## (HI,xnγ) 1999Id01

History

| Type | Author | Citation | Literature Cutoff Date |
|---|---|---|---|
| Full Evaluation | Yu. Khazov, A. Rodionov and G. Shulyak | NDS 136, 163 (2016) | 14-Jul-2016 |

1999Id01: $^{140}$Ce($^{10}$B,4nγ) E=50 MeV, $^{139}$La($^{13}$C,6nγ) E=98 MeV: measured Eγ, γγ(t), γγ coin, γ(θ) at θ=35°, 60°, 90° and 150°, $T_{1/2}$ of isomer. $^{146}$Eu; deduced levels, $J^\pi$, Ge detectors with BGO anti-Compton shield.

1971HaXM: La($^{12}$C,5nγ) E=81 MeV; measured Eγ, Iγ(t), $T_{1/2}$. $^{146}$Eu; deduced levels, $J^\pi$, isomer. Cyclotron, Ge(Li) detector.

1980IsZZ,1980LeZN: $^{140}$Ce($^{10}$B,4n), E not given; $^{142}$Nd($^{7}$Li,3n), E not given; measured Eγ, Iγ, γγ coin, E(ce), Ice. $^{146}$Eu; deduced levels, γ branching.

The $^{146}$Eu level scheme is mainly from result of 1999Id01 reaction measurements, $J^\pi$ assignment was made based on the angular distribution analysis and ce measurement (1980LeZN).

### $^{146}$Eu Levels

| E(level)[†‡] | $J^\pi$[#] | $T_{1/2}$ | E(level)[†‡] | $J^\pi$[#] | E(level)[†‡] | $J^\pi$[#] | $T_{1/2}$ |
|---|---|---|---|---|---|---|---|
| 0 | $4^-$ | | 3469.7 *9* | ($15^+$) | 5525.5 *10* | (18) | |
| 14.5 *5* | $5^-$ | | 3509.3 *8* | (14) | 5830.3 *10* | (19) | |
| 289.3 *6* | $6^-$ | | 3619.3 *9* | (15) | 5905.0 *10* | (20) | |
| 315.9 *5* | $5^-$ | | 3714.3 *9* | (15) | 6184.9 *10* | (21) | |
| 372.8 *5* | $6^-$ | | 3745.9 *9* | (16) | 6345.1 *12* | (22) | |
| 647.6 *6* | $7^-$ | | 3782.1 *10* | (15) | 6350.7 *10* | (20) | |
| 666.5 *6* | $9^+$ | 230[@] μs *10* | 3911.3 *9* | (16) | 6688.8 *10* | (21) | |
| 802.8 *7* | $8^+$ | | 4120.1 *11* | (16) | 6832.7 *12* | (21) | |
| 1266.6 *8* | $9^+$ | | 4160.4 *9* | (17) | 6980.6 *10* | (22) | |
| 1699.4 *7* | $10^+$ | | 4170.8 *9* | (16) | 7535.6 *11* | (23) | |
| 1769.2 *7* | $11^-$ | | 4614.7 *9* | (18) | 8128.6 *12* | (24) | |
| 2027.3 *8* | $12^-$ | | 5022.3 *10* | (19) | 8138.6 *12* | (24) | |
| 2105.4 *7* | $11^+$ | | 5057.8 *10* | (18) | 8207.6 *12* | (25) | |
| 2540.3 *8* | $12^+$ | | 5169.2 *10* | (18) | 8445.6 *13* | (26) | |
| 2666.3 *8* | $13^+$ | | 5184.1 *10* | (20) | 8649.6[a] *14* | (27) | 10.0[&] ns *6* |
| 2951.3 *9* | $14^+$ | | 5372.4 *11* | (19) | 9166.6 *15* | (28) | |
| 3302.3 *9* | (14) | | 5486.0 *10* | (18) | 10365.6 *16* | (29) | |

[†] If ΔEγ not given, ±0.50 keV assumed for least-squares fit.

[‡] From a least-squares fit to Eγ′s; ΔEγ=0.5 assumed by evaluators; normalized $\chi^2$=0.91.

[#] From the angular distribution analysis and ce measurement.

[@] From γ(t) 1980LeZN.

[&] From γγ(t) with pulsed beam (1999Id01).

[a] Possible configuration= $[\nu(f_{7/2}h_{11/2}i_{13/2})\times\pi(d^{-1}_{5/2}h^2_{11/2})]_{27^+}$ (1999Id01), see systematics of high spin isomers (2005Od03,2002Go06).

### γ($^{146}$Eu)

| $E_\gamma$[†] | $E_i$(level) | $J^\pi_i$ | $E_f$ | $J^\pi_f$ | Mult. | α[a] | $I_{(\gamma+ce)}$[&] | Comments |
|---|---|---|---|---|---|---|---|---|
| 14.4[‡] | 14.5 | $5^-$ | 0 | $4^-$ | (M1)[#] | 85.7 | 120.3 | ce(L)/(γ+ce)=0.775 *7*; ce(M)/(γ+ce)=0.168 *3*<br>ce(N)/(γ+ce)=0.0384 *8*; ce(O)/(γ+ce)=0.00607 *12*;<br>ce(P)/(γ+ce)=0.000593 *12*<br>α(L)=67.2 *10*; α(M)=14.56 *21*<br>α(N)=3.33 *5*; α(O)=0.526 *8*; α(P)=0.0514 *8*<br>$I_{(\gamma+ce)}$: from balance of I(γ+ce). |
| (18.8) | 666.5 | $9^+$ | 647.6 | $7^-$ | (M2)[#] | $7.27\times10^3$ | | α(L)=$5.55\times10^3$ *8*; α(M)=1359 *19*<br>α(N)=313 *5*; α(O)=46.8 *7*; α(P)=3.37 *5* |

Continued on next page (footnotes at end of table)

**(HI,xnγ) 1999Id01 (continued)**

γ($^{146}$Eu) (continued)

| $E_\gamma$[†] | $E_i$(level) | $J_i^\pi$ | $E_f$ | $J_f^\pi$ | Mult. | α[a] | $I_{(\gamma+ce)}$[&] | Comments |
|---|---|---|---|---|---|---|---|---|
| 57 | 372.8 | 6⁻ | 315.9 | 5⁻ | | | | |
| 69[@] | 8207.6 | (25) | 8138.6 | (24) | | | 8.6 | |
| 70 | 1769.2 | 11⁻ | 1699.4 | 10⁺ | | | 23.4 | |
| 75 | 5905.0 | (20) | 5830.3 | (19) | | | 1.8 | |
| 79[@] | 8207.6 | (25) | 8128.6 | (24) | | | 5.9 | |
| 84 | 372.8 | 6⁻ | 289.3 | 6⁻ | | | | |
| 110 | 3619.3 | (15) | 3509.3 | (14) | | | 3.7 | |
| 126 | 2666.3 | 13⁺ | 2540.3 | 12⁺ | | | 44.6 | |
| 126 | 3745.9 | (16) | 3619.3 | (15) | | | 5.0 | |
| 136 | 802.8 | 8⁺ | 666.5 | 9⁺ | | | 32.9 | |
| 149 | 3619.3 | (15) | 3469.7 | (15⁺) | | | 4.1 | |
| 162 | 5184.1 | (20) | 5022.3 | (19) | | | 3.6 | |
| 197 | 3911.3 | (16) | 3714.3 | (15) | | | | |
| 204 | 8649.6 | (27) | 8445.6 | (26) | | | 9.6 | |
| 238 | 8445.6 | (26) | 8207.6 | (25) | | | 9.6 | |
| 249 | 4160.4 | (17) | 3911.3 | (16) | | | 4.1 | |
| 258 | 2027.3 | 12⁻ | 1769.2 | 11⁻ | | | 14.9 | |
| 274.9[‡] | 289.3 | 6⁻ | 14.5 | 5⁻ | M1[#] | 0.1110 | 100.0 | ce(K)/(γ+ce)=0.0848 *11*; ce(L)/(γ+ce)=0.01189 *17*; ce(M)/(γ+ce)=0.00256 *4*<br>ce(N)/(γ+ce)=0.000587 *9*; ce(O)/(γ+ce)=9.33×10$^{-5}$ *14*; ce(P)/(γ+ce)=9.30×10$^{-6}$ *13*<br>α(K)=0.0942 *14*; α(L)=0.01321 *19*; α(M)=0.00285 *4*<br>α(N)=0.000653 *10*; α(O)=0.0001037 *15*; α(P)=1.033×10$^{-5}$ *15* |
| 275 | 647.6 | 7⁻ | 372.8 | 6⁻ | | | 21.2 | |
| 280 | 6184.9 | (21) | 5905.0 | (20) | | | 3.2 | |
| 285 | 2951.3 | 14⁺ | 2666.3 | 13⁺ | | | 35.6 | |
| 292 | 3911.3 | (16) | 3619.3 | (15) | | | 7.9 | |
| 292 | 6980.6 | (22) | 6688.8 | (21) | | | 6.3 | |
| 293.9[‡] | 666.5 | 9⁺ | 372.8 | 6⁻ | E3[#] | 0.253 | 7.9 | ce(K)/(γ+ce)=0.1196 *15*; ce(L)/(γ+ce)=0.0635 *9*; ce(M)/(γ+ce)=0.01493 *21*<br>ce(N)/(γ+ce)=0.00334 *5*; ce(O)/(γ+ce)=0.000469 *7*; ce(P)/(γ+ce)=1.180×10$^{-5}$ *17*<br>α(K)=0.1499 *21*; α(L)=0.0796 *12*; α(M)=0.0187 *3*<br>α(N)=0.00419 *6*; α(O)=0.000588 *9*; α(P)=1.479×10$^{-5}$ *21* |
| 305 | 5830.3 | (19) | 5525.5 | (18) | | | 2.7 | |
| 316 | 315.9 | 5⁻ | 0 | 4⁻ | | | 4.5 | |
| 317 | 3619.3 | (15) | 3302.3 | (14) | | | | |
| 338 | 4120.1 | (16) | 3782.1 | (15) | | | 3.6 | |
| 358.0[‡] | 372.8 | 6⁻ | 14.5 | 5⁻ | | | 20.3 | |
| 358.2[‡] | 647.6 | 7⁻ | 289.3 | 6⁻ | M1[#] | 0.0551 | 42.8 | ce(K)/(γ+ce)=0.0444 *6*; ce(L)/(γ+ce)=0.00617 *9*; ce(M)/(γ+ce)=0.001330 *19*<br>ce(N)/(γ+ce)=0.000305 *5*; ce(O)/(γ+ce)=4.84×10$^{-5}$ *7*; ce(P)/(γ+ce)=4.85×10$^{-6}$ *7*<br>α(K)=0.0468 *7*; α(L)=0.00651 *10*; α(M)=0.001403 *20*<br>α(N)=0.000321 *5*; α(O)=5.11×10$^{-5}$ *8*; α(P)=5.11×10$^{-6}$ *8* |
| 377.0[‡] | 666.5 | 9⁺ | 289.3 | 6⁻ | E3[#] | 0.0994 | 8.6 | ce(K)/(γ+ce)=0.0608 *8*; ce(L)/(γ+ce)=0.0229 *4*; ce(M)/(γ+ce)=0.00531 *8*<br>ce(N)/(γ+ce)=0.001193 *17*; ce(O)/(γ+ce)=0.0001710 *24*; ce(P)/(γ+ce)=6.27×10$^{-6}$ *9*<br>α(K)=0.0668 *10*; α(L)=0.0252 *4*; α(M)=0.00584 *9* |

Continued on next page (footnotes at end of table)

**(HI,xn$\gamma$) 1999Id01 (continued)**

$\gamma(^{146}Eu)$ (continued)

| $E_\gamma$ [†] | $E_i$(level) | $J_i^\pi$ | $E_f$ | $J_f^\pi$ | $I_{(\gamma+ce)}$ [&] | Comments |
|---|---|---|---|---|---|---|
| | | | | | | $\alpha$(N)=0.001312 *19*; $\alpha$(O)=0.000188 *3*; $\alpha$(P)=6.89×10$^{-6}$ *10* |
| 389 | 4170.8 | (16) | 3782.1 | (15) | 3.6 | |
| 408 | 5022.3 | (19) | 4614.7 | (18) | 6.3 | |
| 414 | 4160.4 | (17) | 3745.9 | (16) | 6.8 | |
| 433 | 1699.4 | $10^+$ | 1266.6 | $9^+$ | 26.8 | |
| 435 | 2540.3 | $12^+$ | 2105.4 | $11^+$ | 14.4 | |
| 442 | 3911.3 | (16) | 3469.7 | ($15^+$) | 5.4 | |
| 444 | 4614.7 | (18) | 4170.8 | (16) | 5.9 | |
| 454 | 4614.7 | (18) | 4160.4 | (17) | 3.2 | |
| 464 | 1266.6 | $9^+$ | 802.8 | $8^+$ | 21.6 | |
| 468 | 5525.5 | (18) | 5057.8 | (18) | 1.4 | |
| 482 | 6832.7 | (21) | 6350.7 | (20) | 3.2 | |
| 513 | 2540.3 | $12^+$ | 2027.3 | $12^-$ | 9.9 | |
| 517 | 9166.6 | (28) | 8649.6 | (27) | 6.8 | |
| 518 | 3469.7 | ($15^+$) | 2951.3 | $14^+$ | 17.6 | |
| 520 | 6350.7 | (20) | 5830.3 | (19) | 3.7 | |
| 555 | 7535.6 | (23) | 6980.6 | (22) | 9.9 | |
| 558 | 3509.3 | (14) | 2951.3 | $14^+$ | 5.4 | |
| 593 | 8128.6 | (24) | 7535.6 | (23) | 5.9 | |
| 603 | 8138.6 | (24) | 7535.6 | (23) | 8.6 | |
| 639 | 2666.3 | $13^+$ | 2027.3 | $12^-$ | 8.6 | |
| 668 | 3619.3 | (15) | 2951.3 | $14^+$ | 5.0 | |
| 672 | 8207.6 | (25) | 7535.6 | (23) | 3.2 | |
| 701 | 4170.8 | (16) | 3469.7 | ($15^+$) | 4.1 | |
| 704 | 4614.7 | (18) | 3911.3 | (16) | 4.1 | |
| 736 | 5905.0 | (20) | 5169.2 | (18) | 3.2 | |
| 763 | 3714.3 | (15) | 2951.3 | $14^+$ | 5.0 | |
| 772 | 5830.3 | (19) | 5057.8 | (18) | 0.9 | |
| 784 | 6688.8 | (21) | 5905.0 | (20) | 4.5 | |
| 796 | 6980.6 | (22) | 6184.9 | (21) | 5.9 | |
| 831 | 3782.1 | (15) | 2951.3 | $14^+$ | 3.2 | |
| 843 | 3509.3 | (14) | 2666.3 | $13^+$ | 2.7 | |
| 846 | 5905.0 | (20) | 5057.8 | (18) | 2.7 | |
| 865 | 6350.7 | (20) | 5486.0 | (18) | 1.8 | |
| 883 | 5905.0 | (20) | 5022.3 | (19) | 4.1 | |
| 896 | 5057.8 | (18) | 4160.4 | (17) | 2.7 | |
| 966 | 1769.2 | $11^-$ | 802.8 | $8^+$ | 5.4 | |
| 1001 | 6184.9 | (21) | 5184.1 | (20) | 1.4 | |
| 1009 | 5169.2 | (18) | 4160.4 | (17) | 1.4 | |
| 1033 | 1699.4 | $10^+$ | 666.5 | $9^+$ | 11.7 | |
| 1075 | 6980.6 | (22) | 5905.0 | (20) | 3.7 | |
| 1103 | 1769.2 | $11^-$ | 666.5 | $9^+$ | 10.6 | |
| 1127 | 6184.9 | (21) | 5057.8 | (18) | 1.4 | |
| 1161 | 6345.1 | (22) | 5184.1 | (20) | 3.6 | |
| 1199 | 10365.6 | (29) | 9166.6 | (28) | 3.7 | |
| 1212 | 5372.4 | (19) | 4160.4 | (17) | 1.8 | |
| 1275 | 3302.3 | (14) | 2027.3 | $12^-$ | 3.6 | |
| 1312 | 5057.8 | (18) | 3745.9 | (16) | 2.3 | |
| 1326 | 5486.0 | (18) | 4160.4 | (17) | 2.7 | |
| 1365 | 5525.5 | (18) | 4160.4 | (17) | 1.9 | |
| 1439 | 2105.4 | $11^+$ | 666.5 | $9^+$ | 33.8 | |
| 1482 | 3509.3 | (14) | 2027.3 | $12^-$ | 3.2 | |
| 1745 | 5905.0 | (20) | 4160.4 | (17) | 1.4 | |

Continued on next page (footnotes at end of table)

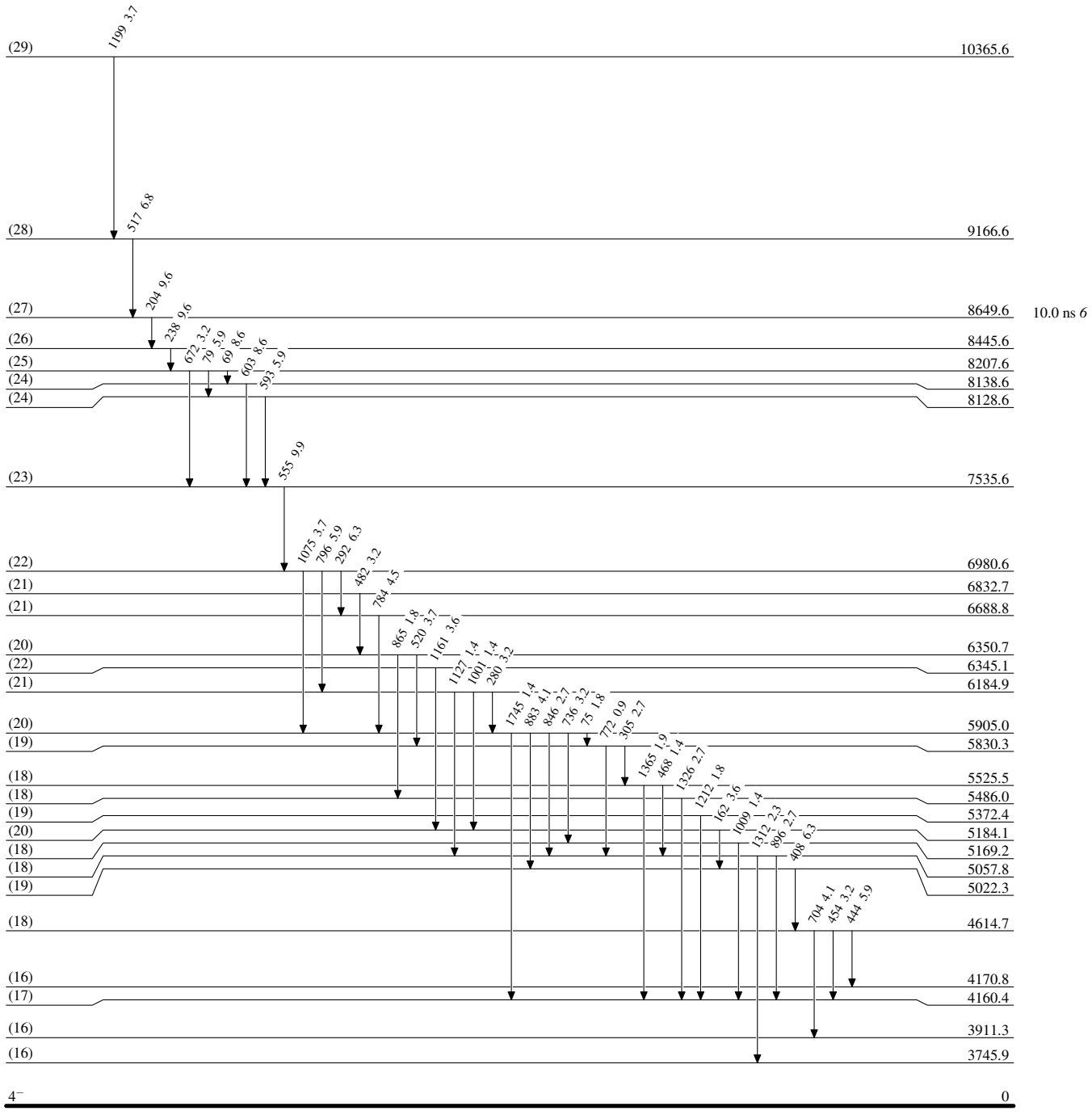
**(HI,xn$\gamma$) 1999Id01 (continued)**

$\gamma(^{146}Eu)$ (continued)

† From 1999Id01, except as noted.
‡ From 1980LeZN.
# From ce measurements by 1980LeZN.
@ In fig. 1 of 1999Id01 this energy is given in figure brackets; the evaluators suppose that it is calculated by the authors.
& Obtained from fig. 1 of 1999Id01 by evaluators according to author's mark that 'the width of arrows is proportional to the intensities of transitions'; systematic inaccuracy $\Delta(I\gamma+ce)\approx 0.5$ for each transition intensity was estimated.
a Additional information 1.

**(HI,xnγ) 1999Id01**

Level Scheme



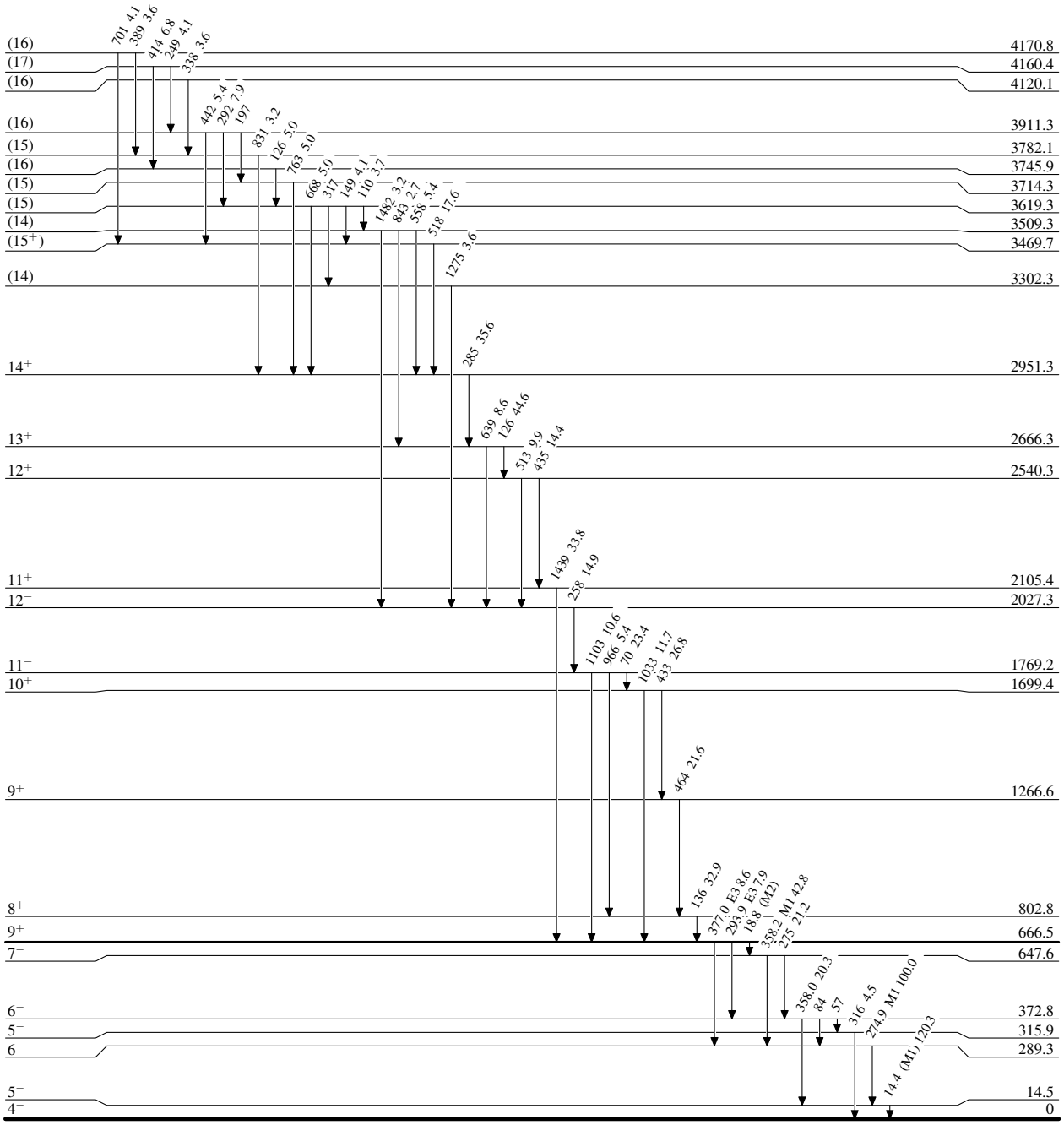

$^{146}_{63}Eu_{83}$

**(HI,xnγ) 1999Id01**

Legend

## Level Scheme (continued)

- - - - - - ► γ Decay (Uncertain)




$^{146}_{63}Eu_{83}$