Radon Mitigation for the NEWS-G Dark Matter Detector

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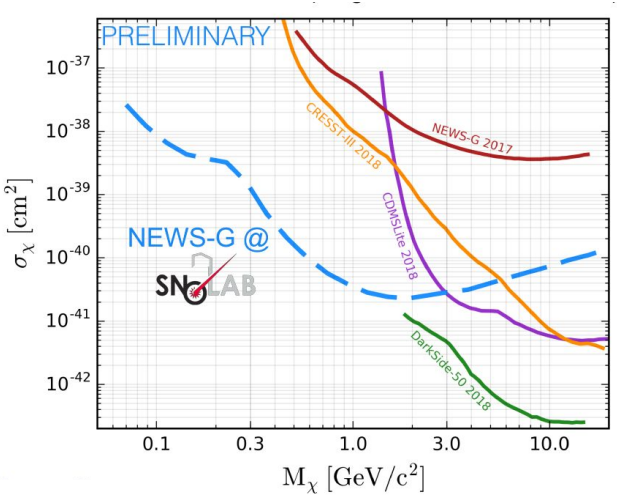
Dark Matter and NEWS-G

The search for dark matter includes the search for WIMPs (Weakly Interacting Massive Particles)

NEWS-G (New Experiment With Spheres -Gas) targets low mass WIMPs

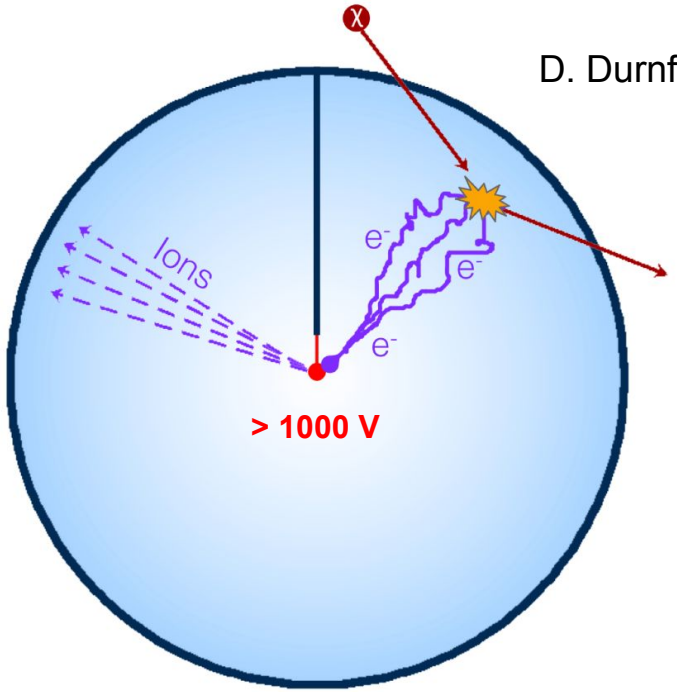


Detection Methods

NEWS-G is a gas detector that uses a methane - noble gas mixture

WIMPs produce a nuclear recoil, ionizing a gas particle

The ionized electron creates an avalanche



D. Durnford

Problems from Radioactivity

A. Brossard	He mixture	Ne mixture
^{218}Po	2411	612
^{214}Pb	663	227
^{214}Bi + ^{214}Po	987	210
Total	4061	1050
To obtain 0.05 dru < 1keV	< 12μBq	< 48μBq

Based on 10^4 radon decays, in DRU/Bq

Radioactivity can saturate the detector

Sourced from both the materials of the detector and the gas in the detector

Methods are used to remove it from the detector walls and the gas

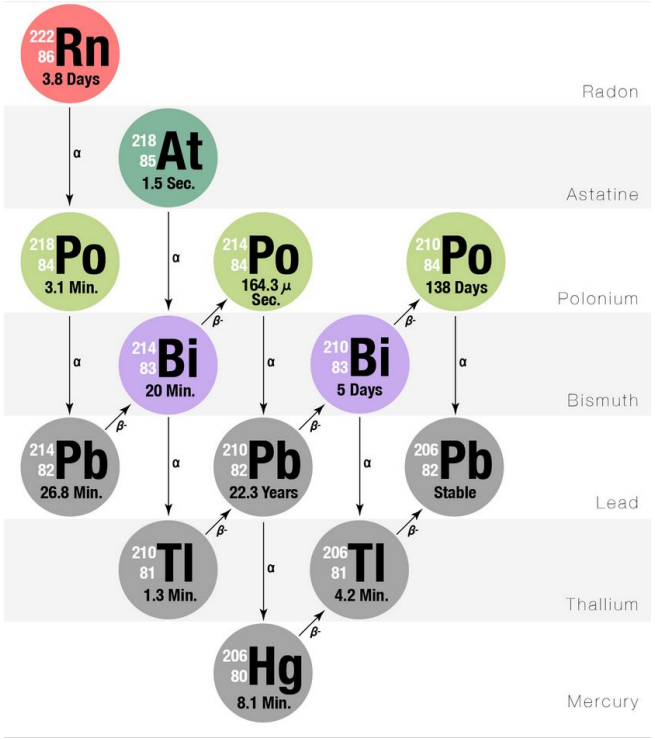
Radon Removal Systems

Radon is a noble gas and has a half-life of ~3.8 days

Radon traps are commonly used to remove from gases

Low radioactivity activated carbon is typically used

A method for radon removal from fluids is a distillation column



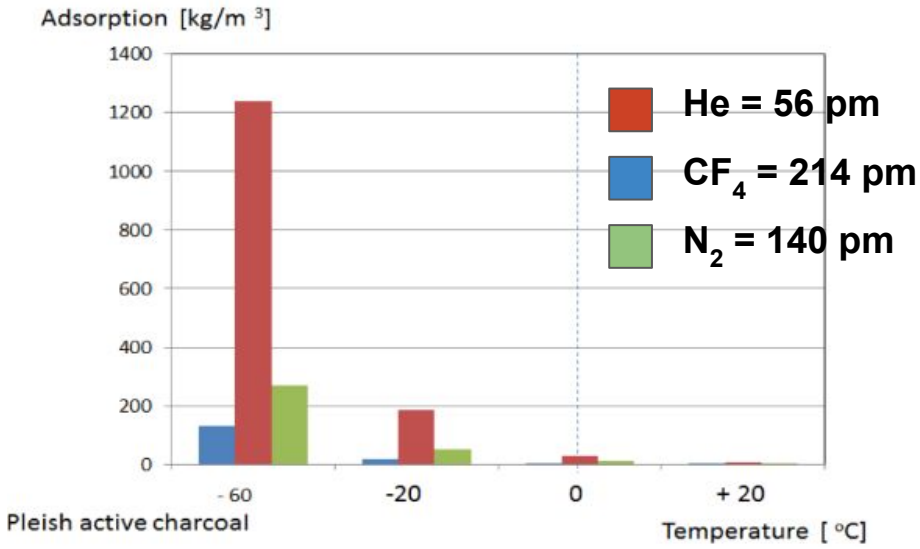
Radon Trap

Activated charcoal traps rely on atomic and molecular size

Radon has a diameter of 300 pm

- **He → 56 pm**
- **Ne → 116 pm**
- **Xe → 280 pm**
- **CH_4 → 400 pm**

Due to the larger size of methane, it will be trapped along with radon



Radon Trap - A New Method

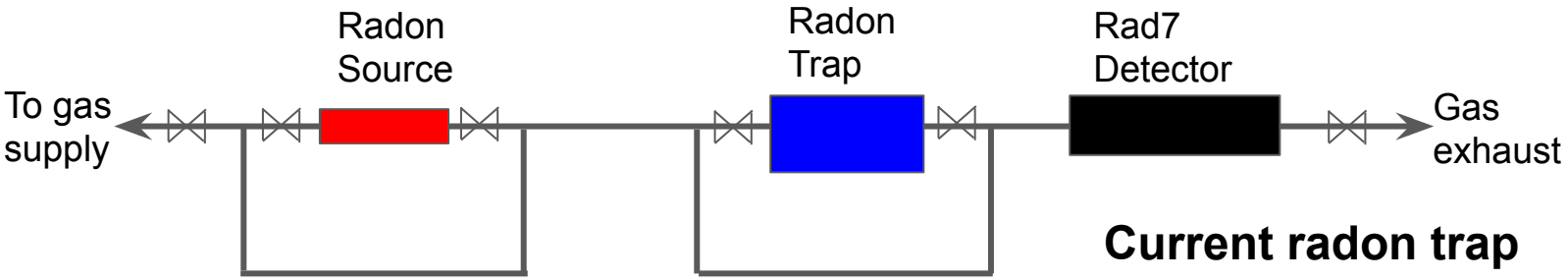
metal	Rn ν_b, $\times 10^{12}$ s^{-1}	Rn IP eV	Rn $-\Delta H_{ads}$ (ther), kJ/mol	Rn $-\Delta H_{ads}$ (kin), kJ/mol	Rn −EB, kJ/mol	Rn $-\Delta H^{M}_{ads}$, kJ/mol	Xe $-\Delta H^{M}_{ads}$, kJ/mo
Cu	6.7	7.72	37 ± 2	40 ± 2	37	25 ± 2	21
Ag	4.65	7.57	20 ± 2	23 ± 2	36	26 ± 2	21.5
Au	4.2	9.22	29 ± 2	33 ± 2	41	33 ± 2	27.5
Pd	6.4	8.33	37 ± 2	41 ± 2	38	35 ± 2	29
Ni	8.1	7.63	39 ± 2	43 ± 2	36	37 ± 2	31

Copper has a high affinity for radon adsorption

Uses same apparatus as carboxen trap

Adsorption of Radon on Metal Surfaces: A Model Study for Chemical Investigations of Elements 112 and 114 - R. Eichler and M. Schädel - The Journal of Physical Chemistry B **2002** *106* (21), 5413-5420

Radon Trap - Design



Current radon trap

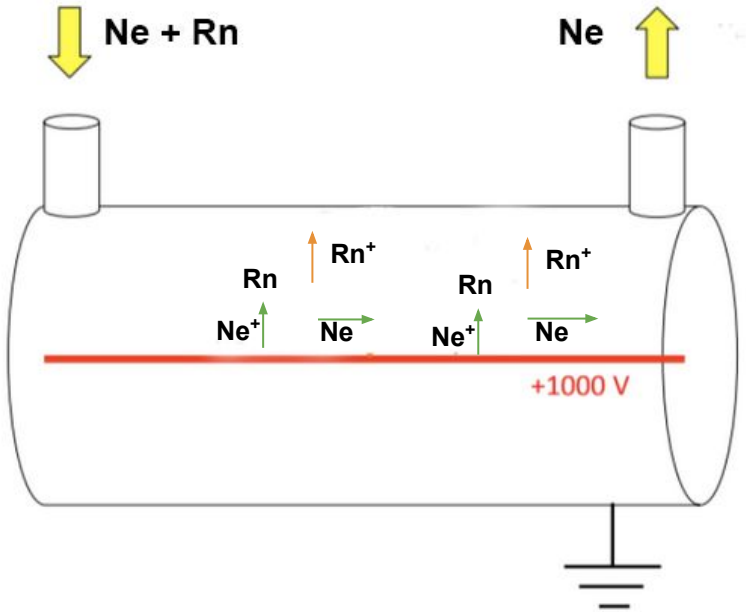
Trap apparatus designed that can be used with all trap iterations

Radon Trap - A New Design

Electrophoresis method

High voltage wire used to repel created radon ions

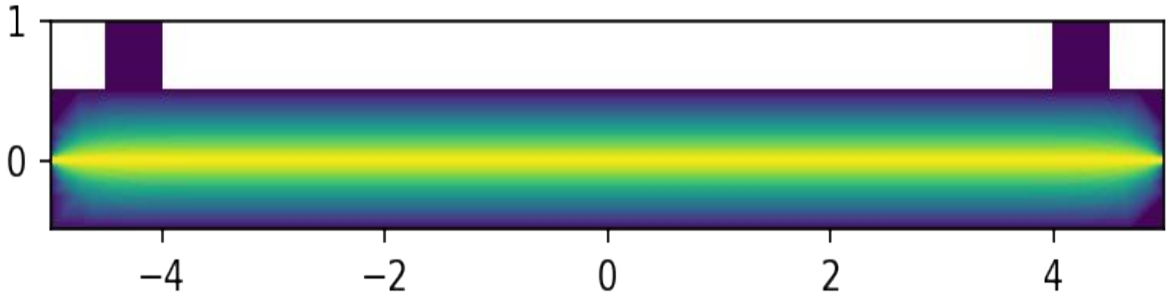
Ions created from collisions with neon ions, and charge transfer occurs

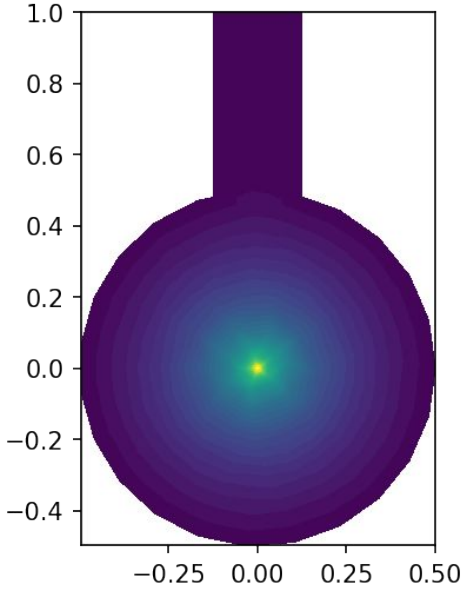


Radon Trap - A New Design

Electric field simulations done using FEniCS (Finite Element Analysis)

Drift simulations can be done using these simulations

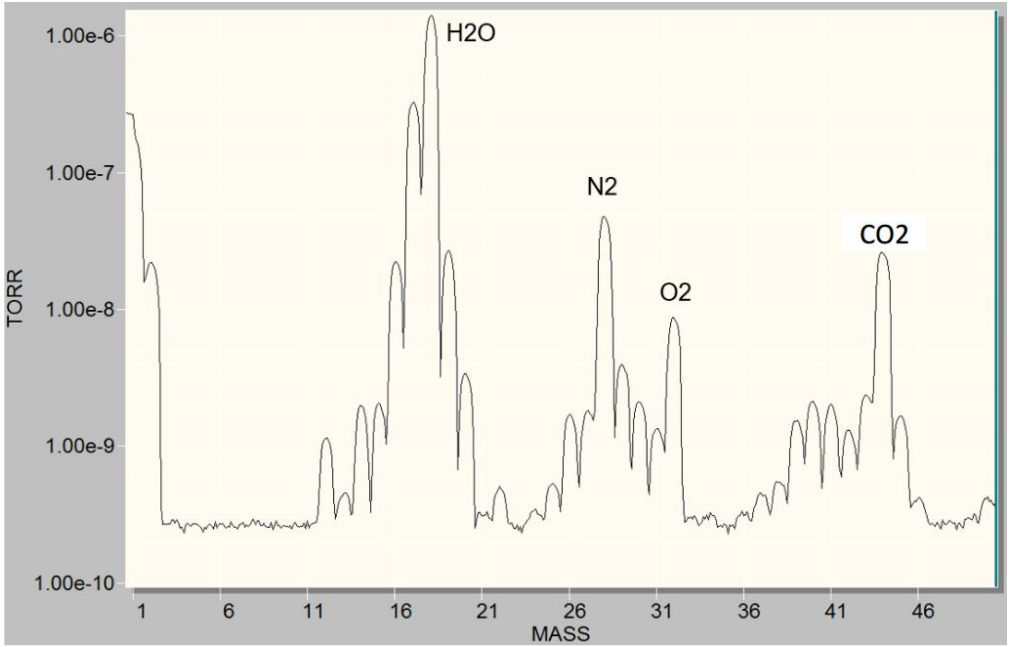




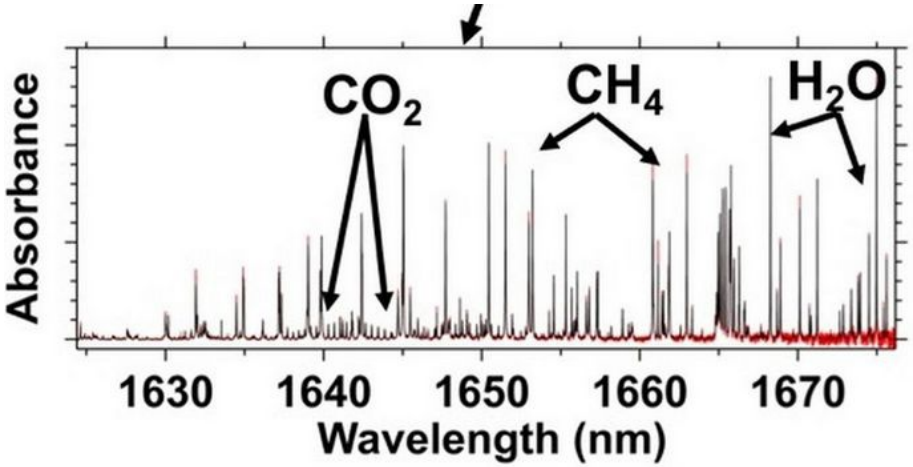
Gas Measurement

Gas components and concentrations measured using a Residual Gas Analyser

Does not operate at atmospheric pressures, relies on a vacuum system



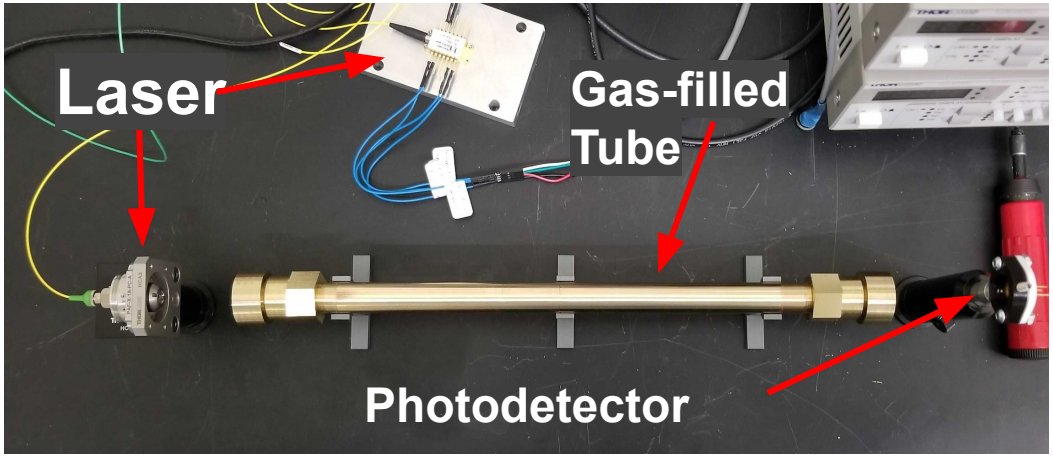
Spectroscopy and Concentrations



Spectroscopy is commonly used in atmospheric and condensed matter physics

Can be used for trace gas detection, properties of gases, and gas concentration measurements

Accurate Gas Concentration



Current apparatus being assembled

Based on absorption of light targeted for methane

Produces absorption spectrum

Methane concentration can be measured with an infrared laser (1654 nm)

Current and Future Work

Test radon trap with Carboxen, copper, and brass

Construct new high voltage radon separation method

Calibrate and test laser spectroscopy concentration system

Work for accurate detection of other gases
e.g. H_2O, water, oxygen

Acknowledgements

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Bonus Slides

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