^{40}Cl β^- decay (1.35 min) 1972Kl06,1970Ke12

Parent: ^{40}Cl: E=0; $J^\pi=2^-$; $T_{1/2}$=1.35 min *2*; $Q(\beta^-)$=7482 *32*; %β^- decay=100.0

^{40}Cl-J^π,$T_{1/2}$: From Adopted Levels of ^{40}Cl.

^{40}Cl-$Q(\beta^-)$: From 2012Wa38.

1972Kl06 (also 1973Kl02,1981HuZT): ^{40}Cl ions were produced via ^{40}Ar(n,p) reaction with E=14 MeV neutron beam on pure natural argon target. γ rays were detected with a Ge(Li) detector (FWHM=4 keV at 1.33 MeV) and a NaI(Tl) detector. Measured Eγ, Iγ, $\gamma\gamma$-coin. Deduced levels, J, π, γ-ray branching ratios.

1970Ke12: ^{40}Cl sources were prepared via the ^{40}Ar(n,p) reaction with E=14.9 MeV neutron produced from the University of Kentucky neutron generator. γ rays were detected with Ge(Li) detectors and NaI(Tl) detectors. Measured Eγ, Iγ, $\gamma\gamma$-coin, decay curve. Deduced levels, J, π, γ-ray branching ratios, parent $T_{1/2}$.

Others:

1989Mi03: Measured Eβ, $\beta\gamma$-coin. Deduced mass excess.

1968Hu07, 1965Gr03, 1956Mo39: Measured Eγ, Iγ. Deduced levels.

Thesis (M.S.) by E.L. Robinson (Purdue, 1958). Eγ, Iγ data and level scheme from this work are quoted by 1970Ke12. This thesis was not available to the present evaluators.

^{40}Ar Levels

E(level)[†]	J^π[&]	$T_{1/2}$
0	0^+	stable
1460.78 *5*	2^+	
2120.82 *19*	0^+	
2524.03 *12*	2^+	
2892.70 *22*	4^+	
3207.89 *14*	2^+	
3511.18 *25*	2^+	
3680.53 *14*	3^-	
3918.82 *13*	2^+	
3941.91?[‡] *20*		
4082.60 *17*	3^-	
4178.9?[‡] *3*		
4301.01 *23*	$(1,3)^-$	
4324.5 *3*	2^+	
4359.5?[‡] *9*		
4481.0?[‡] *3*	1^-	
4562.28 *17*	$(1,3)^-$	
4582.0?[‡] *8*	(3^-)	
4737.8?[‡] *4*		
4769.0 *3*	1^-	
4943.3?[‡] *6*		
5165.7 *7*	$(2)^+$	
5269.6 *3*	$(1^-,3^-)$	
5310.0?[#] *10*	(2^+)	
5400.5 *8*	1^-	
5609.4 *8*	(1,2,3)	
5629.4?[#] *10*		
5717.8 *10*		
5880.1 *4*	1^-	
5905.9 *7*	(1^-)	
5950.5 *10*	(1,2)	
6053.6 *8*	$1^{(-)}$	
6133.5?[@] *10*		
6208.5 *8*	(1,2)	

Continued on next page (footnotes at end of table)

^{40}Cl β^- decay (1.35 min) 1972Kl06,1970Ke12 (continued)

^{40}Ar Levels (continued)

E(level)[†]	J^π[&]	Comments
6276.7? *10*	(1^-,2^-,3^-)	E(level): this level is constructed by 1972Kl06 only based on a 1333-keV transition to a level at 4943 which is considered as improbable by 1983Bi08 in (α,pγ). Therefore, the evaluators have considered this level as questionable as well.
6338.7 *11*	$1^{(-)}$	
6476.1 *8*	$1^{(-)}$	
6651.7? *8*		

[†] From a least-squares fit to γ-ray energies.
[‡] Level considered as improbable based on results of (α,pγ) study of 1983Bi08.
[#] Level considered as improbable since the decay mode is very different from that in (α,pγ) (1983Bi08) from a level near the same energy.
[@] From 1981HuZT only.
[&] From Adopted Levels.

β^- radiations

E(decay)	E(level)	Iβ^-[†‡]	Log *ft*	Comments
(8.3×10^{2}[#] *3*)	6651.7?	0.49 *17*	4.8 *2*	
(1.01×10^{3} *3*)	6476.1	0.16 *3*	5.6 *1*	
(1.14×10^{3} *3*)	6338.7	0.26 *8*	5.6 *2*	
(1.21×10^{3}[#] *3*)	6276.7?	0.32 *6*	5.6 *1*	
(1.27×10^{3} *3*)	6208.5	0.041 *25*	6.6 *3*	
(1.35×10^{3} *3*)	6133.5?	≈0.04	≈6.7	Iβ^-: from 1981HuZT.
(1.43×10^{3} *3*)	6053.6	0.32 *6*	5.9 *1*	
(1.53×10^{3} *3*)	5950.5	0.041 *25*	6.9 *3*	
(1.58×10^{3} *3*)	5905.9	0.65 *9*	5.8 *1*	
(1.60×10^{3} *3*)	5880.1	5.2 *5*	4.9 *1*	
(1.76×10^{3} *3*)	5717.8	0.08 *4*	6.9 *2*	
(1.85×10^{3}[#] *3*)	5629.4?	0.08 *4*	7.0 *2*	
(1.87×10^{3} *3*)	5609.4	0.41 *19*	6.3 *2*	
(2.08×10^{3} *3*)	5400.5	0.16 *7*	6.9 *2*	
(2.17×10^{3}[#] *3*)	5310.0?	0.16 *9*	7.0 *3*	
(2.21×10^{3} *3*)	5269.6	2.1 *3*	5.9 *1*	
(2.32×10^{3} *3*)	5165.7	0.9 *1*	6.3 *1*	
(2.71×10^{3} *3*)	4769.0	0.49 *9*	6.9 *1*	
(2.74×10^{3}[#] *3*)	4737.8?	0.41 *9*	7.0 *1*	
(2.90×10^{3}[#] *3*)	4582.0?	0.17 *7*	7.5 *2*	
(2.92×10^{3} *3*)	4562.28	22.6 *21*	5.4 *1*	E(decay): 2729 *145* (1989Mi03) from β(3101γ).
(3.00×10^{3}[#] *3*)	4481.0?	0.24 *6*	7.4 *1*	
(3.12×10^{3}[#] *3*)	4359.5?	0.24 *8*	7.5 *2*	
(3.16×10^{3} *3*)	4324.5	0.16 *5*	7.7 *2*	
(3.18×10^{3} *3*)	4301.01	27 *5*	5.5 *1*	E(decay): 3086 *75* (1989Mi03) from β(2840γ).
(3.30×10^{3}[#] *3*)	4178.9?	0.24 *6*	7.6 *1*	
(3.40×10^{3} *3*)	4082.60	13.8 *15*	5.9 *1*	E(decay): 3070 *100* (1989Mi03) from β(2622γ).
(3.54×10^{3}[#] *3*)	3941.91?	0.16 *5*	7.9 *2*	
(3.56×10^{3} *3*)	3918.82	5.5 *12*	6.4 *1*	
(3.80×10^{3} *3*)	3680.53	4.6 *11*	6.6 *1*	
(3.97×10^{3} *3*)	3511.18	0.9 *2*	7.4 *1*	
(4.27×10^{3} *3*)	3207.89	2.1 *4*	7.2 *1*	

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^{40}Cl β^- decay (1.35 min) 1972Kl06,1970Ke12 (continued)

β^- radiations (continued)

E(decay)	E(level)	Iβ^- †‡	Log *ft*	Comments
(4.59×10^3 *3*)	2892.70	0.7 *2*	9.5^{1u} *1*	
(4.96×10^3 *3*)	2524.03	1.7 *5*	7.5 *1*	
(6.02×10^3# *3*)	1460.78	4 *4*	>7.2	
(7.48×10^3 *3*)	0	<9	>9.8^{1u}	E(decay): 7390 *118* (1989Mi03). Iβ^-: only available experimental value is 9% from E.L. Robinson (M.S. thesis, Purdue, 1958). This value has been quoted in several papers (1989Mi03,1981HuZT,1972Kl06,1970Ke12) and in Endt's compilations. 1970Ke12 quoted Iβ=9-18%, again based on Robinson's data, suggesting equal feedings to the ground state and the first excited state. The singles β spectrum of 1989Mi03 does show that there is a direct feeding to the ground state, but in the opinion of the evaluators, precise feeding is not known. log $f^{1u}t$>8.5 expected for first-forbidden unique transition allows up to 100% feeding.

† Deduced by evaluators from imbalance of γ-ray intensities at each level using the GTOL program.
‡ Absolute intensity per 100 decays.
\# Existence of this branch is questionable.

γ(^{40}Ar)

Iγ normalization: From Σ(Iγ to g.s.)=95.5 *45*, obtained by assuming β^- feeding to g.s. is <9% (see comments for g.s. β^- branching ratio) which is equivalent to 4.5% *45*. Singles β^- spectrum of 1989Mi03 shows some g.s feeding. But its precise value is unknown.

E$_\gamma$[†]	I$_\gamma$[†b]	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Mult.	δ[a]	α[c]	Comments
222.5[e] *5*	0.20 *6*	4582.0?	(3$^-$)	4359.5?					
239.0[§] *3*	0.28[§] *13*	3918.82	2$^+$	3680.53	3$^-$	[E1]		1.13×10^{-3}	
261.2[§] *7*	1.0[§] *1*	4562.28	(1,3)$^-$	4301.01	(1,3)$^-$				
270[‡]		5880.1	1$^-$	5609.4	(1,2,3)				
303.0 *6*	0.07 *4*	3511.18	2$^+$	3207.89	2$^+$				
315.0 *5*	0.03 *1*	3207.89	2$^+$	2892.70	4$^+$	[E2]		0.00249	
361.3[e] *5*	0.09 *2*	4943.3?		4582.0?	(3$^-$)				
369.0 *6*	0.02 *1*	2892.70	4$^+$	2524.03	2$^+$	[E2]		1.41×10^{-3}	
381.0[e] *5*	0.10 *4*	4943.3?		4562.28	(1,3)$^-$				
472.0 *4*	0.3 *1*	3680.53	3$^-$	3207.89	2$^+$	[E1]		1.64×10^{-4}	
479.9[§] *4*	1.1[§] *2*	4562.28	(1,3)$^-$	4082.60	3$^-$				
621.1[d] *6*	<0.3[d]	3511.18	2$^+$	2892.70	4$^+$	[E2]		2.51×10^{-4}	
621.1[d] *6*	<0.3[d]	4301.01	(1,3)$^-$	3680.53	3$^-$				
643.6[§] *3*	8.3[§] *6*	4562.28	(1,3)$^-$	3918.82	2$^+$				
660.1[§] *4*	3.1[§] *3*	2120.82	0$^+$	1460.78	2$^+$	[E2]		2.09×10^{-4}	
788.1[§] *3*	1.0[§] *1*	3680.53	3$^-$	2892.70	4$^+$	[E1]			
881.3[§] *3*	3.2[§] *3*	4562.28	(1,3)$^-$	3680.53	3$^-$				
1042.3[e] *3*	0.6 *2*	6651.7?		5609.4	(1,2,3)				
1051.1 *5*	0.6 *1*	4562.28	(1,3)$^-$	3511.18	2$^+$				
1063.1[§] *2*	2.9[§] *3*	2524.03	2$^+$	1460.78	2$^+$	M1+E2	−0.41 *+6−13*		
1087.6 *4*	0.10 *5*	3207.89	2$^+$	2120.82	0$^+$	[E2]			
1092.9[§] *8*	0.33[§] *7*	4301.01	(1,3)$^-$	3207.89	2$^+$	[E1]			
1156.2 *4*	0.6 *1*	3680.53	3$^-$	2524.03	2$^+$	[E1]		5.43×10^{-5} *8*	
1186.7 *4*	0.9 *1*	5269.6	(1$^-$,3$^-$)	4082.60	3$^-$				
1317.2 *5*	0.50 *6*	5880.1	1$^-$	4562.28	(1,3)$^-$				
1333.4[e] *8*	0.40 *7*	6276.7?	(1$^-$,2$^-$,3$^-$)	4943.3?					E$_\gamma$: this transition connects to a level at 4943 which is considered as improbable by 1983Bi08 in (α,pγ). Therefore, the evaluators have considered it as questionable as well.
1353.7 *5*	0.25 *10*	4562.28	(1,3)$^-$	3207.89	2$^+$				
1394.7 *3*	1.5 *2*	3918.82	2$^+$	2524.03	2$^+$				
1432.1[§] *4*	2.0[§] *2*	2892.70	4$^+$	1460.78	2$^+$	E2		9.45×10^{-5} *14*	
1460.73[§] *5*	100[§]	1460.78	2$^+$	0	0$^+$	E2		1.03×10^{-4}	

$^{40}_{18}$Ar$_{22}$-4

γ(^{40}Ar) (continued)

E_γ [†]	I_γ [†b]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ [a]	α [c]	Comments
1558.7 4	0.60 7	4082.60	3^-	2524.03	2^+	[E1]		3.25×10^{-4}	
1579.9 8	0.4 1	5880.1	1^-	4301.01	$(1,3)^-$				
1589.0 [§] 3	1.2 [§] 2	5269.6	$(1^-,3^-)$	3680.53	3^-				
1746.5 [§] 2	3.3 [§] 3	3207.89	2^+	1460.78	2^+	M1+E2	+0.11 7	1.65×10^{-4} 3	
1776.9 8	0.020 3	4301.01	$(1,3)^-$	2524.03	2^+	[E1]		4.91×10^{-4}	
1797.8 [§] 2	2.7 [§] 4	3918.82	2^+	2120.82	0^+	[E2]		2.36×10^{-4}	
2050.5 4	1.3 2	3511.18	2^+	1460.78	2^+	M1(+E2)	−0.05 11	2.82×10^{-4} 5	
2063.0 10	0.5 2	5269.6	$(1^-,3^-)$	3207.89	2^+				
2220.0 [§] 2	8.6 [§] 12	3680.53	3^-	1460.78	2^+	E1(+M2)	−0.07 +5−11	7.97×10^{-4} 19	
2457.7 [§] 4	5.8 [§] 10	3918.82	2^+	1460.78	2^+	M1+E2		0.00050 5	δ: <−0.3 or>+6 from (p,p′γ).
2524.1 [§] 2	2.5 [§] 3	2524.03	2^+	0	0^+	E2		5.79×10^{-4}	
2621.7 [§] 2	18.1 [§] 16	4082.60	3^-	1460.78	2^+	[E1]		1.04×10^{-3}	
2840.1 [§] 3	34 [§] 5	4301.01	$(1,3)^-$	1460.78	2^+	[E1]		1.17×10^{-3}	
3101.7 [§] 4	14.0 [@] 20	4562.28	$(1,3)^-$	1460.78	2^+				
3193.7 10	0.10 5	5717.8		2524.03	2^+				
3208.2 3	0.6 1	3207.89	2^+	0	0^+	[E2]		8.79×10^{-4}	
3356.6 8	0.4 1	5880.1	1^-	2524.03	2^+				
3511.0 5	0.20 8	3511.18	2^+	0	0^+	[E2]		1.00×10^{-3}	
3704.6 8	1.0 1	5165.7	$(2)^+$	1460.78	2^+				
3759.9 10	0.10 3	5880.1	1^-	2120.82	0^+				
3784.9 6	0.8 1	5905.9	(1^-)	2120.82	0^+				
3918.6 [§] 2	4.8 [§] 5	3918.82	2^+	0	0^+	E2		1.15×10^{-3}	
3941.7 [&e] 2	0.20 5	3941.91?		0	0^+				
4082.1 8	0.30 6	4082.60	3^-	0	0^+	[E3]		9.21×10^{-4}	
4147.7 10	1.1 1	5609.4	(1,2,3)	1460.78	2^+				
4178.7 [&e] 3	0.30 7	4178.9?		0	0^+				
4324.2 3	0.20 5	4324.5	2^+	0	0^+	[E2]		1.29×10^{-3}	
4357.6 [&e] 3	0.50 7	4359.5?		0	0^+				
4480.7 [&e] 3	0.30 7	4481.0?	1^-	0	0^+	D			
4580.1 [&e] 5	0.10 4	4582.0?	(3^-)	0	0^+	[E3]		1.07×10^{-3}	
4737.5 [&e] 4	0.5 1	4737.8?		0	0^+				
4768.7 3	0.6 1	4769.0	1^-	0	0^+				
5165.5 10	0.10 5	5165.7	$(2)^+$	0	0^+				
5309.6 [e] 10	0.2 1	5310.0?	(2^+)	0	0^+				
5400.1 8	0.20 8	5400.5	1^-	0	0^+				
5629.0 [e] 10	0.10 5	5629.4?		0	0^+				
5879.6 [§] 12	5.0 [§] 4	5880.1	1^-	0	0^+				
5950.0 10	0.05 3	5950.5	(1,2)	0	0^+				
6053.1 8	0.40 6	6053.6	$1^{(-)}$	0	0^+				

$^{40}_{18}$Ar$_{22}$-5

$\gamma(^{40}$Ar) (continued)

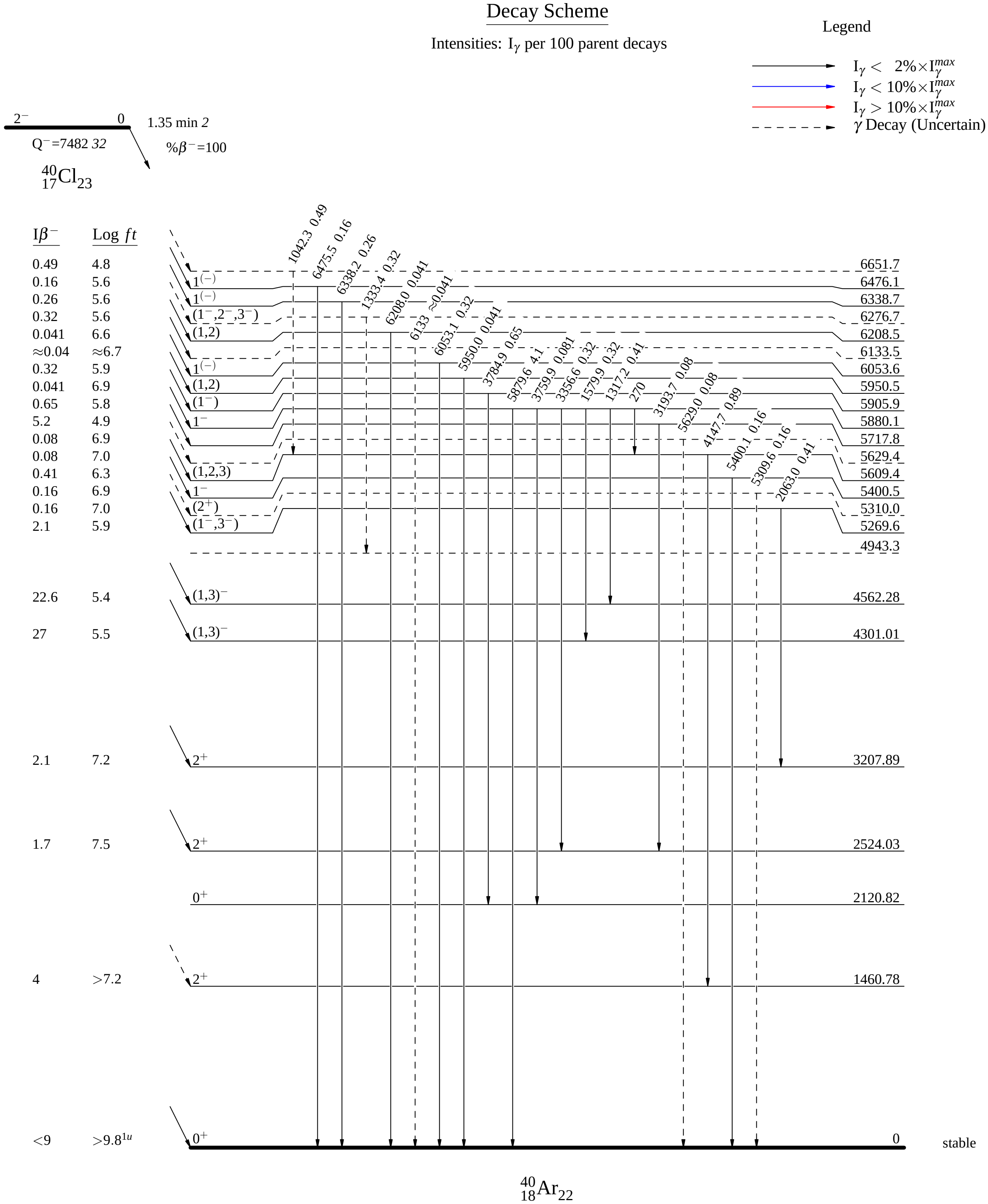
E_γ[†]	I_γ[†b]	E_i(level)	J^π_i	E_f	J^π_f
6133[‡e]	≈0.05[#]	6133.5?		0	0^+
6208.0 *8*	0.05 *3*	6208.5	(1,2)	0	0^+
6338.2[§] *11*	0.32[§] *9*	6338.7	$1^{(-)}$	0	0^+
6475.5 *8*	0.20 *3*	6476.1	$1^{(-)}$	0	0^+

† From 1972Kl06, unless otherwise noted.
‡ From 1981HuZT only, intensity is not available.
§ Weighted average from 1972Kl06 and 1970Ke12.
& Placement questioned by 1983Bi08 based on their (α,pγ) study.
@ From 1972Kl06, obtained in indirect method. Other: 5 *3* in 1970Ke12.
\# From β feeding quoted by 1981HuZT.
a If no value given it was assumed δ=1.00 for E2/M1, δ=1.00 for E3/M2 and δ=0.10 for the other multipolarities.
b For absolute intensity per 100 decays, multiply by 0.81 *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 Multiply placed with undivided intensity.
e Placement of transition in the level scheme is uncertain.

^{40}Cl β^- decay (1.35 min) 1972Kl06,1970Ke12

Decay Scheme

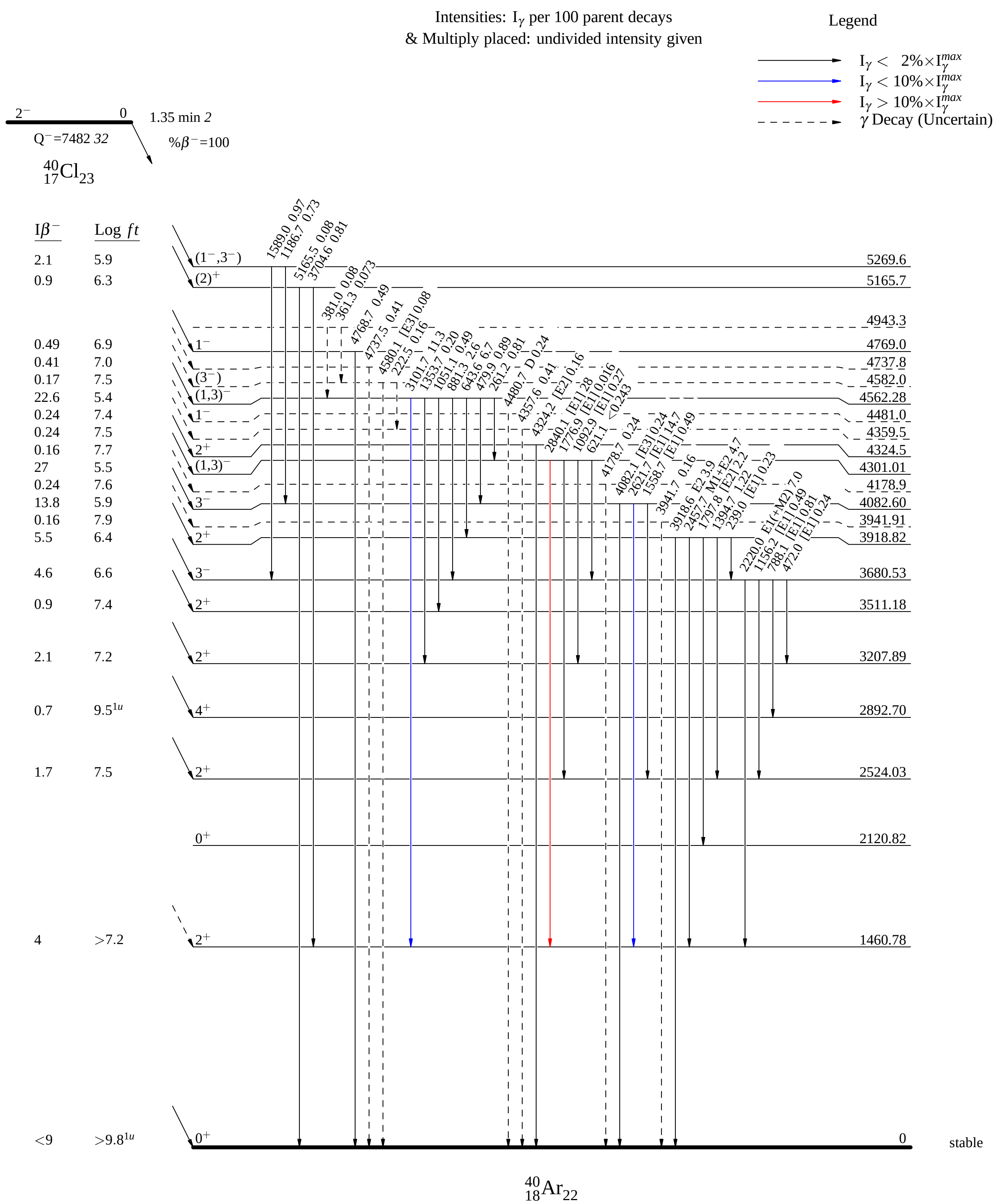
Intensities: I_γ per 100 parent decays



$^{40}Cl\ \beta^-$ decay (1.35 min) 1972Kl06,1970Ke12

Decay Scheme (continued)

Intensities: I_γ per 100 parent decays
& Multiply placed: undivided intensity given



^{40}Cl β^- decay (1.35 min) 1972Kl06,1970Ke12

Decay Scheme (continued)

Intensities: I_γ per 100 parent decays
& Multiply placed: undivided intensity given