particles; multiparticle production

Subject classification

PACS 13.85 – Hadron – induced high – and superhigh – energy interactions, energy > 10 GeV

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1. INTRODUCTION

When a high energy particle collides with a nucleus, a large number of particles are produced. For this purpose nuclear emulsion technique was used to detect the charged particles. Nuclear emulsion consists of elements like hydrogen (H), carbon (C), nitrogen (N), oxygen (O), silver (Ag) and bromine (Br). The particles produced in emulsion appear in the form of tracks. The tracks/particles are classified as shower, grey and black particles, their numbers in an event/interaction are written as N_s, N_g and N_b. The sum of grey and black particles are called as heavily ionizing particle ($N_h=N_g+N_b$). These final state particles produced in hadron-nucleus (hA) interactions have been investigated by several workers [1-5]. It is expected that the study of hA interactions will not only help to explain the production process but also reveal hadron structure. This phenomenon of particle production in such collisions is called the multiparticle production. Most of the studies are based on the relativistic charged particles or fast moving particles. But the studies on grey and black particle may also provide some very useful information about the production process. Jurak and Linscheid [6] studied the characteristics of proton-nucleus collisions by combining shower and grey particles together for the first time and they called this compound particle ($N_c=N_s+N_g$). Many [7-15] workers followed this method to study high energy interactions. We [16,17] also reported some results on compound particles in our earlier publications.

In this paper we have studied the characteristics of compound particles in a different way, instead of combining shower and grey particle to form a compound particle, we define a compound particle by taking shower and black particle together in an event and it is written as N_{c1} (=N_s+N_b). We studied some aspects of this new compound particle in one of our papers [18]. Here, the compound particle multiplicity distribution is studied for different target sizes in pion-nucleus interactions at 340 Gec/c. The events with $N_h\leq1$, $2\leq N_h\leq6$ and$N_h\geq7$ are known as H, CNO and AgBr events.The variations of mean compound particle multiplicity and dispersion of its multiplicity distribution with different particle multiplicities has been studied.

2. EXPERIMENTAL DETAILS

The experimental data was collected using a stack of Ilford-G5 emulsion pellicles exposed to a 340 GeV/c negative pion beam. The flux was (0.5-1.50) X 10^4 particles/cm^2. The plates were area scanned using M4000 Cooke's series microscopes with 15X eye pieces and 20X objectives. The measurement was carried out using an oil immersion objective of 100X magnification. The events were picked up after leaving 3 mm from the leading edges of the pellicles. The interactions, which were produced within 35 µm from top or the bottom surfaces of the pellicles were excluded from the data. To avoid any contamination of primary events with secondary interactions, the primaries of all the events were followed back up to the edge of the plates and only those events whose primary remained parallel to the main direction of the beam were finally picked up as genuine primary events. In each event the tracks of different particles have been categorised according to their specific ionization ($g^*=g/g_o$), where gis the ionization of the track and go the ionization of the primary beam. The tracks with $g^*<1.4$, $1.4\leq g^*\leq10$ and $g^*>10$ have been taken as shower (N_s), grey (N_g) and black (N_b) particles.

3. RESUTS AND DISCUSSION

The compound multiplicity distribution for different groups of events (H, CNO, AgBr and emulsion) are shown in figure1.

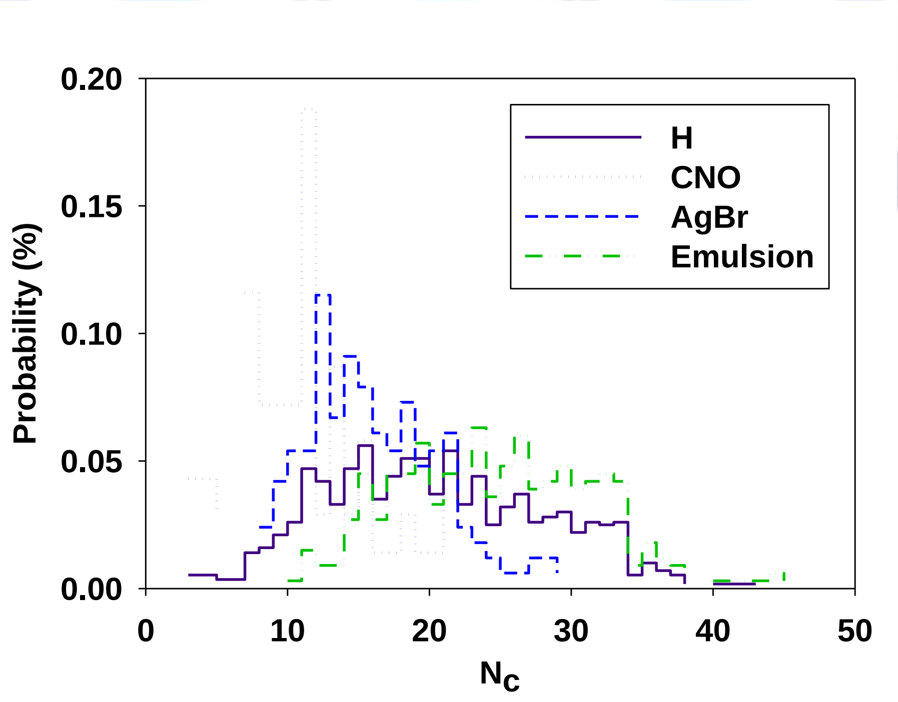

Fig 1: Compound multiplicity distribution for different emulsion targets in pion-nucleus interactions.

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It can be seen from the figure that compound multiplicity distribution becomes broader with increasing target size. One more thing which can be noted is that the peak of the distribution shifts towards the higher values of compound particle multiplicity. Similar results have been observed by other workers [14,15] also. The mean values of the compound multiplicities $<N_{c1}>$ its dispersion defined as $D(N_{c1})=(<N_{c1}^2>-<N_{c1}>^2)^{1/2}$, and the ratio $<N_{c1}>/D(N_{c1})$ are listed in table 1. For comparison the values of these parameters calculated for shower particles are also given in the same table. Figure 2 represents the variation of mean compound multiplicity with N_b. One may notice from the figure that $<N_c>$ and $<N_{c1}>$ increases with N_b up to N_b=13, after that some type of saturation effect is observed and the values of $<N_{c1}>$ dominates over $<N_c>$.

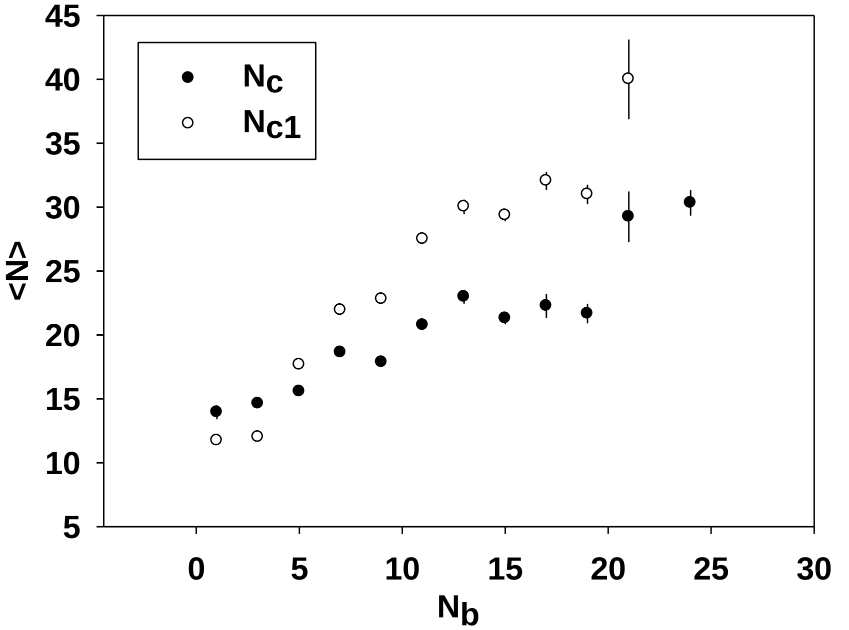

Fig 2: Variation of $<N>$ with N_b.

Table 1. Values of $<N>$, $D(N)$ and $<N>/D(N)$ for different targets in pion-nucleus interactions.

Type of interactions	$<N_c>$	$D(N_c)$	$<N_c>/D(N_c)$
π^--H	10.47±0.26	4.47±0.18	2.34±0.11
π^--CHO	14.08±0.39	5.05±0.28	2.78±0.17
π^--AgBr	16.36±0.08	8.15±0.21	2.00±0.05
π^--Emulsion	19.83±0.38	6.94±0.27	2.85±0.12
π^--H*	11.16±0.57	4.76±0.40	2.34±0.23
π^--CHO*	15.76±0.39	5.04±0.27	3.12±0.18
π^--AgBr*	19.82±0.15	8.28±0.24	2.39±0.07
π^--Emulsion*	24.66±0.41	7.41±0.29	3.32±0.14
π^--H#	10.86±0.21	3.68±0.15	2.95±0.13
π^--CHO#	12.05±0.17	4.66±0.12	2.58±0.07
π^--AgBr#	14.95±0.41	7.56±0.29	1.98±0.09
π^--Emulsion#	14.18±0.16	6.48±0.11	2.07±0.04

* This is for N_{c1}

This is for N_s

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In figure 3 the mean value of compound multiplicity is found to vary linearly with N_h and the lines are represented by the following equations.

$$\langle N_c \rangle = 0.77\, N_h + 8.85$$

$$\langle N_{c1} \rangle = 0.84\, N_h + 12.15$$

We see that the variations are almost similar in nature because the slopes are almost similar.

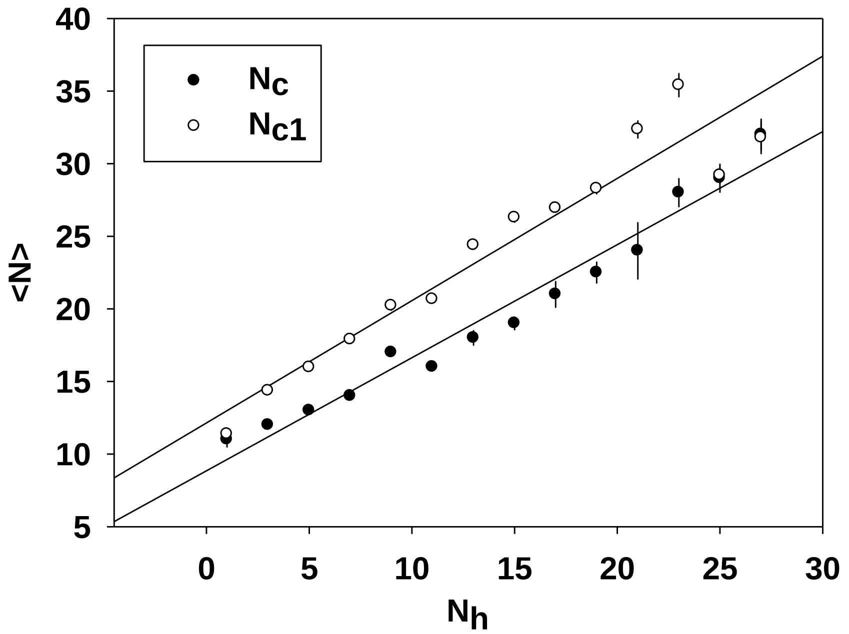

Fig 3: Variation of <N> with N_h.

The plot of $D(N_{c1})$ with N_b and N_h is shown in figure 4.

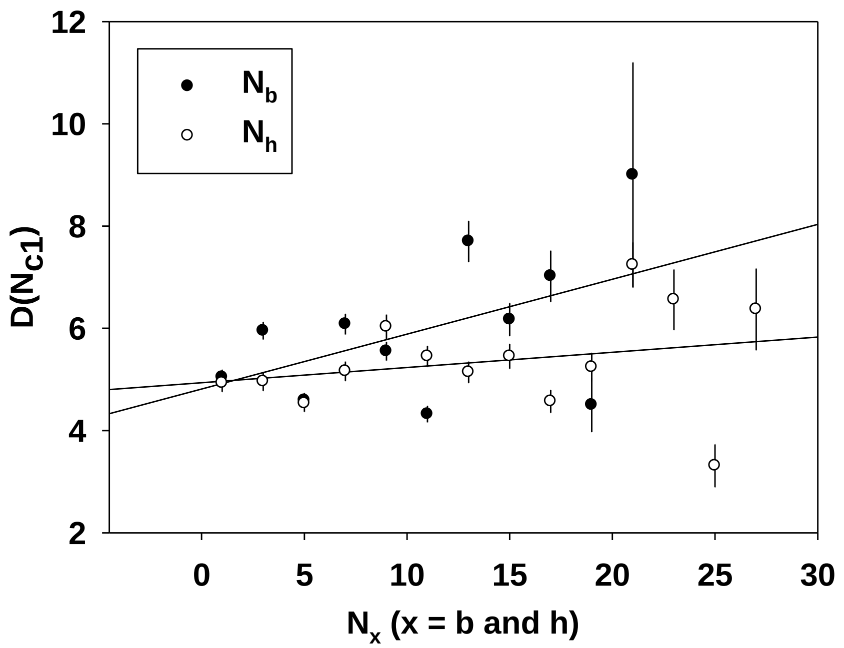

Fig 4: Variation of dispersion of compound multiplicity distribution with N_b and N_h.

Least square fit to the data was performed and the following equations were obtained.

$$D(N_{c1}) = 0.10N_b + 4.81$$

$$D(N_{c1}) = 0.03N_h + 4.93$$

It may be noted from the figure and the slopes of the lines that $D(N_{c1})$ vs N_b dependence is more linear whereas $D(N_{c1})$ seems to be independent of N_h. The variation of the ratio $\langle N_{c1}\rangle/D(N_{c1})$ with N_b and N_h are given in figure 5.

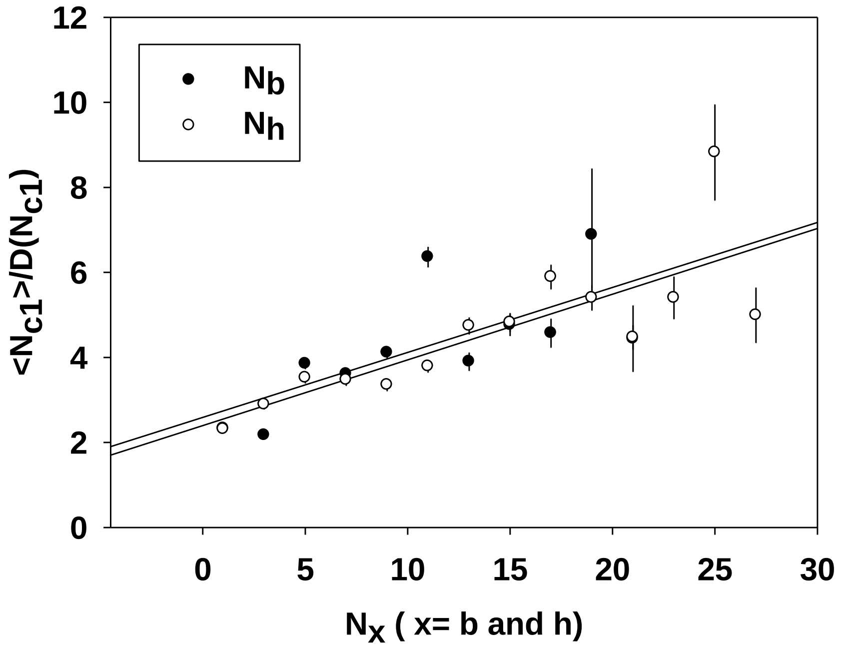

Fig 5: Variation of the ratio $\langle N_{c1}\rangle/D(N_{c1})$ with N_b and N_h.

Here again we observe a linear dependence and straight line fit to the data is represented by the following lines.

$$\langle N_{c1}\rangle/D(N_{c1}) = 0.15\ N_b + 2.58$$

$$\langle N_{c1}\rangle/D(N_{c1}) = 0.15\ N_h + 2.39$$

The remarkable thing which is noted from the figure is that both the lines are parallel with equal slopes showing that the variation is similar.

4. CONCLUDING REMARKS

On the basis of the findings in the present investigation, we conclude the following:

(i) Compound particle multiplicity distribution is observed to be target size dependent.

(ii) Mean compound multiplicity is found to vary linearly with Nh and a saturation effect is observed in the case of N_b

(iii) The variation of the ratio $\langle N_{c1}\rangle/D(N_{c1})$ with N_b and N_h is similar in nature.

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Dr. Tufail Ahmad obtained his PhD degree in the year 1989 in Experimental High Energy Physics from the Aligarh Muslim University, Aligarh, India. From 1990 to 1991, he worked as Research Associate of the University Grants Commission (UGC), Government of India. Presently, he is working as Associate Professor of Physics in the Aligarh Muslim University. Dr. Ahmad has published twenty two research papers in the journals of international repute like Physical Review D, Journal of Physical Society of Japan, Nuovo Cimento, International Journal of Modern Physics, ISRN High Energy Physics and Indian Journal of Pure & Applied Physics etc. He has participated in many symposia and conferences and presented papers also. His area of research is high energy hadronic collisions and relativistic heavy ion collisions.