^{147}Nd β^- decay (11.03 d) 2020Ke08,1997Sa53,1979Se05

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	N. Nica and B. Singh	NDS 181, 1 (2022)	9-Mar-2022

Parent: ^{147}Nd: E=0.0; J$^\pi$=5/2$^-$; T$_{1/2}$=11.03 d *3*; Q(β^-)=895.2 *6*; %β^- decay=100.0

^{147}Nd-J$^\pi$: spin from atomic-beam method (1961Ca07,1960Ca03); 5/2$^-$ from L=3 and analyzing power A$_y(\theta)$ in (pol d,t) from 0$^+$ target (1977St23).

^{147}Nd-T$_{1/2}$: weighted average (NRM) of 11.26 d *1* (2019Br01, decay curve for 91.1-keV γ, also 11.27 d *2* from decay curve for 120.5-keV γ, uncertainty gets increased to 0.11 d in averaging procedure, note that no details are given in the paper about counting losses and systematic uncertainties); 10.98 d *1* (1971Ba28, proportional counter, uncertainty gets increased to 0.03 d in the averaging procedure); 11.02 d *5* (1963Ho15, proportional counter); 11.14 d *6* (1960Al33, β counting); and 11.06 d *4* (1957Wr37, ionization chamber). Regular weighted average is 11.12 d *7*, but with reduced χ^2=100, which implies a discrepant dataset, primarily due to the value in 2019Br01. Unweighted average is 11.09 d *9*. NRM=Normalized Residuals Method. Other (less precise) measurements: 11.2 d *2* (1999Po32, from decay curve for γ rays, 95% confidence level, no details provided); 11.5 d *5* (1960Wi10, proportional counter); 11.9 d *3* (1952Ru10, β with magnetic spectrometer); 11.1 d *5* (1951Em23, β spectrometer); 11.6 d *3* (1951Ko01,1952Ko27, β spectrometer); 11.0 d *3* (1951MaZZ, 1947Ma28, integral β,γ counting); 11.1 d *2* (1946Bo25). Weighted average (NRM) of all the values is 11.05 d *3*, with the same inflation of uncertainties for values from 2019Br01 and 1971Ba28 as above. Regular weighted average is 11.12 d *5*, but with reduced χ^2=37. Unweighted average is 11.24 d *21*.

^{147}Nd-Q(β^-): from 2021Wa16.

The ^{147}Nd isotope was identified by 1946Bo25 in ^{146}Nd(n,γ),E=thermal reaction, with measurement of its half-life as 11.1 d *2*, in agreement with the recommended value of 11.03 d *3*. Earlier, 1941La01 (also 1942Ku03) had identified a 10-d activity in neodymium formed by bombarding Pr, Nd and Sm metals by α particles, 10-MeV deuterons, neutrons and γ rays. From current half-life values for Nd isotopes, this activity could only belong to ^{147}Nd. Firm confirmation for the isotopic assignment of 11-d activity to ^{147}Nd was made by 1947Ma28.

^{147}Nd source was prepared using ^{146}Nd(n,γ),E=thermal reaction in almost all the studies.

Note: this decay is important in fission yield determinations, reactor applications and in monitoring activity from long-lived fission fragments, such as by the CTBTO group. In particular, precise and accurate emission probability of the 531-keV gamma ray is needed for such applications. To address this requirement, recent experiments to measure absolute intensities (per 100 decays of ^{147}Nd) have been carried out at three laboratories: LNHB-CEA, Saclay; LLNL + Texas A&M + ANL collaboration; and NPL, UK. However, final results are available only from LNHB-CEA, Saclay work in 2020Ke08, which are included in the present evaluation. Preliminary results are available from LLNL in 2020KoZZ report, which are also listed here in comments. In October 2021, evaluator also received preliminary results from NPL, UK experiment through a private communication, but these results are not listed here. We hope to revisit the evaluation of this decay when final results from 2020KoZZ, and from NPL, UK become available in open literature.

Previous ENSDF/Nuclear Data Sheets evaluations: 2009Ni02, 1992De38, 1978Ha22, 1967Ew01.

2013BeZP: DDEP evaluation of ^{147}Nd decay, with a literature coverage up to March 2011. The evaluation presented in this dataset differs in many ways from the DDEP evaluation.

Main references for Eγ, Iγ, $\gamma(\theta)$ and $\gamma\gamma(\theta)$ data:

2020Ke08: ^{147}Nd source produced in ^{146}Nd(n,γ) at the SmallBeBe facility in Delft, followed by separation and purification procedure using High Performance Liquid Chromatography (HPLC) coupled with an Inductively Coupled Plasma Mass Spectrometer (ICPMS) at CEA-Saclay. Absolute activity of the source was measured at CEA-Saclay by two methods: 1. 4$\pi\beta$-coin using liquid scintillator for β and NaI(Tl) detector for γ radiation; 2. 4$\pi\gamma$ counting using a well-type NaI(Tl) detector. High-resolution γ spectra were measured for two sets of six sources each one (series 1) using activity before purification and the other (series 2) after purification using a 100 cm^3 HPGe detector, calibrated in efficiency to 0.4% above 100 keV and 1-2% below 100 keV. Weighted averages of the two sets of absolute photon intensities were reported for K$_{\alpha2}$, K$_{\alpha1}$, K$_{\beta1}$ and Kβ_2 x-rays, and 22 γ rays from 91 to 686 keV, including two extremely weak γ rays of 357.7 and 366.5 keV, and with no evidence for the existence of 80.82, 117.9, 159.7, 240.5 and 649.0 γ rays reported in 1997Sa53. The 80.82γ was interpreted as an escape peak of the strong 91.1γ. Absolute intensities of K$_\alpha$ and K$_\beta$ x-rays were also measured. Results from this work have been included in the present evaluation.

2020KoZZ: LLNL, Texas A&M and ANL collaboration. Mass-separated ^{147}Nd ion beam produced in fission by the CARIBU facility at ANL was implanted on a thin carbon foil. Measured β, ce, γ, $\beta\beta$-coin using a 4π gas proportional counter for β and ce (developed at LLNL), an HPGe detector with a superior efficiency response determination to 0.5% in Eγ=50-2000 keV region at Texas A&M. GEANT4 simulations were carried out for the detector systems. From $\beta\gamma$-coin, total β activity, and efficiency curves

^{147}Nd β^- decay (11.03 d) 2020Ke08,1997Sa53,1979Se05 (continued)

for γ and β detection, absolute photon intensities were determined for 12 strong γ rays from 91.1 to 695.9 keV, with 0.4% precision for the 531γ and 1.4% for the 91.1γ. Earlier results were also reported in Ph.D. thesis by A.M. Hennessy (University of California, Irvine, 2018). Results from this work have been quoted in comments, as these are still at a preliminary stage.

1997Sa53: measured Eγ, Iγ, E(ce), I(ce) using HPGe and miniorange spectrometer. A total of 27 γ rays were reported based on singles data only. Evaluator has omitted six of these in this dataset, as these were either not confirmed in complementary decay or in-beam γ-ray studies, or were too low in energy resulting in severe transition-intensity imbalances.

1995Go44: measured Eγ, Iγ, $\gamma\gamma$-coin. Total of 15 γ rays reported.

1983Li19: measured Eγ, Iγ. Total of 24 γ rays observed.

1980Ch38: measured Eγ, Iγ. Total of 14 γ rays observed.

1979Se05: measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$ using Ge(Li) detectors; deduced mixing ratios. Total of 22 γ rays reported.

1979Vo09 (also 1975VoZR): measured Eγ, Iγ, β, ce, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$. A total of 14 γ rays were reported. The γ-ray energies were measured with reference to previous Eγ values from curved-crystal diffraction spectrometer (1967Hi04).

1977Al34: measured $\gamma(\theta$,t) from polarized ^{147}Nd nuclei, and using low temperature orientation method. Also measured $\gamma\gamma(\theta)$ using Ge and Ge(Li) detectors; deduced J^π and mixing ratios.

1974HeYW (Atlas of γ rays): measured Eγ, Iγ of 14 γ rays.

1974Ra30: measured Eγ, Iγ using Ge(Li) detector, and sum-coin spectrometer using NaI(Tl) detectors. A total of 13 γ rays reported from Ge(Li) singles data, and another 19 reported from sum-coincidence. None of the latter 19 γ rays has been confirmed in other studies, thereby rejecting levels proposed at 182, 228, 275, 319 and 725 keV.

1971Si20: measured Eγ, Iγ, level half-lives by $\beta\gamma$(t) and $\gamma\gamma$(t). Total of 16 γ rays reported. A 723 level decaying by a 312.6 *10* (Iγ=0.24 *9*) reported in this work is discarded as 312.6γ is not confirmed in other studies. A γ ray of Eγ=299.7 *8* and Iγ=0.67 *28* is also discarded, as no such γ ray was seen in more recent studies.

1967Hi04: measured Eγ, Iγ, $\gamma\gamma$-coin for 14 γ rays. Energies of eight γ-rays were measured using curved-crystal diffraction spectrometer. Other γ rays were measured using Ge(Li) detector. In authors′ Table 2, measured upper limits (relative to 100 for 531γ) for the following γ rays which were reported in various studies (1964Sa33,1963Sp07,1961Gu04,1960We06,1958Ev81) using NaI(Tl) detectors, but not confirmed by 1967Hi04: 41.7 (<2.0), 78.8 (<0.2), another 91 (<2.0), 149 (<0.1), 154.9 (<0.1), 182 (<0.1), 189 (<0.1), 191 (<0.1), 230 (<0.2), 260 (<0.2), 270 (<0.4), 300 (<0.3), 310 (<0.3), 351 (<0.4), 508 (<0.06), 723 (<0.01).

1967Ja05: measured Eβ, Eγ, Iβ, Iγ, $\beta\gamma$ and $\gamma\gamma$-coin. Total of 13 γ rays reported. A 77 *1* γ with Iγ=5 *3* is discarded as not confirmed in more recent studies.

1967Do07: measured Eγ, Iγ for 13 γ rays.

1967Ca18: measured Eγ, Iγ for 12 γ rays, Eβ, β shape factor.

1967Ba21 (also 1967Ba22): measured Eγ, Iγ, ce, β-polarization. Total of 13 γ rays were reported.

1967Ki08: measured Eγ, Iγ for 11 γ rays.

1966Ar16 (also 1967Ar04): measured Eγ, Iγ for 16 γ rays.

Other measurements:

2003Zh47: measured Eγ, Iγ, x-rays, α(91γ)-coin. Deduced penetration parameter.

1999Po32: measured Eγ, Iγ, half-life of ^{147}Nd decay. Total of eight γ rays reported, and intensities listed for four of these.

1984Wa23: measured Eβ, Iβ using Siegbahn-Slatis magnetic spectrometer. Authors deduced Iβ(896)/Iβ(804)=0.0026 *10*.

1978Ma51: measured Eβ, Iβ using a magnetic spectrometer.

1976Si08: measured $\beta\gamma$(t), $\gamma\gamma$(t), $\gamma\gamma(\theta)$, $\gamma\gamma(\theta$,t), $\gamma\gamma(\theta$,H), $\gamma\gamma(\theta$,H,t), g factors, and level lifetimes using NaI(Tl) detectors.

1975Si01: measured γ spectrum, $\gamma\gamma$(t); deduced lifetime of 410 level.

1974Bh02 (also 1974BhZJ): measured $\gamma\gamma(\theta)$ using NaI(Tl) detectors; deduced δ.

1973Su05: measured $\beta\gamma(\theta)$.

1972Si49: measured $\gamma\gamma(\theta$,H), $T_{1/2}$, μ.

1971Ya12: measured $\beta\gamma(\theta)$.

1971Na11: measured Eβ, Iβ; deduced β-shape factor, quadrupole moment.

1970Va06: calculated penetration factors for 91-keV transition.

1970Bl12: measured $\gamma\gamma$-coin, $\gamma\gamma(\theta)$ using Ge(Li)-NaI(Tl) detectors; deduced δ.

1969Gr32: measured Eγ, Iγ for 91-keV and 120-keV γ rays.

1969Ba32: measured $\gamma(\theta)$ from oriented nuclei using Ge(Li) detector; deduced δ.

1968Ra28: measured $\gamma\gamma(\theta)$ using NaI(Tl) detectors; deduced δ.

1967Ra20: measured half-lives of 91.1 and 531.0 levels by $\beta\gamma$(t).

1967Ba06: measured ce, K/L ratios. Authors reported 135 ce lines to 66 γ transitions in ^{147}Pm from 77 keV to 763 keV, many of which have not been observed in other studies. For the well-known transitions, agreement is poor between their γ-ray energies and energies adopted here, based on more recent measurements. This work is not considered in the evaluation of this decay.

^{147}Nd β^- decay (11.03 d) 2020Ke08,1997Sa53,1979Se05 (continued)

1966Be09: measured Eβ, $\beta\gamma(\theta)$, β(polarization), β shape factors.
1966Va06: measured Longitudinal polarization of 261β.
1966Be42: measured lifetime of the first excited state.
1966Go25: measured $\gamma\gamma(\theta)$ using NaI(Tl) detectors.
1965Ay03: measured β(91γ)(t); deduced $T_{1/2}$(91 level)=2.49 ns *12*.
1964Hu08: measured β, $\gamma\gamma$-coin.
1964Zu03: measured Eβ, Iβ.
1964Sa33: measured Eγ, Iγ, summed γ-γ.
1963Ph02: measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$ for 15 γ rays using NaI(Tl) detector.
1963Sp07: measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$ for four cascades; deduced five excited states defined by 15 γ rays.
1962Ri07: measured (321γ)(91γ)(t); deduced $T_{1/2}$(91 level)=2.50 ns *6*.
1962Be27: measured (β)(91 ceL)(t); deduced $T_{1/2}$(91 level)=2.59 ns *2*.
1962Sh08: measured β, $\beta\gamma$-coin, β shape factor.
1961Ew02 (also 1965Ew03,1957Ew38,1956Ew23,1956EwZZ): measured ce, deduced Eγ values for 11 γ rays.
1961Gu04: measured Eγ, Iγ, $\gamma\gamma$.
1961We07: measured $\gamma(\theta$,t,H) for six γ rays using aligned and polarized source at low temperatures; deduced mixing ratios.
1961Sa13: measured $\gamma\gamma(\theta)$ of five $\gamma\gamma$ cascades; deduced level spins and mixing ratios.
1961Pe10: measured (365β)(531γ circ pol)(θ); deduced δ(531γ)=+1.75 *15* for J^π(g.s. ^{147}Nd)=5/2$^-$ and 7/2$^+$ to 7/2$^+$ 531γ.
1961Ar09: measured γ spectrum, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$ for 320-91 and 280-320 $\gamma\gamma$ cascades; deduced mixing ratios.
1960Wa11: measured Eγ of 91-keV transition using curved-crystal spectrometer.
1960Ma03: measured $\gamma\gamma(\theta)$.
1960Bo17: measured γ spectra, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$ for six $\gamma\gamma$ cascades, $\gamma\gamma(\theta$,H); deduced half-life of 2.50 ns *6* and g factor=+1.42 *20* for the 91 level, $T_{1/2}\leq$0.5 ns for the 412 level, and mixing ratios for five γ rays.
1960We06: measured Eβ, Iβ, $\beta\gamma$-coin, F-K plot.
1958Be77: measured β, $\beta\gamma$-coin.
1958Co61: measured Eβ, Iβ, Eγ from external conversion.
1958Ev81: measured Eγ, Iγ for nine γ rays, Eβ, $\beta\gamma$-coin.
1958Mi88: measured Eβ.
1957Li40: measured $\gamma\gamma(\theta)$ for 320γ-91γ cascade.
1957Kn35 (thesis): deals with low-temperature angular correlation measurements.
1957Bi86: measured $\gamma(\theta)$ and polarization of oriented nuclei at low temperature; deduced mixing ratios of 531 and 91 gamma rays.
1953Gr07: measured β(91γ)(t), α(K) and K/L ratio; deduced half-life of 2.44 ns *8*, α(K)exp=1.8 and K/L=7.3 for 91γ.
1952Ko27: measured Eβ.
1951Em23: measured Eβ, Iβ.
1951MaZZ (also 1950Ma05,1947Ma28): measured Eγ, Iγ, Eβ, Iβ, x-rays, $T_{1/2}$ of ^{147}Nd decay, chemical identification.
1949Ma02 (also C.E. Mandeville and E. Shapiro, Phys. Rev. 79, 391 (1950)): measured β and γ activity.
1948Co09: measured Eβ and Eγ.
1947Ma28: firm isotopic assignment of 11-d activity to ^{147}Nd.
1946Bo25: identification of 11-d activity with possible assignment to ^{147}Nd activity.
1941La01: possible production of ^{147}Nd with 10-d half-life.
Additional information 1.

^{147}Pm Levels

Level at 649 keV with J^π=11/2$^-$ in 1997Sa53 has been omitted as the 117.98 and 159.7 γ rays from this level have not been seen in two different in-beam reaction studies, where this level is populated quite strongly. Fairly intense 240γ from this level should have been detected by 1979Se05, but in their γ-ray spectrum, there is no evidence for such a line. Questionable level at 641 keV shown in level-scheme Fig. 3 of 1997Sa53 has also been omitted here, as there is no evidence for a 230.7 gamma emitted in the decay of ^{147}Nd.

Continued on next page (footnotes at end of table)

^{147}Nd β^- decay (11.03 d) 2020Ke08,1997Sa53,1979Se05 (continued)

^{147}Pm Levels (continued)

E(level)†	J^π	$T_{1/2}$	Comments
0.0	7/2$^+$	2.6234 y *4*	J^π: spin from atomic beam (1960Ca03,1963Bu14) and optical (1960Kl02) measurements, parity from L(^{3}He,d)=L(d,^{3}He)=4 (1979St01,1981Le21), both from 0$^+$ targets. $T_{1/2}$: weighted average of 2.62346 y *27* (1999Po32, γ-decay curve, 95% confidence level, uncertainty tripled for 1σ in averaging procedure, as no details of this measurement are provided); 2.62 y *1* (1968Re04, 2π proportional counter, 1.9 half-lives, previous value from this group using the same method was 2.50 y *3* in 1961Wy01); 2.62343 y *36* (1967Jo07, calorimetry, ≈0.5 half-life, 95% confidence level, uncertainty doubled for 1σ in averaging procedure, previous value from this lab using the same method was 2.6226 y *20* in 1965Ei04); 2.620 y *5* (1965Wh04, calorimetry, ≈0.4 half-life, previous value from this group was 2.67 y *6* in 1963Ro20); 2.618 y *7* (1965An07, 4$\pi\beta$ proportional counter, 0.5 half-life); 2.60 y *2* (1965Fl02, 2π proportional counter, 1.8 half-lives); 2.7 y *1* (1959Ca12); 2.64 y *2* (1957Me47, 4$\pi\beta$ proportional counter, 1.5 half-lives); 2.66 y *2* (1956Sc87, proportional counter, 1.8 half-lives); 2.52 y *8* (1955Me52, mass spectrometry).
91.1051 *16*	5/2$^+$	2.51 ns *2*	Measured μ=+3.22 *16* (1980Ne07, DPAC method). Measured g factor=+1.52 *23* (IPAC), +1.37 *40* (DPAC) (1976Si08); 1.57 *29* (1972Si49, IPAC). J^π: L(^{3}He,d)=L(d,^{3}He)=2 (1979St01,1981Le21), both from 0$^+$ targets; M1+E2 γ to 7/2$^+$ g.s. Configuration: fragment of $\pi d_{5/2}$ orbital. $T_{1/2}$: unweighted average of values from $\beta\gamma$(t) data: 2.44 ns *8* (1953Gr07), 2.45 ns *20* (1960We06), 2.59 ns *2* (1962Be27), 2.49 ns *12* (1965Ay03), 2.34 ns *4* (1966Be42), 2.51 ns *5* (1967Ba22), 2.46 ns *7* (1967Ra20), 2.58 ns *2* (1971Si20), 2.48 ns *2* (1976Si08); and $\gamma\gamma$(t) data: 2.50 ns *6* (1960Bo17), 2.48 ns *4* (1962Ri07), 2.56 ns *3* (1971Si20), 2.51 ns *9* (1972Si49), 2.47 ns *5* (1976Si08), 2.6 ns *2* (1977Ko24, γ(t) in (p,2nγ), 2.66 ns *6* (1980Ne07). Weighted average is 2.53 ns *2*, but with reduced χ^2=3.7 as compared to critical χ^2=1.7. (804β)(91γ)(θ): 1973Su05, 1971Ya12, 1966Be09.
408.14 *4*	9/2$^+$		J^π: M1+E2 γ to 7/2$^+$ g.s.; 241γ E1 from 11/2$^-$, 649 level (in (p,2nγ), 1977Ko24) and ^{136}Xe(^{15}N,4nγ) (1995Ur01).
410.515 *9*	3/2$^+$	0.139 ns *14*	J^π: M1+E2 γ to 5/2$^+$, 91 level; E2 γ to 7/2$^+$ g.s. Combined analysis of $\gamma\gamma(\theta)$ and $\gamma(\theta$,H,t) for 276γ and 410γ data gives best possible choice of 3/2 for 410 level and 5/2 for 686 level. $T_{1/2}$: from (275γ)(319γ)(t) (1975Si01). Others: <0.7 ns (1960We06, $\beta\gamma$(t)), <0.5 ns (1960Bo17, $\gamma\gamma$(t)).
489.247 *13*	7/2$^+$		J^π: M1+E2 γ to 5/2$^+$, 91 level; M1(+E2) γ to 7/2$^+$ g.s.; M2 γ from 11/2$^-$, 649 level in (p,2nγ) (1977Ko24) and ^{136}Xe(^{15}N,4nγ) (1995Ur01). 7/2 is assigned by 1977Al34 based on combined analysis of $\gamma\gamma(\theta)$ and $\gamma(\theta$,H,t) data, which rule out 3/2 and 5/2. Other: 5/2 or 7/2 (1969Ba32,1961We07) based on $\gamma(\theta$,H), and δ(197γ,398γ) from α(K)exp and L-subshell ratios. Configuration: fragment of $\pi g_{7/2}$ orbital.
530.998 *9*	5/2$^+$	0.093 ns *20*	J^π: M1+E2 γs to 5/2$^+$, 91 level and to 3/2$^+$, 410 level; 5/2$^+$ from analysis of 440$\gamma(\theta$,H,t) data by 1977Al34. Configuration: fragment of $\pi d_{5/2}$ orbital. $T_{1/2}$: from difference in centroids of delayed $\beta\gamma$ spectrum for ^{147}Nd and prompt $\beta\gamma$ spectrum from ^{60}Co source. Value is weighted average of 0.083 ns *15* (1967Ra20) and 0.133 ns *30* (1971Si20). Others: ≤0.10 ns (1976Si08, β(531γ)(t)), <0.6 ns (1960We06, $\beta\gamma$(t)), ≤0.4 ns (1957Kn35, $\beta\gamma$(t)). (364β)(531γ)(θ) (1973Su05,1966Be09). (364β)(CP 531γ)(θ) (1961Pe10).
632.85 *4*	1/2$^+$		J^π: L(^{3}He,d)=0 from 0$^+$ target (1979St01).
641.11 *5*	(5/2)$^+$		Level population in ^{147}Nd decay reported by 1983Li19 only. Level known from ^{148}Nd(p,2nγ) work of 1977Ko24. J^π: ΔJ=1, M1(+E2) γ to 410.5, 3/2$^+$ level in (p,2nγ) (1977Ko24).
680.432 *20*	7/2$^+$		J^π: M1+E2 γs to 7/2$^+$, g.s., and 9/2$^+$, 408 level; β feeding from 5/2$^-$ parent not first-forbidden unique from log *ft* value.
685.899 *12*	5/2$^+$	0.25 ns *10*	J^π: M1+E2 γs to 7/2$^+$, g.s. and 5/2$^+$, 91 level; L(^{3}He,d)=(2) and possible $d_{5/2}$ orbital. Combined analysis of $\gamma\gamma(\theta)$ and $\gamma(\theta$,H,t) for 276γ and 410γ data gives best possible choice of 3/2 for 410 level and 5/2 for 686 level (1977Al34). Configuration: fragment of $\pi d_{5/2}$ orbital.

Continued on next page (footnotes at end of table)

^{147}Nd β^- decay (11.03 d) 2020Ke08,1997Sa53,1979Se05 (continued)

^{147}Pm Levels (continued)

E(level)†	J^π	Comments
		$T_{1/2}$: from β(686γ)(t) (1971Si20). Other: <0.8 ns (1960We06, βγ(t)).
807.25 *15*	5/2⁻,7/2⁻	Level population in ^{147}Nd decay proposed in 1983Li19. This level is known from ^{148}Nd(p,2nγ) (1977Ko24). J^π: E1 γs to 91, 5/2⁺ level and g.s., 7/2⁺ from ^{148}Nd(p,2nγ) (1977Ko24).

† From least-squares fit to Eγ data.

β^- radiations

Eβ=720 *30*, Iβ=10% reported by 1960We06 is not observed by 1964Zu03 and 1967Ja05. Eβ=653 *11*, Iβ=5% reported by 1964Hu08 is unaccounted.

E(decay)	E(level)	$I\beta^-$†‡	Log *ft*	Comments
(88.0 *6*)	807.25	0.00058 *12*	9.42 *9*	av Eβ=22.88 *17*
(209.3 *6*)	685.899	2.19 *4*	7.015 *9*	av Eβ=57.39 *18* E(decay): 215 *10* (1967Ja05), 209 (1967Ca18), 224 *10* (1964Zu03), 230 *30* (1964Hu08), 215 *9* (1960We06), 220 (1958Ev81), 230 *50* (1958Co61), 215 *15* (1958Be77), 214 *15* (1956Ew23). $I\beta^-$: 1.0 *5* (1967Ja05, βγ coin), 1.8 (1967Ca18, F-K analysis), 12 (1964Zu03), 8 (1964Hu08), 12 (1960We06), 3 (1958Ev81), 16 (1958Co61).
(214.8 *6*)	680.432	0.0782 *18*	8.50 *1*	av Eβ=59.02 *18*
(254.1 *6*)	641.11	0.0051 *5*	9.92 *5*	av Eβ=70.92 *19*
(262.4# *6*)	632.85	<0.006	>9.6[1u]	av Eβ=85.75 *23*
(364.2 *6*)	530.998	15.25 *21*	6.947 *7*	av Eβ=105.86 *20* E(decay): 365 *8* (1979Vo09), 364 *8* (1971Na11), 369 *10* (1967Ja05), 365 (1967Ca18, F-K analysis), 364 *3* (1966Be09, F-K plot non-linear). 370 *30* (1964Zu03), 357 *18* (1964Zu03), F-K plot linear (1962Sh08), 370 *9* (1960We06, F-K plot linear), 362 (1958Ev81), 380 *50* (1958Co61), 363 *15* (1958Be77), 368 *10* (1956Ew23). β shape factors determined. $I\beta^-$: 15 *5* (1967Ja05), 14.3 (1967Ca18), 13 (1964Zu03), 20 (1964Hu08), 12 (1960We06), 20 (1958Ev81), 18 (1958Co61).
(406.0 *6*)	489.247	0.819 *15*	8.372 *9*	av Eβ=119.67 *20* E(decay): 410 *20* (1967Ja05, β(489γ) coin, F-K plot). $I\beta^-$: 0.7 *5* (1967Ja05).
(484.7 *6*)	410.515	0.62 *3*	8.75 *2*	av Eβ=146.49 *21* E(decay): 500 *30* (1979Vo09), 490 *20* (1967Ja05, β(319γ) coin, F-K plot), 530 *60* (1964Zu03), 500 *40* (1964Hu08), 480 *80* (1960We06), 529 *25* (1958Be77). $I\beta^-$: 0.4 *2* (1967Ja05), 7 (1964Zu03), 8 (1964Hu08), 0.5 (1960We06).
(804.1 *6*)	91.1051	81.0 *3*	7.392 *3*	av Eβ=263.80 *24* $I\beta^-$: from 100−(summed β feeding to other levels)=81.0 *3*. Other: 81 *4* from γ-transition intensity balance. E(decay): 808 *10* (1978Ma51), 806 *3* (1979Vo09, straight line shape for β spectrum), 803 *2* (1971Na11), 810 *10* (1967Ja05), 803.5 *10* (1967Ca18), 806 *2* (1966Be09), 806 *7* (1964Zu03), 817 *9* (1964Hu08), 809 *9* (1960We06, F-K plot linear), 801 (1958Mi88), 812 *30* (1958Co61), 815 *10* (1958Be77), 802 (1958Ev81), 818 *7* (1957Ew38), 780 *8* (1952Ko27), 825 (1952Ru10), 825 *15* (1951Em23); β shape factors determined. Non-linear F-K plot (1962Sh08). Non-unique first-forbidden transition in 1978Ma51 and 1984Wa23. $I\beta^-$: 83 *6* (1967Ja05), 83.9 (1967Ca18, F-K analysis), 68 (1964Zu03), 60

Continued on next page (footnotes at end of table)

^{147}Nd β^- decay (11.03 d) 2020Ke08,1997Sa53,1979Se05 (continued)

β^- radiations (continued)

E(decay)	E(level)	I$\beta^{-\dagger\ddagger}$	Log *ft*	Comments
				(1964Hu08), 65 (1960We06), 76 (1958Ev81), 66 (1958Co61), 60 (1951Em23).
(895.2[#] *6*)	0.0	<0.3	>10.0	av Eβ=299.26 *24* Iβ^-: from 0.22 *10* (1984Wa23, evaluator treats this value as upper limit), <1.1 *7* (1978Ma51, upper limit from priv. comm. with authors), <0.15% (1971Na11,1966Be09), <0.5% (1967Ja05), <0.25% (1962Sh08), <1% (1960We06), <10% (1957Ew38). E(decay): 896 *7* (1984Wa23), 910 *20* (1978Ma51). 1984Wa23 suggest first-forbidden unique shape for the β transition, which is unlikely in view of ΔJ=1 β transition.

† Based on (γ+ce) balance.

‡ Absolute intensity per 100 decays.

Existence of this branch is questionable.

γ(^{147}Pm)

Iγ normalization: From measured absolute (per 100 decays) intensity of 13.11% *13* by 2020Ke08. Others: 0.13019 *53*, preliminary value from measured absolute (per 100 decays) intensity of 13.019% *53* by 2020KoZZ; 0.1282 *18* from summed I(γ+ce)=100 to g.s., and Iβ(g.s.)=0.22 *10* (from 1984Wa23 using magnetic spectrometer, treated here as upper limit), are in agreement with that from 2020Ke08. Others: Iβ(g.s.) $\leq$0.2% (based on β spectrum measurements by 1971Na11 and 1966Be09). Several other β studies measured upper limits, with no evidence for a definite β feeding to the ground state.

Recommended absolute (per 100 decays of ^{147}Nd) intensity of the 531.0-keV γ ray is 13.11% *13* (2020Ke08), i.e. about 1% precise. This value agrees with preliminary values available from 2020KoZZ **and from experiments at NPL, UK.** .

Eγ, Iγ data using Ge(Li) and HPGe detectors: 2020Ke08, 2020KoZZ, 1997Sa53, 1995Go44, 1983Li19, 1980Ch38, 1979Vo09, 1979Se05, 1974HeYW, 1974Ra30, 1971Si20, 1967Ja05, 1967Hi04, 1967Do07, 1967Ca18, 1967Ba21, 1967Ki08, 1966Ar16. Other: 1999Po32 has intensity data for four γ rays. Preliminary Iγ results from 2020KoZZ are listed in comments, but not included in the present evaluation.

Eγ, Iγ data using crystal diffraction spectrometers: 1967Hi04 (data for eight γ rays), 1960Wa11 (Eγ for 91-keV γ). Other: 1957Ew38 (data for four γ rays, not so precise).

Eγ, Iγ, ce data by the detection of conversion electrons using magnetic spectrometers: 1967Ba21, 1966Ar16, 1966Ba46, 1961Ew02, 1958Mi88, 1957Ew38.

Eγ, Iγ data using scintillation detectors: 1967Ra19, 1966Ar16, 1966El02, 1964Hu08, 1964Sa33, 1963Ph02, 1963Sp07, 1961Gu04, 1958Mi88, 1958Co61, 1958Ev81, 1957Ew38, 1955Ha33, 1953Gr07, 1952Sm49, 1952Ru10, 1952Mi18, 1952Ko27.

Following γ rays reported by 1997Sa53, in singles γ-data only, are omitted: 6.8 keV from 641 level; 117.98 keV *5* (Iγ=0.12 *1*) and 159.7 keV *2* (Iγ=0.040 *3*), since both the γ rays are not observed in (p,2nγ) in-beam γ-ray study, where the 649-keV level is strongly populated, also these γ rays were not seen in ^{208}Pb(^{136}Xe,X),E=85 MeV, multi-nucleon transfer reaction, where 649 level in ^{147}Pm is populated (2015Ba20, and priv. comm. from A.A. Sonzogni with reference to scanning of the γ spectra); 31.3 keV *2* (Iγ=0.34 *4*) from 680 level, and 36.75 keV *10* (Iγ=1.13 *10*) from 686 level, as both the γ rays imply unrealistically large transition intensities, thus creating severe intensity imbalances. 1958Co61 identified 31.4 and 36.9 lines as Auger α_1-L and α_1-M lines. In addition, 240.5 keV *2* (Iγ=0.32 *2*) and 649.04 keV *8* (Iγ=0.039 *3*), both from 649-keV level with J^π=11/2$^-$ are omitted, as 240.5γ should have been detected by 1979Se05. With the omission of 240.5γ, existence of 649.04γ is also questionable, thus omitting the population of 649, 11/2$^-$ level in this decay.

Following γ rays were not detected by 2020Ke08, upper limits of intensities given (relative to 100 for 531γ): 117.98 (Iγ<0.012); 159.7 (Iγ<0.014); 240.5 (Iγ<0.0092); 649.0 (Iγ<0.0069);

Following tentative γ rays were reported only by 2020Ke08, with intensities per 100 decays, but not placed in decay scheme: 357.7 (absolute Iγ=0.006 *6*); 366.5 (absolute Iγ=0.0034 *30*).

Following γ rays, reported using Ge(Li) detector data are also omitted, as these are not confirmed in more recent studies: Eγ=77 , Iγ=5 (1967Ja05), this γ also reported by 1967Ar04 and 1963Ph02; Eγ=182, Iγ=0.1 (1967Ar04); Eγ=610 *5*, Iγ=0.2 (1966Ar16); Eγ=621 *5*, Iγ=0.1 (1966Ar16).

Measured Pm x-ray intensities (1995Go44), relative to 100 for 531γ: 144 *7* for K$_{\alpha2}$, 253 *9* for K$_{\alpha1}$, 49.5 *16* for K$_{\beta1}$, and 12.9 *4* for K$_{\beta2}$.

Measured absolute intensities of K x-rays (2020Ke08)

E(x ray)	I(x ray)(absolute)
38.17: K$_{\alpha2}$	0.1281 *16*
38.73: K$_{\alpha1}$	0.2317 *28*
43.83: K$_{\beta1}$	0.0708 *9*
44.94: K$_{\beta2}$	0.01880 *23*

---

^{147}Nd β^- decay (11.03 d) 2020Ke08,1997Sa53,1979Se05 (continued)

$\gamma(^{147}Pm)$ (continued)

E_γ	I_γ[†&]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ	α[a]	Comments
53.1 *2*	0.0057 *33*	685.899	5/2+	632.85	1/2+	[E2]		25.1 *6*	%Iγ=0.0007 *4* α(K)=4.40 *7*; α(L)=16.1 *4*; α(M)=3.73 *9* α(N)=0.808 *19*; α(O)=0.1003 *23*; α(P)=0.000221 *4* E_γ,I_γ: from 1979Se05 only, from γγ-coin and singles spectra. This γ is not reported by 2020Ke08.
81.13 *8*	0.0055 *14*	489.247	7/2+	408.14	9/2+	[M1+E2]		3.8 *11*	%Iγ=0.00072 *18* α(K)=2.24 *16*; α(L)=1.25 *91*; α(M)=0.28 *22* α(N)=0.062 *46*; α(O)=0.0080 *56*; α(P)=1.21×10^{-4} *34* E_γ: weighted average: 81.15 *7* (1979Se05), 80.82 *27* (1997Sa53). I_γ: unweighted average of 0.0068 *9* (1997Sa53), 0.0041 *25* (1979Se05). This γ is not reported by 2020Ke08.
91.1050 *16*	220.8 *27*	91.1051	5/2+	0.0	7/2+	M1+E2	+0.089 *5*	2.03	%Iγ=28.9 *5* α(K)exp=1.73 *6*; α(L)exp=0.248 *9* (1997Sa53) L1/L3=26 *3*; L1/L2=9.6 *3*; K/L=6.8 *2* (1965Ew03) α(K)=1.714 *24*; α(L)=0.249 *4*; α(M)=0.0534 *8* α(N)=0.01202 *18*; α(O)=0.00180 *3*; α(P)=0.0001100 *16* E_γ: from 1967Hi04, crystal diffraction spectrometer. Other precise Eγ=91.05 *4* (1960Wa11, crystal), 91.06 *5* (1961Ew02), 91.106 *20* (1974HeYW), 91.06 *3* (1979Se05), 91.109 *4* (1979Vo09), 91.219 *45* (1980Ch38), 91.10 *3* (1983Li19), 91.004 *2* (1997Sa53, uncertainty seems underestimated). Other less precise Eγ using Ge(Li): 1957Ew38 (crystal), 1967Do07, 1967Ca18, 1967Ja05, 1967Ba21, 1967Ki08, 1971Si20, 1974Ra30. I_γ: weighted average of 218.9 *27* (2020Ke08); 210 *4* (1997Sa53, uncertainty of 2% is underestimated as the efficiency curve in this energy region is not well established, and this peak is situated on a high Compton continuum); 218 *2* (1995Go44, uncertainty of 1% is underestimated for the same reason as explained for 1997Sa53); 240 *12* (1983Li19); 215 *12* (1980Ch38); 230 *25* (1979Se05); 239 *5* (1979Vo09); 213 (1974HeYW); 220 *14* (1974Ra30); 187 (1971Si20); 227 *35* (1967Hi04); 248 *13* (1967Do07); 211 *42* (1967Ca18); 213 *14* (1967Ba21); 300 *100* (1967Ja05); 275 *50* (1966Ar16). Minimum uncertainty of 5% is assumed by evaluator in values measured earlier than the 2020Ke08 value in the averaging procedure, as the efficiency response curve for the Ge detectors is not known well in this energy region. Other: 390 *20* (1967Ki08, is discrepant, not used in averaging). Measured absolute (per 100 decays) Iγ=28.70 *35* (2020Ke08); 29.02 *40* (2020KoZZ, preliminary value). Additional information 2. Ice(K)=27315 *518*, Ice(L)=3916 *101* (1997Sa53); Ice(L1+L2)=3920 *275*, Ice(L3)=119 *18*, Ice(M)=930 *93*, Ice(N)=235 *35* (1967Ba21).

$^{147}_{61}Pm_{86}$-8

γ(^{147}Pm) (continued)

E_γ	I_γ[†&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α[a]	Comments
									91γ(θ,H,t): $B_2U_2A_2$=+0.023 *2*, $B_4U_4A_4$=+0.004 *2* (1977Al34). 91γ(θ,H,t): $G_2U_2F_2$=+0.202 *14* (1969Ba32). (L1+L2):L3:M:N=330 *55*:10:78 *14*:20 *4* (1967Ba21). Probability for emission of two K-electrons in internal conversion of 91-keV γ (relative to one K-electron emission): 1.86×10^{-3} *9* (2003Vi13). Mult.: from α(K)exp=1.63 *4*, with penetration parameter=3.2 *9* (2003Zh47); α(K)exp=1.737 from Ice(K)=173.7 (1961Ew02). δ: from γ(θ,H,t) (1969Ba32, earlier value from this experimental group was +0.13 *2* reported in 1961We07). Others: 0.092 *5* (1965Ew03, L1/L3, L1/L2 and K/L; previous value was 0.089 *11* in 1961Ew02); +0.10 *9* (1957Bi86, γ(θ,H,t)); 0.082 *10* (1967Ba21, ce data). Evaluator prefers to adopt value from γ(θ,H,t) method, as the values deduced from internal conversion data may be dependent on penetration parameters. 1977Kr13 evaluation gives +0.099 *10*, based on data taken from 1969Ba32, 1961We07, 1961Ew02 and 1957Bi86.
120.483 *9*	2.814 *31*	530.998	5/2$^+$	410.515	3/2$^+$	M1+E2	+0.048 *21*	0.911	%Iγ=0.369 *5* α(K)exp=0.79 *3*; α(L)exp=0.113 *5* (1997Sa53); α(K)exp=0.75 *12* (1967Ba21) α(L)exp=0.113 *5* (1997Sa53) α(K)=0.773 *11*; α(L)=0.1089 *17*; α(M)=0.0233 *4* α(N)=0.00524 *8*; α(O)=0.000790 *12*; α(P)=4.96×10^{-5} *7* E_γ: weighted average: 120.47 *5* (1961Ew02), 120.490 *9* (1967Hi04, crystal), 120.48 *5* (1974HeYW), 120.46 *2* (1979Se05), 120.453 *15* (1979Vo09), 120.578 *40* (1980Ch38), 120.51 *3* (1983Li19), 120.488 *20* (1997Sa53, authors′ uncertainty of 0.005 increased by evaluator). Other less precise Eγ using Ge(Li): 1967Do07, 1967Ca18, 1967Ja05, 1967Ba21, 1967Ki08, 1971Si20, 1974Ra30. I_γ: unweighted average of 2.782 *31* (2020Ke08); 2.81 *4* (1997Sa53); 2.81 *14* (1983Li19), 2.96 *16* (1980Ch38), 2.71 *25* (1979Se05); 3.05 *10* (1979Vo09); 3.03 *32* (1974HeYW); 3.3 *5* (1974Ra30); 2.65 *34* (1971Si20); 3.3 *5* (1967Hi04); 2.5 *5* (1967Ca18); 3.0 *2* (1967Ba21); 2.6 *4* (1966Ar16). Others: 3.57 *11* (1995Go44); 8 *1* (1967Ja05), 4.72 *24* (1967Ki08), 2.1 *2* (1967Do07) seem discrepant. Minimum uncertainty of 3% is assumed in values prior to that of 2020Ke08. Measured absolute (per 100 decays) Iγ=0.3647 *41* (2020Ke08); 0.378 *5* (2020KoZZ, preliminary value). Additional information 7. 120γ(θ,H,t): $B_2U_2A_2$=+0.070 *25*, $B_4U_4A_4$=−0.017 *26* (1977Al34). (120γ)[319γ](91γ)(θ): A_2=+0.004 *22*, A_4=+0.020 *52* (1977Al34). (120γ)(410γ)(θ): A_2=−0.009 *78*, A_4=+0.05 *12* (1977Al34). (120γ)(319γ)(θ): A_2=−0.020 *12*, A_4=+0.001 *21* (1977Al34). (121γ)(319γ)(θ): A_2=−0.041 *8*, A_4=+0.006 *10* (1970Bl12,

$\gamma(^{147}$Pm) (continued)

E_γ	I_γ[†&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α[a]	Comments
									Ge(Li)-NaI(Tl) detectors). Ice(K)=166 *5*, Ice(L)=24 *1* (1997Sa53), Ice(K)=166 *17*, Ice(L)=27 *6* (1967Ba21). Mult.: from α(K)exp. δ: weighted average of 0.050 *21* from $\gamma\gamma(\theta)$ and +0.037 *56* from $\gamma(\theta$,H,t) (1977Al34). This value is consistent with ce data. Others: +0.04 *3* (1977Kr13 evaluation, based on $\gamma\gamma(\theta)$ data of 1970Bl12, 1966Go25, 1961Sa13 and 1960Bo17); ≈0.14 (1961Ew02, L-subshell ratios).
149.39 *6*	0.027 *3*	680.432	7/2$^+$	530.998	5/2$^+$	[M1+E2]		0.52 *3*	%Iγ=0.0035 *4* α(K)=0.39 *3*; α(L)=0.101 *42*; α(M)=0.0224 *99* α(N)=0.0050 *22*; α(O)=6.8×10^{-4} *25*; α(P)=2.2×10^{-5} *5* E_γ: weighted average: 149.4 *2* (1979Se05), 149.40 *6* (1983Li19), 149.3 *2* (1997Sa53). I_γ: unweighted average of 0.022 *5* (2020Ke08); 0.029 *3* (1997Sa53); 0.032 *3* (1983Li19); 0.024 *12* (1979Se05). Measured absolute (per 100 decays) Iγ=0.0029 *6* (2020Ke08).
154.91 *5*	0.0486 *40*	685.899	5/2$^+$	530.998	5/2$^+$	[M1+E2]		0.466 *18*	%Iγ=0.0064 *5* α(K)=0.35 *3*; α(L)=0.088 *35*; α(M)=0.0195 *82* α(N)=0.0043 *18*; α(O)=5.9×10^{-4} *21*; α(P)=2.0×10^{-5} *5* E_γ: weighted average 154.92 *5* (1979Se05), 154.92 *5* (1983Li19), 154.7 *2* (1997Sa53). Other: 154 *1* (1967Ja05). I_γ: unweighted average of 0.045 *7* (2020Ke08); 0.052 *4* (1983Li19); 0.0545 *22* (1995Go44, uncertainty seems underestimated); 0.043 *7* (1979Se05). Value of 0.031 *3* in 1997Sa53 seems discrepant. Other: <0.5 (1967Ja05). Measured absolute (per 100 decays) Iγ=0.0059 *9* (2020Ke08). Additional information 12.
191.19 *6*	0.028 *3*	680.432	7/2$^+$	489.247	7/2$^+$	[M1+E2]		0.243 *9*	%Iγ=0.0037 *4* α(K)=0.191 *22*; α(L)=0.040 *11*; α(M)=0.0089 *26* α(N)=0.00197 *55*; α(O)=0.00028 *7*; α(P)=1.1×10^{-5} *3* E_γ: weighted average: 191.24 *9* (1979Se05), 191.18 *6* (1983Li19), 191.0 *3* (1997Sa53). I_γ: unweighted average of 0.024 *8* (2020Ke08); 0.028 *3* (1997Sa53); 0.036 *3* (1983Li19); 0.025 *13* (1979Se05). Measured absolute (per 100 decays) Iγ=0.0032 *10* (2020Ke08).
196.64 *3*	1.377 *24*	685.899	5/2$^+$	489.247	7/2$^+$	M1+E2	−0.22 *10*	0.231	%Iγ=0.181 *4* α(K)exp=0.194 *9* (1997Sa53); α(K)exp=0.192 *35* (1967Ba21) α(K)=0.195 *4*; α(L)=0.0282 *10*; α(M)=0.00605 *23* α(N)=0.00136 *5*; α(O)=0.000204 *6*; α(P)=1.24×10^{-5} *3* E_γ: weighted average: 196.64 *7* (1961Ew02), 196.66 *3* (1967Hi04, crystal), 196.64 *4* (1974HeYW), 196.64 *3* (1979Se05), 196.616 *30* (1979Vo09), 196.69 *5* (1983Li19). Others: Eγ=196.448 *5* (1997Sa53, uncertainty seems underestimated, and discrepant in

γ(^{147}Pm) (continued)

E_γ	I_γ [†&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α [a]	Comments
									energy); Eγ=196.797 *40* (1980Ch38) also seems discrepant. Other less precise Eγ using Ge(Li): 1967Do07, 1967Ca18, 1967Ja05, 1967Ba21, 1967Ki08, 1971Si20, 1974Ra30. I_γ: weighted average of 1.394 *24* (2020Ke08); 1.42 *1* (1997Sa53); 1.329 *22* (1995Go44); 1.42 *6* (1983Li19), 1.33 *10* (1980Ch38); 1.28 *10* (1979Se05); 1.38 *6* (1979Vo09); 1.56 *13* (1974HeYW); 1.4 *4* (1974Ra30); 1.36 *22* (1971Si20); 1.0 *1* (1967Do07); 1.30 *13* (1967Ca18); 1.53 *15* (1967Ba21); 1.3 *2* (1966Ar16); with minimum 3% uncertainty assumed in 1997Sa53 and 1995Go44 Others: 1.92 *16* (1967Ki08, seems discrepant), 2 *1* (1967Ja05), 1.5 *6* (1967Hi04). Measured absolute (per 100 decays) Iγ=0.1828 *32* (2020Ke08); 0.174 *6* (2020KoZZ, preliminary value). Additional information 13. 196γ(θ,H,t): $B_2U_2A_2$=−0.005 *45*, $B_4U_4A_4$=+0.033 *51* (1977Al34). (197γ)[398γ](91γ)(θ): A_2=−0.034 *34*, A_4=+0.026 *51* (1977Al34). Ice(K)=20.7 *8*, Ice(L)=2.6 *2* (1997Sa53). Ice(K)=22 *2*, Ice(L)=3.0 *15* (1967Ba21). Mult.: from α(K)exp. δ: weighted average of −0.27 *10* from $\gamma\gamma(\theta)$ and −0.11 *15* from γ(θ,H,t) (1977Al34). 1977Kr13 evaluation gives +0.50 *2* from 1974Bh02, 1961Sa13 and 1960Bo17; all from $\gamma\gamma(\theta)$ using NaI(Tl) detectors.
222.27[b] *6*	0.011 *3*	632.85	1/2$^+$	410.515	3/2$^+$	[M1+E2]		0.154 *12*	%Iγ=0.0014 *4* E_γ,I_γ: from 1983Li19 only, with tentative placement. Note that this γ was not reported in ^{148}Nd(p,2nγ) work of 1977Ko24. This γ is not reported by 2020Ke08.
230.59 *5*	0.034 *3*	641.11	(5/2)$^+$	410.515	3/2$^+$	M1(+E2)		0.138 *13*	%Iγ=0.0045 *4* α(K)=0.111 *17*; α(L)=0.021 *4*; α(M)=0.0046 *9*; α(N)=0.00102 *18* α(O)=0.000146 *18*; α(P)=6.5×10^{-6} *17* E_γ,I_γ: from 1983Li19 only. This γ was reported in ^{148}Nd(p,2nγ) work of 1977Ko24. This γ not reported in 2020Ke08. Mult.: based on α(K)exp and $\gamma(\theta)$ in ^{148}Nd(p,2nγ) (1977Ko24).
272.30 *4*	0.0897 *19*	680.432	7/2$^+$	408.14	9/2$^+$	M1+E2	+0.10 *3*	0.0962	%Iγ=0.01176 *28* α(K)exp=0.091 *11* (1997Sa53) α(K)=0.0818 *12*; α(L)=0.01131 *16*; α(M)=0.00241 *4* α(N)=0.000544 *8*; α(O)=8.21×10^{-5} *12*; α(P)=5.21×10^{-6} *8* E_γ: from 272.30 *4* (1979Se05) and 272.30 *5* (1983Li19). Other: 271.87 *6* (1997Sa53) seems discrepant. I_γ: weighted average of 0.0886 *18* (2020Ke08); 0.099 *7* (1997Sa53); 0.102 *10* (1983Li19); 0.098 *25* (1979Se05). Measured absolute (per 100 decays) Iγ=0.01161 *24* (2020Ke08). (272γ)(410γ)(θ): A_2=−0.283 *10*, A_4=+0.015 *18* (1979Se05, Ge(Li)-NaI(Tl) detectors).

$^{147}_{61}$Pm$_{86}$-11

γ(^{147}Pm) (continued)

E_γ	I_γ [†&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α[a]	Comments
									Ice(K)=0.68 *6* (1997Sa53). Mult.: from α(K)exp. δ: from $\gamma\gamma(\theta)$ (1979Se05).
275.388 *15*	6.03 *11*	685.899	5/2$^+$	410.515	3/2$^+$	M1+E2	+0.109 *7*	0.0931	%Iγ=0.791 *16* α(N)=0.000526 *8*; α(O)=7.95×10^{-5} *12*; α(P)=5.04×10^{-6} *7* α(K)exp=0.081 *3*; α(L)exp=0.0109 *6* (1997Sa53) α(K)exp=0.080 *6*; α(L)exp=0.0077 *20* (1979Vo09); α(K)exp=0.094 *25* (1967Ba21) α(K)=0.0792 *11*; α(L)=0.01095 *16*; α(M)=0.00233 *4* E_γ: weighted average: 275.36 *8* (1961Ew02), 275.42 *2* (1967Hi04, crystal), 275.374 *15* (1974HeYW), 275.36 *2* (1979Se05), 275.419 *22* (1979Vo09, authors′ uncertainty of 0.011 increased by evaluator), 275.396 *45* (1980Ch38), 275.37 *4* (1983Li19). Other: Eγ=275.209 *5* (1997Sa53, uncertainty seems underestimated, and is discrepant in energy). Other less precise Eγ using Ge(Li): 1967Do07, 1967Ca18, 1967Ja05, 1967Ba21, 1967Ki08, 1971Si20, 1974Ra30. I_γ: weighted average of 5.96 *11* (2020Ke08); 6 *1* (1999Po32); 5.93 *7* (1995Go44, uncertainty increased to 3%); 6.04 *14* (1983Li19); 6.24 *21* (1980Ch38); 5.5 *4* (1979Se05); 6.05 *10* (1979Vo09); 6.1 *4* (1974HeYW); 6.7 *7* (1974Ra30); 5.7 *4* (1971Si20); 6.8 *14* (1967Hi04); 6.1 *5* (1967Do07); 6.5 *7* (1967Ca18); 6.4 *4* (1967Ba21); 6.6 *7* (1966Ar16). Others: 6.81 *6* (1997Sa53); 7.9 *4* (1967Ki08) seem discrepant. Other: 7 *2* (1967Ja05). Measured absolute (per 100 decays) Iγ=0.781 *14* (2020Ke08); 0.776 *9* (2020KoZZ, preliminary value). Additional information 14. 275$\gamma(\theta$,H,t): $B_2U_2A_2$=+0.025 *12*, $B_4U_4A_4$=0.000 *13* (1977Al34). 91$\gamma(\theta$,H,t): $G_2U_2F_2$=+0.13 *6* (1969Ba32). (275γ)(320γ)(θ): A_2=+0.006 *2*, A_4=+0.005 *5* (1979Se05, NaI(Tl) detectors). (275γ)(411γ)(θ): A_2=−0.013 *17*, A_4=−0.008 *30* (1979Se05, Ge(Li)-NaI(Tl) detectors). (276γ)(319γ)(θ): A_2=+0.008 *11*, A_4=+0.005 *19* (1977Al34). (276γ)(410γ)(θ): A_2=−0.048 *78*, A_4=+0.10 *12* (1977Al34). (276γ)[319γ](91γ)(θ): A_2=−0.030 *12*, A_4=+0.049 *26* (1977Al34). (276γ)(319γ)(θ): A_2=+0.019 *10*, A_4=+0.011 *11* (1976Si08, NaI(Tl) detectors). (276γ)(319γ)(θ): A_2=+0.079 *22*, A_4=−0.038 *29* (1970Bl12, Ge(Li)-NaI(Tl) detectors). Ice(K)=41.5 *15*, Ice(L)=5.6 *3* (1997Sa53). Ice(K)=37.5 *25*, Ice(L)=3.6 *9* (1979Vo09). Ice(K)=45 *9* (1967Ba21). Mult.: from α(K)exp. δ: weighted average of +0.107 *7* (1979Se05, $\gamma\gamma(\theta)$); +0.14 *5* from $\gamma\gamma(\theta)$ and +0.14 *3* from $\gamma(\theta$,H,t) (1977Al34); +0.10 *4* (1969Ba32,

$\gamma(^{147}Pm)$ (continued)

E_γ	I_γ[†&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α[a]	Comments
									$\gamma(\theta$,H,t), value as given in 1977Kr13, earlier value was 0.14 *2* in 1961We07). 1977Kr13 evaluation gives +0.14 *1* based on $\gamma\gamma(\theta)$ and $\gamma(\theta$,H,t) data in 1976Si08, 1974Bh02, 1970Bl12, 1969Ba32, 1966Go25, 1963Sp07, 1961We07, 1961Ar09 and 1960Bo17.
319.410 *12*	15.00 *12*	410.515	3/2$^+$	91.1051	5/2$^+$	M1+E2	−0.38 *2*	0.0607	%Iγ=1.967 *25* α(K)exp=0.052 *2*; α(L)exp=0.0079 *4* (1997Sa53) α(K)exp=0.045 *2*; α(L)exp=0.0065 *7* (1979Vo09); α(K)exp=0.052 (1961Ew02) α(K)=0.0514 *8*; α(L)=0.00734 *11*; α(M)=0.001572 *22* α(N)=0.000354 *5*; α(O)=5.30×10^{-5} *8*; α(P)=3.23×10^{-6} *5* E_γ: weighted average: 319.39 *8* (1961Ew02), 319.41 *3* (1967Hi04, crystal), 319.411 *18* (1974HeYW), 319.39 *2* (1979Se05), 319.413 *12* (1979Vo09), 319.447 *40* (1980Ch38), 319.43 *4* (1983Li19). Other: 319.542 *3* (1997Sa53, uncertainty seems underestimated; also a discrepant value). Others less precise Eγ using Ge(Li): 1967Do07, 1967Ca18, 1967Ja05, 1967Ba21, 1967Ki08, 1971Si20, 1974Ra30. I_γ: weighted average of 14.94 *12* (2020Ke08); 15 *2* (1999Po32); 15.91 *11* (1997Sa53); 14.8 *2* (1995Go44); 14.8 *4* (1983Li19); 15.35 *48* (1980Ch38); 13.8 *11* (1979Se05); 15.0 *3* (1979Vo09); 14.9 *9* (1974HeYW); 16.5 *10* (1974Ra30); 14.2 *13* (1971Si20); 16.3 *24* (1967Hi04); 15 *5* (1967Ja05); 15.8 *10* (1967Do07); 14.2 *14* (1967Ca18); 14.5 *11* (1967Ba21); 15.0 *15* (1966Ar16). Minimum uncertainty of 3% is assumed in values measured prior to that of 2020Ke08. Other: 17.0 *9* (1967Ki08) seems discrepant. Measured absolute (per 100 decays) Iγ=1.959 *16* (2020Ke08); 1.917 *13* (2020KoZZ, preliminary value). Additional information 3. 319$\gamma(\theta$,H,t): $B_2U_2A_2$=−0.062 *5*, $B_4U_4A_4$=+0.003 *6* (1977Al34). (319γ)(91γ)(θ): A_2=−0.092 *10*, A_4=+0.009 *14* (1977Al34). 319$\gamma(\theta$,H,t): $G_2U_2F_2$=−0.12 *2* (1969Ba32). (319γ)(91γ)(θ): A_2=−0.080 *6*, A_4=+0.0013 *60* (1979Vo09). (319γ)(91γ)(θ): A_2=−0.088 *8*, G_4A_4=−0.016 *14* (1976Si08, NaI(Tl) detectors). (319γ)(91γ)(θ): A_2=−0.085 *11*, A_4=−0.14 *15* (1970Bl12, Ge(Li)-NaI(Tl) detectors). Ice(K)=62.2 *18*, Ice(L)=9.5 *4* (1997Sa53). Ice(K)=53.0 *15*, Ice(L)=7.5 *8* (1979Vo09). Mult.: from α(K)exp data. δ: weighted average of −0.391 *16* (1979Se05, $\gamma\gamma(\theta)$); −0.41 *3* (1977Al34, $\gamma\gamma(\theta)$, authors′ other value is −0.32 to −1.7 from $\gamma(\theta$,H,t)); and the following values evaluated by 1977Kr13: −0.38 *2* (1976Si08, $\gamma\gamma(\theta)$); −0.37 *3* (1970Bl12, $\gamma\gamma(\theta)$); −0.31 *9* (1969Ba32, $\gamma(\theta$,H,t), authors′ value was +0.55 *5*); −0.34 *2* (1966Go25); −0.39 *4* (1963Sp07); −0.36 *2* (1961We07); −0.42 *8* (1961Ar09); −0.38 *2* (1960Bo17); −0.40 *2*

γ(^{147}Pm) (continued)

E_γ	I_γ [†&]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [#]	δ	α [a]	Comments
									(1957Li40). Others: −0.27 *1* (1960Ma03), ≈0.5 (1961Ew02, L-subshell ratios). 1977Kr13 evaluation gives −0.37 *1*.
398.130 *16*	6.617 *76*	489.247	7/2$^+$	91.1051	5/2$^+$	M1+E2	+0.30 *1*	0.0345 *5*	%Iγ=0.867 *13* α(K)=0.0293 *5*; α(L)=0.00406 *6*; α(M)=0.000866 *13* α(N)=0.000195 *3*; α(O)=2.94×10^{-5} *5*; α(P)=1.85×10^{-6} *3* α(K)exp=0.030 *4* (1997Sa53); α(K)exp=0.033 *3* (1979Vo09); α(K)exp=0.030 *6* (1967Ba21) α(N)=0.000195 *3*; α(O)=2.94×10^{-5} *5*; α(P)=1.85×10^{-6} *4* E_γ: unweighted average: 398.22 *7* (1967Hi04, crystal), 398.155 *20* (1974HeYW), 398.13 *3* (1979Se05), 398.098 *16* (1979Vo09), 398.170 *30* (1980Ch38), 398.14 *5* (1983Li19). Other: Eγ=398.336 *2* (1997Sa53, uncertainty seems underestimated, and is discrepant in energy). Other less precise Eγ using Ge(Li): 1967Do07, 1967Ca18, 1967Ja05, 1967Ba21, 1967Ki08, 1971Si20, 1974Ra30. I_γ: weighted average of 6.598 *76* (2020Ke08); 6.82 *6* (1997Sa53); 6.64 *7* (1995Go44); 6.52 *15* (1983Li19), 6.72 *22* (1980Ch38), 6.5 *5* (1979Se05); 6.59 *10* (1979Vo09); 6.7 *4* (1974HeYW); 6.5 *7* (1974Ra30); 6.3 *5* (1971Si20); 6.6 *3* (1967Ki08); 6.8 *11* (1967Hi04); 6.7 *5* (1967Do07); 6.4 *6* (1967Ca18); 6.6 *6* (1967Ba21); 7.0 *7* (1966Ar16). Other: 5 *2* (1967Ja05). Minimum uncertainty of 3% is assumed in values measured prior to that of 2020Ke08. Measured absolute (per 100 decays) Iγ=0.865 *10* (2020Ke08); 0.840 *9* (2020KoZZ, preliminary value). Additional information 5. 398γ(θ,H,t): $B_2U_2A_2$=−0.052 *9*, $B_4U_4A_4$=+0.009 *10* (1977Al34). 397γ(θ,H,t): $G_2U_2F_2$<0 (1969Ba32). (398γ)(91γ)(θ): A_2=−0.063 *10*, A_4=−0.015 *15* (1979Vo09). (398γ)(91γ)(θ): A_2=−0.092 *10*, A_4=+0.009 *14* (1977Al34). (398γ)(91γ)(θ): A_2=−0.074 *19*, A_4=−0.19 *23* (1970Bl12, Ge(Li)-NaI(Tl) detectors). Ice(K)=15.0 *5* (1997Sa53), 16.6 *10* (1979Vo09), 14.7 *15* (1967Ba21). Mult.: from α(K)exp. δ: from γ(θ) data in (p,2nγ) (1977Ko24). Value from β^- is +0.30 *4* from weighted average of +0.31 *5* from γγ(θ) and +0.29 *4* from γ(θ,H,t) (1977Al34). Others: +0.18 *6* (1974Bh02), +0.14 *6* (1970Bl12), +0.50 *7* (1966Go25), +0.31 *3* (1960Bo17), as evaluated by 1977Kr13 from respective γγ(θ) data, and based on these data, 1977Kr13 give +0.24 *5*. The α(K)exp values are consistent with δ(E2/M1)=0.30 *4*.
408.15 *5*	0.1043 *35*	408.14	9/2$^+$	0.0	7/2$^+$	M1+E2	+0.57 *3*	0.0304	%Iγ=0.0137 *5* α(K)=0.0257 *5*; α(L)=0.00369 *6*; α(M)=0.000790 *12* α(N)=0.000178 *3*; α(O)=2.65×10^{-5} *4*; α(P)=1.60×10^{-6} *3* E_γ: weighted average: 408.16 *5* (1979Se05), 408.14 *5* (1983Li19).

γ(^{147}Pm) (continued)

E_γ	I_γ[†&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α[a]	Comments
									Other: 408.52 *6* (1997Sa53). I_γ: from 2020Ke08. Others: 0.14 *1* (1997Sa53); 0.15 *1* (1983Li19); 0.115 *16* (1979Se05). Measured absolute (per 100 decays) Iγ=0.01368 *46* (2020Ke08). Mult.,δ: from α(K)exp and $\gamma(\theta)$ in ^{148}Nd(p,2nγ) (1977Ko24).
410.52 *3*	0.817 *14*	410.515	3/2$^+$	0.0	7/2$^+$	E2		0.0212	%Iγ=0.1071 *21* α(K)=0.01724 *25*; α(L)=0.00313 *5*; α(M)=0.000683 *10* α(K)exp=0.0171 *11* (1997Sa53); α(K)exp=0.027 *6* (1979Vo09); α(K)exp=0.014 *10* (1967Ba21) α(N)=0.0001520 *22*; α(O)=2.17$\times10^{-5}$ *3*; α(P)=9.80$\times10^{-7}$ *14* E_γ: weighted average of 410.48 *3* (1974HeYW), 410.51 *3* (1979Se05), 410.59 *7* (1979Vo09), 410.48 *5* (1983Li19), 410.58 *3* (1997Sa53). Other less precise Eγ using Ge(Li): 1967Hi04, 1967Do07, 1967Ca18, 1967Ja05, 1967Ba21, 1971Si20, 1974Ra30. Eγ=410.331 *57* in 1980Ch38 seems discrepant. I_γ: weighted average of 0.812 *11* (2020Ke08); 0.78 *4* (1995Go44); 0.73 *5* (1983Li19); 0.95 *5* (1980Ch38); 0.79 *6* (1979Se05); 0.93 *5* (1979Vo09); 1.03 *28* (1971Si20); 1.2 *5* (1967Hi04); 1.0 *6* (1967Ja05); 0.9 *2* (1967Do07). Others: 1.12 *1* (1997Sa53), 1.2 *3* (1974Ra30); 1.07 *6* (1974HeYW); 1.30 *13* (1967Ca18); 1.7 *2* (1967Ba21); 1.3 *1* (1966Ar16) seem too high and discrepant. Measured absolute (per 100 decays) Iγ=0.1065 *14* (2020Ke08). Additional information 4. Mult.: 410γ(θ,H,t): $B_2U_2A_2$=−0.001 *58*, $B_4U_4A_4$=−0.068 *62*, consistent with pure E2 (1977Al34). The α(K)exp from 1997Sa53 is consistent with E2, but that from 1979Vo09 gives δ(E2/M1)<1.3. Ice(K)=1.44 *9* (1997Sa53), 2.0 *5* (1979Vo09), 1.8 *13* (1967Ba21).
439.875 *17*	9.178 *76*	530.998	5/2$^+$	91.1051	5/2$^+$	M1+E2	+0.62 *5*	0.0247 *5*	%Iγ=1.203 *16* α(K)exp=0.0212 *9*; α(L)exp=0.0028 *2* (1997Sa53); α(K)exp=0.016 *1* (1979Vo09) α(K)exp=0.022 (1961Ew02) α(K)=0.0209 *5*; α(L)=0.00299 *5*; α(M)=0.000640 *10* α(N)=0.0001440 *23*; α(O)=2.15$\times10^{-5}$ *4*; α(P)=1.30$\times10^{-6}$ *3* E_γ: weighted average: 439.82 *10* (1961Ew02), 439.85 *8* (1967Hi04, crystal), 439.895 *22* (1974HeYW), 439.92 *5* (1979Se05), 439.856 *17* (1979Vo09), 439.921 *60* (1980Ch38), 439.88 *4* (1983Li19). Other: Eγ=440.062 *2* (1997Sa53, uncertainty seems underestimated, and discrepant in energy, not used in averaging). Other less precise Eγ using Ge(Li): 1967Do07, 1967Ca18, 1967Ja05, 1967Ba21, 1967Ki08, 1971Si20, 1974Ra30. I_γ: weighted average of 9.115 *76* (2020Ke08); 9.54 *7* (1997Sa53); 9.15 *17* (1995Go44); 8.97 *23* (1983Li19), 9.20 *30* (1980Ch38), 9.1 *7* (1979Se05); 9.19 *14* (1979Vo09); 9.2 *6* (1974HeYW); 9.8 *2*

From ENSDF

^{147}Nd β^- decay (11.03 d) 2020Ke08,1997Sa53,1979Se05 (continued)

γ(^{147}Pm) (continued)

E_γ	I_γ[†&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α[a]	Comments
									(1974Ra30); 9.5 *6* (1971Si20); 9.3 *3* (1967Ki08); 9.3 *11* (1967Hi04); 9.7 *6* (1967Do07); 9.2 *9* (1967Ca18); 8.9 *6* (1967Ba21); 8.8 *9* (1966Ar16). Other: 8 *2* (1967Ja05). Minimum uncertainty of 3% is assumed in values prior to that of 2020Ke08. Measured absolute (per 100 decays) Iγ=1.195 *10* (2020Ke08); 1.189 *10* (2020KoZZ, preliminary value). Additional information 8. 440γ(θ,H,t): $B_2U_2A_2$=−0.159 *10*, $B_4U_4A_4$=−0.001 *10* (1977Al34). 440γ(θ,H,t): $G_2U_2F_2$=−0.485 *80* (1969Ba32). (440γ)(91γ)(θ): A_2=+0.073 *11*, A_4=−0.002 *15* (1977Al34). (440γ)(91γ)(θ): A_2=−0.067 *7*, A_4=+0.010 *8* (1979Vo09). (440γ)(91γ)(θ): A_2=+0.048 *9*, G_4A_4=+0.009 *6* (1976Si08, NaI(Tl) detectors). (440γ)(91γ)(θ): A_2=+0.054 *18*, A_4=+0.16 *24* (1970Bl12, Ge(Li)-NaI(Tl) detectors). Ice(K)=15.2 *5*, Ice(L)=2.0 *1* (1997Sa53). Ice(K)=10.9 *6* (1979Vo09). δ: weighted average of +0.77 *10* (1977Al34, γγ(θ)); and the following values evaluated by 1977Kr13: +0.59 *5* (1976Si08, γγ(θ)); +0.62 *7* (1974Bh02); +0.62 *+10−8* (1970Bl12, γγ(θ)); +0.70 *9* (1969Ba32, γ(θ,H,t), previous value was +0.82 *65* in 1961We07); +0.62 *6* (1968Ra28); +0.56 *6* (1966Go25); +0.59 *7* (1963Sp07); +0.69 *+13−10* (1961Sa13); +0.63 *5* (1960Bo17). 1977Kr13 evaluation gives +0.62 *2*.
489.27 *3*	1.086 *33*	489.247	7/2$^+$	0.0	7/2$^+$	M1+E2	−0.79 *+23−45*	0.0179 *18*	%Iγ=0.142 *5* α(K)exp=0.018 *1* (1997Sa53); α(K)exp=0.023 *6* (1979Vo09) α(K)=0.0151 *16*; α(L)=0.00218 *14*; α(M)=0.00047 *3* α(N)=0.000105 *7*; α(O)=1.57×10^{-5} *12*; α(P)=9.4×10^{-7} *12* E_γ: weighted average: 489.240 *28* (1974HeYW), 489.30 *8* (1979Se05), 489.25 *3* (1979Vo09), 489.296 *50* (1980Ch38), 489.25 *5* (1983Li19), 489.35 *4* (1997Sa53, authors′ uncertainty of 0.01 keV increased by evaluator). Other less precise Eγ using Ge(Li): 1967Hi04, 1967Do07, 1967Ca18, 1967Ja05, 1967Ba21, 1967Ki08, 1971Si20, 1974Ra30. I_γ: weighted average of 1.072 *33* (2020Ke08); 1.16 *1* (1997Sa53); 1.07 *24* (1995Go44); 1.04 *5* (1983Li19), 1.06 *5* (1980Ch38), 1.07 *8* (1979Se05); 1.12 *6* (1979Vo09); 1.17 *6* (1974HeYW); 1.4 *4* (1974Ra30); 1.12 *19* (1971Si20); 0.8 *3* (1967Ki08); 1.1 *5* (1967Hi04); 1.0 *5* (1967Ja05); 1.2 *3* (1967Do07); 1.5 *8* (1967Ca18); 1.5 *2* (1967Ba21). Other: 0.70 *8* (1966Ar16) seems discrepant. Minimum uncertainty of 3% is assumed in values in averaging procedure. Measured absolute (per 100 decays) Iγ=0.1406 *43* (2020Ke08); 0.138 *4* (2020KoZZ, preliminary value). Additional information 6. 489γ(θ,H,t): $B_2U_2A_2$=+0.048 *34*, $B_4U_4A_4$=−0.026 *37* (1977Al34). Ice(K)=1.57 *9* (1997Sa53), 2.0 *5* (1979Vo09).

$^{147}_{61}Pm_{86}$-16

γ(^{147}Pm) (continued)

E_γ	I_γ[†&]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	δ	α[a]	Comments
									Mult.: from α(K)exp. δ: from $\gamma(\theta$,H,t) (1977Al34). Other values of δ=>+4 and <−6 from $\gamma(\theta$,H,t) (1977Al34) are inconsistent with conversion data, which suggest dominant M1. δ=+1.2 *+28−8* from 1977Kr13 evaluation, based on $\gamma\gamma(\theta)$ data of 1961Sa13 is not in good agreement with either the value $\gamma(\theta$,H,t) or from ce data.
531.012 *18*	100.0 *10*	530.998	5/2$^+$	0.0	7/2$^+$	M1+E2	−0.40 *3*	0.0162 *3*	%Iγ=13.11 *13* (2020Ke08) α(K)exp=0.0133 *3* (1997Sa53); α(K)exp=0.0135 *20* (1967Ba21) α(L)exp=0.00204 *9* (1997Sa53); α(L)exp=0.0017 *2* (1979Vo09) α(K)=0.01376 *22*; α(L)=0.00189 *3*; α(M)=0.000402 *6* α(N)=9.06×10^{-5} *14*; α(O)=1.366×10^{-5} *21*; α(P)=8.62×10^{-7} *15* E_γ: weighted average: 530.95 *10* (1961Ew02), 531.01 *7* (1967Hi04, crystal), 531.016 *22* (1974HeYW), 531.05 *4* (1979Se05), 530.979 *18* (1979Vo09), 531.002 *27* (1980Ch38), 531.00 *4* (1983Li19), 531.069 *24* (1997Sa53, authors′ uncertainty of 0.006 increased by evaluator). Other less precise Eγ using Ge(Li): 1967Do07, 1967Ca18, 1967Ja05, 1967Ba21, 1967Ki08, 1971Si20, 1974Ra30. I_γ: normalizing γ ray, 1% uncertainty assigned by evaluator. Iγ=100.0 *10* (2020Ke08); 100 (1999Po32); 100.0 *8* (1997Sa53); 100.0 *20* (1995Go44); 100 (1983Li19), 100 (1980Ch38), 100 *7* (1979Se05); 100.0 *20* (1979Vo09); 100 *6* (1974HeYW); 100 (1974Ra30); 100.0 *28* (1971Si20); 100 (1967Ki08); 100 (1967Hi04); 100 (1967Ja05); 100 (1967Do07); 100 (1967Ca18); 100 *6* (1967Ba21); 100 (1966Ar16). Measured absolute (per 100 decays) Iγ=13.11 *13* (2020Ke08); 13.019 *53* (2020KoZZ, preliminary value). Additional information 9. 531$\gamma(\theta$,H,t): $B_2U_2A_2$=−0.074 *2*, $B_4U_4A_4$=−0.002 *2* (1977Al34). 531$\gamma(\theta$,H,t): $G_2U_2F_2$=−0.300 *12* (1969Ba32). Ice(K)=100 *2*, Ice(L)=15.3 *5* (1997Sa53). Ice(K)=100 *5*, Ice(L)=13.1 *7* (1979Vo09). Ice(K)=100 *7* (1967Ba21). Mult.: from α(K)exp. δ: from $\gamma(\theta$,H,t) (1977Al34). 1977Kr13 evaluation gives −0.54 *12* based on $\gamma(\theta$,H,t) data in 1969Ba32, 1961We07 and 1957Bi86.
541.79 *5*	0.0894 *61*	632.85	1/2$^+$	91.1051	5/2$^+$	[E2]		0.00994	%Iγ=0.0117 *8* α(N)=6.47×10^{-5} *9*; α(O)=9.39×10^{-6} *14*; α(P)=4.82×10^{-7} *7* α(K)=0.00824 *12*; α(L)=0.001338 *19*; α(M)=0.000290 *4* E_γ: weighted average: 541.85 *5* (1979Se05), 541.70 *5* (1983Li19), 541.83 *7* (1997Sa53). I_γ: weighted average of 0.0831 *61* (2020Ke08); 0.098 *8* (1983Li19), 0.098 *16* (1979Se05). Others: 0.14 *2* (1997Sa53); 0.20 *5* (1966Ar16) seem discrepant. Measured absolute (per 100 decays) Iγ=0.0109 *8* (2020Ke08).

$^{147}_{61}Pm_{86}$-17

γ(^{147}Pm) (continued)

E_γ	I_γ[†&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α[a]	Comments
589.35 *3*	0.2951 *84*	680.432	7/2$^+$	91.1051	5/2$^+$	(M1+E2)		0.011 *3*	%Iγ=0.0387 *12* α(K)=0.0090 *23*; α(L)=0.00128 *23*; α(M)=0.00027 *5* α(N)=6.2×10^{-5} *11*; α(O)=9.2×10^{-6} *18*; α(P)=5.5×10^{-7} *16* α(K)exp=0.013 *3* (1979Vo09) Eγ: weighted average: Eγ=589.35 *4* (1974HeYW), 589.35 *6* (1979Se05), 589.52 *13* (1979Vo09), 589.32 *4* (1983Li19), 589.33 *4* (1997Sa53, authors′ uncertainty of 0.02 increased by evaluator). Other less precise Eγ using Ge(Li): 1967Hi04, 1967Do07, 1967Ba21, 1971Si20, 1974Ra30, 1980Ch38. Iγ: weighted average of Iγ=0.2860 *84* (2020Ke08); 0.29 *2* (1997Sa53); 0.344 *4* (1995Go44, uncertainty seems underestimated, increased to 0.035); 0.29 *2* (1983Li19); 0.31 *3* (1980Ch38); 0.287 *25* (1979Se05); 0.30 *3* (1979Vo09); 0.350 *34* (1974HeYW); 0.29 *8* (1974Ra30); 0.37 *4* (1971Si20); 0.31 *14* (1967Hi04); 0.26 *6* (1967Do07); 0.28 *4* (1967Ba21); 0.40 *6* (1966Ar16). Measured absolute (per 100 decays) Iγ=0.0375 *11* (2020Ke08); 0.034 *3* (2020KoZZ, preliminary value). Ice(K)=0.29 *8* (1979Vo09). Mult.: from α(K)exp. Additional information 10.
594.796 *21*	1.853 *20*	685.899	5/2$^+$	91.1051	5/2$^+$	E2(+M1)	≥6	0.00790 *13*	%Iγ=0.243 *4* α(K)exp=0.0071 *5* (1997Sa53); α(K)exp=0.0049 *6* (1979Vo09) α(K)exp=0.007 *4* (1967Ba21) α(K)=0.00658 *11*; α(L)=0.001033 *16*; α(M)=0.000223 *4* α(N)=4.98×10^{-5} *8*; α(O)=7.29×10^{-6} *12*; α(P)=3.88×10^{-7} *7* Eγ: weighted average: 594.74 *10* (1961Ew02), 594.80 *3* (1974HeYW), 594.84 *6* (1979Se05), 594.793 *24* (1979Vo09), 594.859 *45* (1980Ch38), 594.79 *3* (1983Li19), 594.783 *21* (1997Sa53, authors′ uncertainty of 0.003 increased by evaluator). Other less precise Eγ using Ge(Li): 1967Do07, 1967Ca18, 1967Hi04, 1967Ja05, 1967Ba21, 1967Ki08, 1971Si20, 1974Ra30. Iγ: weighted average of 1.853 *20* (2020Ke08); 2.0 *3* (1999Po32); 1.852 *22* (1995Go44, uncertainty increased to 3%); 1.81 *5* (1983Li19); 1.63 *10* (1980Ch38); 1.89 *16* (1979Se05); 1.92 *6* (1979Vo09); 2.03 *13* (1974HeYW); 2.0 *3* (1974Ra30); 2.06 *19* (1971Si20); 2.08 *24* (1967Ki08); 1.9 *4* (1967Hi04); 1.6 *2* (1967Do07); 1.9 *2* (1967Ba21). Others: 2.12 *2* (1997Sa53); 2.2 *2* (1967Ca18); 2.2 *2* (1966Ar16) seem discrepant. Other: 2 *1* (1967Ja05). Measured absolute (per 100 decays) Iγ=0.2429 *26* (2020Ke08); 0.253 *5* (2020KoZZ, preliminary value). Additional information 15. 595γ(θ,H,t): $B_2U_2A_2$=+0.047 *36*, $B_4U_4A_4$=+0.001 *37* (1977Al34). (595γ)(91γ)(θ): A_2=+0.043 *38*, A_4=−0.044 *54* (1977Al34). Ice(K)=1.13 *7* (1997Sa53), 0.78 *8* (1979Vo09), 1.0 *6* (1967Ba21).

$^{147}_{61}$Pm$_{86}$-18

γ(^{147}Pm) (continued)

E_γ	I_γ [†&]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α [a]	Comments
									β(595γ) coin from 1960We06. Mult.: from α(K)exp. δ: $\delta\geq$6 from $\gamma\gamma(\theta)$ and $\geq$7 from $\gamma(\theta$,H,t) (1977Al34). This value is consistent with ce data which give dominant E2 1977Kr13 evaluation gives δ=+0.55 *5* from 1974Bh02, 1968Ra28, 1963Sp07 and 1961Sa13; all from $\gamma\gamma(\theta)$ data using NaI(Tl) detectors. But this value is inconsistent with $\gamma\gamma(\theta)$ and $\gamma(\theta$,H,t) data from 1977Al34, as well as with ce data from 1997Sa53 and 1979Vo09.
680.40 *4*	0.1228 *60*	680.432	7/2$^+$	0.0	7/2$^+$	M1+E2		0.0074 *18*	%Iγ=0.0161 *8* α(K)=0.0063 *16*; α(L)=0.00088 *17*; α(M)=0.00019 *4* α(N)=4.2$\times10^{-5}$ *8*; α(O)=6.4$\times10^{-6}$ *13*; α(P)=3.9$\times10^{-7}$ *11* E_γ: weighted average: 680.52 *15* (1974HeYW), 680.39 *5* (1979Se05), 680.42 *4* (1983Li19), 680.36 *5* (1997Sa53). Eγ=681.05 *22* (1979Vo09) seems discrepant. Other less precise Eγ using Ge(Li): 1967Hi04, 1971Si20, 1974Ra30, 1980Ch38. I_γ: weighted average of Iγ=0.1236 *84* (2020Ke08); 0.122 *7* (1995Go44); 0.12 *1* (1983Li19); 0.123 *6* (1979Se05); 0.149 *32* (1974HeYW). Others: 0.22 *1* (1997Sa53), 0.3 *1* (1980Ch38), 0.30 *5* (1979Vo09), 0.06 (1974Ra30), 0.32 *15* (1971Si20), 0.23 *16* (1967Hi04), <0.05 (1967Do07). Values from 1997Sa53, 1980Ch38, 1979Vo09 and 1971Si20 seem high as compared to precise and consistent Iγ data in 2020Ke08, 1979Se05 and 1995Go44. Measured absolute (per 100 decays) Iγ=0.0162 *11* (2020Ke08). Additional information 11. Mult.: from α(K)exp in ^{148}Nd(p,2nγ) (1977Ko24).
685.882 *28*	6.28 *11*	685.899	5/2$^+$	0.0	7/2$^+$	M1+E2	−0.97 *30*	0.0073 *7*	%Iγ=0.823 *17* α(K)=0.0062 *6*; α(L)=0.00087 *6*; α(M)=0.000186 *13* α(N)=4.2$\times10^{-5}$ *3*; α(O)=6.3$\times10^{-6}$ *5*; α(P)=3.8$\times10^{-7}$ *4* E_γ: weighted average: 685.80 *10* (1961Ew02), 685.902 *35* (1974HeYW), 685.89 *4* (1979Se05), 685.889 *28* (1979Vo09), 685.953 *35* (1980Ch38), 685.89 *3* (1983Li19), 685.792 *32* (1997Sa53, authors′ uncertainty of 0.008 increased by evaluator). Other less precise Eγ using Ge(Li): 1967Do07, 1967Ca18, 1967Hi04, 1967Ja05, 1967Ba21, 1967Ki08, 1971Si20, 1974Ra30. I_γ: weighted average of 6.25 *11* (2020Ke08); 6.63 *5* (1997Sa53); 6.21 *7* (1995Go44); 6.24 *13* (1983Li19), 6.07 *15* (1980Ch38), 6.6 *5* (1979Se05); 6.1 *2* (1979Vo09); 6.2 *4* (1974HeYW); 6.7 *6* (1974Ra30); 6.5 *4* (1971Si20); 6.4 *4* (1967Ki08); 5.9 *10* (1967Hi04); 6 *1* (1967Ja05); 5.9 *4* (1967Do07); 6.6 *7* (1967Ca18); 7.0 *4* (1967Ba21); 7.0 *7* (1966Ar16); with minimum uncertainty of 3% in values measured prior to 1998. Measured absolute (per 100 decays) Iγ=0.819 *14* (2020Ke08); 0.815 *8* (2020KoZZ, preliminary value). Additional information 16.

γ(^{147}Pm) (continued)

E_γ	I_γ[†&]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	Comments
							686γ(θ,H,t): $B_2U_2A_2$=−0.116 *9*, $B_4U_4A_4$=+0.002 *10* (1977Al34). 686γ(θ,H,t): $G_2U_2F_2$=−0.329 *6* (1969Ba32). Ice(K)=3.4 *2* (1997Sa53), 3.1 *6* (1979Vo09), 3.4 *5* (1967Ba21). α(K)exp=0.0068 *4* (1997Sa53), 0.0066 *13* (1979Vo09), 0.0065 *15* (1967Ba21). Mult.: from α(K)exp. δ: from γ(θ,H,t); weighted average of −0.95 *30* (1977Al34); and −1.05 *65* (1969Ba32; previous value was −0.95 *33* in 1961We07). 1977Kr13 evaluation gives −0.97 *27* from γ(θ,H,t) date of 1969Ba32 and 1961We07.
716.2[‡] *2*	0.0023[‡] *7*	807.25	5/2⁻,7/2⁻	91.1051	5/2⁺	E1[@]	%Iγ=0.00030 *9*
807.2[‡] *2*	0.0021[‡] *6*	807.25	5/2⁻,7/2⁻	0.0	7/2⁺	E1[@]	%Iγ=0.00028 *8*

[†] From averages of values from various studies as specified with each γ ray. Relative intensities in 1995Go44, 1979Se05, 1974HeYW, 1971Si20 and 1967Ba21 were normalized to 100 for the 91-keV γ ray. Evaluator has renormalized intensity data in references to 100 for the 531-keV γ ray. Except for the 91-keV γ ray, weighted or unweighted averages are taken. Note that 1997Sa53 and 1995Go44 seem to report intensities with low (likely underestimated) uncertainties, as compared to those reported in other studies using nearly similar type of apparatus. In certain cases, values seemed discrepant (either too high or too low) which were not included in the averaging procedure.

[‡] from 1983Li19 only. Note that Eγ value and Iγ(716)/Iγ(807) are the same as in ^{148}Nd(p,2nγ) study (1977Ko24).

[#] Based on α(K)exp, except as noted. The α(K)exp and α(L)exp (1997Sa53) normalized to α(K)exp(531γ)=0.0133 *3*, δ=−0.41 *2*; α(K)exp=ce(K)(1967Ba21)/Iγ normalized to α(L1)+α(L2)(91γ)=0.2458 (M1+E2 theory). The ce(K)(1961Ew02) data are normalized to ce(K)(531γ)=0.626 in accord with 1967Ba21. Exceptions are noted.

[@] From α(K)exp in ^{148}Nd(p,2nγ) (1977Ko24).

[&] For absolute intensity per 100 decays, multiply by 0.1311 *13*.

[a] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

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

^{147}Nd β^- decay (11.03 d) 2020Ke08,1997Sa53,1979Se05