The original evaluation was completed in 2008. An update has been made in November 2014 with a literature cut-off date of October 2014.

1 Decay Scheme

$^{210}\text{Bi}$ disintegrates by beta minus emission to the ground state level of $^{210}\text{Po}$. Weak alpha transitions to excited levels of $^{206}\text{Tl}$ have been observed (1.40 (15) $10^{-4}$ %). Spins and parities are from the ENSDF mass-chain evaluation of Browne for $\text{A} = 210$ (2003Br13). For $^{206}\text{Tl}$, spins and parities are from the mass chain evaluation of Kondev (2008Ko21).

2 Nuclear Data

The Q value is from the atomic mass evaluation of Wang et al. (2012Wa38).

Experimental $^{210}\text{Bi}$ half-life values (in days) are given in Table 1:

<table>
<thead>
<tr>
<th>Reference</th>
<th>Experimental value (d)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>G.N. Antonoff (1910An**)</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>L. Meitner (1911Me**)</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>R. Thaller (1912Th**)</td>
<td>4.85</td>
<td></td>
</tr>
<tr>
<td>L. Bastings (1924Ba**)</td>
<td>4.98</td>
<td></td>
</tr>
<tr>
<td>G. Fournier (1925Fo**)</td>
<td>4.85</td>
<td>Ionization chamber – no uncertainty given.</td>
</tr>
<tr>
<td>J.P. McHutchison (1926Mc**)</td>
<td>4.89 (2)</td>
<td>Electroscope. Simple mean of 3 values, with uncertainty of 1/300 as given in paper.</td>
</tr>
<tr>
<td>L.F. Curtiss (1926Cu**)</td>
<td>5.07 (5)</td>
<td>Beta-ray electroscope. Superseded by 1927Cu**</td>
</tr>
<tr>
<td>L.F. Curtiss (1927Cu**)</td>
<td>4.98 (2)</td>
<td>Beta-ray electroscope. Simple mean of 3 values, uncertainty quoted as ~1/300.</td>
</tr>
<tr>
<td>M. Curie (1931Cu01)</td>
<td>5.0 (1)</td>
<td>Recommended value, hence not used.</td>
</tr>
<tr>
<td>A. Pompéi (1935Po01)</td>
<td>5.02 (1)</td>
<td>Ionization chamber.</td>
</tr>
<tr>
<td>N. Hole (1944Ho**)</td>
<td>5.15 (10)</td>
<td>GM counter.</td>
</tr>
<tr>
<td>F. Begemann (1952Be22)</td>
<td>5.02 (2)</td>
<td>GM counter.</td>
</tr>
<tr>
<td>E.E. Lockett (1953Lo09)</td>
<td>4.989 (13)</td>
<td>Ionization chamber.</td>
</tr>
<tr>
<td>J. Robert (1956Ro18)</td>
<td>5.013 (5)</td>
<td>Ionization chamber. Superseded by 1959Ro51</td>
</tr>
<tr>
<td>J. Robert (1959Ro51)</td>
<td>5.013 (5)</td>
<td>Ionization chamber.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reference</th>
<th>Experimental value (d)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended value</td>
<td>5.011 (5)</td>
<td>$\chi^2 = 1.61, \chi^2_{\text{crit}} = 3.32$</td>
</tr>
</tbody>
</table>

The weighted average has been calculated using the LWEIGHT computer program (version 3).

The evaluators have chosen to use the seven experimental values with uncertainties given in Table 1. The values of McHutchison (1926Mc**) and Hole (1944Ho**) have been rejected by the LWEIGHT program based on Chauvenet’s criterion. With the remaining data set of five values, the largest contribution to the weighted mean comes from the value of Robert (1959Ro51) amounting to 66 % of the total statistical weight.

The recommended value of the $^{210}\text{Bi}$ half-life is thus the weighted mean of 5.011 d with an external uncertainty of 0.005 d. The reduced-$\chi^2$ value is 1.61, compared to $\chi^2_{\text{crit}} = 3.32$. 

LNHB/V. Chisté, M.-M. Bé, M.A. Kellett
Nov. 2014
Half-life of $^{210}\text{Po}$
The half-life of $^{210}\text{Po}$, 138.3763 (17) d, has been taken from the DDEP evaluation of Chisté and Bé (in Bé et al. 2008).

Half-life of $^{206}\text{Tl}$
The half-life of $^{206}\text{Tl}$, 4.202 (11) min, has been taken from the latest DDEP evaluation of Kondev (in Bé et al. 2008).

2.1 $\alpha$ Transitions and Emissions
The recommended values of the emission energies of the $\alpha$-particles (Table 2) are taken from the recommendations of Rytz (1991Ry01), which are based on an adjusted mean value from the measured values of 1960Wa14 and 1969La18.

<table>
<thead>
<tr>
<th>Reference</th>
<th>$\alpha_{0.1}$ (keV)</th>
<th>$\alpha_{0.2}$ (keV)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.J. Walen (1960Wa14)</td>
<td>4686 (2)</td>
<td>4649 (2)</td>
<td>Uncertainty as given by Rytz.</td>
</tr>
<tr>
<td>P. Kauranen (1962Ka27)</td>
<td>4700</td>
<td>4660</td>
<td>Not used: no uncertainty.</td>
</tr>
<tr>
<td>R.C. Lange (1969La18)</td>
<td>4697 (5)</td>
<td>4660 (5)</td>
<td>Uncertainty as given by Rytz.</td>
</tr>
<tr>
<td>Recommended value (1991Ry01)</td>
<td>4687 (4)</td>
<td>4650 (4)</td>
<td>$\chi^2 = 4.2, \chi^2_{crit} = 6.6$</td>
</tr>
</tbody>
</table>

Several experimental values of the $\alpha$ branching to $^{206}\text{Tl}$ are given in Table 3.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Experimental value (10^{-4} %)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. Broda (1947Br36)</td>
<td>0.5</td>
<td>Not used: no uncertainty.</td>
</tr>
<tr>
<td>R.J. Walen (1959Wa05)</td>
<td>1.25</td>
<td>Not used: no uncertainty.</td>
</tr>
<tr>
<td>R.W. Fink (1956Fi09)</td>
<td>1.7 (2)</td>
<td></td>
</tr>
<tr>
<td>M. Nurmia (1961Nu01)</td>
<td>1.9 (4)</td>
<td>Superseded by 1962Ka27</td>
</tr>
<tr>
<td>P. Kauranen (1962Ka27)</td>
<td>1.32 (10)</td>
<td></td>
</tr>
<tr>
<td>Recommended value</td>
<td>1.40 (15)</td>
<td>$\chi^2 = 2.9, \chi^2_{crit} = 6.6$</td>
</tr>
</tbody>
</table>

The recommended value of $\alpha$ transitions to the excited levels of $^{206}\text{Tl}$ is thus $1.40 \times 10^{-4}$ % with an external uncertainty of $0.15 \times 10^{-4}$ %. The reduced-$\chi^2$ value is 2.9.

The individual $\alpha$ particle probabilities to the 265-keV and 304-keV levels are the renormalized values of Walen and Bastin-Scoffier (1959Wa05, 1960Wa14) to the recommended total transition probability of $1.40 \times 10^{-4}$ % to give $0.56 (6) \times 10^{-4}$ % (40 (4) %) to the 2' 266 keV level and $0.84 (9) \times 10^{-4}$ % (60 (4) %) to the 1' 305 keV level, respectively.

2.2 $\beta^-$ Transitions and Emissions
The end-point energy of the $\beta^-$ transition in the decay of $^{210}\text{Bi} \rightarrow ^{210}\text{Po}$ is from the $Q_{\beta^-}$ (2012Wa38), which is an adjusted mean of the two values from Daniel (1962Da03) and Hsue (1967Hs01). The recommended and experimental values are shown in Table 4.
For the $\beta_{0,0}$ transition probability and associated uncertainty, the following relation was applied:

$$P_{\beta_{0,0}} = 100\% - P_{\alpha},$$

where $P_{\alpha} = 1.40 (15) \times 10^{-4}$ % (see 2.1 $\alpha$ Transitions and Emissions). Hence, $P_{\beta_{0,0}} = 99.99986 (2)\%$.

The $\lg ft$ value was calculated with the program LOGFT (assuming an allowed transition) whereas the average $\beta^-$ energy was calculated for a 1st forbidden transition using the experimentally determined shape factors of Grau Carles (2005Gr41) using the BETSHAPE code of Mougeot (2010MoZU).

Table 4: Experimental and recommended values of the end-point energy of the $\beta^-$ transition.

<table>
<thead>
<tr>
<th>Reference</th>
<th>$E_{\beta^-}$ (keV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Flammersfeld (1939Fl02)</td>
<td>1170</td>
</tr>
<tr>
<td>G.J. Neary (1940Ne04)</td>
<td>1170</td>
</tr>
<tr>
<td>E.A. Plassmann (1954Pl30)</td>
<td>1155 (5)</td>
</tr>
<tr>
<td>H. Daniel (1962Da03)</td>
<td>1160.5 (15)</td>
</tr>
<tr>
<td>S.T. Hsue(1967Hs01)</td>
<td>1161.5 (15)</td>
</tr>
<tr>
<td>D. Flothmann (1969Fl02)</td>
<td>1153</td>
</tr>
<tr>
<td>Recommended value (2012Wa38)</td>
<td>1161.2 (8)</td>
</tr>
</tbody>
</table>

2.3 $\gamma$ Transitions and Emissions

The multipolarity of the $\gamma$-ray transitions are from L.I. Rusinov (1961Ru02):

- 265-keV $\gamma$-ray: E2
- 304-keV $\gamma$-ray: M1

The $\gamma$-ray transition probabilities following the $\alpha$-decay of $^{210}\text{Bi} \rightarrow ^{206}\text{Tl}$ were deduced from the decay-scheme balance using the recommended $\alpha$-particle intensity values given in section 2.1 $\alpha$ Transitions and Emissions, shown in Table 5.

Table 5: Adopted values of $\alpha$ transition and $\gamma$-ray emission probabilities.

<table>
<thead>
<tr>
<th>$\gamma$-ray energy (keV)</th>
<th>$\alpha$ probability (%)</th>
<th>$\gamma$-ray absolute transition probability (%)</th>
<th>$\gamma$-ray absolute emission probability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>265.832 (5)</td>
<td>0.000 056 (6)</td>
<td>0.000 056 (6)</td>
<td>0.000 048 (5)</td>
</tr>
<tr>
<td>304.896 (6)</td>
<td>0.000 084 (9)</td>
<td>0.000 084 (9)</td>
<td>0.000 061 (7)</td>
</tr>
</tbody>
</table>

*From 2008Ko21

The $\gamma$-ray emission intensities were obtained using the $\gamma$-ray transition probabilities (given in Table 6) and the relevant internal conversion coefficients, calculated using the frozen orbital approximation with the BRICC computer code (2008Ki07), which are interpolated from the theoretical values of Band et al. (2002Ba85).

3 Atomic Data

Atomic values, $\omega_K$, $\sigma_L$ and $n_{KL}$ are from Schönfeld and Janßen (1996Sc06) as included in the SAISINUC software.
4 References

<table>
<thead>
<tr>
<th>Year</th>
<th>Author(s)</th>
<th>Journal/Book</th>
<th>Reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910</td>
<td>G.N. Antonoff</td>
<td>Phil. Mag. 19(1910)825</td>
<td>[Half-life]</td>
<td></td>
</tr>
<tr>
<td>1911</td>
<td>L. Meitner</td>
<td>Phys. Zeits. 12(1911)1094</td>
<td>[Half-life]</td>
<td></td>
</tr>
<tr>
<td>1924</td>
<td>L. Bastings</td>
<td>Phil. Mag. 48(1924)1075</td>
<td>[Half-life]</td>
<td></td>
</tr>
<tr>
<td>1926</td>
<td>J.P. McHutchison</td>
<td>J. Phys. Chem. 30(1926)925</td>
<td>[Half-life]</td>
<td></td>
</tr>
<tr>
<td>1926</td>
<td>L.F. Curtiss</td>
<td>Phys. Rev. 27(1926)672</td>
<td>[Half-life]</td>
<td></td>
</tr>
<tr>
<td>1927</td>
<td>L.F. Curtiss</td>
<td>Phys. Rev. 30(1927)539</td>
<td>[Half-life]</td>
<td></td>
</tr>
<tr>
<td>1939</td>
<td>A. Flammersfeld</td>
<td>Z. Phys. 112(1939)727</td>
<td>[E_{β-}]</td>
<td></td>
</tr>
<tr>
<td>1945</td>
<td>F. Begemann, F.G. Houtermans</td>
<td>Z. Naturforsch. 7a(1952)143</td>
<td>[Half-life]</td>
<td></td>
</tr>
</tbody>
</table>