^{32}S(p,γ):res 1976Al01,1972Es02

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen and Balraj Singh	NDS 199,1 (2025)	30-Sep-2024

S(p)(^{33}Cl)=2276.8 *4* (2021Wa16).

1976Al01: E=0.4-2.6 MeV proton beams were produced from the 4 MV Van de Graaff accelerator at CENBG. Targets were 15-120 μg/cm^2 Ag_2S (99.86% ^{32}S). γ rays were detected with a 12.7 by 12.7 cm NaI(Tl), a 60 cm^3 Ge(Li) and a 80 cm^3 Ge(Li). Measured σ(E$_p$), Eγ, Iγ, $\gamma(\theta)$, $\gamma\gamma(\theta)$, Doppler-shift attenuation. Deduced levels, J, π, T$_{1/2}$, resonance strengths, γ-ray branching ratios, multipolarities, mixing ratios and transition strengths. Comparisons with available data and theoretical calculations. See also 1974Al04 for E$_p$=580 and 588 resonances.

1972Es02: E=3.36-5.41 MeV proton beams were produced from the 5.5 MeV Van de Graaff accelerator at Trombay. Target was about 300 μg/cm^2 thick water-cooled natural Sb_2S_3(95% ^{32}S) on a thick gold backing. β particles from decay of ^{33}Cl were detected with a 10-cm-diam 2.5-cm-thick plastic scintillator as a β detector and γ rays from resonances were detected a 30-cm^3 Ge(Li) detector. Measured relative yield of ^{33}Cl activity, Eγ. Deduced resonance levels, strengths, widths, γ-ray branching ratios, transition strengths.

2006Tr10: E≈1.75 and 3.4 MeV proton beams were produced from the University of Washington FN tandem accelerator. Targets were 2 mg/cm^2 Ag_2S and 0.13 mg/cm^2 Ag_2S prepared by heating sulphur on Ag backings. γ rays were detected with a 50% efficient high-purity Ge detector. Measured Eγ, Iγ, σ(E$_p$). Deduced levels, γ-ray branching ratios for the transitions from the 3971 and 5548.5 keV levels.

Others:

1958Va22, 1959Su55: E=300-830 keV proton beams at Utrecht. Proton energies determined by measuring the magnetic field of the analyzing magnet with a magnetic resonance fluxmeter. Target was a 10 μg/cm^2 ZnS with natural sulphur. Measured Eγ, Iγ, σ(E$_p$), $\gamma(\theta)$, γ(lin pol). Deduced levels, J, π, resonance strengths, mixing ratio for transitions from 2856 and 2864 levels.

1961Hi12: up to 5.7-MeV proton beams were produced from Osaka University 44-inch cyclotron. Target was natural sulphur. γ rays were detected with NaI(Tl) scintillators. Measured σ(E$_p$). Deduced levels of 6901, 7220, 7463 and 7706 keV. This experiment is mainly about gamma transitions from ^{32}S and ^{34}S.

1966En04: E=0.3-2.1 MeV protons were produced from the Utrecht 850 keV Cockcroft-Walton generator and the 3 MeV Van de Graaff accelerator. Various targets with Z=10-20 prepared by evaporation in vacuo onto 0.3 mm tantalum backings and used for the measurements of resonance strengths. γ rays were detected with a cylindrical 10 cm by 10 cm NaI(Tl) scintillator. Measured Eγ, yields. Deduced level energy and resonance strength for the 2864 keV level.

1968Li07: E=1.75-2.3 MeV proton beams were produced from the Van de Graaff accelerator of the University of Oslo. Targets were made by evaporating Sb_2S_3 of natural isotopic composition onto backings of silver. γ rays were detected with two 10.2 by 10.2 cm NaI(Tl) scintillation crystals. Measured γ yields, Eγ, Iγ $\gamma(\theta)$, $\gamma\gamma(\theta)$. Deduced levels, resonance strengths, J, π, mixing ratios, Γ_γ transition rates for three levels of 3977.8, 4111.7 and 4437.9 keV.

1972Bi19: E=1.7-1.9 MeV proton beams were produced from the 5.5-MV accelerator of the Laboratori Nazionali di Legnaro. Target was thick silver sulphide on silver backing, 99% enriched in ^{32}S. γ rays were detected with a 40 cm^3 Ge(Li) counter. Measured Eγ, Doppler-shift attenuation. Deduced lifetimes, γ rays transition strengths.

1974Ab06: E≈3370 keV proton beam was produced from the 5.5-MV Van de Graaff accelerator of the Laboratori Nazionali di Legnaro. Target was 50 μg/cm^2 natural Sb_2S_3 (95% ^{32}S) on thick Au backing. γ rays were detected with a Ge(Li) detector (FWHM=4.8 keV at 1772 keV). Measured Eγ, γ-ray yield. Deduced widths for the transitions from the level of 5544 keV.

1975Ke11: E≈588 keV proton beam was produced from the 2.5-MV Van de Graaff accelerator at the Helsinki University. Target was a 150 μg/cm^2 ZnS on a tantalum backing. γ rays were detected with a 120 cm^3 Ge(Li) (FWHM=2.9 keV at 2.8 MeV). Measured γ yield. Deduced level energy and resonance strength for level of 2847 keV. Also strengths of analogue resonances for other sulphur isotopes.

1975VaYG: E=1.8-1.9 MeV proton beams were produced from the Groningen 5 MV Van de Graaff generator. Target was PbS (natural isotopic abundance), thickness of about 250 μg/cm^2, evaporated onto a tantalum backing. γ rays were detected with a 10.2-cm by 10.2-cm NaI(Tl) and a 120 c.c. Ge(Li) detectors for detecting γ-rays. Measured Eγ, Iγ, $\gamma(\theta)$. Deduced J, resonance strength for the level of 4113 keV.

1992Il01: E=0.4-2.0 MeV proton beams were produced from the 3 MV Pelletron tandem accelerator at the Kellogg Radiation Laboratory of the California Institute of Technology (FWHM=2 keV at 992 keV). Target was prepared by implanting ^{32}S ions into a 0.5 mm thick Ta backing. γ rays were detected with a 35% Ge detector (FWHM=2 keV at 1.3 MeV). Measured γ yield, Eγ, $\gamma(\theta)$. Deduced levels, resonance strengths, spectroscopic factors, branching ratios. Calculated astrophysical reaction rates.

1970PrZW: measured Eγ, Iγ, $\gamma(\theta)$ at University of Kansas. Deduced levels, J for levels at 1985, 4439, 4465, 4746 and 4834. See also 1971AlZN (thesis by L.A. Alexander, one of the authors of 1970PrZW). Another thesis from University Kansas by J.W.

^{32}S(p,γ):res 1976Al01,1972Es02 (continued)

Gordon (one of authors of 1970PrZW) in 1968 probably contains the same data as reported in 1970PrZW.
1958Mu05,1970Sc16,1973Ta04: measured activity of ^{33}Cl produced by (p,γ) reaction.
Additional information 1.

^{33}Cl Levels

Resonance strength is defined as $S_{p\gamma}=(2J+1)\Gamma_p\Gamma_\gamma/\Gamma$ and quoted values under comments are from 1976Al01, unless otherwise noted. Values for predicted resonances at 2686, 2975 and 4775 levels (resonance not observed in 1976Al01) are estimated by 1976Al01 based on measured γ-ray yields compared with that of the proton resonance at E_p(lab)=588 keV.
Values of C^2S under comments are σ(exp.)/σ(theory) deduced by 1992Il01.

E(level)[†]	J^π[‡]	$T_{1/2}$ or Γ[#]	E_p(lab) (keV)[@]	Comments
0.0	$3/2^+$[&]	2.512 s *5*		$T_{1/2}$: weighted average of 2.52 s *14* (1972Es02), 2.47 s *2* (1970Sc16), 2.513 s *4* (1973Ta04), 2.53 s *2* (1958Mu05). C^2S=0.84 *21* (1992Il01).
810.71 *30*	$1/2^+$[&]	>0.17 ps		$T_{1/2}$: from τ>250 ps by DSAM in 1972Bi19. $\Gamma_\gamma=3.7\times10^{-4}$ eV *6* (1976Al01). C^2S=0.28 *5* (1992Il01).
1986.6 *4*	$5/2^+$	53 fs *12*		J^π: 1986.5γ M1+E2 to $3/2^+$, 988.9γ M1+E2 from $7/2^+$. Additional information 2. $T_{1/2}$: from τ=76 fs *17*, weighted average of 94 fs *+14–20* (1972Bi19) and 61 fs *16* (1976Al01). Γ_γ=0.011 eV *3* (1976Al01). C^2S<0.26 (1992Il01).
2351.89 *30*	$3/2^+$	69 fs *21*		$T_{1/2}$: from τ=100 fs *30* (1976Al01). Γ_γ=0.007 eV *2* (1976Al01). $S_{p\gamma}=7.0\times10^{-17}$ eV with E_p=77.3 *8* deduced from level energy in 1992Il01. C^2S<0.66 (1992Il01).
2685.6 *4*	$(5/2)^-$		424 *2*	J^π: 2090γ M1+E2 from $7/2^-$; 699γ D+Q to $5/2^+$; 2685.5γ to $3/2^+$ and probable 1875γ to $1/2^+$ favor $5/2^-$. But $7/2^-$ from theoretical predictions (1976Al01). E_p(lab) (keV): from 1992Il01. Resonance not observed in 1976Al01; a value of 421.8 *6* is deduced by the authors from level energy. Estimated $S_{p\gamma}=9\times10^{-5}$ eV *4* (1976Al01), 7.4×10^{-5} eV *16* (1992Il01). $\Gamma_\gamma=1.4\times10^{-5}$ eV *6* (1976Al01). C^2S<3.8 (1992Il01).
2839.13 *30*	$5/2^+$	3 fs *1*	579.8 *6*	J^π: from $\gamma(\theta)$ in 1958Va22 and γ(lin pol) in 1959Su55. $T_{1/2}$: from τ=4.4 fs *15* (1976Al01). E_p(lab) (keV): other: 579.8 *15* (1958Va22). $S_{p\gamma}$=0.027 eV *10* (1958Va22), 0.022 eV *6* (1962Lo06), 0.08 eV *1* (1976Al01). Unweighted average is 0.043 eV *19*. Γ_γ=0.14 eV *5* (1976Al01). C^2S<0.47 (1992Il01).
2846.43 *30*	$3/2^-$	≤0.7 fs	588.1 *5*	J^π: from $\gamma(\theta)$ in 1958Va22 and γ(lin pol) in 1959Su55. $T_{1/2}$: from τ<1 fs (1976Al01). E_p(lab) (keV): weighted average of 587.4 *15* (1958Va22), 587.9 *5* (1976Al01) and 589 *1* 1992Il01. $S_{p\gamma}$=0.10 eV *4* (1958Va22), 0.06 eV *2* (1962Lo06), 0.14 eV *2* (1966En04), 0.21 eV *3*(1976Al01), 0.20 eV *4* (1975Ke11), 0.26 eV *6* (1992Il01). Unweighted average is 0.16 eV *3*. Γ_γ=0.070 eV *20* (1976Al01). C^2S=0.77 *13* (1992Il01).
2975.54 *30*	$7/2^+$	60 fs *14*	720.7 *6*	J^π: 2975.4γ E2(+M3) to $3/2^+$.

Continued on next page (footnotes at end of table)

^{32}S(p,γ):res 1976Al01,1972Es02 (continued)

^{33}Cl Levels (continued)

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$ or Γ[#]	E_p(lab) (keV)[@]	Comments
				$T_{1/2}$: from τ=86 fs *20* (1976Al01). E_p(lab) (keV): resonance not observed in 1976Al01; quoted value is deduced by the authors of 1976Al01 from level energy. Estimated $S_{p\gamma}=1.4\times10^{-4}$ eV *6* (1976Al01). $\Gamma_\gamma=7.7\times10^{-3}$ eV *18* (1976Al01).
3816.34 *30*	5/2$^+$		1588.5 *10*	E_p(lab) (keV): weighted average of 1587.8 *11* (1976Al01) and 1589 *1* (1992Il01). $S_{p\gamma}$=0.053 eV *7* (1976Al01), 0.054 eV *12* (1992Il01). $\Gamma_\gamma>8.8\times10^{-3}$ eV (1976Al01).
3971.16 *20*	3/2$^+$	≤0.3 keV	1748.7 *10*	E_p(lab) (keV): weighted average of 1748.4 *10* (1976Al01) and 1949 *1* (1992Il01). Γ: from 2006Tr10. Others: 0.6 keV (1968Li07), 5 keV *3* (1976Al01). $S_{p\gamma}$=0.09 eV *2* (1976Al01), 0.090 eV *18* (1992Il01). Γ_γ=0.023 eV *4* (1976Al01).
3979.06 *20*	5/2$^-$	<0.6 keV	1754.7 *7*	Γ: from 1968Li07. E_p(lab) (keV): from 1968Li07, giving E(level)=3978.3 *8* which is in better agreement with Eγ data than E_p(lab)=1757.2 *9* from 1976Al01 that gives E(level)=3980.8 *10*. $S_{p\gamma}$=0.38 eV *4* (1976Al01), 0.36 eV *12*(1968Li07), 0.14 eV *4* (1962Lo06). Unweighted average is 0.29 eV *8*.
4099.5 *11*	(1/2$^+$,3/2,5/2$^+$)		1879.7 *11*	Additional information 3. E(level): from E_p and S(p). J$^\pi$: 2113γ to 5/2$^+$, 3289γ to 1/2$^+$. $S_{p\gamma}$=0.019 eV *8*.
4112.28 *20*	3/2$^+$	≤0.6 keV	1893.1 *7*	J$^\pi$: spin from $\gamma\gamma(\theta)$ in 1968Li07. Γ: from 1968Li07. E_p(lab) (keV): weighted average of 1892.8 *7* (1968Li07) and 1893.8 *11* (1976Al01). $S_{p\gamma}$=0.07 eV *2* (1976Al01), 0.22 eV *8* (1962Lo06 and 1968Li07), 0.46 eV *15* (1975VaYG). Unweighted average is 0.25 eV *11*.
4118 *2*	3/2$^-$[&]	12 keV *3*	1899 *2*	Additional information 4. E(level): from E_p and S(p). Γ: weighted average of 14 keV *4* (1976Al01) and 10 keV *3* (1992Il01). E_p(lab) (keV): weighted average of 1898 *2* (1976Al01) and 1899 *2* (1992Il01). $S_{p\gamma}$=0.19 eV *7* (1976Al01), 0.18 eV *8* (1992Il01).
4439.02 *20*	1/2,3/2	2 keV *1*	2229.3 *7*	J$^\pi$: from $\gamma(\theta)$ in 1970PrZW. Γ: from 1976Al01. Other: Γ<1 keV (1968Li07). E_p(lab) (keV): from 1968Li07. Other: 2229.4 *13* (1976Al01). $S_{p\gamma}$=0.30 eV *4* (1976Al01), 0.50 eV *20* (1968Li07).
4464.4 *4*	3/2		2255.4 *13*	$S_{p\gamma}$=0.14 eV *2*. J$^\pi$: from $\gamma(\theta)$ in 1970PrZW.
4746.8 *15*	5/2		2547.2 *15*	Additional information 5. E(level): from E_p and S(p). J$^\pi$: from $\gamma(\theta)$ in 1970PrZW. $S_{p\gamma}$=1.4 eV *2*.
4776 *3*	7/2$^-$		2577 *3*	Additional information 6. E(level): from E_p and S(p). Estimated $S_{p\gamma}$=0.093 eV *19* in 1976Al01.
4835	3/2			E(level),J$^\pi$: from 1970PrZW, with spin from $\gamma(\theta)$.

Continued on next page (footnotes at end of table)

^{32}S(p,γ):res 1976Al01,1972Es02 (continued)

^{33}Cl Levels (continued)

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$ or Γ[#]	E_p(lab) (keV)[@]	Comments
5002				E(level): from 1970PrZW.
5090				E(level): from 1970PrZW.
5105				E(level): from 1970PrZW.
5277				E(level): from 1970PrZW.
5548.7 *5*	1/2$^+$[&]	<2 keV	3371 *5*	T=3/2 (1972Es02) E_p(lab) (keV): 3371 *5* (1972Es02); 3370 *8* (1974Ab06). $S_{p\gamma}$=0.76 eV *18*(1972Es02).
5694 *9*			3525 *9*	
5879 *9*		15 keV	3716 *9*	
6142 *9*		13 keV	3987 *9*	
6198 *6*		<10 keV	4045 *6*	
6253 *6*		<6 keV	4102 *6*	
6308 *9*			4158 *9*	
6629 *9*		33 keV	4489 *9*	
6672 *9*			4534 *9*	
6855 *9*			4723 *9*	
6901			4770[a]	E(level): could be same as 6938 resonance in 1972Es02.
6938 *9*			4808 *9*	
6984? *9*			4856 *9*	Resonance considered tentative in 1972Es02. $S_{p\gamma}$<0.29 eV (1972Es02).
7221			5100[a]	
7280 *9*		29 keV	5161 *9*	
7343 *9*				
7397 *6*		<2 keV	5282 *6*	T=3/2 (1972Es02) $S_{p\gamma}$=1.50 eV *37* (1972Es02).
7463			5350[a]	E(level): broad resonance (1961Hi12); probably same as the 7486 resonance seen in 1972Es02.
7486 *6*		<8 keV	5373 *6*	
7706			5600[a]	

[†] From a least-squares fit to γ-ray energies with uncertainties up to 5549 level and from 1972Es02 above that, unless otherwise noted. Where no Eγ with uncertainty is available but measured E_p(lab) is given, E(level) is deduced from $E_{c.m.}$+S(p)(^{33}Cl) with S(p)=2276.8 *4* (2021Wa16) and $E_{c.m.}=E_p(lab)\times m(^{32}S)/[m(p)+m(^{32}S)]$.

[‡] Spin from $\gamma(\theta)$ or/and $\gamma\gamma(\theta)$ in 1976Al01 and parity from electric or magnetic natures of connecting γ transitions determined based on RUL and measured $T_{1/2}$ or width, unless otherwise noted.

[#] Half-life is from DSAM in 1976Al01 and width is from 1972Es02, unless otherwise noted. Uncertainty in half-life values include a 25% systematic uncertainty due to stopping-power theory (1976Al01).

[@] From 1976Al01 up to 4775 level and from 1972Es02 above that, unless otherwise noted.

[&] From the Adopted Levels.

[a] From 1961Hi12.

γ(^{33}Cl)

A_2 and A_4 values under comments are from $\gamma(\theta)$ in 1976Al01, unless otherwise noted.

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[†]	δ[†]	Comments
810.71	1/2$^+$	810.7 *3*	100	0.0	3/2$^+$			A_2=+0.03 *3* (1958Va22)
1986.6	5/2$^+$	1175.9	<6	810.71	1/2$^+$			
		1986.5 *4*	100	0.0	3/2$^+$	M1+E2	+0.53 *6*	A_2=+0.12 *7*; A_4=−0.01 *6* (1968Li07) A_2=+0.35 *4*; A_4=−0.06 *3* (1976Al01)

Continued on next page (footnotes at end of table)

^{32}S(p,γ):res 1976Al01,1972Es02 (continued)

$\gamma(^{33}Cl)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[†]	δ[†]	Comments
								A_2=+0.49 *16*; A_4=+0.29 *17* (1976Al01) δ: other: +4 *1* (1976Al01). $\gamma(\theta)$ from E_p=1588. $\gamma(\theta)$ data from E_p=2577.
2351.89	3/2$^+$	1541.1	74 *2*	810.71	1/2$^+$	M1+E2	+0.44 *4*	A_2=+0.19 *5*; A_4=+0.05 *4*
		2351.8 *3*	26 *2*	0.0	3/2$^+$	M1+E2	−1.3 *4*	A_2=−0.43 *3*; A_4=−0.02 *3*
2685.6	(5/2)$^-$	699.0	69 *11*	1986.6	5/2$^+$	(E1+M2)	−0.0 *6*	I_γ: weighted average of 74 *2* (1976Al01) and 66 *11* (1992Il01). Mult.: D+Q from $\gamma(\theta)$ in 1976Al01; $\Delta\pi$=yes from level scheme. δ: for J=7/2. Other: +0.0 *6* if J=5/2 (1976Al01).
		1874.8	≤10	810.71	1/2$^+$			
		2685.5 *4*	31 *6*	0.0	3/2$^+$			I_γ: weighted average of 28 *11* (1976Al01) and 34 *6* (1992Il01).
2839.13	5/2$^+$	2028.4	1.0 *4*	810.71	1/2$^+$			
		2839.0 *3*	99.0 *4*	0.0	3/2$^+$	M1+E2	−0.10 *2*	A_2=−0.51 *4*; A_4=+0.02 *4* (1976Al01); A_2=−0.68 *2* (1958Va22) δ: Others: +0.014 *8* from $\gamma(\theta)$ in 1958Va22; −0.09 *3* from γ(lin pol) in 1959Su55. POL=+0.55 *22*, consistent with J^π(2839)=5/2$^+$ (1959Su55).
2846.43	3/2$^-$	2035 *15*	54 *4*	810.71	1/2$^+$	E1		A_2=−0.61 *3* (1958Va22); pol=−0.59 *26* (1959Su55) E_γ: from 1958Va22. I_γ: weighted average of 50 *5* (1958Va22), 55 *4* (1976Al01) and 55 *4* (1992Il01). Mult.: from $\gamma(\theta)$ in 1958Va22 and γ(lin pol) in 1959Su55. POL is consistent with J^π(2839)=3/2$^-$ but not 3/2$^+$ (1959Su55).
		2846.3 *3*	46 *4*	0.0	3/2$^+$	E1		A_2=+0.77 *4* (1958Va22); pol=+0.96 *25* (1959Su55) I_γ: weighted average of 50 *5* (1958Va22), 45 *4* (1976Al01) and 45 *4* (1992Il01). Mult.: from $\gamma(\theta)$ in 1958Va22 and γ(lin pol) in 1959Su55. POL is consistent with J^π(2839)=3/2$^-$ but not 3/2$^+$ (1959Su55).
2975.54	7/2$^+$	988.9	15 *4*	1986.6	5/2$^+$	M1+E2	+0.31 *3*	
		2975.4 *3*	85 *4*	0.0	3/2$^+$	E2(+M3)	−0.09 *9*	A_2=+0.23 *10*; A_4=−0.11 *10*
3816.34	5/2$^+$	840.8	8 *1*	2975.54	7/2$^+$			I_γ: not analyzed in 1992Il01 due to strong background contribution.
		977.2	12 *2*	2839.13	5/2$^+$	M1+E2	+0.47 *16*	A_2=+0.70 *5*; A_4=+0.02 *4* I_γ: other: 18 *2* (1992Il01).
		1464.4	43 *3*	2351.89	3/2$^+$	M1+E2	+0.17 *4*	A_2=+0.01 *11*; A_4=−0.03 *8* I_γ: other: 40 *7* (1992Il01).
		1829.7	21 *3*	1986.6	5/2$^+$	M1+E2	−0.22 *3*	A_2=+0.18 *2*; A_4=+0.03 *4* I_γ: other: 24 *4* (1992Il01).
		3005.5	3 *1*	810.71	1/2$^+$			I_γ: other: 2.0 *7* (1992Il01).
		3816.1 *3*	13 *2*	0.0	3/2$^+$	M1+E2	−2.5 *3*	A_2=−0.58 *5*; A_4=+0.49 *5* I_γ: other: 16 *3* (1992Il01).
3971.16	3/2$^+$	1132.0	8[‡] *4*	2839.13	5/2$^+$			I_γ: others: 8 *1* (1976Al01), 11 *3* (1992Il01).
		1619.2	8[‡] *2*	2351.89	3/2$^+$			I_γ: others: 5 *2* (1976Al01), 9 *3* (1992Il01).
		1984.5	16[‡] *2*	1986.6	5/2$^+$			E_γ: other: 2000 *20* (1968Li07).

Continued on next page (footnotes at end of table)

^{32}S(p,γ):res 1976Al01,1972Es02 (continued)

$\gamma(^{33}Cl)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[†]	δ[†]	Comments
								I_γ: others: 16 *3* (1976Al01), 15 *3* (1992Il01); 6 *1* from 1968Li07 is discrepant.
3971.16	$3/2^+$	3160.3	18[‡] *2*	810.71	$1/2^+$	(M1(+E2))	−0.00 *2*	A_2=−0.49 *3*; A_4=+0.09 *3* (1976Al01) E_γ: other: 3190 *50* (1968Li07). I_γ: others: 40 *4* (1976Al01), 39 *8* (1992Il01), 9 *2* (1968Li07), are discrepant. Mult.: D(+Q) from $\gamma(\theta)$ in 1976Al01; $\Delta\pi$=no from level scheme. δ: Others: −1.73 *7* (1976Al01), −0.11 *3* or +2.3 *2* (1968Li07). (3161γ)(811γ)(θ): A_2=−0.257 *50*, A_4=+0.018 *60* (1968Li07).
		3970.9[‡] *2*	50[‡] *3*	0.0	$3/2^+$	M1+E2	+0.50 *4*	A_2=+0.84 *8*; A_4=+0.05 *5* (1976Al01) A_2=−0.26 *3*; A_4=+0.006 *30* (1968Li07) E_γ: other: 4000 *50* (1968Li07). I_γ: others: 31 *4* (1976Al01), 26 *6* (1992Il01), 85 *3* (1968Li07), are discrepant. δ: from $\gamma(\theta)$ in 1968Li07. Others: +0.8 *5* from $\gamma(\theta)$ in 1976Al01; +5.0 *8* also from $\gamma(\theta)$ in 1968Li07.
3979.06	$5/2^-$	1003.5	0.3 *2*	2975.54	$7/2^+$			
		1132.6	2.2 *4*	2846.43	$3/2^-$	M1+E2	−0.23 *8*	A_2=−0.75 *8*; A_4=+0.04 *9* I_γ: Other: 4.7 *8*, energetically not resolved from transition to 2839 level (1992Il01). δ: Other: −1.3 *4* (1976Al01).
		1139.9	1.2 *3*	2839.13	$5/2^+$	(E1(+M2))	−0.03 *15*	A_2=+0.40 *15*; A_4=−0.04 *13* Mult.: D(+Q) from $\gamma(\theta)$ in 1976Al01; $\Delta\pi$=yes from level scheme.
		1293.4	2.3 *4*	2685.6	$(5/2)^-$	M1+E2	+0.25 *6*	A_2=−0.49 *6*; A_4=+0.04 *6* I_γ: Other: 2.3 *5* (1992Il01). δ: for J(2685)=7/2, also δ=+7 *2*. Other: −0.9 *3* for J(2685)=5/2.
		1992.4	3.5 *5*	1986.6	$5/2^+$			I_γ: Other: 5.0 *8* (1992Il01).
		3978.8[‡] *2*	90.5 *10*	0.0	$3/2^+$	(E1(+M2))	−0.01 *2*	A_2=−0.42 *2*; A_4=+0.03 *2* I_γ: Other: 88 *13* (1992Il01). Mult.: D(+Q) from $\gamma(\theta)$ in 1976Al01; $\Delta\pi$=yes from level scheme.
4099.5	$(1/2^+,3/2,5/2^+)$	1253.0	4 *1*	2846.43	$3/2^-$			
		2112.8	60 *4*	1986.6	$5/2^+$			
		3288.6	18 *3*	810.71	$1/2^+$			
		4099.2	18 *2*	0.0	$3/2^+$			
4112.28	$3/2^+$	1265.8[@]		2846.43	$3/2^-$			E_γ,I_γ: contribution from the broad 4117 level can't be ruled out (1976Al01).

Continued on next page (footnotes at end of table)

^{32}S(p,γ):res 1976Al01,1972Es02 (continued)

$\gamma(^{33}Cl)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[†]	δ[†]	Comments
4112.28	3/2$^+$	1760.3[@]		2351.89	3/2$^+$			E_γ,I_γ: contribution from the broad 4117 level can't be ruled out (1976Al01).
		3301.4	50 *5*	810.71	1/2$^+$	M1+E2	−0.10 *5*	E_γ: Other: 3250 *50* from 1968Li07. I_γ,Mult.: from 1968Li07. δ: from 1968Li07. Others: +2.2 *2* giving Γ_γ(M1)=0.47×10^{-2} eV, Γ_γ(E2)=2.28×10^{-2} eV (1968Li07); −0.14 *3* from 1975VaYG. (3301γ)(811γ)(θ): A_2=−0.281 *50*, A_4=−0.020 *60* (1968Li07). Γ_γ(M1)=2.75×10^{-2} eV, Γ_γ(E2)<0.06×10^{-2} eV (1968Li07).
		4112.0[‡] *2*	50 *5*	0.0	3/2$^+$			I_γ: from 1968Li07. δ: −11.4 *25* or 0.17 *3* for J=3/2 (1975VaYG).
4118	3/2$^-$	1272	1.0 *5*	2846.43	3/2$^-$			
		3307	69 *4*	810.71	1/2$^+$			I_γ: other: 74 *10* (1992Il01).
		4118	20 *4*	0.0	3/2$^+$			I_γ: other: 26 *8* (1992Il01).
4439.02	1/2,3/2	1592.6	1.2 *4*	2846.43	3/2$^-$			
		2087.1	7 *1*	2351.89	3/2$^+$			
		3628.1	4 *1*	810.71	1/2$^+$			
		4438.7[‡] *2*	88 *2*	0.0	3/2$^+$			
4464.4	3/2	2477.7	26 *3*	1986.6	5/2$^+$			
		3653.5	27 *3*	810.71	1/2$^+$			
		4464.1[‡] *4*	47 *4*	0.0	3/2$^+$			
4746.8	5/2	1771.2	11 *2*	2975.54	7/2$^+$			
		1907.6	1.0 *3*	2839.13	5/2$^+$			
		2061.1	0.4 *2*	2685.6	(5/2)$^-$			
		2394.8	1.6 *3*	2351.89	3/2$^+$			
		2760.1	8 *2*	1986.6	5/2$^+$			
		3935.8	0.6 *3*	810.71	1/2$^+$			
		4746.4	78 *2*	0.0	3/2$^+$			
4776	7/2$^-$	1800	<3	2975.54	7/2$^+$			
		1930	9 *2*	2846.43	3/2$^-$	E2		A_2=+0.14 *10*; A_4=−0.11 *11* (1976Al01)
		1937	53 *5*	2839.13	5/2$^+$	(E1(+M2))	−0.02 *2*	A_2=−0.39 *3*; A_4=+0.06 *5* Mult.: D(+Q) from $\gamma(\theta)$ in 1976Al01; $\Delta\pi$=yes from level scheme.
		2090	38 *5*	2685.6	(5/2)$^-$	M1+E2	−0.32 *4*	A_2=+0.09 *3*; A_4=+0.06 *5* δ: for J(2685)=7/2, +0.21 *4* for J(2685)=5/2.
		2789	<1	1986.6	5/2$^+$			
4835	3/2	2849	3[#]	1986.6	5/2$^+$			
		4024	17[#]	810.71	1/2$^+$			
		4835	80[#]	0.0	3/2$^+$			
5002		2650	9[#]	2351.89	3/2$^+$			
		3016	4[#]	1986.6	5/2$^+$			
		4191	41[#]	810.71	1/2$^+$			
		5002	46[#]	0.0	3/2$^+$			
5090		4279	29[#]	810.71	1/2$^+$			
		5090	71[#]	0.0	3/2$^+$			
5105		2753	8[#]	2351.89	3/2$^+$			
		4295	6[#]	810.71	1/2$^+$			

Continued on next page (footnotes at end of table)

^{32}S(p,γ):res 1976Al01,1972Es02 (continued)

$\gamma(^{33}Cl)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[†]	Comments
5105		5105	86[#]	0.0	3/2$^+$		
5277		2925	15[#]	2351.89	3/2$^+$		
		3291	17[#]	1986.6	5/2$^+$		
		5277	68[#]	0.0	3/2$^+$		
5548.7	1/2$^+$	4737.6[‡] *4*	91.3 *18*	810.71	1/2$^+$	[M1]	E_γ: other: 4769 *3* (1974Ab06). Additional information 7. I_γ: weighted average of 88 *3* (2006Tr10) and 92.3 *16* (1974Ab06). Other: >88 (1972Es02). Γ(M1)=0.34 eV *9* (1972Es02); Γ_γ=0.695 eV *70*(1974Ab06).
		5548.0[‡] *20*	8.7 *18*	0.0	3/2$^+$	[M1,E2]	E_γ: other: 5558 *3* (1974Ab06). I_γ: weighted average of 12 *3* (2006Tr10) and 7.7 *16* (1974Ab06). Other: <12 (1972Es02). Γ_γ<0.05 eV (1972Es02), 0.058 eV *10*(1974Ab06).

[†] From 1976Al01, unless otherwise noted. Eγ values without uncertainties are not listed explicitly in 1976Al01 and deduced by the evaluators from level-energy differences. Mult and δ are from analysis of measured $\gamma(\theta)$ and/or $\gamma\gamma(\theta)$; magnetic or electric nature is determined based on RUL and measured $T_{1/2}$ or width where available.

[‡] From 2006Tr10.

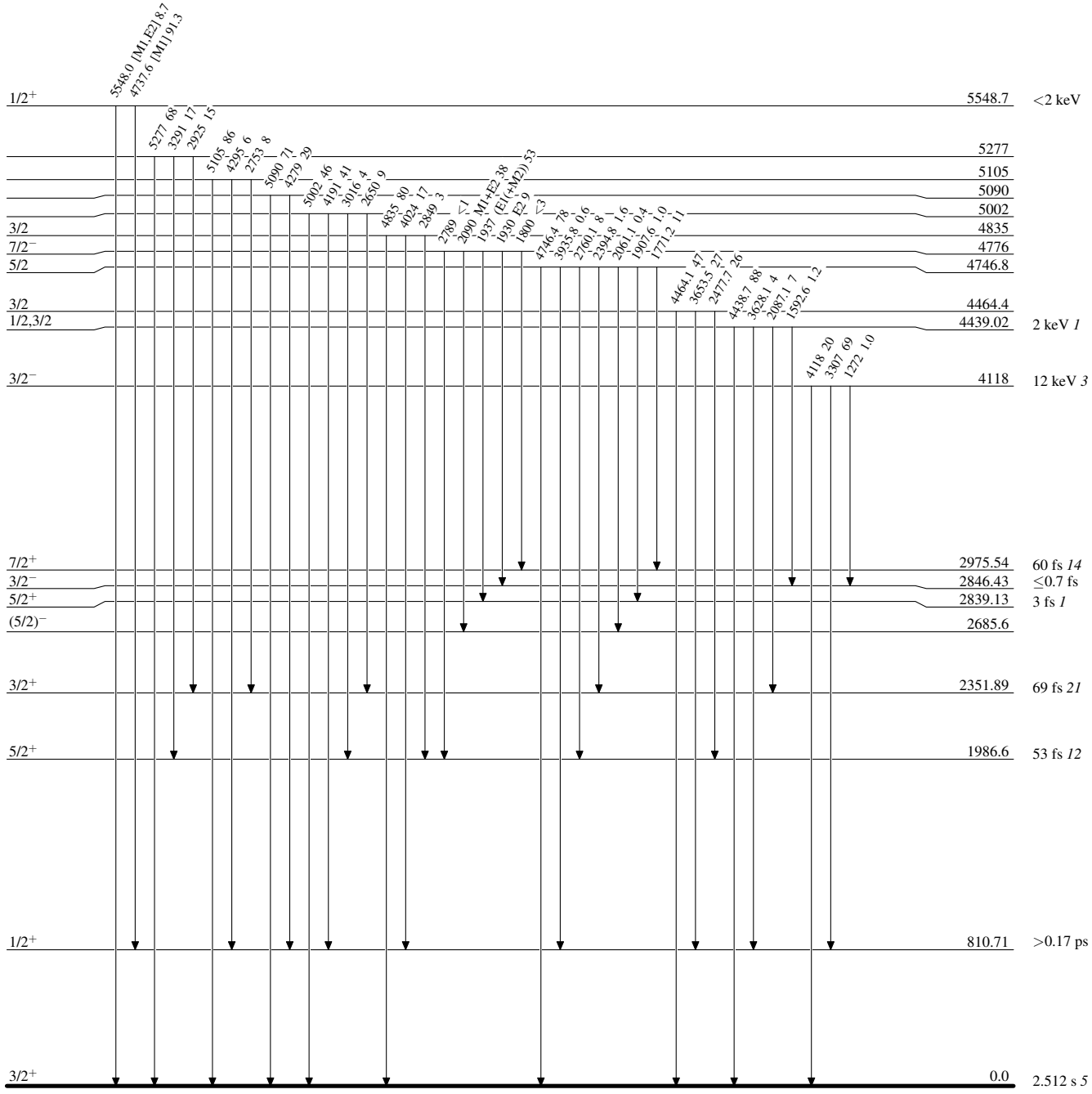
[#] From 1970PrZW only. Transitions are not reported in 1976Al01.

[@] Placement of transition in the level scheme is uncertain.

^{32}S(p,γ):res 1976Al01,1972Es02

Level Scheme

Intensities: % photon branching from each level



$^{33}_{17}Cl_{16}$

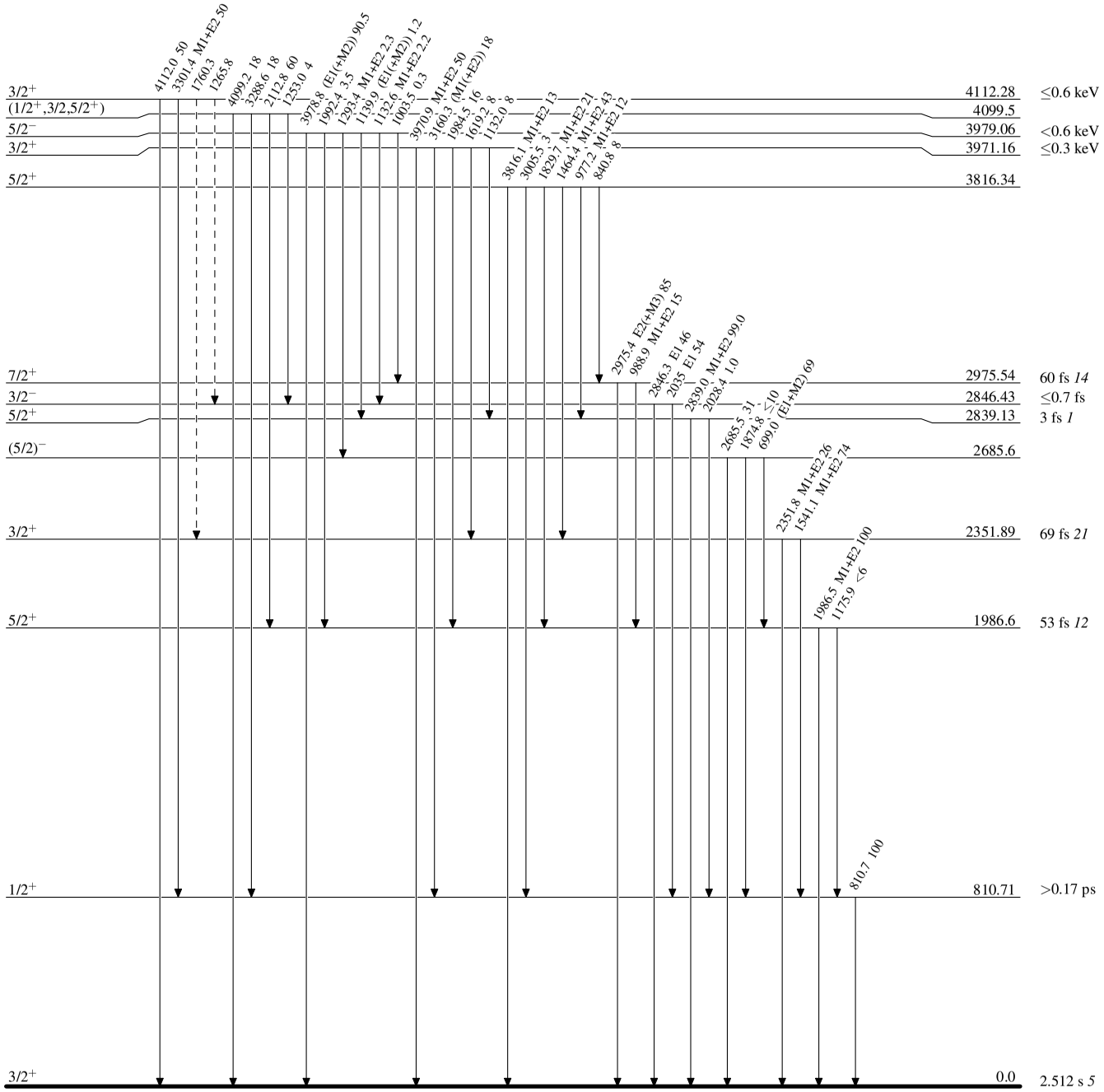
^{32}S(p,γ):res 1976Al01,1972Es02

Legend

Level Scheme (continued)

Intensities: % photon branching from each level

– – – – – – ► γ Decay (Uncertain)



$^{33}_{17}Cl_{16}$