Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 202,59 (2025)	25-Feb-2025

Q(β^-)=5940.6 *21*; S(n)=7464 *20*; S(p)=11505 *5*; Q(α)=−9868 *3* 2021Wa16
S(2n)=13476 *19*, S(2p)=26876 *4* (2021Wa16).
Mass measurements: 2010Fe01 (mass excess=−59185.1 *21*), 1978Ko24 (M.E.=−59168 *20*).
Additional information 1.
2010Fe01 (also 2008Bl05): E=130 MeV/nucleon ^{76}Ge beam was produced from the cyclotron at NSCL. Fragments were separated by the A1900 fragment separator and transported to the Low Energy Beam and Ion Trap (LEBIT) facility. Measured masses using the TOF ion cyclotron resonance (TOF-ICR) technique.
1994Cz02: ^{65}Fe produced from fragmentation of 500-MeV/u ^{86}Kr beam at GSI. Measured ion-β^- time correlation. Deduced half-life.
1988Bo06,1985Ru05: ^{65}Co produced by the irradiation of a natural W target with 11.5-MeV/u ^{76}Ge beam and on-line mass separation at GSI. Measured ^{65}Co $T_{1/2}$.
1978Ko24: ^{65}Co activity from ^{70}Zn(^{3}He,^{8}B) at E(^{3}He)=80.13 MeV *5*; Q3D magnetic spectrometer, proportional counters, plastic scintillator. Measured mass.
Other measurements:
2015Ro11: ^{1}H(^{208}Pb,F) E=500 MeV/nucleon at GSI. Measured fission fragments.
2015Al19: ^{2}H(^{136}Xe,X) E=500 MeV/nucleon at GSI. Measured yield and σ.
2007Na31: ^{136}Xe(p,X) E=1 GeV at GSI. Measured isotopic cross sections and kinetic energies.
2002Kr13: ^{238}U(p,F) E=30 MeV at CERN. Measured fission yields.
Theoretical calculations:
2019Ol02,2012Re11,2011Sr04: calculated levels, J, π.
2015Gu18: calculated negative-parity yrast band, high-spin states, B(E2), B(M1).

^{65}Co Levels

Cross Reference (XREF) Flags

A	^{65}Fe β^- decay (0.805 s)	D	^{238}U(^{64}Ni,Xγ)
B	^{65}Fe β^- decay (1.12 s)	E	^{238}U(^{70}Zn,xγ)
C	^{64}Ni(^{238}U,Xγ)		

E(level)[†‡]	J$^\pi$	$T_{1/2}$[a]	XREF	Comments
0.0[b]	(7/2)$^-$	1.16 s *3*	ABCDE	%β^-=100 J$^\pi$: strong allowed β^- feeding to 5/2$^-$ g.s. in ^{65}Ni; systematics of ^{61}Co and ^{63}Co and shell-model predictions prefer 7/2$^-$. $T_{1/2}$: weighted average of 1.00 s *15* (2009Pa16), 1.12 s *25* (1994Cz02), 1.14 s *3* (1988Bo06), and 1.25 s *5* (1985Ru05).
882.69 *7*	(3/2$^-$)	4 ps *4*	A CDE	XREF: C(883?) J$^\pi$: β^- feeding from (1/2$^-$) parent, less likely to be 1st forbidden unique or higher-order (ΔJ≥2); 882.65γ to (7/2)$^-$.
1095.34 *8*	(1/2$^-$)	1.250 ns *20*	A D	J$^\pi$: proposed by 2009Pa16 in ^{65}Fe β^- decay (0.805 s), based on analogy to the (1/2$^-$) proton intruder state at E=492 keV in ^{67}Co observed in 2008Pa33 of the same author, and on the fact that no γ transition is observed to (7/2)$^-$ ground state. But 2009Pa16 also state that (3/2$^-$) cannot be disregarded.
1222.76 *7*	(3/2$^-$)	55 ps *6*	A DE	J$^\pi$: E2 or M2 ruled out by RUL for 127.3γ to 1095 level if J(1095)=1/2$^-$; 1222.8γ to (7/2)$^-$.
1441.1 *4*	(5/2$^-$,7/2$^-$)[@]		B	
1479.4[b] *2*	(11/2)$^{-}$[#]	0.9 ps *4*	BCDE	XREF: C(1479?) J$^\pi$: 1479.4γ E2, ΔJ=2 to (7/2)$^-$.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{65}Co Levels (continued)

E(level)[†‡]	J^π	$T_{1/2}$[a]	XREF	Comments
				$T_{1/2}$: from Recoil-Distance Doppler-Shift (RDDS) method in (^{64}Ni,Xγ) (2013Mo36).
1557.47 *7*	(3/2$^-$,5/2,7/2$^-$)		A	J^π: 674.9γ to (3/2$^-$), 1557.4γ to (7/2)$^-$.
1625.5 *4*	(5/2$^-$,7/2$^-$)[@]		B	
1642.1 *2*	(9/2$^-$)[#]		B DE	
1948.20 *12*			A	
1959.13 *8*	(3/2$^-$)	<90 ps	A D	J^π: possible strong allowed β^- feeding from (1/2$^-$) parent; 1958.8γ to (7/2)$^-$.
1996.52 *6*	(3/2$^-$)	<90 ps	A D	J^π: possible strong allowed β^- feeding from (1/2$^-$) parent; 1996.5γ to (7/2)$^-$.
2183.83 *11*	(1/2$^-$,3/2$^-$)	<160 ps	A D	J^π: possibly allowed β^- feeding from (1/2$^-$) parent.
2276.07 *12*			A	
2443.4 *4*			B	
2470.12 *12*	(3/2$^-$,5/2,7/2$^-$)		A	J^π: 1587.4γ to (3/2$^-$), 2470.4γ to (7/2)$^-$.
2479.2[b] *2*	(11/2$^-$)		BCDE	XREF: C(2479?) J^π: proposed in 2009Pa16 in ^{65}Fe β^- decay (1.12 s) based on systematics of yrast and near-yrast levels in neighboring ^{61}Co and ^{63}Co. But possibly allowed β^- feeding from (9/2$^+$) parent would suggest π=+. As also noted in 2009Pa16, their reported values of β^- feedings are upper limits due to the possibility of unobserved γ-ray activity from high-energy level.
2557.6 *3*	(7/2$^+$,9/2$^+$)		B	J^π: possibly allowed β^- feeding from (9/2$^+$) parent; 2557.5γ to (7/2)$^-$.
2669.4[b] *2*	(13/2$^-$)	0.6 ps *4*	DE	J^π: 190.2γ D, ΔJ=1 to (11/2$^-$); (13/2$^-$) from systematics of ^{61}Co and ^{63}Co, and shell-model predictions (2009Pa16). $T_{1/2}$: from Recoil-Distance Doppler-Shift (RDDS) method in (^{64}Ni,Xγ) (2013Mo36).
2891.9 *3*	(9/2$^+$,11/2$^+$)		B D	J^π: possibly allowed β^- feeding from (9/2$^+$) parent; 412.9γ to (11/2$^-$).
2896.1 *4*	(7/2,9/2,11/2$^-$)		B	J^π: possibly β^- feeding from (9/2$^+$) parent, less likely to be 1st forbidden unique or higher order (ΔJ$\geq$2); 2896.0γ to (7/2)$^-$.
2926.3 *3*			D	
3028.7[b] *3*	(15/2$^-$)[&]		DE	
3271.5[b] *4*	(15/2$^-$,17/2$^+$)[&]		DE	

† Additional information 2.

‡ From a least-squares fit to γ-ray energies.

Proposed by 2012Re11 in (^{70}Zn,Xγ) for 1479 and 1642 levels, based on their measured $\gamma(\theta)$ and shell-model predictions. Note that the assignments are inverse in 2009Pa16 in their decay scheme of ^{65}Fe β^- decay (1.12 s), mainly based on systematics of neighboring odd-A Co isotopes. 2012Re11 claim that from their data, the intensity ratio of the 1480γ and 1643γ is completely different from those for corresponding transitions in ^{61}Co and ^{63}Co, which, together with measured R_{asym} of 1480γ suggesting ΔJ=2, indicates a spin-parity inversion for the two levels as members of the $\pi f^{-1}_{7/2}\otimes 2^+$(^{66}Ni) multiplet, compared to spin-parities of correspdoning levels in ^{61}Co and ^{63}Co.

@ From shell-model predictions, 2009Pa16 assign 1441 and 1626 levels as the candidates for the 5/2$^-$ and 7/2$^-$ members of the $\pi f^{-1}_{7/2}\otimes 2^+$ multiplet, while 1479 and 1642 levels have been assigned as the (9/2$^-$) and (11/2$^-$) member, respectively, from systematics of ^{59}Co, ^{61}Co and ^{64}Co. The assignments of 1479 and 1642 levels are inverse based on a later study by 2012Re11. See more comments at those levels.

& Proposed by 2009Pa16 based on systematics of ^{61}Co and ^{63}Co, and shell-model predictions (2009Pa16).

a From $\beta\gamma$(t) or $\beta\gamma\gamma$(t) in ^{65}Fe β^- decay (0.805 s) (2019Ol02) for excited levels, unless otherwise noted.

b Seq.(A): Sequence based on g.s.

$\gamma(^{65}Co)$

Additional information 3.

E_i(level)	J^π_i	E_γ[‡]	I_γ[‡]	E_f	J^π_f	Mult.	α[†]	Comments
882.69	(3/2⁻)	882.65 *15*	100	0.0	(7/2)⁻	[E2]	0.000296 *4*	α(K)=0.000267 *4*; α(L)=2.59×10^{-5} *4*; α(M)=3.60×10^{-6} *5* α(N)=1.599×10^{-7} *22* B(E2)(W.u.)>8.5 E_γ: other: 882.3 *7* from (^{70}Zn,xγ).
1095.34	(1/2⁻)	212.7 *1*	100	882.69	(3/2⁻)	[M1,E2]	0.018 *12*	α(K)=0.016 *11*; α(L)=0.0016 *11*; α(M)=2.3×10^{-4} *15* α(N)=9 B(M1)(W.u.)=0.001820 *30* if M1, B(E2)(W.u.)=65.1 *11* if E2.
1222.76	(3/2⁻)	127.3 *1*	4.6 *4*	1095.34	(1/2⁻)	[M1]	0.02147 *30*	α(K)=0.01926 *27*; α(L)=0.001924 *27*; α(M)=0.000268 *4* α(N)=1.171×10^{-5} *17* B(M1)(W.u.)=0.00591 *+90−77*
		340.10 *6*	100 *4*	882.69	(3/2⁻)	[M1,E2]	0.0037 *18*	α(K)=0.0033 *16*; α(L)=3.2×10^{-4} *16*; α(M)=4.5×10^{-5} *22* α(N)=1.9×10^{-6} *9* E_γ: other: 340.7 *7* from (^{70}Zn,xγ). B(M1)(W.u.)=0.00674 *+83−70* if M1, B(E2)(W.u.)=96 *+12−10* if E2.
		1222.8 *1*	46 *4*	0.0	(7/2)⁻	[E2]	0.0001496 *21*	α(K)=0.0001234 *17*; α(L)=1.189×10^{-5} *17*; α(M)=1.658×10^{-6} *23* α(N)=7.40×10^{-8} *10*; α(IPF)=1.258×10^{-5} *18* B(E2)(W.u.)=0.074 *+10−9*
1441.1	(5/2⁻,7/2⁻)	1441.1 *4*	100	0.0	(7/2)⁻			
1479.4	(11/2)⁻	1479.4 *2*	100	0.0	(7/2)⁻	E2	0.0001710 *24*	α(K)=8.24×10^{-5} *12*; α(L)=7.92×10^{-6} *11*; α(M)=1.104×10^{-6} *15* α(N)=4.94×10^{-8} *7*; α(IPF)=7.96×10^{-5} *11* B(E2)(W.u.)=5.7 *+43−18* E_γ: weighted average of 1479.5 *2* from ^{65}Fe β^- decay (1.12 s), 1479.2 *2* from (^{64}Ni,Xγ), and 1479.5 *3* from (^{70}Zn,xγ). Mult.: Q, ΔJ=2 from $\gamma(\theta)$ in (^{70}Zn,xγ); M2 ruled out by RUL.
1557.47	(3/2⁻,5/2,7/2⁻)	674.9 *1*	57 *5*	882.69	(3/2⁻)			
		1557.4 *1*	100 *9*	0.0	(7/2)⁻			
1625.5	(5/2⁻,7/2⁻)	1625.5 *4*	100	0.0	(7/2)⁻			
1642.1	(9/2⁻)	1642.0 *2*	100	0.0	(7/2)⁻			E_γ: from (^{64}Ni,Xγ). Others: 1641.9 *3* from ^{65}Fe β^- decay (1.12 s) and 1642.8 *7* from (^{70}Zn,xγ).
1948.20		1065.5 *1*	100	882.69	(3/2⁻)			
1959.13	(3/2⁻)	736.4 *1*	100 *8*	1222.76	(3/2⁻)	[M1,E2]	0.00040 *7*	α(K)=0.00036 *7*; α(L)=3.5×10^{-5} *7*; α(M)=4.9×10^{-6} *9* α(N)=2.2×10^{-7} *4* B(M1)(W.u.)>3.8×10^{-4} if M1, B(E2)(W.u.)>1.2 if E2.
		863.9 *1*	5.8 *4*	1095.34	(1/2⁻)	[M1,E2]	0.00028 *4*	α(K)=0.000248 *34*; α(L)=2.40×10^{-5} *34*; α(M)=3.3×10^{-6} *5*

$^{65}_{27}Co_{38}$-3

$\gamma(^{65}Co)$ (continued)

E_i(level)	J_i^π	E_γ‡	I_γ‡	E_f	J_f^π	Mult.	α†	Comments
								α(N)=1.49×10^{-7} *20* B(M1)(W.u.)>1.2×10^{-5} if M1, B(E2)(W.u.)>0.028 if E2.
1959.13	($3/2^-$)	1076.3 *1*	44 *5*	882.69	($3/2^-$)	[M1,E2]	0.000168 *15*	α(K)=0.000151 *14*; α(L)=1.46×10^{-5} *13*; α(M)=2.03×10^{-6} *19* α(N)=9.1×10^{-8} *8* B(M1)(W.u.)>4.9×10^{-5} if M1, B(E2)(W.u.)>0.07 if E2.
		1958.8 *5*	1.7 *4*	0.0	$(7/2)^-$	[E2]	0.000345 *5*	α(K)=4.78×10^{-5} *7*; α(L)=4.58×10^{-6} *6*; α(M)=6.39×10^{-7} *9* α(N)=2.87×10^{-8} *4*; α(IPF)=0.000292 *4* B(E2)(W.u.)>1.1×10^{-4}
1996.52	($3/2^-$)	439.1 *1*	4.47 *26*	1557.47	($3/2^-$,5/2,$7/2^-$)			
		773.8 *1*	12.1 *8*	1222.76	($3/2^-$)	[M1,E2]	0.00036 *6*	α(K)=0.00032 *5*; α(L)=3.1×10^{-5} *5*; α(M)=4.4×10^{-6} *7* α(N)=1.94×10^{-7} *32* B(M1)(W.u.)>3.5×10^{-5} if M1, B(E2)(W.u.)>0.097 if E2.
		901.2 *1*	2.37 *26*	1095.34	($1/2^-$)	[M1,E2]	0.000250 *32*	α(K)=0.000225 *28*; α(L)=2.17×10^{-5} *28*; α(M)=3.0×10^{-6} *4* α(N)=1.35×10^{-7} *17* B(M1)(W.u.)>4.1×10^{-6} if M1, B(E2)(W.u.)>0.0084 if E2.
		1113.7 *1*	36.8 *26*	882.69	($3/2^-$)	[M1,E2]	0.000157 *13*	α(K)=0.000141 *12*; α(L)=1.35×10^{-5} *12*; α(M)=1.89×10^{-6} *16* α(N)=8.4×10^{-8} *7*; α(IPF)=1.10×10^{-6} *21* B(M1)(W.u.)>3.7×10^{-5} if M1, B(E2)(W.u.)>0.049 if E2.
		1996.5 *1*	100 *11*	0.0	$(7/2)^-$	[E2]	0.000362 *5*	α(K)=4.62×10^{-5} *6*; α(L)=4.42×10^{-6} *6*; α(M)=6.17×10^{-7} *9* α(N)=2.77×10^{-8} *4*; α(IPF)=0.000310 *4* B(E2)(W.u.)>0.0076
2183.83	($1/2^-$,$3/2^-$)	626.4 *2*	2.9 *7*	1557.47	($3/2^-$,5/2,$7/2^-$)			
		960.8 *3*	100 *14*	1222.76	($3/2^-$)	[M1,E2]	0.000216 *24*	α(K)=0.000194 *22*; α(L)=1.88×10^{-5} *22*; α(M)=2.62×10^{-6} *30* α(N)=1.17×10^{-7} *13* B(M1)(W.u.)>1.1×10^{-4} if M1, B(E2)(W.u.)>0.2 if E2.
		1088.5 *1*	26.4 *22*	1095.34	($1/2^-$)	[M1,E2]	0.000164 *15*	α(K)=0.000148 *13*; α(L)=1.42×10^{-5} *13*; α(M)=1.98×10^{-6} *18* α(N)=8.9×10^{-8} *8* B(M1)(W.u.)>1.8×10^{-5} if M1, B(E2)(W.u.)>0.025 if E2.
2276.07		1053.3 *1*	100	1222.76	($3/2^-$)			
2443.4		2443.3 *4*	100	0.0	$(7/2)^-$			
2470.12	($3/2^-$,5/2,$7/2^-$)	1587.4 *1*	100 *6*	882.69	($3/2^-$)			
		2470.4 *5*	31 *6*	0.0	$(7/2)^-$			
2479.2	($11/2^-$)	836.9 *3*	57 *14*	1642.1	($9/2^-$)			E_γ: weighted average of 836.6 *2* from ^{65}Fe β^- decay (1.12 s) and 837.1 *2* from (^{64}Ni,Xγ).

$^{65}_{27}Co_{38}$-4

Adopted Levels, Gammas (continued)

$\gamma(^{65}Co)$ (continued)

E_i(level)	J^π_i	E_γ‡	I_γ‡	E_f	J^π_f	Mult.	α†	Comments
								I_γ: weighted average of 78 *17* from ^{65}Fe β^- decay (1.12 s) and 48 *11* from (^{64}Ni,Xγ).
2479.2	(11/2$^-$)	999.9# *2*	100# *8*	1479.4	(11/2)$^-$			E_γ: others: 999.7 *3* from ^{65}Fe β^- decay (1.12 s) and 1000.4 *6* from (^{70}Zn,xγ). I_γ: other: 100 *11* from ^{65}Fe β^- decay (1.12 s).
2557.6	(7/2$^+$,9/2$^+$)	2557.5 *3*	100	0.0	(7/2)$^-$			
2669.4	(13/2$^-$)	190.2 *2*	41 *5*	2479.2	(11/2$^-$)	(M1)	0.00766 *11*	α(K)=0.00688 *10*; α(L)=0.000681 *10*; α(M)=9.50×10^{-5} *14* α(N)=4.18×10^{-6} *6* B(M1)(W.u.)=1.6 *+17−7* E_γ: weighted average of 190.1 *2* from (^{64}Ni,Xγ) and 190.5 *3* from (^{70}Zn,xγ). I_γ: weighted average of 38 *7* from (^{64}Ni,Xγ) and 43 *5* from (^{70}Zn,xγ). Mult.: D, ΔJ=1 from $\gamma(\theta)$ in (^{70}Zn,xγ); $\Delta\pi$=(no) from level scheme. B(M1)(W.u.)=1.6 *+17−7* upper bound exceeds RUL=3.
		1190.0# *2*	100# *8*	1479.4	(11/2)$^-$	[M1,E2]	0.000142 *11*	α(K)=0.000122 *9*; α(L)=1.18×10^{-5} *9*; α(M)=1.64×10^{-6} *12* α(N)=7.3×10^{-8} *5*; α(IPF)=6.4×10^{-6} *11* E_γ,I_γ: Other: 1190.5 *9* with Iγ=100 *14* from (^{70}Zn,xγ). B(M1)(W.u.)=0.015 *+16−6* if M1, B(E2)(W.u.)=18 *+19−8* if E2.
2891.9	(9/2$^+$,11/2$^+$)	412.9# *5*	12 *6*	2479.2	(11/2$^-$)			E_γ: other: 413.0 *10* from ^{65}Fe β^- decay (1.12 s).
		1412.5 *2*	100 *14*	1479.4	(11/2)$^-$			E_γ: not seen in (^{64}Ni,Xγ).
2896.1	(7/2,9/2,11/2$^-$)	2896.0 *4*	100	0.0	(7/2)$^-$			
2926.3		447.1# *2*	100	2479.2	(11/2$^-$)			
3028.7	(15/2$^-$)	359.3 *2*	100	2669.4	(13/2$^-$)			E_γ: weighted average of 359.2 *2* from (^{64}Ni,Xγ) and 359.3 *2* from (^{70}Zn,xγ).
3271.5	(15/2$^-$,17/2$^+$)	242.8# *2*	100	3028.7	(15/2$^-$)			E_γ: other: 242.7 *2* from (^{70}Zn,xγ).

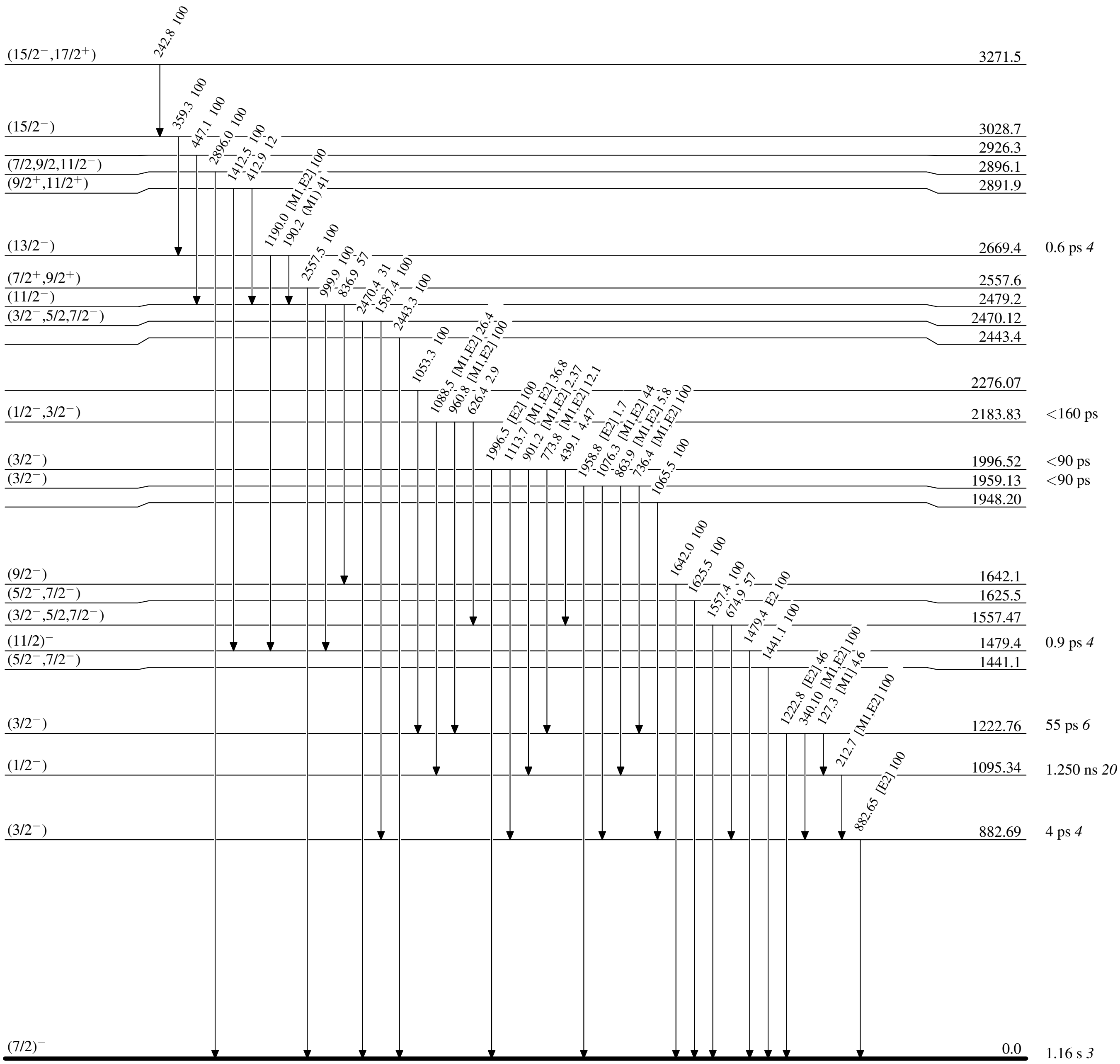
† Additional information 4.
‡ From ^{65}Fe β^- decay (0.805 s) or ^{65}Fe β^- decay (1.16 s) (2009Pa16), unless otherwise noted.
# From ^{238}U(^{64}Ni,Xγ).

$^{65}_{27}Co_{38}$-5

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



Adopted Levels, Gammas