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Low-Background Radioxenon Detector

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Content

The measurement of radioactive xenon (Xe-131m, Xe-133, Xe-133m, Xe-135) in the atmosphere is one of the fundamental approaches to monitor nuclear explosions. The ratios of the four radioxenon isotopes provides the ability to discriminate between a nuclear explosion and other anthropogenic backgrounds such as nuclear reactors. A definitive method for detecting radioxenon is beta-gamma coincidence, in which an inner plastic scintillator cell detects the beta particle, and an outer NaI detector detects the gamma. Measurements of these isotopes via beta-gamma coincidence can be improved by replacing the scintillating plastic β-cells with silicon detectors which have a higher energy resolution. In addition to a higher resolution, silicon detectors do not suffer from xenon diffusing into pores leading to a memory of the previous measurement. An increase in resolution allows for minimization of interferences and a narrowing of the regions of interest of each isotope. In return, this allows for lower minimum detectable activities of radioxenon, quicker measurements for an increase time resolution, and lower backgrounds. A silicon-based CE/β detector cell with higher resolution has been developed by the French Atomic Energy Commission (CEA) and commercially produced by Canberra as the PIPSBOX-2x1200-500A. This detector operates in PNNL's Shallow Underground Laboratory using a high purity germanium Dual Up-looker Down-looker Detector System (DUDDS) inside of a low background shielded cave with cosmic veto panels allowing for unparalleled measurements. Measurements of the pure xenon isotopes allows for definitive determination of the region of interest. Additional measurements of environmental samples from around the world provide insight into the potential limits for the radioxenon-monitoring regime. We report on the measured efficiencies, detection limits, and memory effect of the Canberra PIPSBOX-2x1200-500 in the ultra-low level background environment as well as the results from measurements of environmental samples.

About the Presenter

Dr. Michael Foxe is a staff scientist who joined PNNL as a post-doc in 2013, and has been in the field of radiation detector development since 2007. He spent 6 years at Lawrence Livermore National Lab on the development of a liquid argon detector for nuclear safeguards and nonproliferation as well as dark matter detection. The liquid argon detector was the first of its kind to demonstrate sub-keV spectroscopy through 37Ar detection. He also worked on developing a radiation detector using graphene and a directional fast neutron detector for the Department of Homeland Security. Since joining PNNL, he has been involved in the development and characterization of various radiation detectors focused on the detection of radioxenon and radioargon for treaty verification. He also stays involved with the dark matter and neutrino community through liquid noble gas detector work.

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