National Nuclear Security Administration

SCIENCE CAMPAIGN

OFFICE OF DEFENSE SCIENCE

Assistant Deputy Administrator for Stockpile Stewardship

R&D 100 Award
Multiplexed Velocimetry Technology

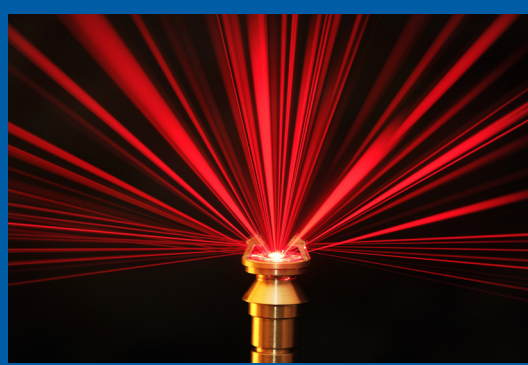
U.S. DEPARTMENT OF ENERGY

Science Campaign

The Science Campaign is part of an evolving security and deterrence environment involved in extending the life of aging weapons under tighter environmental standards. We continue to make technological advances and address the requirements of our weapon systems, laboratories, and production sites. The Science Campaign experimental programs give us a platform for evaluating new technologies and manufacturing techniques and quantifying aging effects so the weapons complex can respond to an evolving stockpile and infrastructure needs. Experiments also expand the bounds of our models of weapons performance, so that we will continue to confidently understand and predict performance for decades to come and avoid any technical need for underground tests in the future. We also turn our knowledge and other tools to analyzing nuclear threats so the Nation can better understand and respond to them.

The control room at the Dual Axis Radiographic Hydrodynamic Test Facility houses the equipment used to control, calibrate, and monitor the ultra high-power x-ray imaging of materials that implode at speeds greater than 10,000 miles an hour.

National Security Technologies, LLC, working with Lawrence Livermore National Laboratory, won an R&D 100 Award for developing multiplexed photon Doppler velocimetry technology. NNSA is using this technical advance in sensors such as the pictured fisheye probe, which track motion at approximately 100 discrete points in weapons physics experiments.



The Nation's nuclear deterrent remains a vital part of our national security infrastructure. It maintains strategic stability, deters potential adversaries, and reassures our allies and partners of our security commitments. Maintaining a stockpile of nuclear weapons that friend and foe alike recognize as second to none requires the best science and technology, particularly in this post-nuclear-testing era.

As part of its pursuit of a range of disarmament, nonproliferation, and nuclear security goals, the United States has sharply reduced the number of weapons in the stockpile while observing a moratorium on underground nuclear tests (UGTs) since 1992. In order to maintain a safe, secure and effective stockpile, DOE and its weapons laboratories replaced UGTs with a combination of nonnuclear experiments, highly accurate physics modeling, and improved computational power. Together, these tools give us the ability to simulate and **predict** nuclear weapon performance over a wide range of conditions to assess the stockpile, maintain performance, improve safety, respond to technological surprise, and support future treaties.

The Science Campaign embraces its primary role in stewardship — conducting scientific experiments and improving the fidelity of the many physics models we employ. Our experimental programs explore weapons performance and physics and apply that knowledge in three areas:

- improving our predictive models so the NNSA complex can confidently conduct annual assessments;
- developing new technology for life extensions; and
- conducting advanced assessments to meet national security needs beyond stockpile maintenance.

Conducting Experiments That Make the Difference

Each year, the directors of the three NNSA laboratories provide an assessment of the safety, security and effectiveness of each weapon type in the stockpile. The Science Campaign consciously shapes many aspects of our work to support this annual evaluation of the stockpile, especially one of the country's greatest stewardship challenges: removing empiricisms from models of weapons performance. In the past, UGTs were the ultimate stockpile evaluation tool. While they were extremely effective in determining that a weapon worked as designed, they were less so at determining **how** a weapon worked, leaving certain aspects of weapons performance known only empirically, that is, determined through nuclear testing and applicable to a specific system. The Science Campaign aims to replace these empirical understandings with *ab initio* understanding of the physics—an understanding that will be universal and generally applicable to any weapon. Although the models in their current state serve the stockpile in many ways, this first principles understanding will be vital for the future stockpile as life extensions, enhanced surety features, and aging evolve the stockpile away from its originally certified designs.

"…I consider the maintenance of a safe and reliable nuclear stockpile to be a supreme national interest of the United States."

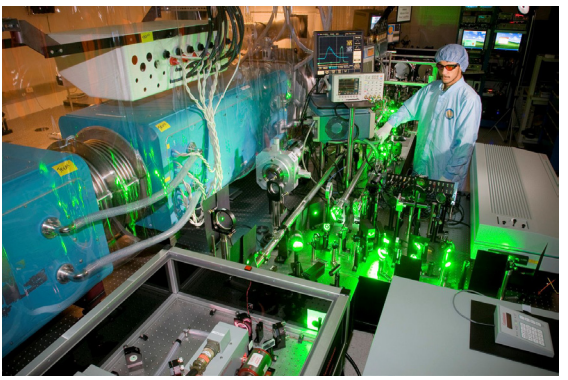
—President Bill Clinton, August 11, 1995

"[T]he U.S. nuclear stockpile must be supported by a highly capable workforce with the specialized skills needed to sustain the nuclear deterrent."

— 2010 Nuclear Posture Review

Maintaining a Pipeline of Scientific Excellence

Sustaining the nuclear deterrent through stockpile stewardship requires a workforce at the cutting edge of weapons physics issues: theorists, experimentalists, diagnosticians and engineering teams to design experiments and operate facilities that support keeping the stockpile safe, secure and effective. By 2025, the weapons complex will have replaced the entire generation of scientists who designed, tested and built the weapons in the current stockpile. In order to maintain a vibrant and skilled workforce, the Science Campaign supports research at U.S. universities in areas relevant to stockpile stewardship to create a pipeline of new talent for the nuclear security complex.



The Science Campaign has more than 100 undergraduate, graduate, Ph.D., and postdoctoral students working with our esteemed academic partners. Top - Texas Center for High Intensity Laser Science at the University of Texas at Austin. Bottom - Rutgers University Center for Excellence for Radioactive Ion Beam Studies for Stewardship Science.

"[W]e will reduce the role of nuclear weapons in our national security strategy, and urge others to do the same. Make no mistake: As long as these weapons exist, the United States will maintain a safe, secure and effective arsenal to deter any adversary, and guarantee that defense to our allies…"

—President Barack Obama, Prague, April 5, 2009

Nuclear weapons, such as the B61, contain thousands of parts; understanding their properties and how they age are essential for assessing weapons and developing life extension technologies.

Supporting Life Extension Programs with New Technologies, Reuse Options and Enhanced Safety Systems

At the time of their original production, our nuclear weapons were not intended to last indefinitely—some components degrade over time. A Life Extension Program (LEP) replaces or refurbishes those components, extending the life of an existing weapon system by 20 to 30 years. This is a difficult task as changes in technology and manufacturing mean that many "factory original" components and production techniques are no longer available. In addition, the 2010 Nuclear Posture Review (NPR) sets two tasks for the weapons complex for future LEPs: (1) develop enhanced safety, security, and use-control systems and (2) explore reuse of nuclear components for application in LEPs. Both are complicated design challenges and will require considerable work to develop the design and verify that they work without compromising weapon performance. The Science Campaign has already contributed to technology alternatives for the B61 LEP and put reuse options and enhanced safety systems at the top of its priority list.

Assessing Nuclear Weapon Performance and Preparing the Nation to Respond to Emerging Nuclear Threats

The Science Campaign supports several efforts related to assessing nuclear weapon performance apart from reliability of the U.S. stockpile. We are working to create better models of weapons outputs and interactions with the surrounding environment. We have also increased our focus on assessing foreign nuclear weapons, as nuclear dangers have increased with more nations acquiring nuclear weapons, terrorists seeking weapons of mass destruction, and the continued growth of black market trade in nuclear technologies. We use our expertise, weapons models, and experimental capabilities to analyze proliferant designs so the Nation can better understand and respond to emerging nuclear threats.

The Joint Actinide Shock Physics Experimental Research (JASPER) gas gun allows us to explore plutonium performance while safely containing the nuclear material. Above - Staff at the Nevada National Security Site prepare JASPER to implement experiments as part of our efforts to improve predictive capability.

"…the biggest threat facing this country is weapons of mass destruction in the hands of a terrorist network."

—President George W. Bush, September 30, 2004

Science Campaign
Main Experimental Facilities

Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility
http://www.lanl.gov/science/NSS/issue2_2010/story2.shtml
Two linear induction accelerators used to produce high intensity x-rays, providing information critical to certifying weapons performance.

Joint Actinide Shock Physics Experimental Research (JASPER)
https://www2.nstec.com/Pages/DESS.aspx
JASPER is a two-stage light-gas gun used to study the behavior of plutonium and other materials under high pressures, temperatures, and strain rates.

Los Alamos Neutron Science Center (LANSCE)
http://lansce.lanl.gov/
The LANSCE supports research on stockpile components and experiments for developing nuclear forensics.

National Ignition Facility (NIF)
http://lasers.llnl.gov/about/nif/
NIF, the world's largest and most energetic laser, is designed to achieve fusion ignition.

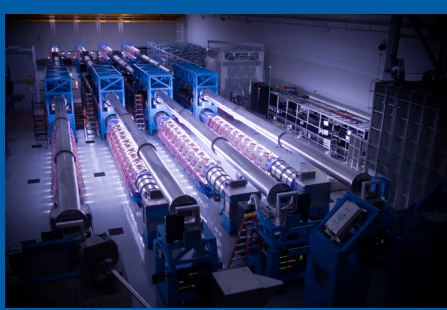
OMEGA
http://www.lle.rochester.edu/omega_facility/
Two of the world's most powerful laser systems and used by scientists all over the world, OMEGA and OMEGA EP support the study of high energy density physics and experiments in support of ignition.

U1a Complex
https://www2.nstec.com/Pages/DESS.aspx
This underground experimental facility hosts subcritical experiments to collect data from plutonium subjected to high pressures and shocks, mimicking the environmental conditions of a nuclear explosion.

Z Machine
http://www.sandia.gov/z-machine/
This pulsed power machine produces abundant amounts of energy in x-rays, large plasma environments, and controlled high pressures.

For more information, contact Dr. Ralph Schneider, Director, Office of Defense Science at (202) 586-0852 or visit http://www.nnsa.energy.gov/defensescience.

NIF



OMEGA EP

Z Machine

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