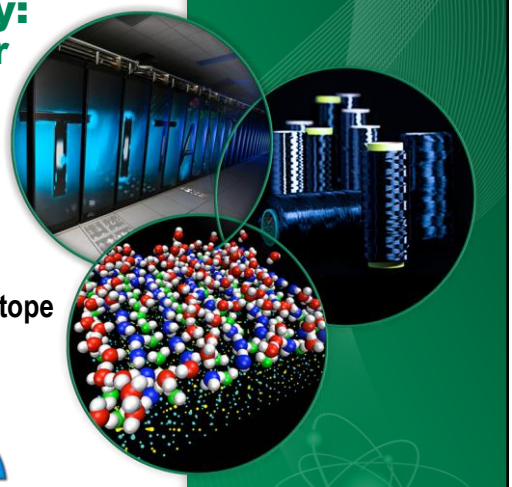
Oak Ridge National Laboratory: Addressing Nuclear Security Technological Challenges



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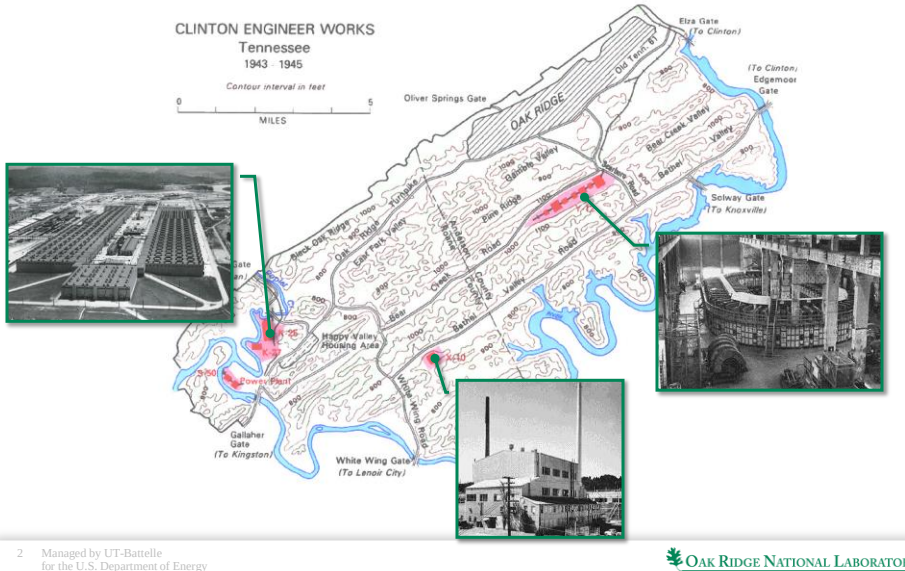
Director, Nuclear Security and Isotope Technology Division
Oak Ridge National Laboratory

June 25, 2013

Launching the First Nuclear Era: The Manhattan Project in Oak Ridge

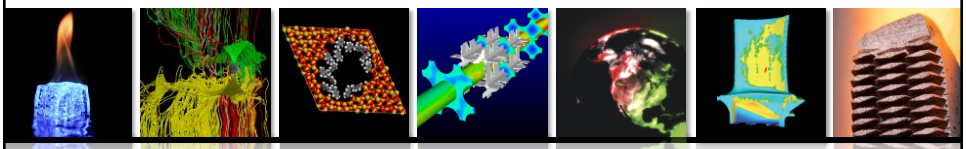


Mission of Clinton Laboratories, 1943:
Produce gram quantities of plutonium for chemical and engineering research

- Construct the world's first operational nuclear reactor
- Develop chemical processing to separate plutonium from irradiated fuel

Today, ORNL is DOE's largest science and energy laboratory

Delivering on our mission
Major initiatives in science and technology



Deliver science using neutrons	Scale computing, data infrastructure, and analytics for science	Discover and demonstrate advanced materials for energy	Advance scientific basis for new nuclear technologies and systems	Advance understanding in biological, environmental systems, and climate change impacts science	Enhance building energy efficiency, sustainable transportation, and advanced manufacturing	Solve the nation's most compelling global security challenges

Maximize ORNL's impact:

- Enhance technology transfer
- Invigorate science through graduate research and education

Developing and Applying the World's Best Tools for Neutron Scattering

High Flux Isotope Reactor:
Intense steady-state neutron flux
and a high-brightness cold neutron source

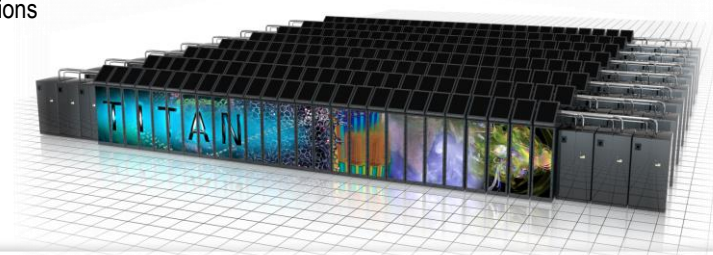
Spallation Neutron Source:
World's most powerful
accelerator-based neutron source

Leading the Development of Ultrascale Scientific Computing

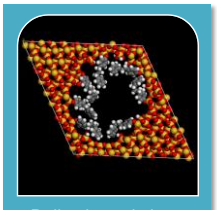
Delivering leading-edge computational science for DOE missions

Deploying and operating computational resources required to tackle national challenges in science, energy, and security

Scaling applications to the exascale

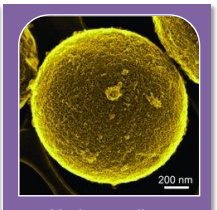


Discovering and Demonstrating Advanced Materials for Energy



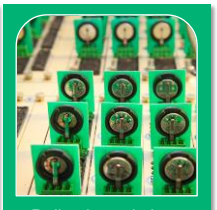
Delivering solutions to technological challenges for electrical energy storage, transportation, solar, and nuclear energy

Materials science



Understanding and controlling structure and function at atomic and molecular levels

Interfacial chemistry



Delivering solutions to technological challenges for electrical energy storage, transportation, solar, and nuclear energy

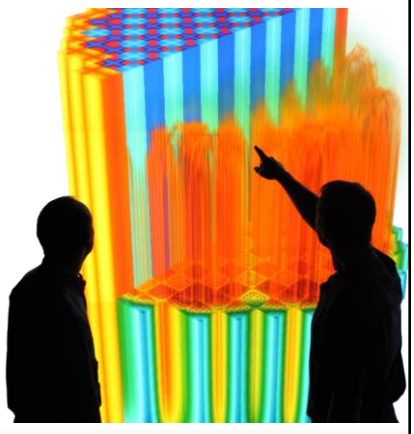
Applications

Delivering next-generation manufacturing processes and materials

Technology transfer

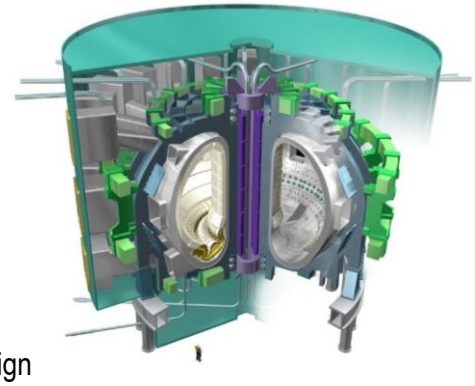
Advancing the Scientific Basis for 21st Century Nuclear Energy

- Materials R&D for safe and efficient high-performance fission and fusion energy systems
- Advanced nuclear fuel cycle R&D
- Modeling and simulation of advanced nuclear systems
  - Leading the Consortium for Advanced Simulation of Light Water Reactors (CASL)
- Stable isotopes and radioisotopes production and R&D



Managing the U.S. ITER Project for DOE

- ITER: International R&D project aimed at demonstrating the scientific and technical feasibility of fusion power
- Under construction in France, with operation to begin at the end of the decade
- The U.S. is contributing ~$2B in key components, R&D, and design



Providing Solutions to Pressing Energy Challenges

Bio-based fuels and materials | Sustainable transportation | Energy efficiency in buildings | Understanding climate change | Advanced manufacturing

Reducing Threats and Shaping the Future of Nuclear Security

Securing Vulnerable Materials

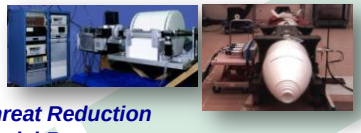
Bolstering Border Security

Nuclear Forensic Sciences

Shaping the Future Of Nuclear Security…

INSTITUTE FOR NUCLEAR SECURITY

Arms Control Verification & Monitoring Technologies



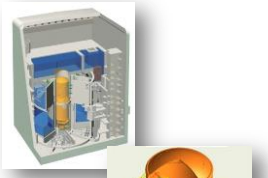
International Export Control and Enforcement

International Safeguards & Security

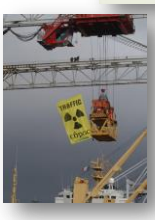
Global Threat Reduction and Material Recovery

Nuclear Security R&D

The Nuclear Security Challenge:



- Enabling the peaceful use of nuclear technology
- Protecting nuclear materials
- Maintaining good stewardship and cooperation with nuclear technology information



How Do We Achieve "Security?"

- Understand the threat
- Keep nuclear weapons safe, secure, and rare
- Reduce or eliminate risk of malicious use or theft
- Find and stop potential threats
- Trace the threat back to the source
- Reduce our vulnerability and limit loss of life if detonation occurs
- Clean up and restore effectively
- Ensure that the strategy is sustainable

A Wide Spectrum of Challenges

Technology Plays a Strong Role in Addressing Nuclear Security Challenges

- International Safeguards and Security
- Securing Vulnerable Materials
- Bolstering Border Security
- Global Threat Reduction
- Transportation Security
- Arms Control Verification & Monitoring Technologies
- Search and Interdiction
- Nuclear Forensics

International Safeguards

Example Roles:

- Development, testing, and evaluation of strengthened safeguards measures
- Training assistance
- Ad hoc support for high-priority inspections
- Technical support to international partners
- Technical support for negotiations
- Proliferation resistance studies and assessments





Securing Vulnerable Materials (First Line of Defense)

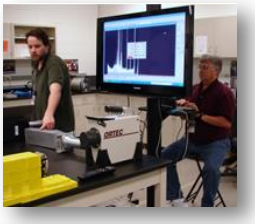
- Nuclear facilities exist worldwide that vary widely in their ability to protect and manage nuclear material
- Programs endeavor to upgrade facilities to international protection and nuclear material management standards





Bolstering Border Security (Second Line of Defense)

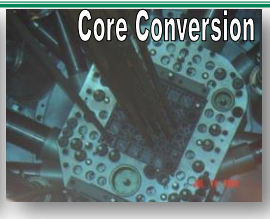
- Detection of nuclear materials smuggling via legal border crossing points
- Interdiction of radioactive materials and items having potential use in radiological dispersal devices
- Support field installation, operation, and optimization of radiation portal monitors, including reachback and testing capabilities
- Large data volume and analysis challenges



Global Deployment to Remove and Reduce Threats

Return of Russian-origin fresh and spent fuel

- Belarus
- Bulgaria
- Czech Republic
- Germany
- Hungary
- Kazakhstan
- Latvia
- Libya
- Poland
- Romania
- Serbia
- Ukraine
- Uzbekistan
- Vietnam



Long-Term Secure Storage

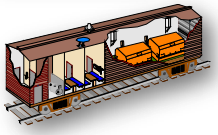
Mobile Uranium Facility

Kazakhstan BN-350 SNF

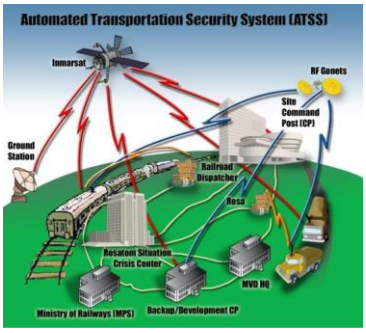
Movement of 300MT of nuclear material – equivalent of 775 nuclear weapons - to long-term safe storage completed in November 2010

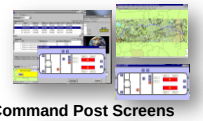
Transportation Security—Providing Technology Solutions

Cargo Railcar



Cargo Railcar Layout





Command Post Screens

Satellite Communication Equipment

Command Post Monitors

Guard Railcar

Security Overpack

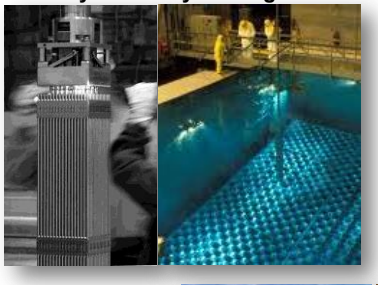
Escort Vehicle

Cargo Vehicle

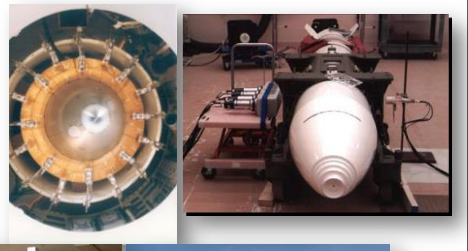
Technology Demonstrations

Radiation Detection Technologies Underpin Many of our Nuclear Security Efforts

Fuel-cycle facility: "Safeguards"



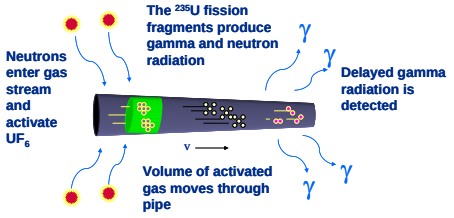
Missile: "Arms Control" or "Treaty Verification"

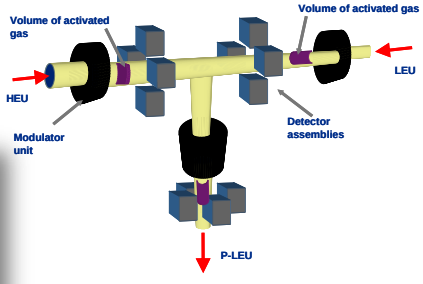


Loose: "Counter-Terrorism" or "Homeland Security"

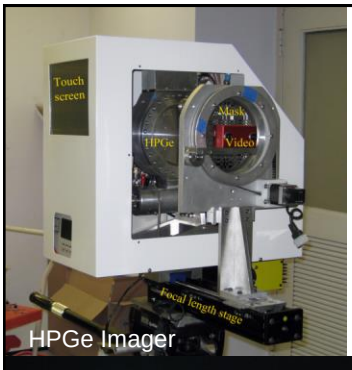
Active Interrogation of Fissile Materials

- The Blend Down Monitoring System (BDMS) is playing a key role in the HEU Transparency Program to monitor the downblending of Russian HEU
- BDMS uses active interrogation to measure the fissile mass flow in all three legs of the blending tee
- Measures traceability of HEU through the blending tee
- Operates unattended
- 450 MT downblended as of July 2012

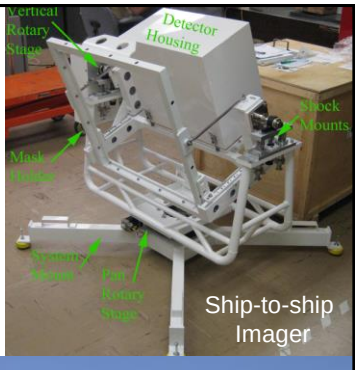




Coded-Aperture Imaging



HPGe Imager



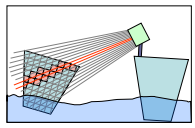
Ship-to-ship Imager

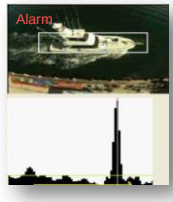

Large Area Imager

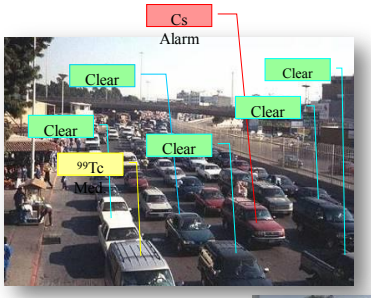

Roadside Tracker

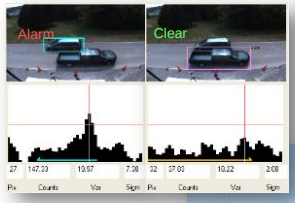
Gamma-Ray Imaging Techniques and Systems—Expanding Applications

- Large Area Imager
- Roadside Tracker: Combining gamma-ray imaging with target tracking in visible-light images
- Ship-to-Ship Motion Correction



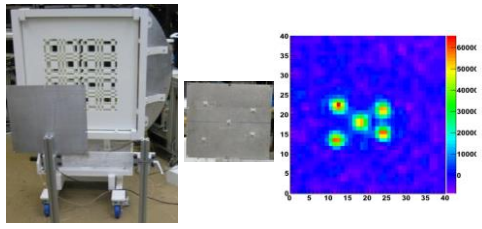




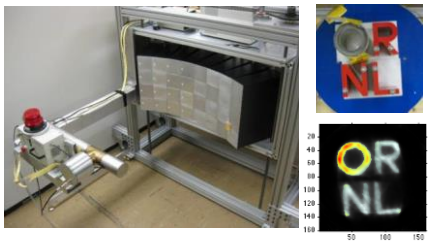


Fast Neutron Radiography and Imaging

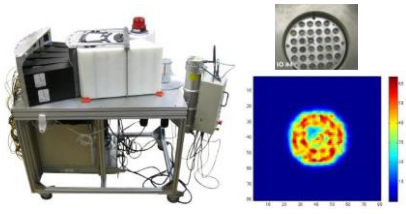
Fast-neutron imaging detectors



Passive fast-neutron imaging with sufficient resolution to count warheads



Active fast-neutron imaging that can image the presence and geometry of fissile material



Passive fast-neutron imaging with sufficient resolution to detect single-pin defects

Development of New Radiation Detection Materials and Systems

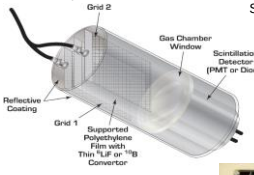
- Strontium Iodide Scintillator
- Transparent Polycrystalline Ceramic Scintillators
- ^{3}He replacement
  - ^{6}Li Proportional Chamber
  - ZnS/^{6}LiF scintillator with fiber optic readout
  - Gas Scintillators
  - $LiCaAlF_6$:Eu Scintillators
- Glass neutron activation detectors, Cherenkov-based

SrI_2:Eu Single Crystal Scintillator

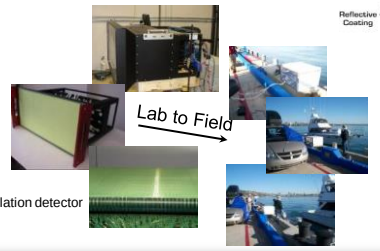
CaF_2:Eu Crystal Scintillator

Lu_2O_3:Eu Ceramic Scintillator

SrI_2:Eu Ceramic Scintillator

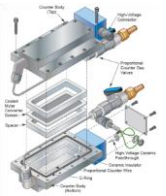


Gas Scintillator Detector



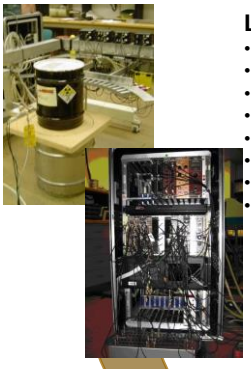
ZnS/^{6}LiF scintillation detector

Neutron-sensitive glass and Cherenkov light detector

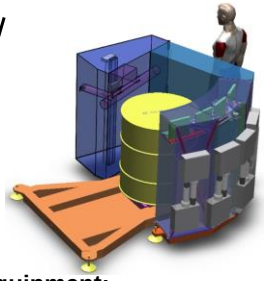


^{6}Li Proportional Counter

Developments in the Laboratory Must be Transitioned to Practical Use Equipment



Laboratory Equipment:
- **Complex**
- **Highly knowledgeable operators required**
- **Difficult to transport**
- **Not rugged**
- **Cumbersome**
- **Great for technology development**
- **Flexible**
- **"Wiry"**



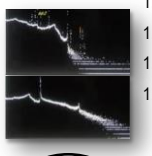
Practical Use Equipment:
- **Mission specific**
- **Readily assembled and repaired**
- **Operable by trained technicians**
- **Rugged and transportable**
- **Two-person portable**
- **Highly reliable**
- **Modular**

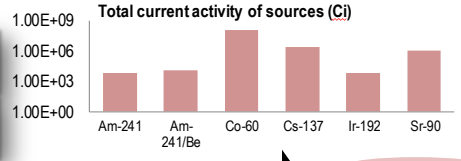
Radiological and nuclear forensics and attribution

Goals	Requirements	ORNL resources
• Identify nature and source of nuclear and radiological materials • Determine their origin • Identify those responsible for an attempted or actual attack	• Nuclear forensic sample analysis • Understanding of radiochemical and environmental signatures • Knowledge of production methods	• Isotope production and processing facilities and expertise • Evaluation of material characteristics and links to processes • Knowledge of materials characteristics and links to processing history • Age dating to determine time since purification • Reactor models to predict signatures and irradiation history to determine production date • Tracing of impurities to processing methods

Leveraging DOE-SC capabilities and facilities to meet nuclear security needs

Key strengths for nuclear forensics:
Integrating sampling science, analysis science, and results interpretation





Intercepted material or post-detonation debris → Receipt and subsampling → Laboratory analysis → Data interpretation → Subject matter expertise

- Facilities
- Techniques

- HEU production
- Isotope source production and distribution

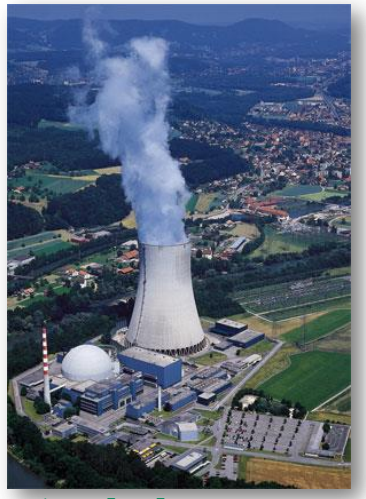
Knowledge base
- New signatures
- Production modeling
- Advanced analytical techniques

Technology Application has Challenges

- How do you know what you are looking for? Declarations complete? Smuggling? Material Unaccounted For?
- Typically no smoking gun
- Balance information sought and gained with intrusiveness
- People are involved in the process – Human reliability
- Sustainability

Nuclear Technology and Materials are Important Elements of the Global Economy

- "Pillar Three" of the NPT
  - Recognition that commercial nuclear power fills a growing need for energy worldwide
  - Verifying that technologies and materials associated with nuclear power generation should not be used for weapons programs
- Concern about theft or diversion of nuclear material by non-state actors for use in terrorist activities



Technology has an important role in ensuring nuclear security

Oak Ridge National Laboratory:

Discovery and innovation for clean energy and global security

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