Highly Enriched Uranium Radiation Signature Training Device

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1. Overview

The US Department of Energy's Oak Ridge National Laboratory has developed Radiological Signature Training Devices (RSTDs) that emulate the radiation signature of larger masses of special nuclear material (SNM) but use relatively small of amounts of SNM.

Highly enriched uranium (HEU) RSTDs are assemblies of sealed SNM sources (^{235}U, ^{238}U).

Designs take advantage of skin effect of heavily self-shielded actinides to emulate the passive gamma signature of much larger masses of SNM by using a thin layer of material.

The large sphere assembly (Figure 4) emulates the IAEA significant quantity of 25 kg of solid metal but only uses ~240 g of ^{235}U. The low base mass reduces security and criticality safety concerns.

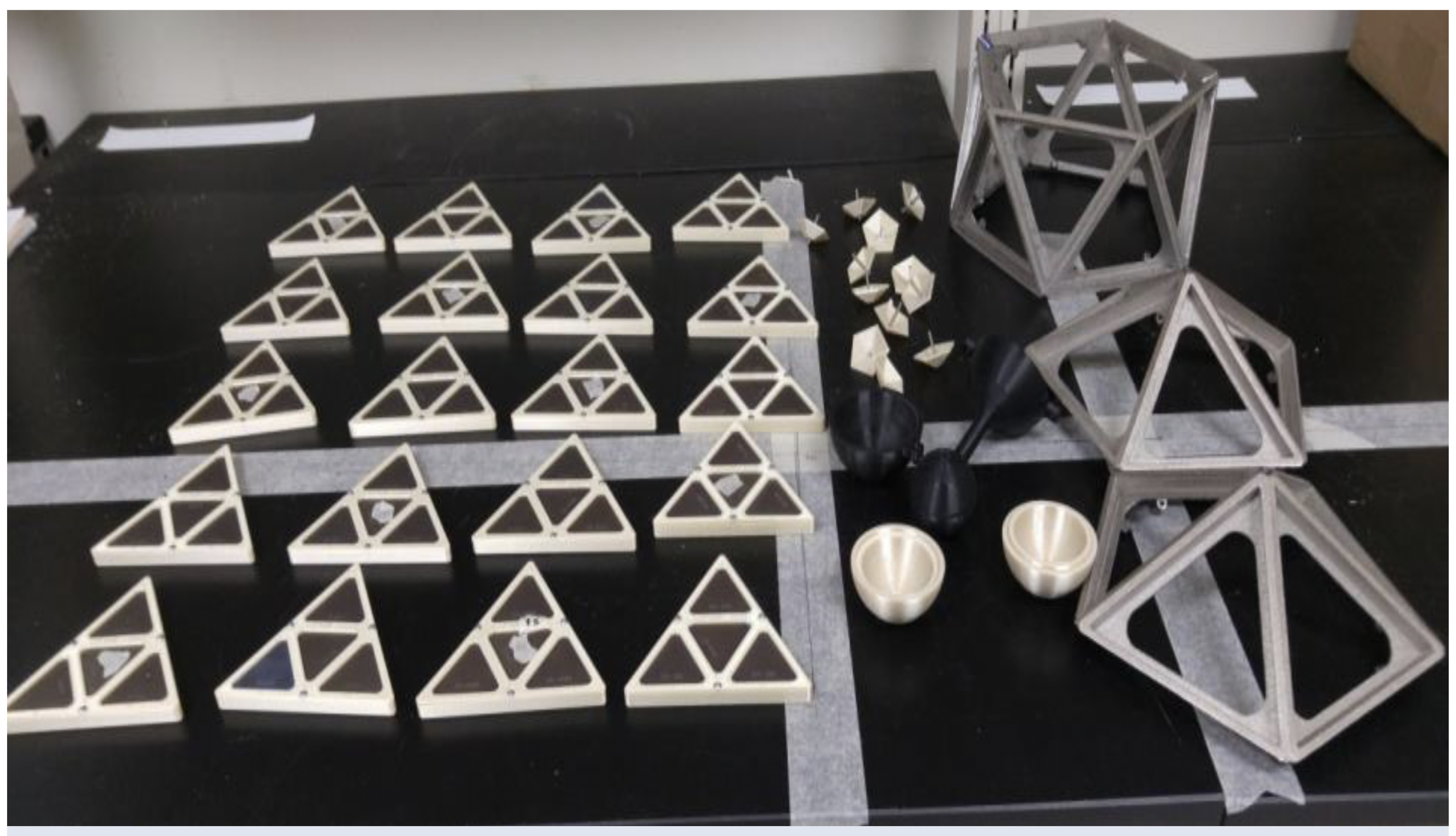

Figure 1. Entire sphere disassembled.

Modularity and scalability are primary features. Assembling fewer sources yields a reduced cumulative apparent mass size. Other geometries can be emulated (for example linear or planar assemblies can be used to emulate material hold-up in a safeguards scenario).

Robust welded titanium encapsulation that meets ANSI Class 3 standards are used as for containment.

2. Components

Instead of a monolithic solid shell, many individual sources were chosen to allow for source flexibility and the capability to ship the source tiles as Type A shipments instead of more expensive and complex Type B shipments.

The ^{235}U signal is generated by a thin shell composed of 80 triangular tiles (Figure 2). The ^{238}U signal is generated by a depleted uranium source in the center of the assembly (Figure 3).

The assembly is held together in a 3D printed icosahedron titanium or plastic frame.

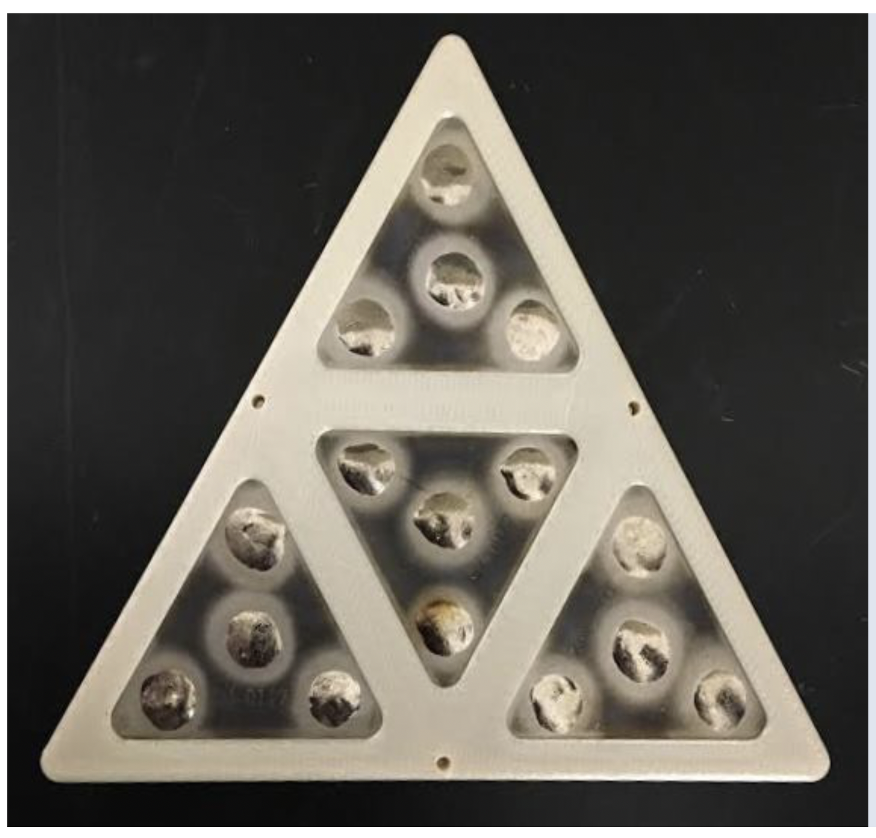

Figure 2. Plastic frame subassembly of four RSTD sources.

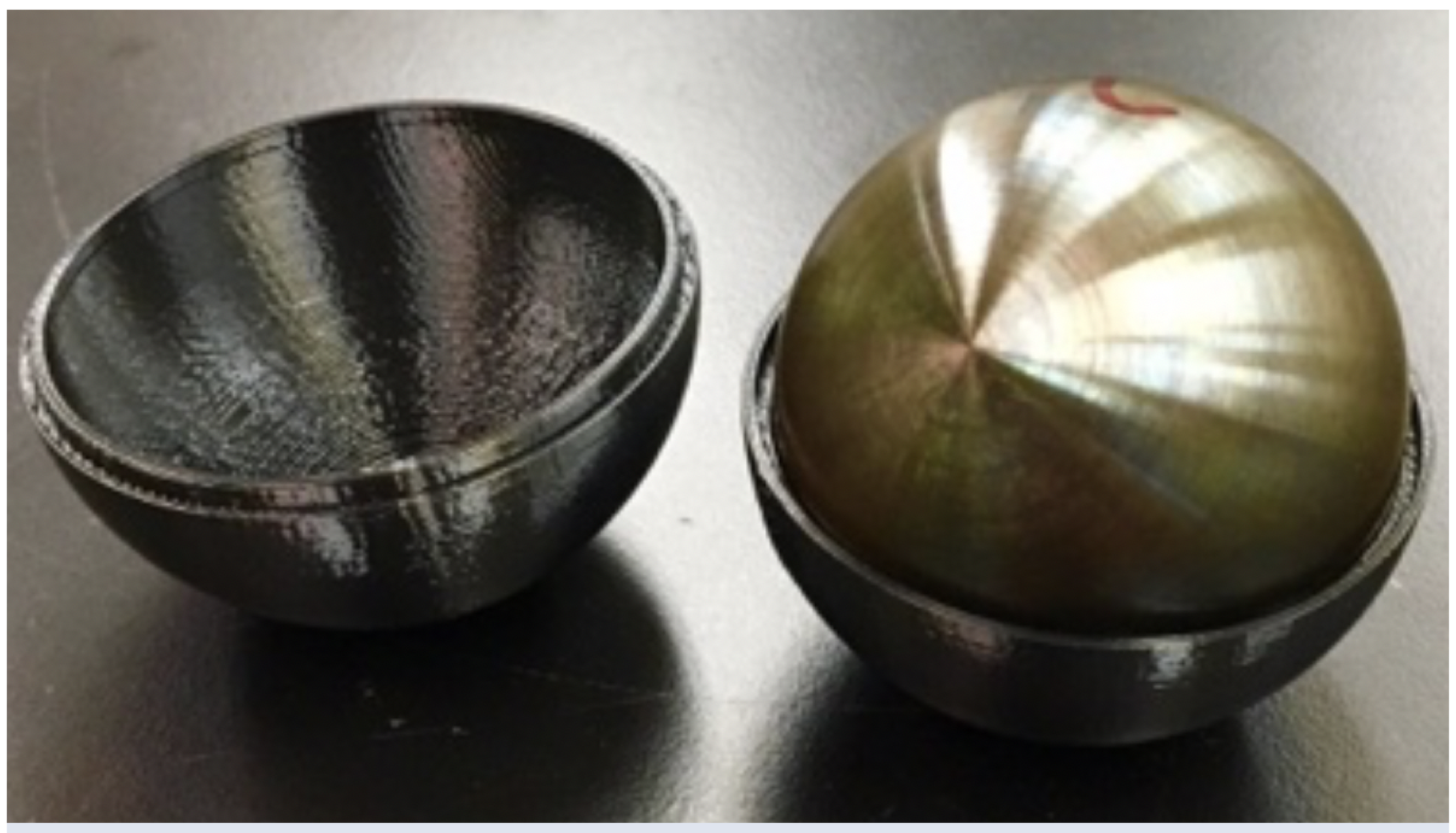

Figure 3. Depleted uranium (1 kg) center of assembly.

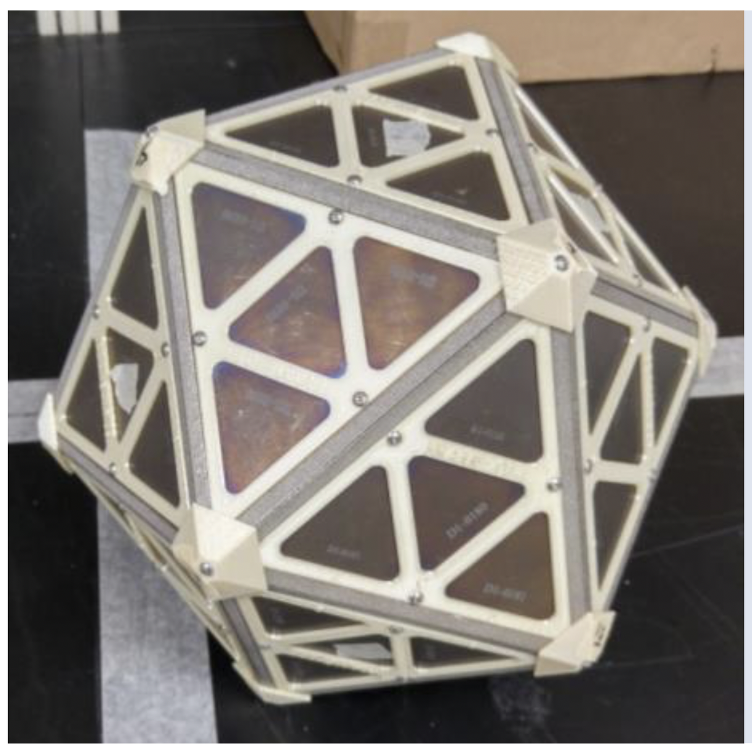

Figure 4. HEU 25 kg equivalent sphere assembly provides the passive gamma signature of a large HEU source using a small quantity of material.

3. Spectra

The units produced have matched the characteristic 186 keV gamma signature from a 25-kg solid sphere composed of 90% U^{235} within ±10%, and uniformity measurements taken at each face and vertex of the assembled icosahedron RSTD have less than ±3% variation.

An overlay of a Gamma Detector Response and Analysis Software (GADRAS) simulated spectra of a 25-kg mass and the actual measured spectra (100–225 keV) from two different HEU RSTDs is shown in Figure 5.

The units have also been demonstrated to be highly isotropic with standard deviations between faces and vertices within approximately 3%.

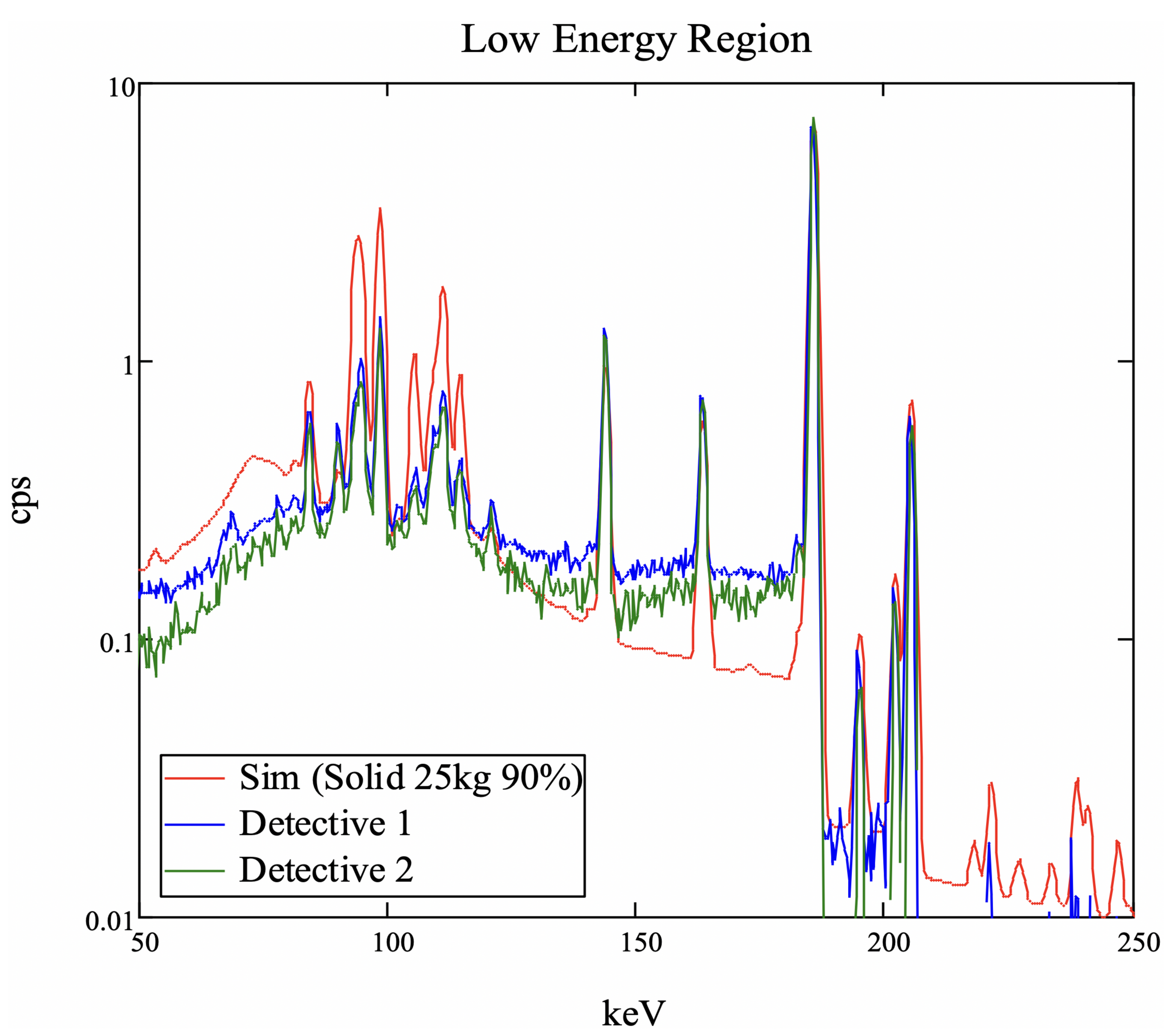

Figure 5. Measured spectra from two gamma detectors of HEU RSTD compared to simulation of a solid metal sphere.

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