Nuclear Explosion Monitoring Research and Engineering (NEMR&E) Program
Quarterly Report - BAA06-36; DE-FC52-06NA27322

Research Title: A Multi-Layer Phoswich Radioxenon Detection System
Name: David M. Hamby, PhD
Institution: Oregon State University
Reporting Period: 10/01/07 – 12/31/07

Technical Progress:

Description of Activities Conducted this Reporting Period:

Electronics Development: To improve the overall performance of the two-channel digital pulse processor (DPP2), the PCB has been redesigned and the new printed board is now under assembly. The system is enhanced with two new fast ADCs from Analog Devices (AD9230-250), each with a sampling rate of 250 MHz and a resolution of 12 bits. The data bus uses a high performance Low Voltage Differential Signaling (LVDS) standard. The offset and gain of each channel are separately controlled digitally by the GUI software.

GUI Software Development: A GUI is being developed using the Python programming language. All functions from the preceding MATLAB code have been re-implemented including basic waveform readout, pulse shape discrimination, and plotting of energy spectra. In addition, the GUI can be used to control sampling runs based on the number of pulses captured, either in real or live time. Calibration coefficients and pulse shape discrimination boundaries can be changed on the fly so that the detector may be characterized experimentally. Plots generated by the GUI can be exported as graphic data. At present, the software has only been tested using one channel, pending availability of the new DPP board (DPP2). However, the functions have been written to allow easy expansion to two channels.

Light Collection Modeling: The XEPHWICH design has been modeled to determine its light capture efficiency. Research in the 7th quarter includes additional simulations representing significant increase in data resolution, well over an order of magnitude greater than previous simulations. The final data set represents approximately 11 billion visible photons divided equally among 110 thousand data points. A laboratory experiment is being designed and executed to experimentally determine light capture efficiency as a function of position within the scintillators.

Radioxenon Fission Source: We have designed and constructed a fission chamber to be used for the collection of radioxenon gases following neutron bombardment of HEU in the Oregon State University TRIGA reactor. The aluminum housing and all vacuum fittings have been assembled, awaiting an HEU transfer from PNNL. Students have worked closely with PNNL and OSU

Radiation Safety personnel to facilitate transfer of the HEU. The OSU TRIGA Reactor Operations Committee has approved the experiment.

Spectral (beta) Recognition: Spectral identification by a neural network developed in our laboratory was compared to that of solvers of a linear system of equations. Data indicate that our neural network is capable of identifying three beta emission sources (^{14}C, ^{36}Cl, and ^{99}Tc) simultaneously with reliability to within 3%.

Progress/Deliverables Required by this Reporting Period per Contract:

The proposed schedule shows that, by the end of the seventh quarter, the experimental measurements with radioxenon would be on going (Phase 1, Task d), the DSP and FPGA programming would be completed (Phase 2, Task b), the writing of the data acquisition software for DPP2 would continue (Phase 2, Task c), and characterization of the XEPHWICH response would begin (Phase 3, Task e).

Reason for Differences in Cooperative Agreement Statement of Objectives/Deliverables and Actual Progress/Deliverables, Corrective Actions:

We are ready to begin Task d of Phase 1 as soon as we have the HEU foil from PNNL. The irradiation chamber and its vacuum system are built and ready for fission-product xenon production. The second task of Phase 2 will begin as soon as our DPP2 boards are assembled with their electronic components. The boards have been designed and printed and are in the final days on assembly.

We were very lucky to find a student to write our GUI software. He has been instrumental in writing code that allows great flexibility and control of our electronics boards. The data acquisition software for the DPP2 is proceeding as scheduled. Our machine shop is constructing mating sleeves for the two facing phoswich detectors. As soon as we are able to generate our xenon source term, characterization of the XEPHWICH response to that specific source will commence.

The project continues to progress as planned, with very little deviation in time and design.