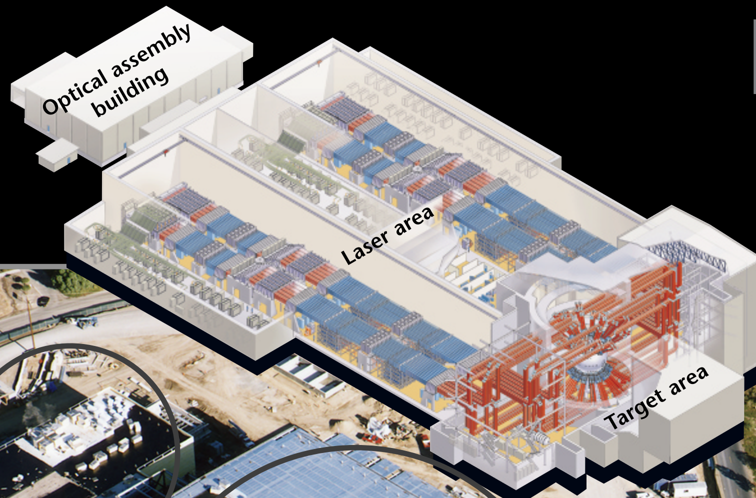
NOVEMBER 1998 UPDATE



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Optics Assembly and Laser Buildings interior installations of the ceilings and under floor ductwork; Target Area Building next level concrete floor and wall; cooling tower base with final laser building steel erection/roofing in place.

NIF top-level performance requirements were driven by inertial confinement fusion ignition mission (x-ray drive)

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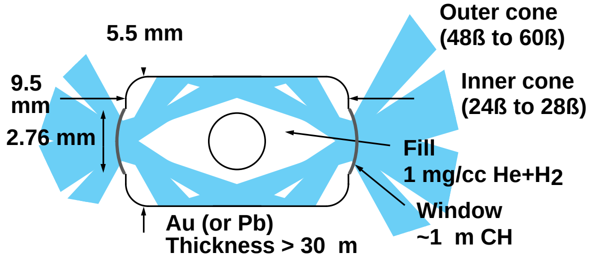
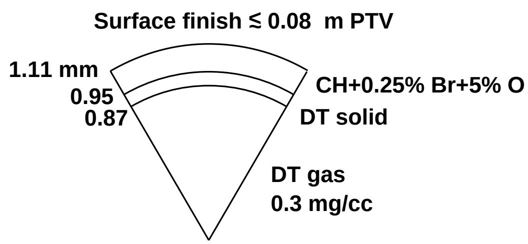
Pulse energy (on target)	1.8 MJ
Peak power	500 TW
Wavelength	0.35 μm
Pulse shaping	Flexible (dynamic range >50)
Power balance	<8%$_{rms}$ over 2 ns
Pointing accuracy	<50 μm
ICF target type	Cryogenic and non-cryogenic
Annual fusion yield compatibility (indirect and direct drive)	50 shots with yield 20 MJ 1200 MJ/y annual yield
Maximum credible DT fusion yield	45 MJ
Classification level of experiments	Classified & unclassified

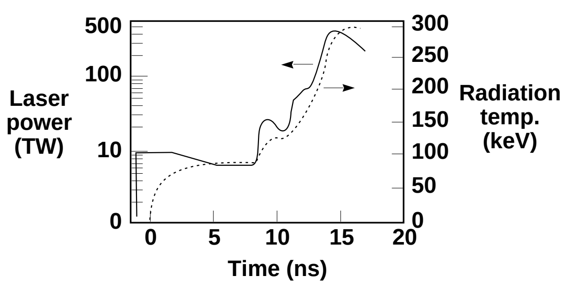
NIF will be a low-hazard, radiological facility

NIF baseline target designs

Indirect Drive

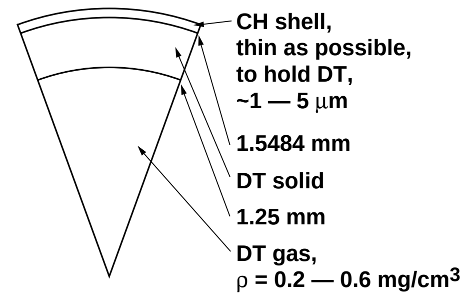


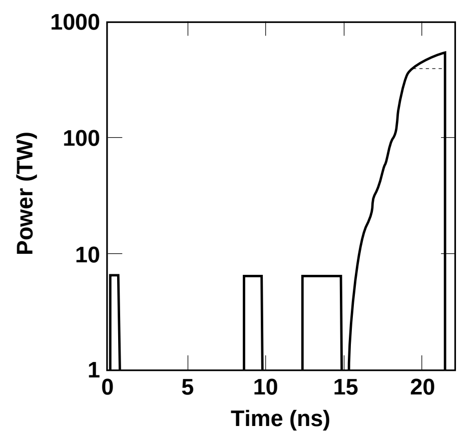




Laser energy = 1.35 MJ
Capsule absorbed energy = 0.15 MJ
Capsule yield = 15 MJ

Direct Drive





Other designs exist with thick CH
or DT-wetted foam ablators

A large number of Target designs calculate to ignite and burn

There are five critical science issues in the design of a high-gain pellet

1. Demonstration of sufficient coupling of the driver energy into the target; $I \sim 10^{14}$–10^{15} W/cm^2

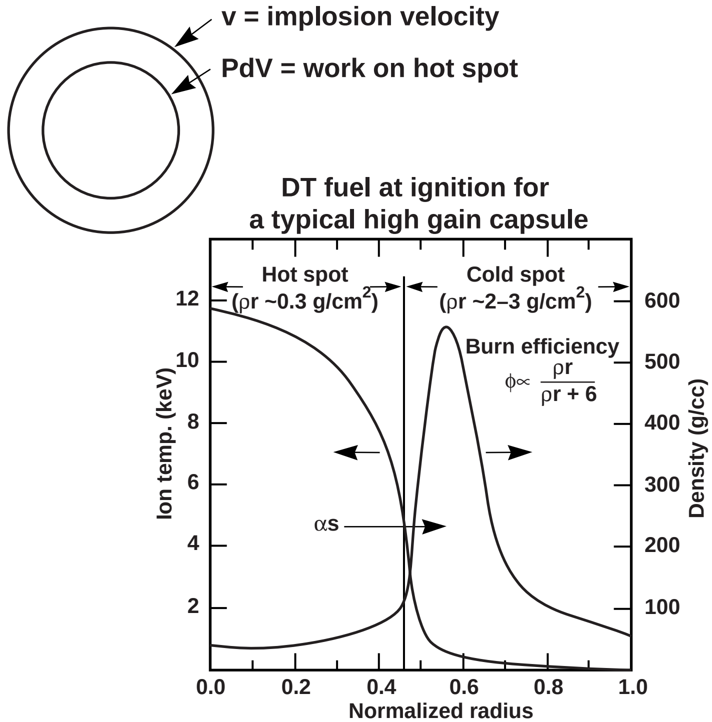
2. Keeping the fuel on a sufficiently low adiabat; $\alpha = 1$–3; gain $\sim \frac{1}{\alpha}$

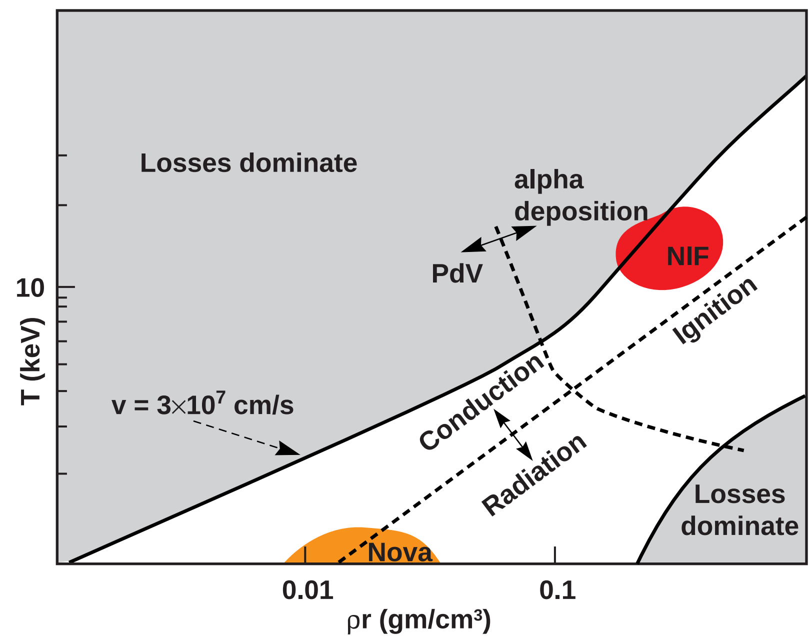
3. Demonstrating sufficient implosion symmetry; 1–2% uniformity for convergence 30–40

4. Demonstrating sufficient target stability; < 6–7 e–foldings $\Rightarrow$ $\frac{R}{\Delta R} < 30$–50

5. Getting a sufficiently large hot spot to achieve ignition and propagating burn; $\rho r_{hot\ spot} \sim 0.3$ g/cm^3 at 10 keV

The increased energy of NIF allows a large enough fuel-areal density for fusion ignition and "propagating burn"





Ignition requires local alpha deposition > local losses (heat conduction & radiation)

	ρr (gm/cm²)	Gain = E_{TN}/E_{laser}
Nova	0.02	0.001
NIF	~1	~10–30

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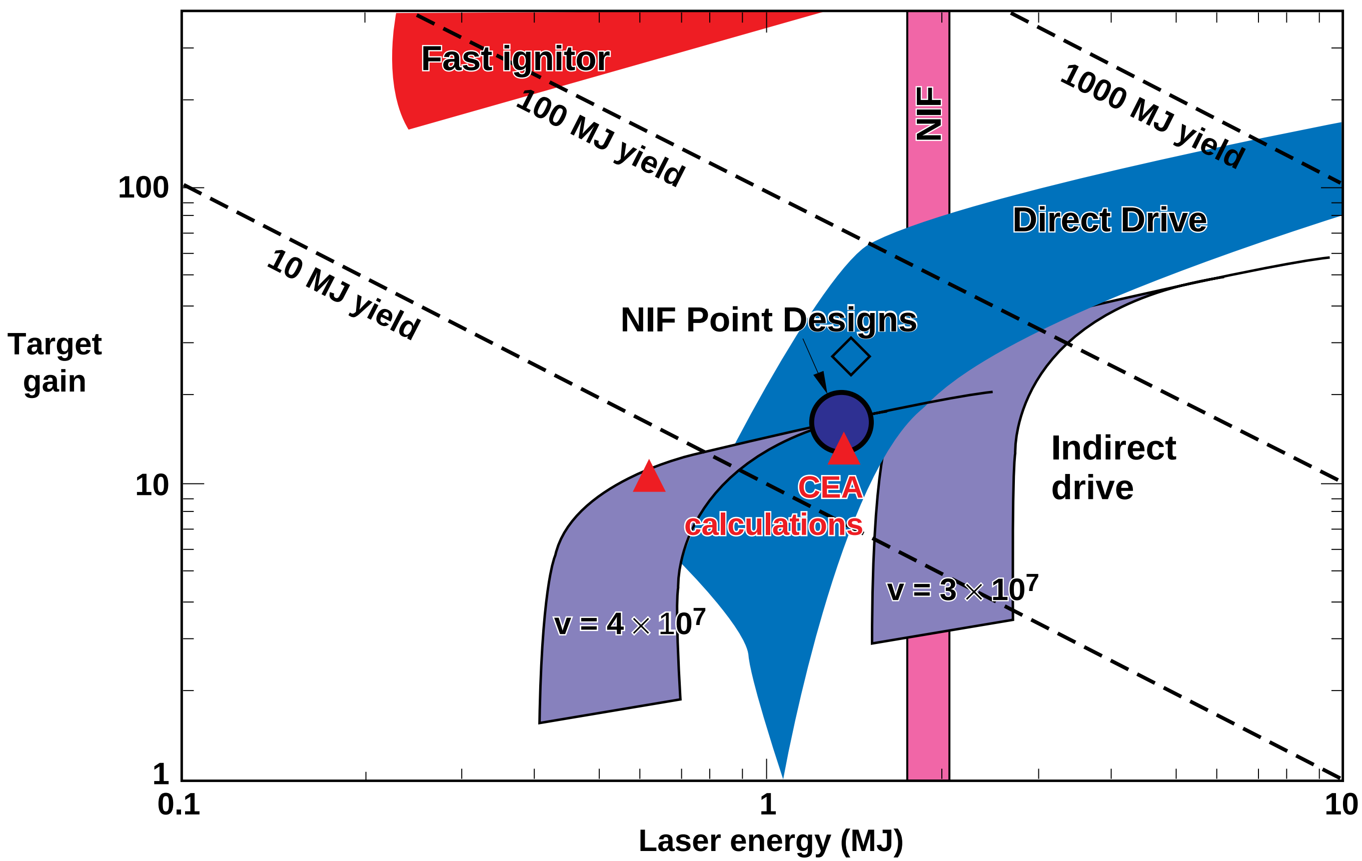
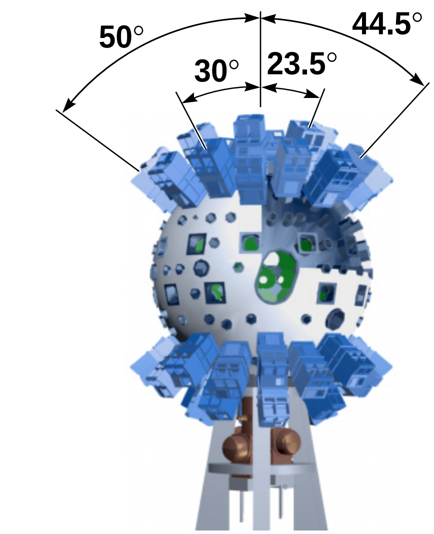
28JDK/cld

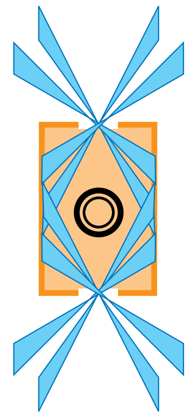
The next step in the development of ICF is to experimentally map out the ignition and gain curves for multiple target concepts and demonstrate the scientific feasibility of laboratory scale ICF



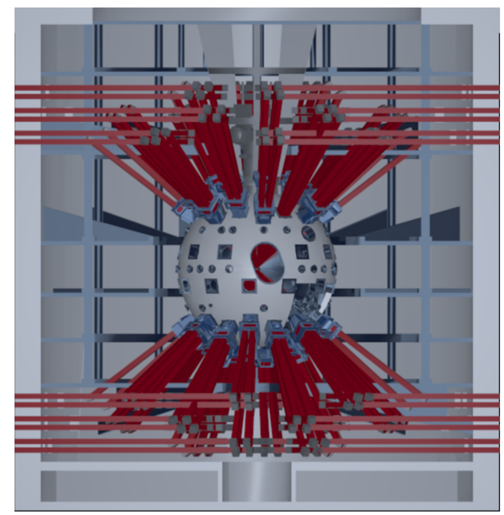
The demonstration of ignition was recommended by NAS, FPAC, ICFAC, and JASONs

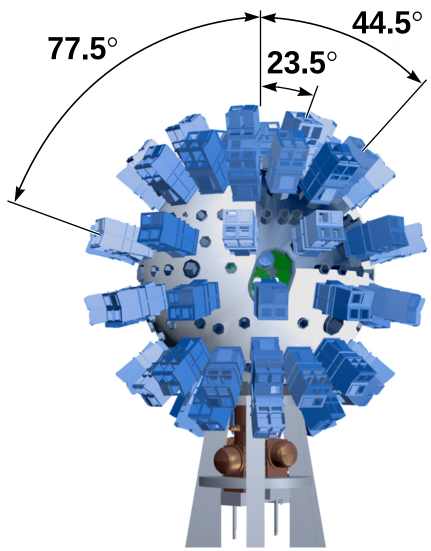
Indirect and direct-drive target illumination geometries can be accommodated by the NIF design

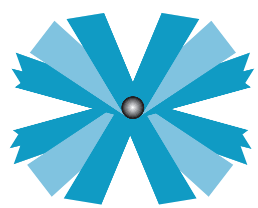




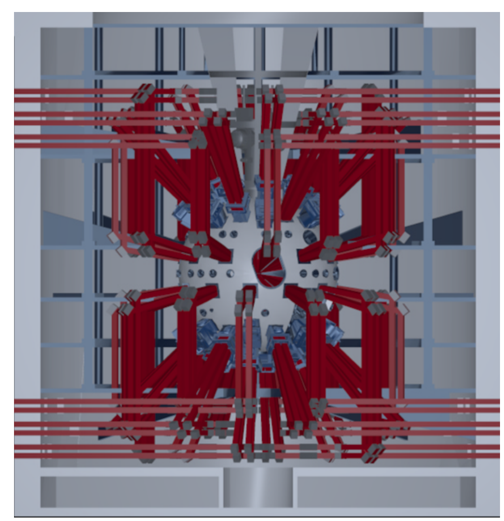
Indirect drive







Direct drive



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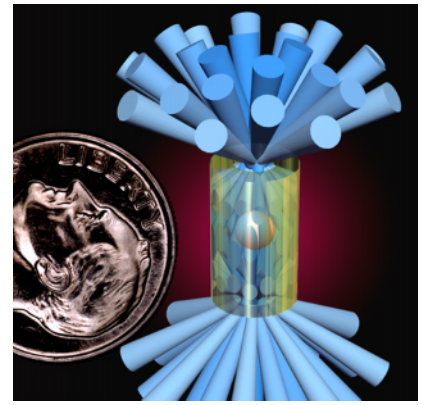
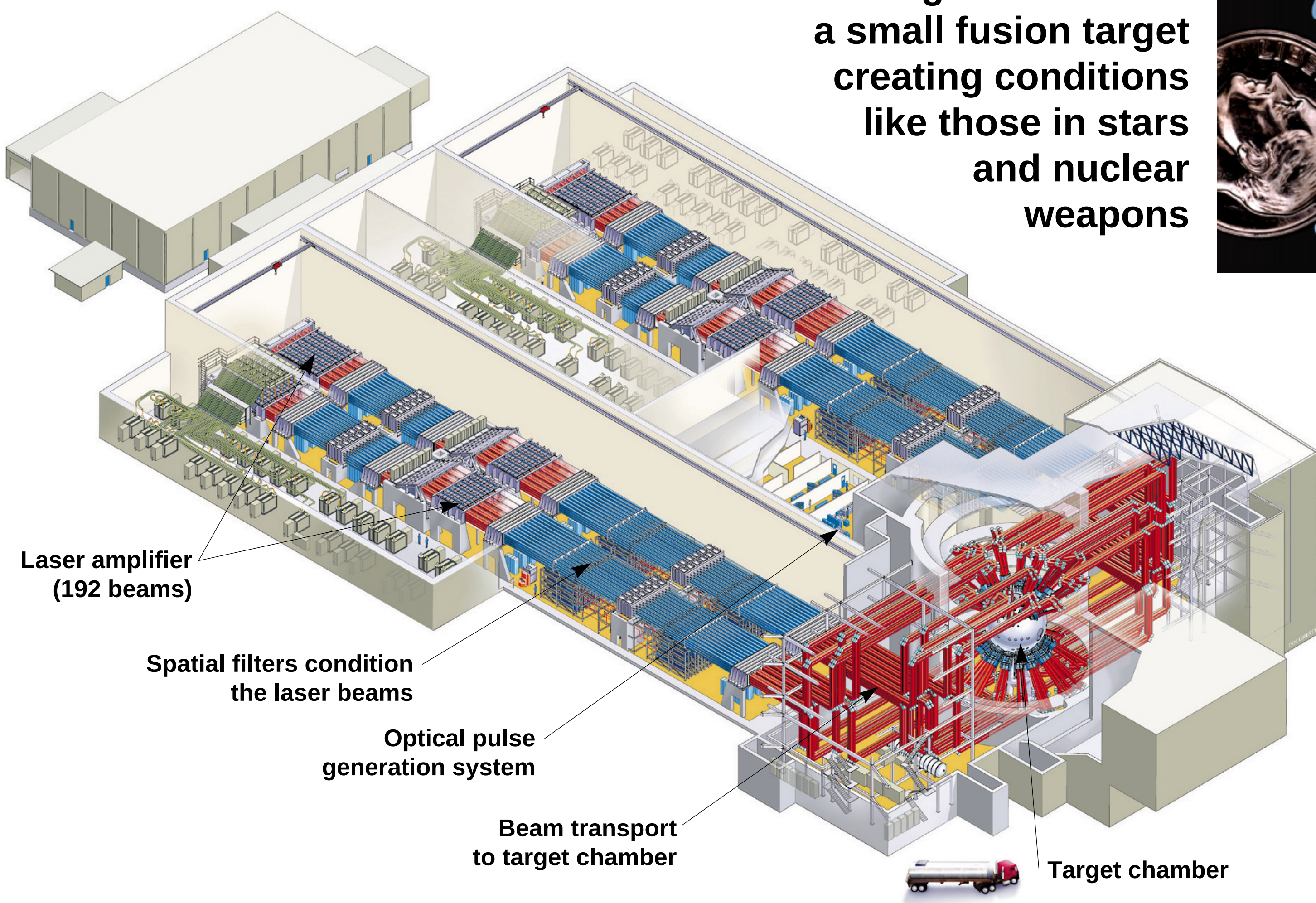
Low-hazard, radiological facility

The goal of the NIF is to ignite and burn a small fusion target creating conditions like those in stars and nuclear weapons





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03GAD/dougherty

Two 20,000 sq. ft. optical factories will be constructed to meet the NIF large aperture optical finishing demands

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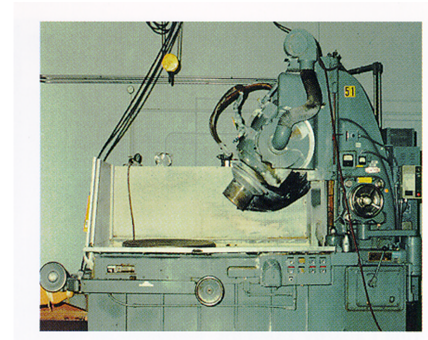
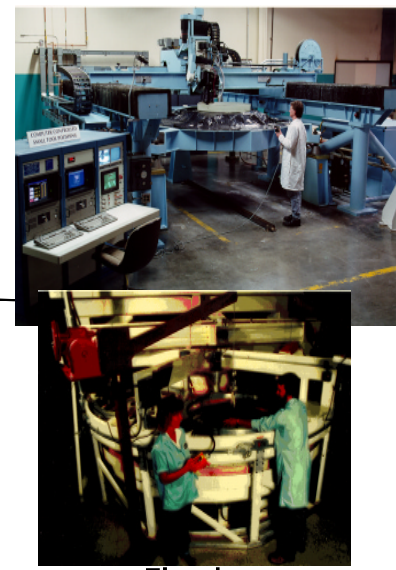
Raw material

Shaping (size)
Cladding

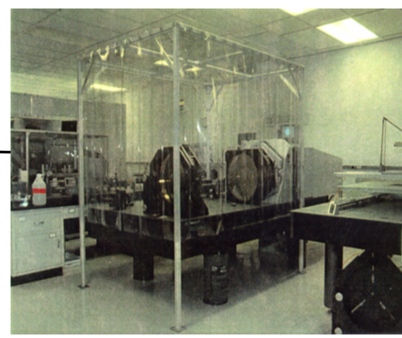


Fixed Abrasive
Grinding
(wedge, thickness,
curvature)

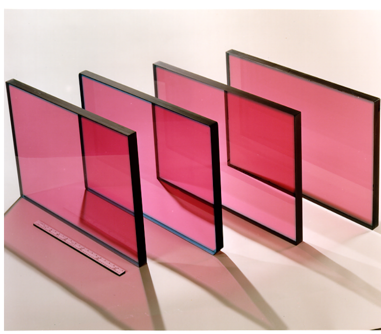
Lapping & Polishing
(sub-surface damage,
figure to 1µm
Roughness to <50nm RMS)



Figuring
(Figure to $\lambda/6$,
Roughness to 0.6nm)



Metrology
(verify figure,
ripple, roughness)



Polished
Surfaces

The size, quality, number and cost of optics needed for NIF presents a manufacturing challenge

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- **Number of optical components**
  - Approximately **7500** meter-scale optics and **30,000** smaller optical components
- **Specifications**
  - Damage thresholds about 3-5× higher than Nova
  - High optical homogeneity and surface finish (< λ/100 P-V)
- **Production schedule**
  - Installation begins in FY00 and extends through FY03
  - Current capacity of U.S. optics industry is limited to ~200 meter-scale optics/year (about 10× too low!)
- **Cost**
  - NIF optics **cost goals are about 3× lower** than Nova
  - Standard manufacturing technologies cannot meet these cost goals

NIF laser technology developments will make the diode pumped solid state laser more credible as an IFE driver

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- Improved optical damage threshold (x3 compared to Nova)
- Stable diode-pumped optical pulse generation system
- Modular 40 cm aperture plasma electrode pockels cell (PEPC) switch
- Improved driver efficiency (x10 compared to Nova)
- Fast growth of KDP crystals
- Fast, lower-cost optical manufacturing processes

NIF ignition experiments will further IFE development

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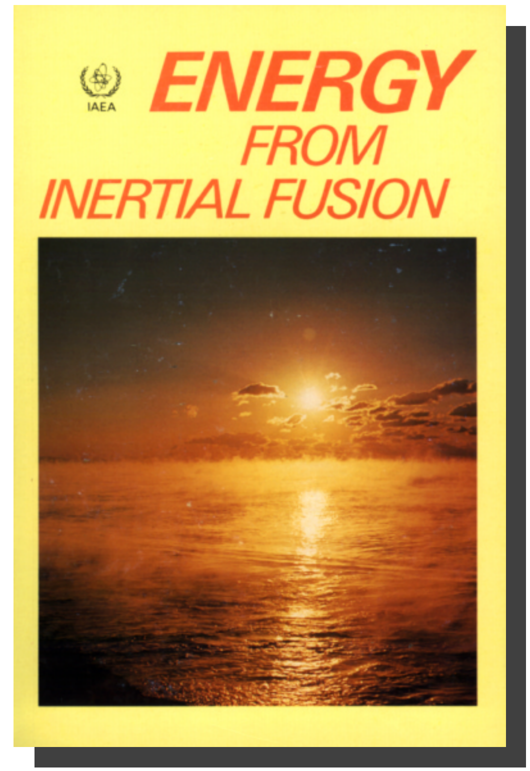
- Target performance vs. target fabrication specifications
- Isochoric heating of liquid curtains to determine droplet size spectra
- Target performance vs. beam pointing and power balance specifications
- Upgrades may allow igniting targets "on the fly" and a short series of pulses

The International Atomic Energy Agency's "Energy from Inertial Fusion" describes several inertial fusion power plant designs with attractive safety and environmental features

Topics include:
- Inertial fusion energy fundamentals
- Inertial confinement target physics
- IFE power plant design principles
- Special design issues
- Inertial fusion energy development strategy
- Safety and environmental impact
- Economics and other figures of merit
- Other uses of inertial fusion
- International activities



Sales and Promotion Unit
International Atomic Energy Agency
Wagramerstrasse 5
P.O. Box 100, A-1400 Vienna, Austria
Telephone: (43) 1 2360-2529/2530
Fax: (43) 1 209 5302

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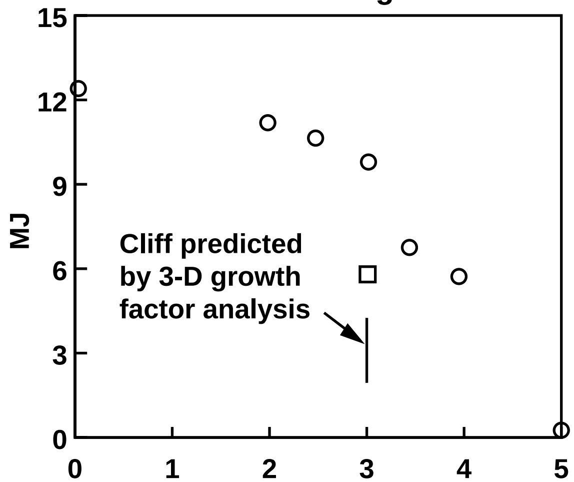
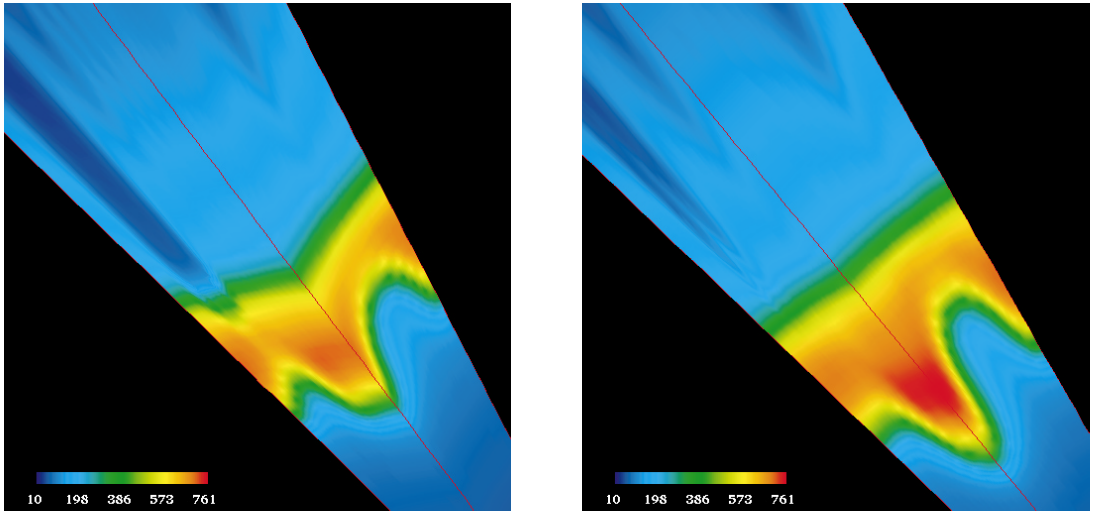
1320 Austrian schillings
Publication date: early 1995

One of the goals of NIF is to understand and quantify sensitivity of ignition/gain to experimental parameters

Yield vs. ice roughness



Simulation includes modes l = 15–120
Two views of density at ignition time



Initial roughnesses: ablator 21 nm p-v, ice 1.3 μm p-v, yield 15.5 MJ
Target fails to ignite if perturbations scaled larger by ×1.7

Encouraging progress at Hoya and Schott in FY96 supports the viability of continuous melting of laser glass for NIF

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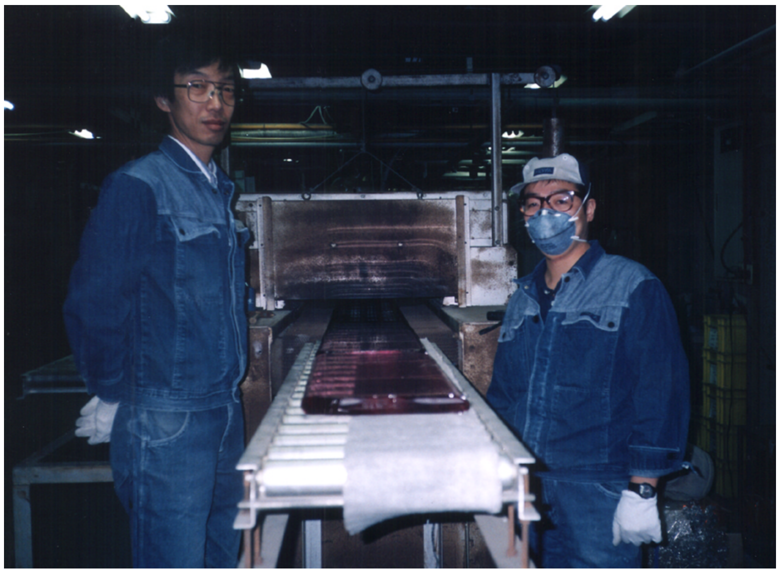
Hoya

Laser glass melter
Half-scale slabs

LHG-8

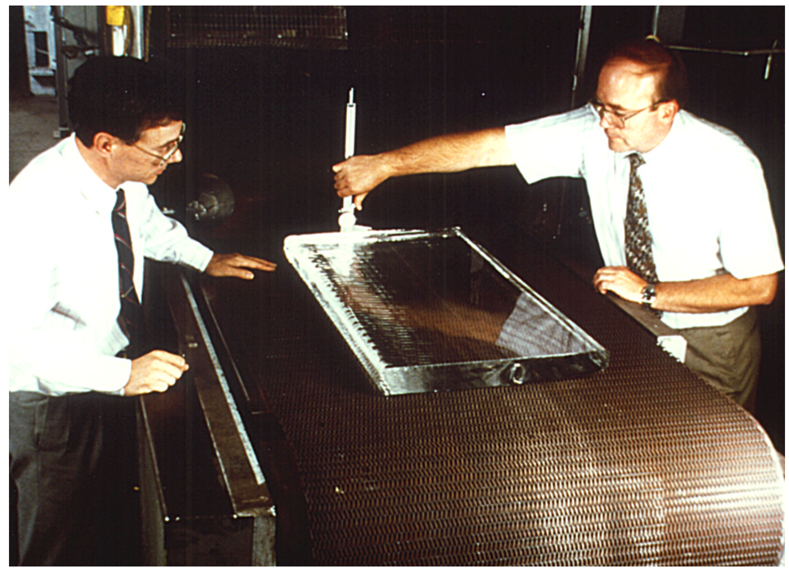


- **Laser glass met all NIF specifications except homogeneity (only 2× higher)**

Schott

BK-7 melter
Full-size slabs

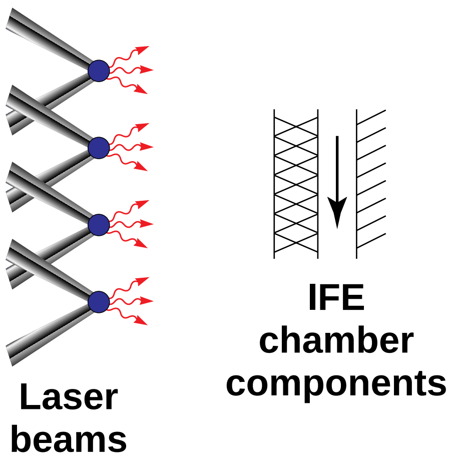
BK-7 (laser glass analog)

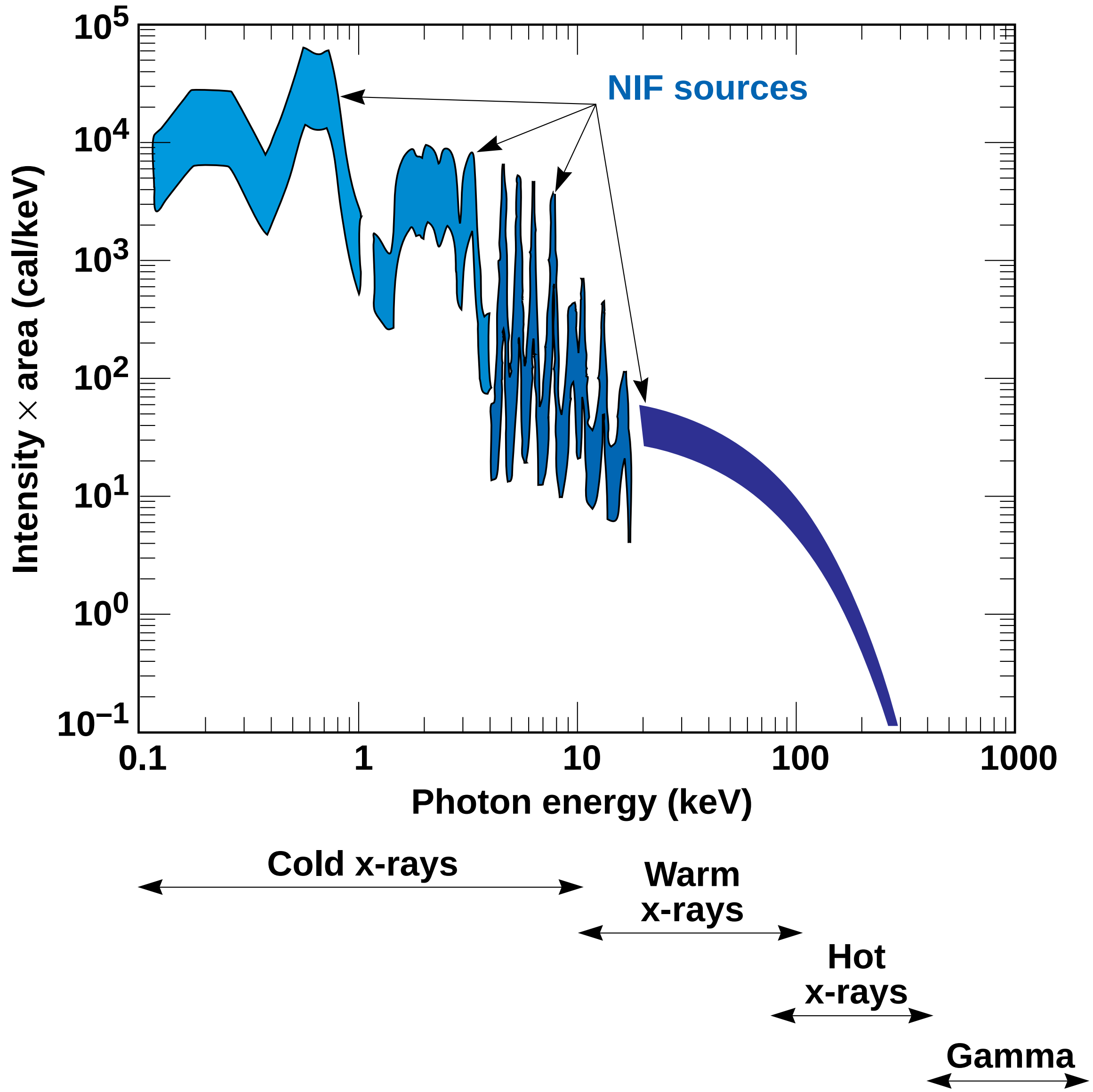


- **BK-7 met all NIF optical specifications**

The NIF, even without ignition, will allow testing of IFE chamber components

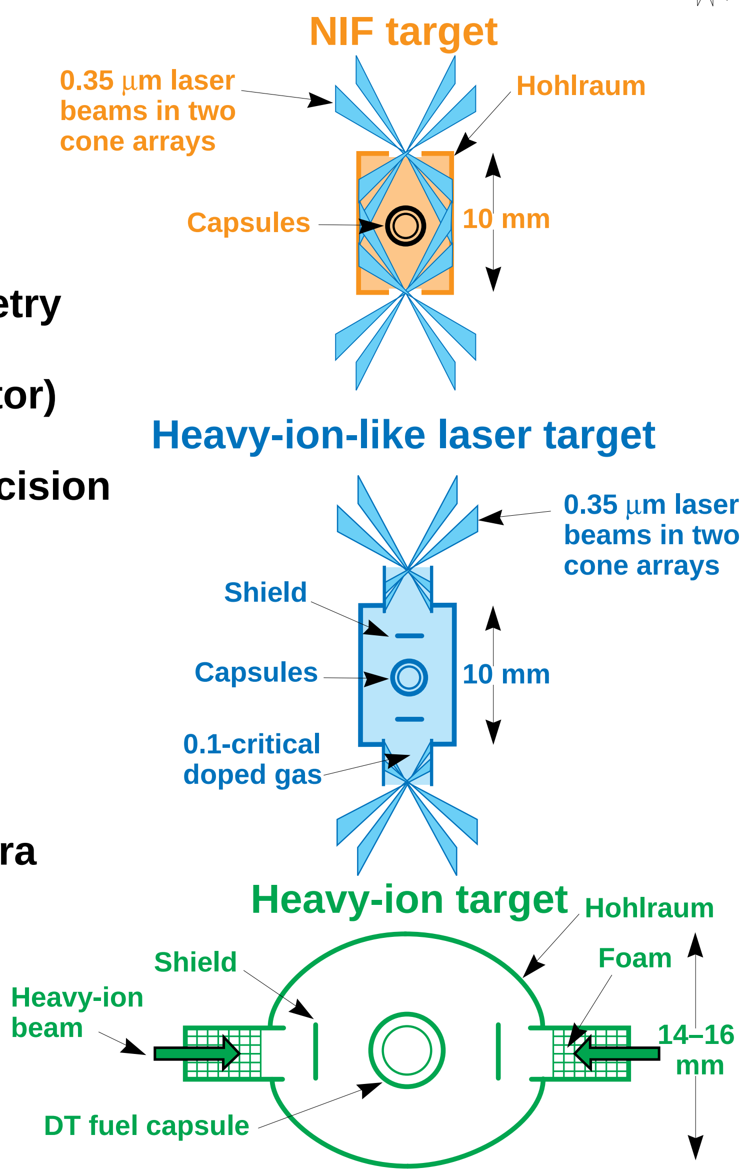
Low density gas bags heated by NIF lasers





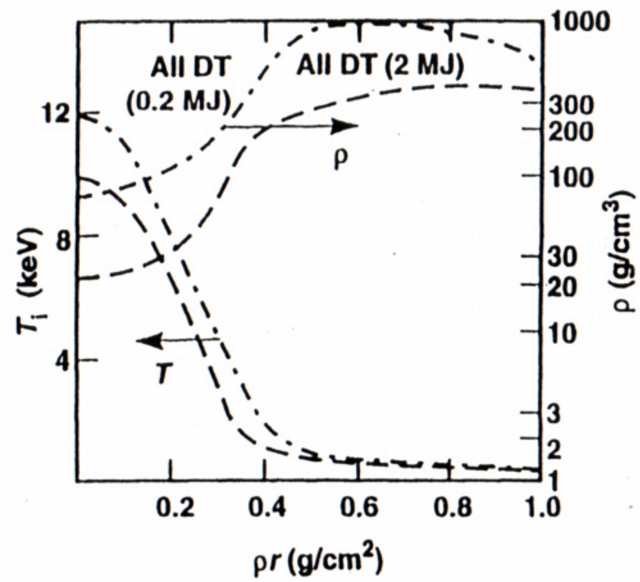
Target physics will be one of the most significant IFE achievements of NIF

- Usability of a variety of pulse shapes
- Radiation flow, illumination geometry, and internal pulse shaping
- Sensitivity of capsules to radiation asymmetry
- Materials issues (capsules, hohlraum, ablator)
- Required fabrication surface finish and precision
- Effects of capsule mounting and injection on performance
- Driver peak power vs. energy tradeoffs (driver cost vs. target performance)
- Feasibility of modifying target output spectra
- Feasibility of reduced tritium designs
- Feasibility of advanced targets

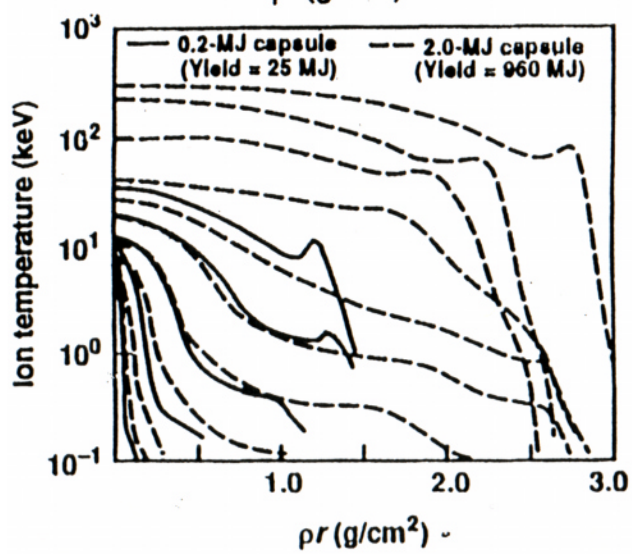


Burn propagation issues for high-gain capsules will be settled by ignition on NIF

- Ignition and high-gain capsules have the same ignition requirements



- Burn propagation for both scales track until the burn reaches the outside of the fuel



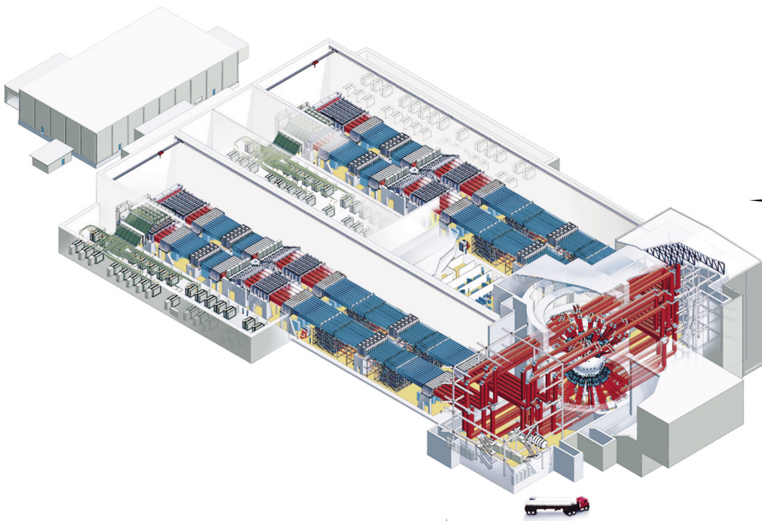
NIF will make a major impact on IFE development

- Ignition and gain curve (all target concepts)
  - — Hydro constraints (fabrication and “laser sources”)
  - — Symmetry (time dependent and time integrated)
  - — Hohlraum energetics (wall loss, rad flow, rad hydro)
  - — Validate design tools
- Target fabrication
- Optical fabrication and laser physics and technology (laser driver)
- Target chamber environment
- Operations of “reactor scale” facility

Additional fusion energy topics (e.g., “hit on the fly,” first wall physics) will be developed during facility lifetime

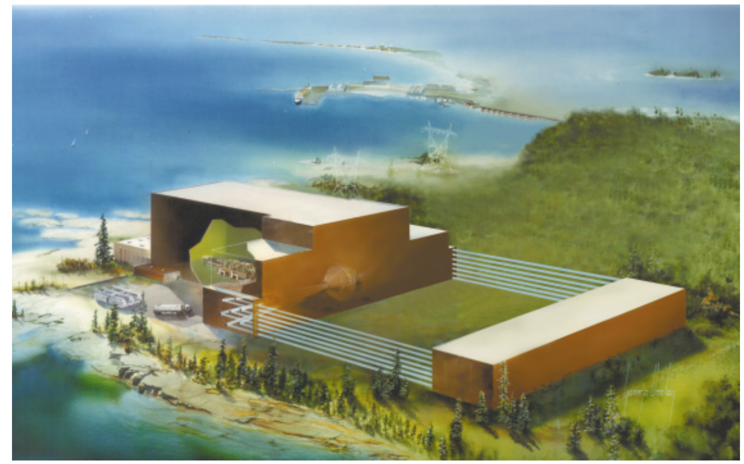
NIF will provide the basis for realistic development of inertial fusion energy

NIF



- Fusion energy > laser energy
- Target physics for all drivers
- Data on required technologies

ETF/Demonstration power plant



High gain target chamber

Small scale reactor vessel selection tests

1/3 power level

- Driver with 5–10 Hz pulse rate and > 10% efficiency
- Low power demonstrations
- High power final demo by 2025

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