Neutron Detector Based on Gas-Filled Glass Shells

The Next Generation of Neutron Detectors

Purpose: Develop a new class of high-performance, cost-effective neutron detectors for detection of covert neutron sources.

Sponsor: Department of Energy, National Nuclear Security Administration, Office of Nonproliferation Research and Development.

Features:
- High efficiency fission neutron detection.
- Low false alarm.
- Great flexibility in physical size and shape.
- Inexpensive fabrication.

Users: Homeland security transportation monitors, scientific and engineering organizations, industry, and government laboratories.

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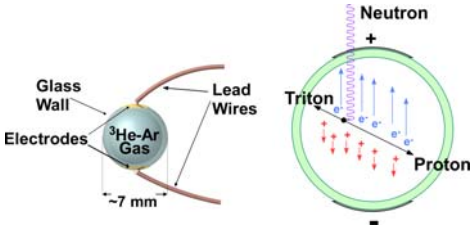
Oak Ridge National Laboratory is developing a new type of neutron detector intended to provide improved neutron detection efficiency and gamma-ray rejection at a lower cost than current-generation, field-deployable neutron detection technologies.

The new neutron sensor is based on small, gas-filled, glass shells with external electrodes. The sensor functions as a small ^{3}He ion chamber, producing small electrical pulses when a neutron is captured. The sensor has a very low gamma-ray sensitivity due to its small size compared to the path-length of electrons resulting from gamma-ray interactions. Multiple shell sensors are deployed within a moderator block to form a single detection system. The resulting detector-moderator configuration approaches the efficiency of a homogeneous system because parasitic neutron capture by the moderator is minimized.



Sensor is a miniature ^{3}He ion chamber with external electrodes.

An efficient, large-area detector system requires many (potentially tens of thousands) individual sensors. Many sensors are connected in common to a preamplifier forming an array. Preamplifier outputs are combined into a common signal processing stage. A large neutron detection area can be created by combining many shell arrays.

First generation gas-filled shell held between circuit boards.

Small Embedded Neutron Sensor Advantages

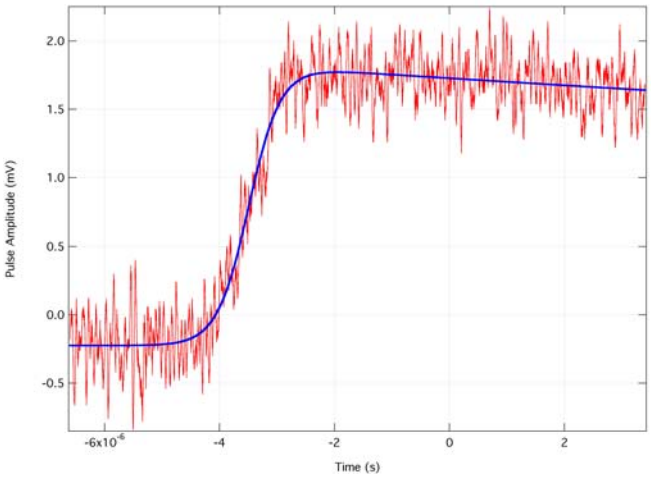
- Optimal neutron moderation provides maximum theoretical neutron detection efficiency for energetic incident neutrons.
- Very low gamma-ray contamination.
- Spherical shape enables high gas pressures.
- Sphere manufacturing and detector assembly process can be automated using standard electronics assembly techniques.
- Customizable configuration.
- Low applied bias (as low as 50 V in some instances).

Shell array to increase detection efficiency.

Sensors and Controls Research

Project Technical Findings

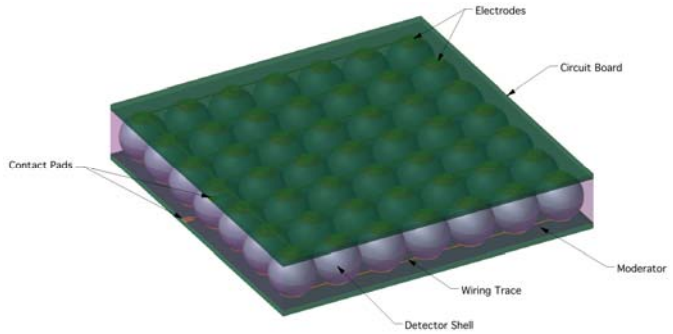
- ^{3}He-Ar-filled glass-walled shells with external electrodes effectively detect neutrons.
- Neutron interactions produce small signals emphasizing the importance of grounding, shielding, materials, and amplification.
- Effective neutron detection requires several atmospheres of internal gas pressure.
- Detectors function under thermal neutron, mixed gamma-neutron, and energetic neutron environments.
- Glass material properties strongly influence the sensor performance.
- Sensor gas pressures may be high (>40 atmospheres) for maximum neutron detection efficiency,
- Integration of multiple preamplifiers and electronics with sensor arrays and moderator is feasible and cost effective.



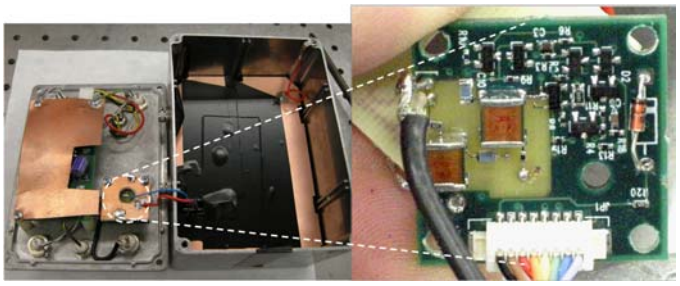
Small pulses detected with high-gain, low-noise amplification.

Next Steps

- Complete the automation of glass shell fabrication.
- Optimize shell glass formulation.
- Demonstrate an integrated assembly prototype exhibiting all of the essential detector characteristics.
- Conduct field demonstration of the integrated detector technology in an uncontrolled environment.
- Transfer technology into commercial sector for detection of covert neutron sources and other nonproliferation uses.



Single array of glass shell sensors.



Aluminum enclosure containing shaping amplifier and preamplifier (inset) was used for detector array testing.

Contact Information

To explore this and other exciting, new nonproliferation technologies, please contact Roger Kisner (kisnerra@ornl.gov) at 865-574-5567.