Purification Measurement of LS

----Hu Wei on behalf of LS group

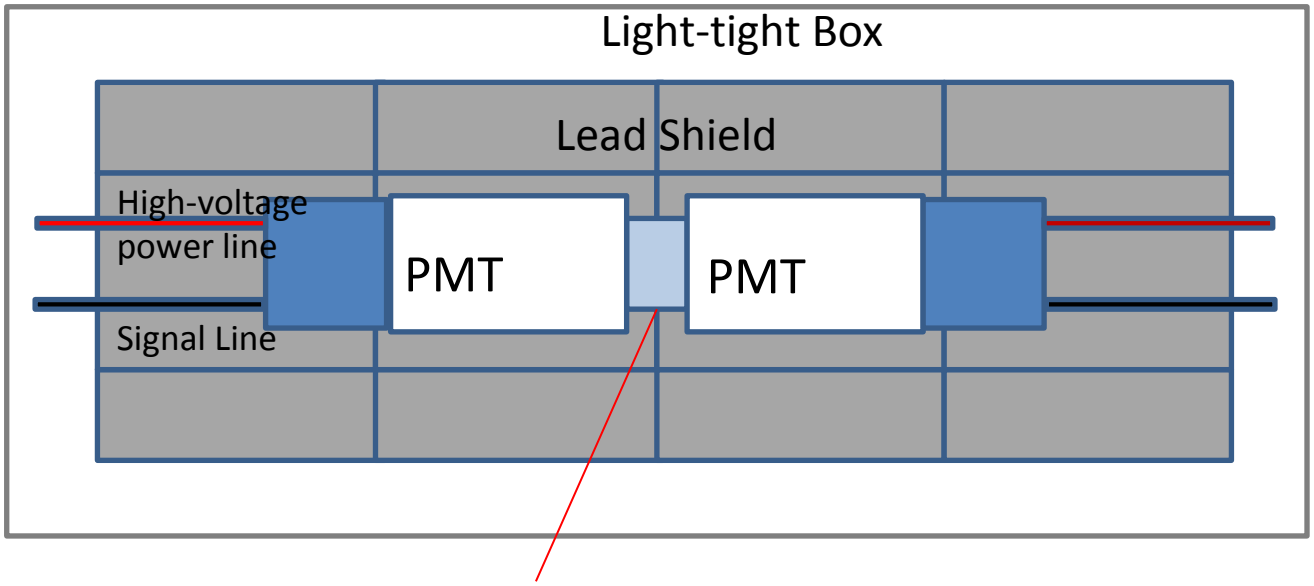
Main Content

- Experiment Purpose
- Experiment Device
- Purification Measurement of Al2O3
- Background Measurement
- Distillation Purification Measurement
- Water Extraction Measurement
- Summary

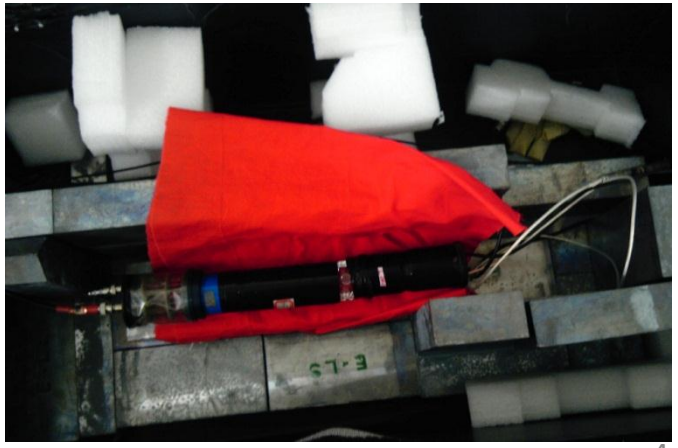
Purpose

- Jiangmen neutrino experiment requires the radioactive background below 10^{-15} g/g of 20kt LS
- To use the radioactive loading method in the lab to measure the efficiency of different purification methods (filtration, distillation, water extraction) .

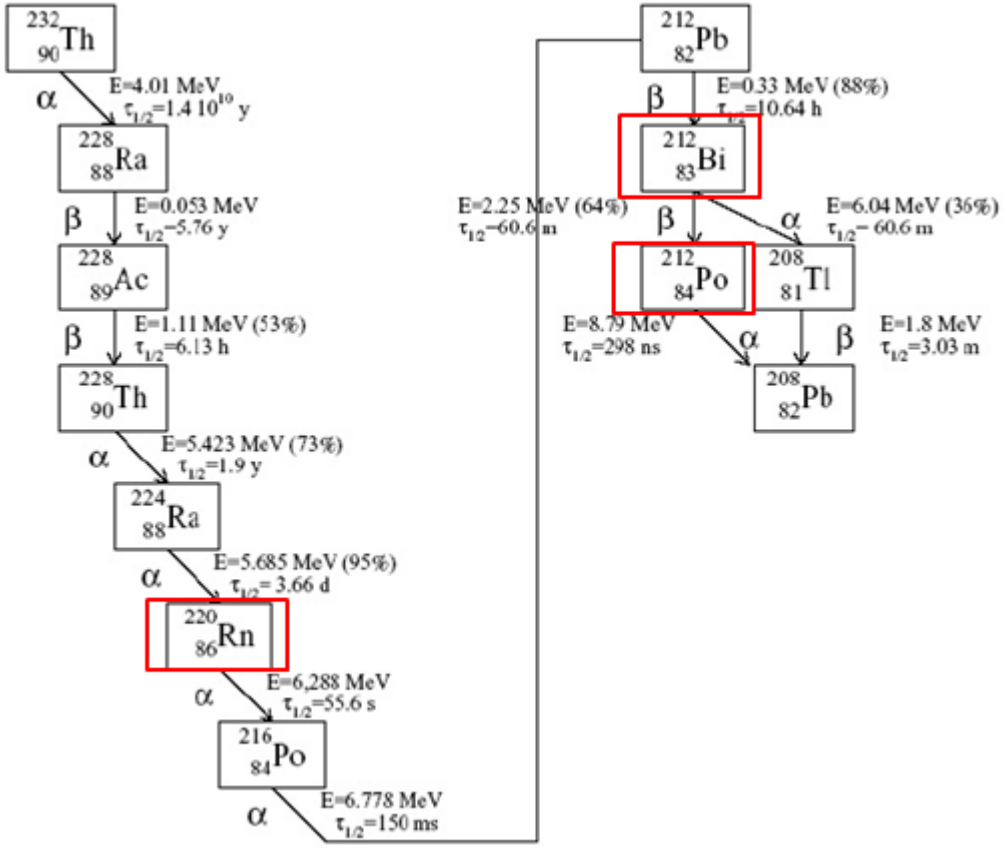
Experiment Device



We conduct the experiment by two PMTs' coincidence measurement.



Device Reliability Test

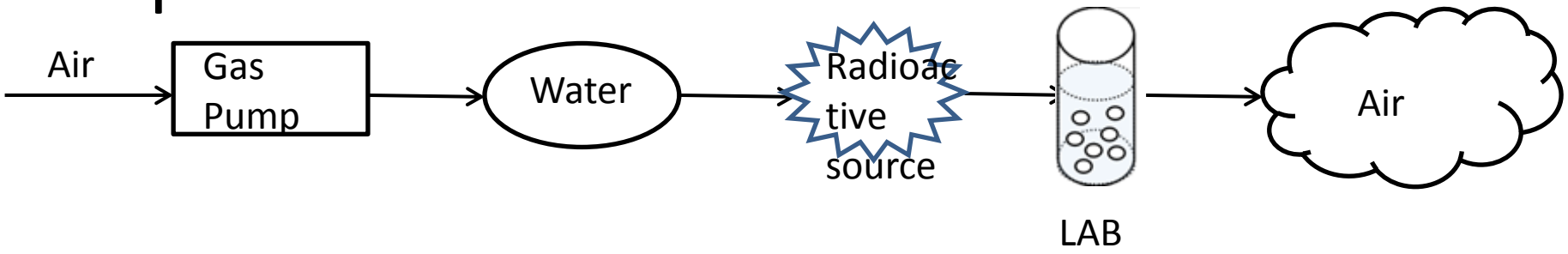


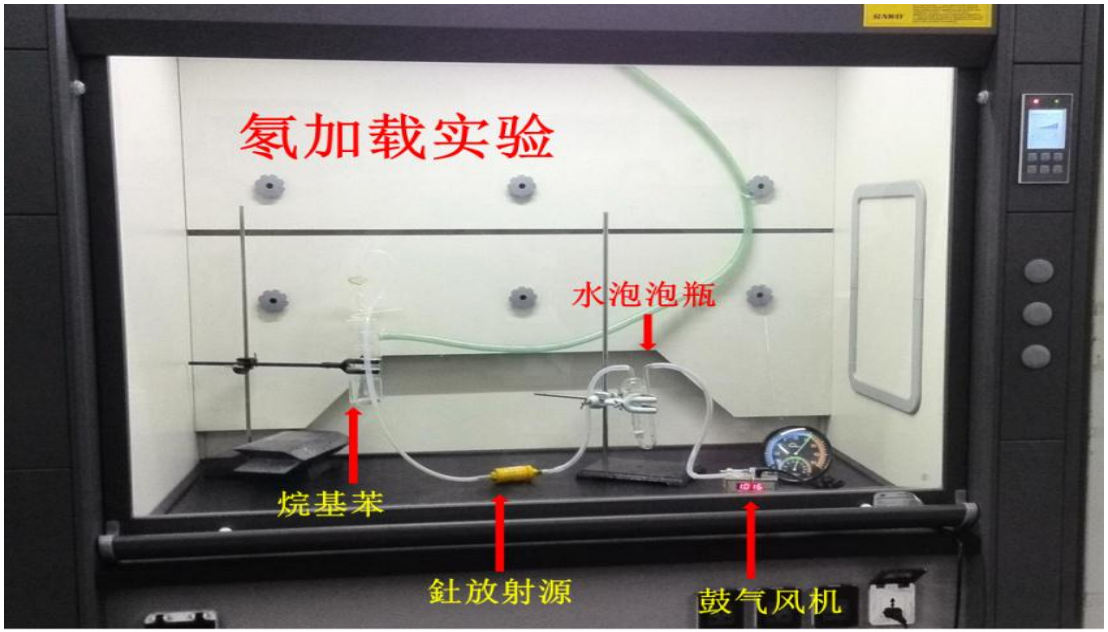
The ^{232}Th decay chain.

To verify the device reliability, we measured the half-life period (10.64h) of Pb212 after bubbling Rn220 into LAB.

^{220}Rn Loading Experiment

Experiment Device

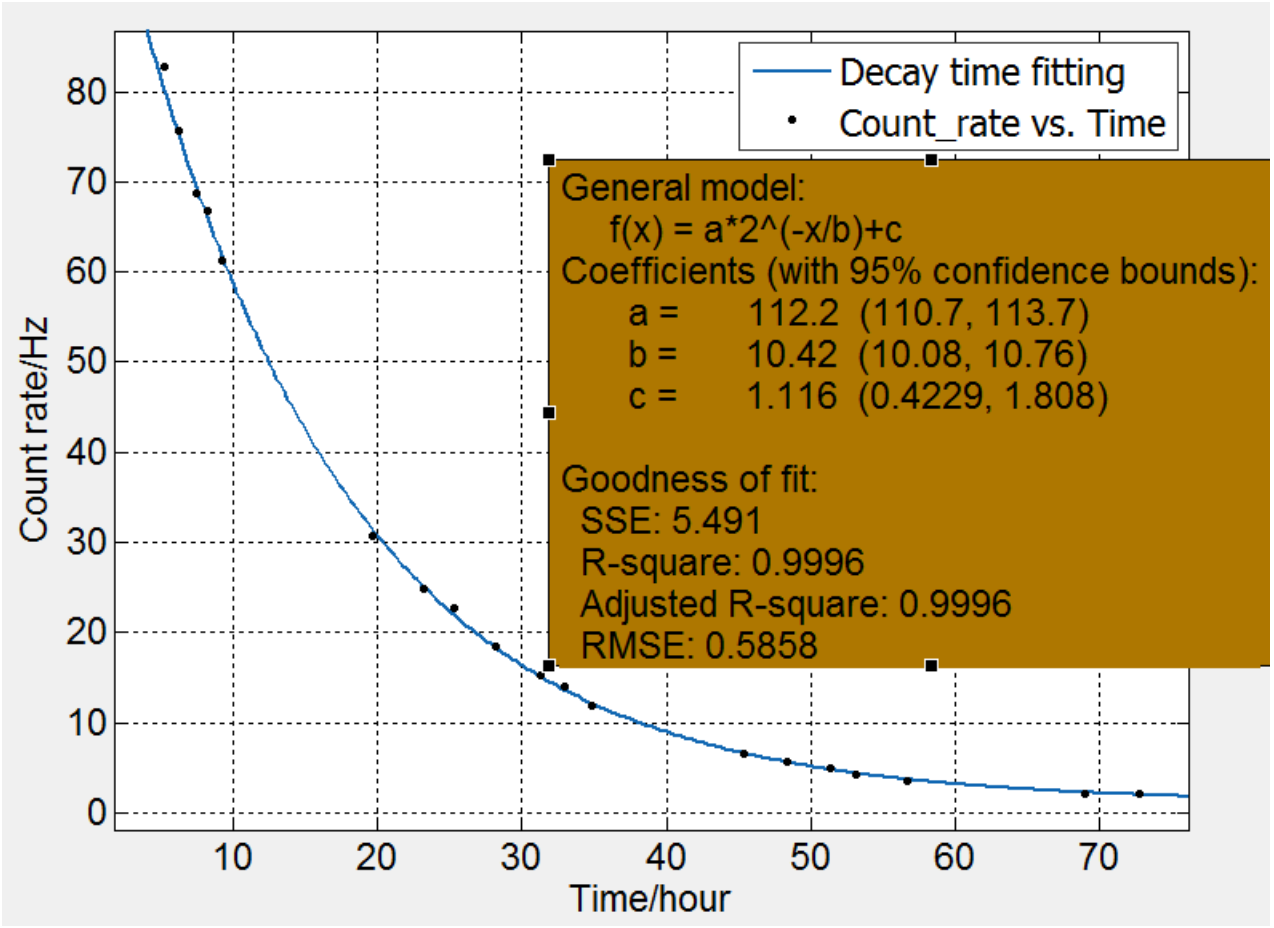




The Decay Measurement of Pb212

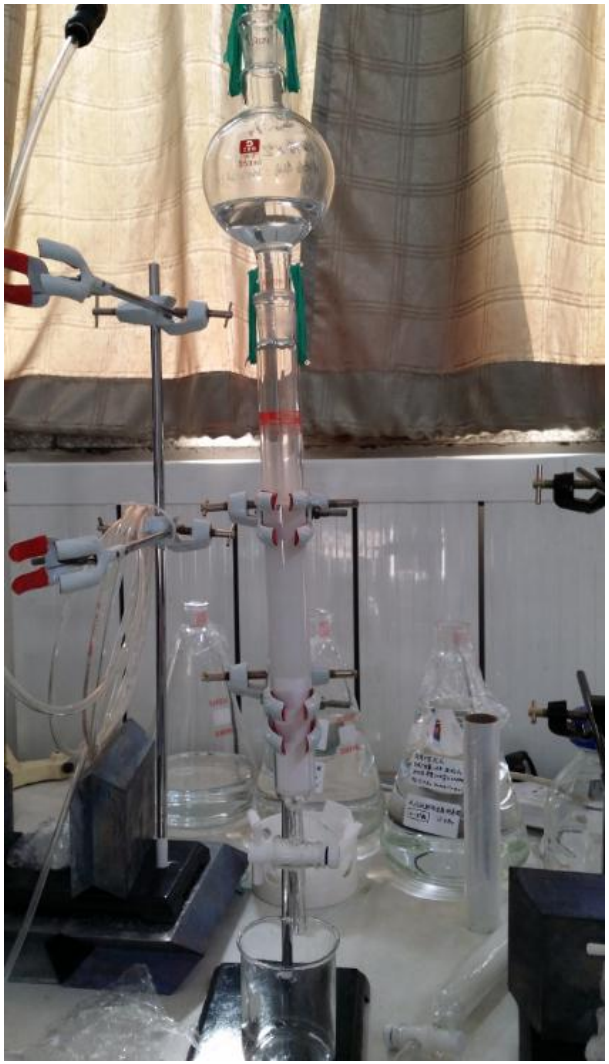
- The gross weight (include the weight of bubbling bottle) is 63.65g
- During the beginning 9hours, we took data at an interval of 1hour,and then at different intervals from April 10^{th} to April 13^{th},2014.
- Using external trigger, 40mV threshold, using counter-module

Counting-rate VS Time



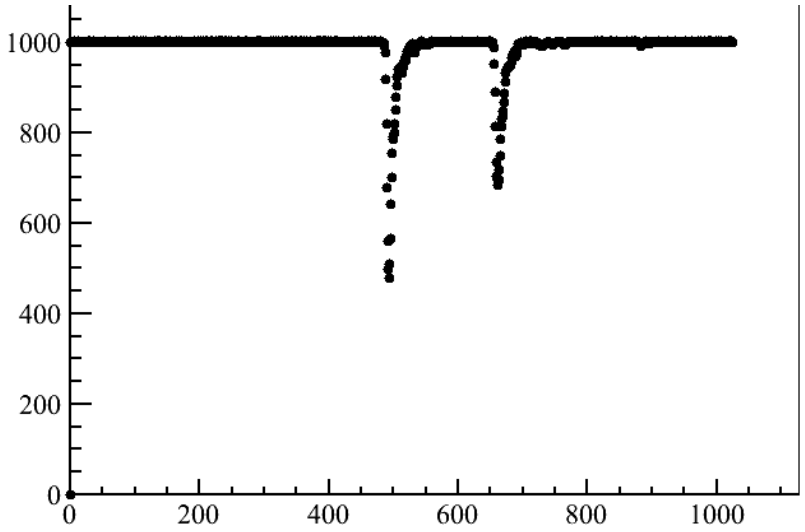
- The fitting result of half-life period is 10.42h, which is consistent with the standard number 10.6h in the decay chain. The bias is only 1.7%.
- Reliable!

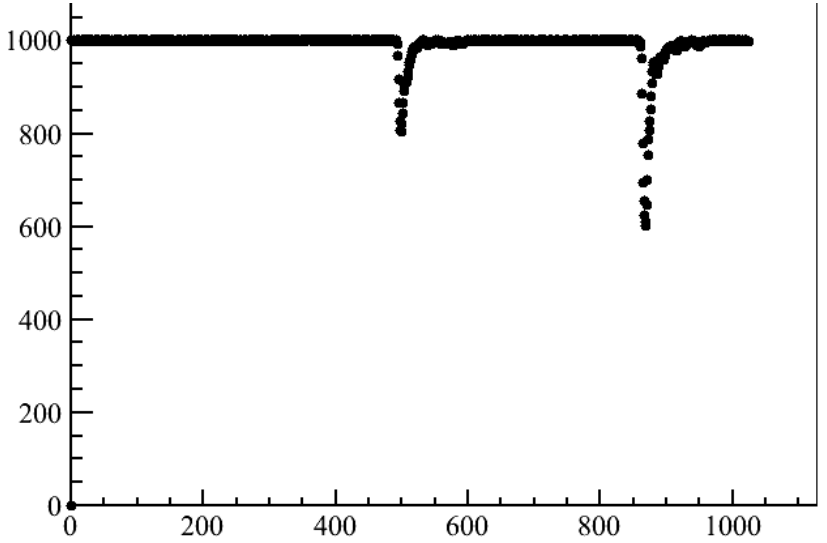
Purification Measurement of Al2O3

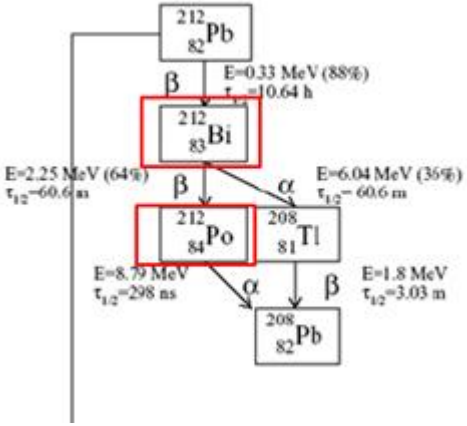


- Before purification, bubble Rn220 into LAB
- Al2O3 after drying under high temperature（122g）， the filling volume is 20cm high
- Purification Weight: LAB 180.5g, Time: 1.5h, N2 Pressure: 0.04MPa
- Measurement quantity: 17.10 g Time: 30min

Event Pulse



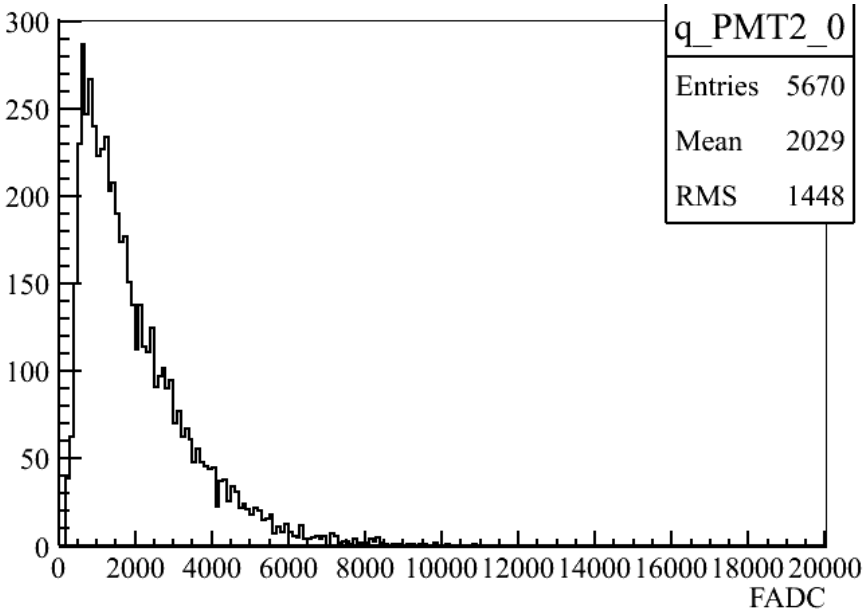




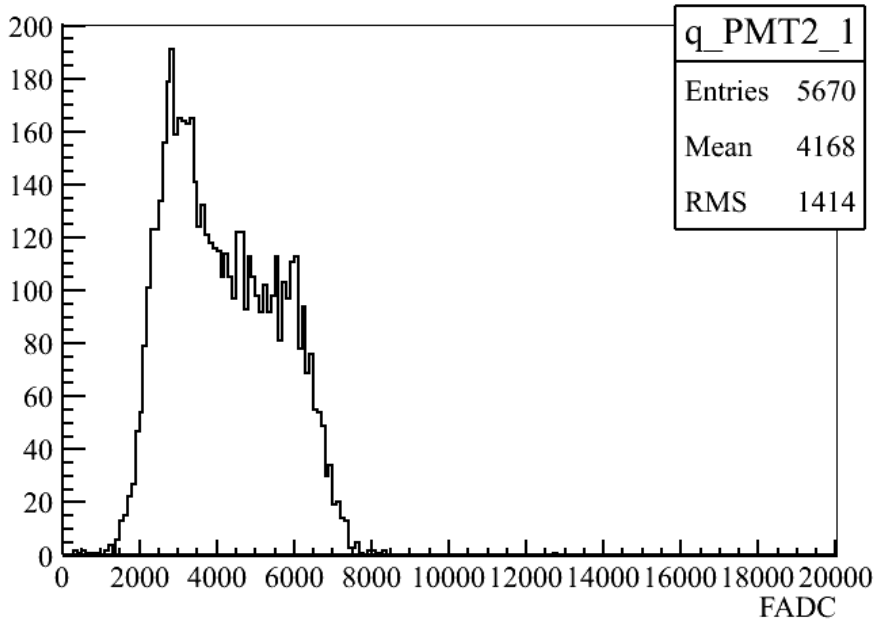
These double pulses are from the branch-chain Bi212----Po212------Pb208. Using double pulses counts, the background can be largely reduced and decreases the influence on real event

Analysis of Al2O3 Purification

- Before Purification

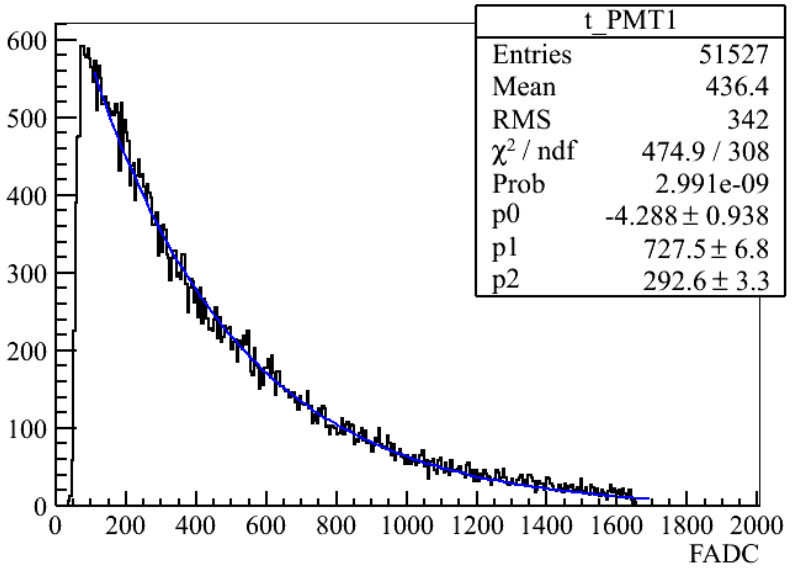


The integral value of the first pulse in right PMT. They are β decay event.

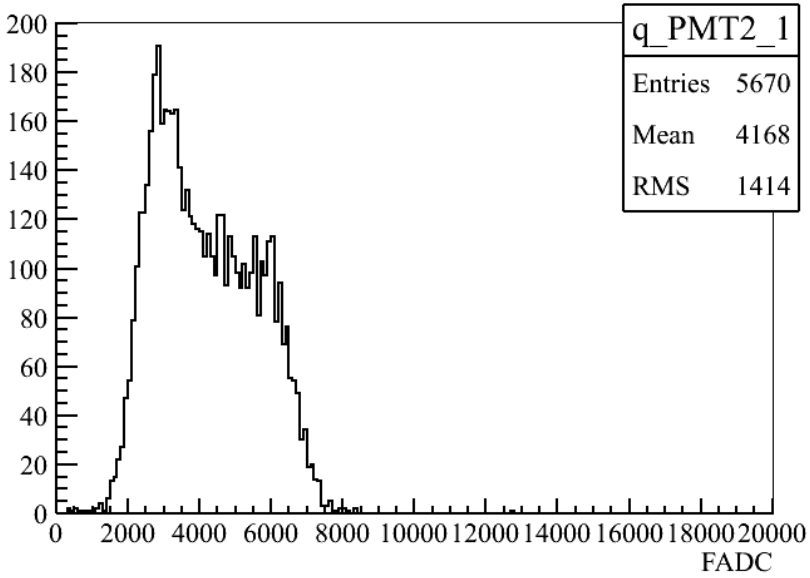


The integral value of the second pulse in right PMT. They are α decay event.

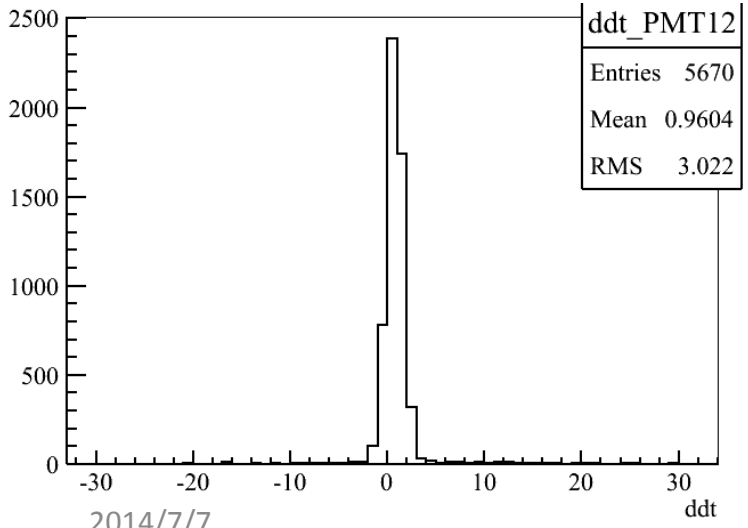
- Before Purification



The time gap of Double pulses



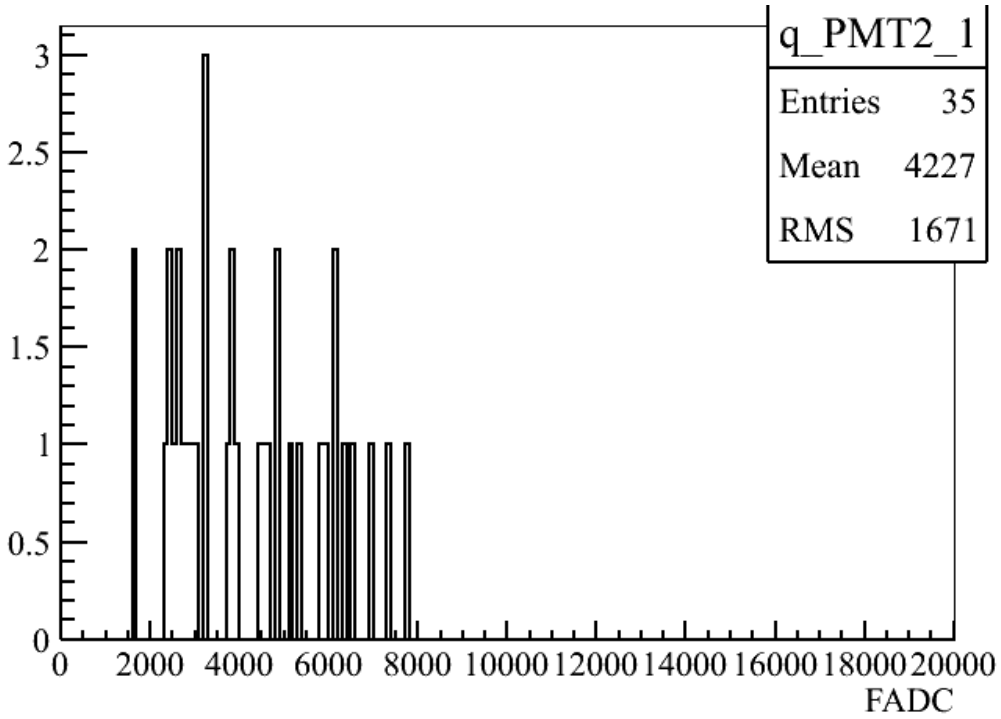
The integral value of the second pulse



The delta time of two PMTs ' double-pulse gap

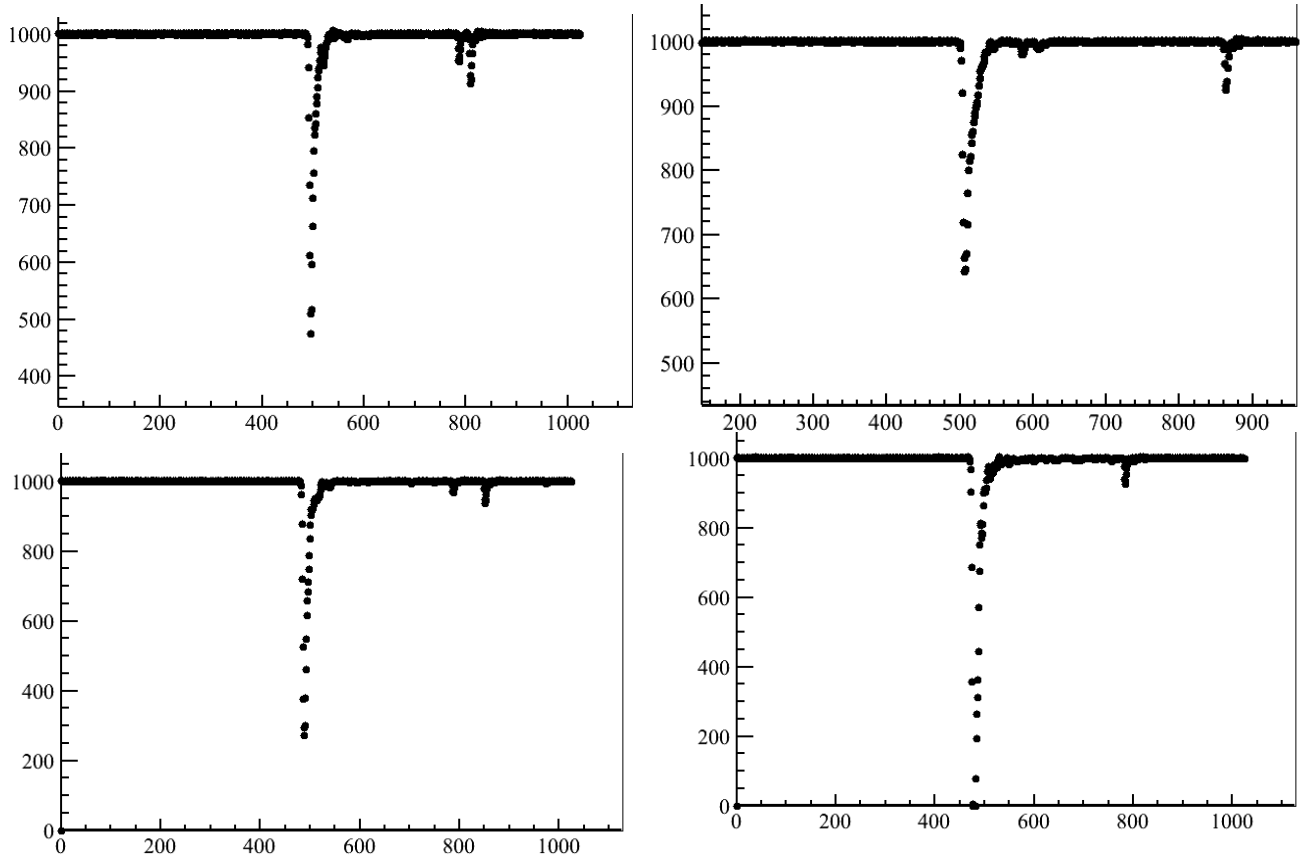
- Date taking time: 30min，The amount of LAB: 17.1g，Double-pulse event number :5670, total number: 65538，
- The delta time of two PMTs ' double-pulse gap are mostly between (-5ns ,5ns),exactly (-2ns, 4ns)
- The integral values of the second pulse are mostly larger than 1500

- After purification

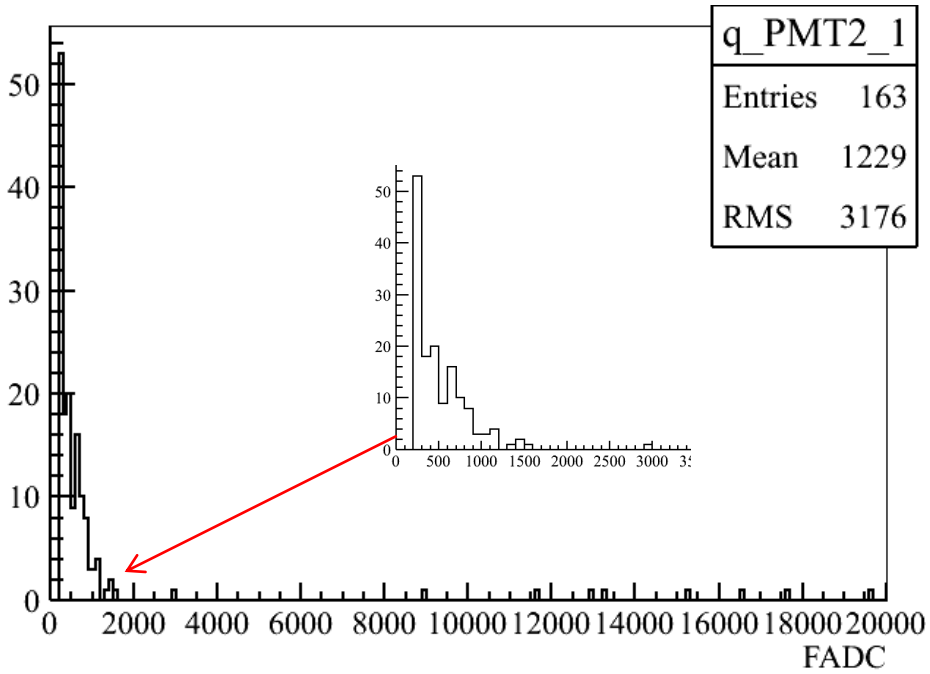


Total event number:1454，double-pulse number:35

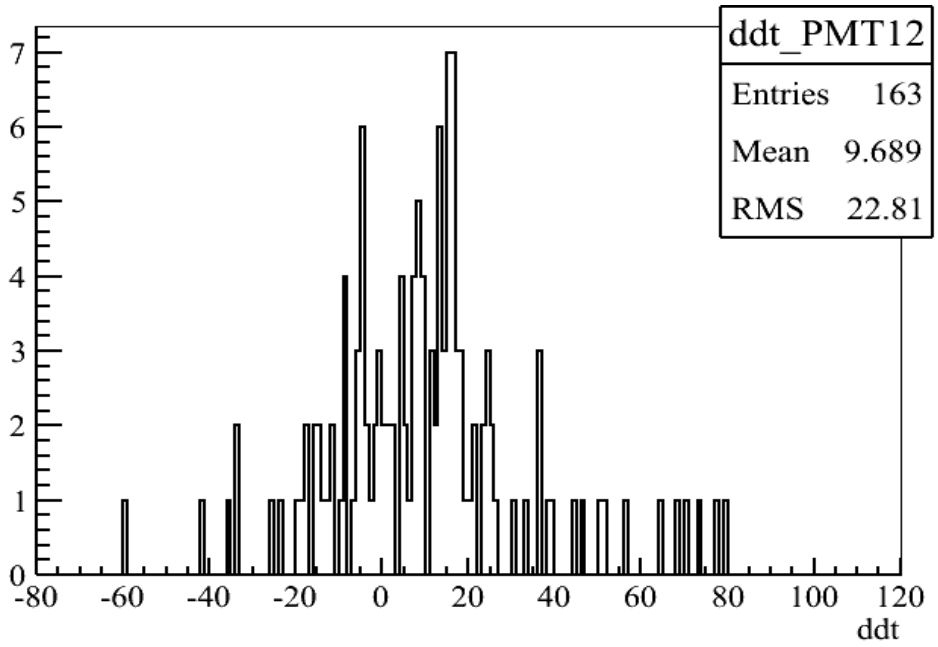
Background measurement



- Data taking time: 23h
- These double or event triple pulse events are found in background measurement



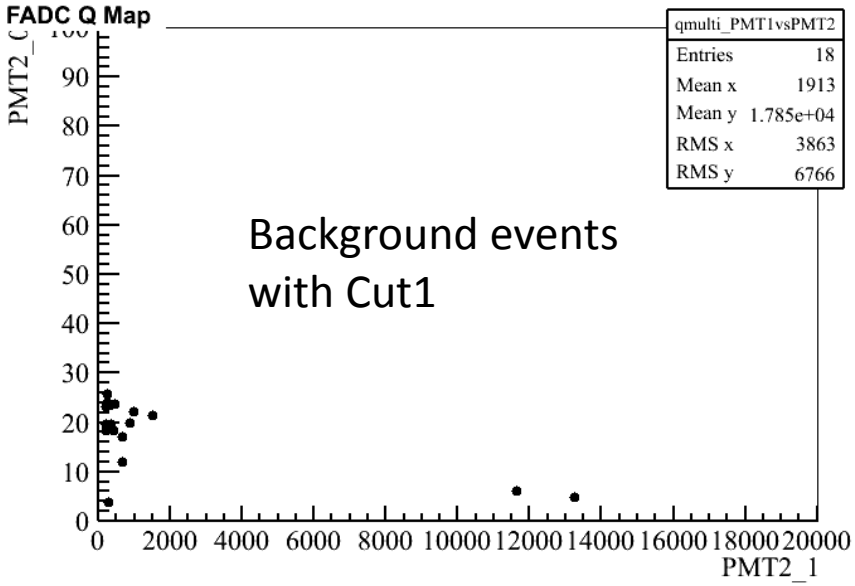
The integral value of the second pulse

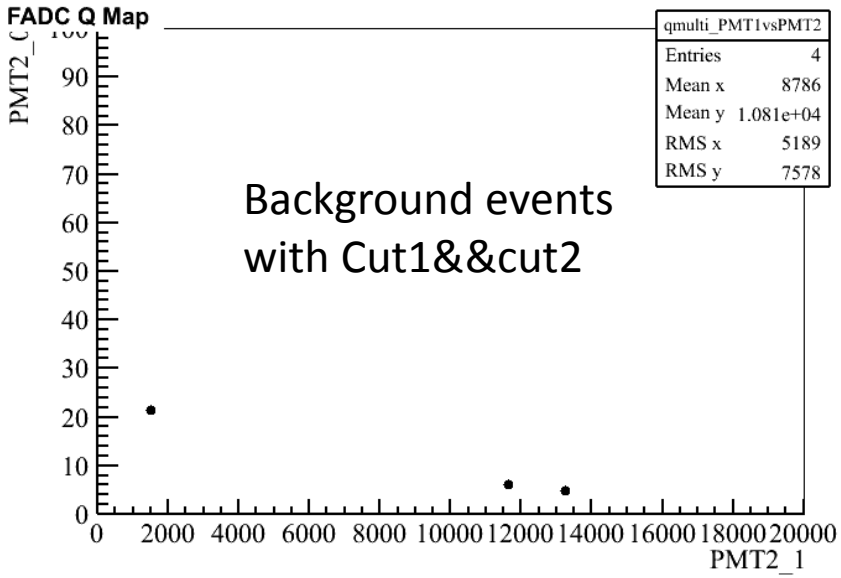


The delta time of two PMTs ‘ double-pulse gap

- Double(triple) pulses：163，total event number：21561
- The integral value of the second pulse is almost less than 1500
- absolute value of the delta time of two PMTs ‘ double-pulse gap is almost larger than 5ns

Cuts

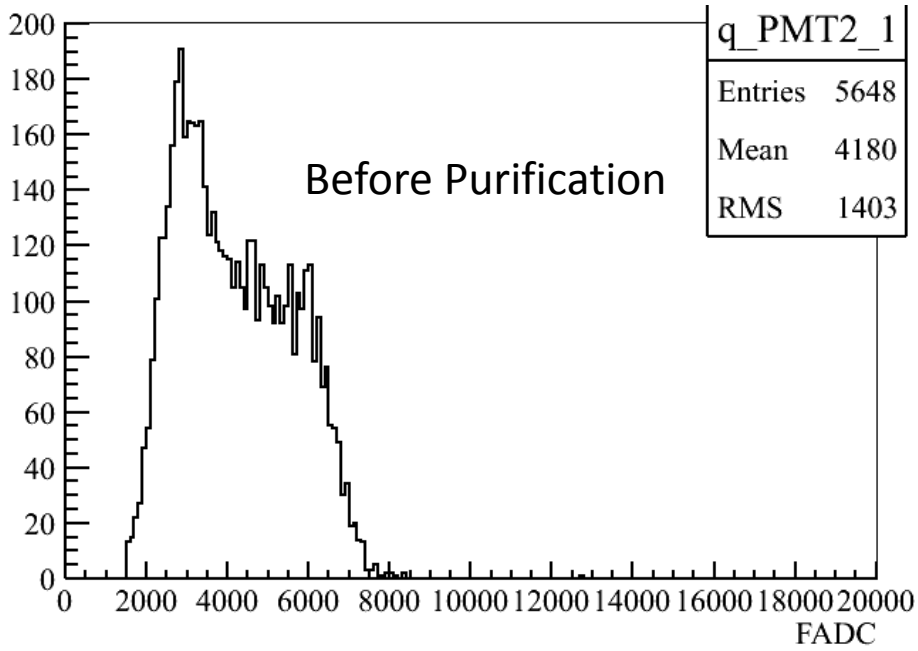


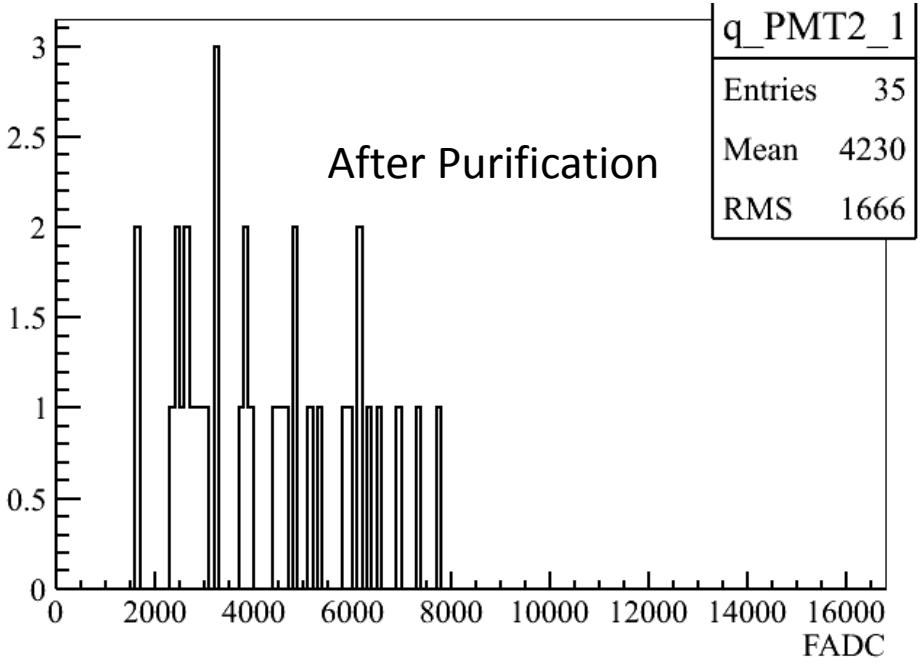


- Cut1:|the delta-delta time|<5ns
- Cut2:The integral value of the second pulse>1500

- After using cut1: double pulses number decreases to 18
- After using these 2 cuts, double pulse number is only 4
- That is 0.1739 background per day.
- If using -2<cut1<4 and cut2>1700, double pulses number becomes to be 2 per day.
- The next several measurements take -2<cut1<4 and cut2>1700

Analysis of Al2O3 Purification with cuts





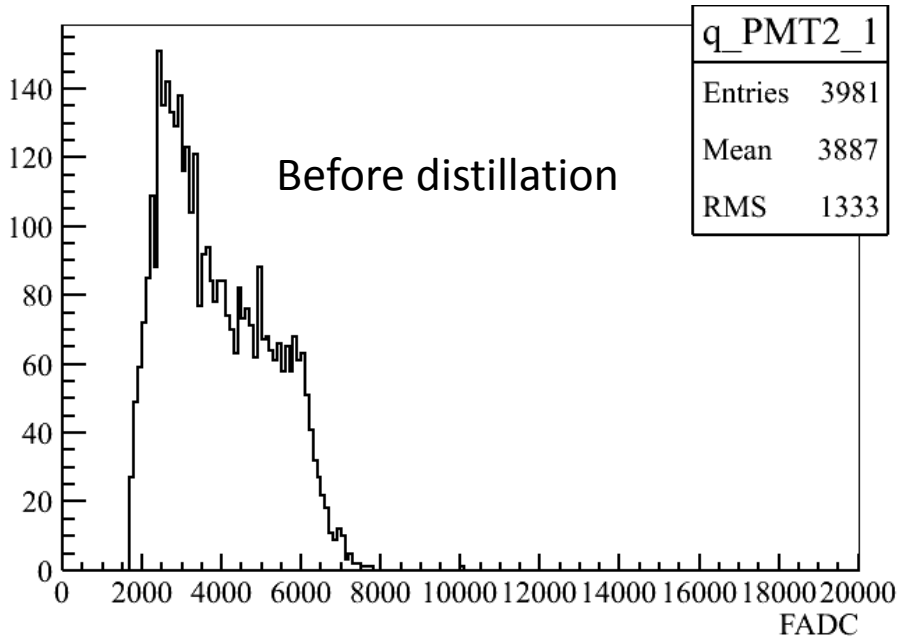
- Using -2<cut1<4 and cut2>1700, double pulses number becomes to be 33.
- · $\text{Efficiency} = \left(1\text{-}\frac{C_s}{C_f}\right)\times 100\%$, purification coefficient $K_d = \frac{C_f}{C_S}$

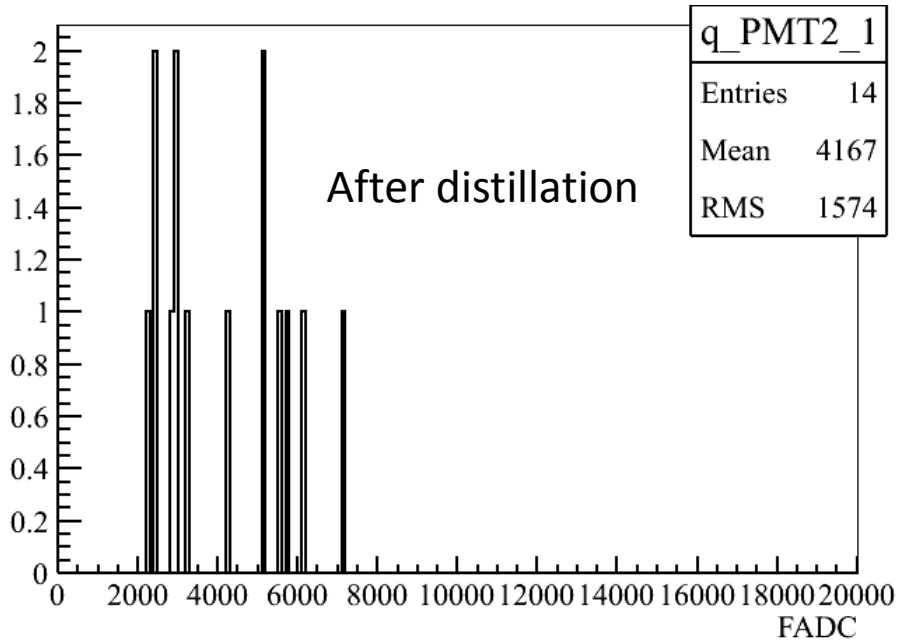
  C_s :event number before purification, C_f :event number after purification
- The radioactive material decreases 99.41%, purification coefficient is 161.
- Kamland: the purification coefficient is 150 with porous silica adsorption of ^{210}Pb.

Distillation purification measurement

- Before distillation, bubbling Rn220 into LAB for about 22 hours
- Distillation time: about6.5h
- Data taking time: 30min，LS amount: 17.10g

Distillation result





cascade decay event number is 3981， while total event number is 42897

cascade decay event number is 14， while total event number is 860

- The radioactive material decreases 99.64% and purification coefficient 284.
- SNO+'s purification coefficient is about 300.

Distillation（with Al_2O_3）

- 173.18gLAB(204ml)+2g Al_2O_3
- Distillation time: 8hours, data taken time: 60mins.
- Before distillation: total event number 66043,double pulse event number 10849
- After distillation: total event number 1297,double pulse event number 2
- The radioactive material decreases 99.98%，purification coefficient 5424.
- SNO+:40ml LAB+0.1g Al_2O_3, purification coefficient：9480（~10^4）

Water extraction purification

Bubbling Rn220 into Dayabay LS for about 24h， then using magneton for water extraction experiment. The water resistivity is 18 MΩ

- different stirring speed, the same stirring time

40ml water with 40ml Dayabay LS, different stirring speed

NO.	component	Stirring speed r/min	Stirring time /min
1	40.04gwater +34.42g LS	1200	5
2	40.03g+34.39g	1200	10
3	40.00g+34.43g	1200	1
4	40.05g+34.41g	1000	1
5	40.00g+34.44g	800	1

Water extraction result

NO.	Data taking moment	Stirring speed and data taking time	Total event number	Double pulse event number	Double pulse event number normalized to the time of first line
	14:52	/	158218	18158	18158
1	15:36	1200, 5	19922	2530	2636
2	16:11	1200, 10	21898	2843	3098
3	16:45	1200, 1	19905	2424	2740
4	18:02	1000, 1	32449	4006	4923
5	18:36	800, 1	51498	6213	7924

- There is some water in No1 sample, so the total event number is a little small
- The radioactive matter decreases 84.91% after water extraction
- SNO+ water extraction efficiency is about 82%~ 87% for ^{212}Pb

Water extraction purification

- the same stirring speed, different stirring time

35ml water with 35ml Dayabay LS

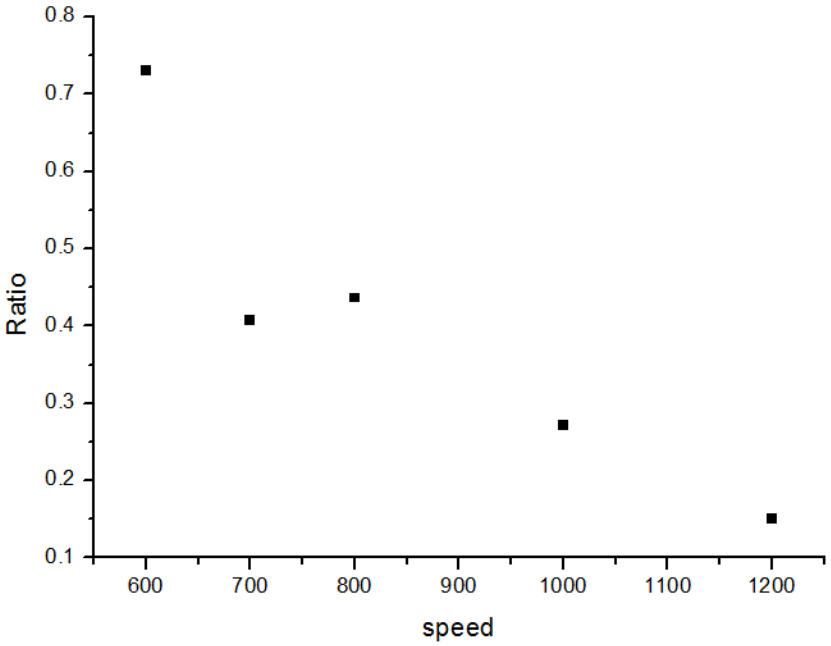
NO.	component	Stirring peed r/min	Stirring time/min
1	35.01gwater +30.10g LS	700	1
2	35.02g+30.09g	600	1
3	35.00g+30.11g	600	2
4	35.01g+30.11g	600	4
5	35.00g+30.12g	600	8
6	35.00g+30.12g	600	16
2	35.02g+30.09g	600	32

result

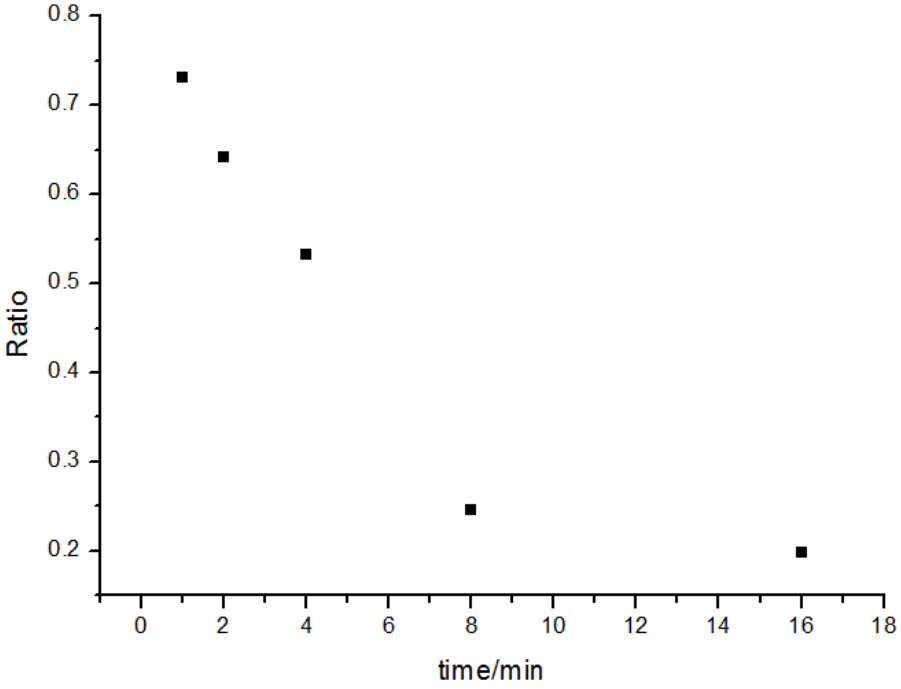
NO.	Data taking moment	Stirring speed and data taking time	Total event number	Double pulse event number	Double pulse event number normalized to time of the first line
Sample without extraction	14:59	/	57911	5529	5529
1	15:20	700, 1	20106	2202	2252
2	15:40	600, 1	37496	3864	4039
3	15:57	600, 2	28574	3335	3551
4	16:17	600, 4	23681	2704	2943
5	16:38	600, 8	10713	1221	1359
6	17:07	600, 16	9705	953	1095
7	18:18	600, 32	6467	595	737

- The radioactive matter decreases 88.67% after water extraction

- Ratio=event number after extraction / event number before extraction



Stirring speed VS efficiency， water extraction time is 1min



water extraction time VS efficiency， stirring speed is 600r/min

Summary

- We measured the efficiency of several different purification methods: for Al2O3 efficiency is 99.4128%， for distillation efficiency is 99.6483 % and for water extraction efficiency is 88.6703%
- We need more efforts in purification research.

THANK YOU!