^{61}Ni(α,nγ),(HI,xnγ) 1978Ne02,1976Ch11

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen	NDS 178, 41 (2021).	12-Nov-2021

Includes ^{56}Fe(^{14}N,αpnγ) and ^{54}Fe(^{12}C,2pγ) from 1978Ne02; and ^{62}Ni(α,2nγ) and ^{55}Mn(^{12}C,p2nγ) from 1976Br12.

1978Ne02: ^{61}Ni(α,nγ),E(α)=14-24 MeV; ^{56}Fe(^{14}N,αpnγ), E(^{14}N)=56 MeV; ^{54}Fe(^{12}C,2pγ),E(^{12}C)=50 MeV. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma(\theta)$, excitation functions at Notre Dame FN tandem van de Graaff accelerator. Data are primarily from (α,nγ). The heavy-ion reactions were used for $\gamma\gamma$-coin data.

1976Ch11: ^{61}Ni(α,nγ),E(α)=6.4-8.0 MeV. Measured Eγ, Iγ, level half-lives by DSAM method at Lyon University Van de Graaff accelerator. Levels studied up to 3425 keV excitation energy.

1976Br12: ^{62}Ni(α,2nγ),E(α)=22-40 MeV; ^{55}Mn(^{12}C,p2nγ), E(^{12}C)=35 MeV; ^{54}Fe(^{12}C,2pγ),E(^{12}C)=35 MeV. Measured Eγ, $\gamma(\theta)$ for seven γ rays, $T_{1/2}$ of 4635 level by recoil distance method at Grenoble cyclotron facility.

Other: 1980ClZY: ^{54}Fe(^{14}N,n3pγ); ^{55}Mn(^{14}N,αnγ); ^{55}Mn(^{16}O,αp2nγ); ^{56}Fe(^{16}O,2$\alpha\gamma$): measured Eγ, $\gamma\gamma$-coin, $\gamma(\theta)$, linear polarization, level half-lives.

Additional information 1.

^{64}Zn Levels

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$[@]	Comments
0.0	0^+		
991.2 *3*	2^+	1.87 ps *+55−35*	
1798.9 *3*	2^+	1.80 ps *+55−35*	
1909.9 *6*	0^+		J$^\pi$: from 1976Ch11. $T_{1/2}$: 2.4 ps *+10−6* from 1976Ch11 seems erroneous.
2306.4 *4*	4^+	0.44 ps *+10−7*	
2609.1 *6*	(0^+)	0.97 ps *+55−35*	J$^\pi$: from 1976Ch11.
2735.9 *3*	4^+	2.1 ps *+8−5*	
2793.7 *6*	2^+[#]	<9 fs	
2979.7 *5*		>2.6 ps	$T_{1/2}$: >1.7 ps from 1180.8γ, >2.6 ps from 1988.5γ.
2998.1 *4*	3^-	>1.0 ps	
3005.5 *4*		47 fs *12*	$T_{1/2}$: weighted average of 56 fs *+17−12* from 1207γ, 22 fs *+21−16* from 2014γ, and 45 fs *+14−10*.
3077.2 *4*	4^+	1.6 ps *+10−6*	$T_{1/2}$: average of 1.4 ps *+10−6* from 771γ, 1.7 ps *+10−6* from 2086γ.
3095.1 *6*		132 fs *+28−21*	
3186.5 *6*	(1^+)[#]	0.40 ps *+21−12*	
3206.0 *6*		0.33 ps *+14−8*	
3261.7 *6*		14 fs *8*	
3296.6 *6*		312 fs *+69−55*	
3364.1? *10*	(2^+)[#]	26 fs *+19−15*	
3425.1? *10*		<10 fs	
3851.9 *5*			
3924.4 *4*	(5^-)		
3992.5 *5*	(6^+)		
4076.0 *4*	(4,5)		
4155.6 *6*	(5)		
4236.0 *5*	(6^+)		
4634.0 *5*	(7^-)	90 ps *10*	$T_{1/2}$: from recoil distance method (1976Br12).
4668.4 *5*	(5,6)		
4822.9 *7*			
4980.2 *6*	(7^-)		
5150.8 *7*	(6,7)		J$^\pi$: (7^-) in the Adopted Levels.
5624.0 *11*			
5680.3 *6*	(8^-)		E(level): with the reassignment of 1046γ in the Adopted dataset, based on results of 2004Ka18, this level corresponds to 6998, (11^-) in the Adopted Levels. J$^\pi$: $\gamma(\theta$,pol) data give 9^- or 7^-, but heavy-ion excitation favors 9^-. J=8 assignment by

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^{61}Ni(α,nγ),(HI,xnγ) 1978Ne02,1976Ch11 (continued)

^{64}Zn Levels (continued)

E(level)†	Jπ‡	Comments
		1978Ne02 not supported by 1980Si02.
5697.7 *6*		
6124.0 *7*	(9⁻)	
6764.8 *10*		E(level): level not included in the Adopted Levels since it is not confirmed in other in-beam γ-ray studies.
6940.0 *15*		E(level): with the reassignment of 1316γ from 5952 level in the Adopted dataset, based on results from 2004Ka18, this level probably corresponds to the 5952 level in the Adopted Levels.

† From a least-squares fit to Eγ data, assuming 0.5 keV uncertainty when not stated.
‡ As assigned in 1978Ne02, based on their γ(θ) data, unless otherwise noted.
# From 1976Ch11.
@ From DSAM in (α,nγ) (1976Ch11), unless otherwise indicated.

γ(^{64}Zn)

A_2 and A_4 values are from 1978Ne02, unless otherwise indicated.

E_i(level)	J_i^π	E_γ†	I_γ†	E_f	J_f^π	Mult.#	δ	Comments
991.2	2⁺	991.2 *3*	100	0.0	0⁺	E2		A_2=+0.177 *15*; A_4=−0.121 *22* (1976Br12) Eγ=991.5, Iγ=380.0 (1976Ch11). Mult.: from 1976Br12.
1798.9	2⁺	807.6 *3*	77 *5*	991.2	2⁺	M1+E2	−0.57 *+13−27*	A_2=−0.216 *26*; A_4=−0.071 *37* (1976Br12) Eγ=807.9, Iγ=100.0 (1976Ch11). Mult.,δ: from 1976Br12.
		1798.7 *4*	23 *5*	0.0	0⁺			Eγ=1799.5, Iγ=39.0 (1976Ch11).
1909.9	0⁺	918.6‡		991.2	2⁺			Eγ=918.8, Iγ=15.0 (1976Ch11).
2306.4	4⁺	1315.1 *4*	100	991.2	2⁺	E2		A_2=+0.33 *1*; A_4=−0.13 *1* A_2=+0.280 *22*; A_4=−0.123 *33* (1976Br12) Eγ=1315.2, Iγ=66.0 (1976Ch11). δ(O/Q)=−0.04 *4* (1978Ne02).
2609.1	(0⁺)	809‡@		1798.9	2⁺			
		1617.8‡		991.2	2⁺			Eγ=1617.8, Iγ=8.8 (1976Ch11).
2735.9	4⁺	429.5 *3*	10 *3*	2306.4	4⁺	M1+E2		
		936.9 *3*	90 *3*	1798.9	2⁺	E2		A_2=+0.30 *2*; A_4=−0.11 *2* A_2=+0.263 *15*; A_4=−0.135 *23* (1976Br12) Eγ=937.1, Iγ=25.0 (1976Ch11). δ(O/Q)=−0.04 *6* for J(2736)=4, +2.5 *3* for J(2736)=2 (1978Ne02).
		1745‡		991.2	2⁺			Eγ=1745, Iγ≈2.5 (1976Ch11).
2793.7	2⁺	994‡@		1798.9	2⁺			
		1802.4‡		991.2	2⁺			Eγ=1802.4, Iγ=20.0 (1976Ch11).
2979.7		1180.8‡		1798.9	2⁺			Eγ=1180.8, Iγ=10.0 (1976Ch11).
		1988.5‡		991.2	2⁺			Eγ=1988.5, Iγ=6.3 (1976Ch11).
2998.1	3⁻	2007.3 *4*	100	991.2	2⁺	D		A_2=−0.46 *4* Eγ=2006.8, Iγ=16.5 (1976Ch11). δ: δ(Q/D)=−0.2 *1* or −1.9 *6* for J(2999)=3; −1.3 *+5−30* for J(2999)=2 (1978Ne02).
3005.5		1206.8‡		1798.9	2⁺			Eγ=1206.8, Iγ=4.5 (1976Ch11).
		2013.7‡		991.2	2⁺			Eγ=2013.7, Iγ=7.5 (1976Ch11).

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^{61}Ni(α,nγ),(HI,xnγ) 1978Ne02,1976Ch11 (continued)

γ(^{64}Zn) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[#]	δ	Comments
3005.5		3005.7[‡]		0.0	0^+			Eγ=3005.7, Iγ=5.0 (1976Ch11).
3077.2	4^+	341.4 *3*	20 *5*	2735.9	4^+	M1(+E2)	<0.5	I_γ: expected I$\gamma\approx$9 (see the Adopted Gammas). δ: from RUL(E2)<300 (see the Adopted Gammas).
		770.9 *4*	52 *9*	2306.4	4^+	D+Q		A_2=+0.11 *1*; A_4=+0.02 *1* Eγ=771.5, Iγ=6.0 (1976Ch11). δ: −0.4 *1* or +1.7 *+10−5* (1978Ne02).
		2085.5 *4*	28 *8*	991.2	2^+	E2		A_2=+0.38 *2*; A_4=−0.14 *3* Eγ=2086.8, Iγ=6.0 (1976Ch11). δ(O/Q)=0.00 *7* (1978Ne02).
3095.1		2103.8[‡]		991.2	2^+			Eγ=2103.8, Iγ=9.7 (1976Ch11).
3186.5	(1^+)	1276[‡@]		1909.9	0^+			Eγ=1276, I$\gamma\approx$1.0 (1976Ch11).
		1387.6[‡]		1798.9	2^+			Eγ=1387.6, Iγ=6.0 (1976Ch11). I_γ: Iγ(1388γ)/Iγ(1278γ) low by a factor of ≈8 when compared to that in other reactions.
		2195[‡@]		991.2	2^+			Eγ=2195, I$\gamma\approx$1.5 (1976Ch11).
3206.0		1407.1[‡]		1798.9	2^+			Eγ=1407.1, Iγ=6.8 (1976Ch11).
		2214[‡@]		991.2	2^+			Eγ=2214, I$\gamma\approx$1.0 (1976Ch11).
3261.7		1462[‡@]		1798.9	2^+			Eγ=1462, I$\gamma\approx$2.0 (1976Ch11).
		2270.4[‡]		991.2	2^+			Eγ=2270.4, Iγ=4.0 (1976Ch11).
3296.6		2305.3[‡]		991.2	2^+			Eγ=2305.3, Iγ=6.5 (1976Ch11).
3364.1?	(2^+)	1566[‡@]		1798.9	2^+			Eγ=1566, I$\gamma\approx$1.5 (1976Ch11).
		2374[‡@]		991.2	2^+			Eγ=2374, I$\gamma\approx$1.0 (1976Ch11).
		3364[‡]		0.0	0^+			Eγ=3364, Iγ=2.0 (1976Ch11).
3425.1?		3425[‡]		0.0	0^+			Eγ=3425, I$\gamma\approx$1.5 (1976Ch11).
3851.9		1116.0 *4*	>99	2735.9	4^+			
3924.4	(5^-)	926.7 *4*	19 *2*	2998.1	3^-	E2		A_2=+0.37 *2*; A_4=−0.16 *3* δ(O/Q)=−0.02 *6* for J(3924)=5. δ(Q/D)=+0.4 *2* for J(3924)=4 (1978Ne02).
		1617.8 *4*	81 *2*	2306.4	4^+	D		A_2=−0.18 *2* δ(D/Q)=+0.04 *4* for J(3924)=5, −1.2 *+3−6* for J(3924)=4 (1978Ne02).
3992.5	(6^+)	1686.0 *4*	100	2306.4	4^+	Q		A_2=+0.37 *1*; A_4=−0.13 *1* A_2=+0.345 *29*; A_4=−0.174 *43* (1976Br12) δ(O/Q)=0.00 *1* for J(3993)=6. δ(Q/D)=+1.0 *1* for J(3993)=4 (1978Ne02).
4076.0	(4,5)	998.7 *3*	56 *9*	3077.2	4^+	D		A_2=−0.46 *11*; A_4=+0.08 *15* δ(Q/D)=−0.1 *2* (1978Ne02). Assignment from 4077 level (1978Ne02) shown to be incorrect by 1980Si02. But in later in-beam studies (2004Ka18,1998Ga11,1994Cr05) 1000γ is shown to deexcite the 4077 level also. It should be noted that A_2=−0.46 *11*, A_4=+0.08 *15* (1978Ne02) for 999γ are in disagreement with A_2=+0.16 *2*, A_4=−0.22 *4* from 1980Si02. So it is possible that there are two different γ rays near this energy. But the absence of 1000γ from 4077 level in (^{11}B,2npγ) (1980Si02) is inexplicable.
		1339.9 *4*	44 *9*	2735.9	4^+	D+Q		A_2=−0.32 *8*; A_4=−0.12 *8*
4155.6	(5)	1078.4 *5*		3077.2	4^+			
4236.0	(6^+)	1500.1 *4*	100	2735.9	4^+	Q		A_2=+0.41 *2*; A_4=−0.10 *2* δ(O/Q)=+0.04 *4* for J(4236)=6; δ(Q/D)=+0.5 *+3−2* for J(4236)=5, −0.2 to +1.2 for J(4236)=4 (1978Ne02).

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^{61}Ni(α,nγ),(HI,xnγ) 1978Ne02,1976Ch11 (continued)

γ(^{64}Zn) (continued)

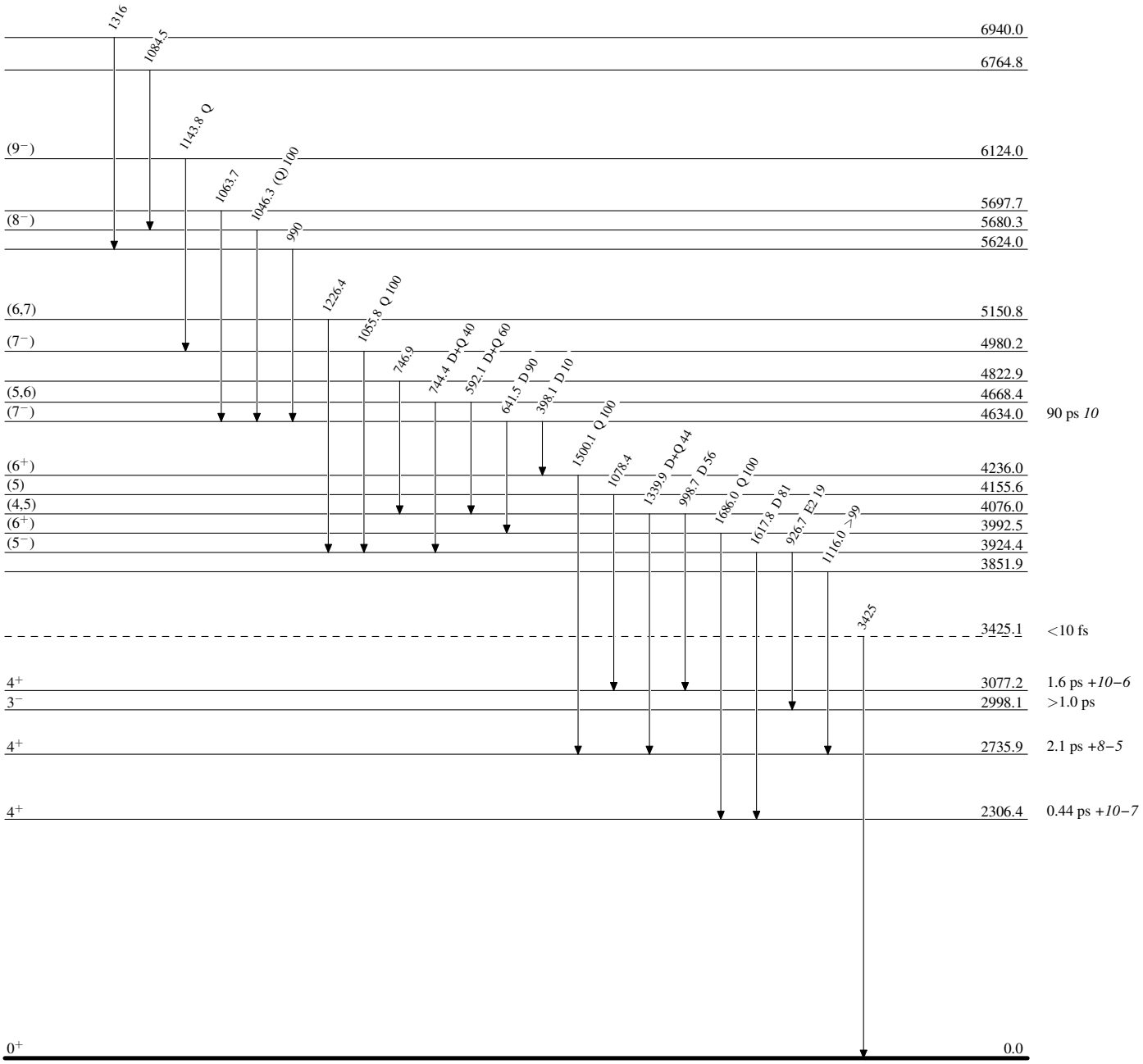
E_i(level)	J_i^π	E_γ †	I_γ †	E_f	J_f^π	Mult. #	Comments
4634.0	(7$^-$)	398.1 *3*	10 *1*	4236.0	(6$^+$)	D	A_2=−0.33 *4* δ(Q/D)=−0.04 *5* (1978Ne02).
		641.5 *3*	90 *1*	3992.5	(6$^+$)	D	A_2=−0.28 *2*; A_4=−0.03 *2* A_2=−0.343 *26*; A_4=−0.071 *37* (1976Br12) δ(Q/D)=0.00 *2* (1978Ne02).
4668.4	(5,6)	592.1 *4*	60 *25*	4076.0	(4,5)	D+Q	A_2=−0.50 *5*; A_4=+0.08 *6* δ(Q/D)=−0.14 *6* or −2.5 *7* for J(4668)=6, −0.14 *6* or −2.3 *7* for J(4668)=5 (1978Ne02).
		744.4 *5*	40 *25*	3924.4	(5$^-$)	D+Q	A_2=−0.40 *6*; A_4=+0.14 *5* δ: −0.04 *12* or −3.5 *+10−22* for J(4668)=6 (1978Ne02).
4822.9		746.9 *5*		4076.0	(4,5)		
4980.2	(7$^-$)	1055.8 *4*	100	3924.4	(5$^-$)	Q	A_2=+0.22 *2*; A_4=−0.12 *2* δ(O/Q)=−0.1 *1* for J(4980)=7; δ(Q/D)=+1.2 *2* for J(4980)=5 (1978Ne02).
5150.8	(6,7)	1226.4 *5*		3924.4	(5$^-$)		A_2=+0.55 *5*; A_4=+0.10 *6*
5624.0		990 *1*		4634.0	(7$^-$)		
5680.3	(8$^-$)	1046.3 *4*	100	4634.0	(7$^-$)	(Q)	A_2=+0.30 *1*; A_4=+0.02 *2* δ(Q/D)=+0.32 *2* for J(5680)=8, −0.25 *8* for J(5680)=7 (1978Ne02).
5697.7		1063.7 *4*		4634.0	(7$^-$)		
6124.0	(9$^-$)	1143.8 *4*		4980.2	(7$^-$)	Q	A_2=+0.45 *8*; A_4=−0.20 *9* δ(O/Q)=0.0 *1* for J(6124)=9; δ(Q/D)=−0.4 to +1.0 for J(6124)=7 (1978Ne02).
6764.8		1084.5 *7*		5680.3	(8$^-$)		
6940.0		1316 *1*		5624.0			

† From 1978Ne02 unless otherwise stated. Above 3425 keV level, data are available from 1978Ne02 only.
‡ γ from 1976Ch11; relative intensity is given under comments. Data are not available in 1978Ne02.
# From $\gamma(\theta)$ data of 1978Ne02, combined with RUL for E2 and M2, unless otherwise stated.
@ Placement of transition in the level scheme is uncertain.

^{61}Ni(α,nγ),(HI,xnγ) 1978Ne02,1976Ch11

Level Scheme

Intensities: % photon branching from each level



$^{64}_{30}Zn_{34}$

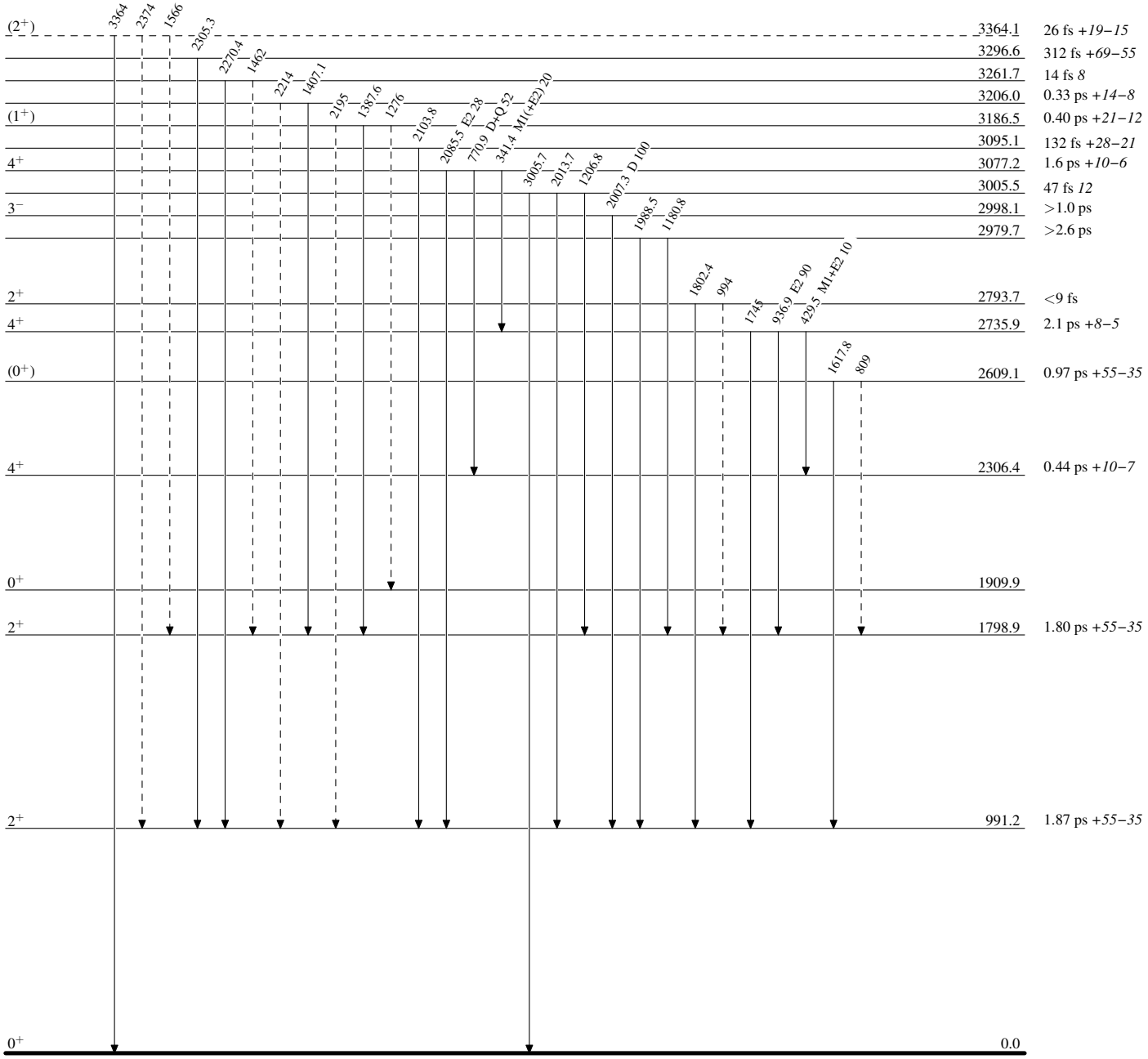
^{61}Ni(α,nγ),(HI,xnγ) 1978Ne02,1976Ch11

Legend

Level Scheme (continued)

Intensities: % photon branching from each level

γ Decay (Uncertain)

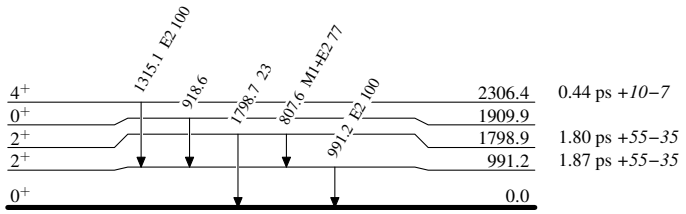


$^{64}_{30}Zn_{34}$

^{61}Ni(α,nγ),(HI,xnγ) 1978Ne02,1976Ch11

Level Scheme (continued)

Intensities: % photon branching from each level



$^{64}_{30}Zn_{34}$