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SUMMARY OF THE RESEARCH PROGRESS MEETING OF DECEMBER 20, 1951

Sergey Shewchuck

March 7, 1952

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SUMMARY OF WEEKLY RESEARCH PROGRESS MEETING OF DEC. 20, 1951

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March 7, 1952

I. \( \mu^- \) Endings in Photographic Emulsions. By Dora Sherman.

A good source of \( \mu^- \)'s is needed so that \( \mu^- \) interaction with matter could be studied. Direct production has never been observed so decay of \( \pi^- \) mesons has to be used; however, \( \pi^- \) are captured by nuclei if one tries to slow them down in matter. The first successful attempt to record \( \mu^- \)'s was by George and Evans in England, who obtained \( \mu^- \)'s from cosmic rays on photographic emulsions exposed underground in a subway at a depth of 60 meters water equivalent. After correcting their data according to the distribution figures for \( \pi^- \) mesons of Adelman and Jones and a \( +/^- \) ratio of 1.27, they had 500 \( \mu^- \) meson tracks. Of the total number of \( \mu^- \) mesons 2 1/2 percent formed one prong stars of an average energy of 7 Mev per prong. Also, three were found which formed two prongs.

Recently a \( \mu^- \) beam has been gotten from the 184" cyclotron by bombarding a Be target with protons. This produces \( \pi^- \) mesons which decayed in vicinity of the target to give a diffuse \( \mu^- \) beam. H. Heckman designed a channel for collimating the particles from the target region. An absorber was used to filter out the \( \pi^- \) mesons. The density was about 4000 \( \mu^-/\text{cm}^3 \). In Fig. 1 is given the energy distribution of \( \mu^- \) mesons in this experiment.

So far, about 240 of the mesons have been studied and the results found are contained in the following table, which also gives the correction factors applied for \( \pi^- \) contamination using the star prong distribution of Adelman and Jones.
As shown in above table, about 12 of the 240, or 5 percent form one prong stars. This tends to give some evidence that $\mu$ mesons form only one prong stars. Too, about 32 percent of the $\mu^-$ mesons appear to end in a spherical blob or in two very short prongs of about one micron in length. A possible interpretation is that these might be slow Auger electrons indicating capture in heavy nuclei. The experiment is not finished as yet. It is intended to grain count the mesons which form stars.

II. Photomesons from Deuterium. By R. Stephen White.

This report was based on a paper entitled "The Production of Charged Photomesons from Deuterium and Hydrogen — Part 1. " by R. Stephen White, Mark J. Jakobson, and Alvin G. Schulz. It was presented at the December, 1951, Meeting of the American Physical Society at Berkeley and is to be published shortly in the "Physical Review". The work in this paper represents a continuation and further developments of a work begun originally by R. Stephen White and described in his thesis entitled "Photomesons from Deuterium", report UCRL-1319, May 24, 1951.

An abstract from the paper is reproduced as follows:

Hydrogen and deuterium gases have been bombarded in a gas target at a temperature of 77°K and at a pressure of about 140 atmospheres by the 318=10 Mev "spread-out" bremsstrahlung photon beam of the Berkeley electron synchrotron. The charged
π mesons which were produced were collimated at angles of 45°, 90° and 135° to the beam direction. The π⁺ mesons were detected with trans-stilbene scintillation crystals using π⁺, π⁻, and πμμ coincidence, and π⁺ and π⁻ mesons were detected with Ilford C-2 200 micron nuclear emulsions. The ratios of the numbers of π⁻ to π⁺ mesons produced in deuterium were 0.96 ± 0.10, 1.09 ± 0.12 and 1.21 ± 0.17 for the angles of 45°, 90° and 135°, respectively. No variation of the ratio with meson energy, outside statistics, was observed. Absolute values for the π⁺ meson energy distribution functions from hydrogen and deuterium per "equivalent quantum" have been measured at each of the above production angles. The differential and total cross sections have been obtained by integrating over energy and angle, respectively. The ratios of the deuterium to hydrogen cross sections have been computed and are in qualitative agreement with the phenomenological theory of Chew and Lewis but the statistics of the data are not sufficient to compute the proton spin-flip probability. The excitation functions for hydrogen and deuterium and points on the angular distribution curves in the center of mass system have been obtained. An upper limit of 0.08 of the charged π meson cross section was obtained for μ meson production from deuterium."

Also, the following is quoted from the introduction:

"......... It is quite probable that production experiments with nuclei of a large number of nucleons yield more information about the structure of the nucleus, than about the initial production of the meson itself. For information concerning the production, therefore, experiments with light nuclei should be performed. Of the light nuclei the photomeson production from the free proton or neutron should be the easiest to interpret theoretically because of the absence of nucleon-nucleon interaction complications. These free nucleon reactions are thought to be

\[
\begin{align*}
\text{hν} & \rightarrow \text{p} \rightarrow n \rightarrow \pi^+ \\
\text{hν} & \rightarrow \text{n} \rightarrow \text{p} \rightarrow \pi^-. 
\end{align*}
\]
As an alternative to the free nucleon reactions, this experiment has utilized the loosely bound neutron and proton in the deuteron to compare the above production cross sections. In addition, by comparing the cross sections for the production of \( \pi^+ \) mesons from deuterium and hydrogen one can study the reduction in the deuteron cross section which results from exclusion effects which was first pointed out by Feshbach and Lax. In the deuteron reaction, as the final state must be antisymmetric, the resulting neutrons or protons can only end in the \( 1s, 3p, \ldots \) states. Since the deuteron is initially in the \( 3s \) state, unless the proton flips its spin in the production of a meson, the available phase space is reduced relative to that for the production from a free proton, or neutron.

The present experiment was designed to investigate the production of \( \pi^+ \) and \( \pi^- \) mesons from deuterium as a function of both angle of emission and meson energy, and to measure the ratios of the production cross sections for \( \pi^+ \) mesons from deuterium and hydrogen.

III. The Positron Spectrum from the Decay of the \( \mu \) Meson. by Harmon Hubbard.

A review was given of the method used, the theory and the problems encountered in this work as reported previously in physics division quarterly reports UCRL-1474 and UCRL-1610. The latest data and developments which were presented are being incorporated in report UCRL-1623, an abstract of which follows:

The \( \pi^+ \) meson beam produced at the cyclotron by the reaction \( p + p \rightarrow \pi^+ + d \) was bent into a cloud chamber located outside the shielding. The chamber was in an 8000 gauss field and contained several thin carbon plates for the purpose of stopping the mesons. \( \mu \) decay positrons were observed emerging from the plates and the curvature of their tracks was measured. The spectrum so obtained contained data from 405
μ decay positron tracks. The average energy of the positrons is 34.2 ± 1 Mev; the most probable energy is about 40 Mev.

An analysis of the spectrum on the basis of Michel's theory yields a value of the parameter \( \rho = 0.26 \pm 0.26 \). The parameter determines the shape of the spectrum. The analysis is made by plotting the function \( 3/8 \cdot W^3/E^2 \cdot f(E) \); where \( f(E) \) is the spectrum, \( E \) the positron energy and \( W \) the maximum positron energy. Assuming a μ mass of 210 electron masses, \( W = 53.6 \) Mev. A plot of this function is a straight line and a least squares adjustment of the slope to the data yields the above value of \( \rho \).

Evaluation of the data of other experimenters does not yield a more accurate value of \( \rho \), but taking all available data into consideration it appears

\[ 0 < \rho < 1/2 \]. \( \rho = 1/2 \) corresponds to the Critchfield-Wigner coupling.