## (HI,xn$\gamma$) 1990Lu04

| Type | Author | History<br>Citation | Literature Cutoff Date |
|---|---|---|---|
| Full Evaluation | N. Nica | NDS 154, 1 (2018) | 20-Nov-2018 |

Includes (HI,xpyn$\gamma$).

$^{114}$Cd($^{30}$Si,4n$\gamma$) E($^{30}$Si)=130 MeV (1990Lu04).

$^{142}$Nd($\alpha$,6n$\gamma$) E($\alpha$)=95 MeV; $^{106}$Pd($^{37}$Cl,p2n$\gamma$) E($^{37}$Cl)=148 MeV (1988St02).

$^{116}$Cd($^{28}$Si,4n$\gamma$) E($^{28}$Si)=125 MeV (1988Ba22).

$^{106}$Pd($^{37}$Cl,p2n$\gamma$) E($^{37}$Cl)=143 MeV (1991Ca17).

$^{124}$Te($^{20}$Ne,4n$\gamma$) E($^{20}$Ne)=82 MeV (2015Be25).

E($\alpha$)=90 MeV (1979Mu03,1976Ma56), E($\alpha$)=94 MeV (1973HaWA,1972Ha23), E($^{20}$Ne)=96 MeV (1985Be23), E($^{32}$S)=126-170 MeV (1984Lu07).

Measured: $\gamma$, $\gamma\gamma$, $\gamma(\theta)$ (1990Lu04), $\gamma$, $\gamma\gamma$, $\gamma$(t) (1991Ca17,1988St02,2015Be25), $\gamma$, $\gamma\gamma$, $\gamma(\theta)$, $\gamma(\theta$,H,t) (1988Ba22); $\gamma$, $\gamma\gamma$, $\gamma$(t), $\gamma(\theta)$, excit (1984Lu07,1979Mu03,1976Ma56) $\gamma(\theta$,t,electric field gradient) (1985Be23).

E, E$\gamma$, I$\gamma$, $\gamma(\theta)$ data are from 1990Lu04.

In the figure of 1990Lu04 the cascade: 218$\gamma$-324$\gamma$-382$\gamma$-465 populate 4404, $14^+$ level, in the table of 1990Lu04 it is shown to populate 3653, $12^+$ level; the evaluator adopted the first (figure) version.

### $^{140}$Sm Levels

| E(level) | J$^{\pi}$† | T$_{1/2}$ | Comments |
|---|---|---|---|
| 0.0 | $0^+$ | | |
| 530.7 *1* | $2^+$ | 6.31 ps *42* | T$_{1/2}$: from 2015Be25 by recoil-distance Doppler-shift (RDDS) method. |
| 1245.7 *2* | $4^+$ | | |
| 2014.5 *4* | $5^-$ | | |
| 2081.8 *3* | $6^+$ | | |
| 2326.2 *4* | $7^-$ | | |
| 2959.1 *6* | | | |
| 2969.4 *3* | $8^+$ | | |
| 3127.6 *4* | $9^-$ | | |
| 3172.0 *4* | $10^+$ | 19.4 ns *7* | $\mu$=−1.76 *20* (1988Ba22,2014StZZ)<br>Q=1.67 *48* (1985Be23,2014StZZ)<br>T$_{1/2}$: from 1988Ba22; other: 22.3 ns *18* (1988St02).<br>$\mu$: From $\gamma(\theta$,H,t).<br>Q: From $\gamma(\theta$,t,electrical gradient). |
| 3194.4 *3* | $8^+$ | | |
| 3210.8 *3* | $10^+$ | 5.20 ns *14* | $\mu$=+12.7 *9* (1988Ba22,2014StZZ)<br>T$_{1/2}$: from 1988Ba22; other: 6.2 ns *8*(1988St02).<br>$\mu$: From $\gamma(\theta$,H,t). |
| 3652.7 *3* | $12^+$ | 15.2 ns *21* | T$_{1/2}$: from 1991Ca17 (recoil-distance Doppler-shift method). |
| 3790.7 *4* | $12^+$ | 7.6 ns *21* | T$_{1/2}$: from 1991Ca17 (recoil-distance Doppler-shift method). |
| 3892.4 *5* | $11^+$ | | |
| 4023.9 *6* | $11^-$ | | |
| 4044.0 *5* | $11^-$ | | |
| 4404.0 *4* | $14^+$ | 1.2 ps *5* | T$_{1/2}$: from 1991Ca17 (recoil-distance Doppler-shift method). |
| 4445.4 *5* | $13^+$ | | |
| 4487.9 *6* | $14^+$ | | |
| 4622.3 *4* | 15 | | |
| 4682.8 *5* | $12^+$ | | |
| 4854.1 *5* | $13^+$ | | |
| 4914.2 *5* | $14^+$ | | |
| 4946.6 *5* | 16 | | |
| 4990.0 *4* | $13^-$ | | |
| 5087.6 *11* | ($14^+$) | | |
| 5194.1 *4* | $14^-$ | | |
| 5254.1 *8* | $15^+$ | | |

Continued on next page (footnotes at end of table)

## (HI,xn$\gamma$) 1990Lu04 (continued)

### $^{140}$Sm Levels (continued)

| E(level) | $J^\pi$[†] | E(level) | $J^\pi$[†] | E(level) | $J^\pi$[†] | E(level) | $J^\pi$[†] |
|---|---|---|---|---|---|---|---|
| 5328.5 *6* | 17 | 5794.0 *8* | 18 | 6420.3 *7* | | 7320.4 *7* | $(20^+)$ |
| 5373.1 *5* | $(15^+)$ | 5810.7 *5* | $16^+$ | 6435.8 *7* | | 7545.7 *8* | |
| 5393.9 *8* | $(16^+)$ | 5892.6 *9* | $(16^+)$ | 6549.3 *6* | $18^+$ | 7751.5 *8* | (21) |
| 5397.8 *5* | $16^+$ | 5998.0 *8* | | 6725.4 *7* | | 7772.4 *7* | $(20^+)$ |
| 5479.1 *4* | $15^-$ | 6023.5 *5* | 17 | 6755.1 *7* | 19 | 8041.3 *9* | |
| 5489.5 *5* | $16^+$ | 6038.7 *6* | 17 | 6778.3 *9* | | 8100.7 *9* | |
| 5499.1 *4* | $15^-$ | 6166.2 *6* | $16^+$ | 6864.2 *7* | 19 | | |
| 5571.9 *5* | $15^-$ | 6272.0 *6* | $18^+$ | 7091.5 *8* | | | |
| 5706.1 *4* | 16 | 6397.0 *6* | 18 | 7269.1 *7* | (20) | | |

[†] Based on $\gamma(\theta)$ data and assumption that Q $\gamma$'s are E2, and systematic correspondence between this nucleus and its isotones ($^{139}$Pm, $^{141}$Eu) and isotopes ($^{141}$Sm, $^{142}$Sm) – see 1990Lu04 and refs herein. See Adopted dataset for adopted $J^\pi$'s.

### $\gamma$($^{140}$Sm)

| $E_\gamma$ | $I_\gamma$ | $E_i$(level) | $J_i^\pi$ | $E_f$ | $J_f^\pi$ | Mult.[†] | Comments |
|---|---|---|---|---|---|---|---|
| (16.4) | | 3210.8 | $10^+$ | 3194.4 | $8^+$ | [E2] | $E_\gamma$: from 1990Lu04 (omitted by 1994Pe19). |
| (39) | | 3210.8 | $10^+$ | 3172.0 | $10^+$ | | $I_{(\gamma+ce)}$: I($\gamma$+ce)(39$\gamma$)/I($\gamma$+ce)(241$\gamma$)=1.6 (1988Ba22). |
| (44) | | 3172.0 | $10^+$ | 3127.6 | $9^-$ | | $I_{(\gamma+ce)}$: I($\gamma$+ce)(44$\gamma$)/I($\gamma$+ce)(202.6$\gamma$)=0.3 (1988Ba22). |
| 134.3 *3* | 60 *7* | 5706.1 | 16 | 5571.9 | $15^-$ | | |
| 171.3 *3* | 19 *5* | 4854.1 | $13^+$ | 4682.8 | $12^+$ | D | Mult.: $A_2=-0.16$ *13*, $A_4=-0.13$ *24*. |
| 202.6 *2* | 337 *34* | 3172.0 | $10^+$ | 2969.4 | $8^+$ | Q | Mult.: $A_2=+0.07$ *10*, $A_4=-0.05$ *14*. |
| 204.2 *3* | 110 *30* | 5194.1 | $14^-$ | 4990.0 | $13^-$ | | |
| 206.9 *3* | 24 *7* | 5706.1 | 16 | 5499.1 | $15^-$ | D | Mult.: $A_2=-0.04$ *5*, $A_4=-0.01$ *6*. |
| 218.3 *2* | 46 *10* | 4622.3 | 15 | 4404.0 | $14^+$ | D | Mult.: $A_2=-0.37$ *14*, $A_4=-0.07$ *19*. |
| 224.9 *2* | 41 *12* | 3194.4 | $8^+$ | 2969.4 | $8^+$ | D+Q | Mult.: $A_2=+0.26$ *10*, $A_4=+0.14$ *14*. |
| 226.9 *3* | 97 *19* | 5706.1 | 16 | 5479.1 | $15^-$ | D | Mult.: $A_2=-0.23$ *9*, $A_4=-0.24$ *12*. |
| 233.5 *3* | 66 *13* | 5087.6 | $(14^+)$ | 4854.1 | $13^+$ | D+Q | Mult.: $A_2=-0.19$ *11*, $A_4=0.24$ *15*. |
| 241.4 *1* | 264 *26* | 3210.8 | $10^+$ | 2969.4 | $8^+$ | Q | Mult.: $A_2=+0.23$ *2*, $A_4=-0.02$ *2*. |
| 254.1 *3* | 21 *5* | 6420.3 | | 6166.2 | $16^+$ | | |
| 269.7 *3* | 23 *6* | 6435.8 | | 6166.2 | $16^+$ | | |
| 285.5 *3* | 43 *8* | 5373.1 | $(15^+)$ | 5087.6 | $(14^+)$ | D+Q | Mult.: $A_2=-0.19$ *33*, $A_4=-0.99$ *47*. |
| 289.6 *3* | 15 *4* | 6725.4 | | 6435.8 | | | |
| 305.0[‡] *3* | 45[‡] *10* | 5499.1 | $15^-$ | 5194.1 | $14^-$ | D | Mult.: $A_2=-0.31$ *3*, $A_4=-0.18$ *5*. |
| 305.0[‡] *3* | 17[‡] *4* | 6725.4 | | 6420.3 | | | Mult.: $A_2=-0.31$ *3*, $A_4=-0.18$ *5*. |
| 311.7 *1* | 189 *12* | 2326.2 | $7^-$ | 2014.5 | $5^-$ | Q | Mult.: $A_2=+0.38$ *2*, $A_4=-0.07$ *3*. |
| 317.4 *2* | 160 *32* | 6023.5 | 17 | 5706.1 | 16 | D | Mult.: $A_2=-0.27$ *2*, $A_4=-0.14$ *4*. |
| 324.3 *2* | 42 *7* | 4946.6 | 16 | 4622.3 | 15 | D | Mult.: $A_2=-0.55$ *6*, $A_4=-0.20$ *8*. |
| 349.2 *3* | 9 *3* | 8100.7 | | 7751.5 | (21) | | |
| 358.1 *2* | 53 *5* | 6755.1 | 19 | 6397.0 | 18 | D | Mult.: $A_2=-0.37$ *5*, $A_4=-0.18$ *7*. |
| 366.1 *3* | 15 *4* | 7091.5 | | 6725.4 | | (Q) | |
| 373.5 *4* | 74 *15* | 6397.0 | 18 | 6023.5 | 17 | D | Mult.: $A_2=-0.28$ *9*, $A_4=-0.06$ *3*. |
| 377.9 *3* | 21 *9* | 5571.9 | $15^-$ | 5194.1 | $14^-$ | D | Mult.: $A_2=-0.31$ *4*, $A_4=-0.10$ *6*. |
| 381.9 *3* | 38 *4* | 5328.5 | 17 | 4946.6 | 16 | D | Mult.: $A_2=-0.28$ *9*, $A_4=-0.28$ *14*. |
| 441.9 *1* | 871 *70* | 3652.7 | $12^+$ | 3210.8 | $10^+$ | Q | Mult.: $A_2=+0.46$ *1*, $A_4=-0.05$ *2*. |
| 454.2 *3* | 15 *5* | 7545.7 | | 7091.5 | | (D) | |
| 465.5 *5* | 7 *3* | 5794.0 | 18 | 5328.5 | 17 | (D) | |
| 482.4 *3* | 9 *3* | 7751.5 | (21) | 7269.1 | (20) | | |
| 495.6 *4* | 9 *3* | 8041.3 | | 7545.7 | | | |
| 514.0 *3* | 19 *4* | 7269.1 | (20) | 6755.1 | 19 | | |
| 519.5 *3* | 7 *3* | 5892.6 | $(16^+)$ | 5373.1 | $(15^+)$ | | |
| 530.7 *1* | 1000 | 530.7 | $2^+$ | 0.0 | $0^+$ | Q | Mult.: $A_2=+0.26$ *2*, $A_4=+0.00$ *3*. |

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## (HI,xn$\gamma$) 1990Lu04 (continued)

### $\gamma$($^{140}$Sm) (continued)

| $E_\gamma$ | $I_\gamma$ | $E_i$(level) | $J^\pi_i$ | $E_f$ | $J^\pi_f$ | Mult.[†] | Comments |
|---|---|---|---|---|---|---|---|
| 575.3 *2* | 64 *6* | 5489.5 | $16^+$ | 4914.2 | $14^+$ | Q | Mult.: $A_2$=+0.52 *7*, $A_4$=0.22 *9*. |
| 604.1 *2* | 41 *5* | 5998.0 | | 5393.9 | $(16^+)$ | | |
| 618.7 *1* | 196 *20* | 3790.7 | $12^+$ | 3172.0 | $10^+$ | Q | Mult.: $A_2$=+0.45 *3*, $A_4$=−0.5 *4*. |
| 632.9 *4* | 23 *7* | 2959.1 | | 2326.2 | $7^-$ | (D) | |
| 640.9 *3* | 61 *6* | 6038.7 | 17 | 5397.8 | $16^+$ | D | Mult.: $A_2$=−0.29 *10*, $A_4$=−0.09 *14*. |
| 681.7 *5* | 116 *12* | 3892.4 | $11^+$ | 3210.8 | $10^+$ | D | Mult.: $A_2$=−0.67 *11*, $A_4$=+0.08 *15*. |
| $^x$686.2 *4* | 18 *5* | | | | | | |
| 715.0 *1* | 948 *50* | 1245.7 | $4^+$ | 530.7 | $2^+$ | Q | Mult.: $A_2$=+0.22 *1*, $A_4$=−0.04 *2*. |
| 751.3 *2* | 637 *70* | 4404.0 | $14^+$ | 3652.7 | $12^+$ | Q | Mult.: $A_2$=+0.43 *2*, $A_4$=−0.09 *2*. |
| 768.8 *3* | 286 *29* | 2014.5 | $5^-$ | 1245.7 | $4^+$ | D | Mult.: $A_2$=−0.17 *3*, $A_4$=−0.00 *4*. |
| 771.1 *3* | 18 *5* | 7320.4 | $(20^+)$ | 6549.3 | $18^+$ | (Q) | |
| 780.3 *4* | 21 *6* | 6778.3 | | 5998.0 | | (D) | |
| 782.5 *2* | 51 *10* | 6272.0 | $18^+$ | 5489.5 | $16^+$ | Q | Mult.: $A_2$=+0.38 *7*, $A_4$=+0.16 *10*. |
| 790.2 *4* | 20 *5* | 5194.1 | $14^-$ | 4404.0 | $14^+$ | | |
| 790.5 *4* | 26 *8* | 4682.8 | $12^+$ | 3892.4 | $11^+$ | | |
| 792.6 *4* | 44 *5* | 4445.4 | $13^+$ | 3652.7 | $12^+$ | (D) | |
| 801.3 *2* | 120 *12* | 3127.6 | $9^-$ | 2326.2 | $7^-$ | Q | Mult.: $A_2$=+0.29 *4*, $A_4$=+0.01 *6*. |
| 808.3 *3* | 13 *4* | 5254.1 | $15^+$ | 4445.4 | $13^+$ | (Q) | |
| 825.5 *3* | 73 *7* | 6864.2 | 19 | 6038.7 | 17 | Q | Mult.: $A_2$=+0.35 *7*, $A_4$=−0.07 *10*. |
| 835.3 *5* | 110 *12* | 4487.9 | $14^+$ | 3652.7 | $12^+$ | | |
| 836.1 *2* | 710 *60* | 2081.8 | $6^+$ | 1245.7 | $4^+$ | Q | Mult.: $A_2$=+0.22 *1*, $A_4$=−0.03 *2*. |
| 850.5 *3* | 54 *5* | 5254.1 | $15^+$ | 4404.0 | $14^+$ | D | Mult.: $A_2$=−0.65 *9*, $A_4$=−0.01 *12*. |
| 887.6 *1* | 659 *33* | 2969.4 | $8^+$ | 2081.8 | $6^+$ | Q | Mult.: $A_2$=+0.21 *2*, $A_4$=−0.06 *3*. |
| 896.3 *4* | 13 *5* | 4023.9 | $11^-$ | 3127.6 | $9^-$ | Q | Mult.: $A_2$=+0.54 *7*, $A_4$=−0.47 *10*. |
| 906.0 *5* | 77 *8* | 5393.9 | $(16^+)$ | 4487.9 | $14^+$ | (Q) | Mult.: $A_2$=+0.03 *5*, $A_4$=−0.27 *7*. |
| 916.4 *3* | 33 *6* | 4044.0 | $11^-$ | 3127.6 | $9^-$ | Q | Mult.: $A_2$=+0.36 *15*, $A_4$=−0.02 *22*. |
| 993.8 *3* | 110 *9* | 5397.8 | $16^+$ | 4404.0 | $14^+$ | Q | Mult.: $A_2$=+0.46 *3*, $A_4$=−0.11 *4*. |
| 1063.4 *3* | 53 *5* | 4854.1 | $13^+$ | 3790.7 | $12^+$ | D | Mult.: $A_2$=−0.38 *8*, $A_4$=+0.09 *12*. |
| 1075.0 *2* | 83 *8* | 5479.1 | $15^-$ | 4404.0 | $14^+$ | D | Mult.: $A_2$=−0.17 *6*, $A_4$=−0.15 *9*. |
| 1095.1 *2* | 58 *6* | 5499.1 | $15^-$ | 4404.0 | $14^+$ | D | Mult.: $A_2$=−0.14 *7*, $A_4$=+0.10 *11*. |
| $^x$1103.0 *4* | 22 *3* | | | | | | |
| 1112.8 *3* | 50 *8* | 3194.4 | $8^+$ | 2081.8 | $6^+$ | Q | Mult.: $A_2$=+0.15 *9*, $A_4$=−0.10 *13*. |
| 1123.5 *3* | 180 *30* | 4914.2 | $14^+$ | 3790.7 | $12^+$ | Q | Mult.: $A_2$=+0.24 *6*, $A_4$=−0.17 *8*. |
| 1151.5 *3* | 70 *9* | 6549.3 | $18^+$ | 5397.8 | $16^+$ | Q | Mult.: $A_2$=+0.25 *7*, $A_4$=−0.13 *10*. |
| 1223.1 *4* | 21 *4* | 7772.4 | $(20^+)$ | 6549.3 | $18^+$ | (Q) | |
| 1252.0 *4* | 40 *4* | 6166.2 | $16^+$ | 4914.2 | $14^+$ | Q | Mult.: $A_2$=+0.22 *11*, $A_4$=−0.28 *16*. |
| 1322.8 *7* | 31 *4* | 5810.7 | $16^+$ | 4487.9 | $14^+$ | Q | Mult.: $A_2$=+0.56 *13*, $A_4$=−0.10 *17*. |
| 1337.4 *2* | 92 *9* | 4990.0 | $13^-$ | 3652.7 | $12^+$ | D | Mult.: $A_2$=−0.16 *5*, $A_4$=+0.00 *8*. |
| 1406.6 *4* | 7 *3* | 5810.7 | $16^+$ | 4404.0 | $14^+$ | Q | Mult.: $A_2$=+0.80 *40*, $A_4$=−0.48 *56*. |

[†] For $\gamma$'s: 454.2, 465.5, 632.9, 780.3, 792.6 I$\gamma$(90°)/I$\gamma$(37°)≤0.8 suggests D; for $\gamma$'s: 366.1, 771.1, 808.3, 1223.1 I$\gamma$(90°)/I$\gamma$(37°)≥1 suggests Q (1990Lu04).

[‡] Multiply placed with intensity suitably divided.

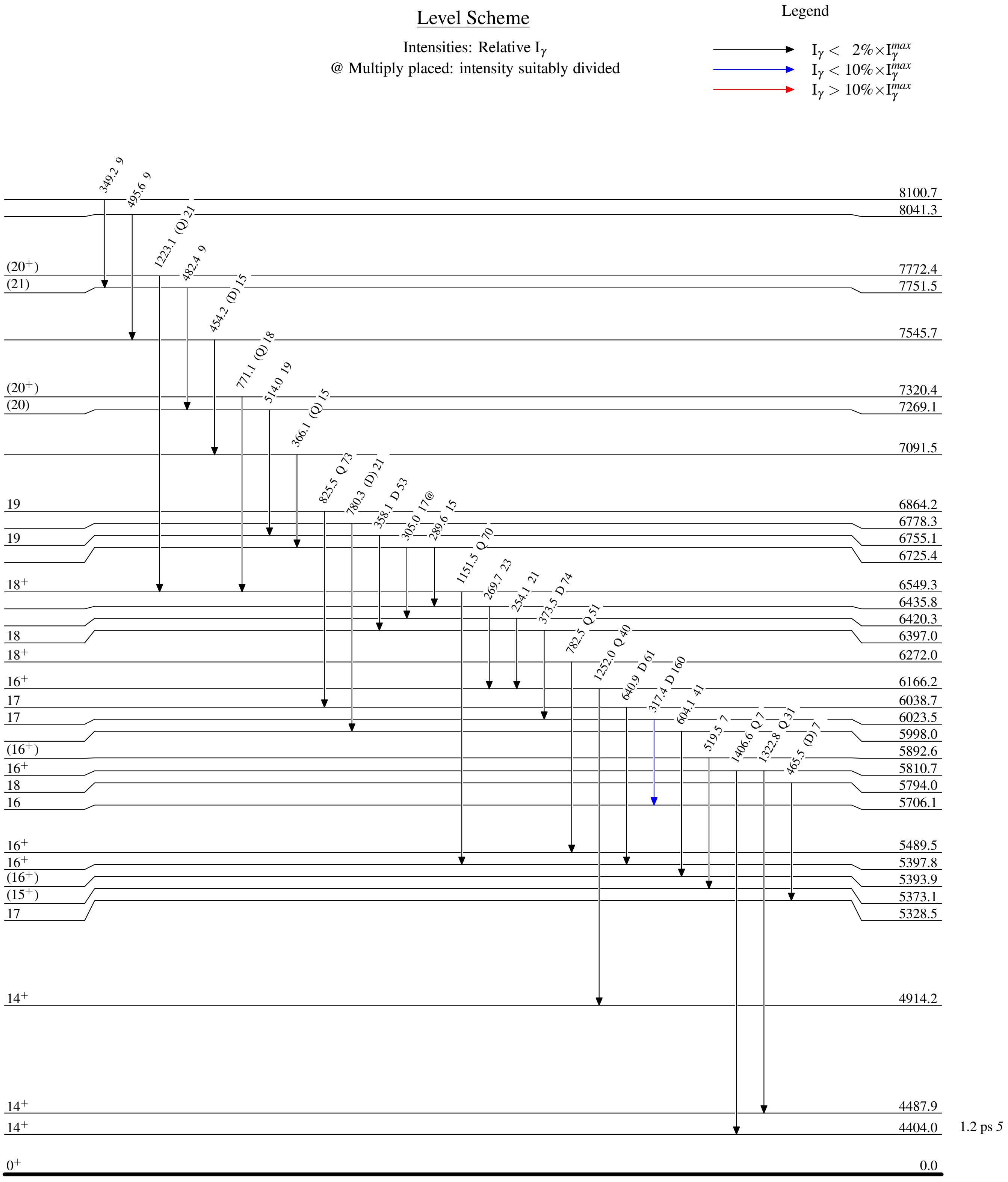
[x] $\gamma$ ray not placed in level scheme.

## (HI,xn$\gamma$) 1990Lu04

### Level Scheme

Intensities: Relative $I_\gamma$

@ Multiply placed: intensity suitably divided



$^{140}_{62}$Sm$_{78}$

## (HI,xn$\gamma$) 1990Lu04

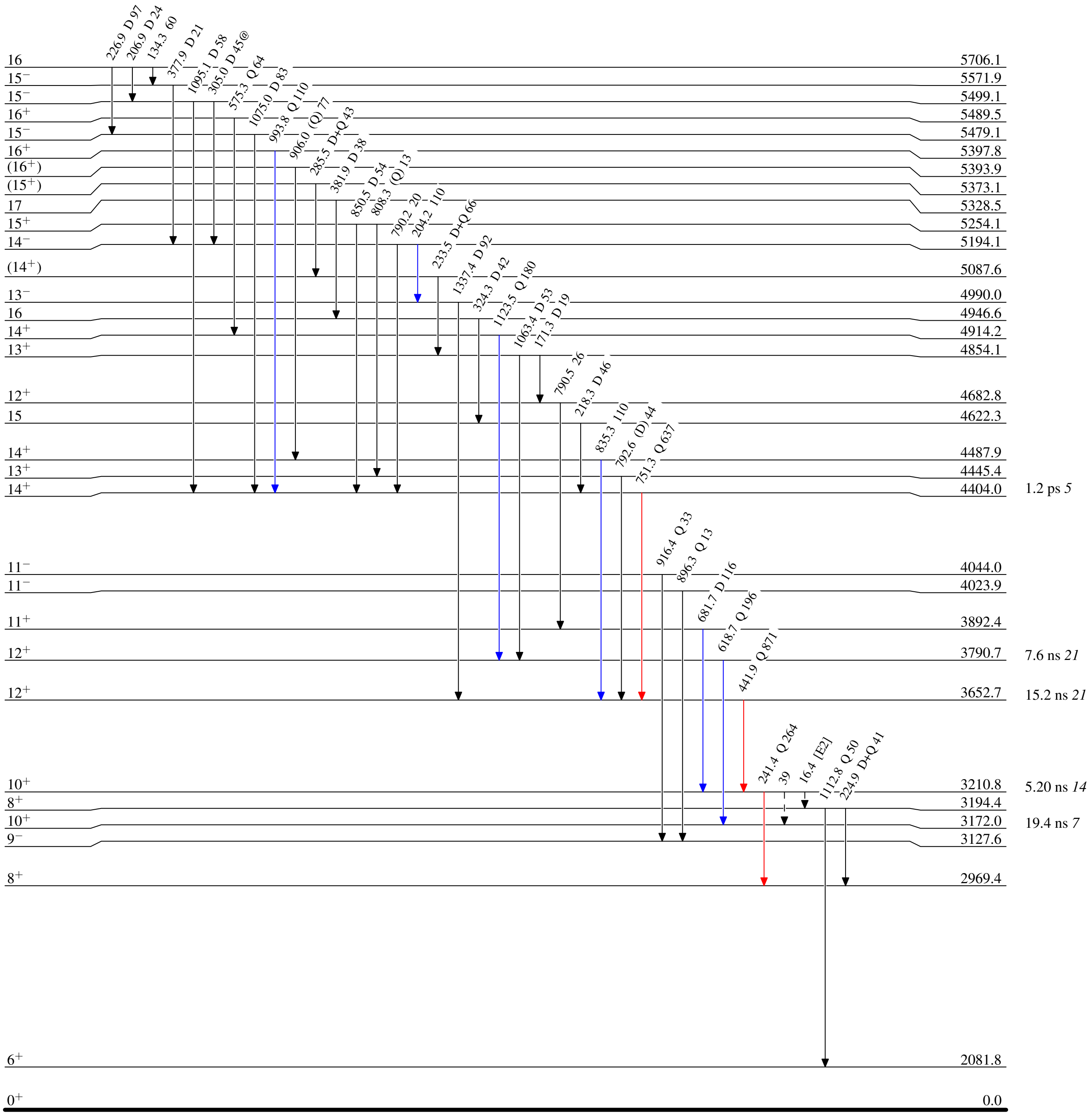
## Level Scheme (continued)

Intensities: Relative I$_\gamma$

@ Multiply placed: intensity suitably divided

Legend

- I$_\gamma$ < 2%×I$_\gamma^{max}$
- I$_\gamma$ < 10%×I$_\gamma^{max}$
- I$_\gamma$ > 10%×I$_\gamma^{max}$
- $\gamma$ Decay (Uncertain)



$^{140}_{62}$Sm$_{78}$

## (HI,xn$\gamma$) 1990Lu04

### Level Scheme (continued)

Intensities: Relative $I_\gamma$

@ Multiply placed: intensity suitably divided

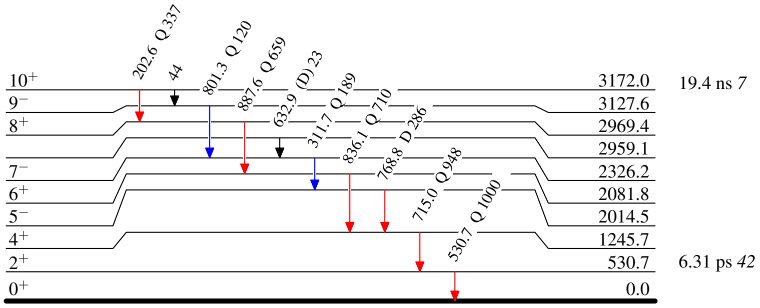
Legend

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

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

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

$\gamma$ Decay (Uncertain)



$^{140}_{62}Sm_{78}$