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Extended Stability of HPGe Spectrometer with Environmental control at the High Flux Isotope Reactor

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Abstract

A High Purity Germanium (HPGe) spectrometer has been designed and constructed for making precision measurements over extended time periods at the High Flux Isotope Reactor (HFIR) located at Oak Ridge National Lab (ORNL). Toward the effort of achieving long-term system stability and high spectral resolution, local environment control is utilized as part of the system design. Further, the remote operation of the spectrometer is aided by live-streaming system conditions and automatic out-of-range alert messaging. System performance over the 7-month Phase I period is presented.

Keywords: HFIR; HPGe; Radioactive decay; Spectrometer;

1. Introduction

Precision life-time measurements of radionuclides are critical across a wide range of fields and applications, including nuclear medicine, inventory stewardship, and studies of novel physics. Recently, there has been significant interest in conducting research near nuclear reactors, as in the case of neutrino oscillation experiments, designed to exploit the associated anti-neutrino flux that is generated. The High Flux Isotope Reactor (HFIR) at Oak Ridge

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National Laboratory (ORNL) offers the ability to locate an experiment close to the core, in addition to operating at very consistent power level, and utilizes a relatively short cycle of operation. These considerations make it an excellent test environment for implementing a robust precision spectrometer in a reactor environment.

With the aim of making long-term precision decay, we have designed and implemented a High Purity Germanium (HPGe) spectrometer which resides in the source control room at HFIR, adjacent to the reactor pool wall and approx. 6 m from the core. Among the challenges presented in attaining long-term system stability are the significant variations in background radiation and environmental conditions, as well as the necessity for remote monitoring. In the following sections, the Phase I system design and performance, relating especially to the achieved temperature stability, are presented.

1.1. System Overview

The spectrometer utilizes two 3.25-inch HPGe detectors for observing a radioactive sample and the background activity. The detectors are cooled via ORTEC XCooler mechanical chillers, and signal processing is performed by ORTEC DSPec multichannel analyzers (MCA). The detectors are shielded by copper, aluminum, borated polyethylene, and approximately 6 tons of lead (Figure 1). The inner bulk structure is contained within a polystyrene enclosure, whose temperature is maintained by a PID-controlled thermoelectric unit (TECA AHP-1200HC). A set point of 10 °C was chosen for the enclosure based on its observed nominal equilibrium temperature of 12 °C - due to cooling by the detectors only - as well as the advantages of operating the thermoelectric unit strictly in one mode when possible. The enclosure is also continuously purged with nitrogen gas to prevent condensation, which can degrade spectral resolution, and to mitigate influx of contaminants such as ^{226}Ra and ^{41}Ar. System power is routed through uninterruptable power supplies (UPS), which provide conditioning as well as approximately 30 minutes of backup power in the event of power loss or necessary platform relocation.

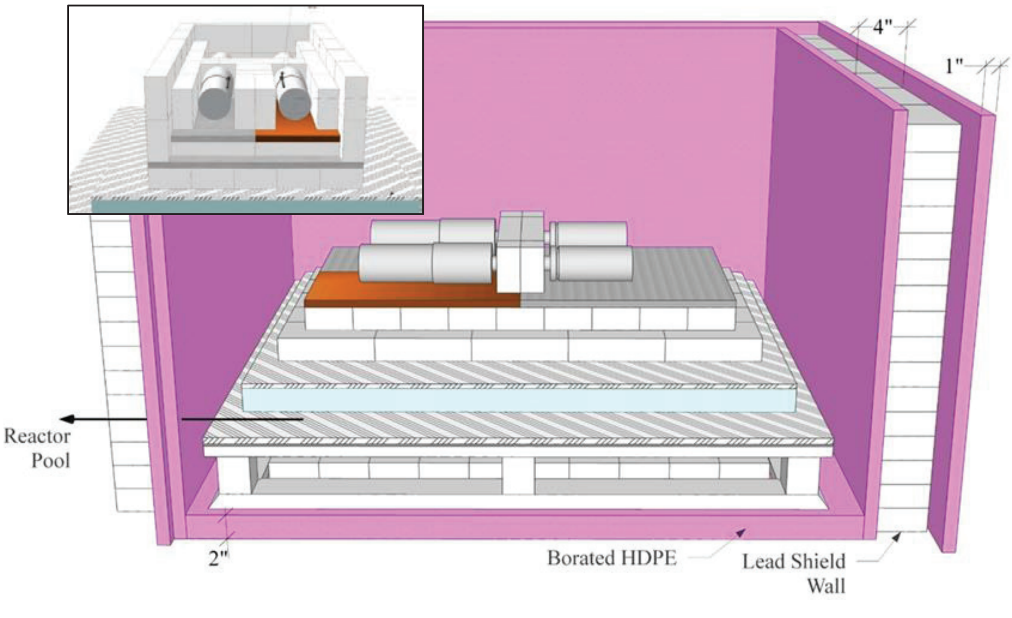

Figure 1. Cut-away view of spectrometer platform construction and shielding. The polystyrene insulated enclosure, referenced in the text, resides on top of the pallet base and inside the borated HDPE structure – the bottom layer of this enclosure is visible between the two large aluminium floor plates. *Inset:* Further depiction of interior lead shielding structure. Full copper and aluminium liners not shown.