A study of nuclear interactions caused by negative pions

Tufail Ahmad

Applied Science & Humanities Section, University Polytechnic, Faculty of Engineering & Technology, Aligarh Muslim University, Aligarh -202002, INDIA

email: tufailahmadphys@gmail.com

Introduction

During the last many years, the work on high energy experiments was carried out by many workers mostly for shower particles which are fast moving particles or we can say that relativistic charged particles in hadron-nucleus (hA) and nucleus-nucleus (AA) collisions. The investigation of hA collisions is fundamental for understanding the nature of the interaction process. It is believed that these interactions may provide some very useful information about the dynamics of multiparticle production. An important feature noticed in these interactions is that the nucleus plays the role of target for the incident hadron. When an incident particle interacts with the nuclei of the emulsion, secondary particles are produced. These secondary particles are classified into three categories viz., shower (N_s), grey (N_g) and black (N_b) particles. For the first time Jurak and Linscheid [1] studied some characteristics of proton-nucleus interactions taking shower and grey particles together without making any distintion between them. The number of shower and grey particles taken together in an event was termed as compound particle multiplicity ($N_c=N_s+N_g$). After that many workers [2,3] studied compound multiplicity distributions, We [4] also studied it in the same manner. But now we define compound multiplicity in a different way which no body has done so far. We define the compound multiplicity as the sum of shower and black particle in an event. Thus the new compound multiplicity may be written as $N_{c1}=N_s+N_b$. The sum of number of grey and black particles are called as heavily ionizing particle and their number in an event is given by $N_h=N_g+N_b$.

In the present paper the data was collected using a stack exposed to a 340 GeV negative pion beam.

Results and discussion

Particle multiplicity is defined as the number of secondary particles produced in an interaction. However, most of the detecting devices record only the charged particles which are produced during the interaction process.

In order to investigate the correlation between different particle multiplicities we have studied the variation of $\langle N_{c1}\rangle$ with N_b and N_h and it is shown in the fig.1.

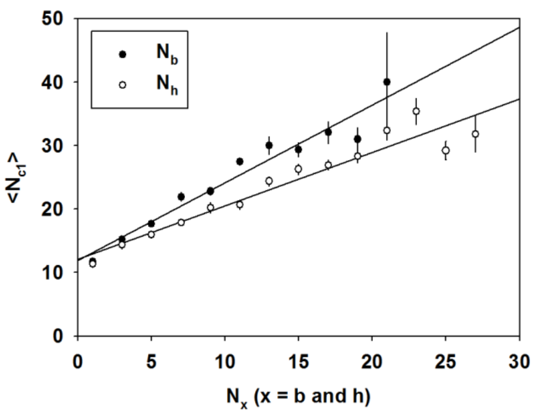

Fig. 1 Variation of $\langle N_{c1}\rangle$ with N_b and N_h

From the figure it is noted that the variation is linear in nature. The value of $\langle N_{c1}\rangle$ increases with N_b and N_h both. Least square fits to the data was performed and the following equations were obtained.

$$\langle N_{c1}\rangle = 11.90 + 1.22\ N_b$$
$$\langle N_{c1}\rangle = 12.15 + 0.84\ N_h$$

The values of the ratios $\langle Ns \rangle_{\pi^- A}/\langle Ns \rangle_{pA}$ and $\langle N_{c1} \rangle_{\pi^- A}/\langle N_{c1} \rangle_{pA}$ at almost the same energy of pion and proton projectiles were calculated and plotted as a function of energy in fig.2. The figure shows that both the ratios do not depend upon energy.

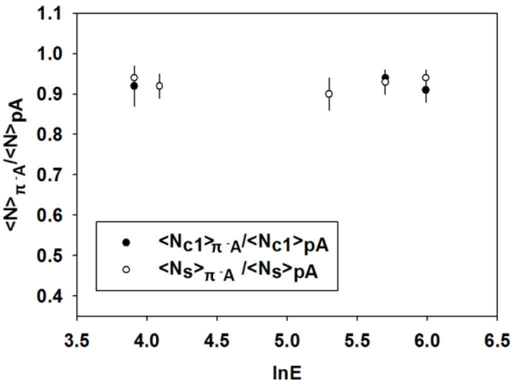

Fig. 2 Variation of $\langle Ns \rangle_{\pi^- A}/\langle Ns \rangle_{pA}$ & $\langle N_{c1} \rangle_{\pi^- A}/\langle N_{c1} \rangle_{pA}$ with natural log of energy

The studies on the multiplicity distribution of charged shower particles produced in hadron-hadron interactions show that the multiplicity distributions change with energy. However, it is observed that if one plots the distribution in terms of a variable $Z=N_s/\langle N_s \rangle$, then the multiplicity distributions at various energies may be represented by the same mathematical function $\psi(Z)$. This fact is observed in hA interactions as well. This means that the multiplicity distribution exhibits a universal behaviour when plotted with Z as the variable. This behaviour of the distribution is known as KNO scaling after Koba, Nielsen and Olesen [5] who first put forward the hypothesis.

We have made an attempt to test the validity of KNO scaling for target protons (grey particles). We have tried to fit the experimental data at three different energies with a scaling function

$$\psi(Z) = AZ \exp(-BZ)$$

The variation of $\psi(Z)$ with Z of grey particle multiplicity distribution is shown in fig. 3.

The solid curve in the figure is due to the above equation with A=3.37±0.43 and B=2.18±0.13. The value of χ^2/dof is found to be 0.65. It is seen from the figure as well as from χ^2/dof that the data is quite well represented by the function with the above values of A and B. Hence KNO scaling is observed in the energy range 50-400 GeV for target protons.

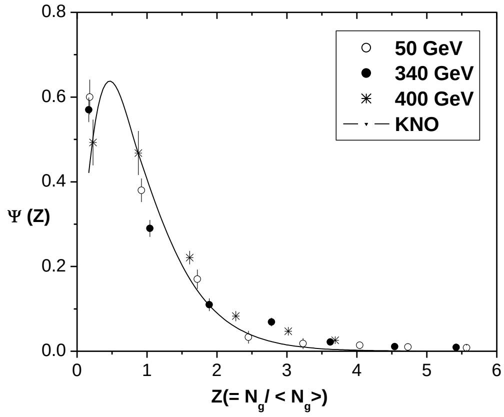

Fig. 3 Multiplicity scaling of grey particles at 50 and 340 GeV pion-nucleus and 400 GeV proton-nucleus interactions

Conclusions

On the basis of the results presented we infer the following:

(i) The value of mean compound multiplicity is found to vary linearly with N_b and N_h.

(ii) The ratios $\langle Ns \rangle_{\pi^- A}/\langle Ns \rangle_{pA}$ and $\langle N_{c1} \rangle_{\pi^- A}/\langle N_{c1} \rangle_{pA}$ are independent of energy.

(iii) The multiplicity distribution of grey particles is well described by a KNO type scaling function.

References

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