^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen, Balraj Singh	NDS 164, 1 (2020)	15-Feb-2020

2016Gi05: E(^{3}He)=13 MeV from CN accelerator of Laboratori Nazionali di Legnaro. Targets: a self-supporting ≈1 mg/cm^2 thick ^{97}Mo foil for conversion electron measurements, and a 92% enriched, 7.2 mg/cm^2 thick ^{97}Mo foil with 100 μg/cm^2 thick layer of gold for γ-ray measurements. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma(\theta)$ and $\gamma\gamma(\theta)$ using five HPGe detectors placed at 60°, 110°, 215°, 270°, and 315° with respect to the beam direction. Conversion electrons were measured using a magnetic transport system, which deflected the electrons emitted at 125° with respect to beam direction towards a Si(Li) detector, while γ-rays were measured simultaneously using an HPGe detector placed at 55°. K-conversion coefficients were deduced from ce data by the normalized peak-to-gamma (NPG) method. Deduced levels, J^π, multipolarities and mixing ratios. Results compared with literature data. Levels deduced up to 4223 keV.

1988Sa01: E=11-16 MeV ^{3}He beams were produced from the Purdue FN Tandem Van de Graaff accelerator. Target was a 7.9 mg/cm^2 94.3% enriched ^{97}Mo foil. γ rays were detected with Ge(Li) detectors. Measured Eγ, Iγ, $\gamma\gamma$-coin, γ(excitation function), $\gamma(\theta)$(0°,45°,90°), γ(lin pol). Deduced levels, J, π. Comparisons with theoretical calculations. Levels deduced up to 4005 keV.

^{98}Ru Levels

Levels at 1953, 2430 and 2474 keV proposed by 1988Sa01 have been rejected by 2016Gi05, as the γ rays from these levels have either been reassigned from $\gamma\gamma$-coin data, or not seen in 2016Gi05.

Levels at 2787 and 3059 proposed by 2004Ca42 in ^{96}Mo(α,2nγ) have not been confirmed by 2016Gi05, as 563.3γ from 2787 level and 835γ from 3059 level have not been seen in the present work.

E(level)[†]	J$^\pi$[#]	Comments
0.0	0$^+$	
652.45 *4*	2$^+$	
1322.14 *7*	0$^+$	
1397.87 *5*	4$^+$	
1414.31 *4*	2$^+$	
1796.97 *5*	3$^+$	
1817.18 *6*	2$^+$	J$^\pi$: 2 from $\gamma\gamma(\theta)$, and 0-3 from $\gamma(\theta)$ (2016Gi05). Parity from mult(1165γ) from α(K)exp (2016Gi05). J^π=1$^+$,2$^+$ in 1988Sa01.
2012.74 *5*	3$^+$	
2222.58 *7*	6$^+$	
2241.5 *3*	2 to 6	J$^\pi$: 4$^+$,6$^+$ in 1988Sa01.
2245.86 *21*	2$^{(+)}$	J$^\pi$: 2 from $\gamma\gamma(\theta)$ (2016Gi05). J=1,2 in 1988Sa01.
2257.8[‡] *4*	0 to 4	
2266.51 *6*	4$^+$	
2277.02 *10*	3$^+$,4$^+$	J$^\pi$: 3,4 from $\gamma\gamma(\theta)$ (2016Gi05). Parity from mult(879γ) from α(K)exp in 2016Gi05 who list (2)$^+$ for 2277 level in Table I. J^π=2$^+$ in 1988Sa01.
2295.47[‡] *21*	2 to 6	
2362.6[‡] *3*	0 to 4	
2371.34 *22*	0 to 4	
2406.10[‡] *14*	1,2$^+$	
2427.01 *7*	2$^+$	J$^\pi$: 2 from $\gamma\gamma(\theta)$; 2,3 from $\gamma(\theta)$ (2016Gi05).
2468.36 *21*	0 to 4	Previously reported 670.2γ from this level was not seen by 2016Gi05. 2468γ from this level could not be confirmed by 2016Gi05 due to the maximum energy limit of 2300 keV in their γ spectra.
2547.02 *7*	5$^+$	J$^\pi$: 5 from $\gamma\gamma(\theta)$; 4,5,6 from $\gamma(\theta)$ (2016Gi05).
2602.28 *12*	2$^+$,3,4$^+$	
2619.5 *4*	0 to 4	A 2619.2γ from this level is not measured by 2016Gi05.
2656.54 *7*	3$^+$,5$^+$	J$^\pi$: 3,5 from $\gamma\gamma(\theta)$, and 3,4,5 from $\gamma(\theta)$ (2016Gi05). J^π=(3) in 1988Sa01.
2659.66 *7*	2$^+$,3,4	J$^\pi$: 2,3,4 from $\gamma(\theta)$ (2016Gi05). J^π=3$^+$,4 in 1988Sa01.
2670.37[‡] *18*	0$^+$ to 3	J$^\pi$: 0 to 3 from $\gamma(\theta)$ (2016Gi05).

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^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01 (continued)

^{98}Ru Levels (continued)

E(level)[†]	J$^{\pi}$[#]	Comments
2707.32[‡] *17*	1,2^{+}	
2720.12 *11*	3,4^{+}	J$^{\pi}$: 3,4,5 from $\gamma(\theta)$, and 3 to 6 from $\gamma\gamma(\theta)$ (2016Gi05). J=3 in 1988Sa01.
2754.2[‡] *3*	0 to 4	
2809.32 *8*	3,4,5^{+}	J$^{\pi}$: 3 to 6 from $\gamma(\theta)$ (2016Gi05). J^{π}=(2^{+}) in 1988Sa01.
2811.54[‡] *25*	2^{+},3,4^{+}	
2816.66[‡] *20*	2^{+},3,4^{+}	
2825.88[‡] *21*	2 to 6	
2859.15[‡] *21*	1 to 5	
2867.34 *11*	4^{+},6^{+}	J$^{\pi}$: 4 to 7 from $\gamma(\theta)$, and 4,6,7,8 from $\gamma\gamma(\theta)$ (2016Gi05). Parity from mult(320γ) and mult(645γ) from α(K)exp (2016Gi05). Authors list (6)$^{+}$ for 2867 level in Table I. J^{π}=6^{+} in 1988Sa01.
2932.65[‡] *20*	4^{+}	
2954.4[‡] *3*	0^{+} to 4^{+}	
2997.8[‡] *7*	1,2^{+}	E(level): 2979.7 in 2016Gi05 is a misprint, as confirmed by e-mail communication of Dec 7, 2016 with A. Giannatiempo by the evaluator(B. Singh).
3014.5[‡] *6*	2 to 6	
3016.9[‡] *3*	2^{+} to 5	J$^{\pi}$: 2 to 5 from $\gamma\gamma(\theta)$ (2016Gi05).
3026.6[‡] *5*	1 to 5	
3064.87 *10*	3,4,5^{+}	J$^{\pi}$: 3 to 6 from $\gamma\gamma(\theta)$, and 3,4,5 from $\gamma(\theta)$ (2016Gi05). J^{π}=3,4^{+} in 1988Sa01.
3069.14 *15*	5^{+},6^{+}	J$^{\pi}$: 5,6 from $\gamma\gamma(\theta)$. Parity from mult(846.6γ) from α(K)exp (2016Gi05). Authors list 4^{+} to 8^{+} for 3069 level in Table I.
3074.66[‡] *14*	2 to 5^{+}	
3093.8[‡] *4*	2^{+},3,4^{+}	
3097.58[‡] *21*	2 to 6	
3109.08[‡] *13*	2^{+},3,4^{+}	
3120.30[‡] *18*	2 to 5	
3126.37 *8*	8^{+}	
3132.6[‡] *3*	2 to 6	
3184.95[‡] *10*	4^{+},5^{+}	
3190.28 *8*	8^{+}	J$^{\pi}$: 7,8 from $\gamma\gamma(\theta)$, and 5 to 8 from $\gamma(\theta)$ (2016Gi05). Parity from mult(967.7γ) from α(K)exp (2016Gi05). Authors list (8)$^{+}$ for 3190 level in Table I.
3205.1 *3*	2^{+},3,4^{+}	A strong 2552.3γ from this level is not measured by 2016Gi05.
3245.25 *10*	5^{+},6^{+}	J$^{\pi}$: 5,6 from $\gamma(\theta)$ (2016Gi05). Parity from mult(978.8γ) from α(K)exp (2016Gi05). Authors list (6)$^{+}$ for 3245 level in Table I. J^{π}=(6^{+}) in 1988Sa01.
3250.83 *12*	4^{+},5^{+}	J$^{\pi}$: 3,4,5 from $\gamma(\theta)$. Parity from mult(984.4γ) from α(K)exp (2016Gi05). Authors list 2^{+} to 6^{+} for 3251 level in Table I.
3279.27[‡] *20*	2 to 5	
3283.32 *9*	5^{+},7^{+}	J$^{\pi}$: 5,7 from $\gamma\gamma(\theta)$, and 5,6,7 from $\gamma(\theta)$ (2016Gi05). Parity from mult(1061γ) from α(K)exp (2016Gi05). Authors list (7)$^{+}$ for 3283 level in Table I. J^{π}=(5^{-}) in 1988Sa01. A 567.4γ from 9^{-} state at 3851.59 was not seen by 2016Gi05.
3287.99[‡] *21*	4 to 8	
3350.4[‡] *3*	2 to 5	
3382.92[‡] *22*	1 to 5	
3442.20 *24*	2^{+},3,4^{+}	A previously proposed 1428γ from this level not confirmed in 2016Gi05.
3474.60 *15*	4^{+},5,6^{+}	
3523.58[‡] *19*	4^{+},5^{+}	
3538.54 *12*	6^{+},7^{+}	J$^{\pi}$: 6,7 from 991.8$\gamma(\theta)$ (2016Gi05). Parity from mult(991.8γ) from α(K)exp) (2016Gi05). J^{π}=6^{+} in 1988Sa01. A 312.7γ from 9^{-} state at 3851.59 was not seen by 2016Gi05.
3562.16[‡] *25*	4 to 7	
3578.49 *11*	5^{+},6,7^{+}	J$^{\pi}$: from text on page 13. In Fig. 13, J=4 to 7.

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^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01 (continued)

^{98}Ru Levels (continued)

E(level)[†]	J$^{\pi}$[#]	Comments
3620.49[‡] *21*	4 to 8	
3623.94[‡] *21*	1 to 7	
3637.8[‡] *3*	4 to 8	
3671.14[‡] *21*	1 to 7	
3703.14[‡] *21*	1 to 7	
3721.77[‡] *18*	3 to 7	
3851.08 *13*	9^-	Previous placement of a 272γ from this level was not confirmed by 2016Gi05 in their $\gamma\gamma$-coin data, this γ remains unplaced. Previously reported 312γ from this level not seen by 2016Gi05. Previously reported 567.4 and 661.3 γ rays are observed by 2016Gi05 at 569.0 and 662.1 keV, respectively, and both placed from a new level at 3852.3 keV. J$^{\pi}$: 9^+ in 1988Sa01 is inconsistent with their $\gamma(\theta)$ and γ(pol) data.
3852.33[‡] *20*	6^+,7^+	
3854.95 *15*	4 to 8	
3944.50 *21*	4 to 8	
3964.9[‡] *4*	4 to 8	
3971.79[‡] *23*	1 to 5	
4000.66 *12*	10^+	
4005.60 *12*	6^+,7^+	E(level): 2016Gi05 confirmed only one level near this energy, and not a doublet at 4006.6 and 4007.4 keV, as reported by 2004Ca42 in ^{96}Mo(α,2nγ).
4134.6 *4*	3 to 8	
4213.76 *24*	6^+,7,8^+	
4222.89 *20*	(10^+)	E(level): 2016Gi05 did not confirm the existence of a 4221.7 keV level depopulated by a 1030.4γ, as reported by 2004Ca42 in ^{96}Mo(α,2nγ).
4256.3 *4*	3 to 8	

[†] From a least-squares fit to γ-ray energies.
[‡] New level proposed by 2016Gi05.
[#] As given by 2016Gi05 in their level-scheme Figs. 9-13, based on previous assignments (1988Sa01), and their $\gamma(\theta)$, $\gamma\gamma(\theta)$ and ce data. For many levels, only a range of spin values is given by 2016Gi05, apparently based on gamma decay pattern, and known J^{π} values of low-lying levels. Assignments in 1988Sa01 are based on $\gamma(\theta)$, γ(pol) and γ(excitation function).

γ(^{98}Ru)

E$_i$(level)	J$_i^{\pi}$	E$_{\gamma}$[†]	I$_{\gamma}$[†]	E$_f$	J$_f^{\pi}$	Mult.[a]	δ[d]	Comments
652.45	2^+	652.45[‡] *5*	100	0.0	0^+	E2		A$_2$=+0.087 *5*, POL=+0.18 *2*, Iγ(rel)=100.0 (1988Sa01); A$_2$=+0.082 *18* (2016Gi05).
1322.14	0^+	669.70[‡] *5*	100	652.45	2^+			E$_{\gamma}$: other: 669.9 *1* mentioned in the text but not adopted in Table II in 2016Gi05. Iγ(rel)=1.7 *3* (1988Sa01).
1397.87	4^+	745.37[‡] *5*	100	652.45	2^+	E2		A$_2$=+0.136 *6*, POL=+0.25 *2*, Iγ(rel)=53.3 *2* (1988Sa01); A$_2$=+0.129 *19* (2016Gi05).
1414.31	2^+	761.84[‡] *5*	100 *2*	652.45	2^+	E2+M1	+11 *+8−3*	Mult.: from Adopted Gammas. δ: from $\gamma\gamma(\theta)$ (2016Gi05). Other values from $\gamma(\theta)$: −0.25 *+14−5* or +6.0 *+23−27* (2016Gi05). A$_2$=+0.01 *1*, POL=−0.05 *4*, Iγ(rel)=10.2 *7* (1988Sa01); A$_2$=+0.02 *2* (2016Gi05).
		1414.29[‡] *5*	49 *1*	0.0	0^+			A$_2$=+0.057 *14*, POL=+0.12 *11*, Iγ(rel)=5.0 *1* (1988Sa01); A$_2$=+0.046 *37* (2016Gi05).

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^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01 (continued)

$\gamma(^{98}Ru)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[a]	δ[d]	Comments
1796.97	3$^+$	382.65[‡] *5*	25.7 *9*	1414.31	2$^+$	M1+E2[b]	0.9 *+8−5*	α(K)exp=0.0090 *8* (2016Gi05) I_γ: weighted average of 25.6 *9* from 1988Sa01 and 27 *3* from 2016Gi05. δ: from α(K)exp in 2016Gi05. Evaluators obtain δ=0.9 *+7−4*. Other values from $\gamma(\theta)$: +0.02 *+10−16* or −3.5 *12* (2016Gi05). A_2=−0.091 *14*, POL=+0.07 *10*, Iγ(rel)=3.0 *1* (1988Sa01); A_2=−0.117 *30* (2016Gi05).
		398.9 *2*	7.1 *9*	1397.87	4$^+$	D+Q[c]		E_γ: weighted average of 399.1 *3* from 1988Sa01 and 398.8 *2* from 2016Gi05. I_γ: weighted average of 6.8 *9* from 1988Sa01 and 10 *3* from 2016Gi05. δ: −0.22 *+7−16* or −5.2 *+12−17* from $\gamma(\theta)$ (2016Gi05). A_2=+0.06 *4*, POL=+0.14 *18*, Iγ(rel)=0.8 *1* (1988Sa01); A_2=+0.08 *6* (2016Gi05).
		1144.52[‡] *5*	100 *1*	652.45	2$^+$	M1,E2[b]		α(K)exp=0.00065 *15* (2016Gi05) I_γ: weighted average of 100 *7* from 1988Sa01 and 100 *1* from 2016Gi05. A_2=+0.025 *10*, POL=+0.01 *5*, Iγ(rel)=11.7 *8* (1988Sa01).
1817.18	2$^+$	494.7 *3*	3 *1*	1322.14	0$^+$			
		1164.78[‡] *5*	100 *5*	652.45	2$^+$	M1+E2[b]	−0.27 *6*	α(K)exp=0.0010 *3* (2016Gi05) δ: from $\gamma\gamma(\theta)$ (2016Gi05). The α(K) exp value is somewhat high for M1 or E2. A_2=−0.03 *2*, POL=+0.07 *21*, Iγ(rel)=3.0 *2* (1988Sa01); A_2=−0.01 *3* (2016Gi05).
		1817.1 *3*	18 *3*	0.0	0$^+$			
2012.74	3$^+$	598.44[‡] *5*	70 *4*	1414.31	2$^+$	D+Q[c]	+0.14 *+6−10*	I_γ: weighted average of 71 *7* from 1988Sa01 and 70 *4* from 2016Gi05. δ: from $\gamma\gamma(\theta)$ (2016Gi05). Iγ(rel)=3.2 *3* (1988Sa01).
		614.87[‡] *5*	100 *4*	1397.87	4$^+$	D+Q[c]	−0.35 *5*	I_γ: weighted average of 100 *7* from 1988Sa01 and 100 *4* from 2016Gi05. δ: from $\gamma\gamma(\theta)$ (2016Gi05). Other values: +0.24 *+20−10* or >+3 from $\gamma(\theta)$ (2016Gi05). Note that the sign(δ) is different in $\gamma\gamma(\theta)$ and $\gamma(\theta)$. A_2=−0.108 *11*, POL=+0.03 *8*, Iγ(rel)=4.5 *3* (1988Sa01); A_2=−0.111 *36* (2016Gi05).
		1360.1 *4*	6 *1*	652.45	2$^+$			
2222.58	6$^+$	824.69[‡] *5*	100	1397.87	4$^+$	E2[b]		α(K)exp=0.00129 *9* (2016Gi05) A_2=+0.187 *5*, POL=+0.27 *3*, Iγ(rel)=19.0 *12* (1988Sa01); A_2=+0.184 *18* (2016Gi05).
2241.5	2 to 6	843.6 *3*	100	1397.87	4$^+$			E_γ: weighted average of 843.6 *3* from 1988Sa01 and 843.6 *5* from 2016Gi05. A_2=+0.18 *7*, POL=+0.5 *4*, Iγ(rel)=0.4 *2* (1988Sa01). Mult.: $\gamma(\theta)$ and POL data in 1988Sa01 suggest mult=E2 or E1 (if ΔJ=0).

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^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01 (continued)

γ(^{98}Ru) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[a]	δ[d]	Comments
2245.86	2$^{(+)}$	1593.4 *2*	100	652.45	2$^+$	D+Q[c]	−0.19 *+10−11*	E_γ: weighted average of 1593.4 *3* from 1988Sa01 and 1593.4 *2* from 2016Gi05. δ: from $\gamma\gamma(\theta)$ (2016Gi05). A_2=+0.06 *14*, Iγ(rel)=0.9 *2* (1988Sa01).
2257.8	0 to 4	843.5[&] *4*	100	1414.31	2$^+$			
2266.51	4$^+$	253.80[‡] *5*	21 *2*	2012.74	3$^+$	M1+E2[b]	−0.9 *5*	α(K)exp=0.020 *2* (2016Gi05) I_γ: weighted average of 22 *2* from 1988Sa01 and 20 *3* from 2016Gi05. A_2=−0.36 *2*, POL=−0.49 *22*, Iγ(rel)=1.1 *1* (1988Sa01); A_2=−0.365 *54* (2016Gi05). δ: from $\gamma(\theta)$ (2016Gi05). Other: δ<0.35 from α(K)exp at 95% confidence level (2016Gi05). Evaluators obtain δ<0.16 for an uncertainty of one σ.
		469.54[‡] *5*	100 *3*	1796.97	3$^+$	E2+M1[c]	+4.20 *+6−13*	I_γ: weighted average of 100 *8* from 1988Sa01 and 100 *3* from 2016Gi05. δ: +0.45 *+14−8* or +4.20 *+6−13* from $\gamma(\theta)$ (2016Gi05), the latter is favored by γ(pol) data of 1988Sa01. A_2=+0.135 *9*, POL=+0.20 *9*, Iγ(rel)=5.0 *4* (1988Sa01); A_2=+0.114 *42* (2016Gi05).
		868.5 *2*	29 *3*	1397.87	4$^+$	E2+M1[b]	+2.3 *+15−8*	E_γ: weighted average of 868.7 *3* from 1988Sa01 and 868.4 *2* from 2016Gi05. I_γ: weighted average of 26 *4* from 1988Sa01 and 30 *3* from 2016Gi05. δ: from $\gamma\gamma(\theta)$ (2016Gi05). Others: −0.37 *+32−12* or +2.1 *+10−12* from $\gamma(\theta)$ (2016Gi05). The γ(pol) data of 1988Sa01 for ΔJ=0 transitions favors dominant E2. A_2=−0.07 *2*, POL=−0.6 *4*, Iγ(rel)=1.3 *2* (1988Sa01); A_2=+0.04 *4* (2016Gi05).
2277.02	3$^+$,4$^+$	264.1[&] *4*	5 *1*	2012.74	3$^+$			
		879.2 *1*	57 *3*	1397.87	4$^+$	M1,E2[b]		α(K)exp=0.00080 *29* (2016Gi05) E_γ: weighted average of 879.0 *3* from 1988Sa01 and 879.2 *1* from 2016Gi05. I_γ: weighted average of 56 *13* from 1988Sa01 and 57 *3* from 2016Gi05. 2016Gi05 state that presence of a very weak 879.5γ from 4005.6-keV level does not affect the α(K)exp value for 879.2γ, as the intensity of the 879.5γ is approximately 4% that of the intensity of 879.2γ. A_2=+0.10 *2*, POL=−0.15 *63*, Iγ(rel)=0.9 *2* (1988Sa01).
		1624.3 *3*	100 *4*	652.45	2$^+$			E_γ: weighted average of 1624.3 *3* from 1988Sa01 and 1624.2 *3* from 2016Gi05. I_γ: weighted average of 100 *25* from 1988Sa01 and 100 *4* from 2016Gi05. A_2=+0.8 *4*, POL=+0.5 *3*, Iγ(rel)=1.6 *4* (1988Sa01).
2295.47	2 to 6	897.6[&] *2*	100	1397.87	4$^+$			
2362.6	0 to 4	1710.1[@&] *3*	100	652.45	2$^+$			

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^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01 (continued)

γ(^{98}Ru) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[a]	δ[d]	Comments
2371.34	0 to 4	956.7[&] *3*	14 *4*	1414.31	2^+			
		1719.2[#] *3*	100 *10*	652.45	2^+			
2406.10	$1,2^+$	991.7[&] *2*	48 *10*	1414.31	2^+			
		1084.1[&] *2*	64 *6*	1322.14	0^+			
		1753.5[&] *3*	100 *16*	652.45	2^+			
2427.01	2^+	610.0 *1*	10 *1*	1817.18	2^+	D+Q[c]	−1.5 *+8−53*	E_γ: weighted average of 610.1 *3* from 1988Sa01 and 610.0 *1* from 2016Gi05. I_γ: weighted average of 9.1 *23* from 1988Sa01 and 10 *1* from 2016Gi05. A_2=−0.11 *8*, POL=−0.4 *4*, Iγ(rel)=0.4 *1* (1988Sa01); A_2=−0.091 *33* (2016Gi05). δ: from $\gamma(\theta)$ for J(2427)=2.
		629.9 *2*	10.3 *15*	1796.97	3^+	M1+E2		E_γ: weighted average of 630.1 *3* from 1988Sa01 and 629.8 *2* from 2016Gi05. I_γ: weighted average of 6.8 *23* from 1988Sa01 and 11 *1* from 2016Gi05. Mult.: γ(pol) in 1988Sa01 suggests dominant M1. δ: δ(Q/D)=−0.04 *45* deduced by 2016Gi05 from A_2 in 1988Sa01 for J(2427)=2. A_2=+0.17 *7*, POL=−1.4 *7*, Iγ(rel)=0.3 *1* (1988Sa01).
		1012.7[&] *1*	11 *1*	1414.31	2^+			
		1029.0 *1*	21 *1*	1397.87	4^+			E_γ: weighted average of 1029.4 *3* from 1988Sa01 and 1029.0 *1* from 2016Gi05. I_γ: weighted average of 18 *5* from 1988Sa01 and 21 *1* from 2016Gi05. A_2=+0.09 *20*, POL=+0.02 *50*, Iγ(rel)=0.8 *2* (1988Sa01).
		1774.5 *3*	100 *2*	652.45	2^+	M1+E2[c]	+0.42 *+7−5*	E_γ: weighted average of 1774.5 *3* from 1988Sa01 and 1774.5 *3* from 2016Gi05. I_γ: weighted average of 100 *11* from 1988Sa01 and 100 *2* from 2016Gi05. Mult.: dominant M1 from γ(pol) in 1988Sa01 if 1774γ is ΔJ=0 transition. δ: from $\gamma\gamma(\theta)$ (2016Gi05). A_2=+0.28 *19*, POL=+0.5 *3*, Iγ(rel)=4.4 *5* (1988Sa01).
2468.36	0 to 4	1815.9[&] *2*	100	652.45	2^+			
2547.02	5^+	280.5 *2*	10 *2*	2266.51	4^+			
		324.4 *1*	21 *2*	2222.58	6^+	M1		E_γ: weighted average of 324.5 *3* from 1988Sa01 and 324.4 *1* from 2016Gi05. I_γ: weighted average of 22 *2* from 1988Sa01 and 20 *2* from 2016Gi05. Mult.: from γ(pol) in 1988Sa01. A_2=+0.01 *14*, POL=−0.55 *16*, Iγ(rel)=1.0 *1* (1988Sa01). In singles, Iγ(324)/Iγ(1149) is larger, as the 324γ is contaminated by a 324.5 line from ^{97}Tc.
		534.2[&] *2*	11 *3*	2012.74	3^+			
		1149.17[‡] *5*	100 *4*	1397.87	4^+	D+Q[c]	+0.37 *5*	I_γ: weighted average of 100 *9* from

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^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01 (continued)

γ(^{98}Ru) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[a]	Comments
							1988Sa01 and 100 *4* from 2016Gi05. A_2=+0.17 *1*, Iγ(rel)=4.5 *4* (1988Sa01); A_2=+0.19 *2* (2016Gi05). δ: from $\gamma\gamma(\theta)$ (2016Gi05). Other values: +0.44 *10* or +3.6 *+5−10* from $\gamma(\theta)$ for J(2547)=5 (2016Gi05).
2602.28	2$^+$,3,4$^+$	325.2[&] *3*	23 *4*	2277.02	3$^+$,4$^+$		
		589.5 *2*	100 *7*	2012.74	3$^+$		Eγ=591 *1*, Iγ(rel)=0.3 *1* (1988Sa01).
		785.3[&] *3*	12 *3*	1817.18	2$^+$		
		1188.0[&] *3*	39 *5*	1414.31	2$^+$		
		1204.4 *2*	67 *5*	1397.87	4$^+$		A_2=+0.14 *12*, POL=+0.6 *11*, Eγ=1204.4 *3*, Iγ(rel)=0.4 *2* (1988Sa01).
		1949.1[&] *10*	40 *18*	652.45	2$^+$		
2619.5	0 to 4	802.2[&] *4*	10 *2*	1817.18	2$^+$		
		1967.2 *5*	100 *7*	652.45	2$^+$		
2656.54	3$^+$,5$^+$	643.9[&] *2*	6 *1*	2012.74	3$^+$		
		1258.69[‡] *5*	100 *2*	1397.87	4$^+$	D	A_2=−0.08 *1*, POL=−0.02 *10*, Iγ(rel)=4.4 *5* (1988Sa01) ; A_2=−0.11 *2* (2016Gi05).
2659.66	2$^+$,3,4	862.66[‡] *5*	100	1796.97	3$^+$	D	A_2=−0.064 *16*, POL=−0.01 *9*, Iγ(rel)=3.0 *3* (1988Sa01); A_2=−0.074 *43*.
2670.37	0$^+$ to 3	853.2[&] *2*	12 *2*	1817.18	2$^+$		
		1256.1[&] *5*	100 *4*	1414.31	2$^+$		A_2=−0.01 *4* (2016Gi05)
		2018.1[&] *7*	14 *3*	652.45	2$^+$		
2707.32	1,2$^+$	889.7[&] *4*	10 *3*	1817.18	2$^+$		
		1293.0[&] *2*	100 *16*	1414.31	2$^+$		
		1385.6[&] *4*	12 *3*	1322.14	0$^+$		
2720.12	3,4$^+$	1322.2 *1*	100 *3*	1397.87	4$^+$	D	E$_\gamma$: weighted average of 1322.5 *3* from 1988Sa01 and 1322.2 *1* from 2016Gi05. A_2=−0.05 *4*, POL=+0.09 *49*, Iγ(rel)=0.9 *2* (1988Sa01); A_2=−0.09 *5* (2016Gi05).
		2068.1[&] *5*	11 *2*	652.45	2$^+$		
2754.2	0 to 4	937.0[&] *3*	100	1817.18	2$^+$		
2809.32	3,4,5$^+$	542.8 *1*	95 *5*	2266.51	4$^+$		E$_\gamma$: weighted average of 542.7 *3* from 1988Sa01 and 542.8 *1* from 2016Gi05. A_2=+0.18 *4*, POL=+0.17 *15*, Iγ(rel)=0.9 *3* (1988Sa01).
		796.4[&] *2*	19 *2*	2012.74	3$^+$		
		1012.4 *1*	100 *8*	1796.97	3$^+$		E$_\gamma$: weighted average of 1012.2 *3* from 1988Sa01 and 1012.4 *1* from 2016Gi05. A_2=+0.15 *7*, POL=+0.14 *42*, Iγ(rel)=0.7 *2* (1988Sa01).
		1411.5[&] *5*	33 *8*	1397.87	4$^+$		
2811.54	2$^+$,3,4$^+$	1397.2[&] *3*	100 *7*	1414.31	2$^+$		
		1413.7[&] *4*	58 *10*	1397.87	4$^+$		
2816.66	2$^+$,3,4$^+$	999.3[&] *4*	17 *4*	1817.18	2$^+$		
		1402.2[&] *4*	33 *8*	1414.31	2$^+$		
		1418.9[&] *3*	100 *11*	1397.87	4$^+$		
		2164.4[&] *6*	91 *15*	652.45	2$^+$		
2825.88	2 to 6	1428.0[&] *2*	100	1397.87	4$^+$		
2859.15	1 to 5	846.4[&] *2*	100	2012.74	3$^+$		

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^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01 (continued)

$\gamma(^{98}Ru)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[a]	δ[d]	Comments
2867.34	4$^+$,6$^+$	320.3 *1*	100 *5*	2547.02	5$^+$	M1(+E2)[b]	0.0 *5*	α(K)exp=0.0123 *12* (2016Gi05) E_γ: weighted average of 320.7 *3* from 1988Sa01 and 320.3 *1* from 2016Gi05. I_γ: weighted average of 100 *18* from 1988Sa01 and 100 *5* from 2016Gi05. A_2=+0.08 *26*, POL=−0.37 *30*, Iγ(rel)=1.1 *2* (1988Sa01); A_2=+0.11 *5* (2016Gi05). δ(E2/M1) from α(K)exp.
		644.9 *2*	51 *3*	2222.58	6$^+$	M1,E2[b]		α(K)exp=0.00244 *52* (2016Gi05) E_γ: weighted average of 645.2 *3* from 1988Sa01 and 644.8 *2* from 2016Gi05. I_γ: weighted average of 45 *9* from 1988Sa01 and 52 *3* from 2016Gi05. Iγ(rel)=0.5 *1* (1988Sa01).
		1469.2[&] *4*	8 *2*	1397.87	4$^+$			
2932.65	4$^+$	710.0[&] *2*	62 *13*	2222.58	6$^+$			
		2280.8[&] *6*	100 *27*	652.45	2$^+$			
2954.4	0$^+$ to 4$^+$	527.4[&] *3*	100	2427.01	2$^+$			
2997.8	1,2$^+$	1675.6[&] *7*	100	1322.14	0$^+$			
3014.5	2 to 6	1616.6[&] *6*	100	1397.87	4$^+$			
3016.9	2$^+$ to 5	1619.0[&] *3*	100	1397.87	4$^+$			
3026.6	1 to 5	1013.9[&] *5*	100	2012.74	3$^+$			
3064.87	3,4,5$^+$	408.3[&] *2*	7 *1*	2656.54	3$^+$,5$^+$			
		1052.1[&] *2*	10 *3*	2012.74	3$^+$			
		1667.0 *1*	100 *4*	1397.87	4$^+$	D		E_γ: weighted average of 1667.1 *3* from 1988Sa01 and 1667.0 *1* from 2016Gi05. A_2=−0.08 *5*, POL=+0.4 *4*, Iγ(rel)=1.0 *3* (1988Sa01); A_2=−0.18 *8* (2016Gi05).
3069.14	5$^+$,6$^+$	522.2 *2*	9 *1*	2547.02	5$^+$			Eγ=522 *1*, Iγ(rel)=0.2 *1* (1988Sa01).
		846.6 *3*	100 *6*	2222.58	6$^+$	M1,E2[b]		α(K)exp=0.00136 *30* (2016Gi05) Eγ=847 *1*, Iγ(rel)=0.7 *2* (1988Sa01).
		1671.0[&] *3*	12 *1*	1397.87	4$^+$			
3074.66	2 to 5$^+$	418.3[&] *2*	55 *6*	2656.54	3$^+$,5$^+$			
		1061.7[&] *3*	45 *9*	2012.74	3$^+$			
		1676.7[&] *2*	100 *12*	1397.87	4$^+$			
3093.8	2$^+$,3,4$^+$	1679.6[&] *4*	51 *16*	1414.31	2$^+$			
		1695.7[&] *5*	100 *18*	1397.87	4$^+$			
3097.58	2 to 6	1699.7[&] *2*	100	1397.87	4$^+$			
3109.08	2$^+$,3,4$^+$	452.3[&] *3*	16 *3*	2656.54	3$^+$,5$^+$			
		682.2[&] *2*	100 *8*	2427.01	2$^+$			
		1312.3[&] *2*	46 *7*	1796.97	3$^+$			
		1710.7[@&] *3*	73 *4*	1397.87	4$^+$			
3120.30	2 to 5	1107.6[&] *3*	28 *7*	2012.74	3$^+$			
		1722.4[#&] *2*	100 *8*	1397.87	4$^+$			
3126.37	8$^+$	903.80[‡] *5*	100	2222.58	6$^+$	E2		A_2=+0.23 *2*, POL=+0.28 *12*, Iγ(rel)=3.4 *3* (1988Sa01); A_2=+0.232 *27* (2016Gi05).
3132.6	2 to 6	476.2[&] *5*	8 *2*	2656.54	3$^+$,5$^+$			
		1734.6[&] *3*	100 *5*	1397.87	4$^+$			

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^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01 (continued)

γ(^{98}Ru) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[a]	Comments
3184.95	4$^+$,5$^+$	638.0[&] *2*	48 *4*	2547.02	5$^+$		
		962.3[&] *2*	43 *3*	2222.58	6$^+$		
		1172.2[&] *1*	100 *5*	2012.74	3$^+$		
3190.28	8$^+$	967.69[‡] *5*	100	2222.58	6$^+$	E2[b]	α(K)exp=0.00084 *20* (2016Gi05) A_2=+0.21 *3*, POL=+0.63 *15*, Iγ(rel)=2.3 *3* (1988Sa01); A_2=+0.192 *22* (2016Gi05).
3205.1	2$^+$,3,4$^+$	1388.5[&] *6*	50 *15*	1817.18	2$^+$		
		1790.6 *4*	72 *21*	1414.31	2$^+$		
		1807.2[&] *6*	100 *20*	1397.87	4$^+$		
3245.25	5$^+$,6$^+$	698.1[&] *2*	12 *2*	2547.02	5$^+$		
		978.8 *1*	100 *4*	2266.51	4$^+$	E2[b]	α(K)exp=0.00081 *27* (2016Gi05) A_2=+0.20 *4*, POL=+0.41 *27*, Eγ=978.9 *3*, Iγ(rel)=1.1 *3* (1988Sa01); A_2=+0.251 *32* (2016Gi05).
		1022.3[&] *2*	15 *2*	2222.58	6$^+$		
3250.83	4$^+$,5$^+$	590.7 *2*	38 *4*	2659.66	2$^+$,3,4		E$_\gamma$: level-energy difference=591.2.
		594.2 *2*	42 *5*	2656.54	3$^+$,5$^+$		
		984.4 *2*	100 *6*	2266.51	4$^+$	M1+E2	α(K)exp=0.00122 *38* (2016Gi05) Eγ=984.4 *3*, Iγ(rel)=0.5 *3* (1988Sa01). A_2=−0.111 *34* (2016Gi05).
3279.27	2 to 5	1482.2[&] *5*	43 *12*	1796.97	3$^+$		
		1881.4[&] *2*	100 *6*	1397.87	4$^+$		
3283.32	5$^+$,7$^+$	626.9 *1*	23 *2*	2656.54	3$^+$,5$^+$		I$_\gamma$: weighted average of 19 *5* from 1988Sa01 and 24.0 *20* from 2016Gi05. Eγ=626.9 *3*, Iγ(rel)=0.4 *1* (1988Sa01).
		1060.6 *1*	100 *2*	2222.58	6$^+$	M1+E2	α(K)exp=0.00090 *25* (2016Gi05) A_2=−0.13 *3*, POL=+0.13 *14*, Eγ=1060.9 *3*, Iγ(rel)=2.1 *3* (1988Sa01); A_2=−0.115 *29* (2016Gi05).
3287.99	4 to 8	1065.4[&] *2*	100	2222.58	6$^+$		
3350.4	2 to 5	1084.0[&] *3*	61 *12*	2266.51	4$^+$		
		1553.0[&] *5*	100 *22*	1796.97	3$^+$		
3382.92	1 to 5	1106.0[&] *3*	58 *11*	2277.02	3$^+$,4$^+$		
		1370.0[&] *4*	48 *14*	2012.74	3$^+$		
		1585.9[&] *4*	100 *28*	1796.97	3$^+$		
3442.20	2$^+$,3,4$^+$	1014.8[&] *3*	42 *12*	2427.01	2$^+$		
		1625.3 *5*	22 *4*	1817.18	2$^+$		
		2045.1[&] *5*	100 *8*	1397.87	4$^+$		
3474.60	4$^+$,5,6$^+$	229.1 *2*	78 *13*	3245.25	5$^+$,6$^+$		
		1252.3 *2*	100 *13*	2222.58	6$^+$		
		2076.5[&] *5*	96 *21*	1397.87	4$^+$		
3523.58	4$^+$,5$^+$	803.0[&] *4*	11 *3*	2720.12	3,4$^+$		
		1301.1 *2*	100 *6*	2222.58	6$^+$		A_2=+0.53 *28*, POL=−0.86 *67*, Iγ(rel)=0.6 *3* (1988Sa01). E$_\gamma$: weighted average of 1301.2 *2* from 2016Gi05 and 1301.0 *3* from 1988Sa01. Placement of 1301.2γ from 1953 level in 1988Sa01 is rejected by 2016Gi05 based on their $\gamma\gamma$-coin data, thus removing the 1953-keV level in 1988Sa01.
3538.54	6$^+$,7$^+$	412.1 *1*	100 *6*	3126.37	8$^+$		A_2=+0.19 *9*, POL=+0.3 *5*, Eγ=412.1 *3*, Iγ(rel)=0.5 *1* (1988Sa01); A_2=+0.197 *80* (2016Gi05).
		991.8 *2*	65 *5*	2547.02	5$^+$	M1,E2	α(K)exp=0.00097 *48* (2016Gi05) Eγ=991.4 *3*, Iγ(rel)=0.6 *2* (1988Sa01); A_2=+0.175 *67* (2016Gi05).

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^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01 (continued)

$\gamma(^{98}Ru)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[a]	Comments
3562.16	4 to 7	1014.9[&] *3*	69 *13*	2547.02	5^+		
		1340.0[&] *4*	100 *11*	2222.58	6^+		
3578.49	5^+,6,7^+	295.0 *2*	19 *4*	3283.32	5^+,7^+		
		1031.5 *1*	100 *7*	2547.02	5^+		
		1356.1 *4*	15 *3*	2222.58	6^+		
3620.49	4 to 8	1397.9[&] *2*	100	2222.58	6^+		
3623.94	1 to 7	967.4[&] *2*	100	2656.54	3^+,5^+		
3637.8	4 to 8	1415.2[&] *3*	100	2222.58	6^+		
3671.14	1 to 7	1014.6[&] *2*	100	2656.54	3^+,5^+		
3703.14	1 to 7	1046.6[&] *2*	100	2656.54	3^+,5^+		
3721.77	3 to 7	438.5[&] *3*	46 *9*	3283.32	5^+,7^+		
		1065.2[&] *2*	100 *10*	2656.54	3^+,5^+		
3851.08	9^-	724.7 *1*	100	3126.37	8^+	E1	E_γ: weighted average of 725.1 *3* from 1988Sa01 and 724.7 *1* from 2016Gi05. A_2=−0.28 *14*, POL=+0.66 *53*, Iγ(rel)=0.4 *1* (1988Sa01).
3852.33	6^+,7^+	569.0 *2*	100 *23*	3283.32	5^+,7^+		A_2=+0.277 *42* 567.4γ previously placed from 3851 level.
		662.1 *4*	51 *16*	3190.28	8^+		661.3γ previously placed from 3851 level.
3854.95	4 to 8	316.4 *1*	100 *19*	3538.54	6^+,7^+		
		987.6[&] *5*	71 *16*	2867.34	4^+,6^+		
3944.50	4 to 8	1721.9[#] *2*	100	2222.58	6^+		
3964.9	4 to 8	1742.3[&] *4*	100	2222.58	6^+		
3971.79	1 to 5	1301.5[&] *3*	70 *11*	2670.37	0^+ to 3		
		1315.7[&] *4*	64 *12*	2656.54	3^+,5^+		
		1958.4[&] *4*	100 *20*	2012.74	3^+		
4000.66	10^+	810.3 *2*	38 *4*	3190.28	8^+		
		874.3 *1*	100 *7*	3126.37	8^+		A_2=+0.286 *65*
4005.60	6^+,7^+	722.4 *2*	100 *8*	3283.32	5^+,7^+		Eγ=722.5 *3*, Iγ(rel)=0.3 *1* (1988Sa01).
		754.3 *2*	48 *15*	3250.83	4^+,5^+		E_γ: level-energy difference=754.8.
		815.4[&] *2*	51 *4*	3190.28	8^+		
		879.5 *2*	43 *5*	3126.37	8^+		Very weak γ detected in $\gamma\gamma$-coin data (2016Gi05).
4134.6	3 to 8	889.3 *3*	100	3245.25	5^+,6^+		
4213.76	6^+,7,8^+	1023.5 *3*	24 *4*	3190.28	8^+		
		1144.6[&] *3*	100 *8*	3069.14	5^+,6^+		
4222.89	(10^+)	1032.5 *2*	100 *10*	3190.28	8^+		Eγ=1032.4 *3*, Iγ(rel)=0.6 *1* (1988Sa01), placed between 2430 and 1398 levels.
		1096.9 *4*	33 *9*	3126.37	8^+		
4256.3	3 to 8	1011.0 *3*	100	3245.25	5^+,6^+		

[†] From 2016Gi05, unless otherwise noted. Weighted average is taken where values are also available from 1988Sa01. Note that Iγ values are given as relative photon branchings from each level by 2016Gi05 but given as relative intensities normalized to Iγ(652.5γ)=100 by 1988Sa01. Relative Iγ values from 1988Sa01 are given under comments and are re-normalized as those in 2016Gi05 for average by evaluators.

[‡] From 1988Sa01.

[#] 1719.2, 1721.9 and 1722.4 γ rays form an unresolved triplet, individual energies based on analysis of $\gamma\gamma$-coin data in 2016Gi05.

[@] 1710.1 and 1710.7 γ rays form an unresolved doublet, individual energies based on analysis of $\gamma\gamma$-coin data in 2016Gi05.

[&] New γ in 2016Gi05.

[a] As implied by ce and $\gamma(\theta)$ in 2016Gi05, and $\gamma(\theta)$ and γ(pol) in (1988Sa01). Mult=D+Q, most likely corresponds to M1+E2

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^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01 (continued)

$\gamma(^{98}Ru)$ (continued)

rather than E1+M2, assuming no long-lived isomers seem populated here. In most cases, α(K)exp value from 2016Gi05 overlaps mult=M1 or E2.

[b] From α(K)exp measurement by 2016Gi05.

[c] ΔJ=1 or 0, D+Q (most likely M1+E2) from $\gamma(\theta)$ data in 2016Gi05.

[d] From ce, $\gamma\gamma(\theta)$ and $\gamma(\theta)$ data in 2016Gi05. Values from $\gamma(\theta)$ data were deduced by 2016Gi05 by taking weighted averages of their A_2 coefficients and those from 1988Sa01.

[x] γ ray not placed in level scheme.

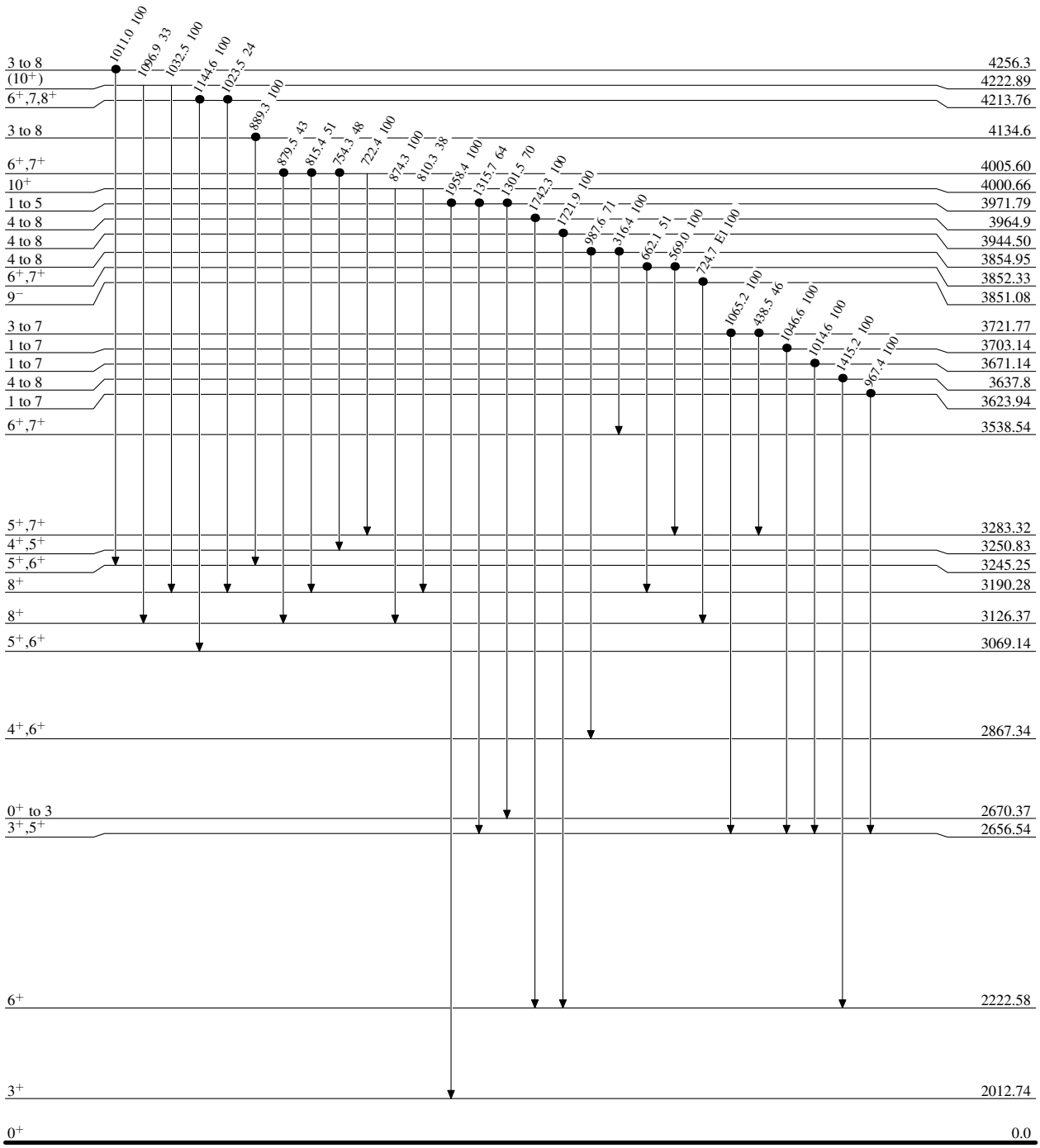
^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01

Legend

Level Scheme

Intensities: Relative photon branching from each level

● Coincidence



$^{98}_{44}Ru_{54}$

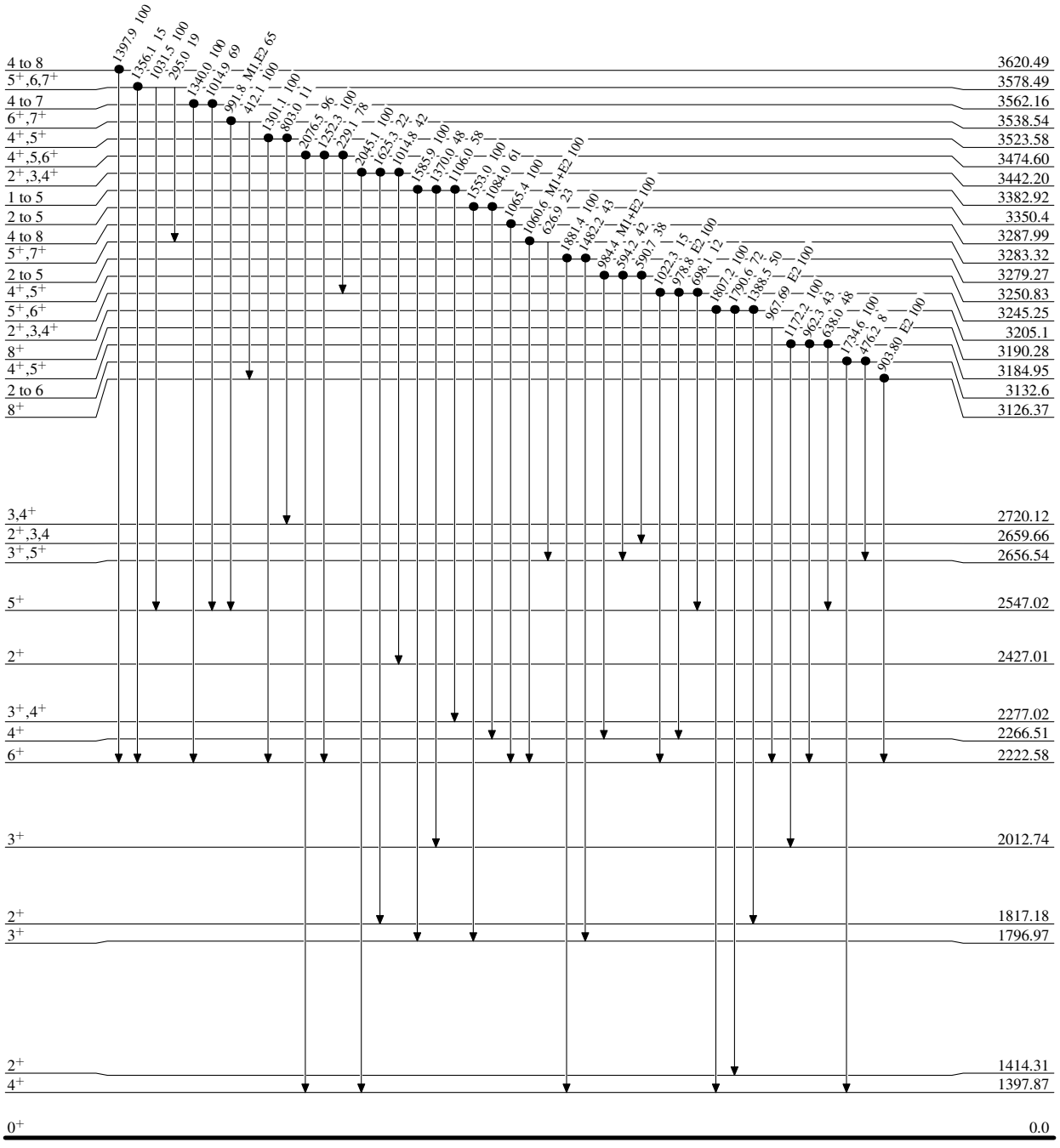
^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

● Coincidence



$^{98}_{44}Ru_{54}$

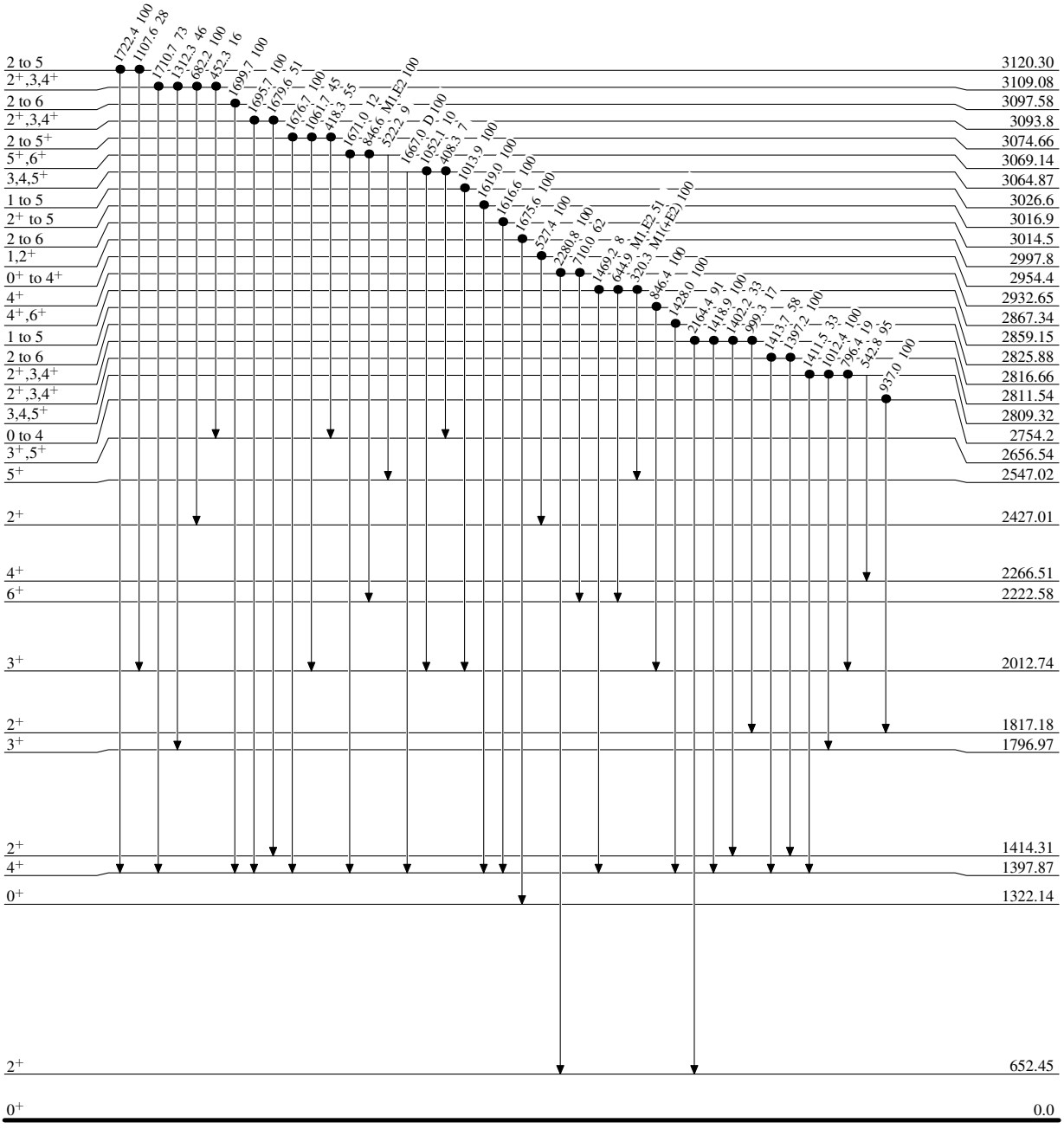
^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

● Coincidence



$^{98}_{44}Ru_{54}$

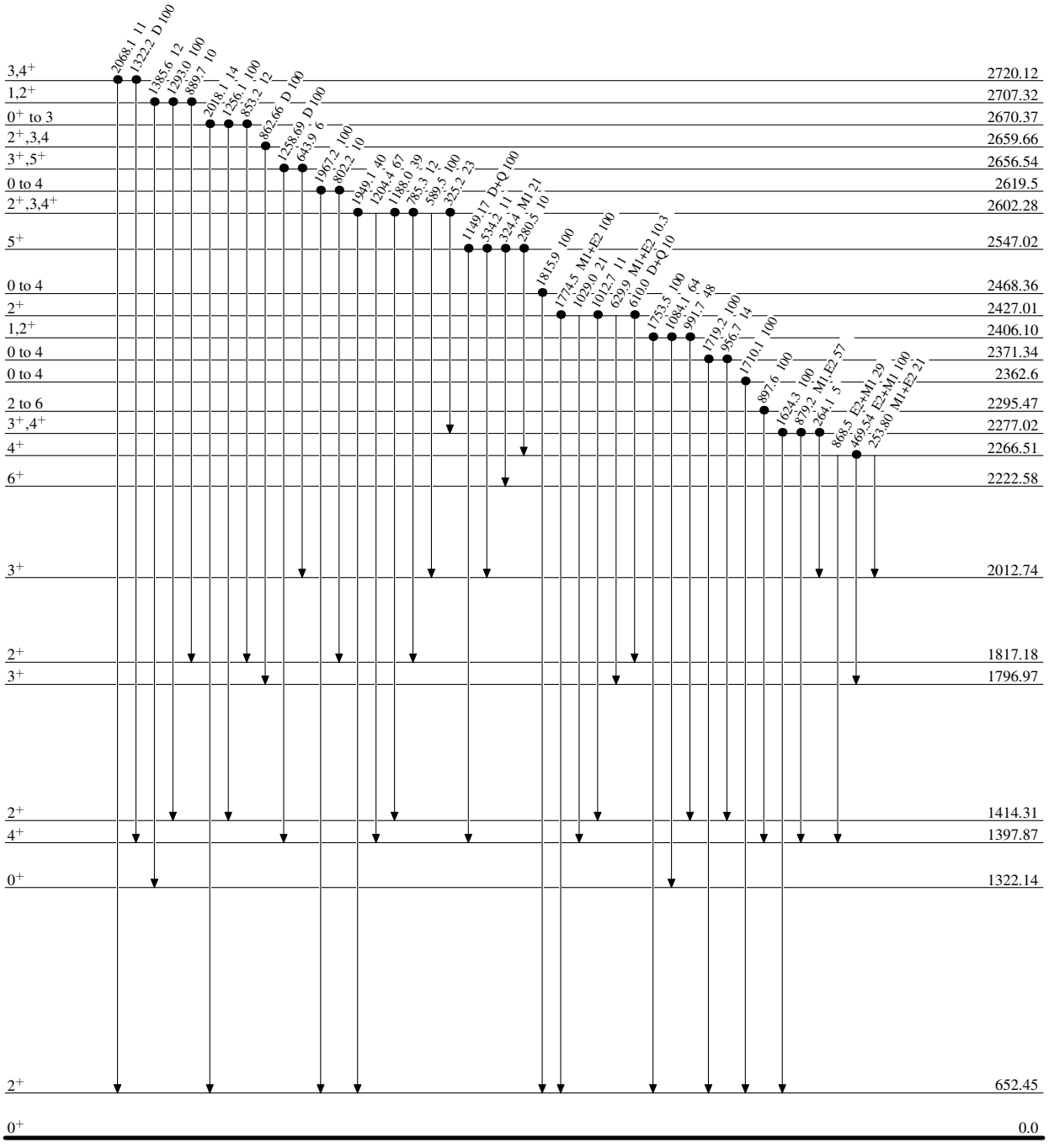
^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

● Coincidence

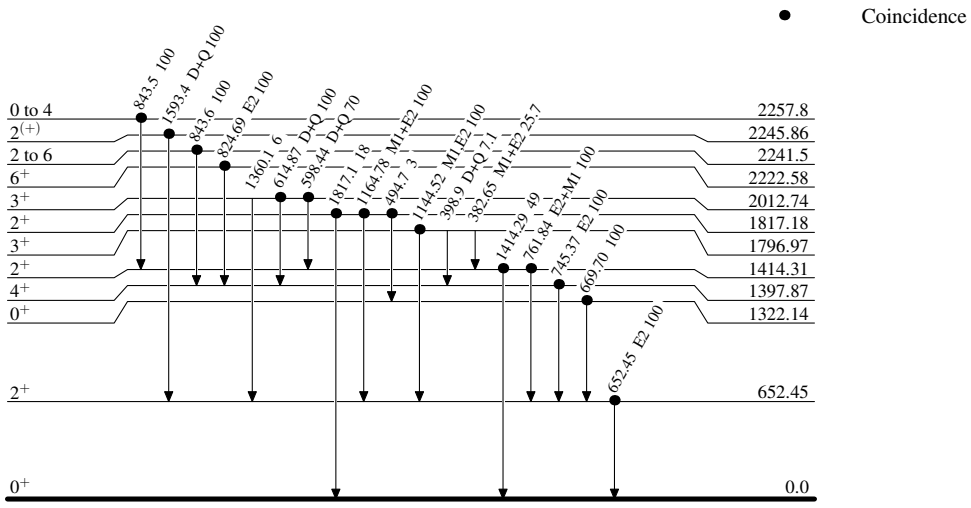


$^{98}_{44}Ru_{54}$

^{97}Mo(^{3}He,2nγ) 2016Gi05,1988Sa01

Level Scheme (continued)

Intensities: Relative photon branching from each level



$^{98}_{44}Ru_{54}$