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THE NEUTRON INDUCED FISSION CROSS SECTION OF U^{236} AS A FUNCTION OF ENERGY

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PHYSICS - FISSION

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ABSTRACT

The neutron-induced fission cross section for the isotope U^{236} has been measured relative to the fission cross section for the isotope U^{235} as a function of neutron energy. The threshold of the reaction is in the neighborhood of 690 kev. The cross section rises to 0.69 barns at 1.3 Mev. At 2.55 Mev it is 0.53 barns, and at 14.1 Mev it is 1.65 barns.

[redacted]

The neutron-induced fission cross section of 26[1] has been

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1. The isotopes are identified throughout by a code using the combination of the terminal number of the atomic number and the terminal number of the atomic weight, thus thorium 232 is 02 and uranium 234 is 25.

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measured relative to the neutron-induced fission cross section of 25 as a function of energy using a parallel-plate comparison chamber[2] in which a 26

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2. LAMS 938

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foil and a 25 foil were placed back-to-back. The chamber was filled with argon to a pressure of 70 cm of mercury and carbon dioxide to a pressure of 5 cm of mercury. Electron collection was employed. Model 502 fast amplifiers were used to minimize "pile-up" of pulses arising from α particles.

The measurements consisted of determining the ratio R_E of the number of fissions in the 26 foil[3] to the number of fissions in the 25 foil[3] when the chamber was placed in a flux of neutrons of known energy E. Except

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3. The foils were prepared by John Povelites of Group CMR-4

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in negligibly few cases, every fission resulted in an ionization pulse in the chamber. A measurement of the ratio R_{th} at thermal energies in the standard graphite pile served to "weigh" the 26 foil, since the isotopic composition of the foils and the mass of the 25 foil is known and it can be assumed that only the 25 undergoes thermal fission. This procedure eliminates some of the uncertainties involved in the preparation and use of a rare isotope foil. The weight of the 26 foil deduced by the method just indicated agreed within 15% with the mass values obtained by balance weighing and by α-counting.

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If the presence of 24 is neglected, the 26 cross section at an energy E can be calculated from the formula:

$$\frac{\sigma_f(26)}{\sigma_f(25)} = \frac{236\ m25}{235\ m26}\left[\frac{R_E}{R_{th}}\left(1+\frac{m'28}{m'25}\ \frac{\sigma_f(28)}{\sigma_f(25)}\ \frac{235}{238}\right)-1\right]-\frac{m28}{m26}\ \frac{\sigma_f(28)\ 236}{\sigma_f(25)\ 238}$$

where m25 = 58.74 ± 0.20 = % 25 (by wt.) of 26 foil

m26 = 37.60 ± 0.20 = % 26 (by wt.) of 26 foil

m28 = 3.03 ± 0.05 = % 28 (by wt.) of 26 foil

m24 = 0.63 ± 0.05 = % 24 (by wt.) of 26 foil

m'25 = 95.7 = % 25 (by wt.) of 25 foil

m'28 = 4.3 = % 28 (by wt.) of 25 foil

The isotopic analysis of the 26 foil was done at the Oak Ridge Laboratory by the Y-12 Mass Spectrometer Laboratory under the supervision of R. F. Hibbs.[4] At energies below the 28 threshold the equation reduces to:

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4. Letter from R. S. Livingston to E. R. Graves dated May 4, 1951 with Oak Ridge reference symbol Y-B20-96. The 26 sample was #BD-454-8. A complete report on the 26 separation is in preparation by the Oak Ridge National Laboratory.

$$\frac{\sigma_f(26)}{\sigma_f(25)} = \frac{m25}{m26}\left(\frac{R_E}{R_{th}} - 1\right)\frac{236}{235}$$

It should be noted that the cross section obtained by these measurements does not depend on knowing the mass of either foil.

The high flux of 14 Mev neutrons from the Z Building Cockcroft-Walton accelerator and a ten channel analyser were used to measure pulse height distributions from the two sections of the chamber. Scaler biases were then set to count only fission pulses. A typical pulse-height distribution curve is shown in Figure 1.

Neutron energies from 690 kev to 1320 kev were obtained from the

Van de Graaff acceleration in W Building using the $T(p,n)He^3$ reaction. The spread in energy of the neutrons from this source was calculated from the thickness of the tritium gas target and the spread in angle between the neutron and the proton beam, which was from 0° to 20°. The energy assigned to each measurement was a value such that half the neutrons had energy greater and half the neutrons energy less than this value. The error in the neutron energy due to uncertainties in the energy loss of protons in aluminum and tritium is about ± 20 kev. No estimate of the errors in the cross section due to the presence of low energy epi-cadmium neutrons was made for any measurement except the 14.1 Mev case. It is believed that this error is small. In all measurements the chamber was surrounded with cadmium to eliminate thermal neutrons. The Van de Graaff accelerator was operated by the P-3 accelerator crew.

The Z Building Cockcroft-Walton accelerator was used to produce the 2.55 and 14.1 Mev neutrons by means of the $D(D,n)He^3$ and $T(D,n)He^4$ reactions, respectively. The measurements were made at 90° to the beam. The energy spread due to angle spread was 160 kev for the 2.55 Mev case and 190 kev for the 14.1 Mev case. A correction of about 3% was applied for the effect of low energy epi-cadmium neutrons in the 14.1 Mev measurement. The magnitude of this correction had been determined by a 25 spiral chamber measurement.[2] Where necessary, corrections were made for the difference in flux at the two foils. These corrections were of the order of a few percent.

The cross sections obtained and the statistical errors are given in Table 1. The 25 and 28 cross sections were taken from the smooth curves in LA-520 for energies below 14 Mev. The 14 Mev values of these cross sections were taken from LA-719 and LAMS-938. The plus and minus values on the neutron energies listed in Table I indicate the spread in neutron energy.

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TABLE I

FISSION CROSS SECTION OF U^{236} AS A FUNCTION OF ENERGY

Neutron Energy	No of 26 Fission Counts	Corrected Ratio of 26 Fissions to 25 Fissions	$\frac{\sigma_f(26)}{\sigma_f(25)}$	$\sigma_f(26)$ (barns)
Thermal	14,178	0.203		
690 $\pm$ 34 kev	1,040	0.207	0.03 $\pm$ 0.6	0.04 $\pm$ .08
770 $^{+35}_{-40}$ kev	1,088	0.221	0.14 $\pm$ .06	0.19 $\pm$ .08
1000 $^{+40}_{-50}$ kev	1,868	0.238	0.27 $\pm$ .05	0.36 $\pm$ .07
1320 $^{+33}_{-52}$	1,014	0.271	0.52 $\pm$ .07	0.69 $\pm$ .10
2.55 $\pm$ .08 Mev	1,155	0.259	0.40 $\pm$ .04	0.53 $\pm$ .06
14.1 $\pm$ .1 Mev	4,684	0.298	0.71 $\pm$ .03	1.65 $\pm$ .10

65 a la Lamphere ORNL
Sept '52

47 - σ ~8 trigger used

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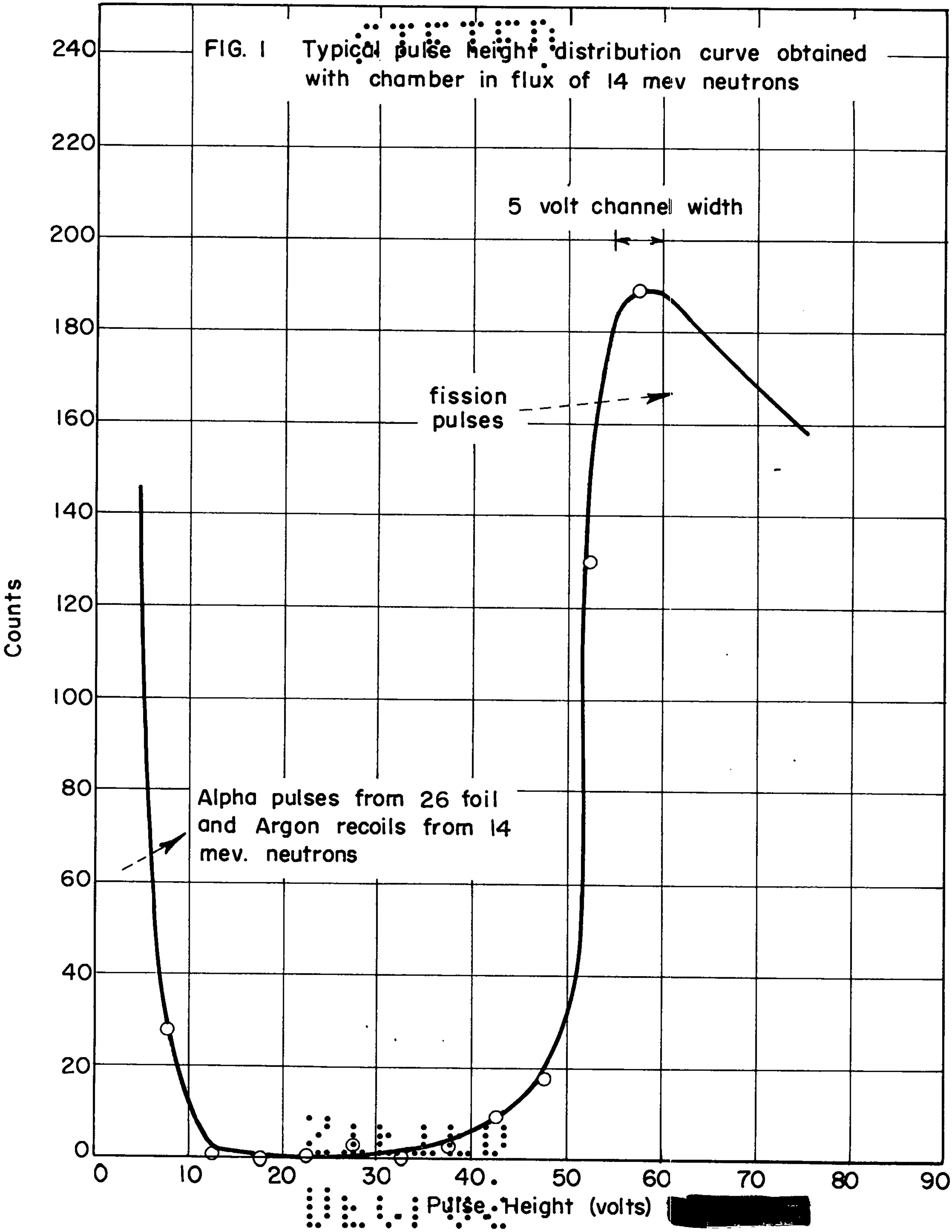

FIG. 1 Typical pulse height distribution curve obtained with chamber in flux of 14 mev neutrons

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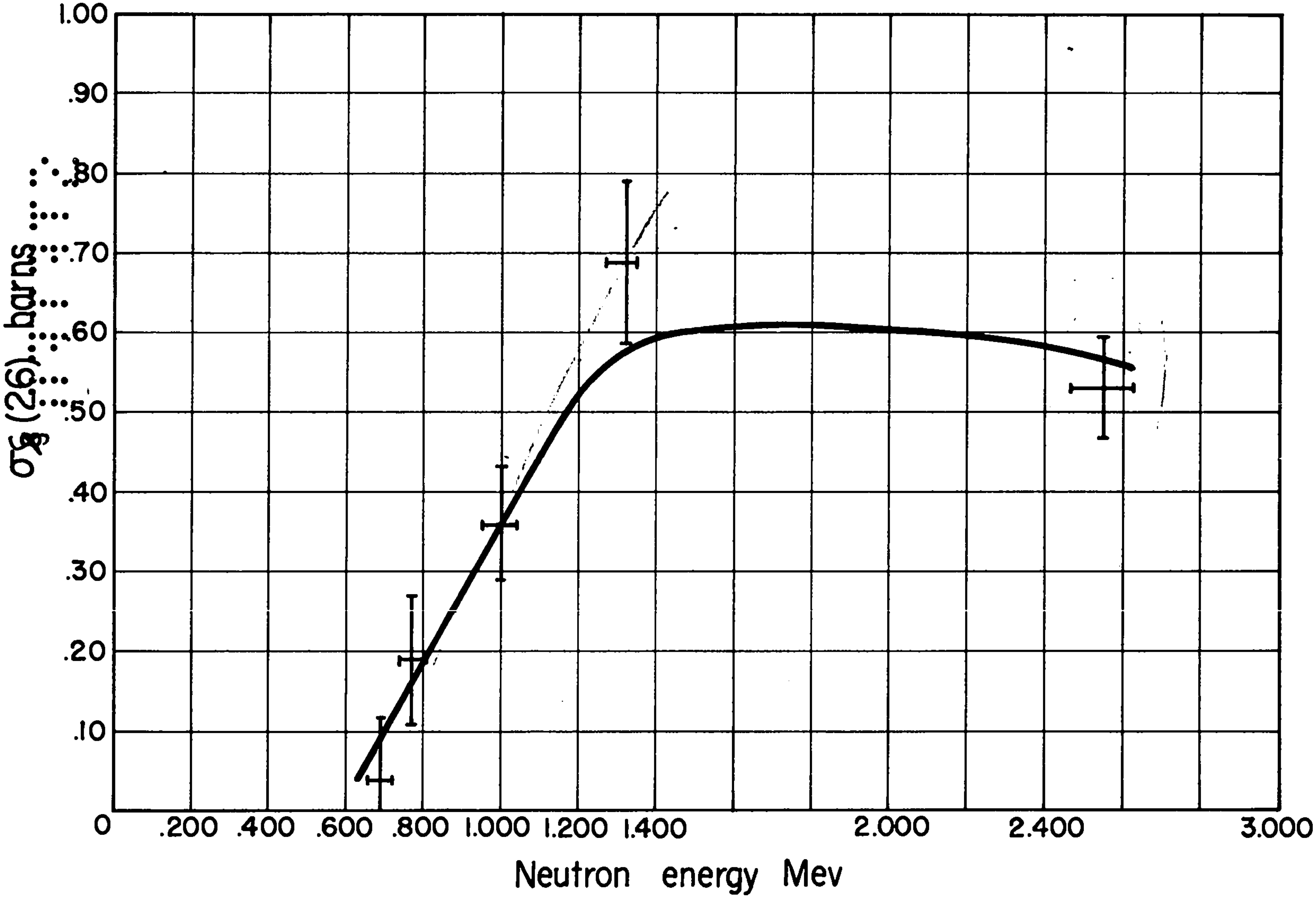

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