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**Data Analyses
(Evaluation of 56Co Decay Data)**

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Evaluation of ^{56}Co Decay Data

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^{56}Co Decay Data

- ^{56}Co decays by positron emission (19.58%) and by electron capture (80.42%) to excited states of ^{56}Fe.
- 46 gamma rays with energies up to 3.6 MeV de-exciting 15 excited states in ^{56}Fe have been reported.
- This energy range makes ^{56}Co useful as a calibration source in gamma ray spectrometry.

^{56}Co Decay Data

- The Q value for the decay is given by Audi *et al*. as **4566 (20) keV.**
- The half-life of ^{56}Co has been evaluated by Woods *et al*. as **77.236 (26) days.**
- The main gamma ray energies are taken from the Helmer & van der Leun evaluation (2000).

^{56}Co Gamma Ray Emission Probabilities

- Relative gamma ray emission probabilities for the 46 gamma rays reported by 31 authors between 1965 and 2002 were tabulated.
- A problem arose when considering the high energy data.
- In many cases detector efficiency curves used measured data up to about 2.5 MeV and were then extrapolated to 3.6 MeV.

^{56}Co Gamma Ray Emission Probabilities

- It was clear from experimentally determined efficiency curves above 3 MeV that the extrapolated curves introduced errors of up to 6%.
- Therefore, of the 31 papers cited, only 8 which had used experimentally determined efficiency curves up to 3.6 MeV were included in the evaluation of data above 3 MeV.

^{56}Co Gamma Ray Emission Probabilities

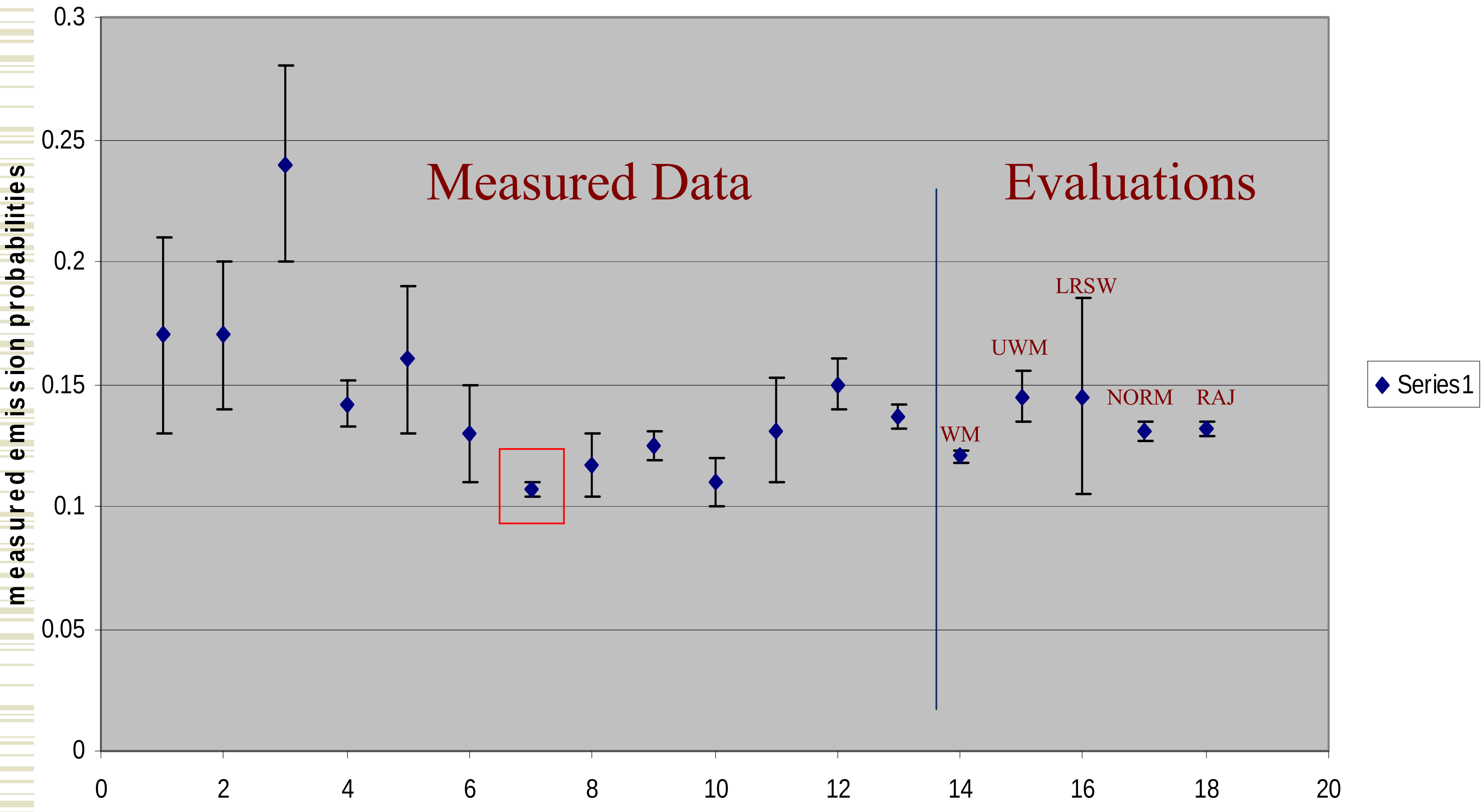
- The second problem was the significant number of discrepant data.
- Of the 46 gamma rays considered, 18 had data sets with a reduced chi-squared ranging from 2.0 to 7.8, indicating significant discrepancies.

^{56}Co Gamma Ray Emission Probabilities

- The following graph shows the data for the 1140.5 keV gamma ray, for which the reduced chi-squared is 5.2.

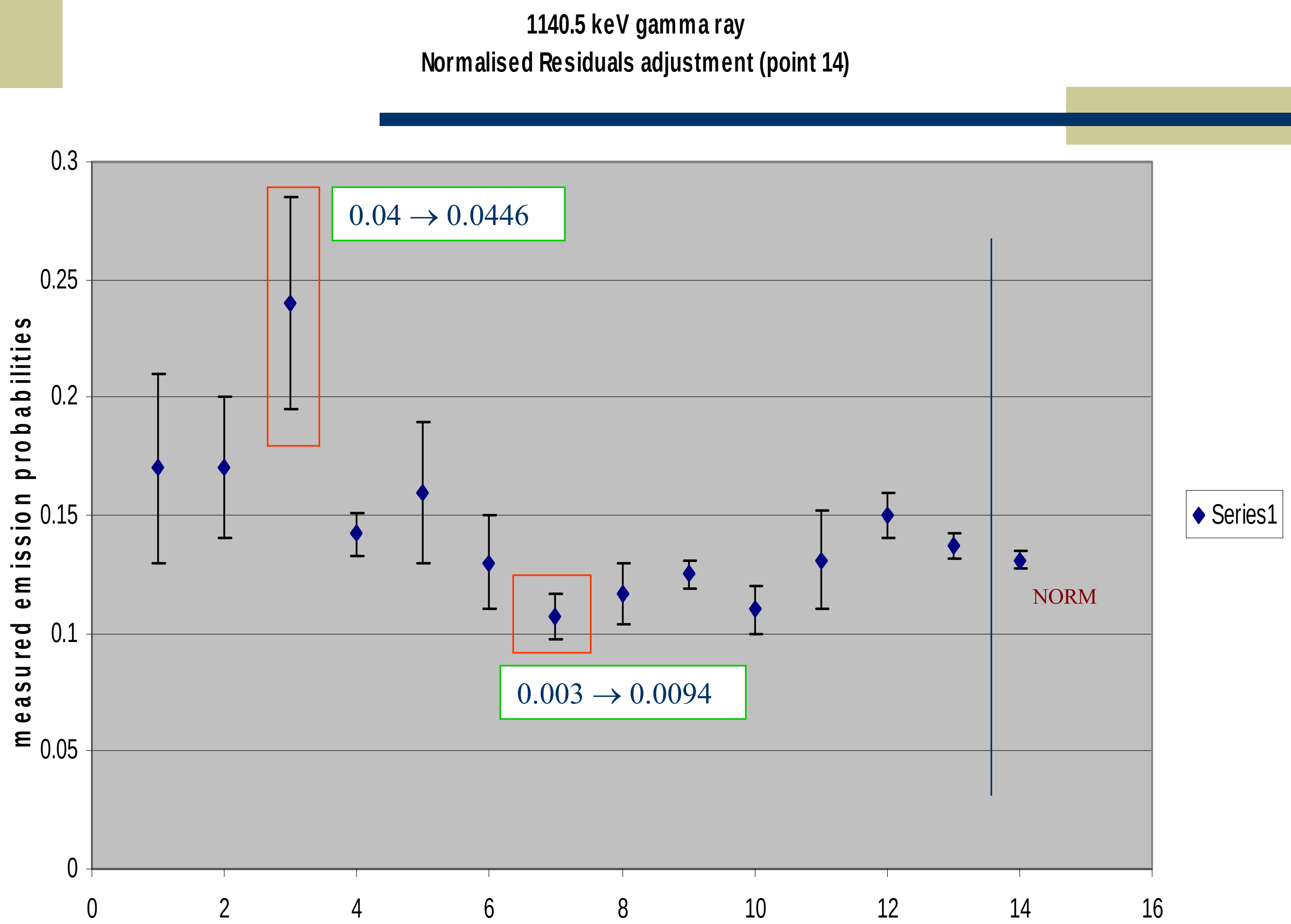
- The discrepancies are clear from the graph.

1140.5 keV gamma ray



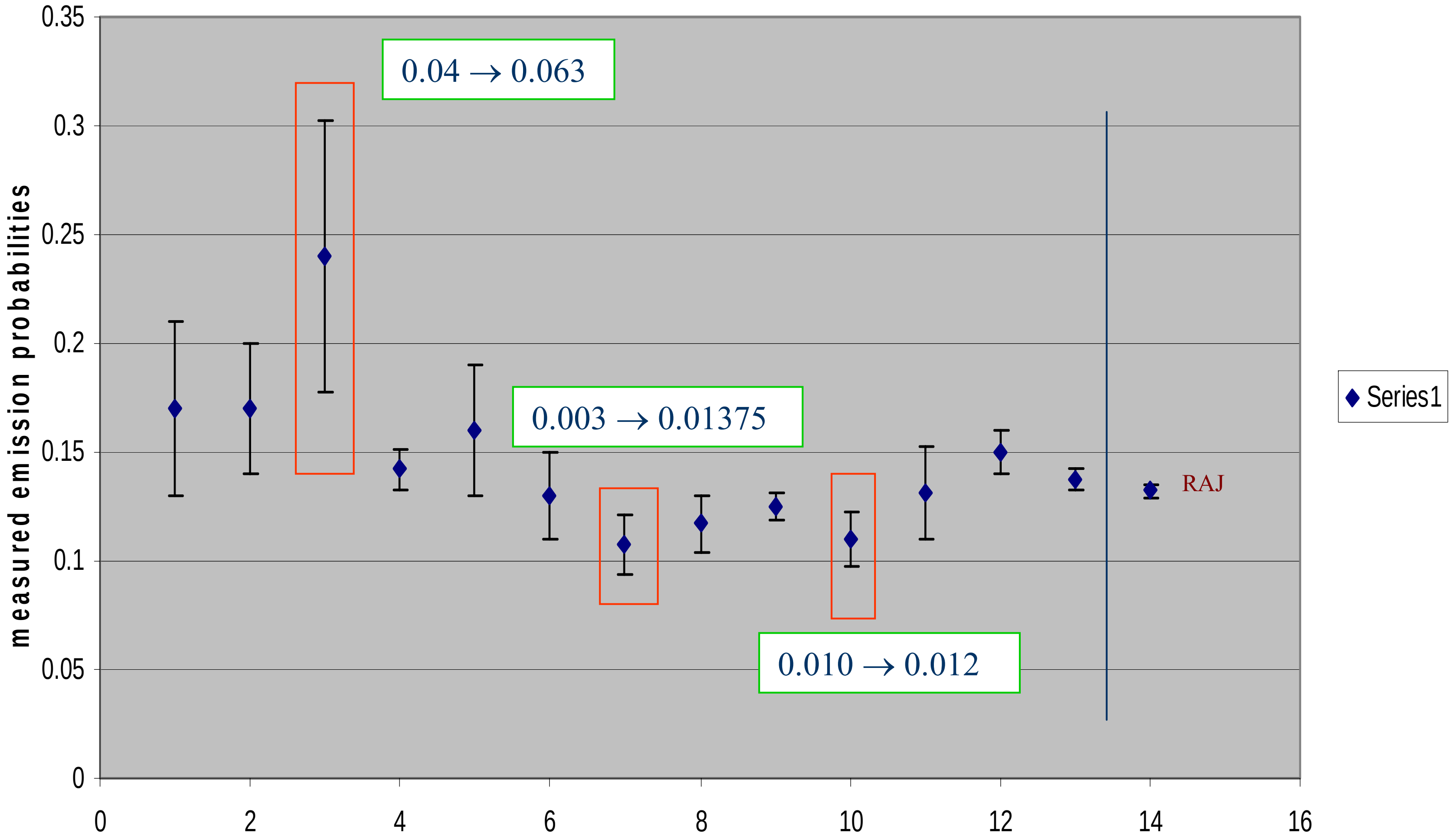
^{56}Co Gamma Ray Emission Probabilities

- On the previous graph points 1 to 13 are the experimental data.
- Point 14 is the weighted mean 0.1204(21)
- Point 15 is the unweighted mean 0.145(10)
- Point 16 is the LRSW 0.145 (38)
- Point 17 is the norm. resid. 0.131(4)
- Point 18 is the Rajeval value 0.132(4)



1140.5 keV gamma ray
Normalised Residuals adjustment (point 14)
measured emission probabilities
0.04 → 0.0446
0.003 → 0.0094
NORM
Series1
0
0.05
0.1
0.15
0.2
0.25
0.3
0
2
4
6
8
10
12
14
16

1140.5 keV gamma ray
Rajeval adjustment (point 14)

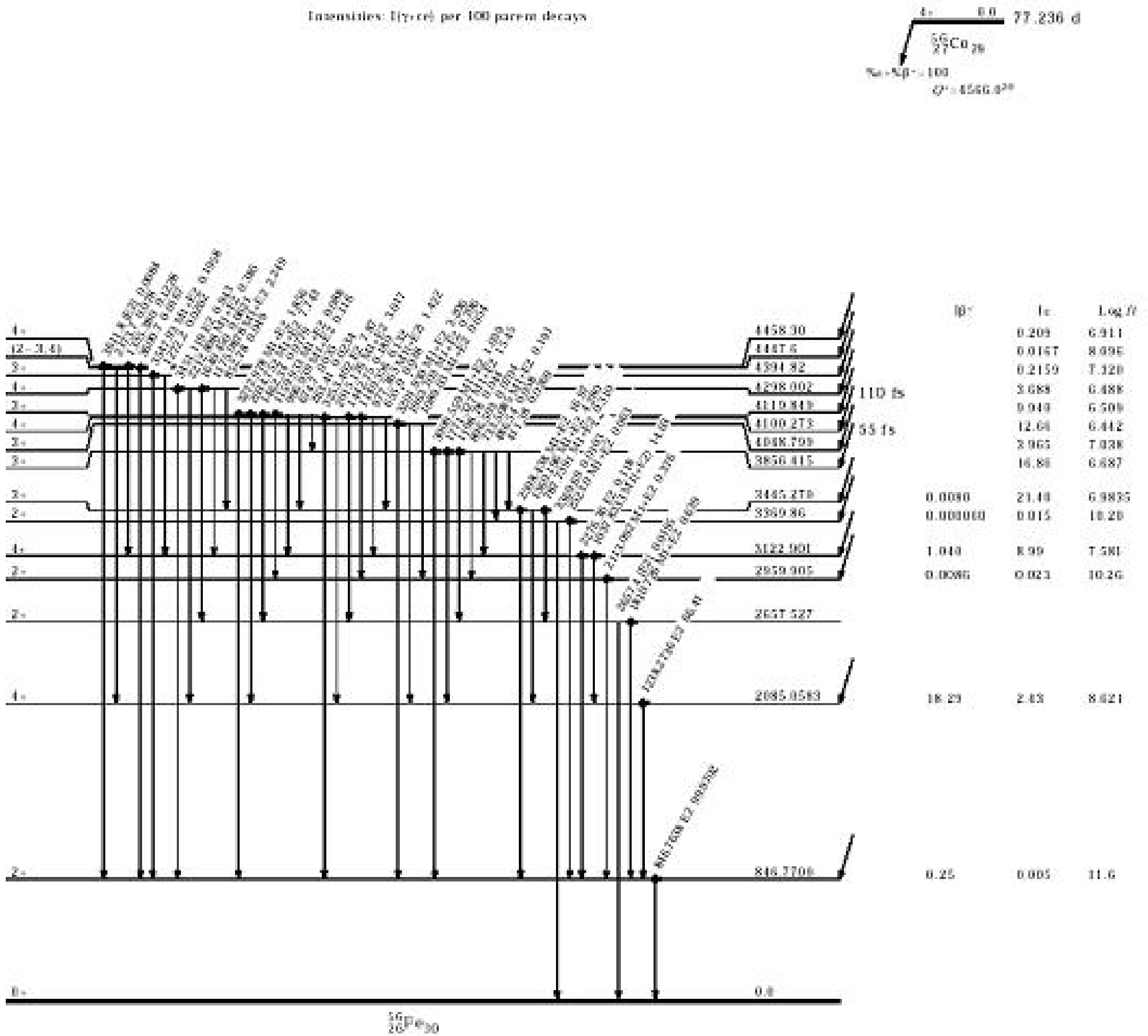


Normalisation

- Evaluated intensities are relative to the strongest 847 keV transition to the ground state.
- Normalisation is accomplished by requiring that all transitions to the ground state add up to 100.

Decay Scheme

Intensities: I(γ+ce) per 100 parent decays



Normalisation

- Assuming zero electron capture/positron feeding from the 4+ ^{56}Co parent to the 0+ ^{56}Fe ground state:

$$\Sigma\left(I\left(\gamma + ce\right) to\ the\ ground\ state\right) = 100$$

Normalisation

$$N = \frac{100}{\left[I(847\gamma)(1+\alpha(847\gamma)) + I(2657\gamma) + I(3370\gamma)\right]}$$

$$= \frac{100}{100.0303(9) + 0.0195(20) + 0.0103(8)}$$

$$= 0.999399(23)$$

Evaluated Data

Gamma Energy keV	Relative Iγ	Absolute Pγ
846.772	100	0.999399(23)
1037.840	14.04(5)	0.1403(5)
1238.282	66.45(16)	0.6641(16)
1360.215	4.283(13)	0.04280(13)
1771.351	15.46(4)	0.1545(4)
2034.755	7.746(13)	0.07741(13)
2598.458	16.97(4)	0.1696(4)
3201.962	3.205(13)	0.03203(13)
3253.416	7.87(3)	0.0787(3)

Positron Emission Probabilities

	Energy (keV)	Probability × 100	Nature	log *ft*
$\beta^{+}_{0,7}$	98.7 (20)	0.0080 (7)	allowed	6.984
$\beta^{+}_{0,6}$	174.3 (20)	6.0 E-5 (20)	2nd forbidden	10.20
$\beta^{+}_{0,5}$	421.1 (20)	1.040 (20)	allowed	7.581
$\beta^{+}_{0,4}$	584.1 (20)	0.0086 (22)	2nd forbidden	10.26
$\beta^{+}_{0,2}$	1458.9 (20)	18.29 (16)	allowed	8.621
$\beta^{+}_{0,1}$	2697.2 (20)	0.25 (17)	2nd forbidden	11.6

Electron Capture Probabilities

	Energy (keV)	Probability × 100	Nature	log *ft*
$\varepsilon_{0,8}$	709.5(20)	16.86(5)	allowed	6.687(3)
$\varepsilon_{0,7}$	1120.7(20)	21.40(5)	allowed	6.984(2)
$\varepsilon_{0,6}$	1195.9(20)	0.015(5)	2^{nd} forbidden	10.20(15)
$\varepsilon_{0'5}$	1443.1(20)	8.99(6)	allowed	7.581(4)
$\varepsilon_{0,4}$	1606.1(20)	0.023(6)	2^{nd} forbidden	10.26(11)
$\varepsilon_{0,2}$	2480.9(20)	2.43(3)	allowed	8.621(5)
$\varepsilon_{0,1}$	3719.2(20)	0.005(3)	2^{nd} forbidden	11.6(3)

Electron Capture Probabilities

	Energy (keV)	Probability × 100	Nature	log *ft*
$\varepsilon_{0,15}$	107.7(20)	0.209(7)	allowed	6.911(23)
$\varepsilon_{0,14}$	118.4(20)	0.0167(5)	unknown	8.096(21)
$\varepsilon_{0,13}$	171.2(20)	0.2159(18)	allowed	7.320(12)
$\varepsilon_{0.12}$	268.0(20)	3.688(13)	allowed	6.489(7)
$\varepsilon_{0,11}$	446.1(20)	9.940(18)	allowed	6.509(4)
$\varepsilon_{0,10}$	465.7(20)	12.66(4)	allowed	6.442(4)
$\varepsilon_{0.9}$	517.2(20)	3.965(15)	allowed	7.038(4)

X Ray Emissions

	Energy (keV)	Photons per 100 disintegrations
XL	0.615-0.792	0.581 (17)
$XK\alpha_2$	6.39091(5)	7.53 (10)
$XK\alpha_1$	6.40391(3)	14.75 (17)
$XK\beta_3$	} 7.05804(7)	} 3.05 (5)
$XK\beta_1$	}	}
$XK\beta''_5$	7.1083(4)	

Auger Electron Emissions

	Energy (keV)	Electrons per 100 disintegrations
e_{AL}	0.510 – 0.594	111.8 (8)
e_{AK}		46.04 (30)
KLL	5.370-5.645	35.61 (25)
KLX	6.158-6.400	9.76 (13)
KXY	6.926-7.105	0.666 (15)