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

Uranium Ore
What is a Radon Assay?

The extraction and counting of radon from a sample of fluid.
How we extract Radon

10 min Volume Shaking

15 min Cryopumping

-196°C

100°C

-196°C

PMT

Lucas Cell on a PMT

Quick Connect

ZnS(Ag) Window to PMT

30 - 60 min
When testing a new trap

30 - 60 min

86 Rn
Radon (222)

Lucas Cell

Secondary Trap

-196°C

Primary Trap

150°C

-70°C
Why do we need a better trap?

What we required: Retainment of efficiency at high flow rates

Primary Trap (Bronze Wool)


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.
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**

---

**100 μm**
STEP 3: Trap Background Assays

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

<table>
<thead>
<tr>
<th></th>
<th>238U from 226Ra [mBq/kg]</th>
<th>238U from 234Th [mBq/kg]</th>
<th>232Th [mBq/kg]</th>
<th>210Pb [mBq/kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Acid Wash</td>
<td>465.5 ± 47.4</td>
<td>&lt; 327.12</td>
<td>114.5 ± 37.6</td>
<td>&lt; 1260.10</td>
</tr>
<tr>
<td>Post-Acid Wash</td>
<td>&lt; 33.25</td>
<td>&lt; 42.92</td>
<td>99.8 ± 20.1</td>
<td>&lt; 548.20</td>
</tr>
</tbody>
</table>

Average Trap Background:

29.42 ± 7.35 Radon atoms/day
1.2 ± 0.3 Radon atoms/hour
STEP 4: Preliminary Qualitative Assays

Activated Charcoal

![Graph showing extrapolated source emanation for Activated Charcoal.](image1)

Using calibration source

Bronze Wool

![Graph showing efficiency at 1 L/min for Bronze Wool.](image2)

Using mine air of known radon concentration

Source: Jerry Lu, SNOLAB, Fall 2022.

Charcoal Trap Assays with Varying Flow Rate
[15-30 min assay time]

~1 day source emanation time
STEP 5: Determining Source Emanation Rate

Calibration Can Emanation Rate, $d \kappa$, vs. Emanation Time, $t \epsilon$

Calibration Can

DEAP Assay Board
STEP 6: Varying Cryogen Temperature

Activated Charcoal Trap Efficiency vs. Cryogen Temperature Using a Source of Known Rn-222 Emanation
[5 L/min flow rate, 60 min assay duration, 2-3 days source emanation]
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
<table>
<thead>
<tr>
<th></th>
<th>Few days of Pre-Emanation</th>
<th>• No Pre-Emanation</th>
<th>• No Pre-Emanation</th>
<th>• No Pre-Emanation</th>
<th>Board Background Assay</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1.26 ± X.XX atoms/hour</td>
<td>34.6 ± X.XX atoms/hour</td>
<td>13.7 ± X.XX atoms/hour</td>
<td>25.3 ± X.XX atoms/hour</td>
<td>12.6 ± X.XX atoms/hour</td>
</tr>
<tr>
<td>II</td>
<td>No Pre-Emanation</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>N₂ Purging</td>
<td>pump out</td>
<td>pump out</td>
<td>pump out</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>30L N₂ @ 1L/min</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>