Office of Defense Nuclear Nonproliferation
Research and Development

University and Industry Technical Interchange (UITI2014) Review Meeting
NC State Consortium
Consortium for Nonproliferation Enabling Capabilities

June 3, 2014

Robin P. Gardner, Clair Sullivan, Alyson Wilson, and John Mattingly
North Carolina State University

MISSION

- **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**

PARTNERS

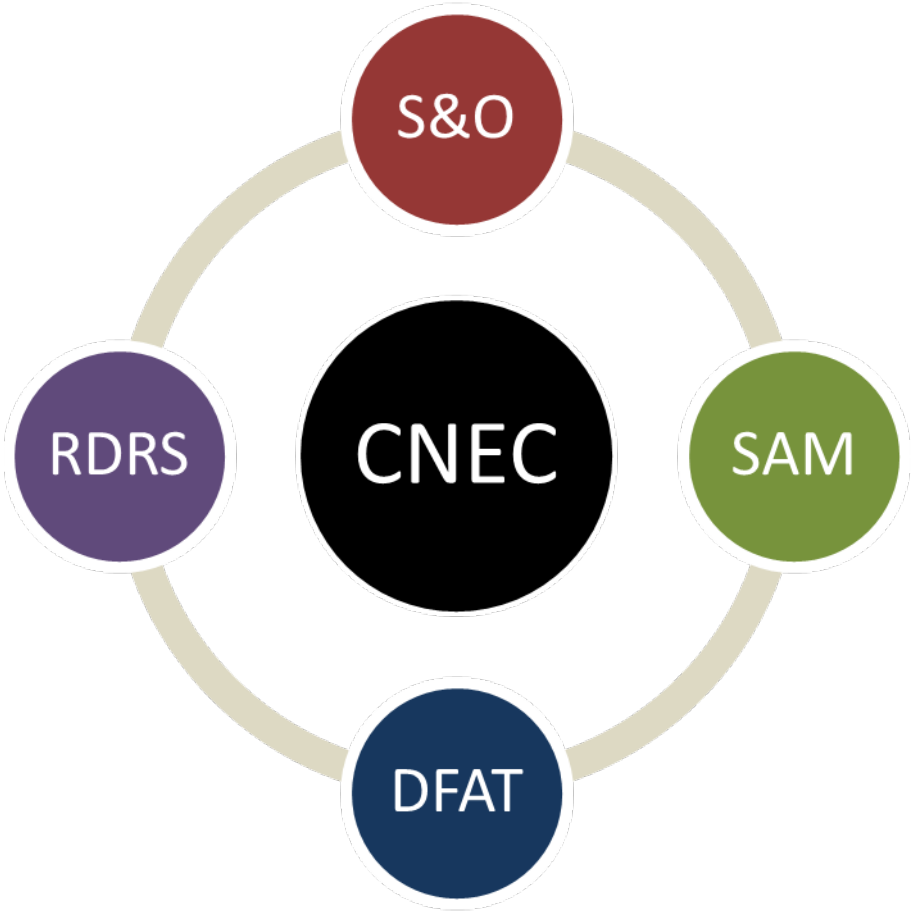
7 Universities

- North Carolina State University (lead institution)
- Georgia Institute of Technology
- University of Illinois at Urbana Champaign
- Kansas State University
- University of Michigan
- North Carolina Agricultural and Technical State University
- Purdue University

3 National Laboratories

- Los Alamos National Laboratory
- Oak Ridge National Laboratory
- Pacific Northwest National Laboratory

RESEARCH PROGRAM



4 thrust areas:

- **S&O:** signatures and observables
- **SAM:** simulation, analysis, and modeling
- **DFAT:** data fusion and analytic techniques
- **RDRS:** replacement of dangerous radiological sources

RESEARCH THRUST AREAS

- **S&O: Identify and exploit signatures and observables associated with special nuclear material (SNM) production, storage, and movement**
- **SAM: Develop simulation, analysis, and modeling methods to identify and characterize SNM and processing of SNM**
- **DFAT: Apply multi-source data fusion and analytic techniques to detect nuclear proliferation activities**
- **RDRS: Develop viable replacements for potentially dangerous industrial and medical radiological sources**

SIGNATURES AND OBSERVABLES (S&O)

National Nuclear Security Administration

- **This thrust focuses on individual sensors and data sources (radiological and non-radiological) as they interface to a larger network of sensors and data.**
- **Objectives:**
- **Identify opportunities for proliferation detection in data sets and sensors**
- **Create simulation tools for signal and noise estimation**
- **Quantify signatures of nuclear proliferation within these sets and sensors**
- **Model single sensor and sensor network performance**
- **Interface with other thrust areas to refine the overall statistics of proliferation detection**

SIMULATION, ANALYSIS, AND MODELING (SAM)

Develop SAM methods to identify and characterize SNM and processing of SNM

Objectives:

- **Develop simulation and modeling methods to analyze and predict signatures associated with SNM**
- **Integrate sensitivity analysis and uncertainty quantification in predictive models**
- **Analyze predictive simulations to identify potential new signatures**
- **Apply simulation and modeling to evaluate the potential effectiveness of new sensing, measurement, and analysis techniques**

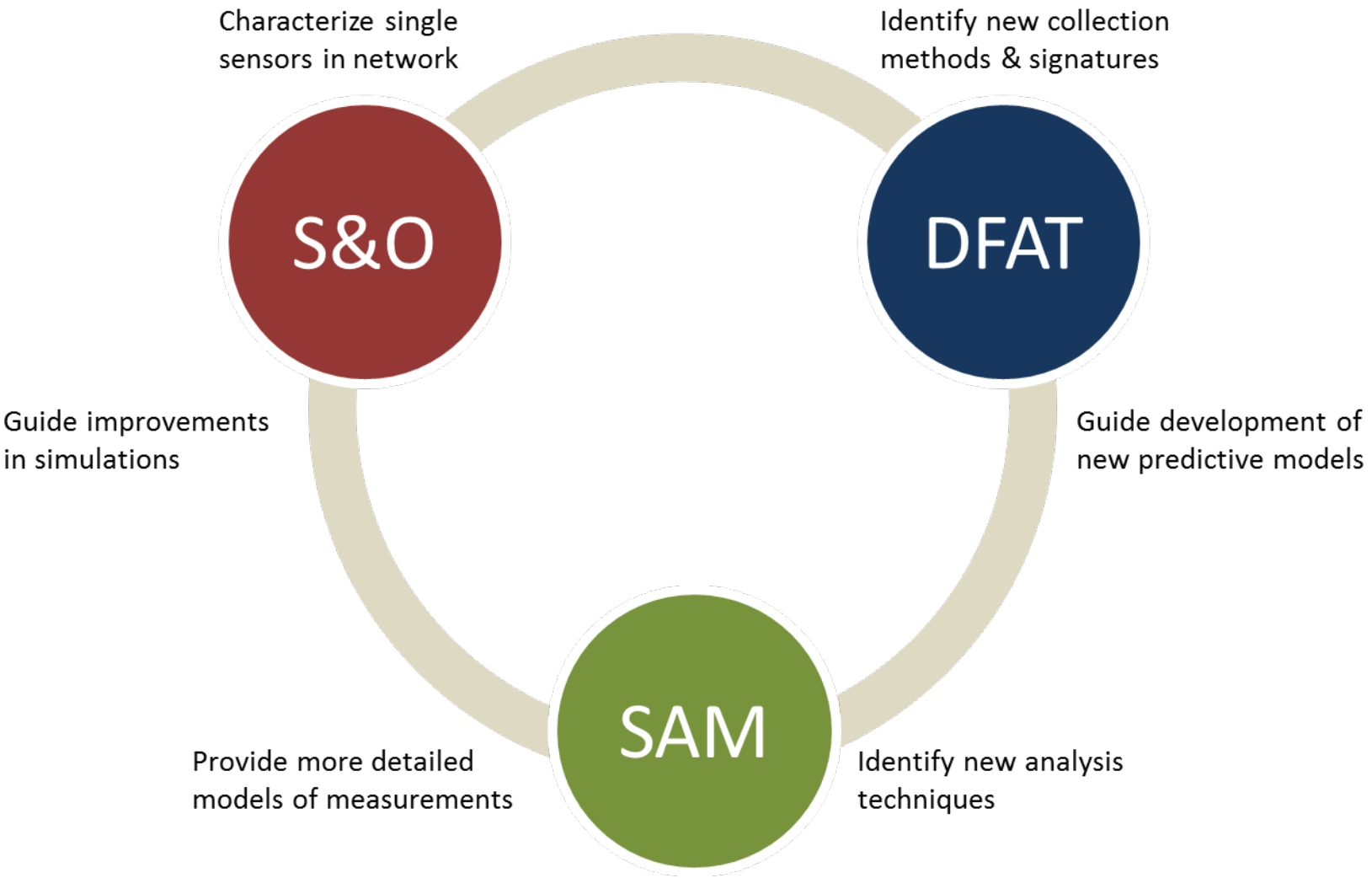
DATA FUSION AND ANALYTIC TECHNIQUES (DFAT)

This thrust focuses on driven discovery, which identifies anomalies and novel patterns using a variety of data

Objectives:

- **Fuse heterogeneous information from multiple data sources**
- **Develop scalable analytic methodologies**
- **Support signature identification, decisions about data collection, and development of simulation and modeling to predict new patterns of proliferation signatures**
- **Interface with other thrust areas to guide discovery analytics**

S&O, DFAT, AND SAM INTERACTION



REPLACEMENT OF DANGEROUS RADIOLOGICAL SOURCES (RDRS)

Replace long-lived radionuclide sources used in industry and medicine with accelerator sources, short-lived radionuclides, or non-nuclear measurements

Objectives:

- **Identify and characterize current applications of radiological sources for industrial processes and medicine**
- **Analyze physical security systems protecting these sources, identify their potential vulnerabilities, and recommend measures to mitigate risks**
- **Characterize signatures associated with theft of industrial and medical radiological sources**
- **Identify and evaluate replacement technologies where they pose significant security risks that cannot be mitigated**

NUCLEAR OIL WELL LOGGING TOOLS EXAMPLE

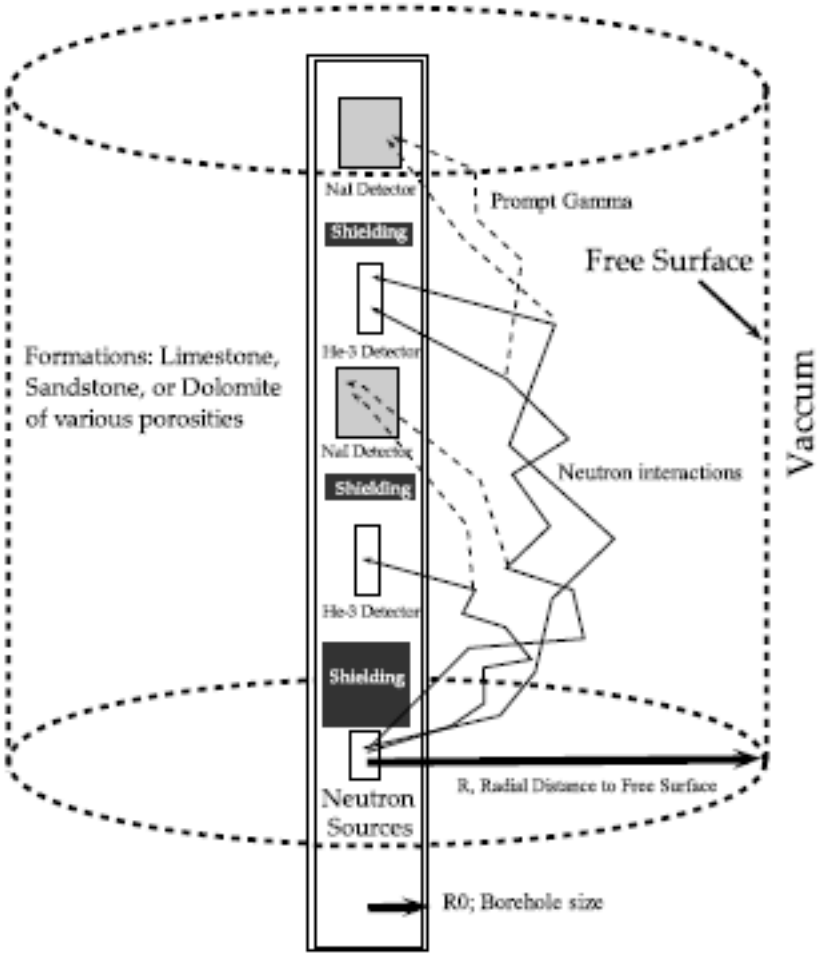


Fig. 1. Configuration of the present benchmark problem

NUCLEAR OIL WELL LOGGING TOOLS PROPOSED RESEARCH

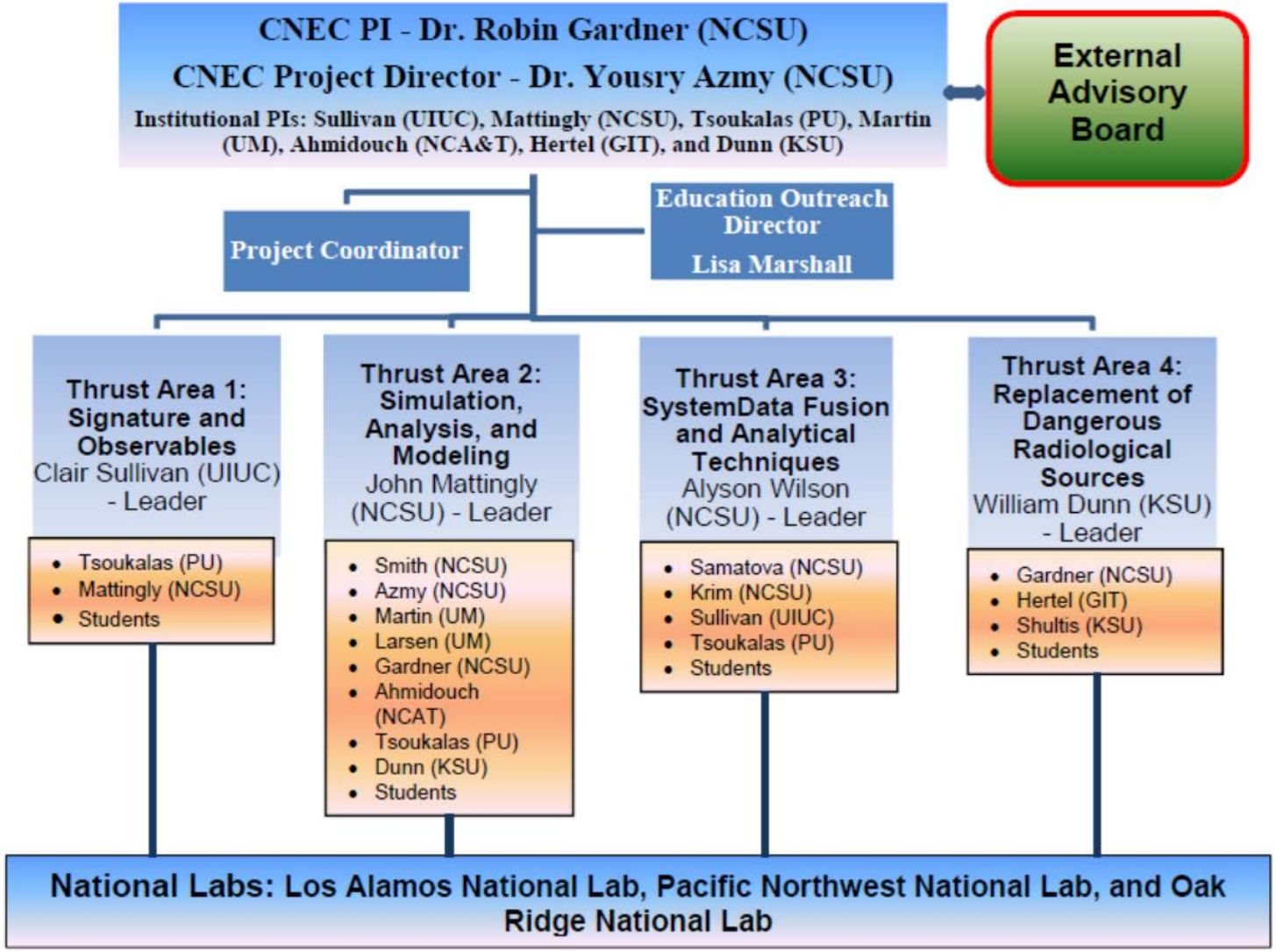
- **Existing important tools are gamma-ray density (porosity) and neutron porosity with Cs-137 and AmBe sources, respectively**
- **Schlumberger has been working on a tool for both of these plus an elemental analyzer (see drawing in previous slide) that replaces both sources with a D-T source**
- **CNEC proposes an inverse analysis for this type of device based on the Monte Carlo – Library Least-Squares (MCLLS) approach**
- **An ADVISORY Committee for this project is being organized and includes EXXON Mobil, Baker Atlas, Schlumberger, Halliburton, COSL, LANL, and possibly BP and CNPC.**
- **Experimental benchmarks by KSU and GT to compliment the MCLLS inverse analysis work are anticipated**

RESEARCH COLLABORATIONS

National Nuclear Security Administration

	NCSU	KSU	UM	GIT	A&T	PU	UIUC	ORNL	LANL	PNNL
S&O										
Characterizing Signatures	●					●	●		●	●
Improving Measurements	●						●	●		
Developing New Measurements	●								●	
Guiding Simulation and Modeling	●					●	●	●	●	●
SAM										
Developing Simulation and Modeling	●	●	●		●			●	●	●
Integrating SA/UQ	●	●	●		●			●		
Identifying New Signatures	●		●			●		●	●	●
Evaluating New Measurements	●	●	●		●				●	
DFAT										
Developing Data Aggregation and Mining Tools	●					●	●		●	
Identifying and Exploiting Signatures	●					●	●		●	●
Guiding Simulation and Modeling	●						●	●	●	●
RDRS										
Characterizing Current Applications	●	●							●	●
Analyzing Security Risks	●	●		●					●	
Identifying Theft Signatures	●	●								
Development of Replacement Technologies	●	●		●					●	

ORGANIZATIONAL STRUCTURE



EDUCATION AND OUTREACH PROGRAM

- **Fellowship Program:** attract nationally ranked graduate students in nuclear science and engineering to conduct research enabling nuclear nonproliferation
- **Course Development:** augment existing and develop new courses in nuclear engineering and science focusing on problems of nuclear nonproliferation; develop short courses on nuclear nonproliferation offered by CNEC partner laboratories
- **National Laboratory Partnership:** engage National Laboratory scientists in the mentorship of graduate student research
- **Unique Educational Experiences:** provide students with a one-of-a-kind experience conducting experiments with SNM at the Nevada National Security Site; develop a new certificate program in the policy and technology of nuclear nonproliferation; leverage the undergraduate research program to attract new students to study nuclear nonproliferation
- **Outreach:** leverage the NCSU's Young Investigator Program for high school seniors and the Science Teachers' Workshop for pre-college educators

NEW JOB OPPORTUNITIES

- **NCSU will create two new junior faculty positions in Nuclear Engineering to support CNEC research**
- **These positions will be jointly funded by the NCSU College of Engineering and Oak Ridge National Laboratory**
- **Interested? Please apply!**