^{18}C β^- decay 1991Pr03

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	R. Spitzer, J. H. Kelley	ENSDF	30-Jun-2021

Parent: ^{18}C: E=0; $J^\pi=0^+$; $T_{1/2}$=92 ms *2*; Q(β^-)=11810 *40*; %β^- decay=100.0
$^{18}C-T_{1/2}$: From (1995Sc03).
^{18}C-Q(β^-): From (2021Wa16).
Decay to neutron-bound levels:
1991Pr03: A beam of ^{18}C, produced using the GANIL/LISE facility, was implanted into a plastic scintillator. Activity was collected for 300 ms followed by an equal time of decay counting. A 40% relative efficience HPGe detector was placed near the stopper, and decay events were recorded for β and β-γ coincidence events. The authors aimed to resolve the β^-0n and β^-1n decay branches. In the article, the decay of ^{18}C and ^{18}N were measured under identical experimental conditions; then the ratio of the intensity of the ^{18}O E_γ=1982 keV transition, which is strongly populated in ^{18}N decay, was analyzed to determine the sum of ^{18}C decay branches to bound ^{18}N states. %β^-0n=81 *5* was deduced. This implies %β^-1n=19 *5*.
A total of 9 γ-ray ^{18}N transitions were identified along with others associated with ^{17}N and ^{18}O. The γ-ray intensities are presented in two formats: first- they are given as relative intensities normalized to the strongest line (Table 1), the E_γ=2614 keV transition; second- intensities are given for a 100% branching sum out of each level (Table 3).
The authors discussed the likelihood of γ-ray summing effects as a potential source of systematic uncertainty; this is because a single HPGe detector was used and it was placed close to the decay stopper foil. Secondly, they discussed an inconsistency of their data where a higher intensity feeds the E_x=115 keV level than is observed exiting the level. Authors suggest this inconsistency may be attributed to the state having a long lifetime causing a significan fraction (≈1/2) to fall outside the DAQ coincidence window.
The evaluator finds significant problems with the intensity balance for the E_x=115 and 572 keV level γ rays; the E_x=115 keV level lifetime is about a ns (2008Wi05). For the analysis, the decay intensities are set equal to the feeding intensities for these two states. Furthermore there is a discrepancy in the decay branching ratios of ^{18}N*(1734) state given in Table 1 vs. Table 3. We take the Table 1 values, since they should require less interpretation to obtain, and since they are required to arrive at their deduced relative β^- branching ratios.
In spite of the experimental uncertainties, (1991Pr03) is the only ^{18}C β^- decay study that provides γ-ray spectroscopy information on ^{18}N levels. In their analysis, the authors suggest a negligible first-forbidden branch to $^{18}N_{g.s.}$, and so they normalize their measured relative branching ratios with %β^-0n=81 *5* to obtain the absolute decay intensities.
The following table is from (1991Pr03). It gives the measured energies and relative intensities of γ-rays assigned to the β^- decay of ^{18}C. The two entries marked with ^{17}N involve beta delayed neutron emission.

$E_\gamma$sssssssssssss	I_γ	$E_\gamma$ssssssss	I_γ.
114.9 *2*	32 *1*	1734.8 *4*	25 *5*.
471.7 *2*	15 *2*	2025.3 *8*	7 5.
879.7 2	44 *4*	2499.3 *4*	41 9.
1147.8 *4*	17 *5*	2614.2 *4*	100 11.
1619.9 *3*	25 *5*.		
^{17}N(E_γ=1374.0 *10*)s	24 *5*.		
^{17}N(E_γ=1849.9 *4*)s	11 *5*.		

Decay to neutron-unbound levels:
1991Pr03: As mentioned above, %β^-1n=19 *5* was deduced by comparing the measured γ-ray yields from ^{18}C and ^{18}N decay reactions.
1988Mu08,1989Le16: ^{18}C ions from fragmentation of ^{86}Kr (1988Mu08) and ^{48}Ca (1989Le16) on a ^{181}Ta target at GANIL were selected using the LISE spectrometer and implanted into a Si detector. The telescope was surrounded by a thin plastic scintillator β counter and segmented 4π NE102A scintillator neutron array. Neutron energy thresholds of 440 keV and 350 keV were utilized in (1988Mu08) and (1989Le16), respectively. Delayed neutron emission probabilities of P_n=(25.0 *45*)% and (50 *10*)% were deduced, respectively.
1991Re02: ^{18}C spallation products from 800 MeV proton bombardment of a ^{232}Th target were transported to the TOFI spectrometer at LAMPF. The ions were implanted in a Si detector. The β-delayed neutrons were detected in a polyethylene moderated ^{3}He counter; half-lives and β-delayed neutron probabilities were deduced from analysis of the number of implanted ions (per beam pulse) and the rate of β-delayed neutrons detected in the zero-threshold counter. The β-delayed neutron probability

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=(43.3 *65*)% was deduced along with $T_{1/2}$=94 ms *27*.

New data was collected using the experimental configuration of (1991Re02), and the collective results were analyzed. In (1994ReZZ) P_n=(30.2 *17*)% and $T_{1/2}$=92.9 ms *53* are given. In later unpublished works (1995ReZZ,2008ReZZ), P_n=(31.5 *15*)% and $T_{1/2}$=92 ms *5* are indicated. Other analyses of these data are found in (1993ReZX,1994KiZU).

1995Sc03: A ^{18}C beam from the NSCL/A1200 was stopped in a plastic scintillator implantaion detector that was surrounded by an array of 15 plastic scintillator neutron detectors. The beam was collected in the stopping detector for 206 ms followed by a 222 ms beam-off counting period. Neutron events are recorded for β signals in the implantation detector in coincidence with neutron signals in the 99.7 cm flight path neutron array. Neutron energies were determined via time-of-flight; the array was configured with a low-energy threshold of ≈750 keV. Background activity from ^{18}N and ^{17}N, the ^{18}C decay daughters, was separable from the ^{18}C decays.

Seven neutron groups are evident in the energy spectrum; however, the lack of n-γ coincidence data and unknown spectroscopy of ^{18}N levels above the neutron binding precludes assignment of the neutron groups to ^{18}N levels. This is further accented by the known participation of ^{17}N*(1374,1850) levels in the β^-n reaction as reported in (1991Pr03). The intensity of β^-n neutron events reported in (1995Sc03) is (21.4 *44*)%. The neutrons can go to ^{17}N*(0,1374,1849), which implies ^{18}N excitation energies listed below.

E_n (MeV)	Branching Ratio (%)	S_n+E(n+$^{17}N_{g.s.}$)	S_n+E(n+^{17}N*(1374))	S_n+E(n+^{17}N*(1849)).
0.88 *2*	13.1 *13*	3.76 MeV *2*	5.13 MeV *2*	5.61 MeV *2*.
1.55 *2*	3.65 *41*	4.47 MeV *2*	5.84 MeV *2*	6.32 MeV *2*.
1.91 *2*	0.87 *16*	4.85 MeV *2*	6.22 MeV *2*	6.70 MeV *2*.
2.47 *2*	0.76 *13*	5.44 MeV *2*	6.81 MeV *2*	7.29 MeV *2*.
2.78 *2*	0.96 *14*	5.77 MeV *2*	7.14 MeV *2*	7.62 MeV *2*.
3.25 *3*	1.24 *15*	6.27 MeV *3*	7.64 MeV *2*	8.12 MeV *2*.
4.59 *4*	0.86 *12*	7.68 MeV *4*	9.05 MeV *2*	9.53 MeV *2*.

Comments:

The P_n=(31.5 *15*)%=%β^-1n value from (2008ReZZ) is reluctantly accepted. The evaluator notes that amongst the Kim/Reeder articles and conference reports, a wide range of values are presented. Measurements listed above using neutron arrays having finite neutron-energy thresholds found discrete neutron groups adding to ≈20% of the decay intensities; however, because the moderated ^{3}He counter used by Reeder is sensitive to all energy neutrons, this approach should provide the most reliable P_n value.

Taking %β^-1n=(31.5 *15*), the relative intensities of γ transitions reported in (1991Pr03) are normalized to give %β^-0n=(68.5 *15*). In (1991Pr03), the feeding into ^{18}N*(115,572) states is greater than the decay out of the states, which required adjustments to the intensity balance.

See theoretical discussion on β decay in (1993Ch06); also see (2016Ta07).

^{18}N Levels

E(level)†	J^π	$T_{1/2}$	Comments
0.0	1^-	619 ms *2*	T=2 $T_{1/2}$: From (2005Li60).
114.71 *10*	(2^-)		
587.39 *20*	(2^-)		
1734.75 *19*	(1,2)		
2614.35 *21*	1^+		

† From Adopted Levels.

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β^- radiations

E(decay)	E(level)	Iβ^- †‡	Log *ft*	Comments
(9.20×10^3 *4*)	2614.35	61 *5*	4.16 *4*	av Eβ=4363 *20*
(1.008×10^4 *4*)	1734.75	7 *3*	5.29 *19*	av Eβ=4799 *20*

† (31.5 *15*)% of the β^- transitions feed levels that decay by neutron emission, so ΣIβ^-=(68.5 *15*)% for the β^- branches included here.
‡ Absolute intensity per 100 decays.

$\gamma(^{18}N)$

E_γ †	I_γ ‡	E_i(level)	J^π_i	E_f	J^π_f	Comments
114.7 *1*	90 *13*	114.71	(2$^-$)	0.0	1$^-$	%Iγ=28.7 *30*
472.7 *2*	24 *7*	587.39	(2$^-$)	114.71	(2$^-$)	%Iγ=7.6 *23*
879.7 *2*	44 *4*	2614.35	1$^+$	1734.75	(1,2)	%Iγ=14.0 *17*
1147.8 *4*	17 *5*	1734.75	(1,2)	587.39	(2$^-$)	%Iγ=5.4 *17*
1619.9 *3*	25 *5*	1734.75	(1,2)	114.71	(2$^-$)	%Iγ=8.0 *17*
1734.8 *4*	25 *5*	1734.75	(1,2)	0.0	1$^-$	%Iγ=8.0 *16*
2025.3 *8*	7 *5*	2614.35	1$^+$	587.39	(2$^-$)	%Iγ=2.2 *16*
2499.3 *4*	41 *9*	2614.35	1$^+$	114.71	(2$^-$)	%Iγ=13.1 *31*
2614.2 *4*	100 *11*	2614.35	1$^+$	0.0	1$^-$	%Iγ=31.9 *29*

† From Adopted Levels and Gammas.
‡ For absolute intensity per 100 decays, multiply by 0.319 *27*.

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Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays