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RADIATION LABORATORY

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Ryokichi Sagane, William L. Gardner, and Harmon W. Hubbard

March 19, 1951

Berkeley, California

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University of California, Berkeley, California

March 19, 1951

Decay electrons of μ mesons have been studied for several years in cosmic ray work. From theoretical studies, the process of $\mu^{\pm} \rightarrow e^{\pm} + 2\nu$ is indicated to be the most likely one out of four or five possibilities.[1] Results of the calculations along this line have been given in the Review of Modern Physics by Tiomno, Wheeler, and Rau.[2]

An attempt to measure the electron energy spectrum is now being made with the use of artificial mesons produced by the proton beam from the 184-inch cyclotron.

The experimental set up for this attempt is shown schematically in Fig. 1. The electrically deflected proton beam from the cyclotron was collimated by a 1-1/4 in. hole on the axis of the iron pole pieces of the magnet. The pole pieces are 20 in. in diameter. π^+ mesons are produced by proton bombardment at the target located in between the polepieces. The targets used are rods: Be 1-1/8 in. x 3 in., C 3/4 in. x 3/in., Al 1-1/4 in. x 3 in. A considerable part of the π^+ mesons thus produced are expected to remain in the target due to absorption and also partly due to the effect of the applied magnetic field. Then these π^+ mesons are expected to produce μ^+ mesons due to the $\pi \rightarrow \mu$ decay process and again most of the μ^+ mesons are also expected to remain inside of the target because of the their low initial energies.

The energy loss for electrons passing through matter is comparatively small when the electron energy is over several million volts. So one can expect a fairly good yield of μ decay electrons coming out of the target.

Electrons of all momenta are produced at the target on the axis of the magnetic field. As shown in Fig. 1, electrons of a certain momentum are focused close to the so called "stable orbit." This method of focusing has been studied and developed at Tokyo University since 1941 and is entitled the "Spiral Orbit Spectrometer."[3]

Four thin anthracene crystals are used for counting the electrons. They are placed close to the "stable orbit" and are separated by a central angle of 15 degrees from each other. High energy electrons focused close to the orbit will go through all of the crystals and are capable of producing quadruple coincidences. Because of the large number of background pulses, especially immediately after the proton beam pulse, counting has been started usually with a delay of 3 to 5 μ sec after each of the beam pulses and continued for the duration of 6 to 10 μ sec.

The energy spectrum obtained so far is shown in Fig. 2. The data have been corrected for the resolution curve of the spectrometer which is now being checked.

This curve indicates the closest similarity to the one given by Tiomno, Wheeler, and Rau for the assumption of $\mu^+ \longrightarrow e^+ + 2\nu$ where $m_\nu \cong 0$ and with tensor coupling in the anti-symmetrical theory with charge exchange. However,[4] by using an appropriate linear combination (e.g. vector and pseudo-vector) of the various forms of coupling in the simple charge exchange theory, it is possible to obtain curves which also have their maximum at p/mc = 70 and $I_{Emax}/I_{Imax} < 1/10$.

Efforts are being made to improve the accuracy, especially for the value of maximum energy, which in turn should give the mass value of the μ meson.

Our results may be summarized in the following three major points:

1. E_{max} = 53 Mev $\pm$ 2 from which we get $m_\mu = 212 \pm 5\ m_e$ with the assumptions $\mu^+ \longrightarrow e^+ + 2\nu$ where $m_\nu \cong 0$.
2. Intensity Max at p = 70 mc $\pm$ 3 on a momentum scale.

3. Intensity at high energy end approaches to zero. That is, the intensity at this limit is indicated to be less than 1/10 of that at p = 70 mc namely, $I_{Emax}/I_{Imax} < 1/10$.

The authors are grateful to Dr. W. Powell for the use of the magnet, and to Dr. W. Barkas for his continuous interest and help throughout the work. Thanks are also due to the crew members of the cyclotron. One of the authors extends his thanks to Professor Lawrence for the privilege of visiting and working at the Radiation Laboratory.

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* On leave from Tokyo University.

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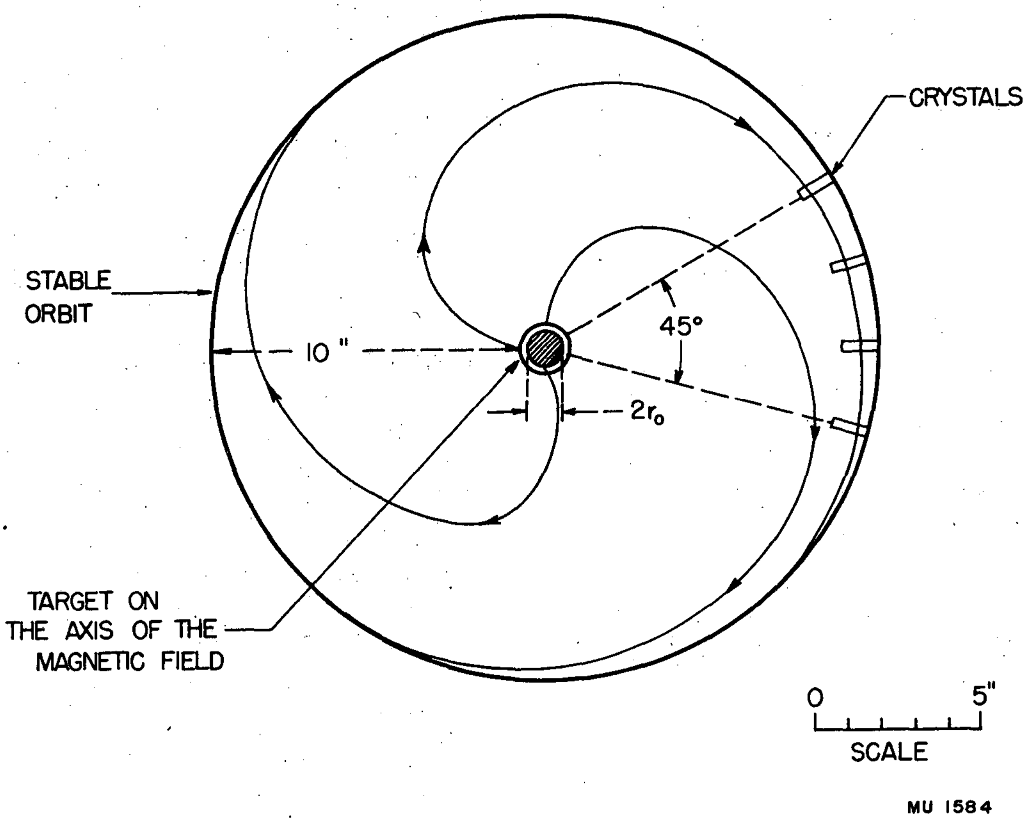
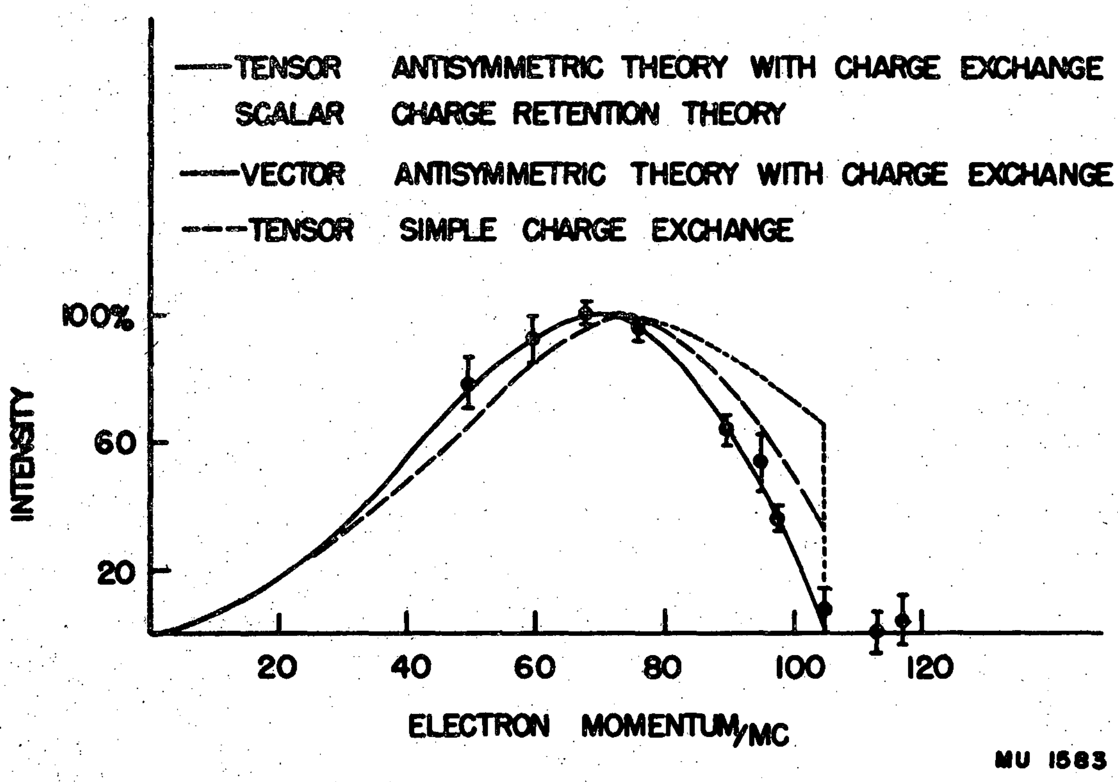

CRYSTALS
STABLE ORBIT
45°
10"
$2r_o$
TARGET ON THE AXIS OF THE MAGNETIC FIELD
0
5"
SCALE
MU 1584

Fig. 1



——TENSOR ANTISYMMETRIC THEORY WITH CHARGE EXCHANGE
SCALAR CHARGE RETENTION THEORY
——VECTOR ANTISYMMETRIC THEORY WITH CHARGE EXCHANGE
----TENSOR SIMPLE CHARGE EXCHANGE
100%
60
20
INTENSITY
20
40
60
80
100
120
ELECTRON MOMENTUM/MC
MU 1583

Fig. 2