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# ELECTRON-POSITRON PAIRS PRODUCED IN THE DECAY

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I4 events of charge-exchange scattering of $\pi^-$-mesons on hydrogen with a subsequent decay of $\pi^0$-meson according to Dalitz' scheme into an electron-positron pair and a $\gamma$-ray[I] were detected in the diffusion cloud chamber filled with hydrogen to the pressure of 25 atmosphere and placed into the I50 Mev $\pi^-$-meson beam of the Joint Institute of Nuclear Research synchrocyclotron[2]. The chamber had a sensitive layer of 380 mm diameter and operated in a magnetic field of 9000 gauss. The I4 events were observed in scanning 45000 stereophotographs and identified by $\pi^-$-meson track ends in hydrogen accompanied by the emission of an electron-positron pair. The photographs of two such events are given in Fig.I. The other processes responsible for the production of similar pairs (internal conversion of a $\gamma$-ray in the reaction $\pi^- + p \rightarrow n + \gamma$, pair production by $\gamma$-ray at small distance from the point of decay $\pi^0 \rightarrow 2\gamma$ and so on), as the estimates showed, have very small probability in our experiment.

In order to determine the relative probability of the decays $\pi^0 \rightarrow e^- + e^+ + \gamma$ and $\pi^0 \rightarrow 2\gamma$ it is necessary to know the number of $\pi^0$-mesons decayed in a usual way (into 2 $\gamma$-rays). Because of the finite thickness of the sensitive layer of the diffusion chamber and the presence of gaps in the layer the direct estimation of the number of charge exchange events is very difficult. However, it is possible to obtain the number of $\pi^0$-mesons if taking into account the data on charge-exchange and elastic $\pi^-$p - scattering cross sections[3] the ratio of which for the energy of I50 Mev is equal to I.8. Since we have found 600 events of the elastic $\pi^-$p - scattering, the number of $\pi^0$-mesons is equal to I080. Thus, the ratio of probabilities of the processes $\pi^0 \rightarrow e^- + e^+ + \gamma$ and $\pi^0 \rightarrow 2\gamma$ is equal to $2\rho_0 = 0.0130 \pm 0.0024$ and the internal conversion coefficient in this reaction is $\rho_0 = 0.0065 \pm 0.0012$. Errors quoted for $2\rho_0$ and $\rho_0$ are the statistical probable ones. The value $\rho_0$ obtained here is in a good agreement with both the theoretical calculations[I,4] and the experimental data[5,6,7,8]*

The results of analysis of electron-positron pairs are given in the table.

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* In [8] the internal conversion coefficients are obtained using the Panofsky ratio $P = 0.94 \pm 0.20$. If taking $P = I.5 - I.9$[9], the internal conversion coefficients obtained from[8] will not agree with the other experimental and theoretical data.

Table

| Numbers of pairs | $E^-$ (Mev) | $E^+$ (Mev) | $E=E^-+E^+$ (Mev) | $\alpha°$ (lab) | $\theta°$ (lab.) |
|---|---|---|---|---|---|
| I | - | - | - | 2.5 | II8 |
| 2 | >I34 | 70 | >204 | I6 | 50 |
| 3 | I9 | 4I | 60 | 36 | 95 |
| 4 | I06 | >24 | >I30 | 7 | 9I |
| 5 | 20 | III | I3I | 8 | I45 |
| 6 | 27 | 6 | 33 | 22 | II7 |
| 7 | 89 | 67 | I56 | 6 | 50 |
| 8 | >I4 | >96 | >II0 | >5 | I00 |
| 9 | - | - | - | 2 | II0 |
| I0 | >58 | I03 | >I6I | 53 | I40 |
| II | 36 | >I34 | >I70 | 3 | 99 |
| I2 | I0 | 24 | 34 | 38 | 86 |
| I3 | I66 | 20 | I86 | 28 | 65 |
| I4 | 22 | 27 | 49 | 46 | II8.5 |

The energies of an electron $E^-$ and a positron $E^+$ are determined from the curvature radius of tracks with the accuracy no less than I0-I5%. In a case of very short tracks it is possible to set only a lower limit of the corresponding energies. Pairs NI and N9 were found in the pictures obtained without magnetic field. The comparison of the $E^-$ and $E^+$ values shows that there is no tendency to the equal division of energy between the particles of the pair observed in[8] and especially in[6]. The total energies $E = E^- + E^+$ of all the pairs are in the energy interval I7-270 Mev corresponding to the energy spectrum of gamma rays from the decay of mesons produced in the charge exchange process.

The last columns of the table show the correlation angles $\alpha$(lab) between electrons and positrons of pairs and the angles $\theta$(lab) between center of mass of a pair and the direction of incident $\pi^-$-meson. The measurement accuracy of angles $\alpha$ is about $\pm$ I° and that of angles $\theta$ is about $\pm$ 2°. The distribution in correlation angle $\alpha$ agrees with the dependence $P(\alpha)d\alpha \simeq \text{const.}\frac{d\alpha}{\alpha}$ obtained by Dalitz[I]. As for the angular distribution of pairs with respect to the incident $\pi^-$-meson, it is characterized on the analogy with distribution obtained in[I0], by the emission of pairs more likely into the back hemisphere. Since the electrons and positrons produced in

the decay $\pi^0 \to e^- + e^+ + \gamma$ are well correlated the angular distribution of pairs should follow with good accuracy the angular distribution of gamma rays from $\pi^0 \to 2\gamma$ decay. Fig.2 represents the hystograms of the angular distribution of pairs (in the laboratory system /a/ and in c.m.system $\pi^- - p$ /b/). It does not disagree with the angular distribution of $\gamma$-rays from the decay of $\pi^0$-mesons produced in the reaction $\pi^- + p \to \pi^0 + n$ at the energy of $\pi^-$-mesons 150 Mev[II], which was plotted in Fig.2 in a form of curves $\frac{d\sigma}{d\Omega} \sin\theta$ (in arbitrary units).

In conclusion it should be noted that the kinematics of neither of seven pairs, the total energy of which was precisely determined, was consistent with the decay $\pi^0 \to e^- + e^+$; neither events of the decay $\pi^0 \to e^- + e^+ + e^- + e^+$ was also found.

At present the work is going on and the summary results will be published.

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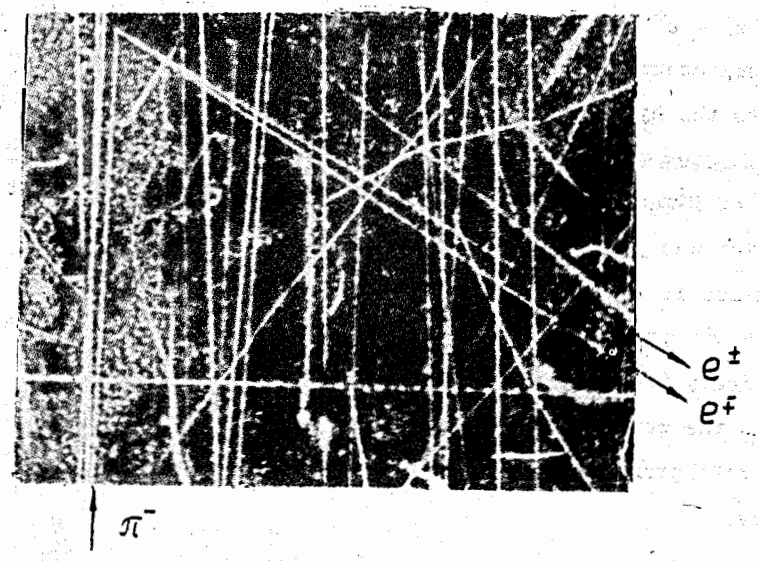


1a

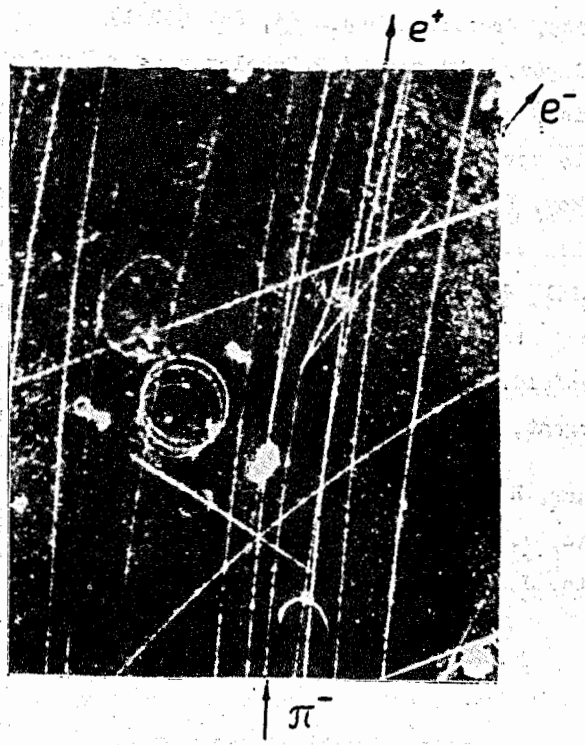


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Fig.I. The photographs of events $\pi^- + p \rightarrow \pi^0 + n$ with the subsequent decay $\pi^0 \rightarrow e^+ + e^- + \gamma$ : a) pair N I, b) pair N2.

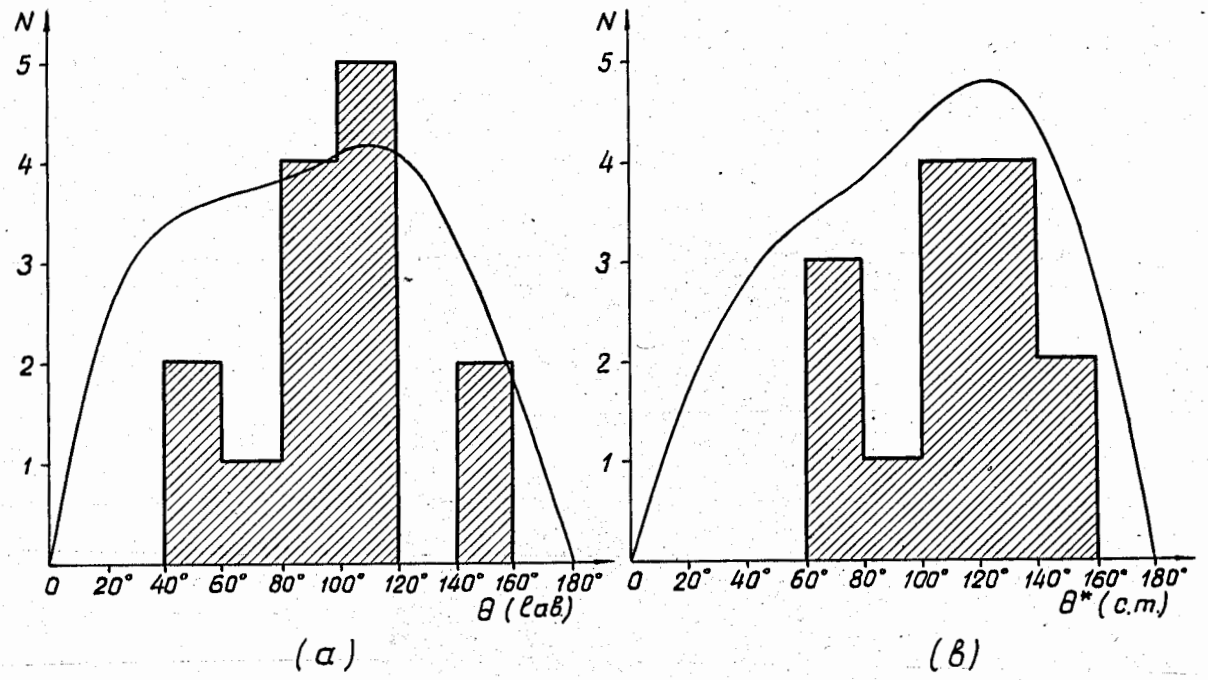


Fig.2. Angular distribution of pairs with respect to the direction of $\pi^-$-meson: a) in the lab.system, b) in c.m.system $\pi^-$-p.
Solid lines represent the angular distributions $\frac{d\sigma}{d\Omega} \sin\theta$ ( in arbitrary units) of gamma-rays from the decay of $\pi^0$-mesons produced in the reaction $\pi^- + p \rightarrow \pi^0 + n$ at the energy of $\pi^-$-mesons 150 Mev[II].