LAMS-777

Series..B

LOS ALAMOS SCIENTIFIC LABORATORY

OF THE

UNIVERSITY OF CALIFORNIA

CONTRACT W-7405-ENG. 36 WITH

U. S. ATOMIC ENERGY COMMISSION

SIFIED

UNCLASSIFIED

PUBLICLY RELEASABLE
Per Fredlund FSS-16 Date: 7-17-80
By L Kolar, CIC-14 Date: 5-23-96

Classification changed to UNCLASSIFIED
by authority of the U. S. Atomic Energy Commission,
Per H. T. Carroll DBOR, 11-9-62
By REPORT LIBRARY 11-21-62

LAMS-777

Series B

[redacted]

8 September 1948

This document contains 13 pages.

PRELIMINARY RESULTS ON THE FISSION CROSS SECTION OF U^{238} IN THE NEUTRON ENERGY RANGE FROM 13.5 TO 18 MEV

<u>Work done by:</u>

George Everhart

H. T. Gittings

Arthur Hemmendinger

R. F. Taschek

<u>Report written by:</u>

G. A. Jarvis

UNCLASSIFIED

[redacted]

UNCLASSIFIED

Abstract

Results on the fission cross section of U^{238} for 13.5 to 18 Mev neutrons are reported.

UNCLASSIFIED

Preliminary Results on the Fission Cross Section of U^{238} in the Neutron Energy Range From 13.5 to 18 Mev

Introduction

Fairly complete measurements on the fission cross section of U^{238} have been made in the neutron energy range from the threshold around 1,100 kev up to 6.0 Mev.[1] Shortly after tritium first became available to the project Bretscher[2] used neutrons from the $T(D,n)He^4$ reaction to obtain a fission cross section for 14 Mev neutrons incident on U^{238}. In his set-up tritons were accelerated onto a heavy ice target by means of the 125 kev Cockcroft-Walton accelerator. Only 168 fissions were observed so that a large statistical error was involved in the figure of approximately 2 barns given for the U^{238} fission cross section. A remeasurement of this point, together with an extension of cross section measurements to other energies in this range, was therefore desirable.

When tritium became available in sufficient quantities the Los Alamos electrostatic generator was equipped with a small volume scattering chamber[3] to be used as a gaseous tritium target for the study of the angular distribution of the reaction products and for use as a monitored variable energy source of high energy neutrons. Taschek has reported in detail on the construction[3], method of operation of the target[4,5] and the

[redacted]

results obtained for the differential and total cross sections of the alpha particles released in the $T(D,n)He^4$ reaction. In the latter report the use of the $T(D,n)He^4$ reaction as a source of mono-ergic high energy neutrons is discussed. Equations and conversion charts are given for the determination of the energy and differential cross sections of the D-T neutrons in terms of the energy of the bombarding deuterons and the observed differential cross sections of the alpha's.

The available deuteron energies from the Los Alamos Electrostatic Generator usable in connection with the small scattering chamber are in the range from around 1 to 2.5 Mev. Since the reaction $T(D,n)He^4$ has a $Q \cong$ 17.6 Mev and has a reasonably large differential cross section of the order of 0.1 barn, it follows that thin gaseous targets of tritium make a satisfactory neutron source of energies variable between about 13 to 18.5 Mev.

In the work reported below some preliminary measurements on the fission cross section of U^{238} for neutrons in the range 13.5 to 18 Mev will be described.

Method

The fission measurements were made with a single foil flat fission chamber, Fig. 1, operated with air at atmospheric pressure. The collection field was about 1000 volts per cm and was connected for electron collection. The fission pulses were

[redacted]

[redacted]

amplified with a model 100 preamp and amplifier. The active area of the foil was a circular patch 3 cm in diameter coated uniformly with a total of 2.67×10^{18} atoms of U^{238}, depleted to the extent of 1 part U^{235} in 3000. That the foil coating was sufficiently thin is evident from the flatness of the integral bias curve taken by placing a one-half gram Ra-Be neutron source near the foil and observing the fissions as a function of discriminator bias settings, Fig. 2. The chamber was cadmium lined to cut down on fissions by thermal neutrons in the small amount of U^{235} present in the sample.

It was desired to monitor the neutron flux through the fission foil during all measurements of fission cross sections. This was accomplished by measuring the corresponding flux of alphas by means of the variable angle recoil counter which is part of the target assembly. The pulses from the alpha counter were amplified by a model 100 amplifier and analyzed with the aid of a ten channel pulse amplitude discriminator[6]. It was possible in all cases to adjust the argon pressure and gas gain of the counter so that the alpha-particle distributions were well resolved from the other particles which could be scattered or knocked into the counter.

Since a deuteron beam was employed, an appreciable background of neutrons, primarily from the D carbon reaction, was present. This was considerably reduced by placing a paraffin barrier, about two feet thick and backed by a sheet of

[redacted]

[redacted]

cadmium metal, between the target and the electrostatic analyzer, magnetic analyzer and the early beam defining slits. Practically all neutrons reaching the fission foil from these points were accordingly degraded in energy by elastic collisions in the paraffin to values well below the 1100 kev threshold for fission in U^{238}. There remained a background of fission producing neutrons resulting from the beam hitting carbon in the target and its associated beam defining apertures. This background was determined by running the beam on a hydrogen filling in the target before or after each measurement with tritium in the target. For each fission counter setting one then subtracted the background fissions from the total fissions for an equal number of deuterons through the target to get the net number of fissions, due to high energy tritium neutrons, to be used in the calculations of the U^{238} fission cross sections.

The Fission Cross Section

An expression for calculating the fission cross sections will now be derived.

The differential cross section in the laboratory system for the observed alpha particle is given by

$$\sigma_\alpha(\theta_\alpha, E_d) = \frac{N_\alpha}{N_d} \quad \frac{\sin\theta_\alpha}{g\, N_T}$$

[redacted]

[redacted]

where

θ_α = laboratory coordinate system angle of observation at the deuteron energy E_d;

N_α = number of alphas during a run;

N_d = number of deuterons through target during a run,

N_T = number of tritons per cm^3 of target gas,

g = $\frac{\pi a^2 \cdot 2b}{R_o \underset{\smile}{h}}$ is the counter geometry factor^6, where

a^2 = area of counter hole,

$2b$ = width of defining slit,

R_o = distance from hole to intersection of normal to hole with axis of deuteron beam,

$\underset{\smile}{h}$ = distance from hole to slit.

Since $\sigma_{dT}(\theta_n) = \sigma_{dT}(\theta_\alpha) \frac{d\Omega_\alpha}{d\Omega_n} = k_{\alpha n} \; \sigma_{dT}(\theta_\alpha)$

where $\frac{d\Omega_\alpha}{d\Omega_n}$ is the solid angle transformation factor, one gets for the differential cross section in the laboratory system for the corresponding neutron

$$\sigma_n(\theta_n, E_d) = k_{\alpha n} \frac{N_\alpha}{N_d} \cdot \frac{\sin \theta_\alpha}{g \, N_T}$$

Now the number of fissions, N_f, observed per incident deuteron is

$$N_f/N_d = (N_n/\Omega \; N_d) \times N_{U238}/d^2 \times \sigma_f(U^{238})$$

where

$\frac{Nn}{N_d \Omega}$ = number of neutrons passing through foil per unit solid angle per incident deuteron,

N_{U238} = number of U^{238} atoms in foil,

d = distance from foil to center of target,

[redacted]

[redacted]

but $$\frac{N_n}{N_d} = N_T \times \ell \times \sigma_n(\theta_n, E_d)$$

where

l = length of path of deuteron beam in target.

Combining these expressions one gets for the fission cross section

$$\sigma_f(U^{238}) = \frac{N_f}{N_\alpha} \quad \frac{gd^2}{k_{\alpha n} \, \ell \, N_{U^{238}} \, \sin \theta_\alpha}$$

whence one immediately sees that the deuteron beam current, target gas pressure, temperature and tritium content do not enter into the expression for the fission cross section when the experiment is carried out in the manner described above.

A plot of the fission cross sections, together with the best results previously obtained up to 6 Mev is shown in Fig. 3. Bretscher's single point at 14 Mev is also included for comparison. Because of the low observed fission counting rate it was necessary to place the foil quite close to the target in order to get a reasonable number of fission counts. The resulting maximum spread in neutron energy is shown by the horizontal spread of the plotted points.

In view of the large discrepancy between Bretscher's 14 Mev point and ours, an overall check on the target and counter performance was made in two ways. First, proton-proton scattering was done at 45° and the value of the cross section, 0.458 barns per unit solid angle obtained agreed, within the limits of the experimental errors involved, with the value

[redacted]

[redacted]

of 0.472 barns given by Herb[6]. This measurement indicated that the value of the geometry factor for the counter was correct to a few percent at least. Since the energy of the alphas released in the $T(D,n)He^4$ reaction was sufficiently greater than that for any other possible particles entering the counter that the alpha distributions could in all cases be well resolved from the other particles, one can feel reasonably certain that the correct number of alphas were counted and hence the corresponding flux of neutrons through the fission foil calculated correctly.

Second, a deuterium filling in the target was bombarded with a deuteron beam and two values for the U^{238} cross section were obtained for neutron energies in the neighborhood of 3 Mev. These points are also plotted in Fig. 3 and within the limits of their statistical errors fall reasonably well on the curve for the older data. In view of this result it seems likely that the values of the fission cross section reported here for the 13 to 18 Mev neutron energy range are correct within the limits of the indicated errors.

[redacted]

[redacted]

References

1. J. H. Williams, LA-520
2. Bretscher and French, LAMS-396
3. Taschek, to appear in R. S. I.
4. Taschek, LA-625
5. Taschek, LAMS-662
6. Los Alamos Technical Series, Vol. 1, Part 1, Section 4.5.
7. Phys. Review, 55, 998 (1939).

[redacted]

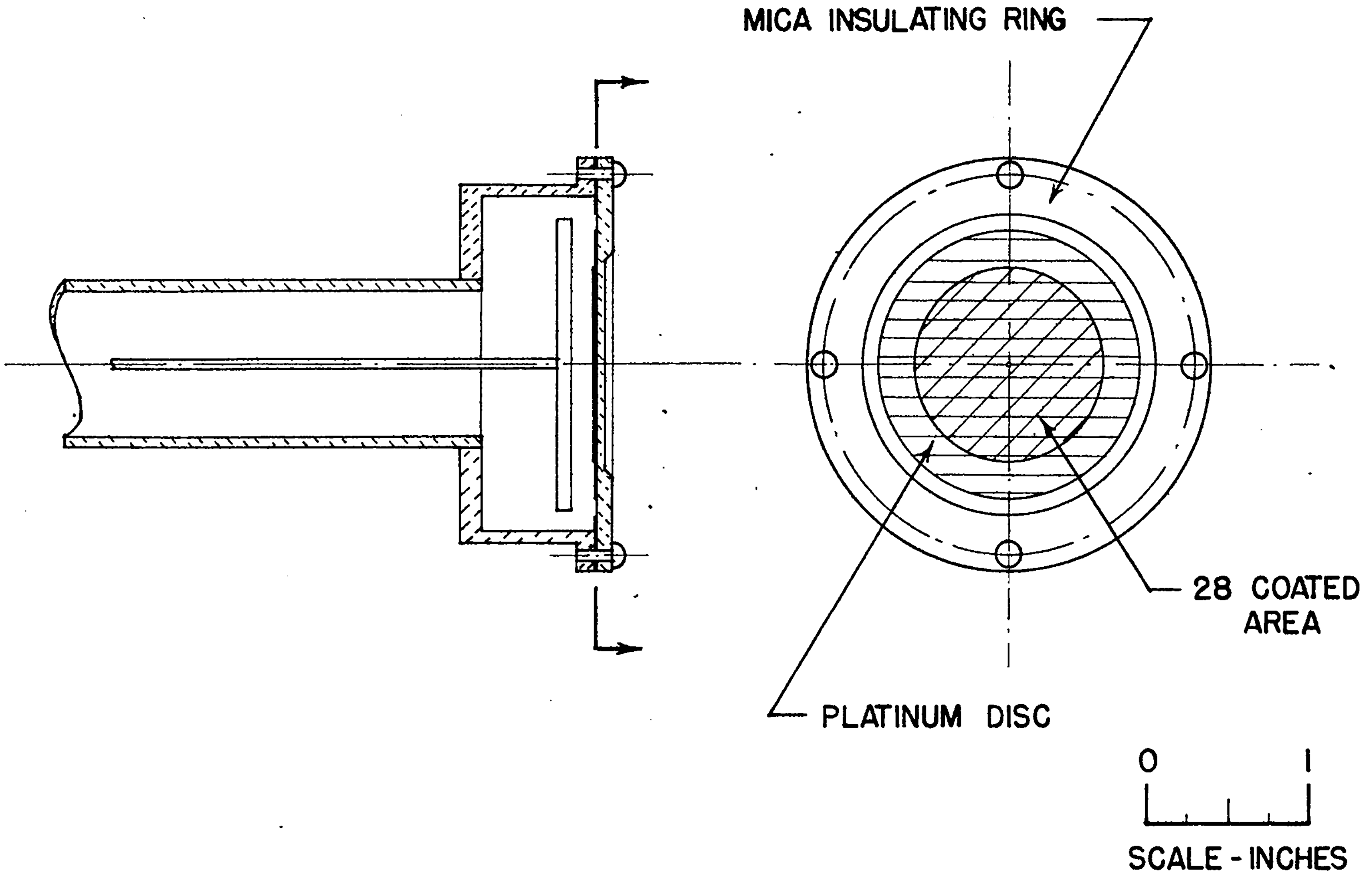
MICA INSULATING RING
28 COATED AREA
PLATINUM DISC
0
1
SCALE - INCHES

FIG. 1

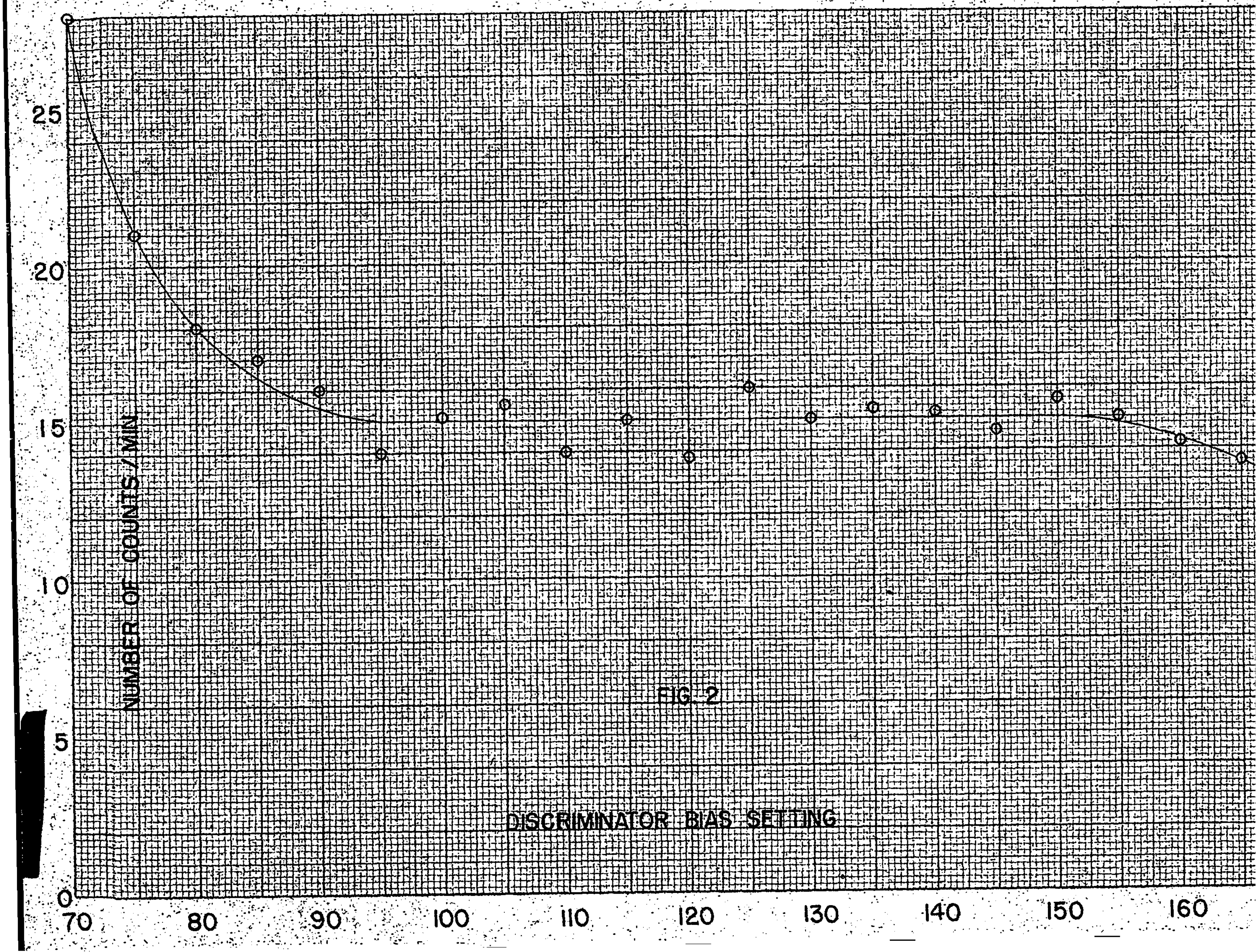

FIG. 2

APPROVED FOR PUBLIC RELEASE

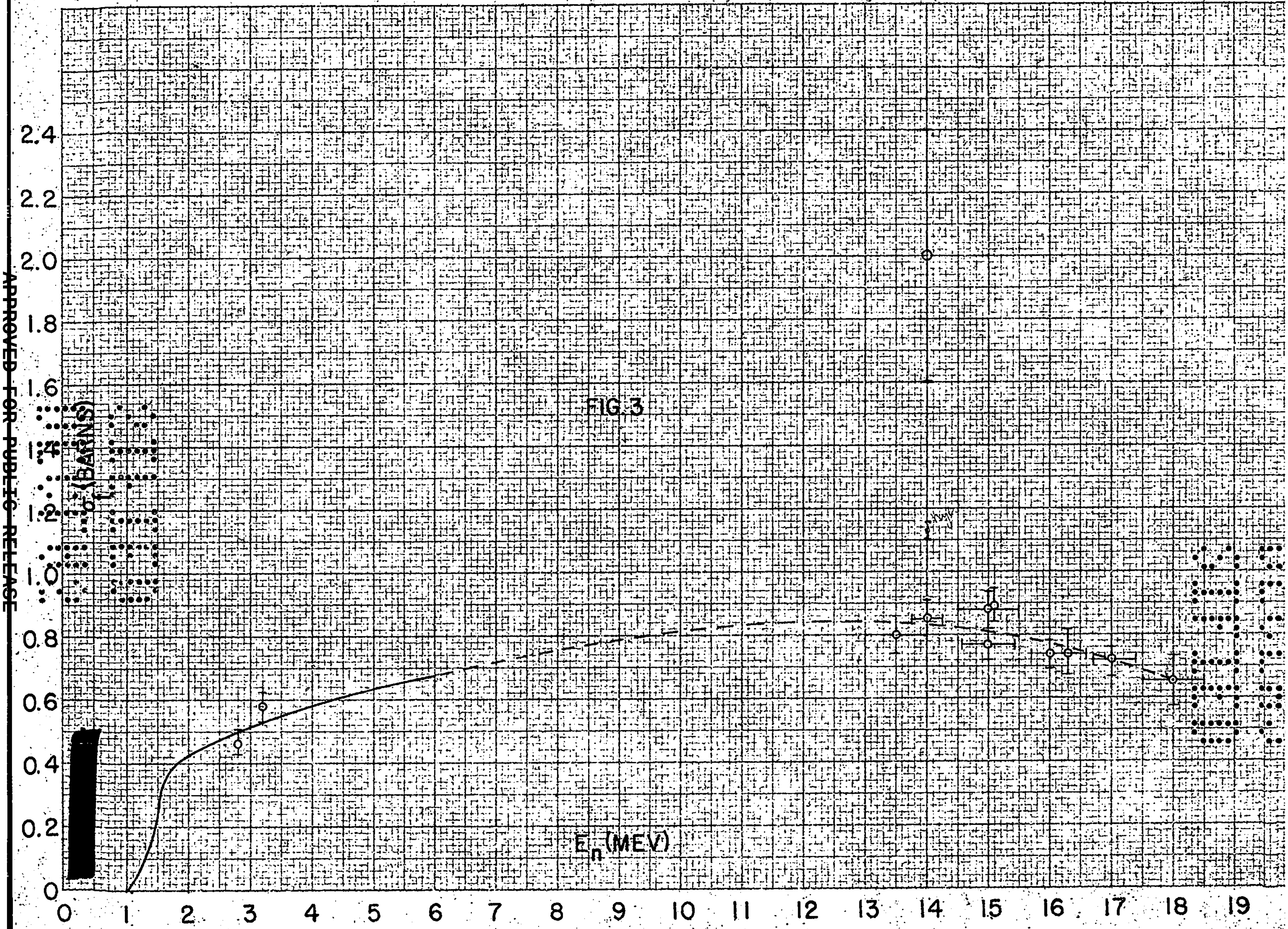

FIG. 3

APPROVED FOR PUBLIC RELEASE

[illegible] Ed. Div

[illegible] 11-9-48

✓

[illegible] NO. REC. [illegible]