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G.Jancsó, J.M.Kohli

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G.Jancsó, J.M.Kohli*

AN ESTIMATE OF ELASTIC $\pi^- p$ AND COHERENT $\pi^- C$ INTERACTION CROSS-SECTIONS AT 40 GEV/C

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* On leave from the Department of Physics, Panjab University, Chandigarh, India.

1. Introduction

In this paper we present results regarding the elastic and coherent cross-sections obtained in $\pi^- p$ and $\pi^- C$ interactions at p_c = 40 GeV. The experiment was performed at Serpukhov by exposing a 2m propane (C_3H_8) bubble chamber to a π^- meson beam. About 17 000 pictures were scanned thrice for the location of 2- to 5-prong interactions and the associated γ -quanta which were materialized in the effective volume of the chamber. Finally, a special methodical scanning was performed in order to ensure maximum efficiency (100%) for the location of such events and γ -quanta. Other details regarding the selection criteria of $\pi^- p$, $\pi^- n$ and $\pi^- C$ interactions have been discussed in Ref. /1/.

Two independent methods were made in order to determine the above-said cross-sections. Firstly, we have estimated the elastic and coherent cross-sections from the distribution of the number of γ -quanta associated with the scanned events. The second method is based on the multiplicity distribution of charged secondaries in $\pi^- p$, $\pi^- n$ interactions. The angles and energies of the secondary particles have not yet been measured on all the tracks and in this regard our estimations are rather preliminary.

2. Distribution of γ -Quanta Associated with 2-5-Prong Events

Table 1 shows the distribution of γ -quanta in 2-5-prong events. The distribution is presented in such a way that all the events with $N_\gamma \geq 1$ have been normalized to 100 for each type of event. We have defined a parameter η which gives us the percentage of the number of events with $N_\gamma = 0$ to the total number of events in a particular type of interaction. There is a marked enhancement of η in the case of 2- and 3-prong events, whereas in 4-prong events η is minumum 33.63. This enhancement, we assume, is due to the presence of elastic events of the type

$$\pi^- p \longrightarrow \pi^- p \qquad (1)$$

in two-prong events without γ -quantum. In three-prong and five-prong events this is due to the presence of coherent interactions of the type

$$\pi^- C \rightarrow \pi^-\pi^+\pi^- C \quad (2)$$

and

$$\pi^- C \rightarrow 3\pi^- 2\pi^+ C . \quad (3)$$

It is interesting to note that the average value $\langle N_\gamma \rangle$ for events with $N_\gamma \geq 1$ remains constant independent of charged prong number up to 5 and the γ -quanta distribution of such events is also identical irrespective of the number of created charged particles. For higher charged prong events, however, $\langle N_\gamma \rangle$ does not remain constant but increases /2/.

Figure 1 shows the distribution of the number of γ -quanta associated with 2 - 5-prong events. A single exponential law of the form

$$N = C e^{-0,43 N_\gamma} \quad (4)$$

can represent the experimental data with $\chi^2 = 6$.

On the assumption that the same law holds good for events with $N_\gamma = 0$ and enhancements of such events in 2-, 3- and 5-prong events are due to elastic and coherent interactions, one can estimate the percentage and hence the cross-sections for their production. Table II shows the results obtained under the heading "Method 1".

3. Charged Prong Multiplicity of π^-p and π^-n Interactions

The results regarding the multiplicity distribution of charged particles are based upon 50 000 pictures taken from the 2m Dubna chamber exposed to the 40 GeV π^- beam /1/. The experimental multiplicity distributions for π^-p and π^-n interactions were fitted with the predictions of Wang Model 1 /3/

$$P_{(n_{cb})} = \frac{(1/2\langle n_{cb} - a\rangle)^{1/2(n_{cb}-a)}}{1/2(n_{cb} - a)!} e^{-1/2\langle n_{cb} - a\rangle} , \quad (5)$$

where a is the number of charged particles in the initial state. The values of χ^2 for π^-p and π^-n events are 25 and 40 respectively. Such bad fits were attributed to the presence of elastic interactions in π^-p events and coherent interactions in 3- and 5-prong events, the contrubution of which must be subtracted correctly. Calculations were again made on the basis of the above formula (5) without taking into consideration 2-prong events in π^-p interactions and 3- and 5-prong events in π^-n interactions. With the knowledge of new parameters, thus obtained, the theoretical distributions were extrapolated in the regions of 2-, 3- and 5-prong events and the correct percentages of the contributions of elastic and coherent events were determined.

Figure 2 shows the charged prong multiplicity distributions of π^-p and π^-n events and the new values of χ^2 obtained after subtracting the contribution of elastic and coherent events. The values of cross-sections are presented in Table II under the heading "Method 2". The values obtained by methods 1 and 2 are in good agreement within the experimental errors. In the estimation of coherent interactions in 3-prong event of the type (2), we have taken into consideration the admixture of such $\pi^- C \rightarrow 3\pi^{\pm} 2\pi^{\circ} C$ events. In accordance with the statistical isospin model /4/ $\sigma(\pi^- C \rightarrow 3\pi^{\pm} 2\pi^{\circ}) / \sigma(\pi^- C \rightarrow 3\pi^- 2\pi^+) = 2.2$. In case of elastic scatterings /6/, we have taken into consideration that 30% of the elastic events are not visible because of the inability of our chamber to record slow recoil protons ($p \leq 180$ MeV/c).

Figure 3 shows the dependence of coherent cross-sections for 3-prong events on the primary energy. Our experimental point agrees well with the theoretical results obtained by Grishin et al. /5/ based purely on kinematical considerations.

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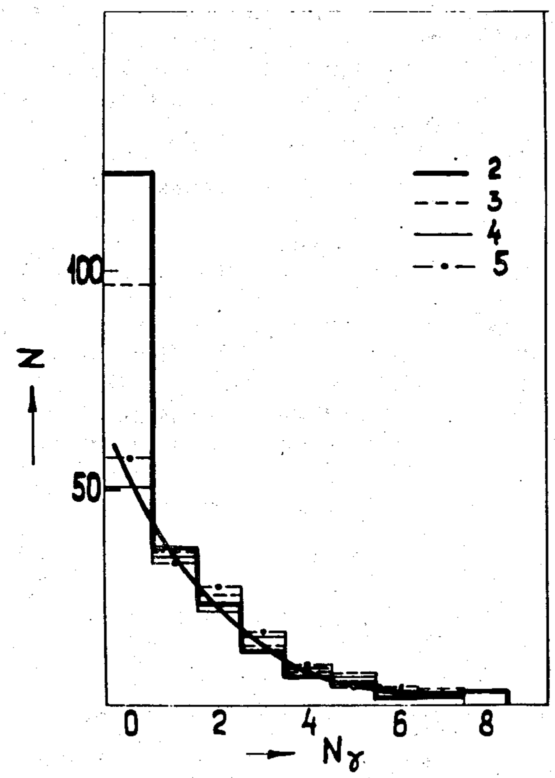

Fig. 1. Distribution of the number of γ -quanta associated with 2 - 5-prong events. The continuous line is due to Eq. 4.

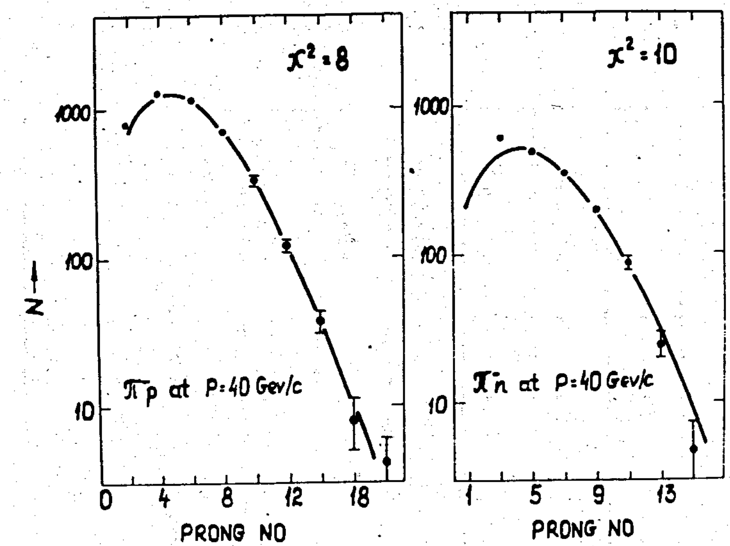

Fig. 2. Charged prong multiplicity distribution of secondaries in case of $\pi^- p$ and $\pi^- n$ interactions. The continuous line is due to Eq. 5.

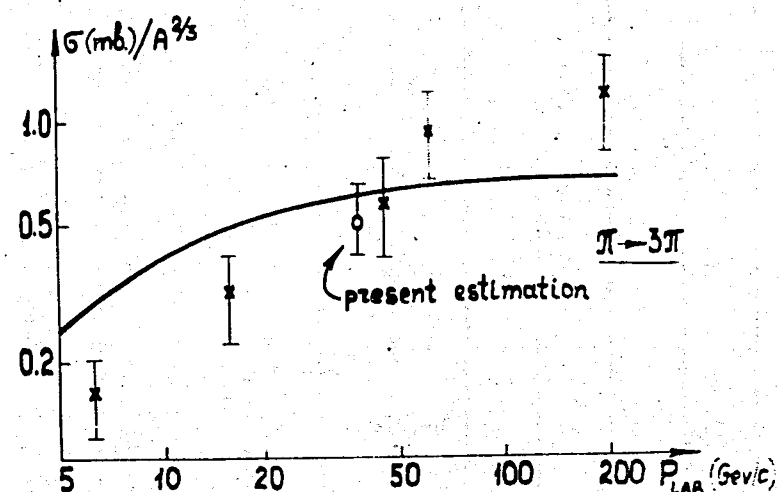

Fig. 3. Dependence of coherent production cross-sections upon the incident energy in the lab. system. The continuous line is due to

Table I
Distribution of the number of γ associated with 2 - 5-prong interactions

N \ Type	2p	3p	4p	5p	Average
0	122.0	97.0	51.0	57.0	
1	36.8	37.0	35.1	33.9	35.9±2.3
2	24.4	26.0	22.3	28.6	24.9±1.8
3	13.8	13.7	16.1	17.8	15.4±1.4
4	6.3	7.5	9.3	7.1	8.1±1.0
5	5.7	8.2	7.1	4.5	6.7±0.9
6	2.3	2.7	4.3	3.6	3.5±0.7
η	54.56	49.82	33.63	36.36	
$\langle N_\gamma \rangle$*	2.68±0.2	2.53±0.2	2.68±0.2	2.51±0.2	

* $N_\gamma \geq 1$

Table II

Type	Cross-section (mb)	
	Method 1	Method 2
2-prong Elastic	4.0 ± 0.4	3.5 ± 0.3
3-prong Coherent	3.2 ± 0.4	3.5 ± 0.3
5-prong Coherent	0.2 ± 0.1	0.3 ± 0.1