^{11}C – Comments on evaluation of decay data by V. Chisté and M. M. Bé

1) Decay Scheme

^{11}C disintegrates by β^+ emission (99.750 (13) %) and electron capture (0.250 (13) %) to the ground state of the stable nuclide ^{11}B. This evaluation was completed in 2002. The half-life value has been updated in 2011 to integrate the Wood's value.

2) Nuclear Data

The Q value (1982.5 (9) keV) is from Audi and Wapstra evaluation (1995Au04), and has been calculated with the formula:

$Q = M(A,Z) - M(A,Z-1)$,
where M(A,Z) and M(A,Z–1) are the measured atomic masses of ^{11}C and ^{11}B, respectively.

$E_{\beta+}$, calculated from this Q value ($E_{\beta+}$ = 960.5 (9) keV), is in agreement with a weighted average value of 959.8 (5) keV, which was calculated from measured values (see **β^+ Transition and Electron Capture Transition**).

The measured ^{11}C half–life values (in minutes) are given below:

$T_{1/2}$

Reference	Value (min)
Smith (1941Sm11)	20.35 (8)
Solomon (1941So01)	20.5 (6)
Siegbahn (1944Si30)	20.0(4)
Dickson (1951Di12)	20.0 (1)
Kundu (1953Ku08)	20.74 (10)
Barber (1955Ba63)	20.26 (10)
Prokoshkin (1957Pr53)	20.8 (2)
Arnell (1958Ar15)	20.11 (13)
Kavanagh (1964Ka31)	20.34 (4)
Patterson (1965Pa10)	20.8 (4)
Awschalom (1969Aw02)	20.40 (4)
Hogstrom (1973Ho43)	19.8 (8)
Singh (1973SiYS)	20.0 (3)
Azuelos (1975Az01)	20.382 (20)
Behrens (1975Be28)	20.32 (12)
Woods (2002Wo02)	20.334 (24)

Evaluators calculated the weighted average of these 16 values using the Lweight program (version 3) as 20.360 min with an external uncertainty of 0.022 min and a reduced χ^2 of 3.0. The value of Azuelos (1975Az01) has a relative statistical weight of 40 %. Evaluators rejected Siegbahn's (1944Si30) value (quoted by Janecke (1960Ja12) and Raman (1978Raman)), because they could not find the article, and therefore no details were available on how Siegbahn obtained such a value. For the remaining 15 values,

the largest contribution to the weighted average comes from the value of Azuelos (1975Az01), with a relative statistical weight of 41 %.
The adopted value is the weighted average: *20.361 min*, with an external uncertainty of *0.023 min*. The reduced χ^2 is 3.1.

β^+ Transition and Electron capture transition

For the K/β^+ ratio, the following values have been found in the literature:

Reference	Value (10^{-3})
Scobie (1957Sc29)	1.9 (3)
Campbell (1967Ca09)	2.30 (+0.14; -0.11)

β^+ and electron capture probabilities have been calculated using the most recent value of K/β^+ ratio measured by Campbell (1967Ca09), P_K/P_{EC} = 0.9174 (91) (See Section 2.2), and normalizing to a total probability ($P_{\beta+}$ + P_{EC}) of 100 %. This leads to $P_{\beta+}$ = 99.750 (13) % and P_{EC} = 0.250 (13) %, respectively. The uncertainties were calculated through their propagation on the above formulas.

The experimental K/β^+ ratio of Campbell is close to the theoretical values:
a) 2.222 10^{-3} calculated with LOGFT program;
b) 2.00 10^{-3} calculated by Scobie (1957Sc29);
c) 2.18 10^{-3} calculated by Campbell (1967Ca09);
d) 2.46 10^{-3} calculated by Vatai (1968Vatai);
e) 2.316 10^{-3} given by Fitzpatrick (1973Fitzpatrick);
f) 2.11 10^{-3} given by Bambynek (1977Ba48);

Evaluators calculated a lg ft of 3.592 for this allowed transition. The value agrees with 3.599 suggested by Ajzenberg–Selove (1980Aj01, 1985Aj01 and 1990Aj01).

The partial sub shell capture probabilities given in Section 2.2 were calculated using the program EC–Capture for an allowed transition.

The weighted mean of the β^+ end–point energy has been calculated (with the Lweight program, version 3) using the following measured values (in keV):

Reference	Values (keV)
Townsend (1940To01)	981 (5)
Moore (1940Mo09)	1030 (30)
Siegbahn(1944Si30)	993 (1)
Richards (1950Richards)	958 (3)
Wong (1954Wo20)	968 (8)
Campbell (1967Ca09)	958.2 (14)
Fitzpatrick (1973Fitzpatrick)	960.2 (10)
Azuelos (1975Az01)	960.0 (10)
Behrens (1978Be28)	960.8 (26)
Raman (1978Raman)	960.1 (11)

The weighted average of these 10 values is 967 keV with an uncertainty of 2.6 keV and a reduced χ^2 of 97. The values of 1944Si30, 1973Fi13 and 1975Az01 have a relative weight of 21 %. The Townsend (1940To01), Moore (1940Mo09), Siegbahn (1944Si30) and Wong (1954Wo20) values have been rejected by the Lweight program, based on the Chauvenet's criterion. For the remaining 6 values, the largest contribution to the weighted average comes from the values of Fitzpatrick (1973Fitzpatrick) and Azuelos (1975Az01), amounting to a statistical weight of 28 %. The weighted average is 959.8 keV, with an

internal uncertainty of 0.5 keV and a reduced χ^2 of 0.41. This value is in agreement with $E_{\beta+}$ (960.5 (9) keV) deduced from the adopted Q value (1995Au04) in this evaluation.

3) Gamma–ray Emissions

The annihilation radiation emission probability ($I_{\gamma 511}$) is $P_{\beta+}$ (= 99.750 (13) %), multiplied by 2, without the correction factor for the annihilation–in–flight process in the medium. That is, $I_{\gamma 511}$ = 199.500 (26) %.

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