Use of K_0 data in decay scheme normalization: An example

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Decay scheme normalization

- From decay scheme
- Absolute intensity of one γ-ray is known
- x-ray intensity is known
- Annihilation radiation intensity is known

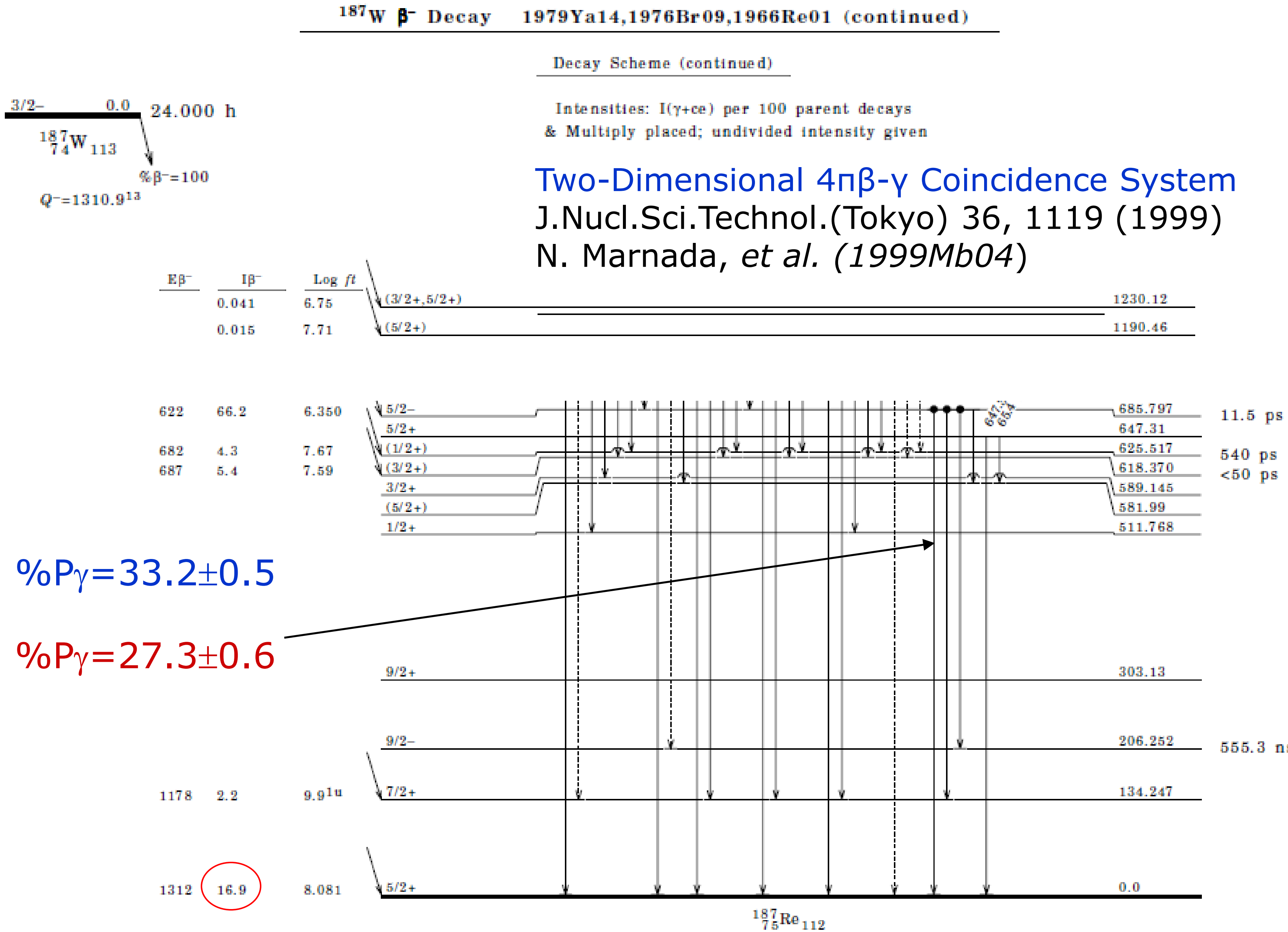
%intensity of γ-rays

Isotope	Half-life	γ-ray (keV)	TOI 7th edition - '78	TORadio Iso '86	Nudat	year
^{52}V	3.75 m	1434.2	100	100 (1)	100.0 (14)	2007
^{24}Na	15.02 h	1368.6	100	100	99.9936 (15)	2007
^{51}Ti	5.75 m	320.1	93.4 (9)	93.0 (4)	93.1 (4)	2006
^{38}Cl	37.2 m	1642.4	31.0 (15)	31.0 (4)	33.3 (7)	2008
^{28}Al	2.24 m	1778.7	100	100	100	1998
^{49}Ca	8.72 m	3084.4	92 (1)	92.1 (10)	90.72 (4)	2008
^{42}K	12.36 h	1524.6	18.8 (6)	18.8 (6)	18.08 (9)	2001
^{66}Cu	5.10 m	1039.2	8 (1)	7.4 (1.8)	9.23 (9)	2010
^{56}Mn	2.58 h	1810.7	27.2 (8)	27.2 (7)	26.9 (4)	2011
^{60m}Co	10.5 m	58.6	2.0 (1)	2.01 (6)	2.0359 (6)	2003
^{187}W	23.9 h	685	**26.3 (2)**	**26.4 (6)**	**33.2 (5)**	2009
^{76}As	1.1 d	559.1	45 (2)	45 (2)	45 (2)	1995
^{110}Ag	24.6 s	657.7	4.5 (2)	4.5 (2)	4.50 (24)	2012
^{116m}In	54.15 m	416.9	**32.4 (15)**	**29.2 (14)**	**27.2 (4)**	2010
^{82}Br	1.47 d	776.5	83.4 (9)	83.6 (8)	83.4 (12)	2003
^{128}I	25 m	442.9	16 (2)	16.9 (17)	12.62 (16)	2001
^{122}Sb	2.7 d	563.9	70 (4)	70.0 (4)	70.67 (18)	2007
^{69m}Zn	13.76 h	438.6	94.8 (3)	94.8 (3)	94.77 (20)	2000
^{125m}Sn	9.52 m	332.1	97.0 (4)	97.0 (19)	97.3 (14)	2011
^{29}Al	6.5 m	1273	89.1 (7)	91.3	91.26 (6)	2012
^{77m}Se	17.4 s	162	52.5 (12)	52.4 (12)	53.2 (7)	2012

Two-Dimensional 4πβ-γ Coincidence System

J.Nucl.Sci.Technol.(Tokyo) 36, 1119 (1999)

N. Marnada, *et al. (1999Mb04*)



%Pγ=33.2±0.5

%Pγ=27.3±0.6

Reliability of Prompt γ-Ray Intensities for the Measurement of Neutron Capture Cross Sections

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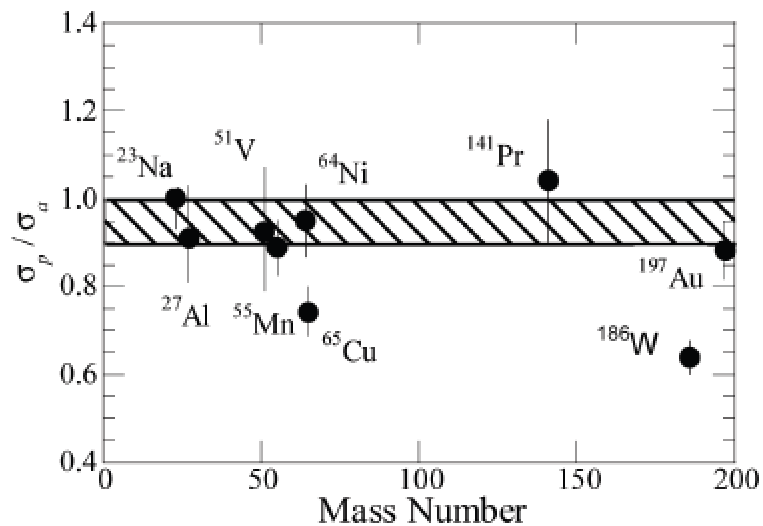

FIGURE 4. The ratio of σ used prompt γ-rays to σ used β-decay γ-rays. The detector used was the 22% HPGe detector. It is clearly seen that the ratios are lower systematically than 1.0 ($\sigma_{prompt}=\sigma_{decay}$).

Nuclear Data Conference, Santa Fe, USA, 2004

Neutron Activation Analysis and K_0-data

- Neutron activation analysis is a non-destructive method for elemental analysis in the sample
- K_0-method eliminates detailed analytical steps by determining a constant for each elements
- Simultaneous irradiation of element with Au target and 412 keV delayed gamma-ray is used from the $^{197}Au(n,\gamma)^{198}Au$ reaction to determine

$$k_{0,\mathrm{Au}}(\mathrm{a}) = \frac{M_{\mathrm{Au}}\theta_{\mathrm{a}}\sigma_{0,\mathrm{a}}\gamma_{\mathrm{a}}}{M_{\mathrm{a}}\theta_{\mathrm{Au}}\sigma_{0,\mathrm{Au}}\gamma_{\mathrm{Au}}}$$

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Atomic Data and Nuclear Data Tables 85 (2003) 47–67

Atomic Data AND Nuclear Data Tables

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Recommended nuclear data for use in the k_0 standardization of neutron activation analysis☆,☆☆

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Abstract

k_0 factors (composite nuclear constants) for use in the k_0 standardization of reactor neutron activation analysis were experimentally measured with great care in several laboratories. The recommended values thus obtained for the relevant gamma rays of 144 analytically interesting radionuclides are tabulated, together with evaluated values for their associated parameters such as resonance integral to thermal cross-section ratios and effective resonance energies. A classification is also given of the various activation-decay types, to which the data are strictly correlated.

Table 1

$k_{0,Au}$ factors and related nuclear data for use in k_0 standardized neutron activation analysis. See page 52 for Explanation of Tables

Element	Target isotope	Q_0 (s, %)	$\bar{E}_r$, eV	Formed isotope (Activation/decay code)	$T_{1/2}$	E_γ, keV	Measured $k_{0,Au}$ (s, %)	Notes
F	^{19}F	2.2	44,700	^{20}F (I)	11.16 s	1633.6	9.98E − 4 (1.2)	Q_0 adopted
Na	^{23}Na	0.59 ( )	3380	^{24}Na (IVb)	14.96 h	1368.6	4.68E − 2 (0.6)	Data for m + g
						2754.0	4.62E − 2 (0.9)	(m 20.2 ms)
Mg	^{26}Mg	0.64	257,000	^{27}Mg (I)	9.462 min	170.7	3.02E − 6 (1.0)	Q_0 adopted
						843.8	2.53E − 4 (0.5)	
						1014.4	9.80E − 5 (0.2)	
Al	^{27}Al	0.71	11,800	^{28}Al (I)	2.2414 min	1778.9	1.75E − 2 (0.8)	Q_0 adopted
Si	^{30}Si	1.11 (6.)	2280	^{31}Si (I)	2.622 h	1266.2	1.45E − 7 (0.7)	
S	^{36}S	1.12 ( )		^{37}S (I)	5.05 min	3103.4	1.96E − 6 (1.8)	No resonance data; large terrestrial variation in θ
Cl	^{37}Cl	0.69 ( )	13,700	^{38}Cl (IVb)	37.24 min	1642.7	1.97E − 3 (1.4)	Data for m + g
						2167.4	2.66E − 3 (1.3)	(m 715 ms)
Ar	^{40}Ar	0.63	31,000	^{41}Ar (I)	1.822 h	1293.6	3.32E − 2 ( )	Q_0 adopted
K	^{41}K	0.87 (3.)	2960	^{42}K (I)	12.36 h	312.7	1.59E − 5 (1.1)	
						1524.7	9.46E − 4 (0.6)	
Ca	^{46}Ca	1.3		^{47}Ca (I)	4.536 d	489.2	9.14E − 8 (1.8)	No resonance data;
						807.9	9.20E − 8 (0.2)	Q_0 adopted;
				↓		1297.1	9.54E − 7 (1.7)	Large terrestrial variation in θ
				^{47}Sc (IIa)	3.349 d	159.4	8.57E − 7 (1.6)	
	^{48}Ca	0.45	1,330,000	^{49}Ca	8.718 min	3084.4	1.01E − 4 (0.9)	Q_0 adopted

- Corrections and new values in NIM A 622 (2010) 377–380

% intensity of 685 keV γ-ray of ^{187}W

$$\gamma_a = \frac{k_{0,Au} M_a \theta_{Au} \sigma_{0,Au} \gamma_{Au}}{M_{Au} \theta_a \sigma_{0,a}}$$

- From K_0 and Mughabghab value: 32 (4)
  - using 38.1 (5) barn for (n,γ)
- Latest evaluation 2009: 33.2 (5)
- Earlier evaluation 1991: 27.3 (6)

J. Rad. Nucl. Chem., vol. 257, 2003, p493 for cross-section

Thank you