$^{222}\text{Rn}$ Concentrations within the Water Phase of the SNO+ Experiment

Pooja Woosaree
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SNO+

- Located 2km underground inside SNOLAB
- Inherited hardware from the SNO detector, which in 2015 was one of the experiments associated with the Nobel Prize Award in Physics for the discovery of neutrino oscillations.
The primary goal of the SNO+ detector is to look for neutrinoless double beta decay (0\(\nu\beta\beta\)), a rare physics interaction where if its existence is proven, allows us to make precise measurements of the effective mass of neutrinos as they would be considered Majorana particles as opposed to Dirac.
The Detector

- 12 m diameter acrylic vessel (AV)
- 9600 Photomultiplier tubes (PMTs)
- 7000 tonnes of surrounding water
- Urylon layer/Radon seal
Detector Phases

- **Phase I**: Water
  - Observes more external backgrounds.

- **Phase II**: Scintillator
  - Observes more internal backgrounds.

- **Phase III**: Tellurium Loading
  - Is the process of adding a Te compound to the scintillator in order to detect neutrinoless double beta decay.
Rn222 as a Background

Backgrounds within physics experiments are anything that will overlap or interfere with the signal of interest. Radon-222 in particular emits $\alpha$- and $\beta$ particles at energies that can mimic physics events. As $^{222}\text{Rn}$ decays, it will reach the more stable isotope of $^{210}\text{Pb}$, which given its long half life of 22 years, is difficult to eliminate.
Radon Assays
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Lucas Cells

Lucas Cells are custom made 2” acrylic vessels with an inner hollow hemisphere coated with a ZnS scintillator. The entrapped $^{222}\text{Rn}$ is decays, releasing $\alpha$ particles that interact with the scintillator, emitting light. The light is ”seen” with optically coupled PMTs, and the raw data can be analyzed.
## Background Assays

<table>
<thead>
<tr>
<th>Parameters (With/Without Water, etc...)</th>
<th>Assay Date</th>
<th>Counts/day (cpd)</th>
<th>Radon Concentration Rn atoms/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Water</td>
<td>Mar 29, 2017</td>
<td>75.63 ± 2.28</td>
<td>26869.4 ± 3312.6</td>
</tr>
<tr>
<td></td>
<td>May 17, 2017</td>
<td>191.92 ± 13.92</td>
<td>38336.3 ± 4996.9</td>
</tr>
<tr>
<td></td>
<td>Aug 17, 2017</td>
<td>102.89 ± 3.9</td>
<td>30461.8 ± 3610.2</td>
</tr>
<tr>
<td></td>
<td>Aug 24, 2017</td>
<td>65.33 ± 4.15</td>
<td>11271.9 ± 2122.7</td>
</tr>
<tr>
<td></td>
<td>Aug 31, 2017</td>
<td>214.39 ± 7.94</td>
<td>52928.7 ± 5893.2</td>
</tr>
<tr>
<td></td>
<td>Sept 7, 2017</td>
<td>223.37 ± 9.33</td>
<td>51606.1 ± 5834.8</td>
</tr>
<tr>
<td></td>
<td>Sept 14, 2017</td>
<td>66.03 ± 1.74</td>
<td>33269.4 ± 5408.8</td>
</tr>
<tr>
<td></td>
<td>May 3, 2018</td>
<td>65.41 ± 3.68</td>
<td>18699.3 ± 2661.1</td>
</tr>
<tr>
<td></td>
<td>May 10, 2018</td>
<td>33.65 ± 1.72</td>
<td>4157.3 ± 2403.9</td>
</tr>
<tr>
<td></td>
<td>May 24, 2018</td>
<td>125.41 ± 4.59</td>
<td>32900.5 ± 4720.3</td>
</tr>
<tr>
<td>With Water</td>
<td>May 17, 2018</td>
<td>76.52 ± 2.48</td>
<td>31623.0 ± 3912.8</td>
</tr>
</tbody>
</table>

Pooja Woosaree (Laurentian University)  Rn222 Concentrations in SNO+  June 13, 2018  12 / 16
PSUP Assay

Blind Flange Installed

NOTE 9
Assay Date: Jun 28, 2017

Measured Rate:
\[3.68 \times 10^{-14} \text{g}^{238}\text{U}/\text{gH}_2\text{O}\]
AV Assay

There are many sample points to chose from to gain an accurate representation of the background levels inside the detector.
Assay Date: Nov 7, 2017

Measured Rate:
\[ 2.9 \times 10^{-11} \text{ g}^{238}\text{U}/\text{gH}_2\text{O} \]

- Preliminary
- Not comparable to \textit{in situ} analysis
- Continued debugging of Rn assay method for possible contamination
Assay Summary

- *in situ* analysis and other assay techniques will monitor internal $^{222}\text{Rn}$ levels
- The current Rn assay system will be used to monitor cavity and PSUP $^{222}\text{Rn}$ levels
- A scintillator Rn assay system will be built for the upcoming phases
Conclusion

- SNO+ is nearing the end of Phase I
- Next phase set to begin Fall 2018
Backup Slides
SNO+ $0\nu\beta\beta$ sensitivity

![Graph showing counts vs reconstructed energy for different processes: $0\nu\beta\beta$ (100 meV), $2\nu\beta\beta$, $(\alpha, n)$, U chain, Th chain, External, $^{8}\text{B} \nu\text{ES}$, and Cosmogenic.](image-url)