$^{166}_{67}Ho_{99}$

Evaluation of the decay data

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This evaluation was completed in January 2024, with the same literature cut-off date.

$^{166}_{67}$ Ho $_{99}$

1 Decay Scheme

^{166}Ho disintegrates 100% by beta minus emission to the ground state and the excited levels of ^{166}Er.
Le ^{166}Ho se désintègre par émission bêta vers le niveau fondamental et les niveaux excités du ^{166}Er.

2 Nuclear Data

$T_{1/2}$(^{166}Ho)	:	26,808	(20)	h
Q^-(^{166}Ho)	:	1853,8	(8)	keV

2.1 β^- Transitions

	Energy (keV)	Probability (%)	Nature	log ft
$\beta^-_{0,8}$	23,4 (8)	0,0339 (4)	Allowed	5,15
$\beta^-_{0,7}$	40,6 (9)	0,00011 (3)	1st Forbidden	8,36
$\beta^-_{0,6}$	191,4 (8)	0,296 (5)	Allowed	6,99
$\beta^-_{0,5}$	325,4 (8)	0,0028 (5)	Unique 1st Forbidden	9,51
$\beta^-_{0,4}$	393,8 (8)	0,953 (21)	1st Forbidden	7,48
$\beta^-_{0,3}$	1067,9 (8)	0,0063 (12)	Unique 1st Forbidden	11,72
$\beta^-_{0,1}$	1773,2 (8)	50,2 (8)	Unique 1st Forbidden	9,03
$\beta^-_{0,0}$	1853,8 (8)	48,4 (8)	1st Forbidden	8,17

2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy (keV)	$P_{\gamma+ce}$ (%)	Multipolarity	α_K (10^{-2})	α_L (10^{-2})	α_M (10^{-2})	α_T
$\gamma_{1,0}$(Er)	80,5776 (20)	51,4 (7)	E2	167,1 (24)	391 (6)	95,4 (14)	6,78 (10)
$\gamma_{2,1}$(Er)	184,4124 (36)	0,00146 (7)	E2	20,5 (3)	9,64 (14)	2,30 (4)	0,331 (5)
$\gamma_{3,2}$(Er)	520,915 (7)	0,000345 (41)	E2	1,184 (17)	0,230 (4)	0,0525 (8)	0,01481 (21)
$\gamma_{4,3}$(Er)	674,126 (8)	0,0195 (11)	E2	0,649 (9)	0,1122 (16)	0,0253 (4)	0,00793 (12)

	Energy (keV)	$P_{\gamma+ce}$ (%)	Multipolarity	α_K (10^{-2})	α_L (10^{-2})	α_M (10^{-2})	α_T
$\gamma_{3,1}$(Er)	705,327 (6)	0,0135 (30)	M1+E2	0,611 (9)	0,1027 (15)	0,0231 (4)	0,00743 (11)
$\gamma_{3,0}$(Er)	785,905 (6)	0,01194 (24)	E2	0,463 (7)	0,0759 (11)	0,01700 (24)	0,00561 (8)
$\gamma_{5,2}$(Er)	1263,411 (10)	0,0015 (3)	E2	0,1772 (25)	0,0259 (4)	0,00573 (8)	0,00212 (3)
$\gamma_{4,1}$(Er)	1379,453 (6)	0,907 (6)	E2	0,1498 (21)	0,0216 (3)	0,00476 (7)	0,00181 (3)
$\gamma_{5,1}$(Er)	1447,823 (10)	0,0013 (4)	M1+E2	0,200 (16)	0,0279 (21)	0,0061 (5)	0,00242 (18)
$\gamma_{4,0}$(Er)	1460,031 (6)		E0				
$\gamma_{5,0}$(Er)	1528,401 (10)	0,00009 (1)	E2	0,1235 (18)	0,01754 (25)	0,00387 (6)	0,001541 (22)
$\gamma_{6,1}$(Er)	1581,857 (5)	0,1791 (14)	E1+M2	0,0524 (11)	0,00694 (15)	0,00152 (4)	0,000869 (15)
$\gamma_{6,0}$(Er)	1662,435 (5)	0,1165 (8)	E1	0,0480 (7)	0,00635 (9)	0,001386 (20)	0,000877 (13)
$\gamma_{7,1}$(Er)	1732,62 (30)	0,00005 (2)	M1+E2	0,1196 (17)	0,01664 (24)	0,00366 (6)	0,001588 (23)
$\gamma_{8,1}$(Er)	1749,847 (12)	0,02587 (27)	E1+M2	0,0462 (7)	0,00614 (9)	0,001341 (19)	0,000920 (13)
$\gamma_{7,0}$(Er)	1813,2 (3)	0,00006 (2)	M1+E2	0,1085 (16)	0,01507 (21)	0,00331 (5)	0,001497 (21)
$\gamma_{8,0}$(Er)	1830,425 (12)	0,00803 (12)	E1	0,0409 (6)	0,00540 (8)	0,001179 (17)	0,000920 (13)

3 Atomic Data

3.1 Er

ω_K : 0,942 (4)
$\bar{\omega}_L$: 0,216 (9)
n_{KL} : 0,838 (4)

3.1.1 X Radiations

		Energy (keV)	Relative probability
X_K			
	$K\alpha_2$	48,222	56,34
	$K\alpha_1$	49,128	100
	$K\beta_3$	55,495	} 32,50
	$K\beta_1$	55,682	}
	$K\beta_5''$	56,040	}
	$K\beta_2$	57,210	} 8,45
	$K\beta_4$	57,313	}
	$KO_{2,3}$	57,456	}
X_L			
	$L\ell$	6,141	
	$L\alpha$	6,906 - 6,948	
	$L\eta$	7,047	
	$L\beta$	7,746 - 8,340	
	$L\gamma$	8,815 - 9,430	

3.1.2 Auger Electrons

		Energy (keV)	Relative probability
Auger K			
	KLL	37,790 - 40,563	100
	KLX	45,446 - 49,098	52,4
	KXY	53,070 - 57,430	6,86
Auger L		3,945 - 9,693	

4 Electron Emissions

		Energy (keV)		Electrons (per 100 disint.)
e_{AL}	(Er)	3,945 - 9,693		27,25 (19)
e_{AK}	(Er)			
	KLL	37,790 - 40,563		0,64 (5)
	KLX	45,446 - 49,098		
	KXY	53,070 - 57,430		
$ec_{1,0\ K}$	(Er)	23,092	(2)	11,04 (17)
$ec_{1,0\ T}$	(Er)	23,092 - 80,548		44,8 (7)
$ec_{1,0\ L}$	(Er)	70,826 - 72,220		25,83 (41)
$ec_{1,0\ M}$	(Er)	78,371 - 79,168		6,3 (1)
$ec_{1,0\ N}$	(Er)	80,129 - 80,573		1,427 (21)
$ec_{1,0\ O}$	(Er)	80,518 - 80,548		0,1658 (27)
$ec_{2,1\ T}$	(Er)	126,927 - 184,383		0,000482 (24)
$ec_{4,3\ T}$	(Er)	616,640 - 674,097		0,000153 (9)
$ec_{3,1\ T}$	(Er)	647,842 - 705,298		0,000100 (22)
$ec_{4,1\ T}$	(Er)	1321,968 - 1379,424		0,001638 (29)
$ec_{6,1\ T}$	(Er)	1524,372 - 1581,828		0,0001555 (29)
$ec_{6,0\ T}$	(Er)	1604,950 - 1662,406		0,0001021 (17)
$\beta^-_{0,8}$	max:	23,4	(8)	0,0339 (4)
	avg:	5,8	(2)	
$\beta^-_{0,7}$	max:	40,6	(9)	0,00011 (3)
	avg:	10,15	(23)	
$\beta^-_{0,6}$	max:	191,4	(8)	0,296 (5)
	avg:	51,28	(23)	
$\beta^-_{0,5}$	max:	325,4	(8)	0,0028 (5)
	avg:	103,42	(26)	
$\beta^-_{0,4}$	max:	393,8	(8)	0,953 (21)
	avg:	113,83	(26)	
$\beta^-_{0,3}$	max:	1067,9	(8)	0,0063 (12)
	avg:	363,16	(30)	

		Energy (keV)		Electrons (per 100 disint.)
$\beta^-_{0,1}$	max:	1773,2	(8)	50,2 (8)
	avg:	599,21	(28)	
$\beta^-_{0,0}$	max:	1853,8	(8)	48,4 (8)
	avg:	671,91	(34)	

5 Photon Emissions

5.1 X-Ray Emissions

		Energy (keV)	Photons (per 100 disint.)	
XL	(Er)	6,141 - 9,430	7,88 (13)	
XKα_2	(Er)	48,222	2,97 (5)	Kα
XKα_1	(Er)	49,128	5,27 (9)	
XKβ_3	(Er)	55,495	1,71 (4)	K$'\beta_1$
XKβ_1	(Er)	55,682		
XKβ_5''	(Er)	56,040		
XKβ_2	(Er)	57,210	0,445 (13)	K$'\beta_2$
XKβ_4	(Er)	57,313		
XKO$_{2,3}$	(Er)	57,456		

5.2 Gamma Emissions

	Energy (keV)	Photons (per 100 disint.)
$\gamma_{1,0}$(Er)	80,5776 (20)	6,605 (28)
$\gamma_{2,1}$(Er)	184,4124 (36)	0,001457 (70)
$\gamma_{3,2}$(Er)	520,914 (7)	0,00034 (4)
$\gamma_{4,3}$(Er)	674,125 (8)	0,0193 (11)
$\gamma_{3,1}$(Er)	705,326 (6)	0,0134 (30)
$\gamma_{3,0}$(Er)	785,903 (6)	0,01187 (24)
$\gamma_{5,2}$(Er)	1263,406 (10)	0,0015 (3)
$\gamma_{4,1}$(Er)	1379,447 (6)	0,905 (6)
$\gamma_{5,1}$(Er)	1447,817 (10)	0,0013 (4)
$\gamma_{5,0}$(Er)	1528,394 (10)	0,00009 (1)
$\gamma_{6,1}$(Er)	1581,849 (5)	0,1789 (14)

	Energy (keV)	Photons (per 100 disint.)
$\gamma_{6,0}$(Er)	1662,426 (5)	0,1164 (8)
$\gamma_{7,1}$(Er)	1732,61 (30)	0,00005 (2)
$\gamma_{8,1}$(Er)	1749,838 (12)	0,02584 (27)
$\gamma_{7,0}$(Er)	1813,19 (30)	0,00006 (2)
$\gamma_{8,0}$(Er)	1830,414 (12)	0,00802 (12)

6 Main Production Modes

$\left\{ \begin{array}{l} ^{165}\mathrm{Ho}(\mathrm{n},\gamma)^{166}\mathrm{Ho} \quad \sigma : 64{,}7 \text{ barns} \\ \text{Possible impurities: } ^{166\mathrm{m}}\mathrm{Ho} \end{array} \right.$

^{165}Ho(d,p)^{166}Ho

^{164}Dy(2n,γ)^{166}Ho

^{166}Dy β^- decay to ^{166}Ho, with $T_{1/2}$ = 81,6 (1) h

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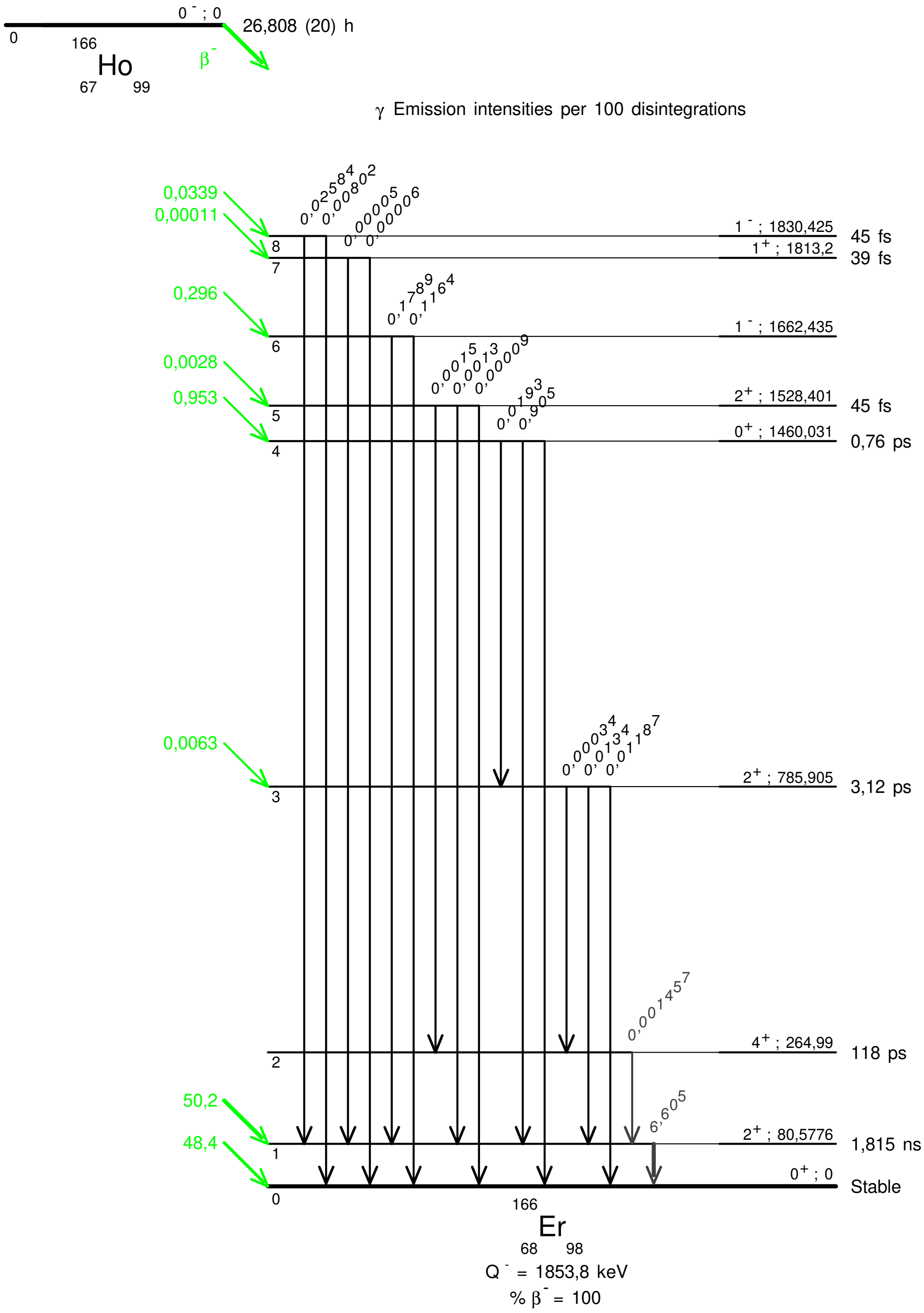
0⁻ ; 0
26,808 (20) h
β⁻
γ Emission intensities per 100 disintegrations
1⁻ ; 1830,425 45 fs
1⁺ ; 1813,2 39 fs
1⁻ ; 1662,435
2⁺ ; 1528,401 45 fs
0⁺ ; 1460,031 0,76 ps
2⁺ ; 785,905 3,12 ps
4⁺ ; 264,99 118 ps
2⁺ ; 80,5776 1,815 ns
0⁺ ; 0 Stable
0,0339
0,00011
0,296
0,0028
0,953
0,0063
50,2
48,4
Q⁻ = 1853,8 keV
% β⁻ = 100

^{166}Ho – Comments on the evaluation of decay data

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This evaluation was completed in January 2024, with the same literature cut-off date.

The Limitation of Relative Statistical Weights Method (LWM) was applied to average the decay data when appropriate by use of the LWEIGHT Excel add-in. All uncertainties are given as the combined uncertainty to one standard deviation.

Prior to this work, the most recent evaluation of decay data from ^{166}Ho was published in the 2008 Evaluated Nuclear Structure Data File by Baglin (2008). A previous evaluation for DDEP was performed by Schönfeld and Dersch in 2004 (Bé *et al.* 2004). Since that time, four national metrology institutes (the Czech Metrology Institute (CMI), the National Physical Laboratory (NPL), the Italian Public Research Institute for New Technologies, Energy and Environment (ENEA), and the Laboratoire National Henri Becquerel (LNHB)) undertook measurements of the decay half-life and gamma-ray emission rates as part of the EURAMET-funded MRTDosimetry project (Bobin *et al.* 2019, Capogni *et al.* 2024). The publication of additional independent gamma-ray emission and half-life measurements (Yamazaki *et al.* 2020), as well as an internal re-assessment of previously published half-life data (Unterweger and Fitzgerald (2014, corrigendum 2020), provided the impetus for a new assessment of this important medical radionuclide.

1 Decay scheme

Holmium-166 decays by β^- emission to 8 excited levels in ^{166}Er. The ground-state of the decay daughter ^{166}Er is stable. Level energies, half-lives (except for the ^{166}Ho ground state), spins, and parities were taken from the ENSDF Adopted Levels tables (Baglin, 2008). Transition multipolarities and mixing ratios, as well as gamma-ray placements in this evaluation are taken from ENSDF Adopted Gamma-rays tables (Baglin, 2008), which are based primarily on the level scheme proposed by Ardisson *et al.* (1992). It should be noted that the level scheme adopted by ENSDF does not include the energy level at 1813 keV, nor the de-excitation gamma rays from the levels that were proposed by Ardisson *et al.* (1992). Both the present evaluation and the previous DDEP evaluation by Schönfeld and Dersch include this level and associated gamma rays (see Bé *et al.* 2004).

The level scheme, seen in Figure 1, is complete and consistent as presented. This is demonstrated by the agreement between Q_{calc} = 1853.0 (21) keV determined by SAISINUC (Dulieu *et al.* 2017) from the sum of the products of the decay energies and probabilities of all the transitions that feed into the levels and depopulate them and Q_{tot} = 1853.8 (8) keV from the most recent atomic mass evaluation of Wang *et al.* (2021). The difference between the summation of all decay out of the levels and the feeding into them by β^- decay is 0.06%.

2 Nuclear data

2.1 Half-life

Only published experimental half-life values with associated uncertainties were considered in this evaluation. The results from three individual laboratories reported in Bobin *et al.* (2019) were treated as independent determinations, as the measurements were made with ^{166}Ho solutions of different origins using different techniques undertaken by different personnel at different times. The value from Unterweger and Fitzgerald (corrigendum 2020) supersedes all previous NIST values considered in previous evaluations. The complete list of 14 half-life values considered for this evaluation is given in Table 1.

For the data reported in Bobin *et al.* (2019), the evaluator has combined the results from the LNHB and NPL data to produce a single result from each. For the LNHB measurements, the adopted value was calculated from the weighted mean of the results of two measurement methods and the uncertainty calculated as the quadratic combination of the relative standard deviation of the weighted mean (0.022%) and the average relative standard uncertainty of the two measurements (0.073%) to give a single value of 26.811 (20) h. The same approach was taken with the NPL data, using the relative standard deviation on the weighted mean (0.013%) and the average relative standard deviation on the individual measurements (0.099%) to calculate the uncertainty, giving a single value of 26.797 (27) h.

Because of the availability of 8 measurements with precision on the order of at least 0.03 h, an additional constraint was placed on the data to include only those results with at least 4 significant figures (i.e., two decimal places). From those 8 remaining measurements, one (Daniel and Kaschl, 1966) was excluded as an outlier by LWEIGHT based on the Chauvenet principle (1891). Careful examination of the paper by Abzouzi *et al.* (1989), reveals that the counting time used by these authors for their measurement was too short (60 min) to give a reliable half-life value for a radionuclide with a half-life longer than 26 h. When this value is removed from the data set, the remaining 6 measurements provide a consistent data set with a χ^2 value of 0.39, compared to a critical χ^2 value of 3.02. From these remaining 6 measurements, a weighted average of 26.808 (10) h is obtained. Recognizing, however, that this uncertainty is lower than any of the values that went into the calculation of the weighted mean, the minimum uncertainty in the data set (the LNHB value) was adopted as a more realistic uncertainty for the recommended value. Therefore, the recommended half-life becomes **26.808 (20) h**.

Table 1. Experimental half-life determinations of ^{166}Ho considered in this evaluation.

Reference	Year	$T_{1/2}$ (h)	Uncertainty (h)
Bothe	1946	27.3[a]	0.5
Grant and Hill	1949	26.8[a]	0.4
Antoneva *et al.*	1950	27.5[a]	0.5
Cork *et al.*	1958	26.9[a]	0.1
Hoffman	1963	27.0[a]	0.2
Daniel and Kaschl	1966	26.74[b]	0.05
Nethaway and Missimer	1968	26.79	0.03
Ryves and Zieba	1974	26.83	0.03
Ramaniah *et al.*	1976	27[a]	0.04
Abzouzi *et al.*	1989	26.827[c]	0.005
Unterweger and Fitzgerald	2014/2020	26.794	0.023
Bobin *et al.* (CMI)	2019	26.828	0.028
Bobin *et al.* (LNHB)	2019	26.811	0.020
Bobin *et al.* (NPL)	2019	26.797	0.027
Recommended[d]		**26.808**	**0.020**
LWEIGHT χ^2 = 0.39 and χ^2 critical = 3.02			

[a] Not included (insufficient precision on measurement).

[b] Rejected by LWEIGHT by the Chauvenet principle.

[c] Removed from data set due to very short measurement time (see text for details).

[d] The recommended half-life is the weighted mean of six values that remained from original data set after removal of outliers, etc. Recommended uncertainty is the standard uncertainty on the weighted mean.

2.2 Gamma transitions

Gamma ray energies and intensities

High-resolution gamma-ray spectroscopy data were considered from 5 primary sources: Ardisson *et al.* (1992), Coursey *et al.* (1994), Bobin *et al.* (2019), Yamazaki *et al.* (2020), and Capogni *et al.* (2024). As with the half-life data, the three sets of results reported by CMI, NPL, and LNHB in Bobin *et al.* were treated as independent measurements, giving a total of 7 independent data sets from which recommended values could be calculated.

The transition energies in this evaluation are taken from the ^{166}Ho β^- decay measurements of Ardisson *et al.* (1992), which was also the basis for the previous DDEP evaluation. The ENSDF Adopted Gammas list is based on data from a single, earlier publication on the electron capture decay of ^{166}Tm and does not provide any improvements in terms of precision over Ardisson *et al.* (1992) and was therefore not adopted for use in this evaluation.

In all cases but that of Ardisson *et al.* (1992), the gamma-ray emission rates were determined on an absolute basis through measurement of the activity using a primary standardization method. Ardisson *et al.* based their absolute intensities on a normalization factor reported by Cline *et al.* (1962) using beta-gamma coincidence counting. However, the photon data measured by Cline *et al.* were not considered for this evaluation because they were obtained with low-resolution NaI(Tl) detectors.
A new normalization factor for the Ardisson *et al.* data was calculated from the set of intensities of the 1379.4 keV gamma ray that excluded the Ardisson *et al.* value. The new factor of 0.905 (6) per 100 decays was then applied to the Ardisson *et al.* data to give a new set of absolute emission rates. It was

evident that Ardisson *et al.* did not include the uncertainty in the Cline *et al.* normalization factor when reporting their emission rates, because to do so would involve a minimum uncertainty of 5% on the absolute intensity in addition to the inherent uncertainty in their own measurements. Since the uncertainty quoted for the 674.2 keV gamma ray is only about 1%, it was assumed that the uncertainty cited by Ardisson *et al.* for their absolute intensities was equal to that on their relative intensities alone. These uncertainties were combined with the uncertainty on the new normalization factor when re-calculating the Ardisson *et al.* absolute emission rates.

The list of published gamma-ray intensities included in this evaluation, including the re-normalized values from Ardisson *et al.*, is given in Table 2. For all of the gamma rays, with exception of that at 184.5 keV, the LWM was used to calculate the recommended value of the intensity using all of the available published data. The complete set of recommended values is included in Table 2.

Within their respective uncertainties, all of the data sets used in the evaluation are consistent with one another, with the exception of the 184.5 keV and 674.2 keV gamma rays, which were found to be discrepant. In the case of the 674.2 keV gamma ray, the adopted value is taken as the weighted mean of the published data, with an uncertainty that has been expanded by LWEIGHT to include the most precise value of 1.82 (3) per 100 decays reported by Ardisson (1992).

For the 184.5 keV gamma ray, there were only two published results to be considered. It was observed that the Ardisson *et al.* value of the absolute emission rate has an uncertainty of 10%, while the NPL value in Bobin *et al.* (2019) has a relative uncertainty of only 4.8%. For the purposes of this evaluation, the more recent and more precise NPL result has been adopted as the recommended value.

The data in Table 2 show clearly that additional measurements of the gamma ray emission intensities are needed in the range 1250 keV to 1580 keV. Such measurements would be particularly useful since the 1262.94 keV, 1447.5 keV, and 1528.23 keV gamma rays de-excite the level at 1528.12 keV and each has only a single measurement of its emission intensity with a large relative uncertainty. Since these data are also used in the calculation of the β^- branching ratios, this also influences the magnitude and uncertainty on the branching to that level.

Multipolarities and internal conversion coefficients

When available, gamma-ray multipolarities and mixing ratios were taken from the ENSDF Adopted Gammas table (Baglin, 2008). Internal conversion coefficients were calculated using BrIcc (Kibédi *et al.*, 2008) with the frozen orbital approximation. Experimental mixing ratios were used in the calculations when available, otherwise equal mixing between the multipolarities was assumed (i.e., $\delta = 1$).

The K conversion coefficient of the 80.57 keV gamma transition was measured by Daniel and Kaschl (1966), Ramaswamy and Brahmavar (1963), Nelson and Hatch (1969), Falkström *et al.* (1968), and Campbell *et al.* (1971). A comparison of these experimental α_K values with the currently recommended value calculated by BrIcc is given in Table 3, along with the recommended value from the previous DDEP evaluation. It should be noted that the previously-recommended DDEP values were obtained from interpolation of the data in the tables by Rösel *et al.* (1978), rather than calculation by BrIcc.

Other published work focused almost exclusively on electron spectroscopy associated with the 80.57-keV transition and determination of relative subshell intensities or intensity ratios between subshells. Karlsson *et al.* (1966), Erman *et al.* (1966) and Gelletly *et al.* (1967) carried out measurements of L subshell ratios, while experimental M-, N-, and O- subshell and O/N ratios were reported by Dragoun *et al.* (1972) and Bulgakov *et al.* (1981), who also reported L/M, N/M, and O/M ratios. Measurements of K/L, L/M, M/(N+O+P) ratios were carried out by Nilsson *et al.* (1968); Bogdanovic *et al.* (1968); and Zylicz *et al.* (1966). Kartashov *et al.* (1977) reported relative intensities of K, L (with subshells), M (with subshells), N, and O conversion electrons.

Table 2. List of evaluated absolute γ-ray probabilities (per 100 decays) in the decay of ^{166}Ho.

	P_γ per 100 decays							
Energy (keV)	**Ardisson *et al.* (1992)[*]**	**Coursey *et al.* (1994)**	**Bobin *et al.* (2019), CMI**	**Bobin *et al.* (2019), LNHB**	**Bobin *et al.* (2019), NPL**	**Yamazaki *et al.* (2020)**	**Capogni *et al.* (2024)**	**Recommended**
80.576 (2)	5.9 (3)	6.55 (7)	6.636 (49)	6.61 (7)	6.618 (51)	6.51 (11)	-	6.605 (28)
184.5 (2)[a]	9 (1) x 10^{-4}	-	-	-	1.457 (70) x 10^{-3}	-	-	1.457 (70) x 10^{-3}
520.8 (5)	3.4 (4) x 10^{-4}	-	-	-	-	-	-	3.4 (4) x 10^{-4}
674.222 (16)	1.82 (3) x 10^{-2}	-	-	1.93 (8) x 10^{-2}	2.142 (68) x 10^{-2}	2.04 (7) x 10^{-2}	2.02 (8) x 10^{-2}	1.93 (11) x 10^{-2}
705.352 (26)	1.30 (2) x 10^{-2}	-	-	1.34 (6) x 10^{-2}	1.474 (65) x 10^{-2}	1.43 (5) x 10^{-2}	1.43 (6) x 10^{-2}	1.340 (30) x 10^{-2}
785.879 (36)	1.16 (2) x 10^{-2}	-	-	1.18 (6) x 10^{-2}	1.306 (58) x 10^{-2}	1.26 (5) x 10^{-2}	1.23 (6) x 10^{-2}	1.187 (24) x 10^{-2}
1262.94 (19)	1.5 (3) x 10^{-3}	-	-	-	-	-	-	1.5 (3) x 10^{-3}
1379.437 (6)	0.905 (11)	-	0.904 (20)	0.896 (13)	0.9051 (69)	0.904 (11)	0.902 (29)	0.905 (6)
1447.5 (1)	1.3 (4) x 10^{-3}	-	-	-	-	-	-	1.3 (4) x 10^{-3}
1460.025 (7)[b]	-	-	-	-	-	-	-	-
1528.23 (15)	9 (1) x 10^{-5}	-	-	-	-	-	-	9 (1) x 10^{-5}
1581.833 (7)	0.178 (2)	-	0.180 (6)	0.180 (4)	0.1792 (24)	0.175 (5)	0.179 (6)	0.1789 (14)
1662.439 (6)	0.118 (1)	-	0.1164 (41)	0.114 (3)	0.1157 (13)	0.114 (3)	0.116 (4)	0.1164 (8)
1732.0 (10)	5 (2) x 10^{-5}	-	-	-	-	-	-	5 (2) x 10^{-5}
1749.833 (14)	2.58 (4) x 10^{-2}	-	-	2.59 (7) x 10^{-2}	2.590 (48) x 10^{-2}	2.55 (8) x 10^{-2}	2.58 (9) x 10^{-2}	2.584 (27) x 10^{-2}
1812.8 (1)	6 (2) x 10^{-5}	-	-	-	-	-	-	6 (2) x 10^{-5}
1830.413 (24)	8.1 (2) x 10^{-3}	-	-	8.0 (3) x 10^{-3}	8.07 (26) x 10^{-3}	7.9 (3) x 10^{-3}	7.8 (5) x 10^{-3}	8.02 (12) x 10^{-3}

[*]Renormalized using factor calculated from weighted mean of measured absolute emission intensities of 1379.4 keV gamma ray excluding Ardisson *et al.* See text for details.

[a] Only two values available; more precise NPL measurement of Bobin *et al.*, (2019) adopted as the recommended value.

[b] E0 transition.

Table 3. Comparison of experimentally-determined and recommended K conversion coefficients for the 80.57-keV gamma transition in the decay of ^{166}Ho. The recommended value from this evaluation is taken from the BrIcc calculations.

Reference	α_K
Ramaswamy and Brahmavar, 1963	1.69 (9)
Daniel and Kaschl, 1966	1.72[a]
Falkstroem *et al.*, 1968	1.63 (5)
Nelson and Hatch, 1969	1.72 (6)
Campbell *et al.*, 1971	1.69 (6)
DDEP, Bé *et al.*, 2004	1.65 (5)
This evaluation	**1.671 (24)**

[a] No uncertainty provided.

2.3 Beta transitions

Maximum beta decay energies were calculated from the adopted *Q*-value and the level energies in the ^{166}Er decay daughter. Transition probabilities were deduced from the imbalance in total intensities of the gamma rays feeding into and out of each level. Log *ft* values and average beta decay energies for each level were calculated with the BetaShape program within SAISINUC (Mougeot, 2017, 2023).

The calculated β^- endpoint energies and emission rates are compared with published experimental values, the previous DDEP evaluation, and the currently-recommended ENSDF values in Table 4. Some differences are observed to exist between the present decay-data recommendations and the current ENSDF evaluation because the latter does not include a level at 1813 keV with depopulating gamma rays. However, it is worth pointing out that this current evaluation is consistent with the previous DDEP recommendations.

Direct beta-spectra measurements have been reported by Graham *et al.* (1955), Cork *et al.* (1958), Funke *et al.* (1963), Grigorev *et al.* (1974), and Venkata Ramaniah *et al.* (1976). Most of these studies suffered from poor resolution due to limitations in either detector type or sample preparation method, with the exception of Grigorev *et al.*, who used thinner samples and were able to achieve better separation between the two primary beta components. Most of the reported values do not have associated uncertainties. Therefore, the data from previous studies are presented only for the strongest transitions in which sufficient resolution allowed for reasonable intensity measurements.

Table 4. Comparison of recommended and experimental β^- endpoint energies and emission probabilities.

		Graham *et al.*, 1955		**Cork *et al.*, 1958**		**Funke *et al.*, 1963**		**Grigorev *et al.*, 1974**		**Venkata Ramaniah *et al.*, 1976**		**Baglin, 2008**		**Schönfeld and Dersch in Bé *et al.*, 2004**		**This evaluation**	
Transition	**Level, keV**	$E_{\beta-,max}$, **keV**	$I_{\beta-}$, **%**	$E_{\beta-,max}$, **keV**	$I_{\beta-}$, **%**[a]	$E_{\beta-,max}$, **keV**	$I_{\beta-}$, **%**[a]	$E_{\beta-,max}$, **keV**	$I_{\beta-}$, **%**	$E_{\beta-,max}$, **keV**	$I_{\beta-}$, **%**[a]	$E_{\beta-,max}$, **keV**	$I_{\beta-}$, **%**	$E_{\beta-,max}$, **keV**	$I_{\beta-}$, **%**	$E_{\beta-,max}$, **keV**	$I_{\beta-}$, **%**
$\beta^-_{0,8}$	1830.425 (12)	-	-	-	-	-		-	-	-	-	24.3 (9)	0.0342 (6)	24.1 (9)	0.0353 (11)	23.4 (8)	0.0339 (4)
$\beta^-_{0,7}$	1813.2 (3)	-	-	-	-	-		-	-	-	-	-	-	41.7 (9)	1.0 (3) 10^{-4}	40.6 (9)	1.1 (3) 10^{-4}
$\beta^-_{0,6}$	1662.433 (15)	-	-	-	-	-		-	-	-	-	192.3 (9)	0.302 (5)	192.0 (9)	0.304 (7)	191.4 (8)	0.296 (5)
$\beta^-_{0,5}$	1528.401 (10)	-	-	-	-	-		-	-	-	-	326.6 (9)	0.00268 (12)	326.2 (9)	0.00276 (22)	325.4 (8)	0.0028 (5)
$\beta^-_{0,4}$	1460.031 (6)	-	-	-	-	-		-	-	-	-	394.7 (9)	0.943 (13)	394.5 (9)	0.955 (16)	393.8 (8)	0.953 (21)
$\beta^-_{0,3}$	785.905 (6)	-	-	-	-	-		-	-	-	-	1068.8 (9)	0.0070 (12)	1068.6 (9)	0.0072 (21)	1067.9 (8)	0.0063 (12)
$\beta^-_{0,2}$	264.990 (3)	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
$\beta^-_{0,1}$	80.5776 (20)	1771 (7)	-	1756 (10)	37	1779 (5)	33.4	1776 (5)	51 (2)	1771 (2)	52.0	1773.1 (14)	49.9 (12)	1773.9 (9)	50.5 (15)	1773.2 (8)	50.2 (8)
$\beta^-_{0,0}$	0.0	1854 (5)	48.4 (4)	1839 (5)	47	1859 (3)	48.8	1854.7 (15)	48 (2)	1845 (2)	47.5	1854.7 (15)	48.8 (12)	1854.5 (9)	48.2 (15)	1853.8 (8)	48.4 (8)

3. Atomic data

Fluorescence yields were calculated within the SAISINUC program (Dulieu *et al.* 2017) using the data of Schönfeld and Janssen (1996) and give values of ω_k = 0.942 (4), average ω_L = 0.216 (9), and η_{KL} = 0.838 (4). Auger-electron and X-ray energies were calculated within the SAISINUC program using the data from Schönfeld and Rodloff (1998, 1999), respectively.

The X-ray and Auger-electron emission intensities were calculated using the 2013 version of the EMISSION code, as described in Schönfeld and Janssen (2000) and implemented in SAISINUC, and based on the adopted γ-ray emission probabilities and conversion coefficients.

Experimental determinations of X-ray intensities relative to the 1379.44-keV gamma ray were made by Chand *et al.* (1989) using planar and coaxial HPGe and Si(Li) detectors. Absolute X-ray intensities were measured as part of the study reported by Bobin *et al.* (2019), with all three participating laboratories providing results from HPGe detectors. In order to compare these data sets with the current and previous DDEP evaluated values, each data set was normalized to the respective intensities of the 1379.44-keV gamma ray. The results are compared with the newly recommended values in Table 5.

Table 5. Comparison of experimental relative X-ray emission probabilities reported by Chand *et al.* (1989), the three participating laboratories in the study reported by Bobin *et al.* (2019), and the present evaluation. In each case, the value is reported relative to the absolute intensity of the 1379.44 keV gamma ray as measured in each study.

Radiation	Chand *et al.* (1989)	Bobin *et al.* (2019), LNHB	Bobin *et al.* (2019), NPL	Bobin *et al.* (2019), CMI	This evaluation
$K_{\alpha 2}$	3.46 (11)	3.402 (62)	3.253 (57)	3.257 (82)	3.28 (6)
$K_{\alpha 1}$	6.13 (22)	5.95 (21)	5.81 (10)	5.77 (15)	5.82 (11)
$K'_{\beta 1}$	1.94 (8)	2.008 (37)	1.878 (32)	1.840 (46)	1.890 (46)
$K'_{\beta 2}$	0.47 (2)	0.642 (12)	0.5103 (85)	0.482 (55)	0.492 (15)
L_l	0.133 (3)	-	-	-	0.1657 (46)
L_α	3.59 (13)	-	-	-	3.82 (9)
L_β	3.81 (13)	-	-	-	3.98 (9)
L_γ	0.59 (3)	-	-	-	0.644 (16)
1379.44-keV γ	1.00 (1)	1	1	1	1

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