

INTERACTION OF PIONS WITH NUCLEI

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(presented by G. Puppi)

Together with the analysis of the elementary pion-proton interaction¹⁾, the Bologna group has carried out in the last few years some work on the interaction of π with nuclei.

The main problem, in this research is to find out whether the characteristics of the interaction with nuclei can be interpreted on the basis of the knowledge of the elementary cross-sections, taking into account the influence of the nucleus. In other words, the problem is to see whether it is possible to interpret these characteristics assuming that within the nuclear matter the nucleons have the same properties of interaction with pions they have in the free state. The simplest way to analyze the results from this point of view, is with the aid of the optical model in which the nuclear matter is described by an index of refraction

$$n = n_0 + i/2k\lambda \quad k = 1/\hbar c \sqrt{E^2 - \mu^2 c^4}$$

or to solve a Klein-Gordon equation with a complex potential inside the nucleus, due to nuclear forces,

$$V_r + i V_{im}$$

The relation between the two formulations is well known and is as follows :

$$n_0 = \sqrt{\frac{(E - V_r)^2 - \mu^2 c^4}{E^2 - \mu^2 c^4}} \quad \lambda = 2 V_{im}/\hbar v$$

Now the real part of the potential can be related to the real part of the forward scattering amplitude f from proton and neutron in the laboratory system as follows :

$$\frac{V_r (V_r - 2E)}{2\mu c^2} = \frac{3\hbar^2}{2\mu r_0^3} \cdot \frac{N f_N(0) + Z f_z(0)}{A}$$

while the imaginary part is connected with the total cross-section for all incoherent phenomena.

The most suitable experiments for studying the real part of the potential are those of elastic scattering; in fact they show that, taking into account the σ_{abs} , they can be interpreted assuming in the region between 80 and

120 Mev the existence of an attractive potential of the order of 30 Mev, which is in agreement with what can be calculated from the elementary cross sections, through the forward scattering amplitudes. This provides us with a first check of the model.

The incoherent processes are essentially of two kinds : inelastic scattering and absorption, the small contribution of charge exchange being included in the absorption. From the knowledge of the total cross-section it is possible to calculate, taking into account Coulomb effects the V_{im} . In fig. 1 are collected some determinations of it from different experiments.

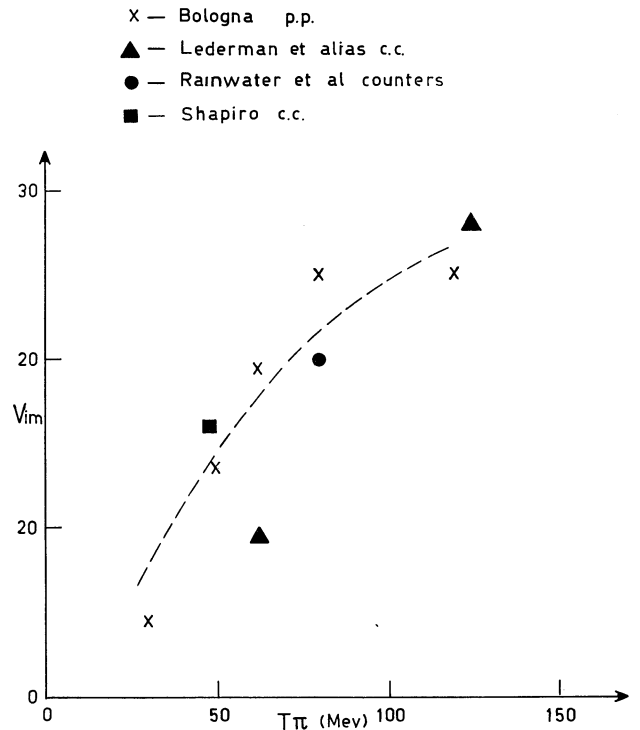


Fig. 1. Imaginary part of the potential as a function of energy.

The inelastic scattering can be considered as due to a close collision between the pion and one nucleon in the nucleus and in that sense it can be investigated with the Goldberger model.

We have analyzed the said phenomenon for π^+ between 0-50 Mev, at 62 Mev and at 120 Mev; for π^- at 80, 100, 120 Mev.

For 62 Mev a Montecarlo calculation has been done; for the other cases similar calculations are in progress. The results indicate that it is possible to obtain a fairly good description of the phenomenon as far as angular distribution and energy losses are concerned. For 62 Mev one single collision is enough, while at 120 Mev there is evidence for a substantial contribution from double scattering. Since the calculations are performed on the basis of the elementary cross-sections taking into account Fermi motion and Pauli principle, the agreement is again a check of the model.

In fig. 2 are given the experimental results at 120 Mev for the energy losses. The differences between π^+ and π^- can be explained as an effect of the real and Coulomb potential.

As regards absorption, this phenomenon is characterized by the disappearance of the pion and the sharing of its total energy by various nucleons.

A complete investigation has been made only for π^- at rest, in the so-called σ -stars. The best agreement with the results is obtained, also with a Montecarlo calculation, in the hypothesis of capture by a proton-neutron pair inside the nuclear matter.

For π^+ the work is in progress, but from the characteristics and the frequency of capture with two fast protons coming out, it is possible to foresee that this type of absorption is the dominant phenomenon also for absorption in flight.

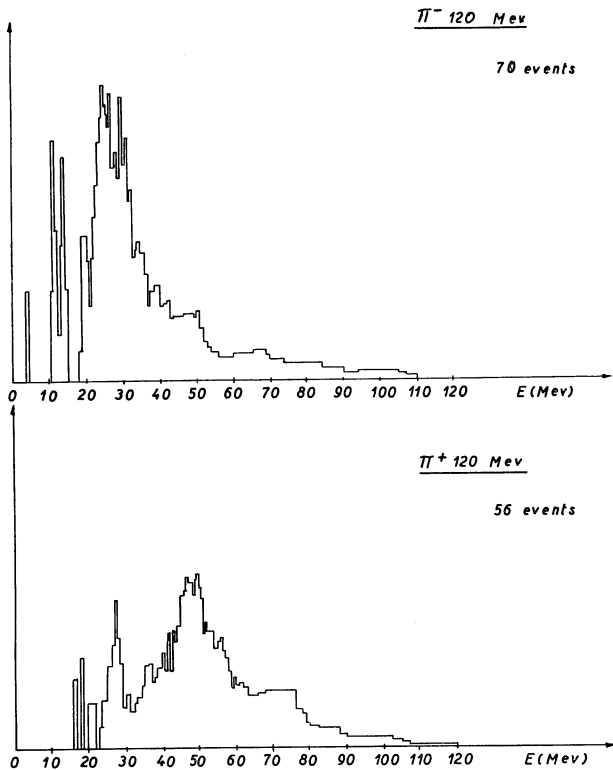


Fig. 2. Inelastic scatterings.

LIST OF REFERENCES

1. Ferrari, G. et al. Experimental results on $\pi^+ + \text{P}$ scattering in the energy range between 70 and 130 Mev. (See p. 230.)