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NUCLEAR SPECTROSCOPY OF IODINE ISOTOPES WITH A≥134

E. O. Achterberg, E. Y. de Aisenberg, F. C. Iglesias, A. E. Jech x), J. A. Moragues x), D. Otero, M. L. Pérez x), A. N. Proto-Otero, J. J. Rossi, W. Scheuer and J. F. Suárez
Comisión Nacional de Energía Atómica,
Buenos Aires, Argentina.

1. INTRODUCTION

During our exploration of the heavy fission peak of ^{235}U in search of iodine isotopes at the Buenos Aires ISOL xx) we were able to record significant activity from mass numbers 134, 135 and 136.

The available information for ^{134}I at that time [1) 2) 3) 4)] included the observation by Erten and Coryell [1)] of a 273 keV gamma ray with a half-life of 3.8 ± 0.5 min, and we decided to investigate the nature of this transition and of the associated isomeric state. Erten and Coryell had concluded that this isomeric level belonged to the I level scheme on the basis of their observtions of the growth and decay of the activity due to low-lying transitions in ^{134}Xe. Once our measurements had started, Erten, Coryell and Walters [5)] suggested that the 273 keV ray itself belonged to I and that it was the transition which depopulated the isomeric level. In a still later report [6)] the same authors included a 44.3 keV transition in cascade with the 273 keV ray, which they had detected as having the proper half-life. After our experimental work on the isomeric transition had been completed, our

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x) Member of the Scientific Research Career of the Consejo Nacional de Investigaciones Científicas y Técnicas

xx) Detailed description to be published.

attention was called to a paper by Carraz, Blachot, Monnand and Moussa [7] dealing with the study of the 272 keV transition. Our conclusions agree with their experimental results, but also allow us to put the assignment of this transition to the I level-scheme on a much firmer basis. Besides, our on-line electron spectra allowed us a definite determination of the multipolarity of the isomeric transition, as well as of other gamma rays following ^{134}I ground-state decay.

2. EXPERIMENTAL RESULTS

We made a considerable number of measurements, mainly on-line, obtaining single and coincidence spectra, both for gamma rays and for electrons. The detectors used were two Ge(Li) diodes of 35 and 45 cm^3 with a resolution of about 2.5 and 3.5 keV FWHM for the 1332 keV ^{60}Co peak. We also used a small Si(Li) detector which had a resolution of about 7 keV for the 976 keV conversion line of ^{207}Bi. These detectors were coupled by means of high quality electronics (Nuclear Diodes preamplifiers and Tennelec amplifiers) to a multichannel analyzer system provided with two 4096 channel ADC's and several readout peripherals under control of a small computer. The software for this system was suitably modified for our requirements and in part developed at our laboratory.

In this way the energies and intensities for the most important transitions following the ^{134}I ground-state decay were determined (Table 1) and found to be in reasonable agreement with the data obtained by other groups [2)4)] in their study of chemically separated I, except in the case of some intensities at low energy.

For the energy of the short-lived transition we obtain

$$E = 271.7 \pm 0.3 \text{ keV}$$

and by following the decay of this ray for several half-lives we also get

$$T_{\frac{1}{2}} = 3.50 \pm 0.12 \text{ min}$$

for the half-life of the isomeric level.

Combining the intensity data from the gamma and electron spectra and using the well-known value for the conversion coefficient of the 279 keV transition in ^{203}Hg as a standard, we get for the 272 keV ray

$$\begin{aligned} \alpha_K &= 0.20 \pm 0.03 \\ K/L+... &= 2.6 \pm 0.3 \end{aligned} \qquad \text{(E3)}$$

We thus conclude that the 272 keV gamma ray is the time-setting isomeric transition.

To confirm the suggested placing of this transition as part of the ^{134}I level-scheme, we measured the energy difference between the L- and K-electron conversion lines, obtaining 28.4 ± 0.2 keV which agrees well with the expected value of 28.3 keV for I, as compared to 29.5 keV for Xe. This conclusion also agrees with the fact that the 272 keV peak does not appear in an on-line coincidence spectrum gated by the prominent 847 and 884 keV transitions in ^{134}Xe.

Further analysis of the on-line spectra obtained with the Si(Li) detector showed that there is conclusive evidence for the existence of a low-lying, highly converted transition in cascade with the 272 keV ray, which might be identical with the 44.3 keV ray reported in ref. 6). Due to experimental difficulties, mainly a very high neutron-induced background, we were unable to obtain more definite data on this transition.

By analyzing the decay of ^{134}I activity for energies above 280 keV we conclude that there is a significant feeding of Xe levels from the isomeric state in I. Further work on the details of this feeding is in progress.

We next used our set-up to measure a number of conversion coefficients for mass 134; the resultant data are summarized in Table 2.

Our work at other masses has been limited so far to the recording of gamma and electron spectra and the calculation of some internal conversion coefficients. The results of these measurements are given in Tables 3 and 4.

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Table 1

γ-rays observed in the decay of ^{134g}I

E_γ(keV)	I_γ	E_γ(keV)	I_γ
134.4 ± 0.5	4.59 ± 0.14	948.3 ± 0.2	4.07 ± 0.09
161.7 ± 0.5	0.28 ± 0.01	966.8 ± 0.3	0.47 ± 0.05
186.8 ± 0.4	0.86 ± 0.09	974.8 ± 0.2	4.75 ± 0.10
217.8 ± 0.3	0.20 ± 0.02	1039.8 ± 0.2	1.90 ± 0.06
235.35 ± 0.07	2.16 ± 0.05	1072.2 ± 0.2	15.52 ± 0.22
279.1 ± 0.3	0.17 ± 0.09	1103.6 ± 0.2	0.88 ± 0.05
313.1 ± 0.3	0.14 ± 0.04	1136.3 ± 0.2	10.09 ± 0.17
319.8 ± 0.2	0.53 ± 0.02	1159.4 ± 0.2	0.37 ± 0.06
351.4 ± 0.2	0.37 ± 0.02	1191.3 ± 0.2	0.28 ± 0.08
405.7 ± 0.2	7.66 ± 0.10	1270.3 ± 0.2	0.61 ± 0.05
411.5 ± 0.2	0.58 ± 0.03	1323.0 ± 0.2	0.19 ± 0.12
434.1 ± 0.2	4.58 ± 0.07	1337.2 ± 0.2	0.14 ± 0.16
459.9 ± 0.2	1.38 ± 0.04	1354.4 ± 0.2	0.41 ± 0.07
489.7 ± 0.2	1.66 ± 0.03	1456.3 ± 0.2	2.10 ± 0.08
515.1 ± 0.2	2.71 ± 0.05	1470.8 ± 0.2	0.77 ± 0.06
541.7 ± 0.2	8.57 ± 0.12	1542.7 ± 0.2	0.48 ± 0.08
566.0 ± 0.2	1.26 ± 0.04	1614.2 ± 0.2	4.25 ± 0.11
570.8 ± 0.2	0.50 ± 0.15	1629.6 ± 0.3	0.14 ± 0.18
595.7 ± 0.2	11.62 ± 0.15	1645.1 ± 0.2	0.44 ± 0.07
622.4 ± 0.2	11.39 ± 0.16	1656.4 ± 0.3	0.16 ± 0.15
628.6 ± 0.2	2.38 ± 0.06	1741.7 ± 0.2	2.46 ± 0.09
677.8 ± 0.2	8.22 ± 0.19	1806.6 ± 0.2	5.52 ± 0.14
731.0 ± 0.2	1.94 ± 0.06	1925.6 ± 0.2	0.18 ± 0.13
739.3 ± 0.2	0.63 ± 0.04	2020.4 ± 0.2	0.17 ± 0.15
767.0 ± 0.2	4.30 ± 0.09	2157.1 ± 0.3	0.15 ± 0.16
817.2 ± 0.2	0.75 ± 0.04	2260.2 ± 0.3	0.12 ± 0.17
836.7 ± 0.2	0.65 ± 0.05	2310.2 ± 0.3	0.22 ± 0.13
847.3 ± 0.2	100.0 ± 1.1	2407.6 ± 0.3	0.07 ± 0.29
857.8 ± 0.2	7.88 ± 0.13	2450.1 ± 0.3	0.07 ± 0.29
884.2 ± 0.2	68.0 ± 0.8	2466.4 ± 0.3	0.12 ± 0.19

Table 2

Conversion coefficients and multipolarities of transitions observed in mass 134.

Source	E_γ(keV)	$\alpha_K \times 10^3$	K/L+...	QL
^{134m}I	271.7	200 ± 30	2.6 ± 0.3	E3
^{134g}I	134.4	260 ± 40		M1
	186.8	170 ± 30		E2(+M1)
	235.4	70 ± 10	6.1 ± 0.7	M1-E2
	405.7	11 ± 2		E2
	434.1	15 ± 3		M1-E2
	541.7	6.6 ± 0.8		E2
	595.7	7.4 ± 0.9		M1
	622.4	4.7 ± 0.6		E2(+M1)
	628.6	1.9 ± 0.5		E1
	677.8			E2-M1-E1 a)
	847.3	1.8 ± 0.4	7.5 ± 0.6	E2
	857.8	4 ± 2		E3-E2-M1
	884.2	1.9 ± 0.3		E2

a) From the gamma intensity and a limit on the electron intensity.

Table 3

Properties of low-energy transitions following decay of ^{139}Xe

E_γ(keV)	I_γ	$\alpha_K x10^3$	K/L+...	QL
104	6 ± 1	800 ± 100	0.7 ± 0.1	E2
175	372 ± 10	120 ± 10	1.9 ± 0.1	E2
219	1100 ± 30	63 ± 5	4.2 ± 0.1	E2
290	198 ± 6	28 ± 5	3.4 ± 0.5	E2(+M1)
297	424 ± 10	31 ± 5	4.5 ± 0.5	E2(+M1)
339	13 ± 1	6 ± 1	3.2 ± 1	E3
357	11 ± 1	75 ± 10	2.2 ± 1	E3
394	156 ± 5	10 ± 3	3.3 ± 0.5	E2-M1

Table 4

Conversion coefficients of transitions observed in the mass region 133-137

Source	E_γ(keV)	$\alpha_K \times 10^3$	K/L+...	QL
^{133}I	529	8.7 ± 1.4		M1
	707			M1-E2-E1 a)
	875			E2-E1 a)
^{133}I + ^{133m}Xe	233	7200 ± 1300	2.45 ± 0.15	M4
^{135}I	857			E1 a)
^{135}I + ^{135m}Xe	527	200 ± 10		M4
^{135}Xe	250	60 ± 4	5.6 ± 0.6	M1 + E2
^{136}I	198	74 ± 15	6 ± 2	E2
	382	19 ± 5		M1-E2
^{137}Xe	456	9.8 ± 0.7	4.2 ± 0.3	E2

a) From the gamma intensity and a limit on the electron intensity.

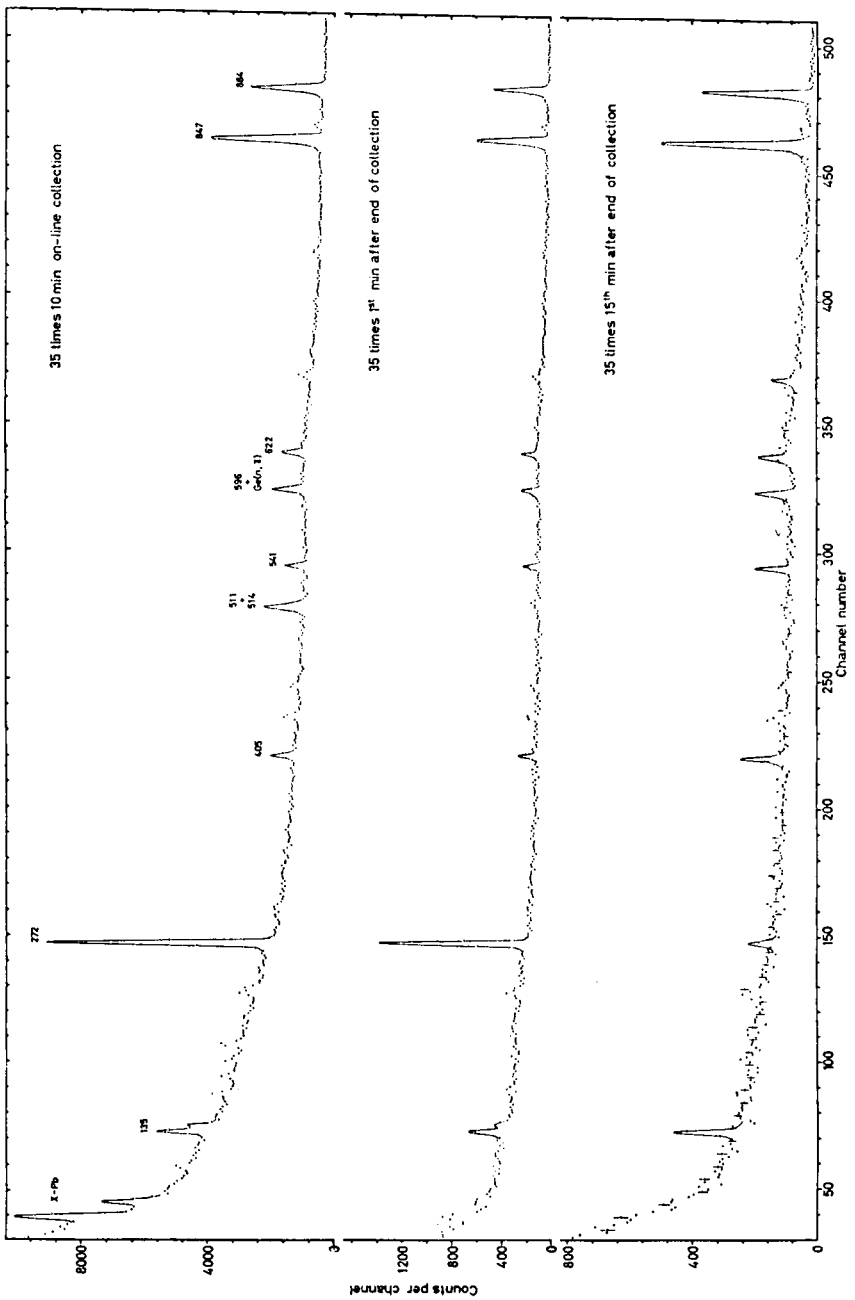

Fig. 1: Gamma spectrum for ^{134}I obtained with the 35 cm^3 Ge(Li) detector: decay of the 272 keV ray with time after end of collection

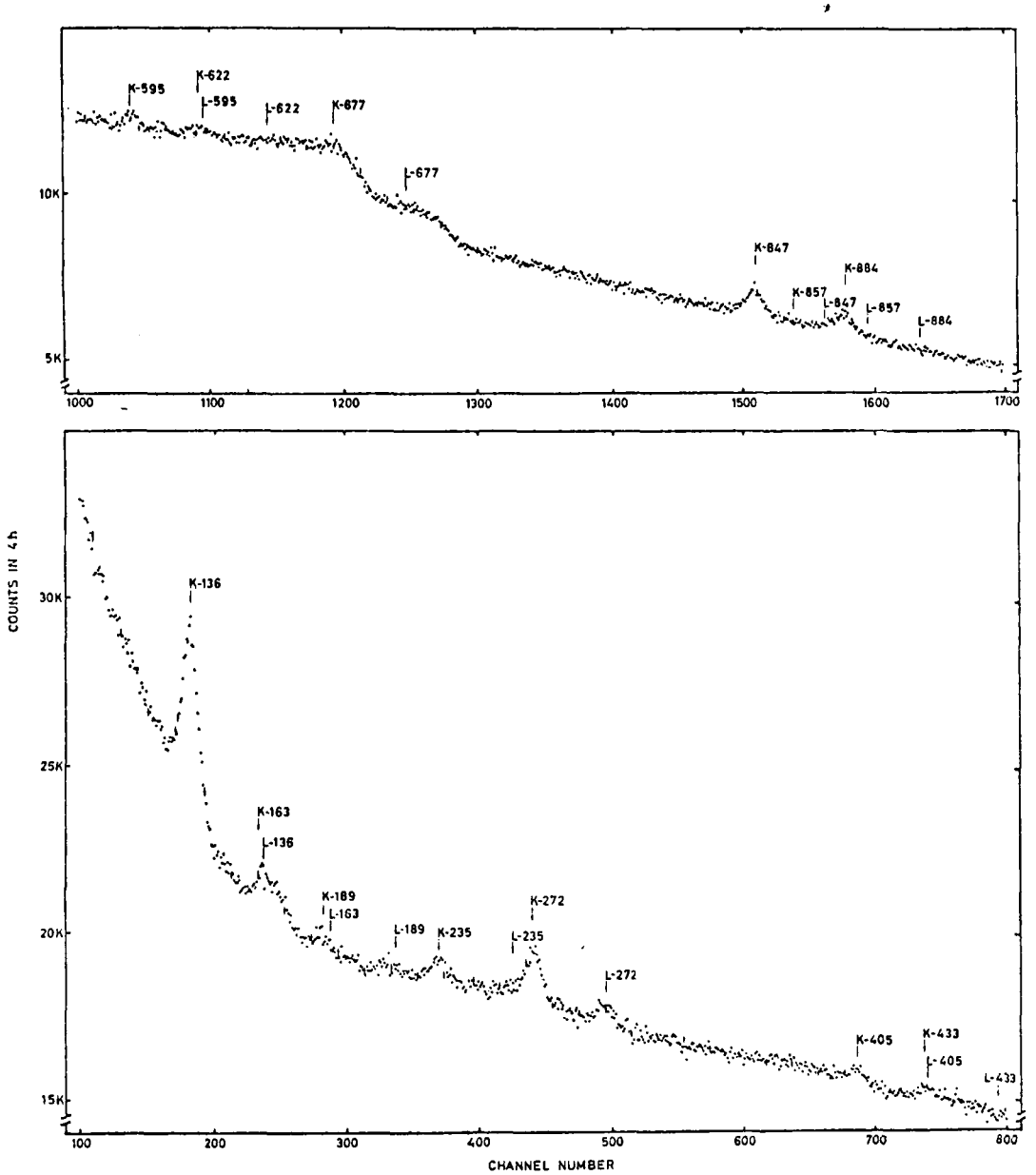

Fig. 2: On-line electron spectrum of ^{134}I

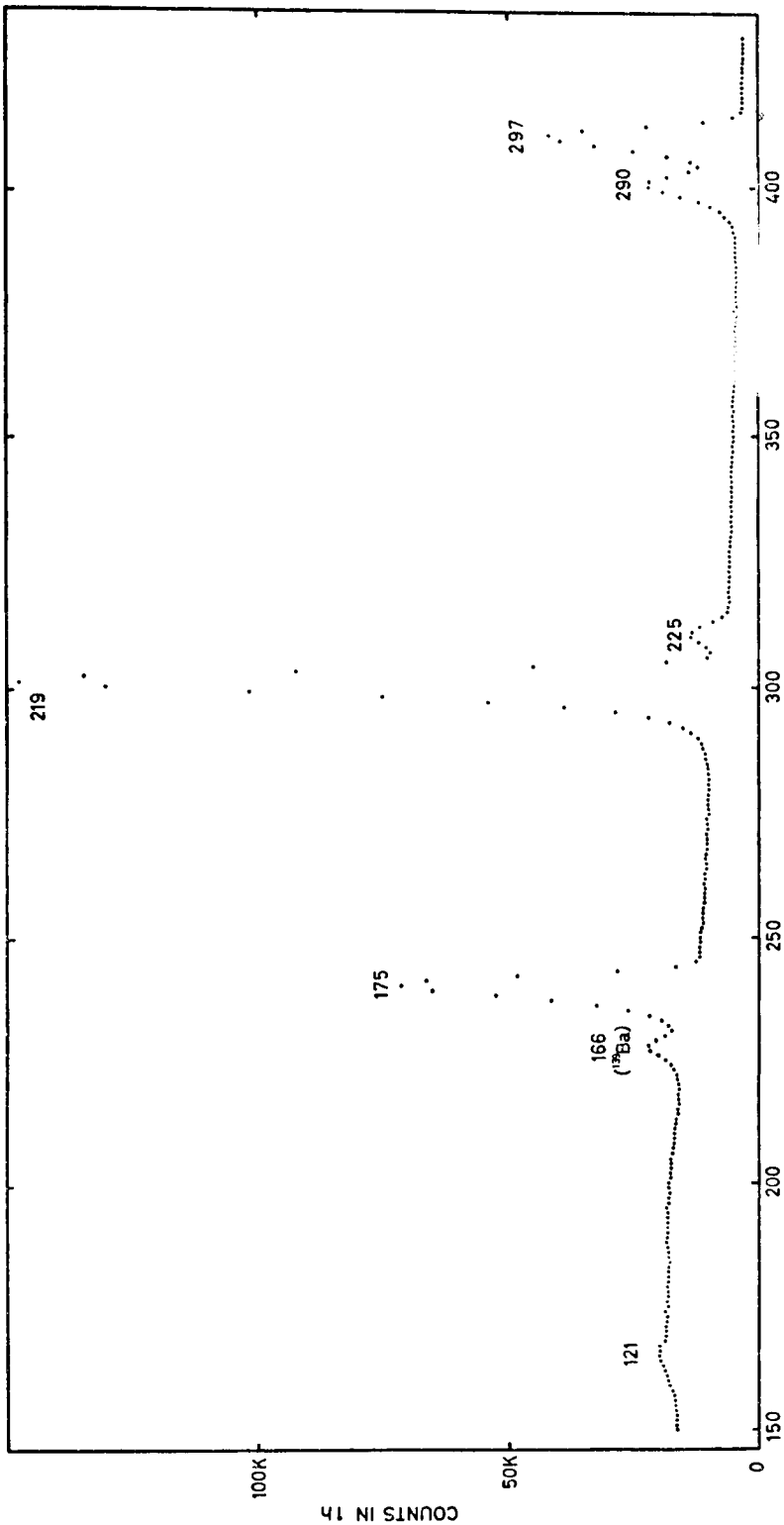

Fig.3: Portion of gamma spectrum for mass 139

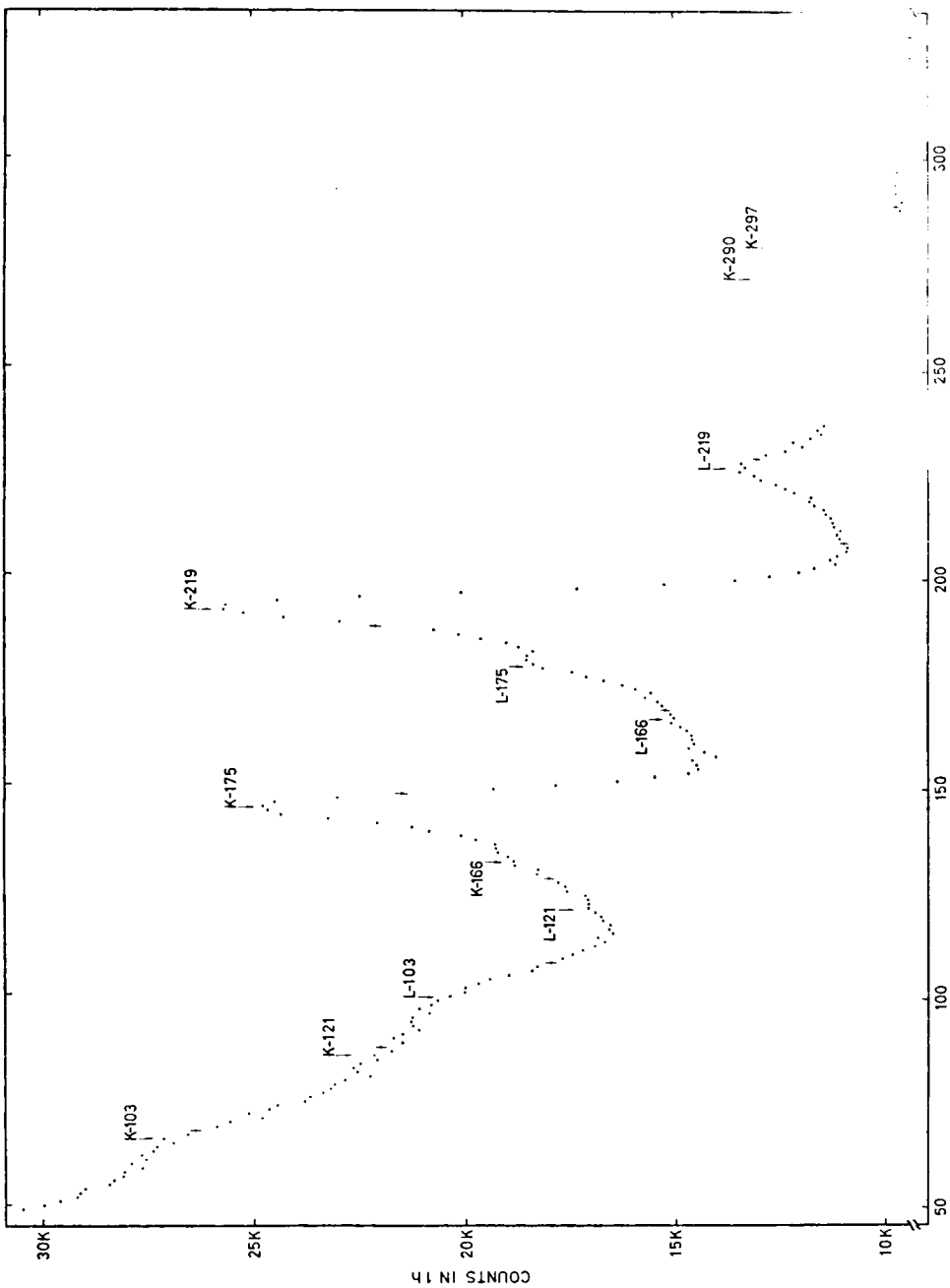

Fig. 4: Electron spectrum for mass 139