Analysis of $^{140}Te \rightarrow {}^{140}I$ β^- - Decay Nuclear Structure

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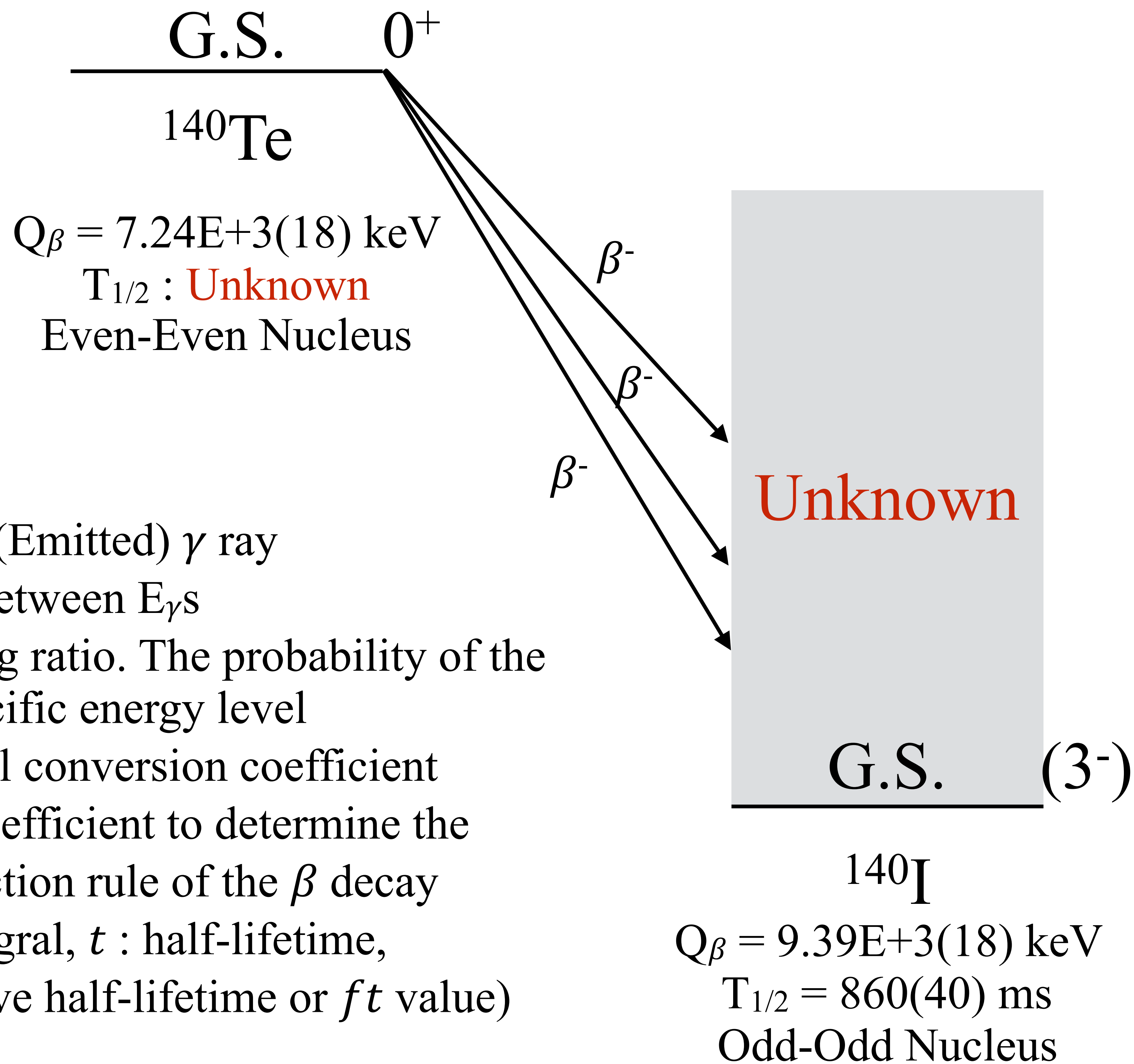
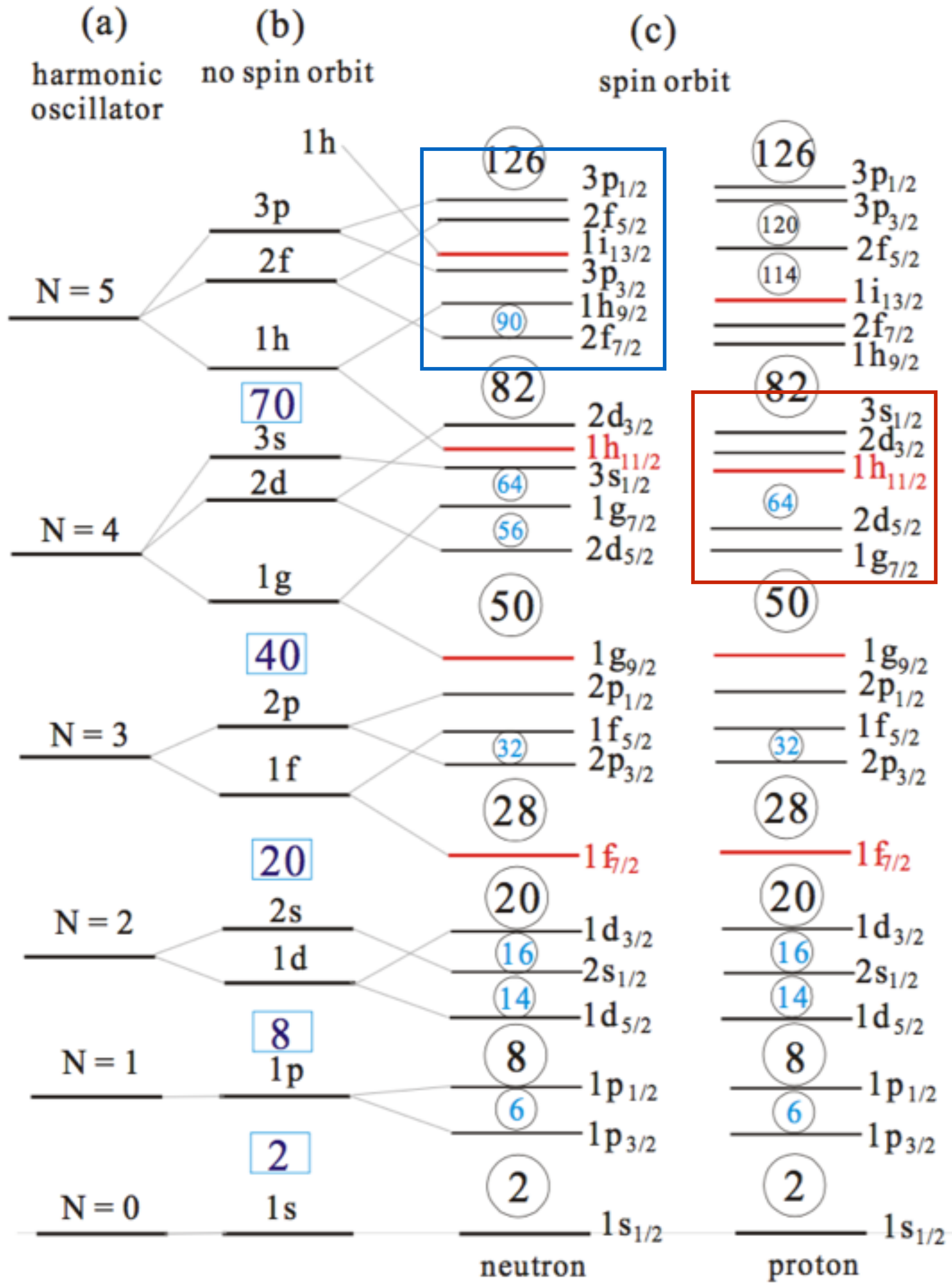
Introduction

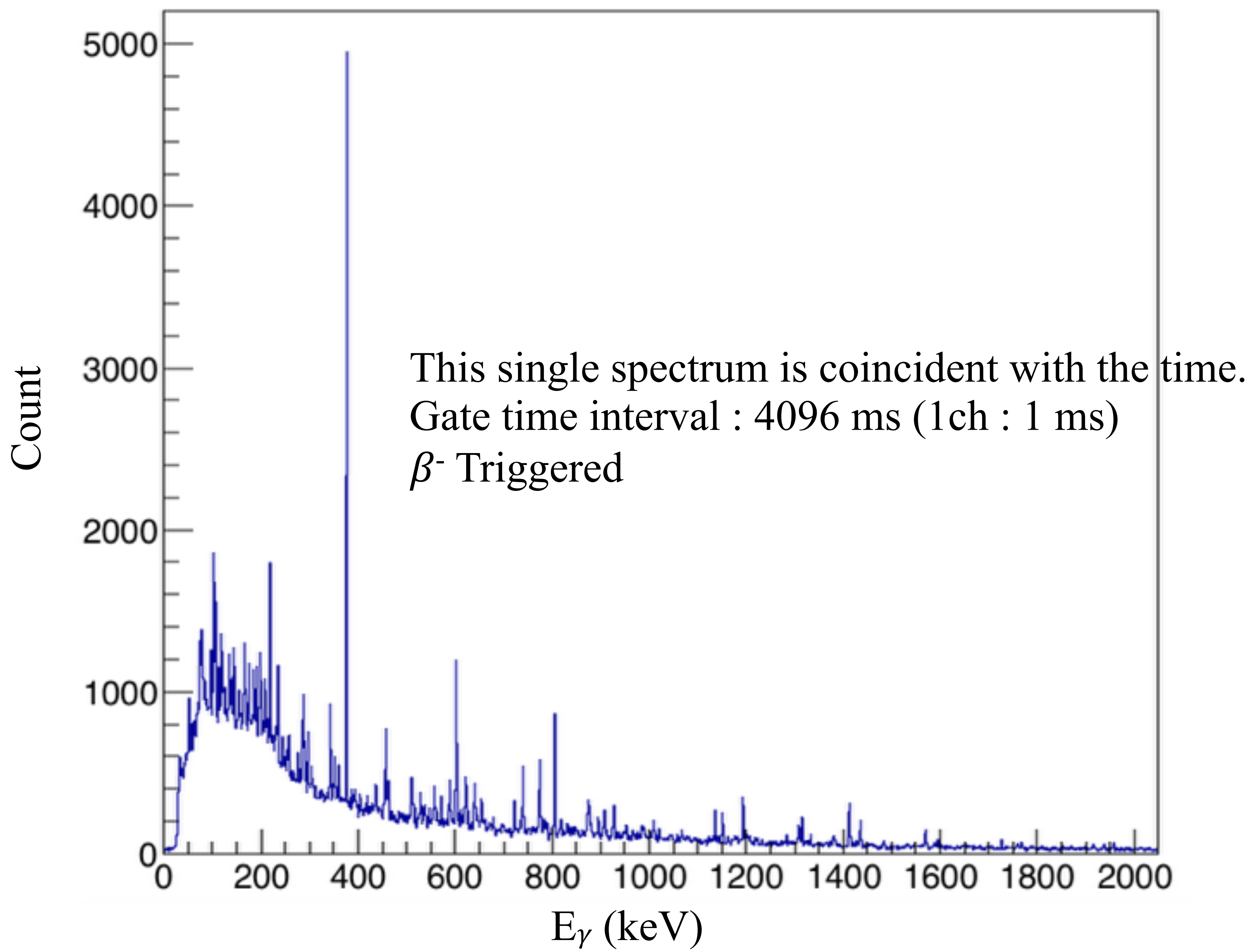


E_γ : Transition(Emitted) γ ray
I_γ : The ratio between E_γs
I_β : β branching ratio. The probability of the decay to a specific energy level
α : The internal conversion coefficient
log ft : The coefficient to determine the transition selection rule of the β decay
(f : Fermi integral, t : half-lifetime,
ft : comparative half-lifetime or ft value)

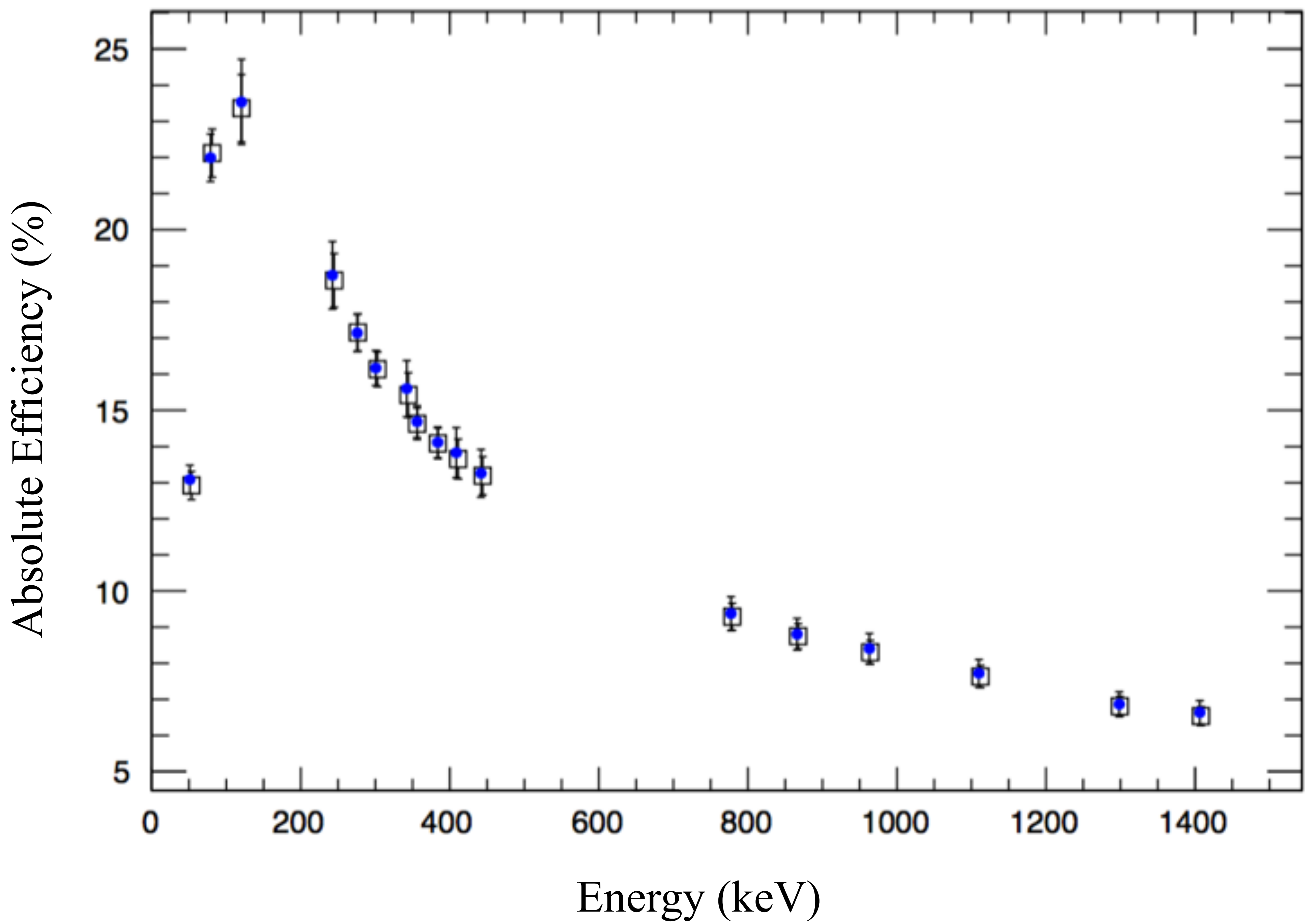


(a)
harmonic oscillator
(b)
no spin orbit
(c)
spin orbit
N = 5
N = 4
N = 3
N = 2
N = 1
N = 0
1h
3p
2f
1h
70
3s
2d
1g
40
2p
1f
20
2s
1d
8
1p
2
1s
126
3p1/2
2f5/2
1i13/2
3p3/2
1h9/2
90
2f7/2
82
2d3/2
1h11/2
3s1/2
64
1g7/2
56
2d5/2
50
1g9/2
2p1/2
1f5/2
32
2p3/2
28
1f7/2
20
1d3/2
16
2s1/2
14
1d5/2
8
1p1/2
6
1p3/2
2
1s1/2
neutron
126
3p1/2
3p3/2
120
2f5/2
114
1i13/2
2f7/2
1h9/2
82
3s1/2
2d3/2
1h11/2
64
2d5/2
1g7/2
50
1g9/2
2p1/2
1f5/2
32
2p3/2
28
1f7/2
20
1d3/2
16
2s1/2
14
1d5/2
8
1p1/2
6
1p3/2
2
1s1/2
proton

Single γ-ray Spectrum

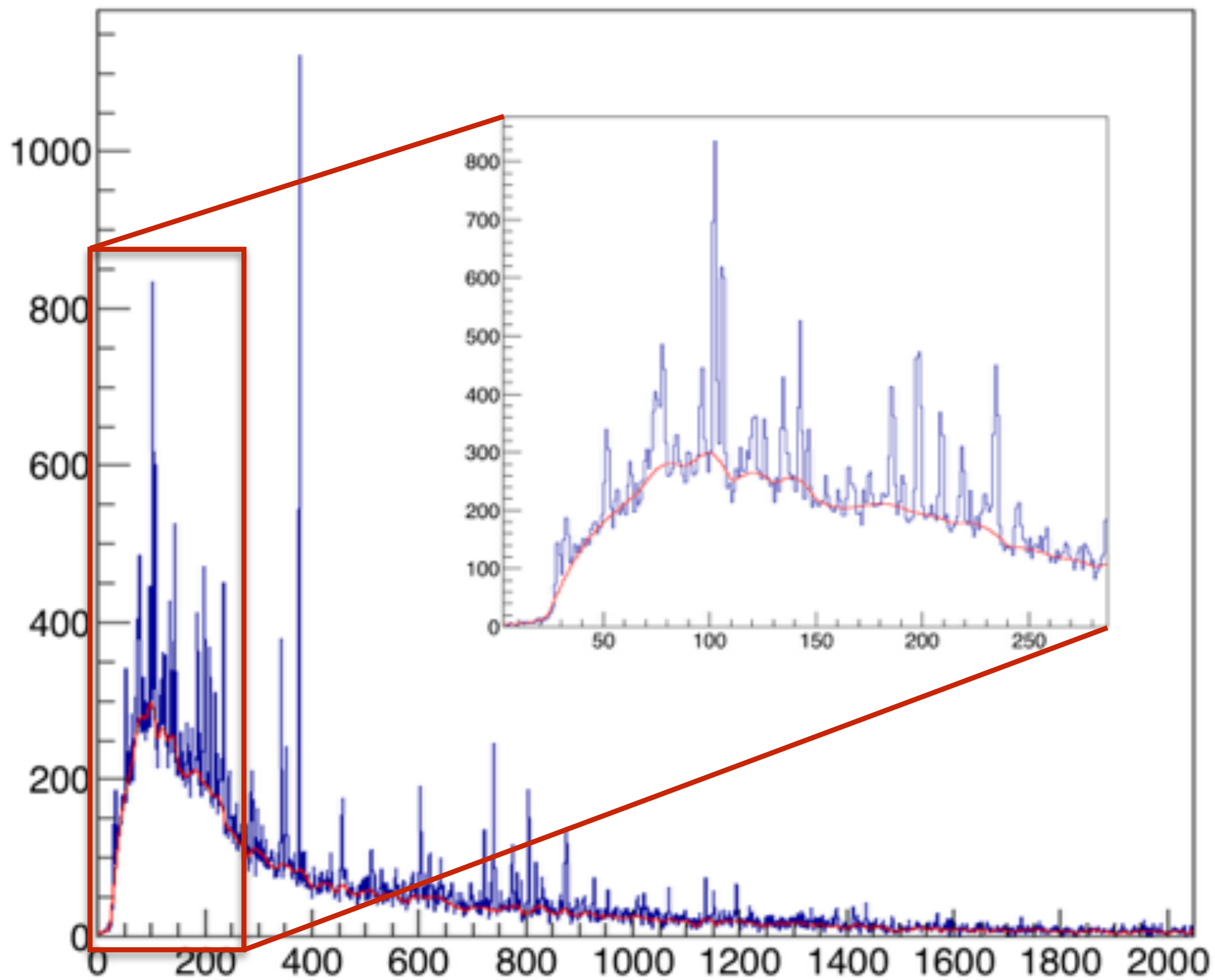


EURICA Efficiency



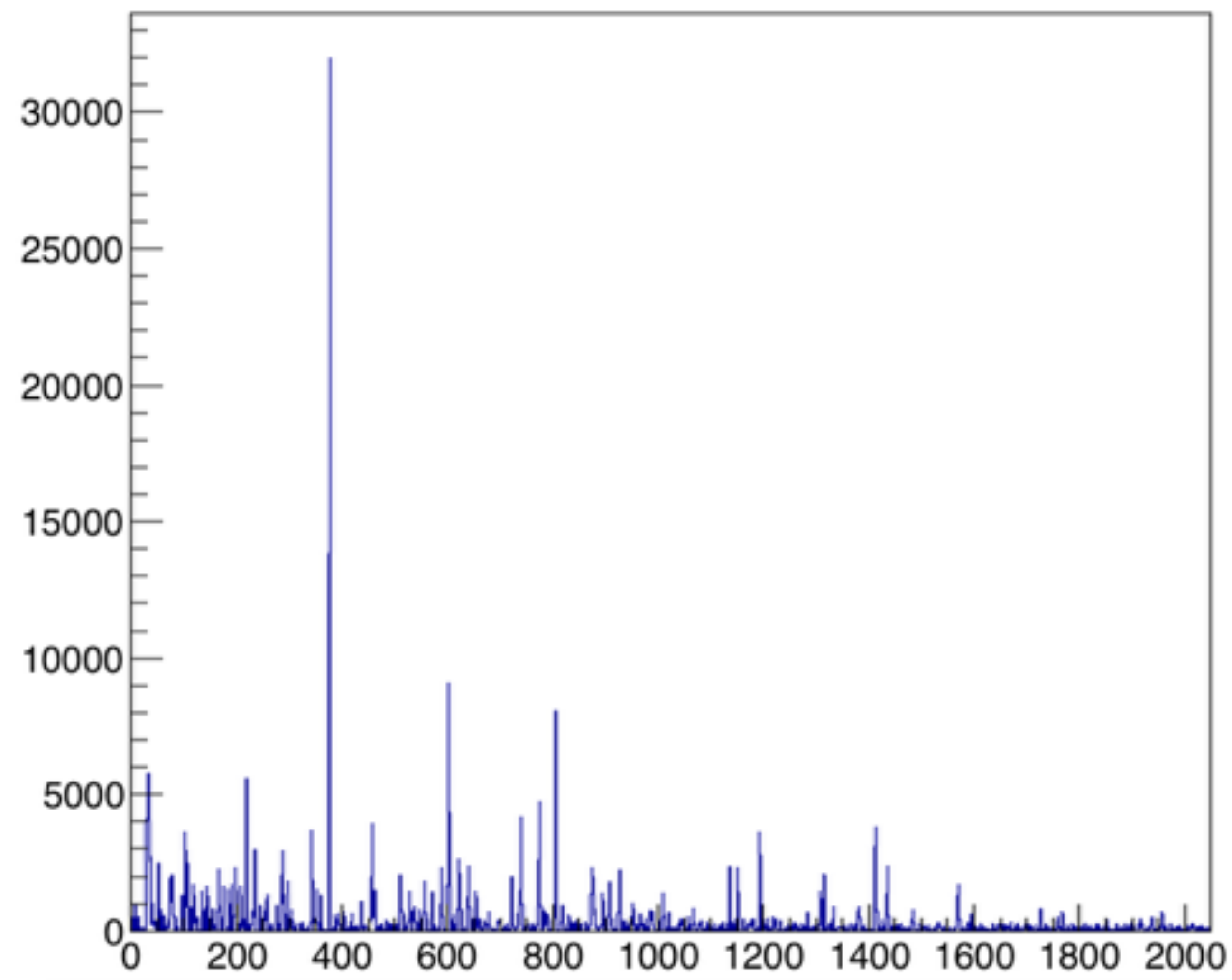
Calibration

Background elimination



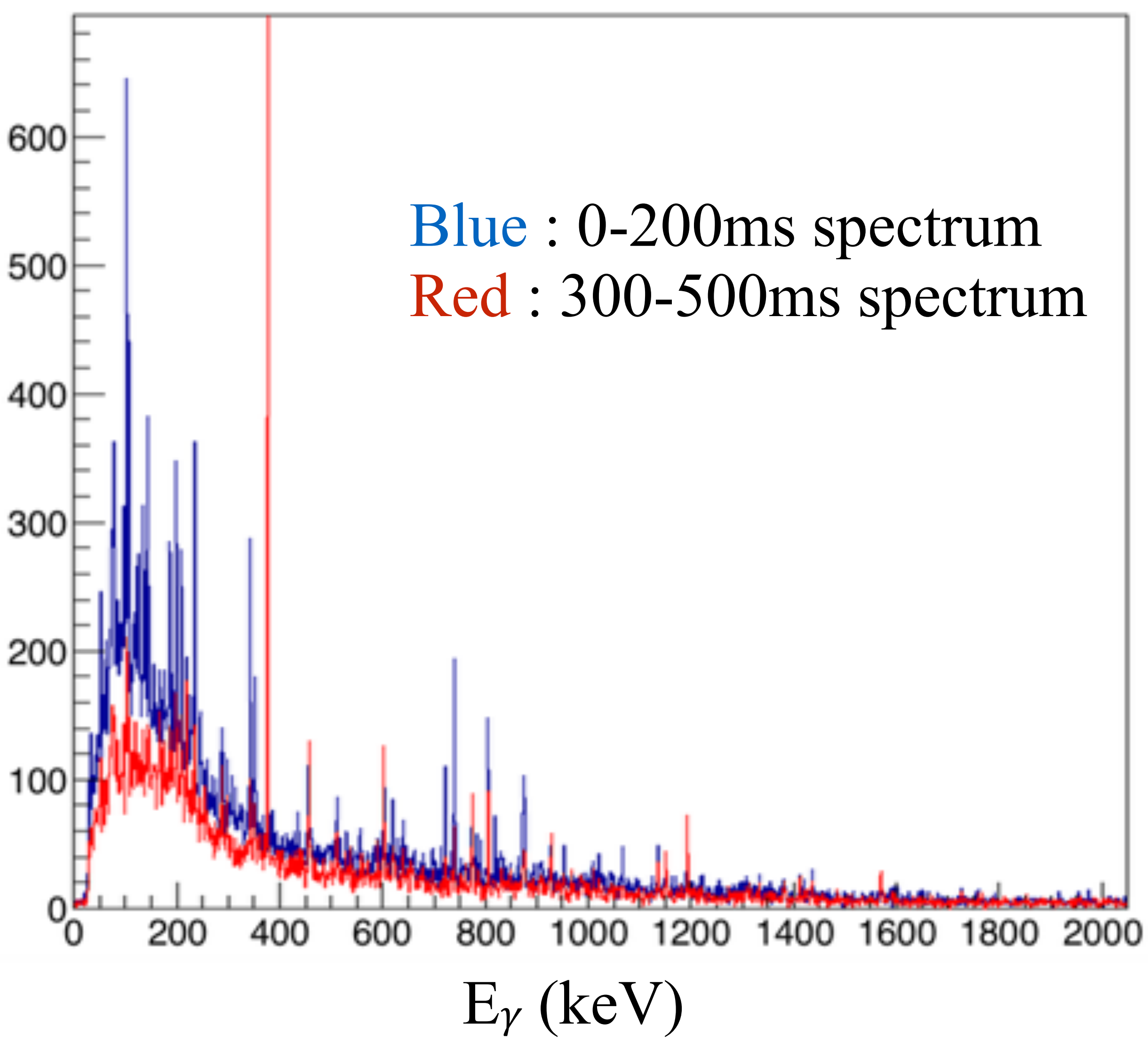
E_γ (keV)

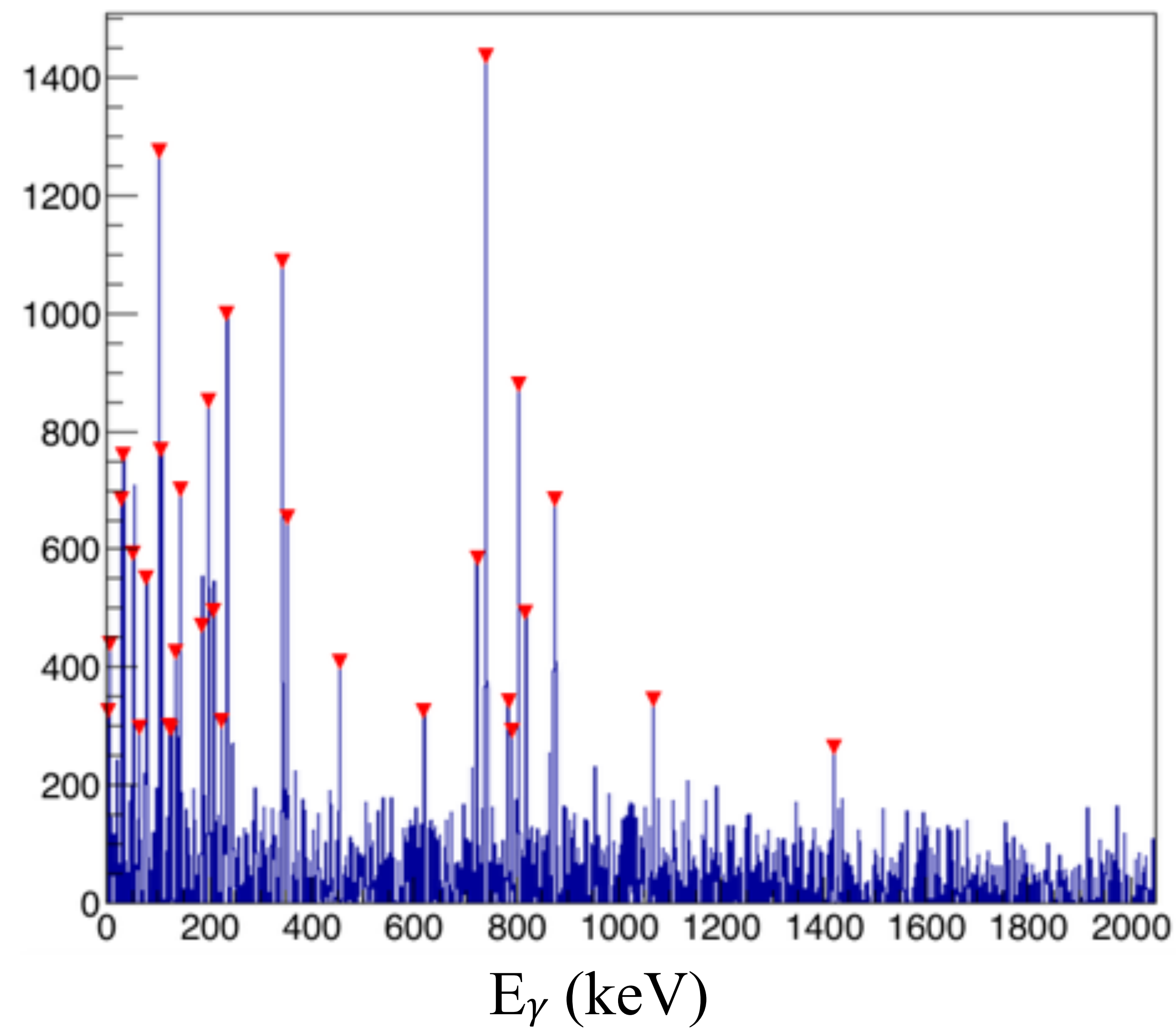
After BG elimination & efficiency calibration



E_γ (keV)

Search Time Decaying γ-Peaks



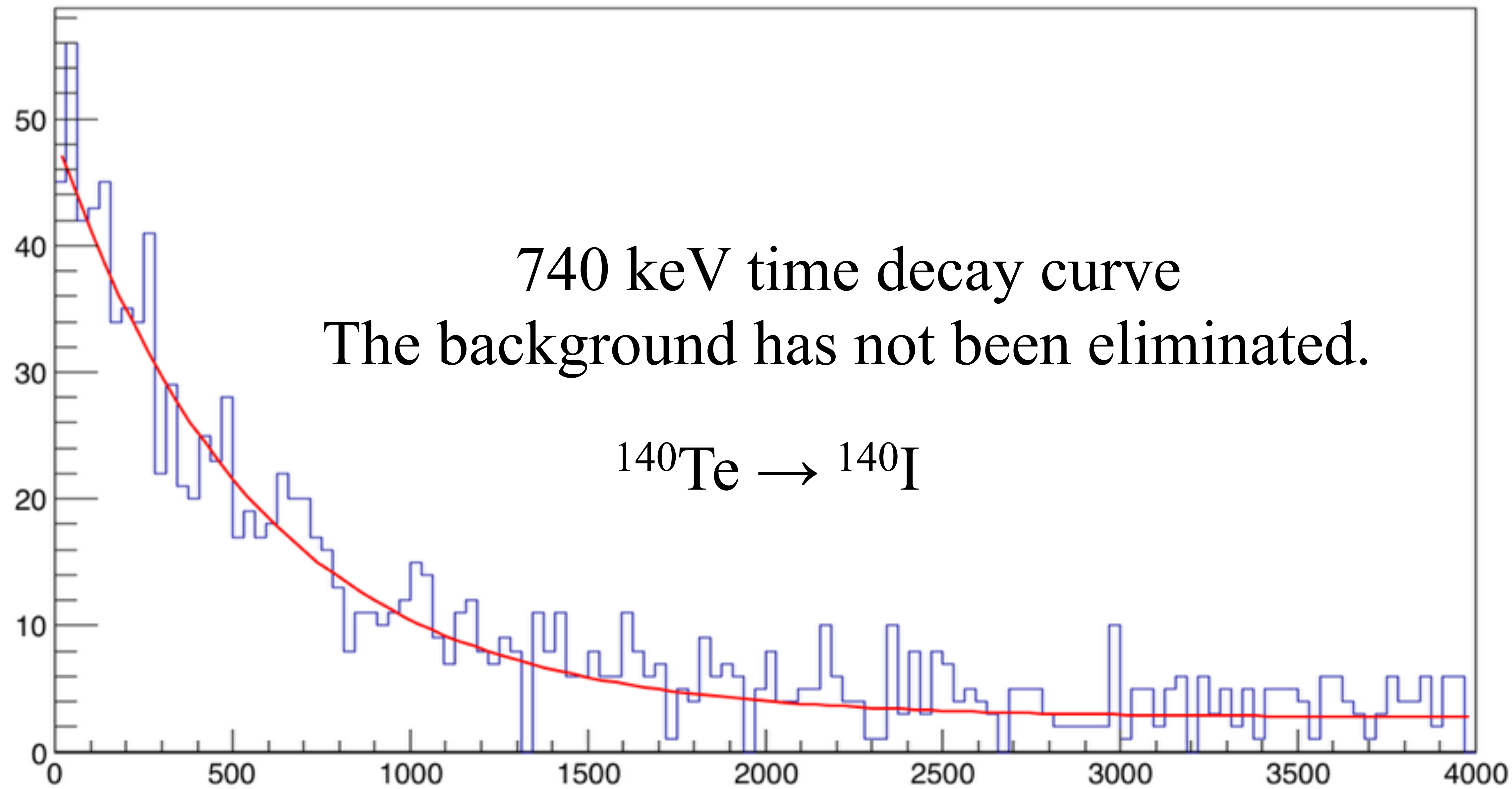


E_γ (keV)	Count	I_γ (%)	E_i (keV)	E_f (keV)	Coincidences (keV) (From total γ-γ spectrum)
739	4207.35	100.00	925	185	51, 134, 185
341	3328.32	79.11	341	0	583
102	2880.79	68.47	108	6	197, 234, 351, 818, 1047
197	2850.59	67.75	925	728	102, 620, 722
875	2797.22	66.48	925	51	51
234	2627.02	62.44	341	108	56, 102, 583
51	1977.64	47.00	51	0	56, 134, 542, 739, 1067
352	1955.41	46.48	458	108	56, 102
722	1651.54	39.25	728	6	197
620	1589.86	37.79	728	108	102, 197
185	1548.05	36.79	185	0	739, 1067
142	1442.13	34.28	925	783	783
134	1416.08	33.66	185	51	51, 740, 1067
818	938.24	22.30	925	108	56, 102
1067	924.96	21.98	1252	185	51, 134, 185
783	742.17	17.64	783	0	142
1601	384.46	9.14	1786	185	51, 134, 185
6	336.57	8.00	6	0	-
583	219.84	5.23	925	341	102, 234, 341
56	203.19	4.83	108	51	51, 234, 351, 818

Gate : 0 - 400ms from the single γ spectrum

Condition : Background elimination and efficiency calibration

Lifetime Measurement



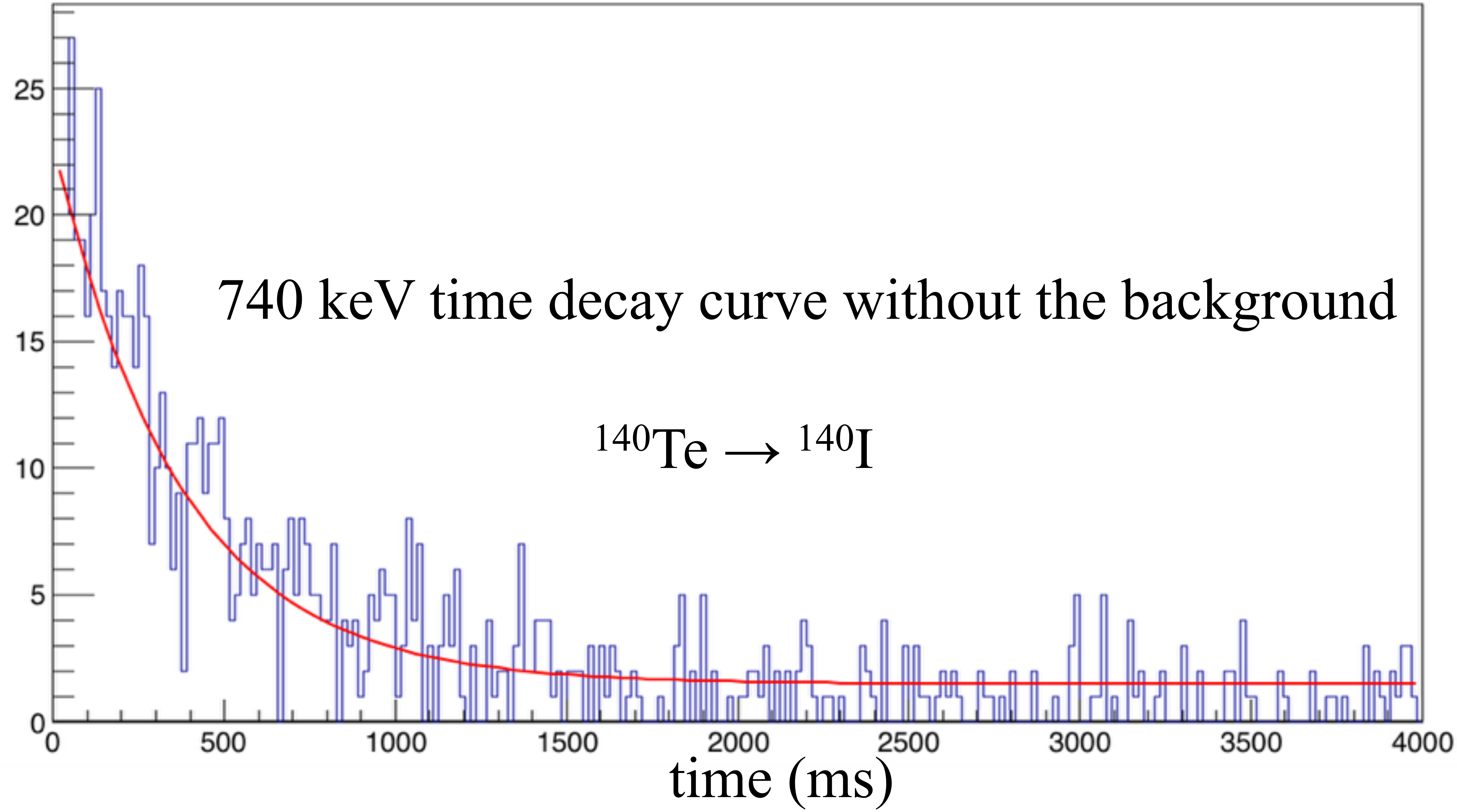
time (ms)

Longer than the expected value

time constant τ = 552.997

half lifetime $T_{1/2}$ = 383.308 ± 20.055 [ms]

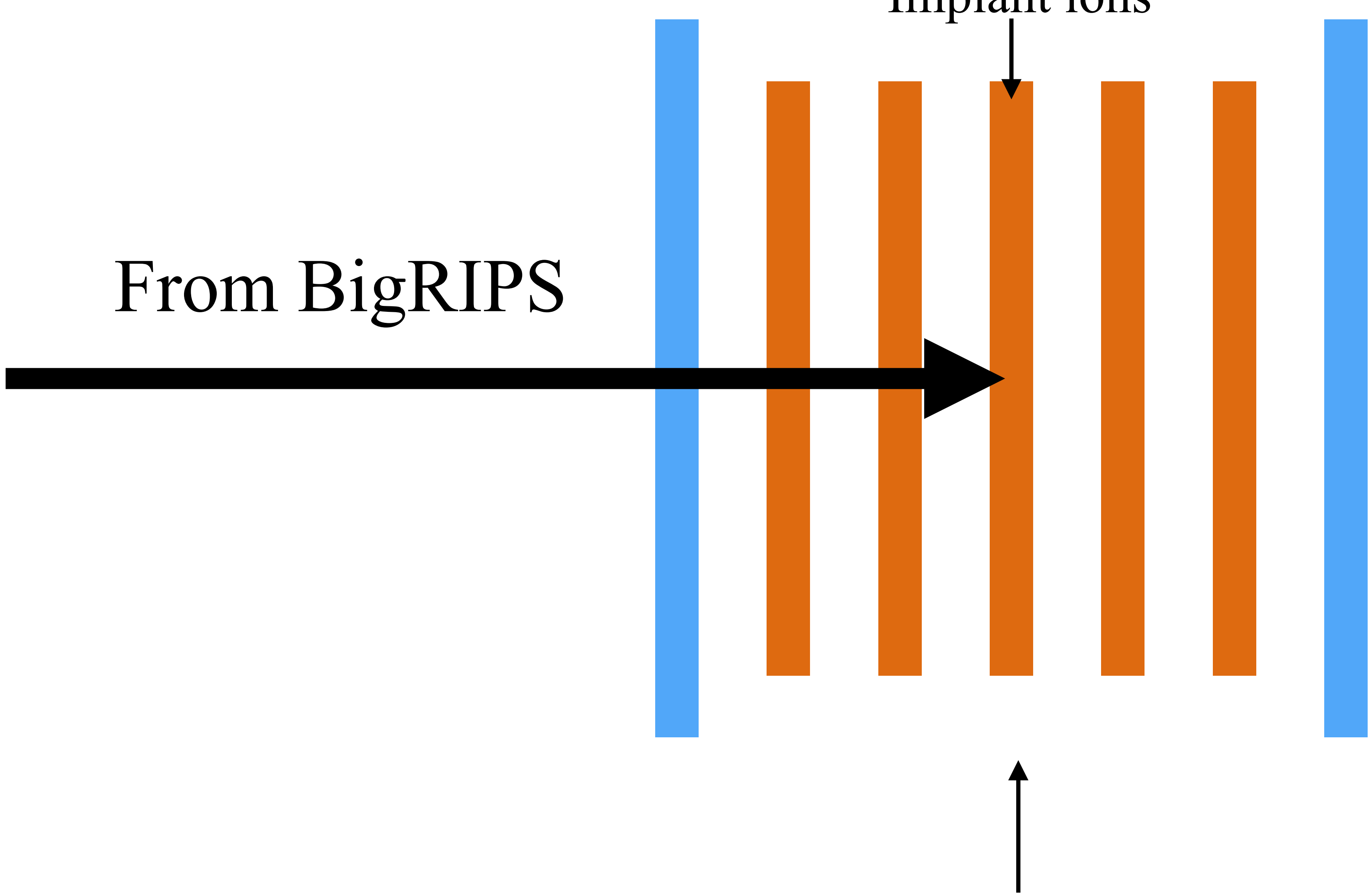
Lifetime Measurement



time constant $\tau = 449.982$

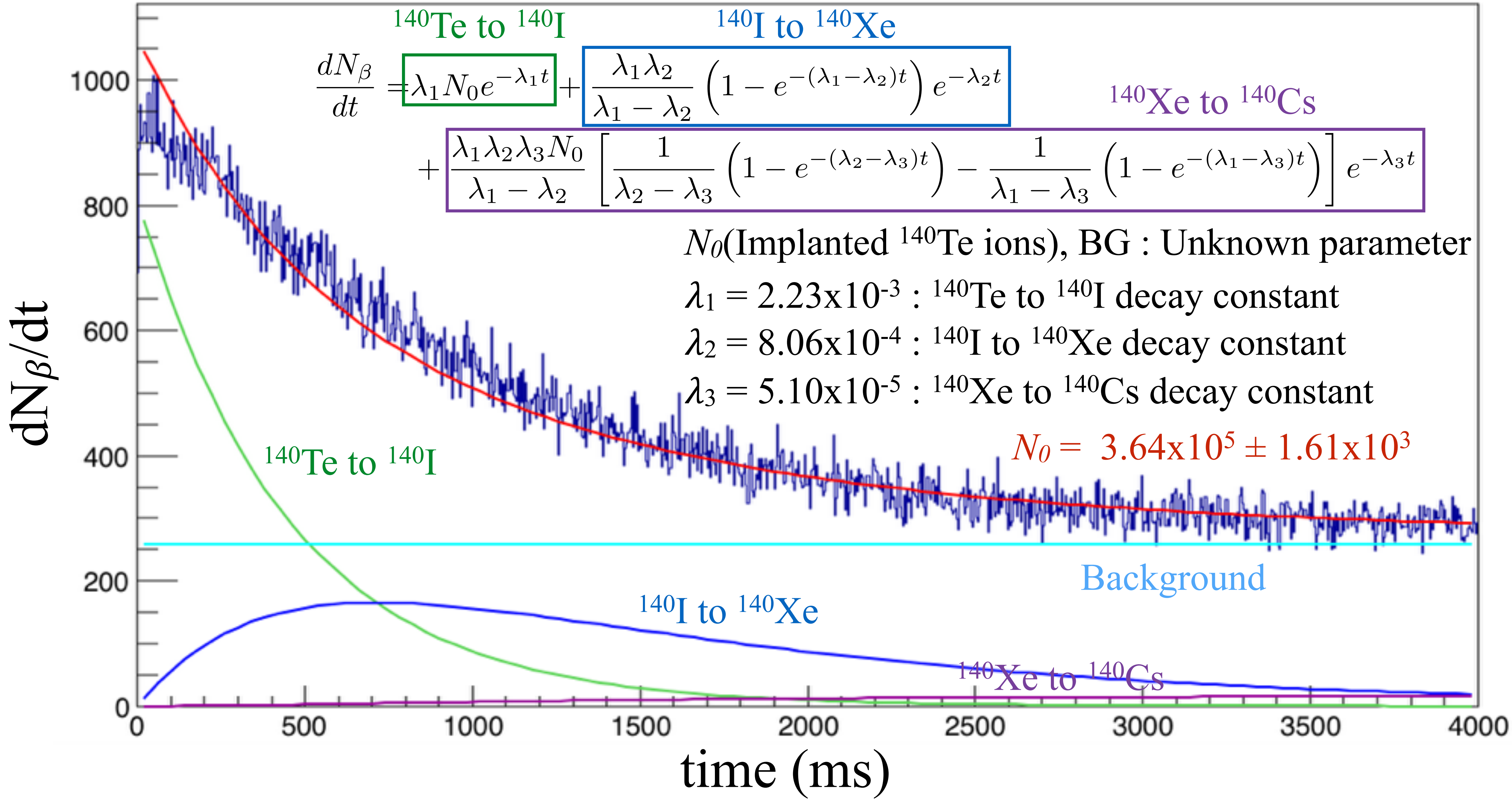
half lifetime $T_{1/2} = 311.904 \pm 16.191$ [ms]

Experimental Setup



For ^{140}Te
Implantation rate : 8.618/s
Total implanted ions : 1.8 E+6
Efficiency to collect β: ~ 40 %

Total β-ray Estimation



Total β-ray Estimation

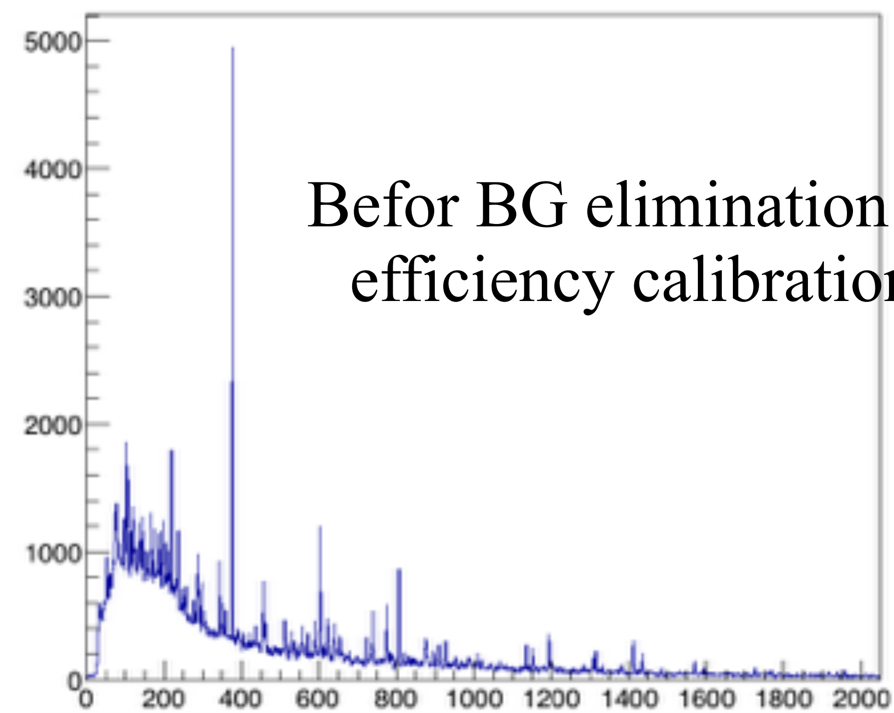
$$\frac{dN_\beta}{dt} = \lambda_1 N_0 e^{-\lambda_1 t}$$

$$N_\beta = \lambda_1 N_0 \int_0^{4000} e^{-\lambda_1 t} = 364051$$

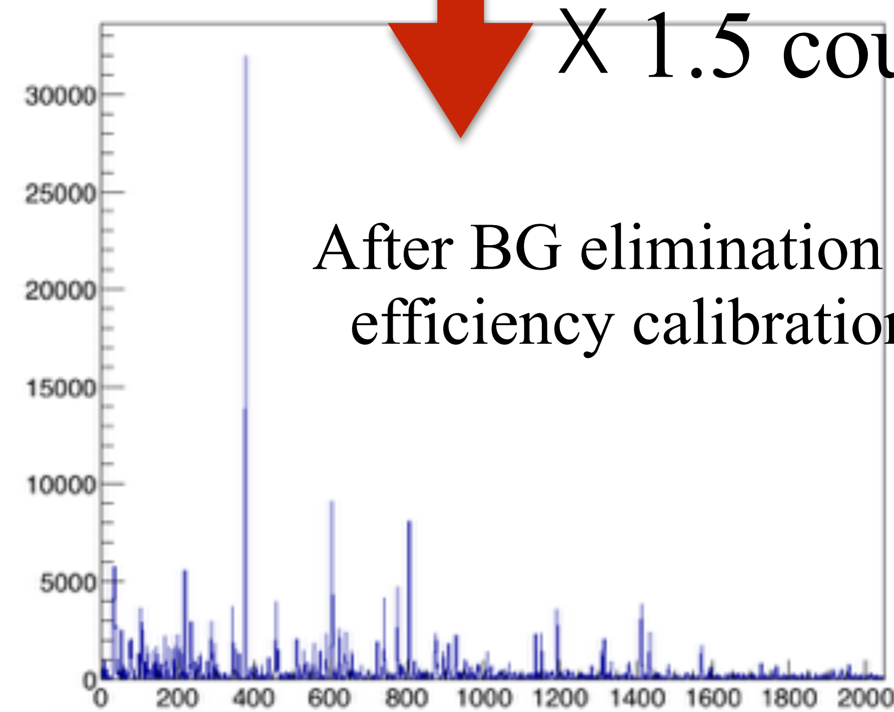
↓ X 1.5 counts

$$N_\beta = 546076 \approx 5.5 \times 10^5$$

Total β particles from the decay of ^{140}Te : 5.5×10^5



X 1.5 counts



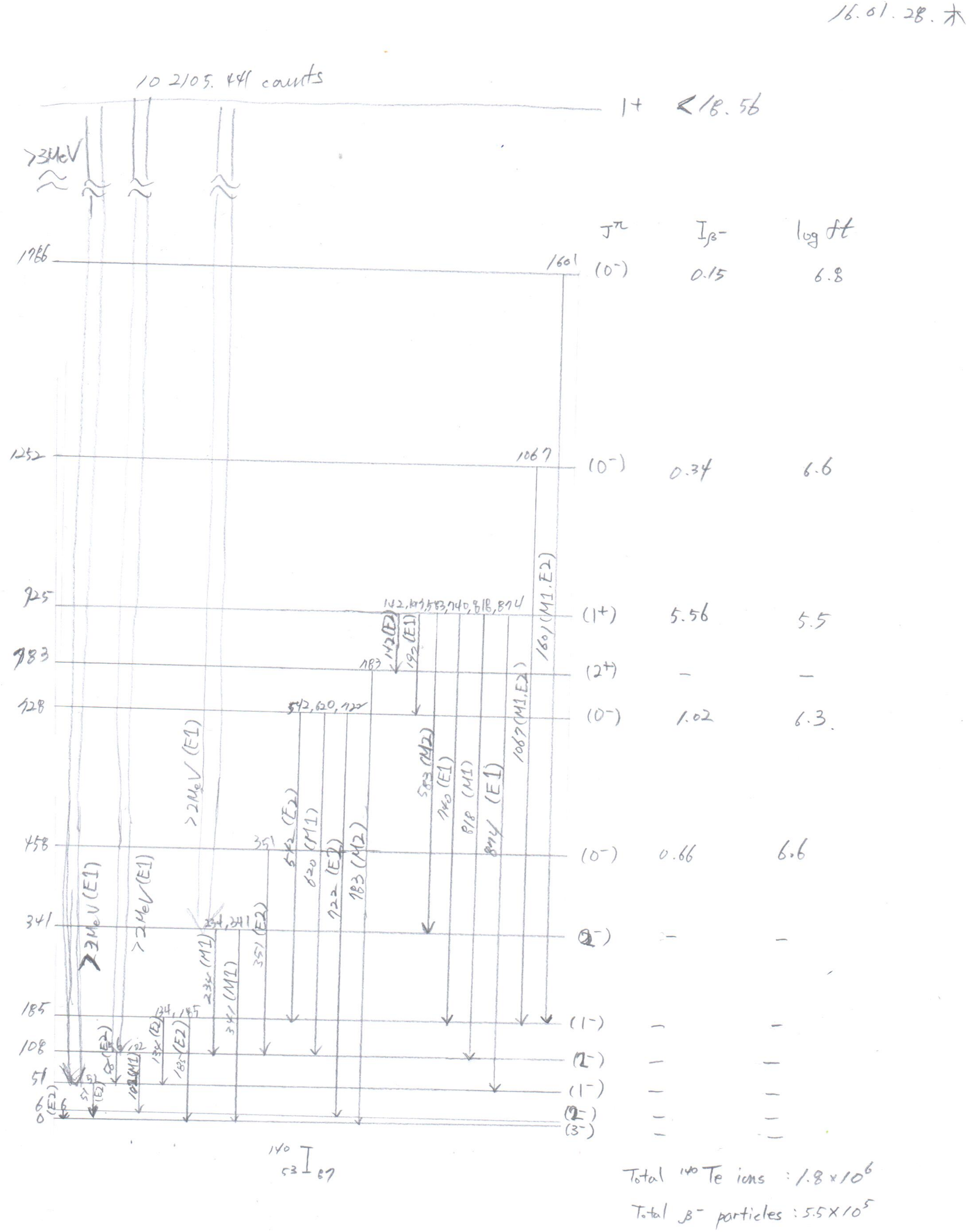
Energy Level	E_γ	Count	Internal Conversion				Effect of Downstream E_γ	Total Count	I_{β^-}	log ft
			M1 α	Count	E2 α	Count				
1786	1601	843.27	-	-	-	-	-	843.27	0.15	6.8
1252	1067	1887.85	-	-	-	-	-	1887.85	0.34	6.6
925	142	3024.7	0.282	3876.77	0.513	4575.31	-	33475.34	6.09	5.5
	197	6631.17	0.115	7393.75	0.164	7718.68				
	583	367.219	-	-	-	-				
	739	10428.3	-	-	-	-				
	818	2221.05	-	-	-	-				
	874	8164.78	-	-	-	-				
783	783	1802.09	-	-	-	-	142 keV	~ 0 (-2773.22)	-	-
728	542	565.219	-	-	-	-	197 keV	5961.229	1.08	6.3
	620	7728.66	-	-	-	-				
	722	5061.1	-	-	-	-				
458	351	3636.74	-	-	-	-	-	3636.74	0.66	6.6
341	234	6868.92	-	-	-	-	583 keV	14969.981	X	
	341	8468.28	-	-	-	-				
185	134	3180.73	0.331	4233.55	0.629	5181.41	542, 739, 1067, 1601 keV	~ 0 (-4389.789)	-	-
	185	3449.7	0.136	3918.86	0.204	4153.44				
108	56	1166.44	4.03	5867.19	14.3	17846.53	234, 351, 620, 818 keV	12241.4	X	
	102	8659.03	0.715	14850.24	1.65	22946.43				
51	51	4980.6	5.29	31327.97	20.3	106086.78	56, 134, 874 keV	74894.06	X	
6	6	-	-	-	-	-	102, 722 keV	-	-	-

From the single γ spectrum with 4096 ms / ^{140}Te ions : 2.2 x 10^6 / Number of β particles : 5.5 x 10^5

Condition : Background elimination and efficiency calibration

1st Scenario

Energy Level (keV)	E_γ (keV)	Count	Internal Conversion		Effect of Downstream E_γ (keV)	Total Count	I_{β^-} (%)	log ft	J^π
			Type (α)	Count					
1786	1601	843.27	M1, E2	-	-	843.27	0.15	6.8	0^-
1252	1067	1887.85	M1, E2	-	-	1887.85	0.34	6.6	0^-
925	142	3024.7	E2 (0.513)	4575.31	-	30586.77	5.56	5.5	1^+
	197	6631.17	E1 (0.03)	6830.11					
	583	367.219	M2	-					
	739	10428.3	E1	-					
	818	2221.05	M1	-					
	874	8164.78	E1	-					
783	783	1802.09	M2	-	142	~ 0 (-2773.22)	-	-	2^+
728	542	565.219	E2	-	197	5636.30	1.02	6.3	0^-
	620	7728.66	M1	-					
	722	5061.1	E2	-					
458	351	3636.74	E2	-	-	3636.74	0.66	6.6	0^-
341	234	6868.92	M1	-	583	14969.981	X		2^-
	341	8468.28	M1	-					
185	134	3180.73	E2 (2.63)	5181.41	542, 739, 1067, 1601	~ 0 (-4389.789)	-	-	1^-
	185	3449.7	E2 (0.204)	4153.44					
108	56	1166.44	E2 (14.3)	17846.53	234, 351, 620, 818	12241.4	X		2^-
	102	8659.03	M1 (0.715)	14850.24					
51	51	4980.6	E2 (20.3)	106086.78	56, 134, 874	74894.06	X		1^-
6	6	-	-	-	102, 722	-	-	-	2^-



The Level Scheme of 1st Scenario

Future Plan

- Find out more coincident E_γ over 1 MeV.
- After access to the raw data, analyze the β spectrum to find peaks of internal conversions.
- After access to the raw data, find the total amount of β particles after the elimination of the background and the efficiency calibration of the 2-D matrix.
- After access to the raw data, find strong peaks to confirm the 1+ state above 2 MeV with more than 15 % of the β branch ratio.
- After access to the raw data, analyze the angular correlation to find the exact transition type.
- Confirm all energy state with correct J^π, β branching ratio and log ft.
- Make the reasonable scenario with physics.