^{10}B(^{40}Ca,pnγ),^{40}Ca(^{10}B,pnγ) 1994Ca04,1979Ha45,1973Ku10

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 179, 1 (2022)	30-Nov-2021

1994Ca04 (also 1993Ca36,1992CaZX): E=150 MeV ^{40}Ca beam was produced from the Daresbury Nuclear Structure Facility. Target was ^{10}B. Fragments were separated with the Daresbury 0° recoil separator. γ rays were detected with the escape-suppressed HPGe detector array (19 detectors in 4 rings at 40°, 101°, 117°, and 143° to the beam direction). Measured Eγ, Iγ, $\gamma\gamma$-coin, γ anisotropies. Deduced levels, J, π, γ-ray multipolarities. No evidence for super- or hyperdeformation at higher energies as speculated by I. Ragnarsson in a private communication to 1994Ca04. 1992CaZX and 1993Ca36 are preliminary reports of the results of 1994Ca04.

1979Ha45: E=14-36 MeV ^{10}B beams were produced from the Aarhus University EN tandem accelerator. Targets are natural Ca (96.9% in ^{40}Ca) layers of 250-400 μg/cm^2 thickness on 100 μg/cm^2 Au backings (150 μg/cm^2 for lifetime measurements). γ rays were detected with two coaxial Ge(Li) detectors. Measured Eγ, Iγ, $\gamma(\theta)$, γ(t). Deduced levels, J, π, $T_{1/2}$, γ-ray multipolarities, mixing ratios.

1973Ku10: E=19-25 MeV ^{10}B beams were produced from the Munich MP-Tandem Van de Graaff accelerator. Target was 2-mm thick foil of natural Ca. γ rays were detected with Ge(Li) detectors; neutrons were detected with a liquid scintillator; scattered protons were detected with an annular Si surface-barrier detector. Measured Eγ, Iγ, $\gamma(\theta)$, recoil distance with a plunger. Deduced levels, J, π, $T_{1/2}$, transition strengths. Comparisons with available data and shell-model calculations.

1979Ek03: E=24 MeV ^{10}B beam was produced from the Liverpool EN tandem accelerator. Target was 300 μg/cm^2 natural Ca on a 2.5 mg/cm^2 gold foil. γ rays were detected with two escape-suppression spectrometer (ESS). Measured Eγ, Iγ, recoil distance with a plunger. Deduced levels, $T_{1/2}$. 1979Ek03 report data mainly from ^{36}Ar(^{14}N,npγ) reaction. See details in that dataset.

2017Ar09: E=26 MeV ^{10}B beam was produced from the FN tandem accelerator at the Institute for Nuclear Physics, University of Cologne. Target was 0.50 mg/cm^2 ^{40}Ca on a 2.0 mg/cm^2 gold backing. γ rays were detected with 12 HPGe detectors. Measured Eγ, $\gamma\gamma$-coin, lifetime of the first 2$^+$ state by recoil-distance Doppler-shift (RDDS) method using the Cologne coincidence-plunger device. Data were recorded at 12 target-to-stopper distances. Comparison of deduced B(E2) values with shell-model calculations with four interactions.

Part of the level scheme above the 3444 level in 1994Ca04 is different from those in other studies and in Adopted Levels. The level scheme here is thus taken from Adopted Levels and inconsistent placements of some transitions in 1994Ca04 have been revised accordingly, as noted under comments. Also note that the level scheme in 1994Ca04 is different from that in their earlier work in 1996Ca38 in ^{28}Si(^{28}Si,2$\alpha\gamma$), with the latter in agreement with other studies.

^{48}Cr Levels

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$	Comments
0.0[#]	0$^+$		
752.01[#] *20*	2$^+$	8.0 ps *5*	J$^\pi$: spin=2 from 752$\gamma(\theta)$ in 1979Ha45 and 1973Ku10. $T_{1/2}$: weighted average of 7.3 ps *8* from RDM in 1979Ek03, 6.7 ps *18* from RDM in 1973Ku10, and 8.43 ps *49* from measured τ=12.16 ps *14*(stat) *69*(syst) (rounded to 12.2 ps *7*) by 2017Ar09 using RDM, determined from the feeding corrected intensity distribution of the 752γ (first 2$^+$ to g.s. transition) with gate on the shifted part of the 1743γ (first 8$^+$ to first 6$^+$ transition).
1858.3[#] *3*	4$^+$	1.0 ps *+14−4*	J$^\pi$: spin=4 from 1106$\gamma(\theta)$ (1979Ha45,1973Ku10) and γ excitation function (1979Ha45). $T_{1/2}$: from RDM in 1973Ku10.
3445.2[#] *6*	6$^+$		J$^\pi$: spin>4 from γ excitation function (1979Ha45).
3533.5 *5*	4$^{(-)}$	3.3 ns *8*	J$^\pi$: (5$^-$) proposed in 1994Ca04 with no arguments; 6$^-$ from 1979Ha45 based on 1675$\gamma(\theta)$ (using ^{34}S(^{16}O,2nγ)) showing a quadrupole character, γ excitation function pointing to high spin, and systematics disfavoring E1 or M1 for 1675γ. But note that 1675$\gamma(\theta)$ in 1979Ha45 and 1973Ku10 are also consistent with ΔJ=0 dipole character. $T_{1/2}$: unweighted average of 4.1 ns *4* from 1675γ(t) in 1979Ha45 and 2.5 ns *7* from RDM in 1979Ek03.
4064.3 *6*	5$^{(-)}$	28 ps *7*	J$^\pi$: (6$^-$) proposed in 1994Ca04 with no arguments; 7$^-$ from 1979Ha45 based on 531$\gamma(\theta)$ showing a strong dipole to 3531 levels with J^π=6$^-$ proposed by 1979Ha45. $T_{1/2}$: from RDM in 1979Ek03. Other: <42 ps from RDM in 1973Ku10.

Continued on next page (footnotes at end of table)

^{10}B(^{40}Ca,pnγ),^{40}Ca(^{10}B,pnγ) 1994Ca04,1979Ha45,1973Ku10 (continued)

^{48}Cr Levels (continued)

E(level)[†]	J$^\pi$[‡]	Comments
4513.2? *12*	(7$^+$)	E(level),J$^\pi$: this level is only proposed in 1994Ca04, with no evidence for decay to negative-parity or 4$^+$ states. This level is not confirmed in later studies. It is considered questionable by the evaluator and is not adopted in Adopted Levels.
4876? *3*	(6$^-$)	
5187.7[#] *12*	8$^+$	J$^\pi$: spin>6 from γ excitation function (1979Ha45).
5649.0? *4*	(7$^-$)	E(level): from Adopted Levels. This level is not proposed in any measurement in this dataset.
7063.8[#] *23*	10$^+$	J$^\pi$: spin>8 from γ excitation function (1979Ha45); evidence for spin alignment from backbending (1992CaZX).
7671.2 *5*	(9$^-$)	E(level): from Adopted Levels.
8411[#] *3*	12$^+$	
9871.4 *6*	(11$^-$)	E(level): from Adopted Levels.

[†] From a least-squares fit to γ-ray energies, assuming $\Delta E\gamma$=1 keV where not given, unless otherwse noted.
[‡] From Adopted Levels, unless otherwise noted. Supporting arguments and assignments from this dataset are given under comments where available.
[#] Band(A): g.s. (yrast) band.

γ(^{48}Cr)

E$_\gamma$	I$_\gamma$[‡]	E$_i$(level)	J$_i^\pi$	E$_f$	J$_f^\pi$	Mult.[#]	δ	Comments
87[@]	0.6	3533.5	4$^{(-)}$	3445.2	6$^+$			E$_\gamma$: from 1994Ca04 only. I$_\gamma$: I(87γ)/I(1675γ)=0.6/6 in 1994Ca04.
530.8 *3*	15 *3*	4064.3	5$^{(-)}$	3533.5	4$^{(-)}$	D+Q	0.24 *3*	E$_\gamma$: weighted average of 530.7 *2* (1979Ha45) and 531.6 *5* (1973Ku10). Other: 531 (1994Ca04). I$_\gamma$: weighted average of 18 *4* (1979Ha45) and 14 *3* (1973Ku10). Other: 5 (1994Ca04). δ: deduced from 5.5% *15-10* E2 component from $\gamma(\theta)$, as given in 1979Ha45. A$_2$=+0.05 *10*, A$_4$=−0.01 *100* (1973Ku10). A$_2$=+0.09 *4*, A$_4$=+0.02 *4* (1979Ha45).
752.0 *2*	100	752.01	2$^+$	0.0	0$^+$	Q		E$_\gamma$: weighted average of 752.0 *2* (1979Ha45) and 752.4 *5* (1973Ku10). other: 752 (1994Ca04). A$_2$=+0.27 *4*, A$_4$=−0.06 *5* (1973Ku10). A$_2$=+0.19 *6*, A$_4$=−0.04 *6* (1979Ha45). anisotropy=1.21 *7* (1994Ca04).
^{x}806[@]	2							E$_\gamma$: seen in 1994Ca04 only and placed from a 5318 level. It could correspond to the 812γ deexciting the 4875 level seen in coincidence with 531γ and 1675γ in ^{28}Si(^{28}Si,2$\alpha\gamma$) (1998Br34).
1068[@]	5	4513.2?	(7$^+$)	3445.2	6$^+$			E$_\gamma$,I$_\gamma$: from 1994Ca04 only. This transition is not seen in any other study and is considered questionable by the evaluator.
1106.3 *2*	65 *10*	1858.3	4$^+$	752.01	2$^+$	Q		E$_\gamma$: from 1979Ha45. Others: 1106.3 *5* (1973Ku10), 1106 (1994Ca04). I$_\gamma$: weighted average of 61 *10* (1979Ha45) and 71 *12* (1973Ku10). Other: 97 (1994Ca04). A$_2$=+0.32 *12*, A$_4$=−0.05 *13* (1973Ku10). A$_2$=+0.25 *6*, A$_4$=−0.03 *4* (1979Ha45). anisotropy=1.3 *1* (1994Ca04).
1343 *3*	7 *3*	4876?	(6$^-$)	3533.5	4$^{(-)}$			E$_\gamma$,I$_\gamma$: from 1979Ha45 only.

Continued on next page (footnotes at end of table)

^{10}B(^{40}Ca,pnγ),^{40}Ca(^{10}B,pnγ) 1994Ca04,1979Ha45,1973Ku10 (continued)

γ(^{48}Cr) (continued)

E_γ	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	Comments
1347	42	8411	12^+	7063.8	10^+	Q	E_γ,I_γ: from 1994Ca04. Mult.: D,Q from anisotropy=1.6 *3* (1994Ca04); Q favored by level scheme.
1585[@]		5649.0?	(7^-)	4064.3	$5^{(-)}$		E_γ: rounded value from Adopted Gammas.
1586.4 *6*	28 *6*	3445.2	6^+	1858.3	4^+	(Q)	E_γ,I_γ: 1979Ha45. Other: 1586, Iγ=97 (1994Ca04). It could be a doublet with the transition deexciting the 5648 level seen in 1998Br34. A_2>0 (1979Ha45). anisotropy=1.4 *1* (1994Ca04).
1675.3 *4*	25 *5*	3533.5	$4^{(-)}$	1858.3	4^+		E_γ: weighted average of 1675.4 *3* (1979Ha45) and 1674.0 *10* (1973Ku10). Other: 1673 (1994Ca04). I_γ: weighted average of 24 *5* (1979Ha45) and 31 *11* (1973Ku10). Other: 6 (1994Ca04). A_2=+0.10 *16*, A_4=+0.04 *19* (1973Ku10).
1742.5[†] *10*	11 *3*	5187.7	8^+	3445.2	6^+	Q	E_γ,I_γ: from 1979Ha45. Other: 1744 with Iγ=65, placed from a 7062 level in 1994Ca04. Mult.: D,Q from anisotropy=1.4 *2* (1994Ca04); Q favored by level scheme.
1876[†] *2*	7 *3*	7063.8	10^+	5187.7	8^+	Q	E_γ,I_γ: from 1979Ha45. Other: 1874 with Iγ=80, placed from a 5318 level in 1994Ca04. Mult.: D,Q from anisotropy=1.4 *2* (1994Ca04); Q favored by level scheme.
2022	11	7671.2	(9^-)	5649.0?	(7^-)		E_γ: placement from Adopted Gammas. It is placed from a 10431, (13^+) to the 8409 level by 1994Ca04. I_γ: from 1994Ca04.
2201	13	9871.4	(11^-)	7671.2	(9^-)		E_γ,I_γ: from 1994Ca04; placement from Adopted Gammas. It is placed from a 10610, (14^+) to the 8409 level by 1994Ca04.
(2205.6)	<20	4064.3	$5^{(-)}$	1858.3	4^+		E_γ,I_γ: from 1973Ku10 only; not observed. A 2205γ is placed from the 4064,J=3 level by 2003Je06 in (^{3}He,nγ), different from this $5^{(-)}$ level, which is also proposed in 2003Je06.
(2780.3)	<20	3533.5	$4^{(-)}$	752.01	2^+		E_γ,I_γ: from 1973Ku10 only; not observed.

[†] The order of 1876γ-1743γ cascade is reversed in 1994Ca04, resulting in a level at 5318, instead of the adopted 5187 level.
[‡] Normalized to Iγ(752γ)=100.
[#] From anisotropy in 1994Ca04, and/or $\gamma(\theta)$ in 1979Ha45 and 1973Ku10. Stretched (ΔJ=2) quadrupole or ΔJ=0 dipole from angular anisotropy (1994Ca04).
[@] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

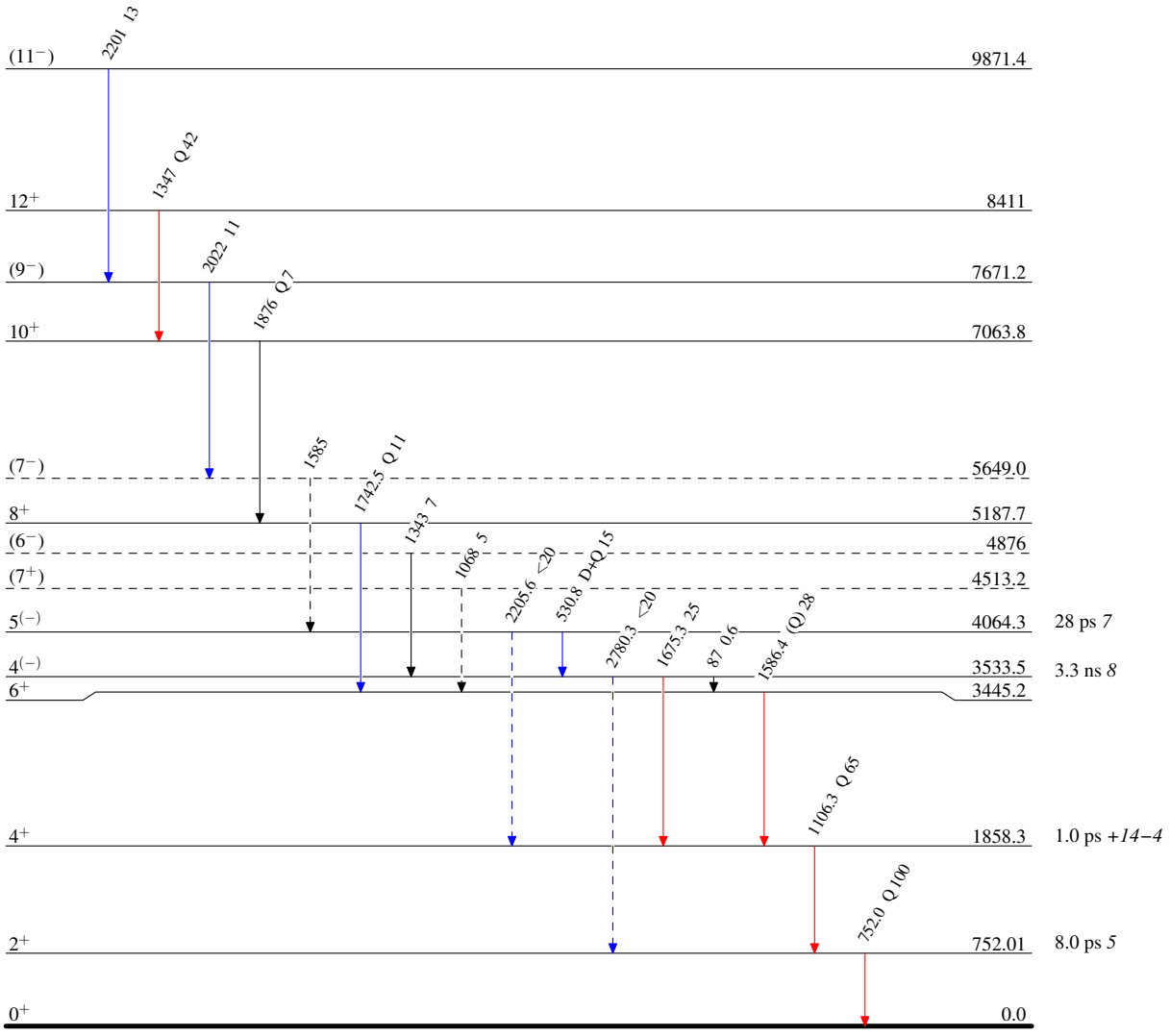
^{10}B(^{40}Ca,pnγ),^{40}Ca(^{10}B,pnγ) 1994Ca04,1979Ha45,1973Ku10

Legend

Level Scheme

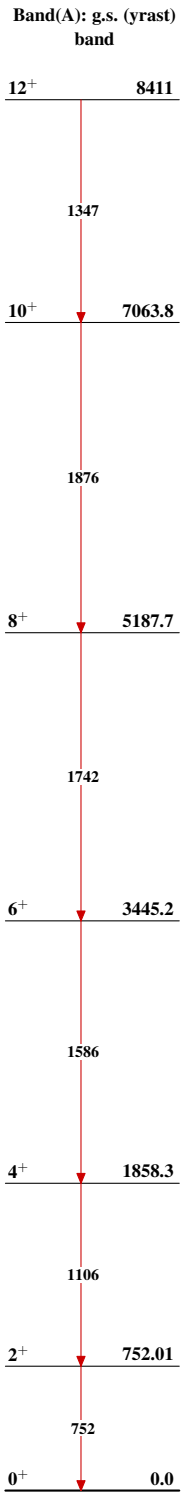
Intensities: Relative I_γ

$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$
γ Decay (Uncertain)



$^{48}_{24}Cr_{24}$

^{10}B(^{40}Ca,pnγ),^{40}Ca(^{10}B,pnγ) 1994Ca04,1979Ha45,1973Ku10



$^{48}_{24}Cr_{24}$