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ELECTRON INDUCED FISSION IN U^{238}, Bi^{209} AND Ta^{181} *

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The purpose of this note is to report the observation of electron induced fission of U^{238}, Bi^{209} and Ta^{181} produced by electrons of energy 250 and 500 MeV from the Stanford Mark III Linear Accelerator. The fission events were produced in thin targets placed in a standard scattering chamber,[1] and the fragments were detected by using the mica technique.[2] In the case of the U^{238} targets, the fissions were also observed with semiconductor counters and preliminary results on the energy spectra of the fragments were obtained. The conditions of the experiments and the measured cross section results are indicated in Table I.

The pulse height distribution of fission fragments from electron induced fission of U^{238} along with the spectrum obtained using the same experimental conditions from spontaneous fission of Cf^{252} are shown in Fig. 1. Both of these spectra are distorted as a result of the severe electronic pulse clipping (20 nsec) which was required for these measurements. The U^{238} spectrum is probably displaced upward in pulse height by the residual background of low energy pulses detected in coincidence with the fission fragments. It can be seen however that the spectrum from U^{238} contains two peaks and therefore seems to indicate the predominantly asymmetric fission mode which is characteristic of excitation energies less than about 40 MeV for this isotope.

The electron beam was found to be relatively free of bremsstrahlung radiation, the latter being separated in the beam transport system[1] by deflecting the electron beam twice before it enters the heavily shielded target area. However, in order to be certain that the fission events observed as described above were, in fact, produced by electrons and not by background radiations, three independent checks were carried out in the following manner:

(1) The fission background in U^{238} induced by bremsstrahlung associated with the 250 MeV electron beam was measured both with mica and fission counters after deflecting the electron beam 2.5 cm away from the target while the target itself was maintained in its standard position. The fission rates observed by both methods were less than 1% of the rates observed when the electron beam impinged on the target.

(2) The dependence of the fission rate in the U^{238} target on thickness of aluminum radiator placed in front of the target was measured using a solid state detector. The results obtained with a 250 MeV electron beam are shown in Fig. 2. The point at zero thickness represents the effect of the electron beam itself without the addition of any absorber and the horizontal line therefore represents the electron induced fission rate. The increase in fission yield corresponding to points above this line is due to bremsstrahlung induced fission. The increase in yield observed on introducing the thinnest aluminum radiator is in approximate agreement with a calculation based on known photofission cross sections.[3]

(3) The general background in the region ~ 5 cm from the target was measured by placing pieces of U^{238}, U^{235} and Th^{232} clamped between sheets of mica in this location during the 250 MeV electron bombardments and counting the tracks produced in the mica. Under these conditions the fission rates were much less than 1% of those observed from the U^{238} targets during the comparable electron bombardments.

Preliminary measurements of the angular distributions of fission fragments from U^{238} bombarded with 250 MeV electrons were made using both the mica technique and semiconductor fragment detectors. The distributions showed less than 10% deviation from isotropy, such a deviation being within the expected errors.

We note that the cross sections for fission induced by electrons as given in Table I are more than an order of magnitude below the bremsstrahlung induced fission cross sections at comparable maximum energies.[3] While the quantitative explanation of the large decrease in cross sections in going to lighter elements is a subject for more detailed analysis, it can be understood in a rough qualitative way in terms of excitation through the giant resonance. The fission barrier for U^{238} (6 MeV) is below the giant resonance while for Bi^{209} (24 MeV) and Ta^{181} (28 MeV) the fission barriers[4] lie higher than the maximum of the giant resonance peak, and absorption in the latter cases must take place from the high energy tail of this peak.

The results reported above are only preliminary. It is of interest to extend the cross section measurements over a much larger energy range, to measure some mass distributions and to confirm the evidence that the fragment angular distributions are isotropic. It should also be possible to determine whether excitations other than the giant resonance absorption are responsible for the excitation of the nuclei.

So far as we have been able to determine, the above-mentioned results represent the first definite measurements of fission cross sections induced by electrons.

Table I. Experimental results.

Target	Thickness	Method Used	Fission Cross Section 250 MeV e^-	Fission Cross Section 500 MeV e^-
$_{92}U^{238}$†	85 micrograms/cm^2	Mica	$(6.0\pm1.2) \times 10^{-27}$ cm^2	$(9.4\pm1.9) \times 10^{-27}$ cm^2
$_{92}U^{238}$	162 micrograms/cm^2	Counter	$(5.0\pm1.0) \times 10^{-27}$ cm^2	$(7.0\pm1.4) \times 10^{-27}$ cm^2
$_{83}Bi^{209}$	1 milligram/cm^2	Mica	$(2.3\pm0.5) \times 10^{-29}$ cm^2	$(1.4\pm0.3) \times 10^{-28}$ cm^2
$_{73}Ta^{181}$	4 milligrams/cm^2	Mica		$(3.9\pm0.2) \times 10^{-31}$ cm^2

† $U^{235}/U^{238} = 1.12 \times 10^{-4}$ in target sample.

FOOTNOTES AND REFERENCES

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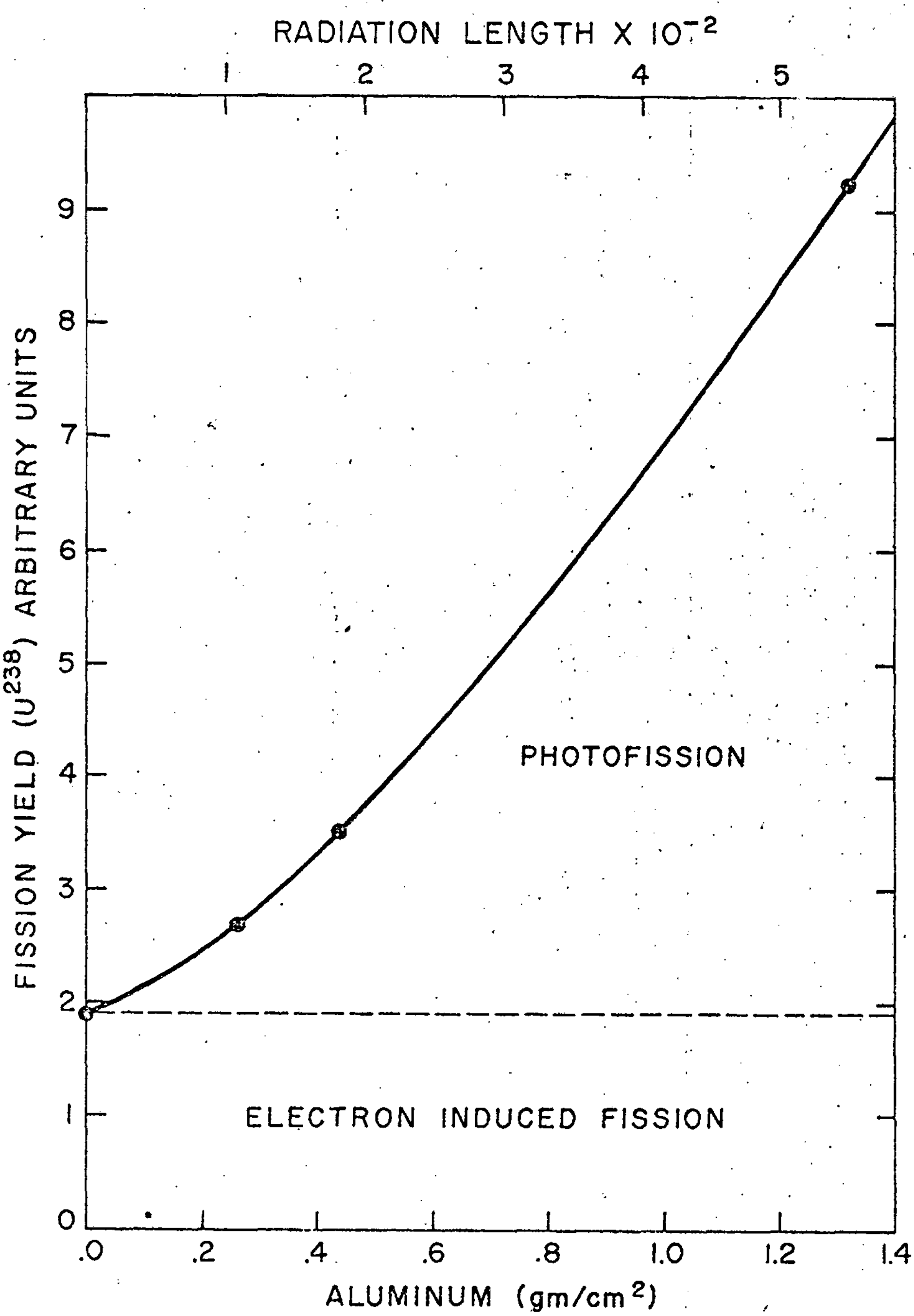
FIGURE CAPTIONS

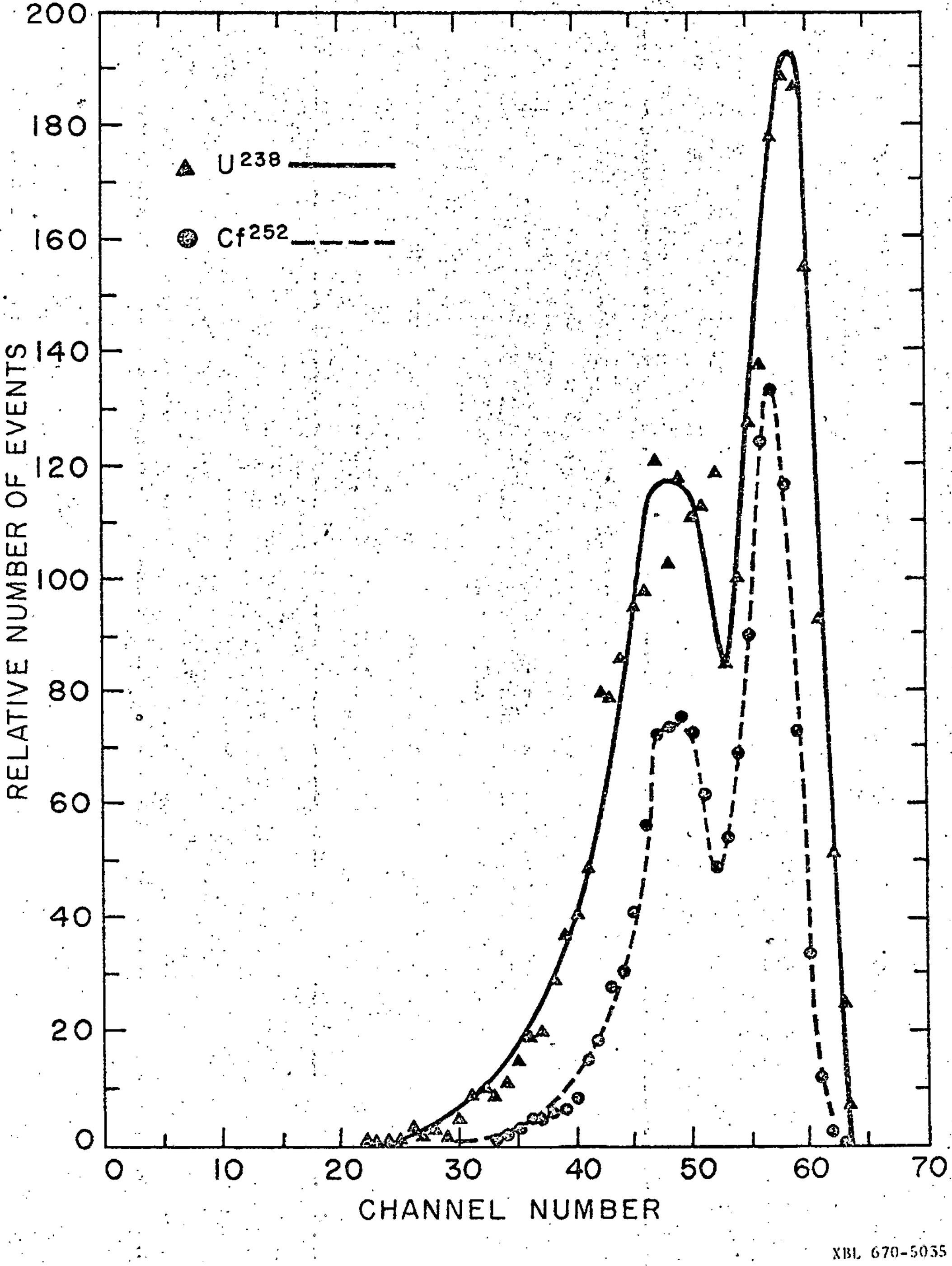
Fig. 1. Dependence of fission rate on radiator thickness.

Fig. 2. Pulse height spectrum of fission fragments.



XBL 670-5036

Fig. 1



U238
Cf252
RELATIVE NUMBER OF EVENTS
CHANNEL NUMBER
200
180
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
XBL 670-5035

Fig. 2