^{31}Cl $\varepsilon+\beta^+$ decay (190 ms) 2018Be12,2011SaZM,2006Ka11

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen and Balraj Singh	NDS 184,29 (2022)	24-Jun-2022

Parent: ^{31}Cl: E=0; J$^\pi$=3/2$^+$; T$_{1/2}$=190 ms *1*; Q(ε)=12008 *3*; %ε+%β^+ decay=100

^{31}Cl-J$^\pi$,T$_{1/2}$: From ^{31}Cl Adopted Levels.

^{31}Cl-Q(ε): From 2021Wa16.

^{31}Cl-%ε+%β^+ decay: %εp=2.4 *2* for ^{31}Cl decay (2011SaZM). Other: 0.65% *5* (2006Ka11).

2018Be12, 2016Be05, 2016Be19: ^{31}Cl ions were produced in ^{9}Be(^{36}Ar,X), E(^{36}Ar)=150 MeV/nucleon reaction at the Coupled Cyclotron Facility of NSCL-MSU. The ions of interest were separated based on Bρ and tof techniques using A1900 Fragment Separator for Bρ and Radio Frequency Fragment Separator (RFFS) for tof. Contaminants in the ^{31}Cl beam were ≈2% ^{24}Na, ≈1.5% ^{29}P, small amount of stable ^{28}Si and other light-ion beams. The beam was implanted in a 25-mm thick plastic scintillator, which also acted as a β detector. The γ rays were detected in coincidence with β rays using Yale Clovershare array comprised of nine HPGe Clover detectors. Measured Eγ, Iγ, $\beta\gamma$-coin, $\beta\gamma\gamma$-coin. Deduced levels, resonances, β feedings, isospin mixing, ratio of thermonuclear reaction rates for ^{30}P(p,γ)^{31}S reaction at T$_9$=0.1-0.4 for the newly discovered state at 6390 keV and the IAS at 6280 keV.

2022Bu14: ^{31}Cl ions were produced by fragmentation of a 150 MeV/nucleon ^{36}Ar beam on a 1645 mg/cm^2 Be production target, separated and purified by the A1900 fragment separator and the the Radio Frequency Fragment Separator (RFFS), and transported into the Gaseous Detector with Germanium Tagging (GADGET) system consisting a customized gas-filled proportional counter called Proton detector (Pd) surrounded by the SeGA array of 16 HPGe crystals. Measured E(p) and I(p) of β-delayed protons, pγ-coin. Deduced proton resonance energy, proton-decay branching ratio, resonance of the 6390 level. Discussed impact on the ^{31}P(p,γ)^{31}S astrophysical reaction rate.

2011SaZM: ^{31}Cl produced in ^{32}S(p,2n) E=40 MeV/nucleon reaction and separated using MARS recoil spectrometer at Texas A&M University accelerator facility. Measured Eγ, Iγ, $\gamma\gamma$, Ep, Ip; deduced decay scheme, IAS in ^{31}S and mass excess of ^{31}Cl. See also articles by Trache et al. in POS (NIC X), 163 (2009); 2012Tr08 and 2011SaZN.

Additional information 1.

2006Ka11 (also 2005Ka46): E=40,45 MeV protons on ZnS target producing ^{31}Cl through fusion evaporation reaction ^{32}S(p,2n) at IGISOL. Measured Eγ, Iγ, E(p), I(p), $\beta\gamma$ coin, proton spectra. Positrons detected with ISOLDE Silicon Ball array of 36 Si detectors, γ-rays were detected by an HPGe detector, protons by DSSSDs.

1985Ay02 (also 1983Ay02, 1982Ay01): E=28-50 MeV protons from LBL cyclotron on ZnS target. Measured delayed protons, deduced log *ft* values. Total of eight observed proton branches reported.

1996Og01: reported two levels, and two proton branches.

^{31}S Levels

Following levels, proposed by 2011SaZM through only a ground-state transition from each, are not confirmed by 2018Be12, and are omitted in the present decay scheme: 5408, 5786, 6421, 7280, 7417, 7632, and 7644; most of these were tentative in 2011SaZM.

E(level)†	J$^\pi$#	T$_{1/2}$#	Comments
0.0	1/2$^+$	2.5534 s *18*	
1248.45 *11*	3/2$^+$	0.50 ps *12*	
2234.06 *12*	5/2$^+$	222 fs *55*	
3076.44 *15*	1/2$^+$		
3283.76 *13*	5/2$^+$		
3349.40 *20*	7/2$^+$		E(level): level proposed by 2018Be12.
3434.78 *19*	3/2$^+$		
4086.21 *19*	5/2$^+$		E(level): level proposed by 2018Be12.
4207.69 *16*	(3/2)$^+$		J$^\pi$: 3/2$^+$ in 2018Be12.
4519.71 *25*	3/2$^+$		
4717.79 *14*	(5/2)$^+$		J$^\pi$: 5/2$^+$ in 2018Be12.
4866.03 *23*	(1/2)$^+$		J$^\pi$: 1/2$^+$ in 2018Be12.
4970.6 *9*	(3/2)$^-$		E(level): level proposed by 2018Be12. J$^\pi$: 3/2$^-$ in 2018Be12.

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^{31}Cl ε+β^+ decay (190 ms) 2018Be12,2011SaZM,2006Ka11 (continued)

^{31}S Levels (continued)

E(level)[†]	J^{π}[#]	Comments
5022.07 *24*	5/2$^+$	E(level): level proposed by 2018Be12.
5156.1 *4*	1/2$^+$	
5436.0 *8*	(3/2$^+$)	E(level): level proposed by 2018Be12. J^{π}: 3/2$^+$ in 2018Be12.
5775.4 *3*	(5/2)$^+$	J^{π}: 5/2$^+$ in 2018Be12.
5890.1 *3*	(3/2)$^+$	E(level): level proposed by 2018Be12. J^{π}: 3/2$^+$ in 2018Be12.
6129.1 *6*	(5/2$^+$)	E(level): level proposed by 2018Be12. J^{π}: 5/2$^+$ in 2018Be12.
6254.8 *3*	1/2$^+$	T=1/2
6278.89 *14*	3/2$^+$	T=3/2 E(level),J^{π}: IAS of ^{31}Cl g.s. 2011SaZM give E(level)=6280.2 *3*.
6390.23 *17*	3/2$^+$	%p=0.025 *+4−3* (2022Bu14) E(level),J^{π}: new level proposed by 2016Be05, unambiguous J^{π} assignment made from identification of this level as isospin mixed with the IAR at 6279.0, 3/2$^+$. E(p)(resonance)=260.3 keV *8*; L=0 resonance in proton capture on ^{30}P (g.s. J^{π}=1$^+$), relevant to ^{30}P(p,γ)^{31}S reaction rates of astrophysical significance. Other: 273 *10* (2022Bu14). %p: deduced by 2022Bu14 based on measured β-delayed γ emissions I($\beta\gamma$)=0.0338 *18* from this level by 2018Be12 and β-delayed proton emission I(βp)=8.3×10^{-6} *+12−9* from this level by 2022Bu14.
6936[‡] *2*	1/2$^+$,3/2$^+$,5/2$^+$	E(p)=780 *2* (2011SaZM), 762 *14* (2006Ka11). Relative I(p)=20.4 *2* (2011SaZM), 9.1 *22* (2006Ka11). I(p)/Iγ(2234γ)=0.43 *1* (2011SaZM), 0.10 *3* (2006Ka11).
7037[‡] *2*	(5/2)$^+$	E(level): E(p)=877 *2* (2011SaZM), 853 *18* (2006Ka11). Relative I(p)=12.4 *2* (2011SaZM), 1.2 *12* (2006Ka11). I(p)/Iγ(2234γ)=0.26 *1* (2011SaZM), 0.013 *13* (2006Ka11).
7050.1 *8*	(1/2$^+$,3/2$^+$,5/2$^+$)	E(level): level proposed by 2018Be12. J^{π}: 1/2$^+$ in 2018Be12.
7149.9 *8*	5/2$^+$,3/2$^+$,1/2$^+$	E(level): level proposed by 2018Be12. J^{π}: 5/2$^+$ in 2018Be12.
7157[‡] *2*	3/2$^+$,5/2$^+$	E(p)=993 *2* (2011SaZM), 978 *15* (2006Ka11), also seen in 1996Og01. Relative I(p)=100 *4* (2011SaZM), 100 *4* (2006Ka11). I(p)/Iγ(2234γ)=2.12 *3* (2011SaZM), 1.08 *14* (2006Ka11).
7355[‡] *3*	1/2$^+$,3/2$^+$,5/2$^+$	E(p)=1185 *3* (2011SaZM), 1175 *19* (2006Ka11). Relative I(p)=2.7 *1* (2011SaZM), 1.7 *6* (2006Ka11). I(p)/Iγ(2234γ)=0.057 *3* (2011SaZM), 0.018 *7* (2006Ka11).
7521?[‡] *17*		E(p)=1345 *17* (2011SaZM). Relative I(p)=1.3 *12* (2011SaZM). I(p)/Iγ(2234γ)=0.028 *26* (2011SaZM).
7701[‡] *3*	1/2$^+$,3/2$^+$,5/2$^+$	E(p)=1520 *3* (2011SaZM), 1521 *20* (2006Ka11), also seen in 1996Og01. Relative I(p)=21.0 *4* (2011SaZM), 13.6 *14* (2006Ka11). I(p)/Iγ(2234γ)=0.44 *1* (2011SaZM), 0.15 *3* (2006Ka11).
7778[‡] *17*	(1/2$^+$,3/2$^+$,5/2$^+$)	E(p)=1594 *17* (2011SaZM). Relative I(p)=1.4 *2* (2011SaZM). I(p)/Iγ(2234γ)=0.030 *4* (2011SaZM).
7894[‡] *3*	1/2$^+$,3/2$^+$,5/2$^+$	E(p)=1706 *3* (2011SaZM), 1688 *22* (2006Ka11). Relative I(p)=6.4 *2* (2011SaZM), 3.9 *7* (2006Ka11). I(p)/Iγ(2234γ)=0.136 *5* (2011SaZM), 0.043 *9* (2006Ka11).
8022[‡] *3*	1/2$^+$,3/2$^+$,5/2$^+$	E(p)=1830 *3* (2011SaZM), 1825 *23* (2006Ka11). Relative I(p)=10.9 *2* (2011SaZM), 8.8 *11* (2006Ka11). I(p)/Iγ(2234γ)=0.231 *5* (2011SaZM), 0.096 *16* (2006Ka11).
8122[‡] *17*	1/2$^+$,3/2$^+$,5/2$^+$	E(p)=1927 *17* (2011SaZM). Relative I(p)=1.4 *1* (2011SaZM).

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^{31}Cl ε+β^{+} decay (190 ms) 2018Be12,2011SaZM,2006Ka11 (continued)

^{31}S Levels (continued)

E(level)[†]	J$^{\pi}$[#]	Comments
		I(p)/Iγ(2234γ)=0.031 *2* (2011SaZM).
8270[‡] *17*	1/2^{+},3/2^{+},5/2^{+}	E(p)=2070 *17* (2011SaZM), 2075 *30* (2006Ka11). Relative I(p)=1.3 *1* (2011SaZM), 1.3 *5* (2006Ka11). I(p)/Iγ(2234γ)=0.028 *2* (2011SaZM), 0.014 *5* (2006Ka11).
8429[‡] *3*	1/2^{+},3/2^{+},5/2^{+}	E(p)=2224 *3* (2011SaZM), 2217 *30* (2006Ka11). Relative I(p)=2.3 *1* (2011SaZM), 4.1 *8* (2006Ka11). I(p)/Iγ(2234γ)=0.048 *2* (2011SaZM), 0.044 *10* (2006Ka11).
8499[‡] *17*	1/2^{+}	J$^{\pi}$: assuming this level corresponds to L=0, 8517 *13* level in (p,d). E(p)=2286 *17* (2011SaZM), 2299 *30* (2006Ka11). Relative I(p)=0.9 *7* (2011SaZM), 1.5 *5* (2006Ka11). I(p)/Iγ(2234γ)=0.018 *2* (2011SaZM), 0.016 *6* (2006Ka11).
8702[‡] *17*	1/2^{+},3/2^{+},5/2^{+}	E(p)=2489 *17* (2011SaZM), 2454 *40* (2006Ka11). Relative I(p)=0.91 *6* (2011SaZM), 1.0 *4* (2006Ka11). I(p)/Iγ(2234γ)=0.019 *2* (2011SaZM), 0.010 *4* (2006Ka11).
8860[‡] *17*	(1/2^{+},3/2^{+},5/2^{+})	E(p)=2641 *17* (2011SaZM), 2601 *40* (2006Ka11). Relative I(p)=0.19 *4* (2011SaZM), 0.4 *3* (2006Ka11). I(p)/Iγ(2234γ)=0.004 *1* (2011SaZM), 0.004 *3* (2006Ka11).
9031[‡] *17*	1/2^{+},3/2^{+},5/2^{+}	E(p)=2807 *17* (2011SaZM), 2751 *40* (2006Ka11). Relative I(p)=0.3 *1* (2011SaZM), 0.6 *3* (2006Ka11). I(p)/Iγ(2234γ)=0.006 *2* (2011SaZM), 0.007 *4* (2006Ka11).

[†] From a least-squares fit to Eγ data, unless otherwise stated.
[‡] Excitation energy deduced by the evaluators from center of mass frame proton energies taken from 2011SaZM and S(p)=6130.65 *24* (2021Wa16).
[#] From the Adopted Levels.

ε,β^{+} radiations

Sum of I(ε+β)=90 *4* could indicate the decay scheme is not complete, also considering that the total released energy of 10700 *260* calculated by the RADLIST code is less than Q(β^{-})value=12008 *3* (2021Wa16). The missing 10% *4* may be accounted for by possible unobserved weak proton emissions from unobserved levels within the large gap between the highest observed level at 9031 and Q(β^{-})value=12008 *3*.

E(decay)	E(level)	Iβ^{+} [‡]	Iε[‡]	Log *ft*	I(ε+β^{+})[†‡]	Comments
(2977 *17*)	9031	0.004 *1*	4.×10^{-5} *1*	5.4 *1*	0.004 *1*	av Eβ=848.6 *81*; εK=0.00846 *23*; εL=0.000797 *22*; εM+=9.7×10^{-5} *3*
(3148 *17*)	8860	0.0025 *6*	1.8×10^{-5} *4*	5.74 *11*	0.0025 *6*	av Eβ=928.1 *81*; εK=0.00657 *17*; εL=0.000619 *16*; εM+=7.56×10^{-5} *19*
(3306 *17*)	8702	0.012 *2*	7.0×10^{-5} *12*	5.19 *8*	0.012 *2*	av Eβ=1002.2 *82*; εK=0.00530 *13*; εL=0.000499 *12*; εM+=6.10×10^{-5} *14*
(3509 *17*)	8499	0.011 *2*	5.0×10^{-5} *9*	5.39 *8*	0.011 *2*	av Eβ=1097.9 *82*; εK=0.00410 *9*; εL=0.000386 *9*; εM+=4.72×10^{-5} *10*
(3579 *5*)	8429	0.030 *2*	0.00013 *1*	5.01 *3*	0.030 *2*	av Eβ=1131.0 *20*; εK=0.003778 *19*; εL=0.0003556 *1*; εM+=4.345×10^{-5} *22*
(3738 *17*)	8270	0.017 *2*	5.9×10^{-5} *7*	5.37 *6*	0.017 *2*	av Eβ=1206.4 *82*; εK=0.00315 *6*; εL=0.000297 *6*; εM+=3.63×10^{-5} *7*
(3886 *17*)	8122	0.019 *2*	5.7×10^{-5} *6*	5.43 *5*	0.019 *2*	av Eβ=1276.9 *83*; εK=0.00269 *5*; εL=0.000253 *5*; εM+=3.10×10^{-5} *6*
(3986 *5*)	8022	0.143 *3*	0.000384 *9*	4.62 *1*	0.143 *3*	av Eβ=1324.6 *21*; εK=0.002429 *11*; εL=0.0002287 *1*;

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^{31}Cl ε+β^+ decay (190 ms) 2018Be12,2011SaZM,2006Ka11 (continued)

ϵ,β^+ radiations (continued)

E(decay)	E(level)	Iβ^+ ‡	Iε‡	Log *ft*	I(ε+β^+)†‡	Comments
						εM+=2.794×10^{-5} 12
(4114 5)	7894	0.084 3	0.00020 1	4.93 2	0.084 3	av Eβ=1386.0 21; εK=0.002142 9; εL=0.0002016 9; εM+=2.463×10^{-5} 11
(4230 17)	7778	0.019 3	4.0×10^{-5} 6	5.65 7	0.019 3	av Eβ=1441.6 83; εK=0.00192 4; εL=0.000181 3; εM+=2.21×10^{-5} 4
(4307 5)	7701	0.27 1	0.00053 2	4.54 2	0.27 1	av Eβ=1478.6 21; εK=0.001788 7; εL=0.0001683 7; εM+=2.056×10^{-5} 8
(4487# 17)	7521?	0.02 2	$3.\times10^{-5}$ 3	5.8 5	0.02 2	av Eβ=1565.2 84; εK=0.001526 23; εL=0.0001436 2; εM+=1.75×10^{-5} 3
(4653 5)	7355	0.035 2	5.1×10^{-5} 3	5.62 3	0.035 2	av Eβ=1645.2 21; εK=0.001327 5; εL=0.0001249 5; εM+=1.526×10^{-5} 6
(4851 4)	7157	1.31 2	0.00164 3	4.16 1	1.31 2	av Eβ=1741.0 18; εK=0.001133 4; εL=0.0001067 3; εM+=1.303×10^{-5} 4
(4858.1 33)	7149.9	0.059 7	7.4×10^{-5} 9	5.51 6	0.059 7	av Eβ=1744.4 15; εK=0.001127 3; εL=0.0001061 3; εM+=1.296×10^{-5} 4
(4957.9 33)	7050.1	0.047 5	5.4×10^{-5} 6	5.65 5	0.047 5	av Eβ=1792.7 15; εK=0.0010444 2; εL=9.828×10^{-5} 23; εM+=1.201×10^{-5} 3
(4971 4)	7037	0.16 1	0.00018 1	5.13 3	0.16 1	av Eβ=1799.1 18; εK=0.001034 3; εL=9.73×10^{-5} 3; εM+=1.189×10^{-5} 4
(5072 4)	6936	0.27 1	0.00029 1	4.95 2	0.27 1	av Eβ=1848.1 18; εK=0.000959 3; εL=9.028×10^{-5} 24; εM+=1.103×10^{-5} 3
(5617.8 32)	6390.23	3.40 11	0.00248 8	4.10 2	3.40 11	av Eβ=2113.6 15; εK=0.0006592 1; εL=6.203×10^{-5} 12; εM+=7.579×10^{-6} 15
(5729.1 32)	6278.89	18.7 7	0.0127 5	3.411 17	18.7 7	av Eβ=2167.9 15; εK=0.0006140 1; εL=5.777×10^{-5} 11; εM+=7.059×10^{-6} 14 Iβ^+: other: 24.3% from large-scale sd shell model, 23% from pure single particle estimate for the Gamow-Teller decay probability (2006Ka11).
(5753.2 32)	6254.8	0.57 4		4.94 3	0.57 4	av Eβ=2179.7 15
(5878.9 32)	6129.1	0.0259 24		6.33 4	0.0259 24	av Eβ=2241.1 15
(6117.9 32)	5890.1	0.269 16		5.41 3	0.269 16	av Eβ=2358.3 19
(6232.6 32)	5775.4	0.254 21		5.48 4	0.254 21	av Eβ=2414.5 15
(6572.0 33)	5436.0	0.023 7		6.7 2	0.023 7	av Eβ=2580.9 16
(6851.9 32)	5156.1	0.93 8		5.15 4	0.93 8	av Eβ=2718.4 15
(6985.9 32)	5022.07	0.273 14		5.72 2	0.273 14	av Eβ=2784.3 15
(7037.4# 33)	4970.6	0.037 7		6.6 1	0.037 7	av Eβ=2809.6 16
(7142.0 32)	4866.03	1.64 7		5.00 2	1.64 7	av Eβ=2860.7 15
(7290.2 32)	4717.79	1.55 6		5.07 2	1.55 6	av Eβ=2933.6 15
(7488.3 32)	4519.71	1.13 7		5.27 3	1.13 7	av Eβ=3031.2 15
(7800.3 32)	4207.69	4.10 21		4.81 2	4.10 21	av Eβ=3185.1 15
(7921.8 32)	4086.21	0.74 4		5.59 3	0.74 4	av Eβ=3245.0 15
(8573.2 32)	3434.78	0.64 4		5.84 3	0.64 4	av Eβ=3566.8 15
(8724.2 32)	3283.76	4.46 25		5.03 3	4.46 25	av Eβ=3641.5 15 I(ε+β^+): 4.64 32 (2018Be12).
(8931.6 32)	3076.44	2.54 14		5.33 3	2.54 14	av Eβ=3744.1 15 I(ε+β^+): 2.58 18 (2018Be12).
(9773.9 32)	2234.06	38 3	0.0041 3	4.37 4	38 3	av Eβ=4161.5 15; εK=9.763×10^{-5} 10; εL=9.183×10^{-6} 10; εM+=1.1220×10^{-6} 1 I(ε+β^+): 47 4 (2018Be12).
(10759.6 32)	1248.45	1.1 6		6.1 3	1.1 6	av Eβ=4650.5 15 I(ε+β^+): 2.5 6 (2018Be12).
(12008.0 33)	0.0	≈7		≈5.6	≈7	av Eβ=5270.9 15 I(ε+β^+): 7 2 estimated by 2006Ka11 based on

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^{31}Cl $\varepsilon+\beta^+$ decay (190 ms) 2018Be12,2011SaZM,2006Ka11 (continued)

ϵ,β^+ radiations (continued)

E(decay)	E(level)	Comments
		similar log *ft* value of 5.53 for $3/2^+$ parent to $1/2^+$ g.s. β transition in the decay of ^{31}Si mirror nucleus to ^{31}P.

† From γ-intensity balances considering corrections for internal conversion are negligible. Above 6.9 MeV excitation, values are deduced from proton intensities in 2011SaZM.
‡ Absolute intensity per 100 decays.
# Existence of this branch is questionable.

γ(^{31}S)

Iγ normalization: 2018Be12 give intensities per 100 decays of the parent.

Eγ[†]	Iγ[†b]	E$_i$(level)	J$^{\pi}_i$	E$_f$	J$^{\pi}_f$	Mult.[a]	δ[a]	α[c]	Comments
[x]846.0[&] *3*	1.7[&] *1*								
985.62 *23*	0.187 *9*	2234.06	5/2$^+$	1248.45	3/2$^+$				Eγ=985.5 *3*, Iγ=0.3 *1* (2011SaZM).
1049.66 *21*	1.40 *5*	3283.76	5/2$^+$	2234.06	5/2$^+$	(M1+E2)			Eγ=1049.0 *3*, Iγ=2.1 *1* (2011SaZM).
1248.40 *20*	12.3 *5*	1248.45	3/2$^+$	0.0	1/2$^+$	M1+E2	+0.35 *2*	3.58×10^{-5} *5*	α(K)=2.123×10^{-5} *30*; α(L)=1.637×10^{-6} *23*; α(M)=1.381×10^{-7} *20* α(IPF)=1.276×10^{-5} *19* Eγ=1247.6 *3*, Iγ=24.0 *3* (2011SaZM). Eγ=1249.1 *14*, Iγ=32 *7* (2006Ka11).
1283.32[‡] *37*	0.043 *7*	4717.79	(5/2)$^+$	3434.78	3/2$^+$				
1368.34[‡] *29*	≤0.018	4717.79	(5/2)$^+$	3349.40	7/2$^+$				
1412.91[‡] *30*	0.082 *7*	6278.89	3/2$^+$	4866.03	(1/2)$^+$				
1433.89[‡] *22*	0.399 *22*	4717.79	(5/2)$^+$	3283.76	5/2$^+$				
1561.01[‡] *29*	0.104 *8*	6278.89	3/2$^+$	4717.79	(5/2)$^+$				
1672.53[‡] *29*	0.114 *9*	5022.07	5/2$^+$	3349.40	7/2$^+$	(M1)		0.0001332 *19*	α(K)=1.234×10^{-5} *17*; α(L)=9.51×10^{-7} *13*; α(M)=8.03×10^{-8} *11* α(IPF)=0.0001198 *17*
1738.52[‡] *36*	0.063 *7*	5022.07	5/2$^+$	3283.76	5/2$^+$				
1759.05[‡] *34*	0.072 *8*	6278.89	3/2$^+$	4519.71	3/2$^+$				
1827.93[‡] *25*	0.205 *14*	3076.44	1/2$^+$	1248.45	3/2$^+$				
1852.19[‡] *25*	0.211 *14*	4086.21	5/2$^+$	2234.06	5/2$^+$				
2035.24 *20*	4.38 *22*	3283.76	5/2$^+$	1248.45	3/2$^+$	(M1+E2)		0.00031 *4*	α(K)=9.4×10^{-6} *5*; α(L)=7.2×10^{-7} *4*; α(M)=6.10×10^{-8} *32* α(IPF)=0.00030 *4* Eγ=2035.2 *2*, Iγ=7.2 *3* (2011SaZM).
2071.11[‡] *22*	0.577 *32*	6278.89	3/2$^+$	4207.69	(3/2)$^+$				
2100.79[‡] *25*	0.076 *14*	3349.40	7/2$^+$	1248.45	3/2$^+$	(E2)		0.000374 *5*	α(K)=9.30×10^{-6} *13*; α(L)=7.17×10^{-7} *10*; α(M)=6.05×10^{-8} *8* α(IPF)=0.000364 *5*
2182.52[‡] *25*	0.210 *16*	6390.23	3/2$^+$	4207.69	(3/2)$^+$				
2186.33 *33*	0.348 *21*	3434.78	3/2$^+$	1248.45	3/2$^+$				Eγ=2186.6 *3*, Iγ=0.5 *1* (2011SaZM).
2192.63[‡] *28*	0.110 *9*	6278.89	3/2$^+$	4086.21	5/2$^+$				
2233.97 *20*	53.2 *27*	2234.06	5/2$^+$	0.0	1/2$^+$	E2		0.000438 *6*	α(K)=8.34×10^{-6} *12*; α(L)=6.43×10^{-7} *9*;

γ(^{31}S) (continued)

E_γ [†]	I_γ [†b]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [a]	δ [a]	α [c]	Comments
									α(M)=5.42×10^{-8} *8* α(IPF)=0.000429 *6* Eγ=2234.2 *2*, Iγ=100 *1* (2011SaZM). Eγ=2234.5 *8*, Iγ=100 *12* (2006Ka11). γ also seen in 1998Ax02.
2483.60[‡] *22*	0.472 *26*	4717.79	(5/2)$^+$	2234.06	5/2$^+$				
2605.9[‡] *5*	0.029 *5*	5890.1	(3/2)$^+$	3283.76	5/2$^+$				
2779.5[‡] *6*	0.0253 *18*	6129.1	(5/2$^+$)	3349.40	7/2$^+$				
2787.7[‡] *8*	0.0173 *39*	5022.07	5/2$^+$	2234.06	5/2$^+$				
2837.60[‡] *32*	0.614 *34*	4086.21	5/2$^+$	1248.45	3/2$^+$	(M1)		0.000602 *8*	α(K)=5.29×10^{-6} *7*; α(L)=4.07×10^{-7} *6*; α(M)=3.44×10^{-8} *5* α(IPF)=0.000597 *8*
2843.9[‡] *4*	0.084 *7*	6278.89	3/2$^+$	3434.78	3/2$^+$				
2959.09 *31*	1.77 *9*	4207.69	(3/2)$^+$	1248.45	3/2$^+$	(M1)		0.000651 *9*	α(K)=4.97×10^{-6} *7*; α(L)=3.82×10^{-7} *5*; α(M)=3.23×10^{-8} *5* α(IPF)=0.000646 *9* Eγ=2960.1 *2*, Iγ=2.6 *2* (2011SaZM).
2970.9[‡] *4*	0.058 *6*	6254.8	1/2$^+$	3283.76	5/2$^+$				
2995.04 *31*	1.15 *6*	6278.89	3/2$^+$	3283.76	5/2$^+$				Eγ=2995.6 *3*, Iγ=1.9 *1* (2011SaZM).
3076.24 *20*	2.82 *14*	3076.44	1/2$^+$	0.0	1/2$^+$				Eγ=3077.1 *2*, Iγ=3.5 *2* (2011SaZM).
3106.28[‡] *31*	0.734 *39*	6390.23	3/2$^+$	3283.76	5/2$^+$				
3202.2[‡] *4*	0.081 *7*	6278.89	3/2$^+$	3076.44	1/2$^+$				
3283.57 *31*	1.11 *6*	3283.76	5/2$^+$	0.0	1/2$^+$	(E2)		0.000908 *13*	α(K)=4.45×10^{-6} *6*; α(L)=3.43×10^{-7} *5*; α(M)=2.89×10^{-8} *4* α(IPF)=0.000903 *13* Eγ=3284.6 *3*, Iγ=1.7 *2* (2011SaZM).
3313.56[‡] *33*	0.401 *22*	6390.23	3/2$^+$	3076.44	1/2$^+$				
3434.70 *32*	0.420 *24*	3434.78	3/2$^+$	0.0	1/2$^+$	(M1+E2)	−0.6 *2*	0.000870 *21*	α(K)=4.03×10^{-6} *6*; α(L)=3.10×10^{-7} *5*; α(M)=2.62×10^{-8} *4* α(IPF)=0.000866 *21* Eγ=3436.1 *7*, Iγ=0.8 *1* (2011SaZM).
3469.13[‡] *31*	0.113 *8*	4717.79	(5/2)$^+$	1248.45	3/2$^+$				
3541.10 *27*	0.254 *21*	5775.4	(5/2)$^+$	2234.06	5/2$^+$				Eγ=3540 *3*, Iγ≈2.9 (2011SaZM). E$_\gamma$: 2006Ka11 give 3536 *2* with Iγ=26 *8* and tentative placement. In 2011SaZM, a γ peak at 3534.7 *2* with Iγ=5.7 *2* matches closely with the first escape peak of 4046.2 *2* γ line. Gate on 2234γ shows a 3540 *3* peak in 2011SaZM which gives a level at 5774 *3*. In an e-mail reply of Oct 31, 2012 from A. Saastamoinen, spectral figure with TAC gate shows 3535 and 3540 resolved with about equal intensities. I$_\gamma$: approximately half the total intensity of 5.7 in 2011SaZM assigned based on spectral figure mentioned above. Intensity

γ(^{31}S) (continued)

Eγ[†]	Iγ[†b]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[a]	α[c]	Comments
								of 26 *8* in 2006Ka11 probably has a dominant component of single escape of 4046 γ line.
3617.40[‡] *31*	1.01 *6*	4866.03	$(1/2)^+$	1248.45	$3/2^+$			
3656.01[‡] *37*	0.170 *12*	5890.1	$(3/2)^+$	2234.06	$5/2^+$			
3773.2[‡] *5*	0.078 *7*	5022.07	$5/2^+$	1248.45	$3/2^+$			
3907.3[‡] *4*	0.091 *8*	5156.1	$1/2^+$	1248.45	$3/2^+$			
4020.2[‡] *5*	0.055 *6*	6254.8	$1/2^+$	2234.06	$5/2^+$			
4044.7 *30*	11.3 *6*	6278.89	$3/2^+$	2234.06	$5/2^+$			Eγ=4046.2 *2*, Iγ=16.0 *4* (2011SaZM). Eγ=4045 *2*, Iγ=14 *6* (2006Ka11).
4085.2[‡] *8*	0.019 *8*	4086.21	$5/2^+$	0.0	$1/2^+$	[E2]	1.20×10^{-3} *2*	α(K)=3.22×10^{-6} *5*; α(L)=2.475×10^{-7} *35*; α(M)=2.088×10^{-8} *29* α(IPF)=0.001199 *17*
4155.84[‡] *31*	1.51 *9*	6390.23	$3/2^+$	2234.06	$5/2^+$			
4187.4[‡] *15*	0.0034 *7*	5436.0	$(3/2^+)$	1248.45	$3/2^+$			
4207.43 *31*	3.12 *18*	4207.69	$(3/2)^+$	0.0	$1/2^+$			Eγ=4208.9 *3*, Iγ=4.2 *2* (2011SaZM).
4519.28 *32*	1.20 *7*	4519.71	$3/2^+$	0.0	$1/2^+$			Eγ=4520.1 *3*, Iγ=1.3 *1* (2011SaZM).
4717.34 *32*	0.618 *37*	4717.79	$(5/2)^+$	0.0	$1/2^+$			Eγ=4719.8 *4*, Iγ=0.9 *1* (2011SaZM).
4865.8 *6*	0.71 *4*	4866.03	$(1/2)^+$	0.0	$1/2^+$			Eγ=4867.1 *4*, Iγ=1 *1* (2011SaZM).
4970.2[‡] *9*	0.037 *7*	4970.6	$(3/2)^-$	0.0	$1/2^+$			
5030.1 *6*	1.94 *18*	6278.89	$3/2^+$	1248.45	$3/2^+$			Eγ=5031.5 *3*, Iγ=2.4 *2* (2011SaZM).
5141.3[‡] *6*	0.368 *36*	6390.23	$3/2^+$	1248.45	$3/2^+$			
5155.7 *6*	0.84 *8*	5156.1	$1/2^+$	0.0	$1/2^+$			Eγ=5157.0 *3*, Iγ=1.2 *1* (from Table 5.8 in 2011SaZM); 5157 *4* in author's table 5.10 seems a misprint.
[x]5407.7[#] *9*	0.01[#] *1*							
5435.4[‡] *9*	0.020 *7*	5436.0	$(3/2^+)$	0.0	$1/2^+$			
[x]5785.6[@] *8*	0.3[@] *1*							
5889.7[‡] *8*	0.070 *9*	5890.1	$(3/2)^+$	0.0	$1/2^+$			
5900.8[‡] *8*	0.059 *7*	7149.9	$5/2^+,3/2^+,1/2^+$	1248.45	$3/2^+$			
6128.7[‡] *10*	≤0.0012	6129.1	$(5/2^+)$	0.0	$1/2^+$			
6254.3 *6*	0.46 *4*	6254.8	$1/2^+$	0.0	$1/2^+$			Eγ=6254.6 *5*, Iγ=0.7 *1* (2011SaZM).
6278.4 *6*	3.15 *30*	6278.89	$3/2^+$	0.0	$1/2^+$			Eγ=6279.5 *3*, Iγ=3.2 *2* (2011SaZM).
6389.5 *7*	0.181 *18*	6390.23	$3/2^+$	0.0	$1/2^+$			Eγ=6389.7 *11*, Eγ=0.24 *7* (2011SaZM). Iγ: according to e-mail reply of Oct 31, 2012 from the author of 2011SaZM, part of the intensity was from double escape of 7415.8γ.
[x]6420.0[#] *6*	0.15[#] *9*							
7049.2[‡] *8*	0.047 *5*	7050.1	$(1/2^+,3/2^+,5/2^+)$	0.0	$1/2^+$			

$^{31}_{16}S_{15}$-8

γ(^{31}S) (continued)

E_γ[†]	I_γ[†b]	E_i(level)
[x]7279.1[#] *10*	0.24[#] *7*	
[x]7415.8[#] *10*	0.15[#] *6*	
[x]7630.8[@] *7*	0.15[@] *5*	
[x]7643.5[@] *8*	0.09[@] *5*	

[†] From 2018Be12, unless otherwise stated. Intensities from 2011SaZM listed under comments are on a different scale than in 2018Be12. Values in 2011SaZM can be multiplied by a factor of 0.53 to compare these with values from 2018Be12.

[‡] New γ ray reported by 2018Be12.

[#] Tentative γ from 2011SaZM placed as a ground-state transition; not confirmed by 2018Be12.

[@] From 2011SaZM placed as a ground-state transition; not confirmed by 2018Be12.

[&] From 2011SaZM, and placed from 3076 level, where the fitting was poor. This γ is not confirmed by 2018Be12; authors fitted energy region and gave $I\gamma \leq 0.018$ *4* at 90% confidence level.

[a] From Adopted Gammas.

[b] Absolute intensity per 100 decays.

[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.

[x] γ ray not placed in level scheme.

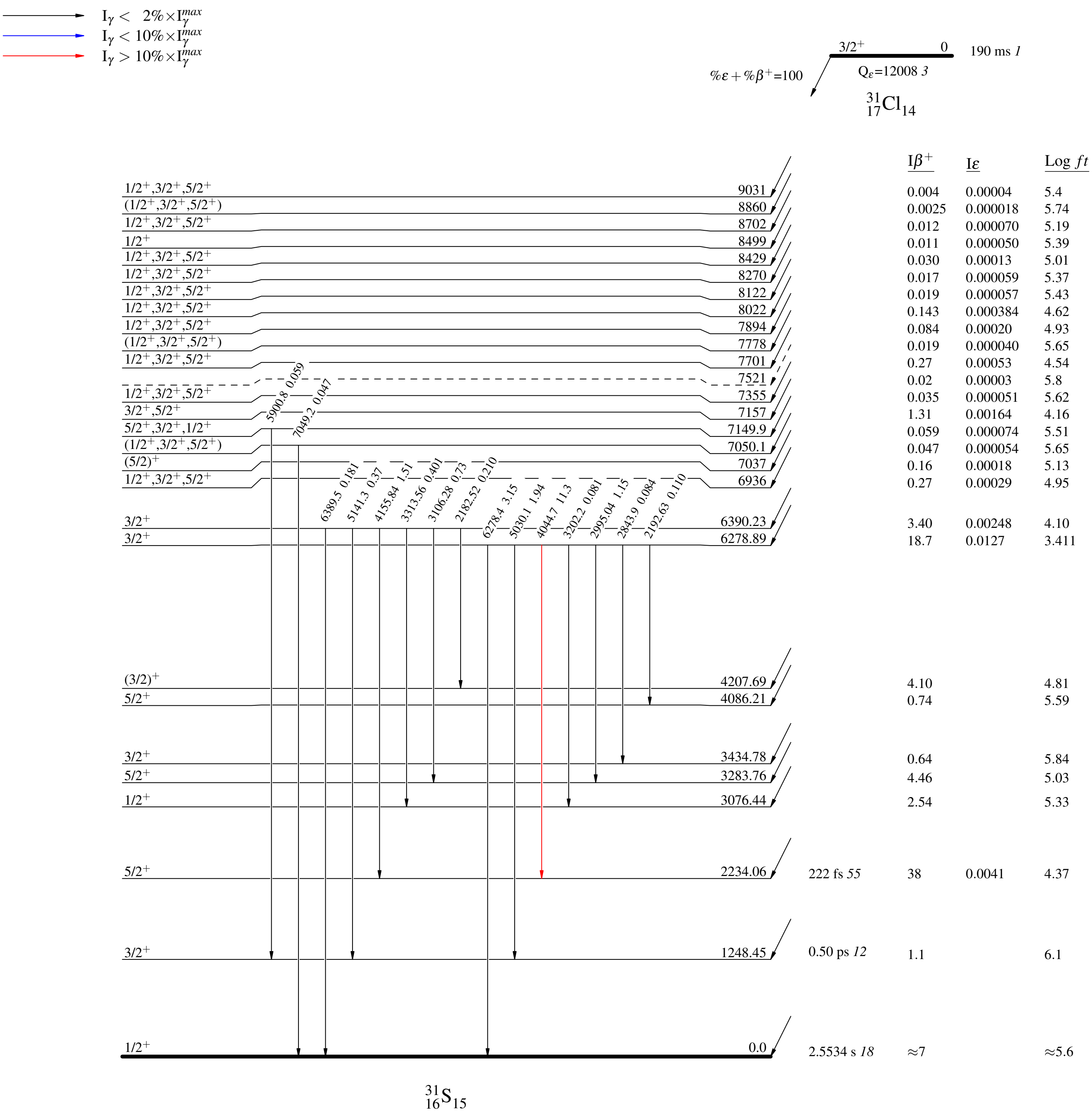
$^{31}_{16}$S$_{15}$-9

^{31}Cl ε decay (190 ms) 2018Be12,2011SaZM,2006Ka11

Decay Scheme

Legend

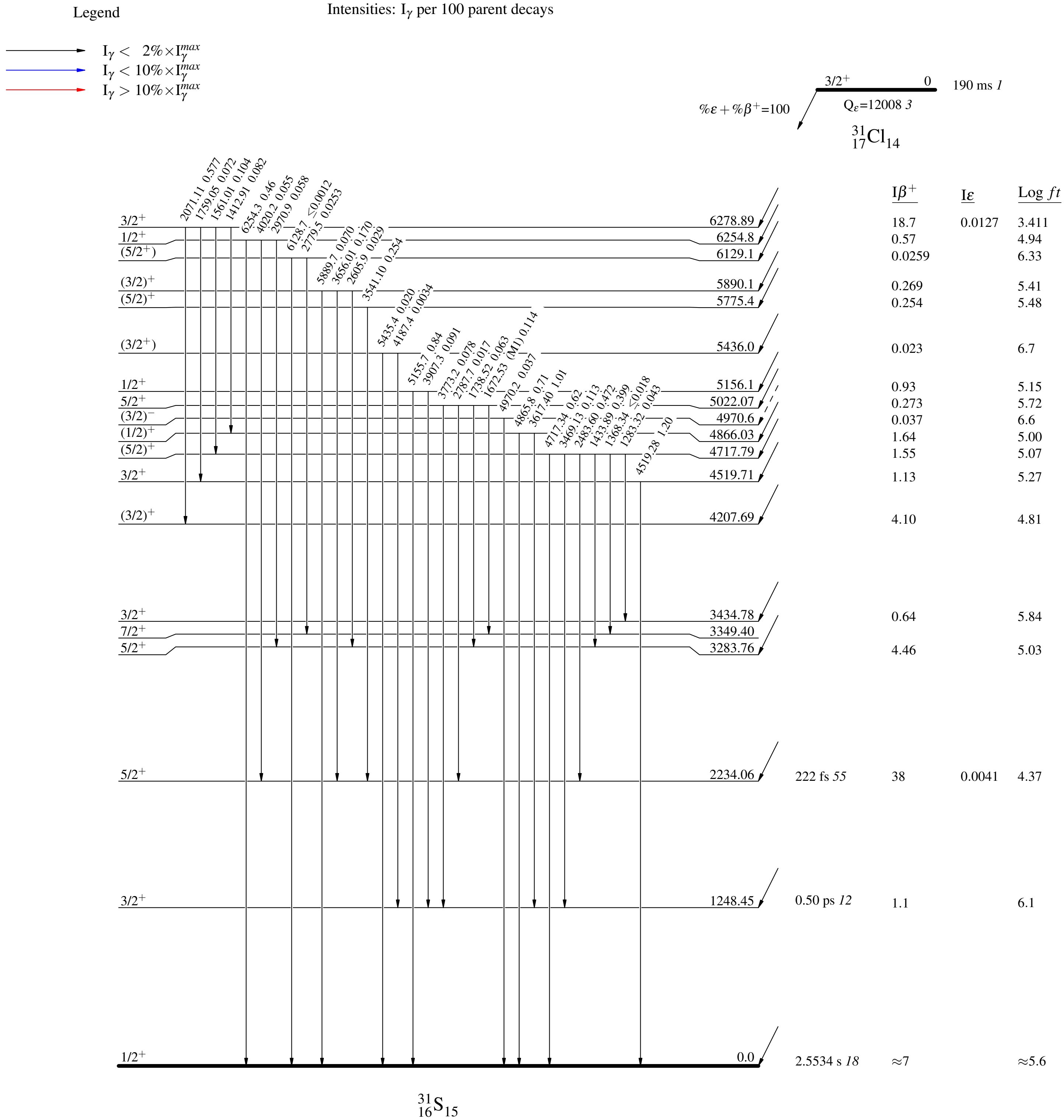
Intensities: I_γ per 100 parent decays



^{31}Cl ε decay (190 ms) 2018Be12,2011SaZM,2006Ka11

Decay Scheme (continued)

Intensities: I_γ per 100 parent decays



^{31}Cl ε decay (190 ms) 2018Be12,2011SaZM,2006Ka11

Decay Scheme (continued)

Intensities: I_γ per 100 parent decays

Legend