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All the experiments on pion β –decay performed up till now refer to the investigation of β–decay of stopping π^+–mesons[1–6]. In two recent papers[5–6] the following result for the relative probability of this process is obtained;

$$\frac{\pi^+ \to e^+ + \nu}{\pi^+ \to \mu^+ + \nu} \cong 1 \cdot 10^{-4} \pm (20\% - 40\%)$$

This value is in agreement with the quantity 1.3×10^{-4} which follows from the universal V–A theory of β–decay[7]. For negative pions, as is follows from the relativistic invariance (CPT – theorem[8]), this process must have the same relative probability as that for positive ones. However, it was important to determine directly from the experiment the relative probability of π^-–meson β–decay.

$\pi^- \to e^-$ decay unlike the $\pi^+ \to e^+$ decay can be found only in flight. Therefore to detect β–decay of π^-–mesons we used the data obtained in a diffusion cloud chamber operating in a magnetic field of 9000 gauss and used for the investigation of 130 and 160 MeV meson interaction with protons and rare modes of π^0–meson decay[9–11]. As a result of triple scanning of about 100000 stereo–photographs, 29 decays were found in which a secondary particle was deflected by the angle $\Theta > 20^o$ (the maximum angle at $\pi \to \mu$–decay for the energy 130 ? MeV is equal to 10^o). In all events the primary and the secondary particles according to visual estimations had the minimum ionization. As a result of measurement (the method of measuring the momenta and angles is similar to that described in our paper[11]), 26 events were identified as $\mu^- \to e^-$ decays and 3 events were attributed to $\pi^- \to e^-$ decays. It should be noted that the conditions of the momentum separation of $\pi \to e$ and $\mu \to e$ decays in flight is rather better than in case when π and μ–mesons come to rest since the relation of the momentum of an electron produced in $\pi \to e$ decay to the maximum possible at the given angle momentum of an electron from $\mu \to e$ decay exceeds in a wide angle region the relation of the indicated momenta for π and μ –mesons coming to rest. The lower background of $\mu \to e$ decays is also favourable. Fig.1 represents the momentum distribution of electrons produced in $\pi^- \to e^-$ and $\mu^- \to e^-$ decays in the rest system of π^- and μ^-–mesons. The indicated errors are the maximum errors of measuring the curvature radius of π^- and μ^-–mesons and electrons. The picture of one of $\pi^- \to e^-$ decay is given in Fig. 2.

The data of the $\pi^- \to e^-$ decay measurement is shown in Table 1.

Table 1

Number of $\pi^- \to e^-$ event	Lab. system			Rest system of π^-–meson	
	π^-–meson momentum (MeV/c)	electron momentum (MeV/c)	θ (grad)	Electron momentum (MeV/c)	θ (grad)
1	228 ± 10	104 ± 8	42.5 ± 0.5	74 ± 7	108 ± 2
2	207 ± 11	103 ± 3	42 ± 0.5	71 ± 4	102 ± 2
3	266 ± 6	156 ± 26	26 ± 0.5	68 ± 11	86 ± 1

As is seen from Fig. 1 and the table, the electron momenta in the rest system of π^-–meson have the values close to 69.8 MeV/c. If one considers the primary particle a μ^-–meson then in the rest system of a μ^-–meson the electrons for these three events will have the momenta (80 ± 8), (77 ± 4) and (70 ± 11) MeV/c, respectively, while the maximum electron momentum in $\mu \to e$–decay is equal to 52.9 MeV/c.

The other possible processes which can imitate $\pi^- \to e^-$–decays (inelastic scattering of π^-–mesons on complex nuclei of contamination in a gas of a chamber, electron bremsstrahlung radiation, a $\pi^- \to \mu^- \to e^-$ decay in flight with a short track of μ^-–meson) are of very small probability.

To determine the relative probability of π^-–meson β–decay it is necessary to know the total number of $\pi^- \to \mu^-$ decays. This number equal to $(5.6 \pm 0.3) \times 10^4$ was calculated from the known total length of π^-–meson path in a chamber equal to $(7.8 \pm 0.4) \times 10^7$ cm. and the mean momentum $P_\pi = 253$ MeV/c. Considering the efficiency of observation of $\pi^- \to e^-$ decays equal to that of $\mu^- \to e^-$ decay observation which according to estimations is equal to 70%, and taking into account the contribution from the angular region $\theta < 20°$ for relative probability of π^-–meson β–decay the following value was obtained:

$$\frac{\pi^- \to e^- + \tilde{\nu}}{\pi^- \to \mu^- + \tilde{\nu}} = (1{,}2 \pm 0{,}7) \cdot 10^{-4}.$$

Within the experimental errors this value is in agreement with the probability of β–decay of positive mesons as well as with the above value calculated on the basis of universal V–A theory of β–interaction.

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References

1. H.L. Friedman, J. Rainwater, Phys.Rev., 84, 684 (1951).
2. S. Lokanathan, J. Steinberger, Nuovo Cim., X, 151 (1955).
3. H.L. Anderson, C.M.G. Lattes, Nuovo Cim., VI, 1356 (1957).
4. T. Fazzini, G. Fidecaro, A.W. Merrison, H. Paul, A.V. Tollestrup, Phys. Rev. Lett. 1, 247 (1958).
5. G. Impeduglia, R. Plano, A. Prodell, N. Samios, M. Schwartz, J. Steinberger, Phys. Rev. Lett. 1, 249 (1958).
6. H.L. Anderson, T. Fujii, R.H. Miller, L. Tau, Phys. Rev. Lett, 2, 53 (1959).
7. M. Ruderman, R. Finkelstein, Phys. Rev., 76, 1458 (1949).
8. G. Luders, B. Zumino, Phys. Rev., 106, 385 (1957).
9. Yu.A. Budagov, S. Wiktor, V.P. Dzhelepov, P.F. Yermolov, V.I. Moskalev, Proceedings of conference on cloud, diffusicn and bubble chambers, JINR, Dubna, 1958.
10. Yu. A. Budagov, S. Wiktor, V.P. Dzhelepov, P.F. Yermolov, V.I. Moskalev, JETP, 35, 1575, 1958.
11. Yu.A. Budagov, S. Wiktor, V.P. Dzhelepov, P.F. Yermolov, V.I. Moskalev, JETP, 36, 1080, 1959.

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Fig.2. The picture of $\pi^- \rightarrow e^- + \tilde{\gamma}$ decay obtained in the diffusion cloud chamber.

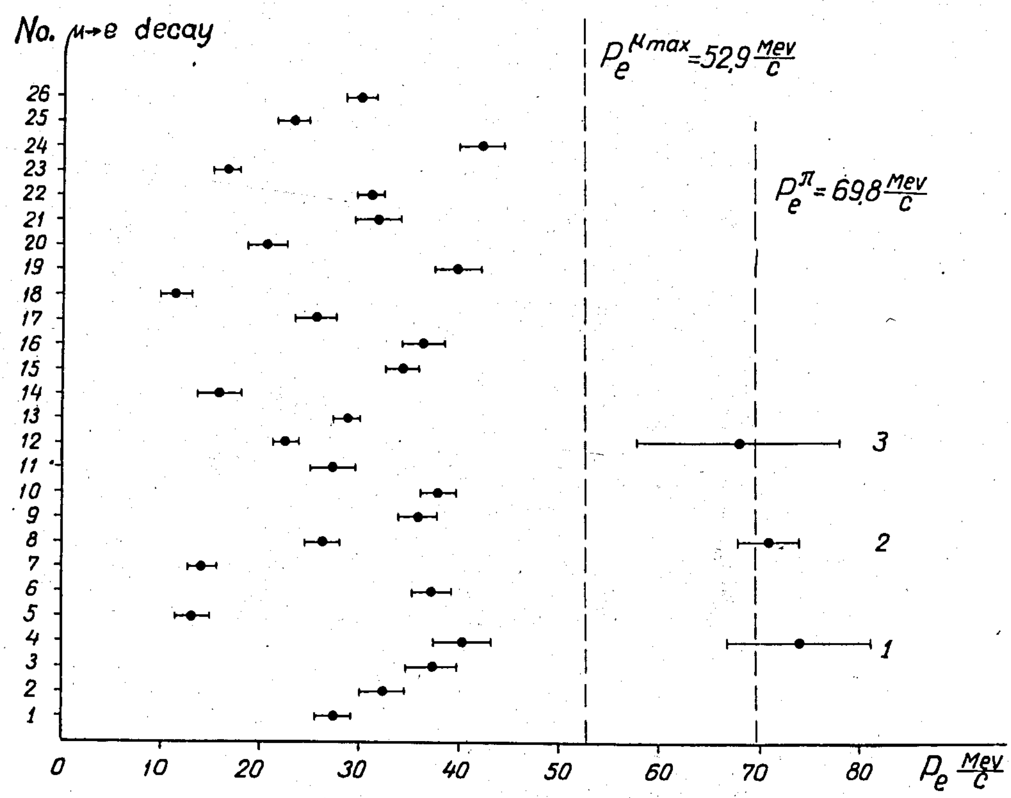

Fig.1. Momentum distribution of electrons from $\pi^- \to e^-$ and $\mu^- \to e^-$ decays (in the rest system of π^- and μ^--mesons).