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ABSTRACT

The average beta and gamma energies in the decay of 382 known fission products have been determined. As far as possible the values are based on experimental data: direct determinations, published decay schemes, and a study of beta strength functions. In cases for which no experimental data exist the average energies have been derived using extrapolated beta strength functions.

1. Introduction

One of the most important quantities in the field of nuclear safety is the power developed by the decaying fission products. The reason for this is obvious. It is possible to stop the fission process in a reactor rapidly, but it is impossible to stop the decay of the fission products. The power developed in this decay is considerable, amounting to about 7 % of the total reactor power at equilibrium. This represents a very large power output, and in case of a loss-of-coolant accident this power might well melt the fuel with a disastrous evolution of radioactivities as a result. This explains the great importance of knowing the fission product power developed for the design and dimensioning of emergency cooling systems.

The decay power can be determined integrally, but such determinations have the weakness that the results are strictly valid only for the experimental conditions used during their determination. A more general method is the summation method. This method employs the summing of the contributions from the individual fission products using the abundances of these nuclides as weights. By separately summing the beta effect and the gamma effect the total beta power and gamma power can be obtained.

A direct experimental determination of the average beta energy of individual fission products has been carried out at this laboratory$^{1)}$. In the present work the results obtained are used to build a table of average beta energies to be used in the evaluation of the beta part of the decay power. The number of fission products studied is limited, but they represent a considerable part of the total beta effect. For the remainder of the known fission products the average beta and also gamma energies have been evaluated partly from known decay data, partly by extrapolating the features of the beta strength in the decay. This set of data are then used in conjunction with an inventory code$^{2)}$ to evaluate the fission product decay power in nuclear fuel.

2. Average beta energies

2.1 The average beta energy of fission products

A convenient way to determine the average beta energy of a nuclide is to measure the whole beta spectrum from as low an energy as possible up to the end-point, and then to evaluate the average value of the spectrum with due account taken of the part of the spectrum below the low-energy cut-off. This method is independent of any assumptions concerning, for example, the kind of beta transitions taking place. The accuracy of the determinations is often high, of the order of a few per cent of the values obtained. Errors of this magnitude will make a negligible contribution to the uncertainty of the beta heat in nuclear fuel.

The number of individual fission products, whose average beta energy has been measured at this laboratory so far, is 36 out of the total number of known radioactive fission products which is at present 382. Many of the measured ones belong to the most important fission products, however, and their combined contribution to the total beta effect is on the order of 30 per cent at cooling times between 0 and 100 seconds after stopping the reactor. Nevertheless, it is obviously also necessary to consider the remainder of the fission products.

If the decay scheme of a nuclide is well known the beta energy can be evaluated. Very few cases are so well known that this can be done without ambiguity, however.

Thus, the shape of the beta spectra has seldom been measured, and one usually has to make assumptions concerning the forbiddenness of the various beta branches in order to calculate the shape. Another questionable circumstance in the determination of the beta energy from published decay schemes is that the beta branches have, as a rule, been obtained from gamma spectroscopy only. The gamma energies, and intensities, are used to build up a decay scheme from which the beta branches are deduced as the difference between the intensities of gamma-rays depopulating and populating the various levels. The uncertainties of the intensities of the beta branches are then obtained from the gamma intensity errors. This method may be adequate if the decay scheme is well known but it obviously breaks down if there are any errors in the decay schemes. Experience shows that mistakes in the construction of decay schemes are not uncommon. In addition, certain gamma-rays may stay unplaced in a scheme, and other gamma transitions may remain undetected because of low intensity (cf. ref.$^{3)}$). Thus, evaluations of the average beta energy from decay scheme work though straightforward, may sometimes be seriously in error, and it is hard to determine the correct error to be attributed to the deduced values.

After these words of caution, it must be recognized that the evaluation of average beta energies from published decay schemes is probably still the best method after direct determinations. This method has therefore been adopted for those fission products for which decay schemes are available - a total of 273 nuclides, including isomers.

In the following discussion those nuclides whose average beta energies (or gamma energies) are deduced from decay schemes are classified at Type A nuclides. The technique used has been described in ref.$^{4)}$. In short, the excitation energy of the daughter is divided into a number of energy channels of size ΔE (usually 142.5 keV), and a beta feed function $b(E)\Delta E$ is defined as the probability of beta decay to an energy interval of size ΔE around the excitation energy E. The $b(E)$-function is obtained from the published data, and all the beta branches are assumed to have an allowed shape.

The beta spectra corresponding to the various energy channels are calculated and summed to give the composite beta spectrum from which the average energy is determined. If the statistical uncertainties of the beta feed function values are known, the error of the average beta energy can be deduced. This statistical error is not the only contribution to the uncertainty of the average energy, however. There is also a "systematic" contribution stemming from the fact that there is an error associated with the total decay energy. This error is evaluated as the difference between the average energy determined for a certain Q_β-value and the average energy obtained with the Q_β-value increased by one standard deviation. The total error is then obtained by adding the statistical and the systematic errors quadratically

In a study of the beta strength of neutron-rich nuclides the beta feed function has been directly determined for some 50 fission products$^{5)}$. This experimental information can also be used for an evaluation of the average beta energy of the nuclides investigated. There are 39 of these nuclides which are classified as Type B nuclides. It is to be expected that the results from Type B nuclides will be somewhat less accurate than those obtained from decay schemes. An analysis along these lines has earlier been done by Reich$^{6)}$.

Finally, there are cases for which no experimental data exist on which to base the calculation of the beta energies. However, the beta strength study referred to above$^{5)}$ led to the conclusion that the reduced transition rates seem to be independent of the excitation energy of the daughter. Using this finding and following the procedure described in ref.$^{4)}$ the beta feed function can be evaluated and the average beta energy calculated. These cases are classified as Type C nuclides, and the number of such nuclides, including isomers, is 132.

2.2 A study of the uncertainty to be expected for the average beta energies

The set of average beta energies determined experimentally$^{1)}$ can be used as a test of the accuracy to be expected for $\bar{E}_\beta$-values calculated according to the prescriptions for Type A, Type B, and Type C nuclides. Calculated results are then compared to experimental ones. The comparison is shown in Table 1 for seven nuclides belonging to Type A. An analysis of the ratio $\overline{E}_{\beta,calc}/\overline{E}_{\beta,exp}$ gives the value 1.02 with a standard deviation of the population of 12 %.

The nuclides belonging to Type B are treated in the same way and also tabulated in Table 1. The average ratio between calculated and experimental average energies turns out to be 1.10 with a standard deviation of 20 % for the population. The standard deviation of the mean value is 0.046, and it therefore seems as if the value 1.10 for the ratio might be significantly larger than unity. This large value may arise from the emission of delayed neutrons, however. The experimental beta feed function was derived from a measurement of the emission of gamma rays. In the case of delayed-neutron emission leading to the ground state of the final nucleus no gamma rays are emitted, and in this case no gamma rays could be observed in the experiment. This means that the beta feed function will be distorted towards lower excitation energies of the daughter as only beta decay to high excitation energy intervals can lead to the emission of delayed neutrons. Consequently, an appreciable beta branching to delayed-neutron emission will lead to too high an average beta energy evaluated for Type B nuclides. If all delayed-neutron precursors with $P_n > 1$ % are excluded the mean value of $\overline{E}_{\beta,calc}/\overline{E}_{\beta,exp}$ becomes 1.01 with a standard deviation of the population of 15 %. If only cases with $P_n > 5$ % are excluded the corresponding values turn out to be 1.05 and 19 %. Thus,after taking account of the delayed neutron precursors, there does not seem to be any significant departure of the ratio from unity.

In order to obtain a sufficient amount of data for a check of the method C most of the fission products for which experimental average beta energies are available have been treated as if they were Type C nuclides.The results,shown in Table 1, give an average value of the ratio of 1.04, and the standard deviation of the population is found to be 28 %.

The spread of the calculated values around the experimental ones is taken to be typical for the three different types of nuclides treated here. That is, statistical errors of 10 %, 20 % and 30 % are attributed to Type A, Type B and

Type C nuclides, respectively. The error caused by the uncertainty of the total beta decay energy, Q_β, is added quadratically to these errors.

3. Average gamma energies

The average gamma energy is easy to determine in simple cases with known energies, absolute branching ratios, and conversion coefficients. The accuracy will in general be higher than the accuracy of the corresponding beta energy because a knowledge of the total decay energy is not needed. In more complicated cases the feeding of high-lying parts of the daughter level structure is often little known, sometimes because of experimental difficulties but also because these level regions have not attracted the interest of the investigators sufficiently strongly to warrant an extensive study. Even in the case of average gamma energies a direct determination is therefore preferable, and such experiments are under way at this laboratory.

Awaiting direct experimental determinations the average gamma energies have been calculated, in analogy with the corresponding beta energies, from existing decay scheme data (Type A), from beta feed functions obtained in beta strength studies (Type B), or from an extrapolation of the trend of the beta strength (Type C). The average energies have been attributed the same accuracy as for the beta determinations, i.e. 10 %, 20 %, and 30 % for Type A, Type B, and Type C nuclides, respectively. For Type C-determinations, but not for the other types, a systematic error arising from the uncertainty of the Q_β-value also enters.

For Type A-nuclides with well-known decay scheme the error estimate given above is very conservative. A more realistic error estimate may be obtained by combining energies and absolute intensities and their associate errors. It is not easy to pick out the "well-known" cases, however, and the conservative error estimate is therefore retained in an attempt to counteract the possible sources of systematic errors mentioned above and in the preceding section.

As explained in the preceding section, the average beta energy determined using beta feed functions from the beta strength measurements (Type B) depends on the emission of delayed neutrons. A similar effect is not expected for the average gamma energy. For Type C-nuclides, however, a correction for the emission of delayed neutrons has to be made. This correction can be made in an approximative way as follows. If a beta branch leads to an excitation energy above the neutron separation energy S_n, the corresponding beta feed value, when used in the calculation of the average gamma energy, should be multiplied by the ratio $\Gamma_\gamma/(\Gamma_\gamma+\Gamma_n)$ where Γ_γ is the total gamma width and Γ_n the neutron width. This ratio generally decreases with increasing excitation energy, but it is replaced by an energy-independent factor taken to be the relative probability of emission of gamma rays from excitation energy regions above the neutron separation energy, *i.e.* of size

$$\frac{\int_{S_n}^{Q_\beta} b(E)dE - P_n}{\int_{S_n}^{Q_\beta} b(E)dE},$$

where P_n is the delayed neutron branching ratio. By making the correction factor energy-independent the resulting average gamma energy might seem to come out too high. However, this at least partly compensates for the fact that beta emission to high excitation energy bands will often lead to neutron emission to excited states in the final nucleus. The subsequent gamma emission from this nucleus will raise the average gamma energy.

4. Results

4.1 Table of average beta and gamma energies

The resulting average beta and gamma energies are tabulated in Table 2. The energies of conversion electrons and X-rays have been added to the beta effect.

The type of treatment has been denoted by the following symbols:

A = nuclide treated as Type A nuclide,
AT = same as above but with correction for conversion electrons and X-rays (from ref.[7]) carried out,
B = nuclide treated as Type B nuclide,
C = nuclide treated as Type C nuclide,

E = nuclide with experimental determination of the average beta energy,
F = nuclide with average energy taken from ref.$^{8)}$,
T = nuclide with average energy taken from ref.$^{7)}$.

Published decay schemes are taken mainly from the compilation of ref.$^{8)}$. Total beta decay energies have been taken from the compilation of ref.$^{9)}$ or from recent publications.

4.2 Comparison with the ENDF/B IV file

A comparison between the average beta and gamma energies obtained in the present work and included in the FPLIB fission product library$^{2)}$ and the values included in the ENDF/B IV file$^{10)}$ has been carried out. The results are shown in Tables 3 and 4 where the ratios between the average beta and gamma energies in the ENDF/B IV and in the FPLIB files are analysed. The mass range 72 - 166 has been split up into regions of roughly equal size in the following way:

Mass region 72 - 87	corresponding to: left wing of low-mass peak
Mass region 88 - 102	corresponding to: low-mass peak
Mass region 103 - 117	corresponding to: right wing of low-mass peak
Mass region 118 - 132	corresponding to: left wing of high-mass peak
Mass region 133 - 147	corresponding to: high-mass peak
Mass region 148 - 166	corresponding to: right wing of high-mass peak.

The agreement is shown separately for the three types of nuclides A, B, and C.

It might be expected that average energies deduced from published decay schemes (type A nuclides) should agree well, i.e. give a ratio of unity. This is the case, the mean values of the ratios being 0.96 ± 0.02 for average beta energies and 1.02 ± 0.02 for average gamma energies. However, there are a number of nuclides where the discrepancies are large, especially for the gamma energies. Such cases are ^{110}Ru, ^{113}Pd, ^{114}Pd, ^{115,115m}Cd, ^{116}Pd, ^{116}Ag,

^{117m}Ag, ^{118}Cd, $^{121,121m}Sn$, ^{122}Sb, ^{124}Cd, $^{128,128m}Sb$, ^{136}Cs, ^{143}La, ^{148}Pr, ^{152m}Pm, ^{157}Sm, and ^{165}Dy. Apparently, different decay schemes have been used for the calculation of the average energies for these nuclides. This exemplifies the danger of putting too much faith into published decay schemes.

The group A contains all long-lived fission products and many of the short-lived ones. Groups B and C are short-lived nuclides with the beta-feed known from beta strength studies (B) or deduced from extrapolations of the beta strength (C). The mean ratios for the average beta energies are 0.90 ± 0.04, and 1.01 ± 0.02 for these groups, i.e. somewhat low for Group B and close to unity for Group C. On the whole, the average beta energies deduced in the present work agree quite well with those included in the ENDF/B IV file, the mean ratio of all the nuclides being 0.98 ± 0.01.

For the average gamma energies there is no significant difference in the case of Type C-nuclides, the mean ratio being 1.04 ± 0.06. For Type B-nuclides there is an important discrepancy, to a large extent caused by a few nuclides, and the mean ratio reaches as high as 1.60 ± 0.22. The error indicates the wide spread of the values in the population. The reason for this discrepancy is not known. These high results lead to a mean ratio of all the fission products of 1.13 ± 0.05, i.e. the average gamma energies in the FPLIB-library are, on the average, 13 % lower than those of the ENDF/B IV file.

Finally, it is of interest to compare the ENDF/B IV file values for average beta energies with experimental values from ref.1). The mean ratio obtained is 1.03 ± 0.05. The standard deviation of the population is quite large, 30 %, but apparently the mean ratio is compatible with the value of unity.

4.3 List of important fission products

Obviously, the importance of knowing the average beta and gamma energies accurately varies widely from fission product to fission product. This has been investigated with ^{235}U fuel that had been irradiated for 10^7 s. The code INVENT and the fission product library FPLIB[2)] were used to evaluate the relative contributions of the fission products to the beta power at the cooling times 1, 3, 10, 30, 100, 300, 1000, 10^4, 10^5, 10^6, 10^7, and 10^8 s. The results are shown in Fig 1 where only those fission products which are among the top three contributors to the beta heat at one or several of the above-mentioned cooling times have been plotted. For the most important fission products in the cooling time range up to about 100 s direct determinations of the average beta energy have been carried out. This list comprises ^{92}Rb, ^{94}Y, ^{95}Sr, ^{95}Y, ^{137}Xe, ^{139}Cs, and ^{140}Cs. Besides those mentioned, the most important ones up to a cooling time of about 10^4 s are ^{88}Rb, ^{92}Y, ^{93}Y, and ^{138}Cs. They can be easily measured at this laboratory. This has not yet been done because the studies have concentrated so far on short-lived nuclides.

Obviously, a figure like Fig 1 can only contain a limited number of fission products. Tables of the contributions of all the fission products to the beta or gamma power can easily be prepared, however, to be used as a means for setting priorities in experimental determinations of average beta and gamma energies.

Acknowledgements

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Table 1

Comparison between experimental average beta energies and calculated ones for Type A, B, and C nuclides

Nuclide	$\overline{E}_{\beta,\mathrm{exp}}$	$\overline{E}_{\beta,\mathrm{calc}}$ Type A	Ratio calc/exp	$\overline{E}_{\beta,\mathrm{calc}}$ Type B	Ratio calc/exp	$\overline{E}_{\beta,\mathrm{calc}}$ Type C	Ratio calc/exp
^{86}Br	1.92±0.11			2.09	1.09	2.27	1.18
^{87}Br	1.20±0.06			1.85	1.54	2.26	1.88
^{88}Br	1.63±0.07			2.43	1.49	2.74	1.68
^{89}Br	2.32±0.12			2.87	1.24	2.63	1.13
^{91}Kr	1.53±0.07			1.86	1.22	2.06	1.35
^{91}Rb	1.36±0.07	1.64	1.21			1.87	1.38
^{92}Kr	2.67±0.47			2.51	0.94	1.85	0.69
^{92}Rb	3.46±0.23			3.39	0.98	2.31	0.67
^{93}Kr	2.70±0.21					2.58	0.96
^{93}Rb	2.59±0.14			2.65	1.02	2.38	0.92
^{93}Sr	0.90±0.03	0.80	0.89			1.24	1.38
^{94}Rb	2.51±0.13			3.09	1.23	2.87	1.14
^{94}Sr	0.91±0.03	0.90	0.98			1.17	1.29
^{94}Y	1.78±0.07	1.82	1.02			1.45	0.81
^{95}Sr	1.92±0.09	2.27	1.18			1.94	1.01
^{95}Y	1.52±0.07	1.43	0.94			1.38	0.91
^{96m}Y	2.83±0.15	2.53	0.89			2.10	0.74
^{136}I	2.11±0.12			2.45	1.16	2.05	0.97
^{137}I	2.25±0.11			2.10	0.93	1.70	0.76
^{137}Xe	1.73±0.03			1.75	1.01	1.30	0.75
^{138}I	2.27±0.13					2.15	0.95
^{138}Xe	0.80±0.10					0.89	1.11
^{138}Cs	1.22±0.12					1.58	1.30
^{139}I	2.01±0.29			2.61	1.30	2.05	1.02
^{139}Xe	1.72±0.06			1.59	0.92	1.44	0.84
^{139}Cs	1.73±0.05			1.80	1.04	1.32	0.76
^{140}Xe	1.52±0.05			1.31	0.86	1.25	0.82
^{140}Cs	1.89±0.04			2.16	1.14	1.76	0.93
^{141}Xe	1.96±0.11			2.25	1.15	1.84	0.94
^{141}Cs	1.68±0.07			1.10	0.65	1.59	0.95
Average value of ratio calc/exp			1.02		1.10		1.04
Standard deviation of population			0.12		0.20		0.28

Table 2

Average beta and gamma energies

Nuclide		Average beta and gamma energies in MeV				Type of treatment
Atomic number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
30	71	1.07 ± .11	.28 ± .03	.58 ± .06	1.52 ± .15	A
31	71	stable				
30	72	.09 ± .01	.14 ± .01			T
31	72	.53 ± .05	2.67 ± .27			A
32	72	stable				
30	73	1.39 ± .42	1.55 ± .47			C
31	73	.45 ± .05	.40 ± .04			A
32	73			.06 ± .01	.01 ± .00	T
30	74	.46 ± .14	.84 ± .25			C
31	74	1.10 ± .11	2.92 ± .29			A
32	74	stable				
30	75	1.39 ± .42	2.57 ± .77			C
31	75	1.42 ± .17	.02 ± .00			A
32	75	.45 ± .04	.02 ± .00	.08 ± .01	.06 ± .01	A,T
33	75	stable				
30	76	1.51 ± .31	.52 ± .10			B
31	76	2.17 ± .44	1.95 ± .39			B
32	76	stable				
33	76	1.10 ± .11	.36 ± .04			A
34	76	stable				
30	77	1.83 ± .38	2.78 ± .56			B
31	77	2.14 ± .43	.57 ± .11			B
32	77	.63 ± .06	1.14 ± .11	.97 ± .10	.04 ± .00	A,T
33	77	.18 ± .02	.01 ± .00			T
34	77			.08 ± .01	.08 ± .01	T
31	78	2.53 ± .70	2.57 ± .51			B
32	78	.25 ± .03	.32 ± .03			A
33	78	1.42 ± .15	1.01 ± .10			A
34	78	stable				
31	79	2.62 ± .52	1.02 ± .20			B
32	79	1.78 ± .37	.06 ± .01	1.67 ± .34	.30 ± .06	B
33	79	.84 ± .09	.02 ± .00			A
34	79	.04 ± .00	0.00 ± 0.00	.09 ± .01	.01 ± .00	T
35	79	stable				

Nuclide		Average beta and gamma energies in MeV				Type of treatment
Atomic number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
31	80	2.38 ± .56	4.65 ± .93			B
32	80	.93 ± .28	.26 ± .08			C
33	80	2.16 ± .22	.54 ± .05			A
34	80	stable				
35	80	.88 ± .09	.02 ± .00	.07 ± .01	.01 ± .00	AT,T
36	80	stable				
31	81	3.22 ± .81	1.54 ± .31			B
32	81	2.69 ± .72	.39 ± .08			B
33	81	1.52 ± .16	.27 ± .03			A
34	81	.63 ± .06	.01 ± .00	.09 ± .01	.01 ± .00	A,T
35	81	stable				
31	82	4.57 ± 1.45	4.65 ± 1.40			C
32	82	1.54 ± .55	.58 ± .17			C
33	82	2.05 ± .63	2.82 ± .56	3.26 ± .59	.30 ± .03	A,B
34	82	stable				
35	82	.18 ± .02	2.61 ± .26	.05 ± .01	.00 ± .00	A,AT
36	82	stable				
31	83	4.23 ± 1.41	3.64 ± 1.09			C
32	83	3.26 ± 1.03	2.75 ± .82			C
33	83	1.86 ± .39	1.26 ± .25			B
34	83	.49 ± .05	2.37 ± .24	1.24 ± .12	.93 ± .93	A
35	83	.31 ± .03	.01 ± .00			A
36	83			.04 ± .00	0.00 ±0.00	T
32	84	2.59 ± .81	1.72 ± .52			C
33	84	3.84 ± 1.25	1.50 ± .45			A
34	84	.53 ± .16	.46 ± .14			A
35	84	1.31 ± .39	1.65 ± .50	.94 ± .25	2.73 ± .27	A
36	84	stable				
33	85	3.32 ± 1.04	1.30 ± .47			C
34	85	2.64 ± .72	.27 ± .05			B
35	85	1.18 ± .24	.09 ± .02			B
36	85	.26 ± .03	.00 ± .00	.28 ± .03	.14 ± .01	A,AT
37	85	stable				
33	86	4.07 ± 1.26	3.33 ± 1.05			C
34	86	1.74 ± .59	.76 ± .23			C
35	86	1.93 ± .11	2.97 ± .59			E,B
36	86	stable				

Nuclide		Average beta and gamma energies in MeV				Type of treatment
Atomic number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
37	86	.67 ± .07	.09 ± .01	.01 ± .00	.55 ± .06	A,T
38	86	stable				
33	87	3.73 ± 1.16	.42 ± .16			C
34	87	2.84 ± .91	2.23 ± .75			C
35	87	1.20 ± .06	2.67 ± .54			E,B
36	87	1.32 ± .13	.83 ± .08			A
37	87	stable				
34	88	2.21 ± .70	1.55 ± .59			C
35	88	1.63 ± .07	3.59 ± .72			E,B
36	88	.37 ± .04	2.00 ± .20			A
37	88	2.05 ± .21	.69 ± .07			A
38	88	stable				
34	89	3.33 ± 1.05	2.59 ± .85			C
35	89	2.32 ± .12	1.80 ± .36			E,B
36	89	1.44 ± .29	1.62 ± .32			B
37	89	1.04 ± .31	2.01 ± .60			C
38	89	.59 ± .06	0.00 ± 0.00			A
39	89	.01 ± .00	.90 ± .09			T
35	90	3.52 ± 1.10	2.00 ± .66			C
36	90	1.18 ± 0.02	.81 ± .16			E,B
37	90	1.36 ± .14	3.21 ± .32	1.32 ± .14	3.39 ± .34	A
38	90	.20 ± .02	0.00 ± 0.00			A
39	90	.94 ± .09	0.00 ± 0.00	.05 ± .01	0.00 ±0.00	A,AT
40	90			.01 ± .00	2.31 ± .27	T
34	91	3.12 ± .99	3.88 ± 1.16			C
35	91	3.17 ± 1.00	2.41 ± .78			C
36	91	1.53 ± .07	2.19 ± .44			E,B
37	91	1.36 ± .07	1.96 ± .39			E,B
38	91	.67 ± .07	1.03 ± .10			A
39	91	.61 ± .06	.00 ± .00	.03 ± .00	.53 ± .05	A,T
40	91	stable				
35	92	3.86 ± 1.31	2.57 ± .90			C
36	92	2.67 ± .47	.41 ± .08			E,B
37	92	3.46 ± .23	.38 ± .08			E,B
38	92	.25 ± .03	1.27 ± .13			A
39	92	1.46 ± .15	.25 ± .02			A
40	92	stable				

Nuclide		Average beta and gamma energies in MeV				Type of treatment
Atomic number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
36	93	2.70 ± .21	2.16 ± .67			E,C
37	93	2.59 ± .14	1.50 ± .30			E,B
38	93	.90 ± .03	2.00 ± .20			E,A
39	93	1.18 ± .12	.09 ± .01			A
40	93	.02 ± .00	0.00 ± 0.00			T
41	93			.03 ± .00	.00 ± .00	
36	94	2.06 ± .66	1.70 ± .62			C
37	94	2.51 ± .13	2.74 ± .55			E,B
38	94	.91 ± .03	1.24 ± .12			E,A
39	94	1.78 ± .07	.74 ± .07			E,A
40	94	stable				
41	94	.17 ± .02	1.60 ± .16	.04 ± .00	.00 ± .00	A,AT
42	94	stable				
37	95	2.72 ± .82	2.10 ± .64			C
38	95	1.92 ± 0.09	1.02 ± .10			E,A
39	95	1.52 ± .07	1.12 ± .11			E,A
40	95	.15 ± .02	.74 ± .07			A
41	95	.05 ± .01	.75 ± .08	.18 ± .02	.06 ± .01	A,T
42	95	stable				
37	96	3.06 ± .97	2.53 ± .82			C
38	96	1.65 ± 0.50	1.06 ± .32			C
39	96	1.10 ± .12	4.39 ± .44	2.83 ± .15	1.39 ± .14	E,A
40	96	stable				
41	96	.26 ± .03	2.47 ± .25			A
42	96	stable				
37	97	2.96 ± .94	1.23 ± .41			C
38	97	2.28 ± .69	2.12 ± .64			C
39	97	2.05 ± .21	2.04 ± .20	2.13 ± .22	1.87 ± .19	A
40	97	.72 ± .07	.87 ± .09			A
41	97	.51 ± .05	.62 ± .06	.02 ± .00	.73 ± .07	A,T
42	97	stable				
37	98	3.65 ± 1.18	3.20 ± 1.05			C
38	98	1.74 ± .52	1.23 ± .37			C
39	98	3.54 ± .60	.39 ± .04	2.51 ± .54	2.52 ± .25	A
40	98	.58 ± .06	.75 ± .07			A
41	98	1.97 ± .20	.12 ± .01	.90 ± .09	2.41 ± .24	A
42	98	stable				

Nuclide Atomic number	 Mass number	Average beta and gamma energies in MeV Ground state Beta	 Gamma	 Isomeric state Beta	 Gamma	Type of treatment
37	99	3.27 ± 1.03	2.48 ± .79			C
38	99	2.64 ± .85	2.50 ± .83			C
39	99	2.01 ± .61	1.79 ± .54			C
40	99	1.57 ± .16	.82 ± .08			A
41	99	1.56 ± .16	.13 ± .01	.98 ± .11	1.63 ± .16	A,AT
42	99	.41 ± .04	.28 ± .03			A
43	99			.10 ± .01	0.00 ±0.00	T
39	100	2.81 ± .89	3.45 ± 1.04			C
40	100	1.09 ± .33	.50 ± .15			C
41	100	1.63 ± .49	2.51 ± .75	1.72 ± .52	2.30 ± .69	C
42	100	stable				
43	100	1.32 ± .13	.08 ± .01			T
44	100	stable				
40	101	1.78 ± .62	1.86 ± .56			C
41	101	1.31 ± .39	1.52 ± .45			C
42	101	.58 ± .06	1.35 ± .14			A
43	101	.49 ± .05	.35 ± .04			AT
44	101	stable				
40	102	1.32 ± .46	.86 ± .26			C
41	102	1.93 ± .66	2.84 ± .85	2.02 ± .68	2.65 ± .80	C
42	102	.39 ± .13	0.00 ± 0.00			A
43	102	1.75 ± .18	.47 ± .05	.91 ± .47	2.53 ± .25	A
44	102	stable				
41	103	1.51 ± .56	1.72 ± .52			C
42	103	1.24 ± .50	1.39 ± .42			C
43	103	.84 ± .10	.28 ± .03			A
44	103	.07 ± .01	.45 ± .05			A,T
45	103	stable				
41	104	2.31 ± .76	3.28 ± .99	2.37 ± .77	3.15 ± .95	C
42	104	.90 ± .34	0.00 ± 0.00			A
43	104	1.62 ± .50	1.66 ± .17			A
44	104	stable				
45	104	1.00 ± .10	.01 ± .00	.10 ± .01	.03 ± .00	A,T
46	104	stable				
41	105	1.95 ± .66	2.20 ± .66			C
42	105	1.59 ± .57	1.74 ± .52			C
43	105	1.27 ± .16	.41 ± .04			A

Nuclide		Average beta and gamma energies in MeV				Type of treatment
Atomic number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
44	105	.42 ± .04	.80 ± .08			A
45	105	.19 ± .02	.08 ± .01	.10 ± .01	.03 ± .00	AT,T
46	105	stable				
41	106	2.80 ± .89	4.09 ± 1.23			C
42	106	1.02 ± .39	.59 ± .18			C
43	106	1.69 ± 0.60	2.43 ± .73			C
44	106	.01 ± .00	0.00 ± 0.00			T
45	106	1.44 ± .14	.18 ± .02	.38 ± .04	2.67 ± .27	A,AT
46	106	stable				
42	107	1.87 ± .64	1.95 ± .58			C
43	107	1.16 ± .48	1.46 ± .44			C
44	107	1.23 ± .19	.24 ± .02			A
45	107	.44 ± .05	.34 ± .03			A
46	107			.09 ± .01	.12 ± .01	T
42	108	1.37 ± .46	1.14 ± .34			C
43	108	2.21 ± .73	3.03 ± .91			C
44	108	.42 ± .13	.14 .04			C
45	108	1.78 ± .34	.40 ± .04	.82 ± .28	2.49 ± .25	A
46	108	stable				
47	108	.64 ± .06	.01 ± .00	.01 ± .00	1.82 ± .18	A,F
48	108	stable				
43	109	1.87 ± .64	2.39 ± .72			C
44	109	1.27 ± .50	1.30 ± .39	1.27 ± .50	1.30 ± .39	C
45	109	.86 ± .38	.37 ± .04			A
46	109	.37 ± .04	.09 ± .01	.07 ± .01	.12 ± .01	A,T
47	109			.09 ± .01	.00 ± .00	T
43	110	2.20 ± .73	3.06 ± .92			C
44	110	.58 ± .25	.22 ± .06			C
45	110	2.16 ± .22	.51 ± .05	1.32 ± .14	2.29 ± .23	A
46	110	stable				
47	110	1.19 ± .12	.04 ± .00	.13 ± .01	2.71 ± .27	A,AT
48	110	stable				
44	111	1.65 ± .58	2.11 ± .63			C
45	111	1.02 ± .46	1.05 ± .31			C
46	111	.84 ± .08	.09 ± .01	.22 ± .02	.38 ± .04	AT
47	111	.38 ± .04	.02 ± .00	.11 ± .01	0.00 ±0.00	A,T
48	111	stable				

Nuclide		Average beta and gamma energies in MeV				Type of treatment
Atom number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
44	112	1.07 ± .39	.72 ± .21			C
45	112	1.93 ± .66	2.68 ± .80			C
46	112	.09 ± .01	.00 ± .00			T
47	112	1.41 ± .14	.65 ± .07			A
48	112	stable				
44	113	1.98 ± .67	2.54 ± .76			C
45	113	1.57 ± .56	1.60 ± .48			C
46	113	1.46 ± .50	.08 ± .01			A
47	113	.78 ± .08	.06 ± .01	.57 ± .23	.58 ± .06	A,AT
48	113			.22 ± .02	0.00 ±0.00	A
49	113	stable				
45	114	2.29 ± .75	3.13 ± .94			C
46	114	.55 ± .23	.02 ± .00			A
47	114	2.08 ± .22	.12 ± .01			A
48	114	stable				
46	115	1.36 ± .51	1.44 ± .43			C
47	115	1.10 ± .12	.56 ± .06	.82 ± .25	1.16 ± .35	AT,C
48	115	.34 ± .03	.53 ± .05	.61 ± .06	.03 ± .00	A
49	115	.19 ± .02	0.00 ± 0.00	.17 ± .02	.16 ± .02	A,T
50	115	stable				
46	116	1.01 ± .14	.16 ± .02			A
47	116	1.61 ± .19	1.55 ± .16	1.89 ± .51	1.85 ± .19	A
48	116	stable				
49	116	1.38 ± .14	.02 ± .00	.35 ± .21	2.46 ± .25	AT
50	116	stable				
46	117	1.70 ± .59	1.81 ± .54			C
47	117	1.36 ± .27	1.25 ± .25	1.64 ± .33	.37 ± .07	B
48	117	.50 ± .05	1.25 ± .12	.28 ± .03	1.78 ± .18	A
49	117	.28 ± .03	.73 ± .07	.41 ± .04	.13 ± .01	AT
50	117			.18 ± .02	.14 ± .01	T
46	118	1.12 ± .40	1.13 ± .34			C
47	118	2.60 ± .70	1.42 ± .28	2.60 ± .70	1.42 ± .28	B
48	118	.27 ± .12	0.00 ± 0.00			A
49	118	.63 ± .15	2.58 ± .26	1.68 ± .22	.30 ± .03	A
50	118	stable				
47	119	1.87 ± .51	1.07 ± .11			A
48	119	.79 ± .15	1.55 ± .15	.89 ± .16	1.31 ± .13	A

Nuclide		Average beta and gamma energies in MeV				Type of treatment
Atomic number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
49	119	.62 ± .06	.75 ± .07	.88 ± .09	.33 ± .03	AT
50	119			.09 ± .01	.00 ± .00	T
47	120	2.18 ± .61	1.17 ± .23	1.51 ± .56	2.82 ± .85	B,C
48	120	.55 ± .17	.22 ± .07			C
49	120	2.23 ± .24	.22 ± .02	.91 ± .12	3.10 ± .31	A
50	120	stable				
47	121	1.61 ± .58	2.03 ± .61			C
48	121	1.33 ± .51	1.68 ± .51			
49	121	.89 ± .27	1.24 ± .37	1.13 ± .34	1.00 ± .30	C
50	121	.15 ± .02	0.00 ± 0.00	.15 ± .02	0.00 ±0.00	A
51	121	stable				
47	122	2.34 ± .76	3.51 ± 1.05			C
48	122	.83 ± .28	.51 ± .15			C
49	122	1.78 ± .54	2.50 ± .75	1.72 ± .52	2.68 ± .81	C
50	122	stable				
51	122	.36 ± .04	1.09 ± .11	.11 ± .01	.05 ± .01	A,T
52	122	stable				
47	123	2.21 ± .73	2.66 ± .80			C
48	123	1.78 ± .60	1.91 ± .57			C
49	123	1.67 ± .34	.51 ± .10	1.32 ± .40	1.63 ± .49	B,C
50	123	.53 ± .05	.01 ± .00	.52 ± .05	.10 ± .01	A,AT
51	123	stable				
48	124	2.01 ± .52	.10 ± .01			A
49	124	2.37 ± .48	1.82 ± .36	2.46 ± .50	1.82 ± .36	B
50	124	stable				
51	124	.42 ± .04	1.86 ± .19	.09 ± .01	.35 ± .04	AT,T
52	124	stable				
48	125	2.10 ± .68	1.92 ± .58			C
49	125	2.04 ± .41	.82 ± .16	2.30 ± .46	.45 ± .09	B
50	125	.83 ± .08	.30 ± .03	.81 ± .08	.35 ± .03	A
51	125	.11 ± .01	.44 ± .04			AT,T
52	125			.11 ± .01	.04 ± .00	
48	126	1.39 ± .47	1.24 ± .37			C
49	126	2.62 ± .53	2.33 ± .47	2.20 ± .66	3.13 ± .94	B,C
50	126	.07 ± .01	.05 ± .01			T
51	126	.37 ± .04	2.63 ± .26	.81 ± .08	1.66 ± .17	A,AT
52	126	stable				

Nuclide		Average beta and gamma energies in MeV				Type of treatment
Atomic number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
49	127	2.51 ± .50	.85 ± .17	1.99 ± .60	2.17 ± .65	B,C
50	127	.68 ± .08	1.43 ± .14	.97 ± .29	.74 ± .22	A,C
51	127	.31 ± .03	.75 ± .07			A
52	127	.25 ± .03	.01 ± .00	.09 ± .01	.00 ± .00	A,AT
53	127	stable				
49	128	3.25 ± .65	2.11 ± .42	3.25 ± .65	2.11 ± .42	B
50	128	.30 ± .03	.46 ± .05			A
51	128	1.02 ± .10	1.90 ± .19	.52 ± .05	3.04 ± .30	A
52	128	stable				
53	128	.86 ± .09	.05 ± .01			AT
54	128	stable				
49	129	3.04 ± .61	.84 ± .17			B
50	129	1.24 ± .37	1.07 ± .32	1.15 ± .48	1.51 ± .45	C
51	129	.39 ± .04	1.37 ± .14			A
52	129	.53 ± .05	.07 ± .01	.28 ± .03	.03 ± .00	AT,T
53	129	stable				
49	130	2.95 ± .90	2.93 ± .88			C
50	130	.45 ± .05	.99 ± .10	1.29 ± .40	.71 ± .21	A,C
51	130	1.35 ± .14	1.75 ± .18	1.01 ± .11	2.50 ± .25	A
52	130	stable				
53	130	.36 ± .04	2.05 ± .21	.17 ± .02	.10 ± .01	AT,T
54	130	stable				
49	131	4.00 ± 1.34	4.74 ± 1.42			C
50	131	1.47 ± .45	1.19 ± .36	1.47 ± .45	1.19 ± .36	C
51	131	.73 ± .08	1.34 ± .13			A
52	131	.74 ± .07	.42 ± .04	.57 ± .06	1.15 ± .12	AT
53	131	.23 ± .02	.35 ± .04			AT
54	131			.16 ± .02	.00 ± .00	T
49	132	3.28 ± 1.02	2.96 ± .89			C
50	132	1.06 ± .32	.34 ± .10			C
51	132	1.65 ± .17	1.70 ± .17	1.49 ± .18	2.10 ± .21	AT
52	132	.11 ± .01	.23 ± .02			T
53	132	.53 ± .05	2.20 ± .22	1.57 ± .50	.00 ± .00	A
54	132	stable				
50	133	2.26 ± .74	2.09 ± .63			C
51	133	.54 ± .10	2.55 ± .26			A
52	133	.81 ± .08	.94 ± .09	1.26 ± .13	.79 ± .08	A,AT

Nuclide Atomic number	Mass number	Average beta and gamma energies in MeV Ground state Beta	 Gamma	 Isomeric state Beta	 Gamma	Type of treatment
53	133	.45 ± .05	.56 ± .06	.00 ± .00	1.56 ± .16	A
54	133	.14 ± .01	.05 ± .01	.21 ± .02	.02 ± .00	T
55	133	stable				
50	134	1.89 ± .61	.97 ± .37			C
51	134	2.89 ± .31	1.77 ± .18	3.81 ± .41	.00 ± .00	A
52	134	.29 ± .05	.77 ± .08			A
53	134	.71 ± .08	2.35 ± .24	.20 ± .06	.17 ± .05	A,AT
54	134	stable				
55	134	.22 ± .02	1.62 ± .16			A
56	134	stable				
51	135	2.39 ± .78	1.48 ± .52			C
52	135	2.29 ± .47	.76 ± .15			B
53	135	.50 ± .05	1.46 ± .15			AT
54	135	.30 ± .03	.26 ± .03	.11 ± .01	.42 ± .04	T
55	135	stable				
51	136	2.79 ± .89	1.77 ± .58			C
52	136	1.69 ± .51	.71 ± .22			C
53	136	2.11 ± .12	1.21 ± .24	1.97 ± .08	1.21 ± .24	E,B
54	136	stable				
55	136	.89 ± .09	.33 ± .03			A
56	136	stable				
52	137	2.02 ± .68	1.82 ± .60			C
53	137	2.25 ± .11	.77 ± .15			E,B
54	137	1.73 ± .03	.27 ± .05			E,B
55	137	.19 ± .02	.00 ± .00			T
56	137			.10 ± .01	.56 ± .06	T
52	138	1.57 ± .52	1.09 ± .45			C
53	138	2.27 ± .13	2.24 ± .69			E,C
54	138	.80 ± .10	1.45 ± .15			E,A
55	138	1.22 ± .12	2.20 ± .22	1.29 ± .14	2.27 ± .23	E,A
56	138	stable				
53	139	2.01 ± .29	.81 ± .16			E,B
54	139	1.72 ± .06	.90 ± .18			E,B
55	139	1.73 ± .05	.26 ± .05			E,B
56	139	.91 ± .09	.04 ± .00			A
57	139	stable				
53	140	2.61 ± .84	1.61 ± .56			C

Nuclide		Average beta ang damma energies in MeV				Type of treatment
Atomic number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
54	140	1.52 ± .05	1.21 ± .24			E,B
55	140	1.89 ± .04	1.21 ± .24			E,B
56	140	.35 ± .04	.15 ± .02			AT
57	140	.51 ± .05	2.42 ± .24			A
58	140	stable				
53	141	2.23 ± .73	.44 ± .19			C
54	141	1.96 ± .11	.86 ± .17			E,B
55	141	1.68 ± .07	2.53 ± .51			E,B
56	141	.98 ± .10	.61 ± .06			A
57	141	.97 ± .10	.03 ± .00			A
58	141	.22 ± .02	.07 ± .01			AT,F
59	141	stable				
54	142	1.35 ± .41	1.08 ± .32			C
55	142	2.59 ± .52	1.01 ± .20			B
56	142	.53 ± .07	.82 ± .08			A
57	142	.97 ± .10	2.11 ± .21			A
58	142	stable				
59	142	.83 ± .08	.06 ± .01	.00 ± .00	.00 ± .00	A,T
60	142	stable				
54	143	2.01 ± .67	2.42 ± .73			C
55	143	1.90 ± 0.07	1.35 ± .14			E,B
56	143	1.26 ± 0.03	.99 ± .20			E,B
57	143	1.21 ± 0.03	.00 ± .00			E,A
58	143	.46 ± .05	.30 ± .03			AT
59	143	.34 ± .03	.00 ± .00			A
60	143	stable				
55	144	2.24 ± .73	2.75 ± .90			C
56	144	0.99 ± 0.02	.61 ± .12			E,B
57	144	0.98 ± 0.05	2.32 ± .46			E,B
58	144	.09 ± .01	.02 ± .00			T
59	144	1.22 ± .12	.03 ± .00	.06 ± .01	.00 ± .00	F
60	144	stable				
54	145	1.88 ± .64	2.34 ± .70			C
55	145	1.81 ± .56	1.26 ± .41			C
56	145	1.23 ± .28	1.20 ± .24			B
57	145	1.01 ± .20	1.51 ± .30			B
58	145	.66 ± .08	.81 ± .08			AT

Nuclide		Average beta and gamma energies in MeV				Type of treatment
Atomic number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
59	145	.69 ± .07	.01 ± .00			A
60	145	stable				
55	146	2.35 ± .76	2.31 ± .76			C
56	146	1.09 ± .33	.90 ± .27			C
57	146	1.56 ± .47	2.34 ± .70			C
58	146	.37 ± .04	.23 ± .02			AT
59	146	.90 ± .10	1.83 ± .18			A
60	146	stable				
55	147	2.06 ± .68	1.06 ± .40			C
56	147	1.59 ± .56	2.14 ± .64			C
57	147	1.34 ± .50	1.85 ± .55			C
58	147	.91 ± .41	1.26 ± .38			C
59	147	.75 ± .08	.82 ± .08			AT
60	147	.31 ± .03	.15 ± .02			AT
61	147	.06 ± .01	.00 ± .00			T
62	147	stable				
56	148	1.07 ± .38	1.23 ± .37			C
57	148	1.85 ± .63	3.02 ± .91			C
58	148	.54 ± .23	.41 ± .12			C
59	148	1.33 ± .15	.75 ± .07			A
60	148	stable				
61	148	.72 ± .07	.62 ± .06	.29 ± .03	1.84 ± .18	A,AT
62	148	stable				
58	149	1.12 ± .45	1.53 ± .46			C
59	149	1.13 ± .47	.26 ± .03			AT
60	149	.57 ± .06	.29 ± .03			AT
61	149	.38 ± .04	.04 ± .00			AT
62	149	stable				
58	150	.70 ± .28	.63 ± .19			C
59	150	1.25 ± .48	2.34 ± .70			C
60	150	stable				
61	150	.77 ± .08	1.54 ± .15			A
62	150	stable				
59	151	.96 ± .42	1.44 ± .43			C
60	151	.62 ± .06	.85 ± .09			A
61	151	.41 ± .04	.24 ± .02			AT
62	151	.02 ± .00	.00 ± .00			T

Nuclide		Average beta and gamma energies in MeV				Type of treatment
Atomic number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
63	151	stable				
60	152	.34 ± .11	.15 ± .05			C
61	152	1.37 ± .15	.19 ± .02	1.41 ± .17	.21 ± .02	A,AT
62	152	stable				
61	153	.67 ± .08	.10 ± .01			AT
62	153	.33 ± .03	.03 ± .00			AT
63	153	stable				
61	154	1.05 ± .14	1.38 ± .14	.98 ± .30	1.60 ± .48	AT,C
62	154	stable				
63	154	.33 ± .03	1.15 ± .12			AT
64	154	stable				
62	155	.59 ± .06	.11 ± .01			AT
63	155	.06 ± .01	.06 ± .01			T
64	155	stable				
62	156	.27 ± .03	.09 ± .01			AT
63	156	.45 ± .05	1.36 ± .14			AT
64	156	stable				
62	157	.84 ± .12	.46 ± .05			A
63	157	.38 ± .04	.34 ± .03			AT
64	157	stable				
63	158	.98 ± .11	1.02 ± .10			AT
64	158	stable				
63	159	.97 ± .10	.27 ± .03			AT
64	159	.32 ± .03	.13 ± .01			AT
65	159	stable				
63	160	1.40 ± .49	1.08 ± .11			AT
64	160	stable				
65	160	.37 ± .04	.97 ± .10			AT
66	160	stable				
64	161	.60 ± .06	.42 ± .04			AT
65	161	.23 ± .02	.02 ± .00			AT
66	161	stable				
64	162	.34 ± .05	.46 ± .05			A
65	162	.54 ± .06	.98 ± .10			A
66	162	stable				
65	163	.33 ± .04	.80 ± .08			A
66	163	stable				

Nuclide		Average beta and gamma energies in MeV				Type of treatment
Atomic number	Mass number	Ground state		Isomeric state		
		Beta	Gamma	Beta	Gamma	
65	164	.73 ± .10	1.98 ± .20			A
66	164	stable				
66	165	.47 ± .05	.03 ± .00	.01 ± .00	.11 ± .01	A
67	165	stable				
66	166	.17 ± .02	.03 ± .00			A
67	166	.72 ± .07	.05 ± .01	.11 ± .01	1.63 ± .16	A
68	166	stable				
67	167	.23 ± .10	.37 ± .04			A
68	167	stable				

Table 3

Mean ratios between average beta energies in ENDF/B IV and FPLIB

	Mass regions						
Type	72-87	88-102	103-117	118-132	133-147	148-166	72-166
A	0.99±0.01	0.97±0.03	0.99±0.06	0.99±0.03	0.94±0.02	0.87±0.05	0.96±0.02
B	0.97±0.07	x)	x)	0.83±0.04	0.90±0.18	-	0.90±0.04
C	1.02±0.08	1.02±0.04	1.11±0.03	0.99±0.04	0.90±0.03	0.89±0.06	1.01±0.02
A+B+C	0.99±0.05	0.99±0.03	1.05±0.03	0.96±0.03	0.92±0.02	0.88±0.03	0.98±0.01

x) Only two values for Type B-nuclides. These have been joined with the Type C-nuclides.

Table 4

Mean ratios between average gamma energies in ENDF/B IV and FPLIB

	Mass regions						
Type	72-87	88-102	103-117	118-132	133-147	148-166	72-166
A	1.07±0.05	0.94±0.05	1.07±0.08	0.98±0.04	1.06±0.04	1.07 ±0.08	1.02±0.02
B	1.53±0.32	1.10±0.18	x)	2.08±0.30	1.62±0.19	-	1.60±0.22
C	1.02±0.08	0.88±0.06	1.03±0.09	1.20±0.14	1.47±0.08	1.26±0.16	1.04±0.06
A+B+C	1.17±0.11	0.94±0.04	1.05±0.06	1.23±0.08	1.33±0.07	1.13±0.07	1.13±0.05

x) Only two values for Type B-nuclides. These have been joined with the Type C-nuclides.

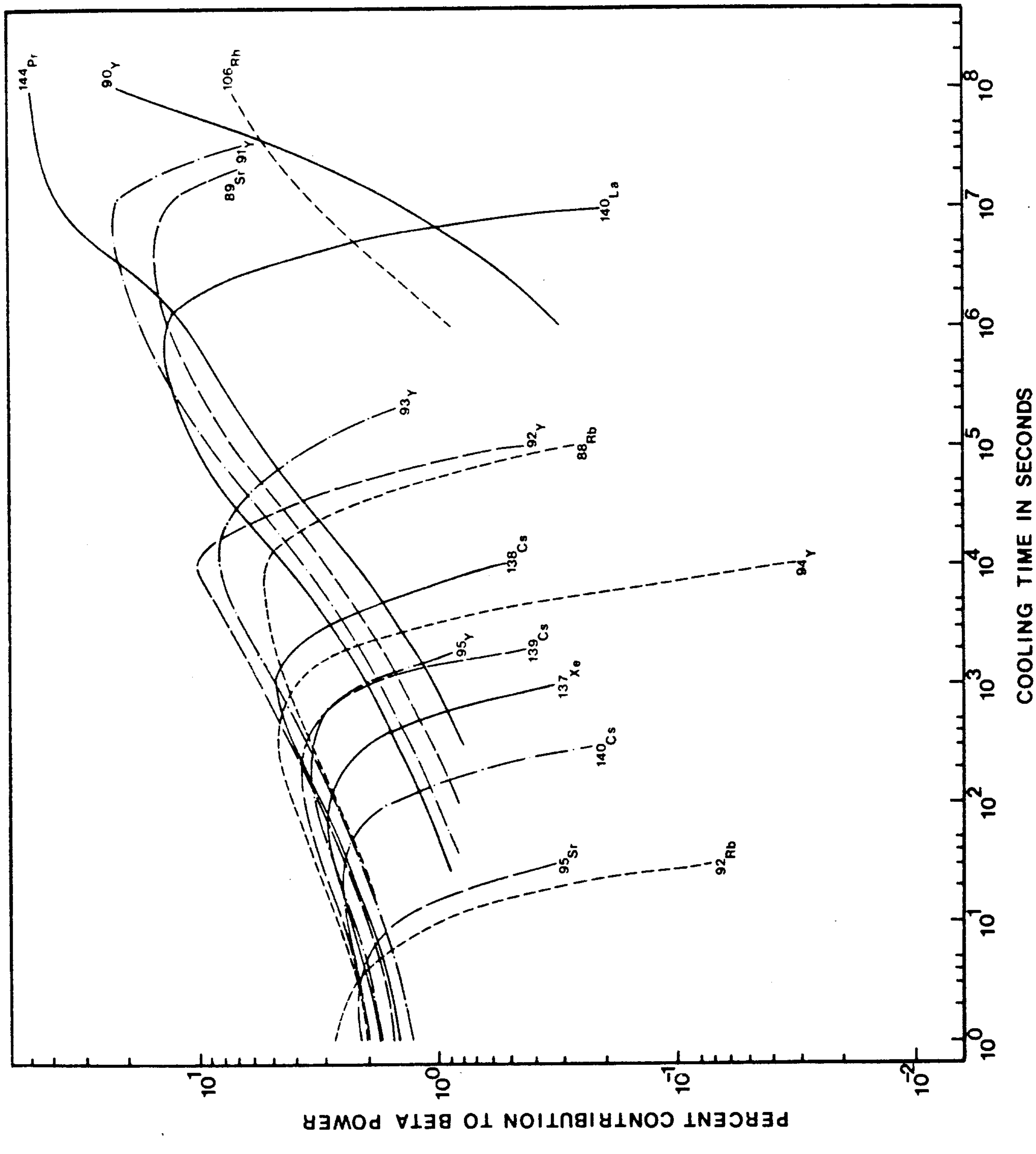

Fig. 1. Per cent contribution to the beta power as a function of cooling time at an irradiation of ^{235}U for 10^7 seconds. Nuclides belonging to the three most important contributors at any cooling time have been included in the figure.