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Sandia National Laboratories

Analytical Capabilities of Sandia's Radiological Laboratory

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Sandia National Laboratories

Radiation Protection and Sample Diagnostics Program

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Overview

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- Routine radiological capabilities and sample types
- Description of radiological laboratory equipment
- Sample Preparation
- Performance Evaluation and Intercomparison Programs
- Supported Programs
- Other SNL Assets That Could Apply to Nuclear Forensics
- Questions

Routine Analytical Capabilities

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- Gamma Spectroscopy
- Gas Proportional Counting
- ISOLO
- Liquid Scintillation
- Alpha Spectroscopy
- ICP-MS
- Drum Counting
- Whole Body Counting
- Portable Gamma Spec
- Falcon Gamma Spec
- Preparation Laboratories

Routine-Environmental and Emergency Sample Types

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- Air
  - Paper and cartridge filters
- Water
  - Ground water
  - Drinking water
- Soil
  - Soil intended for agriculture
  - Environmental soil
- Vegetation
  - Wild plant life
- Food
  - Prepared foods (market ready)
  - Raw foods
- Feed
  - Livestock feed
  - Wild forage
- Milk
  - Milk for human consumption
- Surfaces
  - Swipes

Other Sample types

- Activated materials
  - By Neutron
  - By Intense Gamma
  - By Proton
- Waste Assay
  - Drums
  - Disposal boxes
  - Individually bagged items
- People
  - Urine screening
  - Whole-Body counting
- Decontamination
  - Various items from decontamination and remediation efforts

Radiological Laboratory Equipment

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- Gamma Spectroscopy
  - Solid, Liquid, or contained gaseous samples that are thought to contain gamma or x-ray emitting nuclides
  - Basically any geometry that fits in the shield
    - Appropriate calibrations need to be made
  - Can be used for rapid screening or detailed measurements
  - Portable units can be used to measure basically anything
- Liquid Scintillation Counting (LSC)
  - Rapid screening of liquids, swipes and air filters for low energy beta, beta, and alpha radiation
  - Detailed spectroscopy can be performed after radiochemical separations
- Gas-Flow Proportional Counting
  - Rapid screening of air filter and swipe samples for alpha and beta-emitting isotopes

Radiological Laboratory Equipment

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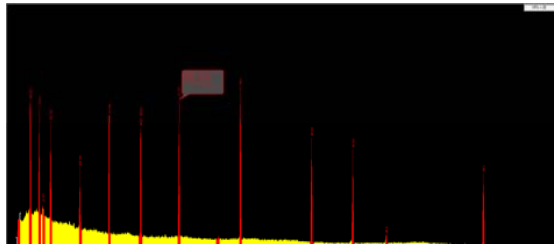
- Alpha Spectroscopy
  - Rapid screening of air filters and swipes by direct counting
  - Detailed spectroscopy of any matrix for alpha-emitting nuclides when the proper radiochemistry method is applied.
- Mass Spectrometry
  - Rapid screening of liquids for heavy metals (Uranium, Transuranic elements, etc.)
  - Detailed spectrometry of any matrix for metals when the proper radiochemistry method is applied

Gamma Spectroscopy

- X-ray and Gamma Energy range
  - 3 keV to 3 MeV
- Resolution
  - FWHM = 0.75 keV @ 112 keV
- Laboratory Units
  - Very low detection levels
  - LN Cooled
- Portable Units
  - Counts any number of geometries “In-Situ”
  - LN cooled or Electrically cooled

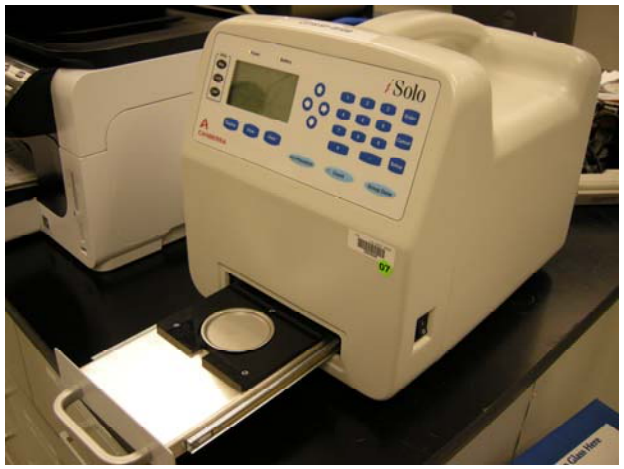


Liquid Scintillation Counting

- Detection
  - Low Energy Beta (H-3, Ni-63, etc.)
  - Gross Beta / Gross Alpha
  - Spectroscopic results when combined with radiochemical separations
- Geometry
  - 20 mL vial including cocktail
  - Maximum 10mL liquid per sample
- Laboratory Units
  - Automatic sample changing
  - Anti-Coincidence background reduction
- Portable Units
  - Guard detector (background reduction)
  - Manual sample changing
  - Single Photomultiplier Tube (no Anti-Coincidence background reduction)

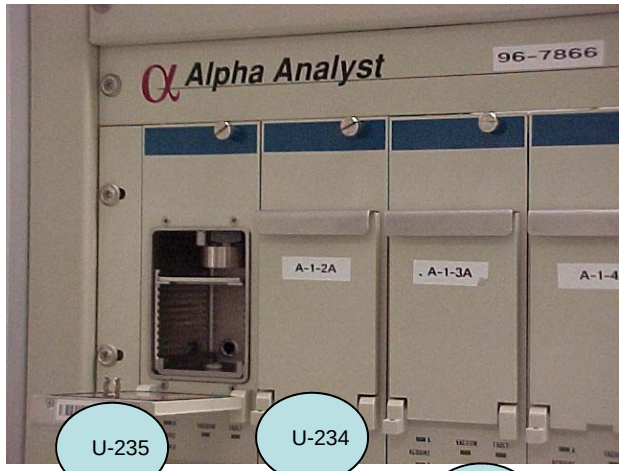
Gas-Flow Proportional Counting
(and other Gross Alpha/Beta instruments)

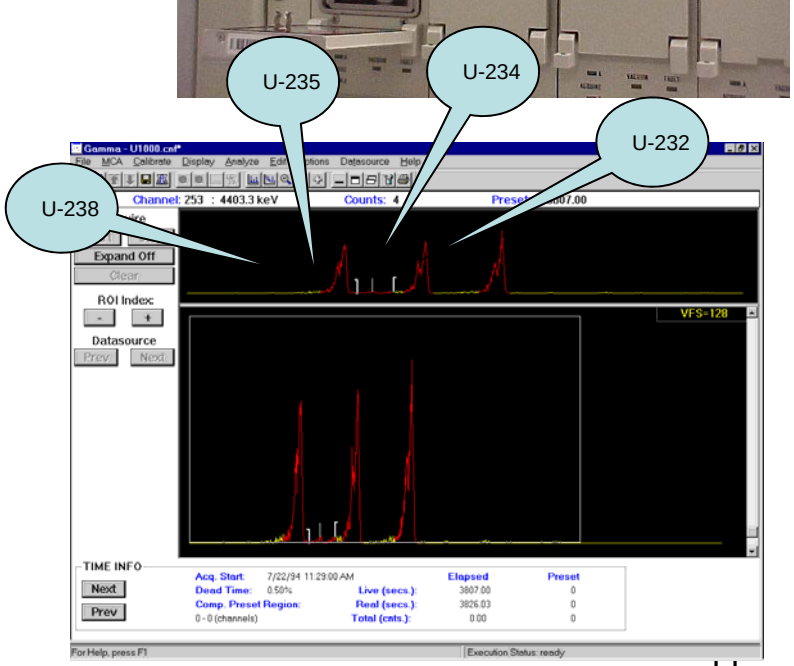
- Detection
  - Gross Alpha / Gross Beta
  - Radon Compensated Gross Alpha/Beta
- Geometry
  - 2” – 4” diameter swipes and air filters
  - dissolved liquids
- Laboratory Units
  - Shielding and Guard Detection
  - Automatic Sample changing
  - Rapid analysis of air filters and swipes
- Portable Units
  - No gas needed (use PIPS detector)
  - Ability to compensate for Radon/Thoron in air samples



Alpha Spectroscopy

- Detection
  - Alpha-emitters (including TRU)
- Geometry
  - 1” diameter radiochemically prepared samples
  - precipitated radionuclides on mirco-filter
- Efficiency
  - > 25% at closest distance from source to detector
- Resolution
  - < 13 keV/channel
- Laboratory Units
  - Multi-detector rack-mounted units with evacuated chambers
  - Manually loaded but many samples can be counting at one time





Inductively Coupled Plasma Mass Spectrometer (ICP-MS)

- Detection
  - Metals (U, Th, Pu, etc.)
  - Other Long-Lived isotopes
- Geometry
  - Digested Sample in diluted liquid form
- Resolution
  - ~0.25 AMU
- Laboratory Units
  - Quadruple mass spectrometer
  - Auto-pipetter
  - High throughput
  - Detection limits of ppt for medium and heavy elements

Sample Preparation and Radiochemistry

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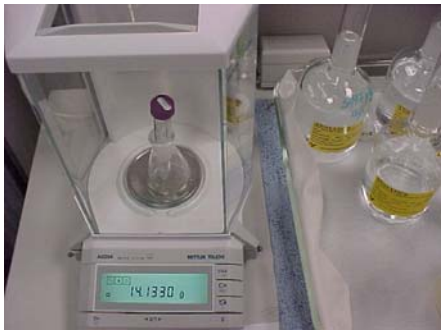

Receive Sample, take aliquot if applicable, add internal tracers

↓

Digest Sample via microwave or wet ash method

↓

Acidify sample for column loading and load onto ion-exchange column

↓

Elute nuclides of interest off of the columns

Alpha-emitting nuclides

Precipitate each nuclide of interest and load onto filter paper

↓

Count sample by alpha spectroscopy

Beta –Emitting Nuclides

Balance pH of eluent

↓

Mix each eluent with LSC cocktail in 20mL vial

↓

Count by LSC using appropriate calibration for cocktail and radionuclide

Performance Evaluation Programs

- DOE Laboratory Accreditation Program (DOELAP)
  - Lungs
  - BOMAB
  - Thyroid
  - Synthetic Urine
- DOE Mixed Analyte Performance Evaluation Program (MAPEP)
  - Radiological constituents in soil, water, air filter and vegetation
- Oak Ridge National Laboratory (ORNL)
  - Whole Body Count

Supported Intercomparison Programs

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- International Atomic Energy Agency
  - Radionuclides in Sea Water
  - Radionuclides in Vegetation (Spinach)
  - Radionuclides in Soil

- Environmental Protection Agency
  - Mixed Fission and Activation Products

- Food and Drug Administration
  - Consumer food products during an emergency response

Supported Internal Programs

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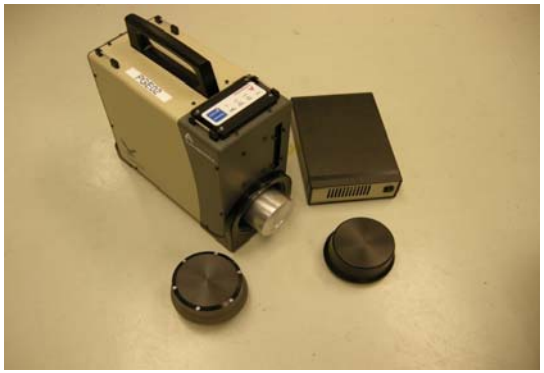
- Radiation Protection Operations
- Radiation Protection Dosimetry
- Environmental Monitoring, Characterization, and Restoration
- Radioactive & Mixed Waste Management
- Reactor Facilities
- Accelerator Facilities
- Radiation Transport Studies
- Research & Investigations
- Training Programs

Supported External Programs

- Centers for Disease Control and Prevention (CDC)
- Nationwide training courses
- NNSA Federal Emergency Response Programs



- Characterization of Waste for disposal at Waste Isolation Pilot Plant (WIPP)
- Environmental Protection Agency (EPA)
- Community Project for Drinking Water
- Development of an analytical field capability

Other Sandia Analytical Capabilities**

- **Ion Beam Laboratory**
- **Rutherford back-scattering spectrometry (RBS)**
  - Compositional and depth profiling of materials
- **Elastic recoil detection of very light elements**
  - High energy, heavy ion beam enables the profiling of very light elements such as Li, B, and H.
- **Time-of-flight elastic recoil detection**
  - High depth resolution (1nm) and greater isotopic separation
- **Ion channeling**
  - Probes near-surface atomic structure
    - depth profiling of defects & strain
- **External ion-beam analysis**
  - For materials that cannot be placed in a vacuum system
- **Particle-induced x-ray emission (PIXE)**
  - Quantitative elemental analysis with detection sensitivities of µg/g (ppm)
- **Three-dimensional elemental distribution maps**

** Some laboratories can only handle very low-level or non-radioactive samples

Other Sandia Analytical Capabilities**

- **Materials Science & Engineering Dept.**
- **Electron-optical instrumentation**
  - Transmission Electron Microscopy (TEM) & Electron Diffraction
  - Scanning Electron Microscopy (SEM)
  - Low-vacuum capabilities, image analysis, Electron MicroProbe Analysis (EMPA)
- **X-Ray Diffraction (XRD)**
  - stress, phase and texture analysis;
  - Micro x-ray diffraction
    - for crystallographic phase analysis and determination of stress on small areas
- **Vibrational and optical spectroscopies**
  - Fourier transform infrared spectroscopy (FT-IR),
  - Raman spectroscopy,
  - Photoluminescence spectroscopy.
- **Surface spectroscopy**
  - X-ray photoelectron spectroscopy (XPS),
  - Scanning Auger,
  - Time-of-flight secondary ion mass spectrometry (TOF-SIMS).
- **Nuclear Magnetic Resonance (NMR).**
- **Analytical chemistry**
  - instrumental and wet-chemistry

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Questions?

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