Screening Materials with the XIA UltraLo Alpha Particle Counter at Southern Methodist University

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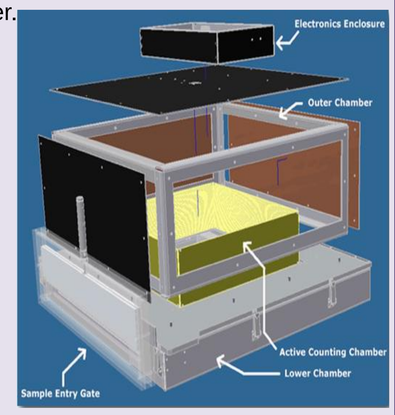
Abstract

Southern Methodist University in Dallas Texas houses one of only five existing UltraLo 1800 production model alpha counters made by XIA LLC. The instrument has an electron drift chamber with a 707 cm^2 or 1800 cm^2 counting region which is determined by selecting the inner electrode size. The SMU team operating this device is part of SuperCDMS screening working group, and uses the alpha counter to study the background rates from the decay of radon in materials used to construct the SuperCDMS experiment. We will present results from our initial calibration and screening runs with the XIA instrument, and will outline our plans for upcoming work to facilitate SuperCDMS to achieve it's goal to limit the experiment's beta backgrounds to a level of less than 0.003 events/cm^2/day.

What is the XIA Alpha Counter?

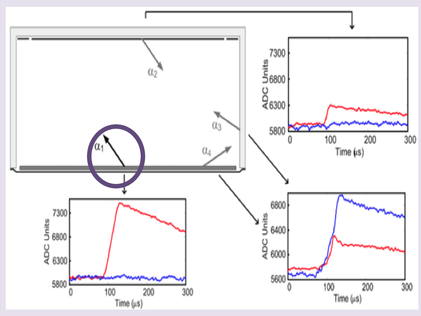
It is a specialized ionization counter comprising an active volume filled with argon, a lower grounded electrode that is a conductive tray holding the sample and an upper pair of positively charged electrodes. Of these two electrodes, the anode sits directly above the sample, while the guard electrode surrounds and encloses the anode. Both electrodes are connected to charge- integrating preamplifiers whose output signals are digitized and then processed by a digital pulse shape analyzer.



Drift Chamber:
- 21 x 21 inches
- 15 inches tall

Counting Area:
- Adjustable inner electrode size: 1800 cm^2 square or 707 cm^2 circular area
- 1 inch guard ring

Argon gas purge:
- 20 L/m prior to data taking (45 min purge)
- 4 L/m during normal operation



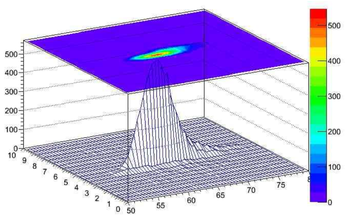
Alphas (α1): Energy > 2 MeV, little guard ring activity, rise time between 60-80 μs (user can modify lower rise time threshold)

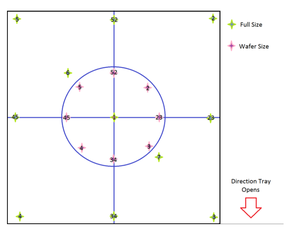
Ceiling(α2): low energy, low rise time

Sidewall(α3-4): significant guard ring activity

Noise: events not fitting into other classification

Tray Calibration with Thorium-230 Source





- Signature: ^{230}Th decays via an alpha of **4.8 MeV**
- Tray position study: spatial characterization of the tray response for both wafer and full size counting area with a ^{230}Th source
- Collection efficiency decreases as we move further away from the center.

Tray position	#Alphas corrected	Run Time (h)	Emissivity (alpha/cm2/h)	Efficiency (%)
W1	11400.42	2	8.06	100.00
W2	7160.78	2	5.06	62.78
W3	8265.349	2	5.85	72.58
W4	10147.24	4	3.59	44.54
W5	5650.117	2	4.00	49.63
W6	12.554	4	0.0044	0.05
W7	4.579	4	0.0016	0.02

Current Running Conditions

In December 2012, the instrument went under some performance studies that showed that it is operating very well.

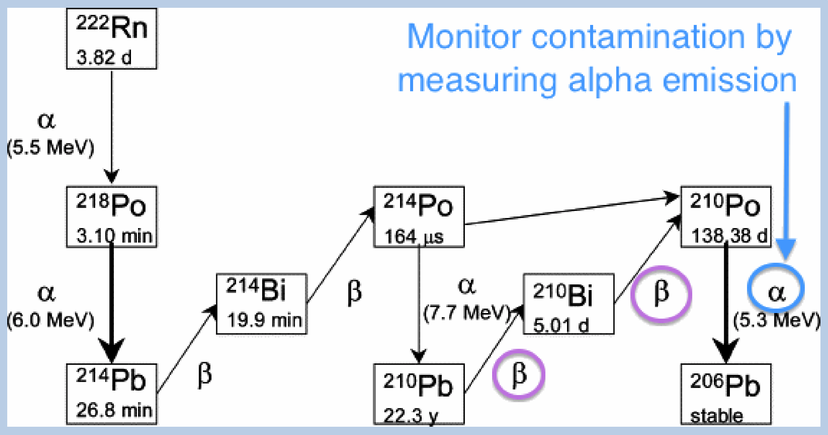
We are running the XIA with teflon covering the tray – performing cleaning procedures with RADIACWASH wipes monthly.

Empty tray emissivity: 0.0011± 0.0003 alpha/cm^2/hr

Alphas: why and from where

In rare event search experiments the reduction of all possible radioactive contaminants is crucial. This is also true for the surface contaminants introduced during the production, handling, treatment and storage of detector components.

^{210}Pb, which emits background particles when it decays, is a long-lived progeny of ^{222}Rn. Hence, control of the contamination induced ^{222}Rn and its progenies in the environment where detectors are assembled and stored is thus a crucial issue. ^{222}Rn daughters emitted in the atmosphere are electrically charged and they can stick on detectors surfaces with a relatively high probability of remaining fixed.



Radon progeny deposition onto acrylic sample (AC) AC samples from the miniCLEAN collaboration

Sample & cleaning techniques details

This study takes into account 4 samples of acrylic, each 6" x 6" x 0.125" (AC01 – AC04). The samples were exposed to ^{222}Rn gas from Sept. 1st to Sept. 16th , 2011 (16 days).

- Prior to cleaning, the ^{210}Po should be at ~50% ingrowth.
- Both sides are assumed to have the same surface activity.
- A layer of protective film remains on the *a priori* chosen bottom side. Only the top side of the acrylic is the surface to be counted.

The cleaning procedures for the samples are detailed below:

- **AC01**: plasma etched by IntlVac (process mostly removes surface dust)
- **AC02 &AC03:** topmost 1mm cut off
- **AC04:** control sample – no cleaning procedure – it is considered as our systematics

Efficiency of Cleaning Techniques

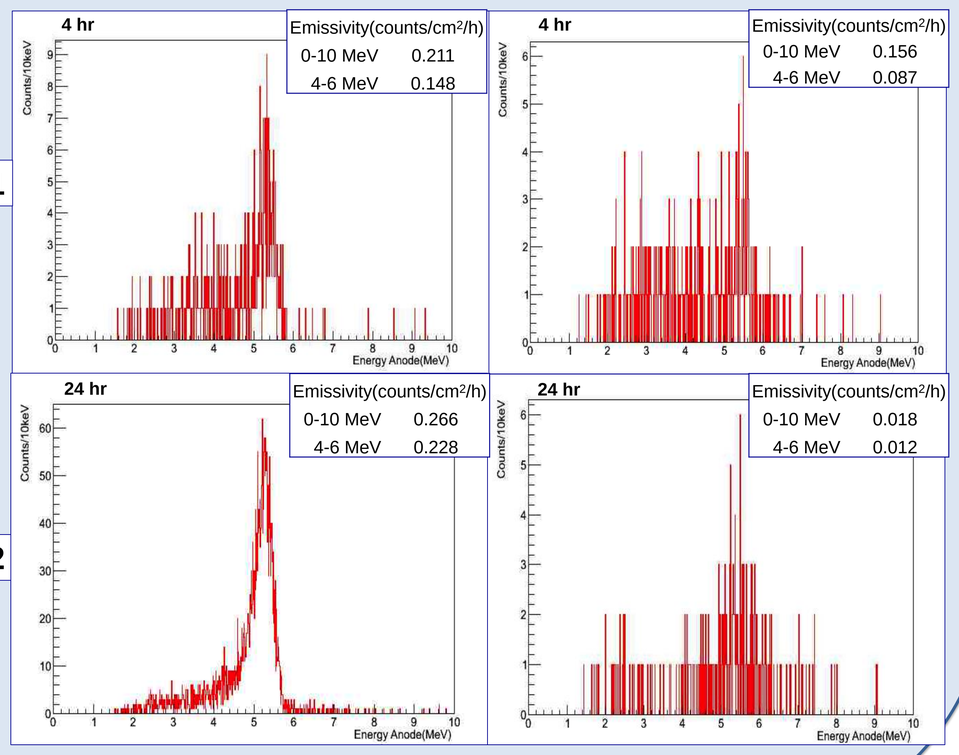
ENERGY RANGE	0-10 MeV	4-6 MeV (ROI)
SAMPLE	Removed Contamination (%)	
AC01	25	38
AC02	93	95
AC03	95	95
AC04	10	38

Summary:
Results from plasma etching are compatible with the control sample in the ROI. Shaving material off the surface is more effective in removing ^{210}Pb daughters.

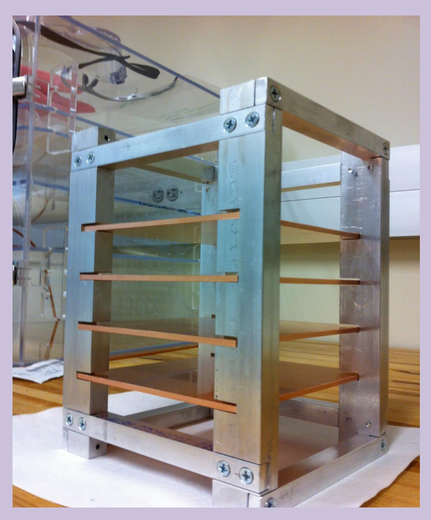
Emissivity (alpha/cm^2/hr)

ENERGY RANGE	0-10 MeV		4-6 MeV (ROI)	
SAMPLE	*Before Cleaning (Feb 2012)*	*After Cleaning (June 2012)*	*Before Cleaning (Feb 2012)*	*After Cleaning (June 2012)*
AC01	**0.2117 ± 0.0011**	**0.159 ± 0.008**	**0.1470 ± 0.0011**	**0.10 ± 0.03**
AC02	**0.269 ± 0.011**	**0.01789 ± 0.00011**	**0.229 ± 0.012**	**0.0118 ± 0.0003**
AC03	**0.463 ± 0.019**	**0.0244 ± 0.0013**	**0.321 ± 0.015**	**0.01650 ± 0.00015**
AC04	**0.287 ± 0.042**	**0.26 ± 0.11**	**0.25 ± 0.05**	**0.17 ± 0.07**

BEFORE CLEANING | **AFTER CLEANING**



Radon Studies – in fieri (SuperCDMS)



The goal is to investigate cleaning procedure techniques to mitigate the effects of the sources of the low energy (0-100 keV) events from progeny nuclear recoil and alpha particles that are bi-products of the Rn decay chain.

The radon contamination of four Cu samples are underway (started on March, 27th 2013).

- The samples are exposed to radon (^{226}Ra , ^{222}Rn passive source) in an Al vessel under a fume hood in Lab3 (FNAL).
- The contamination will last 3 months.

The specific alpha-activity of ^{210}Po resulting from radon daughters implanting due to their alpha recoil will be measured via XIA UltraLo alpha counters at SMU and at FNAL.

Outlook

- The XIA alpha particle counter is a useful tool for low radioactivity experiments.
- The commissioning phase of the SMU XIA alpha counter involving empty tray studies and monitoring and ^{230}Th source calibration has finished.
- We acquired experience in counting and analyzing acrylic samples which have been contaminated with ^{222}Rn source.
- We are currently conducting radon plate-out studies on copper.

Need to count alpha contamination on your samples?

Contact us!

Acknowledgements

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