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SUMMARY OF THE RESEARCH PROGRESS MEETING

of September 1, 1949

R. K. Wakerling

October 13, 1949

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INFORMATION DIVISION
Radiation Laboratory
Univ. of California
Berkeley, California

SUMMARY OF THE RESEARCH PROGRESS MEETING

of September 1, 1949

R. K. Wakerling

Fission Excitation Function. By J. Jungermann.

The absolute excitation functions for the production of fission by charged particle bombardment in several substances were investigated at both high and low energies. The low energy work was done at the 60-inch Crocker cyclotron with alpha particles and deuterons, while the high energy work was done at the 184-inch cyclotron with alpha particles, deuterons, and protons.

The experimental method employed consisted in counting the pulses of ionization produced by the fission fragments in an ionization chamber. The detection of a fission pulse in the presence of the ionization produced by the cyclotron beam itself was made possible by employing a cancellation principle suggested by C. Weigand. A schematic drawing of the experimental arrangement is shown in Figure 1. The energy of the cyclotron beam could be varied by means of aluminum foils placed in two wheels shown in the figure. One of the wheels which could be rotated while the cyclotron was in operation had aluminum foils ranging in thickness from 1.5 to 30 milligrams per square centimeter. The second wheel was provided with foils whose thickness increased about 30 milligrams per square centimeter from slot to slot. In this way it was possible to vary energy of the beam particles over the entire energy range in steps corresponding to the energy loss in 1.5 milligrams per square centimeter of aluminum.

After passing through the energy selecting wheels the beam entered the fission chamber where it passed through an aluminum foil upon which the fissionable material was deposited. This foil was mounted on a wheel A together with 6 other samples any one of which could be rotated into position while the cyclotron was in operation.

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Beyond the sample wheel the beam passed through two thin plates, B and C, accurately positioned 1/2 in. apart, with plate B 1/2 in. from A. Further along were located three plates D, E, and F which together consitituted an ionization chamber employed to measure the beam current. The potentials on these parts are given in Fig. 1. After traversing the ion chamber the beam passed through a window to a Faraday cup. The entire fission ionization chamber was covered with 1/32 in. of cadmium to cut out slow neutrons which would alter the results of the U^{235} runs.

The cancellation action may be described as follows: an electron falling in the potential gradient from A to B produces a small change in voltage in plate B. An electron falling from B to C produces a change in voltage of equal magnitude but of opposite sign on plate B. If the distances AB and BC are equal, the ionization pulse produced from side AB by the charged particle beam passing through all three plates will be cancelled by an equal and opposite pulse from the side BC. The fission fragment however, spends its kinetic energy producing ionization from side AB only and hence, produces a relatively large unbalanced voltage on the preamplifier grid.

Figs. 2, 3 and 4 show the excitation function for the three substances investigated in the low energy range. In each bombardment the energy of the beam particle was determined by measuring the current collected by the ionization chamber as a function of the amount of aluminum placed in the beam by rotating the energy wheel. When the mean range was determined the beam energy was obtained from the range energy relation.

Frequent checks were made during the course of a bombardment on the number of spurious counts given by the aluminum blank target. It was found that the neutron background was very sensitive to beam conditions. The background produced by neutron fission imposed the limit on the sensitivity of the experiment at low energy. In the case of U^{235} the excitation function was not carried below the energy at which the neutron background became one half of the total fission count.

The value of the average number of electron volts necessary for the formation of an ion pair was determined. The results indicate that the value was constant over the energy range of this experiment within the experimental errors. The average value for deuterons of about 17 Mev is 29.6 ev and for alpha particles of about 30 Mev is 30.5 ev.

In order to have an independent check on the absolute value of the cross section it was decided to measure the Bi $(\alpha, 2n)$ At^{211} cross section with the equipment used in this experiment. The excitation function for this reaction has been extensively studied by Kelly and Segrè. The value for the cross section obtained was 0.73 barns which is in agreement with the results by Kelly and Segrè of 0.75 barns.

The experiments on the 184-inch cyclotron were made with a slight modification of the apparatus since the pulsed beam lead to certain difficulties in the cancellation process. All the particles in a given pulse arrive within the resolving time of the apparatus. Since the cancellation must be very accurate it was necessary to revise the apparatus to vary the cancellation electrically. While the cyclotron beam was maintained at a constant level the amount of uncancelled beam pulse could be minimized.

Figures 5-12 show the excitation functions for U^{238}, Th^{232}, U^{235}, Bi^{209}, and Au^{197} bombarded with alpha particles in the energy range 0-400 Mev and deuterons in the range 0 to 200 Mev. Some bombardments were also made with protons from the 184-inch cyclotron. The results are summarized in Figs. 13 and 14.

A comparison was made between the observed fission cross section and the calculated reaction cross section computed by the method of Bethe and Konopinski.

The results of this calculation for Th^{232} bombarded with alpha particles is shown in Fig. 6. It is seen that the competition with the fission process begins to become appreciable above 30 Mev and increases with alpha particle energy.

These experiments are reported in detail in the document UCRL-436, "Fission Excitation Functions for Charged Particles", by J. Jungermann.

Alpha Decay in Medium Weight Isotopes. By S. G. Thompson.

In a talk at the July 21 research progress meeting Rasmussen announced the discovery of two alpha emitting isotopes of atomic number less than 83. In the experiments described at that time thin targets of gold leaf were bombarded with 190 Mev deuterons from the 184-inch cyclotron. Two alpha decay periods one of 0.7 minutes half life and another 4.3 minutes half life were observed in the target. The alpha particle energies were 5.7 and 5.2 Mev respectively. Chemical separation procedures have proved that the 4.3 minute period is due to a gold isotope and suggested that the 0.7 minute period is due to a mercury isotope. The mass numbers of these new isotopes have not been determined, although it is believed that the gold isotopes lie in the mass range 185 to 188.

Following this, studies have been made with a slightly different technique in the rare earth region of the isotope table. In particular, targets of samarium, gadolinium and dysprosium have been bombarded with 200 Mev protons and several new alpha decay periods observed in the gadolinium and dysprosium targets. No significant alpha decay was observed in the samarium target. In the gadolinium bombardment there was found an alpha decay period of approximately 7 minutes half life with an energy of 4.2 Mev and another of about 4 hours half life with an energy of 4.0 Mev. In the dysprosium bombardment 3 decay periods were observed of half lives approximately 7 minutes, 20 minutes, and 4 hours with alpha particle energies of 4.2, 4.1, and 4.0 Mev respectively.

The relationship between the alpha particle energies and the half lives of these new isotopes places them in a new class. The energies are approximately the same as the alpha particle energy of thorium 232 which has a half life of 1.4 x 10^{10} years. These facts are sufficient proof that the new periods could not have been due to contamination by heavy isotopes.

Chemical identification of these rare earths has not been completed as yet. Some chemistry has been done on a dysprosium 66 target bombarded for two hours. In the target activities of half lives 7 minutes, 4 hours, 20 minutes, 17 hours and two weeks were found with energies of 4.2, 4.0, 4.1, 3.8 and 3.1 Mev respectively. It was found that the 4 hour and 17 hour activities were associated with the terbium fraction. Since the 20 minute period was produced only in dysprosium targets, it would appear to be an isotope of dysprosium or holmium. If one assumes the 4 hour period is due to terbium 150, the information fits the theory.

Although it must be emphasised that it is premature to attempt an interpretation of these data, some differences between the alpha emitting isotopes of the gold region and thoseof the rare earth region can be seen. It should be possible to observe artificial activity in the sufficiently neutron deficient isotopes of the region between the rare earths and lead. The alpha emitting isotopes of the gold region might be examples of this since they are observed to decay with short electron capture half lives and with small alpha to electron branching ratios. In this case, alpha particle decay would be largely the consequence of considerable neutron deficiency. The higher alpha to electron capture branching ratio of the new rare earth isotopes is probably due to a more moderate degree of neutron deficiency giving rise to longer electron capture half lives and exceptionally high alpha particle energy giving rise to shorter alpha half lives. These new rare earths periods might therefore be correlated with the stable configuration of 82 neutron just as the isotopes having neutron numbers in the range 127 to 130 of the region above lead. These decay by unusually high energy alpha particle emission as a consequence of their decay to or near the stable configuration of 126 neutrons. Consequently one might expect that isotopes such as terbium 149 or dysprosium 150 and those differing by a few neutrons should decay by a relatively high energy alpha particle emission as a result of their decay to or near the stable configuration of 82 neutrons. Such isotopes would therefore be attractive possibilities for the assignment of these new rare earths.

In view of these new data it can be seen that alpha decay in the lighter elements is more prevalent than heretofore recognized and therefore these investigations are being extended and continued.

An attempt has been made to assign the mass number of some of the new isotopes by use of the mass spectrograph. These attempts have thus far been unsuccessful because of the low specific activities of the samples. This will be tried again when samples of higher specific activities are available.

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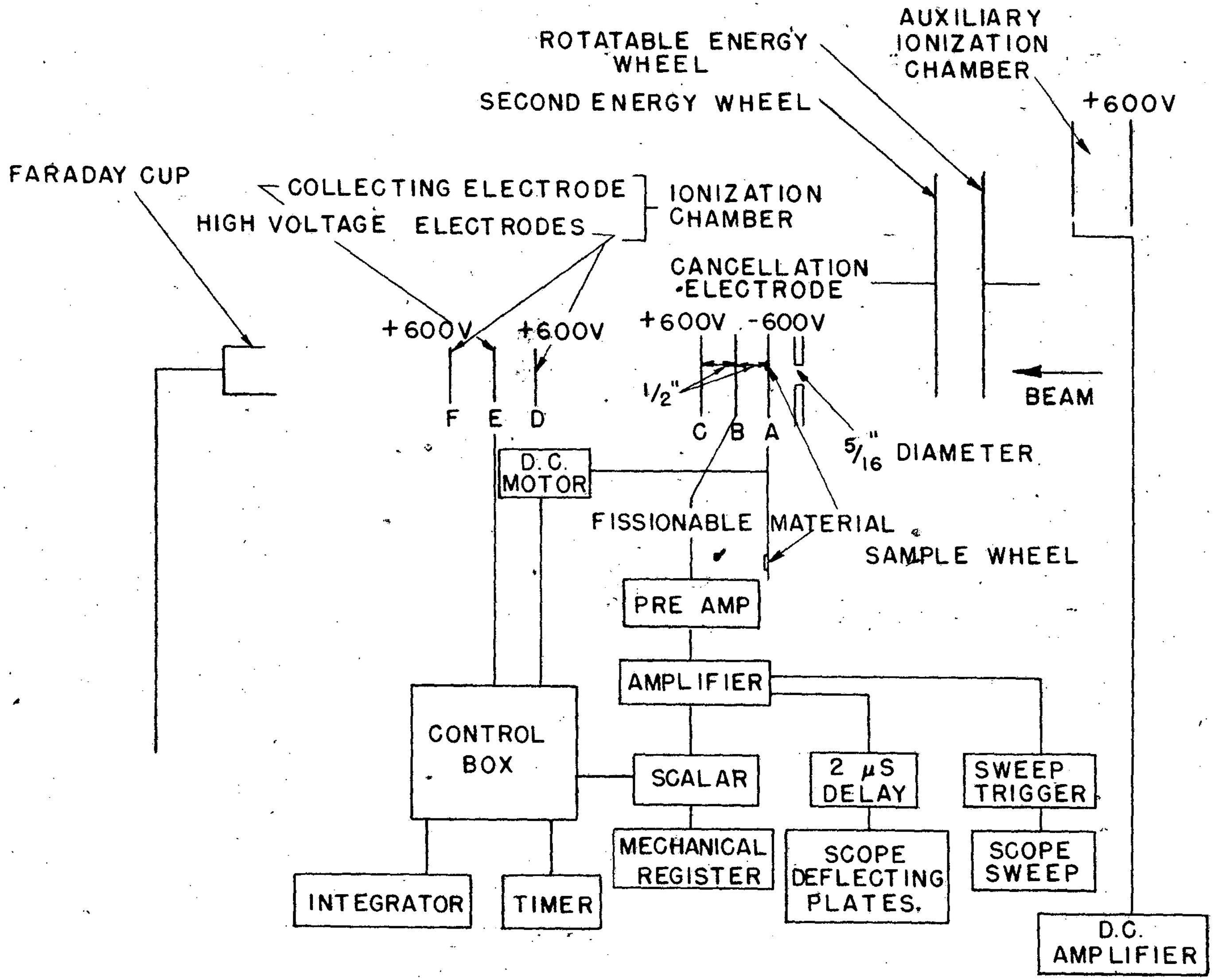


FIG. I
EXPERIMENTAL ARRANGEMENT

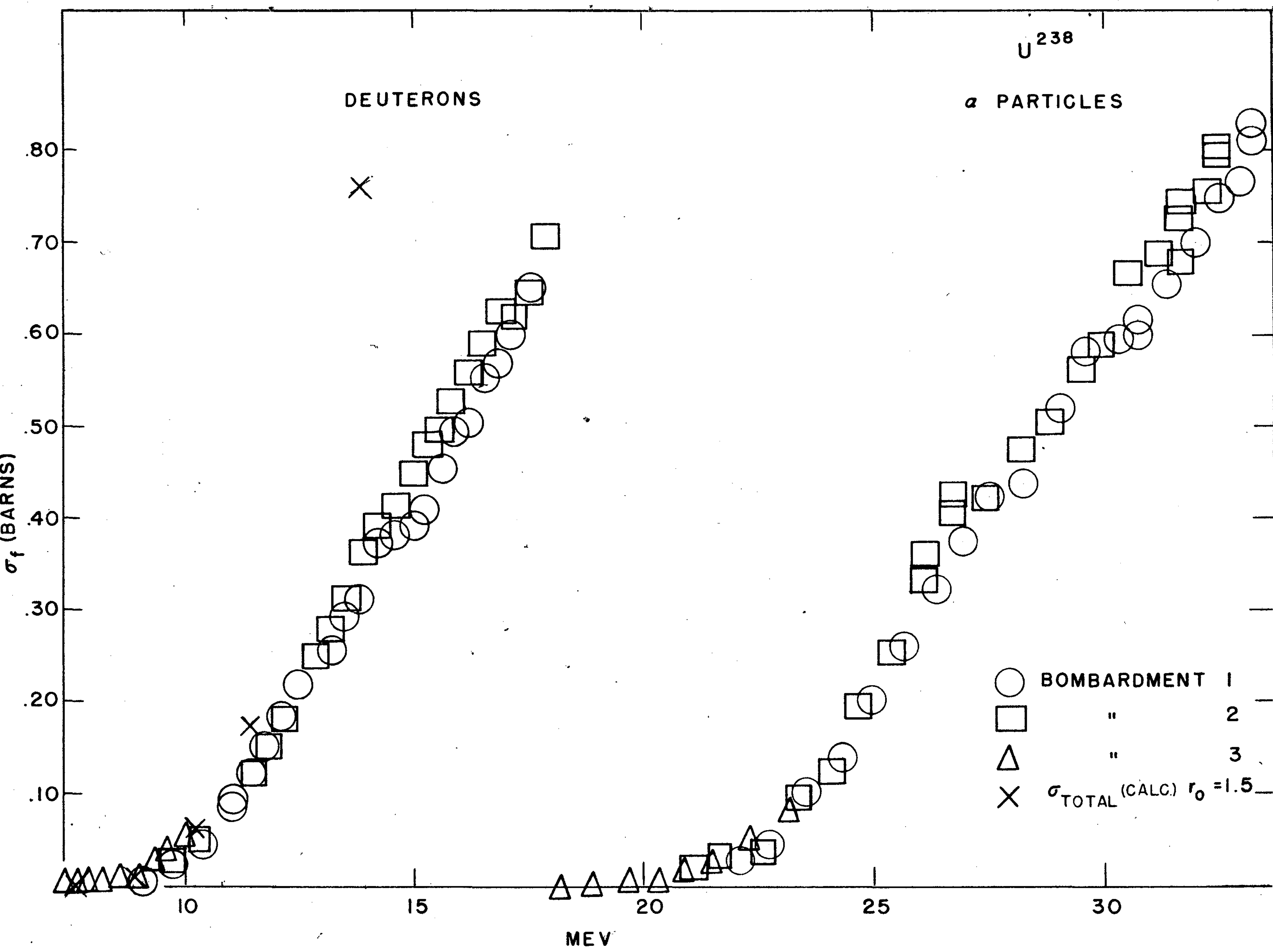
U^{238}
DEUTERONS
α PARTICLES
.80
.70
.60
.50
.40
.30
.20
.10
σ_f (BARNS)
10
15
20
25
30
MEV
BOMBARDMENT 1
" 2
" 3
σ_{TOTAL} (CALC.) r_0 = 1.5

FIG. 2

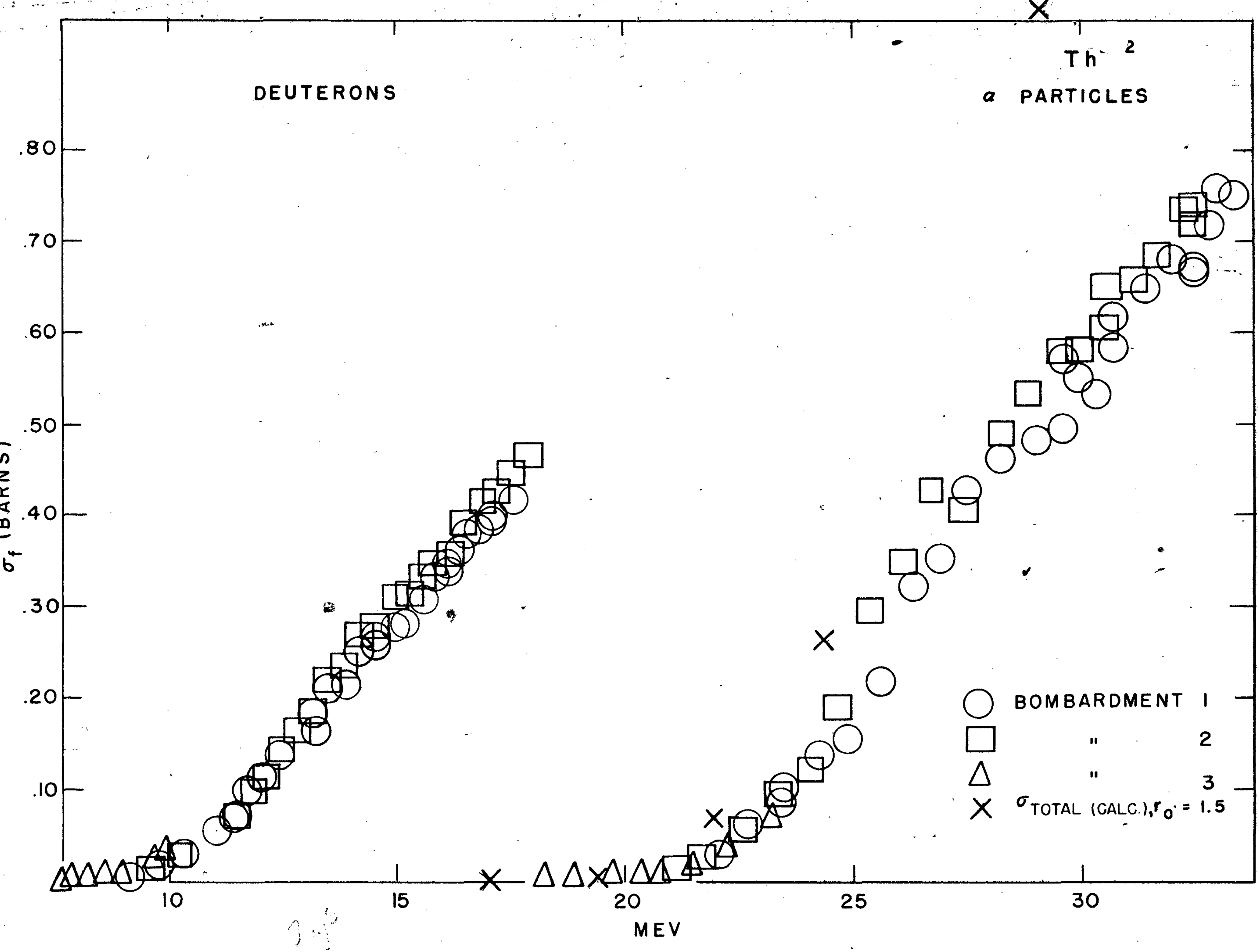
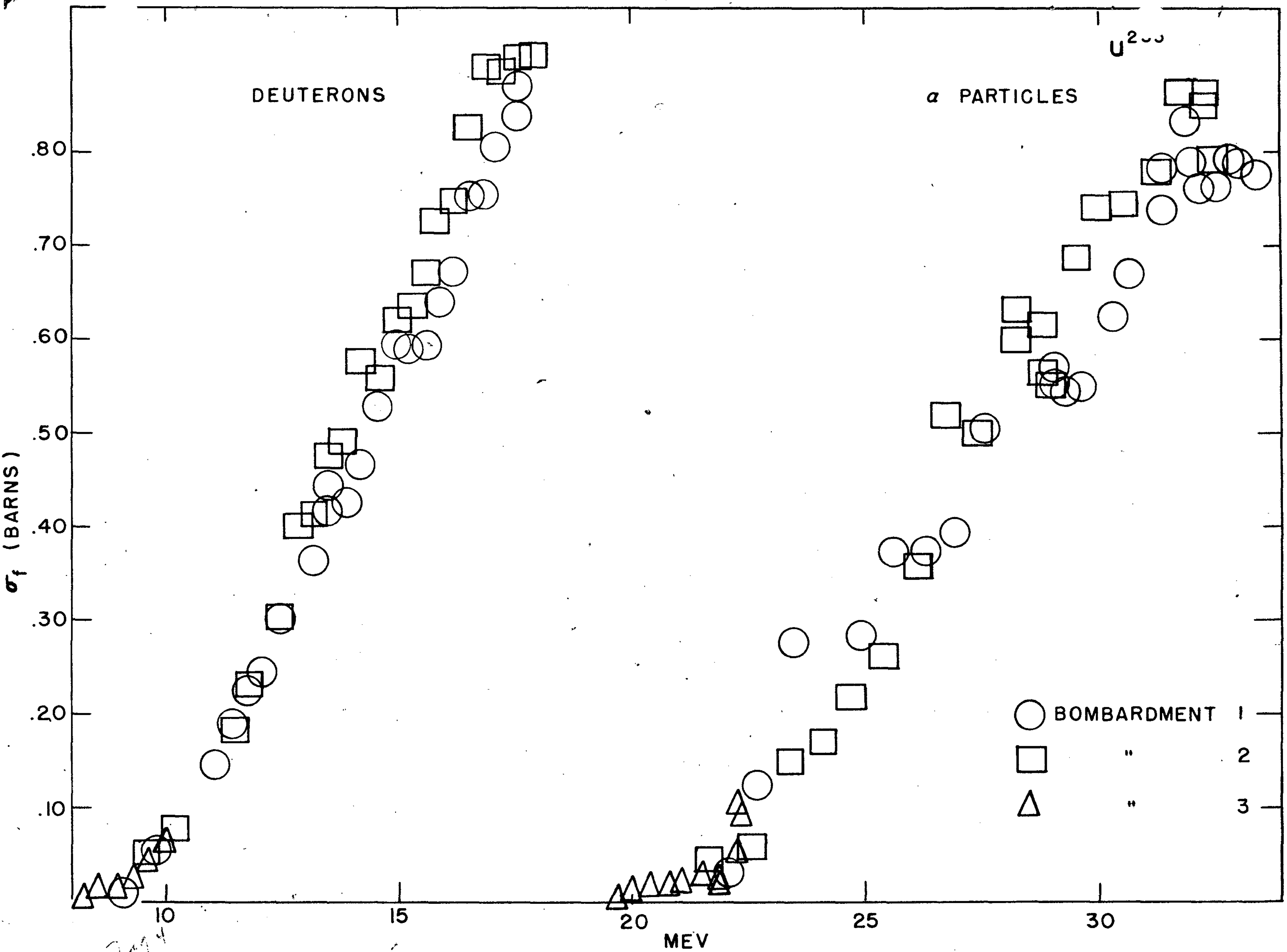

Th 2
DEUTERONS
α PARTICLES
.80
.70
.60
.50
.40
.30
.20
.10
σ_f (BARNS)
10
15
20
25
30
MEV
BOMBARDMENT 1
" 2
" 3
σ TOTAL (CALC.), r_0 = 1.5

FIG. 3

13680-


U2
DEUTERONS
α PARTICLES
σf (BARNS)
.10
.20
.30
.40
.50
.60
.70
.80
10
15
20
25
30
MEV
BOMBARDMENT 1
" 2
" 3

3414

FIG 4

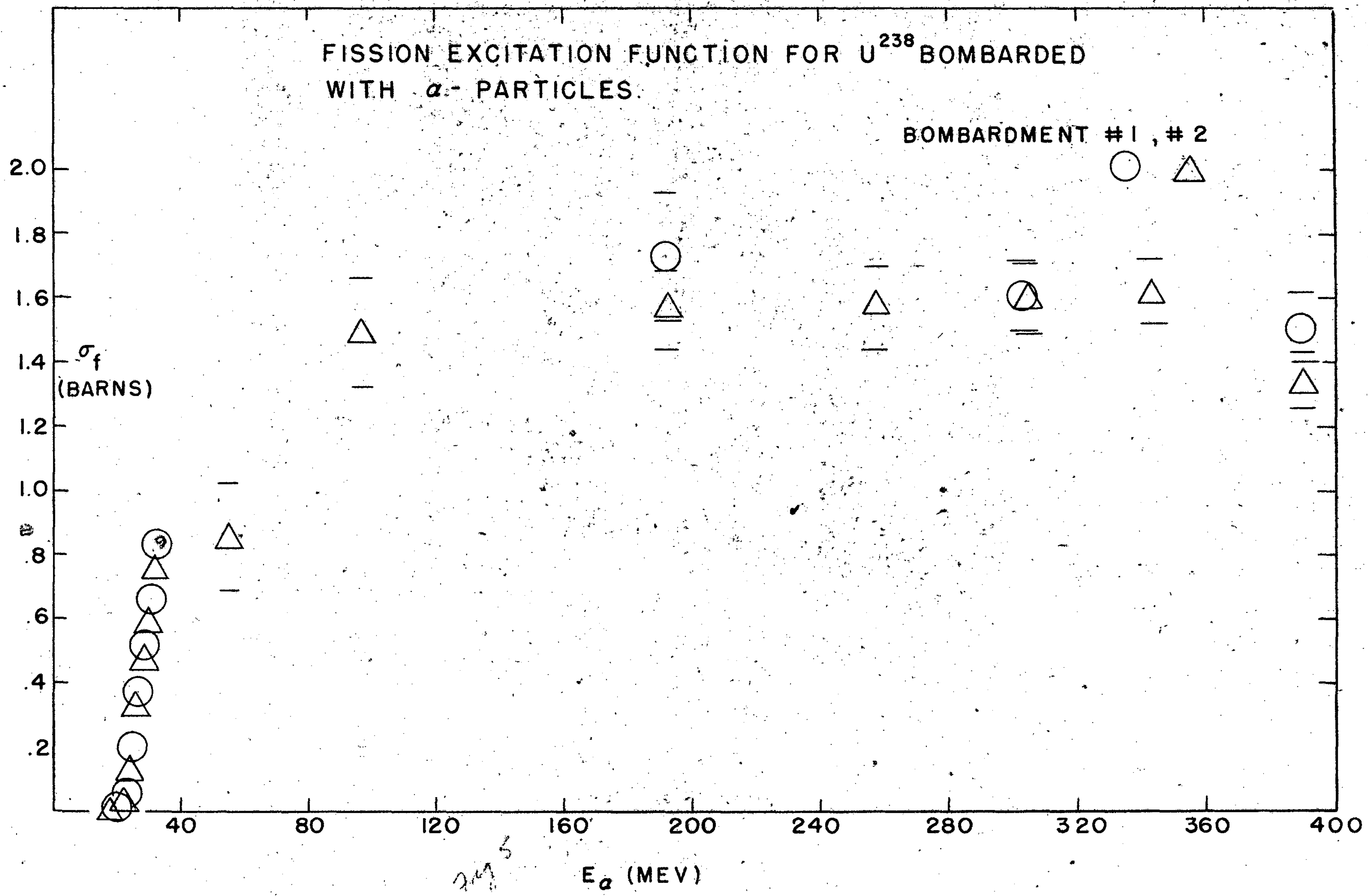

FISSION EXCITATION FUNCTION FOR U^{238} BOMBARDED WITH α- PARTICLES.
BOMBARDMENT #1 , #2
σ_f (BARNS)
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
40
80
120
160
200
240
280
320
360
400
E_α (MEV)

FIG. 5

13991-1

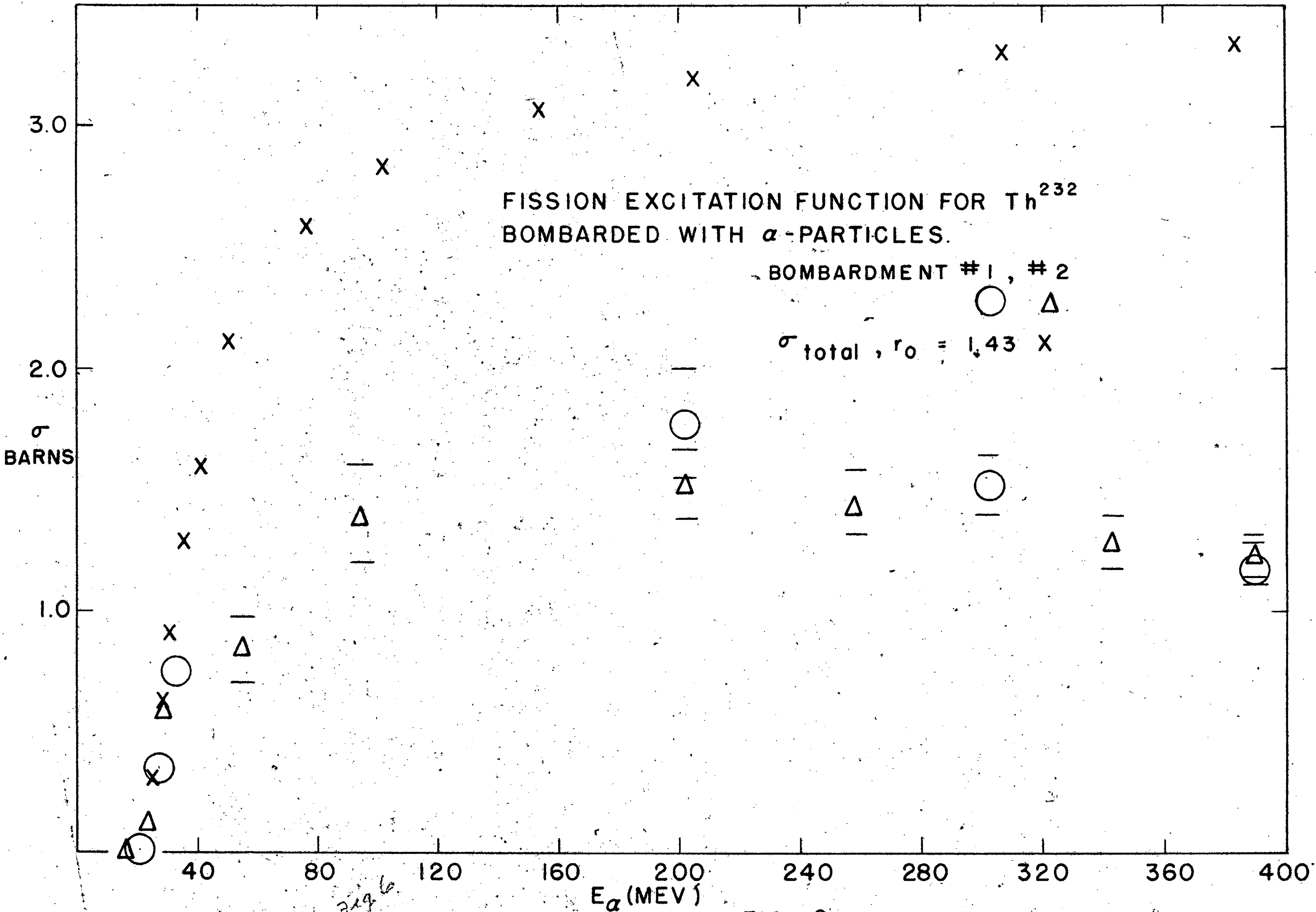


fig 6.

FIG. 6

14076-

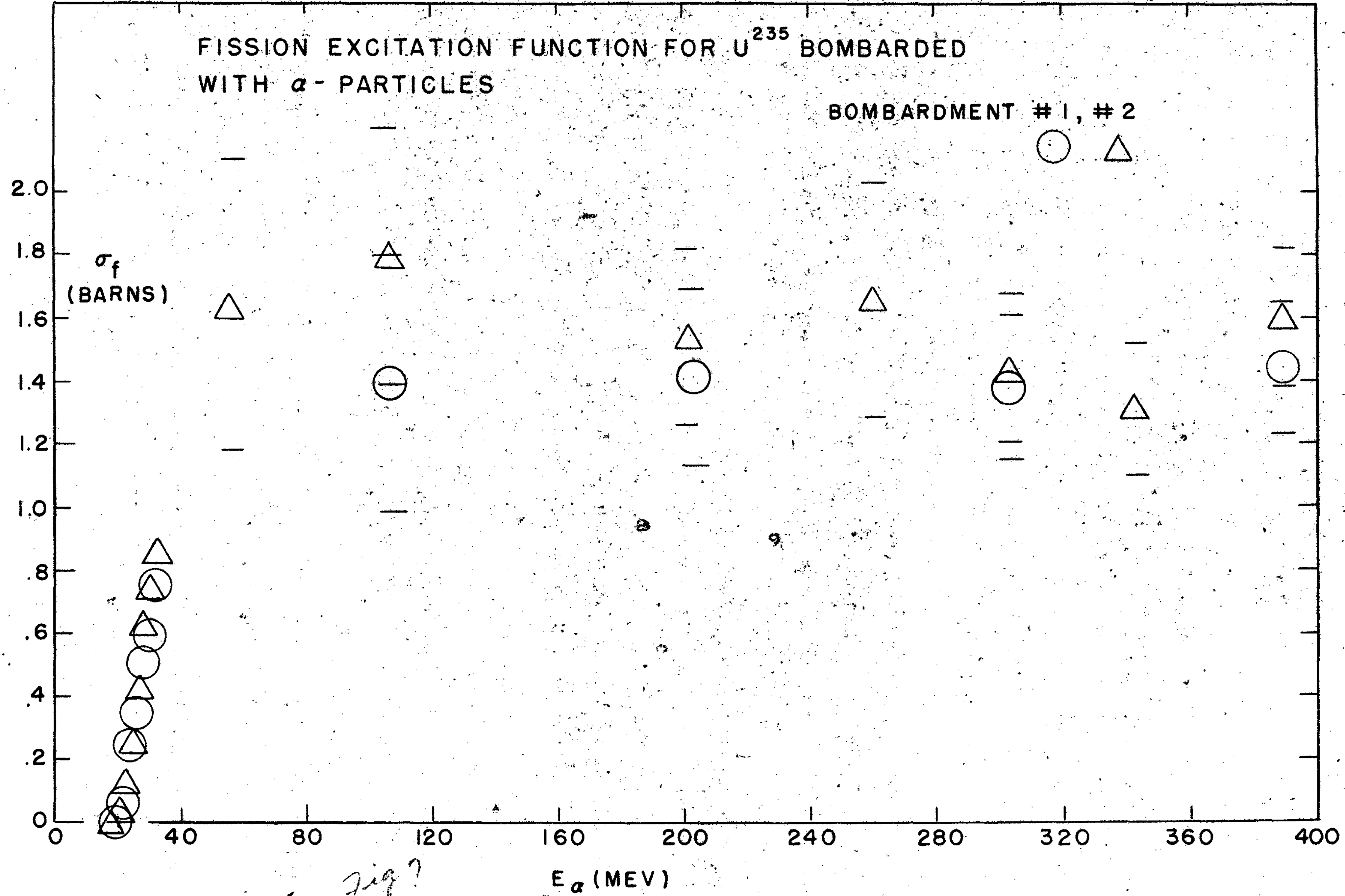


Fig 7

FIG. 7

14002

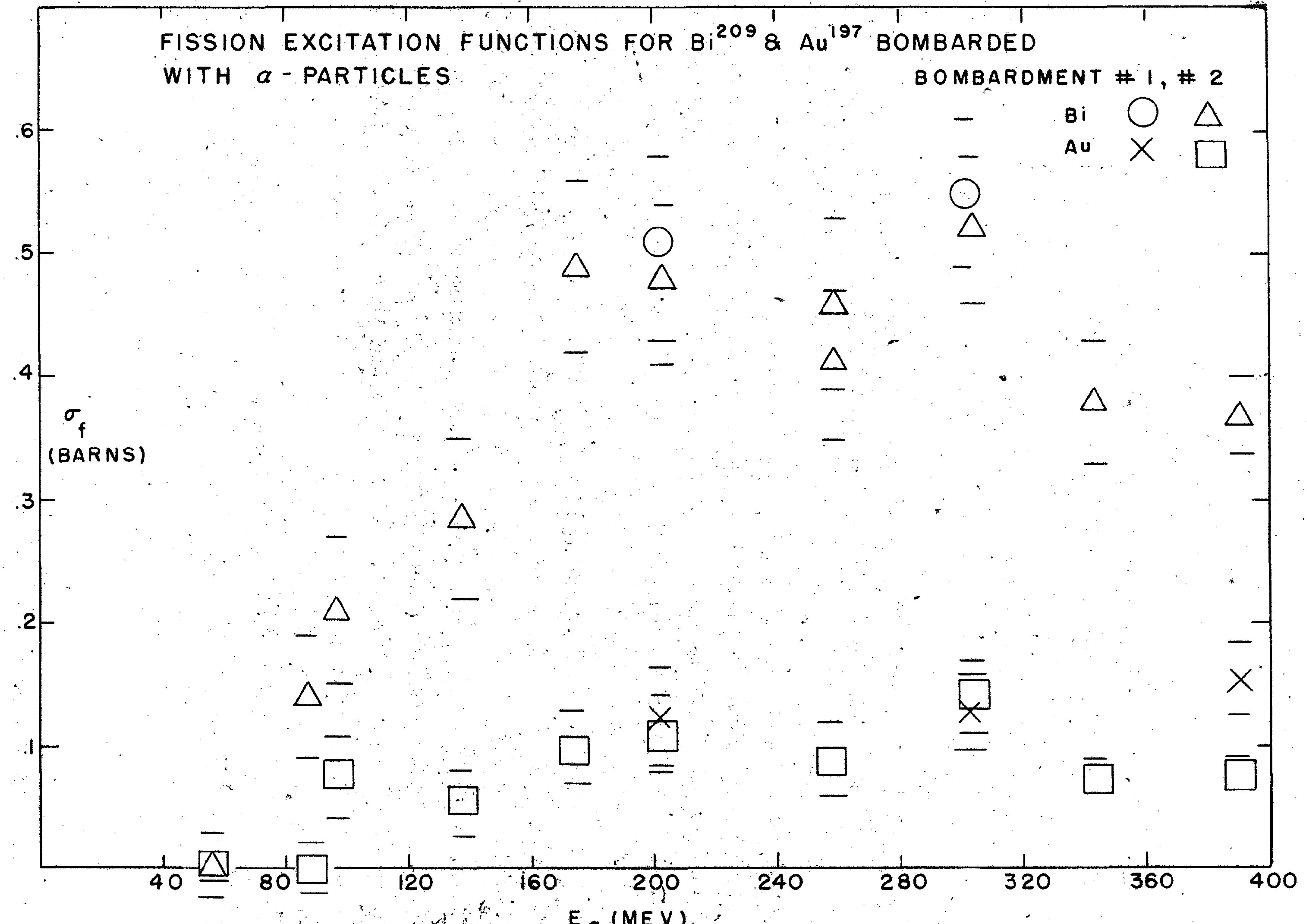

FISSION EXCITATION FUNCTIONS FOR Bi^{209} & Au^{197} BOMBARDED WITH α - PARTICLES
BOMBARDMENT # 1, # 2
Bi ○ △
Au × □
σ_f (BARNS)
.6
.5
.4
.3
.2
.1
40
80
120
160
200
240
280
320
360
400
E_α (MEV)

FIG. 8

13994-

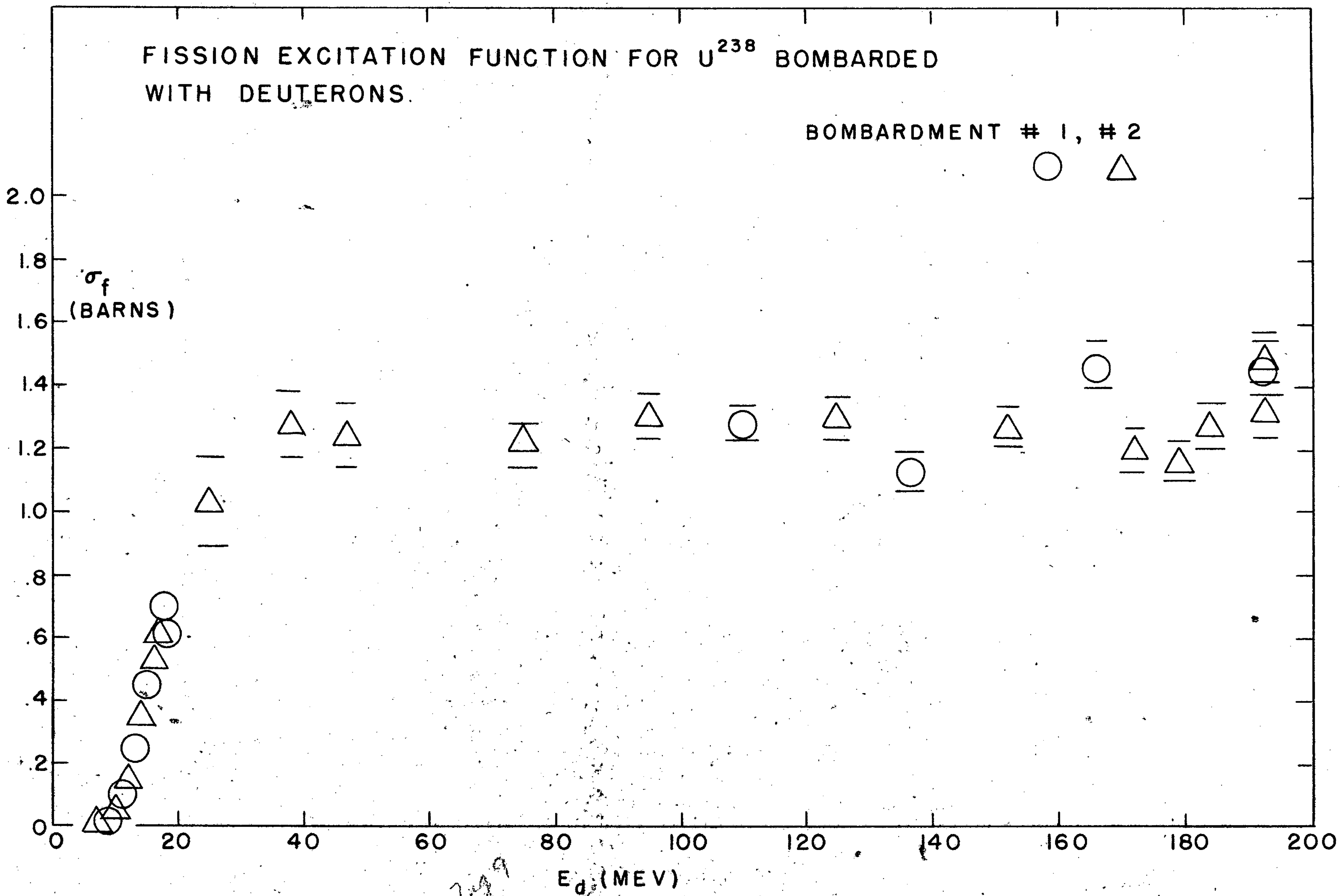

FISSION EXCITATION FUNCTION FOR U^{238} BOMBARDED WITH DEUTERONS.
BOMBARDMENT # 1, # 2
○ △
σ_f (BARNS)
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
0
20
40
60
80
100
120
140
160
180
200
E_d (MEV)

FIG. 9

14001-

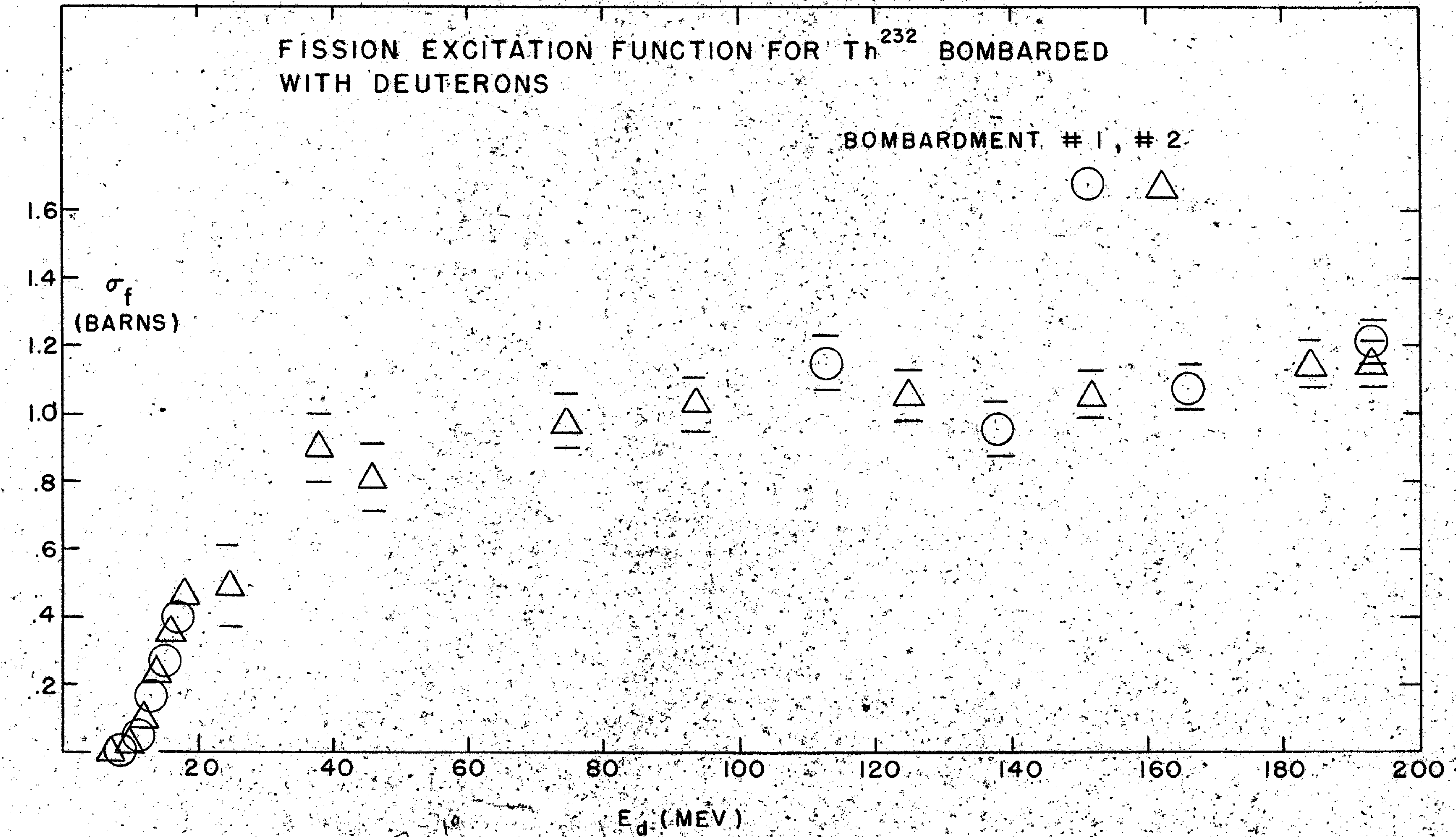


Fig 10

FIG. 10

13992

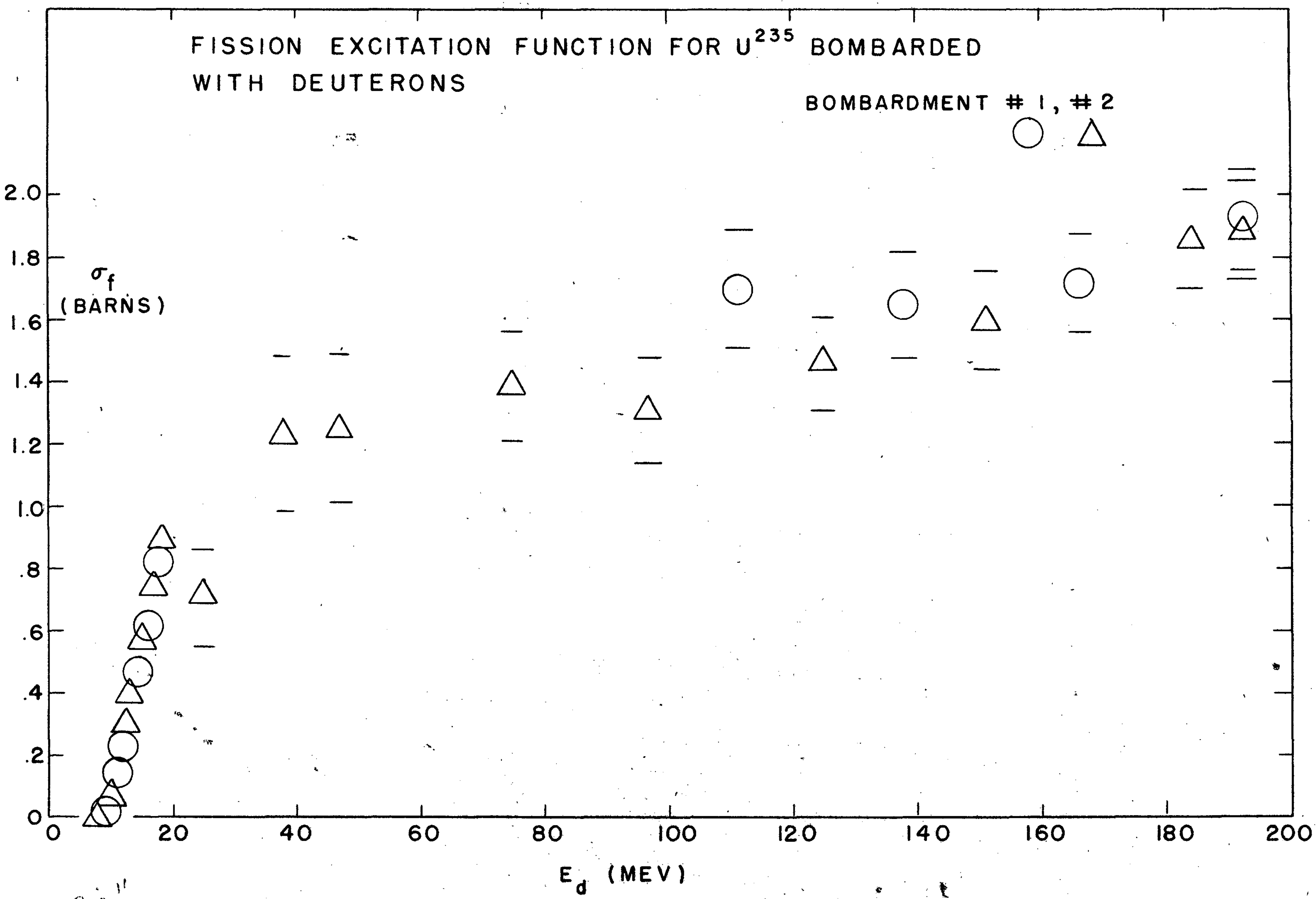


FIG. 11

Fig 11

14000-

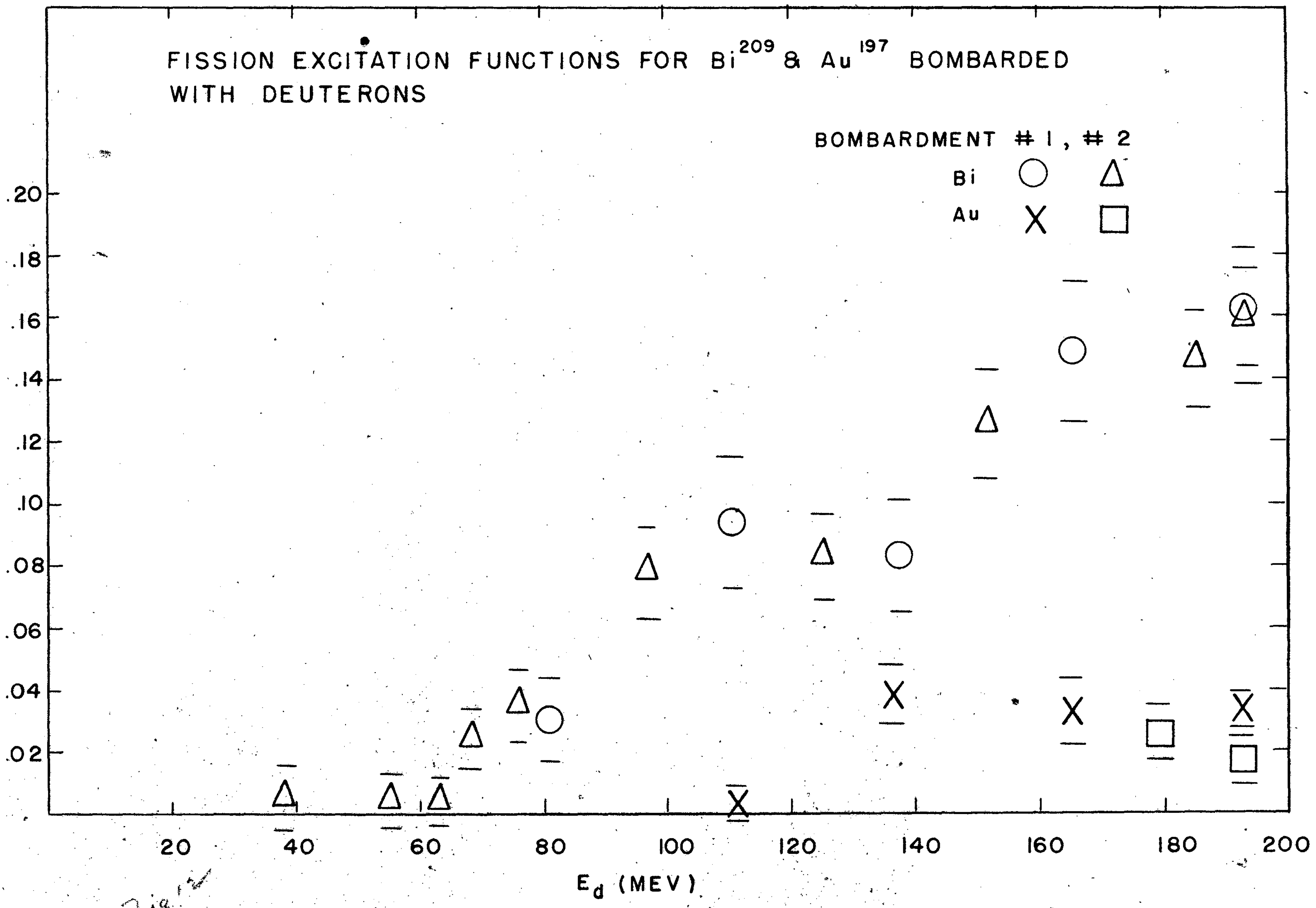

FISSION EXCITATION FUNCTIONS FOR Bi^209 & Au^197 BOMBARDED WITH DEUTERONS
BOMBARDMENT # 1, # 2
Bi ○ △
Au X □
.20
.18
.16
.14
.12
.10
.08
.06
.04
.02
20
40
60
80
100
120
140
160
180
200
E_d (MEV)

Fig 12

FIG. 12

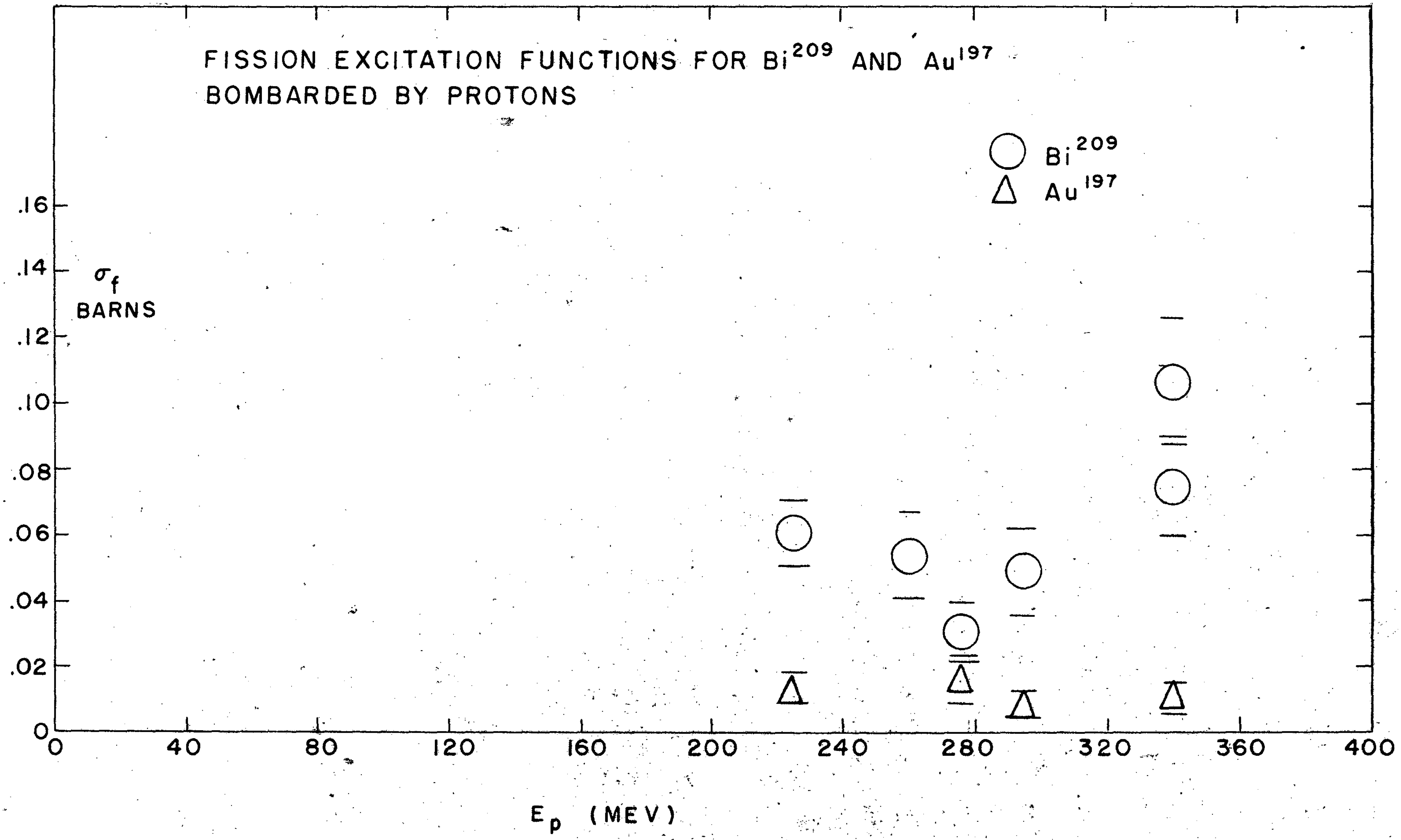

FISSION EXCITATION FUNCTIONS FOR Bi^{209} AND Au^{197}
BOMBARDED BY PROTONS
Bi^{209}
Au^{197}
σ_f
BARNS
.16
.14
.12
.10
.08
.06
.04
.02
0
0
40
80
120
160
200
240
280
320
360
400
E_p (MEV)

Fig 14

FIG. 14

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