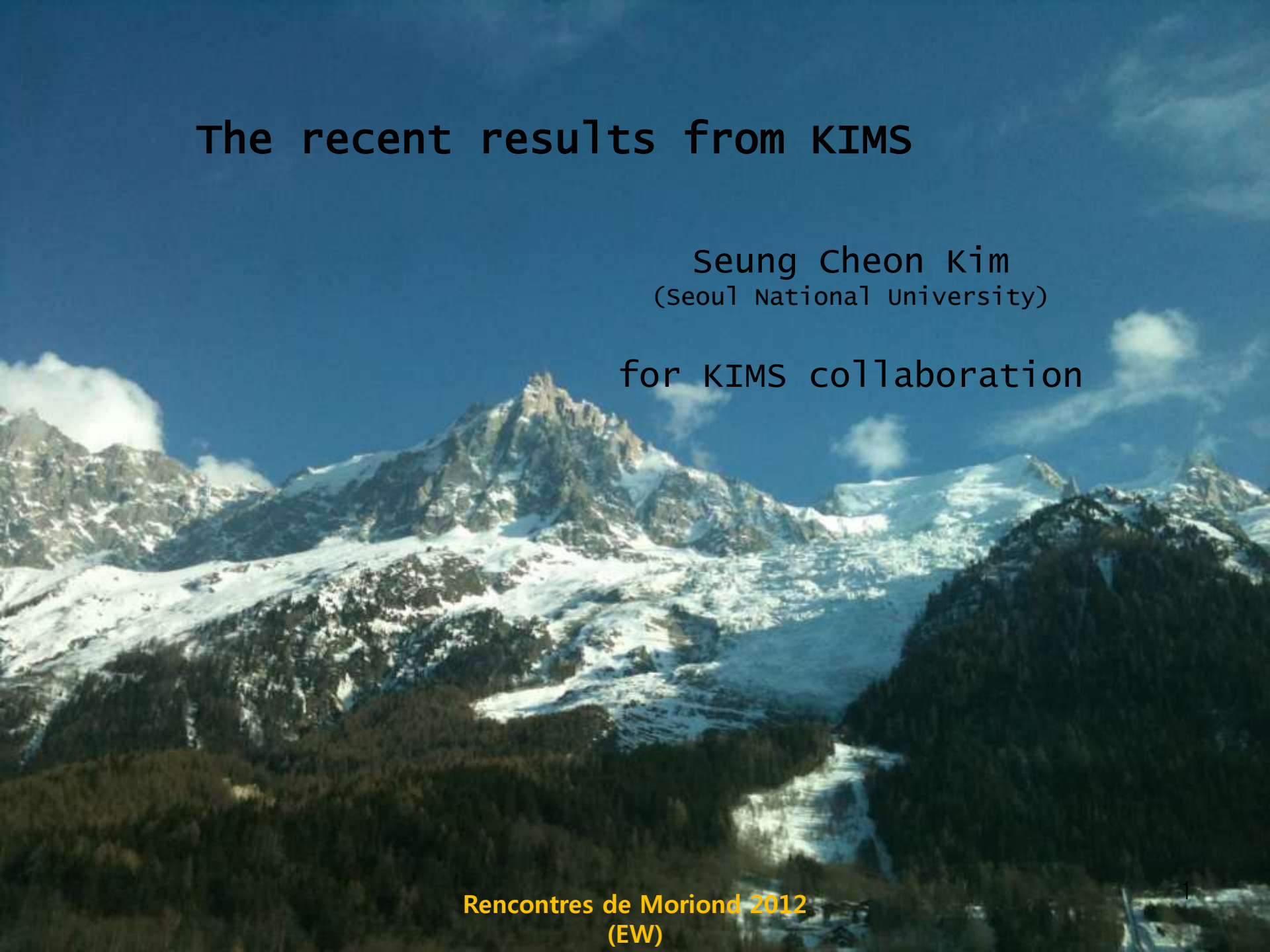
The recent results from KIMS

Seung Cheon Kim
(Seoul National University)

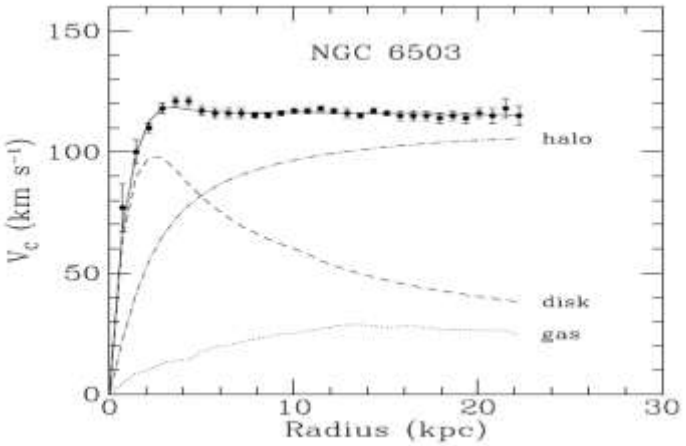
for KIMS collaboration



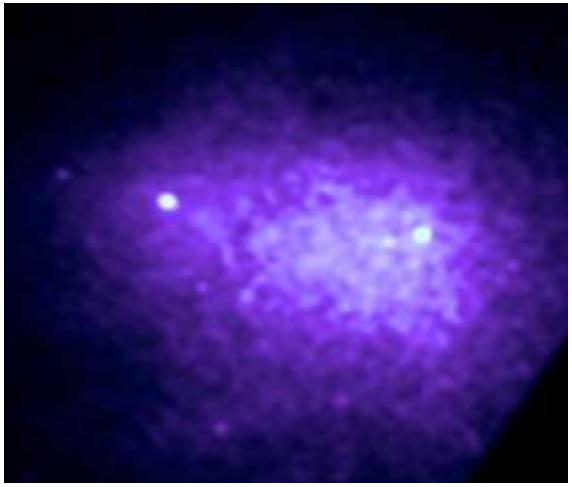
Rencontres de Moriond 2012
(EW)

KIMS(Korea Invisible Mass Search) collaboration

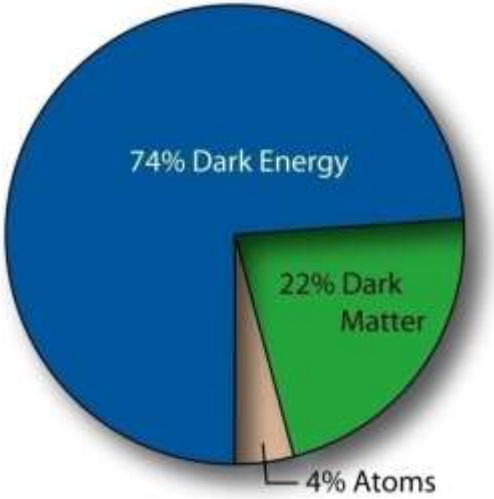
Dark matter ?



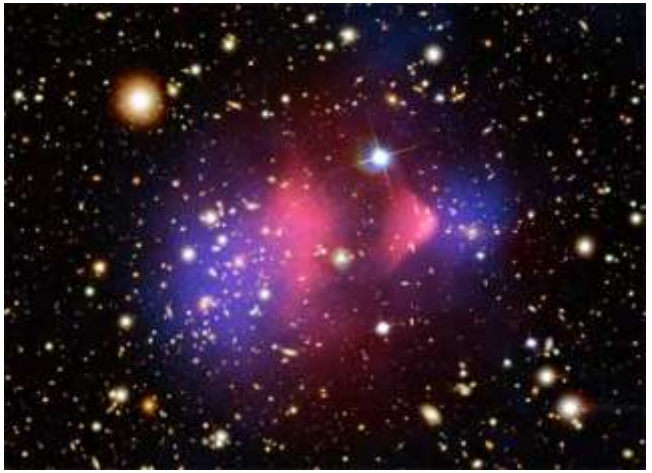
Rotation curve for Galaxy



X-ray from Hot cluster



Parameters of ΛCDM by WMAP

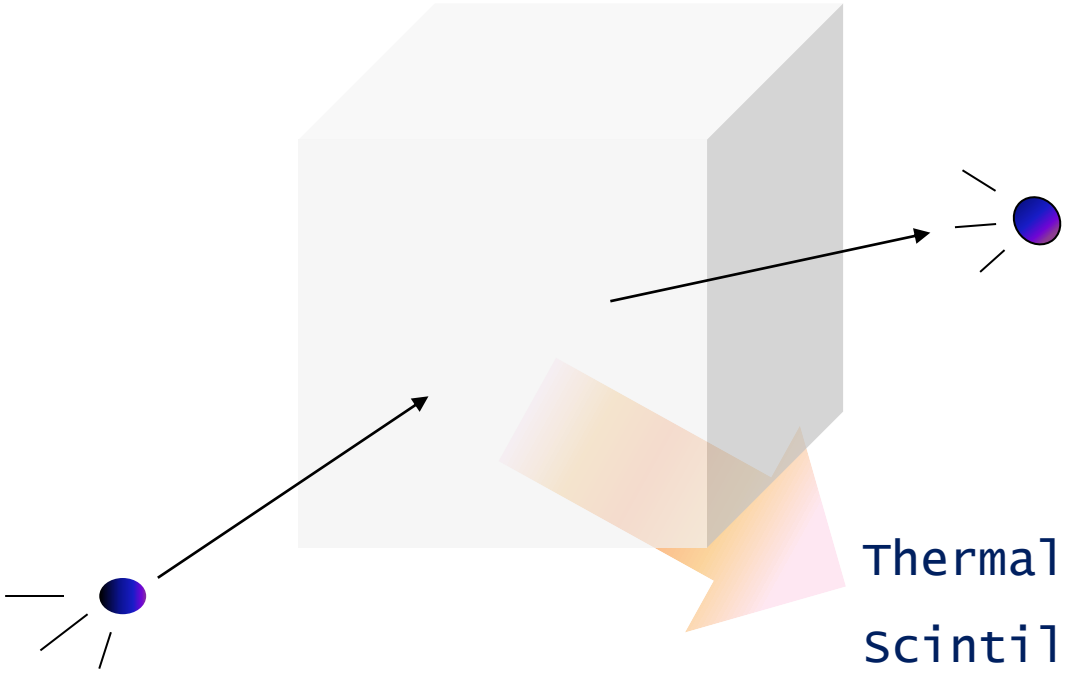


Bullet cluster

Not visible, but gravitationally evident!

If dark matter is WIMP,

It will deposit around 10 keV in the absorber!



Thermal signal

Scintillation, e-h pair

Produced from nuclear Recoil(NR)

But, the event will happen very rarely.
(radioisotope free material, Underground Lab)

KIMS experiment ?

CsI(Tl) scintillator

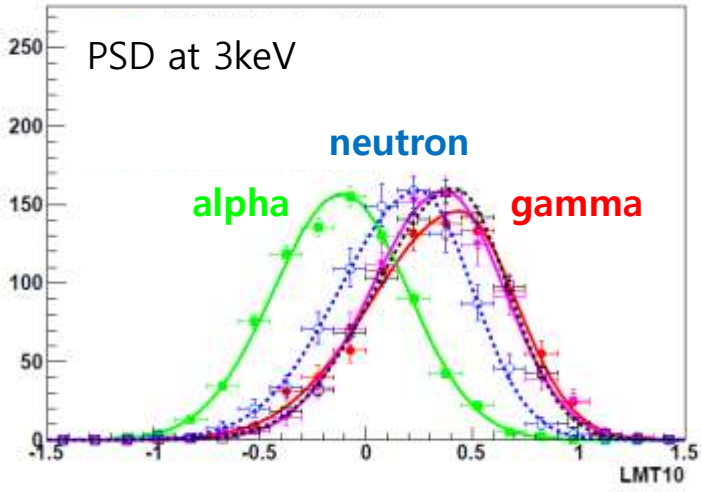
Well-known, widely-used technique

Large atomic number, Cs (133), I (127)
Good for coherent scattering (A^2 scaling)

High spin expectation value for proton
Sensitive to SD interaction

Discrimination of nuclear recoil events by PSD analysis

But, some inherent backgrounds like Cs134, Cs137, Rb87



Detector design

One detector module : one CsI Crystal + 2 PMTs

Crystal size: 8x8x30 cm^3 (8.7 kg)
(Beijing Hamamatsu Photon Techniques Inc.)

PMT : 3” PMT (9269QA),

Quartz window,

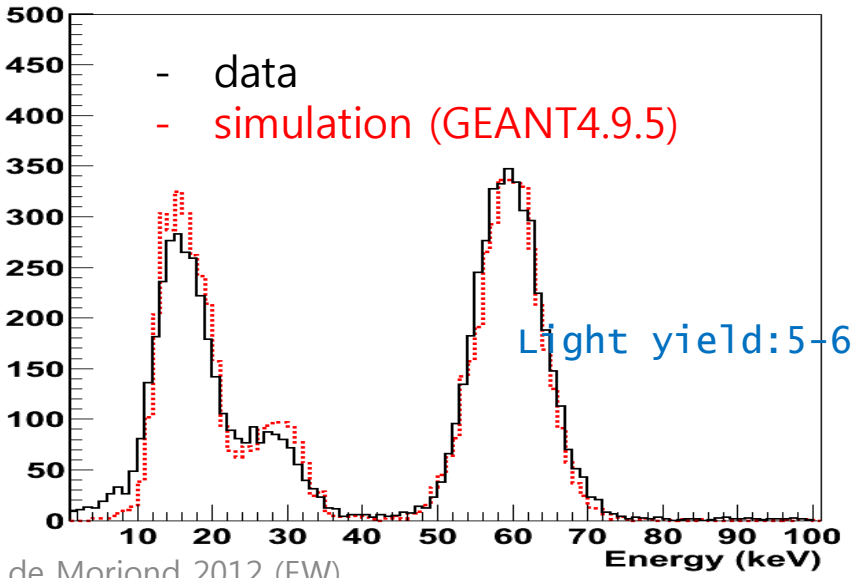
RbCs photo cathode

(green extended)

Event window is 40μs.

Digitized with 400MHz FADC

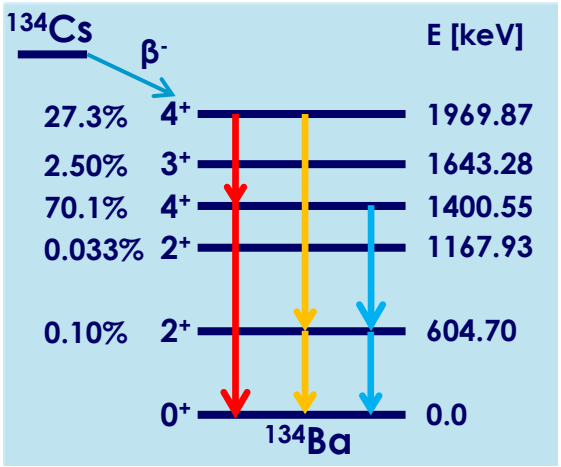
Am241 calibration



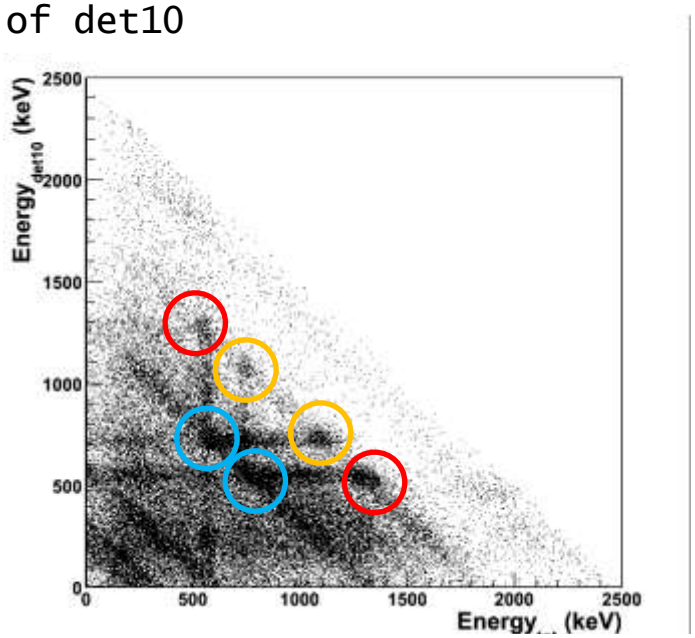
13.9keV Np Lα X-ray
17.8keV Np Lβ X-ray
20.8keV Np Lγ X-ray
26.35keV gamma
Cs, I X -ray escape
59.54 gamma
...

Detector array

3 x 4 detector array
The total mass : 103.4 kg
Surrounded by Muon veto
Multiple hit events
⇒ Vetoed for DM search
But, references for calibration
& event selection



E of det10



Total E except det10

Experimental site

YangYang underground Lab(Y2L)

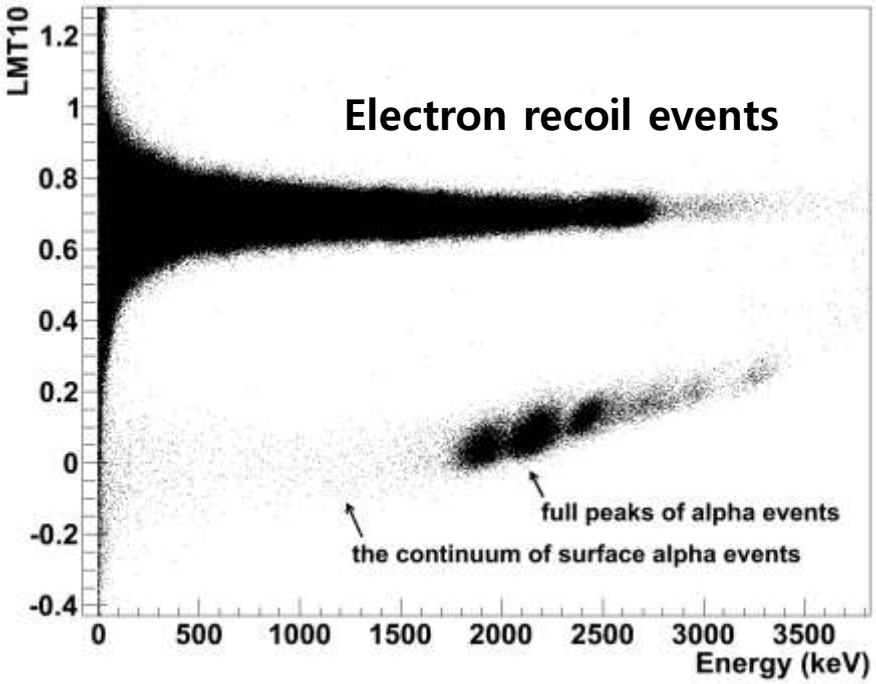
=>Located in Yangyang pumped storage power plant

=>700m minimum depth, muon flux : 2.7 x $10^{-7}/cm^2/s$

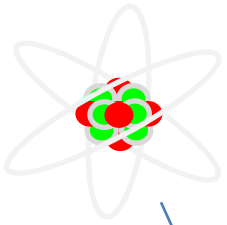
=>accessible by car (tunnel~2km)

양양양수발전소

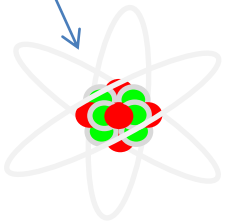
Surface alpha (SA) background

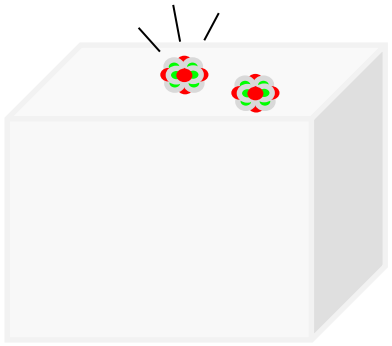


^{222}Rn : noble gas, well permeated in the air



^{218}Po : reactive metal, readily adhering to any surface



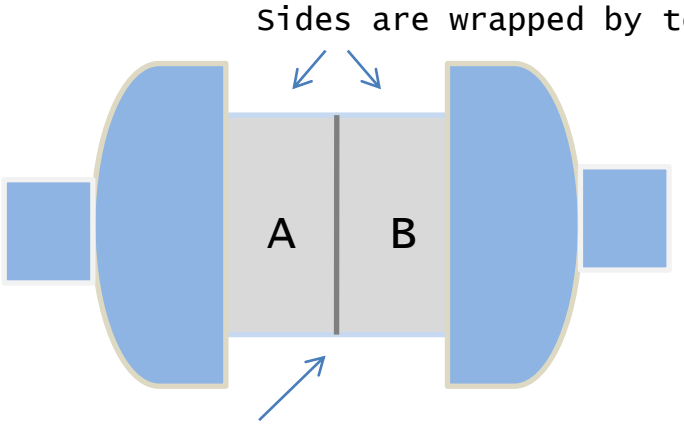


^{210}Pb : half-life of 22 year

^{210}Po : main α emitter at the surface
if the system is isolated.
half-life of 138 days

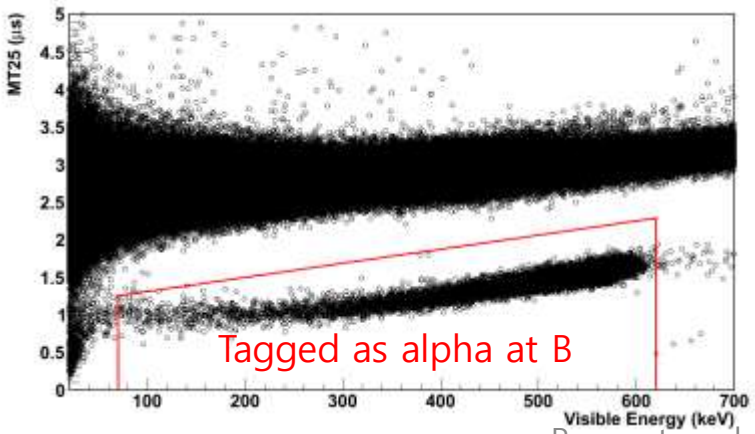
LMT10: logarithm of the mean time (similar to decay time) for each event estimated in 10 μseconds time aperture
PSD parameter

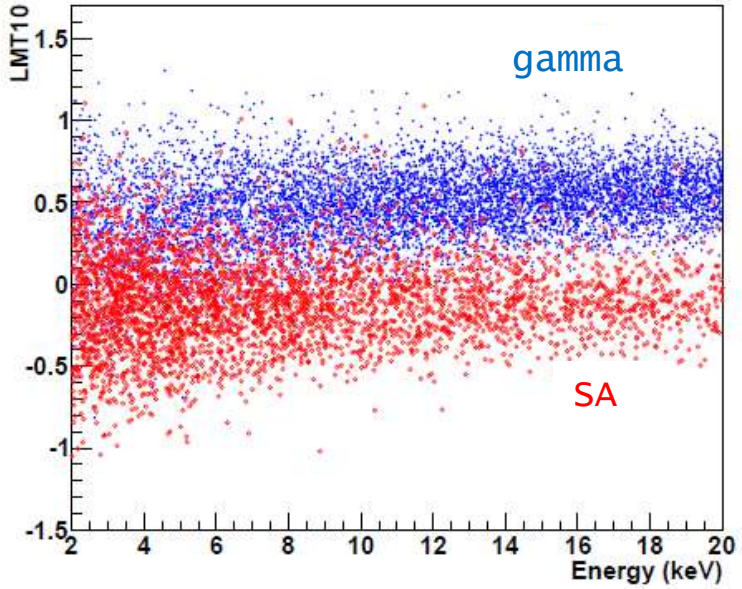
Study of SA events using Rn progeny contaminated crystal



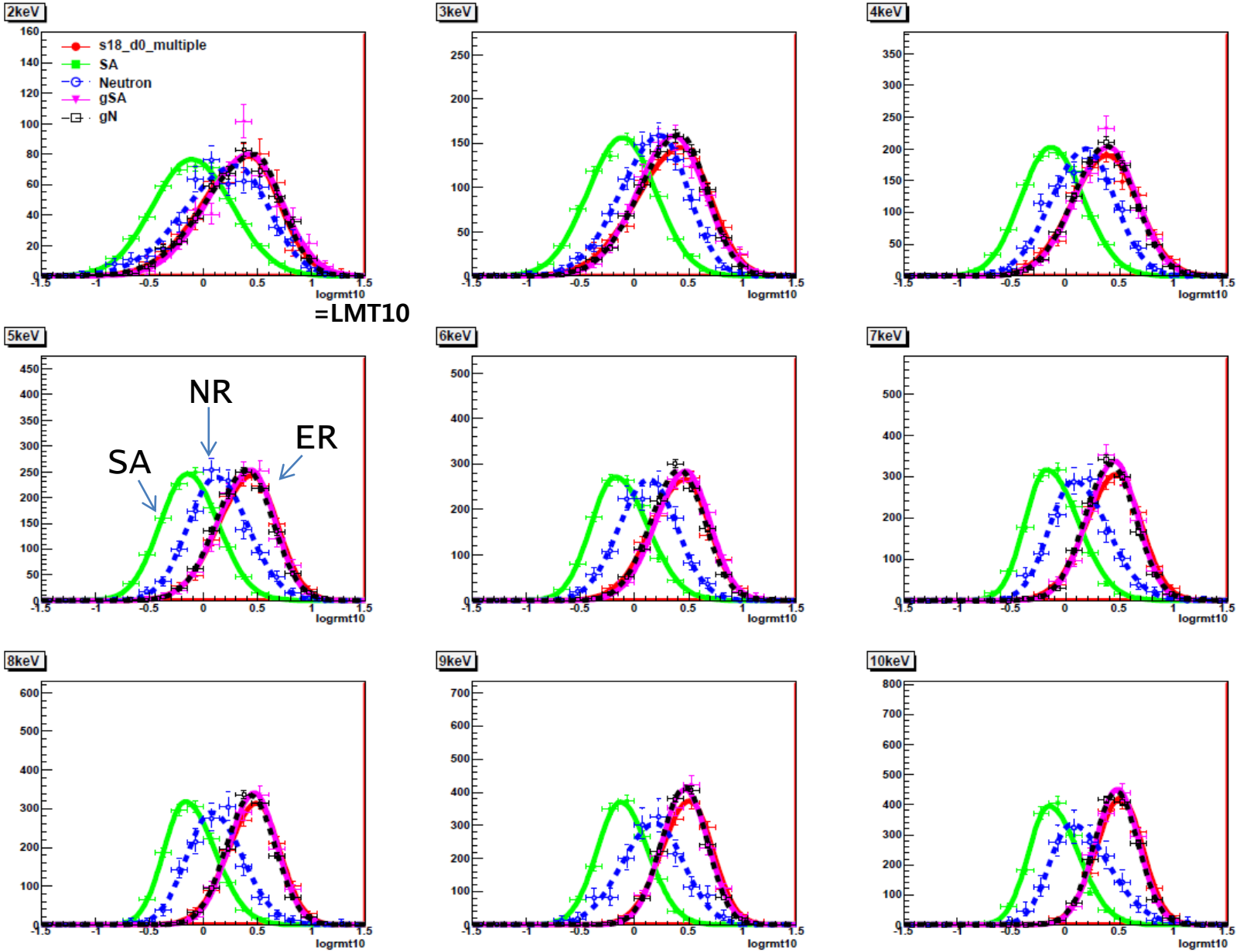
PMTs

CsI(Tl) crystal
A: Rn progeny contaminated
,exposed to Rn gas for 4 days
B: clean





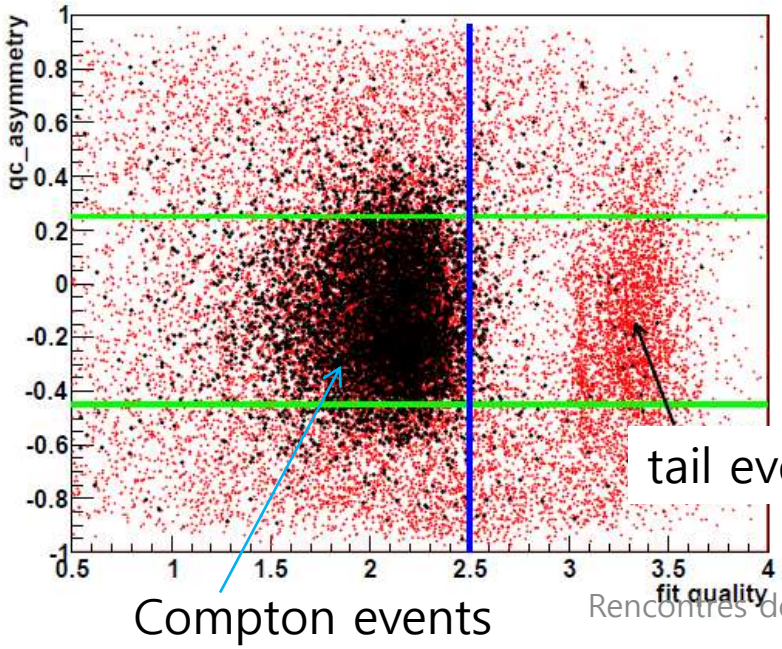
Comparison of PSD parameter, logrmt10

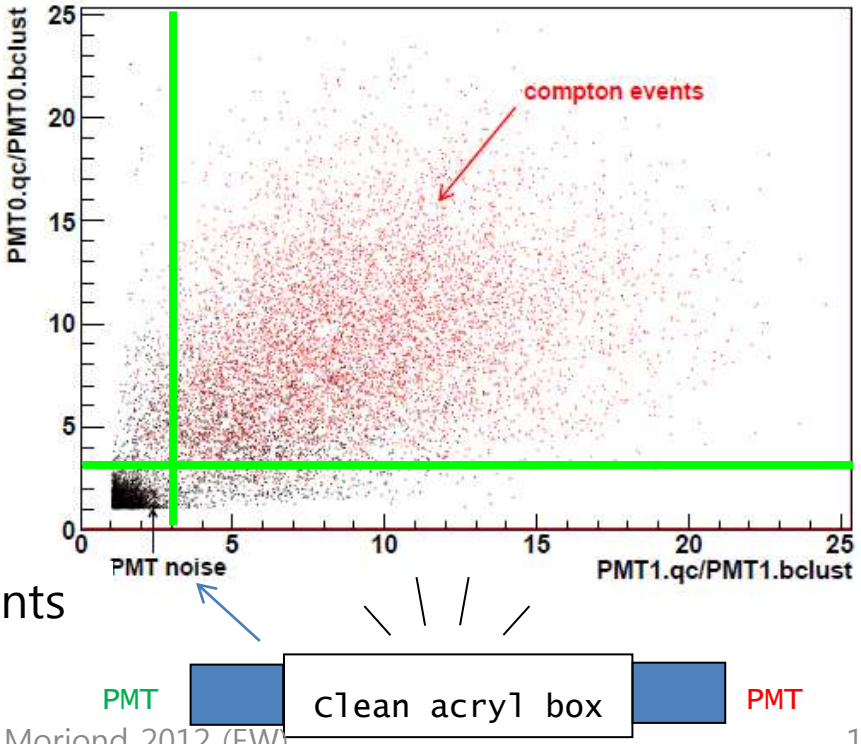


Event selection

Period: September 2009 – August 2010
=> 317.15 live days

PMT noise, muon-coincident events, tail events, multiple hit events rejected

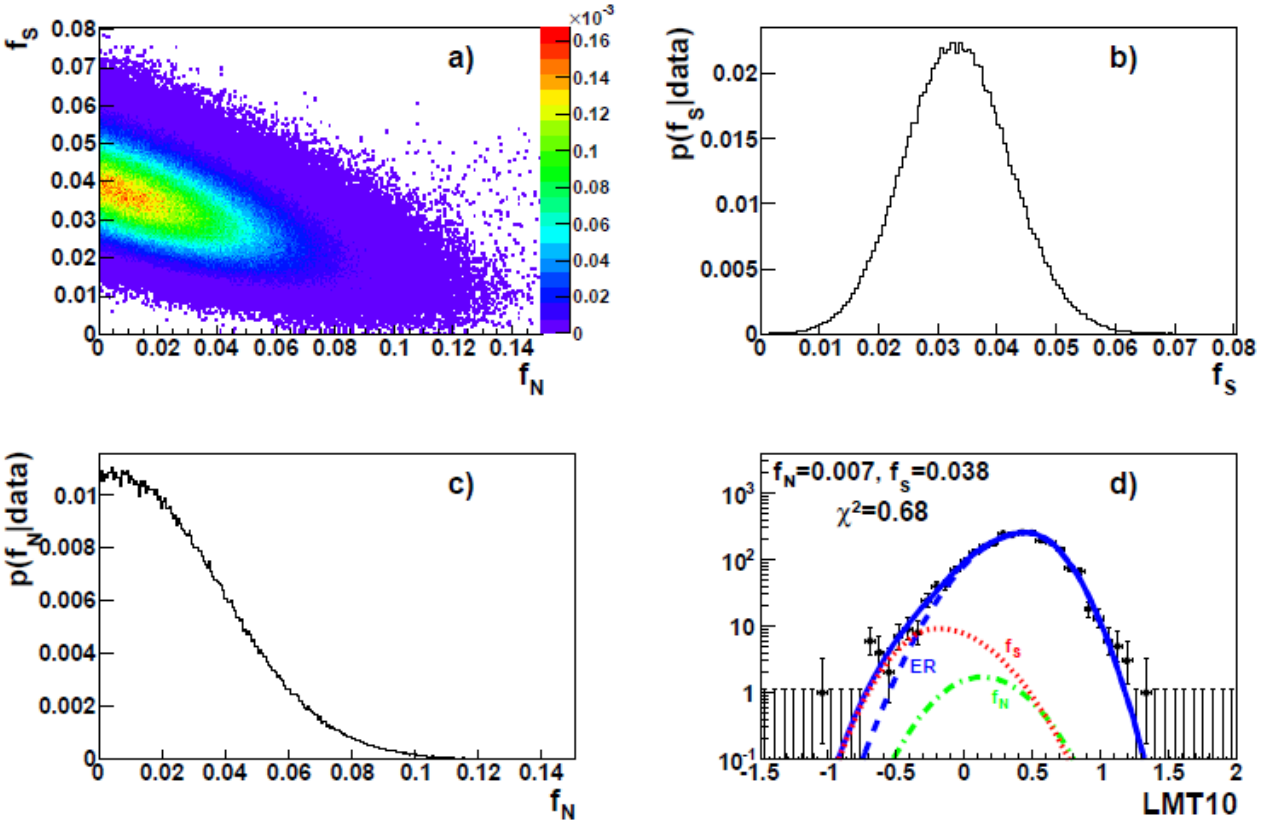




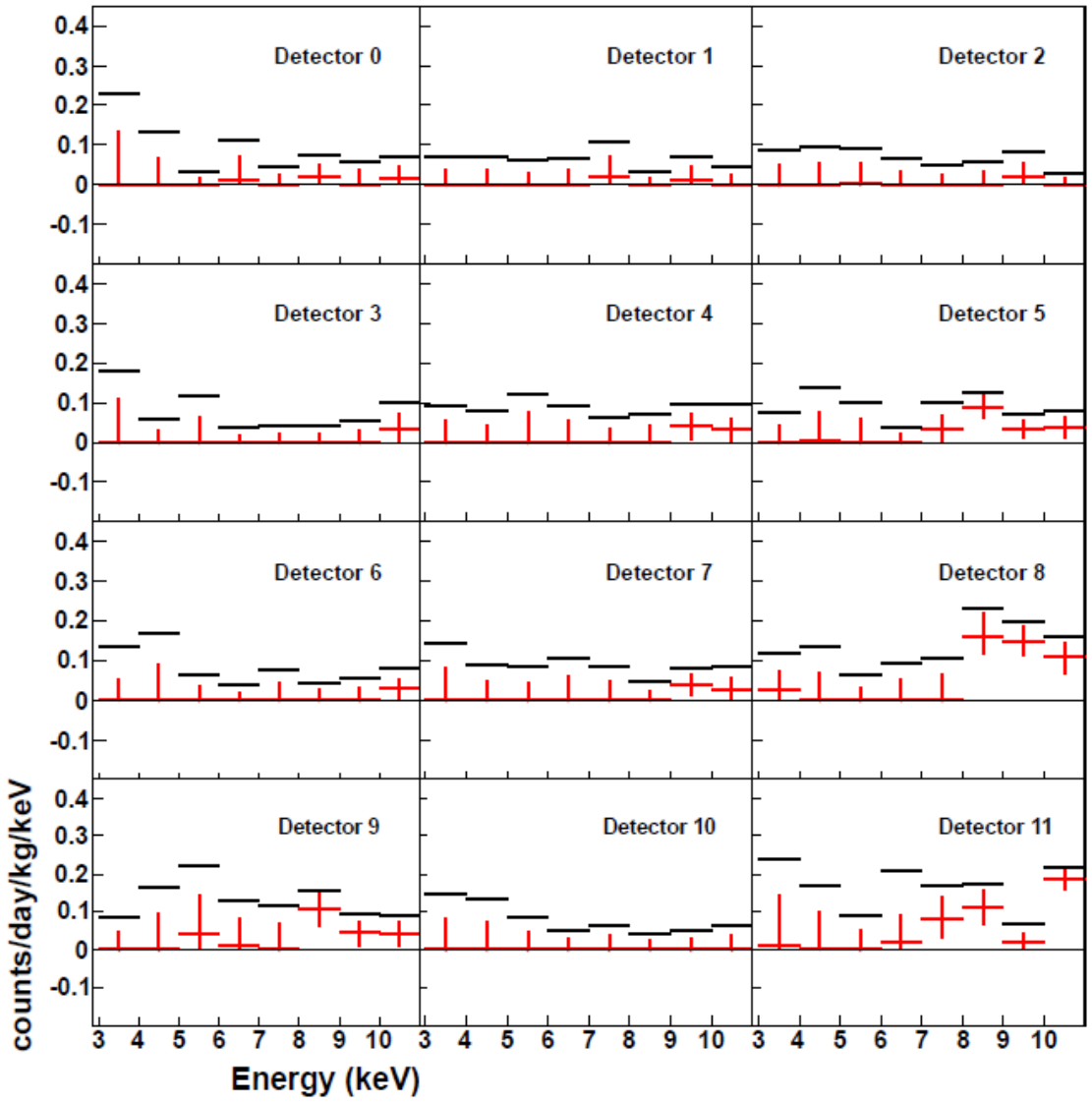
The estimation of the NR events rate

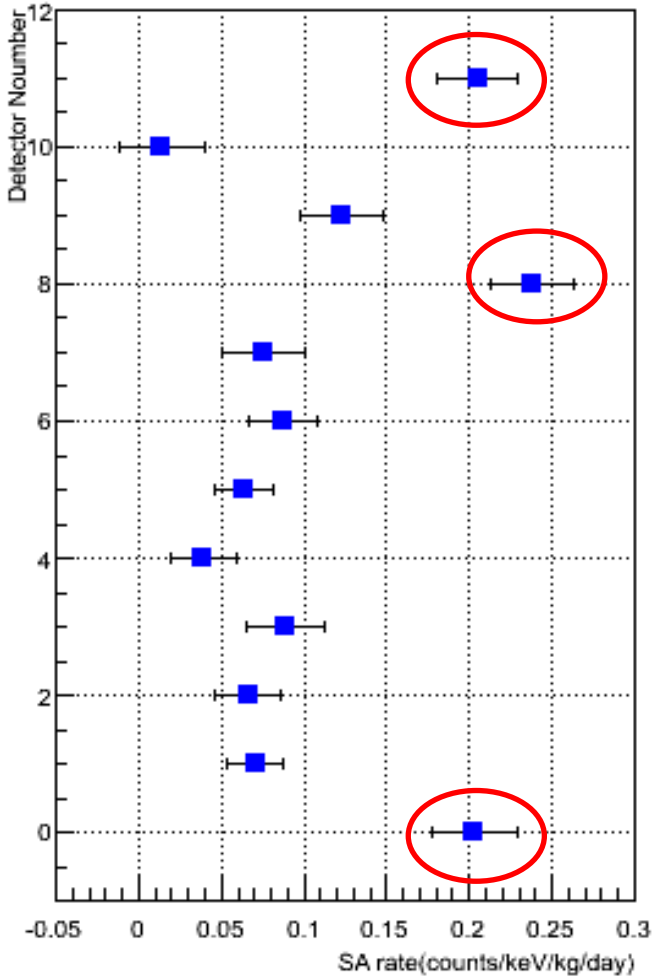
Pdf = f0 x F_{NR} + f1 x F_{SA} + (1-f0-f1) x F_{gamma}

The posterior pdf for f0 & f1 is obtained from Bayesian analysis method.



The estimated NR event rates for 12 detectors



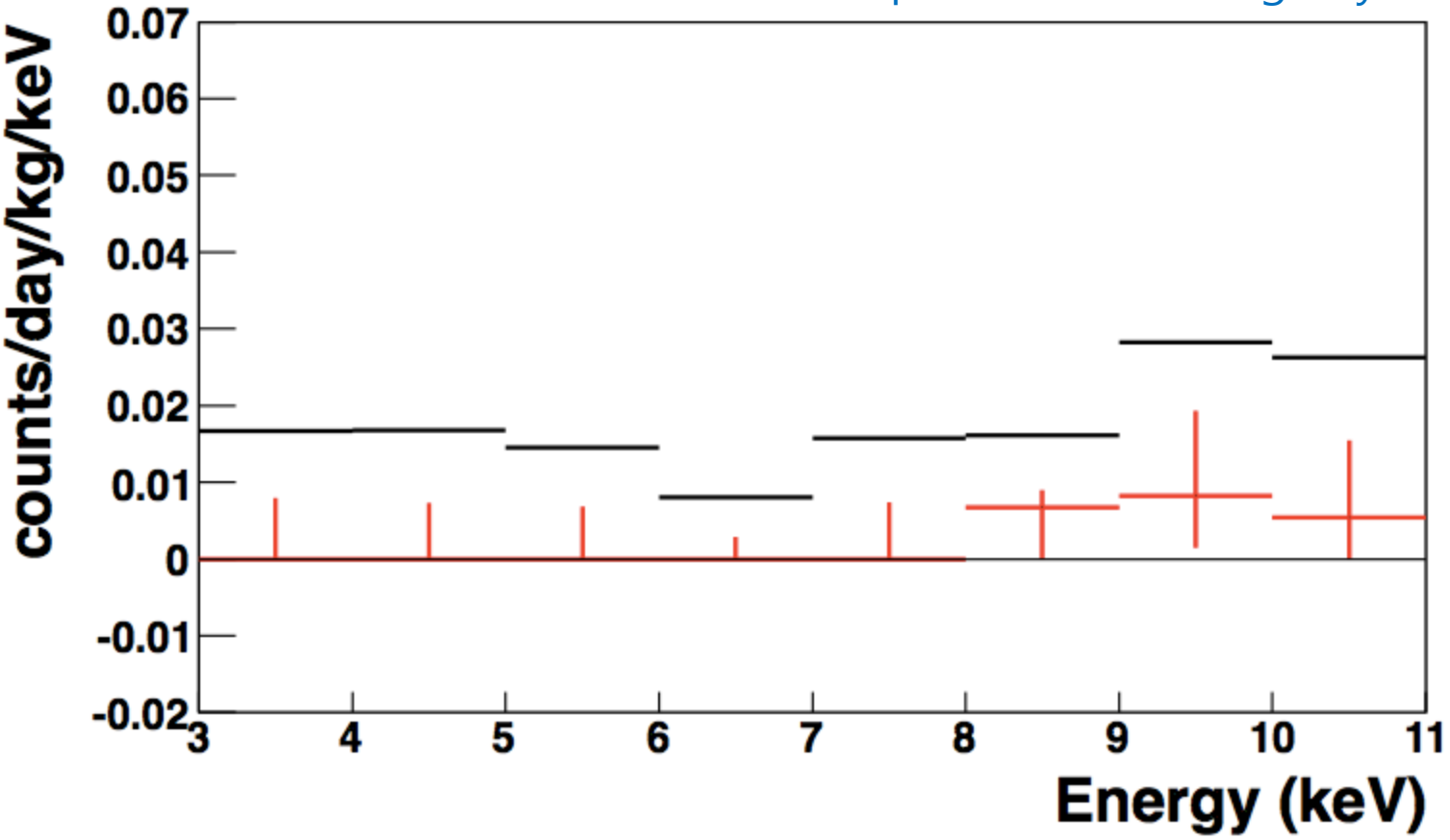


90 % limit

68 % interval

The overall NR events rate

det0, 8, 11 excluded
Total exposure: 24524.3 kg days



No meaningful excess of NR events is observed !!!

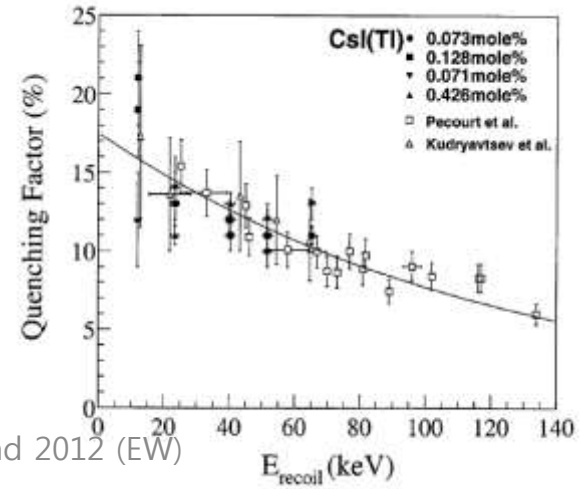
KIMS NR event rates
& DAMA/LIBRA annual modulation amplitude

The annual modulation amplitude from DAMA
⇒ At 2-4keV, 0.0183±0.0022 counts/day/kg/keV

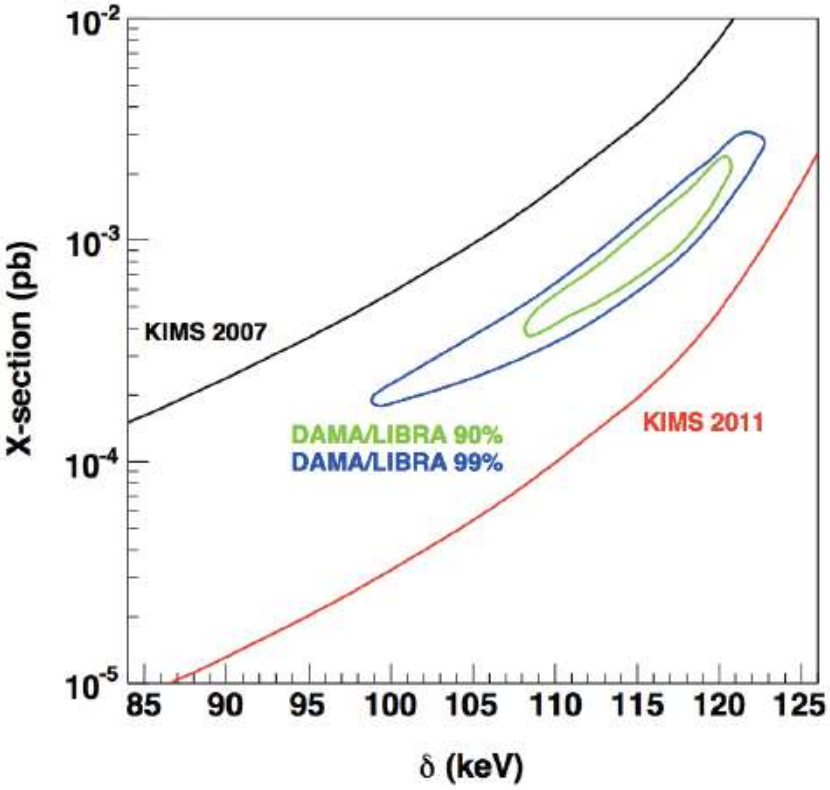
⇒ At the corresponding energy range (3.6-5.8 keV) in KIMS, (QF for DAMA =0.08 adopted)
The 90 % C.L limit is 0.0098 counts/day/kg/keV

This is well below the DAMA modulation amplitude.

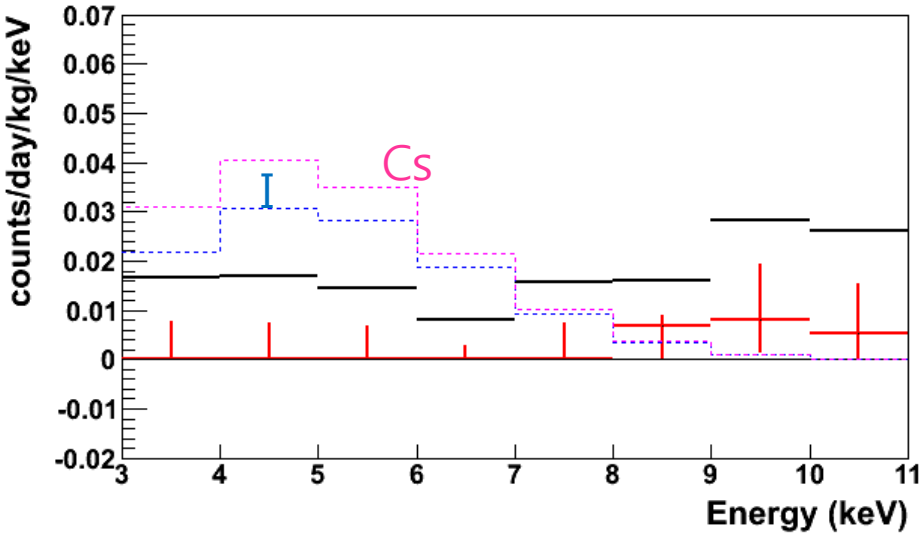
Any scenario with Iodine for DAMA is not consistent with KIMS results !!!



KIMS & DAMA in iDM model

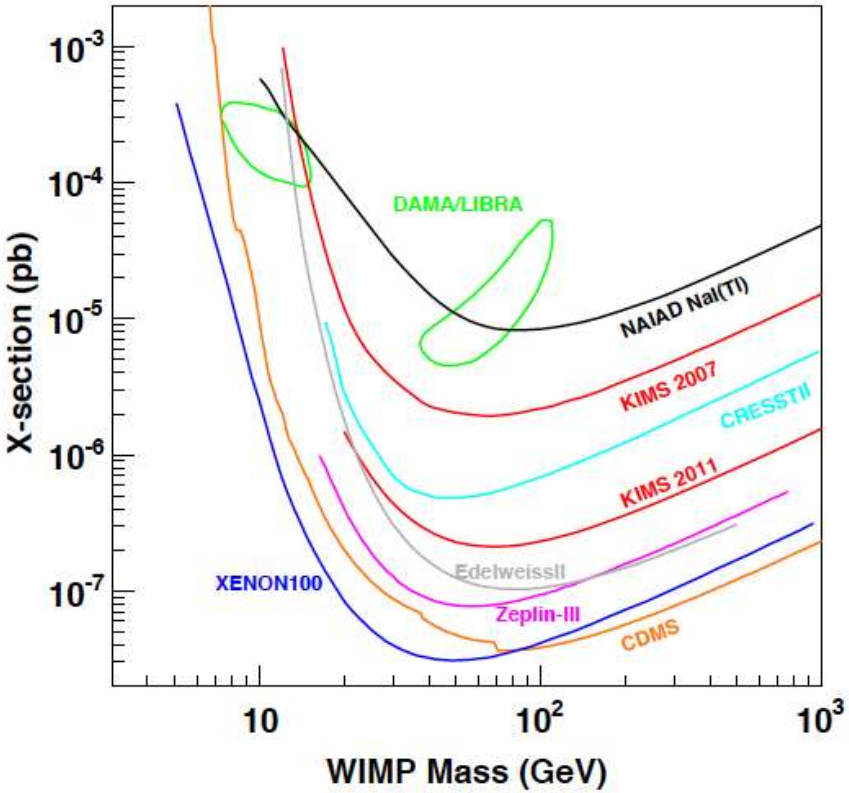


For 70 GeV mass WIMP

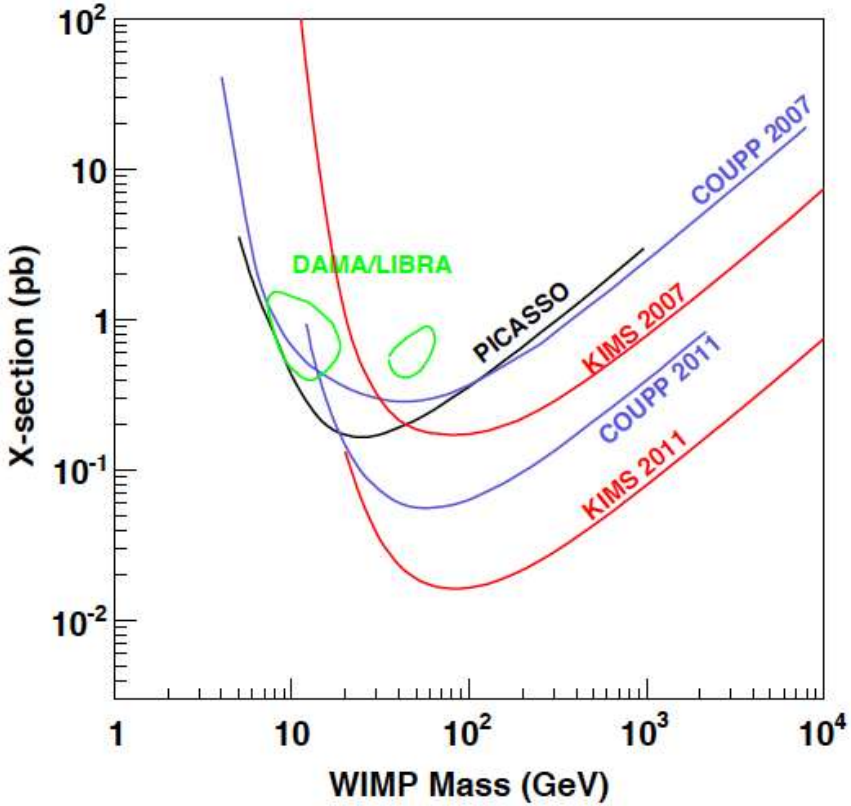


Expected spectrum for iDM in KIMS detector
=> M=70 GeV, δ=116keV, vesc=500 km/s,
ve=235km/s, σ=0.93e-3 pb

The new exclusion limits from KIMS

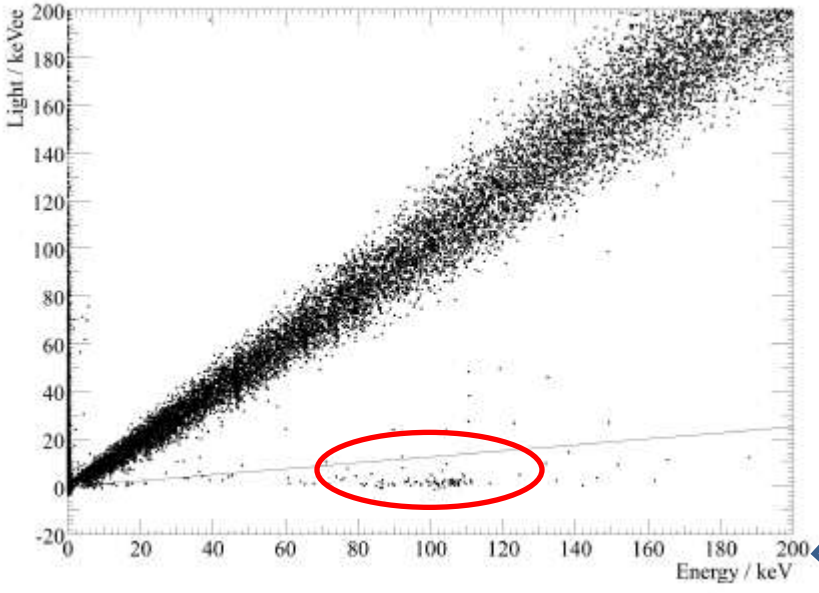


Spin-Independent interaction



Spin-dependent
proton interaction

Surface alpha event rejection with VM2000

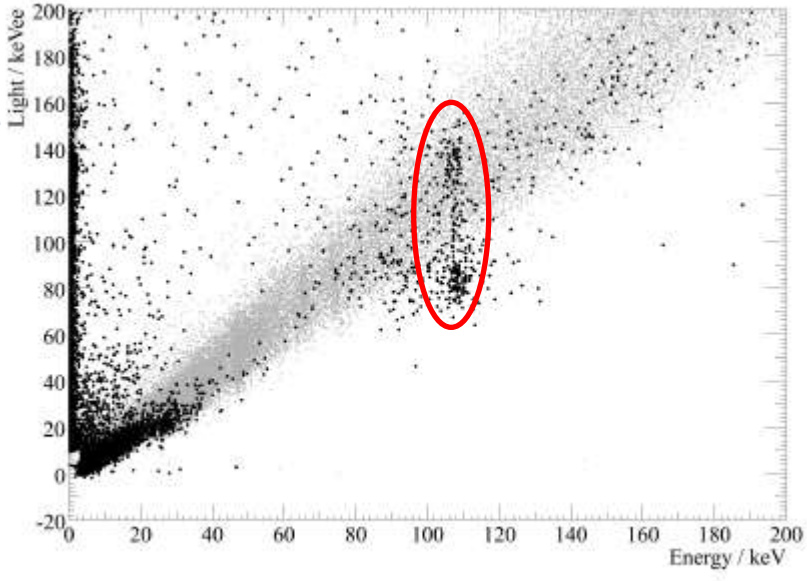


Pb206, daughter of Po210

From CRESST(0903.4687v1)

First used by CRESST group

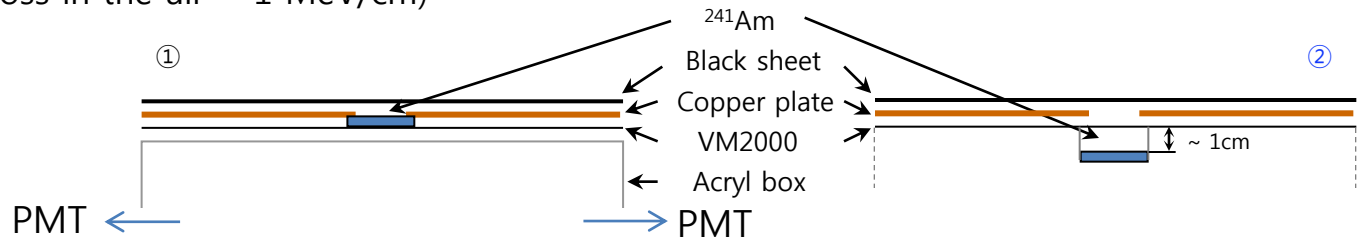
After surrounding detectors with a VM2000 foil,
which acts as reflector and scintillator.



Scintillation in the VM2000 (Enhanced Specular reflector @3M)

Exposed to alpha - ^{241}Am(α, 5.485 MeV)

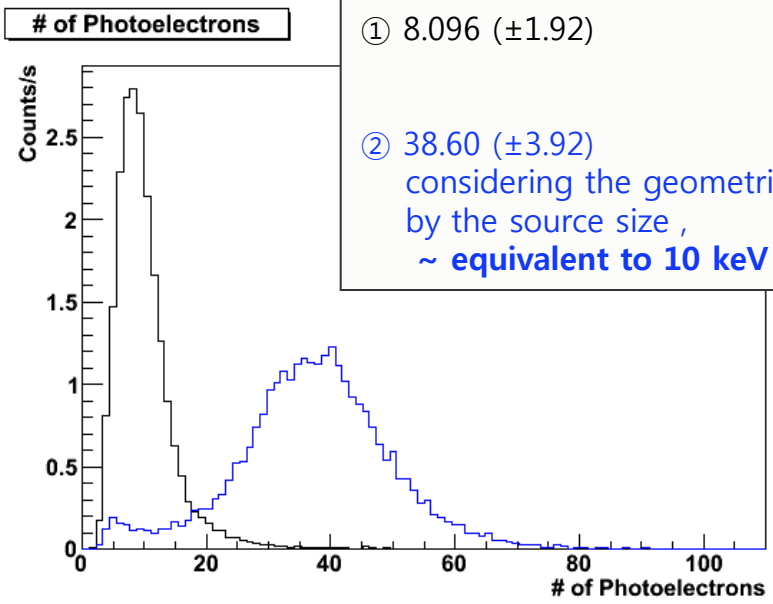
(energy loss in the air ~ 1 MeV/cm)



number of photoelectron :

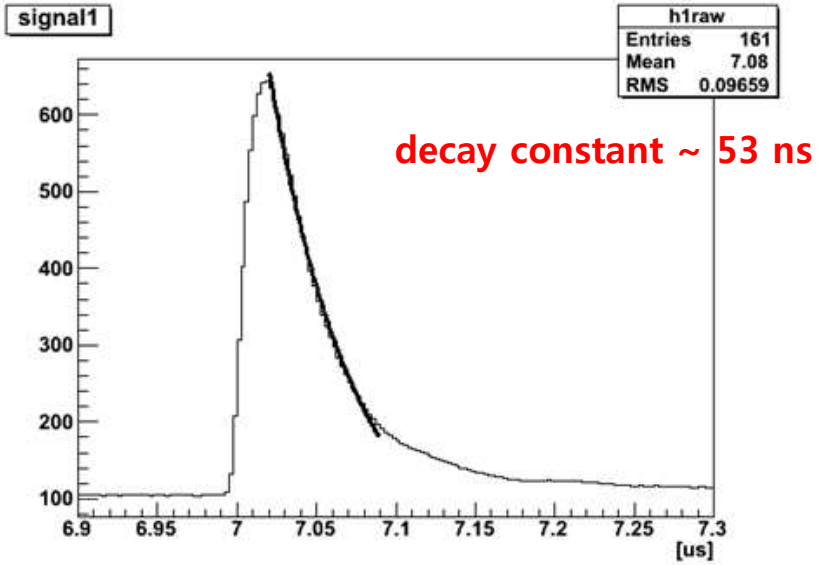
① 8.096 (±1.92)

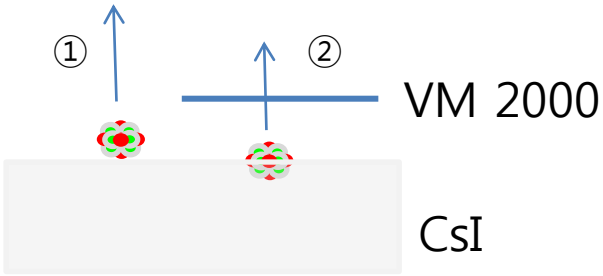
② 38.60 (±3.92)
considering the geometric inefficiency by the source size ,
~ equivalent to 10 keV event



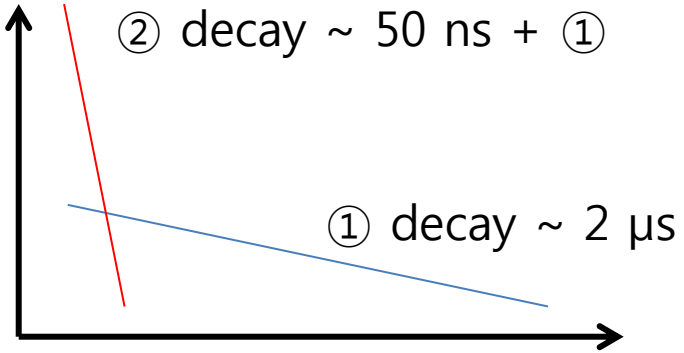
Scintillation in the VM2000 (Enhanced Specular Reflector @3M)

event shape





Expected event shape with VM 2000



New method to reject SA?
The further study is underway.

Annual modulation study

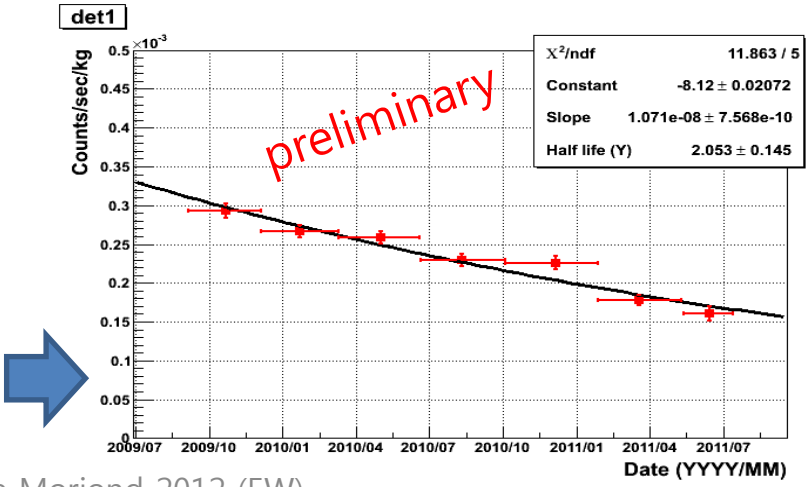
More than 2 year of data have been obtained
in the stable conditions.

Modulation analysis on going
- w/o PSD
- 2keV threshold

Stability of temperature, gain, etc. has been monitored

Low energy contribution from Cs-134, the time varying background

Decay of Cs-134 event rate
($T_{1/2}$=2.06 yr)



Summary

24524.3 kg days data was analyzed with PSD method.

Surface alpha background were identified.

No meaningful excess of NR events were found.

Our 90 % limit for NR events is well below the amplitude observed by DAMA/LIBRA, disfavoring any Iodine interpretation.

New improved exclusion limits for WIMP-nucleon interaction were presented.

The annual modulation study is underway.