Low Background Measurement Capabilities at SNOLAB

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Motivation

Experiments currently searching for dark matter and studying properties of neutrinos require very low levels of radioactive backgrounds both in their own construction materials and in the surrounding environment.

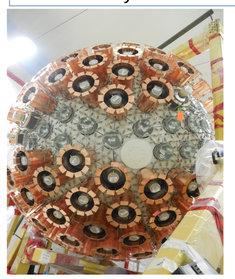
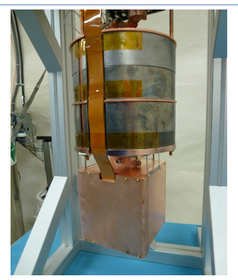
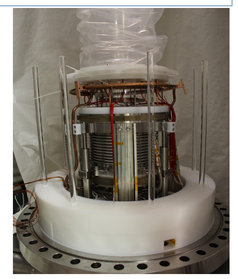
These low background levels are required so that the experiments can achieve the required sensitivities for their searches.

SNOLAB has several facilities which are used to directly measure these radioactive backgrounds.

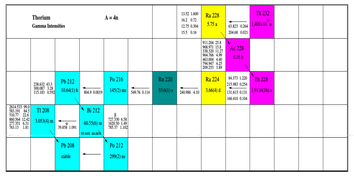
The backgrounds in question are on the order of 1 mBq for ^{238}U, ^{232}Th and ^{235}U and 1 ppm for ^{40}K, or better.

The problem backgrounds can include gammas, alphas and neutrons or resulting interaction products.

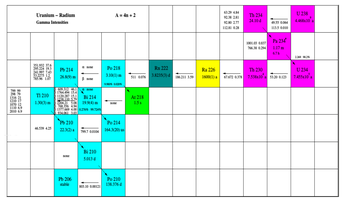
The goal is to measure these backgrounds and then to reduce them to be as low as reasonably achievable.

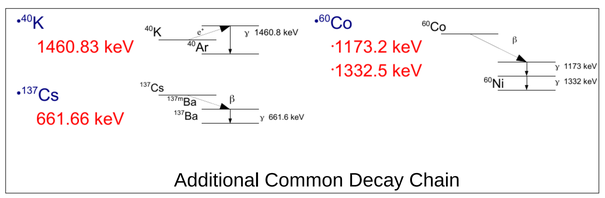
Backgrounds



^{232}Th Decay Chain



^{238}U Decay Chain

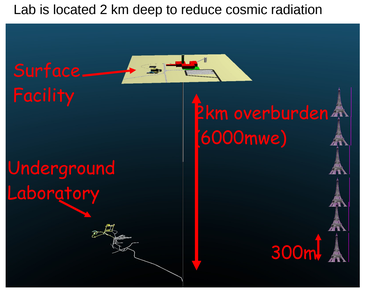


Additional Common Decay Chain

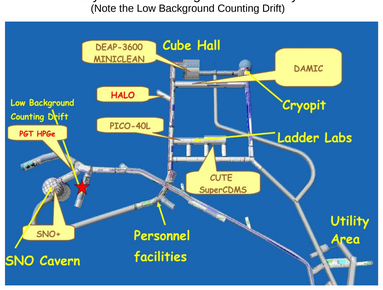
SNOLAB

Lively, ON Canada

Lab is located 2 km deep to reduce cosmic radiation



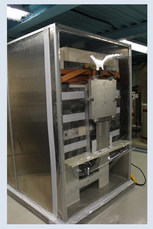
Layout of the underground laboratory
(Note the Low Background Counting Drift)



Gamma Detectors

PGT Detector

Well Detector



Gopher Detector

VdA Detector

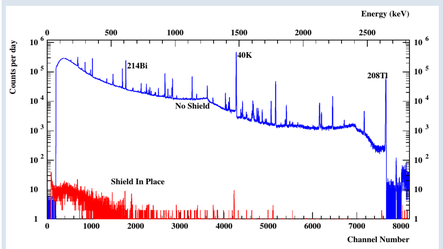
Coax Detector

Detector Sensitivities

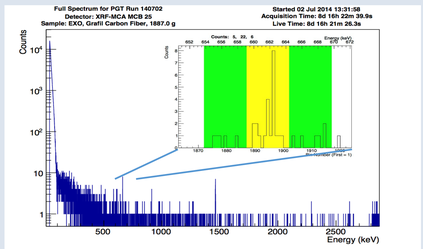
Isotope	PGT Detector Sensitivity	Well Detector Sensitivity	Gopher Detector Sensitivity	VdA Detector Sensitivity	Coax Detector Sensitivity
^{238}U	0.11 mBq	0.04 mBq	0.35 mBq	0.06 mBq	
^{235}U	0.15 mBq	0.02 mBq	0.23 mBq	0.04 mBq	
^{232}Th	0.11 mBq	0.23 mBq	0.32 mBq	0.05 mBq	
^{40}K	1.40 mBq	N/A	1.29 mBq	0.70 mBq	
^{60}Co	0.04 mBq	N/A	0.04 mBq	0.02 mBq	
^{137}Cs	0.14 mBq	0.02 mBq	0.08 mBq	0.03 mBq	
^{54}Mn	0.04 mBq	0.80 mBq	0.05 MBq	0.02 mBq	
210Pb	N/A	0.08 mBq	N/A	1.65 mBq	

Background Run In Progress

Shielding Effects of the PGT Detector



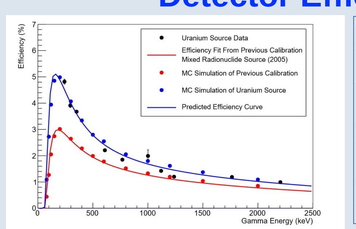
Typical One-week spectrum from PGT Detector



Counting Rate: $N_{Rate} = \frac{(N_{peak} - N_{sideband} - N_{peak})}{(Eff \times Br \times T_L)}$

N_{peak}: number of peak events
$N_{sideband}$: average number of events from the side-bands
N_{peak}: intrinsic detector background in the peak region
Eff: detector efficiency at the peak energy
BR: is the branching ratio
T_L: detector live time

Detector Efficiency and Correction



Efficiency Curve of the PGT detector

The original efficiency was calculated with a mixed radionuclide source in 2005.

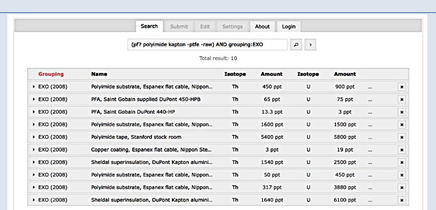
This calibration is being verified with new uranium and thorium sources.

Geant4 simulations are used to adjust the efficiency curve for particular samples based on their geometry and material composition.

Using this method, all of the high purity germanium detectors will be similarly calibrated.

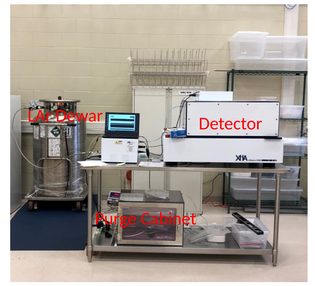
Material Assay Database

radiopurity.org
(hosted by SNOLAB)



Alpha Detectors

XIA Ultralo-1800



Under commissioning at the SNOLAB surface clean lab

Teflon liner tray background runs show 400 nBq/cm^2 emissivity over full energy range (1-10MeV)

Plan to move it underground by summer 2019

Count region: 1800cm^2 square and 707cm^2 circular
Maximum sample weight: 9kg
Maximum sample thickness: 6.3mm

Monitor system of environmental parameters (radon, humidity, temperature, particulates ..)

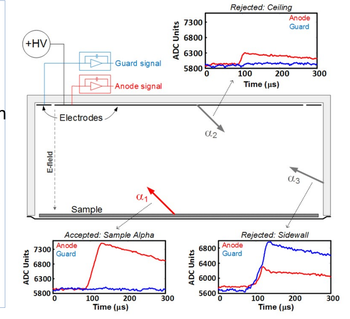
An ionization chamber with no wires.

Alphas ionize Ar gas.

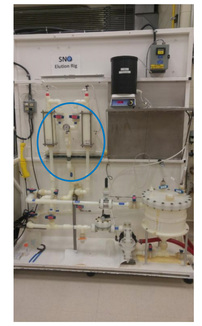
The top of the XIA has a 1100 V anode. Charge drifts from the grounded sample tray. As the charges drift, they induce a current on the anode.

Risetime is the duration of the leading edge of the pulse, the charge drift time.

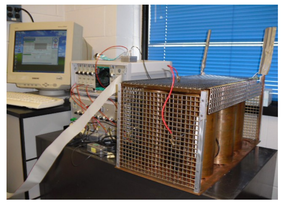
Risetime is a discriminating variable to reject mid-air decays. (Short rise time because of short drift distance.) 60us nominal cut.



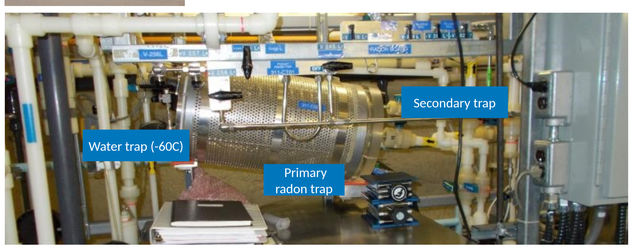
Ultra-pure Water



HTiO columns trap radium for subsequent elution, concentration, Bi-Po beta-alpha counting.



Vials w/ liq scint coupled to 2” PMTs. Sensitivity to U-238 / Th-232 ~ 1mBq.



Radon Board

Used to verify the quality of the ultra-pure water

Radon Emanation

“All” orbital welding

Two chambers:
20cm x 20cm
50cm x 50cm

Choice of primary trap
Brass wool (LN2)
charcoal (methanol slush)

Under construction