

Minimum Acceptable Uncertainties for Adopted Half-lives

Richard B. Firestone
Lawrence Berkeley National Laboratory
USNDN/CSWEG Meeting, November 2-6, 2009

It is well known that there often are substantial discrepancies in precise half-life measurements performed at reputable laboratories. The reason for these discrepancies is unknown. Many efforts have been made to develop methods for averaging these discrepant data, but no averaging method can be a satisfactory solution to this problem. This difficulty is compounded for cases where only one precise half-life has been measured. IN that case there can be no discrepancy so this precise value is usually adopted by ENSDF evaluators.

Woods et al¹ have evaluated the half-lives of 65 isotopes as shown in Table 1. Many are discrepant datasets with $\chi^2/\nu \leq 55$ if the selected data were used and as large as $\chi^2/\nu = 848$ using all of the data. The data in Table 1 have been sorted by external uncertainty where it is seen that the most precise measurement is ⁸⁵Sr where $\Delta t_{1/2}/t_{1/2} = 0.0001$ using all measurements. For Woods' selected data the best measurement is $\Delta t_{1/2}/t_{1/2} = 0.00008$ for the same isotope.

I propose that a minimum uncertainty of 0.01% be applied to all adopted half-lives regardless of whether only one or more precise values exist irrespective of the author's published uncertainty. An example would be the half-life of ²¹⁰Po, given in ENSDF as 138.376(2) d, where the uncertainty should be increased to 0.014 d. These limitations should remain in effect until the nature of the half-life discrepancies is understood.

¹ M.J. Woods, S.M. Collins, and S.A. Woods, NPL Report CAIR 8 (2004).

Table 1. Comparison of external uncertainties for half-lives evaluated by M.J. Woods, S.M. Collins, and S.A. Woods in NPL Report CAIR 8 (2004). The data are sorted by the relative external uncertainty using all data and the lowest external uncertainty from Woods' selected data is shown in bold.

Isotope	$t_{1/2}$	$\Delta t_{1/2}$	$\Delta t_{1/2}/t_{1/2}$	n	$\chi^2/n-1$	$\Delta t_{1/2}/t_{1/2}$ (ext)	n	$\chi^2/n-1$	$\Delta t_{1/2}/t_{1/2}$ (ext)
	(days)								
	All Data				Woods' selected data				
85Sr	64.851	0.005	7.70998E-05	10	1.59	9.72192E-05	9	0.7	7.70998E-05
67Ga	3.2616	0.0004	0.000122639	7	0.98	0.000122639	7	1	0.000122639
51Cr	27.7009	0.002	7.21998E-05	10	3.38	0.000132738	6	1.3	8.23205E-05
139Ce	137.642	0.02	0.000145304	6	0.97	0.000145304	6	1	0.000145304
99Tc-m	0.250281	0.000022	8.79012E-05	9	5.02	0.000196946	6	0.2	8.79012E-05
125Sb	1007.48	0.21	0.000208441	3	0.58	0.000208441	3	0.5	0.000208441
192Ir	73.822	0.009	0.000121915	5	3	0.000211163	4	0.4	0.000121915
88Y	106.625	0.024	0.000225088	8	0.78	0.000225088	5	0.1	0.000225088
123I	0.55098	0.00009	0.000163345	6	2.09	0.000236146	4	1.4	0.000193273
60Co	1925.23	0.27	0.000140243	7	3.17	0.000249696	5	0.2	0.000140243
169Yb	32.016	0.006	0.000187406	7	2.61	0.000302764	6	1.3	0.000213676
228Th	698.6	0.23	0.00032923	3	0.79	0.00032923	3	0.8	0.00032923
113Sn	115.09	0.04	0.000347554	5	0.03	0.000347554	5	0.03	0.000347554
111In	2.8049	0.0006	0.000213911	8	3.57	0.000404174	5	3.7	0.000411467
141Ce	32.503	0.014	0.000430729	5	0.08	0.000430729	5	0.07	0.000430729
154Eu	3138.1	1.4	0.00044613	4	0.01	0.00044613	4	0.01	0.00044613
64Cu	0.52929	0.00018	0.000340078	9	1.83	0.000460049	9	1.8	0.000456263
57Co	271.8	0.05	0.000183959	7	6.35	0.000463562	6	2.6	0.000296625
198Au	2.695	0.0007	0.00025974	9	4.66	0.000560702	8	3.7	0.00049962
22Na	950.57	0.23	0.00024196	3	5.62	0.000573604	3	5.62	0.000573604
56Mn	0.107449	0.000019	0.000176828	6	11.26	0.000593363	6	11.1	0.000589132
103Ru	39.247	0.013	0.000331236	4	3.33	0.000604448	4	3.3	0.000601719

Isotope	$t_{1/2}$ (days)	$\Delta t_{1/2}$	$\Delta t_{1/2}/t_{1/2}$	n	$\chi^2/n-1$	$\Delta t_{1/2}/t_{1/2}$ (ext)	n	$\chi^2/n-1$	$\Delta t_{1/2}/t_{1/2}$ (ext)
All Data							Woods' selected data		
133Ba	3848.7	1.2	0.000311794	8	6.64	0.000803436	6	2.4	0.000483029
59Fe	44.494	0.013	0.000292174	6	10.62	0.000952147	5	3.1	0.000514426
24Na	0.62329	0.00006	9.62634E-05	13	99	0.000957809	10	1.42	0.000114711
201Tl	3.0422	0.0017	0.000558806	5	4.19	0.001143848	5	4.2	0.001145212
125I	59.402	0.014	0.000235682	11	23.62	0.001145426	7	0.6	0.000235682
46Sc	83.79	0.04	0.000477384	7	6.08	0.001177117	6	2.5	0.00075481
99Mo	2.7478	0.0007	0.000254749	4	23.98	0.001247491	4	23.9	0.001245409
58Co	70.86	0.06	0.00084674	8	2.46	0.00132806	6	2.3	0.001284145
95Nb	34.985	0.012	0.000343004	6	19	0.00149512	4	2.6	0.000553078
203Hg	46.594	0.012	0.000257544	6	40.85	0.001646066	4	1.3	0.000293645
110Agm	249.85	0.1	0.00040024	5	18.76	0.001733553	4	4.1	0.000810425
131I	8.0228	0.0024	0.000299147	8	42.24	0.001944228	6	7.1	0.000797103
75Se	119.778	0.029	0.000242115	4	72.66	0.002063805	3	0.2	0.000242115
241Am	157850	230	0.00145708	6	2.19	0.002156281	6	2.2	0.002161198
134Cs	753.5	1	0.00132714	6	4.58	0.002840204	5	4.6	0.002846398
243Am	2692000	8000	0.002971768	3	0.08	0.002971768	3	0.08	0.002971768
68Ga	0.04703	0.00007	0.001488412	3	4.35	0.003104329	3	2.9	0.002534674
65Zn	243.86	0.2	0.000820143	7	22.31	0.003873818	5	4.1	0.001660662
40K	4.56E+11	1.30E+09	0.002849003	3	3.03	0.004959229	3	3	0.004934618
225Ra	586200	2200	0.003752985	4	1.77	0.004993022	4	1.3	0.004279062
152Eu	4941	7	0.001416717	8	15.23	0.005528829	5	3.7	0.00272511
55Fe	1002.7	2.3	0.002293807	5	6.14	0.005683829	5	6.1	0.005665285
166Ho	1.1165	0.0013	0.001164353	4	36.5	0.007034465	3	36.3	0.007015166
123Tem	119.45	0.25	0.002092926	2	12.5	0.007399611	2	12.5	0.007399611
66Ga	0.3889	0.0034	0.008742607	4	0.23	0.008742607	4	0.2	0.008742607

Isotope	$t_{1/2}$ (days)	$\Delta t_{1/2}$	$\Delta t_{1/2}/t_{1/2}$	n	$\chi^2/n-1$	$\Delta t_{1/2}/t_{1/2}$ (ext)	n	$\chi^2/n-1$	$\Delta t_{1/2}/t_{1/2}$ (ext)
All Data							Woods' selected data		
85Kr	3927	8	0.002037179	3	18.87	0.008849425	3	14.3	0.00770366
109Cd	461.4	1.2	0.00260078	7	14.33	0.00984525	6	16.2	0.010467939
124I	4.16	0.06	0.014423077	3	0.13	0.014423077	3	0.08	0.014423077
144Ce	285.1	0.5	0.001753771	6	70.17	0.014690904	6	55.3	0.013041734
56Co	77.236	0.26	0.003366306	8	24.59	0.01669294	6	1.9	0.004640132
137Cs	10990	40	0.003639672	11	23.78	0.017748768	11	23.8	0.017756231
106Ru	371.8	1.8	0.004841313	5	14.72	0.018574495	5	9	0.014523938
54Mn	312.29	0.26	0.000832559	9	848.34	0.024249358	8	38	0.005132241
153Sm	1.938	0.01	0.005159959	6	24.4	0.025488316	6	24.3	0.025436032
170Tm	127.8	0.8	0.006259781	5	18.29	0.026771086	4	4.7	0.013570882
234Pam	0.000805	0.000011	0.013664596	4	4.02	0.02739743	4	2.6	0.022033499
155Eu	1736	6	0.003456221	6	66.9	0.02826927	4	0.9	0.003456221
106Rh	0.000348	0.000004	0.011494253	2	11.42	0.038843093	2	7.3	0.031055761
207Bi	11800	300	0.025423729	4	3.32	0.046324239	4	2	0.035954582
129I	5.89E+09	2.30E+08	0.039049236	4	3.27	0.070613285	4	3.2	0.069853397
147Pm	940	40	0.042553191	4	6.69	0.110063976	4	5	0.095151829
94Nb	7300000	900000	0.123287671	3	0.19	0.123287671	3	0.2	0.123287671
93Nb	5730	220	0.038394415	4	27.99	0.203127867	4	28	0.20316415

χ^2/f (tot)=26.1

χ^2/f (tot)=6.2