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# Physics Flash

March 2016

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To reveal structural secrets of the Florence cathedral and help protect it against further damage, Elena Guardincerri is designing lightweight muon trackers made of 2-inch-diameter carbon fiber drift tubes for measuring the dome's thick-walled passageways.

## Elena Guardincerri

*Tracking muons to reduce  
nuclear threats and help preserve  
architectural treasures*

By Diana Del Mauro, ADEPS Communications

When Elena Guardincerri was a physics PhD student at the University of Genova, she considered muons a nuisance. She built muon detectors to snare these secondary cosmic rays, which were interfering with her experiments to study elusive neutrinos. Now, as a member of the Subatomic Physics (P-25) Muon Tomography team, she is developing a muon detector to assist in saving a 37,000-ton masonry cathedral dome, known as il Duomo, in Florence, Italy, from severe cracks and earthquake damage. Her novel method uses muons as a probe to image reinforcement elements inside thick-walled structures.

"Elena is an extremely creative physicist," said her team leader Chris Morris, who invented multiple scattering muon imaging, which exposes smuggled nuclear material even when it is concealed by shielding material.

*continued on page 3*



## From David's desk ...

*In April, I will start trying to meet with a different team each week, cycling back through the teams about twice a year. I am looking forward to hearing about all of the progress that is being made.*

“ ”

*David*

I was too optimistic in January. I have finally finished meeting with each of the teams in the division (as well as one from MPA/MST). While I learned a great deal about the division in these meetings, I also learned that my calendar is not my own. I apologize to all over how many times we had to reschedule. In April, I will start trying to meet with a different team each week, cycling back through the teams about twice a year. I am looking forward to hearing about all of the progress that is being made. I expect to hold an All Hands meeting in April where you can raise your questions and concerns and will continue to hold brown bag meetings where we can have discussions on a more informal basis.

The 2015/2016 LANSCE run cycle ended last month. There were advances in nuclear physics, materials science, and dynamic experiments on pRad. Two important experiments were performed on pRad near the end of the run cycle, HEKLA and Sushi. With support from J Division, the Sushi experiment was performed on a Saturday. I took advantage of a day free of meetings to spend about seven hours in the counting house (with a little time in the Dome) observing the preparations for the shot and seeing the initial results. It was a great learning experience for me. I am grateful to all of the staff, from a number of divisions, who worked to make this happen. On page 4 of this issue you can read about a new 10-frame camera that took useful data during the Sushi experiment, making the first 31-frame pRad movie ever taken.

Another highlight from the end of the LANSCE run was a result of combining teams and capabilities across Physics Division to perform an experiment that could not have been done elsewhere. Neutrino scientists from P-23 and P-25 worked with staff in P-27 to test the neutron response of the liquid argon time projection chamber, mini-CAPTAIN, in a WNR beamline. Neutron-induced tracks were observed. I believe that this was the first time such a neutrino detector had been tested in a neutron beamline, with LANL having the breadth of capabilities to pull this off. I am sure that the results will be highlighted in a future *Physics Flash*.

As described in the accompanying article on page 7, the world has a new, and very different, magnetic fusion device. The Wendelstein 7-X (W7-X) stellarator at the Max Planck Institute for Plasma Physics in Germany has performed its first experimental run. Glen Wurden (P-24) leads LANL's collaboration on the device, installing and operating visible and mid-band infrared cameras to study plasma-wall interactions. The billion-dollar-class W7-X took 19 years to design and build. Amazing persistence. Congratulations to Glen for being named an Associate Editor of the *Journal of Fusion Energy*.

Welcome to spring! One other thing that I learned is that spring brings Juniper and other pollens to the air and I am allergic to them. Nothing a little allergy medicine won't take care of.

*Physics Division Leader David Meyerhofer*

## Guardincerri cont.

Muons can identify dense objects and make distinctions between substances, such as water and melted nuclear fuel, and unlike x-rays, they can penetrate deep inside materials, allowing images of thick objects. Cosmic muon radiography does all of this without damaging structures and without the need of an artificial radiation source.

Guardincerri helped write software for the muon trackers built in Japan by Toshiba that will obtain precise images of the Fukushima Daiichi nuclear power plant, a critical step before disaster cleanup can begin safely. In other high-profile work, Guardincerri is “contributing enormously to the Physics Division threat reduction effort,” Morris said. For instance, she is testing how well muons can scout for nuclear weapons effects underground.

Guardincerri credits former team member Cas Milner for proposing muon tomography for the dome—one of several ideas the Lab presented to an Italian delegation of conservation experts in 2013.

Designed by the secretive master builder Filippo Brunelleschi, the 15th-century dome of Santa Maria del Fiore Cathedral is an architectural marvel, and it is has been affected by ever-expanding cracks for centuries. Some scholars believe, based on historical documents, that iron reinforcements might be inside the dome’s thick masonry, but investigations with metal detectors failed to yield conclusive evidence either for or against this view. To determine the dome’s strength and need for further reinforcements, the cathedral’s preservationists are looking to Los Alamos to help determine the exact location of the iron—if it exists—and compile a more detailed crack profile, which will be used in their models.

In 2015, Guardincerri visited Florence to explain to the cathedral’s conservation committee why she believes the Lab’s muon tracker technology could provide precious information regarding the inside of the dome. She presented vivid images of iron bars embedded in a replica wall built at Los Alamos. The committee approved the design of a pair of portable trackers, each weighing no more than 220 pounds, one of which will be suspended inside the cathedral near Giorgio Vasari’s Last Judgment fresco.

“This will be a great stage to show the world that this [muon imaging] works,” said Guardincerri, who grew up in a nearby town.

With Laboratory Directed R&D Early Career Award funding, she is redesigning the muon trackers, which currently weigh 800 pounds each. Following a recent visit to the National Geographic Society, she and National Geographic are exploring ways to collaborate on the project based on a mutual interest in innovative imaging technology as well as in the history of Florence.

She and colleague Matt Durham (P-25) explained how the one-detector method that has been used for pyramids is better for a wider field of view and the award-winning Los Alamos technology is better for seeing details in smaller structures. By sandwiching a structure between two detectors and measuring the muon rays entering and exiting a structure, the Los Alamos muon tracker distinguishes dense objects with a resolution that other muon imaging methods cannot achieve. For the dome application in particular, “our technique is more accurate and the spatial resolution is much better,” Guardincerri said.

## Elena Guardincerri’s favorite experiment

**What:** Demonstrated that multiple scattering muon radiography is a new method to image reinforcement elements inside thick-walled structures. It uses cosmic-ray muons as probes.

**Why:** To determine if this imaging tool, developed at Los Alamos, could provide crucial information about the cracking dome of the Florence Cathedral and solve the mystery of its internal supports (iron bars, clamps, and chains)

**When:** Summer 2015

**Where:** Los Alamos Neutron Science Center

**Who:** Elena Guardincerri, Matt Durham, Chris Morris, Jeff Bacon, Tess Daughton, Shelby Fellows, Olivia Johnson, Deborah Morley, Kenie Plaud-Ramos, Daniel Poulson, Zhehui Wang (all P-25)

**How:** Summer students built a replica of the dome’s thickest inner wall and hid three iron bars inside it. Two muon tracker modules, placed on either side of the wall, took data for 35 days.

**The “a-ha moment:”** After 17 days of taking data, all three iron bars were visible. Guardincerri reported the results in Florence, receiving approval from the cathedral’s guild to develop thinner, portable muon tracker modules to install in the dome.

## Enhanced imaging for dynamic physics research at the Proton Radiography facility

Researchers have successfully installed and operated a new and improved high-speed imaging system at the Laboratory's Proton Radiography (pRad) facility at the Los Alamos Neutron Science Center (LANSCE).

The imaging system is designed for dynamic experimental studies. These advances significantly enhance the pRad capabilities for users in the materials and shock physics communities.

The Laboratory pioneered proton radiography, which is well suited to the study of dynamic processes in materials. The technology features excellent contrast and the capability to radiograph dynamic events on short time scales (e.g., a few microseconds) multiple times during its evolution. With the LANSCE accelerator's capabilities, the number of radiographs is limited only by the camera technology.

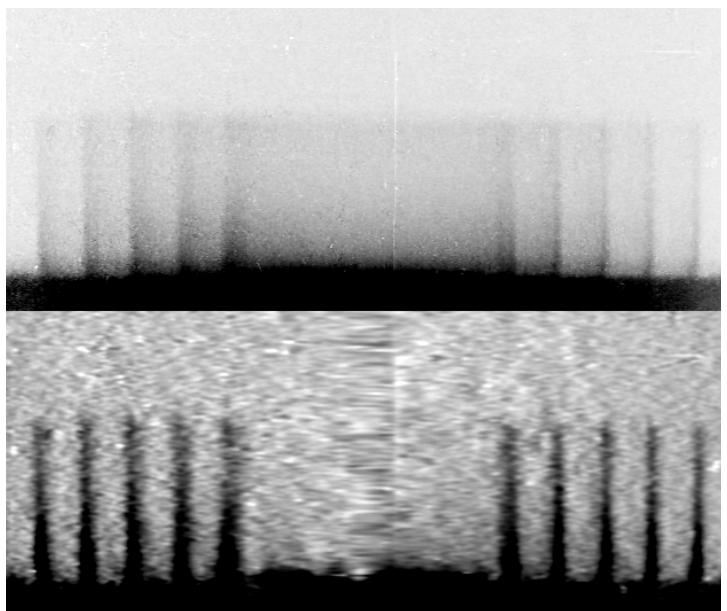
The large-format, 10-frame hybridized focal plane array design of the new imaging system offers much improved spatial and charge resolution, higher quantum efficiency, lower noise, and faster repetition rate over the current state of the art, with integration times below 50 ns.

The new camera design, slated to replace an earlier 3-frame design, allows experimenters more than 40 radiographs per event as opposed to the 21 provided in the current system, and with fewer cameras.

The goal for the current experimental run cycle was to prove that the camera could operate in the harsh ionizing environment of the proton beam. Physics Division researchers made an aggressive push to prepare the camera to take data in a dynamic experiment.

In its first deployment, the camera recorded the evolution of Richtmeyer-Meshkov instabilities at late times (see image). The team will focus on quantitative characterization of the camera's capabilities (i.e., measurements of transfer curves) and integration of the sensor into a production camera design.

Materials experiments at the Laboratory's proposed Matter-Radiation Interactions in Extremes (MaRIE) experimental facility would demand unprecedented time-resolved imaging capabilities. MaRIE is designed for the study of time-dependent mesoscale materials science. Many of the technologies featured in this new imaging prototype (e.g., improvements in in-pixel memory and quantum efficiency) are promising additions to the suite of technologies researchers could employ in conceptual designs of MaRIE.



The team performed two identical experiments at about 7 atm (atmospheric pressure) of helium. Two shots—one from 0–5.5  $\mu$ s with an interframe time of 275 ns (21 images and a static) and one from 5.8–13.8  $\mu$ s (21 images)—will be combined.

The 10-frame camera, which was fielded on the second, from 5.9–9.5  $\mu$ s with an interframe time of 400 ns, is a link between the two, to verify repeatability. The image taken using the 10-frame camera shows (top) areal density and (bottom) Abel-inverted.

The Lab's Neutron Science and Technology (P-23) and Subatomic Physics (P-25) groups, Teledyne Imaging Sensors, Fishcamp Engineering, and Sandia National Laboratories collaborated to develop this new imaging system.

Billy Buttler (P-23) is the principal investigator. NNSA Science Campaign 3 funded the work, which supports the Laboratory's Nuclear Deterrence mission area and the Materials for the Future and Science of Signatures science pillars through dynamic materials and shock physics investigations.

*Technical contact: Johnny Goett*

## Experimental platform to study heterogeneous mix in ICF implosions

The goal of the Inertial Confinement Fusion (ICF) program is thermonuclear ignition and burn of a deuterium-tritium (DT) capsule in a laboratory environment. Understanding turbulent mix remains a key obstacle on the path to ignition.

As part of this program, a multi-division Los Alamos team has taken a major step in the development of an experimental platform for studying the effect of heterogeneous mix on thermonuclear burn. The researchers imploded a capsule filled with low-density deuterated plastic foam on the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory. Building on work performed at the OMEGA Laser Facility at the University of Rochester, a team led by Melissa Douglas (XTD Integrated Design & Assessment, XTD-IDA) designed, fabricated, and fielded two implosion experiments to determine the feasibility of the concept and reproducibility of the target performance.

Two capsules containing deuterated hydrocarbon foam ( $\text{CH}_{0.5}\text{D}_{0.5}$ ) at  $40 \text{ mg/cm}^3$  were imploded using x-ray drive from NIF hohlraums. Measurements of the neutron yield, x-ray bang time, and symmetry of the implosions were performed.

Reproducibility was exceptional, with the yield varying by only 4% from one shot to the next, and the bang times were consistent to within 20 ps. Yields were 70% of pre-shot cal-

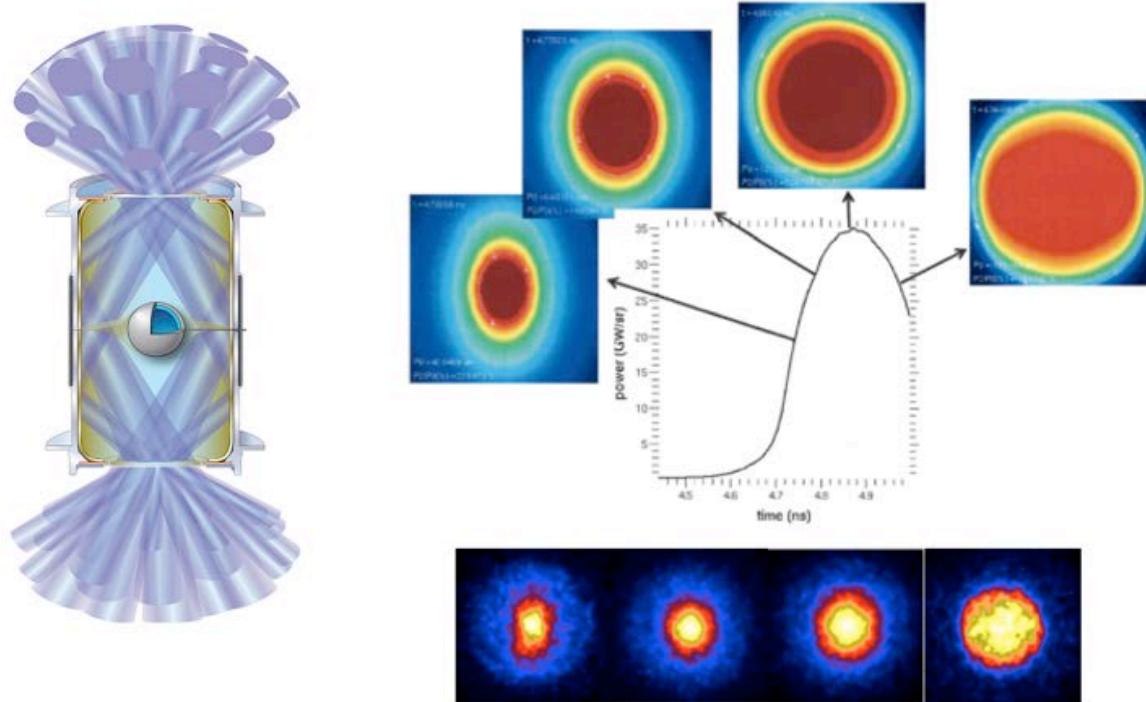
culations, and the bang times were predicted to within 50 ps of measured values.

Mix of ablator material into the fuel of an inertial confinement fusion capsule introduces non-burning material, diluting the fuel and reducing the burn. The amount of the reduction is dependent in part on the morphology of the mix. Uniform mix produces the greatest dilution, whereas heterogeneous (or “chunky”) mix can have regions of higher fuel concentration that allow more burn to occur.

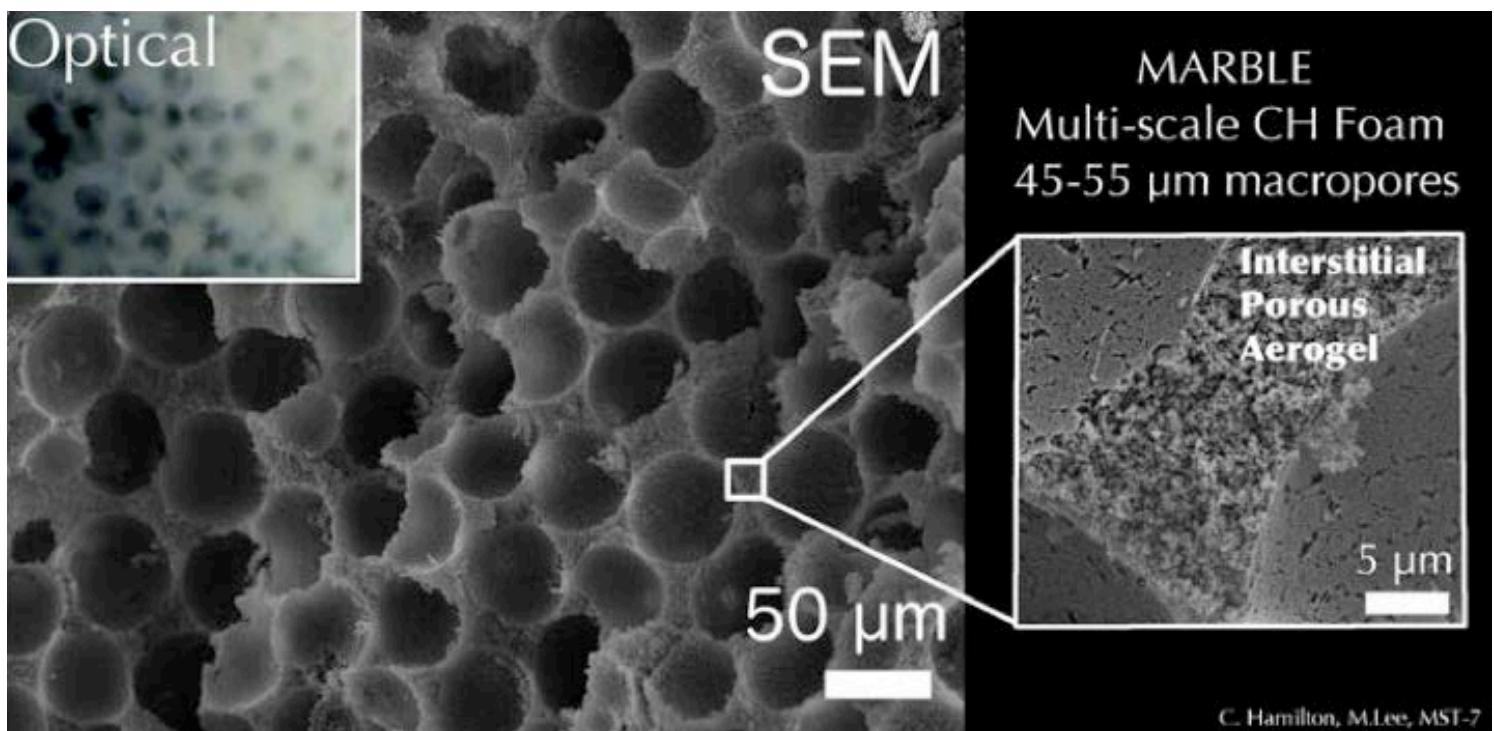
A probability distribution function (PDF) burn model approach has been developed to estimate the burn rate in unresolved but mixed material computational cells. This model uses the average concentration of mixed materials and the variance in this quantity across computational cells, which are provided by the BHR turbulent transport mode. The result is a prescription for the concentration (i.e., morphology) of fuel and ablator material in a cell.

The team is developing the MARBLE ICF platform for use on NIF to test the probability distribution function burn model. This platform consists of a capsule filled with deuterated plastic foam at a density of a few tens of milligrams per cubic centimeter, with tritium gas filling the voids in the foam. X-rays from a laser-driven hohlraum will drive the capsule, and the resulting shocks will induce turbulence that

*continued on next page*



Foam-filled capsules were imploded using x-ray drive from a NIF hohlraum (left). Measured implosion symmetry (lower right) matched predictions (upper right), as did bang time.



**Engineered foam with prescribed voids that will be used to control the homogeneity of mix in future experiments to test the PDF burn model.**

will result in the mixing of deuterium from the foam with the tritium gas.

The neutron yield will measure capsule performance. Fusion neutrons are produced from two reactions. The fusion of two deuterium nuclei in the foam produces 2.5-MeV neutrons. Because the foam makes up more than 95% of the mass inside the capsule, the yield of these DD neutrons is insensitive to the degree of mix.

Fusion of the deuterium nuclei with tritium nuclei in the gas produces 14-MeV neutrons. Because the foam and gas must mix to produce these 14-MeV neutrons, the DT neutron yield is proportional to the degree of mixing. The ratio of DT to DD neutrons is a sensitive indicator of the degree of mix. This ratio will be compared with predictions from a variation of the probability distribution function burn model that quantifies reaction rates from initially separated reactants.

The team will perform experiments using foam with voids of varying size to create and control the heterogeneity of the mix. Small voids are expected to mix with the plastic, approximating uniform mix and producing the greatest DT/DD yield ratio. The mix will remain incomplete for the largest voids, and the ratio will be reduced. Researchers will conduct foam development work at Materials Science and Technology (MST) Division's Target Fabrication Facility.

Initial experiments have demonstrated that the use of low-density foam in ICF capsules is feasible and that current simulation techniques accurately predict implosion behavior. Accurate and reproducible yields and bang times facilitate design of the more complex targets needed to begin the heterogeneous mix experiments.

Melissa Douglas (XTD-IDA) leads the MARBLE team, which includes experiment [T. Murphy, R. Shah, and J. Cobble (Plasma Physics, P-24)], simulation [R. Olson and I. Tregillis (Plasma Theory and Applications, XCP-6); B. Haines (Eulerian Codes, XCP-2)]; J. Smidt and J. Fincke (XTD-IDA)], and target fabrication [J. Oertel, C. Hamilton, M. Lee, B. Randolph, and D. Schmidt (Engineered Materials, MST-7)].

NNSA funded this work through the Inertial Confinement Fusion Program and the Science Campaigns. The research supports the Lab's Nuclear Deterrence and Energy Security mission areas and the Nuclear and Particle Futures science pillar, with a focus on the High Energy Density Plasma and Fluids thrust area.

*Technical contacts: Melissa Douglas and Thomas Murphy*

## Los Alamos collaborates at the world's largest and newest stellarator experiment

The Wendelstein 7-X stellarator recently began operations at the Max Planck Institute for Plasma Physics in Germany, with the help of American researchers from several universities and institutes including Los Alamos National Laboratory. The W7-X machine is the world's largest superconducting magnetic fusion experiment and has optimized three-dimensional magnetic fields designed to test an alternative to the tokamak approach to harnessing fusion energy. Presently no commercially viable technology exists to exploit fusion energy, a potential source of clean, plentiful, reliable power.

Preparations for this start of operations, with U.S.-designed hardware and software, have been ongoing for the last four years by a Department of Energy-sponsored U.S.-German laboratory collaboration involving Princeton Plasma Physics Laboratory, Oak Ridge National Laboratory, and Los Alamos. The team plans to demonstrate steady-state, high-temperature (100 million °C) plasmas for up to 30 minutes after the machine is fully operational with deuterium in the next three years.

While W7-X was under construction, Los Alamos National Laboratory developed and installed a high-resolution visible and infrared camera diagnostic set needed to study the effects of three-dimensional magnetic geometries on the plasma edge, mainly interactions with the armored walls inside W7-X. The Germans already have several lower-resolution imaging systems.

Glen Wurden (Plasma Physics, P-24) recommended using an infrared camera developed for the U.S. military, which offered the highest resolution available at that time. He and John Dunn (P-24) designed two imaging systems: one for initial operations with the poloidal graphite limiter, and another for use in a future phase with a test divertor unit and an Oak Ridge scraper element. Optical access at the stellarator was obtained using a large sapphire vacuum window, which can be mounted on several diagnostic ports. Software for real-time acquisition and analysis was written in Matlab with multi-core graphics image processing.



Glen Wurden in the stellarator's vacuum vessel during camera installation, with one hand on tile-backing plates and the other on a manned-entry port. Cameras capture images of the plasma effects on armored tile segments.

For W7-X's inaugural run in December 2015, magnetically shielded cameras—visible (400–700 nm) and mid-band infrared (3–5 μm)—shared a nearly identical view of the limiter through a sapphire window mounted on the AEA30 port. Both systems offer sub-mm spatial resolution and 10-ms time resolution, while viewing three of the limiter tiles. Wurden and collaborators will compare heat flux patterns observed on the limiter with numerical predictions corresponding to different plasma diffusivities.

The DOE Office of Science's Office of Fusion Energy Sciences (Program Director Don Rej) funded the work, which supports the Lab's Energy Security mission and the Nuclear and Particle Futures science pillar by building the scientific foundation needed to develop a fusion energy source.

The Los Alamos portfolio ranges from discovery plasma science to high-power, long-pulse, and foundational burning plasma research. This year, the DOE Advanced Research Projects Agency—Energy program selected Los Alamos researchers to participate in three groundbreaking prototype technologies to explore new pathways for fusion power.

*Technical contact: Glen Wurden*



Using a high-resolution visible imaging diagnostic developed at Los Alamos National Laboratory, Glen Wurden took this single-frame, 30-ms-exposure image of W7-X's first plasma on Dec. 10, 2015. The image shows one of the five graphite limiters, visible behind the plasma as several tiled segments. He was one of six U.S. collaborators in the control room when the instrument came online.



The Wendelstein 7-X stellarator required 19 years to build, from design to first operation.

## Los Alamos quantum cryptography featured in *Scientific American*

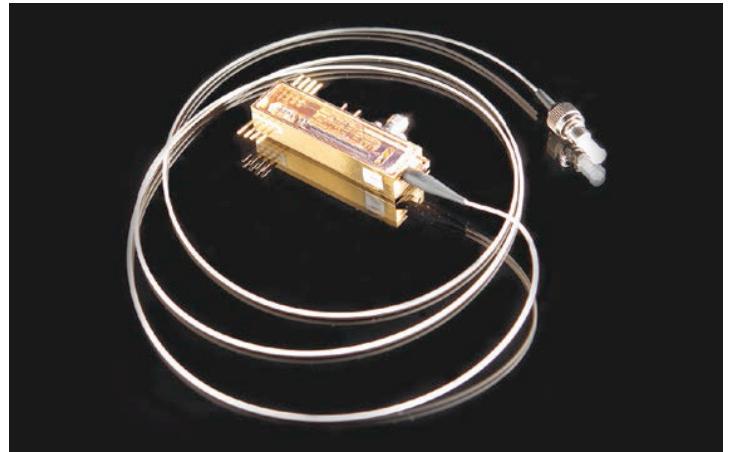
The work of Los Alamos physicists who invented a quantum key network poised for commercialization is featured in a recent *Scientific American* article, which delves into the race to find new encryption schemes before quantum computers become a reality and render current safeguards obsolete.

“The Quantum Hack” by Tim Folger, explores various attempts internationally to deploy quantum cryptography, while questioning whether the world’s encryption systems can realistically make the quantum leap in time to protect online commerce and communication. Quantum cryptography differs from current encryption systems because it is based on single particles of light, which are unpredictable, instead of mathematical algorithms, which can be cracked.

The Quantum-secured Communications team in Applied Modern Physics (P-21) has developed data protection technologies based on quantum physics—and 25 years worth of research. Team Leader Ray Newell and Glen Peterson are working with former Los Alamos physicists Richard Hughes and Beth Nordholt to help Whitewood Encryption Systems Inc. engineer products that could revolutionize computer security for the future. Hughes and Nordholt recently joined Whitewood as senior advisors.

One of those devices, called QKarD, is discussed at length. The article describes how QKarD works and the state of efforts to scale up the device from prototype to production.

In addition, team members are quoted on pressing matters, including the likelihood that the first quantum computer will boot up in 10 years, the technical difficulty of increasing key size in current encryption systems, the threat of hackers controlling the power grid, and a quantum network under construction in China to protect government and banking transactions.



A *Scientific American* article on the need for quantum cryptography features this photograph of QKarD, a quantum key generator developed at Los Alamos National Laboratory that would allow computers, cell phones, and other devices to exchange quantum keys through a secure, central server.

The Laboratory Directed Research and Development program, the U.S. Department of Energy, and sources in the intelligence and defense communities have funded the team’s quantum communications research, which supports the Lab’s Global Security mission area and the Information, Science, and Technology science pillar.

Reference: Folger, Tim. “The Quantum Hack: Quantum computers will render today’s cryptographic methods obsolete. What happens then?” *Scientific American* Feb. 2016: 49–55.

Technical contact: Ray Newell

## Turbulent Mixing Tunnel jet experiments provide new insights into buoyancy effects in mixing

The Turbulent Mixing Tunnel (TMT) in Physics Division is a new, open-circuit wind tunnel facility designed to study jet and shear flow conditions for Science Campaign 4. Its unique diagnostic suite and multi-fluid capability make it the premiere source for experimental data on variable density mixing in shear conditions. The TMT facility has capabilities for many experimental configurations, including studying transient flow conditions, multiple/colliding jets, and other flow geometries.

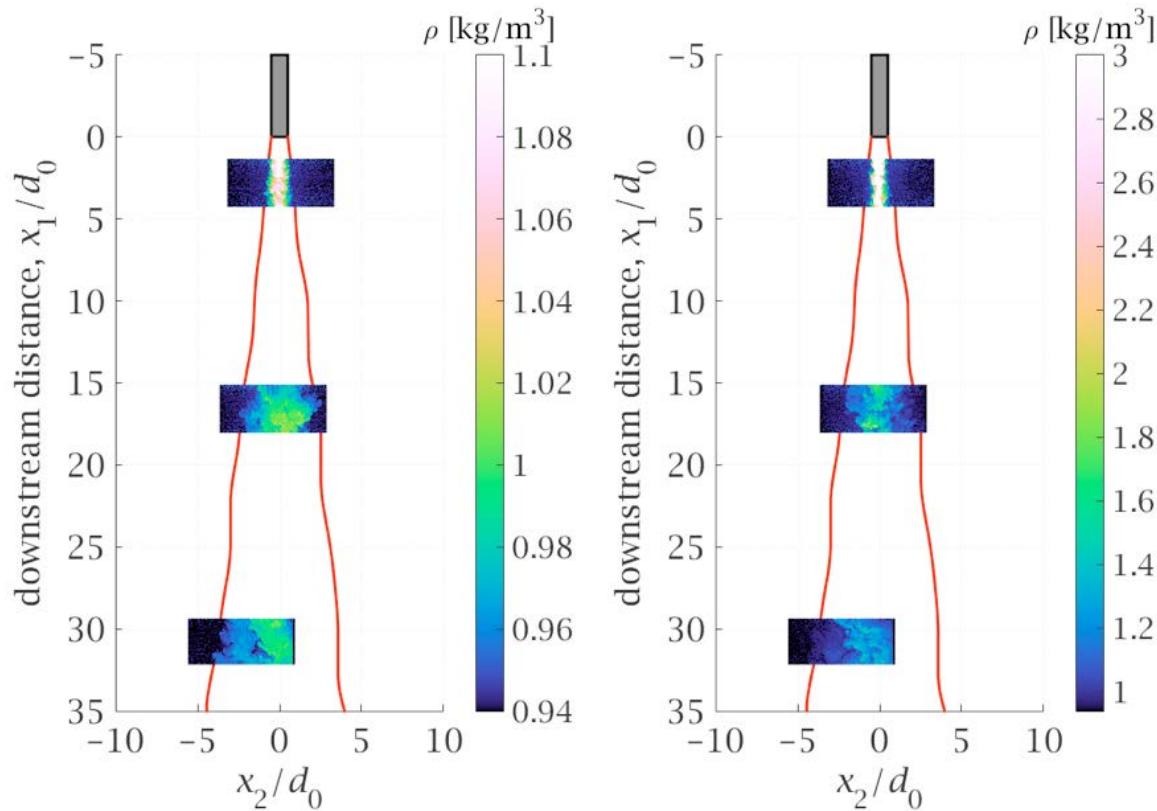
Data from the TMT are being used to validate turbulence models for variable-density mixing conditions. Particle image velocimetry and planar laser-induced fluorescence are employed to measure the velocity and density fields simultaneously in two dimensions. The current experiments are designed to study the effects of changing the Atwood number

of the jets (difference in density between the jet flow and the coflow) with matched Reynolds numbers. Jets provide a useful configuration for studying mixing because the jet does not mix with the surrounding air in a uniform way, so the turbulence is characterized by intermittent, large-scale structures. This leads to turbulence that does not necessarily behave the way the models that have been implemented into numerical codes might predict.

Density-weighted turbulence quantities in variable-density jets are revealing flow dynamics that are highly dependent upon initial conditions, with buoyancy effects that are evolving in space and time. Both turbulence and mean quantities are sensitive to these effects, and turbulence quantities are particularly revealing of important turbulent jet behaviors.

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## Turbulent Mixing Tunnel cont.

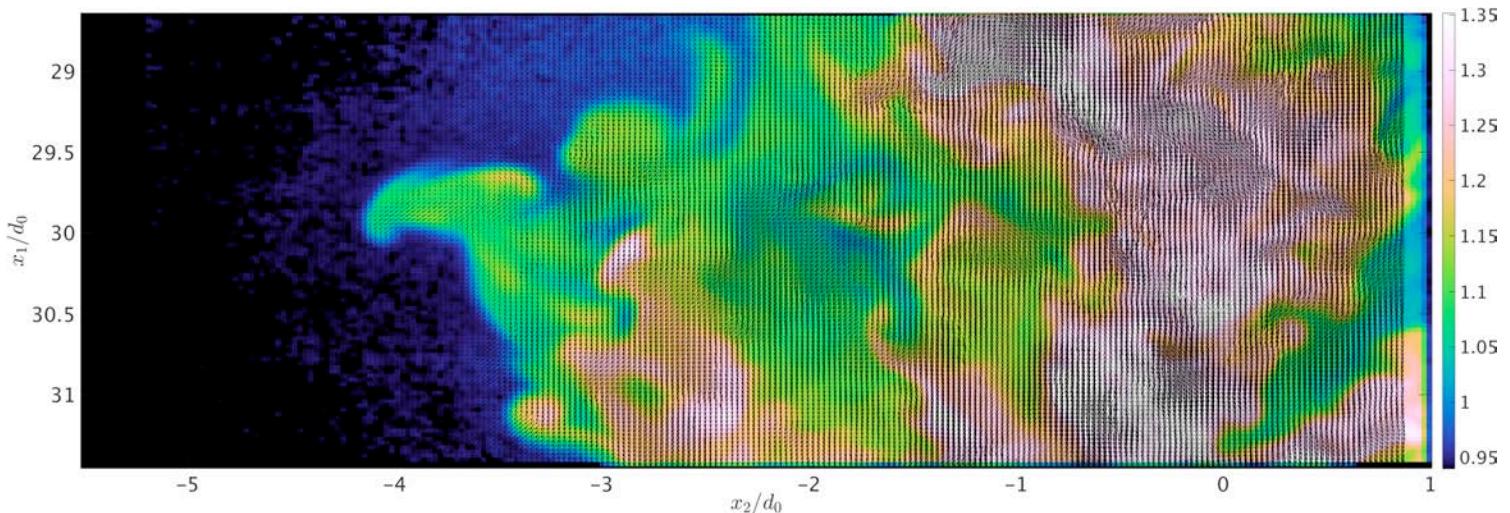


With these data, researchers will be able to develop important scaling relations that take into account initial conditions effects, Atwood number variation, and flow conditions. Few experimental measurements have been made on variable-density mixing, especially at these flow conditions (high Reynolds numbers). And no previous experiments have made measurements of the 2D density and velocity fields simultaneously.

The measurement regions for the air (left) and  $\text{SF}_6$  (right) jets are shown to scale in the figure above.

At each of these downstream locations, 10,000 simultaneous density and velocity fields are acquired. An example of one such field is shown below. The color scale is density in  $\text{kg}/\text{m}^3$ , and the field also constrains velocity vectors (even in the dark regions there are vectors). The spatial resolution and accuracy of the application of particle image velocimetry allows researchers to resolve the wide range of spatial scales that are present in the flow field. Mean quantities are calculated using all 10,000 images and fluctuations by subtracting the mean field from each of the instantaneous fields.

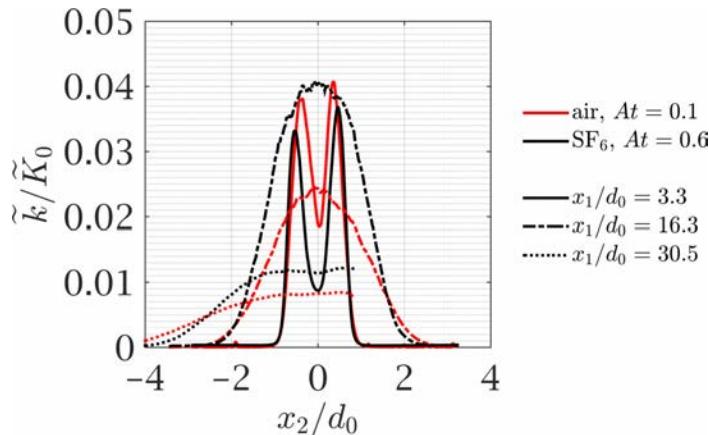
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## Turbulent Mixing Tunnel cont.

The trends seen in the Reynolds stresses are clearer if one examines the turbulent kinetic energy (TKE), defined in our experiments as  $k \approx 1/2(\tilde{R}_{11} + 2\tilde{R}_{22})$ .

This density-weighted quantity, below, shows us how much total kinetic energy is in the density and velocity fluctuations of the flow field.



As the figure shows, the TKE increases dramatically for the SF<sub>6</sub> jet from the near field to the buoyancy-dominated region. Even at 30 diameters downstream, the TKE is still higher in the SF<sub>6</sub> jet, even though it started out with a lower TKE than the air jet. Other important quantities for the BHR model, such as turbulent mass flux and density-specific volume covariance, are also measured experimentally. Comparisons with simulations are ongoing. Normalization with the local value shows much higher dissipation rates in the air jet, and with dissipation increasing then decreasing in the air jet. Analysis of the dissipation rates is continuing.

The work at the TMT supports the Laboratory's Stockpile Stewardship mission and Nuclear and Particle Futures science pillar by providing important facility and measurement capabilities in experimental fluid dynamics and turbulence. The experiments are funded by Science Campaign 4 under Program Manager John Scott. Researchers are John Charko and Kathy Prestridge (Neutron Science and Technology, P-23).

Technical contact: Kathy Prestridge, P-23

## Celebrating service

Congratulations to the following Physics Division employees celebrating service anniversaries recently:

Tsutomu Shimada, P-24	30
Steven Batha, P-DO	25
Richard Van De Water, P-25	20
Sky Sjue, P-21	15
Carl Wilde, P-23	5
Jose Dominguez, P-25	5

## Wurden named associate editor for *Journal of Fusion Energy*

Glen Wurden (Plasma Physics, P-24) has accepted an invitation from the *Journal of Fusion Energy* to serve as an associate editor. The journal publishes international research on the development of thermonuclear fusion as a power source, in print and online editions, while also providing a forum for discussion of broader policy and planning issues in energy fusion programs. Springer US publishes the journal six times a year. Wurden leads P-24's Magnetized Plasma team, which uses a range of plasmas and plasma diagnostic techniques to understand complex processes in hot fusion plasmas.



Technical contact: Glen Wurden

## HeadsUP!

### Safety leadership: Reinvigorating HPI

Applying the understanding of human behaviors and the role they play in work processes to improve performance in safety and productivity is the essence of human performance improvement (HPI). In a new Safety Leadership campaign column, [int.lanl.gov/safety/safety-leadership/new-hpi-team.shtml](http://int.lanl.gov/safety/safety-leadership/new-hpi-team.shtml), read how the Environment, Safety and Health Directorate recently brought in three individuals with HPI skills in targeted areas that compliment the unique institutional needs of the Lab.



Published by the Experimental Physical Sciences Directorate.

To submit news items or for more information, contact Karen Kippen, ADEPS Communications, at 505-606-1822, or [kkippen@lanl.gov](mailto:kkippen@lanl.gov).

For past issues, see [www.lanl.gov/org/padste/adeps/physics/physics-flash-archive.php](http://www.lanl.gov/org/padste/adeps/physics/physics-flash-archive.php)



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