Environmental Sampling / Destructive Analysis for IAEA Verification

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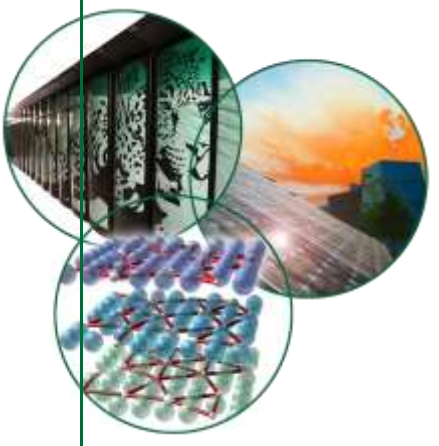

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Atomic Detectives:
Detecting Undeclared Nuclear Activities through Environmental Sampling

Diane Fischer
Senior Nuclear Analyst
Department of Safeguards

Oak Ridge National Laboratory, Dec 2009

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International Atomic Energy Agency
Atoms for Peace

Purpose of IAEA Safeguards

Objective

Timely detection of diversion and deterrence through risk of early detection

Provide assurance about the exclusively peaceful use of nuclear material and facilities

Task

Verify correctness and completeness of declarations made by States

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Safeguards Objectives

- **Verify correctness of a State's Declaration**
  - Containment (Seals)
  - Surveillance and Remote Monitoring
  - Visual Observation
  - Account for declared nuclear materials (**Nuclear Material Samples**)
- **Verify the absence of undeclared activities and nuclear materials** (i.e., completeness).
  - **Environmental Sampling (ES)**
  - Satellite Imagery
  - Open Source Information and Nuclear Trade Analysis

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Cotton Swipe

Swipe sampling the surfaces of equipment inside a facility

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IAEA Inspector taking a sample

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The Typical ES Sample

Standard sample: **Swipe samples**

- are easy to collect and transport
- can be used to detect a variety of nuclear signatures.

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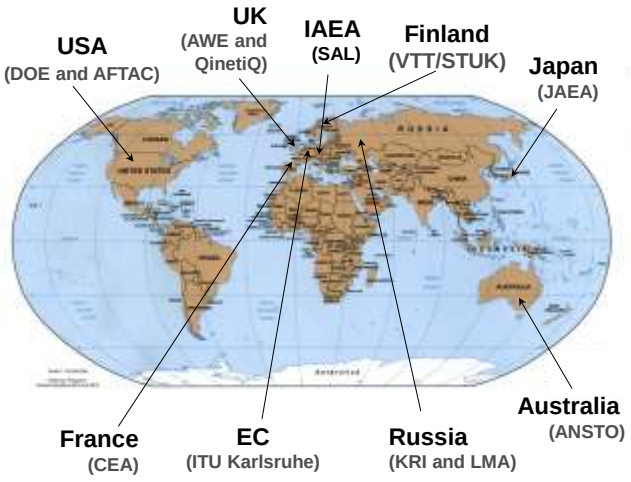
IAEA Network of Analytical Laboratories
for Environmental Sampling



- **SAL + 14 Laboratories worldwide**
- **Provide complementary analytical capability**
- **Samples sent anonymously to Laboratories**
- **Two lab confirmation of results**
- **NWAL expansion expected in the future**

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Destructive Analysis

- Quantitative methods for determining elemental composition, elemental assay, or isotopic composition of a sample
- All or part of the sample is consumed in analysis
  - Sample cannot be recovered (eg. it is volatilized)
- Sample is irreversibly altered
  - Dissolved
  - Radiochemically purified
- Does not necessarily mean important sample attributes are destroyed
  - Analyte separated from matrix, but preserved

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Examples of DA techniques

- Elemental assay methods
  - Titration
- Elemental composition methods
  - Atomic emission spectroscopy
  - Mass spectrometry
- Isotopic analysis methods
  - Mass spectrometry
  - Alpha spectrometry
  - Radiochemical gamma-ray spectrometry
  - Radiochemical beta or liquid scintillation counting

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Advantages of DA techniques

- Precision of DA techniques is usually much better than NDA methods
  - Effect of matrix can be eliminated or corrected
- Detection limits of DA techniques are usually lower than NDA methods
  - Eliminates background from matrix
  - Techniques are generally much more sensitive because of detection method (eg. atom counting vs. activity counting)

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Disadvantages of Destructive Analysis

- Typically much more labor intensive than NDA techniques
  - Sample preparation can take days to complete
- Opportunities to induce problems
  - Cross-contamination of samples
  - Contamination from previous facility operations
- More expensive than many NDA techniques
  - Instruments and supporting facilities are very expensive to build and maintain

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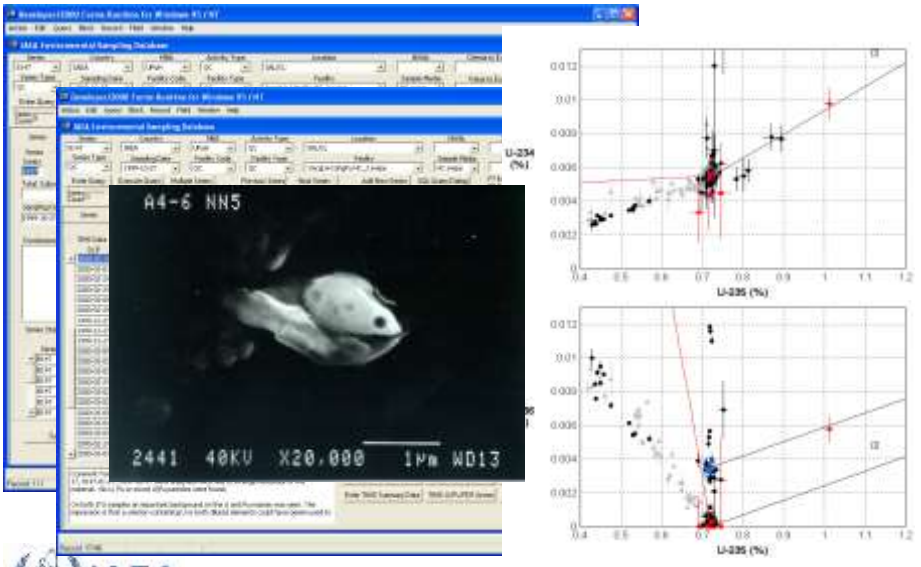
But what do the data mean?



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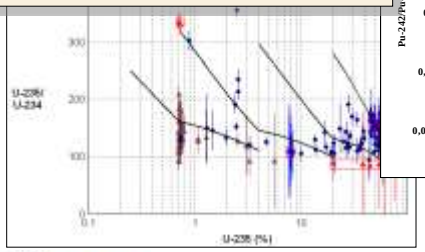
Determination of Nuclear Activities

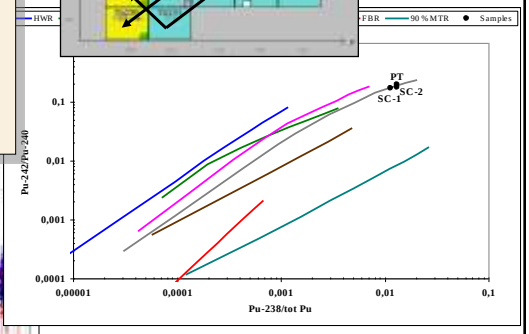
Compare data to predictive calculations to determine:

- Enrichment Activities
- Pu Production and Separation
- Age
- Reactor type and irradiation history

Age; time since last chemical processing



Batch enrichment process



Higher initial ^{235}U enrichment – higher ^{238}Pu abundance

Softer neutron spectrum – higher $^{242}Pu/^{240}Pu$ ratio

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Technical Information Resources

- **SG information (State Declarations, Inspector reports, etc.)**
- **Research Reactor Data Base (RRDB)**
- **Power Reactor Information System (PRIS)**
- **Technical Cooperation Country Profiles**
- **IAEA Country Files**
- **Nuclear Events DB (NEWS)**
- **Research Papers (INIS)**

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Open Information Sources

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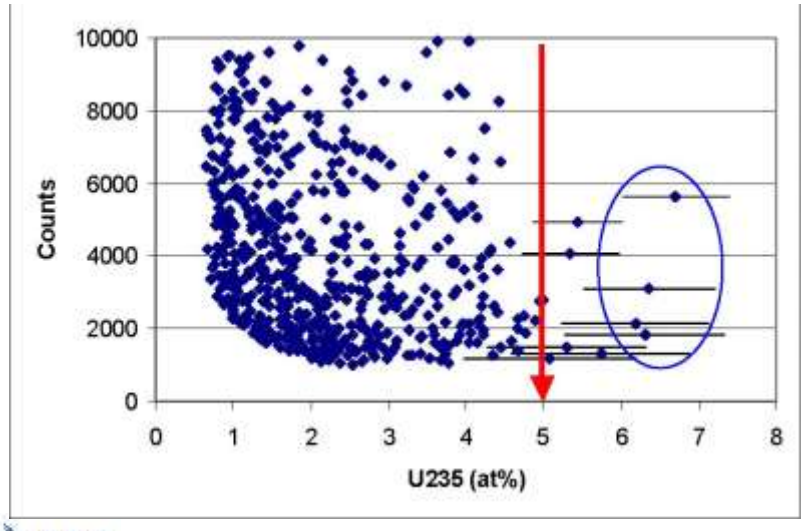
Open Source Center

Detecting Enrichment Activities



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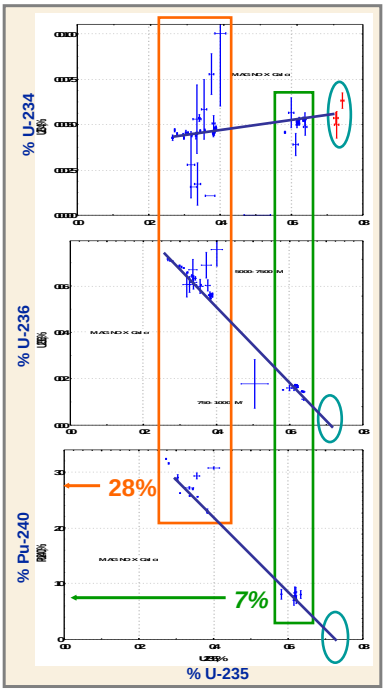
ES Particle Results

Hot Cell used for examining reactor fuel assemblies

- **Natural Uranium Fuel**
  - **"Fresh" (non-irradiated)**
- **Irradiated Fuel**
  - **Typical for MAGNOX reactor**
- **2 irradiation periods**
  - **5000-7500 MWd/t**
  - **750-1000 MWd/t**
- **Material with 7% ^{240}Pu needs further investigation**



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Detecting Undeclared Nuclear Activities

- Traces of nuclear material can be detected through environmental sampling
- Detection of undeclared nuclear activities relies on:
  - Collection of high quality samples
  - Sophisticated Analytical Techniques
  - Interpretation of analytical results using a variety of information and data evaluation methods.

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