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Radiation Laboratory

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SUMMARY OF THE RESEARCH PROGRESS MEETING OF SEPTEMBER 13, 1951

S. Shewchuck

October 25, 1951

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Berkeley, California

SUMMARY OF THE RESEARCH PROGRESS MEETING OF SEPTEMBER 13, 1951

S. Shewchuck

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

October 25, 1951

I. Neutron Deficient Isotopes of Curium. Gary Higgins.

Curium was discovered in 1944 by Seaborg. Some decay characteristics had been discovered at first in the isotopes Cm^{240}, Cm^{241}, and Cm^{242} from the bombardment of Pu^{239} with alpha particles. The relative positions of curium to plutonium isotopes are shown as follows on the nuclide chart:

Atomic No. 96	Cm^{240} 26 dα	Cm^{241} 55 d K	Cm^{242} 5 moα
95		Am^{240}	Am^{241}
94		Pu^{239}	Pu^{240}

By repeating the above mentioned reaction it was found that Cm^{241} was not a K capture element, contrary to earlier work. Cm^{242} is thought to be the first isotope stable to beta decay. Recently, bombardments were repeated with larger samples and better techniques. No K capture for Cm^{240} was proved by a limit of <1/2 percent K capture branching for Am^{240}. No 55 day activity was found in Cm^{241} fraction. In another bombardment with He ions the decay half life was found to be 35 days and not 55 days and an alpha half life ~40 years. Cm^{242} has a 5.89 Mev alpha particle. There should be another alpha group of 6.08 Mev possibly covered by this one. To check this, Cm^{241} will be produced by some other method, as bombarding Am^{241} whenever the target materials are obtained and the techniques improved. The K to alpha

ratio was determined; K capture count was assumed to be 30 percent of the yield, which was taken as the best figure.

II. Grain Density Law for Nuclear Emissions; and also, New Experimental Results in the Film Program. W. H. Barkas.

A. For his first talk Dr. W. H. Barkas read from his paper entitled, "Observations on the Grain Density Law for Nuclear Emissions", which was to be the basis for his talk at the Congress of Photography in Paris. The equations and results in his paper were elaborated upon and illustrated by film slides. An abstract of the paper follows:

> "It has been assumed that the grain density of tracks in a particular emulsion is a function solely of the ionization, or, neglecting radiation, etc., of the rate of energy loss of the moving particle. We have found this assumption to be valid irrespective of the charge or mass of the particle by grain counting high energy alpha particles, protons, and mesons in the same emulsion.
>
> We have observed at low grain density that the grain density is proportional to the ionization, but because of the finite maximum grain density, saturation occurs. The best expression of the law of grain density is the statement that an increment of grain density is proportional both to the increment in the rate of energy loss and to the density of grains not already rendered developable. This statement may be integrated to give
>
> $$n = n_o (1 - e^{-\lambda I}),$$
>
> where n_o is the density of potentially developable grains

threaded by the moving particle, and n is the density of grains which develop. I is the ionization or rate of energy loss and λ is a constant measuring the emulsion sensitivity. Because of non-uniformity in grain size and imperfections in the emulsions, some deviations from this law are found from measurements of gap lengths in nearly saturated tracks, but even here the gap density is a function only of the ionization.

Very highly ionizing particles, particularly stripped carbon atoms, have been accelerated in the cyclotron and detected in emulsions. Grain counts of such ions have been compared with those of alpha particles in the same under-developed insensitive emulsion.

A number of new techniques have been developed incidental to obtaining quantitative measurements in nuclear emulsions."

B. The new experimental results in the Film Program are concerned chiefly with electron-electron scattering. Figure 1 gives the schematics of the experimental apparatus, showing how the electrons from the synchroton entered the emulsions. Figure 2 depicts the pairs of tracks resulting from the scattering produced by 200 Mev electrons. Figure 3 shows the absolute cross section (barns/Mev) for the electron-electron scattering for 185 Mev primary electrons vs. the energy of the knock-on electron as found by the range and/or the angle of scattered electrons. The effect changes by a factor

of 10^6 in the range of 10^{-2} to 50 Mev energy of the knock-on electrons. A similar experiment is planned for positron-electron scattering though such a curve is not expected. Figure 4 is an example of pair production in the field of a nucleus by a 300 Mev positron where three tracks are produced in lieu of the anticipated two. Two such events were found in scanning 120 cm of 185 Mev electron track. Figure 5 shows the apparatus for filtering out the π mesons to obtain a μ meson beam in the 184 inch cyclotron. Well over 200 μ meson tracks have been obtained on the plates, of which 104 have been well analyzed. About 40 percent of the tracks look like this ⟋. The results of this analysis revealed the following groupings:

42 tracks have a "nob" or some characteristic terminal phenomena.

(6 have one pronged stars, already mentioned by British, and 36 have two pronged starlets as ⟋.)

60 tracks stopped with no evidence of nuclear capture.

2 tracks have large stars, probably due to stray π mesons.

Total 104

Last fall Barkas and Sagane experimented on the production of mesons as a function of the atomic number, using Be, C, Al, Cu, Ag, and Pb. A schematic drawing for this experiment is shown in Figure 6.

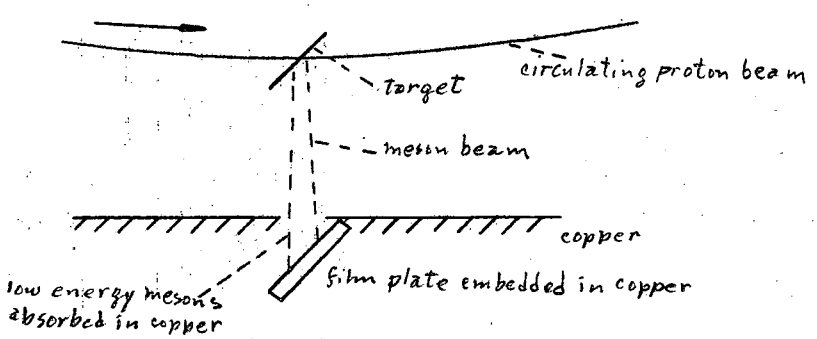

Figure 6

The film plates obtained were sent to Japan for analysis and counting of mesons. An attempt, also, was made to relate the σ's using C^{11} as a monitor. Too, the production ratio of +'s to -'s was determined and found to be four for Al. The preliminary results from Kyoto on the meson plates giving the relative distribution of the 408^{+} counted mesons are shown in Figure 7. In the area of 30 Mev and below the data are not reliable due to high proton background.

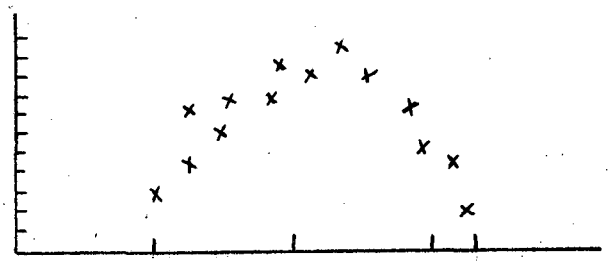

Figure 7

The negative mesons (102) give approximately the same distribution curve. A correction has been applied for nuclear absorption.

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EXPERIMENTAL ARRANGEMENT
OF PAIR SPECTROMETER

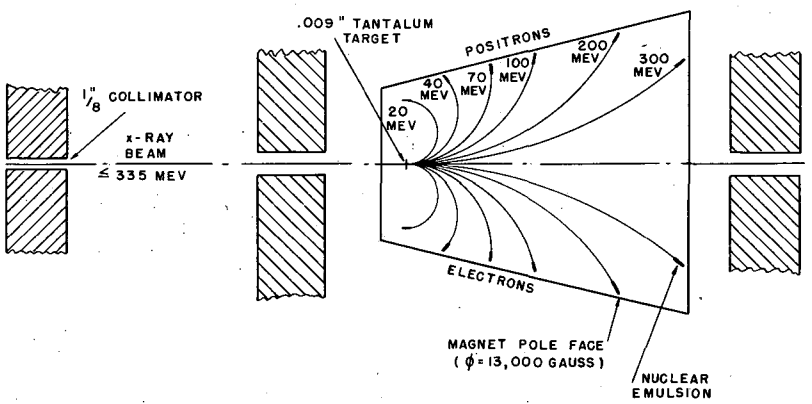

Fig. 1

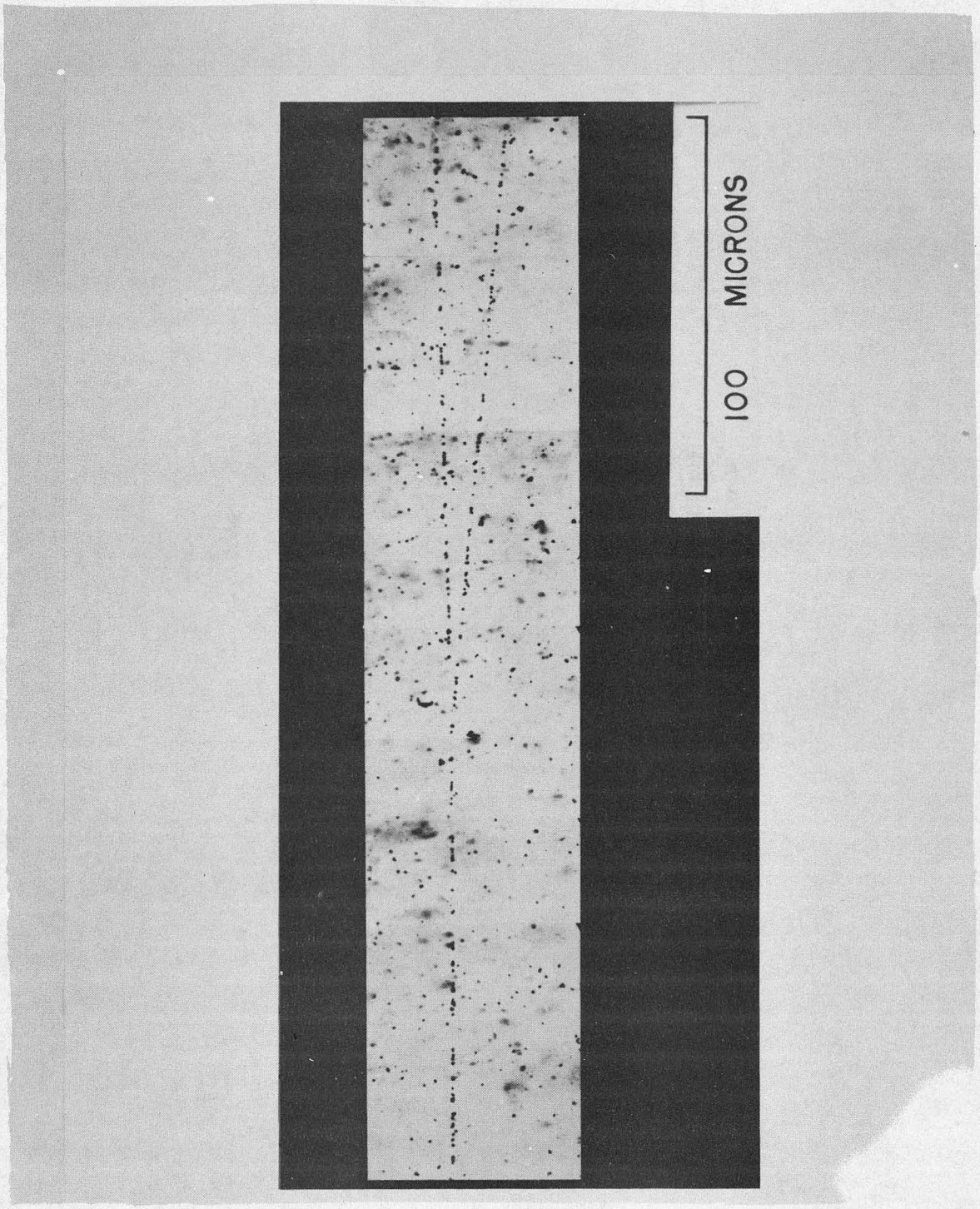

Fig. 2

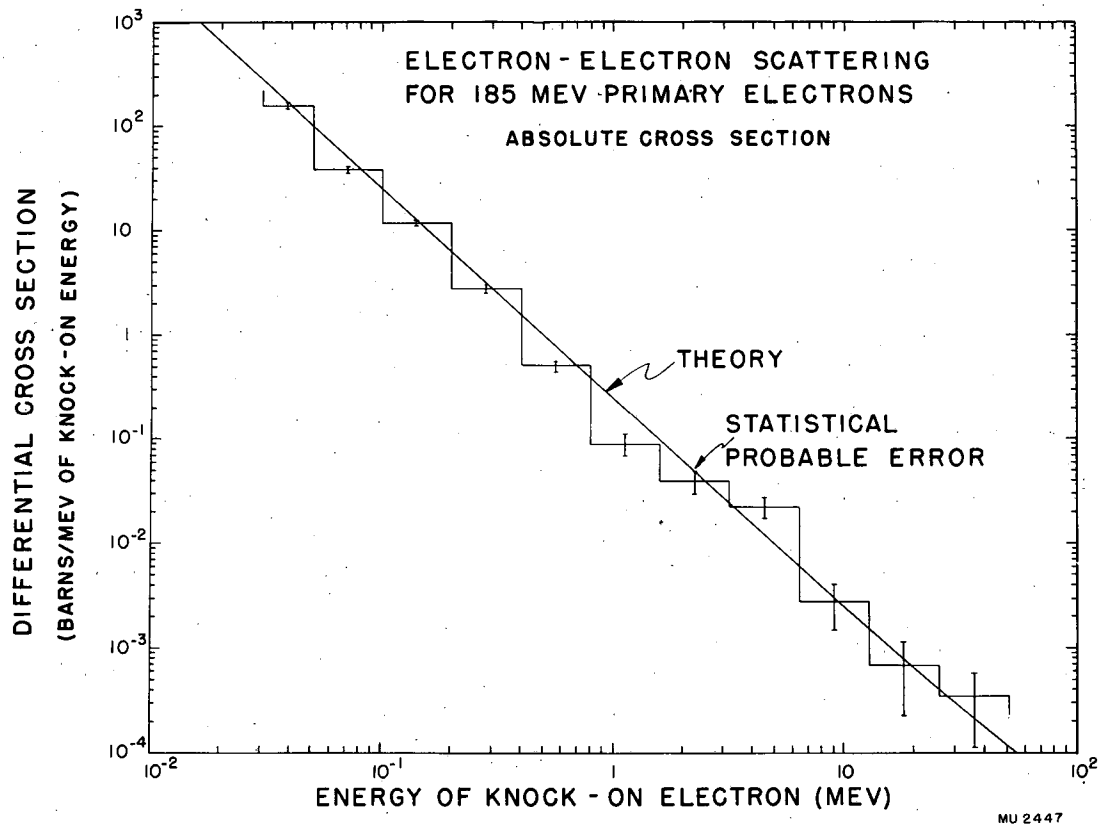
ELECTRON - ELECTRON SCATTERING
FOR 185 MEV PRIMARY ELECTRONS
ABSOLUTE CROSS SECTION
THEORY
STATISTICAL
PROBABLE ERROR
DIFFERENTIAL CROSS SECTION
(BARNS/MEV OF KNOCK-ON ENERGY)
ENERGY OF KNOCK - ON ELECTRON (MEV)
MU 2447

Fig. 3

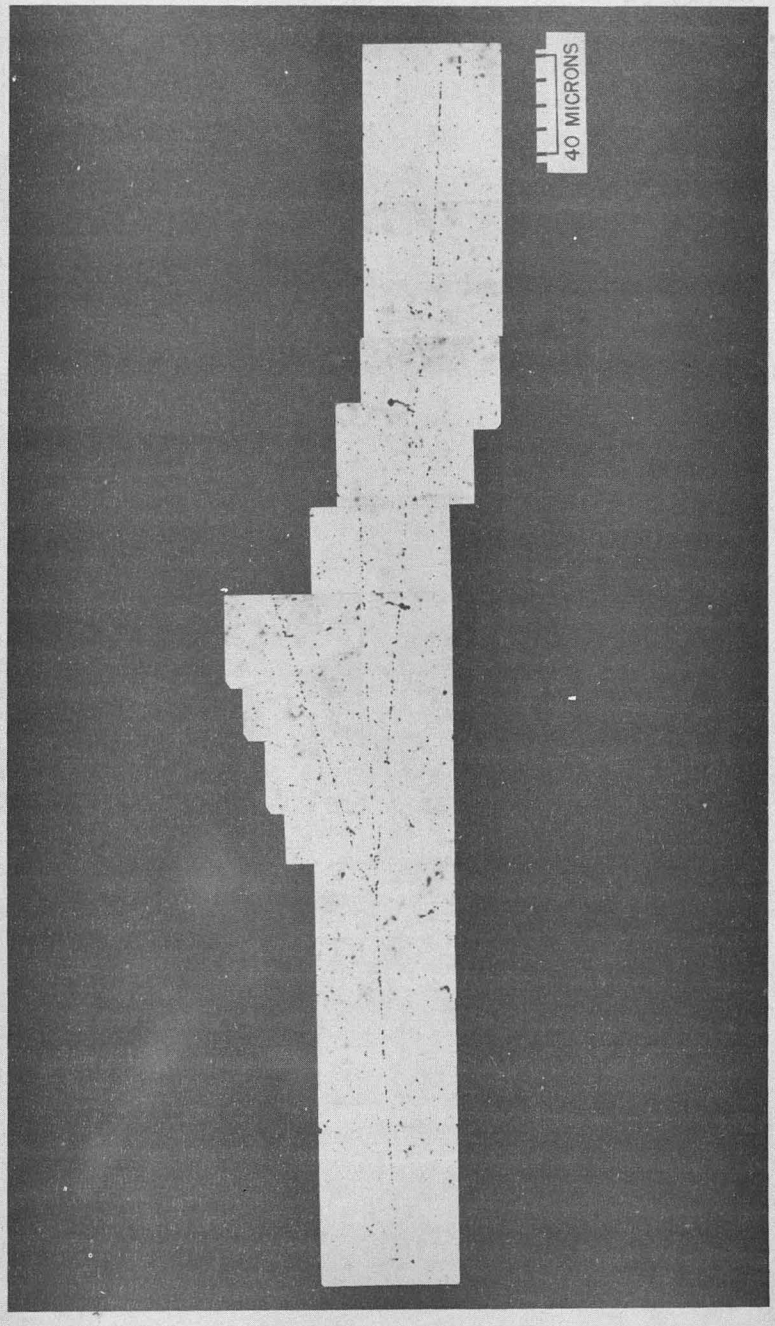

Fig. 4

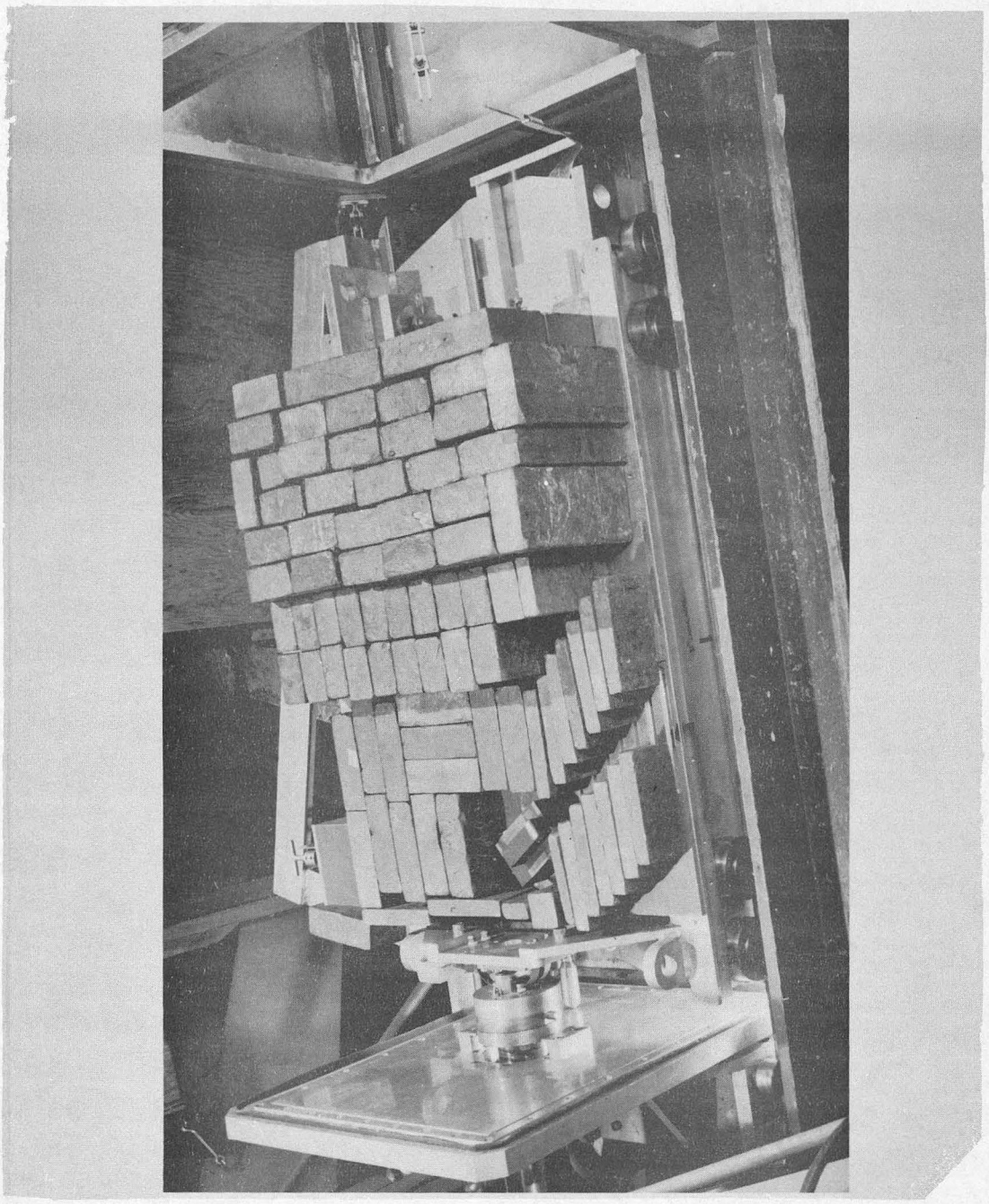

Fig. 5

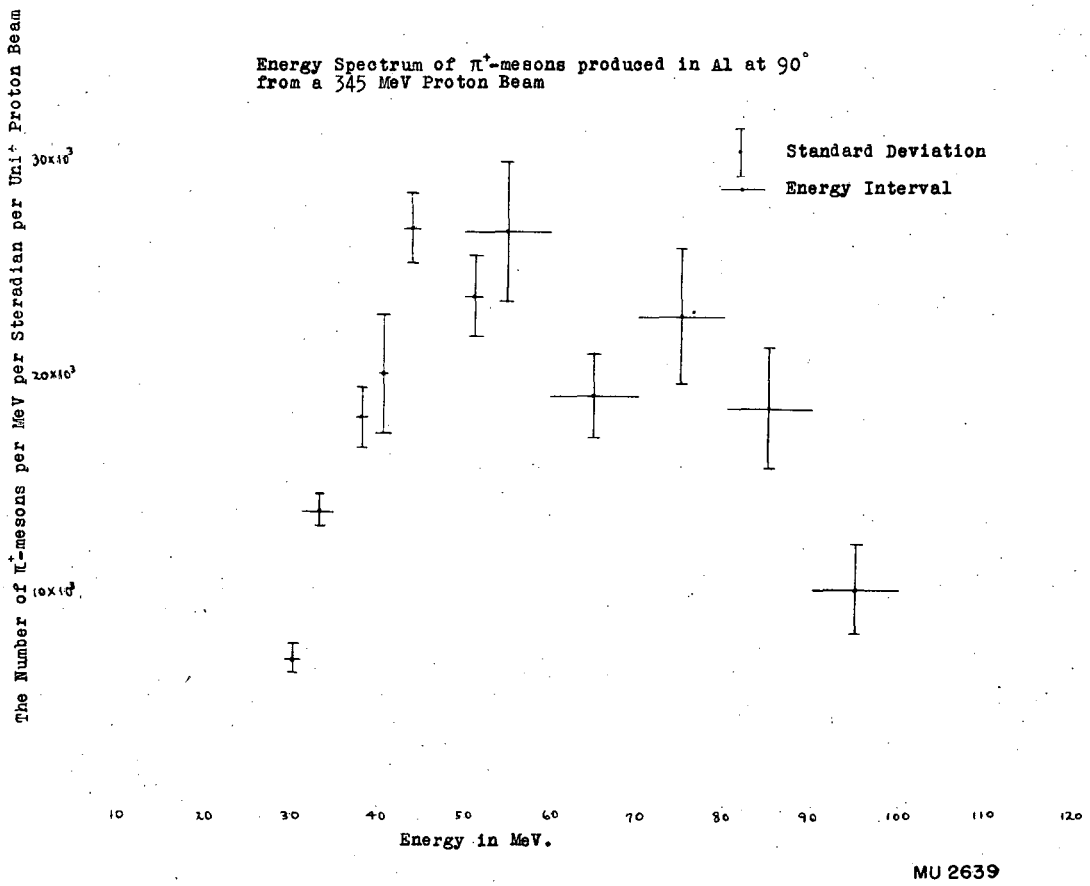
Energy Spectrum of π+-mesons produced in Al at 90°
from a 345 MeV Proton Beam
Standard Deviation
Energy Interval
The Number of π+-mesons per MeV per Steradian per Unit Proton Beam
30x10³
20x10³
10x10³
10
20
30
40
50
60
70
80
90
100
110
120
Energy in MeV.
MU 2639

Fig. 7