



Office of Defense Nuclear Nonproliferation
Research and Development



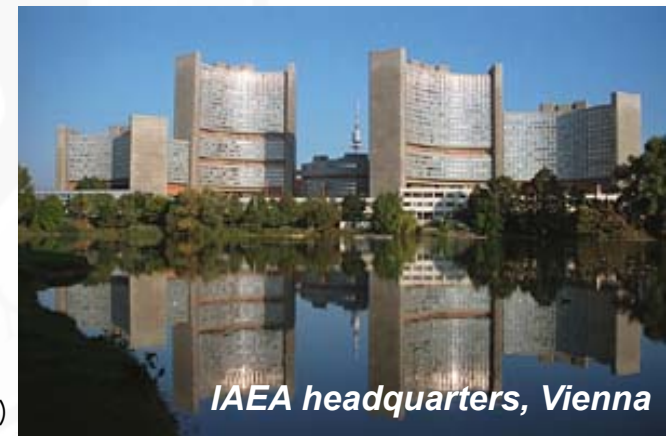
CVT YEAR 1 ACCOMPLISHMENTS

Professor Sara Pozzi
University of Michigan

Consortium for Verification Technology

Background and Motivation

- Preventing the spread of nuclear weapons is a top priority for our nation and the world
- The fast-growing expansion of nuclear capabilities of the 1950's and 60's was ultimately countered by the Nuclear Nonproliferation Treaty
- There are states inside and states outside this treaty that may be pursuing elements of an overt or covert nuclear weapons program
- Several other treaties have been negotiated to limit and then stop nuclear weapons testing, and to reduce the nuclear arsenals of the Soviet Union/Russia, the United States and other states
- Need: new technologies for the verification of existing and proposed nuclear treaties
 - Nuclear Nonproliferation Treaty (NPT), Fissile Material Cutoff Treaty (FMCT)
 - Comprehensive Test Ban Treaty (CTBT)
 - Disarmament Treaties



Consortium for Verification Technology

Mission and Expected Outcomes

The CVT's mission is the advancement of the state-of-the-art in technologies and policies related to the verification of nuclear treaties and training the next-generation of nuclear professionals.

Expected outcomes:

1. A deep understanding of the policy and technical aspects of nuclear treaty verification
2. Next-generation set of computational capabilities
3. New, more effective and reliable capabilities and tools for treaty verification
4. More than 80 B.S., M.S., and Ph.D. graduates with talent, training, and commitment in the fields of nonproliferation and safeguards with strong ties to the national laboratory system

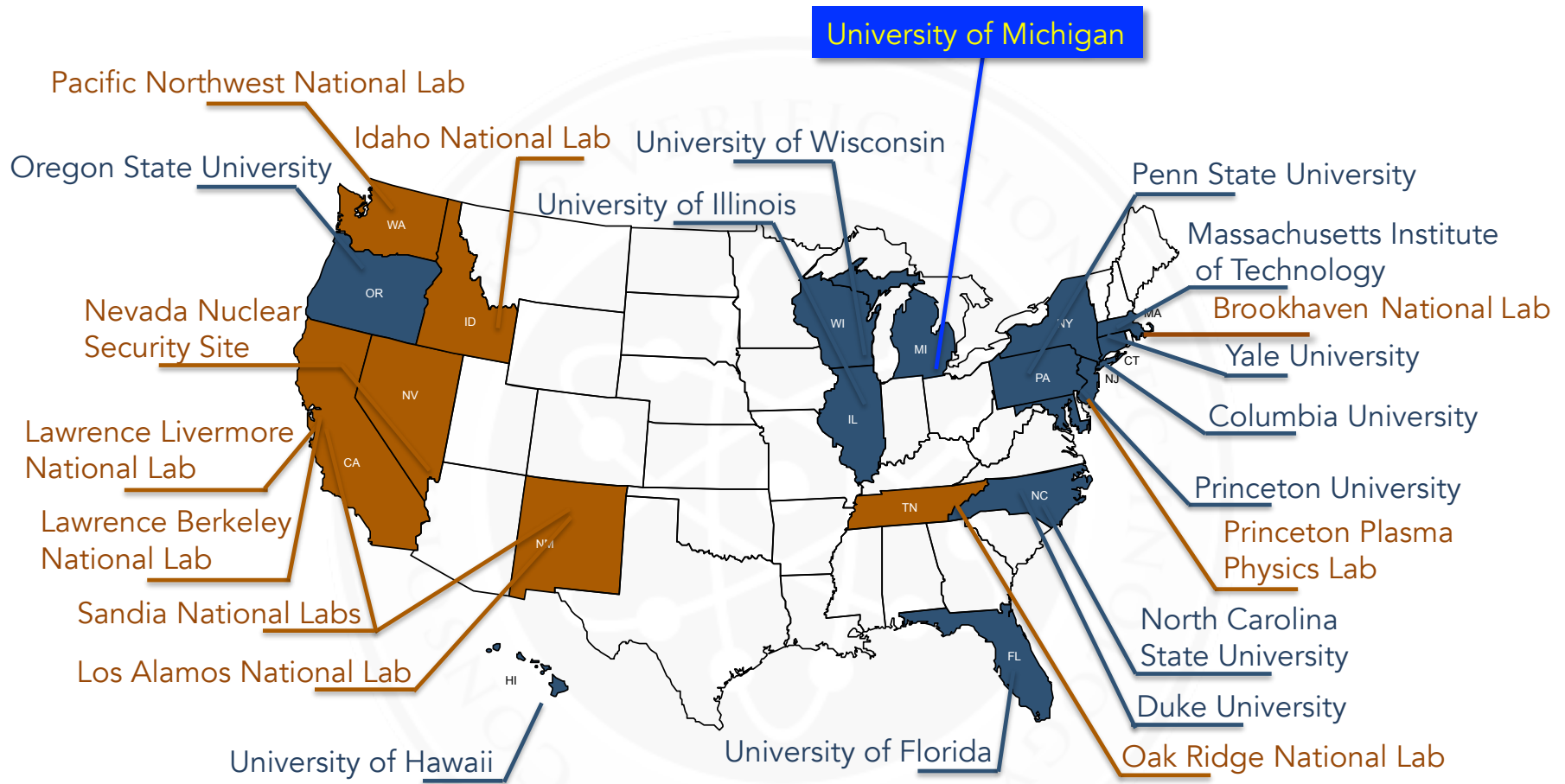
Anne Harrington, Deputy Administrator for Defense Nuclear Nonproliferation for the National Nuclear Security Administration, visits students and faculty at the University of Michigan, March 2015



CVT faculty, NNSA sponsors, and National Laboratory participants in October, 2014



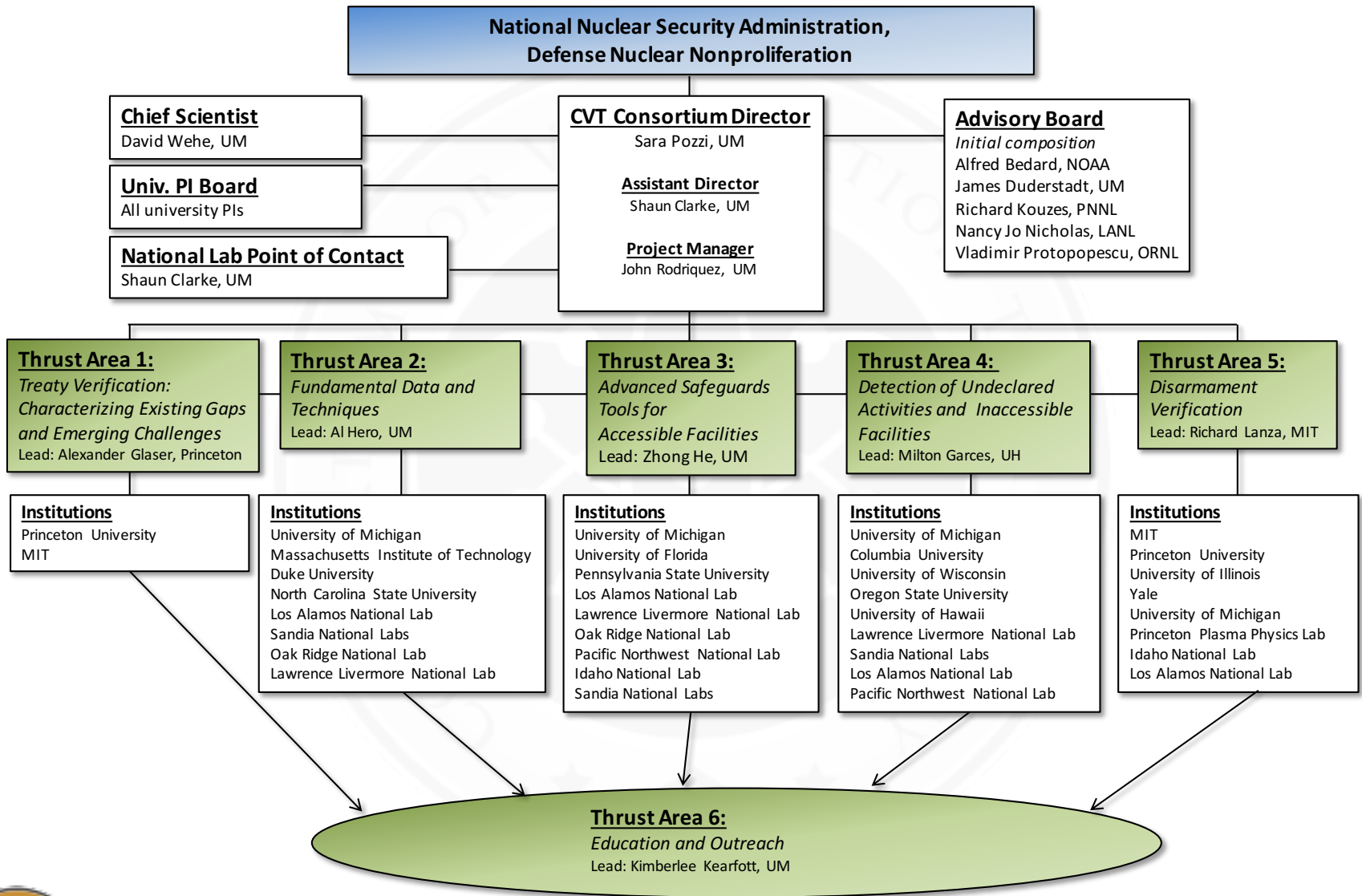
CVT Collaborating Institutions



CVT Team: 13 Universities and 9 National Labs
Total funding \$25M over 5 years

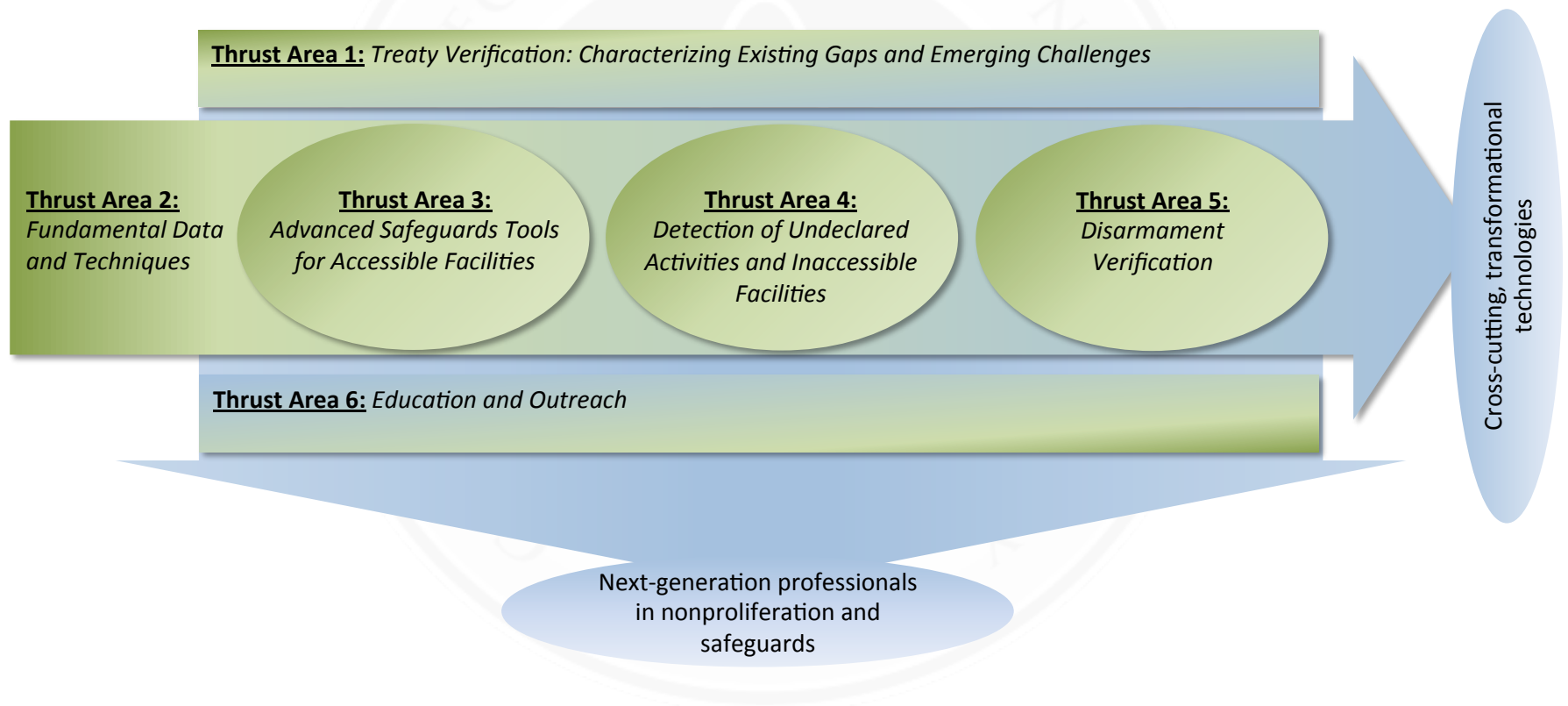


CVT Organization Chart



Consortium for Verification Technology

Thrust Areas, Interactions, and Expected Outcomes



Treaty Verification: Characterizing Gaps and Emerging Challenges

Thrust Area 1

Nonproliferation Treaty,
Fissile Material Cutoff Treaty

Gaps &
Challenges

- Determine the mass, enrichment, and location of fissile material
- Address the He-3 shortage
- Detect clandestine fissile material production

CVT Thrust
Area

Advanced Safeguards Tools
For Accessible Facilities

Thrust Area 3

Comprehensive Test Ban Treaty,
Nonproliferation Treaty

Gaps &
Challenges

- Detect small-yield nuclear explosions anywhere on Earth
- Uncertainty management in source identification
- Data collection under Additional Protocol
- Site inspections

CVT Thrust
Area

Undeclared Activities
and Facilities

Thrust Area 4

Disarmament Treaties

Gaps &
Challenges

- Verify warheads instead of delivery vehicles
- Limit the release of classified information while verifying disarmament

CVT Thrust
Area

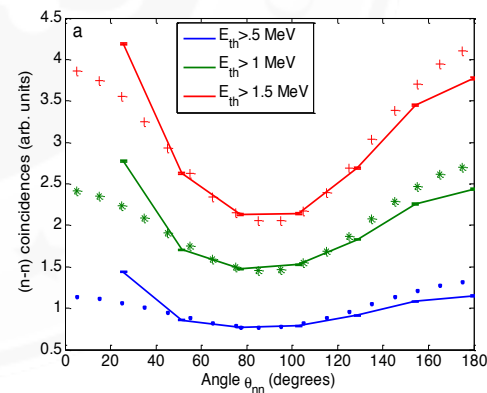
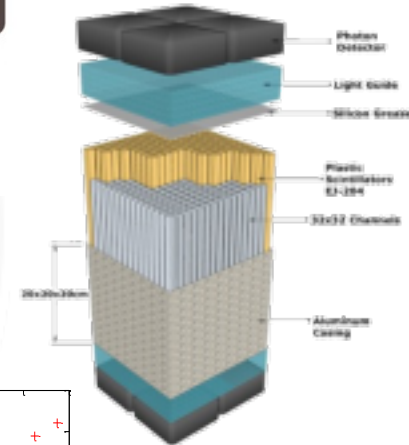
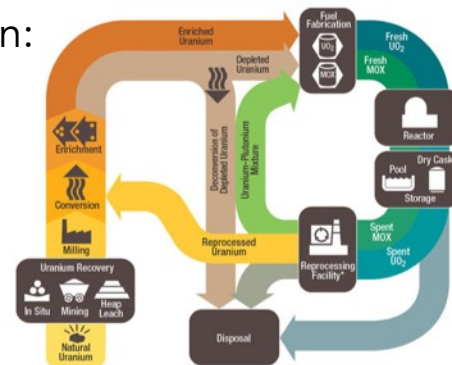
Disarmament Verification

Thrust Area 5

Fundamental Data and Techniques

Thrust Area 2

- Cross-cutting needs in nuclear treaty verification:
 - Reliable nuclear radiation detection and quantification
 - Fuel-cycle monitoring and diversion detection
 - Information fusion from diverse high and low throughput sources
 - Gaps in nuclear fission data



- Developed new models and algorithms for correlation-based anomaly/diversion detection (Hero)
- Data acquisition and signal processing algorithms for emerging radiation detection technologies (Mattingly)
- Data compression and compressive sampling for high throughput detector instruments (Carin)
- Measured fission parameters (Pozzi)



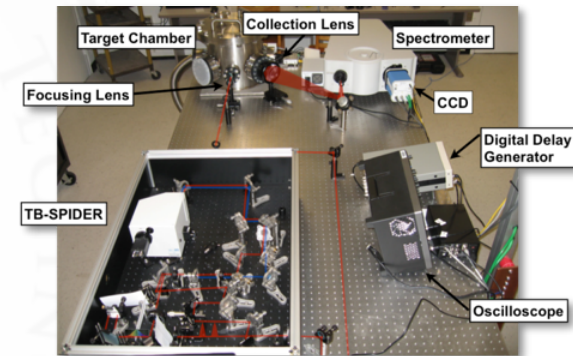
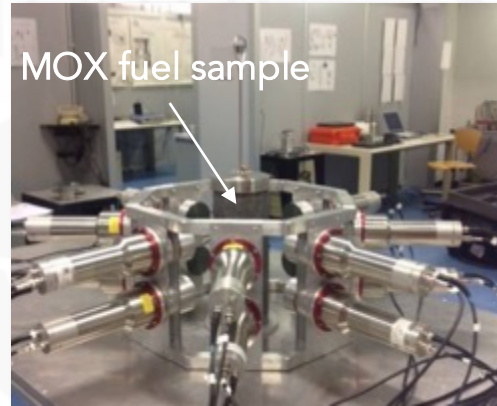
Advanced Safeguards Tools for Accessible Facilities

Thrust Area 3

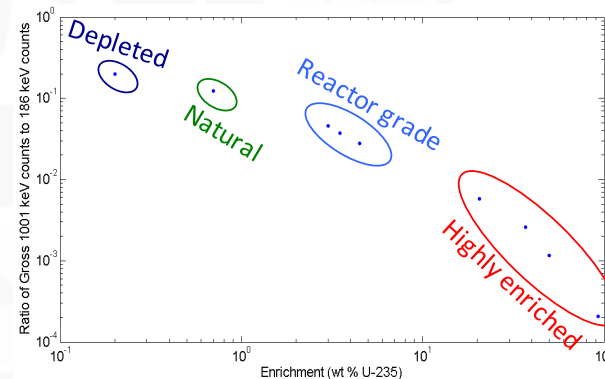
Nonproliferation Treaty,
Fissile Material Cutoff Treaty

Gaps & Challenges

- Determine the mass, enrichment, and location of fissile material
- Address the He-3 shortage
- Detect clandestine fissile material production



- Developed and tested a new safeguards instrument for characterization of SNM (Pozzi)
- Constructed and tested acoustic measurement experimental setup for filament length measurements (Jovanovic)
- Conducted successful experiments at Ohio State, Y-12, and Nevada Nuclear Security Site using Polaris, Orion, Dual Particle Imager, and neutron coded aperture camera imaging systems (He, Pozzi, Mattingly)
- Studied new detection systems (Baciak, Enqvist)



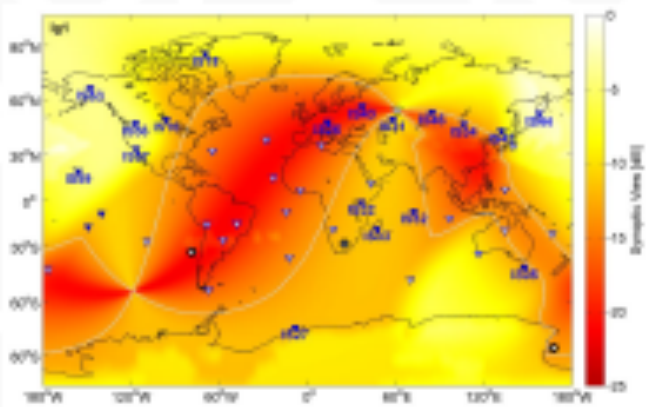
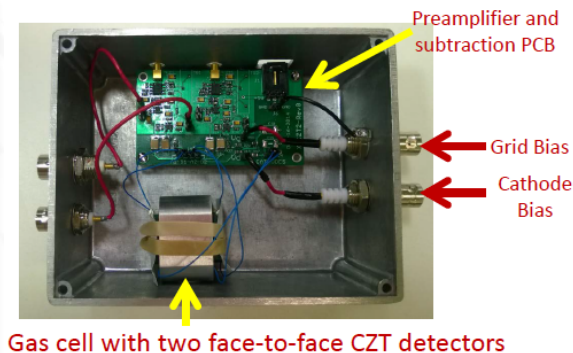
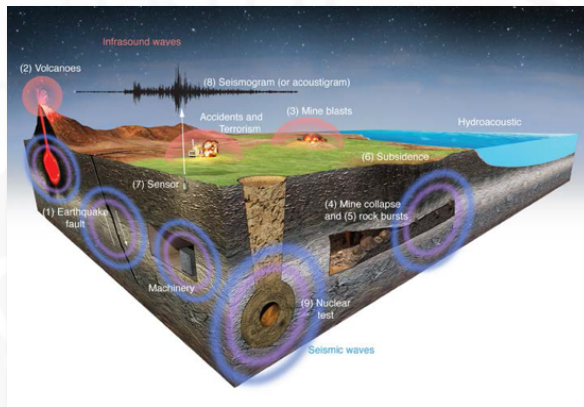
Detection of Undeclared Activities and Inaccessible Facilities

Comprehensive Test Ban Treaty,
Nonproliferation Treaty

Thrust Area 4

Gaps & Challenges

- Detect small-yield nuclear explosions anywhere on Earth
- Uncertainty management in source identification
- Data collection under Additional Protocol
- Site inspections



- Acquired and analyzed seismic signals from nuclear explosions from 1955-1996 (Richards)
- Evaluated recent claim of possible small nuclear explosion in North Korea on May 12, 2010 (Richards)
- Designed new detection system for radio-xenon monitoring using gold-plated CZT crystals (Farsoni)
- Built iOS application and cloud services for infrasound detection
- Completed forensic analysis of Tianjin Harbor explosion in China (Garces)
- Started analysis of radionuclide data from IMS stations (Lee)
- Modeled HEU diversion using the Cyclus code (Wilson)

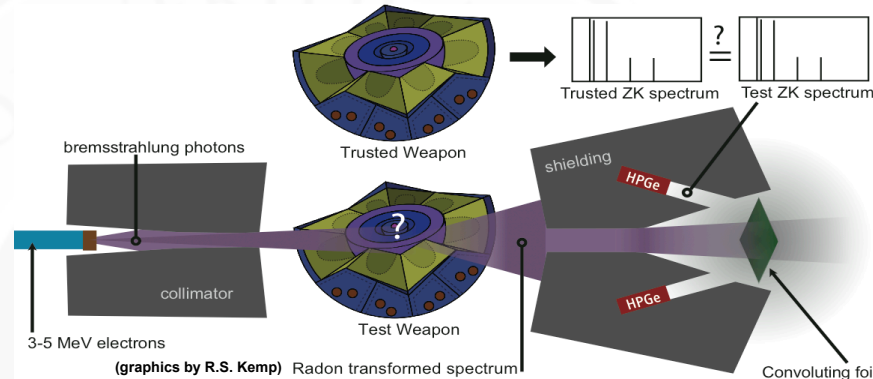
Disarmament Verification

Thrust Area 5

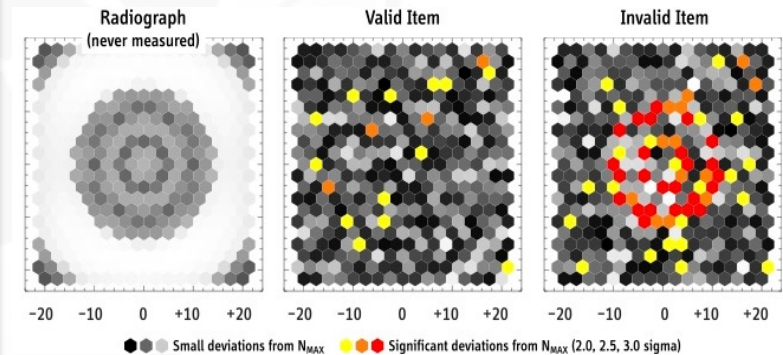
Disarmament Treaties

Gaps & Challenges

- Verify warheads instead of delivery vehicles
- Limit the release of classified information while verifying disarmament



- Validated nuclear resonance fluorescence simulations (GEANT4) against theory – completed database of potential vulnerabilities (Lanza, Danagoulian)
- Tested bubble detectors using 14-MeV neutron generator (D'Errico)
- Developed new algorithms based on wavelets for gamma ray spectrum analysis (Sullivan)
- Investigated the design of Flash ADCs to have built-in information barrier (Wehe)

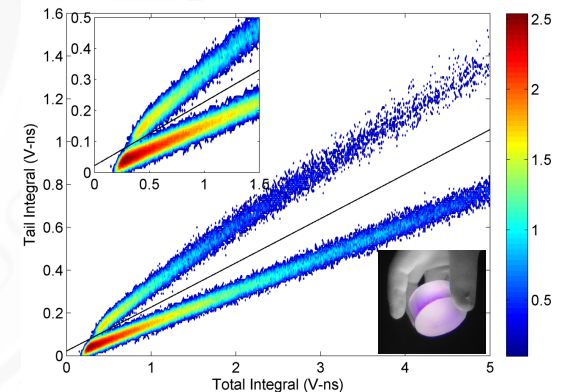


Education and Outreach

Thrust Area 6

CVT Graduate Fellow: Mark Bourne, *University of Michigan*

- 6th year graduate student in Nuclear Engineering and Radiological Sciences
- CVT Graduate Fellow since September 2014
- Member of the Detection for Nuclear Nonproliferation Group led by Prof. Sara Pozzi
- Developed a hand-held detection systems for detection of special nuclear material
- Performed experiments on various fissile material
- Thesis work includes new algorithms for digital data acquisition using organic scintillation detectors



Pulse shape discrimination of ^{252}Cf using solution-grown stilbene

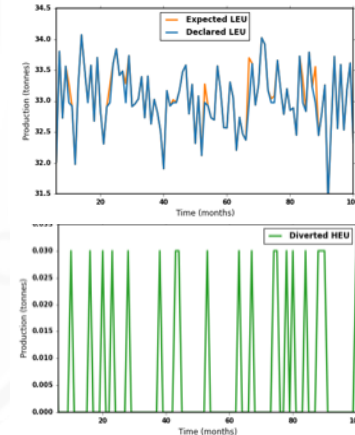
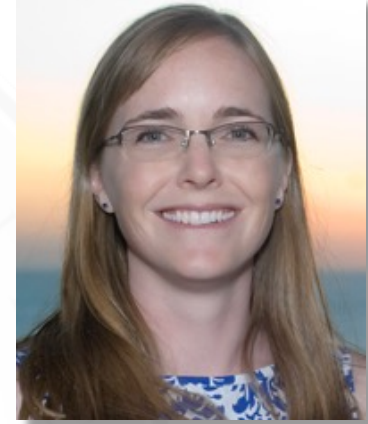


Education and Outreach

Thrust Area 6

CVT Postdoctoral Fellow: Meghan McGarry, *University of Wisconsin*

- 2nd year postdoctoral fellow in Nuclear Engineering
- Holds a Ph.D. in experimental physics from University of Wisconsin
- Member of the Computational Nuclear Engineering Research Group led by Prof. Paul Wilson
- Using the Cyclus nuclear fuel cycle simulator to model clandestine material diversion for weapons production and identify signatures of diversion by looking at signals accessible to inspectors
- Currently focusing on the development of socio-behavioral models to describe patterns of activity in diversion scenarios



Synthetic material production signals that incorporate diversion at random intervals

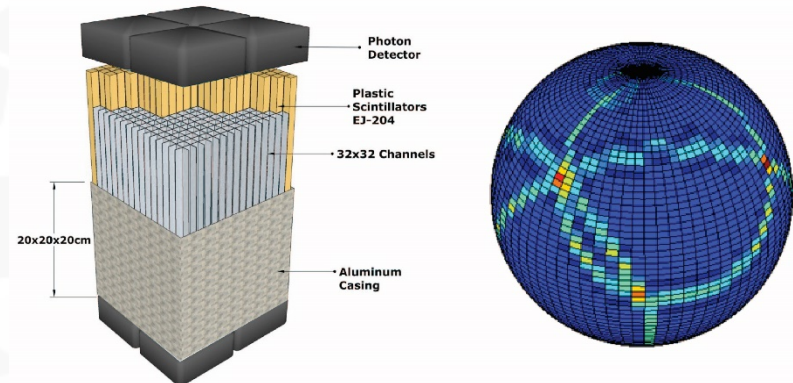


Education and Outreach

Thrust Area 6

CVT Graduate Associate: Kyle Weinfurther, North Carolina State University

- 4th year Ph.D. student in Nuclear Engineering
- CVT graduate associate since September 2014
- Member of the RADIANS team led by Prof. John Mattingly
- Research supported by Sandia LDRD
- Developing high-efficiency single-volume scatter camera (SVSC) for standoff source detection
- Thesis work focused on analysis algorithms for reconstructing scintillation positions in SVSC



Optically-segmented single-volume scatter camera



Education and Outreach

Thrust Area 6

CVT Undergraduate Fellowships

- In summer, 2015 the CVT appointed six undergraduate students to 12-week research fellowships at UM
- Fellows gained practical experience conducting mission-relevant research

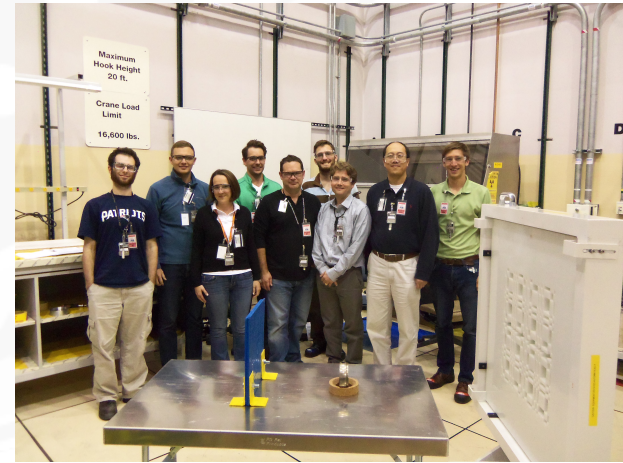


Education and Outreach

Thrust Area 6

CVT/National Laboratory Research Collaboration

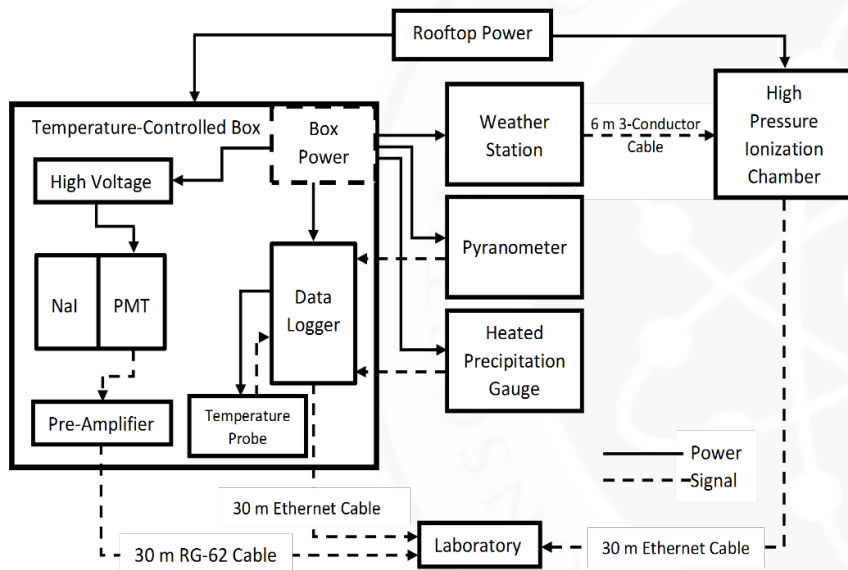
- The CVT universities invite national laboratory scientists to spend time on campus researching with CVT faculty and students and participate in activities such as
 - serving on graduate student thesis committees,
 - teaching a short course on a topic of interest to verification technology and policy, or
 - presenting invited seminars and lectures.
- The CVT will support up to **4 national laboratory scientists** to spend up to two weeks researching at CVT universities in collaboration with faculty and students in 2016



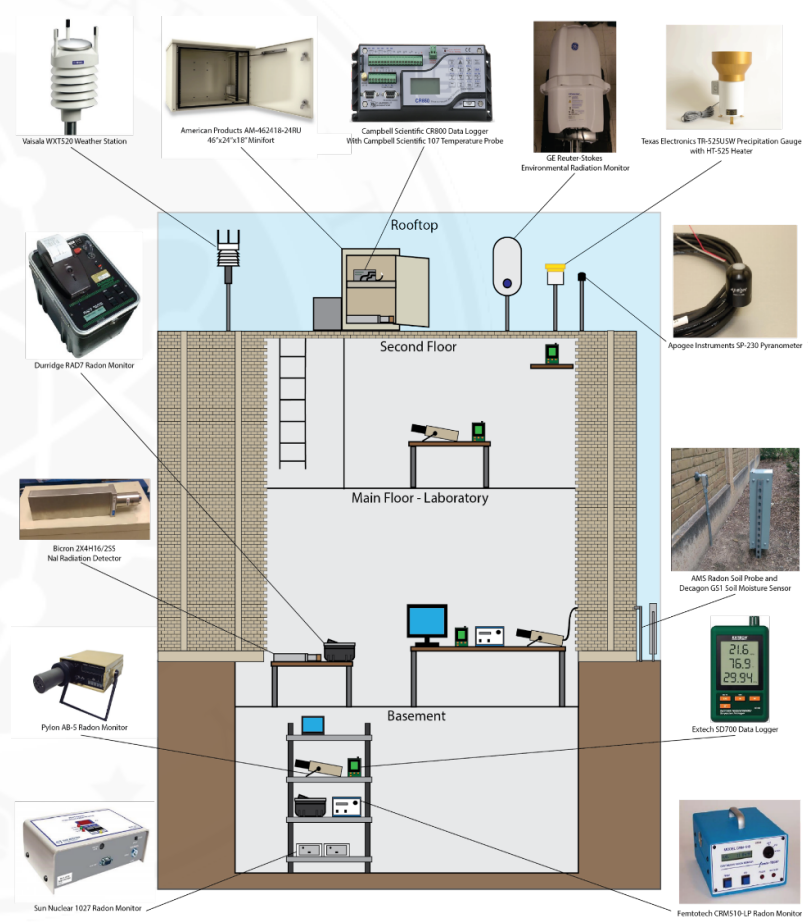
Education and Outreach

Thrust Area 6

Environmental Monitoring For Community Outreach



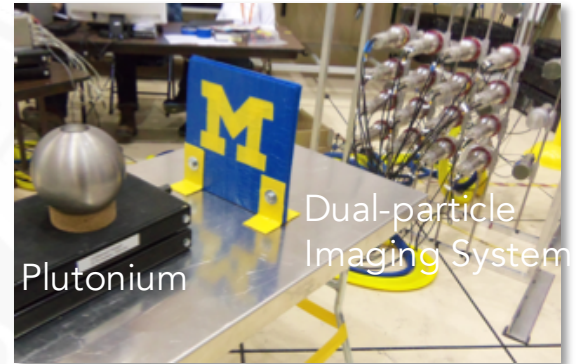
Radiological Health Engineering Laboratory
 K. J. Kearfott, S. Frank, T. J. Buth, M. L. Jacobs



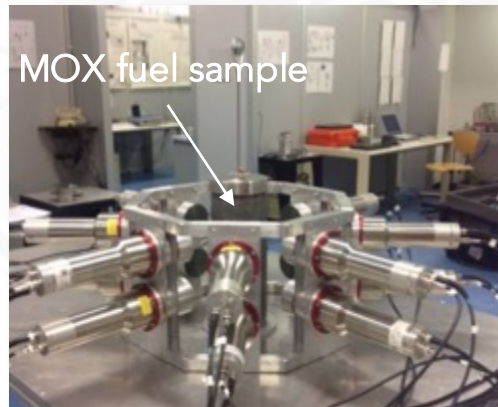
Consortium for Verification Technology

Summary Year 1 Accomplishments

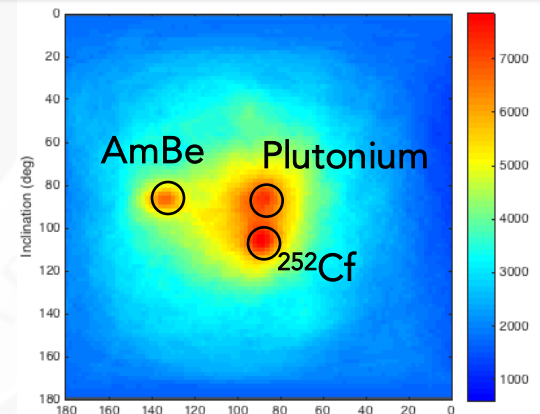
- A successful CVT Kickoff Workshop was held on October 16 and 17, 2014 at the Campus Inn in Ann Arbor, MI: 58 representatives from 13 collaborating universities and 9 national laboratories were present, including 10 CVT fellows
- A successful UITI conference was held in June, 2015 in Ann Arbor, MI with nearly 300 attendees
- 90 students and postdocs are engaged in CVT research
- Successful experimental measurement campaigns including students
- Technical findings published in 33 journal articles and presented in 57 conference papers and 38 invited talks



CVT-led experiments at the Nevada Nuclear Security Site



Nuclear fuel characterization measurements using novel safeguards instruments



Detecting and characterizing nuclear material at large distances



Consortium for Verification Technology

Summary Year 1 Accomplishments

CVT has begun a coordinated effort to bridge the gaps and address challenges in three technical thrust areas: advanced safeguards tools for accessible facilities, tools for detecting undeclared activities and facilities, and disarmament verification

1. Development of He-3 free detection systems → developing new multiplicity counters based on organic scintillators
2. Characterization and localization of SNM → developing new imaging systems and standoff detection techniques
3. Low-yield nuclear explosion monitoring → fusing information from seismic, ubiquitous infrasound signatures, and new radioxenon detection methods for explosion monitoring
4. Disarmament verification → developing NRF using witness foil method; active interrogation using non-electronic detectors; new electronics as information barriers



Acknowledgement

This work was funded by the Consortium for Verification Technology under Department of Energy National Nuclear Security Administration award number DE-NA0002534.

Connect with us online!



<http://cvt.engin.umich.edu>



@NNSA_CVT

