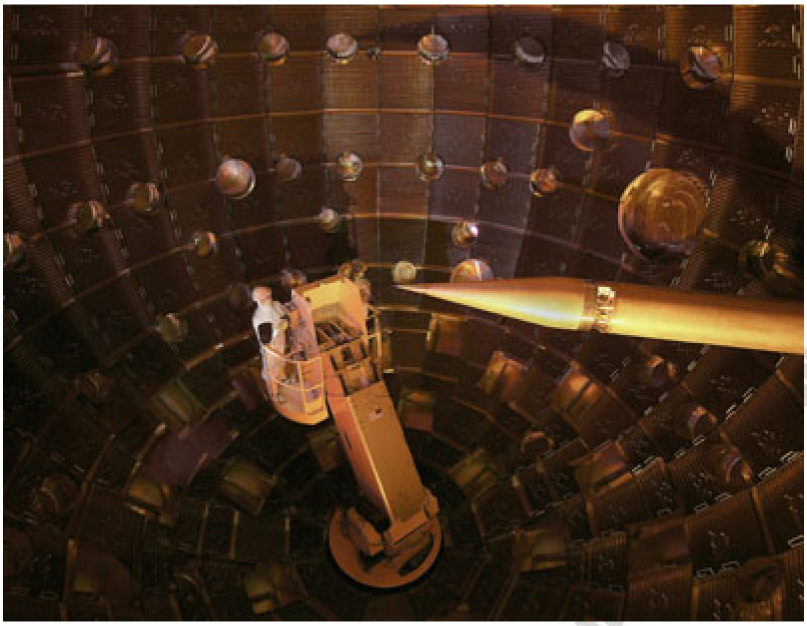
On target, finally

A machine for testing nuclear weapons opens for business.



What do you get when you focus 192 lasers onto a pellet the size of a match head and press the "fire" button? The answer, hope physicists at the National Ignition Facility (NIF) in Livermore, California, is: the most powerful machine on the planet. The NIF, which is scheduled to go into operation on May 29th, is designed to create conditions like those found in stars—and also in the explosions of hydrogen bombs. To do that requires, for the brief instants when it is operating at full tilt (a total of three thousandths of a second a year), that it has a power of 500 trillion watts, about 3,000 times the average electricity consumption of the whole of planet Earth.

The pellets at which this energy is directed are made of frozen hydrogen. The aim is to make those pellets undergo nuclear fusion—the process that causes stars to shine and hydrogen bombs to explode. Although the justification for building the NIF has changed over the years (originally there was talk of it being a prototype for fusion-based power stations), it is the resemblance to bombs which has saved the project from the budgetary chop. For the NIF provides America with a way to carry out nuclear-weapons tests without actually testing any weapons.

Had the NIF been a purely scientific project, it would almost certainly have been cancelled. It has cost $4 billion so far, almost four times the original estimate, and is running more than five years behind schedule. Construction started in May 1997 but the initial design proved impractical and was sent back to the drawing board. In 2000 the Department of Energy, which is responsible for the Lawrence Livermore National Laboratory, the NIF's host, altered the design and revised its budget and deadlines. And in July 2005 Congress actually voted to suspend construction of the machine—relenting only when extra money was found to compensate for cost overruns that had threatened to penalise the work of two other energy-department laboratories that drew their cash from the same pot.

Testing, testing

What ultimately saved the NIF from cancellation was that its backers persuaded politicians it was vital to the "stockpile stewardship" programme for America's nuclear bombs. Although America has not ratified the Comprehensive Test-Ban Treaty, it suspended the testing of its nuclear weapons in 1992. Instead of weapons development, nuclear-weapons scientists are now engaged in a programme intended to ensure that the country's existing warheads will continue to function predictably as they age. This work uses "subcritical" tests that do not involve full nuclear detonations, and computer simulations of how a weapon would explode.

Such simulations are all well and good, but they must, from time to time, be tested against the real world. That is where the NIF comes in. It will, if it works, create real nuclear explosions, not subcritical phuts. These explosions will be too small to count as nuclear tests within the meaning of the treaty (which America tries to abide by, even though it has not signed). They will, however, be big enough to yield information useful to nuclear-weapons scientists.

Each laser pulse will begin as a weak infra-red beam. This is split into 48 daughter beams that are then fed into preamplifiers which increase their power 20 billion times. Each of the daughters is split further, into four, and passed repeatedly through the main amplifiers. These increase the beams' power 15,000 times and push their wavelengths into the ultraviolet.

The pellet itself contains a sphere of deuterium (a heavy form of hydrogen, with nuclei consisting of a proton and a neutron) and tritium (even heavier hydrogen, with a proton and two neutrons) that is chilled to just a degree or so above absolute zero. The beams should compress the sphere so rapidly that it implodes, squeezing deuterium and tritium nuclei together until they overcome their mutual repulsion and fuse to form helium (two protons and two neutrons) together with a surplus neutron and a lot of heat. If enough heat is generated it will sustain the process of fusion without laser input, until most of the nuclear fuel has been used up.

Physicists hope that in the coming year or so the NIF will become the first machine to achieve a nuclear-fusion reaction that produces more energy than it takes to ignite, albeit for only a fraction of a second. Sceptics reckon that the machine may not be capable of such a feat. Creating a sustained nuclear-fusion reaction that could generate power is the goal of another mammoth experiment, the International Experimental Thermonuclear Reactor, which is being built in Cadarache, France. Plenty of people are sceptical about the likely success of that project, too. Like the NIF, it appears to be slipping behind schedule. Full experiments to test nuclear fusion as a power source seem likely to be delayed until 2025.

If the NIF does work, the bomb-scientists will be ecstatic. Astrophysicists will be pretty pleased, too. Although they will get only about 200 of the annual budget of between 700 and 1,000 runs, they will be able to use their time on the machine to simulate the interiors of giant planets, stars and exploding supernovae, by varying the compositions of the pellets to match what they think those things are made of. Bombs or no bombs, astronomy will start to move from being an observational to an experimental science. At a mere $140m a year, then, the NIF is a snip.

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