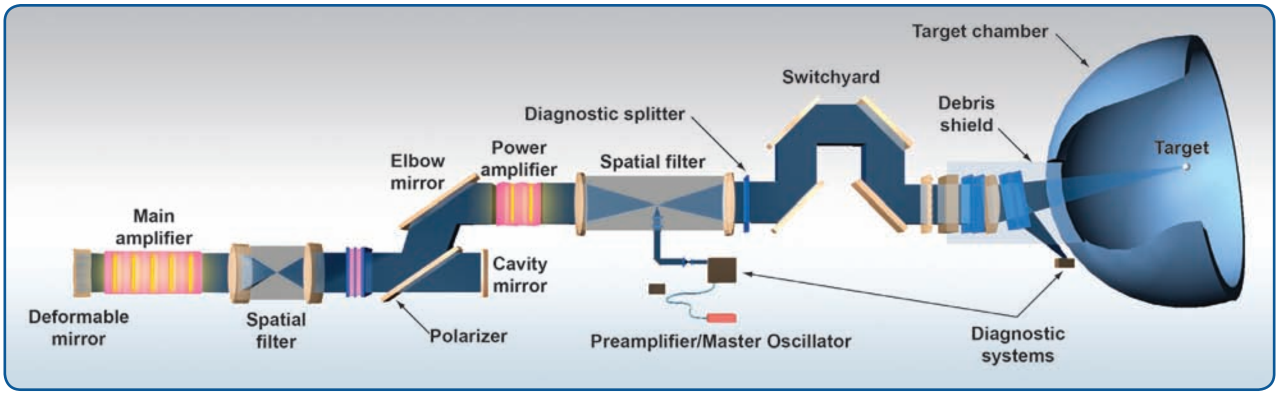
Beam Me Up: How NIF Works

In the National Ignition Facility (NIF), 192 laser beams travel a long path, about 1,500 meters, from their birth at the master oscillator—a device that generates the single pulse that seeds the entire NIF laser system—to the center of the target chamber. As the beams move through NIF's amplifiers, their energy increases exponentially. From beginning to end, the beams' total energy grows from one-billionth of a joule to four million joules, a factor of more than a quadrillion—and it all happens in about five millionths of a second.

Each beam zooms through two systems of large glass amplifiers, first through the power amplifier and then into the main amplifier. In the main amplifier, a special optical switch called a plasma electrode Pockels cell (PEPC) traps the light, forcing it to travel back and forth four times through 11 sets of laser amplifier glass slabs before it can exit the main amplifier cavity. Without this optical switch, the NIF main laser building would have to be about 230 meters longer to achieve the same amplification.



A NIF Beamline
Every NIF beam starts at the master oscillator (bottom center). The low-energy laser beam is amplified in the preamplifier module and then in the power amplifier, the main amplifier, and again in the power amplifier before it runs through the switchyard and into the target chamber.

The master oscillator generates a very small, low-energy laser pulse. The pulse may range from 100 trillionths to 25 billionths of a second long, and has a specific temporal shape as requested by NIF experimenters.

The low-energy pulse is split and carried on optical fibers to 48 preamplifier modules for initial amplification and beam conditioning. In the preamplifiers, the energy is increased by a factor of 10 billion to a few joules. The 48 beams from the 48 preamplifiers are then split into four beams each for injection into the 192 main laser amplifier beamlines.

From the main amplifier, the beam makes a final pass through the power amplifier before speeding into the target chamber. As the pulse's energy is being amplified, a special deformable mirror and other devices ensure that the beams are of high quality, uniformity, and smoothness.

NIF's large glass amplifiers are unique. Other large laser systems use a series of amplifiers of increasing size to raise the beam's energy. NIF's amplifiers are all the same size and use more than 3,000 one-meter-long slabs of special phosphate glass containing neodymium atoms.

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(NIF), the world's most energetic laser, will be used to create fusion, the same process that powers the stars, in the laboratory. NIF's 192 laser beams, housed in two laser bays and operated from the control room, are focused onto a target assembly positioned inside the target chamber.

Powering the Flashlamps

A split second before the initial weak laser pulse begins life at the master oscillator, more than 7,500 two-meter-long flashlamps, powered by huge capacitors that store electricity, energize the neodymium atoms in the amplifier glass by bathing them in intense white light. When the laser beams leave the preamplifiers, the amplifiers are already powered up and ready to receive them. After passing through all the amplifiers, each NIF laser beam has been amplified to about 20,000 joules of energy.

A complex system of special mirrors in two 10-story steel structures known as "switchyards" rearrange the parallel, linear array of 192 laser beams into a spherical configuration so that the beams can be focused into the center of the target chamber. Among the stiffest structures ever built, the switchyard's towers are built to resist vibration and are firmly anchored to the inside of the building's one-meter-thick reinforced concrete walls.

Each beam passes through a final optics assembly that converts the wavelength of the laser from infrared to ultraviolet and is focused through a final focus lens onto a target located at the chamber's center. Targets are positioned with a precision that is measured in fractions of the thickness of a sheet of paper.