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Office of Research, Development, Test, and Evaluation

Stockpile Stewardship *Quarterly*

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Message from the Assistant Deputy Administrator for Research, Development, Test, and Evaluation, Dr. Kathleen Alexander

It is an exciting and extremely busy time within the Office of Research, Development, Test, and Evaluation (RDT&E). We recently briefed congressional staffers on the National Nuclear Security Administration (NNSA) portions of the Fiscal Year 2018 President's Budget Request. Additionally, I am pleased to welcome aboard several new federal staff whose biographies are highlighted in this issue. The remainder of the *Stockpile Stewardship Quarterly* highlights some of the exciting work within RDT&E.

The first technical article showcases a highly effective collaboration between Lawrence Livermore National Laboratory, Sandia National Laboratories, Kentech Instruments Ltd., and General Atomics that has led to a major breakthrough in high-speed imaging diagnostics for high-energy-density experiments in support of the Stockpile Stewardship Program.

The Laboratory Directed Research and Development program at the laboratories enables high-risk research and development (R&D) at the NNSA laboratories and serves as a proving ground for advanced R&D concepts that are often subsequently pursued by NNSA programs and other federal agencies. The second article describes nuclear physics and chemistry research that paves the way for an advanced treatment of cancer. We close this issue with a new federal employee's perspective following a tour of an Air Force nuclear weapons base. Last but not least, congratulations to the winners of the poster session at the well-attended 2017 Stewardship Science Academic Programs Annual Review Symposium held in Naperville, Illinois (see photos above).

Continue the great work in support of RDT&E programs!

Stewardship Science Academic Programs (SSAP) Annual Review Symposium, April 12-13, 2017. Attendees discuss cutting edge research during the Poster Session held on the first evening. This year's symposium, held in Naperville, Illinois, hosted a record number of attendees. See page 8 to learn more and for a list of the poster winners.

Inside

Comments

The *Stockpile Stewardship Quarterly* is produced by the National Nuclear Security Administration (NNSA) Office of Research, Development, Test, and Evaluation. Questions and comments regarding this publication should be directed to Terri Stone at terri.stone@nnsa.doe.gov.

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Multi-Institution Collaboration Achieves Major Breakthrough in High-Speed Imaging

by Terance Hilsabeck (General Atomics)

Fast-gated imaging diagnostics are a key element of high-energy-density (HED) experiments in stockpile stewardship. For example, in implosion experiments, this capability enables recording the symmetry and duration of hot spot formation and the ability to investigate problems in the fuel assembly process. Unfortunately, existing sub-nanosecond x-ray cameras are unable to capture more than one frame from a single input image due to their reliance on microchannel plate (MCP) detectors. In November 2016, a multi-institution collaboration led to a major breakthrough in high-speed imaging diagnostics for HED experiments. The new device is a single line-of-sight (SLOS) x-ray imager that provides multi-frame two-dimensional imaging with a shutter speed of 25 picoseconds–the time it takes light to travel about a quarter of an inch. Instead of an MCP, the SLOS camera utilizes a burst-mode complementary metal oxide semiconductor (CMOS) sensor.

Figure 1. Team members involved in the SLOS development collaboration. Clockwise from upper left: General Atomics, Kentech Instruments, Sandia National Laboratories, and Lawrence Livermore National Laboratory.

This breakthrough sensor is capable of recording multiple frames with nanosecond separation. It represents a 50-fold improvement in shutter speed over previous devices. The shutter speed of the CMOS sensor is further increased by 100x by coupling it to a "temporal zoom lens," also known as a pulse-dilation electron tube. This achievement was made possible by an unusual and highly effective collaboration between Lawrence Livermore National Laboratory (LLNL), Sandia National Laboratories (Sandia), Kentech Instruments Ltd., and General Atomics (GA) (see Figure 1).

Multiple Temporal Frames

High-speed SLOS imaging enables several key improvements to conventional data acquisition systems. The sub-nanosecond gated MCP detectors that are currently used for self-emission imaging of imploding inertial confinement fusion (ICF) cores are limited to a single frame capture per shot. In order to obtain a time series, many x-ray images are projected onto the detector using an array of pinhole optics by sweeping the gate across the active area of the detector. Unfortunately, the reliance on pinhole optics limits both the resolution and the signal-to-noise ratio of the images. More advanced x-ray optics (e.g., Kirkpatrick-Baez or Wolter microscopes) improve x-ray image quality, but the complexity and expense of these devices make it impractical to construct a separate optic for each temporal frame. The new SLOS technology, by contrast, provides a fast imager capable of capturing multiple temporal frames, complementing these advanced x-ray optics.

Point projection backlighting will also benefit. In this approach, a radiograph is produced by generating an x-ray source very close to the target under study. However, a conventional point-projection system requires different lines of sight for each temporally separated frame. That introduces uncertainty into the measurement, since differences between frames could be due either to variations in time or to the changing view angle. The SLOS imager can capture multiple frames from a single long-pulse backlighting source without parallax, which is a displacement or difference in the apparent position of an object viewed along two different lines of sight. This will greatly improve the accuracy of radiograph interpretations (i.e., changes are only due to time evolutions of the hot spot.)

A Merger of New Technologies

Sub-nanosecond, multi-frame SLOS imaging was achieved by integrating two recently developed high-speed imaging technologies: electron-pulse dilation imagers and nanosecond-burst-mode CMOS sensors.

The first is used in the Dilation X-ray Imager (DIXI) instrument at the National Ignition Facility (NIF). An electron-pulse dilation imager creates a "temporal zoom lens" by converting the incident photon signal into electrons by the photoelectric effect, and it then stretches that electron signal with a chirped accelerating potential. But DIXI's image capture device is a conventional MCP detector, and it is thus limited to single-frame recording.

Burst-mode CMOS sensors were developed under the Ultrafast X-ray Imager (UXI) project[1] at Sandia, and they are able to achieve nanosecond-scale, multi-frame image recording by storing data locally in pixel during the fast event and reading off, post-shot. However, the physics of signal propagation on the chip limit the gate speed to around a nanosecond, which is too slow for time-resolved core imaging.

Scientists from the multi-institution collaboration realized that these two technologies complement each other, and that combining them could lead to the development of a transformative diagnostic for HED science. The team faced several technical challenges in operating a burst-mode CMOS sensor inside an electron pulse–dilation tube. First, the CMOS sensor has 160 electrical connections that must penetrate the vacuum barrier of the electron tube. In addition, the sensor's photodiode array was originally designed to detect visible light and 6 keV x-rays. Detecting electrons would require tripling the electron energy in the tube. Also, adequate radio-frequency shielding would be necessary because the photocathode at the input end of the SLOS instrument is excited at the kilovolt level, while the sensor–which sits only 50 cm away–is recording millivolts.

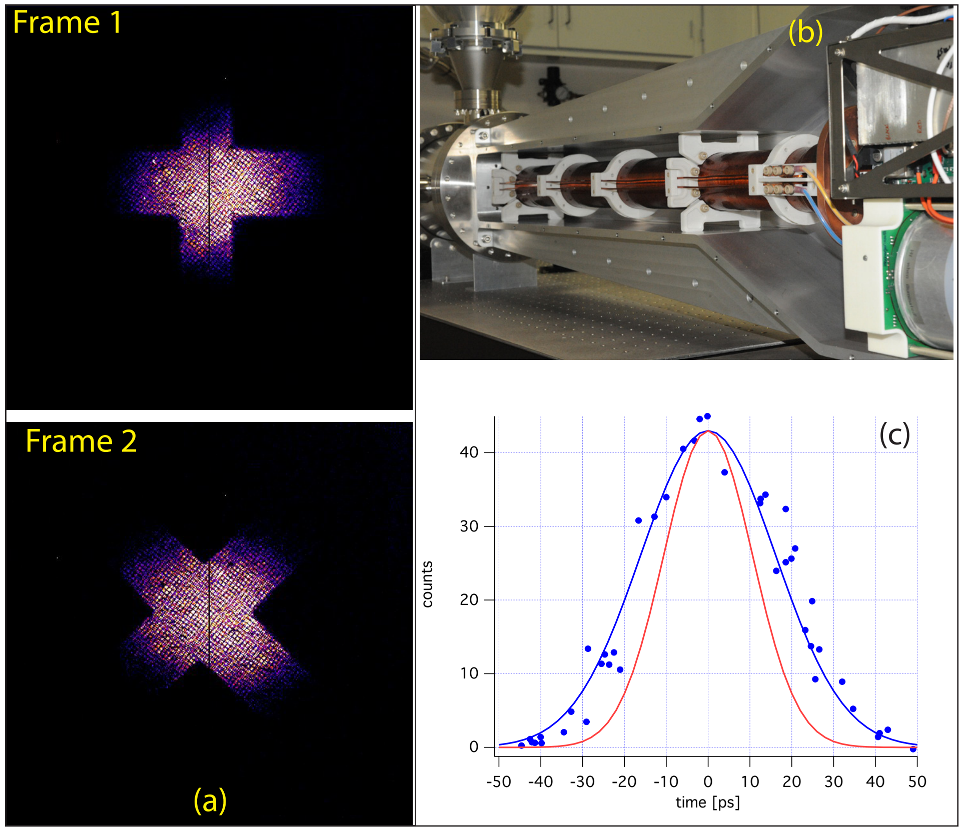

Figure 2. (a) Independent frame capture of two laser pulses separated by 100 ps. (b) Electron drift tube for SLOS camera used at LLE's Omega Laser Facility. (c) Gate width profile measurements and fit. Red curve represents inferred camera gate after adjusting for probe laser pulse width.

Measurement Challenges

Another major challenge in development of the SLOS was obtaining the proper potential ramp across the electron accelerating gap. In order to achieve uniform temporal magnification over the approximately 200 picoseconds (ps) recording interval, the temporal profile of the acceleration potential had to be controlled to within tens of volts over tens of ps. But this level of accuracy is difficult to measure or precisely control inside a vacuum tube.

To solve this problem, Kentech scientists developed a new type of high-voltage electronic driver that produces a very fast rise time electrical pulse with a programmable output waveform. The high-voltage waveform temporal profile is controlled by adding up eight individual voltage steps with adjustable relative time delays. This device provides great flexibility in shaping the ramp pulse.

Measuring the voltage on the photocathode at the required bandwidth was also a major challenge. Physicists at GA developed a method for measuring the times required for electrons to drift down the tube and used those drift times to infer the voltage present when the electrons were emitted. To do it, they integrated hardware into a computer-controlled optimization routine that fired many thousands of shots, then searched the large parameter space of step delays to find the correct settings for the tube.

A Long Road to Success

Kentech's Jonathan Hares and Tony Dymoke-Bradshaw first proposed pulse-dilation imaging in the 1980s, but early attempts to build a working device based on this idea were unsuccessful. In 2008, the approach was revisited as a method to achieve better temporal resolution for x-ray imaging at the NIF. The next year, Kentech Instruments and GA collaborated on a demonstration device.[2] A follow-on project with LLNL produced the DIXI instrument, which achieved 10 ps temporal resolution x-ray imaging and was installed on the NIF in 2011.[3]

The UXI project began at Sandia in 2006 with the goal of creating a multi-frame, nanosecond-gated, solid-state imaging sensor by leveraging the integrated circuit fabrication resources at Sandia's Microsystems & Engineering Sciences Applications (MESA) facility. The initial application centered on 6 keV crystal backlit imaging at Sandia's Z Pulsed Power Facility.

By 2012, the UXI team had a working prototype 15 x 128 pixel sensor known as Griffin. At that time, the DIXI team was looking for a way to create a ps multi-frame camera to further improve x-ray imaging at the NIF. An initial attempt using a fast-decay phosphor MCP detector demonstrated that this technique was cumbersome and did not scale advantageously to many frames.

LLNL's Perry Bell was aware of the UXI work at Sandia and suggested contacting Sandia to discuss the potential for collaboration. A small group met for the first time at GA in San Diego in December 2012, and a few months later the Griffin sensor was operated in an electron drift tube at GA. The results looked promising, and the SLOS project was born.

In November 2016, the first prototype SLOS camera captured two frames spaced by 100 ps (Figure 2a). This instrument was then reconfigured for use at the Laboratory for Laser Energetics (LLE) Omega Laser Facility (Figure

2b) and achieved a 25 ps gate width (Figure 2c). Another camera is currently being assembled for the NIF, and it will be coupled to a crystal backlit imager to give late-stage radiographs of imploding capsules. The collaborative team also has plans for a two-sensor instrument to be used with a Kirkpatrick-Baez microscope system at the NIF and a hardened instrument to be used at Z.

The coupling of pulse-dilation and nanosecond-gated CMOS imaging is a revolutionary step forward in high-speed imaging, achieved through a unique collaboration. Sandia developed the nanosecond-gate burst-mode CMOS sensor; Kentech developed the concept of pulse-dilation imaging and the high-voltage pulser electronics, which drive the electron tube; LLNL developed camera software and test facilities for sensor characterization; and GA designed and built a pulse-dilation tube, which incorporated the CMOS sensor, and performed the first demonstration experiments.

Each collaborating institution was indispensible to the success of the project and the manner in which they supported and complemented each other was as impressive and enjoyable as the resulting technical achievement itself.

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Nuclear War Against Cancer *by Craig Tyler (Los Alamos National Laboratory)*

Exposure to nuclear radiation causes cancer—and sometimes cures it. But radiation, like chemotherapy, can be an indiscriminate killer, attacking cancerous and healthy cells alike. The damage to healthy cells can be quite widespread, which is why the prospect of cancer treatment often generates apprehension nearly on par with the cancer itself.

However, a treatment called targeted alpha therapy (TAT) delivers specialized, radioactive isotopes, or radioisotopes, directly to cancerous tumors within a patient's body. There, cell-killing radiation from the radioisotope bombards cancer cells while minimizing damage to the surrounding healthy tissue (see Figure 1). The key to success is multi-pronged, requiring the ideal radioisotope to obliterate the tumor, a biological delivery system to get it there, and a specialized molecule that holds the radioisotope tightly within the delivery system.

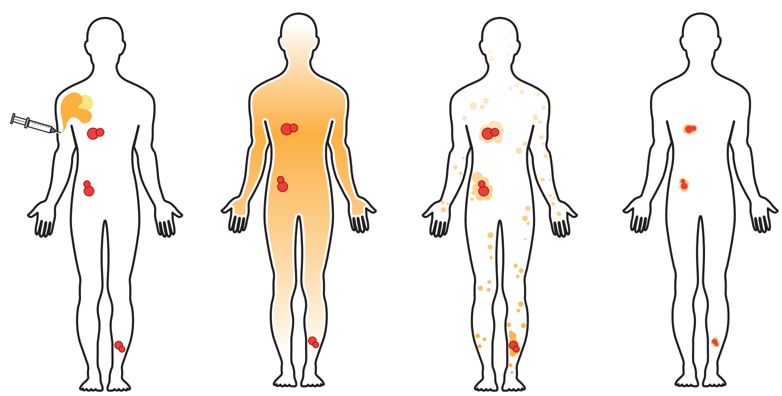

Figure 1. Targeted alpha therapy (TAT) process. Image courtesy of Donald Montoya (Los Alamos National Laboratory).

TAT targets cancer cells that express a distinctive antigen on their outer surfaces. An antibody specific to that antigen is attached to the radioisotope, and when the antibody encounters its antigen, that means the medicine has reached the tumor, even if tumors are scattered all over the body. Not all cancers produce a distinctive antigen for targeting, and therefore not all cancers can be treated with TAT, but those that do include heavy hitters such as prostate cancer, colorectal cancer, melanoma (skin), leukemia (bone marrow), and non-Hodgkins lymphoma (blood). While several successful antibodies have been demonstrated in early clinical work, finding strong antibody candidates for more cancer types is an active area of research that still faces many challenges.

Eva Birnbaum runs the Los Alamos program for isotope production and

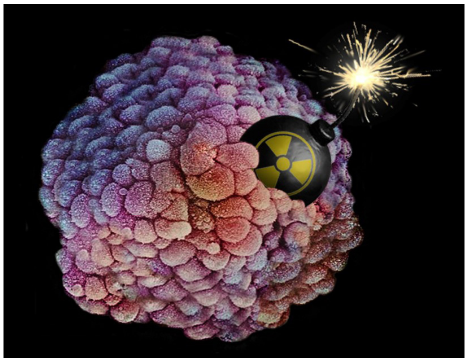

Figure 2. A short-lived, highly radioactive isotope that is selectively delivered to cancerous cells within the body could change humanity's fortune against several particularly deadly types of cancer. Image courtesy of Donald Montoya (Los Alamos National Laboratory).

applications, sponsored by the DOE Office of Science, and Kevin John leads the national tri-lab isotope effort, which engages the Los Alamos, Oak Ridge, and Brookhaven national laboratories to produce TAT isotopes. While other researchers work to refine the antibodies, Birnbaum and John focus on finding and demonstrating the most effective radioisotope for treatment—and then making a lot of it. "The optimal radioisotope needs to do two almost contradictory things," John explains. "It has to deliver a powerful dose of radiation to kill the tumor completely—without damaging healthy tissue in the immediate vicinity of the tumor and without lingering too long in the patient's system. It has to show up, do its job, and then go away."

Birnbaum and John believe the tri-lab team has found its winner with the isotope actinium-225, which undergoes radioactive decay by emitting an alpha particle. Being far more massive than the particles produced by any other form of radioactivity, alpha particles are released with high energy and relatively slow speed. As a result, they deliver a powerful punch in a short distance—typically only a few cell diameters—thereby affecting the tumor cells but not many of the surrounding healthy cells.

Actinium-225 also has the benefit that, after its nucleus decays by expelling an alpha particle, what's left behind is no longer actinium-225 but francium-221, which is also an alpha emitter. So, too, are the next two decay products, for a total of four alpha particles for every atom of actinium-225. So a little goes a long way. "The four alphas are especially important," Birnbaum says. "It's like repeated hammer blows in the same spot. After the initial hit, each successive impact multiplies the damage."

Additionally, actinium-225 has a half-life of just 10 days—long enough that most of the administered dose has time to reach the tumor before decaying but short enough that very little of it lingers in a patient's body in the months following treatment. (Francium and its decay products have a half-life of only minutes or seconds.) The short timescale in which the isotope's powerful four-alpha radiation dose is concentrated and its subsequent radiological inertness are what make actinium-225 such an ideal nuclear weapon against cancer.

For all these reasons, actinium-225 is a promising agent for TAT, but there's still that business of finding a delivery system to get the radioisotope where it needs to be and not lose it along the way, as the radioisotope is toxic to healthy tissue. In fact, TAT can only become a reliable cancer treatment if actinium-225 securely binds to a chelator—a molecule that traps the isotope in the antibody so that it gets delivered to the tumor and not released freely in the body.

So far, widespread clinical utility of actinium-225 has been hindered by limited supply, as well as radiotoxic side effects that result from detachment of the radioisotope from its antibody-based delivery system. The tri-lab effort is addressing the supply, but the design of chelator molecules that hold on to actinium under biological conditions has been impeded by a lack of fundamental knowledge of this rare, highly radioactive element.

That's where the Laboratory Directed Research and Development (LDRD) program at Los Alamos comes on the scene. Birnbaum is leading an LDRD project specifically geared toward gaining a better understanding of the chemistry of actinium. "Imagine if someone gave you the element iron and nothing was known about it. That's almost the same place we were in with actinium, as far as macroscopic chemistry goes," says Birnbaum. A little more than two years into the project, the LDRD team has already come a long way from that starting point.

For their actinium work, the team used a spectroscopic analysis called X-ray Absorption Fine Structure (XAFS), a sensitive technique that can determine chemical information, such as the number of atoms surrounding actinium, their type (i.e., oxygen or chlorine) and their distances from each other. To help understand actinium's behavior in solution and interpret the data obtained with XAFS, these experimental results were compared with sophisticated computer model calculations.

The study showed that actinium, in solutions of concentrated hydrochloric acid, is surrounded by three atoms of chlorine and six atoms of water. Yet americium, another +3 actinide often used as a surrogate for actinium, is surrounded only by one chlorine atom and eight water molecules. It had been assumed in the past that actinium would behave similarly to americium.

"Our study shows that the two are different in a way that could help change how actinium ligands are designed," says Maryline Ferrier, a postdoctoral researcher on the LDRD team. "We're actively working to gather more fundamental data that will help understand how actinium behaves chemically."

Findings from the LDRD project were published on August 17, 2016, in Nature Communications.[1] The article highlights the first-ever characterization of an actinium bond length. A follow-up Nature News & Views article[2] gave a nod to the importance of the LDRD team's work for cancer treatment.

"They reveal that the chemical behaviour of actinium in water differs from that of the heavier actinides, and in so doing provide a clue that might enable actinium to be used in cancer radiotherapy," writes Thomas E. Albrecht-Schmitt of Florida State University's Department of Chemistry and Biochemistry.

Because of its brief half-life, actinium-225 cannot be found in nature and must be made in a laboratory. Los Alamos and Brookhaven national laboratories are doing so with their powerful proton accelerator beams trained on a thorium target, resulting in a variety of radioisotopes, including actinium-225. Scientists then apply a series of chemistry-based purification methods to isolate the actinium from the other elements produced. It might sound straightforward, but the details matter. The targets have to be designed to withstand irradiation conditions that could otherwise melt them, and the chemistry process has to isolate highly pure actinium-225 from approximately 400 other isotopes.

Broad application of TAT with actinium-225 requires that the isotope's production be scaled up to meet the increasing medical demand. Indeed, actinium-225 was originally developed for clinical research at Oak Ridge around 15 years ago, but practical applications remained limited by an insufficient supply. Fortunately, tri-lab scientists have successfully demonstrated the first major steps toward a large-scale, economically viable supply of the needed isotope. They estimate that once the full production pipeline is established—an investment of 5–10 years—it will take only a few days of beam time to match the present global annual production of actinium-225. Thereafter, accelerators at Los Alamos and Brookhaven, and chemical-processing capabilities at Oak Ridge, are planning to keep pace with the growing medical need.

So will it cure, or at least treat, different cancers? To find out, the tri-lab team has been collaborating with international clinical research leaders, building on years of research using actinium-225 on cancer-cell cultures and cancer-afflicted mice. In addition, human clinical trials performed to date show great effectiveness with a variety of actinium-225- based drugs. One such drug under development to treat acute myeloid leukemia (AML), for example, has been tested on 18 patients at varying dosages and every time showed significant anti-leukemic activity with no toxicity to the patient. An expanded clinical trial is further assessing the drug's effectiveness, and several others drugs based on actinium-225 are in the development pipeline as well.

"Very encouraging results are being published now," Birnbaum says. "If FDA-approved clinical trials continue to pan out, then doctors can establish guidelines for actinium-225 treatments, what dosages to use, and so on. It's a real opportunity to deliver life-saving medicine in quantities that can have a tremendous impact."

"Through nuclear physics and chemistry," adds John.

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New Federal Staff Join the Office of Research, Development, Test, and Evaluation

NNSA's Office of Research, Development, Test, and Evaluation is pleased to welcome five new professionals to our organization: two Office Directors and three Federal Program Managers. Each brings impressive expertise and skillsets to our offices. Read about them in the following paragraphs.

Mark Anderson, PhD

Director, Office of Advanced Simulation & Computing and Institutional Research & Development (NA-114)

Dr. Anderson's distinguished career in support of national defense includes 23 years of experience in the private sector in a variety of leadership and technical positions providing support to the Navy, Air Force, Army, Defense Threat Reduction Agency, and Department of Energy. The most recent 17 years of his career have been spent at Los Alamos National Laboratory. During his time at the laboratory, Mark held leadership positions in experimental science, weapon engineering, weapon physics, and simulation and computing. Mark has served in a wide array of leadership capacities for the Advanced Simulation and Computing (ASC) Program at Los Alamos. He served as an Executive Advisor, held four different Project Leader and two different Program Manager positions, and served as the Deputy Program Director for ASC at Los Alamos. Most recently, Mark has been on detail from Los Alamos as a member of the Defense Programs Science Council. He was a recipient of the Howard Hughes Doctoral Fellowship for graduate work at the California Institute of Technology (Caltech) where he obtained his PhD. He received his master's degree in Mechanical Engineering from Caltech and bachelor's degree in Mechanical Engineering from Christian Brothers College.

David Etim, MS

Federal Program Manager, Office of Advanced Simulation & Computing and Institutional Research & Development (NA-114)

David Etim became a Federal Program Manager with the Office of Advanced Simulation & Computing and Institutional Research & Development immediately following a year-long fellowhip with the NNSA Graduate Fellowship Program under the same office. He received his Master of Science degree in Computer Science & Engineering from the University of Connecticut and is pursuing his PhD in the same discipline with the same institution. He holds a bachelor's degree in Computer Science, with a minor in Applied Mathematics from North Carolina Agricultural & Technical State University (NCA&T).

As an undergraduate, David participated in various research/intern opportunities.

For example, he worked for the National Oceanographic Atmospheric Administration in Boulder, Colorado, where he collaborated with scientists on client-server projects to display and forecast weather hazards for surrounding territories with emergency management centers. In 2014, David was a summer graduate student intern at the Goddard Space Flight Center with the National Aeronautics and Space Administration. In this role, in addition to coding and scripting, he collaborated with eight scientists for usability testing of a web-based application that provides analysis of earth science data. In 2015 while pursuing his graduate degree, David was selected as one of 50 Mickey Leland Energy Fellows to participate at the DOE National Energy Technology Laboratory in Pittsburgh, Pennsylvania, where he worked on developing a methodology on identifying data on steel alloys and extracting useful information on predictive analytics tools as well as defining a framework for storing, preprocessing, and analyzing data.

David's previous experiences have shaped his understanding of science and technology and prepared him to take on nuclear security challenges and continue to help contribute to the safety, reliability, and the protection of the United States.

Sean Finnegan, PhD

Federal Program Manager, Office of Inertial Confinement Fusion (NA-112)

Dr. Finnegan started his career as a post-doctoral researcher studying laser plasma interactions at Los Alamos National Laboratory (LANL). During his time at the laboratory, Sean worked to resolve physics issues relating to both laser- and radiation-driven target performance at the National Ignition Facility and the Omega Laser Facility using high performance computing tools such as HYDRA and VPIC. Sean joined the federal service in 2011 as a Program Manager for the High Energy Density Laboratory Plasmas program activities in the Office of Science's Fusion Energy Sciences program. For the last three years, he led the Office of Science's Plasma Science Frontiers team, responsible for setting strategic direction and priorities for the DOE's stewardship of basic plasma science research. He also served on the Office of Science's National User Facilities Working Group. Sean earned his doctorate and master's degrees in Physics from West Virginia University and his Bachelor's degree in Physics from Dickinson College in Pennsylvania.

Jason Pruet, PhD

Director, Office of Engineering, Stockpile Assessments, and Responsiveness (NA-115)

Dr. Pruet started his career as a post-doctoral researcher studying supernovae at Lawrence Livermore National Laboratory (LLNL). He went on to become a staff scientist and later to lead the Computational Nuclear Physics group at LLNL. During his time at the laboratory, Jason worked to improve the nuclear data needed for forensic attribution, was awarded patents for new technologies used to detect smuggled nuclear material, and studied the science of boost. Jason joined the federal service in 2011 as a Program Manager in NA-11 for Primary Assessments in the Science Campaign in Defense Sciences (now NA-113). For the last three years, he led an intelligence branch responsible for assessments of foreign nuclear weapons in DOE's Office of Intelligence and Counterintelligence. Jason earned his doctorate and master's degrees in Physics from the University of California at San Diego and his bachelor's degree in Physics from California State University Northridge.

Enrique Wong, MS

Federal Program Manager, Office of Engineering, Stockpile Assessments, and Responsiveness (NA-115)

Enrique Wong has an academic background and research experience in the field of nuclear detection and applications. His studies spanned the nonproliferation and security climate. Prior to entering the NNSA Graduate Fellowship Program, he was a research assistant as well as laboratory teaching assistant in nuclear detection and instrumentation at the University of Florida's Nuclear Radiation Detection and Instrumentation Laboratory. He is a member of the American Nuclear Society (ANS), Institute of Electrical and Electronics Engineers (IEEE), the Consortium of Verification Technology (CVT), and the Alpha Nu Sigma National Honor Society for Nuclear Science and Engineering. In 2015, he received the honorable mention for the Nuclear Nonproliferation International Safeguards Graduate Fellowship.

Enrique's graduate research involved investigating the performance of bismuth tri-iodide gamma-ray spectrometers for a project funded through the DOE Nuclear Energy University Program. He was responsible for working on a team to develop a compact electronics system and detector platform. In addition, Enrique performed material degradation analyses due to atmospheric conditions and aging.

In addition, Enrique's experience included systems engineering as an intern for Northrop Grumman Aerospace Systems for the summers of 2012 and 2013. In this role, he worked with requirements traceability, configuration management, and product development; drafted system architecture models; and conducted a tooling integration analysis. In the past, Enrique has also participated in a Next Generation Safeguards Initiative program workshop, local Institute of Nuclear Materials Management meetings, and toured the Nuclear Fuel Services downblending plant.

Enrique is trained in radiation safety, cleanroom, and laboratory waste management. He has intermediate proficiency in Spanish and elementary proficiency in Mandarin.

In his new role, Enrique is a program manager within the Office of Engineering, Stockpile Assessments, and Responsiveness (NA-115). Within NA-115, Enrique is the NNSA Coordinator for the Annual Assessment process and spearheads the Archiving Data and Management Program.

Enrique earned his master's and bachelor's degrees in Nuclear Engineering from the University of Florida in 2015 and 2014, respectively. •

2017 Stewardship Science Academic Programs Symposium

The 2017 Stewardship Science Academic Programs (SSAP) Annual Review Symposium was held in Naperville, Illinois on April 12-13, 2017. The Symposium, which hosted approximately 300 attendees, featured overviews of work to date from ongoing grants and cooperative agreements from the following programs: Stewardship Science Academic Alliances, High Energy Density Laboratory Plasmas, and the National Laser Users' Facility.

This year, attendees were able to take a pre-symposium tour of the Advanced Photon Source at Argonne National Laboratory. Highlights of the Symposium included the research presentations, keynote speaker Dr. Stephen Streiffer, Director, Advanced Photon Source & Associate Laboratory Director, Photon Sciences, Argonne National Laboratory, and the Poster Session featuring the students' cutting-edge research. The winners of the Poster Session follow.

Jason Baker, University of Nevada, Las Vegas, *High-Pressure Thermoelectric and Structural Behavior of Half-Heusler Compounds*

Jacob Banasek, Cornell University, Las Vegas, *Initial Results from Streaked Thomson Scattering Measurements on Laboratory Plasma Jets*

Jonathan Barney, Michigan State University, *First Experiment of the SpiRIT Time Projection Chamber*

Paul Campbell, University of Michigan, *Electron and X-ray Measurements of Relativistic Magnetic Reconnection in Layered Targets and Preformed Plasmas*

Samantha Clarke, Northwestern University, *Creating Binary Cu-Bi Intermetallic Compounds at High Pressure*

Sakun Duwal, Washington State University, *Phase Diagram and Photo-chemistry of H2S and H2+S Under Pressure*

Rachel Flanagan, University of Tennessee, Knoxville, *Non-Equilibrium Simulations of Shock-Induced Horizontal Defects and Amorphization in 4H Silicon Carbide*

Dorothy Miller, University of California Berkeley, *Advanced Gas-Phase Separations of Lanthanide Fission Products*

Daniel Sneed, University of Nevada, Las Vegas, *Forcing Cesium into Higher Oxidation States via High Pressure Hard X-ray Induced Chemistry*

Nicholas Thompson, Rensselaer Polytechnic Institute, *Measurements and Analysis of Neutron Capture Rates Using a Lead Slowing-Down Spectrometer*

Thomas Underwood, Stanford University, *Studying the Use of Pulsed Plasma Jets for Simulating Fusion Wall Response to Disruptions* •

Touring the Air Force Nuclear Weapons Site at Minot Air Force Base in North Dakota *by Bryan Sims (National Nuclear Security Administration)*

As a new federal employee, I see a perennial challenge in science policy of remembering that the decisions made, policies established, and accomplishments highlighted do make an impact at the research facilities spread throughout the country. In this spirit of better understanding NNSA's impact, when invited to join Defense Program's Principal Assistant Deputy Administrator for Military Application, Brigadier General Michael J. Lutton on a trip to Minot Air Force Base, I was eager to see what the execution side of the nuclear deterrent looked like.

Not long into the trip, I realized that the young specialists who make up two thirds of the nuclear triad maintain a high level of professionalism and have a deeply held respect for the nuclear mission. There was also an engrained culture of professional development where we saw enlisted and officers alike taking online classes during the brief downtimes between patrols and exercises. It was also surprising to see that many of the challenges faced by the NNSA complex are mirrored in the Department of Defense (DOD). Whether these are 50+-year-old B-52s or WWII-era nuclear research / production facilities, both organizations strive to maintain current capabilities while making responsible long-term investments.

Figure 1. A B-52 sits on the tarmac. The ground crews regularly practice the loading of munitions to maintain their certifications. For nuclear missions, the plane can be equipped with 20 air-launched cruise missiles, 6 on each wing and 8 in its internal weapons bay. Despite the heavy load, this is only counted as one warhead under New START.

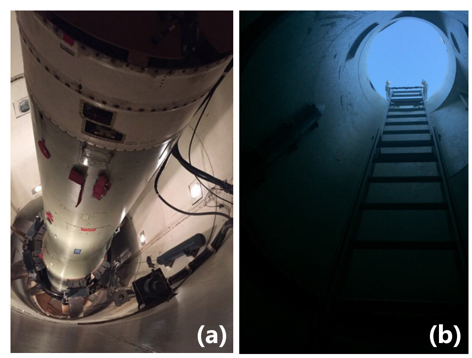

Figure 2. (a) A Minuteman III sits in Minot's silo trainer where airmen are first introduced to missile support systems. (b) A silo access point. All the equipment and tools found in a silo must be lowered through this entryway often leading to some tight squeezes.

Perhaps the most striking thing was recognizing that the decisions made at the confluence of experimental data, weapons simulations, and budget tables mean something much more concrete while standing on the frigid plains of North Dakota in February. The requirements in place for weapons components and surveillance can make a big difference in the field and the DOD's experience in their execution role should become more integrated into decision making in future life extension programs.

Thanks for hosting us Minot! •