

²⁵²Cf SF decay 2004Lu20,2010Gu07

| Type | Author | History | Citation | Literature Cutoff Date |
|-----------------|--|---------|-------------------|------------------------|
| Full Evaluation | S. Kumar(a), J. Chen(b) and F. G. Kondev | | NDS 137, 1 (2016) | 31-May-2016 |

Parent: ²⁵²Cf: E=0.0; J^π=0⁺; T_{1/2}=2.645 y 8; %SF decay=3.092 8

2004Lu20, 2010Gu07: ²⁵²Cf source ≈62 μCi sandwiched between two Fe foils with a thickness of 10 mg/cm² at LBNL.

Detectors: Gammasphere array (consisting of 102 Compton-suppressed Ge detectors). Measured: E_γ, I_γ, γγ. A total of 5.7×10¹¹ triple-γ or higher coincident events were collected. Deduced: level scheme, band structure.

Others: 1998Hw04, 1970Wa05, 1971Ho29, 1970Jo20, 1973Ho22.

The interpretation of the collective structures in 2004Lu20 was not adopted by the evaluators.

¹⁰⁹Tc Levels

| E(level) [†] | J ^π [‡] | T _{1/2} | Comments |
|---------------------------|-----------------------------|------------------|--|
| 0.0 | (5/2 ⁺) | 0.91 s 3 | T _{1/2} : From Adopted Levels. |
| 69.37 [#] 9 | (7/2 ⁺) | | |
| 206.68 [#] 10 | (9/2 ⁺) | | |
| 504.81 [#] 11 | (11/2 ⁺) | | |
| 633.21 [@] 11 | (11/2 ⁺) | | |
| 644.35 [#] 12 | (13/2 ⁺) | | |
| 965.30 [@] 12 | (13/2 ⁺) | | |
| 1084.41 [#] 12 | (15/2 ⁺) | | |
| 1231.99 [#] 13 | (17/2 ⁺) | | |
| 1263.24 [@] 13 | (15/2 ⁺) | | |
| 1383.8 ^{&} 4 | (15/2 ⁺) | | E(level),J ^π : from 2010Gu07. |
| 1636.86 [@] 14 | (17/2 ⁺) | | |
| 1681.1 ^{&} 4 | (17/2 ⁺) | | E(level),J ^π : From 2010Gu07. |
| 1796.69 [#] 14 | (19/2 ⁺) | | |
| 1931.7 [@] 3 | (19/2 ⁺) | | E(level),J ^π : From 2010Gu07. |
| 1951.71 [#] 15 | (21/2 ⁺) | | |
| 2078.8 ^{&} 6 | (19/2 ⁺) | | E(level),J ^π : From 2010Gu07. |
| 2137.46 ^a 17 | (19/2 ⁺) | | |
| 2375.99 ^a 20 | (21/2 ⁺) | | |
| 2553.03 [#] 17 | (23/2 ⁺) | | |
| 2643.35 ^a 18 | (23/2 ⁺) | | |
| 2754.08 [#] 17 | (25/2 ⁺) | | |
| 3218.13 [#] 19 | (27/2 ⁺) | | |
| 3439.56 [#] 20 | (29/2 ⁺) | | |
| 4072.7 [#] 6 | (33/2 ⁺) | | E(level),J ^π : From 2010Gu07. |
| 4834.0 [#] 6 | (37/2 ⁺) | | E(level),J ^π : From 2010Gu07. |

[†] From a least-squares fit to E_γ.

[‡] From 2004Lu20, unless otherwise stated,

[#] Band(A): Band 1 in 2004Lu20, interpreted as π7/2[413].

[@] Band(B): Band 6 in 2004Lu20 (band 2 in 2010Gu07), interpreted as K=11/2⁺, 1-phonon γ-vibrational band.

[&] Band(C): Band 3 in 2010Gu07, interpreted as K=15/2⁺, 2-phonon γ-vibrational band.

^a Band(D): Band 2 in 2004Lu20, interpreted as (19/2⁺) band.

²⁵²Cf SF decay **2004Lu20,2010Gu07 (continued)**

| $\gamma(^{109}\text{Tc})$ | | | | | | | | | |
|---------------------------|--------------|---------------------|----------------------|---------|----------------------|---------|-------------|------------|---|
| E_γ † | I_γ † | $E_i(\text{level})$ | J_i^π | E_f | J_f^π | Mult. # | $\delta^\#$ | $\alpha^@$ | Comments |
| 69.43 10 | | 69.37 | (7/2 ⁺) | 0.0 | (5/2 ⁺) | M1+E2 | 0.16 +7-12 | 0.88 10 | $\alpha(\text{K})=0.75$ 7; $\alpha(\text{L})=0.105$ 23; $\alpha(\text{M})=0.019$ 5 $\alpha(\text{N})=0.0007$ 4; $\alpha(\text{O})=3.3\times 10^{-5}$ 13 Mult., δ : using $\alpha(\text{exp})=0.80$ 9 (2004Lu20) from intensity balance considerations. |
| ^x 115.1 2 | | | | | | | | | E_γ : observed by 1971Ho29 and 1970Jo20. 1970Jo20 measured $T_{1/2}=18$ ns 4 for this γ . |
| ^x 119.7 2 | | | | | | | | | E_γ : observed by 1971Ho29 and 1970Jo20. 1970Jo20 measured $T_{1/2}=16$ ns 5 for this γ . |
| ^x 123.2 2 | | | | | | | | | E_γ : observed by 1970Wa05 and 1971Ho29. |
| ^x 125.3 2 | | | | | | | | | E_γ : observed by 1973Ho22 only. |
| 137.26 10 | 100 | 206.68 | (9/2 ⁺) | 69.37 | (7/2 ⁺) | M1+E2 | 0.6 6 | 0.19 10 | $\alpha(\text{K})=0.16$ 8; $\alpha(\text{L})=0.024$ 15; $\alpha(\text{M})=0.004$ 3 $\alpha(\text{N})=0.0007$ 4; $\alpha(\text{O})=3.3\times 10^{-5}$ 13 Mult., δ : using $\alpha(\text{exp})=0.19$ 9 (2004Lu20) from intensity balance considerations. |
| 139.63 10 | 23.3 | 644.35 | (13/2 ⁺) | 504.81 | (11/2 ⁺) | | | | |
| 147.49 10 | 2.9 | 1231.99 | (17/2 ⁺) | 1084.41 | (15/2 ⁺) | | | | |
| 155.13 10 | 1.6 | 1951.71 | (21/2 ⁺) | 1796.69 | (19/2 ⁺) | | | | |
| 201.1 1 | 0.4 | 2754.08 | (25/2 ⁺) | 2553.03 | (23/2 ⁺) | | | | |
| 206.54 15 | <1.5 | 206.68 | (9/2 ⁺) | 0.0 | (5/2 ⁺) | | | | |
| 221.49 23 | | 3439.56 | (29/2 ⁺) | 3218.13 | (27/2 ⁺) | | | | |
| 238.58 13 | 0.4 | 2375.99 | (21/2 ⁺) | 2137.46 | (19/2 ⁺) | | | | |
| 267.41 15 | 0.2 | 2643.35 | (23/2 ⁺) | 2375.99 | (21/2 ⁺) | | | | |
| 294.9 ‡ 5 | | 1931.7 | (19/2 ⁺) | 1636.86 | (17/2 ⁺) | | | | |
| 297.3 ‡ 5 | | 1681.1 | (17/2 ⁺) | 1383.8 | (15/2 ⁺) | | | | |
| 297.91 10 | 3.6 | 1263.24 | (15/2 ⁺) | 965.30 | (13/2 ⁺) | | | | |
| 298.08 10 | 28.0 | 504.81 | (11/2 ⁺) | 206.68 | (9/2 ⁺) | | | | |
| 332.09 10 | 7.8 | 965.30 | (13/2 ⁺) | 633.21 | (11/2 ⁺) | | | | |
| 373.62 12 | 0.3 | 1636.86 | (17/2 ⁺) | 1263.24 | (15/2 ⁺) | | | | |
| 418.4 ‡ 5 | | 1383.8 | (15/2 ⁺) | 965.30 | (13/2 ⁺) | | | | |
| 426.53 10 | 9.9 | 633.21 | (11/2 ⁺) | 206.68 | (9/2 ⁺) | | | | |
| 435.51 10 | 2.8 | 504.81 | (11/2 ⁺) | 69.37 | (7/2 ⁺) | | | | |
| 437.58 10 | 22.4 | 644.35 | (13/2 ⁺) | 206.68 | (9/2 ⁺) | | | | |
| 440.12 10 | 5.7 | 1084.41 | (15/2 ⁺) | 644.35 | (13/2 ⁺) | | | | |
| 460.44 13 | 1.2 | 965.30 | (13/2 ⁺) | 504.81 | (11/2 ⁺) | | | | |
| 464.10 13 | | 3218.13 | (27/2 ⁺) | 2754.08 | (25/2 ⁺) | | | | |
| 505.89 12 | 0.5 | 2643.35 | (23/2 ⁺) | 2137.46 | (19/2 ⁺) | | | | |
| 552.1 ‡ 5 | | 1636.86 | (17/2 ⁺) | 1084.41 | (15/2 ⁺) | | | | |
| 563.9 1 | 0.9 | 633.21 | (11/2 ⁺) | 69.37 | (7/2 ⁺) | | | | |
| 564.70 10 | 1.9 | 1796.69 | (19/2 ⁺) | 1231.99 | (17/2 ⁺) | | | | |
| 579.56 10 | 1.8 | 1084.41 | (15/2 ⁺) | 504.81 | (11/2 ⁺) | | | | |
| 587.59 10 | 17.9 | 1231.99 | (17/2 ⁺) | 644.35 | (13/2 ⁺) | | | | |
| 601.33 23 | 0.8 | 2553.03 | (23/2 ⁺) | 1951.71 | (21/2 ⁺) | | | | |
| 618.7 ‡ 5 | | 1263.24 | (15/2 ⁺) | 644.35 | (13/2 ⁺) | | | | |
| 630.08 10 | 2.1 | 1263.24 | (15/2 ⁺) | 633.21 | (11/2 ⁺) | | | | |
| 633.1 ‡ 5 | | 4072.7 | (33/2 ⁺) | 3439.56 | (29/2 ⁺) | | | | |

Continued on next page (footnotes at end of table)

^{252}Cf SF decay [2004Lu20,2010Gu07](#) (continued) $\gamma(^{109}\text{Tc})$ (continued)

| E_γ [†] | I_γ [†] | $E_i(\text{level})$ | J_i^π | E_f | J_f^π | Comments |
|-------------------------|-------------------------|---------------------|----------------------|---------|----------------------|--|
| 665.01 22 | 0.3 | 3218.13 | (27/2 ⁺) | 2553.03 | (23/2 ⁺) | |
| 668.6 [‡] 5 | | 1931.7 | (19/2 ⁺) | 1263.24 | (15/2 ⁺) | |
| 671.57 11 | 0.7 | 1636.86 | (17/2 ⁺) | 965.30 | (13/2 ⁺) | |
| 685.46 11 | 1.6 | 3439.56 | (29/2 ⁺) | 2754.08 | (25/2 ⁺) | |
| 691.55 18 | 0.2 | 2643.35 | (23/2 ⁺) | 1951.71 | (21/2 ⁺) | |
| 695.0 [‡] 5 | | 2078.8 | (19/2 ⁺) | 1383.8 | (15/2 ⁺) | |
| 699.7 [‡] 5 | | 1931.7 | (19/2 ⁺) | 1231.99 | (17/2 ⁺) | |
| 712.43 11 | 1.1 | 1796.69 | (19/2 ⁺) | 1084.41 | (15/2 ⁺) | |
| 715.7 [‡] 5 | | 1681.1 | (17/2 ⁺) | 965.30 | (13/2 ⁺) | |
| 719.57 10 | 7.9 | 1951.71 | (21/2 ⁺) | 1231.99 | (17/2 ⁺) | |
| 750.8 [‡] 5 | | 1383.8 | (15/2 ⁺) | 633.21 | (11/2 ⁺) | |
| 756.40 15 | 0.4 | 2553.03 | (23/2 ⁺) | 1796.69 | (19/2 ⁺) | |
| 758.4 [‡] 5 | | 1263.24 | (15/2 ⁺) | 504.81 | (11/2 ⁺) | |
| 758.8 [‡] 5 | | 965.30 | (13/2 ⁺) | 206.68 | (9/2 ⁺) | |
| 761.37 12 | 0.4 | 4834.0 | (37/2 ⁺) | 4072.7 | (33/2 ⁺) | E_γ : from 2004Lu20 ; placement from 2010Gu07 . This gamma was placed by 2004Lu20 from a level at E=4200.8. |
| 802.33 10 | 2.8 | 2754.08 | (25/2 ⁺) | 1951.71 | (21/2 ⁺) | |
| 847.0 [‡] 5 | | 1931.7 | (19/2 ⁺) | 1084.41 | (15/2 ⁺) | |
| 905.51 13 | 1.4 | 2137.46 | (19/2 ⁺) | 1231.99 | (17/2 ⁺) | |
| 992.4 [‡] 5 | | 1636.86 | (17/2 ⁺) | 644.35 | (13/2 ⁺) | |
| 1053.0 5 | | 2137.46 | (19/2 ⁺) | 1084.41 | (15/2 ⁺) | |

[†] From [2004Lu20](#), unless otherwise stated. The E_γ uncertainties are estimated by evaluators by adding in quadrature the quoted statistical and systematic (0.1 keV) uncertainties in [2004Lu20](#).

[‡] From [2010Gu07](#), $\Delta E_\gamma=0.5$ keV were assumed by the evaluators.

[#] From $\alpha(\text{exp})$ using intensity balances consideration. BrIccMixing v2.3 program was used in δ deduction.

[@] Total theoretical internal conversion coefficients, calculated using the BrIcc code ([2008Ki07](#)) with Frozen orbital approximation based on γ -ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

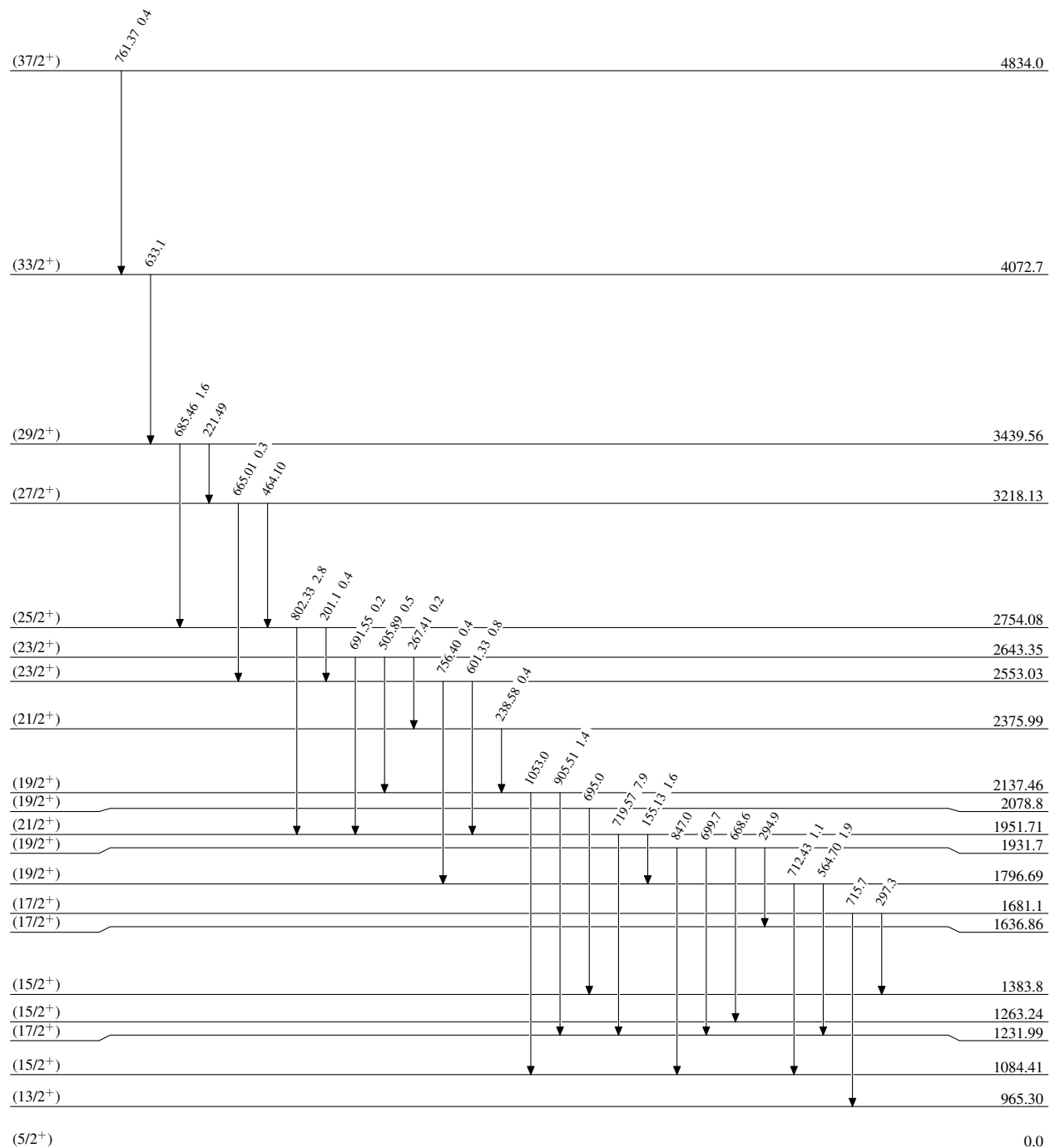
^x γ ray not placed in level scheme.

$^{252}\text{Cf SF decay}$ 2004Lu20,2010Gu07

Level Scheme
 Intensities: Relative I_γ

Legend

\longrightarrow $I_\gamma < 2\% \times I_\gamma^{\max}$
 \longrightarrow $I_\gamma < 10\% \times I_\gamma^{\max}$
 \longrightarrow $I_\gamma > 10\% \times I_\gamma^{\max}$



0.91 s 3

 $^{109}_{43}\text{Tc}_{66}$

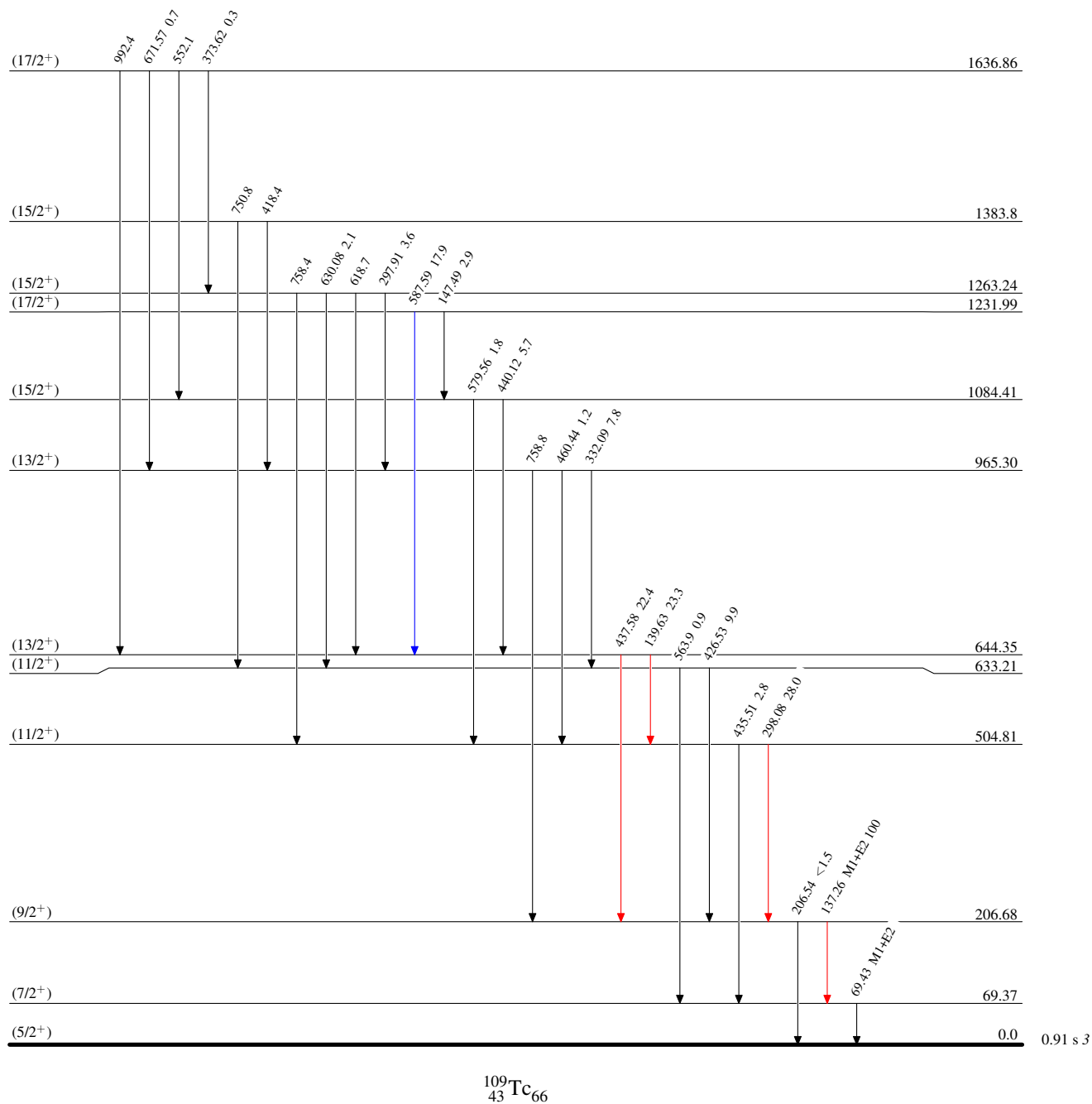
$^{252}\text{Cf SF decay}$ 2004Lu20,2010Gu07

Level Scheme (continued)

Intensities: Relative I_γ

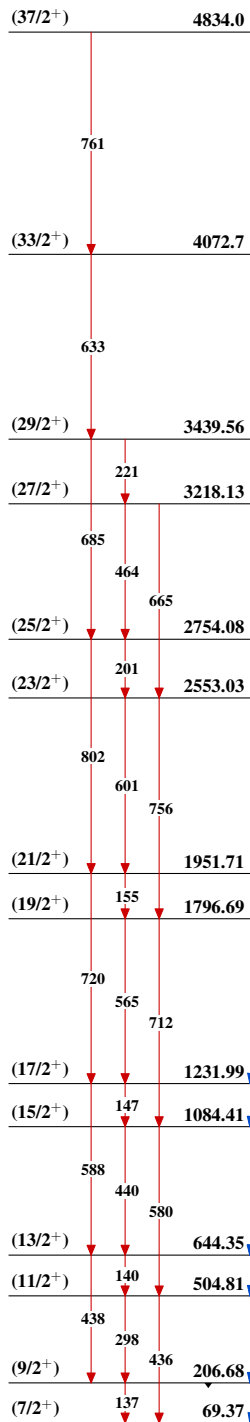
Legend

- $I_\gamma < 2\% \times I_\gamma^{\max}$
- $I_\gamma < 10\% \times I_\gamma^{\max}$
- $I_\gamma > 10\% \times I_\gamma^{\max}$

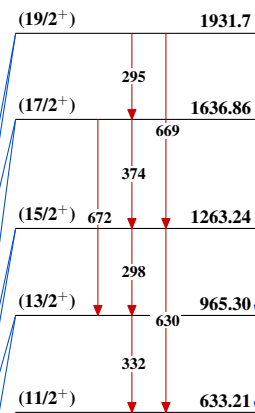


^{252}Cf SF decay 2004Lu20,2010Gu07

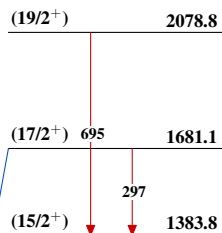
Band(A): Band 1 in 2004Lu20,
interpreted as $\pi 7/2[413]$



Band(B): Band 6 in 2004Lu20 (band
2 in 2010Gu07), interpreted as
 $K=11/2^+$, 1-phonon γ -vibrational
band



Band(C): Band 3 in
2010Gu07, interpreted as
 $K=15/2^+$, 2-phonon
 γ -vibrational band



Band(D): Band 2 in
2004Lu20, interpreted as
 $(19/2^+)$ band

