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Design, Contruction, and Performance of a New Low-Background, External Source Gas Proportional Counter for Environmental Sample Measurements

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Content

A new thin-window, external source beta counter was developed for use in the Pacific Northwest National Laboratory (PNNL) shallow underground laboratory. One driver for this effort was to support the measurement of P-32 for Si-32 sediment age dating; another potential application is the measurement of Si-32 in semiconductor grade silicon to support background calculations for dark matter experiments. The detector design utilizes two thin-window counters, in a clamshell configuration to provide a 4 pi counting geometry. Materials were carefully selected to limit background contributions; during the detector design phase, a detailed background budget was developed. This background projection will be compared with recent background measurements in the PNNL shallow underground laboratory, to demonstrate that the counters have achieved background performance consistent with the preliminary background budget analysis. To achieve the desired background level, the detectors are operated in a copper-lined lead shield that includes borated polyethylene for neutron suppression, active anti-cosmic shielding, and a polycarbonate enclosure to reduce radon and radon daughter activity in the vicinity of the detectors. Materials selected for the Mylar entrance windows and for sample mounting were carefully selected to minimize attenuating layers between the sample and the active gas volume. This effort resulted in measured detection efficiencies approaching 100% for measured beta emitting radioisotopes. Initial measurements with the new beta counter design showed that the detectors were extremely sensitive to ambient high-frequency electromagnetic noise because the detector ends are made of polychlorotrifluoroethylene (PCTFE). This sensitivity resulted in an unacceptably high level of noise for the detectors, and limited their low energy performance / threshold. A new copper carrier was designed to eliminate this sensitivity, as well as to provide a means to stabilize the absolute pressure in the detectors, and to provide an added layer of radiological protection for the clean underground laboratory. This work was entirely successful at eliminating the high frequency noise previously observed in the detectors. This work will present details of the detector and carrier design, compare the original background budget and current background performance, and present other detector performance characteristics.

About the Presenter

Martin Keillor is a nuclear engineer who has worked at Pacific Northwest National Laboratory (PNNL) for the past ten years, after retiring from the United States Air Force (USAF). His focus at PNNL is on low-background radiation detection for various nuclear treaty monitoring and national security applications, and he has worked primarily on germanium-based gamma spectrometry and gas proportional detectors.

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