^{184}Re ε decay (35.4 d) 1974Mc08

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 111,275 (2010)	1-Oct-2009

Parent: ^{184}Re: E=0.0; J$^\pi$=3$^{(-)}$; T$_{1/2}$=35.4 d *7*; Q(ε)=1481 *4*; %ε+%β^+ decay=100.0

Others: 1960Bo07, 1962Bl12, 1963Bi04, 1963Dz05, 1963Jo03, 1964Ha06, 1966Ag03, 1966Dz04, 1968Ag01, 1969Gl04, 1969Zu01, 1970Ag06, 1970BlZT, 1970Do08, 1970Ku05, 1971Ta19, 1973Ag03, 1973Ag07, 1973Ca08, 1973Hu06, 1973Kr01, 1974SvZY, 1975Bu01, 1976Kl06, 1977Ga21, 1982Al05, 1987Bu26.

The decay scheme is that proposed by 1974Mc08 based on energy sums and $\gamma\gamma$-coincidence data.

^{184}W Levels

E(level)†	J$^\pi$‡	T$_{1/2}$	Comments
0.0	0$^+$		
111.2174 *4*	2$^+$	1.251 ns *12*	T$_{1/2}$: from 1984Al06. Other values: 1960Bo07 (1.28 ns *8*), 1964Ko13 (1.24 ns *4*) based on (γ)(111γ)(t). g=+0.289 *7* (1984Al06; IPAC). Value corrected for Knight shift and diamagnetism.
364.064 *9*	4$^+$		g=+0.293 *23* (1984Al06; IPAC).
748.314 *15*	6$^+$		g=+0.299 *43* (1984Al06; IPAC).
903.294 *11*	2$^+$	<1.1 ns	T$_{1/2}$: from (γ)(793γ)(t), (γ)(903γ)(t) (1958Ga17).
1005.985 *12*	3$^+$		
1121.447 *21*	2$^+$		
1130.046 *13*	(2)$^-$		
1133.836 *16*	4$^+$		
1386.331 *19*	2$^+$		
1425.03 *4*	(3)$^+$		
1431.01 *7*	2$^+$		

† From least-squares fit to Eγ, assigning 1 keV uncertainty to data for which the authors gave No uncertainty.
‡ From Adopted Levels.

ε,β^+ radiations

E(decay)	E(level)	Iε‡	Log *ft*	I($\varepsilon+\beta^+$)†‡	Comments
(50 *4*)	1431.01	0.0047 *5*	8.55 *11*	0.0047 *5*	εL=0.678 *10*; εM+=0.322 *10*
(56 *4*)	1425.03	0.036 *5*	7.78 *10*	0.036 *5*	εL=0.690 *8*; εM+=0.310 *8*
(95 *4*)	1386.331	0.254 *12*	7.61 *8*	0.254 *12*	εK=0.30 *5*; εL=0.51 *4*; εM+=0.193 *16*
(347 *4*)	1133.836	1.23 *6*	8.60 *3*	1.23 *6*	εK=0.7656 *10*; εL=0.1770 *7*; εM+=0.0574 *3*
(360 *4*)	1121.447	0.189 *10*	9.45 *3*	0.189 *10*	εK=0.7683 *9*; εL=0.1750 *7*; εM+=0.05666 *24*
(475 *4*)	1005.985	17.8 *6*	7.762 *19*	17.8 *6*	εK=0.7856 *5*; εL=0.1625 *4*; εM+=0.05193 *12*
(578 *4*)	903.294	76.5 *22*	7.320 *17*	76.5 *22*	εK=0.7943 *3*; εL=0.15613 *20*; εM+=0.04955 *8*
(1117# *4*)	364.064	0.4 *3*	10.2 *4*	0.4 *3*	εK=0.8119; εL=0.14333 *5*; εM+=0.04478 *2*
(1370 *4*)	111.2174	3.5 *24*	9.5 *3*	3.5 *24*	εK=0.8149; εL=0.14096 *4*; εM+=0.04390 *2*

† From intensity imbalance At each level.
‡ Absolute intensity per 100 decays.
# Existence of this branch is questionable.

$\gamma(^{184}$W)

Iγ normalization: From Σ (I(γ+ce) to g.s.)=100.
For $\gamma\gamma$ see 1973Ag03, 1974Mc08.
For (ce)(γ) see 1963Dz05, 1966Dz04.
ce data have been reported by 1966Ag03, 1968Ag01, 1970Ag06, 1973Ag03, 1973Ag07, 1973Ca08, 1974Mc08, 1974SvZY. Others: 1966Dz04, 1964Ha06.
Extensive internal conversion coefficient data have been deduced by 1973Ag07, 1974Mc08, and 1974SvZY based on their relative I(ce) and I(γ) measurements normalized so that α(K)(903γ)=0.00452 (E2 theory).

E_γ [†]	I_γ [‡&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.	δ	α [a]	Comments
111.2174 *4*	40.9 *14*	111.2174	2$^+$	0.0	0$^+$	E2		2.57	α(K)=0.720 *10*; α(L)=1.402 *20*; α(M)=0.354 *5*; α(N+..)=0.0949 *14* α(N)=0.0834 *12*; α(O)=0.01145 *16*; α(P)=5.54×10^{-5} *8* E$_\gamma$: from E(ce(K)) (1988BuZD). others: 111.2172 *11* (1988BuZD, from E(ce(L))); 111.207 *7* (1974Mc08). %Iγ=17.2 *4* assuming adopted normalization. Mult.: from L1/L2= 0.124 *14*, L1/L3=0.132 *12*, L2/L3=1.07 *8*, M1/M2=0.110 *15*, M1/M3=0.12 *2*, M2/M3=1.1 *1* (1970Ag06) and α(K)exp=0.71 *3* (1973Ag07).
124.060 *20*	0.0042 *8*	1130.046	(2)$^-$	1005.985	3$^+$	(E1)		0.215	α(K)=0.1762 *25*; α(L)=0.0297 *5*; α(M)=0.00677 *10*; α(N+..)=0.00186 *3* α(N)=0.001603 *23*; α(O)=0.000245 *4*; α(P)=1.294×10^{-5} *19* Mult.: from α(K)exp<1.1 (1973Ag07) and level scheme.
127.67 *10*	0.0038 *16*	1133.836	4$^+$	1005.985	3$^+$	E2(+M1)	>2.8	1.57 *6*	α(K)=0.61 *9*; α(L)=0.72 *3*; α(M)=0.182 *8*; α(N+..)=0.0488 *19* α(N)=0.0429 *17*; α(O)=0.00593 *21*; α(P)=4.9×10^{-5} *9* E$_\gamma$: from 1976Kl06. I$_\gamma$: from I(ce(K))/I(903ce(K))<0.0047 *19* (1976Kl06) if mult=E2. Mult.,δ: from L1/L2<0.3, L1/L3<0.3, L2/L3=1.2 *6* (1976Kl06).
226.748 *10*	0.043 *8*	1130.046	(2)$^-$	903.294	2$^+$	E1+M2+E3		0.059 *5*	α(K)=0.059; α(L)=0.042; α(M)=0.0132; α(N+..)=0.00088 Mult.,δ: α(K)exp=0.0421 *12* (1974Mc08), 0.0032 *10* (1973Ag07). From $\gamma(\theta$,H,T) (1973Kr01) and α(K)exp, δ(M2,E1)=−0.02 *3*, δ(E3,E1)=0.10 *3*.
230.45 *6*	0.035 *8*	1133.836	4$^+$	903.294	2$^+$	E2		0.193	α(K)=0.1152 *17*; α(L)=0.0593 *9*; α(M)=0.01467 *21*; α(N+..)=0.00398 *6* α(N)=0.00347 *5*; α(O)=0.000495 *7*; α(P)=9.38×10^{-6} *14* Mult.: from L1/L2=0.43 *20*, L2/L3=1.8 *7* (1976Kl06).
252.845 *10*	7.2 *6*	364.064	4$^+$	111.2174	2$^+$	E2		0.1437	α(K)=0.0898 *13*; α(L)=0.0411 *6*; α(M)=0.01011 *15*; α(N+..)=0.00275 *4* α(N)=0.00240 *4*; α(O)=0.000344 *5*; α(P)=7.45×10^{-6} *11* Mult.: from L2:L3:M:N=280 *28*:120 *12*:≈70:≈14 (1968Ag01), α(K)exp=0.086 *10* (1973Ag07), α(K)exp=0.085 *8* (1974Mc08).
(256.3)	<0.014 [#]	1386.331	2$^+$	1130.046	(2)$^-$	[E1]		0.0336	α(K)=0.0280 *4*; α(L)=0.00436 *7*; α(M)=0.000989 *14*; α(N+..)=0.000275 *4* α(N)=0.000236 *4*; α(O)=3.72×10^{-5} *6*; α(P)=2.26×10^{-6} *4*

$^{184}_{74}$W$_{110}$-2

γ(^{184}W) (continued)

E_γ[†]	I_γ[‡&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.	δ	α[a]	Comments
(265.0)	<0.0036[#]	1386.331	2^+	1121.447	2^+	[E2]		0.1240	α(K)=0.0792 *11*; α(L)=0.0342 *5*; α(M)=0.00840 *12*; α(N+..)=0.00229 *4* α(N)=0.00199 *3*; α(O)=0.000287 *4*; α(P)=6.63×10^{-6} *10*
295.01 *7*	0.052 *10*	1425.03	$(3)^+$	1130.046	$(2)^-$	E1		0.0238	α(K)=0.0199 *3*; α(L)=0.00306 *5*; α(M)=0.000694 *10*; α(N+..)=0.000193 *3* α(N)=0.0001656 *24*; α(O)=2.62×10^{-5} *4*; α(P)=1.630×10^{-6} *23* Mult.: from α(K)exp≈0.021 (1976Kl06).
380.34 *4*	0.011 *3*	1386.331	2^+	1005.985	3^+	M1+E2	1.3 *+23−6*	0.070 *22*	α(K)=0.055 *20*; α(L)=0.0113 *18*; α(M)=0.0027 *4*; α(N+..)=0.00074 *11* α(N)=0.00064 *9*; α(O)=9.9×10^{-5} *17*; α(P)=5.3×10^{-6} *21* E_γ: from 1976Kl06. I_γ: from adopted I(γ)/I(1275γ)=0.039 *10*. Mult.,δ: from α(K)exp=0.055 *21* based on I(ce(K))/I(903ce(K))=0.0015 *4* (1976Kl06) and $I\gamma$.
(384.250 *12*)	<0.013[#]	748.314	6^+	364.064	4^+	E2		0.0418	α(K)=0.0302 *5*; α(L)=0.00885 *13*; α(M)=0.00213 *3*; α(N+..)=0.000585 *9* α(N)=0.000507 *8*; α(O)=7.54×10^{-5} *11*; α(P)=2.69×10^{-6} *4* Mult.: from Adopted Gammas.
(385.4)	<0.016[#]	1133.836	4^+	748.314	6^+	[E2]		0.0414	α(K)=0.0300 *5*; α(L)=0.00877 *13*; α(M)=0.00211 *3*; α(N+..)=0.000579 *9* α(N)=0.000502 *7*; α(O)=7.46×10^{-5} *11*; α(P)=2.67×10^{-6} *4*
482.98 *16*	0.044 *8*	1386.331	2^+	903.294	2^+	M1+E2		0.042 *20*	α(K)=0.034 *17*; α(L)=0.0061 *19*; α(M)=0.0014 *4*; α(N+..)=0.00039 *12* α(N)=0.00034 *10*; α(O)=5.4×10^{-5} *18*; α(P)=3.3×10^{-6} *18* Mult.: α(K)exp=0.039 *19* (1973Ag07), but 1974SvZY report α(K)exp=0.16 *7*. The latter value, if correct, would imply an E0 component (α(K)=0.0174, 0.0516 from E2,M1 theory, respectively).
539.220 *25*	0.78 *4*	903.294	2^+	364.064	4^+	E2		0.01744	α(K)=0.01349 *19*; α(L)=0.00303 *5*; α(M)=0.000716 *10*; α(N+..)=0.000198 *3* α(N)=0.0001710 *24*; α(O)=2.62×10^{-5} *4*; α(P)=1.238×10^{-6} *18* Mult.: from α(K)exp=0.0129 *16* (1974Mc08).
641.915 *20*	4.63 *8*	1005.985	3^+	364.064	4^+	M1+E2	−8.5 *8*	0.01183 *18*	α(K)=0.00938 *14*; α(L)=0.00188 *3*; α(M)=0.000440 *7*; α(N+..)=0.0001225 *18* α(N)=0.0001052 *15*; α(O)=1.636×10^{-5} *24*; α(P)=8.70×10^{-7} *13* Mult.: from L1/L2=3.0 *5*, L1/L3=8.8 *18*, L2/L3=2.9 *8* (1976Kl06), α(K)exp=0.0087 *13* (1973Ag07), α(K)exp=0.0089 *6* (1974Mc04). δ: from $\gamma(\theta$,H,T) (1973Kr01). Others: −6.7 *+15−26* (1973Hu06), −8.3 *+16−28* (1973Ca08; $\gamma\gamma(\theta)$).
757.36 *4*	0.147 *10*	1121.447	2^+	364.064	4^+	E2		0.00803	α(K)=0.00647 *9*; α(L)=0.001206 *17*; α(M)=0.000280 *4*;

γ(^{184}W) (continued)

E_γ[†]	I_γ[‡&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.	δ	α[a]	Comments
									α(N+..)=7.81×10^{-5} *11* α(N)=6.70×10^{-5} *10*; α(O)=1.052×10^{-5} *15*; α(P)=6.00×10^{-7} *9* Mult.: α(K)exp=0.005 *2* (1973Ag07).
769.778 *17*	1.60 *6*	1133.836	4$^+$	364.064	4$^+$	M1+E2	−6.3 *+20−32*	0.0080 *4*	α(K)=0.0065 *7*; α(L)=0.00119 *9*; α(M)=0.000275 *19*; α(N+..)=7.7×10^{-5} *6* α(N)=6.6×10^{-5} *5*; α(O)=1.04×10^{-5} *8*; α(P)=6.0×10^{-7} *7* Mult.: α(K)exp=0.0065 *6* (1974Mc08), α(K)exp=0.0053 *13* (1973Ag07). δ: from γ(θ,H,T) (1973Kr01). Other: 1/δ=−0.01 *6* (1973Hu06).
792.067 *22*	89.5 *14*	903.294	2$^+$	111.2174	2$^+$	M1+E2	−16.8[@] *5*	0.00733	α(K)=0.00593 *9*; α(L)=0.001082 *16*; α(M)=0.000251 *4*; α(N+..)=7.00×10^{-5} *10* α(N)=6.00×10^{-5} *9*; α(O)=9.45×10^{-6} *14*; α(P)=5.50×10^{-7} *8* Mult.: α(K)exp=0.0063 *6*, L1/L2=3.6 *3*, L1/L3=10.2 *10*, L2/L3=2.8 *3* (1970Ag06); α(K)exp=0.0058 *3* (1974Mc08); K:L:M:N=132:24:6.2:≈1.4 (1966Ag03).
894.760 *19*	37.3 *7*	1005.985	3$^+$	111.2174	2$^+$	M1+E2	−13.2 *9*	0.00569 *8*	α(K)=0.00464 *7*; α(L)=0.000808 *12*; α(M)=0.000186 *3*; α(N+..)=5.21×10^{-5} *8* α(N)=4.46×10^{-5} *7*; α(O)=7.08×10^{-6} *10*; α(P)=4.32×10^{-7} *6* Mult.: L1/L2=4.5 *4*, L1/L3=11.6 *15*, L2/L3=2.6 *4* (1970Ag06), α(K)exp=0.0050 *7* (1973Ag07), α(K)exp=0.0046 *2* (1974Mc08), K:L=47:7.0 (1966Ag03). δ: from γ(θ,H,T) (1973Kr01). Others: −17.5 *+8−10* (1973Hu06), −13 *+4−12* (1973Ca08; γγ(θ)).
903.282 *19*	90.5 *14*	903.294	2$^+$	0.0	0$^+$	E2		0.00554 *8*	α(K)=0.00452 *7*; α(L)=0.000786 *11*; α(M)=0.000181 *3*; α(N+..)=5.07×10^{-5} *7* α(N)=4.34×10^{-5} *6*; α(O)=6.89×10^{-6} *10*; α(P)=4.20×10^{-7} *6* %Iγ=38.1 *11* assuming adopted normalization. Mult.: from L1/L3=12.6 *18* (1970Ag06), L1/L2=1.3 *+9−5* (1973Ag03), K:L:M:N=100:18:4.2:≈0.8 (1966Ag03).
1010.24 *3*	0.218 *15*	1121.447	2$^+$	111.2174	2$^+$	M1+E2+E0		0.0139 *13*	δ(D,Q)=+2.3 *6* from γ(θ,H,T) (1973Kr01). Mult.: from α(K)exp=0.0107 *10*, weighted average of 0.0110 *11* (1974Mc08) and 0.0093 *22* (1973Ag07). α: from 1.3 α(K)exp.
1018.93 *5*	0.0027 *5*	1130.046	(2)$^-$	111.2174	2$^+$	(E1)			Mult.: from α(K)exp=0.0018 *12* (1976Kl06).
1022.63 *3*	1.24 *9*	1133.836	4$^+$	111.2174	2$^+$	E2		0.00431 *6*	α(K)=0.00354 *5*; α(L)=0.000591 *9*; α(M)=0.0001356 *19*; α(N+..)=3.80×10^{-5} *6*

$\gamma(^{184}W)$ (continued)

E_γ[†]	I_γ[‡&]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ	α[a]	Comments
									α(N)=3.25×10^{-5} *5*; α(O)=5.19×10^{-6} *8*; α(P)=3.29×10^{-7} *5* Mult.: from α(K)exp=0.0037 *3* (1974Mc08), 0.0030 *4* (1973Ag07); K:L=1.2:0.22 (1966Ag03).
1061.04 *14*	0.0062 *12*	1425.03	(3)$^+$	364.064	4$^+$	E2		0.00400	α(K)=0.00330 *5*; α(L)=0.000545 *8*; α(M)=0.0001247 *18*; α(N+..)=3.50×10^{-5} *5* α(N)=2.99×10^{-5} *5*; α(O)=4.79×10^{-6} *7*; α(P)=3.06×10^{-7} *5* Mult.: from α(K)exp≈0.003 (1976Kl06).
1121.44 *4*	0.084 *6*	1121.447	2$^+$	0.0	0$^+$	E2		0.00359	α(K)=0.00297 *5*; α(L)=0.000482 *7*; α(M)=0.0001102 *16*; α(N+..)=3.14×10^{-5} *5* α(N)=2.65×10^{-5} *4*; α(O)=4.24×10^{-6} *6*; α(P)=2.75×10^{-7} *4*; α(IPF)=4.76×10^{-7} *7* Mult.,δ: δ(E2,M1)>1.1 from α(K)exp=0.0035 *10* (1973Ag07). Others: 1974Mc08 (α(K)exp=0.0037 *19*), 1974SvZY. Feeding to 0$^+$ g.s. rules out mixed multipolarity.
1275.11 *3*	0.285 *14*	1386.331	2$^+$	111.2174	2$^+$	M1+E2	≥+3	0.00294 *14*	α=0.00294 *14*; α(K)=0.00243 *12*; α(L)=0.000382 *16*; α(M)=8.7×10^{-5} *4*; α(N+..)=3.84×10^{-5} *14* α(N)=2.08×10^{-5} *9*; α(O)=3.36×10^{-6} *15*; α(P)=2.26×10^{-7} *12*; α(IPF)=1.39×10^{-5} *4* Mult.: α(K)exp=0.0036 *6* (1974Mc08), 0.0027 *6* (1973Ag07). δ: from Adopted Gammas. δ=−0.42 *4* or >18, <−50 from $\gamma(\theta$,H,T) (1973Kr01). δ=1.2 *+10−5* from α(K)exp=0.0032 *5* (weighted average of data of 1973Ag07, 1974Mc08). 1974Mc08 suggest the possible presence of an E0 component.
1313.79 *4*	0.0266 *20*	1425.03	(3)$^+$	111.2174	2$^+$	E2		0.00266 *4*	α(K)=0.00220 *3*; α(L)=0.000345 *5*; α(M)=7.84×10^{-5} *11*; α(N+..)=4.20×10^{-5} *6* α(N)=1.88×10^{-5} *3*; α(O)=3.03×10^{-6} *5*; α(P)=2.04×10^{-7} *3*; α(IPF)=1.99×10^{-5} *3* Mult.: from α(K)exp=0.0018 *3* (1977Ga21). other α(K)exp: 0.0026 *11* (1973Ag07).
1319.94 *14*	0.0054 *6*	1431.01	2$^+$	111.2174	2$^+$	M1+E2+E0			Mult.: α(K)exp≥0.0095 *11* (1973Ag07), 0.018 *3* (1977Ga21).
1386.33 *3*	0.245 *12*	1386.331	2$^+$	0.0	0$^+$	E2		0.00242 *4*	α(K)=0.00199 *3*; α(L)=0.000308 *5*; α(M)=7.00×10^{-5} *10*; α(N+..)=5.55×10^{-5} *8* α(N)=1.682×10^{-5} *24*; α(O)=2.72×10^{-6} *4*; α(P)=1.84×10^{-7} *3*; α(IPF)=3.58×10^{-5} *5* Mult.: α(K)exp=0.0021 *2* (1973Ag07), 0.0020 *8* (1974Mc08). Other: 1974SvZY. Feeding of 0$^+$ g.s. rules out mixed multipolarity. δ(E2,M1)>2.2 from α(K)exp (1973Ag07).
1430.96 *8*	0.0057 *8*	1431.01	2$^+$	0.0	0$^+$	E2		0.00230 *4*	α(K)=0.00187 *3*; α(L)=0.000289 *4*; α(M)=6.56×10^{-5} *10*; α(N+..)=6.63×10^{-5} *10* α(N)=1.576×10^{-5} *22*; α(O)=2.55×10^{-6} *4*; α(P)=1.735×10^{-7} *25*; α(IPF)=4.78×10^{-5} *7* Mult.: from α(K)exp=0.0020 *6* (1977Ga21).

γ(^{184}W) (continued)

† From 1974Mc08, except As noted. Others: 1970Ku05, 1971Ta19, 1973Ag07, 1975Bu01, 1974SvZY, 1988BuZD.

‡ Relative Iγ based on the decay scheme and Iγ from 1974Mc08 measured for a ^{184}Re ground-state plus metastable-state source in secular equilibrium. The mixed decay can be decomposed to obtain separately the ground-state and metastable-state contributions because 169 d ^{184}Re ε decay directly populates just one level and that level is not fed In ^{184}Re(g.s.) ε decay. the evaluator has revised the authors′ values taking into account small changes In the theoretical conversion coefficients. Other Iγ: 1970Ku05, 1973Ag07, 1973Ca08, 1974SvZY, 1975Bu01.

Photons unobserved. Limit on Iγ from I(ce(K)) of 1976Kl06 if multipolarity is as indicated.

@ from $\gamma(\theta$,H,T); weighted average of −16.7 *8* (1972Bu35), −18.2 *12* (1973Hu06), −16.1 *9* (1973Kr01)). Others: 1969Zu01, −19 *+3−5* (1970Do08), −22 *+6−7* (1973Ca08; $\gamma\gamma(\theta)$), −17.6 *+15−18* (1982Al05). Based on γ-$\gamma(\theta)$, ce-$\gamma(\theta)$, 1969Zu01 and 1970Do08 suggest the possibility of E0 admixture and M1 penetration effects. Taking δ(E2,M1)=−18 *2*, and α(K)=0.0061 *6*, 1969Zu01 obtain E0/E2<0.37, $-82<\lambda<+196$. Taking δ(E2,M1)=−16.7 *+14−12*, and α(K)=0.0064 *3*, 1970Do08 obtain −0.28<E0/E2<+0.38, $-113<\lambda<+53$. Based on L-subshell ratios, 1972KaYB obtain E0/E2<0.54, but do not consider penetration effects. In the above, E0/E2 is the ratio of conversion electron components, and λ is the M1 penetration parameter.

& For absolute intensity per 100 decays, multiply by 0.421 *11*.

[a] 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.

^{184}Re ε decay (35.4 d) 1974Mc08

Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays