Comparison of Neutron Activation Analysis k_0 and σ_0 Data

Richard B. Firestone

Lawrence Berkeley National Laboratory, Berkeley CA

Third Co-ordination Meeting on a *Reference Database for Neutron Activation Analysis*

17-19 November 2008

IAEA, Vienna

Sources of Data

k_0 – De Corte and Simonits, ADNDT **85**, 47-67 (2003) and literature

σ_0 – Mughabghab, *Atlas of Neutron Resonances* (Elsevier, Amsterdam 2006)

σ_γ – *Handbood of Prompt Gamma Activation Analysis* (Kluwer 2004)

σ_0(literature) CSISRS file, NNDC, Brookhaven Laboratory

P_γ – *Table of Radionuclides,* Bureau International des Poids et Measures

P_γ – Evaluated Nuclear Structure Data File, NNDC, Brookhaven Laboratory

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

M = atomic mass (M_{Au}=196.96655), θ = isotopic abundance (θ_{Au}=100),

σ_0 = thermal radiative neutron cross section ($\sigma_{0,Au}$=98.65 b), and

P_γ = γ-ray transition probability (P_{Au}=0.9554)

BERKELEY LAB

Preliminary Results

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	ΔEγ	k0(Atlas)	±%	k_0(ATNDT)	±%	k_0(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

BERKELEY LAB

Preliminary results for Z≤47 are available in report

^{23}Na

^{23}Na(n,γ)		
Reference	**σ_0(b)**	**$\Delta\sigma_0$(b)**
De Corte ADNDT	0.513	0.006
NSE41,445	0.5	0.03
RRL23,317	0.54	0.02
NSE9,132	0.47	0.06
PR83,641	0.47	0.024
ANL-5031	0.503	0.005
CJC31,204	0.53	0.032
55ANS,203	0.5	0.05
78MAYAG,495	0.523	0.005
JNE1,231	0.51	0.03
NUK2,255	0.531	0.008
JNE24,419	0.5269	0.0045
AERE-NP/R-1894	0.536	0.006
ZNA18,1339	0.5	0.02
PNE3,242	0.536	0.008
JJAP21,366	0.577	0.008
PNE3,242	0.539	0.008
Szentmiklosi	0.527	0.008
Mughabghab	0.517	0.004
Budapest PGAA	0.540	0.004
Budapest NAA	0.542	0.003
Adopted Value	**0.541**	**0.004**

Recent Budapest σ_0 values higher than De Corte or Mughabghab values.

New measurements planned with A. Simonits and Zs. Revay at the Budapest Reactor.

BERKELEY LAB

^{41}K

^{41}K(n,γ)		
Reference	**σ_0(b)**	**$\Delta\sigma_0$(b)**
RRL23,317	1.43	0.03
DAB27,919	1.5	0.05
DAB27,919	1.49	0.03
PR72,888	1	0.2
PR88,412	1.19	0.1
NSE8,378	1.45	
78MAYAG,495	1.43	0.03
Gryntakis thesis	1.28	0.06
NUK9,270	1.2	0.1
JNE24,35	1.46	0.03
JJAP21,636	1.57	0.17
De Corte ADNDT	1.42	0.02
NPA439,219	1.523	0.022
Mughabghab	1.46	0.03
Budapest PGAA	1.523	0.022
Budapest NAA	1.733	0.013
Adopted Value	**1.73**	**0.03**

Recent Budapest σ_0 values higher than De Corte or Mughabghab values.

New measurements planned with A. Simonits and Zs. Revay at the Budapest Reactor.

New statistical model calculations in progress to correct Budapest PGAA σ_0 value for missing statistical feeding, see [PRC77, 054615 (2008)]

BERKELEY LAB

^{64}Ni

^{64}Ni(n,γ)		
Reference	**σ_0(b)**	**$\Delta\sigma_0$(b)**
RRL23,317	1.49	0.07
ZPA281,365	1.63	
PR72,888	1.96	0.39
NSE8,378	1.45	
ORNL-4343	1.35	0.1
78MAYAG,495	1.49	0.02
Gryntakis Thesis	1.58	0.04
JNE24,35	1.49	0.04
ARI48,493	1.6	0.1
YFI-1,17	2.1	
De Corte ADNDT	1.61	0.01
Mughabghab	1.64	0.04
Budapest PGAA	2.36	0.26
Adopted Value	**2.3**	**0.3**

Budapest PGAA value needs to be rechecked.

BERKELEY LAB

Reference Database for Neutron Activation Analysis

- Recommended k_0, σ_γ and σ_0 data for selected γ-rays from all thermal neutron activation products
- Publication in a representative journal
- Review by IAEA CRP participants would be appreciated.

BERKELEY LAB

Evaluated Gamma-Ray Activation File (EGAF) 1st Revision

- Complete documentation of k_0, σ_γ, σ_0 and P_γ input data from all sources
- Recommended k_0, σ_γ and σ_0 data for all known γ-rays from all thermal neutron activation products.
- Tabular and ENSDF format presentation.
- Dissemination of the 1st Revision of EGAF through the IAEA and LBNL websites

BERKELEY LAB