^{58}Co - Comments on evaluation of decay data by M.M. Bé

A first evaluation was completed in November 1993 with minor editing in October 1998 and in March 2002. This new evaluation was completed in August 2013 in accordance with the DDEP rules. Various quantities have been updated (Q value, ICC…) and some references published to this date included.

Decay Scheme

A comprehensive study of the ^{58}Co decay was published by Bambynek and Legrand (1973Ba67).
^{58}Co ($T_{1/2}$ = 70,85 d) decays 100 % by electron capture and/or β^+ disintegrations to the two first excited levels in ^{58}Fe. The electron capture probabilities to upper levels in ^{58}Fe nucleus, if they exist, are of very weak intensity, since no gamma radiations have been observed from these levels. Disintegration by β^- transition to ^{58}Ni has never been observed.

Q^{EC} value for ^{68}Co decay was adopted from Wang *et al.* (2012Wa38).
The spins, parities and level energies are based on the mass-chain evaluation of Nesaraja *et al.* (2010Ne01).

The proposed decay scheme is consistent since Q_{calc} = 2307,9 (27) keV, deduced from the evaluated average energies of all emissions, is identical to Q_{β^-} = 2307,9 (11) from the 2012 atomic mass evaluation of M. Wang *et al.* (2012Wa38).

Half-life

The experimental half-life values used to calculate the recommended value are listed in the following table:

References	$T_{½}$ (d)	uc (d)	Comments
Schumann, 1956Sc87	71,3	0,2	
Decowski, 1968De08	71,54	0,75	
Werner, 1972We17	71,1	0,2	
Araminowicz, 1973ArZI	71,83	6,12	
Lagoutine, 1975La16	70,78	0,033	Original uc divided by 3
Vaninbroukx, 1976Va30	70,81	0,033	Original uc divided by 3
Houtermans, 1980Ho17	70,916	0,03	Original uc multiplied by 2
Hoppes, 1982HoZJ	70,75	0,07	Superseded by 2012Fi12
Fitzgerald, 2012Fi12	70,77	0,11	
Crit (χ^2)	2,6		
χ^2 /(n-1)	2,7		
UWM	71,131		
WM	70,845		
uc(WM)int. :	0,018		
uc(WM)ext. :	0,029		
Adopted	**70,85**	**0,03**	

Values given by Crisler *et al.* (1972Cr02) have not been taken into account because they were obtained as a mean to control another experiment and not as a specific study.

Uncertainties given by 1975La16 and 1976Va30 were divided by three because they are for a 99,7 % confidence level. But the unrealistic uncertainty of 0,015 claimed by 1980Ho17 was multiplied by two, then giving to the 1980Ho17 result a relative weight of 36 % comparable to 30 % for 1975La16 and 1976Va30.
The set of data is just consistent, the weighted mean is preferred with an uncertainty which is the lowest experimental uncertainty.

Electron Capture and Positron Emission

- The electron capture probability to the 1674 keV level is deduced from the decay scheme balance.
- The electron capture and the β^+ emission probabilities to the 810 keV level are deduced from the level balance and from the theoretical EC/β+ ratio of 5,61 (8). The resulting $I\beta^+$ intensity and the adopted EC/β^+ ratio are in good agreement with the measured values as shown in the table below.
- The lg ft values, the fractional atomic shell electron capture probabilities and the average β+ energy are calculated with the LOGFT program.

Measured values of $I\beta^+$ and ε / β^+ to the 811 keV level:

Reference	**$I\beta^+$ (%)**	**ε / β^+**
Good, 1946Go01	14,5 (5)	
Cook, 1956Co70		5,9 (2)
Grace, 1956Gr**	13,0 (13)	
Konijn, 1958Ko64	14,77 (30)	5,67 (14)
Ramaswamy, 1961Ra13	15,1 (5)	5,49 (18)
Biryukov, 1966Bi13	15,2 (2)	
Bambynek, 1968Ba49	15,00 (5)	
Williams, 1970Wi14		5,76 (4)
Goodier, 1971GoYM		5,76 (13)
Sykora, 1992Sy**		5,68 (21)
Adopted	**14,94 (16)**	**5,61 (8)**

The deduced value 14,94 (16) % for the $\beta+_{0,1}$ transition implies a 511 keV gamma emission of 29,88 (32) % which is in agreement with the measured values : 29,2 (1969GuZV) and 29,5 (3) (1974HeYW).

- A weak β^+ transition to the ground state was observed by Daniel (1958Da03), using a double focusing β spectrometer, with intensity 6,3 (+8,0 -5,4) 10^{-4} %, which was symmetrized to 8 (7) 10^{-4} %, following the method given in 1993Au03.

Gamma Rays

- The gamma ray energies are from Helmer (2000He14).

Relative γ ray intensities

- The measured 864 keV gamma ray intensities, relative to the 810 keV line, are:

References	I_{grel} (%)	uc (%)	Comments
Frauenfelder, 1956Fr17	1,6	0,5	Omitted
MacArthur, 1962Ma33	1,2	0,06	Omitted
Malmskog, 1964Ma09	1,38	0,04	Omitted
Hill, 1965Hi12	0,77	0,04	
Bambynek, 1968Ba49	0,645	0,015	Superseded by Denecke
Ritter, 1968Ri03	0,81	0,03	
Dyer, 1972DyZY	0,7	0,02	
Denecke, 1973Ba67	0,69	0,02	As quoted in 1973Ba67
Legrand, 1973Ba67	0,69	0,02	As quoted in 1973Ba67
Heath, 1974HeYW	0,74		Given in the γ spectra catalogue, no information
Grütter, 1982Gr10	0,682	0,017	
Crit. χ^2	3,0		
Reduced χ^2	3,6		
UWM :	0,724		
WM :	0,704		
uc(WM)int. :	0,009		
uc(WM)ext. :	0,017		
Adopted :	**0,704**	**0,022**	**Expanded**

The set of the six adopted values (1965Hi12, 1968Ri03, 1972DyZY, Denecke, Legrand, 1982Gr10) is discrepant. The weighted mean with an expanded uncertainty to cover the most precise value is adopted.

- The 1674 gamma-ray emission intensities, relative to the 810 keV line, are:

References	I_{grel} (%)	uc (%)	Comments
Frauenfelder, 1956Fr17	0,5	0,1	Omitted
Mac Arthur, 1962Ma33	0,66	0,05	Omitted
Malmskog, 1964Ma09	0,61	0,05	Omitted
Hill, 1965Hi12	0,68	0,05	
Bambynek, 1968Ba49	0,506	0,015	Superseded by Denecke
Ritter, 1968Ri03	0,57	0,03	
Dyer, 1972DyZY	0,49	0,03	
Denecke, 1973Ba67	0,527	0,015	As quoted in 1973Ba67
Legrand, 1973Ba67	0,525	0,013	As quoted in 1973Ba67
Heath, 1974HeYW	0,54		Given in the γ spectra catalogue, no information
Grütter, 1982Gr10	0,511	0,015	
Crit. χ^2	2,5		
Reduced χ^2	3,0		
UWM :	0,564		
WM :	0,531		
uc(WM)int. :	0,007		
uc(WM)ext. :	0,013		
Adopted :	**0,531**	**0,013**	

The set of the six adopted values (1965Hi12, 1968Ri03, 1972DyZY, Denecke, Legrand, 1982Gr10) is discrepant. The weighted mean with the external uncertainty is adopted.

Internal Conversion Coefficients

The γ transitions with energies 810 and 1674 keV respectively are of pure E2 character. The 864 keV transition is a M1 + E2 mixture.

Measured mixing ratio, δ, for the 864 keV transition:

References	**δ**	**uc**	**Comments**
1956Fr17	2,20	0,30	Co-58 decay, NaI-NaI, omitted
1962Ma33	1,5	+0,4 -0,5	Co-58 decay, NaI-NaI, omitted
1964Ma09	1,6	0,2	Co-58 decay, NaI-NaI, omitted
1966Ra22	1,56	0,04	Co-58 decay, NaI-NaI, omitted
1969Si13	1,46	0,07	Co-58 decay, NaI-NaI, omitted
1969Sc11	1,10	0,20	Co-58 decay, NaI-NaI, omitted
1969Fa05	0,57	0,06	Fe-57(n, γ), NaI – Ge(Li)
1971Si15	0,67	0,15	Co-58 decay, NaI – Ge(Li), original value: 0,61(+0,19 -0,10)
1972Fo05	0,94	+0,09 -0,08	Co-58 decay, NaI-NaI, omitted
1972Fo05	1,0	+0,6 -0,2	Co-58 decay, NaI – Ge(Li), omitted
1972Fo05	0,69	0,05	Co-58 decay, Ge(Li)
Adopted	**0,643**	**0,041**	

The adopted value is the weighted mean of the three results measured with a Ge(Li) detector: 1969Fa05, 1971Si15, and the last published value of 1972Fo05.
The result of 1971Si15 has been symmetrized following the method given in 1993Au03.

The adopted ICC(s) are the theoretical values interpolated by the BrIcc program (2008Ki07) from the tables of Band *et al.* (2002Ba85).

Absolute γ ray intensities

Considering the decay scheme, the β+ transition (0,0008 %) being negligible, the sum of the two γ transitions populating the ground state must be equal to 100 %:

$$\sum_i I_{\gamma i}\,[1+\alpha_{Ti}] = \frac{100\ \%}{N}$$

where:
$I_{\gamma i}$ is the relative emission intensity of the 810 and 1674 keV rays and, α_{Ti} the related total internal conversion coefficient. N is a normalisation factor between the relative γ intensities and the absolute intensities.
N = 0,9944 (2).

Atomic Data

The adopted ω_K value of 0,355 (4) (1996Sc06) is in agreement with (0,352 (4)) from the measurement of Solé (1992So04).
The X-ray and Auger electron emission intensities are derived from the decay scheme parameters by using the program EMISSION.
The calculated K X-ray intensity of 26,8 (4) % is in good agreement with the measured K X-ray intensity of 25,96 (10) % (1968Ba49).

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