^{65}Ni β^- decay (2.5175 h) 1987Ju05,1990Lo03,1973Ra10

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

Parent: ^{65}Ni: E=0; J$^\pi$=5/2$^-$; T$_{1/2}$=2.5175 h *5*; Q(β^-)=2137.9 *7*; %β^- decay=100

^{65}Ni-J$^\pi$,T$_{1/2}$: From Adopted Levels.

^{65}Ni-Q(β^-): From 2021Wa16.

1987Ju05: ^{65}Ni source was produced from irradiation of enriched ^{64}Ni metal with thermal neutrons at Technabsexport, USSR. β particles were detected with a gas-flow proportional counter; γ rays were detected with two co-axial Ge detectors. Measured Eγ, Iγ, Iβ, β(t), 4$\pi\beta\gamma$-coin. Deduced parent T$_{1/2}$, relative γ-ray emission probabilities and absolute emission probabilites for 1482γ.

1973Ra10: ^{65}Ni source was from ^{64}Ni(n,γ). Measured Eγ, Iγ with a Ge(Li) detector. Deduced levels, β-decay branching ratios, log *ft*.

1990Lo03: ^{65}Ni source was produced by ^{65}Ni(n,γ) with thermal neutrons from the CONSORT II reactor on an enriched ^{64}Ni target. β particles were detected with a beta detector and γ rays were detected with Ge(Li) detectors. Measured Eγ, Iγ, Iβ, 4$\pi\beta\gamma$-coin. Deduced relative and absolute γ-ray emission probabilies. Comparisons with available data.

1971Me14,1980RuZY: ^{65}Ni source was from ^{64}Ni(n,γ) at the NRU rabbit facility, Canada. Measured Eγ, Iγ, Iβ^-, β(t), 4$\pi\beta\gamma$-coin. Deduced parent T$_{1/2}$, absolute emission probability of 1482γ.

Additional information 1.

1972Pa30: ^{65}Ni source was from ^{64}Ni(n,γ) with neutrons from the the 5 MV reactor of DEMOCRITOS NRC. γ rays were detected with a Ge(Li) and a NaI(Tl) detector. Measured Eγ, Iγ, $\gamma\gamma$-coin. Deduced levels, β-decay branching ratios, absolute γ-ray emission probabilies based an known value of %Iβ(g.s.)=58.

1972Co31: ^{65}Ni source was from ^{64}Ni(n,γ) with thermal neutrons from the Brookhaven High Flux Beam Reactor (HFBR). γ rays were detected with Ge(Li) detectors. Measured Eγ, Iγ, $\gamma\gamma$-coin. Deduced relative and absolute γ-ray emission probabilies, with the latter deduced by the authors based on an assumption of a combined yield of 45.5% for 366γ, 1116γ and 1482γ.

1963Cl06: ^{65}Ni source was from ^{64}Ni(n,γ) with thermal neutrons from the Materials Testing Reactor of National Reactor Testing Station in Idaho. γ rays were detected with NaI(Tl) detectors; β particles were detected with a 4π β-flow proportional counter. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$, 4$\pi\beta\gamma$-coin, β(t). Deduced parent T$_{1/2}$, relative and absolute γ-ray emission probabilies, with the latter determined by comparions of relative γ-ray intensities with absolute disintegration from 4$\beta\gamma$-coin measurements.

1976Kr09: ^{65}Ni source was from ^{64}Ni(n,γ) with thermal neutrons from the Los Alamos Omega West Reactor. γ rays were detected with a Ge(Li) detector. Measured Eγ, Iγ, $\gamma(\theta)$. Deduced γ-ray multipolarties and mixing ratios.

1968Re04: measured ^{65}Ni T$_{1/2}$ at ORNL.

1968At03,1969Be28: measured β-γ circular polarization correlations for 1116γ at the Lawrence Radiation Laboratory, Livermore.

1977Ba64: ^{65}Ni T$_{1/2}$ at JAERI.

1965Sp07: ^{65}Ni source was from irradiation of 99.98% purified metallic Ni with neutrons from the FiR-1 reactor at Otaniemi, Finland. γ rays were detected with NaI(Tl) and Ge(Li) detectors. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$. Deduced levels, J, π, γ-ray multipolarities, mixing ratios, and absolute emission probabilies by assuming %Iβ(g.s.)=57 taken from 1949Si21.

1964Fr04: measured Eγ, Iγ, Eβ^-, Iβ^- with a magnetic spectrometer for β particles and a NaI for γ rays at the Nuclear Research Institute, Czechosl. Acad. Sci., Rez. Deduced absolute γ-ray emission probabilies by comparion of γ-ray intensities with measured total number of decays.

1960Ja16: measured Eγ, Iγ, $\gamma\gamma(\theta)$ using NaI(Tl) detectors at the Atomic Energy Establishment, India. Deduced levels, J, π, γ-ray multipolarities, and absolute γ-ray emission probabilies based on %Iβ(g.s.)=57 taken from 1949Si21.

1960Ri06: measured Eγ, Iγ, γ(t) with a NaI(Tl) detector at the Instituut voor Kernphysisch Onderzoek in Amsterdam. Deduced parent T$_{1/2}$, relative γ-ray emission probabilities.

Others: 1949Si21, 1958Ha11, 1962Ba27, 1964Ma05, 1972RaZN.

The decay scheme is considered fairly complete by the evaluator.

^{65}Cu Levels

E(level)[†‡]	J$^\pi$[#]	T$_{1/2}$[#]	Comments
0	3/2$^-$		
770.63 *13*	1/2$^-$	101 fs *6*	
1115.55 *3*	5/2$^-$	0.285 ps *11*	J$^\pi$: 5/2$^-$ from $\beta\gamma$(CP) in 1969Be28; spin=5/2 from $\gamma\gamma(\theta)$ in 1960Ja16, 1963Cl06, 1965Sp07.

Continued on next page (footnotes at end of table)

^{65}Ni β^- decay (2.5175 h) 1987Ju05,1990Lo03,1973Ra10 (continued)

^{65}Cu Levels (continued)

E(level)[†‡]	J^{π}[#]	$T_{1/2}$[#]	Comments
1481.83 *4*	7/2$^-$	0.45 ps *+11−9*	J^{π}: spin=7/2 from $\gamma\gamma(\theta)$ in 1960Ja16, 1965Sp07.
1623.44 *5*	5/2$^-$	0.86 ps *+31−20*	J^{π}: spin=3/2,5/2 from $\gamma\gamma(\theta)$ in 1965Sp07.
1724.98 *5*	3/2$^-$	77 fs *+17−13*	J^{π}: spin=5/2 from $\gamma\gamma(\theta)$ in 1965Sp07 is inconsistent.

† Additional information 2.
‡ From a least-squares fit to γ-ray energies.
# From Adopted Levels. Supporting arguments for J^{π} from this dataset are given under comments where available.

β^- radiations

av Eβ: Additional information 3.

E(decay)	E(level)	Iβ^-[†‡]	Log *ft*	Comments
(412.9 *12*)	1724.98	0.546 *8*	5.93 *1*	av Eβ=128.06 *25*
(514.5 *12*)	1623.44	0.854 *10*	6.06 *1*	av Eβ=165.51 *26*
(656.1 *12*)	1481.83	28.36 *17*	4.919 *5*	av Eβ=220.22 *28* E(decay): measured value: 650 *30* from 1964Fr04 with %Iβ=30 *5*.
(1022.4 *12*)	1115.55	10.32 *9*	6.072 *5*	av Eβ=371.26 *30* E(decay): measured value: 1020 *25* from 1964Fr04 with %Iβ=11 *3*.
(2137.9 *16*)	0	59.19 *19*	6.595 *2*	av Eβ=874.03 *33* E(decay): measured value: 2140 *10* from 1964Fr04 with %Iβ=58 *5*. Iβ^-: from 100−Σ%I(β to excited level). Other: 58 *5* from measured β intensity compared to the measured total number of decays (1964Fr04).

† From γ+ce intensity imbalance at each level for excited levels.
‡ Absolute intensity per 100 decays.

γ(^{65}Cu)

Iγ normalization: From absolute %Iγ(1482)=23.59 *14*, determined using 4$\pi\beta\gamma$-coin (1987Ju05). Other: 21.95 *28* (1990Lo03), 23.5 *8* (1971Me14), 25.0 *20* (1963Cl06), 24 (1964Fr04). Note that the value in 1990Lo03 is lower than values from other studies. 1990Lo03 mention this discrepancy but state that it cannot be resolved in their work. The evaluator has adopted the value from 1987Ju05 which agrees with most of other studies.

E_γ[‡]	I_γ[#a]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ[@&]	α[†]	Comments
344.9[b]	0.0040 *4*	1115.55	5/2$^-$	770.63	1/2$^-$				%Iγ=9.4×10^{-4} *10* E$_\gamma$,I$_\gamma$: tentatively placed in 1973Ra10 only.
366.27 *3*	20.15 *15*	1481.83	7/2$^-$	1115.55	5/2$^-$	M1+E2	−0.03 *1*	2.02×10^{-3} *3*	%Iγ=4.75 *5* α(K)=0.001810 *25*; α(L)=0.0001812 *25*; α(M)=2.55×10^{-5} *4* α(N)=7.74×10^{-7} *11* E$_\gamma$: others: 366.3 *1* (1972Pa30), 366.4 *3* (1972Co31), 365 *5* (1963Cl06), 366 *1* (1965Sp07), 370 *5* (1964Fr04). I$_\gamma$: weighted average of 20.37 *22* (1987Ju05), 20.15 *14* (1990Lo03), 20.2 *6* (1973Ra10), 18.6 *8* (1972Pa30), 18 *1* (1963Cl06), 21 *2* (1960Ri06), 12 *5* with Ge(Li) and 17 *5* with NaI(Tl) (1965Sp07), 19 *3* (1972Co31). Others: 19 (1960Ja16), 19 (1964Fr04). δ: value from this dataset: −0.033 *30* from measured $\gamma(\theta)$ anisotropy from oriented nuclei (1976Kr09). Additional information 4. 366γ-1116$\gamma(\theta)$: A$_2$=+0.189 *5*, A$_4$=+0.013 *8* (1963Cl06); A$_2$=+0.172 *6*, A$_4$=+0.013 *10* (1965Sp07).
507.9 *1*	1.216 *10*	1623.44	5/2$^-$	1115.55	5/2$^-$	M1+E2	+0.20 *3*	0.000980 *17*	%Iγ=0.2869 *29* α(K)=0.000880 *15*; α(L)=8.76×10^{-5} *15*; α(M)=1.232×10^{-5} *21* α(N)=3.75×10^{-7} *6* E$_\gamma$: from 1972Pa30. Others: 507.8 *2* (1973Ra10), 507.8 *6* (1972Co31), 509 *7* (1963Cl06), 508 *10* (1965Sp07), 510 *5* (1964Fr04). I$_\gamma$: weighted average of 1.240 *19* (1987Ju05), 1.21 *1* (1990Lo03), 1.28 *8* (1973Ra10), 1.15 *5* (1972Pa30), 1.5 *2* (1963Cl06), 1.9 *5* with NaI(Tl) (1965Sp07), 1.1 *3* (1972Co31). Others: 0.5 (1960Ja16), 1.5 (1964Fr04). 507γ-1116$\gamma(\theta)$: A$_2$=−0.200 *35*, A$_4$=−0.013 *57* (1965Sp07). δ: −2.8 *2* or +0.20 *3* reported in 1976Kr09, from re-analysis of $\gamma\gamma(\theta)$ data of 1965Sp07. $\gamma(\theta)$ anisotropy from 1976Kr09 favors +0.20 *3*, which is adopted in Adopted Gammas.
609.5 *1*	0.674 *21*	1724.98	3/2$^-$	1115.55	5/2$^-$	[M1+E2]	<0.5	0.00067 *4*	%Iγ=0.159 *5*

From ENSDF

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

E_γ[‡]	I_γ[#a]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ[@&]	α[†]	Comments
									α(K)=0.000602 *33*; α(L)=5.98×10^{-5} *34*; α(M)=8.4×10^{-6} *5* α(N)=2.56×10^{-7} *14* E_γ: 1972Pa30. Others: 609.3 *2* (1973Ra10), 609.8 *5* (1972Co31), 611 *7* (1963Cl06), 608 *10* (1965Sp07), 610 *5* (1964Fr04). I_γ: weighted average of 0.655 *17* (1987Ju05), 0.73 *2* (1990Lo03), 0.624 *36* (1973Ra10), 0.57 *5* (1972Pa30), 1.0 *2* (1963Cl06), 0.6 *3* with NaI(Tl) (1965Sp07), 0.6 *2* (1972Co31). Others: 0.2 (1960Ja16), 0.9 (1964Fr04). 610γ-1116$\gamma(\theta)$: A_2=0.209 *69*, A_4=−0.160 *111* (1965Sp07). Additional information 5.
710[b] *10*	<0.024	1481.83	7/2$^-$	770.63	1/2$^-$				%Iγ<0.0057 E_γ,I_γ: from 1963Cl06 only.
770.6 *2*	0.395 *16*	770.63	1/2$^-$	0	3/2$^-$	M1+E2	0.099 *6*	0.000384 *5*	%Iγ=0.093 *4* α(K)=0.000345 *5*; α(L)=3.41×10^{-5} *5*; α(M)=4.80×10^{-6} *7* α(N)=1.470×10^{-7} *21* E_γ: others: 770.7 *3* (1972Pa30), 771.0 *10* (1972Co31), 770 *10* (1963Cl06). I_γ: weighted average of 0.439 *30* (1987Ju05), 0.44 *4* (1990Lo03), 0.380 *16* (1973Ra10), 0.3 *1* (1963Cl06), 0.3 *1* (1972Co31). Others: 0.28 *3* (1972Pa30) (outlier), ≈0.3 (1960Ja16), <0.13 (1964Fr04).
852.7 *2*	0.331 *20*	1623.44	5/2$^-$	770.63	1/2$^-$				%Iγ=0.078 *5* E_γ: others: 852.7 *3* (1972Pa30), 852.8 *10* (1972Co31), 855 *10* (1963Cl06), 855 *10* (1965Sp07). I_γ: weighted average of 0.41 *5* (1987Ju05), 0.40 *5* (1990Lo03), 0.340 *16* (1973Ra10), 0.26 *3* (1972Pa30), 0.3 *1* (1963Cl06), 1.0 *5* with NaI(Tl) (1965Sp07), 0.2 *1* (1972Co31). Others: ≈0.2 (1960Ja16), <0.13 (1964Fr04).
954.5 *3*	<0.015	1724.98	3/2$^-$	770.63	1/2$^-$				%Iγ<0.0035 E_γ: others: 954.5 (1990Lo03), 960 (1963Cl06), 950 (1960Ja16). I_γ: others: 0.040 *4* (1973Ra10), <0.024 (1963Cl06), ≈0.1 (1960Ja16).
1115.53 *4*	65.8 *2*	1115.55	5/2$^-$	0	3/2$^-$	M1+E2	−0.34 *5*	0.0001833 *27*	%Iγ=15.52 *11* α(K)=0.0001639 *24*; α(L)=1.615×10^{-5} *24*; α(M)=2.271×10^{-6} *33* α(N)=6.97×10^{-8} *10*; α(IPF)=9.61×10^{-7} *18* E_γ: others: 1115.5 *1* (1972Pa30), 1115.4 *3* (1972Co31), 1114 *3* (1963Cl06), 1117 *2* (1965Sp07), 1115 *5* (1964Fr04). I_γ: weighted average of 65.4 *4* (1987Ju05), 66.0 *2* (1990Lo03), 64.4 *16* (1973Ra10), 60.0 *25* (1972Pa30), 63 *3* (1963Cl06), 63 *5*

From ENSDF

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

E_γ[‡]	I_γ[#a]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ[@&]	α[†]	Comments
									with Ge(Li) and 58 *5* with NaI(Tl) (1965Sp07), 63 *7* (1972Co31). Others: 64 (1960Ri06), 48 (1960Ja16), 71 (1964Fr04). δ: value from this dataset: −0.4 *+2−1* from measured $\gamma(\theta)$ anisotropy from oriented nuclei (1976Kr09). $\beta\gamma$(CP) data, asymmetry A=0.23 *4* (1968At03) and A=0.292 *37* (1969Be28) consistent with a 5/2−(β^-)5/2−(γ)3/2$^-$ cascade.
1481.84 *5*	100	1481.83	7/2$^-$	0	3/2$^-$	E2		0.0001922 *27*	%Iγ=24 α(K)=0.0001008 *14*; α(L)=9.92×10^{-6} *14*; α(M)=1.395×10^{-6} *20* α(N)=4.27×10^{-8} *6*; α(IPF)=8.00×10^{-5} *11* E_γ: others: 1481.9 *1* (1972Pa30), 1481.7 *3* (1972Co31), 1480 *5* (1963Cl06), 1483 *3* (1965Sp07), 1480 *5* (1964Fr04).
1623.42 *6*	2.07 *3*	1623.44	5/2$^-$	0	3/2$^-$	M1+E2	−0.75 *+30−45*	0.000208 *9*	%Iγ=0.488 *8* α(K)=8.07×10^{-5} *16*; α(L)=7.92×10^{-6} *16*; α(M)=1.114×10^{-6} *23* α(N)=3.43×10^{-8} *7*; α(IPF)=0.000118 *7* E_γ: others: 1623.5 *2* (1972Pa30), 1622.6 *5* (1972Co31), 1625 *10* (1963Cl06), 1625 *3* (1965Sp07), 1620 *10* (1964Fr04). I_γ: weighted average of 2.11 *6* (1987Ju05), 2.06 *2* (1990Lo03), 2.08 *8* (1973Ra10), 1.88 *12* (1972Pa30), 2.8 *4* (1963Cl06), 2.4 *2* (1960Ri06), 1.5 *5* with Ge(Li) and 4 *1* with NaI(Tl) (1965Sp07), 2.1 *5* (1972Co31). Others: 3.4 (1960Ja16), 2.1 (1964Fr04). Mult.,δ: D+Q and δ from measured $\gamma(\theta)$ anisotropy from oriented nuclei (1976Kr09). The same value is adopted in Adopted Gammas.
1724.92 *6*	1.63 *1*	1724.98	3/2$^-$	0	3/2$^-$	M1+E2	0.32 *5*	0.0002269 *34*	%Iγ=0.3845 *33* α(K)=7.092×10^{-5} *99*; α(L)=6.96×10^{-6} *10*; α(M)=9.79×10^{-7} *14* α(N)=3.01×10^{-8} *4*; α(IPF)=0.0001480 *23* Mult.,δ: D+Q and δ=−0.15 *+31−35* or <−4.6 or >+2.3 from measured $\gamma(\theta)$ anisotropy from oriented nuclei (1976Kr09). Adopted in Adopted Gammas. E_γ: others: 1725.0 *2* (1972Pa30), 1725.2 *5* (1972Co31), 1724 *10* (1963Cl06), 1725 *3* (1965Sp07), 1720 *10* (1964Fr04). I_γ: weighted average of 1.69 *5* (1987Ju05), 1.62 *1* (1990Lo03), 1.68 *8* (1973Ra10), 1.61 *10* (1972Pa30), 1.8 *2* (1963Cl06), 2.2 *2* (1960Ri06), 1.4 *5* with Ge(Li) and 2.5 *5* with NaI(Tl) (1965Sp07), 1.7 *5* (1972Co31). Others: 2.1 (1960Ja16), 1.9 (1964Fr04).

† Additional information 6.
‡ From 1973Ra10, except as noted.
\# Relative intensity from 1987Ju05, unless otherwise noted. For values from 1972Co31, no uncertainty is given by the authors and the quoted uncertainties are

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γ(^{65}Cu) (continued)

estimated by the evaluator based on those for absolute intensities as listed in Table I of 1972Co31.

[@] From Adopted Gammas. Supporting arguments and values from this data are given under comments where available.

[&] Additional information 7.

[a] For absolute intensity per 100 decays, multiply by 0.2359 *14*.

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

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^{65}Ni β^- decay (2.5175 h) 1987Ju05,1990Lo03,1973Ra10