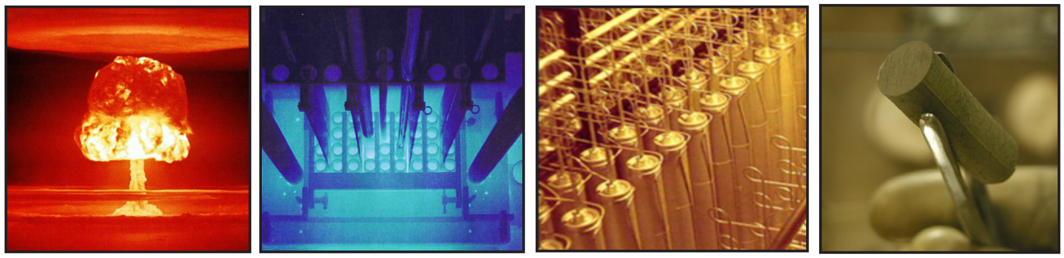
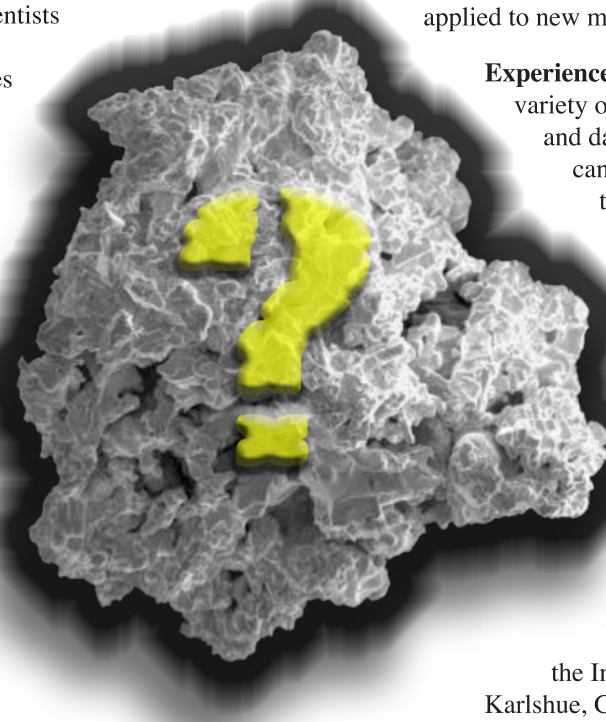


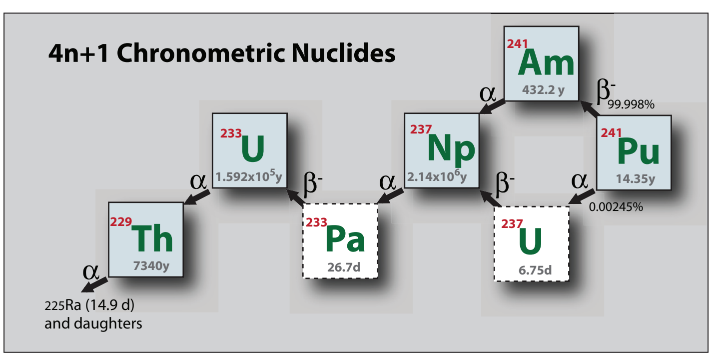
Using our expertise in actinide science to characterize illicit nuclear materials.

Nuclear Forensics – Special Nuclear Materials

An important part of the United States' nuclear forensics effort is the interception and tracing of unknown nuclear materials. These materials might be discovered at border crossings or during international inspections, and shutting down the pathways that lead to their production and distribution is key to international nuclear security. Scientists at Los Alamos support this important mission by using analytical techniques to determine the sources of a range of nuclear materials, from weapons grade uranium and plutonium, reactor fuel, fission and activation products and more. These techniques use key nuclear, chemical, and physical signatures to identify manufacturing process, intended use, and origin of the interdicted nuclear material.



Discriminating characteristics might be total actinide content, isotopics, activation and fission products, metallic and non-trace elemental data. Microstructural and morphological features of material can also be informative, and reactor modeling is a useful tool. Information gathered from examining containers or associated materials can yield valuable data concerning the sample.



When radioactive materials decay, they give rise to "daughter products." The ratios of original material to daughter products may yield valuable forensic information about age and how a material was processed.

Why Los Alamos?

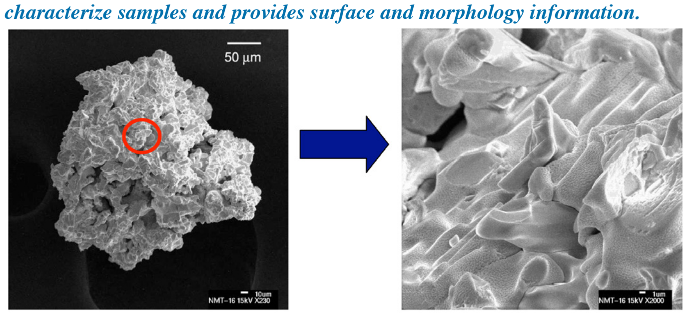
Qualified and approved analytical methods are used for analyzing special nuclear materials. Many of these techniques were developed and refined over years for the Stockpile Stewardship and Nuclear Fuel programs and are now being applied to new mission areas such as nuclear forensics.

Experienced and trained personnel from a wide variety of disciplines perform analytical analyses and data interpretation. If needed, expertise can be drawn from nearly every corner of the 10,000+ person institution.

Participation in international and national exchanges for special nuclear materials characterization ensures integration with the world community. Los Alamos participates in the Nuclear Smuggling International Technical Working Group exercises, and in international plutonium and uranium metal exchange programs. Collaborators include other DOE national laboratories; the Atomic Weapons Establishment; the Institute for Transuranium Elements in Karlshue, Germany; and the International Atomic Energy Agency.

Core facilities and capabilities allow handling of everything from femtogram to kilogram quantities of plutonium and other special nuclear materials.

Electron microscopy is one of the many specialized techniques used to characterize samples and provides surface and morphology information.



Q: How was it made?
Surface morphology and characteristics indicate method of manufacture.

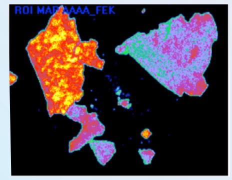
A: Precipitation process, at R&D facility, not production.

Hypothetical Case Study:

A suspect material is confiscated at a border and sent to Los Alamos for treaty or safeguards verification. A noninvasive standoff technique called gamma-ray spectroscopy is used to analyze the container without opening it. This technique can determine type, mass, and isotopic composition of a sample; it indicates that the container likely contains 100 grams of weapons grade plutonium.

The container itself is then analyzed using x-ray fluorescence, which shows that the paint used is a lead-based iron oxide with a polyvinyl chloride plasticizer and was most likely produced before 1980.

When the container is opened in a glove-bag, inside is found a fine brown powder that suggests that the material is an oxide of plutonium. Destructive analysis using a wide variety of techniques (Gamma, Combustion/Infrared, Spectrophotometry, XRF, ICPMS, TIMS, and IC) give the purity of the plutonium and the concentrations of trace elements such as aluminum, carbon, fluoride, etc., which indicate that this material is quite pure. These tests also give vitally important information about the isotopes of uranium and plutonium present in the sample. The isotope ratios and americium content show that the sample was last chemically separated in the early 1980s. The analyses also show a lack of alloys which, along with the color, give information about how the material was refined; either with acid aqueous processing or calcinations treatment in air. A limited number of countries use this technology for reprocessing, therefore possibilities for the source are narrowed down. More tests such as optical microscopy, scanning electron microscopy, and pycnometry give information on microstrucutre and morophology and density, which when combined with the other information tell that the material was most likely intended for long term storage or as a feed material for mixed-oxide reactor fuel. The countries capable of producing the material are limited to those with relatively well developed nuclear programs, such as US, Russia, France, the UK, and Japan.



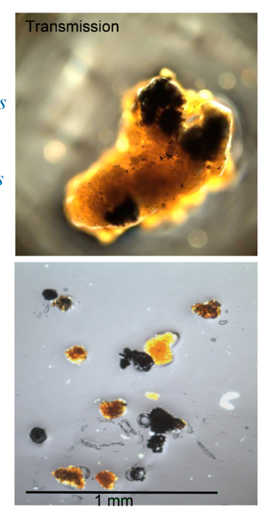
Paint chips analyzed with X-ray fluorescence.

This narrowing down of possibilities through scientific analysis is the backbone of nuclear forensics, and the systematic analysis of an interdicted material using the latest technology is a vital step in keeping the US safe and in keeping nuclear materials secure.

Mass spectrometry is used to determine the isotopic actinide ratios present in a sample. These ratios are useful for determining how a sample was processed and how old it is.

Tool	Tells you
High resolution autoradiography	***Size, initial characterization.*** How much radioactive material there is within a sample? Is it powder free flowing or chunk? And what is the approximate size and shape of the sample?
High resolution gamma-ray spectrometry (Radiochemistry)	***Age, origin, and processing history***. Isotopic composition and content of Pu, U, Am, Np and their daughters, activation and fission products.
Micro X-ray fluorescence (XRF)	***Origin, processing history.*** Nondestructive elemental mapping of radioactive particles and nonradioactive components.
Optical/electron microscopy	***Origin, processing history.*** Morphology, phase, particle size, aspect ratio, porosity, elemental distribution.
Mass Spectrometry (MS): *Thermal Ionization (TIMS), Inductively Coupled Plasma (ICPMS), Laser Ablation ICP (LA-ICPMS), Isotope Dilution (IDMS)*	***Age, origin, processing, intended use.*** High accuracy and precision isotopic composition of U and Pu, impurities, oxygen isotope ratios, U and Pu content destructively of both bulk and particle samples.
Plasma Methods	***Origin, processing history.*** Quantitative major, minor and trace element content.
X-ray Diffraction	***Origin, intended use.*** Phase and composition of U and Pu.

Optical microscopy gives clues to how a material was refined. Features of interest are color, aspect ratio, and heterogeneity.



Special nuclear materials can have complicated histories, which means that a variety of techniques must be used to determine information about them. If one, two, or more techniques suggest age or origin of a material, then forensic scientists can provide increasingly reliable information for the U.S. Government to act upon. The tools listed above are some of those available to researchers at Los Alamos. The wide selection allows exceptional analytical capability depth.

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