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SUMMARY OF THE RESEARCH PROGRESS MEETING

April 7, 1949

H. P. Kramer

Berkeley, California

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Fission and Spallation Products of Uranium. R. Folger.

In conjunction with the high energy helium ion bombardment of uranium reported by O'Connor and Seaborg in the Physical Review, 74, 1189-90, (1948), a comparable bombardment with hydrogen ions has been carried out.

Fig. 1 shows the yield curve that was obtained over a wide range of mass numbers, from about 55 to 230. The yields are computed as fractions of that of the standard 12.8 day isotope of barium, Ba^{140}.

It is of some interest to compare the distribution of yields obtained from the alpha particle bombardment to that from protons. The following is a partial list of yields that are in both cases computed relative to Ba^{140}.

	Protons	Alphas
Isotope	Rel. Yield	Rel. Yield
Ba^{140}	1	1
Cu^{67}	9.5×10^{-2}	9.0×10^{-5}
Sr^{89}	3.5	2
Cd^{115}	5.4	2.5
Ra^{224}	2.4×10^{-1}	6×10^{-3} (experimental point)
		2×10^{-2} (least squares curve)

A comparison of the two curves is shown in Fig. 2. The curves are drawn on the supposition that the peak of both curves which occurs at Cd^{115} represents the same absolute yield. With this assumption it is seen that the curves are practically

identical with the exception that points of equal yield are separated slightly in mass number.

The samples of uranium that were bombarded contained slight Pb and Fe impurities. A separate bombardment of Pb will be carried out to judge what inaccuracies in the yield curve are caused by the presence of spallation products of Pb. Because of the iron content of the samples, the yields of none of the products with atomic number less than 26 are very reliable. The Ag contamination was insignificant.

It is likely that the fission products as well as the spallation products of uranium are distributed over the entire range of the curve.

There is some uncertainty as to whether the yield of Ba^{140} measures the total yield of mass number 140 since the isobars La^{140} and Ce^{140} may also have been produced. It is planned to determine the production of Ba^{140} separately.

The ratio of yields Cd^{115} 2.3 d Cd^{115} 43 d $\cong$ 2. There is evidence to the effect that Cd^{115} 43 d is produced independently whereas Cd^{115} 2.3 d is the daughter of a decay chain.

Eventually it would be desirable to obtain a surface of yields plotted against A and Z.

The absolute cross section of U for the formation of Ba^{140} from the bombardment with 200 Mev deuterons is .05 b. It is not known for protons or α particles.

Neutron Total Cross Sections. C. Leith.

Neutron total cross section measurements that were begun by K. MacKenzie have been continued by R. Fox. L. Wouters, C. Leith, et al and extended to higher energies. Measurements with a 280 Mev neutron beam produced on a beryllium target in the 184-inch cyclotron have been made with crystal counters in place of the conventional gas filled counting tubes that were formerly used at lower energies.

The apparatus is sketched in Fig. 3. The neutron beam is defined by passage

through a collimator. It is monitored either by a BF_3 filled proportional counter or by a Bi fission chamber. It then passes through the attenuator whose total neutron cross section is to be determined. The neutrons that survive scattering and absorption in the material are counted in the form of recoil protons produced in a paraffin target. An energy cut-off is achieved by placing the two crystal counters in coincidence and inserting an absorber of known characteristics between them. The absorber that was used permits the transition of only those protons that correspond to a neutron energy in excess of 250 Mev. The maximum energy of the beam is approximately 330 Mev.

40 percent of the protons from the paraffin scatterer originate within the C atoms and 60 percent within the H atoms of the paraffin molecules. The ratio of the total number of counts on the first counter to the number of coincidences is 18. For the second counter, this ratio is 6. In order to obtain a measure of the background, the scatterer was removed. The number of coincidences dropped to 2 percent of the number observed with the scatterer.

The total cross section has been measured for the following elements: H^1, H^2, Li, Be, C, N, O, Al, Cl, Cu, Sn, Pb, U. The results for those elements that had to be introduced in compounds were obtained by subtraction. Fig. 4 shows a graph of the variation of cross section with energy. Four points are now available for each element shown, 14 Mev., 85 Mev., 95 Mev., and 280 Mev.

If one regards the nucleus as a liquid drop of mass A of a density that does not vary from one element to another, one may define a quantity R, the 'radius' of the drop, and state that it is proportional to the cube root of the mass A. If one extends this model to illustrate the interaction between neutrons and nuclei, one would like to be able to say that the total cross section is proportional to the square of the radius R, or, if one postulates a quantity r defined by the formula

$$\sigma_t = 2\pi r^2$$

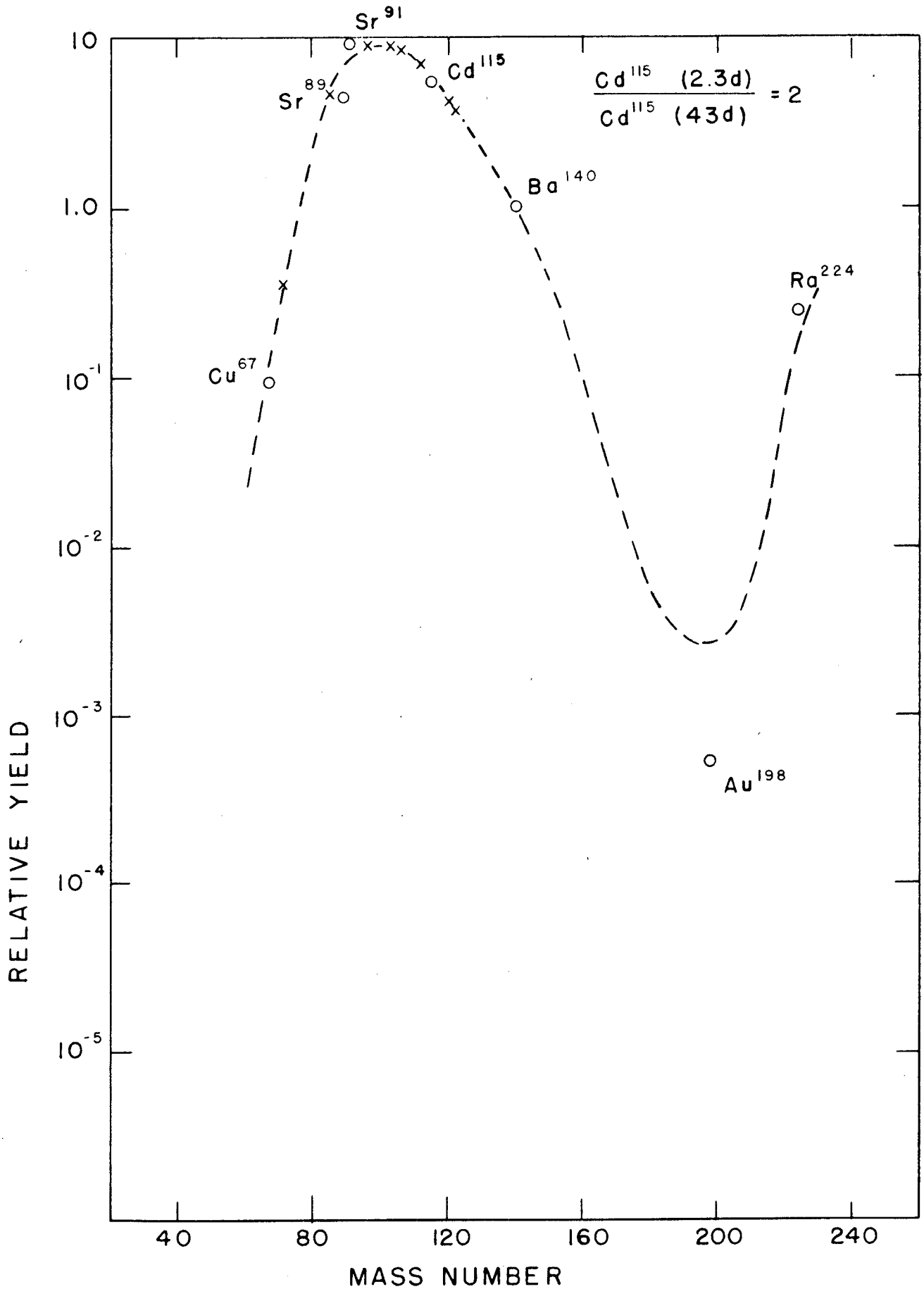
it would be an example of the consistency of this model if r turned out to be linearly related to $A^{1/3}$. Fig. 5 shows a plot of r x 10^{-2} against $A^{1/3}$ at the three experimental energies. It is seen that the slope of the line decreases with energy. This may be thought of as an increase in transparency for neutrons with energy.

The plot of Fig. 6 of the cross section per nucleon vs. the mass number is useful in examining the addition of cross section.

Proton-proton Scattering-Photographic Method. F. Fillmore.

The graph of Fig. 7 displays the results of two runs. The point in the 8°-10° interval is very much in doubt since the method was strained to obtain it. The tracks may very well be due to slit scattering rather than to scattering in the hydrogen atmosphere. The tracks in the 80°-82° interval are too short for positive identification. Symmetry was found to be very satisfactory for tracks at all other angles.

The absolute cross section on the basis of these measurements is 1.57 x 10^{-26} cm^2. B.Cork and C. Richman with their counter method have found an absolute cross section of 1.45 x 10^{-26} cm^2. The measurements are made with the 32 Mev proton beam from the linear accelerator.



RELATIVE YIELD CURVE FOR PRODUCTS FROM 350 MEV PROTON BOMBARDMENT OF URANIUM

FIG. 1

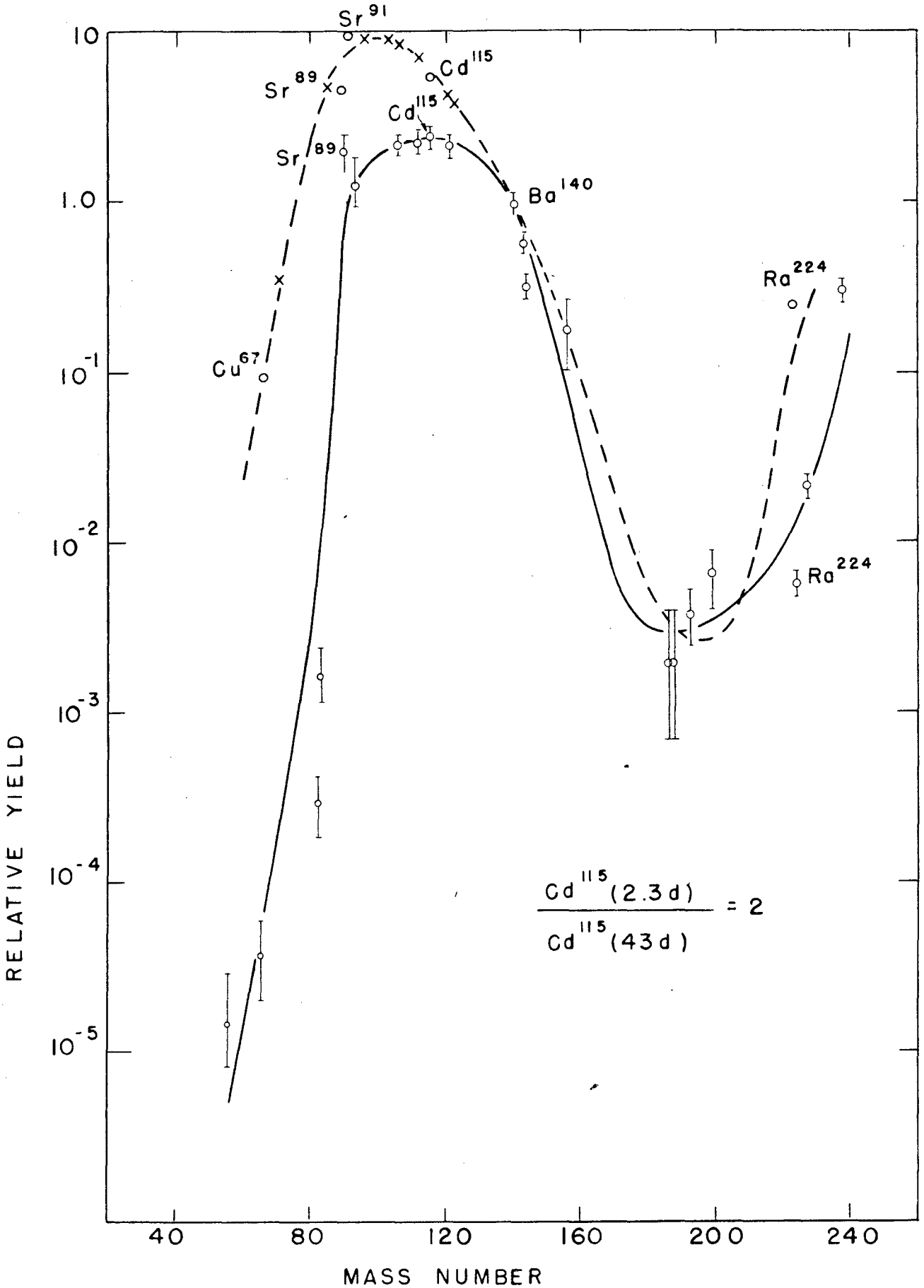

Sr91
Sr89
Cd115
Cd115
Sr89
Ba140
Ra224
Cu67
Ra224
Cd115(2.3d) / Cd115(43d) = 2
RELATIVE YIELD
MASS NUMBER
10
1.0
10-1
10-2
10-3
10-4
10-5
40
80
120
160
200
240

FIG. 2

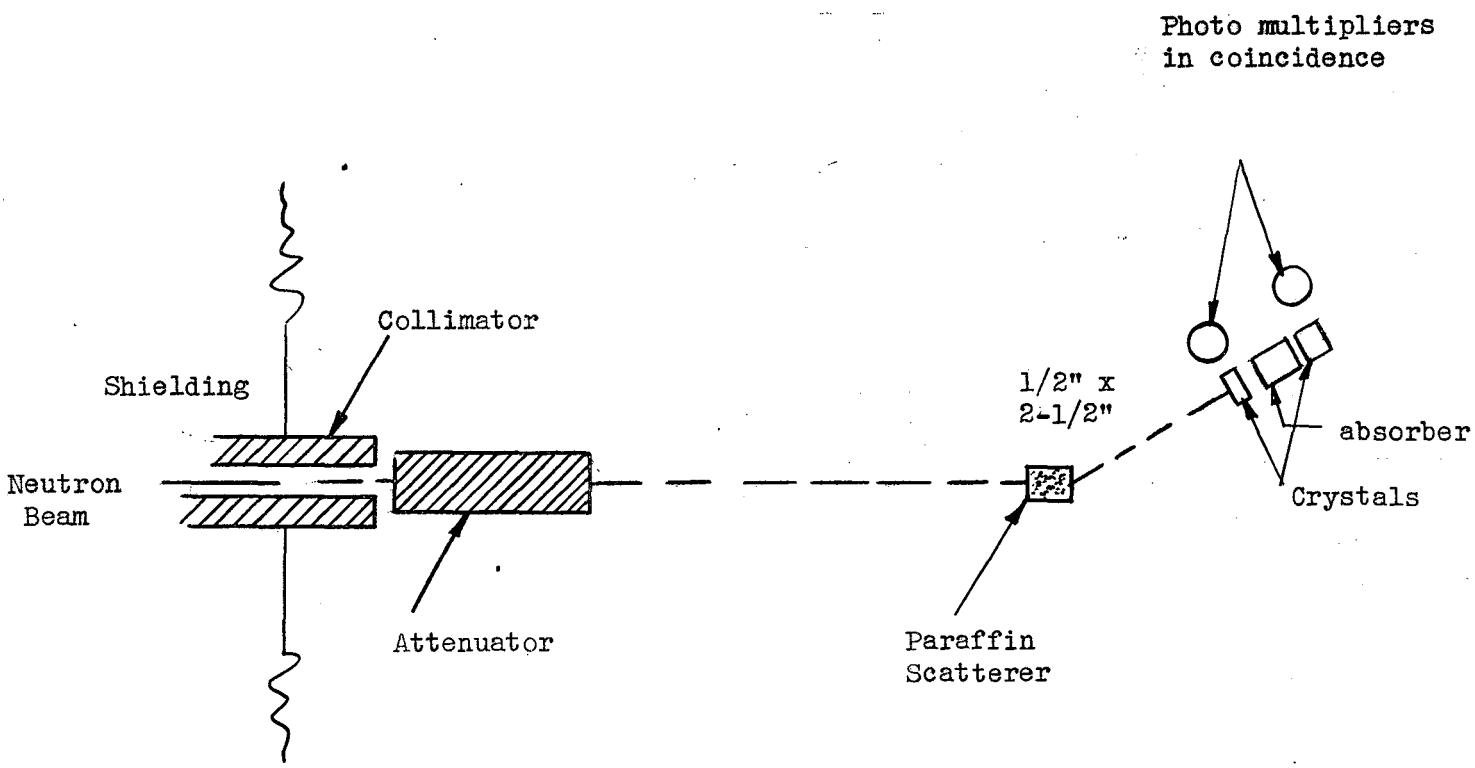


Fig. 3

Apparatus for the measurement of the total neutron cross sections.

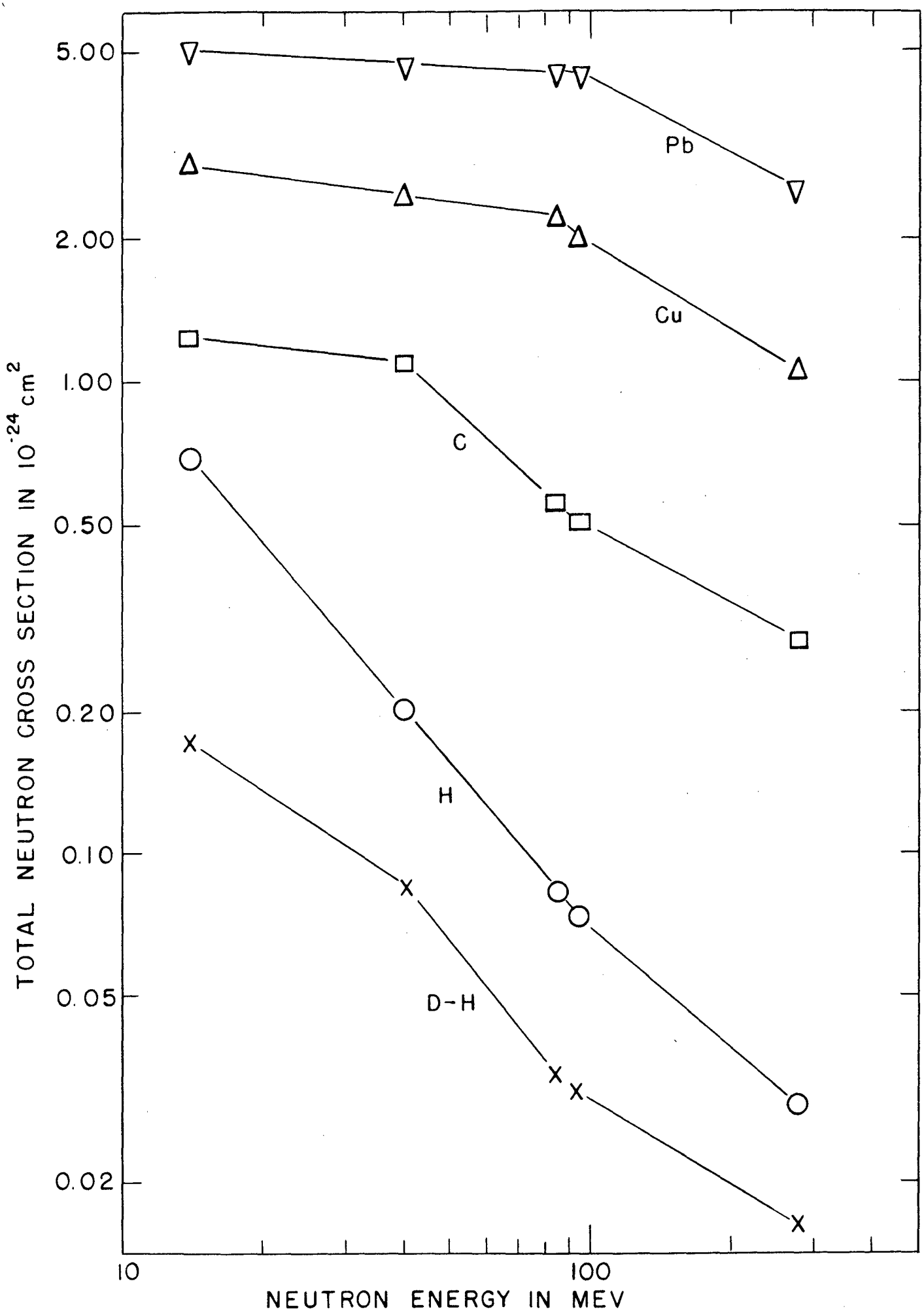

5.00
2.00
1.00
0.50
0.20
0.10
0.05
0.02
TOTAL NEUTRON CROSS SECTION IN 10^{-24} cm^2
Pb
Cu
C
H
D-H
10
100
NEUTRON ENERGY IN MEV

FIG. 4

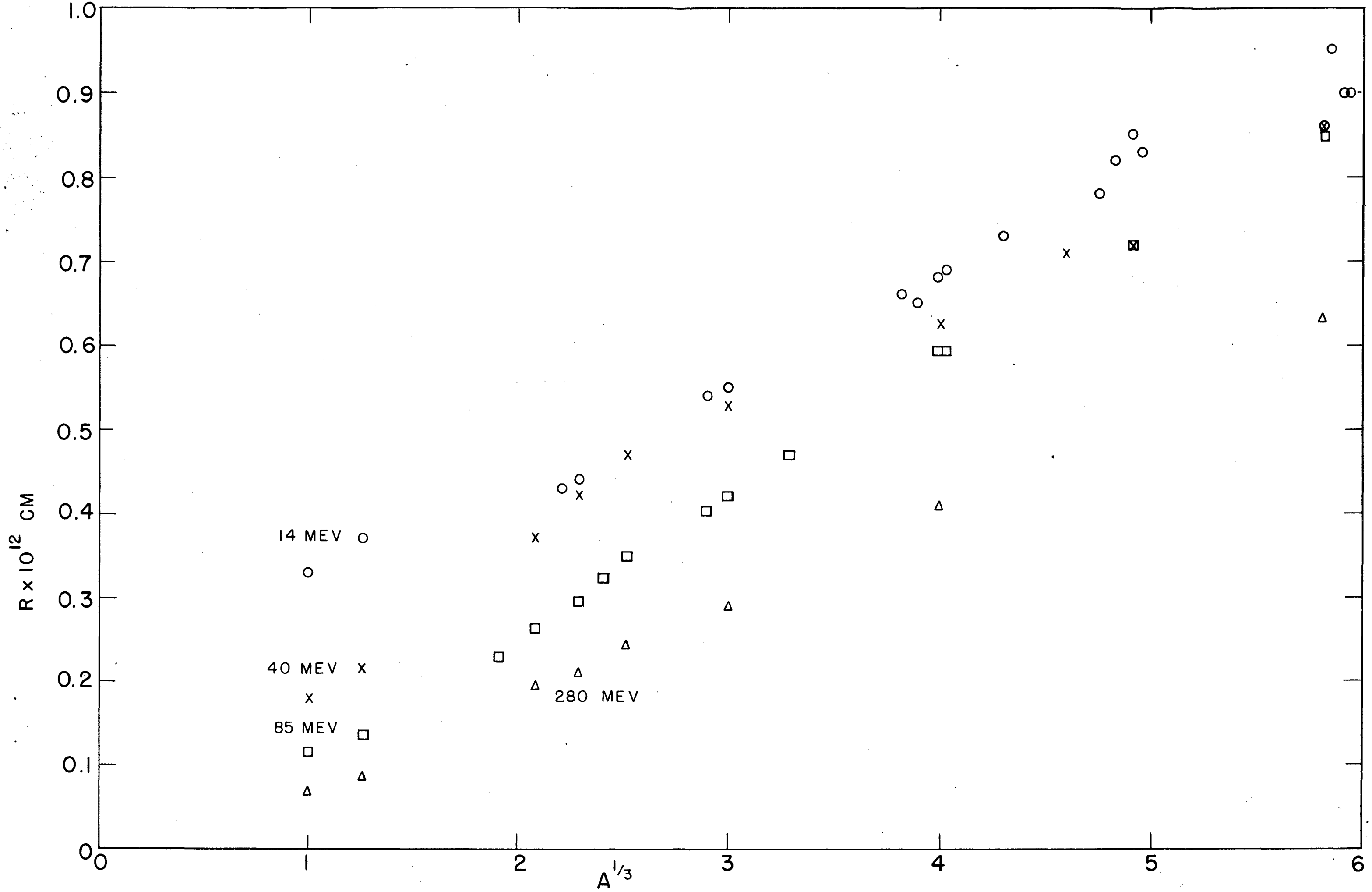

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
R x 10^12 CM
14 MEV
40 MEV
85 MEV
280 MEV
0
1
2
3
4
5
6
A^1/3

FIG. 5

13554

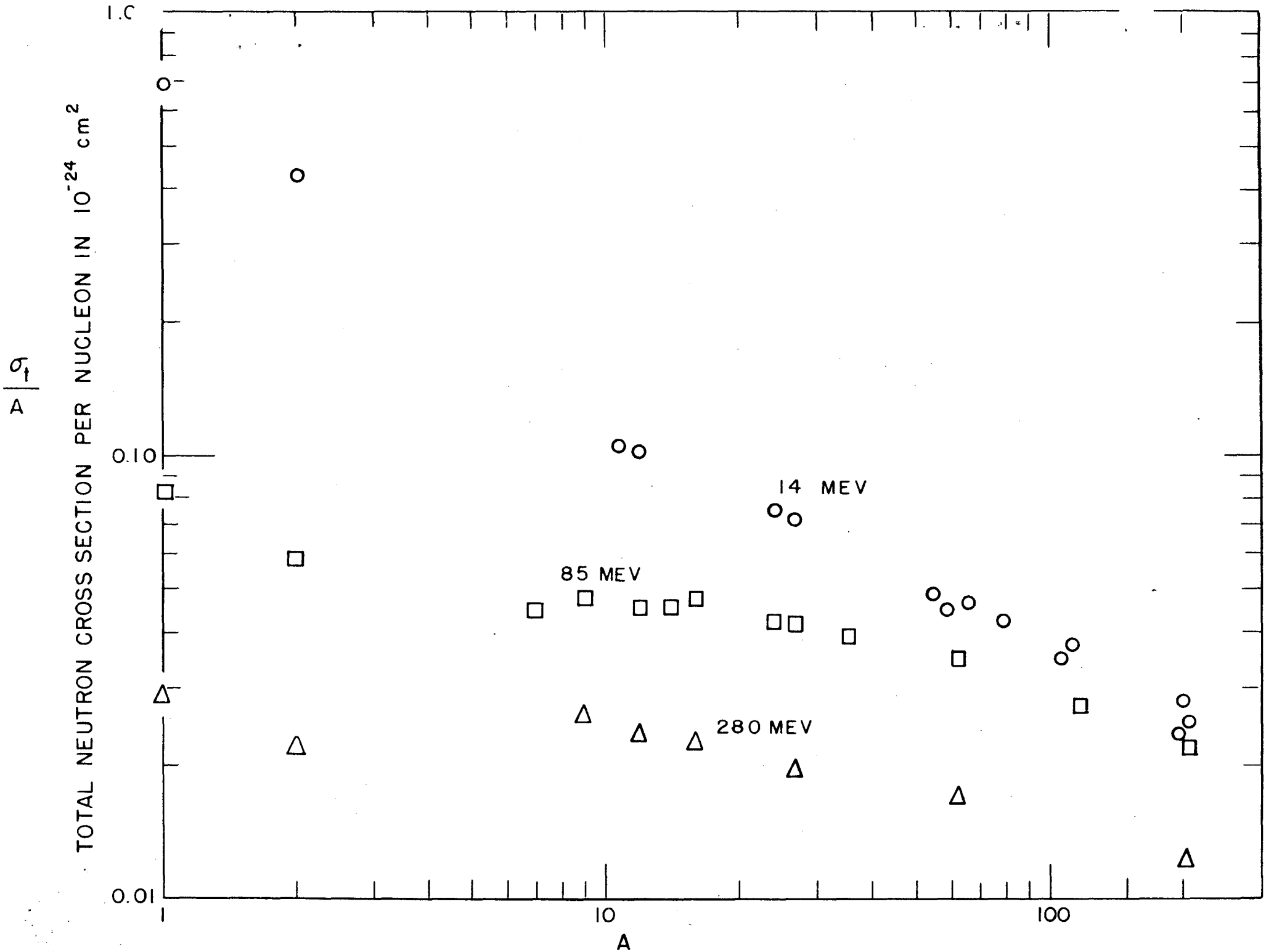

1.0
0.10
0.01
$\frac{\sigma_t}{A}$
TOTAL NEUTRON CROSS SECTION PER NUCLEON IN 10^{-24} cm^2
14 MEV
85 MEV
280 MEV
1
10
100
A

FIG. 6

13553-1