## $^{176}$Hf($\gamma$,$\gamma'$) 2003Sc15,1964Br27

| Type | Author | History Citation | Literature Cutoff Date |
|---|---|---|---|
| Full Evaluation | M. S. Basunia | NDS 107,791 (2006) | 15-Sep-2005 |

2003Sc15: Target: 77% enriched $^{176}$Hf. Projectile: Bremsstrahlung beam of end-point energies 2.4 and 4.1 MeV were used for nuclear resonance fluorescence experiment. Detector: HPGe detectors at 90°, 127°, 150° with respect to incident beam. The HPGe detector at 127° was surrounded by a BGO anti-Compton shield. Measured: E$\gamma$, $I_{s,o}$, $\Gamma_o$, $R_{expt}$, B(M1),B(E1).

1964Br27: a $^{177}$Hf target was irradiated with 23-MeV endpoint bremsstrahlung. Measured E$\gamma$, $\gamma\gamma$ coin, $\gamma\gamma$(t). Detector: scint.

### $^{176}$Hf Levels

| E(level)[†] | J$^\pi$[a] | $T_{1/2}$ | Comments |
|---|---|---|---|
| 0.0 | $0^+$[b] | | |
| 88.41 *24* | $2^+$[b] | | |
| 286 *5* | $4^+$[b] | | |
| 589 *8* | $6^+$[b] | | |
| 1310 *20* | $6^+$[b] | 10.5 $\mu$s *7* | $T_{1/2}$: From $\gamma\gamma$(t) in 1964Br27. |
| 1341.0 *8* | $2^+$ | | B(E2)↑=0.195 *17*<br>$\Gamma_{\gamma 0}$=0.0014 *1*. |
| 1643.0[‡] *8* | $1^-$ | | B(E1)↑=4.82×10$^{-5}$ *23*<br>$\Gamma_{\gamma 0}$=0.0075 *4*. |
| 1692.0 *10* | $2^+$ | | B(E2)↑=0.0106 *21*<br>$\Gamma_{\gamma 0}$=0.0002 *1*. |
| 1704.0 *10* | $2^+$ | | B(E2)↑=0.022 *4*<br>$\Gamma_{\gamma 0}$=0.0005 *1*. |
| 1721.0[#] *8* | $1^-$ | | B(E1)↑=8.2×10$^{-6}$ *8*<br>$\Gamma_{\gamma 0}$=0.0015 *2*. |
| 1978.0 *10* | (1) | | $\Gamma_{\gamma 0}$=0.0011 *1*. |
| 2044.0[@] *8* | $1^{(+)}$ | | B(M1)↑=0.130 *8*<br>$\Gamma_{\gamma 0}$=0.0043 *3*. |
| 2280.0 *8* | (2) | | B(E2)↑=0.0098 *18*<br>$\Gamma_{\gamma 0}$=0.0010 *2*. |
| 2361.0 *10* | (1) | | $\Gamma_{\gamma 0}$=0.0011 *2*. |
| 2405.0 *10* | 1 | | $\Gamma_{\gamma 0}$=0.0020 *3*. |
| 2484.0 *10* | (1) | | $\Gamma_{\gamma 0}$=0.0008 *2*. |
| 2514.0[@] *8* | $1^{(+)}$ | | B(M1)↑=0.150 *13*<br>$\Gamma_{\gamma 0}$=0.0092 *8*. |
| 2530.0[&] *8* | 1 | | B(M1)↑=0.076 *8*<br>$\Gamma_{\gamma 0}$=0.0047 *5*. |
| 2548.0[#] *8* | 1 | | B(E1)↑=8.0×10$^{-6}$ *10*<br>$\Gamma_{\gamma 0}$=0.0046 *6*. |
| 2690.0[#] *8* | 1 | | B(E1)↑=1.59×10$^{-5}$ *12*<br>$\Gamma_{\gamma 0}$=0.0108 *8*. |
| 2722.0[@] *8* | $1^{(+)}$ | | B(M1)↑=0.504 *12*<br>$\Gamma_{\gamma 0}$=0.0392 *23*. |
| 2831.0 *10* | 1 | | $\Gamma_{\gamma 0}$=0.0023 *4*. |
| 2885.0[@] *8* | $1^{(+)}$ | | B(M1)↑=0.104 *9*<br>$\Gamma_{\gamma 0}$=0.0097 *8*. |
| 2940.0[@] *8* | $1^{(+)}$ | | B(M1)↑=0.143 *10*<br>$\Gamma_{\gamma 0}$=0.014 *1*. |
| 2994.0[@] *8* | $1^{(+)}$ | | B(M1)↑=0.082 *7*<br>$\Gamma_{\gamma 0}$=0.0085 *7*. |

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## $^{176}$Hf($\gamma,\gamma'$) 2003Sc15,1964Br27 (continued)

### $^{176}$Hf Levels (continued)

| E(level)[†] | J$^{\pi}$[a] | Comments |
|---|---|---|
| 3044.0[‡] *8* | 1$^{(-)}$ | B(E1)↑=1.61×10$^{-5}$ *12*<br>$\Gamma_{\gamma 0}$=0.0159 *12*. |
| 3059.0 *10* | 1 | $\Gamma_{\gamma 0}$=0.0032 *5*. |
| 3098.0 *10* | (1) | $\Gamma_{\gamma 0}$=0.0029 *5*. |
| 3107.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.134 *10*<br>$\Gamma_{\gamma 0}$=0.0155 *12*. |
| 3115.0[‡] *8* | 1$^{(-)}$ | B(E1)↑=2.61×10$^{-5}$ *16*<br>$\Gamma_{\gamma 0}$=0.0276 *17*. |
| 3159.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.127 *10*<br>$\Gamma_{\gamma 0}$=0.0154 *12*. |
| 3200.0 *10* | 1 | $\Gamma_{\gamma 0}$=0.0047 *6*. |
| 3218.0 *10* | 1 | $\Gamma_{\gamma 0}$=0.0068 *8*. |
| 3222.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.046 *6*<br>$\Gamma_{\gamma 0}$=0.0060 *8*. |
| 3232.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.053 *6*<br>$\Gamma_{\gamma 0}$=0.0070 *8*. |
| 3261.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.390 *22*<br>$\Gamma_{\gamma 0}$=0.052 *3*. |
| 3306.0 *10* | (1) | $\Gamma_{\gamma 0}$=0.0028 *7*. |
| 3322.0 *10* | 1 | $\Gamma_{\gamma 0}$=0.0173 *17*. |
| 3343.0[#] *8* | 1 | B(E1)↑=1.05×10$^{-5}$ *11*<br>$\Gamma_{\gamma 0}$=0.0137 *14*. |
| 3361.0[‡] *8* | 1$^{(-)}$ | B(E1)↑=1.64×10$^{-5}$ *12*<br>$\Gamma_{\gamma 0}$=0.0217 *16*. |
| 3372.0[‡] *8* | 1$^{(-)}$ | B(E1)↑=8.2×10$^{-6}$ *8*<br>$\Gamma_{\gamma 0}$=0.0109 *11*. |
| 3385.0[&] *8* | 1 | B(M1)↑=0.052 *7*<br>$\Gamma_{\gamma 0}$=0.0078 *10*. |
| 3406.0 *10* | (1) | $\Gamma_{\gamma 0}$=0.0054 *9*. |
| 3438.0 *10* | 1 | $\Gamma_{\gamma 0}$=0.0087 *11*. |
| 3454.0 *10* | 1 | $\Gamma_{\gamma 0}$=0.0108 *12*. |
| 3485.0[#] *8* | 1 | B(E1)↑=1.89×10$^{-5}$ *21*<br>$\Gamma_{\gamma 0}$=0.028 *3*. |
| 3490.0 *10* | 1 | $\Gamma_{\gamma 0}$=0.0045 *11*. |
| 3519.0 *10* | (1) | $\Gamma_{\gamma 0}$=0.0045 *14*. |
| 3550.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.174 *16*<br>$\Gamma_{\gamma 0}$=0.030 *3*. |
| 3580.0 *10* | (1) | $\Gamma_{\gamma 0}$=0.0122 *17*. |
| 3602.0[&] *8* | 1 | B(M1)↑=0.086 *10*<br>$\Gamma_{\gamma 0}$=0.0156 *18*. |
| 3608.0 *10* | 1 | $\Gamma_{\gamma 0}$=0.0055 *12*. |
| 3627.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.068 *8*<br>$\Gamma_{\gamma 0}$=0.0126 *14*. |
| 3662.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.239 *22*<br>$\Gamma_{\gamma 0}$=0.045 *4*. |
| 3671.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.135 *12*<br>$\Gamma_{\gamma 0}$=0.0258 *24*. |
| 3689.0 *10* | (1) | $\Gamma_{\gamma 0}$=0.0086 *15*. |
| 3695.0 *10* | (2) | B(E2)↑=0.0037 *6*<br>$\Gamma_{\gamma 0}$=0.0041 *6*. |
| 3722.0 *10* | (1) | $\Gamma_{\gamma 0}$=0.0063 *12*. |

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## $^{176}$Hf($\gamma,\gamma'$) 2003Sc15,1964Br27 (continued)

### $^{176}$Hf Levels (continued)

| E(level)[†] | J$^{\pi}$[a] | Comments |
|---|---|---|
| 3746.0[&] *8* | 1 | B(M1)↑=0.143 *19*<br>$\Gamma_{\gamma 0}$=0.029 *4*. |
| 3767.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.170 *14*<br>$\Gamma_{\gamma 0}$=0.035 *3*. |
| 3774.0 *10* | 1 | $\Gamma_{\gamma 0}$=0.0114 *15*. |
| 3805.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.090 *10*<br>$\Gamma_{\gamma 0}$=0.0192 *21*. |
| 3816.0[@] *8* | 1$^{(+)}$ | B(M1)↑=0.224 *18*<br>$\Gamma_{\gamma 0}$=0.048 *4*. |
| 3824.0[&] *10* | (1) | $\Gamma_{\gamma 0}$=0.0075 *14*. |
| 3838.0[‡] *8* | 1$^{(-)}$ | B(E1)↑=1.72×10$^{-5}$ *18*<br>$\Gamma_{\gamma 0}$=0.034 *4*. |
| 3844.0[&] *10* | (1) | $\Gamma_{\gamma 0}$=0.0081 *16*. |
| 3856.0[&] *10* | (1) | $\Gamma_{\gamma 0}$=0.0114 *21*. |
| 3916.0[&] *10* | (1) | $\Gamma_{\gamma 0}$=0.015 *3*. |

[†] Deduced by the evaluator from a least squares fit to the $\gamma$-ray energies assuming $\Delta$E=1 keV for all $\gamma$-rays.
[‡] K=0.
[#] K=(0).
[@] K=1.
[&] K=(1).
[a] From 2003Sc15, except otherwise noted. Assignments in 2003Sc15 are from angular distribution. Tentative parities are assigned to levels, if the decay branching ratios match reasonably close to the Alaga rules.
[b] From Adopted Levels.

### $\gamma$($^{176}$Hf)

| E$_i$(level) | J$_i^{\pi}$ | E$_{\gamma}$[†] | I$_{\gamma}$[@] | E$_f$ | J$_f^{\pi}$ | Comments |
|---|---|---|---|---|---|---|
| 88.41 | 2$^+$ | 90[‡] *4* | | 0.0 | 0$^+$ | |
| 286 | 4$^+$ | 198[‡] *5* | | 88.41 | 2$^+$ | |
| 589 | 6$^+$ | 303[‡] *6* | | 286 | 4$^+$ | |
| 1310 | 6$^+$ | 736.20 *7* | | 589 | 6$^+$ | E$_{\gamma}$: From adopted gammas. E$\gamma$=720 *15* in 1964Br27. |
| | | 1043.0 *1* | | 286 | 4$^+$ | E$_{\gamma}$: From adopted gammas. E$\gamma$=1020 *20* in 1964Br27. |
| 1341.0 | 2$^+$ | 1252.6[#] | 93 *15* | 88.41 | 2$^+$ | |
| | | 1341 | 100 | 0.0 | 0$^+$ | |
| 1643.0 | 1$^-$ | 1554.6[#] | 100 *9* | 88.41 | 2$^+$ | |
| | | 1643 | 68.6 | 0.0 | 0$^+$ | |
| 1692.0 | 2$^+$ | 1692 | | 0.0 | 0$^+$ | |
| 1704.0 | 2$^+$ | 1704 | | 0.0 | 0$^+$ | |
| 1721.0 | 1$^-$ | 1632.6[#] | 89 *18* | 88.41 | 2$^+$ | |
| | | 1721 | 100 | 0.0 | 0$^+$ | |
| 1978.0 | (1) | 1978 | | 0.0 | 0$^+$ | |
| 2044.0 | 1$^{(+)}$ | 1955.6[#] | 58 *7* | 88.41 | 2$^+$ | |
| | | 2044 | 100 | 0.0 | 0$^+$ | |
| 2280.0 | (2) | 2191.6[#] | 69 *25* | 88.41 | 2$^+$ | |
| | | 2280 | 100 | 0.0 | 0$^+$ | |
| 2361.0 | (1) | 2361 | | 0.0 | 0$^+$ | |
| 2405.0 | 1 | 2405 | | 0.0 | 0$^+$ | |

Continued on next page (footnotes at end of table)

## $^{176}$Hf($\gamma,\gamma'$) 2003Sc15,1964Br27 (continued)

### $\gamma(^{176}Hf)$ (continued)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$[†] | $I_\gamma$[@] | $E_f$ | $J_f^\pi$ |
|---|---|---|---|---|---|
| 2484.0 | (1) | 2484 | | 0.0 | $0^+$ |
| 2514.0 | $1^{(+)}$ | 2425.6[#] | 33 *8* | 88.41 | $2^+$ |
| | | 2514 | 100 | 0.0 | $0^+$ |
| 2530.0 | 1 | 2441.6[#] | 84 *19* | 88.41 | $2^+$ |
| | | 2530 | 100 | 0.0 | $0^+$ |
| 2548.0 | 1 | 2459.6[#] | 100 *24* | 88.41 | $2^+$ |
| | | 2548 | 88 | 0.0 | $0^+$ |
| 2690.0 | 1 | 2601.6[#] | 94 *14* | 88.41 | $2^+$ |
| | | 2690 | 100 | 0.0 | $0^+$ |
| 2722.0 | $1^{(+)}$ | 2633.6[#] | 41 *5* | 88.41 | $2^+$ |
| | | 2722 | 100 | 0.0 | $0^+$ |
| 2831.0 | 1 | 2831 | | 0.0 | $0^+$ |
| 2885.0 | $1^{(+)}$ | 2796.6[#] | 72 *13* | 88.41 | $2^+$ |
| | | 2885 | 100 | 0.0 | $0^+$ |
| 2940.0 | $1^{(+)}$ | 2851.6[#] | 37 *6* | 88.41 | $2^+$ |
| | | 2940 | 100 | 0.0 | $0^+$ |
| 2994.0 | $1^{(+)}$ | 2905.6[#] | 62 *11* | 88.41 | $2^+$ |
| | | 2994 | 100 | 0.0 | $0^+$ |
| 3044.0 | $1^{(-)}$ | 2955.6[#] | 100 *15* | 88.41 | $2^+$ |
| | | 3044 | 46 | 0.0 | $0^+$ |
| 3059.0 | 1 | 3059 | | 0.0 | $0^+$ |
| 3098.0 | (1) | 3098 | | 0.0 | $0^+$ |
| 3107.0 | $1^{(+)}$ | 3018.6[#] | 49 *8* | 88.41 | $2^+$ |
| | | 3107 | 100 | 0.0 | $0^+$ |
| 3115.0 | $1^{(-)}$ | 3026.6[#] | 100 *12* | 88.41 | $2^+$ |
| | | 3115 | 56 | 0.0 | $0^+$ |
| 3159.0 | $1^{(+)}$ | 3070.6[#] | 51 *8* | 88.41 | $2^+$ |
| | | 3159 | 100 | 0.0 | $0^+$ |
| 3200.0 | 1 | 3200 | | 0.0 | $0^+$ |
| 3218.0 | 1 | 3218 | | 0.0 | $0^+$ |
| 3222.0 | $1^{(+)}$ | 3133.6[#] | 61 *17* | 88.41 | $2^+$ |
| | | 3222 | 100 | 0.0 | $0^+$ |
| 3232.0 | $1^{(+)}$ | 3143.6[#] | 59 *16* | 88.41 | $2^+$ |
| | | 3232 | 100 | 0.0 | $0^+$ |
| 3261.0 | $1^{(+)}$ | 3172.6[#] | 71 *8* | 88.41 | $2^+$ |
| | | 3261 | 100 | 0.0 | $0^+$ |
| 3306.0 | (1) | 3306 | | 0.0 | $0^+$ |
| 3322.0 | 1 | 3322 | | 0.0 | $0^+$ |
| 3343.0 | 1 | 3254.6[#] | 100 *20* | 88.41 | $2^+$ |
| | | 3343 | 98 | 0.0 | $0^+$ |
| 3361.0 | $1^{(-)}$ | 3272.6[#] | 100 *16* | 88.41 | $2^+$ |
| | | 3361 | 54 | 0.0 | $0^+$ |
| 3372.0 | $1^{(-)}$ | 3283.6[#] | 100 *21* | 88.41 | $2^+$ |
| | | 3372 | 61 | 0.0 | $0^+$ |
| 3385.0 | 1 | 3296.6[#] | 74 *18* | 88.41 | $2^+$ |
| | | 3385 | 100 | 0.0 | $0^+$ |
| 3406.0 | (1) | 3406 | | 0.0 | $0^+$ |
| 3438.0 | 1 | 3438 | | 0.0 | $0^+$ |
| 3454.0 | 1 | 3454 | | 0.0 | $0^+$ |
| 3485.0 | 1 | 3396.6[#] | 100 *22* | 88.41 | $2^+$ |
| | | 3485 | 77 | 0.0 | $0^+$ |
| 3490.0 | 1 | 3490 | | 0.0 | $0^+$ |
| 3519.0 | (1) | 3519 | | 0.0 | $0^+$ |
| 3550.0 | $1^{(+)}$ | 3461.6[#] | 44 *7* | 88.41 | $2^+$ |
| | | 3550 | 100 | 0.0 | $0^+$ |
| 3580.0 | (1) | 3580 | | 0.0 | $0^+$ |
| 3602.0 | 1 | 3513.6[#] | 71 *18* | 88.41 | $2^+$ |
| | | 3602 | 100 | 0.0 | $0^+$ |
| 3608.0 | 1 | 3608 | | 0.0 | $0^+$ |
| 3627.0 | $1^{(+)}$ | 3538.6[#] | 57 *14* | 88.41 | $2^+$ |
| | | 3627 | 100 | 0.0 | $0^+$ |
| 3662.0 | $1^{(+)}$ | 3573.6[#] | 30 *6* | 88.41 | $2^+$ |
| | | 3662 | 100 | 0.0 | $0^+$ |
| 3671.0 | $1^{(+)}$ | 3582.6[#] | 41 *9* | 88.41 | $2^+$ |
| | | 3671 | 100 | 0.0 | $0^+$ |
| 3689.0 | (1) | 3689 | | 0.0 | $0^+$ |
| 3695.0 | (2) | 3695 | | 0.0 | $0^+$ |
| 3722.0 | (1) | 3722 | | 0.0 | $0^+$ |
| 3746.0 | 1 | 3657.6[#] | 78 *21* | 88.41 | $2^+$ |
| | | 3746 | 100 | 0.0 | $0^+$ |
| 3767.0 | $1^{(+)}$ | 3678.6[#] | 55 *9* | 88.41 | $2^+$ |
| | | 3767 | 100 | 0.0 | $0^+$ |
| 3774.0 | 1 | 3774 | | 0.0 | $0^+$ |
| 3805.0 | $1^{(+)}$ | 3716.6[#] | 48 *11* | 88.41 | $2^+$ |
| | | 3805 | 100 | 0.0 | $0^+$ |
| 3816.0 | $1^{(+)}$ | 3727.6[#] | 36 *7* | 88.41 | $2^+$ |
| | | 3816 | 100 | 0.0 | $0^+$ |
| 3824.0 | (1) | 3824 | | 0.0 | $0^+$ |
| 3838.0 | $1^{(-)}$ | 3749.6[#] | 100 *21* | 88.41 | $2^+$ |
| | | 3838 | 66.6 | 0.0 | $0^+$ |
| 3844.0 | (1) | 3844 | | 0.0 | $0^+$ |
| 3856.0 | (1) | 3856 | | 0.0 | $0^+$ |
| 3916.0 | (1) | 3916 | | 0.0 | $0^+$ |

[†] From 2003Sc15, except otherwise noted. Estimated uncertainty ≤1 keV in 2003Sc15.
[‡] From 1964Br27.
[#] Generated by evaluator from the differences of depopulating state and 1st excited state at 88.35 keV for deducing respective I$\gamma$

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## $^{176}$Hf($\gamma,\gamma'$) 2003Sc15,1964Br27 (continued)

### $\gamma(^{176}Hf)$ (continued)

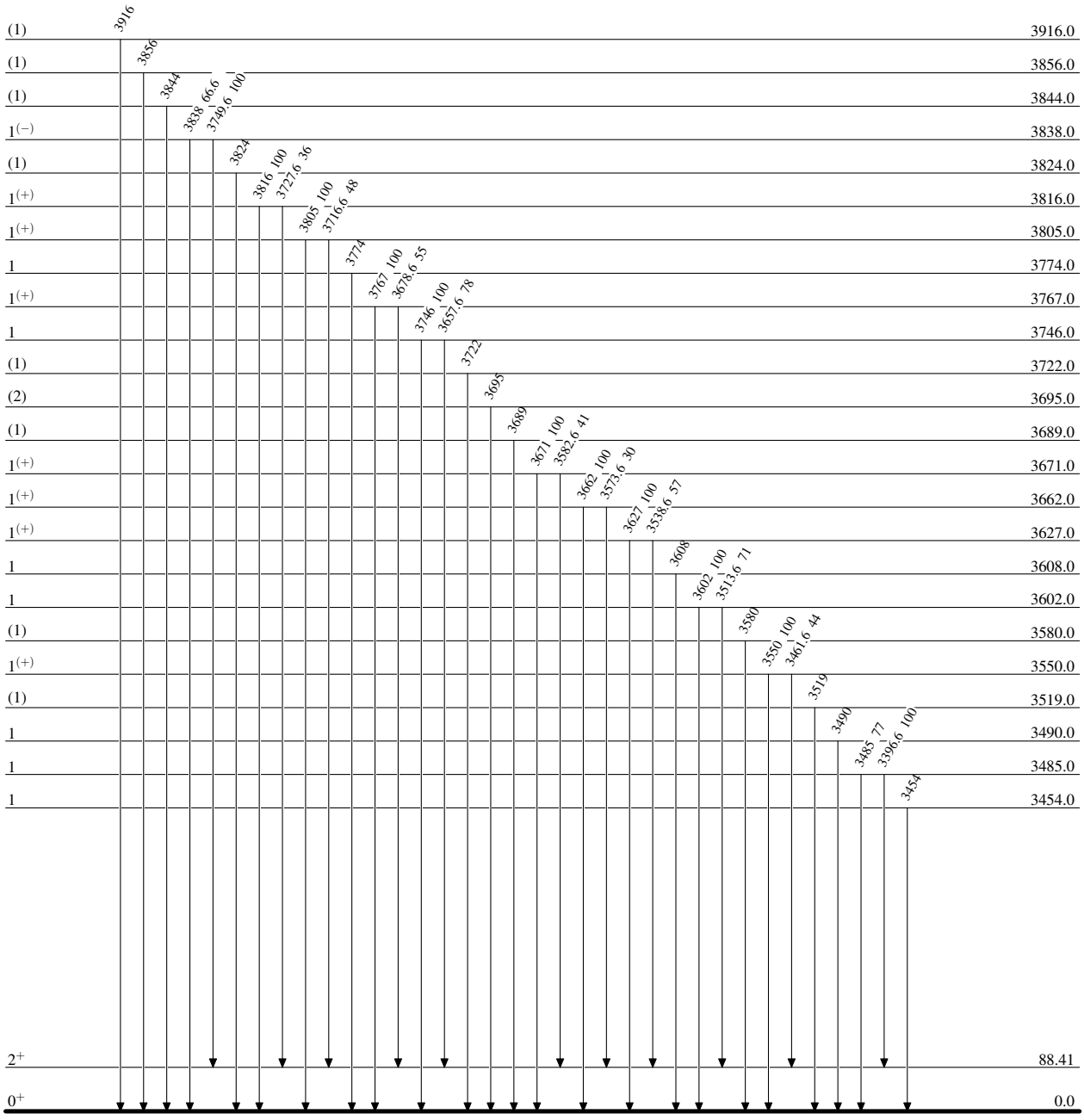
using $R_{exp}$ value.

@ Deduced from given $R_{exp}$ values using the relation $R_{exp}=(\Gamma_i E^3_{\gamma 0}) / (\Gamma_0 E^3_{\gamma i})$.

## $^{176}$Hf(γ,γ′) 2003Sc15,1964Br27

### Level Scheme

Intensities: Relative photon branching from each level

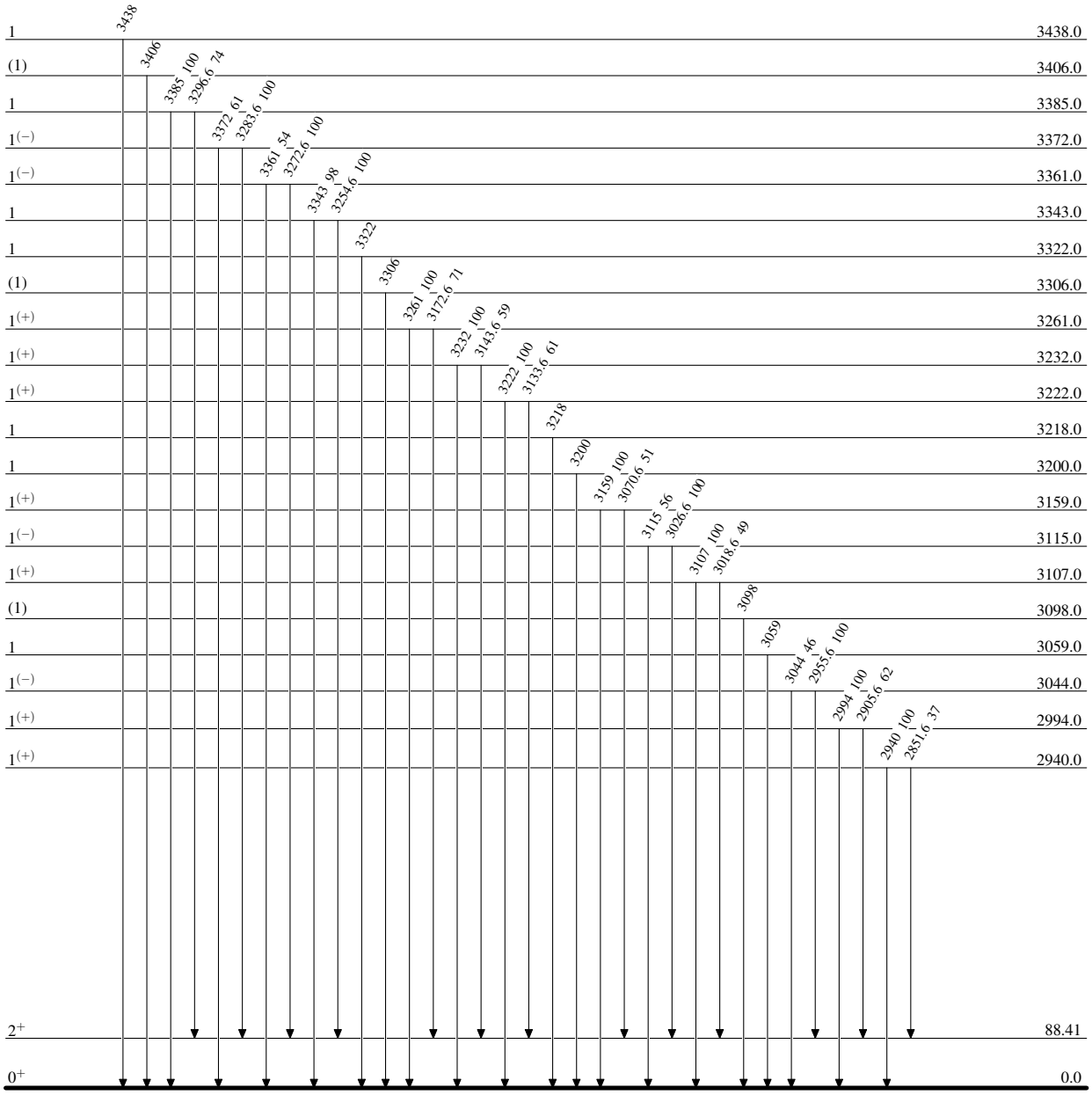



$^{176}_{72}Hf_{104}$

## $^{176}$Hf(γ,γ′) 2003Sc15,1964Br27

### Level Scheme (continued)

Intensities: Relative photon branching from each level




$^{176}_{72}Hf_{104}$

## $^{176}$Hf(γ,γ′) 2003Sc15,1964Br27

### Level Scheme (continued)

Intensities: Relative photon branching from each level