

SACHS: I believe you must be referring to the fact that radiative corrections will become important eventually for large q^2 . This analysis is based on a hope that there is a region above which the strong interactions are cut off, but which is still not sufficiently high so that high order electromagnetic radiative corrections become important. There may not exist such a region. But if there exists such a region, then one can make

an interpretation this way. If not, this interpretation, as you say, is nonsense. There is a theorem by Drell and Zachariasen, I believe, which says that if Z_2 , the photon propagator renormalization, is finite, then Z_2 must be zero when you take into account all the electromagnetic radiative corrections. This theorem was actually given first by Evans, I believe, but maybe by Källén; everything was in Källén's article.

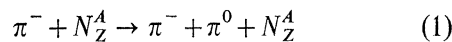
THE π^0 -PRODUCTION IN THE COULOMB NUCLEAR FIELD

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(presented by V. V. Vladimirovsky)

In the theoretical papers by Pomeranchuk and Shmushkevich¹⁾ and Good and Walker²⁾ the coherent Coulomb interactions of fast particles with a nucleus were considered. We have investigated experimentally a particular case of the coherent interaction



As follows from ref.¹⁾ at $q^2 \ll m^2/A^{2/3}$ (q^2 being the momentum transfer to the nucleus and m being the mass of the pion) the differential cross section of the reaction has the shape

$$d\sigma_c = \frac{Z^2 d}{\pi} \cdot \frac{dW^2}{W^2 - m^2} \frac{dq^2}{q^4} \left[q^2 - \left(\frac{W^2 - m^2}{2E_L} \right)^2 \right] \times |F(q^2)|^2 \sigma_p(W) \quad (2)$$

where W is the total energy of two pions in their centre-of-mass system, E_L is the energy of the incident negative pion in the laboratory coordinate system, F is the form-factor of a nucleus and σ_p is the cross section of the photoreaction



In the present work the reaction (1) on xenon nuclei ($Z = 54$, $A = 131$) was investigated at

$E_L = 2.8$ GeV. At this comparatively low energy the charge distribution in the nucleus should be taken into account. We assume the form-factor of a nucleus to be

$$F(q^2) = \frac{1}{1 + q^2 \frac{R^2}{\sigma}} \quad (4)$$

Here $R = \frac{A^{1/3}}{m}$ denotes the nuclear radius and

$\hbar = c = 1$. The effective momentum transfer is restricted by the condition $q \leq \frac{\sqrt{\sigma}}{R}$, that yields for

a xenon nucleus the value $\sim m/2$, i.e. ~ 70 MeV/c. Assuming this value and integrating the expression (2)

over the intervals $\left[\frac{(W^2 - m^2)}{2E_L} \right]^2 \leq q^2 \leq \frac{\sigma m^2}{A^{2/3}}$ and

$4m^2 \leq W^2 \leq \left(\frac{2E_L m \sqrt{\sigma}}{A^{1/3}} \right)$ we have for xenon nucleus at our energy

$$\sigma_c \cong 7.5 \bar{\sigma}_p \quad (5)$$

where $\bar{\sigma}_p$ is the cross section of the reaction (3) averaged in the interval $4m^2 \leq w^2 \leq 21m^2$. At $w^2 = 21m^2$

the maximum angle of deflection of the π^- -meson is 30° . The experiment was performed with a 2-litre xenon bubble chamber exposed to 2.8 GeV/c π^- -mesons (JINR). About 10 000 stereophotographs were scanned by three independent scanners for this work. The events of π^- -scattering in the angle interval $3-30^\circ$ which are accompanied by two electron-positron pairs directed to the point of the interaction (decay $\pi^0 \rightarrow 2\gamma$) were searched for. The requirement of absence of any other tracks besides the π^- -track was also imposed.

48 such events were found, the total number of the inelastic interactions being 8007. To evaluate the nuclear background a method of kinematical analysis was developed. The angles were measured between the scattered π^- -meson, the two γ -rays and the axes of the chosen coordinate system. It was found that this information (including the momentum of the incident pion) was sufficient to identify 23 events with $q > 70$ MeV/c.

To evaluate the nuclear background for the other 25 events the proportionality of the Coulomb effect to Z^2 was taken into consideration. A 17-litre bubble chamber filled with freon mixture ($C_2F_5Cl_3$, $Z^2 = 136$) was exposed to the same beam. The Coulomb effect in the freon bubble chamber is negligible as compared with the xenon bubble chamber since $Z_{Xe}^2 (= 2900) \gg Z_{Fr}^2 (= 136)$. All π^- -meson scattering events accompanied by two γ rays which have been found in the freon bubble chamber should thus be considered to be the nuclear background. About 10 000 freon chamber photographs were scanned and 31 events of π^- -meson scattering in the angle interval $3^\circ-30^\circ$ accompanied by two γ -rays were found, the total number of inelastic interactions being 22226.

After the kinematical analysis 18 events were rejected and only 13 Coulomb-like events remained.

The true number (n) of events, necessary for calculating the cross section σ_c of the reaction $\pi^- + Xe \rightarrow \pi^- + \pi^0 + Xe$ was determined by the formula

$$n = \frac{n_1}{\eta_1} - \frac{n_2 N_1}{\eta_2 N_2} \quad (6)$$

where n_1 , η_1 and N_1 are respectively: the number of the events found; the efficiency of registration of two γ quanta from the decay of one π^0 -meson; and the number of all the inelastic interactions on the scanned

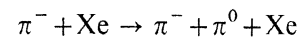
photographs for xenon. n_2 , η_2 and N_2 are the analogous values for freon. The efficiencies were $\eta_1 = 0,57$ and $\eta_2 = 0,33$. The angular distribution of the events is given in Table I.

TABLE I

π^- -scattering angle (degrees)	n_1	n_2	n_1/η_1	$\frac{n_2 N_1}{\eta_2 N_2}$	n
3-10	12	2	21,0	2,2	18,8
10-17	7	7	12,3	7,6	4,7
17-24	4	1	7,0	1,1	5,9
24-30	2	3	3,5	3,3	0,2

One can see that in the interval $3^\circ-10^\circ$ the nuclear background, i.e., the quantity $\frac{n_2 N_1}{\eta_2 N_2}$ is not large and is about 10% of the effect under consideration.

However, in the interval $10^\circ-30^\circ$ the nuclear background becomes rather large. Thus, the main part of the effect depending on Z^2 is concentrated at small angles. This is obvious from Fig. 1, where a plot is shown of the differential cross section of the emerging π^- -meson from the reaction



For comparison the angular dependence of the differential cross section for the nuclei of the freon mixture is also represented (these data are normalized to the xenon data). As it was expected, the angular

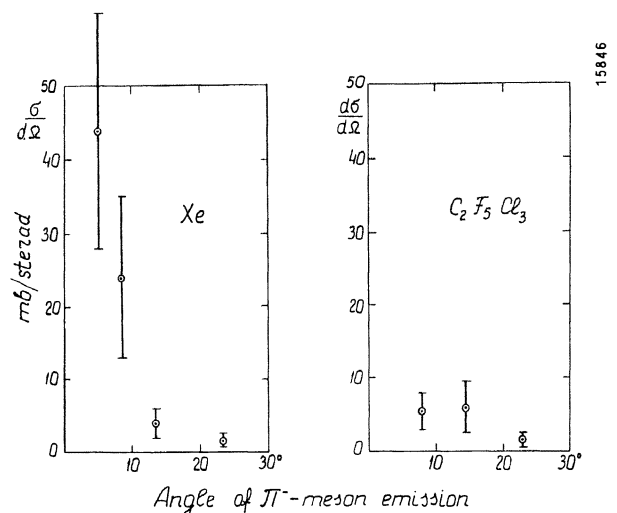
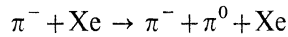


Fig. 1

distribution for light nuclei does not tend to increase sharply at small angles.

In the angular interval investigated, the Coulomb reaction,



is a fraction $n/N_1 = (3.7 \pm 1.3)10^{-3}$ of the total inelastic cross-section. (N_1 is the total number of inelastic interactions.) Assuming for xenon $\sigma_{\text{in}} = 1200$ mb, we have $\sigma_c = (4.4 \pm 1.6)$ mb.

In accordance with the expression (5) the cross section of the reaction $\gamma + \pi^- \rightarrow \pi^- + \pi^0$ is equal to $\bar{\sigma}_p = \sigma_c/7.5 = (0.6 \pm 0.2)$ mb. This quantity exceeds the value $\sigma_p \cong l^2/m^2 = 0.15$ mb which should be expected in that energy region where there are no π - π resonances. It is possible that the large value of $\bar{\sigma}_p$ indicates the influence of the π - π resonances. Indeed, the maximum value $w^2 = 21 \text{ m}^2$ is rather close to the ρ -resonance. Furthermore, some data appeared lately indicating the possible existence of the π - π resonance at $w^2 = 17 \text{ m}^2$ ³⁾.

LIST OF REFERENCES

1. I. Ya. Pomeranchuk, I. M. Shmushkevich, Nucl. Phys. 23, 452 (1961).
2. M. L. Good, W. D. Walker, Phys. Rev. 120, 1855 (1960).
3. R. Barloutand, J. Heughebaert, A. Leveque, J. Meyer, R. Omnès, Phys. Rev. Letters, 8, 32 (1962).

DISCUSSION

PANOFSKY: In using your form factor for Xe you assumed that the photon-Xenon interaction is elastic. Actually at momentum transfers up to 70 MeV/c a considerable inelastic contribution could occur. Was this taken into account?

VLADIMIRSKY: We eliminated all stars, but cannot eliminate events in which only neutrons were produced.

WALKER: How do you determine the momentum transfer to the nucleus? Can you measure the momenta well in xenon?

VLADIMIRSKY: No, we have not enough data, because the momenta of π^- and γ are unknown. But it is possible to compute the lower limit of q in part of our events. 23 events with $q > 70$ MeV are excluded after such a kinematical analysis.