The Journey into a New Era of Scientific Discoveries

THE National Ignition Facility (NIF), the world's largest laser, will be dedicated on May 29, 2009. The facility was designed and built to achieve fusion ignition and energy gain in a laboratory setting—a major scientific achievement with far-reaching benefits for humankind. NIF will serve as a unique national resource for sustaining confidence in the U.S. nuclear weapons arsenal, pursuing options for nearly limitless sources of clean energy, and exploring the science of most of the known matter in the universe.

NIF has been the largest scientific-facility construction project in the U.S. With about 7,500 meter-scale and 26,000 small optical components, the stadium-size laser facility required Laboratory scientists and engineers to make many enormous leaps in technology. The result is a laser system capable of producing 1.8 million joules of ultraviolet light—60 times more energy than any previous laser.

The energy will be delivered to the center of a 10-meter-diameter, 1-million-pound target chamber. NIF's 192 beams produce a 10-nanosecond pulse aimed with 50-micrometer accuracy and precisely shaped in time. In inertial confinement fusion (ICF) experiments, the target is a peppercorn-size capsule filled with deuterium and tritium (DT) fuel inside a small can, called a hohlraum, with openings at the ends to admit laser light. In an instant, the fuel will be imploded and compressed to nearly 100 times the density of lead and a temperature of 100 million kelvins. Fusion of the DT will release more energy than delivered by the laser.

Ground was broken for NIF 12 years ago. Design and development of the laser systems and components, construction of the facility, assembly and installation of equipment, and commissioning of the lasers have been a massive effort. Success would not have been possible without the dedication and enormous effort of people from virtually every directorate within the Laboratory, the work of more than 1,000 industrial partners, and the many contributions from other research institutions in this multilaboratory project. Leaders in the executive branch and Congress recognized the importance of NIF, and have provided strong support for NIF construction and now the National Ignition Campaign.

The journey to NIF's dedication began about 50 years ago with two nearly coincidental events. At Livermore, scientists were interested in the peaceful use of nuclear explosions and the possibility of using a series of explosions as a source of electric power. John Nuckolls, later to become Laboratory director, focused on the question, "How small a nuclear explosion is possible?" In June 1960, he calculated that ignition and efficient burn of about 1 milligram of DT might be possible, yielding about 50 megajoules of energy. But what was needed was a precise, extremely powerful nonnuclear driver to power the tiny implosion. In July 1960, the Hughes Research Laboratory in Malibu, California, announced that Theodore Maiman had won the race to build the first laser. The idea of the laser—then called an optical maser—had been proposed by Arthur L. Schawlow and Charles Townes in a 1958 paper.

In 1962, the Laboratory launched a laser-fusion project. Within a few years, work begun to focus on the use of neodymium-doped glass lasers. In the early 1970s, the effort rapidly expanded,

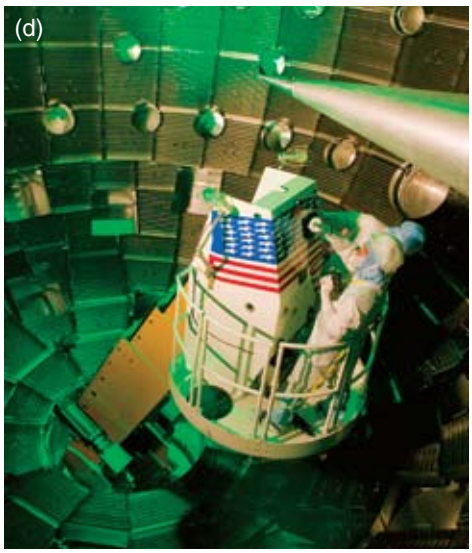
Lawrence Livermore National Laboratory

and Livermore moved to "front stage" in ICF research. The concept of ICF became much more widespread within the technical community with publication in 1972 of the groundbreaking paper in *Nature* by John Nuckolls and collaborators on fusion ignition of a bare sphere of DT. In 1971, Carl Haussmann convinced the Atomic Energy Commission to build a 10-kilojoule laser for ICF research (the future Shiva), and he recruited outstanding young laser scientists to be part of the effort.

Laboratory researchers built the Janus, Argus, and Cyclops sequence of lasers, which led to the 20-beam Shiva, Livermore's first large ICF research laser. The rapid learning process benefited from two factors that have been behind the Laboratory's many successes in ICF research. First, research on ICF targets and lasers has always integrated theory, thoroughly diagnosed experiments, simulations using the most advanced computers of the day, and precision and systems engineering. Second, industries were included as partners in technology development to ensure that laser components, especially precision optics, could be manufactured with high quality and at affordable costs.

One of the lessons learned from these 1970s laser systems is that use of light at higher (ultraviolet) frequencies was necessary to succeed at ignition. Constructed in the 1980s, the 10-beam Nova laser was the first high-energy glass laser that included optical elements to convert infrared light to ultraviolet. Nova experiments performed in the early 1990s using 40 to 50 kilojoules of ultraviolet light provided confidence that a 1- to 2-megajoule ultraviolet laser would be able to achieve ignition and energy gain. Conceptual planning for NIF began.

The NIF dedication is the culmination of a long and exciting journey. A new, even more exciting one is about to begin. As a unique resource for exploring high-energy-density physics, NIF offers the promise of helping to resolve key issues about nuclear weapons performance, providing a pathway to clean energy (see p. 6), and creating opportunities for exciting scientific discoveries about the universe.



NIF in the NEWS

(a) Then Energy Secretary Federico Peña joined Laboratory Director Bruce Tarter and Congresswoman Ellen Tauscher on May 29, 1997, to break ground for the National Ignition Facility (NIF). (b) California Governor Arnold Schwarzenegger (left) is briefed by Ed Moses, principal associate director of NIF, while on a tour of the laser facility in November 2008. (c) In the 1970s, fusion fuel was compressed to about the density of lead in the Shiva target chamber. (d) In the NIF target chamber, fuel will be imploded and compressed to nearly 100 times the density of lead and a temperature of 100 million kelvins.