## $^{90}$Zr(n,n′γ) 2003Ga23

History

| Type | Author | Citation | Literature Cutoff Date |
|---|---|---|---|
| Full Evaluation | S. K. Basu, E. A. Mccutchan | NDS 165,1 (2020) | 1-Mar-2020 |

2003Ga23: Neutrons from spallation reaction with the maximum energy of the "WHITE" neutron spectrum up to 800 MeV. For accelerator produced neutrons, E(n)≈5.5 and ≈9 MeV. Measured Eγ, Iγ, γγ, γ(θ), excitation functions, lifetimes by Doppler-shift attenuation method (DSAM) using the GEANIE detector array consisting of 11 planars and 15 HPGe detectors, nine of the HPGe detectors had BGO suppression shields.

2013Pe16: E(n) = 2.5 and 3.5 MeVn on natural Zr target; measured lifetimes of first and second $2^+$ levels in $^{90}$Zr by Doppler-shift attenuation method (DSAM); used ZR metal and oxide targets of natural isotopic abundance.

1971Gl11: E(n)=2.85-5.97 MeV, enriched target, semi. Measured Eγ, Iγ.

1963Sc14: Be(d,n) source, natural target, scin. Measured Eγ, Iγ, $T_{1/2}$.

Others: 1959Kl46, 1963Wa08, 1972Br53.

### $^{90}$Zr Levels

| E(level)† | Jπ‡ | $T_{1/2}$# | Comments |
|---|---|---|---|
| 0.0 | $0^+$ | | |
| 1760.61 *9* | $0^+$ | 62 ns *4* | $T_{1/2}$: from 1959Kl46. |
| 2186.21 *6* | $2^+$ | 86.6 fs *+49−42* | $T_{1/2}$: from DSAM (2013Pe13). Value is the average of half-lives obtained from the metal and oxide scattering samples. |
| 2318.96 *6* | $5^-$ | 809.2 ms *20* | $T_{1/2}$: from 1972Br53. Other: 801 ms *5* (1963Wa08). |
| 2739.27 *8* | $4^-$ | | |
| 2747.60 *6* | $3^-$ | | |
| 3076.79 *7* | $4^+$ | | |
| 3308.10 *8* | $2^+$ | 67.9 fs *+42−35* | $T_{1/2}$: from DSAM (2013Pe16); measurement with metallic sample. |
| 3448.14 *10* | $6^+$ | >1.46 ps | |
| 3589.29 *12* | $8^+$ | | |
| 3842.27 *13* | $2^+$ | 24 fs *5* | |
| 3958.59 *10* | $5^-$ | 33 fs *6* | |
| 4058.07 *9* | $4^+$ | 0.12 ps *+6−4* | Jπ: shape of excitation function consistent with J=4 (2003Ga23). |
| 4124.49 *14* | $0^+$ | | |
| 4225.35 *12* | $4^-$ | 20 fs *5* | |
| 4229.05 *9* | $2^+$ | 27 fs *3* | |
| 4231.93 *13* | $(6^-)$ | 45 fs *+37−19* | |
| 4236.96 *10* | $(1,2^+)$ | 104 fs *21* | |
| 4262.37 *8* | $3^+$ | 0.28 ps *+13−7* | Jπ: shape of excitation function consistent with J=3 (2003Ga23). |
| 4299.12 *11* | $(5^-)$ | 31 fs *6* | Jπ: shape of excitation function consistent with J=4 or 5 (2003Ga23). |
| 4331.93 *9* | $4^+$ | 37 fs *6* | |
| 4348.10 *13* | $(4^+)$ | 29 fs *7* | $T_{1/2}$: likely contamination of the 2161.9γ from $^{209}$Bi makes the lifetime derived from DSAM using this transition suspect (2003Ga23). Jπ: shape of excitation function consistent with J=4 (2003Ga23). |
| 4374.76 *14* | $7^-$ | | |
| 4426.43 *13* | $0^+$ | 0.20 ps *+24−8* | |
| 4454.71 *10* | $(5^+)$ | | Jπ: shape of excitation function consistent with J=4 or 5 (2003Ga23). |
| 4455.58 *10* | $2^{(-)}$ | 0.14 ps *+5−3* | Jπ: shape of excitation function consistent with J=2 or 3 (2003Ga23). |
| 4474.31 *14* | $4^+$ | 0.15 ps *+18−6* | |
| 4494.79 *12* | $3^-$ | 42 fs *8* | |
| 4533.52 *10* | $3^-$ | 69 fs *+35−28* | Jπ: shape of excitation function consistent with J=3 (2003Ga23). |
| 4537.70 *11* | $4^{(-)}$ | 0.13 ps *+7−5* | Jπ: shape of excitation function consistent with J=4 (2003Ga23). |
| 4541.37 *12* | $6^+$ | 59 fs *+17−12* | |
| 4562.02 *14* | 5 | 0.14 ps *+10−4* | Jπ: shape of excitation function consistent with J=5 (2003Ga23). |
| 4578.93 *13* | $1^{(+)}$ | 5.1 fs *20* | |
| 4591.37 *10* | $3^+$ | 0.14 ps *+4−3* | Jπ: shape of excitation function consistent with J=3 (2003Ga23). |
| 4614.42 *13* | $6^+$ | | Jπ: shape of excitation function consistent with J=6 (2003Ga23). |
| 4640.58 *17* | 7,8 | | |

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## $^{90}$Zr(n,n′γ) 2003Ga23 (continued)

### $^{90}$Zr Levels (continued)

| E(level)[†] | Jπ[‡] | $T_{1/2}$[#] | Comments |
|---|---|---|---|
| 4646.7 *3* | 1,2$^+$ | 5 fs *4* | |
| 4681.26 *12* | 2$^+$ | 31 fs *7* | |
| 4701.10 *10* | 2$^+$ | 46 fs *7* | |
| 4774.29 *13* | (1,2)$^+$ | | |
| 4781.81 *20* | 4,(3$^-$) | 14 fs *+22−13* | Jπ: shape of excitation function consistent with J=3 or 4 (2003Ga23). |
| 4795.6 *3* | 2$^+$ | 7 fs *+6−3* | |
| 4814.44 *11* | 3$^-$ | | |
| 4818.02 *12* | 3,4$^+$ | 0.14 ps *+19−7* | Jπ: shape of excitation function consistent with J=3 or 4 (2003Ga23). |
| 4824.21 *13* | 2$^+$ | 40 fs *+10−8* | |
| 4840.27 *14* | 5$^-$ | 83 fs *+28−14* | Jπ: shape of excitation function consistent with J=5 (2003Ga23). |
| 4867.47 *12* | 5$^+$ | 0.14 ps *+5−4* | Jπ: shape of excitation function consistent with J=5 (2003Ga23). |
| 4932.6 *4* | 1,2$^+$ | 0.18 ps *+35−11* | $T_{1/2}$: positive part of the uncertainty is missing in Table II of 2003Ga23; estimated here from listed uncertainties for F(τ) value. |
| 4941.89 *13* | 4$^+$ | 49 fs *10* | |
| 4992.36 *12* | 2$^-$ | 0.21 ps *+13−6* | |
| 5060.85 *17* | 7$^+$ | | |
| 5068.6 *6* | 1$^-$ | 7 fs *+13−6* | |
| 5084.03 *14* | 2$^{(-)}$,3$^{(-)}$ | 46 fs *+12−10* | Jπ: shape of excitation function consistent with J=2 or 3 (2003Ga23). |
| 5090.30 *23* | (3$^-$) | | Jπ: shape of excitation function consistent with J=3 (2003Ga23). |
| 5107.92 *21* | (3),4$^+$ | 0.07 ps *+4−3* | |
| 5112.6 *14* | 3$^-$ | | |
| 5171.90 *16* | (4) | 23 fs *+8−6* | Jπ: shape of excitation function consistent with J=4 (2003Ga23). |
| 5175.8 *3* | 3,4$^+$ | 22 fs *+21−8* | Jπ: shape of excitation function consistent with J=3 or 4 (2003Ga23). |
| 5183.61 *18* | 1$^+$,2$^+$ | 6.9 fs *35* | |
| 5222.97 *23* | 4$^+$ | | |
| 5232.3 *3* | 3,4$^+$ | 34.0 fs *28* | |
| 5270.74 *20* | 3,4 | 17 fs *+53−16* | |
| 5305.97 *20* | 2$^+$ | 17 fs *5* | |
| 5307.75 *15* | 3$^-$,4$^+$ | 0.07 ps *+8−2* | |
| 5312.77 *20* | 1,(2$^+$) | 59 fs *10* | |
| 5317.7 *3* | 3$^-$ | 0.19 ps *+11−6* | |
| 5359.22 *19* | 3$^+$,4 | 22.9 fs *28* | Jπ: shape of excitation function consistent with J=3 or 4 (2003Ga23). |
| 5379.8 *3* | 4$^+$ | 20 fs *4* | |
| 5426.01 *13* | 3$^-$ | 52 fs *+19−14* | |
| 5437.33 *13* | 2$^+$ | 24.3 fs *35* | |
| 5457.70 *18* | 4$^+$ | 115.9 fs *28* | |
| 5504.75 *19* | 1$^-$ | 7.7 fs *7* | |
| 5513.41 *16* | (3,4) | 0.16 ps *+8−6* | |
| 5564.2 *4* | 2,3,4 | 7.6 fs *28* | |
| 5590.58 *14* | 2$^+$ | 15.9 fs *21* | |
| 5601.8 *4* | 3,4$^+$ | 24 fs *4* | |
| 5607.6 *4* | 3,4$^+$ | 14 fs *+9−7* | |
| 5651.1 *3* | | 45 fs *5* | |
| 5724.3 *4* | | 22 fs *4* | |
| 5775.1 *5* | | 24 fs *+21−6* | |
| 5821.8 *6* | | | |
| 5846.4 *5* | | 14 fs *+44−13* | |

[†] From least-squares fit to Eγ′s; systematic uncertainty of 0.1 keV for each γ ray was added in quadrature in this procedure.
[‡] As proposed by 2003Ga23 based on γ(θ), excitation functions and decay pattern.
[#] From DSAM measurements (2003Ga23), except where noted.

## $^{90}$Zr(n,n′γ) 2003Ga23 (continued)

### γ($^{90}$Zr)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$[†] | $I_\gamma$[‡] | $E_f$ | $J_f^\pi$ | Mult.[@] | δ[&] | Comments |
|---|---|---|---|---|---|---|---|---|
| 1760.61 | $0^+$ | 1760.70 *20* | | 0.0 | $0^+$ | E0 | | $E_\gamma$,Mult.: from the Adopted Levels. |
| 2186.21 | $2^+$ | 2186.224 *23* | 100 | 0.0 | $0^+$ | Q | | $A_2$=+0.20 *2* |
| 2318.96 | $5^-$ | 132.716 *18* | | 2186.21 | $2^+$ | | | α(K)exp=2.2 *3* (1963Sc14)<br>Mult.: from α(K)exp. |
| | | 2318.96 *3* | | 0.0 | $0^+$ | | | |
| 2739.27 | $4^-$ | 420.321 *13* | 100 | 2318.96 | $5^-$ | D | | $A_2$=+0.05 *2* |
| 2747.60 | $3^-$ | 429.0 *3* | 0.5 *1* | 2318.96 | $5^-$ | | | |
| | | 561.3 *1* | 93.8 *3* | 2186.21 | $2^+$ | D | | $A_2$=−0.06 *1* |
| | | 2747.47 *5* | 5.7 *3* | 0.0 | $0^+$ | O | | $A_2$=+0.55 *8* |
| 3076.79 | $4^+$ | 329.125 *15* | 6.0 *3* | 2747.60 | $3^-$ | D | | $A_2$=−0.05 *6* |
| | | 337.8 *2* | 0.8 *1* | 2739.27 | $4^-$ | | | |
| | | 757.80 *4* | 2.5 *1* | 2318.96 | $5^-$ | | | |
| | | 890.629 *14* | 90.7 *3* | 2186.21 | $2^+$ | Q | | $A_2$=+0.40 *3* |
| 3308.10 | $2^+$ | 1121.990 *22* | 30 *3* | 2186.21 | $2^+$ | D+Q | +0.25 | $A_2$=+0.31 *6*<br>δ: other: +1.3. |
| | | 1547.5[#] | 2.6 *7* | 1760.61 | $0^+$ | | | |
| | | 3308.1 *2* | 67 *3* | 0.0 | $0^+$ | Q | | $A_2$=+0.29 *3* |
| 3448.14 | $6^+$ | 1129.113 *17* | 100 | 2318.96 | $5^-$ | D | | $A_2$=+0.0 *1* |
| 3589.29 | $8^+$ | 141.178 *15* | | 3448.14 | $6^+$ | | | |
| | | 1270.16 *16* | | 2318.96 | $5^-$ | | | |
| 3842.27 | $2^+$ | 1656.05 *11* | 14.5 *13* | 2186.21 | $2^+$ | D+Q | +1.1 | $A_2$=+0.43 *7*<br>δ: other: +0.3. |
| | | 3842.2 *4* | 85.5 *13* | 0.0 | $0^+$ | Q | | $A_2$=+0.38 *2* |
| 3958.59 | $5^-$ | 1219.33 *3* | 35.0 *8* | 2739.27 | $4^-$ | D+Q | +0.08 | $A_2$=−0.16 *7* |
| | | 1639.60 *4* | 65.0 *8* | 2318.96 | $5^-$ | D+Q | +0.06 | $A_2$=+0.48 *4* |
| 4058.07 | $4^+$ | 981.31 *7* | 6.8 *13* | 3076.79 | $4^+$ | D+Q | −0.11 | $A_2$=+0.31 *23* |
| | | 1310.00 *18* | 3.7 *12* | 2747.60 | $3^-$ | | | |
| | | 1318.92 *19* | 2.1 *11* | 2739.27 | $4^-$ | | | |
| | | 1871.90 *3* | 87 *3* | 2186.21 | $2^+$ | Q | | $A_2$=+0.46 *5* |
| 4124.49 | $0^+$ | 1938.26 *6* | 100 | 2186.21 | $2^+$ | | | |
| 4225.35 | $4^-$ | 1478.02 *16* | 15 *3* | 2747.60 | $3^-$ | | | |
| | | 1485.75 *14* | 67 *3* | 2739.27 | $4^-$ | D+Q | +0.31 | $A_2$=+0.54 *5* |
| | | 1906.50 *17* | 18 *4* | 2318.96 | $5^-$ | D+Q | −0.57 | $A_2$=+0.43 *14* |
| 4229.05 | $2^+$ | 1481.40 *6* | 34 *8* | 2747.60 | $3^-$ | | | |
| | | 2042.73 *4* | 52 *6* | 2186.21 | $2^+$ | D+Q | +0.04 | $A_2$=+0.30 *8*<br>δ: other: +2.0. |
| | | 4229.3 *2* | 14.5 *24* | 0.0 | $0^+$ | Q | | $A_2$=+0.47 *7* |
| 4231.93 | $(6^-)$ | 1912.94 *4* | 100 | 2318.96 | $5^-$ | D+Q | +0.5 | $A_2$=+0.50 *25* |
| 4236.96 | $(1,2^+)$ | 929.01 *18* | 5.7 *2* | 3308.10 | $2^+$ | | | |
| | | 2050.81 *9* | 19.8 *35* | 2186.21 | $2^+$ | | | |
| | | 2476.22 *4* | 74.4 *35* | 1760.61 | $0^+$ | | | |
| 4262.37 | $3^+$ | 954.2 *1* | 6.9 *6* | 3308.10 | $2^+$ | D+Q | +0.06 | $A_2$=−0.20 *13* |
| | | 1185.56 *5* | 14.1 *15* | 3076.79 | $4^+$ | D+Q | −3.1 | $A_2$=+0.11 *20*<br>δ: other: −0.2. |
| | | 1514.8 *1* | 14.8 *25* | 2747.60 | $3^-$ | | | $A_2$=+0.38 *14* |
| | | 1523.07 *4* | 29.4 *7* | 2739.27 | $4^-$ | | | $A_2$=−0.01 *11* |
| | | 2076.20 *4* | 34.7 *16* | 2186.21 | $2^+$ | D+Q | +0.6 | $A_2$=+0.44 *10* |
| 4299.12 | $(5^-)$ | 1559.91 *7* | 33.5 *11* | 2739.27 | $4^-$ | D+Q | +0.34 | $A_2$=+0.30 *9* |
| | | 1980.06 *8* | 66.5 *11* | 2318.96 | $5^-$ | D+Q | +0.85 | $A_2$=+0.40 *7* |
| 4331.93 | $4^+$ | 1255.18 *3* | 38.2 *11* | 3076.79 | $4^+$ | D+Q | +0.1 | $A_2$=+0.48 *4* |
| | | 1584.25 *4* | 51.3 *14* | 2747.60 | $3^-$ | | | $A_2$=−0.08 *5* |
| | | 2012.9 *2* | 10.5 *20* | 2318.96 | $5^-$ | | | |
| 4348.10 | $(4^+)$ | 1608.8[#] | | 2739.27 | $4^-$ | | | placement from γγ coin. |
| | | 2161.87 *3* | 100 | 2186.21 | $2^+$ | | | $A_2$=−0.12 *5* |

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## $^{90}$Zr(n,n′γ) 2003Ga23 (continued)

### γ($^{90}$Zr) (continued)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$[†] | $I_\gamma$[‡] | $E_f$ | $J_f^\pi$ | Mult.[@] | δ[&] | Comments |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | $A_2$ likely has contamination from $^{209}$Bi (2003Ga23). |
| 4374.76 | $7^-$ | 2055.77 *7* | 100 | 2318.96 | $5^-$ | Q | | $A_2$=+0.31 *19* |
| 4426.43 | $0^+$ | 2240.20 *5* | 100 | 2186.21 | $2^+$ | | | $A_2$=0.00 *7* |
| 4454.71 | $(5^+)$ | 1377.74 *12* | 11.9 *22* | 3076.79 | $4^+$ | | | |
| | | 1715.73 *14* | 13.8 *50* | 2739.27 | $4^-$ | | | |
| | | 2135.70 *5* | 74.3 *51* | 2318.96 | $5^-$ | | | $A_2$=+0.53 *10* |
| 4455.58 | $2^{(-)}$ | 1707.90 *5* | 42.7 *25* | 2747.60 | $3^-$ | D+Q | +0.024 | $A_2$=−0.10 *7* |
| | | 2269.40 *4* | 57.3 *25* | 2186.21 | $2^+$ | | | $A_2$=+0.32 *9* |
| 4474.31 | $4^+$ | 1726.68 *7* | 71.3 *33* | 2747.60 | $3^-$ | | | |
| | | 1735.0[#] | 28.7 *33* | 2739.27 | $4^-$ | | | |
| 4494.79 | $3^-$ | 1747.2 *2* | 4.7 *30* | 2747.60 | $3^-$ | | | |
| | | 1755.49 *4* | 95.3 *30* | 2739.27 | $4^-$ | D+Q | −0.02 | $A_2$=−0.08 *3*<br>δ: other: −6.4. |
| 4533.52 | $3^-$ | 1225.3[a] *2* | 10.4 *13* | 3308.10 | $2^+$ | | | |
| | | 1456.78 *4* | 58.9 *62* | 3076.79 | $4^+$ | | | $A_2$=+0.54 *11* |
| | | 1794.15 *6* | 22.7 *23* | 2739.27 | $4^-$ | D+Q | +2.0 | $A_2$=+0.12 *9*<br>δ: other: −0.4. |
| | | 2347.3[#] | 8.0 *22* | 2186.21 | $2^+$ | | | |
| 4537.70 | $4^{(-)}$ | 1460.95 *6* | 38.5 *35* | 3076.79 | $4^+$ | | | |
| | | 2218.65 *7* | 61.5 *35* | 2318.96 | $5^-$ | D+Q | −0.36 | $A_2$=+0.3 *3*<br>δ: other: −1.8. |
| 4541.37 | $6^+$ | 1092.97 *23* | 7.5 *20* | 3448.14 | $6^+$ | | | |
| | | 2222.43 *4* | 92.5 *20* | 2318.96 | $5^-$ | | | |
| 4562.02 | 5 | 1822.74 *5* | 100 | 2739.27 | $4^-$ | | | |
| 4578.93 | $1^{(+)}$ | 2818.33 *10* | 54.5 *44* | 1760.61 | $0^+$ | | | |
| | | 4578.7 *2* | 45.5 *44* | 0.0 | $0^+$ | | | $A_2$=−0.01 *7* |
| 4591.37 | $3^+$ | 1843.70 *5* | 73.2 *9* | 2747.60 | $3^-$ | | | $A_2$=+0.43 *6* |
| | | 2405.18 *7* | 26.8 *9* | 2186.21 | $2^+$ | D+Q | −0.07 | $A_2$=−0.38 *7* |
| 4614.42 | $6^+$ | 1166.24 *12* | 40 *4* | 3448.14 | $6^+$ | | | |
| | | 1537.64 *12* | 30 *4* | 3076.79 | $4^+$ | | | |
| | | 2295.5[#] | 30 *3* | 2318.96 | $5^-$ | | | |
| 4640.58 | 7,8 | 1051.29 *4* | 100 | 3589.29 | $8^+$ | | | |
| 4646.7 | $1,2^+$ | 2884.8 *13* | 84.5 *24* | 1760.61 | $0^+$ | | | |
| | | 4646.6 *3* | 15.5 *24* | 0.0 | $0^+$ | | | |
| 4681.26 | $2^+$ | 1933.77 *8* | 50 *5* | 2747.60 | $3^-$ | | | |
| | | 2495.1[#] | 21 *3* | 2186.21 | $2^+$ | | | |
| | | 4680.8 *2* | 29 *4* | 0.0 | $0^+$ | Q | | $A_2$=+0.51 *7* |
| 4701.10 | $2^+$ | 1953.26 *17* | 39.6 *18* | 2747.60 | $3^-$ | | | |
| | | 2514.76 *13* | 15.4 *11* | 2186.21 | $2^+$ | | | |
| | | 2940.60 *12* | 37.6 *17* | 1760.61 | $0^+$ | Q | | $A_2$=+0.51 *11* |
| | | 4701.2 *3* | 7.4 *16* | 0.0 | $0^+$ | Q | | $A_2$=+0.7 *4* |
| 4774.29 | $(1,2)^+$ | 537.34 *5* | 25.4 *24* | 4236.96 | $(1,2^+)$ | | | |
| | | 2587.96 *25* | 74.6 *24* | 2186.21 | $2^+$ | | | |
| 4781.81 | $4,(3^-)$ | 2462.81 *19* | 100 | 2318.96 | $5^-$ | | | |
| 4795.6 | $2^+$ | 4795.5 *3* | 100 | 0.0 | $0^+$ | Q | | $A_2$=+0.5 *3* |
| 4814.44 | $3^-$ | 2066.95 *8* | 76 *5* | 2747.60 | $3^-$ | D+Q | +0.34 | $A_2$=+0.7 *3* |
| | | 2495.5[#] | 12.0 *23* | 2318.96 | $5^-$ | | | |
| | | 2628.01 *10* | 12.5 *24* | 2186.21 | $2^+$ | | | $A_2$=−0.02 *9* |
| 4818.02 | $3,4^+$ | 975.75 *15* | 14 *3* | 3842.27 | $2^+$ | | | |
| | | 2070.39 *7* | 86 *3* | 2747.60 | $3^-$ | | | |
| 4824.21 | $2^+$ | 1747.2 *2* | 6 *4* | 3076.79 | $4^+$ | | | |
| | | 2638.07 *11* | 80 *4* | 2186.21 | $2^+$ | D+Q | +0.11 | $A_2$=+0.34 *6*<br>δ: other: +1.7. |

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## $^{90}$Zr(n,n′γ) 2003Ga23 (continued)

### γ($^{90}$Zr) (continued)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$[†] | $I_\gamma$[‡] | $E_f$ | $J_f^\pi$ | Mult.[@] | δ[&] | Comments |
|---|---|---|---|---|---|---|---|---|
| 4824.21 | $2^+$ | 4823.9 *5* | 13.9 *25* | 0.0 | $0^+$ | Q | | $A_2$=+0.75 *14* |
| 4840.27 | $5^-$ | 1763.46 *6* | 70 *4* | 3076.79 | $4^+$ | | | |
| | | 2092.7[#] | 30 *4* | 2747.60 | $3^-$ | | | |
| 4867.47 | $5^+$ | 1419.23 *10* | 31 *3* | 3448.14 | $6^+$ | D+Q | −1.0 | $A_2$=+0.58 *14* |
| | | 1790.73 *8* | 59 *5* | 3076.79 | $4^+$ | D+Q | +0.8 | $A_2$=+0.75 *16* |
| | | 2128.2[#] | 10 *4* | 2739.27 | $4^-$ | | | |
| 4932.6 | $1,2^+$ | 4932.5 *4* | 100 | 0.0 | $0^+$ | | | |
| 4941.89 | $4^+$ | 1865.03 *8* | 75.7 *24* | 3076.79 | $4^+$ | | | |
| | | 2623.0 *2* | 24.3 *24* | 2318.96 | $5^-$ | | | |
| 4992.36 | $2^-$ | 1150.3[#] | 16.6 *17* | 3842.27 | $2^+$ | | | |
| | | 1684.35 *8* | 55 *3* | 3308.10 | $2^+$ | | | $A_2$=+0.35 *7* |
| | | 2244.5 *3* | 17.2 *17* | 2747.60 | $3^-$ | | | |
| | | 2252.9 *2* | 10.8 *16* | 2739.27 | $4^-$ | | | |
| 5060.85 | $7^+$ | 1612.69 *11* | 100 | 3448.14 | $6^+$ | | | |
| 5068.6 | $1^-$ | 5068.4 *6* | 100 | 0.0 | $0^+$ | | | |
| 5084.03 | $2^{(-)},3^{(-)}$ | 2336.18 *10* | 73 *5* | 2747.60 | $3^-$ | | | |
| | | 2345.7 *3* | 27 *5* | 2739.27 | $4^-$ | | | |
| 5090.30 | $(3^-)$ | 2904.03 *23* | 100 | 2186.21 | $2^+$ | | | |
| 5107.92 | $(3),4^+$ | 2368.6[#] | | 2739.27 | $4^-$ | | | |
| | | 2921.7 *2* | 100 | 2186.21 | $2^+$ | | | $A_2$=+0.51 *14* |
| 5112.6 | $3^-$ | 2365.0 *10* | 100 | 2747.60 | $3^-$ | D+Q | −0.1 | $A_2$=+0.25 *11*<br>$E_\gamma$: from γγ coin spectra. |
| 5171.90 | (4) | 2432.0 *3* | 36 *3* | 2739.27 | $4^-$ | | | $A_2$=+0.6 *3* |
| | | 2853.06 *14* | 64 *3* | 2318.96 | $5^-$ | | | |
| 5175.8 | $3,4^+$ | 2989.5 *3* | 100 | 2186.21 | $2^+$ | | | |
| 5183.61 | $1^+,2^+$ | 2997.5 *2* | 46 *7* | 2186.21 | $2^+$ | | | |
| | | 5183.2 *3* | 54 *7* | 0.0 | $0^+$ | | | |
| 5222.97 | $4^+$ | 2483.67 *19* | 100 | 2739.27 | $4^-$ | | | $A_2$=+0.41 *23* |
| 5232.3 | $3,4^+$ | 3046.0 *3* | 100 | 2186.21 | $2^+$ | | | |
| 5270.74 | 3,4 | 2531.44 *16* | 100 | 2739.27 | $4^-$ | | | |
| 5305.97 | $2^+$ | 5305.8 *2* | 100 | 0.0 | $0^+$ | Q | | $A_2$=+0.26 *19* |
| 5307.75 | $3^-,4^+$ | 2560.2 *4* | 10 *4* | 2747.60 | $3^-$ | | | |
| | | 2988.9 *2* | 15 *3* | 2318.96 | $5^-$ | | | |
| | | 3121.3 *2* | 75 *5* | 2186.21 | $2^+$ | | | |
| 5312.77 | $1,(2^+)$ | 3551.4[a] *6* | | 1760.61 | $0^+$ | | | |
| | | 5312.6 *2* | 100 | 0.0 | $0^+$ | | | |
| 5317.7 | $3^-$ | 2570.2 *4* | 58 *7* | 2747.60 | $3^-$ | | | |
| | | 3131.2 *4* | 42 *7* | 2186.21 | $2^+$ | | | |
| 5359.22 | $3^+,4$ | 2282.4 *2* | 100 | 3076.79 | $4^+$ | | | $A_2$=+0.34 *13* |
| 5379.8 | $4^+$ | 3193.6 *3* | 100 | 2186.21 | $2^+$ | | | |
| 5426.01 | $3^-$ | 2118.1 *2* | 48.2 *86* | 3308.10 | $2^+$ | | | |
| | | 3106.8 *2* | 38.4 *66* | 2318.96 | $5^-$ | Q | | $A_2$=+0.7 *4* |
| | | 3239.7 *2* | 13.3 *28* | 2186.21 | $2^+$ | | | |
| 5437.33 | $2^+$ | 2690.08 *23* | 61.8 *20* | 2747.60 | $3^-$ | | | $A_2$=−0.14 *14* |
| | | 3676.6 *2* | 21.0 *17* | 1760.61 | $0^+$ | Q | | $A_2$=+0.48 *23* |
| | | 5436.9 *2* | 18.0 *11* | 0.0 | $0^+$ | Q | | $A_2$=+0.47 *19* |
| 5457.70 | $4^+$ | 2380.6 *3* | 34 *11* | 3076.79 | $4^+$ | | | |
| | | 2710.2 *2* | 66 *11* | 2747.60 | $3^-$ | | | $A_2$=−0.43 *12* |
| 5504.75 | $1^-$ | 3744.5 *5* | 57 *3* | 1760.61 | $0^+$ | | | |
| | | 5504.5 *2* | 43 *3* | 0.0 | $0^+$ | | | |
| 5513.41 | (3,4) | 2436.5 *3* | 34 *8* | 3076.79 | $4^+$ | | | $A_2$=−0.21 *16* |
| | | 2765.8 *2* | 64 *8* | 2747.60 | $3^-$ | | | |
| 5564.2 | 2,3,4 | 3377.9 *4* | 100 | 2186.21 | $2^+$ | | | |
| 5590.58 | $2^+$ | 2842.9 *2* | 18.1 *30* | 2747.60 | $3^-$ | | | |

Continued on next page (footnotes at end of table)

## $^{90}$Zr(n,n′γ) 2003Ga23 (continued)

### γ($^{90}$Zr) (continued)

| $E_i$(level) | $J_i^\pi$ | $E_\gamma$ † | $I_\gamma$ ‡ | $E_f$ | $J_f^\pi$ | Mult. @ | Comments |
|---|---|---|---|---|---|---|---|
| 5590.58 | $2^+$ | 3404.1 *2* | 52.3 *24* | 2186.21 | $2^+$ | | |
| | | 5590.9 *3* | 29.7 *17* | 0.0 | $0^+$ | Q | $A_2$=+0.55 *14* |
| 5601.8 | $3,4^+$ | 3415.5 *4* | 100 | 2186.21 | $2^+$ | | $A_2$=+0.5 *3* |
| 5607.6 | $3,4^+$ | 2299.5 *3* | 100 | 3308.10 | $2^+$ | | |
| 5651.1 | | 2911.8 *3* | 100 | 2739.27 | $4^-$ | | $A_2$=+0.25 *18* |
| 5724.3 | | 3538.0 *4* | 100 | 2186.21 | $2^+$ | | $A_2$=−0.22 *15* |
| 5775.1 | | 3588.8 *5* | 100 | 2186.21 | $2^+$ | | |
| 5821.8 | | 3635.5 *6* | 100 | 2186.21 | $2^+$ | | |
| 5846.4 | | 3660.1 *5* | 100 | 2186.21 | $2^+$ | | |

† From 2003Ga23, except where noted.
‡ From 2003Ga23, except where noted. Values are relative branching from each level.
# From level energy difference. 2003Ga23 state that peak in singles spectrum was either component of unresolved doublet or heavily influenced by background.
@ From $\gamma(\theta)$ in 2003Ga23, except where noted.
& From $\gamma(\theta)$ in 2003Ga23. The value with smaller $\chi^2$ is listed in the data field while the value with larger $\chi^2$ is given in the comments.
a Placement of transition in the level scheme is uncertain.

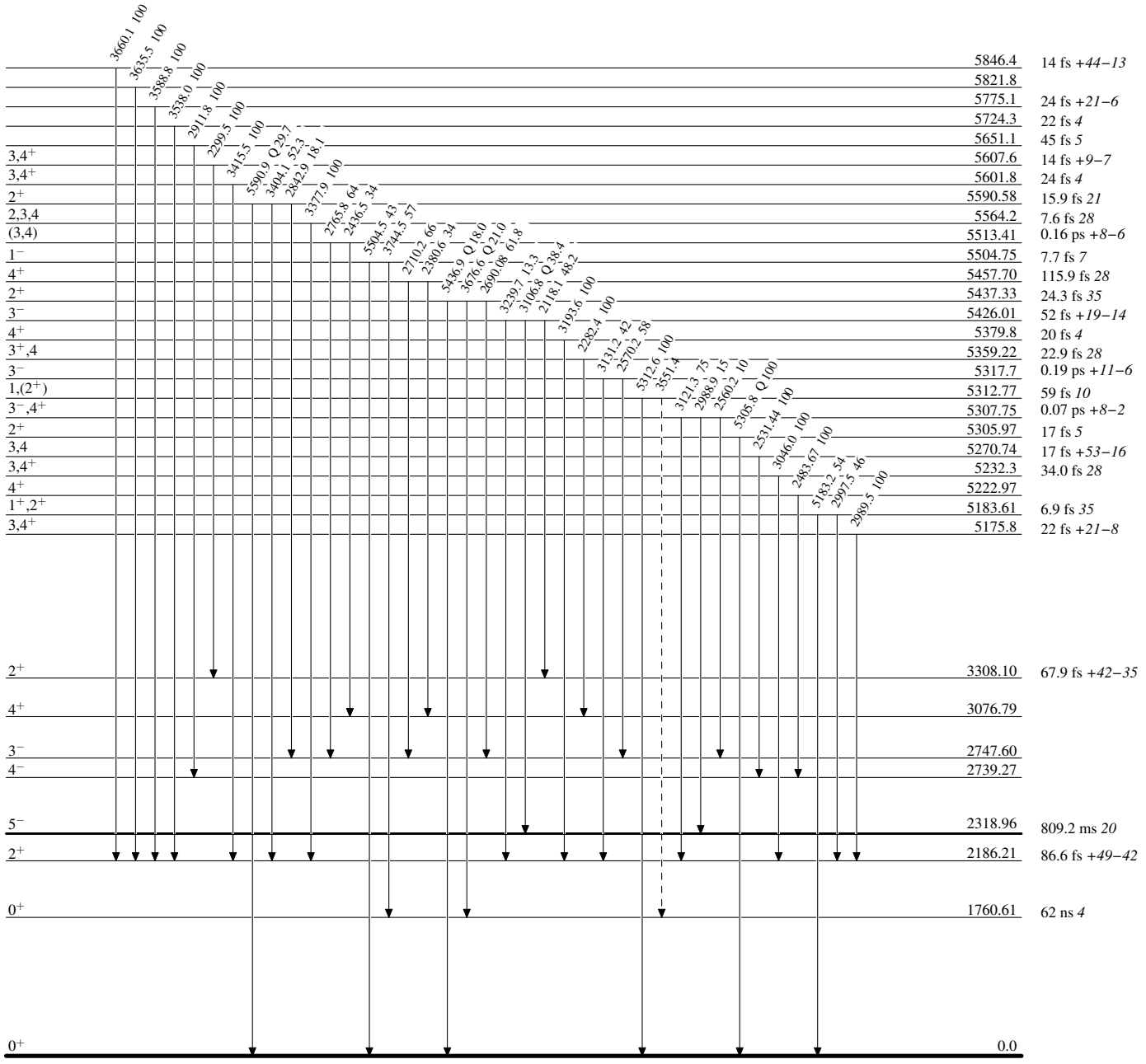
## $^{90}$Zr(n,n′γ) 2003Ga23

Legend

### Level Scheme

Intensities: % photon branching from each level

– – – – – – ► γ Decay (Uncertain)

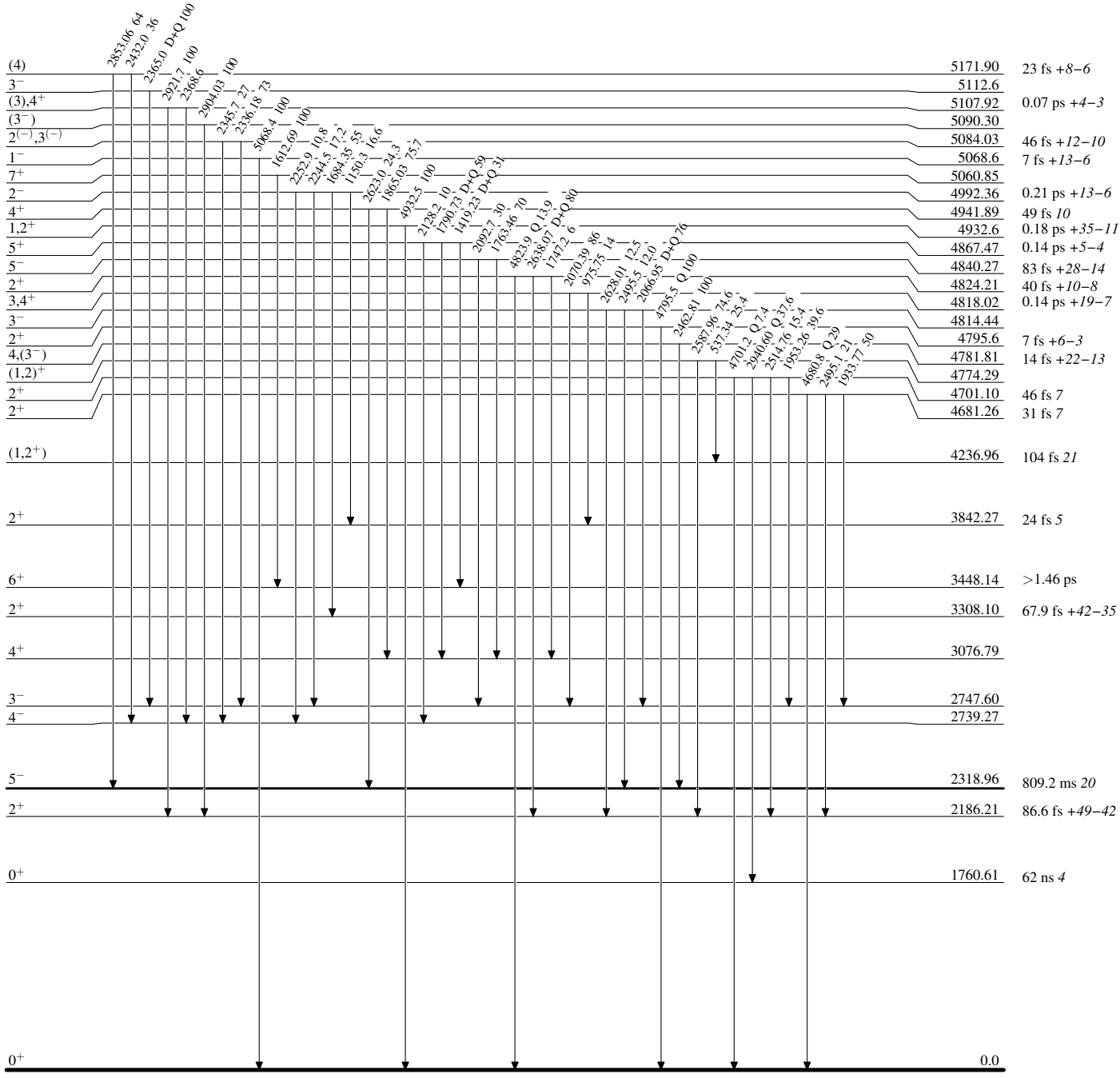



$^{90}_{40}Zr_{50}$

## $^{90}$Zr(n,n′γ) 2003Ga23

### Level Scheme (continued)

Intensities: % photon branching from each level




$^{90}_{40}Zr_{50}$

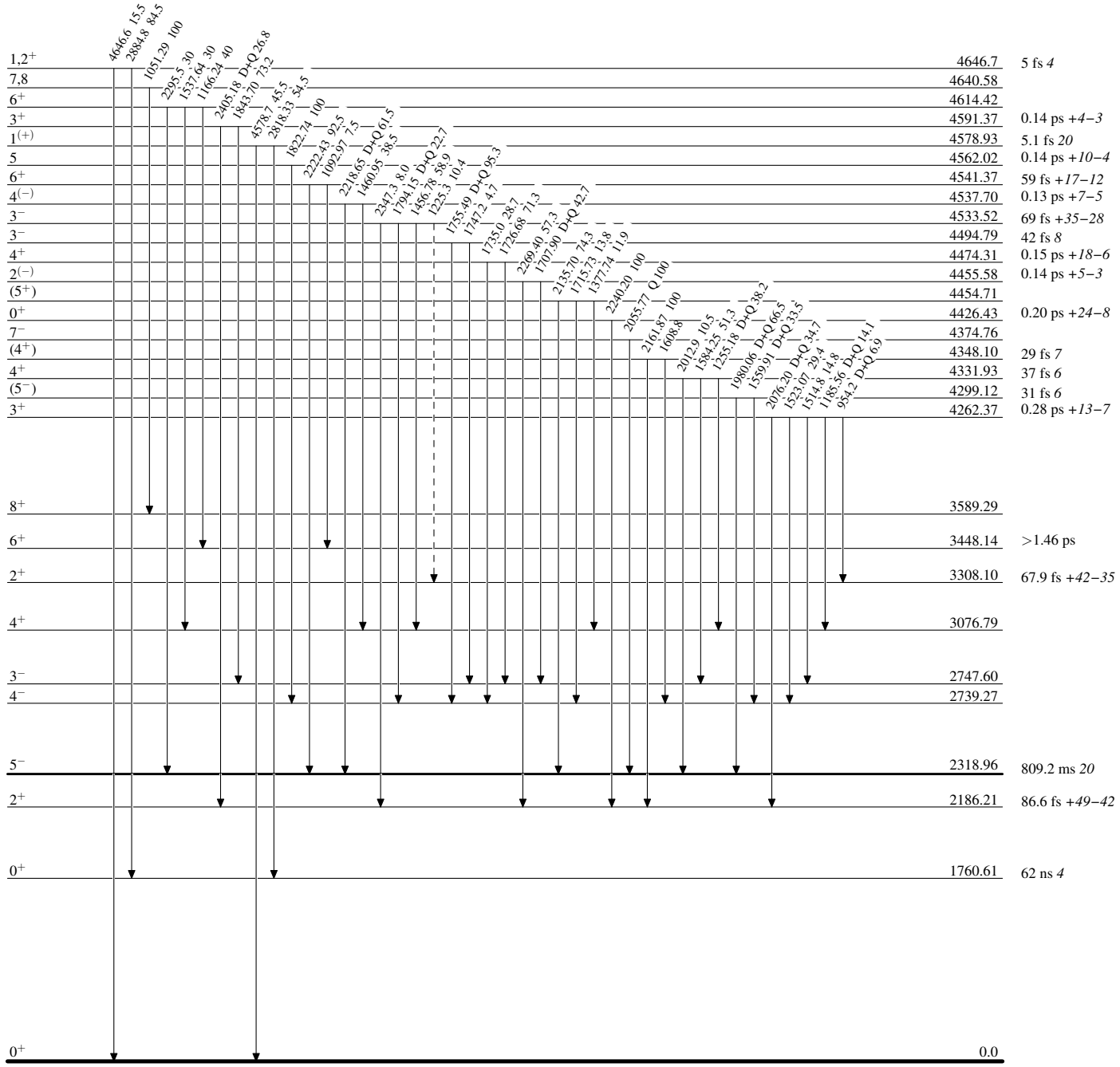
## $^{90}$Zr(n,n′γ) 2003Ga23

Legend

### Level Scheme (continued)

Intensities: % photon branching from each level

– – – – – – ► γ Decay (Uncertain)

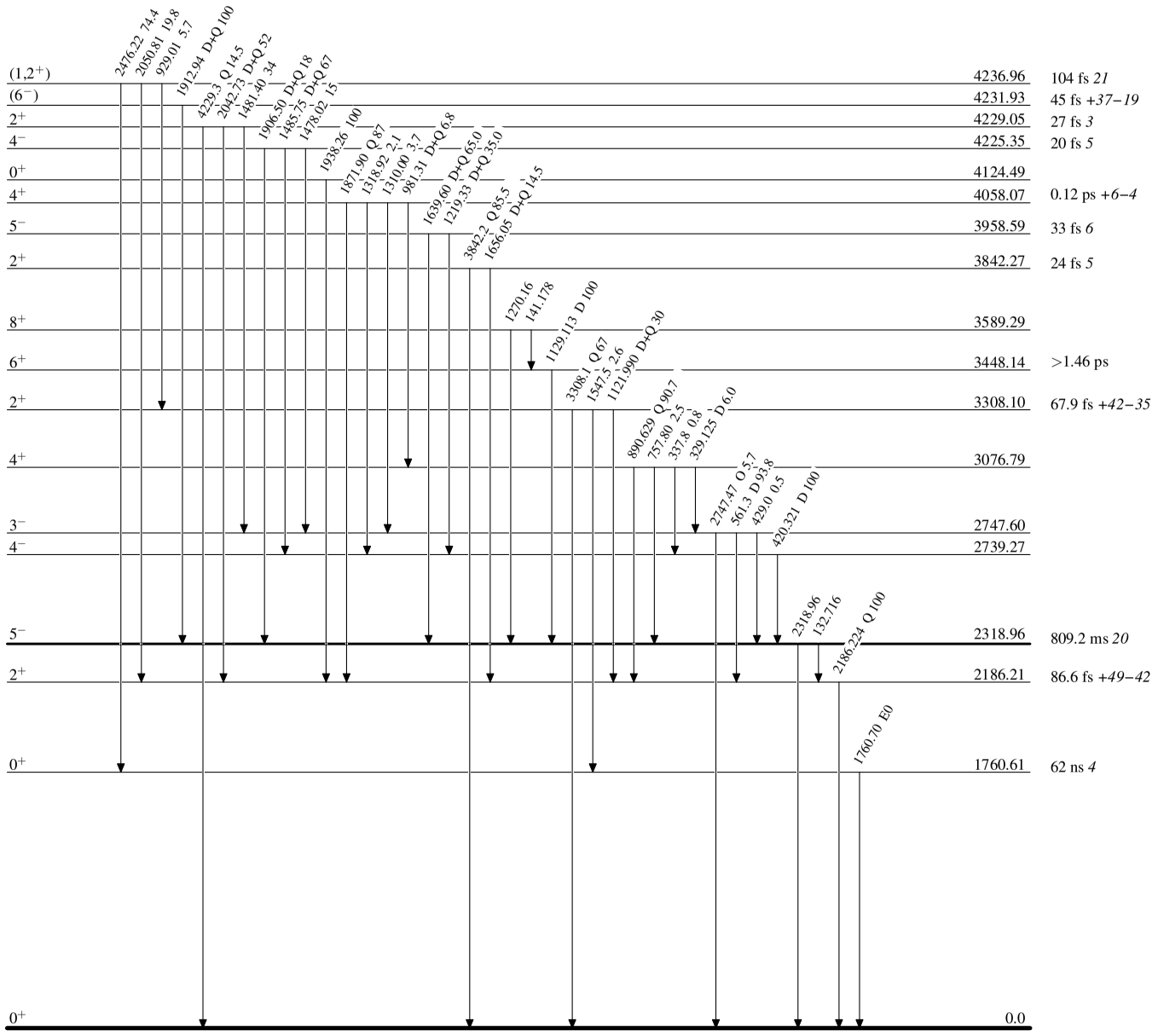



$^{90}_{40}Zr_{50}$

## $^{90}$Zr(n,n′γ) 2003Ga23

### Level Scheme (continued)

Intensities: % photon branching from each level




$^{90}_{40}Zr_{50}$