# *Domestic Nuclear Detection Office (DNDO)*

## *Approaches to Detect Concealed Threats*

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# *Nuclear Terrorism is a Persistent Threat*

"No threat poses as grave a danger to our security and well-being as the potential use of nuclear weapons and materials by irresponsible states or terrorists." - President's National Security Strategy, February 2015

- The nature of the threat:
  - Improvised Nuclear Device (IND)
  - Radiological Dispersal Device (RDD) – "dirty bomb"
  - Radiation Exposure Device (RED)


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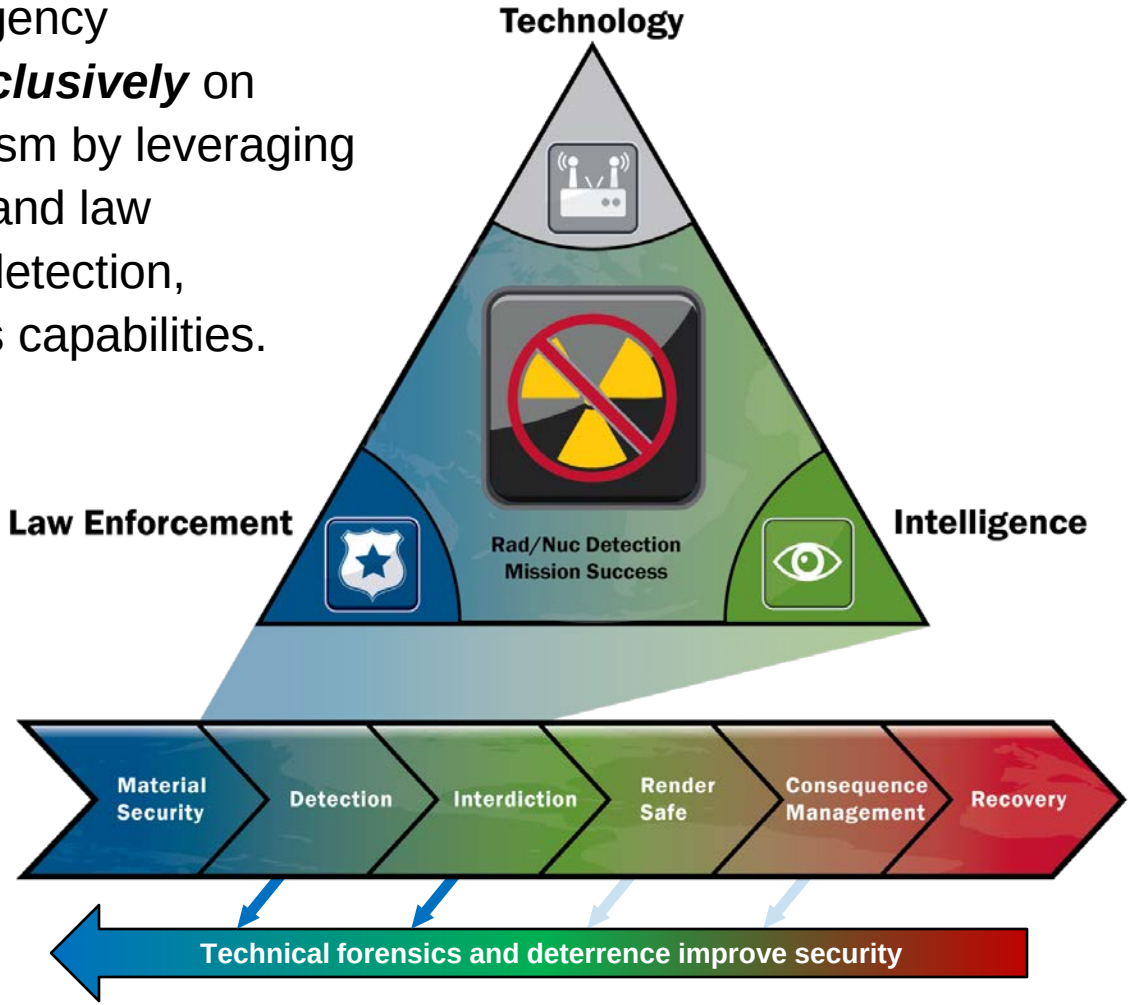
# *DNDO Mission*

- DNDO is a unique interagency organization ***focused exclusively*** on preventing nuclear terrorism by leveraging technology, intelligence, and law enforcement to improve detection, interdiction, and forensics capabilities.




**Nuclear Defense Spectrum**

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# *DNDO Functions*

- Develop the global nuclear detection architecture (GNDA), and implement its domestic component
  - Systems Architecture: Develop strategies & plans, analyze risk, initiate programs
  - **Research & Development: Conduct basic & applied research and engineering development**
  - Systems Acquisition: Procure & deploy nuclear detections systems to support frontline operations
  - Assessments: Test & evaluate systems in controlled and operational environments, develop standards, assess deployed systems and operations using adversary tactics (Red Team)
  - Operations Support: Assist State & local stakeholders in developing nuclear detection programs, develop training curricula, conduct exercises, maintain situational awareness of the GNDA

- Provide centralized planning, integration, and advancement of USG technical nuclear forensics (TNF) programs
  - Technology Advancement: Conduct research to discover signatures of interest, develop analysis techniques and standard reference materials
  - Operational Readiness: Develop and conduct joint planning, exercising and assessments
  - National Expertise Development: Restore and maintain a nuclear forensics expertise pipeline

# *Global Nuclear Detection Architecture (GNDA)*

**Vision:**

A coordinated, layered defense of effective capabilities for rapid and responsive detection, analysis, and reporting on nuclear and other radioactive materials out of regulatory control that makes nuclear terrorism prohibitively difficult.

**The GNDA is a framework for:**

- Technical radiological and nuclear detection
- Intelligence and analysis
- Communication
- Law enforcement
- CONOPS


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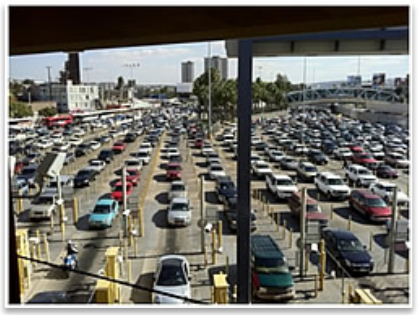
# How Operational Realities Impact the GNDA

- Land Border Pathway
  - 1.1 million individuals legally cross U.S. borders every day
  - 14,000 trucks cross into the U.S through our Southern Border daily
  - 7,400 miles of border with Canada and Mexico
  - 5,400 loaded rail cars cross into the United States every day



- Aviation Pathway
  - 640 million domestic and international aviation passengers and 1.5 billion checked and carry-on bags are screened annually.
  - 200,000 general aviation aircraft and 19,500 landing facilities are in the U.S.

- Maritime Pathway
  - 32,000 seagoing containers arrive and are offloaded at U.S. seaports each day
  - 13 million registered U.S. recreational vessels, 282,000 fishing vessels, and 100,000 other commercial small vessels

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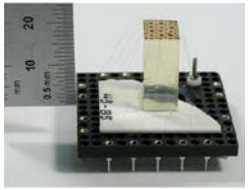
*Approximate numbers

# Grand R&D Challenges

- *Cost effective equipment* with sufficient performance to ensure wide spread deployment



- ***Detection of special nuclear material*** **even when heavily shielded**

- *Enhanced wide area search* in a variety of scenarios, to include urban and highly cluttered environments

- Monitoring along *challenging GNDA pathways*, to include general aviation, small vessels, and in between ports of entry

- Forensic *determination of origin* and/or route of interdicted materials

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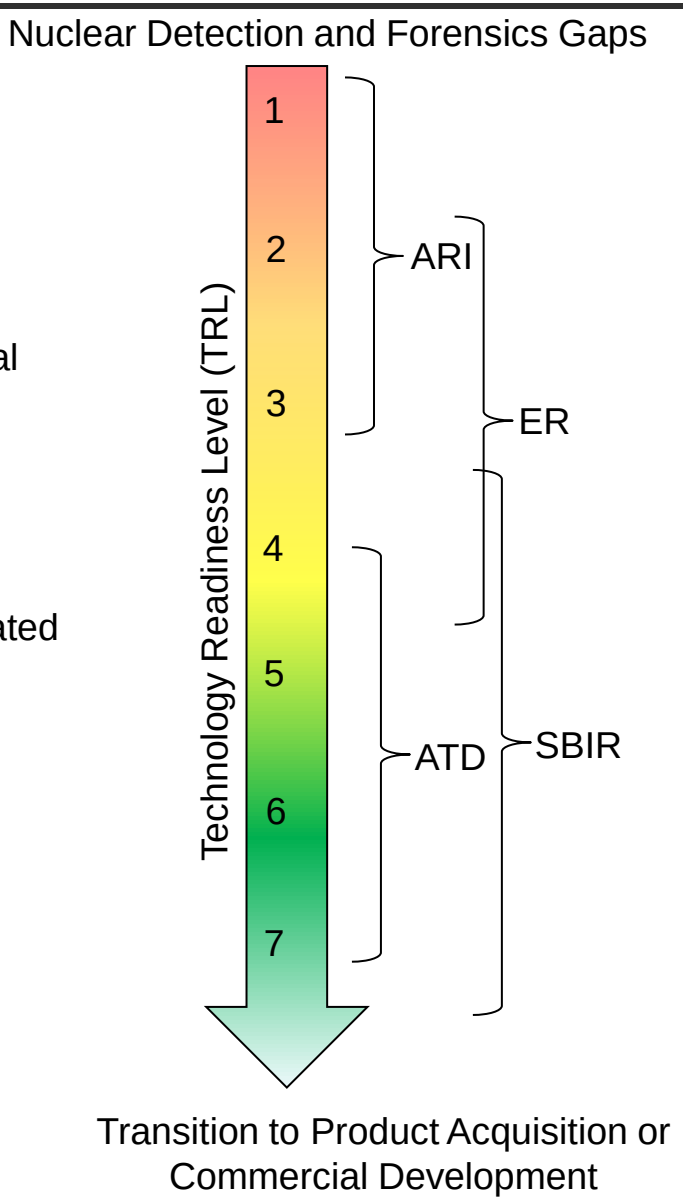
# R&D Program Elements

- Academic Research Initiative (ARI)
  - Advance fundamental knowledge for nuclear detection and forensics while investigating the toughest challenges
  - Create next generation of scientists and engineers
- Exploratory Research (ER)
  - Driven by gaps and weaknesses in the GNDA and technical nuclear forensics
  - Investigate promising concepts to show feasibility through laboratory Proof-of-Concept (PoC) demonstrations
- Advanced Technology Demonstration (ATD)
  - Further develop technology concepts previously demonstrated under the ER or equivalent
  - Characterize Performance Test Units (PTU) in a simulated operational environment to assess technology transition potential
- Small Business Innovative Research (SBIR)
  - Strengthen the role of innovative small business concerns with federally-funded research and development
  - Augments the ATD and ER with 2-4 new topics a year

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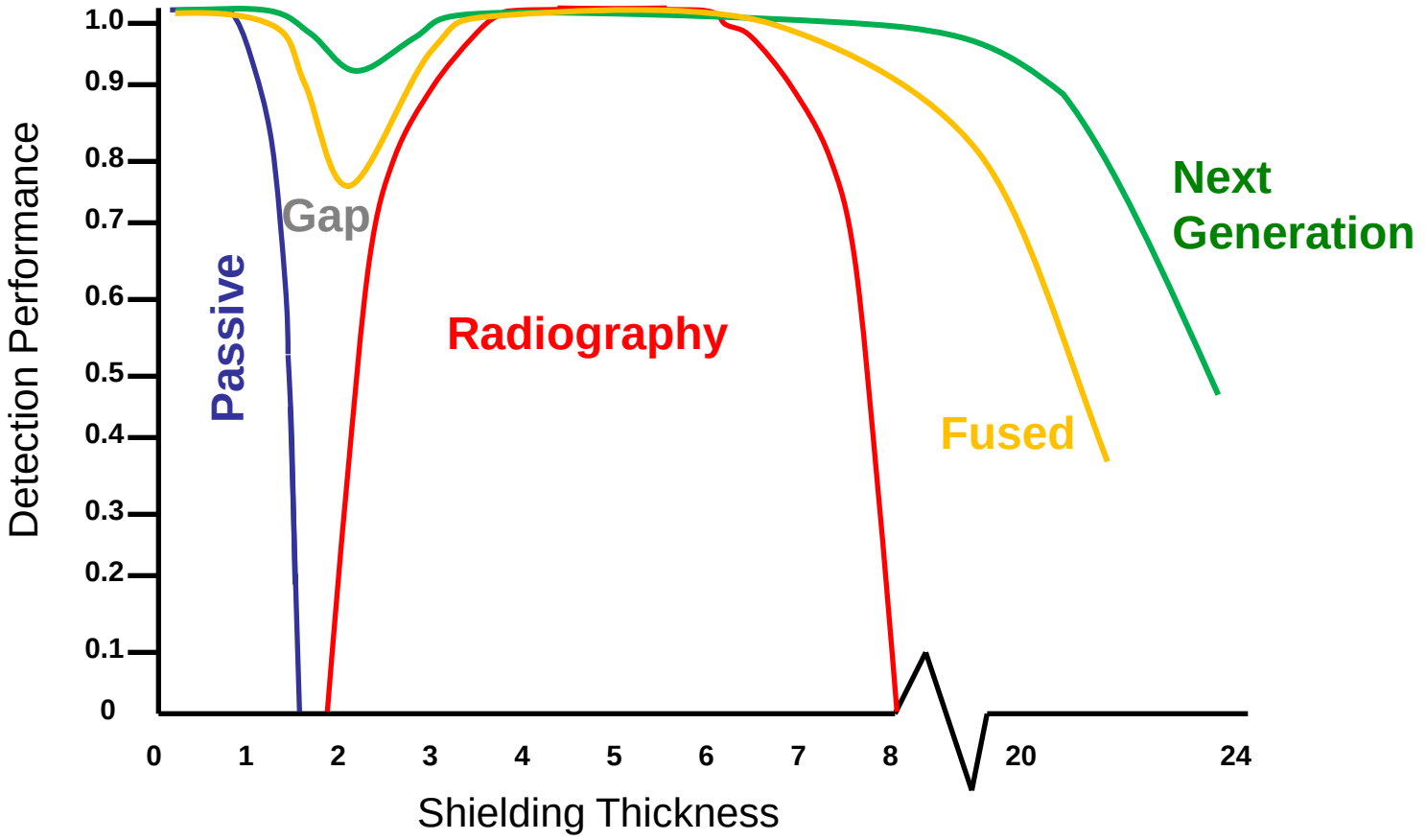
# Notional Shielding Problem




The actual plot is more complicated and may vary significantly depending on the threat and shielding material.

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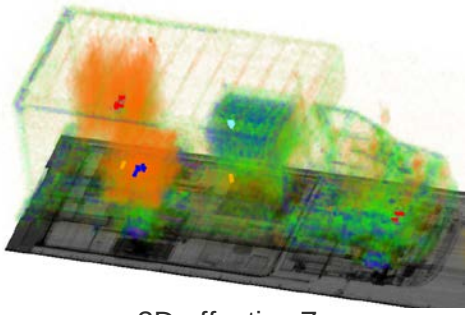
# *Shielded Threat Portfolio Overview*

- **Objective**: Develop operationally viable technologies that can detect shielded threats and clear innocent objects for existing and new application scenarios
  - Enhanced Capability for Ports of Entry / Departure
    - Primary and secondary radiography/active interrogation
    - Fused radiation detection and particle interrogation
  - Exploration of New Application Scenarios
    - Highly mobile and human-portable systems
    - Rail, aircraft, and small vessel inspections
    - Personally occupied vehicles
  - Enabling Components
    - Compact high flux neutron generators and multi-energy, varying intensity electron accelerators
    - Mono-energetic photons sources and other techniques for low dose scanning
    - Fast detectors and electronics for more efficient signature extraction
    - Automated algorithms to enhance capability of existing radiographic systems
    - Exploration of new signatures to provide enhanced material discrimination (Z dependence)

# *Enhanced Capability at the Ports*

- Nuclear and Radiological Imaging Platform – Primary Screening
  - Baseline characterization of commercial systems with integrated passive detection and radiography and/or automated threat recognition
    - SAIC IP6500, Smiths HVCP 6030, Varian IntellX3, Rapiscan Eagle M60
  - Next Generation X-ray Imager
    - High energy backscatter to create three dimensional (3D) image, photo-fission, transmission radiography, passive detection, and nuclear resonance fluorescence (NRF)
    - Continuous Wave (CW) electron accelerator
  - Muon Tomography – no radioactive source
- Shielded Nuclear Alarm Resolution – Secondary Scanning
  - Photofission Based Alarm Resolution (PBAR)
    - 9 MeV linac enables: transmission radiography, spectroscopic radiography, photo-fission
  - Differential Die-Away Analysis (DDAA)
    - 9 MeV linac with neutron convertor enables: DDAA, prompt neutron and delayed gamma from neutron induced fission and photo-fission, cargo characterization
- Passive and X-ray Imaging System
  - Test and Evaluation of deployed systems

Commercial System



3D effective Z map

PBAR Prototype


Varian IntellX3

DDAA Prototype

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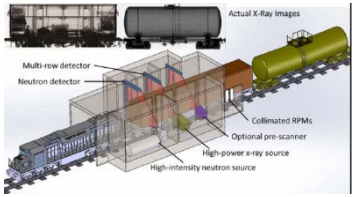
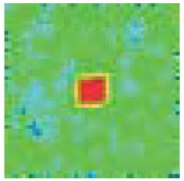
# *Exploration of New Applications*

- Mobile SNM Detection System
  - Compact deuteron on deuterium (DD) neutron generator enables mobile detection of nuclear threats with optimized low dose
- Air Craft Inspection System
  - Low energy accelerator and compact DD neutron generator for primary and secondary scanning of airplanes
- High Speed Rail Cargo Scanning
  - Burst-mode, multi-energy linac specifically designed to take advantage of novel fast detectors needed for high speed scanning
  - High power intensity modulated x-ray and neutron sources
- Low Dose Inspection Using Mono-energetic X-rays
  - Ultra-compact ion accelerator capable of generating mono-energetic photons through nuclear reactions
- Mobile Radiography with Dose Mitigation
  - Tunable CW x-ray source with raster pencil beam scanning to provide optimized dose for each pixel

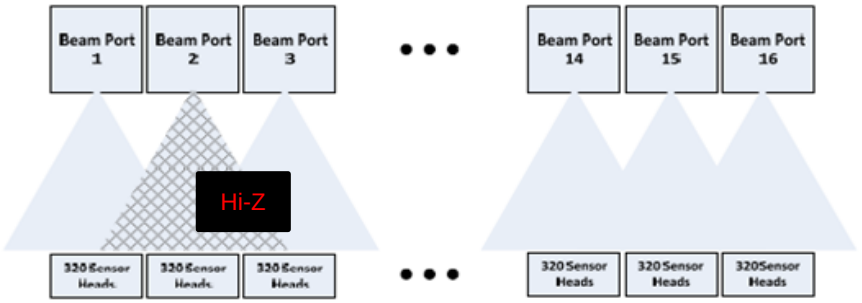



Conceptual Design of Mobile, Airplane, and Rail System



100 cc U cube in 40 cm Fe block imaged with 15.1 MeV gammas (MCNPX simulation)

Material Discrimination Enabled by Mono-Energetic Photons




Innovative Techniques to Mitigate Dose

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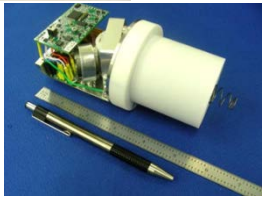
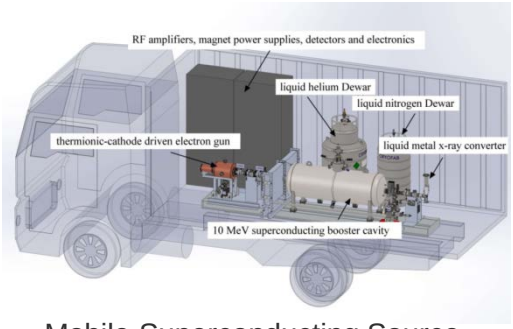
# Sources

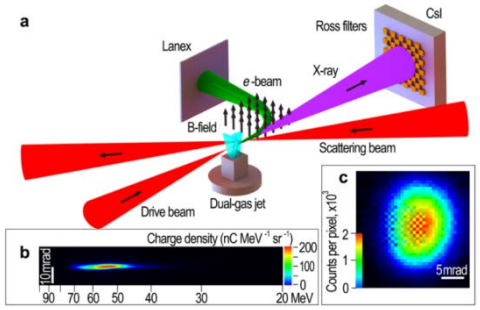
- Portable D-D Neutron Generator
  - Human-portable neutron generator capable of $10^7$ D-D n/s, 200Hz, 2kHz rep rate and 5% duty cycle to help enable mobile scanning systems
  - Compact, high-voltage power supply to reduce the weight and size of generator
- Miniaturized High Energy X-ray Source for Mobile Systems
  - Compact , dual energy (6/9 MeV) x-band x-ray source suitable for mobile radiography applications
- Portable High-Power Superconducting RF X-ray Source
  - Compact and portable, high intensity, CW, x-ray source based on a 10 MeV, 10 kW superconducting RF linac
- Laser Driven X-ray Source for Low-Dose Radiography
  - Compact, beam-steerable, tunable multi-energy (4-12 MeV) and narrow-band x-ray source utilizing a laser plasma accelerator (LPA)
- Inexpensive High-Performance Betatron Source
  - Improved performance and reliability 6/9 MeV interlaced betatron producing 50 cGy/min @ 1 m dose rate.
- Mono-energetic Photon Source (MEPS) Study


Enabling Technology for a Portable Neutron Source






Mobile Superconducting Source




Laser Driven Source

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# Recent and Future Events

- Small Business Innovation Research (SBIR)
  - Two topic solicitation closed early in 2015
  - Topic 1: Mass/Shielding Anomaly Passive Detector Module
  - New solicitation likely in December 2015
- Academic Research Initiative (ARI)
  - Four topic solicitation closed June 19, 2015
  - Topic 4: Approaches to Detect Shielded Special Nuclear Materials (SNM)
  - New solicitation likely in January 2016
  - Web Site: https://www.grants.gov search for “DNDO”
- Exploratory Research (ER) Broad Agency Announcement (BAA) for industry / academia and Call For Proposals (CFP) for laboratories
  - Likely released in August 2015
  - Topic 3: Radiographic Platform Agnostic Automatic Threat Detection Algorithm
  - Web Site: https://www.fbo.gov search for “DNDO”
- DNDO Development of Accelerator Requirements for Homeland Security Applications meeting
  - Held August 5-7, 2015 at Fermilab
  - Anticipate outcomes will be used to inform future research topics

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