Liquid scintillator purification

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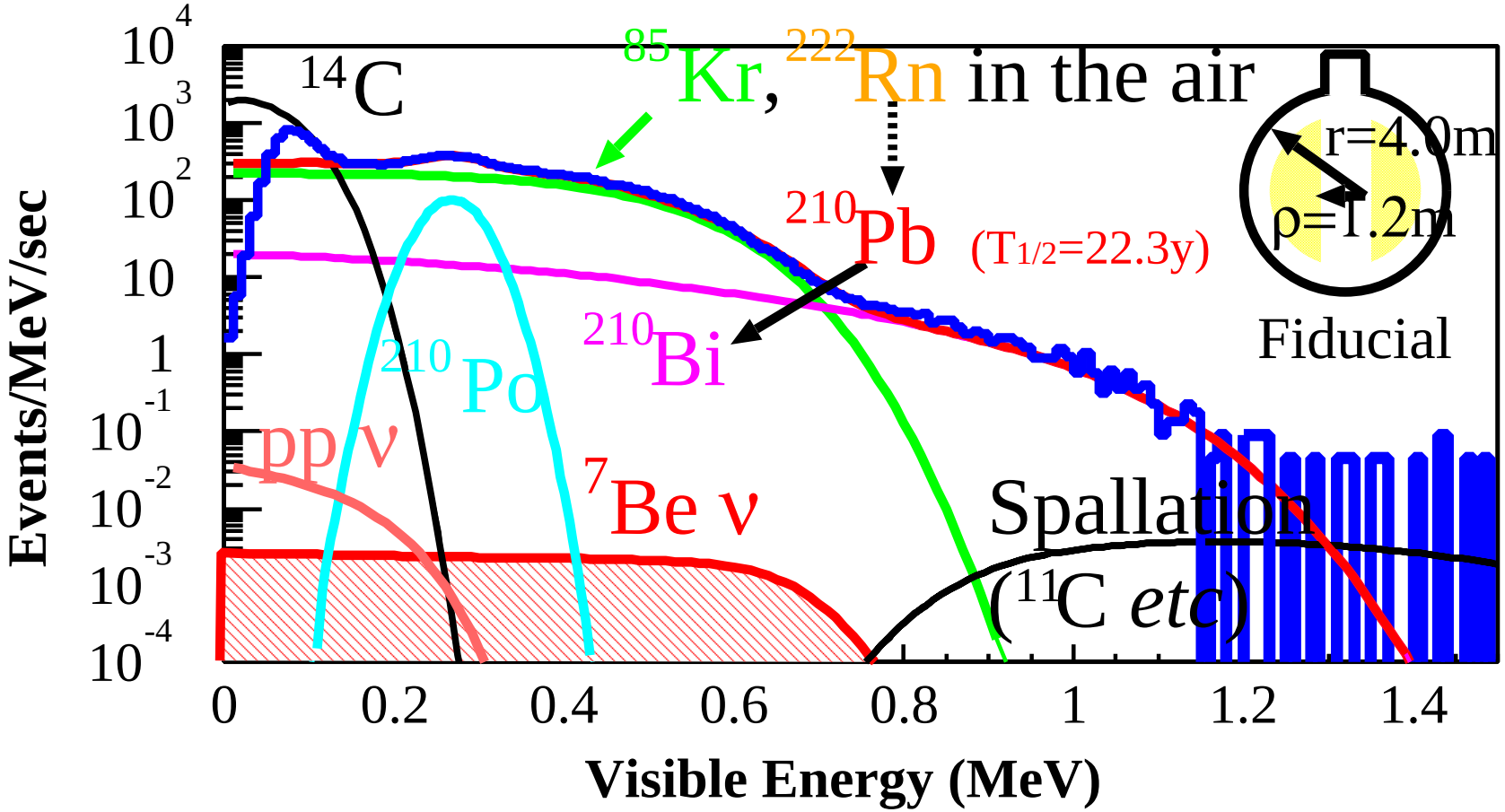
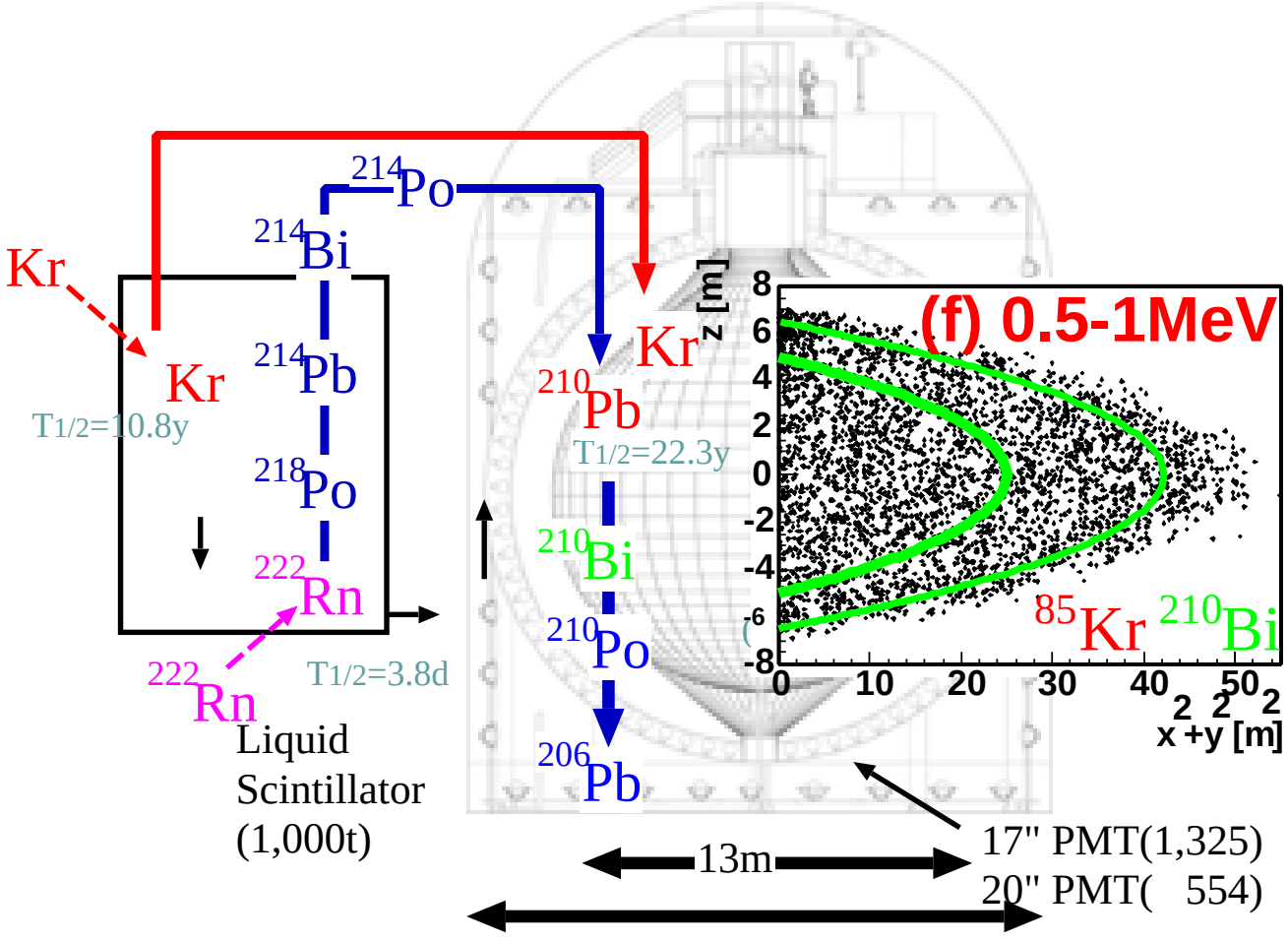
Contents

Energy spectrum

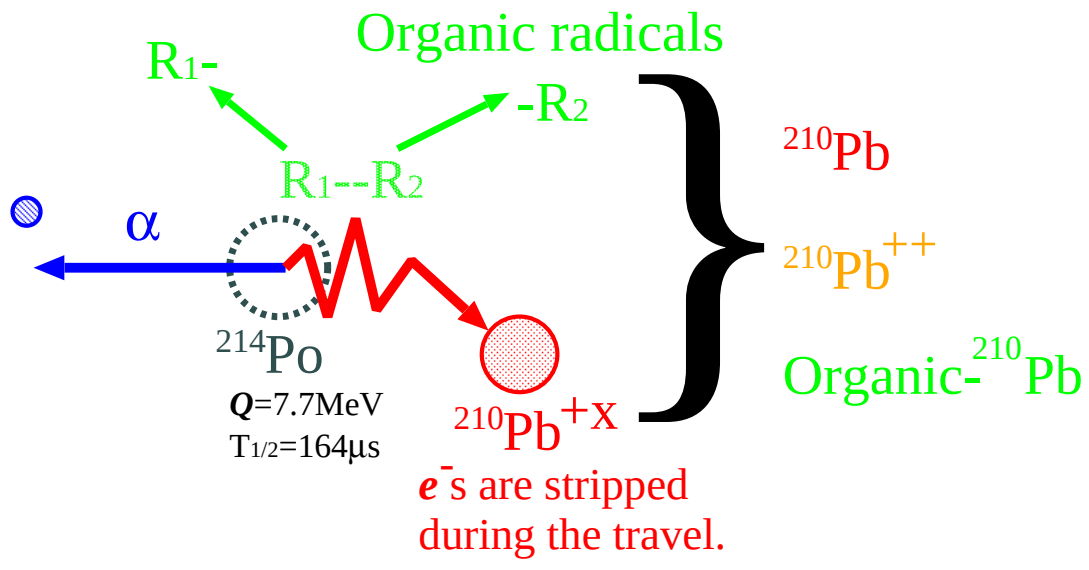


Vertex distribution at low energy region



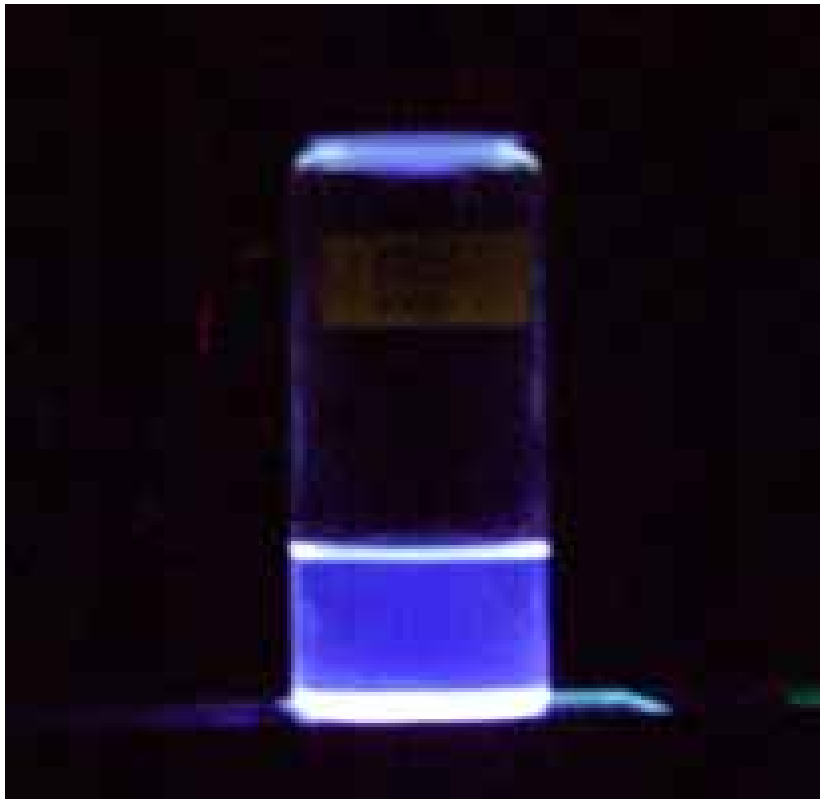
Chemical forms of ^{210}Pb and ^{85}Kr

- ^{210}Pb ...
  - metal (^{210}Pb)
  - ion (^{210}Pb^{++})
  - organic-^{210}Pb
- ^{85}Kr ... gas (^{85}Kr)



How to purify KamLAND liquid scintillator

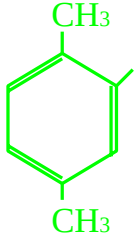
- Candidates
  - Distillation
  - Adsorption
  - Gas purge
  - *etc.*
- Issues
  - Reduction efficiency
  - Attenuation length
  - Light yield



Distillation technique

We can distill off various impurities.
But KamLAND LS is made of three chemical components...

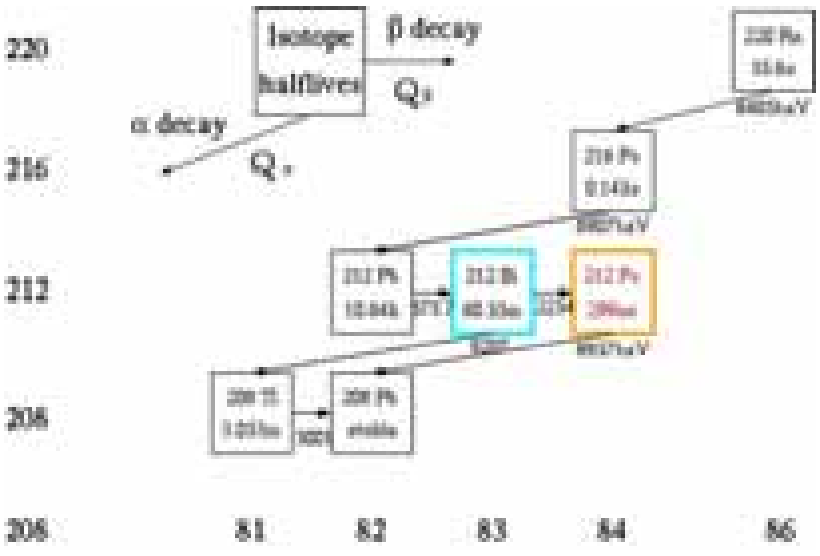
$CH_3\text{-}(CH_2)_{10}\text{-}CH_3$ n-Dodecane — 80%



1, 2, 4-trimethyl-benzen [Pseudo-cumen] — 20%

2, 5-diphynil oxazole [PPO, DPO] — 1.5g/*l*

Experimental procedure for Pb purification

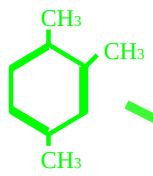


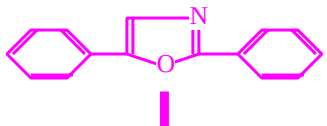
$^{210}Pb \approx {}^{212}Pb$ in LS

Bubbling ^{220}Rn

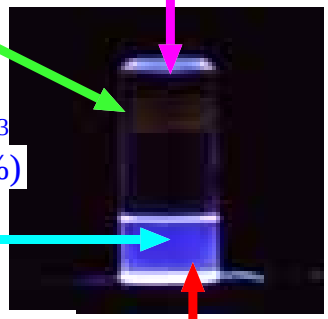
PPO(1.5 or 6.0g/*l*)

PC(20%)





CH_3-$(CH_2)_{10}$-CH_3
n-dodecane(80%)



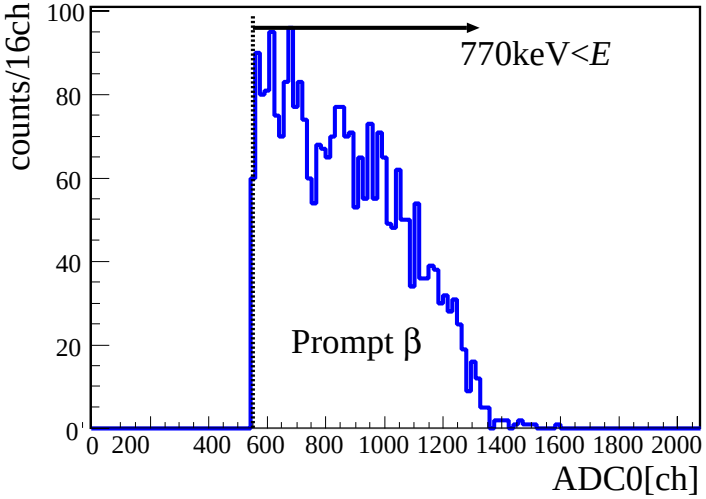
Distillation

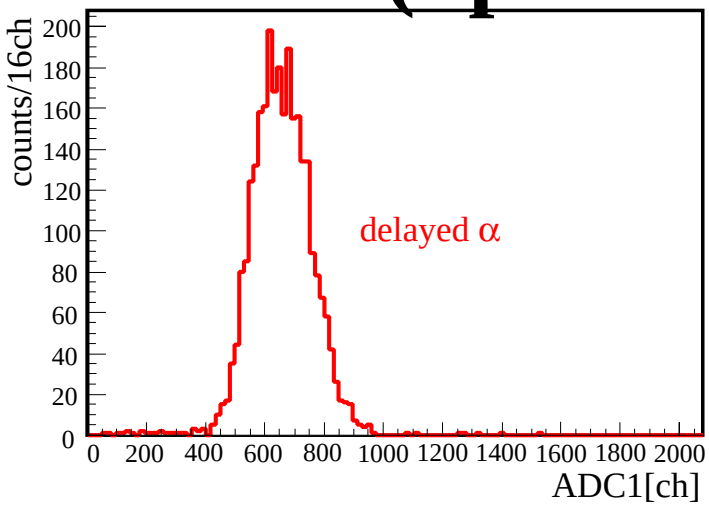
Let's start distillation !

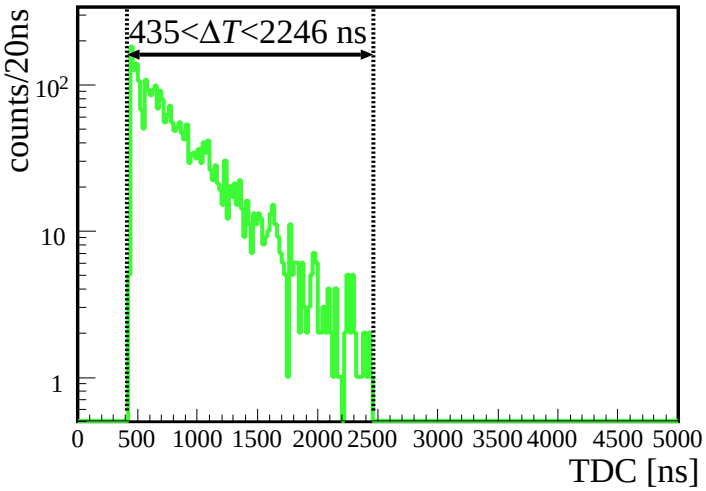
$P = 300\text{hPa},$

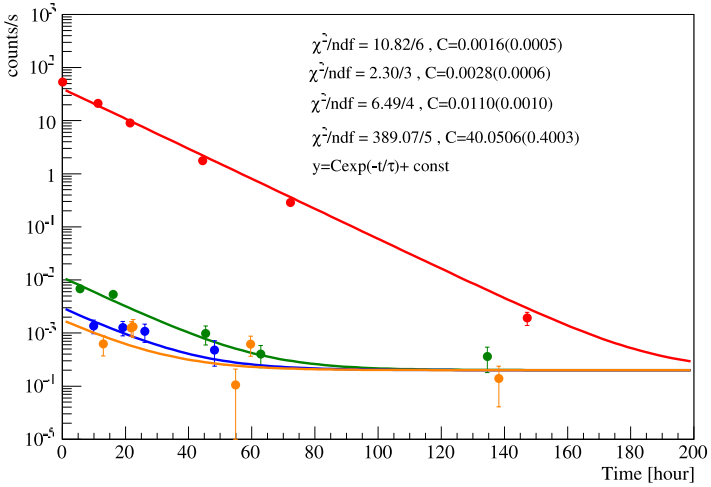
$T = 144°\text{C}$

Results of dodecane distillation (Spectrum)









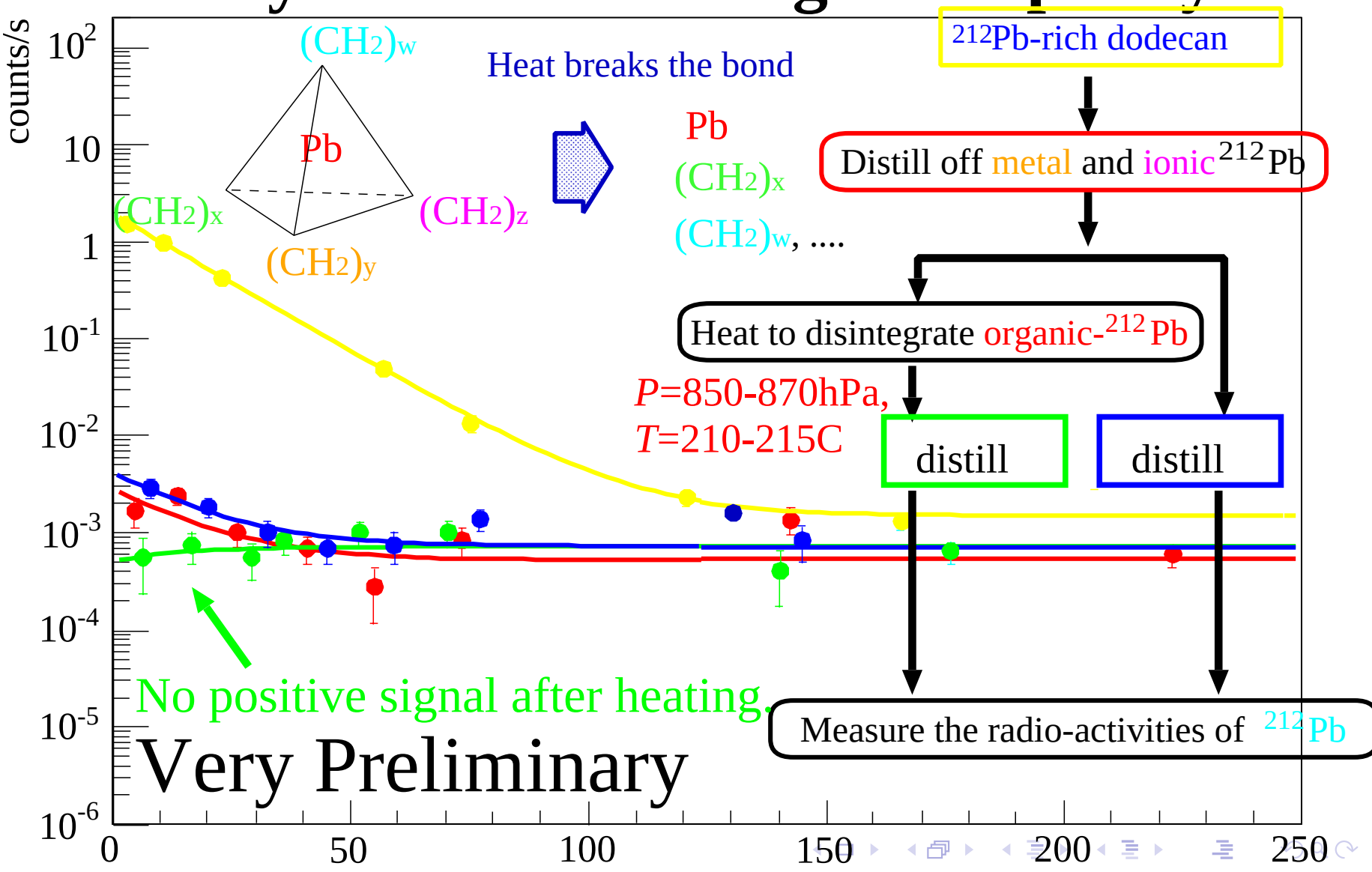
Summary of dodecane distillation

	First	Third	Fifth	Seventh
trial 1	2.7×10^{-4}	7.0×10^{-5}	4.0×10^{-5}	
trial 2	1.6×10^{-4}	4.1×10^{-5}	4.1×10^{-5}	
trial 3	1.3×10^{-4}	2.9×10^{-5}	4.3×10^{-5}	
trial 4	1.3×10^{-4}		3.0×10^{-5}	3.1×10^{-5}
trial 5	5.3×10^{-4}		6.4×10^{-5}	4.3×10^{-5}
trial 6	2.7×10^{-4}		3.4×10^{-5}	3.2×10^{-5}

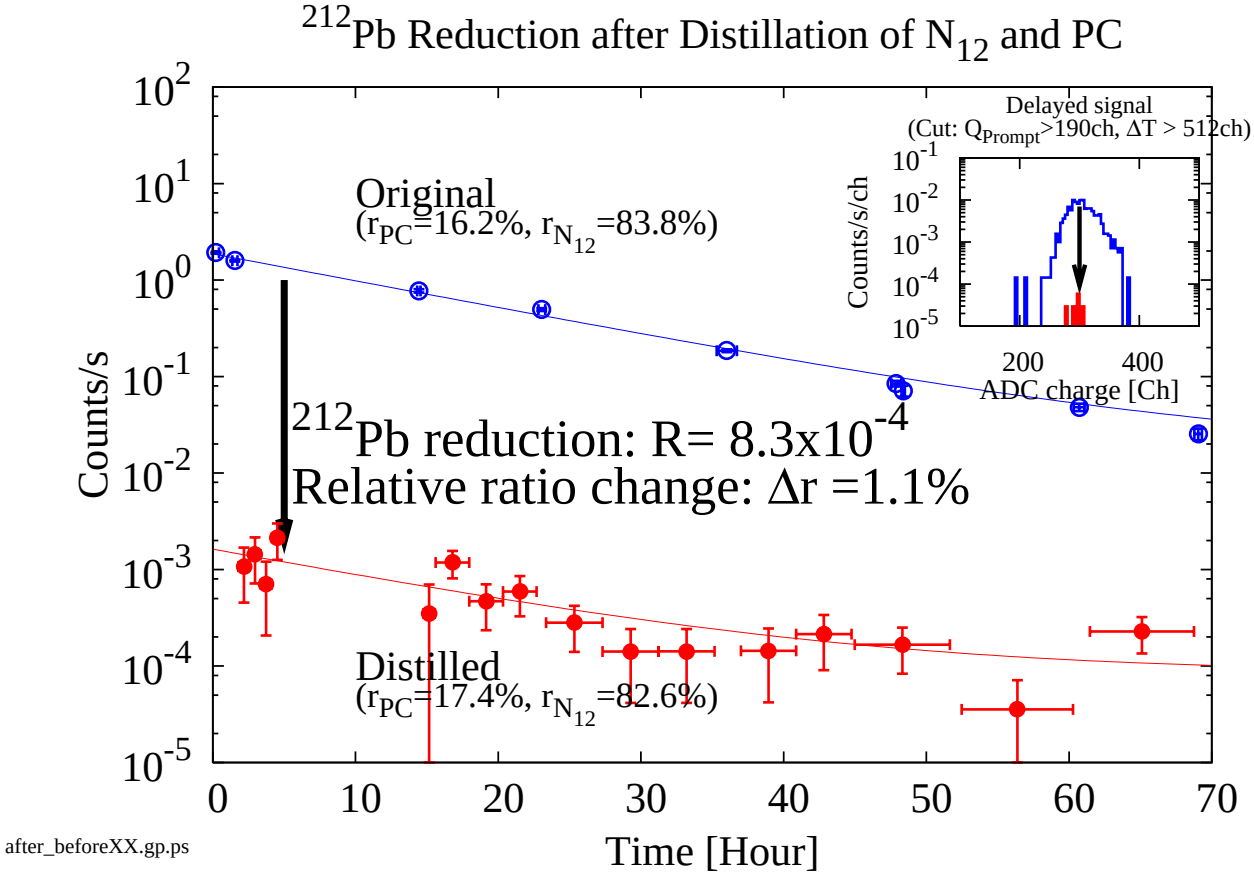
3×10^{-5} after 7th distillation

PPO concentrations in the orange and green lines are $1.5\mathrm{g}/\ell$ and $6.0\mathrm{g}/\ell$, respectively.

Preliminary result on heating LS to purify LS



Results of dodecane + PC distillation



Distillation of the chemical compound is also effective.

PPO are added to distilled mixture to make LS.

Liquid scintillator properties after distillation

LS made of individually distilled PPO, PC, and dodecane has no difference on the LS properties from that made of commercial components.

- Attenuation length: L[m]

Sample	L at 365nm	L at 436nm
LS (Original)	1.4 ± 0.5	12.7 ± 0.4
LS (Distilled)	1.0 ± 0.3	11.2 ± 0.4

- Light yield: ADC Charge Q of ^{137}Cs Compton edge

Sample	Q[ch]
LS (Original)	1392 ± 4
LS (Distilled)	1401 ± 7

Remaining issues on distillation technique

No big problems are found in the distillation technique.

- High reduction efficiency
- No negative effects on LS properties

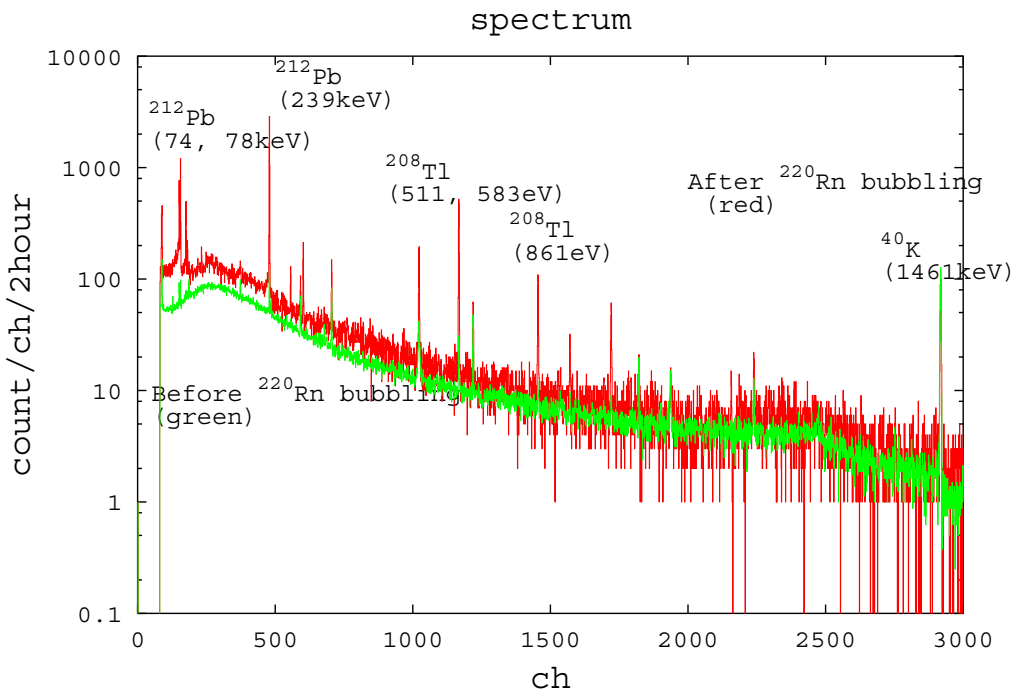
Issues are :

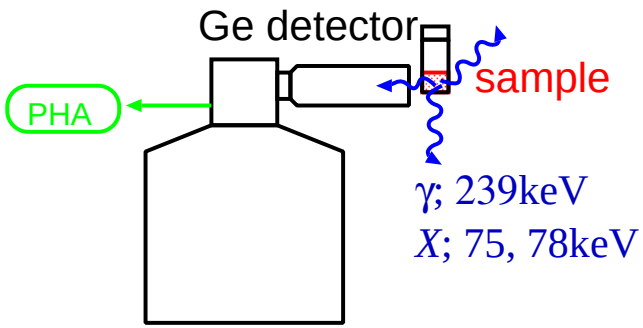
- Gas reduction efficiency (Very preliminary: $R < 10^{-4}$ for ^{222}Rn)
- LS mixture distillation (How to treat PPO)

Adsorption technique

Merit of the Adsorption technique

- Easy and safe
- Effective for metal and ion.





Results of adsorption technique

- The best reduction

Sample	Reduction R
Selecto Si-Gel (32-63mum)	$19.1 \pm 0.5_{\text{stat.}} \pm 1.5_{sys.}$
Selecto Alusil 70	$27.0 \pm 0.7_{\text{stat.}} \pm 2.9_{sys.}$
Crushed Cu/Mn Ctalyst	$26.3 \pm 0.7_{\text{stat.}}$

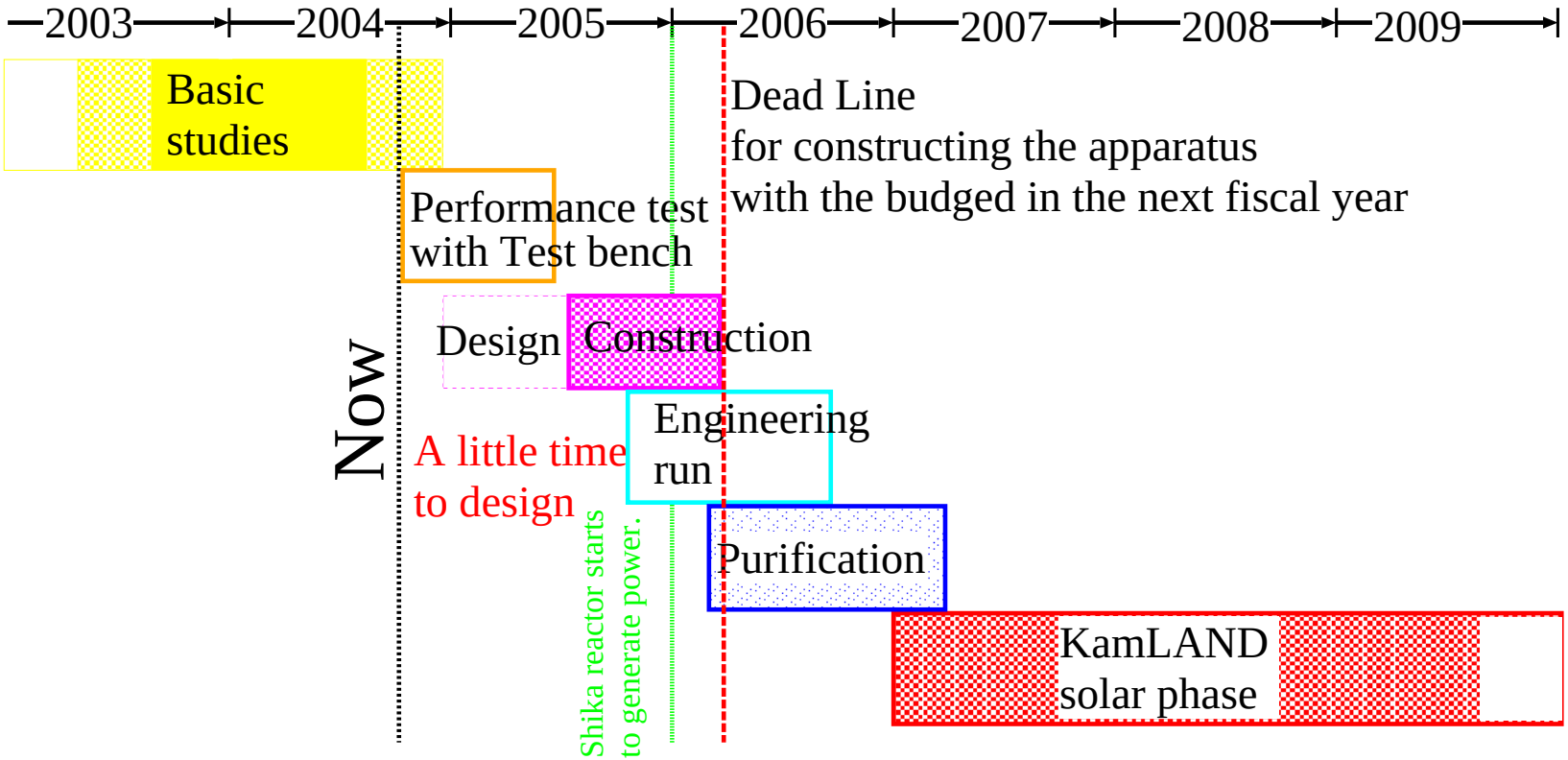
- Attenuation length

Sample	L at 365nm	L at 436nm
LS (Original)	1.4 ± 0.5	12.7 ± 0.4
LS (SiO_2)	1.3 ± 0.4	9.3 ± 0.2

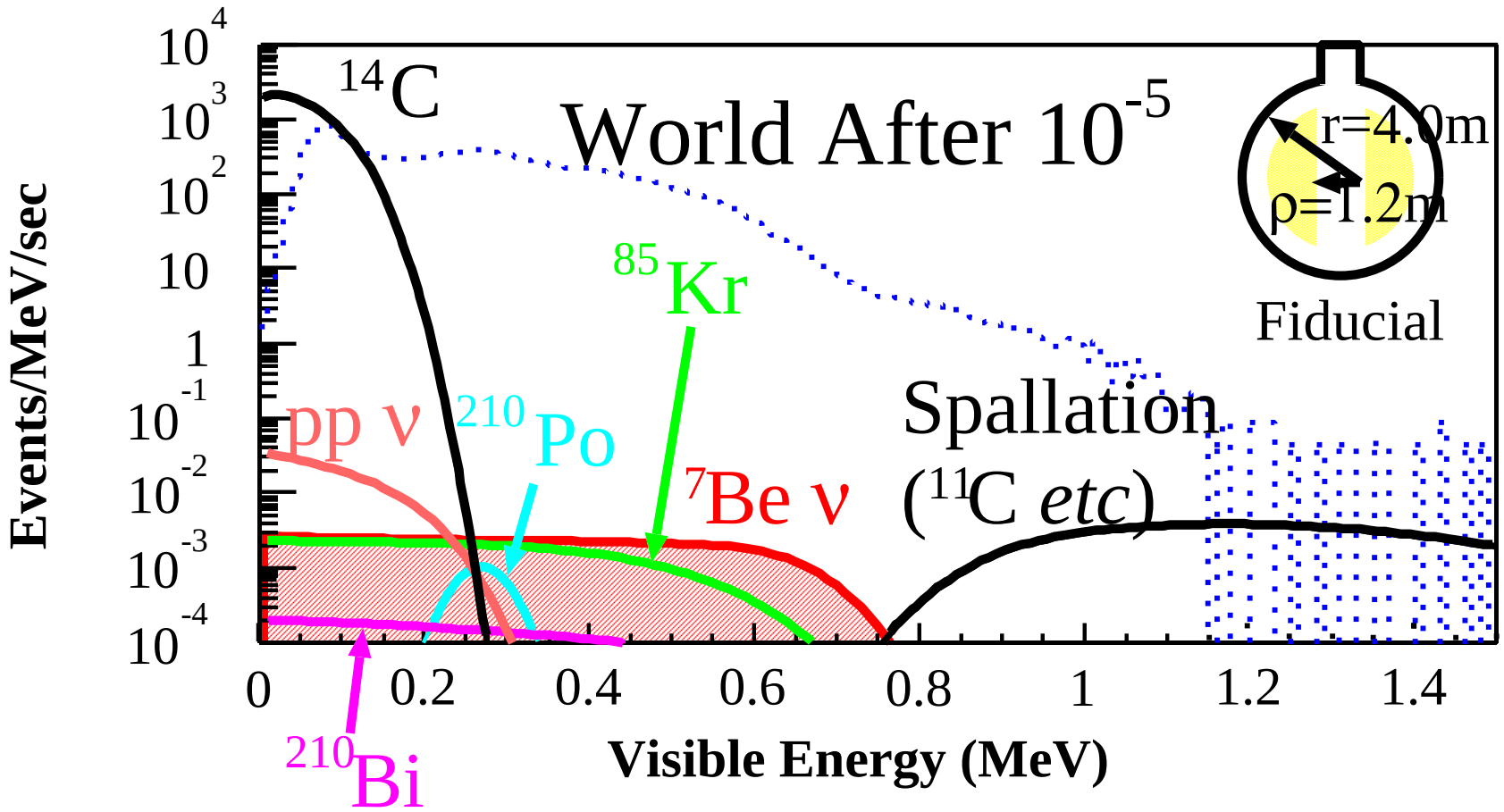
- Light yield: PPO is removed in the adsorption process.

Sample	PPO [g/ℓ]
LS (Original)	1.5 ± 0.2
LS (SiO_2)	0.19 ± 0.03

My schedule (unofficial)



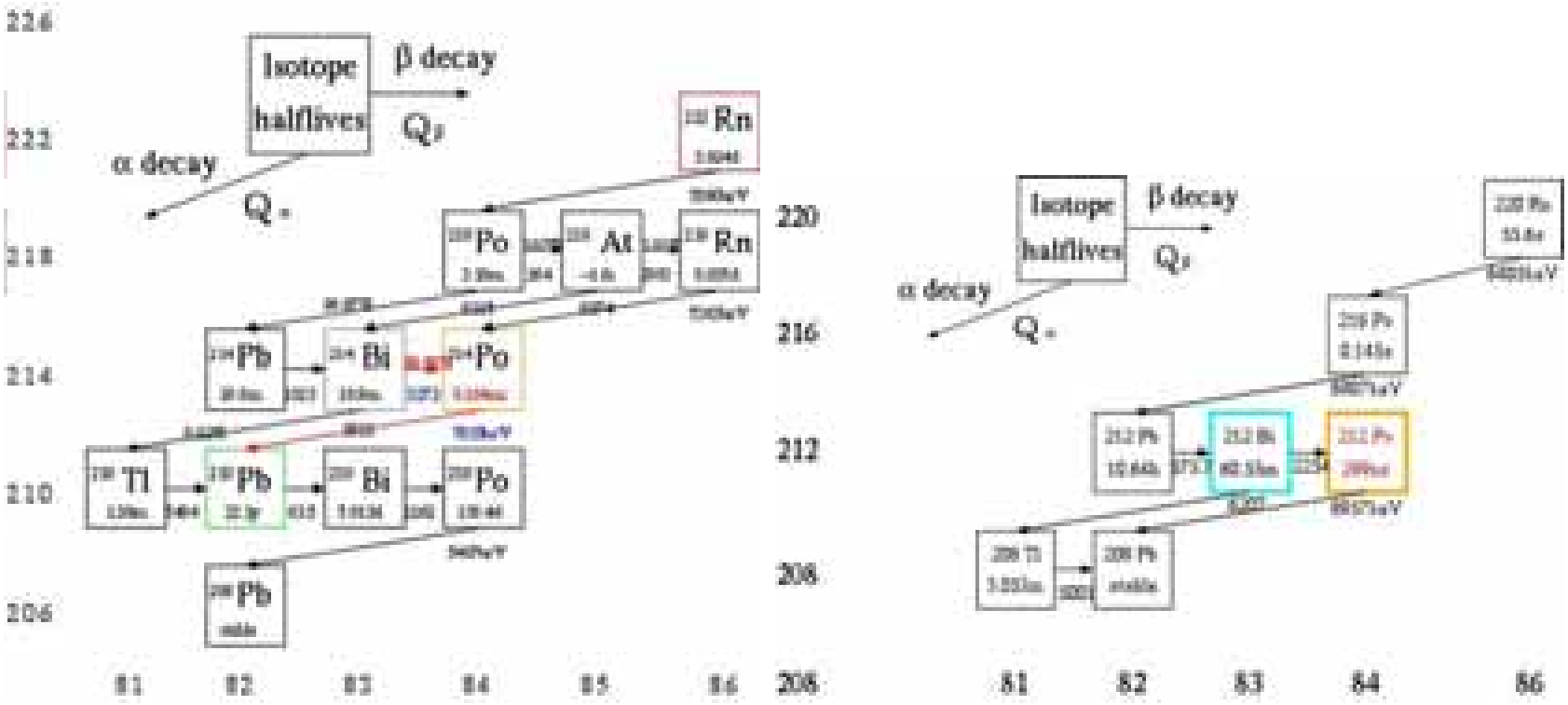
Future KamLAND



Summary

- Main BG sources in KamLAND now are ^{210}Pb and ^{85}Kr.
- The studies on the LS purification are now going.
  - Distillation technique
  - Adsorption technique
- There are some issues to be solved.
- KamLAND solar phase is planed to start around the beginning of 2007.
- Interesting results are coming after the purification.

Appendix: ^{210}Pb and ^{212}Pb



Background sources

Background	now	goal
^{238}U(by Bi-Po)	3.4×10^{-18}g/g	**OK!!**
^{238}U(by ^{234}Pa)	1×10^{-14}g/g (Max.)	10^{-18}g/g
^{232}Th (by Bi-Po)	5.6×10^{-17}g/g	**OK!!**
^{40}K	2.7×10^{-16}g/g(Max.)	$< 10^{-18}$g/g
^{210}Pb	$\sim 10^{-20}$g/g	5×10^{-25}g/g $\sim 1\mu$Bq/m^3
^{85}Kr	0.46 ± 0.10Bq/m^3	1μBq/m^3
^{39}Ar	0.2Bq/m^3(Max.)	1μBq/m^3
^{222}Rn (after purification)	^{238}U $= 3.5 \times 10^{-18}$g/g $= 3.3 \times 10^{-8}$Bq/m^3	**OK!!** (1μBq/m^3)
^{222}Rn (during purification)		1mBq/m^3 ^{210}Pb $= 0.5\mu$Bq/m^3 after decay