

Cup grown crystal alpha-alpha analysis (NaI-025,034,035)

2020/01/08

Jae Jin Choi



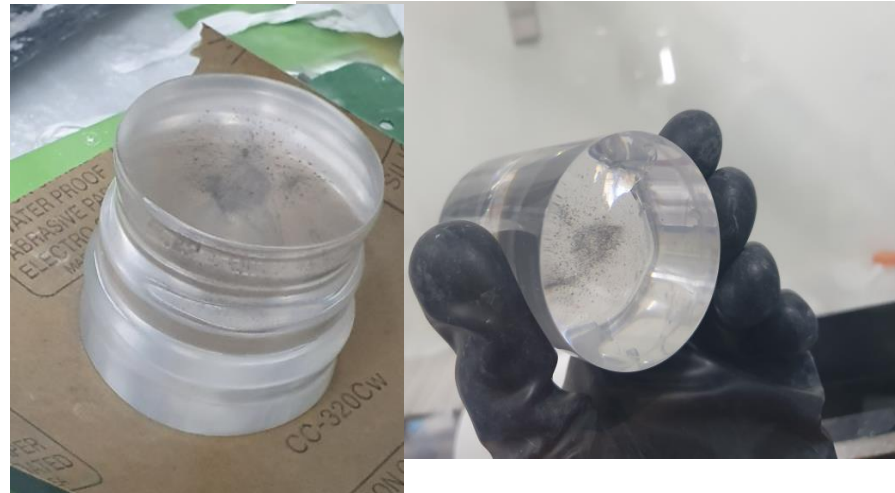
CUP grown crystal

	Crystal Mass(kg)	powder	TII input(mol%)	ICP-MS TI concentration(mol%)	crucible	Grown date
Nal-025(Nal-024 reencapsulation)	0.654	Astro grade	0.1	-	Quartz	2018/05/24
Nal-034	0.922->0.666	Astro grade	0.1	0.0146	Pt3	2019/09/17
Nal-035	0.613	Astro grade	0.12(changed TII)	0.0123	Kihteck quartz crucible	2019/11/13



Nal-025

2020-01-08



Nal-034

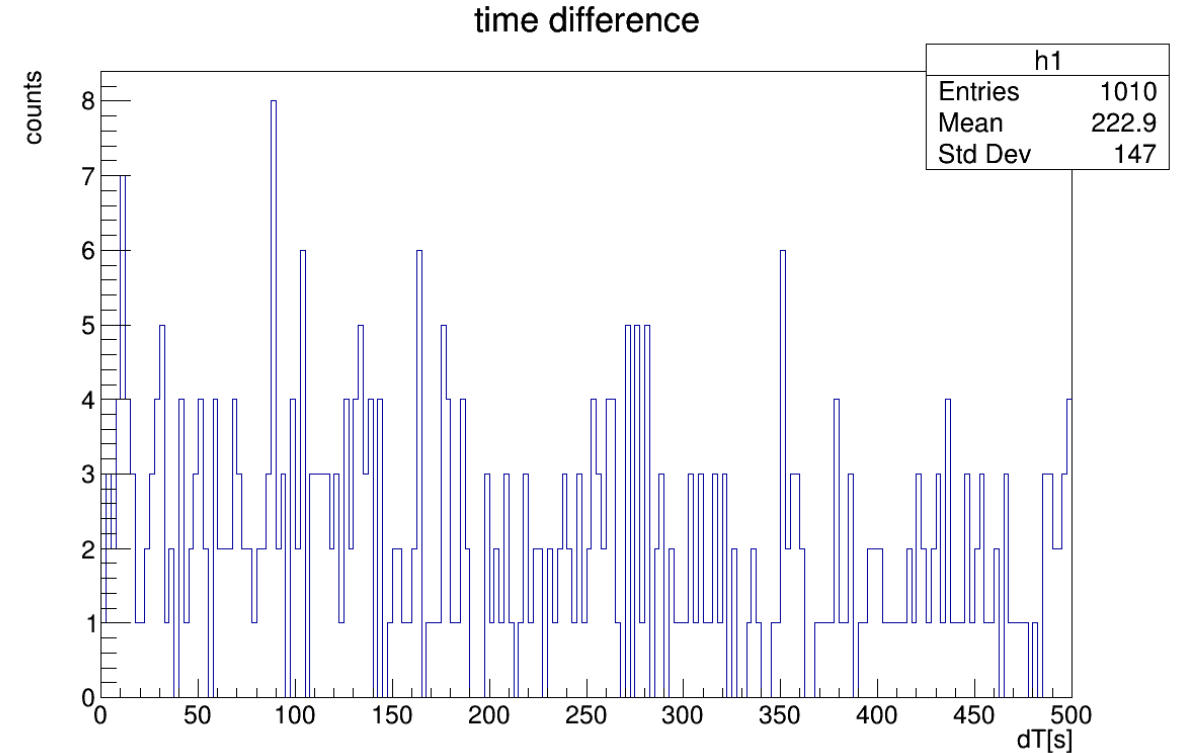
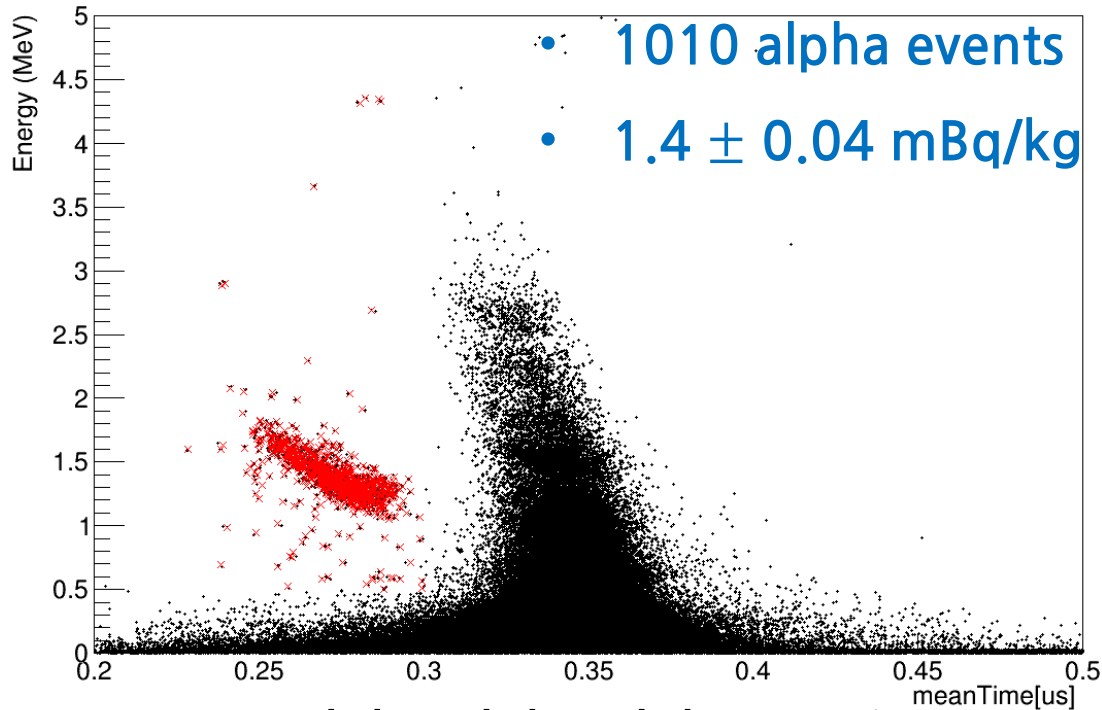
COSINE lab_meeting



Nal-035

Nal-025 alpha distribution(energy distribution)

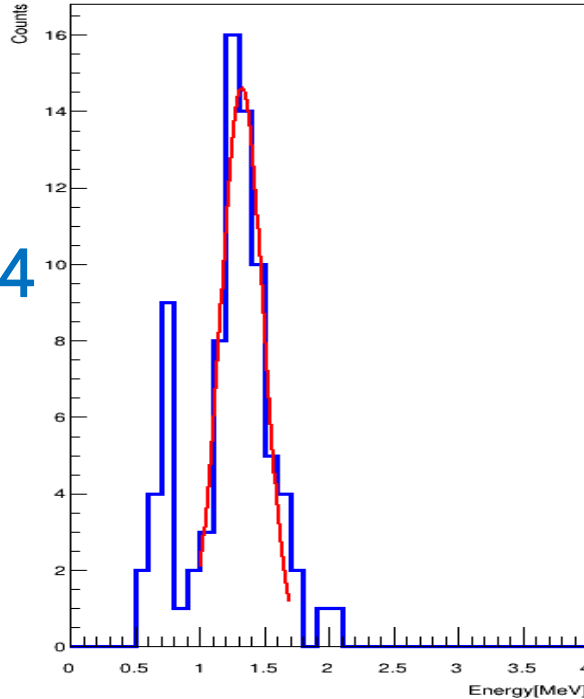
- Nal-025(306 hour)
- 1010 alpha events
- 1.4 ± 0.04 mBq/kg



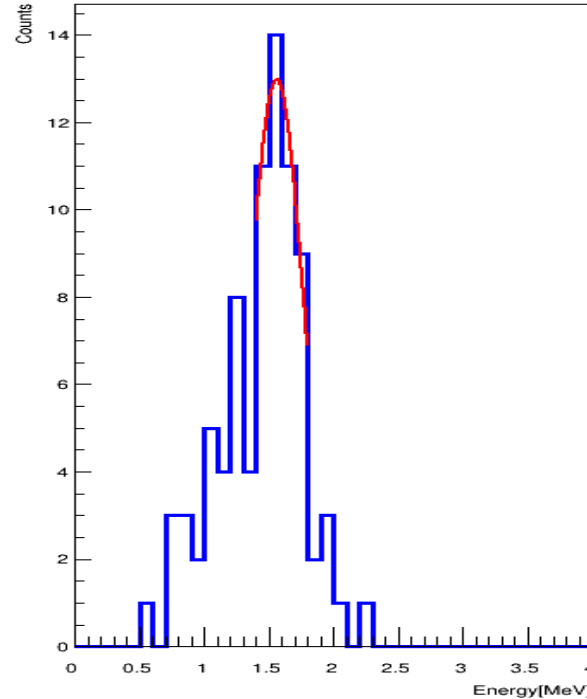
- No alpha-alpha-alpha tagging events
- one alpha-alpha event below than 2 seconds but it seems accidental events(after alpha energy is lower than before alpha energy)
- Th-232 contamination(90% C.L.) : < 0.78 ppt(< 3.1 uBq/kg)

Nal-034&035 quenching factor(Th-232 chain)

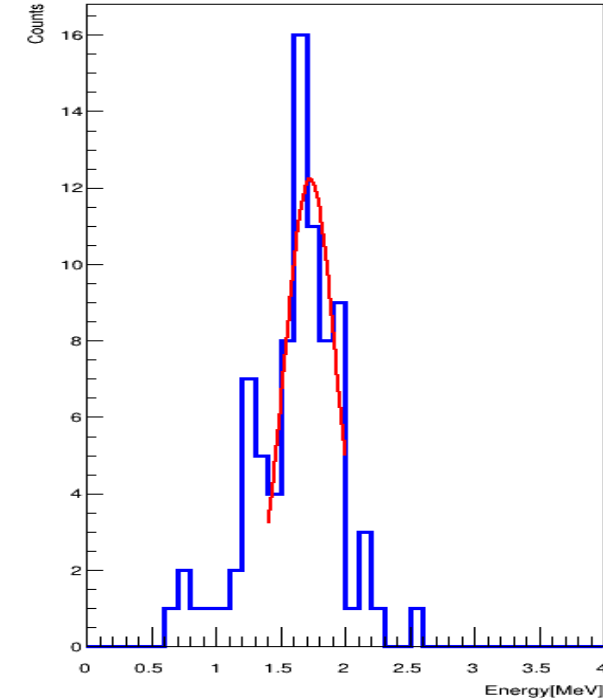
Ra-224(5.7 MeV)



Rn-220(6.4 MeV)



Po-216(6.9 MeV)



Nal-034

%	Ra-224	Rn-220	Po-216
Nal-034	22.9 %	24.3 %	25 %
Nal-035(8 events avg)	34 %	36 %	37.2 %
Nal-035/Nal-034 percentage	148.4 %	148.1 %	148.8 %



Nal-035 quenching factor is about 1.5 times higher than Nal-034

Nal-034&Nal-035 contamination(Th-232,U-238)

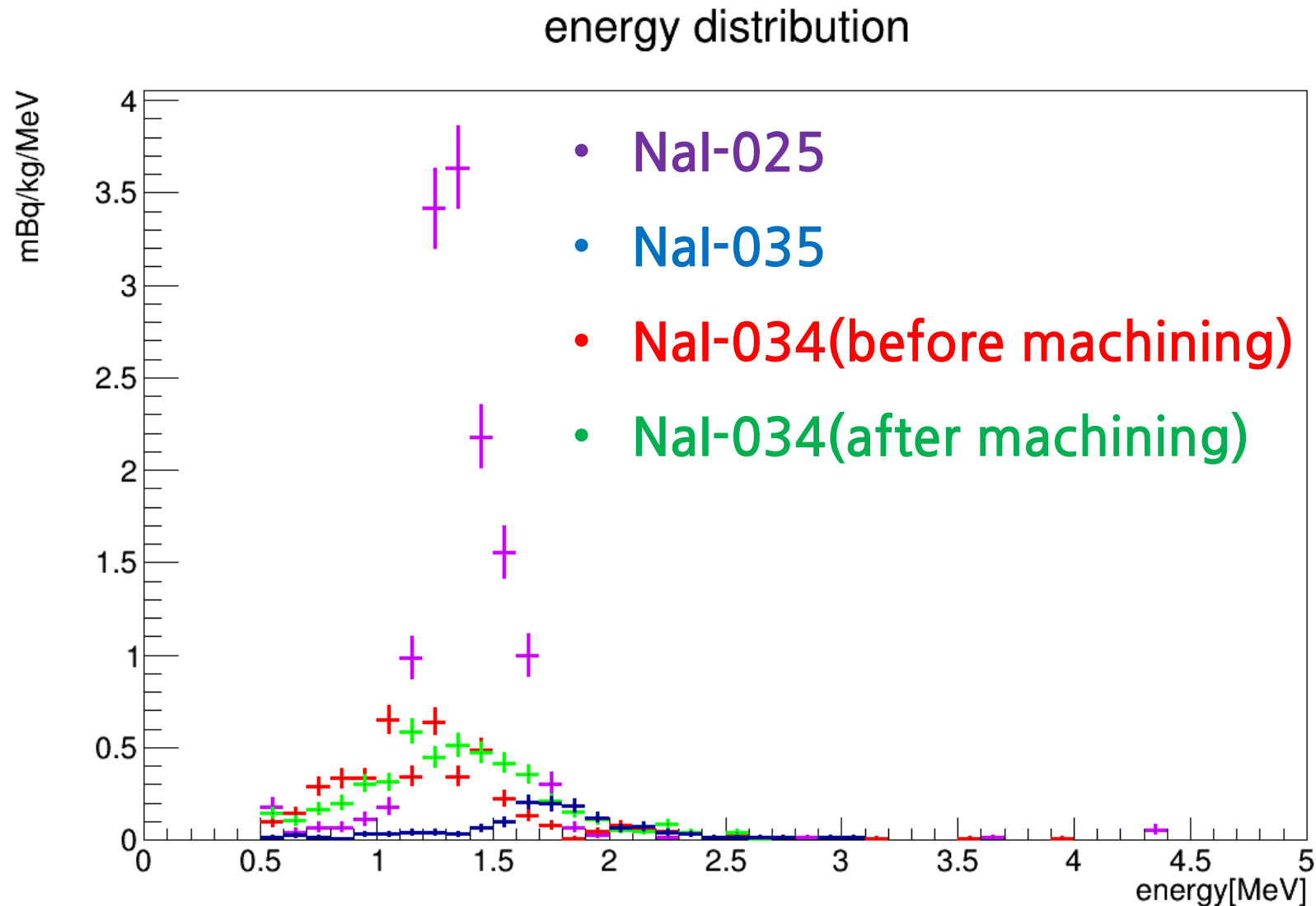
Using Alpha-alpha-alpha tagging events(only Th-232)

	Mass(kg)	Activity(uBq/kg)	Conversion to ppt(if th232 is in equilibrium)
Nal-034 Before machining(334 h)	0.922	29.7 ± 5.2	7.3 ± 1.2
Nal-034 After machining(520 h)	0.666	35.2 ± 5.2	8.6 ± 1.3
Nal-035(558 h)	0.613	5.6 ± 2.1	1.3 ± 0.5

Summary

- NaI-025 didn't have alpha-alpha events from Th-232 chain(most alphas from Pb-210)
- NaI-035 quenching factor is 1.5 times higher than NaI-034
- NaI-035 Th-232 contamination is almost 5 times less than NaI-034

NaI-025&034&035 alpha energy distribution



Nal-034&Nal-035 contamination(Th-232,U-238)

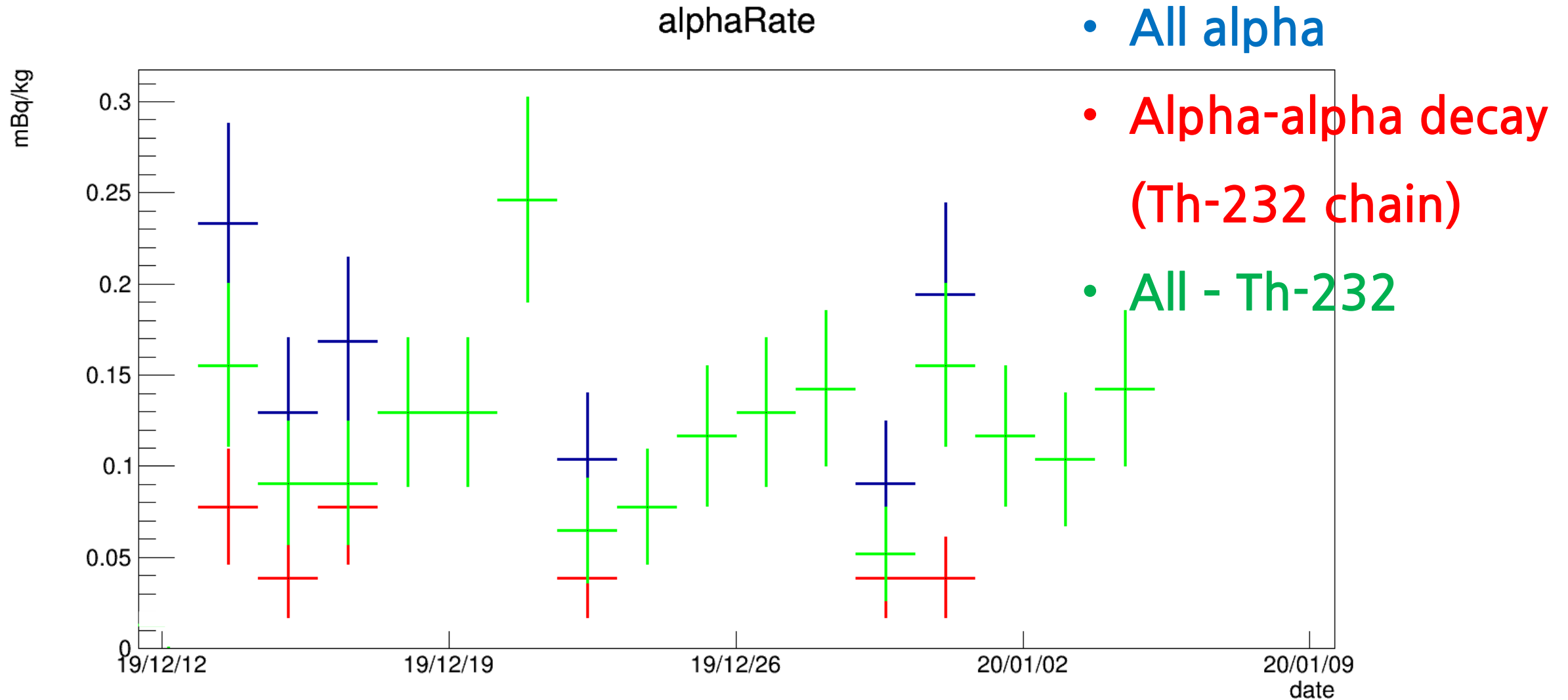
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Nal-035(558 h)	0.613	5.6 ± 2.1	1.3 ± 0.5

Using fitting line integral(Th-232,Po-216 fitting($dT < 1\text{sec}$) & U-238,Po-218 fitting($dT < 1000\text{sec}$))

Mass average(0.744 kg) Time(750 h)	Activity(uBq/kg)	Conversion to ppt(equilibrium)
Nal-034 Th-232 contamination	34.7 ± 5.4	8.5 ± 1.3
Nal-034 U-238 contamination	80.5 ± 38.6	6.5 ± 3.1

NaI-035 alpha rate



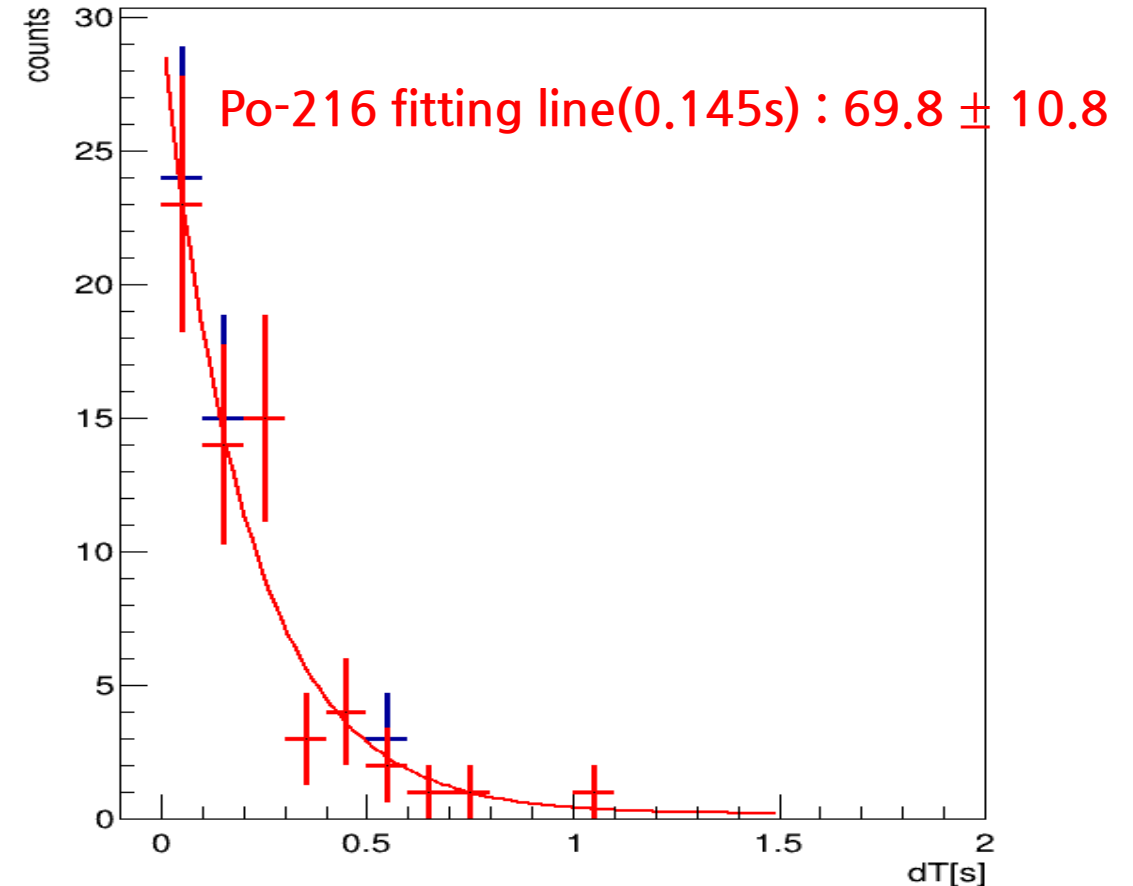
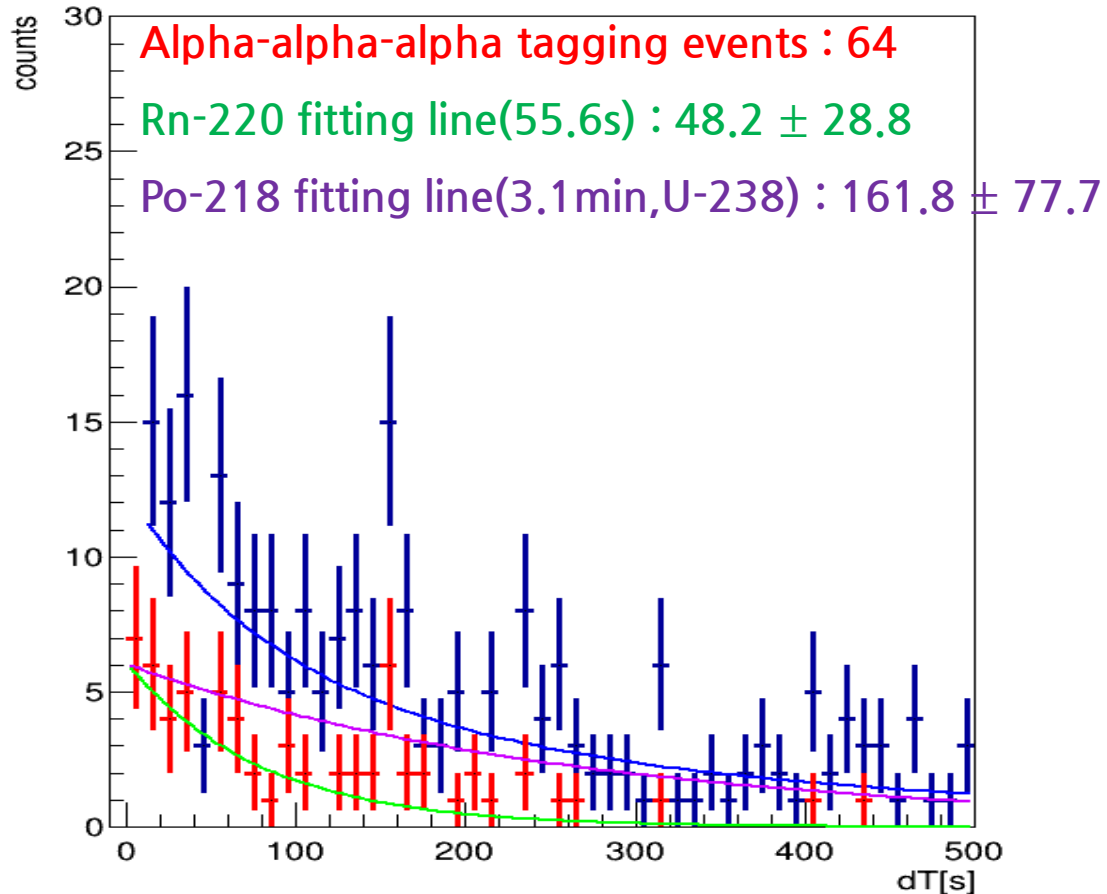
Nal-034&Nal-035 quenching factor(Th-232 chain)

Using Alpha-alpha-alpha tagging events(only Th-232)

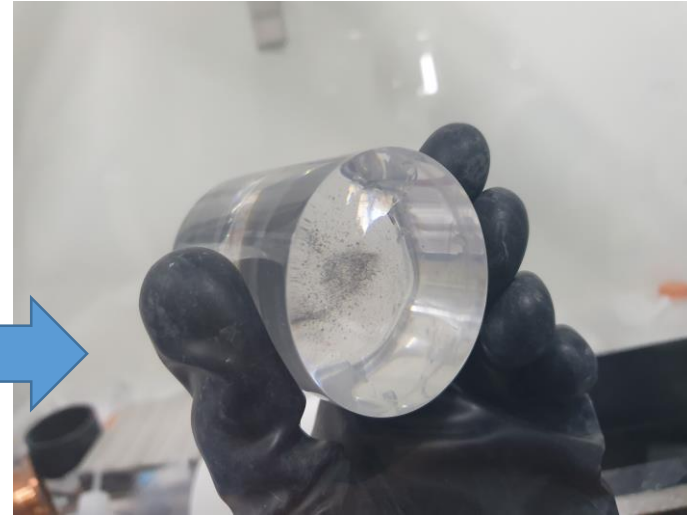
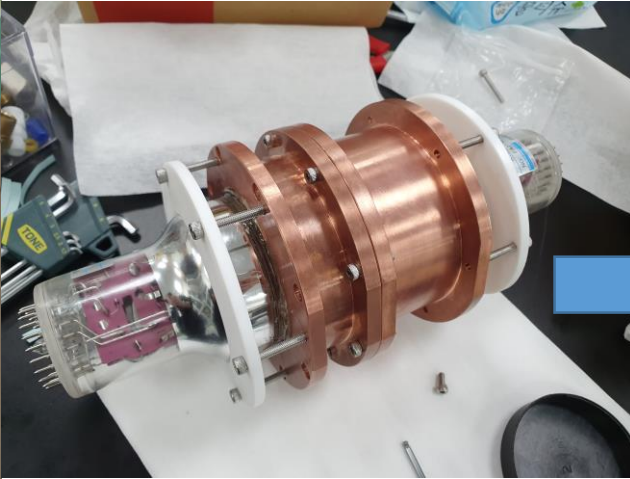
%	Ra-224	Rn-220	Po-216
Nal-034	22.9	24.3	25
Nal-035(7 events avg)	38.8	41.1	42.6

Nal-034 time difference distribution

ALL alpha events



Nal-034 machining & encapsulation



- Before machining(0.922 kg)

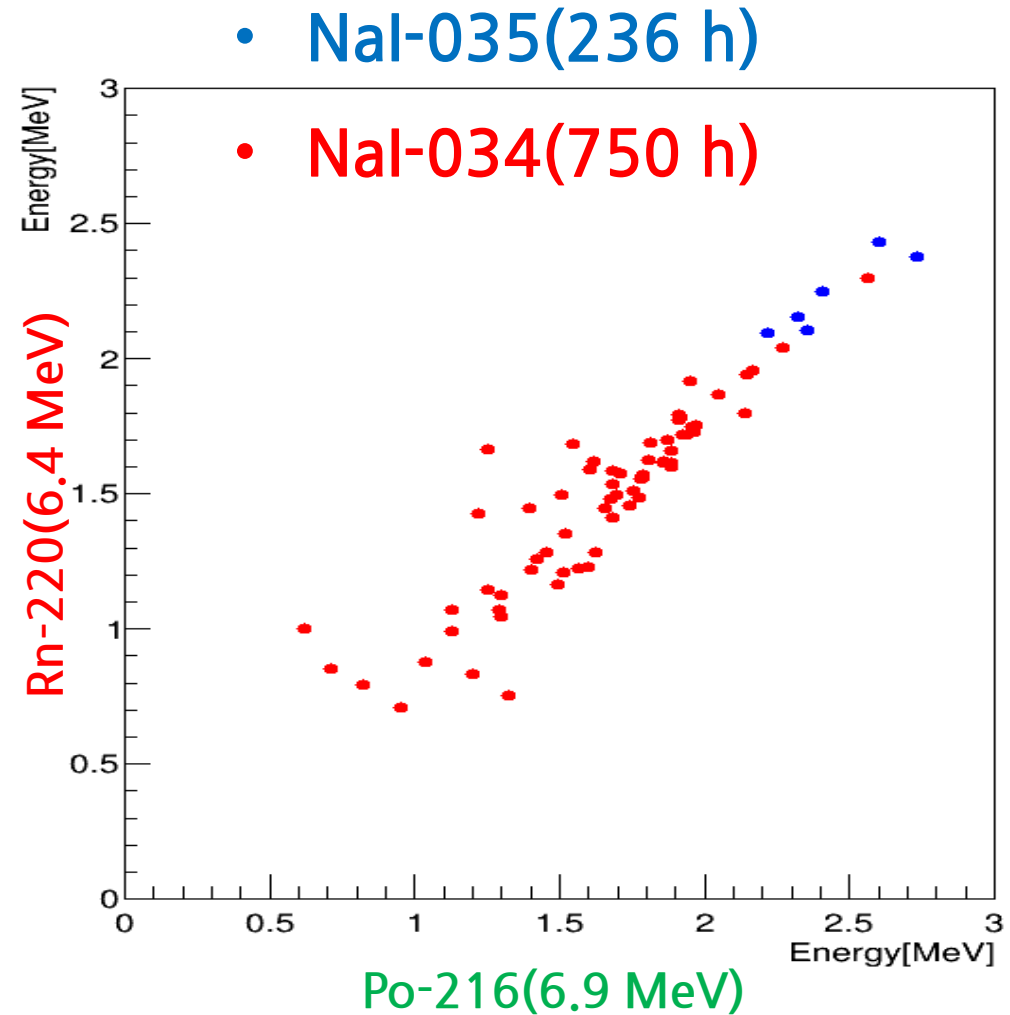
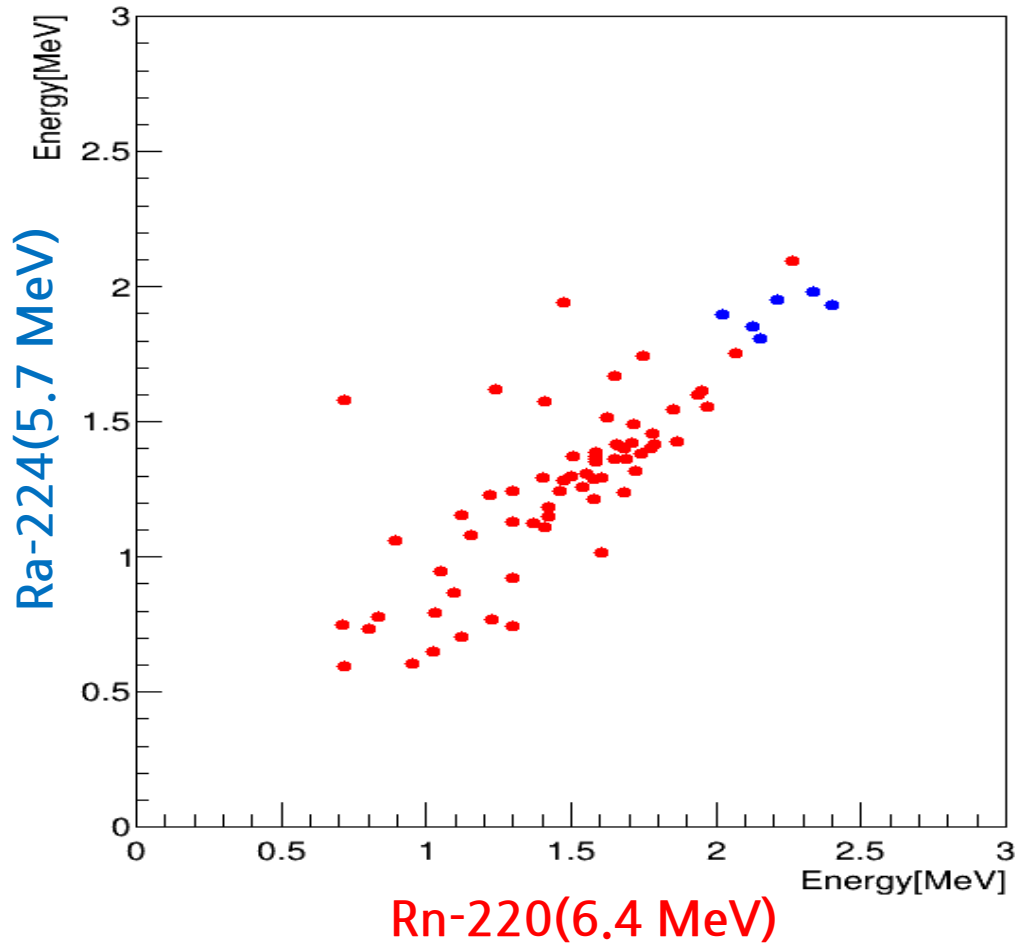
- After machining(cylinder,0.666 kg)

Nal-034 machining & encapsulation



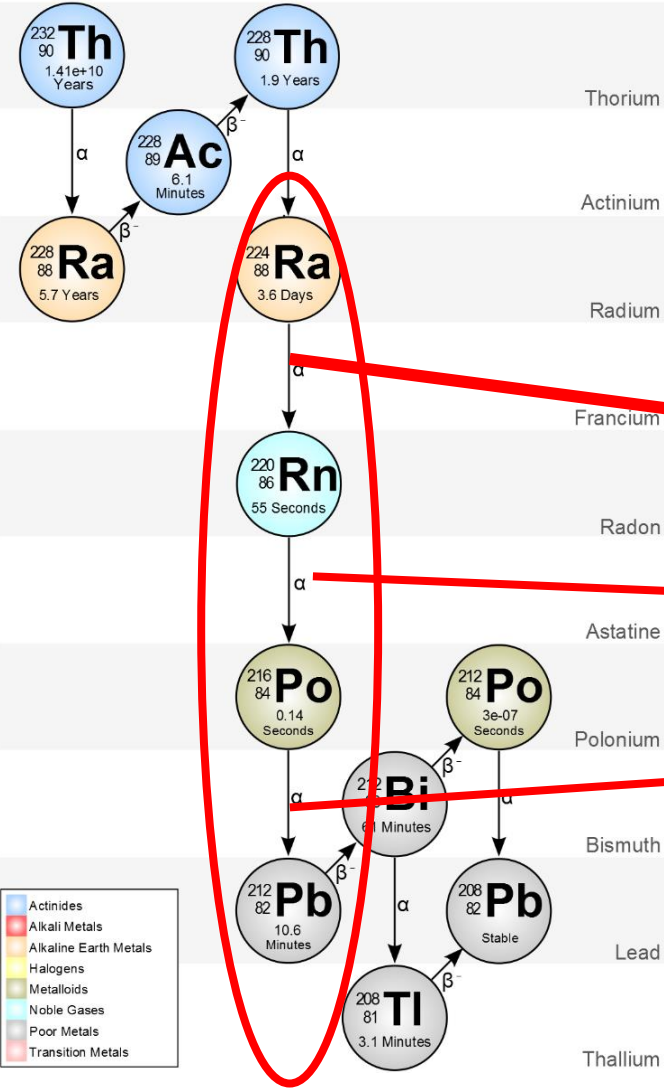
- No black dust(different TI)
- some cracks(new glove box with low humidity)

NaI-034&035 distribution(alpha-alpha energy comparison)



NaI-035 quenching factor is higher than NaI-034

Th-232 contamination



	Half life	Q value(Me V)
Th-228	1.91y	5.520
Ra-224	3.66d	5.789
Rn-220	55.6s	6.405
Po-216	0.145s	6.906

subrun	:	42		
time difference	:	32.6 s	before energy : 1.339	after energy : 1.561
time difference	:	0.02 s	before energy : 1.561	after energy : 1.787
subrun	:	43		
time difference	:	12.84 s	before energy : 0.747	after energy : 0.8847
time difference	:	0.2616 s	before energy : 0.8847	after energy : 0.7816

Th-232 alpha-alpha-alpha decay

NaI-034 alpha-alpha-alpha events(Th-232)

			Ra-224(5.7 MeV)	Rn-220(6.4 MeV)	Po-216(6.9 MeV)			
subrun	:	20						
time difference	:	0.2503 s	time difference between 3 alpha :	207.6 s	before2 energy : 1.437	before energy : 1.7	after energy : 1.912	
subrun	:	38				before2 energy : 1.481	before energy : 1.739	after energy : 1.981
time difference	:	0.0486 s	time difference between 3 alpha :	34.47 s	before2 energy : 1.339	before energy : 1.561	after energy : 1.787	
subrun	:	42				before2 energy : 0.747	before energy : 0.8847	after energy : 0.7816
time difference	:	0.02 s	time difference between 3 alpha :	32.62 s	before2 energy : 1.293	before energy : 1.409	after energy : 1.628	
subrun	:	43				before2 energy : 0.7308	before energy : 0.7338	after energy : 0.8285
time difference	:	0.2616 s	time difference between 3 alpha :	13.1 s	before2 energy : 1.79	before energy : 2.078	after energy : 2.279	
subrun	:	28						
time difference	:	0.2141 s	time difference between 3 alpha :	263.4 s				
subrun	:	42						
time difference	:	0.1505 s	time difference between 3 alpha :	160 s				
subrun	:	46						
time difference	:	0.06316 s	time difference between 3 alpha :	153.9 s				

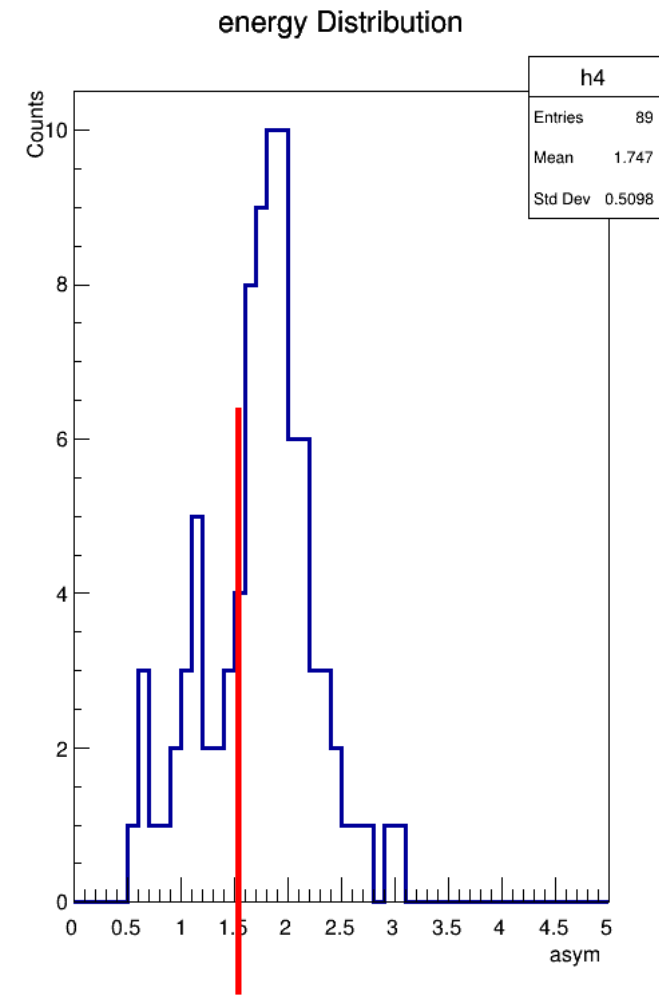
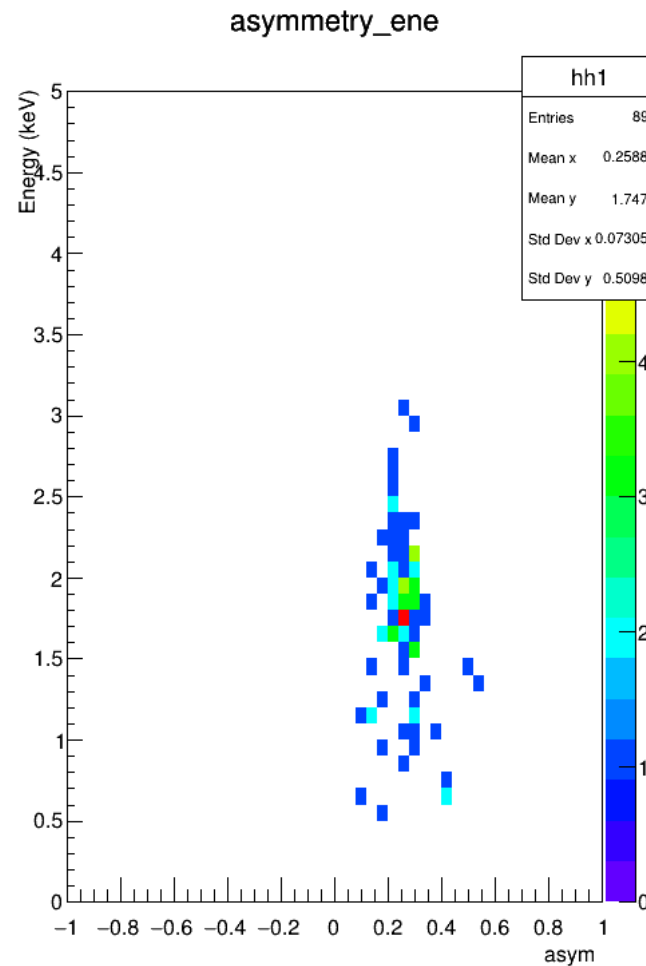
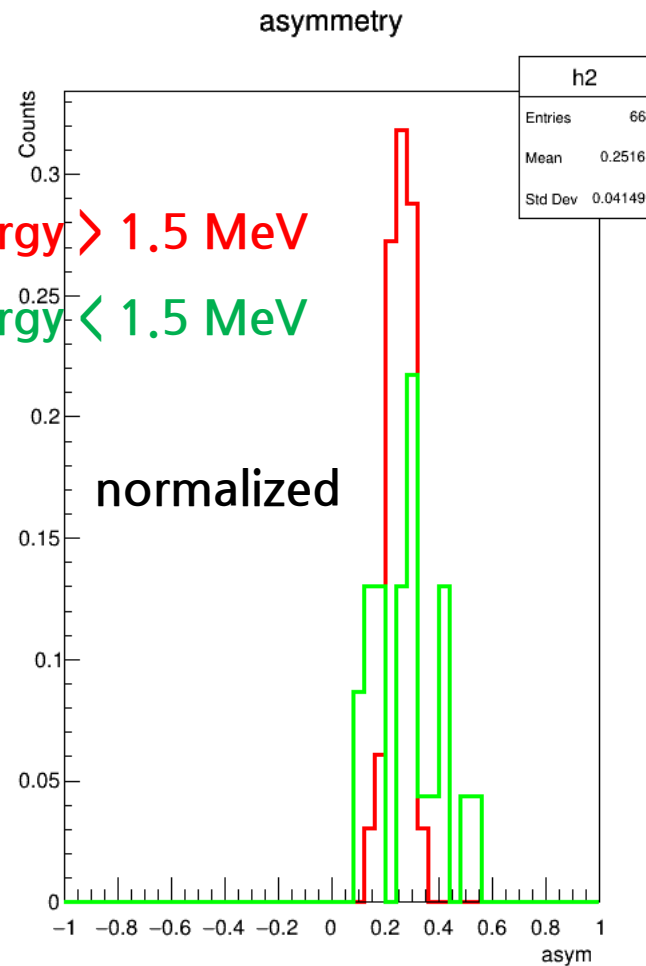
- Quenching factors are similar if there are from same Th-232 origin
- Quenching factors are different by Th-232 origin like two peak alpha events which are from COSINE crystals



Quenching factors have position dependence

Nal-035 asymmetry

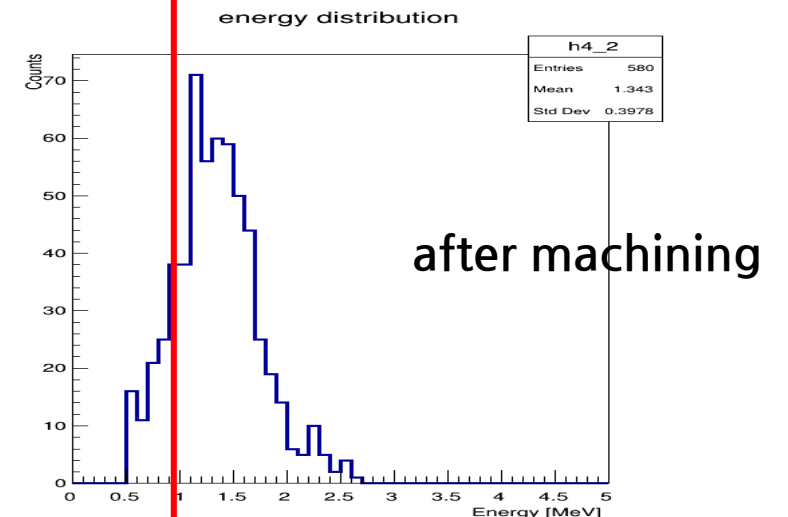
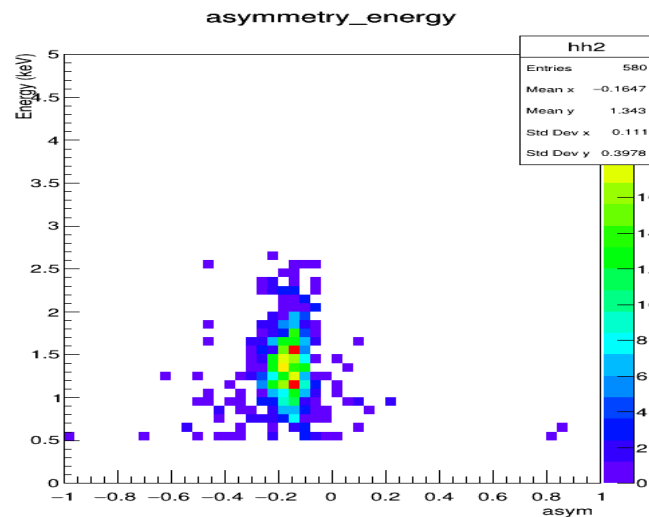
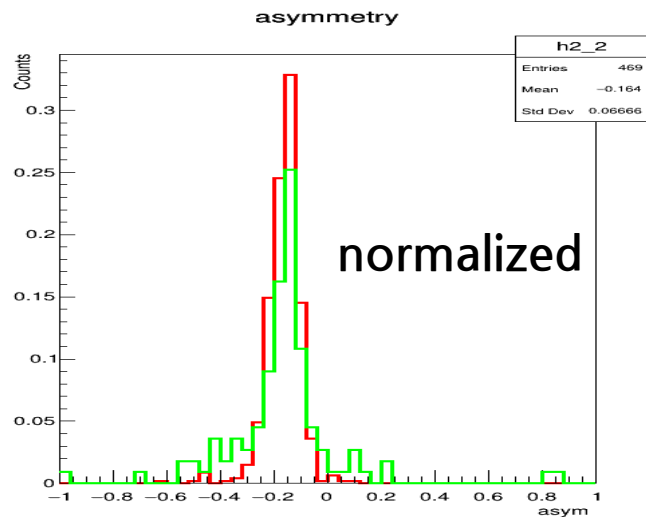
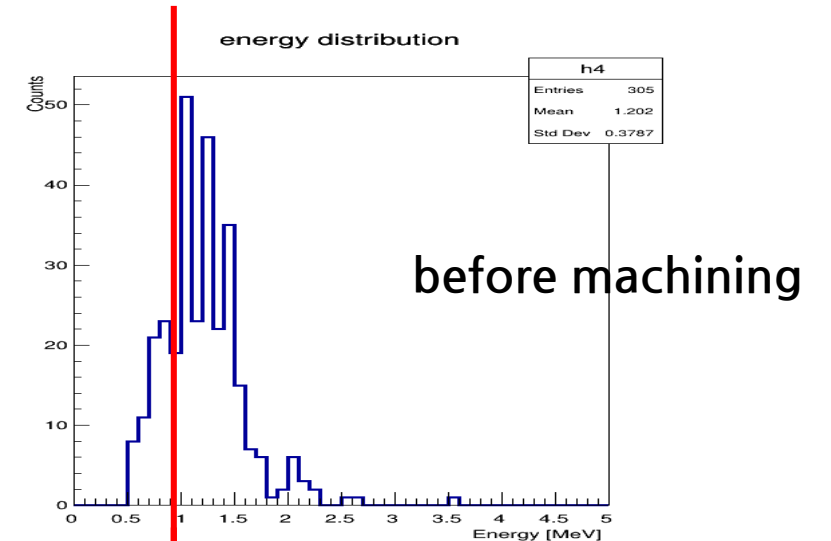
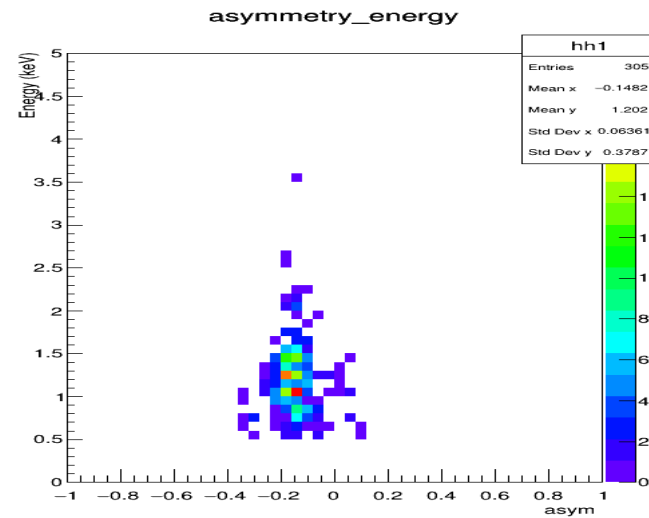
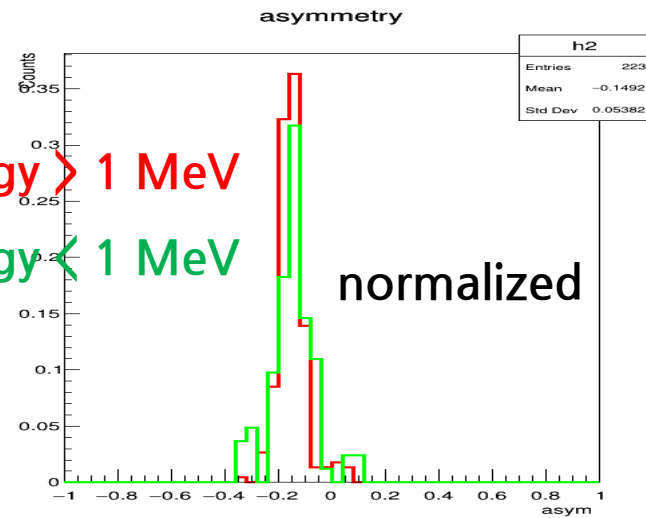
- Energy > 1.5 MeV
- Energy < 1.5 MeV



Some low energy(<1.5 MeV) alpha events are from surface

Nal-034 asymmetry

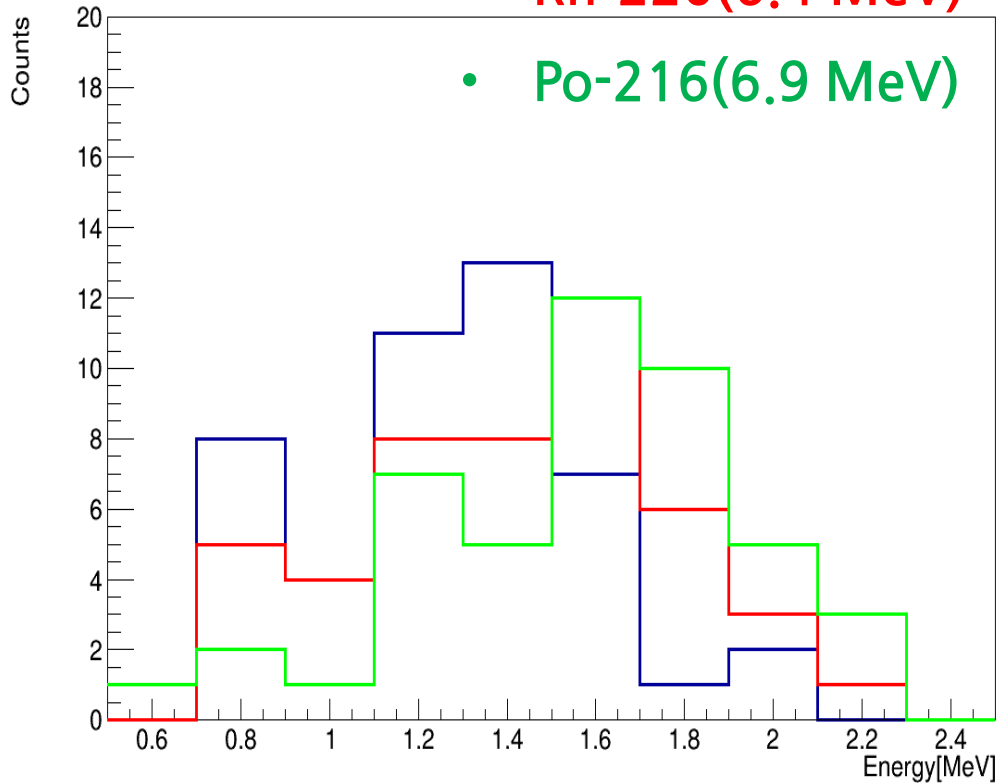
- Energy > 1 MeV
- Energy < 1 MeV



Some low energy(<1 MeV) alpha events are from surface

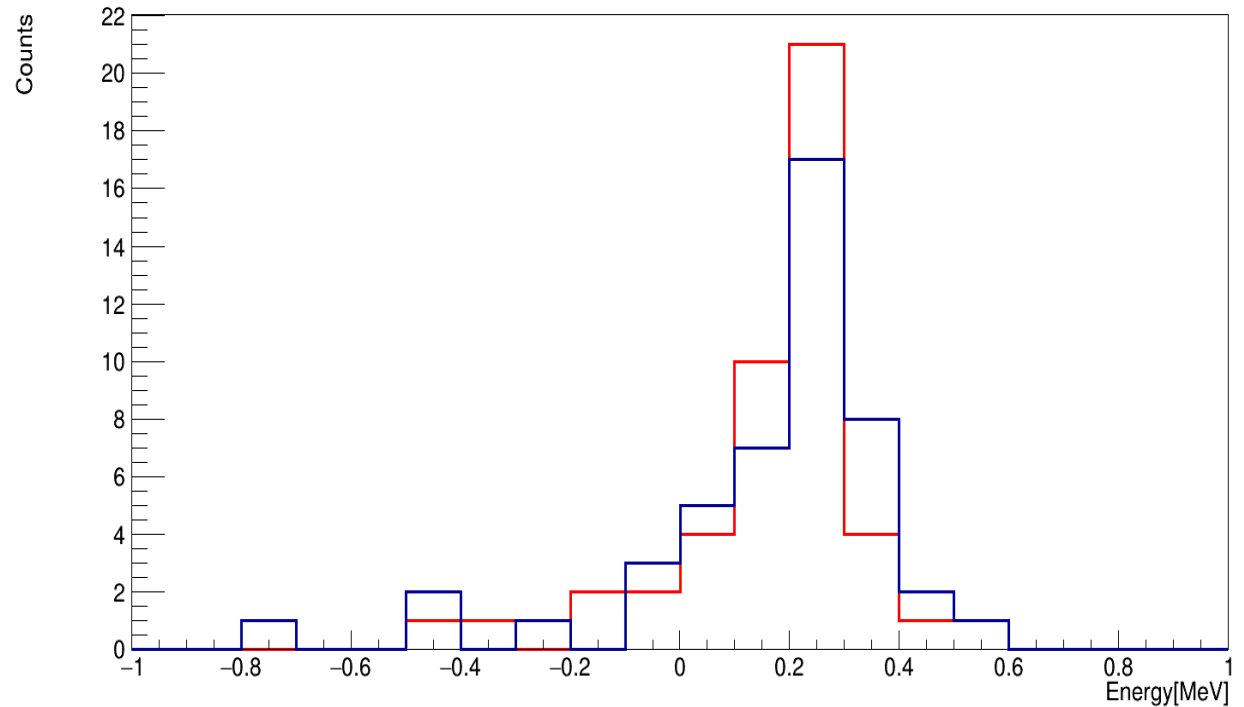
NaI-034 distribution

- Ra-224(5.7 MeV)
- Rn-220(6.4 MeV)
- Po-216(6.9 MeV)



Alpha energy distribution

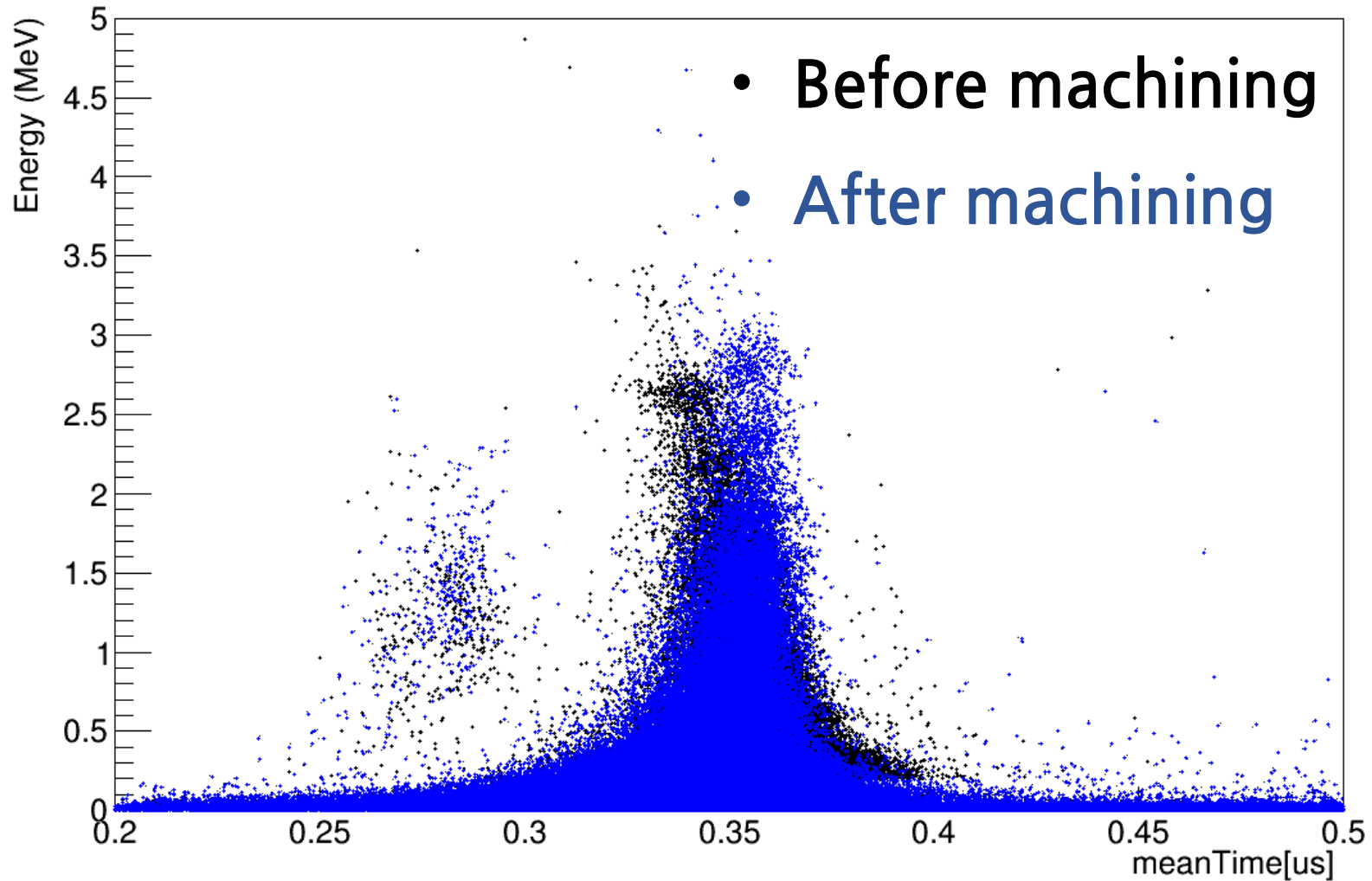
- Rn-220(6.4 MeV) - Ra-224(5.7 MeV)
- Po-216(6.9 MeV) - Rn-220(6.4 MeV)



Alpha-alpha energy difference distribution

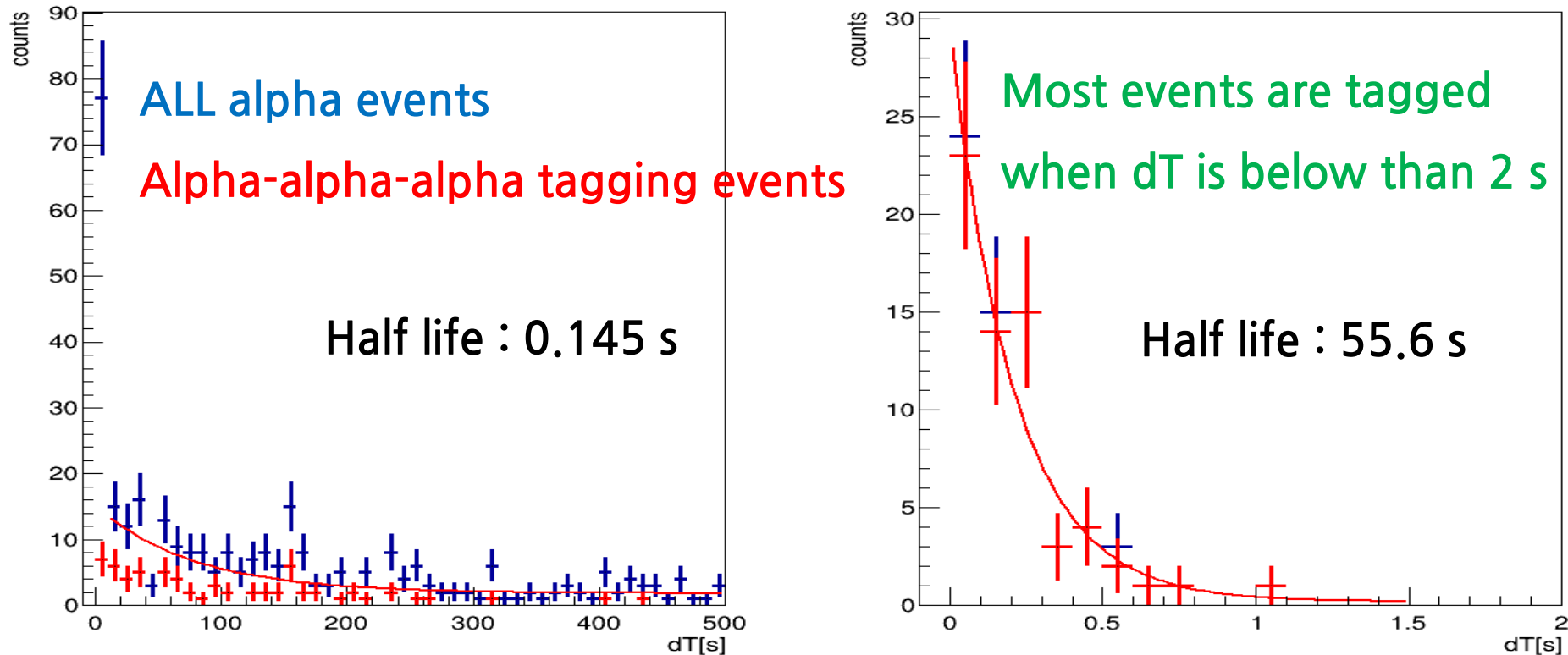
NaI-034 alpha

- Voltage changed 1100 V ,1280 V - > 1050 V, 1150 V



Nal-034 alpha decay time

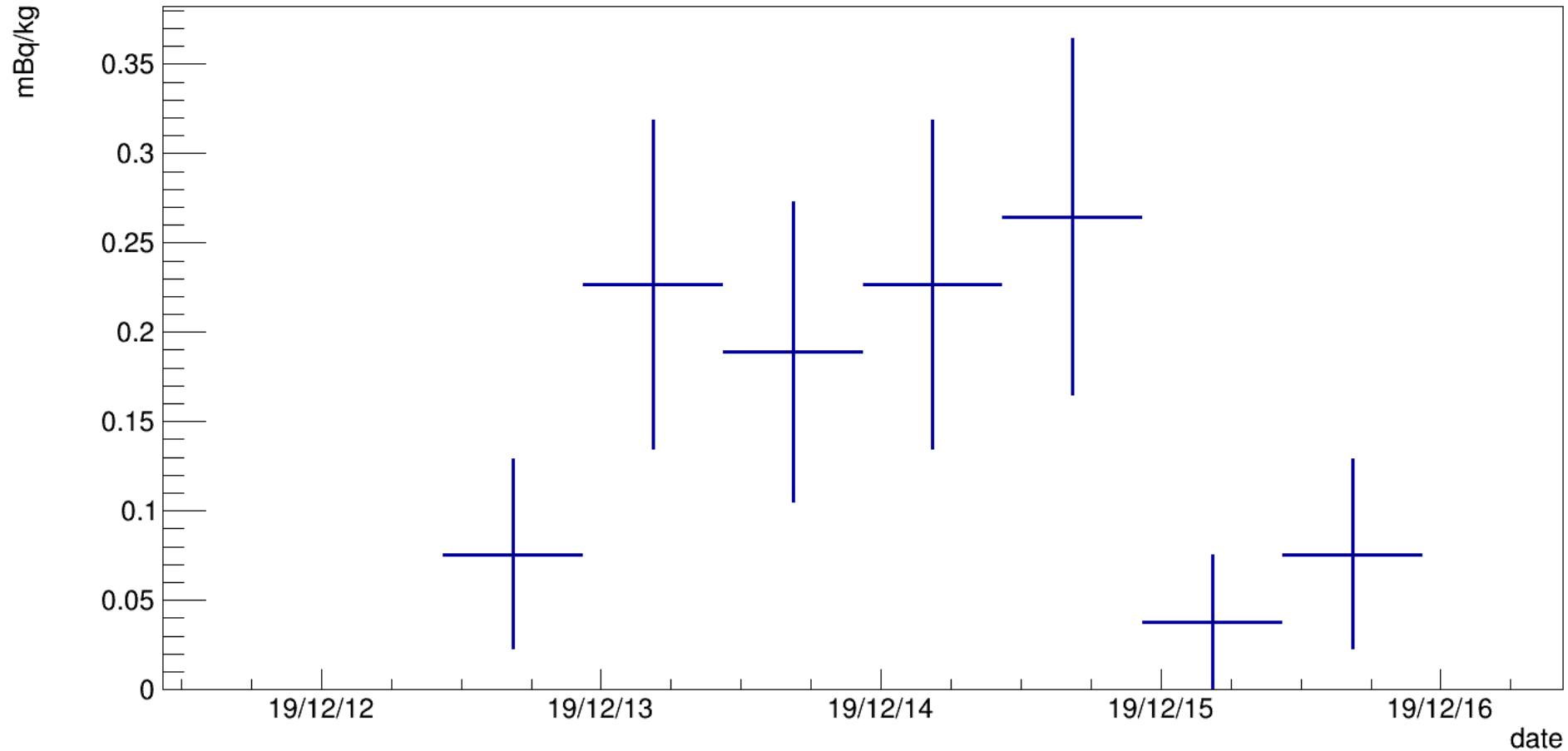
Time difference distribution



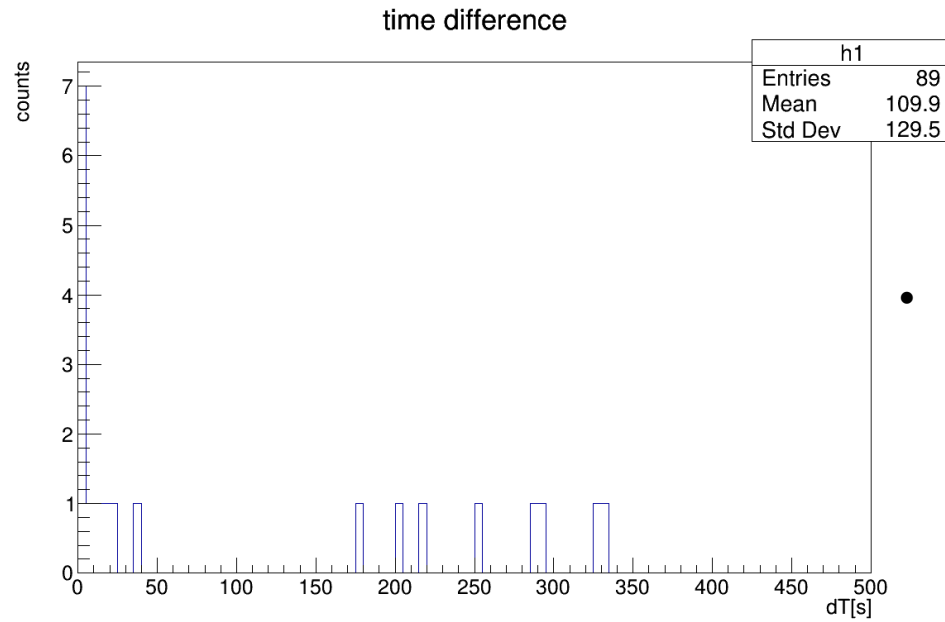
	Activity(uBq/kg)	Conversion to ppt(if th232 is in equilibrium)
Nal-034 Before machining(230 h)	24.8 ± 5.5	6.1 ± 1.4
Nal-034 After machining(520 h)	35.2 ± 5.2	8.6 ± 1.3
Nal-035	11.5 ± 4.7	2.8 ± 1.1

NaI-035 alpha rate

- 82 hours data



Nal-035 alpha rate(Th-232 contamination)



- ~ 20 % alpha events from alpha-alpha-alpha decay in Th232 chain

Backup