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MIRION Connect 24

Annual Users' Conference

July 29 - August 2 | Omni Dallas Hotel, Dallas, TX

MIRION TECHNOLOGIES

Exploring the Art of Non-Destructive Assay

Unveiling the Power of Measurement Services in Assay Work

Adam Gallegos

NDA Expert Analyst and Site Manager

Savannah River Site

Mirion Connect | Annual Users' Conference 2024

Dallas, Texas

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Non-Destructive Assay and Measurement Services: An Overview

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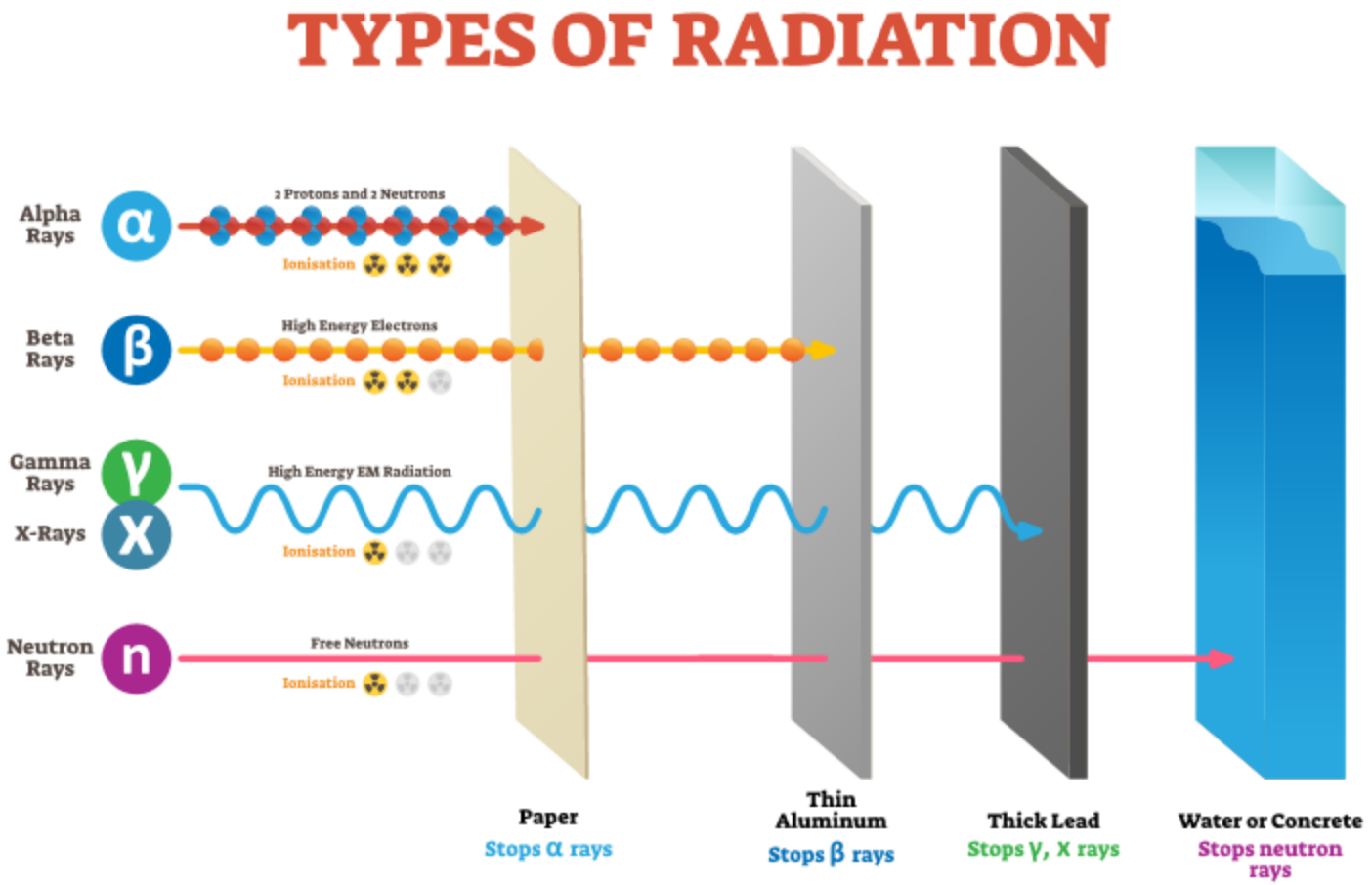
Non-Destructive Assay: Overview

Non-Destructive Assay (NDA) : Defined

- The term **nondestructive assay** (NDA) is applied to a series of measurement techniques for nuclear fuel materials. The techniques measure radiation induced or emitted spontaneously from the nuclear material; the measurements are non-destructive, in that they do not alter the physical or chemical state of the nuclear material. In some cases, the emitted radiation is unique to the isotope(s) of interest and the radiation intensity can often be related to the mass of the isotopes.[1]

1. Reiley D., et. al *Passive Nondestructive Assay of Nuclear Materials* NUREG/CR-5550 LA-UR-90-732, March 1991

Non-Destructive Assay: Overview



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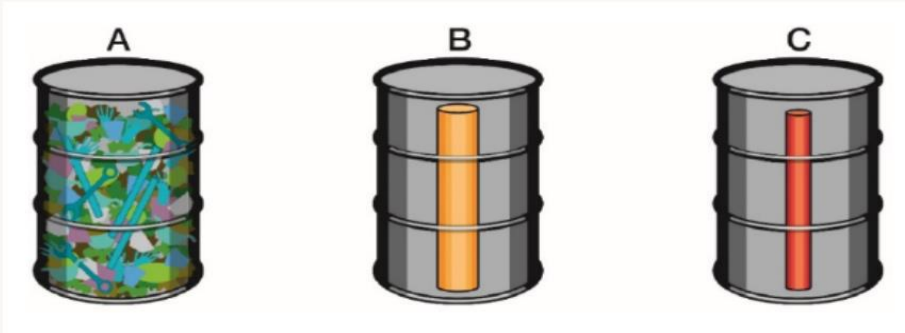
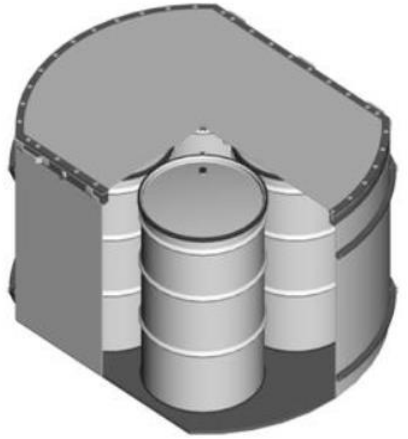
Non-Destructive Assay: SNM & Waste

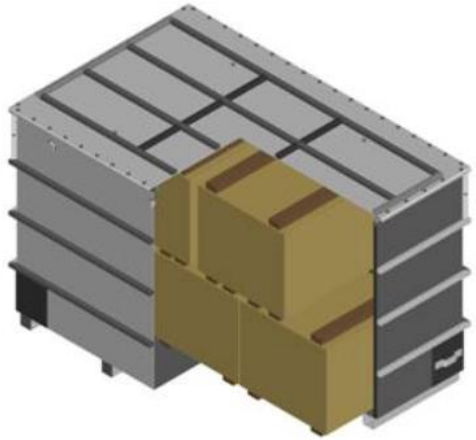
Common Nuclear Materials Containment

- Nuclear waste and SNM are housed in various containment vessels, shielding materials and configurations.
- How the nuclear materials are dispersed, shielded and contained can present measurement challenges to field personnel.
- Measurement considerations include measurement precision, accuracy, uncertainty and repeatability.





Standard Waste Box

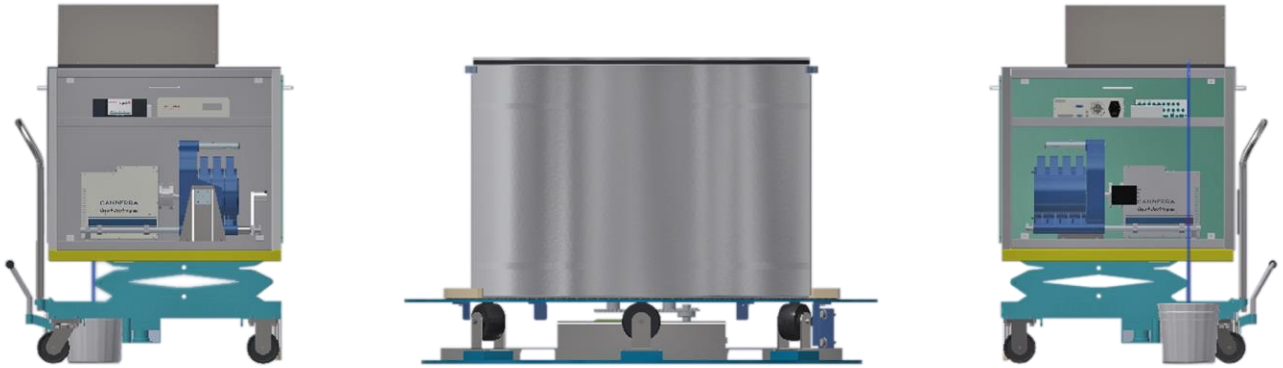


TRUPACT-III Standard Large Box 2

NDA Instrumentation Examples

Gamma and Neutron NDA Equipment

Mobile High Efficiency Neutron Counter (HENC)



Mobile ISOCS Large Container Counter (MILCC)

Segmented Gamma Scanner (SGS)

High Efficiency Neutron Counter (HENC)

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Non-Destructive Assay: Pathway to Solution

- Understand the measurement challenges for nuclear material (e.g. U, Pu)
- Definition of Solution → Selection of detectors and physical layout
- Selection of nucleonics components for appropriate data acquisition
- Design, Builds, Factory Test, Calibration, Commissioning

Discussion Question

What are the immediate concerns when starting any new Project or Process?

Discussion Question

What are the immediate concerns when starting any new Project or Process?

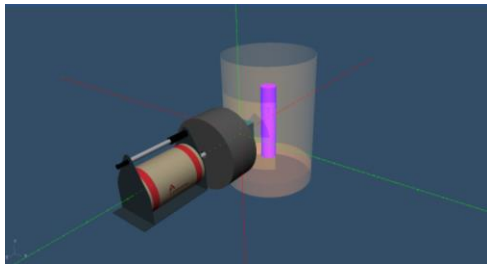
- Budget
- Resource Allocation
- Defined Goals and Potential Scope Creep
- Time Constraints
- Team and Communication
- Methodology, Tools and Expertise

NDA Measurement Services

Technological Teamwork in Action!

NDA Instrumentation

Physics Applications



Technological Expertise

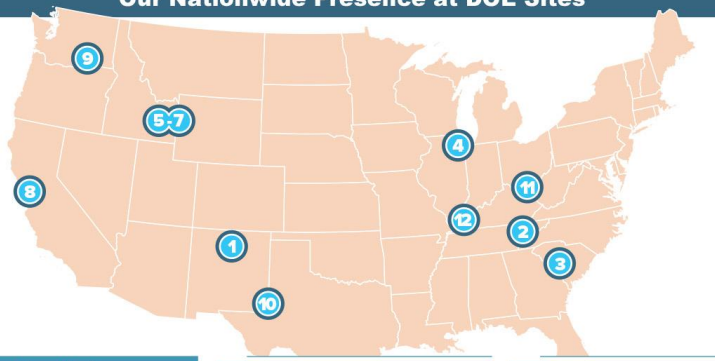
Value-added and Cost-effective solutions

Mirion Technologies
NDA Measurement Services

Measurement Services Introduction

- Onsite measurements for several different sites across the United States
- Gamma spectroscopy performed at most of the Department of Energy Sites and others
- High activity measurements for fuel-based waste and process type waste at various sites
- Neutron measurements performed by the group as well.
- Combined measurements integrating gamma and neutron results .
- Experts available for a multitude of needs.

Our Nationwide Presence at DOE Sites



1 LANL – New Mexico NDA and Service Personnel: 15	5 AMWTP – Idaho NDA and Service Personnel: 9	9 Hanford – Washington NDA and Service Personnel: 2
2 ORNL – Tennessee NDA and Service Personnel: 7	6 NRF – Idaho NDA and Service Personnel: 1	10 WCS – New Mexico & Texas NDA and Service Personnel: 2
3 SRS – South Carolina NDA and Service Personnel: 5	7 INL – Idaho NDA and Service Personnel: 1	11 Portsmouth – Ohio NDA and Service Personnel: 1
4 ANL – Illinois NDA and Service Personnel: 3	8 LLNL – California NDA and Service Personnel: 6	12 Paducah – Kentucky NDA and Service Personnel: 1

Mirion products used at some of these projects

NDA Systems:
ISOCS Systems
WRAP Gamma Systems
HENC System
Slab Counters
ISOCS Software
Gamma Counter
Q2 System
Hex Counter
SGS System
Neutron Multiplicity Counters
HENC System
Falcon 5000 Instrument
MILCC System

NDA WIPP Certified Equipment:
MILCC #1
MILCC #2
MILCC #3
MILCC #4
MILCC #5
HENC#1
HENC#2
HENC#3
SuperHENC#1
IQ3 System
IWAS Systems
SGRS
WAGS
ISOCS Software

NDA Equipment:
ISOCS Software
Q2 System
SGS System
Box Counter
ISOCS Systems
Shuffler System
Slab Counters

WIPP Certified Equipment:
Osprey DTC

NDA Software Toolkit

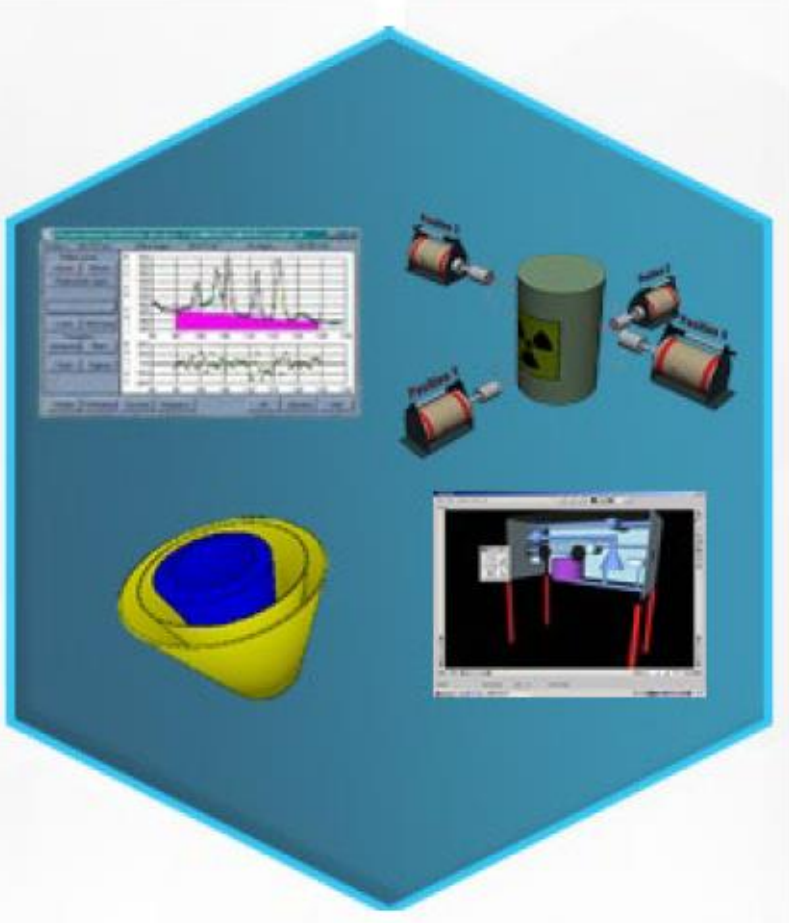
NDA Software and Modeling Tools :

Acquisition & analysis:

- Genie 2000 & NDA 2000 for characterization
- Specific software for U/Pu isotopic measurements (MGA, MGAU & FRAM)
- Custom tools and scripting

Modeling:

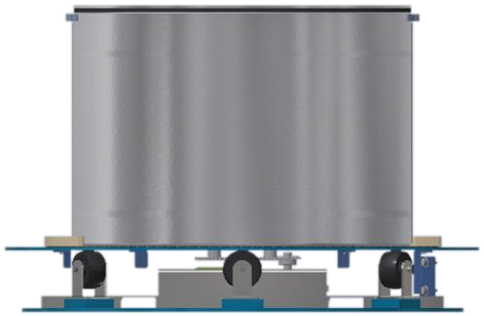
- MCNP / MCNPX
- ISOCS / ISOCS Uncertainty Estimator
- Advanced ISOCS, SuperISOCS

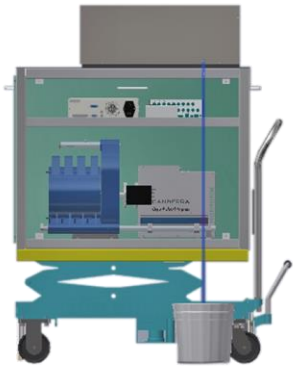


NDA Technology – Waste Assay Systems

Fixed NDA Instrumentation

- Accurate measurement and characterization of nuclear materials.
- NDA Instruments can perform gamma and or neutron measurement, providing highly accurate results.
- Mirion Technologies NDA systems are deployed across the DOE complex to support waste and characterization and NMC&A safeguards measurements.





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Portable Non-Destructive Assay: D & D

Portable and Small Footprint Instrumentation

DECOMMISSIONING PREPARATION

- Investigation & Characterisation
- Radiological inventory
- Modeling and scenarios studies
- Regulations vs solution and costs impact studies

CLEANING AND DECOMMISSIONING

- Solid and liquid waste characterization and sorting
- Solution definitions,
- Performances studies
- Qualifications strategies definition,
- Qualification

PACKAGING, TRANSPORT AND STORAGE

- Drum and container measurement,
- Qualification regarding regulations,
- Support for systems acceptance by regulatory instances

RELEASE

- Facilities and soil characterization,

NDA Technology – Robotics

Leverage various robotics platforms to perform NDA

DualRoboCount™ 2020

Boston Dynamics SPOT Robot

NDA Technology – Robotics

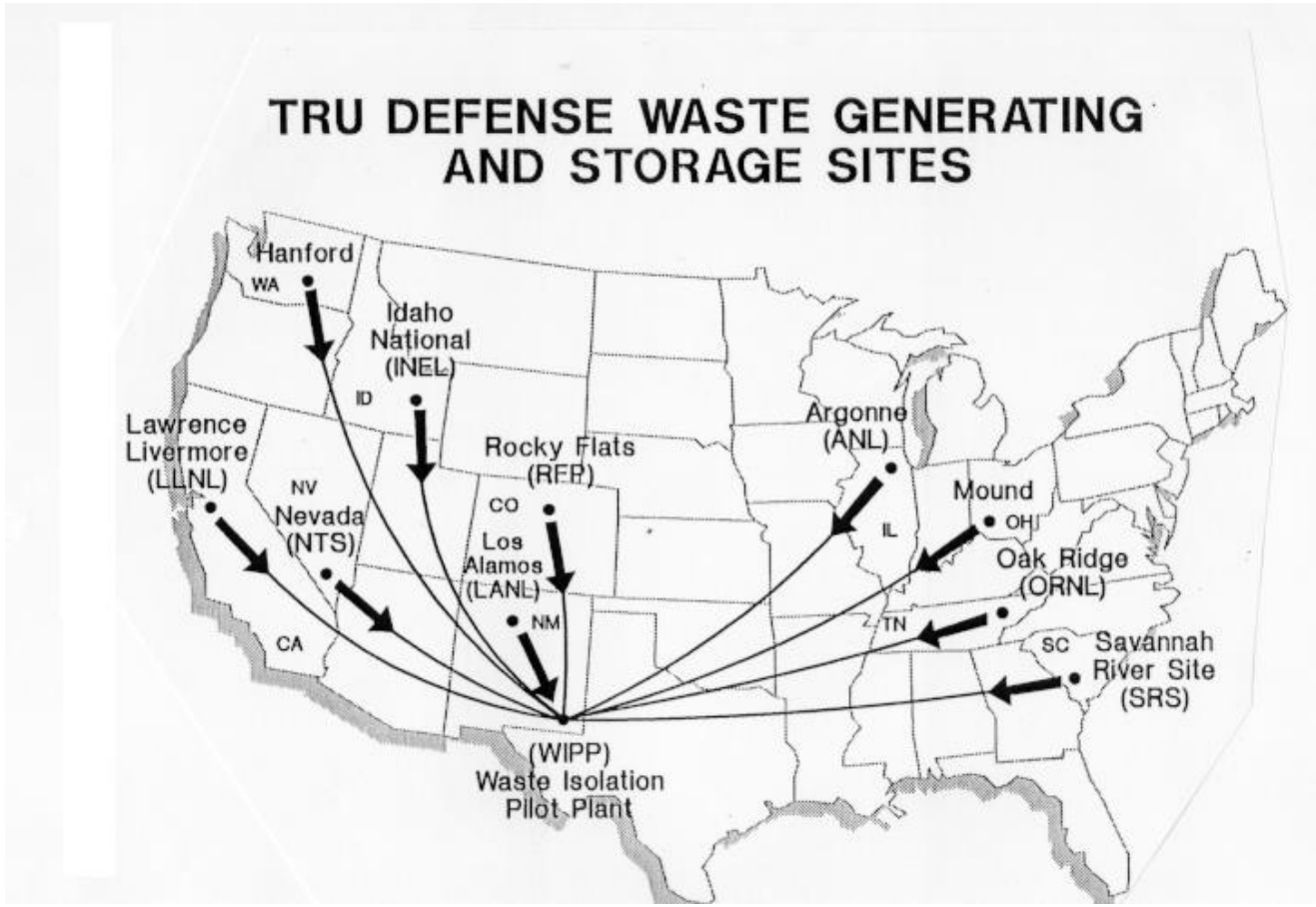
Adapt Robotics Platforms to Perform NDA

- Improved flexibility for multiple geometries
- Simple User Interface
- Building Block Technology Approach
- Industry partnerships for robotics supply

NDA Solutions for Characterization Programs: WIPP

Measurement Services for WIPP Characterization

- The Waste Isolation Pilot Plant (WIPP) disposes of TRU defense waste within the underground repository in Carlsbad, New Mexico.
- WIPP is responsible for creating and maintaining the TRU waste Central Characterization Program (CCP), which utilizes NDA equipment, field personnel and analysis experts.



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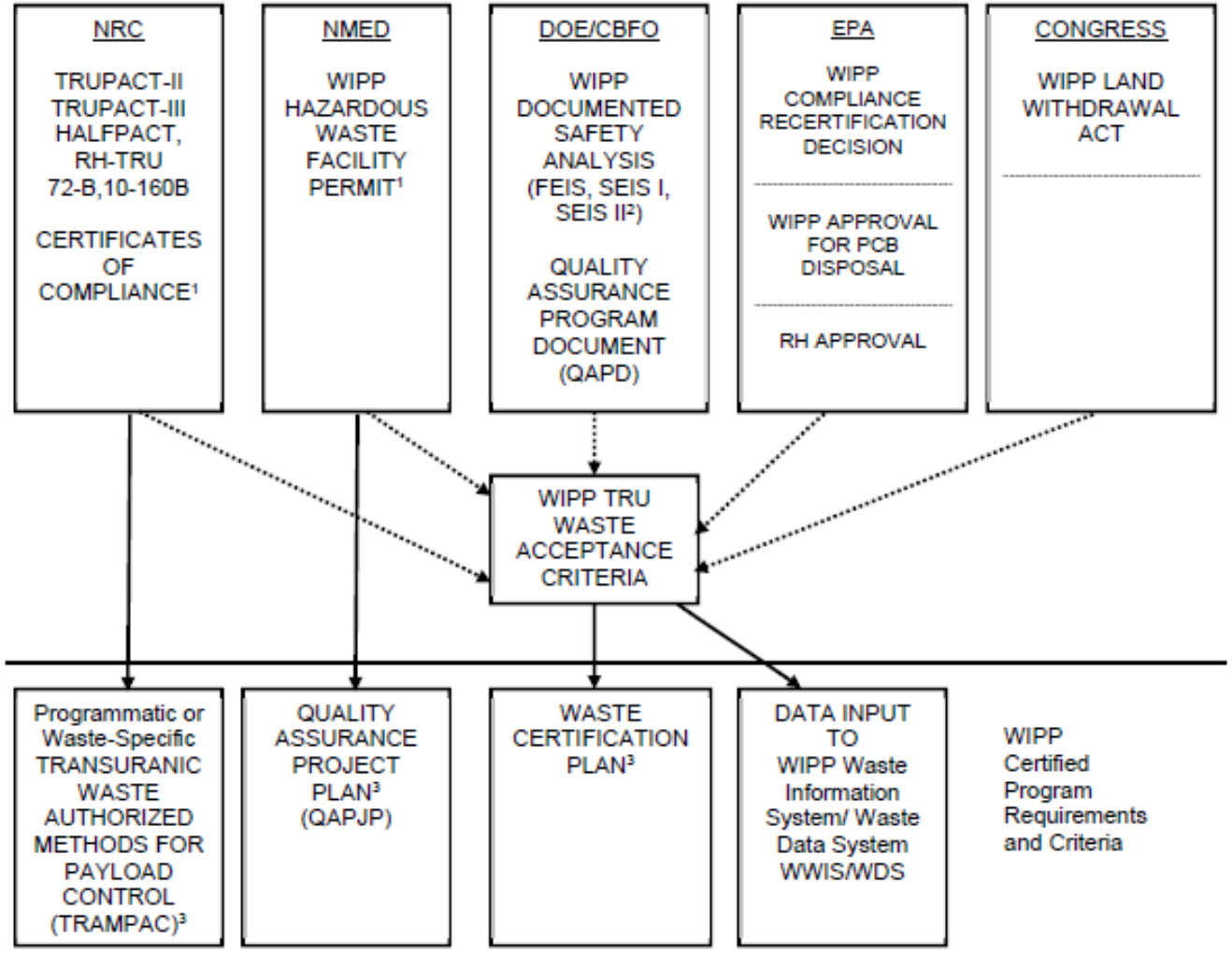
Measurement Services for WIPP Characterization Cont'd.

WIPP Regulatory Oversight

- WIPP waste is highly regulated, with strict waste acceptance criteria for the disposal facility.
- Mirion Measurement Services has modeled many technological and analytical features of its products to support this program.
- Measurement Services routinely interfaces with regulators through annual auditing and compliance reviews.



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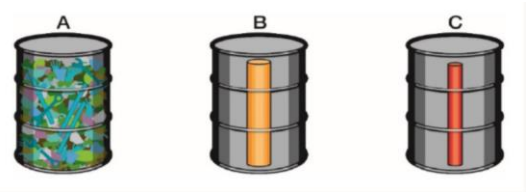
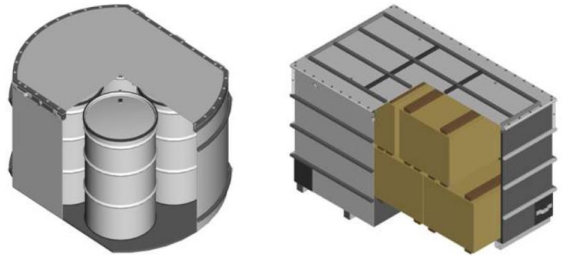
Measurement Services for WIPP Characterization

NDA Measurements for the Department of Energy

- DOE generator sites utilize standard containment for waste materials.
- NDA instrumentation has been selected, calibrated and tested to measure each container type and expected waste profile.
- ISOCS, IUE and Genie2000 software are used to configure accurate and precise NDA systems
- NDA2000 measurement software is customized to automate equipment functions and analyze measurement data.





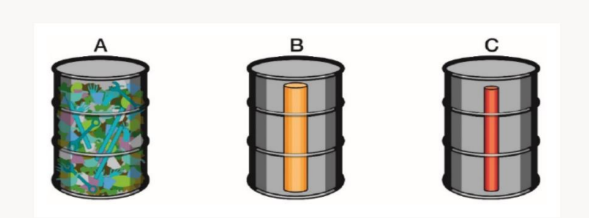
Standard Waste Box

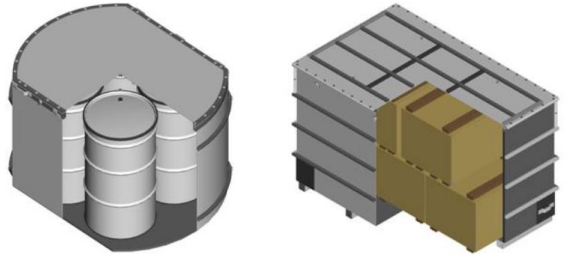
TRUPACT-III Standard Large Box 2

Measurement Services for WIPP Characterization Cont'd.

Standardizing NDA Measurements

- Standardizing material containment has led to precise and accurate instrumentation measurement.
- Standardization of measurement geometries has led to efficient production throughput.
- Standardization of equipment has led to decreased lead time from personnel date of hire to qualification.





Standard Waste Box

TRUPACT-III Standard Large Box 2

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NDA Measurement Services Beyond WIPP

Measurement Services – ISOCS at Millstone Power Plant

Millstone Power Plant Tanks

- Characterization of Feedwater Heaters to Support Release Criteria
- Mirion Measurement Services was onsite at Millstone perform In-Situ Gamma measurements
- The tanks were staged on standard 40ft open flatbed trailers in an unused parking area north of the power station but within the bounds of plant property.
- Falcon 5000 combines Broad Energy Germanium (BEGe) detector, utilizing the In-Situ Object Counting System (ISOCS™).

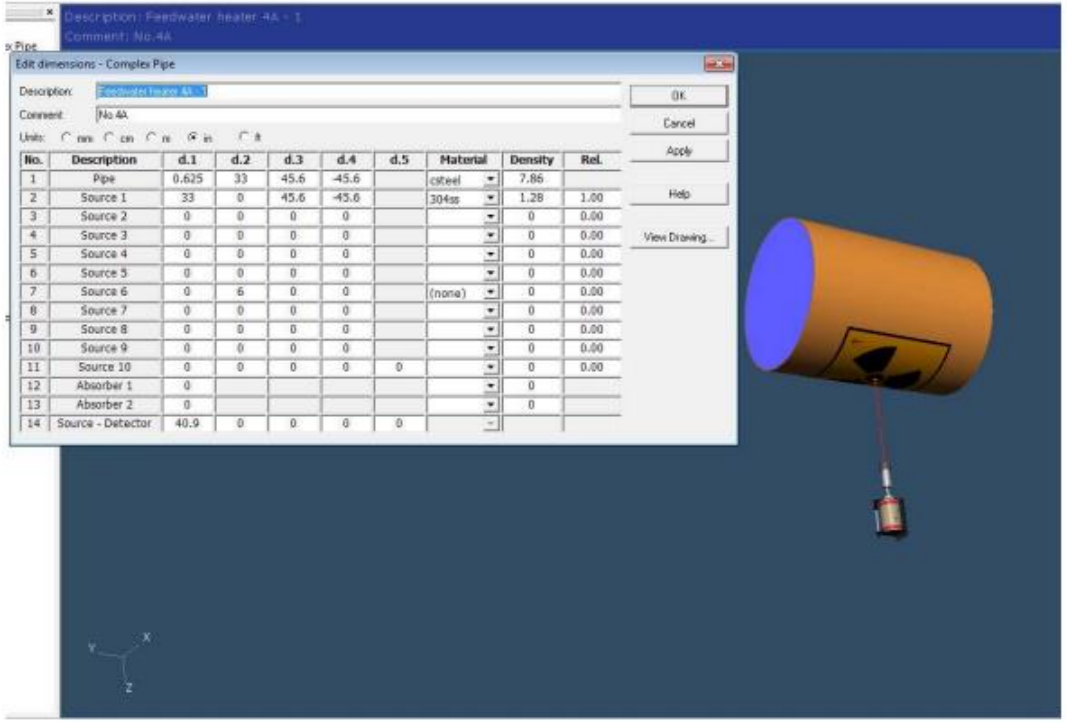
Measurement Services – ISOCS at Millstone Power Plant

Millstone Power Plant Tanks

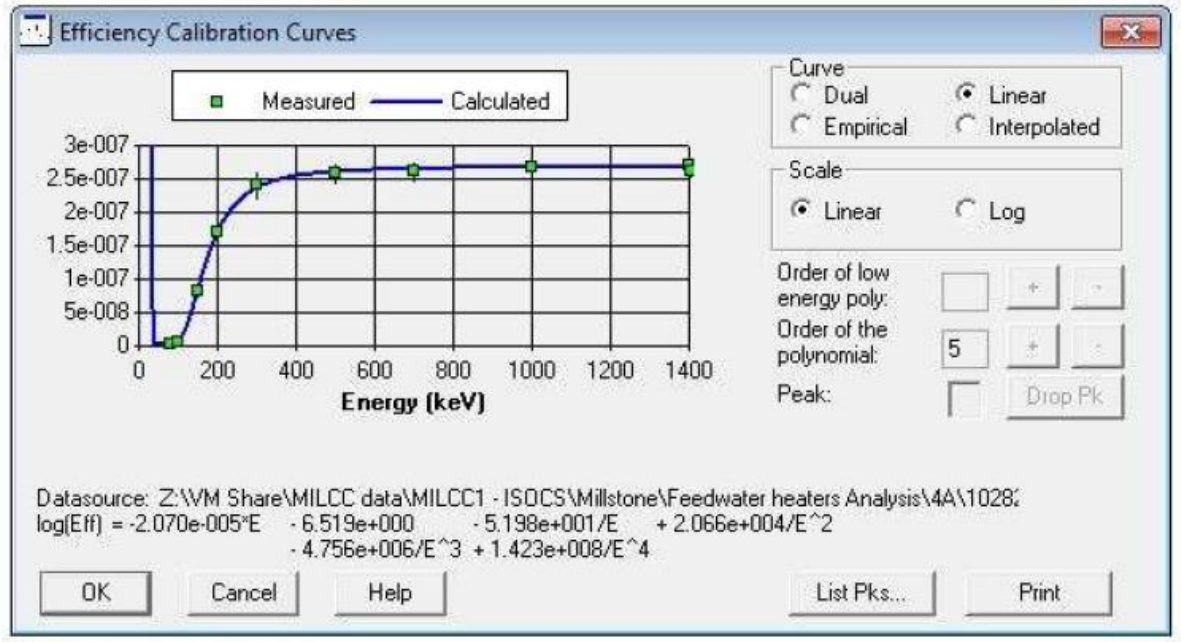
- The primary nuclide of concern is ^{60}Co and ^{137}Cs, but other radionuclides such ^{40}K and along with radon progeny may be expected.
- Due to the size of the tank (~40-ft), multiple measurements are required to adequately measure the total activity. Each feedwater heater was measured in 5 segments.
- The number of segments performed on each item was selected with regard to the detector standoff distance, total overall length of the feedwater heater and the detector field of view.

Measurement Services – ISOCS at Millstone Power Plant

Millstone Power Plant Feedwater Heater Tanks



ISOCS model of segment 1 on tank No. 4A shows a source density of 1.28 g/cc and the outer shell as 5/8” thick and 91.2 ft long (1 of 5 segments)



Efficiency and Energy curves for detector 13000318

Measurement Services – ISOCS at Millstone Power Plant

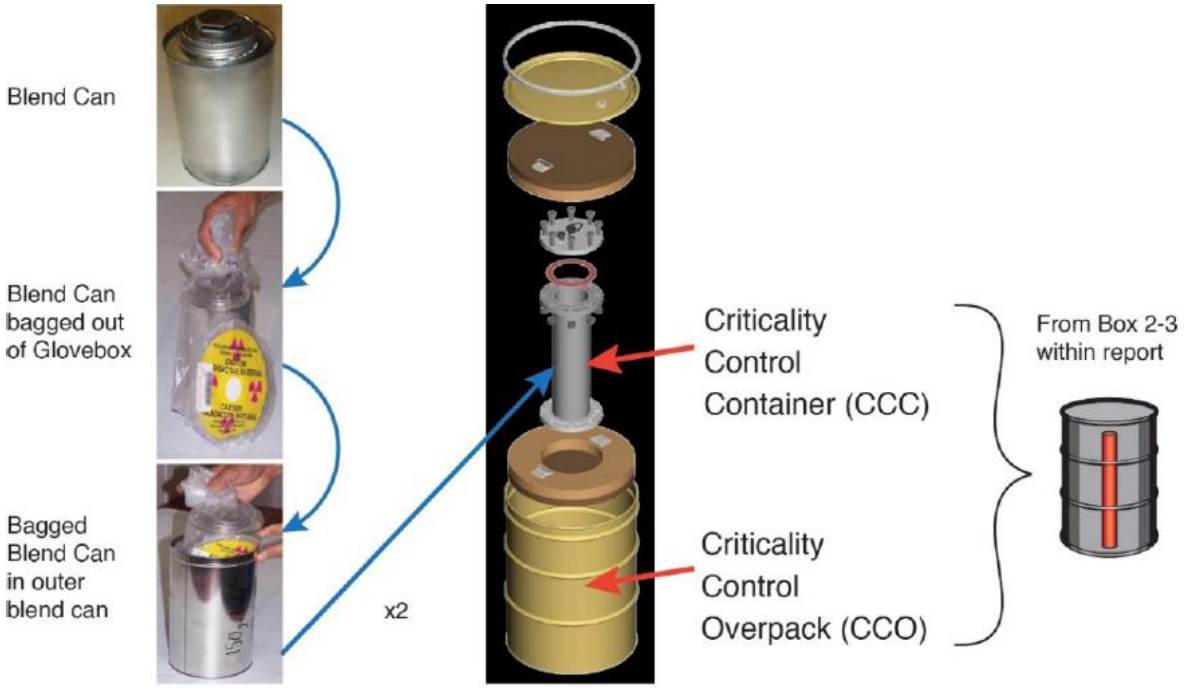
Millstone Power Plant Tanks

- Results of In-Situ and hand held measurements provide support for the free release of the components based on no detection of plant related nuclides.
- The analysis results included in the report were determined to be valid based on analysis processing, detector performance and standard measurement practices.
- The assay activity results of Feedwater Heaters 4A and 4B are determined to be below facility limits for the nuclides of concern.

NDA Developments across the Nuclear Waste Complex

Savannah River Site – Surplus Plutonium Disposal

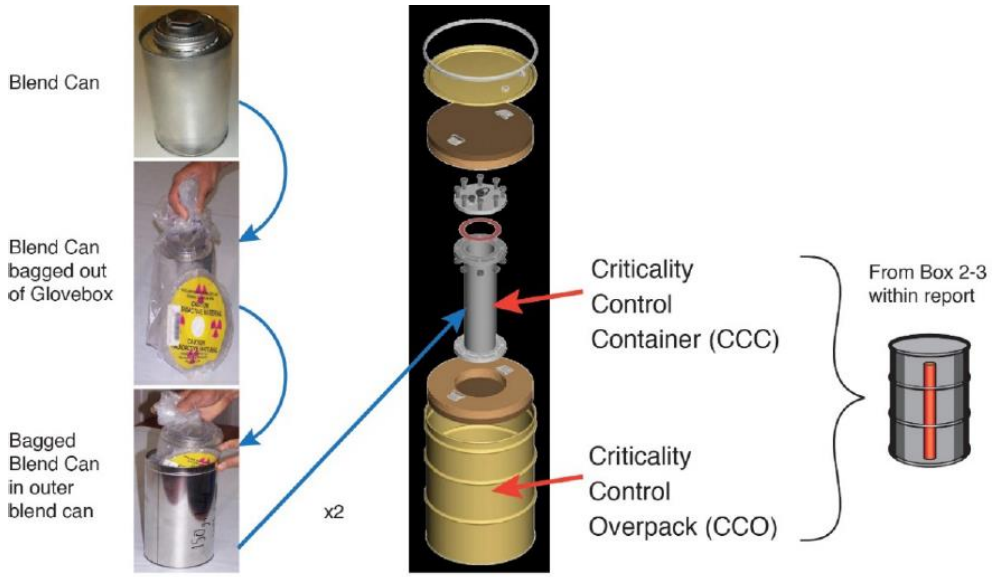
Savannah River Site K-Area Complex Weapons Material Disposal Program



Savannah River Site – Surplus Plutonium Disposal

Standardized Waste Form Can Present Measurement Challenges

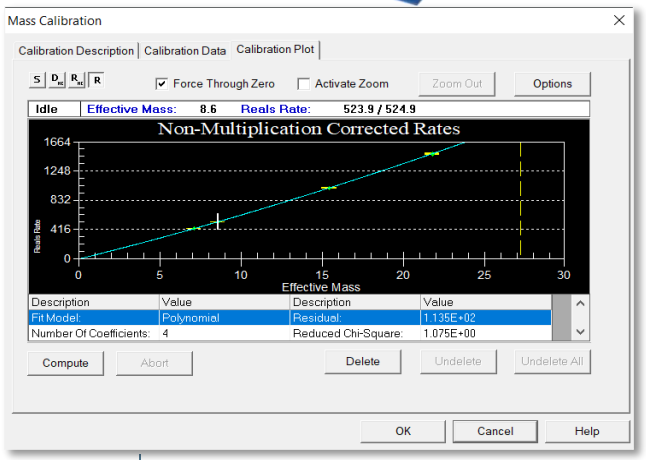
- Savannah River Site has been tasked with disposing of 34MT of excess Plutonium from the state of South Carolina. The Plutonium is diluted and packaged in a customized safety container – the Criticality-Control Overpack.
- Measurement challenges include material impurities, diluent constituents and packaging have a varying impact on the neutron signal. Also, large amounts of Pu (>300g).
- Mirion Technologies worked with PNNL, LANL, SRNL, DOE, EPA and SRNS to accurately measure the new waste form.



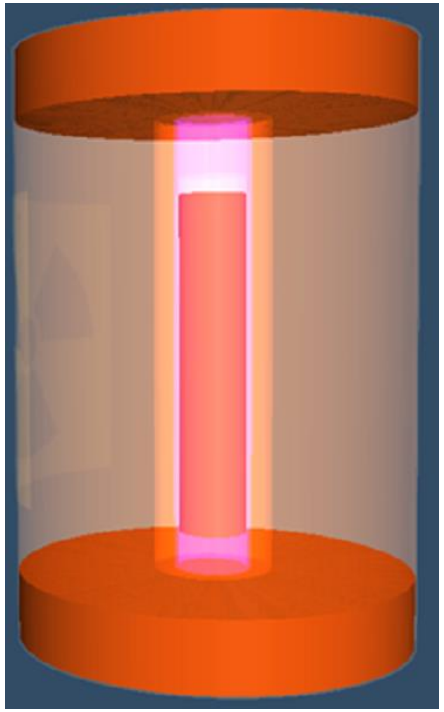
Savannah River Site – Surplus Plutonium Disposal

Software and Calibration Methods Used to Solve Measurement Challenges

- Utilizing NDA 2000 software and the High Efficiency Neutron Counter (HENC), Mirion has helped developed a passive neutron calibration curve using diluted and CCO-packaged Plutonium, which helps realistically represent the expected neutron emission rate after dilution, as well as helping minimize the impact of uncertainty introduced by material impurities.
- This novel approach to calibrating the HENC was reviewed and accepted by DOE, EPA, NMED and associated regulatory agencies.



Savannah River Site – Surplus Plutonium Disposal



Criticality Control Overpack (CCO) Savannah River – Gamma Analysis

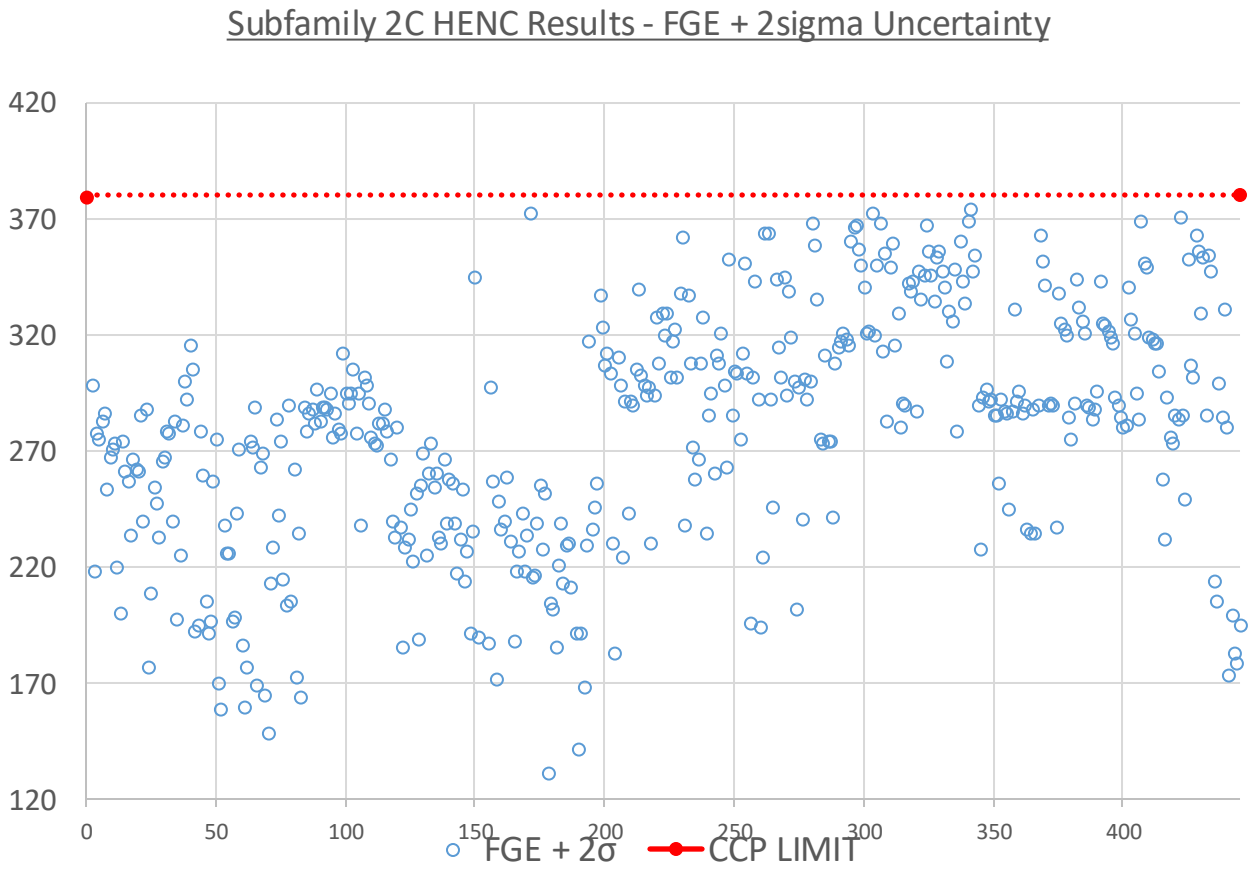
- Example ISOCS model rendering showing the basic mode for the CCO.
- Inner pipe container with cans of material loaded evenly into the pipe.
- Usually, will contain at least two cans of material placed into the CCO.

Sequence #	239 Pu Gamma Ray Energies (keV)						
	375.05	392.53	413.71	422.6	451.48	645.94	769.26
725	1.06E+07	1.06E+07	1.10E+07	1.04E+07	1.12E+07	9.98E+06	1.04E+07
726	1.07E+07	1.06E+07	1.10E+07	1.11E+07	1.11E+07	9.87E+06	9.73E+06
727	1.06E+07	1.04E+07	1.11E+07	1.07E+07	1.11E+07	1.07E+07	1.01E+07
Average:	1.06E+07	1.05E+07	1.10E+07	1.07E+07	1.11E+07	1.02E+07	1.01E+07
Std Dev:	8.30E+04	8.69E+04	8.24E+04	3.49E+05	6.60E+04	4.40E+05	3.47E+05
%R:	95.55%	94.58%	99.20%	96.47%	100.06%	91.41%	90.52%
%RSD:	0.78%	0.83%	0.75%	3.25%	0.59%	4.33%	3.45%

Savannah River Site – Surplus Plutonium Disposal

Software and Calibration Methods Used to Solve Measurement Challenges

- An informed approach has led to the characterization of >1200 CCO containers, many of which have been disposed of at WIPP.
- Modeling and calibration efforts led to measurement precision and uncertainty estimation that allowed for efficient packaging of CCOs.
- Continual monitoring of measurement impacts due to material impurities is ongoing.



Large Item Neutron Assay System (LINAS) At Paducah Gaseous Diffusion Plant

LINAS System Overview

- The Large Item Neutron Assay System (LINAS) is a passive neutron coincidence counter built to quantify the ^{235}U mass contained in objects originating from the Paducah Gaseous Diffusion Plant.
- LINAS uses a total of 122 ^{3}He proportional tubes arranged into a configuration of 19 neutron counting slabs.
- Fifteen (15) neutron slabs are mounted on a series of 3 ring structures to position each slab separated by 60º, in a circular suspension to form a ring with a radius of 7.5 feet.

Figure 1. LINAS on-site installation

Large Item Neutron Assay System (LINAS) At Paducah Gaseous Diffusion Plant

Large Surrogate Containers used for Calibration Confirmation

Figure 25. SQR2RND surrogate.

Figure 27. 00 converter surrogate with cradle and cart.

Large Item Neutron Assay System (LINAS) At Paducah Gaseous Diffusion Plant

NeutVox – Voxelization Approach to Neutron Counting

- NeutVOX is an algorithm for estimating the total neutron counting efficiency for an integrated array of neutron sensors.
- The primary intended use is with large neutron counting systems with a closed “4-pi” shielding architecture that surrounds the assay sample.
- The algorithm uses a sum-of-point-sources approach that is similar to ISOCS software, which estimate gamma-ray detection efficiencies.

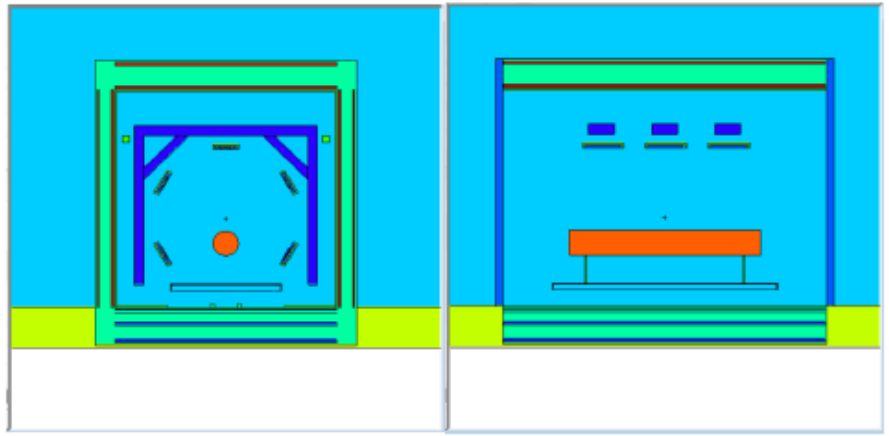


Figure 7: Screenshots from MCNP Visual Editor of the Pipe assay geometry

Figure 26: 30" pipe surrogate.

NDA Technologies What's Next?

Preliminary Rendering of the LINAS II

Thank you