LA-10111-MS

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Thermal Equilibrium Population of the First Few Nuclear Excited States (Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, and Cf Isotopes)

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THERMAL EQUILIBRIUM POPULATION OF THE FIRST FEW NUCLEAR EXCITED STATES (Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, and Cf ISOTOPES)

by

G. D. Doolen, H. H. Hsu, and C. L. Doolen

ABSTRACT

The Boltzmann distributions of nuclear excited states are plotted for most actinide isotopes for temperatures from 0 to 60 keV.

When working with nuclear excited states, it is often useful to refer to plots of thermal equilibrium populations as a function of material temperature. These Boltzmann distribution plots are easily generated, and they are useful for understanding nuclear behavior in high-temperature environments. Such plots for the actinides form the main content of this report. Two subsequent reports are planned: one on the lanthanides and the other on the remaining detector isotopes.

The plots contain the Boltzmann thermal equilibrium nuclear excited state populations. The fraction excited in state i, with excitation energy, E_i, equals

$$(2J_i + 1) \exp(-E_i/kT) / \sum_n (2J_n + 1) \exp(-E_n/kT) ,$$

where k is the Boltzmann constant, T is the temperature, and J_i is the nuclear spin of the i^{th} state. The sum over n goes over those states included in each plot label. Generally, states with excitation energies below 200 keV are included. The spins and energy levels are from the most recent data available from the *Nuclear Data Sheets*[1] or from the *Table of Isotopes*.[2]

Each of the 81 plots contains, as a function of temperature, the thermal equilibrium total excited state fraction of an actinide isotope. The population of each excited state is also plotted. The actinide isotopes plotted are shown in Fig. 1. A few isotopes are included for which unknown spins were estimated from systematics. These spins are followed by a ? in the plots.

ACKNOWLEDGMENTS

Special thanks go to Dave Madland and Ed Arthur for constructive advice and for encouraging the compilation of these plots and to Richard Hoff for providing spins and energy levels for ^{250}Bk.

REFERENCES

1. M. J. Martin and J. K. Tuli, Eds., *Nuclear Data Sheets* (Academic Press, New York, 1980-1982), Vols. 31-37.

2. C. Michael Lederer and Virginia S. Shirley, Eds., *Table of Isotopes*, 7th Ed., (John Wiley and Sons, New York, 1978).

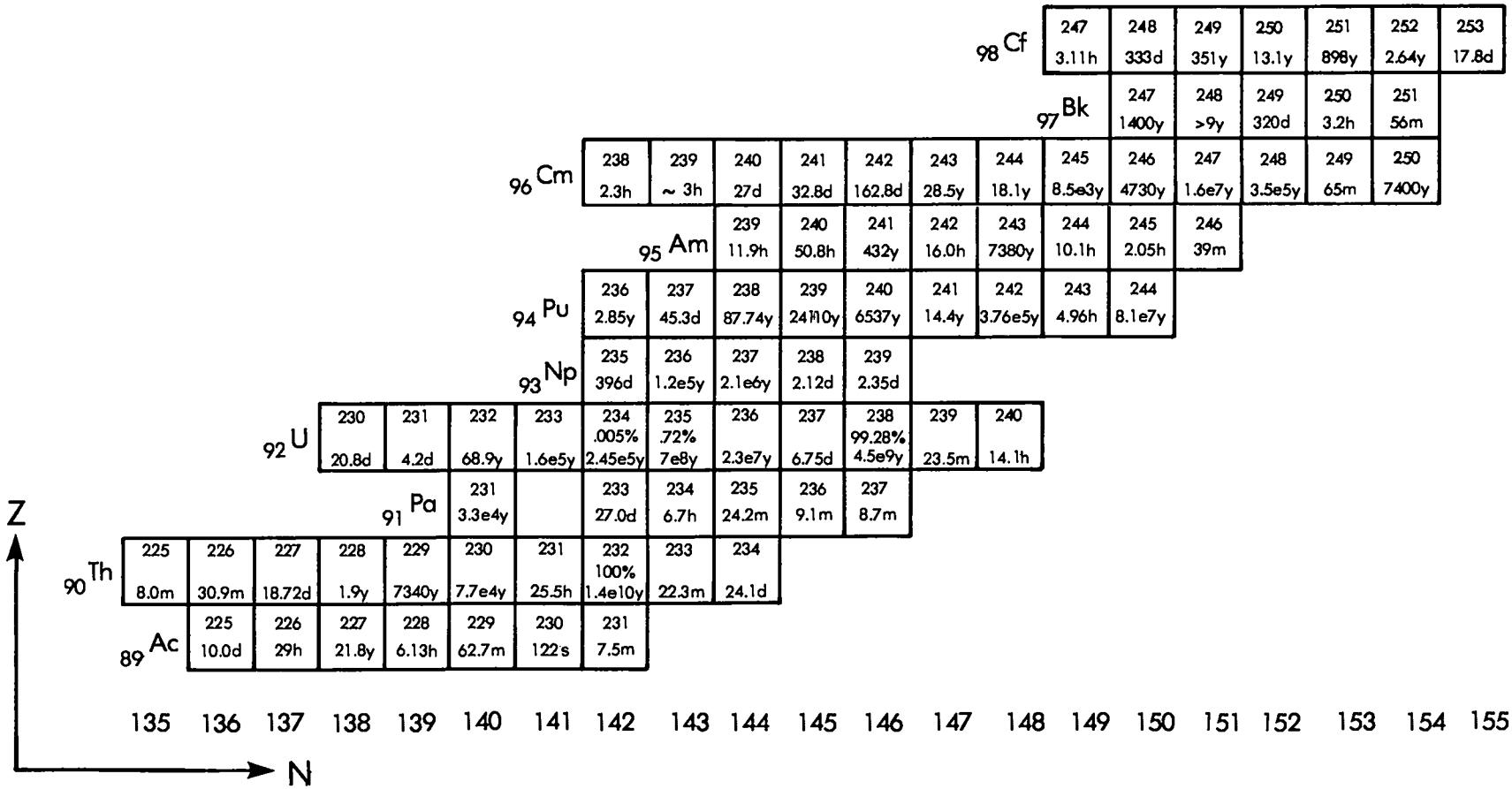
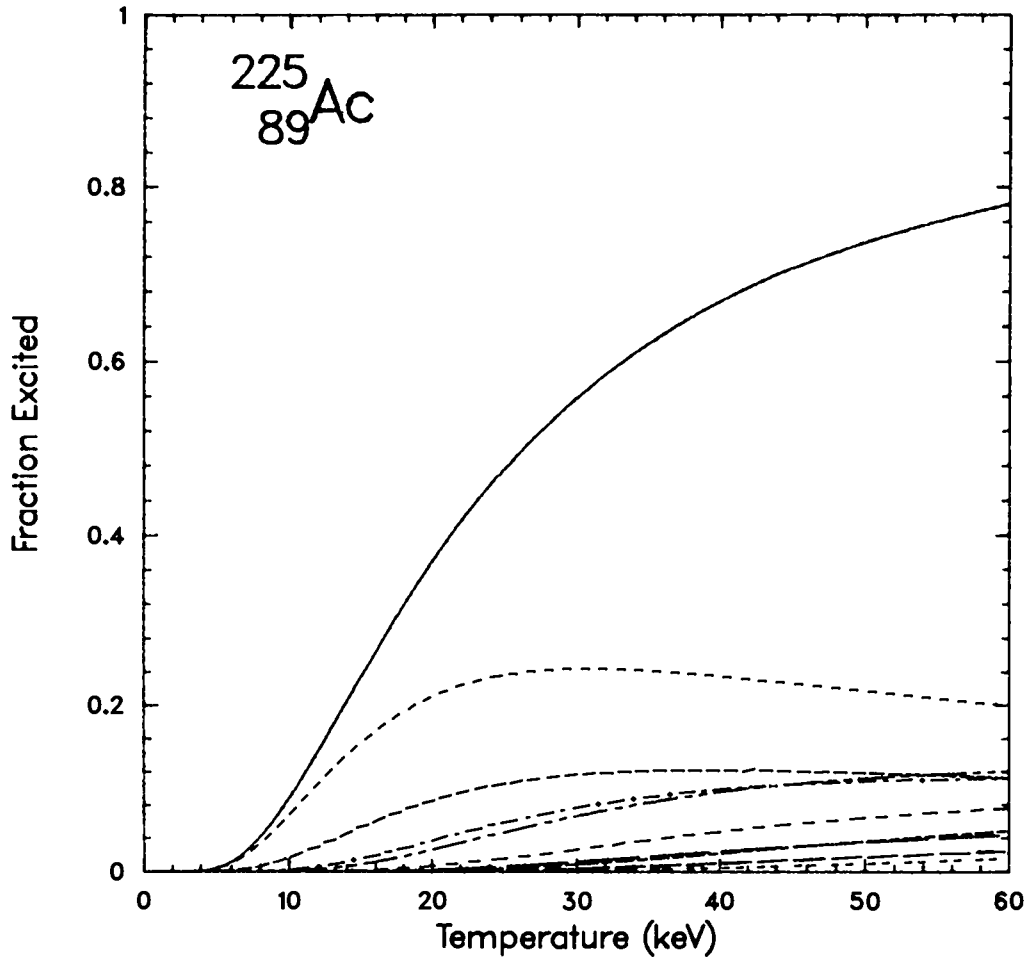
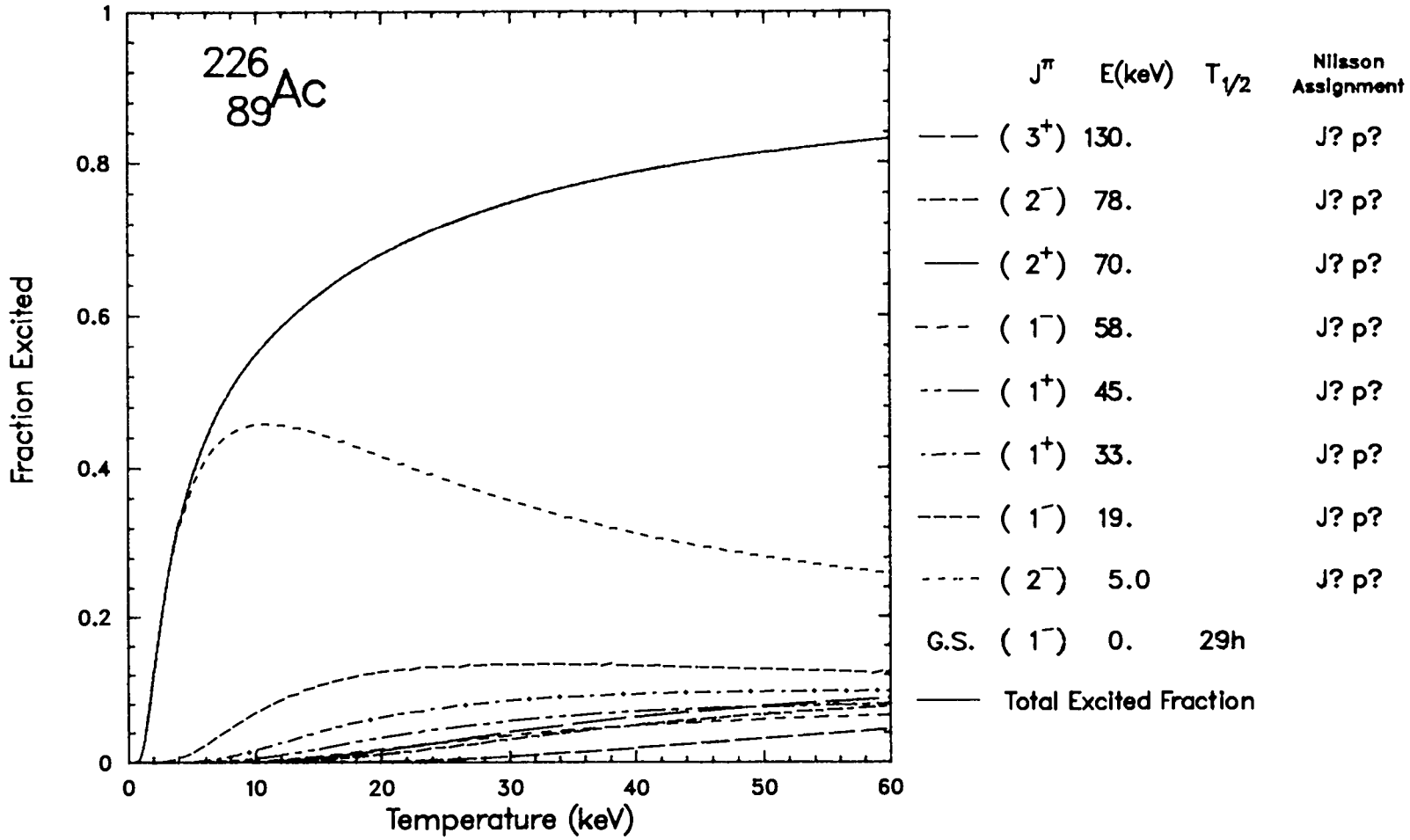
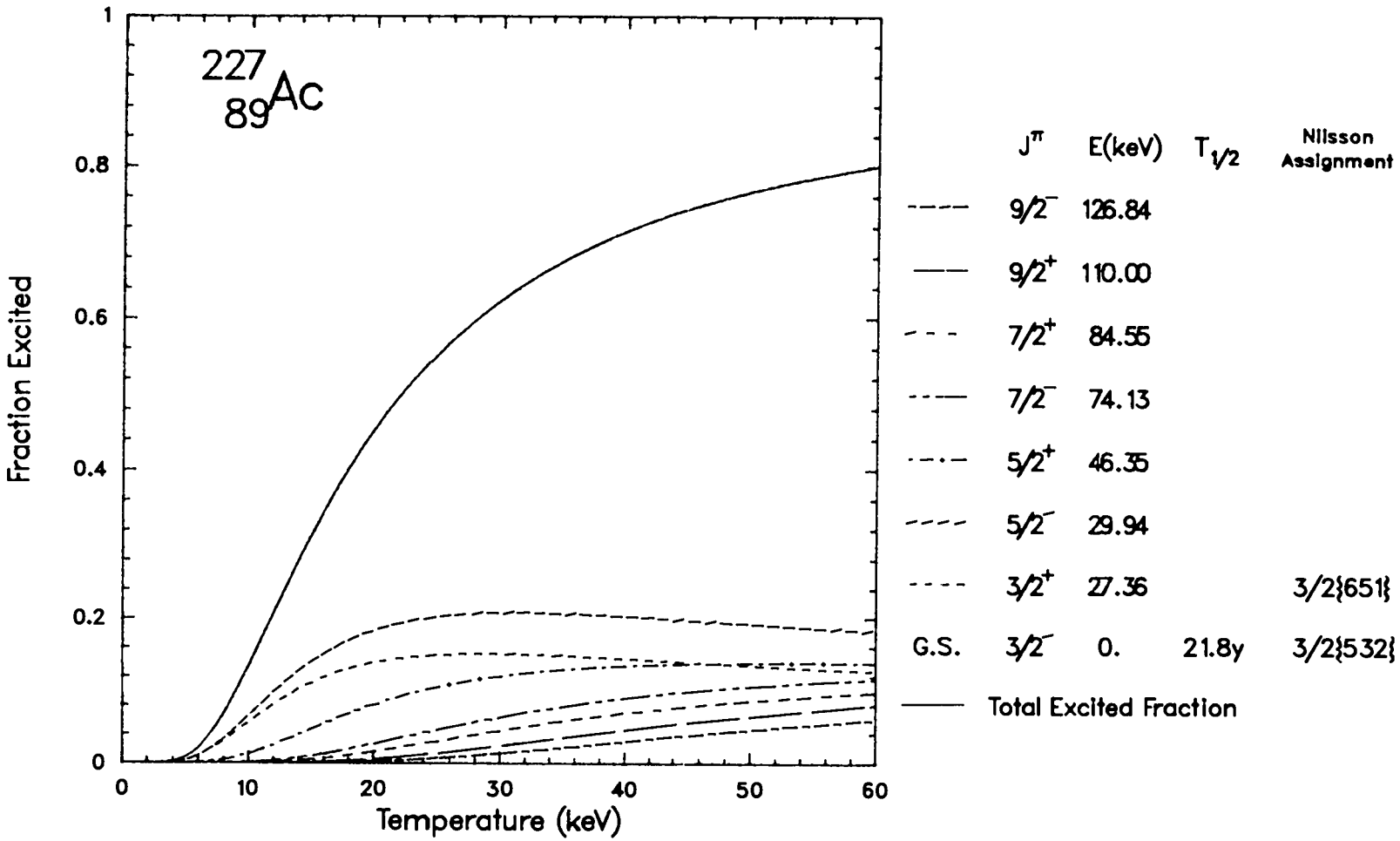


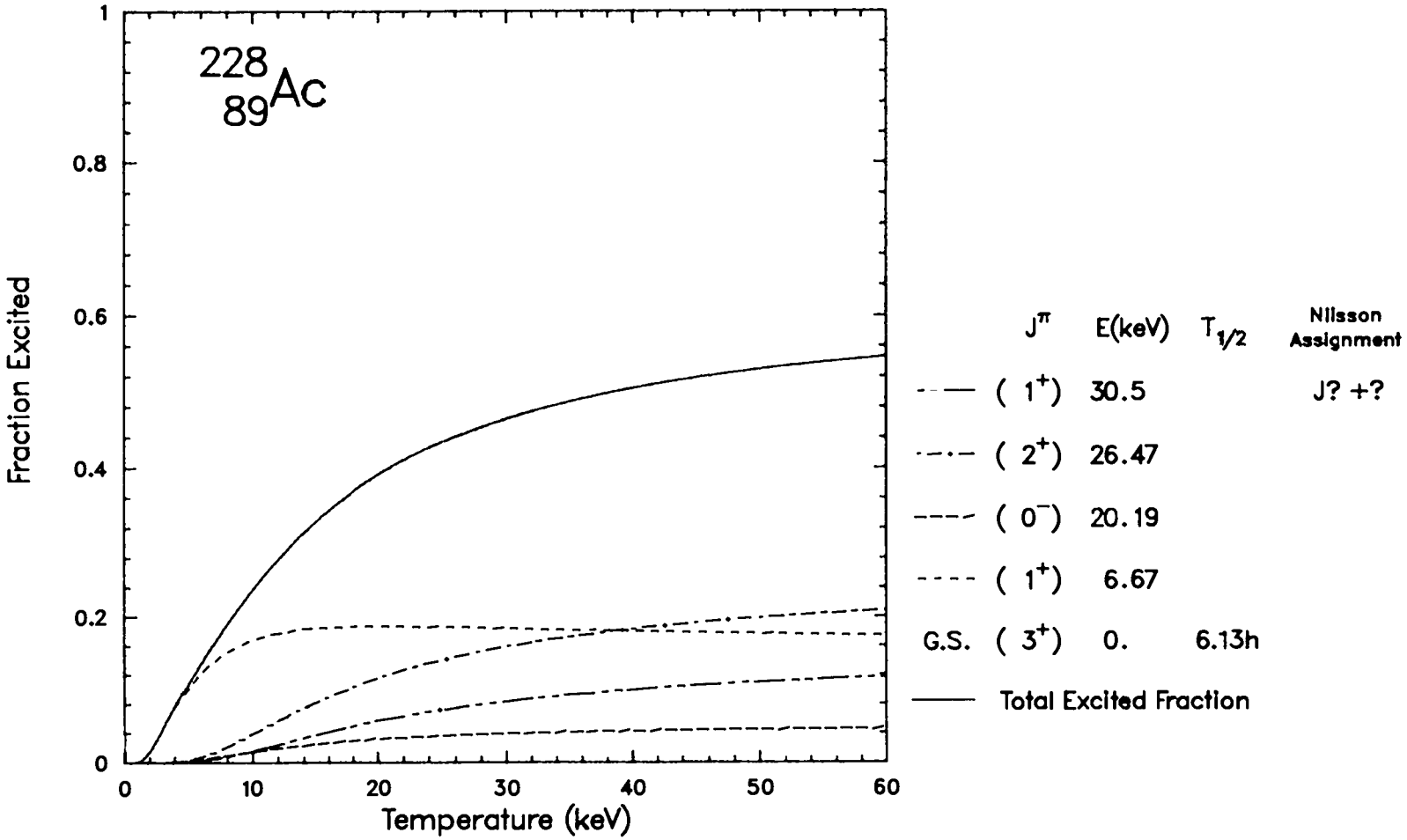
Fig. 1. Actinides.

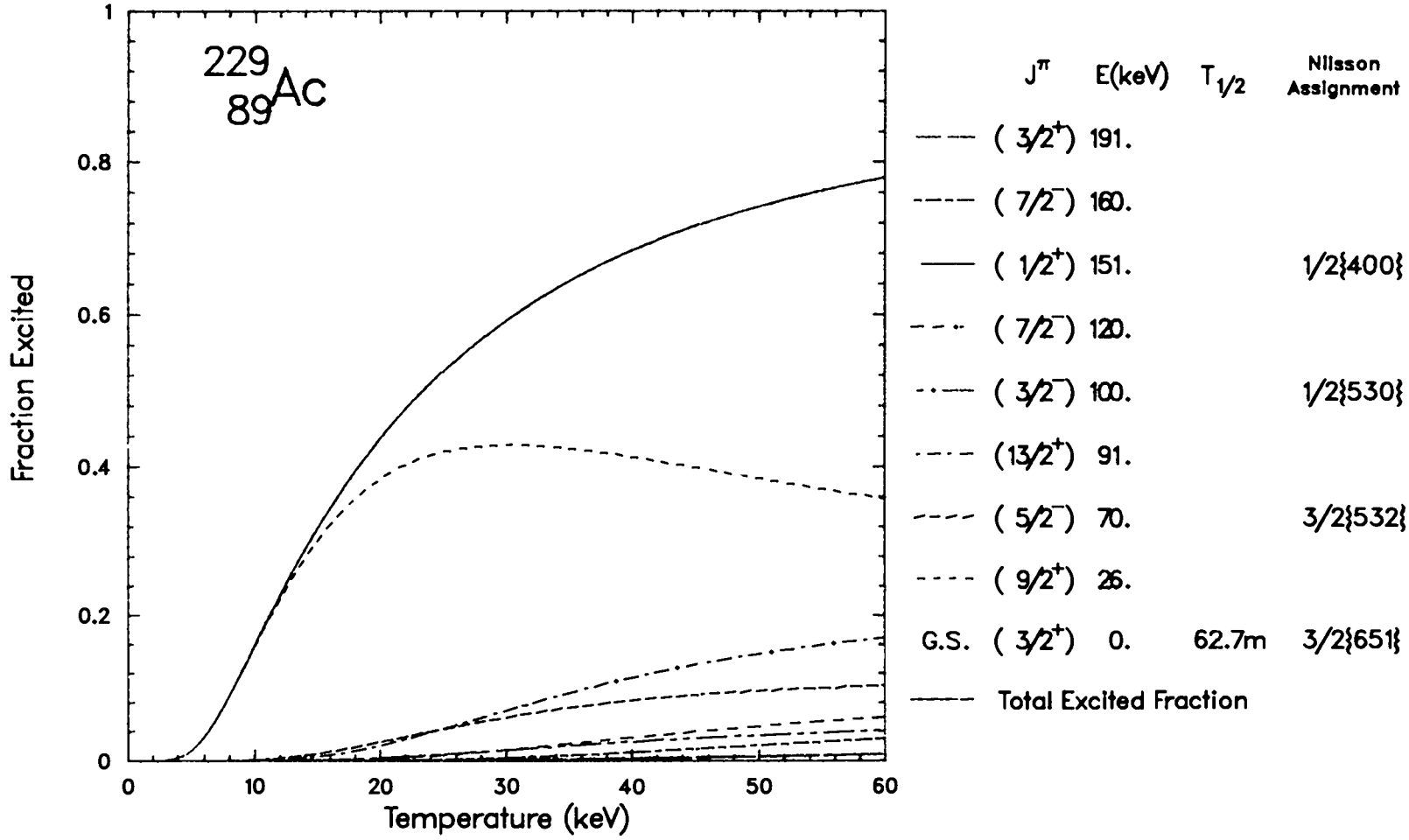


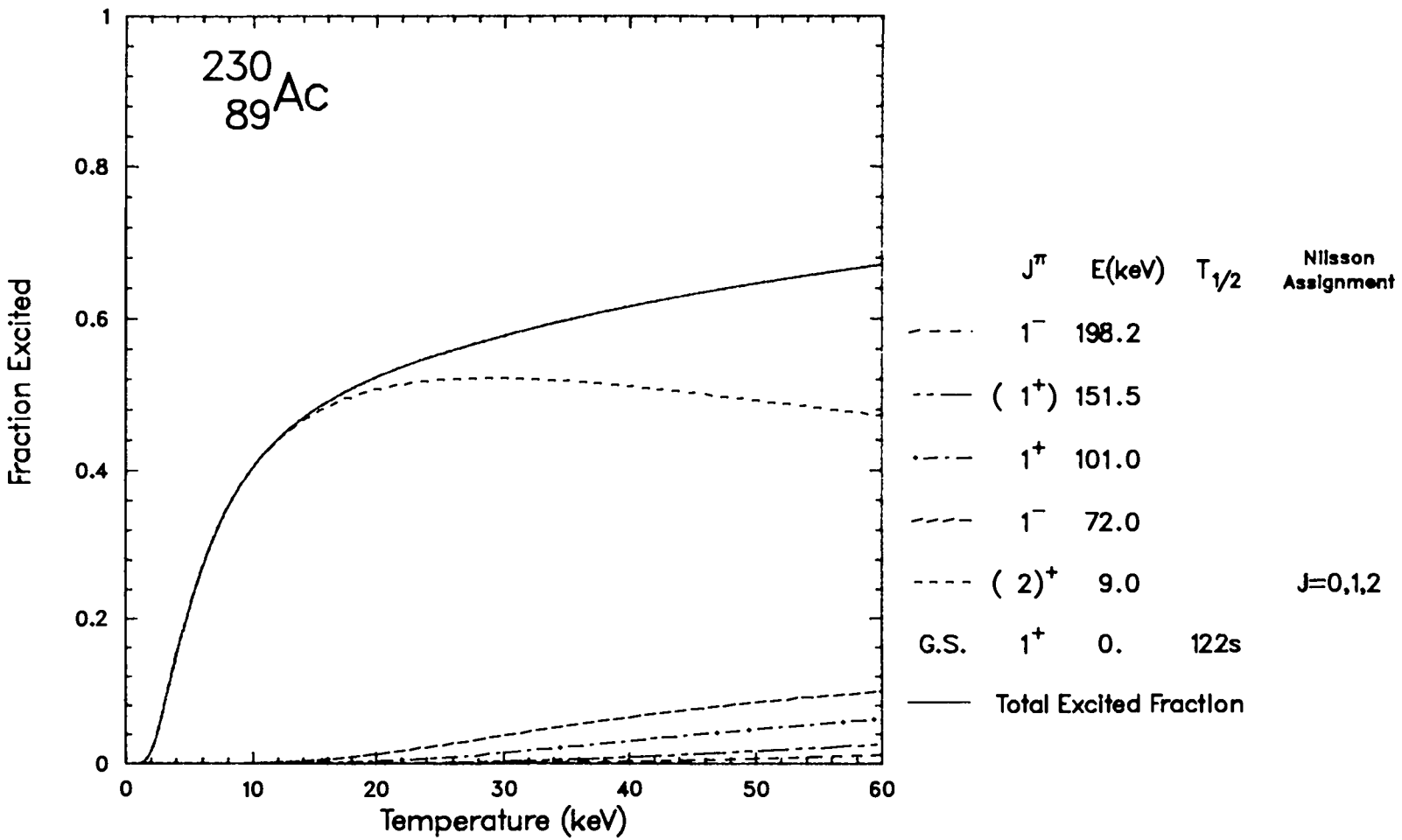
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
- - -	($7/2^{+}$)	199.9		
– –	($7/2^{-}$)	170.6		
——	($5/2^{+}$)	155.5		5/2{642}
----	($9/2^{+}$)	145.		J?
——	($5/2^{-}$)	120.8		5/2{523}
- - - ·	($7/2^{+}$)	105.1		J?
- - —	($7/2^{-}$)	77.5		
·–·–	($5/2^{+}$)	64.7		J? +?
----	($3/2^{+}$)	40.		3/2{651}
----	($5/2^{-}$)	30.		
G.S.	($3/2^{-}$)	0.	10.0d	3/2{532}
——	Total Excited Fraction			

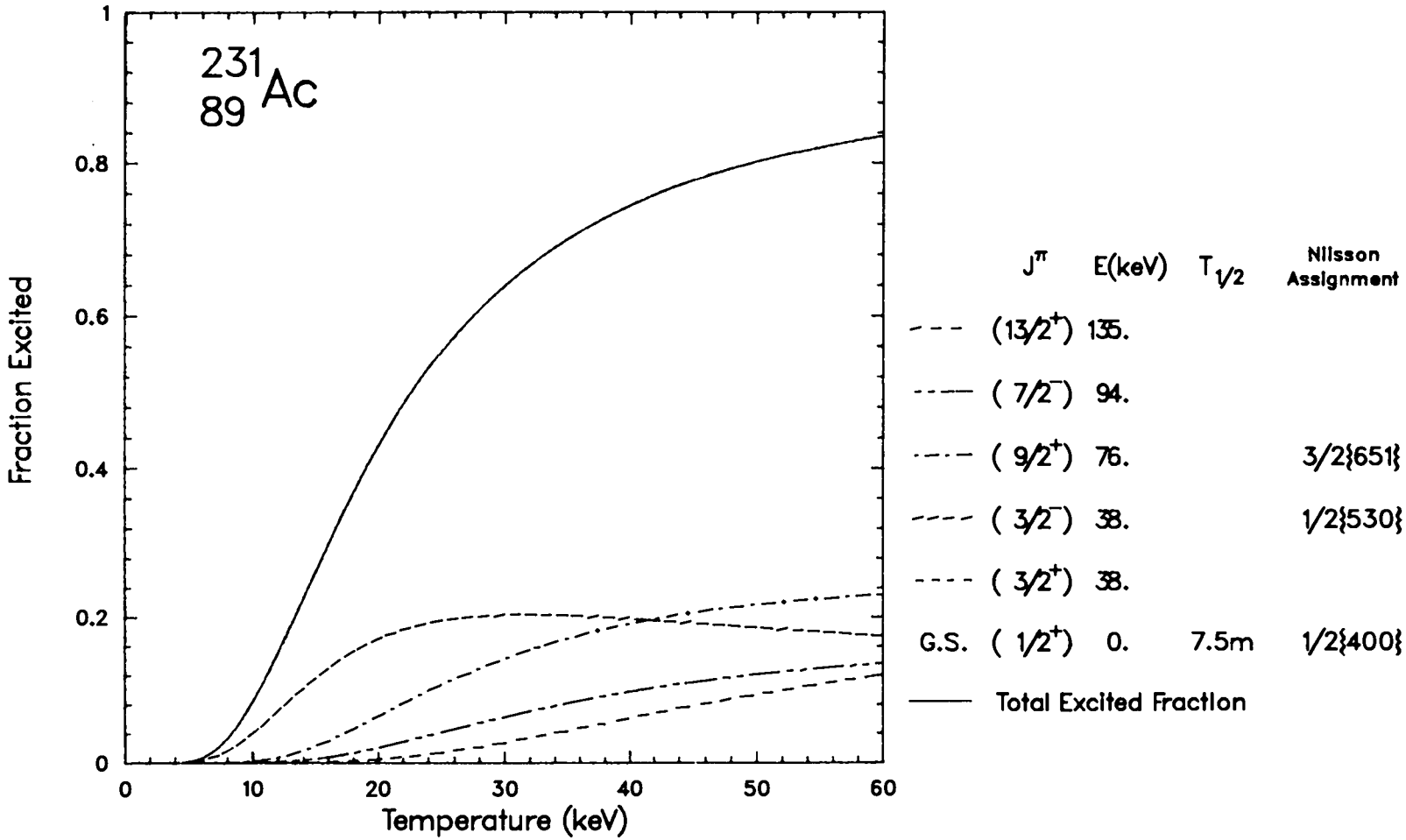

226 89Ac
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
(3+) 130. J? p?
(2−) 78. J? p?
(2+) 70. J? p?
(1−) 58. J? p?
(1+) 45. J? p?
(1+) 33. J? p?
(1−) 19. J? p?
(2−) 5.0 J? p?
G.S. (1−) 0. 29h
Total Excited Fraction

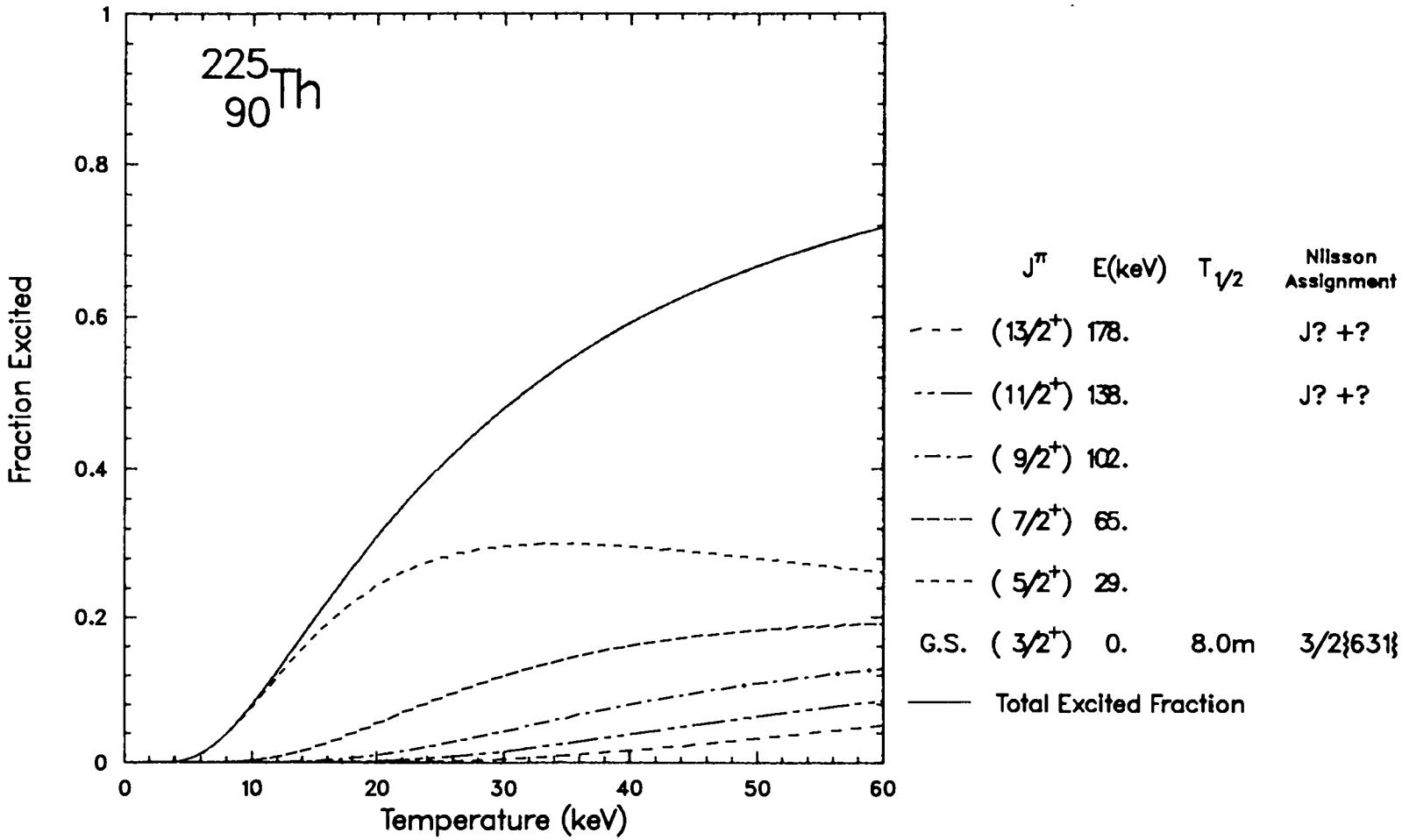

$^{227}_{89}Ac$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J$^{\pi}$ E(keV) $T_{1/2}$ Nilsson Assignment
9/2$^-$ 126.84
9/2$^+$ 110.00
7/2$^+$ 84.55
7/2$^-$ 74.13
5/2$^+$ 46.35
5/2$^-$ 29.94
3/2$^+$ 27.36 3/2{651}
G.S. 3/2$^-$ 0. 21.8y 3/2{532}
Total Excited Fraction

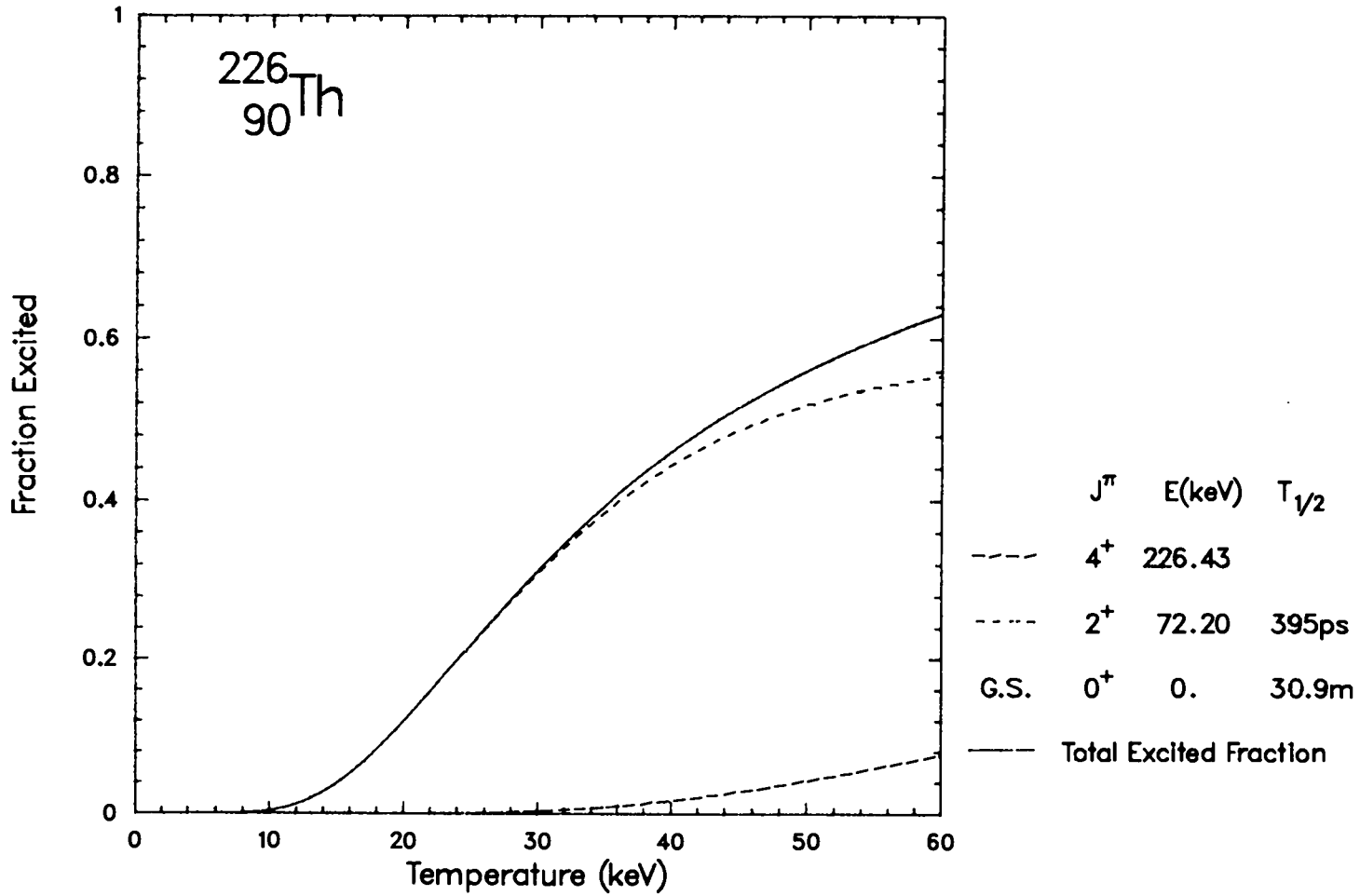

228 89Ac
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
(1+) 30.5 J? +?
(2+) 26.47
(0−) 20.19
(1+) 6.67
G.S. (3+) 0. 6.13h
Total Excited Fraction

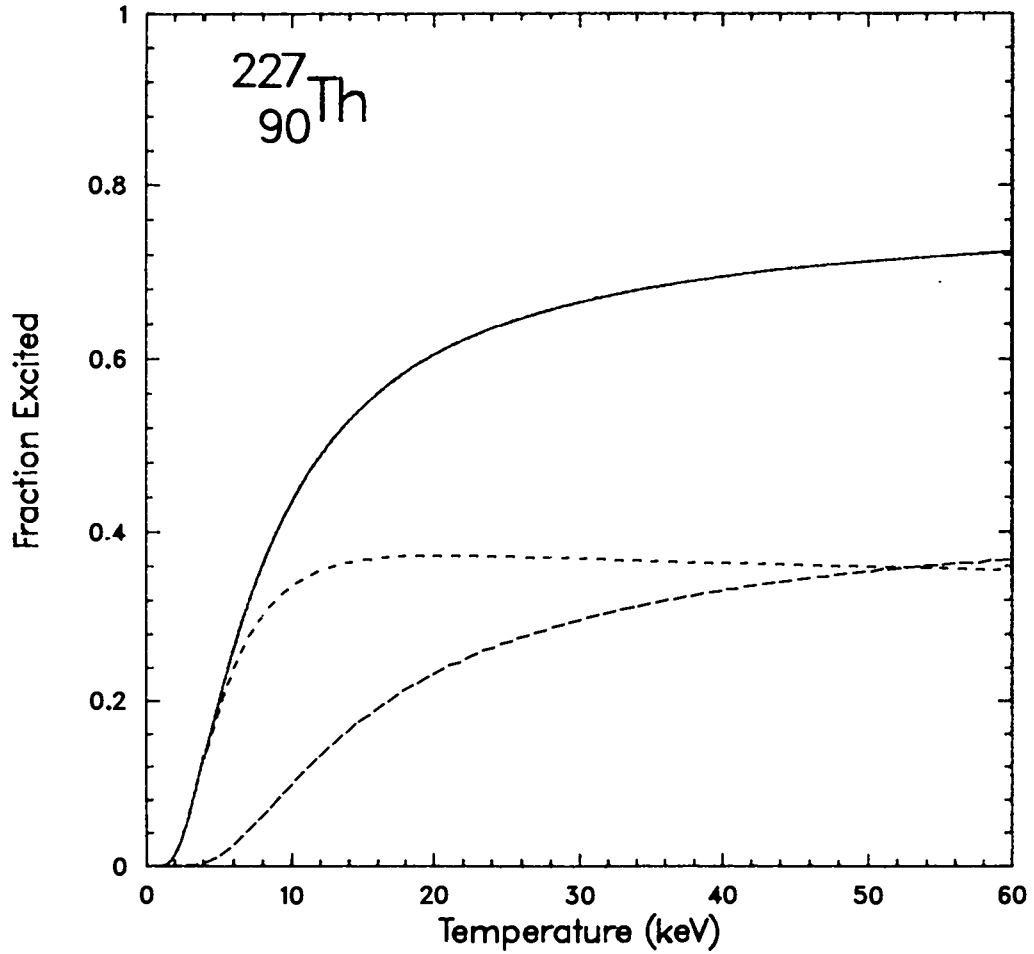

229 89Ac
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
(3/2+) 191.
(7/2−) 160.
(1/2+) 151. 1/2{400}
(7/2−) 120.
(3/2−) 100. 1/2{530}
(13/2+) 91.
(5/2−) 70. 3/2{532}
(9/2+) 26.
G.S. (3/2+) 0. 62.7m 3/2{651}
Total Excited Fraction


230 89Ac
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
1− 198.2
(1+) 151.5
1+ 101.0
1− 72.0
(2)+ 9.0 J=0,1,2
G.S. 1+ 0. 122s
Total Excited Fraction

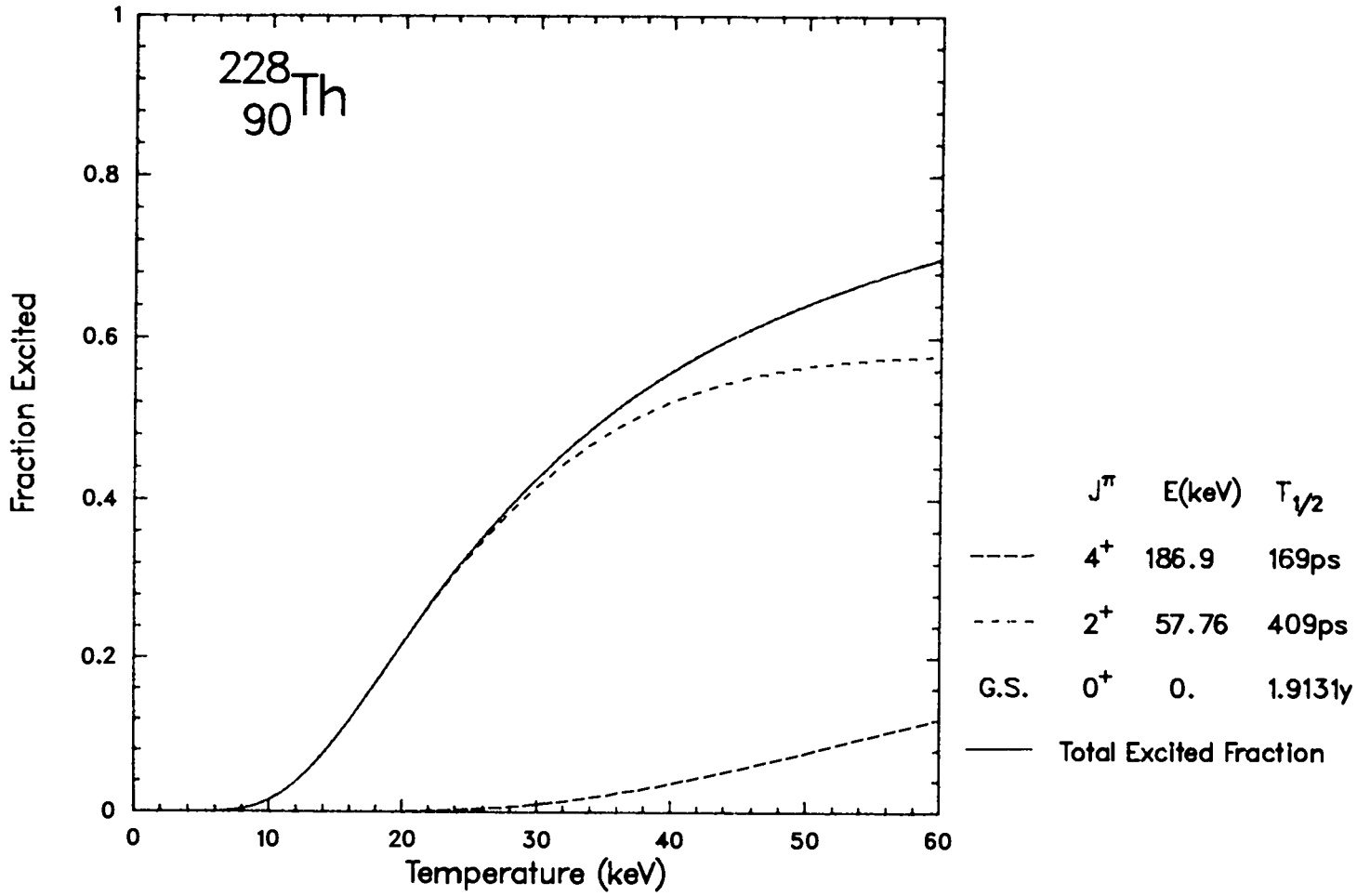

231 89 Ac
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
(13/2+) 135.
(7/2−) 94.
(9/2+) 76. 3/2{651}
(3/2−) 38. 1/2{530}
(3/2+) 38.
G.S. (1/2+) 0. 7.5m 1/2{400}
Total Excited Fraction

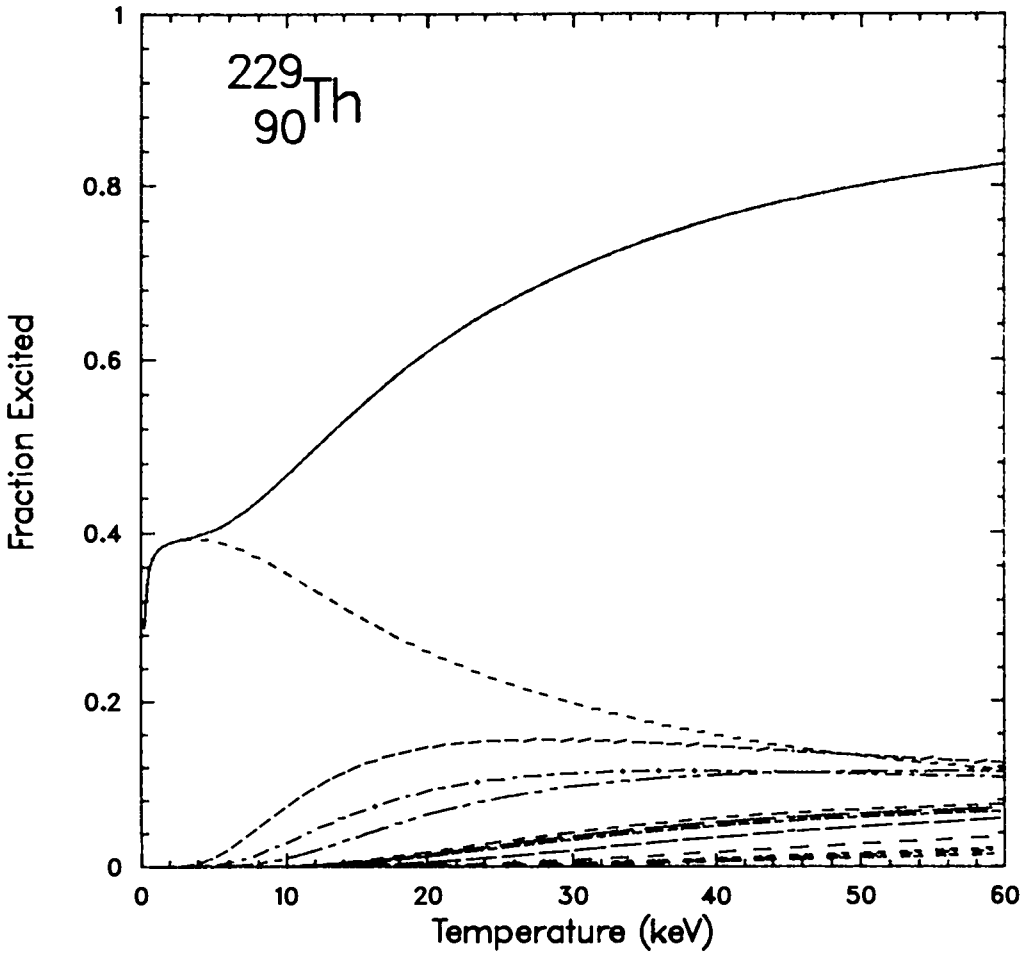

225 90Th
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
(13/2+) 178. J? +?
(11/2+) 138. J? +?
(9/2+) 102.
(7/2+) 65.
(5/2+) 29.
G.S. (3/2+) 0. 8.0m 3/2{631}
Total Excited Fraction


226 90 Th
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) T1/2
4+ 226.43
2+ 72.20 395ps
G.S. 0+ 0. 30.9m
Total Excited Fraction

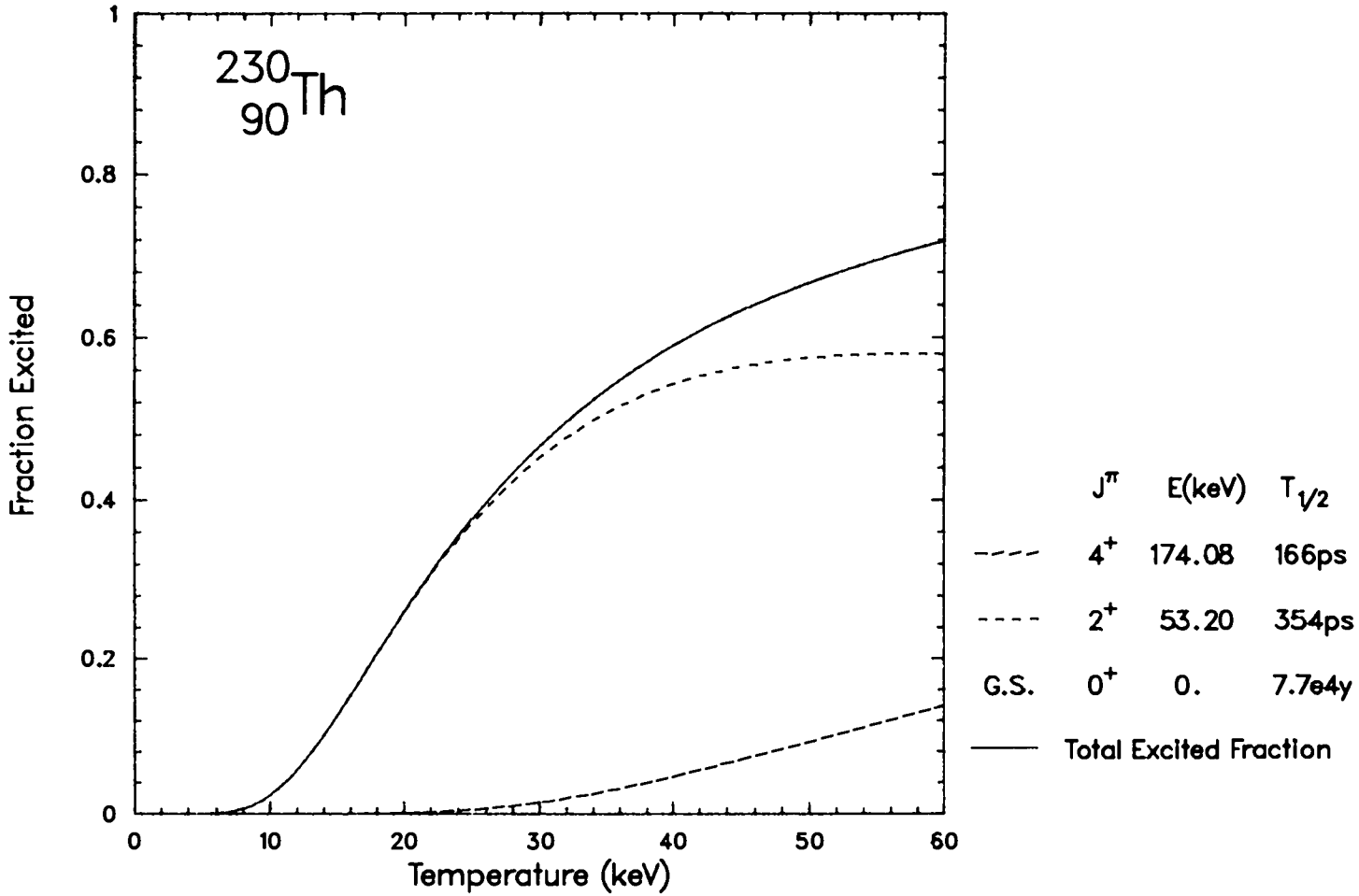


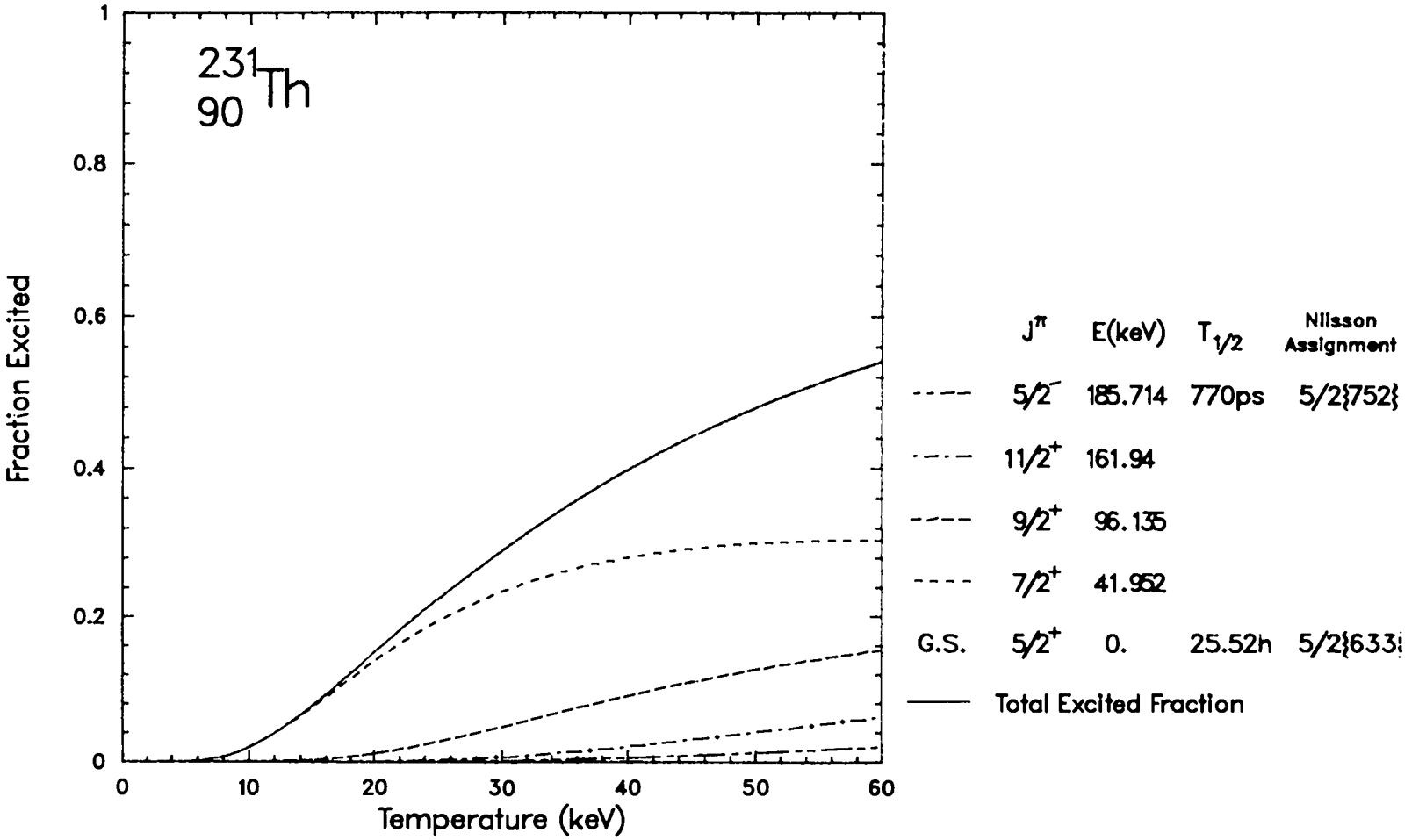
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
- - -	$7/2^{+}$	24.5		J? +?
- - - -	$5/2^{+}$	9.3		J? +?
G.S.	$3/2^{+}$	0.	18.718d	3/2{631}
——	Total Excited Fraction			

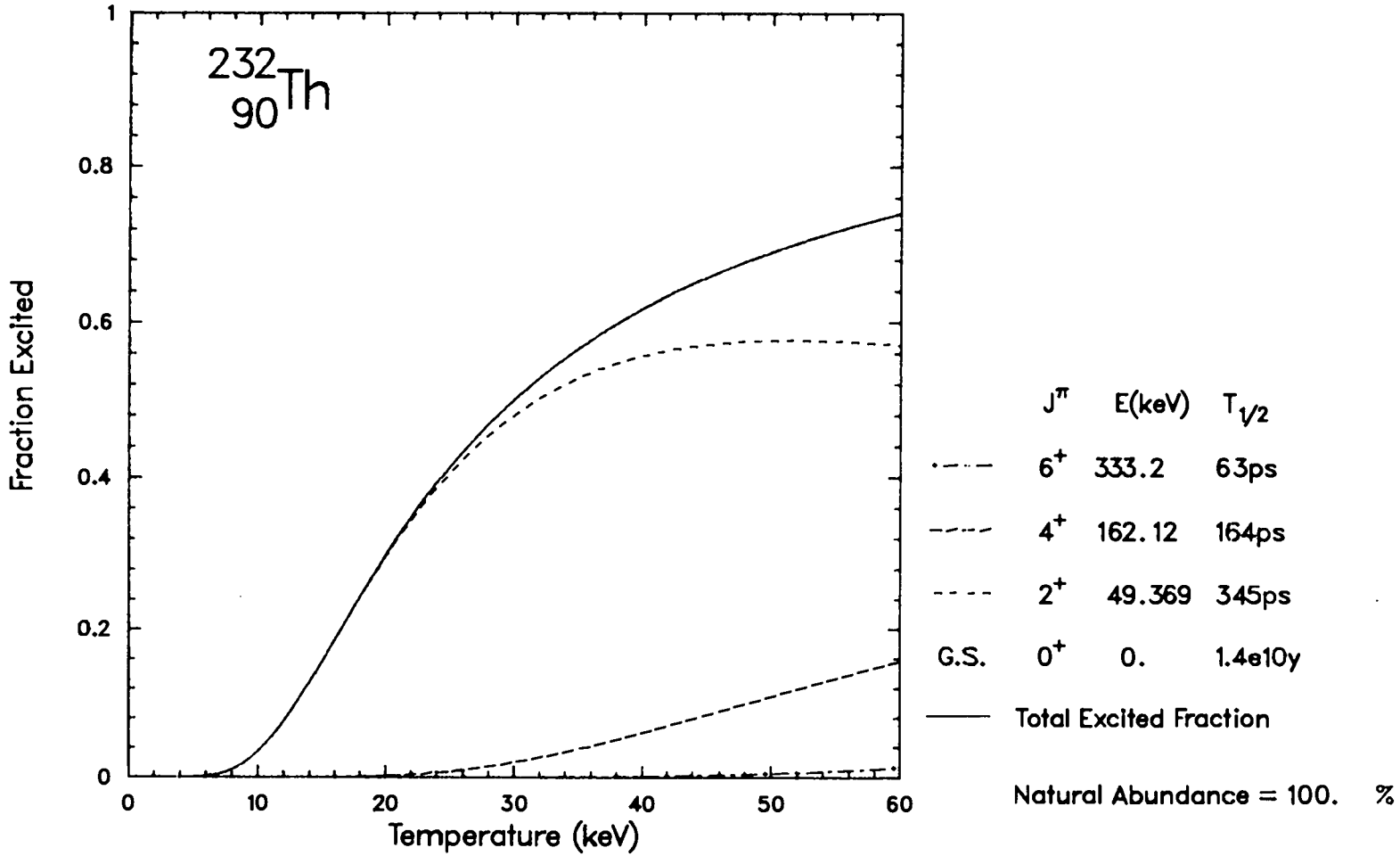

$^{228}_{90}$Th
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$
4^+ 186.9 169ps
2^+ 57.76 409ps
G.S. 0^+ 0. 1.9131y
Total Excited Fraction

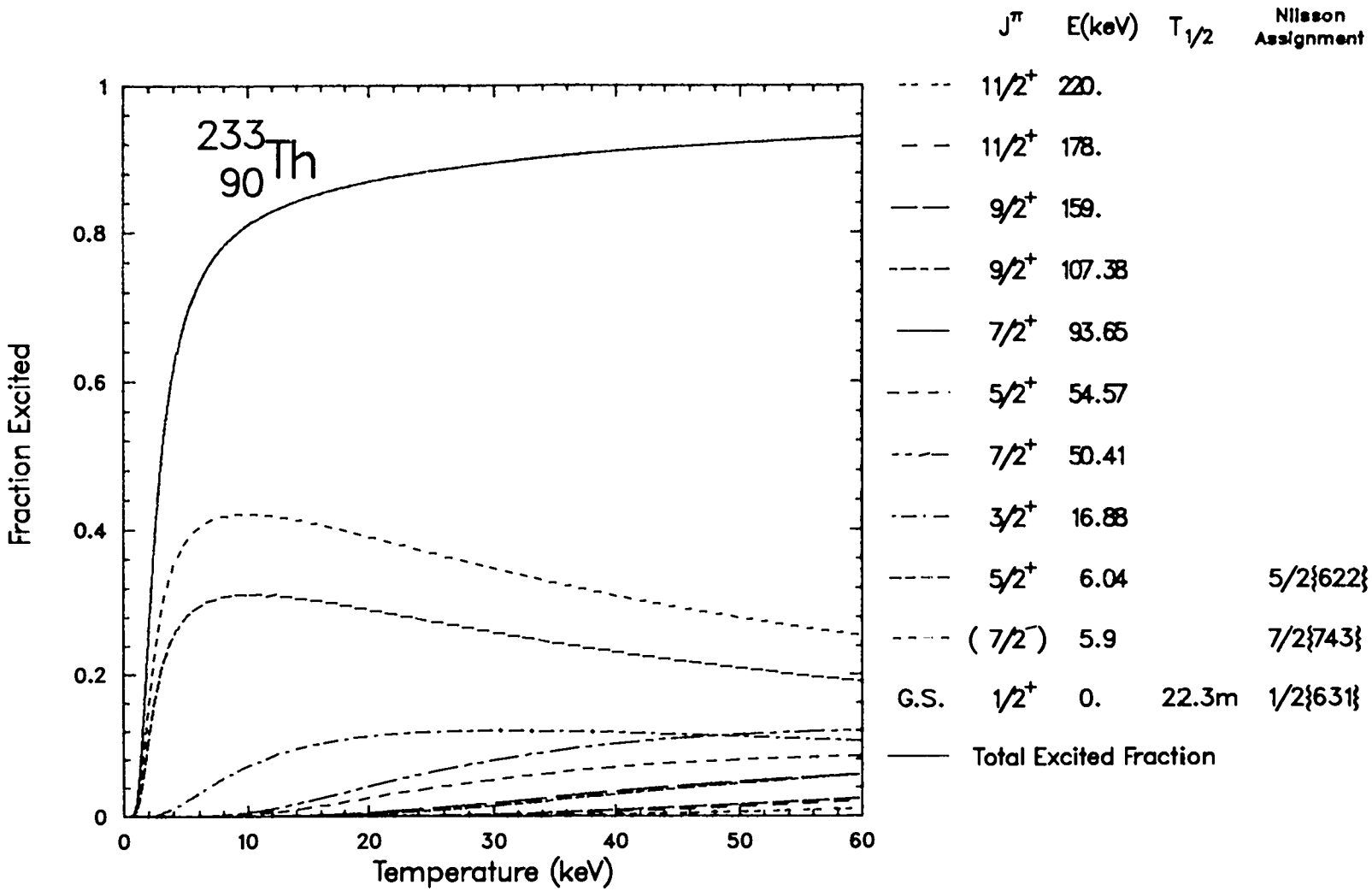


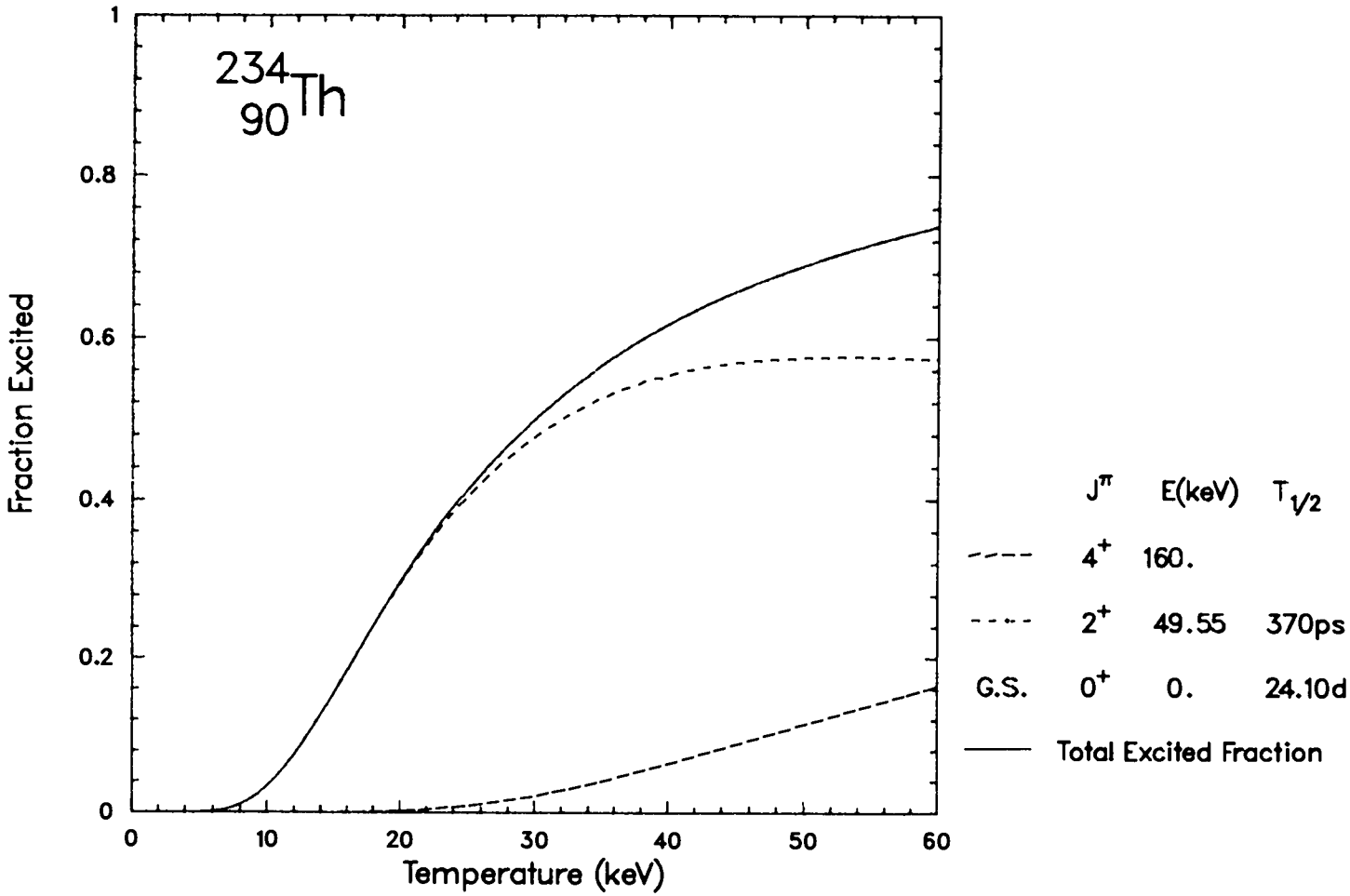
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
	(7/2$^-$)	148.16		
	(5/2$^-$)	146.36		5/2{752}
	(7/2$^+$)	140.		J? +?
	(9/2$^+$)	125.4		
	9/2$^+$	97.13	147ps	
	(7/2$^+$)	75.		
	(7/2$^+$)	71.82		
	7/2$^-$	68.		J? +?
	7/2$^+$	42.44	172ps	
	(5/2$^+$)	29.2		
	5/2$^-$	20.		J? +?
	(3/2$^+$)	.1		3/2{631}
G.S.	5/2$^+$	0.	7340y	5/2{633}
	Total Excited Fraction			

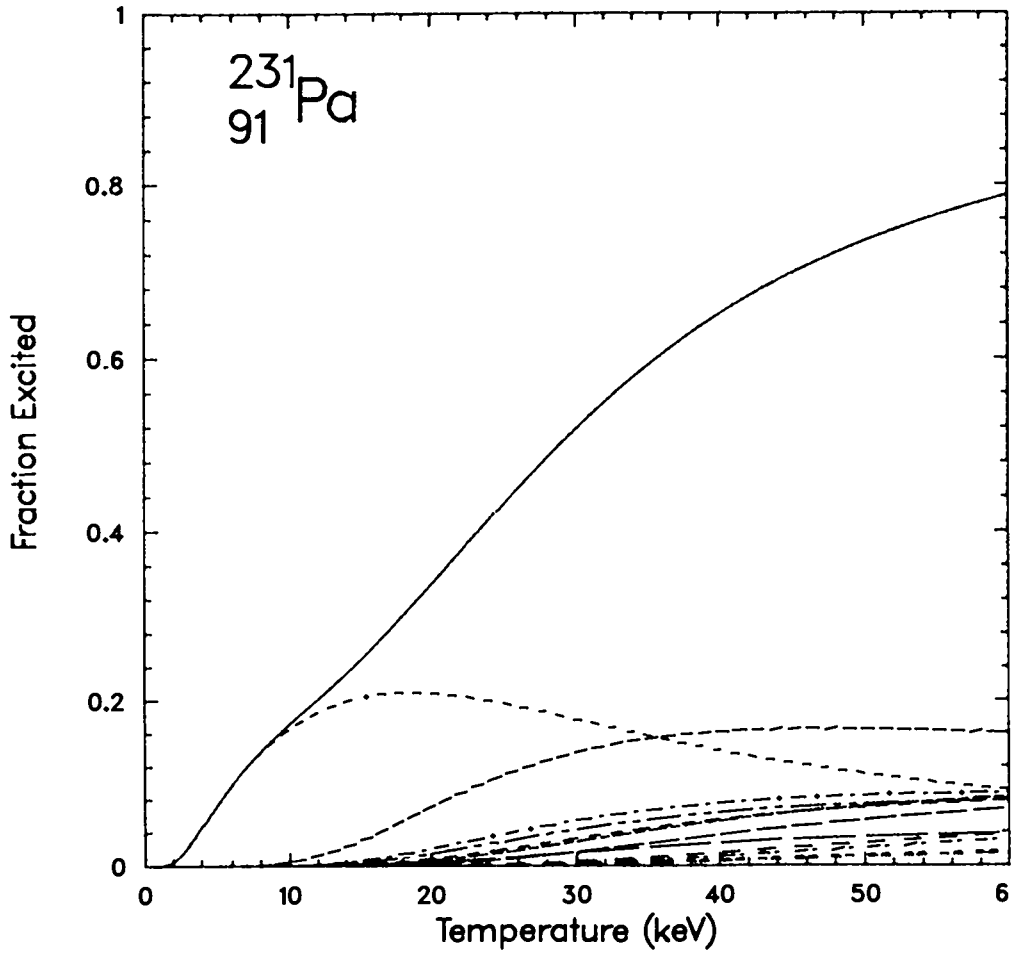

230 90 Th
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) T1/2
4+ 174.08 166ps
2+ 53.20 354ps
G.S. 0+ 0. 7.7e4y
Total Excited Fraction


$^{231}_{90}$Th
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J$^{\pi}$ E(keV) T$_{1/2}$ Nilsson Assignment
5/2$^-$ 185.714 770ps 5/2{752}
11/2$^+$ 161.94
9/2$^+$ 96.135
7/2$^+$ 41.952
G.S. 5/2$^+$ 0. 25.52h 5/2{633}
Total Excited Fraction

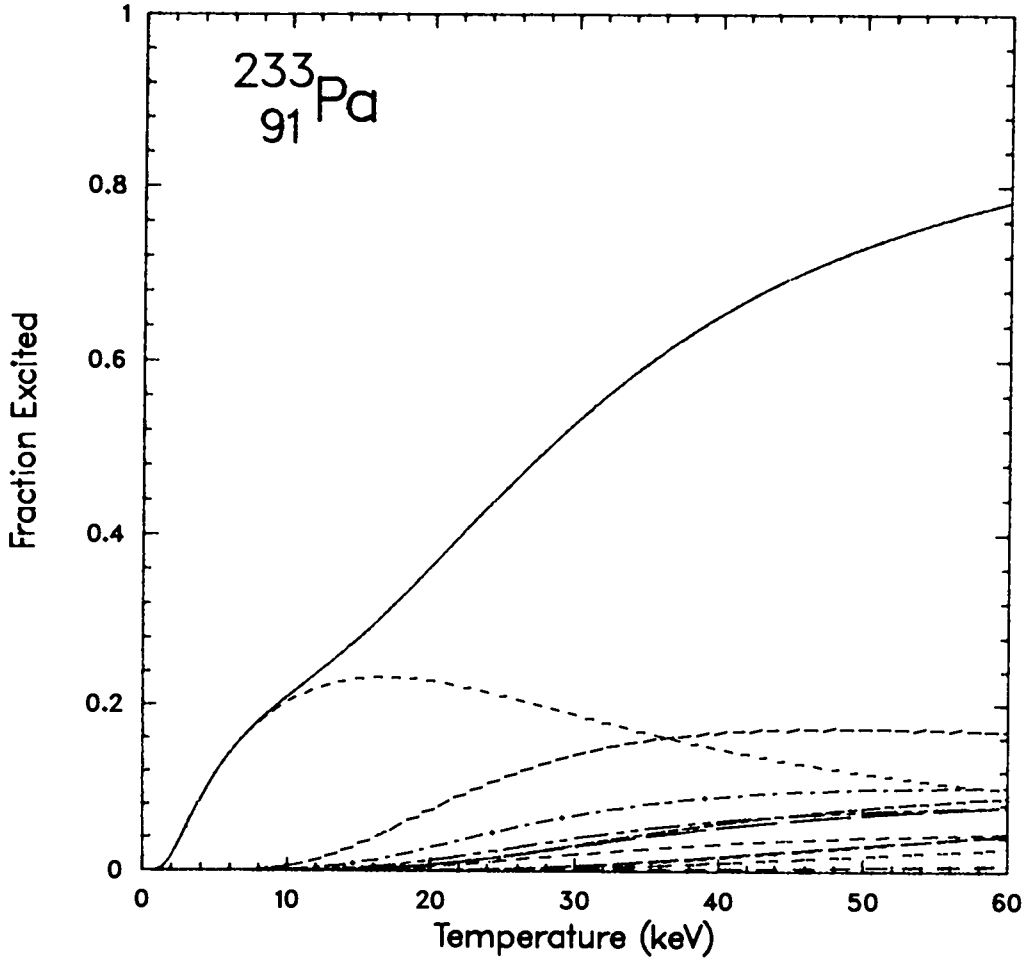

$^{232}_{90}$Th
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J$^{\pi}$ E(keV) T$_{1/2}$
6^{+} 333.2 63ps
4^{+} 162.12 164ps
2^{+} 49.369 345ps
G.S. 0^{+} 0. 1.4e10y
Total Excited Fraction
Natural Abundance = 100. %


233 90 Th
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) T1/2 Nilsson Assignment
11/2+ 220.
11/2+ 178.
9/2+ 159.
9/2+ 107.38
7/2+ 93.65
5/2+ 54.57
7/2+ 50.41
3/2+ 16.88
5/2+ 6.04 5/2{622}
(7/2-) 5.9 7/2{743}
G.S. 1/2+ 0. 22.3m 1/2{631}
Total Excited Fraction

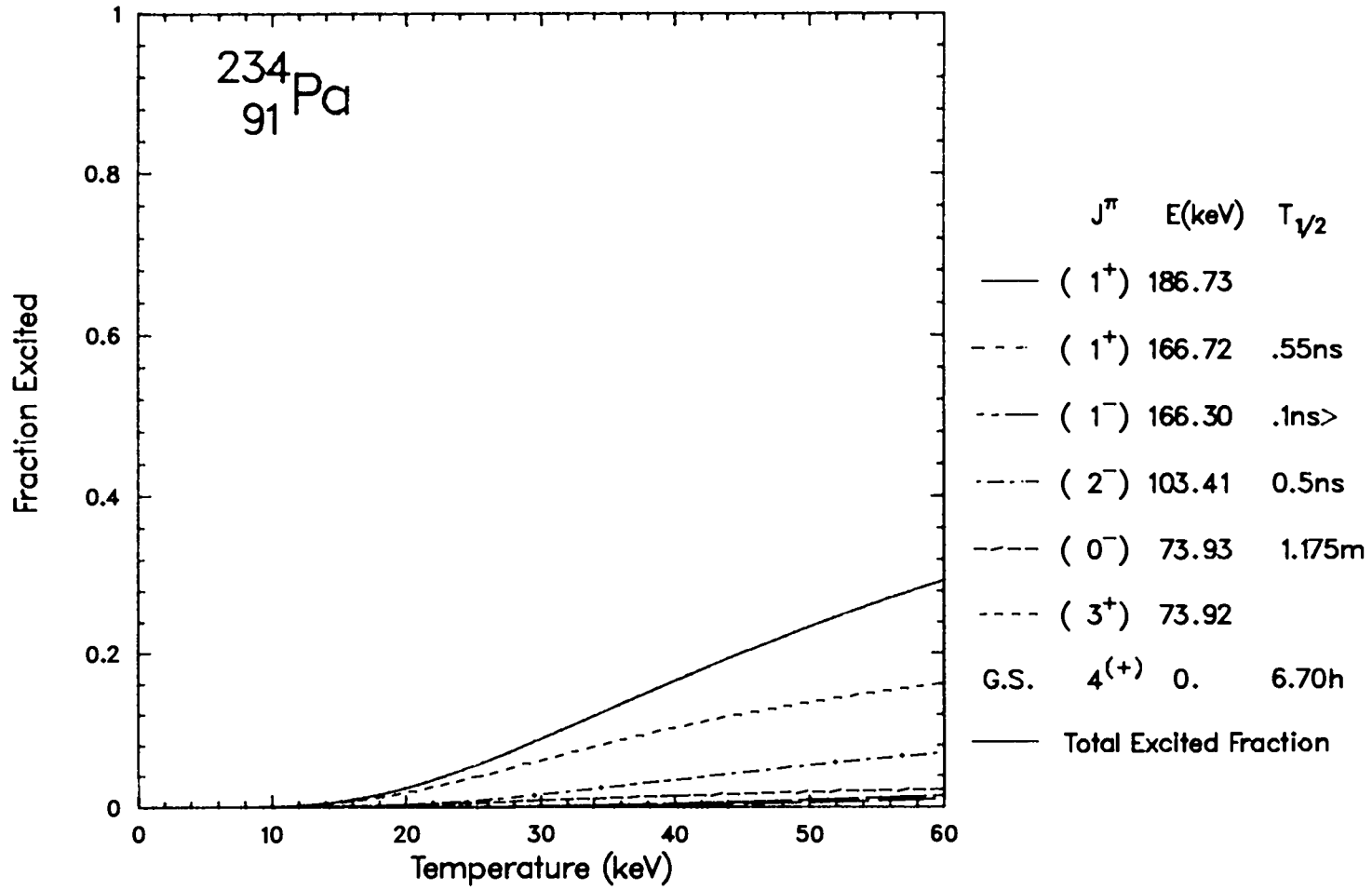

$^{234}_{90}$Th
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J$^{\pi}$ E(keV) T$_{1/2}$
4^{+} 160.
2^{+} 49.55 370ps
G.S. 0^{+} 0. 24.10d
Total Excited Fraction

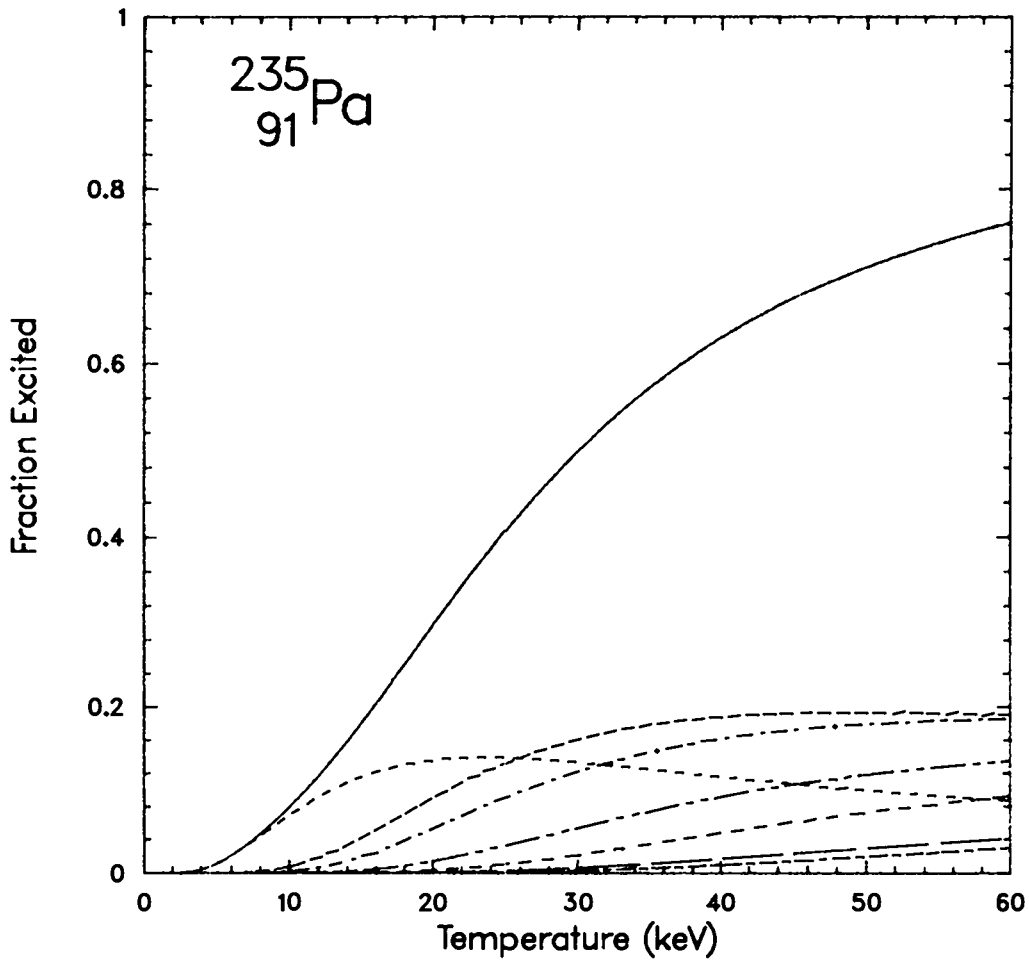


	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
-- · --	$(13/2^{+})$	189.		
-- —	$5/2^{+}$	183.494		5/2{642}
-- --	$5/2^{-}$	174.166		5/2{523}
— —	$(11/2^{-})$	169.3		
——	$(11/2^{+})$	134.		
----	$(9/2^{+})$	111.64		
——	$3/2^{+}$	102.259		
- - -	$7/2^{+}$	101.393		
---—	$5/2^{+}$	84.208	45.1ns	3/2{651}
-·-·	$5/2^{-}$	77.69		
-·--·	$7/2^{-}$	58.564	274ps	
----	$1/2^{-}$	9.20		
G.S.	$3/2^{-}$	0.	3.28e4y	1/2{530}
——	Total Excited Fraction			

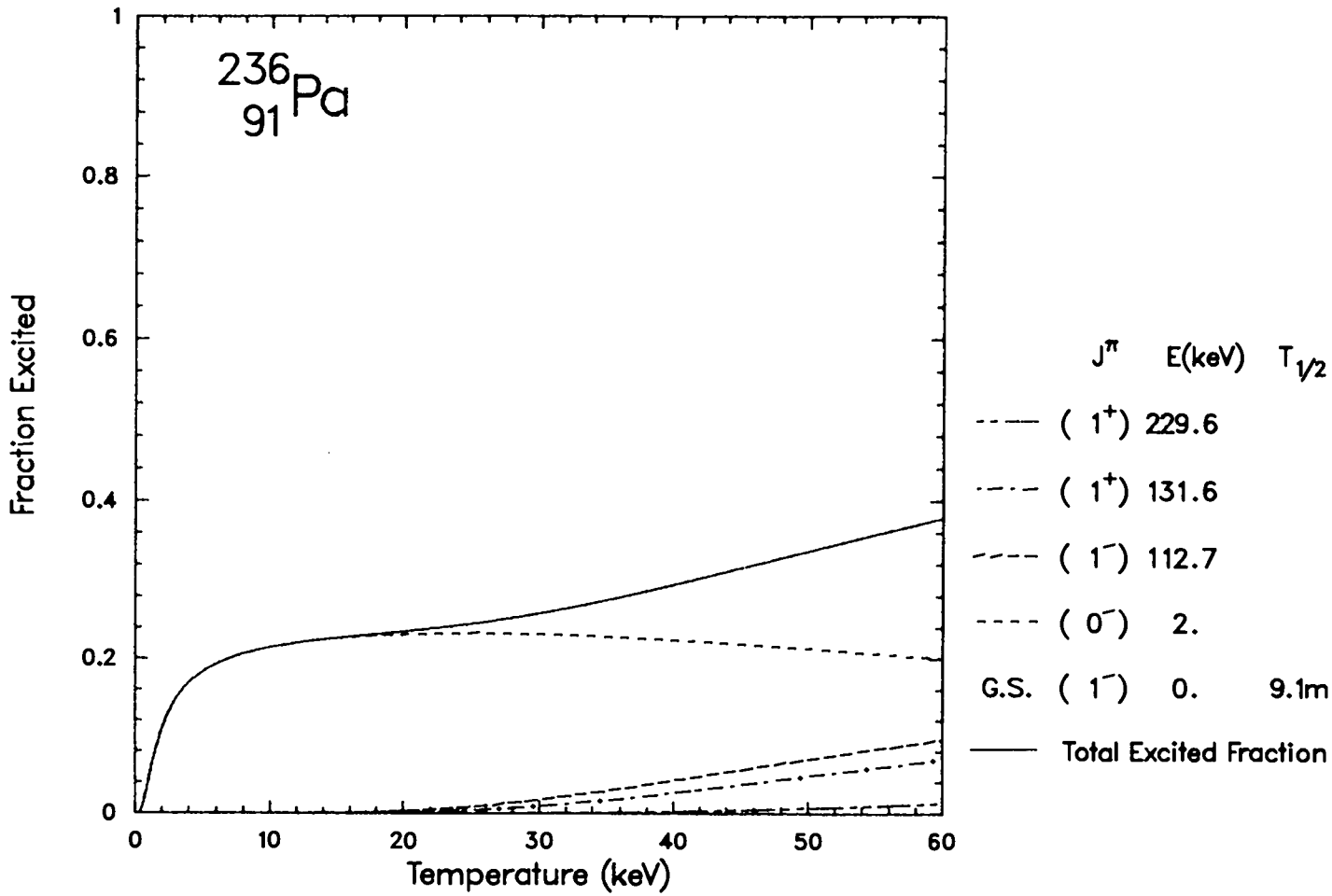


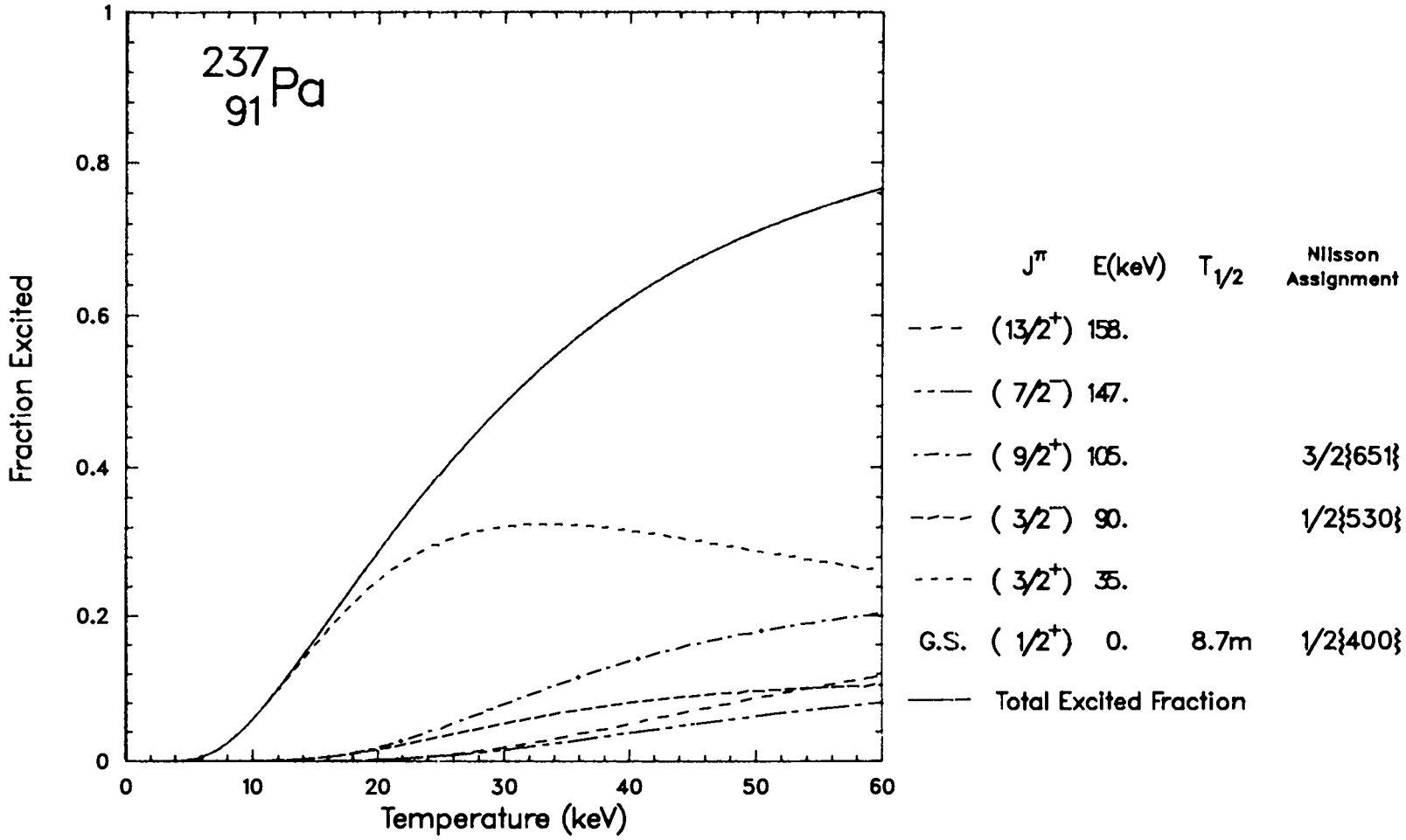
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
	$3/2^{+}$	201.7		
	$9/2^{-}$	179.4		
	$(13/2^{+})$	173.		
	$(1/2^{+})$	169.15		1/2{400}
	$(11/2^{-})$	163.27		
	$9/2^{+}$	109.10		
	$7/2^{+}$	103.8		
	$3/2^{+}$	94.7		
	$5/2^{+}$	86.5	35.7ns	3/2{651}
	$5/2^{-}$	70.6		
	$7/2^{-}$	57.15		
	$1/2^{-}$	6.65		
G.S.	$3/2^{-}$	0.	27.0d	1/2{530}
	Total Excited Fraction			

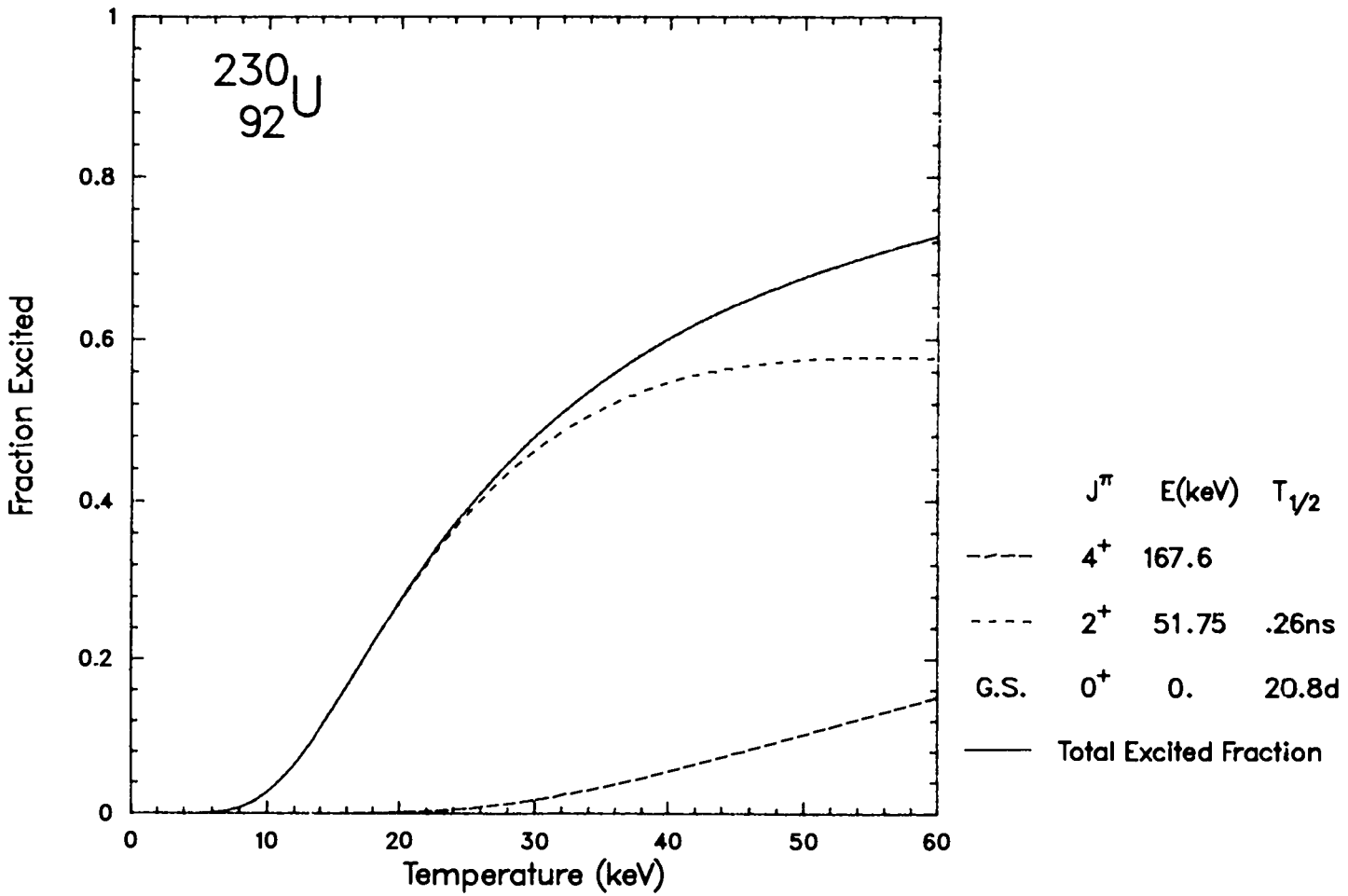

234 91 Pa
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2
(1+) 186.73
(1+) 166.72 .55ns
(1−) 166.30 .1ns>
(2−) 103.41 0.5ns
(0−) 73.93 1.175m
(3+) 73.92
G.S. 4(+) 0. 6.70h
Total Excited Fraction

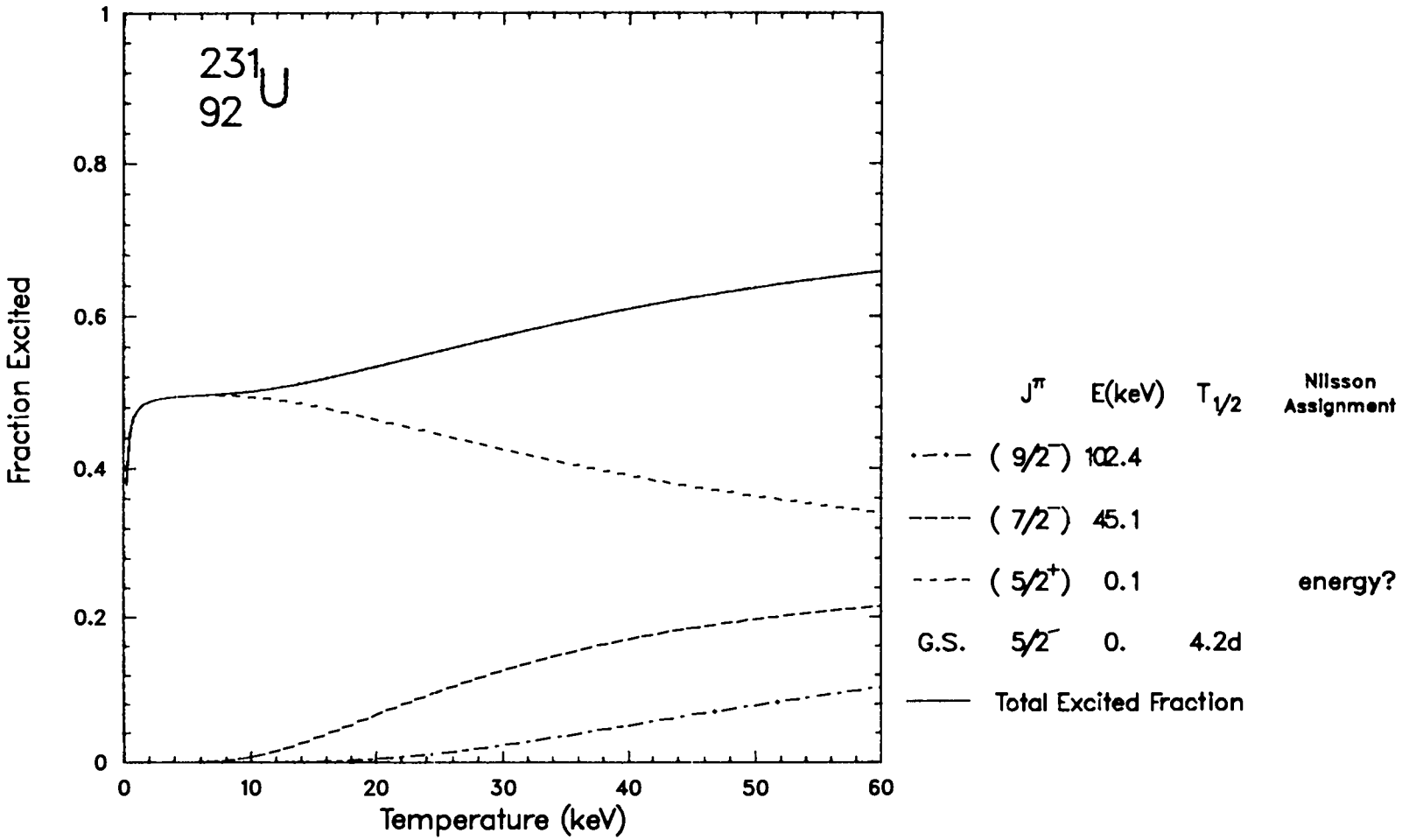


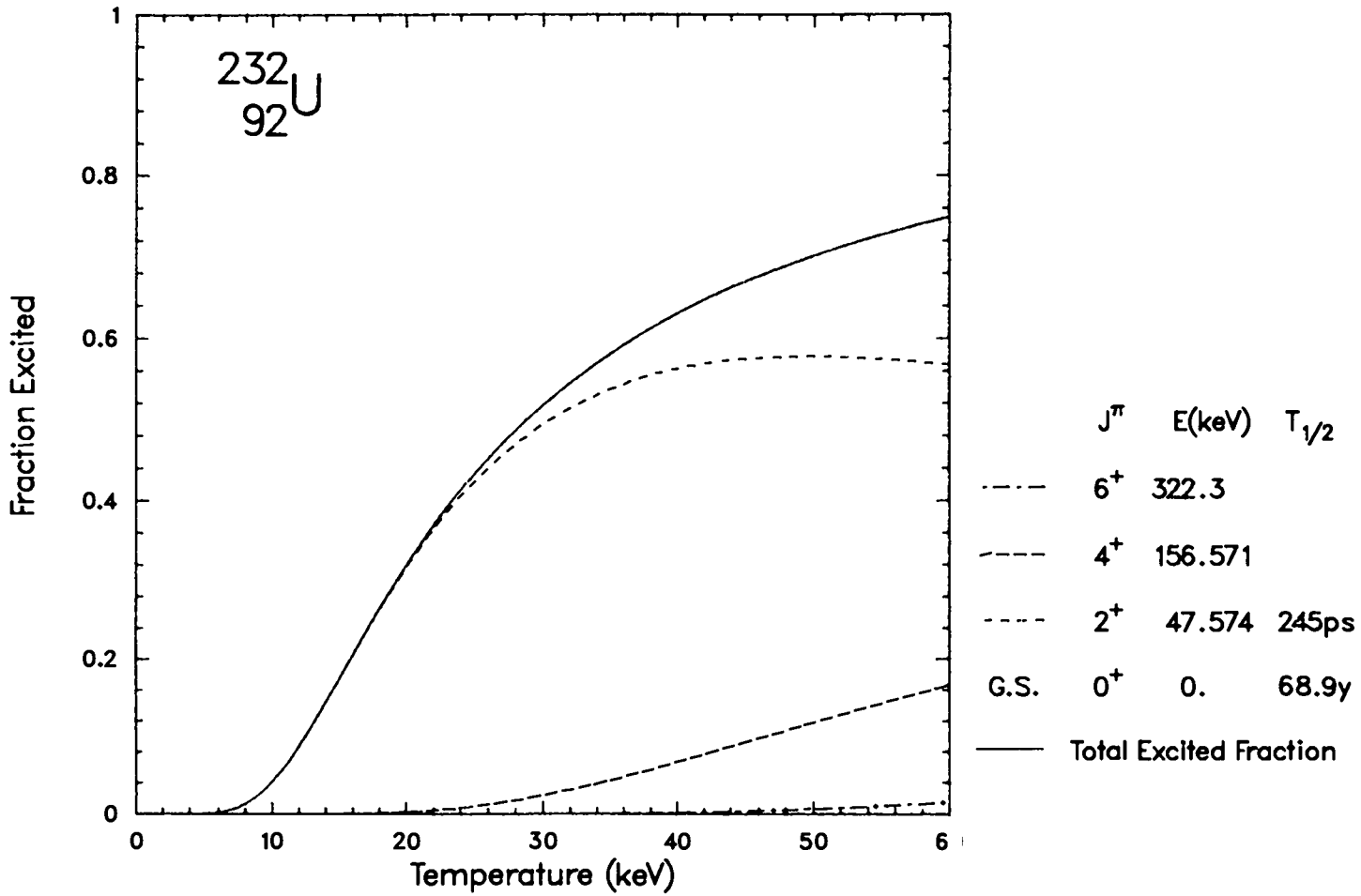
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
----	$(11/2^-)$	190.		J? +?
——	$(9/2^-)$	160.		J? +?
- - -	$(13/2^+)$	132.		J? +?
-·—	$(11/2^+)$	100.		J? +?
·-·-	$(9/2^+)$	70.		3/2{651}
----	$(7/2^-)$	55.		
----	$(1/2^+)$	19.		1/2{400}
G.S.	$(3/2^-)$	0.	24.2m	1/2{530}
——	Total Excited Fraction			

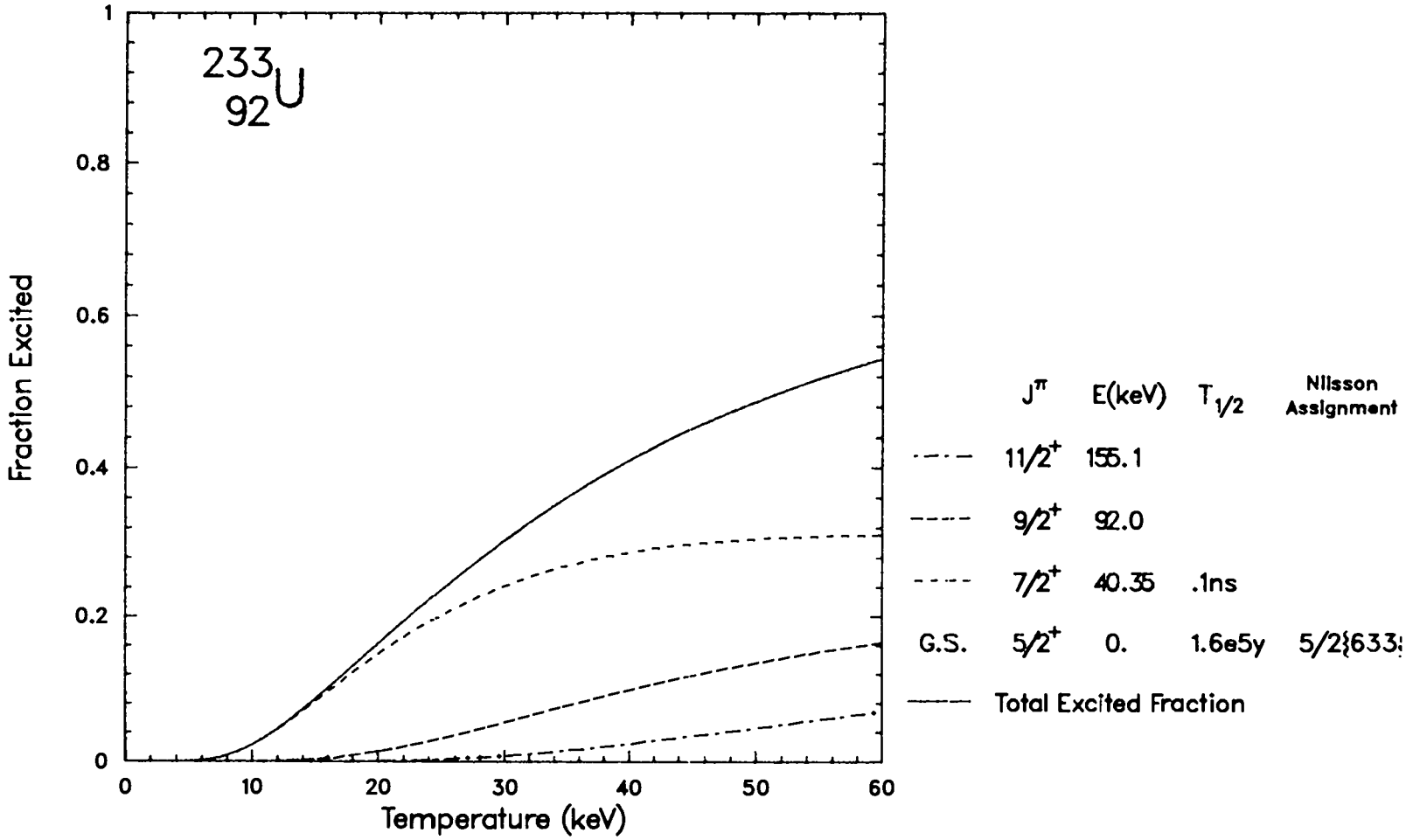

$^{236}_{91}$Pa
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2
(1+) 229.6
(1+) 131.6
(1-) 112.7
(0-) 2.
G.S. (1-) 0. 9.1m
Total Excited Fraction

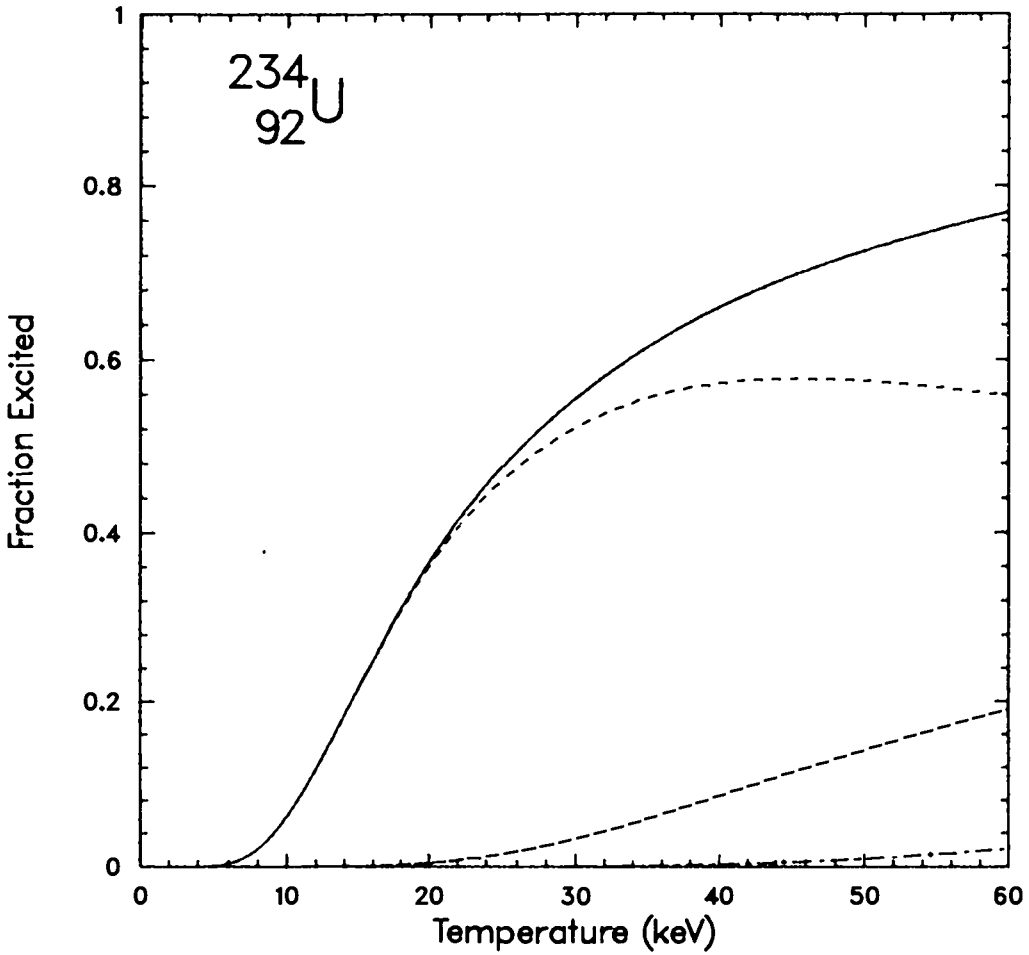

$^{237}_{91}$Pa
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J$^{\pi}$ E(keV) T$_{1/2}$ Nilsson Assignment
(13/2^{+}) 158.
(7/2^{-}) 147.
(9/2^{+}) 105. 3/2{651}
(3/2^{-}) 90. 1/2{530}
(3/2^{+}) 35.
G.S. (1/2^{+}) 0. 8.7m 1/2{400}
Total Excited Fraction


$^{230}_{92}U$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) $T_{1/2}$
4^+ 167.6
2^+ 51.75 .26ns
G.S. 0^+ 0. 20.8d
Total Excited Fraction


231 92 U
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
(9/2⁻) 102.4
(7/2⁻) 45.1
(5/2⁺) 0.1 energy?
G.S. 5/2⁻ 0. 4.2d
Total Excited Fraction


$^{232}_{92}U$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
6
J$^{\pi}$ E(keV) T$_{1/2}$
6^{+} 322.3
4^{+} 156.571
2^{+} 47.574 245ps
G.S. 0^{+} 0. 68.9y
Total Excited Fraction

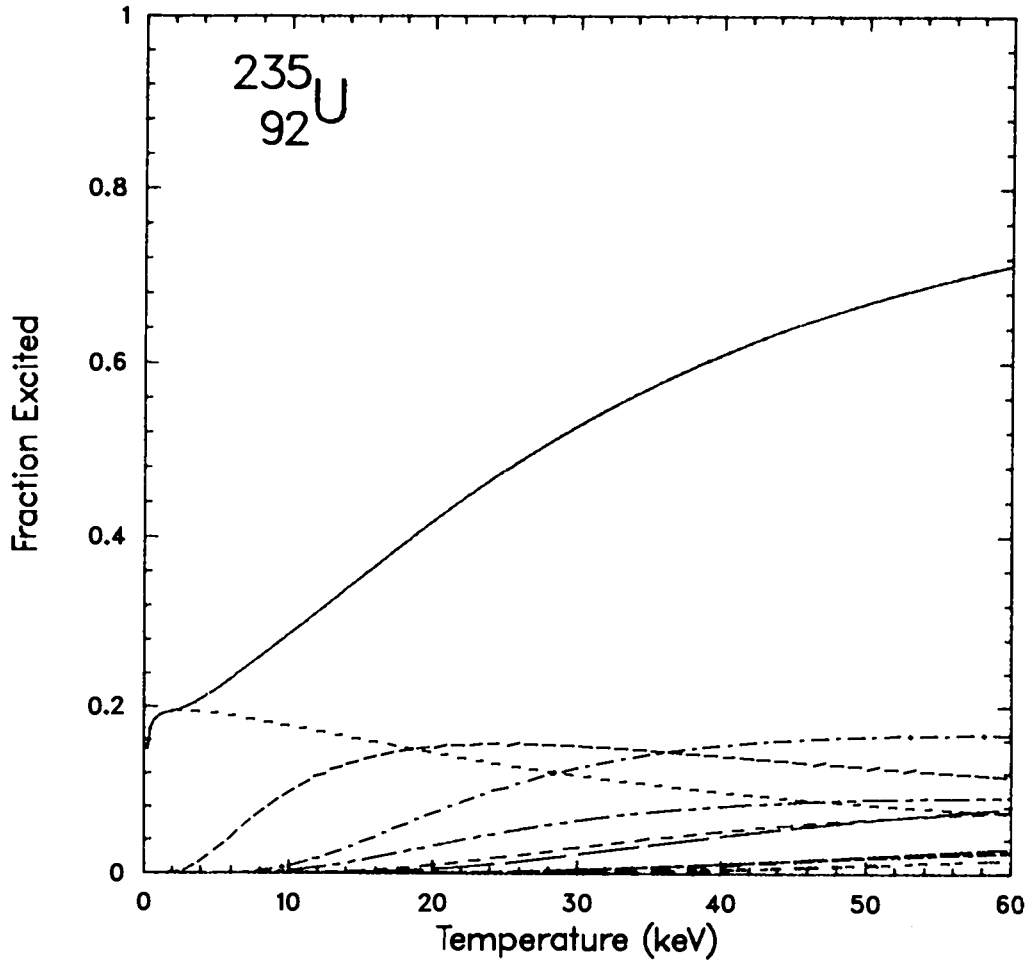

233 92 U
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
11/2+ 155.1
9/2+ 92.0
7/2+ 40.35 .1ns
G.S. 5/2+ 0. 1.6e5y 5/2{633
Total Excited Fraction



	J^{π}	E(keV)	$T_{1/2}$
·-·-·	6^+	296.03	
-·-·-	4^+	143.32	
- - - -	2^+	43.48	252ps
G.S.	0^+	0.	2.45e5y

——— Total Excited Fraction

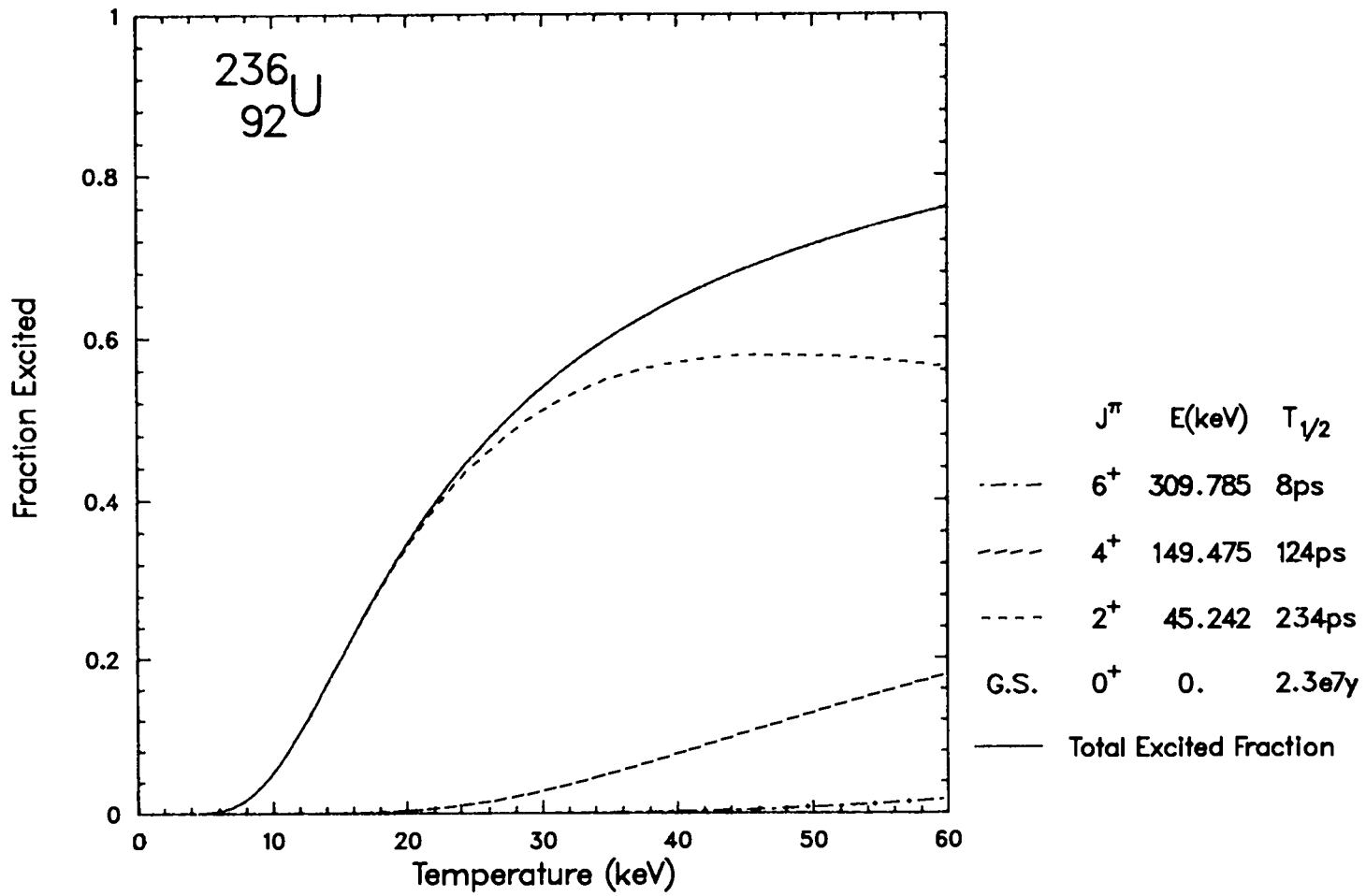
Natural Abundance = .0054 %

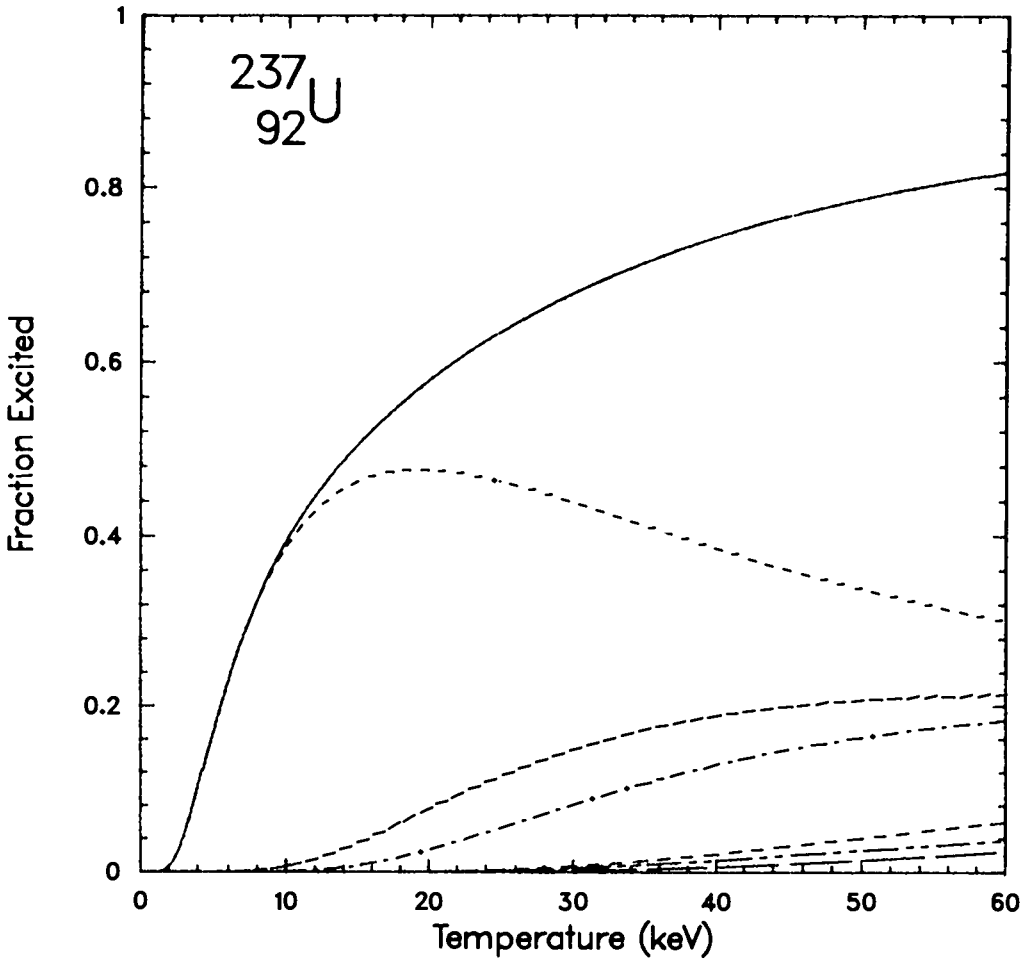


	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
- - - -	$11/2^{+}$	197.13		
- - - -	$7/2^{+}$	171.376		
- -	$13/2^{-}$	170.73		
——	$9/2^{+}$	150.5		
----	$5/2^{+}$	129.29		5/2{622}
——	$11/2^{-}$	103.03		
- - - -	$7/2^{+}$	81.77		
- - —	$5/2^{+}$	51.69	191ps	
- · - ·	$9/2^{-}$	46.21		
- - - -	$3/2^{+}$	13.01	.5ns	
- - - -	$1/2^{+}$	.073	25m	1/2{631}
G.S.	$7/2^{-}$	0.	7.04e8y	7/2{743}

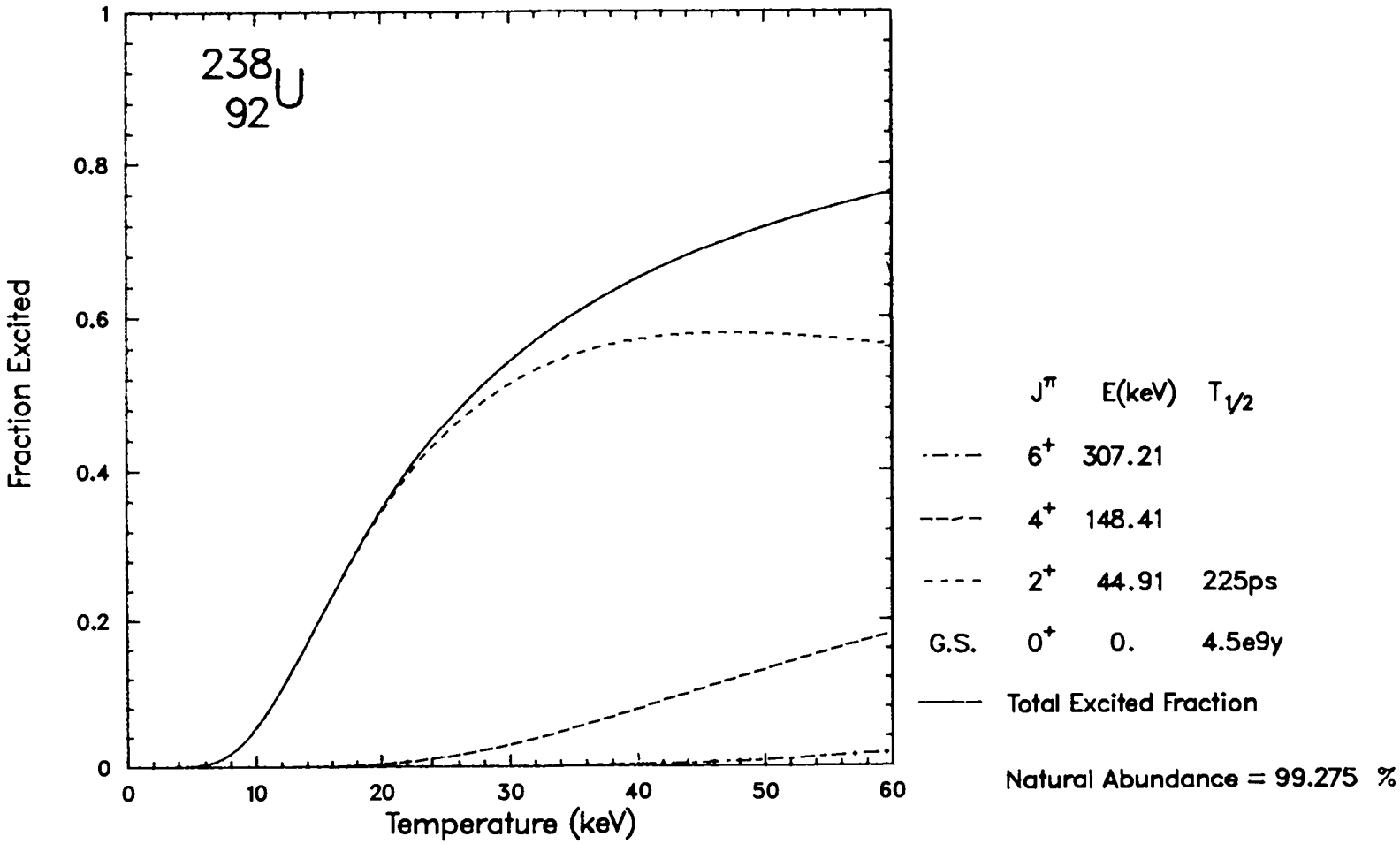
—— Total Excited Fraction

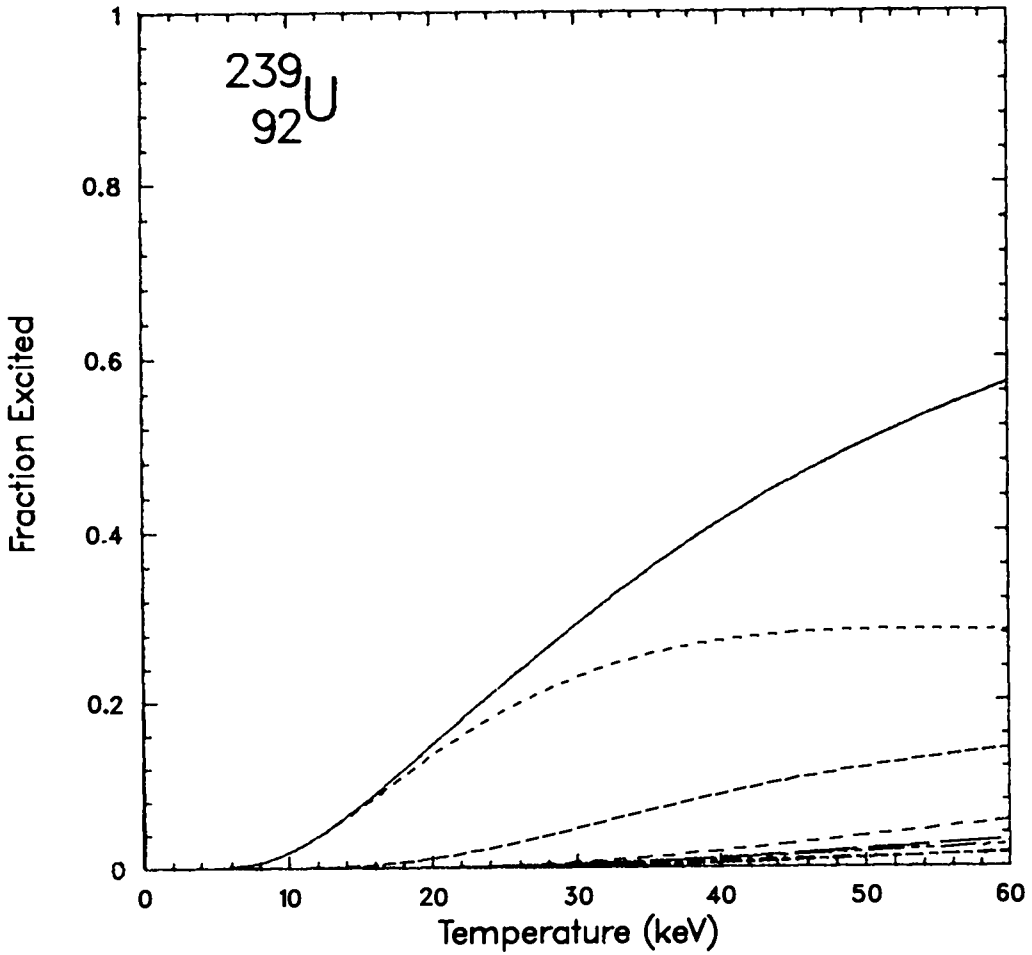
Natural Abundance = .720 %


$^{236}_{92}U$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) $T_{1/2}$
6^+ 309.785 8ps
4^+ 149.475 124ps
2^+ 45.242 234ps
G.S. 0^+ 0. 2.3e7y
Total Excited Fraction

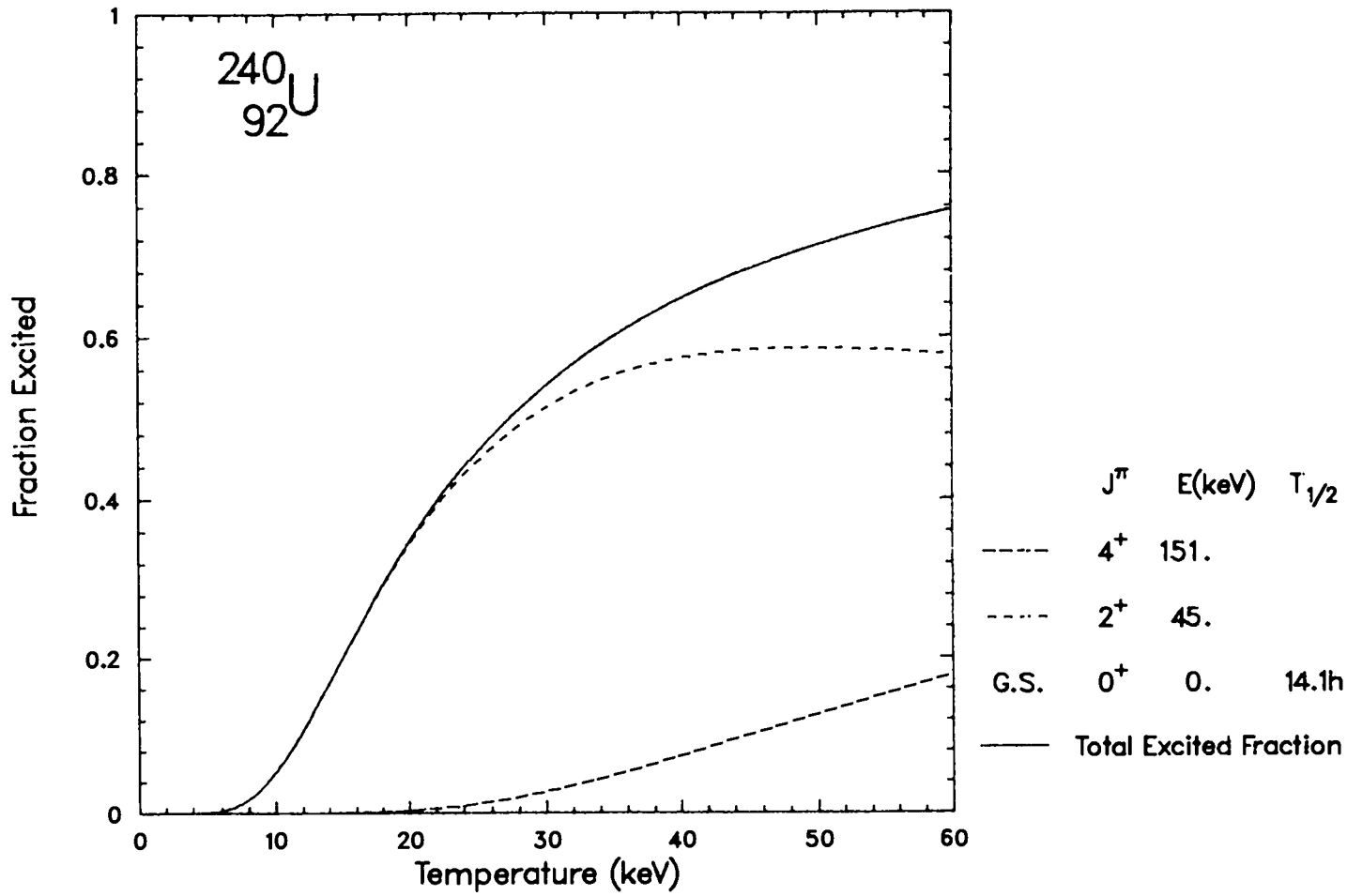


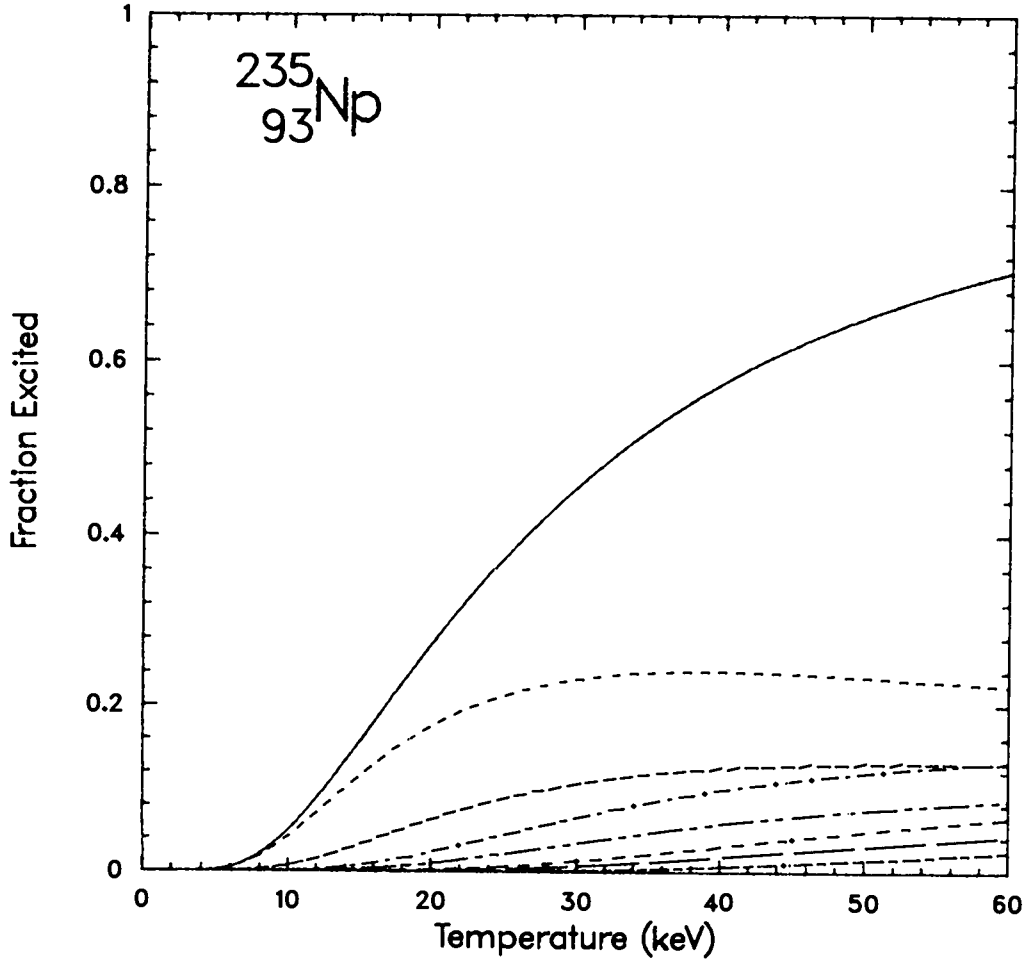
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
——	$7/2^+$	204.15		
- - -	$9/2^+$	163.		
- - -	$5/2^+$	159.957	3.1ns>	5/2{622}
- · -	$7/2^+$	82.89		
- - -	$5/2^+$	56.28		
- - -	$3/2^+$	11.39		
G.S.	$1/2^+$	0.	6.75d	1/2{631}
——	Total Excited Fraction			


238 92U
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) T1/2
6+ 307.21
4+ 148.41
2+ 44.91 225ps
G.S. 0+ 0. 4.5e9y
Total Excited Fraction
Natural Abundance = 99.275 %

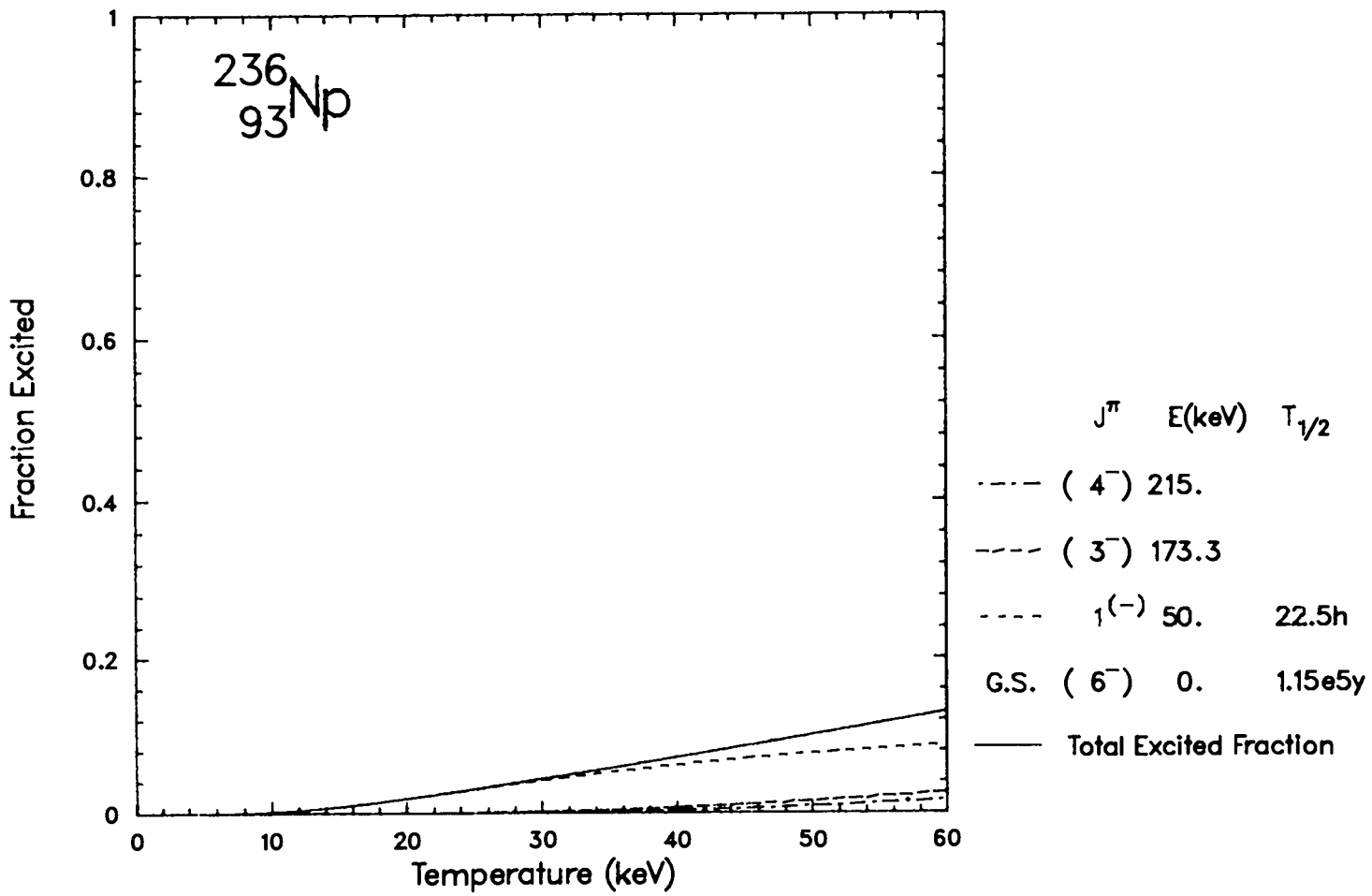


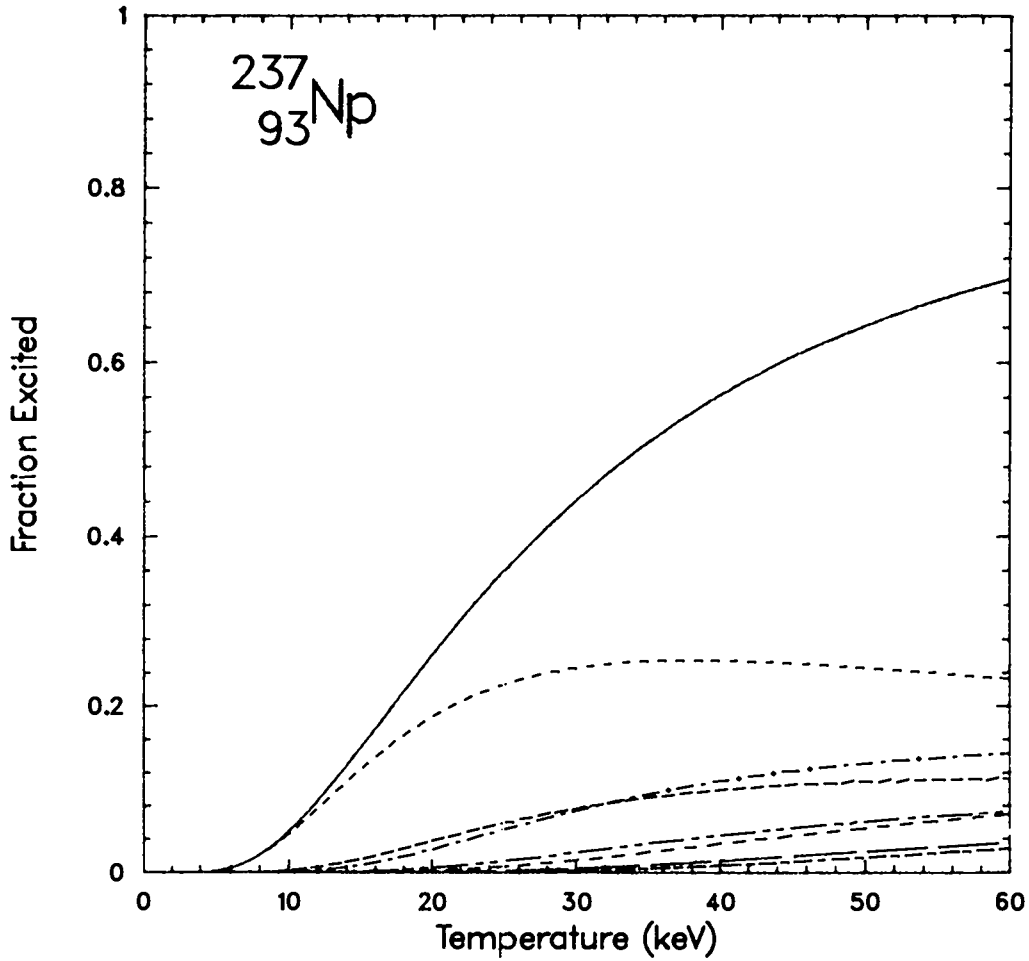
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
----	$5/2^{+}$	193.9		
——	$(7/2^{+})$	173.		7/2{624}
- - -	$(11/2^{+})$	165.		
--—	$3/2^{+}$	145.6		
-·-·	$1/2^{+}$	133.799	780ns	1/2{631}
----	$9/2^{+}$	97.		
----	$7/2^{+}$	42.54		
G.S.	$5/2^{+}$	0.	23.50m	5/2{622}
——	Total Excited Fraction			


240 92U
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2
4+ 151.
2+ 45.
G.S. 0+ 0. 14.1h
Total Excited Fraction

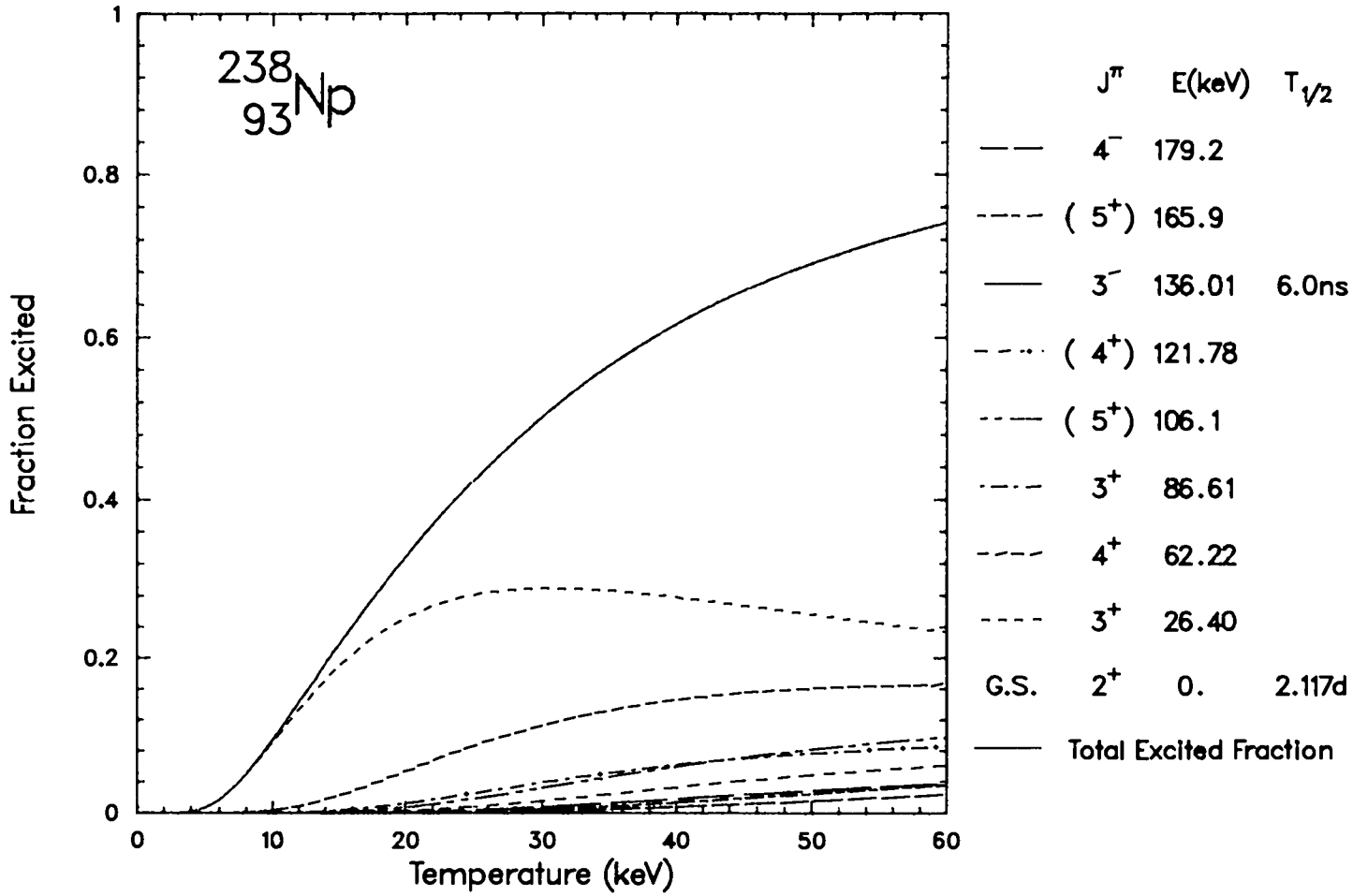


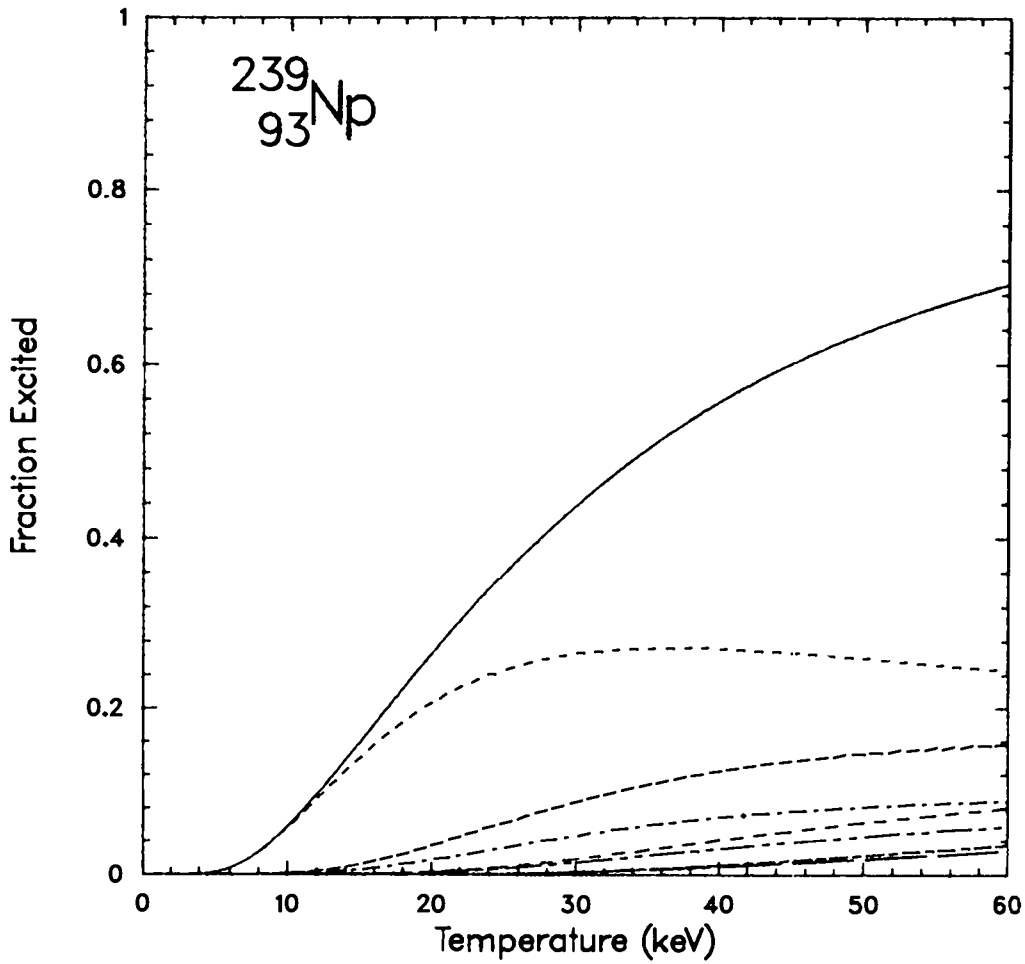
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
----	$13/2^{+}$	201.		
——	$9/2^{-}$	146.8		
- - -	$(11/2^{+})$	133.		
---—	$(7/2)^{-}$	91.6		
-·-·	$(9/2^{+})$	79.1		
-·-·-	$(5/2)^{-}$	49.10	6.9ns	5/2{523}
----	$(7/2^{+})$	34.23		
G.S.	$5/2^{+}$	0.	396d	5/2{642}
——	Total Excited Fraction			


$^{236}_{93}Np$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$
(4^-) 215.
(3^-) 173.3
$1^{(-)}$ 50. 22.5h
G.S. (6^-) 0. 1.15e5y
Total Excited Fraction

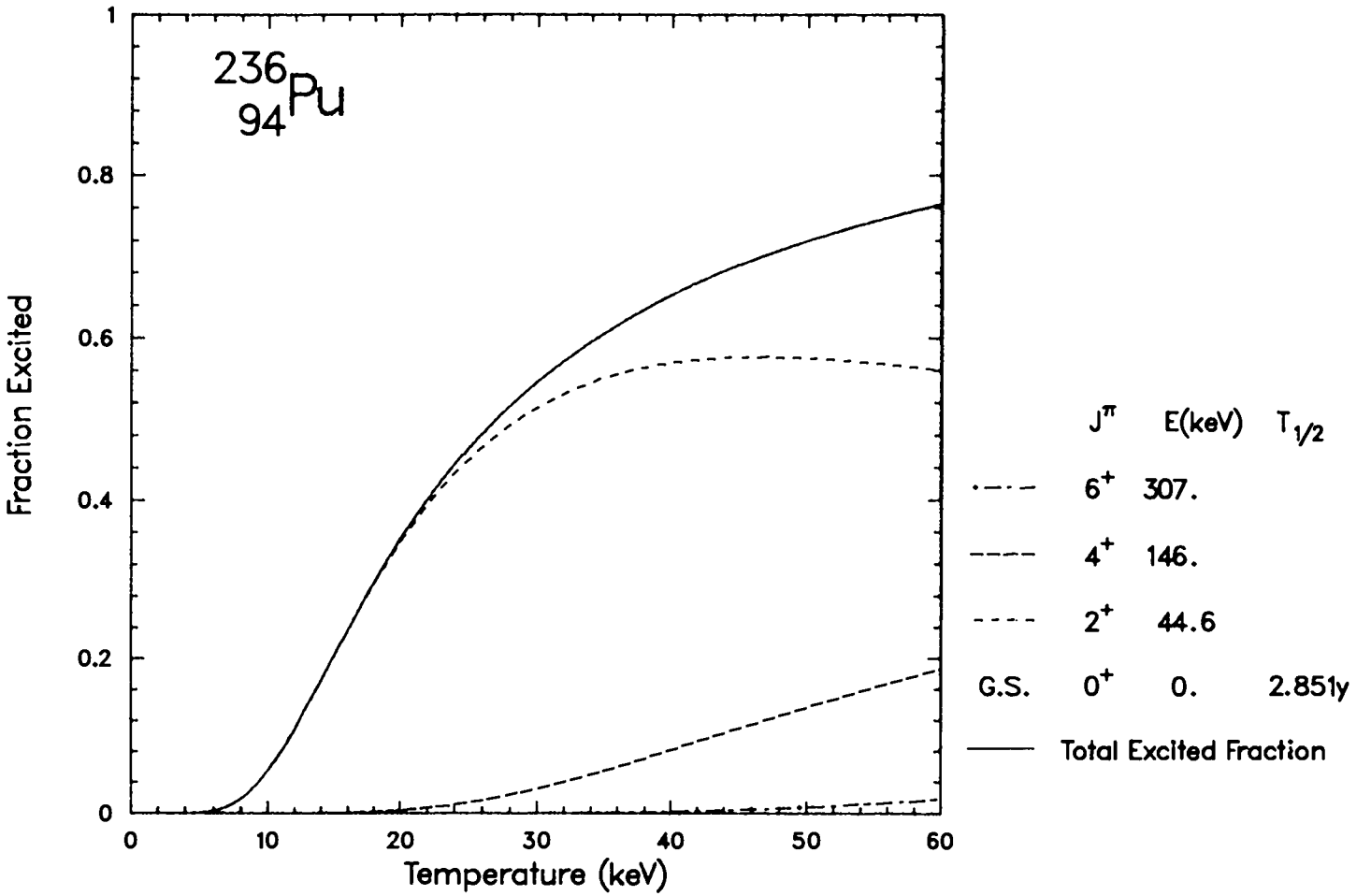


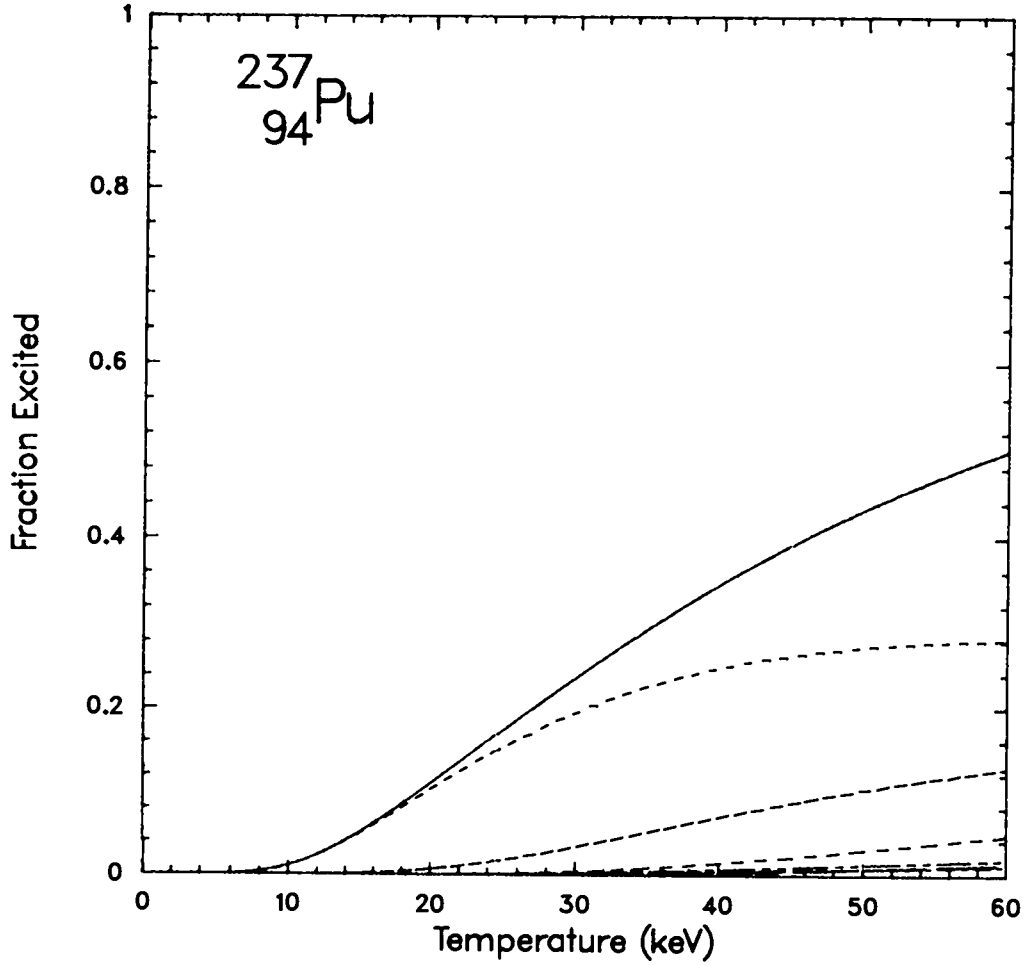
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
----	$13/2^{+}$	192.		
——	$9/2^{-}$	158.48		
- - -	$11/2^{+}$	129.89		
-·—	$7/2^{-}$	102.96	80ps	
-·-·	$9/2^{+}$	75.83		
----	$5/2^{-}$	59.537	67ns	5/2{523}
----	$7/2^{+}$	33.195	61ps	
G.S.	$5/2^{+}$	0.	2.14e6y	5/2{642}
——	Total Excited Fraction			


238 93Np
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2
4− 179.2
(5+) 165.9
3− 136.01 6.0ns
(4+) 121.78
(5+) 106.1
3+ 86.61
4+ 62.22
3+ 26.40
G.S. 2+ 0. 2.117d
Total Excited Fraction

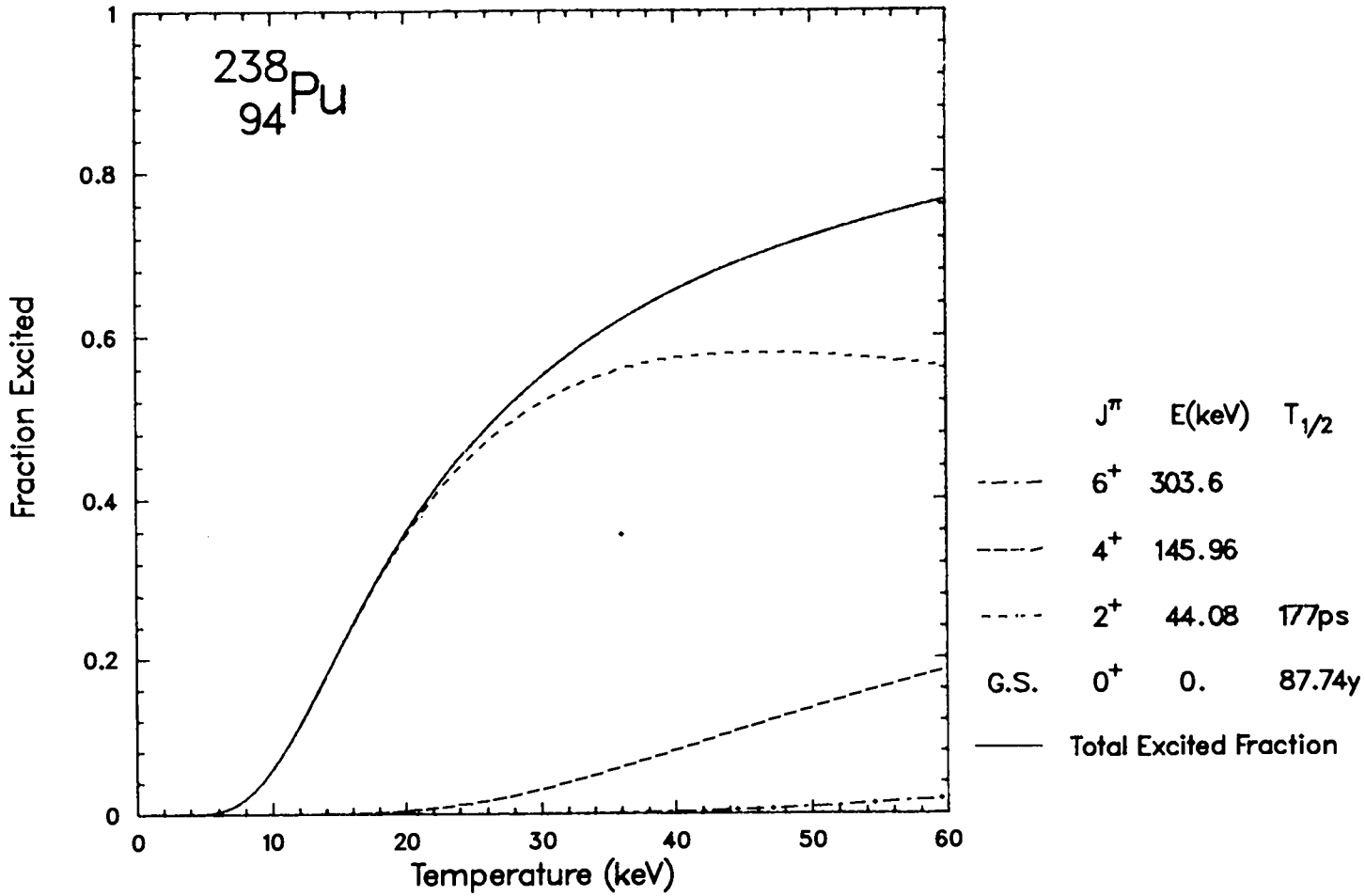


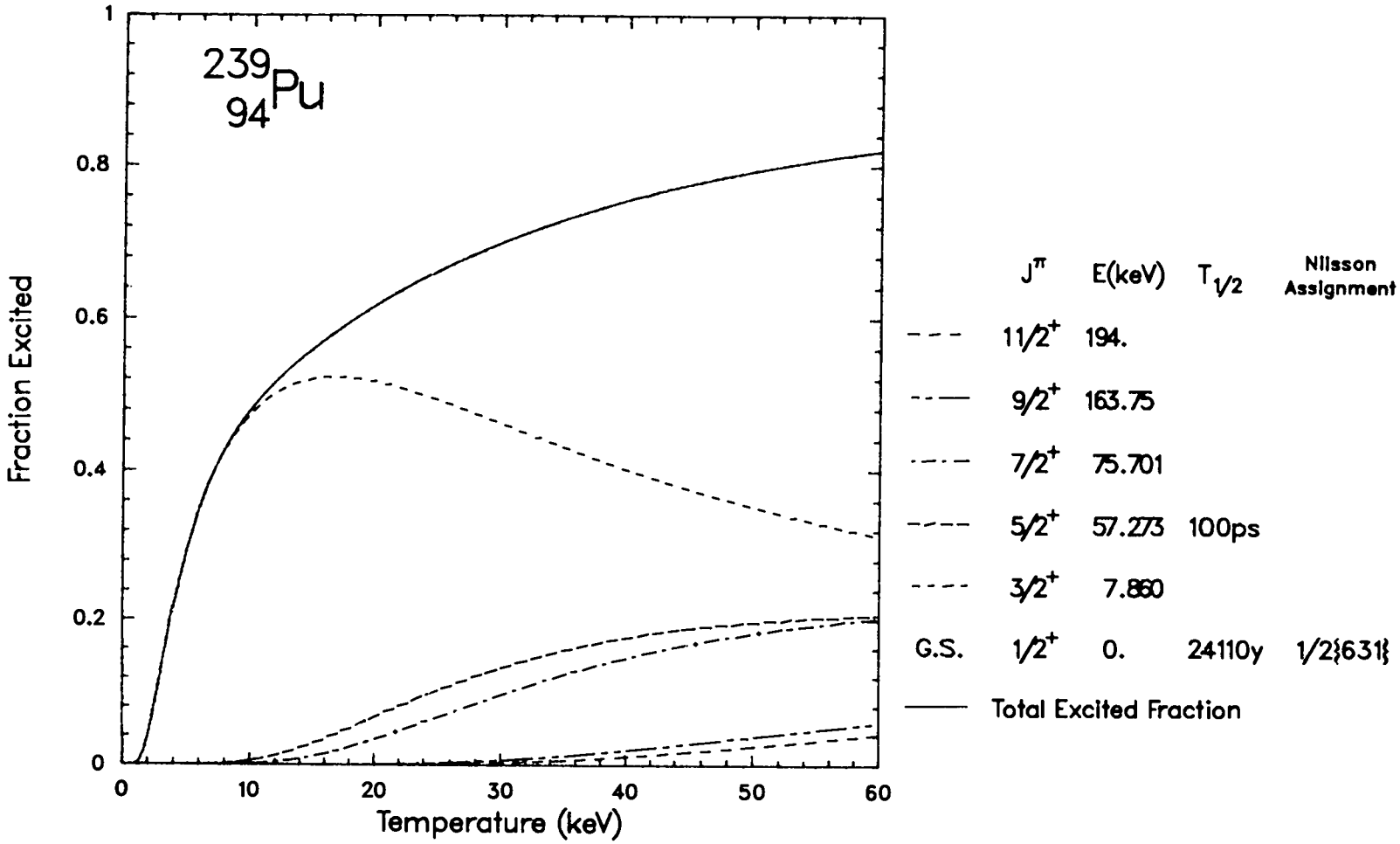
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
----	$13/2^{+}$	180.0		
——	$9/2^{-}$	173.02		
- - -	$11/2^{+}$	122.6		
---	$7/2^{-}$	117.73	0.4ns>	
-·-·	$5/2^{-}$	74.669	1.4ns	5/2{523}
----	$9/2^{+}$	71.21		
- - - -	$7/2^{+}$	31.135		
G.S.	$5/2^{+}$	0.	2.35d	5/2{642}
——	Total Excited Fraction			

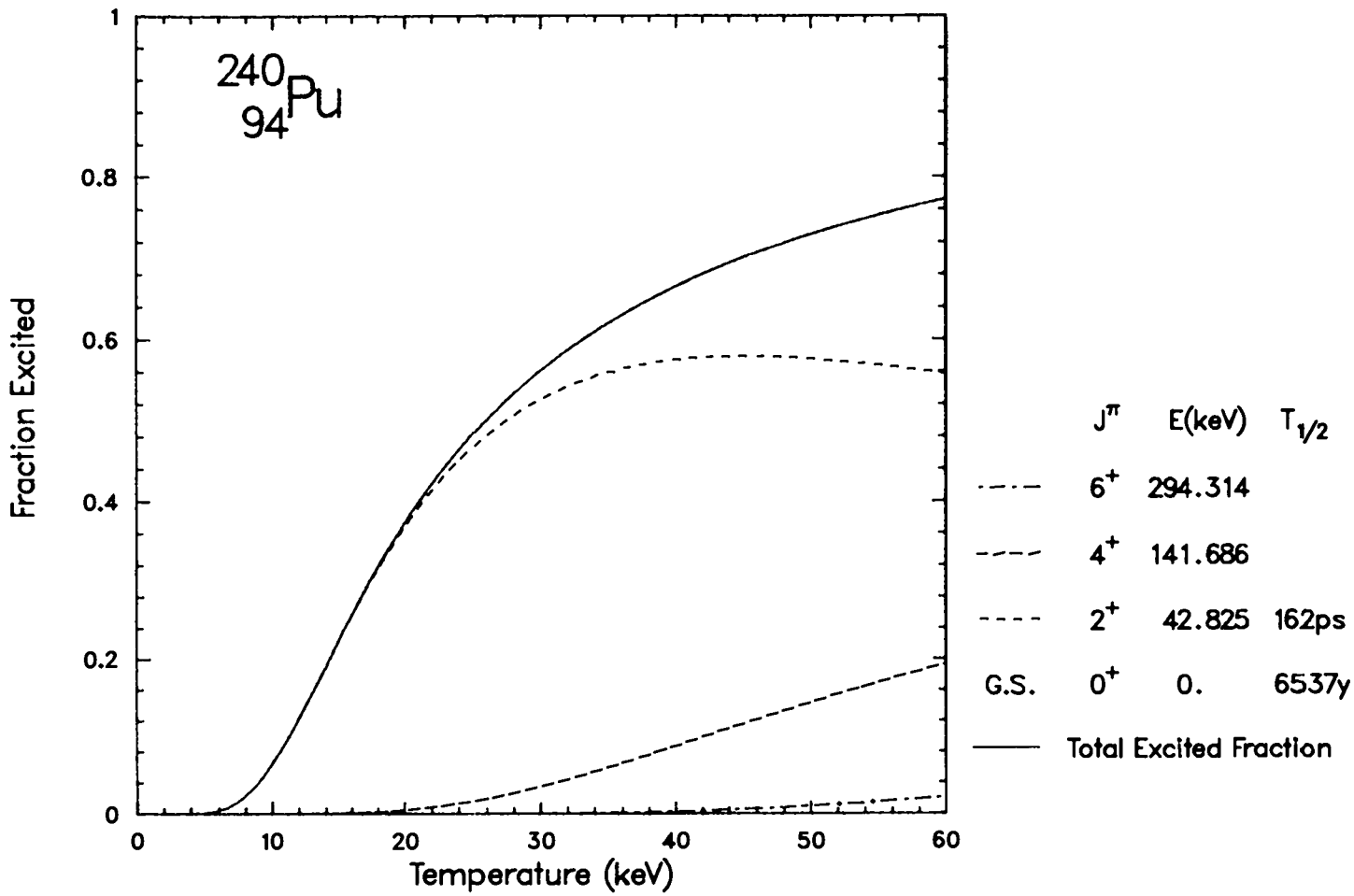

$^{236}_{94}Pu$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J$^{\pi}$ E(keV) T$_{1/2}$
6^{+} 307.
4^{+} 146.
2^{+} 44.6
G.S. 0^{+} 0. 2.851y
Total Excited Fraction

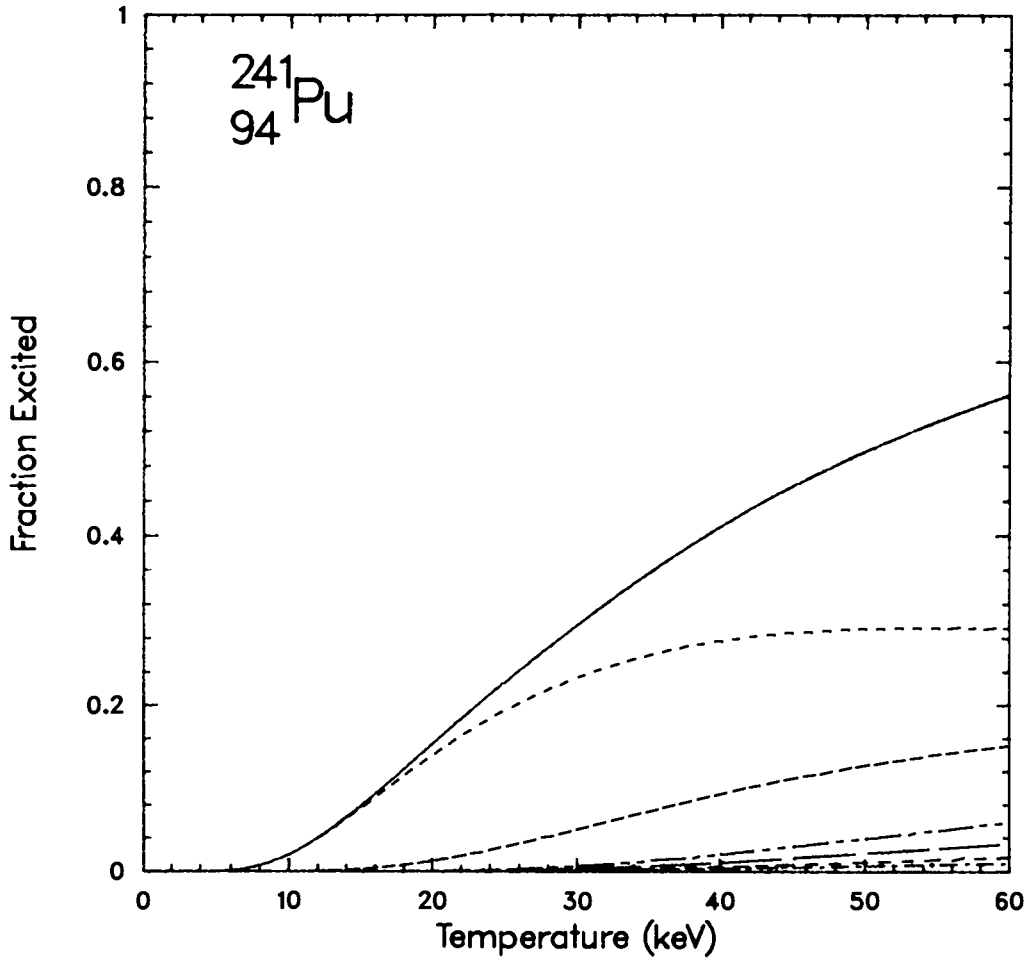


	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
——	$5/2^{+}$	201.18		
- - -	$(13/2^{-})$	175.		
--—	$3/2^{+}$	155.45		
-·—	$1/2^{+}$	145.544	.18s	1/2{631}
-···-	$11/2^{-}$	106.		
- - - -	$9/2^{-}$	47.71		
G.S.	$7/2^{-}$	0.	45.3d	7/2{743}
——	Total Excited Fraction			

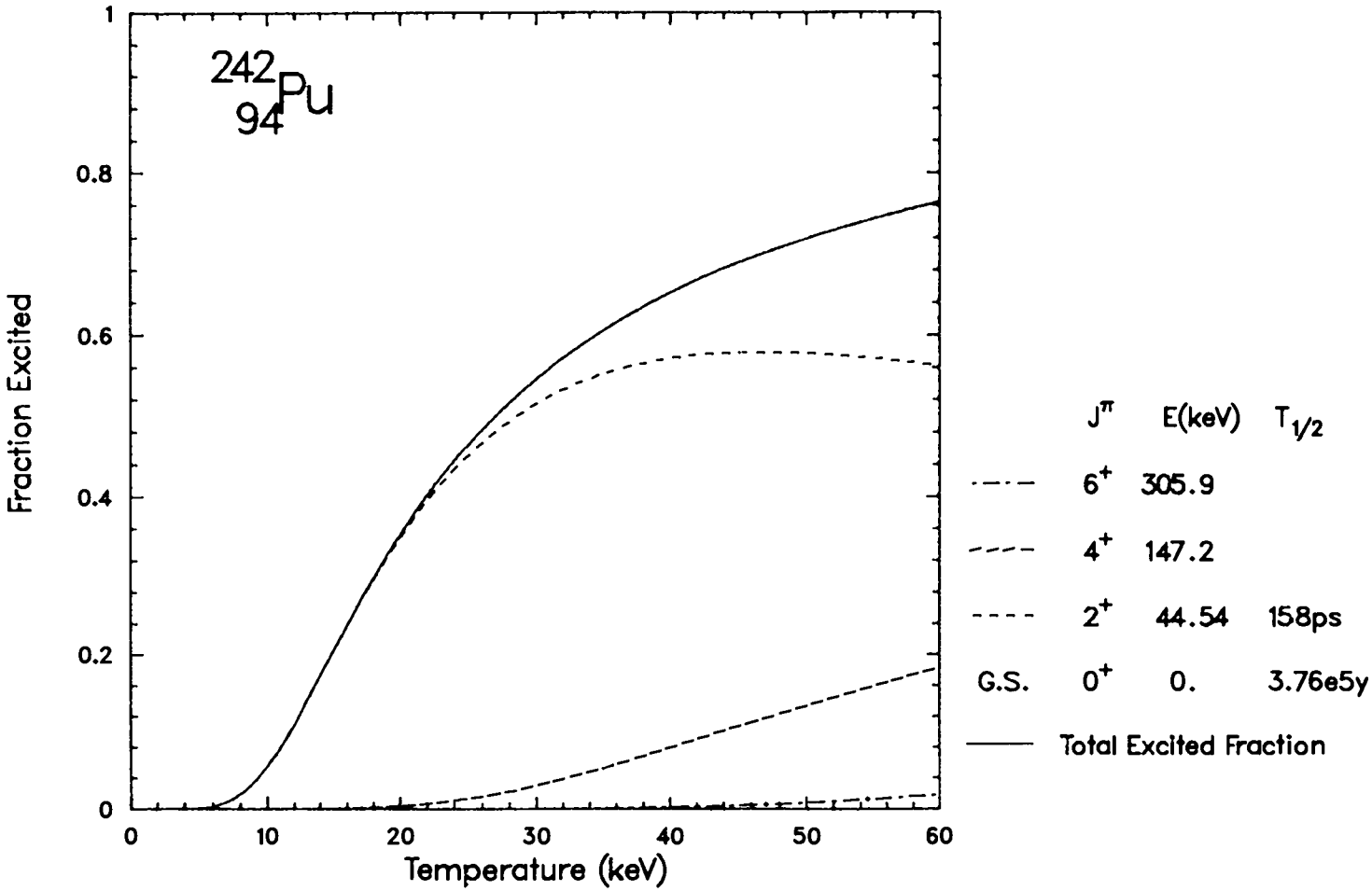

238 94Pu
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2
6+ 303.6
4+ 145.96
2+ 44.08 177ps
G.S. 0+ 0. 87.74y
Total Excited Fraction

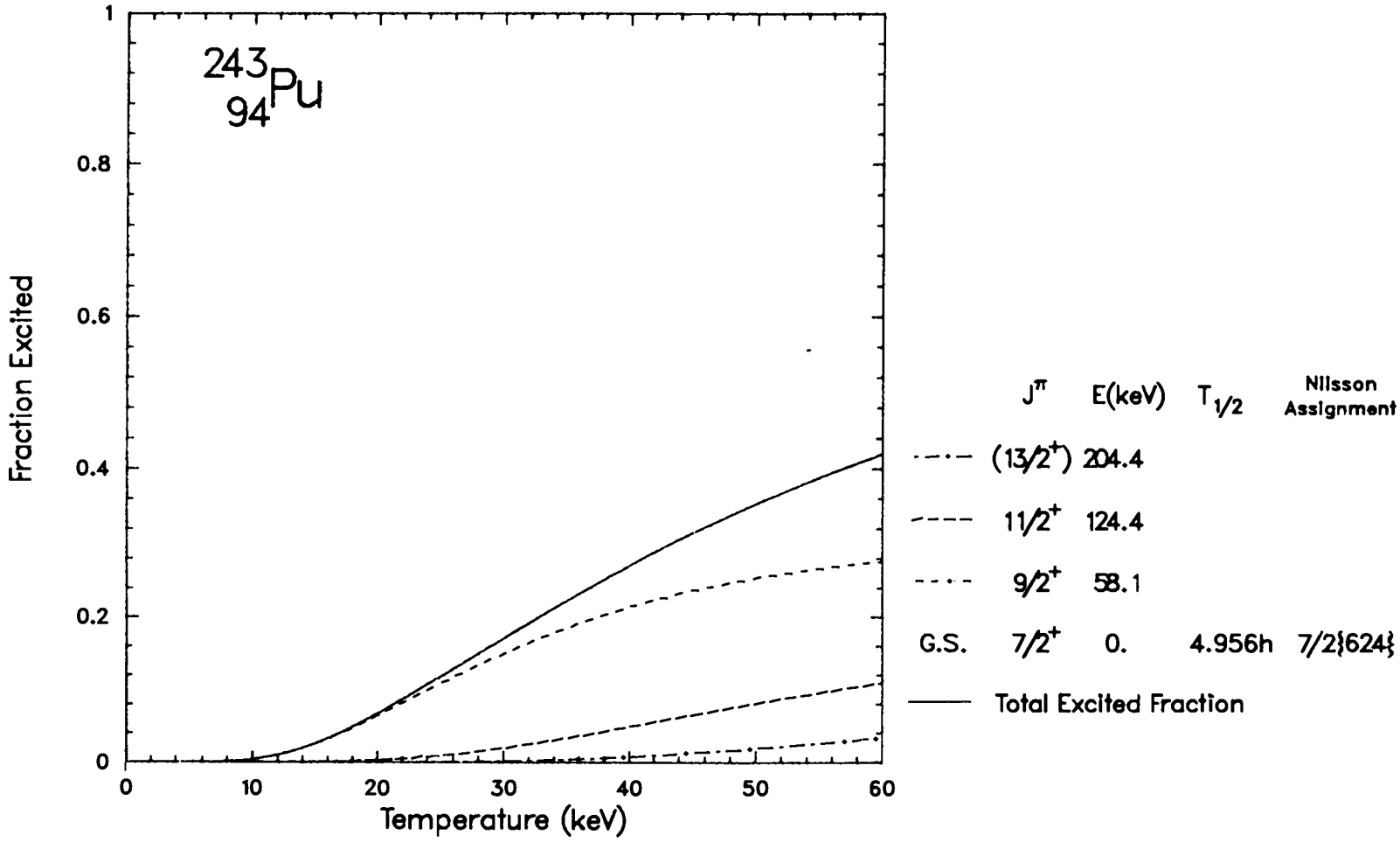

239 94 Pu
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) T1/2 Nilsson Assignment
11/2+ 194.
9/2+ 163.75
7/2+ 75.701
5/2+ 57.273 100ps
3/2+ 7.860
G.S. 1/2+ 0. 24110y 1/2{631}
Total Excited Fraction

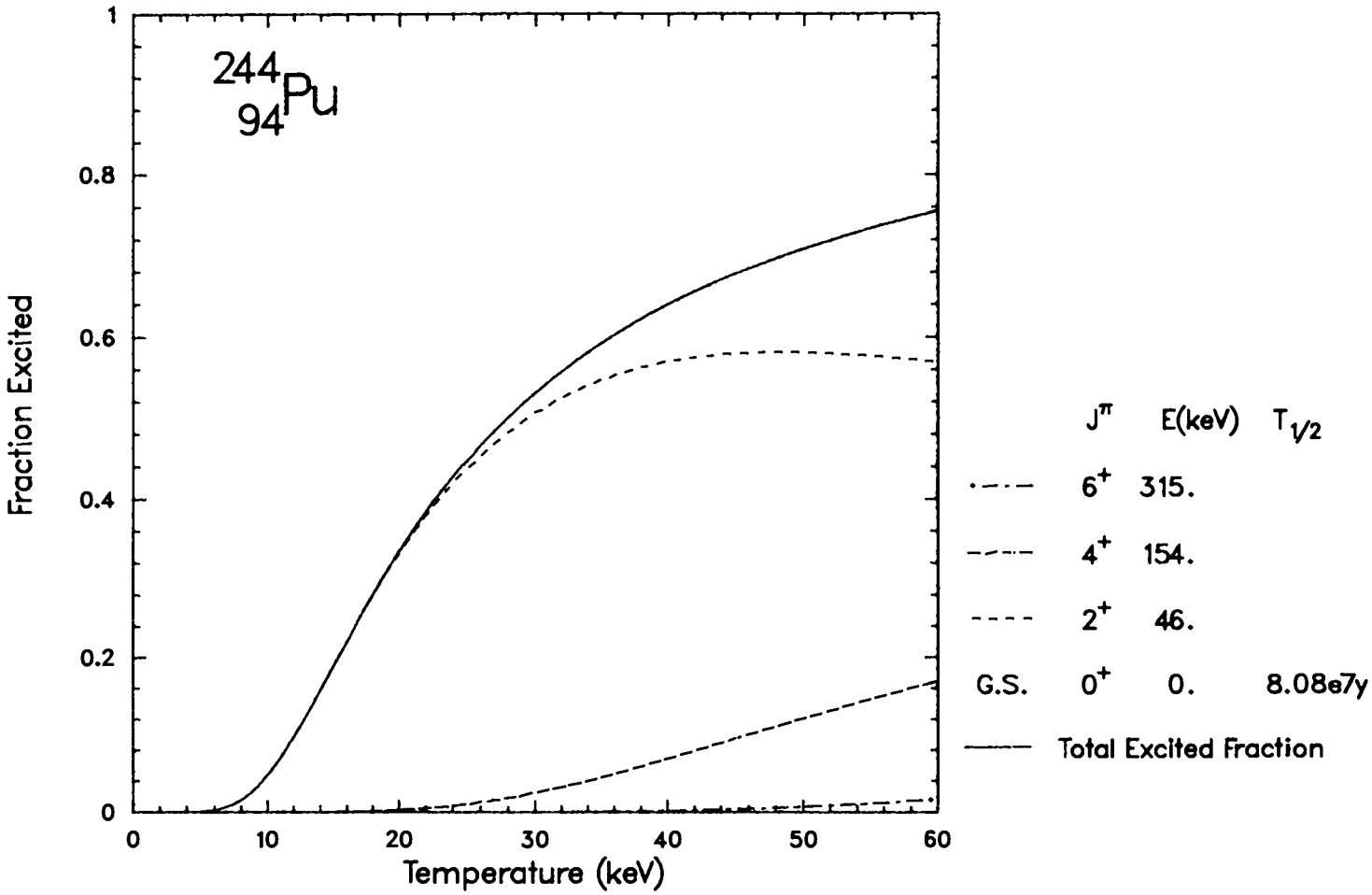

$^{240}_{94}Pu$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2
6+ 294.314
4+ 141.686
2+ 42.825 162ps
G.S. 0+ 0. 6537y
Total Excited Fraction

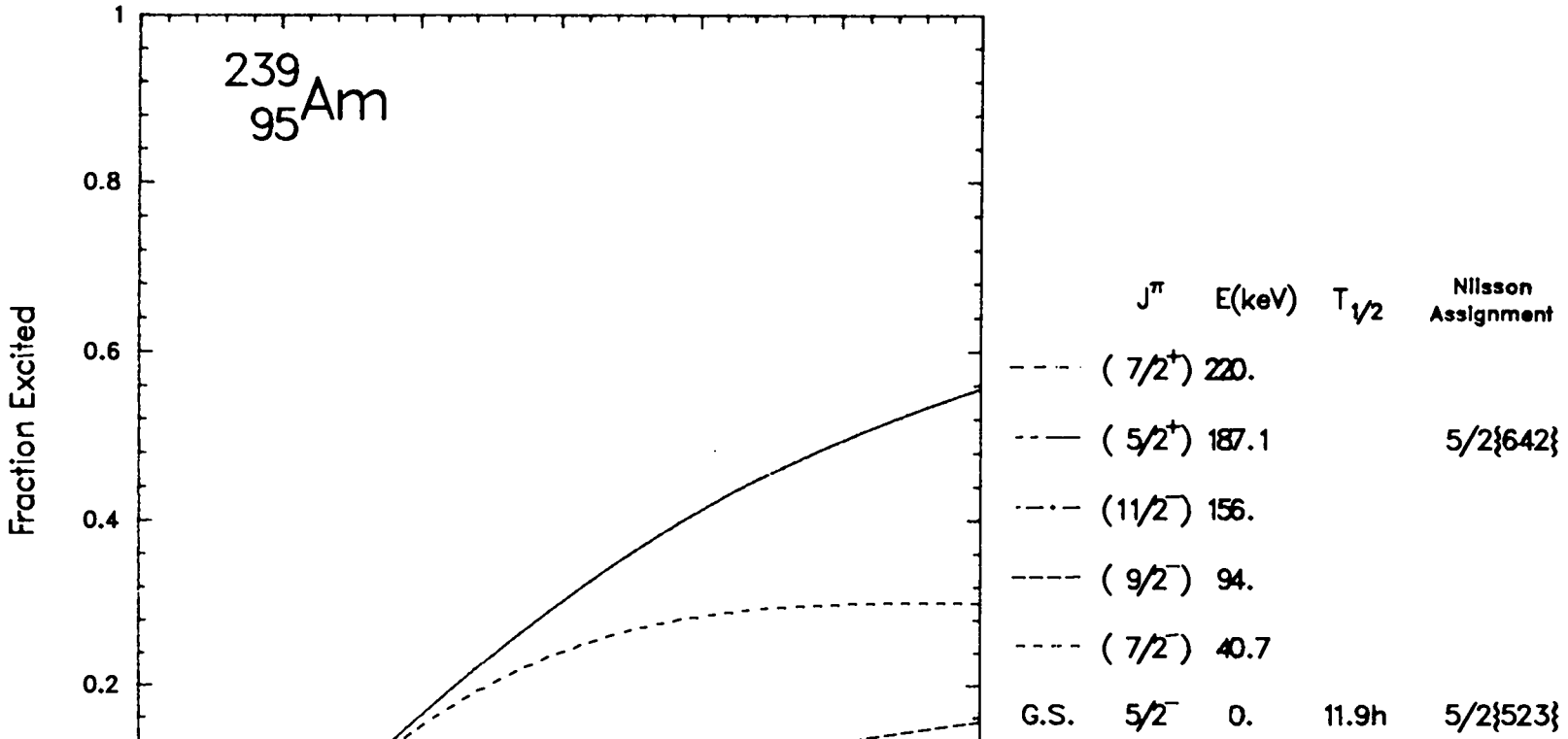


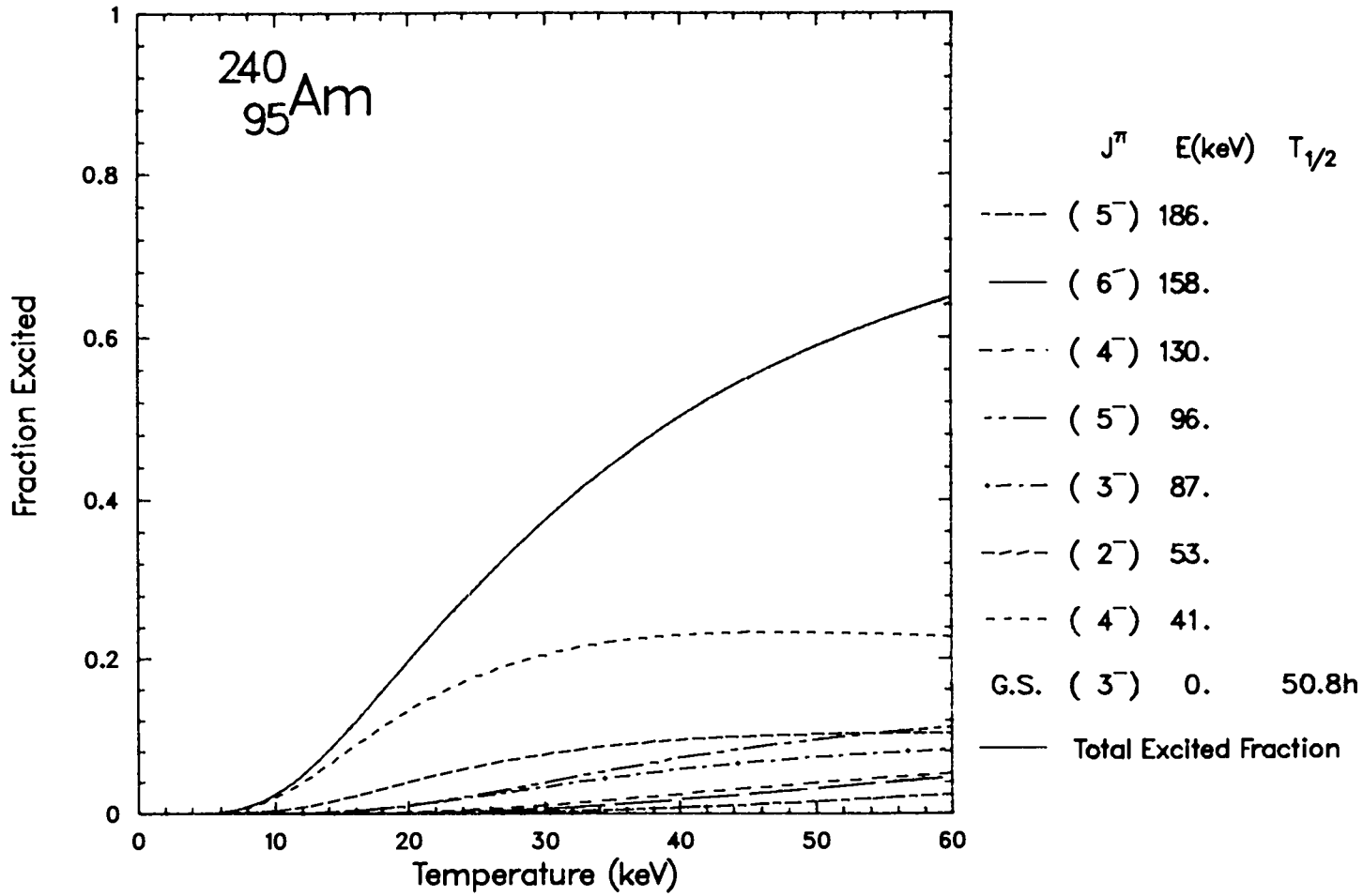
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
——	$7/2^+$	172.		7/2{642}
- - ··	$(3/2^+)$	170.8		
- - —	$(11/2^+)$	162.		
- · - ·	$1/2^+$	161.4	880ns	1/2{631}
- - - -	$9/2^+$	94.4		
- - - -	$7/2^+$	41.8		
G.S.	$5/2^+$	0.	14.4y	5/2{622}
——	Total Excited Fraction			

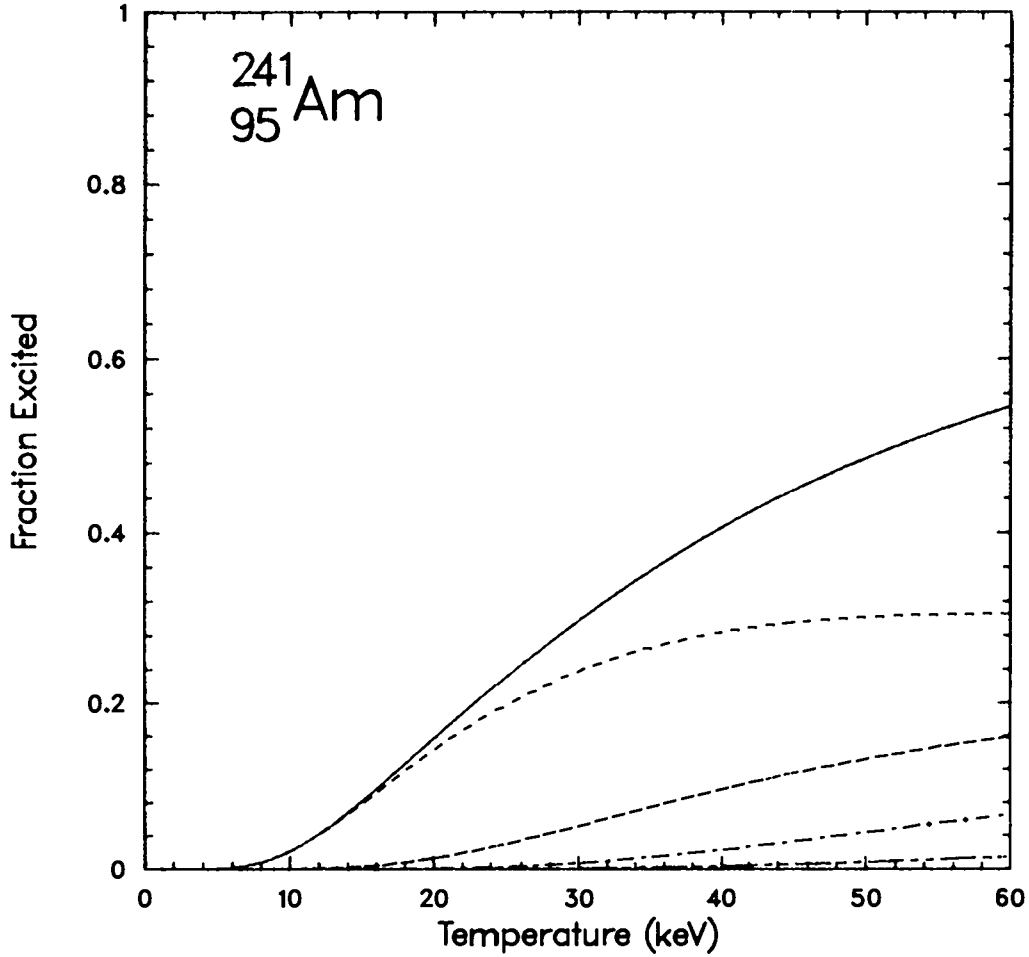

242 94Pu
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) T1/2
6+ 305.9
4+ 147.2
2+ 44.54 158ps
G.S. 0+ 0. 3.76e5y
Total Excited Fraction


$^{243}_{94}Pu$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$ Nilsson Assignment
(13/2+) 204.4
11/2+ 124.4
9/2+ 58.1
G.S. 7/2+ 0. 4.956h 7/2[624]
Total Excited Fraction

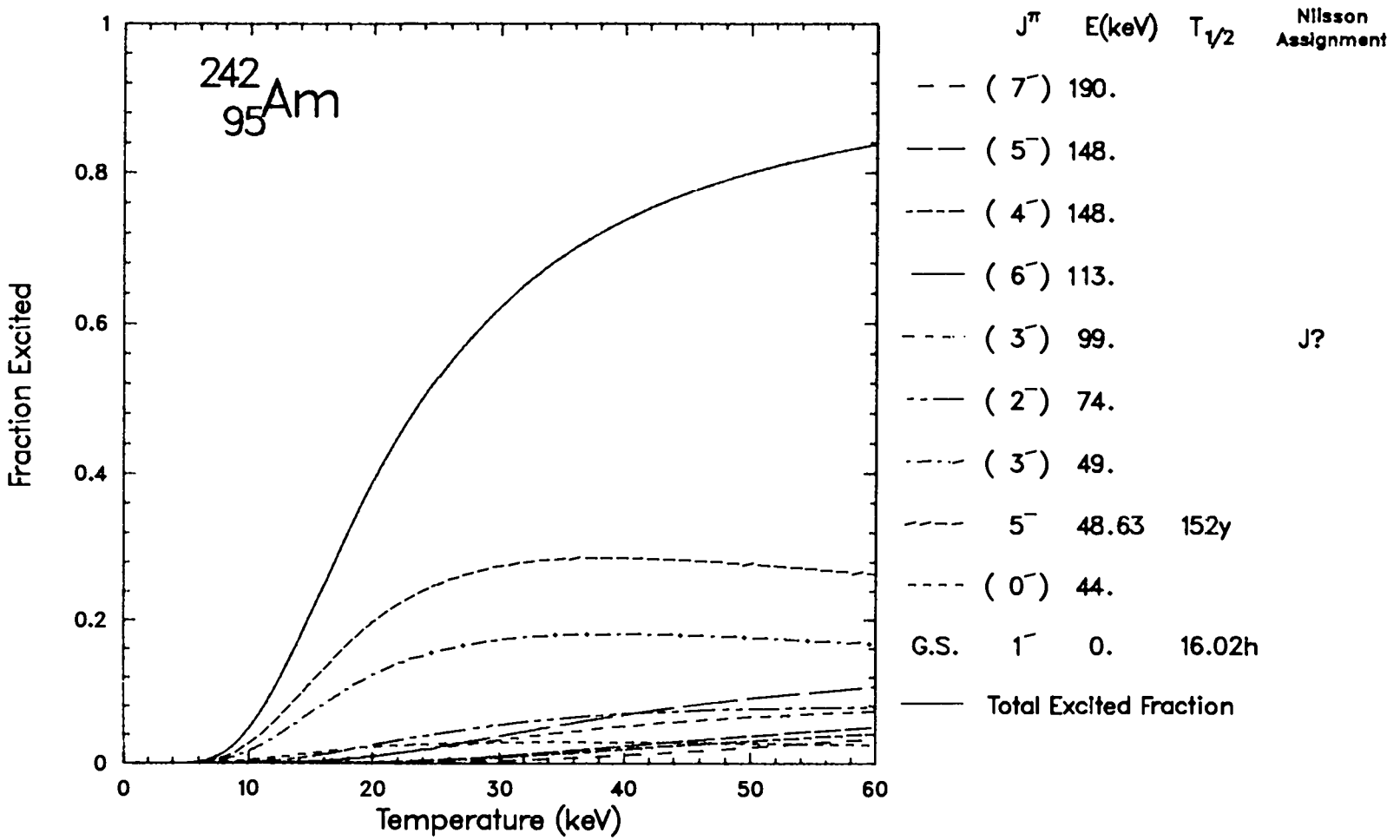

$^{244}_{94}Pu$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$
6^+ 315.
4^+ 154.
2^+ 46.
G.S. 0^+ 0. 8.08e7y
Total Excited Fraction

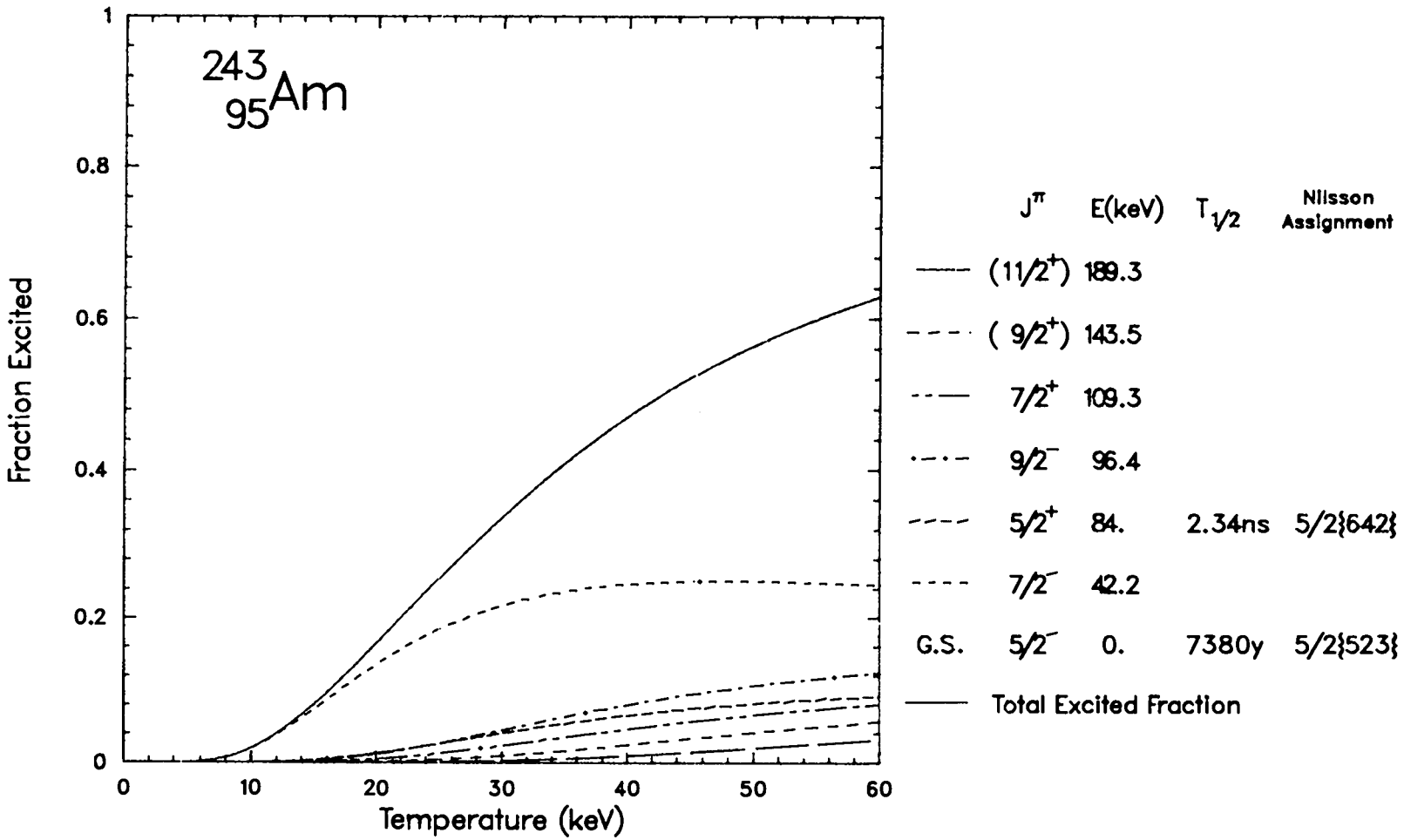

$^{239}_{95}Am$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$ Nilsson Assignment
(7/2+) 220.
(5/2+) 187.1 5/2{642}
(11/2−) 156.
(9/2−) 94.
(7/2−) 40.7
G.S. 5/2− 0. 11.9h 5/2{523}
Total Excited Fraction

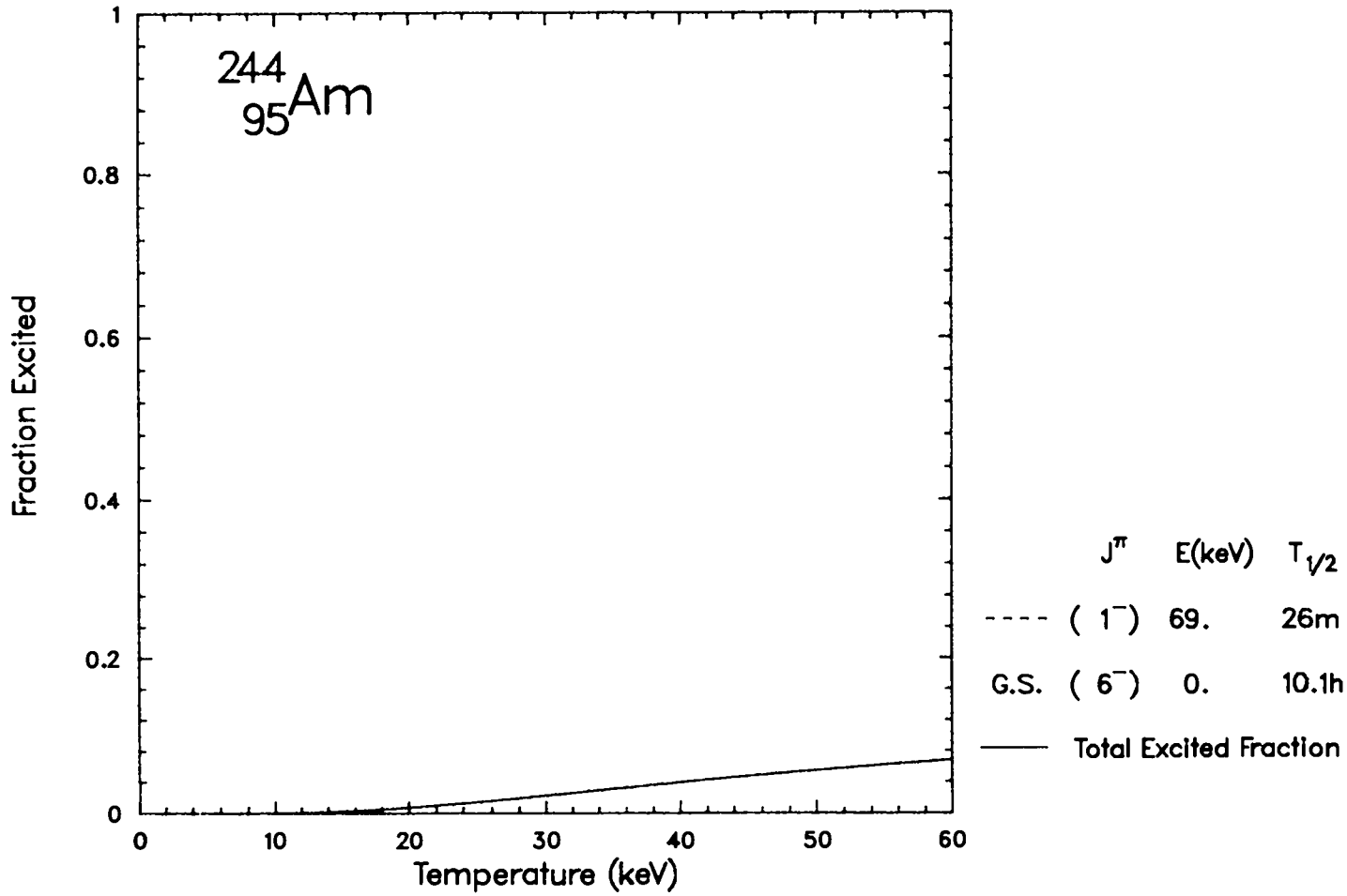

240 95Am
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2
(5⁻) 186.
(6⁻) 158.
(4⁻) 130.
(5⁻) 96.
(3⁻) 87.
(2⁻) 53.
(4⁻) 41.
G.S. (3⁻) 0. 50.8h
Total Excited Fraction

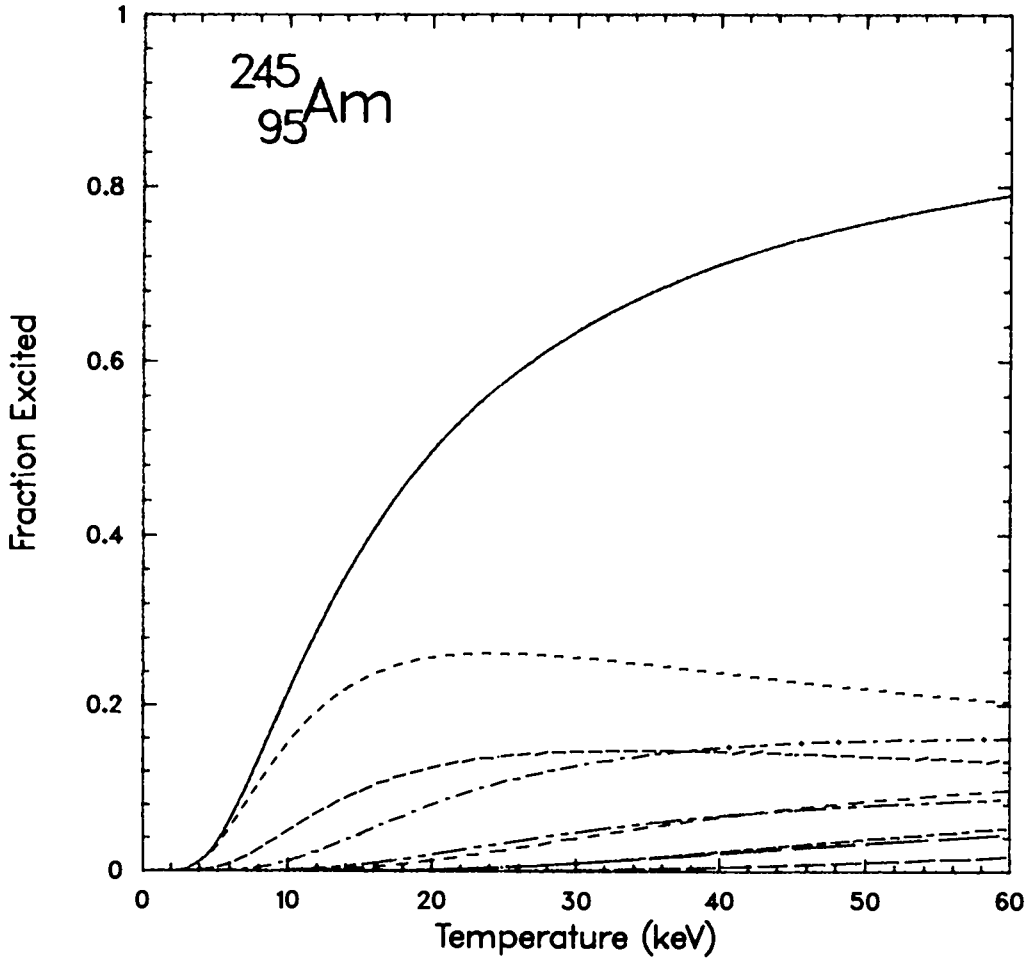


	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
- - —	$5/2^{+}$	205.883		5/2{642
-·-·-	$11/2^{-}$	158.		
-·-·-·	$9/2^{-}$	93.65		
- - - -	$7/2^{-}$	41.176		
G.S.	$5/2^{-}$	0.	432.2y	5/2{523}
——	Total Excited Fraction			

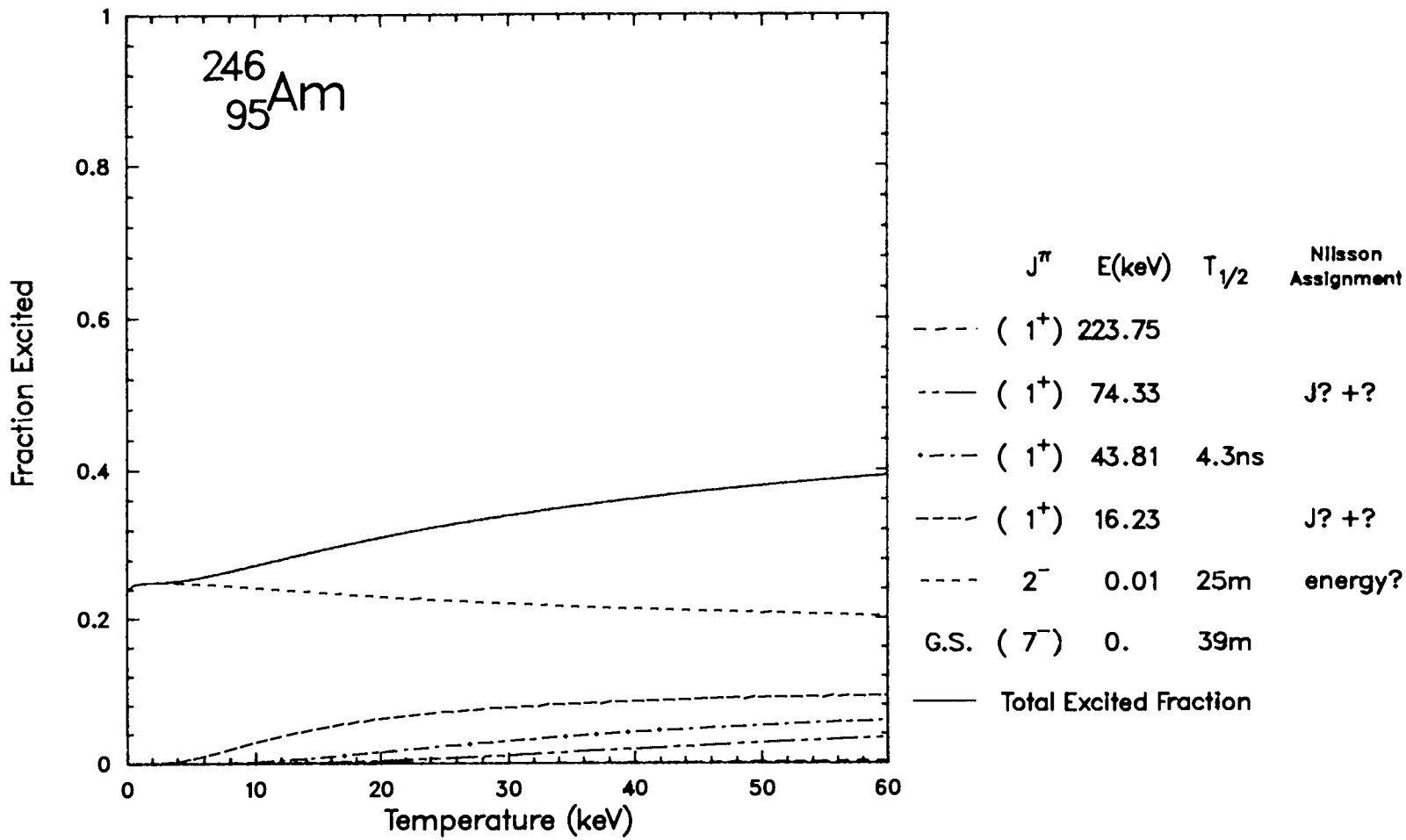

242 95Am
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
(7⁻) 190.
(5⁻) 148.
(4⁻) 148.
(6⁻) 113.
(3⁻) 99. J?
(2⁻) 74.
(3⁻) 49.
5⁻ 48.63 152y
(0⁻) 44.
G.S. 1⁻ 0. 16.02h
Total Excited Fraction

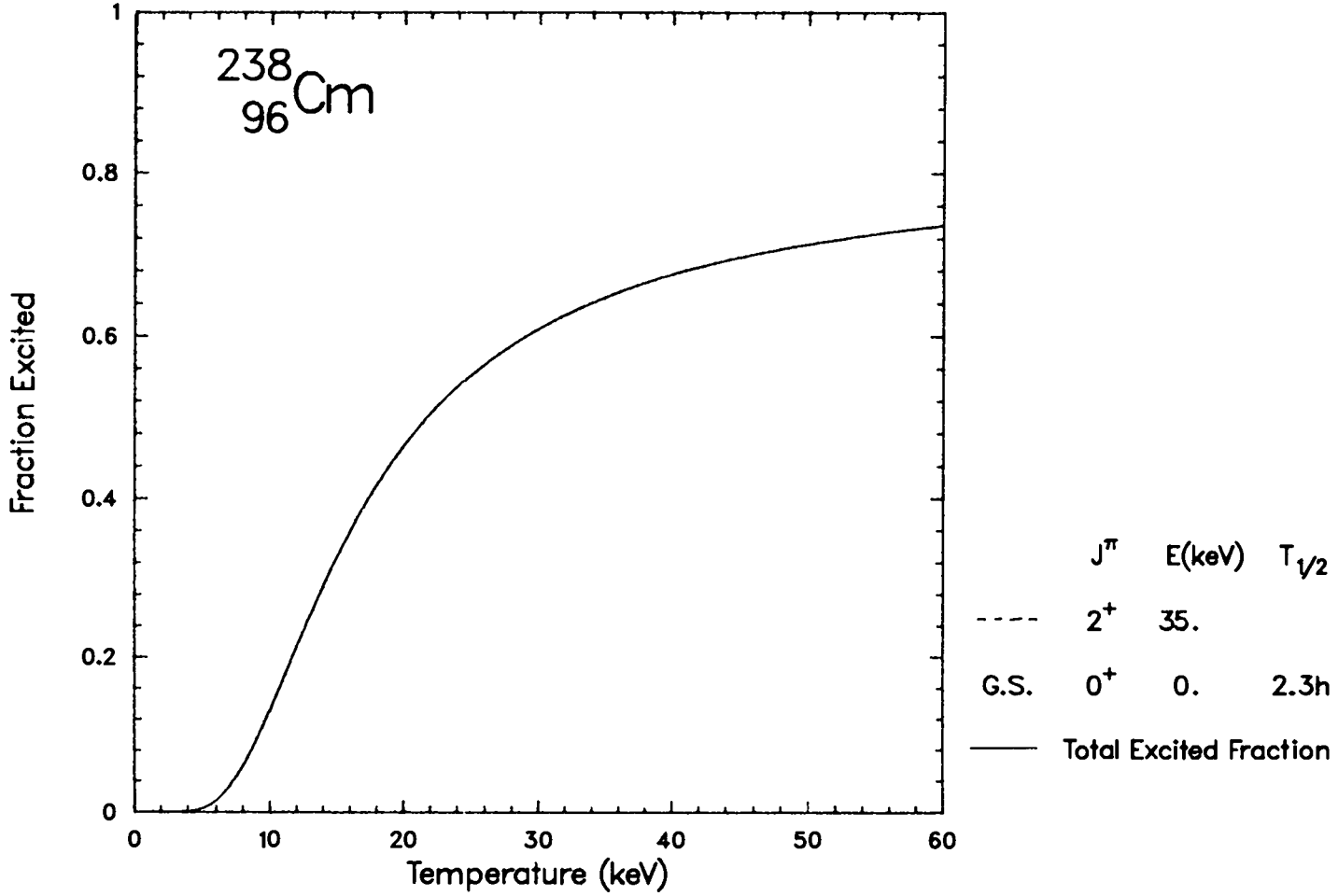

$^{243}_{95}$Am
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J$^{\pi}$ E(keV) T$_{1/2}$ Nilsson Assignment
(11/2$^+$) 189.3
(9/2$^+$) 143.5
7/2$^+$ 109.3
9/2$^-$ 96.4
5/2$^+$ 84. 2.34ns 5/2{642}
7/2$^-$ 42.2
G.S. 5/2$^-$ 0. 7380y 5/2{523}
Total Excited Fraction

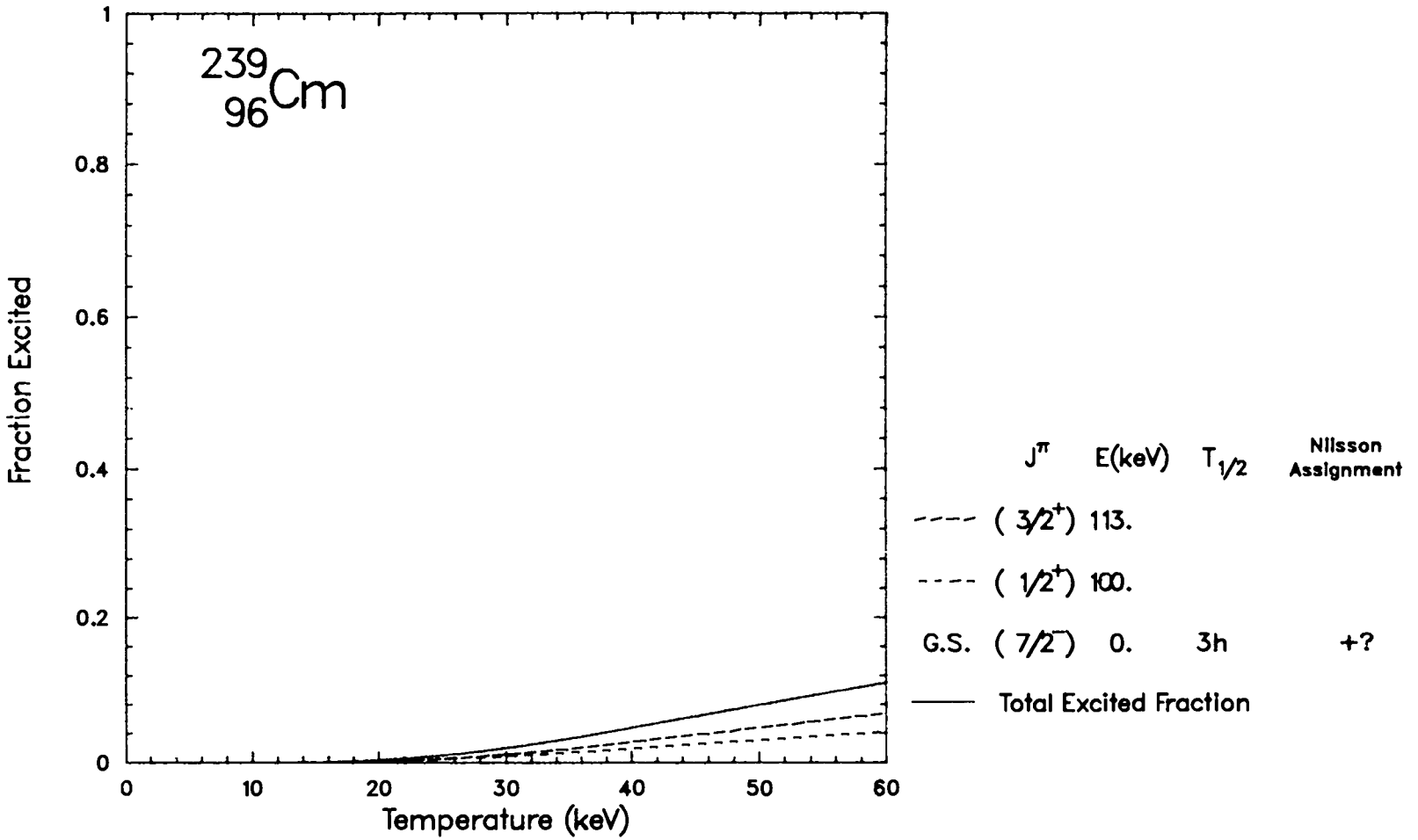

$^{244}_{95}Am$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$
---- (1^-) 69. 26m
G.S. (6^-) 0. 10.1h
Total Excited Fraction

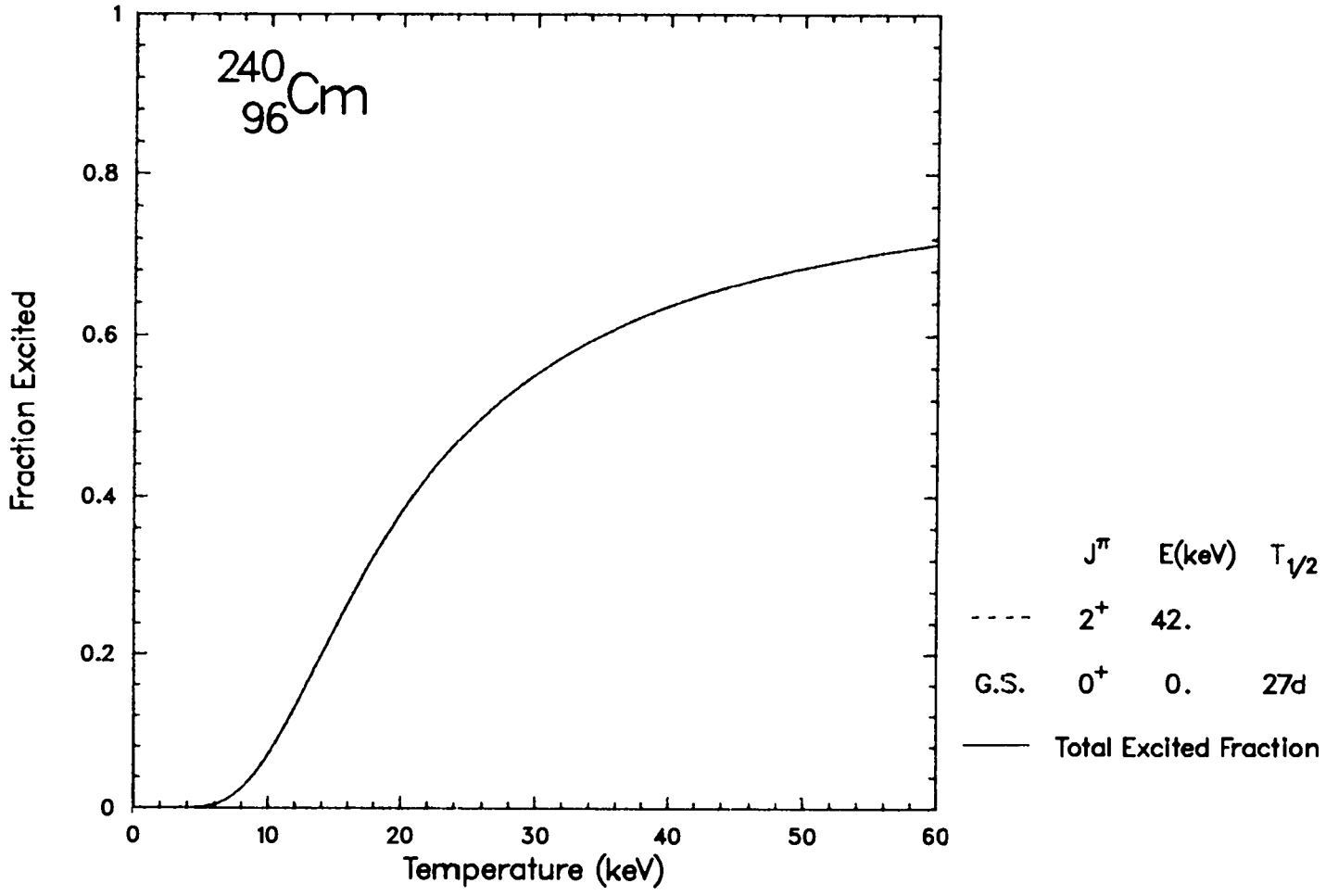


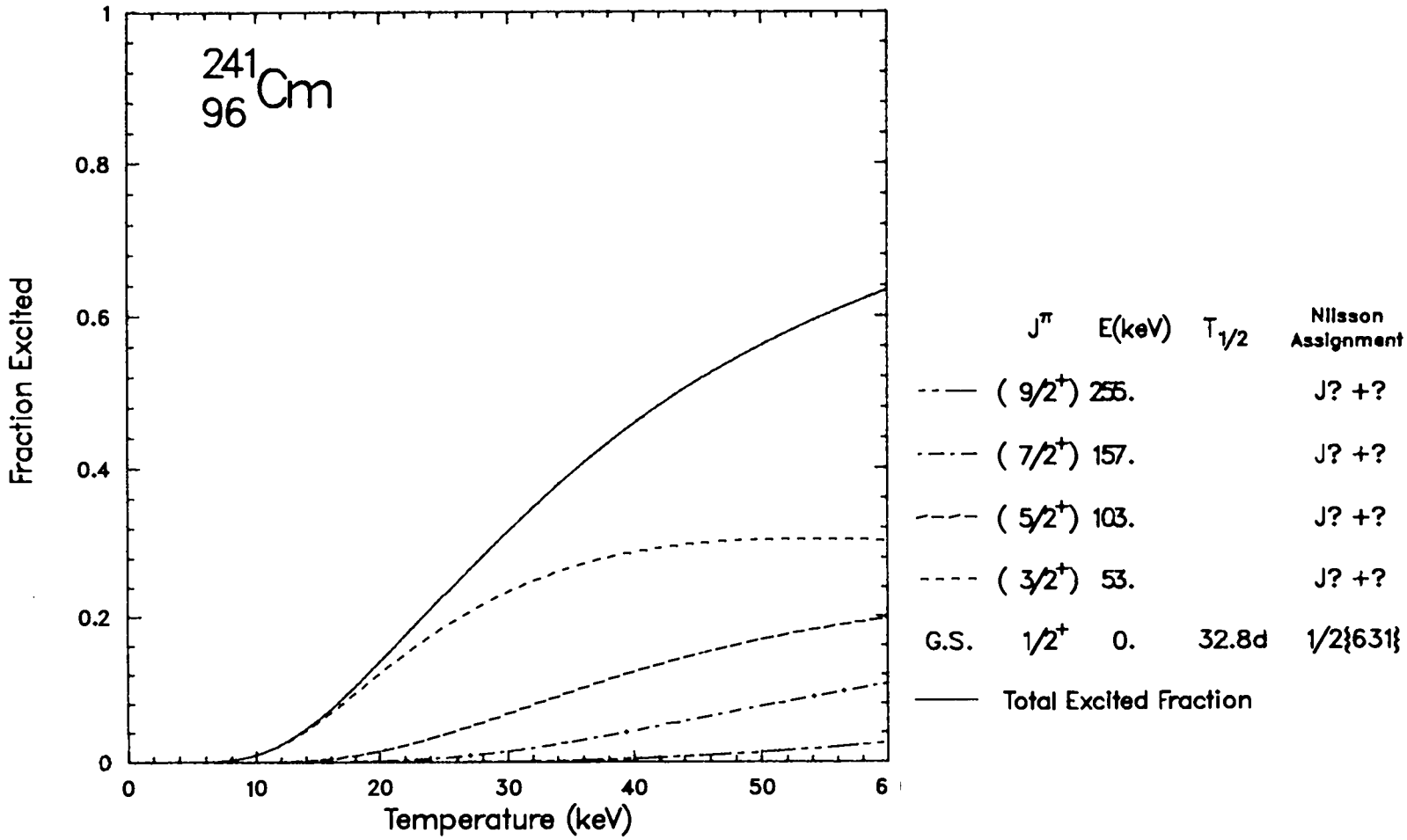
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
----	$(11/2^-)$	190.82		
----	$(13/2^+)$	134.51		
——	$(9/2^-)$	124.59		
- - -	$(11/2^+)$	87.65		
----	$(7/2^-)$	70.43		
-·-·	$(9/2^+)$	47.07		
----	$(5/2^-)$	27.93		5/2{523}
----	$(7/2^+)$	19.20		
G.S.	$(5/2^+)$	0.	2.05h	5/2{642}
——	Total Excited Fraction			

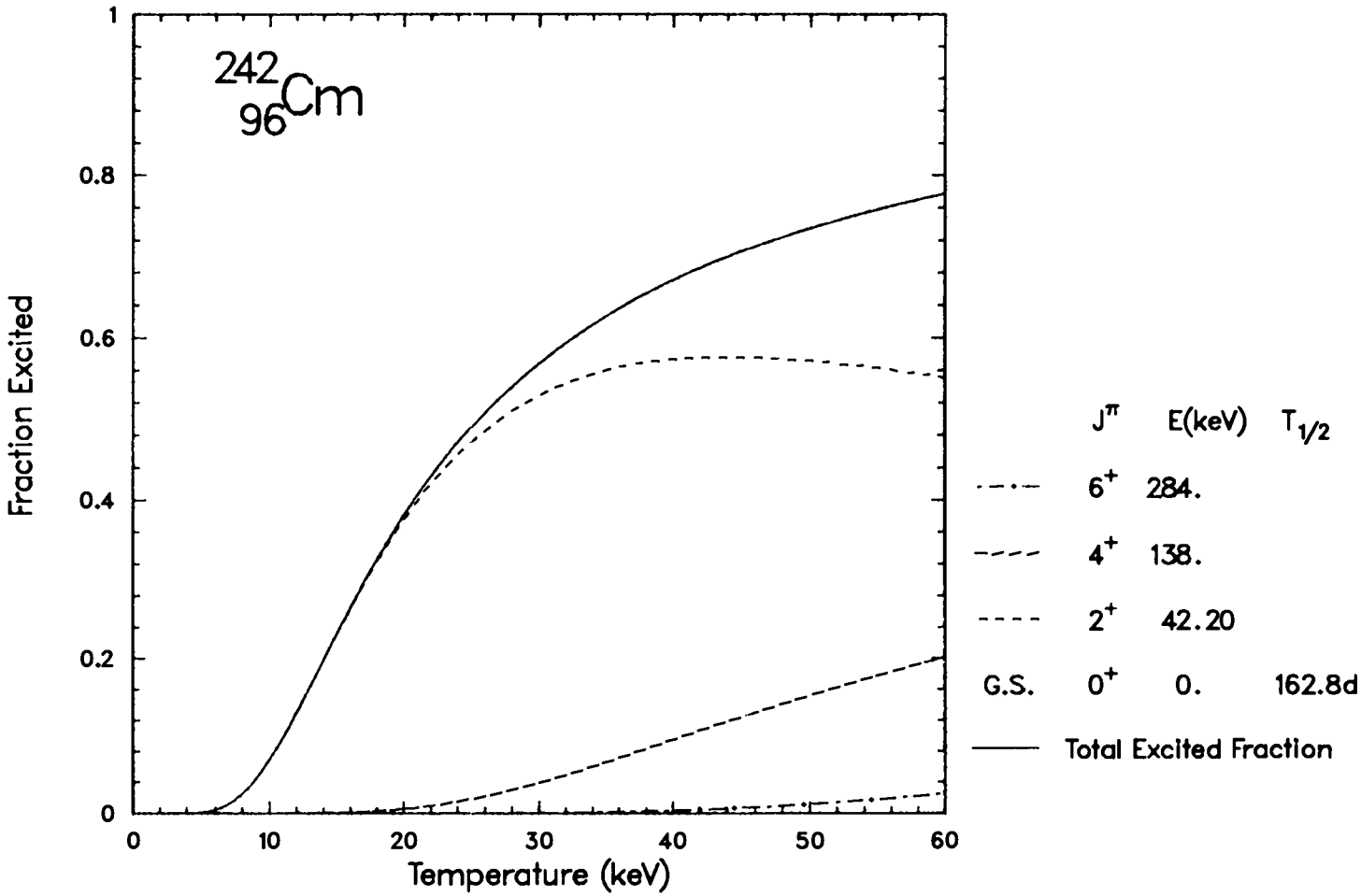

246 95Am
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
(1+) 223.75
(1+) 74.33 J? +?
(1+) 43.81 4.3ns
(1+) 16.23 J? +?
2− 0.01 25m energy?
G.S. (7−) 0. 39m
Total Excited Fraction

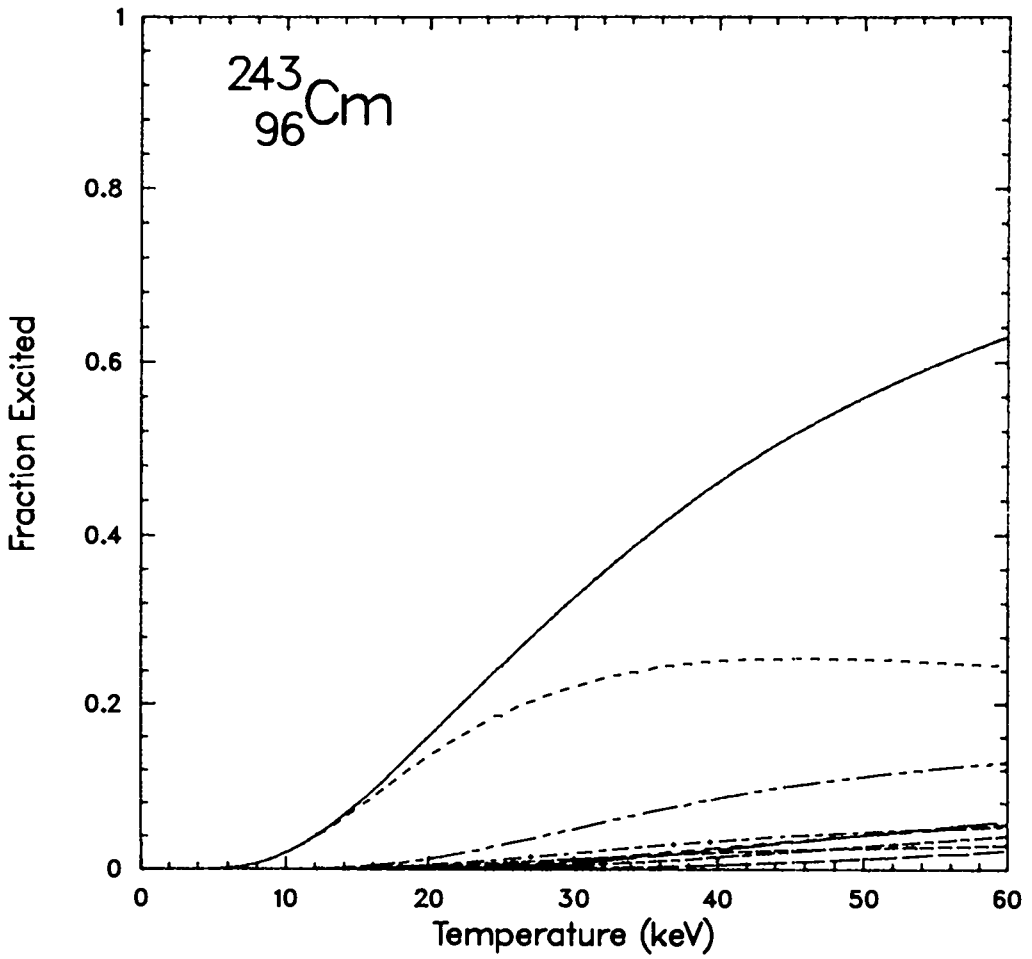

238 96 Cm
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) T1/2
2+ 35.
G.S. 0+ 0. 2.3h
Total Excited Fraction


239 96 Cm
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) T1/2 Nilsson Assignment
(3/2+) 113.
(1/2+) 100.
G.S. (7/2−) 0. 3h +?
Total Excited Fraction

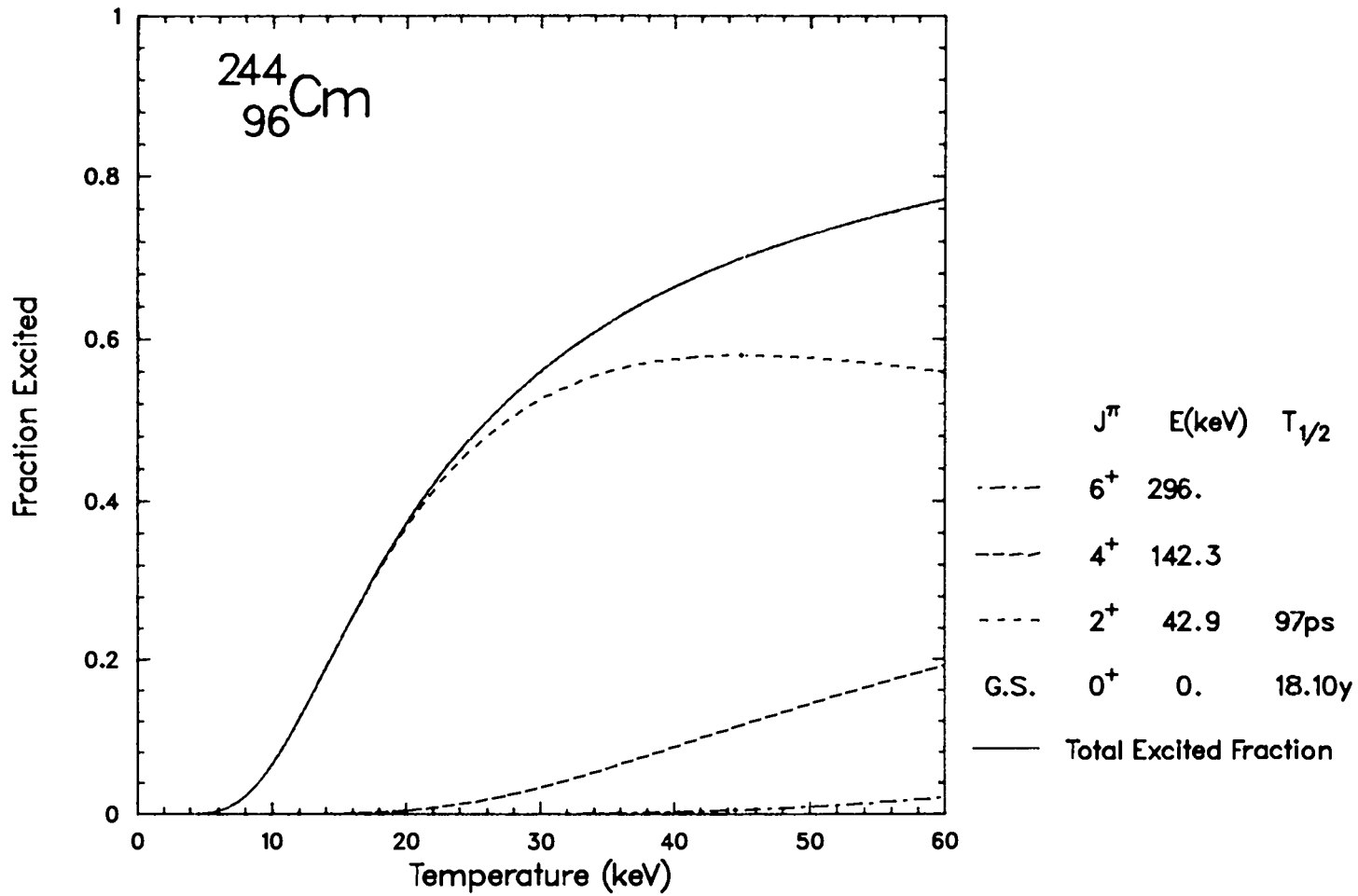

$^{240}_{96}Cm$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$
2^+ 42.
G.S. 0^+ 0. 27d
Total Excited Fraction

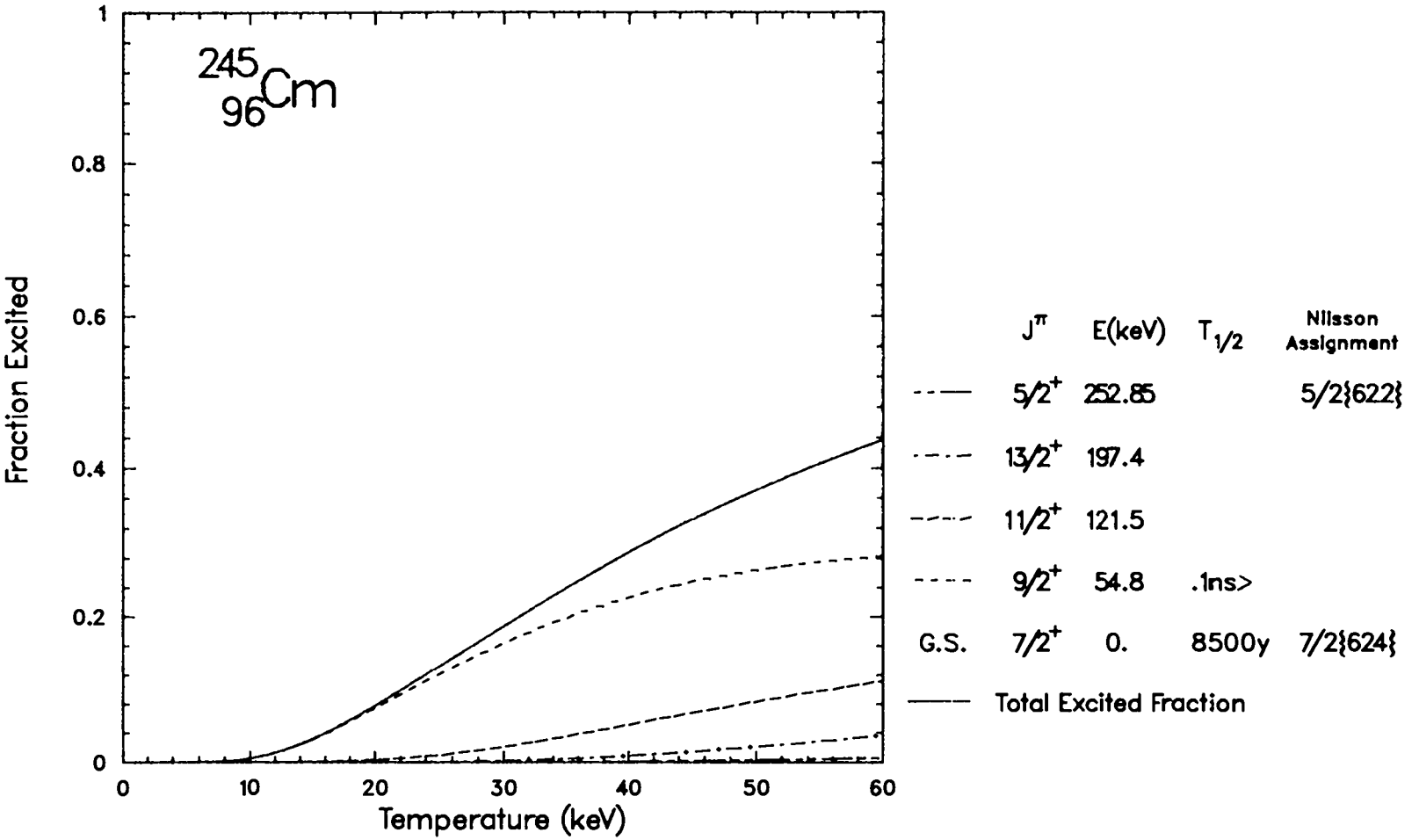

241 96 Cm
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
6
Jπ E(keV) T1/2 Nilsson Assignment
(9/2+) 255. J? +?
(7/2+) 157. J? +?
(5/2+) 103. J? +?
(3/2+) 53. J? +?
G.S. 1/2+ 0. 32.8d 1/2{631}
Total Excited Fraction

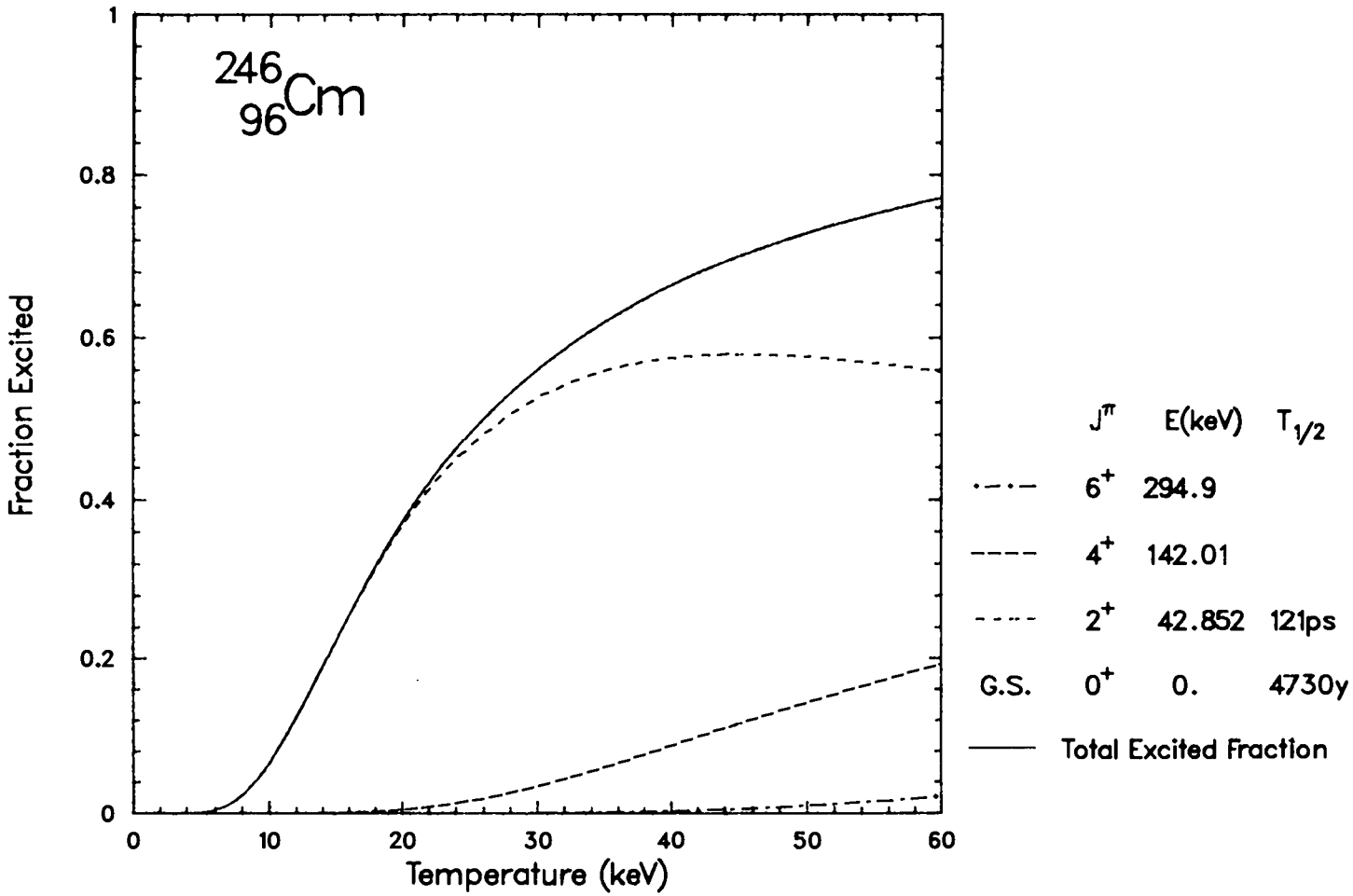

$^{242}_{96}Cm$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J$^{\pi}$ E(keV) T$_{1/2}$
6^{+} 284.
4^{+} 138.
2^{+} 42.20
G.S. 0^{+} 0. 162.8d
Total Excited Fraction

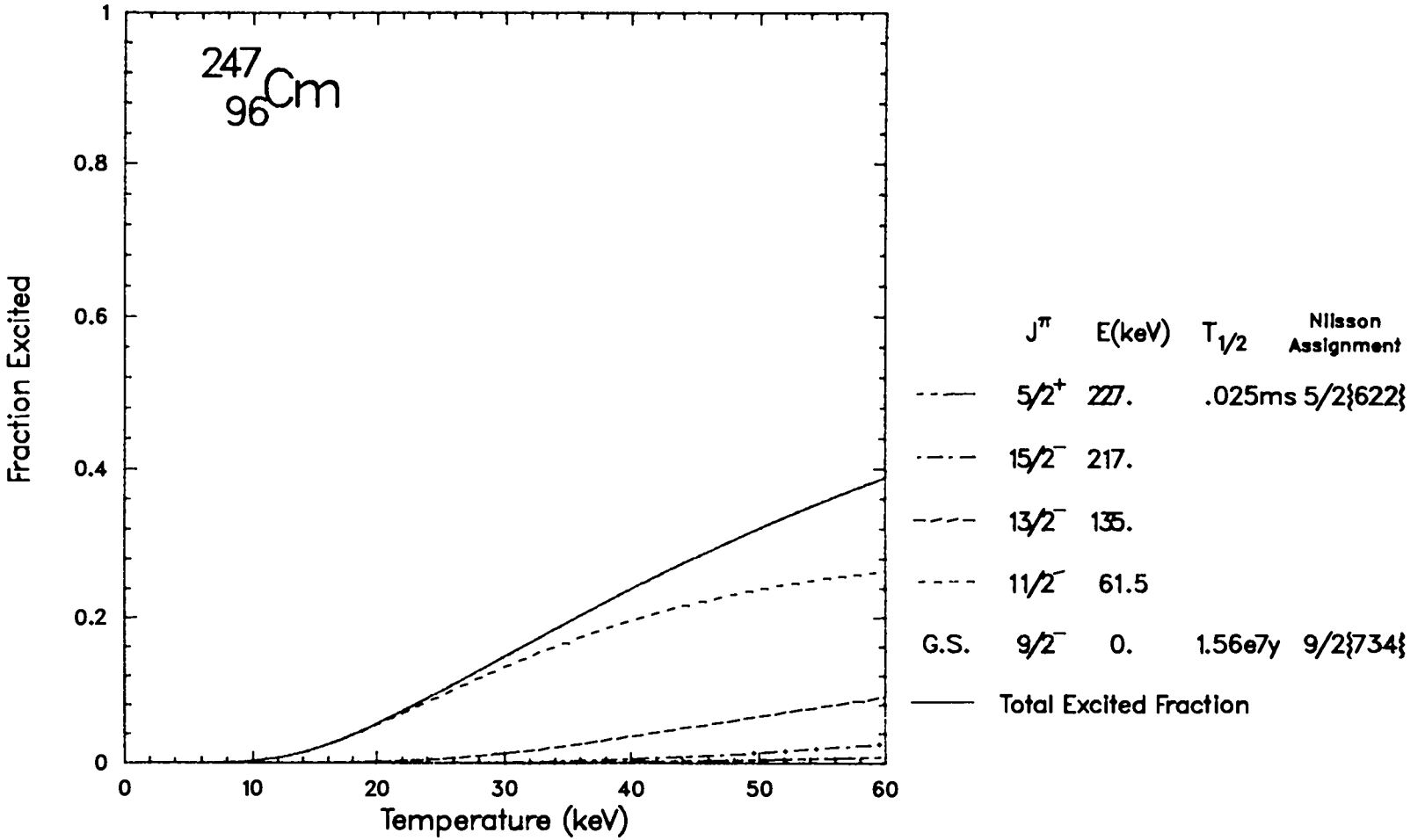


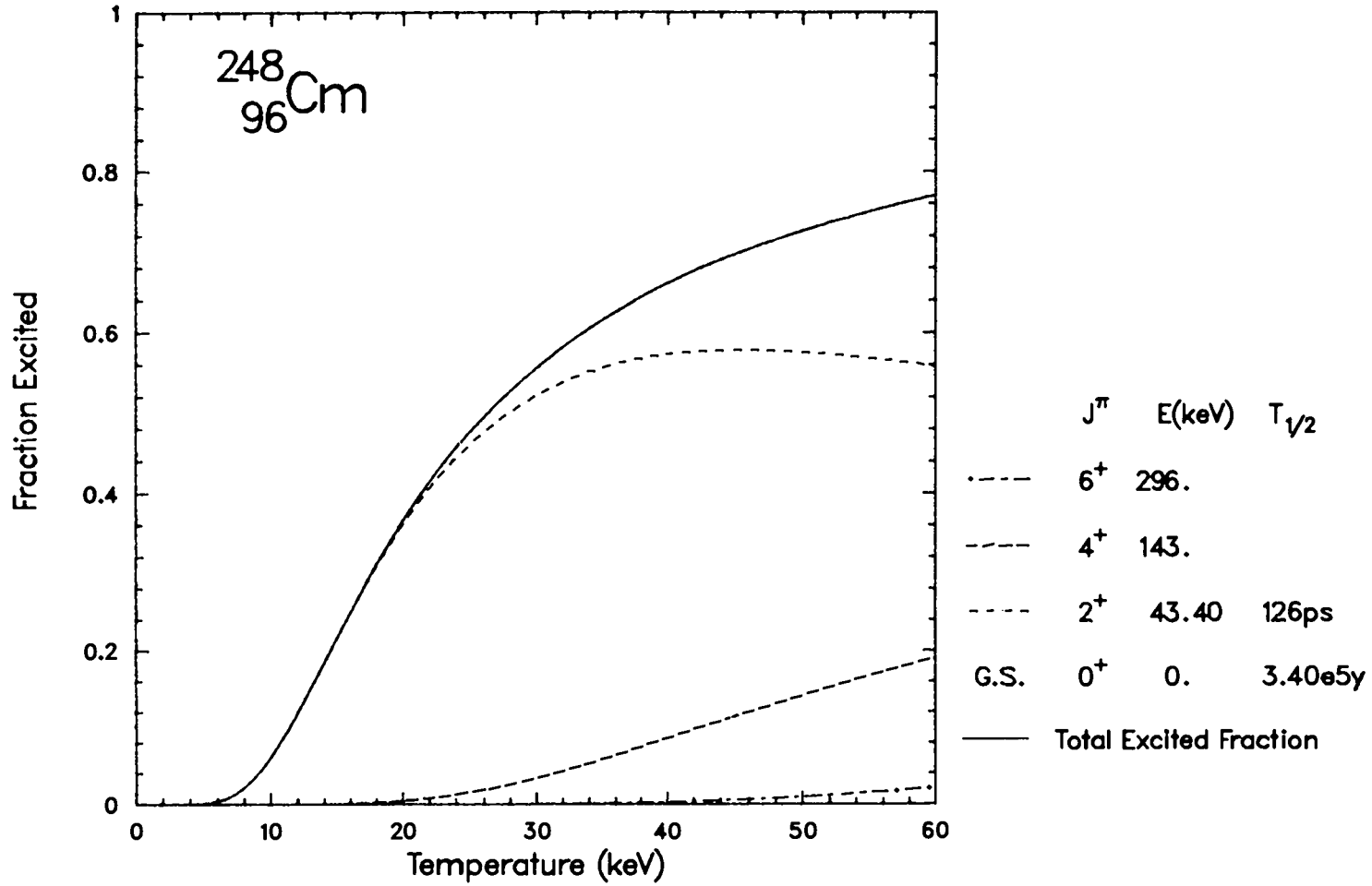
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
——	$(13/2^+)$	219.		J? +?
-----	$(9/2^+)$	164.		J? +?
——	$(11/2^+)$	153.		J? +?
- - - -	$(7/2^+)$	133.		J? +?
--—	$9/2^+$	94.		
-·-·	$(3/2^+)$	94.		
----	$1/2^+$	87.4	1080ns	1/2{631}
----	$7/2^+$	42.		
G.S.	$5/2^+$	0.	28.5y	5/2{622}
——	Total Excited Fraction			

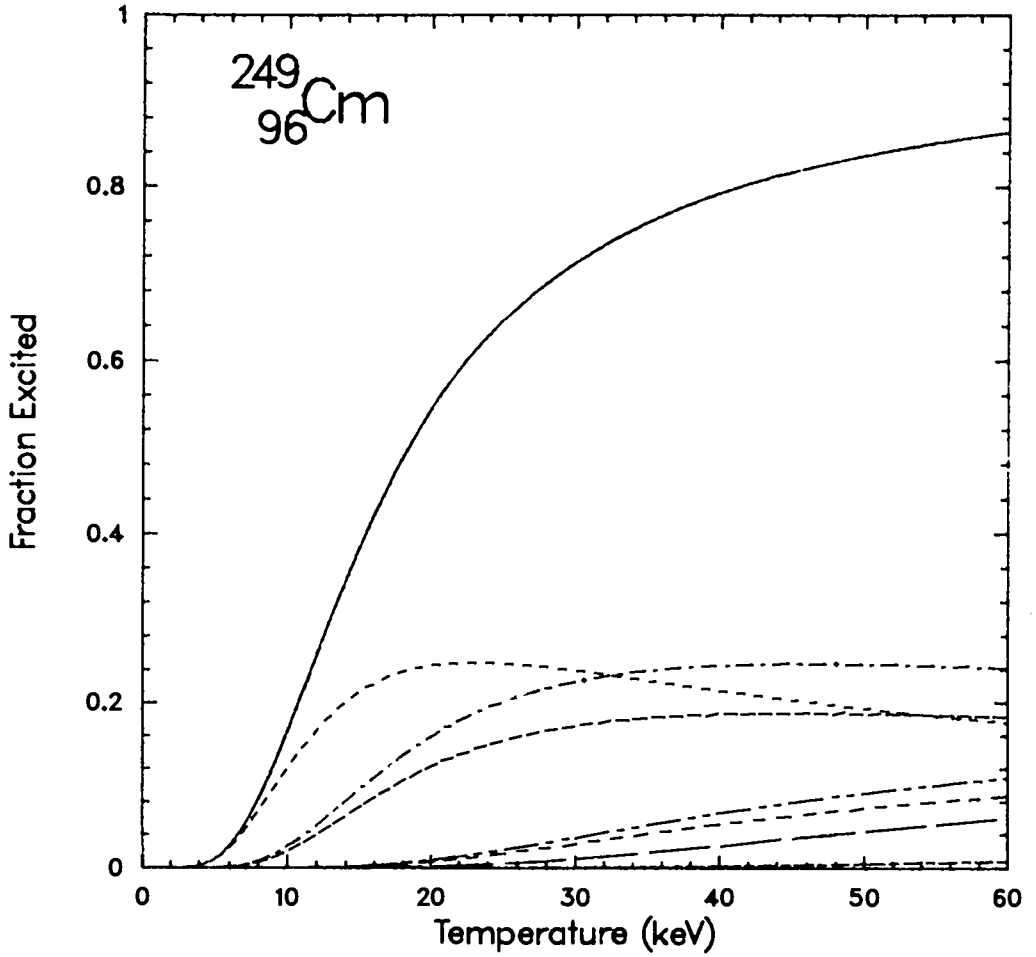

$^{244}_{96}Cm$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) $T_{1/2}$
6^+ 296.
4^+ 142.3
2^+ 42.9 97ps
G.S. 0^+ 0. 18.10y
Total Excited Fraction


$^{245}_{96}Cm$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J$^{\pi}$ E(keV) $T_{1/2}$ Nilsson Assignment
5/2^{+} 252.85 5/2{622}
13/2^{+} 197.4
11/2^{+} 121.5
9/2^{+} 54.8 .1ns>
G.S. 7/2^{+} 0. 8500y 7/2{624}
Total Excited Fraction

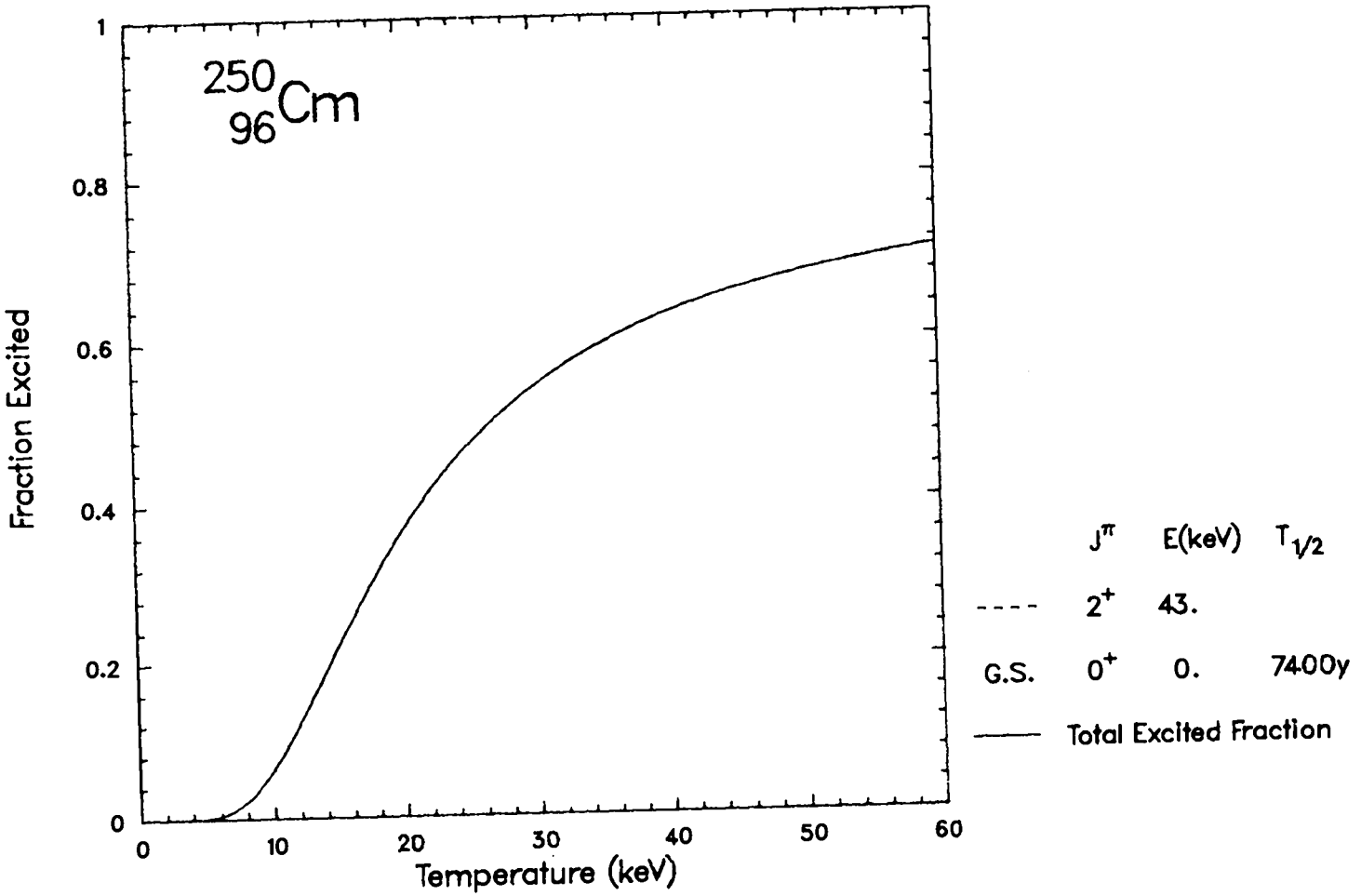

246 96Cm
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) T1/2
6+ 294.9
4+ 142.01
2+ 42.852 121ps
G.S. 0+ 0. 4730y
Total Excited Fraction

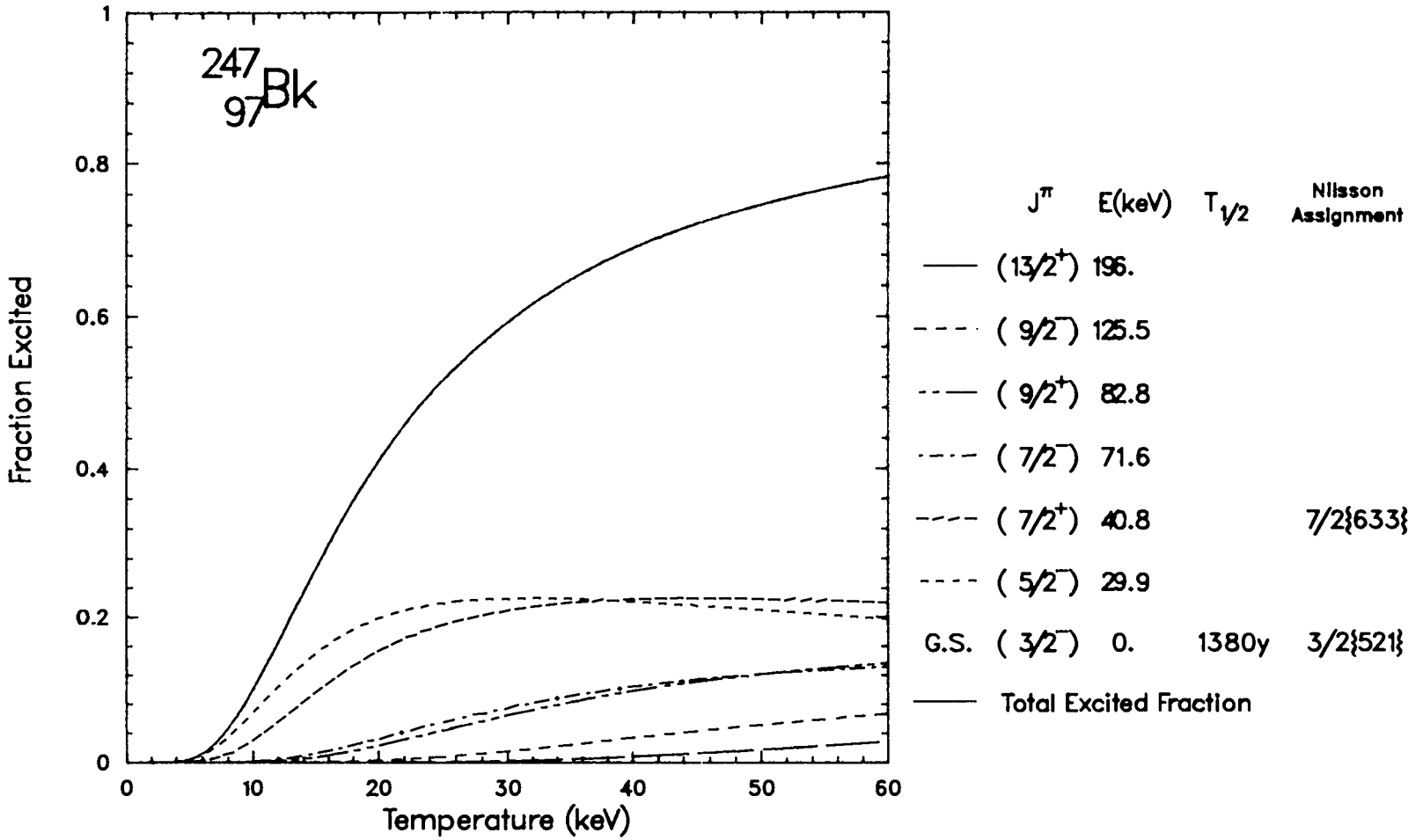

$^{247}_{96}Cm$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$ Nilsson Assignment
$5/2^{+}$ 227. .025ms 5/2{622}
$15/2^{-}$ 217.
$13/2^{-}$ 135.
$11/2^{-}$ 61.5
G.S. $9/2^{-}$ 0. 1.56e7y 9/2{734}
Total Excited Fraction

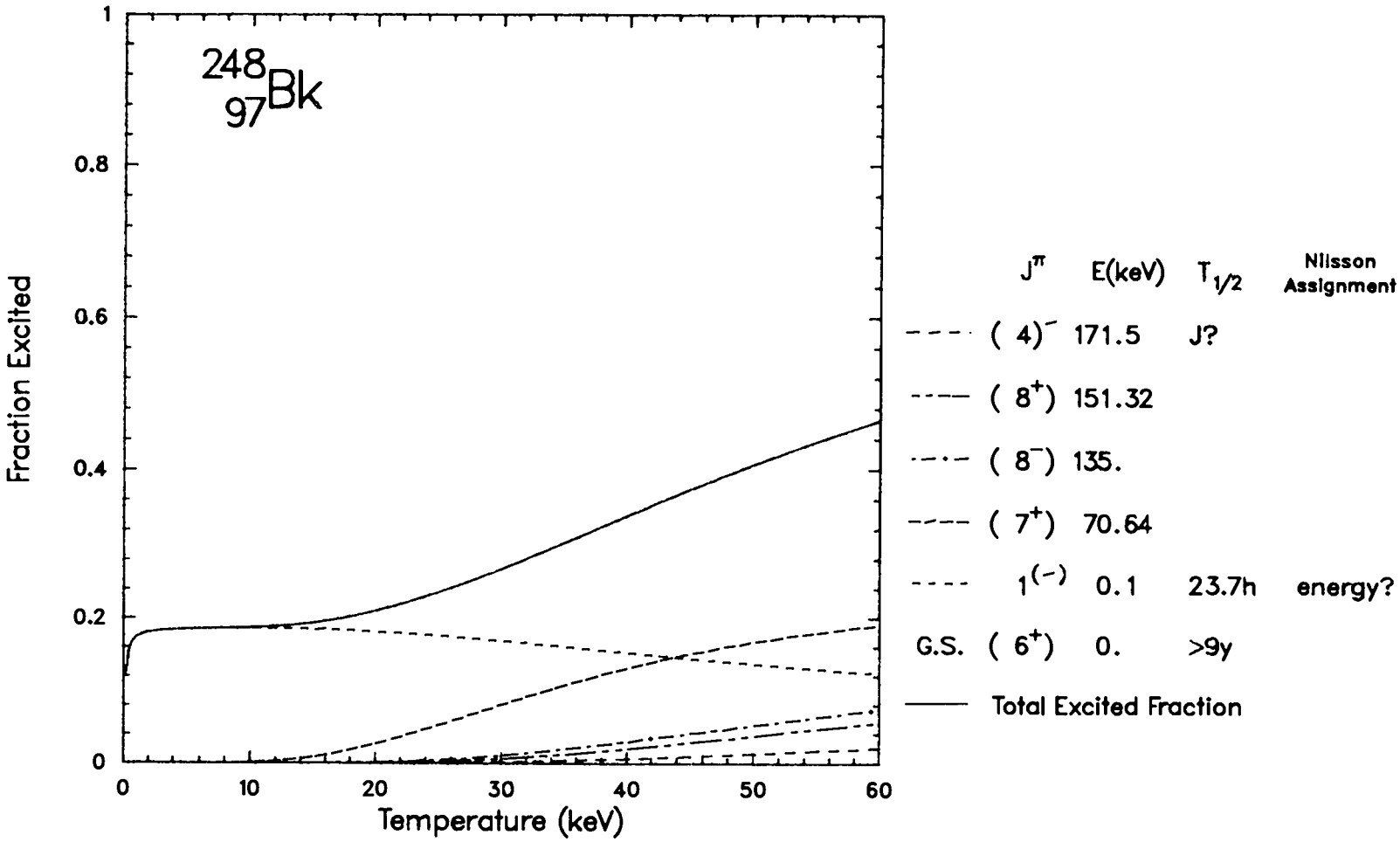

$^{248}_{96}Cm$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J$^{\pi}$ E(keV) T$_{1/2}$
6^{+} 296.
4^{+} 143.
2^{+} 43.40 126ps
G.S. 0^{+} 0. 3.40e5y
Total Excited Fraction

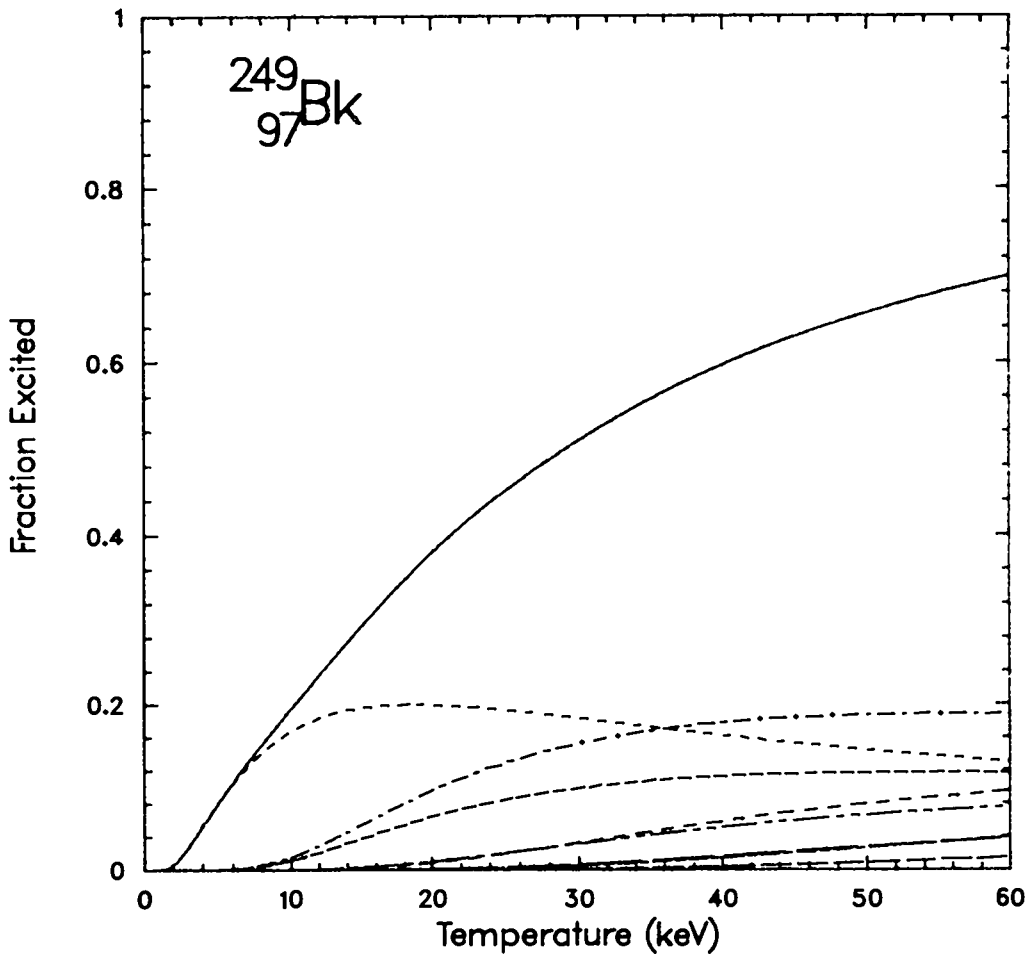


	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
-----	($3/2^+$)	207.995		3/2{622}
——	($9/2^+$)	146.		
- - - -	($7/2^+$)	110.17		
--—	($9/2^+$)	110.		
-·-·	($7/2^+$)	48.743		7/2{613}
----	$5/2^+$	48.203		
----	$3/2^+$	26.234	.023ms	
G.S.	$1/2^+$	0.	64.15m	1/2{620}
——	Total Excited Fraction			

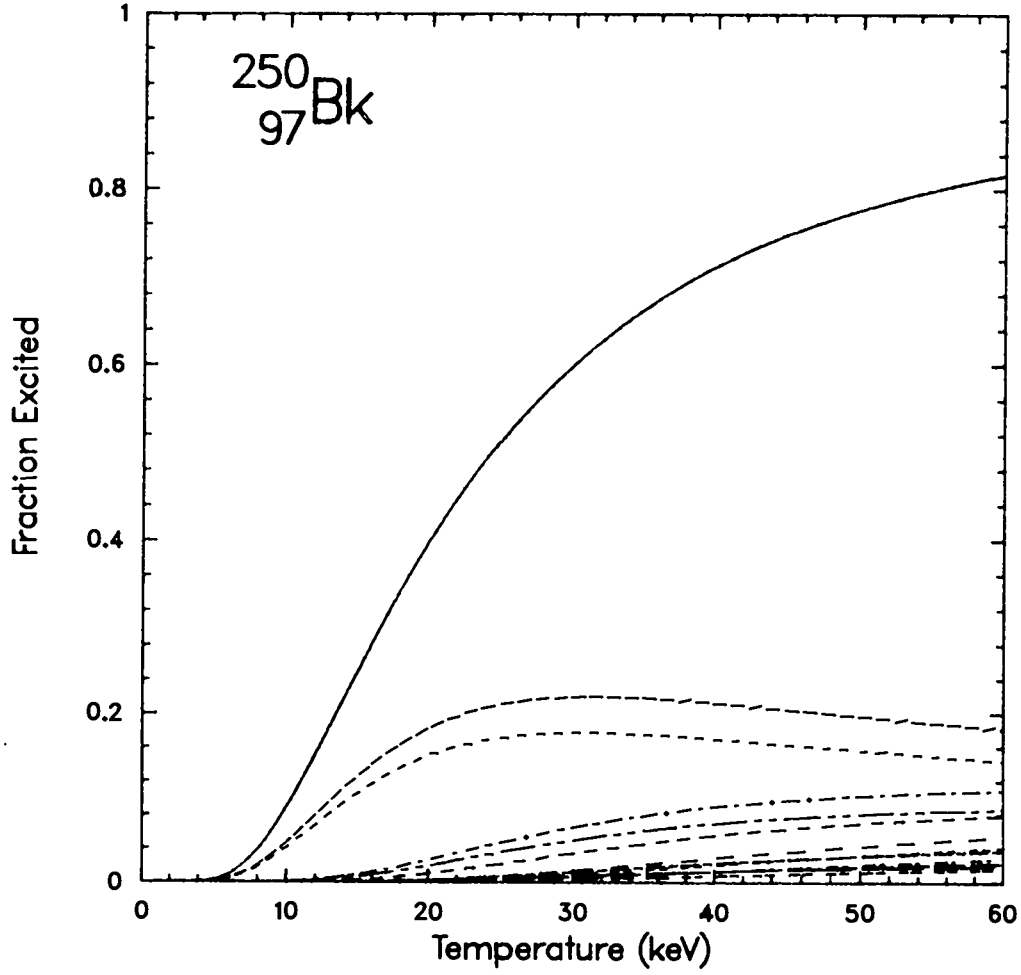

250 96 Cm
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) T1/2
2+ 43.
G.S. 0+ 0. 7400y
Total Excited Fraction


247 97Bk
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
(13/2+) 196.
(9/2−) 125.5
(9/2+) 82.8
(7/2−) 71.6
(7/2+) 40.8 7/2{633}
(5/2−) 29.9
G.S. (3/2−) 0. 1380y 3/2{521}
Total Excited Fraction

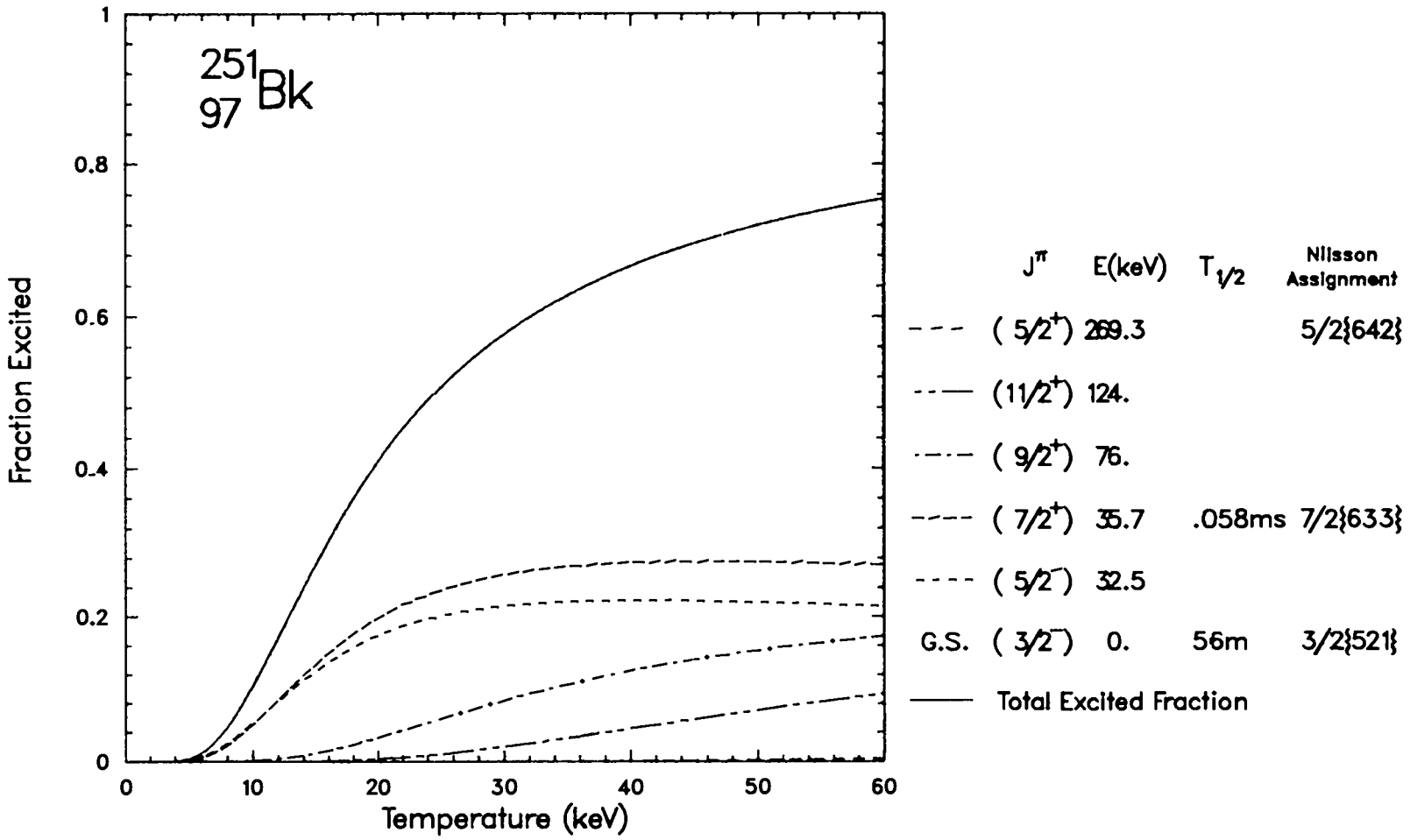

$^{248}_{97}$Bk
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$ Nilsson Assignment
(4)$^-$ 171.5 J?
(8$^+$) 151.32
(8$^-$) 135.
(7$^+$) 70.64
1$^{(-)}$ 0.1 23.7h energy?
G.S. (6$^+$) 0. >9y
Total Excited Fraction

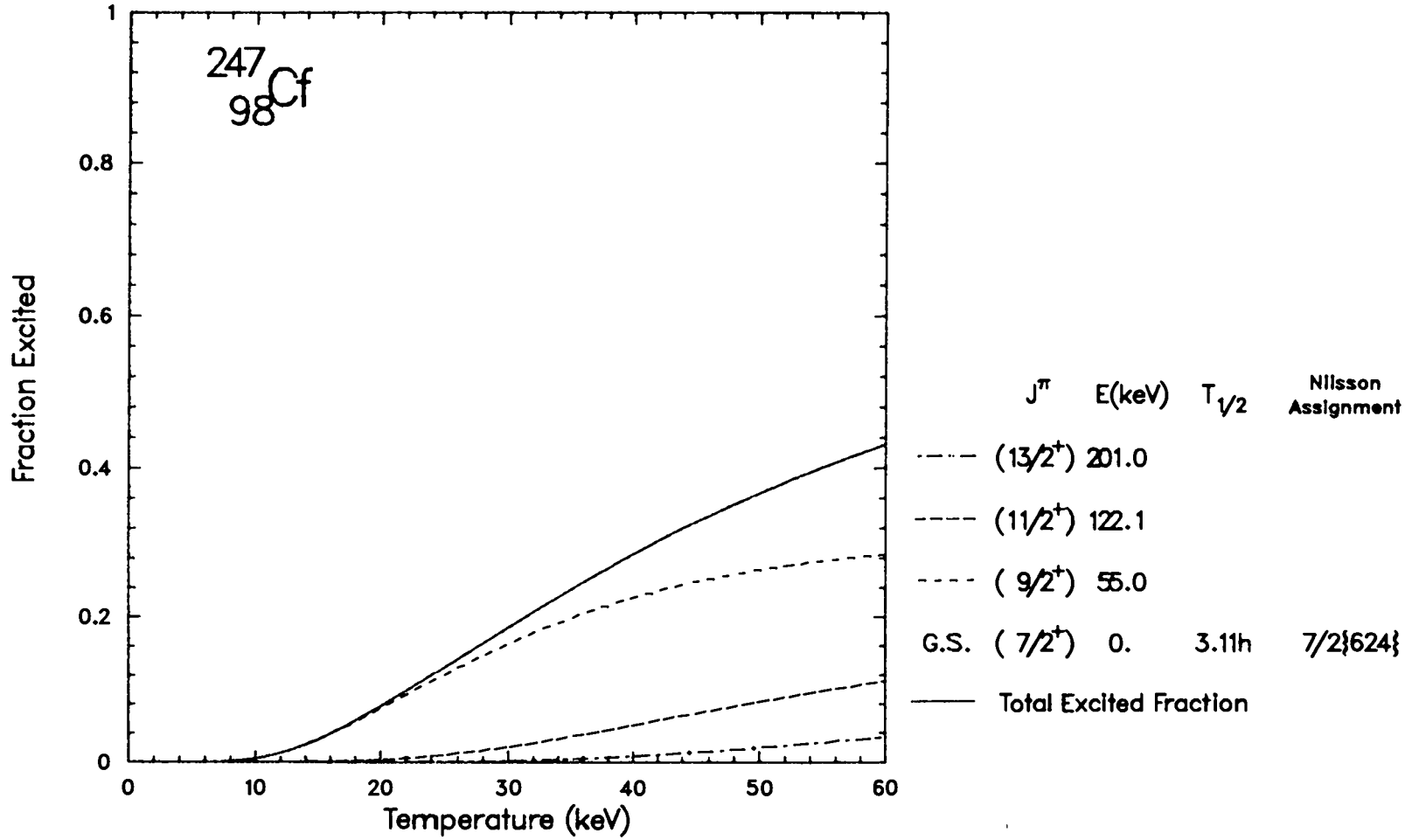


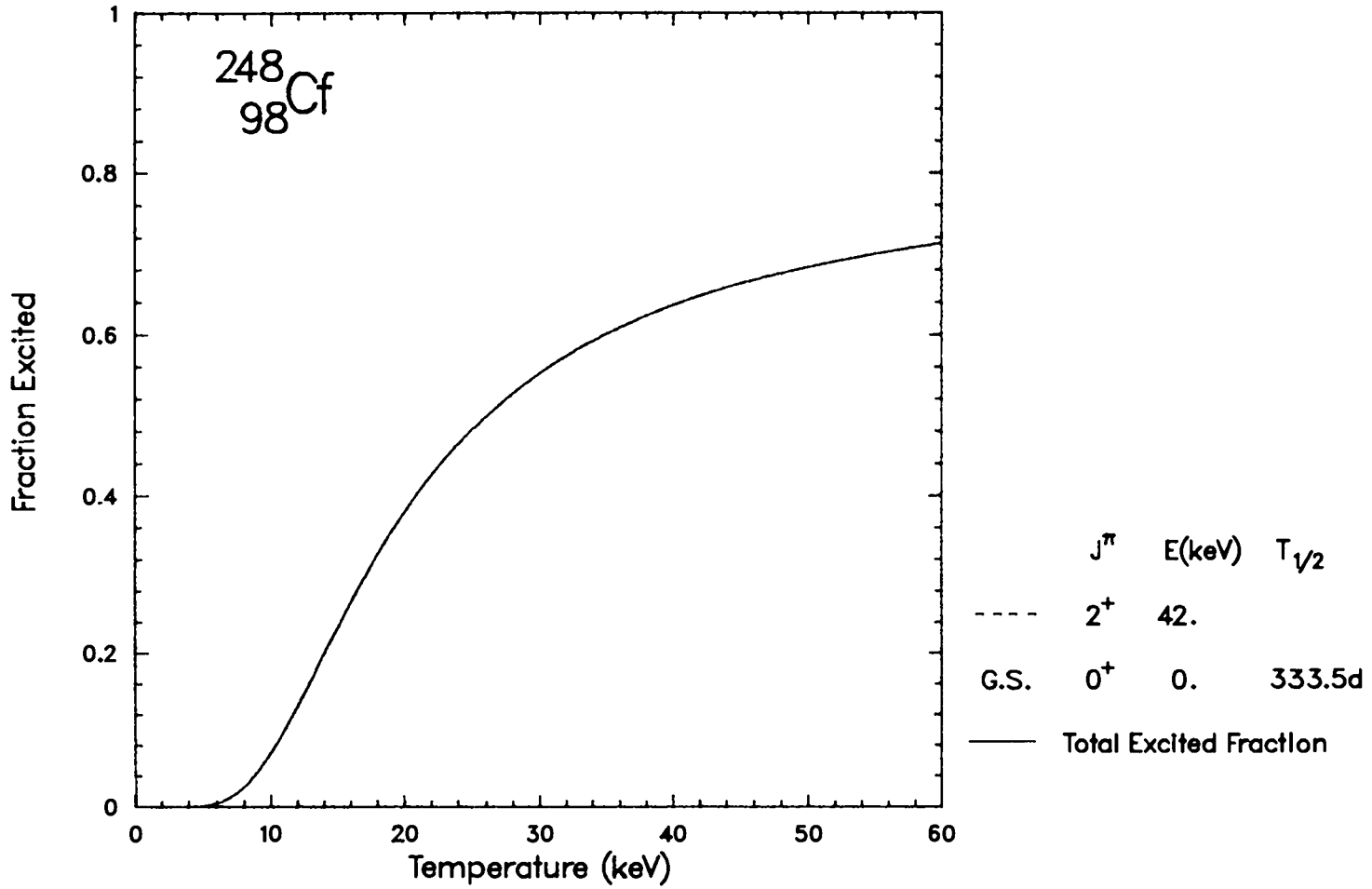
	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
——	$11/2^-$	204.57		
----	$13/2^+$	155.83		
——	$9/2^-$	137.73		
- - -	$11/2^+$	93.74	5ps	
- - —	$7/2^-$	82.61		
-·-·	$9/2^+$	41.79		
----	$5/2^-$	39.64	9ps	
- - - -	$3/2^-$	8.78	0.3ms	3/2{521}
G.S.	$7/2^+$	0.	320d	7/2{633}
——	Total Excited Fraction			

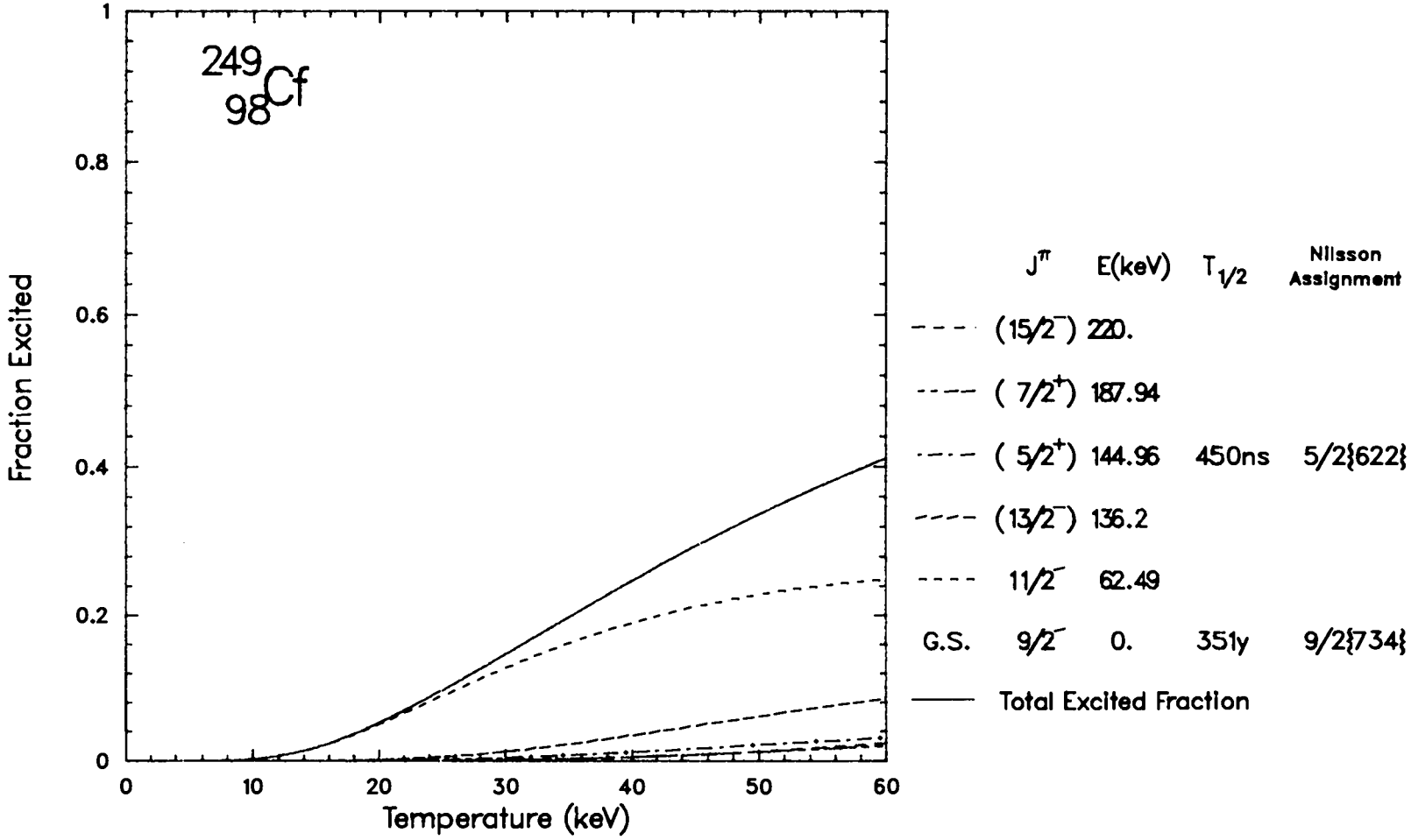


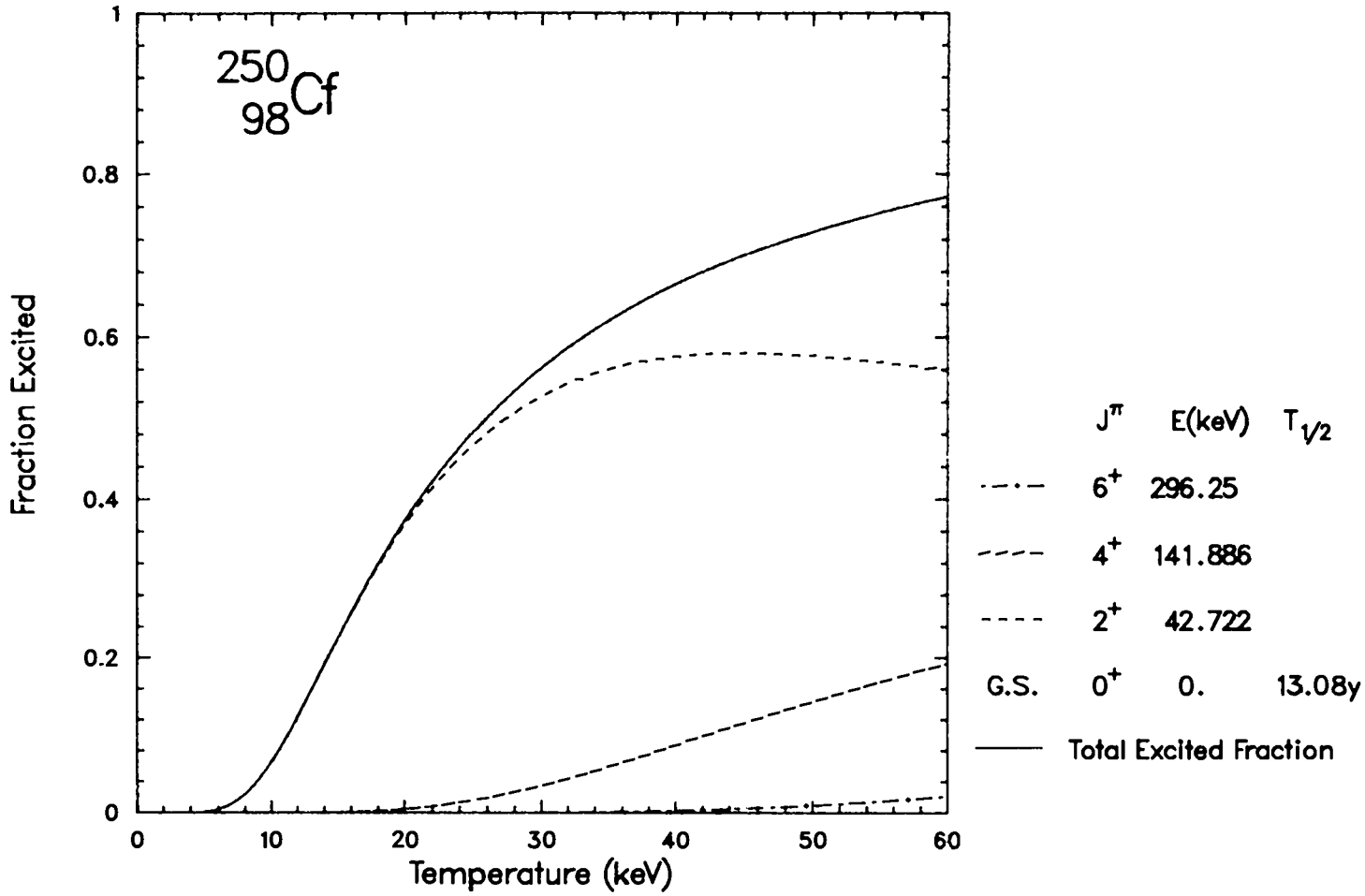
	J^π	E(keV)	$T_{1/2}$
	4^+	148.595	
	2^-	146.472	
	5^-	137.32	
	6^+	130.492	
	2^-	125.007	
	3^+	115.442	
	1^-	103.828	
	5^-	97.493	
	4^-	80.258	38ns
	5^+	78.326	.21ms
	4^+	35.587	.029ms
	3^-	34.472	
G.S.	2^-	0.	3.217h
	Total Excited Fraction		

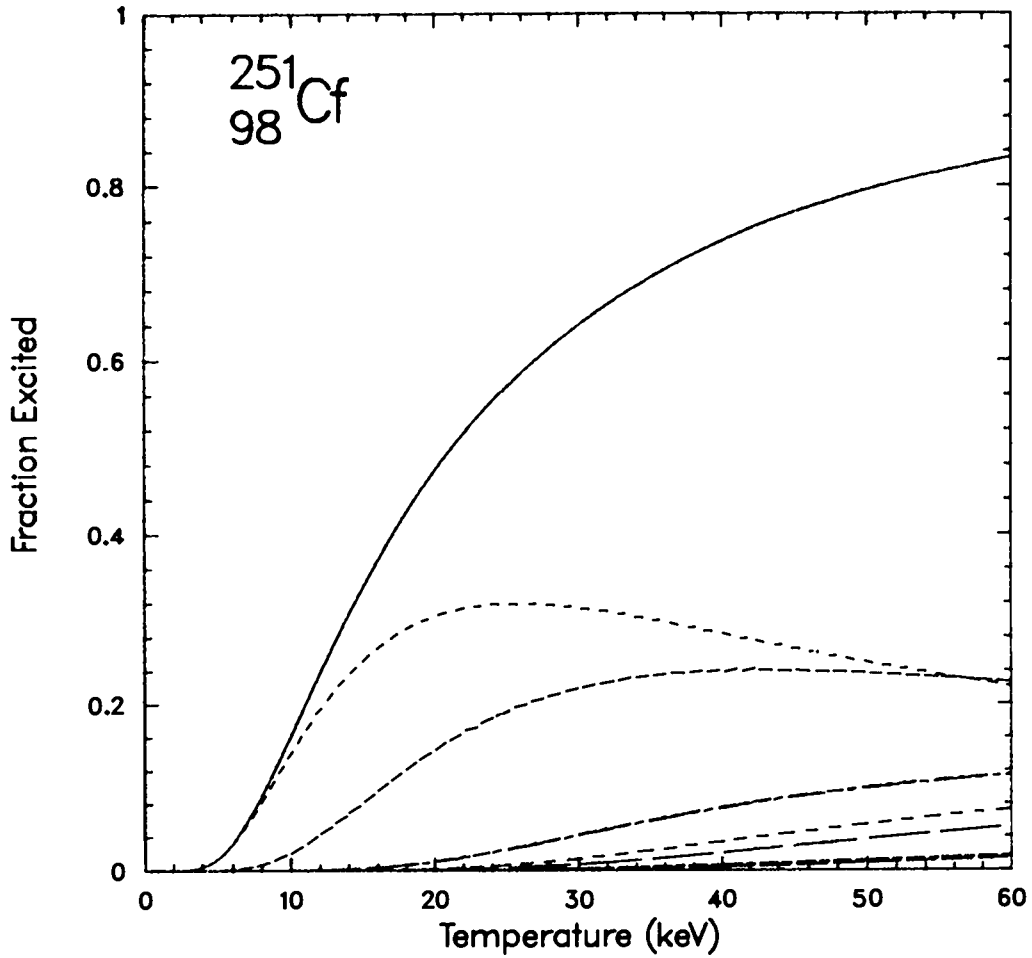

$^{251}_{97}$Bk
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$ Nilsson Assignment
(5/2$^+$) 269.3 5/2{642}
(11/2$^+$) 124.
(9/2$^+$) 76.
(7/2$^+$) 35.7 .058ms 7/2{633}
(5/2$^-$) 32.5
G.S. (3/2$^-$) 0. 56m 3/2{521}
Total Excited Fraction


247 98Cf
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
Jπ E(keV) T1/2 Nilsson Assignment
(13/2+) 201.0
(11/2+) 122.1
(9/2+) 55.0
G.S. (7/2+) 0. 3.11h 7/2{624}
Total Excited Fraction

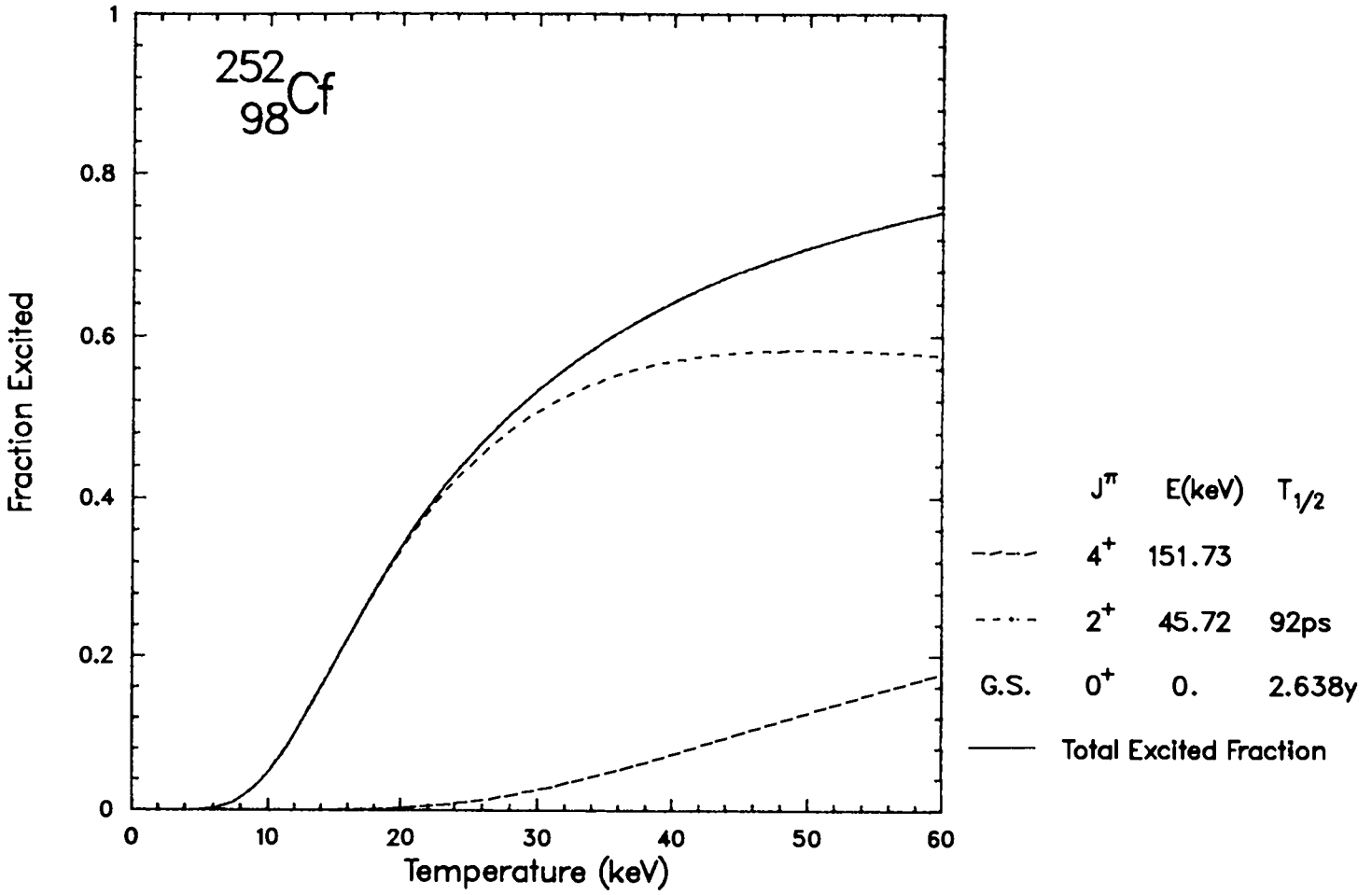

$^{248}_{98}Cf$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J$^{\pi}$ E(keV) T$_{1/2}$
2^{+} 42.
G.S. 0^{+} 0. 333.5d
Total Excited Fraction

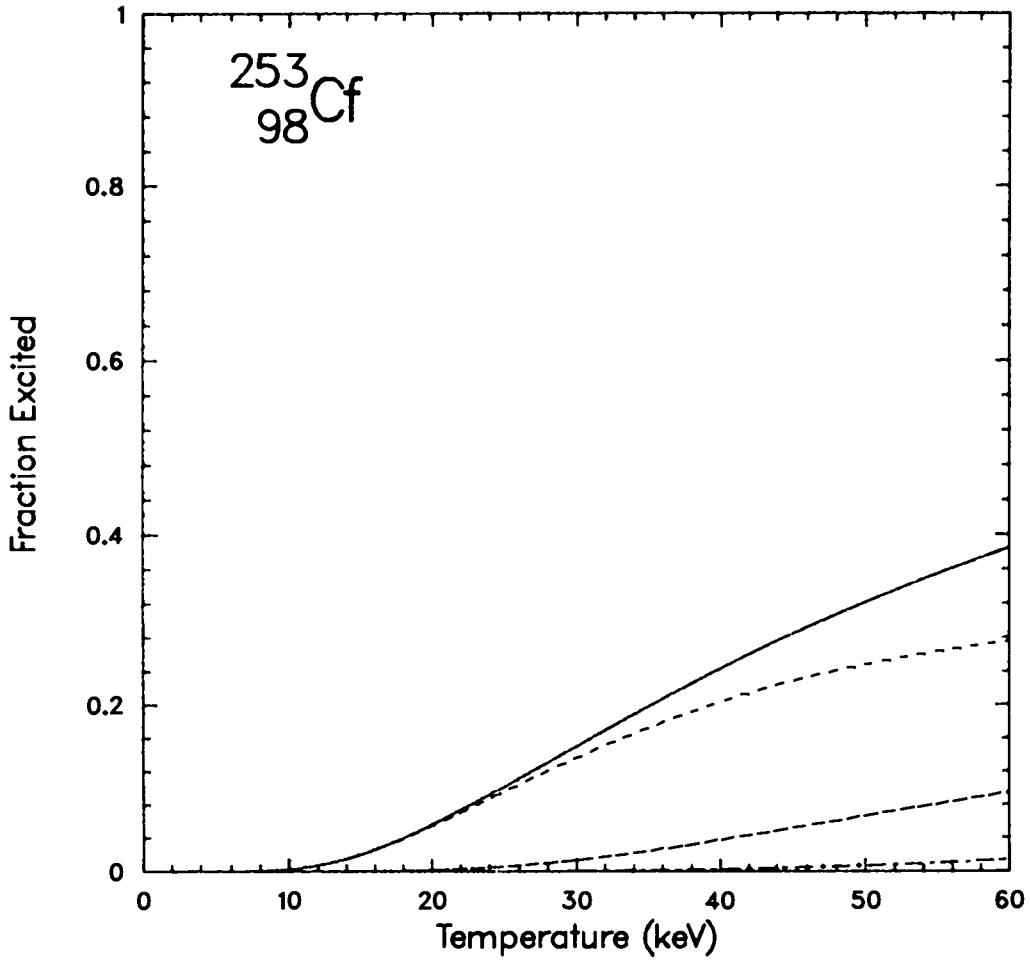

$^{249}_{98}Cf$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$ Nilsson Assignment
(15/2⁻) 220.
(7/2⁺) 187.94
(5/2⁺) 144.96 450ns 5/2{622}
(13/2⁻) 136.2
11/2⁻ 62.49
G.S. 9/2⁻ 0. 351y 9/2{734}
Total Excited Fraction


250 98Cf
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^π E(keV) T1/2
6+ 296.25
4+ 141.886
2+ 42.722
G.S. 0+ 0. 13.08y
Total Excited Fraction



	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
— —	$5/2^+$	211.72		
- - - -	$3/2^+$	177.69		3/2{622}
——	$9/2^+$	166.31		
- - -	$9/2^+$	146.46		
- - —	$7/2^+$	106.304	38ns	7/2{613}
· - · -	$7/2^+$	105.73		
- - - -	$5/2^+$	47.828		
- - - -	$3/2^+$	24.825		
G.S.	$1/2^+$	0.	898y	1/2{620}
——	Total Excited Fraction			


$^{252}_{98}Cf$
Fraction Excited
Temperature (keV)
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
J^{π} E(keV) $T_{1/2}$
4^+ 151.73
2^+ 45.72 92ps
G.S. 0^+ 0. 2.638y
Total Excited Fraction



	J^{π}	E(keV)	$T_{1/2}$	Nilsson Assignment
·-·-·	(9/2$^+$)	240.99		9/2{615}
- - - -	(11/2$^+$)	136.55		
- - - -	(9/2$^+$)	61.61		
G.S.	(7/2$^+$)	0.	17.81d	7/2{613}
——	Total Excited Fraction			

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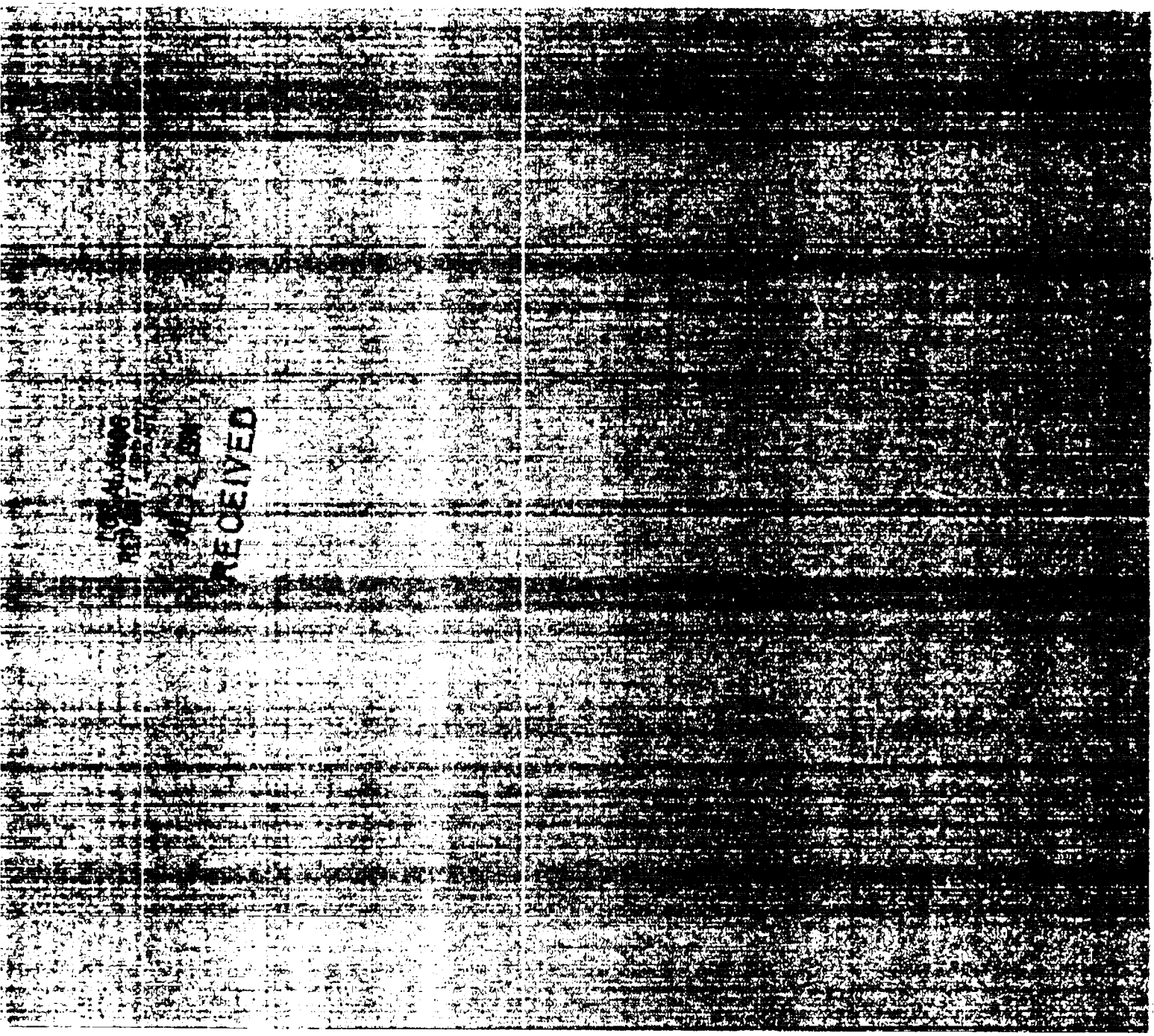
						601-up*	A99

*Contact NTIS for a price quote.



Los Alamos