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Title:	The U.S. National Nuclear Forensics Library, Nuclear Materials Information Program, and Data Dictionary
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The U.S. National Nuclear Forensics Library, Nuclear Materials Information Program, and Data Dictionary

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Nuclear forensics assessments to determine material process history requires careful comparison of sample data to both measured and modeled nuclear material characteristics. Developing centralized databases, or nuclear forensics libraries, to house this information is an important step to ensure all relevant data will be available for comparison during a nuclear forensics analysis and help expedite the assessment of material history. The approach most widely accepted by the international community at this time is the implementation of National Nuclear Forensics Libraries, which would be developed and maintained by individual nations. This is an attractive alternative to an international database since it provides an understanding that each country has data on materials produced and stored within their borders, but eliminates the need to reveal any proprietary or sensitive information to other nations. To support the concept of National Nuclear Forensics Libraries, the United States Department of Energy has developed a model library, based on a data dictionary, or set of parameters designed to capture all nuclear forensic relevant information about a nuclear material. Specifically, information includes material identification, collection background and current location, analytical laboratories where measurements were made, material packaging and container descriptions, physical characteristics including mass and dimensions, chemical and isotopic characteristics, particle morphology or metallurgical properties, process history including facilities, and measurement quality assurance information. While not necessarily required, it may also be valuable to store modeled data sets including reactor burn-up or enrichment cascade data for comparison. It is fully expected that only a subset of this information is available or relevant to many materials, and much of the data populating a National Nuclear Forensics Library would be process analytical or material accountability measurement data as opposed to a complete forensic analysis of each material in the library.

The U.S. National Nuclear Forensics Library, Nuclear Materials Information Program, and Data Dictionary

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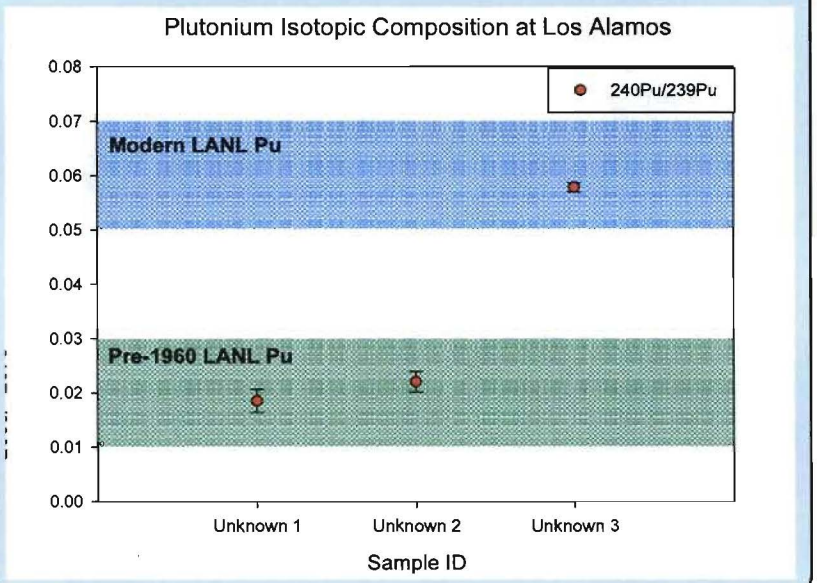
Outline

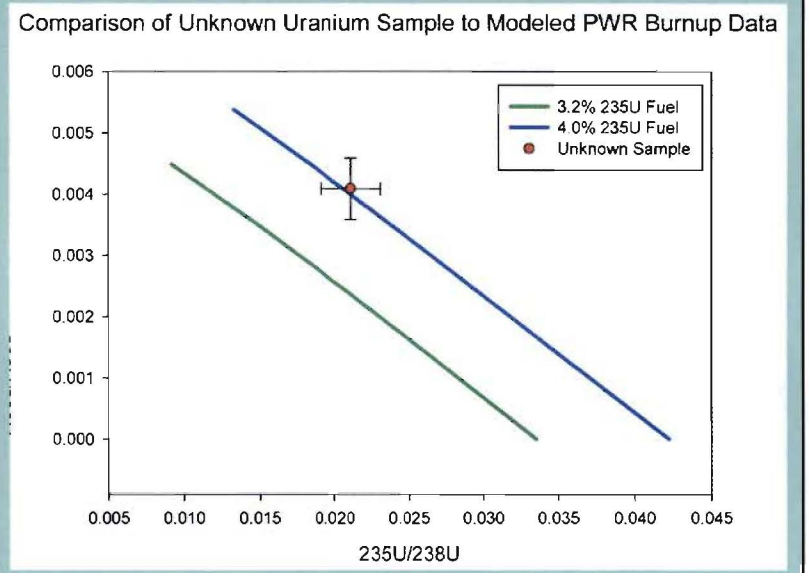
- How libraries support the nuclear forensics process
- U.S. National Nuclear Forensics Library implementation
- Data dictionary development and description
- Summary

Nuclear Forensics is a Comparative Science

Unknown vs. Measured



Unknown vs. Modeled



- *Centralized nuclear material characteristics libraries enable timely and accurate nuclear forensic assessments*

The National Nuclear Forensic Library Model

- Each country should be able to identify nuclear materials consistent with their inventories
  - Part of a greater nuclear security responsibility
  - Focus on material produced within a country
  - Builds international confidence
- National nuclear forensics libraries
  - Database of nuclear material characteristics (measured and modeled)
  - Enables comparative analysis during forensics investigations
  - Centralized or distributed, but rapidly accessible when needed
  - Complexity tailored to each countries specific situation
- National point-of-contact (POC)
  - Single, internationally identified POC to field queries
- *National library and point-of-contact model designed to protect proprietary and sensitive nuclear material characteristics and inventories*

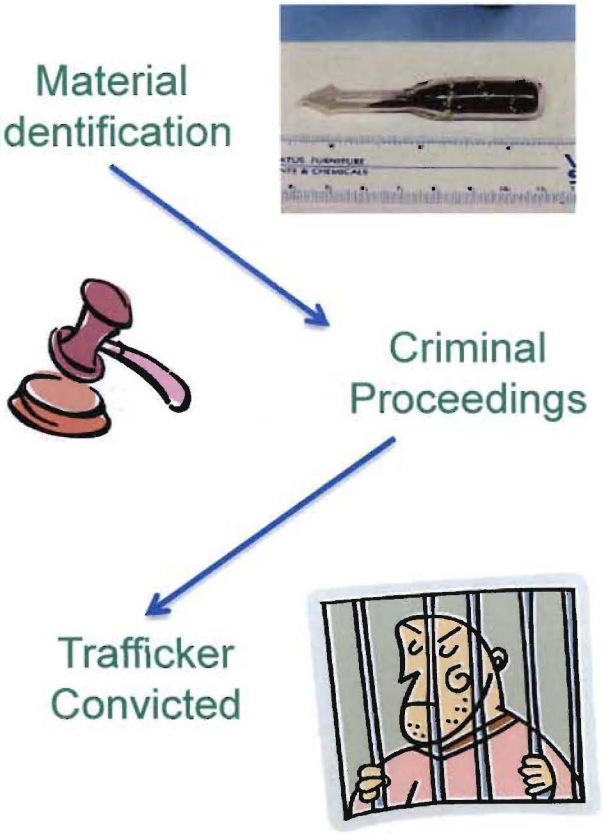
Where does the data come from?

- Many possible sources of data could support a national library
  - New measurements
    - Targeted full characterization efforts
  - Process control or quality control data
    - Commercial fuel cycle materials
    - Technical specifications
  - Safeguards and accountability data
  - Modeled data
    - Calculated burnup
  - Historic data (properly vetted)

- *No unique solution – data can come from many sources*

Nuclear Forensics: Part 1

Part 1: Traditional Forensics:
Link individuals to criminal activity

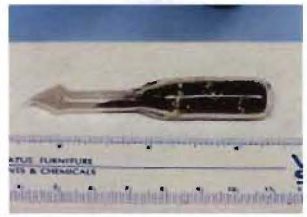


- Important for criminal proceedings
- Requires high-quality, legally defensible analyses
  - What is it?
  - How much is there?
- Does not require a detailed analysis of all material attributes
- *National libraries are minimally beneficial to these activities*

Nuclear Forensics: Part 2

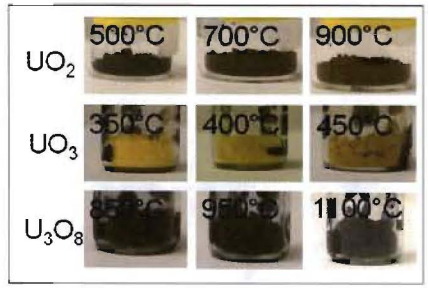
- Detailed analysis of all material attributes
- Expert evaluation and comparative analysis
- Assessment of domestic or foreign material origin
- Enhanced nuclear security
- *National libraries are essential for these activities*

Part 2: Investigative Forensics: History of nuclear material



Full Characterization
- Precision isotopics
- Chemical composition
- Age dating
- Morphology

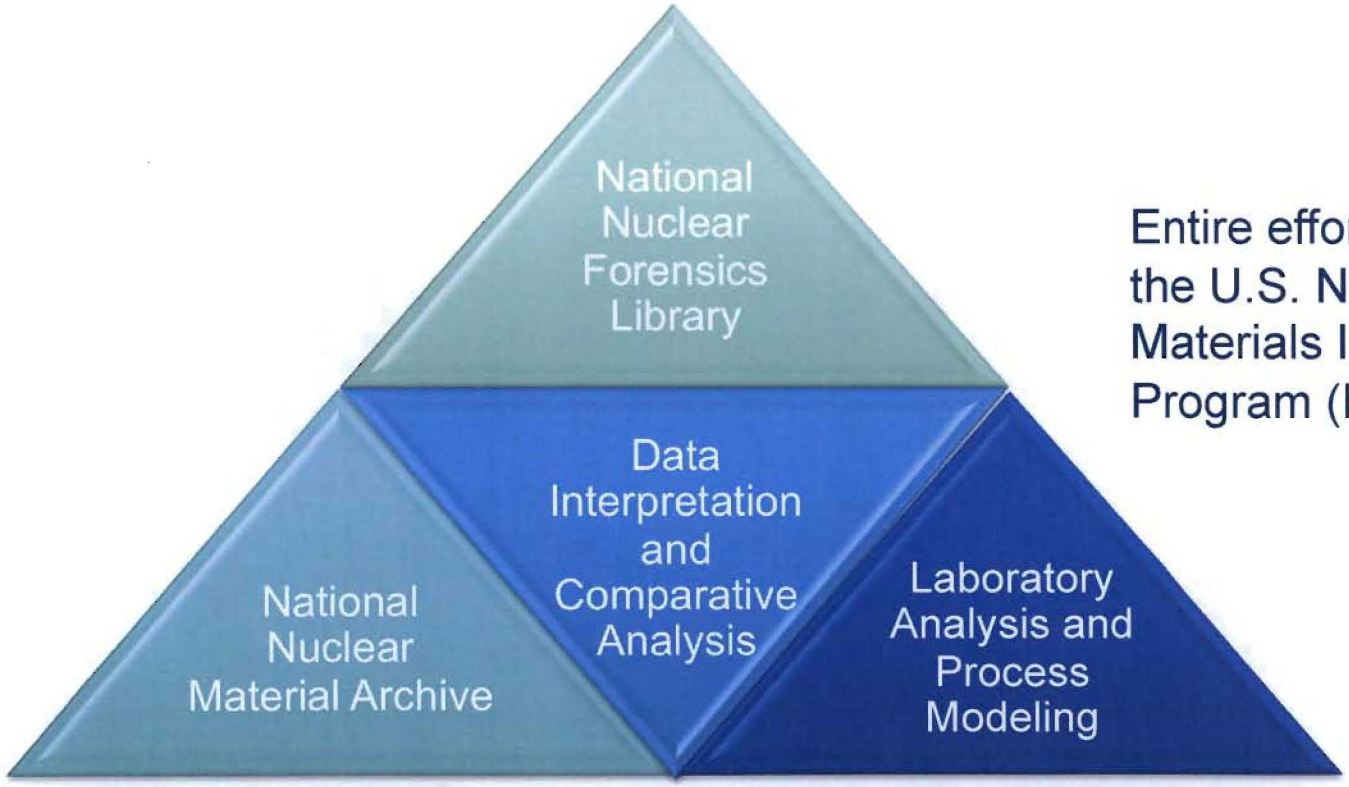
Comparative Analysis
- Intended use
- Process history
- Fuel cycle information
- Possible origins



Outcome
- Enhanced security
- Signature knowledge

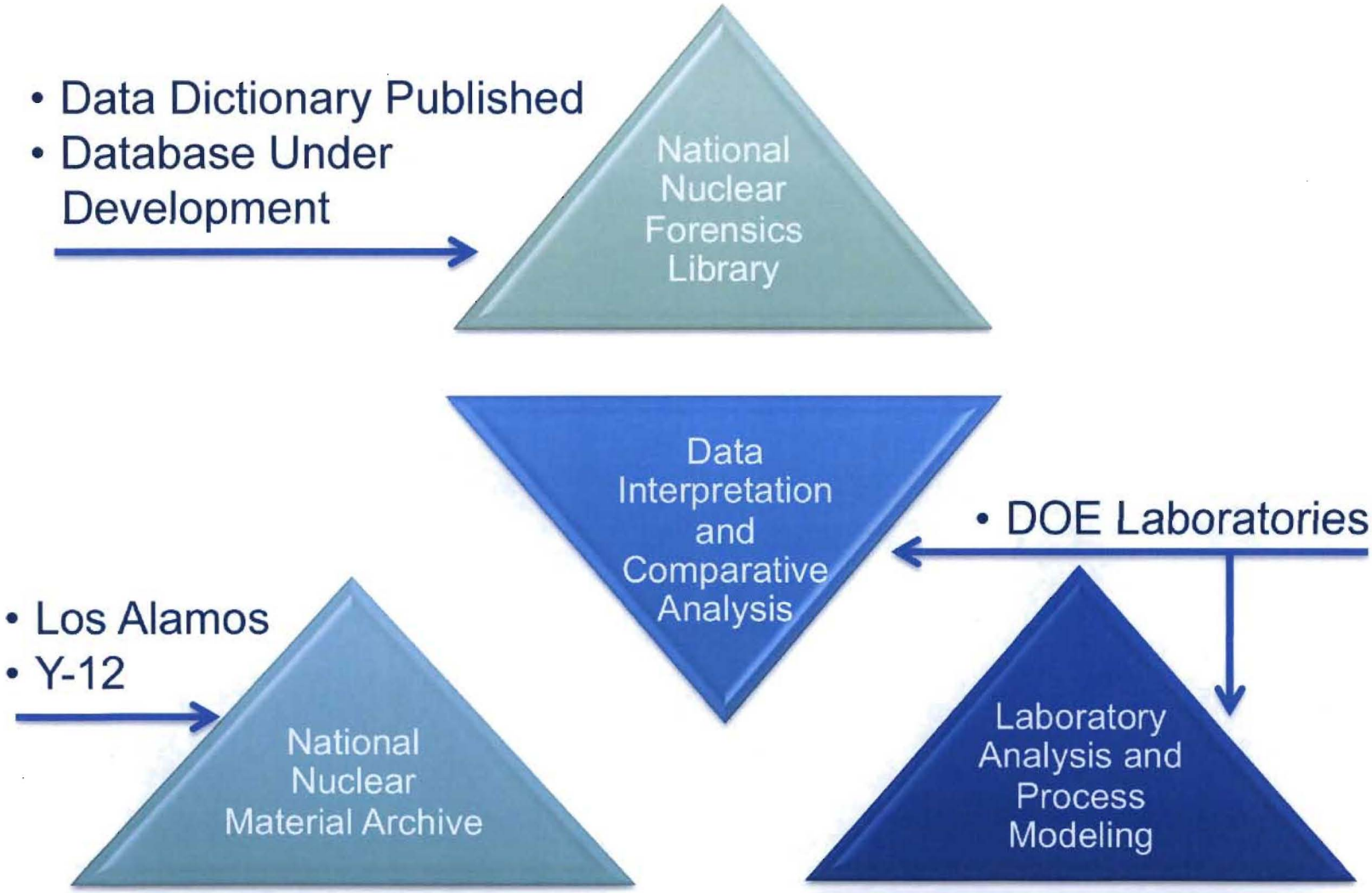
United States National Library

- Goal: Ensure domestic material would be recognized if interdicted
- Approach: Develop a Library with adequate support structure



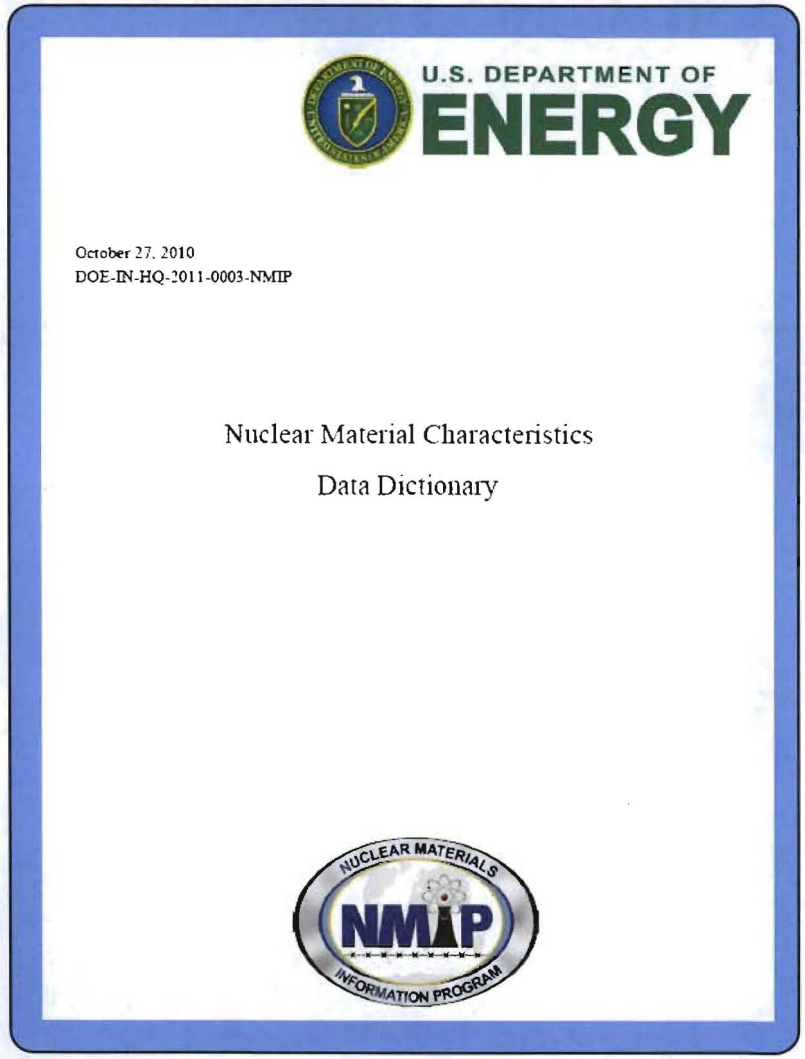
Entire effort is part of the U.S. Nuclear Materials Information Program (NMIP)

U.S. National Library: Implementation



Data Dictionary Development

- Published Fall 2010
  - Transferrable to international partners
- Complete list of nuclear material characteristics relevant to nuclear forensics
  - Over 250 parameters
  - Working document based on current knowledge
  - Not all characteristics are appropriate or available for all materials
  - Can be customized to each countries individual nuclear material holdings



Eight Categories of Dictionary Information

1. Material Identity
2. Analysis Laboratory
3. Material Packaging and Container
4. Sample or Item Physical Characteristics
5. Sample or Item Chemistry
6. Sample or Item Morphology
7. Material Process or Location History
8. Data Vetting and Quality Assurance

Examples from Data Dictionary Table

	Essential Information Element	Description	Type of Information	Units	Possible Values	Notes
Identification	Sample ID	Sample designation	String			Format recommended is year of entry into database plus a unique sequential record entry, i.e. 2007-1, 2007-2, etc.
Physical Characteristics	Sample Dimensions	Standard dimensions table	String	m		Height, length, width, outside diameter, inside diameter
Physical Characteristics	Rods per element	For multiple rods per element	Integer			Primarily for fuel assembly description
Chemical Characteristics	ElementPct_n	Elemental percent of entire sample	Decimal	Atom or wt. percent		
Chemical Characteristics	ElementPct Uncertainty type_n	Uncertainty type	String	Atom or wt. percent	GUM, std. dev, assigned	A field to identify origin of uncertainty estimates

Material Identity

- Material identification
  - Sample or object identifying numbers
  - Collection location
  - Current location
  - Connections with other samples or materials
  - Supporting information (pictures, reports, etc.)

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Chemical Analysis of Plutonium-238 for Space Applications

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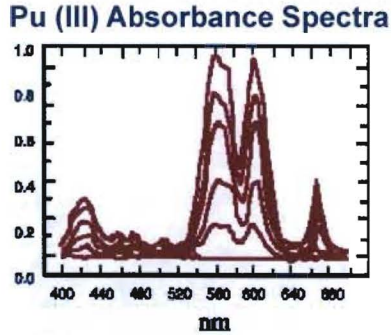
Abstract. Los Alamos National Laboratory (LANL) has produced general-purpose heat sources (GPHS) containing plutonium-238 oxide for space and terrestrial uses over the past two decades. Power Source Technologies Group (NMT-9) has full capabilities to both recover and purify $^{238}PuO_2$ from scrap and aged fuels and to fabricate oxides into fuel pellets for heat sources.

Analytical chemistry supports processing monitoring and product certification for ^{238}Pu operations. The ^{238}Pu oxides are dissolved and submitted for plutonium assay (% Pu), actinide impurity (^{236}Pu, ^{237}Np, ^{234}U, and ^{241}Am), plutonium isotopic composition, and non-actinide cationic and anionic impurities analyses. The data obtained from these measurements provide baseline parameters for processing, waste disposal, and product certifications.



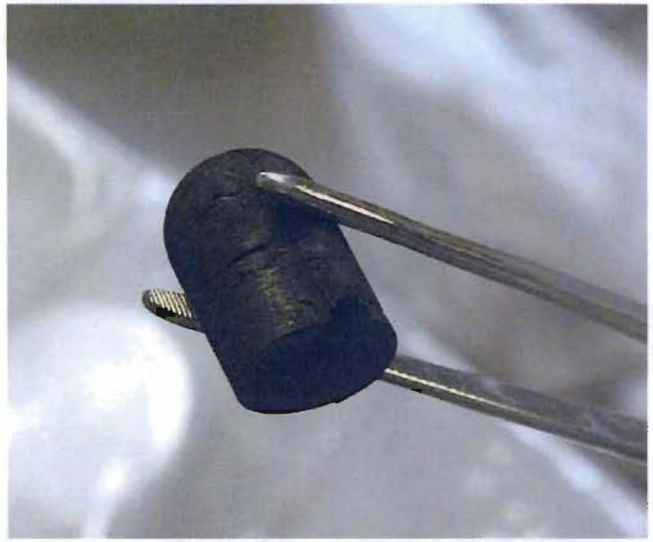
Material Packaging and Container Description

- Packaging / container serial numbers
- Physical container description, dimensions, and mass
- Dose rate information
- Other materials stored in the same container

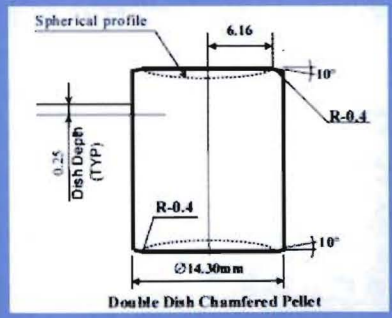
LANL Assembly

Sample or Item Physical Characteristics

- Shape and dimensions
- Density
- Overall material use descriptions
  - eg. Fuel pellets, fuel pin or assembly cladding and dimensions



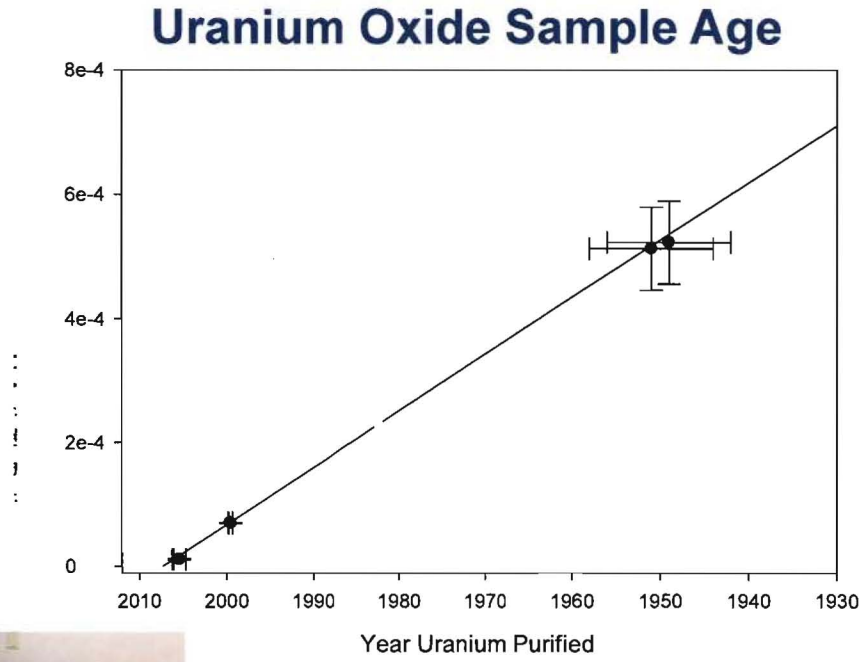
PHWR Fuel Pellet Dimensions*



*R.N.Jayraj & C. Ganguly
IAEA-TECDOC-1416

Sample or Item Chemistry

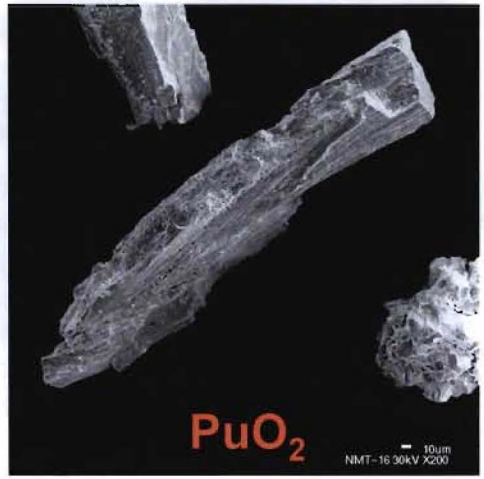
- Chemical form
- Elemental composition
- Isotopic composition
- Minor and trace constituents
- Material age information (separation date, discharge date, etc.)
- Specific activity
- Fuel burn-up

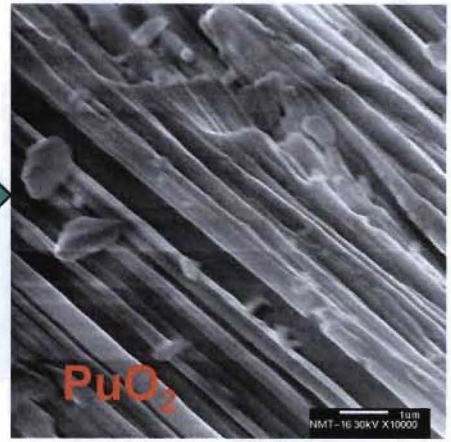


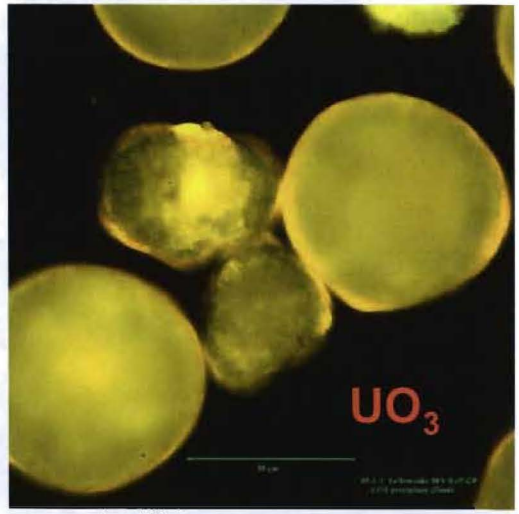
IsotopX IsoprobeT Thermal Ionization Mass Spectrometer (TIMS)

Material Morphology

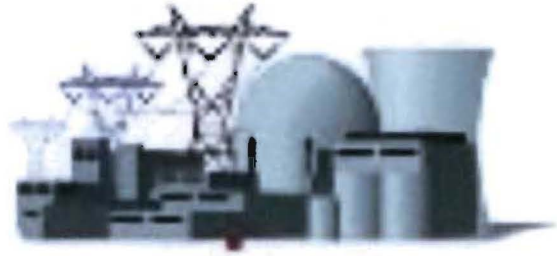
- Grain mean size
- Grain size histogram
- Shape description
- Homogeneity
- Aspect Ratio
- Inclusions
- Crystal Structure
- Porosity
- Friability







Process and Location History



- Production facility name
  - Geographic coordinates
- Facility purpose (eg. enrichment, fuel fabrication, reactor, etc.)
  - Process description (eg. gas centrifuge, PUREX, etc.)
- Chemical form (Yellowcake, UF_4, PuO_2, MOX, etc.)
- Intended purpose (eg. LWR fuel)
  - Intended use location (eg. US BWR reactors)
  - Intended use notes (eg. designed for 50,000 MWD/MT burn-up)
  - Transportation comments (eg. routes, frequency, etc.)

Data Vetting Information

- Peer-review of data quality and confidence in reported results
- Describe and document the original purpose of the analytical data
  - Quality control
  - Forensics assessment
- Assign a confidence of High, Medium, or Low
  - Knowledge of analytical protocols
  - Provenance of data
- Describe why confidence level was chosen

Path Forward

- Engaged with IAEA, ITWG, GICNT
  - June 2010 ITWG Annual Meeting
  - November 2010 IAEA Consultancy on National Libraries
- Beginning bilateral international outreach
  - Get peer country feedback on Data Dictionary
  - National Library / Data Dictionary basis for new cooperative agreements through DOE/NNSA and Department of State

Summary

- National Nuclear Forensic Library concept
  - Country specific implementation
  - U.S. Data Dictionary serves as technical basis

- Value of nuclear material libraries
  - Critical for timely and informed nuclear forensics assessments
  - Understanding material history and origin
  - Deter illicit activities involving nuclear material
  - Overall enhancement for nuclear security