^{94m}Tc – Comments on evaluation of decay data by A. L. Nichols

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Evaluation Procedures

Limitation of Relative Statistical Weight Method (LWM) and other analytical techniques were applied to obtain averaged data throughout the evaluation. The uncertainty assigned to the average value was always greater than or equal to the smallest uncertainty of the values used to calculate the average.

Decay Scheme

^{94m}Tc ($T_{½}$ = 51.9 min) undergoes 100% electron capture/β^+ decay (Q(EC) = 4332 (5) keV) to various excited nuclear levels and the ground state of ^{94}Mo. A reasonably well-defined decay scheme was derived from the gamma-ray measurements of 1969Ba09 and 1986AgZX, and γ-γ coincidence studies of 2003Fr02, consisting of 16 EC/7 β^+ transitions and 52 gamma-ray emissions. While nineteen gamma-ray emissions were originally defined as unplaced in the decay scheme, twelve of these transitions have been successfully incorporated into the proposed decay scheme during the course of the current study, while the 1022-keV gamma emission was identified as the (511 + 511 keV) sum peak. Thus, six of the observed gamma rays remain unplaced. Weighted mean relative emission probabilities were calculated for a significant number of the gamma rays, although some of the recommended values arose solely from either 1969Ba09 or 1986AgZX. All of these relative emission probabilities have been defined in terms of the 871.094-keV gamma ray (100%).

A further sixteen gamma rays have been observed/proposed by Fransen *et al*. (2003Fr02), but an inability to derive and quantify their absolute emission probabilities has prevented their satisfactory insertion and adoption in the decay scheme and data file. If these additional gamma transitions could have been suitably introduced into the ^{94m}Tc decay scheme, they would have impacted to a small degree on the EC/β^+ decay data.

Nuclear Data

^{94m}Tc decay is viewed as a potentially suitable β^+ emitter for application in positron emission tomography (PET).

Half-life of ^{94m}Tc

The measurements of 1948Mo19 (enriched ^{94}Mo(d,2n) ^{94m}Tc), 1950Me21 (^{94}Mo(p,n) ^{94m}Tc) and 1962Mo06 (enriched ^{94}Mo(d,2n) ^{94m}Tc) were adopted to give a weighted mean half-life of 51.9 (10) minutes based on the limitation of relative statistical weight method (LWM). There is no evidence for the production of ^{94}Ru (half-life of 52.1 (6) minutes), or potential complication of transient equilibrium that would be associated with such an occurrence. Furthermore, unrelated studies involving the ^{94}Mo(d,2n) reaction that focus on the resulting gamma ray emissions have shown that only Tc activities are produced, without the presence of the 367-, 525- and 892-keV gamma rays of ^{94}Ru (1969Ba09). All half-life measurements of ^{94m}Tc as produced via the ^{94}Mo(d,2n) and ^{94}Mo(p,n) reactions are judged to be valid, while under certain circumstances (e.g. adoption of ^{92}Mo(α,2n)^{94}Ru(EC) ^{94m}Tc and ^{94}Mo(α,4n)^{94}Ru(EC) ^{94m}Tc as modes of preparation), the presence of parent ^{94}Ru with an extremely similar half-life of 52.1 (6) minutes will complicate data analyses.

Reference	Half-life (min)
1948Mo19	50 (2)
1950Me21	) 52.5 (15)
	) 51.5 (10)
1962Mo06	53 (2)
Recommended value	51.9 (10)*

* Recommended uncertainty has been adjusted from ± 0.8 to 1.0, in alignment with the smallest uncertainty of the values used to calculate the average value.

Half-life of ^{94}Tc ground state

The measurements of 1962Mo06, 1963Ma21 and 1965Ba48 were adopted to give a weighted mean half-life of 293 (1) minutes based on the limitation of relative statistical weight method (LWM).

Reference	Half-life (min)
1962Mo06	270 (12)
1963Ma21	293 (1)
1965Ba48	295 (10)
Recommended value	293 (1)

Half-life of parent ^{94}Ru

^{94}Ru undergoes 100% EC decay through the population of the 443(3)- and 968(3)-keV nuclear levels of ^{94}Tc and the 367-, 525- and 892-keV gamma transitions to populate the ^{94m}Tc metastable level at 76 (3) keV. No other gamma-ray emissions are identified with the EC decay of ^{94}Ru. With parent ^{94}Ru (half-life of 52.1 (6) min) and ^{94m}Tc as a daughter radionuclide (half-life of 51.9 (10) min), the determination of these almost identical half-lives necessitated additional investigation to ensure these two separate values are valid and not a consequence of transient equilibrium being established between parent and daughter prior to measurements.

Reference	Half-life (min)
1967Ei01	53 ± 1
1968Bo27	51.8 ± 0.6
Recommended value	52.1 ± 0.6*

* Recommended uncertainty has been adjusted from ± 0.5 to 0.6, in alignment with the smallest uncertainty of the values used to calculate the average value.

Eichler et al. (1967Ei01) produced ^{94}Ru by means of the ^{94}Mo(α,4n)^{94}Ru and ^{92}Mo(α,2n)^{94}Ru with 58- and 32-MeV α particles, respectively. This material was purified by distillation and precipitation, and the only contaminant activities were observed to be ^{95}Ru and ^{94m}Tc. Little to no positron emission was observed to occur in the ^{94}Ru decay process on the basis of the 511-keV annihilation radiation, which only increased substantially with the in-growth of ^{94m}Tc. A ^{94}Ru half-life of (53 ± 1) min was measured by following the decay of only the 367.2(5)-, 525(1)- and 891.2(5)-keV gamma rays, which constitute the primary decay signatures of ^{94}Ru (and are not attributed to ^{94m}Tc); other peaks in the spectrum were assigned to ^{94m}Tc and ^{95}Ru.

Boswell and McGee (1968Bo27) also produced ^{94}Ru by irradiation of natural Mo foil with 80-100 μA beam of 40-MeV α particles to induced the ^{94}Mo(α,4n)^{94}Ru and ^{92}Mo(α,2n)^{94}Ru reactions. Subsequent purification included dissolution of the target and distillation of ruthenium tetraoxide (RuO_4), followed by removal of Tc daughters by a milking procedure with a growth period of 20 minutes between each of six milkings. Decay of each milking sample was followed for seven days by means of a NaI(Tl) well-type detector. Corrected yields of ^{94}Tc were determined and plotted against time of separation to give a half-life for parent ^{94}Ru of (51.8 ± 0.6) min. The gamma-ray spectrum emitted from the decay of an isolated ruthenium fraction was also determined by means of NaI(Tl) and Ge(Li) detectors – both the 367- and 890-keV gamma rays assigned to ^{94}Ru were determined to decay with a half-life of (53 ± 1) min.

Q-value

Q_{EC}-value for ^{94m}Tc EC/β^+ decay of 4332 (5) keV was adopted from Wang *et al*. (2012Wa38).

Gamma-ray energies and emission probabilities

<u>Energies</u>

The well-defined nuclear level energies of 2006Ab37 were used to calculate the gamma transition energies and their uncertainties, and these data were adjusted to account for gamma recoil in the formulation of recommended gamma-ray emission energies and uncertainties. Greater confidence was placed on this overall method of assignment because of the more wide-ranging origins of the gamma transition data in 2006Ab37. The 1573.76-, 1741.65-, 3331.74- and 3534.32-keV levels are exceptions to this approach – the energies of these particular nuclear levels of ^{94}Mo were determined from previously unplaced gamma rays that possess the potential to depopulate nuclear levels derived from the γ-γ coincidence studies of 2003Fr02.

Adopted energies, spins and parities for the nuclear levels of ^{94}Tc and ^{94}Mo (2003Fr02, 2006Ab37).

Nuclear level number	Nuclear level energy (keV)	Spin and parity	Half-life	
0	0.0	7 +	293 (1) min	^{94}Tc
1	76 (3)	(2) +	51.9 (10) min	^{94m}Tc
0	0.0	0 +	stable	^{94}Mo
1	871.098 (16)	2 +		
2	1573.76 (4)*	4 +		
3	1741.65 (15)*	0 +		
4	1864.31 (5)	2 +		
5	2067.35 (6)	2 +		
6	2294.79 (16)	4 +		
7	2393.02 (6)	2 +		
8	2423.45 (9)	6 +		
9	2533.87 (12)	3 −		
10	2610.57 (16)	5 −		
11	2739.91 (7)	1 +		
12	2805.04 (19)	3 +		
13	2869.90 (8)	2 +		
14	2872.40 (11)	6 +		
15	2955.55 (13)	(8 +)		
16	2965.41 (6)	3 +		
17	3128.66 (7)	1 +		
18	3163.29 (19)	(3 +)		
19	3165.77 (9)	6 +		
20	3331.74 (17)*	(3 +)		
21	3339.54 (17)	6 +		
22	3400.83 (17)			
23	3447.6 (4)	(1, 2 +)		
24	3511.86 (14)	1 (+)		
25	3534.32 (9)*	2 +		
26	3792.87 (15)	2 +		
27	3892.16 (7)	(2 +)		

* Nuclear level assignment based originally on studies of other related nuclear processes, but introduced in the proposed ^{94m}Tc decay scheme to explain observations of previously unplaced gamma-ray emissions.

Emission Probabilities

All of the relative emission probabilities were suitably quantified in terms of the emission probability of the 871.094-keV gamma ray (100.0%). Sufficiently detailed decay data measurements were only reported in gamma-ray spectroscopic studies by 1969Ba09 and 1986AgZX, and γ-γ coincidence studies of 2003Fr02. When appropriate, weighted-mean analyses have been undertaken for the recommendation of the most significant gamma-ray emission probabilities. Although lacking necessary descriptive detail, the measurements of Ageev *et al*. (1986AgZX) and Fransen *et al*. (2003Fr02) are the most substantial, and therefore their data were adopted for many of the low-intensity gamma-ray emissions in preference to any semi-artificial weighting procedure. This approach was occasionally fortified with data supportive towards the emission of particular gamma rays by Sugiyama and Kikuchi (1976Su04), as taken from their nuclear-level studies of ^{94}Mo populated by the ^{94}Mo(n,n'γ)^{94}Mo reaction. The comprehensive studies of 2003Fr02 focused on γ intensity ratios from individual nuclear levels of ^{94}Mo rather than the determination of absolute γ-ray emission probabilities, and therefore not all of these observed transitions could be suitably quantified in the desired manner – while listed in the tabulations below, these particular γ rays are not included in the decay-data file because their absolute emission probabilities remain unknown. Nineteen previously unplaced gamma-ray emissions were re-considered from the point of view of the known nuclear levels of ^{94}Mo. A number of these gamma-ray emissions can be incorporated into the proposed decay scheme: 875.1, 998.2, 1499.0, 1670.1, 1757.9, 1769.9, 2027.5, 2257.5, 2664.1, 2869.9, 3400.8 and 3640.6 keV. Despite these efforts, six observed gamma rays remain unplaced in the proposed decay scheme, although they are contained within the recommended data set: 1037.2, 1357.4, 3065.6, 3085.8, 3640.6 and 4136.2 keV.

Gamma transition energies, and measured and recommended gamma-ray energies.

E_{TP} (keV)[#]	E_γ (keV)								
	1962Mo06	**1964Ha29**	**1968Ar06**	**1968Ka25**[‡]	**1969Ba09**	**1976Su04**	**1986AgZX***	**2003Fr02**	**Recommended**[§]
293.37 (14)	−	−	−	293 (1)	−	−	−	293.4 (1)	293.37 (14)
325.67 (9)	−	−	−	−	−	−	−	325.7 (3)	325.67 (9)
358.3 (3)	−	−	−	−	−	−	−	358.0 (5)	358.3 (3)
448.95 (14)	−	−	−	449.0 (10)	−	−	−	449.0 (1)	448.95 (14)
466.52 (13)	−	−	−	−	−	466.7 (8)	−	466.4 (3)	466.52 (13)
−	511	511	−	−	−	−	−	−	annihilation radiation
528.71 (8)	−	−	−	−	−	−	−	528.7 (3)	528.71 (8)
532.10 (16)	−	−	−	532.0 (10)	−	−	−	532.1 (1)	532.10 (16)
669.56 (13)	−	−	−	−	−	−	−	669.6 (2)	669.56 (13)
672.56 (9)	−	−	−	−	−	−	−	672.0 (7)	672.56 (9)
702.66 (4)	−	−	−	704.0 (8)	−	702.5 (5)	−	702.63 (10)	702.66 (4)[θ]
721.03 (17)	−	−	−	−	−	721.5 (5)	−	721.0 (2)	721.03 (17)
742.32 (13)	−	−	−	743.0 (15)	−	−	−	742.2 (2)	742.32 (13)
802.55 (10)	−	−	−	−	−	−	−	802.6 (2)	802.55 (10)
849.69 (10)	−	−	−	851.0 (10)	−	−	−	849.7 (1)	849.69 (10)
870.55 (22)	(	(	(	(	(	871.4 (5)	(	(	870.55 (22)[†]
871.098 (16)	870 (5) (	870.7 (7) (	870.9(2) (	872.5 (10) (	871.05 (7) (	871.4 (5)	871.0 (3) (	871.09 (10) (	871.094 (16)
875.60 (9)	(	(	(	(	(		875.1 (3)	875.5 (2)	875.60 (9)
898.06 (9)	−	−	−	−	−	−	−	898.1 (1)	898.06 (9)
916.09 (19)	−	−	−	917.0 (10)	−	−	−	916.2 (1)	916.09 (19)
940.73 (20)	−	−	−	−	−	−	−	−	940.72 (20)
960.11 (13)	−	−	−	−	−	961.5 (10)	−	960.1 (3)	960.10 (13)
993.21 (5)	−	−	993.1 (5)	−	993.19 (9)	993.1 (8)	993.4 (3)	993.1 (1)	993.20 (5)
998.26 (17)	−	−	−	−	998.1 (10)	−	998.2 (3)	998.2 (2)	998.25 (17)
1005.59 (9)	−	−	−	−	1005.8 (3)	−	1006.1 (3)	1005.5 (1)	1005.58 (9)
−	−	−	−	−	−	−	1022.2 (3)	−	(511 + 511) keV sum peak
1037.2 (3)[Δ]	−	−	−	−	−	−	1037.2 (3)	1036.8 (2)	1037.2 (3)[Δ]
1061.31 (9)				−		−		1061.1 (5)	1061.30 (9)
1101.10 (8)	−	−	−	−	−	−	1101.3 (3)	1101.1 (1)	1101.09 (8)
1196.25 (6)	−	−	1196.2 (7)	−	1196.4 (3)	−	1196.4 (3)	1196.2 (1)	1196.24 (6)
1231.28 (19)	−	−	−	−	−	−	−	−	1231.27 (19)
1264.35 (9)	−	−	−	−	1264.9 (4)	−	1264.7 (3)	1264.3 (1)	1264.34 (9)
1357.4 (15)[Δ]	−	−	−	−	1357.4 (15)	−	−	−	1357.4 (15)[Δ]
1391.65 (7)	−	−	−	−	−	1391.4 (10)	−	1391.6 (1)	1391.64 (7)
1399.85 (16)	−	−	−	−	−	−	−	1399.9 (2)	1399.84 (16)
1423.69 (16)	−	−	−	−	−	−	−	1423.7 (3)	1423.68 (16)
1467.43 (18)	−	−	−	−	−	−	−	1467.3 (3)	1467.42 (18)

1499.14 (9)	–	–	–	–	–	–	1499.0 (3)	1499.1 (1)	1499.13 (9)
1521.92 (6)	1530 (10)	1530 (70)	1522.0 (3)	1510 (2)	1522.1 (2)	1522.3 (10)	1521.7 (3)	1521.8 (1)	1521.91 (6)
1536.52 (18)	–	–	–	–	–	–	–	1536.5 (2)	1536.51 (18)
1592.01 (10)	–	–	–	1593 (2)	–	–	–	1592.0 (1)	1592.00 (1)
1662.77 (12)	–	–	–	–	–	1663.1 (10)	–	1662.7 (3)	1662.75 (12)
1670.01 (10)	–	–	–	–	–	–	1670.1 (3)	1670.0 (1)	1669.99 (10)
1757.98 (17)	–	–	–	1767 (2)	1757.9 (10)	–	1757.9 (3)	1758.0 (2)	1757.96 (17)
1770.21 (21)	–	–	–	–	–	–	1769.9 (3)	1770.4 (2)	1770.19 (21)
1824.81 (9)	–	–	–	–	–	–	–	1824.9 (3)	1824.79 (9)
1864.31 (5)	1870 (20) (	1870 (70) (	–	1868 (	1864.2	1864.5 (10)	1864.4 (3)	1864.3 (2)	1864.29 (5)
1868.81 (7)	(	(	1868.8 (3)	(	1868.68 (8)	1869 (2)	1868.6 (3)	1868.8 (1)	1868.79 (7)
1928.56 (16)	–	–	–	–	1928.8 (20)	–	1928.2 (3)	1928.5 (2)	1928.54 (16)
1933.94 (19)	–	–	–	–	–	–	–	–	1933.92 (19)
1998.80 (8)	–	–	–	–	–	–	–	1998.9 (2)	1998.78 (8)
2027.85 (9)	–	–	–	–	–	–	2027.5 (3)	2027.9 (2)	2027.83 (9)
2067.35 (6)	–	–	–	–	2067.4 (5)	–	2066.7 (3)	2067.4 (1)	2067.33 (6)
2094.31 (6)	–	–	–	–	–	–	–	2094.3 (1)	2094.28 (6)
2257.56 (7)	–	–	–	–	–	–	2257.5 (3)	2257.6 (1)	2257.53 (7)
2292.19 (19)	–	–	–	–	–	–	2292.2 (3)	2292.2 (2)	2292.16 (19)
2393.02 (6)	2410 (20)	2410 (100)	2393.0 (7)	–	2393.2 (4)	–	2392.6 (3)	2393.1 (1)	2392.99 (6)
2460.64 (17)	–	–	–	–	–	–	–	2460.8 (8)	2460.61 (17)
2529.73 (17)	–	–	2530.0 (10)	–	2529.8 (3)	2530.9 (20)	2529.6 (3)	2529.7 (3)	2529.69 (17)
2576.5 (4)	–	–	–	–	2577.2 (20)	2577.9 (20)	2577.2 (3)	2576.5 (5)	2576.5 (4)
2640.76 (14)	–	–	–	–	2641.6 (15)	–	2640.6 (3)	2640.7 (3)	2640.72 (14)
2663.22 (9)	–	–	–	–	2664.1 (20)	–	–	2663.2 (2)	2663.18 (9)
2739.91 (7)	2730 (20)	2740 (100)	2740.0 (7)	2740	2740.1 (3)	2741.8 (20)	2739.8 (3)	2739.9 (1)	2739.87 (7)
2869.90 (8)	–	–	–	–	–	–	2869.9 (3)	2870.0 (2)	2869.85 (8)
3021.06 (7)	–	–	–	–	3021.6 (10)	–	3020.9 (3)	3021.0 (1)	3021.01 (7)
3065.7 (3)$^{\Delta}$	–	–	–	–	–	–	3065.6 (3)	–	3065.6 (3)$^{\Delta}$
3085.9 (3)$^{\Delta}$	–	–	–	–	–	–	3085.8 (3)	–	3085.8 (3)$^{\Delta}$
3128.66 (7)	3200 (30)	3200 (100)	3129.2 (7)	–	3129.1 (5)	–	3128.6 (3)	3128.5 (2)	3128.60 (7)
3400.83 (17)	–	–	–	–	–	–	3400.8 (3)	–	3400.76(17)
3447.6 (4)	–	–	–	–	–	–	3447.0 (3)	3447.5 (10)	3447.5 (4)
3511.86 (14)	–	–	–	–	3512.5 (15)	–	3511.8 (3)	3511.6 (2)	3511.79 (14)
3534.32 (9)	–	–	–	–	–	–	–	3534.0 (4)	3534.25 (9)
3640.7 (3)$^{\Delta}$	–	–	–	–	–	–	3640.6 (3)	–	3640.6 (3)$^{\Delta}$
3792.87 (15)	–	–	3793.5 (10)	–	3793.1 (15)	–	3792.5 (3)	3792.3 (10)	3792.79 (15)
3892.16 (7)	–	–	–	–	3892.7 (25)	–	3891.7 (3)	3891.6 (10)	3892.07 (7)
4136.3 (3)$^{\Delta}$	–	–	–	–	–	–	4136.2 (3)	–	4136.2 (3)$^{\Delta}$

$^{\#}$ Determined from the nuclear level energies of 2006Ab37.
‡ All gamma-ray energies listed as reported by 1968Ka25, but only 872.5 (10)-, 1868- and 2740-keV gamma rays were identified with the EC/β^+ decay of ^{94m}Tc – as defined in their proposed decay schemes, all other gamma rays were assigned to EC/β^+ decay of ^{94}Tc.
* All uncertainties defined as ± 0.3 keV.
§ Calculated by subtracting gamma recoil from gamma transition energy (E_{TP} (keV)).
$^{\theta}$ Introduced as depopulating (1573.76 – 871.098)-keV transition from proposed 1573.76-keV nuclear level, although unobserved in published ^{94m}Tc gamma-ray measurements.
† Introduced as depopulating (1741.65 – 871.098)-keV transition from proposed 1741.65-keV nuclear level, although unobserved in published ^{94m}Tc gamma-ray measurements.
$^{\Delta}$ Unplaced in proposed decay scheme.

Previously unplaced gamma transitions (2006Ab37).

E_γ (keV)	P_γ^{rel}	Assignment	Comments
875.1 (3)	1.1 (3)	2739.91 → 1864.31	Observed by 1986AgZX, and supported by the studies of 2003Fr02.
998.2 (3)	0.25 (2)	2739.91 → 1741.65	Observed by 1969Ba09 and 1986AgZX, and supported by the studies of 2003Fr02.
1022.2 (3)	0.029 (15)	N/A	(511 + 511) keV sum peak.
1037.2 (3)	0.047 (15)	–	Only observed by 1986AgZX.
1357.4 (15)	0.20 (8)	–	Only observed by 1969Ba09.
1499.0 (3)	0.071 (12)	3892.16 → 2393.02	Observed by 1986AgZX, and supported by the studies of 2003Fr02.
1670.1 (3)	0.039 (2)	3534.32 → 1864.31	Observed by 1986AgZX, and supported by the studies of 2003Fr02.
1757.9 (3)	0.16 (2)	3331.74 → 1573.76	Observed by 1969Ba09 and 1986AgZX, and supported by the studies of 2003Fr02.
1769.9 (3)	0.027 (7)	3511.86 → 1741.65	Observed by 1986AgZX, and supported by the studies of 2003Fr02.
2027.5 (3)	0.022 (4)	3892.16 → 1864.31	Observed by 1986AgZX, and supported by the studies of 2003Fr02.
2257.5 (3)	0.061 (5)	3128.66 → 871.098	Observed by 1986AgZX, and supported by the studies of 2003Fr02.
2664.1 (20)	0.070 (2)	3534.32 → 871.098	Observed by 1969Ba09, and supported by the studies of 2003Fr02.
2869.9 (3)	0.017 (2)	2869.90 → 0.0	Observed by 1986AgZX, and supported by the studies of 2003Fr02.
3065.6 (3)	0.012 (4)	–	Only observed by 1986AgZX
3085.8 (3)	0.017 (4)	–	Only observed by 1986AgZX.
3400.8 (3)	0.005 (2)	3400.83 → 0.0	Only observed by 1986AgZX.
3447.0 (3)	0.006 (1)	3447.6 → 0.0	Observed by 1986AgZX, and supported by the studies of 2003Fr02.
3640.6 (3)	0.007 (2)	–	Only observed by 1986AgZX.
4136.2 (3)	0.007 (1)	–	Only observed by 1986AgZX.

Another point of note involves summed gamma peaks that could also be potentially observed:

unplaced 1022.2-keV gamma transition is believed to be the sum peak of (511 + 511);
placed 1864.79-keV gamma could partially contain or fully be the sum peak of (871.09 + 993.20);
placed 2392.99-keV gamma could partially contain the sum peak of (871.09 + 1521.91);
placed 2739.87-keV gamma could partially contain the sum peak of (871.09 + 1868.79).

Multiple assignments of this nature are very difficult to address when experimental details are lacking. Therefore, these possible summing effects have been ignored, other than defining the 1022.2-keV emission as a (511 + 511) sum peak.

The existence of the 1864.29-keV γ ray is uncertain, being effectively unobserved by 1969Ba09 (assigned relative emission probability ≤ 0.25), but detected by 1986AgZX (relative emission probability of 0.41 (4)). Extensive γ-ray studies by 2003Fr02 indicate the depopulation of the 1864.31-keV nuclear level of ^{94}Mo by means of 993.20- and 1864.29-keV γ transitions. Under these circumstances, the relative emission probabilities of these two γ rays as determined by 2003Fr02 have been adopted to determine a relative emission probability of 0.24 (3) % for the previously ill-defined 1864.29-keV γ ray.

As proposed, population of the 1741.65-keV nuclear level by the 998.25- and 1770.19-keV γ rays requires depopulation by an unobserved 870.55-keV γ transition. Similarly, population of the 1573.76-keV nuclear level by the 1757.96-keV γ ray implies depopulation by an unobserved 702.66-keV γ transition. Both of these ill-defined depopulating γ rays have been added to the proposed decay scheme, with relative emission probabilities based on the values of two (and one) transition probabilities populating the original nuclear levels. One implication of the above is that the 871-keV γ emission constitutes an unresolved doublet (870.55 and 871.094 keV) – however, the relative emission probability of the postulated 870.55-keV γ ray is so small at 0.28 (3) % compared with the main 871.094-keV γ ray of 100% (99.72%) as to be of negligible impact on calculations of all of the absolute γ-ray emission probabilities.

The studies of Fransen *et al*. are particularly noteworthy from the point of view of their comprehensive nature when compared with all other previous measurements (2003Fr02). Their experimental studies included photon scattering experiments, γ-γ coincidence measurements of the EC/β^+ decay of ^{94m}Tc, and in-beam γ-γ coincidence studies of the emissions from the ^{91}Zr(α,n)^{94}Mo and ^{94}Mo(n,n'γ) reactions. Much quantitative detail was derived from these studies concerning γ emissions and their mixing ratios, along with the identification of 57 nuclear levels of ^{94}Mo, of which seventeen were newly observed. Only nuclear level data of direct relevance to their γ-γ coincidence measurements of the EC/β^+ decay of ^{94m}Tc are given below in tabulated form, and assisted greatly in the derivation of a more comprehensive decay scheme. Unfortunately, the relative γ-ray emission probabilities derived by 2003Fr02 apply only in terms of depopulating groups of γ transitions for a particular nuclear level – therefore, absolute emission probabilities for the full γ-ray decay cannot be determined from this source. Some of these parameters can be calculated in conjunction with the equivalent 1969Ba09/1986AgZX singles measurements, but this approach was not possible when direct γ equivalence data were unavailable (as was found to be the case for the 293.37-, 448.95-, 466.52-, 532.10-, 669.56-, 702.66-, 721.03-, 742.32-, 849.69-, 870.55-, 916.09-, 940.72-, 960.10-, 1231.27-, 1423.68-, 1592.00-, 1662.75- and 1933.97-keV γ rays). With such a significant lack of emission probability data, these particular γ transitions have not been included in the proposed decay scheme, although relevant nuclear levels have been noted.

Nuclear levels of ^{94}Mo and γ transitions of relevance to the EC/β$^+$ decay of ^{94m}Tc – as listed below, I$_\gamma$ are sets of relative intensities as applied only to individual groups of γ emissions depopulating each specific nuclear level (2003Fr02).

E$_x$ (keV)	J_i^π	J_f^π	E$_\gamma$ (keV)*	I$_\gamma$ (%)	$\delta(J_i^\pi \rightarrow J_f^\pi)$	P_γ^{rel} (%)*
871.09 (10)	2_1^+	0_1^+	871.09 (10)	100.0	0	100
1573.72 (14)	4_1^+	2_1^+	702.63 (10)	100.0	0.00 (4)	–
1741.65 (15)†	0_2^+	2_1^+	870.55 (22)	100.0	–	–
1864.3 (1)	2_2^+	0_1^+	1864.3 (2)	10.3 (10)	0	0.24 (3) / 0.24 (3)
		2_1^+	993.1 (1)	100.0 (10)	− 2.0 (10)	2.35 (19)
2067.4 (1)	2_3^+	0_1^+	2067.4 (1)	15.1 (7)	0	0.13 (1) / 0.12 (1)
		2_1^+	1196.2 (1)	100.0 (7)	0.15 (4)	0.76 (7)
2294.7 (2)	4_2^+	2_1^+	1423.7 (3)	13.3 (2)	0.08 (8)	–
		4_1^+	721.0 (2)	100.0 (2)	0.03 (4)	–
2393.1 (1)	2_4^+	0_1^+	2393.1 (1)	11.11 (22)	0	0.52 (5) / 0.53 (4)
		2_1^+	1521.8 (1)	100.0 (20)	− 0.12 (3)	4.76 (30)
		2_2^+	528.7 (3)	0.719 (33)	–	0.034 (2)
		2_3^+	325.7 (3)	0.61 (4)	–	0.029 (2)
2423.4 (2)	6_1^+	4_1^+	849.7 (1)	100.0	− 0.04 (5)	–
2533.8 (3)	3_1^-	2_1^+	1662.7 (3)	100.0 (22)	0.03 (7)	–
		4_1^+	960.1 (3)	81.3 (31)	0.00 (2)	–
		2_2^+	669.6 (2)	31.9 (13)	− 0.03 (13)	–
		2_3^+	466.4 (3)	57.3 (10)	0.00 (3)	–
2610.5 (2) ?	5_1^-	4_1^+	1036.8 (2) ?	100.0	0.00 (4)	–
2739.9 (1)	1_1^+	0_1^+	2739.9 (1)	65.4 (13)	0	3.69 (26) / 3.82 (21)
		2_1^+	1868.8 (1)	100.0 (20)	− 0.12 (2)	5.84 (30)
		0_2^+	998.2 (2)	4.44 (10)	0	0.23 (2) / 0.26 (2)
		2_2^+	875.5 (2)	24.4 (5)	− 0.10 (2)	0.84 (20) / 1.42 (8)
		2_3^+	672.0 (7)	3.02 (48)	–	0.18 (3)
2805.0 (3)‡	3_1^+	2_1^+	1933.9 (4)	75.7 (30)	$-0.66\ (14)$ or $-1.7^{+0.4}_{-0.5}$	–
		4_1^+	1231.2 (3)	100.0 (53)	$7.6^{+4.7}_{-3.0}$	–
		2_2^+	940.7 (4)	62.9 (39)	$2.3^{+0.7}_{-0.5}$	–
2870.0 (2)	2_5^+	0_1^+	2870.0 (2)	17.3 (5)	0	0.022 (7) / 0.017 (2)
		2_1^+	1998.9 (2)	13.1 (6)	$1.3^{+1.4}_{-0.4}$	0.0131 (6)
		2_2^+	1005.5 (1)	100.0 (36)	− 0.05 (4)	0.10 (3)
		2_3^+	802.6 (2)	26.2 (15)	–	0.0262 (15)
2872.4 (2)	6_2^+	6_1^+	449.0 (1)	100.0	0.14 (6)	–
2955.5 (3)	(8_1^+)	6_1^+	532.1 (1)	100.0	− 0.03 (5)	–
2965.3 (2)	3_2^+	2_1^+	2094.3 (1)	36.9 (14)	$1.1^{+1.0}_{-0.4}$	0.0166 (6)
		4_1^+	1391.6 (1)	63.0 (24)	− 0.08 (6)	0.0284 (11)
		2_2^+	1101.1 (1)	100.0 (23)	− 0.09 (6)	0.045 (15)
		2_3^+	898.1 (1)	23.0 (12)	$2.0^{+1.2}_{-0.6}$ *or* 0.39 (25)	0.0104 (5)
3128.6 (2)	1_2^+	0_1^+	3128.5 (2)	100.0 (3)	0	1.42 (10)
		2_1^+	2257.6 (1)	4.29 (10)	$0.74^{+0.21}_{-0.17}$	0.056 (18) / 0.061 (5)
		2_2^+	1264.3 (1)	18.27 (37)	− 0.08 (3)	0.21 (2) / 0.26 (2)
		2_3^+	1061.1 (5)	1.16 (11)	$-7.0^{+3.0}_{-20.0}$ *or* − 0.57 (16)	0.017 (2)
3163.3 (3)	(3_4^+)	2_1^+	2292.2 (2)	100.0 (13)	0.17 (4)	0.053 (18)
		3_1^+	358.0 (5)	16.7 (13)	− 0.35 (12)	0.0089 (7)
3165.8 (2)	6_3^+	4_1^+	1592.0 (1)	100.0 (35)	− 0.01 (6)	–
		6_1^+	742.2 (2)	29.4 (11)	0.15 (7)	–
		6_2^+	293.4 (1)	79.4 (25)	0.18 (5)	–
3331.7 (3)	(3^+)	2_1^+	2460.8 (8)	7.4 (11)	–	0.012 (2)
		4_1^+	1758.0 (2)	100.0 (55)	− 0.10 (3)	0.16 (2)
		2_2^+	1467.3 (3)	47.9 (29)	$0.3^{+2.9}_{-0.2}$	0.077 (5)
3339.6 (3)	6_4^+	6_1^+	916.2 (1)	100.0	− 0.02 (7)	–
3400.8 (2)‡	–	0_1^+	3400.76 (17)	–	–	0.005 (2)
		2_1^+	2529.7 (3)	100.0 (8)	–	0.36 (4)

		2_2^+	1536.5 (2)	4.2 (8)	−	0.015 (3)
3447.6 (5)	(2)	0_1^+	$\underline{3447.5\ (10)}$	5.1 (3)	0	$\underline{0.005\ (2)}$ / 0.006 (1)
		2_1^+	$\underline{2576.5\ (5)}$	100.0 (3)	$-1.9^{+0.5}_{-0.6}\ or -0.08\ (10)$	$\underline{0.12\ (2)}$
3511.7 (2)	$1_3^{(+)}$	0_1^+	$\underline{3511.6\ (2)}$	100.0 (11)	0	$\underline{0.067\ (7)}$
		2_1^+	$\underline{2640.7\ (3)}$	51.6 (13)	−	$\underline{0.037\ (9)}$ / 0.035 (4)
		0_2^+	$\underline{1770.4\ (2)}$	48.6 (92)	0	$\underline{0.020\ (8)}$ / 0.033 (7)
3534.3 (2)	2_8^+	0_1^+	3534.0 (4)	5.09 (55)	0	0.0036 (4)
		2_1^+	$\underline{2663.2\ (2)}$	100.0 (23)	− 0.3 (2)	$\underline{0.07\ (6)}$ → 0.070 (2)
		2_2^+	$\underline{1670.0\ (1)}$	56.1 (20)	0.15 (19)	$\underline{0.037\ (12)}$ / 0.04 (3) → 0.039 (2)
3792.8 (3)	2_9^+	0_1^+	$\underline{3792.3\ (10)}$	77.8 (20)	0	$\underline{0.054\ (8)}$ / 0.062 (16)
		2_2^+	$\underline{1928.5\ (2)}$	100.0 (40)	−	$\underline{0.08\ (2)}$
		2_4^+	1399.9 (2)	54.9 (30)	−	0.044 (3)
3892.2 (2)	(2^+)	0_1^+	$\underline{3891.6\ (10)}$	17.4 (9)	−	$\underline{0.014\ (2)}$ / 0.016 (3)
		2_1^+	$\underline{3021.0\ (1)}$	100.0 (24)	−	$\underline{0.093\ (15)}$
		2_2^+	$\underline{2027.9\ (2)}$	22.3 (10)	−	$\underline{0.025\ (6)}$ / 0.021 (4)
		2_3^+	1824.9 (3)	25.8 (10)	−	0.024 (1)
		2_4^+	$\underline{1499.1\ (1)}$	79.4 (22)	−	$\underline{0.062\ (20)}$ / 0.074 (12)

* Underscored entries for E_γ and P_γ^{rel} denote previously observed/determined data; other P_γ^{rel} data have been calculated from relevant ratios of I_γ and P_γ^{rel} as tabled.

† While not specified in the studies of 2003Fr02, the proposed 1741.65-keV nuclear level arises from the observed population of this level by the 998.2- and 1770.4-keV γ transitions.

‡ Although not identified in the EC/β^+ decay studies of ^{94m}Tc by 2003Fr02, the 2805.0- and 3400.8-keV nuclear levels have been introduced as a consequence of the observation of the 358.0-keV γ transition that populates the 2805.0-keV level (2003Fr02), and the 2529.7 and 3400.76-keV γ transitions that depopulate the 3400.8-keV level (1969Ba09, 1986AgZX).

Measured and recommended gamma-ray emission probabilities relative to P_γ(871.094 keV) of 100%.

E_γ (keV)		$P_\gamma^{rel\,*}$							
		1962Mo06	**1964Ha29**	**1965Ba48**	**1968Ar06**	**1968Ka25**[¶]	**1969Ba09**	**1986AgZX**	**2003Fr02**[†]
$\gamma_{19,14}$	293.37 (14)	–	–	–	–	–	–	–	unquantified
$\gamma_{7,5}$	325.67 (9)	–	–	–	–	–	–	–	0.029 (2)
$\gamma_{18,12}$	358.3 (3)	–	–	–	–	–	–	–	0.0089 (7)
$\gamma_{14,8}$	448.95 (14)	–	–	–	–	–	–	–	unquantified
$\gamma_{9,5}$	466.52 (13)	–	–	–	–	–	–	–	unquantified
$\gamma^{\pm}$	511	144 (12) → 158 (13)	–	160	–	–	–	–	–
$\gamma_{7,4}$	528.71 (8)	–	–	–	–	–	–	–	0.034 (2)
$\gamma_{15,8}$	532.10 (16)	–	–	–	–	–	–	–	unquantified
$\gamma_{9,4}$	669.56 (13)	–	–	–	–	–	–	–	unquantified
$\gamma_{11,5}$	672.56 (9)	–	–	–	–	–	–	–	0.18 (3)
$\gamma_{2,1}$	702.66 (4)	–	–	–	–	–	–	–	unquantified
$\gamma_{6,2}$	721.03 (17)	–	–	–	–	–	–	–	unquantified
$\gamma_{19,8}$	742.32 (13)	–	–	–	–	–	–	–	unquantified
$\gamma_{13,5}$	802.55 (10)	–	–	–	–	–	–	–	0.0262 (15)
$\gamma_{8,2}$	849.69 (10)	–	–	–	–	–	–	–	unquantified
$\gamma_{3,1}$	870.55 (22)	–	–	–	–	–	–	–	–
$\gamma_{1,0}$	871.094 (16)	91 → 100	91 → 100	100	100	100 (5)	100	100	unquantified
$\gamma_{11,4}$	875.60 (9)	–	–	–	–	–	–	**0.84 (20)**	**1.42 (8)**
$\gamma_{16,5}$	898.06 (9)	–	–	–	–	–	–	–	0.0104 (5)
$\gamma_{21,8}$	916.09 (19)	–	–	–	–	–	–	–	unquantified
$\gamma_{12,4}$	940.72 (20)	–	–	–	–	–	–	–	–
$\gamma_{9,2}$	960.10 (13)	–	–	–	–	–	–	–	unquantified
$\gamma_{4,1}$	993.20 (5)	–	–	–	2.6	–	**2.35 (30)**	**2.35 (19)**	[2.35 (19)]
$\gamma_{11,3}$	998.25 (17)	–	–	–	–	–	**0.25 (8)**	**0.23 (2)**	**0.26 (2)**
$\gamma_{13,4}$	1005.58 (9)	–	–	–	–	–	**0.16 (8)**	**0.094 (30)**	[0.10 (3)]
$2\gamma^{\pm}$	1022	–	–	–	–	–	–	0.029 (15)	
γ	1037.2 (3)[Δ]	–	–	–	–	–	–	0.047 (15)	unquantified
$\gamma_{17,5}$	1061.31 (9)	–	–	–	–	–	–	–	0.017 (2)
$\gamma_{16,4}$	1101.09 (8)	–	–	–	–	–	–	0.045 (15)	[0.045 (15)]
$\gamma_{5,1}$	1196.24 (6)	–	–	–	0.9	–	**0.80 (10)**	**0.74 (7)**	[0.76 (7)]
$\gamma_{12,2}$	1231.27 (19)	–	–	–	–	–	–	–	–
$\gamma_{17,4}$	1264.34 (9)	–	–	–	–	–	**0.23 (8)**	**0.21 (2)**	**0.26 (2)**
γ	1357.4 (15)[Δ]	–	–	–	–	–	0.20 (8)	–	–
$\gamma_{16,2}$	1391.64 (7)	–	–	–	–	–	–	–	0.0284 (11)
$\gamma_{26,7}$	1399.84 (16)	–	–	–	–	–	–	–	0.044 (3)
$\gamma_{6,1}$	1423.68 (16)	–	–	–	–	–	–	–	unquantified
$\gamma_{20,4}$	1467.42 (18)	–	–	–	–	–	–	–	0.077 (5)
$\gamma_{27,7}$	1499.13 (9)	–	–	–	–	–	–	**0.062 (20)**	**0.074 (12)**

$\gamma_{7,1}$ 1521.91 (6)	10 (2) → 11 (2)	10 (2) → 11 (2)	38	5.9	–	**4.80 (30)**	**4.72 (33)**	[4.76 (30)]
$\gamma_{22,4}$ 1536.51 (18)	–	–	–	–	–	–	–	0.015 (3)
$\gamma_{19,2}$ 1592.00 (10)	–	–	–	–	–	–	–	unquantified
$\gamma_{9,1}$ 1662.75 (12)	–	–	–	–	–	–	–	unquantified
$\gamma_{25,4}$ 1669.99 (10)	–	–	–	–	–	–	**0.037 (12)**	**0.039 (2)**
$\gamma_{20,2}$ 1757.96 (17)	–	–	–	–	–	**0.16 (4)**	**0.16 (2)**	[0.16 (2)]
$\gamma_{24,3}$ 1770.19 (21)	–	–	–	–	–	–	**0.020 (8)**	**0.033 (7)**
$\gamma_{27,5}$ 1824.79 (9)	–	–	–	–	–	–	–	0.024 (1)
$\gamma_{4,0}$ 1864.29 (5)	–	–	–	–	unquantified (	≤ 0.25	0.41 (4)	0.24 (3)
$\gamma_{11,1}$ 1868.79 (7)	9 (2) → 10 (2)	9 (2) → 10 (2)	21	5.8	(	**6.10 (30)**	**5.42 (38)**	[5.84 (30)]
$\gamma_{26,4}$ 1928.54 (16)	–	–	–	–	–	**0.09 (5)**	**0.08 (2)**	[0.08 (2)]
$\gamma_{12,1}$ 1933.97 (19)					–			–
$\gamma_{13,1}$ 1998.78 (8)	–	–	–	–	–	–	–	0.0131 (6)
$\gamma_{27,4}$ 2027.83 (9)	–	–	–	–	–	–	**0.025 (6)**	**0.021 (4)**
$\gamma_{5,0}$ 2067.33 (6)	–	–	–	–	–	**0.09 (3)**	**0.13 (1)**	**0.12 (1)**
$\gamma_{16,1}$ 2094.28 (6)	–	–	–	–	–	–	–	0.0166 (6)
$\gamma_{17,1}$ 2257.53 (7)	–	–	–	–	–	–	**0.056 (18)**	**0.061 (5)**
$\gamma_{18,1}$ 2292.16 (19)	–	–	–	–	–	–	0.053 (18)	[0.053 (18)]
$\gamma_{7,0}$ 2392.99 (6)	1.4 (5) → 1.5 (5)	< 1.4 (5) → < 1.5 (5)	–	0.6	–	**0.50 (20)**	**0.52 (5)**	**0.53 (4)**
$\gamma_{20,1}$ 2460.61 (17)	–	–	–	–	–	–	–	0.012 (2)
$\gamma_{22,1}$ 2529.69 (17)	–	–	–	0.7	–	**0.33 (8)**	**0.37 (4)**	[0.36 (4)]
$\gamma_{23,1}$ 2576.5 (4)	–	–	–	–	–	**0.13 (5)**	**0.12 (2)**	[0.12 (2)]
$\gamma_{24,1}$ 2640.72 (14)	–	–	–	–	–	very weak	**0.037 (9)**	**0.035 (4)**
$\gamma_{25,1}$ 2663.18 (9)	–	–	–	–	–	0.07 (6)	–	0.070 (2)
$\gamma_{11,0}$ 2739.87 (7)	5.0 (15) → 5.5 (17)	5.0 (15) → 5.5 (17)	2.2	3.8	unquantified	**3.74 (35)**	**3.66 (26)**	**3.82 (21)**
$\gamma_{13,0}$ 2869.85 (8)	–	–	–	–	–	–	**0.022 (7)**	**0.017 (2)**
$\gamma_{27,1}$ 3021.01 (7)	–	–	–	–	–	**0.08 (6)**	**0.094 (15)**	[0.093 (15)]
γ 3065.6 (3)$^{\Delta}$	–	–	–	–	–	–	0.012 (4)	–
γ 3085.8 (3)$^{\Delta}$	–	–	–	–	–	–	0.017 (4)	–
$\gamma_{17,0}$ 3128.60 (7)	2.2 (8) → 2.4 (9)	2.2 (8) → 2.4 (9)	3.3	1.2	–	**1.47 (15)**	**1.39 (10)**	[1.42 (10)]
$\gamma_{22,0}$ 3400.76 (17)	–	–	–	–	–	–	0.005 (2)	–
$\gamma_{23,0}$ 3447.5 (4)	–	–	–	–	–	–	**0.005 (2)**	**0.006 (1)**
$\gamma_{24,0}$ 3511.79 (14)	–	–	–	–	–	**0.06 (2)**	**0.068 (7)**	[0.067 (7)]
$\gamma_{25,0}$ 3534.25 (9)	–	–	–	–	–	–	–	0.0036 (4)
γ 3640.6 (3)$^{\Delta}$	–	–	–	–	–	–	0.007 (2)	–
$\gamma_{26,0}$ 3792.79 (15)	–	–	–	0.1	–	**0.05 (2)**	**0.054 (5)**	**0.062 (16)**
$\gamma_{27,0}$ 3892.07 (7)	–	–	–	–	–	**0.016 (10)**	**0.014 (2)**	**0.016 (3)**
γ 4136.2 (3)$^{\Delta}$	–	–	–	–	–	–	0.007 (1)	–

Measured and recommended gamma-ray emission probabilities relative to P_γ(871.094 keV) of 100% (continued).

E_γ (keV)		$P_\gamma^{rel\,*}$		
		Assessed and/or calculated‡		Recommended*
		1969Ba09/1986AgZX	1969Ba09/1986AgZX/ 2003Fr02	
$\gamma_{19,14}$	293.37 (14)	–	–	unknown
$\gamma_{7,5}$	325.67 (9)	–	–	0.029 (2)
$\gamma_{18,12}$	358.3 (3)	–	–	0.0089 (7)
$\gamma_{14,8}$	448.95 (14)	–	–	unknown
$\gamma_{9,5}$	466.52 (13)	–	–	unknown
$\gamma^{\pm}$	511	–	–	147 (1)$^{\theta}$ annihilation radiation
$\gamma_{7,4}$	528.71 (8)	–	–	0.034 (2)
$\gamma_{15,8}$	532.10 (16)	–	–	unknown
$\gamma_{9,4}$	669.56 (13)	–	–	unknown
$\gamma_{11,5}$	672.56 (9)	–	–	0.18 (3)
$\gamma_{2,1}$	702.66 (4)	0.19 (2)$^{+}$	–	0.19 (2)$^{+}$
$\gamma_{6,2}$	721.03 (17)	–	–	unknown
$\gamma_{19,8}$	742.32 (13)	–	–	unknown
$\gamma_{13,5}$	802.55 (10)	–	–	0.0262 (15)
$\gamma_{8,2}$	849.69 (10)	–	–	unknown
$\gamma_{3,1}$	870.55 (22)	0.28 (3)§	–	0.28 (3)§
$\gamma_{1,0}$	871.094 (16)	100	(100)	100
$\gamma_{11,4}$	875.60 (9)	0.84 (20)	1.1 (3)	1.1 (3)
$\gamma_{16,5}$	898.06 (9)	–	–	0.0104 (5)
$\gamma_{21,8}$	916.09 (19)	–	–	unknown
$\gamma_{12,4}$	940.72 (20)	–	–	unknown
$\gamma_{9,2}$	960.10 (13)	–	–	unknown
$\gamma_{4,1}$	993.20 (5)	2.35 (19)	–	2.35 (19)
$\gamma_{11,3}$	998.25 (17)	0.23 (2)	0.25 (2)	0.25 (2)
$\gamma_{13,4}$	1005.58 (9)	0.10 (3)	–	0.10 (3)
$2\gamma^{\pm}$	1022	0.029 (15) (511 + 511) keV sum peak	–	0.029 (15) (511 + 511) keV sum peak
γ	1037.2 (3)$^{\Delta}$	0.047 (15)	–	0.047 (15)
$\gamma_{17,5}$	1061.31 (9)	–	–	0.017 (2)
$\gamma_{16,4}$	1101.09 (8)	0.045 (15)	–	0.045 (15)
$\gamma_{5,1}$	1196.24 (6)	0.76 (7)	–	0.76 (7)
$\gamma_{12,2}$	1231.27 (19)	–	–	unknown
$\gamma_{17,4}$	1264.34 (9)	0.21 (2)	0.23 (2)	0.23 (2)
γ	1357.4 (15)$^{\Delta}$	0.20 (8)	–	0.20 (8)
$\gamma_{16,2}$	1391.64 (7)	–	–	0.0284 (11)
$\gamma_{26,7}$	1399.84 (16)	–	–	0.044 (3)
$\gamma_{6,1}$	1423.68 (16)	–	–	unknown
$\gamma_{20,4}$	1467.42 (18)	–	–	0.077 (5)

$\gamma_{27,7}$ 1499.13 (9)	0.062 (20)	0.071 (12)	0.071 (12)
$\gamma_{7,1}$ 1521.91 (6)	4.76 (30)	−	4.76 (30)
$\gamma_{22,4}$ 1536.51 (18)	−	−	0.015 (3)
$\gamma_{19,2}$ 1592.00 (10)	−	−	unknown
$\gamma_{9,1}$ 1662.75 (12)	−	−	unknown
$\gamma_{25,4}$ 1669.99 (10)	0.037 (12)	0.039 (2)	0.039 (2)
$\gamma_{20,2}$ 1757.96 (17)	0.16 (2)	−	0.16 (2)
$\gamma_{24,3}$ 1770.19 (21)	0.020 (8)	0.027 (7)	0.027 (7)
$\gamma_{27,5}$ 1824.79 (9)	−	−	0.024 (1)
$\gamma_{4,0}$ 1864.29 (5)	0.24 (3)$^{\$}$	0.24 (3)	0.24 (3)$^{\$}$
$\gamma_{11,1}$ 1868.79 (7)	5.84 (30)	−	5.84 (30)
$\gamma_{26,4}$ 1928.54 (16)	0.08 (2)	−	0.08 (2)
$\gamma_{12,1}$ 1933.97 (19)	−	−	unknown
$\gamma_{13,1}$ 1998.78 (8)	−	−	0.0131 (6)
$\gamma_{27,4}$ 2027.83 (9)	0.025 (6)	0.022 (4)	0.022 (4)
$\gamma_{5,0}$ 2067.33 (6)	0.13 (1)	0.12 (1)	0.12 (1)
$\gamma_{16,1}$ 2094.28 (6)	−	−	0.0166 (6)
$\gamma_{17,1}$ 2257.53 (7)	0.056 (18)	0.061 (5)	0.061 (5)
$\gamma_{18,1}$ 2292.16 (19)	0.053 (18)	−	0.053 (18)
$\gamma_{7,0}$ 2392.99 (6)	0.52 (5)	0.53 (4)	0.53 (4)
$\gamma_{20,1}$ 2460.61 (17)	−	−	0.012 (2)
$\gamma_{22,1}$ 2529.69 (17)	0.36 (4)	−	0.36 (4)
$\gamma_{23,1}$ 2576.5 (4)	0.12 (2)	−	0.12 (2)
$\gamma_{24,1}$ 2640.72 (14)	0.037 (9)	0.035 (4)	0.035 (4)
$\gamma_{25,1}$ 2663.18 (9)	0.07 (6)	−	0.070 (2)
$\gamma_{11,0}$ 2739.87 (7)	3.69 (26)	3.75 (21)	3.75 (21)
$\gamma_{13,0}$ 2869.85 (8)	0.022 (7)	0.017 (2)	0.017 (2)
$\gamma_{27,1}$ 3021.01 (7)	0.093 (15)	−	0.093 (15)
γ 3065.6 (3)$^{\Delta}$	0.012 (4)	−	0.012 (4)
γ 3085.8 (3)$^{\Delta}$	0.017 (4)	−	0.017 (4)
$\gamma_{17,0}$ 3128.60 (7)	1.42 (10)	−	1.42 (10)
$\gamma_{22,0}$ 3400.76 (17)	0.005 (2)	−	0.005 (2)
$\gamma_{23,0}$ 3447.5 (4)	0.005 (2)	0.006 (1)	0.006 (1)
$\gamma_{24,0}$ 3511.79 (14)	0.067 (7)	−	0.067 (7)
$\gamma_{25,0}$ 3534.25 (9)	−	−	0.0036 (4)
γ 3640.6 (3)$^{\Delta}$	0.007 (2)	−	0.007 (2)
$\gamma_{26,0}$ 3792.79 (15)	0.054 (5)	0.055 (5)	0.055 (5)
$\gamma_{27,0}$ 3892.07 (7)	0.014 (2)	0.015 (2)	0.015 (2)
γ 4136.2 (3)$^{\Delta}$	0.007 (1)	−	0.007 (1)

[*] Emission probabilities expressed relative to P_γ(871.094 keV) of 100%.

[¶] As reported by 1968Ka25, only 872.5(10)-, 1868- and 2740-keV gamma rays were identified with the EC/β^+ decay of ^{94m}Tc – all other gamma rays were assigned to EC/β^+ decay of ^{94}Tc.

[†] P_γ^{rel} data of 2003Fr02 are only based on the relative depopulation of individual nuclear levels of ^{94}Mo, and are not relative to P_γ(871.094 keV) of 100%, nor expressed per 100 decays of ^{94m}Tc – P_γ^{rel} data cannot always be quantified in the form required, as denoted by "unquantified" or placing specific values in parentheses [ ] when they have been adopted directly from the data of 1969Ba09 and 1986AgZX in order to calculate lesser gamma transitions depopulating the same nuclear level.

‡ Derived by various means: calculated gamma depopulation of particular nuclear levels based entirely on their known population sum; weighted mean of either direct gamma-ray spectroscopy measurements (1969Ba09 and 1986AgZX) and combination of various gamma-ray studies (1969Ba09, 1986AgZX and 2003 Fr02).

θ Relative emission probability of 147 (1) % for the 511-keV annihilation radiation was calculated from the total absolute positron emission probability of 69.2 (4) % and normalisation factor of 0.9404 (21).

+ As observed by 1976Su04 and 2003Fr02, population of the 1573.76-keV nuclear level by the 1391.64- and 1757.96-keV γ rays with relative emission probabilities of 0.027 (7) and 0.16 (2) %, respectively, implies depopulation by a 702.66-keV γ transition with a relative emission probability of 0.19 (2) %.

§ Population of the 1741.65-keV nuclear level by the 998.25- and 1770.19-keV γ rays requires depopulation by an 870.55-keV γ transition as observed by 1976Su04, with a sum relative emission probability of 0.28 (3) %.

$ Existence of 1864.29-keV γ ray and presence within the proposed decay scheme are questionable (compare 1969Ba09 with 1986AgZX) - relative emission probability calculated to be 0.24 (3) % from the relative emission probability ratio of 993.20-keV γ ray depopulating the same 1864.31-keV nuclear level of ^{94}Mo (relative emission probabilities from 2003Fr02 of 10.3(10) and 100.0 (10) for the 1864.29- and 993.20-keV γ rays, respectively).

Δ Unplaced in proposed decay scheme.

The normalisation factor for the relative gamma-ray emission and EC/β^+ transition probabilities can be calculated via two related routes:

(a). A total value of 100% can be assigned to the gamma transition probabilities directly populating the 0.0-keV nuclear level of ^{94}Mo, assuming zero EC/β^+ decay directly to the ground state on the basis of spin-parity considerations ((2)+ → 0+ constitutes a second forbidden non-unique transition (2, no)):

$$\sum_{0.0\ keV}^{\gamma\ population} TP_{\gamma} = 100$$

Thus: $106.34\ (24) * F = 100$

where F is the normalisation factor for the relative gamma-ray emission and EC/β^+ transition probabilities.

$$F = 100 / 106.34\ (24) = 0.9404 \pm 0.0021$$

(b). Gamma population-depopulation of the various nuclear levels of ^{94}Mo provide a means of determining the relative EC/β^+ transition probabilities from the relative γ-ray transition probabilities. Assuming zero EC/β^+ decay directly to the ground state based on spin-parity considerations (second forbidden non-unique), the calculated relative EC/β^+ transition probabilities sum to 100%:

$$\sum_{0}^{EC/\beta^+\ populations} TP_{EC} = 100$$

Thus: $106.35\ (77) * F = 100$

where F is the normalisation factor for the relative gamma-ray emission and EC/β^+ transition probabilities

$$F = 100 / 106.35\ (77) = 0.940 \pm 0.007$$

Therefore, a normalization factor of (0.9404 ± 0.0021) was adopted for the relative gamma-ray emission and EC/β^+ transition probabilities.

<u>Multipolarities, and Internal Conversion and Internal-Pair Coefficients</u>

The nuclear level scheme specified by Abriola and Sonzogni has been used to define the multipolarities of the gamma transitions on the basis of known spins and parities (2006Ab37). A significant number of transition types and mixing ratios have been determined from the γ-γ coincidence measurements of Fransen *et al*. (2003Fr02): (89.1%M1 + 10.9%E2) for the 358.3-keV gamma ray, (99.0%M1 + 1.0%E2) for the 875.60- and 1757.96-keV gamma rays, (20%M1 + 80%E2) for the 898.06- and 993.20-keV gamma rays, (99.75%M1 + 0.25%E2) for the 1005.58-keV gamma ray, (75.5% + 24.5%E2) for the 1061.31-keV gamma ray, (99.20%M1 + 0.80%E2) for the 1101.09-keV gamma ray, (97.80%M1 + 2.20%E2) for the 1196.24- and 1669.99-keV gamma rays, (99.36%M1 + 0.64%E2) for the 1264.34- and 1391.64-keV gamma rays, (91.7% + 8.3%E2) for the 1467.42- and 2663.18 -keV gamma rays, (98.58%M1 + 1.42%E2) for the 1521.91- and 1868.79-keV gamma rays, (37.2%M1 + 62.8%E2) for the 1998.78-keV gamma ray, (45.2%M1 + 54.8%E2) for the 2094.28-keV gamma ray, (64.6%M1 + 35.4%E2) for the 2257.53-keV gamma ray, (97.2 %M1 + 2.8%E2) for the 2292.16-keV gamma ray, and provisional selection of (21.7%M1 + 78.3%E2) for the 2576.5-keV gamma ray. The 998.25-, 2739.87- and 3128.60-keV gamma rays were defined as 100%M1, and the 325.67-, 528.71-, 672.56- and 802.55-keV gamma rays were arbitrarily assigned multipolarities of (50%M1 + 50%E2), while various E2 gamma transitions were also identified.

Recommended internal conversion coefficients have been determined from the frozen orbital approximation of Kibédi *et al*. (2008Ki07), based on the theoretical model of Band *et al*. (2002Ba85, 2002Ra45). A significant number of gamma transitions undergo decay via internal-pair formation, and the coefficient for this process has also been quantified in a few cases from the tabulations of 2008Ki07.

Gamma-ray emissions: multipolarities, and theoretical internal-conversion (frozen orbital approximation) and internal-pair formation coefficients.

E_γ(keV)	Multipolarity	α_K	α_L	α_{M+}	$\alpha_{totalICC}$	α_{IPF}	α_{total}
293.37 (14)	96.9%M1 + 3.1%E2 δ = + 0.18 (5) 2003Fr02	0.0128 (3)	0.00149 (4)	0.00031	0.0146 (3)	−	0.0146 (3)
325.67 (9)	50%M1 + 50%E2 δ = 1.0 (2)	0.0128 (8)	0.00156 (11)	0.00034	0.0147 (9)	−	0.0147 (9)
358.3 (3)	89.1%M1 + 10.9%E2 δ = − 0.35 (12) 2003Fr02	0.0080 (4)	0.00093 (5)	0.00027	0.0092 (4)		0.0092 (4)
448.95 (14)	98.1%M1 + 1.9%E2 δ = + 0.14 (6) 2003Fr02	0.00442 (7)	0.000503 (8)	0.000107	0.00503 (8)	−	0.00503 (8)
466.52 (13)	E1	0.001544 (22)	0.0001729 (25)	0.000036	0.001753 (25)	−	0.001753 (25)
528.71 (8)	50%M1 + 50%E2 δ = 1.0 (2)	0.00325 (8)	0.000378 (11)	0.000082	0.00371 (9)	−	0.00371 (9)
532.10 (16)	(E2)	0.00346 (5)	0.000412 (6)	0.000078	0.00395 (6)	−	0.00395 (6)
669.56 (13)	E1	0.000666 (10)	0.0000740 (11)	0.000015	0.000755 (11)	−	0.000755 (11)
672.56 (9)	50%M1 + 50%E2 δ = 1.0 (2)	0.00176 (3)	0.000201 (4)	0.000039	0.00200 (3)	−	0.00200 (3)
702.66 (4)	E2	0.001608 (23)	0.000187 (3)	0.000035	0.00183 (3)	−	0.00183 (3)
721.03 (17)	99.91%M1 + 0.09%E2 δ = + 0.03 (4) 2003Fr02	0.001457 (21)	0.0001636 (23)	0.0000334	0.001654 (24)	−	0.001654 (24)
742.32 (13)	97.8%M1 + 2.2%E2 δ = + 0.15 (7) 2003Fr02	0.001365 (20)	0.0001533 (22)	0.0000317	0.001550 (22)	−	0.001550 (22)
802.55 (10)	50%M1 + 50%E2 δ = 1.0 (2)	0.001146 (16)	0.0001301 (19)	0.0000269	0.001303 (19)	−	0.001303 (19)
849.69 (10)	E2	0.000997 (14)	0.0001141 (16)	0.000023	0.001134 (16)	−	0.001134 (16)
870.55 (22)	E2	0.000940 (4)	0.0001075 (15)	0.0000225	0.001070 (15)	−	0.001070 (15)
871.094 (16)	E2	0.000939 (14)	0.0001073 (15)	0.0000217	0.001068 (15)	−	0.001068 (15)
875.60 (9)	99.0%M1 + 1.0%E2 δ = − 0.10 (2) 2003Fr02	0.000945 (14)	0.0001056 (15)	0.0000214	0.001072 (15)	−	0.001072 (15)
898.06 (9)	(20%M1 + 80%E2) **δ = + 2.0 (+1.2, -0.6)** [or 0.39 (25)] 2003Fr02	0.000877 (13) 0.000891 (13)	0.0000996 (14) 0.0000998 (14)	0.0000204 0.0000212	0.000997 (15) 0.001012 (15)	− −	0.000997 (15) 0.001012 (15)
916.09 (19)	99.96%M1 + 0.04%E2 δ = − 0.02 (7) 2003Fr02	0.000856 (12)	0.0000956 (13)	0.0000194	0.000971 (14)	−	0.000971 (14)
940.72 (20)	16%M1 + 84%E2	0.000786 (12)	0.0000892 (13)	0.0000188	0.000894 (13)	−	0.000894 (13)

	δ = + 2.3 (+0.7, -0.5) 2003Fr02						
960.10 (13)	E1	0.000316 (5)	0.0000349 (5)	0.0000071	0.000358 (5)	−	0.000358 (5)
993.20 (5)	20%M1 + 80%E2 δ = − 2.0 (10) 2003Fr02	0.000696 (13)	0.0000786 (13)	0.0000164	0.000791 (15)	−	0.000791 (15)
998.25 (17)	100%M1	0.000710 (10)	0.0000792 (11)	0.0000167	0.000806 (12)	−	0.000806 (12)
1005.58 (9)	99.75%M1 + 0.25%E2 δ = − 0.05 (4) 2003Fr02	0.000699 (10)	0.0000779 (11)	0.0000161	0.000793 (12)	−	0.000793 (12)
1037.2 (3)$^{\Delta}$	−	−	−	−	−	−	−
1061.31 (9)	(75.5%M1 + 24.5%E2) δ = − 7.0 (+3.0, -20.0) [or **− 0.57 (16)**] 2003Fr02	0.000595 (9) 0.000616 (10)	0.0000672 (10) 0.0000688 (10)	0.0000138 0.0000142	0.000676 (10) 0.000699 (11)	− −	0.000676 (10) 0.000699 (11)
1101.09 (8)	99.20%M1 + 0.80%E2 δ = − 0.09 (6) 2003Fr02	0.000576 (8)	0.0000640 (9)	0.0000130	0.000653 (9)	0.000000492 (8)	0.000653 (10)
1196.24 (6)	97.80%M1 + 2.20%E2 δ = + 0.15 (4) 2003Fr02	0.000483 (7)	0.0000536 (8)	0.0000114	0.000548 (7)	0.00000577 (9)	0.000553 (8)
1231.27 (19)	1.7%M1 + 98.3%E2 δ = + 7.6 (+4.7, -3.0) 2003Fr02	0.000431 (6)	0.0000483 (7)	0.0000097	0.000489 (7)	0.0000125 (20)	0.000502 (7)
1264.34 (9)	99.36%M1 + 0.64%E2 δ = − 0.08 (3) 2003Fr02	0.000431 (6)	0.0000478 (7)	0.0000092	0.000488 (6)	0.00001516 (22)	0.000503 (7)
1357.4 (15)$^{\Delta}$	−	−	−	−	−	−	−
1391.64 (7)	99.36%M1 + 0.64%E2 δ = − 0.08 (6) 2003Fr02	0.000353 (5)	0.0000391 (6)	0.0000079	0.000400 (5)	0.0000404 (6)	0.000441 (7)
1399.84 (16)	M1 + E2	−	−	−	−	−	−
1423.68 (16)	E2	0.000319 (5)	0.0000355 (5)	0.0000075	0.000362 (5)	0.0000577 (8)	0.000419 (6)
1467.42 (18)	91.7%M1 + 8.3%E2 δ = + 0.3 (+2.9, -0.2) 2003Fr02	0.000316 (15)	0.0000350 (15)	0.0000070	0.000358 (16)	0.000061 (10)	0.000419 (9)
1499.13 (9)	M1 + E2	−	−	−	−	−	−
1521.91 (6)	98.58%M1 + 1.42%E2 δ = − 0.12 (3) 2003Fr02	0.000295 (5)	0.0000326 (5)	0.0000064	0.000334 (5)	0.0000776 (11)	0.000411 (6)
1536.51 (18)	−	−	−	−	−	−	−
1592.00 (10)	E2	0.000255 (4)	0.0000284 (4)	0.0000066	0.000290 (4)	0.0001198 (17)	0.000410 (6)
1662.75 (12)	E1	0.0001198 (17)	0.00001311 (19)	0.0000027	0.0001356 (17)	0.000369 (6)	0.000505 (7)
1669.99 (10)	97.80%M1 + 2.20%E2	0.000245 (4)	0.0000270 (4)	0.0000055	0.000277 (4)	0.000132 (3)	0.000410 (6)

	δ = + 0.15 (19) 2003Fr02						
1757.96 (17)	99.0%M1 + 1.0%E2 δ = − 0.10 (3) 2003Fr02	0.000221 (3)	0.0000244 (3)	0.0000050	0.000251 (4)	0.0001677 (24)	0.000418 (6)
1770.19 (21)	(M1 + E2)	−	−	−	−	−	−
1824.79 (9)	(M1 + E2)	−	−	−	−	−	−
1864.29 (5)	E2	0.000189 (3)	0.0000209 (3)	0.0000041	0.000214 (3)	0.000241 (4)	0.000455 (7)
1868.79 (7)	98.58%M1 + 1.42%E2 δ = − 0.12 (2) 2003Fr02	0.000196 (3)	0.0000216 (3)	0.0000044	0.000222 (3)	0.000215 (3)	0.000438 (7)
1928.54 (16)	M1 + E2	−	−	−	−	−	−
1933.97 (19)	69.7%M1 + 30.3%E2 **δ = − 0.66 (14)** [or − 1.7 (+0.4, -0.5)] 2003Fr02	0.000182 (3) 0.000178 (3)	0.0000200 (3) 0.0000197 (3)	0.0000040 0.0000043	0.000206 (3) 0.000202 (3)	0.000253 (5) 0.000266 (5)	0.000459 (7) 0.000468 (7)
1998.78 (8)	37.2%M1 + 62.8%E2 δ = + 1.3 (+1.4, -0.4) 2003Fr02	0.000168 (3)	0.0000186 (3)	0.0000044	0.000191 (3)	0.000293 (9)	0.000484 (10)
2027.83 (9)	(M1 + E2)	−	−	−	−	−	−
2067.33 (6)	E2	0.0001562 (22)	0.00001722 (25)	0.00000358	0.0001770 (22)	0.000338 (5)	0.000515 (8)
2094.28 (6)	45.2%M1 + 54.8%E2 δ = + 1.1 (+1.0, -0.4) 2003Fr02	0.000155 (3)	0.0000171 (3)	0.0000039	0.000176 (3)	0.000336 (11)	0.000512 (11)
2257.53 (7)	64.6%M1 + 35.4%E2 δ = + 0.74 (+0.21, -0.17) 2003Fr02	0.0001356 (20)	0.00001491 (22)	0.00000309	0.0001536 (20)	0.000407 (8)	0.000561 (9)
2292.16 (19)	(97.2%M1 + 2.8%E2) δ = + 0.17 (4) 2003Fr02	0.0001330 (19)	0.00001461 (21)	0.00000300	0.0001506 (19)	0.000411 (6)	0.000562 (8)
2392.99 (6)	E2	0.0001203 (17)	0.00001322 (19)	0.00000278	0.0001363 (17)	0.000496 (7)	0.000633 (9)
2460.61 (17)	(M1 + E2)	−	−	−	−	−	−
2529.69 (17)	−	−	−	−	−	−	−
2576.5 (4)	(21.7%M1 + 78.3%E2) **δ = − 1.9 (+0.5, -0.6)** [or − 0.08 (10)] 2003Fr02	0.0001061 (15) 0.0001072 (15)	0.00001164 (17) 0.00001176 (17)	0.00000246 0.00000243	0.0001202 (16) 0.0001214 (16)	0.000574 (11) 0.000542 (8)	0.000694 (12) 0.000664 (10)
2640.72 (14)	(M1 + E2)	−	−	−	−	−	−
2663.18 (9)	91.7%M1 + 8.3%E2 δ = − 0.3 (2) 2003Fr02	0.0001009 (15)	0.00001106 (16)	0.00000224	0.0001142 (15)	0.000585 (10)	0.000699 (11)
2739.87 (7)	100%M1	0.0000959 (14)	0.00001051 (15)	0.00000217	0.000109 (14)	0.000616 (9)	0.000725 (11)
2869.85 (8)	E2	0.0000881 (13)	0.00000964 (14)	0.00000196	0.0000997 (13)	0.000717 (10)	0.000816 (12)

3021.01 (7)	(M1 + E2)	–	–	–	–	–	–
3065.6 (3)[Δ]	–	–	–	–	–	–	–
3085.8 (3)[Δ]	–	–	–	–	–	–	–
3128.60 (7)	100%M1	0.0000758 (11)	0.00000829 (12)	0.00000172	0.000086 (11)	0.000785 (11)	0.000871 (13)
3400.8(3)	–	–	–	–	–	–	–
3447.5 (4)	–	–	–	–	–	–	–
3511.79 (14)	(M1 + E2)	–	–	–	–	–	–
3534.25 (9)	E2	0.0000625 (9)	0.00000682 (10)	0.00000148	0.0000708 (9)	0.000994 (14)	0.001065 (15)
3640.6 (3)[Δ]	–	–	–	–	–	–	–
3792.79 (15)	E2	0.0000559 (8)	0.00000609 (9)	0.00000121	0.0000632 (8)	0.001086 (16)	0.001149 (16)
3892.07 (7)	–	–	–	–	–	–	–
4136.2 (3)[Δ]	–	–	–	–	–	–	–

[Δ] Unplaced in proposed decay scheme.

Recommended gamma-ray energies, relative and absolute emission probabilities, and transition probabilities.

	E_γ (keV)	origins	P_γ^{rel}	origins	P_γ^{abs}	Transition probability (%)
$\gamma_{19,14}$	293.37 (14)	2003Fr02	unknown	–	–	–
$\gamma_{7,5}$	325.67 (9)	2003Fr02	0.029 (2)	2003Fr02	0.027 (2)	0.027 (2)
$\gamma_{18,12}$	358.3 (3)	2003Fr02	0.0089 (7)	2003Fr02	0.0084 (7)	0.0085 (7)
$\gamma_{14,8}$	448.95 (14)	2003Fr02	unknown	–	–	–
$\gamma_{9,5}$	466.52 (13)	1976Su04/2003Fr02	unknown	–	–	–
$\gamma^{\pm}$	511	annihilation radiation	147 (1)	annihilation radiation	138 (1)	–
$\gamma_{7,4}$	528.71 (8)	2003Fr02	0.034 (2)	2003Fr02	0.032 (2)	0.032 (2)
$\gamma_{15,8}$	532.10 (16)	2003Fr02	unknown	–	–	–
$\gamma_{9,4}$	669.56 (13)	2003Fr02	unknown	–	–	–
$\gamma_{11,5}$	672.56 (9)	2003Fr02	0.18 (3)	2003Fr02	0.17 (3)	0.17 (3)
$\gamma_{2,1}$	702.66 (4)	1976Su04/2003Fr02	0.19 (2)$^{+}$	–	0.18 (2)	0.18 (2)
$\gamma_{6,2}$	721.03 (17)	1976Su04/2003Fr02	unknown	–	–	–
$\gamma_{19,8}$	742.32 (13)	2003Fr02	unknown	–	–	–
$\gamma_{13,5}$	802.55 (10)	2003Fr02	0.0262 (15)	2003Fr02	0.0246 (14)	0.0246 (14)
$\gamma_{8,2}$	849.69 (10)	2003Fr02	unknown	–	–	–
$\gamma_{3,1}$	870.55 (22))	1976Su04	0.28 (3)§	–	0.26 (3)	0.26 (3)
$\gamma_{1,0}$	871.094 (16))	1969Ba09/1976Su04/1986AgZX/2003Fr02	100	1969Ba09/1986AgZX/2003Fr02	94.04 (21)	94.14 (21)
$\gamma_{11,4}$	875.60 (9)	1986AgZX/2003Fr02	1.1 (3)	1986AgZX/2003Fr02	1.0 (3)	1.0 (3)
$\gamma_{16,5}$	898.06 (9)	2003Fr02	0.0104 (5)	2003Fr02	0.0098 (5)	0.0098 (5)
$\gamma_{21,8}$	916.09 (19)	2003Fr02	unknown	–	–	–
$\gamma_{12,4}$	940.72 (20)	2003Fr02	unknown	–	–	–
$\gamma_{9,2}$	960.10 (13)	1976Su04/2003Fr02	unknown	–	–	–
$\gamma_{4,1}$	993.20 (5)	1969Ba09/1976Su04/1986AgZX/2003Fr02	2.35 (19)	1969Ba09/1986AgZX	2.21 (18)	2.21 (18)
$\gamma_{11,3}$	998.25 (17)	1969Ba09/1986AgZX/2003Fr02	0.25 (2)	1969Ba09/1986AgZX/2003Fr02	0.24 (2)	0.24 (2)
$\gamma_{13,4}$	1005.58 (9)	1969Ba09/1976Su04/1986AgZX/2003Fr02	0.10 (3)	1969Ba09/1986AgZX	0.09 (3)	0.09 (3)
2 x $\gamma^{\pm}$	1022	(511 + 511) keV sum peak	0.029 (15)	1986AgZX	0.027 (14)	–
$\gamma_{-1,1}$	1037.2 (3)$^{\Delta}$	1976Su04/1986AgZX	0.047 (15)	1986AgZX	0.044 (14)	0.044 (14)
$\gamma_{17,5}$	1061.31 (9)	2003Fr02	0.017 (2)	2003Fr02	0.016 (2)	0.016 (2)
$\gamma_{16,4}$	1101.09 (8)	1976Su04/1986AgZX/2003Fr02	0.045 (15)	1986AgZX	0.042 (14)	0.042 (14)
$\gamma_{5,1}$	1196.24 (6)	1969Ba09/1976Su04/1986AgZX/2003Fr02	0.76 (7)	1969Ba09/1986AgZX	0.71 (7)	0.71 (7)
$\gamma_{12,2}$	1231.27 (19)	1976Su04/2003Fr02	unknown	–	–	–
$\gamma_{17,4}$	1264.34 (9)	1969Ba09/1986AgZX/2003Fr02	0.23 (2)	1969Ba09/1986AgZX/2003Fr02	0.22 (2)	0.22 (2)
$\gamma_{-1,2}$	1357.4 (15)$^{\Delta}$	1969Ba09	0.20 (8)	1969Ba09	0.19 (8)	0.19 (8)
$\gamma_{16,2}$	1391.64 (7)	1976Su04/2003Fr02	0.0284 (11)	2003Fr02	0.0267 (10)	0.0267 (10)
$\gamma_{26,7}$	1399.84 (16)	2003Fr02	0.044 (3)	2003Fr02	0.041 (3)	0.041 (3)
$\gamma_{6,1}$	1423.68 (16)	2003Fr02	unknown	–	–	–
$\gamma_{20,4}$	1467.42 (18)	2003Fr02	0.077 (5)	2003Fr02	0.072 (5)	0.072 (5)
$\gamma_{27,7}$	1499.13 (9)	1986AgZX/2003Fr02	0.071 (12)	1986AgZX/2003Fr02	0.067 (11)	0.067 (11)
$\gamma_{7,1}$	1521.91 (6)	1969Ba09/1976Su04/1986AgZX/2003Fr02	4.76 (30)	1969Ba09/1986AgZX	4.48 (28)	4.48 (28)
$\gamma_{22,4}$	1536.51 (18)	2003Fr02	0.015 (3)	2003Fr02	0.014 (3)	0.014 (3)

$\gamma_{19,2}$	1592.00 (10)	2003Fr02	unknown	–	–	–
$\gamma_{9,1}$	1662.75 (12)	1976Su04/2003Fr02	unknown	–	–	–
$\gamma_{25,4}$	1669.99 (10)	1986AgZX/2003Fr02	0.039 (2)	1986AgZX/2003Fr02	0.037 (2)	0.037 (2)
$\gamma_{20,2}$	1757.96 (17)	1969Ba09/1986AgZX/2003Fr02	0.16 (2)	1969Ba09/1986AgZX	0.15 (2)	0.15 (2)
$\gamma_{24,3}$	1770.19 (21)	1986AgZX/2003Fr02	0.027 (7)	1986AgZX/2003Fr02	0.025 (6)	0.025 (6)
$\gamma_{27,5}$	1824.79 (9)	2003Fr02	0.024 (1)	2003Fr02	0.023 (1)	0.023 (1)
$\gamma_{4,0}$	1864.29 (5)	1969Ba09/1976Su04/1986AgZX/2003Fr02	0.24 (3)§	2003Fr02	0.23 (3)	0.23 (3)
$\gamma_{11,1}$	1868.79 (7)	1969Ba09/1976Su04/1986AgZX/2003Fr02	5.84 (30)	1969Ba09/1986AgZX	5.49 (28)	5.49 (28)
$\gamma_{26,4}$	1928.54 (16)	1969Ba09/1986AgZX/2003Fr02	0.08 (2)	1969Ba09/1986AgZX	0.075 (19)	0.075 (19)
$\gamma_{12,1}$	1933.97 (19)	1976Su04/2003Fr02	unknown	–	–	–
$\gamma_{13,1}$	1998.78 (8)	2003Fr02	0.0131 (6)	2003Fr02	0.0123 (6)	0.0123 (6)
$\gamma_{27,4}$	2027.83 (9)	1986AgZX/2003Fr02	0.022 (4)	1986AgZX/2003Fr02	0.021 (4)	0.021 (4)
$\gamma_{5,0}$	2067.33 (6)	1969Ba09/1976Su04/1986AgZX/2003Fr02	0.12 (1)	1969Ba09/1986AgZX/2003Fr02	0.11 (1)	0.11 (1)
$\gamma_{16,1}$	2094.28 (6)	2003Fr02	0.0166 (6)	2003Fr02	0.0156 (6)	0.0156 (6)
$\gamma_{17,1}$	2257.53 (7)	1986AgZX/2003Fr02	0.061 (5)	1986AgZX/2003Fr02	0.057 (5)	0.057 (5)
$\gamma_{18,1}$	2292.16 (19)	1976Su04/1986AgZX/2003Fr02	0.053 (18)	1986AgZX	0.050 (17)	0.050 (17)
$\gamma_{7,0}$	2392.99 (6)	1969Ba09/1986AgZX/2003Fr02	0.53 (4)	1969Ba09/1986AgZX/2003Fr02	0.50 (4)	0.50 (4)
$\gamma_{20,1}$	2460.61 (17)	2003Fr02	0.012 (2)	2003Fr02	0.011 (2)	0.011 (2)
$\gamma_{22,1}$	2529.69 (17)	1969Ba09/1976Su04/1986AgZX/2003Fr02	0.36 (4)	1969Ba09/1986AgZX	0.34 (4)	0.34 (4)
$\gamma_{23,1}$	2576.5 (4)	1969Ba09/1976Su04/1986AgZX/2003Fr02	0.12 (2)	1969Ba09/1986AgZX	0.11 (2)	0.11 (2)
$\gamma_{24,1}$	2640.72 (14)	1969Ba09/1986AgZX/2003Fr02	0.035 (4)	1986AgZX/2003Fr02	0.033 (4)	0.033 (4)
$\gamma_{25,1}$	2663.18 (9)	1969Ba09/2003Fr02	0.070 (2)	1969Ba09/2003Fr02	0.066 (2)	0.066 (2)
$\gamma_{11,0}$	2739.87 (7)	1969Ba09/1976Su04/1986AgZX/2003Fr02	3.75 (21)	1969Ba09/1986AgZX/2003Fr02	3.53 (20)	3.53 (20)
$\gamma_{13,0}$	2869.85 (8)	1986AgZX/2003Fr02	0.017 (2)	1986AgZX/2003Fr02	0.016 (2)	0.016 (2)
$\gamma_{27,1}$	3021.01 (7)	1969Ba09/1986AgZX/2003Fr02	0.093 (15)	1969Ba09/1986AgZX	0.087 (14)	0.087 (14)
$\gamma_{-1,3}$	3065.6 (3)Δ	1986AgZX	0.012 (4)	1986AgZX	0.011 (4)	0.011 (4)
$\gamma_{-1,4}$	3085.8 (3)Δ	1986AgZX	0.017 (4)	1986AgZX	0.016 (4)	0.016 (4)
$\gamma_{17,0}$	3128.60 (7)	1969Ba09/1986AgZX/2003Fr02	1.42 (10)	1969Ba09/1986AgZX	1.34 (9)	1.34 (9)
$\gamma_{22,0}$	3400.76 (17)	1986AgZX	0.005 (2)	1986AgZX	0.005 (2)	0.005 (2)
$\gamma_{23,0}$	3447.5 (4)	1986AgZX/2003Fr02	0.006 (1)	1986AgZX/2003Fr02	0.006 (1)	0.006 (1)
$\gamma_{24,0}$	3511.79 (14)	1969Ba09/1986AgZX/2003Fr02	0.067 (7)	1969Ba09/1986AgZX	0.063 (7)	0.063 (7)
$\gamma_{25,0}$	3534.25 (9)	2003Fr02	0.0036 (4)	2003Fr02	0.0034 (4)	0.0034 (4)
$\gamma_{-1,5}$	3640.6 (3)Δ	1986AgZX	0.007 (2)	1986AgZX	0.007 (2)	0.007 (2)
$\gamma_{26,0}$	3792.79 (15)	1969Ba09/1986AgZX/2003Fr02	0.055 (5)	1969Ba09/1986AgZX/2003Fr02	0.052 (5)	0.052 (5)
$\gamma_{27,0}$	3892.07 (7)	1969Ba09/1986AgZX/2003Fr02	0.015 (2)	1969Ba09/1986AgZX/2003Fr02	0.014 (2)	0.014 (2)
$\gamma_{-1,6}$	4136.2 (3)Δ	1986AgZX	0.007 (1)	1986AgZX	0.007 (1)	0.007 (1)

+ Population of the 1573.76-keV nuclear level by the 1391.64- and 1757.96-keV γ rays with relative emission probabilities of 0.027 (7) and 0.16 (2) %, respectively, implies depopulation by a 702.66-keV γ transition observed by 1976Su04 and 2003Fr02, with a relative emission probability of 0.19 (2) %.

§ Population of the 1741.65-keV nuclear level by the 998.25- and 1770.19-keV γ rays requires depopulation by an 870.55-keV γ transition observed by 1976Su04, with a sum relative emission probability of 0.28 (3) %.

Δ Unplaced in proposed decay scheme.

EC/β+ Transitions

Energies

All EC/β^+ energies were derived from the structural details of the proposed decay scheme. The nuclear level energies of 2006Ab37 and evaluated Q_{EC}-value of 4332 (5) keV (2012Wa38) were used to determine the recommended energies and uncertainties of the EC transitions and β^+ emissions.

Transition and Emission Probabilities

Gamma-ray studies of the EC decay of ^{94}Ru have revealed 100% feeding to ^{94m}Tc, and a lack of evidence for subsequent ^{94m}Tc IT decay to the ground state (≤ 0.1% relative to the 871.094-keV gamma-ray emission of ^{94m}Tc (1967Ei01)). On the basis of these findings, ^{94m}Tc has been assumed to undergo 100% EC/β^+ decay.

A large majority of the EC transition probabilities were derived from the population-depopulation imbalances of the relative emission probabilities of the gamma rays, their theoretical internal-conversion and internal-pair formation coefficients. A value of 0.9404 (21) was adopted as the normalisation factor in order to determine the absolute transition and emission probabilities of the EC and β^+ particles from their resulting relative transition and emission probabilities. Component EC and β^+ transition and emission probabilities were determined from EC/β^+ ratios (1971Go40), and log*ft* values and average $E_{\beta+}$ energies were derived by means of the LOGFT code. Fractional EC probabilities P_K, P_L, P_M and P_N were calculated by means of the EC-CAPTURE code (1998Sc28) as developed from the data tabulations of 1995ScZY.

Possible EC transitions directly to the 3339.54-, 3165.77-, 2955.55-, 2872.40-, 2610.57-, 2423.45-, 2294.79-, 1741.65- and 1573.76-keV nuclear levels of ^{94}Mo were assumed to be zero, based on gamma population-depopulation balances and/or spin-parity considerations, while EC decay directly to the ground state was assigned a value of zero from a spin-parity assessment alone (second forbidden non-unique (2, no)). Although both the 2805.04- and 2533.87-keV nuclear levels of ^{94}Mo may undergo EC and γ population and γ depopulation, these possibilities have not been confidently confirmed, and therefore direct EC transition probabilities of zero were assigned (despite these possible transitions being allowed (1, no) and first forbidden non-unique (1, yes), respectively).

The absolute emission probability of the 511-keV annihilation radiation was derived from the total absolute positron emission probability of 69.2 (4) % as determined during the evaluation of the EC/β^+ transitions/emissions:

$$absolute\ P_\gamma^\pm = 2 \times 69.2\ (4) = 138.4\ (8)\ \% \rightarrow 138\ (1)\ \%$$

$$[\ relative\ P_\gamma^\pm = \frac{absolute\ P_\gamma^\pm}{F} = \frac{138.4\ (8)}{0.9404\ (21)} = 147.2\ (9)\ \% \rightarrow 147\ (1)\ \%\ ]$$

where *F* is the normalisation factor for the gamma-ray emission probabilities.

A decay scheme was derived that consists of 16 EC/7 β^+ transitions and 52 gamma-ray emissions. Substantial 511-keV annihilation radiation was also observed. A further sixteen gamma rays have been observed/proposed by Fransen *et al*. (2003Fr02), but an inability to derive and quantify their absolute emission probabilities has prevented their satisfactory insertion and adoption in the decay scheme and data file – if these additional gamma transitions could have been suitably introduced into the ^{94m}Tc decay scheme, they would have impacted to a small degree on the EC/β^+ decay data. Finally, although six other gamma-ray emissions of reasonably low intensity could not be placed in the proposed decay scheme, they have been included in the final data set because their absolute emission probabilities have been measured.

Recommended energies and transition probabilities of the EC/β$^+$ decay of ^{94m}Tc.

	E_{EC} (keV)*	$E_{\beta+}$ (keV)	Av. $E_{\beta+}$ (keV)	P_{EC}(total)	ϵ/β+ (theory) 1971Go40	P_{EC}	$P_{\beta+}$	^{94m}Tc	^{94}Mo	transition type	log *ft*	P_K	P_L	P_M	P_N
$EC_{0,27}$	440 (5)	–	–	0.212 (13)	–	0.212 (13)	–	(2) +	(2 +)	(allowed)	5.6	0.8620 (15)	0.1121 (12)	0.0220 (4)	0.0039 (2)
$EC_{0,26}$	539 (5)	–	–	0.169 (20)	–	0.169 (20)	–	(2) +	2 +	(allowed)	5.9	0.8639 (15)	0.1106 (11)	0.0216 (4)	0.0039 (2)
$EC_{0,25}$	798 (5)	–	–	0.106 (3)	–	0.106 (3)	–	(2) +	2 +	(allowed)	6.4	0.8664 (15)	0.1086 (11)	0.0212 (4)	0.0038 (2)
$EC_{0,24}$	820 (5)	–	–	0.121 (10)	–	0.121 (10)	–	(2) +	1 (+)	(allowed)	6.4	0.8666 (15)	0.1085 (11)	0.0212 (4)	0.0038 (2)
$EC_{0,23}$	884 (5)	–	–	0.118 (19)	–	0.118 (19)	–	(2) +	(1, 2 +)	(allowed)	6.4	0.8669 (14)	0.1082 (11)	0.0211 (4)	0.0038 (2)
$EC_{0,22}$	931 (5)	–	–	0.36 (4)	–	0.36 (4)	–	(2) +		[allowed]	6.0	0.8672 (14)	0.1080 (11)	0.0211 (4)	0.0038 (2)
$EC_{0,20}$	1000 (5)	–	–	0.234 (20)	–	0.234 (20)	–	(2) +	(3 +)	(allowed)	6.3	0.8675 (14)	0.1078 (11)	0.0210 (4)	0.0038 (2)
$EC_{0,18}$	1169 (5)	147 (5)	–	0.058 (17)	5888	0.058 (17)	–	(2) +	(3 +)	(allowed)	7.0	0.8681 (14)	0.1073 (11)	0.0209 (4)	0.0037 (2)
$EC_{0,17}$	1203 (5)	181 (5)	–	1.63 (9)	2344	1.63 (9)	–	(2) +	1 +	(allowed)	5.57	0.8682 (14)	0.1072 (11)	0.0209 (4)	0.0037 (2)
$EC_{0,16}$	1367 (5)	345 (5)	157.5 (22)	0.094 (14)	160	0.093 (14)	0.00058 (9)	(2) +	3 +	(allowed)	6.9	0.8686 (14)	0.1069 (11)	0.0208 (4)	0.0037 (2)
$EC_{0,13}$	1462 (5)	440 (5)	198.5 (22)	0.15 (3)	61.66	0.15 (3)	0.0024 (5)	(2) +	2 +	(allowed)	6.8	0.8688 (14)	0.1067 (11)	0.0208 (4)	0.0037 (2)
$EC_{0,11}$	1592 (5)	570 (5)	254.3 (22)	10.5 (4)	23.44	10.1 (4)	0.427 (21)	(2) +	1 +	(allowed)	5.03	0.8690 (14)	0.1066 (11)	0.0207 (4)	0.0037 (2)
$EC_{0,7}$	1939 (5)	917 (5)	404.8 (22)	4.9 (3)	4.41	4.0 (2)	0.91 (6)	(2) +	2 +	(allowed)	5.60	0.8694 (14)	0.1062 (11)	0.0207 (4)	0.0037 (2)
$EC_{0,5}$	2265 (5)	1243 (5)	548.7 (23)	0.56 (8)	1.595	0.34 (5)	0.22 (3)	(2) +	2 +	(allowed)	6.8	0.8697 (14)	0.1060 (11)	0.0206 (4)	0.0037 (2)
$EC_{0,4}$	2468 (5)	1446 (5)	639.6 (23)	0.80 (19)	0.974	0.39 (9)	0.41 (10)	(2) +	2 +	(allowed)	6.82	0.8699 (14)	0.1059 (11)	0.0206 (4)	0.0037 (2)
$EC_{0,1}$	3461 (5)	2439 (5)	1094.4 (24)	80.0 (5)	0.1908	12.8 (1)	67.2 (4)	(2) +	2 +	(allowed)	5.606	0.8704 (14)	0.1055 (11)	0.0205 (4)	0.0037 (2)
				∑ 100.012		∑ 30.881	∑ 69.16998								
						∑ 100.05098									

* Determined from the nuclear level energies of 2006Ab37 and Q-value of 4332 (5) keV (2012Wa38).

Atomic Data

The x-ray and Auger-electron data have been calculated using the evaluated gamma-ray data, and atomic data from 1996Sc06, 1998ScZM and 1999ScZX. Both the X-ray and Auger-electron emission probabilities were determined by means of the EMISSION computer program (version 4.02, 28 February 2012), as described in 2000Sc47. This program incorporates atomic data from 1996Sc06 and the evaluated gamma-ray data.

K and L X-ray energies and emission probabilities of ^{94m}Tc.

			Energy (keV)	Photons per 100 disint.	Relative probability
XL		(Mo)	2.016 – 2.831	1.198 (22)	10.6
	XL_l	(Mo)	2.016	0.0279 (8)	
	XL_α	(Mo)	2.290 – 2.293	0.750 (18)	
	XL_η	(Mo)	2.120	0.0100 (3)	
	XL_β	(Mo)	2.395 – 2.518	0.389 (10)	
	XL_γ	(Mo)	2.623 – 2.831	0.0208 (4)	
XK_α	$XK_{\alpha2}$	(Mo)	17.3745 (2)	5.93 (11)	52.4
	$XK_{\alpha1}$	(Mo)	17.47954 (2)	11.31 (19)	100
$XK'_{\beta1}$	$XK_{\beta3}$	(Mo)	19.5904 (2)	)	
	$XK_{\beta1}$	(Mo)	19.6085 (2)	) 2.97 (6)	26.3
	$XK_{\beta5}$	(Mo)	19.774 (5)	)	
$XK'_{\beta2}$	$XK_{\beta2}$	(Mo)	19.9653 (7)	) 0.457 (18)	4.04
	$XK_{\beta4}$	(Mo)	19.998	)	

Auger-electron energies and emission probabilities of ^{94m}Tc.

		Energy (keV)	Electrons per 100 disint.	Relative probability
e_{AK}	(Mo)		6.28 (15)	
	KLL	14.172 – 14.855	4.37 (11)	100
	KLX	16.592 – 17.478	1.74 (5)	39.8
	KXY	18.990 – 19.996	0.172 (5)	3.94
e_{AL}	(Mo)	1.48 – 2.25	29.8 (4)	682

Mo: $\omega_K = 0.767$ (4); $\varpi_L = 0.0381$ (9); $n_{KL} = 1.029$ (4) were taken from 1996Sc06.

Electron energies were determined from electron binding energies tabulated by Larkins (1977La19) and the evaluated gamma-ray energies. Absolute electron emission probabilities were calculated from the evaluated absolute gamma-ray emission probabilities and associated internal conversion coefficients.

Data Consistency

A Q_{EC}-value of 4332 (5) keV has been adopted from the atomic mass evaluation of Wang *et al.* (2012Wa38) while in the course of formulating the decay scheme of ^{94m}Tc. This value has subsequently been compared with the Q-value calculated by summing the contributions of the individual emissions to the ^{94m}Tc EC-decay process (i.e. EC/β^+, electron, γ, etc.):

$$\text{calculated Q-value} = \sum (E_i \; x \; P_i) = 4331\ (17)\ \text{keV}$$

Percentage deviation from the Q-value of Wang *et al.* is 0.02 (42) %, which supports the derivation of a reasonably consistent decay scheme with a large variant.

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