## Adopted Levels, Gammas

| Type | Author | History Citation | Literature Cutoff Date |
|---|---|---|---|
| Full Evaluation | Jean Blachot | NDS 108,2035 (2007) | 30-Mar-2007 |

Q($\beta^-$)=−1138 *4*; S(n)=8901 *3*; S(p)=10781 *10*; Q($\alpha$)=−4329 *3* 2012Wa38
Note: Current evaluation has used the following Q record −1139 4 *8901* 3 *10781* 9 −4329 7 2003Au03.

### $^{104}$Ru Levels

Cross Reference (XREF) Flags

| | | | |
|---|---|---|---|
| A | $^{104}$Tc $\beta^-$ decay | F | $^{232}$Th($^{18}$O,xn$\gamma$) |
| B | $^{104}$Rh $\varepsilon$ decay (42.3 s) | G | $^{162}$Dy($^{36}$S,xn$\gamma$) |
| C | $^{104}$Ru($\pi^-$,$\pi^-$X) | H | $^{110}$Pd($^{86}$Kr,xn$\gamma$) |
| D | $^{104}$Ru(d,d′) E=12 MeV | I | $^{176}$Yb($^{28}$Si,X$\gamma$) |
| E | Coulomb excitation | | |

| E(level)[‡] | J$^\pi$[†] | T$_{1/2}$ | XREF | Comments |
|---|---|---|---|---|
| 0.0[#] | 0$^+$ | stable | ABCDEFGHI | |
| 358.02[#] *7* | 2$^+$ | 56.4 ps *10* | AB DEFGHI | $\mu$=+0.82 *10* (1969He11,1974Hu01,1989Ra17); Q=−0.70 *8*<br>Q: from Coul. ex.<br>$\mu$: from IMPAC (1989Ra17).<br>J$^\pi$: Coul. excited, L in (d,d′).<br>T$_{1/2}$: from B(E2)=0.841 *16* (1987Ra01) in Coul. ex. |
| 888.48[#] *9* | 4$^+$ | 5.6 ps *6* | A DEFGHI | T$_{1/2}$: from B(E2) in Coul. ex.<br>J$^\pi$: E2 $\gamma$ to 2$^+$, L=4 in (d,d′). |
| 893.10[&] *8* | 2$^+$ | 5.0 ps *5* | A DE I | J$^\pi$: $\gamma\gamma(\theta)$ in Tc decay, L=2 in (d,d′).<br>T$_{1/2}$: from B(E2) in Coul. ex. |
| 988.27 *17* | 0$^+$ | 7.9 ps *9* | AB E | T$_{1/2}$: from B(E2) in Coul. ex.<br>J$^\pi$: $\gamma\gamma(\theta)$ in Tc decay. |
| 1242.36[&] *9* | 3$^+$ | | A E I | J$^\pi$: J=3 from $\gamma\gamma(\theta)$ in Tc decay. M1+E2 $\gamma$ to 2$^+$. |
| 1335 | 0$^+$ | 0.90 ps *5* | E | |
| 1502.60[&] *10* | 4$^+$ | 2.7 ps *3* | A E I | J$^\pi$: from $\gamma\gamma(\theta)$ in Tc decay.<br>T$_{1/2}$: from B(E2) in Coul. ex. |
| 1515.44[b] *9* | 2$^+$ | 1.2 ps *2* | A E | T$_{1/2}$: from B(E2) in Coul. ex.<br>J$^\pi$: from $\gamma\gamma(\theta)$ in Tc decay. |
| 1556.4[#] *3* | 6$^+$ | 1.33 ps *+12−4* | EFGHI | T$_{1/2}$: from B(E2) in Coul. ex. |
| 1750? | (2$^+$) | | E | |
| 1872.39[&] *12* | (5$^+$) | | A I | |
| 1970.43 *10* | 3$^-$ | | A DE H | J$^\pi$: $\gamma\gamma(\theta)$ in Tc decay gives J=1 or 3, DWBA in (d,d′) gives J=3. |
| 1974.8 *4* | (6$^-$,7) | | H | |
| 2004 *5* | | | D | |
| 2034.85 *9* | 2$^+$ | | A D | J$^\pi$: from $\gamma\gamma(\theta)$ in Tc decay. Observed in (d,d′). |
| 2080.84[b] *10* | 4$^+$ | 0.7 ps *+3−2* | A E | T$_{1/2}$: from B(E2) in Coul. ex. |
| 2095 | (2$^+$,4$^+$) | | E | |
| 2196.6 *10* | (6$^+$) | | E I | |
| 2232.8[a] *3* | (5$^-$) | | HI | |
| 2269.04 *10* | (3,4) | | A | J$^\pi$: from $\gamma\gamma(\theta)$ in Tc decay. |
| 2285.07 *12* | 2$^+$ | | A D | J$^\pi$: from $\gamma\gamma(\theta)$ in Tc decay. Observed in (d,d′). |
| 2320.4[#] *4* | 8$^+$ | 0.56 ps *+5−10* | EFGHI | T$_{1/2}$: from B(E2) in Coul. ex. |
| 2329.22 *18* | (1,2,3) | | A | J$^\pi$: from $\gamma\gamma(\theta)$ in Tc decay. |
| 2373.75 *12* | (3,1) | | A | J$^\pi$: from $\gamma\gamma(\theta)$ in Tc decay J=3 is most probable, but J=1 is not ruled out. |
| 2429.85 *12* | | | A | |

Continued on next page (footnotes at end of table)

## Adopted Levels, Gammas (continued)

### $^{104}$Ru Levels (continued)

| E(level)[‡] | Jπ[†] | $T_{1/2}$ | XREF | Comments |
|---|---|---|---|---|
| 2443 *5* | | | D | |
| 2481.90 *11* | 3⁻ | | A D | Jπ: DWBA in (d,d′) fits well with 3⁻. |
| 2489.91 *10* | | | A | |
| 2524.28 *10* | | | A | |
| 2597.31 *16* | | | A | |
| 2600.7[@] *4* | (6⁻) | | HI | |
| 2613.9[a] *3* | (7⁻) | | HI | |
| 2618.97 *18* | | | A | |
| 2623.4[&] *10* | (7⁺) | | I | |
| 2627.8 *11* | | | I | |
| 2629.99 *12* | | | A | |
| 2758.1 *9* | | | I | |
| 2759.95 *16* | | | A | |
| 2823.43 *17* | | | A | |
| 2847.6[&] *15* | (8⁺) | 2.1 ps +*13*−*4* | E I | $T_{1/2}$: from B(E2) in Coul. ex. |
| 2861.4 *11* | | | I | |
| 2927.9[@] *9* | (8⁻) | | I | |
| 3035.9 *8* | | | I | |
| 3075.03 *11* | | | A | |
| 3075.2[a] *4* | (9⁻) | | HI | |
| 3111.9[#] *5* | 10⁺ | | EFGHI | |
| 3284.7 *5* | (10⁺) | 0.26 ps +*16*−*7* | E HI | $T_{1/2}$: from B(E2) in Coul. ex. |
| 3333.80 *23* | | | A | |
| 3384.4 *15* | | | I | |
| 3414.42 *20* | | | A | |
| 3443.34 *14* | | | A | |
| 3472.9[@] *14* | (10⁻) | | I | |
| 3501.59 *11* | | | A | |
| 3507.32 *12* | | | A | |
| 3582.81 *14* | | | A | |
| 3583.90 *15* | | | A | |
| 3618.16 *15* | | | A | |
| 3676.74 *19* | | | A | |
| 3691.2[a] *5* | (11⁻) | | HI | |
| 3713.4[#] *6* | (12⁺) | | FGHI | |
| 3875.40 *18* | | | A | |
| 3919.45 *19* | | | A | |
| 4163.9[@] *17* | (12⁻) | | I | |
| 4170.10 *17* | | | A | |
| 4263.72 *20* | | | A | |
| 4267.70 *19* | | | A | |
| 4439.2[#] *7* | (14⁺) | | GHI | |
| 4443.2[a] *12* | (13⁻) | | I | |
| 5357.0[#] *12* | (16⁺) | | HI | |

† Jπ without comments are from γ properties and band assignments.
‡ Level energy from least-squares adjustment.
# Band(A): g.s. band.
@ Band(B): Band based on (6⁻).
& Band(C): $K^{\pi}=2^{+}$ band(Gamma Band).
a Band(D): Band based on 5⁻.
b Band(E): Beta Band.

## Adopted Levels, Gammas (continued)

### $\gamma(^{104}Ru)$

| $E_i$(level) | $J^\pi_i$ | $E_\gamma$ | $I_\gamma$[†] | $E_f$ | $J^\pi_f$ | Mult.[‡] | $\delta$[‡] | $\alpha$[#] | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 358.02 | 2+ | 358.0 *1* | 100 | 0.0 | 0+ | E2 | | 0.01502 | B(E2)(W.u.)=57.9 *11* |
| 888.48 | 4+ | 530.5 *1* | 100 | 358.02 | 2+ | E2 | | | B(E2)(W.u.)=83 *9* |
| 893.10 | 2+ | 535.1 *1* | 100 *7* | 358.02 | 2+ | M1+E2 | −9 *2* | | B(M1)(W.u.)=0.00022 *10*; B(E2)(W.u.)=55 *6* |
| | | 893.1 *1* | 70 *7* | 0.0 | 0+ | E2 | | | B(E2)(W.u.)=2.8 *5*<br>Mult.: from Coul. ex. |
| 988.27 | 0+ | 630.3 *3* | 100 | 358.02 | 2+ | E2 | | | B(E2)(W.u.)=25 *3*<br>Mult.: from Coul. ex. |
| 1242.36 | 3+ | 349.3 *2* | 22.8 *24* | 893.10 | 2+ | | | | |
| | | 353.7 *3* | 8.9 *16* | 888.48 | 4+ | | | | |
| | | 884.4 *1* | 100 *13* | 358.02 | 2+ | M1+E2 | 3.2 *4* | | |
| 1335 | 0+ | 442[@] *1* | | 893.10 | 2+ | | | | |
| | | 977 *1* | | 358.02 | 2+ | | | | |
| 1502.60 | 4+ | 609.5 *1* | 100 *14* | 893.10 | 2+ | | | | |
| | | 614.2 *1* | 59 *5* | 888.48 | 4+ | | | | |
| | | 1144.7 *2* | 21 *3* | 358.02 | 2+ | | | | |
| 1515.44 | 2+ | 527.2 *2* | 13.7 *25* | 988.27 | 0+ | | | | |
| | | 627.0 *2* | 7.8 *16* | 888.48 | 4+ | | | | |
| | | 1157.4 *1* | 100 *9* | 358.02 | 2+ | | | | |
| | | 1515.5 *2* | 28 *3* | 0.0 | 0+ | | | | |
| 1556.4 | 6+ | 667.9 *3* | 100 | 888.48 | 4+ | | | | |
| 1872.39 | (5+) | 630.0 *1* | 100 *40* | 1242.36 | 3+ | | | | |
| | | 984.0 *2* | 34 *6* | 888.48 | 4+ | | | | |
| 1970.43 | 3− | 1612.4 *1* | 100 | 358.02 | 2+ | E1+M2 | 0.01 | | |
| 1974.8 | (6−,7) | 418.4 *3* | 100 | 1556.4 | 6+ | | | | |
| 2034.85 | 2+ | 519.4 *1* | 11.4 *11* | 1515.44 | 2+ | | | | |
| | | 792.5 *1* | 32 *3* | 1242.36 | 3+ | | | | |
| | | 1676.8 *1* | 100 *9* | 358.02 | 2+ | | | | |
| 2080.84 | 4+ | 565.5 *3* | 11.4 *20* | 1515.44 | 2+ | | | | |
| | | 838.6 *1* | 100 *10* | 1242.36 | 3+ | | | | |
| | | 1187.7 *2* | 43 *5* | 893.10 | 2+ | | | | |
| | | 1722.7 *1* | 89 *9* | 358.02 | 2+ | | | | |
| 2095 | (2+,4+) | 580[@] *1* | | 1515.44 | 2+ | | | | |
| | | 852 *1* | | 1242.36 | 3+ | | | | |
| | | 1203 *1* | | 893.10 | 2+ | | | | |
| | | 1206 *1* | | 888.48 | 4+ | | | | |
| 2196.6 | (6+) | 694 *1* | 100 | 1502.60 | 4+ | | | | |
| 2232.8 | (5−) | 1344.2 *3* | 100 | 888.48 | 4+ | | | | |
| 2269.04 | (3,4) | 298.6 *2* | 5.5 *14* | 1970.43 | 3− | | | | |
| | | 1376.1 *2* | 18.6 *25* | 893.10 | 2+ | | | | |
| | | 1380.5 *1* | 86 *9* | 888.48 | 4+ | | | | |
| | | 1911.0 *1* | 100 *9* | 358.02 | 2+ | | | | |
| 2285.07 | 2+ | 314.7 *3* | 7.8 *19* | 1970.43 | 3− | | | | |
| | | 1396.6 *1* | 100 *11* | 888.48 | 4+ | | | | |
| 2320.4 | 8+ | 764.0 *3* | 100 | 1556.4 | 6+ | | | | |
| 2329.22 | (1,2,3) | 1436.3 *3* | 23 *6* | 893.10 | 2+ | | | | |
| | | 1971.1 *2* | 100 *11* | 358.02 | 2+ | | | | |
| 2373.75 | (3,1) | 2015.7 *1* | 100 | 358.02 | 2+ | | | | |
| 2429.85 | | 349.1 *3* | 8 *4* | 2080.84 | 4+ | | | | |
| | | 459.6 *2* | 10 *3* | 1970.43 | 3− | | | | |
| | | 1541.3 *1* | 100 *8* | 888.48 | 4+ | | | | |
| 2481.90 | 3− | 511.6 *3* | 6.4 *16* | 1970.43 | 3− | | | | |
| | | 1239.6 *2* | 8.0 *12* | 1242.36 | 3+ | | | | |
| | | 1593.6 *3* | 15.2 *20* | 888.48 | 4+ | | | | |
| | | 2123.8 *1* | 100 *8* | 358.02 | 2+ | | | | |

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## Adopted Levels, Gammas (continued)

### $\gamma(^{104}Ru)$ (continued)

| $E_i$(level) | $J^\pi_i$ | $E_\gamma$ | $I_\gamma$[†] | $E_f$ | $J^\pi_f$ |
|---|---|---|---|---|---|
| 2489.91 | | 1247.6 *1* | 13.4 *14* | 1242.36 | 3+ |
| | | 1596.7 *1* | 100 *9* | 893.10 | 2+ |
| | | 1601.5 *2* | 4.5 *10* | 888.48 | 4+ |
| 2524.28 | | 553.8 *1* | 15 *3* | 1970.43 | 3− |
| | | 1021.8 *1* | 22.6 *20* | 1502.60 | 4+ |
| | | 1281.8 *1* | 100 *9* | 1242.36 | 3+ |
| | | 1635.8 *2* | 31 *4* | 888.48 | 4+ |
| 2597.31 | | 1609.0 *3* | 35 *10* | 988.27 | 0+ |
| | | 2239.3 *2* | 100 *13* | 358.02 | 2+ |
| 2600.7 | (6−) | 1044.3 *3* | 100 | 1556.4 | 6+ |
| 2613.9 | (7−) | 381.0 *3* | 15 *3* | 2232.8 | (5−) |
| | | 1057.5 *3* | 100 *11* | 1556.4 | 6+ |
| 2618.97 | | 333.8 *3* | 100 *14* | 2285.07 | 2+ |
| | | 584.0 *3* | 99 *14* | 2034.85 | 2+ |
| | | 648.7 *3* | 36 *7* | 1970.43 | 3− |
| 2623.4 | (7+) | 751 *1* | | 1872.39 | (5+) |
| 2627.8 | | 395 *1* | | 2232.8 | (5−) |
| 2629.99 | | 659.3 *3* | 4.8 | 1970.43 | 3− |
| | | 1736.9 *1* | 100 *10* | 893.10 | 2+ |
| 2758.1 | | 1202 *1* | | 1556.4 | 6+ |
| 2759.95 | | 475.0 *2* | 34 *10* | 2285.07 | 2+ |
| | | 1517.4 *2* | 100 *12* | 1242.36 | 3+ |
| | | 1871.6 *3* | 30 *12* | 888.48 | 4+ |
| 2823.43 | | 1580.9 *3* | 25 *4* | 1242.36 | 3+ |
| | | 1934.8 *3* | 19 *3* | 888.48 | 4+ |
| | | 2465.5 *2* | 100 *8* | 358.02 | 2+ |
| 2847.6 | (8+) | 651 *1* | | 2196.6 | (6+) |
| 2861.4 | | 1305 *1* | | 1556.4 | 6+ |
| 2927.9 | (8−) | 170 *1* | | 2758.1 | |
| | | 327 *1* | | 2600.7 | (6−) |
| 3035.9 | | 406 *1* | | 2627.8 | |
| | | 422 *1* | | 2613.9 | (7−) |
| 3075.03 | | 585.1 *3* | 33 *9* | 2489.91 | |
| | | 2181.9 *1* | 76 *8* | 893.10 | 2+ |
| | | 2717.0 *2* | 100 *10* | 358.02 | 2+ |
| 3075.2 | (9−) | 316 *1* | | 2758.1 | |
| | | 461.3 *3* | 100 | 2613.9 | (7−) |
| 3111.9 | 10+ | 791.5 *3* | 11.2 *15* | 2320.4 | 8+ |
| 3284.7 | (10+) | 964.3 *3* | 100 | 2320.4 | 8+ |
| 3333.80 | | 1363.3 *3* | 100 *18* | 1970.43 | 3− |
| | | 2975.8 *3* | 92 *11* | 358.02 | 2+ |
| 3384.4 | | 523 *1* | | 2861.4 | |
| 3414.42 | | 795.4 *3* | 55 *15* | 2618.97 | |
| | | 2525.8 *3* | 31 *6* | 888.48 | 4+ |
| | | 3056.5 *3* | 100 *11* | 358.02 | 2+ |
| 3443.34 | | 919.0 *2* | 14 *5* | 2524.28 | |
| | | 1927.9 *3* | 48 *6* | 1515.44 | 2+ |
| | | 2550.2 *2* | 100 *9* | 893.10 | 2+ |
| | | 3085.4 *3* | 17 *3* | 358.02 | 2+ |
| 3472.9 | (10−) | 545 *1* | | 2927.9 | (8−) |
| 3501.59 | | 1128.0 *3* | 19 *6* | 2373.75 | (3,1) |
| | | 1466.7 *1* | 56 *6* | 2034.85 | 2+ |
| | | 1531.2 *3* | 25 *5* | 1970.43 | 3− |
| | | 1986.2 *2* | 11 *6* | 1515.44 | 2+ |
| | | 2608.5 *2* | 100 *11* | 893.10 | 2+ |
| | | 3143.4 *2* | 50 *5* | 358.02 | 2+ |

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## Adopted Levels, Gammas (continued)

### $\gamma(^{104}Ru)$ (continued)

| $E_i$(level) | $J^\pi_i$ | $E_\gamma$ | $I_\gamma$[†] | $E_f$ | $J^\pi_f$ | Comments |
|---|---|---|---|---|---|---|
| 3507.32 | | 1133.4 *3* | 19 *8* | 2373.75 | (3,1) | |
| | | 1472.5 *1* | 60 *6* | 2034.85 | $2^+$ | |
| | | 1536.7 *4* | 15 *4* | 1970.43 | $3^-$ | |
| | | 3149.2 *2* | 100 *8* | 358.02 | $2^+$ | |
| 3582.81 | | 1092.9 *1* | 100 *10* | 2489.91 | | |
| | | 2340.4 *5* | 49 *12* | 1242.36 | $3^+$ | |
| 3583.90 | | 986.6 *2* | 69 *12* | 2597.31 | | |
| | | 1210.0 *3* | 94 *12* | 2373.75 | (3,1) | |
| | | 2690.9 *2* | 57 *11* | 893.10 | $2^+$ | |
| | | 3225.6 *3* | 100 *11* | 358.02 | $2^+$ | |
| 3618.16 | | 2375.8 *2* | 51 *12* | 1242.36 | $3^+$ | |
| | | 2724.9 *2* | 100 *12* | 893.10 | $2^+$ | |
| | | 3260.3 *3* | 46 *7* | 358.02 | $2^+$ | |
| 3676.74 | | 2788.2 *2* | 100 *10* | 888.48 | $4^+$ | |
| | | 3318.7 *3* | 55 *7* | 358.02 | $2^+$ | |
| 3691.2 | $(11^-)$ | 616.0 *3* | 100 | 3075.2 | $(9^-)$ | |
| 3713.4 | $(12^+)$ | 429 *1* | | 3284.7 | $(10^+)$ | |
| | | 601.5 *3* | 100 | 3111.9 | $10^+$ | |
| 3875.40 | | 1840.5 *3* | 100 *25* | 2034.85 | $2^+$ | |
| | | 2633.0 *3* | 55 *20* | 1242.36 | $3^+$ | |
| | | 2982.3 *3* | 60 *10* | 893.10 | $2^+$ | |
| | | 3517.3 *4* | 90 *15* | 358.02 | $2^+$ | |
| 3919.45 | | 2677.0 *2* | 100 *14* | 1242.36 | $3^+$ | |
| | | 3026.4 *3* | 68 *8* | 893.10 | $2^+$ | |
| 4163.9 | $(12^-)$ | 691 *1* | 100 | 3472.9 | $(10^-)$ | |
| 4170.10 | | 2089.3 *2* | 100 *11* | 2080.84 | $4^+$ | |
| | | 2927.9 *5* | 33 *11* | 1242.36 | $3^+$ | |
| | | 3276.8 *3* | 33 *7* | 893.10 | $2^+$ | |
| | | 3811.9 *4* | 30 *9* | 358.02 | $2^+$ | |
| 4263.72 | | 1633.7 *2* | 39 *12* | 2629.99 | | |
| | | 3370.6 *3* | 100 *12* | 893.10 | $2^+$ | |
| 4267.70 | | 2395.3 *2* | 100 *13* | 1872.39 | $(5^+)$ | |
| | | 3374.5 *3* | 69 *10* | 893.10 | $2^+$ | |
| 4439.2 | $(14^+)$ | 725.8 *3* | 100 | 3713.4 | $(12^+)$ | |
| 4443.2 | $(13^-)$ | 752 *1* | 100 | 3691.2 | $(11^-)$ | |
| 5357.0 | $(16^+)$ | 917.8 | | 4439.2 | $(14^+)$ | $E_\gamma$: From 1998Fo08. |

[†] Photon branching from each level.

[‡] From $^{104}$Tc $\beta^-$ decay, unless indicated otherwise.

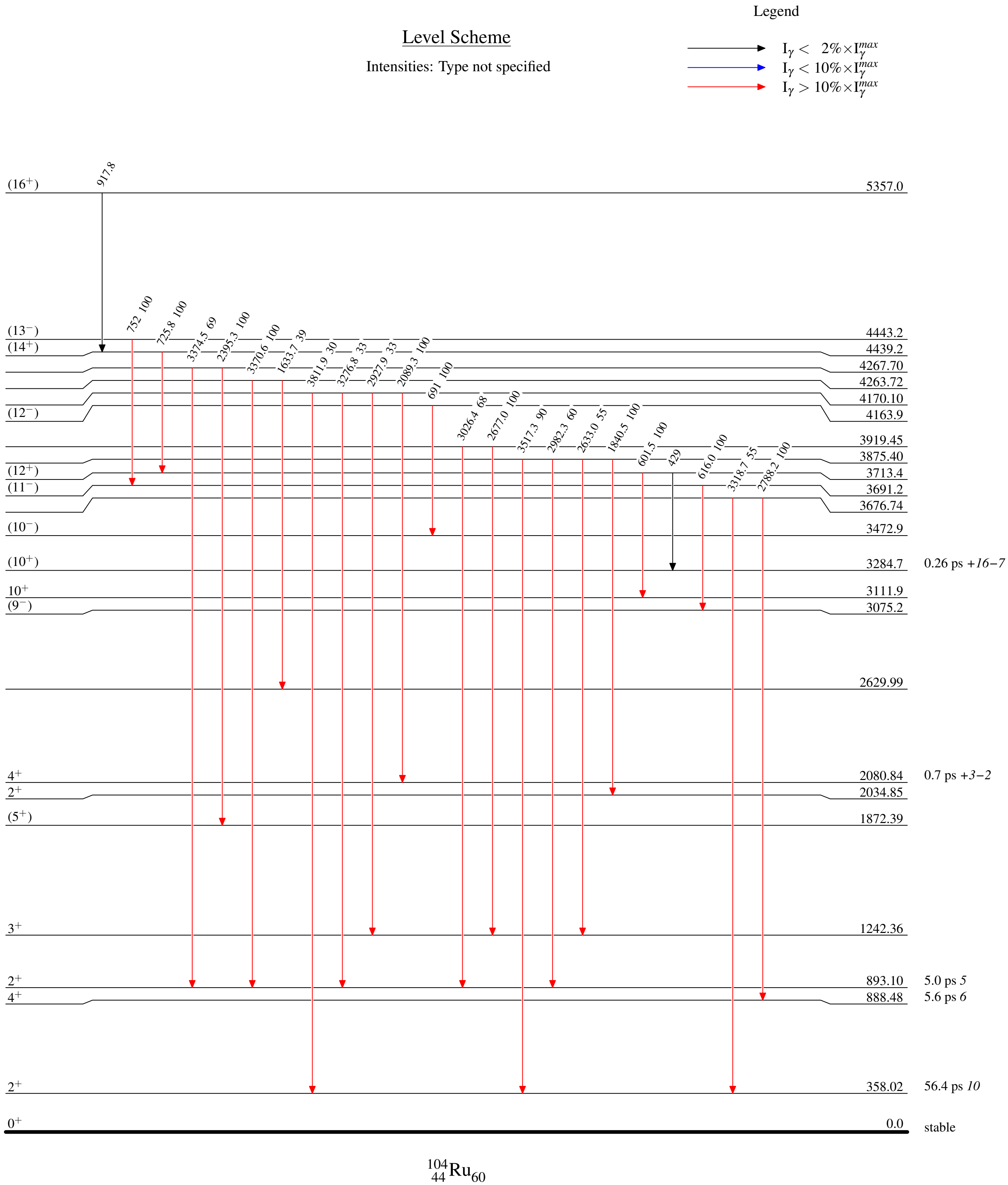
[#] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on $\gamma$-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.

[@] Placement of transition in the level scheme is uncertain.

## Adopted Levels, Gammas

Level Scheme

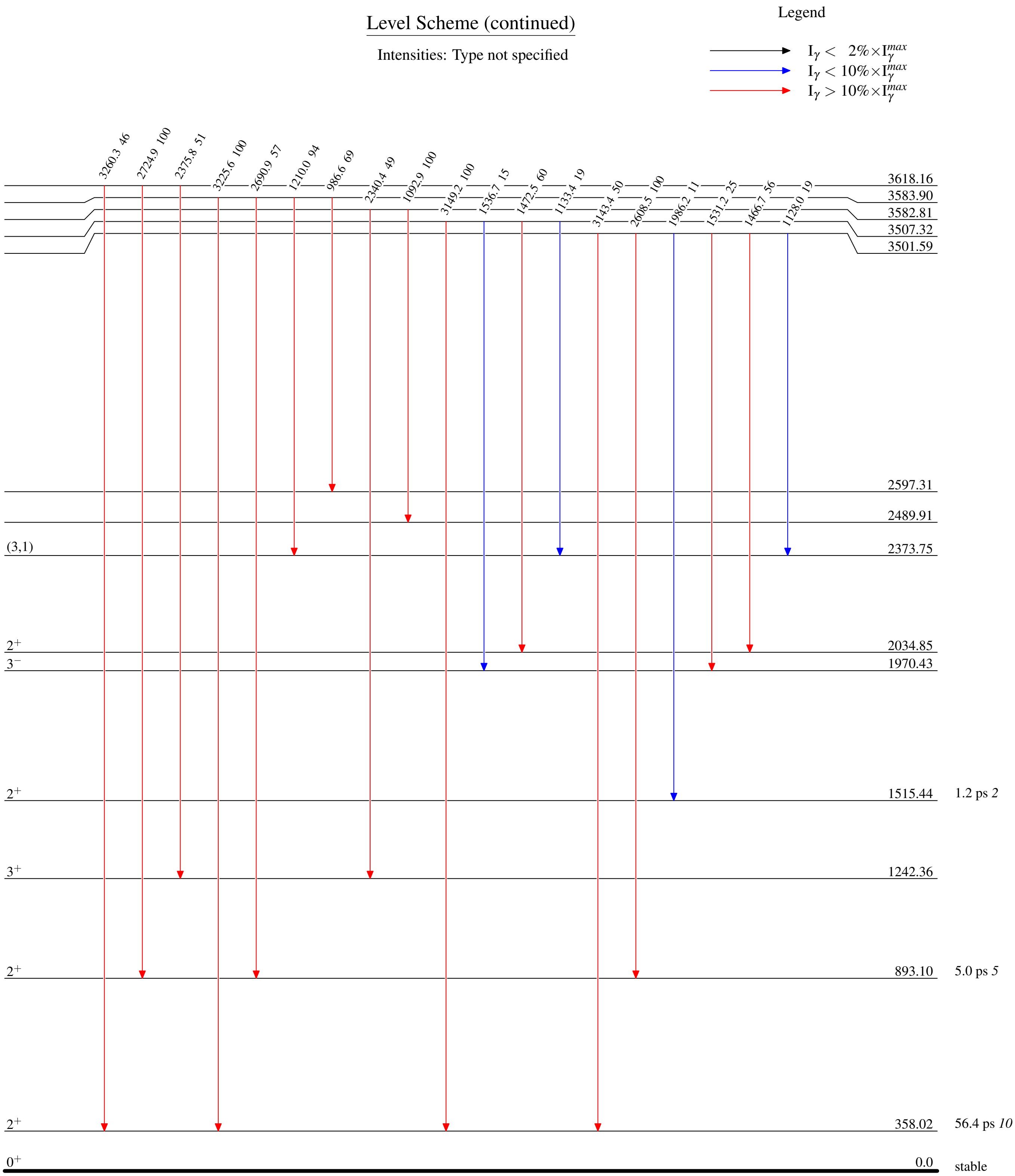
Intensities: Type not specified



## Adopted Levels, Gammas

### Level Scheme (continued)

Intensities: Type not specified




$^{104}_{44}Ru_{60}$

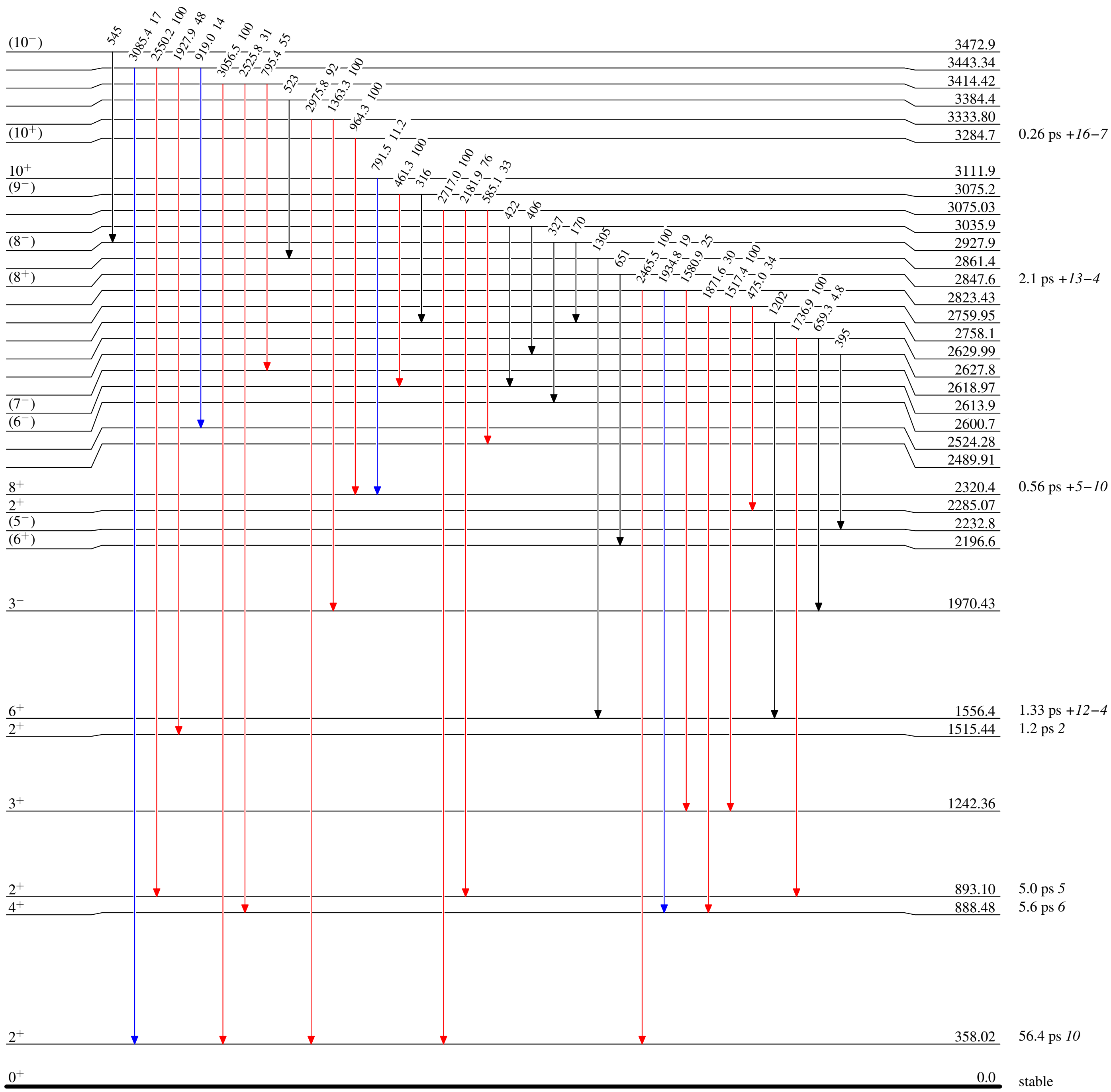
## Adopted Levels, Gammas

### Level Scheme (continued)

Intensities: Type not specified

Legend

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

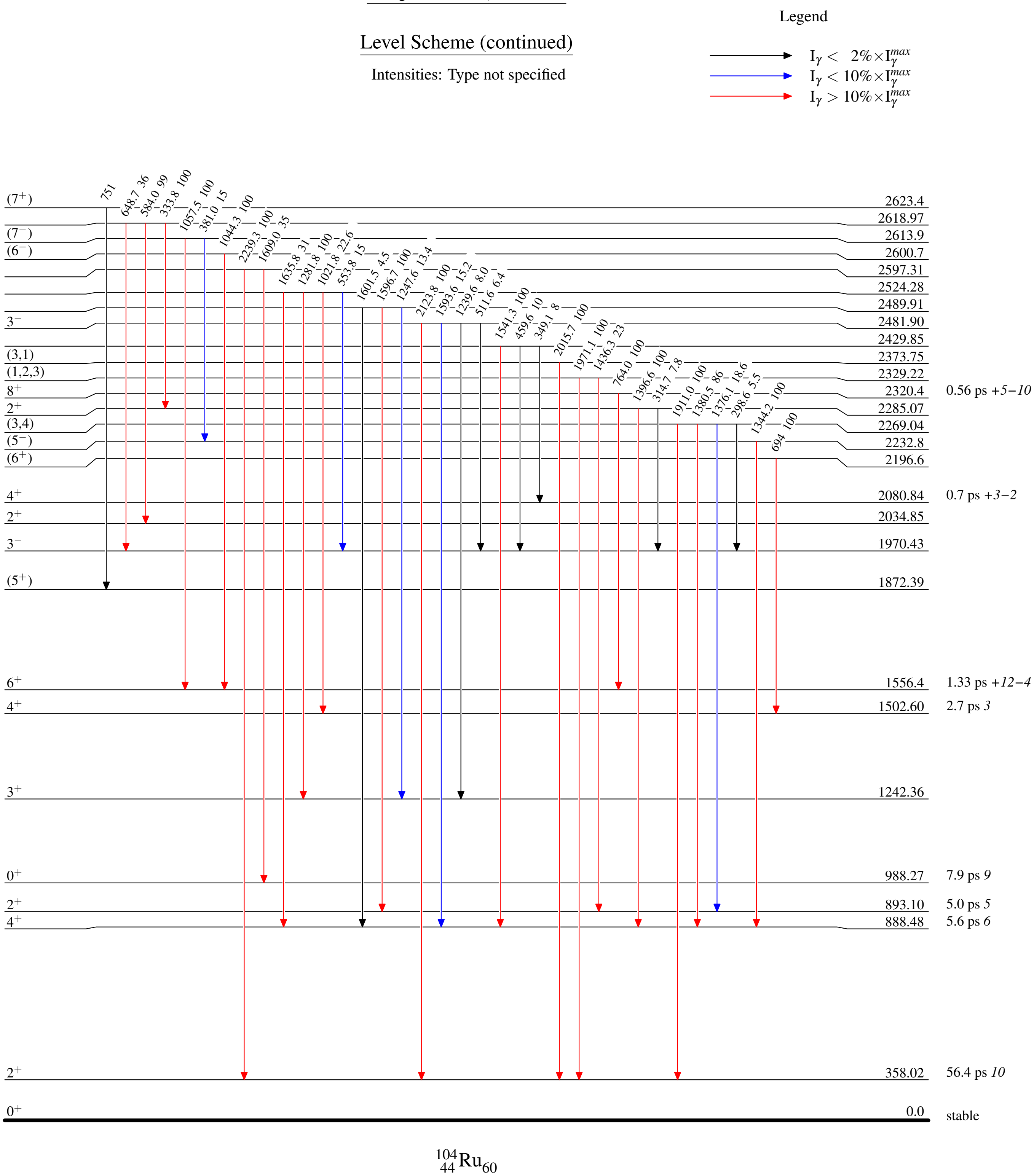



$^{104}_{44}Ru_{60}$

**Adopted Levels, Gammas**

Level Scheme (continued)

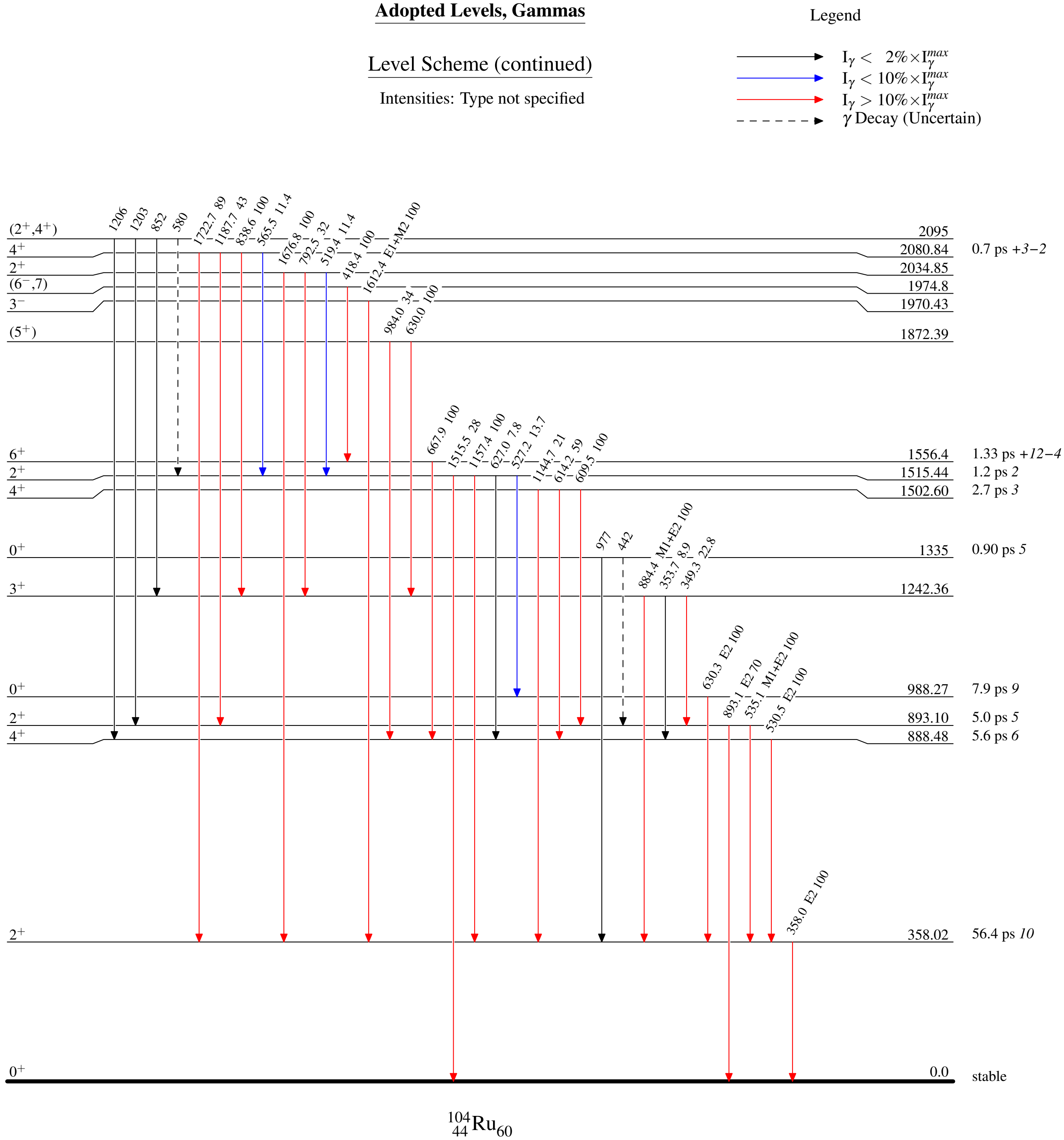
Intensities: Type not specified



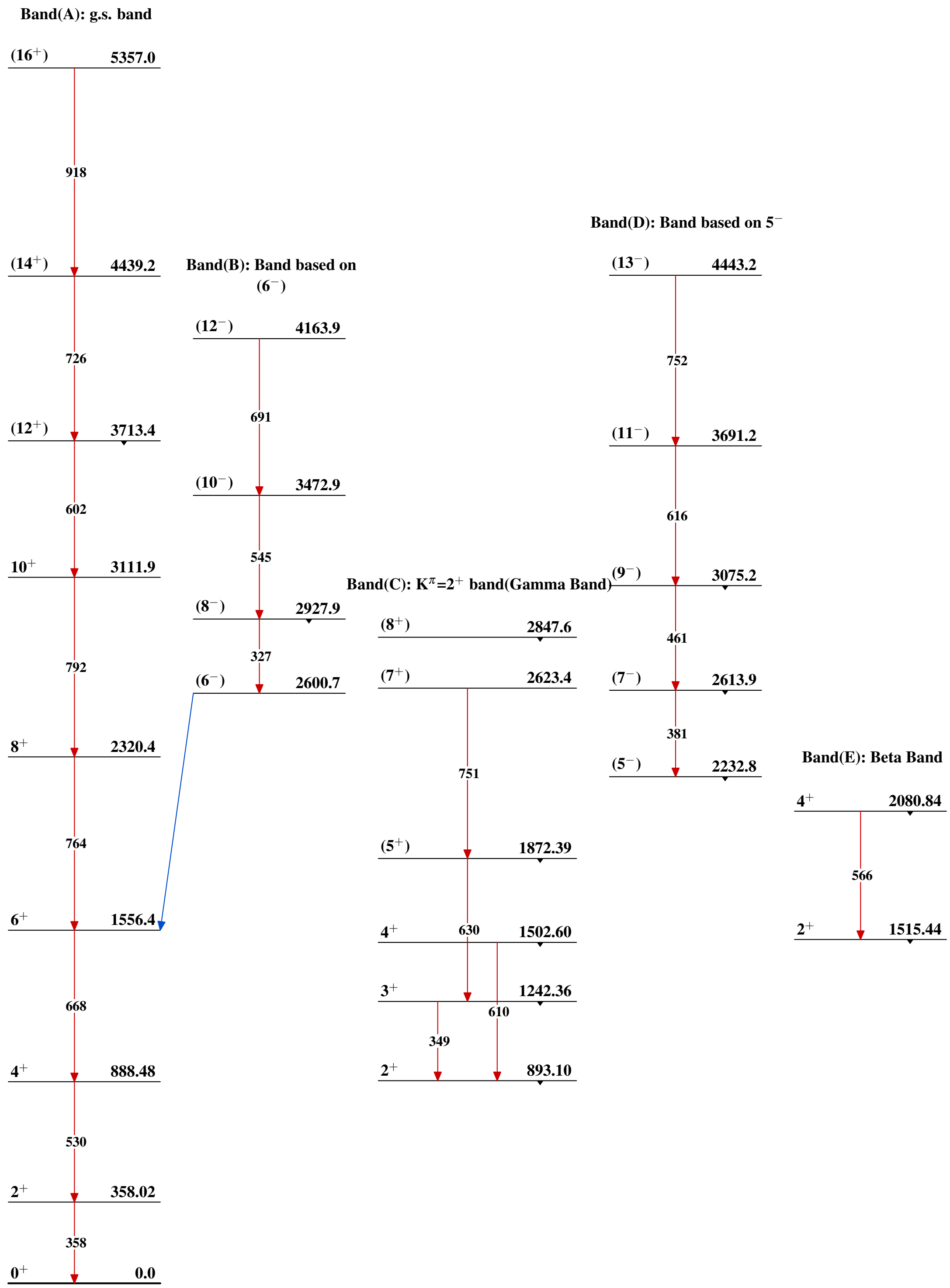
**Adopted Levels, Gammas**

Level Scheme (continued)

Intensities: Type not specified



## Adopted Levels, Gammas




$^{104}_{44}Ru_{60}$