LLNL-JRNL-404182

LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

Rick Sawicki Interview for Dartmouth Engineer Magazine

R. Sawicki

May 27, 2008

Dartmouth Engineer Magazine

Disclaimer

Rick Sawicki Interview for Dartmouth Engineer Magazine

What is your role as chief engineer on this project?

There are two major roles for the Chief Engineer position: 1) to assure that the engineering that is being performed for the project is safely completed in full compliance with all federal, state and Lawrence Livermore National Laboratory policies, standards and procedures and 2) as needed, address special engineering issues as they arise assuring that their resolution is completed in the safest, most effective manner consistent with the project's budget and schedule constraints. Currently the project is nearing completion. Many activities are rapidly coming to a conclusion and many new, complex systems are being activated. I am presently playing a major role in coordinating these activities so that the work can be executed safely and efficiently and the project will complete on schedule.

What is the timetable to have this facility up and running for experimentation?

The National Ignition Facility project commenced in 1995 with a major engineering effort to develop its conceptual design. Since that time we have completed all major design reviews, constructed a 705,000-gross-square-foot facility that houses all of the experimental equipment and commissioned most of the special laser and target area equipment. Presently NIF is about 96% complete and on track to meet our project completion milestones next spring and continue preparing for experiments in 2009 and 2010. In 2010 the full-scale campaign leading up to fusion ignition will be in full swing.

Where is the facility?

The facility is located at Lawrence Livermore National Laboratory in Livermore, California. Livermore is a city with a population of about 50,000 and is located about 50 miles east of San Francisco.

How large is your team of designers, engineers, etc.?

At present there are approximately 110 engineers, 60 designers and 220 technicians working on the NIF project. In the late 1990's and early 2000's these numbers were much larger. At that time we were designing, engineering, constructing and commissioning many elements of this large facility all at the same time. During those years the number of engineers needed was more than 200 and the number of designers was about 250.

What are the means of achieving nuclear fusion?

At LLNL we have been developing the technologies to achieve nuclear fusion through the process called inertial confinement fusion (ICF). This process utilizes very high-power laser beams to bathe a small spherical target, the size of a BB, containing the hydrogen isotopes deuterium and tritium (DT) with an intense energy pulse. If this energy can be deposited uniformly enough and with enough power density then the

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

surface of the target will rapidly heat up and blow off. The reaction of the blow-off will compress the remaining capsule to a fraction of its original size. When successful we will compress the capsule to more than 20 times the density of lead, creating extreme temperatures and pressures in the DT mix – equivalent to conditions at the center of the sun. These conditions will enable the fusion process to ignite, releasing huge amounts of energy in the form of neutrons, x-rays and gamma rays and creating, in effect, a miniature star in the laboratory.

Our initial attempts at fusion will utilize an indirect method of depositing energy on the target. We contain the capsule in a small cylinder slightly larger than the target capsule itself. The laser beams enter the ends of this can and deposit their energy on its inside wall. Since the wall will be coated with gold, this will release x-rays which in turn will expose the target to a bath of intense energy, causing the blow-off. This indirect method creates an x-ray "oven" which helps to assure greater uniformity of energy deposition than would be achieved by directly illuminating the target with the laser beams.

To create the amount of energy needed to cause these conditions a very large laser system is needed. NIF will utilize 192 lasers, each with an aperture of about 40 square cm, collectively capable of generating more than four megajoules of precision infrared light energy. The hardware needed to generate this laser power fits into a stadium-sized facility, requires some 7,500 meter-sized optics and about 30,000 smaller optics, 7,600 flashlamps, each 180 cm long, and an extraordinary control system to maintain more than 65,000 control points. Fusion will occur in a 10-meter-diameter vacuum chamber located in a concrete building that is over 100 feet high. To enable fusion, all of these systems needed to be engineered to strict requirements and constructed with high levels of quality control.

What are the special engineering challenges of this project?

NIF has been a dream challenge for all of its workers, including the engineers. Prior to the commencement of the project we executed a three-year development program that demonstrated the feasibility of large-aperture Pockels cells (laser switches), large-scale optical production technologies, compact and low-cost, high-gain amplifier systems, thermal control systems for the main amplifier and numerous other technologies that enabled the facility to be built at the lowest cost and still meet stringent technical requirements. We pushed the state-of-the-art in many areas to extremes that had not been achieved anywhere before.

The construction project itself demanded that we build 192 identical lasers capable of delivering more than four megajoules of infrared laser light, which is frequency converted to nearly two megajoules of ultraviolet light, in a pulse lasting only a few billionths of a second – the equivalent of 500 trillion watts of power. This demanded a facility the size of three football fields. At the same time, the precision required to uniformly compress the small target required us to be able to point each of the laser beams with an accuracy of about 50 microns, about the thickness of a piece of paper. This required comprehensive end-to-end engineering analysis, design and construction

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

carried out over a 14-year time frame.

The grand challenge that we faced was how to pack all of this state-of-the-art equipment into this large facility while at the same time achieving incredible precision. NIF is an amazing collage of the immense and the miniature, all in a single integrated system.

How close are scientists to achieving nuclear fusion?

NIF full-scale ignition experiments will commence in Fiscal Year 2010. These experiments will involve a very large set of complex experiments designed to first calibrate scientific models and then optimize target design relative to that new information. Detailed shot plans have been assembled and are now being simulated to accomplish this on a tight timeline starting in less than a year. The extreme temperature and pressure conditions achieved in the NIF target chamber are not available in any other experimental facility. This capability provides world-class opportunities to demonstrate the feasibility of using inertial confinement fusion as a clean, safe, carbon-neutral and virtually unlimited source of energy, and also to conduct high energy density physics, allowing researchers to study many astrophysical phenomena that are shaping our universe. For example, instead of searching the skies with telescopes hoping to find supernovae, researchers will be able to schedule and study a miniature supernova right here in the laboratory.

What safety issues are involved in nuclear fusion?

Fusion is an inherently safe process; there is no danger of a “meltdown.” If any aspect of the process is interrupted, the reaction shuts down on its own.

Are there any waste issues involved in nuclear fusion that need to be solved?

Nuclear fusion offers an almost limitless source of energy for the future. The deuterium that is needed for a future power plant can be extracted from seawater. Waste material from such a facility is tiny compared to fission power plants. Material exposed to the tritium can be cleaned up with existing, standard cleanup processes.

Are there security issues to take into consideration in designing a facility for nuclear fusion?

A fusion power plant would not require the high level of security that a fission power plant would have. As there are no special nuclear materials involved in the process, foreign countries and terrorists would have little incentive to gain entry. On the other hand, the fusion power plant would be a complex facility requiring careful control of every aspect of its operation.

Do you work directly with any of the scientists who are working on nuclear fusion?

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

The engineers are building NIF for the scientists who have established the basis for inertial confinement fusion. We work with them every day to assure that we meet all of their requirements and are knowledgeable of any late-breaking information resulting from their latest analyses and simulations. It has been, for me, an exceptional thrill to have had the opportunity to have worked with so many brilliant scientists, some of them world class, on such an exciting project.

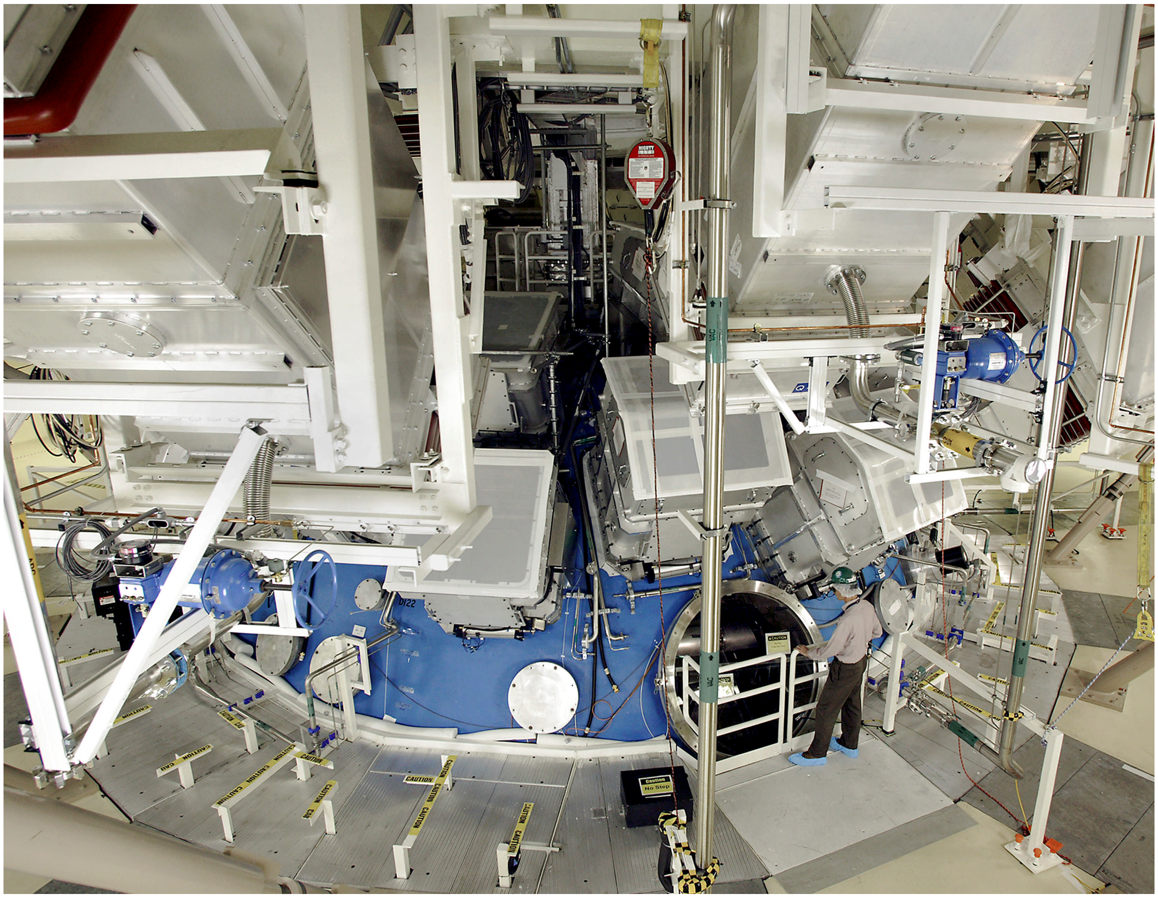
What are kinds of engineers are needed in your area of expertise?

NIF is an amazingly complex scientific instrument – some might say one of the most complex scientific instruments ever built. It is a $3.5-billion facility containing the world's largest laser system, an extraordinary control system, and complex target diagnostics capable of studying minute details of the fusion process. It will be conducting experiments simulating conditions similar to stellar interiors. To make such an extreme system work you need almost every engineering discipline to design, construct and operate it.

Anything else you think is important for people to know about nuclear fusion as a piece of the energy solutions puzzle?

The National Ignition Facility is a major step forward along the path to fusion energy, but it's not the last step. We will demonstrate the ability to create self-sustained nuclear fusion in the laboratory, producing many times more energy than the amount of laser energy required to initiate the reaction. NIF will make history and pave the way for fusion energy power plants, while also providing scientists with an incredible tool capable of studying matter in conditions not available anywhere else except in the far reaches of our universe. We need the next generation of engineers to take the next step – developing an actual fusion power plant. Such a facility offers us an unlimited, carbon-free energy source for the future. We have to make this advance. I am honored to have contributed to NIF and hope engineers now graduating from Dartmouth can provide some of the horsepower needed to take on that next great challenge.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344



NIF Target Chamber – The NIF target chamber is a 10-meter aluminum sphere, 10 centimeters thick and covered with 30 centimeters of concrete. Forty-eight final optics assemblies are attached to its outer surface. These contain optical elements that frequency convert the incoming light from infrared to ultraviolet, a more effective wavelength for achieving ignition. The final optics also focus the laser light, in groups of four, onto the target at target chamber center. The chamber is maintained at high vacuum conditions during experiments.

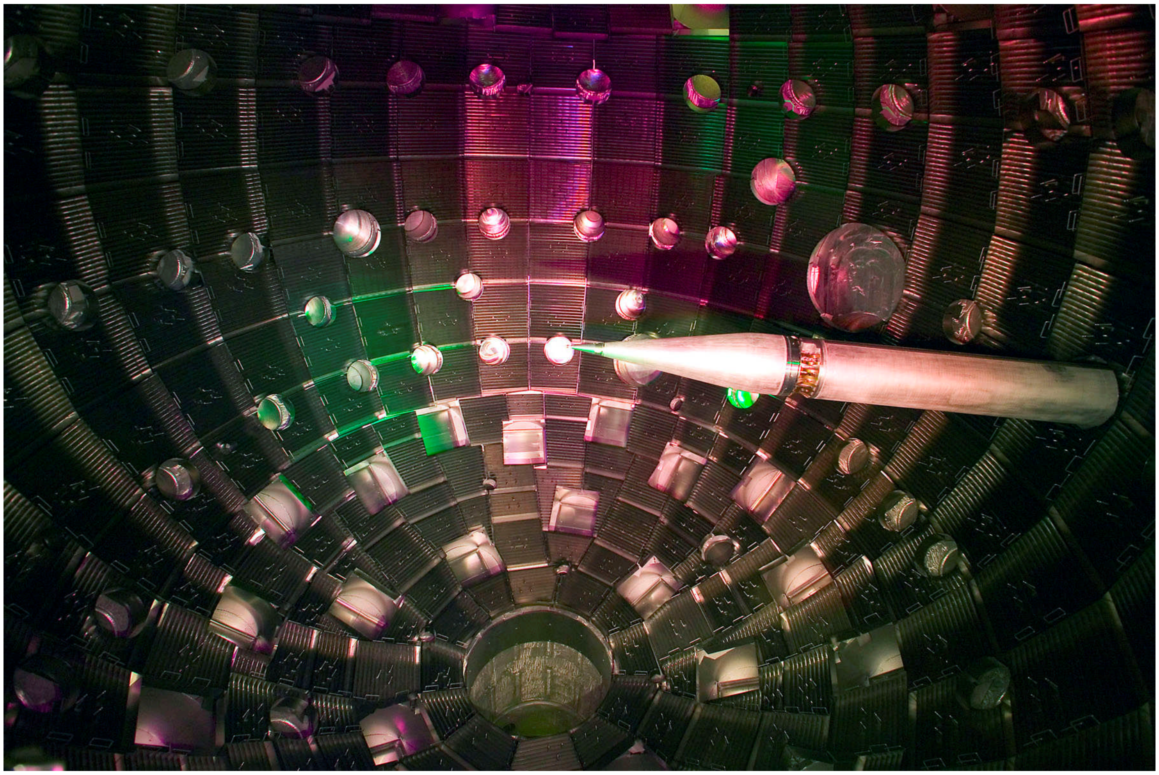
This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

NIF Aerial View – This bird's-eye view of the NIF facility shows the main 705,000-gross-square-foot building. The structure includes two laser bays capable of generating more than four million joules (MJ) of infrared laser light; four capacitor bays, which store approximately 400 MJ of electrical energy; two switchyards, which direct all 192 laser beams into the target bay; the target bay, where experiments activities are conducted; the target diagnostic building, for assembling and maintaining diagnostic equipment for experiments; and the Optical Assembly Building (upper left), where optics assemblies are prepared for installation.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

NIF Laser Bay – This is one of NIF's two laser bays. This room is the about the length of a football field and contains grouped beampaths that transport 96 laser beams through a four-pass amplifier system and spatial filtering chambers and then send the beams to the target chamber. Vacuum, gas, water and other utility systems have been installed to provide tightly controlled environmental conditions to assure that each laser beam meets the specifications required for NIF experiments.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344



Target Chamber Interior – Inside the 10-meter-diameter NIF target chamber, a cantilevered pylon holds a target in position for an experiment. It is here that future fusion events will occur. In groups of four, NIF's laser beams enter the chamber through the rectangular ports seen in the bottom of the photo and converge on the target located at the center of the chamber. The smaller round ports are openings through which diagnostic equipment can record and analyze the details of each experiment.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344