Proceedings of ICRC 2001: 1385 © Copernicus Gesellschaft 2001

ICRC 2001

Some analysis of hadron mucleon collisions at high energy inelastic interactions in photoemulsion

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Abstract The interaction of 400 GeV protons and 340 GeV π^- with nucleons in nuclear emulsion has been investigated . The interaction mean free paths *(m.f.p)* and the orresponding reaction cross-sections (σ_{in}) has been found, the multiplicity distributions for the events with $N_h = 0$ (clean events) is measured and studied as well as the angular and pseudorapidity distributions . Finally the coherent multiparticle production cross-sections ($\sigma_{coh.}$) were estimated and compared with other data, where it found to be independent of energy for protons at very high energy while it increase rapidly with incident π^-energy .

1 Introduction

The study of high-energy interactions in the last few years has given valuable informations about collision mechanisms in hadron-hadron and hadron-nucleus interactions . These interactions have been studied at ever increasing energy as new accelerator beams become available .The coherent production mechanism is one of the most interesting mechanisms specially at high energy , it may furnish information about the properties of the nuclear target , information about the nuclear shape , the distribution of nucleons, and the short range correlations .

2 Experimental Materials

A stack of *Ilford G5* emulsion pellicles of dimensions 10 x 8 x 0.06 cm^3 was exposed to a proton beam of energy 400 GeV at Fermi lab . Another stack of *Ilford G5* emulsion pellicles of dimensions 6 x 15 x 0.06 cm^3 was exposed to a pion beam of energy 340 GeV at the *S.P.S CERN* accelerator. The emulsion plates were carefully scanned by-along-the track scanning method .This scanning was employed to locate a sample of 850 and 1016 inelastic interaction of P(400 GeV) and π^- (340 GeV) with emulsion nuclei respectively . The scanning and measurements were performed using the same criteria as were used in (EL-Nadi, Abd-El-Halim ,Yasein and El-Nagdy.,1996; El-Nadi, Yasein, Abd-El-Halim.,1994). Secondary tracks emerging from each interaction are classified according to the emulsion experiment terminology based upon their appearance in the microscope . These tracks are shower "N_s" (β = v/c ≥ 0.7), grey "N_g" (0.3 ≤ β ≤ 0.7) and black "N_b"(β ≤ 0.3) .

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The separation of *P*, π^--nucleon interactions was carried out giving 116 and 420 clean events-respectively . these events satisfy the criteria given in (El-Nagdy, Yasein, Abd-El-Halim.,1994).

3 Results and Discussion

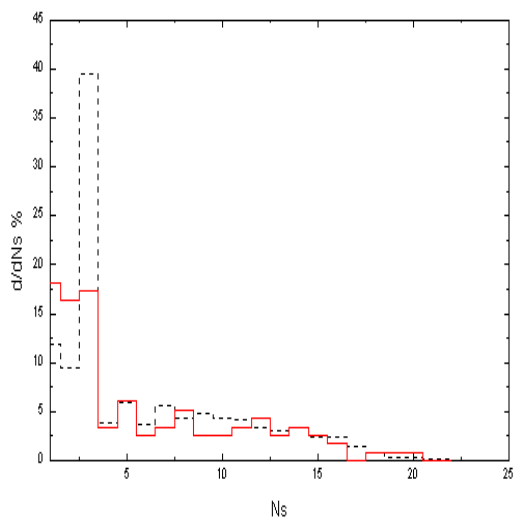
Table1 includes the mean free paths, the reaction cross-sections and the mean values of shower particles for *P*(400 GeV) and π^- (340 GeV) with emulsion nuclei and nucleons.

Table 1

beam	P(400GeV)	π^-(340GeV)
$\lambda_{int.}$(h-A) cm	35.38±1.10	39.47±1.24
$\sigma_{in.}$(h-A) mb	738.35±222.67	756.19
$\lambda_{int.}$(h-N) cm	259.25	95.48
$\sigma_{in.}$(h-N) mb	100.76	312.60
<N_s>(h-A)	15.87±0.54	13.38±0.18
<N_s>(h-N)	8.26±0.77	6.46±0.32

As shown from this table , λ_{int} *or* (σ_{in}) are energy independent as it is expected, while σ_{in} *(*π^- *- N)* is about 3 times that for proton σ_{in} *(P - N)* .

Figure 1 : the multiplicity distribution for *P*(400 GeV) and π^- (340 GeV) nucleon interactions .

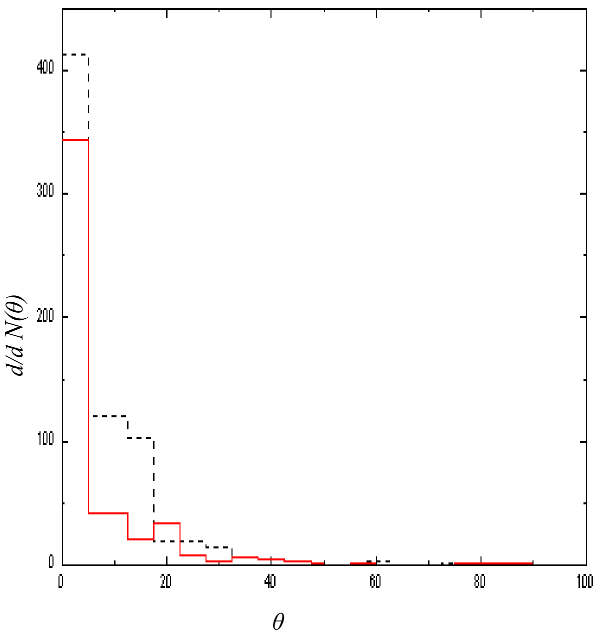


3.1 The multiplicity distribution :

The multiplicity distribution for clean events of *P*(400 GeV) and π^- (340 GeV) is presented in Fig1. Distinct peak is clearly observed at multiplicity $(N_s = 3)$ for π^- which is

far from the expected value of $<N_s>$ which is equal (9) for π^--nucleon interaction (Azimov ,1978) . This peak may attributed to the coherent production . The same effect was observed before at lower energies for π^-(Azimov, 1978; Antonova, 1972; Czachowska, 1967; Jain, 1975) .

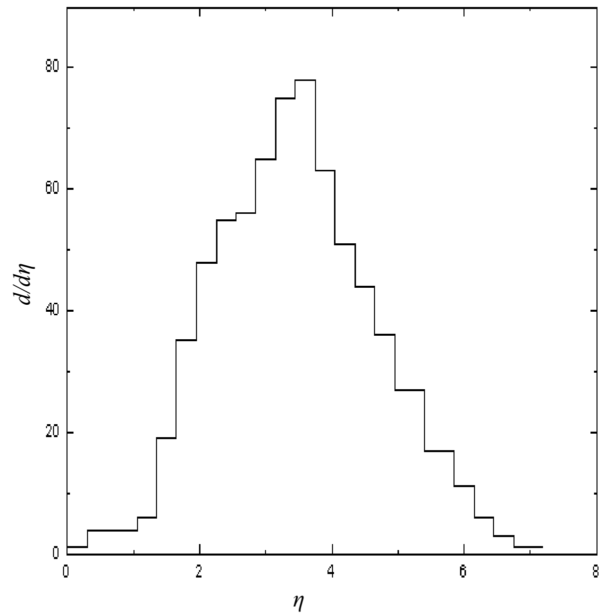
Figure 2: the angular distribution for P(400 GeV) and π^- (340) nucleon interaction .

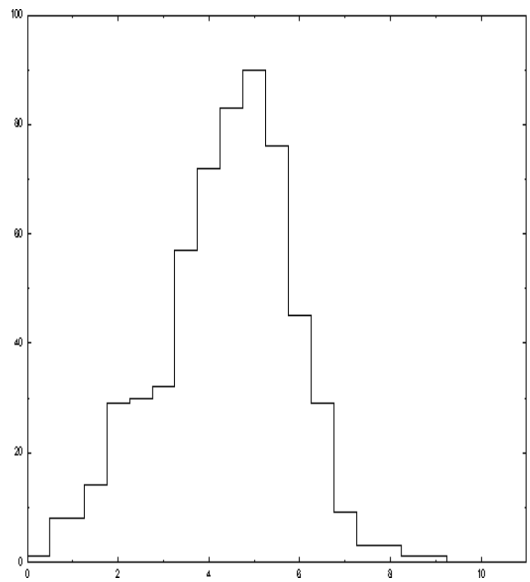


3.2 the angular and pseudorapidity distributions:

Fig2 and Fig3 show the angular and pseudorapidity distributions for *P*, π^- nucleon interactions at 400, 340 GeV respectively, where the angular distributions of fast particles is presented in terms of pseudorapidity variable $(\eta = -\ln \tan \theta/2)$, where θ is the laporatory production angle of relativistic particles .It is clear from Fig3 that *η-spectra* are shifted towards the high-rapidity region (that is the projectile fragmentation region) for π^- than that for *P* .the average pseudorapidity $< \eta >$ for π^- (340 GeV) = 4.41±0.22 and $<\eta>$ for *P*(400 GeV) = 3.75 ± 0.38 . If we subtract the coherent events which have ($< \eta >_{coh.} = 5.35 \pm 0.66$) from the total π^--nucleon events we have $< \eta >$ for π^- nucleon interaction = 3.94 ± 0.21 which is approximately equal to that of proton at nearly the same energy . This means that the coherent mechanism is important one for π^- interactions.

Figure 3(a) : pseudorapidity distributions for *P(400 GeV)*





3.3 The coherent production cross-section :

The coherent production can result from the interaction of the incident Hadron with the nuclear field of the target nucleus where as called diffraction dissociation (DD), which as the interaction with the coulomb field leads to the coulomb dissociation (CD), which is a function of the charge of the target nucleus .The target nucleus remains in its ground state before and after the interaction, since the momentum transfer to it is small . This condition roughly puts an upper limit to the longitudinal component of the momentum transfer (q_L) . From the uncertainty principle one finds that $q_L \leq R^{-1} = m_h /A^{1/3}$ where R is the radius of the nucleus and A its mass number. For (*CD)* the main contribution to the coherent cross-section is due to collisions with (A_gB_r) for which $q_L \approx 30$ MeV/c , So we expect $\sum^3_{i=1} \boldsymbol{sin}\, \theta_i \leq 0.22$, where θ_i is the angle of emission of the i^{th} particle in lab-system The (DD) is expected to take place with (*CNO*) where $q_L\ max \approx 60$ MeV/c and hence the geometrical condition is $\sum^3_{i=1} \boldsymbol{sin}\, \theta_i \leq 0.43$, This for π^-.

For proton we find that $q_L\ max \approx 208$ MeV/c for (*CD*) and $q_L\ max \approx 390$ MeV/c for (*DD*) .

These two conditions are necessary but not sufficient. According to the above restriction, we have found 10 events in case of *P*(400 GeV)and 65 events for π^- (340 GeV). The coherent-production cross-section can be calculated experimentally from the coherent interaction length using the formula : $\sigma_{coh.} =1/\lambda_{coh.}n_{eff}$, where n_{eff} is the effective number of atoms per cm^3 in the emulsion used .

Fig 4 shows the coherent cross-section divided by $A^{2/3}$ (to eliminate the dependence on *A*) for P and π^- at different momenta (El-Nadi, Yasein, Abd-El-Halim.,1994) .we can clearly observe the increase of $\sigma_{coh.}$ with the increase of pion momentum , this may be explained by the increase of the maximum mass of the system that can be produced coherently where $\sigma_{coh.}$ Is proportional to the incident momentum with the polynomial of the second order relation :

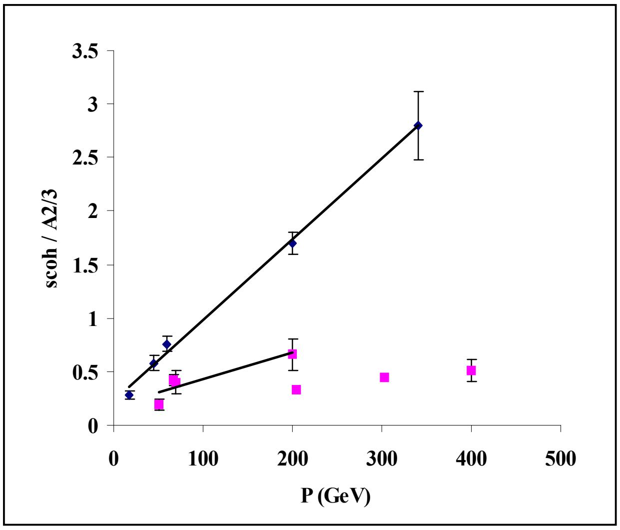
$\sigma_{coh.}\ /\ A^{2/3} = 0.22+0.008P$

For proton , we can notice that at low energy, $\sigma_{coh.}$ Increase slowly with the incident momentum (less than that for pion) while at high momentum. ($P>100$ GeV/c) there is no significant change for $\sigma_{coh.}$ With increasing the momentum . A confirmation of this result was given in recent paper (Jain,1975) .

4 Conclusion

The mean free pathes, the reaction cross-sections, and the mean values of shower particles for P(400 GeV) and π^-(340 GeV) were measured ,we have found that $\sigma_{in}(\pi^- -N)$ is abot 3 times that for proton (P-N) . The multiplicity distributions for clean events (N_h=0) as well as the angular and pseudorapdity distribution have been studied . The coherent production was found to be an important mechanism for π^- interactions at different energies while at high energies there is no significant change for $\sigma_{coh.}$ of proton .

Figure 4 :the coherent production cross-section for $\boldsymbol{\pi}^-$ and proton at diferent momenta .



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