INVESTIGATION OF THE $\pi^+ + d \to 2p$ REACTION FOR 174–307 Mev π^+ MESONS

B. S. NEGANOV and L. B. PARFENOV

Joint Institute for Nuclear Research

Submitted to JETP editor December 18, 1957

J. Exptl. Theoret. Phys. (U.S.S.R.) **34**, 767-769 (March, 1958).

USING ganged telescopes of scintillation counters, we investigated the reaction

$$\pi^+ + d \to 2p \qquad (1)$$

at pion energies of 174, 200, 227, 262, and 307 Mev. A beam of π^+ mesons was obtained by irradiating a hydrogen-containing target with a beam of protons, extracted from the synchrocyclotron of the Joint Institute for Nuclear Research. The yield of reaction (1) was determined by the difference of the counting rate of double coincidences from D_2O and H_2O targets. The measured differential cross sections for four angles, in the center of mass system, are represented in the table (E_π is the pion energy in the c.m.s.).

The angular distributions of the protons can be represented in the form $A + \cos^2\theta$ with the following coefficients, obtained by the least-squares method.

$$E_\pi = 140 \text{ Mev}; \quad d\sigma/d\Omega = [(0.31 \pm 0.03) + \cos^2\theta] \times (2.54 \pm 0.15)\cdot 10^{-27} \text{ cm}^2/\text{sterad},$$
$$\sigma = (10.4 \pm 0.8)\cdot 10^{-27} \text{ cm}^2.$$

$$E_\pi = 160 \text{ Mev}; \quad d\sigma/d\Omega = [(0.35 \pm 0.03) + \cos^2\theta] \times (1.76 \pm 0.11)\cdot 10^{-27} \text{ cm}^2/\text{sterad}, \quad \sigma = (7.6 \pm 0.6)\cdot 10^{-27} \text{ cm}^2.$$

$$E_\pi = 180 \text{ Mev}; \quad d\sigma/d\Omega = [(0.49 \pm 0.03) + \cos^2\theta] \times (1.05 \pm 0.06)\cdot 10^{-27} \text{ cm}^2/\text{sterad}, \quad \sigma = (5.4 \pm 0.4)\cdot 10^{-27} \text{ cm}^2.$$

$$E_\pi = 205 \text{ Mev}; \quad d\sigma/d\Omega = [(0.49 \pm 0.06) + \cos^2\theta] \times (0.66 \pm 0.04)\cdot 10^{-27} \text{ cm}^2/\text{sterad}, \quad \sigma = (3.4 \pm 0.3)\cdot 10^{-27} \text{ cm}^2.$$

$$E_\pi = 236 \text{ Mev}; \quad d\sigma/d\Omega = [(0.59 \pm 0.07) + \cos^2\theta] \times (0.32 \pm 0.02)\cdot 10^{-27} \text{ cm}^2/\text{sterad}, \quad \sigma = (1.9 \pm 0.2)\cdot 10^{-27} \text{ cm}^2$$

[σ is the total cross section of reaction (1)].

The total cross sections for the reaction

$$p + p \to d + \pi^+, \qquad (2)$$

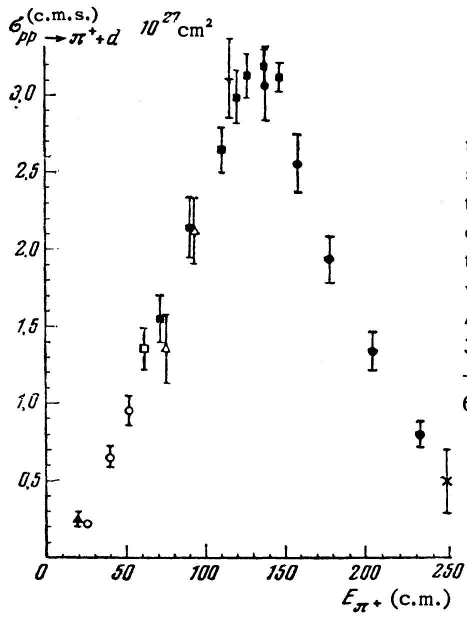
calculated on the basis of the detailed-balance principle, are 3.05 ± 0.23, 2.50 ± 0.18, 1.93 ± 0.14, 133 ± 0.12, and 0.80 ± 0.08 millibarns at proton energies of 633, 690, 743, 812, and 903 Mev respectively. The dependence of the total cross section of reaction (2) on the pion energy in the c.m.s. is represented on the diagram.

Differential Cross Section in Units of 10^{-27} cm²/sterad (statistical errors)

E_π, Mev	θ = 30°	45°	60°	90°
140	2.62±0.11	2.11±0.19	1.56±0.08	0.75±0.06
160	1.82±0.10	1.56±0.06	1.06±0.05	0.61±0.04
180	1.22±0.03	1.10±0.03	0.86±0.03	0.47±0.02
205	0.77±0.05	0.67±0.05	0.54±0.03	0.30±0.03
236	0.42±0.03	0.35±0.01	0.29±0.02	0.18±0.02

The data obtained confirm the conclusion reached earlier by Meshcheriakov and Neganov[1] concerning the resonant character of the investigated reaction. The maximum of the excitation function is obtained at $E_n = 135$ Mev. These results are in agreement with the Mandel' shtam theory (Birmingham, Private Communication, 1957).

The change in the angular distribution at energies above resonant is apparently the result of the increase in the relative role of the transitions $^3P_{1,2} \to {}^3S_1$ and $^3F_{2,3} \to {}^3S_1$, which lead to the production of mesons in the d state. This assumption can be verified by polarization experiment and also by a further analysis and refinement of the angular distribution at a pion energy of 230



Dependence of the total cross-section of the reaction on the energy of the π^+ meson in the c.m.s. ●– our work; ■–Ref. 1. △–Ref. 2. □–Ref. 3; ○–Ref. 4; +–Ref. 5; ▲–Ref. 6; ×–Ref. 7.

Mev in the laboratory system, at which a term proportional to $\cos^4\theta$ apparently appears in the angular distribution. From the point of view of the resonance model of pion production in nucleon-nucleon collisions, this means that the p state of the system (isobar nucleon), which precedes the radiation of a meson in the d state, start assuming an important role. In this case the amplitude of the $^1S_0 \rightarrow {}^3S_1$ transition should be small, since this transition corresponds to the d state of the isobar-nucleon system.

[1] M. G. Meshcheriakov and B. S. Neganov, Dokl. Akad. Nauk SSSR **100**, 677 (1955).
[2] H. L. Stadler, Phys. Rev. **96**, 496 (1954).
[3] T. H. Fields et al., Phys. Rev. **95**, 638 (1954).
[4] Durbin, Loar, and Steinberger, Phys. Rev. **84**, 581 (1951).
[5] C. E. Cohn, Phys. Rev. **105**, 1582 (1957).
[6] Clark, Roberts, and Wilson, Phys. Rev. **83**, 649 (1951).
[7] Batson, Culwich, and Riddiford, Rochester Conference Report, 1957.

Translated by J. G. Adashko
153

ELECTRON-NEUTRINO CORRELATION IN THE NEGATIVE DECAY OF Na^{24}

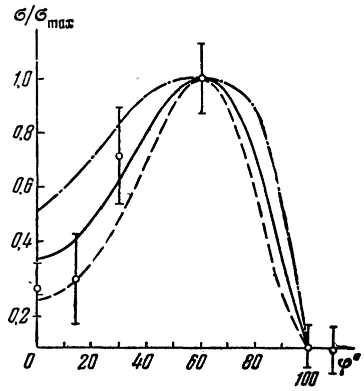
N. A. BURGOV and Iu. V. TEREKHOV

Submitted to JETP editor December 20, 1957

J. Exptl. Theoret Phys. (U.S.S.R.) **34**, 769 (March, 1958)

EXPERIMENTS for the determination of the electron-neutrino correlation through the use of resonant scattering of γ rays were proposed in Ref. 1. In the same reference, we calculated the dependence of the additional cross-section of the resonant scattering on the angle between the registered γ quanta for the β^--decay of Na^{24}. We have now carried out experiments using a gaseous source of Na^{24}.

The experimental setup was similar to that used in Ref. 2, with certain modifications. We employed FEU-33 instead of FEU-19 photomultipliers, which made it possible to dispense with broadband amplifiers and reduce the resolution time of the coincidence circuit to 3×10^{-9} sec. The source of γ-rays was metallic-sodium vapor containing radioactive Na^{24}. The source was kept at a temperature of 1,000°, corresponding to ~ 1 atmos vapor pressure of metallic sodium.



Dependence of the cross-section on the angle. Solid curve – λ = 0, dotted – λ = – 1, dash-dot – λ = 1

The diagram shows the results obtained. The average value of the correlation constant λ from one series of experiments is −0.3. The values of λ range from 0 to −1 with a probability of 80%.

The measured maximum resonant-scattering cross section at an angle of 120° between the registered γ-quanta was $(3.1 \pm 0.4) \times 10^{-24}$ cm^2.

The lifetime of the level is ~ 2×10^{-13} sec. The estimated average time between two collisions of the recoil nucleus in the source is ~ 10^{-11} sec, and the recoil nuclei can therefore be considered free and the calculations made in Ref. 1 are thus confirmed.

[1] N. A. Burgov, J. Exptl. Theoret. Phys. (U.S.S.R.) **33**, 655 (1957), Soviet Phys. JETP 6, 502 (1958).
[2] N. A. Burgov and Iu. V. Terekhov, Атомная энергия (Atomic Energy) **2**, 514 (1957).

Translated by J. G. Adashko
154