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The PNNL Radon Emanation System

Content

Radon is an important background concern for most low-background, rare-event searches. Dark matter direct detection and neutrinoless double-beta decay experiments, in particular, have become so sensitive that specifications for the materials of construction often require measurement of ultra-low radon levels, sometimes corresponding to only a few tens of atoms in equilibrium. A material's potential for radon emanation can be inferred from its bulk uranium content through a combination of gamma spectroscopy and diffusion calculations. Temperature and near-surface effects, however, may result in large systematic uncertainties such that direct quantification through radon emanation assay is usually more accurate and robust.

Existing emanation systems are either insufficiently sensitive or lack the requisite throughput for the suite of next-generation rare-event searches; the best systems are typically limited in sensitivity to no fewer than 100 radon atoms. To address this need for improved sensitivity and greater assay capacity, a radon emanation system for low-level measurements has been commissioned at the Pacific Northwest National Laboratory (PNNL). The system consists of small and large emanation chambers, 0.33 and 35 liters, integrated with a gas handling system that includes a network of computer-controlled pneumatic valves connecting the chambers to a cryogenic radon trap and a detector loading manifold. Radon is emanated, trapped, and then loaded into a custom ultra-low-background proportional counter that is operated in PNNL's shallow underground laboratory in an ultra-low-background counting system; alpha decays from radon and its two subsequent polonium daughters are detected with high efficiency and near-zero background. Relative to other systems, the superior detection efficiency of these custom detectors offers more than a two-fold improvement in sensitivity. Further, the system utilizes a standardized gas-panel design and data-acquisition software, making it possible to improve assay consistency, accuracy, and throughput via automation. The system design, characterization of its backgrounds and efficiencies using a calibrated radon source, and initial assays will be discussed.

About the Presenter

Dr. Bunker earned his Ph.D. in particle astrophysics from the University of California Santa Barbara with a dissertation featuring the first low-threshold search for dark matter using data from the Cryogenic Dark Matter Search. He continued to investigate dark matter as a postdoc at Syracuse University, working on both the SuperCDMS Soudan and MiniCLEAN experiments, while also acquiring expertise in radon mitigation and detection. Before starting his current position as a postdoc at Pacific Northwest National Laboratory (PNNL) in September 2015, he was a research scientist at the South Dakota School of Mines & Technology where he contributed to both SuperCDMS and LZ. Dr. Bunker is the Analysis Coordinator for the SuperCDMS collaboration and the level-3 manager of radon exclusion for the SuperCDMS SNOLAB experiment. He will transition to a full staff position at PNNL in October 2016.

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