Final results for ^{23}Na, ^{24,25,26}Mg and ^{39,40,41}K(n,γ)

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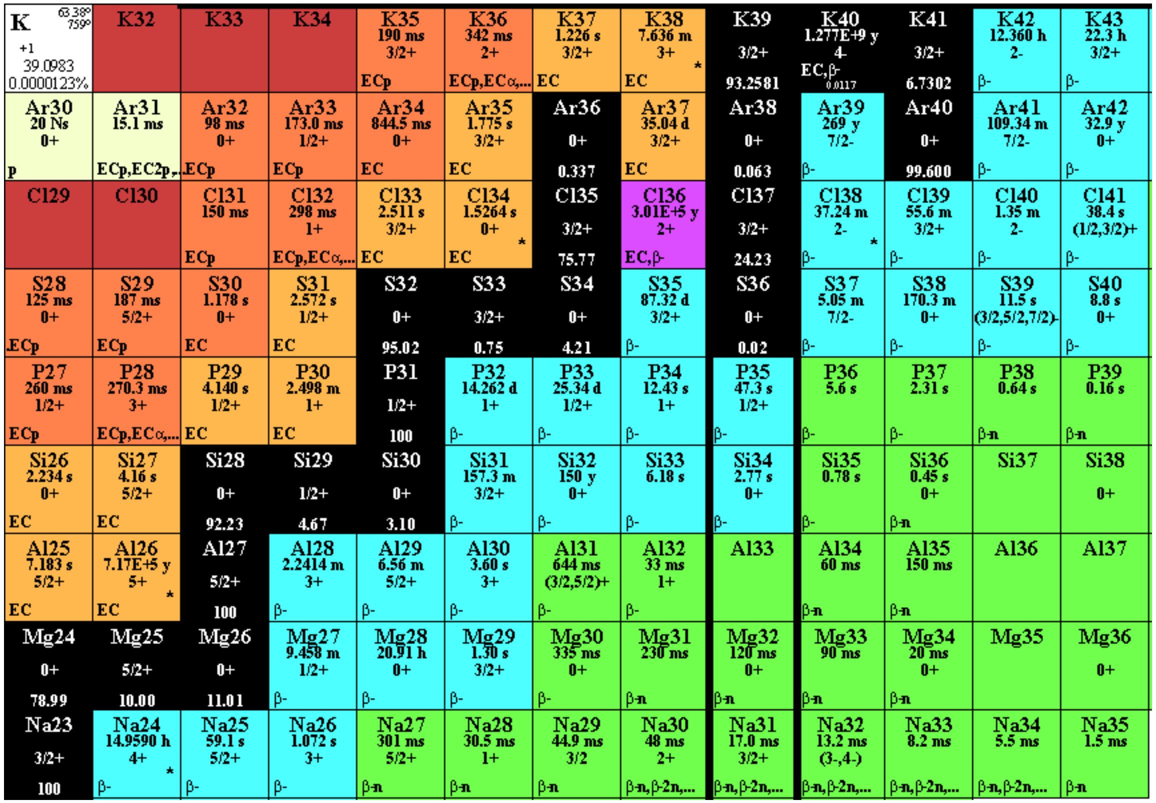


Evaluation of Z<20 Nuclei

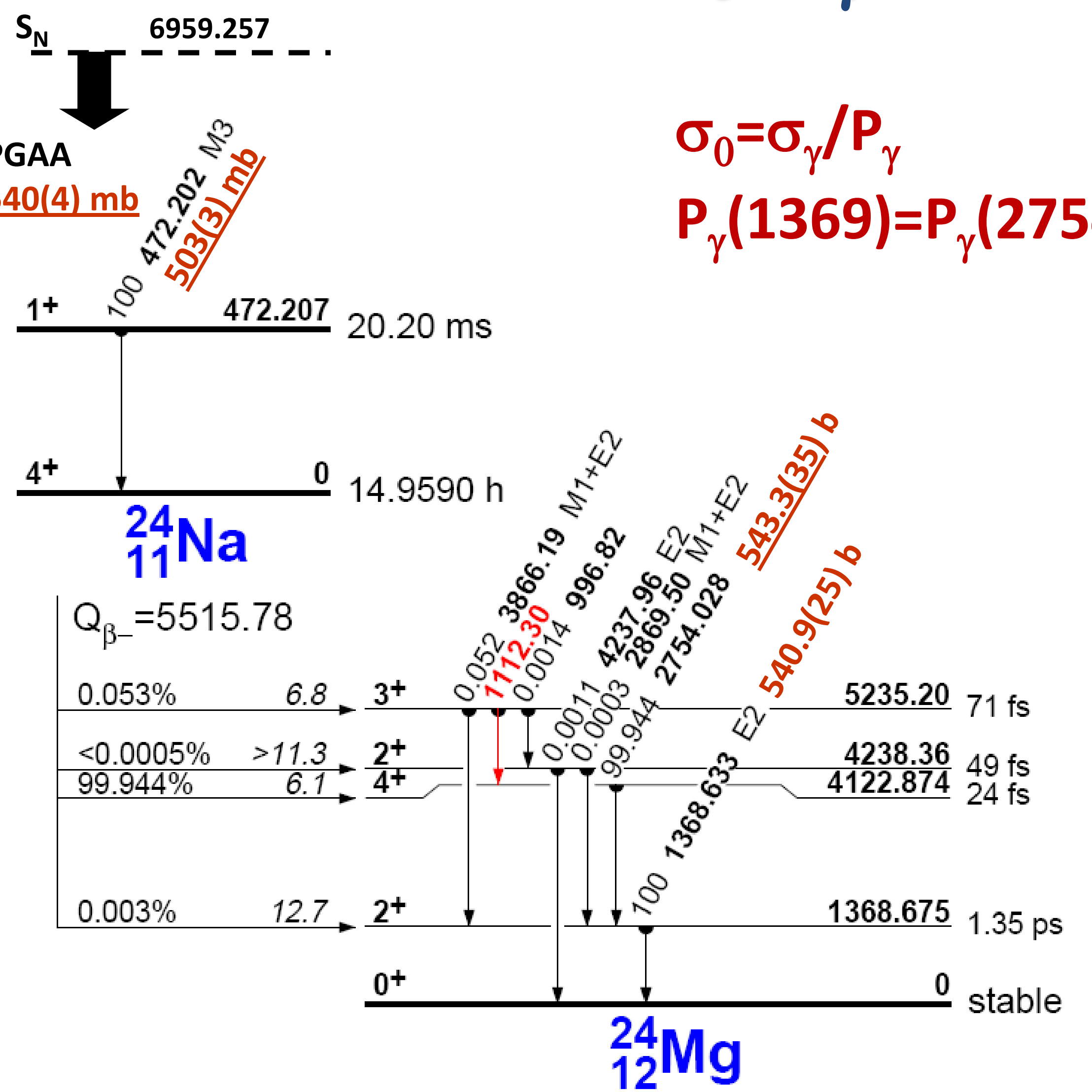
- Data are from thermal/cold guided neutron beam measurements at the Budapest and Garching FRM-II reactors, except as noted.
- Capture γ-ray decay schemes are "complete".
- Total radiative cross sections

$$\sigma_0=\Sigma\sigma_\gamma(GS)=\Sigma\sigma_\gamma(CS)$$

- Decay scheme normalizations/σ_0 from decay data

$$P_\gamma=\sigma_\gamma/\sigma_0$$

Determination of σ_0/P_γ: $^{23}Na(n,\gamma)$



$\sigma_0=\sigma_\gamma/P_\gamma$

$P_\gamma(1369)=P_\gamma(2754)=1$

Comparison with Previous Measurements

^{23}Na	Author (year)	$\sigma_0 \pm \Delta\sigma$ (b)
	Coltman (1946)	0.47±0.04
	Pomerance (1951)	0.470±0.024
	Meadows (1961)	0.47±0.06
	Brooksbank (1955)	0.50±0.05
	Koehler (1963)	0.50±0.02
	Yamamuro (1970)	0.50±0.03
	Harris (1953)	0.503±0.005
	Grimeland (1955)	0.51±0.03
	De Corte (2003)	**0.513±0.006**
	Kennedy (2003)	0.515±0.021
	Heft (1978)	0.523±0.005
	Ryves (1970)	0.527±0.005
	Szentmiklosi (2006)	0.527±0.008
	Bartholomew (1953)	0.530±0.032
	Wolf (1960)	0.531±0.008
	Cocking (1958)	0.536±0.006
	Jowitt (1959)	0.536±0.008
	Rose (1959)	0.539±0.008
	Gleason (1975)	0.54±0.02
	Kaminishi (1963)	0.577±0.008
	Seren (1947)	0.63±0.13
	Atlas	**0.517±0.004**
	EGAF - Primary	**0.534±0.003**
	EGAF - Secondary	**0.540±0.004**
	EGAF - Activation	**0.542±0.003**

^{23m}Na	Author (year)	$\sigma_0 \pm \Delta\sigma$ (b)
	Alexander	0.40±0.03
	Groshev	0.39±0.06
	Matsue	0.476±0.011
	Atlas	**0.40±0.03**
	EGAF - Feeding	**0.506±0.004**
	EGAF - Deexciting	**0.501±0.003**

The Atlas value was based on De Corte (2003). It was likely affected by summing (private communication).

Intensity balance through ^{24}Mg(n,γ) decay scheme

Level Energy	J^{π}	σ_{γ}(feeding)	σ_{γ}(deexciting)	Net Feeding
0	5/2+	0.0539(20)		
585.074(25)	1/2+	0.0403(14)	0.0400(19)	0
974.81(3)	3/2+	0.0158(5)	0.0158(5)	0
1964.71(14)	5/2+	0.00034(6)	0.00034(4)	0
2563.43(5)	1/2+	0.00204(10)	0.00190(10)	-0.00014(14)
2801.67(14)	3/2+	0.00037(6)	0.00046(5)	0.00009(8)
3413.43(3)	3/2-	0.0403(19)	0.0412(14)	0.0009(24)
4276.49(4)	1/2-	0.0105(5)	0.0108(4)	0.0003(6)
4358.3(6)	3/2+	0.00009(3)	0.00009(3)	0
5116.62(23)	1/2-	0.00029(5)	0.00023(3)	0.00006(6)
7330.66(4)	1/2+		0.0530(20)	

^{24}Mg(n,γ)

Literature values

Author (Year)	$\sigma_0 \pm \Delta\sigma$ (mb)
Pomerance(1952)	0.033±0.010
Prestwich(1990)	0.0515±0.0025
Walkiewicz(1992)	0.0541±0.0013
Spilling(1967)	0.052±0.013
Selin(1970)	0.041±0.010
Atlas	**0.0538±0.0013**

Intensity balance through $^{25}Mg(n,\gamma)$ decay scheme

$^{25}Mg(n,\gamma)$

Level Energy	Jπ	σ_γ(feeding)	σ_γ(deexciting)	Net Feeding
0	0+	0.196(8)		
1808.74(3)	2+	0.183(5)	0.181(8)	0
2938.33(3)	2+	0.0977(24)	0.099(4)	0
3588.57(8)	0+	0.00090(7)	0.00127(6)	0.00037(9)
3941.54(4)	3+	0.0247(10)	0.0252(9)	0.0005(14)
4318.89(5)	4+	0.0089(6)	0.0057(4)	-0.0032(7)
4332.57(5)	2+	0.0139(8)	0.0123(6)	-0.0017(10)
4350.08(4)	3+	0.0248(10)	0.0287(11)	0.0039(15)
4835.15(4)	2+	0.0107(5)	0.0130(7)	0.0023(9)
4901.30(8)	4+	0.0050(4)	0.00265(23)	-0.0024(5)
4972.30(5)	0+	0.00044(5)	0.00067(15)	0.00023(16)
5291.74(5)	2+	0.0037(3)	0.0049(3)	0.0012(5)
5476.12(7)	4+	0.00084(7)	0.00208(13)	0.00124(15)
5691.11(17)	1	0.00039(4)	0.00090(8)	0.00051(9)
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10718.75(6)		0.00026(8)	0	-0.00026(8)
10745.98(9)		0.00011(20)	0.00141(20)	0.00130(20)
10805.8(4)		0.00005(20)	0.00005(10)	-0.00005(22)
11093.18(3)	2+,3+		0.187(4)	

Literature values

Author (Year)	$\sigma_0 \pm \Delta\sigma$ (mb)
Pomerance(1952)	0.27±0.08
Prestwich(1990)	0.201±0.009
Walkiewicz(1992)	0.200±0.003
Spilling(1967)	0.181±0.050
Selin(1970)	0.125±0.030
Atlas	**0.199±0.003**

$^{26}Mg(n,\gamma)$

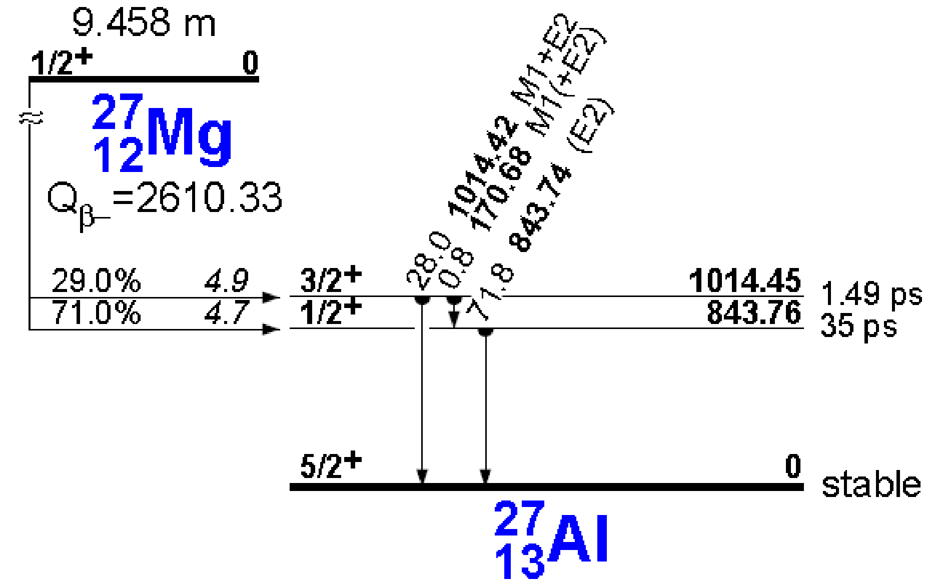
Intensity balance through $^{26}Mg(n,\gamma)$ decay scheme

Level Energy	J^{π}	σ_{γ}(feeding)	σ_{γ}(deexciting)	Net Feeding
0	1/2+	0.0381(14)		
984.92(3)	3/2+	0.0063(4)	0.0058(4)	-0.0004(5)
1698.62(4)	5/2+	0.00108(6)	0.00107(18)	0
1940.37(7)	5/2+	0.00029(4)	0.00037(5)	0.00008(6)
3476.35(6)	1/2+	0.00124(13)	0.0014(3)	0.00010(3)
3491.43(15)	(3/2,5/2)+	0.00038(11)	0.00037(4)	0
3561.55(3)	3/2-	0.0257(14)	0.0249(12)	-0.0008(18)
3787.37(5)	3/2+	0.00120(17)	0.00133(8)	0.00013(19)
4828.17(4)	(1/2,3/2)-	0.0064(4)	0.0060(4)	-0.0004(6)
5028.57(15)	1/2+	0.00016(3)	0.00014(3)	-0.00003(4)
5925.93(18)		0.00022(3)	0.00021(3)	0
6443.38(3)	1/2+		0.0395(15)	0.0395(15)

$^{26}Mg(n,\gamma)$ Reaction and Decay

Literature values

Author (Year)	$\sigma_0 \pm \Delta\sigma$ (mb)
Gleason(1975)	0.034±0.002
Seren(1947)	0.048±0.010
Pomerance(1952)	0.06±0.06
Heft(1978)	0.0365±0.0010
Walkiewicz(1992)	0.0392±0.0010
Spilling(1967)	0.034±0.010
Gryntakis(1976)	0.035±0.020
Ryves(1970)	0.0382±0.0008
De Corte	0.0371±0.0005
Atlas	0.0384±0.0006
EGAF – primary	0.0395±0.0015
EGAF - secondary	0.0381±0.0014



$E(\gamma)$	P_γ(ENSDF)	σ_γ (b)	σ_0 (b)	P_γ(EGAF)
170.63(12)	0.0086(2)	0.00032 (7)	0.037(8)	0.0093(20)
843.71(3)	0.7180(2)	0.0285(14)	0.0397(19)	0.72(5)
1014.30(4)	0.2820(2)	0.0112(5)	0.0396(18)	0.282(19)

Potassium Data

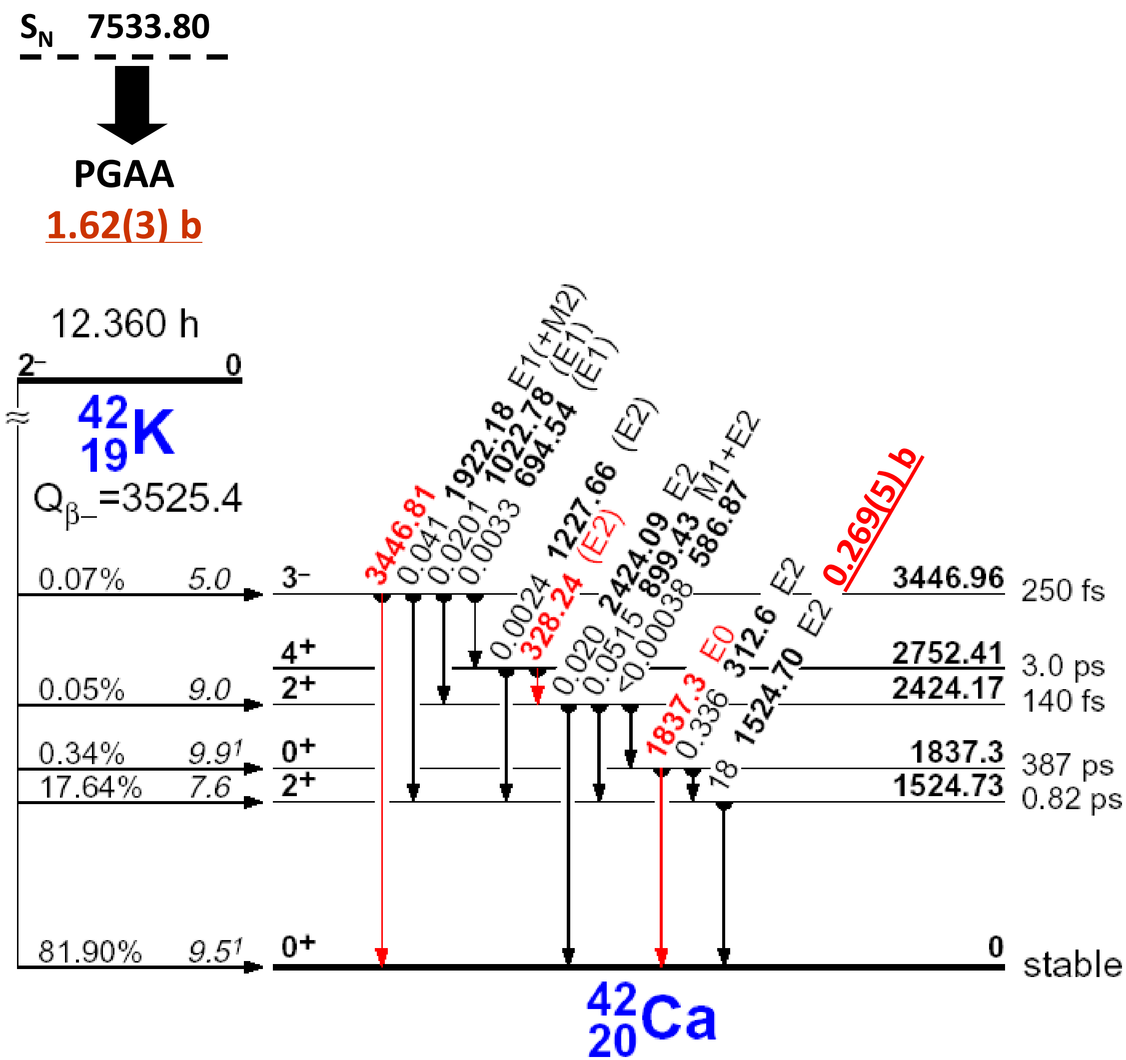
In addition to the EGAF measurements at the Budapest Reactor we used the Grenoble measurements of von Egidy, Krause, et al to complete the level schemes.

[3] T. von Egidy, H. Daniel, P. Hungerford, H. Schmidt, K. Lieb, B. Krusche, S. Kerr, G. Barreau, H. Borner, R. Brissot, et al., J. Phys. G. Nucl. Phys. **10**, 221 (1984).

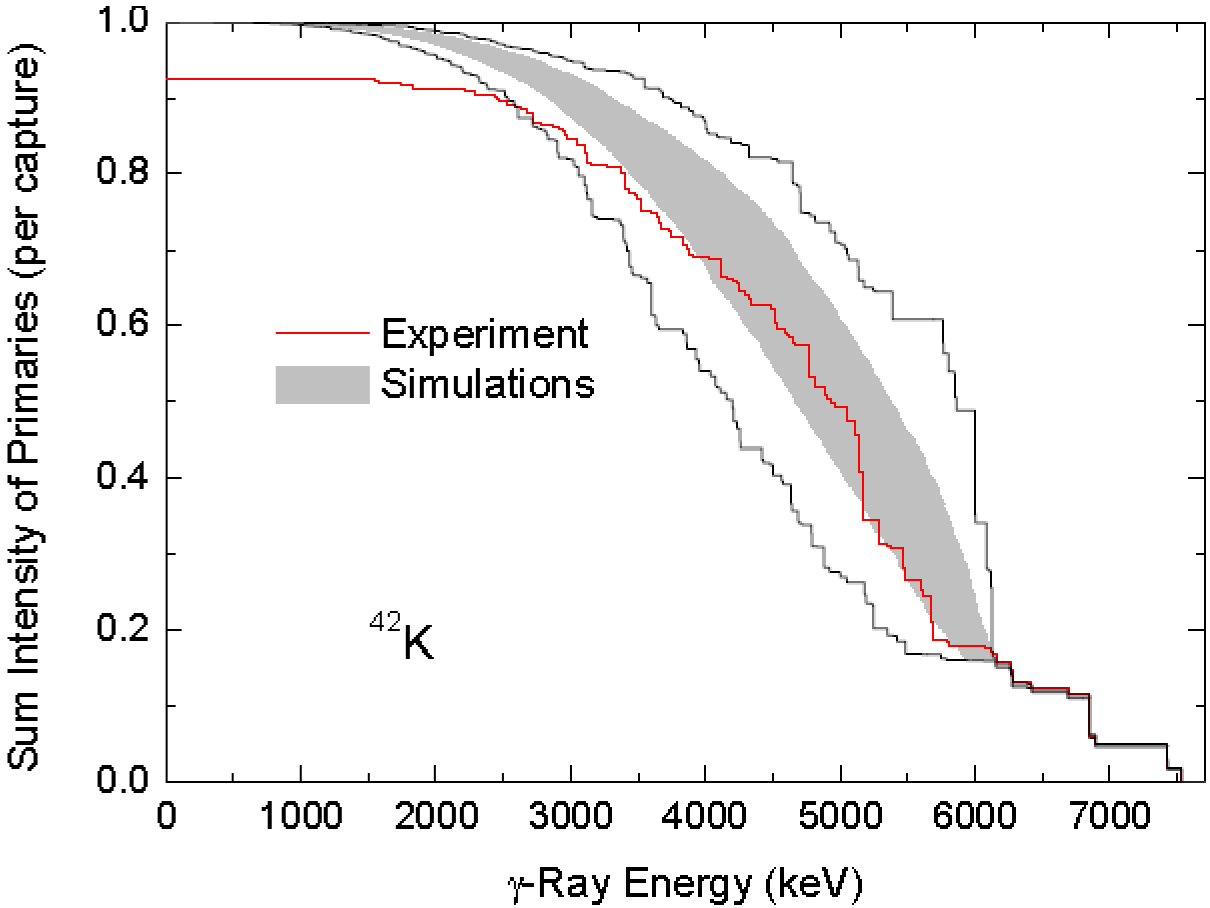
[4] B. Krusche, K. Lieb, L. Ziegler, H. Daniel, T. von Egidy, R. Rascher, G. Barreau, H. Borner, and D. Warner, Nucl. Phys. A **417**, 231 (1984).

[5] B. Krusche, C. Winter, K. Lieb, P. Hungerford, H. Schmidt, T. von Egidy, H. Scheerer, S. Kerr, and H. Borner, Nucl. Phys. A **439**, 219 (1985).

Determination of σ_0/P_γ: ^{41}K

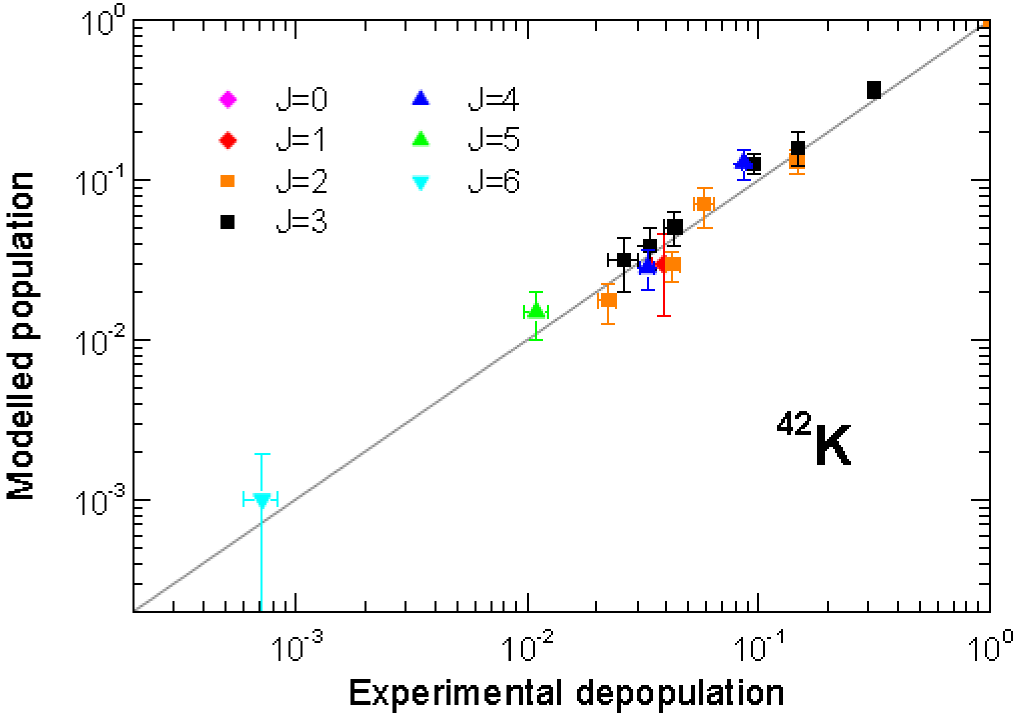


Statistical Model Simulation



Simulation of primary γ-ray intensities. 100 simulations were performed, 68% fall in the gray area. Experimental primary γ-ray are complete >4 MeV and 92% of primary intensity is observed.

Population/Depopulation Plot



Best fit population/depopulationplot. E_{crit}=1.4 MeV (17 levels).

$^{41}K(n,\gamma)$ Cross Section

Method 1:

$\Sigma\sigma_\gamma(GS)^{EXPT}=1.604\pm0.023$ b

$\Sigma\sigma_\gamma(GS)^{CALC}<0.035$ b ($E_\gamma>4$ MeV)

$\sigma_0(^{41}K)=1.62\pm0.03$ b

Method 2:

$\Sigma\sigma_\gamma(GS)^{E<Ecrit}=1.185\pm0.019$ b (experiment)

$\Sigma\sigma_\gamma(GS)^{E>Ecrit}=0.37\pm0.11$ b (calculated)

$\sigma_0(^{41}K)=1.56\pm0.11$ b

$^{41}K(n,\gamma)$: Comparison with Previous Measurements

Author (Year)	$\sigma_0 \pm \Delta\sigma$ (mb)	$\sigma_\gamma(1525)$
Seren (1947)	1.0±0.2	
Pomerance (1952)	1.19±0.10	
Koehler (1967)	1.2±0.1	
Gryntakis (1976)	1.28±0.06	
De Corte (2003)	1.42±0.02	0.263(2)
Gleason (1975)	1.43±0.03	0.257(5)
Heft (1978)	1.43±0.03	0.252(5)
Lyon (1960)	1.45	
Ryves (1970)	1.46±0.03	
Kappe (1966)	1.49±0.03	0.266(8)
Kaminishi (1982)*	1.57±0.17	
EGAF	**1.62±0.03**	**0.269(5)**
Atlas	**1.46±0.03**	

Bad agreement with previous results!

$^{41}K(n,\gamma)$: Determination of P_γ

$P_\gamma = \sigma_\gamma / \sigma_0$

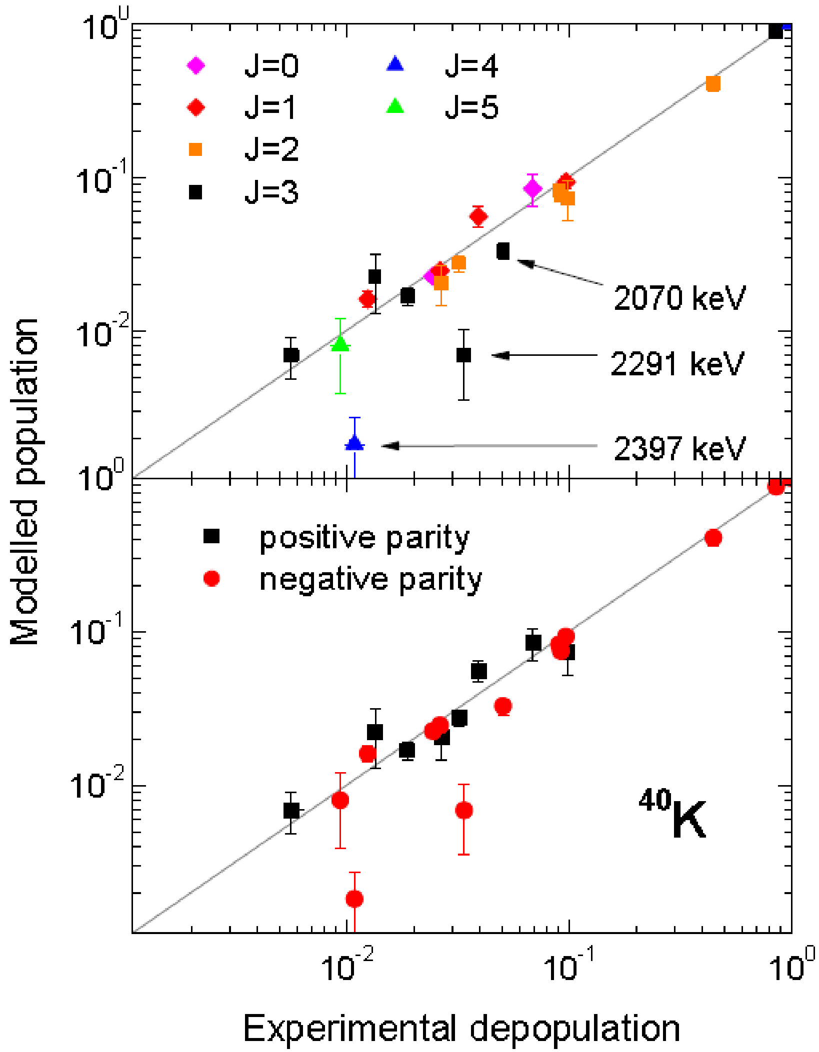
σ_γ=0.269±0.005 b, σ_0=1.62±0.03 b from same spectrum

Author (Year)	P_g (1566)
Miyahara (1990)*	0.1808(9)
Simoes (2001)*	0.1813(14)
Kaminishi (1982)#	0.171(12)
EGAF	**0.166(4)**

* $4\pi\beta-\gamma$ measurements not corrected for self-absorption in the target.

$4\pi\beta-\gamma$ measurement corrected for self-absorption in the target.

$^{39}K(n,\gamma)$



Author (Year)	$\sigma_0 \pm \Delta\sigma$ (mb)
Hansen (1949)	3.0±1.5
Pomerance (1952)	1.9±0.2
Gillette (1966)	1.4
Atlas	**2.1±0.2**

Population/depopulation plot. For selected levels where direct reactions dominate. Confirmed in (d,p).

E_{crit}=2.82 MeV (21 levels),

30 keV level not observed

Method 1:

$\Sigma\sigma_\gamma(GS+30)^{EXPT}=2.252\pm0.016$ b

$\Sigma\sigma_\gamma(GS+30)^{CALC}<0.056$ b

$\sigma_0(^{39}K)=2.28\pm0.04$ b

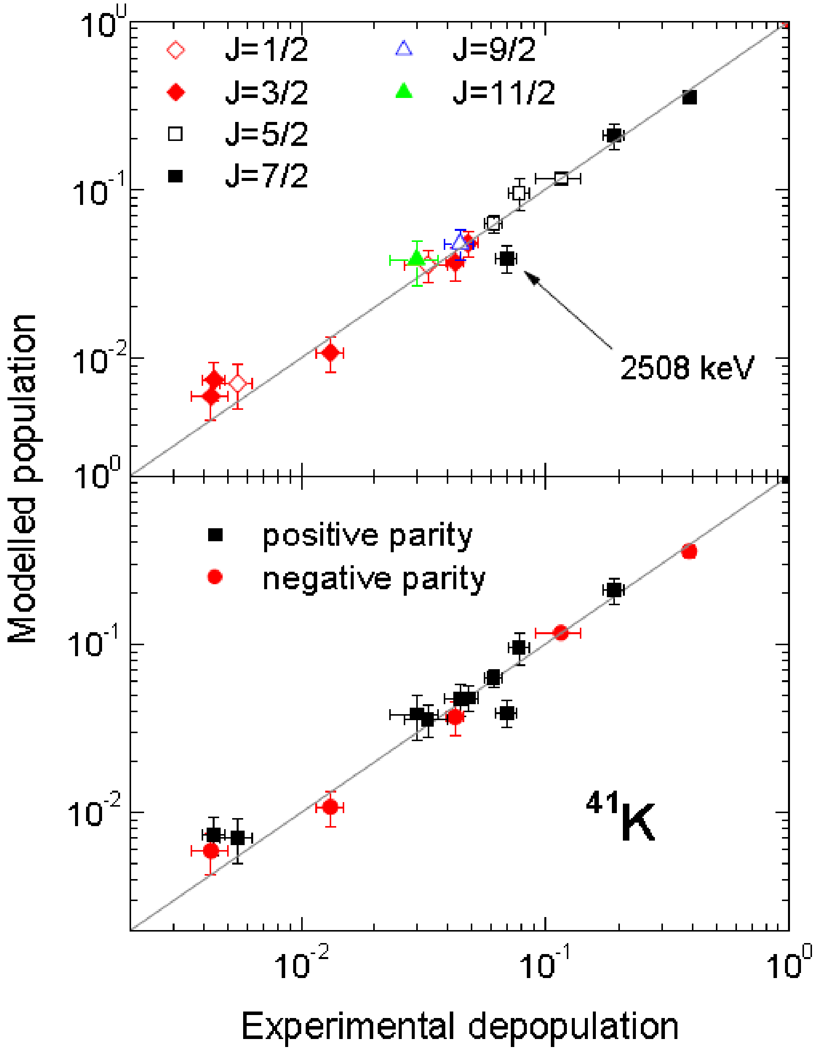
Method 2:

$\Sigma\sigma_\gamma(GS+30)^{E<Ecrit}=1.836\pm0.014$ b

$\Sigma\sigma_\gamma(GS+30)^{E>Ecrit}=0.52\pm0.12$ b

$\sigma_0(^{39}K)=2.35\pm0.15$ b

$^{40}K(n,\gamma)$



Author (Year)	$\sigma_0 \pm \Delta\sigma$ (mb)
Pomerance (1952)	66±30
Gillette (1966)	≈70
Beckstrand (1971)	30±8
Atlas	**30±8**

Population/depopulation plot.

E_{crit}=2.60 MeV (16 levels)

Method 1:

$\Sigma\sigma_\gamma(GS)^{EXPT}=86\pm7$ b

$\Sigma\sigma_\gamma(GS)^{CALC}<7$ b

$\sigma_0(^{40}K)=90\pm8$ b

Method 2:

$\Sigma\sigma_\gamma(GS)^{E<Ecrit}=75\pm4$ b

$\Sigma\sigma_\gamma(GS)^{E>Ecrit}=15\pm5$ b

$\sigma_0(^{40}K)=90\pm7$ b

Summary of results

Isotope	σ_0 (Atlas) b	σ_0 (EGAF) b
^{23}Na-0	0.517±0.004	0.541±0.003
^{23}Na-478	0.40±0.03	0.503±0.003
^{24}Mg	0.0538±0.013	0.0539±0.020
^{25}Mg	0.199±0.003	0.196±0.008
^{26}Mg	0.0384±0.006	0.0387±0.014
^{39}K	2.1±2	2.28±0.04
^{40}K	30±8	90±7
^{41}K	1.46±0.03	1.62±0.03
	P_γ (ENSDF)	**P_γ (EGAF)**
^{42}K-1525γ	0.1809±0.0009	0.166±0.004