Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen and Balraj Singh	NDS 199,1 (2025)	30-Sep-2024

Q(β^-)=12017 *7*; S(n)=5469 *10*; S(p)=14957 *8*; Q(α)=−13602 *10* 2021Wa16
S(2n)=9689 *7*, S(2p)=35321 *16*, Q(β^-n)=7509 *7* (2021Wa16).
Identification by 1971Ar32: ^{232}Th(^{40}Ar,X) E=290 MeV, measured fragment isotopic yield.
Later studies of production and decay studies of ^{33}Al: 1979We10, 1986Vi09, 1987Gi05, 1991Zh24, 1991Or01, 1995ReZZ, 1997Ta22, 2002Mo29, 2006Ro34, 2013Ic02.
Mass measurements: 2015Kw01, 2015Xu14, 2014ChZY, 2008Su19, 1991Or01, 1991Zh24, 1987Gi05, 1987VaZS, 1986Vi09, 1986Wo07.
Other measurements:
1986Wo07: ^{48}Ca(^{36}S,^{33}Al)^{51}V: E=198 MeV. Measured particle spectra with a magnetic spectrometer. Deduced mass excess. Peaks also seen at 1600, 2700, 3590, 4310 and 5270. These belong to ^{33}Al and/or ^{51}V.
1999Ai02: Cross section measurement in Si(^{33}Al,X) E=38-80 MeV/nucleon at NSCL facility. Deduced strong absorption radius.
2006Hi18: Spin-polarized ^{33}Al beam produced by fragmentation of a ^{36}S (77.5 MeV/nucleon) on a ^{9}Be target and selected with the high-resolution fragment separator LISE at GANIL. Measured J^π of ground state, magnetic moments, hyperfine structure using laser and β-NMR spectroscopy; deduced g factors, magnetic dipole moments. Compared with shell-model calculations.
2006Kh08: Cross section measurement in Si(^{33}Al,X) E=30-65 MeV/nucleon, deduced reduced strong absorption radius= 1.229 fm^2 *17*. The ^{33}Al beam was obtained from fragmentation of ^{48}Ca beam with ^{181}Ta target at GANIL facility.
2015Mo17: ^{9}Be(^{40}Ar,X) E=95 MeV/nucleon at RIKEN. Measured transverse momentum distributions.
Structure calculations:
2020Ku10: calculated M(>) matrix elements, log *ft*, $T_{1/2}$.
2017Du03: calculated low-lying levels, J, π.
2017Sa48: calculated μ and Q moments for g.s.
2013Li39: calculated β-delayed emission probabilities, $T_{1/2}$, log *ft*, branching ratios.
2011Ki12: calculated single-particle energies and quadrupole deformation.
Additional information 1.
Level scheme is combination of that from 2006AnZW in ^{33}Mg β^- decay and that from 2017Mu05 in ^{9}Be(^{34}Si,^{33}Alγ).

^{33}Al Levels

Cross Reference (XREF) Flags

A	^{33}Mg β^- decay (90.3 ms)	D	He(^{33}Al,^{33}Alγ)
B	^{34}Mg β^-n decay (44.9 ms)	E	Si(^{33}Al,^{33}Al′γ)
C	^{9}Be(^{34}Si,^{33}Alγ)		

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$	XREF	Comments
0.0	(5/2)$^+$	41.5 ms *1*	ABCDE	%β^-=100; %β^-n=8.5 *7* (1995ReZZ,2008ReZZ) μ=4.090 *5* (2006Hi18,2019StZV) Q=0.141 *3* (2016He09,2021StZZ) J$^\pi$: L=2 proton removal from the ^{34}Si g.s. in (^{34}Si,^{33}Alγ) (2017Mu05); 5/2 from shell-model predictions (2006AnZW) and agreement of measured g-factor with theoretical predictions (2006Hi18). $T_{1/2}$: weighted average of 41.4 ms *1* (2017Ha23, implant-β decay curve); 41.7 ms *2* (2002Mo29, implant-β decay curve). Other: 40.5 ms *28* (1995ReZZ,2008ReZZ, decay curve for delayed neutrons). μ: measured using β-NMR method in 2006Hi18. Q: from β-detected nuclear quadrupole resonance (β-NQR) method (2016He09). Other: 0.132 *16* (2012Sh22) and ≈0.13 (2009Na41), both previous work of 2016He09 at LISE-GANIL. Additional information 2.
747.5 *10*	(5/2$^+$)		DE	XREF: E(730).

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{33}Al Levels (continued)

E(level)[†]	Jπ[‡]	XREF	Comments
			Jπ: from shell-model predictions (2002Mi44) in Si(^{33}Al,^{33}Al′γ).
1618.6 *13*	(5/2)$^+$[@]	ABC	
1651.0 *40*	(5/2)$^+$[@]	A C	
1838.5 *11*	(1/2$^+$,3/2,5/2)	A CD	Jπ: possible β^- feeding from 3/2$^-$ parent; 1838.6γ to (5/2)$^+$.
2097.8 *21*	1/2$^+$[a]	ABC	
2365.1 *10*	(1/2$^+$,3/2,5/2)	A C	XREF: C(2366?). Jπ: possible β^- feeding from 3/2$^-$ parent; 2365γ to (5/2)$^+$.
2585.6 *22*		C	
2663.6 *33*	(1/2$^+$,3/2,5/2)	A C	Jπ: possible β^- feeding from 3/2$^-$ parent; 1046γ to (5/2)$^+$.
2692.3 *10*	(1/2$^+$,3/2,5/2$^+$)	A C	Jπ: 596γ to 1/2$^+$, 2692γ to (5/2)$^+$.
2787 *7*		C	
2813.6 *33*		C	
3189 *5*	(1/2$^+$,3/2,5/2$^+$)	C	Jπ: 511γ from 1/2$^+$; 3193γ to (5/2)$^+$.
3284 *7*		C	
3472.6 *30*		C	
3700.1 *44*	1/2$^+$[a]	C	
3714.4? *10*	(3/2$^-$,5/2$^-$)	A	XREF: A(3714?). This level is proposed by 2008Tr07 in ^{33}Mg β^- decay based on a very weak 1618γ-2096γ-coin and a proposed 3714γ g.s. transition seen only in 2008Tr07, while the 2096γ is placed as a g.s. transition in both 2006AnZW in ^{33}Mg β^- and 2017Mu05 in (^{34}Si,^{33}Alγ). The evaluators consider this level questionable but the possibility of its existence cannot be completely ruled out. It could be the same level as the 3700 level (3704 in 2017Mu05). Jπ: log *ft*=5.0 from 3/2$^-$ parent; γ to (5/2)$^+$.
3924 *6*	(3/2)$^+$[&]	C	
4047 *7*		C	
4085.6 *36*		C	
4730.5 *9*	(3/2$^-$,5/2$^-$)	A	Jπ: possible allowed β^- feeding from 3/2$^-$ parent; 4730γ to (5/2)$^+$.
5930[#]	(1/2$^-$,3/2$^-$,5/2$^-$)[#]	A	
5980[#]	(1/2$^-$,3/2$^-$,5/2$^-$)[#]	A	
6820[#]	(1/2$^-$,3/2$^-$,5/2$^-$)[#]	A	
7250[#]	(1/2$^-$,3/2$^-$,5/2$^-$)[#]	A	
7470[#]	(1/2$^-$,3/2$^-$,5/2$^-$)[#]	A	
8870[#]	(1/2$^-$,3/2$^-$,5/2$^-$)[#]	A	

[†] From a least-squares fit to γ-ray energies (assuming ΔEγ=1 keV where not given) for levels connected with γ transitions and from measured E(n) for levels above S(n)=5469 *10* that decay by neutron emission.

[‡] From allowed β transitions in ^{33}Mg decay. The evaluators consider the level scheme as incomplete, thus all assignments are given under parentheses.

[#] Level decays by neutrons to ^{32}Al; spin-parity from direct β^- feeding from 3/2$^-$ parent, possibly allowed based on estimated log *ft*<5.5.

[@] L(^{34}Si,^{33}Al)=2 from 0$^+$, with assumed 1d$_{5/2}$ orbit for removed proton.

[&] L(^{34}Si,^{33}Al)=2 from 0$^+$, with assumed 1d$_{3/2}$ orbit for removed proton.

[a] L(^{34}Si,^{33}Al)=0 from 0$^+$.

Adopted Levels, Gammas (continued)

γ(^{33}Al)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Comments
747.5	$(5/2^+)$	747.5 *10*		0.0	$(5/2)^+$	E_γ: from (^{33}Al,^{33}Alγ). Other: 730 *50* from (^{33}Al,^{33}Al′γ).
1618.6	$(5/2)^+$	1621 *4*	100	0.0	$(5/2)^+$	E_γ: from ^{34}Mg β^-n decay. Other: 1621 *4* from (^{34}Si,^{33}Alγ); 1618 from ^{33}Mg β^- decay.
1651.0	$(5/2)^+$	1651 *4*	100	0.0	$(5/2)^+$	E_γ: other: 1651 *4* from (^{34}Si,^{33}Alγ).
1838.5	$(1/2^+,3/2,5/2)$	1838.9 *17*	100	0.0	$(5/2)^+$	E_γ: weighted average of 1841 *5* from (^{34}Si,^{33}Alγ) and 1838.6 *17* from (^{33}Al,^{33}Alγ).
2097.8	$1/2^+$	2101 *5*	100	0.0	$(5/2)^+$	E_γ: from ^{34}Mg β^-n decay. Other: 2101 *5* from (^{34}Si,^{33}Alγ).
2365.1	$(1/2^+,3/2,5/2)$	2365	100	0.0	$(5/2)^+$	E_γ: other: 2366 *6* from (^{34}Si,^{33}Alγ).
2585.6		747[‡] *2*		1838.5	$(1/2^+,3/2,5/2)$	
		2586[‡#] *7*		0.0	$(5/2)^+$	
2663.6	$(1/2^+,3/2,5/2)$	1045 *3*	100	1618.6	$(5/2)^+$	E_γ: other: 1045 *3* from (^{34}Si,^{33}Alγ).
2692.3	$(1/2^+,3/2,5/2^+)$	595 *2*	100 *20*	2097.8	$1/2^+$	E_γ: other: 595 *2* from (^{34}Si,^{33}Alγ).
		2692	80 *40*	0.0	$(5/2)^+$	E_γ: from ^{33}Mg β^- decay only; not seen in (^{34}Si,^{33}Alγ) (2017Mu05).
2787		2787[‡] *7*	100	0.0	$(5/2)^+$	
2813.6		1195[‡] *3*	100	1618.6	$(5/2)^+$	
3189	$(1/2^+,3/2,5/2^+)$	3193[‡] *8*	100	0.0	$(5/2)^+$	
3284		497[‡] *1*	100	2787		
3472.6		887[‡] *2*	100	2585.6		
3700.1	$1/2^+$	511[‡] *2*		3189	$(1/2^+,3/2,5/2^+)$	
		2080[‡] *5*		1618.6	$(5/2)^+$	
3714.4?	$(3/2^-,5/2^-)$	2096[#]		1618.6	$(5/2)^+$	E_γ: could be a doublet of 2080γ from 3704 level and 2101γ from 2101 level in (^{34}Si,^{33}Alγ) (2017Mu05).
		3714[#]	100 *25*	0.0	$(5/2)^+$	
3924	$(3/2)^+$	2305[‡] *6*	100	1618.6	$(5/2)^+$	
4047		763[‡] *2*	100	3284		
4085.6		613[‡] *2*	100	3472.6		
4730.5	$(3/2^-,5/2^-)$	2892	30 *10*	1838.5	$(1/2^+,3/2,5/2)$	
		4730	100 *30*	0.0	$(5/2)^+$	

[†] From ^{33}Mg β^- decay, unless otherwise noted.
[‡] From (^{34}Si,^{33}Alγ) only.
[#] Placement of transition in the level scheme is uncertain.

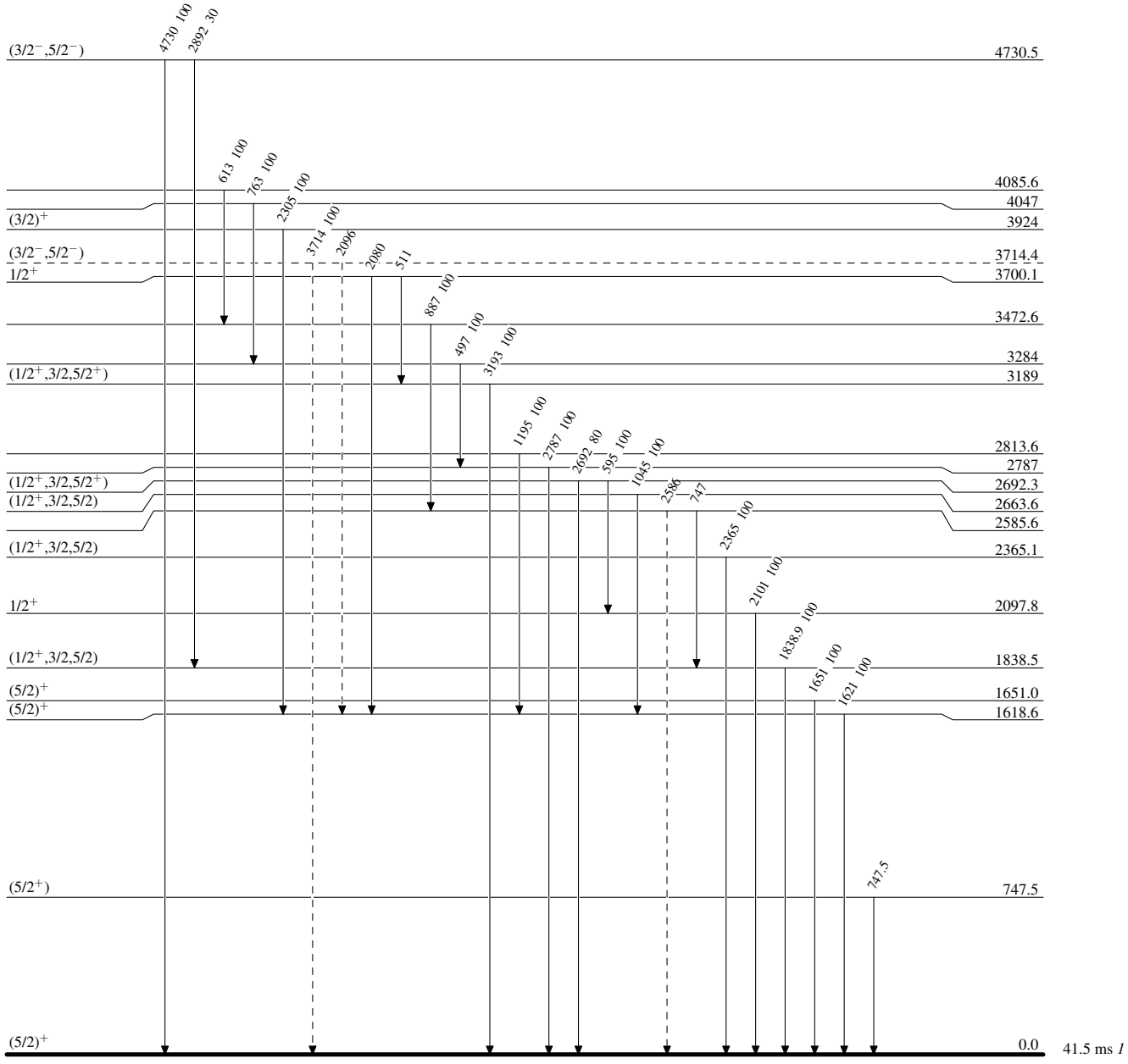
Adopted Levels, Gammas

Legend

Level Scheme

Intensities: Relative photon branching from each level

- - - - - - ► γ Decay (Uncertain)



$^{33}_{13}Al_{20}$