Production of ρ^- mesons on nuclei by 3.9-GeV/c π^- mesons and cross section of ρ^- N interaction

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We investigated the production of negative ρ mesons on nuclei of the freon mixture (C, F, Cl) by 3.9-GeV/c π^- mesons in the reaction $\pi^- + A \to \rho^- + A^*$. The cross section in the momentum-transfer interval 0.04 $(\text{GeV}/c)^2 \leq |t| \leq 0.5$ $(\text{GeV}/c)^2$ is 3.0 ± 0.3 mb for the average mixture nucleus ($A = 22.5$). Within the framework of the Glauber model, we determined the cross section for the interaction of the ρ^- meson with an intranuclear nucleon, namely $\sigma_{\rho^- N} = 30^{+11}_{-8}$ mb.

The only method of investigating the interactions between short-lived hadrons and nucleons is to study their production on complex nuclei. No investigations of the production of charged ρ mesons on nuclei have been carried out so far for this purpose.

We have studied the production of ρ^- mesons in the reaction

$$\pi^- + A \to \rho^- + A^* \quad (1)$$
$$\rho^- \to \pi^- + \pi^0$$

at a π^--meson momentum 3.9 GeV/c. The work was performed with the 105-cm freon bubble chamber of our Institute (the nuclei C, F, Cl), exposed in the π^--meson beam of the proton synchrotron of the Institute of Theoretical and Experimental Physics.

We selected stars with one negative track and two electron-positron pairs looking into the star. To determine the cross sections of the reaction (1), we specially selected from part of the material stars with arbitrary numbers of accompaniment protons. We found altogether 2500 events, of which 1400 were measured. After calculation with the geometrical-reconstruction program and selection in accord with the measurement accuracy

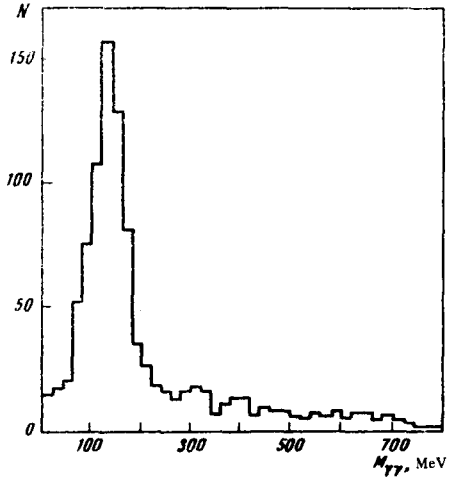

FIG. 1. Distribution with respect to the effective mass of two γ quanta.

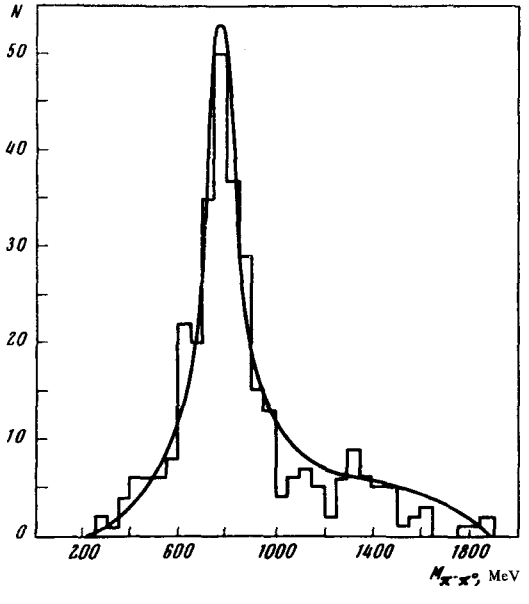

FIG. 2. Distribution with respect to the effective $\pi^-\pi^0$ mass for the fitted events.

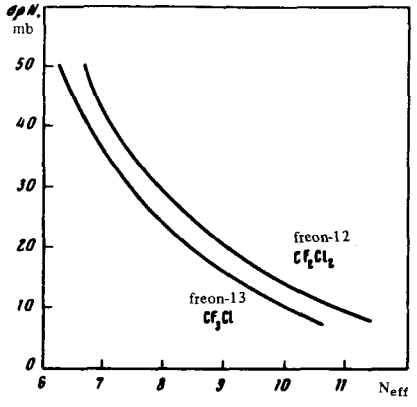

FIG. 3. Effective number of nucleons N_{eff} for freon-12 and freon-13 at $r_0 = 1.2$ F and $d = 0.545$ F.

and in accord with the criterion under which the γ quantum belongs to the star, we retained 981 events for the subsequent analysis.

Figure 1 shows the distribution with respect to the effective mass of the two γ quanta, in which the π^0 meson appears clearly. The subsequent event-fit procedure makes it possible to get rid of cases of production of additional π^0 mesons not registered in the chamber. The obtained distribution with respect to the effective $\pi^-\pi^0$ mass, after the fit, is shown in Fig. 2. The smooth curve corresponds to a 65% contribution of the ρ^- meson distribution ($M_{\rho^-} = 780$ MeV, $\Gamma = 160$ MeV) and a 35% contribution of the three-particle ($\pi^-\pi^0 N$) reaction. The cross section for the production of the ρ^- meson on the average nucleus of the freon mixture in the momentum-transfer interval $0.04\ (\mathrm{GeV}/c)^2 \leq |t| \leq 0.5\ (\mathrm{GeV}/c)^2$ turned out to be $\sigma_{\rho^-} = 3.0 \pm 0.3$ mb (the mixture composition can be represented by the formula $C_2F_3Cl_5$). The cross section was corrected for the scanning efficiency, for the γ-quantum registration efficiency in the chamber, and for events that could not be measured. The use of the missing mass to the $\pi^-\pi^0$ system as the criterion for separating the reaction channels, in place of the fit procedure, yields the same result within the limits of statistical errors.

The cross section for ρ^--meson production and free nucleons at our energy, taken from the published data,[1,2] is 0.56 mb, and when the cutoff of the momentum transfer is taken into account, its value is 0.39 mb. The effective nucleon number is therefore $N_{eff} = 7.7 \pm 0.8$.

To determine the cross section $\sigma_{\rho-N}$ for the interaction of the ρ^- meson with the intranuclear nucleon, we calculated the dependence of the effective number of nucleons N_{eff} on $\sigma_{\rho-N}$ with allowance for multiple rescattering of the π and ρ mesons in the nucleus.[3] The calculation results are shown in Fig. 3. The nuclear density was assumed to have a Fermi distribution with parameters $r_0 = 1.12$ F and $d = 0.545$ F, as given in[4], where $\sigma_{\rho N}$ was determined from the data on the (γ, ρ) reaction.

According to the calculation results, the value of N_{eff} obtained by us corresponds to a cross section $\sigma_{\rho-N} = 30^{+11}_{-8}$ mb for the interaction of the ρ^- meson with the intranuclear nucleon. The result agrees with the predictions of the quark model and with the data on the interaction of the neutral ρ meson from photoproduction processes[4] and nondiffraction production by pions on nuclei.[5,6]

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