

COSINE-100 experiment at Yangyang underground laboratory


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on behalf of the COSINE collaboration
25 July, 2016

What is COSINE-100 experiment for?

- It is a **C**ollaboration **O**f **S**odium **I**odi**N**e **E**xperiments
- It is founded by KIMS-Nal and DM-ICE experiments
- It is to prove/disprove the DAMA/LIBRA annual modulation
- COSINE-100 will use 106 kg NaI(Tl) crystals

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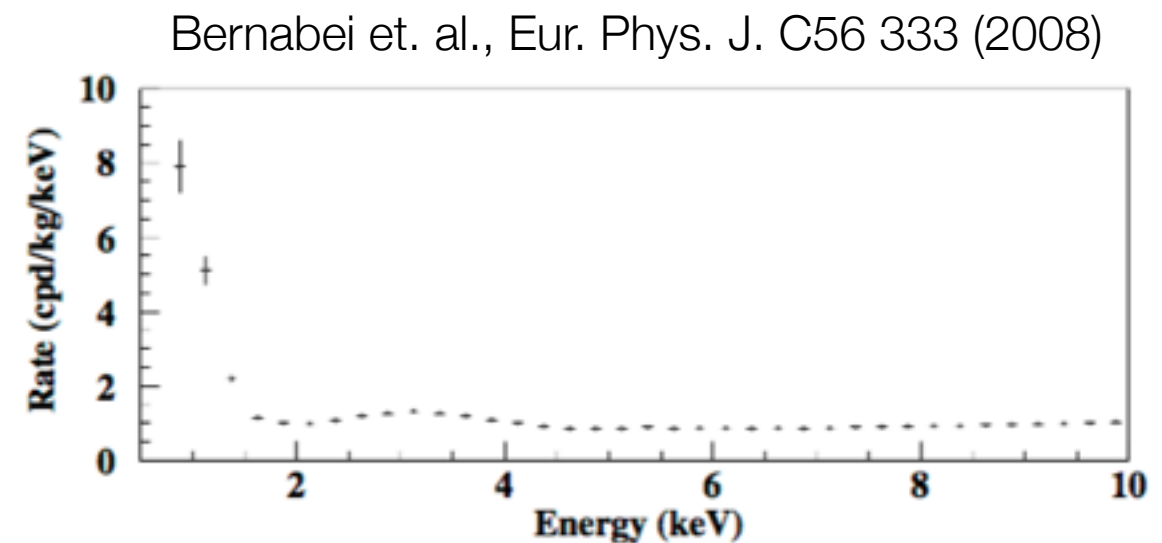
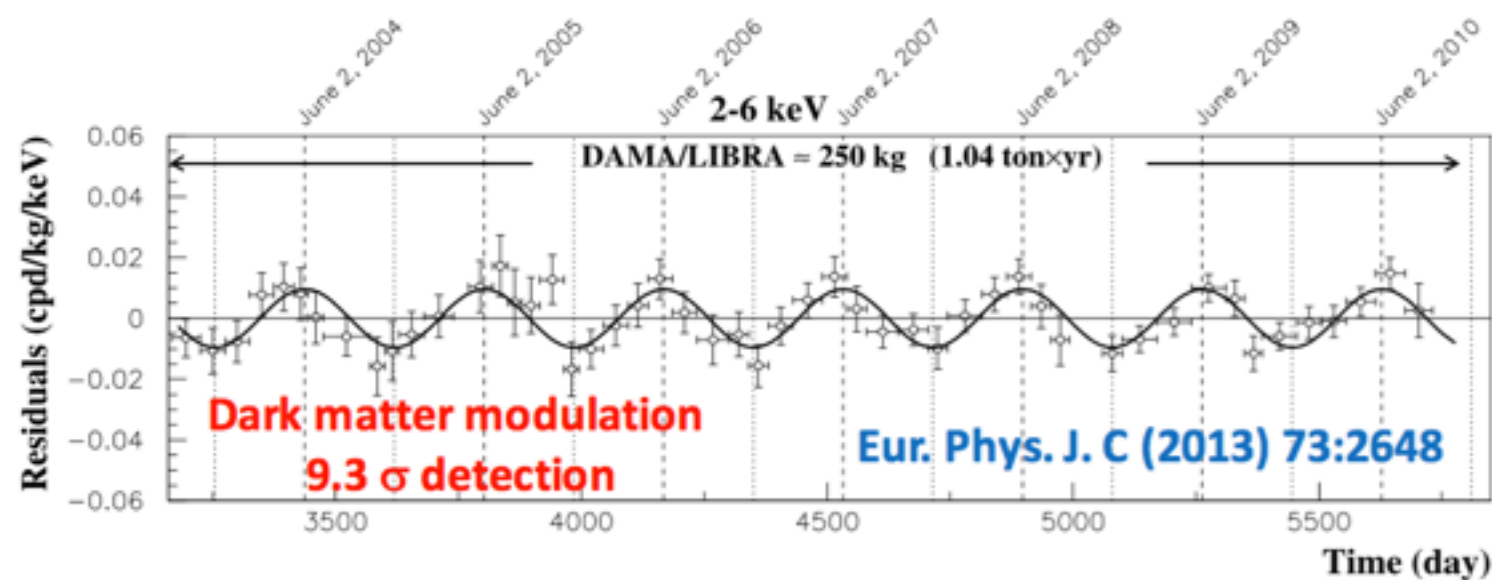
KIMS-Nal  **DM-Ice**

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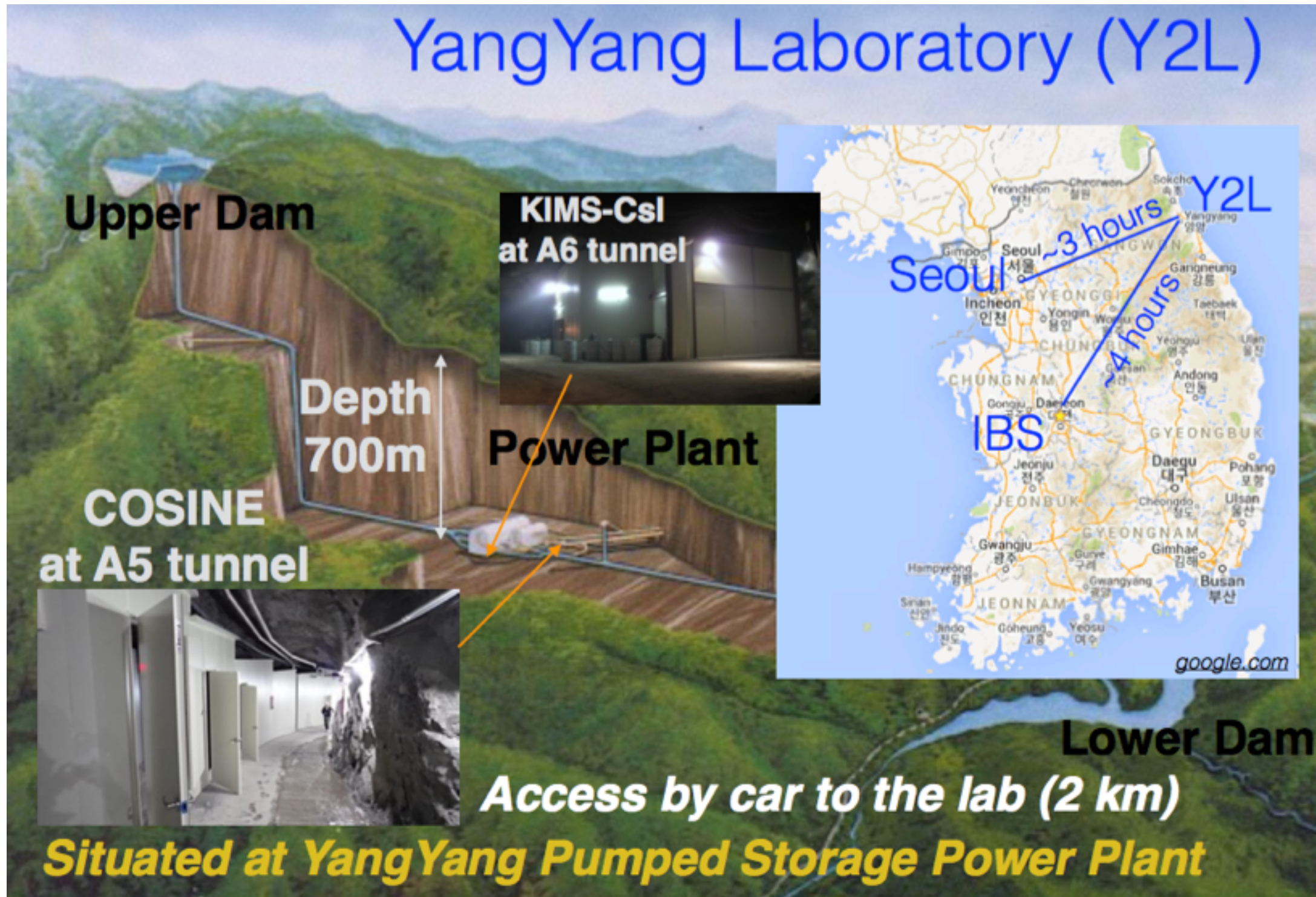
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- DAMA result
 - DAMA/LIBRA single hit events rate shows a flat background of ~ 1 dru and a peak of 0.5 dru at 3 keV
 - Modulation is only observed at low energy and an amplitude is less than 3% of single rate



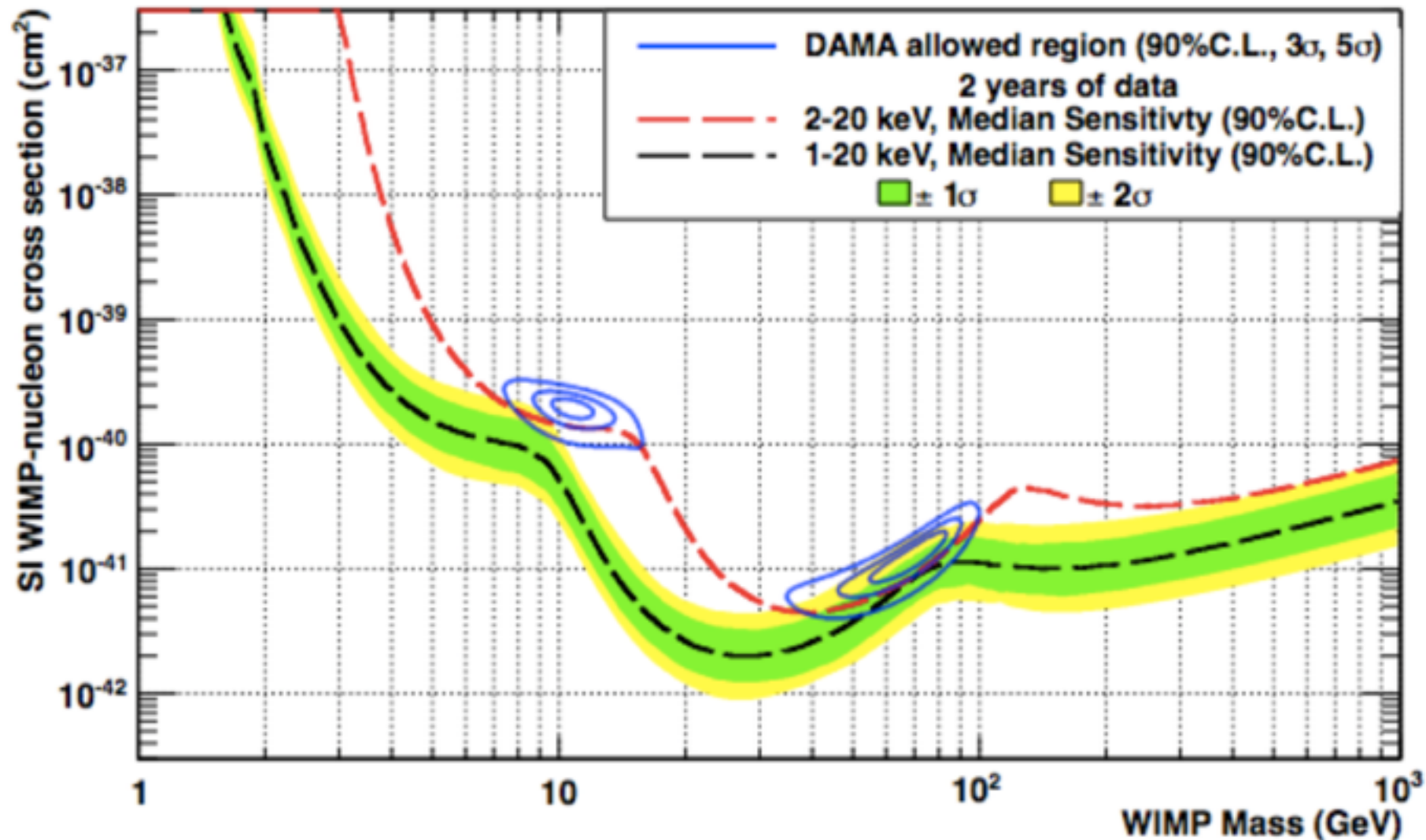
- To clarify it we need a NaI experiment with lower background and lower energy threshold and ideally doing better than DAMA

Yangyang underground laboratory (Y2L)



Expected sensitivity

- COSINE-100 at YangYang, with 1 keV and 2 keV energy threshold.
- Assumed flat background with 2 dru for several crystals and 4 dru for other crystals.
- Assumed 2 years of data taking.



Nal crystals for COSINE-100

- ^{40}K and ^{210}Pb (alpha)
 - 25ppb ^{40}K : ~ 0.4 dru @ 2-4keV
 - 0.5mBq/kg with bulk ^{210}Pb : ~ 0.7 dru @ 2keV
- They can be reduced by using active background rejection with LS

Astropart. Phys. 62, 249 (2015)
EJPC 76, 185 (2016)

AS: Alpha Spectra Inc
(US company)

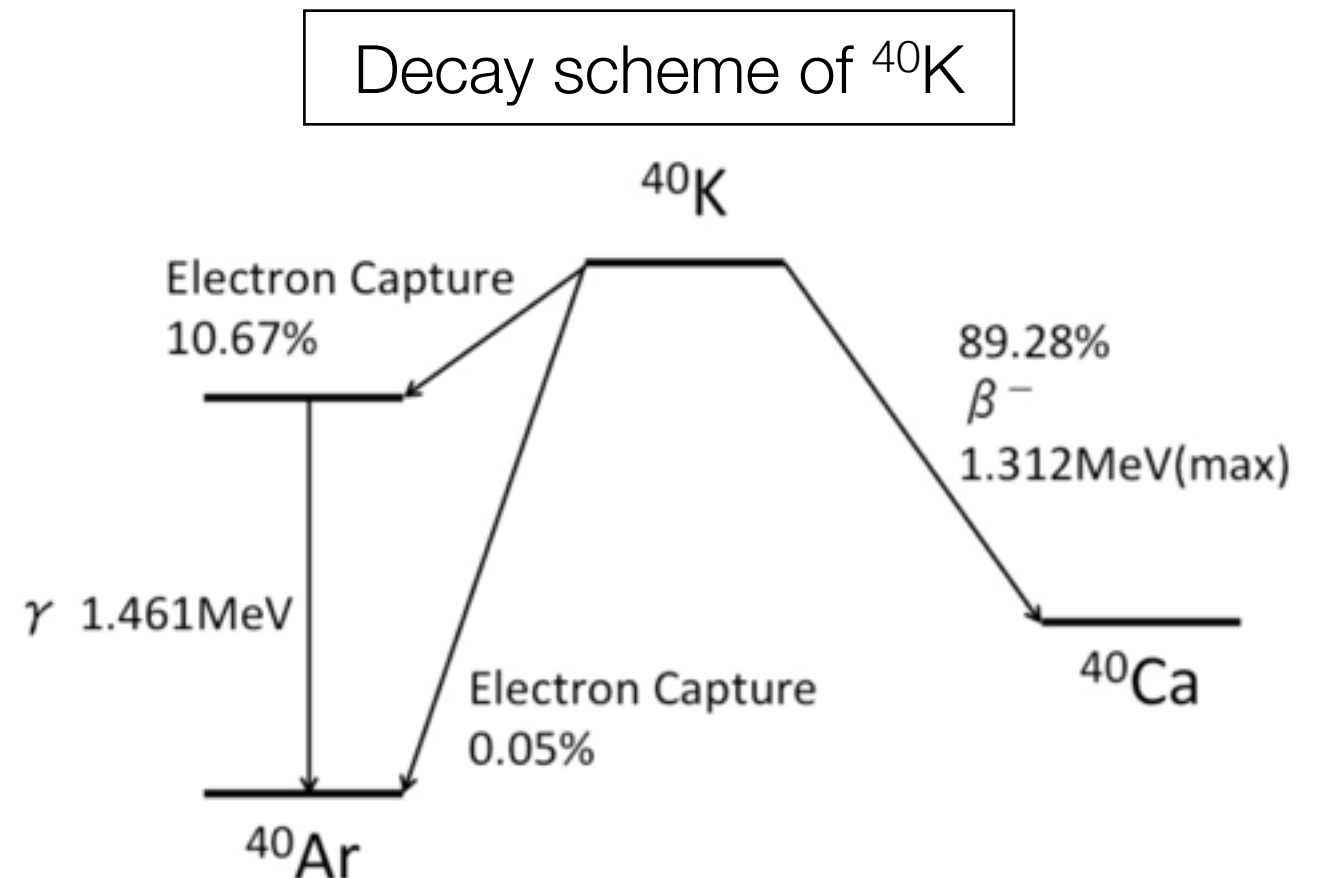


Crystals	Powder	Mass (kg)	$^{nat}\text{K} (^{40}\text{K})$ (ppb)	^{238}U (ppt)	^{232}Th (ppt)	α rate (mBq/kg)	Light Yield (pe/keV)
NaI-001 (C1)	AS B	8.3	40.4 ± 2.9	< 0.02	< 3.2	3.29 ± 0.02	15.6 ± 1.4
NaI-002 (C2)	AS C	9.2	48.2 ± 2.3	< 0.12	0.5 ± 0.3	1.77 ± 0.01	15.5 ± 1.4
NaI-007 (C3)	AS WimpScint II	9.3	38.1 ± 5.5	< 0.04	0.20 ± 0.01	0.85 ± 0.06	15.2 ± 1.4
AS3 (C4)	AS WimpScint II	18.0					
AS1 (C5)	AS C	18.3					
NaI-011 (C6)	AS WimpScint III	12.5	18.5 ± 3.2	< 0.018	< 0.079	1.03 ± 0.13	16.8 ± 1.2
NaI-012 (C7)	AS WimpScint III	12.5					
AS2 (C8)	AS C	18.3					
DAMA			< 20	$0.7 - 10$	$0.5 - 7.5$		

~ 106 kg
in total

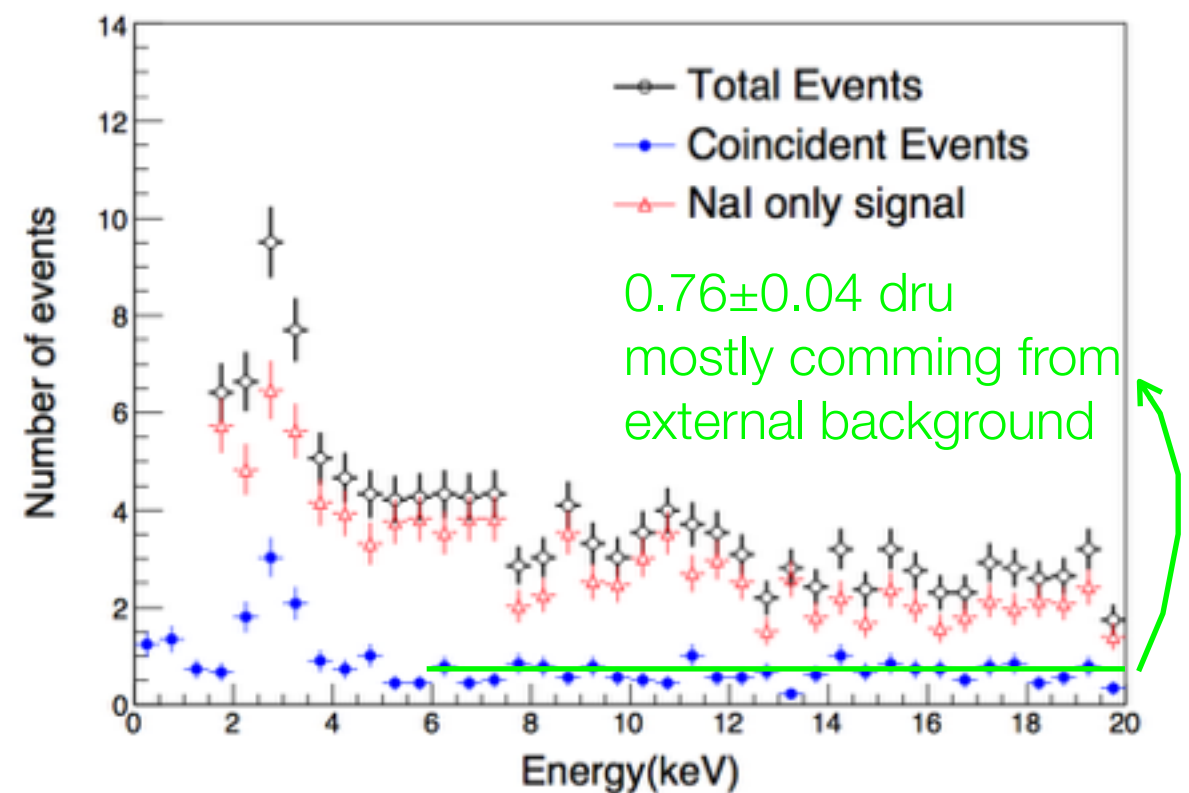
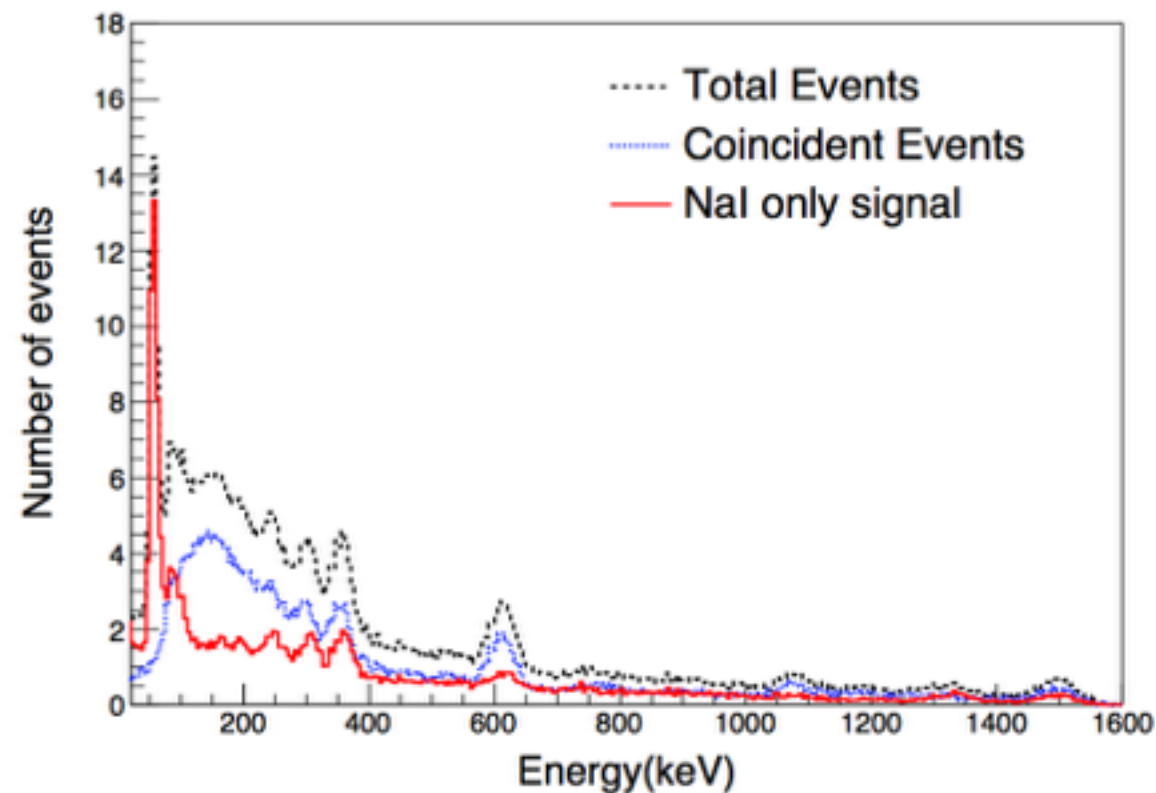
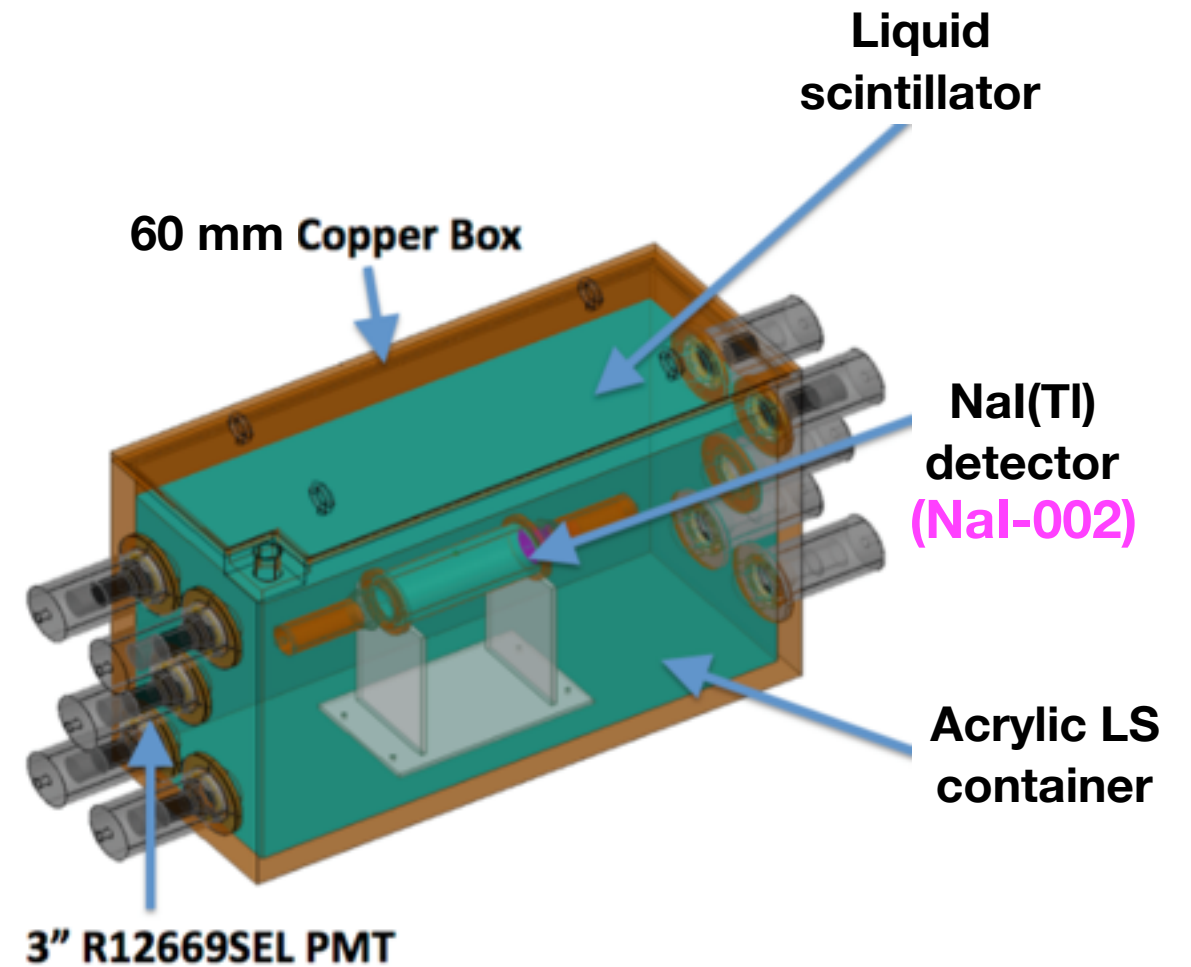
Active background rejection with liquid scintillator (LS)

- 10.7% of ^{40}K decays to ^{40}Ar by electron capture with emission of 1460 keV γ ray, which makes ~ 3 keV X-ray/Auger electron. 1460 keV γ ray escaped from NaI crystal can be tagged by LS
- External backgrounds come from outside NaI crystals would be vetoed by LS

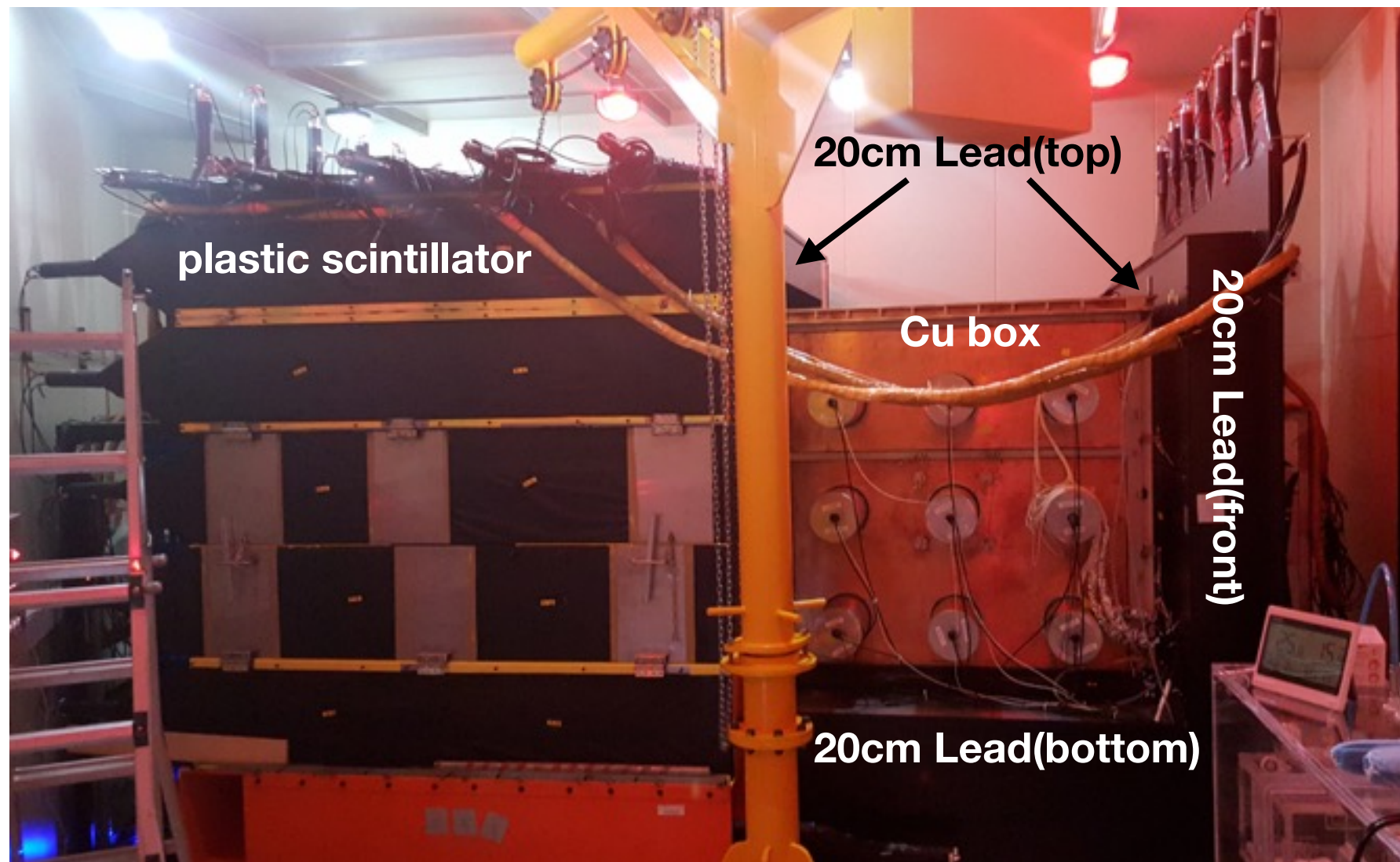


LS veto prototype

- Tagging efficiency
 - $26.5 \pm 1.7\%$ in 6-20 keV
 - $63 \pm 1\%$ in 100-1500 keV
- It's limited by narrow thickness of LS container of prototype → will be increased in main detector



Detector construction & shielding structure

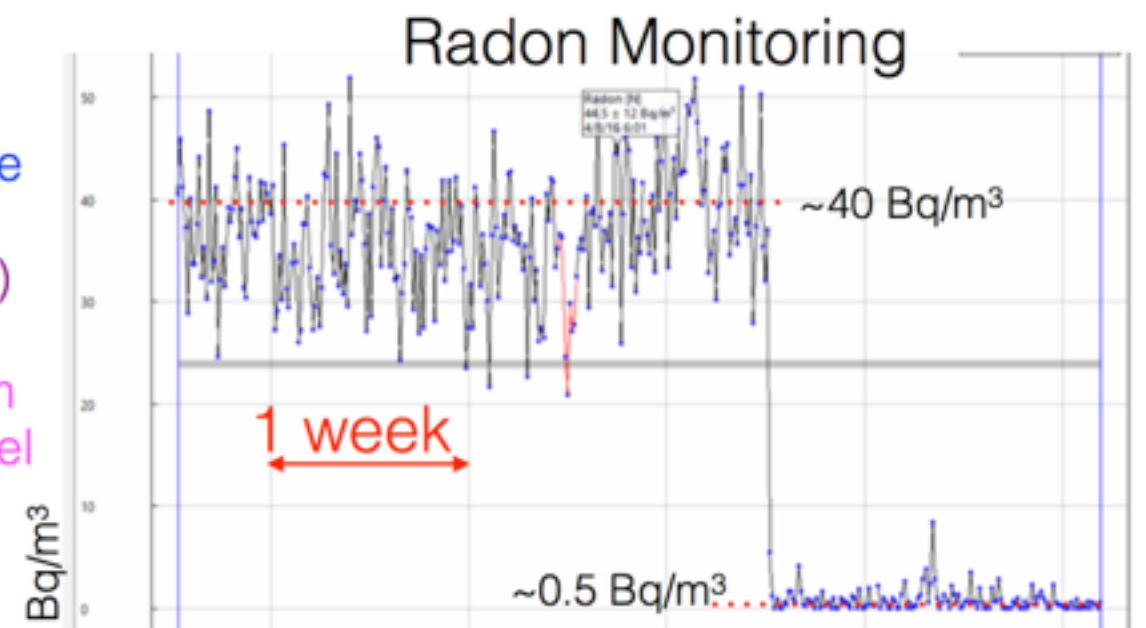
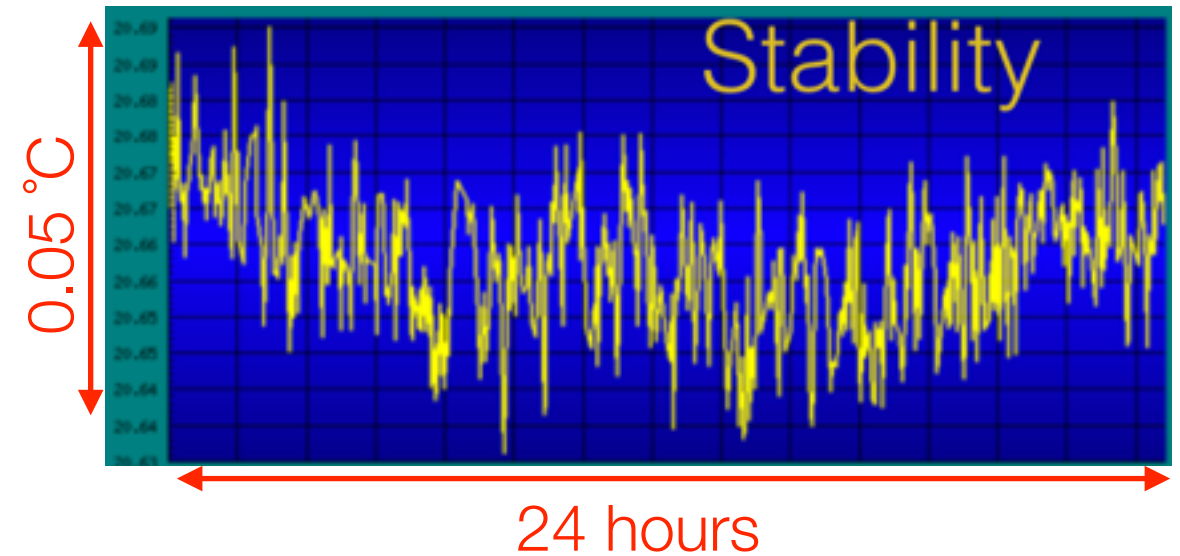


Data Acquisition & Slow monitoring system



DAQ :
FADC500 readout
- Flash ADC that stores waveforms.
- 500 MHz, 2.5V dynamic range, 12 bit resolution.
- Reads out 32 ch. from NaI(Tl) crystals & 4 ch. from neutron detectors.
ADC readout
- 64 MHz and reads out signals from plastic and liquid scintillators.

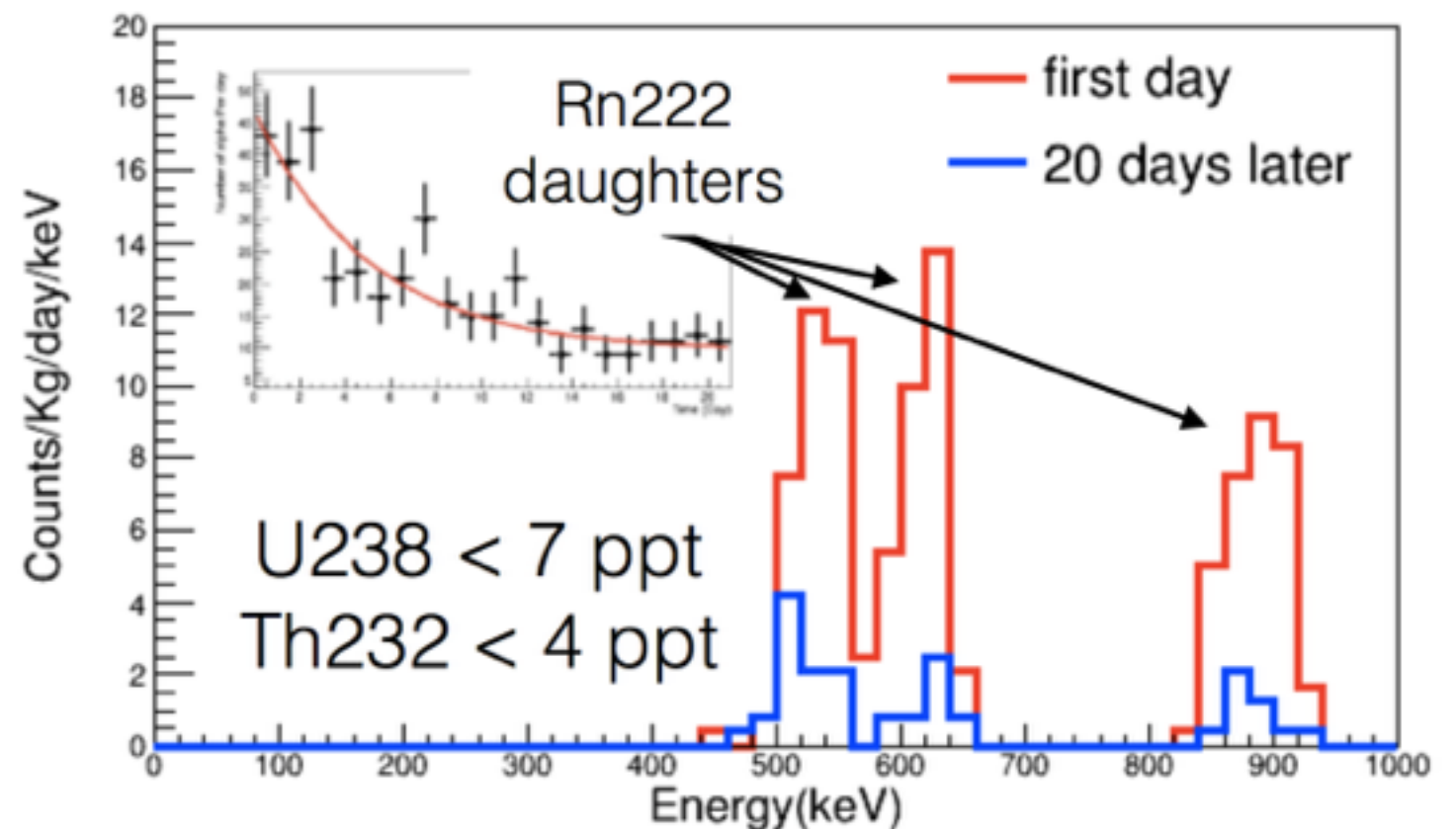
Radon level monitoring in the detector room. (RAD7)
~40 Bq/m³ (No Rn-free gas)
~0.5 Bq/m³ (Rn-free gas)
Rn emanation from the room limits the lowest possible level



Lab-based liquid scintillator production

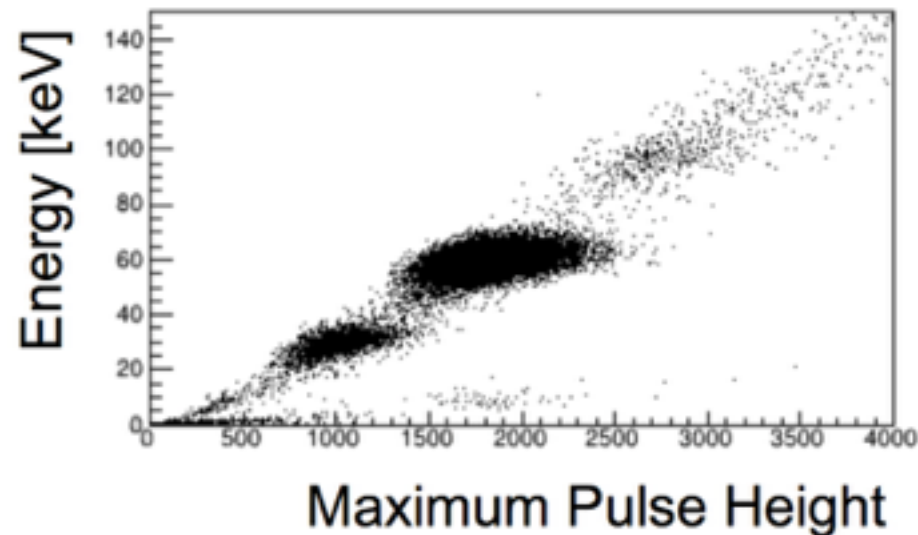


- LAB-based LS
 - Linear alkyibenzene (LAB)
 - PPO (3 g/L)
 - bis-MSB (3 mg/L)

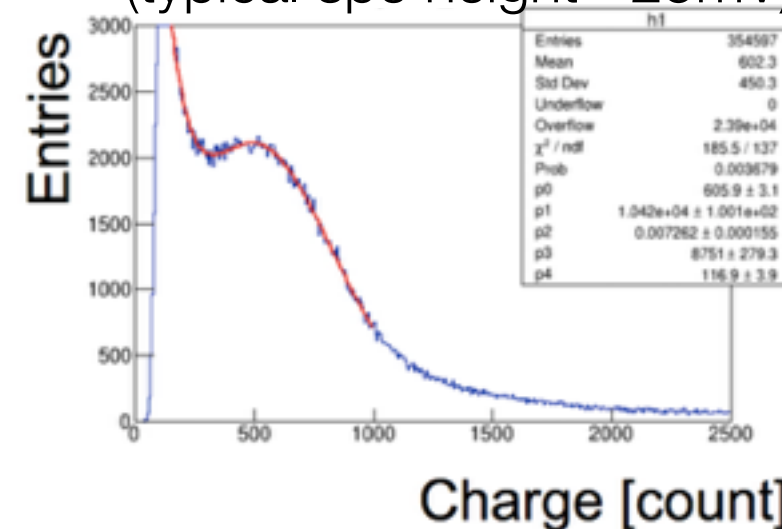


Dry run test with a new NaI detector (W/O LS) (Preliminary)

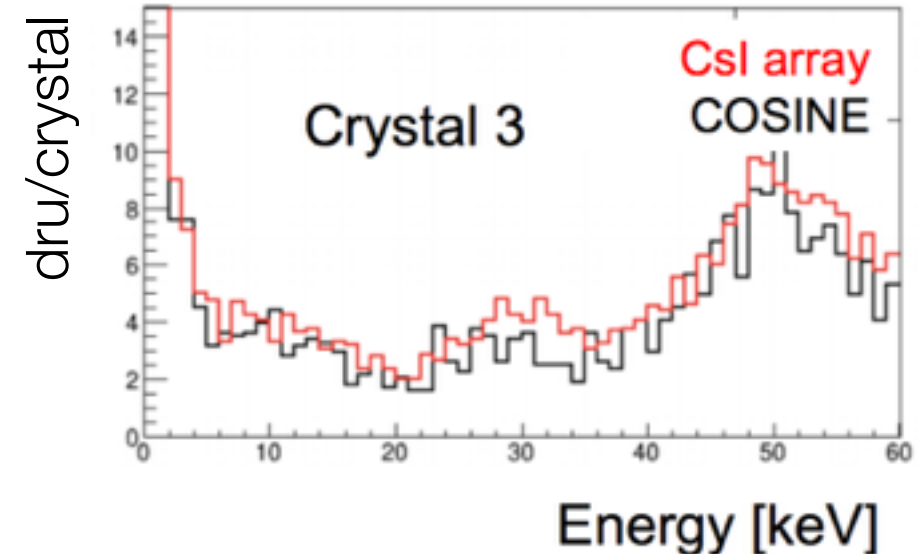
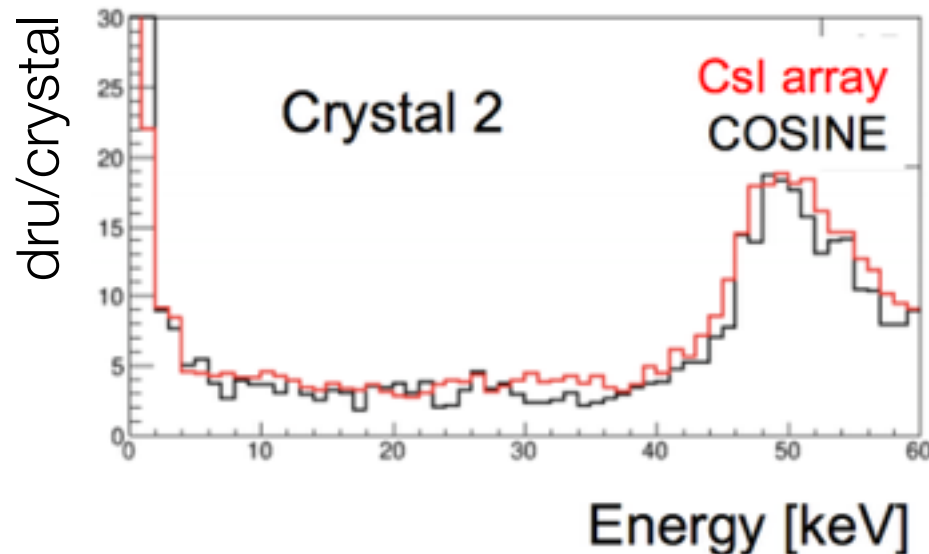
- ^{241}Am source data to calibrate each PMTs.
- Average light yield is ~ 15 p.e./keV



spe charge spectrum
(typical spe height ~ 25 mV)



- Energy spectrum comparison of dry run



Summary & schedule

- COSINE is a collaboration of NaI experiments working for the goal to prove/disprove the DAMA/LIBRA annual modulation
- COSINE-100 runs to start at Yangyang this summer w/ 106 kg NaI(Tl) crystals
 - Detector construction is completed w/o LS
 - It is in the preparation of a dry run
 - After the dry run LS will be filled
 - Data commissioning will start in August, 2016
- Slow monitoring system for temperature, humidity, and ^{222}Rn level in the detector room is set up and now is working well
- We will continue developing NaI crystal purification to reach the background level less than 1 dmu

BACKUP

Shielding structure

