^{33}Ar εp decay (173.0 ms) 2010Ad03,1993Sc16,1987Bo21

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 201,1 (2025)	31-Oct-2024

Parent: ^{33}Ar: E=0.0; $J^\pi=1/2^+$; $T_{1/2}$=173.0 ms *20*; Q(εp)=9342.3 *4*; %εp decay=38.8 *12*

^{33}Ar-J^π,$T_{1/2}$: From Adopted Levels of ^{33}Ar in ENSDF database.

^{33}Ar-Q(εp): From 2021Wa16.

^{33}Ar-%εp decay: %εp=38.8 *12*, weighted average of 37.5 *14* from Σ[%I(p)] in this dataset and 39.7(12)% from 2010Ad03 using the ratio of 3173-keV IAS proton line to the total proton intensity. Other: 36.9 *17* from Σ[%I(p)] in 2010Ad03, 38.7 *10* from Σ[%I(p)] 1987Bo21.

Identification and production of ^{33}Ar: 1966Po12 and 1964Re08: ^{32}S(^{3}He,2n) reaction at 31.8 MeV, delayed protons; 1966Ha22 and 1965Ha08: ^{33}Cl(p,X). Later studies of ^{33}Ar decay: 2002Fy01, 1999Th09, 1996Ho24, 1993Sc16, 1987Bo21, 1971Ha05 (also 1971EsZR thesis), 1970Ce02.

2010Ad03: isotopes of interest were produced by projectile fragmentation of 95 MeV/nucleon ^{36}Ar primary beam provided by the coupled cyclotrons of GANIL on the SPIRAL carbon target. Fragments were directed to and identified in the SPIRAL identification station. Charged particles were detected with a silicon cube detector (6 DSSSDs) and γ rays were detected with three HPGe detectors. Measured E_p, I(p), Eγ, Iγ, pγ-coin. Deduced levels, J, π, decay branching ratios, B(GT), log *ft*. Comparisons with theoretical calculations. Deduced levels, J^π, branching ratios for ^{33}Cl.

1993Sc16: ^{33}Ar ions were produced from spallation reaction of 600 MeV protons on CaO targets at ISOLDE-II and collected on a thin carbon catcher foil. Charged particles were detected with a Si surface barrier detector. Measured E(p), I(p). Deduced β-delayed proton emission probabilities.

1987Bo21: ^{33}Ar ions were produced from spallation reaction at the ISOLDE facility at CERN. Charged particles were detected with a Si surface-barrier detector and γ rays were detected with a Ge(Li) detector. Measured E(p), I(p), Eγ, Iγ, pγ-coin, decay curve. Deduced parent $T_{1/2}$, proton emission probabilities.

1971Ha05: ^{33}Ar ions from ^{32}S(^{3}He,2n) with ^{3}He beam from the Berkeley 88-inch cyclotron. Charged particles were detected with a counter telescope and γ rays were detected with a NaI(Tl) detector. Measured E(p), I(p), Eγ, Iγ, pγ-coin, p(t). Deduced parent $T_{1/2}$, proton emission probabilities.

1996Ho24: ^{33}Ar from spallation reaction of 1 GeV protons from the PS- Booster at CERN. Silicon ΔE-E telescope, novel gas-Si combination detector and one annular Si detector. Ge detector for γ rays. Measured β-delayed proton energies, intensities. Other papers by the same group: 2002Fy01, 1999Th09.

2014Ko17: measured Eγ and Iγ of 2230γ.

^{32}S Levels

E(level)†	J^π†
0.0	0^+
2230.68 *12*	2^+
3778.52 *24*	0^+

† From Adopted Levels.

γ(^{32}S)

E_γ	I_γ†	E_i(level)	J_i^π	E_f	J_f^π	Comments
2230.3 *5*	0.77 *10*	2230.68	2^+	0.0	0^+	E_γ: from 2010Ad03. Others: 2230.6 *9* (1989Bo21), 2230.4 *19* (2014Ko17). I_γ: deduced from Iγ(2230.3)=1.83 *24* relative Iγ=100 for 810.6γ in ^{33}Cl and %Iγ(810.6)=42.1 *11* from ^{33}Ar ε decay. Relative Iγ(2230.3)=1.83 *24* is from pγ-coin in 1987Bo21. Others: 1.8 *5* from γ singles in 1987Bo21; 3.9 *4* from 2014Ko17; 6.1 *2* in 2010Ad03 is too high as explained by the authors due to some trigger problems.

† Absolute intensity per 100 decays.

^{33}Ar εp decay (173.0 ms) 2010Ad03,1993Sc16,1987Bo21 (continued)

Delayed Protons (^{32}S)

Above E(p)≈4.5 MeV, level energies from 1987Bo21 are discrepant with those in 2010Ad03 and 1993Sc16, while values from latter two are in good agreement. 2010Ad03 point out that it is due to the energy calibration using known α energies in 1987Bo21 which was not corrected for the pulse height defect when applied to proton energies. The correspondence of those proton lines to lines observed in 2010Ad03 is made by the authors after correcting the effect for values from 1987Bo21. Values are also available in 1971Ha05 and 1996Ho24 but less precise and less complete.

E(p)‡	E(^{32}S)	I(p)†‡@	E(^{33}Cl)	Comments
762 *10*	2230.68	0.0202 *17*	5310	
1321 *2*	2230.68	0.180 *4*	5865	E(p),I(p): from 1993Sc16. Other: 1317 *8* with I(p)=0.168 *9* (2010Ad03). Other: I(p)=0.27 *+15−8* for 3483(g.s.)+1323(1st) in 1971Ha05, while the 3484 line is also assigned to 1st excited level in 2010Ad03.
1645 *2*	0.0	0.401 *25*	3973	I(p): unweighted average of 0.46 *5* (1971Ha05), 0.34 *1* (1987Bo21), 0.391 *6* (1993Sc16), and 0.411 *20* (2010Ad03).
1665 *6*	3778.52	0.0080 *20*	7762	I(p): unweighted average of 0.0099 *16* (1993Sc16) and 0.0060 *11* (2010Ad03).
1696 *2*	2230.68	0.0329 *22*	6253	E(p): weighted average of 1697 *2* (1993Sc16) and 1691 *6* (2010Ad03). I(p): weighted average of 0.046 *6* (1987Bo21), 0.0319 *16* (1993Sc16), and 0.0332 *32* (2010Ad03).
1757 *7*	2230.68	0.015 *7*	6326	E(p): weighted average of 1750 *2* (1993Sc16) and 1764 *5* (2010Ad03). I(p): weighted average of 0.0220 *31* (1993Sc16) and 0.0081 *13* (2010Ad03).
1781 *2*	0.0	0.453 *8*	4113	E(p): weighted average of 1780 *2* (1993Sc16) and 1781 *2* (2010Ad03). I(p): weighted average of 0.50 *6* (1971Ha05), 0.43 *1* (1987Bo21), 0.459 *6* (1993Sc16), and 0.471 *22* (2010Ad03).
2024 *5*	2230.68	0.0043 *7*	6594	
2097 *2*	0.0	2.59 *13*	4442	E(p): weighted average of 2096 *2* (1993Sc16) and 2100 *3* (2010Ad03). I(p): unweighted average of 2.90 *30* (1971Ha05), 2.37 *2* (1987Bo21), 2.368 *16* (1993Sc16), and 2.73 *12* (2010Ad03).
2365 *2*	2230.68	0.0158 *12*	6951	E(p): weighted average of 2364 *2* (1993Sc16) and 2370 *5* (2010Ad03). I(p): weighted average of 0.019 *3* (1987Bo21), 0.0158 *31* (1993Sc16), and 0.0153 *12* (2010Ad03). Other: 0.055 *9* from 1971Ha05 for a group at 2365, assigned to g.s.
2368 *6*	3778.52	0.0012 *3*	8491	
2480 *2*	0.0	0.348 *6*	4835	E(p): weighted average of 2478 *2* (1993Sc16) and 2481 *2* (2010Ad03). I(p): weighted average of 0.36 *5* (1971Ha05), 0.33 *1* (1987Bo21), 0.353 *6* (1993Sc16), and 0.362 *17* (2010Ad03).
2710 *7*	2230.68	0.0069 *12*	7292	
2741 *2*	0.0	0.0430 *31*	5106	E(p): weighted average of 2740 *2* (1993Sc16) and 2744 *3* (2010Ad03). I(p): weighted average of 0.045 *5* (1987Bo21), 0.0403 *31* (1993Sc16), and 0.048 *5* (2010Ad03). Other: 0.094 *15* for a 2749 group in 1971Ha05.
2810 *10*	2230.68	0.00141 *14*	7405	
2882 *2*	2230.68	0.046 *10*	7475	E(p): from 1993Sc16. Other: 2886 *7* (2010Ad03). I(p): unweighted average of 0.065 *6* (1987Bo21), 0.0341 *31* (1993Sc16), and 0.0376 *35* (2010Ad03).
2934 *7*	0.0	0.089 *16*	5310	E(p): unweighted average of 2927 *2* (1993Sc16) and 2941 *4* (2010Ad03). I(p): unweighted average of 0.122 *8* (1987Bo21), 0.0713 *31* (1993Sc16), and 0.075 *6* (2010Ad03).
2949 *3*	2230.68	0.040 *4*	7556	E(p): weighted average of 2948 *2* (1993Sc16) and 2957 *7* (2010Ad03). I(p): weighted average of 0.0434 *31* (1993Sc16) and 0.0359 *32* (2010Ad03).
3016 *10*	3778.52	0.0007 *2*	9152	
3066 *6*	2230.68	0.037 *33*	7666	I(p): unweighted average of 0.07 *2* (1987Bo21) and 0.0044 *6* (2010Ad03). Other: 0.66 *7* for a group at 3069. This line is assigned to g.s. in 1987Bo21 and 1971Ha05.
3173 *3*	0.0	31.0 *14*	5549	I(p): determined in 2010Ad03 using statistical rate function. %I(p) of values from other studies haven renormalized relative this value by the evaluator. Others: original value of 30.7 from 1987Bo21, and 26.7 *27* from 1971Ha05 using the ratio of measured proton and γ intensities.

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^{33}Ar εp decay (173.0 ms) 2010Ad03,1993Sc16,1987Bo21 (continued)

Delayed Protons (continued)

E(p)‡	E(^{32}S)	I(p)†‡@	E(^{33}Cl)	Comments
3348 *3*	0.0	0.33 *17*	5731	E(p): weighted average of 3347 *3* (1993Sc16) and 3350 *4* (2010Ad03). I(p): values from different studies are significantly discrepant: 0.76 *4* (1987Bo21), 0.031 *6* (1993Sc16), 0.092 *5* (2010Ad03), 0.43 *5* for 3364(to g.s.)+1226(to 1st) in 1971Ha05 with 1226 very weak. Quoted value is taken as unweighted average of all values.
3469 *6*	2230.68	0.23 *18*	8077	I(p): unweighted average of 0.41 *4* (1987Bo21) and 0.053 *4* (2010Ad03). This proton line is assigned to g.s. in 1987Bo21. See comment for 1317 proton line.
3509 *3*	2230.68	0.011 *4*	8132	E(p): weighted average of 3508 *3* (1993Sc16) and 3515 *6* (2010Ad03). I(p): unweighted average of 0.0065 *16* (1993Sc16) and 0.0150 *25* (2010Ad03).
3576 *5*	2230.68	0.054 *46*	8182	I(p): unweighted average of 0.10 *1* (1987Bo21) and 0.0085 *16* (2010Ad03).
3854 *4*	0.0	0.733 *29*	6253	E(p): weighted average of 3850 *3* (1993Sc16) and 3857 *3* (2010Ad03). I(p): unweighted average of 0.67 *7* (1971Ha05), 0.81 *2* (1987Bo21), 0.716 *6* (1993Sc16), and 0.735 *34* (2010Ad03).
3926 *5*	2230.68	0.014 *6*	8557	I(p): unweighted average of 0.019 *4* (1987Bo21) and 0.0082 *13* (2010Ad03).
4209 *5*	2230.68	0.012 *5*	8847	I(p): unweighted average of 0.017 *3* (1987Bo21) and 0.0065 *8* (2010Ad03).
4330 *8*	2230.68	0.0047 *33*	8967	I(p): unweighted average of 0.008 *2* (1987Bo21) and 0.0014 *4* (2010Ad03).
4474 *5*	2230.68	0.0037 *6*	9119	
4505 *6*	2230.68	0.011 *7*	9152	I(p): unweighted average of 0.018 *5* (1987Bo21) and 0.0047 *6* (2010Ad03).
4719 *5*	0.0	0.00079 *10*	7143	
4853 *7*	0.0	0.016 *4*	7292	E(p): unweighted average of 4846 *4* (1993Sc16) and 4860 *4* (2010Ad03). I(p): unweighted average of 0.023 *3* (1987Bo21), 0.0152 *31* (1993Sc16), and 0.0097 *8* (2010Ad03). Other: 0.048 *9* for 4833(to g.s.)+2606(to 1st) from 1971Ha05, with 2606 line very weak and not seen in other studies.
4923 *6*	2230.68	0.00066 *16*	9584	
5037 *4*	0.0	0.26 *4*	7475	E(p): weighted average of 5033 *5* (1993Sc16) and 5039 *4* (2010Ad03). I(p): unweighted average of 0.33 *1* (1987Bo21), 0.217 *6* (1993Sc16), and 0.224 *12* (2010Ad03). Other: 0.34 *4* for 5032(to g.s.)+2885(to 1st) from 1971Ha05.
5100 *4*	0.0	0.072 *19*	7537	E(p): weighted average of 5098 *5* (1993Sc16) and 5101 *4* (2010Ad03). I(p): unweighted average of 0.11 *1* (1987Bo21), 0.0589 *31* (1993Sc16), and 0.047 *5* (2010Ad03). Other: 0.29 *4* for 5180(to g.s.)+2956(to 1st) from 1971Ha05.
5223 *4*	0.0	0.036 *10*	7666	E(p): weighted average of 5219 *5* (1993Sc16) and 5225 *4* (2010Ad03). I(p): unweighted average of 0.055 *4* (1987Bo21), 0.0288 *16* (1993Sc16), and 0.0234 *24* (2010Ad03).
5316 *3*	0.0	0.0239 *20*	7762	E(p): weighted average of 5312 *5* (1993Sc16) and 5317 *3* (2010Ad03). I(p): unweighted average of 0.012 *5*, 0.018 *3* (1987Bo21), 0.0133 *13* (1993Sc16), and 0.0083 *12* (2010Ad03).
5621 *4*	0.0	0.154 *33*	8077	E(p): weighted average of 5613 *6* (1993Sc16) and 5623 *3* (2010Ad03). I(p): unweighted average of 0.22 *1* (1987Bo21), 0.118 *25* (1993Sc16), and 0.124 *7* (2010Ad03). Other: 0.27 *+15−8* for 5627(to g.s.)+3483(to 1st)+1961(to 2nd) from 1971Ha05, with 1961 line not seen in other studies.
5722 *3*	0.0	0.108 *32*	8182	E(p): weighted average of 5719 *6* (1993Sc16) and 5723 *3* (2010Ad03). I(p): unweighted average of 0.17 *1* (1987Bo21), 0.062 *16* (1993Sc16), and 0.092 *5* (2010Ad03). Other: 0.16 *+15−8* for 5723(to g.s.)+3483(to 1st) from 1971Ha05, with 3483 line doubly placed.
5855 *9*	0.0	0.012 *5*	8315	E(p): others: 5797 *12* (1987Bo21), 5846 *30* (1971Ha05). I(p): unweighted average of 0.020 *5* (1971Ha05), 0.012 *2* (1987Bo21) and 0.0028 *4* (2010Ad03).
6011 *10*	0.0	0.00100 *15*	8491	
6100 *10*	0.0	0.0147 *24*	8557	E(p): others: 6047 *17* (1987Bo21), 6119 *40* (1971Ha05). I(p): weighted average of 0.021 *4* (1987Bo21) and 0.0138 *15* (2010Ad03). Other: 0.020 *5* for 6119(to g.s.)+3982(to 1st) from 1971Ha05.
6344 *8*	0.0	0.0028 *22*	8819	E(p): other: 6255 *18* (1987Bo21). I(p): unweighted average of 0.005 *2* (1987Bo21) and 0.00053 *9* (2010Ad03).
6389 *10*	0.0	0.00027 *8*	8865	
6480 *10*	0.0	0.010 *4*	8967	E(p): others: 6403 *15* (1987Bo21), 6485 *30* (1971Ha05). I(p): unweighted average of 0.0035 *18* (1971Ha05), 0.016 *2* (1987Bo21) and 0.0103 *11* (2010Ad03).

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^{33}Ar εp decay (173.0 ms) 2010Ad03,1993Sc16,1987Bo21 (continued)

Delayed Protons (continued)

E(p)‡	E(^{32}S)	I(p)†‡@	E(^{33}Cl)	Comments
6628 *10*	0.0	0.00173 *26*	9119	E(p): other: 6545 *15* (1987Bo21). I(p): weighted average of 0.004 *2* (1987Bo21) and 0.00170 *23* (2010Ad03).
6657 *9*	0.0	0.00049 *10*	9152	
6715 *9*	0.0	0.00102 *20*	9202	E(p): other: 6619 *15* (1987Bo21). I(p): weighted average of 0.0036 *16* (1987Bo21) and 0.00100 *12* (2010Ad03).
6850 *50*	0.0	0.00023 *9*	9350#	
6950 *50*	0.0	0.00007 *3*	9450#	
7050 *50*	0.0	0.00032 *4*	9550#	
7150 *50*	0.0		9650#	
7250 *50*	0.0	0.00012 *3*	9750#	
7350 *50*	0.0	0.00010 *3*	9850#	
7450 *50*	0.0	0.00008 *3*	9950#	
775×10^{1} *25*	0.0	0.00006 *3*	10250#	
850×10^{1} *50*	0.0	0.00004 *3*	11000#	

† Additional information 1.

‡ Primarily from 2010Ad03; average is taken where values also available in 1993Sc16, 1987Bo21 or 1971Ha05, as noted under comments. I(p) values from 1993Sc16 and 1987Bo21 have been re-normalized by the evaluator relative to the strongest %I(p)=31.0 *14* of the IAS proton line, as determined by 2010Ad03 using statistical rate function.

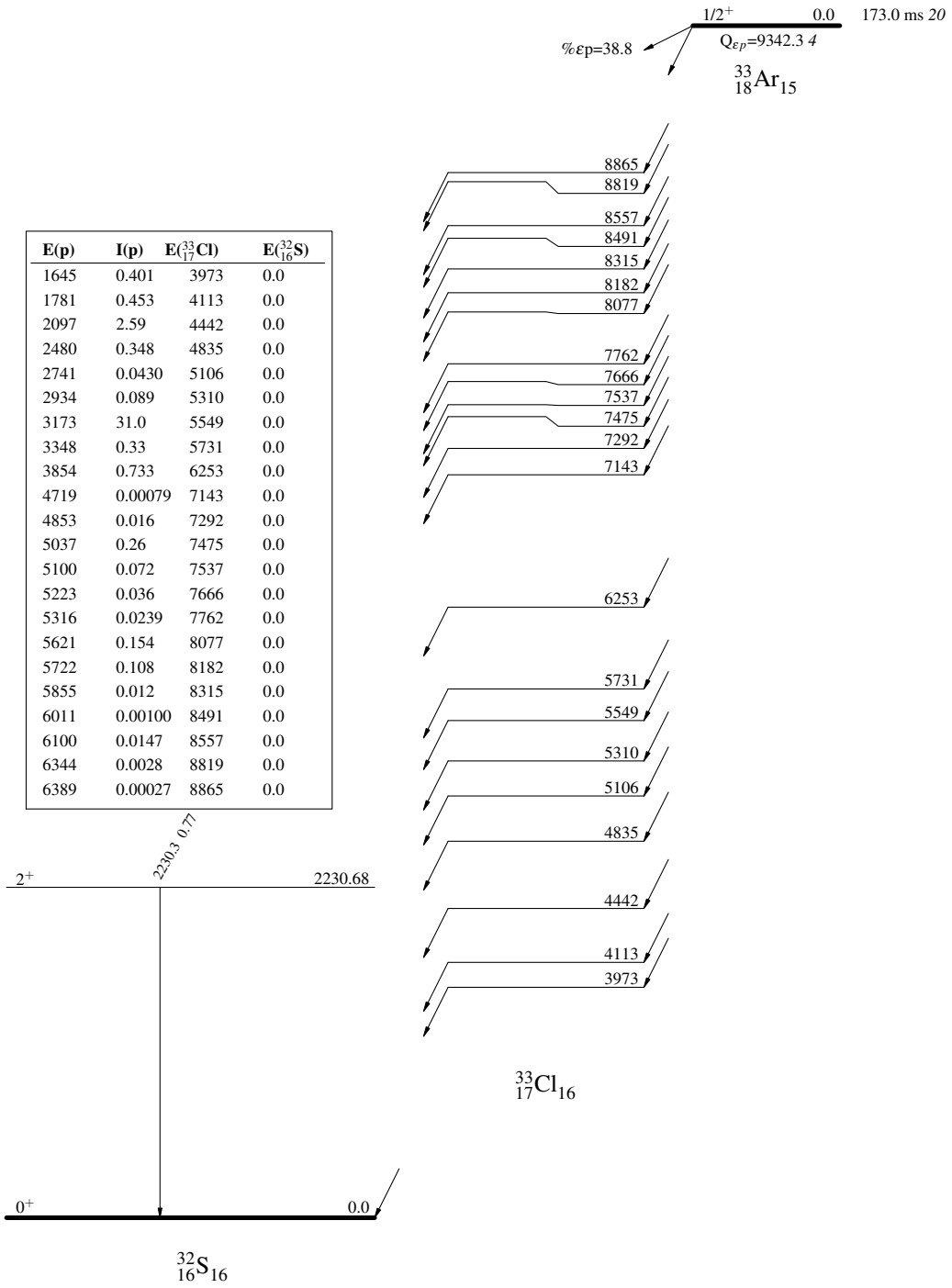
From 2010Ad03, unless otherwise noted. Pseudo level in a wide (100 keV or higher) range of energy in quoted values is taken as the central value of the range.

@ Absolute intensity per 100 decays.

^{33}Ar εp decay (173.0 ms) 2010Ad03,1993Sc16,1987Bo21

Decay Scheme

γ Intensities: Relative I_γ
I(p) Intensities: I(p) per 100 parent decays

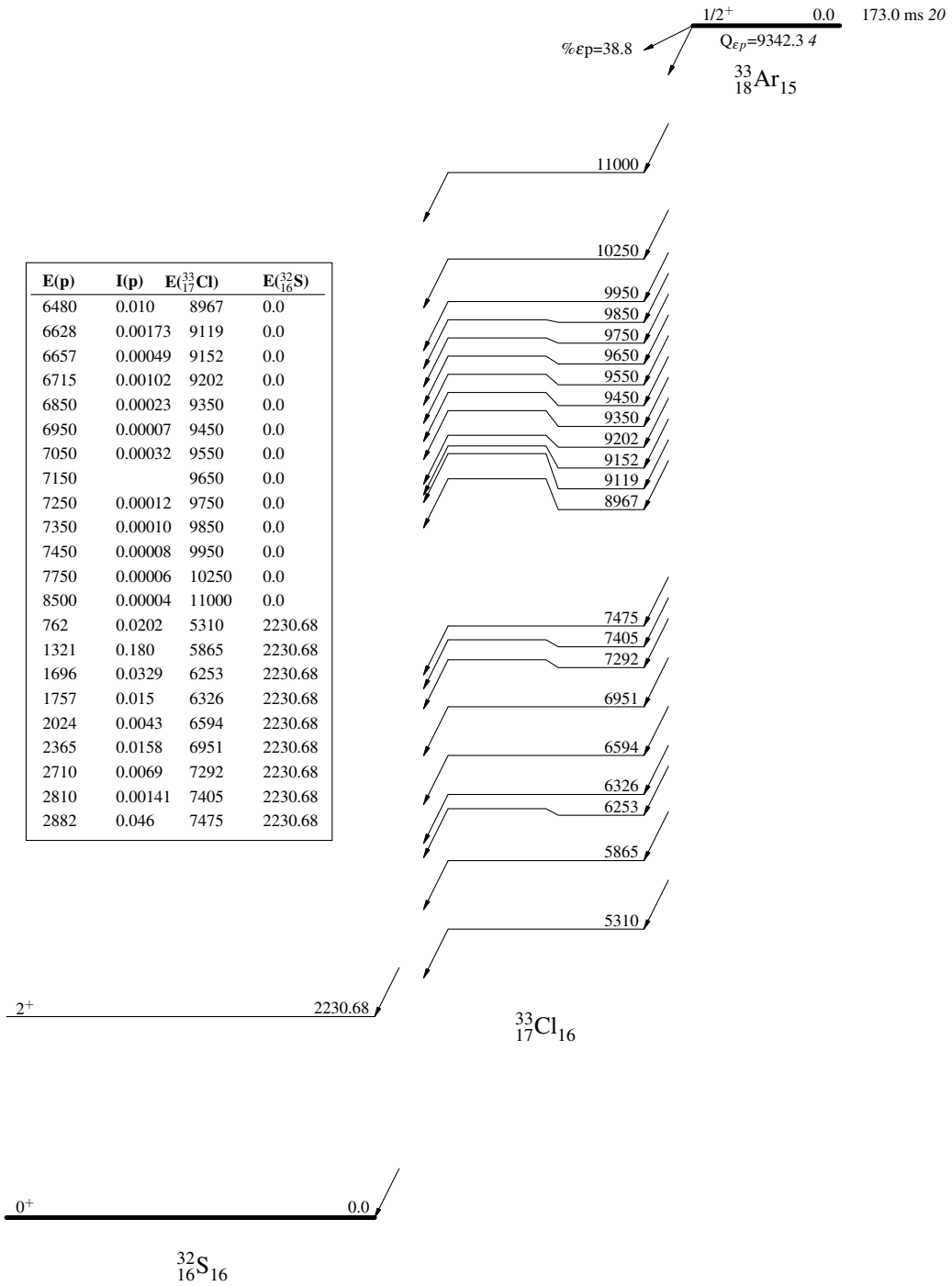


E(p)	I(p)	E($^{33}_{17}$Cl)	E($^{32}_{16}$S)
1645	0.401	3973	0.0
1781	0.453	4113	0.0
2097	2.59	4442	0.0
2480	0.348	4835	0.0
2741	0.0430	5106	0.0
2934	0.089	5310	0.0
3173	31.0	5549	0.0
3348	0.33	5731	0.0
3854	0.733	6253	0.0
4719	0.00079	7143	0.0
4853	0.016	7292	0.0
5037	0.26	7475	0.0
5100	0.072	7537	0.0
5223	0.036	7666	0.0
5316	0.0239	7762	0.0
5621	0.154	8077	0.0
5722	0.108	8182	0.0
5855	0.012	8315	0.0
6011	0.00100	8491	0.0
6100	0.0147	8557	0.0
6344	0.0028	8819	0.0
6389	0.00027	8865	0.0

^{33}Ar εp decay (173.0 ms) 2010Ad03,1993Sc16,1987Bo21

Decay Scheme (continued)

γ Intensities: Relative I_γ
I(p) Intensities: I(p) per 100 parent decays

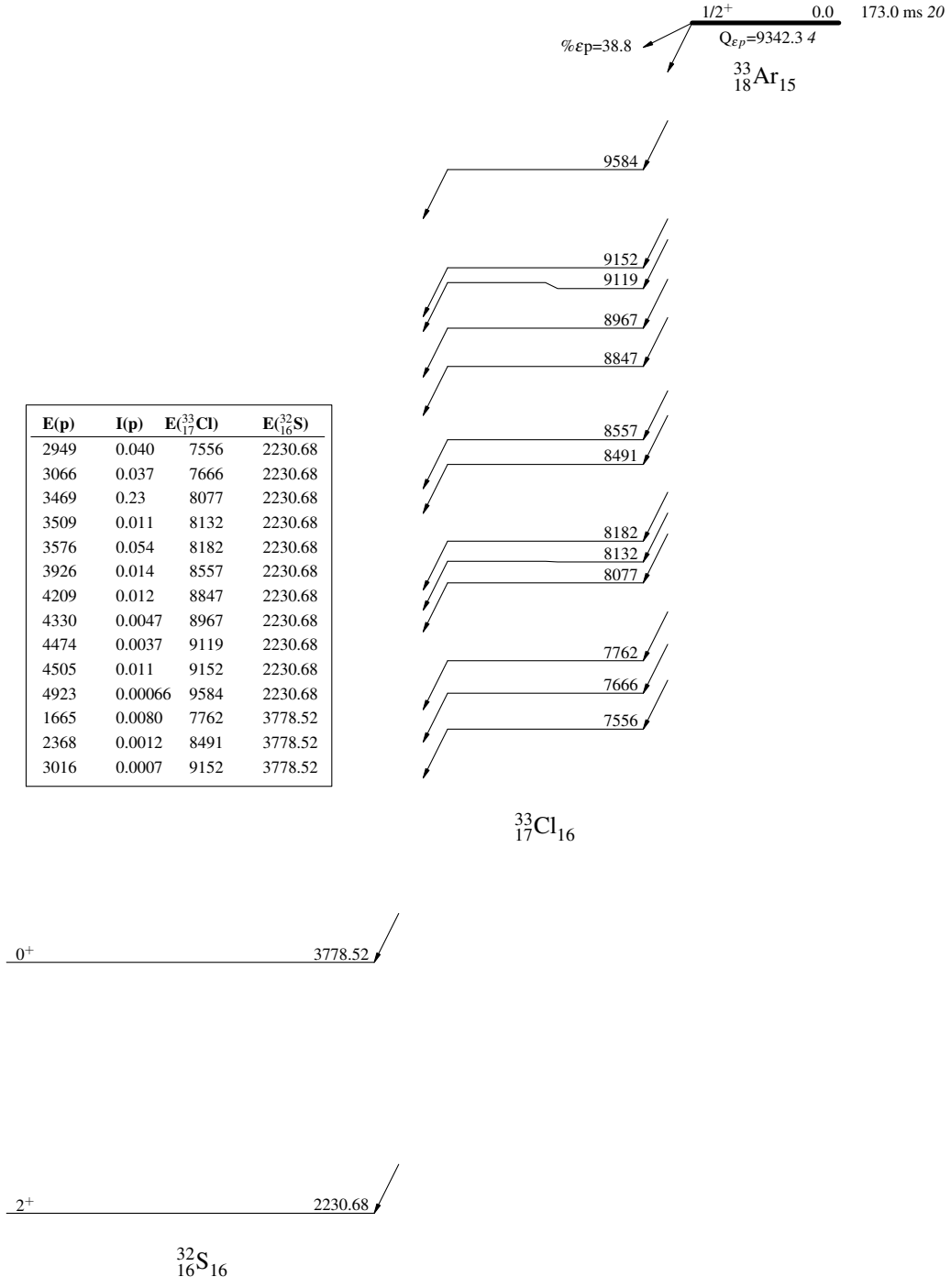


E(p)	I(p)	E($^{33}_{17}$Cl)	E($^{32}_{16}$S)
6480	0.010	8967	0.0
6628	0.00173	9119	0.0
6657	0.00049	9152	0.0
6715	0.00102	9202	0.0
6850	0.00023	9350	0.0
6950	0.00007	9450	0.0
7050	0.00032	9550	0.0
7150		9650	0.0
7250	0.00012	9750	0.0
7350	0.00010	9850	0.0
7450	0.00008	9950	0.0
7750	0.00006	10250	0.0
8500	0.00004	11000	0.0
762	0.0202	5310	2230.68
1321	0.180	5865	2230.68
1696	0.0329	6253	2230.68
1757	0.015	6326	2230.68
2024	0.0043	6594	2230.68
2365	0.0158	6951	2230.68
2710	0.0069	7292	2230.68
2810	0.00141	7405	2230.68
2882	0.046	7475	2230.68

^{33}Ar εp decay (173.0 ms) 2010Ad03,1993Sc16,1987Bo21

Decay Scheme (continued)

γ Intensities: Relative I_γ
I(p) Intensities: I(p) per 100 parent decays



E(p)	I(p)	E($^{33}_{17}$Cl)	E($^{32}_{16}$S)
2949	0.040	7556	2230.68
3066	0.037	7666	2230.68
3469	0.23	8077	2230.68
3509	0.011	8132	2230.68
3576	0.054	8182	2230.68
3926	0.014	8557	2230.68
4209	0.012	8847	2230.68
4330	0.0047	8967	2230.68
4474	0.0037	9119	2230.68
4505	0.011	9152	2230.68
4923	0.00066	9584	2230.68
1665	0.0080	7762	3778.52
2368	0.0012	8491	3778.52
3016	0.0007	9152	3778.52