U.S. DEPARTMENT OF ENERGY (DOE)
NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA)
DEFENSE NUCLEAR NONPROLIFERATION (DNN)

DNN Sentinel

DEFENSE BY OTHER MEANS

Vol. V, No. 1

IN THIS ISSUE:

Making a Big Difference

Washington State University student Jacqueline Reeve assembles an apparatus that bends the metal filament to hold samples for thermal ionization mass spectrometer analysis. NNSA's Office of International Nuclear Safeguards Human Capital Development program brings together PNNL safeguards researchers and WSU students enrolled in WSU's Industrial Design Clinic. Photo credit: Maren Disney | Pacific Northwest National Laboratory

See more at https://www.energy.gov/nnsa/articles/interns-make-big-difference-some-very-small-creations-pnnl

DNN SENTINEL:
DEFENSE BY OTHER MEANS

VOL. V, NO. 1

https://www.energy.gov/nnsa/missions/nonproliferation

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NNSA ARTICLES

NNSA/DNN QUICK LINKS

Follow the links below to learn more about recent NNSA and DNN activities.

Press Releases

FY20 Presidential Budget Request for NNSA Released

https://www.energy.gov/nnsa/articles/fy20-presidential-budget-request-nnsa-released

NNSA completes first production unit of modified warhead

https://www.energy.gov/nnsa/articles/nnsa-completes-first-production-unit-modified-warhead

Articles

NNSA, IAEA, and Argentina partner to reduce the risk of radiological terrorism through alternative technologies

NNSA's Office of Radiological Security (ORS) works with partners worldwide to enhance global security by preventing high-activity radioactive materials from being used in acts of terrorism.

https://www.energy.gov/nnsa/articles/nnsa-iaea-and-argentina-partner-reduce-risk-radiological-terrorism-through-alternative

NNSA Senior Executive Service tells all

To whom much is given, much is expected. The members of the Senior Executive Service (SES) know this well. A panel of representatives spoke candidly about the pros and cons of SES positions at a recent "Aspiring Leaders Series" discussion at NNSA headquarters in Washington, D.C.

https://www.energy.gov/nnsa/articles/nnsa-senior-executive-service-tells-all

Uranium Processing Facility marks construction milestone with "topping off"

The Uranium Processing Facility (UPF) at the Y-12 National Security Complex in Oak Ridge, Tennessee, achieved another construction milestone in February – "topping off" the final piece of structural frame on the Mechanical Electrical Building (MEB).

https://www.energy.gov/nnsa/articles/uranium-processing-facility-marks-construction-milestone-topping

NNSA helps emergency response partners plan for the "First 100 Minutes" of a radiological attack

Experts from NNSA's Office of Counterterrorism and Counterproliferation, in collaboration with the Federal Emergency Management Agency (FEMA), recently trained emergency responders in Oak Ridge, Tennessee, on best practices in dealing with radiological dispersal devices, also known as "dirty bombs."

https://www.energy.gov/nnsa/articles/nnsa-helps-emergency-response-partners-plan-first-100-minutes-radiological-attack

From the Deputy Administrator

I am happy to introduce the 11th issue of the Sentinel, highlighting major accomplishments for the Office of Defense Nuclear Nonproliferation over the last year. This quarter, several of the articles focus on key technological developments that assist our programs with their work to advance NNSA's nonproliferation and nuclear security mission. It also highlights additional impressive and important collaborations between DNN programs and the DOE/NNSA laboratories, sites, and plants.

I recognize and appreciate a need for the long-term commitment required for advancing the nonproliferation and nuclear security mission. This enduring effort is made possible by the hardworking teams across the DOE/NNSA complex that are dedicated to upholding our national security. I am continually impressed by the vast array of experts in our workforce who develop and implement technologies, plan and execute projects, and continue to look towards the future of U.S. national security together.

I hope that reading this issue of the DNN Sentinel will provide you with a sense of the impressive range of projects that fall in the nonproliferation and nuclear security space. The work represented here ranges from the production of medical isotopes without the use of highly enriched uranium, to advancing the technologies which permit us to monitor nuclear explosions, to improving radiation portal monitors through machine learning. DNN, in partnership with our laboratory partners, continues to become more efficient, agile, and forward-looking in ensuring our nation's security and achieving our nonproliferation goals at home and abroad.

Dr. Brent K. Park
Deputy Administrator
Defense Nuclear Nonproliferation

DNN Program Raises Readiness Levels through Experience, Training

By Jason Shepherd

In 2004, technical experts from DNN's Office of Nonproliferation and Arms Control (NPAC) and several U.S. National Laboratories deployed to Libya on short notice to verify and monitor the complete dismantlement of the Libyan nuclear program.

In 2008, NPAC and National Laboratory technical experts deployed to the Democratic People's Republic of Korea (DPRK) to monitor the disablement of several nuclear facilities. Using lessons learned during the earlier Libya deployment, these experts worked around the clock in the DPRK for 18 months overseeing multiple sites and locations with versatile four- to eight-person teams to achieve goals agreed upon during the Six-Party Talks (United States, Japan, South Korea, North Korea, China, Russia) process.

NPAC is applying this past experience, along with its current training and technical development activities to be prepared to implement any future negotiated agreements. NPAC is ready to deploy teams and technologies to monitor and verify the operating status, fissile material inventory, process history, and disablement/dismantlement of any foreign nuclear fuel cycle facility. Two specialized teams, the Uranium and Plutonium Verification Teams (UVT and PVT) are trained and ready to deploy at a moment's notice.

"These teams will be called upon to address nuclear fuel cycle facilities ranging from uranium mines to facilities that form nuclear weapons components," said Greg Dwyer, director of NPAC's Office of Nuclear Verification.

Uranium Verification Team members practice verifying material production declarations at a uranium processing facility. (Photos courtesy of NPAC program)

NPAC worked throughout the year to raise readiness levels for the UVT and PVT with specialized verification tool training and verification scenario exercises. In February 2018, the PVT trained at Hanford on the specifics of graphite moderated reactors and associated material processing facilities. In June, they trained and exercised with a specialized reactor disablement tool. The UVT

Not only do technical experts rely on their Libya and the DPRK experience and recent training, they draw upon over two decades of experience in negotiating and implementing on-site nuclear material process monitoring under the 1997 U.S.-Russia Plutonium Production Reactor Agreement (PPRA) and the 1993 U.S.-Russia Highly Enriched Uranium (HEU) Purchase Agreement.

Over a 20-year period under the HEU agreement, U.S. experts conducted 385 monitoring visits to Russian HEU facilities, performed over 41,000 non-destructive measurements to confirm declared material enrichment, reviewed over 300,000 pages of facility process and shipping declarations, and successfully confirmed that 500 metric tons of HEU had been converted into low-enriched uranium under the agreement.

PVT members study graphite moderated reactors at the Hanford Site.

PVT members practice deploying a specialized reactor disablement technology.

PVT members practice deploying a specialized reactor disablement technology.

Raising verification readiness levels by building on past experience

July 2018 - UVT exercise at Y-12

June 2018 - PVT training and exercise reactor disablement tool

May 2018 - UVT exercise at Y-12

Feb. 2018 - PVT training at Hanford

500 metric tons of HEU converted into low-enriched uranium

300,000 pages of facility process and shipping declarations

41,000 non-destructive measurements to confirm declared material enrichment

385 monitoring visits to Russian HEU facilities

1997 PPRA

1993 HEU Purchase Agreement

participated in scenario-based exercises in uranium chemical processing facilities at the Y-12 National Security Complex in May and July to develop and practice verification mindsets and techniques.

"As a result of these team development, training, and exercise activities, we are better prepared to safely and more effectively characterize and verifiably disable nuclear weapons material processing facilities during future missions," said Kasia Mendelsohn, Associate Deputy Administrator, NPAC.

Additionally, this year NPAC established a dedicated team of health and safety experts who will deploy with the UVT and PVT to ensure radiation and industrial safety of deployed personnel.

"We made great progress in 2018 under enormous pressure from many stakeholders. The headquarters staff and our technical teams from the labs, plants, and sites all came together to get the work done and through our readiness, planning, and technical preparedness position our teams for action when called upon. We're looking forward to more outstanding accomplishments from the program in 2019," said Brent Park, Deputy Administrator, DNN.

DNN R&D and GMS Collaborate on Technology for Radiological Security

By Lance Garrison

High-activity cesium and cobalt sources are widely used in the field of medicine for blood treatment and biological research, but if they fell into the wrong hands, these sources could be used in a radiological dispersal device, or "dirty bomb." DNN's Office of Global Material Security (GMS) works to prevent these and other sources from being used in acts of terrorism. One approach is to encourage the adoption and development of non-radioisotopic alternative technologies, such as X-ray devices, that can be used in lieu of radioactive source-based devices.

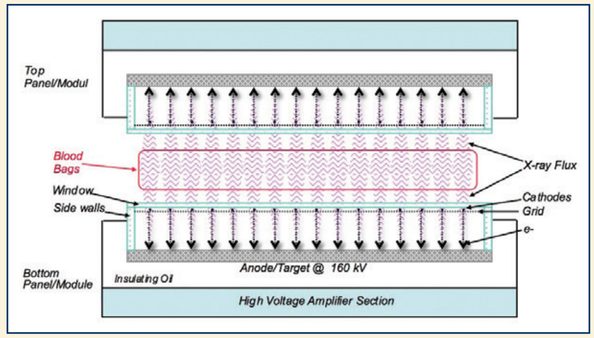
"X-ray irradiators for blood irradiation and research applications have been available for many years, and there is a strong trend toward their use instead of cesium- or cobalt-based irradiators," said Nicholas Butler, Domestic Director of GMS's Office of Radiological Security's Domestic Director. "Over the past two years approximately one-fifth of the cesium and cobalt irradiators in the United States have been replaced or are in the process of being replaced with X-ray devices through GMS's Cesium Irradiator Replacement Project. New York City and the University of California are leading this trend by replacing around 80 percent and 90 percent of their irradiators, respectively, including 100 percent of their blood irradiators."

Despite this trend in X-ray irradiator use, some researchers are not yet ready or able to move away from cesium and cobalt devices. The DNN project with Stellarray Inc. aims to address most of the X-ray technology challenges for these users, which may include:

- X-ray irradiators are more complex than radioactive source-based devices, raising a concern about potential maintenance issues, even though newer models are generally perceived as reliable;
- Some X-ray irradiators require complex cooling systems;
- X-ray irradiators have trouble maintaining dose delivery for long-exposure studies; and
- X-ray radiation is less penetrating than cobalt or cesium, making it less suitable for research studies that require deeper doses.

"Stellarray is developing a highly novel X-ray source that will enable X-ray irradiators to overcome many of these challenges and exceed the performance of existing cesium, cobalt, and X-ray irradiators," according to Mark Eaton, President and CEO of Stellarray Inc.

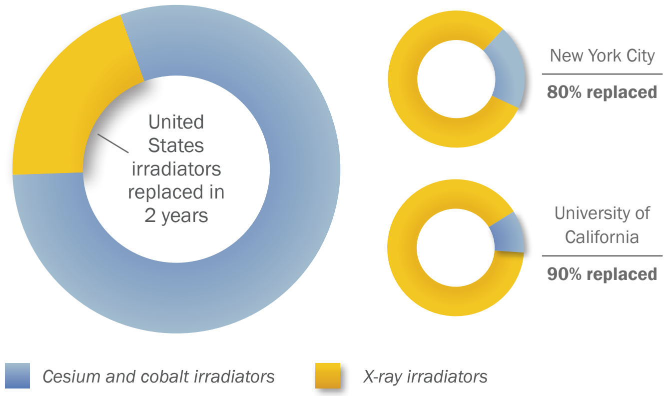
The key development is a flat panel X-ray source rather than the point source X-ray tube that is typical in current models.



The principle of operation for the Stellarray blood irradiator is to have two flat panel X-ray sources, one above and one below the blood bag to be irradiated. When compared to traditional X-ray tubes, the flat panel design enables a more uniform dose, a smaller irradiation chamber, and a simpler cooling system.

GMS's Cesium Irradiator Replacement Project has replaced one-fifth of cesium and cobalt irradiators in the United States in the past two years.

New York City and the University of the California are leading the way.



This allows for a simpler irradiator that is easier to cool, is smaller and lighter, delivers a more uniform dose, and requires less power to operate. The models under development include three different sized blood irradiators and three models of research irradiator. The three models offer different benefits: one provides a very uniform dose with higher energy X-rays, one is designed for long exposure studies, and one provides doses within a small defined area of a sample – a capability that is desirable in cellular and other small sample research that no competing technology device can provide. These models are expected to be commercially available by 2020, starting with the blood irradiators.

DNN has played a key role in the development of these novel irradiators through the DOE Small Business Innovative Research (SBIR) grant. DNN's Office of Research and Development funded two SBIR grants for both phase 1 and phase 2 of the blood and research irradiator projects to develop working prototypes. GMS is currently funding two phase 3 SBIR projects to bring these irradiators to commercialization.

"Having these additional X-ray models on the market will help extend the current trend in cesium irradiator replacement and help NNSA meet the goal laid out in the FY 2019 National Defense Authorization Act of 'eliminating the use of blood irradiation devices in the United States that rely on cesium chloride by December 31, 2027,'" said Butler.

Stellarray was formed in 2008 as a spin-off from Stellar Micro Devices. In addition to DNN, Stellarray received support from the National Institute of Standards and Technology, the National Institutes of Health, and the Texas Emerging Technology Fund, a fund created by Secretary of Energy Rick Perry while serving as the Governor of Texas.

A complete, operational prototype blood irradiator using Stellarray's novel flat panel X-ray sources.

Lance Garrison manages the Domestic Alternative Technology Portfolio, including the Cesium Irradiator Replacement Project, in DNN's Office of Radiological Security. He previously served DNN's Office of Research and Development as a 2015 NNSA Graduate Fellow.

Joule Award Creates Energy Across Labs

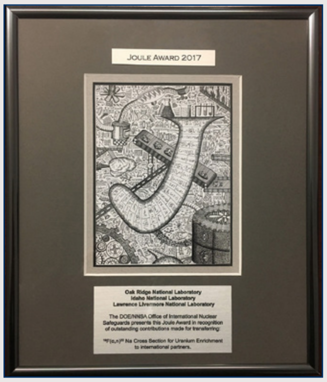
By Jason Shepherd

In accordance with the Government Performance and Results Modernization Act of 2010, the Department of Energy sets targets for, and tracks progress toward, achieving performance goals for each of its programs. One of these programs is the Office of International Nuclear Safeguards, which commits to a yearly goal of transferring five safeguards tools, technologies and methods to the International Atomic Energy Agency and other international partners.

OINS is in the Office of Nonproliferation and Arms Control and works closely with the Department of Energy laboratories to develop new safeguards technologies and identify promising ones for transfer. This coordination has led to over 50 transferred tools, technologies and methods since 2008. Developing new nuclear safeguards technologies for transfer is vital to national security because it helps ensure the continued peaceful use of nuclear material, equipment, and expertise. This work improves the IAEA's and partner countries' efficiency and effectiveness by providing the tools, technologies, and methods they need to continually monitor, measure, and control nuclear material.

When Dr. Arden Dougan became program director of the OINS Safeguards Technology Development Program in 2015, she noticed that even though the NNSA was successful in meeting this metric every year, the labs were not getting the recognition they deserved. In 2017, Dougan created the Joule Award, presented to national laboratories and researchers whose technologies are transferred to international partners within the fiscal year and meet the criteria for the metric.

"We needed a way to show the labs that we appreciate their hard work, and I thought we could present them something tangible they could hang on their wall," Dougan said. "Internally, we called this requirement the JOULE metric, so it was an easy jump to call this the Joule Award."



FY 2017 Joule Award shared by three national laboratories. (Joule artwork used with permission.)

The Joule Award is named after James Prescott Joule, an English physicist and mathematician who studied the nature of heat and discovered its relationship to mechanical work, leading to the law of conservation of energy. In creating the actual award, the OINS team licensed the "J" in Robert A. Friedenberg's *Physics Alphabet Book*.

continued on page 9

National Laboratories Play Key Role in Mo-99 Health Care Industry

By DNN's Office of Material Management and Minimization

Since 2010, DNN has granted laboratories over $100 million to assist U.S. industry in advancing innovative molybdenum-99 (Mo-99) technologies that do not use highly-enriched uranium (HEU).

Technetium-99m (Tc-99m), the decay product of Mo-99, is used in approximately 80 percent of all nuclear medical diagnostic procedures and in roughly 40,000 diagnostic and therapeutic nuclear medicine procedures every day in the United States. Tc-99m's primary uses include diagnosing heart disease, treating cancer, and studying organ structure and function.

The U.S. medical community depends on a reliable supply of the radioisotope Mo-99 for nuclear medical diagnostic procedures. Mo-99's short half-life and excellent binding properties make it uniquely suited for medical procedures, but its 66-hour half-life also makes it impossible to stockpile.

Prior to 2018, the United States did not have the capability to produce Mo-99 domestically and consequently imported 100 percent of its supply from international producers. Some of that was produced using proliferation-sensitive HEU.

Technical difficulties and shutdowns in 2009 and 2010 at the major international Mo-99 production facilities caused serious supply shortages in the United States. The shortages spurred Congress to pass the American Medical Isotope Production Act of 2012 directing DOE/NNSA to establish a reliable domestic supply of Mo-99 produced without the use of HEU.

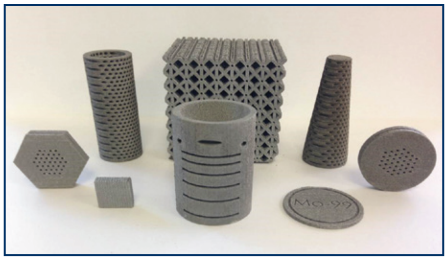
"Our goal is to enhance U.S. national security and minimize the use of HEU in civilian applications by enabling U.S. industry to reliably produce Mo-99, without the use of HEU," said Peter Karcz, DOE/NNSA's Mo-99 Program Manager.

Argonne National Laboratory designed and built a full-scale dissolver to dissolve irradiated molybdenum targets. (Photos courtesy of M3)

Using the National Laboratories' unique technical expertise and state-of-the-art facilities is a natural fit to help DOE/NNSA accomplish this important nonproliferation and health care goal. "Our ability to collaborate and work closely with our Lab partners perfectly positions us to assist U.S. isotope producers in developing their Mo-99 production capabilities," Karcz added.

DOE/NNSA's Mo-99 Laboratory and Partnership Support team consists of closely coordinated efforts from a variety of laboratories and sites including Argonne National Laboratory, Oak Ridge National Laboratory, Savannah River National Laboratory, Los Alamos National Laboratory, Pacific Northwest National Laboratory, and the Y-12 National Security Complex.

The team supports an array of domestic Mo-99 projects ranging from the more traditional low-enriched uranium target technologies, to the more novel



Several molybdenum accelerator target shapes produced by 3-D printing at Oak Ridge National Laboratory.

accelerator-driven processes that produce Mo-99 from a uranium solution or a Mo-98/Mo-100 target, as well as experimental technologies that produce Mo-99 using fusion techniques.

In February 2018, NorthStar Medical Radioisotopes in Wisconsin, a DOE/NNSA cooperative agreement partner, received U.S. Food and Drug Administration approval for its RadioGenix system which will provide for the first domestic production of Mo-99 without HEU in 30 years. The National Laboratories played a critical

Mo-99 – *Continued*

role in meeting this milestone by maturing crucial technology and components for NorthStar's neutron-capture process and by generating test data to support NorthStar's licensing submittals.

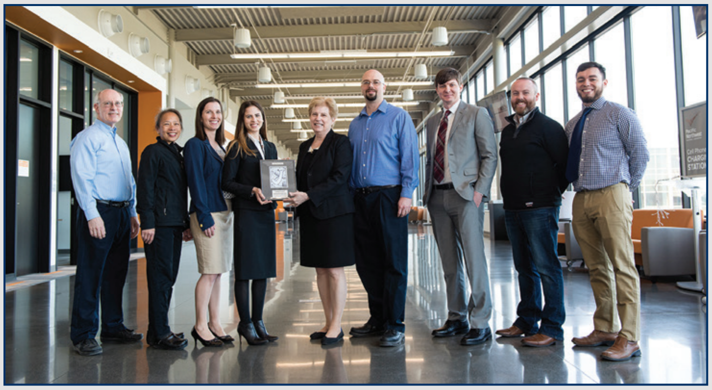
Today, the National Laboratories work closely with over a half-dozen U.S. industry partners and use capabilities at the Low Enriched Accelerator Facility at Argonne and the High Flux Isotope Reactor at Oak Ridge.

The Laboratories have designed, developed and fabricated critical Mo-99 production components, tested production materials and welds, optimized uranium extraction and fuel fabrication processes, and adapted and transferred tritium purification technology. The National Laboratories and sites will continue to assist in the development of new Mo-99 production technologies to support DOE/NNSA's goal of establishing reliable domestic supplies of Mo-99 without the use of HEU, and ultimately, will directly influence the quality of health care for millions of U.S. patients.

"We are excited about progress made thus far on the domestic Mo-99 production front, and look forward to future successes on this critical national security mission," Karcz said.

Pete Karcz graduated from the U.S. Naval Academy with a B.S. in Mathematics and attended the Navy's Nuclear Power School. Since 1991, he has been assigned a variety of positions in the Department of Energy including the Deputy Director of the Actinide Recycle Division in the Office of Nuclear Energy and Director of the Office of Environmental and Regulatory Analysis in DOE's Office of Environmental Management. Karcz has worked in NNSA's Office of Defense Nuclear Nonproliferation for the past 18 years in the capacity of Deputy Director of International Programs and Senior Program Manager for the Mo-99 Uranium Lease and Take-Back Program. He is currently assigned as the Mo-99 Program Manager in M3.

Award – *Continued*



The Single Use Destructive Assay (SUDA) coupon team: (from left) Bret Cannon, May-Lin Thomas, Chelsie Beck, Cristina Padilla-Cintron, Arden Dougan, Richard Clark, Tim Pope, Chris Barrett, and Rodrigo Guerrero. Norm Anheier is not pictured.

In April 2019, Dougan presented Pacific Northwest National Laboratory with two of the six Joule Awards for Fiscal Year 2018. The first was shared with Oak Ridge National Laboratory and was for a Single-Use Destructive Assay (SUDA) coupon designed to collect samples during on-site gaseous enrichment plant safeguards inspections conducted by the IAEA. The SUDA coupon is a way to collect a much smaller quantity of material into a stable, non-toxic, solid form that is safer to handle and transport than gaseous uranium hexafluoride. IAEA inspectors collects samples of uranium hexafluoride in enrichment plants to check material accounting and confirm state's declarations.

The second award went to a Particle Reference Materials for Quality Control project that provides the IAEA a reliable supply of certified particle standards for calibration, quality control, and validation of large-geometry secondary ion mass spectrometers (LG-SIMS) in the IAEA Network of Analytical Laboratories. This aids the analysis of IAEA environmental swipe samples. The IAEA collects and analyzes environmental samples to detect the absence of undeclared nuclear activities.

"It was a great honor that PNNL received two Joule awards in FY 2018," said James Ely, PNNL Project Manager of Safeguards Technology. "This type of recognition is an exceptional motivation for the project teams."

Lawrence Livermore National Laboratory and Los Alamos National Laboratory were also recognized in Fiscal Year 2018 with each receiving two Joule Awards. In total, OINS has presented 13 Joule Awards since its inception in 2017.

"The superb work of our labs in the development of safeguards technologies is crucial to ensuring a strong and effective international safeguards system." added Dr. Kevin Veal, Office Director for OINS. "The workforce in the DOE complex is so amazing and being able to recognize them for their efforts helps to show how much we value them in the success of our mission. That's why this Joule Award is such a great idea."

Process Intensification: How Advances in Chemical Engineering Enable Radioxenon Monitoring for Nuclear Explosions

By DNN Research & Development

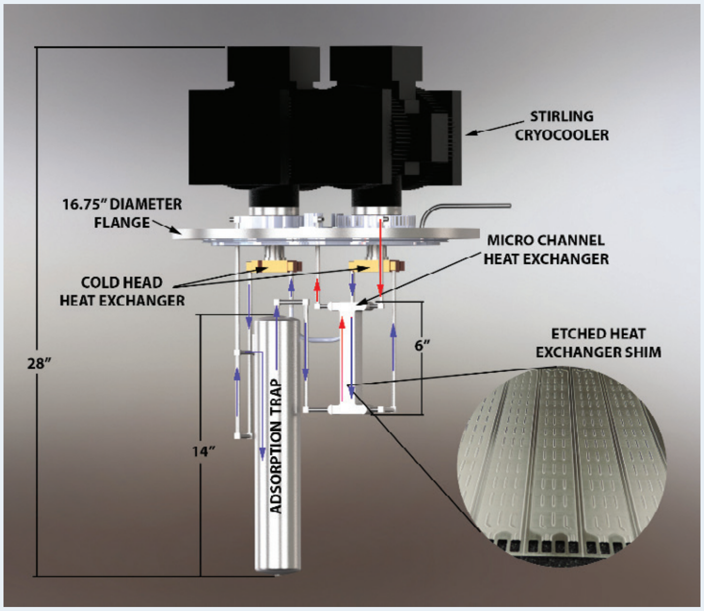
Detection of xenon isotopes is a proven and important method for distinguishing nuclear explosions from other explosions or earthquakes. Radioxenon is a product of nuclear explosions that can reach the detector without reacting with chemicals in the air or soil because xenon is a noble gas.

"The radioxenon isotopes (^{131m}Xe, ^{133}Xe, ^{133m}Xe, and ^{135}Xe) are of high value in identifying nuclear explosions," said Dr. Jim Hayes, lead principal investigator for the development of unattended radionuclide collection and measurement capabilities at Pacific Northwest National Laboratory (PNNL). Researchers at PNNL have incorporated substantially smaller, faster, and more energy-efficient processes to produce a next-generation radioxenon monitoring system called "Xenon International" which is now commercially available. Commercialization is a necessary step in making the system sustainable and available to national and international monitoring organizations.

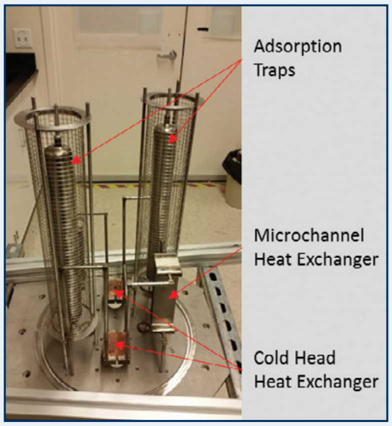
"The goal was to create a system with improved sensitivity by increasing the throughput of air sampled, while minimizing system size and energy consumption," added Dr. Paul Humble, a senior chemical engineer at PNNL. Extracting the xenon isotopes from air is the focus of noble gas monitoring systems with the chemical engineering goal of maximizing the amount of activity in the gas sample measured in the nuclear detector.

Development priorities for Xenon International included improving the energy efficiency, reducing the physical size and eliminating consumables which are important to keeping the system operating unattended for lengthy periods of time. For xenon collection, the use of low-temperature activated charcoal minimizes the size and mass of the xenon collection trap while increasing xenon concentration. The small size and mass enables faster heating and cooling, reducing the energy needed to regenerate the charcoal trap. To effectively use low temperature xenon collection techniques, researchers turned to advanced microchannel heat exchanger technology developed at PNNL.

PNNL has created the Xenon International next generation radioxenon monitoring system, now commercially available.



The Xenon International adsorption trap includes the Stirling cryocoolers to cool the air flow connected to the cold head heat exchangers and showing the microchannel heat exchanger, which is used to recuperate the lost cold used for precooling the airflow.



Closer view of the adsorption trap, cold head heat exchanger, and the microchannel heat exchanger.

"The careful engineering design of Xenon International has enabled a next generation radioxenon monitoring system," said Hayes. "The Xenon International system collects and separates roughly twice the amount of xenon in half the time as previous systems, resulting in the ability to detect nuclear testing at the most remote places on earth."

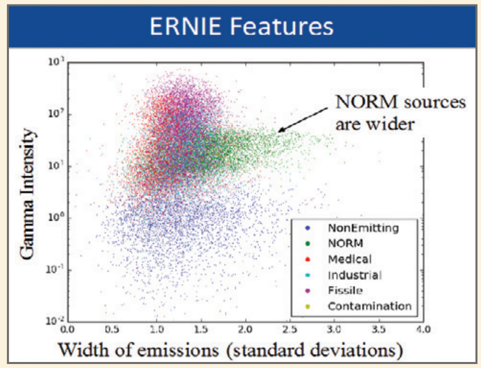
Paul H. Humble, Ph.D., is a senior chemical engineer. He joined PNNL in the fall of 2005. At PNNL, Humble has been involved in developing gas separation techniques, including temperature and pressure swing adsorption processes, gas chromatography, distillation, and microchannel based techniques. Humble's work has involved the development of microchannel based reactors and heat exchangers for a number of processes, as well as modeling complex systems that include heat and mass transport, chemical reactions, and thermodynamics.

James C. Hayes, Ph.D., is the lead principal investigator for the development of autonomous in-field radionuclide collection and measurement capabilities at PNNL. Hayes has worked in the area of radiation detection systems and nuclear technologies since 1997. His main focus area has been in developing radionuclide measurement capabilities used to verify signatory countries' compliance with treaties covering nuclear development and testing.

Addressing Radiation Portal Monitor Nuisance Alarms with Machine Learning

By Paul Dimmerling and Donald Hornback

DNN's Office of Global Material Security (GMS) has deployed radiation portal monitors (RPMs) at many locations around the world as part of its mission to prevent nuclear smuggling. RPMs scan cargo for the presence of special nuclear and radioactive materials. However, they also detect naturally occurring radioactive material (NORM) that is present in many commercial goods that pass through official crossing points, such as ceramic goods. GMS is working to reduce nuisance alarms through the use of advanced machine learning algorithms to help operators of RPMs focus on alarms of concern and screen out NORM alarms. This work is being carried out in collaboration with DNN's Office of Research and Development (DNN R&D). Recently, DNN R&D supported a feasibility study of an algorithm called Enhanced Radiological Nuclear Inspection and Evaluation (ERNIE) that shows strong promise when applied to systems deployed by GMS.



ERNIE analyzes RPM data on alarm duration and emission rate to find trends that help identify when an alarm is caused by naturally occurring radioactive material (a nuisance alarm).

ERNIE originally was developed and implemented by Lawrence Livermore National Laboratory and Carnegie Mellon University to address reduction of NORM alarms for U.S. Department of Homeland Security Customs and Border Protection and Domestic Nuclear Detection Office. ERNIE uses a machine learning approach from tens of thousands of transits of cargo through RPMs to identify unique features which indicate an anomaly or signature that traditional algorithms can miss.

The DNN R&D-supported research effort determined that the ERNIE machine learning approach is effective when applied to the GMS RPM systems and that it could greatly reduce the nuisance alarm rate at some busy crossing points. With these promising results, GMS seeks to conduct some field trials in FY 2019. GMS also plans to evaluate the algorithm against program performance goals and prepare ERNIE for possible deployment on systems with interested partner countries.

Paul Dimmerling is a general engineer at DOE/NNSA Headquarters and Deputy Manager of the Science and Engineering Team that carries out technical efforts for the Nuclear Smuggling Detection and Deterrence Program. He has degrees in Mechanical Engineering and Health Physics with an additional ten years of experience managing detector development and testing projects to design, test, and evaluate radiation detection equipment for national and international security applications.

Donald Hornback is a Senior Program Manager within DNN R&D for Near Field Detection that supports research and development for improved radiation detection capabilities at the National Laboratories in detection materials, instrumentation, nuclear data, and detection system design and prototyping.

Benchmark Signatures Data from Nuclear Weapons in Support of National Security

By Lt. Col. Michael Koehl and Riad Manaa

A fully assembled nuclear weapon generates unique signatures that reveal a wealth of information regarding its design and material characteristics. This information could be used in support of several national security missions such as nuclear nonproliferation, arms control, and stockpile stewardship.

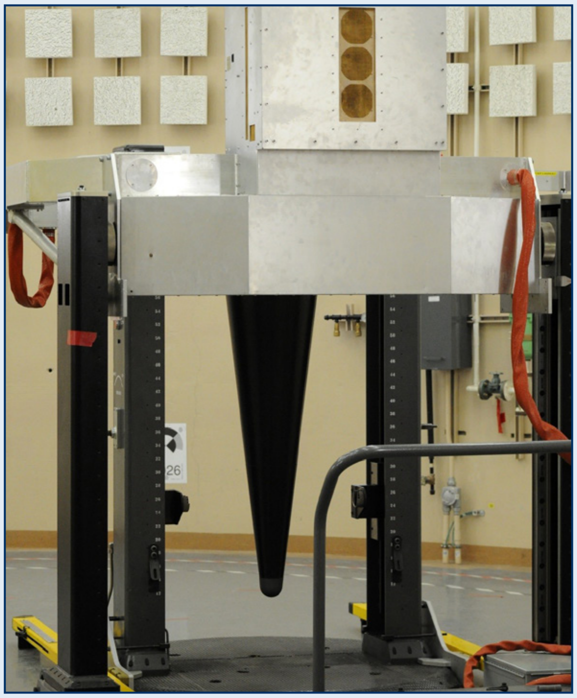
For example, future arms control treaties may require more invasive measurements to ensure a nuclear warhead is as declared. A set of benchmarked signatures could be used to probe the warheads against the purported declaration with a much higher level of confidence. Furthermore, a validated and reliable set of signatures could serve to enhance the assessment capabilities in emergency response scenarios involving a suspected nuclear threat device.

To begin to explore the potential of these measurements, DNN's Office of Research and Development (DNN R&D) sponsored a multi-year weapon measurement campaign to acquire a set of radiation signatures from the U.S. nuclear stockpile.

This recently completed, multi-phase campaign was conducted at the Pantex Plant and the Y-12 National Security Complex. Researchers from Los Alamos, Lawrence Livermore, Sandia, Idaho, and Oak Ridge national laboratories designed measurements of neutron and gamma emissions and collected tomographic, spectroscopic, and materials characterization data from several different U.S. stockpile weapons and components. These weapons represent a cross-section of the U.S. stockpile that include tactical and strategic gravity bombs and a missile warhead.

The campaign allowed National Laboratory scientists to deploy and apply their state-of-the-art detection and measurement capabilities outside of the confinement of laboratory research and in real-world conditions. It also allowed researchers from the United Kingdom's Atomic Weapon Establishment to observe the early phases of this effort.

Significant technological advances including high-speed digital electronics, cheap mass storage, multiplicity counting, and imaging presented a nascent opportunity for the effort. Researchers on future projects will have the opportunity to analyze the archived data and identify gaps or areas for improvement in these capabilities. These efforts will enable a more robust modeling and simulation capability to support national security missions.



The Vertical Pantex Scanner scans the W76/Mk4 Warhead for benchmark signature data.

The final phase of this project operated at the intersection of cutting-edge technology and nuclear explosive safety. The unique challenge of this environment necessitated a technically rigorous Nuclear Explosive Safety Study, conducted by NNSA's Defense Programs. This comprehensive review was required to introduce R&D equipment into a production environment with strict rules and processes geared toward nuclear safety.

"This effort would not have been possible without the support of Defense Programs, which helped researchers address the safety and security requirements associated with working with nuclear weapons," said Craig Sloan, director of DNN R&D's Office of Proliferation Detection. "I also want to thank the Offices of Nonproliferation and Arms Control and of Nuclear Incident Response for providing additional resources. Overall, I was very pleased with how the Warhead Measurement Campaign concluded."

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