CNEC | Consortium for Nonproliferation Enabling Capabilities

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Dr. John Mattingly, PI, Chief Scientist
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CNEC Newsletter

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Message from the Director

Dr. Yousry Azmy

As we approach the endpoint of CNEC's original five year term this July it is valuable to look back and take stock of what we have accomplished together and to gain a sense of CNEC's lasting legacy.

CNEC crafted a vision that revolves around creating an interdisciplinary environment for research to flourish and advance the state of the art in nuclear nonproliferation. Our strategy is to intimately mix education and research across disciplines in order to pave the way for future products that address challenges that are beyond the horizon. The *Enabling Capabilities* in CNEC carries this message of laying the groundwork for future technological solutions to currently intractable problems by developing theories, methods, and techniques that shine a light, even if it seems faded, to guide new research directions. But our focus did not stop at these scientific products, it included the development of a top notch cadre of scientists and engineers poised to lead our nation's charge in nuclear nonproliferation. Not only did we heavily engage graduate students and postdocs in exciting research, we facilitated internships at national labs, created the nationally competitive CNEC Fellowship program, and created the Graduate Certificate in Nuclear Nonproliferation Science and Policy at NC State.

I am very proud of what our team has accomplished over the past four and a half years, and I look forward to completing our activities on a high note, whether this July or in July 2020 if we are granted the No-Cost Extension that we requested from our sponsor. Either way, CNEC will continue to pay dividends on our sponsor's investment as our alumni lead productive careers, and as the products of our research facilitate the creation of new tools to combat nuclear proliferation.

I am grateful for all the support I received over the life of CNEC from our sponsor (the National Nuclear Security Administration's Office of Defense Nuclear Nonproliferation R&D (NA-22)) from our faculty and staff, and from our lab liaisons. Our Advisory Board's guidance and feedback was instrumental in setting us on an ambitious yet judicious course. While the ride was rough at times, I couldn't have wished for better companions! Let's continue to chase our dreams until CNEC's last minute and beyond.

Our Vision

Create a preeminent research and education hub dedicated to the development of enabling technologies and technical talent for meeting the present and future grand challenges of nuclear nonproliferation.

Our Mission

Through an intimate mix of innovative research and development (R&D) and education activities, CNEC will enhance national capabilities in the detection and characterization of special nuclear material (SNM) and facilities processing SNM to enable the U.S. to meet its international nonproliferation goals, as well as to investigate the replacement of radiological sources so that they could not be misappropriated and used in dirty bombs or other deleterious uses.

IN THIS ISSUE

UNIVERSITY PARTNERS

Georgia Tech
Kansas State
NC State
North Carolina A&T
Purdue University
University of Illinois
University of Michigan

NATIONAL LABORATORY PARTNERS

Lawrence Livermore
Los Alamos
Oak Ridge
Pacific Northwest

Dr. Yousry Azmy, Director

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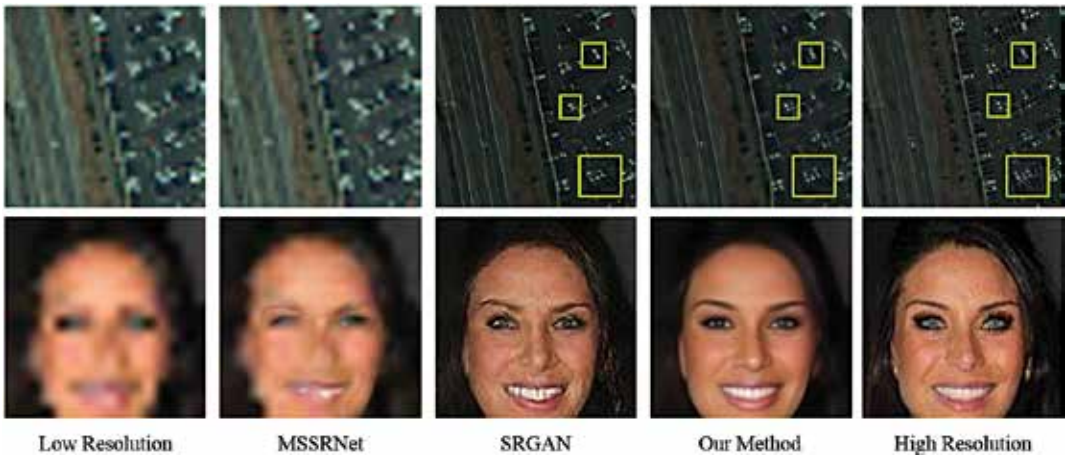
CNEC Thrust Area Highlights

Data Fusion and Analytic Techniques (DFAT)

Dr. Alyson Wilson, North Carolina State University

The Data Fusion and Analytic Techniques (DFAT) thrust area focuses on the development of methods that fuse data from multiple sources to provide a more complete picture of proliferation events and networks. We have four investigators: Alyson Wilson, Thrust Lead, Department of Statistics, NC State, whose interest is in combining multiple sources of information to make inferences and quantify uncertainty; Hamid Krim, Department of Electrical and Computer Engineering, NC State, whose interests are in principled frameworks for multi-modality data fusion; Eric Laber, Department of Statistics, NC State, whose interest is in data-driven decision making; and Raju Vatsavai, Department of Computer Science, NC State, whose interest is in image and geospatial analytics.

Dr. Hamid Krim and his students in the Vision Information and Statistical Signal Theories and Applications (VISSTA) Laboratory are developing algorithms for multi-modality data to improve nuclear activity detection. Surveillance and monitoring of nuclear activities heavily rely on information from remote sensing data, such as satellite imagery. Detecting these activities is difficult because of deliberate efforts to conceal facilities. VISSTA's goal is to develop methodologies that can learn characteristic signatures of landslides and landscape changes from well documented and known testing regions and transfer this knowledge to detect "suspect" activities in areas with more limited information. These tasks often make use of high resolution satellite imagery, like WorldView-3, with low measurement frequency and high cost. With Lawrence Livermore National Laboratory (LLNL), Dr. Krim's group is working to achieve both high spatial resolution and high temporal resolution by taking advantage of deep structure learning to develop a super-resolution technique. The lower resolution PlanetScope satellite images are measured at a much higher frequency and are publicly available. The method boosts their resolution by using learned high resolution features from training examples to generate super-resolved images at a high temporal rate. The figure shows a super-resolved version of a low resolution satellite image and of a celebrity image.



Converting low-resolution images to high-resolution images. The method developed by Dr. Hamid Krim's VISSTA Lab is able to better restore the fine details region (indicated by green boxes) in the high-resolution image.

Data Fusion and Analytic Techniques (DFAT) *Continued from page 3.*

PhD student Zhen Li and former CNEC fellow Nick Meyer had their paper on adaptive search accepted to the 2019 Association for the Advancement of Artificial Intelligence workshop on reinforcement learning in games. Zhen will be traveling to Honolulu, HI to present a poster. Pursuit-evasion is a multi-agent sequential decision problem wherein a group of agents known as pursuers coordinate their traversal of a spatial domain to locate an agent trying to evade them. Learning to optimally coordinate pursuer behaviors so as to minimize time to capture of the evader is challenging because of a large action space and sparse noisy state information; consequently, previous approaches have relied primarily on heuristics. Li and Meyer propose a variant of Thompson Sampling for pursuit-evasion that allows for the application of existing model-based planning algorithms. This approach is general in that it allows for an arbitrary number of pursuers, a general spatial domain, and the integration of auxiliary information provided by informants. A suite of simulation experiments suggests that Thompson Sampling for pursuit-evasion significantly reduces time-to-capture relative to competing algorithms.

Dr. Alyson Wilson is the recipient of the 2018 Distinguished Achievement Award from the American Statistical Association Section on Statistics in Defense and National Security. This annual award recognizes an outstanding accomplishment or sustained contribution at the intersection of the statistical profession and national defense.

Simulation, Analysis, and Modeling (SAM)

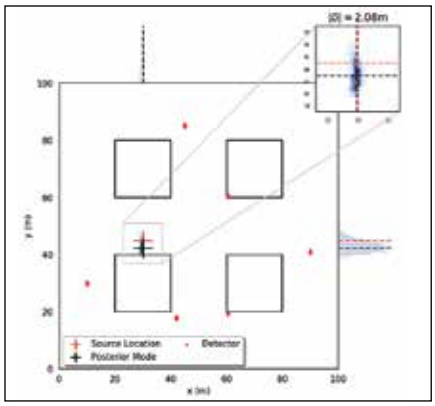
Dr. Ralph Smith, North Carolina State University

A significant collaborative SAM research thrust has focused on the challenge problem of isolating a radiation point source in an urban environment. This has been addressed via three parallel synergistic tasks: statistical inference methods for source localization, estimation of background, and two-way coupled deterministic and Monte Carlo radiation transport simulations.

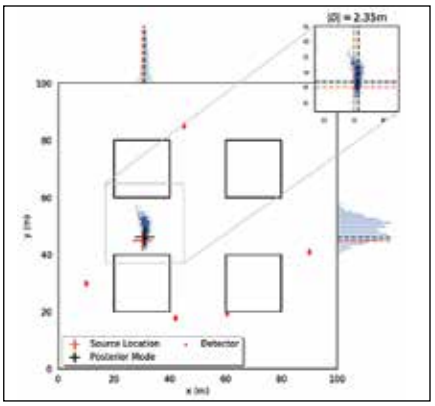
The team investigating statistical inference techniques has focused on a hierarchy of models in addition to conducting experiments at ORNL in May 2017. The models include 3-D high-fidelity Monte Carlo N-Particle (MCNP6.1) simulations performed at the University of Michigan, a moderate-fidelity 2-D ray tracing model, and lower-fidelity surrogate and simplified transport models investigated at North Carolina State University. Whereas the MCNP6.1 simulations provide significant resolution, the hours-long runtimes preclude Markov chain Monte Carlo (MCMC) Bayesian inference techniques, which require thousands to millions of model evaluations. MCNP6.1-based surrogate model construction, performed through collaboration by the NC State and Michigan teams, is summarized in the September 2018 CNEC Newsletter.

The objective with the 2-D ray-tracing and line-of-sight models is to incorporate sufficient physics to localize the source and infer background while providing the efficiency required for Bayesian inference and mutual information-based experimental design for fixed and moving sensor strategies. In recent work, Jason Hite and John Mattingly, NC State, have demonstrated that inference of the source location is dominated by sensors having a nearly unobstructed line-of-sight to the source and is more sensitive to building geometries than compositions. This permits the use of a simplified transport model, which treats sensors obscured by more than 1 meter of building material as measuring only background, to achieve reasonable source

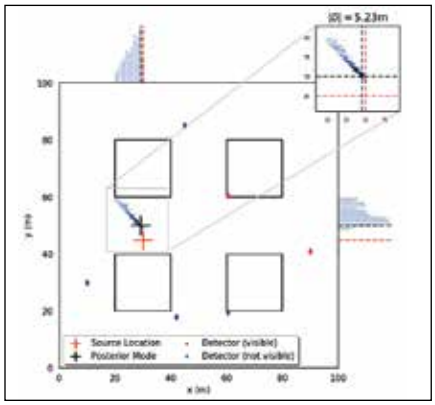
localization for many geometries. Posterior distributions obtained using 6, 5, 2 and 1 unobscured sensors are plotted in the figure. The posterior densities for the first two cases provide reasonable localization whereas the cases of 2 and 1 unobscured sensors yield larger discrepancies between the source location and posterior mode.



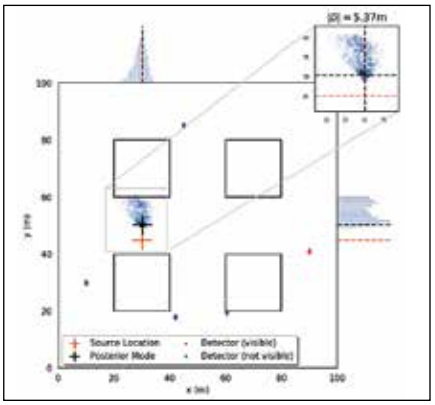
6 Detectors



5 Detectors



2 Detectors



1 Detector

North Carolina State University hosted a Schubert review of SAM on November 7-8, 2018. Following overviews of CNEC and SAM, the following graduate students and postdocs presented research highlights: Jason Hite, Jared Cook, Paul Miles, Isaac Michaud, Raffi Yessayan, Alex Clark, and Eva Brayfindley (NC State), Evan Gonzalez (Michigan), Pola-Lydia Lagari and Alexis Verney-Provatas (Purdue) and Modeste Tchakoua Tchouaso (NC A&T State University). The final session was comprised of teleconferenced lab partner presentations by Dave Williams (ORNL), Robert Brigantic (PNNL), Jeff Favorite (LANL) and Stephan Friedrich (LLNL) summarizing SAM internships and collaborations.

Signatures and Observables (S&O)

Dr. Katy Huff, University of Illinois at Urbana-Champaign

This past summer, Erik Medhurst and mentor Nick Cramer developed an augmented reality (AR) application to supplement the radiological sample collection process currently implemented by the Visual Sample Plan (VSP) software. Their application walks users through generating a radiation sample collection plan and then projects holograms onto the environment to designate locations that should be sampled. Microsoft HoloLens glasses run the application and display holograms generated in the application to the user.

The Holo-Visual Sample Plan (HoloVSP) application streamlines the data collection process following emergency events. The user is voiced-guided through the process of mapping a 3D mesh of a room, generating random sample locations on the mesh, and collecting measurements at each sample point. Samples are numbered and will change color when a user marks them as collected via voice or gesture control. A 3D .obj file saves the room mesh and sample positions for later review. A video demonstration of the capabilities can be seen here: http://bit.ly/2QcILyB.

S&O investigators and students participated at the ANS Winter Meeting in November 2018 in Orlando, Florida. The meeting included the embedded topical on nonproliferation.

Snapshot of a 3D mesh generated by the Microsoft HoloLens with completed samples (green) and unmarked samples (yellow);

Screenshot of the user's view while using the application.

Dr. Robert Hayes of NC State also organized a session titled "ETHICS IN NUCLEAR ENGINEERING AND DESIGN–PANEL".

Advances in Nonproliferation Technology and Policy (ANTPC 2018) November 12-14, 2018

- Gross Uncertainties in Treaty Verification by Aerosol Assay by Robert B. Hayes and S. Joseph Cope
- Incremental Gains of a Conservative Transuranic Alpha Activity Assay Method in Air Samples by S. Joseph Cope and Robert B. Hayes
- Grain Size and Density Separation Effects on Luminescence Dose Estimates Using Brick Material by Ryan P. O'Mara and Robert B. Hayes
- Evaluation of BC-454 for Gamma Spectroscopic and Neutron Detection Applications by Robert B. Hayes
- Enabling Nuclear Forensics Applications from the Mineral Particulate in Contamination Surveys by Robert B. Hayes and Ryan P. O'Mara

ANS Winter Meeting General Sessions

- Differential Isotopic Diffusion in Nuclear Forensics of Fallout by Robert B. Hayes
- The Benefit of Professional Licensure in an Engineering Career by Robert B. Hayes
- Measurement of Gamma Ray Dose Rates from Bricks for Hazard Assessment by Ryan P. O'Mara and Robert B. Hayes
- Emergency Response Transuranic Activity Assay Method for Mixed Alpha/Beta Air Samples by S. Joseph Cope and Robert B. Hayes

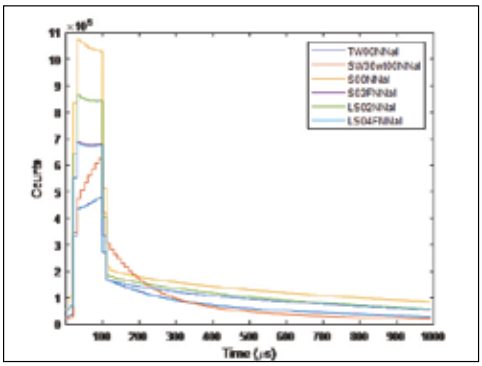
Replacement of Dangerous Radiological Sources (RDRS)

Dr. Walter McNeil, Kansas State University

Aaron Hellinger (shown right) is at Lawrence Livermore National Laboratory (LLNL) and just completed the construction of an isomer trap and turned it on for the first time. Now he is tuning quadrupoles to optimize trapping efficiency. He has recently tested the voltage of all of their numerous quadrupoles and loaded U-233 as a source in the assembly.

Aaron Hellinger

Long Vo has just published a paper following up the presentation of his work at the Conference on Application of Accelerators in Research and Industry (CAARI). Has been comparing time dependent response among the different bulk material data sets and has been collecting die-away response of individual features within the gamma-ray spectrum. Die away time constants appear to have trends that we anticipate with increasing hydrogen content and also prove to be more sensitive to small concentrations than we expected.



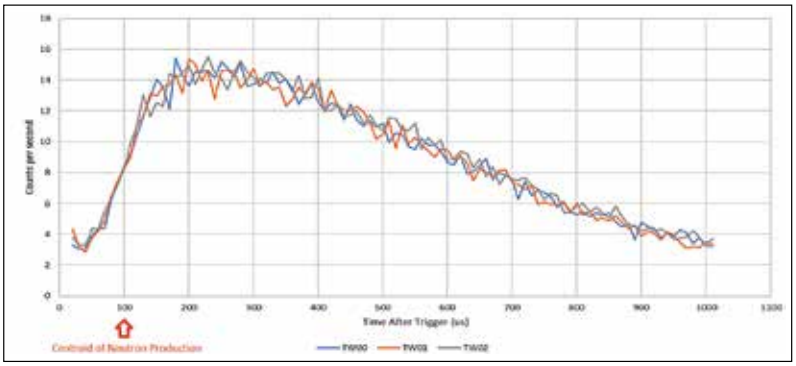


Figure 1. (left) Gamma-ray gross count time response to a 100 microsecond neutron pulse from the D-T generator from tap water, salt water, sand, and limestone media. (right) Neutron sensor response in the same time pulse duration for tap water media.

Maria Pinilla is comparing integral spectral response between AmBe and D-T generator sources in tap water and is modifying radiation transport simulations such that they better represent the measured sensor response in experiments. She is currently submitting a paper on the simulation of the entire KSU test facility for the purpose of dosimetry and the shielding plan required to gain state licensing for D-T generator operations. Maria just recently attended the International Symposium on Radiation Physics (ISRP) in Argentina along with Dr. Bill Dunn who gave a plenary lecture on Well-logging source replacement with D-T generators.

Vincent Dinova is working with Elastic Net and the Least Absolute Selection and Shrinkage Operator (LASSO) to encourage a "grouping effect" and stabilize a regularization path in the process of fitting with libraries of water, Sodium, and Chlorine which align with the first measured data collected at KSU including tap water and salt water. This is in addition to previous work Vincent has done to incorporate activation within the NaI sensors that contribute to a beta continuum in the sensor response.

Replacement of Dangerous Radiological Sources (RDRS)

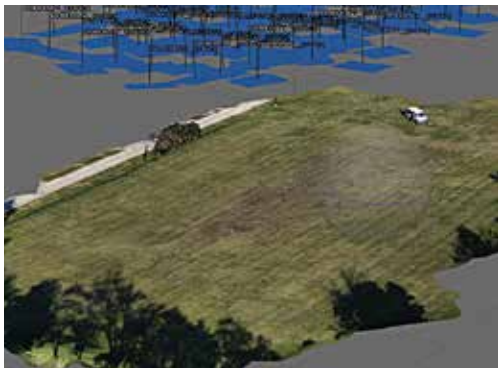
Continued from page 7.

Aaron Feinberg has recently been working on transforming MCNP spectra into detector response functions and is leveraging Bayesian methods, Markov Chain Monte Carlo, to process simulation data. It is viable since the oil-well application has less than 20 variables and will handle gain shifts, broadening, and non-linearity in sensor response.

The water-filled tank configuration of the KSU well-logging benchmark facility has recently drawn interest from external researchers exploring underwater active interrogation. It is far easier for us to setup configurations to test sensor response than to travel to maritime test sites. However, those applications are interested in gamma-ray energies that extend beyond 10 MeV which is at the upper limit of the spectroscopy of our existing data. Reducing the gain of the sensors will enable such investigations.

KSU is kicking-off an effort to 3-D print signal processing circuitry for radiation detection systems. A PDRD with the Nuclear Security Campus will begin fabricating fundamental circuit articles to test material performance properties that influence the analog circuit design parameters for charge sensitive amplifiers, shapers, and threshold functions.

Nathan Hines and Jace Beavers, KSU graduate students, visited Argonne National Laboratory (ANL) and Brookhaven National Laboratory (BNL) to gather information on high quantum efficiency photo-cathode deposition, as fundamental research is beginning on the fabrication of a new type of PMT that may better support large area and low profile scintillator crystals for mobile detection and spectroscopy. Junqi Xie at ANL showed his photo-cathode deposition process along with the assembly of glass components to house large area micro-channel plates along with the photo-cathode layer. John Smedley at BNL showed several photo-cathode growth facilities which are installed in the beamline to study the photocathode growth process with real-time x-ray reflectometry and diffraction to monitor changes in crystallinity and phase while monitoring quantum efficiency and stoichiometry.



Nathanael Simerl is executing UAV flight operations that enable the transport of a dosimetric sensor payload at the very low altitude necessary to meet the requirements for hand-held personnel dose-rate surveys. He has retrofitted a downward-looking Lidar range finder into the flight control of a U.S. manufactured UAV and has upgraded optical cameras to efficiently capture 3-D photogrammetry of a scene and to use aerial imagery to flight-plan around structures and obstacles. This work is in preparation to support dirty-bomb test operations at Idaho National Lab.

Nathanael has also temporarily installed a commercial X-ray spectrometer into an electronics inspection system on the production floor at NSC for the purpose of capturing emission intensity and energy from an X-ray generator so that integral dose to specific circuit board components can be determined during the X-ray inspection process. This is achieved by importing cad renditions of PCB geometry and source properties from measurements into Monte-Carlo transport simulations to provide a complete dose map and dose record of each electronic component.

CNEC University Featured Program

Purdue University

Dr. Lefteri Tsoukalas

Department and Courses - Purdue University's School of Nuclear Engineering consists of 19 faculty members, four of them with a courtesy appointment. Purdue's nonproliferation area of strength includes the fields of radiation detection, safeguards, radiation protection and artificial intelligence.

The courses both for undergraduate and graduate students, which focus on these topics, are:

ENGR 103: Introduction to Engineering in Practice

NUCL 579N: Nuclear Power & Nonproliferation

NUCL 504: Nuclear Engineering Experiments

NUCL 570: Fuzzy Approaches in Engineering

NUCL 575: Neural Computing in Engineering

NUCL 560: Introduction to Fusion Technology

Research and Facilities -

Purdue's goals for CNEC are to develop tools for:

- Analyzing nuclear data
- Estimating the background
- Identifying new Special Nuclear Material signatures

These goals are achieved by the use of:

- Machine Learning tools
- Non Linear Signal Processing
- Pattern Recognition Algorithms
- Simulation tools (eg. Geant-4, GADRAS)

More specifically, Purdue's AI Systems Lab (AISL), has developed a neural network approach for radionuclide identification of unknown sources utilizing gamma-ray spectra, and is currently working on expanding the radionuclide library up to 100 radionuclides.

Another ongoing work in the lab is a simulation platform for data generation in analysis of detection algorithms, in radioactive source search. Part of this work was presented at the Annual ANS meeting this past November in Orlando, FL.

CNEC University Featured Program

Continued from page 7.

Students work together on campus, to collect urban background measurements, using a sodium iodide (NaI) detector, in order to use them for their ongoing research.

AISL also attended the Simulation and Modeling Review meeting on November 7th, hosted by NC State University in Raleigh.

As for the facilities, apart from the classrooms and laboratories, the School of Nuclear Engineering at Purdue is home of the Purdue University's Multi-dimensional Integral Test Assembly facility (PUMA), and also the Purdue University's Reactor Number One (PUR-1) research reactor. It is the first and only nuclear reactor operating in Indiana and it will soon be licensed as the first and only reactor in the United States to have full digital instrumentation and control (I&C) capability.

CNEC Reclaimed Funds Project:

"Autonomous Source Detection System"

Dr. Shiva Abbaszadeh, University of Illinois

Proliferation of special nuclear material (SNM) is an ever present concern, and technologies for detecting and localizing rogue sources are needed in increasing quality and accessibility to combat potential threats. Many urban settings are left without any security options due to the inhibitive costs and complexity of many detection and localization systems. Our work strives to provide a cost-effective and simple tool for anomaly detection and source localization through development of an autonomous, mobile, single-detector system. Figure 1 summarizes the many facets of this project below. This is achieved through development of two learning algorithms optimized for sparse data collected from a single, mobile detector, and the construction of an in-house detector that maintains high sensitivity while mitigating cost and weight.

The system is comprised of a DJI Inspire 2 quadcopter (Fig. 1f) – chosen for its cargo capacity and developer toolkit – equip with a lightweight gamma ray detector. It is further augmented with an anomaly detection algorithm (Fig. 1d) to process collected spectra and identify relevant source information. This source data is then fed into a navigational algorithm (Fig. 1e) to decide on the next most valuable sampling position. The UIUC RDII (Radiation Detection & Isotope Identification) android application (Fig. 1c) is a simple interface for acquiring the spectra from the detector via Bluetooth. Investigations into improved detector design focus on lightweight, cost-effective construction while maintaining sensitivity. Pioneering amorphous-Selenium deposition techniques focus on developing an evaporation chamber (Fig. 1a, 1b) for large surface area deposition. This allows for improved use of a mature and economical technology.

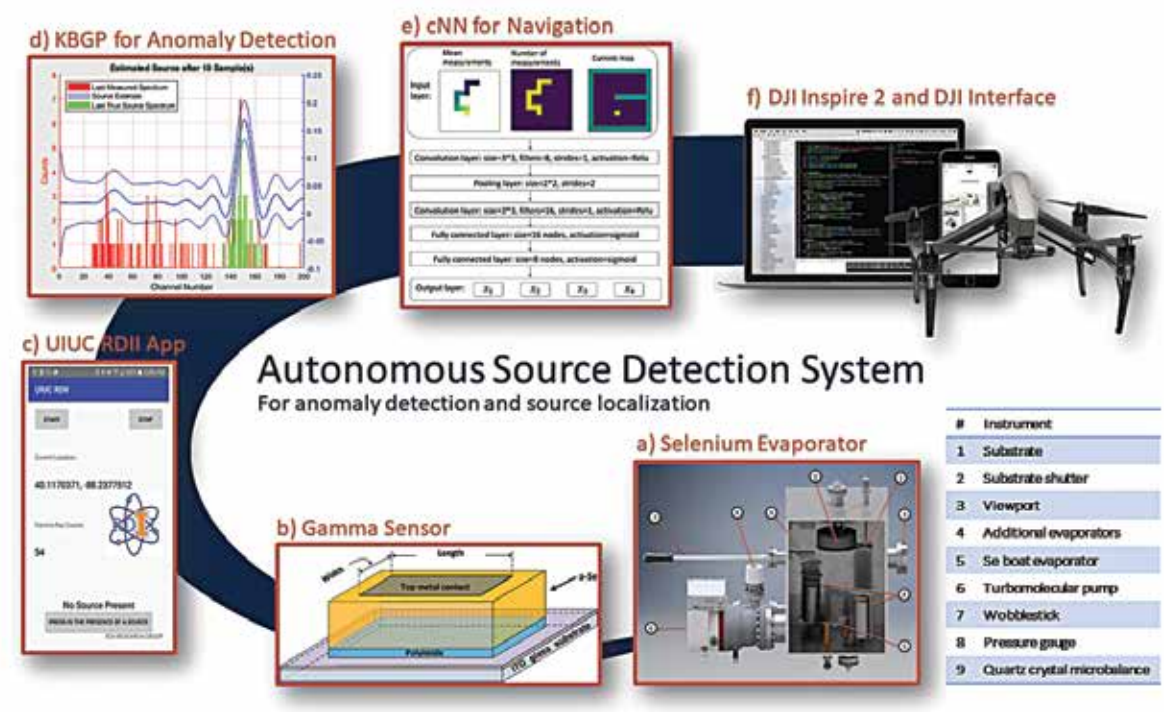


Figure 1. System overview.

Due to the short flight time of drones and the need for quick decision making during emergency situations, each spectrum sampling time is limited to a few seconds. With the potential distance from the source, we expect an extremely sparse and noise (background) dominated spectrum. Sparse, noisy data requires we assume no prior information about the background spectrum is available. Kernel Based Gaussian Processes (KBGPs) are well suited for not only background prediction in this setting, but also anomaly detection. The high-level explanation of this learning algorithm is that similar inputs should have similar outputs. Two KBGPs are employed in our algorithm: one for background estimation, whose input is channel number and output is expected background counts; and a second for anomaly prediction whose input is an estimated source spectrum and output is a density of source likelihood. Since KBGPs yield both a mean and variance for every tested input, confidence intervals are automatically acquired for every estimation. The repeated samplings performed in source surveying then contribute to the confidence, or lack thereof, in anomalous peaks. Once a peak reaches a sufficient confidence level, further techniques can be employed for isotope identification.

Developed previously is a convolutional neural network (cNN) designed to optimize sample pathing. This algorithm takes in gross counts and updates the position of the drone to maximize potential data collection. The cNN is being adapted for this work to rely on estimated source counts rather than gross counts, which can be misleading with sparse data. Also available to our system is the environmental sensors of the DJI Inspire 2, which will aid in collision detection. The cNN has been trained with obstacles present, so such information is valuable for maneuvering as well as recognizing potential attenuation patterns learned during training.

All together, the autonomous, mobile anomaly detection and source localization system will provide expanded access to security through an easy to implement, all-in-one system. Spanning fields from data science to materials research, each component of the system contributes to a low-cost and effective alternative to human surveying or more complicated mobile systems.

Laboratory Highlights September-December 2018

Los Alamos National Laboratory (LANL)

Dr. Jeff Favorite

Two CNEC Fellows, both long-term interns at Los Alamos National Laboratory (LANL) and students from the University of Michigan, graduated this quarter.

Jennifer Arthur

Jennifer Arthur was awarded a CNEC Fellowship in fall 2015, one year into her Ph.D. program. She was already a student at the University of Michigan. She had already earned a Bachelor's degree from Georgia Institute of Technology in 2014. On December 11, 2018, she defended her Ph.D. thesis, "Subcritical Neutron Multiplication Measurements for Computational Methods and Nuclear Data Validation." Her advisor at the University of Michigan was Professor Sara Pozzi. She has been a student intern at LANL off-and-on since the end of 2015, but since 2017 she has been a full-time graduate research assistant (GRA) under Rian Bahrain and Jesson Hutchinson. While a student at LANL, Jennifer presented three conference papers and published two journal articles. Jennifer is planning for a post-doc position at LANL.

Joel Kulesza

Joel Kulesza was awarded a CNEC Fellowship in spring 2016, near the end of the second year of his Ph.D. program. He too was already a student at the University of Michigan. He had already earned a Bachelor's degree from the University of Michigan in 2006, a Master's degree from the University of Tennessee in 2011, and another Master's degree from the University of Michigan in 2016. He began his graduate work at Michigan under Prof. Ed Larsen but transitioned to work under Prof. Brian Kiedrowski. On Oct. 18, 2018, he defended his Ph.D. thesis, "Cost-Optimized Automated Variance Reduction for Highly Angle-Dependent Radiation Transport Analyses." Interestingly, Joel and Brian were student interns together at Knolls Atomic Power Laboratory in 2005! Joel began working at LANL in May 2015 under Roger Martz, and then as a full-time GRA the next year under CJ Solomon. While a student at LANL, Joel presented five conference papers and published four journal articles. Joel has been hired as a staff scientist at LANL,

Oak Ridge National Laboratory (ORNL)

Dr. David Williams

Joseph Cope, CNEC Fellow, interned at ORNL in fall 2018. He worked under Dr. Vince Jodoin in the Nuclear Security Modeling group in the recently formed Nuclear Nonproliferation Division. Dr. Jodoin

is also a recent appointee as adjunct faculty in Nuclear Engineering at NC State and serves on Joseph's dissertation committee. Joseph conducted environmental air sample studies with support from the Radiation Standards and Calibration Laboratory at ORNL. These studies will fold into his PhD research in radiological emergency response air sampling methods and provided interactions with the Radiological Assistance Program (RAP) Region 2 folks at ORNL and Y-12.

Joseph also supported work on a modeling project, an NA-22 Forensics sponsored project, for the optimal placement of air samplers for ground-based collection of fine particulates for volatile samples. His previous summer internship in 2016 with ORNL provided the foundation for input on the project with familiarity of both national and global air sampling networks related to radiation detection.

Pacific Northwest National Laboratory (PNNL)

Dr. Robert Brigantic

Pacific Northwest National Laboratory (PNNL) Dr. Robert Brigantic PNNL supported the CNEC SAM Schubert Review meeting in November and provided a presentation that recapped SAM activities and engagement with CNEC SAM students and faculty since the program started. PNNL also continued to support the on-going research activities of CNEC SAM Ph.D. student Eva Brayfindley. PNNL is currently working to identify potential research opportunities and mentors available for CNEC Summer Interns in 2019. These will be made available to CNEC shortly and will also be presented in more detail at the CNEC Workshop in February. PNNL also supported on-going work of Zhen Li (under Eric Laber and DFAT thrust area) leading to a conference presentation/paper "Thompson Sampling for Pursuit-Evasion Problems" at the AAAI-19 Workshop on Reinforcement Learning in Games.

Conferences

ANS Nonproliferation Topical

Dr. John Mattingly

This year, the American Nuclear Society (ANS) Nuclear Nonproliferation Policy Division (NNPD) and Fuel Cycle & Waste Management Division (FCWMD) co-sponsored the topical meeting on Advances in Nonproliferation Technology and Policy (ANTPC 2018) November 12-14, during the ANS Winter Meeting in Orlando, Florida. The overarching theme of ANTPC 2018 was Global Nuclear Security: Technical Leadership for the Modern World. ANTPC 2018 featured over 60 papers in seven tracks:

- Nuclear Material Control and Accountability
- Nonproliferation Policy: Present and Future
- Analysis and Modeling Methods in Nonproliferation
- Nuclear Nonproliferation and the Fuel Cycle
- Challenges in Monitoring the Nuclear Fuel Cycle
- Nuclear Facilities and Infrastructure
- Nonproliferation Education and Training

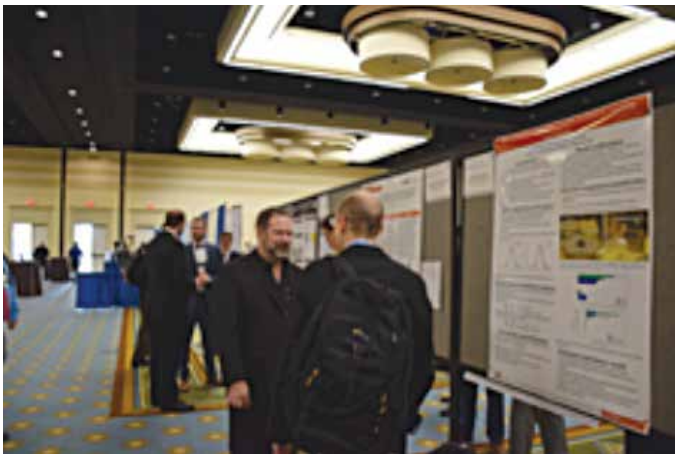
Talks and posters were presented over 3 days in 15 parallel sessions, and speakers, panelists, and poster presenters addressed a wide variety of current and future technical and policy challenges to implementing nuclear security, including:

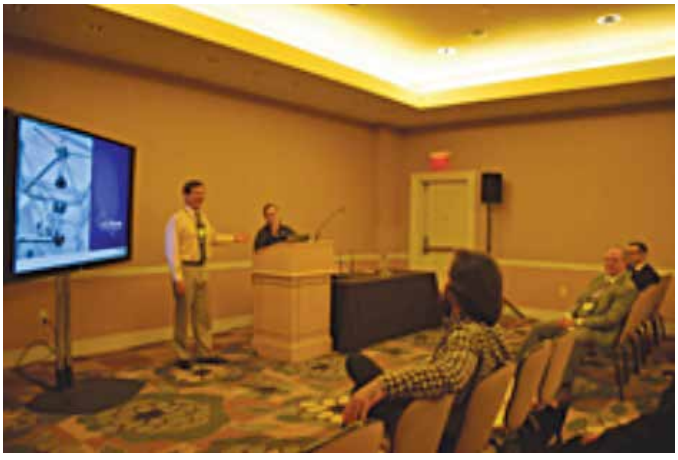
- Risks of Proliferation (panel)
- Contemporary Practice of Nonproliferation Policy
- Weapons-Usable Material Minimization
- Technologies for Arms Control & International Safeguards Verification
- Nondestructive and Destructive Assay Methods
- Techniques for Nuclear Forensics and Environmental Sampling
- Pyroprocessing Material Control and Accountancy Strategies
- Data Synthesis for Pyroprocessing Safeguards
- Challenges to Computational Radiation Transport Methods in Nuclear Security Applications
- Sensitivity and Uncertainty Analysis
- Enhancements to Nuclear Data
- Detection Using Advanced Data Science Methods
- Education and Training in Nonproliferation (panel)
- Human Capital Development

The papers that will be published in the ANTPC 2018 proceedings represent the ongoing work of over a hundred people from national laboratories, academic institutions, industry, and non-government organizations (NGOs), all focused on the development and implementation of methods to support nuclear security objectives through technical capability and sound policy analysis. About two-thirds of the papers were presented by university students and faculty, and most of the remaining third were presented by national laboratory scientists. Numerous papers co-authored by laboratory scientists with students and faculty were presented, and industrial and NGO speakers represented Duke Energy, Nuclear Threat Initiative (NTI), and South Carolina University Research and Education Foundation (SCUREF). Over half of the papers were presented by university and national laboratory members of CNEC, and numerous papers were presented by academic and laboratory members of the other two NNSA academic consortia, the Nuclear Science and Security Consortium (NSSC) and Consortium for Verification Technology (CVT).

There were two special events during the meeting. Yousry Azmy organized two special sessions on Challenges to Computational Radiation Transport Methods in Nuclear Security Applications featuring invited speakers from Sandia National Laboratories, Los Alamos National Laboratory, University of Michigan, and NC State University. CNEC Fellows Alex Clark and Raffi Yessayan organized a student paper competition. Jayson Vavrek of MIT won the best student presentation award for his paper on "Warhead Verification Experiments Using Nuclear Resonance Fluorescence," and Wesley Gillis won the best student poster award for his paper on "Simulation Optimization for the Creation of Training Data for Deep Learning Aided X-Ray Radiography in International Safeguards."

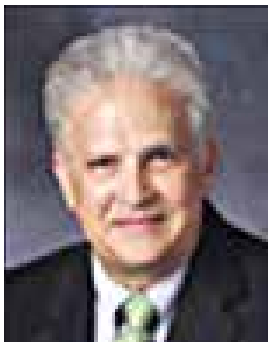
The ANTPC 2018 organizing committee was led by Assistant General Chair Brandon Smith of the Wilmington, NC ANS chapter, and John Mattingly served as General Chair.





Honors and Awards

Georgia Tech Professor receives the American Nuclear Society's Rockwell Lifetime Achievement Award



Dr. Nolan Hertel

Professor Nolan Hertel of Georgia Tech is the 2018 recipient of the ANS Rockwell Lifetime Achievement Award. Dr. Hertel was cited for his achievements in radiation detection and shielding, computational dosimetry, neutron spectrometry and dosimetry, radiological risk assessment as well as his dedication to the education of students. Dr. Hertel is a CNEC principal investigator in RDRS and S&O.

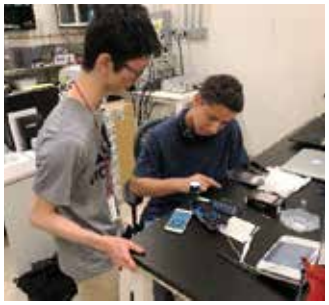
NC State Statistics Professor is the Recipient of 2018 Distinguished Achievement Award

Dr. Alyson Wilson, right

Professor Alyson Wilson is the recipient of the 2018 Distinguished Achievement Award from the American Statistical Association Section on Statistics in Defense and National Security. This annual award recognizes an outstanding accomplishment or sustained contribution at the intersection of the statistical profession and national defense. Dr. Wilson is the thrust lead for CNEC's Data Fusion and Analytics.

Outreach

Lisa Marshall



Plans for spring and summer 2019 are well underway.

On February 17-23, 2019 we will host Engineers' Week activities. Events will include, 'Introduce a Girl to Engineering' day and Future Cities' (regional) finals.

In March 2019, students will be completing their graduate school visits. Dates will be shared for all CNEC schools.

On April 3, 2019, the Global Day of the Engineer will highlight nuclear research including nuclear safety and security.

In addition, the application portal is open for the Young Investigators' Summer Program in Nuclear Engineering. This academic program for high school rising juniors, rising seniors and graduating seniors uses labs, group projects, lectures and industrial field trips to explore nuclear science and technology. This is the only three-week residential program in the nation, now attracting international participation. The dates will be July 8-27, 2019. More information is available at https://www.ne.ncsu.edu/outreach-engagement/pre-college-students-educators/.

Research Paper Highlight

Design of a benchmarking tool and a test facility for studies of the replacement of dangerous radionuclide sources

Maria Isabel Pinilla, Kansas State University

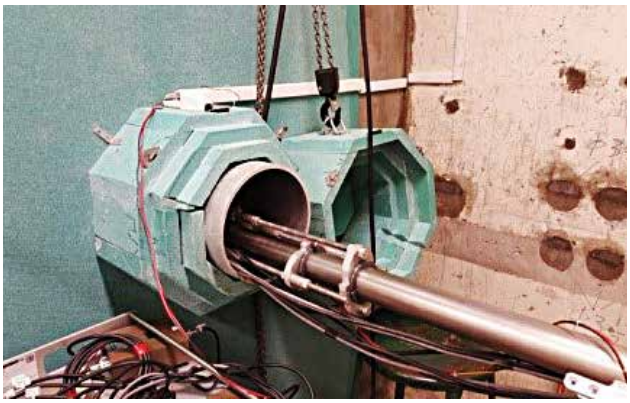
The replacement of dangerous radionuclide sources is one of four CNEC thrust areas. One of our challenges involves the replacement of 241Am-Be and 137Cs sources in oil well logging tools with machine neutron sources. The use of radioisotopes in the oil industry is of concern due to the environments in which the sources are used, which are less secure than those of fixed facilities. Oil well logging tools typically carry on board curie-level neutron and/or gamma-ray radionuclide sources. These tools often operate in remote areas where there is little infrastructure to fully secure these dangerous radionuclides.

North Carolina State University is developing a Monte-Carlo Library Least Squares (MCLLS) code, which will use libraries of simulated detector responses to estimate properties of the media surrounding a borehole. Kansas State University has been tasked with designing an oil well logging tool and a testing facility that can be used to benchmark Monte Carlo simulation codes, including the NC State MCLLS code, and to perform various materials interrogation studies. A major objective is to study the replacement of dangerous radionuclides such as 241Am-Be and 137Cs sources with machine sources.

An oil well logging prototype tool was designed using MCNP6.1. The prototype tool contains a Deuterium-Tritium (DT) generator, a pair of gamma-ray detectors and a pair of neutron detectors. DT generators produce 14.1 MeV neutrons which generate secondary gamma rays as they interact with the surrounding media. A DT generator contains a small amount of tritium in a fully sealed containment that prevents the extraction of the radionuclide in significant amounts. MCNP simulations were used to optimize detector locations and source shielding. The size of the final tool was considered in designing the testing facility.

The Kansas State University Materials Interrogation (KSUMI) facility was designed to conduct experiments using the oil well logging tool prototype. KSUMI contains a chamber large enough to mimic a borehole environment, which can be filled with a variety of materials both dry and

liquid. Experimental measurements using water of different salinities, dry sand, wet sand, dry limestone, and wet limestone have been collected to benchmark the MCLLS code as well as our own Monte Carlo simulations. NaI(Tl), 3He, and BF3 detector responses have been simulated using MCNP6 and compared to experimental measurements using Am-Be and DT neutron sources.

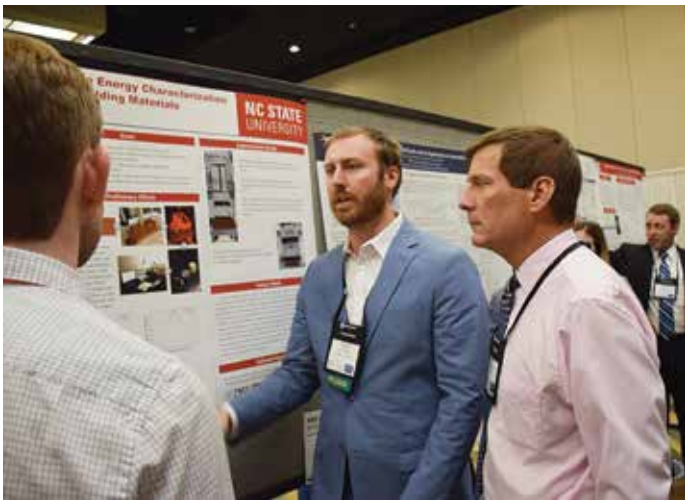


KSU Experimental Facility for Oil Well Logging Studies

National Lab Experience

During my internships at Los Alamos National Lab in the summers of 2016 and 2017, I worked on code development, verification, and benchmarking. Specifically, I worked with DRiFT (Detector Response Function Toolkit for MCNP), which is a code that is being developed at LANL to be used in conjunction with MCNP to generate high fidelity detector response functions. The code is in its early stages of development and I was tasked with adding stilbene processing capabilities. I used experimental data to fit functions to generate MCNP Gaussian Energy Broadening (GEB) parameters for stilbene to improve modeling accuracy. I added light output functions, light emission spectra, neutron and gamma-ray waveforms, and PMT quantum efficiency curves into DRiFT to model stilbene and compare those results to MCNP as well as experimental data.

I participated in the NSSC-LANL Keepin Nonproliferation Science Summer Program in 2017. The program consisted of 8 weeks of intensive hands-on training and seminars. I also attended the NSSC-LANL Nuclear Safeguards Summer School where I took the Fundamentals of Nondestructive Assay Training course. The topics covered include: neutron and gamma counting, coincidence counting, passive assay, active assay, gamma spectroscopy, radionuclide identification, isotopic composition, uranium and plutonium enrichment, and material identification exercises.



Upcoming Events

Event	Date	Location
CNEC Annual Workshop and Advisory Board Meeting	February 6-7, 2019	NC State, Raleigh, North Carolina
University Program Review	June 4-6, 2019	Marriott Downtown Raleigh, North Carolina

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