

CNEC Newsletter

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cneec.ncsu.edu

Director's News

Dr. Yousry Azmy



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UNIVERSITY PARTNERS

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

LABORATORY PARTNERS

LANL
LLNL
ORNL
PNNL

UPCOMING EVENTS

FEBRUARY 6-7, 2017
CNEC Workshop
Advisory Board

JUNE 6-8, 2017
UITI

Welcome to the inaugural issue of CNEC's newsletter!

On April 16, 2014, the National Nuclear Security Administration (NNSA) announced that it awarded a five-year, \$25M grant to the Consortium for Nonproliferation Enabling Capabilities (CNEC) team of academic and national laboratory researchers led by NC State University. Our multidisciplinary group comprises faculty and students from seven universities: NC State University, Georgia Tech, Kansas State University, North Carolina Agricultural and Technical State University, Purdue University, University of Illinois at Urbana-Champaign, and University of Michigan. Research scientists from Los Alamos, Oak Ridge and Pacific Northwest, and more recently Lawrence Livermore, National Laboratories engage our faculty and students in conducting their research projects and aligning them with national objectives. To illustrate the level of multidisciplinary mix among our team's expertise, in NC State alone the CNEC faculty belong to six departments that reside in three colleges.

CNEC's vision is to become the 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. This vision will be achieved by applying our collective expertise and focused efforts towards achieving CNEC's mission as captured in our Mission Statement "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 the next few pages you will read about the scope of our research projects and the progress we have achieved so far on multiple fronts. I invite you to keep pace with our progress via our website at <https://www.cneec.ncsu.edu/> where you will also find a wealth of information including career opportunities in the area of nuclear nonproliferation. Thank you for your interest in CNEC and I hope you enjoy reading about us.

CNEC Thrust Areas

Signatures and Observables (S&O)



Dr. Clair Sullivan

The S&O thrust area focuses on improving existing and future systems for detecting proliferation activities by conducting multidisciplinary research in the analysis and uncertainty quantification of sensor signals. In S&O, “sensors” include instruments that measure traditional emissions (“signals”) of materials, facilities, and processes such as ionizing radiation, chemical effluents, radio frequency signals, etc. However, S&O’s research also expands the traditional meaning of “signal” to analyze open source, “big data” streams as potential signals for detecting proliferation activities. S&O’s principal goal is to develop methods to enable the detection proliferation activities in signals containing significant noise, i.e., background. The thrust area’s objectives are to develop techniques for knowledge-based background estimation and feature-based anomaly detection. S&O is led by Prof. Clair Sullivan of University of Illinois, Urbana-Champaign (UIUC); her team includes faculty, students, and lab scientists from UIUC, NC State, Purdue, Los Alamos, Oak Ridge, and Pacific Northwest with expertise in nuclear science and engineering, geography, statistics, and machine learning.

Simulation, Analysis and Modeling (SAM) News



Dr. John Mattingly

The SAM thrust area is focused on developing new simulation and modeling methods to predict the characteristics of observable signals of special nuclear material (SNM). SAM is working to integrate sensitivity analysis and uncertainty quantification in physical models of SNM signals, analyze predictive simulations of these signals to potentially identify new signatures, and apply simulation and modeling to evaluate the potential effectiveness of new sensing, measurement, and analysis techniques. SAM’s principal goal is to develop methods to solve the inverse problem of estimating SNM properties from sensor signals, particularly in problems that exhibit high dimensionality in parameter and response space (i.e., when there are numerous sensor signals and SNM properties). The thrust area’s objectives are to develop efficient numerical methods for predicting sensor responses to SNM and to create new methods of analyzing sensor signals to estimate SNM properties. SAM is led by Prof. John Mattingly of NC State University; his team includes faculty, students, and lab scientists from NC State, Michigan, NC A&T, Purdue, Los Alamos, Oak Ridge, and Pacific Northwest with expertise in nuclear science and engineering, mathematics, statistics, and physics.

Data Fusion and Analytics Techniques (DFAT)



Dr. Alyson Wilson

The DFAT thrust area is focused on developing new techniques to combine multiple sources of information to enable the detection of proliferation activities. Data sources that can be exploited for proliferation detection include traditional sensor signals, but they also include still and video images, hyper-spectral imagery, simulation and modeling outputs, unstructured text, and internet traffic. DFAT's research seeks to combine this heterogeneous information at three levels: (1) data fusion, which combines raw measurements from multiple sensors; (2) feature fusion, which combines characteristics extracted from the raw measurements; and (3) decision fusion, where multiple sensors' detection of a signals presence are fused. DFAT's principal goal is to create tools to collect, fuse, and analyze data from multiple, heterogeneous, unstructured sources to enable the identification of proliferation signatures. The thrust area's objectives are to apply data fusion and analytics to identify patterns of signatures associated with nuclear proliferation activities and exploit those patterns to detect proliferation. DFAT is led by Prof. Alyson Wilson of NC State University; her team includes faculty, students, and lab scientists from NC State, Purdue, Los Alamos, Oak Ridge, and Pacific Northwest with expertise in statistics, mathematics, computer science, and nuclear science and engineering.

Replacement of Dangerous Radiological Sources (RDRS)



Dr. Bill Dunn

The RDRS thrust area is focused on developing viable replacements for potentially dangerous radiological sources currently used in industry and medicine. A variety of instruments for industrial diagnostics, including oil-well logging tools, soil density gauges, and radiographic cameras use long-lived neutron and gamma radiation sources, including ^{252}Cf , americium-beryllium (AmBe), ^{137}Cs , ^{60}Co , and ^{192}Ir . Long-lived gamma radiation sources are also used in blood sterilization and food sterilization. RDRS is working to (1) identify industrial and medical devices containing radiological sources that present the most significant security risks and (2) develop alternative designs of those devices that replace the potentially dangerous sources. In particular, RDRS's research has focused on an alternative oil-well logging tool design that replaces AmBe and ^{137}Cs with a deuterium-tritium (DT) accelerator source. RDRS is led by Prof. Bill Dunn of Kansas State University; his team includes faculty, students, and lab scientists from Kansas State, Georgia Tech, NC State, and Los Alamos with expertise in nuclear science and engineering.

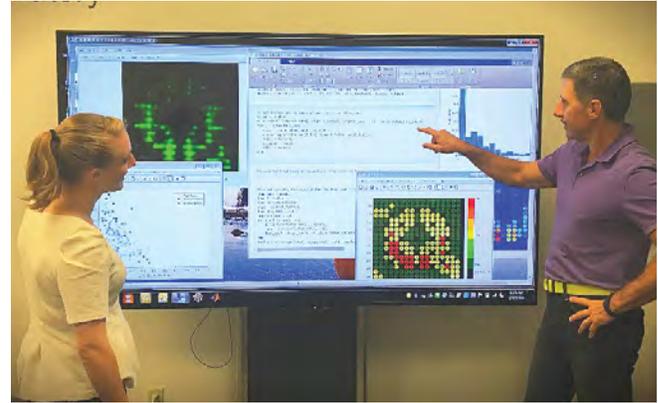
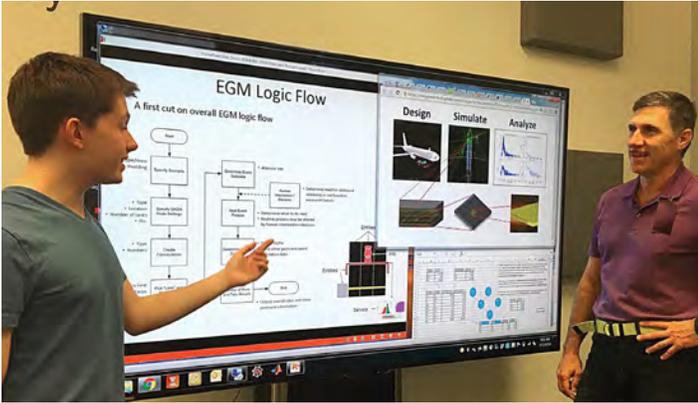
CNEC Faculty, Students and Postdocs Participate in a High-Level Technical Tour at the Device Assembly Facility in Nevada

Contributed by Rian Bahran

Faculty, students, and post-docs from CNEC had the chance to observe measurements of radiation signatures from Category I Special Nuclear Material (SNM) at the Device Assembly Facility (DAF) at the Nevada National Security Site (NNSS) this summer as part of a one-day tour organized by Los Alamos National Laboratory. The DAF is home to the National Criticality Experiments Research Center (NCERC), which is operated by Los Alamos and maintains a substantial SNM inventory and expertise to support a variety of nuclear security missions that require hands-on access to significant quantities of weaponsgrade plutonium and highly enriched uranium in numerous configurations. The tour participants also visited the famous Sedan Crater (1,280' wide, 320' deep) which was formed in 1962.



2016 CNEC Internships



Pacific Northwest National Laboratory

Bobbie-Jo Webb-Robertson and Robert Brigantic

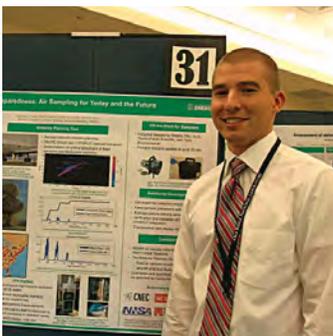
Three CNEC interns have been engaged in project work in the summer of 2016, with collaborations ongoing for all three. Over the summer Karl Roth from the University of Illinois Urbana-Champaign and Evangelina Brayfindley from North Carolina State University joined the Applied Statistics and Computational Modeling group under mentor Robert Brigantic. Both interns tackled the IAEA Improved Cherenkov Viewing Device (ICVD) challenge to identify missing fuel rods from analysis of ICVD images. Karl also worked on an on-going project for the Department of Homeland Security (DHS) Domestic Nuclear Detection Office (DNDO), Karl learned how to install and run the SoftWare for Optimization of Radiation Detectors (SWORD) developed by the Naval Research Lab (NRL). Likewise, Karl also learned how to install and run the Monte Carlo N-Particle (MCNP) code developed by Los Alamos National Laboratory (LANL). Eva worked on an on-going project for DHS DNDO, developing a first of its kind Bayes net for estimating the propensity for human errors in security screening operations with a focus on U.S. ports of entry and radiological and nuclear screening of conveyances. PNNL remains engaged with both Eva and Karl now that they have returned to their respective universities to continue their PhD programs. Karl will help to conduct additional largescale MCNP simulation runs to support the development of the Nuclear Inspection Node Event SIMulator (NINESIM) tool for DNDO. Likewise, Eva will continue to support the NINESIM model development with a focus on the Bayes net. However, her main focus and interactions with PNNL will be developing her dissertation related to on-going research to model and automate analysis based on ICVD images. This includes learning new software codes such as MCNP and Geant4 (GEometry ANd Tracking which is a toolkit for the simulation of the passage of particles through matter). Dr. Brigantic will support Eva's dissertation committee and holds monthly telecons with her and her advisor, Dr. Ralph Smith. Lastly, PNNL continues to support CNEC student Nick Meyer is conducting research related to developing algorithms to optimize the search for evasive adversaries. Nick was a summer intern at PNNL in 2015 and then spent three weeks at PNNL again in the fall of 2016 for additional input and discussions to support his dissertation research. PNNL has also developed joint proposals with Nick's advisor, Dr. Eric Laber, to DNDO.

2016 CNEC Internships

Oak Ridge National Laboratory

Dave Williams

Oak Ridge National Laboratory supported 7 summer sessions in 2016 as part of the CNEC Consortia. Lydia Lagari of Professor Lefteri Tsoukalas research group at Purdue University was hosted by Vladimir Sobes of the ORNL Nuclear Criticality and Safety Group and worked on the project “Nuclear Resonance Characterization for Special Nuclear Material Detection and Identification” using advanced neural network analysis. This collaboration continued after the summer session and resulted in a joint Purdue/ORNL paper (Application of Artificial Neural Networks for Reliable Nuclear Data for Nonproliferation Modeling and Simulation) submitted to the International Joint Conference on Neural Networks (IJCNN 2017). Kayla Coleman of Professor Ralph Smith’s research group at NCSU worked with Kevin Clarno of ORNL on a multi-physics fuel performance code in coordination with the Consortium for Advanced LWRs (CASL). Kayla was awarded third prize in the NESLS poster completion for her presentation of “Rigorous Generation of Low-order Fuel Temperature Models using the Bison Fuel Performance Code”. Aaron Bevill of Bill Martin’s group at the University of Michigan completed his work with Keith Bledsoe solving inverse transport problems using passive gamma-ray analysis and quantitative imaging. Aaron presented his work at UITI 2016 and co-authored and presented “Uncertainty Quantification for Quantitative Imaging Holdup Measurements” at the 2016 INMM Meeting. Susheela Singh - a member of Alyson Wilson’s group at NCSU - completed her summer session with Catherine Schuman of ORNL in the area of neuromorphic network analysis. Their joint work “Parallel Evolutionary Optimization for Neuromorphic Network Training” was presented in Machine Learning in HPC Environments Workshop, held in conjunction with SC16 – The International Conference for High Performance Computing, Networking, Storage and Analysis (Nov.14, 2016 Salt Lake City, UT). S. Joseph Cope (CNEC fellow and student of Professor Rob Hayes) of NCSU started his work with Vince Jodoin of ORNL on the Airborne Debris Collection Planning Tool this summer. Mark Buckner of ORNL hosted Professor Miltos Alamaniotis of Purdue University this past summer for a two-week work session in the area of electrical grid security. A number of joint proposal opportunities were identified and an invited joint paper to the IEEE International Conference on Tools with Artificial Intelligence (ICTAI 2016: Privacy-Driven Electricity Group Demand Response in Smart Cities Using Particle Swarm Optimization) was developed as part of this cooperation. Adam Drescher of the University of Texas, Austin interned with Roger David Glasgow; his project was titled “Simultaneous Determination of Anthropogenic and Natural Uranium Enrichment Levels”.

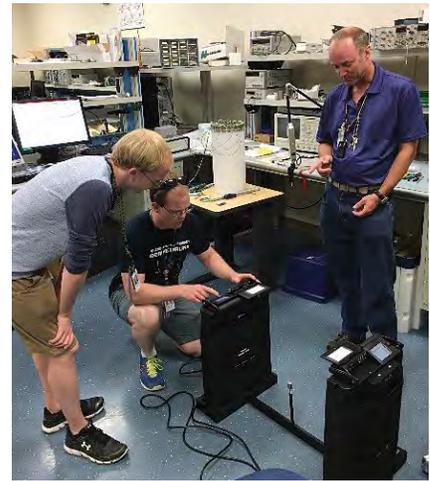


2016 CNEC Internships

Los Alamos National Laboratory

Jeffrey Favorite

Los Alamos National Laboratory hosted seven CNEC student interns in the summer of 2016. Adrian Beard, from North Carolina A&T (Prof. Ahmidouch), returned for his second summer. He worked with Theresa Cutler and Michael Rising on “CNEC Subcritical Measurements at the Device Assembly Facility (DAF).” Alex Clark, a CNEC Fellow from NC State (Prof. Mattingly), worked with Mark Smith-Nelson using MCNP6 to estimate fission-inducing neutron energies, neutron multiplicity statistics, and neutron multiplication for the beryllium-reflected plutonium (BeRP) ball. Joel Kulesza from U. Michigan (Profs. Larsen and Kiedrowski) worked with C. J. Solomon and Avneet Sood on a project called “Cost-Optimized Automated Variance Reduction Tool Benchmarking.” An extended summary of this work has been submitted to the International Conference on Mathematics & Computational Methods Applied to Nuclear Science and Engineering (M&C 2017), Jeju, Korea, April 16-20, 2017. Joel is still at LANL as a year-round student. Alex McSpaden from U. Michigan (Prof. Martin) worked with Mark Smith-Nelson and Jae Chang on deterministic calculations of neutron multiplicity statistics using the LANL deterministic transport code CAPSAICIN. Isaac Michaud of NC State (Prof. Wilson) worked with Brian Weaver on using Gaussian process approximations for designing experiments. Maria Pinilla of Kansas State (Prof. Dunn) worked with Michael Rising on developing accurate MCNP6 simulations of correlated data in fission events. Erik Skau of NC State (Prof. Krim) returned to work with Brendt Wohlberg for the second summer. Their project was on dictionary learning and its applications. In addition to these students, CNEC Fellow Jennifer Arthur of U. Michigan (Prof. Pozzi) has an on-going collaboration with Rian Bahrn and Rensselaer Polytechnic Institute (RPI) on measurements and simulations using the RPI reactor and LANL detectors.



GEANT4 Workshop May 11-12, 2016

Professors Abdellah Ahmidouch of North Carolina Agricultural and Technical State University (NC A&T) and John Mattingly of North Carolina State University (NCSU) hosted a two-day workshop on the modeling

software GEANT4 for nonproliferation application. The workshop was held at NC A&T.



Dr. Makoto Asai and Dr. Dennis Wright of the SLAC National Accelerator Laboratory (SLAC), members of the United States GEANT4 collaboration team, were the instructors in the two-day workshop.

ANS Nonproliferation Topical Meeting

CNEC FELLOWS

Jennifer Arthur

University of Michigan

Connor Awe

Duke University

Carl Britt

University of Tennessee

Alex Clark

North Carolina State University

Joseph Cope

North Carolina State University

Adam Drescher

University of Texas

Samuel Hedges

Duke University

Dylan Hoagland

North Carolina State University

Joel Kulesza

University of Michigan

Nicholas Meyer

North Carolina State University

Karl Roth

University of Illinois

Richard Scott

University of Tennessee

Raffi Yessayan

North Carolina State University

Dr. Sara Pozzi, Consortium for Verification Technology (CVT), Dr. Bethany Goldblum of the Nuclear Science and Security Consortium (NSSC), and Dr. John Mattingly of the Consortium for Nonproliferation Enabling Capabilities (CNEC) were invited panelists at



the American Nuclear Society's (ANS) first topical meeting of the Nuclear Nonproliferation Policy Division (NNPD). The panel was moderated by CNEC LANL representative Dr. Jeffrey Favorite. The meeting was held from September 25-29, 2016 in Santa Fe, New Mexico. Presentations were also given by Dr. Robert Hayes, Dr. Robert Reardon, Dr. Bill Boettcher and several CNEC students.

Recent Graduates and Employment

Name	Univ. Degree	Field of Study	Advisor	Employment
Katie Schmidt	NCSU, PhD	Mathematics	Ralph Smith	LLNL
Sean O'Brien	NCSU, PhD	Nuclear Engineering	John Mattingly	Sandia
Razvan Stefanescu	NCSU, PhD	Mathematics	Ralph Smith	Spire
Kelsey Noonan	NCSU, MA	International Studies	Bill Boettcher	Dept. of State
Jacob Stinnett	UIUC, PhD	Nuclear Engineering	Clair Sullivan	LANL
Stylianios Chatzidakis	Purdue, PhD	Nuclear Engineering	Lefteri H. Tsoukalas	ORNL
Bryan Sims	Purdue, PhD	Nuclear Engineering	Chan Choi	NNSA
Philip Forsberg	Purdue, MS	Nuclear Engineering	Lefteri H. Tsoukalas	NNSA

CNEC Outreach at American Nuclear Society's Winter Meeting

CNEC hosted a booth during the ANS November 6-10, 2016 Winter Meeting held in Las Vegas, Nevada. CNEC director, Yousry Azmy (pictured on the right) and assistant director, Stefani Buster (on the left) coordinated the setup. About 1500 attendees with expertise in nuclear science and technology were at the conference. Students were well represented and many of them stopped by the booth. Four national laboratories also hosted booths – Idaho, Argonne, Oak Ridge and Los Alamos.

