

²³²Th(²⁰⁹Bi, ²⁰⁸Pbγ) **2002AbZV**

| Type | Author | History | Citation | Literature Cutoff Date |
|-----------------|---------------------------------|---------|---------------------|------------------------|
| Full Evaluation | B. Singh, J. K. Tuli, E. Browne | | NDS 170, 499 (2020) | 8-Oct-2020 |

One-proton transfer channel.

2002AbZV: E(²⁰⁹Bi)=1450 MeV, ≈14% above the Coulomb barrier for projectile-target combination. Measured γ, γγ using Gammasphere array with 101 Compton-suppressed Ge detectors at ANL.

²³³Pa Levels

| E(level) [†] | J ^π [‡] | E(level) [†] | J ^π [‡] | E(level) [†] | J ^π [‡] | E(level) [†] | J ^π [‡] |
|------------------------|-----------------------------|-----------------------|-----------------------------|-----------------------|-----------------------------|------------------------|-----------------------------|
| 0.0 [@] | 3/2 ⁻ | 331.5 [#] 4 | (13/2 ⁻) | 1277.1 [#] 7 | (29/2 ⁻) | 2532.9 [@] 9 | (43/2 ⁻) |
| 6.66 [#] 5 | 1/2 ⁻ | 518.3 [#] 5 | (17/2 ⁻) | 1384.6 [@] 8 | (31/2 ⁻) | 2693.3 [#] 9 | (45/2 ⁻) |
| 57.100 [@] 20 | 7/2 ⁻ | 528.7 [@] 5 | (19/2 ⁻) | 1589.2 [#] 8 | (33/2 ⁻) | 2973.0 [@] 10 | (47/2 ⁻) |
| 70.56 [#] 7 | 5/2 ⁻ | 739.9 [#] 6 | (21/2 ⁻) | 1738.3 [@] 8 | (35/2 ⁻) | 3115.9 [#] 10 | (49/2 ⁻) |
| 163.2 [@] 3 | (11/2 ⁻) | 776.6 [@] 6 | (23/2 ⁻) | 1929.4 [#] 8 | (37/2 ⁻) | 3570.2 [#] 10 | (53/2 ⁻) |
| 179.66 [#] 12 | (9/2 ⁻) | 993.5 [#] 7 | (25/2 ⁻) | 2121.4 [@] 9 | (39/2 ⁻) | 4051.5 [#] 11 | (57/2) |
| 323.5 [@] 4 | (15/2 ⁻) | 1062.8 [@] 7 | (27/2 ⁻) | 2298.0 [#] 9 | (41/2 ⁻) | | |

[†] From E_γ data; ΔE_γ=0.3 keV assumed for each γ-ray when not stated. Low-lying levels up to 179.6 keV are from Adopted Levels levels.

[‡] As given by **2002AbZV** in their figure 4.15 and table 4.19, based on possible band assignments. The assignments are considered as tentative above 7/2⁻.

[#] Band(A): π1/2[530], α=+1/2.

[@] Band(a): π1/2[530], α=-1/2.

γ(²³³Pa)

| E _γ [†] | E _i (level) | J _i ^π | E _f | J _f ^π | E _γ [†] | E _i (level) | J _i ^π | E _f | J _f ^π |
|-----------------------------|------------------------|-----------------------------|----------------|-----------------------------|-----------------------------|------------------------|-----------------------------|----------------|-----------------------------|
| 6.68 [‡] 5 | 6.66 | 1/2 ⁻ | 0.0 | 3/2 ⁻ | 286.2 | 1062.8 | (27/2 ⁻) | 776.6 | (23/2 ⁻) |
| 57.10 [‡] 2 | 57.100 | 7/2 ⁻ | 0.0 | 3/2 ⁻ | 312.1 | 1589.2 | (33/2 ⁻) | 1277.1 | (29/2 ⁻) |
| 63.92 [‡] 6 | 70.56 | 5/2 ⁻ | 6.66 | 1/2 ⁻ | 321.8 | 1384.6 | (31/2 ⁻) | 1062.8 | (27/2 ⁻) |
| 70.49 [‡] 10 | 70.56 | 5/2 ⁻ | 0.0 | 3/2 ⁻ | 340.2 | 1929.4 | (37/2 ⁻) | 1589.2 | (33/2 ⁻) |
| 106.15 [‡] 25 | 163.2 | (11/2 ⁻) | 57.100 | 7/2 ⁻ | 353.7 | 1738.3 | (35/2 ⁻) | 1384.6 | (31/2 ⁻) |
| 109.10 [#] 10 | 179.66 | (9/2 ⁻) | 70.56 | 5/2 ⁻ | 368.6 | 2298.0 | (41/2 ⁻) | 1929.4 | (37/2 ⁻) |
| 151.8 | 331.5 | (13/2 ⁻) | 179.66 | (9/2 ⁻) | 383.1 | 2121.4 | (39/2 ⁻) | 1738.3 | (35/2 ⁻) |
| 160.3 | 323.5 | (15/2 ⁻) | 163.2 | (11/2 ⁻) | 395.3 | 2693.3 | (45/2 ⁻) | 2298.0 | (41/2 ⁻) |
| 186.8 | 518.3 | (17/2 ⁻) | 331.5 | (13/2 ⁻) | 411.5 | 2532.9 | (43/2 ⁻) | 2121.4 | (39/2 ⁻) |
| 205.2 | 528.7 | (19/2 ⁻) | 323.5 | (15/2 ⁻) | 422.6 | 3115.9 | (49/2 ⁻) | 2693.3 | (45/2 ⁻) |
| 221.6 | 739.9 | (21/2 ⁻) | 518.3 | (17/2 ⁻) | 440.0 | 2973.0 | (47/2 ⁻) | 2532.9 | (43/2 ⁻) |
| 247.9 | 776.6 | (23/2 ⁻) | 528.7 | (19/2 ⁻) | 454.3 | 3570.2 | (53/2 ⁻) | 3115.9 | (49/2 ⁻) |
| 253.6 | 993.5 | (25/2 ⁻) | 739.9 | (21/2 ⁻) | 481.3 [#] | 4051.5 | (57/2) | 3570.2 | (53/2 ⁻) |
| 283.6 | 1277.1 | (29/2 ⁻) | 993.5 | (25/2 ⁻) | | | | | |

[†] From Table 4.19 of **2002AbZV**, unless otherwise stated. The 583γ in ²⁰⁸Pb is seen in coin with gamma rays assigned to ²³³Pa.

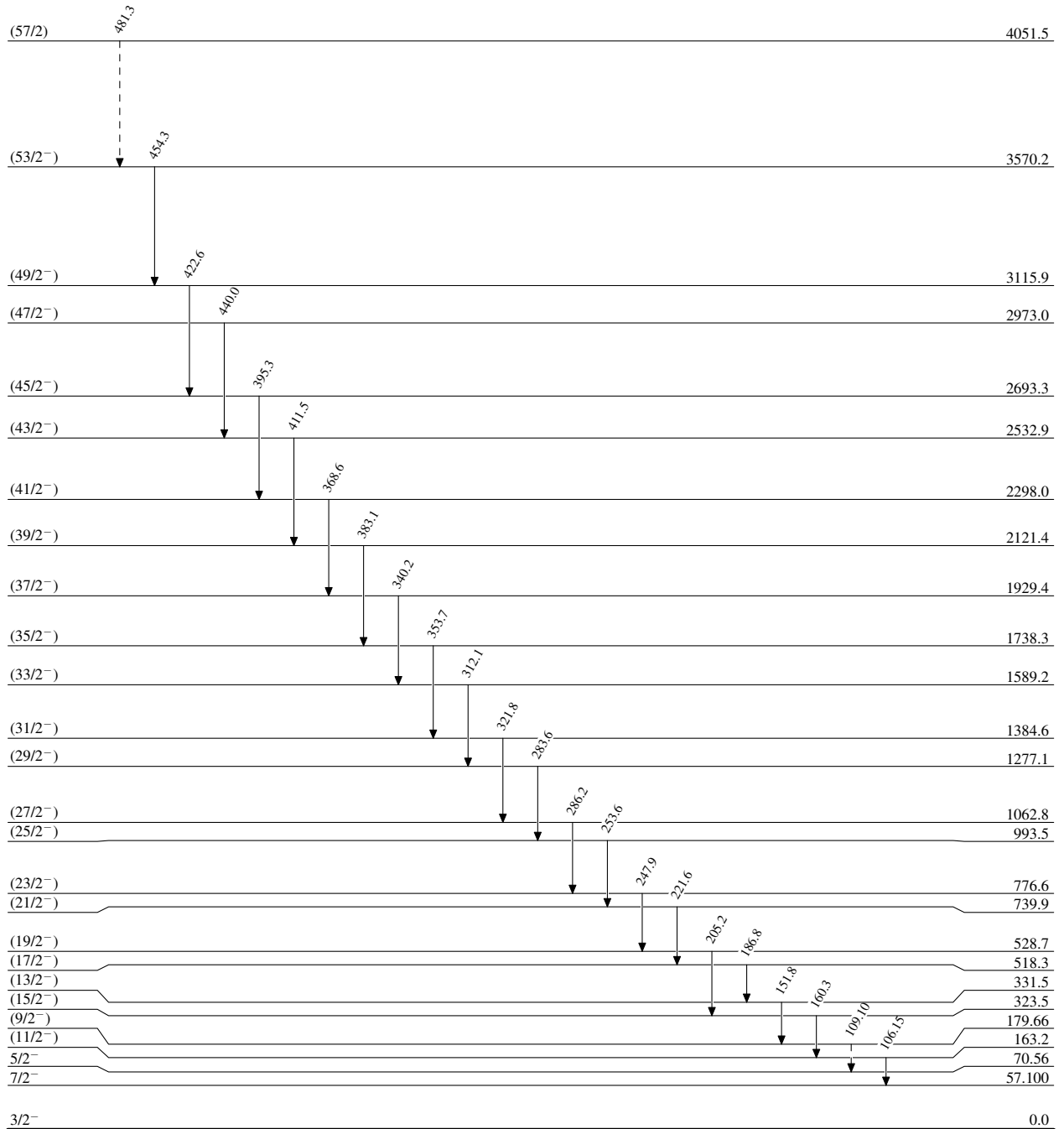
[‡] From the Adopted Levels.

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

$^{232}\text{Th}(^{209}\text{Bi}, ^{208}\text{Pb}\gamma)$ 2002AbZV

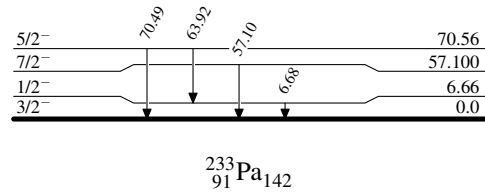
Legend

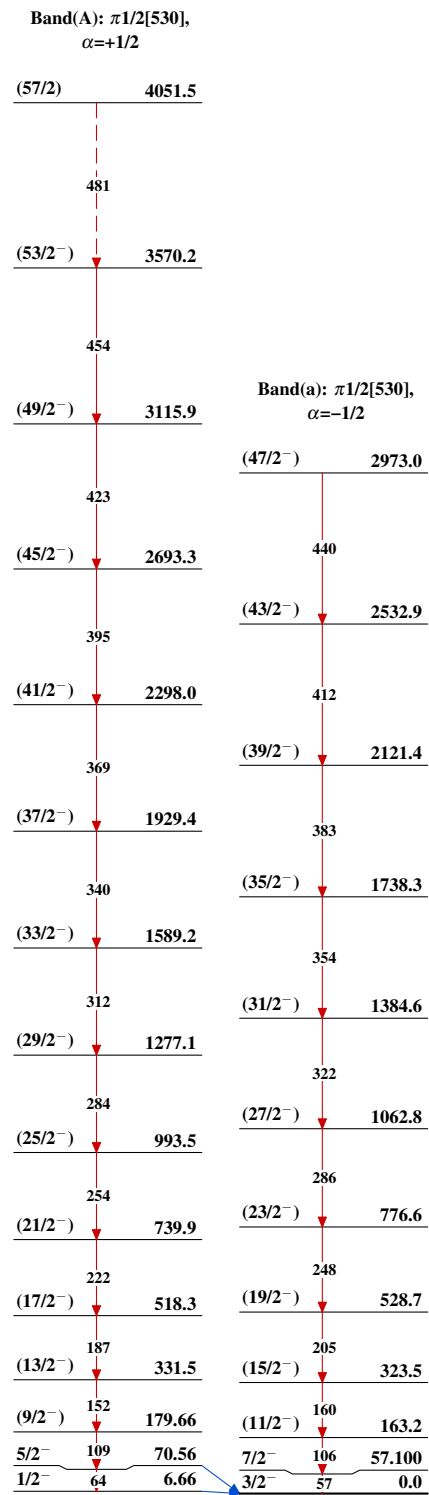
Level Scheme

-----► γ Decay (Uncertain) $^{233}_{91}\text{Pa}_{142}$

$^{232}\text{Th}(^{209}\text{Bi}, ^{208}\text{Pb}\gamma)$ 2002AbZV

Level Scheme (continued)



$^{232}\text{Th}(^{209}\text{Bi}, ^{208}\text{Pb}\gamma)$ 2002AbZV $^{233}_{91}\text{Pa}_{142}$