

^{84}Y ε decay (39.5 min) [1981FrZY,1970Re03,1969Za06](#)

Type	Author	History	Citation	Literature Cutoff Date
Full Evaluation	B. Singh, A. Negret, and K. Zuber		NDS 110,2815 (2009)	30-Sep-2009

Parent: ^{84}Y : $E=0$; $J^\pi=(6^+)$; $T_{1/2}=39.5$ min 8; $Q(\varepsilon)=6757$ 5; $\% \varepsilon + \% \beta^+$ decay=100.0

^{84}Y -E, J^π , $T_{1/2}$: from Adopted Levels for ^{84}Y .

^{84}Y - $Q(\varepsilon)$: from [2009AuZZ](#). Other: 6490 90 ([2003Au03](#)).

[1981FrZY](#): source from $^{70}\text{Ge}(^{16}\text{O},\text{pn}\gamma)$ reaction. Measured E_γ , I_γ , $\gamma\gamma$, $E\beta$ from $\beta\gamma$ coin using Ge(Li), Si(Li) and plastic scintillators. A total of 20 γ rays reported up to 1503 keV and confirmed another seven γ rays at higher energies from $\gamma\gamma$ data. The source prepared in heavy-ion studies contained many impurities.

[1970Re03](#): measured E_γ , I_γ , $\gamma\gamma$, $E\beta$, ce, $\gamma\gamma(\theta)$ using Ge(Li) and NaI(Tl) detectors. A total of 60 γ rays reported. This work is the most detailed study of ^{84}Y but it is a private communication, and the results have not appeared in open literature.

[1969Za06](#): measured E_γ , I_γ . A total of 24 γ rays reported and level scheme proposed with 11 excited states.

Other measurements:

[2000Do10](#): Decay of ^{84}Y g.s. and isomer studied by using several gamma-ray detectors. The authors stated that 50 γ rays were observed in the decay of the high-spin isomer (assigned as g.s. by [2000Do10](#)) as well as in the decay of 5.6-s activity, including population of a 7^+ member of quasi- γ band from the decay of 39.5-min activity. But details of this study are not available either in the (conference) paper or according to an e-mail reply from the first author of this work on May 24, 2003.

[1984Ak02](#): measured $\gamma\gamma(\theta)$ for four $\gamma\gamma$ cascades using Ge(Li) and NaI(Tl) detector combination.

[1981Li12](#): measured $\beta\gamma$ coin.

[1976Ia01](#): measured E_γ for three γ rays.

Additional information 1.

[1971Do01](#): measured E_γ , I_γ for 12 γ rays.

[1962Ya02](#): measured E_γ , I_γ , ce for six γ rays, $T_{1/2}$ of ^{84}Y .

The level scheme given here is mostly from [1970Re03](#) with some revisions based on in-beam γ -ray studies. The level scheme given by [1981FrZY](#) is quite similar to the one given in [1970Re03](#) with some minor differences.

The evaluators treat the level scheme as incomplete since many transitions are either unplaced or questionable. In the opinion of the evaluators there is no complete and comprehensive study of this decay in the literature.

 ^{84}Sr Levels

Following levels proposed in different studies have been omitted: 2367 and 4290 levels in [1962Ya02](#); 2558, 3086, 3202 and 4177 levels in [1969Za06](#); 1833 level in [1971Do01](#); 3385, 3449 and 4539 levels in [1981FrZY](#). The γ rays associated with these levels have either been placed differently or not seen consistently in all studies.

E(level) [†]	J^π [‡]	$T_{1/2}$	E(level) [†]	J^π [‡]	E(level) [†]	J^π [‡]
0.0	0 ⁺	stable	2734.7 [#] 3	(5 ⁺)	3577.8? 3	
793.03 16	2 ⁺		2768.2 [#] 3	(5 ⁻)	3819.12? 20	
1453.48 16	2 ⁺		2807.28 20	6 ⁺	3917.64? 22	
1767.13 19	4 ⁺		2886.57 20	2 ⁺	4062.10 20	4 ⁺
2055.52 19	(3) ⁺		3097.8 [#] 5	6 ⁽⁺⁾	4365.50 23	(4 ⁺)
2447.85 18	3 ⁻		3270.01 23	(4,5,6) ⁺	5150.2? 3	
2598.22? 22	(4 ⁺)		3511.25 22	(4 ⁺ ,5 ⁻)		

[†] From least-squares fit to E_γ 's; normalized $\chi^2=3.0$ whereas critical $\chi^2=1.7$. Two γ rays show poor fits.

[‡] From Adopted Levels.

[#] Level proposed by the evaluators based on high-spin studies.

^{84}Y ε decay (39.5 min) 1981FrZY,1970Re03,1969Za06 (continued) ε, β^+ radiations

From intensity balance following direct $\beta^+ + \varepsilon$ feedings treated as zero are as follows: 3.4 for 793 level, -3.8.9 for 1454 level, -1.5 for 1767 level, 0.1.8 for 2448 level, 0.8.5 for 2886 level.

Additional information 2.

The $\beta\gamma$ coin study of 1970Re03 shows that observed β branches are in coin with 793, 974 and 1040 γ rays implying that the 2808 keV level is the lowest level which has appreciable direct $\beta^+ + \varepsilon$ feeding. The β branches reported by 1970Re03 are: $E\beta=1641$ 10 ($I\beta=47\%$); $E\beta=2242$ 17 ($I\beta=25\%$); $E\beta=2637$ 20 ($I\beta=21\%$); $E\beta=3148$ 20 ($I\beta=7\%$).

$E(\beta^+ \text{ endpoint})=4.2$ MeV 1 from 793 $\gamma(\beta)$ coin (1981FrZY) cannot be accounted, it implies a direct feeding of 1454 level, which is inconsistent with γ intensity balance. This β branch may be associated either with an impurity or with the decay of 4.6-s activity of ^{84}Y .

E(decay)	E(level)	$I\beta^+$ #	$I\varepsilon$ #	Log ft †	$I(\varepsilon + \beta^+)$ †#	Comments
(1607 @ 5)	5150.2?	0.30 3	4.0 4	5.2	4.3 4	av $E\beta=257.5$ 22; $\varepsilon K=0.8141$ 18; $\varepsilon L=0.09618$ 21; $\varepsilon M+=0.02099$ 5
(2392 5)	4365.50	2.8 3	2.1 3	5.8	4.9 6	av $E\beta=602.0$ 23; $\varepsilon K=0.375$ 3; $\varepsilon L=0.0441$ 3; $\varepsilon M+=0.00962$ 7
(2695 5)	4062.10	8.0 6	3.2 3	5.7	11.2 9	av $E\beta=739.1$ 23; $\varepsilon K=0.2489$ 17; $\varepsilon L=0.02920$ 20; $\varepsilon M+=0.00637$ 5 $E\beta=1641$ 10, $I\beta=47\%$ (1970Re03) from $\beta\gamma$.
(2839 @ 5)	3917.64?	2.6 4	0.80 12	6.4	3.4 5	av $E\beta=805.0$ 23; $\varepsilon K=0.2053$ 14; $\varepsilon L=0.02407$ 16; $\varepsilon M+=0.00525$ 4
(2938 @ 5)	3819.12?	0.8 4	0.21 10	7.0	1.0 5	av $E\beta=850.1$ 23; $\varepsilon K=0.1806$ 12; $\varepsilon L=0.02117$ 14; $\varepsilon M+=0.00462$ 3
(3179 @ 5)	3577.8?	2.0 7	0.37 12	6.8	2.4 8	av $E\beta=961.3$ 24; $\varepsilon K=0.1336$ 9; $\varepsilon L=0.01565$ 10; $\varepsilon M+=0.003411$ 21
(3246 5)	3511.25	7.5 7	1.2 1	6.3	8.7 8	av $E\beta=992.1$ 24; $\varepsilon K=0.1234$ 8; $\varepsilon L=0.01445$ 9; $\varepsilon M+=0.003149$ 19 $E\beta=2242$ 17, $I\beta=25\%$ (1970Re03) from $\beta\gamma$.
(3487 5)	3270.01	14.5 7	1.73 9	6.2	16.2 8	av $E\beta=1104.4$ 24; $\varepsilon K=0.0936$ 6; $\varepsilon L=0.01095$ 6; $\varepsilon M+=0.002388$ 14 $E\beta=2637$ 20, $I\beta=21\%$ (1970Re03) from $\beta\gamma$.
(3659 5)	3097.8	2.6 3	0.26 3	7.1	2.9 3	av $E\beta=1184.9$ 24; $\varepsilon K=0.0778$ 5; $\varepsilon L=0.00910$ 5; $\varepsilon M+=0.001983$ 11
(3950 5)	2807.28	28 4	2.0 3	6.2	30 4	av $E\beta=1321.4$ 24; $\varepsilon K=0.0581$ 3; $\varepsilon L=0.00679$ 4; $\varepsilon M+=0.001480$ 8 E(decay): 3.2 MeV 1 from 1039 $\gamma(\beta)$ coin; 3.1 MeV 1 from 974 $\gamma(\beta)$ coin (1981FrZY). $E\beta=3148$ 20, $I\beta=7\%$ (1970Re03) from $\beta\gamma$. $Q(\varepsilon)=6409$ 170 from (2580 170 β)(974 γ +1040 γ) coin (1981Li12).
(3989 5)	2768.2	2.4 3	0.17 2	7.3	2.6 3	av $E\beta=1339.9$ 24; $\varepsilon K=0.0560$ 3; $\varepsilon L=0.00654$ 4; $\varepsilon M+=0.001426$ 7
(4022 5)	2734.7	5.8 5	0.38 3	7.0	6.2 5	av $E\beta=1355.7$ 24; $\varepsilon K=0.0542$ 3; $\varepsilon L=0.00634$ 3; $\varepsilon M+=0.001381$ 7
(4159 @ 5)	2598.22?	1.9 7	0.11 4	7.6	2.0 ‡ 7	av $E\beta=1420.2$ 24; $\varepsilon K=0.04778$ 22; $\varepsilon L=0.00559$ 3; $\varepsilon M+=0.001217$ 6
(4701 @ 5)	2055.52	4.7 8	0.17 3	7.5	4.9 ‡ 8	av $E\beta=1678.3$ 24; $\varepsilon K=0.03026$ 12; $\varepsilon L=0.003534$ 14; $\varepsilon M+=0.000770$ 3

† The decay scheme seems to be incomplete, thus all weak feedings and associated log ft values should be regarded as tentative.

‡ Feeding is too large for the high degree of forbiddenness probably due to incompleteness of the decay scheme.

Absolute intensity per 100 decays.

@ Existence of this branch is questionable.

^{84}Y ε decay (39.5 min) **1981FrZY,1970Re03,1969Za06** (continued) $\gamma(^{84}\text{Sr})$

I_γ normalization: From $\text{Ti}(793\gamma+1453.4\gamma)=100$. Direct β feeding of the g.s. is not expected due to $\Delta J=6$ involved.
1970Re03 give A_2 and A_4 coefficients from $\gamma\gamma(\theta)$ data for 17 cascades but the authors state that poor statistics make most of these of dubious nature. These are listed in this dataset under document records.
 $\gamma\gamma$ coin information is from **1970Re03**.

E_γ [†]	I_γ ^{‡b}	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. [#]	$\delta^\#$	α^c	Comments
241.2 & 5	0.3 2	3511.25	(4 ⁺ , 5 ⁻)	3270.01	(4, 5, 6) ⁺				
288.3 & 5	0.8 2	2055.52	(3) ⁺	1767.13	4 ⁺				
462.8 2	10.3 5	3270.01	(4, 5, 6) ⁺	2807.28	6 ⁺	M1, E2		0.0039 8	Mult.: from $\alpha(K)\text{exp}=0.0039$ 16. Additional information 18.
602.2 2	9.7 5	2055.52	(3) ⁺	1453.48	2 ⁺	M1+E2	+0.24 8	0.00173	$\alpha(K)\text{exp}=0.00155$ 7 (1970Re03) δ : +0.24 8 or +2.3 5, evaluators' analysis of $A_2=+0.032$ 14, $A_4=-0.001$ 25 (1984Ak02) for (602 γ)(661 γ)(793 γ)(θ) which is consistent with 3-2-2-0 cascade using $\delta(661\gamma)=+0.59$. $\alpha(K)\text{exp}$ gives mainly M1. 1984Ak02 give $\leq 1.0\%$ E2 implying $\delta \leq 0.1$. Additional information 8.
^x 635 ^a 1	≤ 3								E_γ : tentative placement from a 3086 level (1969Za06) not substantiated and γ ray not seen in 1970Re03 .
^x 658.3 & 2	4.5 5								E_γ : see comment for 660.6 γ . $\alpha(K)=0.00129$; $\alpha(L)=0.00014$
660.6 2	11.5 5	1453.48	2 ⁺	793.03	2 ⁺	M1+E2	+0.59 5	0.00145	E_γ, I_γ : 1970Re03 resolved doublet 658.3 and 660.6 with $I_\gamma=4.5$ 5 and 11.5 10, respectively. Combined E_γ and I_γ given in other studies: $E_\gamma=660.5$ 5, $I_\gamma=25.9$ 26 (1981FrZY); $E_\gamma=660.5$ 5, $I_\gamma=12.6$ 10 (1971Do01); $E_\gamma=662$ 1, $I_\gamma=16.5$ 22 (1969Za06). Additional information 5.
680.6 4	4.8 4	2734.7	(5 ⁺)	2055.52	(3) ⁺				δ : from evaluators' analysis of : $A_2=-0.161$ 24, $A_4=+0.04$ 4 (1984Ak02) for (661 γ)(793 γ)(θ) which is consistent with 2-2-0 cascade. 1984Ak02 give 27% 5 E2 implying $\delta=0.61$ 7. note that the placement from 2448 level in 1970Re03 and 1981FrZY is in disagreement with results from (p,p' γ) and

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^{84}Y ε decay (39.5 min) [1981FrZY,1970Re03,1969Za06](#) (continued) $\gamma(^{84}\text{Sr})$ (continued)

E_γ [†]	I_γ ^{‡b}	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Mult. [#]	α^c	Comments
								($\alpha, \alpha'\gamma$) studies of 1973Re01 and high-spin studies. E_γ : level-energy difference=679.2. Additional information 13.
703.6 2	5.9 6	3511.25	(4 ⁺ ,5 ⁻)	2807.28	6 ⁺			E_γ, I_γ : 1970Re03 resolved doublet 703.6 and 705.8 with $I_\gamma=5.9$ 6 and 3.8 4, respectively. Combined E_γ and I_γ given In other studies: $E_\gamma=704.5$ 5, $I_\gamma=8.6$ 9 (1981FrZY); $E_\gamma=704.1$ 5, $I_\gamma=7.3$ 15 (1971Do01).
^x 705.8 & 2 793.1 2	3.8 4 100	793.03	2 ⁺	0.0	0 ⁺	E2	0.00106	E_γ : see comment for 703.6 γ . Ice(K)=100 (1962Ya02). Additional information 4.
932.2 ^d 2	1.14 10	3819.12?		2886.57	2 ⁺			Additional information 22.
967.2 & 2 974.3 2	1.51 15 79 4	2734.7 1767.13	(5 ⁺) 4 ⁺	1767.13 793.03	4 ⁺ 2 ⁺	E2		Placement based on high-spin data. $\alpha(K)_{\text{exp}}=0.00066$ 6 (974 γ)(793 γ)(θ): $A_2=+0.093$ 14, $A_4=+0.009$ 23 (1984Ak02) consistent with 4-2-0 cascade. $A_2=+0.93$ quoted by 1984Ak02 is likely a misprint. $\alpha(K)_{\text{exp}}$ gives E2,M1. Additional information 7.
980.2 & ^d 10 994.8 2	0.9 5 4.1 4	3577.8? 2447.85		2598.22? (4 ⁺) 1453.48 2 ⁺				Additional information 10.
1001.1 2	2.6 3	2768.2	(5 ⁻)	1767.13	4 ⁺			E_γ : tentative placement from a 3449 level (1981FrZY) not supported by $\gamma\gamma$ data of 1970Re03 . Placement based on high-spin data. Additional information 14.
1039.7 2	57 3	2807.28	6 ⁺	1767.13	4 ⁺	(E2)		$\alpha(K)_{\text{exp}}=0.00049$ 9 (1040 γ)[974 γ](793 γ)(θ): $A_2=+0.097$ 18, $A_4=+0.01$ 3 (1984Ak02) consistent with 6-4-2-0 cascade. $\alpha(K)_{\text{exp}}$ gives E2,M1. Additional information 15.
1063.5 & 3 ^x 1092.3 2	0.77 25 4.5 4	3511.25	(4 ⁺ ,5 ⁻)	2447.85	3 ⁻			Additional information 3.
1110.3 ^d 2	3.1 3	3917.64?		2807.28	6 ⁺			Additional information 24.
1119.6 2	2.0 2	2886.57	2 ⁺	1767.13	4 ⁺			Additional information 16.
1129.6 & ^d 4 1144.2 ^d 2	0.4 2 3.2 3	3577.8? 2598.22?		2447.85 1453.48	3 ⁻ 2 ⁺			Additional information 12.
^x 1154.9 @ 5	0.7							E_γ : tentative placement from a 4539 level (1981FrZY) not substantiated and γ ray not seen in 1970Re03 .

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^{84}Y ε decay (39.5 min) [1981FrZY](#),[1970Re03](#),[1969Za06](#) (continued) $\gamma(^{84}\text{Sr})$ (continued)

E_γ [†]	I_γ ^{‡b}	$E_i(\text{level})$	J_i^π	E_f	J_f^π	Comments
^x 1185.1 &d 2	0.5 2					
1232.9 &d 3	1.1 1	5150.2?		3917.64?		
1255.0 2	6.7 7	4062.10	4 ⁺	2807.28	6 ⁺	Additional information 25.
1262.6 2	2.7 3	2055.52	(3) ⁺	793.03	2 ⁺	Additional information 9.
^x 1270.7 & 10	0.9 3					
^x 1280.8 & 10	0.22 10					
1330.7 4	2.9 3	3097.8	6 ⁽⁺⁾	1767.13	4 ⁺	E_γ : tentative placement from a 3385 level (1981FrZY) not substantiated. Placement based on high-spin data.
						Additional information 17.
1330.7 d 4	2.9 3	5150.2?		3819.12?		Additional information 31.
^x 1362.8 & 10	0.20 10					
1370.8 &d 3	0.4 2	3819.12?		2447.85	3 ⁻	
^x 1411.1 & 2	0.7 3					
1453.4 2	1.6 3	1453.48	2 ⁺	0.0	0 ⁺	Additional information 6.
1463.3 &d 2	0.4 2	4062.10	4 ⁺	2598.22?	(4 ⁺)	
1469.9 &d 2	0.9 3	3917.64?		2447.85	3 ⁻	
1479.2 & 2	0.9 3	4365.50	(4 ⁺)	2886.57	2 ⁺	
1502.8 2	6.4 6	3270.01	(4,5,6) ⁺	1767.13	4 ⁺	Additional information 19.
^x 1520.2 & 5	0.4 2					
1557.6 3	0.6 3	4365.50	(4 ⁺)	2807.28	6 ⁺	Additional information 28.
1614.5 2	1.8 2	4062.10	4 ⁺	2447.85	3 ⁻	Additional information 26.
^x 1628 a 1	1					E_γ : tentative placement from a 3086 level (1969Za06) not substantiated and γ ray not seen in 1970Re03 .
1638.6 &d 7	0.35 25	5150.2?		3511.25	(4 ⁺ ,5 ⁻)	
1654.6 2	2.6 2	2447.85	3 ⁻	793.03	2 ⁺	Additional information 11.
^x 1711 a 1	1.5 5					
1744.4 2	2.24 25	3511.25	(4 ⁺ ,5 ⁻)	1767.13	4 ⁺	Additional information 20.
1763.6 d 2	1.9 2	3819.12?		2055.52	(3) ⁺	Additional information 23.
1805.0 &d 10	0.15 15	2598.22?	(4 ⁺)	793.03	2 ⁺	
1810.8 d 3	1.1 5	3577.8?		1767.13	4 ⁺	Additional information 21.
1918.0 4	2.3 3	4365.50	(4 ⁺)	2447.85	3 ⁻	Additional information 29.
2006.7 &d 5	0.3 2	4062.10	4 ⁺	2055.52	(3) ⁺	
2052.9 &d 3	0.50 25	3819.12?		1767.13	4 ⁺	E_γ : level-energy difference=2052.9.
2093.3 & 2	0.9 3	2886.57	2 ⁺	793.03	2 ⁺	
2150.9 &d 5	0.52 25	3917.64?		1767.13	4 ⁺	
2295.3 4	2.2 3	4062.10	4 ⁺	1767.13	4 ⁺	Additional information 27.
2309.5 & 4	1.2 2	4365.50	(4 ⁺)	2055.52	(3) ⁺	Additional information 30.
^x 2807.8 & 10	0.13 13					most likely a sum line.
^x 2908 & 1	0.3 1					
^x 2945 & 1	0.2 1					
^x 2968 & 1	0.2 1					
^x 3315 & 1	0.1 1					

[†] From weighted averages of values from [1970Re03](#), [1971Do01](#) and [1981FrZY](#) when possible. Values from [1969Za06](#) are not used due to less precision in this work.

[‡] From weighted averages of values from [1970Re03](#), [1969Za06](#) and [1981FrZY](#) when possible. Values from [1971Do01](#) are not used

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^{84}Y ε decay (39.5 min) [1981FrZY](#), [1970Re03](#), [1969Za06](#) (continued)

$\gamma(^{84}\text{Sr})$ (continued)

since these values are systematically lower by about 25-50%.

[#] From $\gamma\gamma(\theta)$ ([1984Ak02](#)). Pure quadrupole transitions and transitions with significant quadrupole admixture are assigned E2 and M1+E2, respectively, based on RUL.

[@] From [1981FrZY](#).

[&] From [1970Re03](#) only.

^a From [1969Za06](#) only.

^b For absolute intensity per 100 decays, multiply by 0.983 4.

^c Total theoretical internal conversion coefficients, calculated using the BrIcc code ([2008Ki07](#)) with Frozen orbital approximation based on γ -ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

^d Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

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Legend

- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- - - - - γ Decay (Uncertain)
- Coincidence

Decay Scheme

Intensities: Relative I_γ

