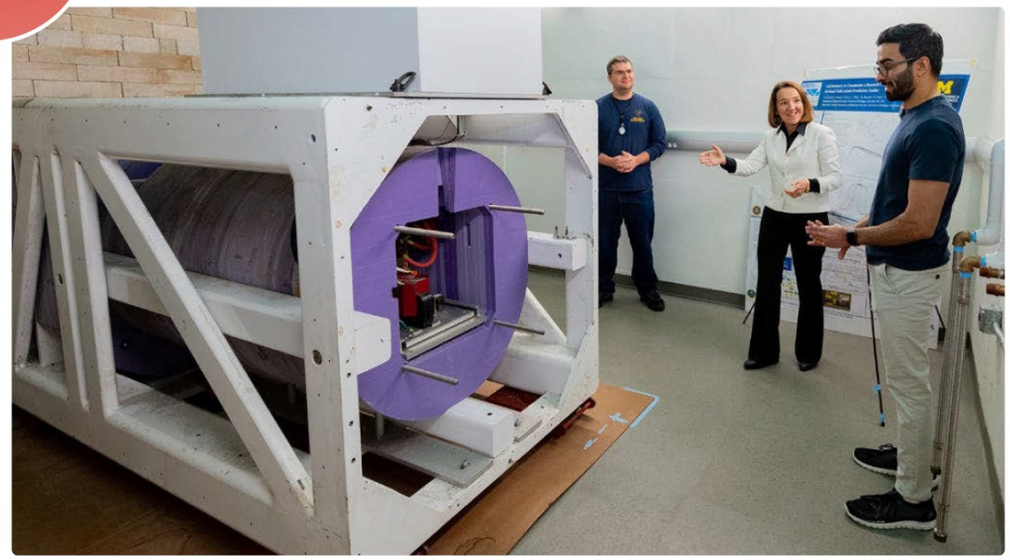


Professor Sara Pozzi with students and researchers in the UM Detection for Nuclear Nonproliferation Group lab. (Photo: Daryl Marshke, University of Michigan)

The MTV at the cutting edge of nonproliferation technology

The Consortium for Monitoring, Technology, and Verification (MTV), led by the University of Michigan–Ann Arbor, is a group of 14 universities and 13 national laboratories at the cutting edge of research and education related to nuclear security and nonproliferation. Funded with a $25 million grant from the Department of Energy's National Nuclear Security Administration plus $2.6 million cost-share from the University of Michigan for a five-year period from 2019 to 2024, the MTV is directed by Sara A. Pozzi, Ph.D., a professor in University of Michigan's Department of Nuclear Engineering and Radiological Sciences and a former staff scientist at Oak Ridge National Laboratory.

Pozzi describes the work of the consortium as "developing new technologies that detect and deter nuclear proliferation activities and training the next generation of nuclear professionals with knowledge, responsibility, and deep commitment in nuclear nonproliferation." She adds, "The work done within the MTV is interdisciplinary and collaborative. We learn from each other and our national laboratory partners and work together to ensure that the research carried out in the MTV is sound, thoroughly validated, and has relevant practical applications." The MTV's mission is elaborated on the consortium's website: "We are addressing gaps and challenges in the technologies needed to monitor and verify nuclear capabilities around the world by executing research projects in close collaboration with the national laboratories."

The MTV was preceded by the Consortium for Verification Technology (CVT), also funded by the NNSA and headed by Pozzi. From 2014 to 2019, the CVT had the mission of, in Pozzi's words, "performing research and development to address technology and policy issues in monitoring nuclear treaty compliance, safeguards, and explosions."

MTV research activities

Researchers with the MTV are, as noted on the consortium website, "deeply delving into the physics and chemistry of fission, discovering new relevant science, delivering advanced technologies to monitor special nuclear material at all stages of the nuclear fuel cycle, and significantly improving our ability to detect and characterize a nuclear explosion." The research activities of consortium students and postdoctoral researchers at the national laboratories (for which University of Michigan professor Igor Jovanovic serves as the point of contact) are classified into three technical thrust areas: fundamentals of nuclear and particle physics, signals and source terms for nuclear nonproliferation, and nuclear explosion monitoring. In addition, the consortium includes the three crosscutting areas of modeling and simulation, nuclear policy, and education and outreach.

Among the research topics explored in the fundamentals of nuclear and particle physics thrust area are nuclear resonance parameters, reaction theory and modeling, novel imaging techniques, and antineutrino-based technologies. The second thrust area, signals and source terms for nuclear nonproliferation, covers topics including isotopic science, spatial/temporal spectroscopic analysis, *in situ* natural monitoring based on biota, and nuclear fuel cycle process modeling. Researchers investigating nuclear explosion monitoring have worked with such subjects as infrasound, seismology, radiation background monitoring, and environmental fate and transport of radionuclides.

Pozzi informed *Nuclear News* about some of the MTV's pioneering research in radiation imaging, noting, "Our imaging systems will enable the detection, localization, and characterization of multiple radiation sources in the same field of view, which will be very useful in various inspection and monitoring scenarios. For example, an IAEA [International Atomic Energy Agency] inspector could walk through a nuclear facility with the imaging system and wear an augmented reality headset, such as the Microsoft HoloLens 2, that would show them images from our imaging detection system."

Consortium partners

As leader of the MTV, the University of Michigan collaborates with 13 other universities:

Columbia University
Georgia Institute of Technology
Massachusetts Institute of Technology
Pennsylvania State University
Princeton University
Texas A&M University
University of California–Berkeley
University of Florida
University of Hawaii
University of New Mexico
University of Tennessee–Knoxville
University of Wisconsin
Virginia Polytechnic Institute and State University

Also included in the consortium are 13 national laboratories:

Argonne National Laboratory
Brookhaven National Laboratory
Idaho National Laboratory
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
Nevada National Security Site
Oak Ridge National Laboratory
Pacific Northwest National Laboratory
Princeton Plasma Physics Laboratory
Sandia National Laboratories
Savannah River National Laboratory
Y-12 National Security Complex

Regarding the MTV's physics research, Pozzi says, "We are designing and performing new experiments to understand the physics of fission in more detail, including the correlations that exist between the neutrons and gamma rays emitted by the deexcitation of fission fragments following the fission process. We also study antineutrino physics for undeclared nuclear reactors detection and declared reactors monitoring. Being able to detect the presence of an undeclared reactor or monitor the unscheduled shutdown of a declared reactor could provide important monitoring information for nonproliferation."

Continued

One timely practical application is the MTV's research in the area of explosion detection research. Pozzi explains, "We work on improving our ability to monitor nuclear explosions around the world, should they occur. We are analyzing seismic data from stations at various locations around the North Korean test site and developing ways to correct the data to get better estimates of the yield of the explosion."

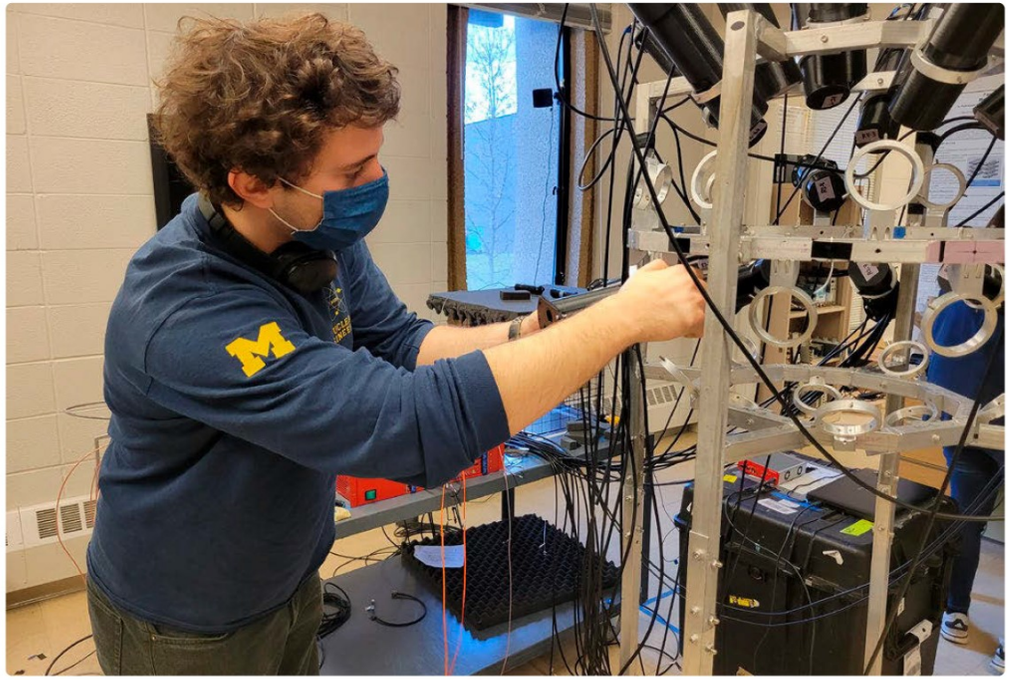
Educational activities and opportunities

The MTV's educational and outreach activities, led by University of Michigan professor Kimberlee J. Kearfott, advance the consortium's objectives in nuclear nonproliferation. These activities include internships and fellowships, summer schools, workshops, research symposia, conferences and teleconferences, and webinars.

Through the consortium's internship program, graduate students engage in collaborative research projects within the national laboratory system. "Every doctoral student who receives full funding from the MTV is considered a fellow and participates in at least one internship with a national laboratory during their time with the consortium," according to Pozzi.

In addition to the regular fellowships, she notes that the consortium also offers fellowships in nonproliferation-applicable antineutrino physics, which "are unique in that they are [also] available through open competition to students at non-MTV universities." These fellowships may be renewed annually for up to three years, pending satisfactory performance.

The work of a number of consortium students has been recognized with fellowships and awards from other organizations, such as the NNSA Nuclear Nonproliferation International Safeguards Fellowship, the IAEA Marie Sklodowska-Curie Fellowship, and the Institute of Nuclear Materials Management J.D. Williams Student Paper Award.



Stefano Marin, UM Ph.D. student, assembles the Fission Sphere 3 detector, an array of 40 trans-stilbene detectors used for fission studies. (Photo: Courtney Wagoner)

The annual MTV Nuclear Engineering Summer School is another opportunity for academic exploration. Now in its third year, this program has reached over 600 students and researchers from around the world. In 2022, the eight-week program, running June 14–August 11 at the University of Michigan, includes both on-campus and online lectures by MTV faculty, national lab scientists, and Ph.D. students on a variety of topics, such as gamma detection, neutron detection, active interrogation, Monte Carlo codes, and radiation imaging.

The MTV also holds an annual general workshop, as well as workshops on specific topics. The 2022 MTV Workshop, held March 22–23, was a hybrid event that included reviews of consortium goals and accomplishments, 26 oral presentations by MTV researchers, 39 poster presentations, and three panel discussions (with alumni, fellows, and national lab partners). The 2022 MCNP/MCNPX-PoliMi Workshop, held in May of this year, focused on Monte Carlo codes, state-of-the-art algorithms that can have applications in nuclear nonproliferation—for example, in detector response simulation, fission physics simulation, and variance reduction techniques.

Consortium students are also given opportunities to present their work at research symposia. In June 2020, the COVID-19 pandemic led to the MTV Student Virtual Research Symposium, with students making online presentations and faculty chairing sessions. In addition, monthly teleconferences cover updates on the research being performed at the national labs, with presentations from students or professors representing the students.

Online events offered by the MTV include webinars hosted by the consortium as well as other institutions. "We host webinars and stream other events, such as the MTV student research symposia and our MTV annual workshop presentations," says Pozzi. "Recently, we hosted a webinar by scientists at Caen Technologies to discuss recent developments in waveform digitizers." In May 2022, MTV students had the chance to participate in the webinar "Introduction to International Safeguards," which was sponsored by Brookhaven National Laboratory's Nonproliferation and National Security Department. Videos of a number of MTV events, including workshops, summer schools, and research presentations, can be seen on the MTV Consortium YouTube channel.

Noora Ba Sunbul, UM Ph.D. student, discusses her research in radiation dosimetry at the MTV workshop in 2022. (Photo: Daryl Marshke, University of Michigan)

Launching careers in nonproliferation

As of April 2022, there were 237 students and postdoctoral researchers engaged in MTV research. MTV fellows, who receive full funding from the consortium, included three postdoctoral researchers, 55 graduate students, and 27 undergraduate students. MTV associates, who work on MTV-related projects and receive partial funding from the consortium, included three postdoctoral researchers, 68 graduate students, and 81 undergraduate students.

Pozzi is proud that the MTV has done well with its objective of launching professional careers that further the NNSA's nonproliferation agenda. "Since the start of the MTV in 2019, 17 Ph.D. students have graduated and obtained jobs in national labs, other government agencies, academia, and industry." Because of the collaborative nature of the consortium, students build strong ties and find valuable mentors at the national labs during their time with the MTV. Ultimately, due to the experience gained as integral and important members of research teams, they will be well positioned to find careers within either the public or private sector. ⊠