$^{58}Ni + ^{96}Ru$ 实验数据处理

^{151}Lu（实验目的1：isomer质子发射）

Physics Letters B 770 (2017) 83–87

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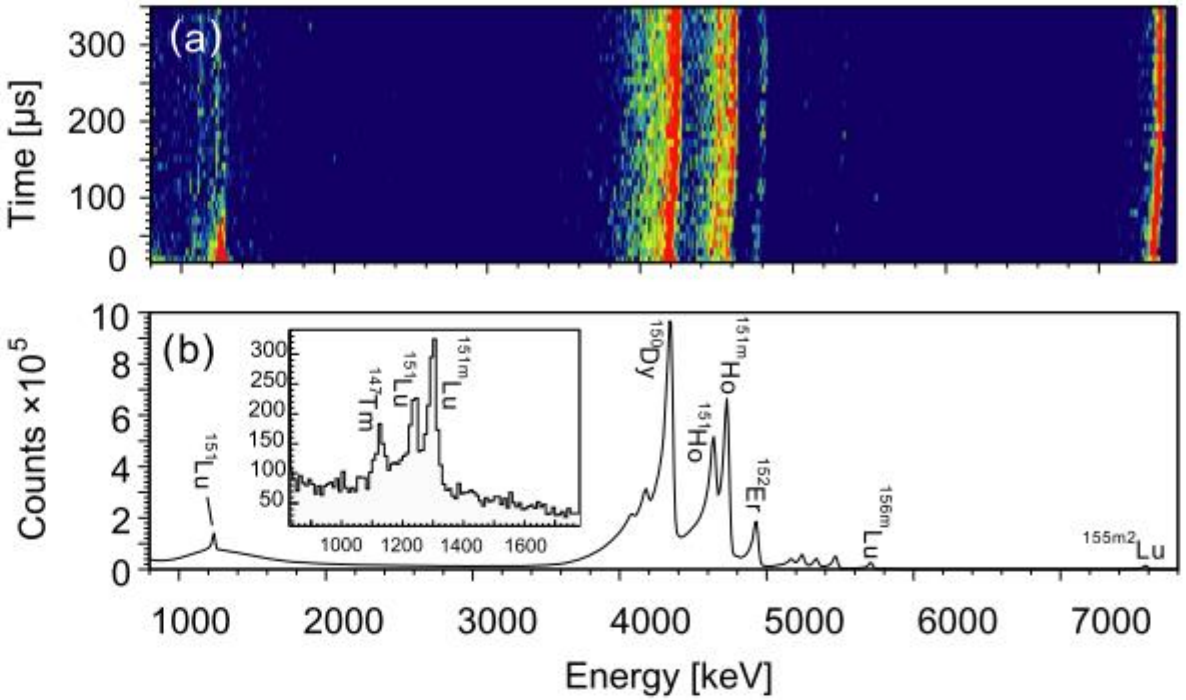
Spectroscopic factor and proton formation probability for the $d_{3/2}$ proton emitter ^{151m}Lu

F. Wang et al. / Physics Letters B 770 (2017) 83–87



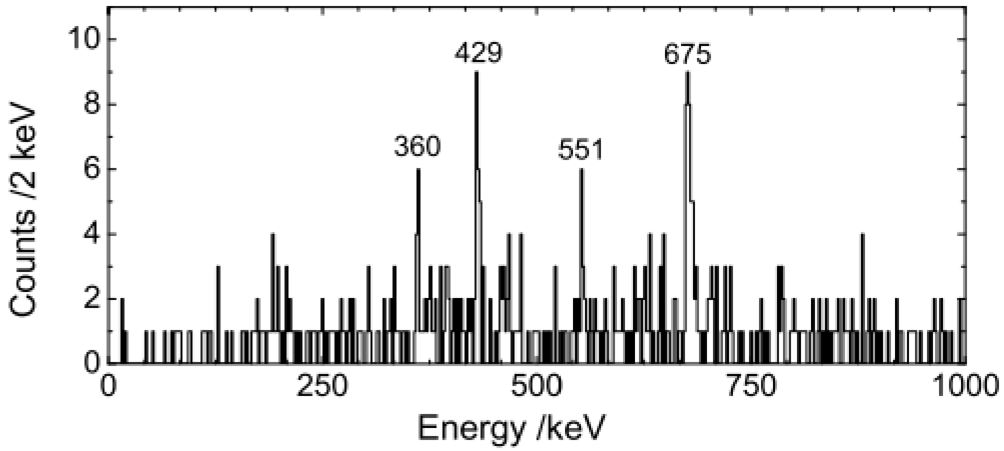


Fig. 2. Prompt γ-ray spectrum tagged with proton decay from the ^{151m}Lu.

Table 1
Energies and efficiency-corrected relative intensities for γ-ray transitions assigned to ^{151m}Lu. The relative intensities are normalized to that of the 675 keV transition.

E_γ /keV	I_γ
675	100(28)
429	35(14)
360	33(15)
551	30(15)

^{151}Lu（实验目的1：结构研究）

PHYSICAL REVIEW C **96**, 064307 (2017)

Reinvestigation of the excited states in the proton emitter ^{151}Lu: Particle-hole excitations across the $N = Z = 64$ subshell

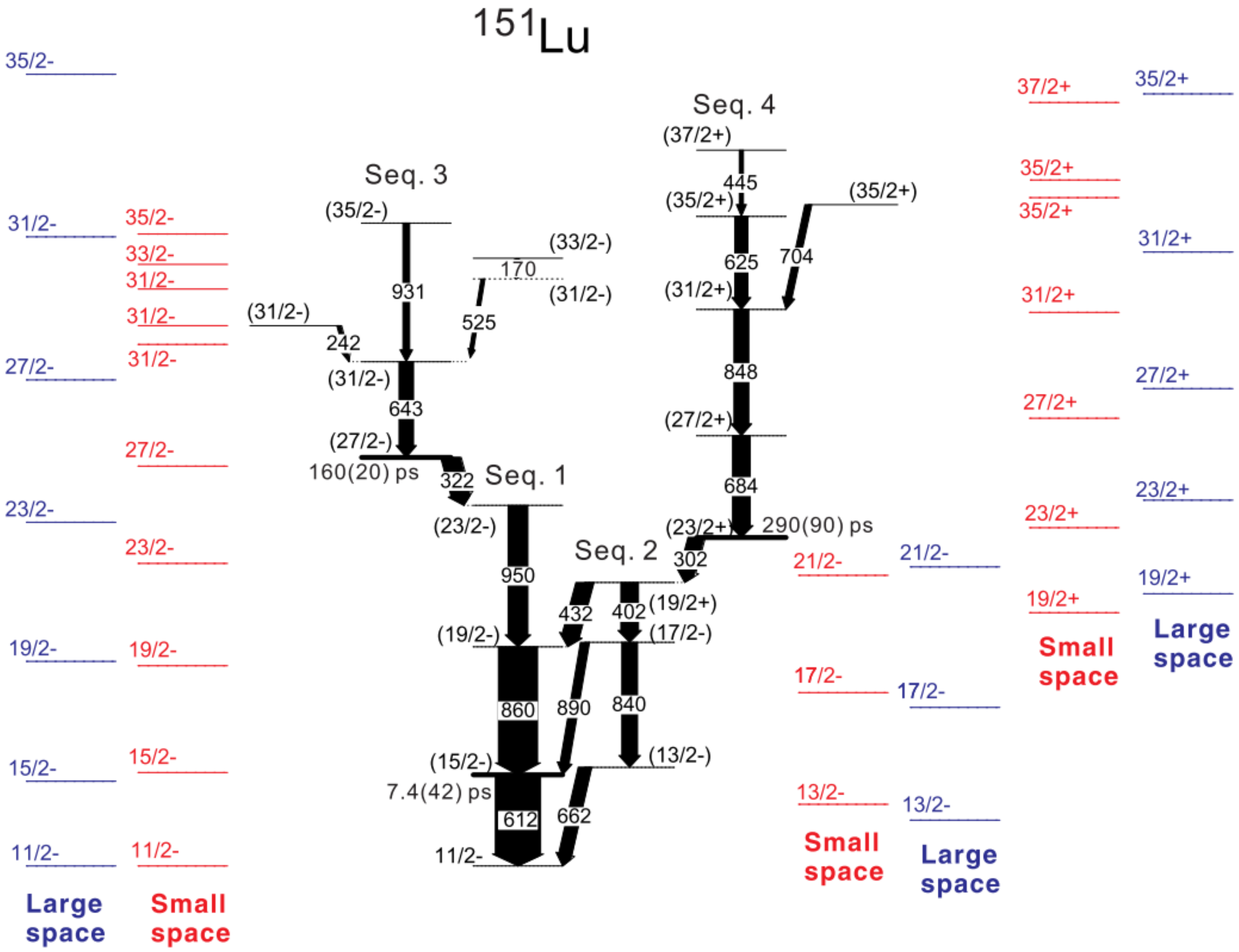


FIG. 3. Level scheme based on the g.s. of ^{151}Lu established in this work. Tentative spin-parity assignments in the four level sequences (Seq.) are indicted in brackets. Theoretical calculations are done in the large-scale shell model. The half-lives for the $(15/2^-)$, $(27/2^-)$, and $(23/2^+)$ states are from Ref. [10].

^{150}Yb（实验目的2：研究其衰变和结构）

E(level)	J^{π}	$T_{1/2}$	XREF	Comments
0.0	0^+	≥200 ns	AB	$T_{1/2}$: This level was observed in the ^{197}Au(30 MeV/A) + ^{90}Zr reaction. The minimum observed flight path in this expt. was 200 ns (2000So11).

^{151}Lu p decay (80.6 ms) 1993Se04,1982Ho04

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	S. K. Basu, A. A. Sonzogni	NDS 114, 435 (2013)	1-Apr-2013

Parent: ^{151}Lu: E=0.0; J^{π}=11/2$^-$; $T_{1/2}$=80.6 ms *19*; Q(p)=1241 *3*; %p decay=63.4 *9*
^{151}Lu-%p decay: from experimental $T_{1/2}$ and assuming $T_{1/2}(\varepsilon+\beta^+)$=220 ms (1997Mo25).
1993Se04: ^{96}Ru(^{58}Ni,X) E=300, 311 MeV. ^{151}Lu separated by recoil-mass separator. Measured proton spectra and $T_{1/2}$.
1982Ho04: ^{96}Ru(^{58}Ni,X) E=240-302 MeV. ^{151}Lu is produced by p2n channel.
1995Ho26: compilation of earlier measurements on proton emitters, including that on ^{151}Lu.

^{150}Yb Levels

E(level)	J^{π}
0.0	0^+

Protons (^{150}Yb)

E(p)	E(^{150}Yb)	Comments
1233 *3*	0.0	from 1993Se04. Other: 1231 *3* (1982Ho04). Identified as L(p)=5 transition (1993Se04,1982Ho04).

^{151}Lu p decay (16 μs) 1999Bi14

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	S. K. Basu, A. A. Sonzogni	NDS 114, 435 (2013)	1-Apr-2013

Parent: ^{151}Lu: E=77 *5*; J^{π}=3/2$^+$; $T_{1/2}$=16 μs *1*; Q(p)=1241 *3*; %p decay=100.0
^{151}Lu-%p decay: From measured $T_{1/2}$ much smaller than calculated values from 1997Mo25: $T_{1/2}(\beta)$=0.2200 s, $T_{1/2}(\alpha)=8.341\times10^5$ y.
1999Bi14: ^{96}Ru(^{58}Ni,X) E=266 MeV. ^{151}Lu separated by recoil-mass separator at HRIBF(ORNL) and implanted in double sided silicon strip detector. Measured proton spectra and $T_{1/2}$.
E(p)=1310 *10*.

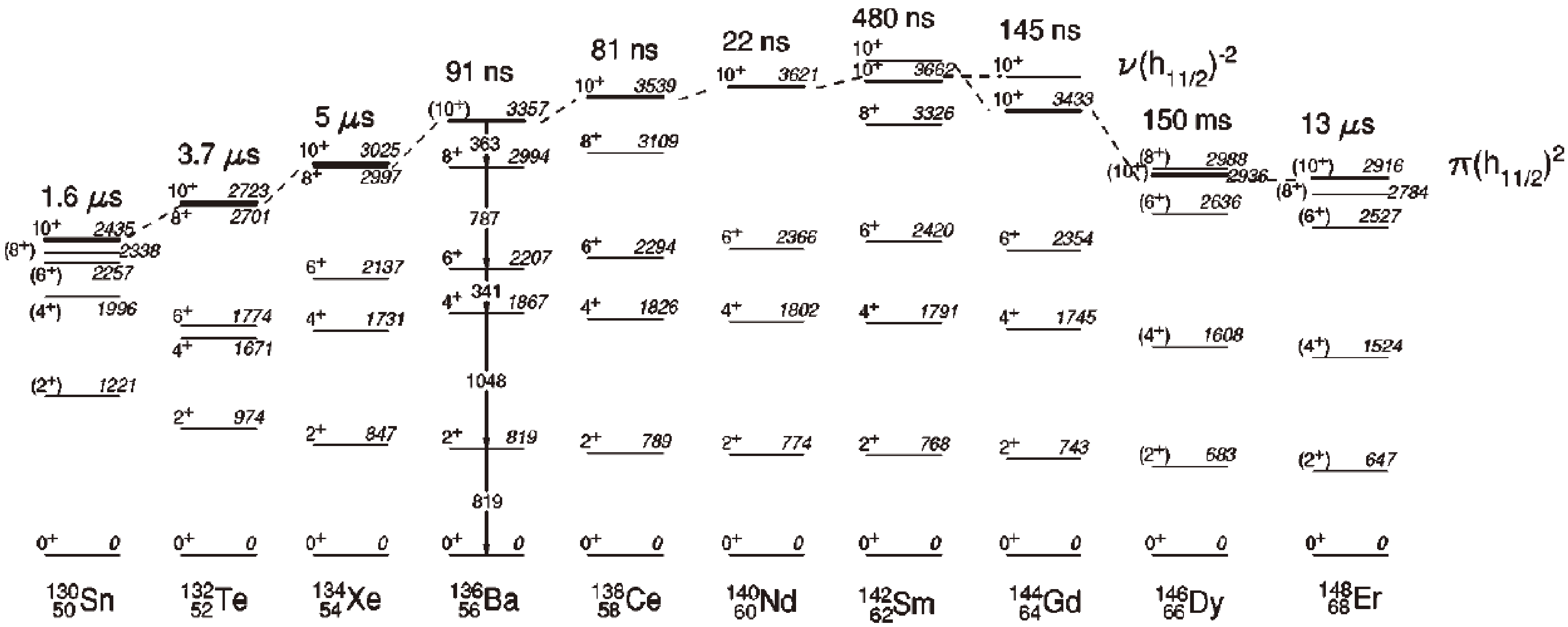
^{150}Yb Levels

E(level)	J^{π}
0.0	0^+

Protons (^{150}Yb)

E(p)	E(^{150}Yb)	Comments
1310 *10*	0.0	Identified as L(p)=2 transition (1999Bi14).

^{150}Yb （实验目的2：找10+ isomer）



Products $^{58}Ni + ^{96,99,101,102}Ru \rightarrow ^{154,157,159,160}Hf$

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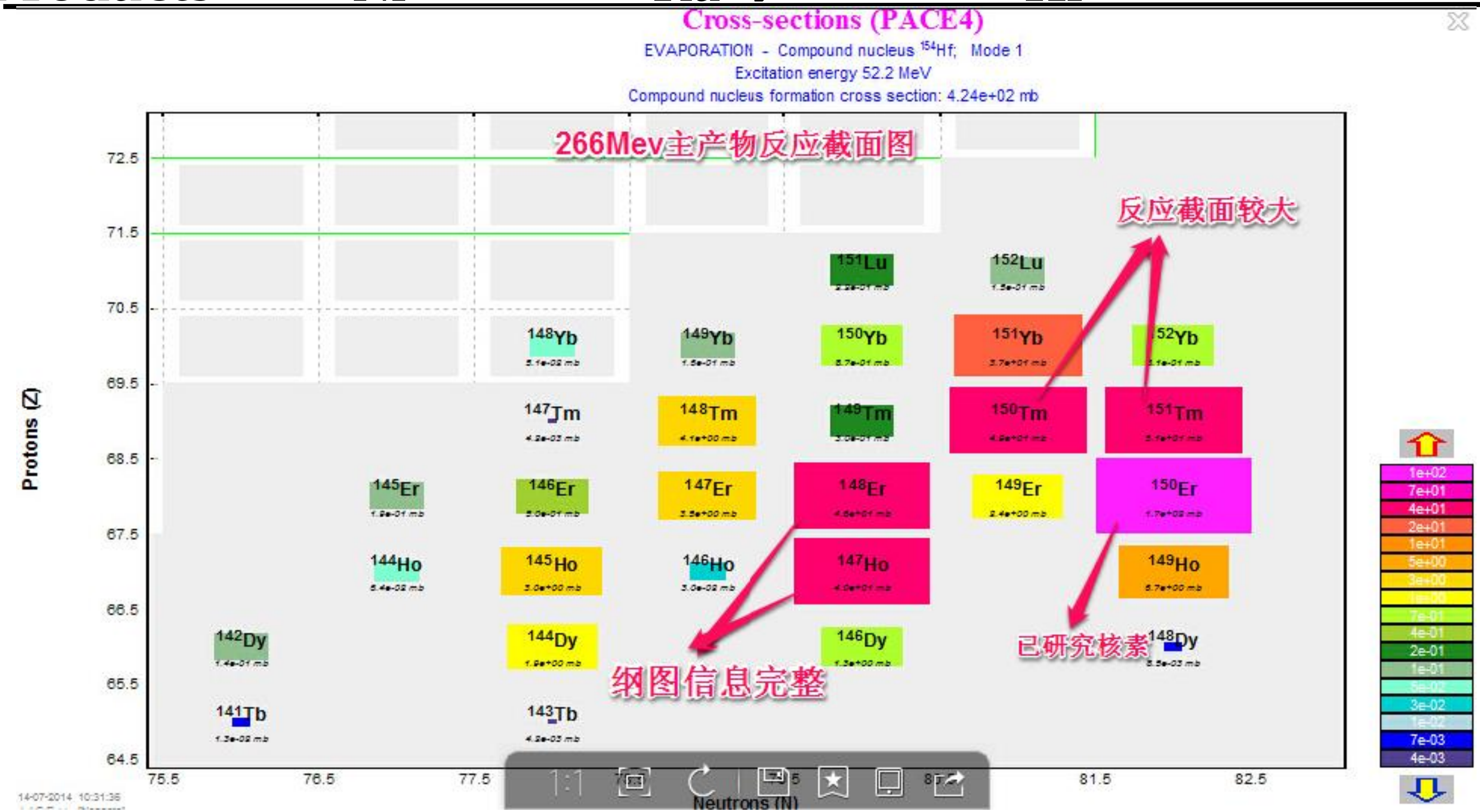


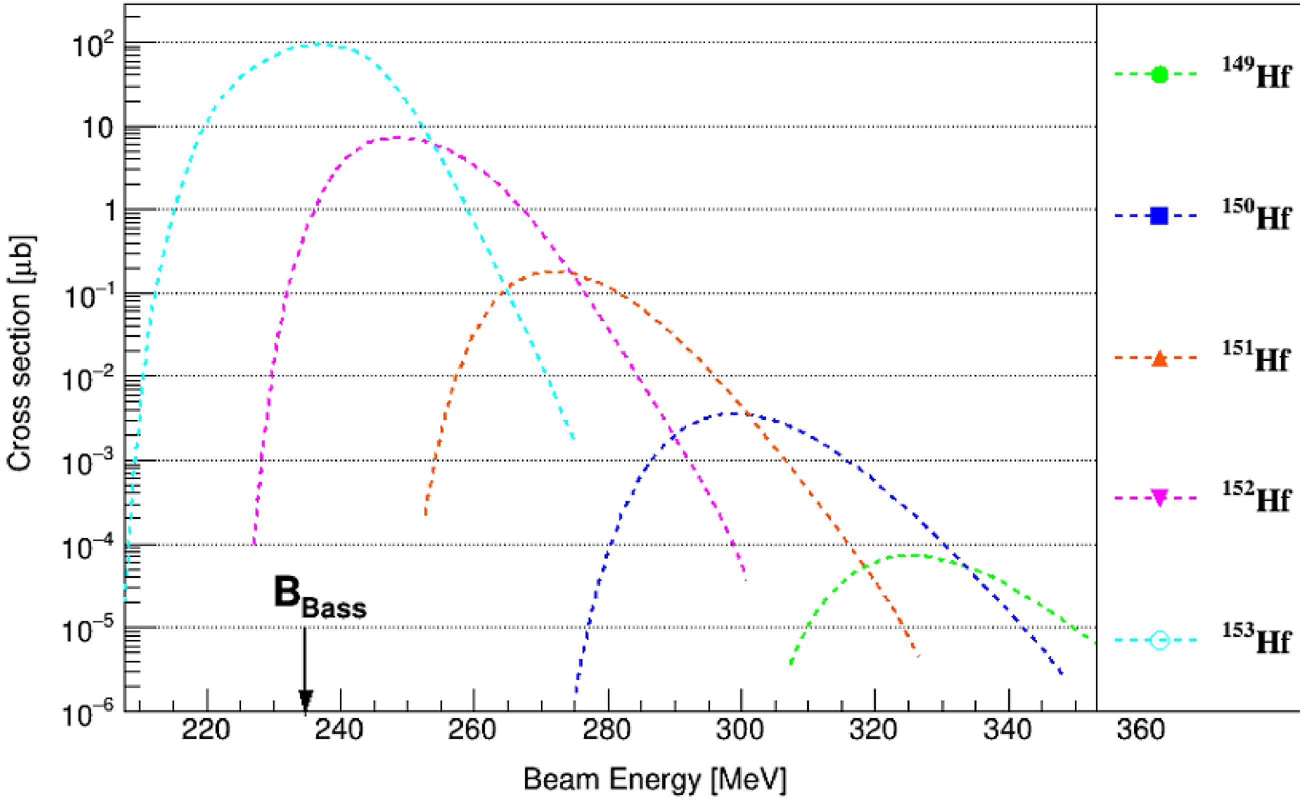
Products

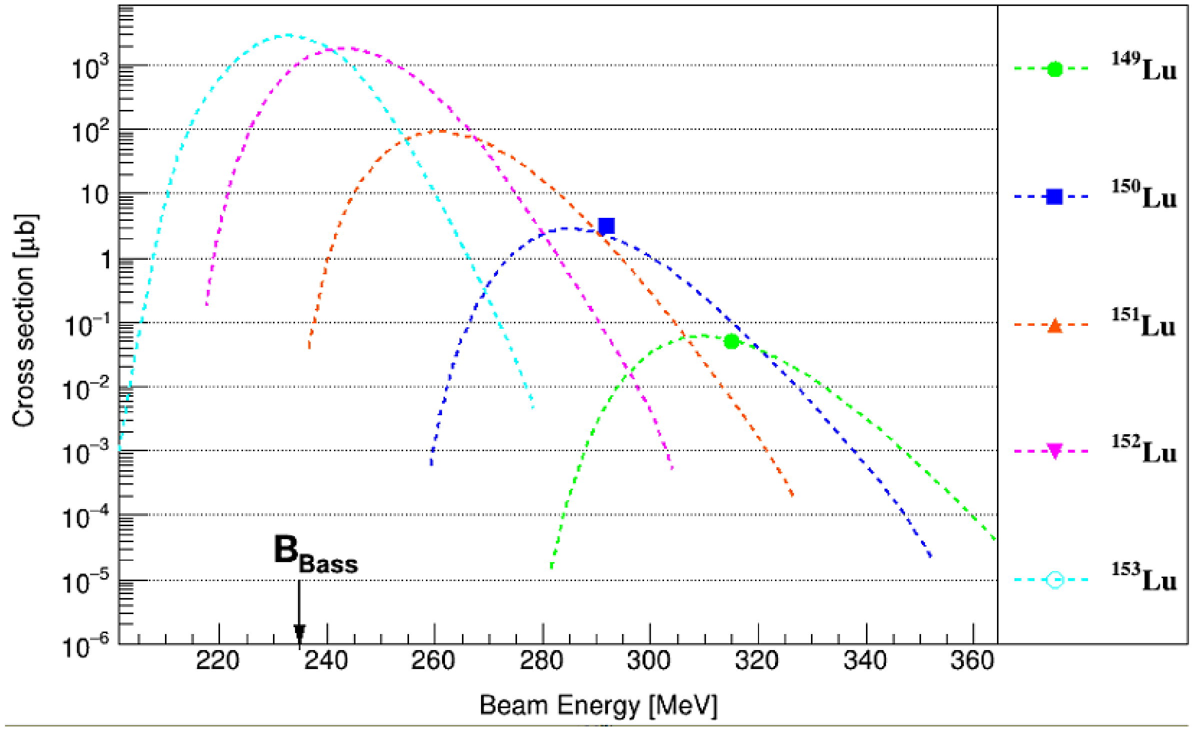
^{58}Ni + ^{96,99,101,102}Ru → ^{154,157,159,160}Hf (266 MeV/274MeV)

Z \ N	77	78	80	81	82	83	84	85
72	$^{150}_{72}Hf$	$^{151}_{72}Hf$ (0.1ub)	$^{152}_{72}Hf$ (2ub)	$^{153}_{72}Hf$	$^{154}_{72}Hf$	$^{155}_{72}Hf$	$^{156}_{72}Hf$ g 23ms 100% 5873 m 0.52ms 100% 7782	$^{157}_{72}Hf$ g 115ms 94% 5731
71	$^{149}_{71}Lu$	$^{150}_{71}Lu$(0.1ub) g 46 ms 1261 m 43us 1283	$^{151}_{71}Lu$(100ub) g 80.6ms 63.4% 1233 m 16us 100% 1310	$^{152}_{71}Lu$(100ub) 10+ isomer? g.S EC + ECP	$^{153}_{71}Lu$	$^{154}_{71}Lu$	$^{155}_{71}Lu$ g 68ms 90% 5650 m1 138ms 76% 5581 m2 2.7ms 100% 7390	$^{156}_{71}Lu$ g 494ms 95% 5453 m 198ms100% 5565
70	$^{148}_{70}Yb$	$^{149}_{70}Yb$(20ub) 0.7s	$^{150}_{70}Yb$(300ub) g >= 200ns	$^{151}_{70}Yb$(8mb) 1.6s 11/2- 0+x 1.6s g.s EC +P	$^{152}_{70}Yb$ (2mb) 3.03s	$^{153}_{70}Yb$ 4.2 s	$^{154}_{70}Yb$ g 0.409s 92.6% 5330.9	$^{155}_{70}Yb$ g 1.8s 89% 5200
69	$^{147}_{69}Tm$ m 360us 100% 1113	$^{148}_{69}Tm$	$^{149}_{69}Tm$ 300ub	$^{150}_{69}Tm$(10mb) 10+ 5.2ms gs EC + P g.S 2.2s IT	$^{151}_{69}Tm$(γ) 10 mb	$^{152}_{69}Tm$	$^{153}_{69}Tm$ g 1.48s 91% 5103	$^{154}_{69}Tm$ m 3.3s 58% 5031
68	$^{146}_{68}Er$	$^{147}_{68}Er$	$^{148}_{68}Er$	$^{149}_{68}Er$ 3mb	$^{150}_{68}Er$(γ) 50 mb	$^{151}_{68}Er$	$^{152}_{68}Er$ g 10.3s 91% 4804.3	$^{153}_{68}Er$ g 37.1s 53% 4674
67	$^{145}_{67}Ho$	$^{146}_{67}Ho$	$^{147}_{67}Ho$	$^{148}_{67}Ho$	$^{149}_{67}Ho$	$^{150}_{67}Ho$	$^{151}_{67}Ho$ g 35.2s 22% 4522 m 47.2s 80% 4611	$^{152}_{67}Ho$ g 83.8s 0.064 4232
66	$^{144}_{66}Dy$	$^{145}_{66}Dy$	$^{146}_{66}Dy$	$^{147}_{66}Dy$	$^{148}_{66}Dy$	$^{149}_{66}Dy$	$^{150}_{66}Dy$ g 7.17min 33.6% 4232	$^{151}_{66}Dy$ g 17.9min 5.6% 4069

Products

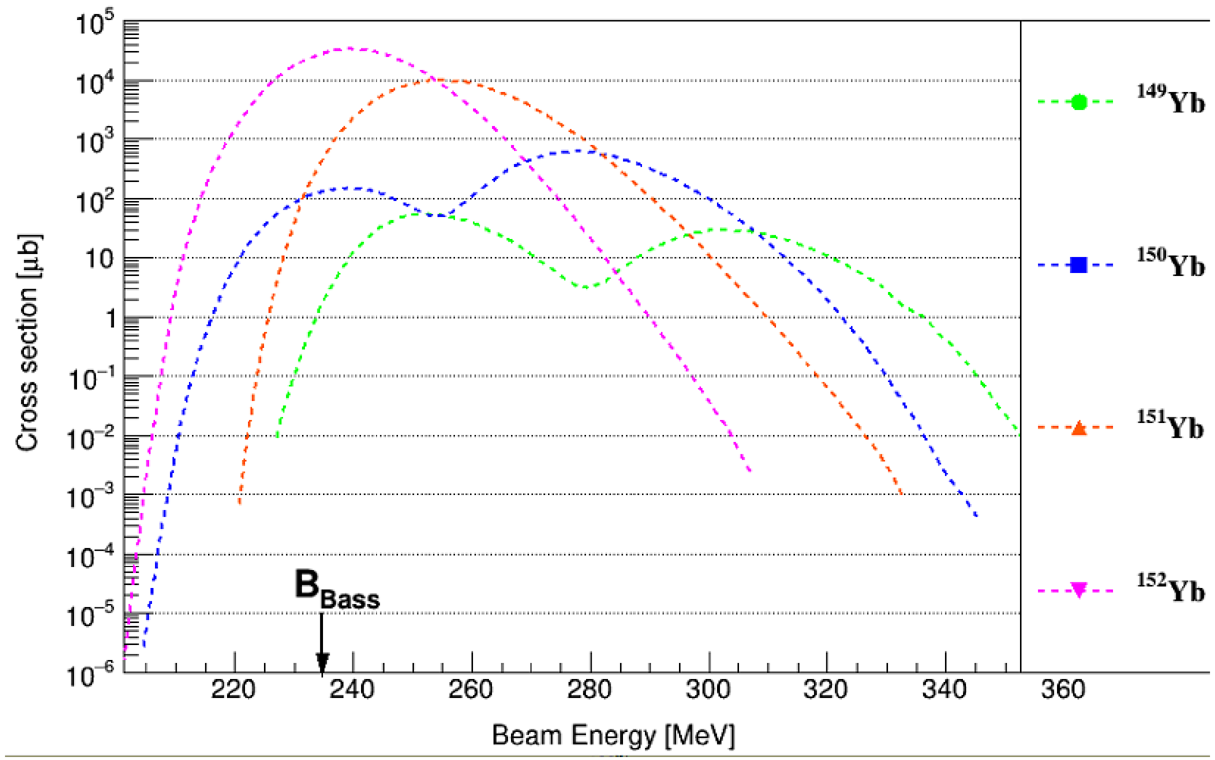
$^{58}Ni + ^{96,99,101,102}Ru \rightarrow ^{154,157,159,160}Hf$ (266 MeV/274MeV)

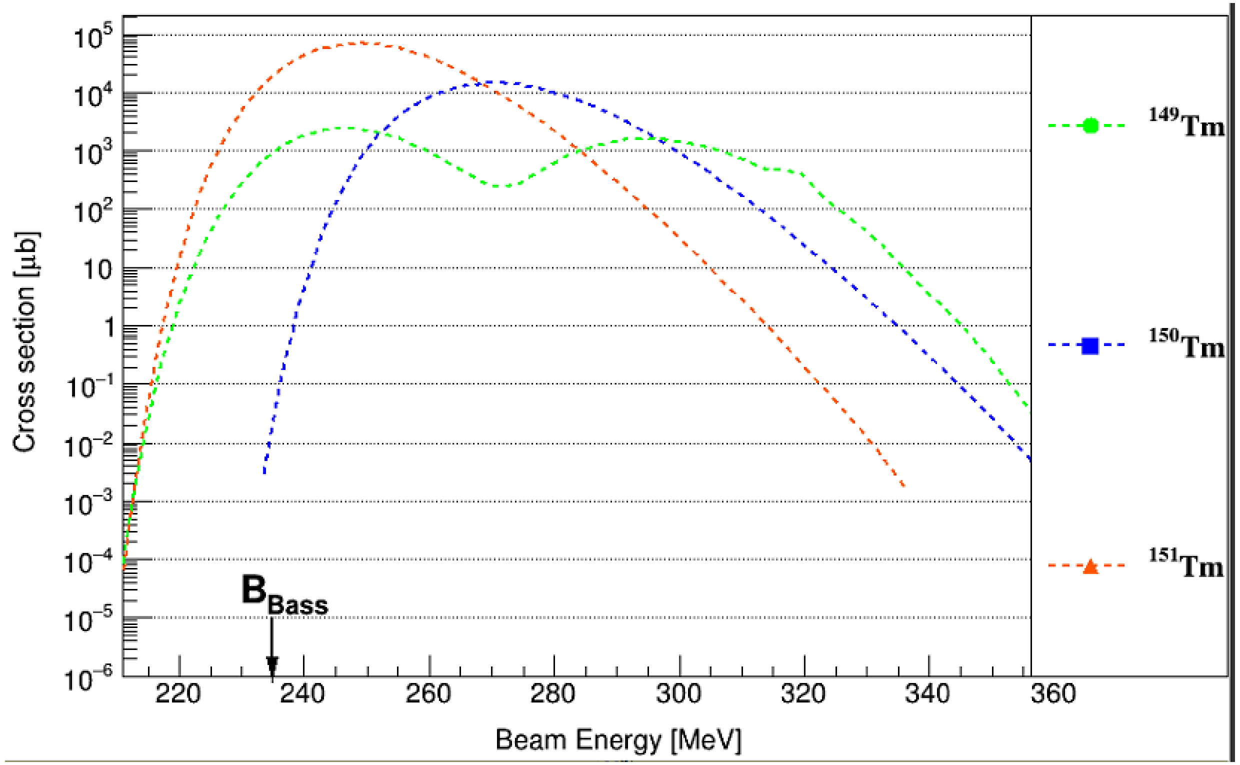




Products

$^{58}Ni + ^{96,99,101,102}Ru \rightarrow ^{154,157,159,160}Hf$ (266 MeV/274MeV)

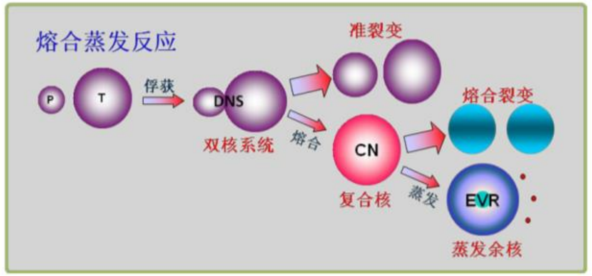


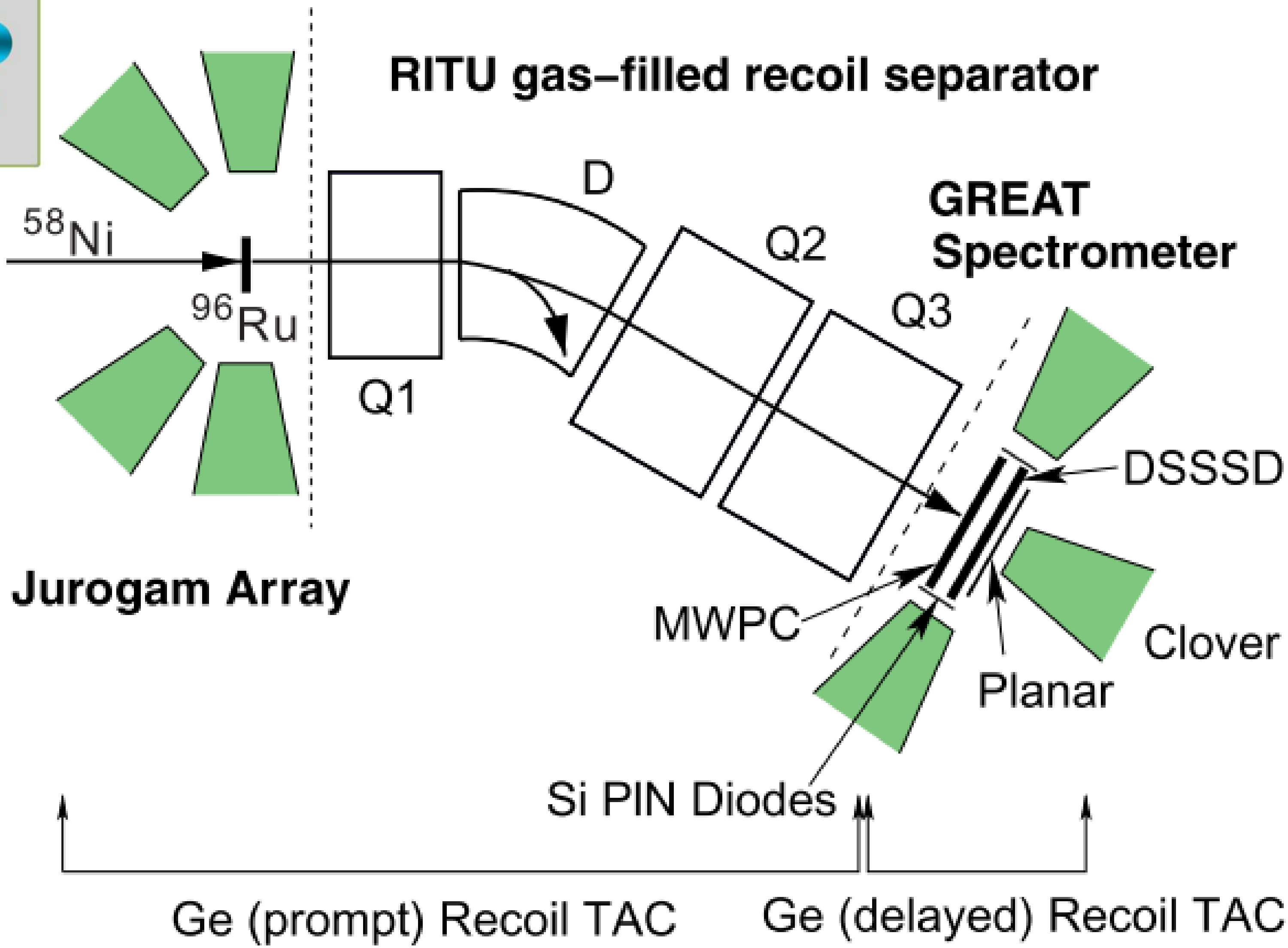


Experiment(^{96}Ru(^{58}Ni, p2n/2p2n)^{151}Lu/^{150}Yb)

- **Target:** ^{96}**Ru**(0.5mg/cm^2)+50ug /cm^2 · C(reset foil)
- **Beam energy:** 274 MeV, 266MeV *110h
- **Beam intensity**: 3 pnA
- **Energy in middle of target**:
  - 269.5 MeV, 261.5 MeV

实验设置


熔合蒸发反应
P
T
俘获
DNS
双核系统
准裂变
熔合
CN
复合核
熔合裂变
蒸发
EVR
蒸发余核


RITU gas–filled recoil separator
^{58}Ni
^{96}Ru
Q1
D
Q2
Q3
GREAT
Spectrometer
DSSSD
Jurogam Array
MWPC
Clover
Planar
Si PIN Diodes
Ge (prompt) Recoil TAC
Ge (delayed) Recoil TAC

多普勒修正

Doppler correction:

Beam Energy		Compound nucleus		
In front of target	In middle of target	Energy	beta	V
266 MeV	261.5 MeV	98.487 MeV	0.03706	1.112 cm/ns
274 MeV	269.53 MeV	101.511 MeV	0.03762	1.129 cm/ns

beta足够小后修正为

我们用的即为此公式。对目标核151Lu，我们的beta~0.0335 (266 MeV) and 0.0345 (274MeV).

$$E_{C.M.} = \gamma(1 - \beta \cos \theta_{Lab}) E_{Lab}$$

$$\gamma = \frac{1}{\sqrt{1-(v/c)^2}} = \frac{1}{\sqrt{1-\beta^2}}$$

Doppler correction:

Starting conditions

	Z	N	A
Projectile	28	30	58
Target	44	52	9
Compound nucleus	72	82	15

Bombarding energy (MeV)	215.00
Center of mass energy (MeV)	134.03
Compound nucleus excitation energy (MeV)	20.387
Q-value of reaction (MeV)	-113.639
Compound nucleus recoil energy (MeV)	80.974
Compound nucleus recoil velocity (cm/ns)	1.008e+00
Compound nucleus velocity/c	3.360e-02
Beam velocity (cm/ns)	2.676e+00
Beam velocity/c	8.921e-02

2.1 Energy and angular distribution of residual nucleus Z=71 N=82 (153Lu)

Residual Velocity/c Vz=3.44e-02(sig=5.63e-04) root-mean-square Vxy=7.85e-04

2.2 Energy and angular distribution of residual nucleus Z=70 N=82 (152Yb)

Residual Velocity/c Vz=3.47e-02(sig=6.59e-04) root-mean-square Vxy=9.66e-04

$$E_\gamma = E_0\left(1+\frac{v}{c}cos\theta\right),$$

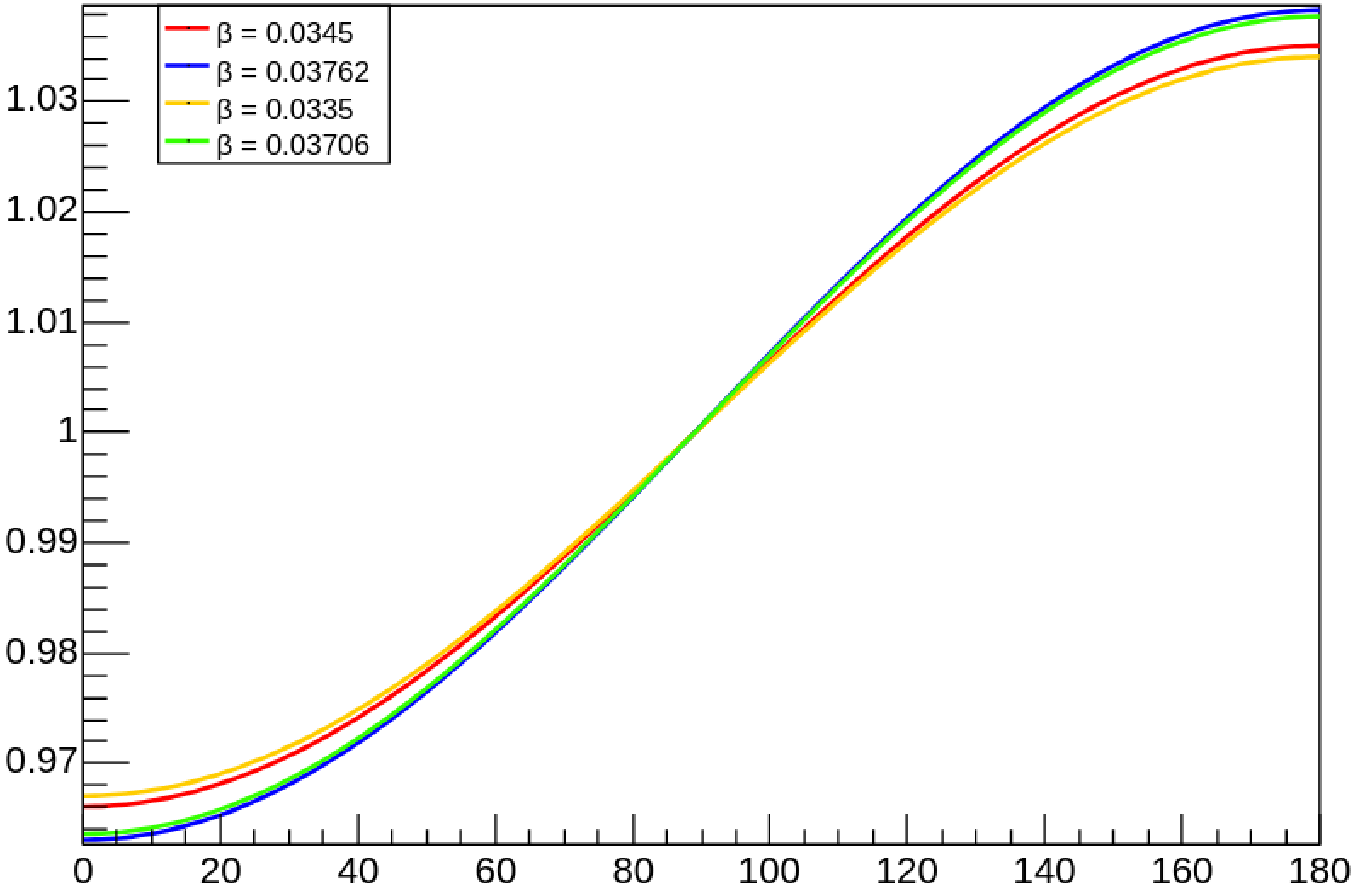
beta足够小后修正为

我们用的即为此公式。对目标核151Lu，我们的beta~0.0335 (266 MeV) and 0.0345 (274MeV).

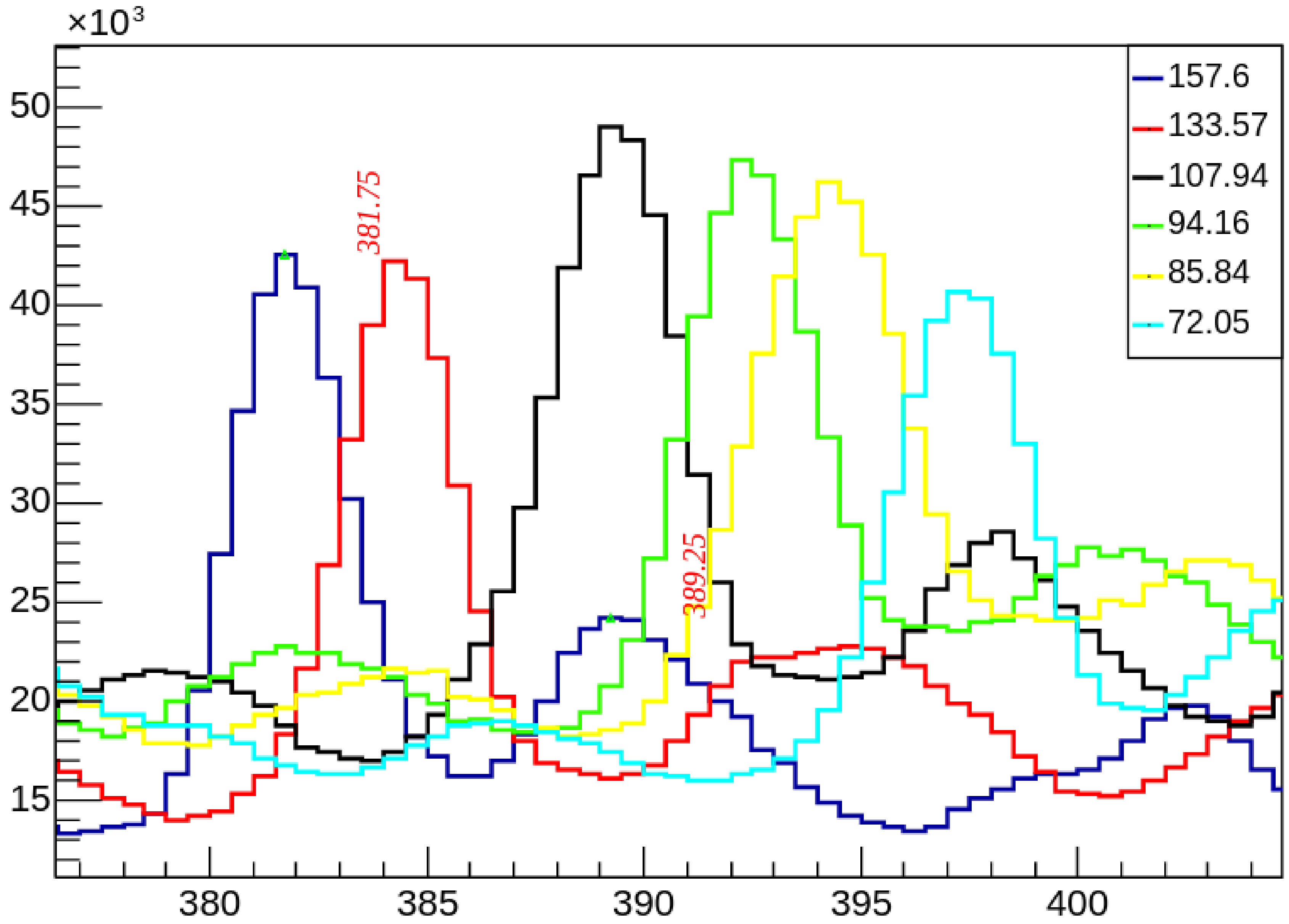
Doppler correction:

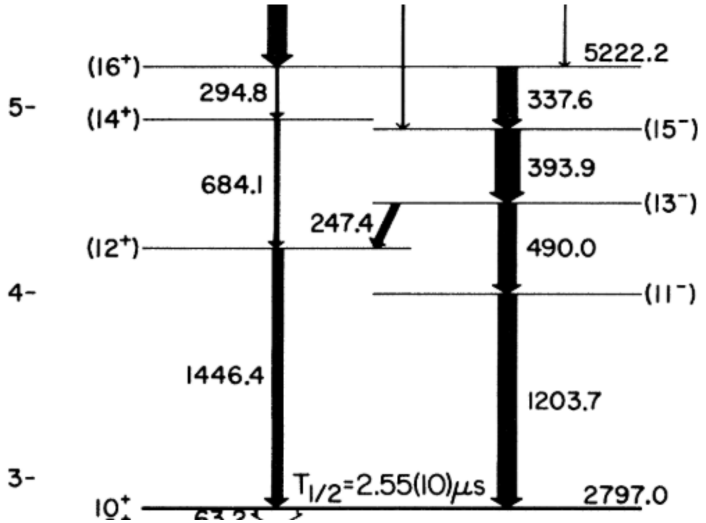
$$E_{C.M.} = \boxed{\gamma(1-\beta\cos\theta_{Lab})}E_{Lab}$$

$$\gamma = \frac{1}{\sqrt{1-(v/c)^2}} = \frac{1}{\sqrt{1-\beta^2}}$$

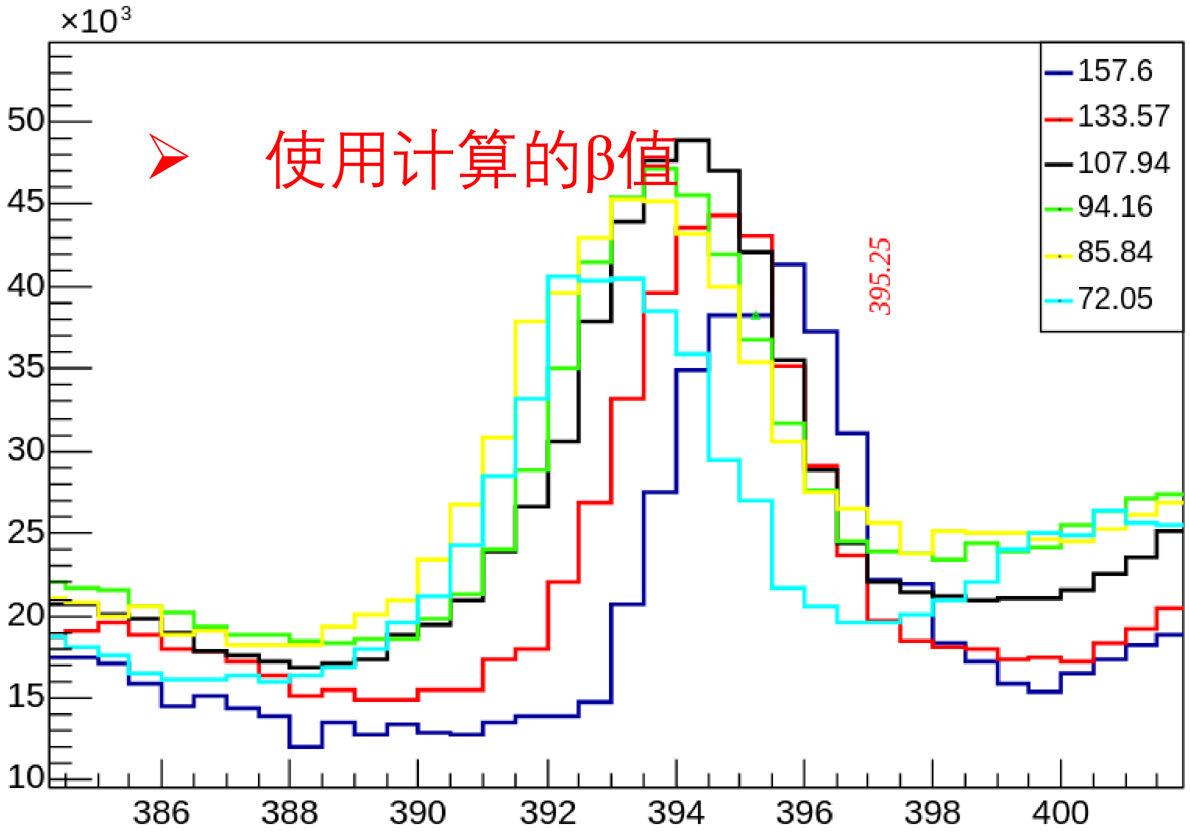


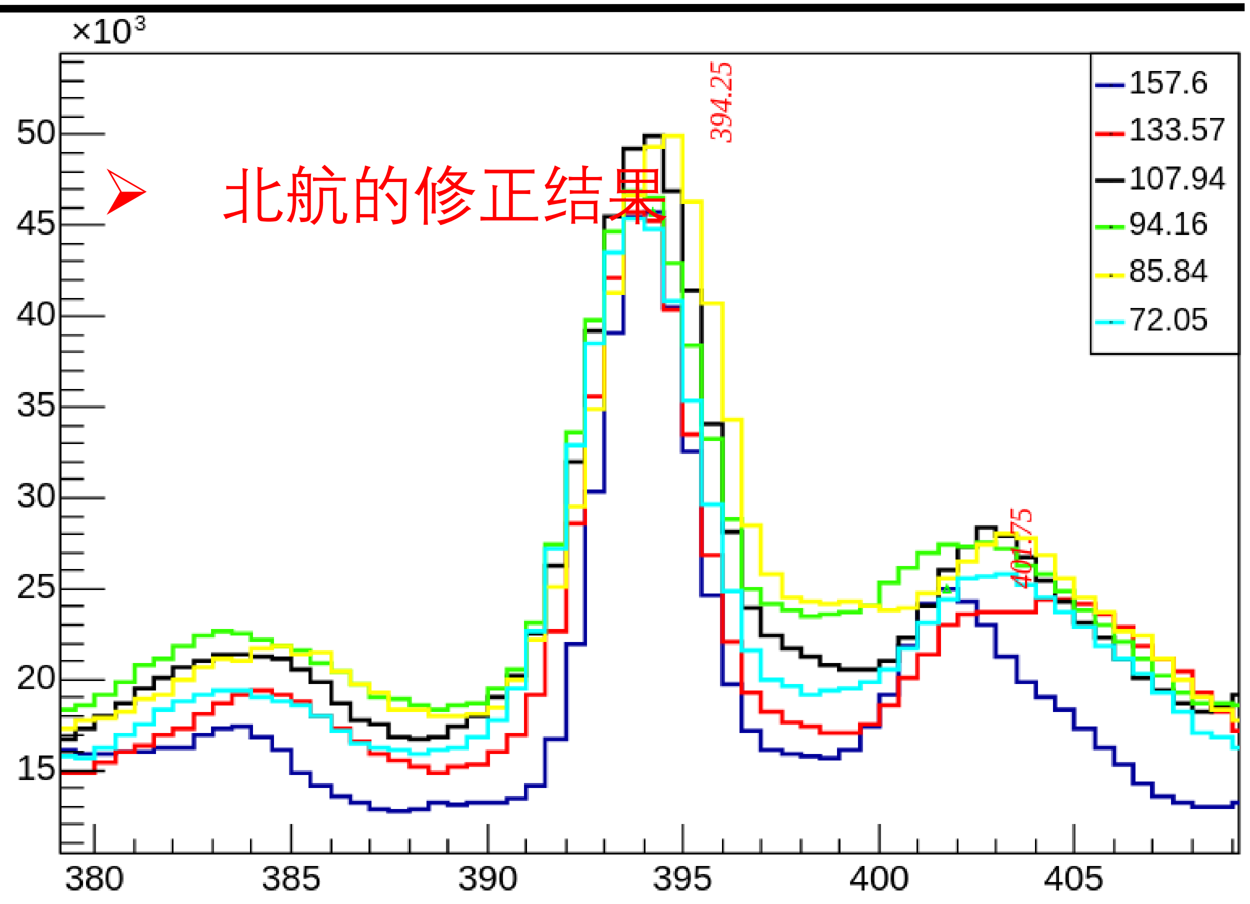
Without Doppler correction:





Doppler correction:





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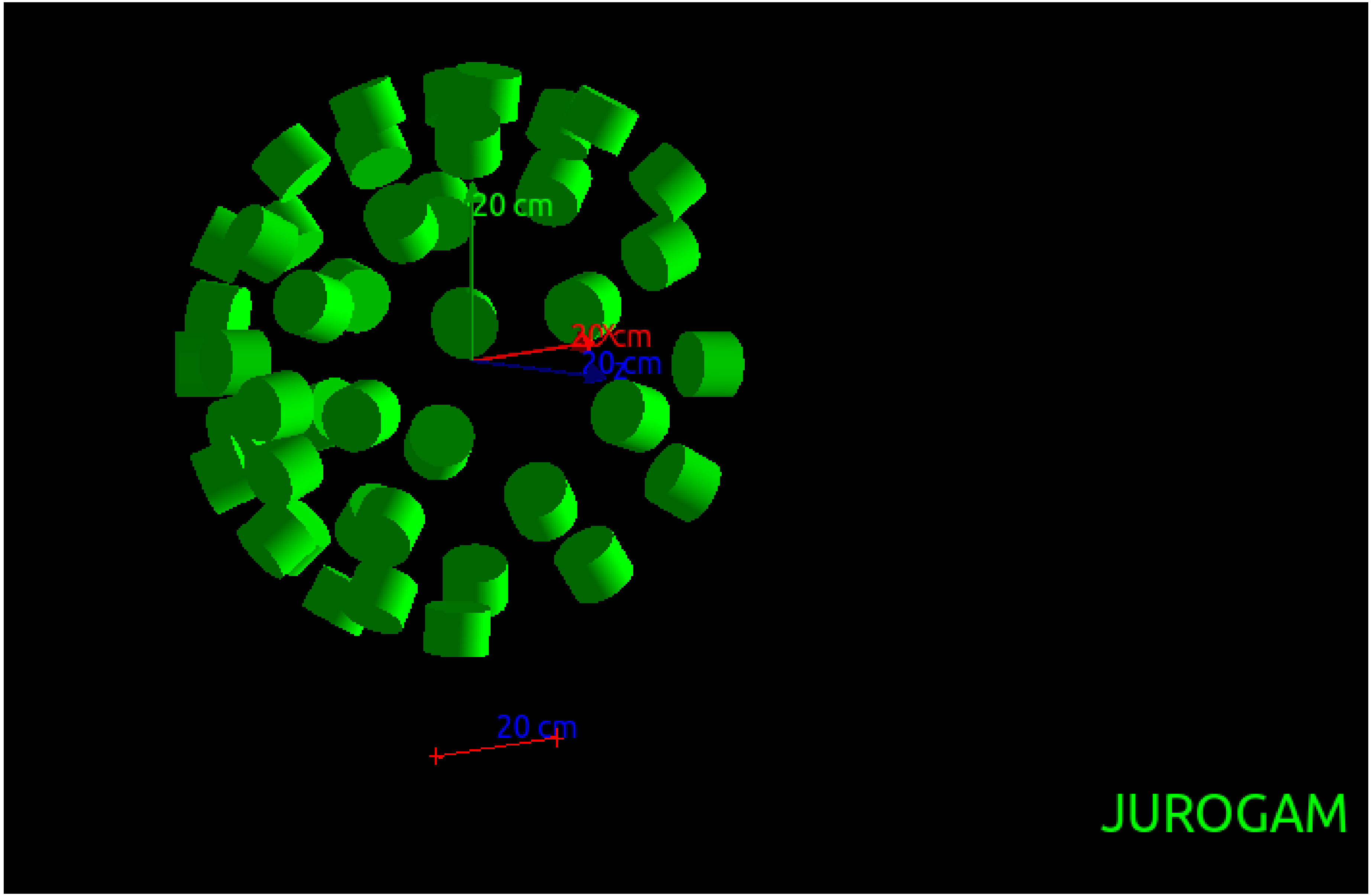
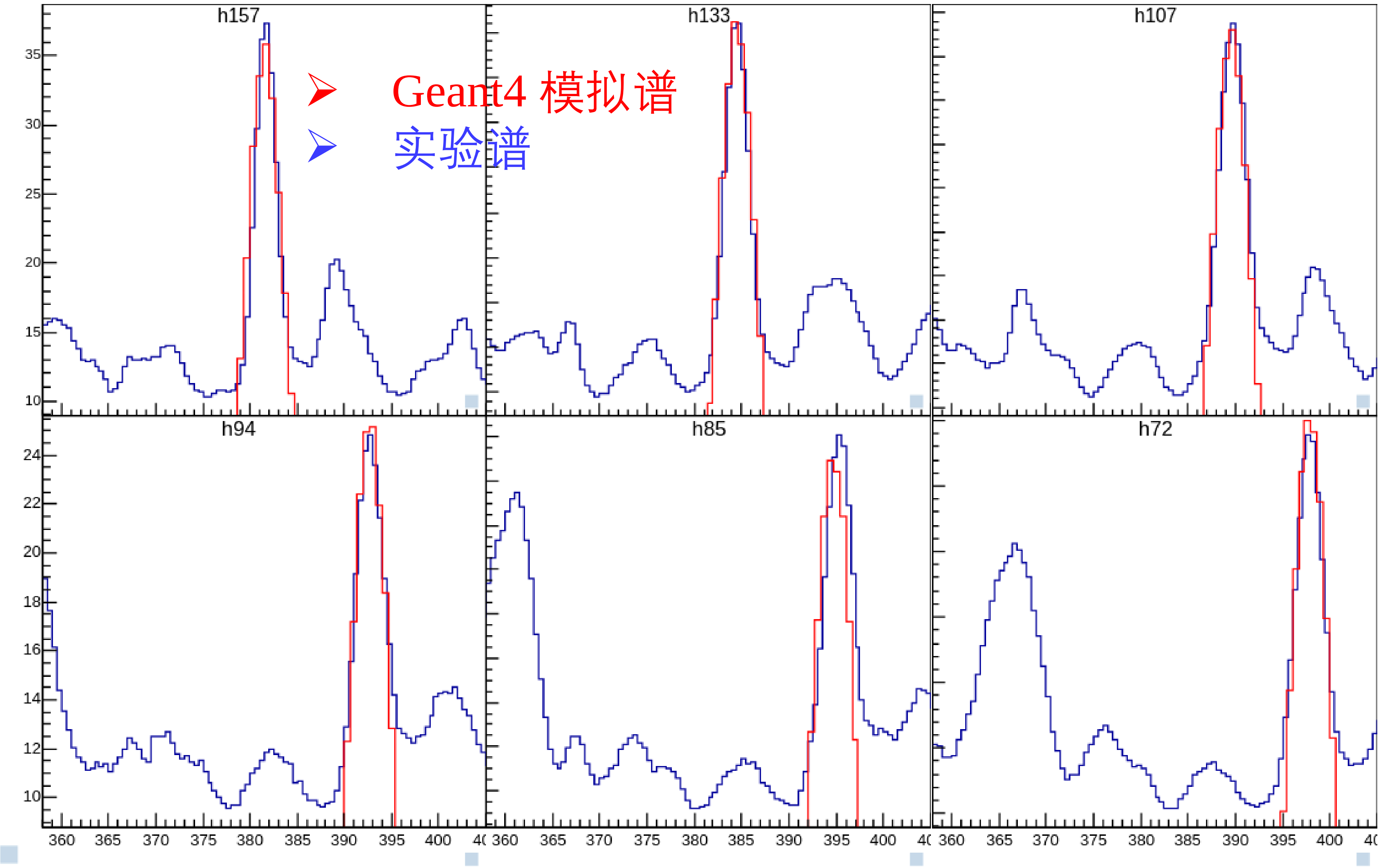
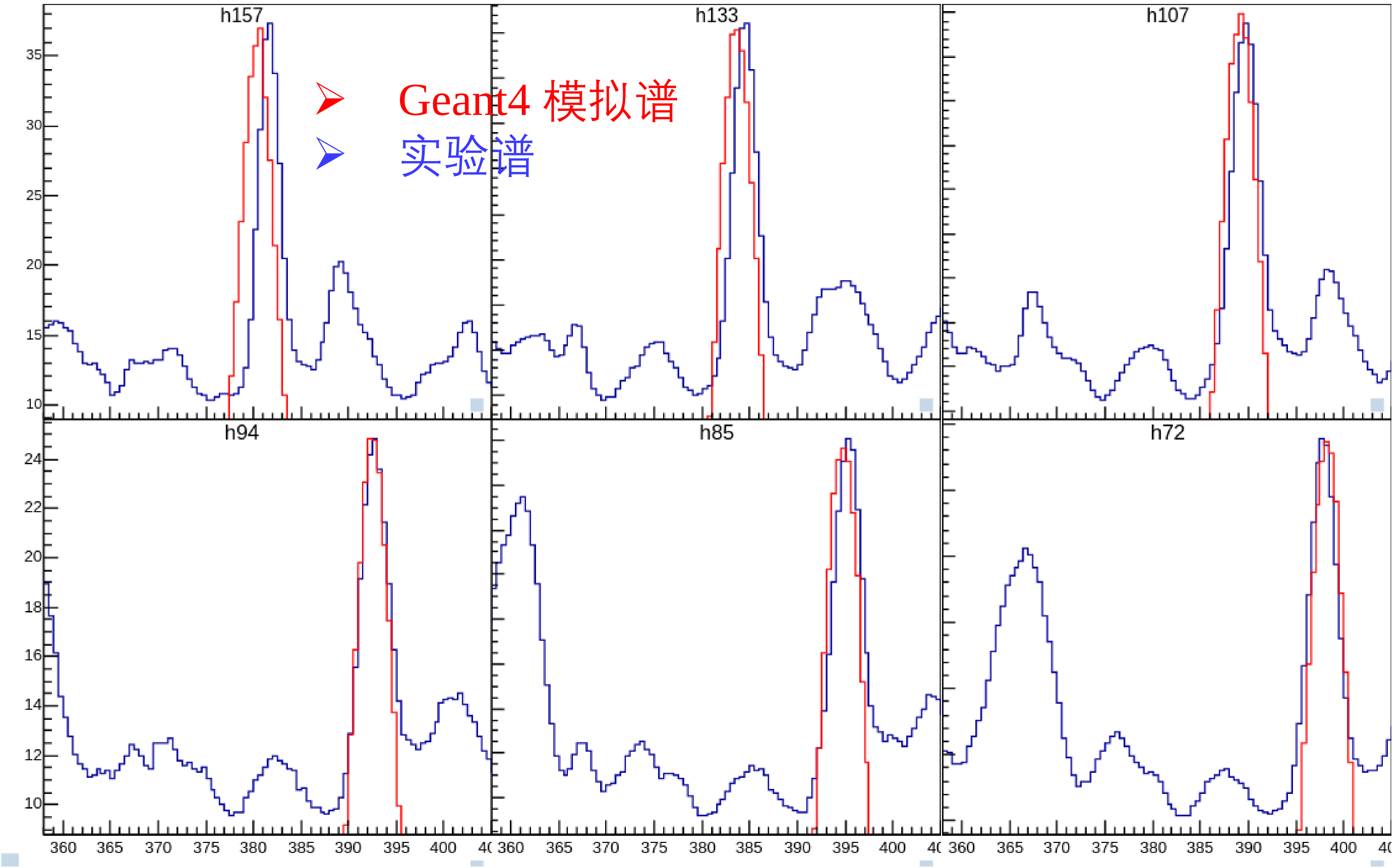


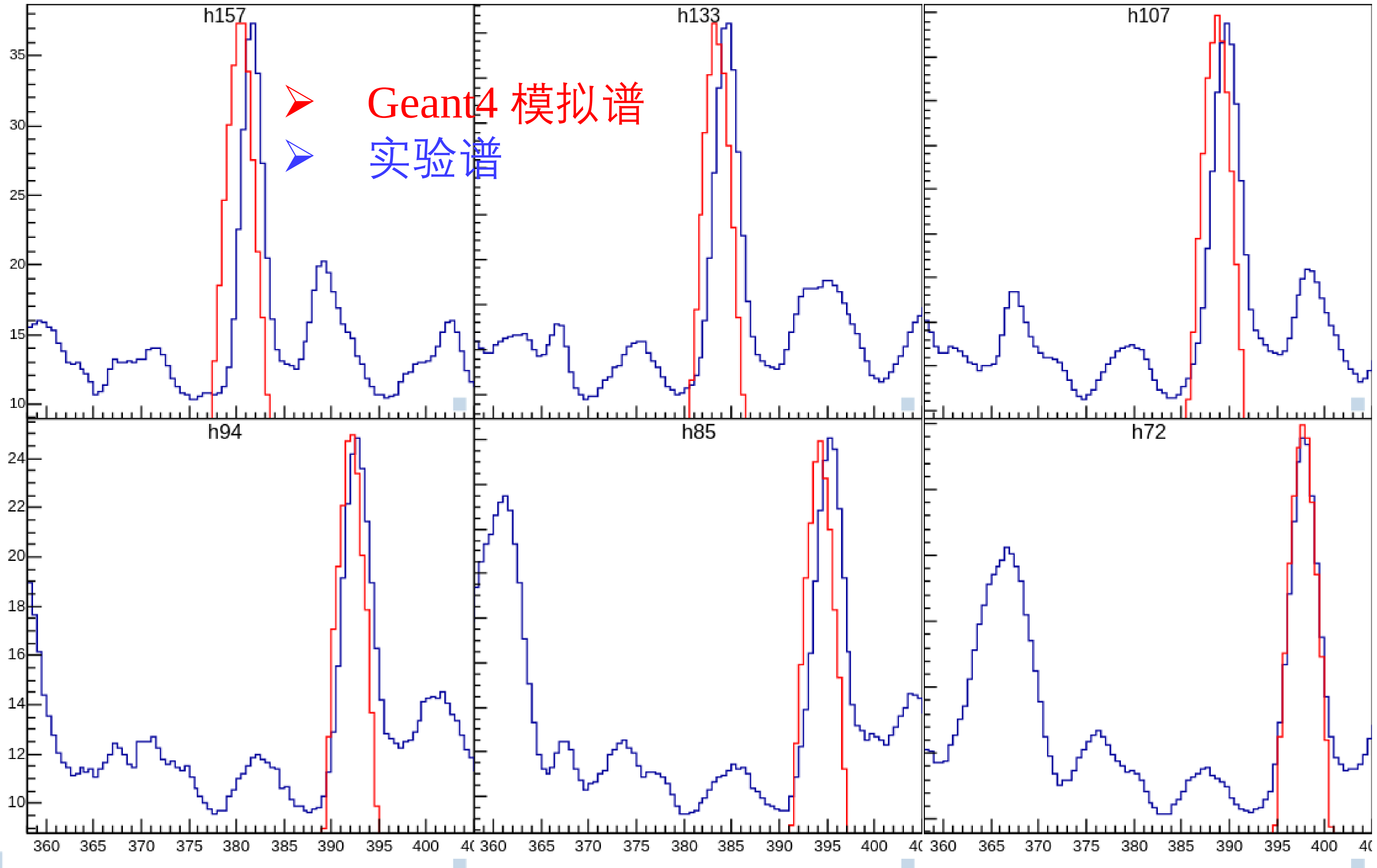
Doppler correction(β=0.0345):



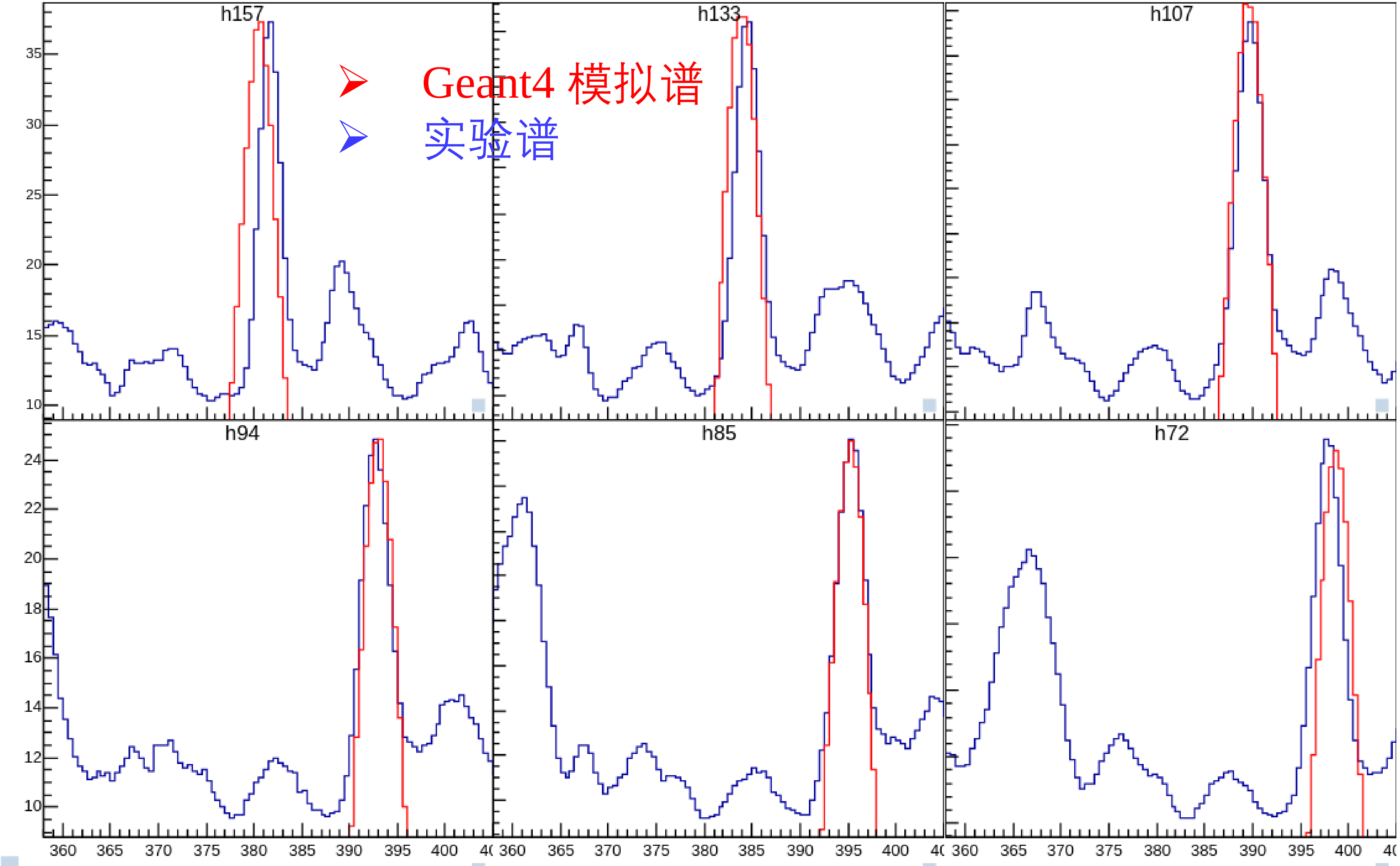
Doppler correction（β =0.03762）：



Doppler correction（β =0.03762, z=1cm）：



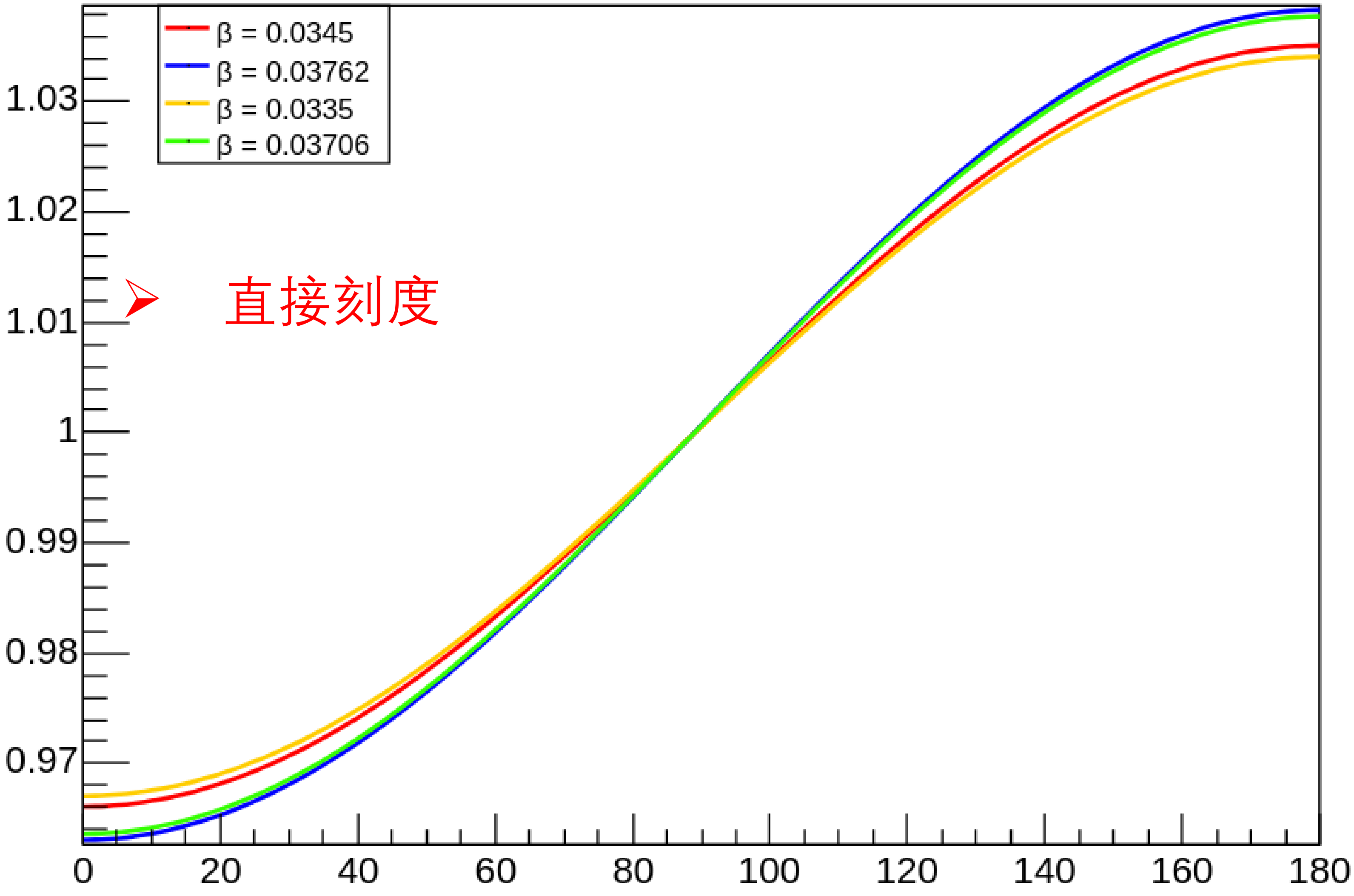
Doppler correction（β=0.03762, z=-1cm）：



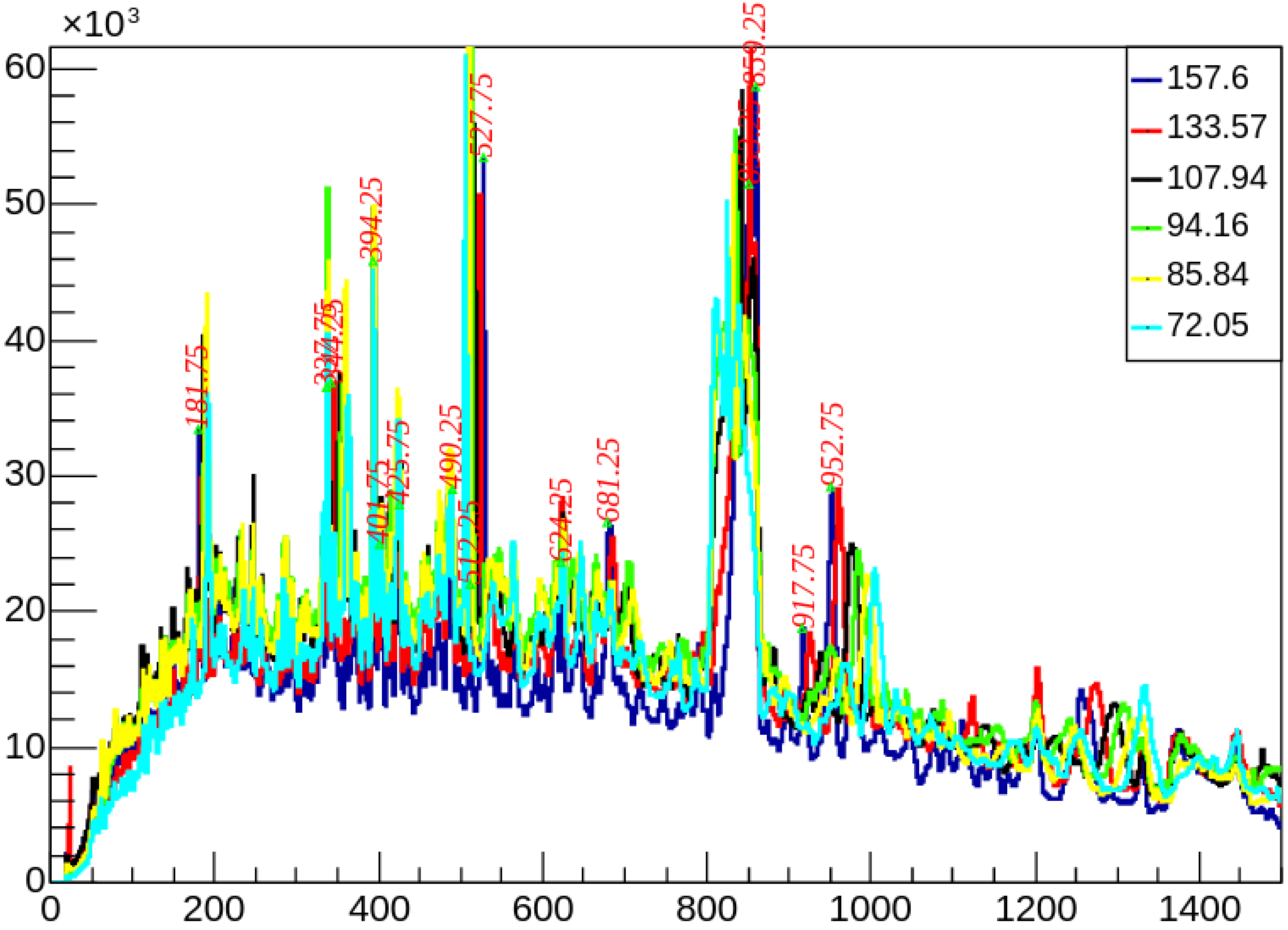
Doppler correction:

$$E_{C.M.} = \boxed{\gamma(1-\beta\cos\theta_{Lab})}E_{Lab}$$

$$\gamma = \frac{1}{\sqrt{1-(v/c)^2}} = \frac{1}{\sqrt{1-\beta^2}}$$



Doppler correction:



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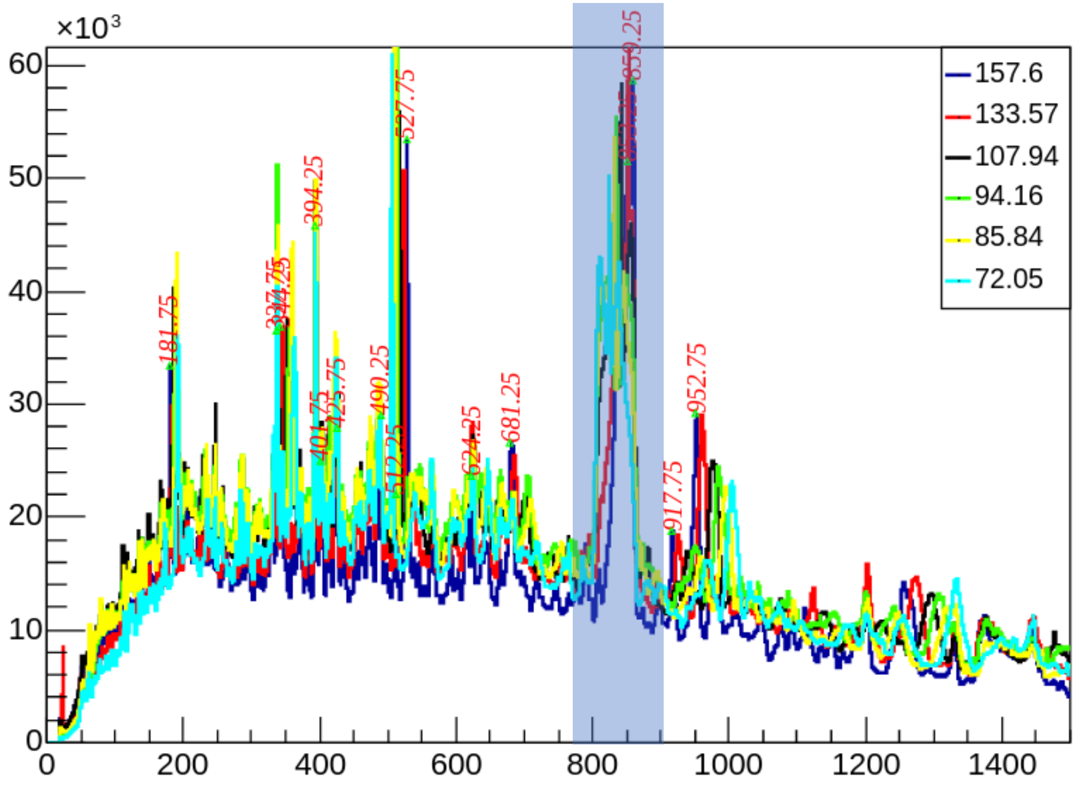
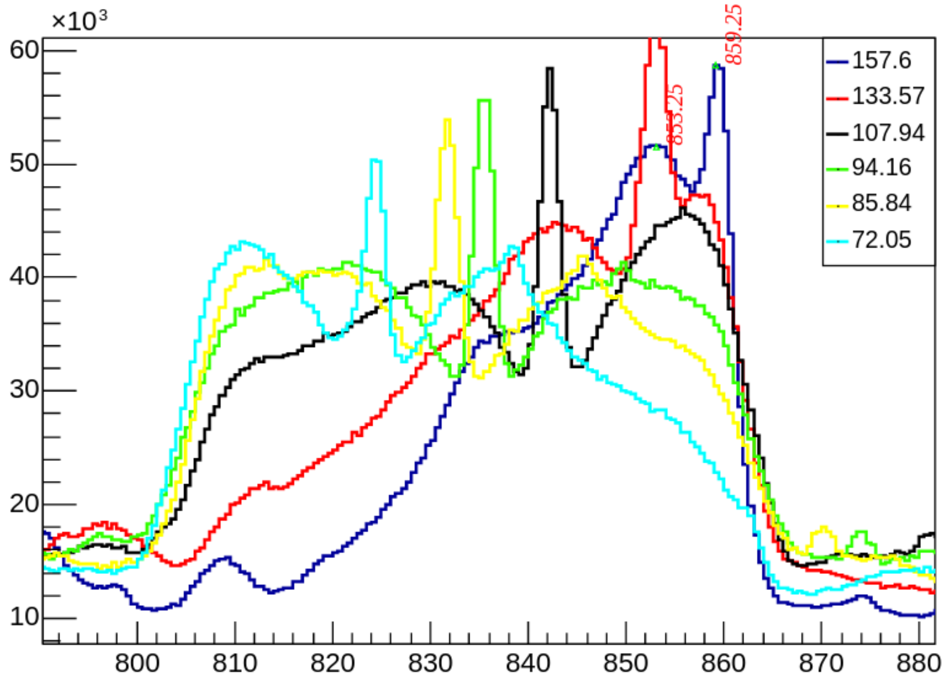
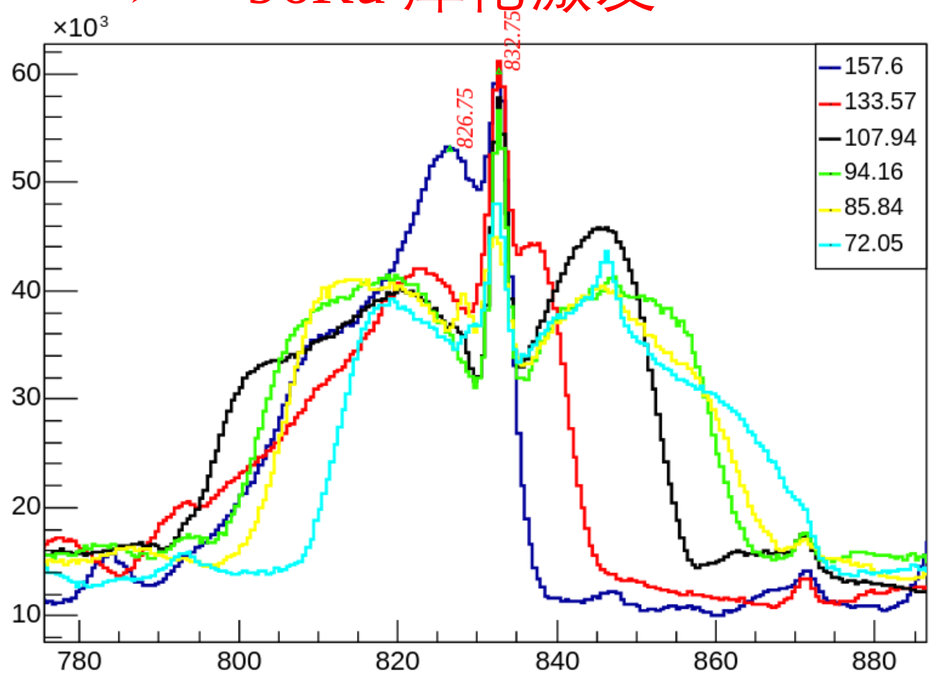


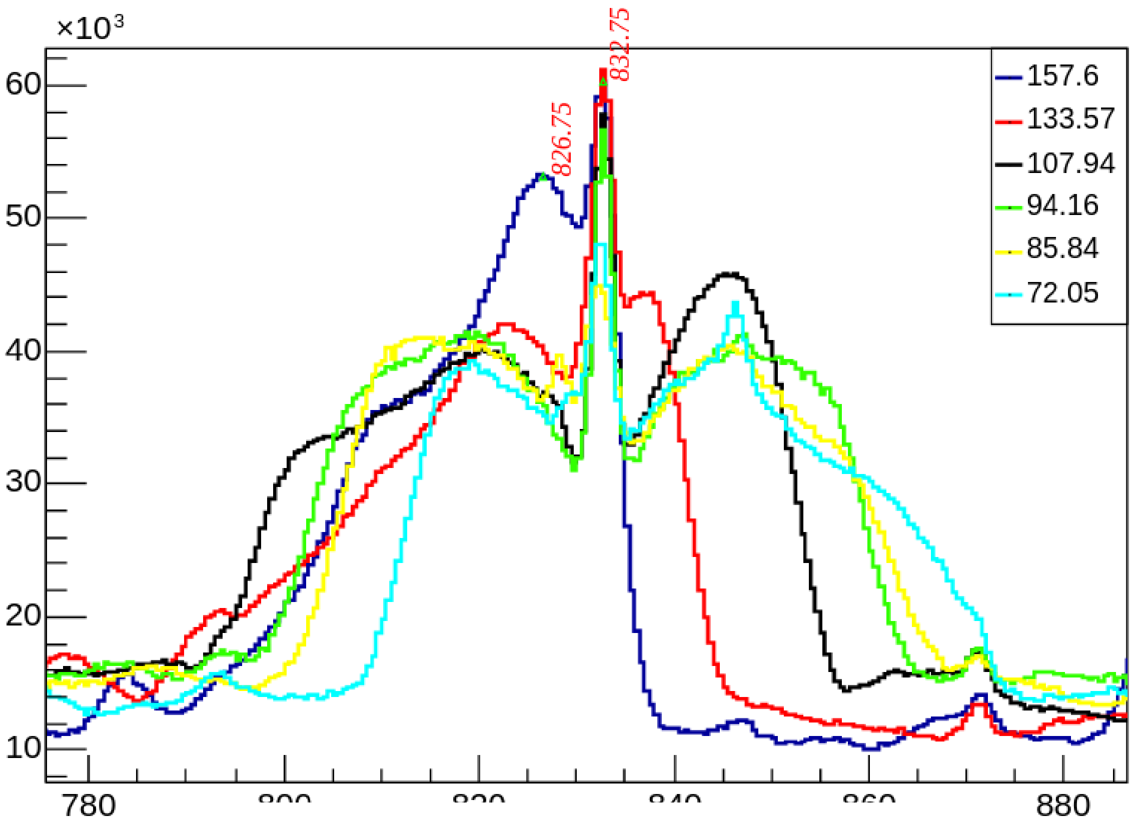
E(level)	J^{π} †	$T_{1/2}$ ‡
0.0#	0^+	stable
832.56# 5	2^+	2.94 ps 6

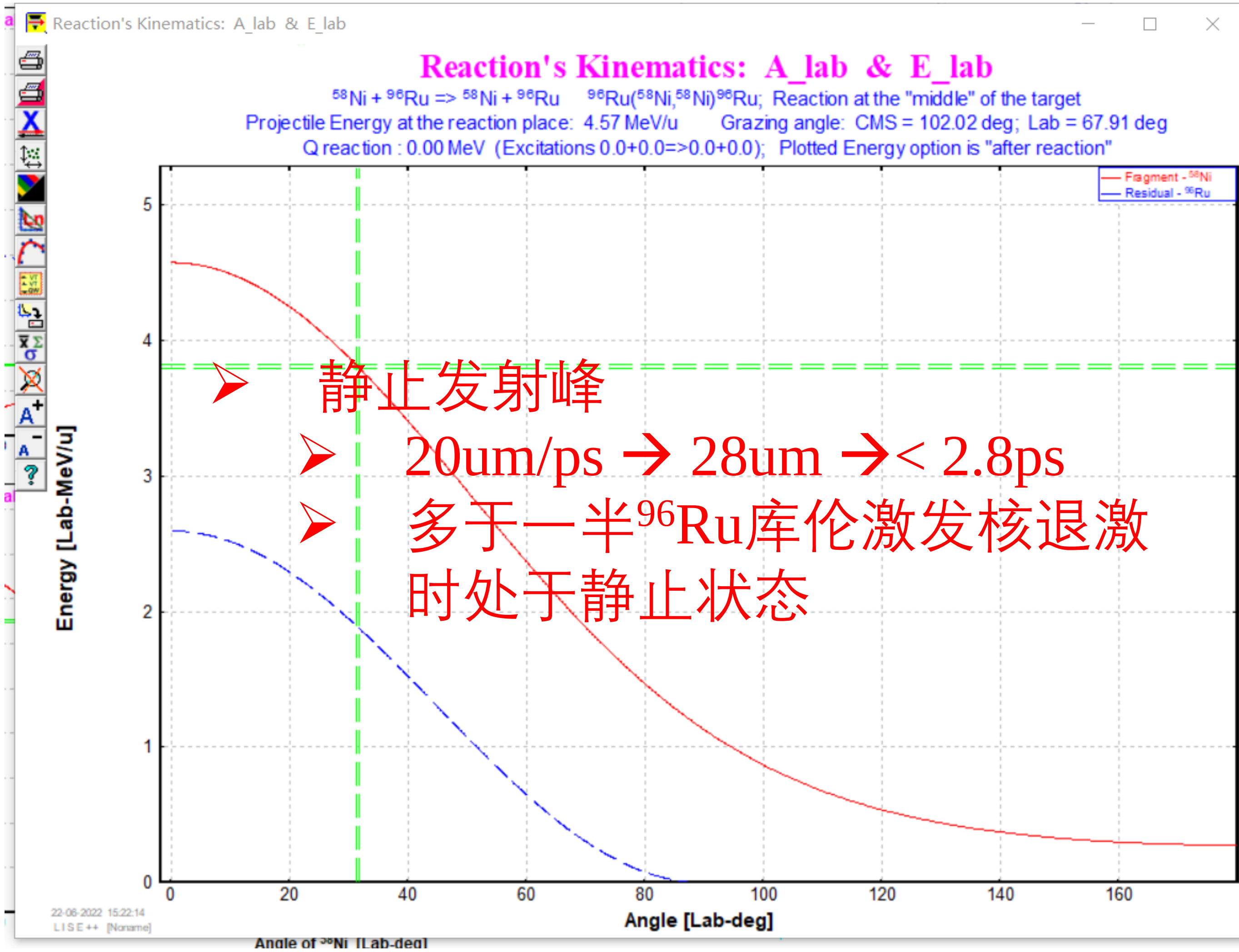


➢ 96Ru 库伦激发



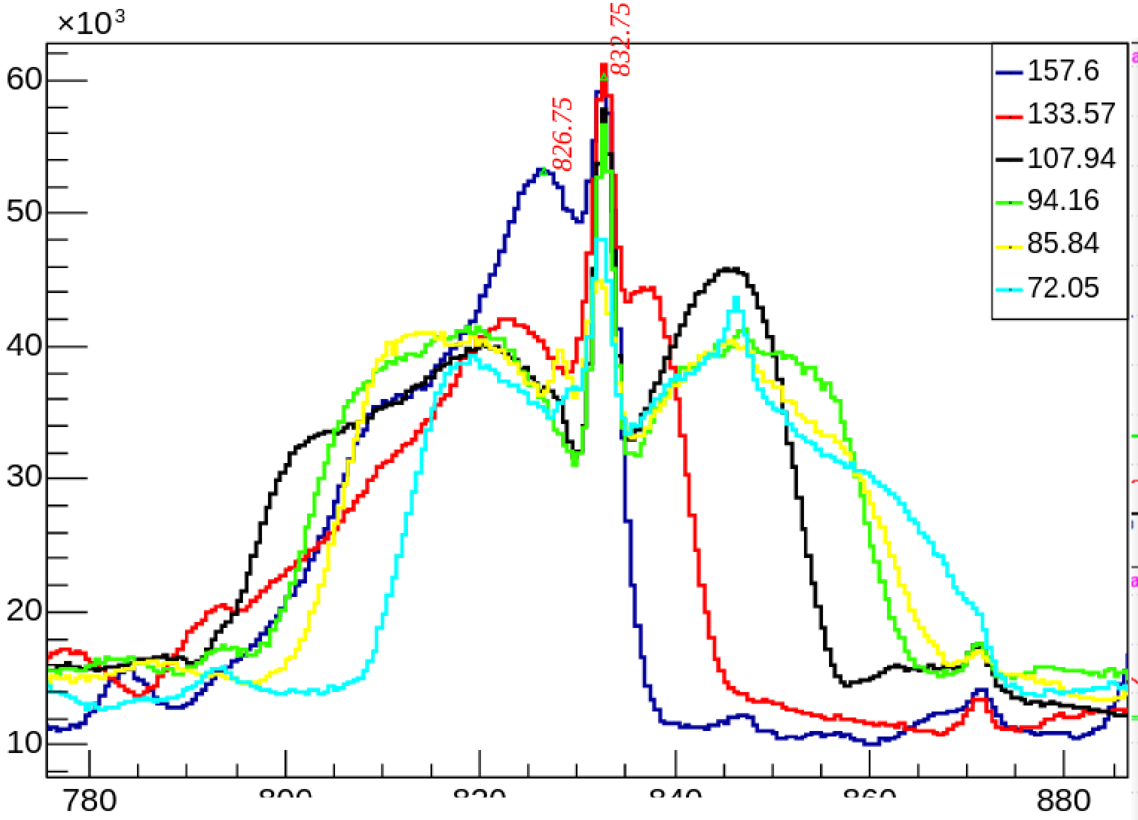
Doppler correction:

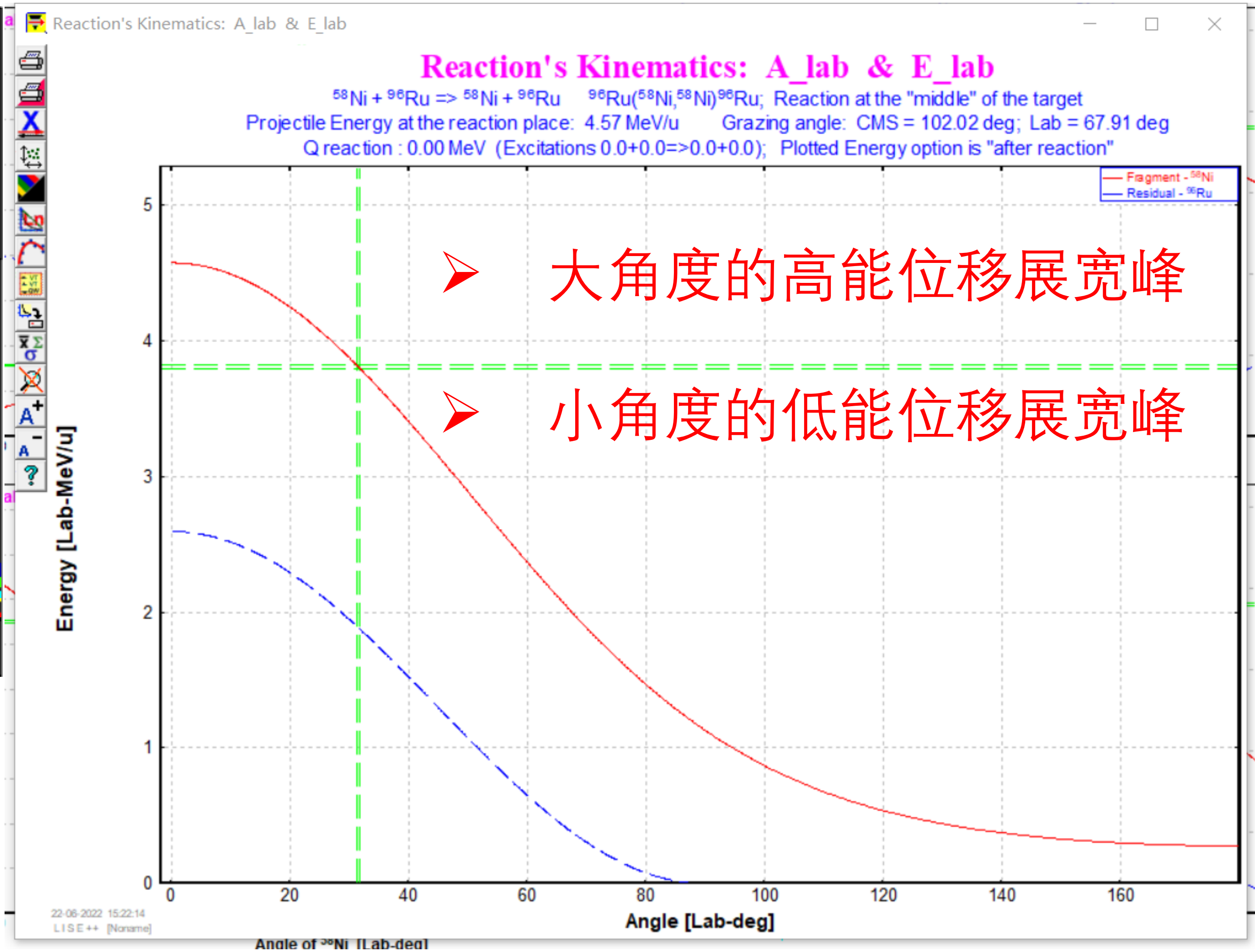




E(level)	J^{π} †	$T_{1/2}$ ‡
0.0#	0^+	stable
832.56# 5	2^+	2.94 ps 6

Doppler correction:

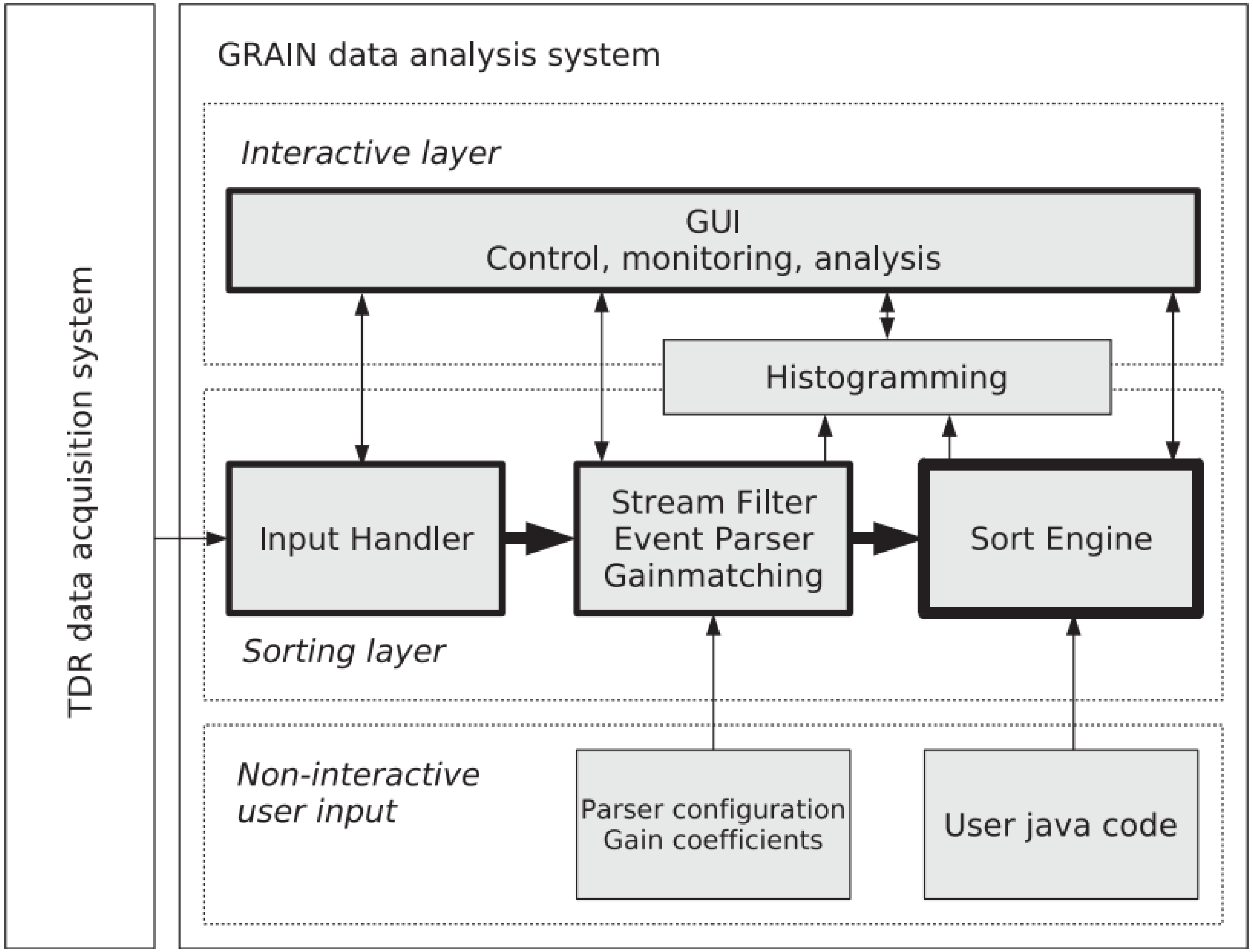




- 大角度的高能位移展宽峰
- 小角度的低能位移展宽峰

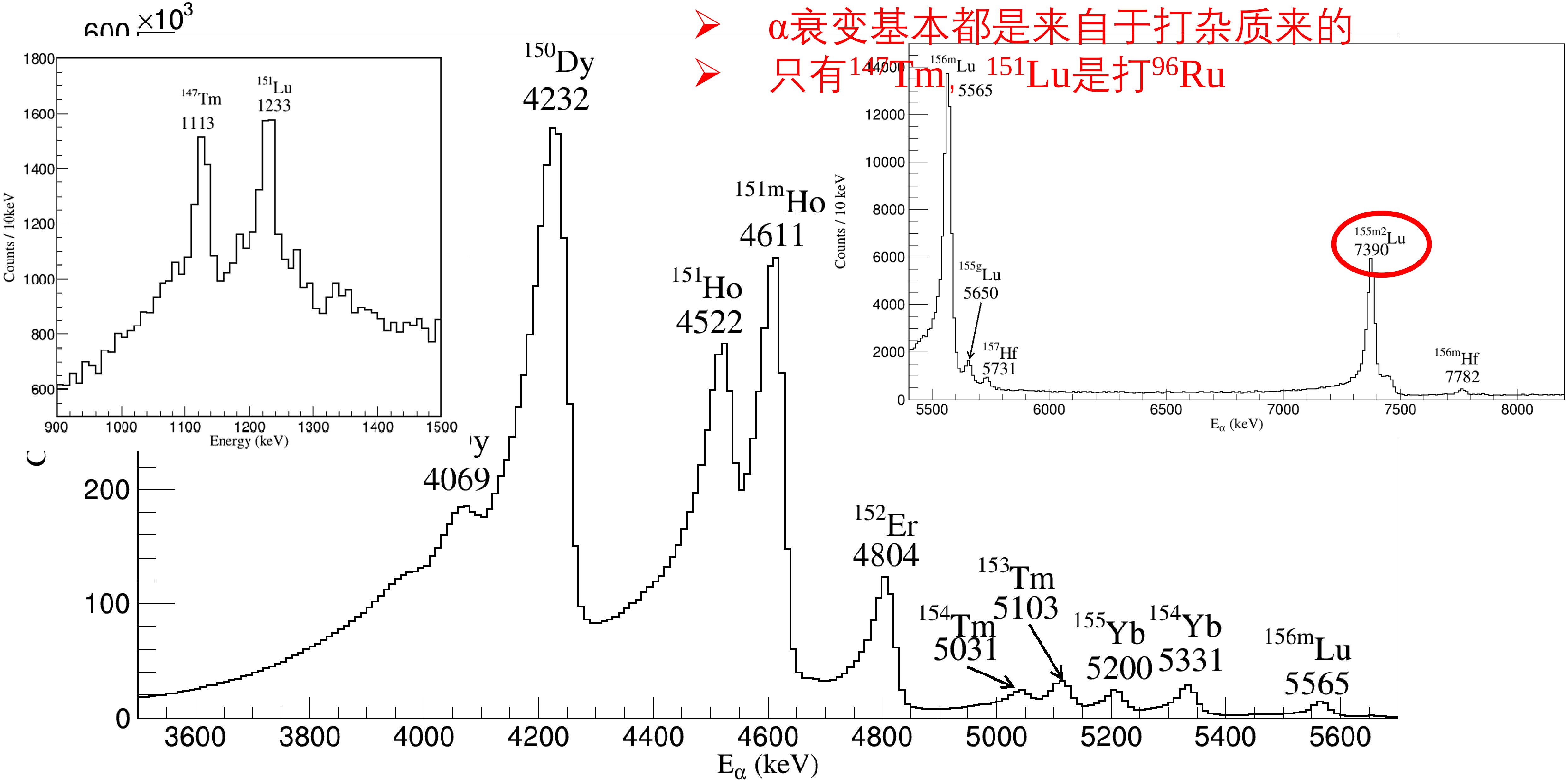
E(level)	J^{π}†	$T_{1/2}$‡
0.0#	0^+	stable
832.56# 5	2^+	2.94 ps 6

Grain(^{96}Ru(^{58}Ni, p2n/2p2n)^{151}Lu/^{150}Yb)

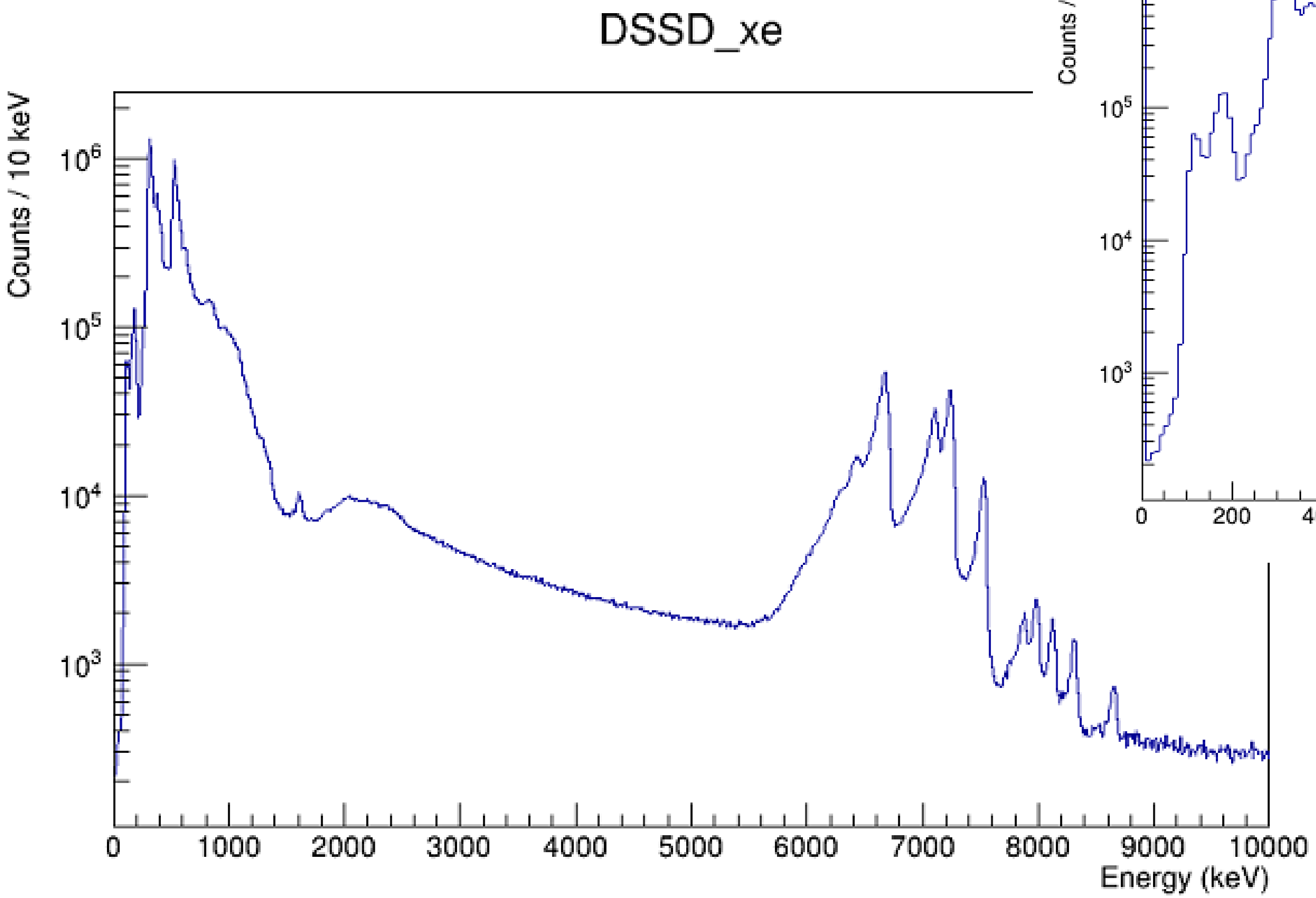


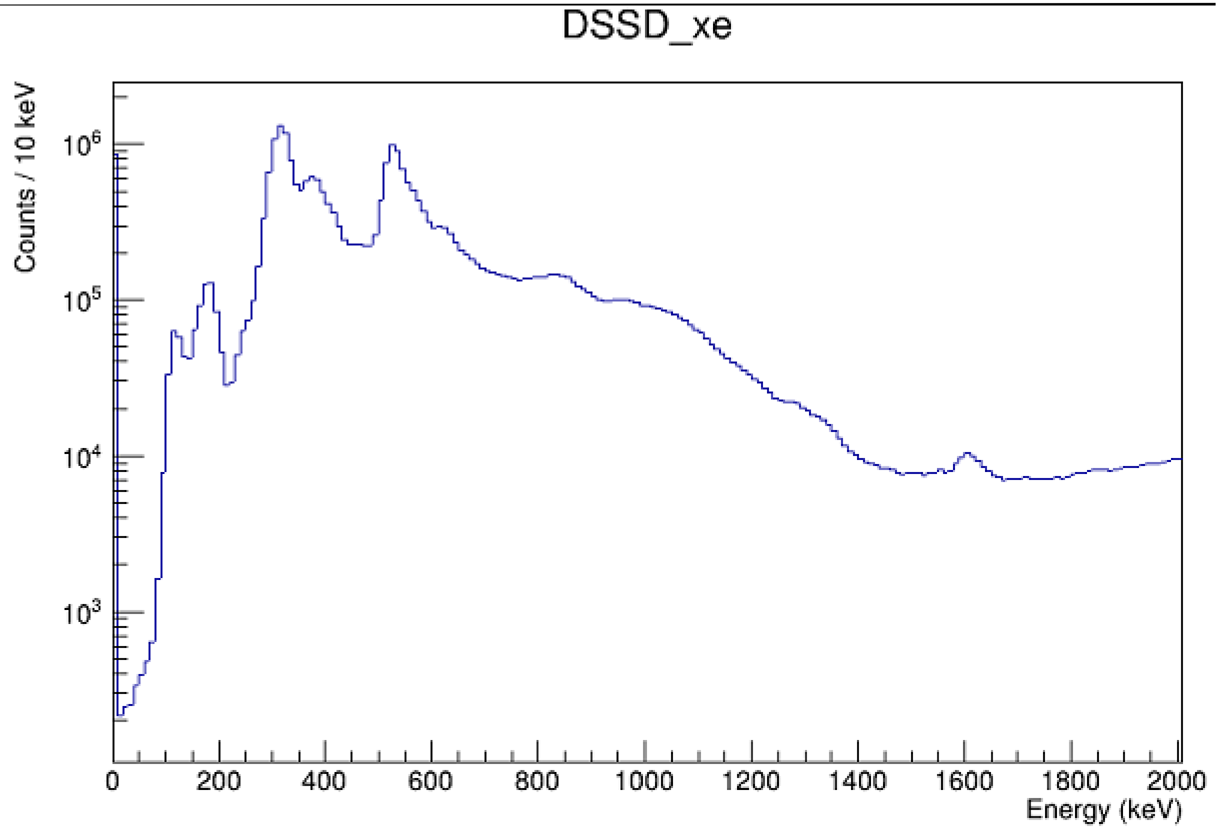
Products $^{58}Ni + ^{96,99,101,102}Ru \rightarrow ^{154,157,159,160}Hf$

- α衰变基本都是来自于打杂质来的
- 只有^{147}Tm, ^{151}Lu是打^{96}Ru

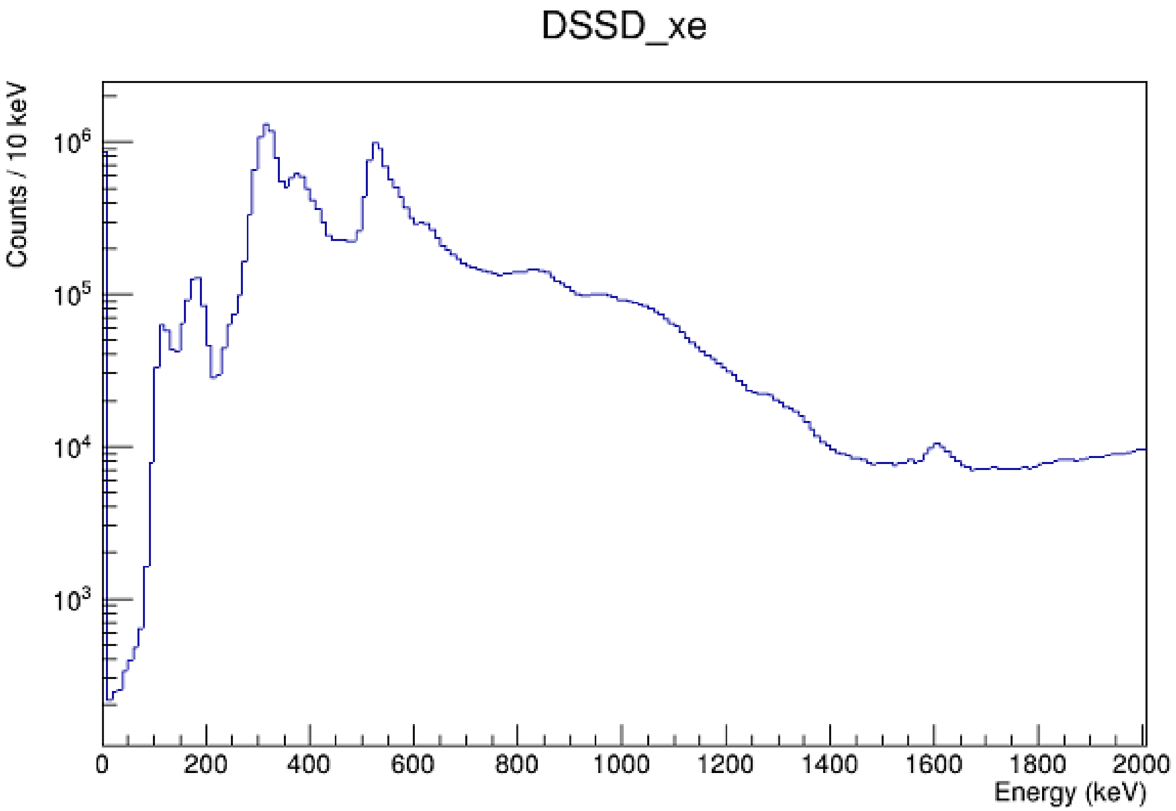


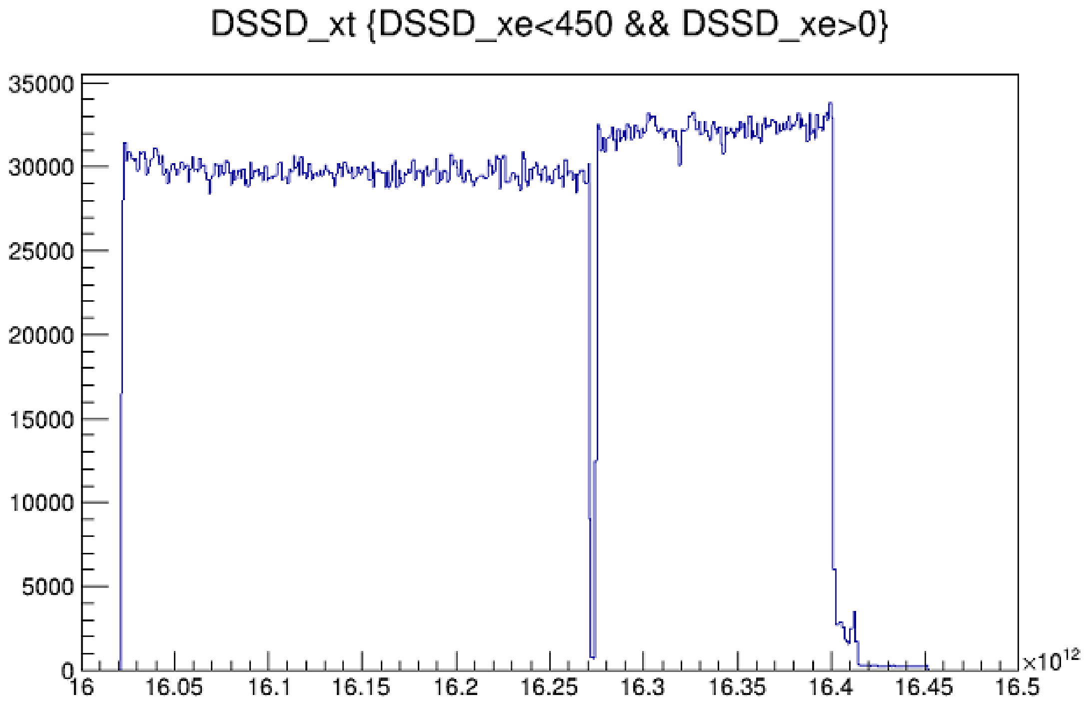
带电粒子谱

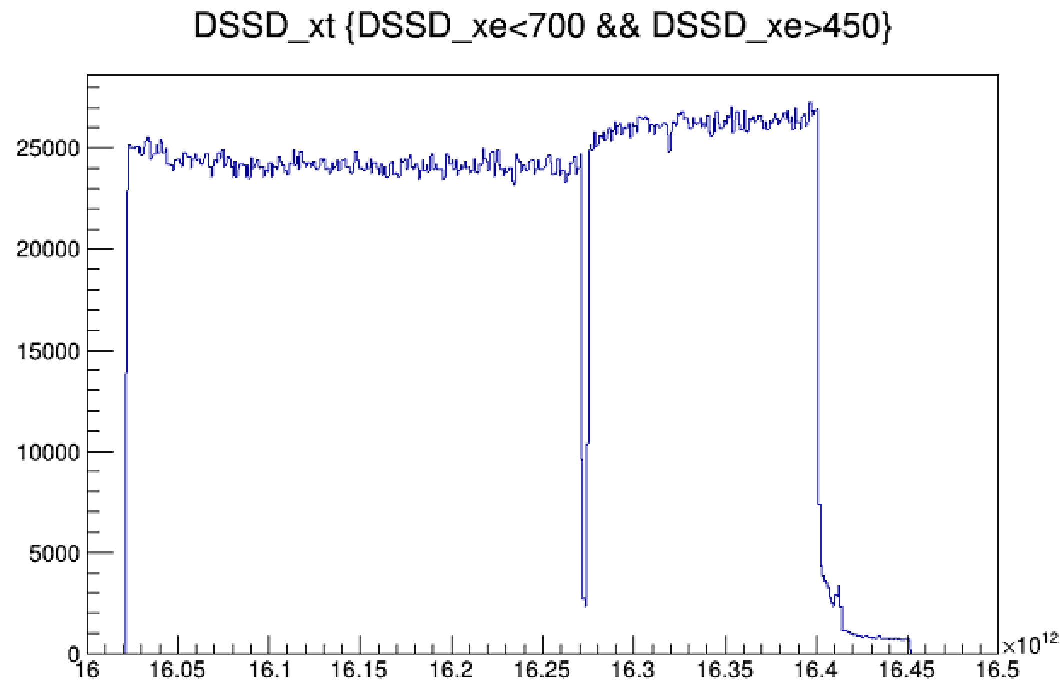

DSSD_xe
Counts / 10 keV
10^6
10^5
10^4
10^3
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Energy (keV)


DSSD_xe
Counts / 10 keV
10^6
10^5
10^4
10^3
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Energy (keV)

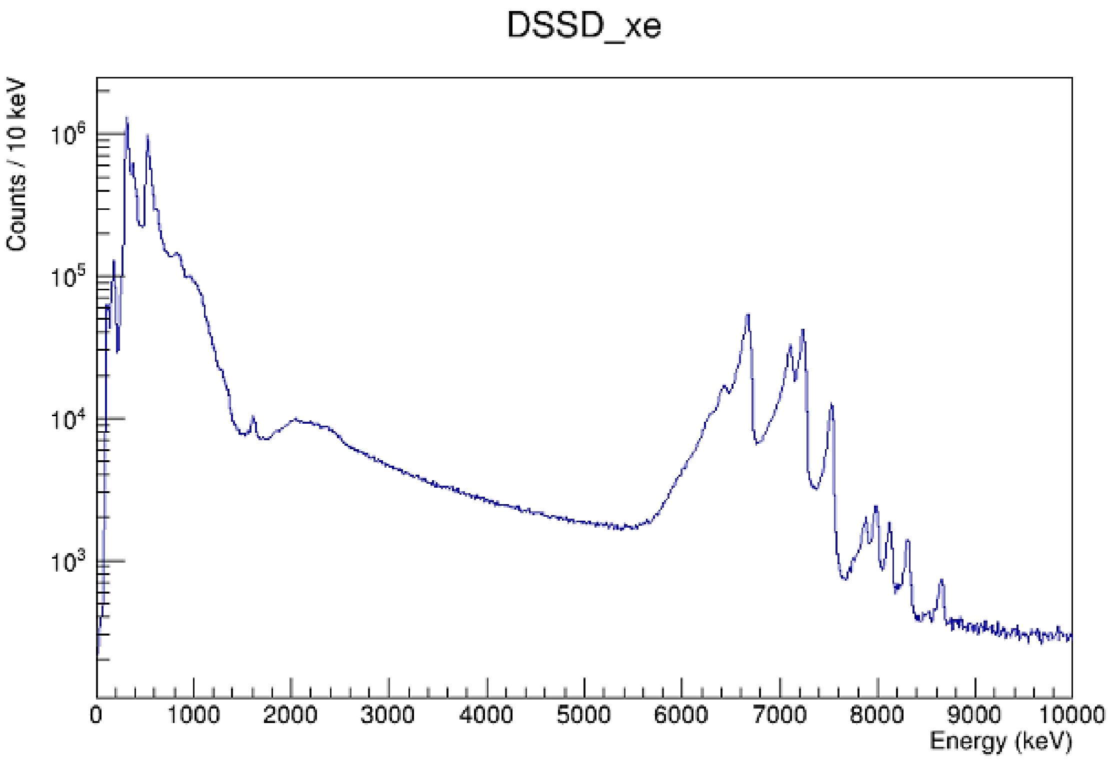
轻粒子计数率


DSSD_xe
Counts / 10 keV
10^6
10^5
10^4
10^3
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Energy (keV)

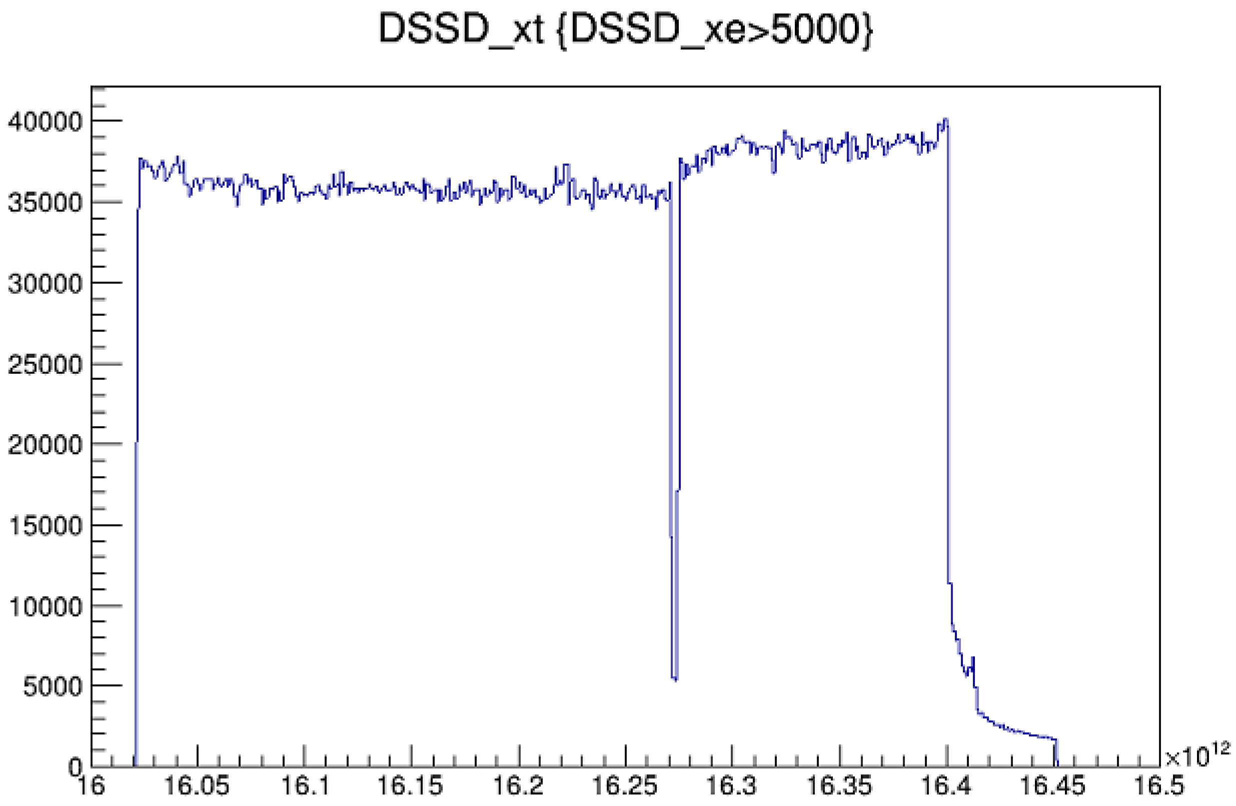

DSSD_xt {DSSD_xe<450 && DSSD_xe>0}
35000
30000
25000
20000
15000
10000
5000
0
16
16.05
16.1
16.15
16.2
16.25
16.3
16.35
16.4
16.45
16.5
$\times10^{12}$


DSSD_xt {DSSD_xe<700 && DSSD_xe>450}
25000
20000
15000
10000
5000
0
16
16.05
16.1
16.15
16.2
16.25
16.3
16.35
16.4
16.45
16.5
$\times10^{12}$

重离子计数率

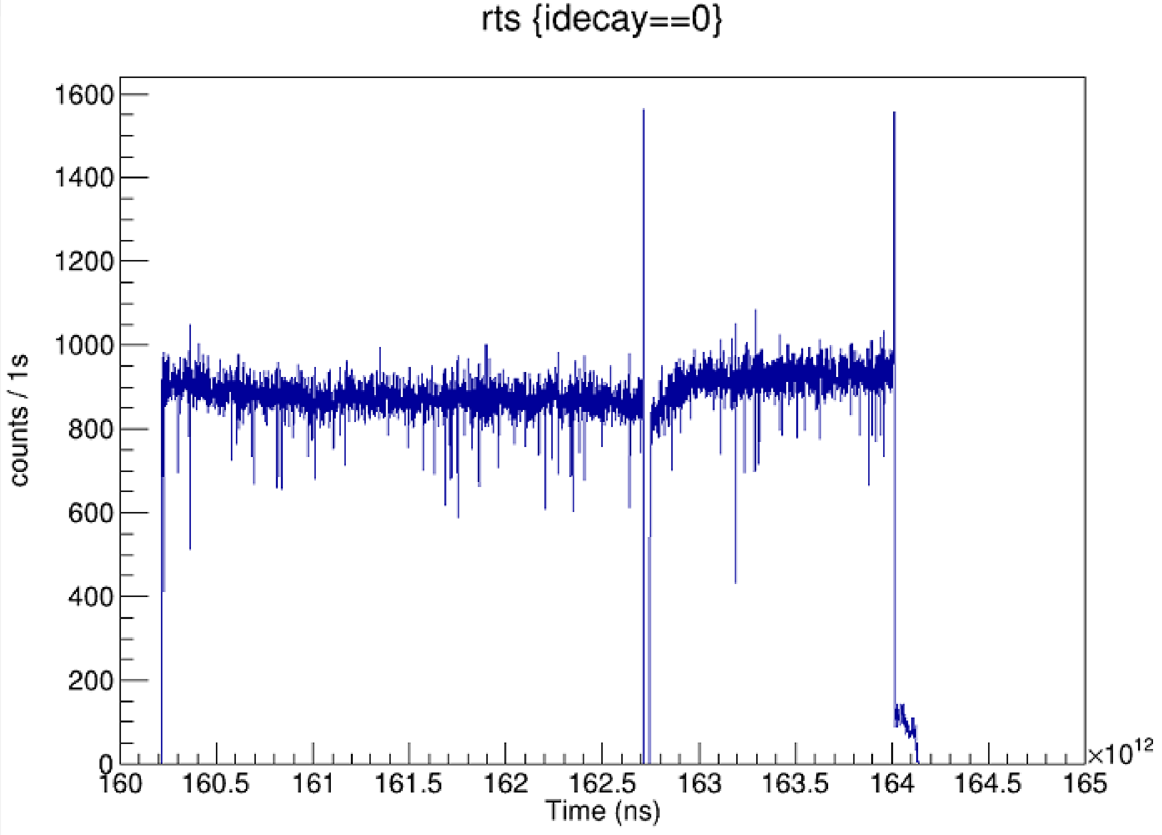


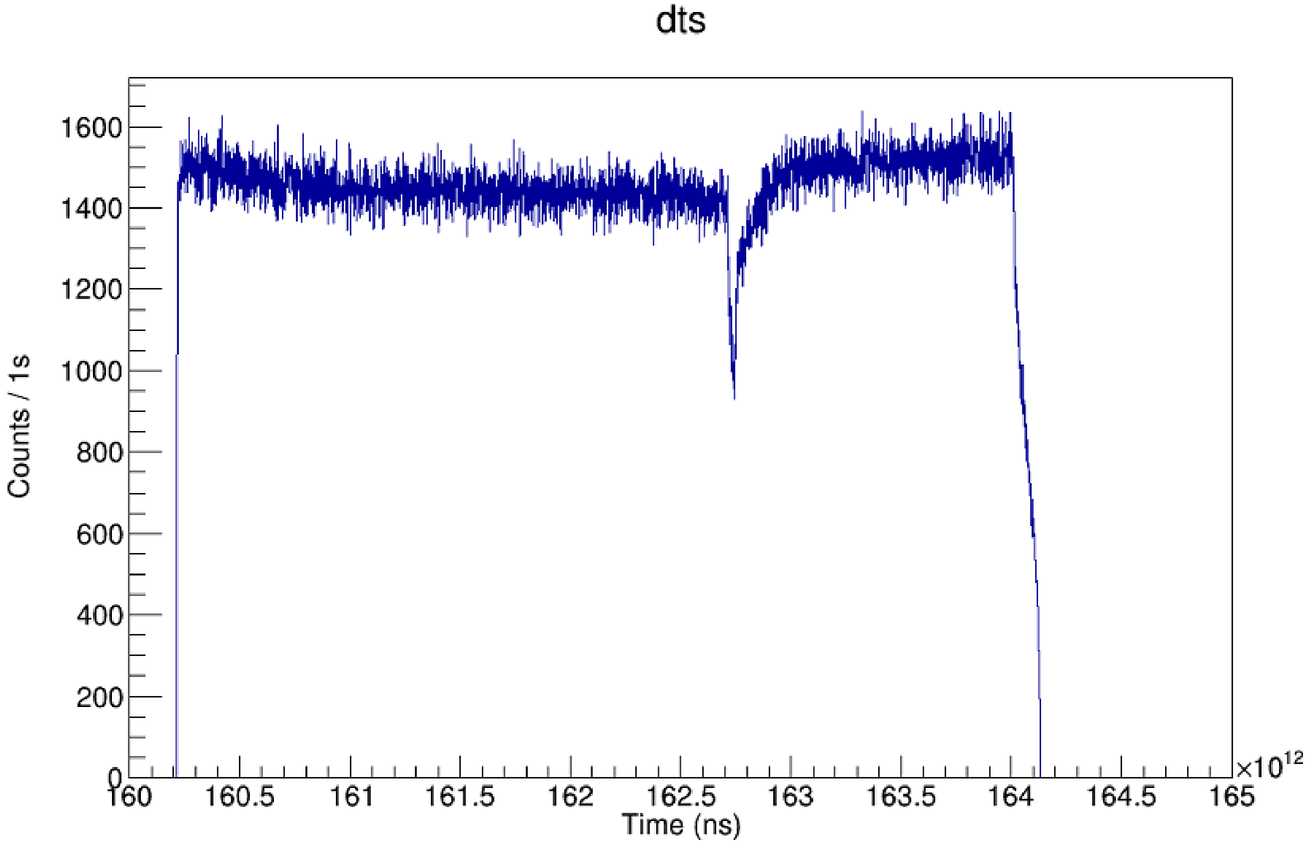
DSSD_xe
Counts / 10 keV
10^6
10^5
10^4
10^3
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Energy (keV)



DSSD_xt {DSSD_xe>5000}
40000
35000
30000
25000
20000
15000
10000
5000
0
16
16.05
16.1
16.15
16.2
16.25
16.3
16.35
16.4
16.45
16.5
$\times 10^{12}$

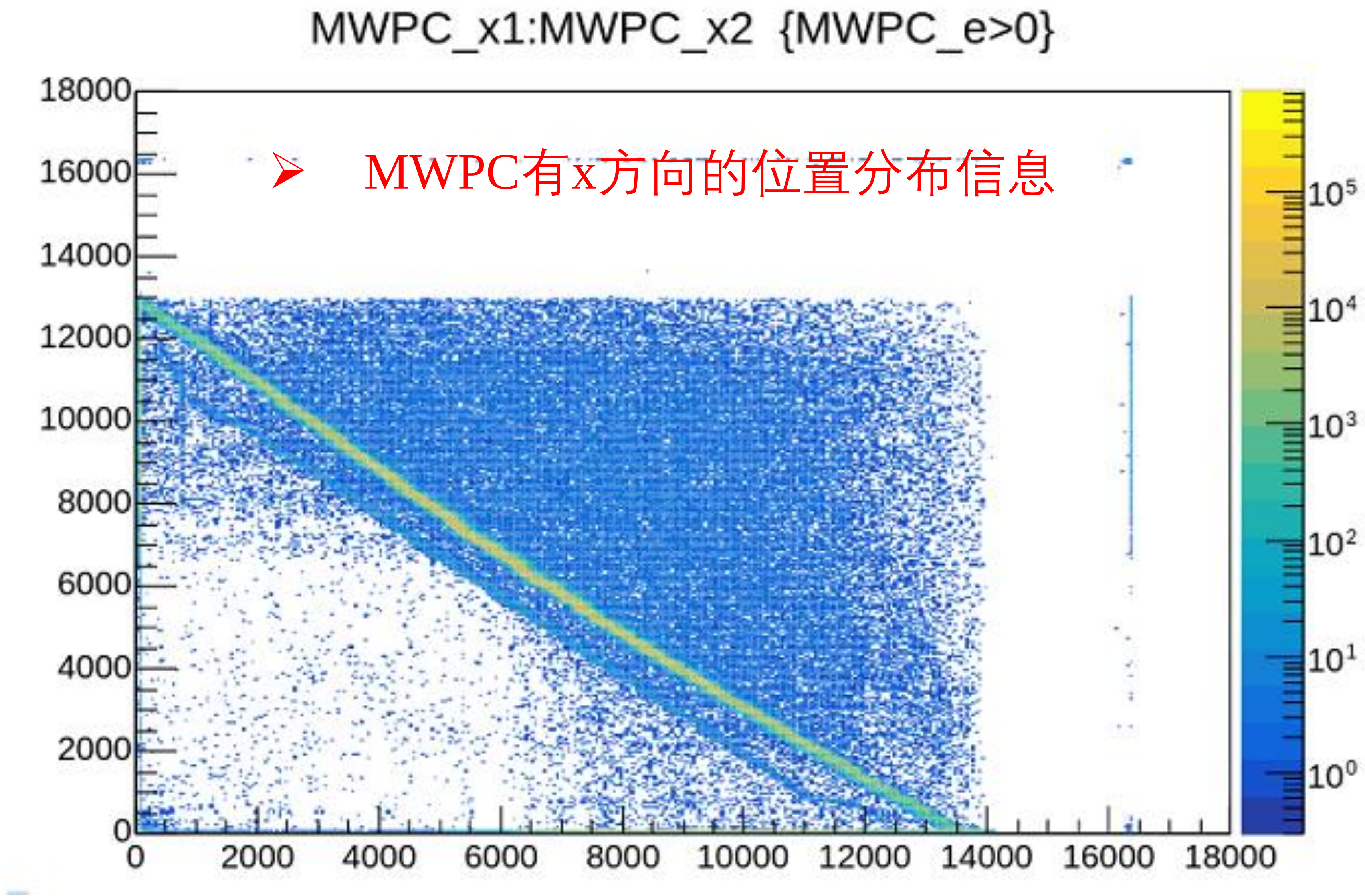
关联到的注入衰变计数率





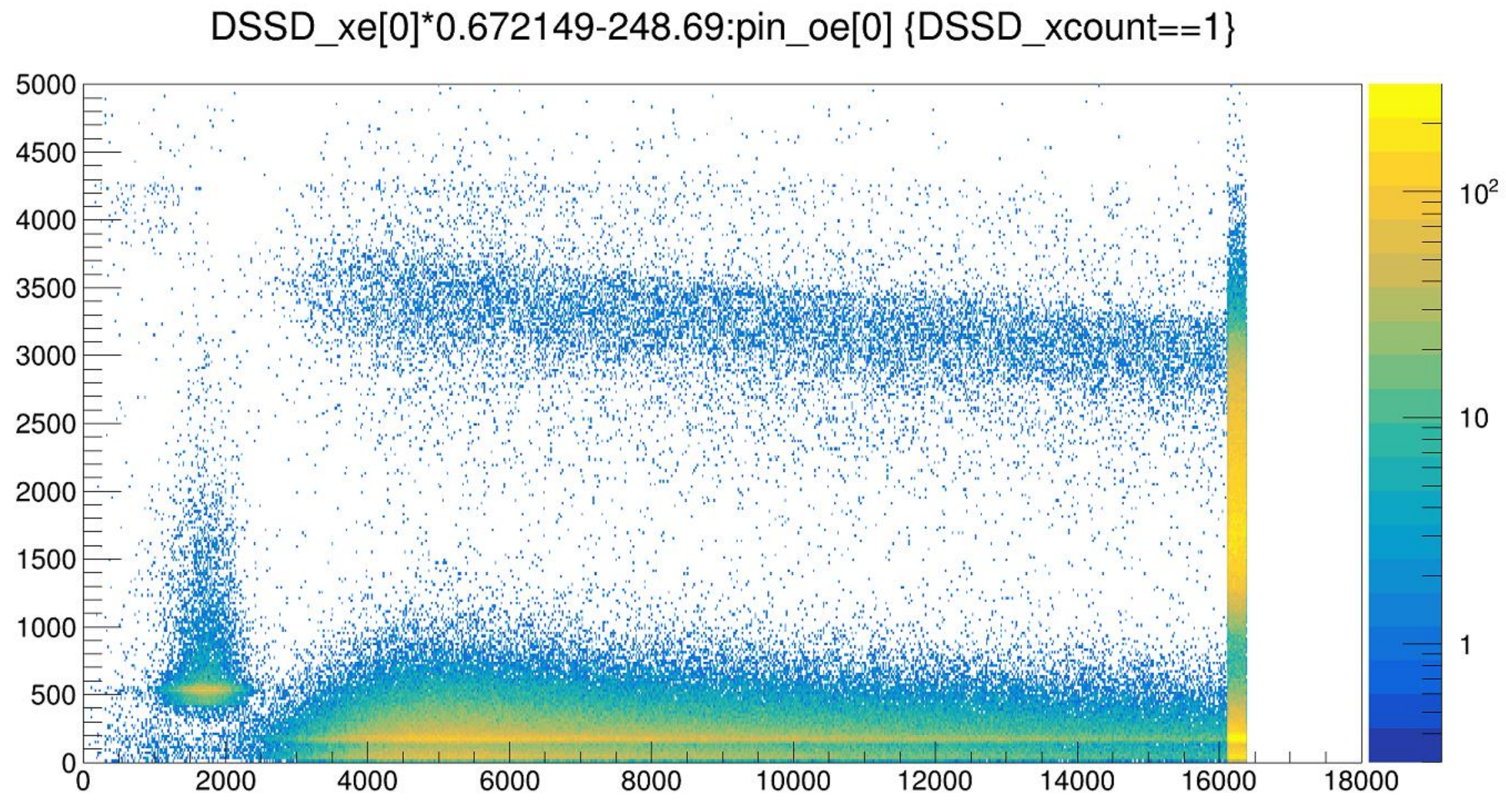
- 打到焦平面的融合蒸发产物占总粒子的比例较小
- 充气谱仪并没有完全把不感兴趣的粒子分离掉，穿过来的还是很多

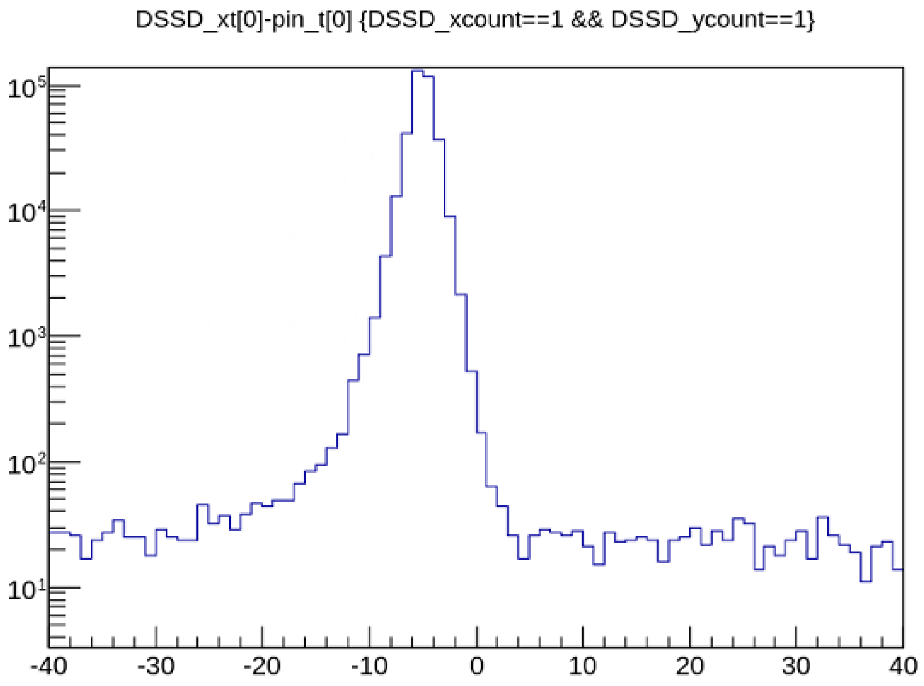
MWPC(^{96}Ru(^{58}Ni, p2n/2p2n)^{151}Lu/^{150}Yb)



- MWPC有x方向的位置分布信息

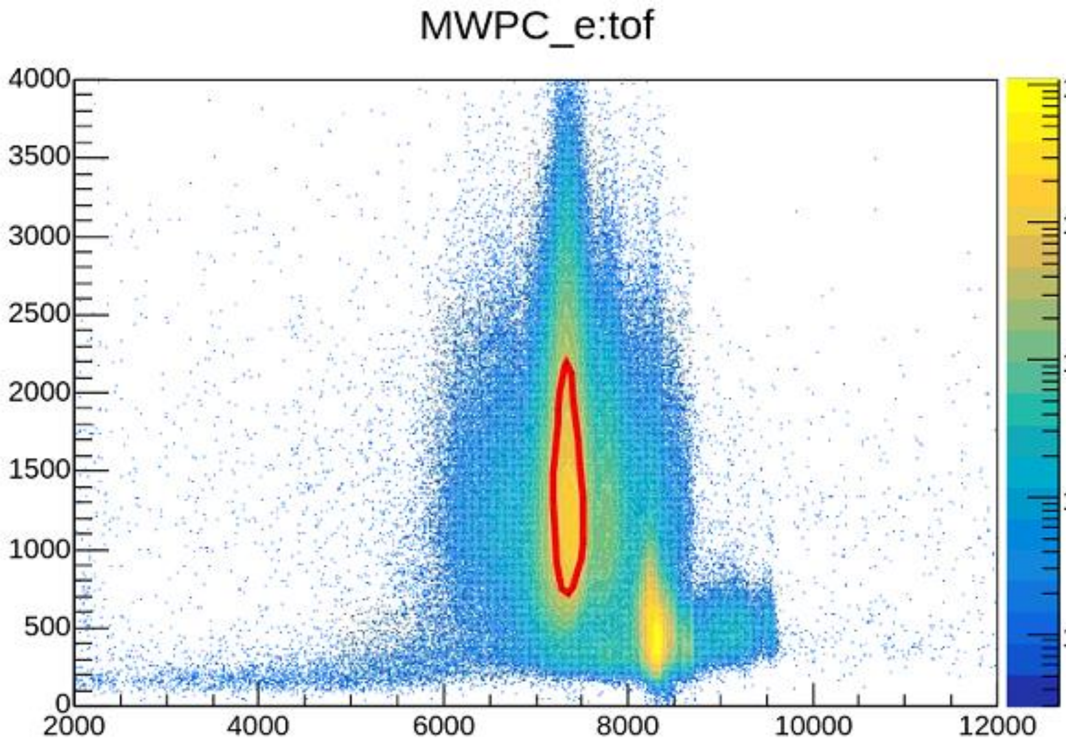
DSSD-Pin

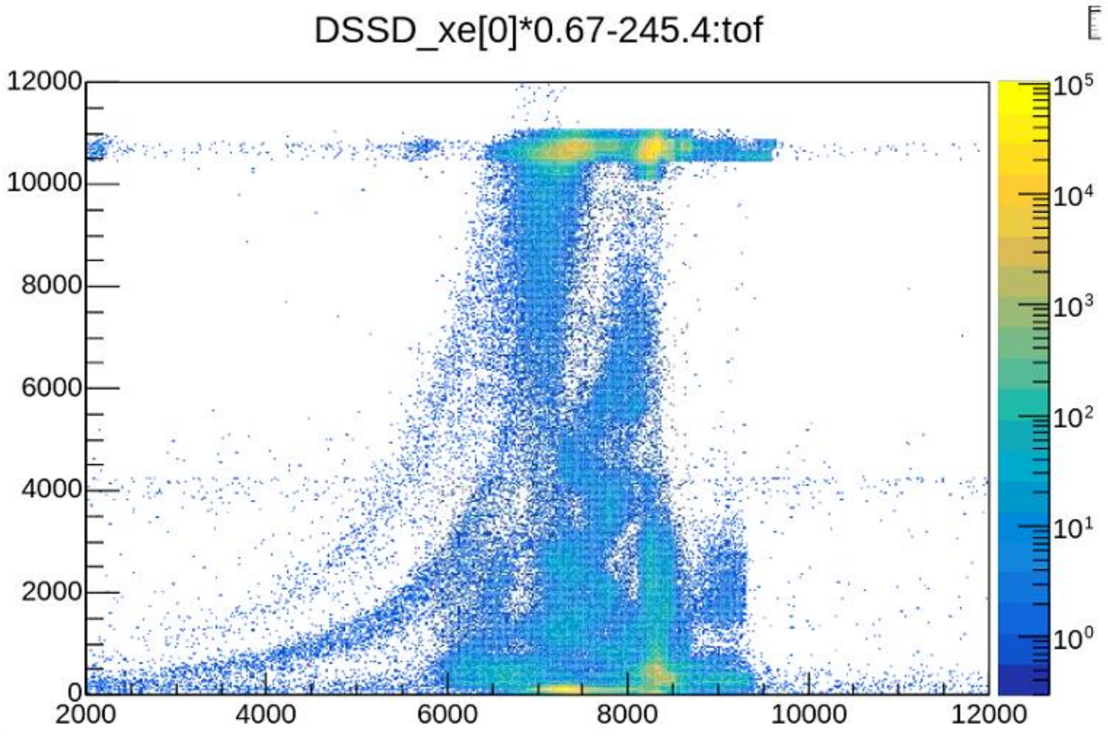




- Si二极管探测器前放放大倍数太大或者量程太小，基本都超界，可以用来veto逃逸信号，但是无法找回逃逸能量

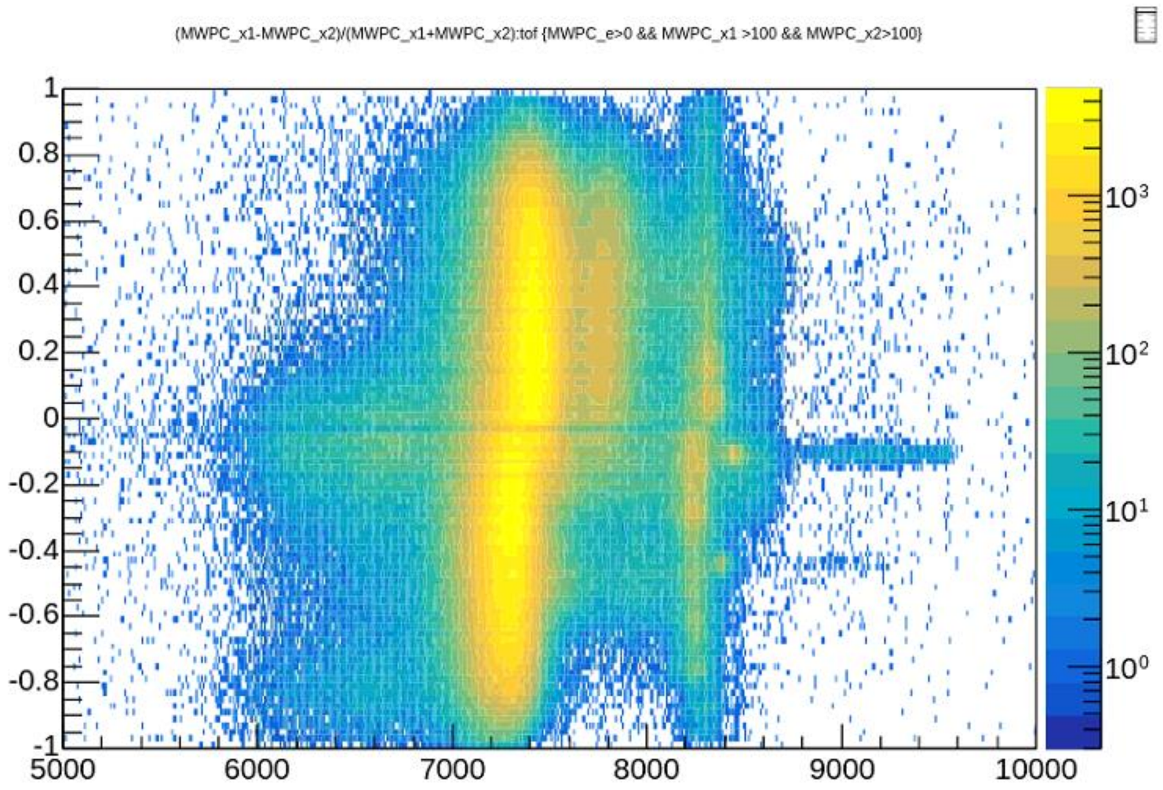
MWPC-TOF(MWPC-DSSD)

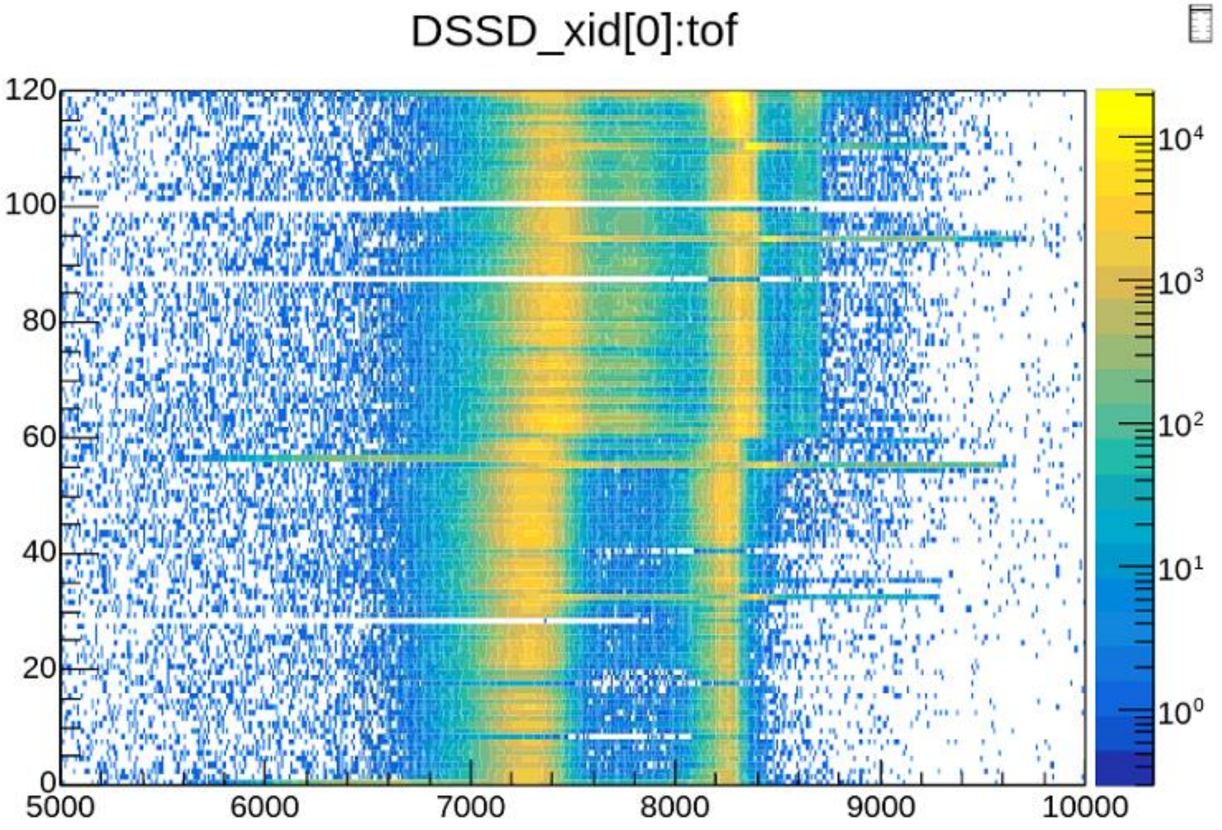




- Recoil: 100 MeV →11MeV(注入关联后得到的结果)
- Beam: 266 MeV →11MeV (不太可能是束流造成的)

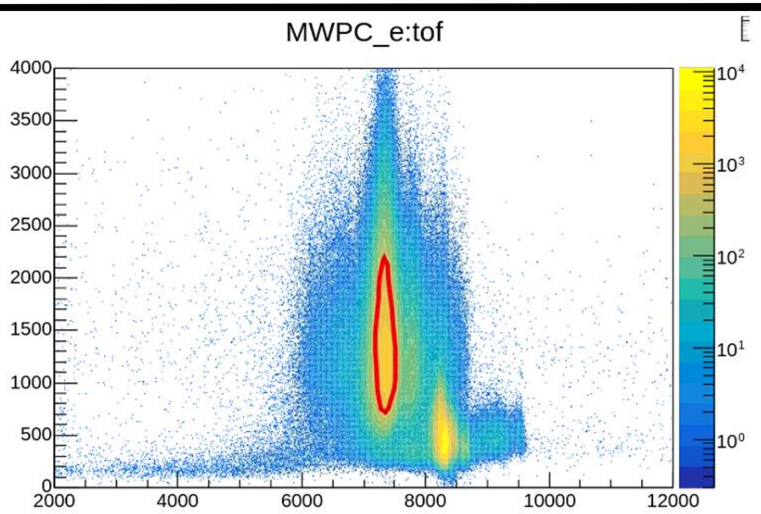
MWPC-TOF(MWPC-DSSD)-E

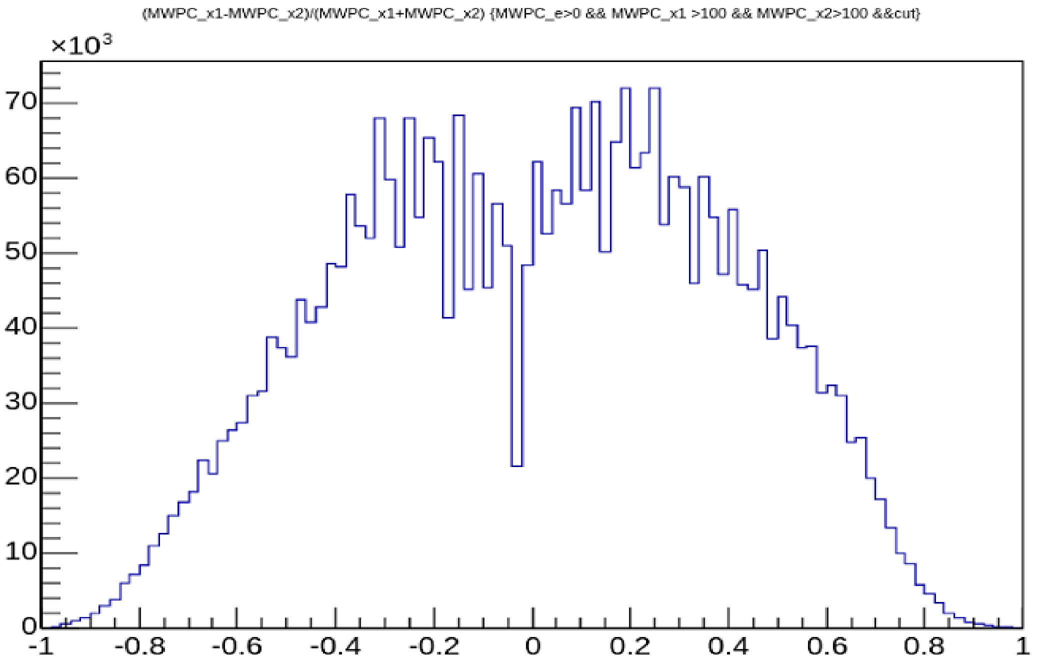


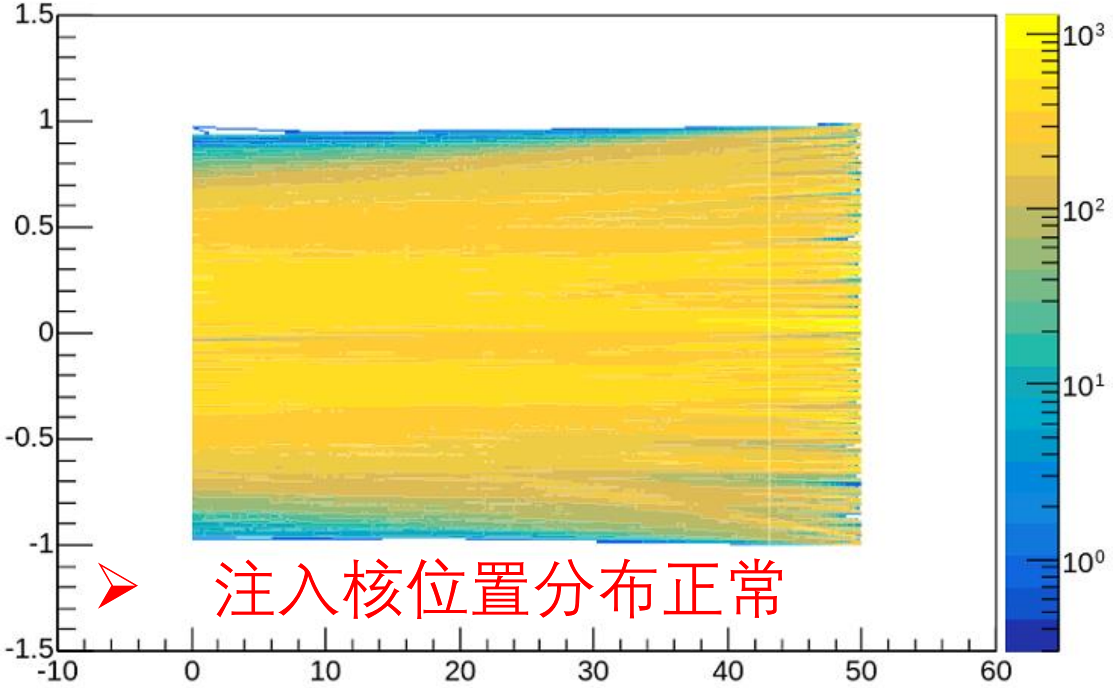


- TOF和位置无关

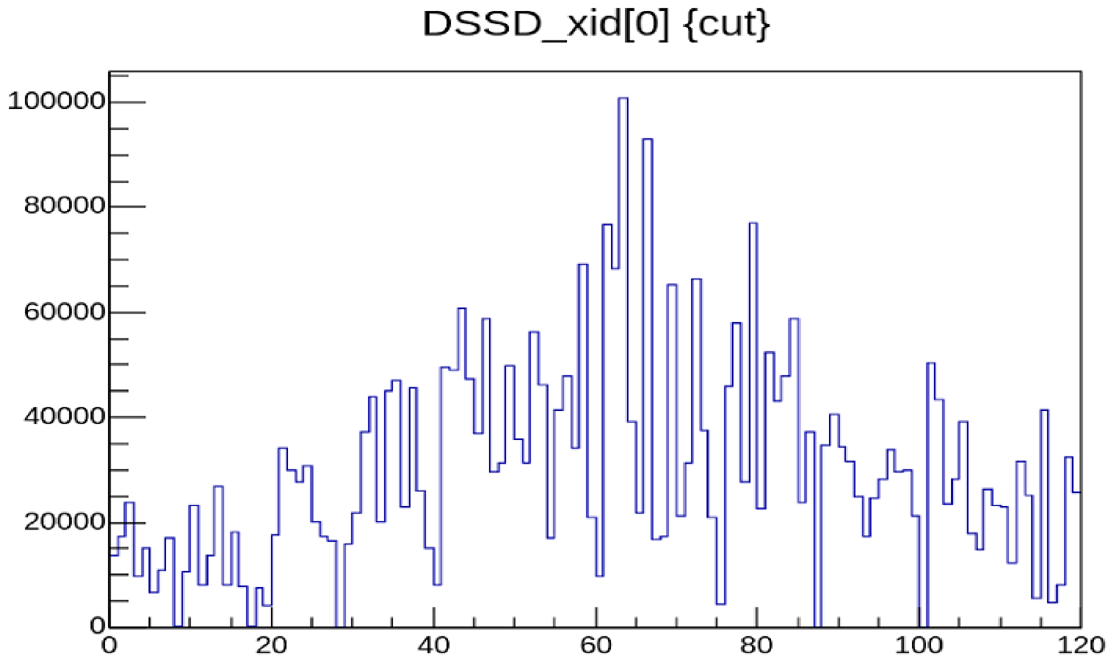
MWPC-TOF(MWPC-DSSD)-E



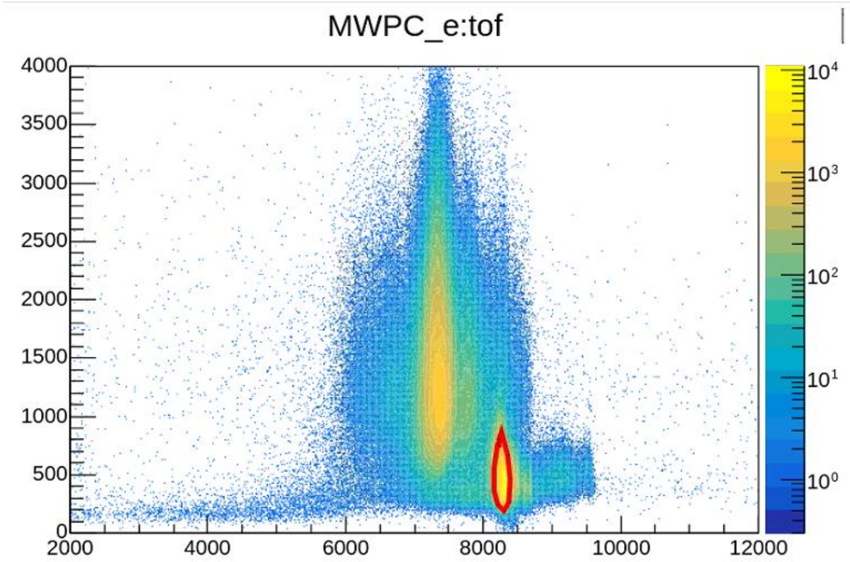


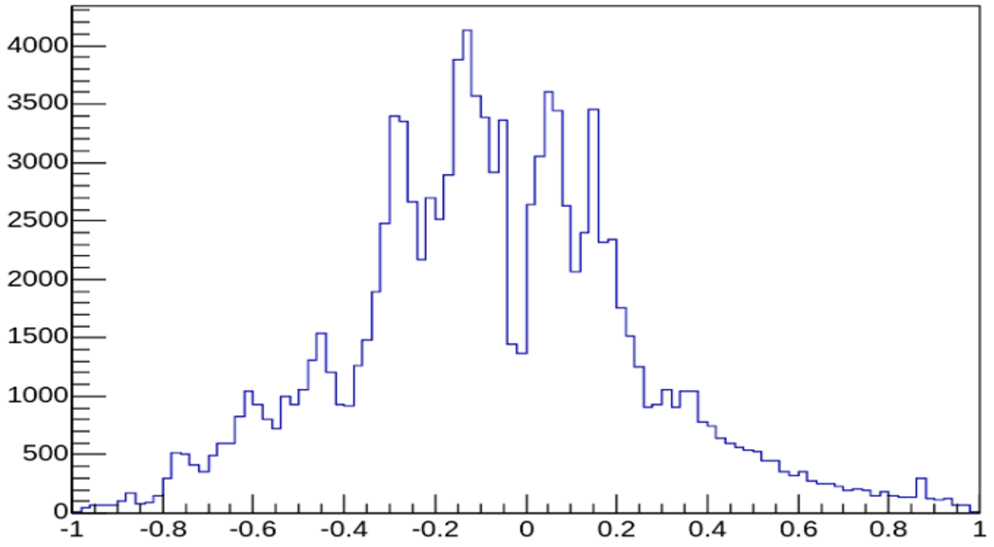


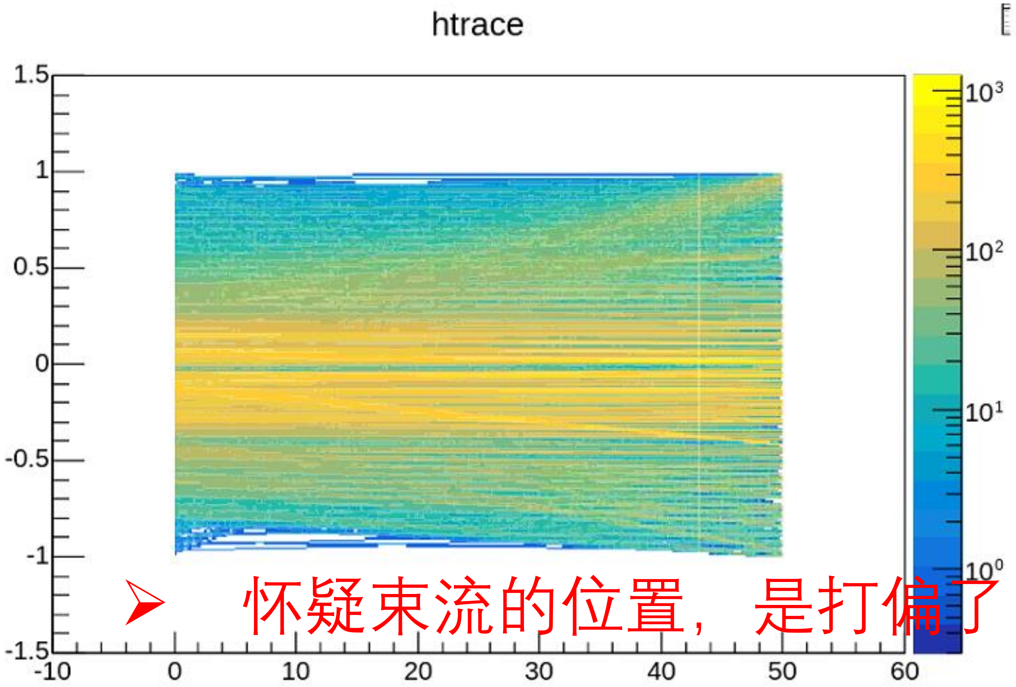
➤ 注入核位置分布正常

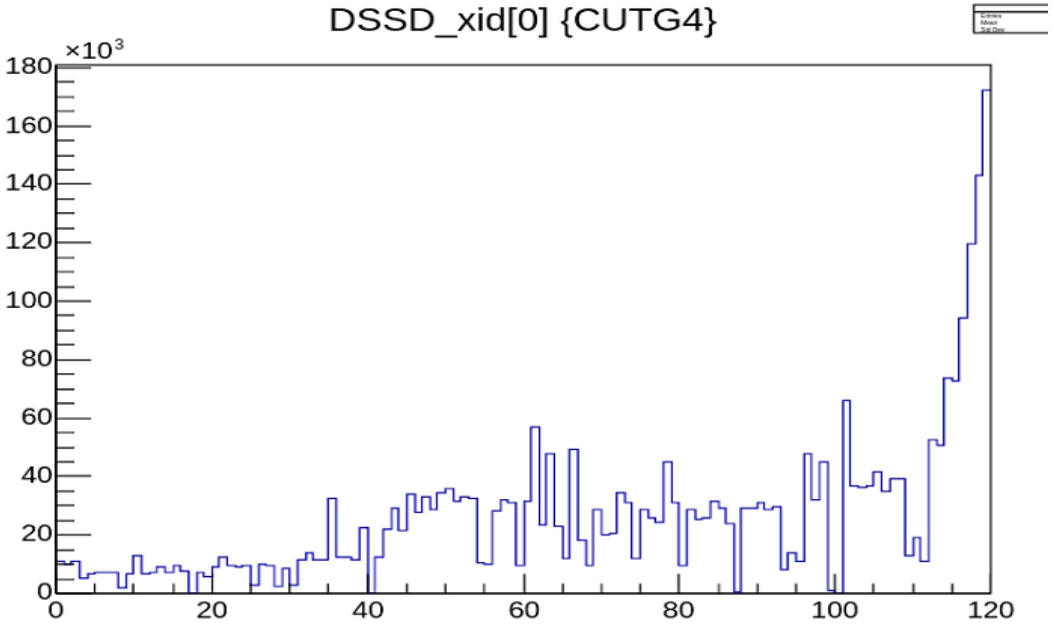


MWPC-TOF(MWPC-DSSD)-E



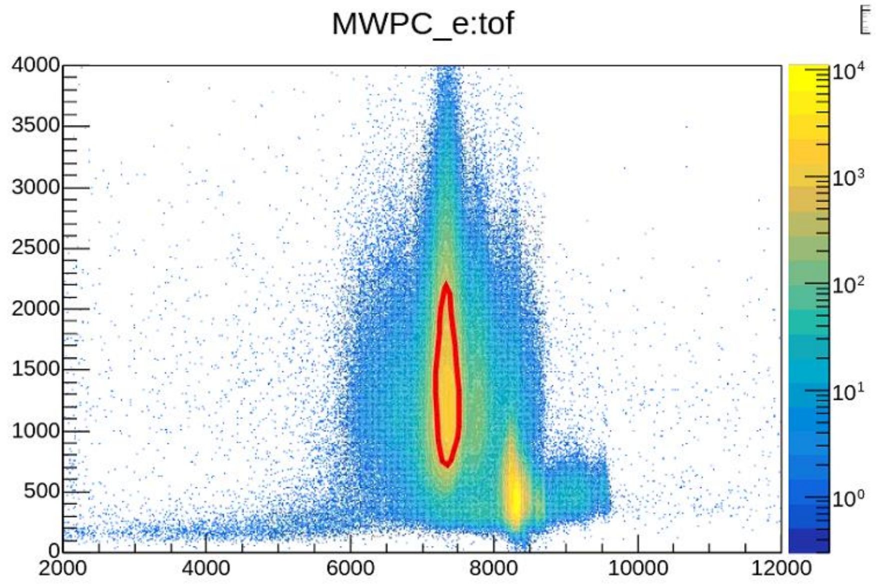


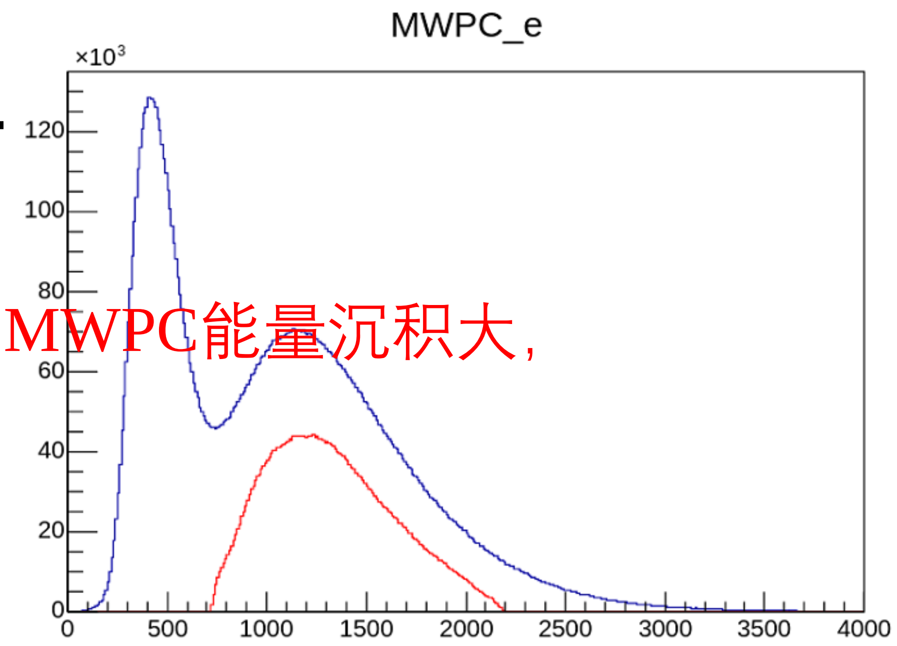




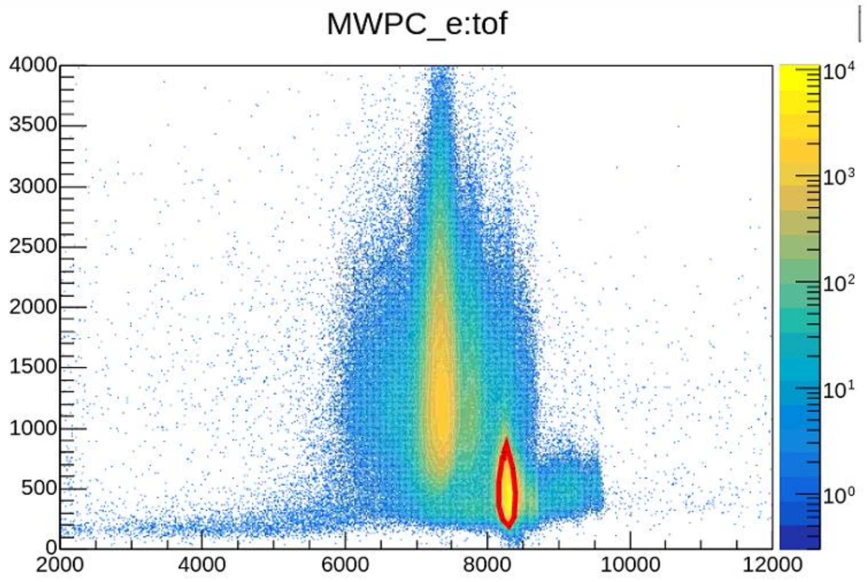
➢ 怀疑束流的位置，是打偏了

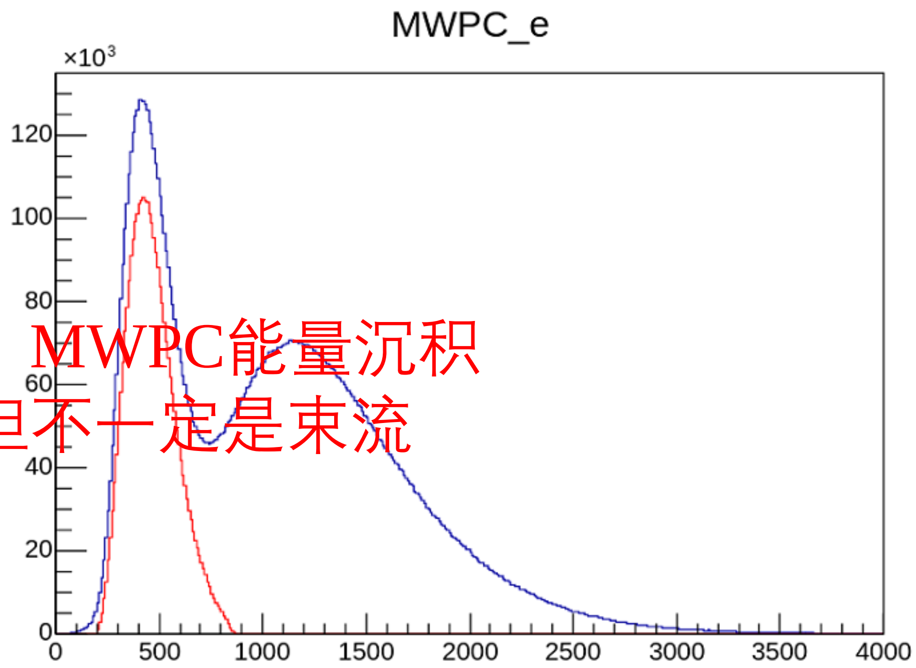
MWPC-TOF(MWPC-DSSD)-E





- 认为注入的位置，MWPC能量沉积大，确实是反冲核

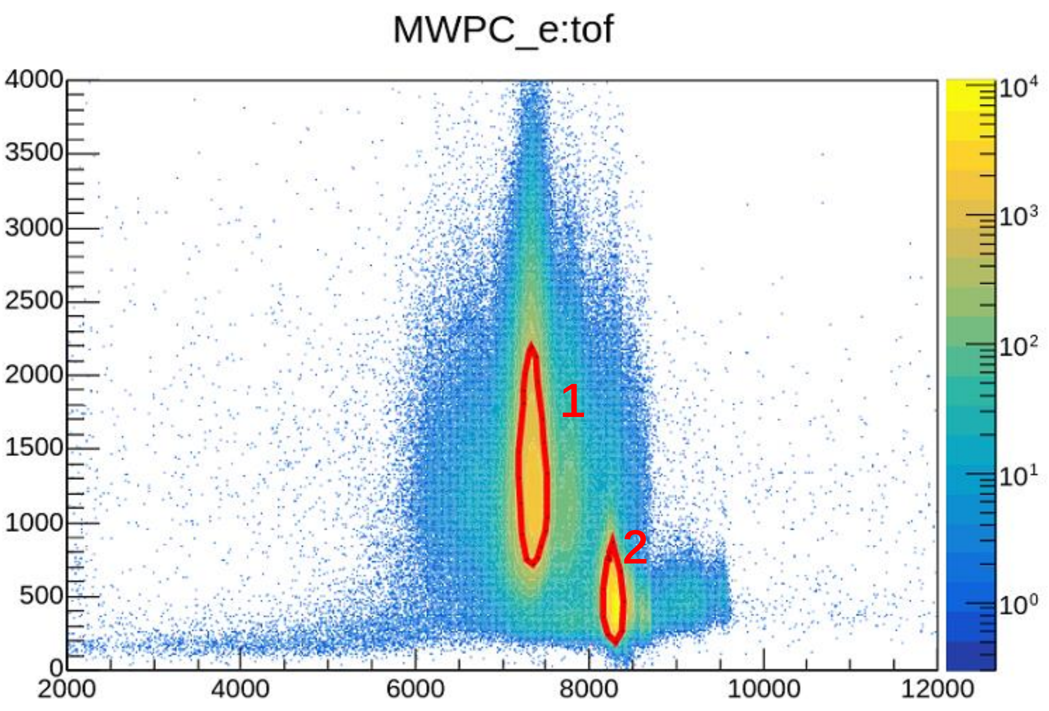


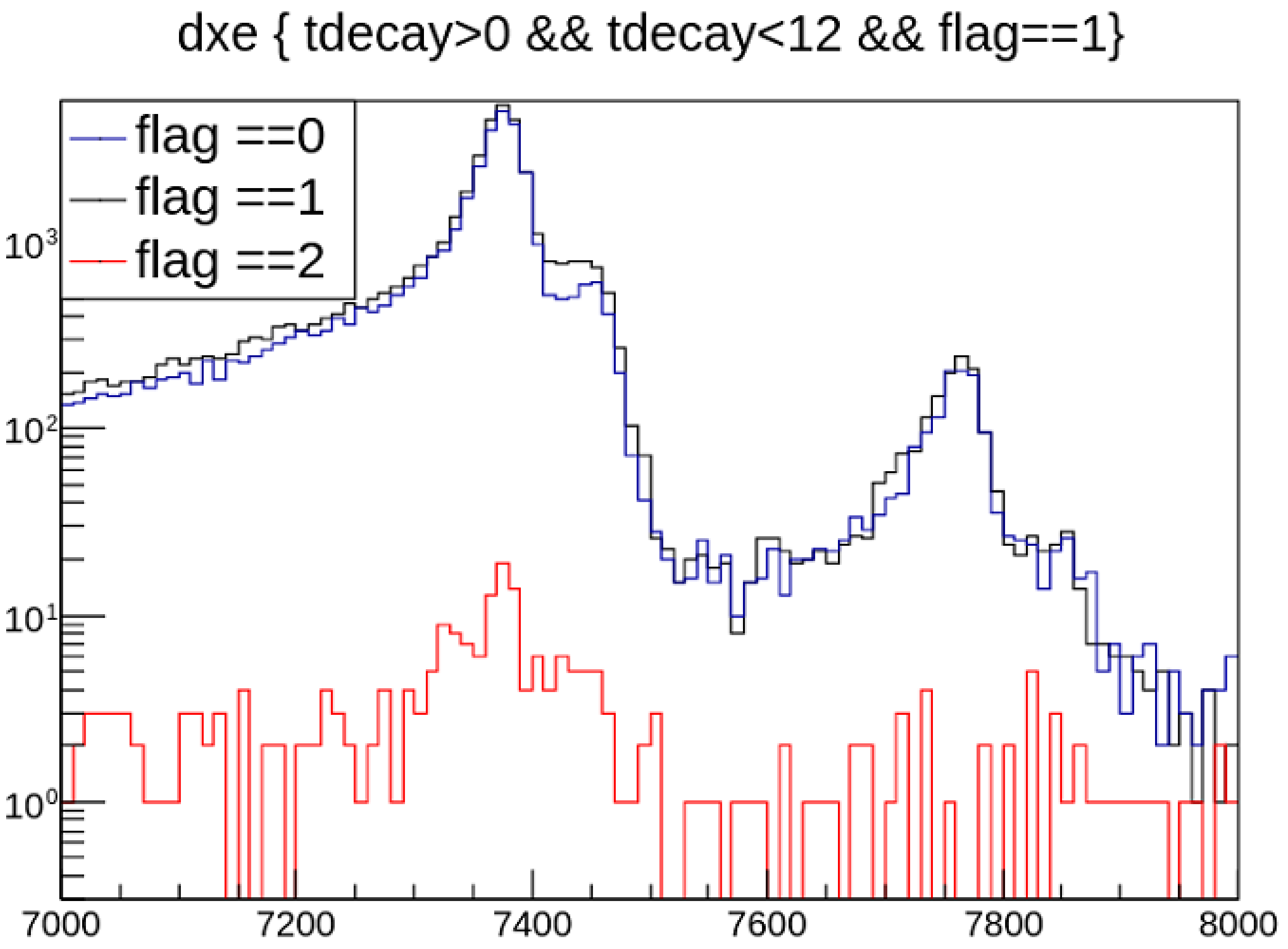


- 认为是束流的位置，MWPC能量沉积小，应该是轻核，但不一定是束流

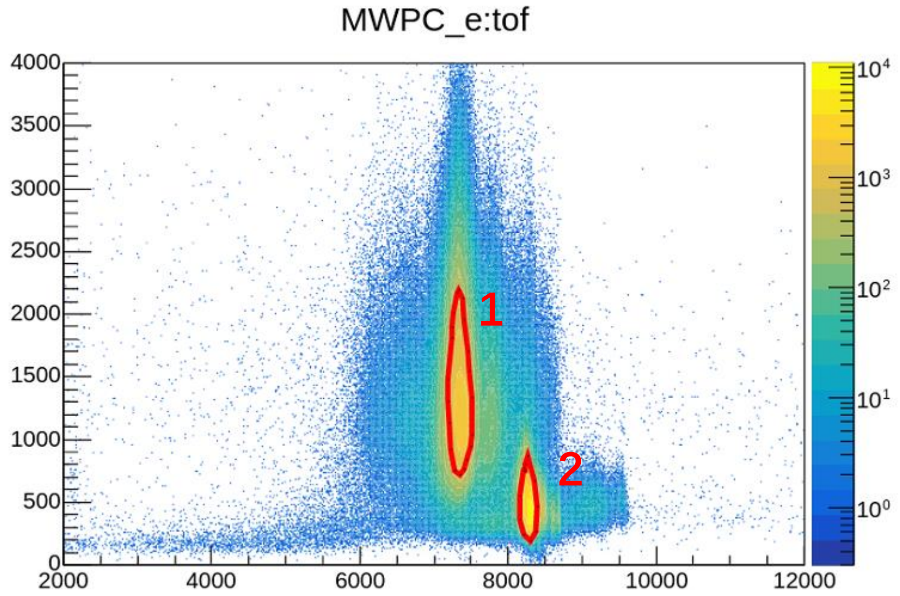
产物分布

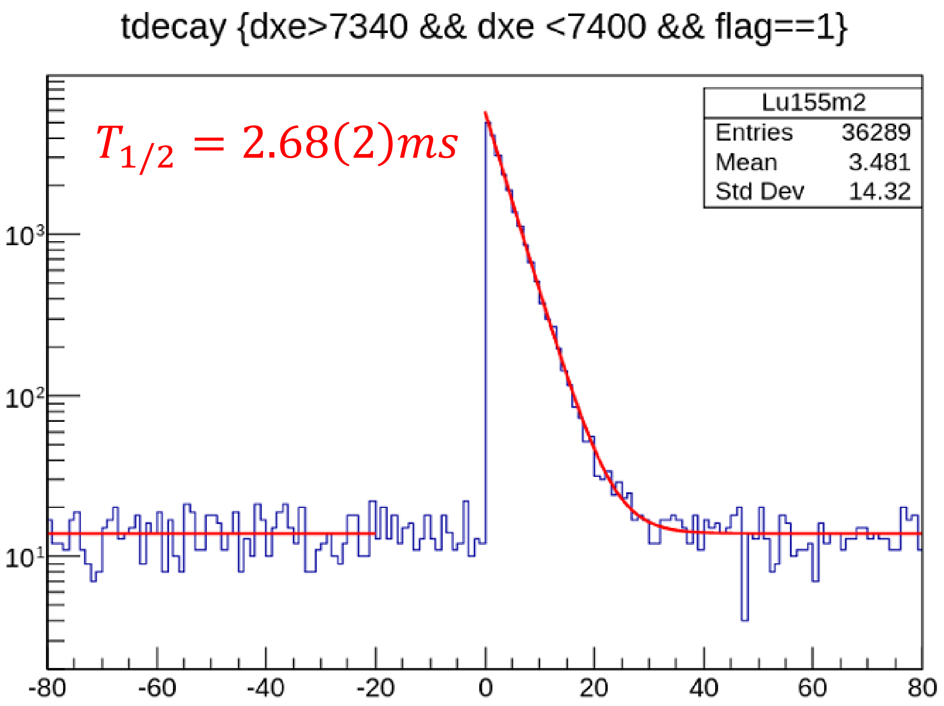
- 1区域之外也存在一半的融合蒸发产物

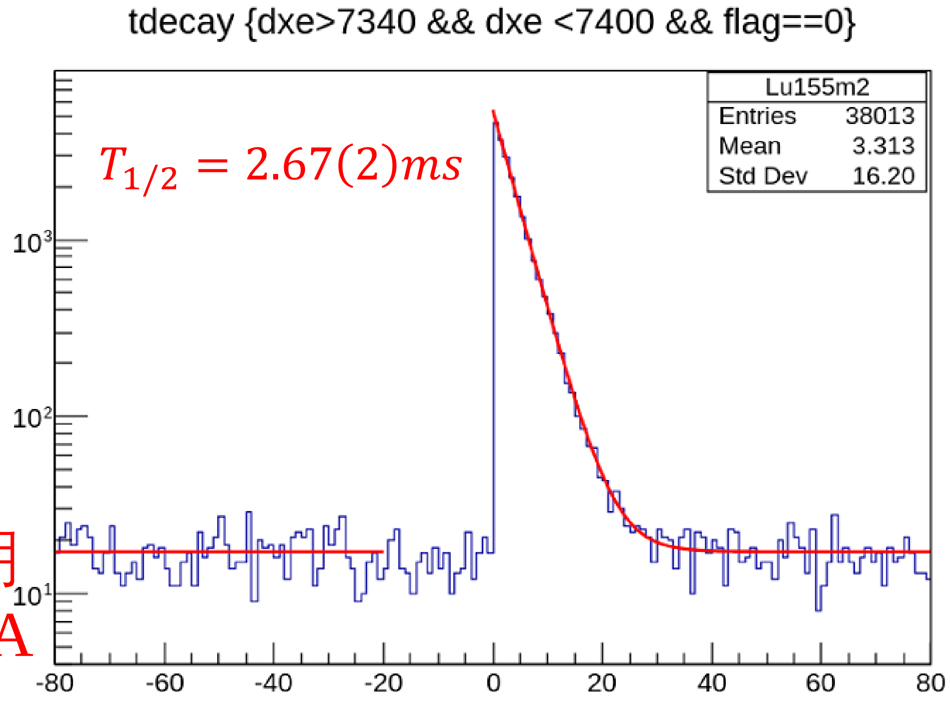




^{155m2}Lu(2.69(3)ms)







- ➢ 1区域之外确实是融合蒸发产物，因为提取的半衰期没有问题（注入核有问题半衰期一定有问题，虽然A程序是衰变为主）

150Yb

- 150Yb可能的衰变方式为β+，会布局到150Tm的激发态上
- 但150Tm中已知激发态的自旋和0+相差太大，对应得衰变严格禁戒
- Δl>3的β衰变基本没有
- 结论：通过β衰变到子核的激发态退激的γ线鉴别的路线走不通

150Yb

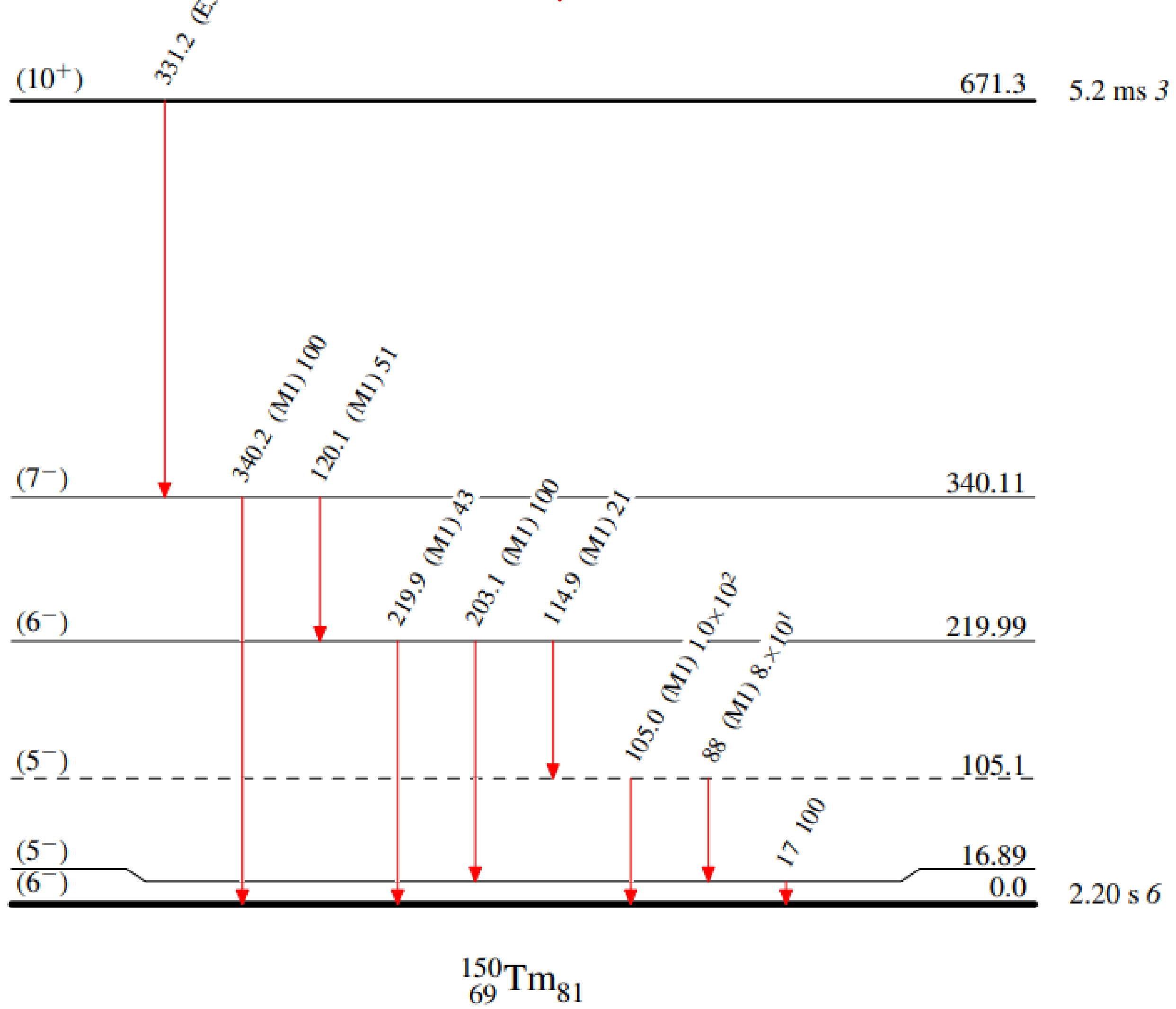
Ytterbium-150 (Z=70, N=80)

Ground state properties

$J^{\pi} = 0^{+}$
$t_{1/2}$ = 700 ms #
β^{+} (possible)

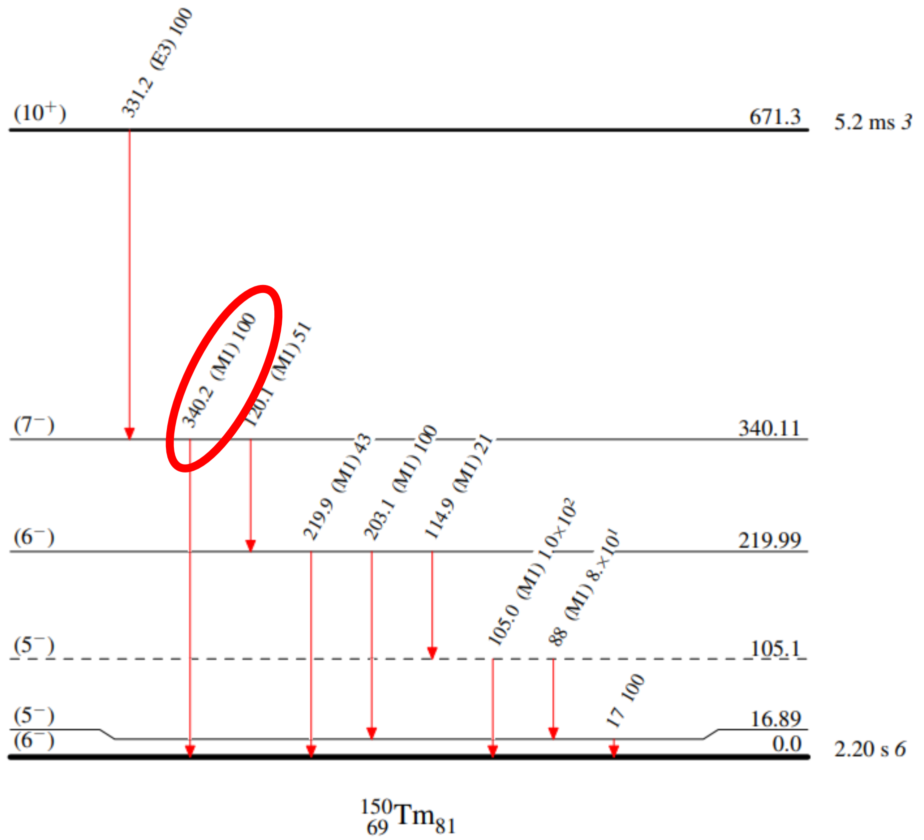
Mass and related properties

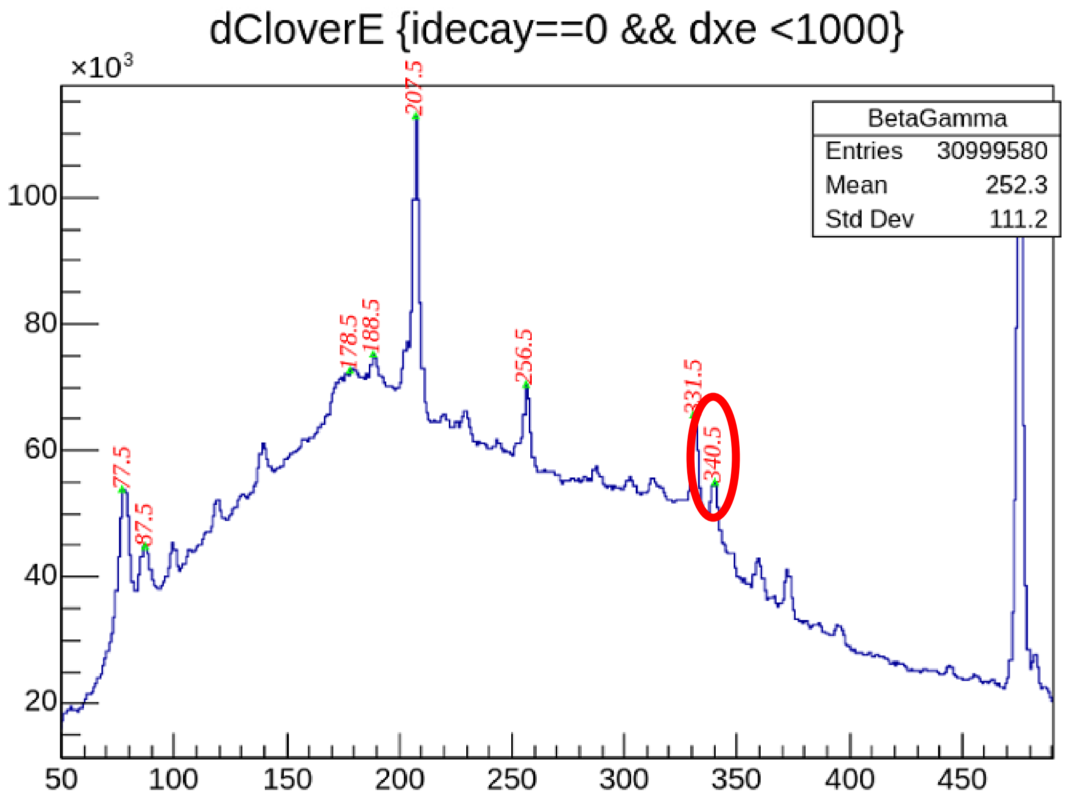
M	= 149958314	± 322	μu	#
M_{ex}	= -38.83	± 0.3	MeV	#
B/A	= 7.965	± 0.002	MeV	#
S_p	= 2.179	± 0.361	MeV	#
S_{2p}	= 1.929	± 0.3	MeV	#
S_n	= 13.572	± 0.424	MeV	#
S_{2n}	= 24.743	± 0.5	MeV	#
Q_{α}	= 3.067	± 0.3	MeV	#
E_{β}	= -14.059	± 0.424	MeV	#



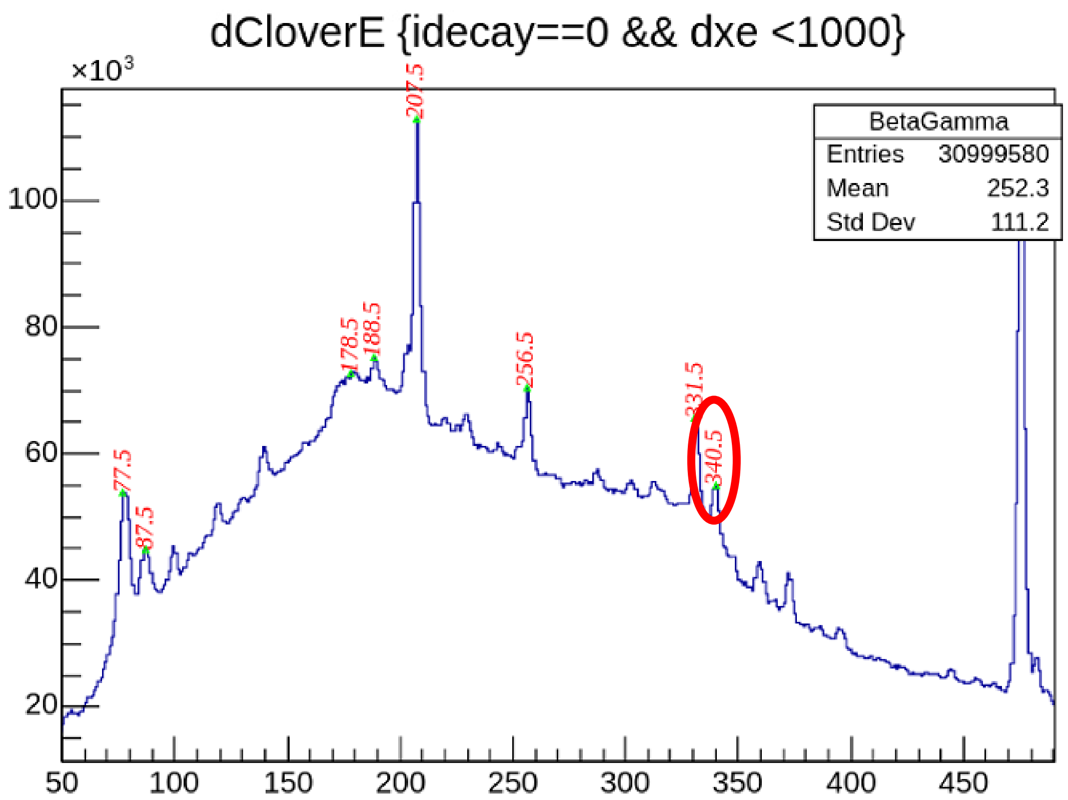
^{150}Yb

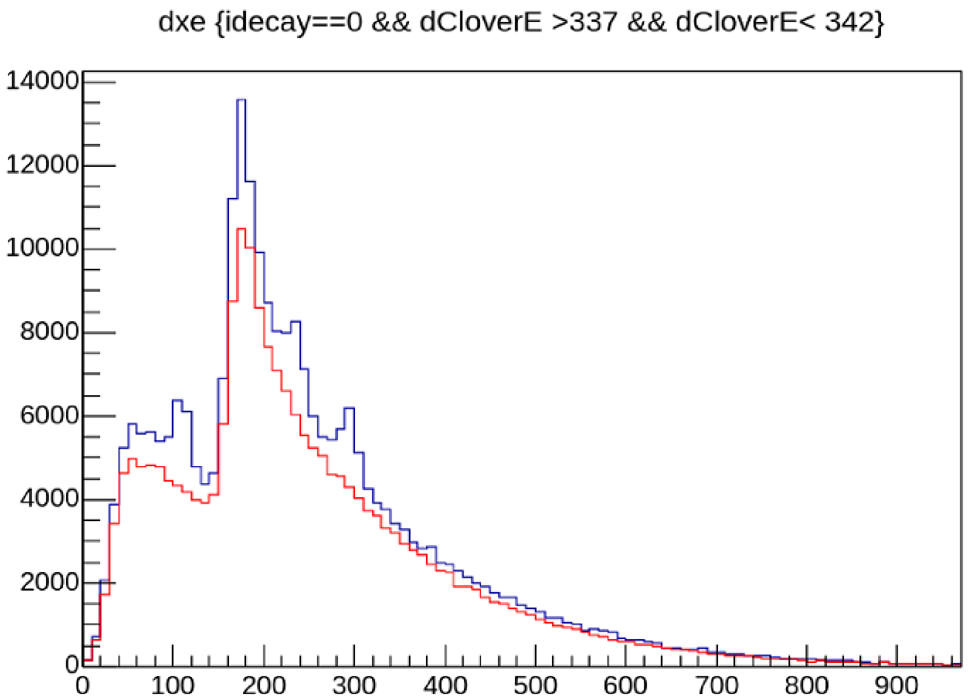
- 可能是直接产生的151Tm

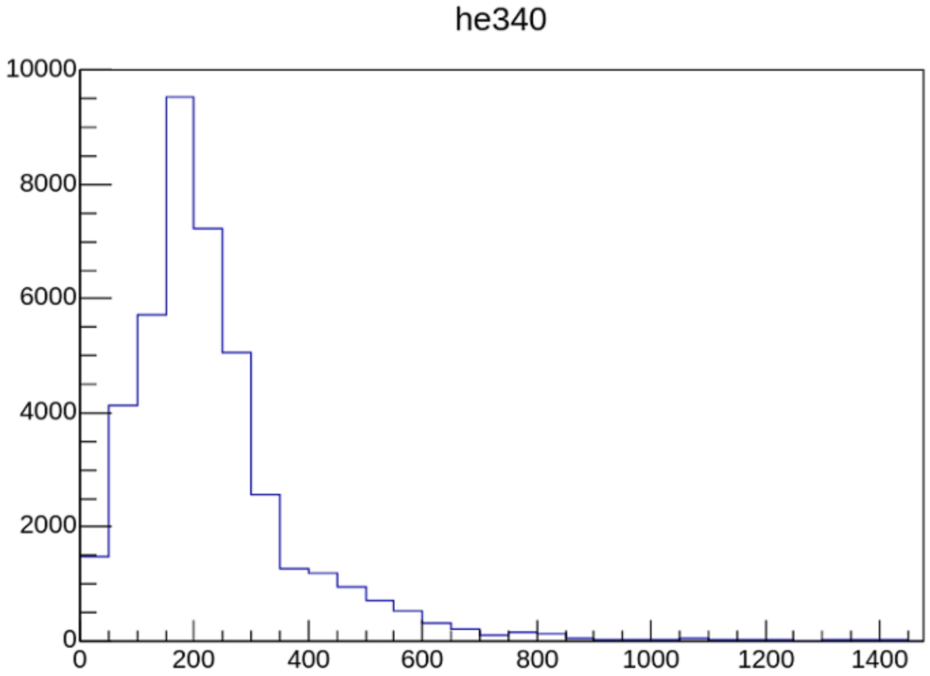




^{150}Yb

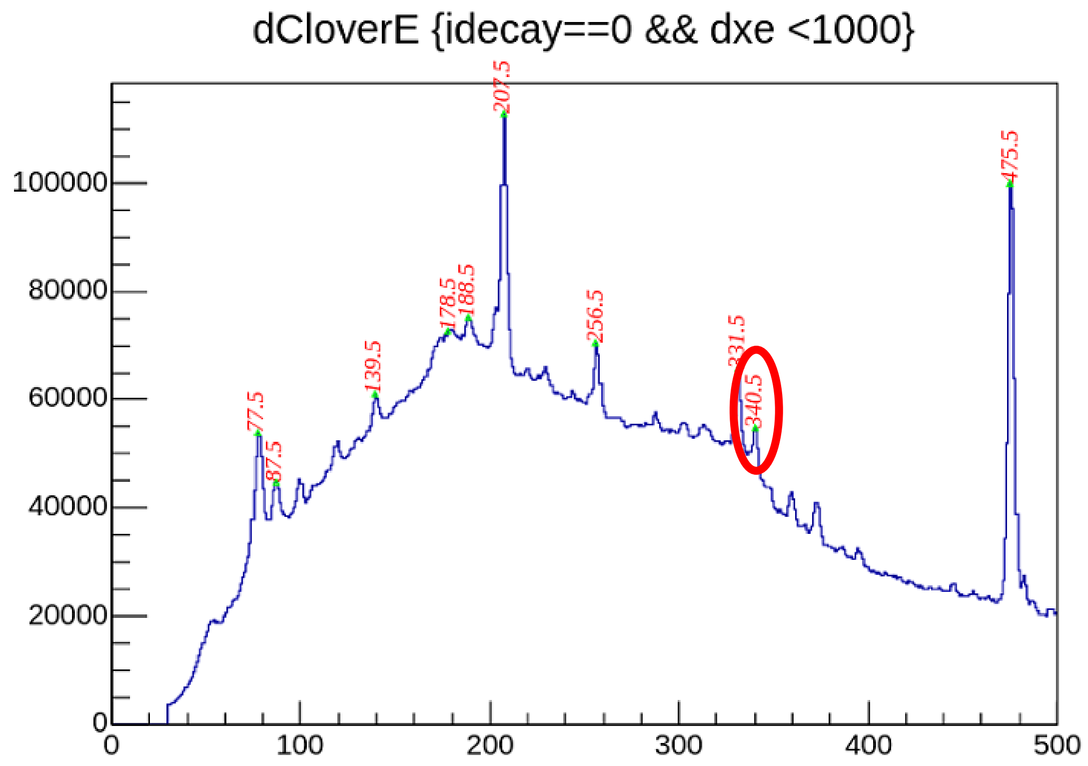


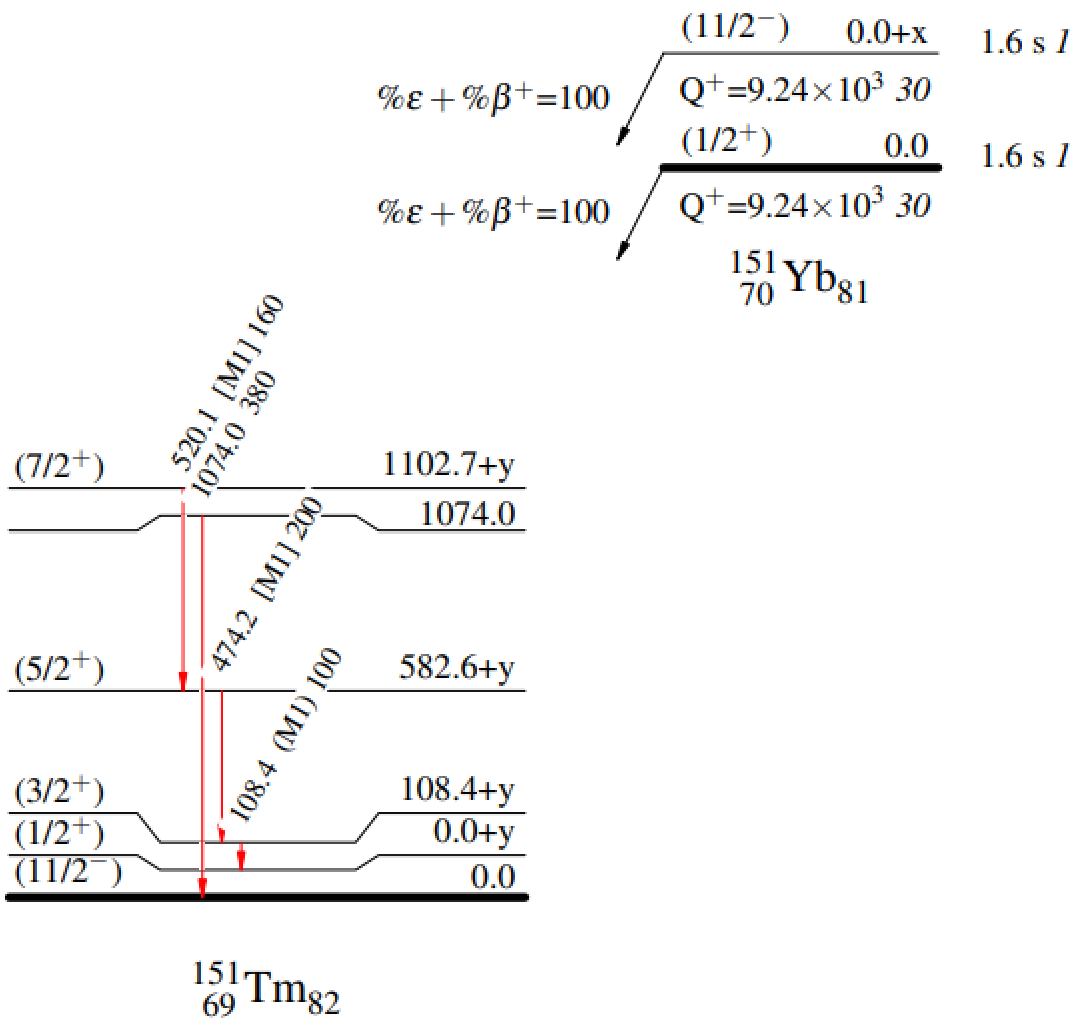




峰能量	拟合范围	λ	△λ	T/tics	△ T	来源	备注
765	20-200	0.02341	0.0006113	29.61	0.77	147Ho	
919	20-200	0.02574	0.001071	26.93	1.12	147Ho	
971	20-200	0.02455	0.0007137	28.23	0.82	147Ho	
339	20-200	0.0166	8.486e-5	41.76	0.21	151Tm	

^{150}Yb





峰能量	拟合范围	λ	△λ	T/tics	△T	来源	备注
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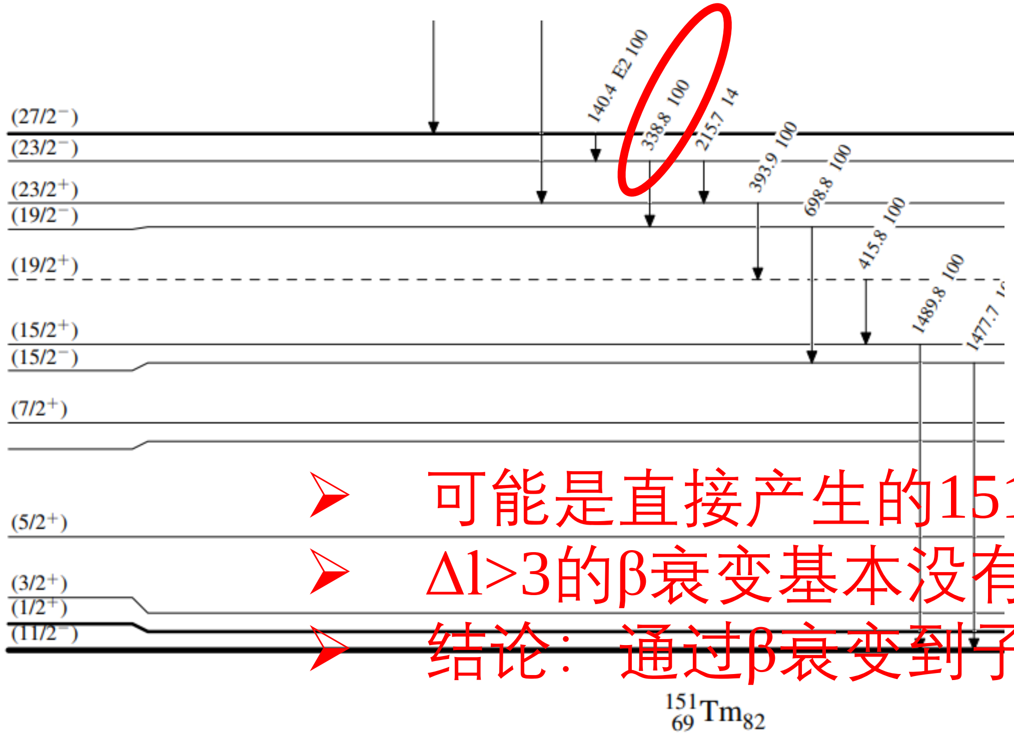
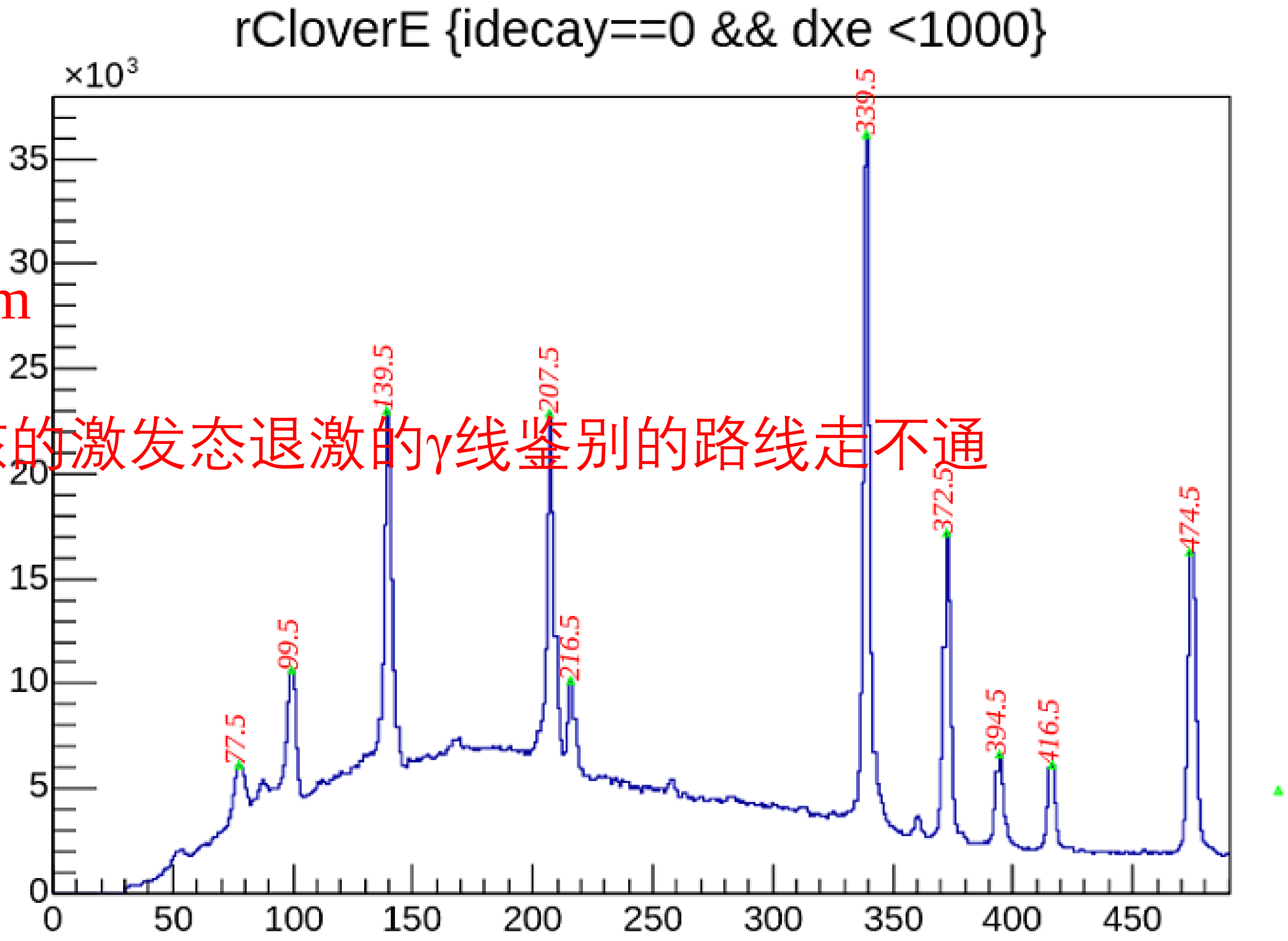
971	20-200	0.02455	0.0007137	28.23	0.82	147Ho	
339	20-200	0.0166	8.486e-5	41.76	0.21	151Tm	

^{150}Yb

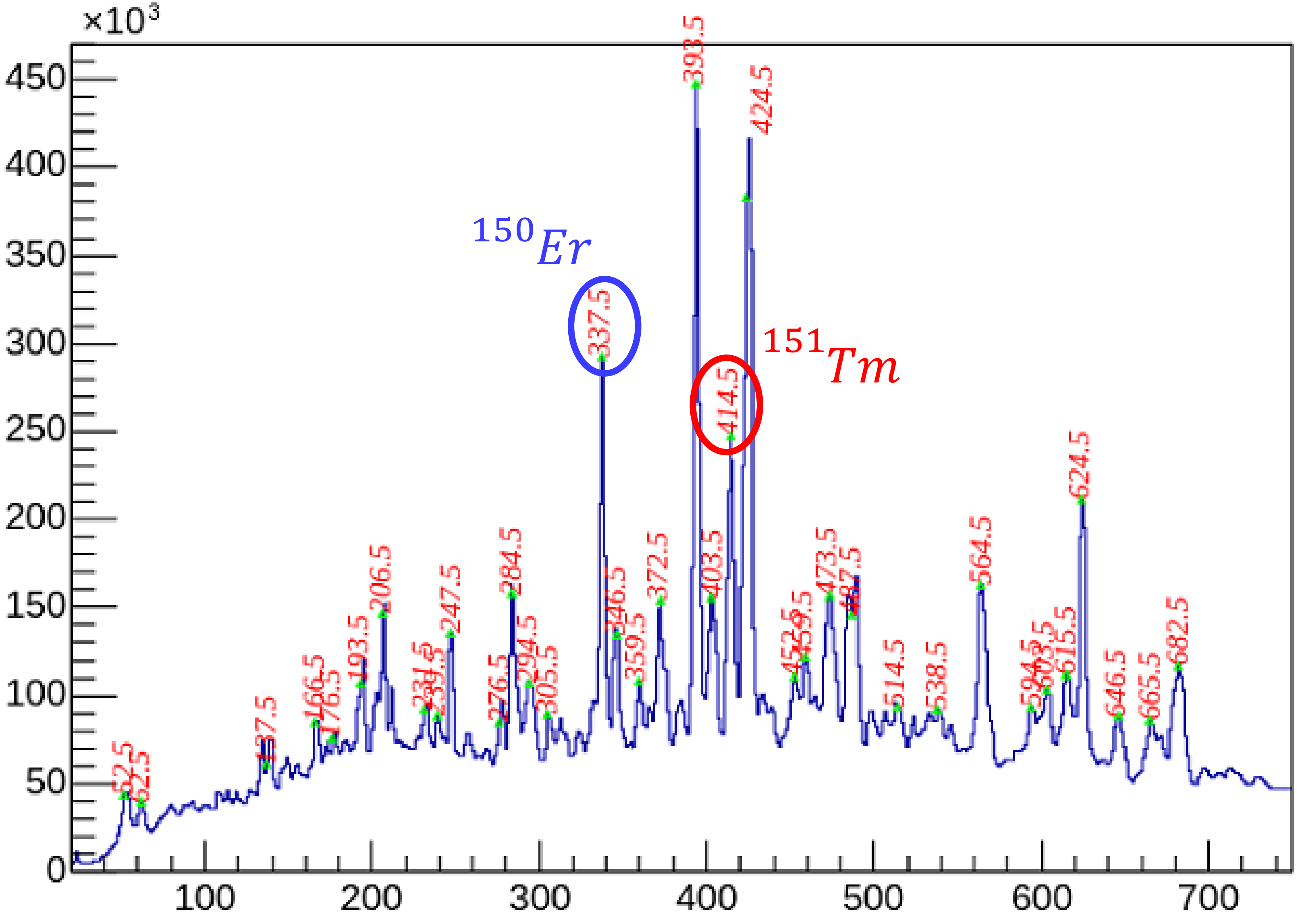




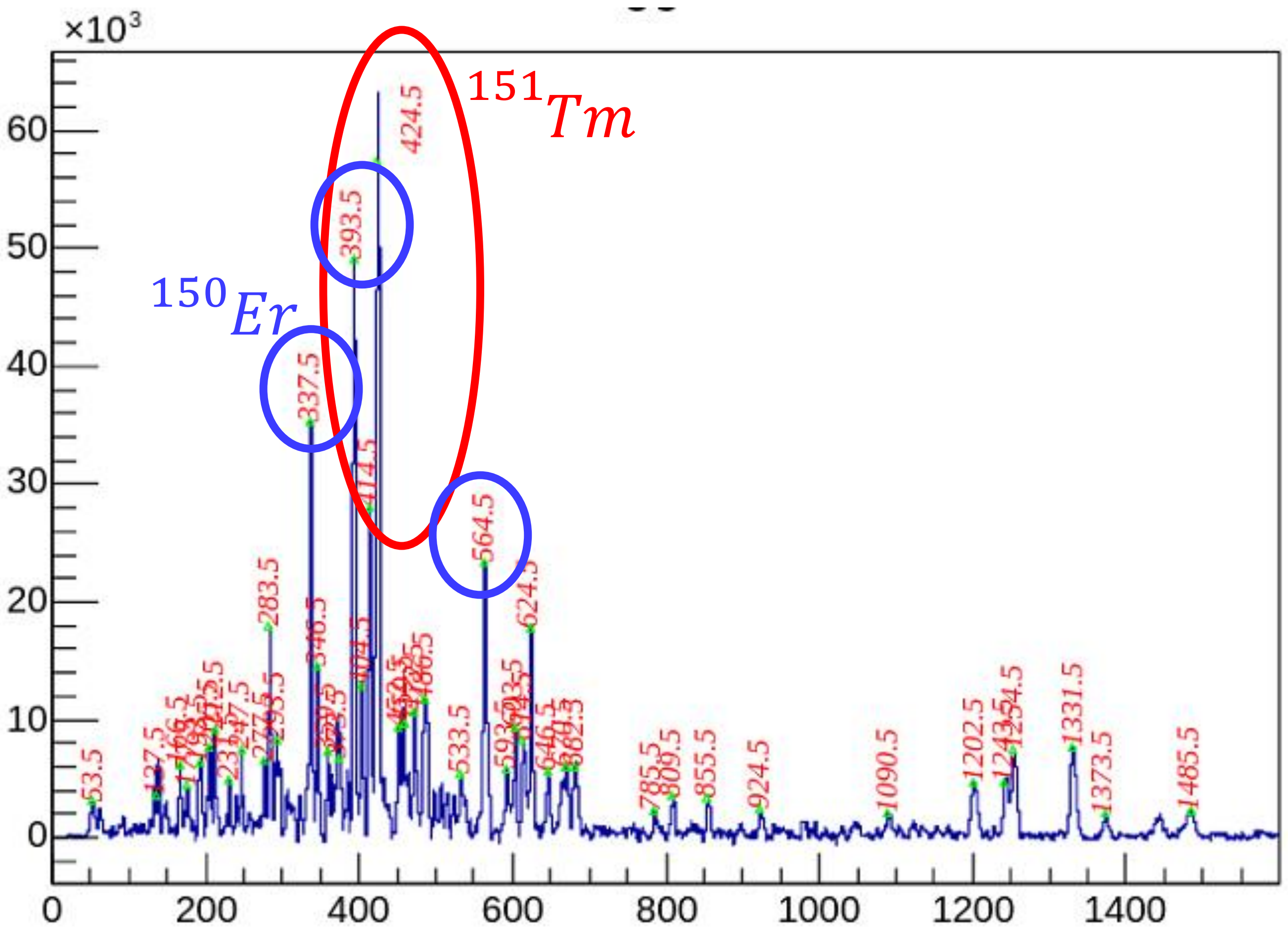
- 可能是直接产生的151Tm
- Δl>3的β衰变基本没有
- 结论：通过β衰变到子核的激发态退激的γ线鉴别的路线走不通

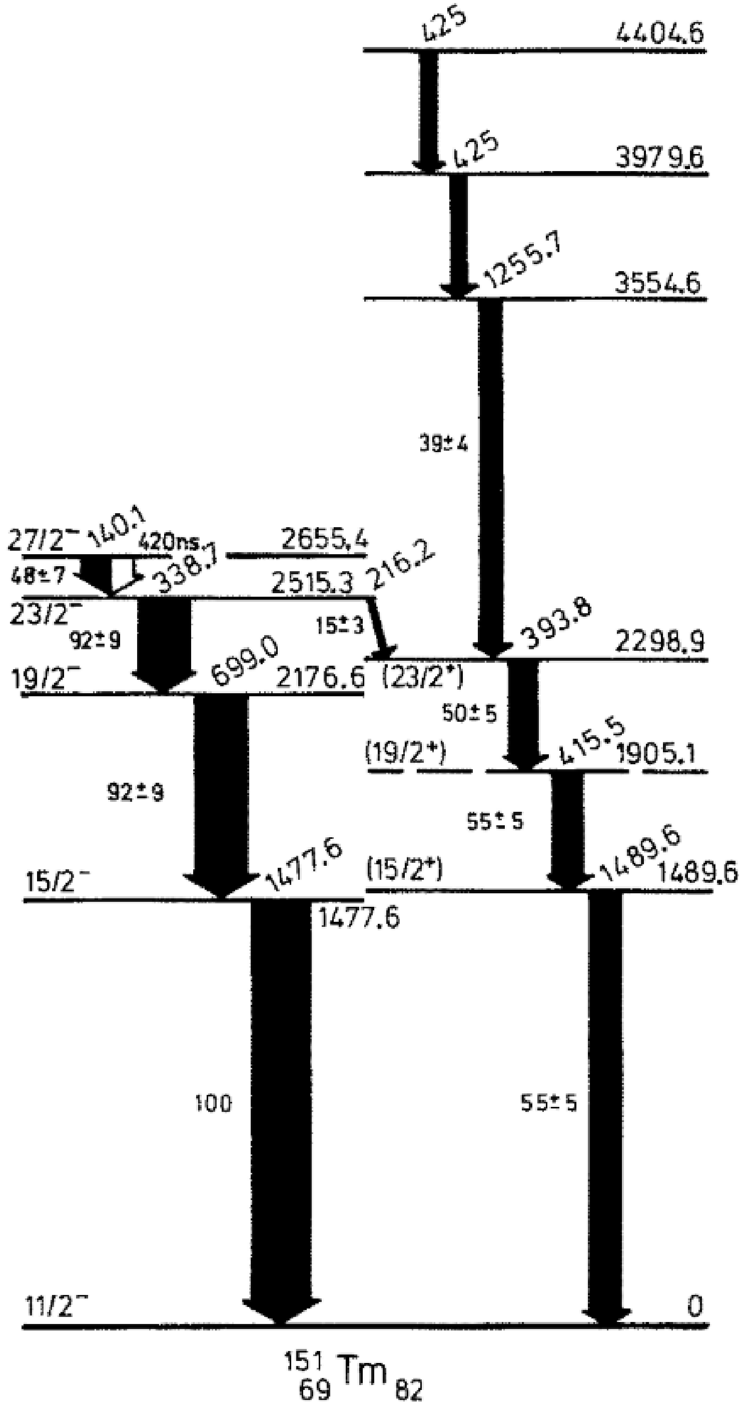
In beam

Inbeam Study

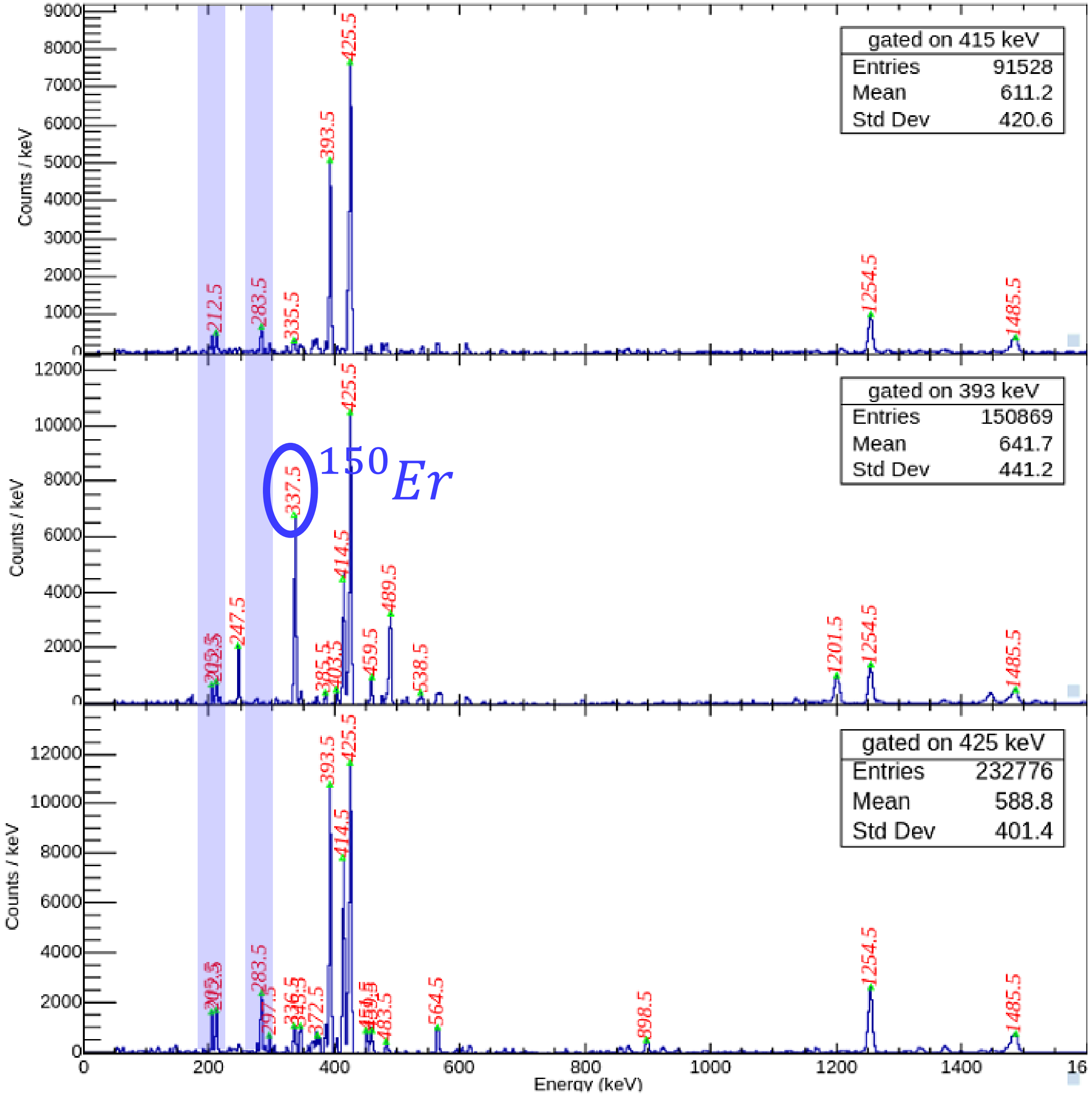


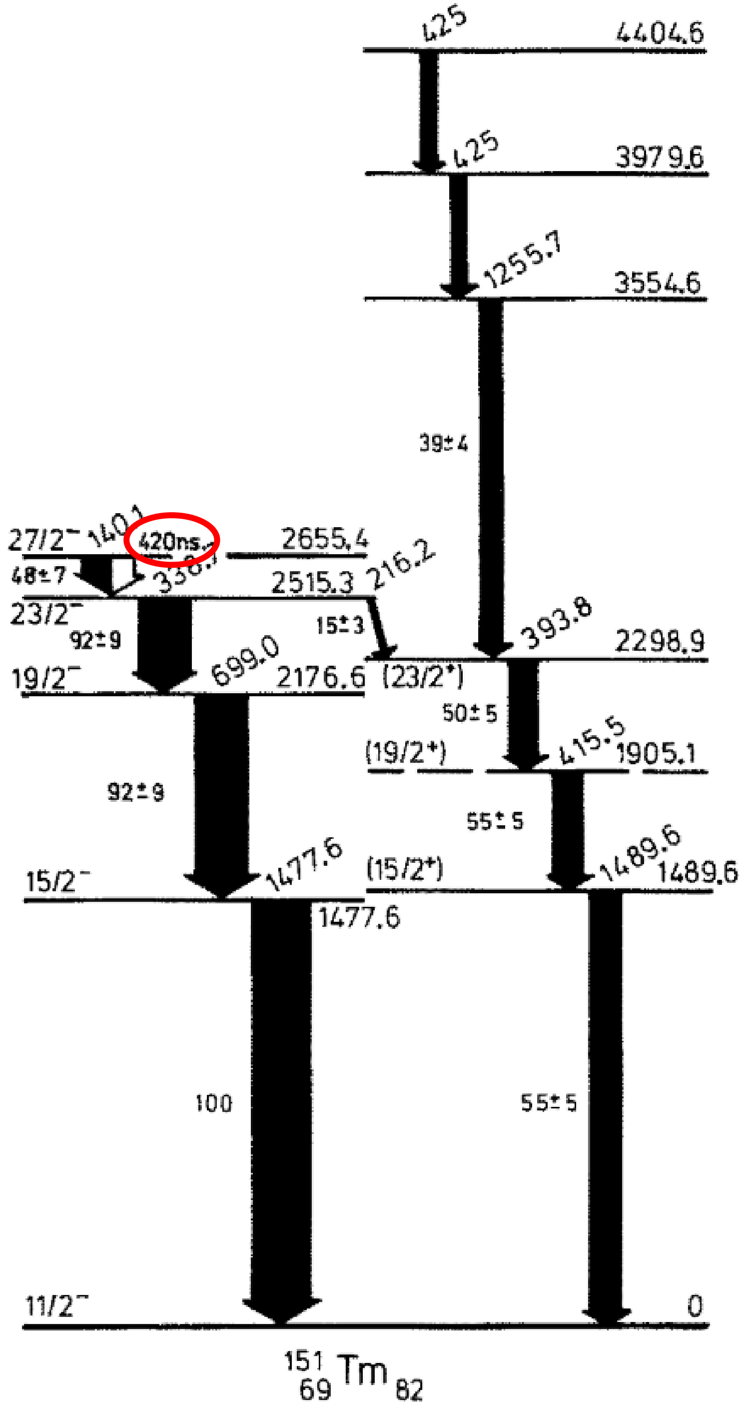
Inbeam Study



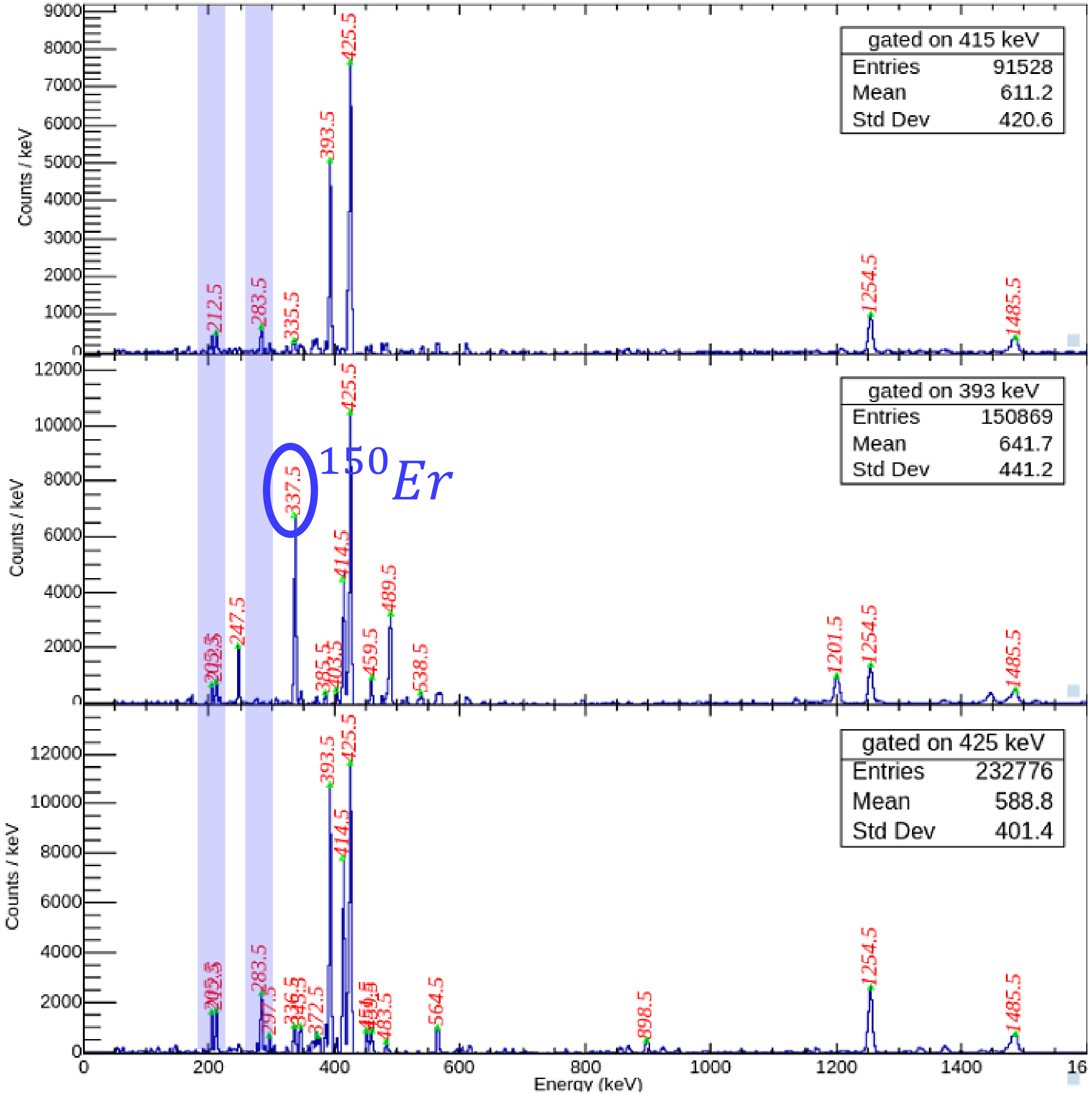


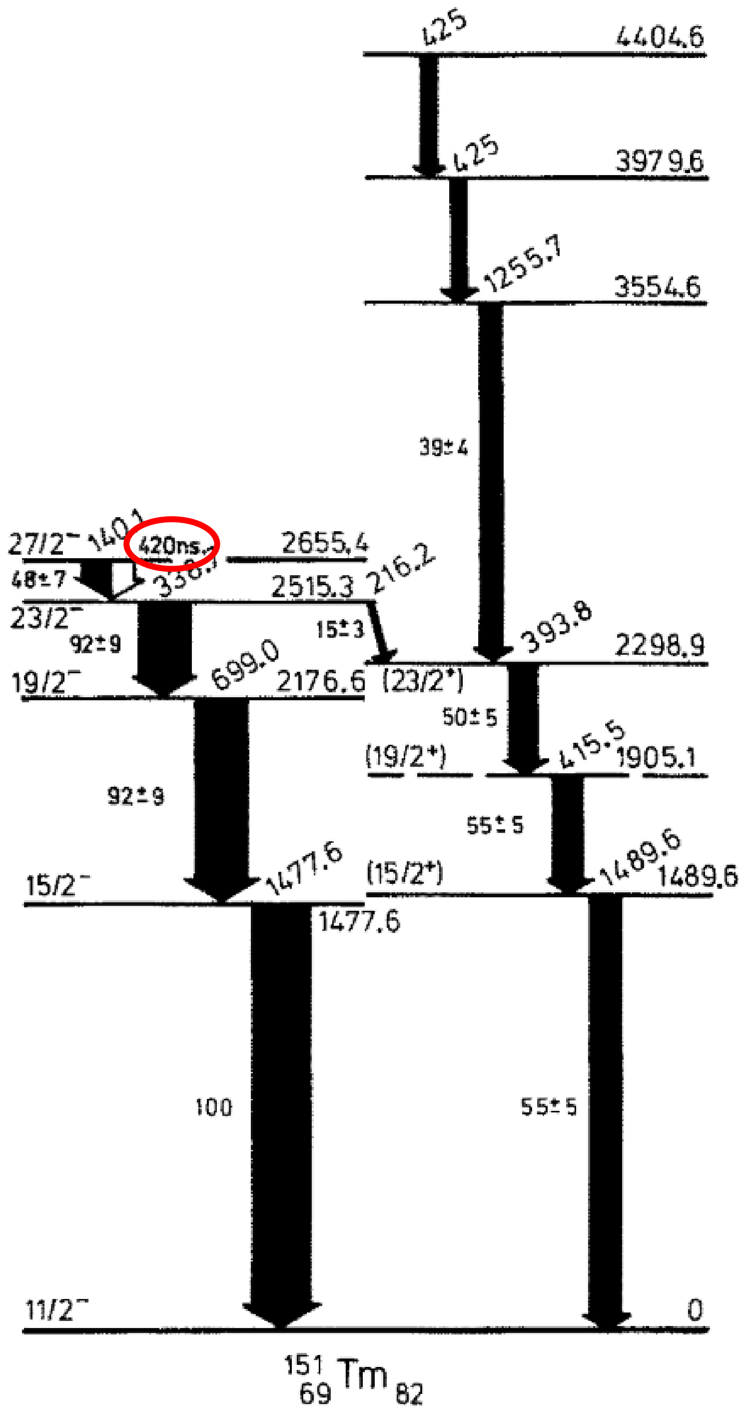
Inbeam Study(^{151}Tm)



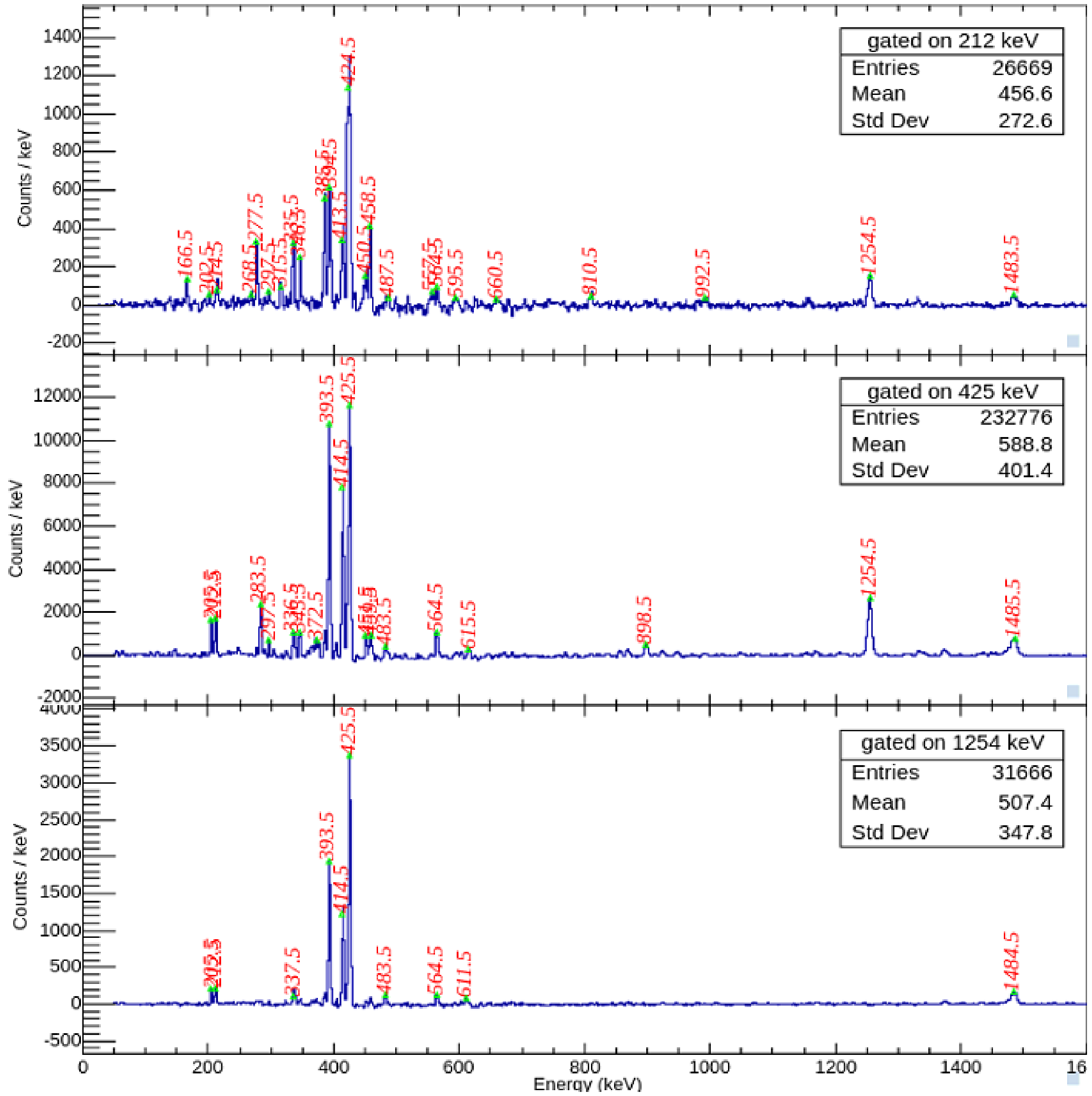


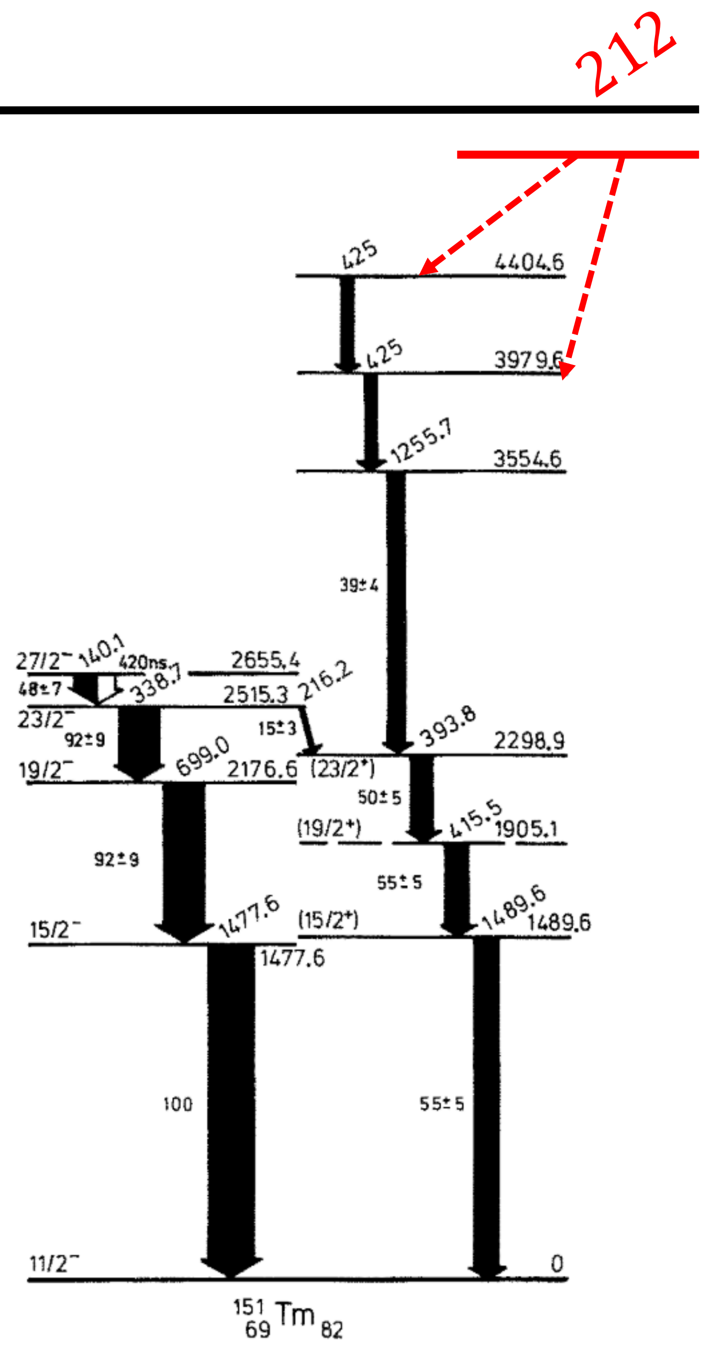
Inbeam Study(^{151}Tm)



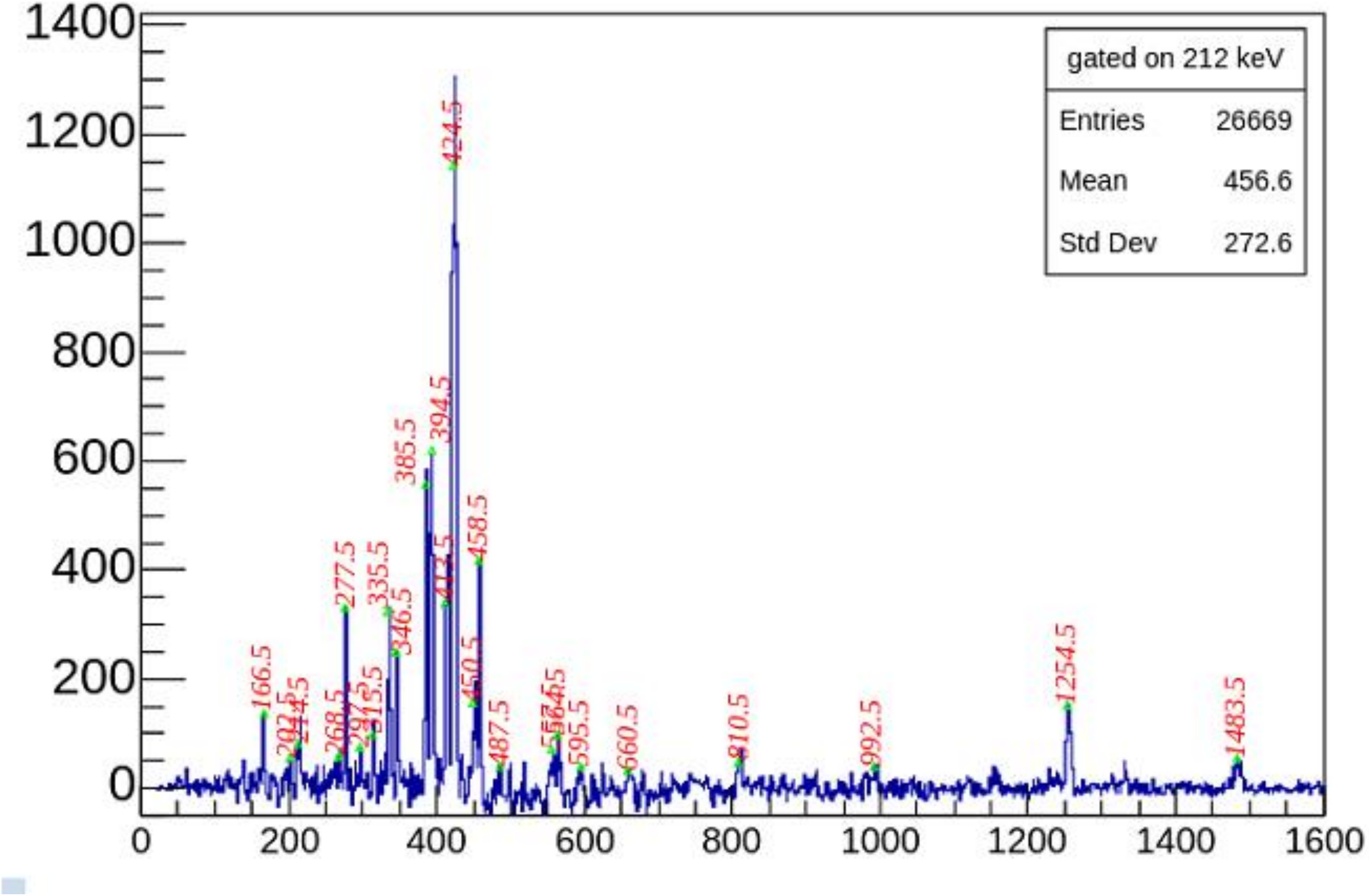


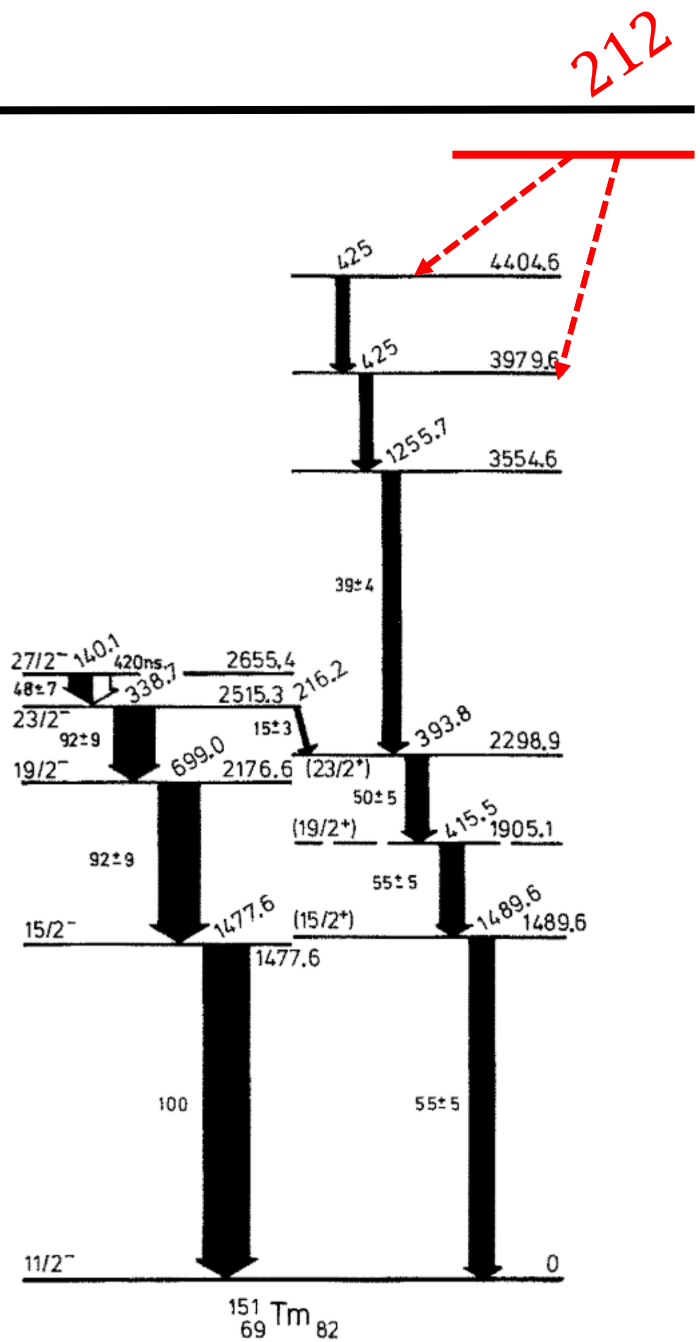
Inbeam Study(^{151}Tm) (212 keV)



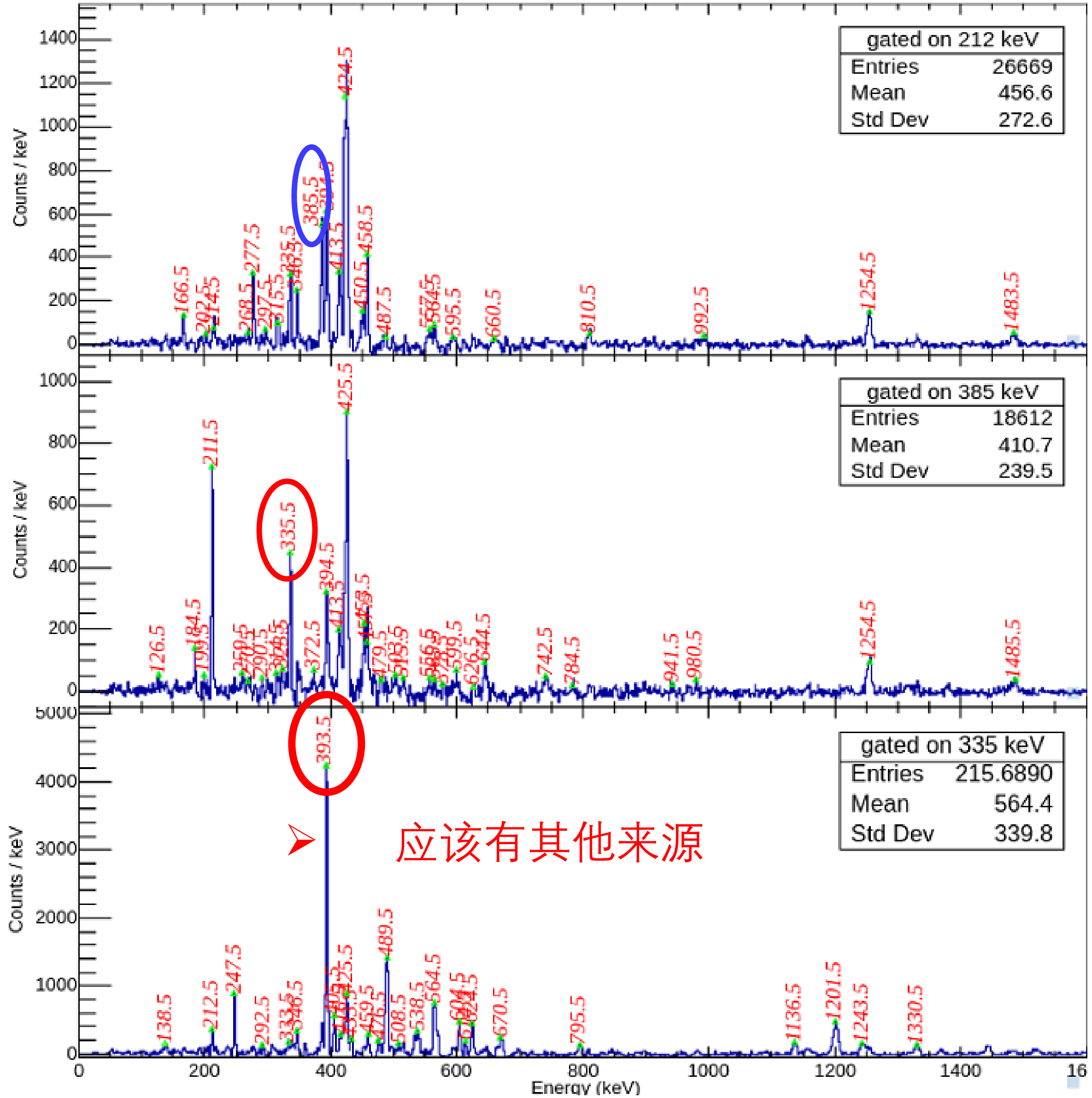


Inbeam Study(^{151}Tm) (212 keV)

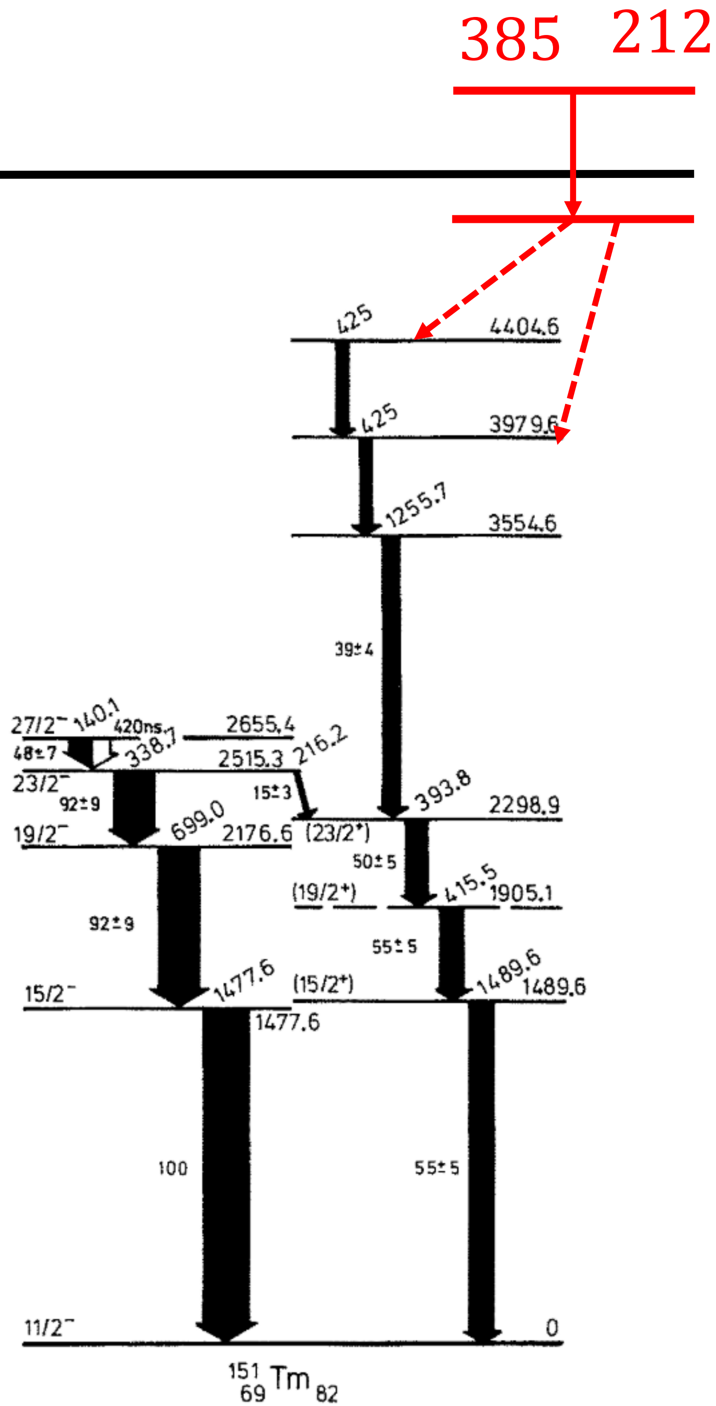




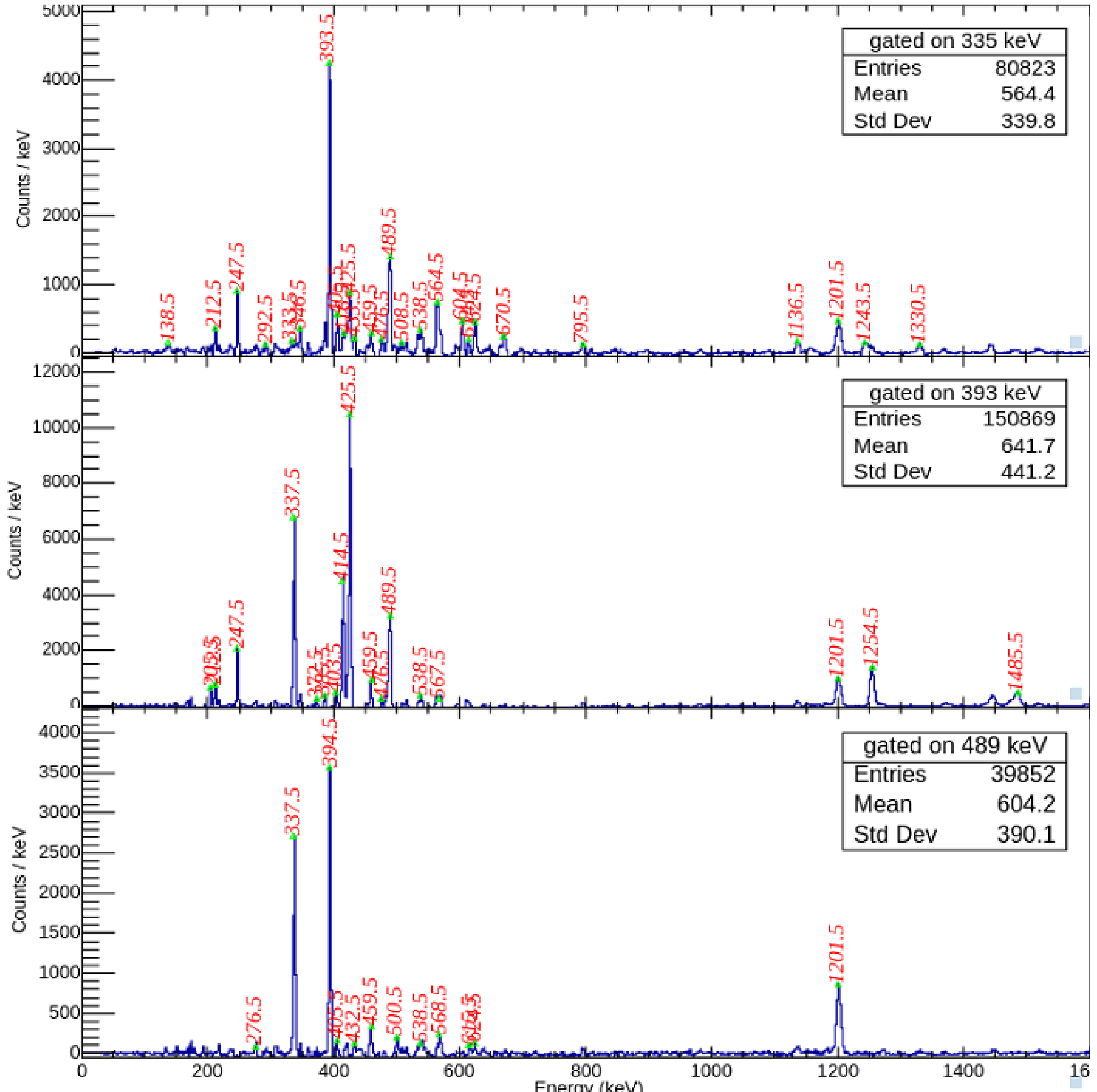
Inbeam Study(^{151}Tm) (212 - 385 keV)

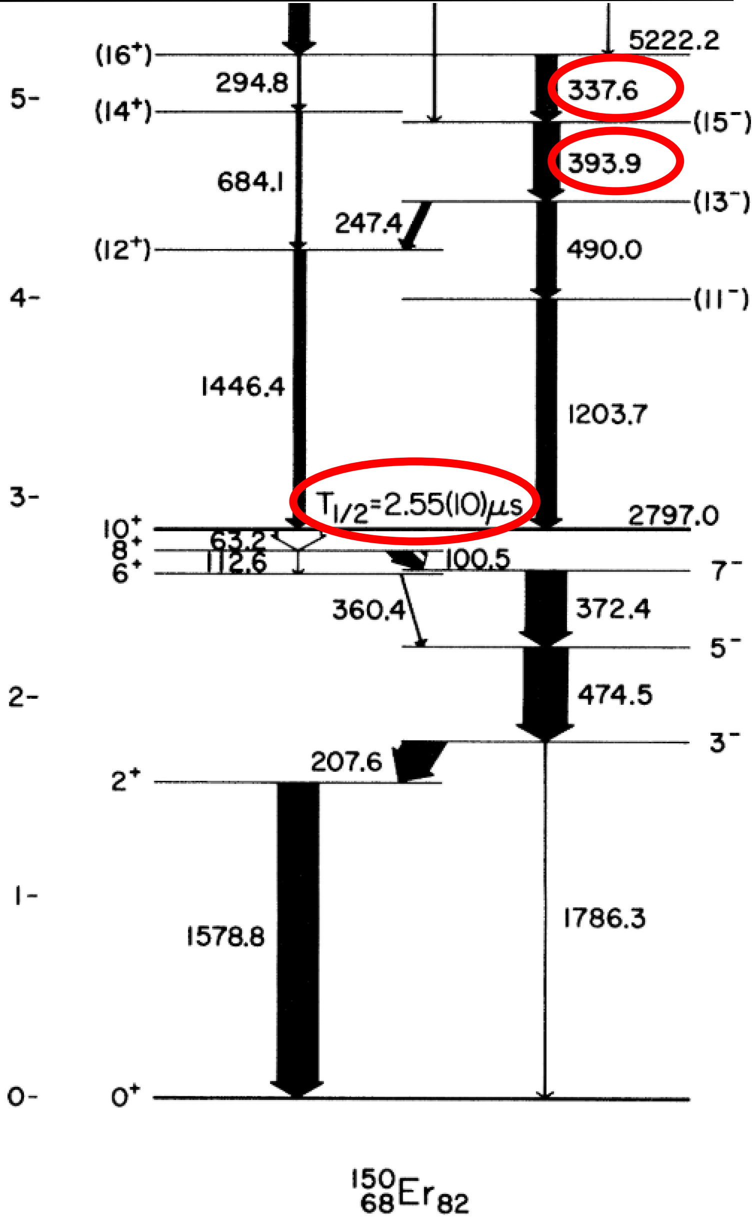


➢ 应该有其他来源

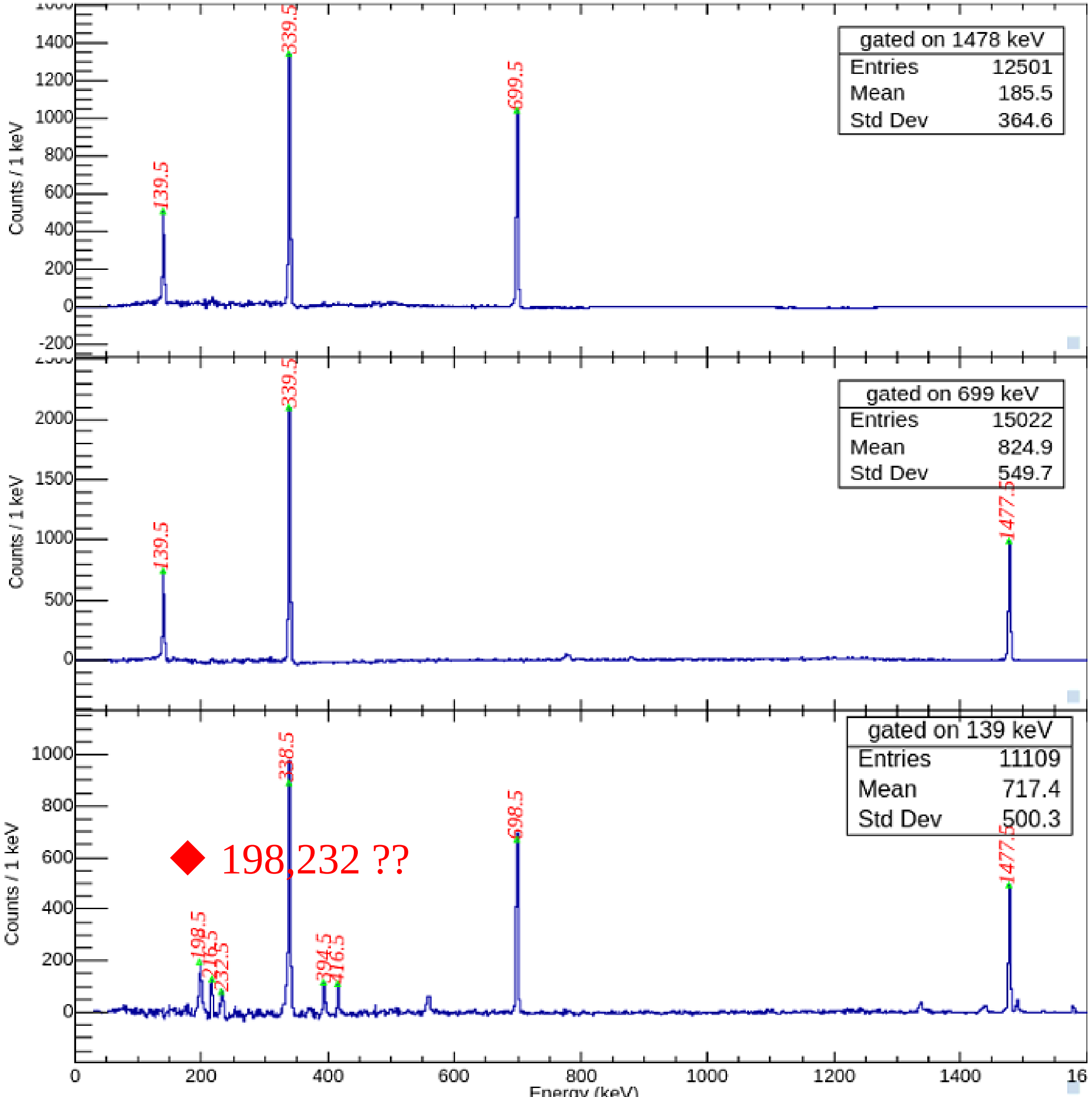


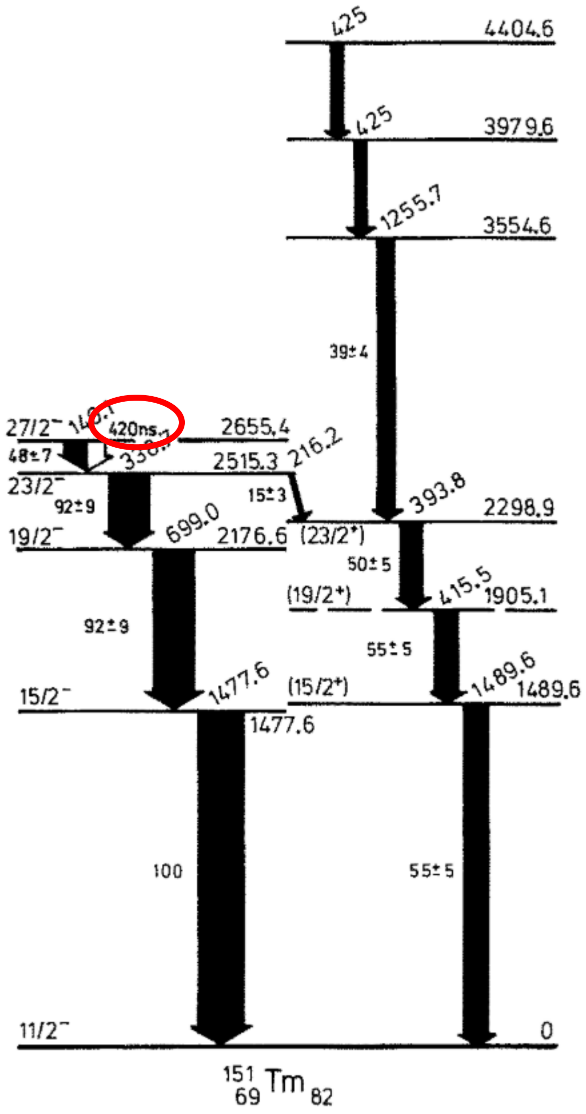
Inbeam Study(^{151}Tm) (335 - 393 keV)



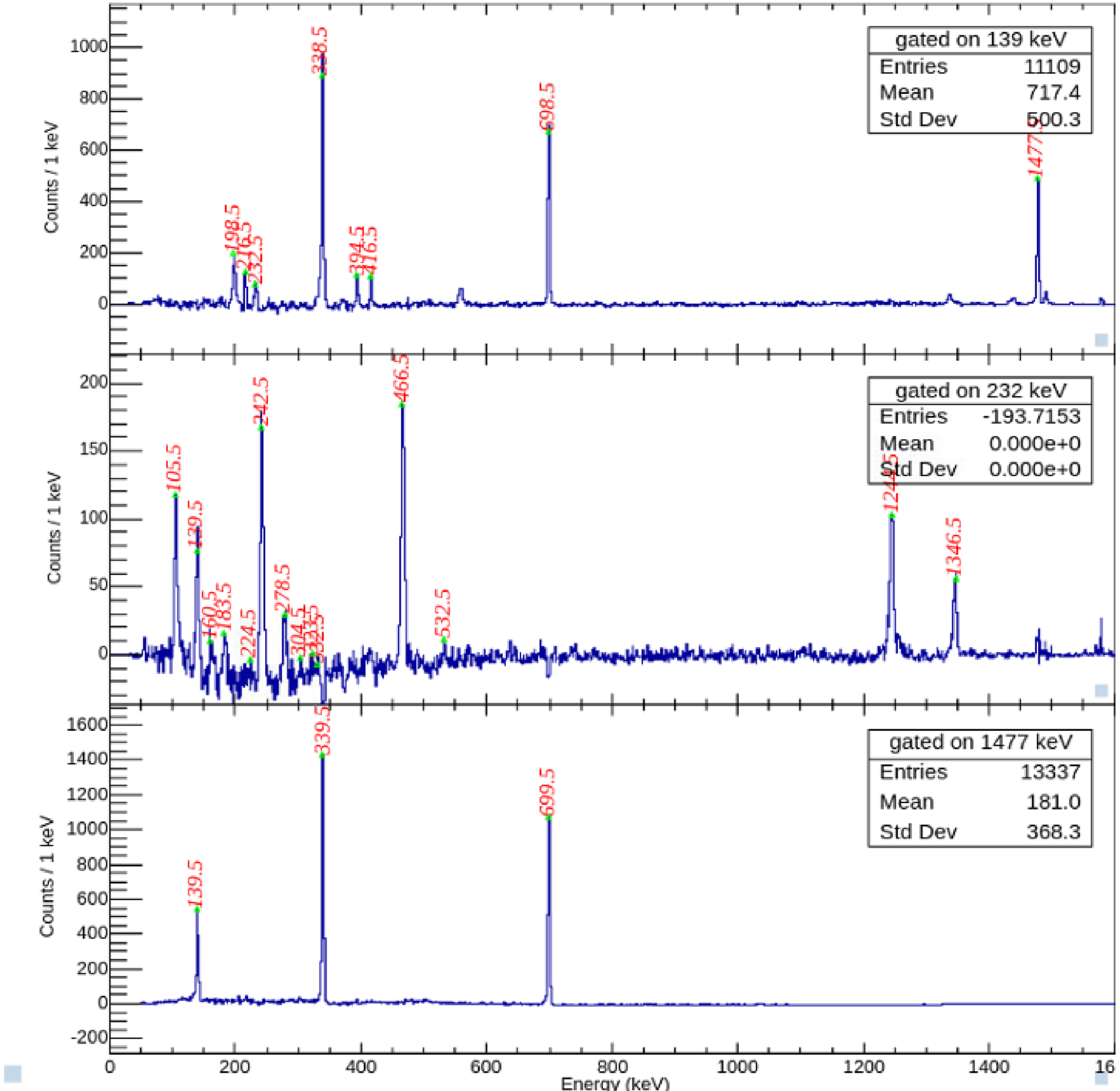


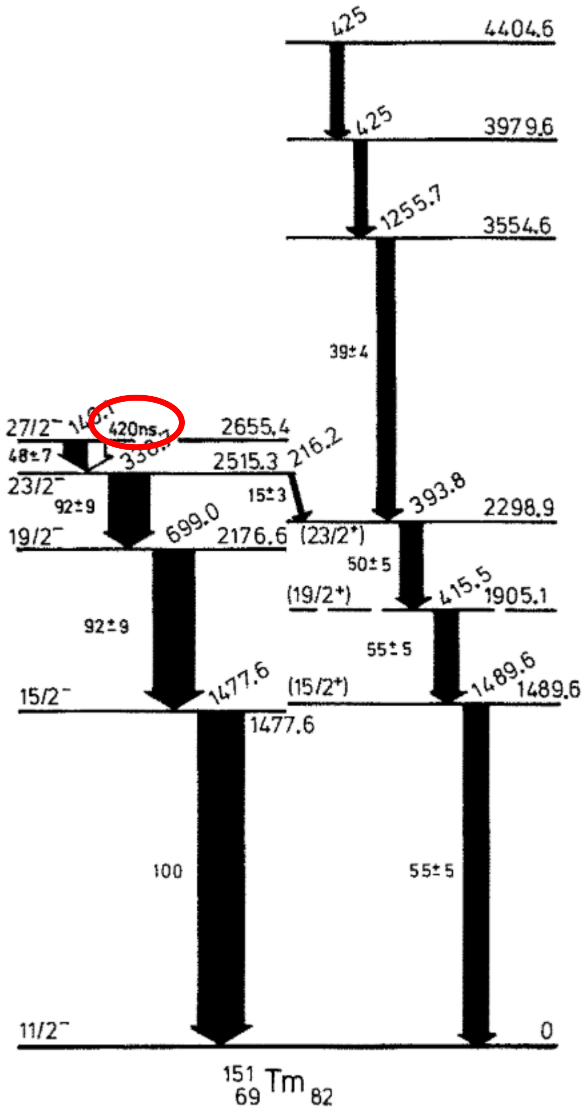
Isomer(^{151}Tm)--Clover



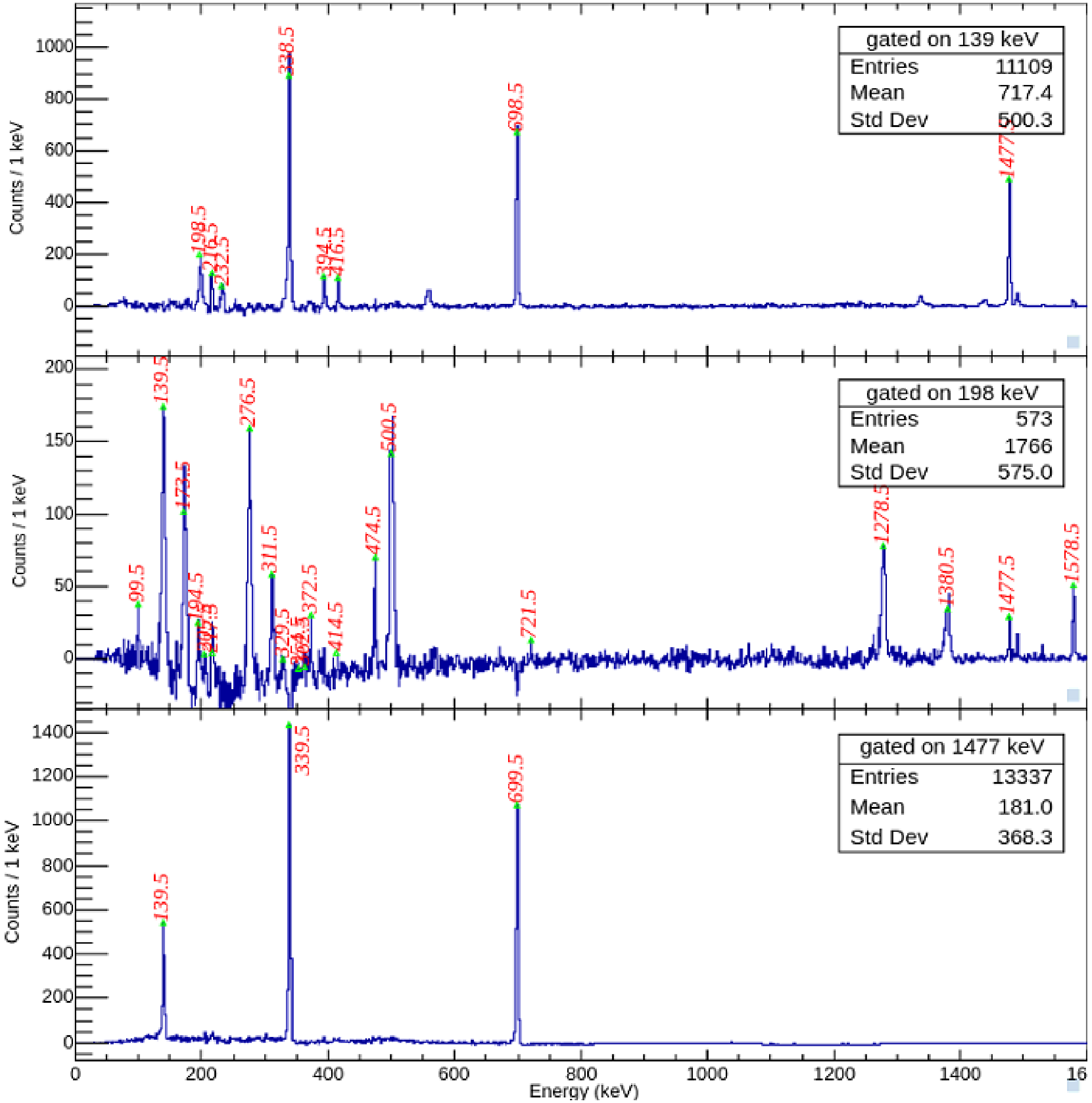


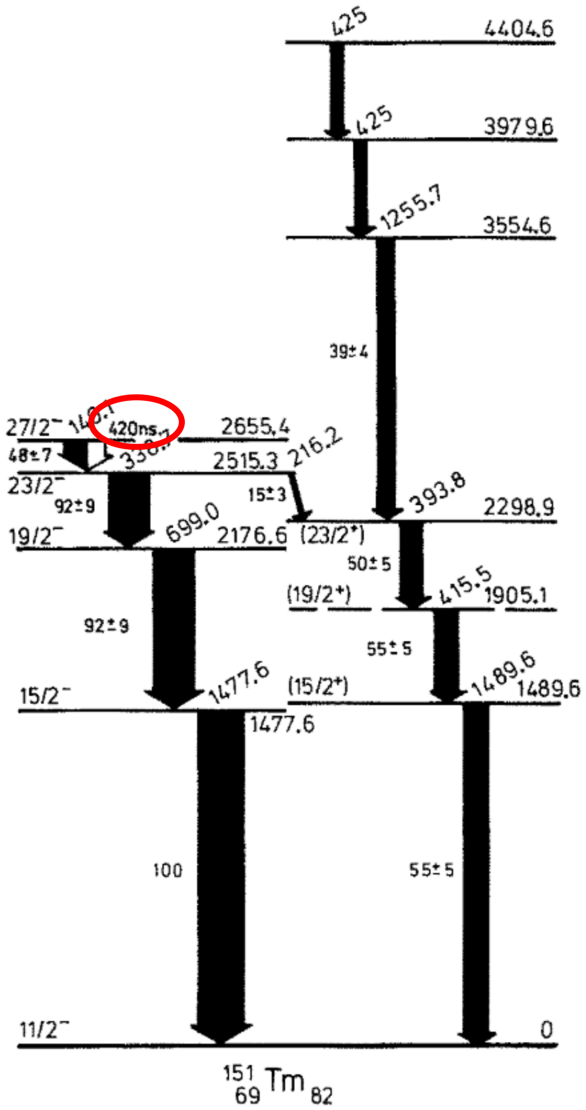
Isomer(^{151}Tm)(232 keV) --Clover



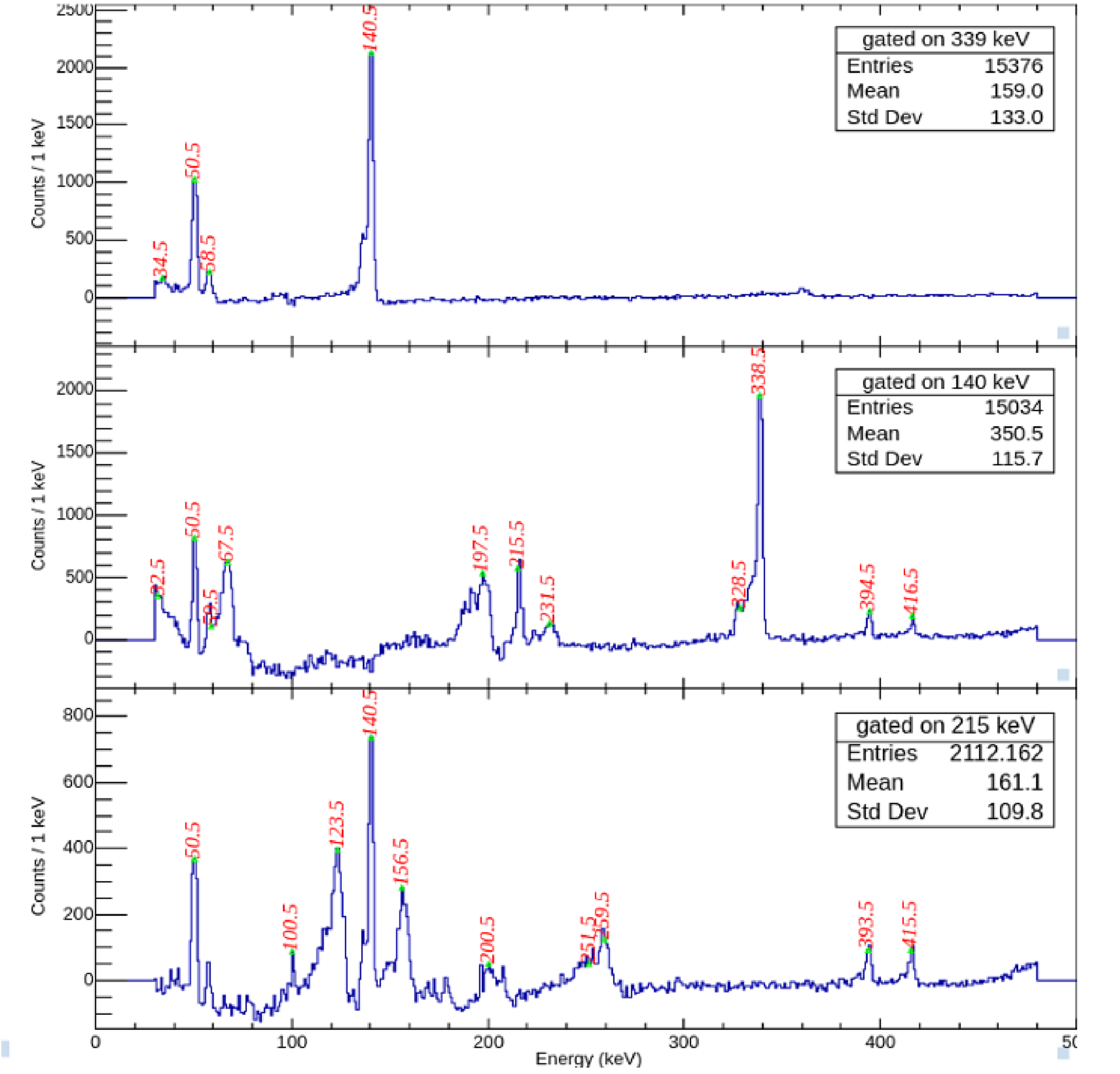


Isomer(^{151}Tm)(198 keV) --Clover

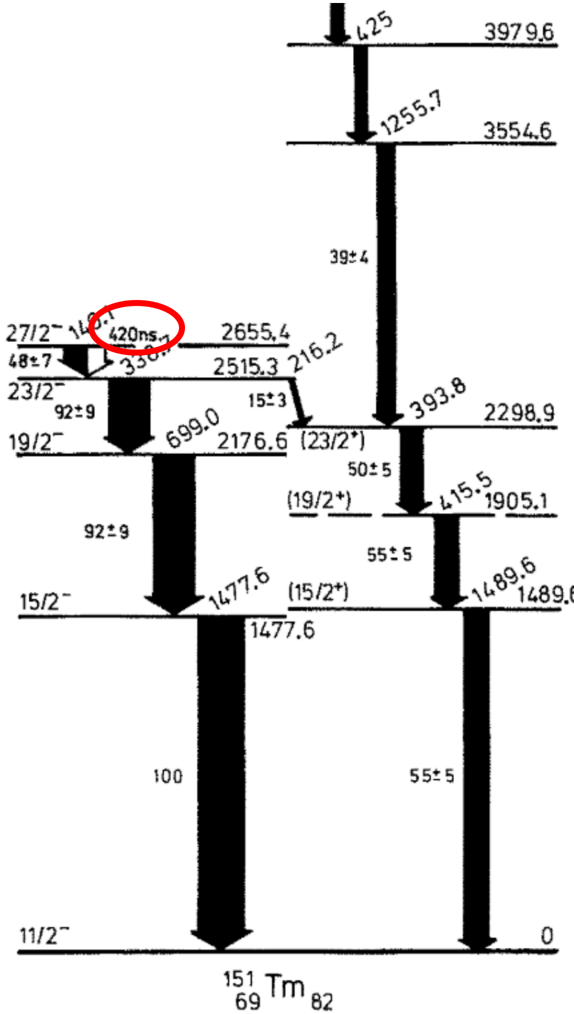




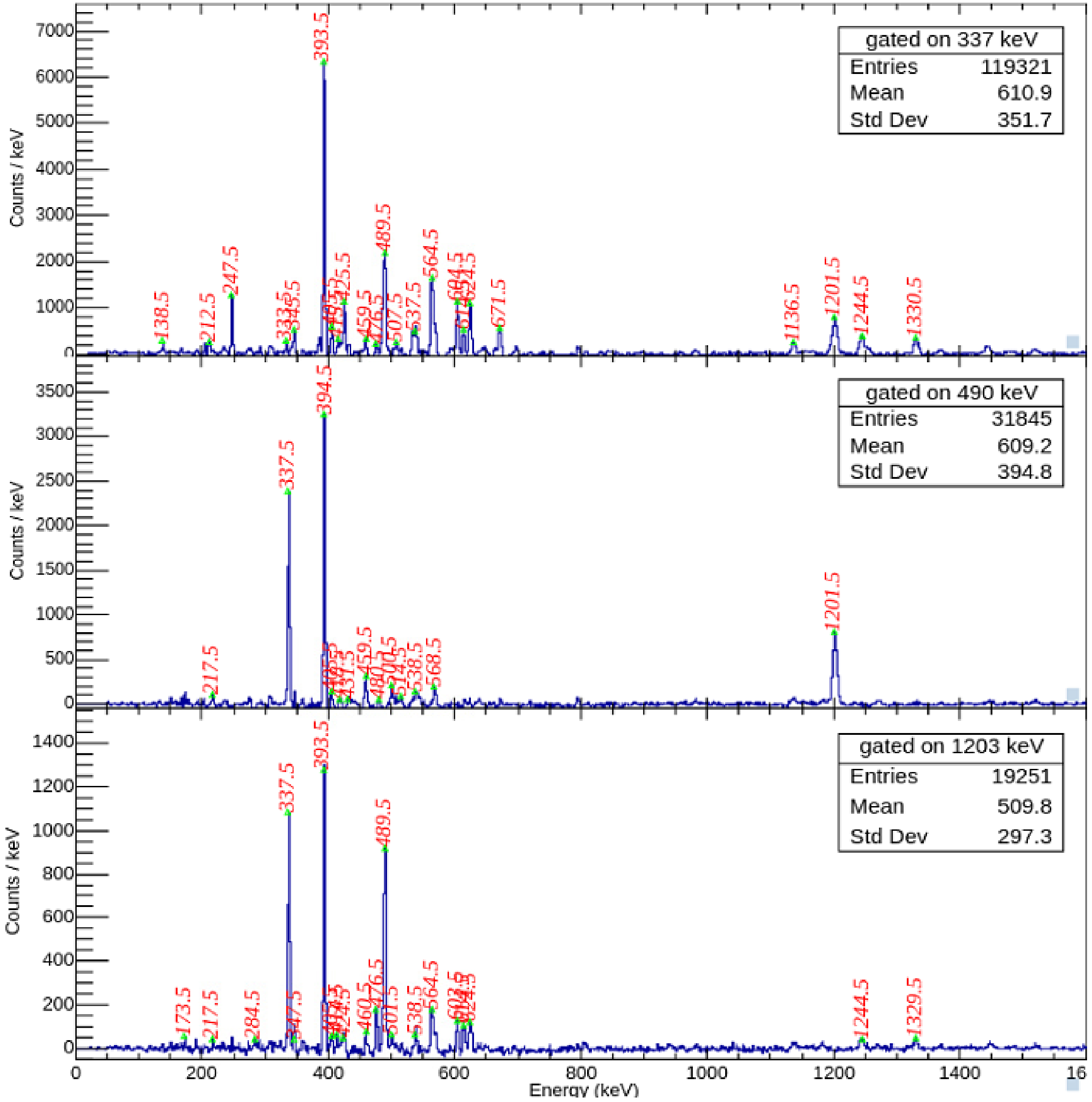
Isomer(^{151}Tm)— PGe-X

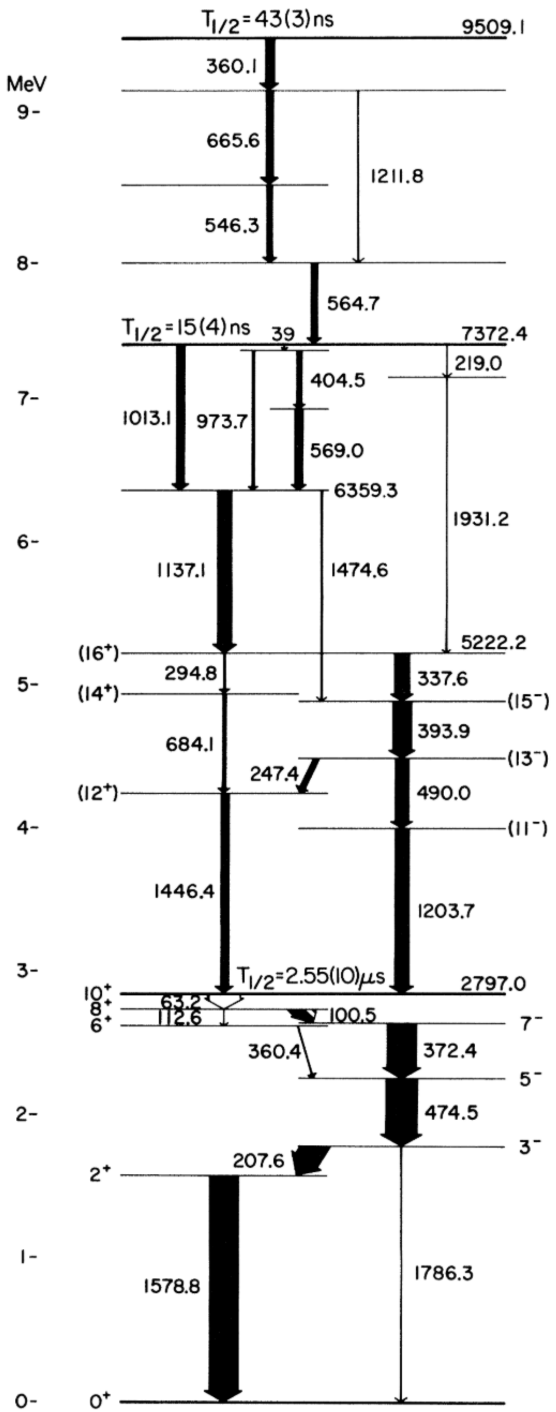


	$_{65}$Tb	$_{66}$Dy	$_{67}$Ho	$_{68}$Er	$_{69}$Tm	$_{70}$Yb
$K_{\alpha1}$	**44.482** 47.5 10	**45.998** 47.5 10	**47.547** 47.5 10	**49.128** 47.5 10	**50.742** 47.4 10	**52.389** 47.4 10
$K_{\alpha2}$	**43.744** 26.7 6	**45.208** 26.8 6	**46.700** 26.9 6	**48.221** 27.0 6	**49.773** 27.2 6	**51.354** 27.2 6
$K_{\alpha3}$	**43.288** 0.0092 3	**44.743** 0.0102 3	**46.224** 0.0111 3	**47.734** 0.0126 4	**49.274** 0.0135 4	**50.846** 0.0145 4
$K_{\beta1}$	**50.384** 9.44 19	**52.113** 9.58 20	**53.877** 9.68 20	**55.674** 9.77 20	**57.505** 9.86 20	**59.383** 9.99 20
$K_{\beta2}$	**51.698** 3.15 7	**53.476** 3.20 7	**55.293** 3.24 7	**57.142** 3.28 7	**59.028** 3.32 7	**60.962** 3.38 7

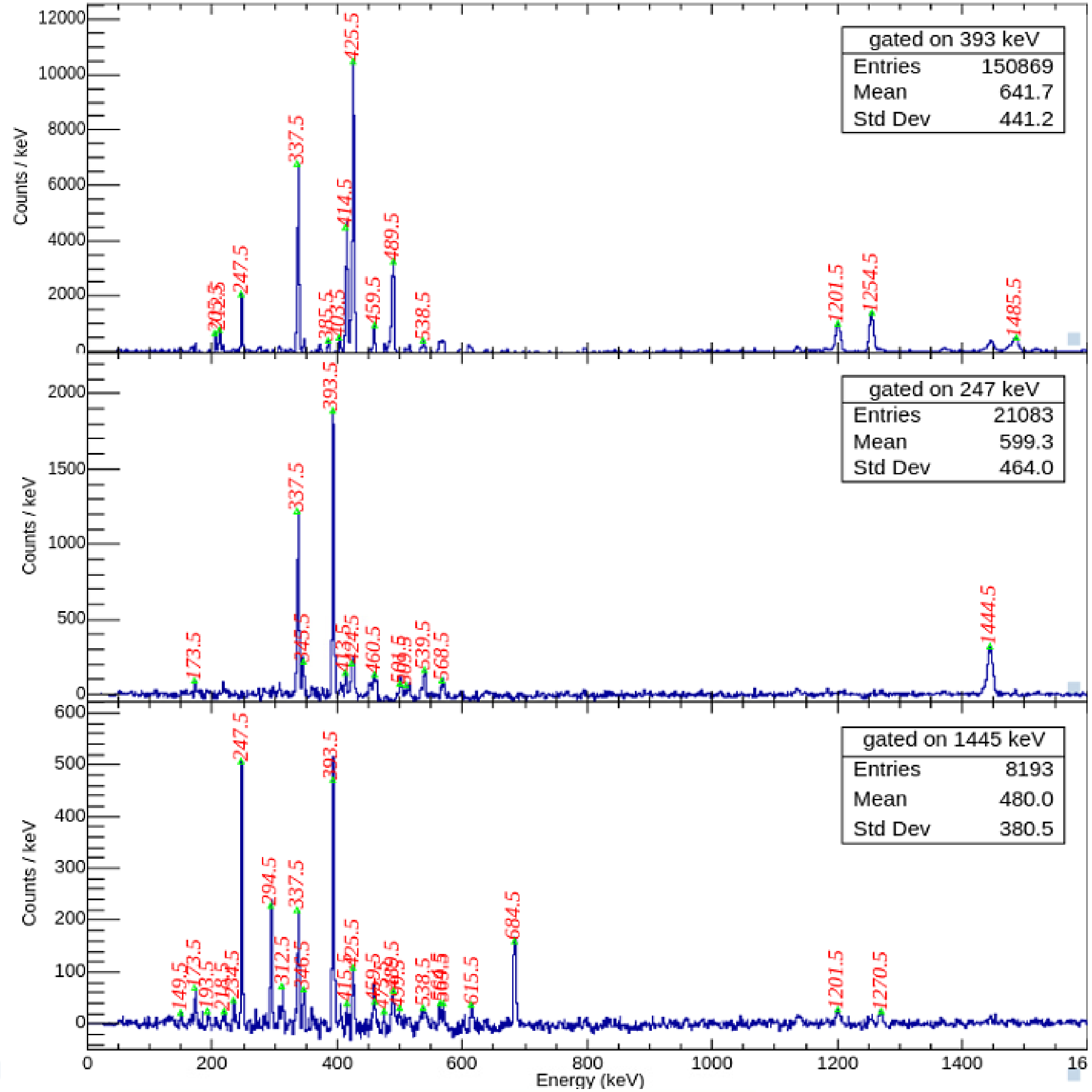


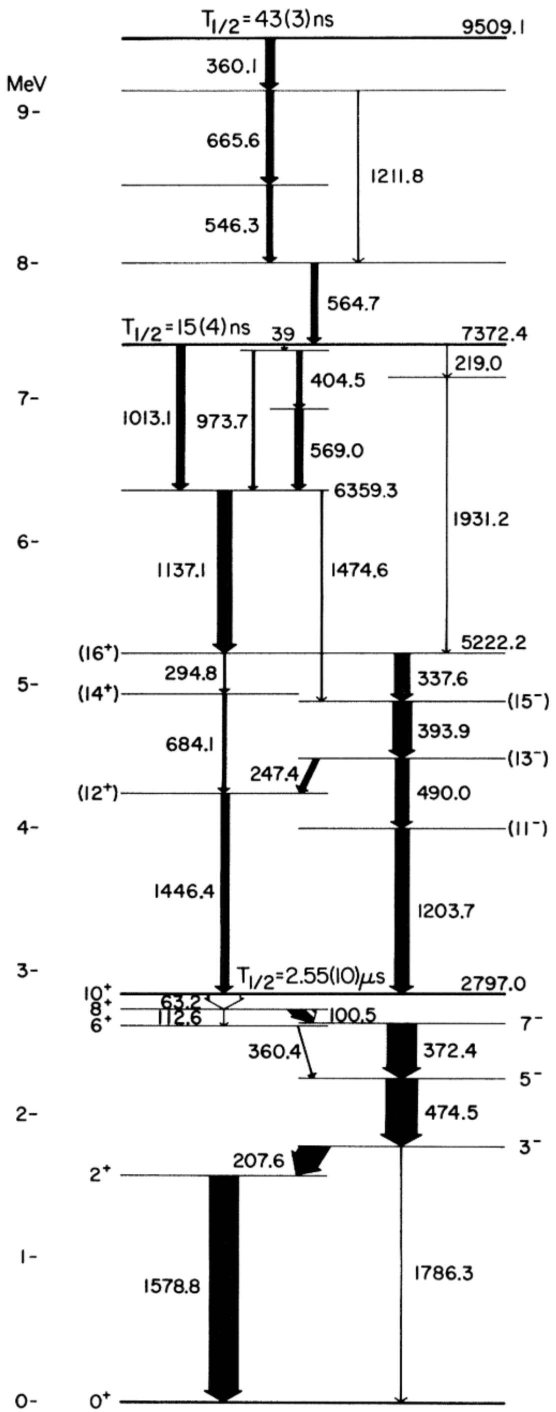
Inbeam Study(^{150}Er)



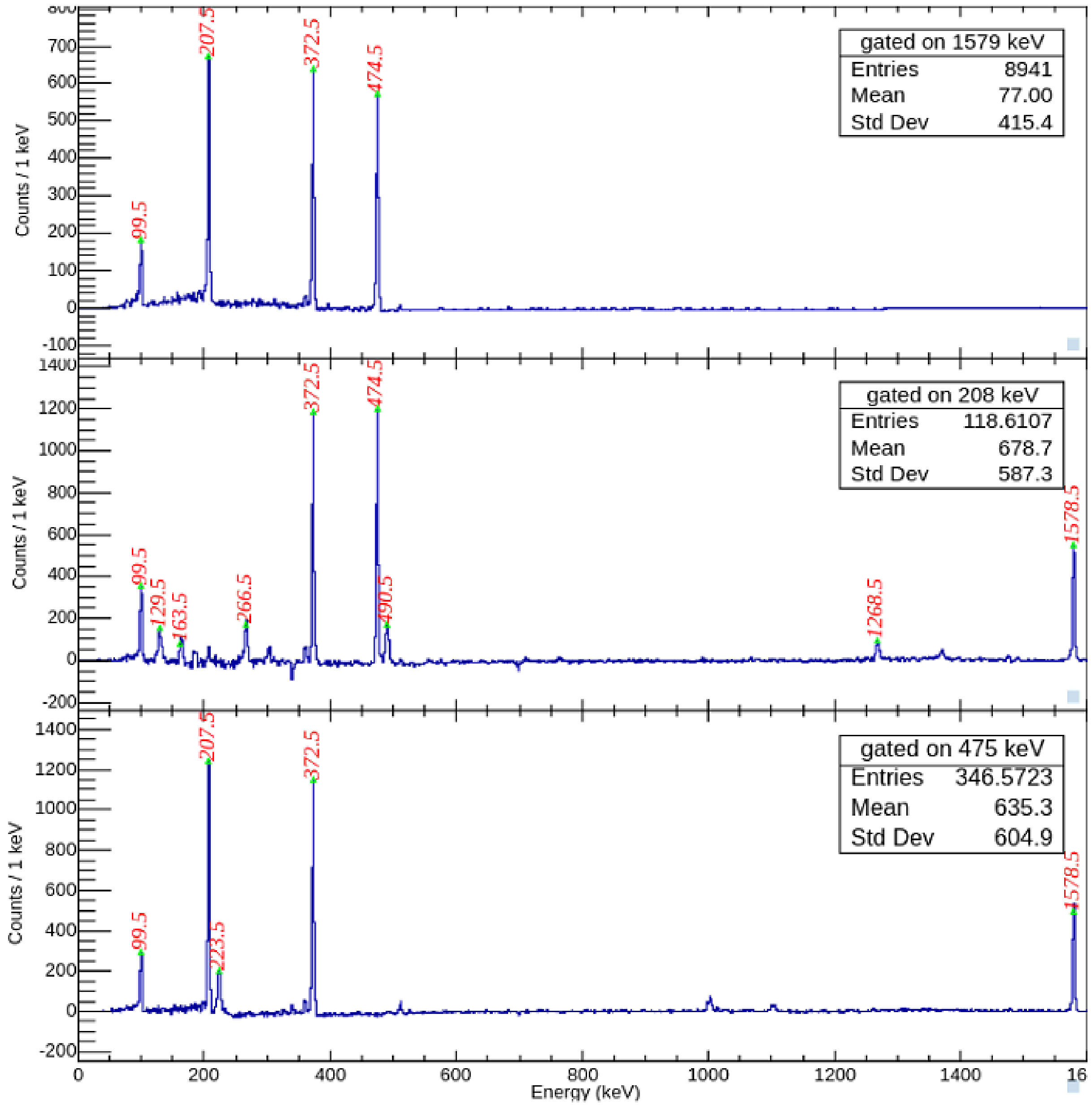


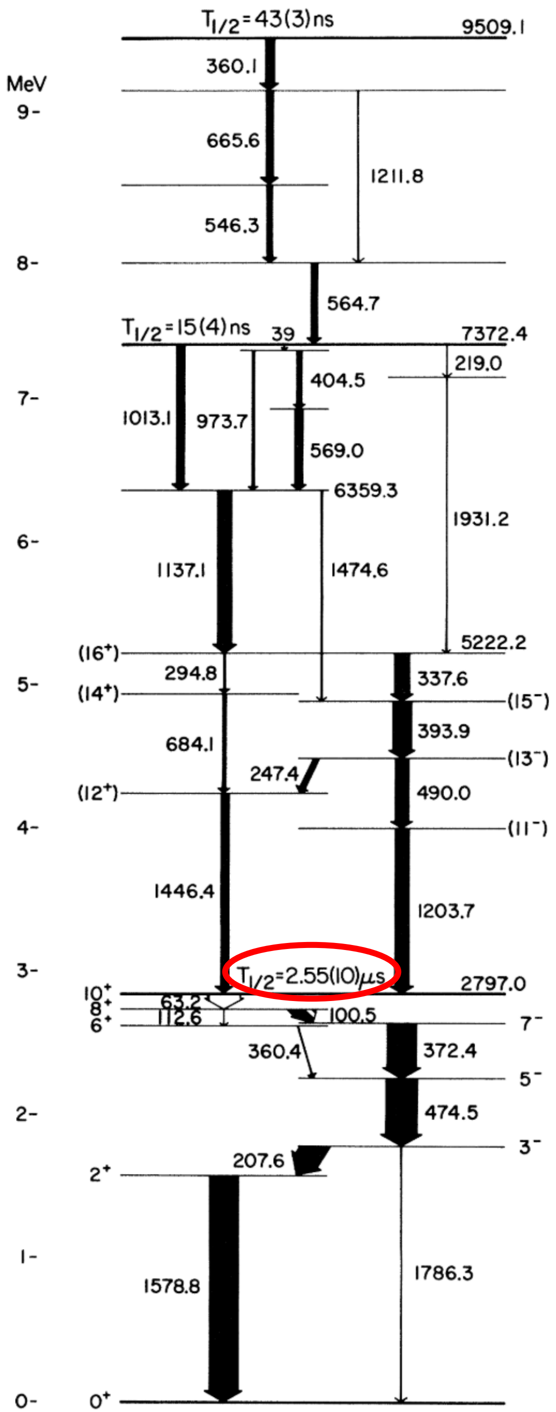
Inbeam Study(^{150}Er)



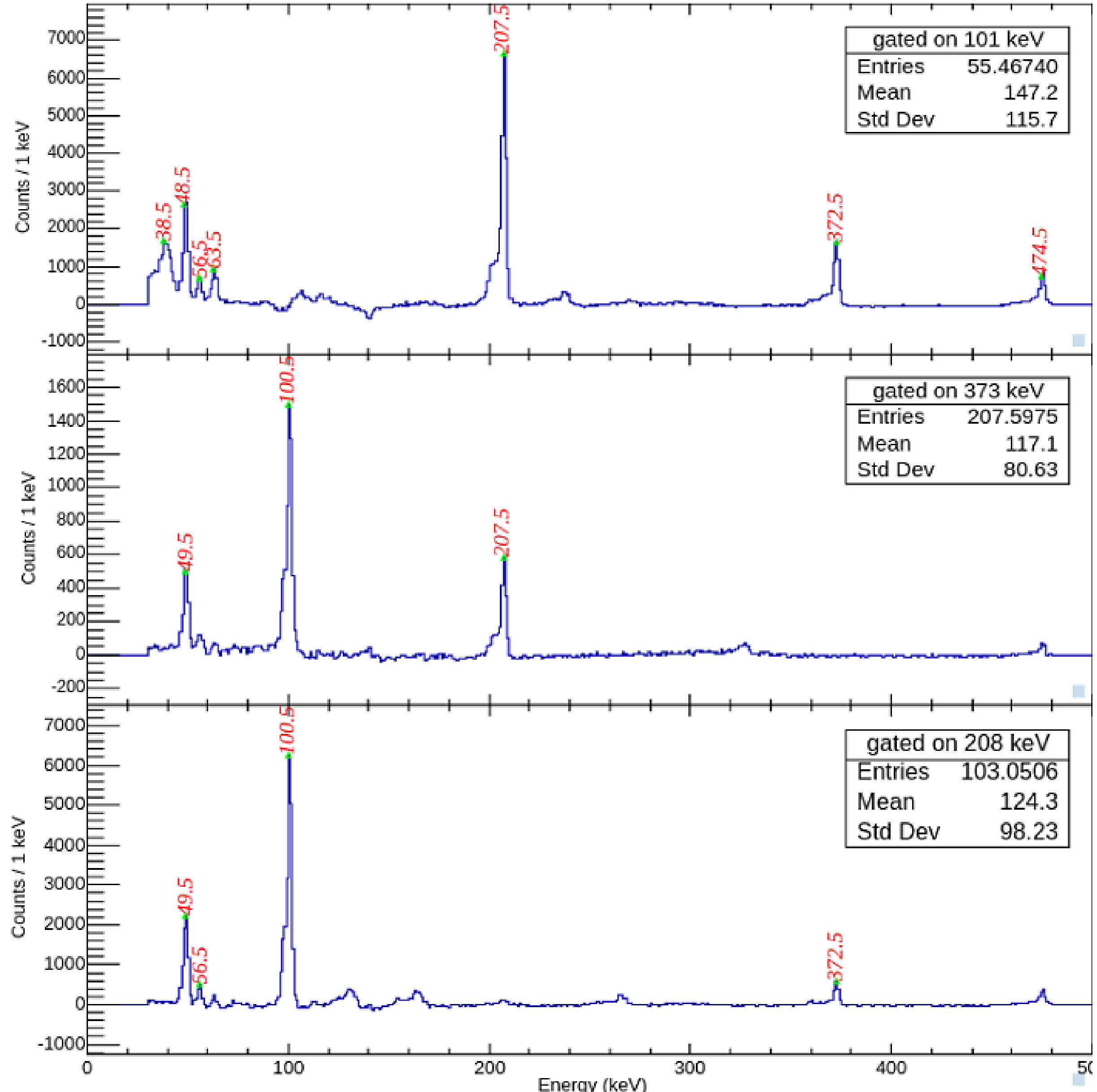


Isomer(^{150}Er)--Clover





Isomer(^{150}Er)— PGe-X



	$_{65}$Tb	$_{66}$Dy	$_{67}$Ho	$_{68}$Er	$_{69}$Tm	$_{70}$Yb
$K_{\alpha 1}$	**44.482** 47.5 10	**45.998** 47.5 10	**47.547** 47.5 10	**49.128** 47.5 10	**50.742** 47.4 10	**52.389** 47.4 10
$K_{\alpha 2}$	**43.744** 26.7 6	**45.208** 26.8 6	**46.700** 26.9 6	**48.221** 27.0 6	**49.773** 27.2 6	**51.354** 27.2 6
$K_{\alpha 3}$	**43.288** 0.0092 3	**44.743** 0.0102 3	**46.224** 0.0111 3	**47.734** 0.0126 4	**49.274** 0.0135 4	**50.846** 0.0145 4
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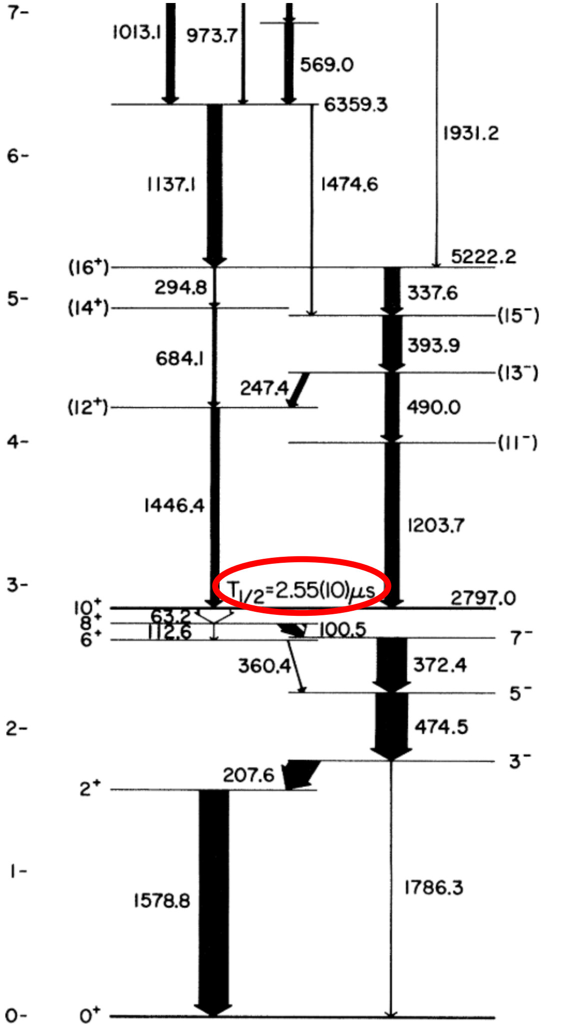
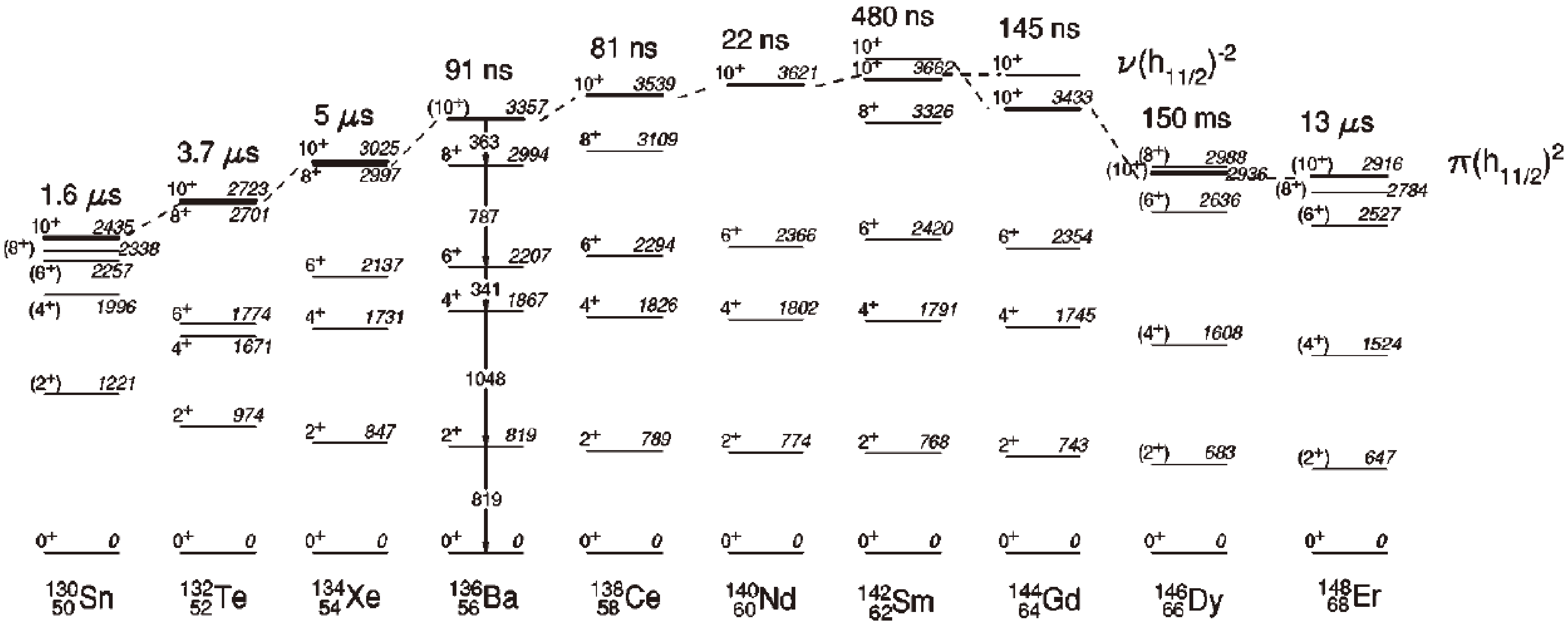
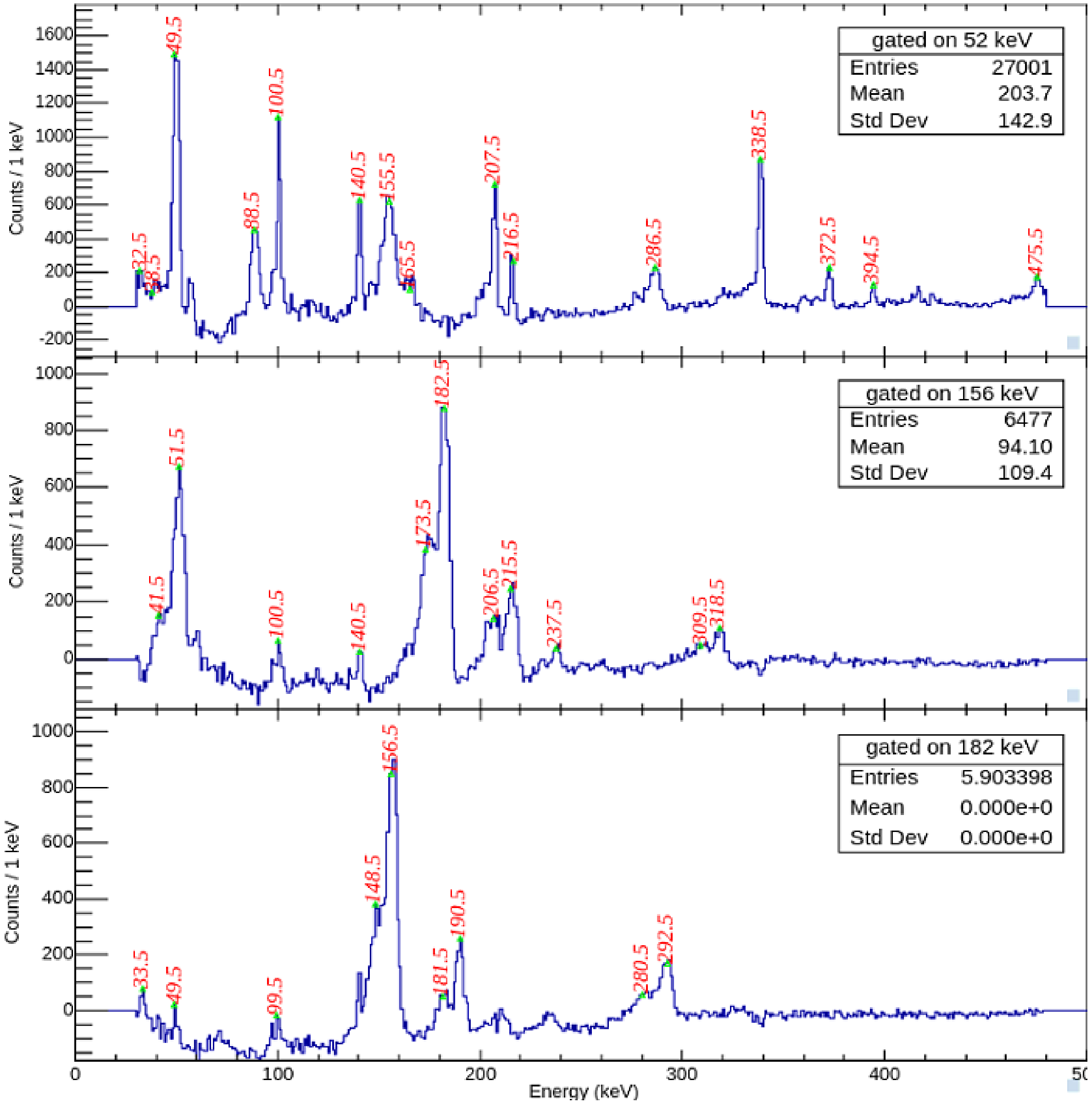
$K_{\beta 2}$	**51.698** 3.15 7	**53.476** 3.20 7	**55.293** 3.24 7	**57.142** 3.28 7	**59.028** 3.32 7	**60.962** 3.38 7



^{150}Yb


1.6 μs
3.7 μs
5 μs
91 ns
81 ns
22 ns
480 ns
145 ns
150 ms
13 μs
ν(h11/2)-2
π(h11/2)2
10+ 2435
(8+) 2338
(6+) 2257
(4+) 1996
(2+) 1221
0+ 0
10+ 2723
8+ 2701
6+ 1774
4+ 1671
2+ 974
0+ 0
10+ 3025
8+ 2997
6+ 2137
4+ 1731
2+ 847
0+ 0
(10+) 3357
8+ 2994
6+ 2207
4+ 1867
2+ 819
0+ 0
363
787
341
1048
819
10+ 3539
8+ 3109
6+ 2294
4+ 1826
2+ 789
0+ 0
10+ 3621
6+ 2366
4+ 1802
2+ 774
0+ 0
10+
10+ 3662
8+ 3326
6+ 2420
4+ 1791
2+ 768
0+ 0
10+
10+ 3433
6+ 2354
4+ 1745
2+ 743
0+ 0
(8+) 2988
(10+) 2936
(6+) 2636
(4+) 1608
(2+) 683
0+ 0
(10+) 2916
(8+) 2784
(6+) 2527
(4+) 1524
(2+) 647
0+ 0
130 50 Sn
132 52 Te
134 54 Xe
136 56 Ba
138 58 Ce
140 60 Nd
142 62 Sm
144 64 Gd
146 66 Dy
148 68 Er

^{150}Yb — PGe-X



	$_{65}$Tb	$_{66}$Dy	$_{67}$Ho	$_{68}$Er	$_{69}$Tm	$_{70}$Yb
$K_{\alpha 1}$	**44.482** 47.5 10	**45.998** 47.5 10	**47.547** 47.5 10	**49.128** 47.5 10	**50.742** 47.4 10	**52.389** 47.4 10
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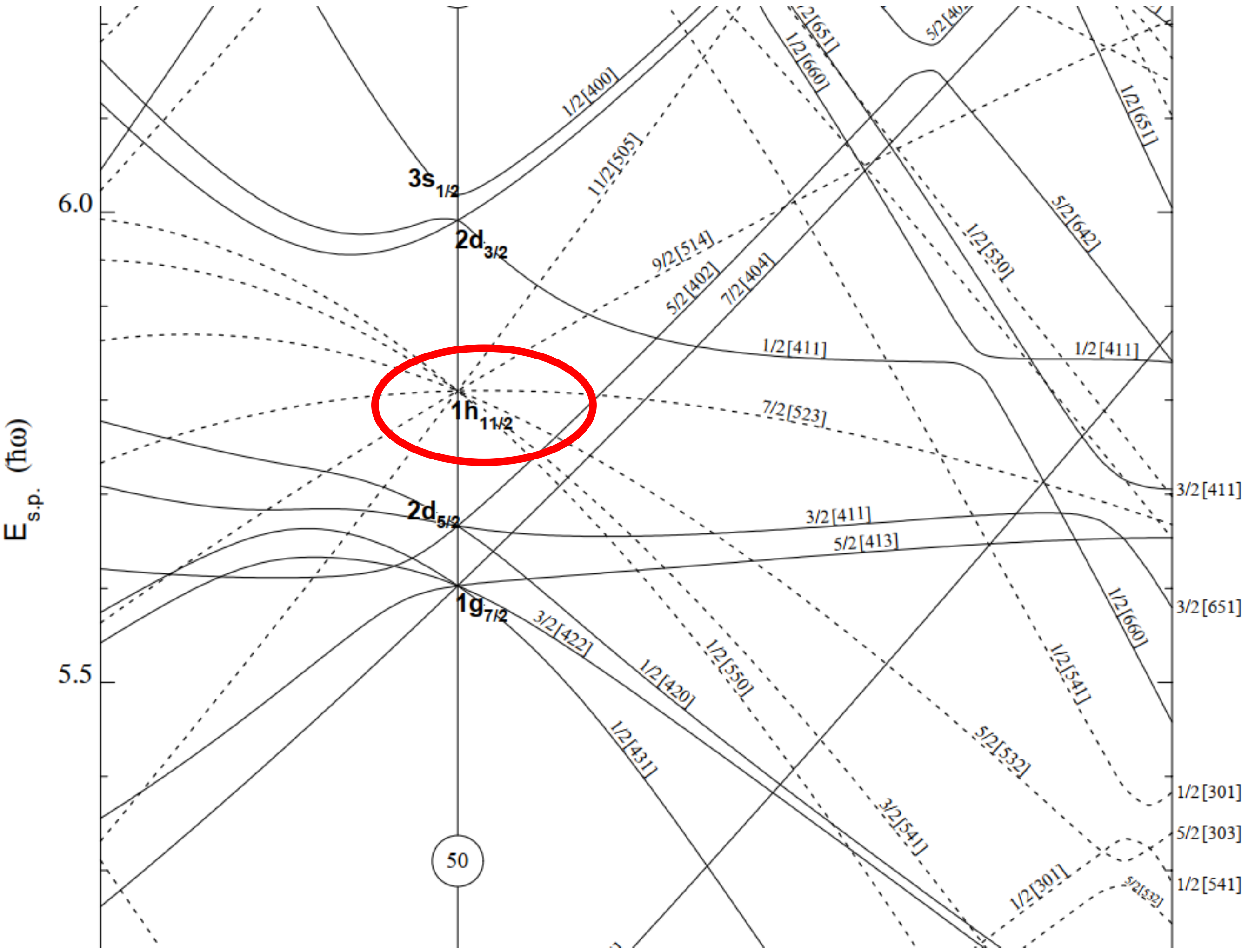
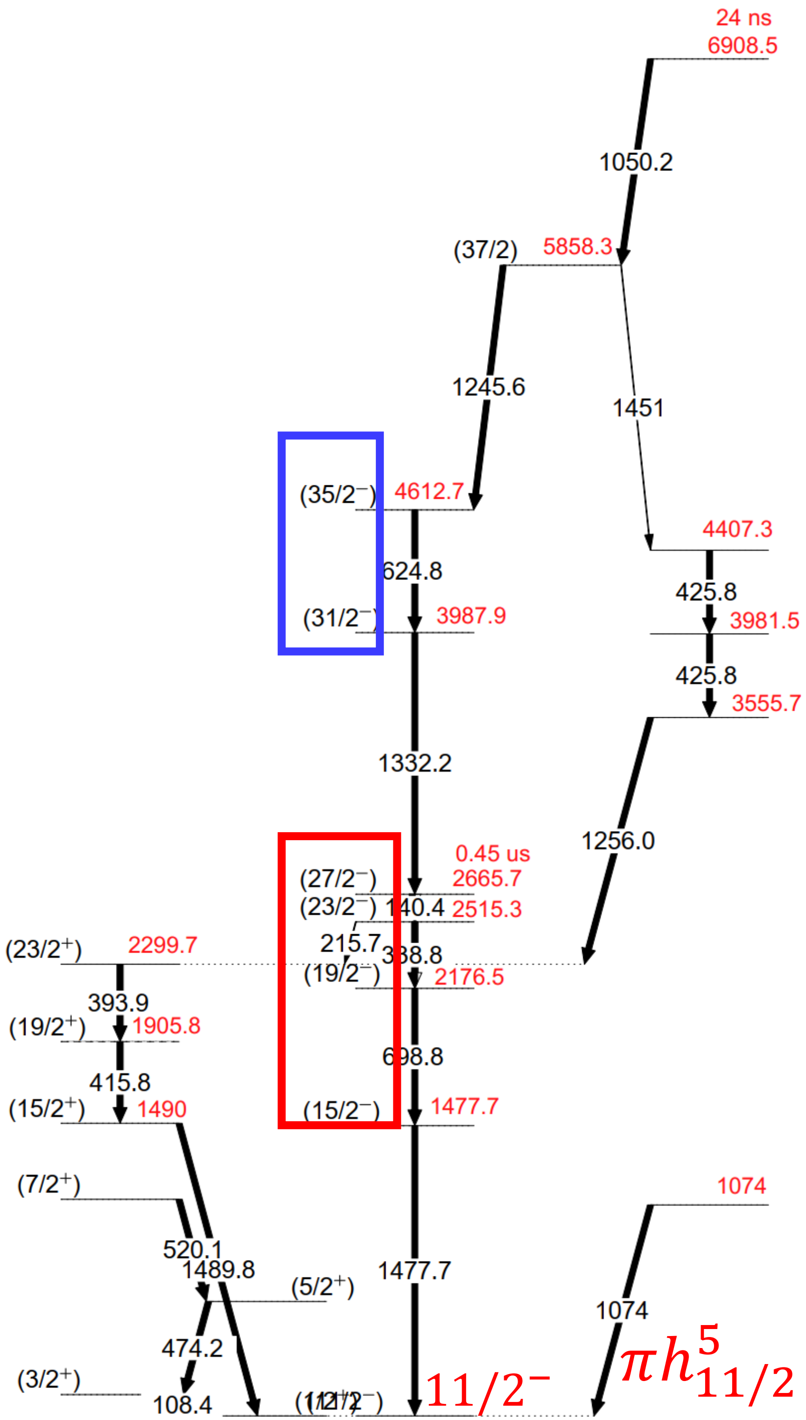
$K_{\alpha 3}$	**43.288** 0.0092 3	**44.743** 0.0102 3	**46.224** 0.0111 3	**47.734** 0.0126 4	**49.274** 0.0135 4	**50.846** 0.0145 4
$K_{\beta 1}$	**50.384** 9.44 19	**52.113** 9.58 20	**53.877** 9.68 20	**55.674** 9.77 20	**57.505** 9.86 20	**59.383** 9.99 20
$K_{\beta 2}$	**51.698** 3.15 7	**53.476** 3.20 7	**55.293** 3.24 7	**57.142** 3.28 7	**59.028** 3.32 7	**60.962** 3.38 7

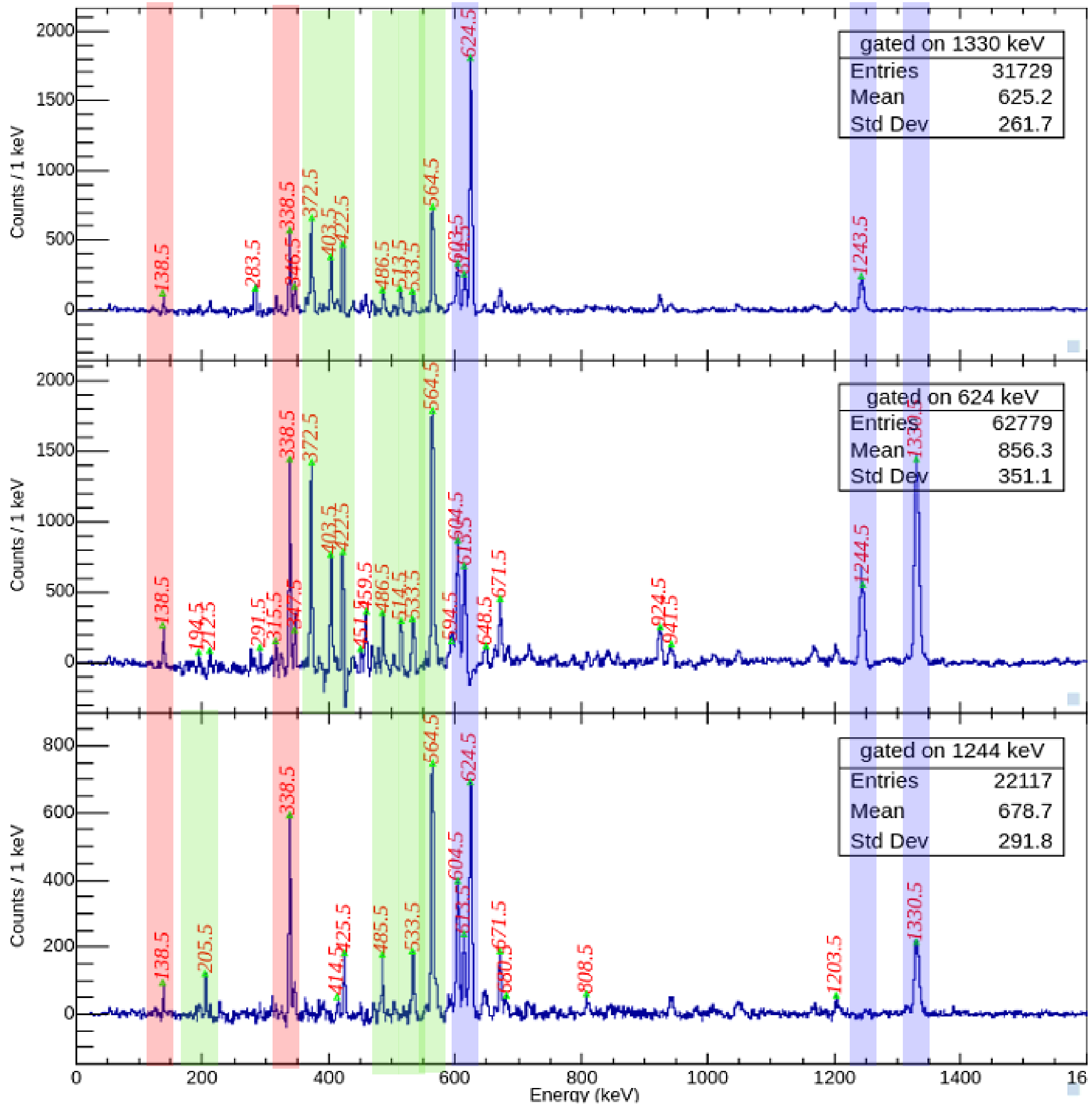
- 156keV、182keV？

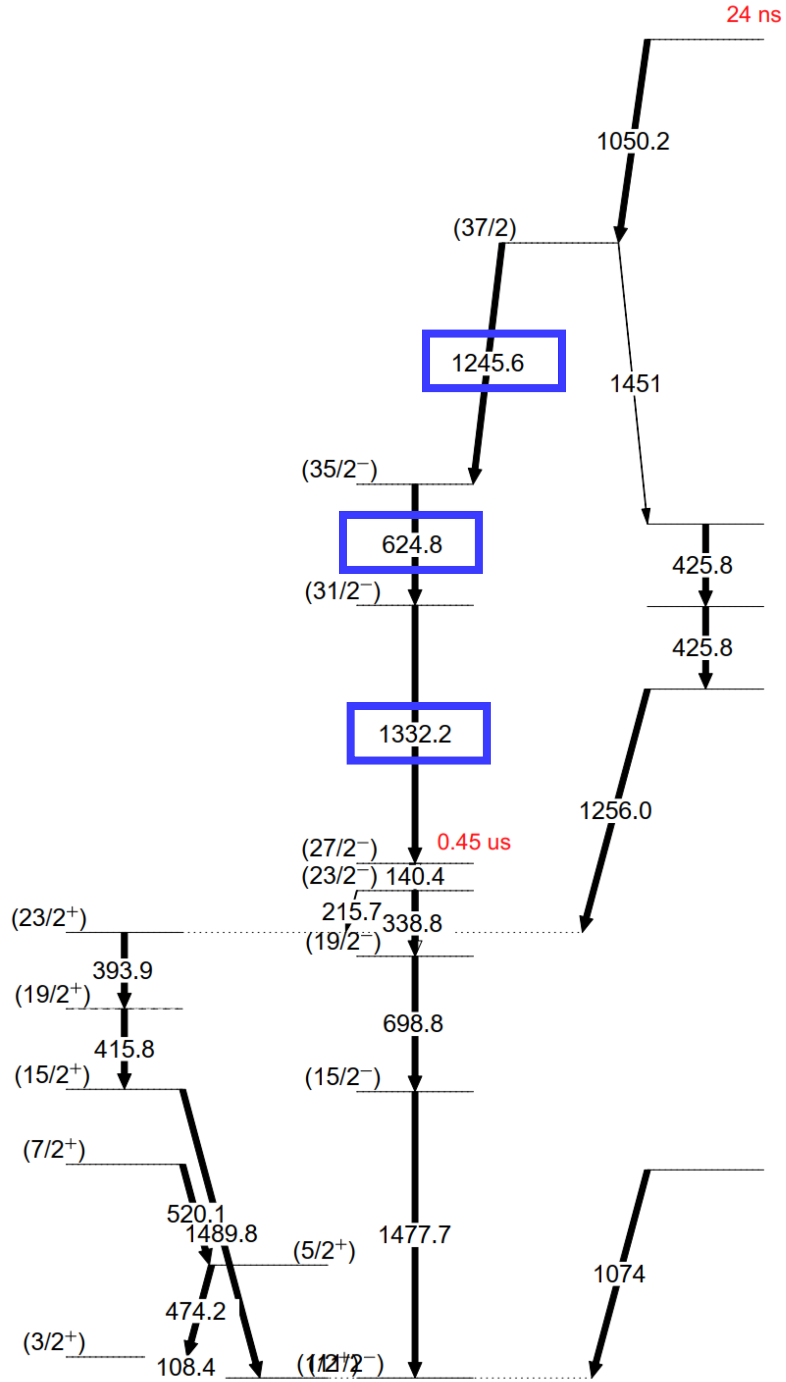
$^{151}_{69}Tm_{82}$ （Inbeam）



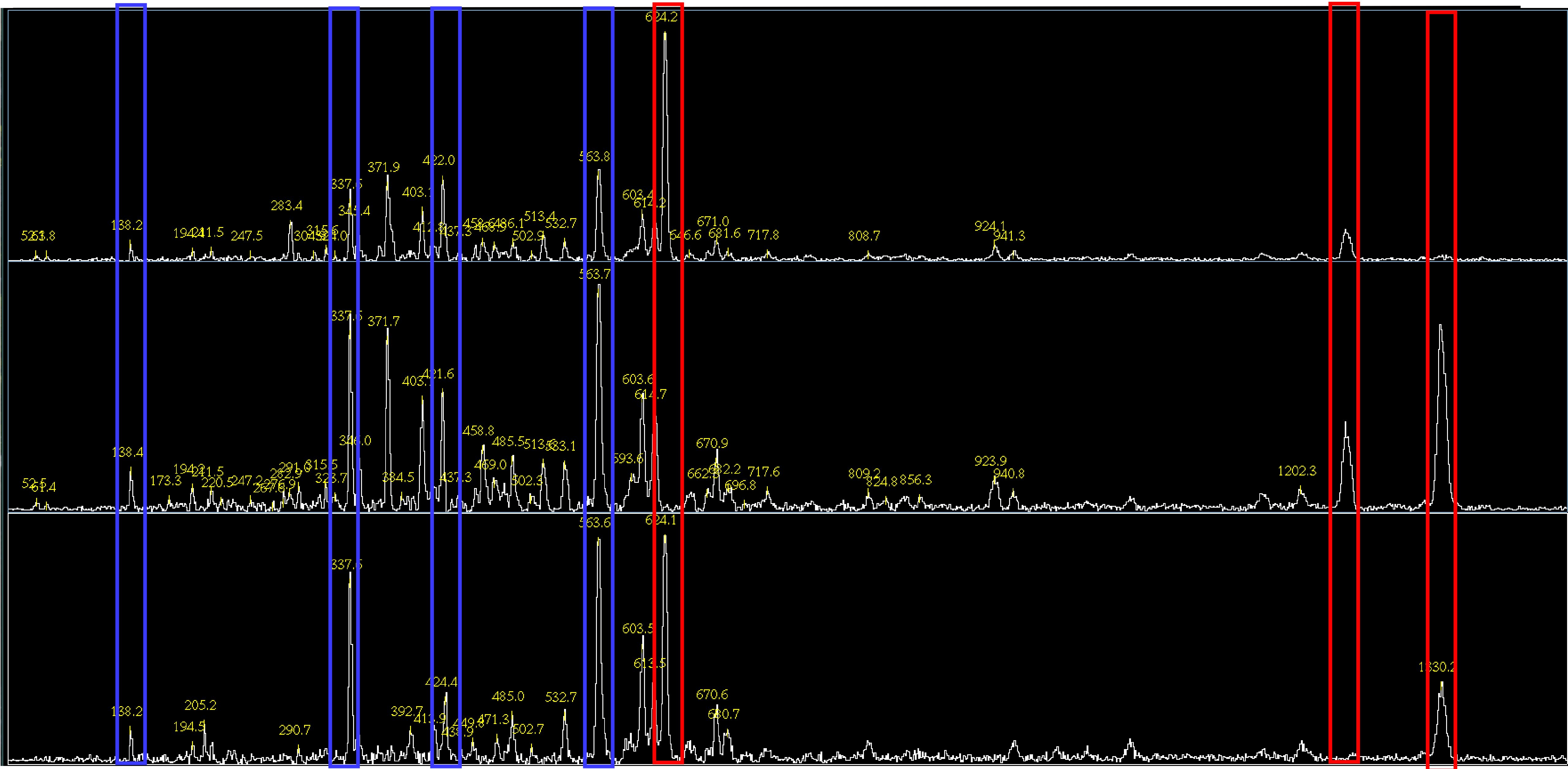


Inbeam Study(^{151}Tm)(Δt~60ns)

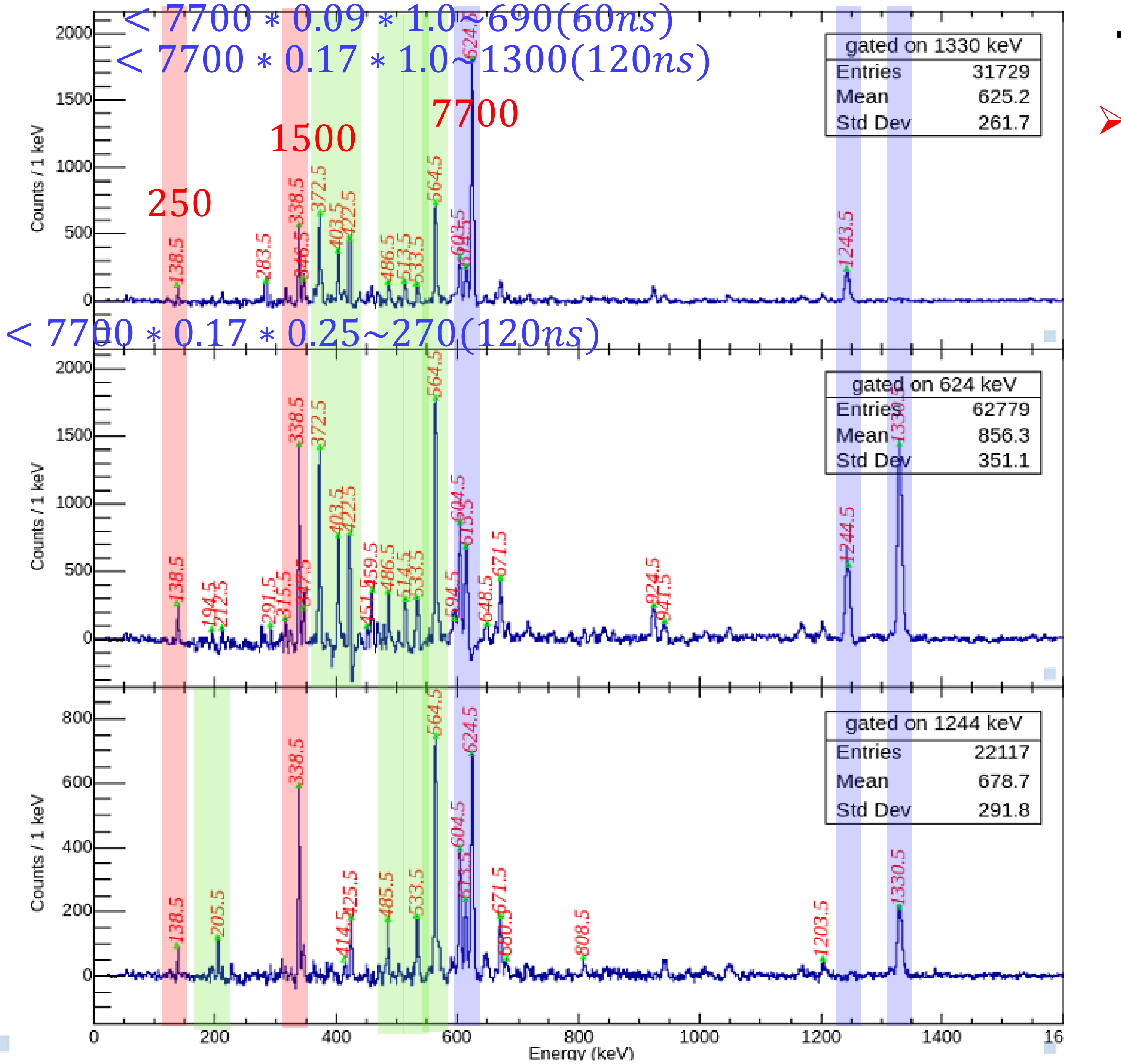




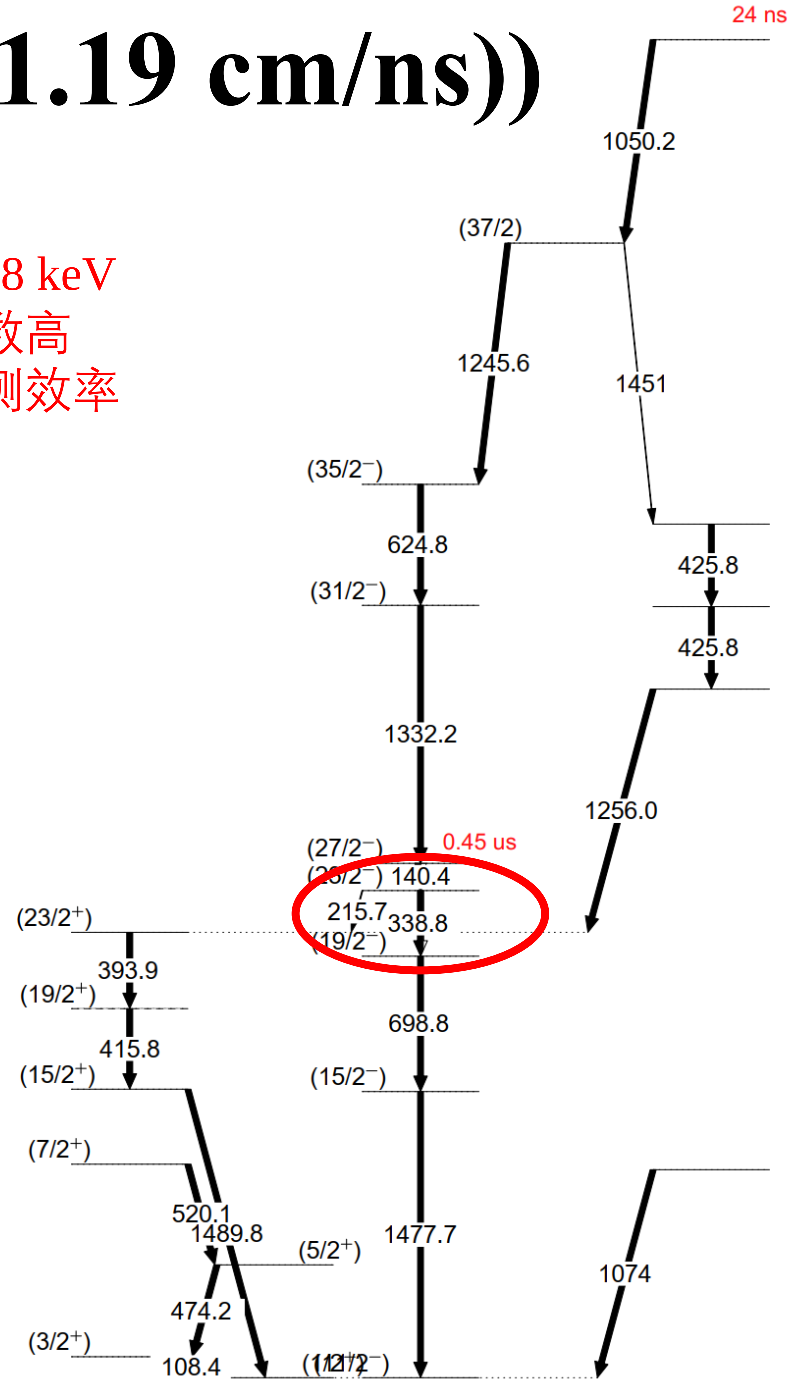
Inbeam Study(^{151}Tm)



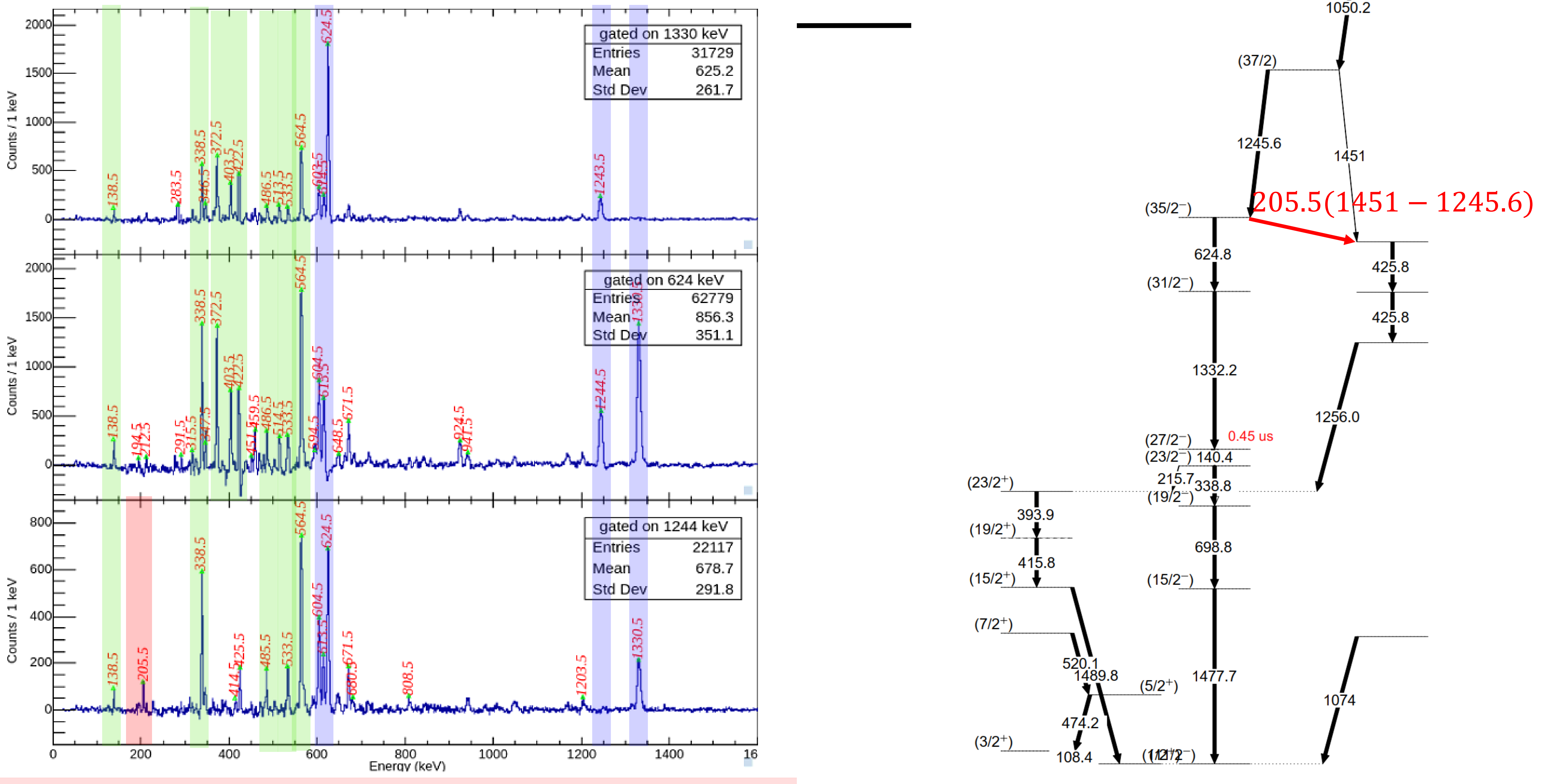
Inbeam Study(^{151}Tm)(Δt~60ns (v=1.19 cm/ns))



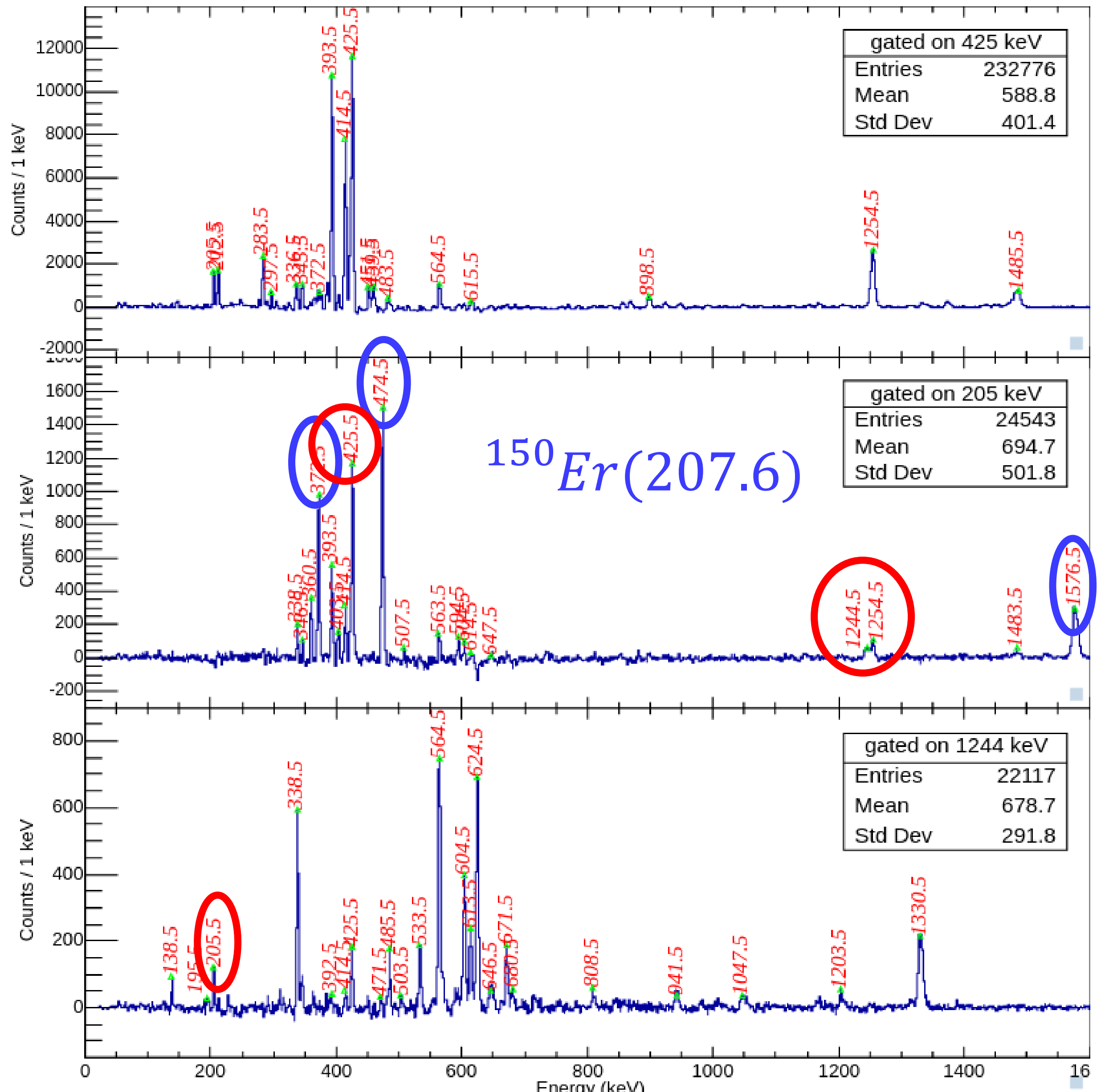
- 138、338 keV
  - 计数高
  - 探测效率

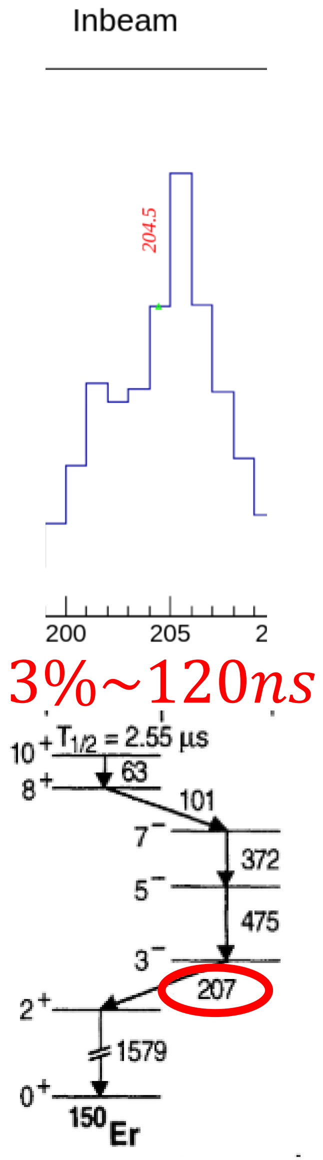


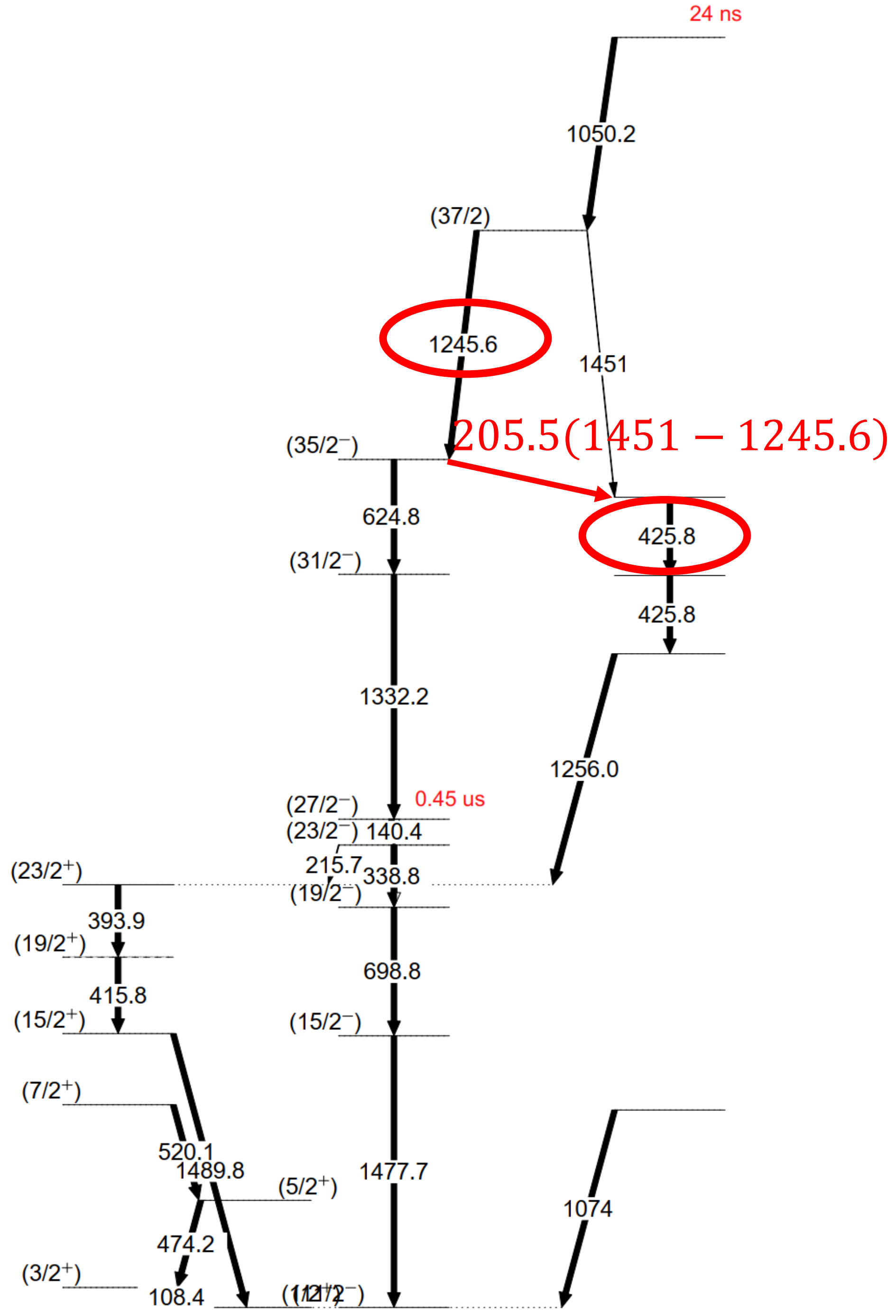
Inbeam Study(^{151}Tm)(205.5 keV)



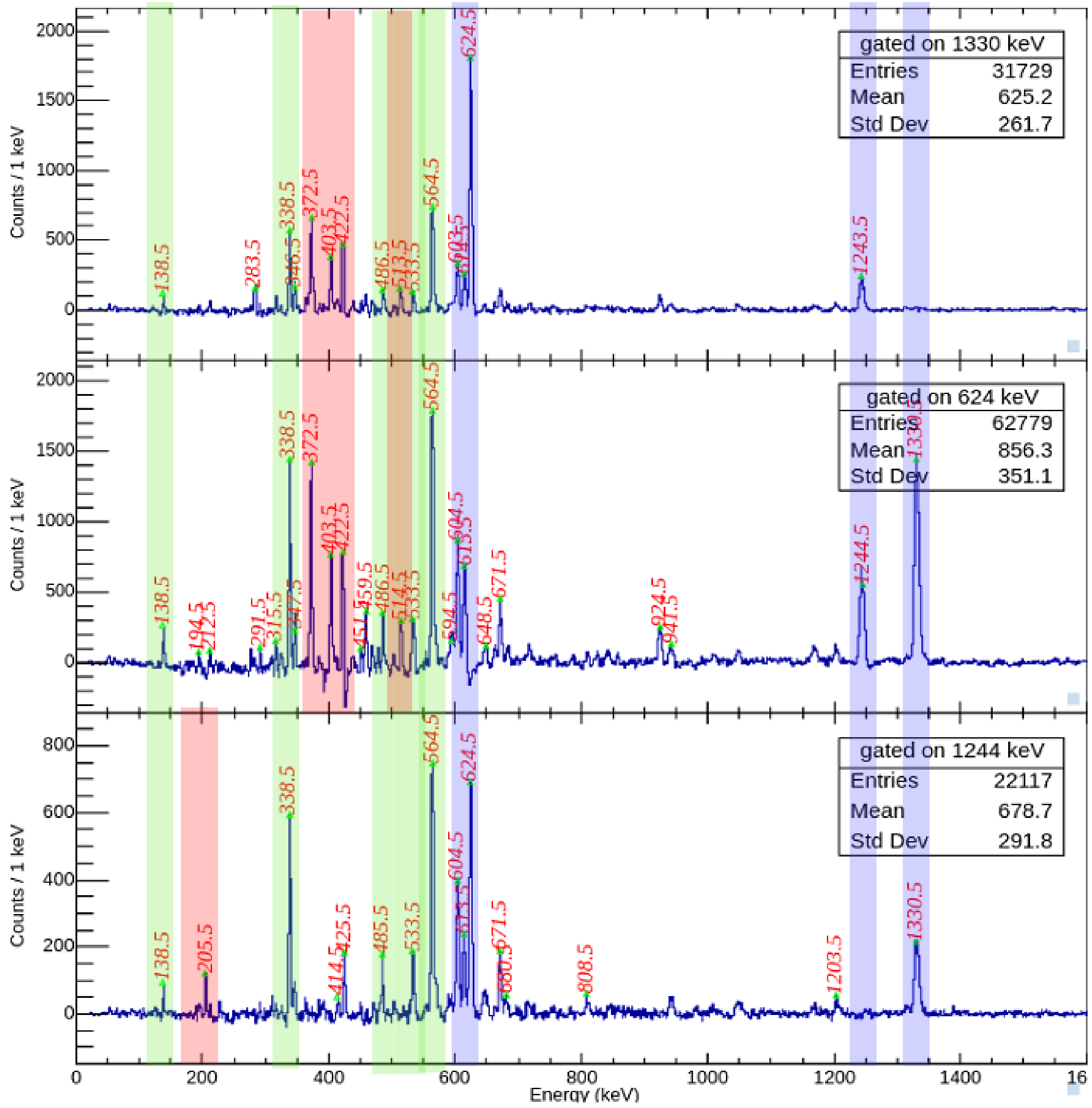
Inbeam Study(^{151}Tm)(205.5 keV)

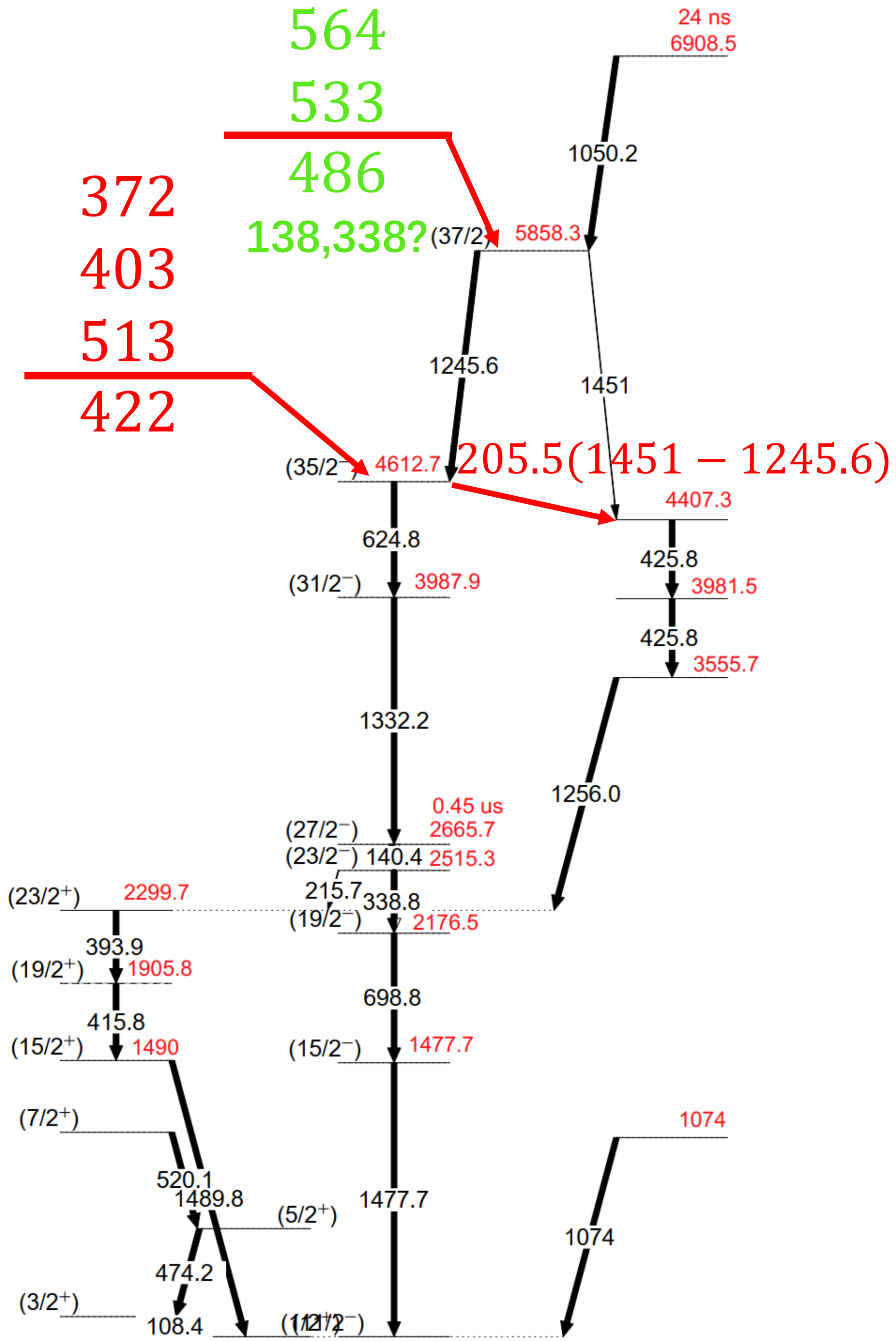




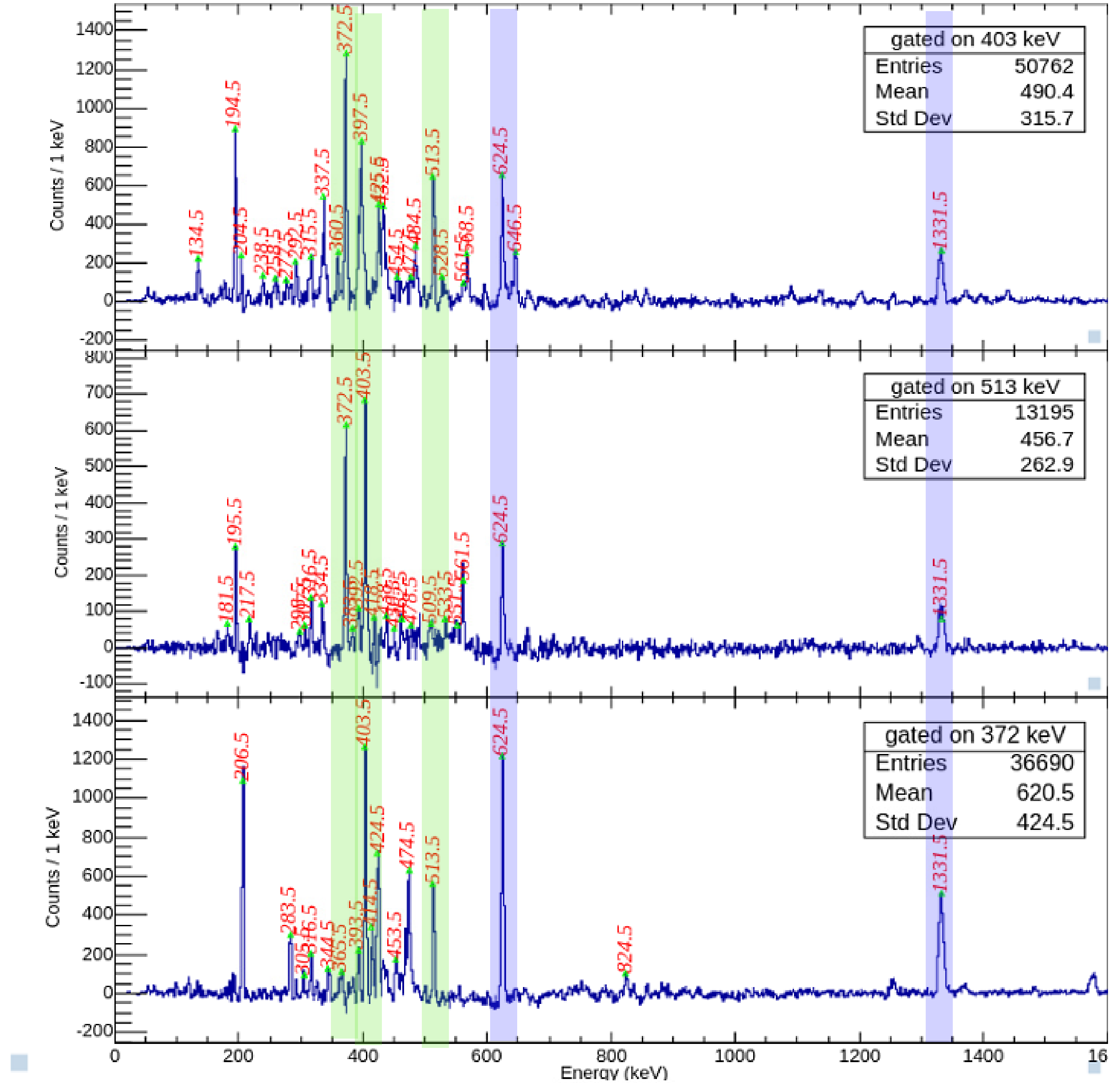


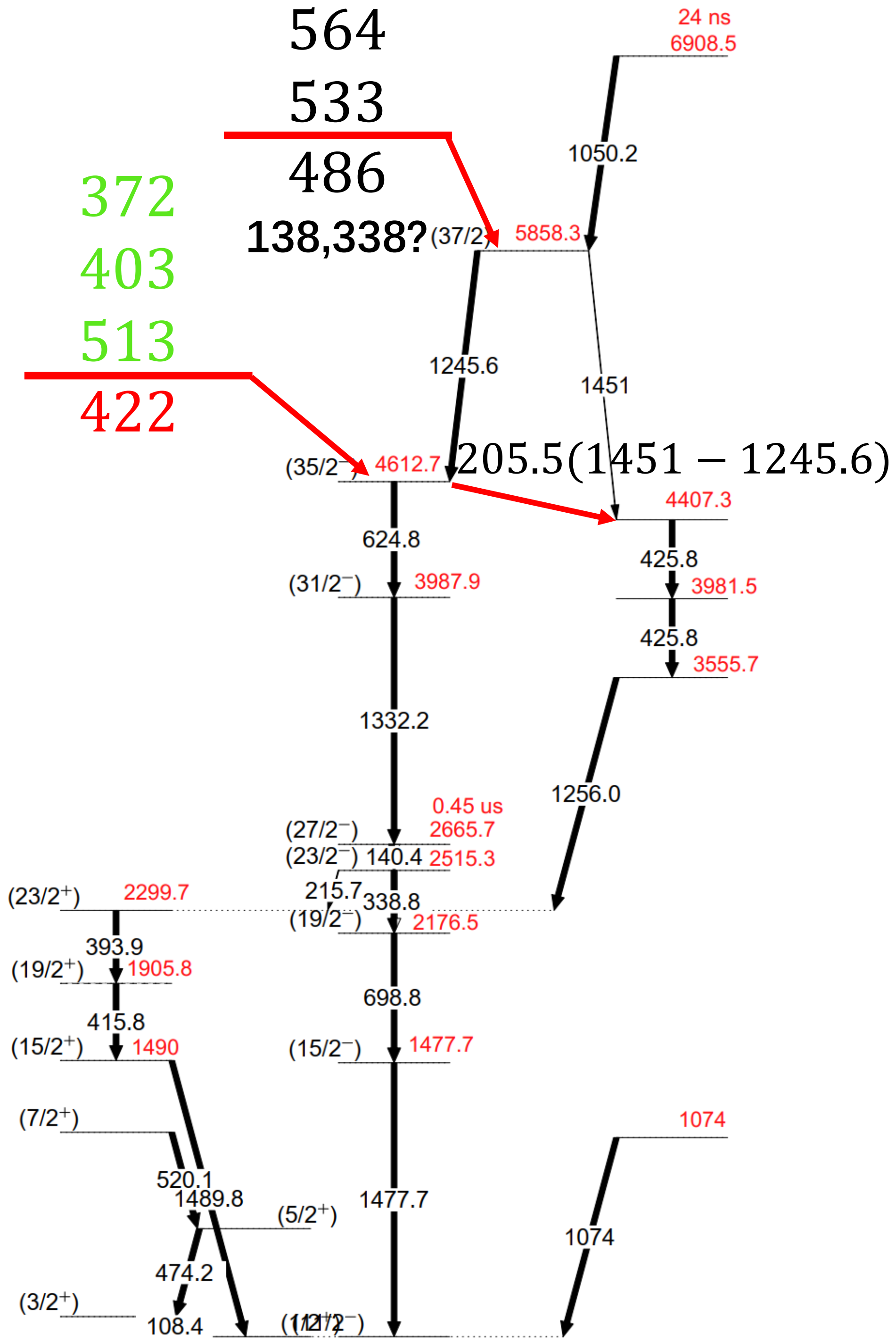
Inbeam Study(^{151}Tm)



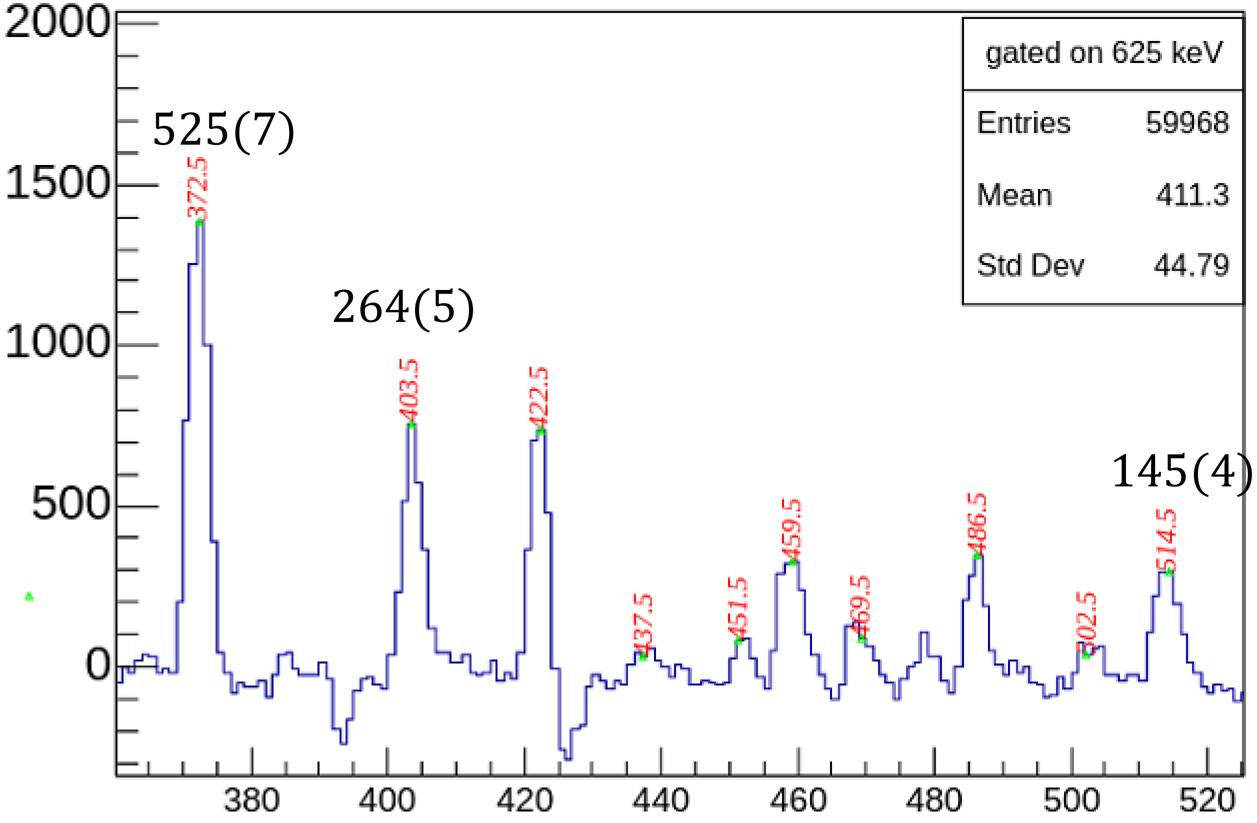


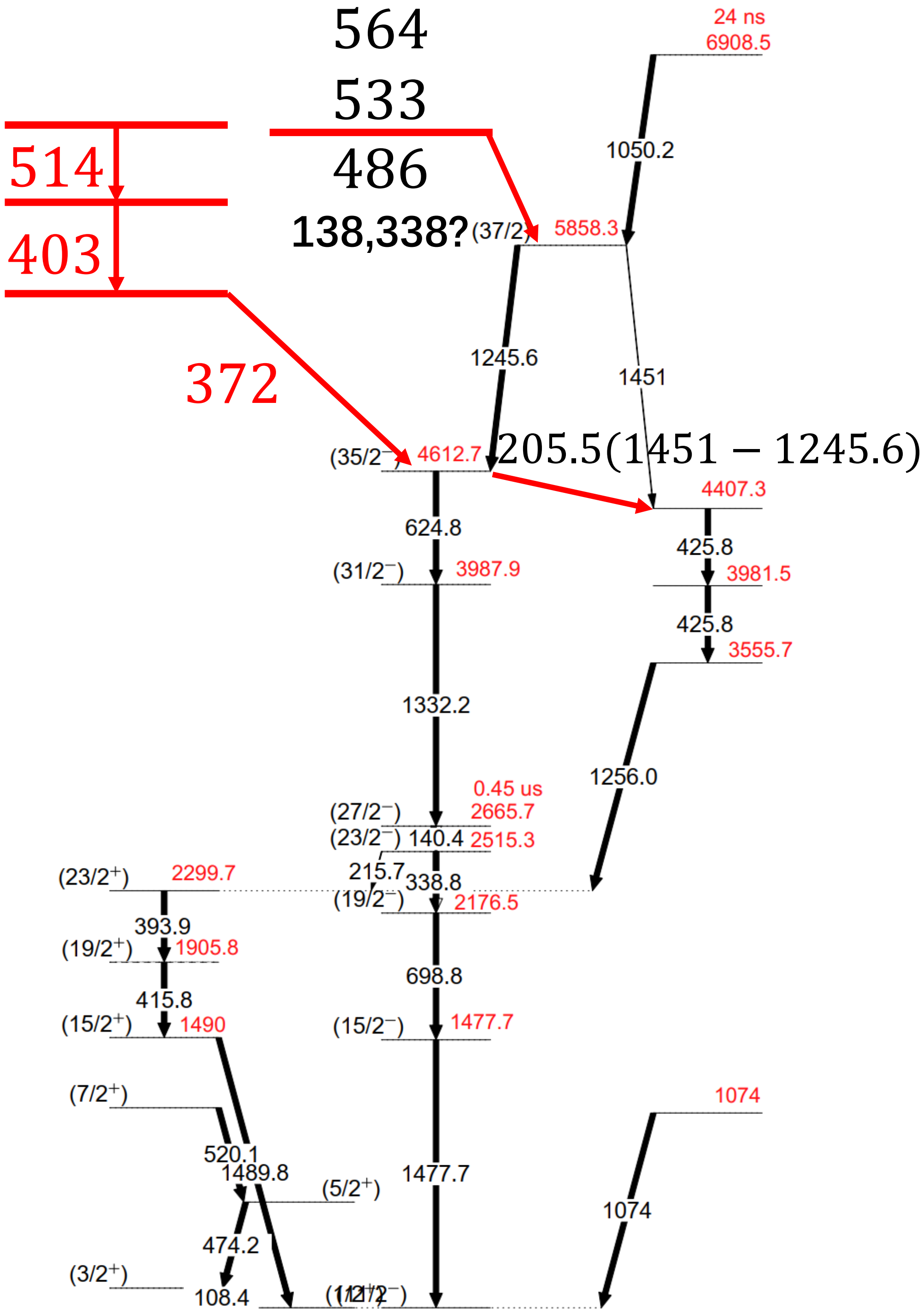
Inbeam Study(^{151}Tm)



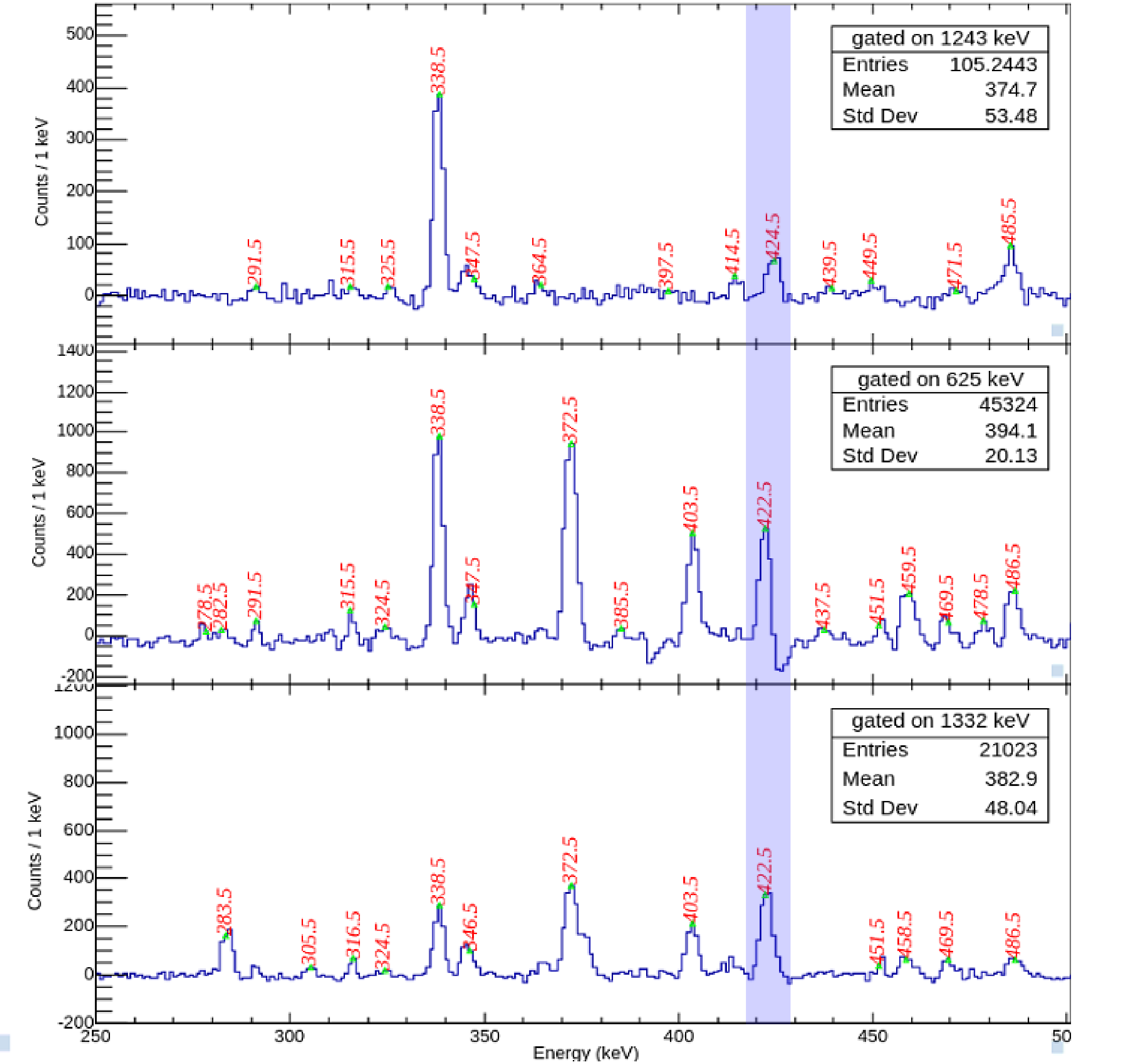


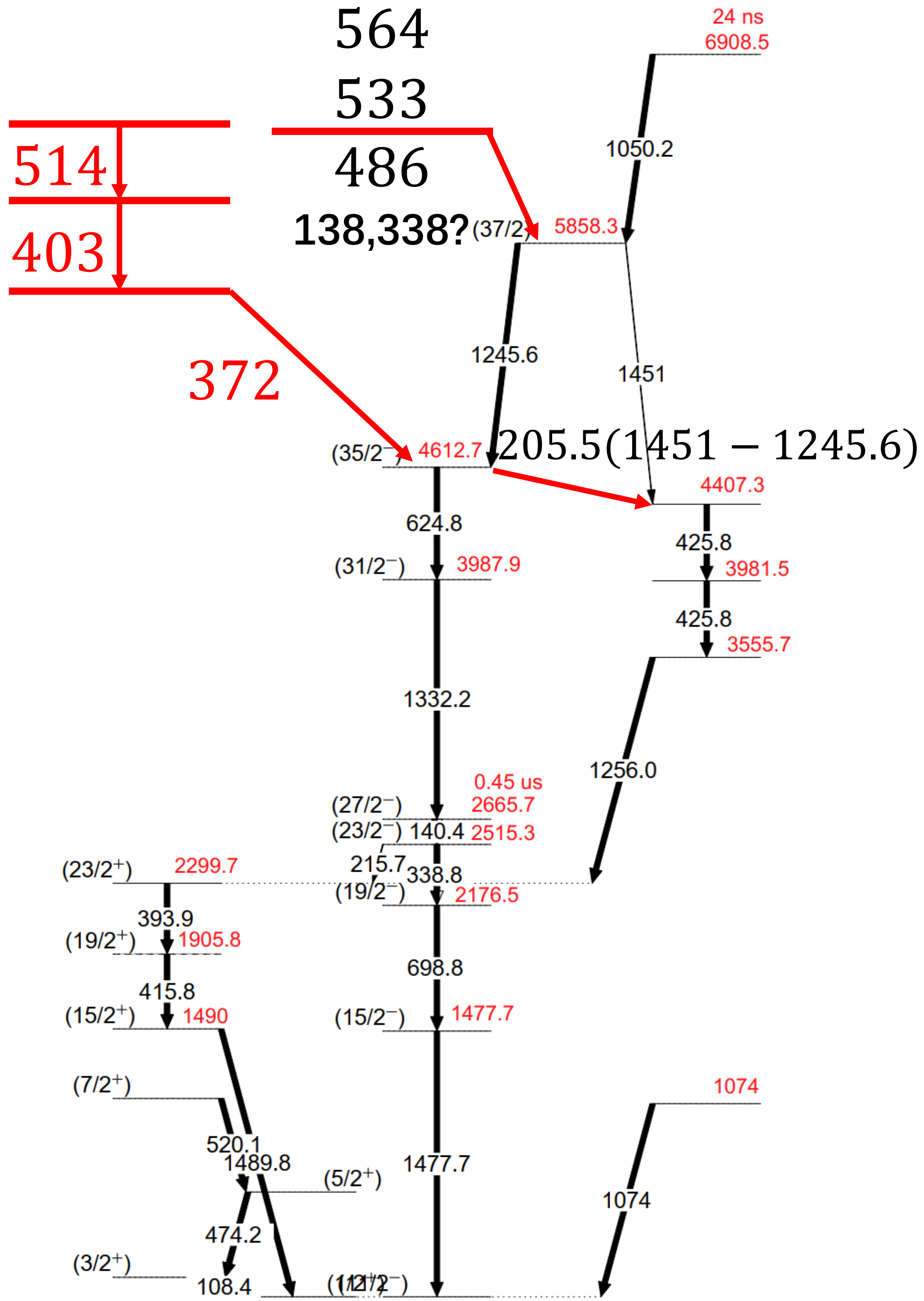
Inbeam Study(^{151}Tm)



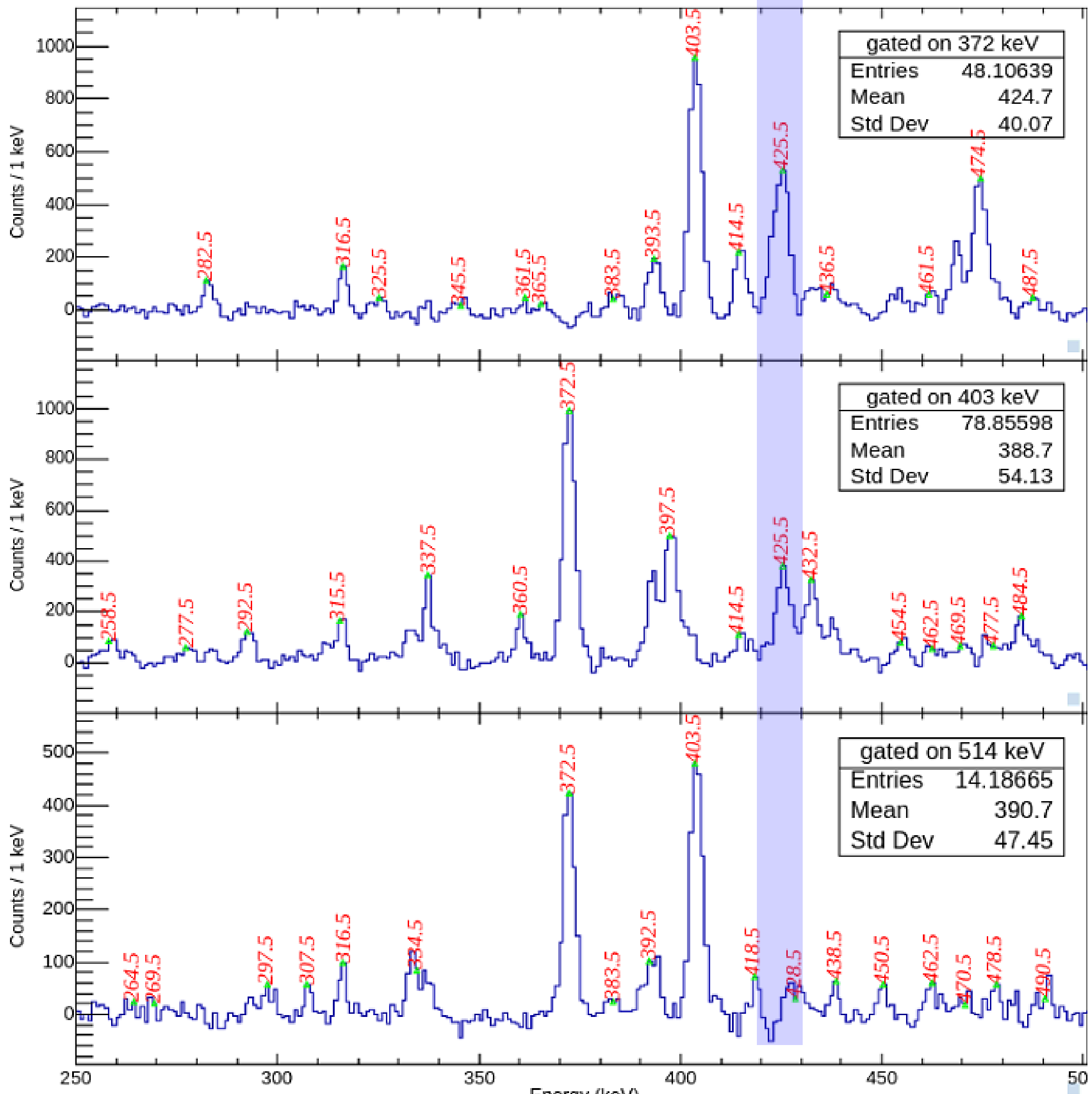


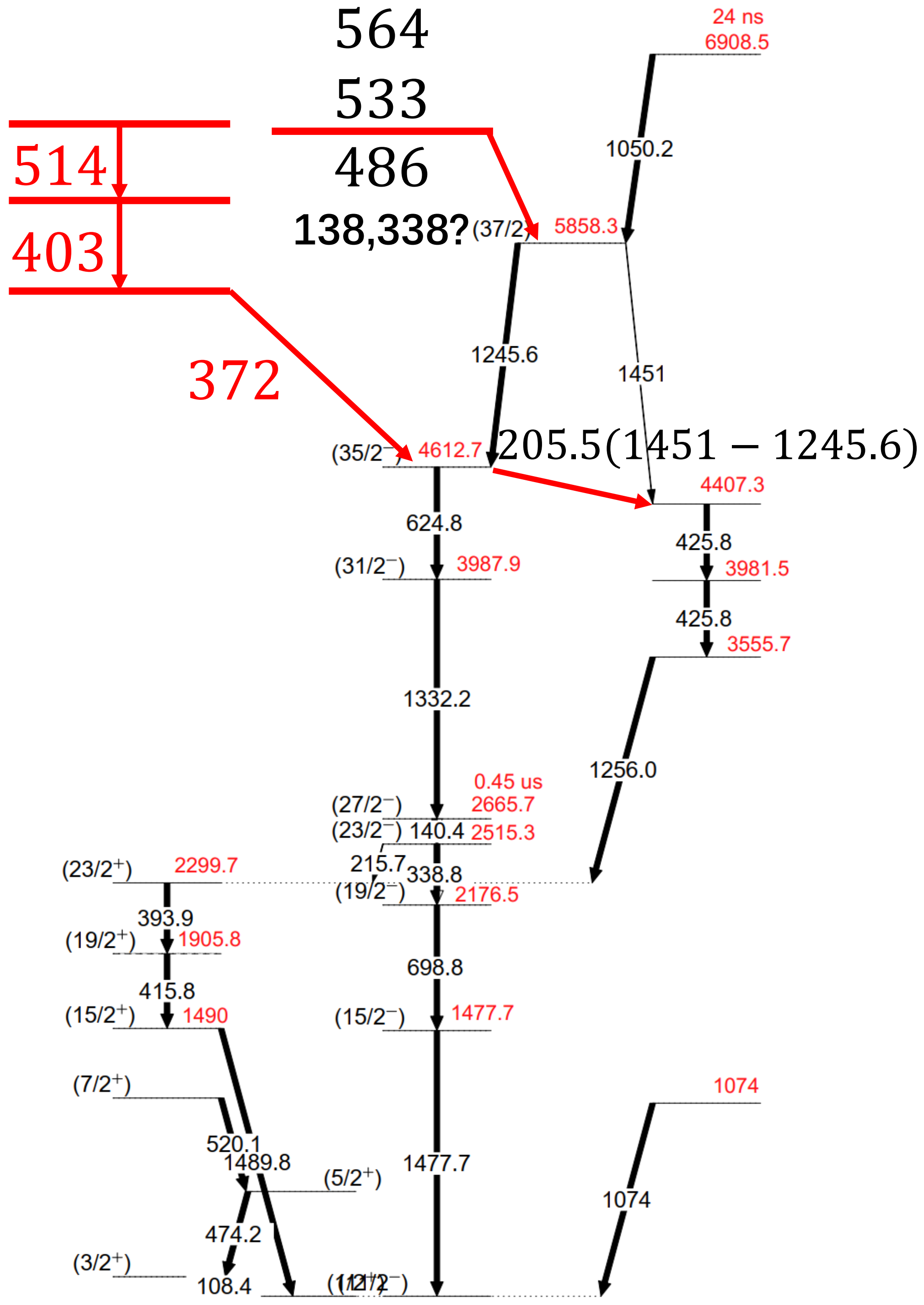
Inbeam Study(^{151}Tm)(422)



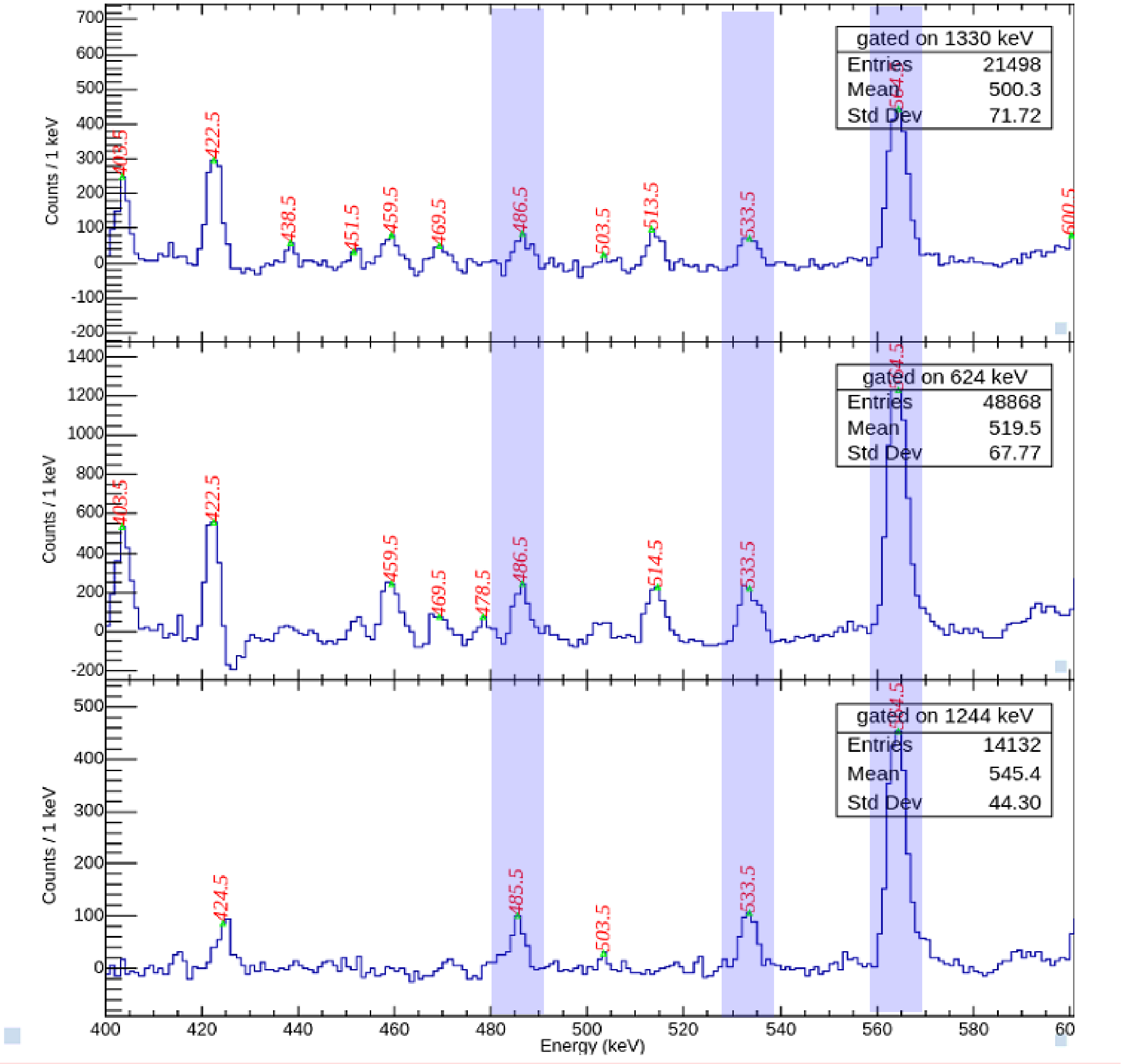


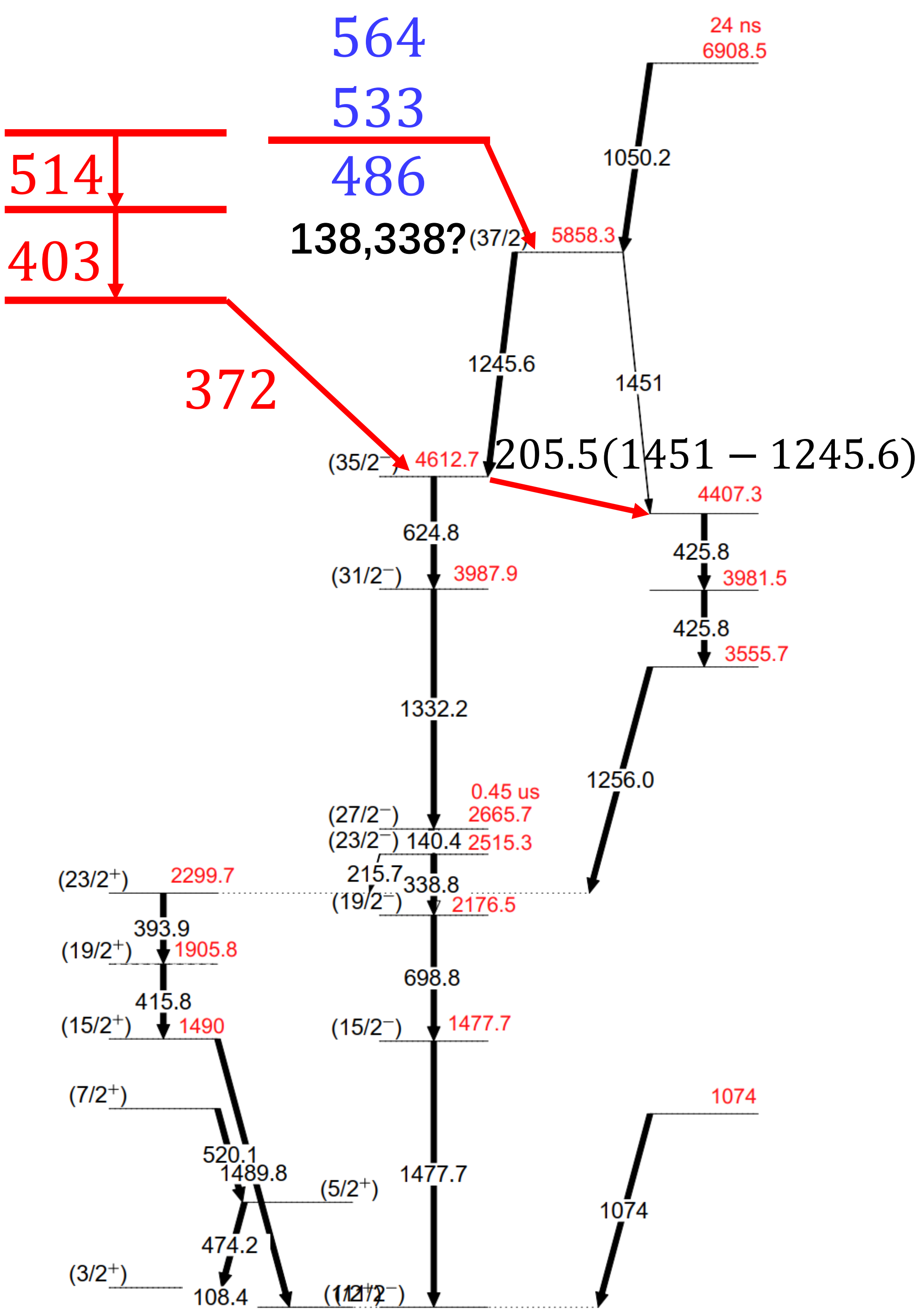
Inbeam Study(^{151}Tm)(422)





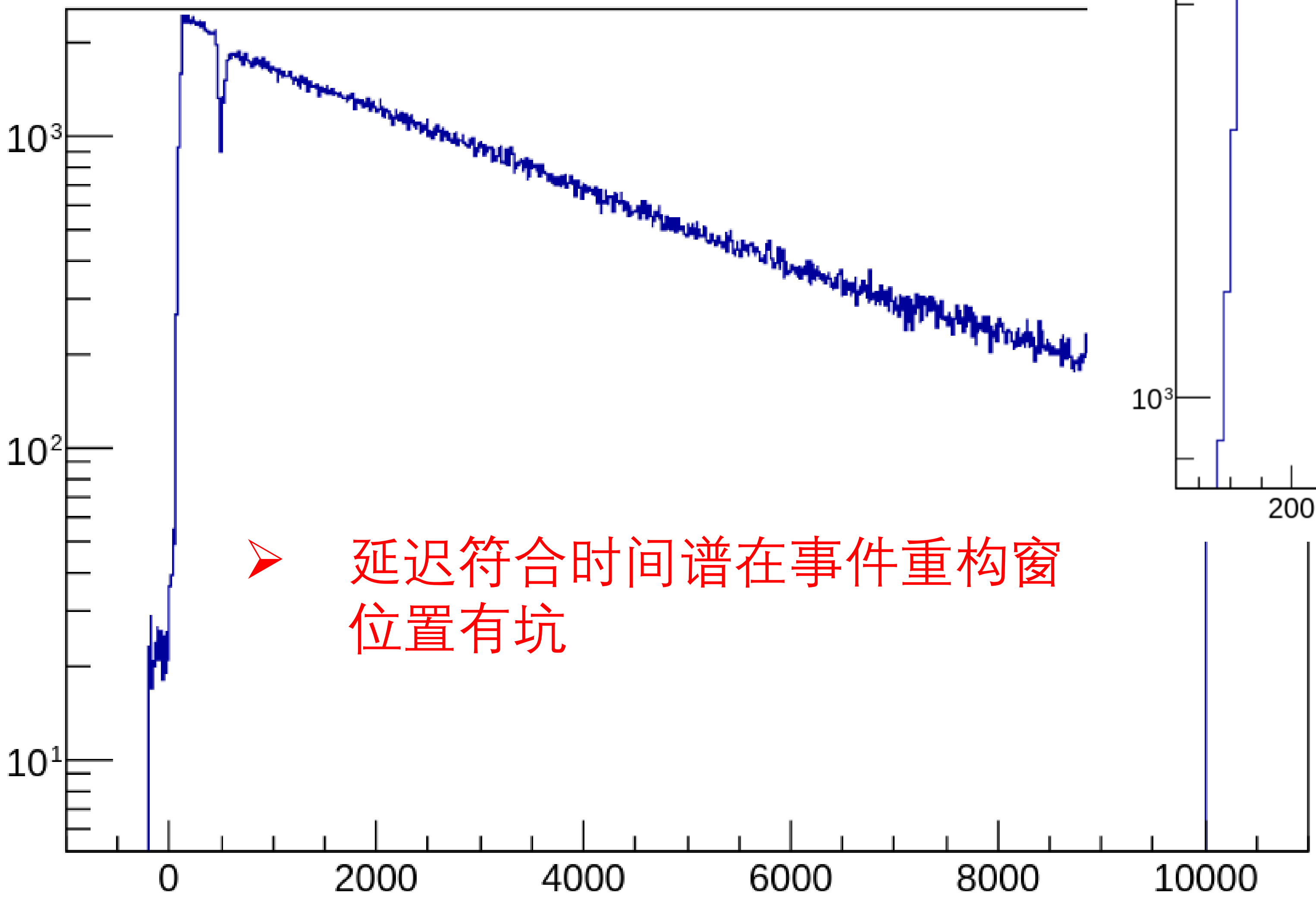
Inbeam Study(^{151}Tm)



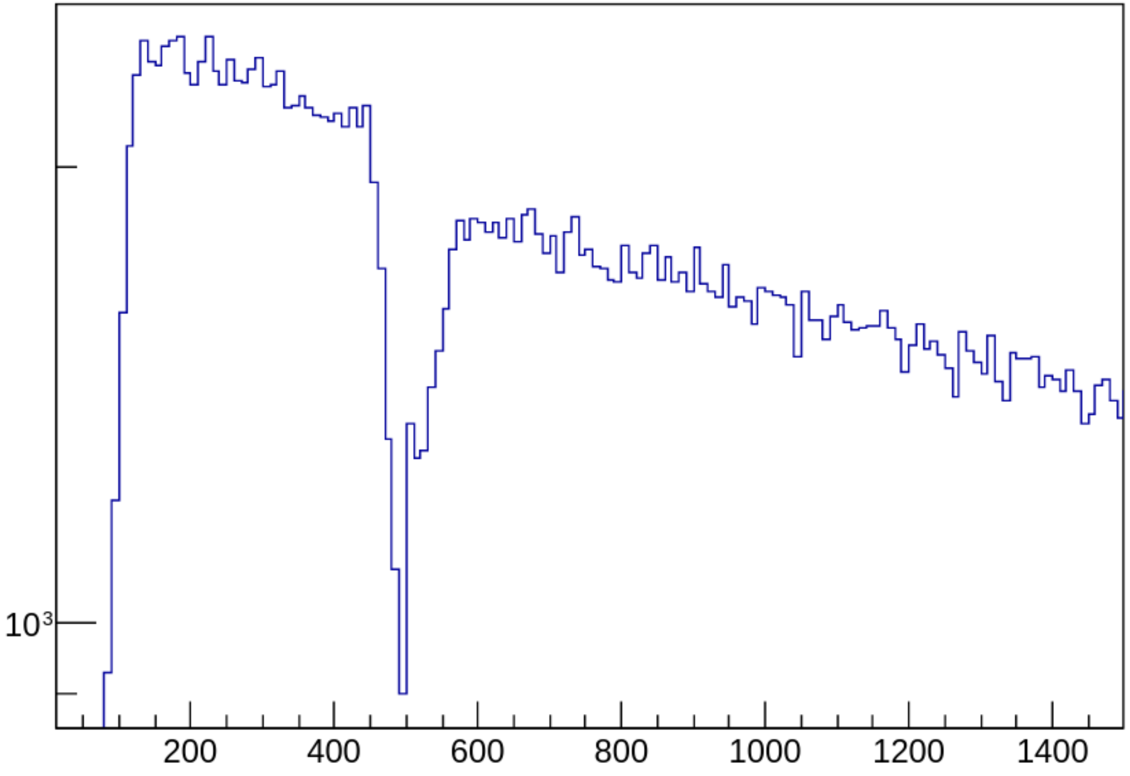


事件重构的问题

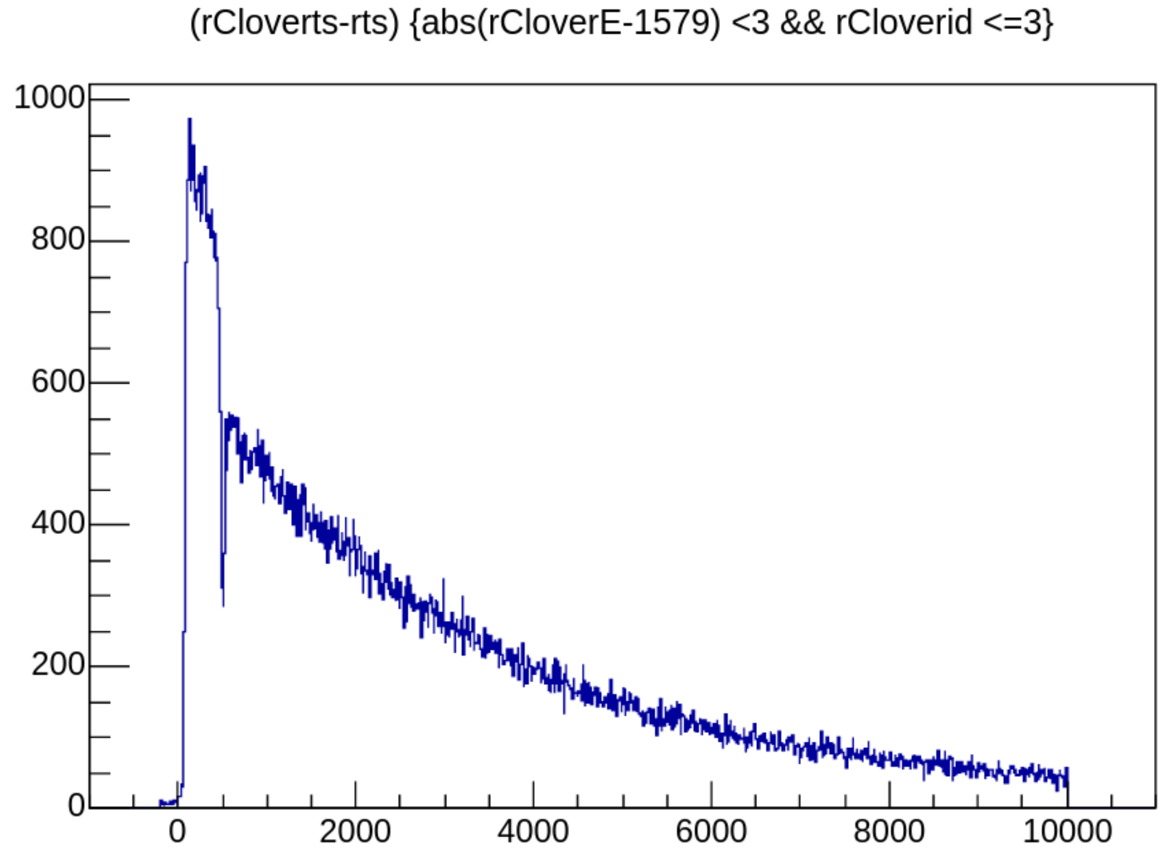
γ-recoil delay coincidence(gate on 1579) ^{150}Er

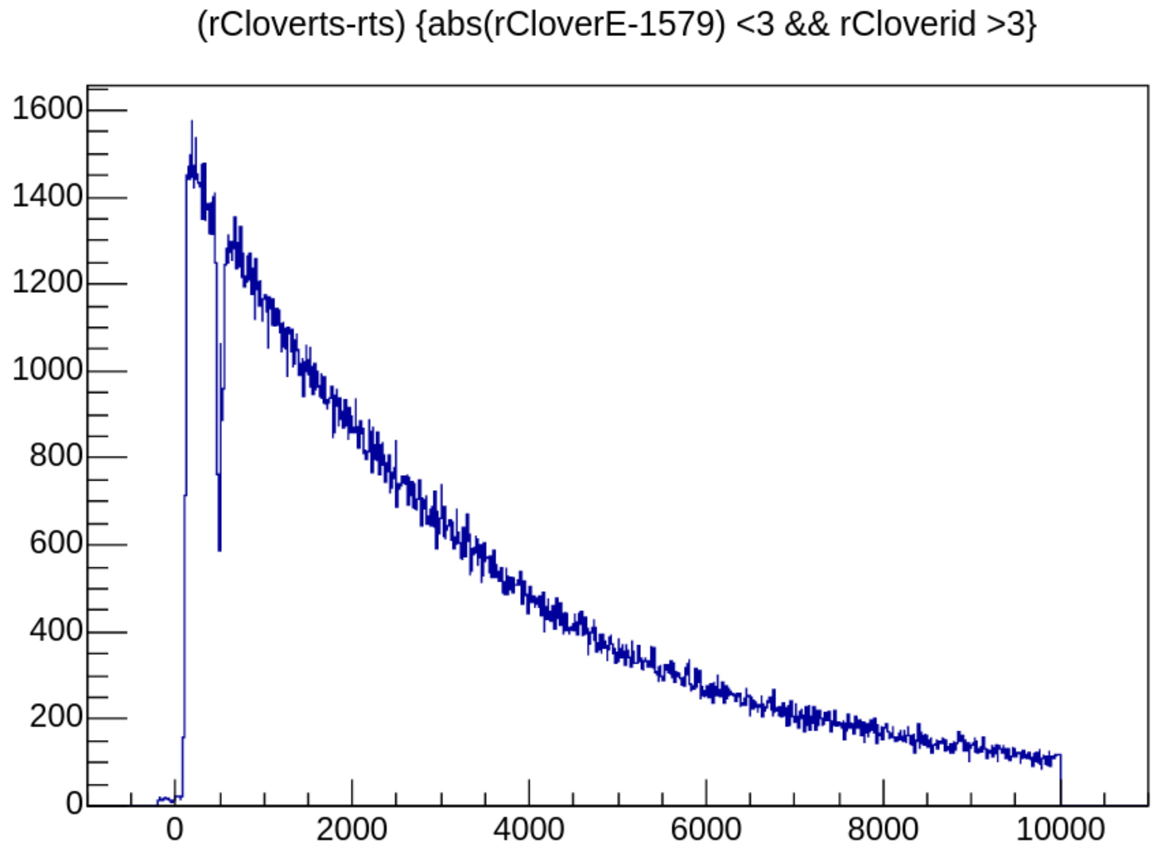


- 延迟符合时间谱在事件重构窗位置有坑



γ-recoil delay coincidence(gate on 1579) ^{150}Er

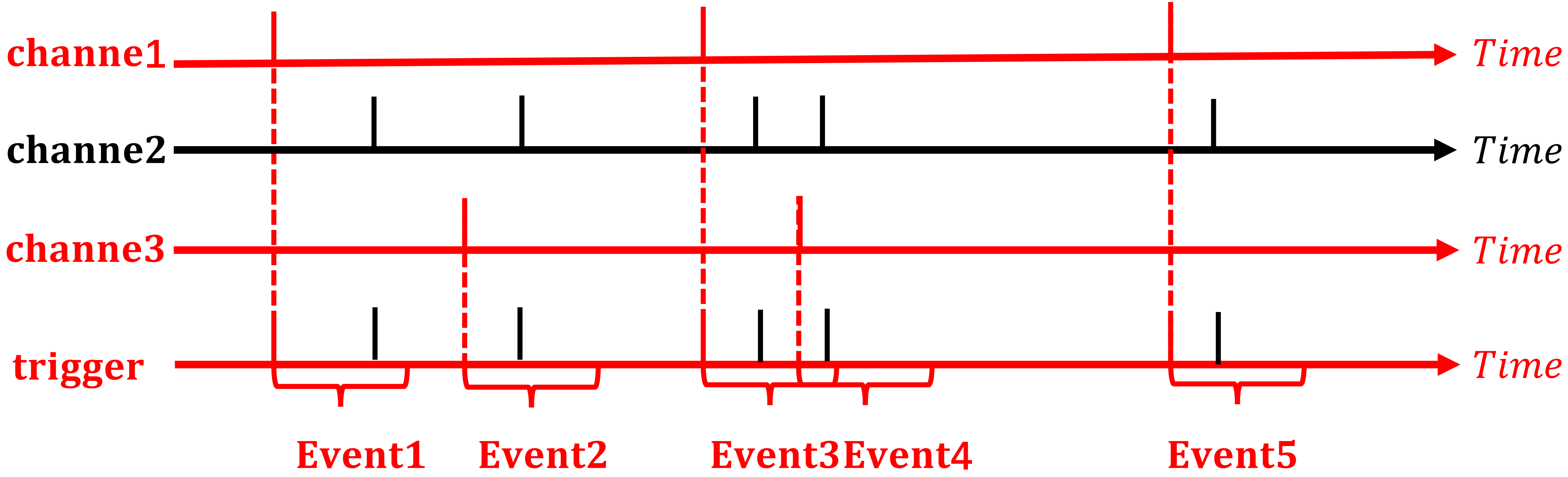




- Clover1除了有坑外，在时间窗内有突起
- 原因：Clover1的自触发没打开

Event-building

- Grain的事件重构方法：特定通道的触发
- 十六位逻辑控制




```
23 trigger.delay=-50
24 trigger.width=100
25 trigger.deadtime=10
26 trigger.1= 0XFFFFFFFF
27 trigger.2= 0XFFFFFFFF
```

0/1	1
0/1	2
0/1	4
0/1	8

Map

- Module 1
  - FFFFFFFF → DSSD1_y : 0 ~ 31
- Module 2
  - 000000FF → DSSD1_y : 32 ~ 39
  - FFFFFF00 → DSSD2_y : 16 ~ 39
- Module 3
  - 0000FFFF → DSSD2_y : 0 ~ 15
  - FFFF0000 → DSSD_x : 0 ~ 15
- Module 4
  - FFFFFFFF → DSSD_x : 16 ~ 47
- Module 5
  - FFFFFFFF → DSSD_x : 79 ~ 48
- Module 6
  - FFFFFFFF → DSSD_x : 80 ~ 111
- Module 7
  - 000000FF → DSSD_x : 112 ~ 119
  - 0000FF00 → No
  - FFFF0000 → Pin : 0 ~ 15 (6,10~12
- Module 8
  - 00000FFF → Pin : 16 ~ 27 (18,22 broken)
  - 0000F000 → No
  - FFFF0000 → PGeX : 8 ~ 23
- Module 9
  - 000000FF → PGeX : 0 ~ 7
  - 0000FF00 → No
  - 0FFF0000 → PGeY : 11 ~ 0
  - F0000000 → No
- Module 10
  - 00000001 → Clover : 0
  - 0000000E → trigger but no data
  - 000000F0 → trigger but no data
  - 00000100 → Clover : 1
  - 00000E00 → trigger but no data
  - 0000F000 → trigger but no data
  - 00010000 → Clover : 2
  - 000E0000 → trigger but no data
  - 00F00000 → trigger but no data
  - 01000000 → Clover : 3
  - 0E000000 → trigger but no data
  - F0000000 → trigger but no data
- Module 11
  - FFFFFFFF → HPGe : 0 ~ 31
- Module 12
  - 00001FFF → HPGe : 32 ~ 44 (39,40 broken)
  - 0000E000 → No
  - 000F0000 → Clover : 4 ~ 7
  - 00F00000 → Clover : 8 ~ 11(broken)
  - 0F000000 → Clover : 12 ~ 15
  - F000e000 → No
- Module 13
  - 00000001 → MWPC x1
  - 00000002 → MWPC x2
  - 00000004 → MWPC y1
  - 00000008 → MWPC y2
  - 00000010 → MWPC e t
  - 0000FFE0 → No
  - 00010000 → tof
  - FFFE0000 → trigger but no data
- Module 14
  - FFFFFFFF → No
- Module 15
  - FFFFFFFF → No

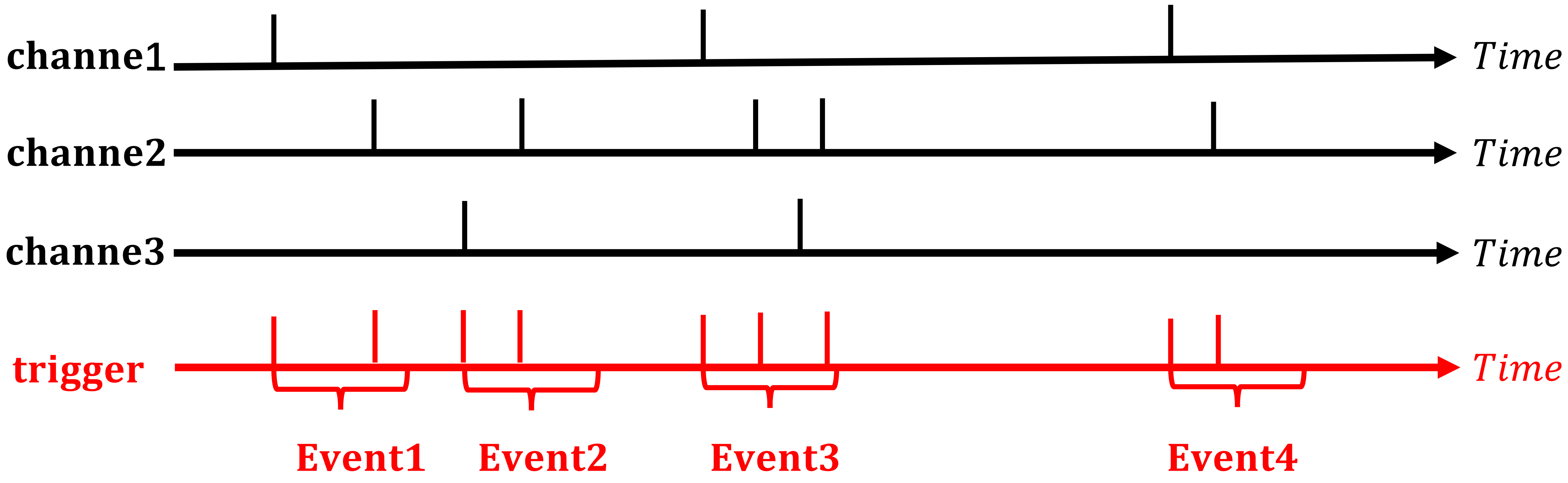
Trigger

- Module 8
  - 00000FFF → Pin : 16 ~ 27 (18,22 broken)
  - 0000F000 → No
  - FFFF0000 → PGeX : 8 ~ 23
- Module 9
  - 000000FF → PGeX : 0 ~ 7
  - 0000FF00 → No
  - 0FFF0000 → PGeY : 11 ~ 0
  - F0000000 → No
- Module 10
  - 00000001 → Clover : 0
  - 0000000E → trigger but no data
  - 000000F0 → trigger but no data
  - 00000100 → Clover : 1
  - 00000E00 → trigger but no data
  - 0000F000 → trigger but no data
  - 00010000 → Clover : 2
  - 000E0000 → trigger but no data
  - 00F00000 → trigger but no data
  - 01000000 → Clover : 3
  - 0E000000 → trigger but no data
  - F0000000 → trigger but no data

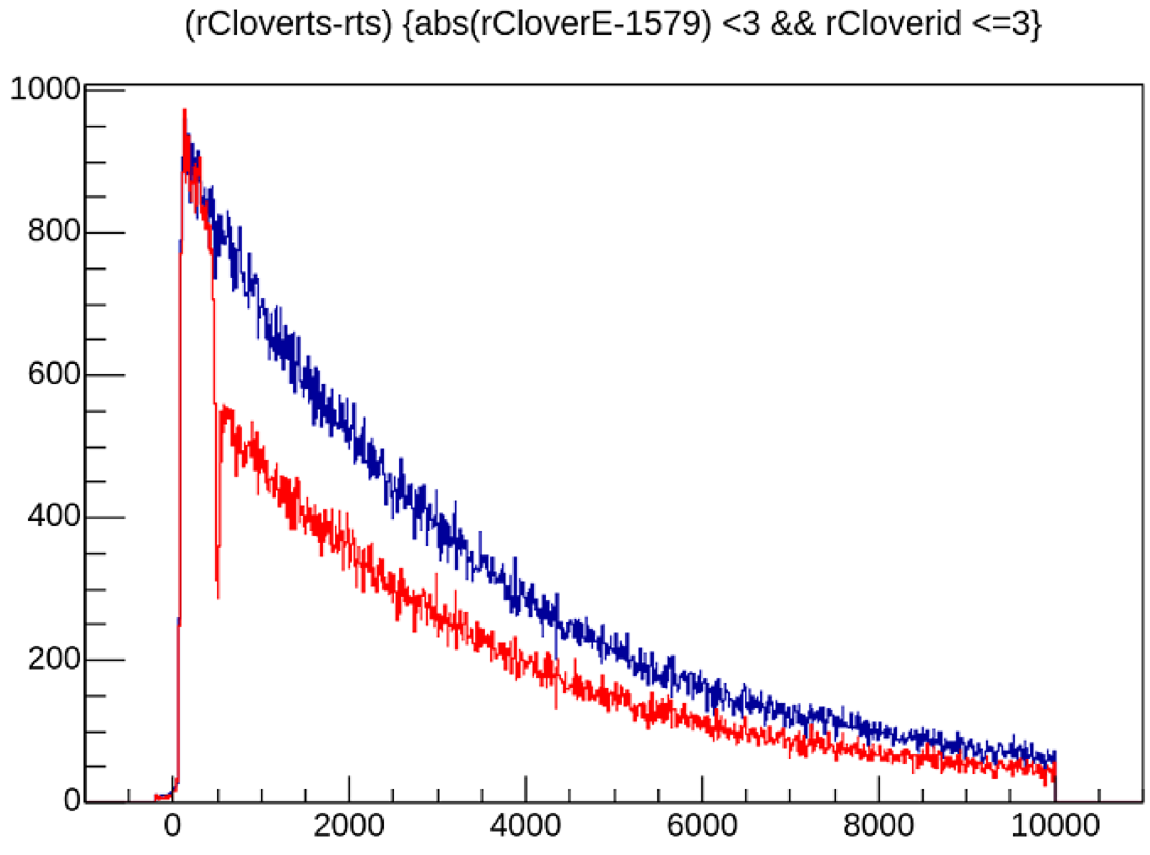
```
trigger.delay=-50
trigger.width=100
trigger.deadtime=10
trigger.1= 0XFFFFFFFF
trigger.2= 0XFFFFFFFF
trigger.3= 0XFFFFFFFF
trigger.4= 0XFFFFFFFF
trigger.5= 0XFFFFFFFF
trigger.6= 0XFFFFFFFF
trigger.7= 0XFFFFFFFF
trigger.8= 0XFFFFFFFF
trigger.9= 0XFFFFFFFF
trigger.10=0X00000000
trigger.11=0XFFFFFFFF
trigger.12=0XFFFFFFFF
trigger.13=0X00000000
trigger.14=0X00000000
trigger.15=0X00000000
```

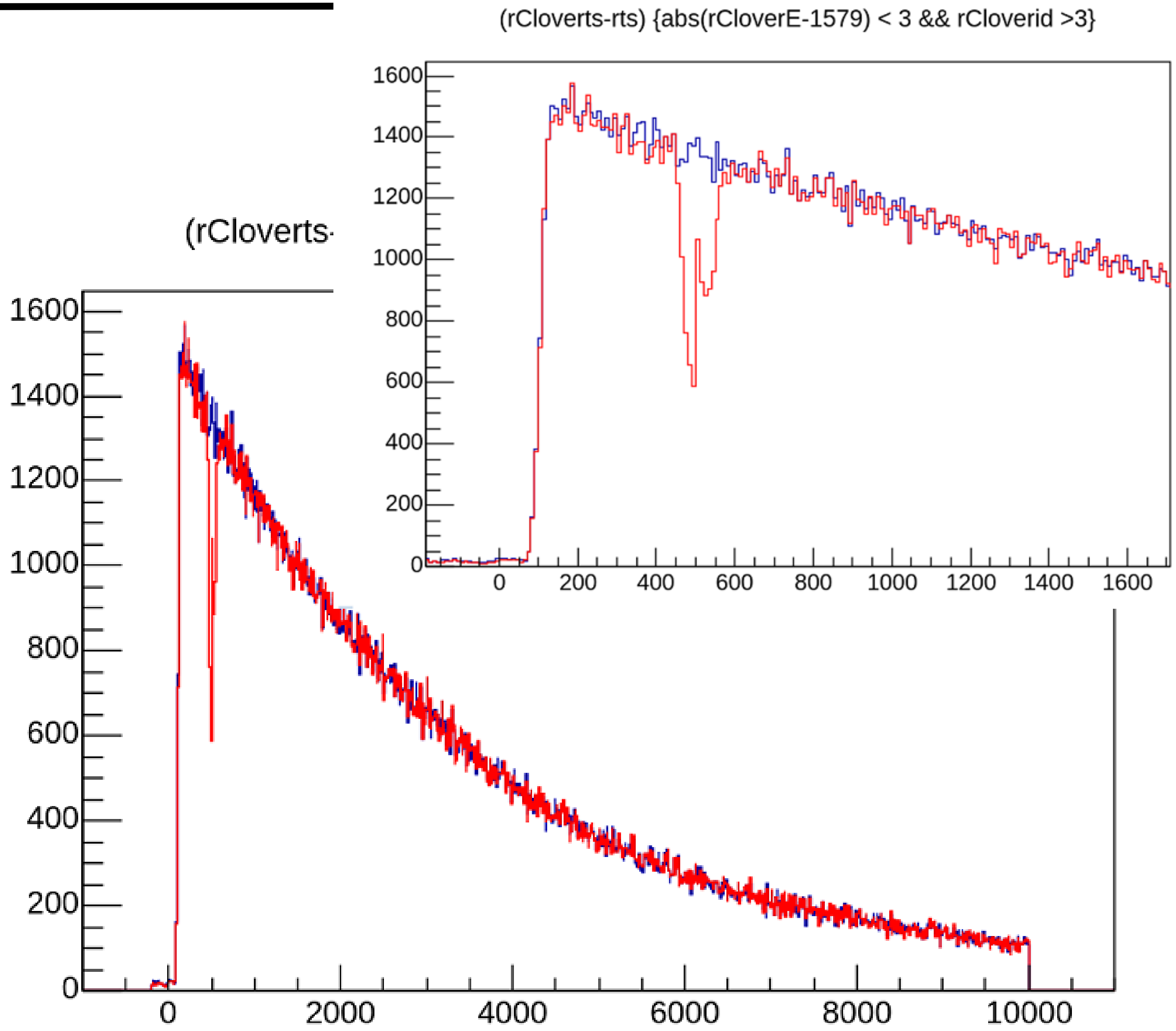
➢ 插Clover1的10号采集卡自触发没开

Event-building(XIA/AGAFA 事件重构方法)



γ-recoil delay coincidence(gate on 1579) ^{150}Er

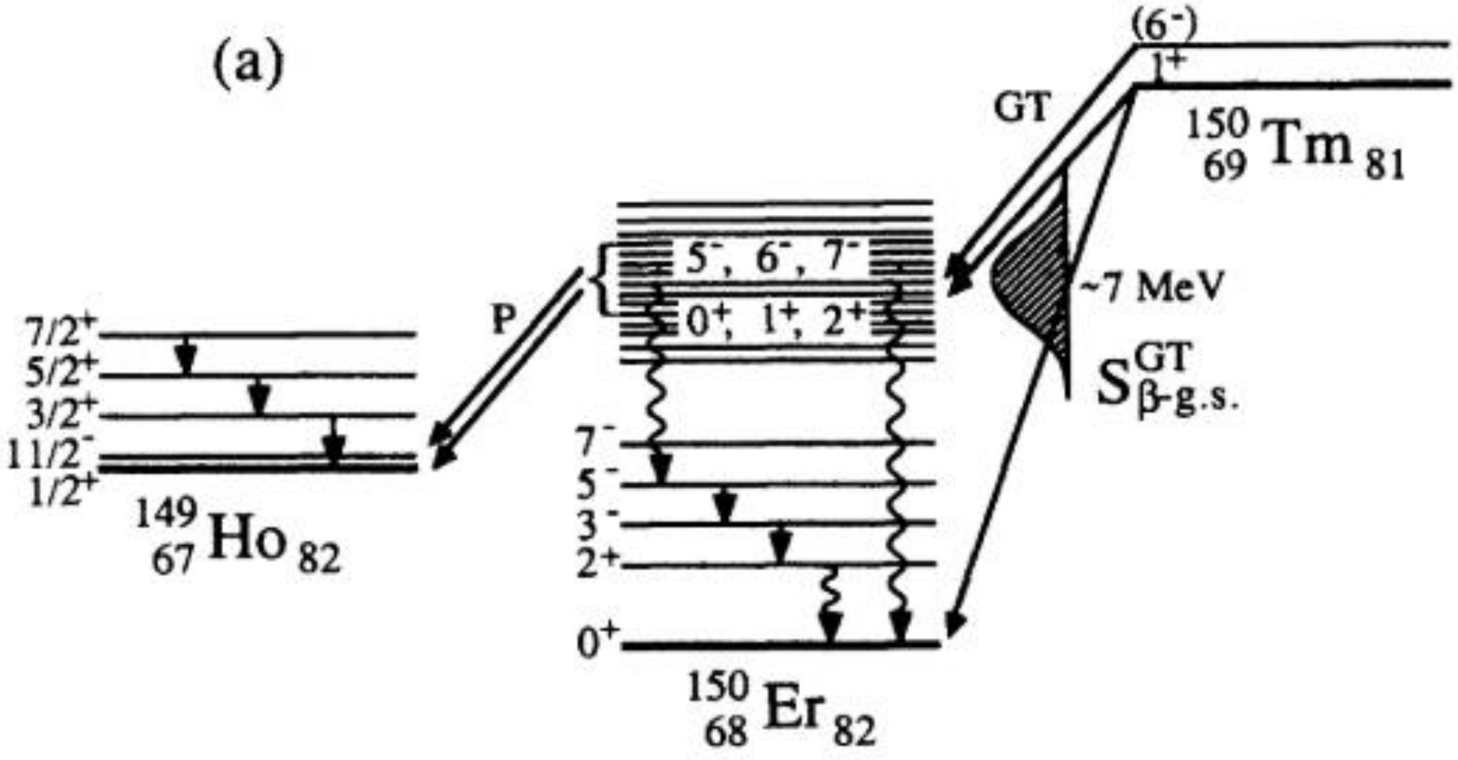




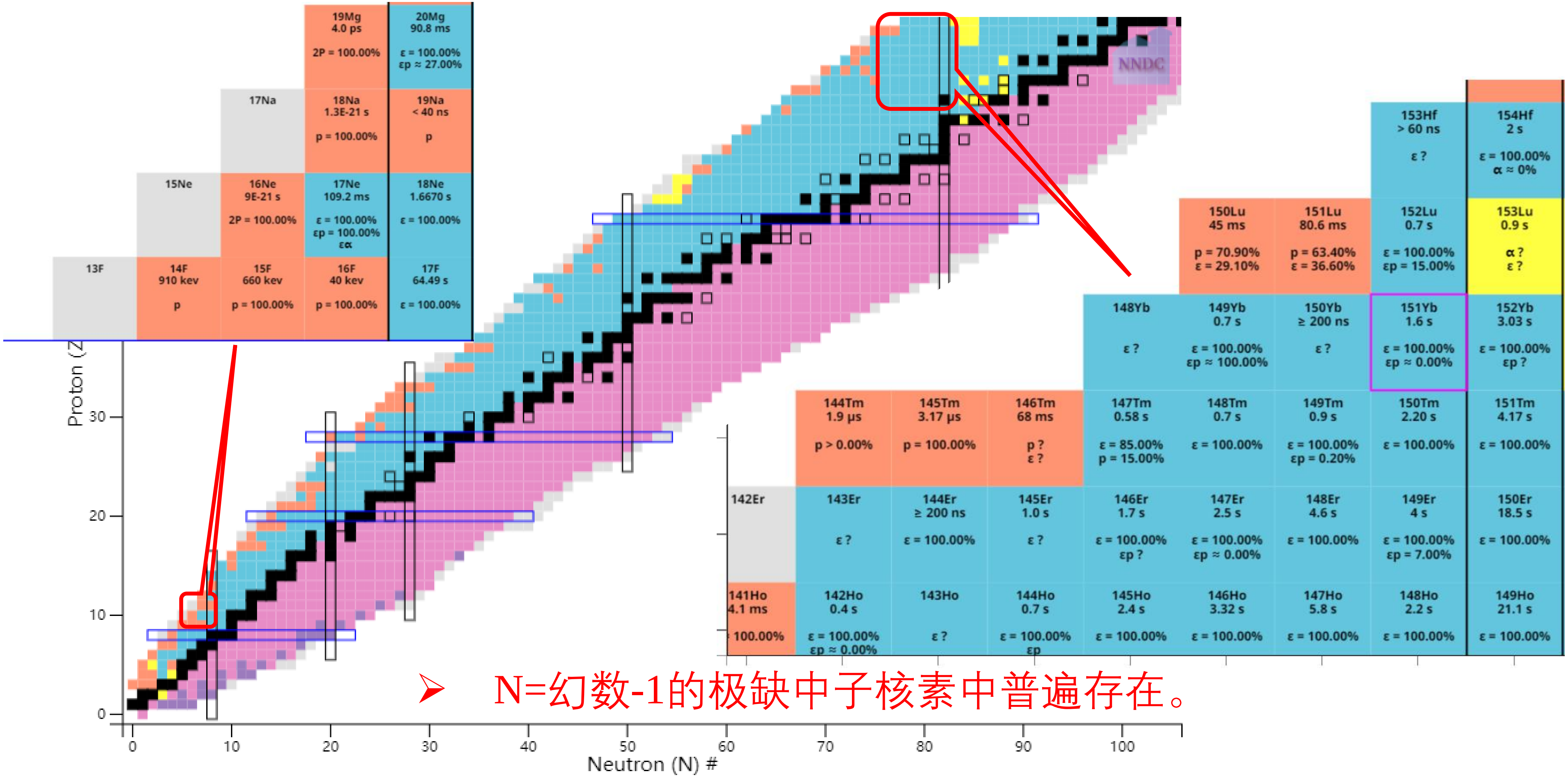
- 全部更改为自触发无窗输出
- 2us事件重构

β delayed proton emitter

β delayed proton emitter



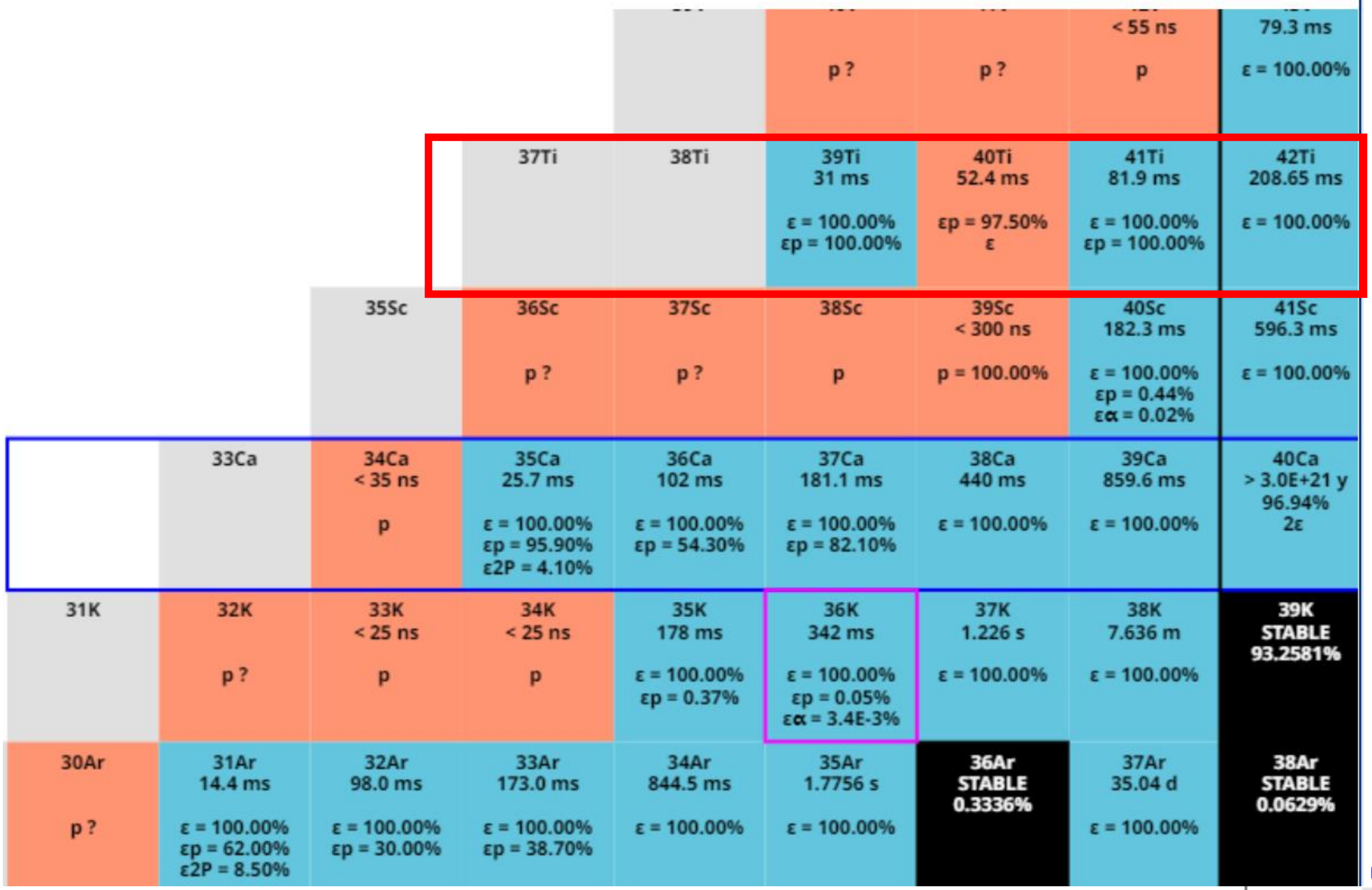
β delayed proton emitter

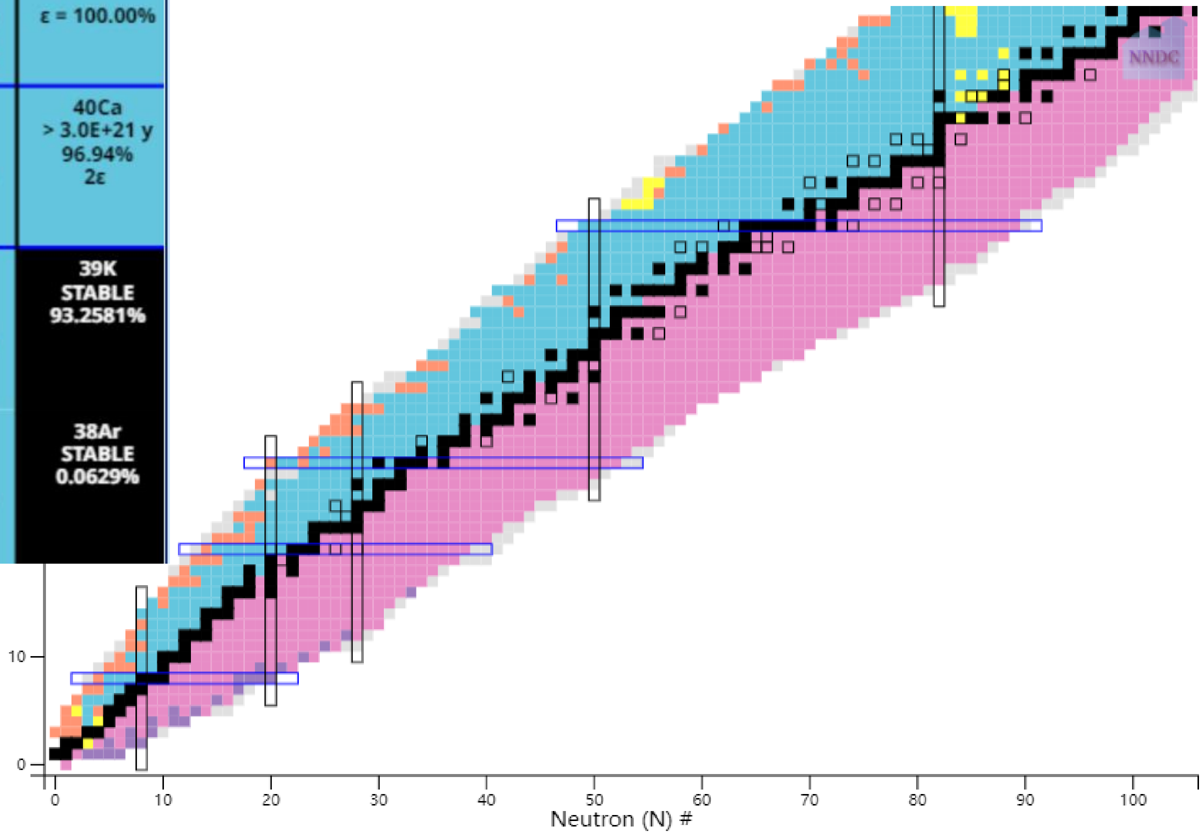


➢ N=幻数-1的极缺中子核素中普遍存在。

β delayed proton emitter

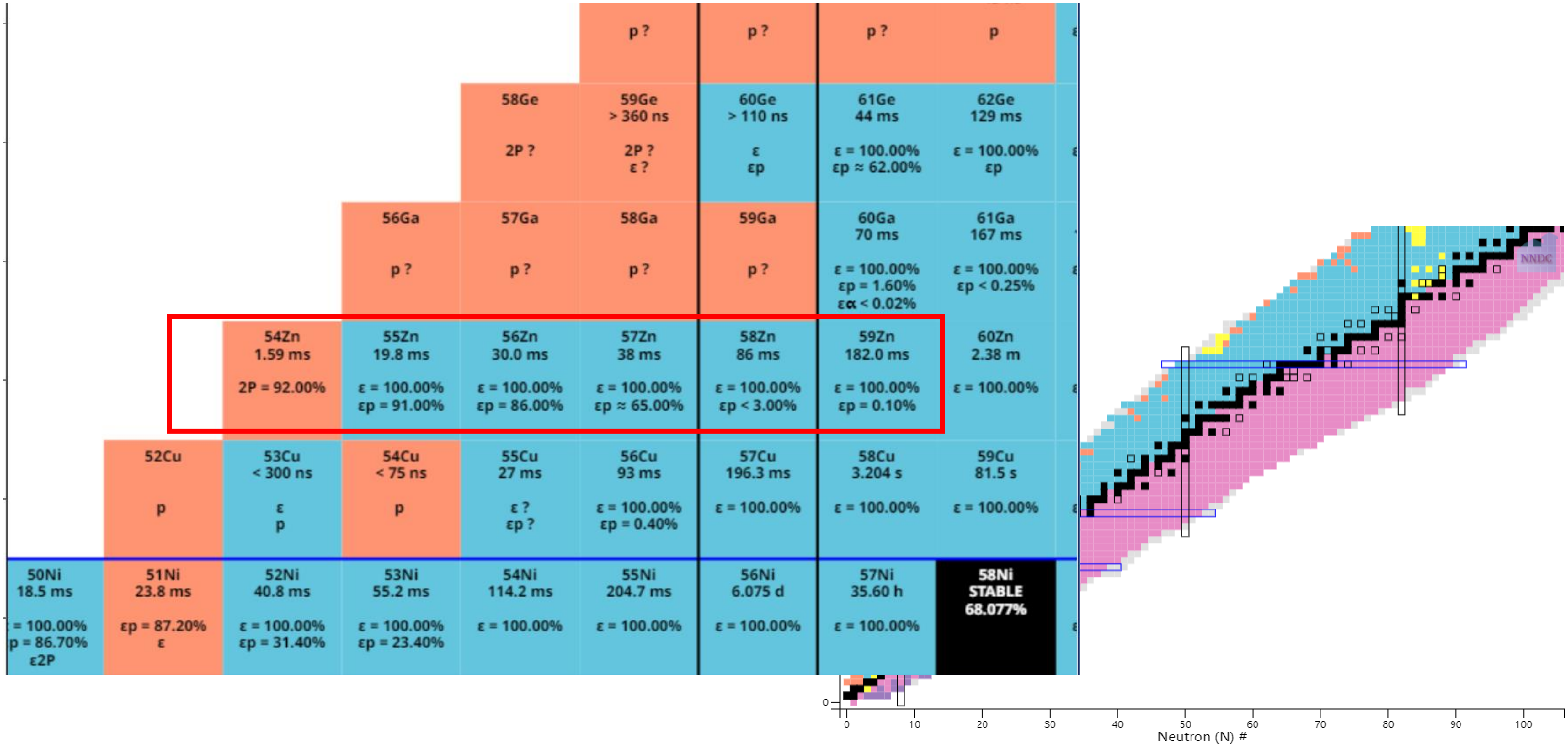
➢ Z=幻数+2的极缺中子核中普遍存在





β delayed proton emitter

➢ Z=幻数+2的极缺中子核中普遍存在



β delayed proton emitter

PHYSICAL REVIEW C VOLUME 30, NUMBER 2 AUGUST 1984

Beta-delayed proton activities: ^{147}Dy and ^{149}Er

146Dy 33.2 s ε = 100.00%	147Dy 67 s ε = 100.00% εp = 0.05%	148Dy 3.3 m ε = 100.00%
145Tb 30.9 s ε ?	146Tb 8 s ε = 100.00%	147Tb 1.64 h ε = 100.00%
144Gd 4.47 m ε = 100.00%	145Gd 23.0 m ε = 100.00%	146Gd 48.27 d ε = 100.00%

- ^{142}Nd(^{12}C, 7n)^{147}Dy
- ^{144}Sm(^{12}C,7n)^{149}Er
- Helium gas-jet apparatus + Collection box(Si telescope(20um ΔE+300um E) + Ge detector)

β delayed proton emitter

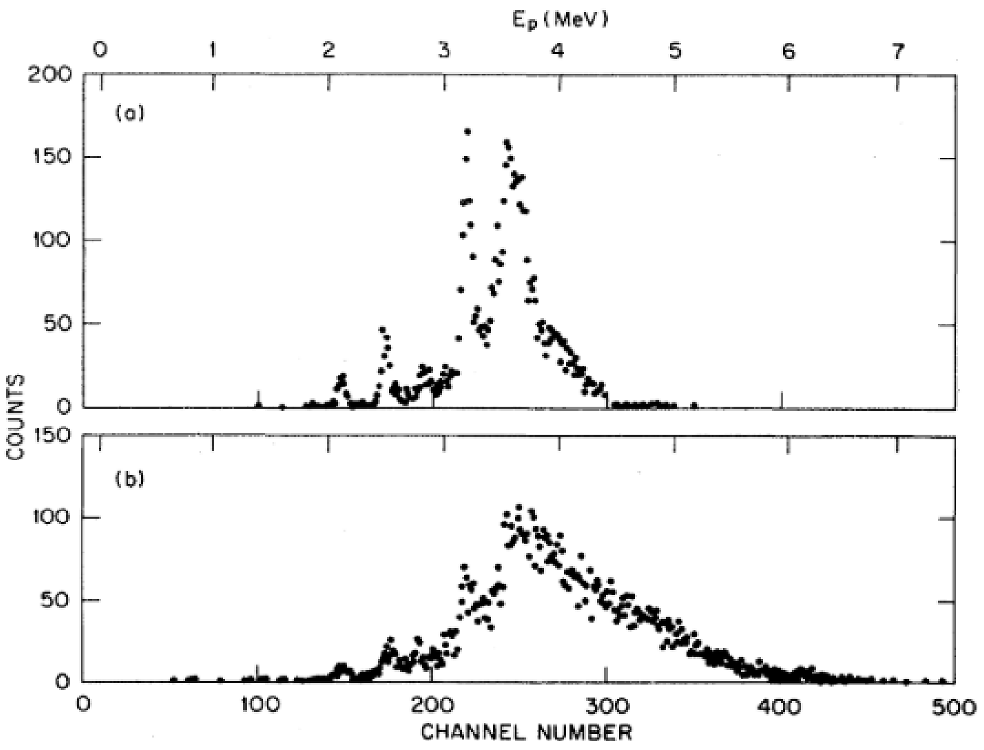
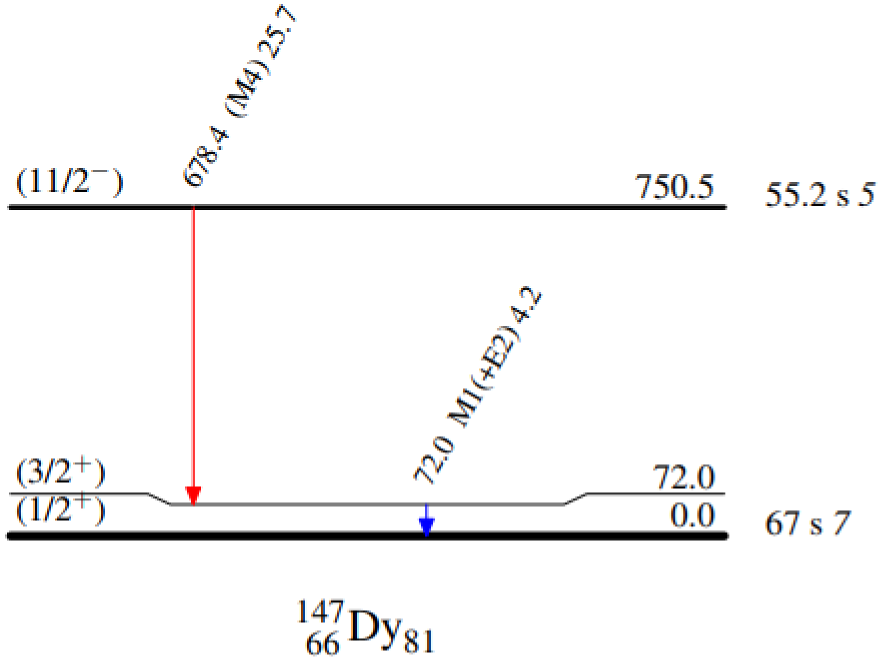


FIG. 1. Delayed-proton spectra observed in (a) $^{12}C+^{142}Nd$ and (b) $^{12}C+^{144}Sm$ irradiations made at an incident energy of ~135 MeV.

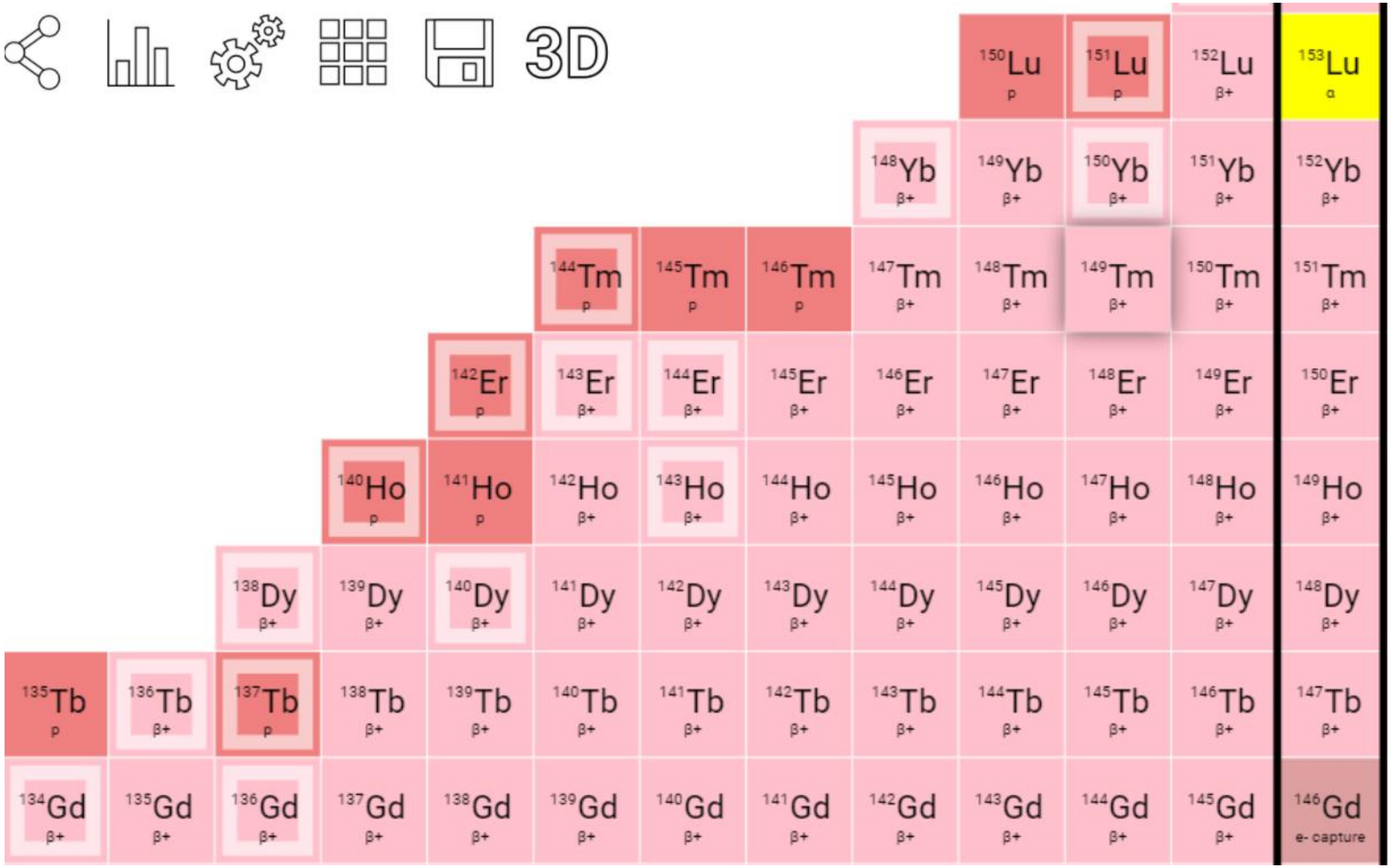


- ($I_{protron}/I_{679\gamma}$ = 1.3E-3) && (679 transition is estimated to be ≲40% of the total ^{147}Dy decay strength) → branch ratio ~ 4E-4.
- In ^{144}Sm(^{12}C,α5n)^{147}Dy, ^{147}Dy produced (679 transition is clearly seen.), together with another proton emitter.

β delayed proton emitter

PHYSICAL REVIEW C VOLUME 37, NUMBER 6 JUNE 1988

Delayed proton emission of $N = 81$ odd-odd precursors: ^{148}Ho, ^{150}Tm, and ^{152}Lu



- ^{147}Dy, at first, attributed to the reduced level density associated with both the N =82 shell and Z = 64 subshell closures, but it was later shown that the relevant shell is N =82, since the sharp structure was also observed ^{149}Er and ^{151}Yb.

β delayed proton emitter

PHYSICAL REVIEW C VOLUME 37, NUMBER 6 JUNE 1988

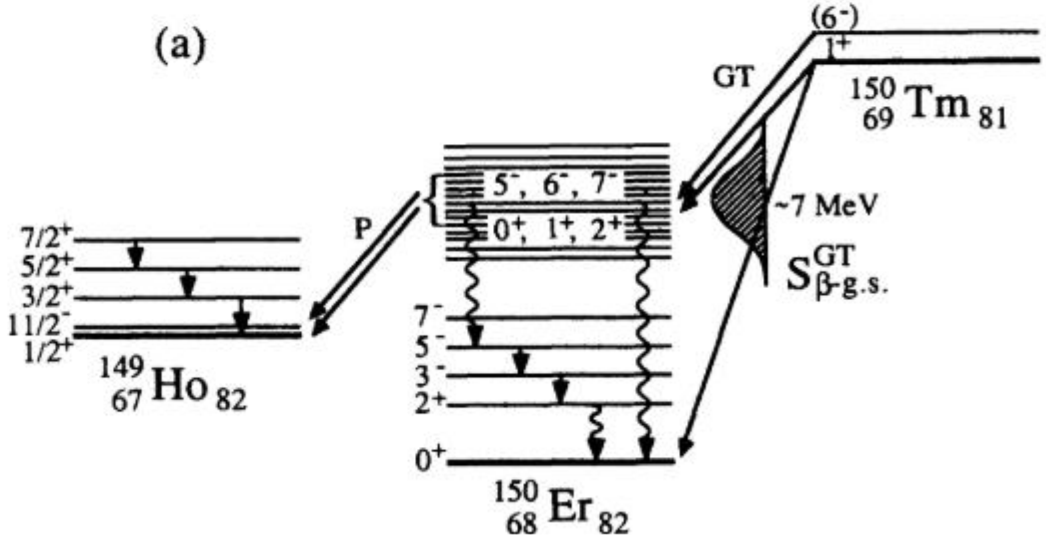
Delayed proton emission of $N=81$ odd-odd precursors: ^{148}Ho, ^{150}Tm, and ^{152}Lu

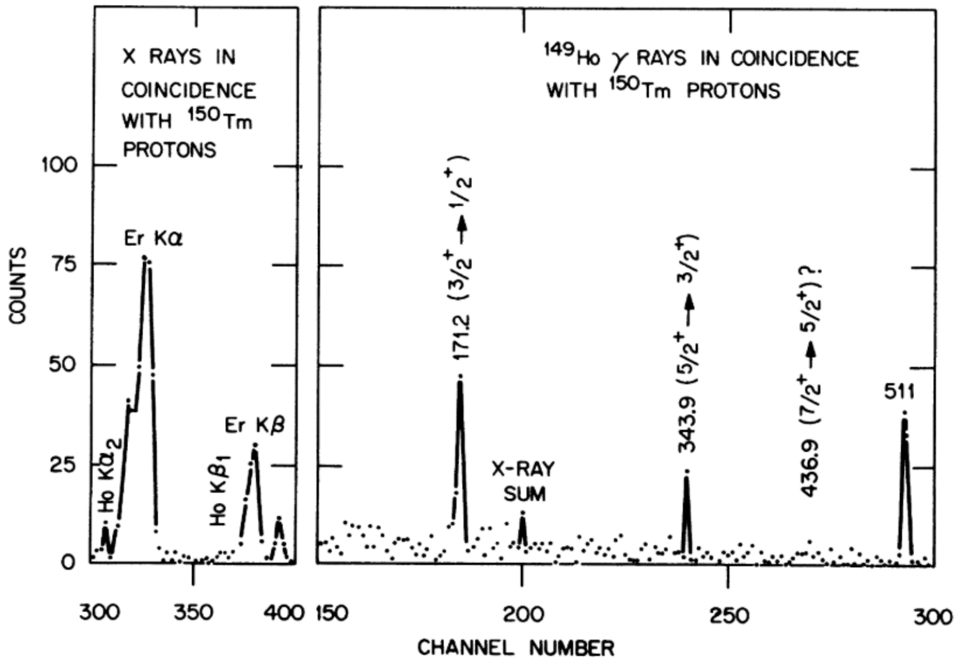
TABLE I. Experimental parameters for the production of the β-delayed proton precursors $^{152}_{71}$Lu, $^{150}_{69}$Tm, and $^{148}_{67}$Ho.

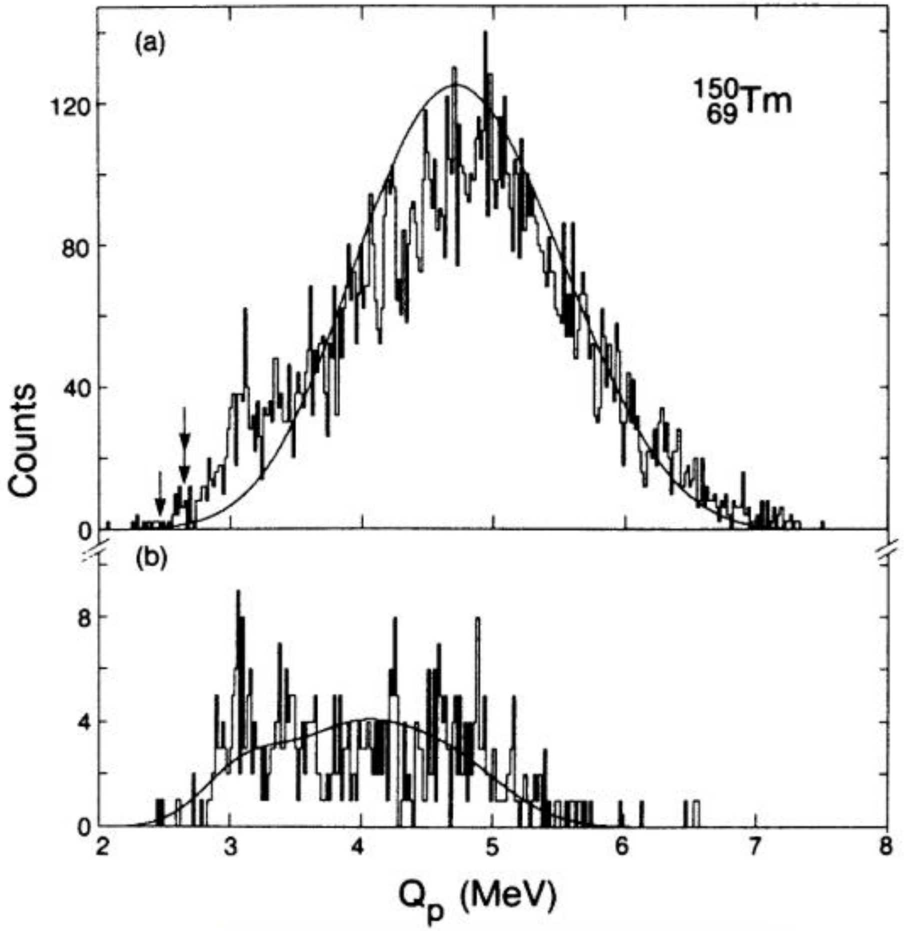
Isotope	Target	Projectile	Reaction channel	Target thickness (mg/cm^2)	Target enrichment (%)	Projectile lab. energy target center (MeV)	Calculated cross section at projectile energy (mb)
$^{148}_{67}$Ho	$^{94}_{42}$Mo	$^{58}_{28}$Ni	3pn	2.0	93.9	257	80
$^{150}_{69}$Tm	$^{96}_{44}$Ru	$^{58}_{28}$Ni	3pn	1.6	96.5	267	20
$^{152}_{71}$Lu	$^{96}_{44}$Ru	$^{58}_{28}$Ni	pn	1.5	96.5	244	0.4

- On-line isotope separator OASIS
- Implanted in a 50-um Mylar tape and transported within 180 ms to an array of detectors consisting of a Si ΔE-E particle telescope, a HPGe detector, two n-type Ge detectors and a thin plastic ΔE_β detector

β delayed proton emitter







$$Q_{\beta^-} = M\left({}^{\mathrm{A}}_{\mathrm{Z}}\mathrm{X}\right)c^2 - M\left({}^{\mathrm{A}}_{\mathrm{Z+1}}\mathrm{Y}\right)c^2$$

$$Q_{\beta^+} = M\left({}^{\mathrm{A}}_{\mathrm{Z}}\mathrm{X}\right)c^2 - M\left({}^{\mathrm{A}}_{\mathrm{Z\text{-}1}}\mathrm{Y}\right)c^2 - 2m_ec^2$$

$$Q_{EC} = M\left({}^{\mathrm{A}}_{\mathrm{Z}}\mathrm{X}\right)c^2 - M\left({}^{\mathrm{A}}_{\mathrm{Z\text{-}1+1}}\mathrm{Y}\right)c^2$$

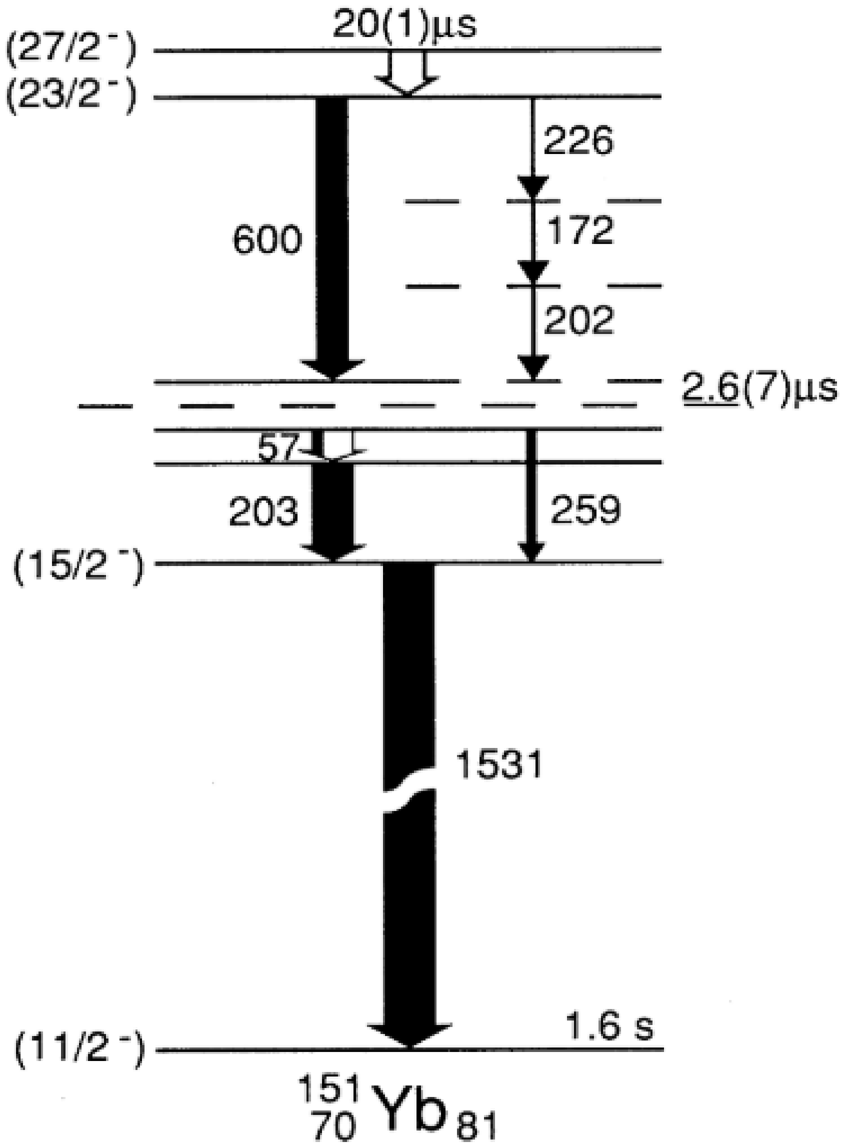
Isomeric Decay Tagging

Products

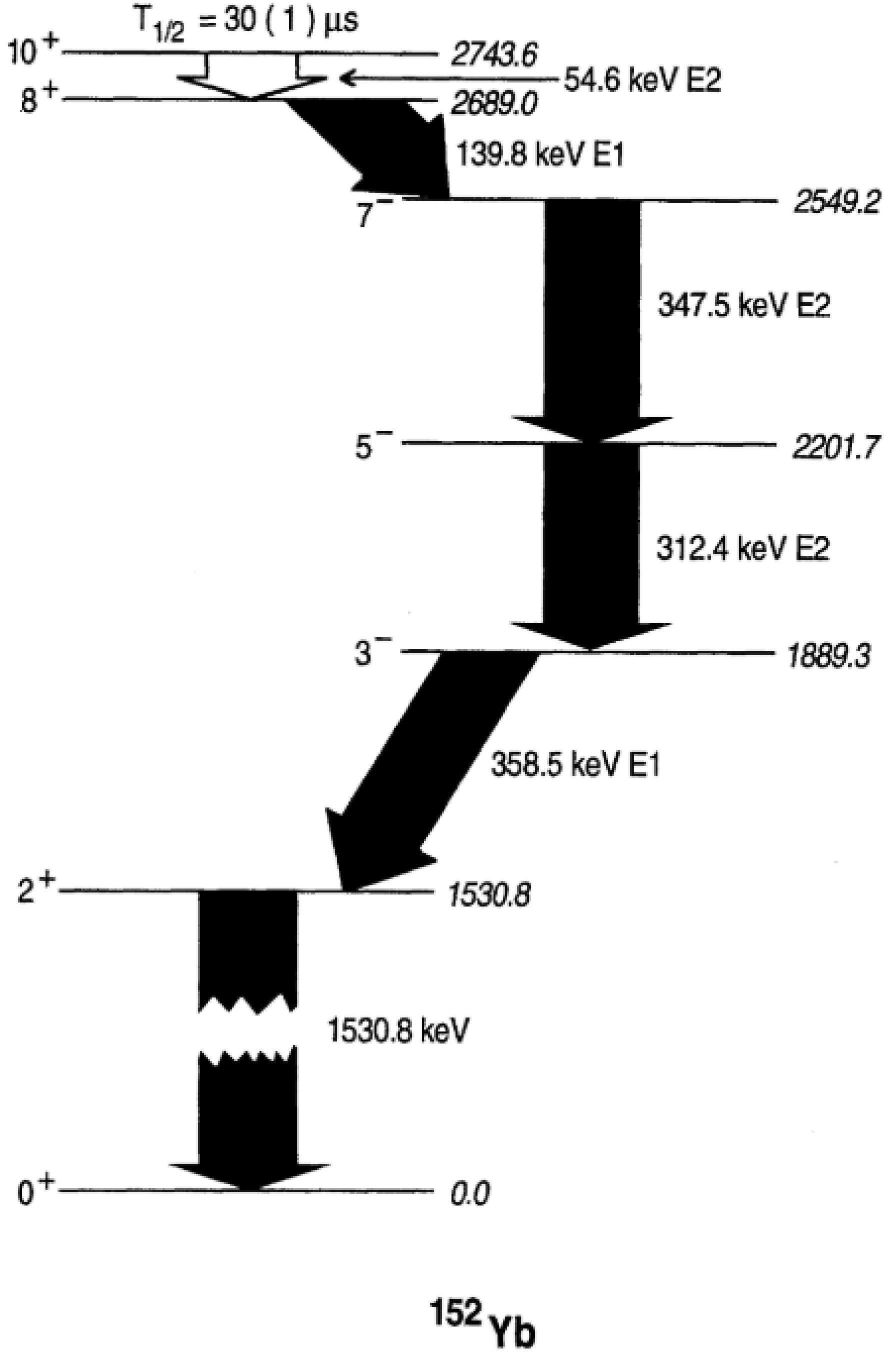
^{58}Ni + $^{96,99,101,102}Ru$ → $^{154,157,159,160}Hf$ (266 MeV/274MeV)

Z \ N	77	78	80	81	82	83	84	85
72	${}^{150}_{72}Hf$	${}^{151}_{72}Hf$ (0.1ub)	${}^{152}_{72}Hf$ (2ub)	${}^{153}_{72}Hf$	${}^{154}_{72}Hf$	${}^{155}_{72}Hf$	${}^{156}_{72}Hf$ g 23ms 100% 5873 m 0.52ms 100% 7782	${}^{157}_{72}Hf$ g 115ms 94% 5731
71	${}^{149}_{71}Lu$	${}^{150}_{71}Lu$ (0.1ub) g 46 ms 1261 m 43us 1283	${}^{151}_{71}Lu$ (100ub) g 80.6ms 63.4% 1233 m 16us 100% 1310	${}^{152}_{71}Lu$ (100ub) 10+ isomer? g.S EC + ECP	${}^{153}_{71}Lu$	${}^{154}_{71}Lu$	${}^{155}_{71}Lu$ g 68ms 90% 5650 m1 138ms 76% 5581 m2 2.7ms 100% 7390	${}^{156}_{71}Lu$ g 494ms 95% 5453 m 198ms100% 5565
70	${}^{148}_{70}Yb$	${}^{149}_{70}Yb$ (20ub) 0.7s	${}^{150}_{70}Yb$ (300ub) g >= 200ns	${}^{151}_{70}Yb$ (8mb) 1.6s 11/2- 0+x 1.6s g.s EC +P 20 us	${}^{152}_{70}Yb$ (2mb) 3.03s 30 us	${}^{153}_{70}Yb$ 4.2 s	${}^{154}_{70}Yb$ g 0.409s 92.6% 5330.9	${}^{155}_{70}Yb$ g 1.8s 89% 5200
69	${}^{147}_{69}Tm$ m 360us 100% 1113	${}^{148}_{69}Tm$	${}^{149}_{69}Tm$ 300ub	${}^{150}_{69}Tm$ (10mb) 10+ 5.2ms gs EC + P g.S 2.2s IT	${}^{151}_{69}Tm$(γ) 10 mb	${}^{152}_{69}Tm$	${}^{153}_{69}Tm$ g 1.48s 91% 5103	${}^{154}_{69}Tm$ m 3.3s 58% 5031
68	${}^{146}_{68}Er$	${}^{147}_{68}Er$	${}^{148}_{68}Er$	${}^{149}_{68}Er$ 4.8us 3mb	${}^{150}_{68}Er$(γ) 50 mb	${}^{151}_{68}Er$	${}^{152}_{68}Er$ g 10.3s 91% 4804.3	${}^{153}_{68}Er$ g 37.1s 53% 4674
67	${}^{145}_{67}Ho$	${}^{146}_{67}Ho$	${}^{147}_{67}Ho$	${}^{148}_{67}Ho$	${}^{149}_{67}Ho$	${}^{150}_{67}Ho$	${}^{151}_{67}Ho$ g 35.2s 22% 4522 m 47.2s 80% 4611	${}^{152}_{67}Ho$ g 83.8s 0.064 4232
66	${}^{144}_{66}Dy$	${}^{145}_{66}Dy$	${}^{146}_{66}Dy$	${}^{147}_{66}Dy$	${}^{148}_{66}Dy$	${}^{149}_{66}Dy$	${}^{150}_{66}Dy$ g 7.17min 33.6% 4232	${}^{151}_{66}Dy$ g 17.9min 5.6% 4069

^{151,152}Yb

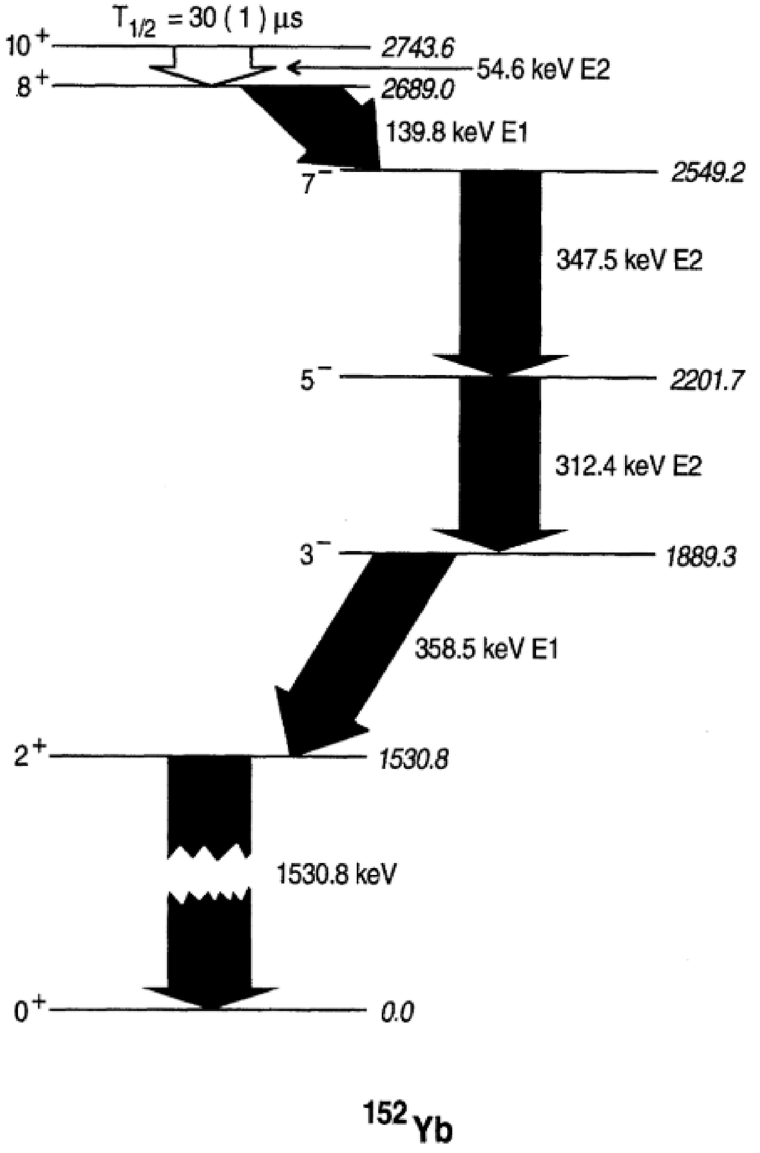


20(1)μs
(27/2⁻)
(23/2⁻)
600
226
172
202
2.6(7)μs
57
203
259
(15/2⁻)
1531
1.6 s
(11/2⁻)
151 70 Yb 81

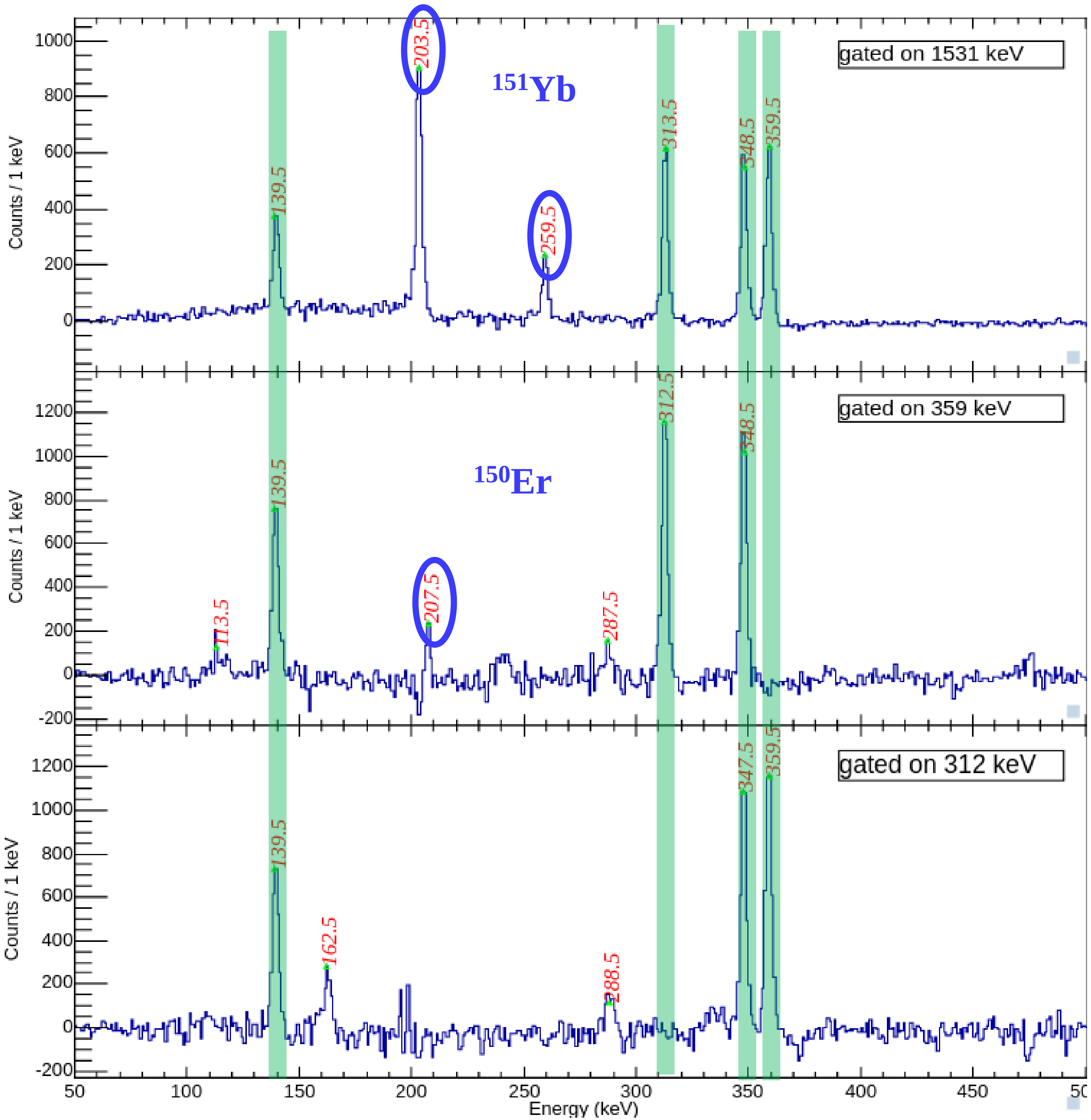


T1/2 = 30 (1) μs
10+ 2743.6
54.6 keV E2
8+ 2689.0
139.8 keV E1
7⁻ 2549.2
347.5 keV E2
5⁻ 2201.7
312.4 keV E2
3⁻ 1889.3
358.5 keV E1
2+ 1530.8
1530.8 keV
0+ 0.0
152 Yb

^{152}Yb

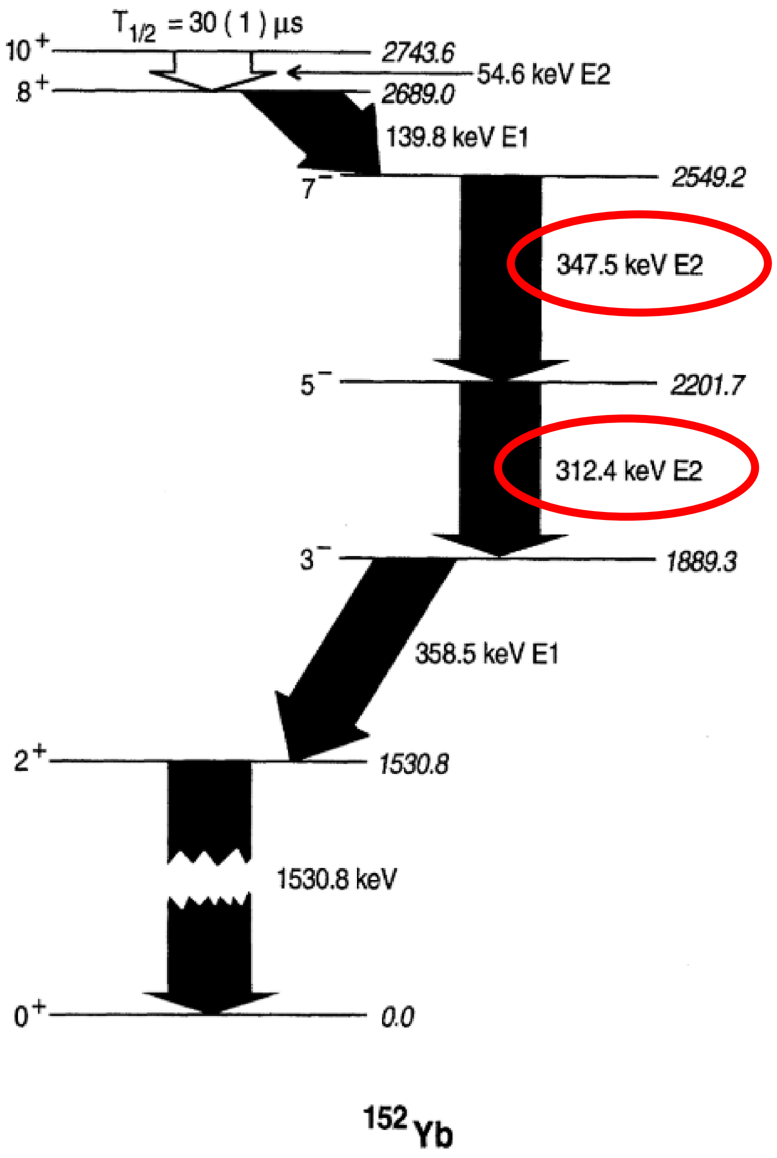


$T_{1/2}$ = 30 (1) µs
10+
2743.6
54.6 keV E2
8+
2689.0
139.8 keV E1
7−
2549.2
347.5 keV E2
5−
2201.7
312.4 keV E2
3−
1889.3
358.5 keV E1
2+
1530.8
1530.8 keV
0+
0.0
152Yb

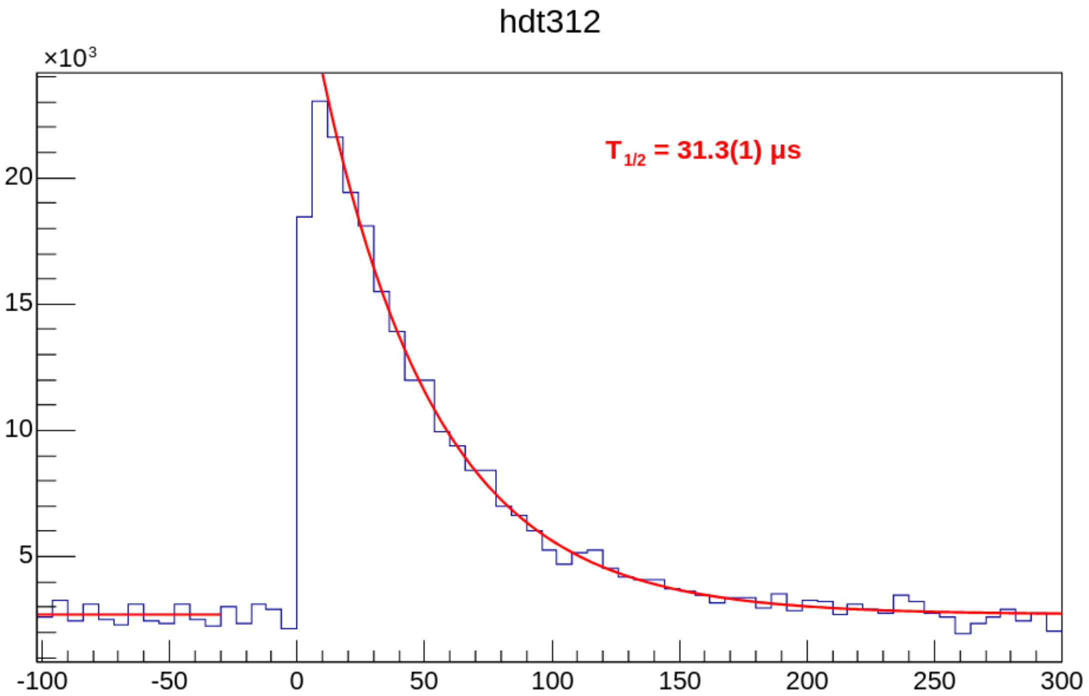


gated on 1531 keV
151Yb
gated on 359 keV
150Er
gated on 312 keV
Counts / 1 keV
Energy (keV)
139.5
203.5
259.5
313.5
348.5
359.5
113.5
207.5
287.5
312.5
162.5
288.5
347.5

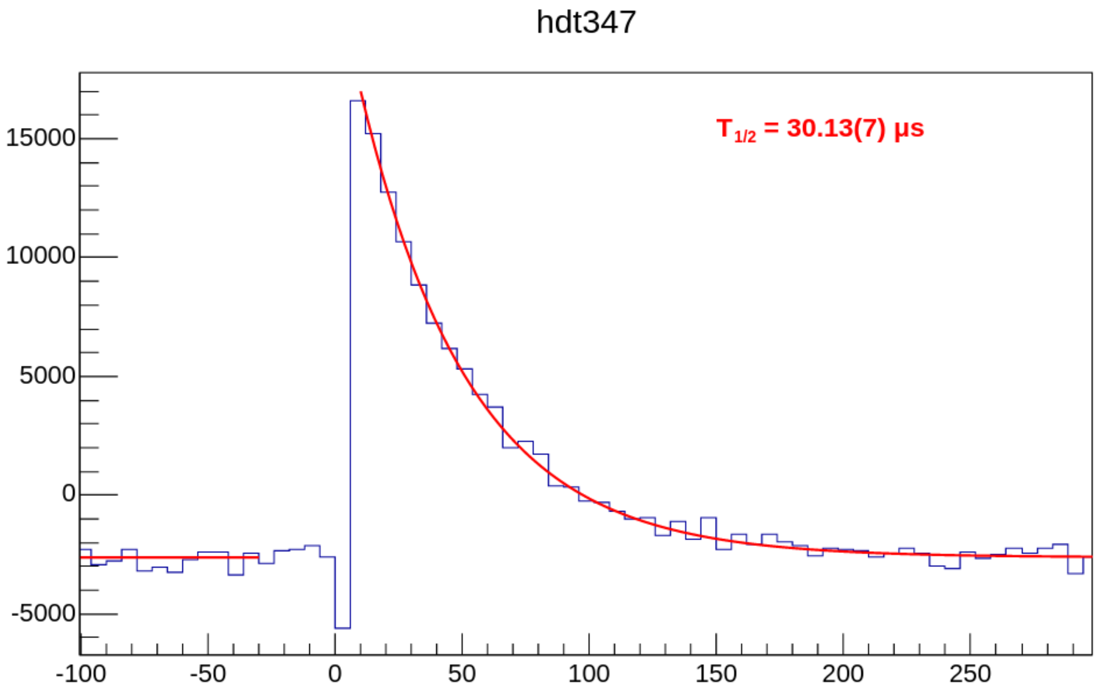
^{152}Yb



T1/2 = 30 (1) µs
10+
2743.6
54.6 keV E2
8+
2689.0
139.8 keV E1
7−
2549.2
347.5 keV E2
5−
2201.7
312.4 keV E2
3−
1889.3
358.5 keV E1
2+
1530.8
1530.8 keV
0+
0.0
152Yb

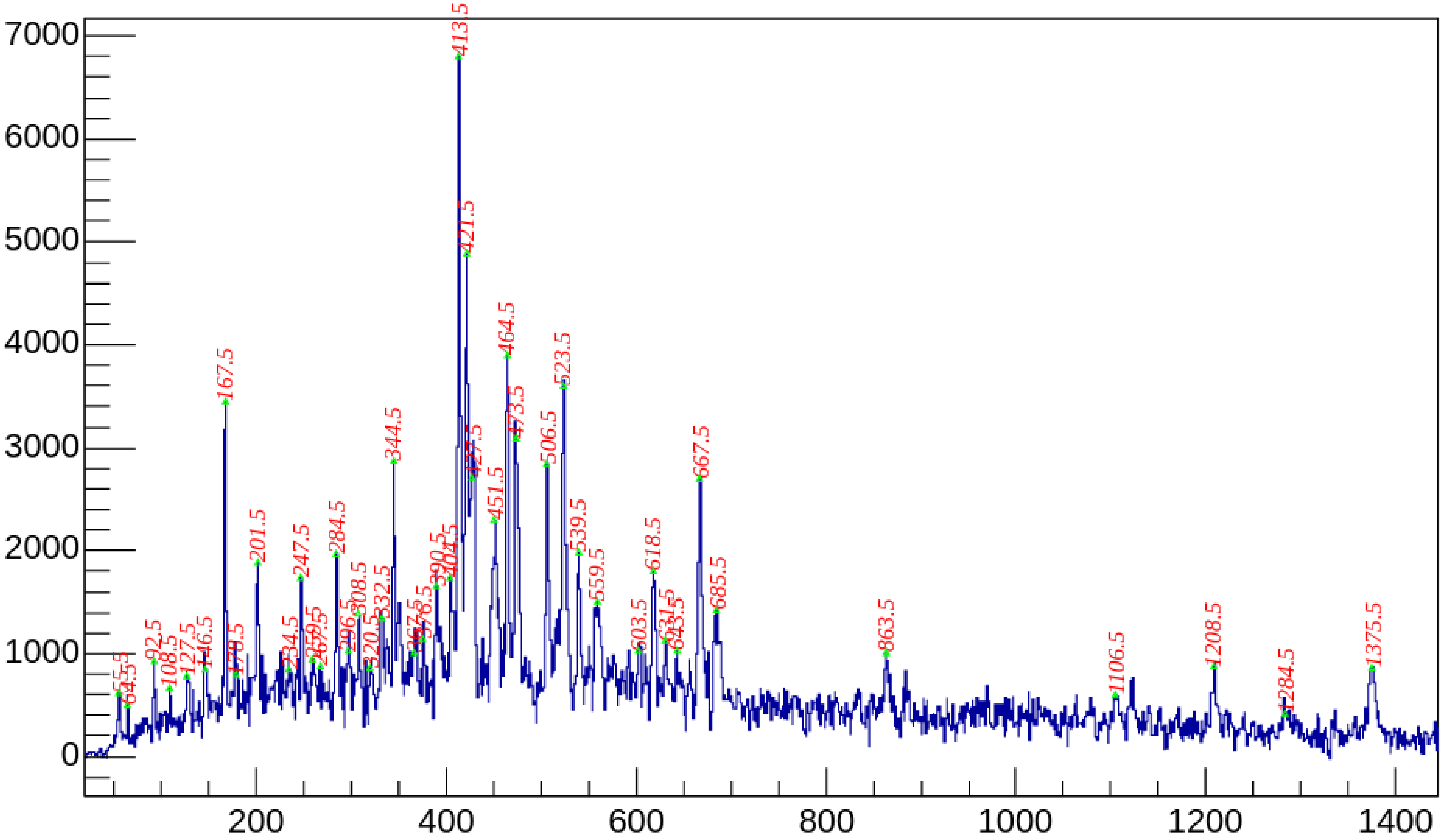


hdt312
×10³
T1/2 = 31.3(1) µs
20
15
10
5
-100
-50
0
50
100
150
200
250
300



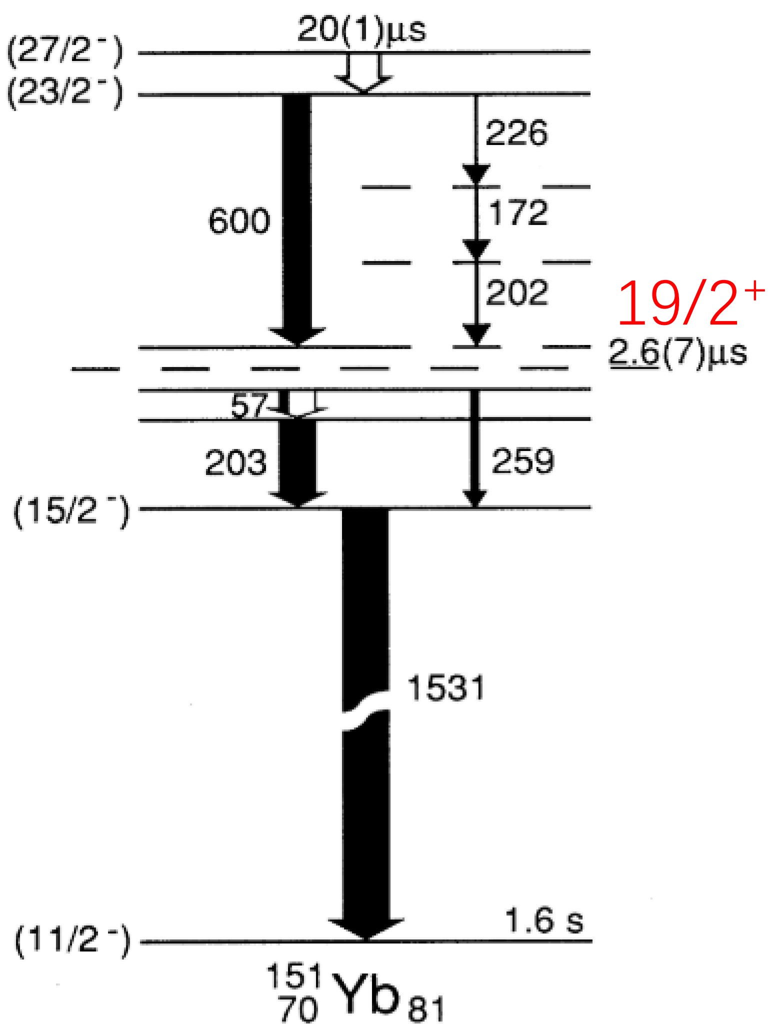
hdt347
T1/2 = 30.13(7) µs
15000
10000
5000
0
-5000
-100
-50
0
50
100
150
200
250

^{152}Yb(IDT)

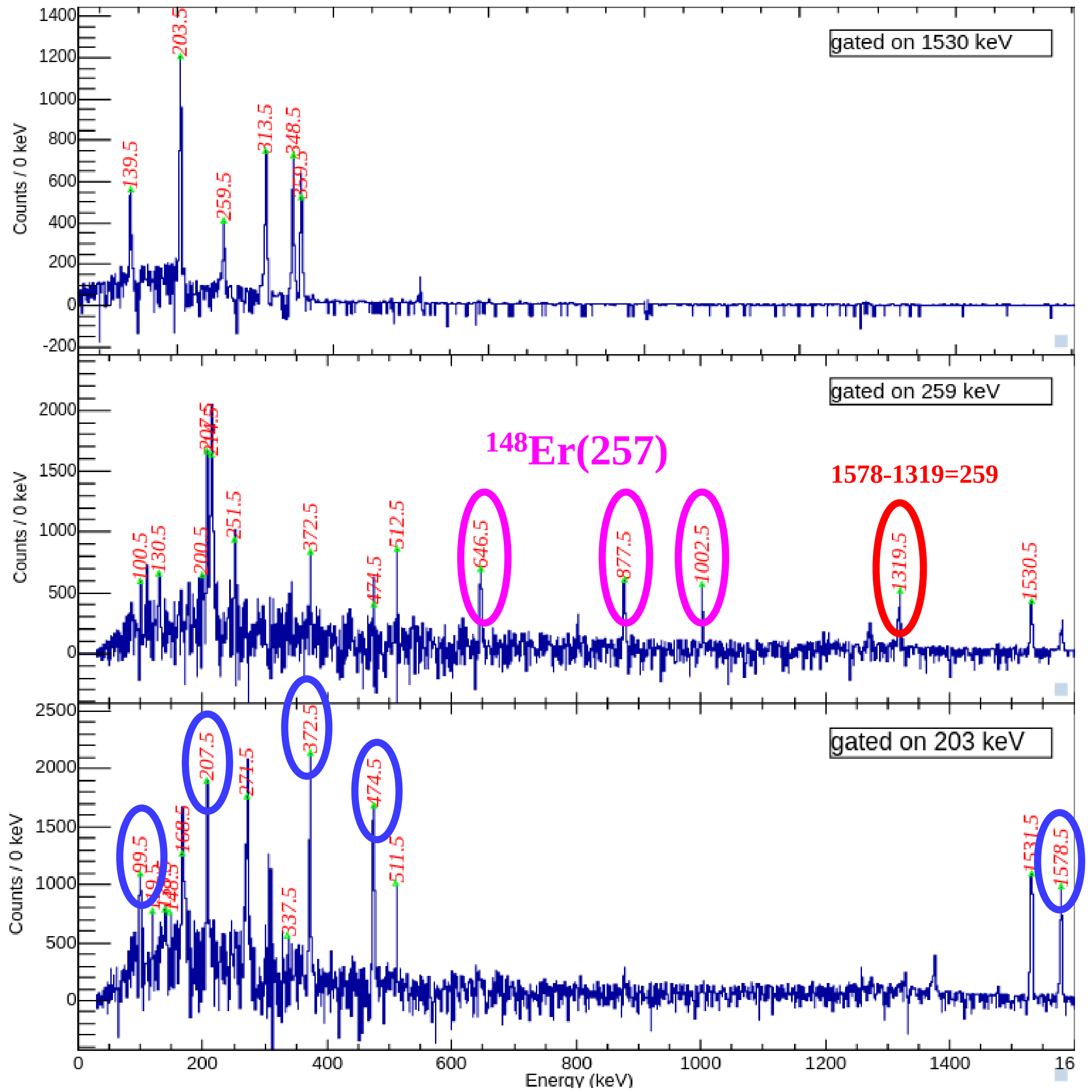


7000
6000
5000
4000
3000
2000
1000
0
200
400
600
800
1000
1200
1400
413.5
421.5
464.5
523.5
473.5
167.5
344.5
506.5
427.5
667.5
451.5
201.5
247.5
284.5
539.5
618.5
685.5
559.5
308.5
332.5
863.5
1106.5
1208.5
1284.5
1375.5

^{151}Yb

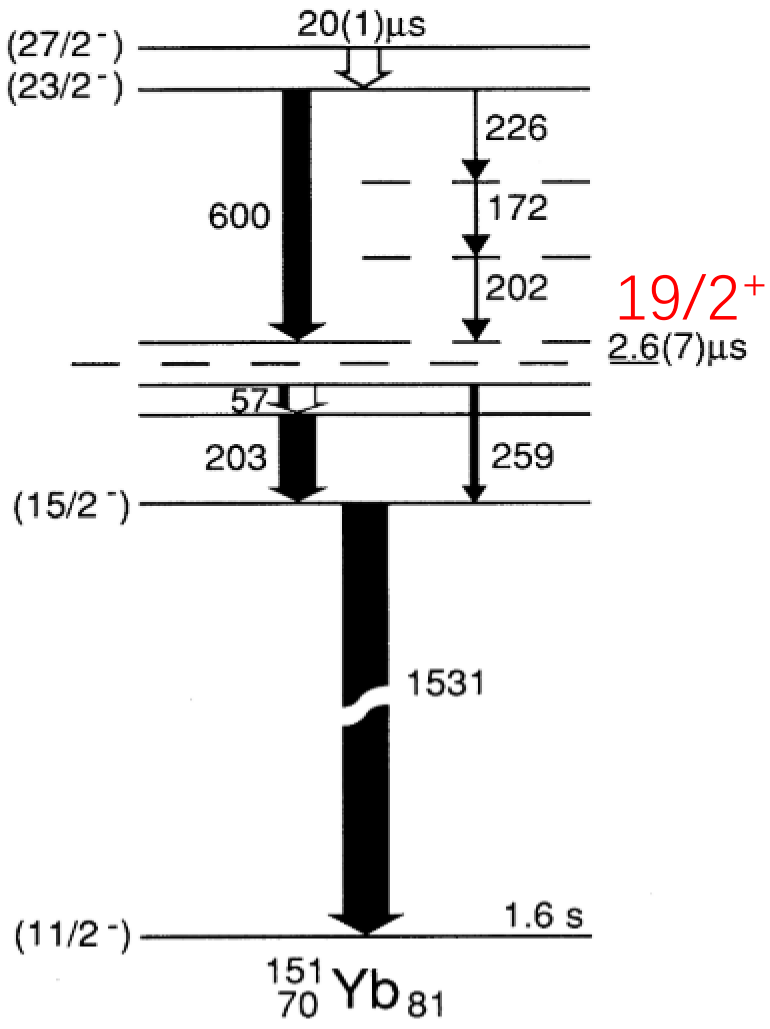


20(1)µs
(27/2⁻)
(23/2⁻)
226
600
172
202
19/2⁺
2.6(7)µs
57
203
259
(15/2⁻)
1531
1.6 s
(11/2⁻)
$^{151}_{70}$Yb$_{81}$

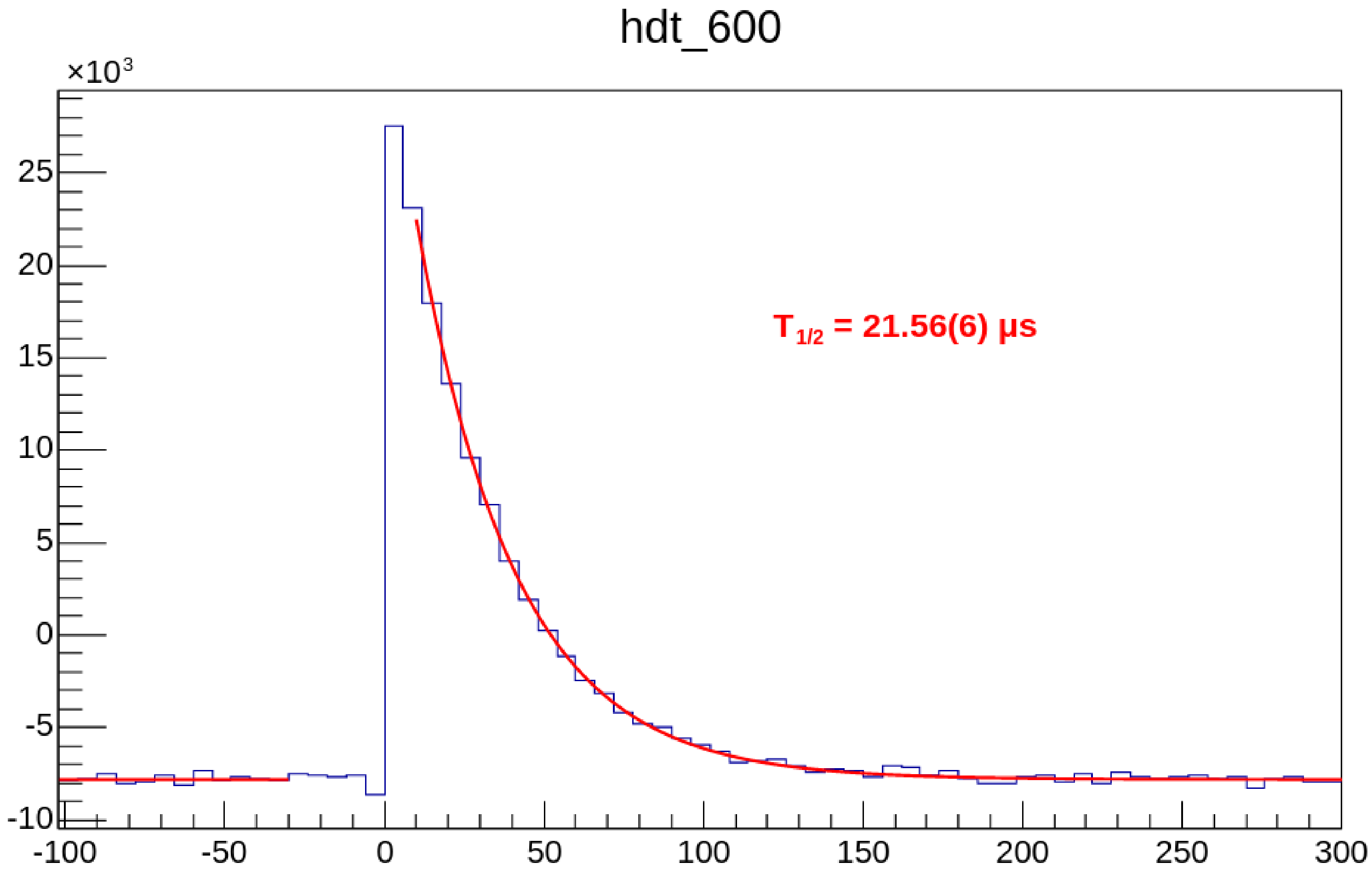


gated on 1530 keV
gated on 259 keV
gated on 203 keV
^{148}Er(257)
1578-1319=259
Counts / 0 keV
Energy (keV)

^{151}Yb

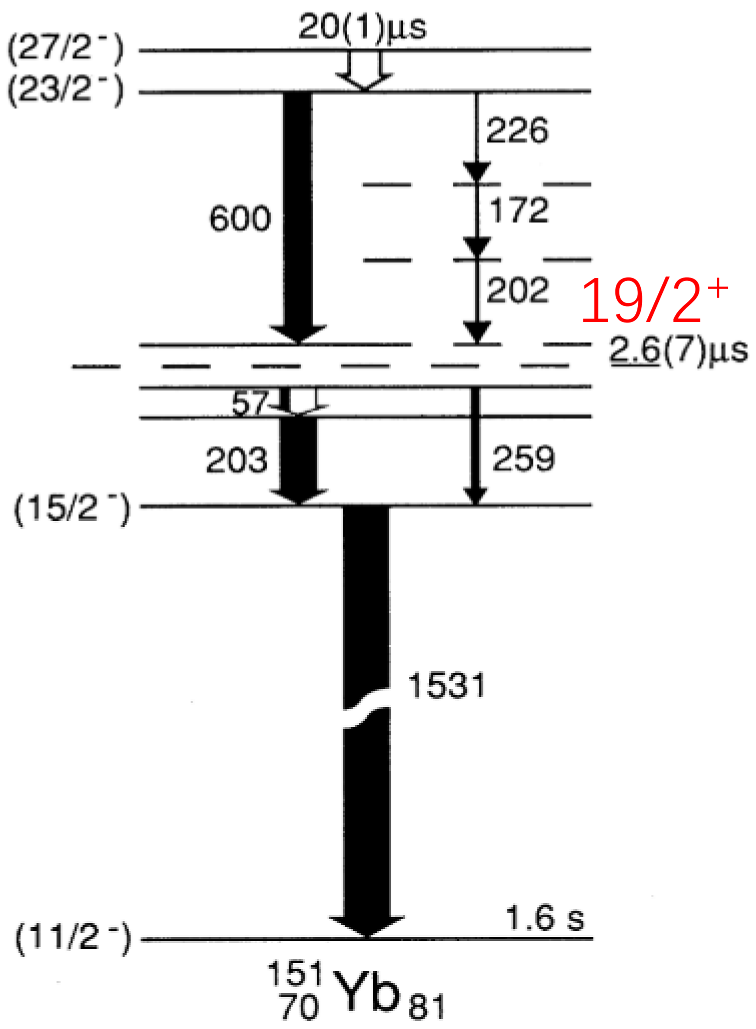


(27/2⁻)
(23/2⁻)
20(1)μs
226
600
172
202
19/2+
2.6(7)μs
57
203
259
(15/2⁻)
1531
1.6 s
(11/2⁻)
151 70 Yb 81

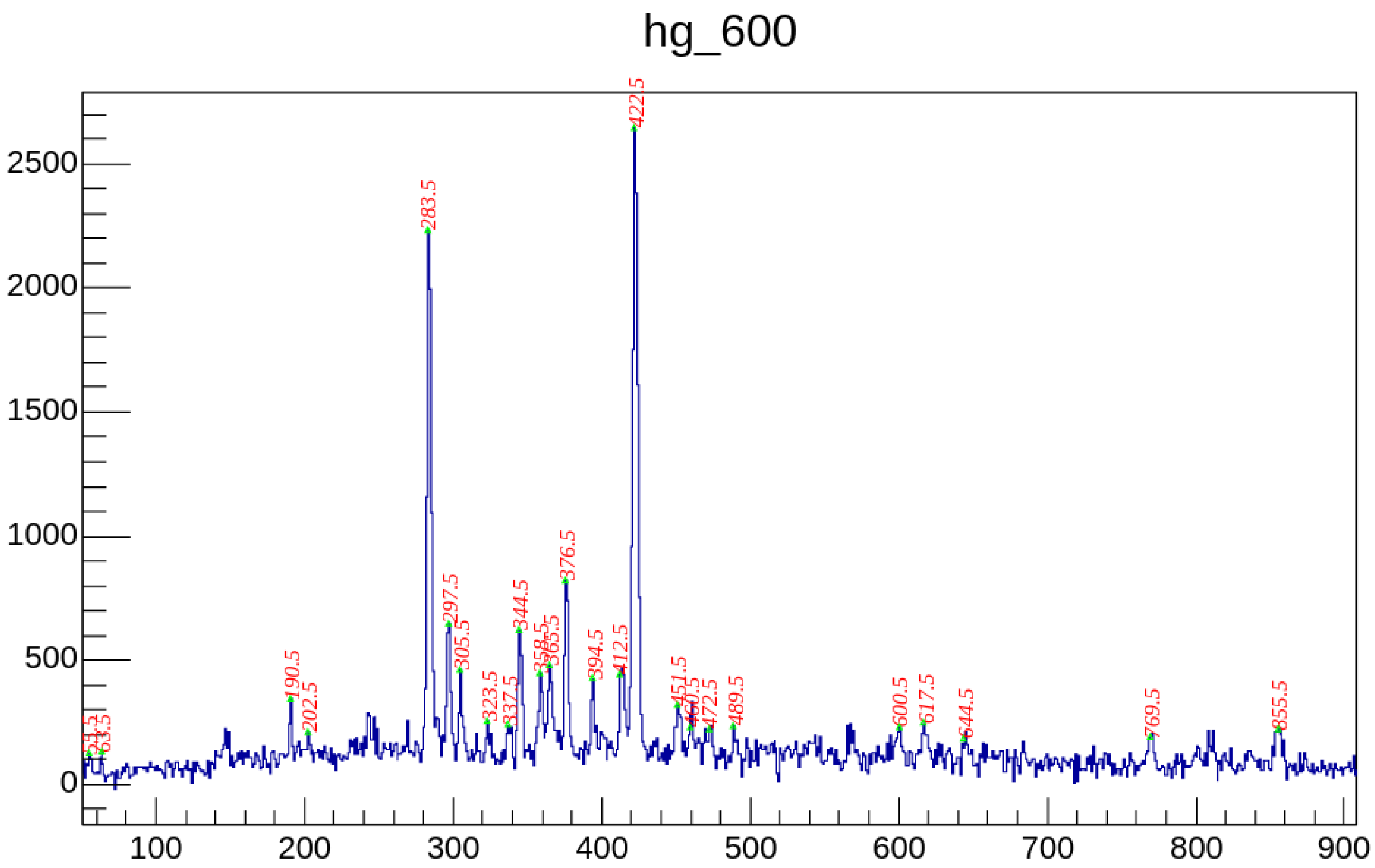


hdt_600
×10³
T1/2 = 21.56(6) μs
25
20
15
10
5
0
-5
-10
-100
-50
0
50
100
150
200
250
300

^{151}Yb



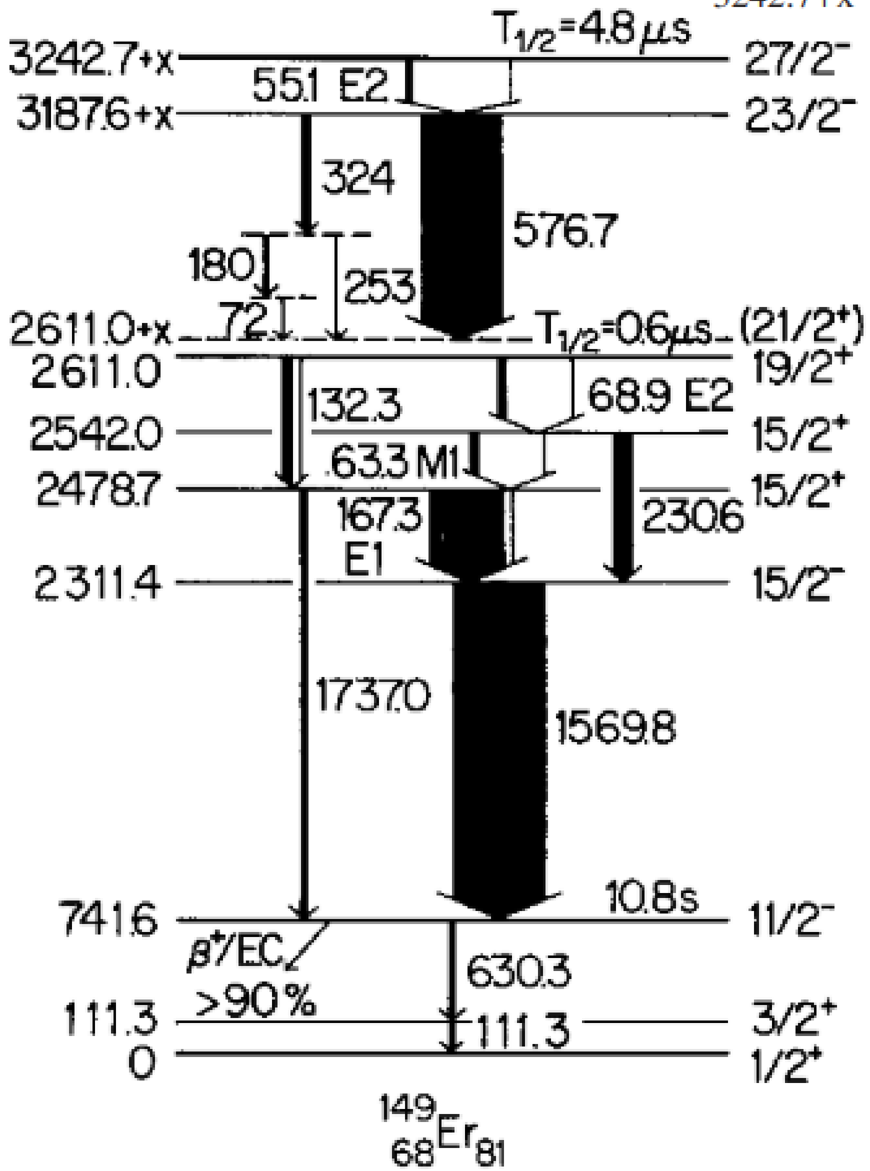
20(1)μs
(27/2⁻)
(23/2⁻)
226
172
600
202
19/2+
2.6(7)μs
57
203
259
(15/2⁻)
1531
1.6 s
(11/2⁻)
151 70 Yb 81

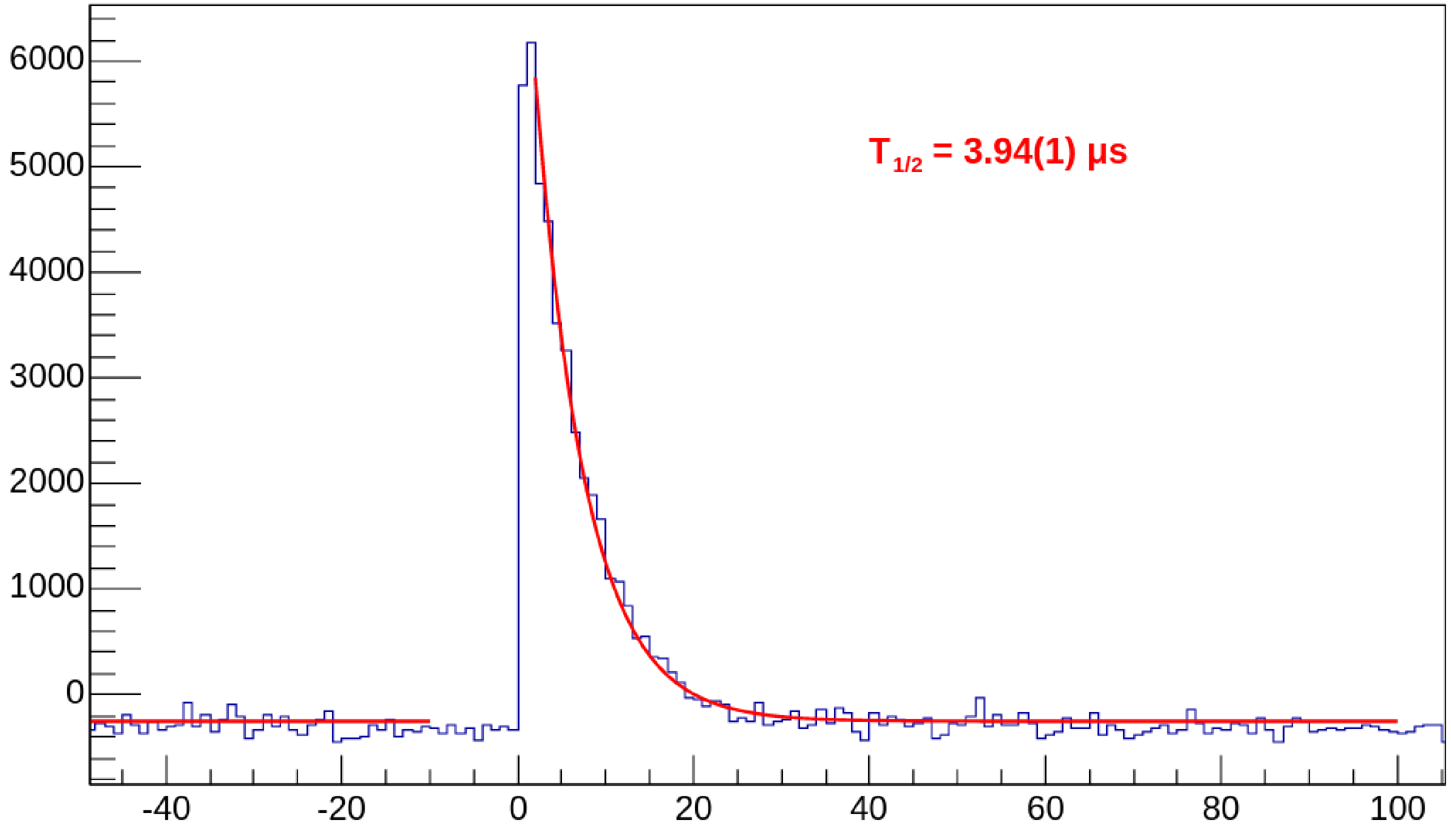


hg_600
422.5
283.5
376.5
297.5
344.5
305.5
358.5
365.5
394.5
412.5
190.5
202.5
323.5
337.5
451.5
460.5
472.5
489.5
600.5
617.5
644.5
769.5
855.5
2500
2000
1500
1000
500
0
100
200
300
400
500
600
700
800
900

^{149}Er

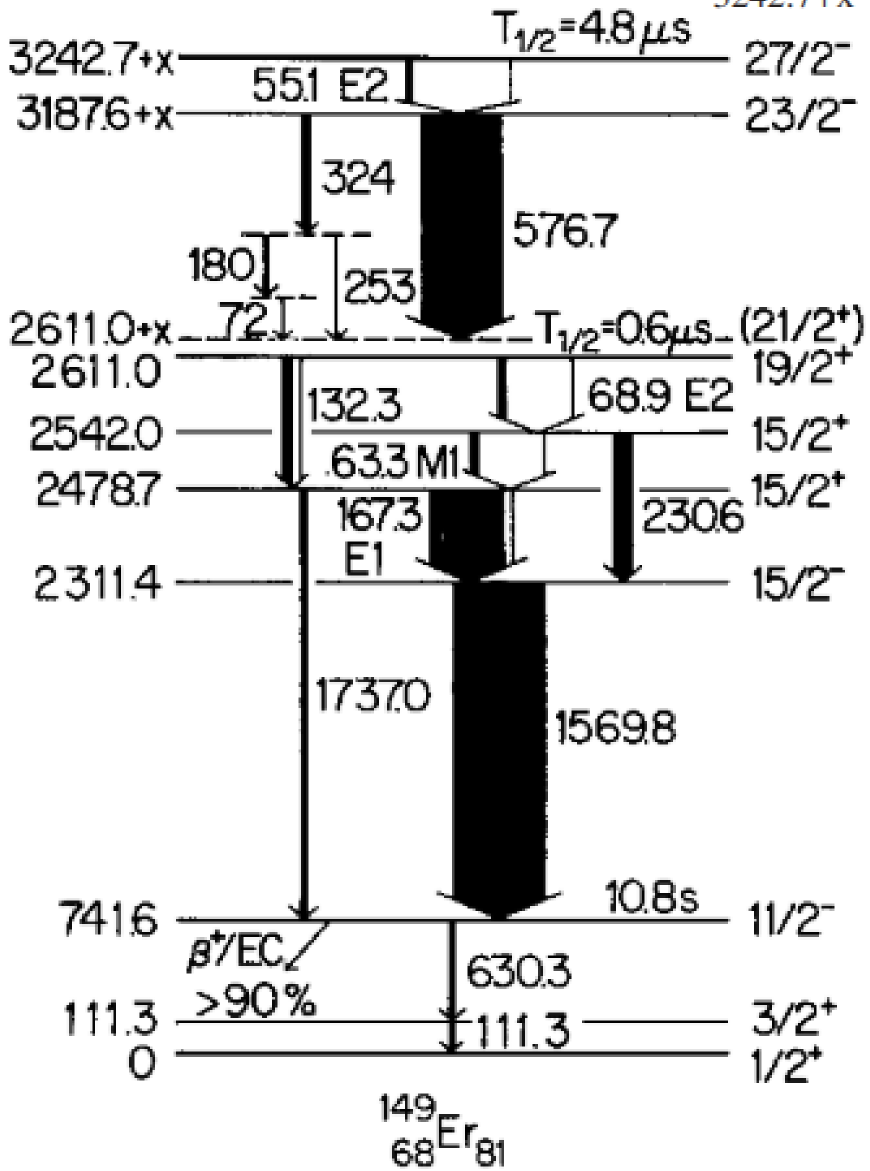
3242.7+x	(27/2$^-$)	4.8 μs *1*	$T_{1/2}$: from $\gamma\gamma$(t) 1987Br14. Others: 3.8 μs *3* (1984HoZN), 2.5 μs *9* (1982No07)

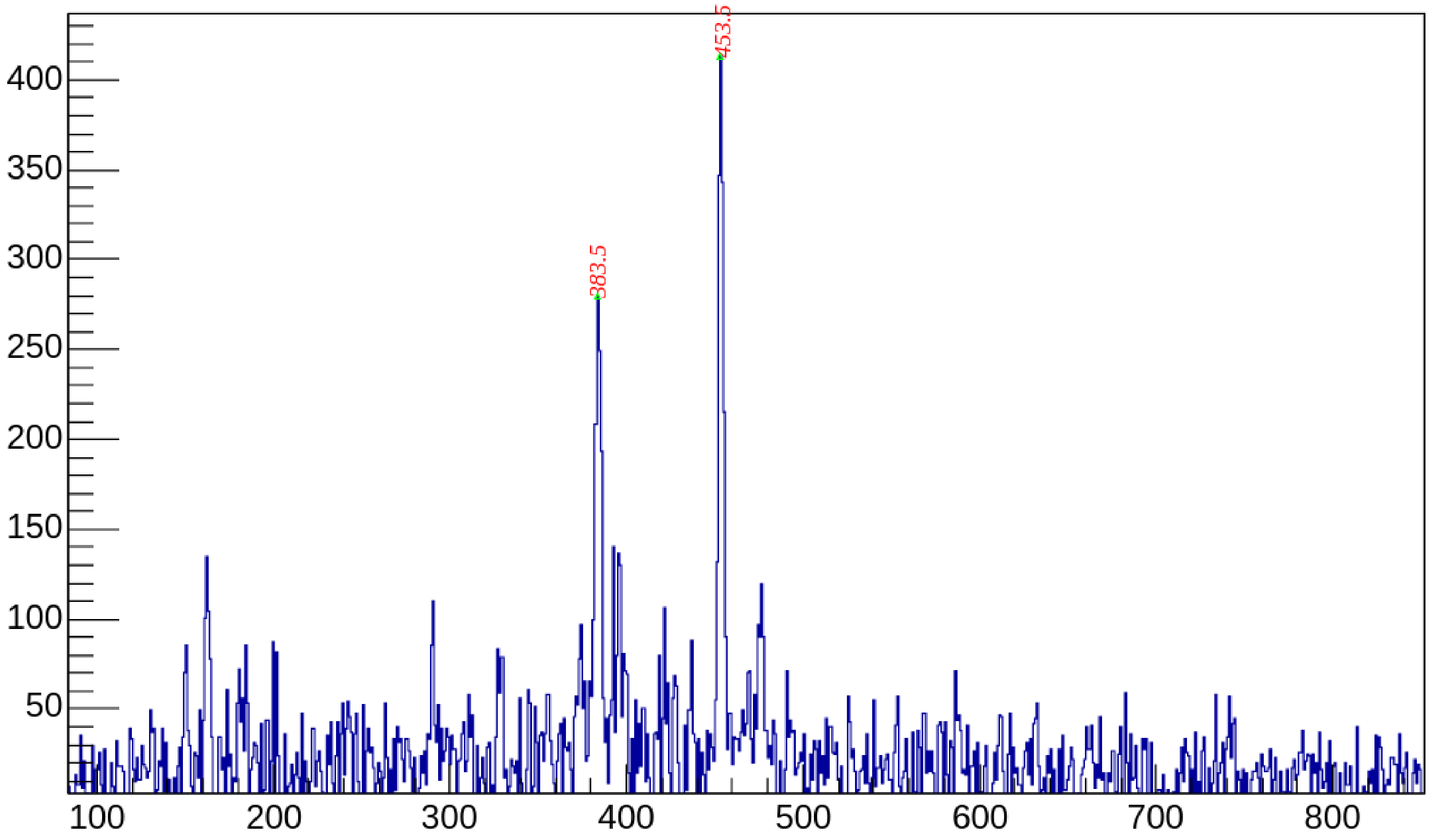




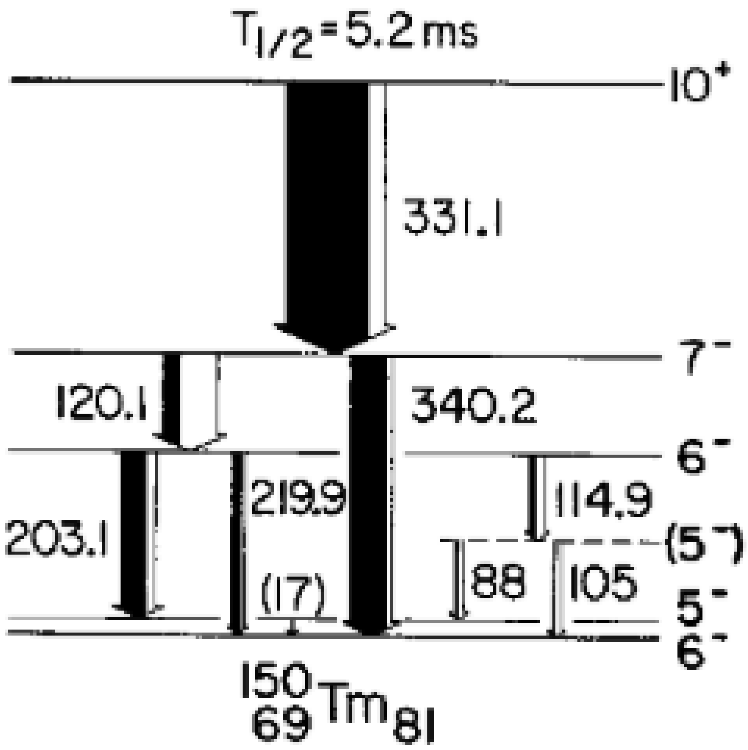
^{149}Er

3242.7+x (27/2$^-$) 4.8 μs *1* $T_{1/2}$: from $\gamma\gamma$(t) 1987Br14. Others: 3.8 μs *3* (1984HoZN), 2.5 μs *9* (1982No07)

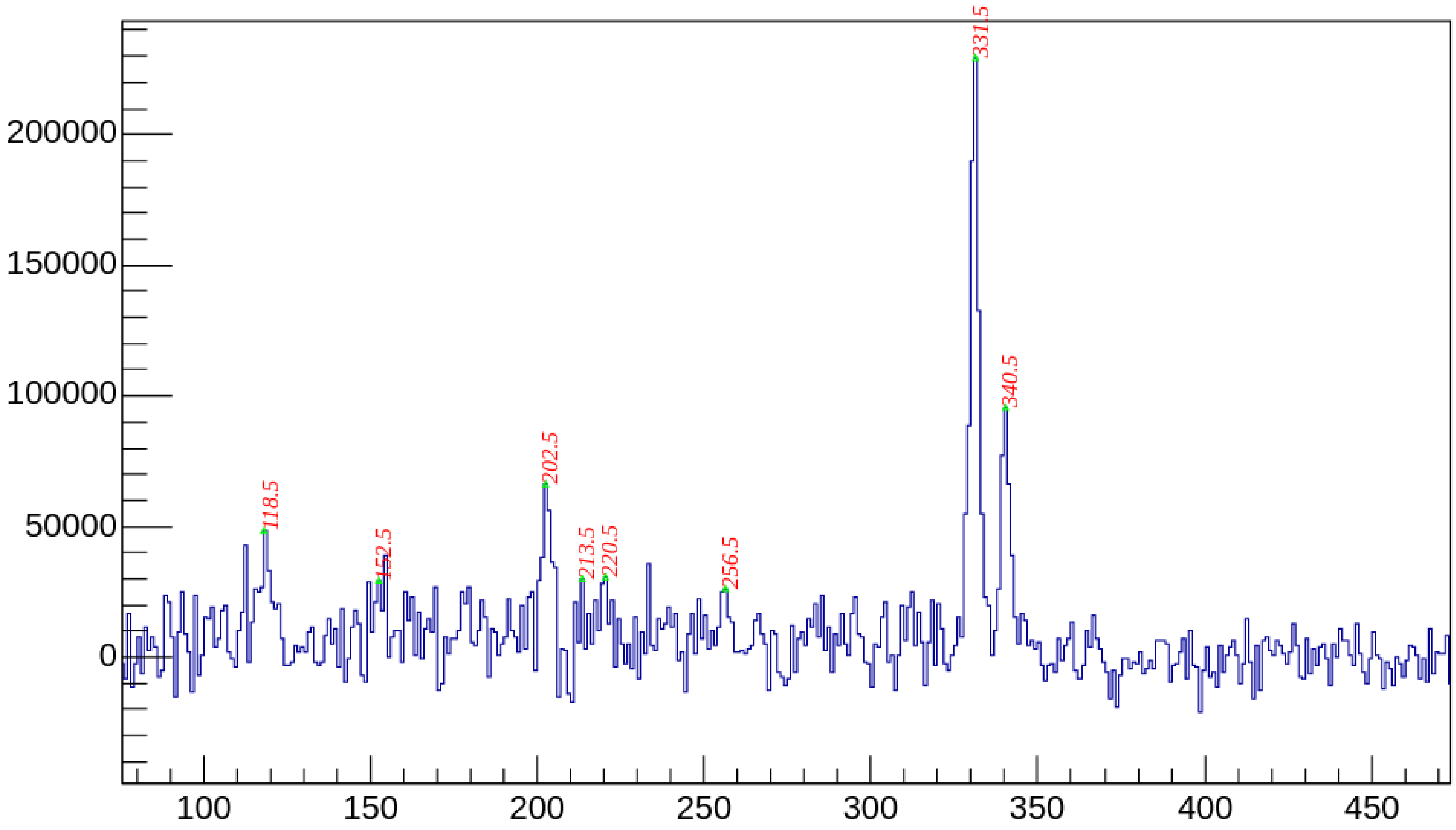




^{150}Tm

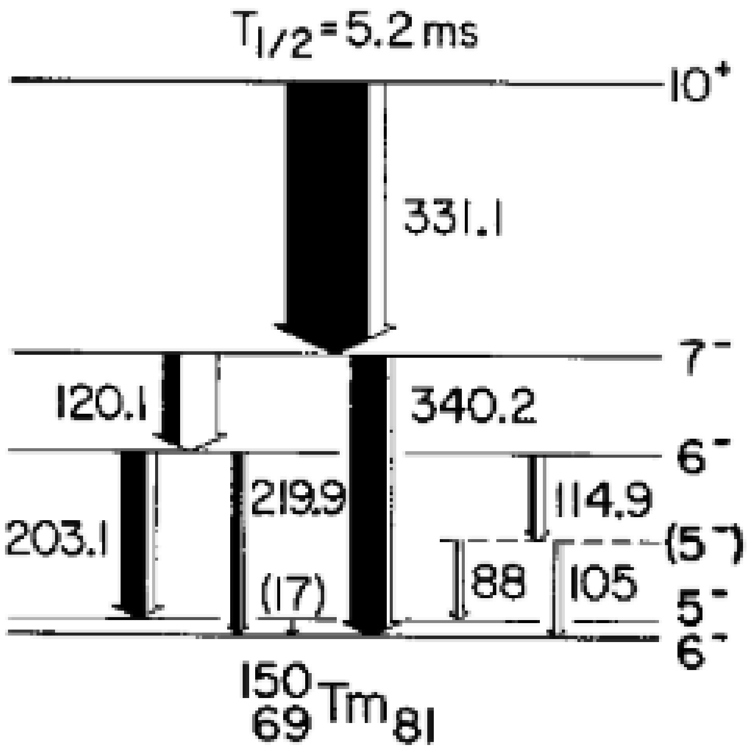


T1/2=5.2 ms
10+
331.1
7-
120.1
340.2
6-
203.1
219.9
114.9
(5-)
88
105
(17)
5-
6-
150 69 Tm 81

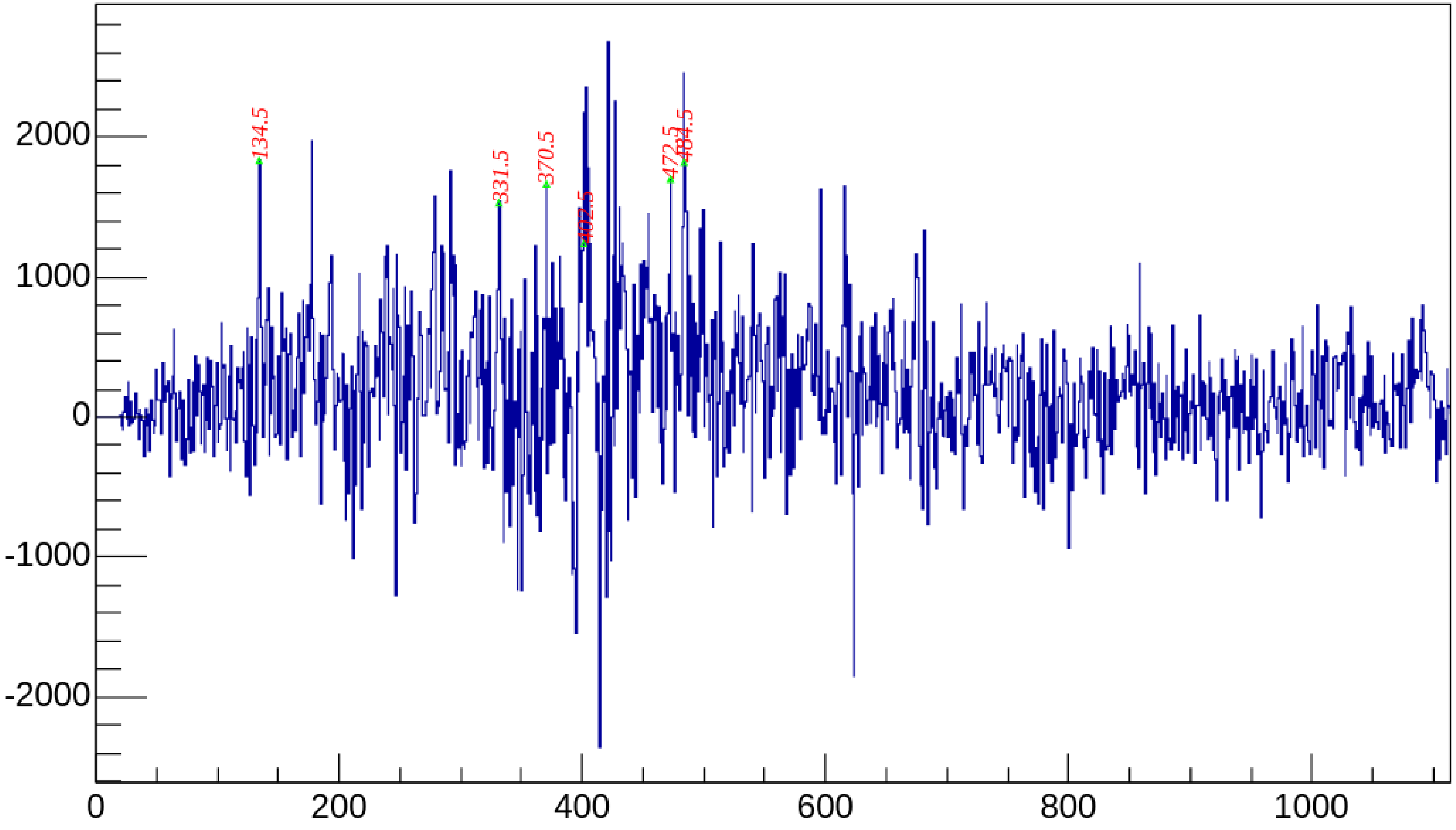


331.5
340.5
202.5
118.5
152.5
213.5
220.5
256.5
200000
150000
100000
50000
0
100
150
200
250
300
350
400
450

^{150}Tm



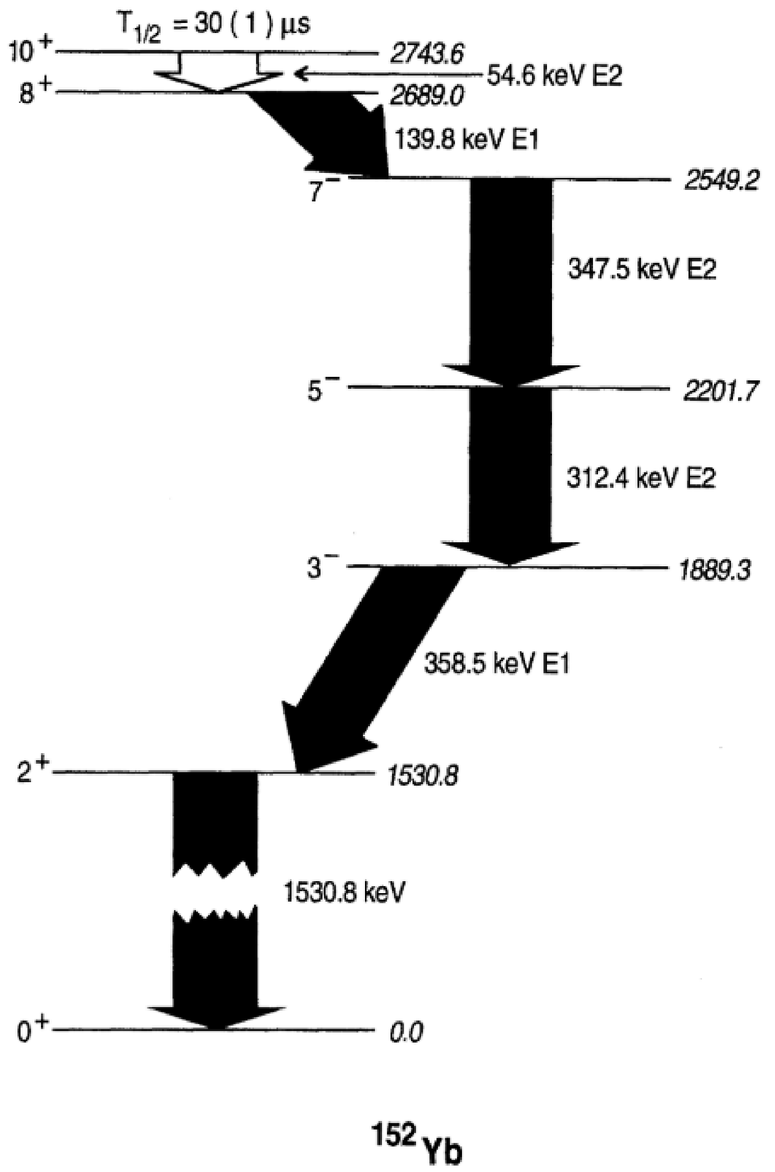
T1/2=5.2 ms
10+
331.1
7-
120.1
340.2
6-
203.1
219.9
114.9
(5-)
(17)
88
105
5-
6-
150 69 Tm 81

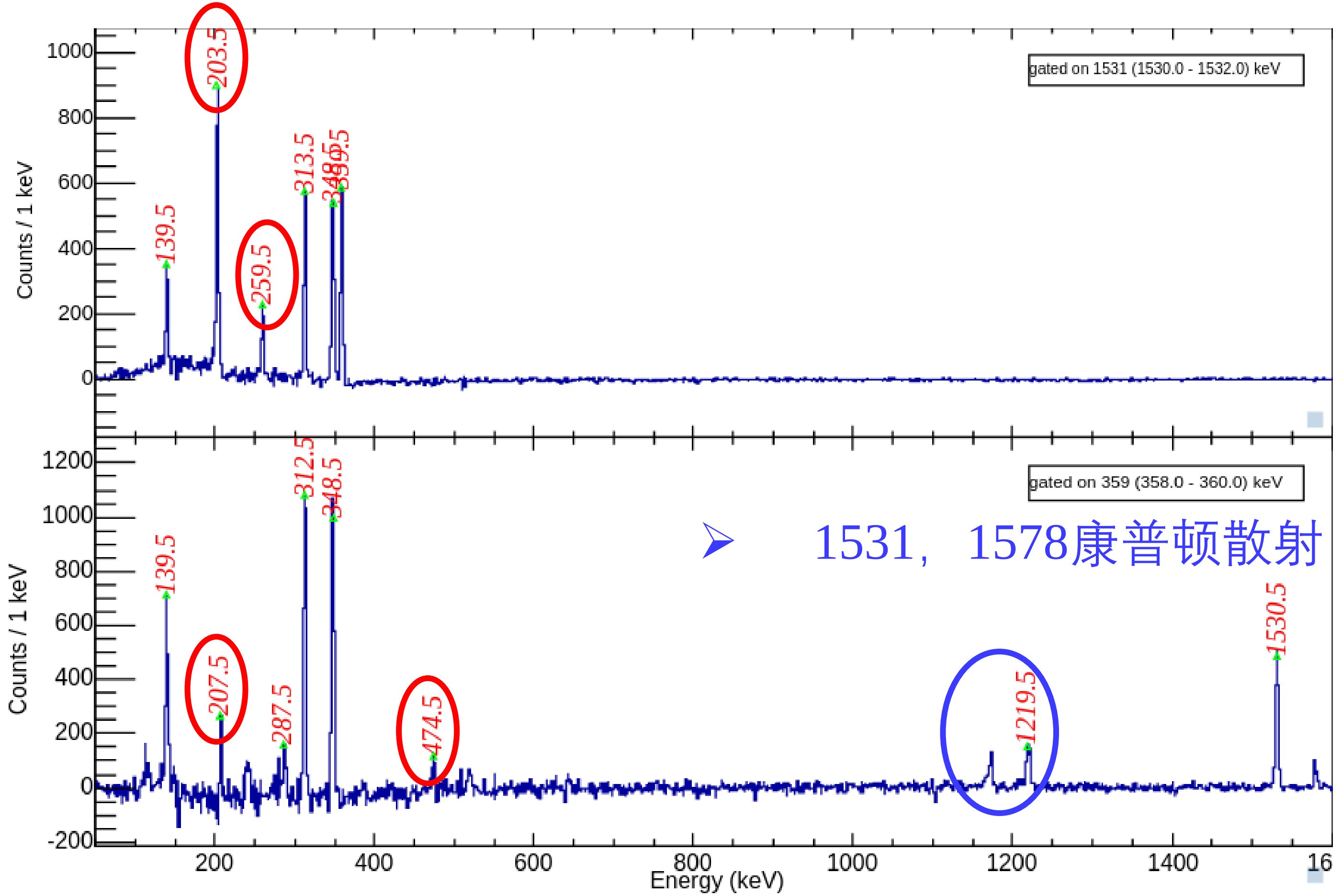


134.5
331.5
370.5
402.5
472.5
484.5
2000
1000
0
-1000
-2000
0
200
400
600
800
1000

^{152}Yb IDT

^{152}Yb:

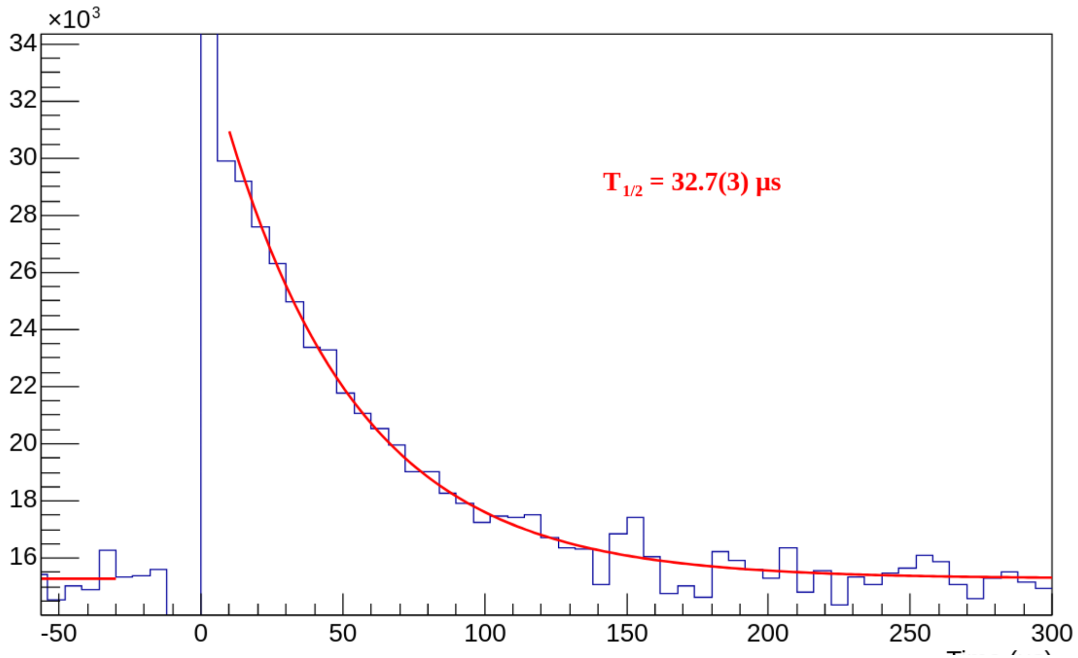




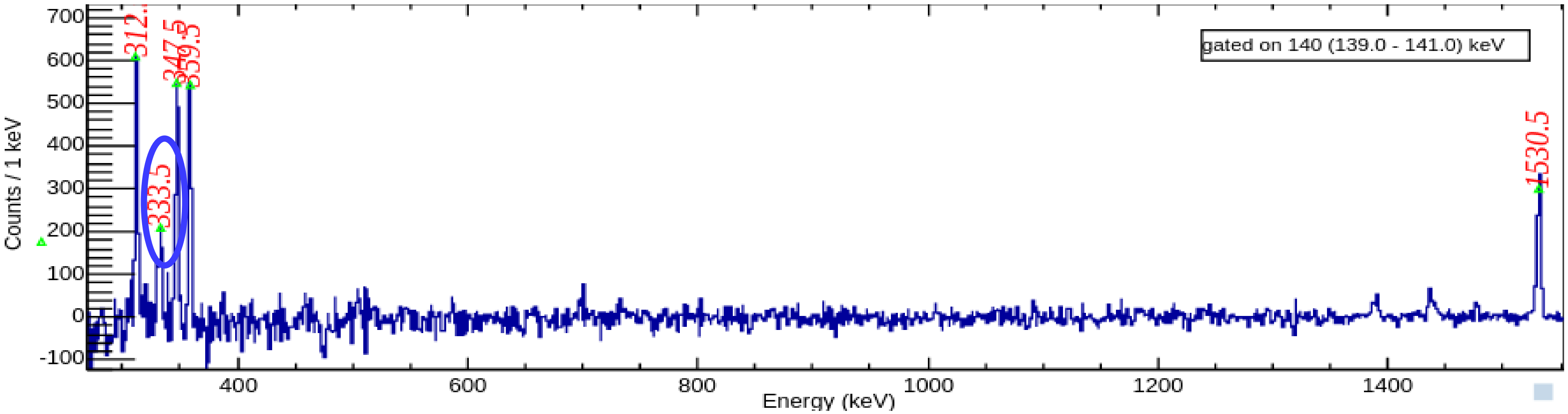
➢ 1531，1578康普顿散射

gate \ peaks	1531	359	312	347	140	55	other
1531	X	O	O	O	O	X	203, 259 (^{151}Yb)
359	O	X	O	O	O	X	207 (^{150}Er 360)
312	O	O	X	O	O	X	162?
347	O	O	O	x	O	X	No
140	O	O	O	O	X	X	No
55	X	X	X	X	X	x	No

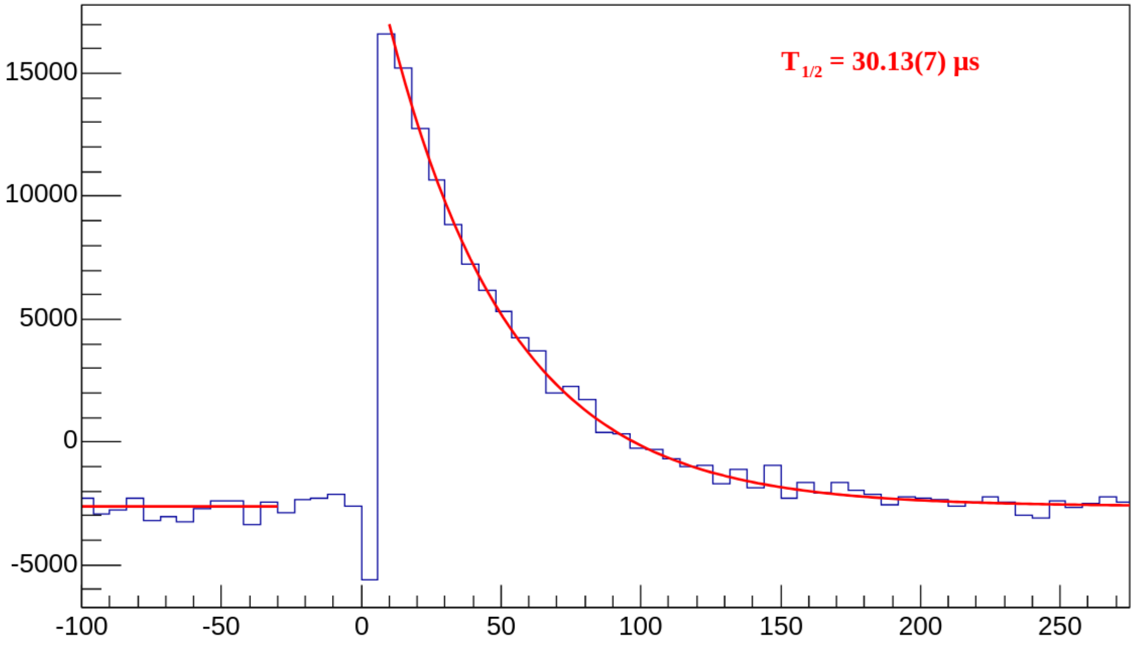
^{152}Yb (139 keV gate (140.4, ^{151}Tm, 0.45us)):



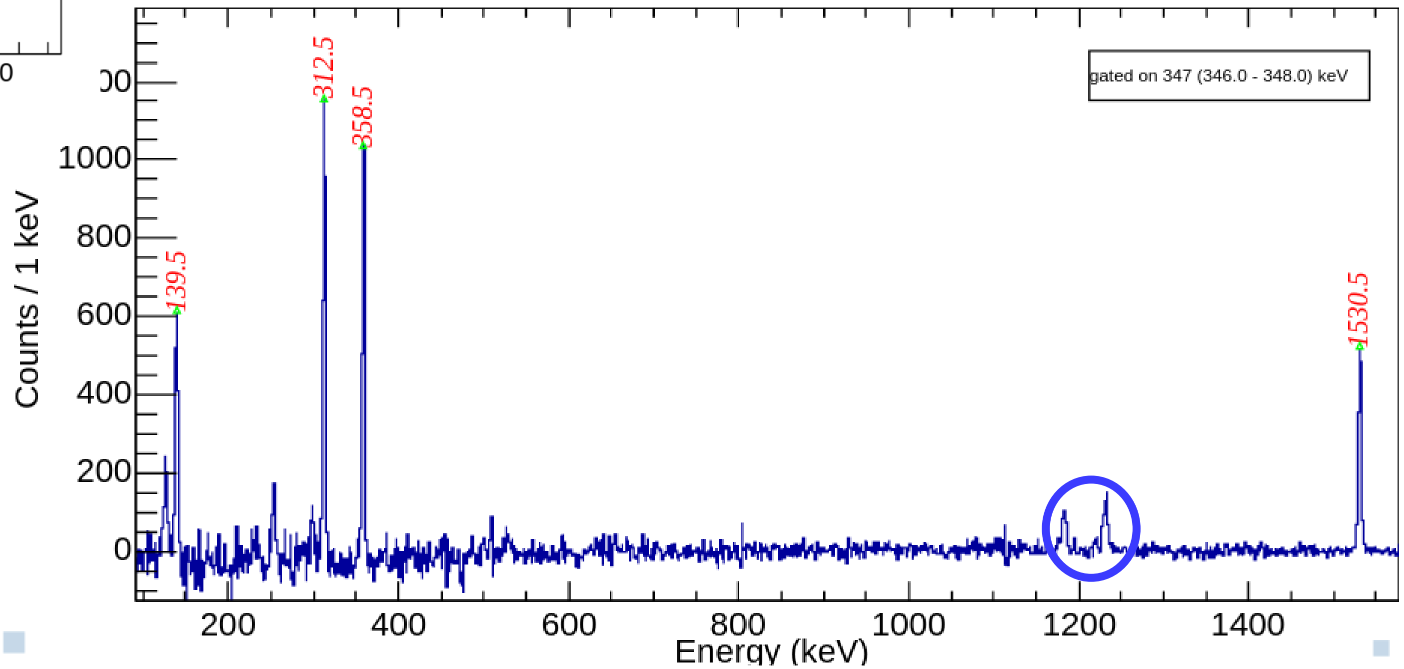
➢ 需要排除掉短寿命的140



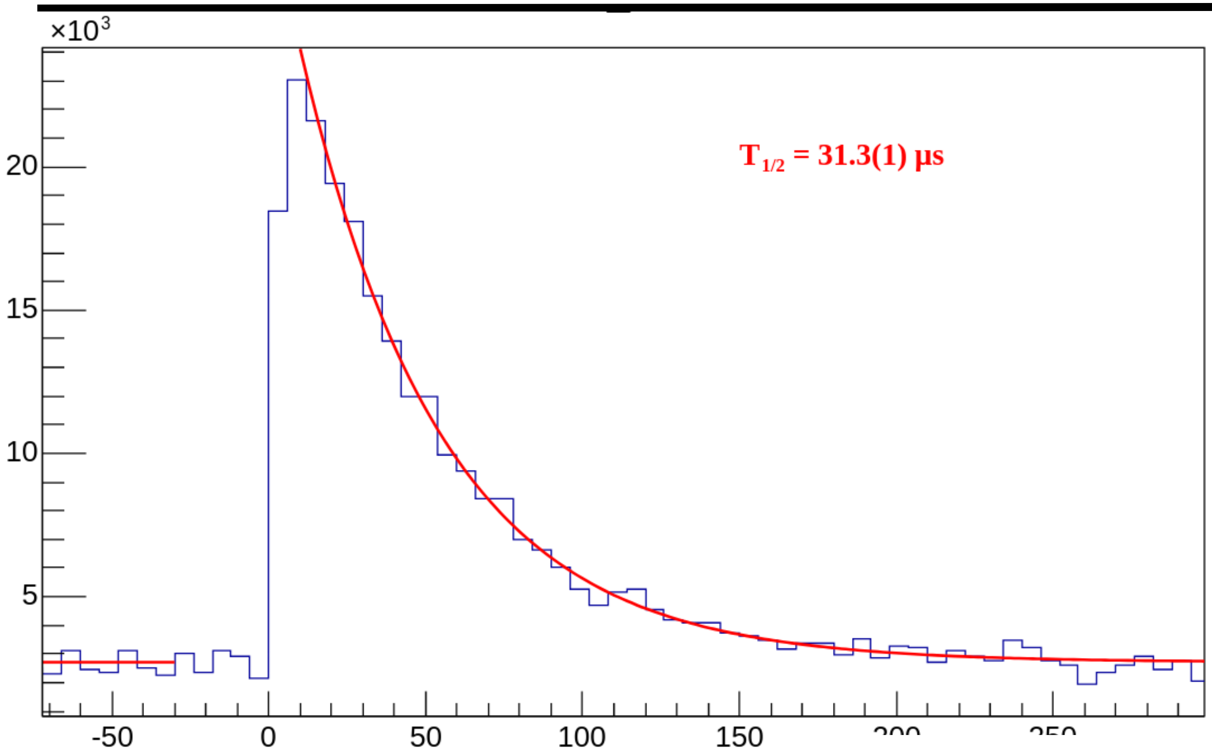
^{152}Yb (347 keV gate):



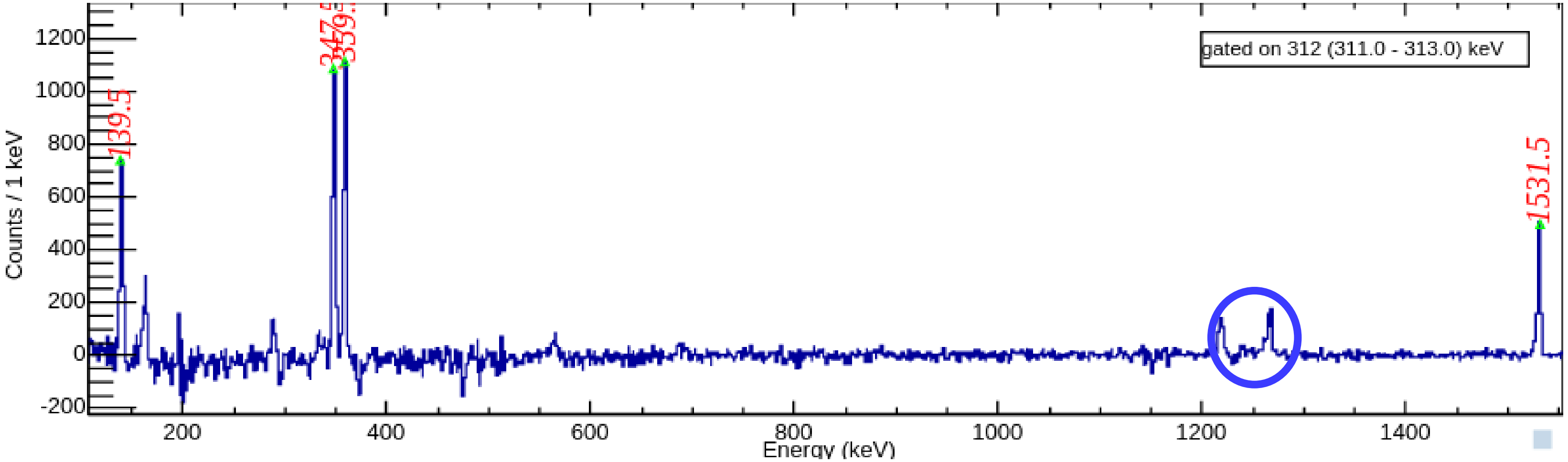
➤ 谱正常，可用于IDT



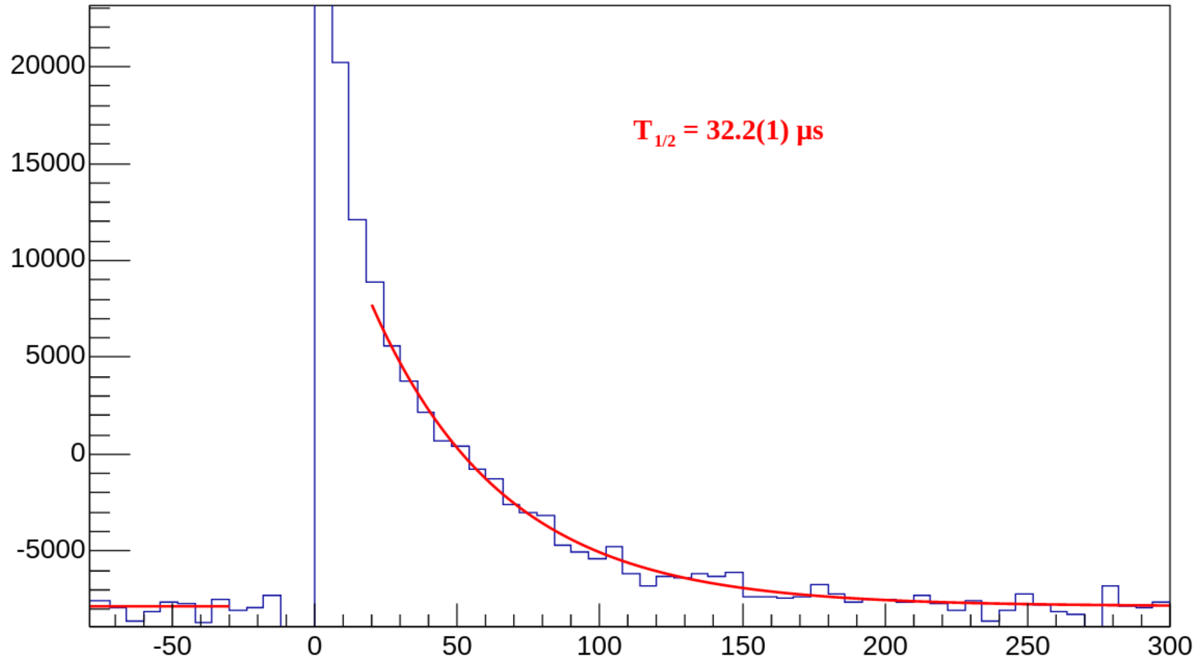
^{152}Yb (312 keV gate)：



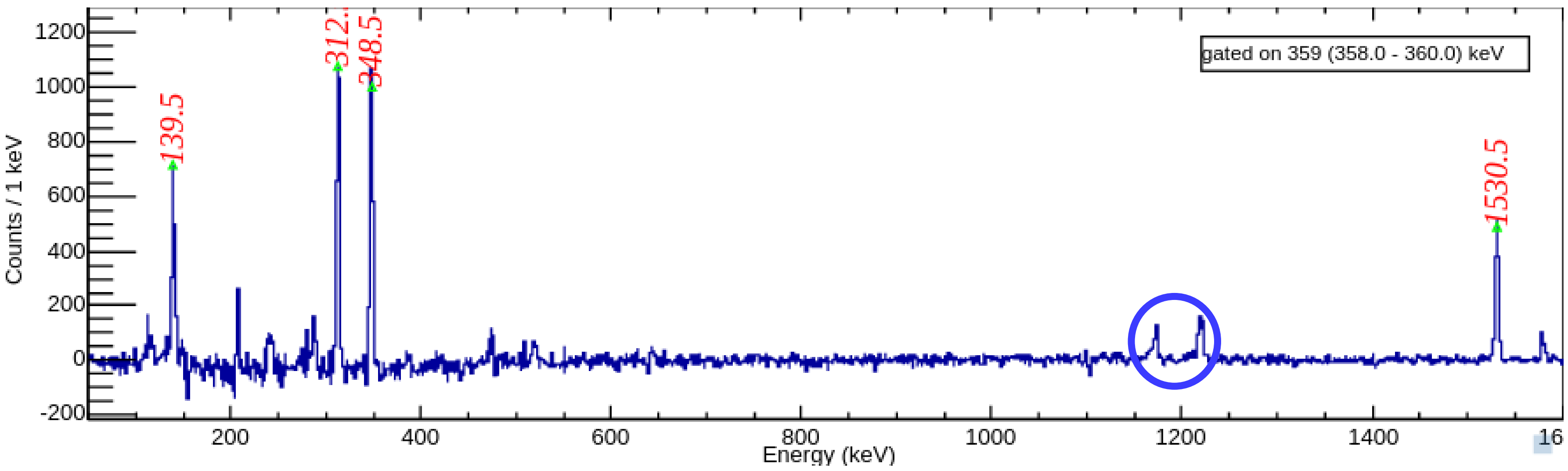
➤ 谱正常，可用于IDT



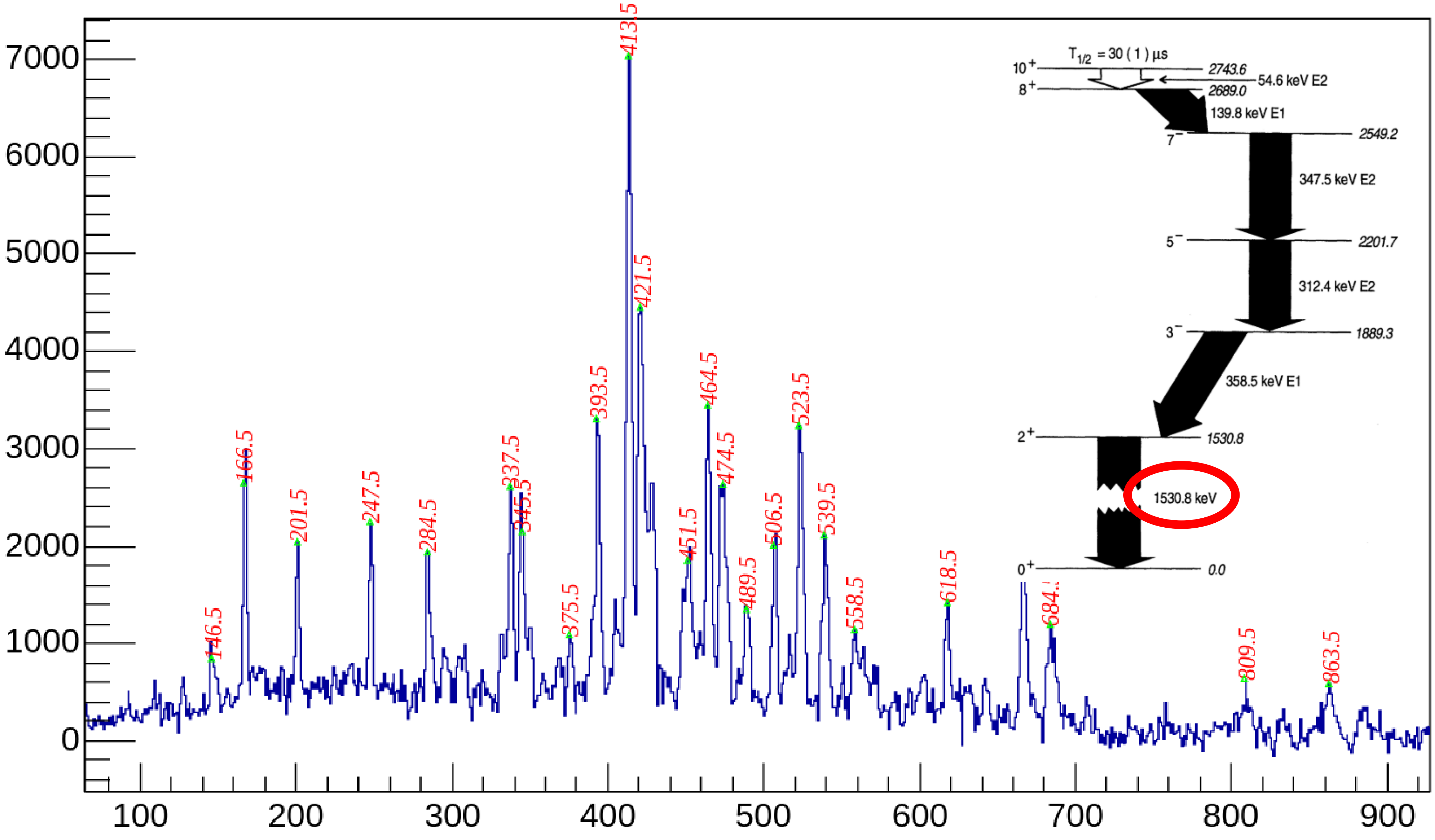
^{152}Yb (358 keV gate (360, ^{150}Er, 2.55us)):



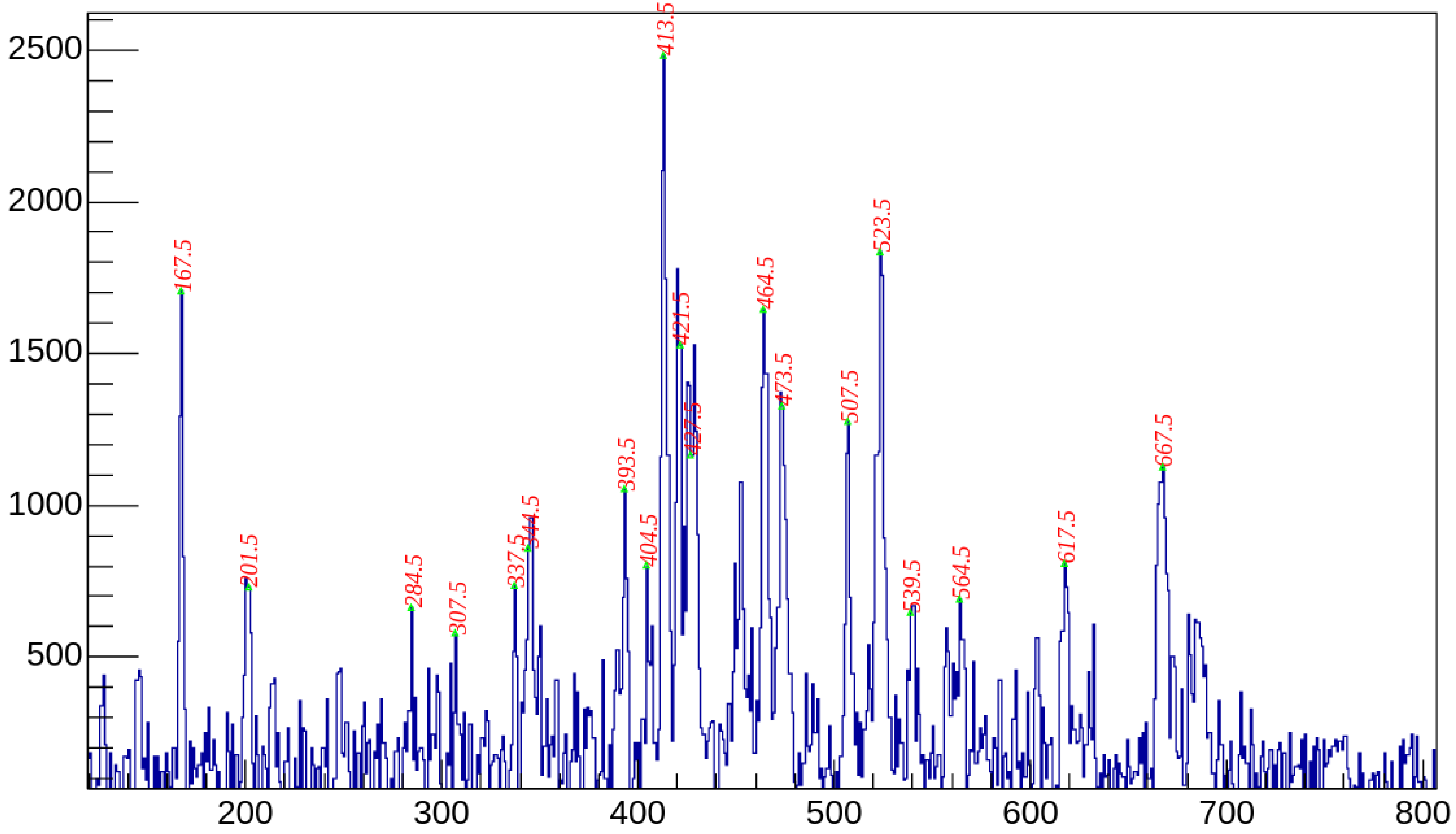
- 需要排除掉短寿命的360



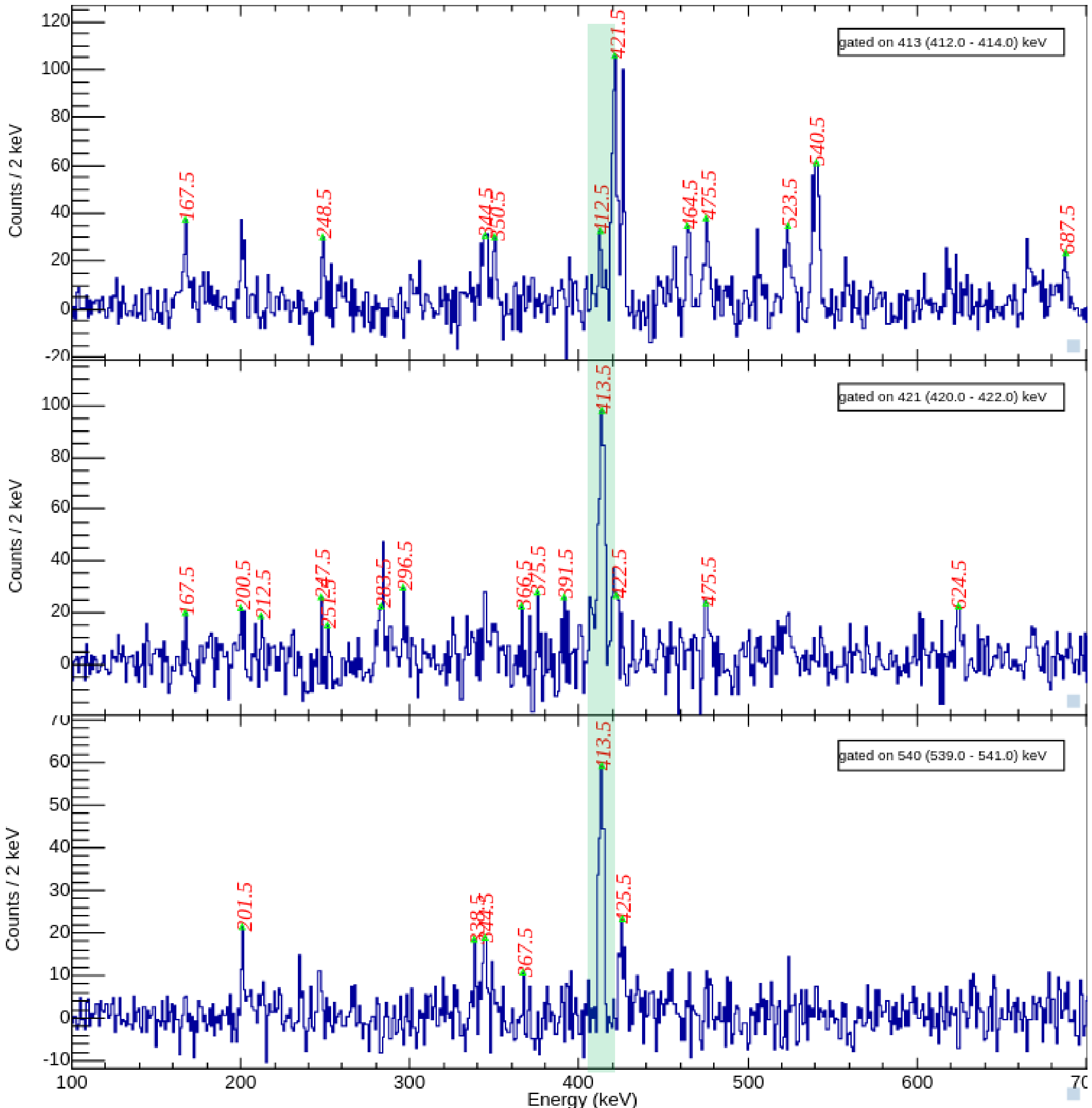
^{152}Yb IDT(347，312，139，359 keV gate)：

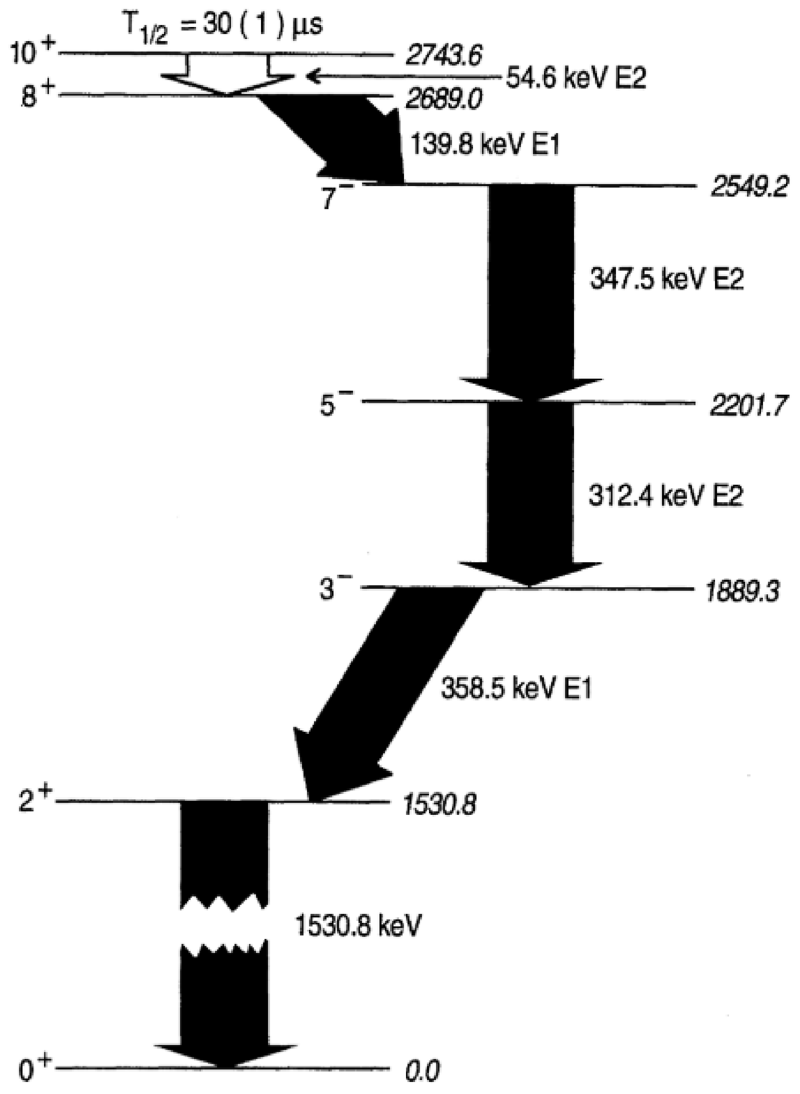


^{152}Yb IDT(347, 312, 139, 359 keV gate):



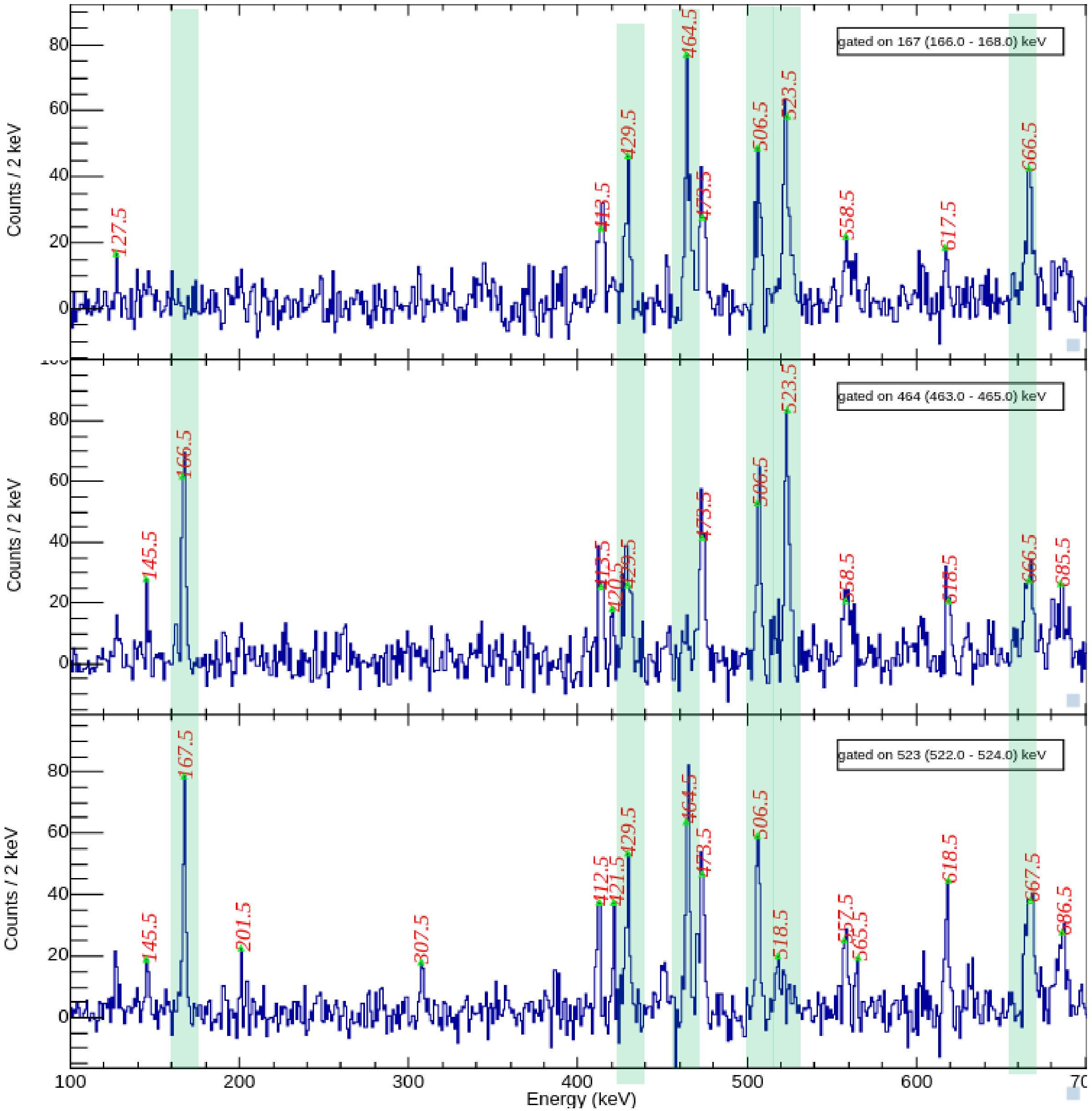
^{152}Yb (413, 421, 541 keV gate)：

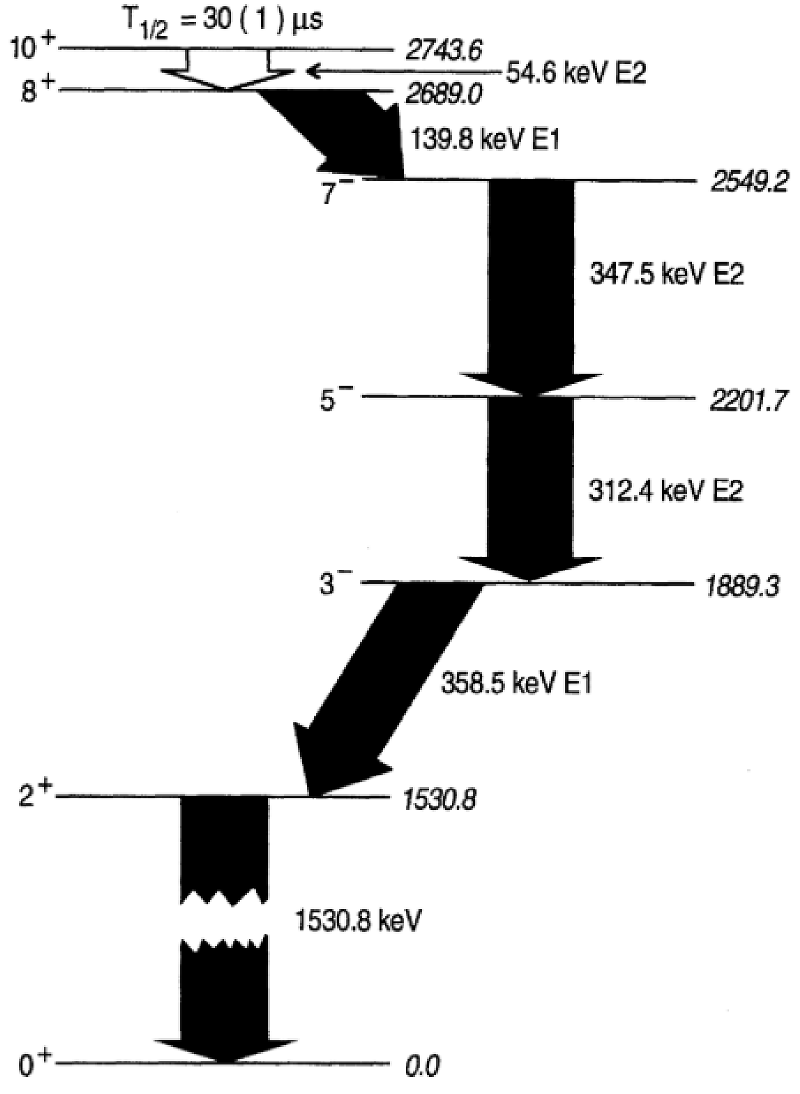




^{152}Yb (167 keV gate):

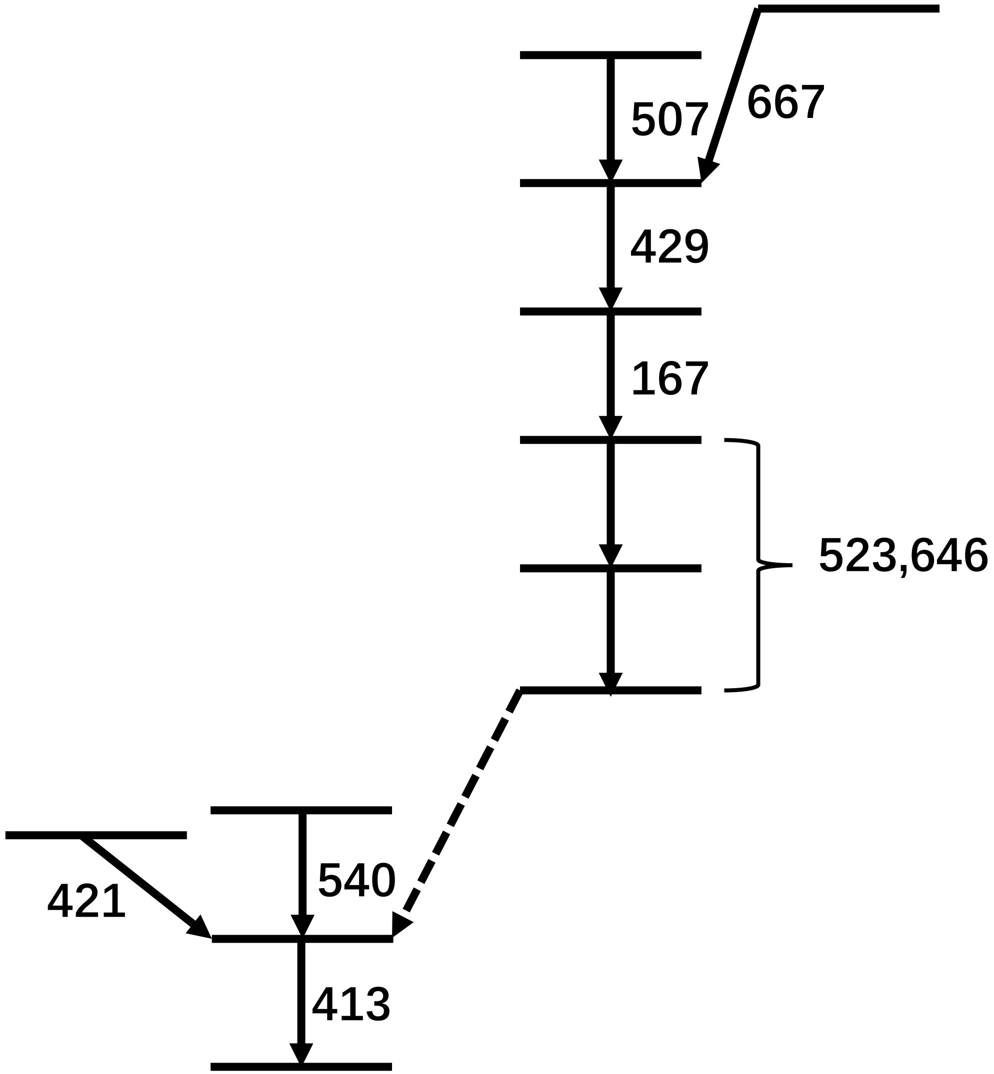
- cascade:
  - 507 → 167 → 464 → 523 → 429





^{152}Yb level scheme:

gate \ peaks	413	421	540	464	167	523	507	429	667
413	X	O(94)	O(46)	O(34)	O(25)	O(25)	?	X	X
421	O(82)	?	X	X	X	?	X	X	X
540	O(42)	X	X	X	X	O(12)	X	X	X
464	O(20)	X	X	X	O(50)	O(75)	O(49)	O(25)	O(21)
167	O(~15)	X	X	O(66)	X	O(48)	O(43)	O(46)	O(29)
523	O(28)	?	X	O(73)	O(57)	X	O(50)	O(53)	O(29)
507	O(14)	X	X	O(50)	O(33)	O(50)	X	O(24)	?
429	X	X	X	O(33)	O(47)	O(45)	O(31)	X	O(30)
667	O(24)	X	X	?	O(40)	O(35)	?	O(38)	X
Efficiency	9.2	9.1	8.2	8.8	9.9	8.3	8.4	9.06	7.2
Height	7040	4460	2110	3444	3003	3235	2130	2643	1677
Intensity	765	490	257	391	303	390	254	291	233



N =82

^{150}Er:

PHYSICAL REVIEW C VOLUME 29, NUMBER 6 JUNE 1984

Four-valence-proton yrast states in $^{150}_{68}Er_{82}$

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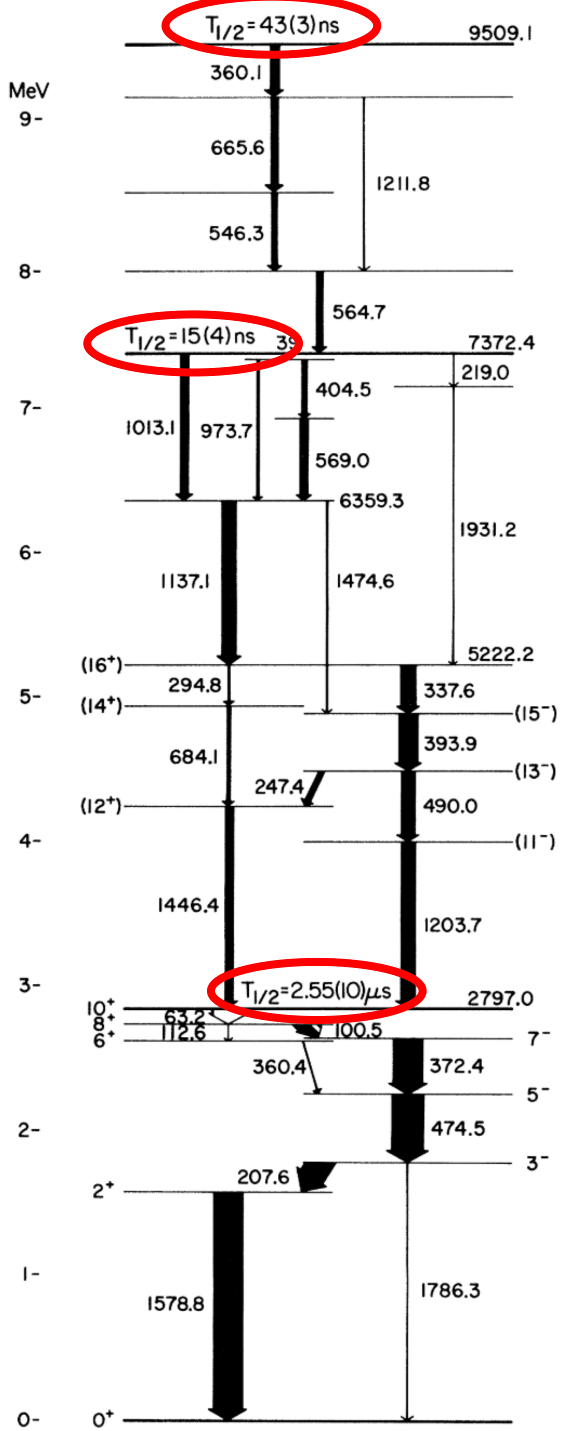
(Received 7 March 1984)

^{150}Er：

Four-valence-proton yrast states in $^{150}_{68}Er_{82}$

- ^{58,60}Ni + ^{92,94}Zr,^{93}Nb,^{92,94,95}Mo(~1 mg/cm^2)@225-255 MeV
- Recoiling residual nuclei were stopped in an 11mg/cm^2 ^{208}Pb catcher foil placed 21 cm downstream(~20 ns).
- Measurements of γ rays from products deposited on the catcher foil were performed (1 planar and 3 large coaxial GE(Li) detectors).
- Studying the decay of isomers with half-lives exceeding 10 ns.

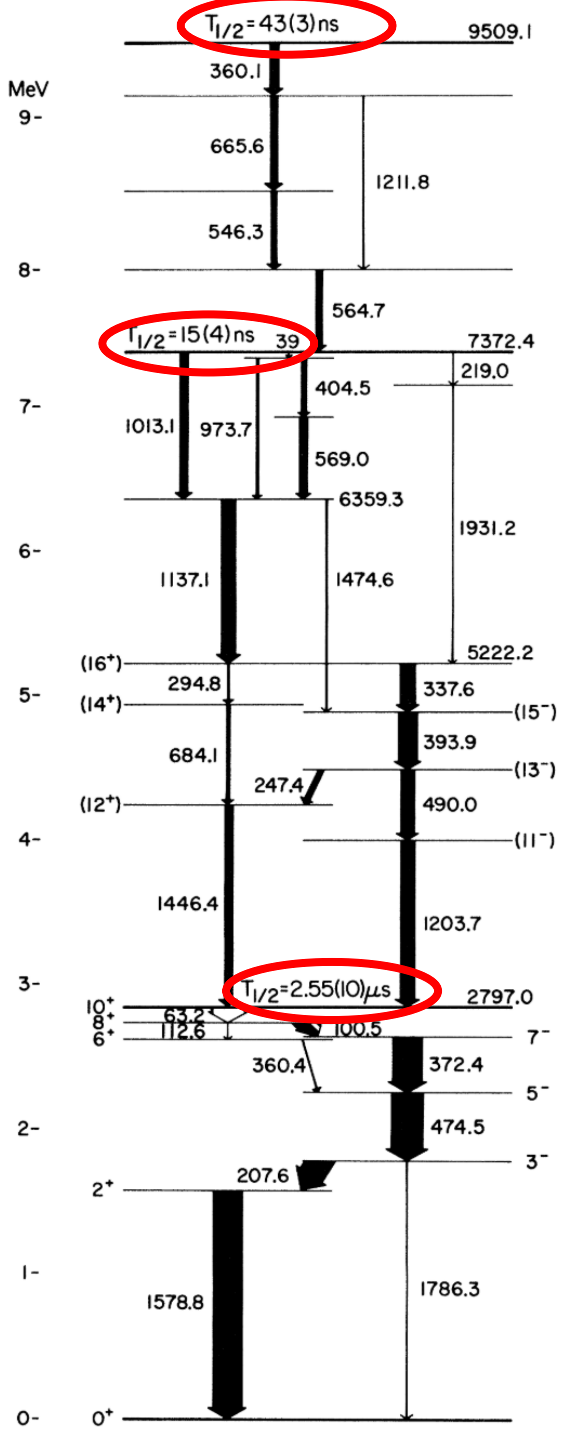
^{150}Er:



Four-valence-proton yrast states in $^{150}_{68}Er_{82}$

- 2797-keV, 2.55-us isomer as the $\pi h_{11/2}{}^4$ $\nu = 2$ 10^+
- 3^- octupole state
  - ^{146}Gd: 1579 keV ($\pi h_{11/2} d_{5/2}^{-1}$), involving promotion of a proton across the Z=64 gap.
  - ^{148}Dy: 1688 keV (1688-1579 =) 109 keV shift ← Pauli interference effect arising from coupling of the 3^- excitation to $\pi h_{11/2}^2$ component of the ^{148}Dy 0^+ ground state)
  - ^{150}Er: The excitation of 3^- is predicted to be 1579+2*109=1797 keV (1786.3 keV)
  - ^{152}Yb: The excitation of 3^- is predicted to be 1579+3*109 = 1906 keV (1889.3 keV)

^{150}Er:



Four-valence-proton yrast states in $^{150}_{68}\mathrm{Er}_{82}$

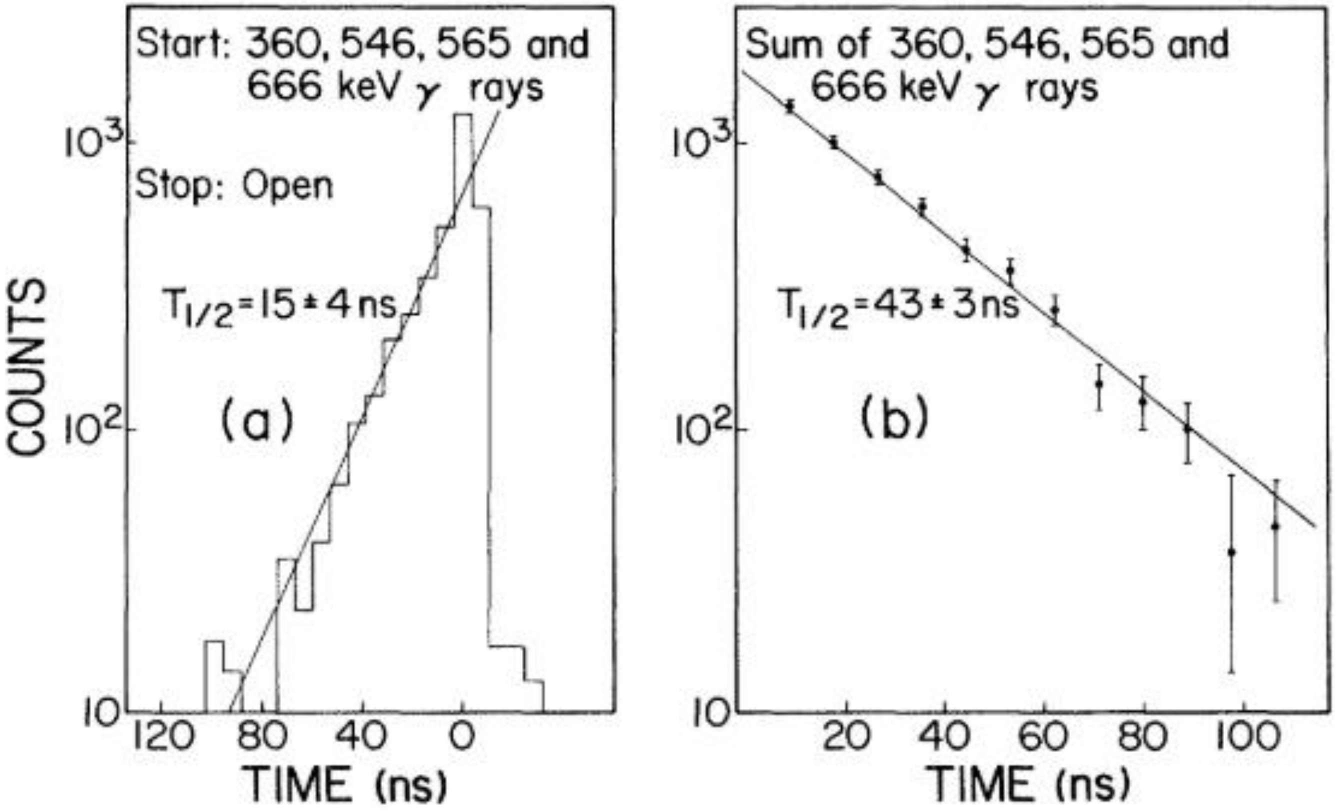
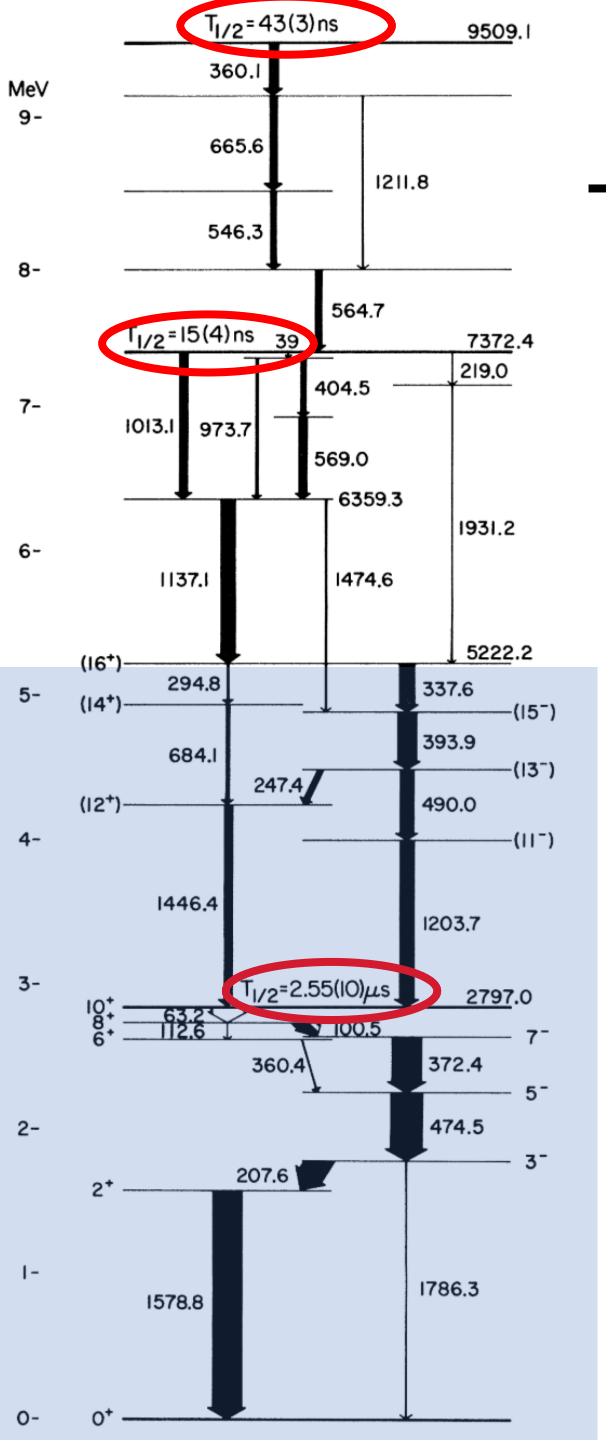


FIG. 6. (a) the $t_{\gamma\gamma}$ time distribution data used to determine the half-life of the 7372 keV isomer. (b) The $t_{\gamma\,\mathrm{sum}}$ time distribution used to determine the half-life of the 9509-keV isomer.

^{150}Er:



Four-valence-proton yrast states in $^{150}_{68}Er_{82}$

- $I^{\pi} = 16^{+}$: is the highest spin configuration arising from valence protons alone, and higher spin states must involve excitation of the ^{146}Gd core.
- The 17⁻ state with the configuration $\pi h^{3}_{11/2} g^{-1}_{7/2}$ in ^{146}Gd (7165 keV) and ^{148}Dy(6263 keV), in both cases about 3.3 MeV above the $\pi h^{2}_{11/2}$ 10^{+} state. Hence, the corresponding 17⁻ state in ^{150}Er should come at about 6.1 MeV(level at 6359 keV seems very probable)
- States with spins higher than 17 can be formed by 6qp state.
- 15-ns isomer at 7372 keV is not easily understood as a pure proton state, it may involve the excitation of one or two neutrons across the N = 82 gap.

^{148}Dy:

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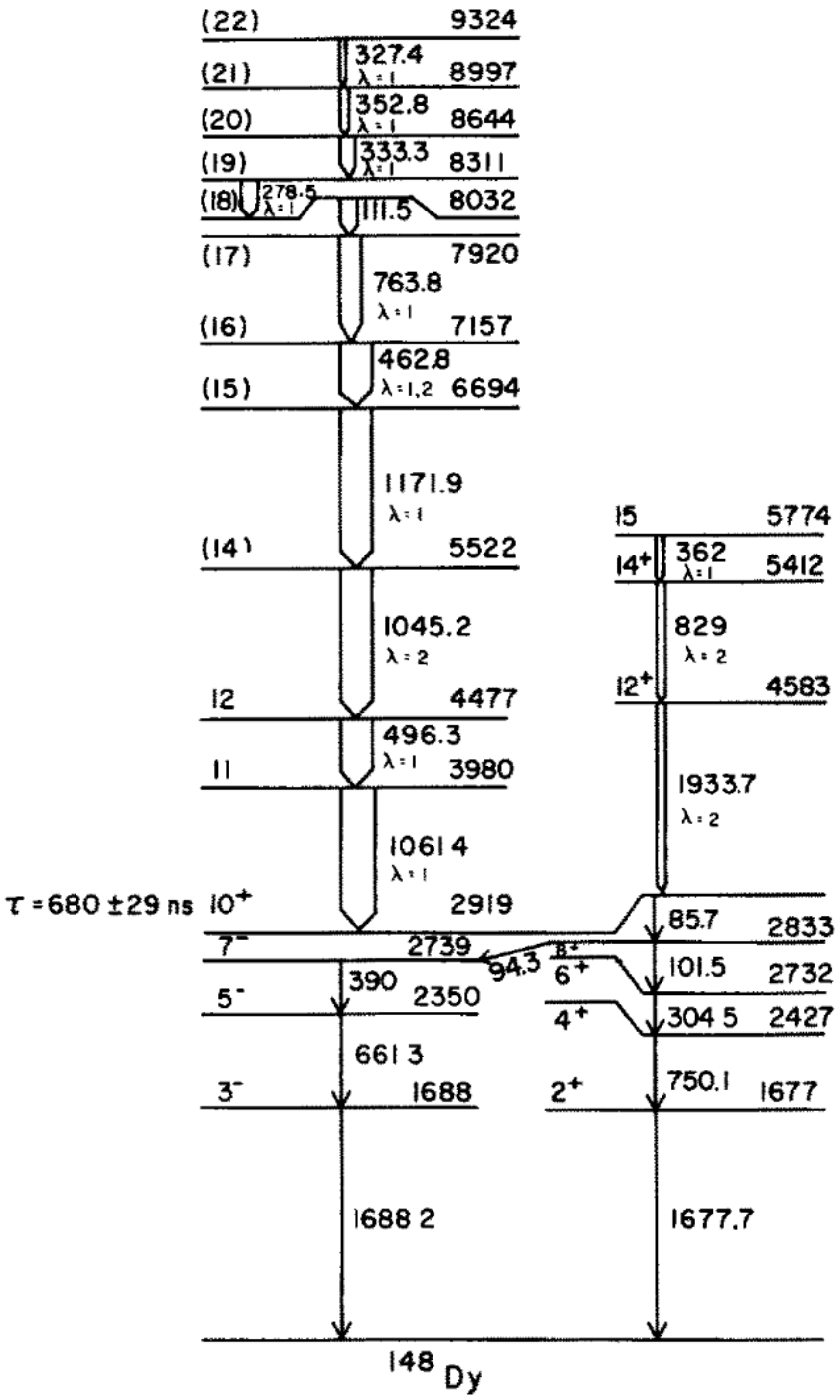
YRAST ISOMERS AND VERY HIGH SPIN STATES IN ^{148,149,151,152}Dy AND ^{147}Gd

- ^{32,34}S + $^{120-124}$Sn(~2 mg/cm^2 ,evaporated onto thick lead backings)@129-165 MeV
- Pulse separation times between 200 and 5000 ns were selected according to the isomer studied @ Argonne.

^{148}Dy:


(22) 9324
327.4 λ=1
(21) 8997
352.8 λ=1
(20) 8644
333.3 λ=1
(19) 8311
(18) 278.5 λ=1 111.5 8032
(17) 7920
763.8 λ=1
(16) 7157
462.8 λ=1,2
(15) 6694
1171.9 λ=1
(14) 5522
1045.2 λ=2
12 4477
496.3 λ=1
11 3980
1061.4 λ=1
τ=680±29 ns 10+ 2919
7- 2739
94.3
390
5- 2350
661.3
3- 1688
1688.2
15 5774
362 λ=1
14+ 5412
829 λ=2
12+ 4583
1933.7 λ=2
85.7 2833
8+
101.5 2732
6+
304.5 2427
4+
750.1 1677
2+
1677.7
148 Dy

^{148}Dy:

NON-COLLECTIVE HIGH-SPIN STATES IN ^{148}Dy

by

Eugene Liviu Dines

April 1985

Nuclear Science Division
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

and

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University of California at Davis
Davis, California 95616

- ^{40}Ar + ^{112}Cd(~1 mg/cm^2 , lead foil)@175,185 MeV
- 70 ns separation between beam bursts, whose average length was about a few nanoseconds

^{148}Dy:

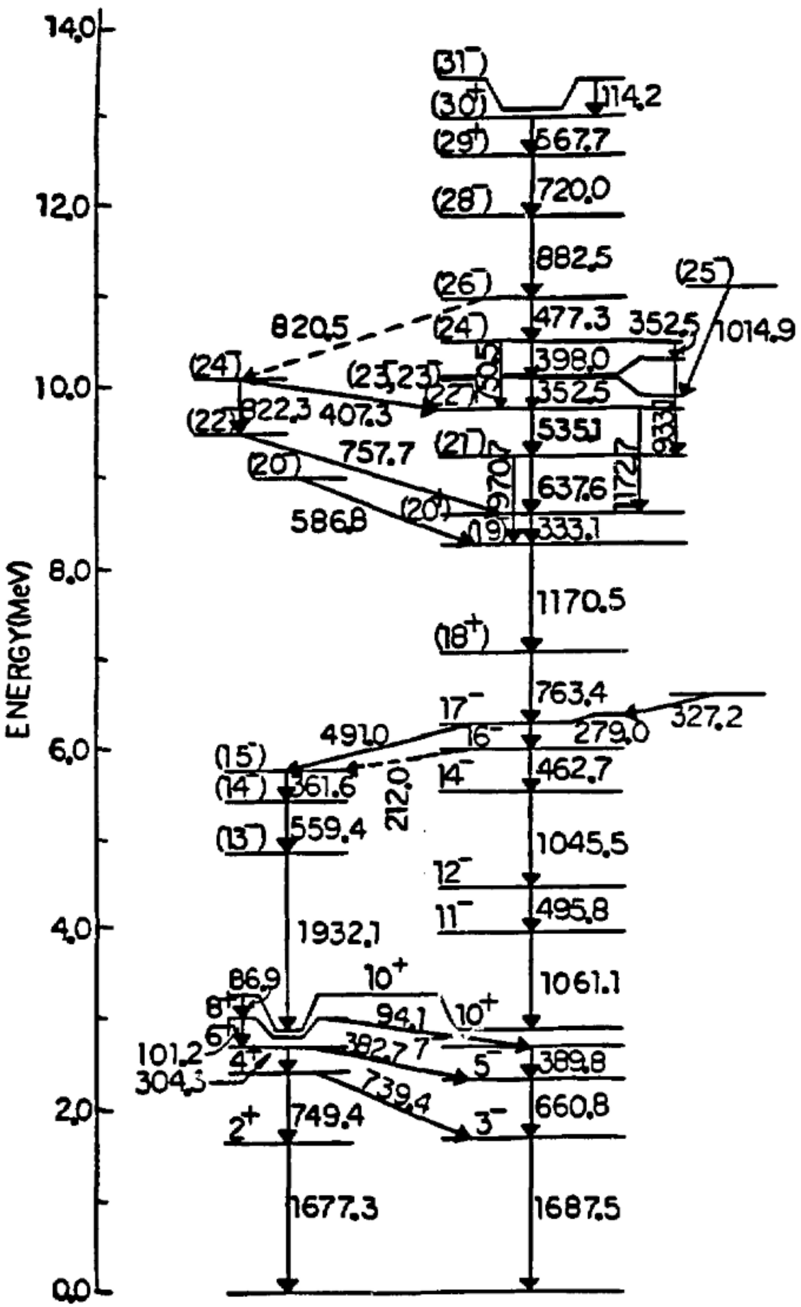
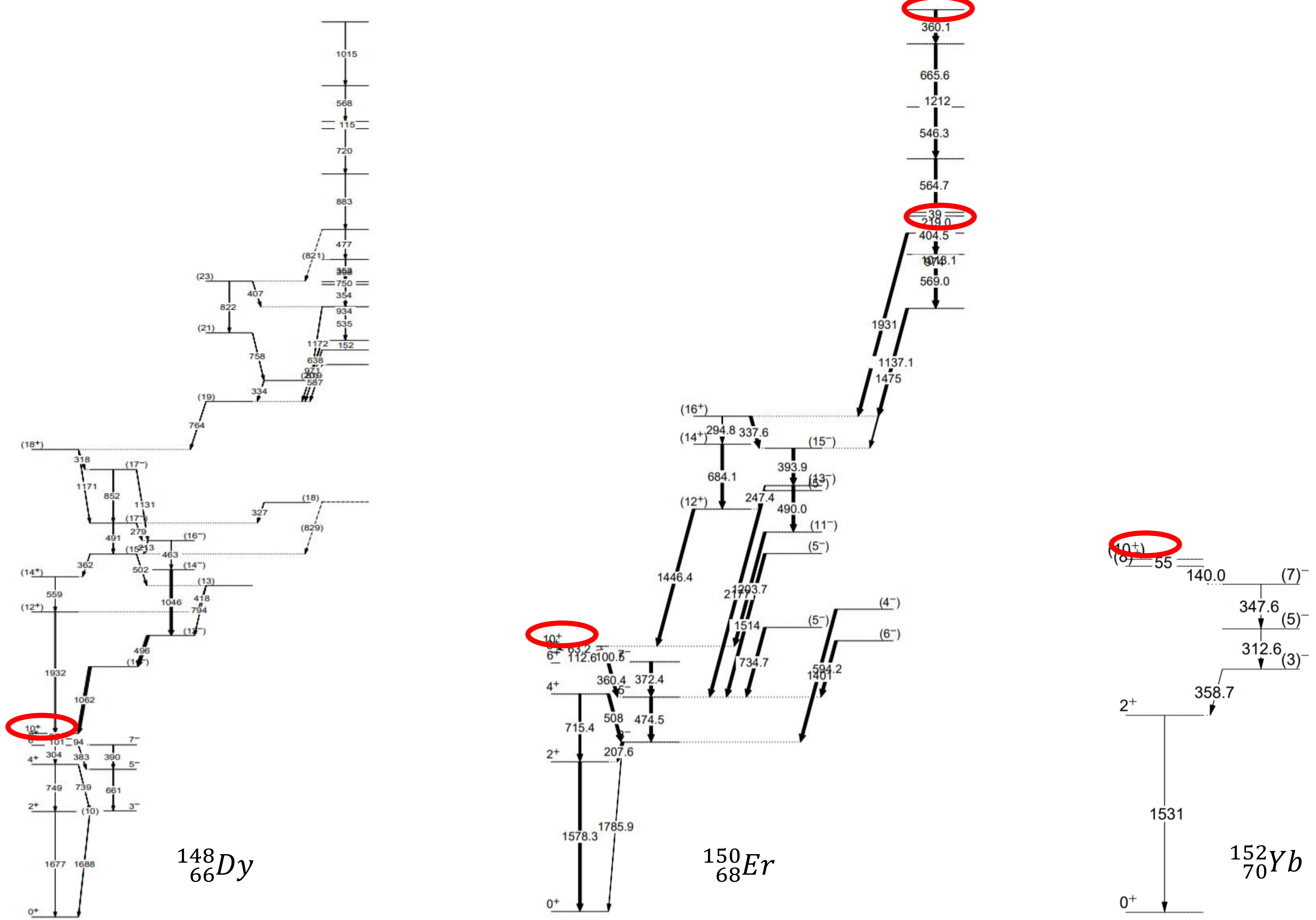


Fig. 4.1.1



$^{148}_{66}Dy$
1015
568
115
720
883
477
(821)
(23)
822
407
750
354
934
535
(21)
758
1172
152
638
334
587
(19)
764
(18+)
318
(17−)
1171
852
1131
(18)
327
(829)
491
279
(16−)
463
(14+)
362
502
(14−)
(13)
559
(12+)
418
794
1046
496
1932
1062
10+
101
94
7−
304
383
390
5−
4+
749
739
661
2+
(10)
3−
1677
1688
0+
$^{150}_{68}Er$
360.1
665.6
1212
546.3
564.7
39
404.5
569.0
1931
1137.1
1475
(16+)
294.8
337.6
(14+)
(15−)
684.1
393.9
(13−)
247.4
(12+)
490.0
(11−)
(5−)
1446.4
1293.7
2177
(4−)
1514
(5−)
(6−)
10+
63.2
6+
112.6
100.5
7−
734.7
594.2
1401
360.4
372.4
4+
5−
715.4
508
474.5
2+
207.6
1578.3
1785.9
0+
$^{152}_{70}Yb$
(10+)
(8)
55
140.0
(7)−
347.6
(5)−
312.6
(3)−
358.7
2+
1531
0+