



# The National Ignition Facility: Exploring ICF Burning Plasmas in the Laboratory

Presentation to  
American Association for the  
Advancement of Science

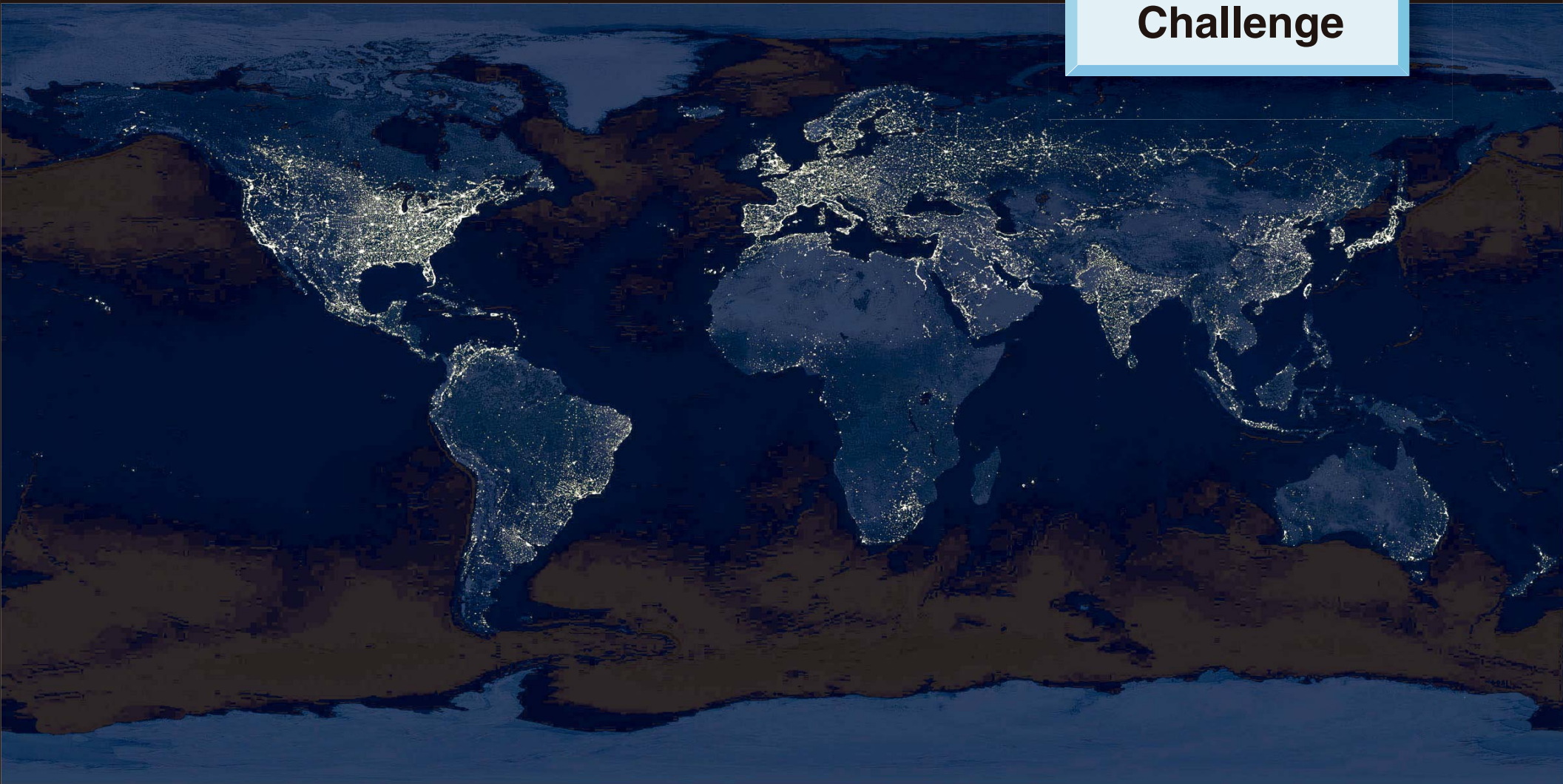
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Principal Deputy Associate Director  
Lawrence Livermore National Laboratory

February 18, 2005



**SCIENCE IN THE NATIONAL INTEREST**

# Clean Energy: Humankind's Challenge

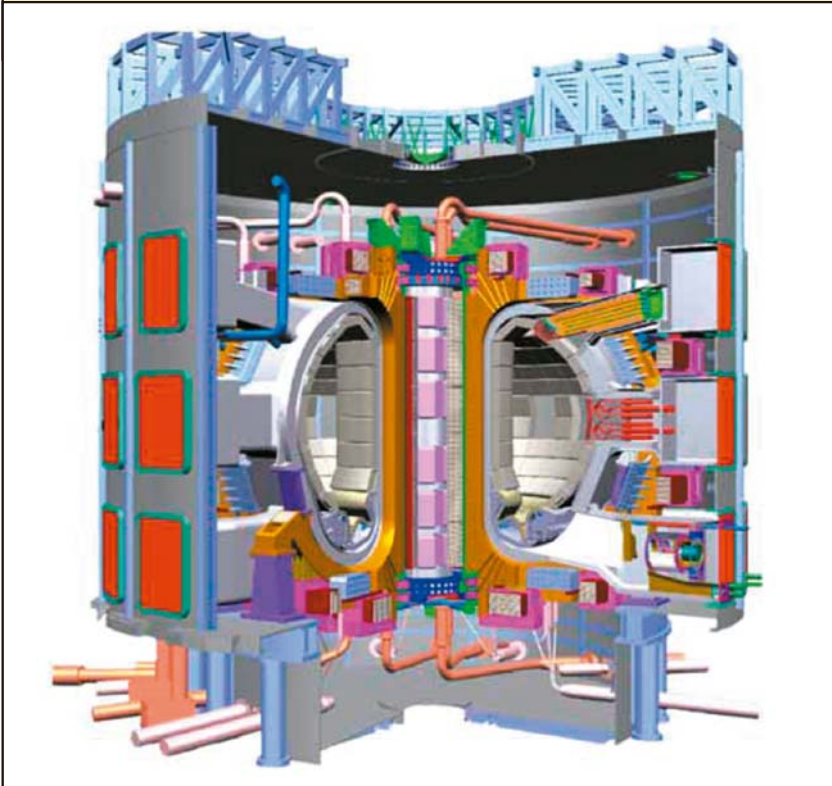


# Fusion energy may be a future energy option

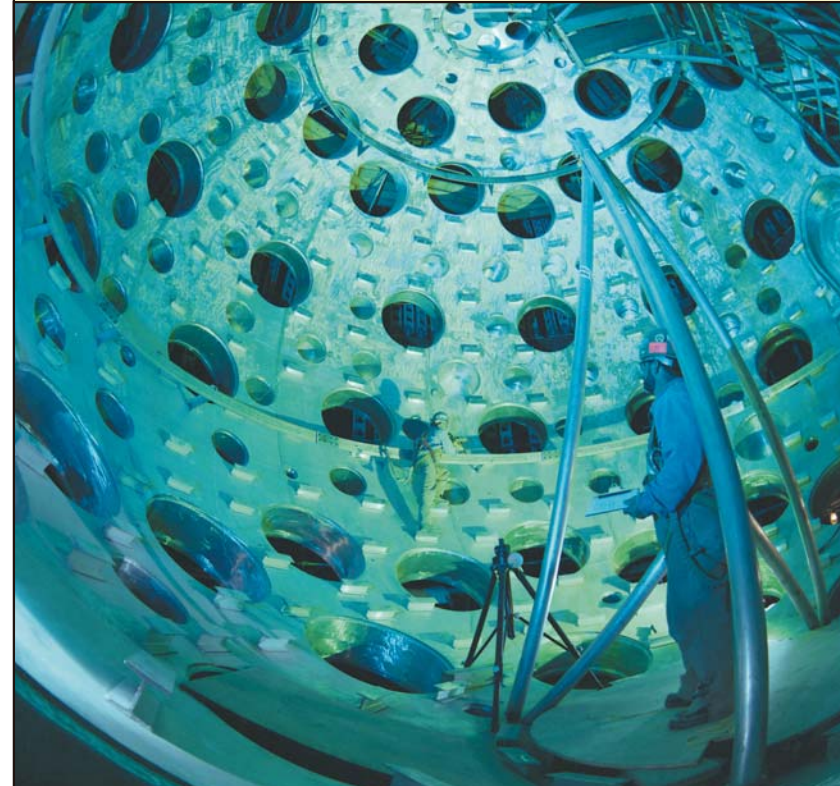


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## Magnetic Fusion Energy



## Inertial Fusion Energy



**Biggest challenge is making it safe, reliable, and cost effective**

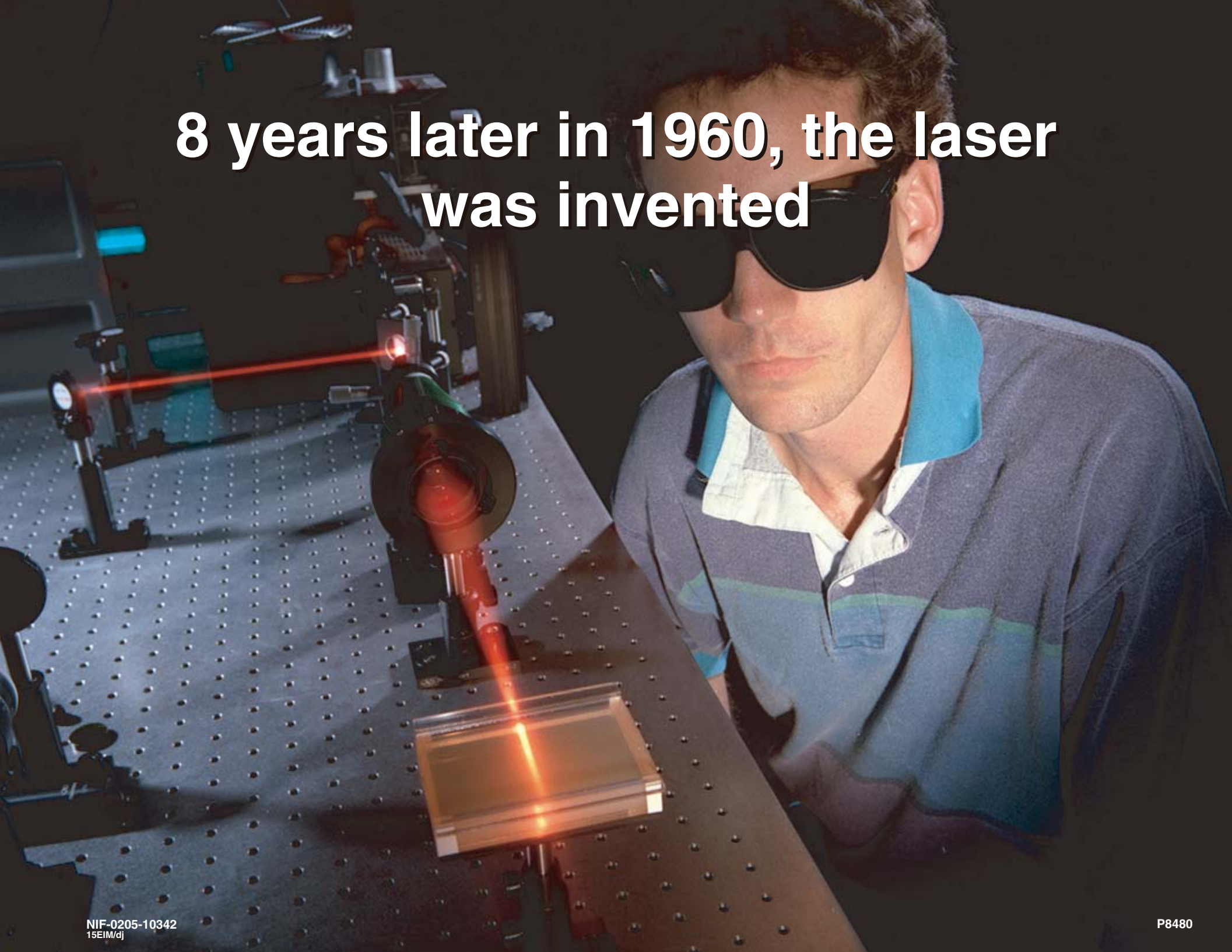


**Could we build a miniature  
sun on earth?**

**1952**



**8 years later in 1960, the laser  
was invented**





**Lawrence Livermore  
National Laboratory — 1960**

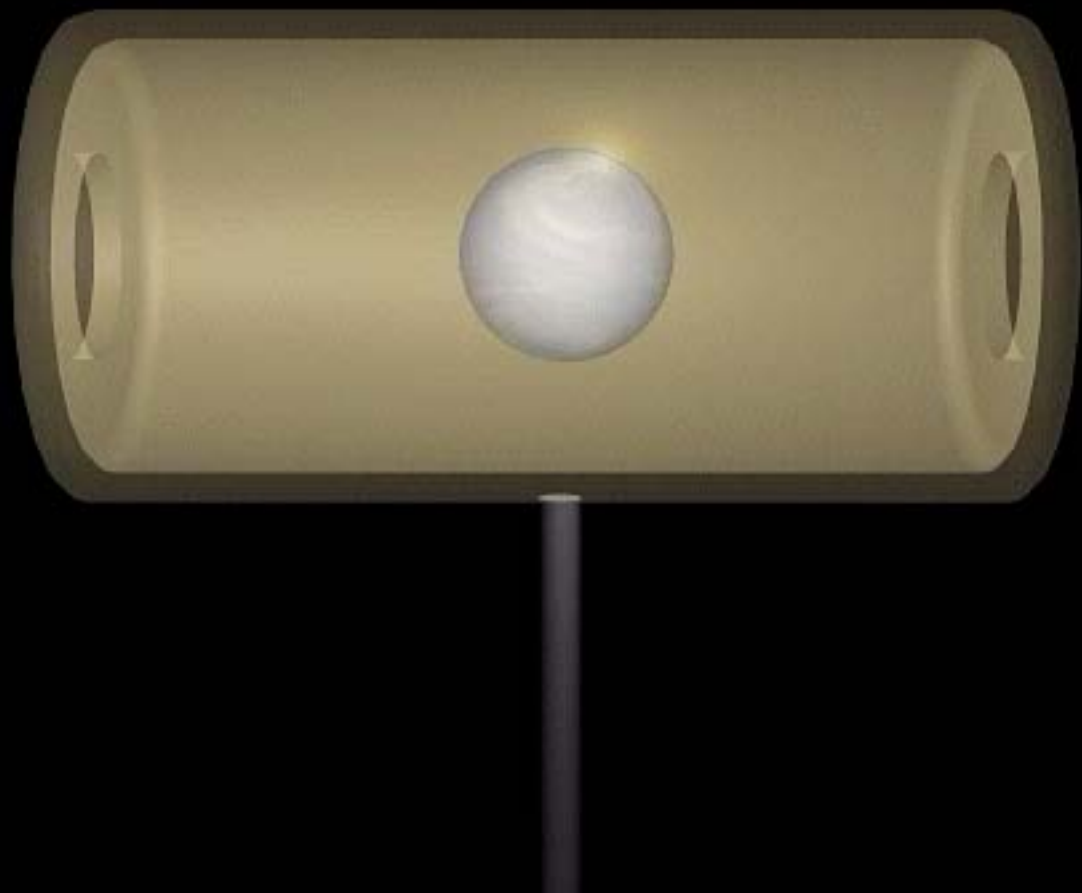
**3 days later**

**Proposal to use lasers  
for fusion energy**

A complex scientific instrument, possibly a synchrotron or X-ray source, with a central bright light source. The image shows various components, including pipes, lenses, and structural elements, illuminated by a mix of green and orange light. The central light source is very bright, creating a strong glow. The overall scene is a detailed view of a high-tech facility.

**It seems likely!**







San Francisco

LLNL



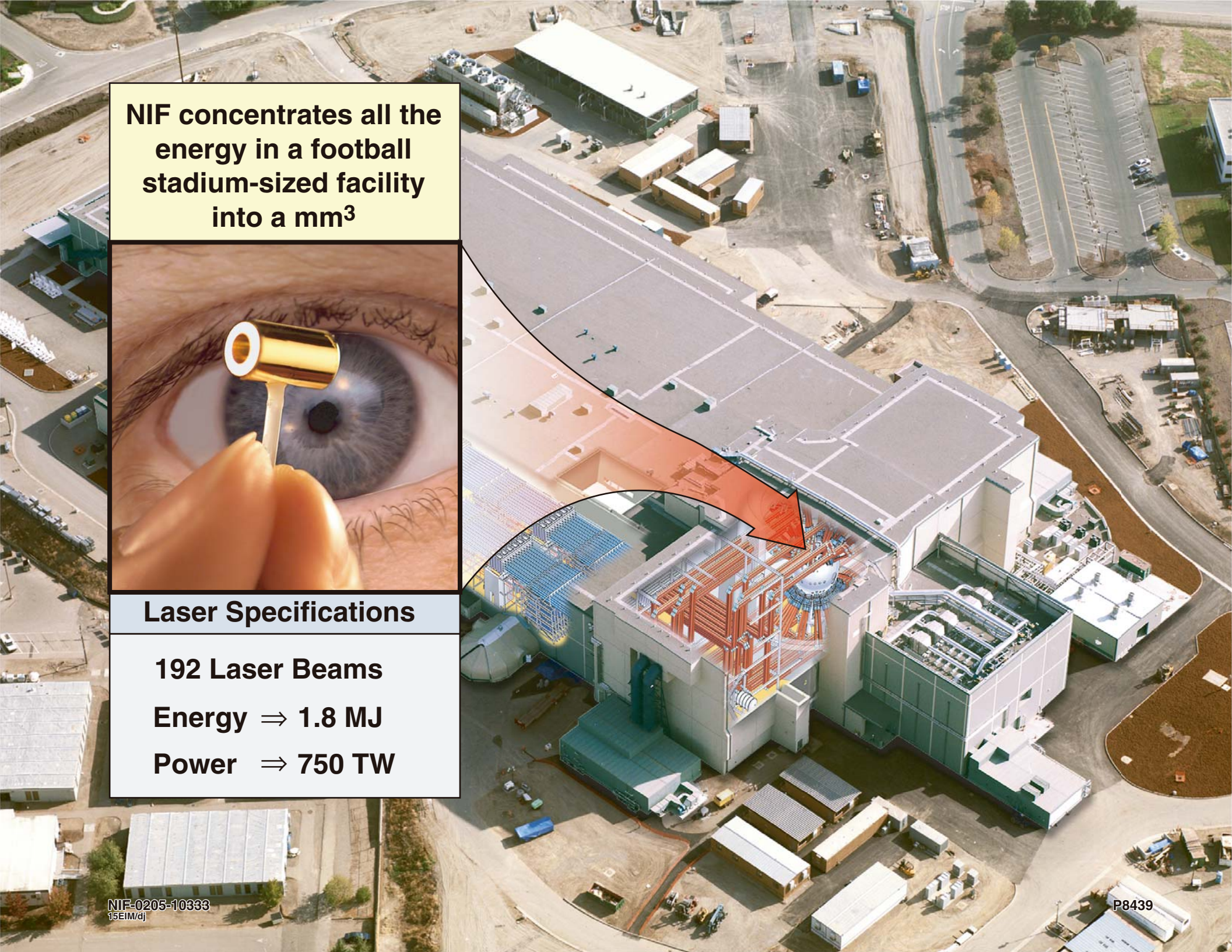
LLNL

National Ignition Facility

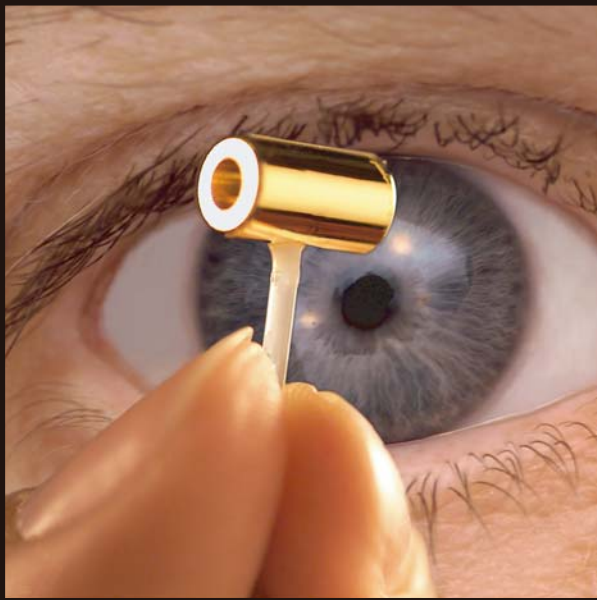








**NIF concentrates all the energy in a football stadium-sized facility into a mm<sup>3</sup>**



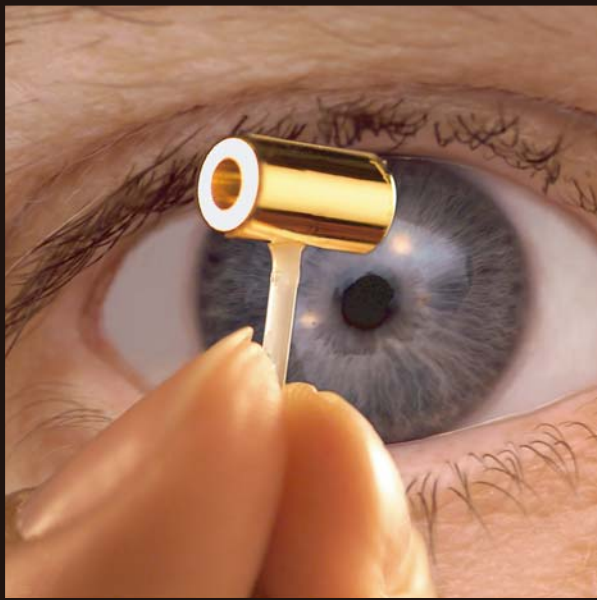
### **Laser Specifications**

**192 Laser Beams**

**Energy  $\Rightarrow$  1.8 MJ**

**Power  $\Rightarrow$  750 TW**

**NIF concentrates all the energy in a football stadium-sized facility into a mm<sup>3</sup>**



### Conditions

**Matter**

**Temperature**  $\Rightarrow >10^8$  K  
 $\sim 10$  keV

**Radiation**

**Temperature**  $\Rightarrow >3.5 \times 10^6$  K  
 $>300$  eV

**Pressures**  $\Rightarrow >10^{11}$  atm

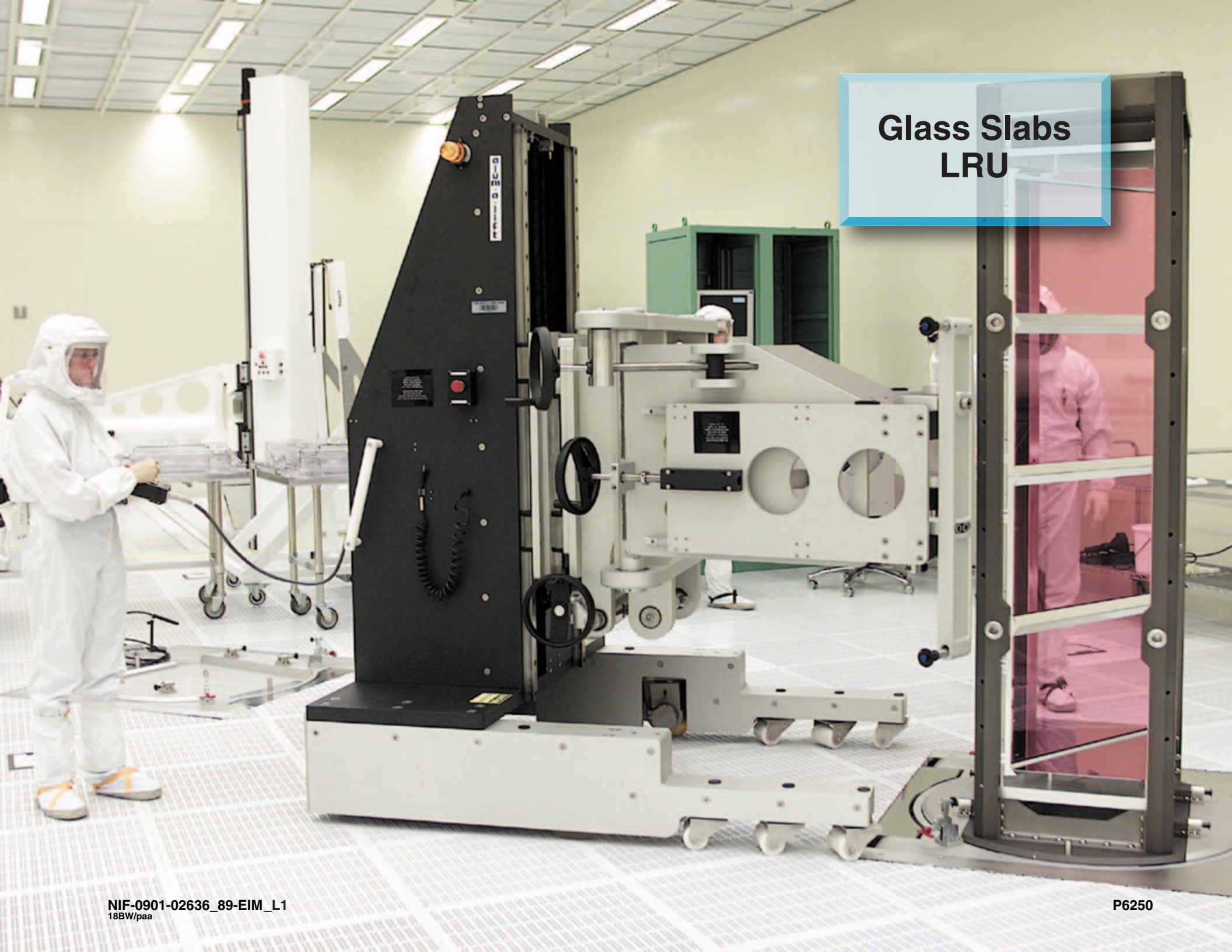




# Laser Bay 2 Flyover

## Laser Glass

# Glass Slabs LRU





## Power Amplifier

# Target Chamber



# Target Bay



## Target Chamber

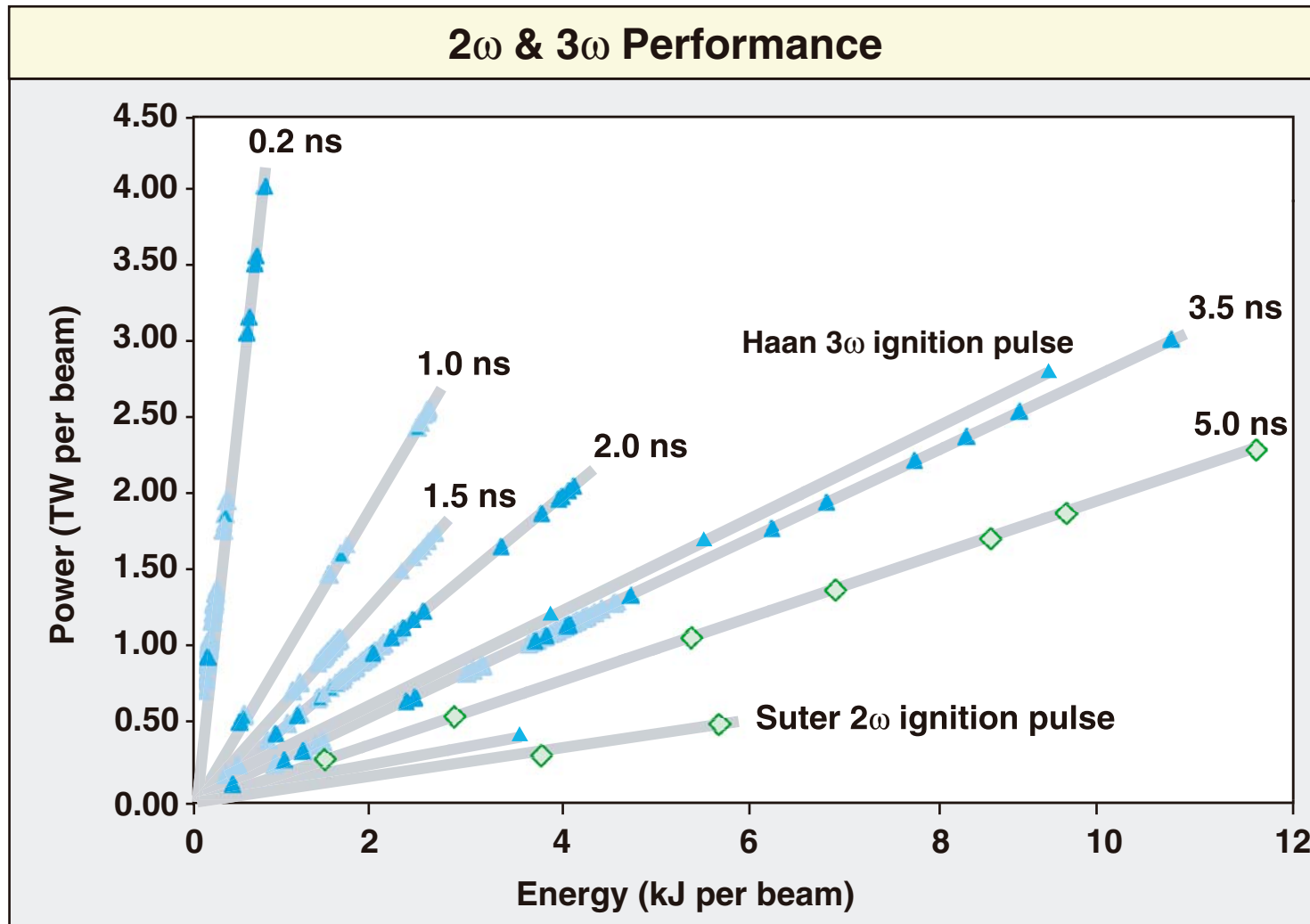
**Main Amplifier  
Flashlamp Tests  
Laser Bay 2  
July 2002**



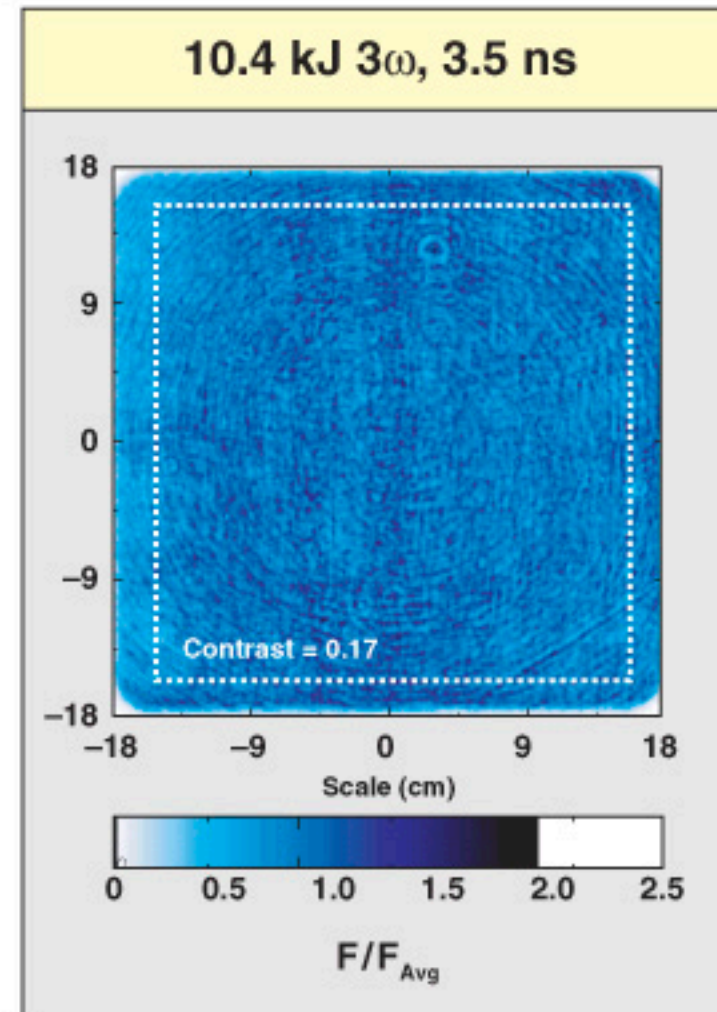
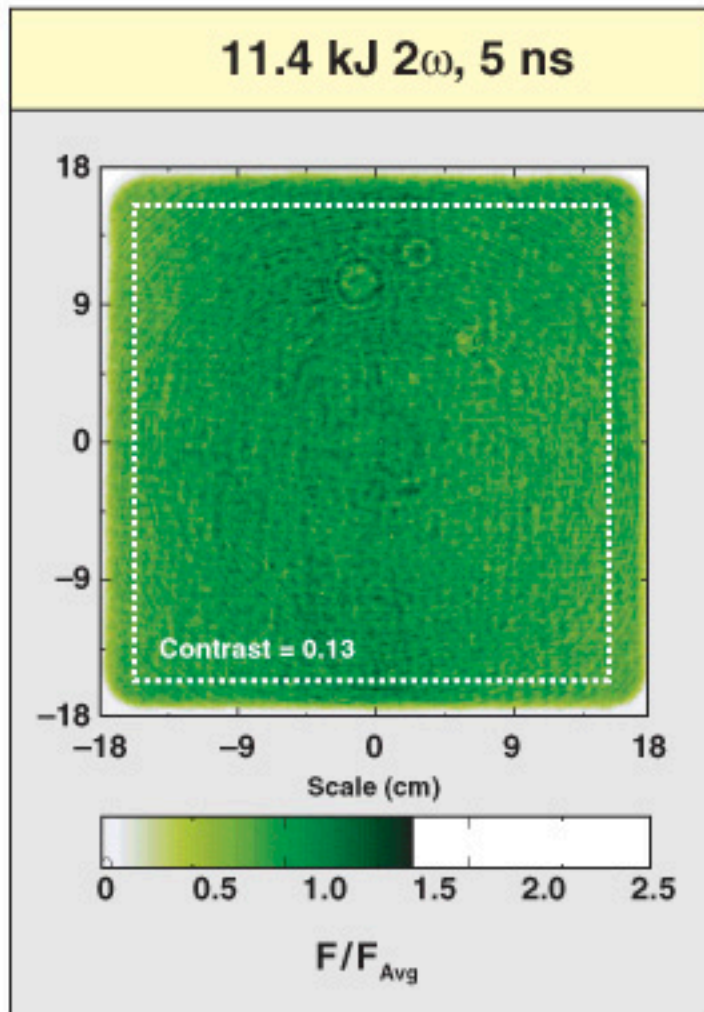
# NIF has been fired over 400 times



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# $2\omega$ and $3\omega$ beamline energies are highest ever achieved



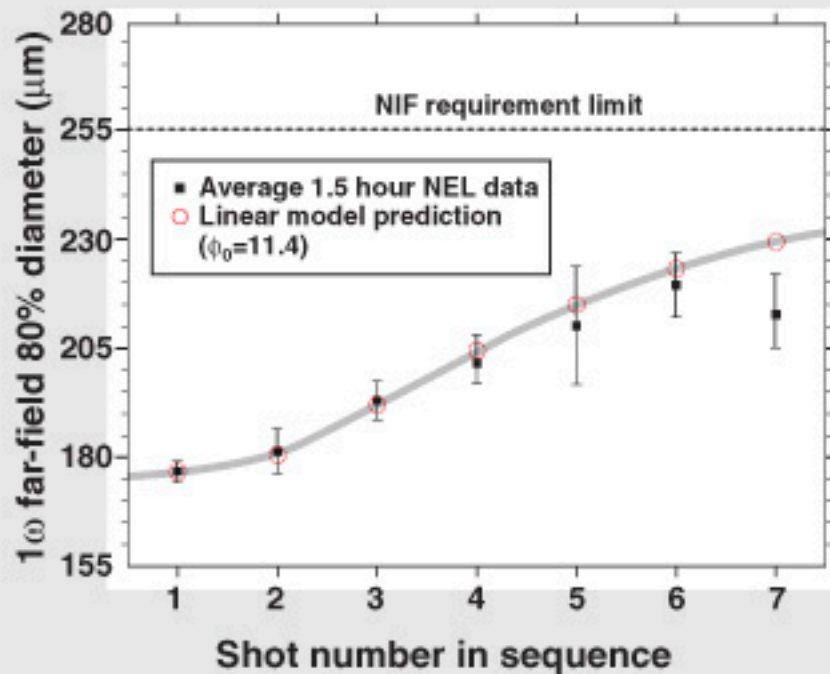
**NIF Completion Criteria as well as Functional Requirements and Primary Criteria have been demonstrated on a single beamline at  $3\omega$**

# Shot cooling periods as short as 1.5 hours have been demonstrated on NIF

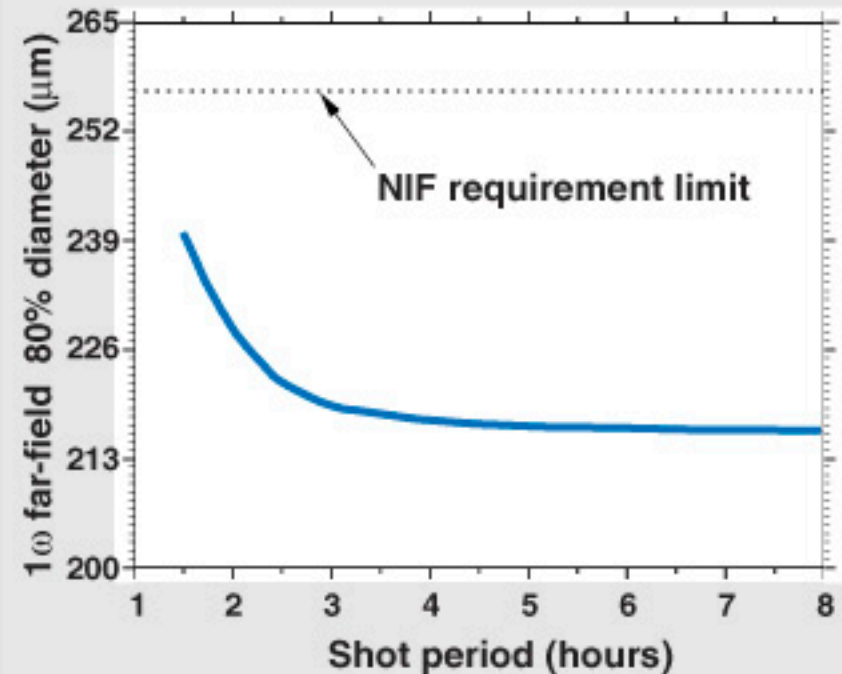


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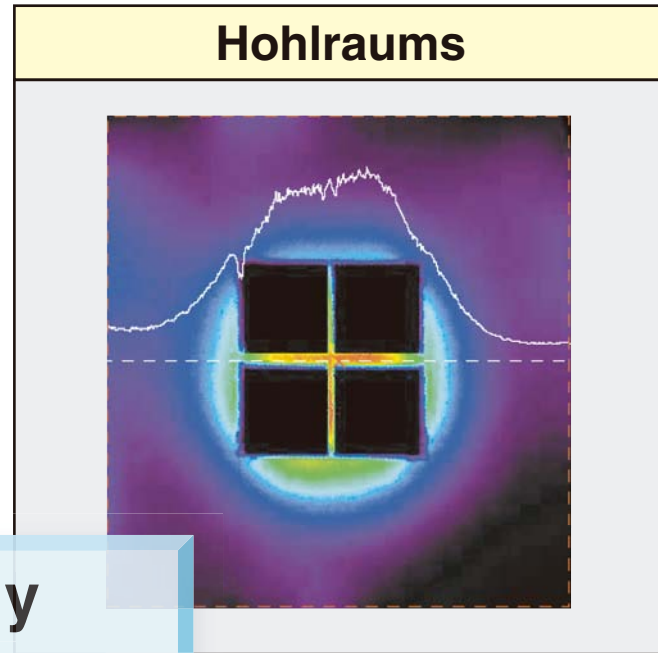
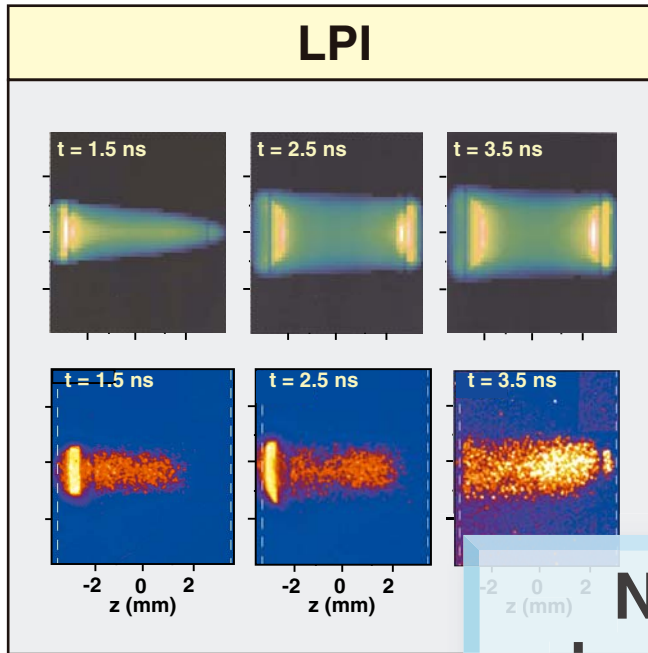
CFD Calculations Fit our Measured Focal Spot Size Data even at 1.5h Shot Rate



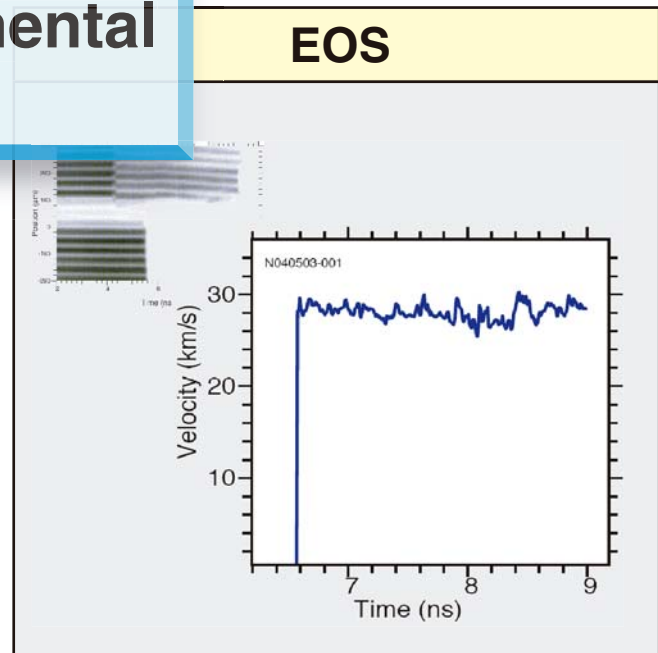
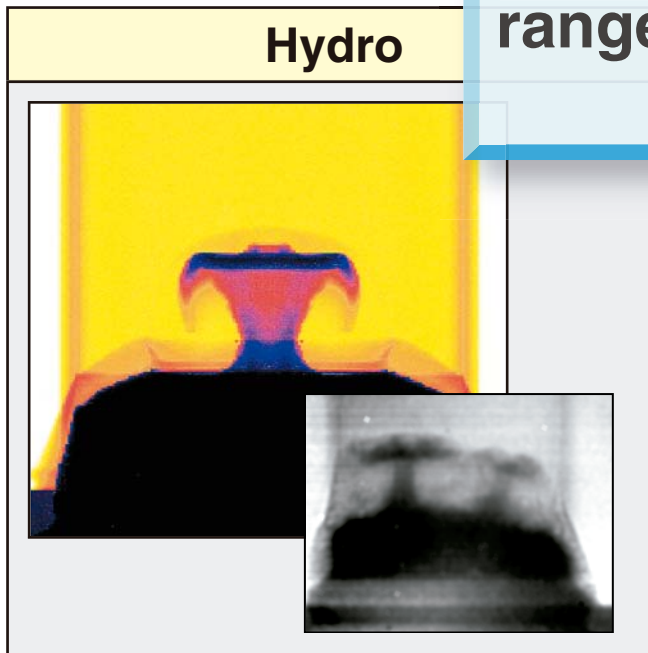
Shot Cooling Periods are Calculated to only Marginally Increase Focal Spot Size



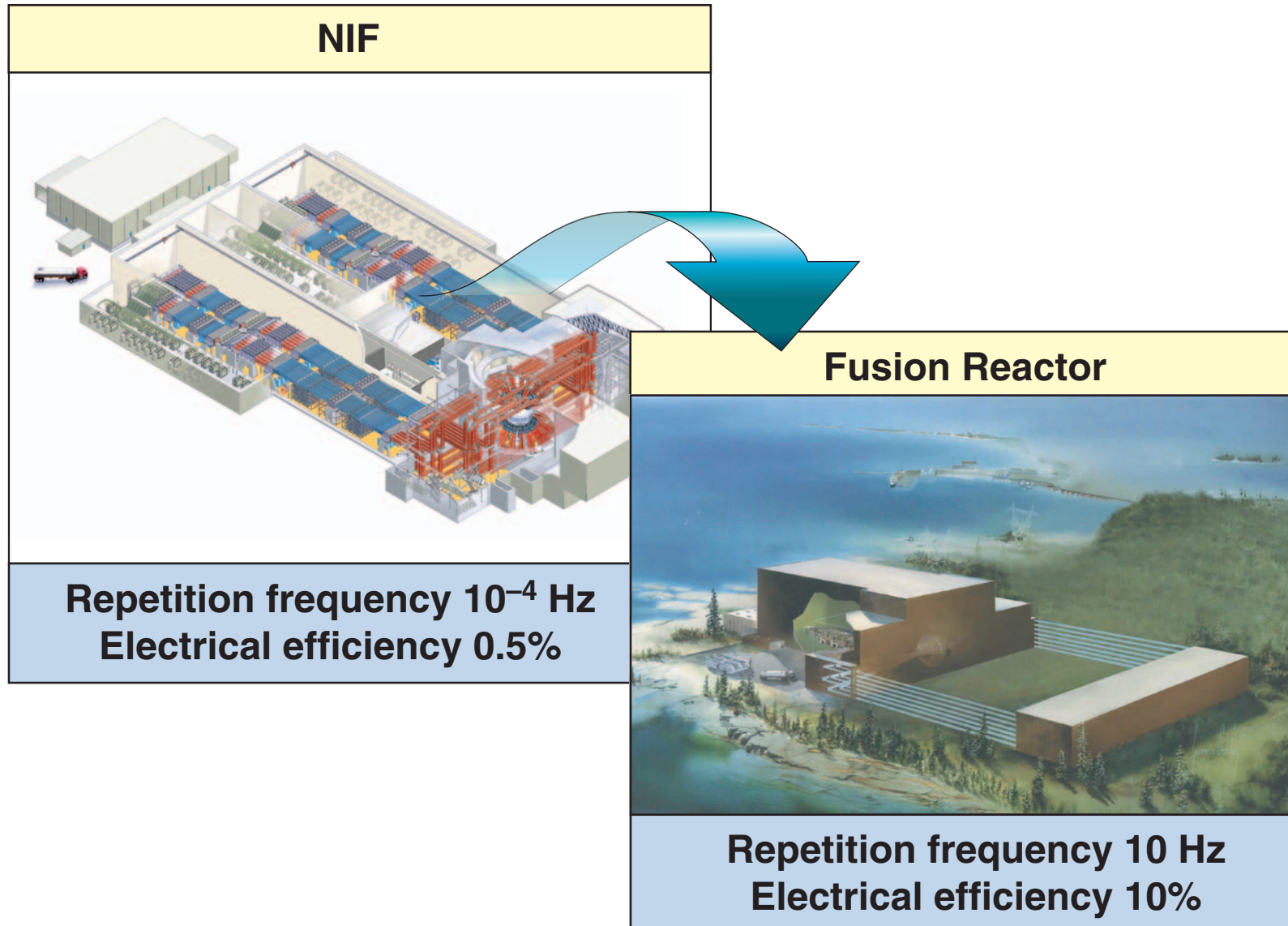
Short shot cycles appear practical even for the most demanding users



**NIF is steadily developing a large range of experimental capabilities**



# Is NIF a precursor to an IFE plant?



# NIF is about 5 orders of magnitude more energetic than its earliest predecessor



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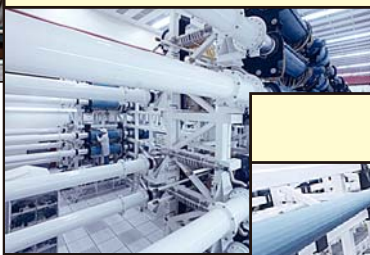
**Janus**

**100J IR**



**Shiva**

**10KJ IR**



**Nova**

**30KJ UV**



**NIF**

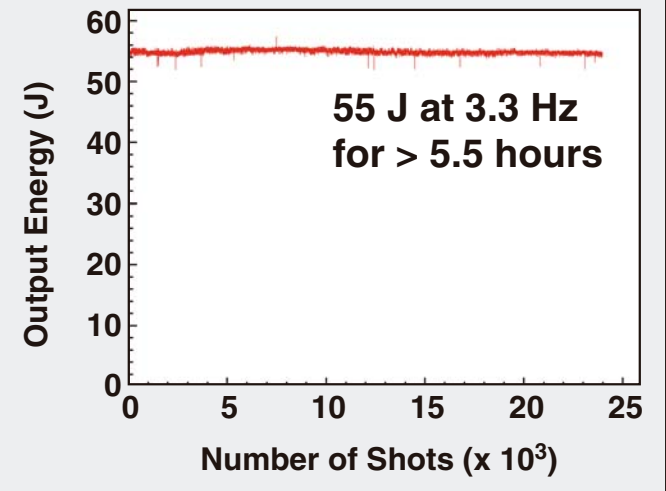
**1.8MJ UV**



**Remaining Challenge:**

- Rep rate
- Efficiency

# Mercury Laser at LLNL

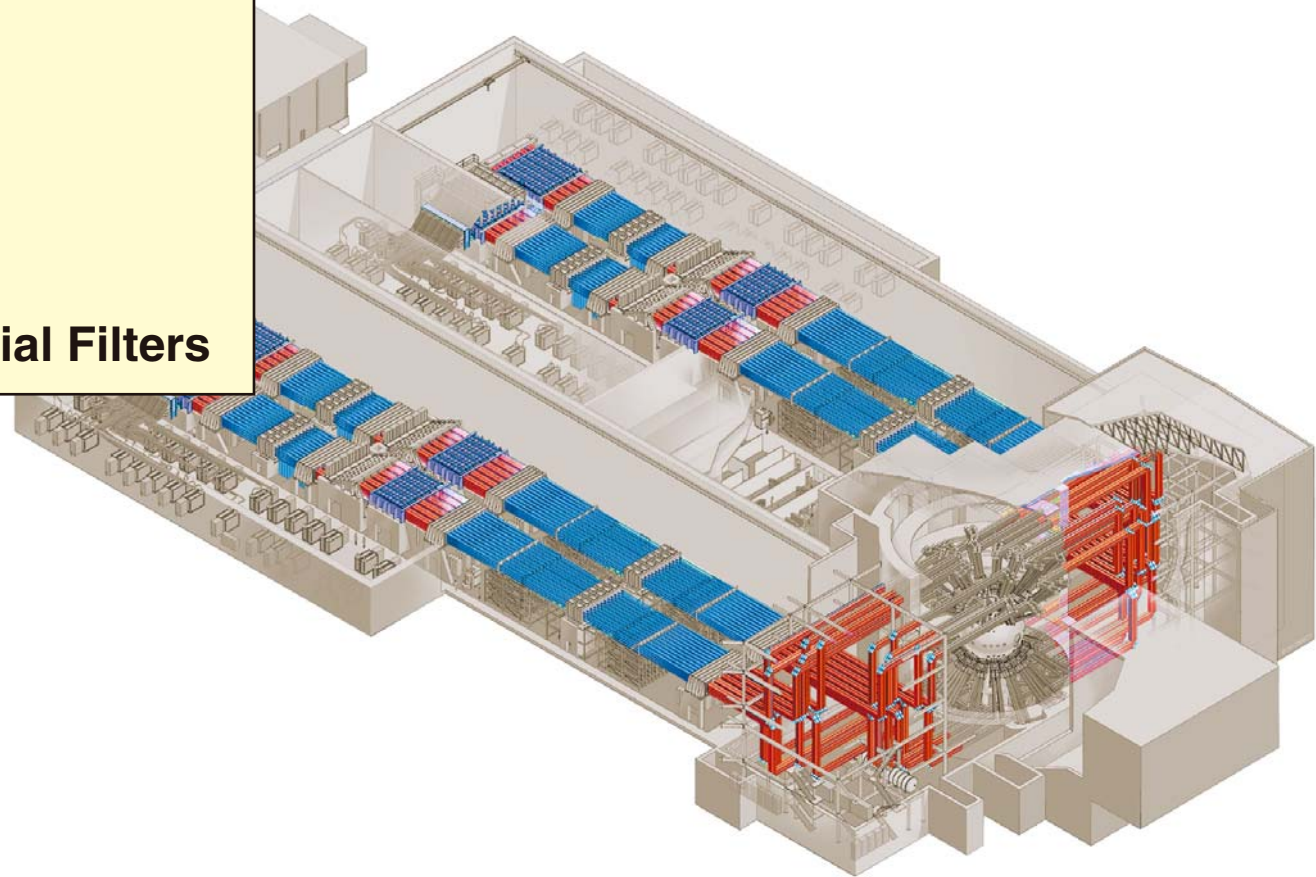


# NIF is based on 1960's — 1990's laser technology



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- Glass
- Flashlamps
- KDP
- Air cooling
- Discrete Spatial Filters

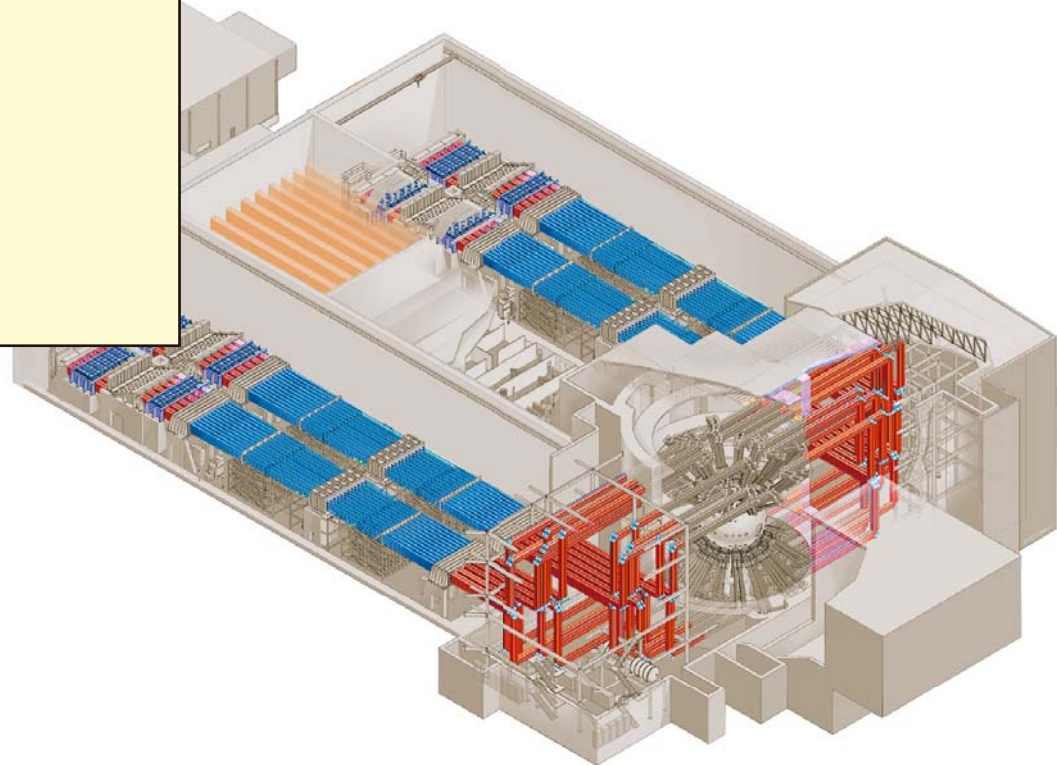


**These technologies result in a low rep rate,  
low efficiency laser fusion driver**



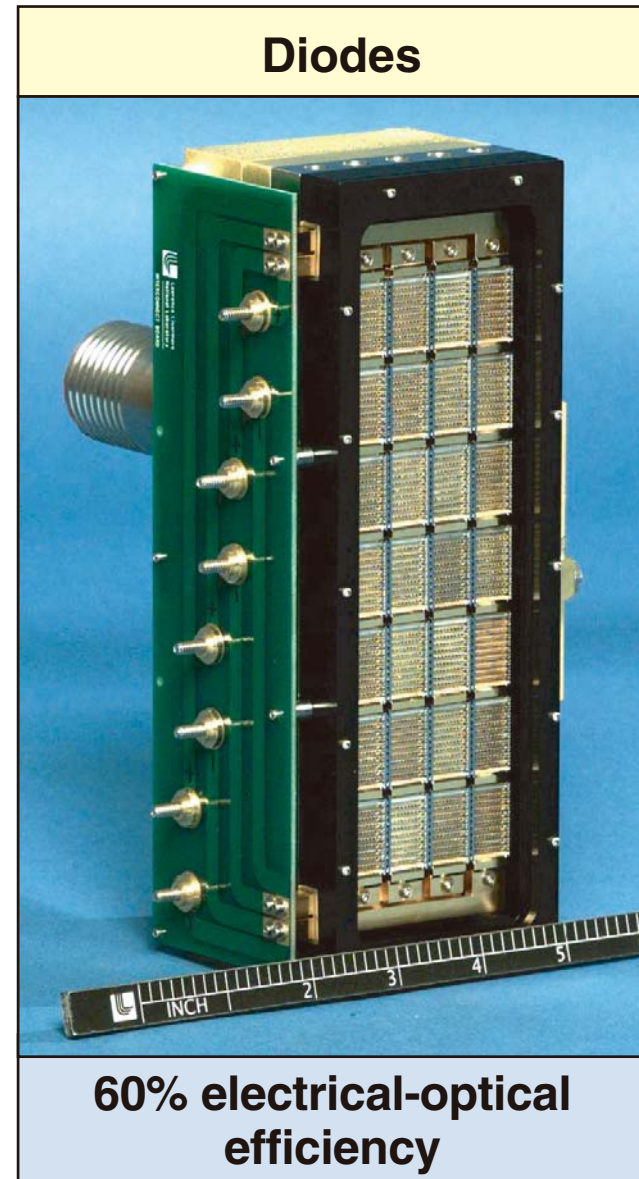
# IFE laser will be based on 1960's — 2020's technology

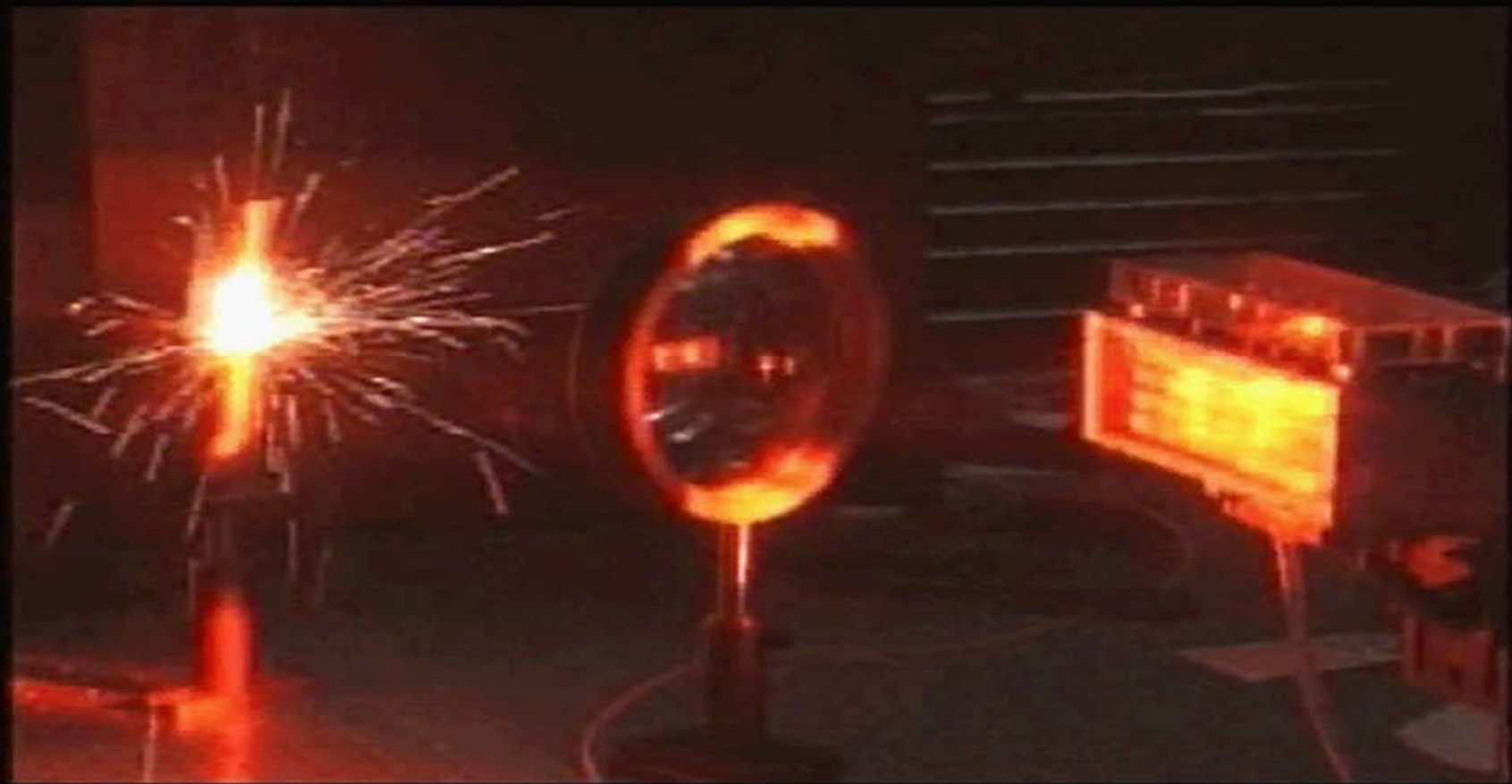
- ~~Glass~~ Glass/Ceramics/Crystals
- ~~Flashlamps~~ Diodes
- ~~KDP~~ DKDP
- ~~Air cooling~~ He cooling
- ~~Discrete Spatial Filters~~  
Rugate reflectors



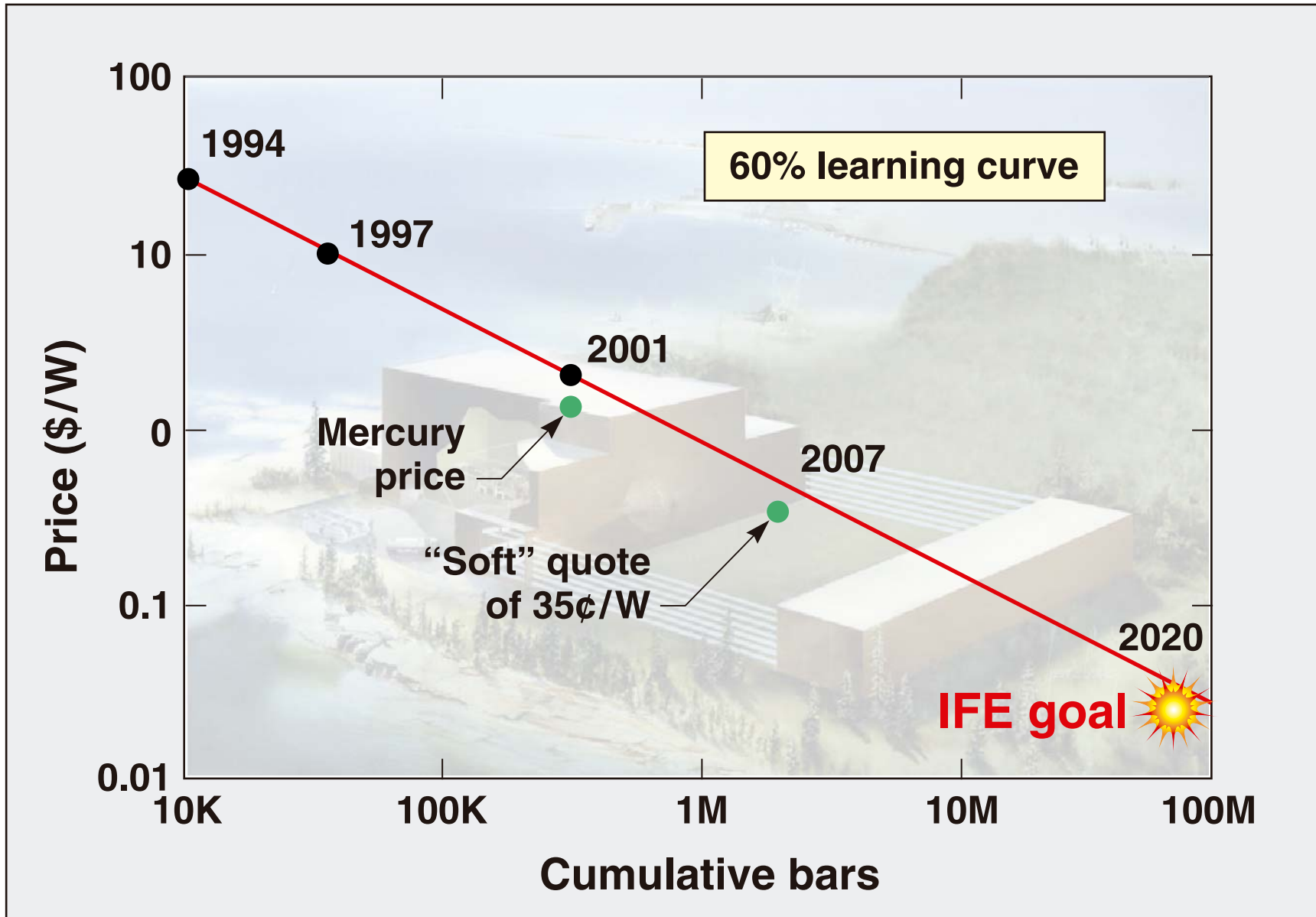
- These “plug and play” modifications to NIF architecture could increase rep rate by 100,000x and efficiency by 40x

# Diodes are significantly more energy efficient than flashlamps





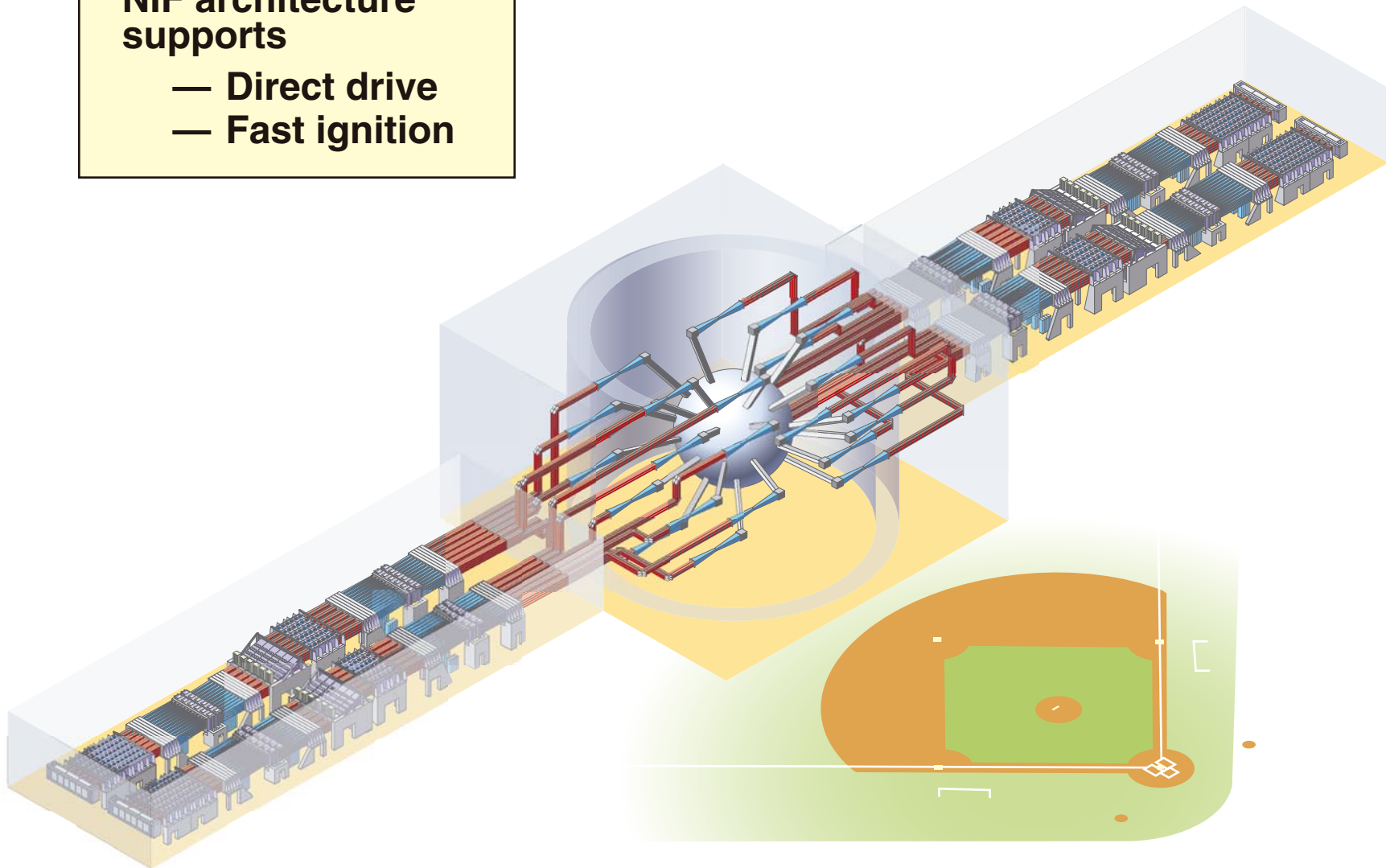
# Projected diode costs support economic IFE driver



# Optional IFE configuration

**NIF architecture supports**

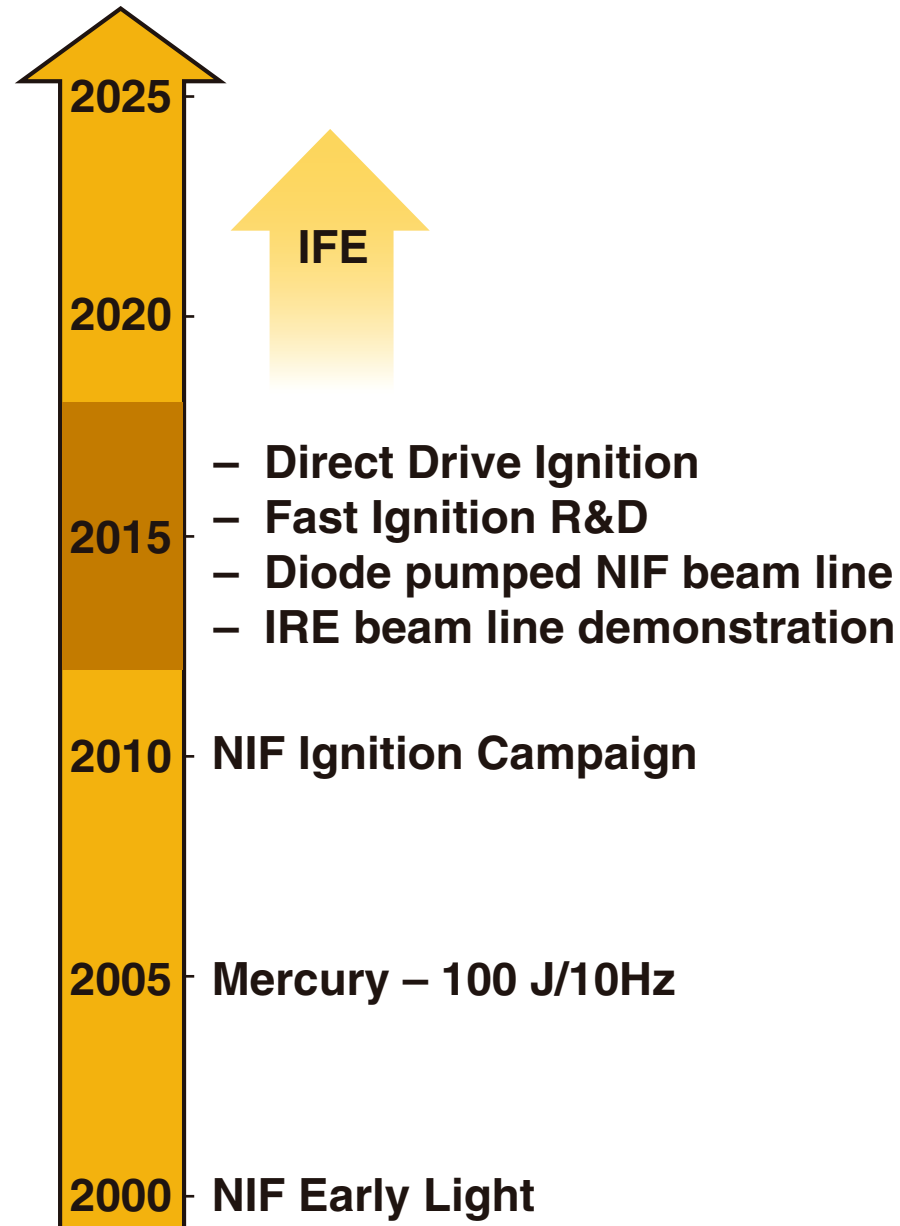
- Direct drive
- Fast ignition



# Leveraging the NIF provide a near-term pathway to the demonstration of an IRE beam line

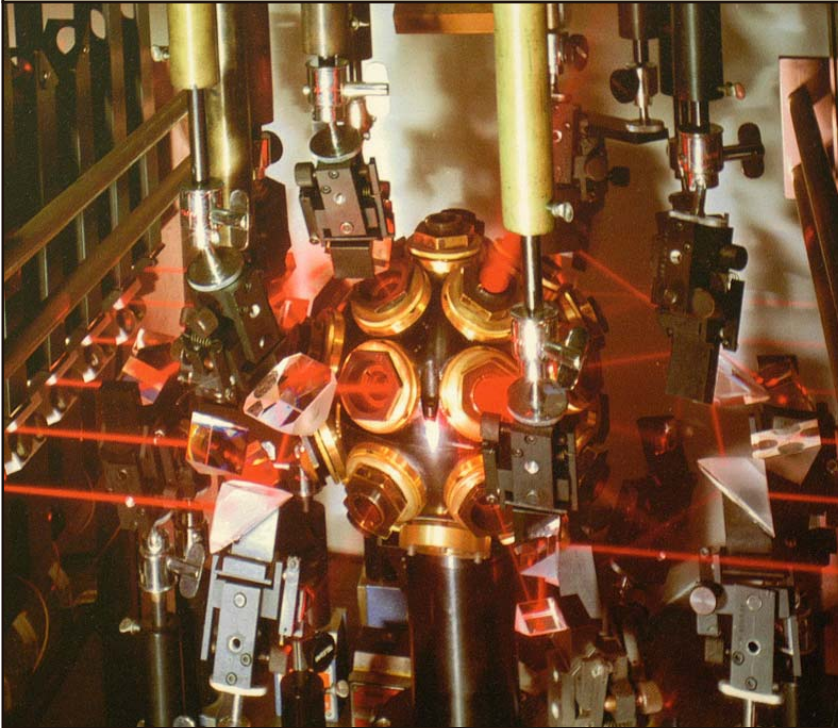


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# NIF: Visions becoming reality

1960's



2000's



**Ignition in 2010  
Golden Anniversary of the Laser!**



Oct '03



