

**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

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Reporting Period: 07/01/07 – 09/30/07

Technical Progress:

Description of Activities Conducted this Reporting Period:

Detector Development: During this quarter, the detector manufacturer (Saint-Gobain) delivered one side of the prototype two-channel phoswich detector (XEPHWICH). Once received, our Digital Pulse Processor (DPP1, 12-bit/ 100 MHz) was employed to capture and digitally process phoswich pulses from laboratory radioactive sources. Our previous pulse shape discrimination algorithm was modified by utilizing three trapezoidal digital filters. This algorithm provides a two-dimensional plot in which the pulse shapes of interest are classified and then can be well identified. The preliminary experimental results will be presented at the 2007 Informal Xenon Monitoring Workshop.

Electronics Development: The DPP2 (two-channel, 12-bit/ 250 MHz Digital Pulse Processor) is at the prototyping stage. The analog sections have been designed, prototyped and tested. A 6-layer Printed Circuit Board (PCB) was designed, ordered and delivered. The board components were ordered and are now being assembled and examined for proper functionality. In addition, the related FPGA hardware description code (using VHDL) is under development and simulation. Additionally, our researchers have been studying materials regarding wavelet transforms for incorporation into the project. Wavelet transform is an interesting tool for signal processing; one use for our purpose would be to de-noise the detector signal and to express the signal in a few coefficients for signal compression and increased speed.

Light Collection Modeling: Light capture efficiency modeling and analysis was performed on the XEPHWICH design. Increased understanding of the modeling software was obtained by the discovery of a bug and successful workaround techniques with the DETECT2000 software. Further modeling and plot generation experience was had by the continued use of CERN's ROOT and GEANT4 software packages. Simulations have been performed to compare the output of points versus planes in light capture efficiency. An additional simulation was made with a runtime that was an order-of-magnitude greater than previous simulations, to confirm convergence of the solutions provided by our software methods.

Radon Sources: We have initiated our investigation into the radon signature expected in our XEPHWICH system. We intend to utilize this signature to confirm earth movement, in the event of an underground nuclear explosion, by continuously monitoring radon levels and noting increases in radon concentration in conjunction with increased levels of radon xenons.

Radon Fission Source: The research group is also designing and constructing a fission chamber to be used for the collection of radon gases following neutron bombardment of HEU in the Oregon State University TRIGA reactor. To this point, we have completed milling the aluminum housing and have modeled fission product nuclide production associated with the fissioning of HEU. Additionally, the students have been busy compiling the appropriate information in preparation for irradiation approvals.

Spectral (beta) Recognition: Using beta spectra of three initial nuclides collected on the prototype phoswich detector, spectral identification by a preliminary neural network was compared to that of solvers of a linear system of equations. Pre-processing in areas such as smoothing and endpoint identification is also being investigated as a means of improving spectral identification.

Progress/Deliverables Required by this Reporting Period per Contract:

The proposed schedule shows that, by the end of the sixth quarter, the planar XEPHWICH response with the existing DPP1 would be completed (Phase 1, Task c), the experimental measurements with radon would be initiated (Phase 1, Task d), the DSP and FPGA programming is continuing (Phase 2, Task b), the writing of the data acquisition software for DPP2 would begin (Phase 2, Task c), and the dual (saddle) XEPHWICH design/construction would be completed (Phase 3, Task c), and the knowledge of planar detectors would be incorporated into the saddle geometry design (Phase 3, Task d).

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

As proposed, we have completed our DPP1/XEPHWICH response work and we continue work on the DPP2 two-channel controller. The sampling frequency of the DPP2 has been increased to 250 MHz, using cutting-edge ADC technologies. Such a very high sampling rate will allow us to have a more in-depth analysis of the signal pulses in which three timing components may be superimposed. Two digital control features, offset and gain, are also being added to the design of each channel of the DPP2 to obtain maximum dynamic range from the ADC.

We have constructed a fission chamber and have completed fission-product modeling to gain approvals for irradiation. Experimental measurements with surrogate radionuclides (^{60}Co , ^{137}Cs , ^{241}Am) have demonstrated that the

XEPHWICH is working beautifully, but we still want to take laboratory measurements with actual fission-product ratios of xenons.

The proposed saddle design has been replaced with a dual, planar design and construction (by St. Gobain) of the first side of that detector is completed and the detector delivered to our labs. Task d of Phase 3, therefore, is not necessary and has been removed from the plan.

As can be seen from our list of ongoing projects (above), we are excited about the radioxenon research and our development goals for the XEPHWICH system.