Measuring Phenomena That Power Nuclear Weapons and Stars

The Los Alamos Thermonuclear Experiments (TNX) Program uses lasers and the Z x-ray machine at Sandia National Laboratories to create extreme states of matter usually found only in stars and nuclear weapons. Materials are heated to temperatures as high as hundreds of millions of degrees and compressed to pressures of millions of atmospheres. Work on current lasers and the Z machine is being extended to the National Ignition Facility (NIF), where larger output of power—500 terawatts in about 3 billionths of a second—will generate even more extreme conditions in experiments beginning in May 2004.

The TNX Program is managed by the Physics Division in collaboration with Applied Physics, Materials Science and Technology, Dynamic Experimentation,Theoretical, and Engineering Sciences and Applications Divisions.

The Z Machine

The Z x-ray machine at Sandia National Laboratories creates extreme states of matter.

Schematic of NIF

The National Ignition Facility

The 192 individual laser beam lines form the architecture of the NIF laser.

The huge target chamber (about 32 feet in diameter) allows for a large variety of experiments.

Huge single crystals are used to convert the natural red laser light to blue light, which is more efficient in heating matter.

The control room is the nerve center of this massive experimental facility.

Elements of the TNX Program

As part of the TNX Program, experiments are conducted to investigate the following:

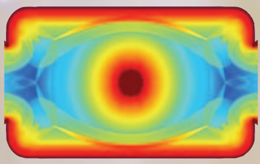
Thermonuclear ignition, a precursor to nuclear-fusion power production

Plasma physics, hydrodynamics, and radiation physics used to validate advanced modeling required for weapons certification

Matter under extreme conditions, such as the simulation of astrophysical phenomena

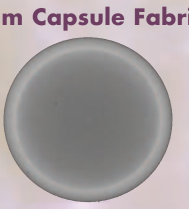
Thermonuclear Ignition

Los Alamos Target Design



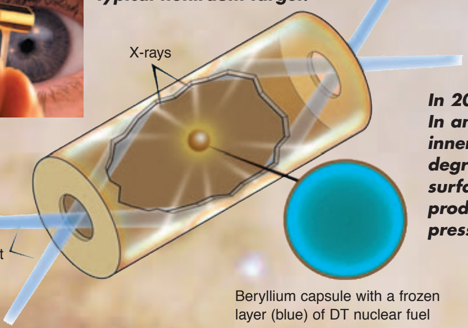
This NIF laser-heated hohlraum was designed with an Advanced Simulation and Computing (ASCI) hydrodynamic code known as RAGE. The colors represent temperatures with the hottest region (red) at about 10 kilo-electron-volts or about 100 million degrees.

Beryllium Capsule Fabrication

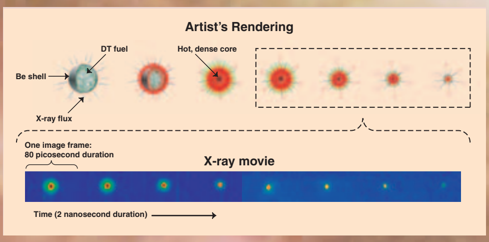


This is an x-ray radiograph of a beryllium shell (2 millimeters in diameter) fabricated at Los Alamos to the extremely precise tolerances required for ignition capsules. These shells will be used to contain the deuterium and tritium (DT) nuclear fuel in NIF ignition experiments.

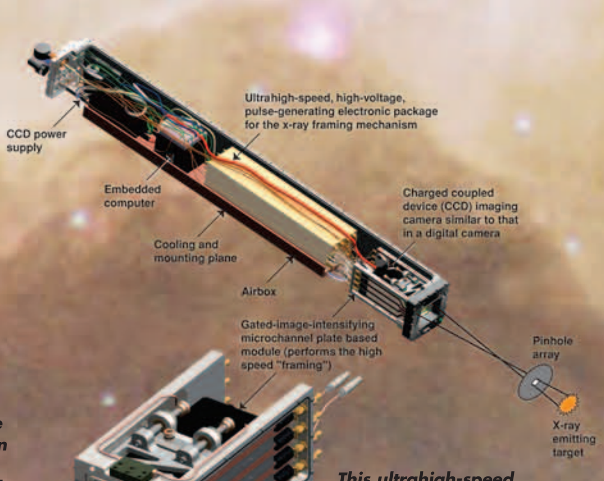
This image shows the scale of a typical hohlraum target.



In 2009, Los Alamos will begin fusion-ignition experiments at NIF. In an "indirect-drive" implosion, high-intensity laser beams heat the inner surface of a gold enclosure, or "hohlraum," to millions of degrees. The x-rays created in this process heat and ablate the surface of a beryllium capsule that contains DT nuclear fuel. Ablation produces a "rocket-like" effect, which implodes the capsule, compresses the DT nuclear fuel, and thus initiates thermonuclear fusion.



Capsules containing DT nuclear fuel are imploded as they absorb high-intensity radiation either directly with lasers ("direct drive") or indirectly with a flux of x-rays produced by the lasers ("indirect drive") as in the artist's rendering. The radiation is absorbed in the outer regions of the capsule creating a very high temperature gas. In turn, the expansion of this gas produces a rocket-like effect, driving (imploding) the unablated portion of the capsule and the DT nuclear fuel to a very dense and hot small core. The conditions in this dense high-temperature core produce the thermonuclear fusion reactions. Advanced diagnostics developed at Los Alamos enable precision measurements of high-energy-density phenomena. The x-ray "movie" shows an implosion performed on current lasers. Each image frame is for 80 picoseconds; the total observation time of the movie is 2 nanoseconds. The "movie" was taken with a prototype of the NIF instrument using the lower-energy Nova predecessor of NIF.



This ultrahigh-speed, computer-controlled x-ray camera built at Los Alamos for use on NIF can detect radiation from the ultraviolet regime to hard x-rays. It has gate or frame times from 70 to 500 picoseconds and a 30-millimeter-square active image area. This camera is used to diagnose laser-driven implosions.

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