ABSTRACT

In the beginning the studies on hadron-hadron and hadron-nucleus collisions were confined to interactions with cosmic rays. Hence the studies were not conclusive owing to the fact that neither the identities nor the energies of the impinging hadrons were accurately known. However, the interest in these studies has increased manifold during recent years after the advent of high energy accelerators. A survey of the literature shows that most of the earlier experiments using the accelerator energies have been done to understand the nuclear evaporation processes. Therefore, the attention of most of the physicists remained focussed mainly to study the characteristics of low and medium energy particles and light fragments. The study of more energetic particles (β > 0.7) produced in these collisions remained almost untouched because the investigation of the mechanism of hadron-nucleus collisions was considered to be rather messy affair. However, in recent years it has been realized that the study of hadron-nucleus collisions may reveal some interesting aspects of high energy nuclear physics. Keeping this in mind, we have carried out an extensive study of the interactions at 24, 50, 340 and 400 GeV/c. Some other relevant discussion and a brief introduction of the studies on hadron-hadron and hadron-nucleus collision is given in Chapter I.
In Chapter II, a brief account of current theoretical models which are being used to explain the experimental results has been given.

Chapter III is devoted to the description of the experimental technique. It gives an idea of nuclear emulsion, details of stack used, method of scanning, classification of tracks, methods measurements etc.

In Chapter IV, some results on the medium energy protons emanating from hadron-nucleus collisions have been given. Some important characteristics of protons such as their angular and energy distributions, the transverse and longitudinal momenta distributions etc. have been given in this chapter. It is found that the overall characteristics of these particles do not seem to depend upon either the identity or the energy of the incident hadrons in the energy range of 4-400 GeV/c.

Chapter V deals with the experimental results on various characteristics of interactions of 340 GeV/c pion with nuclei. The general characteristics of shower, grey, black heavy tracks such as their multiplicity distributions, various moments, distributions and scaling, correlations among the secondary particles, mean normalized multiplicity etc. have been given. The average multiplicity of heavily ionizing particles is found to be essentially energy independent and weakly dependent
on the nature of the incident hadron. It is found that the ratios of $\langle n_s \rangle_A / \langle n_b \rangle_A$ and $\langle n_s \rangle_pA / \langle n_b \rangle_pA$ are very close to the ratio of the mean number of intranuclear collisions, $\langle \nu \rangle_A / \langle \nu \rangle_pA \approx 0.81$. From this we conclude that $\nu$ is only the number of mesons, $n_s$, which could be compared with $\nu$, the number of collisions made by the incident hadron inside the nucleus.

The Koba-Neilsen and Ulesen (KNO) scaling of shower particles in pion-nucleus collisions has also been tested, it is seen that the main features of the KNO scaling agree with the data. The Burns scaling function $\Psi(Z') A(Z' + B) \exp(CZ' + DZ'^2)$ fits the distributions at 50 and 340 GeV/c. It is interesting to note that the same function fits the multiplicity distributions of showers in different $n_h$ or $n_g$ groups.

The study of correlations between $\langle n_s \rangle$, $\langle n_b \rangle$, $\langle n_b \rangle$, and $\langle N_h \rangle$ revealed that these parameters are linearly related to each other.

The estimation of $R_A$ has been carried out in several ways in accordance with requirements of different models. We have estimate the values of $R_A$ by considering (i) all the final state particles and (ii) only the created particles. The dependence of $R_A^*$ on energy show that $R_A^*$ remain essentially energy independent from $\sim 20$ GeV onwards. The energy independent value of $R_A^{*2}$ rules out

\[ R_A = \frac{\langle n_s \rangle}{\langle n_b \rangle} \]

where $\frac{\langle n_s \rangle}{\langle n_b \rangle} = \frac{\langle n_s \rangle}{\langle n_{ch} \rangle} \approx 0.50$ for proton-nucleus and pion-nucleus collisions.
\[ \frac{d\phi}{d\eta} = A \exp(-B\eta) + C \exp(-D\eta) \]
is found to describe the data well. Plots of two particle rapidity-gap distributions at 24, 50, 340 and 400 GeV/c has been given in this Chapter, the values of the parameters appearing in expression fitted to the data have been calculated by the VAX-11 computer, using the method of least squares fit. From these distributions the following conclusions have been drawn, (i) the presence of sharp peaks at small values of rapidity-gap shows the existence of short range correlations among secondaries (ii) the slope parameters B and D have been found to be independent of target size (iii) the particles are found more strongly correlated in the forward region of rapidity space.

Three and four particle rapidity-gap distributions at 24, 50, 340 and 400 GeV/c show that higher order correlations are not present at these energies. Some other results have also been obtained from the study of (i) short-short and long-short correlations (ii) determination of cluster size (iii) maximum rapidity-gap length distribution and (iv) production of heavy clusters etc.

The short-short range correlations reveal that a cluster should consists of atleast three charged particles and heavy cluster studies show that the production of heavy clusters is energy dependent and 340 GeV/c is below the threshold at which heavy cluster may begin to be produced.

Chapter VII, the last chapter of this thesis is devoted to detailed summary of the results obtained and our future work plan.
ratios \( r(\eta) \) demonstrates that the value of pseudorapidity for which \( \langle 1/n \, dn/d\eta \rangle_{\pi A} = \langle 1/n \, dn/d\eta \rangle_{\pi N} \) is target size dependent.

The behavior of characteristics such as \( \langle \eta \rangle \) and \( \eta(n) \) with \( n_s, n_g \) and \( N_h \) have also been studied. The result show that \( \langle \eta \rangle \) decreases monotonically with \( n_s, n_g \) and \( N_h \) and a linear dependence of \( \langle \eta \rangle \) on \( \sqrt{n_g} \) and \( \sqrt{N_h} \) is observed. The study of \( D(\eta) \) as a function of \( n_s, n_g \) and \( N_h \) shows no appreciable change with \( n_s, n_g \) and \( N_h \). This observation is in agreement with the prediction of Energy Flux Cascade Model.

The method of rapidity-gap has been used to study the clute formation at 24, 50, 340 and 400 GeV/c. We find that in two parti rapidity-gap distribution sharp peaks are observed at small values of rapidity-gaps which gives an evidence for strong correlations among secondary particles. Keeping in mind that the behavior of the two particle rapidity-gap distributions might be due to phase space effect. We have generated about 500 pseudoevents at 3 GeV/c by combining tracks from different events and a two particle rapidity-gap distribution has been obtained. A difference distribution of the experimental and generated events shows a definite excess at small value of rapidity-gaps. We have therefore concluded that the correlations observed at these energies can not be attributed entirely to phase space effects. The two channel generalization of the Chew Pignotti model of the form
the possibilities of single step model and at the same time
agrees with the predictions of the double step models. Furthermore, we find that the variation of $R_{A2}$ with $<\nu>_{HA}$ is projectile dependent whereas variation of $R_{A2}$ with $<\nu>_{HA}$, where $<\nu>_{HA}$ is the effective number of collisions calculated using additive quark model, is found both projectile and energy independent, which leads to a new kind of nuclear scaling.

Chapter VI is devoted to the study of rapidity and rapidity-gap distributions at 540 GeV/c. The pseudorapidity distributions of the total sample and of events in different $n_g$-bins have been plotted. Plots of the differences $d(\eta) = (1/n \frac{dn}{d\eta})_{\pi A} - (1/n \frac{dn}{d\eta})_{\pi}$ and the ratios $r(\eta) = (1/n \frac{dn}{d\eta})_{\pi A}/(1/n \frac{dn}{d\eta})_{\pi N}$ for different $n_g$-intervals have also been obtained. The following observations have been made (i) the pseudorapidity distributions of pion-emulsion ($\pi A$) and pion-nucleon ($\pi N$) collisions differ in the sense that $\pi A$ interactions are enriched with particles of small rapidity while $\pi N$ interactions are enriched with large rapidities, (ii) the larger the value of $n_g$, the stronger is the deformation in the angular spectrum, which indicates that the number of medium fast particles are related to the influence of the target on the particle production process, (iii) bimodal structure is present in all the $n_g$-intervals and the centroid of the distribution of the excess particles continuously shifts towards lower values of rapidity as $n_g$ increases and (iv) the study of differences $d(\eta)$ and the