RESEARCH OPPORTUNITIES AT THE CNS (Y-12 AND PANTEX) NUCLEAR DETECTION AND SENSOR TESTING CENTERS (NDSTC)

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UNCLASSIFED


But it is a sacrifice required
for the future of the human race.

Presentation Overview

- U.S. National Security Enterprise – CNS (Y-12 & Pantex)
- Y-12 Nuclear Detection and Sensor Testing Center (NDSTC)
- NDSTC Measurement Facilities
  - Site 1
  - Site 2
- Metallic Enriched and Highly Enriched Uranium (EU-HEU) Standards
- EU-HEU Chemical Standards
- New & Planned NDSTC Capabilities
- Summary
- Acknowledgments

IAEA Detector Test Facility for the Illicit Trafficking Radiation Detector Assessment Program (ITRAP 1) conducted at Seibersdorf, Austria (Stonehenge).

National Security Enterprise

Six production facilities and three design labs

Purpose of the CNS (Y-12 & Pantex) Nuclear Detection and Sensor Testing Centers (NDSTC)

The testing centers at Y-12 & Pantex offers researchers opportunities to evaluate their instrumentation systems with:

- Objects and Assemblies
- New EU-HEU Metallic Enrichment Standards
- Radiation Signature Training Devices (RSTD)
- Compounds and alloys with various ^{235}U enrichments
- Other matrices containing EU-HEU
- Additional source materials in the current and historical inventory

Nuclear Measurements Imaging System (NMIS) measurement of a containerized object. Use of photograph courtesy of Oak Ridge National Laboratory.

Overview of Y-12 NDSTC Measurements Facilities

Two sites at Y-12 for measurements with radiation detection systems and related technologies. Additional sites may be designated.

SITE 1

- A dedicated testing area within a highly secure facility
- Applications requiring Category I (≥5 kg) or Category II (<5 but >1 Kg) quantities of HEU
- Site 1 access allows the use of specific materials and objects stored in this facility
- Items in the 'Library of Test Objects'

NMIS with D-T generator. Figure from *Recent Measurements with NMIS at ORNL, Mullens, J. A., et al., 2005.* Used courtesy of ORNL.

Y-12 NDSTC – Examples of Site 1 Measurements

Site 1 – Measurements with specific components and assemblies

Approvals for:

- Verification Technologies
- Warhead Counting Applications
- Active Interrogation of objects (*e.g.* with D-T and D-D neutron generators)
- Passive measurements of materials / objects within storage arrays

Recent Approvals for:

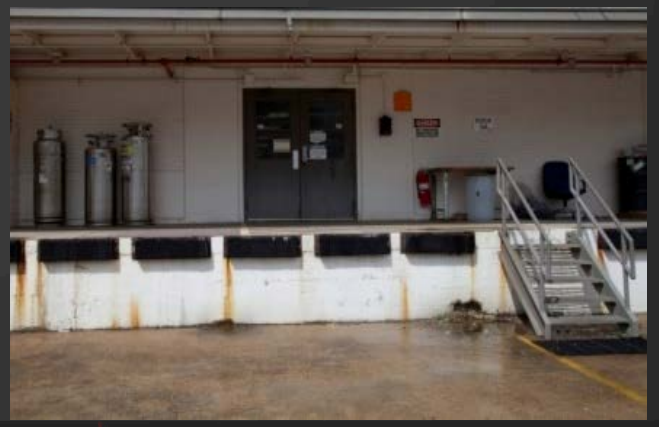
- Monitoring / verification of dismantlement operations and component signatures
- Measurements for Next Generation Safeguards Initiatives

Portable Isotopic Neutron Spectroscopy (PINS) measurements at NDSTC by Idaho National Laboratory researchers. Use of photograph courtesy of INL.

Y-12 NDSTC – Site 2

Site 2 – Less restrictive areas for measuring Category IV quantities of HEU (typically <500 g):

- Users may operate their own instrumentation
- Users may conduct demonstrations / short courses
- Passive gamma-ray and neutron measurements
- Approvals underway for Active Interrogation at Site 2 (D-D and D-T generators)

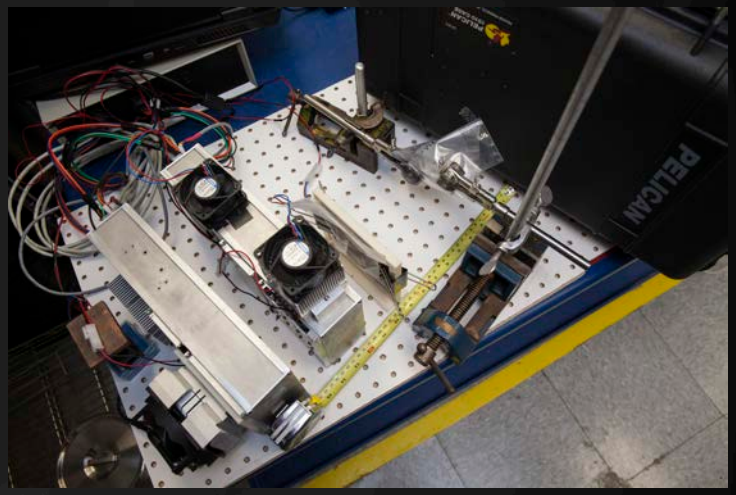


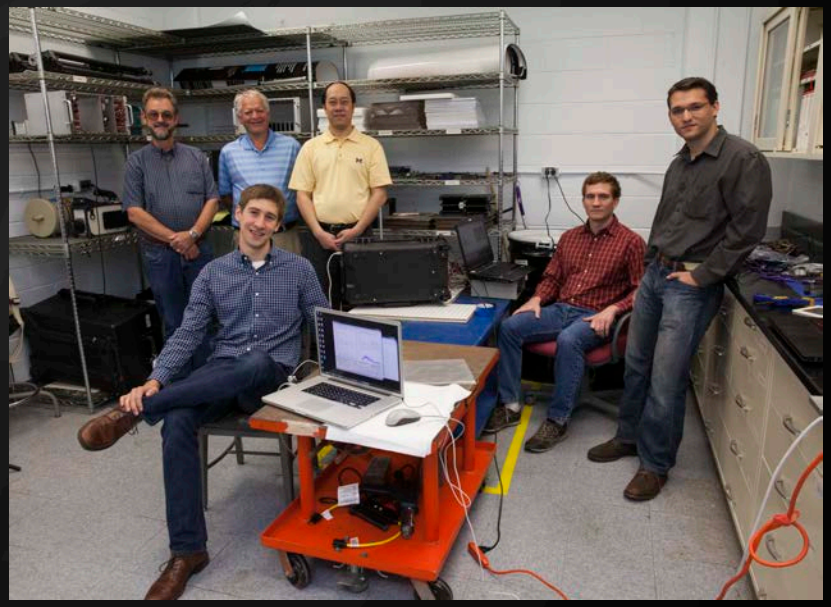
Y-12 NDSTC – Site 2

Site 2 – Who may test at Site 2?

- Personnel with or without security clearances
- University Research Groups
- Nuclear Instrumentation Companies
- National Laboratory Personnel
- Other government funded groups (DTRA, DHS, NRL, *etc*.)
- Foreign Nationals (given adequate lead time)

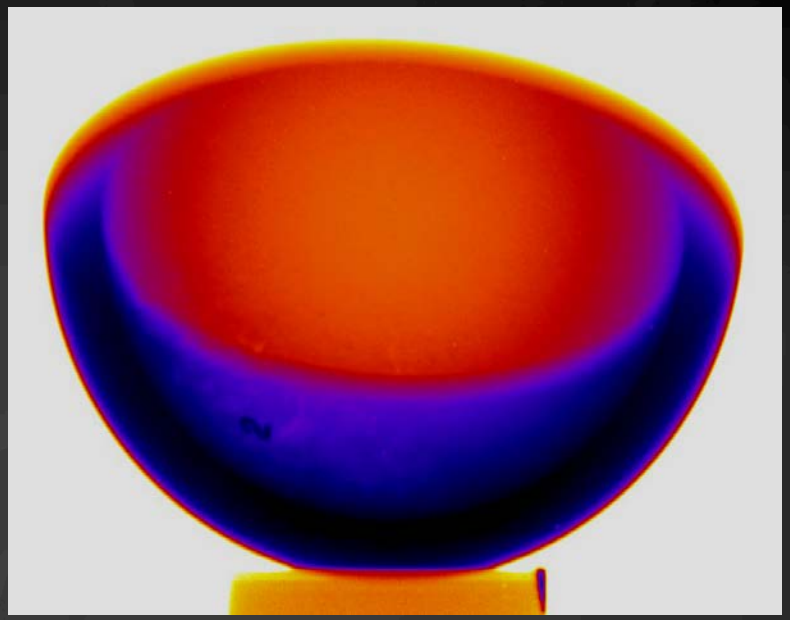
University of Michigan NERS Measurements at Y-12 NDSTC Site 2





Enriched and Highly Enriched Uranium (EU-HEU) Standards

- Y-12's forte is Uranium
- NDSTC has new sets of EU-HEU and depleted (DU) standards
- These are available for measurements; data are unclassified
- New and planned standards include:
  - Metallic DU-EU-HEU Enrichment and Mass Standards
  - Radiation Signature Training Devices (RSTD); data are unclassified
  - DU-EU-HEU chemical compound standards



Radiographic image of an Aluminum – Uranium alloy hemi-casting used in one model of Radiation Signature Training Devices (RSTD).

Radiation Signature Training Devices (RSTD)

- Two Radiation Signature Training Devices (RSTD) are available to NDSTC users
- RSTD produce virtually exact gamma-ray spectra of much more massive amounts of HEU
- RSTD are the result of an extremely successful joint project by Y-12 and Oak Ridge National Laboratory
- NNSA NA-221 funded RSTD R&D

Radiation Signature Training Device

Metallic Uranium Enrichment Standards

Table 1 – Enrichment Standards Planned for NDSTC			
Enrichment	Diameter	Thickness	Mass
%^{235}U	cm	cm	g
0.2	3.00	0.30	40.8
0.7	3.00	0.31	41.6
3.0	3.01	0.30	40.0
3.5	3.00	0.31	41.1
4.7	3.00	0.31	41.3
19.4	3.00	0.31	41.0
54.9	3.00	0.30	40.0
93.2	3.00	0.33	43.0
Awaiting Analytical Chemistry Results			
37.0	3.00	0.31	41.0
20.5	3.00	0.30	40.7
70.0	3.00	0.30	40.7

Uranium Enrichment Standards

The enriched uranium metal standards were designed to provide users access to a wide variety of measurement scenarios in a single testing venue. The standards are approximately 3 cm in diameter and 3 mm thick (**Figure 1**). The complete set of 11 standards will have enrichments as listed in **Table 1**.

Figure 1 - Enriched Metallic Uranium Standard at Y-12 NDSTC.

From Cantrell, J. A., 2012, INMM 53rd Annual Meeting Poster. Associated technical paper in the Proceedings of the INMM 53rd Annual Meeting.

New DU & HEU Mass Standards

Table 2 – Mass Standards Planned For The NDSTC

Mass	Radius	Volume	Enrichment	Mass	Enrichment
(g)	(cm)	(cm^3)	(%)	(g)	(%)
100	1.08	5.28	0.2	100.6	0.2
1000	2.32	52.31	0.2	993.0	0.2
5000	3.96	260.12	0.2	Available October 2012	
10	0.5	0.52	93	Available October 2013	
50	0.85	2.57	93	Available October 2013	
100	1.08	5.28	93	Available October 2013	

Figure 2 - Depleted Uranium Mass Standards available at the NDSTC

Mass Standards

A series of uranium metal mass standards are being developed (**Table 2**). These standards will be used to test equipment designed to test minimal detection capabilities of enriched or depleted uranium found in various packaging configurations.

From Cantrell, J. A., 2012, INMM 53rd Annual Meeting Poster. Associated technical paper in the Proceedings of the INMM 53rd Annual Meeting.

Gamma-Ray Spectra Produced with New EU-HEU Standards

Spectral Database

Spectra were taken of each enriched uranium metal standard in well defined experimental setups. A user interface was created to allow for easier reference and comparison of the spectra. The user interface can compare spectra based on five dependent variables (detector type, enrichment of the source, source distance, shielding material and shielding thickness). Information stored in the spectral database includes: raw count data (including background spectra), ROIs, peak ratios, and FWHM calculations.

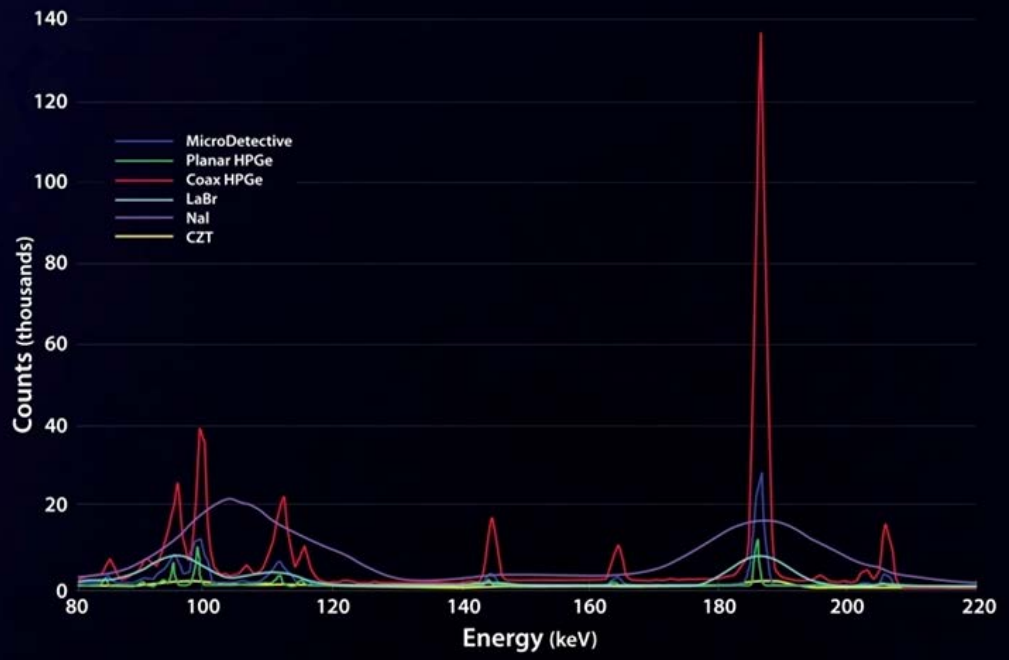


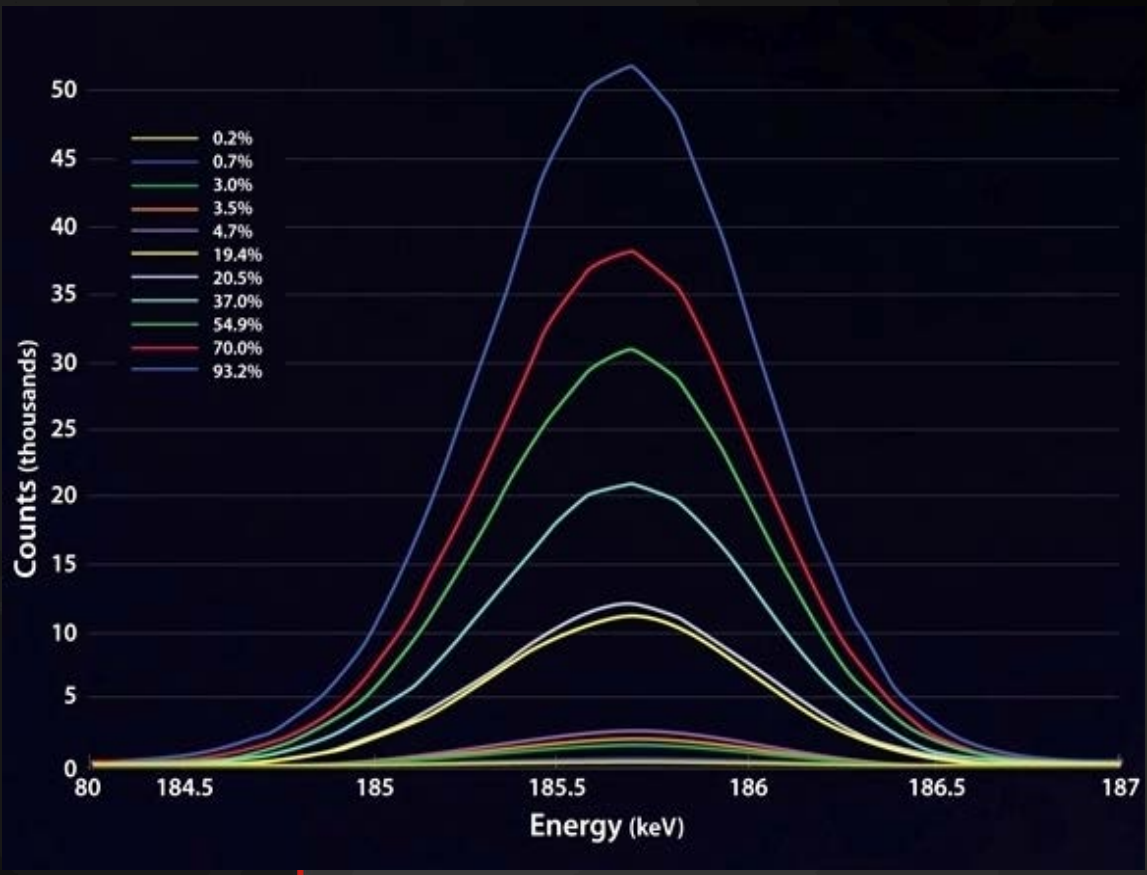
Figure 3 - Comparison of Spectra from Different Detector Types

Gamma-ray spectra database is available to NDSTC users and for licensing.

Gamma-Ray Counts in ^{235}U 186 keV Peak Measured using New Metallic Enrichment Standards

Table 3 – Counts observed in the 186 keV peak for various standards using identical measurement setup

Enrichment	186 keV Peak	Error
%	Counts	Counts
0.2	829	84
0.7	3077	95
3.0	12968	150
3.5	15053	147
4.7	19977	164
19.4	83956	310
20.5	88174	318
37.0	157832	422
54.9	231390	513
70.0	287254	574
93.2	393711	677



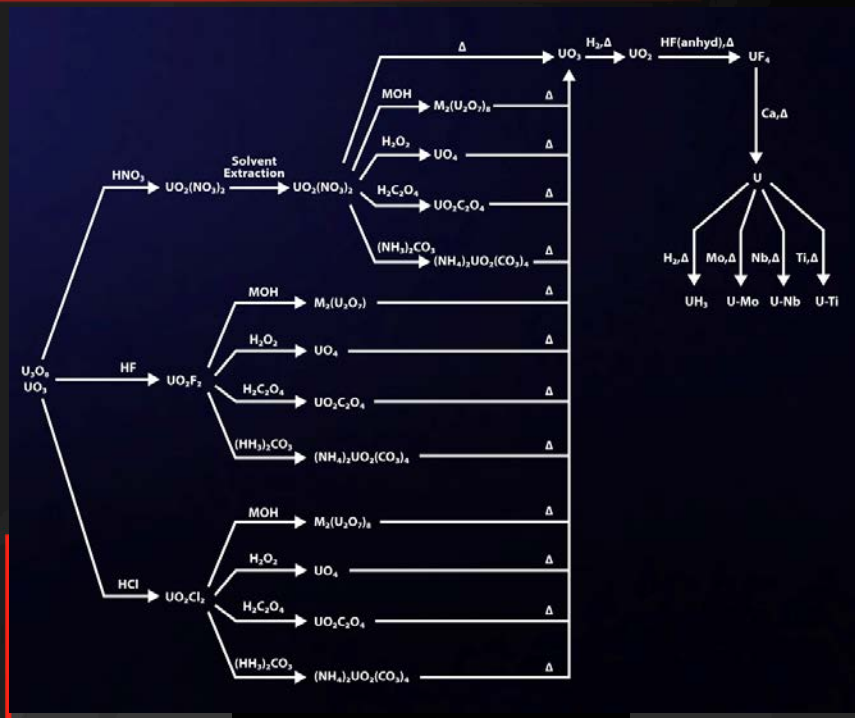
From Cantrell, J. A., 2012, INMM 53rd Annual Meeting Poster. Associated technical paper in the Proceedings of the INMM 53rd Annual Meeting.

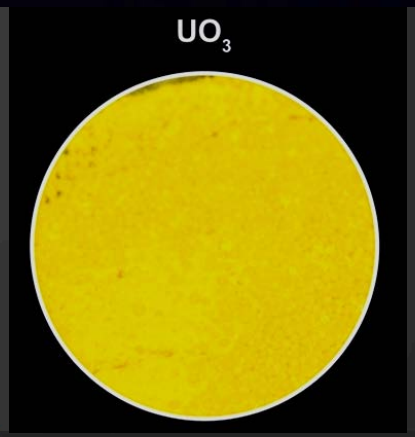
EU-HEU Compounds and Alloy Standards at NDSTC

Table 1 – Uranium Forms	
Material Name	Chemical Formula
Uranium metal	U
Uranium-molybdenum alloy	U-Mo
Uranium-niobium alloy	U-Nb
Uranium-titanium alloy	U-Ti
Uranium dioxide	UO_2
Uranium trioxide	UO_3
Triuranium octaoxide	U_3O_8
Uranyl fluoride	UO_2F_2
Uranium tetrafluoride	UF_4
Uranyl nitrate	$UO_2(NO_3)_2$
Uranium trichloride	UCl_3
Uranium tetrachloride	UCl_4
Uranates	$M_2(U_2O_7)x$ where (M = Na, K, NH_4, Ca, Mg, Ba)
Uranium peroxide	UO_4
Ammonium uranyl carbonate	$(NH_4)_2UO_2(CO_3)_{24}$
Uranium hydride	UH_3
Uranium oxalate	$UO_2C_2O_4$

Planned NDSTC Capabilities

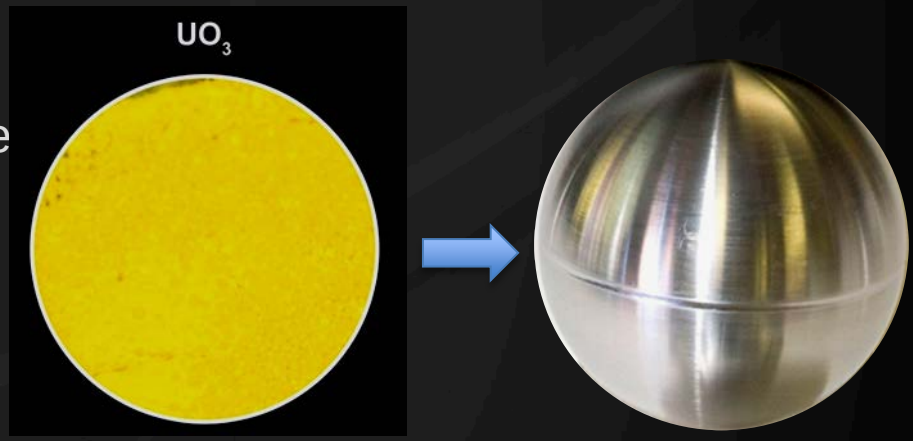
- Library of Test Objects – near completion
- Photonuclear Measurements
- Continued characterization of the new EU-HEU Enrichment Standards
- EU-HEU Gamma-ray Spectra Library
- Much more massive metallic EU-HEU ‘castings’ of various ^{235}U enrichments
- Chemical compound standards for Nonproliferation and International Safeguards
- Support for Universities, U.S. and International Safeguards, Treaty Verification, IAEA





Summary

- Three dedicated measurement sites are built out (Y-12 and Pantex) and operational. Additional sites can be designated.
- Measurements for:
  - Monitored Dismantlement & Storage
  - Treaty Verification Technologies
  - Warhead Signature Campaigns
  - Fissile Material Control
  - Chain-of-Custody Studies
  - Future Nonproliferation Initiatives



- HEU components and assemblies, EU-HEU metallic enrichment standards, and compounds are available for measurements
- Additional EU-HEU standards can be created; input welcome
- Measurement capabilities continue to be expanded

Acknowledgments

- This work was funded in-part by the Consortium for Verification Technology under Department of Energy National Nuclear Security Administration award number DE-NA0002534

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- NNSA Defense Nuclear Nonproliferation, Office of Nonproliferation and Verification Research & Development (DNN R&D), Proliferation Detection (NA-221) provided funding to fabricate a RSTD at Y-12 and permission to permanently house this standard at NDSTC Site 2.

- Y-12 NDSTC acknowledges NNSA Nonproliferation and International Security, Office of Nuclear Verification, Warhead and Fissile Materials Transparency (NA-243) for funding the fabrication and analysis of four of the new EU–HEU disc standards.

Questions – Discussion

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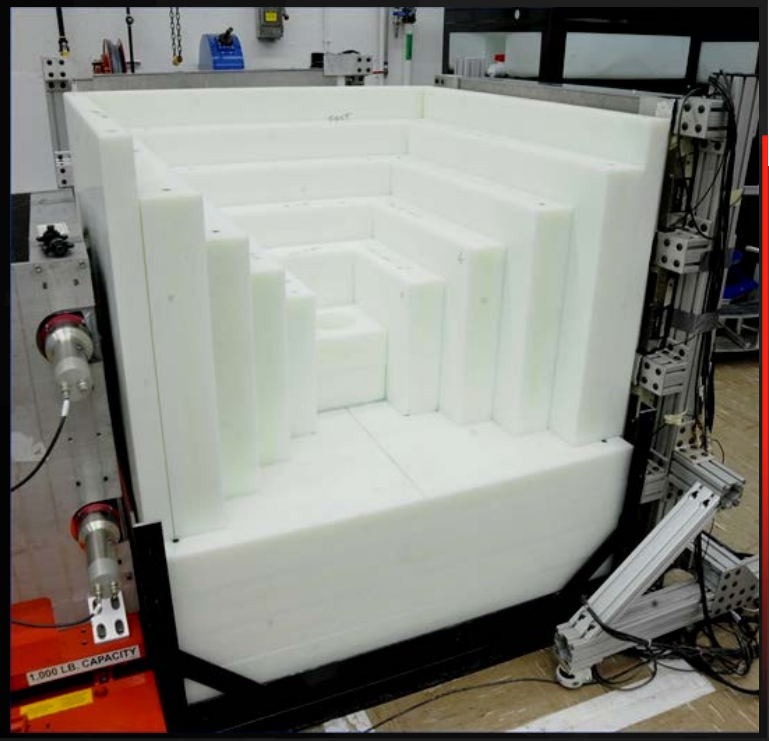

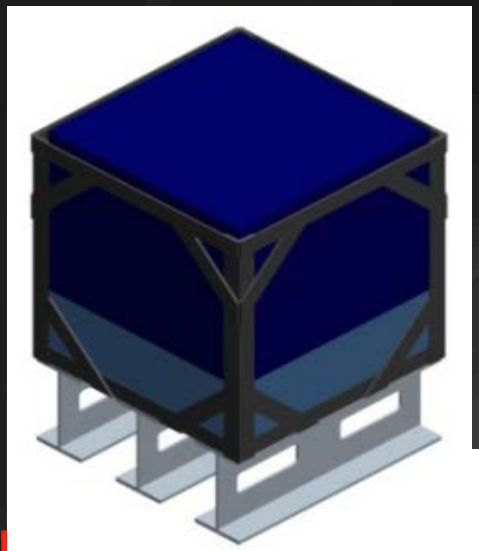

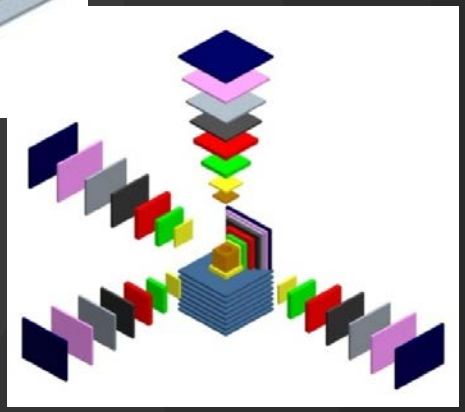

Configurable steel shielding and High Density Polyethylene reflector - moderator assemblies are available. “Exploded” view depicts shielded HEU source within shielding.

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