Special Nuclear Materials Detection Using IEC Fusion Pulsed Neutron Source

J.H. Sorebo[1], G.L. Kulcinski[2], R.F. Radel[3], J.F. Santarius[2]

[1]Plexus Corporation, Neenah WI

[2]Fusion Technology Institute, University of Wisconsin-Madison, Madison WI

[3]Sandia National Laboratories, Albuquerque NM

The Problem:

How may one detect or assure the absence of illicit highly enriched uranium in cross-border traffic without substantially impeding the flow of commerce?

Hypotheses:

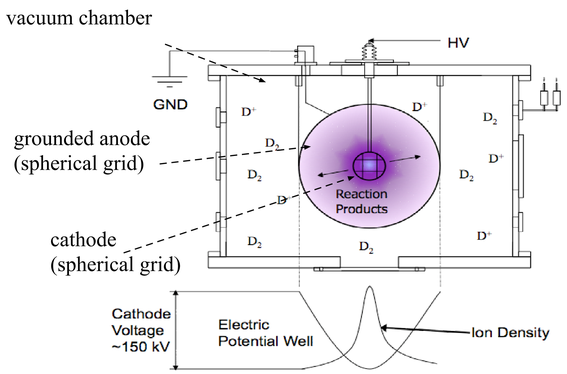
- Highly enriched uranium which is hidden in vehicles, vessels, or shipping containers can be detected by subjecting the carrier to bursts of neutrons and detecting either induced-fission neutrons or neutrons produced by the somewhat later decay of induced-fission products.
- A gridded IEC device can produce neutrons in sufficient quantities and with appropriate pulse shape to induce fission in hidden HEU.

Techniques to be Tested

Delayed Neutron Analysis (DNA)
- Interrogating, thermalized neutron induces fission of U235 nucleus.
- After a short delay, immediate fission products undergo Beta-decay, emitting neutrons.
- These neutrons are then detected.

Differential Die-away Analysis (DDA)
- Interrogating, thermalized neutron induces fission of U235 nucleus.
- many neutrons are released as direct products of the fission.
- these neutrons are sensed immediately after the interrogating neutrons have dissipated.

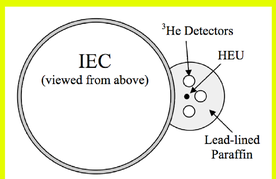
General Experimental Set-up of IEC Device



Ionized deuterium is accelerated toward the center by radial electric field produced by spherical electrodes. The UW IEC device is capable of producing a 10 Hz source of 2.45 MeV neutrons at 5×10^9 neutrons/s in a 110μs pulse at a -120 kV cathode potential and 6 amperes of D+ current.

Delayed-Neutron Analysis (DNA)

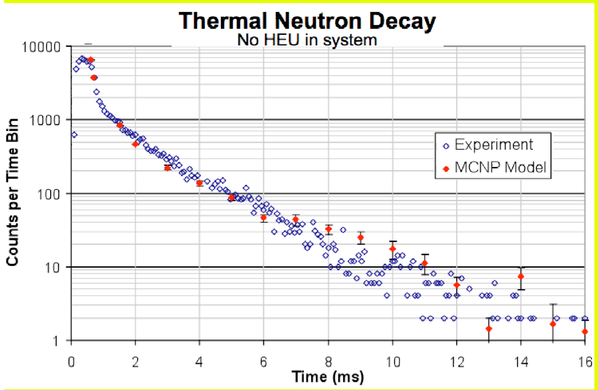
Delayed neutron analysis was performed both in simulation and experimentally with excellent data corroboration.



Experiment Configuration

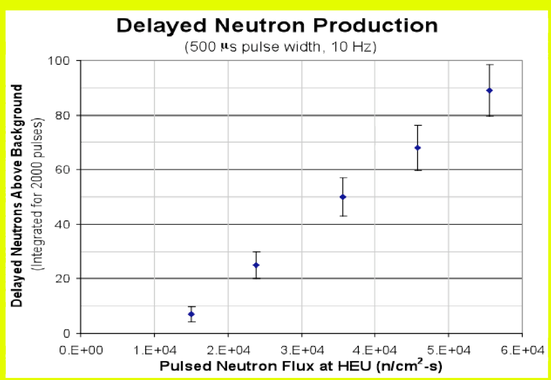
The HEU sample, ^{3}He detectors, and paraffin moderator were surrounded by lead to block x-ray radiation from entering the detectors.

DNA Base-Case (No HEU) Result



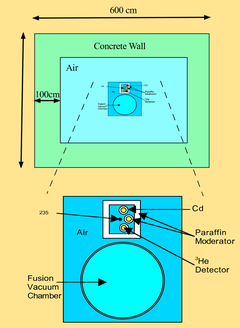
Comparison of experimental versus simulated DNA thermal neutron data. The time = 0 data point is the rising edge of the interrogating neutron pulse. The pulse duration was 500μs for this experiment.

DNA Results with HEU

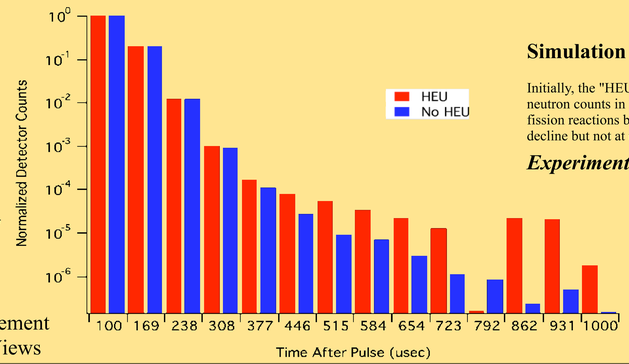


Experimental data for delayed neutron production above background versus interrogating neutron flux. As expected, the number of delayed neutrons increases with increasing interrogating neutron flux.

Differential Die-away Analysis (DDA) -- Simulations and Preparations for Experiments



Laboratory Model Arrangement
Room Scale and Detail Views



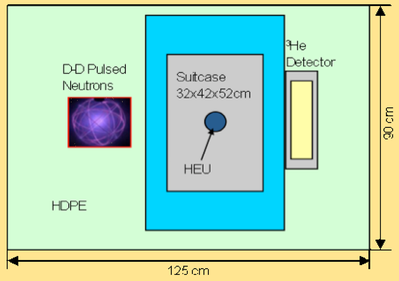
Simulation Result for Laboratory Geometry

Initially, the "HEU" and "No HEU" traces show equivalent numbers of neutron counts in the detectors. However, in time, prompt neutrons from fission reactions begin to dominate and the traces continue to exponentially decline but not at the same rate.

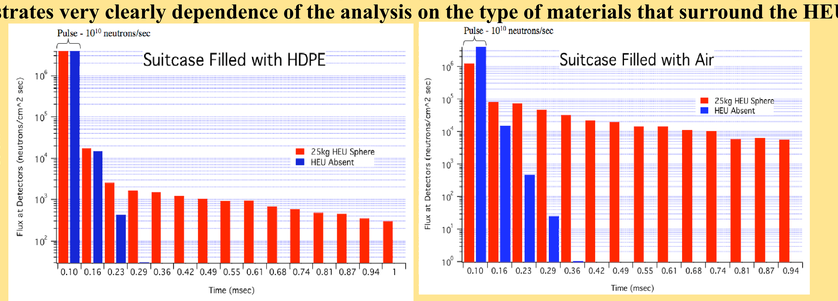
Experimental work in this geometry is in progress.

DDA Suitcase Simulation

The suitcase was modeled with both HDPE (High Density Polyethylene) contents and also empty (air). **This demonstrates very clearly dependence of the analysis on the type of materials that surround the HEU.**



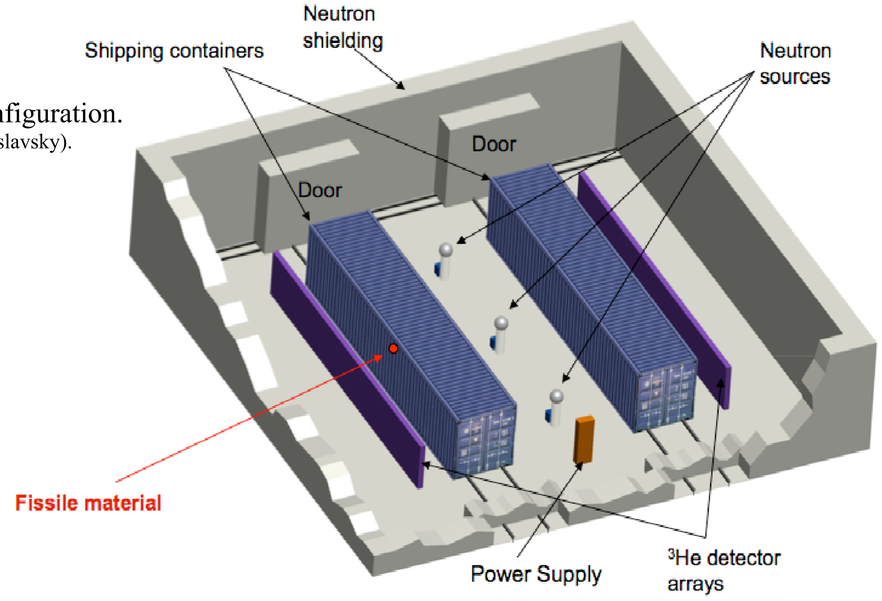
HEU in Suitcase Simulation Geometry



Simulated neutron count versus time for HDPE contents (left). Simulated neutron count versus time for air contents (right).

Future Concept

Potential Container SNM Configuration.
(Graphic courtesy of Greg Sviatoslavsky).



Conclusions

- **DNA neutron analysis method is seen to be an effective technique when using IEC devices to interrogate HEU in the structured laboratory environment.**
- **Data obtained from DNA experiments corroborated the MCNP-simulated data.**
- **DDA appears to be a robust technique for SNM detection involving highly moderating environments of substantial size.**
- **Simulation results indicate IEC-type fusion devices show promise in addressing the neutron sourcing aspect of SNM detection for laboratory experiments, suitcases, and containers.**
- **Special Nuclear Materials detection in hidden environments can be accomplished using a pulsed neutron source to activate fissile materials**

Layout: This poster was produced by Richard Bonomo of the research staff of the Fusion Technology Institute from materials supplied by the authors.
e-mail: bonomo@engr.wisc.edu