CAP Conference 2024

Improving the Radon Trapping Capability at SNOLAB using Activated Charcoal

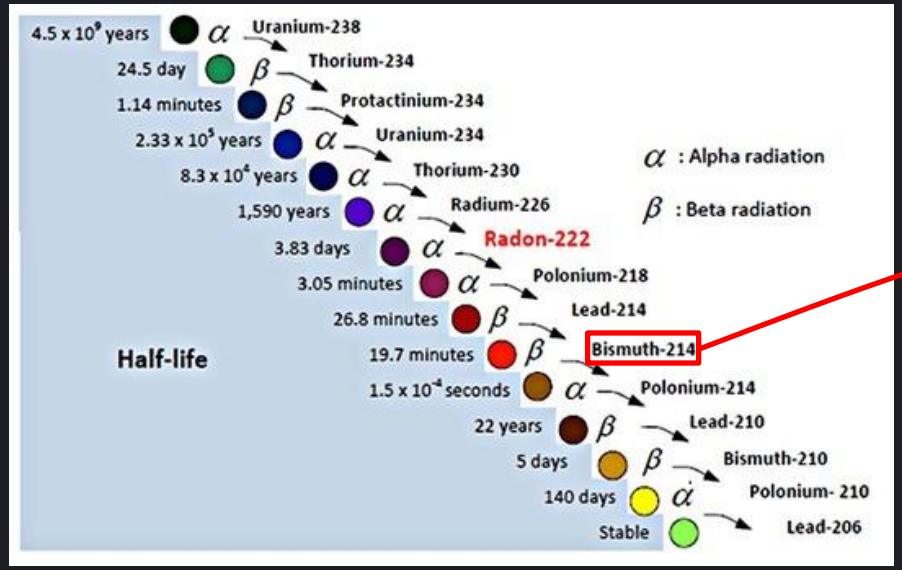
CASST 2023 Winner

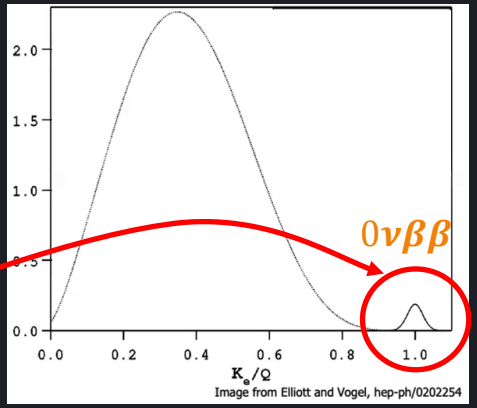
Yusuf Ahmed

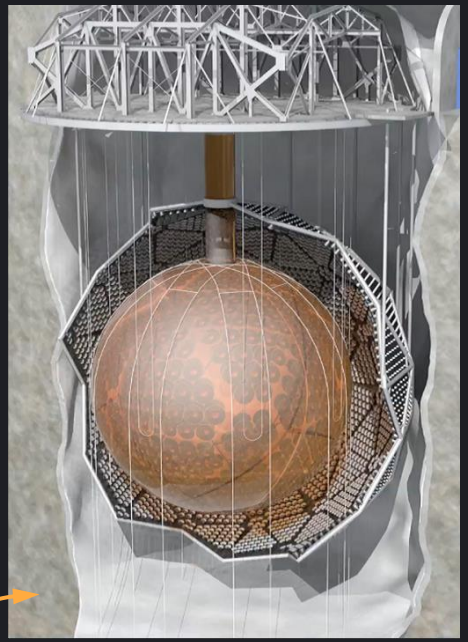
Supervisors: Dr. Nasim Fatemighomi & Lina Anselmo

Why is ^{222}Radon A Problem?

Radioactive, inert, gas







SNO+

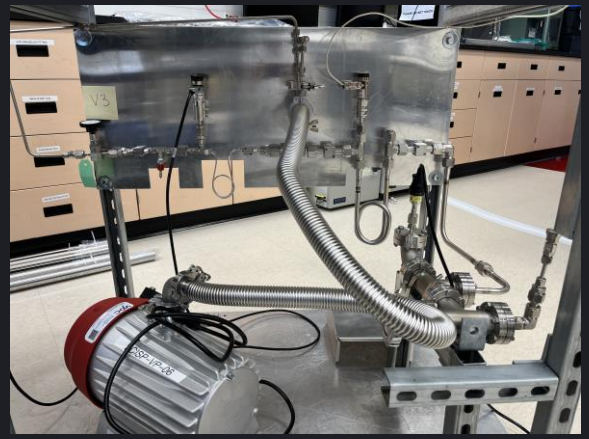
Uranium Ore

SNOLAB

What is a Radon Assay?

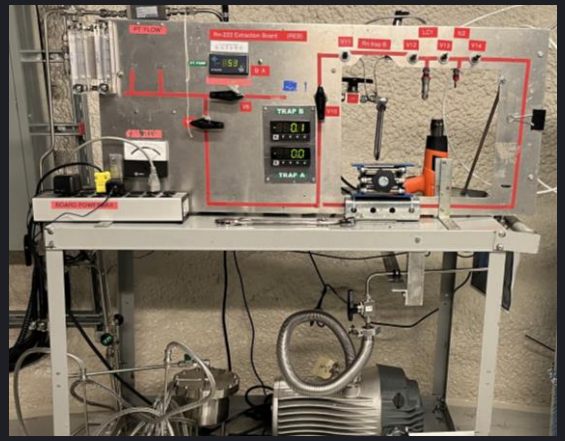
The extraction and counting of radon from a sample of fluid.

Surface Gas Assay Board



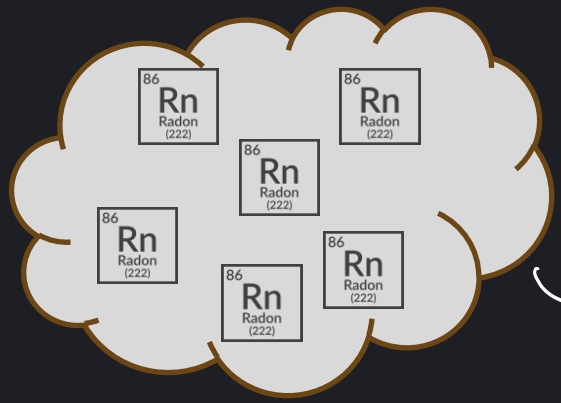
Surface DEAP Gas Assay Board

Underground SNO+ Gas Assay Board



Underground UPW Assay System

How we extract Radon



30 – 60 min

15 min
Cryopumping

10 min
Volume Sharing

-196°C

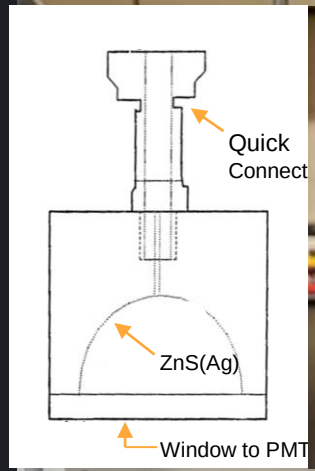
100°C

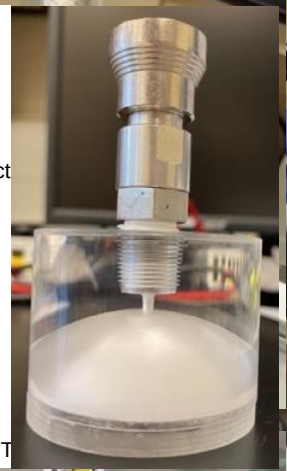
-196°C

Lucas Cell

Secondary Trap

Primary Trap





PMT

Lucas Cell on a PMT

When testing a new trap

^{86}Rn
Radon
(222)

30 - 60 min

150°C

-70°C

-196°C

100°C

-196°C

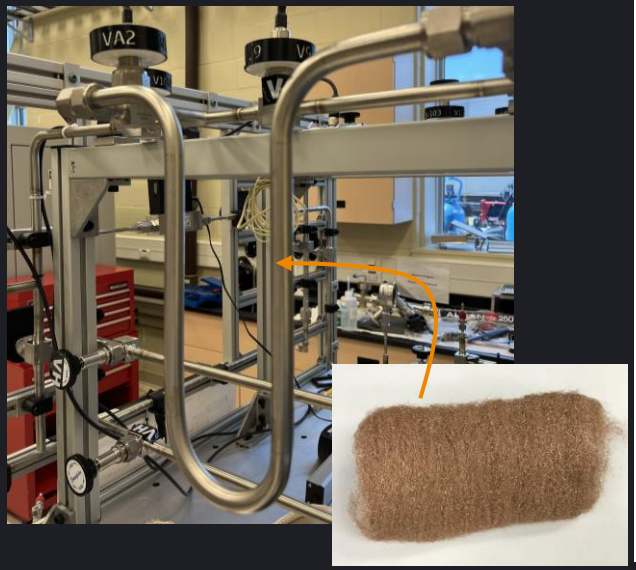
Lucas Cell

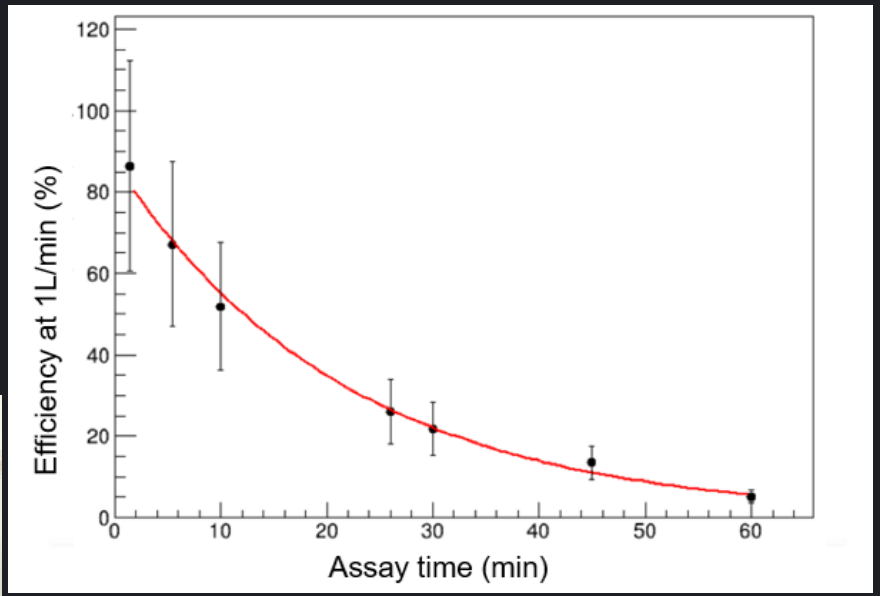
Secondary Trap

Primary Trap

Why do we need a better trap?

Primary Trap (Bronze Wool)





Source: Adil Hussain, S. M. (2022) *Evaluating 238U External Background for SNO+ Experiment using Radon Assays and 214Bi Analysis.*

Note: The underground gas assay board's primary bronze trap was used to for these data points. The picture beside the plot is of the surface board's primary bronze trap.

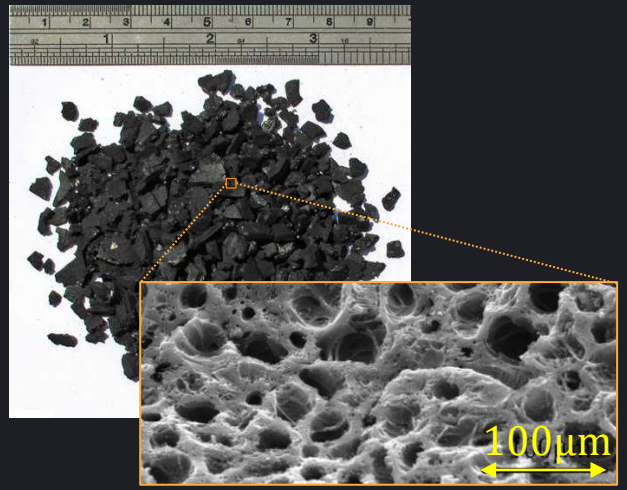
What we required: Retainment of efficiency at high flow rates

The Progress So Far

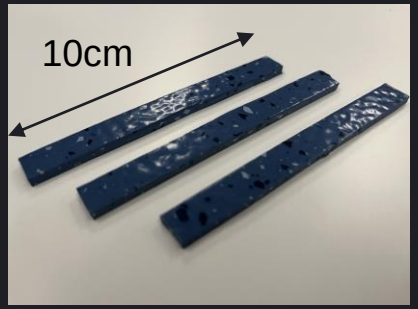
STEP 1: Making the Trap

Activated Charcoal

Greater heat capacity & surface area.
(In principle, can sustain longer and higher flow rates)



STEP 2: Making a Calibration Source



STEP 3: Trap Background Assays

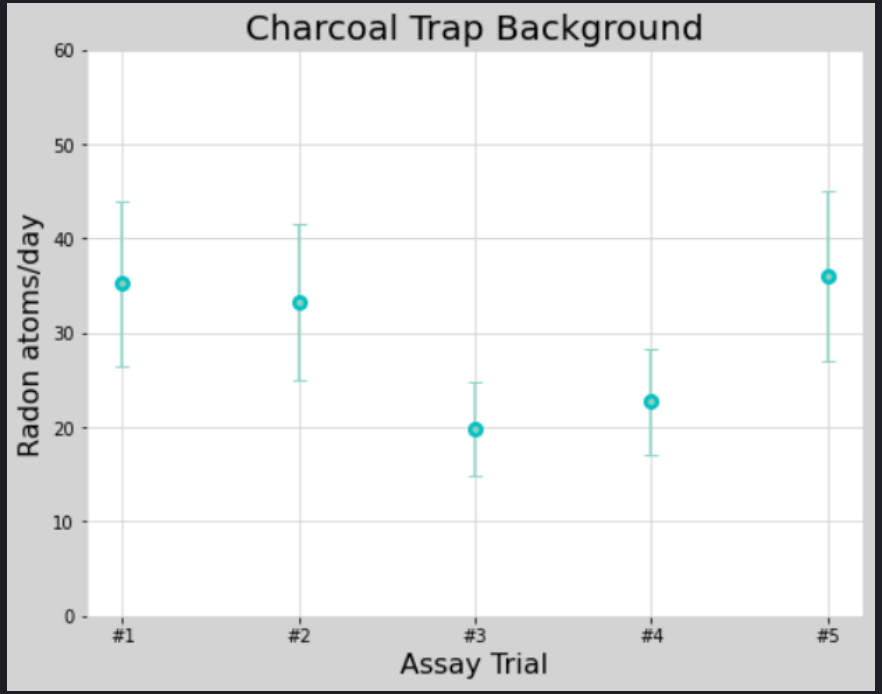


Table 1: Activated charcoal gamma counting results (2 weeks of counting)

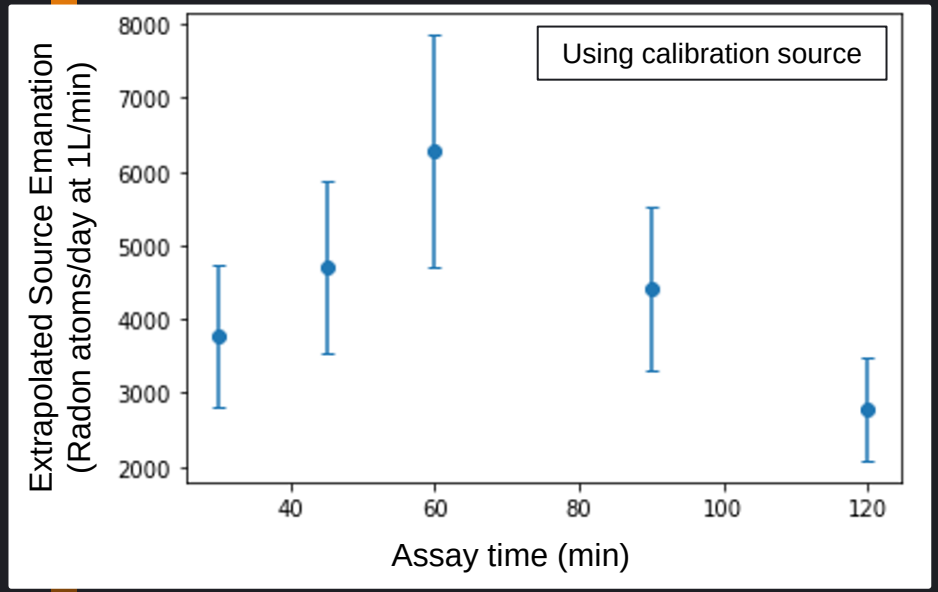
	238U from 226Ra [mBq/kg]	238U from 234Th [mBq/kg]	232Th [mBq/kg]	210Pb [mBq/kg]
Pre-Acid Wash	465.5 ± 47.4	< 327.12	114.5 ± 37.6	< 1260.10
Post-Acid Wash	< 33.25	< 42.92	99.8 ± 20.1	< 548.20

Average Trap Background:

29.42 ± 7.35 Radon atoms/day
1.2 ± 0.3 Radon atoms/hour

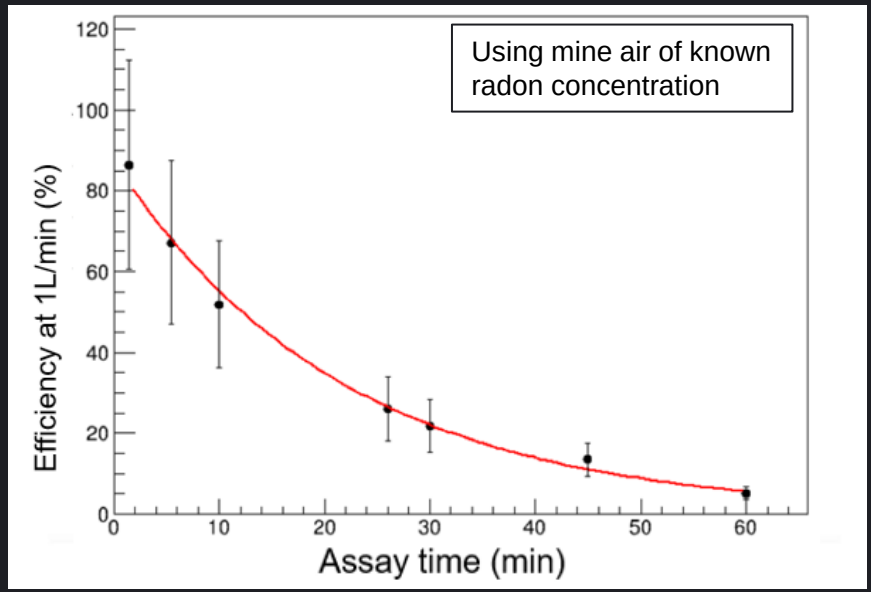
STEP 4: Preliminary Qualitative Assays

Activated Charcoal

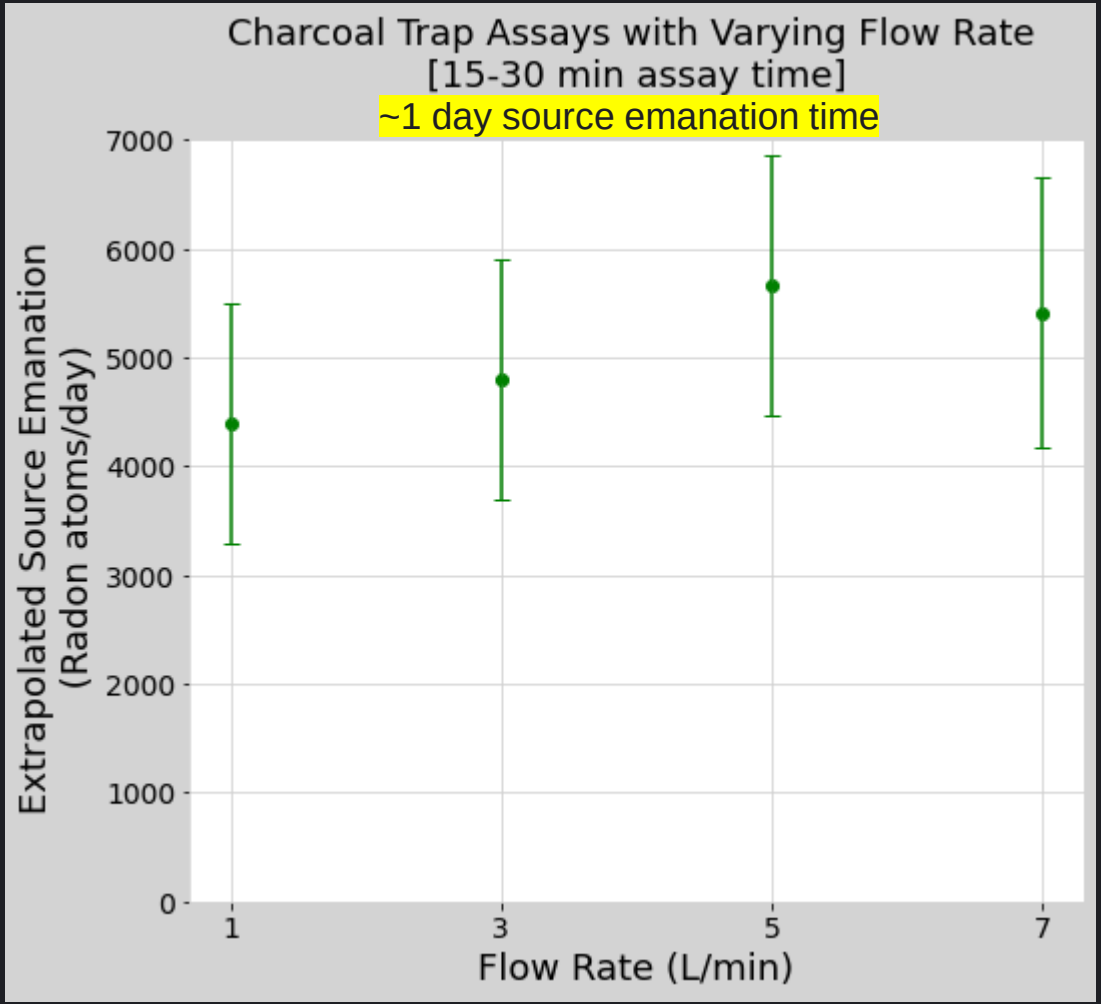


Source: Jerry Lu, SNOLAB, Fall 2022.

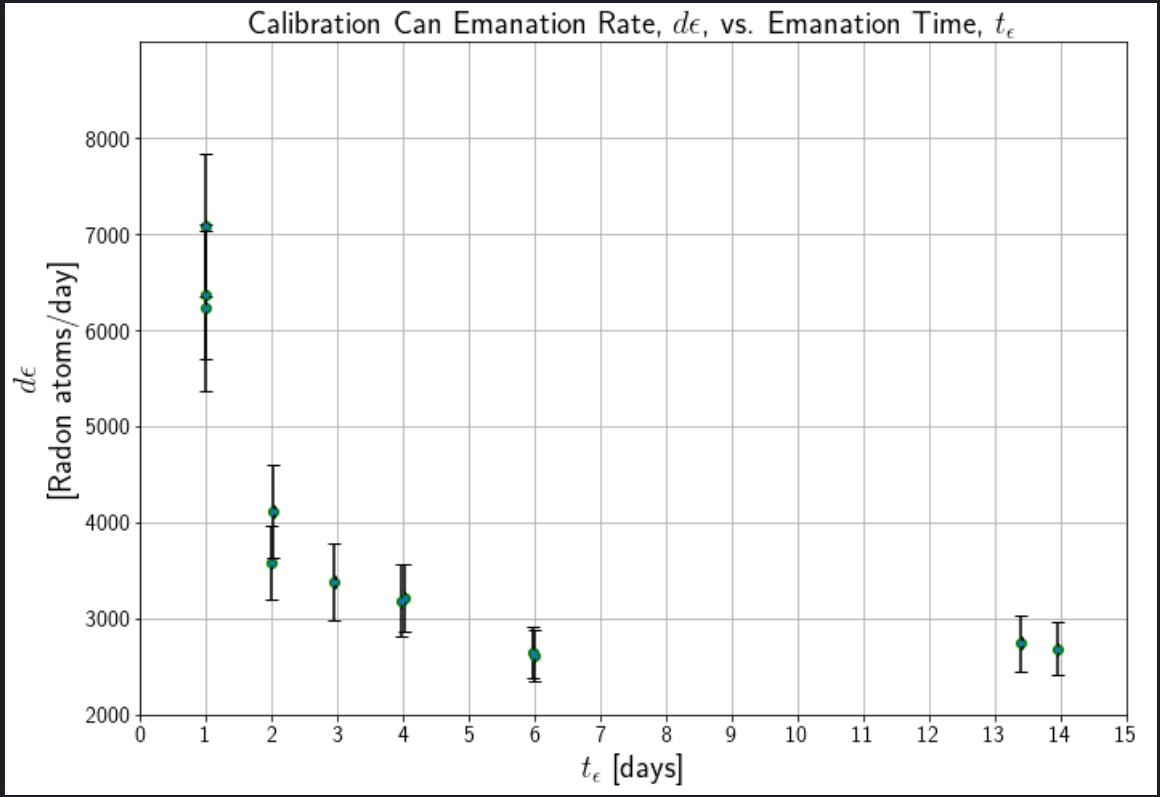
Bronze Wool

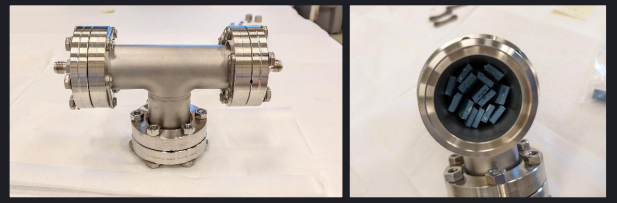


Source: Adil Hussain, S. M. (2022).


Charcoal Trap Assays with Varying Flow Rate
[15-30 min assay time]
~1 day source emanation time
Extrapolated Source Emanation
(Radon atoms/day)
7000
6000
5000
4000
3000
2000
1000
0
1
3
5
7
Flow Rate (L/min)

STEP 5: Determining Source Emanation Rate

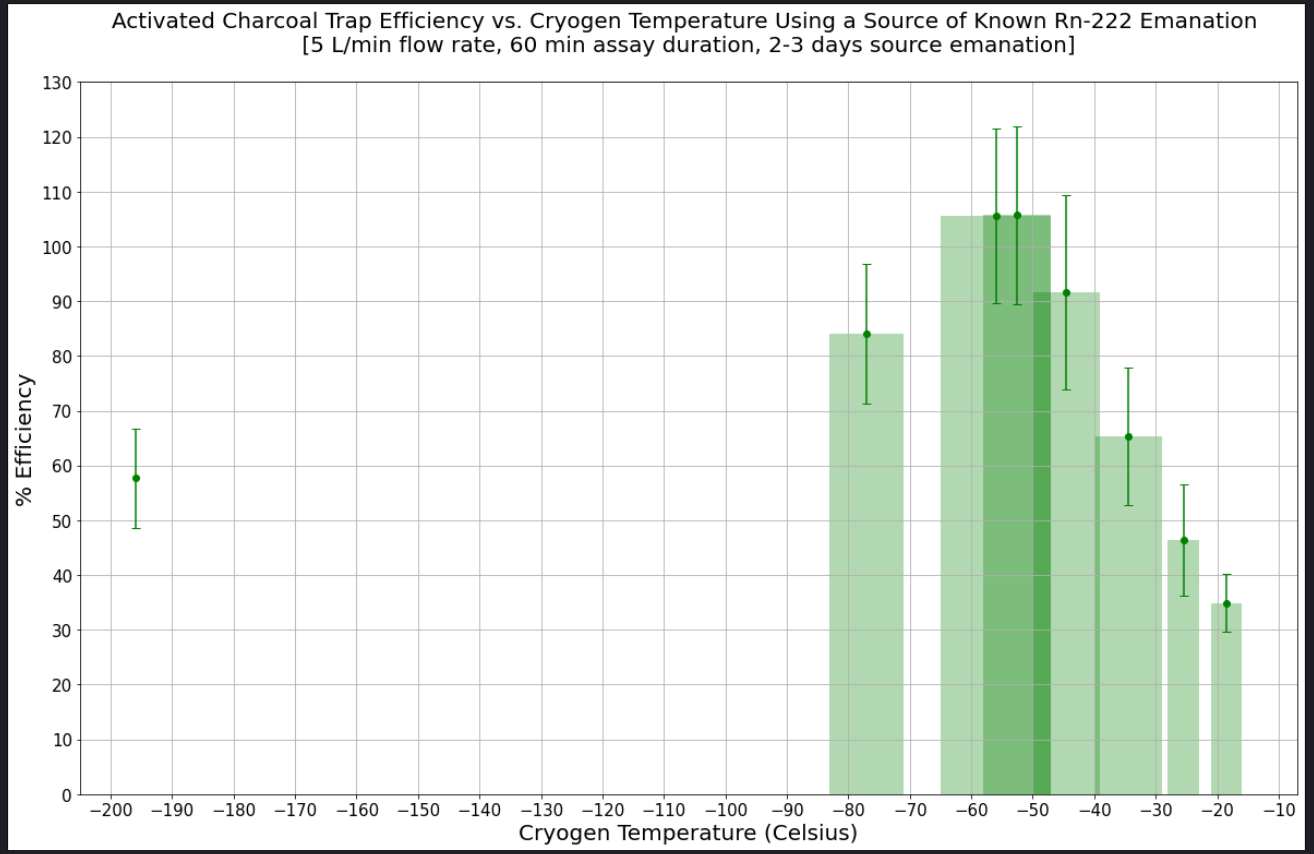




Calibration Can

DEAP Assay Board

STEP 6: Varying Cryogen Temperature



Reagent Alcohol + LN_2

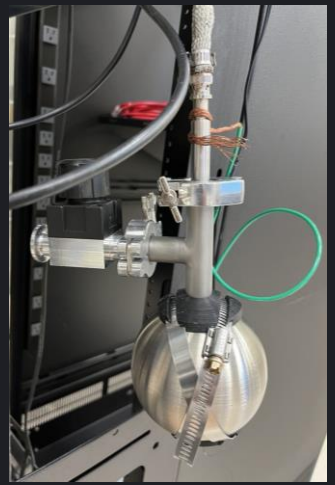
The Next Steps

- Confirm the reproducibility of results.
- Test new polymer based activated charcoal beads.
- Sample underground cover gas systems.

A New Project: Improving Radon Counting

Lucas Cell:

- Low energy resolution
- Cannot distinguish radon's alpha
- Pb^{210} background build up



Spherical Proportional Counter:

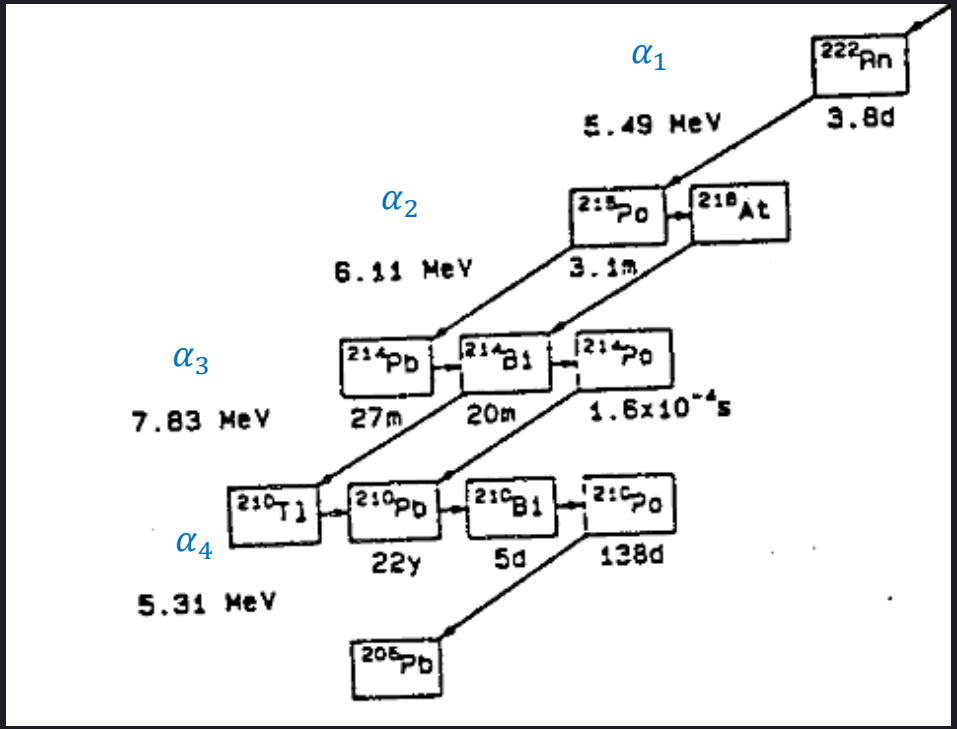
- High energy resolution
- Can distinguish radon's alpha
- Pb^{210} can physically be removed

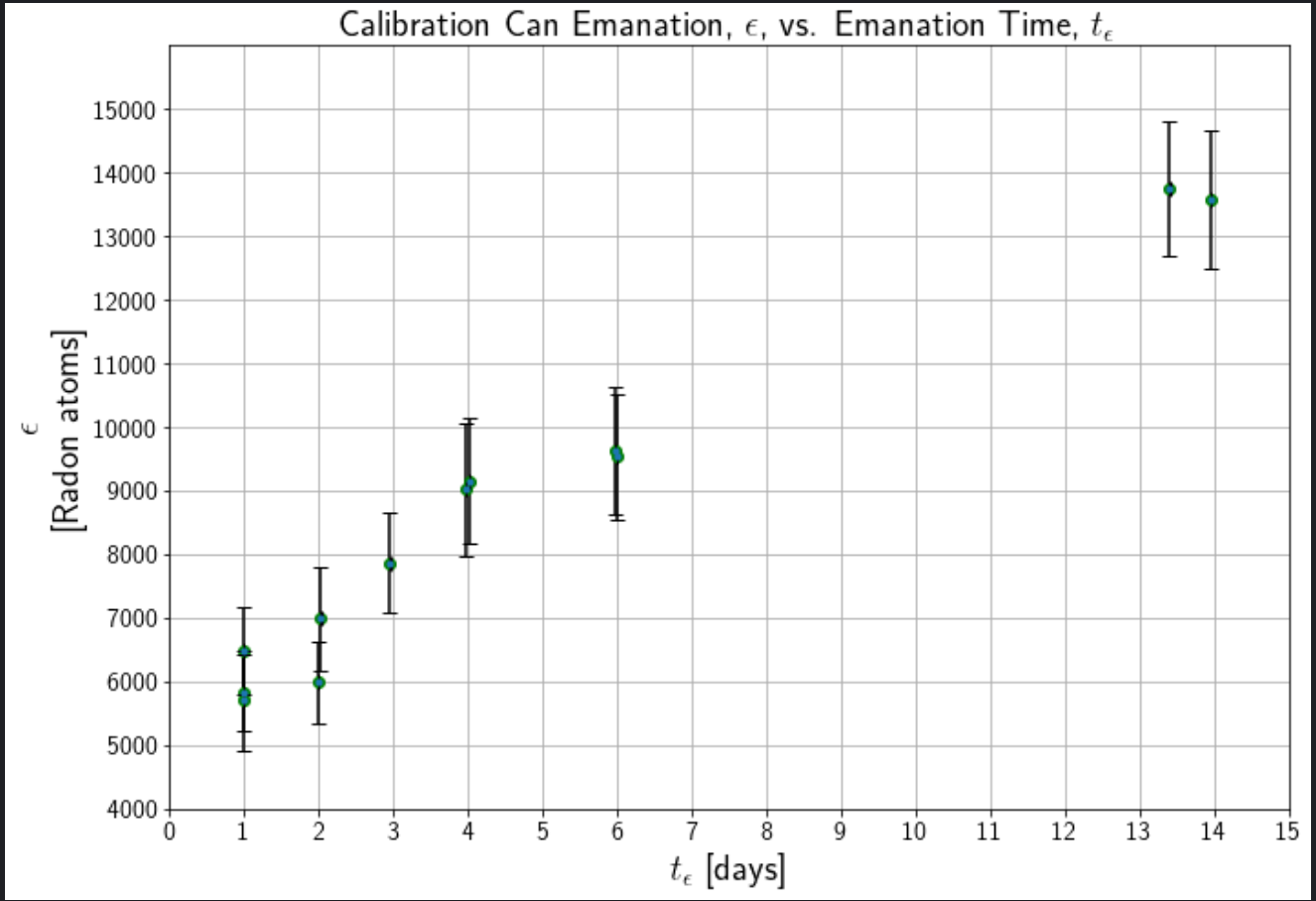
Thank you!

Supervisors: Dr. Nasim Fatemighomi & Lina Anselmo

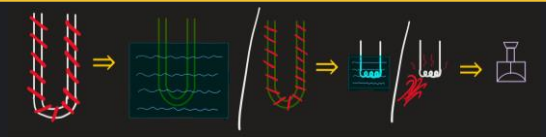
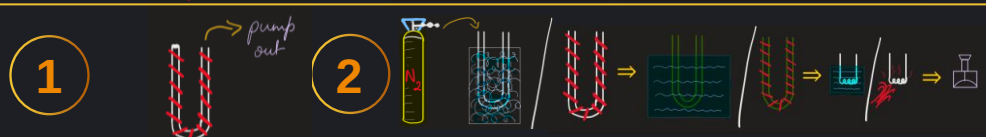
Mentors: Dr. Pierre Gorel,
Dr. Mark Ward,
Dr. Alex Wright,
Dr. Ian Lawson,
Dr. Christine Kraus,
Juliette DeLoye,
Syed Adil Hussain,
Deena Fabris.

SUPPLEMENTARY SLIDES


α_1
5.49 MeV
^{222}Rn
3.8d
α_2
6.11 MeV
^{218}Po
3.1m
^{218}At
α_3
7.83 MeV
^{214}Pb
27m
^{214}Bi
20m
^{214}Po
1.6x10^{-4}s
α_4
5.31 MeV
^{210}Tl
^{210}Pb
22y
^{210}Bi
5d
^{210}Po
138d
^{206}Pb


Calibration Can Emanation, ϵ, vs. Emanation Time, t_ϵ
ϵ [Radon atoms]
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
t_ϵ [days]

Background Assays

I	Few days of Pre-Emanation		1.26 ± X.XX atoms/hour
II	• No Pre-Emanation • N_2 Purging		34.6 ± X.XX atoms/hour
III	• No Pre-Emanation • No N_2 Purging		13.7 ± X.XX atoms/hour
IV	• No Pre-Emanation • 30L N_2 @ 1L/min		25.3 ± X.XX atoms/hour
	Board Background Assay		12.6 ± X.XX atoms/hour