CNEC Participates in UPR 2018

Poster Session

Oral Presentations
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, 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.

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Dr. John Mattingly, Chief Scientist
Stefani Buster, J.D. Assistant Director
News From Management
Stefani Buster, J.D.

From June 5th to 7th in Ann Arbor, Michigan, dozens of Consortium for Nonproliferation Enabling Capabilities (CNEC) members participated (for the fourth year) in the annual review—now called the University Program Review (UPR). This year’s meeting was hosted by the Consortium for Verification Technologies (CVT) and also attended by Nuclear Science and Security Consortium (NSSC) as well as other individual research grantees.

During the 2018 UPR, Ms. Lisa Gordon-Hagerty, Department of Energy Under Secretary for Nuclear Security and Administrator of the National Nuclear Security Administration (NNSA), attended and provided opening remarks which highlighted the importance of the Integrated University Program (IUP) and the critical role it plays in helping the NNSA accomplish its mission. Ms. Gordon-Haggerty presented awards to three outstanding students, one from each consortium, for their innovative research conducted in collaboration with a US national laboratory. CNEC participants gave 15 oral and 30 poster presentations covering the Consortium’s four Thrust Areas along with policy research and outreach efforts. In addition, several CNEC students won awards for their work. CNEC Fellow Connor Awe, a Physics graduate student from Duke University, was awarded the Best National Laboratory Collaboration prize for his work with Oak Ridge National Laboratory on “Experimental observation of coherent elastic neutrino-nucleus scattering (CEv NS) and evaluation of neutrino detector designs for reactor monitoring”. Nathanael Simerl, a Kansas State University Nuclear Engineering graduate student, was awarded Best Oral Presentation for his work entitled “Radiological Dispersal Device with a UAV-Mounted Portable Spectroscopic Sensor”. University of Illinois at Urbana-Champaign graduate student Aric Tate was awarded Best Poster Presentation for his research on “Muon Tomography with Fast Timing for Fissile Material Detection”.

CNEC looks forward to hosting the next University Program Review (UPR).

CNEC Thrust Area Highlights

Data Fusion and Analytic Techniques (DFAT)

Dr. Alyson Wilson

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.

DFAT students have worked on a variety of projects with CNEC national lab partners. James Gilman is starting his 4th year as a PhD student in Statistics at NC State working with Eric Laber. He interned at...
Pacific Northwest National Laboratory this summer. He worked on two nonproliferation-related projects. First, the Nuclear Inspection Node Event SIMulator (NINESIM), which is a project to develop a tool to provide a graphical detectability and operational cost analysis of special nuclear material (SNM) movement through an arbitrary port-of-entry node as modeled by the user. He applied statistical design of experiments methodology to this problem to help evaluate the model and output results across a wide set of input values, as well as identifying potential model discrepancies. Second, he supported the Front End Personnel Reliability Assurance Program (FEPRAP). The main goal of the project is to assess the reliability of nuclear fuel supply. James helped with building a simulation and optimization model to better understand how different disruptions in the nuclear fuel process could be handled and the effects on the global power grid. The disruption events include shutdown events that would cause different fabrication plants offline and global trade events such as an embargo. James will transition back to work on semi-parametric Thompson Sampling for adversarial decision problems with application to adaptive search.

Dr. Hamid Krim, together with members from his VISSTA Laboratory (Vision, Information and Statistical Signal Theories and Applications) are focusing on developing a new computational model that combines normally incompatible data sets, such as satellite imagery and social media posts, to answer questions about what is happening in targeted locations. For development, VISSTA researchers have been using data which was collected over Boulder, CO in 2013 during severe flooding. Images are processed to determine whether they are images of flooding; text posts (tweets) are processed to determine whether they include references to flooding. Once the data streams are translated into a neutral format – indicating flooding or no flooding – they can be compared to each other to determine whether two information streams support (are consistent with) each other.

The largely open theoretical problem of fusing highly incompatible sensing modalities potentially including invoices, Geiger counter measurements, and others, has been at the center of the research, which was recently featured in Defense One Magazine (https://www.defenseone.com/technology/2018/07/satellite-imagery-social-media-new-way-spot-emerging-nuclear-threats/150146/), as these methodologies are also of crucial importance to target recognition problems of great interest to DoD. Their current and future research work aims to integrate unobservable environments (due to deliberate concealment) with other observable measurements to infer activity over a region. This entails the development of adversarial inference methodologies.
Simulation, Analysis, and Modeling (SAM)
Dr. Ralph Smith

The SAM working group is broadly investigating statistical inference techniques for source detection and localization, surrogate model construction, estimation of background, and coupled deterministic/Monte Carlo radiation transport simulation.

An undergraduate, graduate students, postdoc, and faculty at the University of Michigan and North Carolina State University are collaborating to use Monte Carlo N-Particle (MCNP6.1) simulations to guide radiation source detection and localization in a 3-D urban environment as depicted below.

The high-fidelity MCNP6.1 simulations are initially performed to determine the expected response for a set of detectors at fixed locations within the simulated environment. The simulations are modeling a single cobalt 60 radiation source at different locations. Each simulation returns the relative count at each detector for the specified source location. Initial results demonstrate that uncertainties in building dimensions on the order of a meter produce 10-20% uncertainties in detector responses. To address the computational expense of running MCNP6.1 simulations, the team is developing highly efficient surrogate models to predict detector responses with quantified accuracy. The surrogate models are constructed using Gaussian process, neural network, and polynomial representations computed using MCNP6.1-generated training data at predetermined source locations. The surrogate models are then verified using MCNP6.1 simulations at random source locations within the domain. Because the surrogate models run in approximately 0.01 second, as compared with the MCNP6.1 simulations that take over 5 minutes, they will be employed in future research when using Markov chain Monte Carlo (MCMC) simulations to infer a distribution for the radiation source given a set of detector readings.

Twelve SAM undergraduates and graduate students had summer internships at Los Alamos National Laboratory (LANL), Pacific Northwest National Laboratory (PNNL), Oak Ridge National Laboratory (ORNL), Sandia National Laboratories in Albuquerque, and Hill Air Force Base. Additionally, SAM students and postdocs gave two oral presentations and eleven posters at the University Program Review (UPR) Meeting in Ann Arbor, MI, on June 5-7, 2018.
Signatures and Observables (S&O)

Dr. Katy Huff

Best Poster Award, Aric Tate, “Muon Tomography with Fast Timing for Fissile Material Detection”

University of Illinois CNEC-supported PhD student Aric Tate won a Best Poster Award for his work, “Muon Tomography with Fast Timing for Fissile Material Detection,” presented during the University Program Review meeting. Tate’s work adds precision timing to a high-Z detection technique. Muons, which make up much of the cosmic radiation reaching the earth’s surface, can be used for detection of nuclear material in road transport vehicles and cargo containers for the purposes of non-proliferation. Such muon tomography systems measure the Compton scattering of cosmic ray muons to generate three-dimensional images of volumes.

Tate’s research proposes adding resistive plate chambers to muon detection systems to provide the systems with the high precision timing necessary for time-of-flight measurements. More precise timing will improve the reconstruction of material held within a container. During Summer 2018, Tate worked directly with the Threat Reduction team at LANL P-25 (Subatomic Physics). His work this summer aimed to build and test muon detectors for use in nonproliferation and treaty verification purposes.

New CNEC Effort Presents Results

Prof. Abbaszadeh, a recent addition to the CNEC consortium, has designed a preliminary detector system with Kromek D3S detectors and a DJI Inspire 2 drone. This work, supported as a CNEC Reclaimed Funds Project beginning in January 2018, has already begun to produce results and was presented at both the University Program Review meeting. With CNEC-supported graduate student Gregory Romanchek, Prof. Abbaszadeh has completed reviewing anomaly detection algorithms for spectra data and designed a system for detection. This summer, this review of algorithms is directly contributing to developing a learning-based anomaly detection method to evaluate the abnormality of a spectrum.
Invited Paper at SPIE Optics and Photonics

CNEC faculty and students from Georgia Tech presented an invited paper in the Lighting and Out-Coupling session at the August SPIE Optics and Photonics Conference in San Diego, CA. Prof. Bernard Kippelen and Dr. Canek Fuentes-Hernández authored this work along with students Xiaojia Jia, Xiaoqing Zhang, Youngrak Park, and Felipe A. Larrain.

The paper, ”Recent advances in organic materials and devices for adaptive solid-state lighting” discussed recent advances in developing new thermally activated delayed fluorescent materials and recent progress in organic thin-film transistors (OTFTs) \(^1\). The researchers reported on exhaustive characterization of OTFTs with an ultra-thin bilayer geometry that results in two distinct aging mechanisms that through a compensation effect, yields devices with very low threshold voltage shifts.

Prof. Bernard Kippelen, Dr. Canek Fuentes-Hernández, Xiaojia Jia, Xiaoqing Zhang, Youngrak Park, and Felipe Larrain.


Replacement of Dangerous Radiological Sources (RDRS)

Dr. Walter McNeil

Time-dependent sensor response data has been collected at the Kansas State University (KSU) oil-well logging benchmark facility for a number of different bulk media including water, salt-water, sand, and limestone. This is working toward the creation of templates for algorithm development in the MCLLS method at NC State. Initial data sets have already been transferred to the NSCU and models are being updated to reproduce the sensor response. Large sets of data have been generated and are currently being processed to confirm measurement reliability and to identify unique response characteristics or signatures from the differing media in both the energy and time domain. This includes die-away response which is captured between 1 kHz pulses of neutrons from a D-T generator. Already, gamma-ray spectral signatures have been observed, indicative of prompt and delayed reactions in the media. Long Vo presented details of the KSU benchmarking facility and instrumentation at the Conference on Application of Accelerators in Research and Industry (CAARI) in Grapevine, TX.

Data acquired with AmBe in place of the D-T generator is being studied as well, to provide a good representation of the established technique which we strive to replace with the capabilities of the machine source. Here, MCNP is being utilized to simulate AmBe source signatures as well as the sensor response.
Replacement of Dangerous Radiological Sources (RDRS)  
Continued from page 7.

Data has been collected with the AmBe source outside of the well-bore test facility to better-quantify its characteristic output with the use of both CeBr and NaI scintillator sensors.

Several students have returned from National laboratory research projects and are back to work at KSU. Welcome, back! Over the summer Nathanael Simerl earned a best presentation award at the NNSA UPR2018 for his work with sensor-mounted UAV mapping of dirty bomb contamination. He traveled to Croatia to give a talk on the subject at the CBRNe Applied Science & Consequence Management World Congress (CSCM) where Idaho National Lab is chairing a session on radiological dispersal device (RDD) response exercises. His recent effort on this work includes the import of immediately-acquired UAV aerial imagery into flight-planning software to enable ultra-low altitude navigation around and over obstacles. This enables accurate exposure-rate measurements and radiological surveys by UAV. Furthermore, it provides a path for automated or autonomous contamination mapping with existing UAV and sensor technologies.

Check out other highlights from KSU and the Radiological System Integration Laboratory (RSIL) in the CNEC University Featured Program of this newsletter!

Policy Research and Education Initiative

Dr. Robert Reardon

In December 2017, Dr. Robert Reardon of NC State’s School of Public and International Affairs traveled to Tokyo to interview defense officials and experts and Japanese academics about the Japan’s nuclear program and Japanese views on nuclear weapons proliferation in Northeast Asia, especially toward advances in North Korea’s nuclear and missile programs. The trip included a tour of Japan’s Ministry of Defense and interviews where Dr. Reardon met with Japanese defense experts. In February 2018, he presented findings from the trip at an invited talk at the University of Southern California. In May 2018, he spent a week in residence at the Vienna Center for Nonproliferation and Disarmament in Vienna’s International Centre, where the International Atomic Energy Agency is based. His hosts provided him with impressive access to the highest officials in the IAEA’s Safeguards Department for both on- and off-the-record interviews. His research there focused on third-party intelligence sharing on safeguards compliance with the IAEA. He is currently planning follow-up trips to both locations.
CNEC University Featured Program

Kansas State University (KSU)
Dr. Walter McNeil

Department and Courses - Kansas State University’s Mechanical and Nuclear Engineering (MNE) Department is rapidly growing and consists of 7 faculty members having nuclear focus. The nonproliferation component of the program includes great strength in radiation detection, applications, and shielding. The KSU/MNE catalog contains relevant graduate and undergraduate courses including:

- NE612 - Principles of Radiation Detection
- NE690 - Radiation Protection and Shielding
- NE737 - Intermediate Radiation Measurement Applications
- NE761 - Radiation Measurement Systems (sensor and read-out component focus)

Many new courses are being developed and currently offered as special topics courses including Numerical Transport, Applied Reactor Physics, Radiation Health and Dosimetry, Radiation Sensor Signal Acquisition and Data Processing. The latter is currently a special topics course focused on system-level techniques for mobile detection including signal-chain design decisions and algorithmic computation for specific applications such as detection, localization, and isotope identification.

The MNE department participates in the University Engineering Alliance which offers online nuclear engineering courses, some of which are relevant to nonproliferation. The two most relevant courses include Science and Technology of Terrorism and Counter Terrorism and Nonproliferation Issues for Weapons of Mass Destruction. Both course are administered from the University of Missouri and are accessible through Kansas State University’s Global Campus program.

Research and Facilities - In research, the MNE department of KSU has non-proliferation relevant activities and facilities including the Semiconductor Materials and Radiological Technologies (SMART) Laboratory directed by Douglas McGregor and the Radiological System Integration Laboratory (RSIL) directed by Walter McNeil. The SMART lab is 7,000 square-feet of materials processing workspace for including 40+ crystal growth machines, semiconductor wafer-scale processing and microfabrication equipment, a Class 1000 and a Class 100 cleanroom. Currently, a 300 square-foot dry room is being installed for processing hygroscopic materials such as scintillator crystals and materials that are reactive with the environment such as Lithium metals and photocathode films.
Supporting radiation detection system development and applications, RSIL has numerous portable radiation detection equipment, a mobile laboratory, and 3 multi-rotor UAVs (including a heavy-lift UAV with a 22 lb. payload capacity). These resources are currently active in researching methods of radiation contamination surveying and monitoring of dirty-bomb plumes in collaboration with Idaho National Laboratory and their Radiological Response Test Range (RRTR).

In simulation and modeling capabilities, all students and faculty have access to the KSU “Beocat” supercomputer which currently has 7,800 cores and 2.2PB of storage and supports a number of popular radiation transport codes along with commercial FEA and multi-physics software packages. RSIL students are currently creating coupled-physics response models of sensor systems such as crystal & PMT assemblies. Having a system integration focus, RSIL is also currently engaged in research to reduce power consumption of signal chain and computational hardware for algorithmic execution in battery-powered detection systems. With regard to system size-reduction, RSIL is researching methods to shrink discrete electronic assemblies with 3D additive manufacturing concepts. Size, power, and computational efficiency are all enabling capabilities in supporting dispersed-networked detector architectures.
KSU’s proximity to the National Security Campus supports close working relations and has resulted in numerous RSIL projects supporting the mission of the NNSA. These projects include the research and development of various radiation imaging systems and methods, active interrogation studies, and the simulation and quantification of radiation damage to electronics in real-time during nuclear non-destructive analysis. Shown below is the result of tomography completed with a portable gamma-ray imaging system.

KSU has a TRIGA nuclear reactor which is operated within the MNE department and provides neutron irradiation capabilities with multiple in-core and beam-line experiment stations. In addition TRIGA fuel elements are accessible for sensor interrogation with various levels of burn-up history. One beam-line provides diffracted neutrons with energy distribution centered near 2200 m/s and other beams provide harder neutron energy distributions originating from the reactor reflector and from the unobstructed core.

With the support of CNEC, KSU has completed the installation of a machine-source laboratory utilizing a D-T neutron generator for large scale experiments emitting high-energy neutrons into bulk media. Currently these experiments are demonstrating the ability for this type of machine source to potentially replace natural radiological sources used in industry that pose greater risk in proliferation. Capabilities will soon be expanded to include an intense X-ray generator for imaging and non-destructive analysis studies.

**Program Growth** - Many opportunities in the area of non-proliferation exist in the MNE department at Kansas State University including 2 tenure-track faculty openings, post-doc positions to fill, and numerous fully-funded M.S. and Ph.D. student research positions available right-now!
Labortory Highlights

Los Alamos National Laboratory (LANL)

Dr. Jeffrey Favorite

**Dr. Jeffrey Favorite**, PhD Nuclear Engineering from Georgia Tech, was recently appointed as an adjunct professor at NC State. Jeff is in the Monte Carlo Methods, Codes, and Applications Group (XCP-3) at Los Alamos National Laboratory (LANL), where he specializes in neutron and photon transport simulations and methods, sensitivity and perturbation analysis, and model parameter optimization. Jeff has been LANL’s representative to CNEC since the beginning of the Consortium in 2014. Jeff’s appointment began on Aug. 6, 2018, and is effective until Aug. 5, 2021.

Oak Ridge National Laboratory (ORNL)

Dr. David Williams

**Dr. David Williams** attended the UPR 2018 meeting and participated in the Student Meet and Greet Luncheon and the Consortia and DNN R&D Leaders Executive Meeting at the end of UPR 2018.

Connor Awe was recognized as participating in the most outstanding Laboratory-Consortia Research Project for the CNEC Consortium. Connor was nominated for “Contributions to Experimental Measurement of Coherent Elastic Neutrino-Nucleus Scattering and Evaluation of Various Detector Types for Reactor Monitoring” and spent last summer at ORNL.

Pacific Northwest National Laboratory (PNNL)

Dr. Robert Brigantic

CNEC intern **Dylan Hoagland** (North Carolina State University) is spending the summer at PNNL investigating the use of deterministic radiation transport calculations for emission tomography of spent nuclear fuel, in support of nuclear safeguards. Passive gamma emission tomography uses small gamma detectors behind a collimator, which narrows their field of view, to reconstruct a pin-wise emission distribution inside a spent fuel assembly, thus allowing for the detection of proliferated nuclear material. Dylan’s work is focused on investigating the origin of gammas which reach the detectors, so as to gain insight into the advantageous parts of the model to allocate computational resources to in order to resolve a discrepancy between models. Preliminary results have shown scattering within the collimator or more prominent septal penetration than originally suspected to be the most likely causes of RADSAT and MCNP’s disagreement of results. Theoretical analysis has shown scattering between detectors to be negligible due to the high energy loss associated with such scattering events. Dylan has learned the RADSAT package for coupled deterministic-Monte Carlo transport, and has been investigating the use of both forward and adjoint calculations to help understand scatter and septal penetration in a collimator.
CNEC intern **Erik Medhurst** (Illinois) has been supporting work related to the Visual Sample Plan (VSP). VSP is a statistical and modeling software used to plan out sample collection to make statistical judgments on a volume of space. VSP is useful in a range of applications including response to radiation terrorist events. Erik has been working on an application for the Microsoft Hololens that will make the sample collection process easier and quicker. His application allows users to map a room into a 3D mesh, and randomly generate sample points on top of the 3D mesh. The user is walked through the process of crafting the sample plan via voice guidance and sets up the sample plan with a combination of voice commands and hand gestures. This work focuses on visualizing where measurements should be taken which ties into his university research that focuses on displaying measurements. The combination of the two tools simplifies collecting and interpreting radiation measurements.

CNEC interns **Lydia Lagari** (Purdue University) and **James Gilman** (North Carolina State University) have both been supporting test and evaluation of the Nuclear Inspection Node Event SIMulator (NINESIM) tool to provide a graphical detectability and operational cost analysis of special nuclear material (SNM) movement through an arbitrary port-of-entry node as modeled by the user. They have applied statistical design of experiments methodology to this problem to help evaluate the model and output results across a wide set of input values, as well as identifying potential model discrepancies. They have also both supported the development of the risk methodology and test and evaluation of the Airport Risk Assessment Model (ARAM). The goal of this tool is to implement an operational risk-based, intel-driven decision platform to assess and quantify terrorism risk at airports. This information will be used to improve the way limited security countermeasures representing federal and state/local agencies and associated resources are deployed at an airport in order to minimize risk across the system as a whole. Both Lydia and James were also able to travel with the PNNL project team to demonstrate the model to the Transportation Security Administration (TSA) and security organizations at the Seattle-Tacoma International Airport. They also helped co-author a journal paper that presents the risk methodology which has been submitted for publication to *Risk Analysis: An International Journal*. Lydia also worked on a Xenon detection project with the objective to improve quantification of complex coincident data and to automatically determine the activity of four different Xe isotopes (Xe-131m, Xe-133, Xe133m, Xe-135) from a beta vs gamma plot. She also became familiar with the use of Convolutional Neural Networks (CNNs) and Keras, an open source neural network library. James also supported the Front End Personnel Reliability Assurance Program (FEPRAP).
Continued from page 13.

The main goal of the project is assessing the reliability of nuclear fuel supply. James helped with building a simulation and optimization model to better understand how different disruptions in the nuclear fuel process could be handled and the effects on the global power grid. The disruption events include shutdown events that would cause different fabrication plants offline and global trade events such as an embargo.

CNEC intern **Diego Laramore** (Kansas State University) has been investigating the properties of CLYC based low-profile detectors. The relatively new scintillating detection material CLYC is capable of both gamma and neutron radiation detection at excellent resolution, and can be coupled to existing detection systems using conventional light collection devices. Diego has been analyzing the light emission characteristics of CLYC by acquiring large data samples in the lab from real detectors and radiation sources, then using conventional pulse height analysis (PHA), waveform digitization, pulse-shape discrimination (PSD), and “super-pulse” averaging techniques. Work has also been done on generating radiation and optical photon transport models of CLYC detectors in Geant4 Monte-Carlo code. These methods will lead to insights into the limitations and design constraints of CLYC based systems for current and future designs.

CNEC intern **Eva Brayfindley** (North Carolina State University) was also able to attend a two week course at PNNL on Radiation Detection for Nuclear Security. While here, Eva also met with her PNNL mentor Robert Brigantic to tag-up on her progress related to her CNEC focused dissertation on using data fusion methods for combining Cerenkov radiation and gamma emission tomography for automating defect detection in spent nuclear fuel. Eva has had a journal paper stemming from this work accepted for publication as well.

In addition, all the CNEC summer interns at PNNL have been attending and participating in various activities to enhance their knowledge and experience in nonproliferation including short technical tutorials on various topics (machine learning, optimization, discrete event simulation, and creating Shiny apps in R) and tours to include the B Reactor National Historic Landmark, “part of the Hanford Unit of the Manhattan Project National Historical Park, is the world’s first full-scale plutonium production reactor” [https://manhattanprojectbreactor.hanford.gov/], the USS Triton Submarine Memorial Park (picture below) “the USS Triton submarine was the first to circumnavigate around the world submerged, and is the only U.S. submarine built with two nuclear reactors” [http://portofbenton.com/community/triton-sail/], and the Laser Interferometer Gravitational-Wave Observatory (LIGO) at Hanford [https://www.ligo.caltech.edu/page/ligo-detectors]. Additionally, CNEC interns were able to participate in the week long Nonproliferation and International Safeguards Summer Course at PNNL. Finally, CNEC interns participated in numerous extracurricular activities to include softball, volleyball and tennis, boating and floating down the Columbia River, and backpacking and fishing in the Pacific Northwest.

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CNEC Interns and PNNL Mentors at PNNL (Dr. Robert Brigantic, Dr. Deborah Fagan, Lydia Lagari, Erik Medhurst, James Gilman, Mitch Myjak, Dylan Hoagland, and Sarah Cederbloom) Touring the USS Triton Sail

CNEC Interns James Gilman and Lydia Lagari and Mentor Dr. Robert Brigantic
In June, Mr. Bill Magwood, Director-General of the Nuclear Energy Agency (NEA) in Paris, France visited NC State University, accompanied by Tatiana Ivanova, Head of Division of Nuclear Science and Aleshia Duncan, Senior Advisor for Multilateral Co-ordination and Secretary to the Steering Committee.

During their visit, Mr. Magwood gave a presentation to the wider university community, with several CNEC participants in attendance. His presentation highlighted information about the make-up of the NEA, their nuclear science activities, lessons in nuclear safety, and electricity mix and carbon emissions. Mr. Magwood also spoke about energy in the 21st century, cost issues associated with nuclear power, mixing nuclear and renewables, and addressing the challenge of nuclear waste disposal.

Following his presentation, Mr. Magwood and NEA’s delegation heard a presentation from CNEC’s director, Dr. Yousry Azmy. Dr. Azmy’s presentation covered CNEC’s operations, activities, innovative technical outputs, and explored areas of potential collaboration within topics that intersect nuclear energy and nonproliferation.

CNEC leadership appreciated and benefitted from being included in Mr. Magwood’s visit to NC State’s campus and looks forward to hosting Mr. Magwood again during any future visits.
Honors and Awards

**Dr. Ralph C. Smith** of NC State was named a Distinguished University Professor of Mathematics for his work on modeling, control and uncertainty quantification for smart material systems and for improving the quality of NC State and serving its mission through service and involvement in the campus community.

**Dr. Robert Hayes** of NC State received a citation from the Institute of Electrical and Electronics Engineers (IEEE) for his contribution to the American National Standard Instrumentation and System for Monitoring Airborne Radioactivity. The standard encompasses monitoring all types of airborne radioactivity including aerosols, noble gases, iodines, and tritium in the workplace, in effluent, and in the environment. It also includes initial design, manufacture, minimum performance, performance testing, calibration, and maintenance requirements. The standard covers both real-time monitors and air samplers and is intended to provide guidance on industry best practices to obtain continual quality in the life cycle of relevant systems. In addition, the purpose of this standard was to integrate the relevant materials from ANSI N42.17B, ANSI N42.18, ANSI N42.30, and ANSI N323C into a single standard. The intended users would be government and commercial facilities having the potential for airborne radioactivity.

**James Gilman**, CNEC Intern from North Carolina State University, was recognized by Pacific Northwest National Laboratory as he especially distinguished himself this summer by supporting test and evaluation of the Nuclear Inspection Node Event SIMulator (NINESIM) tool being developed for the Countering Weapons of Mass Destruction (CWMD) Office. CWMD’s mission is to “counter attempts by terrorists or other threat actors to carry out an attack against the United States or its interests using a weapon of mass destruction” [https://www.dhs.gov/countering-weapons-mass-destruction-office]. As a joint national laboratory (Los Alamos National Laboratory (project lead), Naval Research Laboratory, and PNNL) effort, NINESIM has been designed to provide a graphical detectability and operational cost analysis of special nuclear material (SNM) movement through an arbitrary port-of-entry node as modeled by the user. James formulated and implemented a statistical design of experiments (DOE) methodology to this problem to help evaluate the model and output results across a wide set of input values (over 90,000 different permutations of input variables). To accomplish this, James first figured out how to configure and run NINESIM on a local virtual machine (VM) setup which allowed the model to be run locally on a cluster computer resident at Los Alamos National Laboratory. He then authored a complex python script that could launch the various model input settings and collect the NINESIM output results. Two heroic accomplishments in themselves, but James then led the DOE analysis of the results and presented findings and insights from this work to our national lab partners and soon this will also be presented to CWMD. James deserves special recognition for his outstanding contributions and devotion to this effort that went above and beyond expectations!
CNEC and Pre-College Summer Programming

Lisa Marshall, NC State

CNEC participated in NC State’s Young Investigators’ Summer Program in Nuclear Engineering for the 3rd time. Eighteen (18) students from North Carolina, Maine, Florida, New Jersey, Kentucky, Virginia and China participated this July 2018. Our international student, Haoxaun Yu, is a rising high school senior, and attends Wycombe Abbey International School in Changzhou located in the province of Jiangsu, China. Haoxaun developed interests for advanced reactors and high temperature plasmas early on and expressed delight as he explored these and other topics in the program.

Over the three-week residential period students took part in lectures, labs, projects and industrial field trips. Group projects included work in the areas of radiation monitoring, light sensitive monitors for the PULSTAR research reactor and nuclear materials. Lectures were given by faculty, professional staff and post-doctoral scholars on such topics as fission power systems, computational fluid dynamics, environmental assessment and applications in nuclear medicine, to name a few.

Popular was the seminar on the Waste Isolation Pilot Project (WIPP) by Dr. Robert Hayes, Associate Professor of Nuclear Engineering. His project this year was entitled “Characterizing Radioactive Emission from Common Items Using Small Modular Radiation Detectors”. Hayes is a member of the Consortium on Nonproliferation Enabling Capabilities (CNEC) and holds a joint appointment with Oak Ridge National Laboratory.

Ms. Lisa Marshall, Educational Director for CNEC (& the program director for the Young Investigators’ Summer Program) also lectured on the US energy plan, nonproliferation initiatives and nuclear engineering education. The closing ceremony was held on Friday, July 27 in McKimmon Center. Students presented their projects to project mentors, parents and family friends. Doctoral candidate, Vincent Di Nova, served as this year’s guest speaker.

The Young Investigators’ Summer Program (YISP) thanks faculty, staff, university students and corporate contributors (e.g. Duke Energy, Framatome, and PetNet Solutions) for their time and effort. Students come away with a multifaceted examination of what nuclear science and technology has to offer and are more informed about engineering education especially nuclear.

University News

Joseph Cope, NC State graduate student, received the Everitt P. Blizard Graduate Scholarship from the American Nuclear Society’s Radiation Protection and Shielding Division (ANS/RPSD). Blizard was best known as the “father of reactor shielding”.

Ryan O’Mara, graduate student at NC State, was elected as the student member to the ANS/RPSD executive committee and is currently serving in that capacity.

North Carolina State University’s Nuclear Engineering Department is now offering a minor in Health Physics.
Research Paper Highlight

Preliminary Work Toward a Transuranic Activity Estimation Method for Rapid Discrimination of Anthropogenic from Transuranic Activity in Alpha Air Samples

Joseph Cope, CNEC Fellow, North Carolina State University

In radiological emergency response, air monitoring techniques are typically employed surrounding the release. In order to avoid donning personal protective equipment and to uphold ALARA principles, air sampling is conducted on the outskirts of the plume where the source term is comparable to background radiation levels. As such, the transuranic (TRU) activity signals of interest are inherently low and potentially only fractions of the background activity; this presents a complex need for accurate background compensation to appropriately assay the TRU activity levels, the associated risk to human health and prescription of any evacuation or shelter-in-place guidelines.

A main contributor to your background terrestrial radiation dose is due to radon; here, radon and its decay products become the noise term we seek to discriminate against any TRU activity signal. For alpha particle spectrometry, significant left-tailing of background peaks is well-studied in typical detectors as alpha particles lose energy in both the interstitial air and the detector dead layer. Complicating analysis methods, the left-tailing of the background radon progeny peaks overlap the TRU energy region-of-interest where a threatening source term may be masked due to a high background activity. If that wasn’t enough, the natural background radiation levels vary widely throughout the day and have seasonal, atmospheric and geographic dependencies.

Typically, an air sample is collected and then gross counted, which requires delays of many hours while the radon progeny decays (approximate 30 minute half-life) such that the long-lived TRU content is the only significant activity remaining on the filter. However, in an emergency response context, this delay is clearly not ideal in terms of enabling rapid, quality data assessment provision to decision makers.

This research seeks to produce a rapid and conservative method which can assay the transuranic content of the filter in under 2 hours. The activity uncertainty decreases with additional time and this work seeks to fill the gap of time between sample collection and current analysis methods.
Portable air samplers and a portable PIPS detector for alpha-beta measurements similar to those used in radiological emergency response scenarios were used in the data collection. These portable instruments provide a driving force for the development of a field-deployable package to quickly determine the transuranic activity present in a sample.

A time-series activity decay plot is noted on regular interval spacing and then fit using a simplified exponential decay curve which approximates the known solution of the Bateman equations for several radionuclides. Due to employing a Levenberg-Marquardt (LM) fitting algorithm, each parameter in the fit equation includes an uncertainty estimate. Determined from the fit for each sample, an estimate of the long-lived activity is provided with uncertainty. Consequently, each observation can be approximated as a Gaussian distribution. The Gaussian distributions of the long-lived transuranic activity estimate for each filter are then summed together and normalized to produce a continuous distribution from which the mean, mode and other statistics parameters can be determined.

A benefit of the technique is the ability to utilize a time-series decay plot, enabling a suite of existing emergency response equipment to collect the alpha measurements. The first set of measurements involved no transuranic activity with the goal of accurately being able to determine a “zero” or clean filter that is indistinguishable from background. The results predicted the long-lived activity within a background level bias. Additional measurements with transuranic check sources in the detector environment to simulate an air filter with transuranic activity have been analyzed showing rapid and conservative prediction of the transuranic content. Development of an integrated analysis package for operational, ruggedized use is under development to perform the fitting, alert a user to a poor fitting result and also to display appropriate summary values of interest to both assessment scientists and decision makers.

Full development and implementation of this technique will contribute to the preparedness of the radiological emergency response community. By employing existing equipment, this research allows actionable measurement data in times not currently utilized in the monitoring and assessment framework.
Upcoming Events

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<td>ANS Winter Meeting and Nuclear Technology Expo</td>
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