

Comparison of Neutron Activation Analysis k_0 and σ_0 Data

Richard B. Firestone
Lawrence Berkeley National Laboratory, Berkeley CA 94720 USA

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Summary: Neutron Activation Analysis (NAA) k_0 factors from De Corte and Simonits [1] for $Z \leq 47$ have been compared with k_0 values calculated from the evaluated total thermal neutron capture radiative cross sections σ_0 in the Atlas of Neutron Resonances [2] and partial γ -ray cross sections σ_γ measured with neutron beams at the Budapest Reactor [3,4]. The k_0 factors derived from these independent data sources generally agree although several discrepancies need to be resolved. New self-consistent k_0 and σ_0 values have been adopted by evaluation of these data and other published information. It is proposed to publish a *Reference Database for Neutron Activation Analysis* containing the a summary of all measurements and tables of recommended k_0 and σ_0 data. These data will also be updated in the first revision of the Evaluated Gamma-ray Activation File (EGAF) [5] for dissemination by the IAEA and Lawrence Berkeley National Laboratory (LBNL).

Introduction: The Neutron Activation Analysis (NAA) k_0 factors $(k_{0,Au})_x$ for γ -rays emitted by activation products (x) are defined relative to the Au comparator as,

$$(1) \quad (k_{0,Au})_x = [M_{Au}\theta_x\sigma_{0,x}P_x] / [M_x\theta_{Au}\sigma_{0,Au}P_{Au}]$$

where M is the atomic mass ($M_{Au}=196.96655$), θ is the isotopic abundance ($\theta_{Au}=100$), σ_0 is the total thermal radiative cross section ($\sigma_{0,Au}=98.65$ b), and P is the γ -ray transition probability ($P_{Au}=0.9554$). Precise k_0 factors have been measured by De Corte and Simonits [1] for the principal γ -rays from more than 130 isotopes and isomers using gold as a comparator. These values are compared in Table 1 with k_0 values derived from σ_0 values compiled in the Atlas of Neutron Resonances [2] and σ_γ values measured with guided neutron beams at the Budapest Reactor [3,4]. As shown in Eq. 1 k_0 values derived from σ_0 also require γ -ray transition probabilities, P_γ , which are taken either from the Decay Data Evaluation Project (DDEP) evaluations [6] or the ENSDF database [7]. Table 1 also compares the recommended σ_0 values [2] with adopted σ_0 values from this work based on all measurements referenced in the CSISRS file [8] and the σ_γ and k_0 values. An example of the cross section comparison for $^{26}\text{Mg}(n,\gamma)^{27}\text{Mg}$ is shown in Table 2. New recommended k_0 values based on the adopted σ_0 values are presented in Table 1. The agreement between the De

Corte and Simonits [1] k_0 values and those derived from the cross section data are generally very good although some important discrepancies remain.

Table 2. $^{26}\text{Mg}(n,\gamma)^{27}\text{Mg}$ σ_0 measurements.

Reference	σ_0	$\Delta\sigma_0$
RRL23,317	0.034	0.002
PR72,888	0.048	0.01
PR88,412	0.06	0.06
78MAYAG,1495	0.0365	0.001
PRC45,1597	0.0392	0.001
NPA102,209	0.034	0.01
Gryntakis Thesis	0.035	0.02
JNE24,35	0.0382	0.0008
ADNDT 85,47	0.0371	0.0005
Budapest NAA	0.0378	0.0008
Budapest PGAA	0.0377	0.0013
Atlas Neutron Res.	0.0384	0.0006
Adopted Value	0.0379	0.0008

Discrepant values: A total of 213 k_0 and σ_0 factors for $Z=5-47$ are compared in Table 1. Data for additional isotopes not included in Ref. 1 have been added. Agreement is generally excellent and the following discrepancies are noted.

^{23}Na – $\sigma_0(\text{Atlas})=517(4)$ mb is consistent with $\sigma_0(\text{ADNDT})=513(6)$ mb but inconsistent with the Budapest values $\sigma_0(\text{PGAA})=540(4)$ mb and $\sigma_0(\text{NAA})=542(3)$ mb. The higher values are consistent with several measurements in the literature. New experiments are planned in collaboration with A. Simonits and Zs. Revay to remeasure this cross section.

^{36}S – significant variations in the abundance of ^{36}S make these k_0 values very unreliable. Value from Atlas is adopted assuming normal natural abundance.

^{41}K - $\sigma_0(\text{Atlas})=1.46(3)$ b is consistent with $\sigma_0(\text{ADNDT})=1.42(2)$ mb but inconsistent with the Budapest value $\sigma_0(\text{NAA})=1.73(1)$ b. New experiments are planned in collaboration with A. Simonits and Zs. Revay to remeasure this cross section.

^{46}Ca – $k_0(\text{ADNDT})=8.57\text{E-}07$ is lower than $k_0(\text{Adopt})=9.97\text{E-}07$ to ^{47}Sc . Needs to be remeasured. Possible P_γ problem.

^{64}Ni - $\sigma_0(\text{Atlas})=1.64(4)$ b is consistent with $\sigma_0(\text{ADNDT})=1.61(1)$ b but inconsistent with the Budapest value $\sigma_0(\text{PGAA})=2.36(26)$ b. PGAA measurement will be rechecked.

^{64}Zn – $k_0(\text{ADNDT})=5.72\text{E-}03$ is lower than $k_0(\text{Adopt})=6.55\text{E-}03$.

^{74}Ge – $k_0(\text{ADNDT})=5.73\text{E-}04$ for 139.7 keV gamma is inconsistent with $k_0(\text{Adopt})=6.71\text{E-}04$ and $k_0(\text{Budapest})=6.68\text{E-}04$. New value adopted.

^{89}Y – new cross section inconsistent with $k_0(\text{ADNDT})$. Check cross section.

^{98}Mo – For 140.5-keV gamma from $^{99\text{m}}\text{Tc}$ $k_0(\text{ADNDT})=5.27\text{E-}04$ is lower than $k_0(\text{Adopt})=6.05\text{E-}04$ but comparable to $k_0(\text{Budapest})=5.56\text{E-}04$. Check cross sections and decay scheme.

Proposed Reference Database for Neutron Activation Analysis: Evaluation of thermal neutron capture data for Neutron Activation Analysis will be completed over the next year. The resulting database will include recommended self-consistent data for k_0 values and associated target σ_0 cross sections and contain

1. k_0 measurements by De Corte and Simonits [1], Budapest NAA measurements with the neutron beam, and from other literature sources.
2. σ_0 values from the Atlas of Neutron Resonances [2], CSISRS file [8], Budapest PGAA measurements and other literature sources.
3. P_γ values from the BIPM evaluation [6] and the ENSDF file [7].
4. Self consistent recommended k_0 and σ_0 values for selected gamma rays and targets.
5. Complete gamma-ray k_0 library for all know gamma rays produced by NAA.

It is proposed to publish this database in the open literature and as the first revision of the EGAF database which is disseminated by the IAEA and Lawrence Berkeley National Laboratory, Berkeley CA.

References

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- [6] *Table of Radionuclides*, ed. M.-M. Be et al, Bureau International des Poids et Mesures, Pavillon de Breteuil, F-92310 Sevres (2004).
- [7] Evaluated Nuclear Structure Data File, a computer file of evaluated experimental nuclear structure data maintained by the National Nuclear Data Center, Brookhaven National Laboratory.
- [8] Cross Section Information Storage and Retrieval System(CSISRS), a computer file of evaluated experimental nuclear structure data maintained by the National Nuclear Data Center, Brookhaven National Laboratory.

Table 1. Preliminary k_0 and σ_0 values for Z=5-47 from the Atlas of Neutron Resonances (Elsevier,2006) , ADNDT 85,47 (2003), and the Budapest Reactor Centre.

Target Isotope		t1/2	E _y	ΔE _y	k0(Atlas) ±%	k0(ATNDT) ±%	k0(Budap) ±%	σ ₀ (Atlas)	σ ₀ (Adopt)	k0(Adopt) ±%	
11B	12B	20.20 ms	3214.8	0.2	7.07E-06 20.6			1.08E-05 21.4	5.5(33) mb	9.06(2) mb	1.16E-05 12.5
11B	12B	20.20 ms	4438.9	0.3	1.79E-05 23.9			1.18E-05 21.3	5.5(33) mb	9.06(2) mb	2.95E-05 14.5
15N	16N	7.13 s	6128.63	0.04	8.83E-09 7.7				2.4(8) μb	3.9(3) μb	1.43E-08 4.8
18O	19O	26.88 s	1356.843	0.008	2.16E-08 5.1				0.16(1) mb	0.175(8) mb	2.36E-08 4.6
19F	20F	11.163 s	1633.602	0.015	1.05E-03 1.0	9.98E-04 1.2	1.06E-03 4.2	9.51(9) mb	9.35(9) mb	1.03E-03 1.0	
22Ne	23Ne	37.24 s	1635.96	0.03	4.36E-06 15.7			4.25E-05 3.4	45.5(6) mb	33(5) mb	3.16E-06 21.6
23Na	24Na	14.9574 h	1368.626	0.005	4.70E-02 0.8	4.68E-02 0.6	4.93E-02 1.5	517(4) mb	541(3) mb	4.92E-02 0.7	
23Na	24Na	14.9574 h	2754.007	0.011	4.69E-02 0.8	4.62E-02 0.9	4.93E-02 1.5	517(4) mb	541(3) mb	4.91E-02 0.7	
23Na	24Na-m	20.18 ms	472.207	0.009	3.63E-02 0.8		4.35E-02 0.8	400(30) mb	478(4) mb	4.34E-02 0.7	
26Mg	27Mg	9.4580 m	170.686	0.15	2.91E-06 12.7	3.02E-06 1.0	2.84E-06 21.2	38.4(6) mb	37.9(8) mb	2.87E-06 12.8	
26Mg	27Mg	9.4580 m	843.76	0.03	2.61E-04 2.2	2.53E-04 0.4	2.56E-04 4.7	38.4(6) mb	37.9(8) mb	2.58E-04 2.2	
26Mg	27Mg	9.4580 m	1014.44	0.04	1.02E-04 2.5	9.80E-05 2.0	1.01E-04 5.1	38.4(6) mb	37.9(8) mb	1.00E-04 2.6	
27Al	28Al	2.2414 m	1778.85	0.03	1.79E-02 1.3	1.75E-02 0.6	1.80E-02 1.3	231(3) mb	232(3) mb	1.80E-02 1.3	
30Si	31Si	157.3000 m	1266.15	0.1	1.72E-07 28.7	1.45E-07 0.7		107(2) mb	116(3) mb	1.33E-07 7.8	
36S	37S	5.05 m	3103.36	0.02	2.89E-06 7.1	1.96E-06 1.8	1.50E-05 26.1	236(6) mb	249(8) mb	3.05E-06 6.8	
37Cl	38Cl	37.24 m	1642.714	0.016	1.97E-03 3.4	1.97E-03 1.5	1.41E-03 20.8	433(6) mb	433(6) mb	1.97E-03 3.4	
37Cl	38Cl	37.24 m	2167.405	0.009	2.62E-03 2.9	2.66E-03 1.1	1.89E-03 12.5	433(6) mb	433(6) mb	2.62E-03 2.9	
37Cl	38Cl-m	715.00 ms	671.361	0.008	6.71E-04 2.4		7.07E-04 15.8	47(10) mb	53.7(13) mb	7.66E-04 2.1	
40Ar	41Ar	109.61 m	1293.64	0.04	3.44E-02 4.8	3.32E-02		660(10) mb	630(30) mb	3.28E-02 5.0	
41K	42K	12.360 h	312.60	0.25	1.76E-05 6.1	1.59E-05 1.3		1.46(3) b	1.733(13) b	2.09E-05 5.1	
41K	42K	12.360 h	1524.6	0.3	9.50E-04 1.5	9.46E-04 0.6	1.07E-03 0.1	1.46(3) b	1.733(13) b	1.13E-03 1.1	
46Ca	47Ca	4.536 d	489.23	0.1	9.57E-08 21.4	9.14E-08 1.8		740(70) mb	710(20) mb	9.05E-08 22.6	
46Ca	47Ca	4.536 d	807.86	0.1	9.57E-08 21.4	9.20E-08 0.2		740(70) mb	710(20) mb	9.05E-08 22.6	
46Ca	47Ca	4.536 d	1297.09	0.1	1.10E-06 10.8	9.54E-07 0.2		740(70) mb	710(20) mb	1.04E-06 11.4	
46Ca	47Sc	3.3492 d	159.381	0.015	1.05E-06 4.3	8.57E-07 1.6		740(70) mb	710(20) mb	9.97E-07 4.6	
48Ca	49Ca	8.718 m	3084.4	0.1	9.79E-05 2.3	1.01E-04 0.9	1.10E-04 23.8	1.09(14) b	1.125(20) b	1.01E-04 2.0	
45Sc	46Sc	83.7880 d	889.271	0.002	1.26E+00 1.1	1.22E+00 0.4		27.2(2) b	26.1(3) b	1.21E+00 1.2	
45Sc	46Sc	83.7880 d	1120.537	0.003	1.26E+00 1.1	1.22E+00 1.1		27.2(2) b	26.1(3) b	1.21E+00 1.2	
45Sc	46Sc-m	18.7500 s	142.528	0.007	2.86E-01 2.0		2.27E-01 1.4	9.8(11) b	7.77(11) b	2.24E-01 4.4	
50Ti	51Ti	5.76 m	320.076	0.006	3.77E-04 1.7	3.74E-04 1.1	3.75E-04 1.1	179(3) mb	178(3) mb	3.75E-04 1.7	

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Target Isotope		t1/2	E _y	ΔE _y	k0(Atlas) ±%	k0(ATNDT) ±%	k0(Budap) ±%	σ ₀ (Atlas)	σ ₀ (Adopt)	k0(Adopt) ±%
50Ti	51Ti	5.76 m	928.63	0.04	2.79E-05 3.6	2.65E-05 1.1	1.40E-04 18.8	179(3) mb	178(3) mb	2.77E-05 3.6
51V	52V	3.743 m	647.47	0.02	4.85E-05 8.4		4.72E-05 10.4	5.04(4) b	4.85(5) b	4.76E-05 8.6
51V	52V	3.743 m	1333.62	0.03	1.19E-03 2.0		1.16E-03 1.8	5.04(4) b	4.85(5) b	1.17E-03 2.0
51V	52V	3.743 m	1434.06	0.01	2.02E-01 1.4	1.96E-01 1.2	1.97E-01 2.1	5.04(4) b	4.85(5) b	1.98E-01 1.5
50Cr	51Cr	27.703 d	320.0835	0.0004	2.65E-03 2.0	2.62E-03 5.0	3.82E-05 22.1	15.4(2) b	15.7(3) b	2.71E-03 1.9
54Cr	55Cr	3.497 m	1528.0	0.2	2.65E-07 10.6			410(40) mb	440(30) mb	2.84E-07 9.9
55Mn	56Mn	2.5788 h	846.7638	0.0019	5.02E-01 0.4	4.96E-01 0.6	4.98E-01 0.3	13.36(5) b	13.41(5) b	5.04E-01 0.4
55Mn	56Mn	2.5788 h	1810.726	0.004	1.37E-01 1.5	1.35E-01 0.4	1.38E-01 3.0	13.36(5) b	13.41(5) b	1.37E-01 1.5
55Mn	56Mn	2.5788 h	2113.092	0.006	7.22E-02 2.1	7.17E-02 0.2	7.27E-02 2.6	13.36(5) b	13.41(5) b	7.24E-02 2.1
58Fe	59Fe	44.495 d	142.651	0.002	1.35E-06 2.2	1.33E-06 1.5		1.32(3) b	1.30(2) b	1.33E-06 2.2
58Fe	59Fe	44.495 d	192.349	0.005	4.06E-06 1.8	3.78E-06 0.5		1.32(3) b	1.30(2) b	4.00E-06 1.9
58Fe	59Fe	44.495 d	334.8	0.2	3.68E-07 3.1	3.82E-07 0.0		1.32(3) b	1.30(2) b	3.62E-07 3.1
58Fe	59Fe	44.495 d	1099.245	0.003	7.88E-05 1.6	7.77E-05 0.5		1.32(3) b	1.30(2) b	7.76E-05 1.6
58Fe	59Fe	44.495 d	1291.590	0.006	6.02E-05 1.6	5.93E-05 0.3		1.32(3) b	1.30(2) b	5.93E-05 1.7
59Co	60Co	5.2710 y	1173.228	0.003	1.32E+00 0.3	1.32E+00 0.4		37.18(6) b	37.10(11) b	1.31E+00 0.3
59Co	60Co	5.2710 y	1332.492	0.004	1.32E+00 0.3	1.32E+00 0.5		37.18(6) b	37.10(11) b	1.32E+00 0.3
59Co	60Co-m	10.467 m	58.603	0.007	1.48E-02 3.3	1.51E-02 0.8	1.46E-02 1.0	20.4(8) b	21.0(3) b	1.52E-02 3.2
59Co	60Co-m	10.467 m	1332.501	0.005	1.74E-03 12.6	1.75E-03 1.4	2.41E-03 11.8	20.4(8) b	21.0(3) b	1.79E-03 12.2
64Ni	65Ni	2.5172 h	366.27	0.03	2.59E-05 13.1	2.51E-05 1.2	2.73E-05 28.6	1.64(4) b	2.3(3) b	3.64E-05 9.3
64Ni	65Ni	2.5172 h	1115.53	0.04	8.34E-05 13.1	8.14E-05 0.5	1.12E-04	1.64(4) b	2.3(3) b	1.17E-04 9.3
64Ni	65Ni	2.5172 h	1481.84	0.05	1.28E-04 13.1	1.27E-04 0.6	1.42E-04 12.5	1.64(4) b	2.3(3) b	1.79E-04 9.3
63Cu	64Cu	12.701 h	511		3.62E-02 1.0	3.70E-02 0.0		4.50(2) b	4.76(3) b	3.83E-02 1.0
63Cu	64Cu	12.701 h	1345.77	0.16	4.86E-04 2.2	4.98E-04 0.9	5.10E-04 1.9	4.50(2) b	4.76(3) b	5.14E-04 2.1
65Cu	66Cu	5.12 m	1039.2	0.2	2.03E-03 1.3	1.86E-03 0.5	1.97E-03 2.2	2.17(3) b	2.16(2) b	2.02E-03 1.4
64Zn	65Zn	244.01 d	1115.539	0.002	6.16E-03 3.6	5.72E-03 0.3		790(20) mb	840(30) mb	6.55E-03 3.4
68Zn	69Zn	56.4 m	318.4	0.2	7.71E-08 41.5			1.0(1) b	0.79(3) b	5.70E-08 41.5
68Zn	69Zn-m	13.76 h	438.634	0.018	4.10E-04 4.2	3.98E-04 0.6	3.91E-04 3.9	72(4) mb	73(3) mb	4.10E-04 4.2
70Zn	71Zn	2.45 m	121.52	0.05	4.93E-07 16.9	1.09E-07 3.0		83(5) mb	22(3) mb	1.43E-07 10.0
70Zn	71Zn	2.45 m	511.6	0.1	5.26E-06 14.0	1.55E-06 2.1		83(5) mb	22(3) mb	1.39E-06 14.0
69Ga	70Ga	21.14 m	176.17	0.02	9.14E-05 4.1		6.29E-05 33.3	1.75(7) b	2.22(5) b	1.16E-04 3.2

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69Ga 70Ga	21.14 m	1039.2	0.08	2.05E-04 8.0		2.10E-04 14.3	1.75(7) b	2.22(5) b	2.60E-04 6.3
71Ga 72Ga	14.10 h	629.96	0.04	1.37E-02 2.1	1.49E-02 1.0	1.47E-02 4.5	4.61(15) b	4.63(4) B	1.37E-02 2.1
71Ga 72Ga	14.10 h	834.03	0.03	5.27E-02 0.9	5.23E-02 0.6	4.95E-02 3.0	4.61(15) b	4.63(4) B	5.29E-02 0.9
71Ga 72Ga	14.10 h	894.25	0.1	5.45E-03 1.9	5.46E-03 0.9	4.95E-04 8.5	4.61(15) b	4.63(4) B	5.47E-03 1.9
71Ga 72Ga	14.10 h	1050.69	0.05	3.81E-03 1.9	3.83E-03 0.8	3.57E-03 10.9	4.61(15) b	4.63(4) B	3.83E-03 1.9
71Ga 72Ga	14.10 h	2201.66	0.07	1.43E-02 2.0	1.48E-02 1.0	1.56E-02 7.7	4.61(15) b	4.63(4) B	1.43E-02 2.0
71Ga 72Ga	14.10 h	2490.98	0.07	4.23E-03 3.1	4.19E-03 1.7	5.10E-03 23.5	4.61(15) b	4.63(4) B	4.25E-03 3.1
71Ga 72Ga	14.10 h	2507.79	0.07	7.04E-03 2.0	7.16E-03 2.2	8.39E-03 14.3	4.61(15) b	4.63(4) B	7.07E-03 2.0
70Ge 71Ge-m	20.4 ms	174.954	0.005	1.54E-03 21.4		2.24E-03 6.4	280(70) mb	470(100) mb	2.58E-03 12.7
74Ge 75Ge	82.78 m	198.6	0.1	6.44E-05 13.9	6.15E-05 1.0	5.18E-04 6.7	360(40) mb	420(40) mb	5.20E-05 17.2
74Ge 75Ge	82.78 m	468.8	0.2	1.21E-05 14.2	1.20E-05 8.3		360(40) mb	420(40) mb	9.80E-06 17.4
74Ge 75Ge	82.78 m	617.7	0.2	6.19E-06 14.5	4.69E-06 1.1		360(40) mb	420(40) mb	5.00E-06 17.9
74Ge 75Ge-m	47.7 s	139.68	0.03	6.75E-04 3.7	5.73E-04 1.6	6.68E-04 3.0	164(10) mb	163(5) mb	6.71E-04 3.7
76Ge 77Ge	11.30 h	211.03	0.03	5.20E-05 5.7	3.90E-05		100(10) mb	63(3) mb	4.25E-05 9.0
76Ge 77Ge	11.30 h	215.5	0.03	4.83E-05 5.7	3.55E-05		100(10) mb	63(3) mb	3.95E-05 9.1
76Ge 77Ge	11.30 h	264.44	0.03	1.18E-04 4.9	6.88E-05	4.58E-04 10.7	100(10) mb	63(3) mb	7.44E-05 7.7
76Ge 77Ge	11.30 h	367.4	0.03	2.36E-05 5.4	1.94E-05		100(10) mb	63(3) mb	1.93E-05 8.5
76Ge 77Ge	11.30 h	416.33	0.03	3.68E-05 5.3	3.06E-05	2.09E-04 10.0	100(10) mb	63(3) mb	3.01E-05 8.5
76Ge 77Ge	11.30 h	558.02	0.03	2.71E-05 5.4	2.28E-05		100(10) mb	63(3) mb	2.22E-05 8.6
76Ge 77Ge	11.30 h	631.82	0.03	1.17E-05 5.4	1.04E-05		100(10) mb	63(3) mb	9.59E-06 8.5
76Ge 77Ge	11.30 h	1085.19	0.03	1.02E-05 5.3	8.35E-06		100(10) mb	63(3) mb	8.34E-06 8.4
76Ge 77As	38.83 h	239.011	0.006	3.48E-06			100(10) mb	63(3) mb	6.27E-06 14.9
76Ge 77Ge-m	52.9 s	159.7	0.1	2.26E-05 23.8	2.45E-05 1.0	2.88E-05 23.0	55(2) mb	140(30) mb	3.16E-05 17.0
76Ge 77Ge-m	52.9 s	215.53	0.06	4.73E-05 26.3		7.20E-05 16.0	55(2) mb	140(30) mb	6.62E-05 18.8
75As 76As	26.24 h	559.1	0.05	5.13E-02 6.6	4.83E-02 1.7	5.58E-02 0.5	4.09(8) b	4.33(23) b	5.44E-02 6.2
75As 76As	26.24 h	563.23	0.05	1.37E-03 8.4	1.40E-03 1.6	1.51E-03 5.6	4.09(8) b	4.33(23) b	1.45E-03 7.9
75As 76As	26.24 h	657.05	0.05	7.03E-03 8.3	6.61E-03 1.4	7.78E-03 5.0	4.09(8) b	4.33(23) b	7.45E-03 7.9
75As 76As	26.24 h	1212.92	0.05	1.64E-03 9.1	1.52E-03 1.3	1.81E-03 6.2	4.09(8) b	4.33(23) b	1.74E-03 8.6
75As 76As	26.24 h	1216.08	0.05	3.90E-03 8.4	3.73E-03 0.8	4.32E-03 5.2	4.09(8) b	4.33(23) b	4.13E-03 8.0
75As 76As	26.24 h	1228.52	0.05	1.39E-03		1.53E-03	4.09(8) b	4.33(23) b	1.47E-03 9.4

Table 1. Preliminary k_0 and σ_0 values for Z=5-47 from the Atlas of Neutron Resonances (Elsevier,2006) , ADNDT 85,47 (2003), and the Budapest Reactor Centre.

Target Isotope		t1/2	E _y	ΔE _y	k0(Atlas) ±%	k0(ATNDT) ±%	k0(Budap) ±%	σ ₀ (Atlas)	σ ₀ (Adopt)	k0(Adopt) ±%	
75As	76As	26.24 h	2096.3	0.05	6.26E-04		6.92E-04	4.09(8) b	4.33(23) b	6.63E-04 8.2	
74Se	75Se	119.79 d	121.1155	0.0011	2.11E-03	2.7	1.94E-03 0.6	52.2(8) b	50(1) b	2.03E-03 2.8	
74Se	75Se	119.79 d	136.0001	0.0006	7.16E-03	2.3	6.76E-03 1.0	52.2(8) b	50(1) b	6.85E-03 2.4	
74Se	75Se	119.79 d	264.6576	0.0009	7.24E-03	2.1	7.11E-03 0.7	52.2(8) b	50(1) b	6.94E-03 2.2	
74Se	75Se	119.79 d	279.5422	0.001	3.07E-03	2.1	3.00E-03 1.2	52.2(8) b	50(1) b	2.94E-03 2.2	
74Se	75Se	119.79 d	400.6572	0.0008	1.41E-03	2.1	1.43E-03 0.8	52.2(8) b	50(1) b	1.35E-03 2.2	
76Se	77Se-m	17.36 s	162	0.1	2.64E-02	3.2	2.49E-02 20.1	2.26E-02 2.7	20(1)	17.2(5) b	2.27E-02 3.7
78Se	79Se-m	3.91 m	95.73	0.03	2.29E-04	5.5		380(20) mb	380(20) mb	2.29E-04 5.5	
79Br	80Br	17.68 m	616.3	0.5	9.17E-03	11.7	6.92E-03 0.3	6.70E-03 1.6	7.88(24) b	7.9(6) b	7.02E-03 15.3
79Br	80Br	17.68 m	665.8	0.2	1.48E-03	14.3	1.22E-03 0.5	1.44E-03 5.5	7.88(24) b	7.9(6) b	1.13E-03 18.6
79Br	80Br-m	4.4205 h	37.052	0.002	1.26E-02	3.8			2.44(8) b	2.46(8) b	1.28E-02 3.8
79Br	80Br-m	4.4205 h	85.902	0.03	1.03E-04	4.3			2.44(8) b	2.46(8) b	1.03E-04 4.3
81Br	82Br	35.282 h	554.348	0.002	2.15E-02	3.6	2.38E-02 1.1		235(8) mb	235(8) mb	2.15E-03 36.1
81Br	82Br	35.282 h	619.106	0.004	1.32E-02	3.6	1.45E-02 0.8		235(8) mb	235(8) mb	1.32E-03 36.2
81Br	82Br	35.282 h	698.374	0.005	8.57E-03	3.7	9.38E-03 1.0		235(8) mb	235(8) mb	8.57E-04 37.3
81Br	82Br	35.282 h	776.517	0.003	2.53E-02	3.7	2.76E-02 0.8		235(8) mb	235(8) mb	2.53E-03 36.8
81Br	82Br	35.282 h	827.828	0.006	7.28E-03	3.8	7.99E-03 0.9		235(8) mb	235(8) mb	7.28E-04 38.0
81Br	82Br	35.282 h	1044.002	0.005	8.57E-03	3.7	9.14E-03 0.7		235(8) mb	235(8) mb	8.57E-04 37.3
81Br	82Br	35.282 h	1317.473	0.01	8.11E-03	3.7	8.91E-03 0.4		235(8) mb	235(8) mb	8.11E-04 37.5
81Br	82Br	35.282 h	1474.88	0.01	5.03E-03	3.7	5.42E-03 0.5		235(8) mb	235(8) mb	5.03E-04 36.8
81Br	82Br-m	6.13 m	776.52	0.01	7.11E-05	11.6			2.12(5) b	2.29(3) b	7.68E-05 10.8
78Kr	79Kr-m	50 s	130.01	0.02	4.35E-06	16.8			108(30) mb	180(30) mb	4.35E-06 16.8
80Kr	81Kr-m	13.10 s	190.46	0.16	1.74E-03	9.0			4.53(65) b	5.6(5) b	2.15E-03 7.3
82Kr	83Kr-m	1.83 h	9.4051	0.0008	2.41E-03	21.3			15.1(27) b	19(4) b	3.03E-03 16.9
82Kr	83Kr-m	1.83 h	32.1498	0.0008	2.14E-05	21.3			15.1(27) b	19(4) b	2.69E-05 16.9
84Kr	85Kr-m	4.480 h	151.195	0.006	9.59E-04	7.1			90(13) mb	85(6) mb	9.06E-04 7.5
84Kr	85Kr-m	4.480 h	304.87	0.02	1.79E-04	7.4			90(13) mb	85(6) mb	1.69E-04 7.8
86Kr	87Kr	76.3 m	402.587	0.01	6.42E-06	23.9			3(2) mb	3.4(8) mb	7.28E-06 21.1
86Kr	87Kr	76.3 m	673.83	0.08	2.45E-07	23.7			3(2) mb	3.4(8) mb	2.77E-07 20.9
86Kr	87Kr	76.3 m	845.44	0.04	9.50E-07	23.7			3(2) mb	3.4(8) mb	1.08E-06 20.9

Table 1. Preliminary k_0 and σ_0 values for Z=5-47 from the Atlas of Neutron Resonances (Elsevier,2006) , ADNDT 85,47 (2003), and the Budapest Reactor Centre.

Target Isotope	t1/2	E _y	ΔE _y	k0(Atlas) ±%	k0(ATNDT) ±%	k0(Budap) ±%	σ ₀ (Atlas)	σ ₀ (Adopt)	k0(Adopt) ±%
86Kr 87Kr	76.3 m	1175.4	0.08	1.43E-07 23.7			3(2) mb	3.4(8) mb	3.93E-09 28.6
86Kr 87Kr	76.3 m	1740.52	0.08	2.64E-07 23.6			3(2) mb	3.4(8) mb	2.99E-07 20.9
86Kr 87Kr	76.3 m	2011.88	0.1	3.73E-07 23.9			3(2) mb	3.4(8) mb	4.23E-07 21.1
86Kr 87Kr	76.3 m	2554.8	0.2	1.19E-06 24.0			3(2) mb	3.4(8) mb	1.35E-06 21.2
86Kr 87Kr	76.3 m	2558.1	0.2	5.07E-07 24.4			3(2) mb	3.4(8) mb	5.75E-07 21.5
85Rb 86Rb	18.642 d	1077	0.4	7.53E-04 1.3	7.65E-04 1.0	7.36E-04 1.7	494(7) mb	501(6) mb	7.64E-04 1.3
87Rb 88Rb	17.78 m	898.03	0.04	1.17E-04 6.6	1.01E-04 1.5	1.14E-04 0.6	122(3) mb	90(3) mb	8.60E-05 8.9
87Rb 88Rb	17.78 m	1836	0.05	1.78E-04 6.6	1.57E-04 1.1	1.75E-04 1.1	122(3) mb	90(3) mb	1.31E-04 9.0
87Rb 88Rb	17.78 m	2677.892	0.021	1.63E-05 6.7	1.47E-05 1.4		122(3) mb	90(3) mb	1.20E-05 9.1
84Sr 85Sr	64.850 d	514.0048	0.0022	9.74E-05 1.2	9.15E-05 0.9		199(10) mb	81(6) mb	9.14E-05 1.3
84Sr 85Sr-m	67.63 m	231.86	0.02	7.02E-05 2.7	6.92E-05 1.0	6.92E-05 10.3	623(6) mb	614(6) mb	6.92E-05 2.8
86Sr 87Sr	2.815 h	388.531	0.003	1.49E-03 2.5	1.49E-03 0.5	1.87E-03 2.9	770(60) mb	820(20) mb	1.59E-03 2.3
89Y 90Y	3.19 h	202.53	0.03	2.28E-05 12.1	2.36E-05 1.9		1.0(2) mb	2.5(3) mb	5.71E-05 4.8
89Y 90Y	3.19 h	479.51	0.07	2.14E-05 12.0	2.23E-05 0.9		1.0(2) mb	2.5(3) mb	5.35E-05 4.8
94Zr 95Zr	64.032 d	724.193	0.003	8.71E-05 1.3	8.90E-05 1.2		49.4(17) mb	50.4(6) mb	8.88E-05 1.3
94Zr 95Zr	64.032 d	756.729	0.012	1.07E-04 1.3	1.10E-04 1.3		49.4(17) mb	50.4(6) mb	1.09E-04 1.2
94Zr 95Nb	34.991 d	765.803	0.006	1.94E-04 1.2	2.17E-04 1.6		49.4(17) mb	50.4(6) mb	2.00E-04 1.2
96Zr 97Zr	16.744 m	254.17	0.14	1.68E-07 7.1	1.82E-07 2.0		22.9(10) mb	21.2(6) mb	1.56E-07 7.7
96Zr 97Zr	16.744 m	355.4	0.09	3.08E-07 5.3	2.92E-07 2.0		22.9(10) mb	21.2(6) mb	2.85E-07 5.7
96Zr 97Zr	16.744 m	507.64	0.08	7.38E-07 4.7	6.79E-07 0.2		22.9(10) mb	21.2(6) mb	6.83E-07 5.0
96Zr 97Zr	16.744 m	602.37	0.14	2.02E-07 6.1	1.90E-07 2.0		22.9(10) mb	21.2(6) mb	1.87E-07 6.6
96Zr 97Zr	16.744 m	703.76	0.05	1.49E-07 5.4	1.36E-07 2.0		22.9(10) mb	21.2(6) mb	1.38E-07 5.8
96Zr 97Zr	16.744 m	1147.97	0.08	3.84E-07 4.8	3.41E-07 2.0		22.9(10) mb	21.2(6) mb	3.56E-07 5.2
96Zr 97Nb	72.1 m	657.94	0.09	1.44E-05 2.8	1.24E-05 0.9		22.9(10) mb	21.2(6) mb	1.34E-05 3.1
96Zr 97Nb-m	52.7 s	743.36	0.03	1.43E-05 2.8	1.24E-05 0.3		21.3(10) mb	19.7(6) mb	1.33E-05 3.0
93Nb 94Nb	2.03E+04 y	702.622	0.019	2.54E-02 3.5			1.15(5) b	1.39(4) b	3.06E-02 2.9
93Nb 94Nb	2.03E+04 y	871.091	0.018	2.59E-02 2.9			1.15(5) b	1.39(4) b	3.13E-02 2.4
93Nb 94Nb-m	6.263 m	871.087	0.018	1.29E-04 12.3	9.70E-05 1.6	1.57E-04 8.6		1.04(4) b	
92Mo 93Mo-m	6.85 h	743.36	0.03					2.0E-7(7) b	
98Mo 99Mo	2.7479 d	181.068	0.008	4.11E-05 2.9	4.15E-05 0.6		130(6) mb	136(3) mb	4.30E-05 2.7

Table 1. Preliminary k_0 and σ_0 values for Z=5-47 from the Atlas of Neutron Resonances (Elsevier,2006) , ADNDT 85,47 (2003), and the Budapest Reactor Centre.

Target Isotope	t1/2	E _y	ΔE _y	k0(Atlas) ±%	k0(ATNDT) ±%	k0(Budap) ±%	σ ₀ (Atlas)	σ ₀ (Adopt)	k0(Adopt) ±%
98Mo 99Mo	2.7479 d	366.421	0.015	8.16E-06 2.9	8.36E-06 1.3		130(6) mb	136(3) mb	8.54E-06 2.8
98Mo 99Mo	2.7479 d	739.5	0.017	8.28E-05 2.5	8.46E-05 0.7		130(6) mb	136(3) mb	8.66E-05 2.4
98Mo 99Mo	2.7479 d	777.921	0.02	2.92E-05 2.9	2.97E-05 0.7		130(6) mb	136(3) mb	3.06E-05 2.8
98Mo 99Tc-m	6.0067 h	140.511	0.001	6.12E-04 2.9	5.27E-04 0.5	5.56E-04 2.6	130(6) mb	136(3) mb	6.05E-04 2.3
100Mo 101Mo	14.61 m	80.92	0.03	1.56E-05 3.5	1.80E-05 3.0		199(3) mb	197(3) mb	1.54E-05 3.5
100Mo 101Mo	14.61 m	191.92	0.02	7.60E-05 1.9	7.25E-05 1.7		199(3) mb	197(3) mb	7.53E-05 1.9
100Mo 101Mo	14.61 m	195.93	0.04	1.16E-05 3.3	1.11E-05 1.8		199(3) mb	197(3) mb	1.14E-05 3.3
100Mo 101Mo	14.61 m	408.69	0.06	6.39E-06 4.1	5.85E-06 30.8		199(3) mb	197(3) mb	6.32E-06 4.1
100Mo 101Mo	14.61 m	499.65	0.03	5.82E-06 3.7	5.63E-06 3.0		199(3) mb	197(3) mb	5.76E-06 3.7
100Mo 101Mo	14.61 m	695.56	0.06	2.78E-05 2.9	2.79E-05 1.8		199(3) mb	197(3) mb	2.75E-05 2.9
100Mo 101Mo	14.61 m	713.04	0.09	1.39E-05 4.8	1.37E-05 2.9		199(3) mb	197(3) mb	1.38E-05 4.8
100Mo 101Mo	14.61 m	877.39	0.04	1.35E-05 6.0	1.53E-05 3.3		199(3) mb	197(3) mb	1.33E-05 6.0
100Mo 101Mo	14.61 m	1011.05	0.14	3.72E-06 8.4	3.75E-06 2.9		199(3) mb	197(3) mb	3.69E-06 8.5
100Mo 101Mo	14.61 m	1012.47	0.04	5.44E-05 5.5	5.80E-05 2.2		199(3) mb	197(3) mb	5.38E-05 5.6
100Mo 101Mo	14.61 m	1160.98	0.04	1.68E-05 3.7	1.82E-05 3.0		199(3) mb	197(3) mb	1.66E-05 3.7
100Mo 101Mo	14.61 m	1304	0.04	1.13E-05 3.3	1.30E-05 3.1		199(3) mb	197(3) mb	1.12E-05 3.3
100Mo 101Mo	14.61 m	1532.49	0.04	2.56E-05 3.5	2.73E-05 2.9		199(3) mb	197(3) mb	2.54E-05 3.6
100Mo 101Tc	14.22 m	127.22	0.03	1.08E-05 3.4	1.20E-05 5.0		199(3) mb	197(3) mb	1.07E-05 3.4
100Mo 101Tc	14.22 m	184.12	0.05	6.59E-06 3.7	5.50E-06 0.0		199(3) mb	197(3) mb	6.52E-06 3.7
100Mo 101Tc	14.22 m	306.83	0.03	2.01E-07 16.4	3.73E-04 1.3	3.33E-04 3.8	199(3) mb	197(3) mb	3.62E-04 5.3
100Mo 101Tc	14.22 m	531.42	0.05	4.14E-06 3.9	5.01E-06 3.0		199(3) mb	197(3) mb	4.10E-06 3.9
100Mo 101Tc	14.22 m	545.05	0.06	2.46E-05 3.1	2.49E-05 1.0		199(3) mb	197(3) mb	2.44E-05 3.1
96Ru 97Ru	2.9 d	215.7	0.03	2.84E-04 2.5	2.25E-04 0.4		290(20) mb	225(5) mb	2.21E-04 3.2
102Ru 103Ru	39.26 d	497.084	0.006	7.54E-03 4.3	6.89E-03 0.4		290(20) mb	225(5) mb	7.24E-03 4.5
102Ru 103Ru	39.26 d	610.33	0.02	4.77E-04 4.2	4.30E-04 0.5		1.27(4) b	1.22(5) b	4.58E-04 4.4
102Ru 103Ru-m	1.69 ms	210.519	0.023						
104Ru 105Ru	4.44 h	262.83	0.1	1.24E-04 2.6	1.31E-04 1.5		491(10) mb	489(5) mb	1.24E-04 2.6
104Ru 105Ru	4.44 h	469.37	0.1	3.32E-04 3.3	3.26E-04 1.5	5.81E-04 3.2	491(10) mb	489(5) mb	3.30E-04 3.3
104Ru 105Ru	4.44 h	676.36	0.08	2.96E-04 3.4	2.95E-04 3.1	5.19E-04 3.6	491(10) mb	489(5) mb	2.95E-04 3.4
104Ru 105Ru	4.44 h	724.3	0.03	8.94E-04 1.5	8.87E-04 1.7	1.57E-03 1.5	491(10) mb	489(5) mb	8.91E-04 1.5

Table 1. Preliminary k_0 and σ_0 values for Z=5-47 from the Atlas of Neutron Resonances (Elsevier,2006) , ADNDT 85,47 (2003), and the Budapest Reactor Centre.

Target Isotope	t1/2	E _y	ΔE _y	k0(Atlas) ±%	k0(ATNDT) ±%	k0(Budap) ±%	σ ₀ (Atlas)	σ ₀ (Adopt)	k0(Adopt) ±%
104Ru 105Rh	35.36 h	306.1	0.2	9.64E-05 6.5	1.01E-04 1.5		491(10) mb	489(5) mb	9.60E-05 6.5
104Ru 105Rh	35.36 h	318.9	0.1	3.61E-04 3.3	3.57E-04 1.7		491(10) mb	489(5) mb	3.60E-04 3.3
104Ru 105Rh-m	43 s	129.57	0.08	1.07E-04 4.2	9.20E-05 1.3	4.96E-05 25.0	27.9(8) mb	27.8(6) mb	1.06E-04 4.2
103Rh 104Rh	42.3 s	555.81	0.04	5.83E-02 25.0	6.92E-02 1.4	6.38E-02 2.9	143.5(15) b		
103Rh 104Rh-m	4.34 m	55.81	0.04	2.80E-04 12.6		1.54E-02 19.7	10.6(3) b		
108Pd 109Pd	13.7012 h	309.1	0.5	1.93E-06 30.2	1.90E-06 2.1		8.48(50) b	8.34(8) b	2.11E-06 27.5
108Pd 109Pd	13.7012 h	311.4	0.1	1.26E-05 9.6	1.48E-05 1.4		8.48(50) b	8.34(8) b	1.39E-05 8.8
108Pd 109Pd	13.7012 h	602.5	0.1	3.15E-06 6.6	3.43E-06 0.0		8.48(50) b	8.34(8) b	3.46E-06 6.0
108Pd 109Pd	13.7012 h	636.3	0.1	3.94E-06 5.5	4.62E-06 0.0		8.48(50) b	8.34(8) b	4.32E-06 5.1
108Pd 109Pd	13.7012 h	647.3	0.1	9.64E-06 3.0	1.13E-05 0.5		8.48(50) b	8.34(8) b	1.06E-05 2.8
108Pd 109Pd	13.7012 h	781.4	0.2	4.43E-06 11.3	4.61E-06 0.0		8.48(50) b	8.34(8) b	4.86E-06 10.3
108Pd 109Pd-m	4.696 m	188.9	0.1	5.37E-04 5.5	4.94E-04 0.3	5.36E-04 5.5	185(10) mb	185(10) mb	5.37E-04 5.5
108Pd 109Ag-m	39.6 s	88.0336	0.0001	1.46E-03 2.9	1.71E-03 0.0		389(23) mb	383(4) mb	1.60E-03 2.6
110Pd 111Pd	5.5 h	172.2	0.1	2.58E-05 4.4	1.07E-05 1.4		700(170) mb	370(100) mb	1.07E-05 10.5
107Ag 108Ag	2.395 m	433.938	0.005	1.74E-03 15.3	1.59E-03 1.9		37.6(12) b	37.9(4) b	1.75E-03 15.1
107Ag 108Ag	2.395 m	618.86	0.05	9.25E-04 16.0	9.33E-04 0.0		37.6(12) b	37.9(4) b	9.33E-04 15.8
107Ag 108Ag	2.395 m	632.98	0.05	6.12E-03 16.1	6.10E-03 2.0	7.15E-03 5.7	37.6(12) b	37.9(4) b	6.17E-03 16.0
109Ag 110Ag	24.56 s	657.76	0.0011	3.74E-02 9.0	3.06E-02 0.4	3.60E-02 2.7	91(1) b	91(2) b	3.91E-02 8.6
109Ag 110Ag-m	249.78 d	446.812	0.003	1.35E-03 1.9	1.36E-03 1.5		3.95(5) b	3.99(5) b	1.36E-03 1.8
109Ag 110Ag-m	249.78 d	620.3553	0.0017	1.00E-03 3.2	1.02E-03 0.7		3.95(5) b	3.99(5) b	1.01E-03 3.2
109Ag 110Ag-m	249.78 d	657.76	0.0011	3.48E-02 1.3	3.50E-02 0.7		3.95(5) b	3.99(5) b	3.51E-02 1.2
109Ag 110Ag-m	249.78 d	677.6217	0.0012	3.89E-03 1.4	3.93E-03 1.3		3.95(5) b	3.99(5) b	3.93E-03 1.4
109Ag 110Ag-m	249.78 d	687.0091	0.0018	2.38E-03 1.3	2.43E-03 1.1		3.95(5) b	3.99(5) b	2.40E-03 1.3
109Ag 110Ag-m	249.78 d	706.676	0.0015	6.07E-03 1.3	6.03E-03 0.8		3.95(5) b	3.99(5) b	6.14E-03 1.3
109Ag 110Ag-m	249.78 d	744.2755	0.0018	1.74E-03 1.4	1.69E-03 1.2		3.95(5) b	3.99(5) b	1.75E-03 1.4
109Ag 110Ag-m	249.78 d	763.9424	0.0017	8.22E-03 1.3	8.27E-03 0.7		3.95(5) b	3.99(5) b	8.31E-03 1.3
109Ag 110Ag-m	249.78 d	818.0244	0.0018	2.70E-03 1.4	2.69E-03 1.1		3.95(5) b	3.99(5) b	2.73E-03 1.4
109Ag 110Ag-m	249.78 d	884.6781	0.0013	2.73E-02 2.0	2.69E-02 0.7		3.95(5) b	3.99(5) b	2.75E-02 2.0
109Ag 110Ag-m	249.78 d	937.485	0.003	1.27E-02 1.5	1.27E-02 0.8		3.95(5) b	3.99(5) b	1.28E-02 1.5
109Ag 110Ag-m	249.78 d	1384.2931	0.002	9.10E-03 2.4	9.12E-03 0.9		3.95(5) b	3.99(5) b	9.20E-03 2.4

Table 1. Preliminary k_0 and σ_0 values for Z=5-47 from the Atlas of Neutron Resonances (Elsevier,2006) , ADNDT 85,47 (2003), and the Budapest Reactor Centre.

Target Isotope	t1/2	Eγ	$\Delta E\gamma$	k0(Atlas) $\pm\%$	k0(ATNDT) $\pm\%$	k0(Budap) $\pm\%$	σ_0(Atlas)	σ_0(Adopt)	k0(Adopt) $\pm\%$
109Ag 110Ag-m	249.78 d	1475.7792	0.0023	1.49E-03 1.8	1.50E-03 0.7		3.95(5) b	3.99(5) b	1.50E-03 1.7
109Ag 110Ag-m	249.78 d	1505.028	0.002	4.85E-03 1.7	4.84E-03 0.8		3.95(5) b	3.99(5) b	4.90E-03 1.7
109Ag 110Ag-m	249.78 d	1562.294	0.0018	4.46E-04 2.8	4.35E-04 0.9		3.95(5) b	3.99(5) b	4.50E-04 2.8