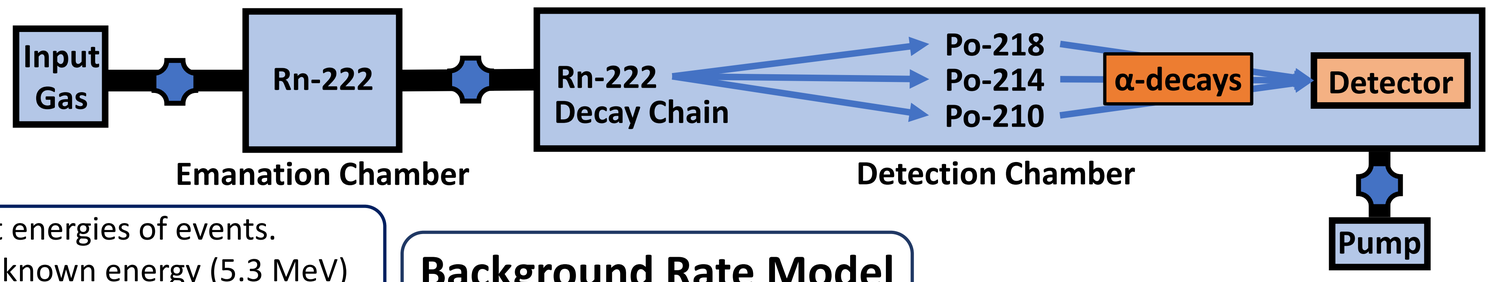
Radon Emanation Analysis

Seth Bendigo

Advisor: Dr. Richard Schnee, South Dakota Mines Physics Department

Highly sensitive experiments, such as the LZ dark matter experiment, have backgrounds due to radon emanating out of materials. The radon emanation system at Mines is used to reduce radon background by measuring the emanation rate of radon out of these materials. If the emanation rate is too high, those objects can be replaced. Analysis of the emanation rate requires corrections when the detector's gain shifts, a log-likelihood analysis, and an understanding of background rates. Due to statistical uncertainty, the background for the system and its time dependence cannot be determined accurately from a single background run. However, co-adding multiple background runs together provides sufficient statistics. I will summarize my contributions to the Python code that performs this analysis, show how the co-added data constrains the background of the radon emanation system, and discuss the implications.

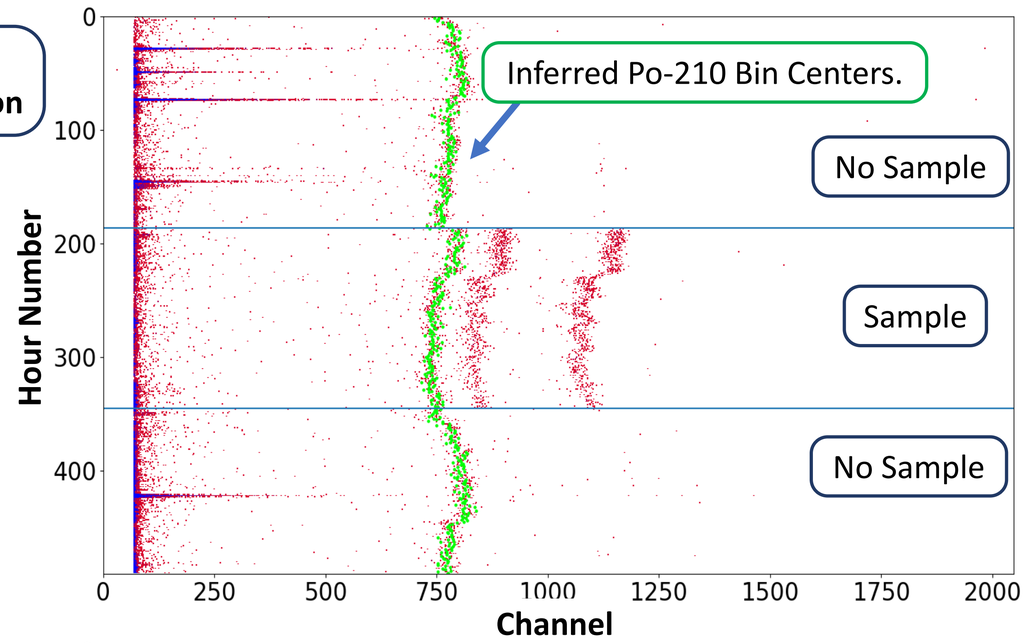
Emanation System Diagram



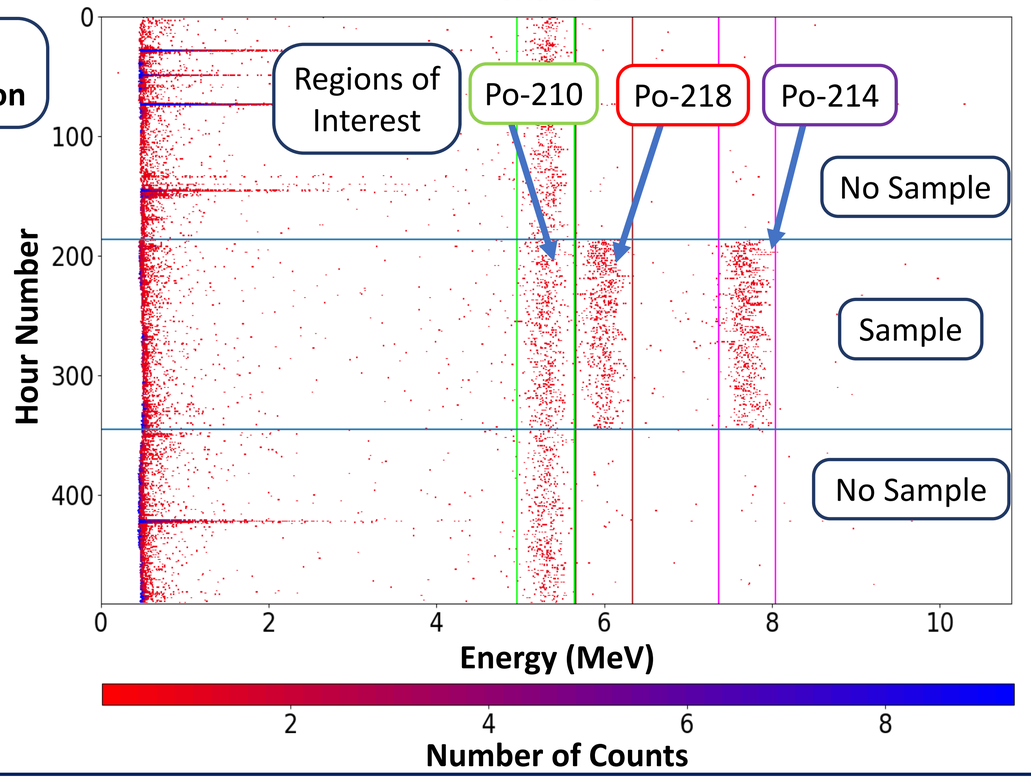
Gain Correction

Changes in electronics gain with time change the apparent energies of events. Correction to this gain is done using Po-210 α-decays with known energy (5.3 MeV) as a calibration source.

Before Correction

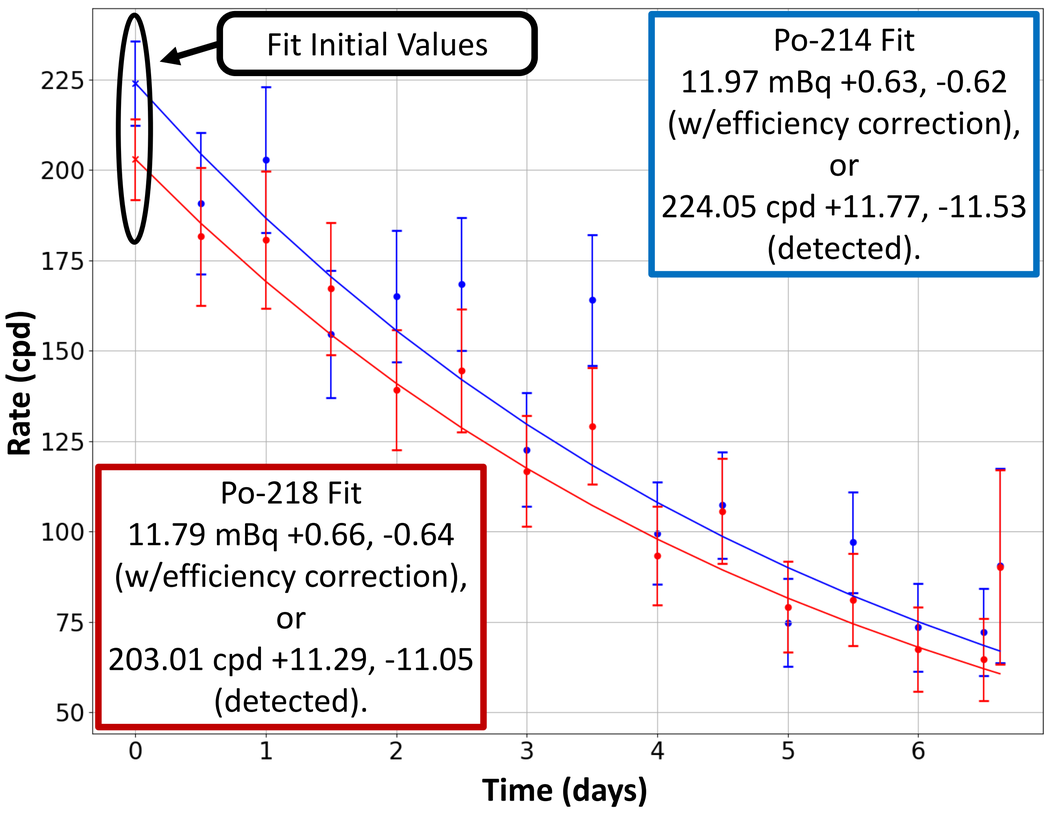


After Correction



Radon Rate of Sample

Maximize likelihood to the best-fit estimate of initial Rn-222 rate from the Po-218 and Po-214 data. Used to model time dependence of rate.



Background Rate Model

Individual background runs (no sample) do not have enough data to analyze the time dependence of the background.

To overcome this, we co-add background runs together by averaging the data of 17 runs. A model is fit to the Po-214 data:

$$R(t) = R_a\left(1 - e^{-t/\tau}\right) + R_n e^{-t/\tau} + C$$

τ: Rn-222 mean lifetime ~ 5.51 days.

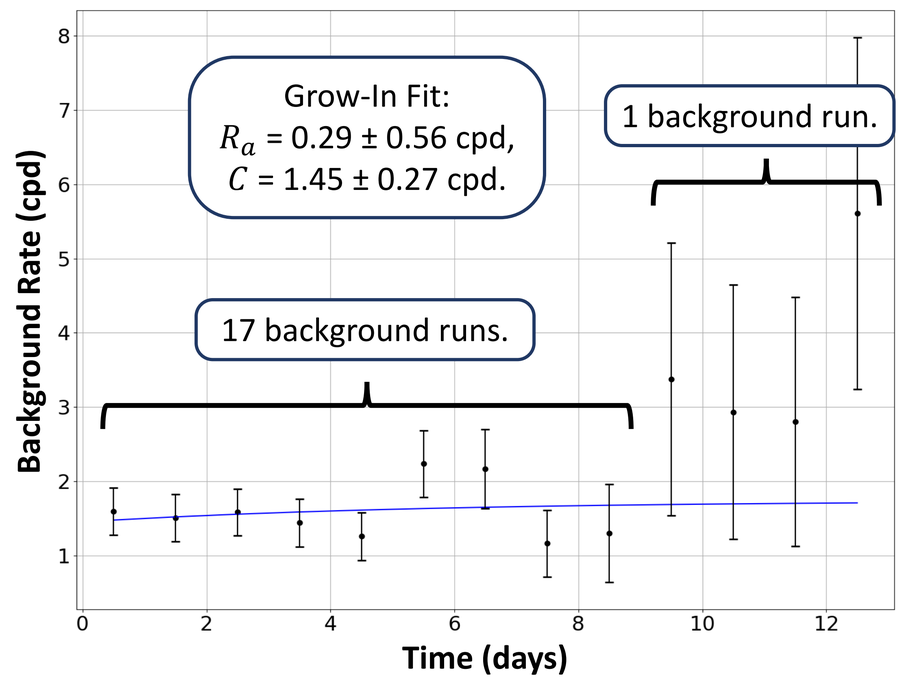
Grow-in term. Radium in detection chamber material decays into radon. R_a is the initial rate of radium decay.

Decay term. Some radon in input gas. R_n is the initial rate of radon decay.

Constant background term (e.g., cosmic muons).

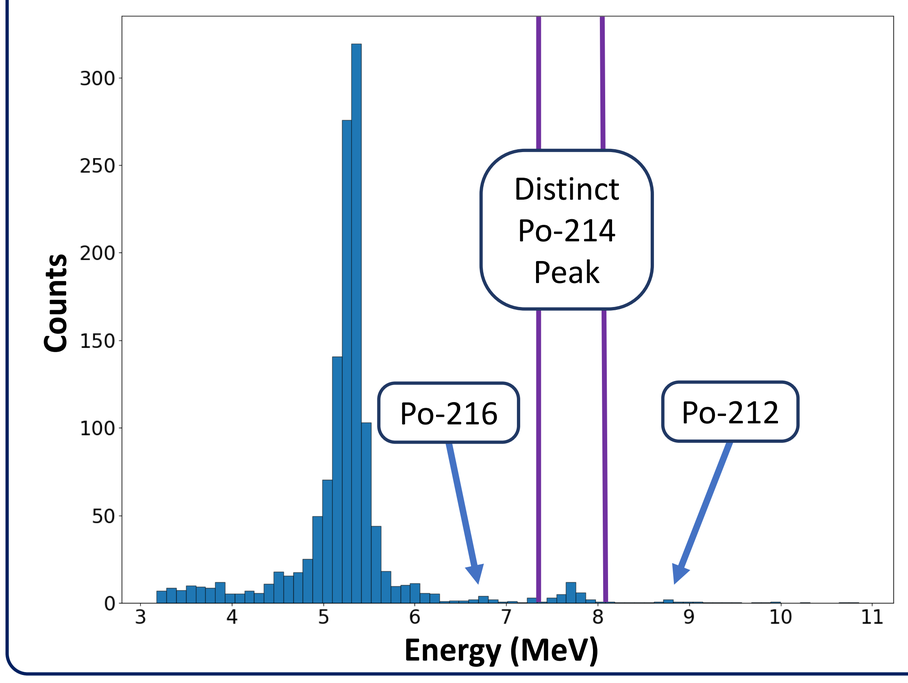
Fit to data uses only grow-in or decay.

Background Results



Dominating constant background consistent with no grow-in source.

Expected sources of a constant background would be continuous in energy.



Additional peaks appear due to Rn-220 daughters. Presumably, from detection chamber.

Conclusions & Future Work

A potential explanation for the dominating constant term is that the grow-in and decay terms sum to a constant rate.

- More analysis needed.
- Can reduce background by removing radon from input gas to emanation chamber.

Future work will include:

- Validation checks on the model fit.
- A similar time dependence model fit to the Po-216 and Po-212 peaks.