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Alpha active iridium isotopes

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Abstract: Seven alpha active isotopes of iridium have been found in ^{16}O and ^{19}F bombardments of thulium and erbium targets. The activities were observed by using a fast recoil collection apparatus and they were identified by cross bombardments and excitation function measurements. Their decay characteristics are as follows:

	E_α (MeV)	$T_{1/2}$ (s)
^{177}Ir	5.011 ± 0.010	21 ± 2
^{176}Ir	5.118 ± 0.008	8 ± 1
^{175}Ir	5.393 ± 0.005	4.5 ± 1
^{174}Ir	5.478 ± 0.006	4.0 ± 1
^{173}Ir	5.665 ± 0.005	3.0 ± 1
^{172}Ir	5.810 ± 0.005	1.7 ± 0.5
^{171}Ir	5.910 ± 0.005	1.0 ± 0.3

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* Work supported by the U.S. Atomic Energy Commission.

RADIOACTIVITY $^{171-177}Ir$ [from $^{169}Tm(^{16}O,xn)$, $^{162-166}Er(^{19}F,xn)$] ; measured E_α, $T_{1/2}$. Enriched targets.

1. Introduction

During an earlier study dealing with light platinum isotopes[1)] a few alpha groups appeared that can be assigned to neutron deficient isotopes of iridium. This paper gives a report on experiments performed in order to determine some of the decay properties of these activities.

2. Experimental

Iridium activities were produced by bombarding thulium and erbium isotopes with heavy ion beams from the Berkeley Hilac. A continuously operating recoil collection apparatus was used to transfer the resulting activities from the target chamber to the counting position. The alpha spectrum was measured with a Au-Si surface barrier counter; this was done at various bombarding energies. Northcliffe's range-energy curves[2)] were used to determine the actual bombarding energies from the full energy (10.4 MeV/amu) and known degrader thickness. A more detailed description of the method was given in the preceeding paper[1)].

3. Results

3.1. Alpha spectra

In the first experiments where thulium was bombarded with oxygen ions a few new alpha groups were observed. Their energies were approximately 5.0, 5.1, and 5.4 MeV. The excitation functions for the reactions $^{169}Tm(^{16}O,xn)^{185-x}Ir$ (assuming that the activities are isotopes of iridium) indicate that the mass numbers of the alpha emitters are equal or less than 177 (see fig.3).

All other experiments were performed with ^{19}F beam and erbium isotopes as targets. The isotopic composition of these targets * was not as good as would have been desirable except for ^{166}Er.

The alpha spectra showed a number of new groups that can be assigned to iridium. Two representative spectra are shown in figures 1 and 2. The alpha particle energies were determined by linear interpolation from standards ^{234}U, ^{241}Am, ^{244}Cm, and ^{252}Cf, whose energies were taken from Wapstra's table[3]. The resulting energies are listed in table 1. All energy measurements gave results inside the indicated error limits. The 5.393MeV group was the most prominent activity.

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* The isotopic compositions (in %) were as follows:

	162	164	166	167	168	170
^{162}Er	14.1	9.0	40.0	17.1	14.6	5.2
^{164}Er	<0.2	35.1	47.4	9.8	6.2	1.5
^{166}Er	<0.1	0.1	72.9	17.7	8.5	0.8

The half-lives, also shown in table 1, were determined during the ^{19}F + Er experiments. This was done by cycling the accelerator and pulse-height analyzer to obtain eight successive spectra between beam-on periods.

3.2. Rare earth alpha emitters

In the alpha spectra (see figs.1 and 2) numerous peaks can be seen in the energy region from 4 to 4.8MeV. As is indicated these are rare earth alpha emitters, some of them are identified in fig.2. Their energies and half-lives agree very well with those reported by Macfarlane and Griffioen[4,5]. The yield of these activities was highest at highest bombarding energies and when the lightest target ^{162}Er was used. In a ^{20}Ne+ ^{162}Er bombardment the yield was much smaller than in the ^{19}F+ ^{162}Er experiment.

There are two ways through which the rare earth alpha emitters can be produced by bombardments like ^{19}F+ ^{162}Er (possible impurities in targets are definitely ruled out). Firstly, it is possible that very neutron deficient isotopes of Ir, Os, etc., that are produced through ordinary compound nucleus reactions, lead to alpha decay chains with the rare earths as final steps. These chains would be very difficult to study because the alpha particle energy would be almost constant throughout the chain. Secondly, very light rare earth isotopes can be directly produced through reactions of the type (^{19}F,xnyp) and those lighter than erbium through various multinucleon stripping reactions. The latter have been studied by Grochulski et.al.[6] and they are known to have nonzero cross sections.

3.3 Excitation functions

The activities listed in table 1 are assigned to the element iridium because they are produced in bombardments where the compound nuclei were isotopes of iridium. They were not present in ^{16}O + Er bombardments which produce isotopes of osmium and lighter elements.

The excitation functions obtained from the $^{16}O + ^{169}Tm = ^{185}Ir^{*}$ and $^{19}F + ^{166}Er = ^{185}Ir^{*}$ are shown in fig. 3. The two reactions that show a maximum are a (^{19}F,8n) and a (^{19}F,9n), and the corresponding alpha groups (5.011 and 5.118 MeV) belong to ^{177}Ir and ^{176}Ir. These assignments are based on the results obtained during the platinum study[1] and on the same arguments as were used in assigning the platinum alpha activities. The third activity (5.393 MeV) has not gone through its maximum yet, although the last point indicates the proximity of the peak. We assign this activity to the next lighter isotope ^{175}Ir, the corresponding reaction is a (^{19}F,10n).

In the other bombardments, $^{19}F + ^{164,162}Er$, the excitation functions were not as clean because of the poor enrichments (see footnote p.3). The curves are shown in fig. 4. The maxima in the upper part of the figure represent most probably contributions from the reactions ^{162}Er(^{19}F,6n) and ^{162}Er(^{19}F,8n) to the production of the indicated activities. This is in agreement with our earlier assignment of the 5.393MeV alpha group to ^{175}Ir and indicates that the 5.665MeV alpha emitter is ^{173}Ir. The other activities with alpha energies of 5.478, 5.810, and 5.910 MeV are assigned to ^{174}Ir, ^{172}Ir, and ^{171}Ir according to the order in which they appear when bombarding energy is increased.

To make sure that all these activities are not due to isotopes of osmium, ^{16}O + Er bombardments were performed. None of the alpha groups in the table 1 were observed. A few weak activities that could be light osmiums were present together with large amounts of rare earths. Because of the latter no attempt was made to study the possible osmium alpha activities in more detail.

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References:

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Table 1

Decay properties of iridium alpha emitters

A	E_α(MeV)	$T_{1/2}$ (s)
177	5.011 ± 0.010	21 ± 2
176	5.118 ± 0.008	8 ± 1
175	5.393 ± 0.005	4.5 ± 1
174	5.478 ± 0.006	4.0 ± 1
173	5.665 ± 0.005	3.0 ± 1
172	5.810 ± 0.005	1.7 ± 0.5
171	5.910 ± 0.005	1.0 ± 0.3

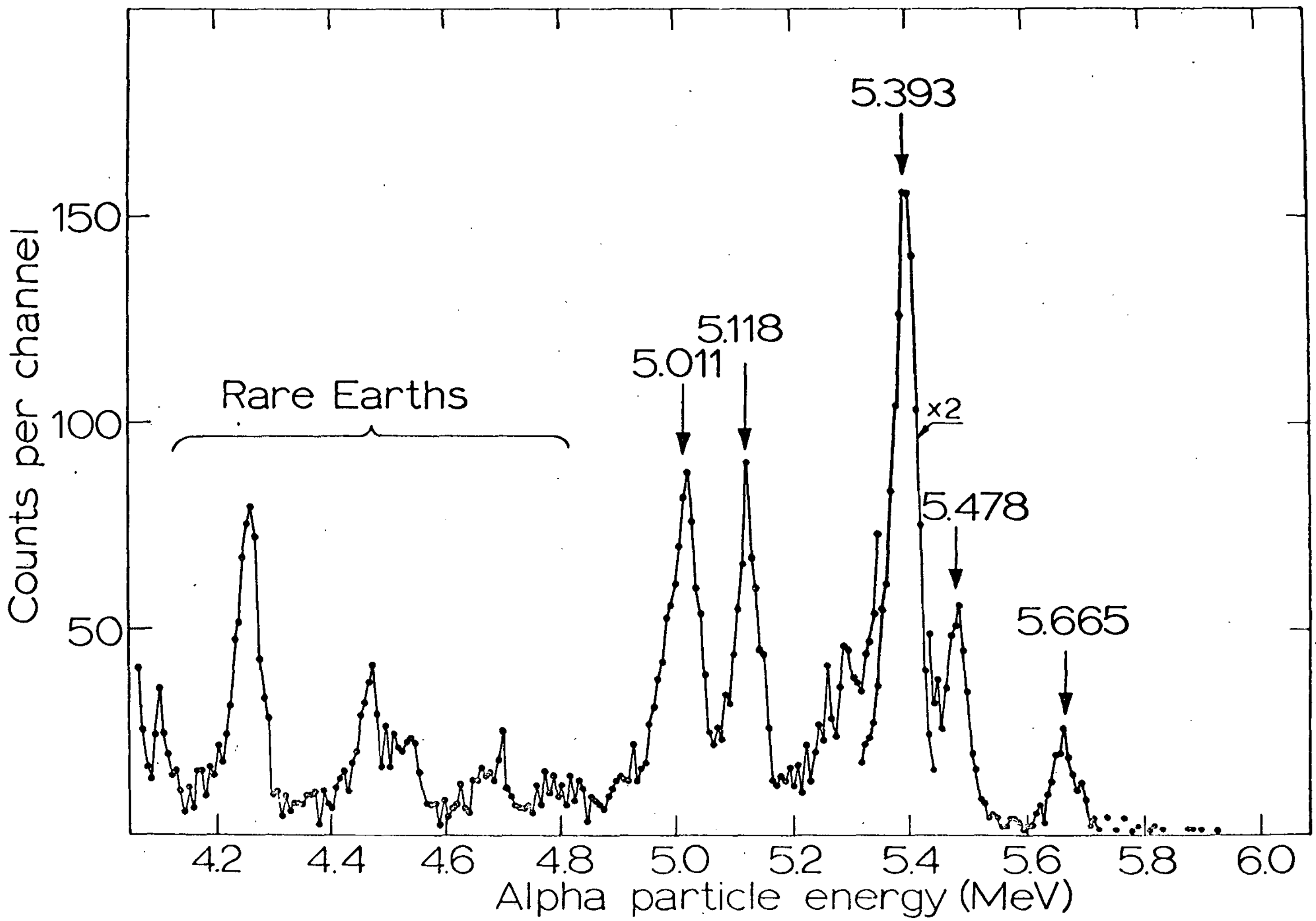
Figure captions:

Fig. 1 An alpha spectrum of iridium isotopes. This is a sum of five spectra taken during ^{19}F + ^{164}Er bombardments at laboratory energies from 145 to 175 MeV.

Fig. 2 An alpha spectrum of iridium isotopes produced in a ^{19}F + ^{162}Er bombardment at 185 MeV_{lab}.

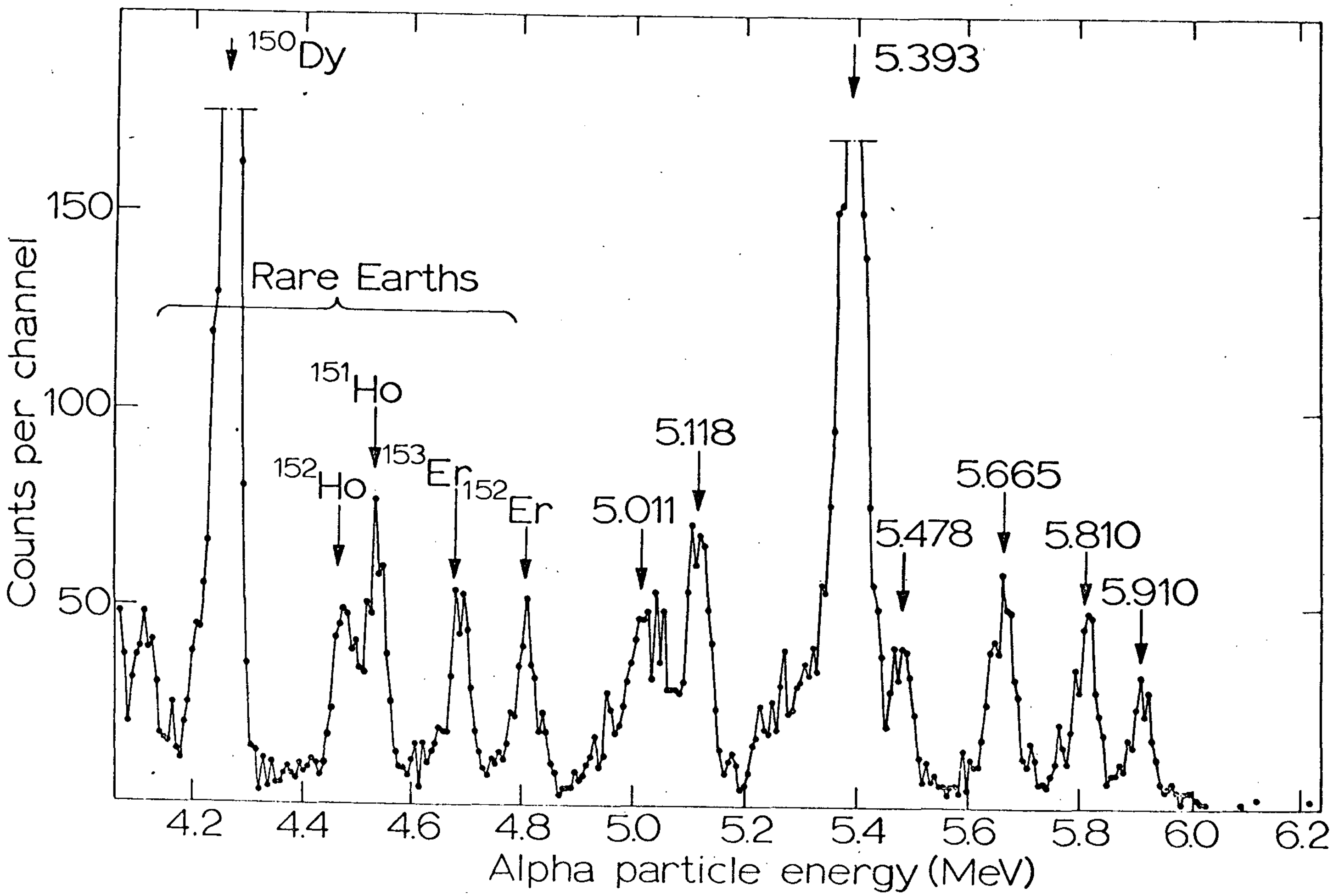
Fig. 3 Excitation functions for the 5.01 (▼), 5.12 (✶), and 5.39 MeV (◘) activities when they are produced in a ^{16}O + ^{169}Tm (dashed line) and a ^{19}F + ^{166}Er (solid line) bombardment, both of which result in the same compound nucleus ^{185}Ir.

Fig.4 Excitation functions obtained from ^{19}F bombardments of ^{164}Er and ^{162}Er targets. Because the targets were not very pure (see footnote p.3) many compound nuclei are formed in each experiment. The reactions producing the indicated alpha activities from various erbium isotopes are identified through the number of evaporated neutrons at the high energy end of the curves.



Counts per channel
150
100
50
Rare Earths
5.011
5.118
5.393
×2
5.478
5.665
4.2
4.4
4.6
4.8
5.0
5.2
5.4
5.6
5.8
6.0
Alpha particle energy (MeV)

Fig. 1



150Dy
5.393
Rare Earths
151Ho
152Ho
153Er
152Er
5.011
5.118
5.478
5.665
5.810
5.910
Counts per channel
50
100
150
4.2
4.4
4.6
4.8
5.0
5.2
5.4
5.6
5.8
6.0
6.2
Alpha particle energy (MeV)

Fig. 2

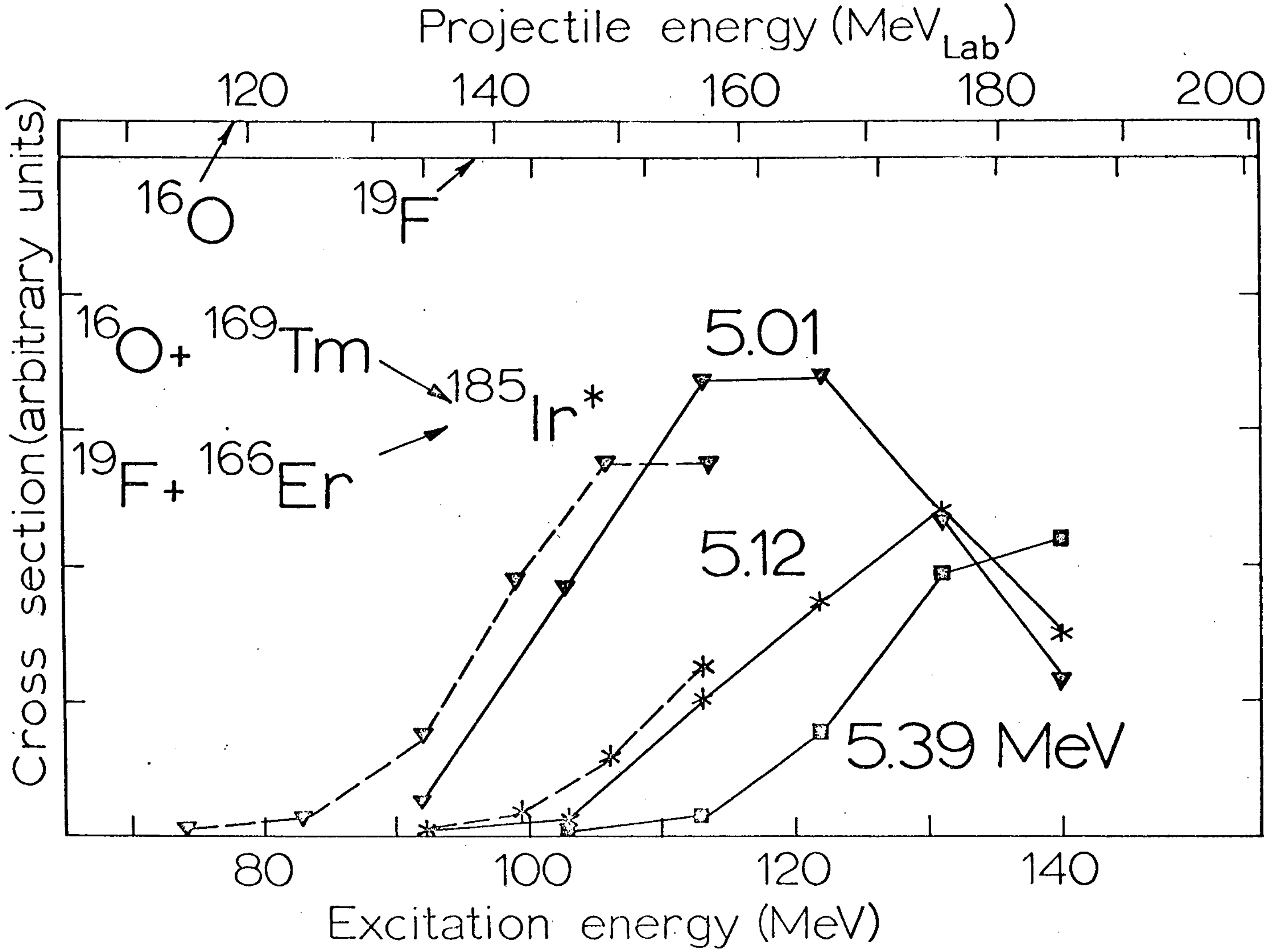


Fig. 5

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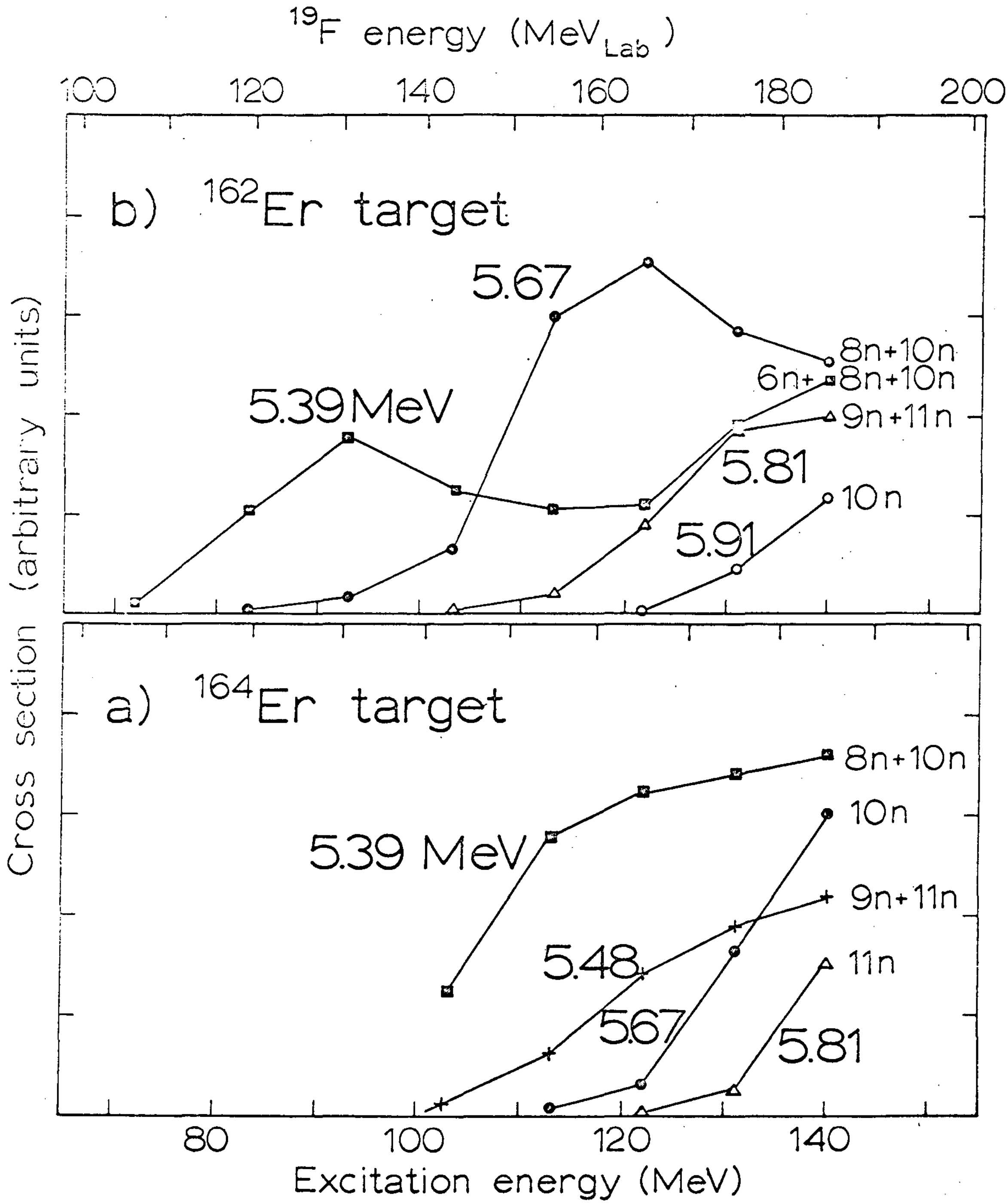

^{19}F energy (MeV$_{Lab}$)
100
120
140
160
180
200
b) ^{162}Er target
5.67
8n+10n
6n+ 8n+10n
5.39 MeV
9n+11n
5.81
10n
5.91
Cross section (arbitrary units)
a) ^{164}Er target
8n+10n
10n
5.39 MeV
9n+11n
5.48
11n
5.67
5.81
80
100
120
140
Excitation energy (MeV)

Fig. 4