## $^{87}$Rb(p,2n$\gamma$) 2017Du08

History

| Type | Author | Citation | Literature Cutoff Date |
|---|---|---|---|
| Full Evaluation | A. Negret and B. Singh | NDS 203,283 (2025) | 20-Jan-2025 |

2017Du08: E(p)=16 MeV. Target=1.0 mg/cm$^2$, $^{87}$RbCl, enriched in $^{87}$Rb, on a 1.0-mg/cm$^2$ thick $^{197}$Au backing. Measured E$\gamma$, I$\gamma$, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$, level half-lives using HORUS spectrometer at the FN Tandem accelerator of the University of Cologne. Deduced levels, $J^\pi$, branching, multipolarities and mixing ratios, B(E2), B(M1), configurations. Monte Carlo simulated B($\lambda$) values. Comparison with shell Model calculations, mixed-symmetry states.

### $^{86}$Sr Levels

For detailed shell-model configurations, see Table 10 of 2017Du08.

| E(level)[†] | J$^\pi$[‡] | T$_{1/2}$ | Comments |
|---|---|---|---|
| 0.0 | 0$^+$ | | |
| 1076.6 *2* | 2$^+$ | | |
| 1854.0 *2* | 2$^+$ | 193 fs *30* | J$^\pi$: spin from $\gamma\gamma(\theta)$.<br>T$_{1/2}$: from spectral difference method (SDM) (2017Du08). |
| 2103.4 *3* | 0$^+$ | | |
| 2201.6 *3* | 0$^+$ | | |
| 2229.8 *2* | 4$^+$ | | |
| 2481.5 *2* | 3$^-$[#] | | |
| 2641.1 *2* | 2$^+$ | 84 fs *+45−42* | T$_{1/2}$: from DSAM (2017Du08). Other values: <146 fs (SDM), 87 fs *19* (DSAM), 189 fs *+35−32* (effective half-life, DSAM) (2017Du08). |
| 2672.5 *2* | 5$^-$ | | |
| 2787.2 *3* | 2$^+$ | <62 fs | T$_{1/2}$: from DSAM (2017Du08). Other value: 130 fs *+24−25* (DSAM,effective half-life) (2017Du08). Literature value=25 fs *12*. |
| 2856.9 *2* | 6$^+$[#] | | |
| 2878.0 *2* | 3$^+$ | 110 fs *+53−49* | T$_{1/2}$: from DSAM (2017Du08). Other (effective) half-life from DSAM: 261 fs *+32−31* as averaged of 270 fs *+42−40* and 248 fs *+53−46*, (2017Du08). |
| 2955.4 *3* | 8$^+$[#] | 0.455 $\mu$s *7* | T$_{1/2}$: from the Adopted Levels. |
| 2996.2 *2* | 3$^+$ | 162[@] fs *+9−8* | |
| 3055.5 *2* | 5$^-$[#] | | |
| 3184.7 *2* | 4$^-$ | | |
| 3187.2 *4* | 2$^+$ | 113[@] fs *+71−39* | |
| 3290.9 *2* | 6$^-$ | | |
| 3317.6 *2* | 4$^{(+)}$ | | J$^\pi$: from $\gamma\gamma(\theta)$. |
| 3346.1 *4* | | | |
| 3361.7 *2* | 4$^+$[#] | | |
| 3389.8 *3* | [#] | | |
| 3429.5 *4* | 2$^+$[#] | 91[@] fs *+51−47* | |
| 3490.9 *2* | (4$^+$) | 166[@] fs *+30−27* | T$_{1/2}$: average of 200 fs *+44−42*, 119 fs *+80−69* and 132 fs *+46−44* (2017Du08), all the three values are effective half-lives. |
| 3499.9 *4* | 4$^-$[#] | | |
| 3555.3 *2* | 7$^-$,6,5 | | J$^\pi$: 370.4$\gamma$ from 3925, (4)$^+$ level makes 7$^-$ and 6$^-$ less likely (evaluators′ note). |
| 3643.9 *2* | 4$^+$,3,2$^+$ | 151[@] fs *+42−37* | E(level): only one level at 3645.0 was assigned in other datasets with 144.5, 1163.0, 1415.2, 1790.9, and 2567.97 $\gamma$ rays from this level. 2017Du08 propose two separate levels near this energy. In the Adopted dataset, only one level is recommended at 3644.6 keV, where all the five $\gamma$ rays fit well.<br>J$^\pi$: assignment of (3$^-$) in other datasets.<br>T$_{1/2}$: average of 148 fs *+80−67* and 152 fs *+45−41* (2017Du08), both are effective half-lives. |
| 3644.4 *3* | 4$^+$,3,2,1$^-$ | | |

Continued on next page (footnotes at end of table)

## $^{87}$Rb(p,2nγ) 2017Du08 (continued)

### $^{86}$Sr Levels (continued)

| E(level)[†] | Jπ[‡] | $T_{1/2}$ | Comments |
|---|---|---|---|
| 3663.8 *3* | $7^{-}$[#] | | |
| 3687.1 *3* | $3^{-}$[#] | 105[@] fs *+28–27* | |
| 3765.2 *2* | $3^{-},4,5^{+}$ | | |
| 3774.3 *3* | $(4)^{+}$[#] | 204[@] fs *+51–46* | |
| 3782.6 *3* | $(5,6^{+})$ | 299[@] fs *+68–63* | |
| 3806.2 *6* | | | |
| 3811.0 *3* | 4 to $7^{(-)}$ | 270[@] fs *+40–37* | $T_{1/2}$: other value: <131 fs (DSAM, 2017Du08). |
| 3830.2 *2* | $(3)^{-}$[#] | | |
| 3870.3 *3* | $3^{-}$[#] | | |
| 3903.6 *5* | | | |
| 3925.5 *2* | $(4^{-})$[#] | | Jπ: $(4^{-},5^{-})$ in the Adopted Levels, Gammas. |
| 3942.3 *4* | $3^{-}$[#] | | |
| 3968.1 *3* | $4^{-}$[#] | | |
| 3974.8 *4* | | | |
| 3986.4 *5* | | | |
| 4010.5 *4* | | | |
| 4042.1 *3* | 4 to $7^{(-)}$ | | |
| 4074.7 *3* | (6) | 225[@] fs *+77–63* | |
| 4144.5 *6* | $(3,4^{+})$[#] | <168[@] fs | |
| 4153.3 *5* | $8^{+}$[#] | | |
| 4163.1 *5* | | <237[@] fs | |
| 4205.1 *3* | $3^{-},4$ | | |
| 4219.8 *4* | | | |
| 4224.9 *5* | | | |
| 4254.7 *5* | | | |
| 4261.6 *4* | | 176[@] fs *+57–51* | |
| 4281.0 *6* | 1,2 | | |
| 4305.1 *5* | | | |
| 4395.5 *6* | | | |
| 4408.9 *8* | | | |
| 4442.8 *5* | | | |
| 4468.0 *4* | | | |
| 4976.3 *5* | | | |

[†] From least-squares fit to Eγ data.
[‡] As proposed by 2017Du08 based on γγ(θ) data, previous assignments, and other considerations, unless otherwise indicated.
[#] Value adopted by 2017Du08 from the Adopted Levels, Gammas of the 2015Ne01 evaluation.
[@] Effective half-life (2017Du08) from DSAM, not corrected for side feeding.

## $^{87}$Rb(p,2n$\gamma$) 2017Du08 (continued)

### $\gamma(^{86}Sr)$

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$ | $I_\gamma$ | $E_f$ | $J_f^\pi$ | Mult.[†] | $\delta$[†] | $\alpha$[‡] | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 1076.6 | $2^+$ | 1076.6 *2* | 100 | 0.0 | $0^+$ | E2 | | | |
| 1854.0 | $2^+$ | 777.2 *2* | 100 | 1076.6 | $2^+$ | M1+E2 | +0.37 *5* | | $\delta$: from $\gamma\gamma(\theta)$. |
| | | 1854.0 *2* | 79.5 *7* | 0.0 | $0^+$ | E2 | | | |
| 2103.4 | $0^+$ | 1026.8 *2* | 100 | 1076.6 | $2^+$ | E2 | | | |
| 2201.6 | $0^+$ | 1125.0 *2* | 100 | 1076.6 | $2^+$ | E2 | | | |
| 2229.8 | $4^+$ | 1152.9 *2* | 100 | 1076.6 | $2^+$ | E2 | | | |
| 2481.5 | $3^-$ | 252.0 *3* | 2.1 *4* | 2229.8 | $4^+$ | E1 | | | |
| | | 627.5 *2* | 100 | 1854.0 | $2^+$ | (E1(+M2)) | −0.01 *3* | | $\delta$: from $\gamma\gamma(\theta)$. |
| 2641.1 | $2^+$ | 1564.5 *3* | 100 | 1076.6 | $2^+$ | M1+E2 | −0.49 *22* | | $\delta$: from $\gamma\gamma(\theta)$. |
| | | 2641.0 *4* | 73.3 *71* | 0.0 | $0^+$ | E2 | | | |
| 2672.5 | $5^-$ | 190.9 *2* | 5.9 *7* | 2481.5 | $3^-$ | E2 | | | |
| | | 442.9 *2* | 100 | 2229.8 | $4^+$ | (E1(+M2)) | 0.00 *2* | | $\delta$: from $\gamma\gamma(\theta)$. |
| | | 1596.5 *4* | 1.9 *3* | 1076.6 | $2^+$ | E3 | | | |
| 2787.2 | $2^+$ | 1710.8 *3* | 100 | 1076.6 | $2^+$ | M1+E2 | −0.26 *13* | | |
| | | 2786.2 *9* | 13.2 *53* | 0.0 | $0^+$ | E2 | | | |
| 2856.9 | $6^+$ | 184.4 *2* | 23.7 *14* | 2672.5 | $5^-$ | E1 | | | |
| | | 627.1 *2* | 100 | 2229.8 | $4^+$ | E2(+M3) | +0.03 *4* | | |
| 2878.0 | $3^+$ | 648.2 *3* | 10.3 *16* | 2229.8 | $4^+$ | | | | |
| | | 1024.0 *2* | 100 | 1854.0 | $2^+$ | M1+E2 | +0.46 *12* | | |
| | | 1801.5 *2* | 30.5 *20* | 1076.6 | $2^+$ | M1+E2 | +61 *6* | | |
| 2955.4 | $8^+$ | 98.6 *2* | 100 | 2856.9 | $6^+$ | E2 | | 1.068 | |
| 2996.2 | $3^+$ | 515.0 *3* | 21.2 *51* | 2481.5 | $3^-$ | E1(+M2) | −0.09 *+47−51* | | |
| | | 765.6 *2* | 16.5 *50* | 2229.8 | $4^+$ | M1+E2 | −0.34 *10* | | $E_\gamma$: poor fit. Level-energy difference=766.4. |
| | | 1140.3 *6* | <6.3 | 1854.0 | $2^+$ | | | | $E_\gamma$: poor fit. Level-energy difference=1142.1. |
| | | 1919.7 *2* | 100 | 1076.6 | $2^+$ | M1+E2 | +0.16 *4* | | $\delta$: other: −0.01 *3* from literature. |
| 3055.5 | $5^-$ | 382.7 *2* | 69.8 *12* | 2672.5 | $5^-$ | M1(+E2) | +0.04 *12* | | |
| | | 825.9 *2* | 100 | 2229.8 | $4^+$ | E1(+M2) | −0.02 *3* | | $\delta$: other: +0.01 *2* from other datasets. |
| 3184.7 | $4^-$ | 187.8 *3* | 10.3 *36* | 2996.2 | $3^+$ | E1 | | | |
| | | 306.8 *2* | 23.5 *22* | 2878.0 | $3^+$ | E1(+M2) | +0.02 *8* | | |
| | | 703.2 *2* | 100 | 2481.5 | $3^-$ | M1+E2 | +0.31 *6* | | |
| | | 955.0 *3* | 6.4 *22* | 2229.8 | $4^+$ | | | | |
| 3187.2 | $2^+$ | 2110.6 *3* | 100 | 1076.6 | $2^+$ | M1(+E2) | −0.20 *24* | | This $\gamma$ ray is assigned from 3184.7 level in other datasets. |
| 3290.9 | $6^-$ | 235.3 *2* | 100 | 3055.5 | $5^-$ | M1+E2 | | | $\delta$=−0.43 *13* or −2.09 *+46−72*. |
| | | 434.0 *2* | 64.5 *53* | 2856.9 | $6^+$ | E1+M2 | −0.39 *+26−32* | | |
| | | 618.3 *2* | 47.3 *41* | 2672.5 | $5^-$ | M1+E2 | | | $\delta$=−0.44 *14* or −2.12 *+52−87*. |
| 3317.6 | $4^{(+)}$ | 439.6 *3* | 5.8 *18* | 2878.0 | $3^+$ | | | | |
| | | 645.0 *2* | 11.6 *14* | 2672.5 | $5^-$ | (E1(+M2)) | −0.07 *7* | | $\delta$: from $\gamma\gamma(\theta)$. |
| | | 836.0 *2* | 100 | 2481.5 | $3^-$ | (E1+M2) | −0.13 *8* | | |
| 3346.1 | | 489.3 *3* | 100 | 2856.9 | $6^+$ | | | | |
| 3361.7 | $4^+$ | 688.8 *3* | 24.6 *10* | 2672.5 | $5^-$ | E1 | | | |
| | | 1132.4 *3* | 63.3 *11* | 2229.8 | $4^+$ | M1(+E2) | <−0.63 | | |





$^{86}_{38}Sr_{48}$-3

## $^{87}$Rb(p,2nγ) 2017Du08 (continued)

### γ($^{86}$Sr) (continued)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$ | $I_\gamma$ | $E_f$ | $J_f^\pi$ | Mult.[†] | δ[†] |
|---|---|---|---|---|---|---|---|
| 3361.7 | $4^+$ | 1507.6 *2* | 100 | 1854.0 | $2^+$ | E2(+M3) | −0.03 *15* |
| 3389.8 | | 1535.7 *3* | 33.8 *35* | 1854.0 | $2^+$ | | |
| | | 2313.2 *3* | 100 | 1076.6 | $2^+$ | | |
| 3429.5 | $2^+$ | 2352.9 *3* | 100 | 1076.6 | $2^+$ | | |
| 3490.9 | $(4^+)$ | 1261.0 *2* | 100 | 2229.8 | $4^+$ | (M1(+E2)) | −0.26 *24* |
| | | 1636.9 *3* | 74.4 *25* | 1854.0 | $2^+$ | | |
| | | 2414.5 *3* | 82.5 *28* | 1076.6 | $2^+$ | | |
| 3499.9 | $4^-$ | 1270.1 *3* | 100 | 2229.8 | $4^+$ | | |
| 3555.3 | $7^-$,6,5 | 264.2 *3* | 85.0 *94* | 3290.9 | $6^-$ | | |
| | | 698.7 *3* | 100 | 2856.9 | $6^+$ | | |
| | | 882.8 *3* | 73.1 *27* | 2672.5 | $5^-$ | | |
| 3643.9 | $4^+$,3,$2^+$ | 765.7 *3* | 15.0 *13* | 2878.0 | $3^+$ | | |
| | | 1414.1 *3* | 64 *15* | 2229.8 | $4^+$ | | |
| | | 2567.4 *3* | 100 | 1076.6 | $2^+$ | | |
| 3644.4 | $4^+$,3,2,$1^-$ | 1163.1 *4* | 72.0 *32* | 2481.5 | $3^-$ | | |
| | | 1790.2 *3* | 100 | 1854.0 | $2^+$ | | |
| 3663.8 | $7^-$ | 806.9 *2* | 100 | 2856.9 | $6^+$ | E1(+M2) | 0.00 *7* |
| 3687.1 | $3^-$ | 900.1 *5* | 21.0 *17* | 2787.2 | $2^+$ | E1 | |
| | | 1046.3 *3* | 32.0 *25* | 2641.1 | $2^+$ | E1 | |
| | | 2609.6 *5* | 100 | 1076.6 | $2^+$ | E1 | |
| 3765.2 | $3^-$,4,$5^+$ | 580.3 *3* | 100 | 3184.7 | $4^-$ | | |
| | | 709.6 *3* | 76 *10* | 3055.5 | $5^-$ | | |
| | | 887.5 *4* | 23.7 *97* | 2878.0 | $3^+$ | | |
| | | 1092.7 *4* | 22.6 *58* | 2672.5 | $5^-$ | | |
| 3774.3 | $(4)^+$ | 718.8 *3* | 39.7 *30* | 3055.5 | $5^-$ | | |
| | | 1102.0 *3* | 37.1 *19* | 2672.5 | $5^-$ | | |
| | | 1292.6 *3* | 100 | 2481.5 | $3^-$ | | |
| 3782.6 | $(5,6^+)$ | 925.7 *3* | 31.5 *13* | 2856.9 | $6^+$ | | |
| | | 1552.8 *3* | 100 | 2229.8 | $4^+$ | | |
| 3806.2 | | 1324.7 *5* | 100 | 2481.5 | $3^-$ | | |
| 3811.0 | 4 to $7^{(-)}$ | 520.0 *4* | 69.2 *68* | 3290.9 | $6^-$ | | |
| | | 1138.4 *3* | 100 | 2672.5 | $5^-$ | | |
| 3830.2 | $(3)^-$ | 645.8 *3* | 100 | 3184.7 | $4^-$ | | |
| | | 833.6 *3* | 68.1 *74* | 2996.2 | $3^+$ | | |
| | | 1349.0 *3* | 63.0 *34* | 2481.5 | $3^-$ | | |
| 3870.3 | $3^-$ | 1228.8 *4* | 1.8 *79* | 2641.1 | $2^+$ | E1 | |
| | | 2016.3 *4* | 71.4 *62* | 1854.0 | $2^+$ | E1 | |
| | | 2794.0 *4* | 100 | 1076.6 | $2^+$ | E1 | |
| 3903.6 | | 1673.8 *4* | 100 | 2229.8 | $4^+$ | | |
| 3925.5 | $(4^-)$ | 370.4 *3* | 85 *14* | 3555.3 | $7^-$,6,5 | | |
| | | 607.8 *4* | 63.1 *83* | 3317.6 | $4^{(+)}$ | | |





$^{86}_{38}Sr_{48}$-4

## $^{87}$Rb(p,2n$\gamma$) 2017Du08 (continued)

### $\gamma(^{86}Sr)$ (continued)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$ | $I_\gamma$ | $E_f$ | $J_f^\pi$ | Mult.[†] |
|---|---|---|---|---|---|---|
| 3925.5 | (4$^-$) | 740.4 *4* | 55.2 *80* | 3184.7 | 4$^-$ | |
| | | 1253.1 *3* | 100 | 2672.5 | 5$^-$ | |
| | | 1695.7 *4* | 98.3 *66* | 2229.8 | 4$^+$ | |
| 3942.3 | 3$^-$ | 2088.5 *4* | 72 *11* | 1854.0 | 2$^+$ | E1 |
| | | 2865.5 *4* | 100 | 1076.6 | 2$^+$ | E1 |
| 3968.1 | 4$^-$ | 783.5 *4* | 59.5 *55* | 3184.7 | 4$^-$ | |
| | | 971.5 *3* | 55.8 *70* | 2996.2 | 3$^+$ | |
| | | 1295.9 *3* | 100 | 2672.5 | 5$^-$ | |
| 3974.8 | | 1745.0 *3* | 100 | 2229.8 | 4$^+$ | |
| 3986.4 | | 2909.8 *4* | 100 | 1076.6 | 2$^+$ | |
| 4010.5 | | 1014.3 *3* | 100 | 2996.2 | 3$^+$ | |
| 4042.1 | 4 to 7$^{(-)}$ | 751.1 *3* | 46.2 *54* | 3290.9 | 6$^-$ | |
| | | 986.7 *3* | 100 | 3055.5 | 5$^-$ | |
| 4074.7 | (6) | 263.7 *3* | 30.5 *40* | 3811.0 | 4 to 7$^{(-)}$ | |
| | | 1402.2 *3* | 100 | 2672.5 | 5$^-$ | |
| 4144.5 | (3,4$^+$) | 3067.9 *5* | 100 | 1076.6 | 2$^+$ | |
| 4153.3 | 8$^+$ | 489.5 *3* | 100 | 3663.8 | 7$^-$ | |
| 4163.1 | | 1933.3 *4* | 100 | 2229.8 | 4$^+$ | |
| 4205.1 | 3$^-$,4 | 1326.5 *5* | 23.4 *42* | 2878.0 | 3$^+$ | |
| | | 1532.8 *5* | 53.9 *75* | 2672.5 | 5$^-$ | |
| | | 1723.8 *3* | 100 | 2481.5 | 3$^-$ | |
| 4219.8 | | 928.9 *3* | 100 | 3290.9 | 6$^-$ | |
| 4224.9 | | 1995.1 *4* | 100 | 2229.8 | 4$^+$ | |
| 4254.7 | | 2024.9 *4* | 100 | 2229.8 | 4$^+$ | |
| 4261.6 | | 1589.0 *3* | 100 | 2672.5 | 5$^-$ | |
| 4281.0 | 1,2 | 2177.6 *5* | 100 | 2103.4 | 0$^+$ | |
| 4305.1 | | 1014.2 *4* | 100 | 3290.9 | 6$^-$ | |
| 4395.5 | | 1722.9 *5* | 100 | 2672.5 | 5$^-$ | |
| 4408.9 | | 3332.3 *7* | 100 | 1076.6 | 2$^+$ | |
| 4442.8 | | 1387.3 *4* | 100 | 3055.5 | 5$^-$ | |
| 4468.0 | | 1611.1 *3* | 100 | 2856.9 | 6$^+$ | |
| 4976.3 | | 1331.9 *3* | 100 | 3644.4 | 4$^+$,3,2,1$^-$ | |

[†] As assigned in 2017Du08, based on their $\gamma\gamma(\theta)$ data. Width of the magnetic substates kept constant at $\sigma\approx2.6$ (2017Du08).

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



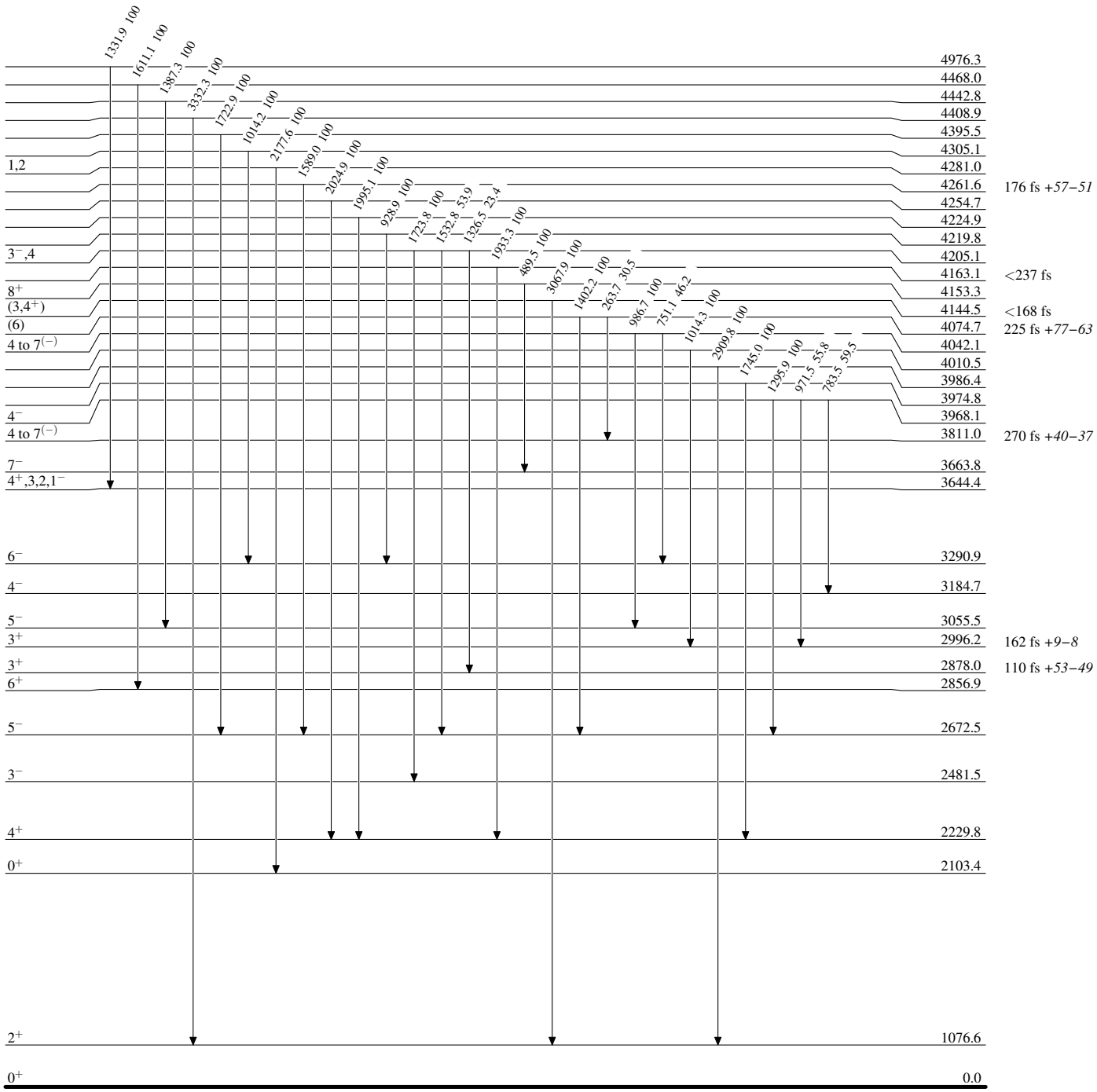


$^{86}_{38}Sr_{48}$-5

## $^{87}$Rb(p,2nγ) 2017Du08

### Level Scheme

Intensities: Relative photon branching from each level

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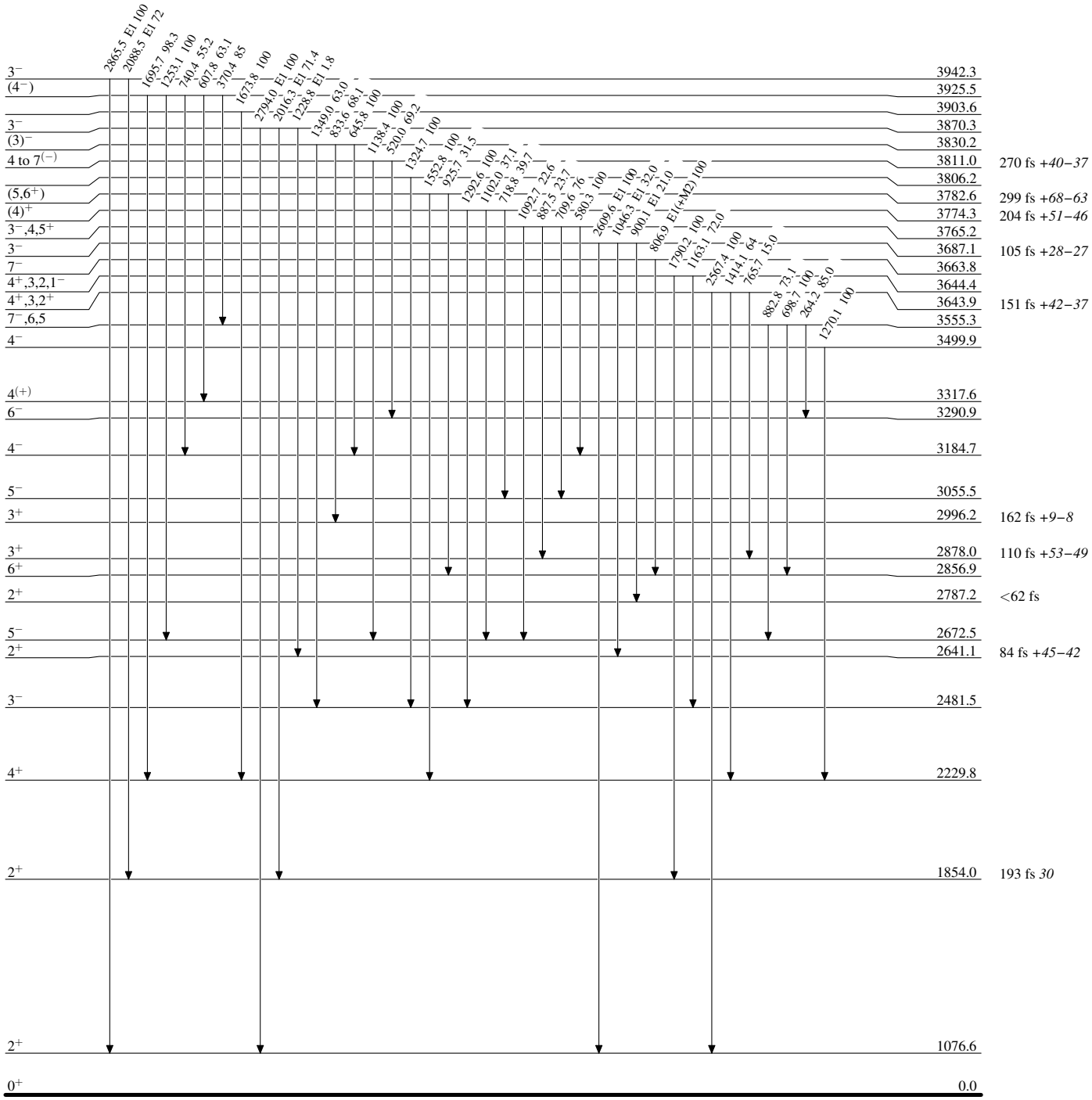
## $^{87}$Rb(p,2nγ) 2017Du08

### Level Scheme (continued)

Intensities: Relative photon branching from each level

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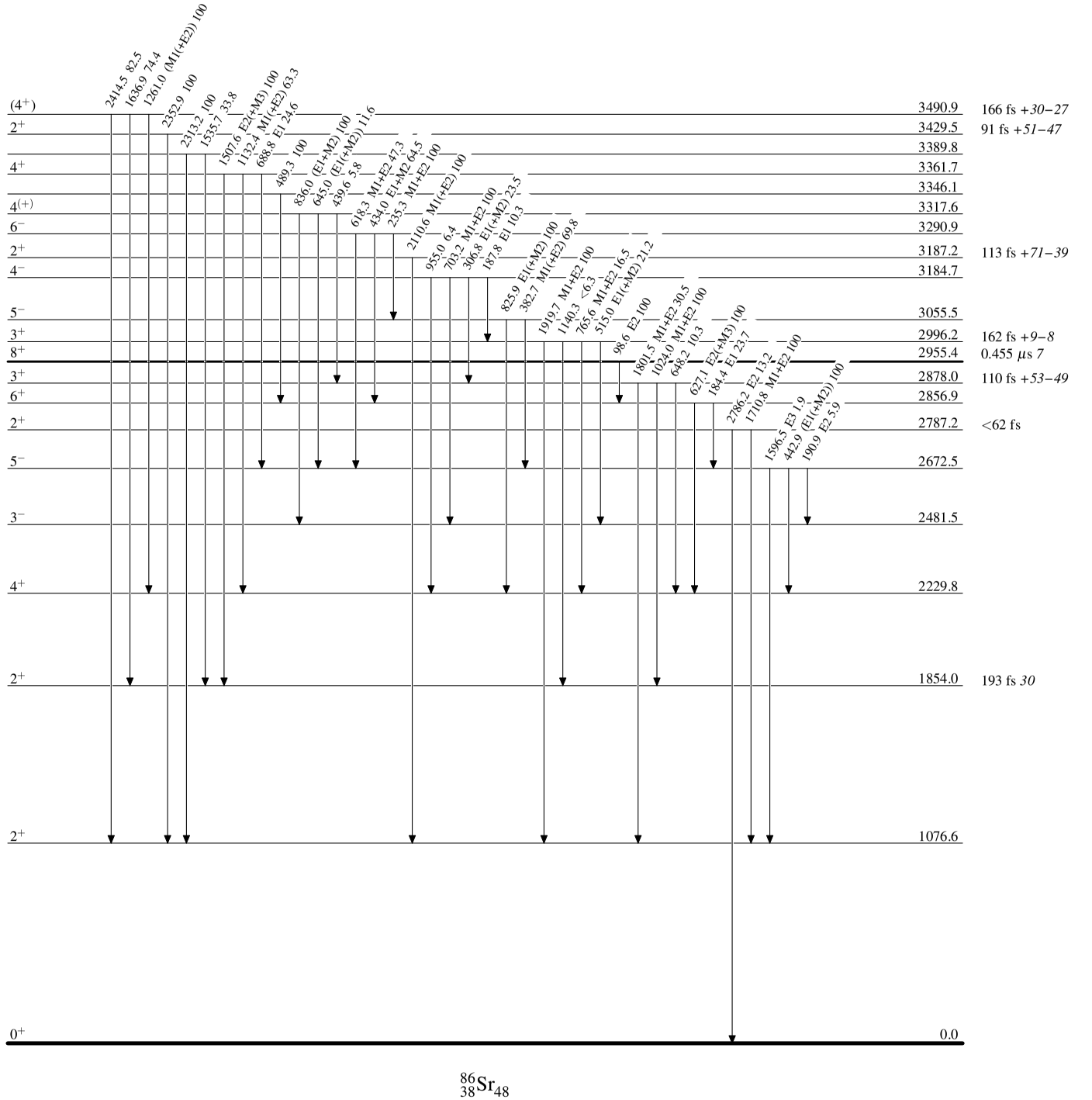
## $^{87}$Rb(p,2nγ) 2017Du08

### Level Scheme (continued)

Intensities: Relative photon branching from each level

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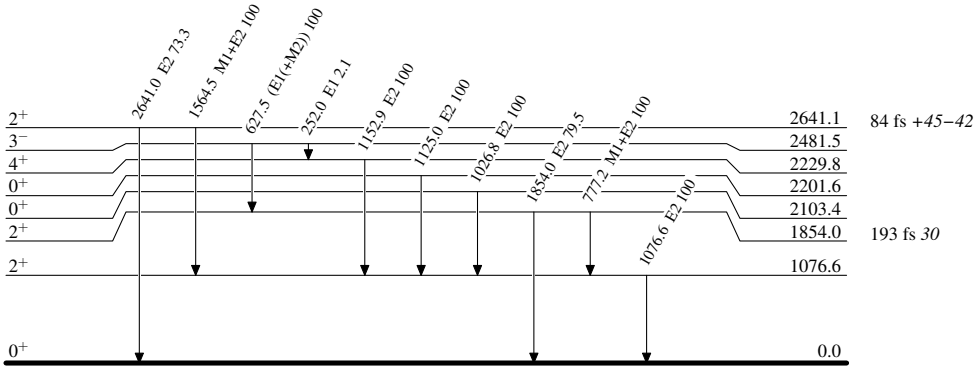
## $^{87}$Rb(p,2nγ) 2017Du08

### Level Scheme (continued)

Intensities: Relative photon branching from each level




$^{86}_{38}Sr_{48}$