^{182}Ta - Comments on evaluation of decay data by V. Chisté and M. M. Bé

This evaluation was completed in September 2010, including all publications by this date.

1 Decay Scheme

^{182}Ta disintegrates 100 % by beta minus emissions to excited levels of ^{182}W.

A good agreement was found between the effective Q value (1821 (19) keV) calculated from the decay scheme data and the adopted and recommended value from the mass adjustment of Audi (2003Au03).

2 Nuclear Data

The Q value is from the atomic mass evaluation of Audi *et al.* (2003Au03).

Experimental ^{182}Ta half-life values (in days) are given in Table 1:

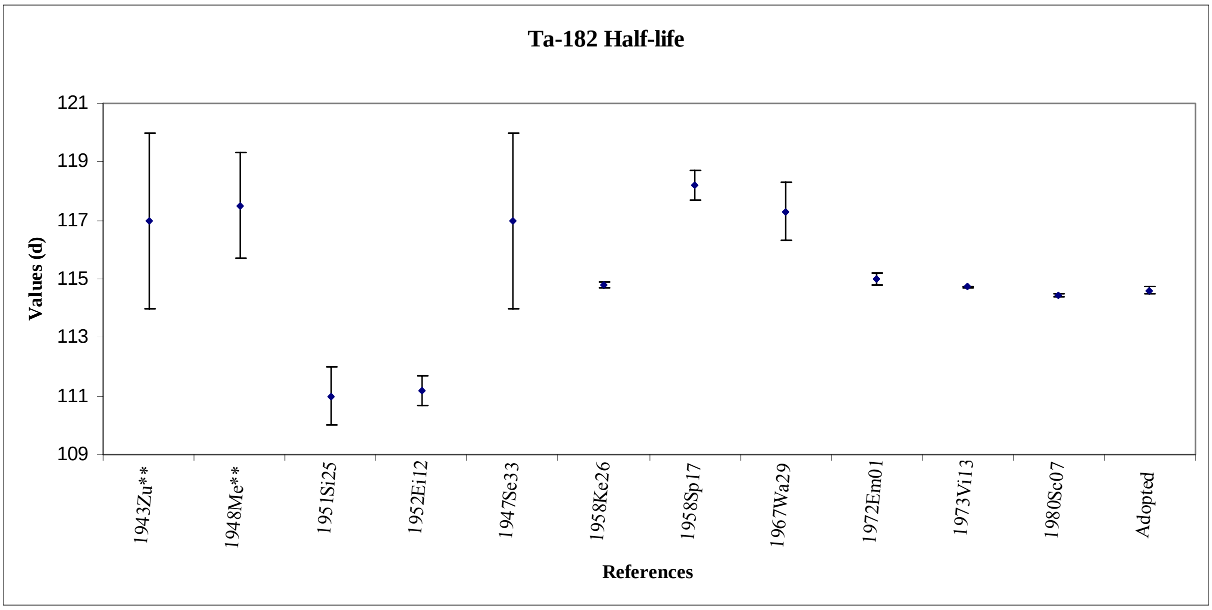
Table 1: Experimental values of ^{182}Ta half-life

Reference	Experimental value (d)	Comments
R. V. Zumstein (1943Zu**)	117 (3)	
L. Seren (1947Se33)	117 (3)	
L. Meitner (1948Me**)	117.5 (18)	
W. K. Sinclair (1951Si25)	111 (1)	
G. G. Eichholz(1952Ei02)	111.2 (5)	
H. W. Wright (1957Wr37)	115.05 (25)	Superseded by 1972Em01
J. P. Keene (1958Ke26)	114.80 (12)	
A. Speecke (1958Sp17)	118.2 (5)	
D. A. Walker (1967Wa29)	117.3 (10)	
J. F. Emery (1972Em01)	115.0 (2)	
C. J. Visser (1973Vi13)	114.740 (24)	Original uncertainty is 3σ (0.08)
U. Schötzig (1980Sc07)	114.43 (4)	
Recommended value	**114.61 (13)**	$\chi^2 = 16$

For the data of L. Meitner (1948Me**), the evaluators have chosen to use the average value of 117.5 (18), calculated from two experimental values given in the paper to produce a single DDEP value for each laboratory. A weighted average has been calculated using LWEIGHT computer program (version 3). Originally, the largest contributions to the weighted average come from the values of U. Schötzig (1980Sc07) and C. J. Visser (1973Vi13), amounting to 43 % and 70 %, respectively. LWEIGHT increased the uncertainty of 1973Vi13 value from 0.024 to 0.037 in order to reduce its relative weight from 70 % to 50 %.

The adopted value is the weighted average of 114.61 d with an uncertainty of 0.13 d (expanded so range to include the most precise value of C. J. Visser (1973Vi13)). The reduced-χ^2 value is 16, that reflects the high discrepancy of the set of data. See Graphic 1.

Graphic 1: ^{182}Ta half-life values



2.1 β- Transitions

The maximum energies of the β^- transitions in the decay of ^{182}Ta → ^{182}W have been obtained from the Q^- value (2003Au03) and the level energies given in Table 2 from B. Singh (2010Si13).

Table 2: ^{182}W levels populated in the decay of ^{182}Ta and the adopted β^- transition probabilities

Level Number	Level energy, (keV)	Spin and parity	Half-life	Adopted $P_{\beta-}$ (%)
0	0	0^+		
1	100.10598 (7)	2^+	1.40 (2) ns	~ 0*
2	329.4268 (6)	4^+	62 (3) ps	~ 0*
5	1221.4001 (10)	2^+	0.434 (11) ps	1.6 (22)
6	1257.4121 (11)	2^+	1.71 (13) ps	0.22 (21)
7	1289.1498 (10)	2^-	1.12 (4) ns	45.1 (23)
8	1331.1153 (10)	3^+	< 0.6 ns	2.39 (15)
9	1373.8301 (10)	3^-	78 (10) ps	19.9 (7)
10	1442.836 (9)	4^+	0.32 (3) ps	0.563 (10)
11	1487.5018 (10)	4^-	< 49 ps	1.5 (7)
12	1510.25 (7)	4^+		0.1414 (39)
13	1553.2240 (10)	4^-	1.27 (4) ns	29.0 (7)

* Measured values by 1967Ba01 are 0.058 (6) and 0.096 (10), respectively. These values are inconsistent with intensity balance at each level of the decay scheme.

The adopted β^- transition probabilities and the associated uncertainties (Table 2) were deduced from the γ transition probability balance at each level of the decay scheme.

The values of log ft and average β^- energies have been calculated with the program LOGFT for the allowed and 1st forbidden β^- transitions.

2.2 γ Transitions

The γ-ray transition probabilities were calculated using the γ-ray emission intensities and the relevant internal conversion coefficients (see **5.2 γ Emissions**).

For all γ transitions, the internal conversion coefficients (ICC) and the associated uncertainties were interpolated from the theoretical values of I. M. Band et al. (2002Ba85) using the BrIcc computer program (2008Ki07) for the "frozen orbital" approximation.

For multipolarities and mixing ratios, the evaluators used:

1) Multipolarities and mixing ratios of the γ-ray transitions listed in the Table 3 are from B. Singh (2010Si13).

Table 3: Multipolarities of γ-ray transitions

	Multipolarity	E_γ (keV)
^{182}W	[E2]	(121.50 (14)), 829.80 (12)
	[E1]	110.388 (9)
	E3	1373.824 (3)
	E2	100.10595 (7), 198.35187 (29), 229.3207 (6), 264.0740 (3), 351.06 (6), 891.9710 (12), 927.9828 (13), 1035.80 (14), 1221.395 (3), 1257.407 (3), 1410.14 (7)
	E1	31.7377 (15), 42.7148 (14), 116.4179 (6), 152.42991 (26), 156.3864 (3), 222.1085 (3), 1158.0711 (12),
	E0	1135.91 (14)
	M1 + E2	1231.004 (3) δ = - 33 (+6, -9) 1180.82 (7) δ = - 2.8 (10) 1001.6856 (12) δ = - 8.9 (+18, -21)
^{182}W	M2	1289.145 (3)
	M2 + E3	1387.390 (3) δ = 2.6 (3)
	E1 + M2 + E3	1273.719 (3) δ(M2/E1) = 0.36 (10), δ(E3/E1) = - 0.28 (12)

2) For the 84-,113- and 179-keV γ-ray transitions (M1 + E2), the adopted mixing ratios (δ) are the weighted means of the δ values found in the literature and shown in Table 4. A good agreement has been found between the experimental values of K and L internal coefficients and the calculated ones obtained by using the evaluated δ values and the BrIcc program.

Table 4: Experimental and recommended conversion coefficients and mixing ratios for 84-, 113- and 179-keV γ-ray transitions

E_γ (keV)	δ experimental (mixing ratio)	α experimental	α theoretical (given by BRICC)
84.68024 (26)	0.30 (9) (1964Ba12) 0.33 (17) (1966Gr21) 0.35 (7) (1967Ni03) 0.352 (45) (1972He10) 0.30 (2) (1972Kr05) 0.31 (5) (1975Qu01) 0.30 (2) (1980Sp01) 0.32 (3) (1983Ri05)	α_K = 5.2 (10) α_L = 1.44 (10) (1963Ni07)	α_K = 5.88 (9) α_L = 1.36 (4)
Recommended value	**0.309 (12)**	χ^2 = 0.26	

E_γ (keV)	δ experimental (mixing ratio)	α experimental	α theoretical (given by BRICC)
113. 67170 (22)	0.21 (6) (1964Ba12) 0.32 (17) (1966Gr21) 0.30 (14) (1967Ni03) 0.36 (8) (1972He10) 0.31 (2) (1972Kr05) 0.31 (5) (1975Qu01) 0.36 (3) (1980Sp01) 0.36 (2) (1983Ri05)	$\alpha_K = 2.4$ (10) $\alpha_L = 0.50$ (5) (1963Ni07)	$\alpha_K = 2.52$ (4) $\alpha_L = 0.519$ (10)
Recommended value	**0.338 (12)**	$\chi^2 = 0.70$	
179.39381 (25)	2.8 (8) (1964Ba12) 0.72 (26) (1966Gr21) 0.84 (32) (1967Ni03) 0.92 (10) (1972Kr05) 1.26 (15) (1981Ka22) 2.1 (3) (1983Ri05) 2.2 (2) (1992Ch26)	$\alpha_K = 0.49$ (5) $\alpha_L = 0.15$ (2) (1963Ni07)	$\alpha_K = 0.44$ (8) $\alpha_L = 0.148$ (7)
Recommended value	**1.21 (29)**	$\chi^2 = 7$	

3) For the eleven remaining γ-ray transitions, the mixing ratios (δ) were deduced by comparison between the weighted mean of the experimental values of internal coefficients and the theoretical ICC calculated using the BrIcc computer code (2008Ki07), shown in the Table 5.

Table 5: Experimental and recommended conversion coefficients and mixing ratios

E_γ (keV)	α experimental	δ (mixing ratio)	α theoretical (given by BRICC)	Multipolarities
65.72215 (15)	$\alpha_L = 2.5$ (1) (1963Ni07)	0.094 (43)	$\alpha_L = 2.3$ (1)	M1 + E2
67.74970 (10)	$\alpha_L = 0.18$ (2) (1963Ni07)	0.018 (9)	$\alpha_L = 0.17$ (2)	E1 + M2
959.7203 (12)	$\alpha_K = 7$ (5) 10^{-3} (1961Gr21) $\alpha_K = 9.2$ (24) 10^{-3} (1966Dz01) $\alpha_K = 9.08$ (20) 10^{-3} (1976He18) α_K (LWM) = 9.08 (20) 10^{-3}	- 5.48 (44)	$\alpha_K = 9.01$ (15) 10^{-3}	M2 + E3
1044.4001 (12)	$\alpha_K = 2.4$ (6) 10^{-3} (1966Dz01) $\alpha_K = 4.4$ (20) 10^{-3} (1969Ga23) $\alpha_K = 4.35$ (10) 10^{-3} (1976He18) α_K (LWM) = 4.36 (10) 10^{-3}	0.48 (1)	$\alpha_K = 4.44$ (12) 10^{-3}	E1 + M2
1113.406 (9)	$\alpha_K = 4.8$ (8) 10^{-3} (1972Ga23) $\alpha_K = 3.59$ (13) 10^{-3} (1975We22) $\alpha_K = 3.02$ (6) 10^{-3} (1976He18) α_K (LWM) = 3.32 (30) 10^{-3}	5.6 (+13,-10) (from 1983Ri05)	$\alpha_K = 3.11$ (8) 10^{-3}	M1 + E2
1121.290 (3)	$\alpha_K = 3.9$ (2) 10^{-3} (1960Gr**) $\alpha_K = 3.2$ (2) 10^{-3} (1964Da15) $\alpha_K = 2.9$ (3) 10^{-3} (1966Dz01) $\alpha_K = 3.28$ (15) 10^{-3} (1966Ko12) $\alpha_K = 3.15$ (19) 10^{-3} (1972Ga23) $\alpha_K = 3.16$ (10) 10^{-3} (1975We22) $\alpha_K = 2.99$ (4) 10^{-3} (1976He18) α_K (LWM) = 3.036 (40) 10^{-3}	30 (+6,-4) (from 1983Ri05)	$\alpha_K = 2.97$ (5) 10^{-3}	M1 + E2

E_γ (keV)	α experimental	δ (mixing ratio)	α theoretical (given by BRICC)	Multipolarities
1157.3022 (11)	α_K = 2.7 (3) 10^{-3} (1960Gr**) α_K = 3.5 (5) 10^{-3} (1964Da15) α_K = 3.5 (8) 10^{-3} (1966Dz01) α_K = 6.3 (4) 10^{-3} (1966Ko12) α_K = 6.8 (7) 10^{-3} (1972Ga23) α_K (LWM) = 4.1 (14) 10^{-3}	1.3 (7)	α_K = 3.9 (11) 10^{-3}	M1 + E2
1189.040 (3)	α_K = 4.3 (2) 10^{-3} (1960Gr**) α_K = 4.6 (3) 10^{-3} (1964Da15) α_K = 3.6 (4) 10^{-3} (1966Dz01) α_K = 4.22 (40) 10^{-3} (1966Ko12) α_K = 4.10 (21) 10^{-3} (1972Ga23) α_K = 4.18 (14) 10^{-3} (1975We22) α_K = 3.88 (4) 10^{-3} (1976He18) α_K (LWM) = 3.93 (6) 10^{-3}	δ(M2/E1) = 0.470 (17), δ(E3/E1) = - 0.662 (32)	α_K = 3.732 (33) 10^{-3}	E1 + M2 + E3
1223.7928 (12)	α_K = 2.4 (4) 10^{-3} (1976He18)	0.38 (7)	α_K = 2.4 (5) 10^{-3}	E1 + M2
1342.72(5)	α_K = 1.9 (10) 10^{-3} (1966Dz01) α_K = 2.20 (85) 10^{-3} (1966Ko12) α_K = 2.28 (6) 10^{-3} (1976He18) α_K (LWM) = 2.28 (6) 10^{-3}	- 0.11 (11)	α_K = 2.3 (5) 10^{-3}	E2 + M3
1453.1118 (10)	α_K = 3.7 (6) 10^{-3} (1966Dz01) α_K = 2.4 (16) 10^{-3} (1966Ko12) α_K = 4.38 (30) 10^{-3} (1976He18) α_K (LWM) = 4.28 (29) 10^{-3}	2.1 (4)	α_K = 4.3 (3) 10^{-3}	M2 + E3

For the 1113-, 1121- and 1157-keV γ-ray transitions, from comparison between measured and calculated ICCs, the introduction of a third E0 component appears not to be necessary. This was proposed for:

1. 1113-keV by 1975We22, but not by 1972Ga23 and 1976He18;
2. 1121-keV by 1966Ko12 and 1975We22, but not by 1960Gr**, 1964Da15, 1966Dz01 and 1972Ga23;
3. 1157-keV by 1966Ko12 and 1972Ga23, but not by 1960Gr**, 1964Da15 and 1966Dz01.

3 Atomic Data

Atomic values, ω_K, ϖ_L, ϖ_M, n_{KL} and the X-ray and Auger electron relative probabilities are from Schönfeld and Janβen (1996Sc06).

4 Electron emissions

The conversion electron emission probabilities were deduced from the ICC values and the γ-ray emission intensities.

5 Photon emissions

5.1 X-ray emissions

The X-ray absolute intensities were deduced from the decay data using the EMISSION computer code and are compared in Table 6 with measured values found in the literature. A good agreement has been found between the experimental and calculated values, supporting the overall consistency of the decay scheme data.

Table 6: Experimental and recommended (calculated) values of X-ray absolute intensities (%)

	U. Schötzig (1980Sc07)	B. Chand (1992Ch26)@	**Recommended values**
Kα x-ray	28.02 (52)	27.82 (39)	**27.54 (34)**
K β_1 x-ray		6.01 (12)	**5.79 (13)**
K β_2 x-ray		1.51 (5)	**1.59 (5)**
L x-ray		21.84 (44)	**24.4 (4)**

@Using a normalization factor of 0.3517 (33) (see **5.2 Gamma Emissions**)

5.2 Photon emissions

The energies of the γ-rays in Table 7 are from R. G. Helmer (2000He14). For other γ-rays, the energy values come from B. Singh (2010Si13).

Table 7: γ-ray energies given by R. G. Helmer (2000He14).

E_γ (keV)	65.722 15 (15), 67.749 70 (10), 84.680 24 (26), 100.105 95 (7), 113.671 70 (22), 116.417 9 (6), 152.429 91 (26), 156.386 4 (3), 179.393 81 (25), 198.351 87 (29), 222.108 5 (3), 229.320 7 (6), 264.074 0 (3), 1121.290 (3), 1189.040 (3), 1221.395 (3), 1231.004 (3), 1257.407 (3), 1273.719 (3), 1289.145 (3), 1373.824 (3), 1387.390 (3)

The experimental relative γ-ray emission intensities from ^{182}Ta were obtained from all the available relative values (Table 8).

The normalization factor to convert the relative emission intensities to absolute emission intensities was calculated using the formula:

$$N = \left(\frac{100}{(\sum(1 + \alpha_T)P_{rel})} \right) = 0.3517\ (33),$$

where the sum is over all the γ transitions to the ground state (100-, 1135-, 1221-, 1257-, 1289- and 1373-keV) and α_T is the relevant coefficient. The uncertainty was calculated through its propagation on the formula given above.
The experimental γ-ray emission probabilities relative to 100 for the 1121-keV γ-ray are given in Table 8, except for the Edwards's values (1965Ed01) who measured only the low energy γ-rays until 264-keV relatively to the 100 keV line.

Our recommended relative and absolute γ-ray emission probabilities are given in Table 9.

The adopted values are the weighted means calculated by the LWEIGHT program (version 3).

Were omitted from analysis:

- * : N. A. Voinova (1959Vo27), V. D. Vitman (1961Vi07) and N. A. Voinova (1961Vo05), because these values come from the same laboratory that B. S. Dzhelepov (1966Dz01);
- $: Idem for 1976He18 superseded by 1977Ge12 only for high energy γ-rays (1121-keV to 1453-keV), where both measured the same energies. For other energies (891-keV to 1113-keV), the evaluators used the values given by 1976He18;
- £ : Idem to 1983El02, superseded by 1990Ja02;
- § : Idem to 1989Ka20, superseded by 1992Ch26;
- ¤ : 1969Wh03 - superseded by 1970Wh03;
- µ : the set of value from H. Daniel (1964Da15), because of a lack of information on the γ-ray reference line more generally, on γ spectrometry part of the experiment;
- & : the set of value from W. F. Edwards (1965Ed01), because of a lack of information in the article about the experimental measurements carried out and, therefore on the results.

Table 8: Experimental data sets of the relative γ-ray emission intensities (%) (cont'd. next pages)

Energy (keV) Reference	31	42	65	67	84	100	110	113	116	152
1959Vo27*										
1961Ry03						67.2 (47)£				33.2 (29)£
1961Vi07*										
1961Vo05*						15 (7)				18 (4)
1964Da15µ			8.6 (5)	128 (6)	9.0 (6)	43.2 (25)		5.6 (3)	1.41 (12)	19.4 (8)
1965Ed01&		1.73 (9)	20.0 (10)	293 (15)	18.8 (9)	100		13.6 (7)	3.16 (19)	51.0 (20)
1965He07										
1966Dz01										
1966Ko12										
1969Sa25					7.0 (7)	40.7 (41)		5.2 (5)	1.2 (2)	19.5 (20)
1969Wh03¤										
1970Wh03										21.3 (10)
1971Ja21						40.2 (10)				20.5 (5)
197Ml01					6.70 (22)*	38.0 (23)		4.90 (29)	1.00 (8)*	19.7 (12)
1972Ga23					7.6 (8)	40.3 (40)		5.28 (40)	1.27 (13)	19.3 (14)
1974La15				121.0 (52)	7.82 (16)	37.43 (80)*		6.15 (14)*		18.70 (60)
1976He18$										
1977Ge12				122 (7)	7.80 (41)	40.8 (35)		5.43 (18)	1.260 (42)	20.5 (6)
1978MeZK/1990Me15	2.75 (6)	0.86 (7)	8.75 (17)	130 (10)	7.19 (14)	40.4 (5)	0.330 (20)	5.34 (5)	1.260 (20)	19.95 (19)
1980Ro22						40.6 (26)		4.95 (40)	1.18 (18)	19.59 (80)
1980Sc07	2.53 (6)	0.750 (21)	161.7 (36)		7.45 (17)	40.3 (10)		5.29 (19)	1.26 (5)	19.69 (28)
1981Is08	1.18 (12)*	0.82 (10)	13.5 (14)*		7.6 (6)	41.6 (14)*	0.25 (4)	5.87 (40)*	1.14 (8)*	23.15 (50)*
1983Ji01						40.3 (6)	0.25 (6)	5.36 (7)	1.260 (30)	19.94 (19)
1983El02£	1.40 (2)	0.80 (1)	8.45 (14)	118.3 (20)	6.81 (26)	40.50 (64)	0.25 (1)	5.47 (8)	1.22 (2)	19.52 (32)
1986Wa35					7.30 (22)	39.03 (64)*		4.44 (16)*		21.19 (39)
1989Ka20§					7.87 (14)	41.50 (51)		5.47 (8)	1.24 (4)	20.30 (25)
1990Ja02	2.21 (2)	0.82 (3)	8.55 (7)	120.0 (11)	7.31 (5)	40.45 (51)	0.30 (4)	5.31 (8)	1.28 (6)	19.86 (17)
1992Su09	1.80 (6)*	0.827 (24)	7.61 (16)	126.2 (24)	7.80 (16)	42.6 (9)*	0.37 (3)	5.64 (11)	1.33 (3)	20.94 (24)
1992Ch26	2.44 (7)	0.710 (21)	8.40 (21)	131.8 (24)	7.65 (10)	41.4 (5)*	0.300 (10)	5.27 (10)	1.230 (22)	20.40 (26)
1992Ke02	2.46 (5)	0.754 (18)	9.02 (22)		7.43 (12)	40.5 (5)	0.320 (20)	5.34 (6)	1.270 (21)	19.81 (22)
1998Mi17					7.58 (7)	38.50 (23)*		5.21 (5)		19.60 (11)
Evaluated	**2.38 (17)**	**0.765 (18)**	**8.45 (20)**	**124.0 (40)**	**7.45 (14)**	**40.42(24)**	**0.305 (9)**	**5.315 (29)**	**1.264 (10)**	**19.93 (33)**
χ^2	**20**	**3.3**	**9.7**	**3.8**	**2.6**	**0.025**	**1.4**	**1.5**	**0.8**	**3.2**

* Outliers values, based on the Chauvenet's criterion and thus were omitted in the final calculation.

£ Data rejection parameters for deviation from weighted mean (3σ).

Energy (keV) Reference	156	179	198	222	229	264	351	829	891	927	959
1959Vo27*									< 1.4	3 (2)	2.5 (15)
1961Ry03	13.7 (35)£	19.5 (39)£	7.7 (13)£	29.2 (18)£	14.2 (11)£	13.4 (41)£					
1961Vi07*									< 0.5		
1961Vo05*	18 (3)	3 (1)		19 (3)		8 (1)					
1964Da15µ	7.3 (4)	10.0 (5)	4.5 (3)	23.4 (7)	10.3 (5)	10.6 (7)					
1965Ed01&	20.0 (9)	22.9 (10)	10.7 (6)	56.1 (22)	27.7 (12)	26.9 (12)					
1965He07									1	1	2
1966Dz01									~ 0.3	1.74 (26)	0.94 (24)
1966Ko12											
1969Sa25	7.5 (8)	8.7 (9)	4.3 (4)	21.2 (21)	10.5 (11)	10.3 (10)			0.20 (7)	1.6 (2)*	1.3 (2)£
1969Wh03¤									0.15 (2)	1.79 (9)	1.02 (6)
1970Wh03	8.07 (40)*	9.57 (5)£	4.40 (25)*	22.6 (12)*	10.9 (5)*	10.6 (4)			0.15 (2)	1.79 (9)	1.02 (6)
1971Ja21	7.6 (2)	8.8 (3)		21.30 (55)	10.3 (3)	10.1 (3)					
1971Ml01	7.5 (7)	8.70 (48)	4.20 (24)	21.5 (12)	10.3 (7)	10.0 (6)				1.50 (30)*	1.00 (10)
1972Ga23	7.13 (48)*	8.7 (6)	4.15 (28)	21.5 (15)	10.3 (7)	10.4 (7)				1.75 (20)	0.95 (11)
1974La15	7.78 (20)	8.57 (25)	3.75 (12)£	21.26 (62)	9.24 (26)£	9.46 (29)*				2.10 (8)*	1.12 (6)*
1976He18$									0.164 (19)	1.779 (27)	0.998 (18)
1977Ge12	7.77 (24)	9.10 (29)	4.31 (14)	21.9 (7)	10.60 (32)	10.50 (32)					
1978MeZK/1990Me15	7.59 (10)	8.82 (10)	4.19 (9)	21.60 (31)	10.39 (18)	10.26 (18)	0.034 (8)			1.730 (30)	0.980 (30)
1980Ro22	7.43 (40)	8.88 (66)	4.13 (28)	21.75 (56)	10.39 (34)	10.36 (52)				1.53 (45)*	0.92 (47)
1980Sc07	7.46 (12)	8.75 (11)	4.09 (6)	21.27 (28)	10.32 (13)	10.26 (16)					
1981Is08	7.6 (8)	9.1 (7)	4.2 (2)	21.3 (8)	10.2 (6)	9.98 (50)			0.21 (5)	1.64 (10)*	0.87 (8)*
1983Ji01	7.60 (7)	8.84 (9)	4.22 (6)	21.61 (20)	10.49 (10)	10.37 (7)	0.033 (19)	0.038 (15)	0.16 (5)	1.760 (40)	0.98 (5)
1983El02£	7.26 (11)	8.38 (9)	3.91 (4)	21.12 (22)	10.33 (13)	9.81 (12)	0.24 (1)		0.14 (4)	1.85 (3)	1.06 (3)
1986Wa35	7.26 (18)*	8.85 (24)	4.14 (7)	21.62 (51)	10.24 (22)	9.9 (8)					
1989Ka20§	7.51 (15)	8.92 (10)	4.23 (4)	21.90 (24)	10.59 (13)	10.32 (12)				1.71 (4)	0.93 (2)
1990Ja02	7.59 (12)	8.83 (8)	4.12 (5)	21.80 (20)	10.38 (11)	10.14 (9)			0.15 (4)	1.77 (6)	1.01 (3)
1992Su09	7.89 (16)*	9.04 (18)	4.21 (10)	21.6 (5)	10.5 (2)	10.26 (22)	0.03 (1)	0.05 (2)	0.20 (6)	1.72 (8)	0.99 (8)
1992Ch26	7.54 (10)	8.93 (12)	4.19 (5)	21.90 (27)	10.43 (13)	10.37 (15)	0.0330 (10)	0.039 (8)	0.160 (10)	1.720 (24)	0.970 (21)
1992Ke02	7.51 (9)	8.81 (9)	4.12 (6)	21.43 (24)	10.43 (12)	10.43 (14)	0.028 (6)		0.174 (22)	1.75 (7)	0.99 (8)
1998Mi17	7.570 (46)	8.770 (48)	4.150 (24)	21.17 (12)	10.20 (6)	10.13 (6)					
Evaluated	**7.570 (29)**	**8.811 (29)**	**4.155 (16)**	**21.45 (7)**	**10.334 (36)**	**10.243 (35)**	**0.0329 (10)**	**0.040 (7)**	**0.162 (7)**	**1.746 (13)**	**0.989 (11)**
χ^2	**0.3**	**0.4**	**0.4**	**0.9**	**0.7**	**0.8**	**0.2**	**0.1**	**0.3**	**0.4**	**0.2**

* Outliers values, based on the Chauvenet's criterion and thus were omitted in the final calculation.

£ Data rejection parameters for deviation from weighted mean (3σ).

Energy (keV) Reference	1001	1035	1044	1113	1121	1135	1157	1158	1180	1189	1221
1959Vo27*	9 (3)				100			< 4		45 (8)	84 (8)
1961Ry03					100			4.2 (9)		47.5 (27)	81 (6)*
1961Vi07*	5 (2)		0.9 (8)		100			3.6 (10)		44 (3)	80 (6)
1961Vo05*					100					43	118
1964Da15µ											
1965Ed01&											
1965He07	6 (2)		2 (1)£		100			3		44	72
1966Dz01	5.4 (3)		1.2 (2)*		100			4.1 (12)		44.3 (15)*	77 (6)
1966Ko12	7.9 (26)£		< 1		100		2.67 (15)			48.1 (20)	85.1 (31)£
1969Sa25	5.6 (6)		0.8 (1)	1.2 (2)	100		2.0 (3)	0.76 (16)	0.25 (4)	46.3 (32)	77.3 (54)
1969Wh03¤	5.98 (30)		0.69 (8)	1.13 (10)	100		1.84 (35)	0.99 (28)		47.7 (7)	79.3 (12)
1970Wh03	5.98 (30)		0.69 (8)	1.13 (10)	100		1.84 (35)	0.99 (28)		47.7 (7)	79.3 (12)*
1971Ja21					100					46.5 (7)	77.3 (12)
1971Ml01	5.4 (10)		0.60 (10)		100		2.60 (21)			47.2 (21)	78.0 (34)
1972Ga23	5.66 (40)		0.69 (10)	1.44 (20)	100		2.90 (20)		0.28 (4)	46.7 (23)	80.3 (41)*
1974La15	6.43 (11)*			1.11 (7)	100		2.96 (9)			46.1 (15)	78.4 (12)
1976He18$	5.90 (8)		0.678 (14)	1.276 (19)	100		2.838 (39)		0.249 (15)	46.64 (46)	77.3 (6)
1977Ge12					100		2.850 (49)			46.5 (7)	77.0 (11)
1978MeZK/1990Me15	5.87 (6)			1.320 (30)	100		2.920 (31)			47.1 (8)	77.80 (38)
1980Ro22	5.99 (35)			1.18 (7)	100					47.61 (53)	78.1 (9)
1980Sc07					100					46.59 (46)	77.0 (8)
1981Is08	5.36 (11)		0.58 (10)	2.21 (20)£	100			2.65 (20)	0.56 (7)*	48.8 (17)*	77.9 (27)
1983Ji01	5.85 (10)		0.72 (7)	1.30 (3)	100		1.66 (24)	1.22 (21)	0.210 (40)	46.40 (20)	76.8 (6)
1983El02£	5.99 (6)		0.68 (3)	0.95 (4)	100		2.72 (6)		0.10 (3)	46.90 (45)	78.31 (79)
1986Wa35	5.89 (34)				100		2.92 (34			47.02 (48)	77.3 (13)
1989Ka20§	5.92 (7)		0.66 (2)	1.15 (3)	100					47.18 (67)	78.38 (81)
1990Ja02	6.01 (5)		0.70 (8)	1.35 (15)	100		2.71 (20)		0.23 (9)	47.37 (9)	77.48 (34)
1992Su09	5.87 (13)	0.017 (6)	0.68 (5)	1.08 (5)	100		2.01 (7)	0.82 (5)	0.23 (4)	46.3 (19)	76.2 (15)
1992Ch26	5.86 (10)		0.660 (21)	1.240 (22)	100		2.830 (46)		0.250 (10)	46.6 (8)	
1992Ke02	5.89 (13)		0.72 (5)	1.19 (7)	100		2.87 (5)		0.22 (6)	47.0 (6)	78.0 (10)[a]
1998Mi17					100		2.930 (22)			46.70 (24)	
Evaluated	**5.88 (13)**	**0.017 (6)**	**0.677 (10)**	**1.257 (19)**	**100**		**2.37 (36)**	**0.84 (5)**	**0.248 (8)**	**47.13 (9)**	**77.53 (20)**
χ^2	**2.2**		**0.5**	**2.7**			**12**	**1.3**	**0.3**	**1.7**	**0.3**

* Outliers values, based on the Chauvenet's criterion and thus were omitted in the final calculation.

£ Data rejection parameters for deviation from weighted mean (3σ).

a Doublet with 1223 keV gamma-ray.

Energy (keV) Reference	1223	1231	1257	1273	1289	1342	1373	1387	1410	1453
1959Vo27*		35 (10)	6 (2)	3 (2)	5 (2)		< 1.4			
1961Ry03		29.1 (22)*	5.1 (9)£		< 2.9					
1961Vi07*		25 (5)	4 (1)							
1961Vo05*		118		~ 4	~ 4		~ 2			~ 0.4
1964Da15µ										
1965Ed01&										
1965He07		36	4.5	2	4	0.80 (16)	0.70 (14)			
1966Dz01		26 (5)£	3.8 (3)*	1.5 (3)*	3.7 (2)	0.60 (9)*	0.52 (9)	0.25 (6)	0.115 (17)	0.094 (12)
1966Ko12		28.6 (10)*	3.91 (15)£	1.64 (15)	3.67 (15)	0.79 (5)	0.70 (14)	0.184 (41)	0.13 (6)	0.14 (6)
1969Sa25	0.6 (1)	32.7 (23)	4.3 (3)	1.8 (1)	3.8 (3)	0.7 (1)	0.6 (1)	0.18 (2)	0.11 (2)	0.12 (2)
1969Wh03¤		33.4 (5)	4.33 (7)	1.90 (4)	4.05 (7)	0.75 (2)	0.66 (2)	0.217 (10)	0.117 (8)	0.123 (10)
1970Wh03		33.4 (5)	4.33 (7)	1.90 (4)	4.05 (7)	0.75 (2)	0.66 (2)	0.217 (10)	0.117 (8)	0.123 (10)
1971Ja21		32.8 (5)								
1971Ml01		32.3 (14)	4.27 (19)	1.92 (10)	4.06 (19)	0.750 (38)	0.690 (36)	0.240 (21)	0.140 (30)	0.120 (30)
1972Ga23		34.5 (25)*	4.46 (45)*	1.96 (19)	4.10 (40)	0.80 (9)	0.70 (8)	0.225 (23)	0.130 (25)	0.10 (2)
1974La15		32.60 (52)	4.31 (8)	1.83 (5)	3.96 (8)	0.74 (3)	0.65 (3)	0.21 (1)		
1976He18$		32.92 (30)	4.269 (46)	1.864 (28)	3.87 (5)	0.720 (11)	0.628 (9)	0.2019 (39)	0.1152 (46)	0.0804 (32)
1977Ge12	0.778 (11)	32.96 (47)	4.26 (6)	1.860 (27)	3.86 (6)	0.718 (12)	0.628 (11)	0.202 (5)	0.112 (6)	0.0790 (31)
1978MeZK/1990Me15	0.30 (10)*	33.1 (5)	4.36 (8)	1.950 (31)	4.29 (8)	0.740 (10)	0.680 (10)	0.270 (10)*	0.1170 (40)	0.123 (8)
1980Ro22		32.32 (56)	4.33 (15)	1.66 (18)	4.06 (22)					
1980Sc07		32.81 (33)	4.250 (36)		3.860 (34)					
1981Is08		32.3 (11)	4.07 (30)*	1.67 (15)	3.65 (20)	0.66 (8)	0.58 (8)	0.20 (5)	0.10 (4)	0.10 (4)
1983Ji01	0.53 (24)	32.72 (14)	4.276 (24)	1.871 (13)	3.800 (32)	0.723 (7)	0.626 (6)	0.2040 (40)	0.111 (5)	0.0872 (24)
1983El02£		33.20 (22)	4.27 (2)	1.87 (1)	3.89 (4)	0.72 (1)	0.60 (1)	0.20 (1)	0.10 (1)	0.09
1986Wa35		33.42 (31)	4.36 (16)	1.73 (12)	4.17 (30)					
1989Ka20§		33.28 (45)	4.40 (6)	1.92 (3)	4.01 (5)	0.75 (1)	0.68 (2)			
1990Ja02	0.55 (12)	33.85 (22)	4.35 (6)	1.90 (4)	3.90 (5)	0.76 (4)	0.65 (2)	0.24 (3)	0.14 (2)	0.11 (2)
1992Su09	0.58 (10)	32.2 (7)	4.22 (9)	1.84 (5)	3.80 (8)	0.69 (3)	0.55 (2)	0.19 (2)	0.083 (10)*	0.11 (1)
1992Ch26		32.80 (48)	4.31 (7)	1.850 (33)	3.91 (6)	0.720 (12)	0.610 (11)	0.205 (6)	0.1090 (41)	0.0830 (31)
1992Ke02	78.0 (10)[a]	33.17 (37)	4.34 (7)	1.860 (31)	4.03 (7)	0.748 (21)	0.628 (13)	0.220 (11)	0.117 (8)	0.097 (7)
1998Mi17		33.18 (19)	4.320 (24)		3.940 (23)					
Evaluated	0.58 (6)	33.04 (10)	4.296 (13)	1.872 (9)	3.907 (33)	0.7284 (43)	0.633 (7)	0.2060 (24)	0.1136 (21)	0.106 (19)
χ^2	0.05	1.7	0.5	1.1	3.0	0.8	3.2	0.9	0.5	4.3

* Outliers values, based on the Chauvenet's criterion and thus were omitted in the final calculation.

£ Data rejection parameters for deviation from weighted mean (3σ).

a Doublet with 1221 keV gamma-ray.

Table 9: Recommended relative and absolute γ-ray intensities (%)

Eγ (keV)	Relative γ-ray intensity (%)	Absolute γ-ray intensity (%)	Eγ (keV)	Relative γ-ray intensity (%)	Absolute γ-ray intensity (%)	Eγ (keV)	Relative γ-ray intensity (%)	Absolute γ-ray intensity (%)
31	2.38 (17)	0.84 (6)	229	10.334 (36)	3.634 (36)	1180	0.247 (8)	0.0869 (29)
42	0.765 (18)	0.269 (7)	264	10.243 (35)	3.602 (36)	1189	47.13 (9)	16.58 (16)
65	8.45 (20)	2.97 (8)	351	0.0329 (10)	0.01157 (37)	1221	77.53 (20)	27.27 (27)
67	124.0 (40)	43.6 (15)	829	0.040 (7)	0.0141 (25)	1223	0.58 (6)	0.204 (21)
84	7.45 (14)	2.62 (6)	891	0.162 (7)	0.0570 (25)	1231	33.04 (11)	11.62 (12)
100	40.42 (24)	14.22 (16)	927	1.746 (13)	0.614 (7)	1257	4.296 (13)	1.511 (15)
110	0.305 (9)	0.1073 (33)	959	0.989 (11)	0.348 (5)	1273	1.872 (9)	0.658 (7)
113	5.315 (29)	1.869 (20)	1001	5.88 (13)	2.07 (5)	1289	3.906 (33)	1.374 (17)
116	1.264 (10)	0.445 (5)	1035	0.017 (6)	0.0060 (21)	1342	0.7284 (43)	0.2562 (28)
(121)*		0.0021 (7)	1044	0.677 (10)	0.2381 (42)	1373	0.633 (7)	0.2226 (32)
152	19.93 (33)	7.01 (13)	1113	1.257 (19)	0.442 (8)	1387	0.2060 (24)	0.0725 (11)
156	7.570 (29)	2.662 (27)	1121	100	35.17 (33)	1410	0.1136 (21)	0.0400 (8)
179	8.811 (29)	3.099 (31)	1135			1453	0.106 (19)	0.037 (7)
198	4.155 (16)	1.461 (15)	1157	2.37 (36)	0.83 (13)			
222	21.45 (7)	7.54 (7)	1158	0.84 (5)	0.295 (18)			

*Deduced from gamma-ray probability imbalance at level 4 (1135 keV) of the decay scheme.

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