The National Ignition Facility – Status and Future Directions

LLNL-PRES-421079

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Director, National Ignition Facility & National Ignition Campaign

Presented to: Fusion Power Associates
December 2nd, 2009

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NIF is the culmination of a long line of glass laser systems

Janus, 1973

100J IR

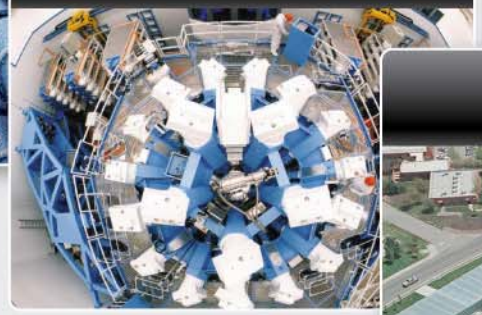
Shiva, 1977

10kJ IR

Nova, 1984

30kJ UV

OMEGA, 1995



25kJ UV

NIF, 2009

1.8MJ UV

NIF concentrates all 192 laser beam energy in a football stadium-sized facility into a mm^3

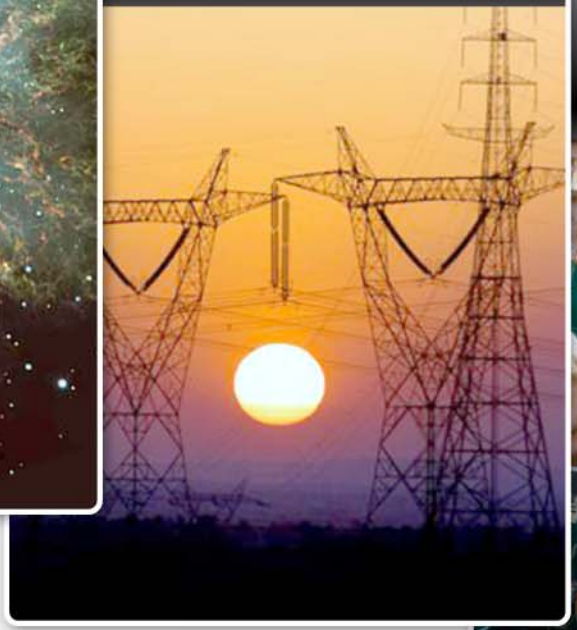
Matter Temperature	$>10^8$ K
Radiation Temperature	$>3.5 \times 10^6$ K
Densities	$>10^3$ g/cm^3
Pressures	$>10^{11}$ atm

NIF missions

Ensuring Global Stability & Global Security

Advancing Frontier Science

Enabling Clean Energy

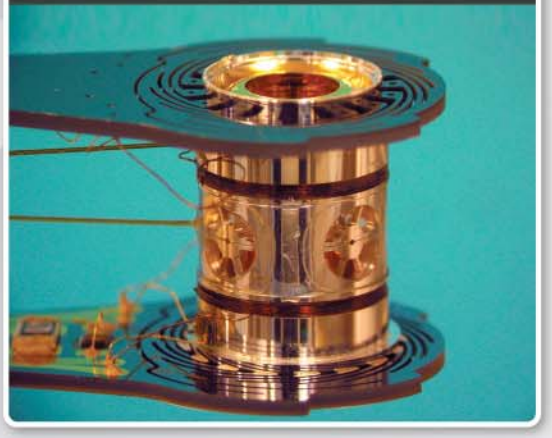


Building Future Generations of HED Scientists

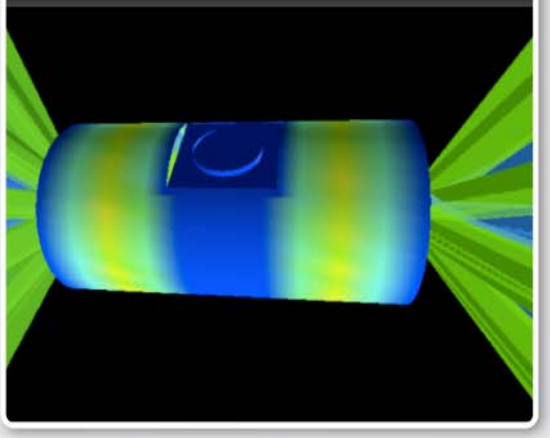
NIF is operational, conducting experiments and acquiring great data

FY2010 NIF National Security planned experiments

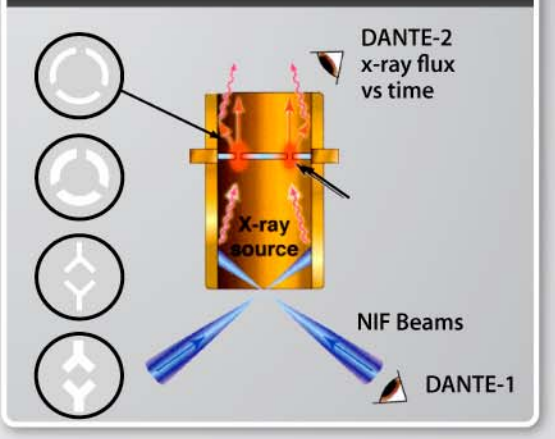
SSP/NIC - Commence layered target experiments



SSP/HED - EOS measurements of Ta to 5 M Bar



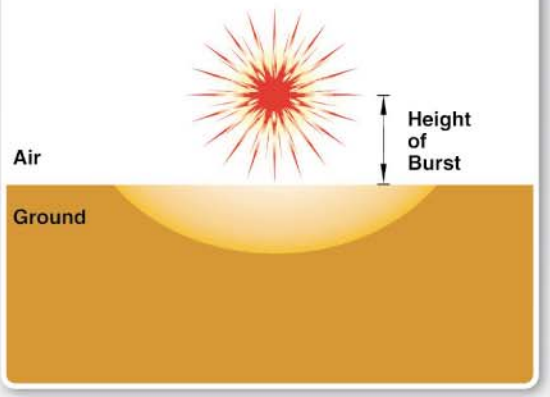
SSP/HED - complete radiation transport experiments



Pleiades

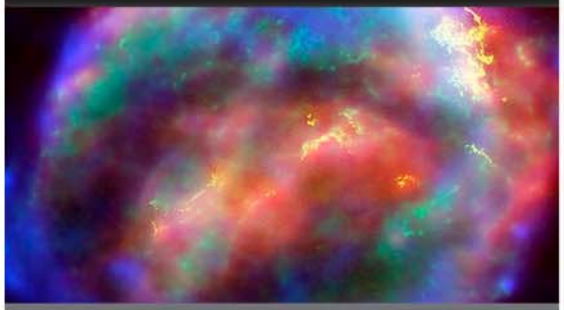
Los Alamos
NATIONAL LABORATORY

Global security/ nuclear forensics - height of burst studies



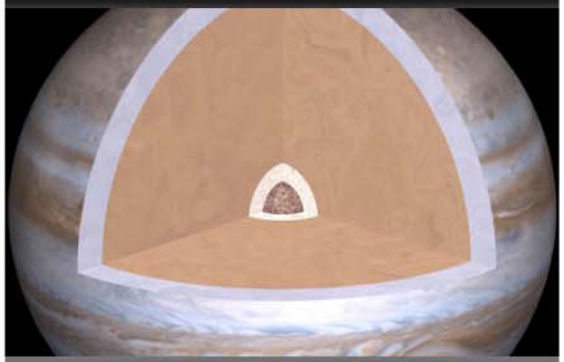
We are developing academic users and need to continue growing this community

Astro/Nuclear Physics



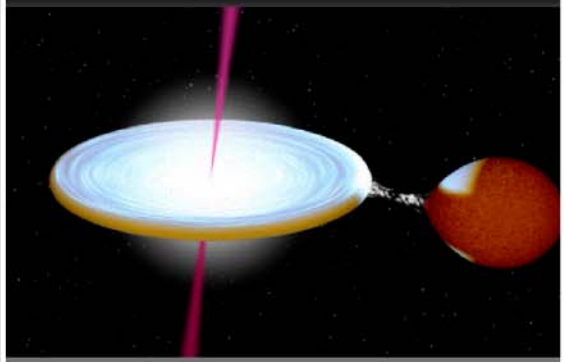
George Fuller, UC San Diego
Carl Brune, Ohio State

Ultra-Dense Matter



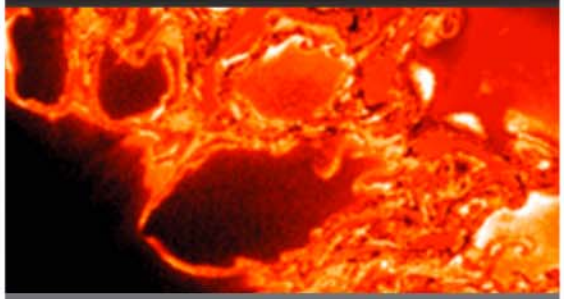
Tom Duffy, Princeton

Burning Plasmas



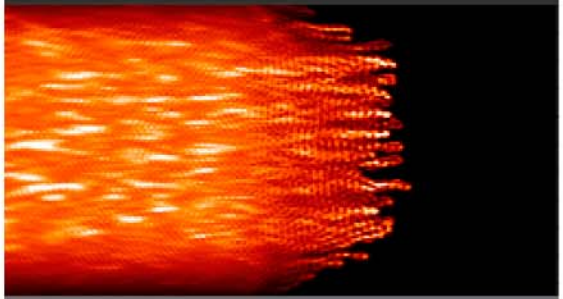
Steve Rose, Imperial College

Supernova Hydrodynamics



Paul Drake, Univ. of Michigan

LPI and Ultra-Intense Light Sources

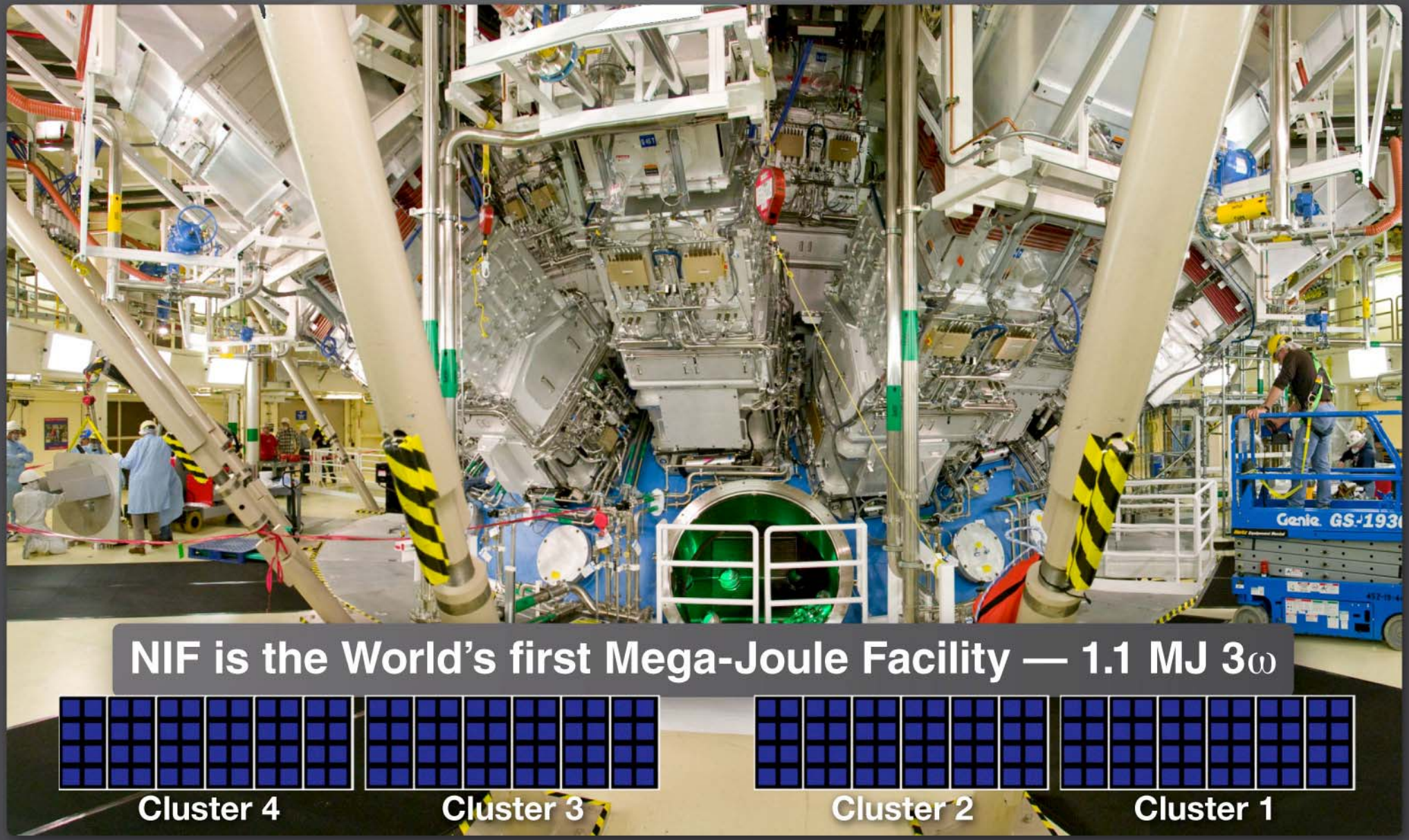


Nat Fisch, Princeton

Since last year's FPA meeting…

- NIF completed, 192 beams operational, dedicated and made operational with over 175 systems shots showing both energetic capability of the facility and its precision
- NIC experiments at NIF have begun
  - Symmetry control, control over laser plasma interactions in a variety of warm and cryogenic target configurations
  - Now preparing for scale implosion experiments
- First radiation transport milestones completed, now ongoing
- First low energy x-ray effects and first university experiments conducted

NIF Laser Operationally Qualified to 1 MJ on March 10, 2009



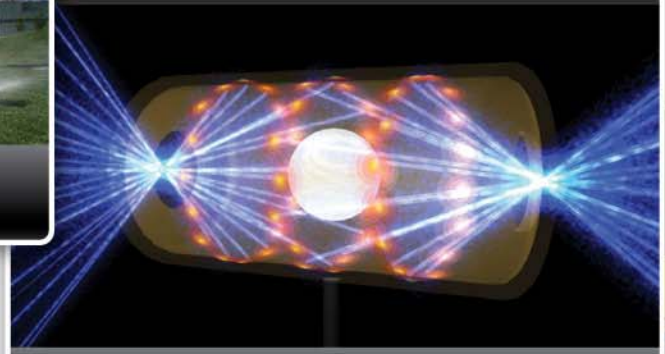
NIF Dedication
May 29, 2009

NIF Master Strategy

NIF Project

Operational

National Ignition Campaign

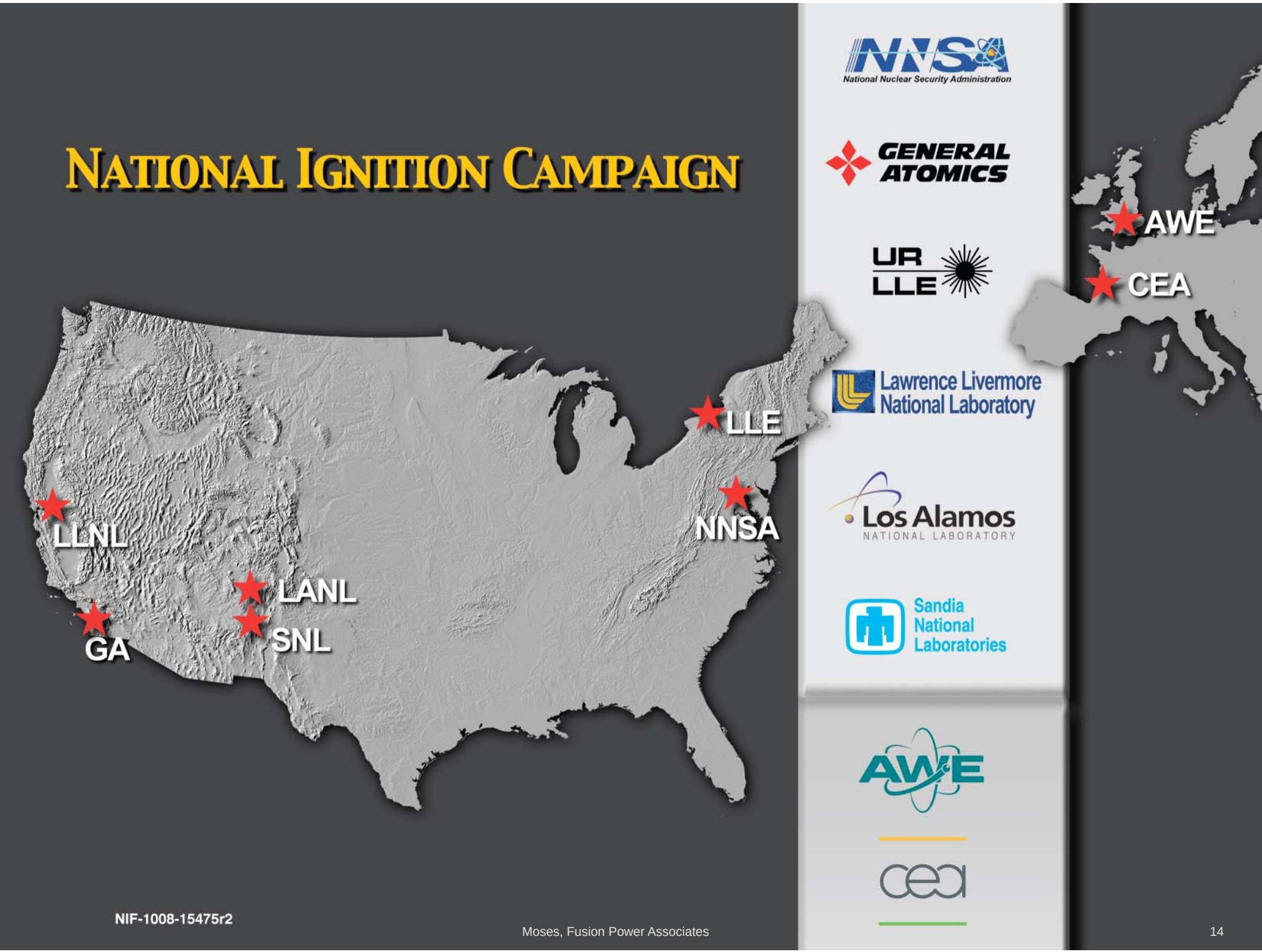


2006–2012

National User Facility

2009–2030

National Ignition Campaign



NIF-1008-15475r2

National Ignition Campaign goals

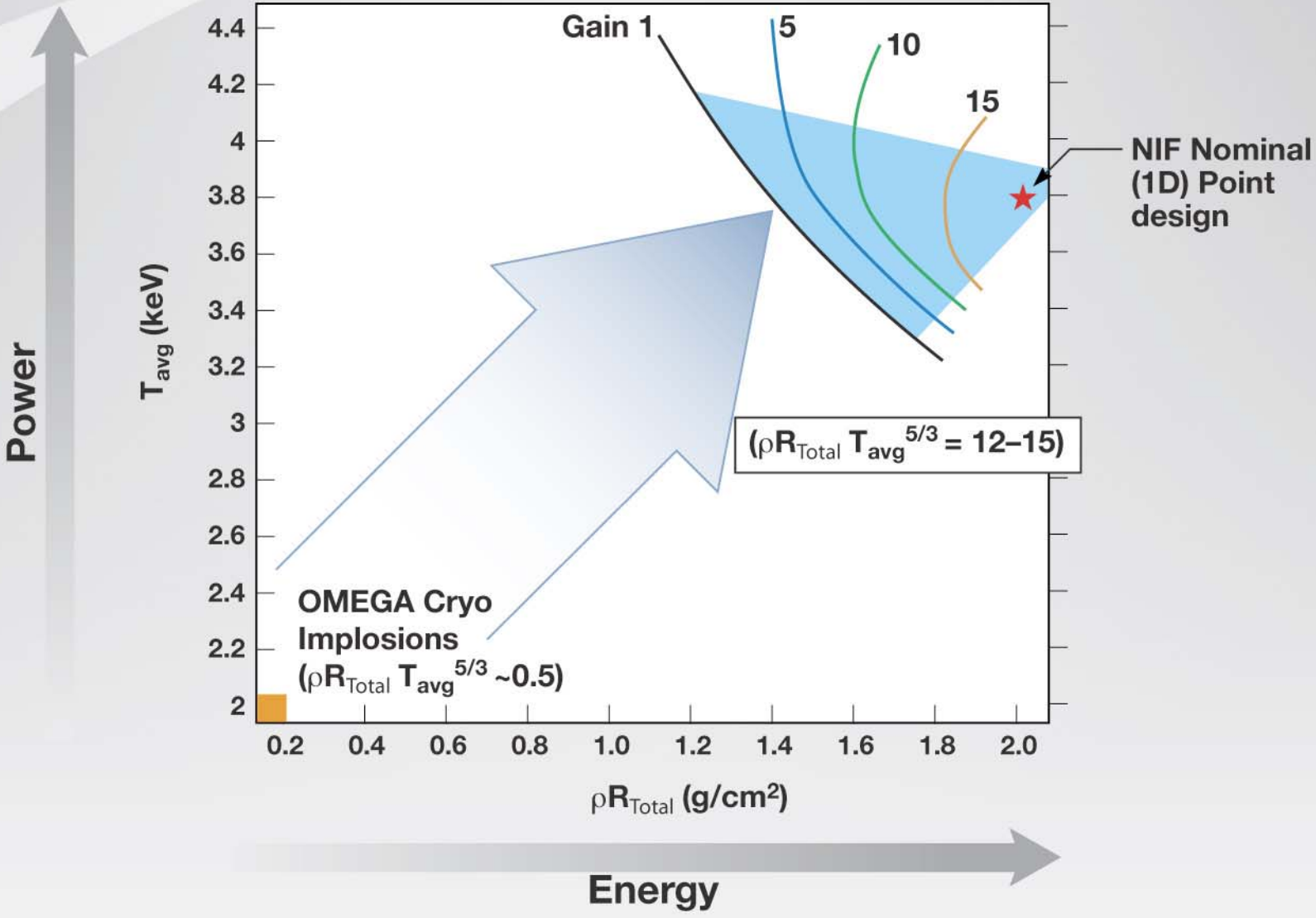
Begin ignition experiments starting in FY2010

Layered implosion, THD or DT

Demonstrate a reliable and repeatable ignition platform

Transition NIF from project completion to routine facility operation by end of FY2012

NIF will access density and temperature conditions required for ignition

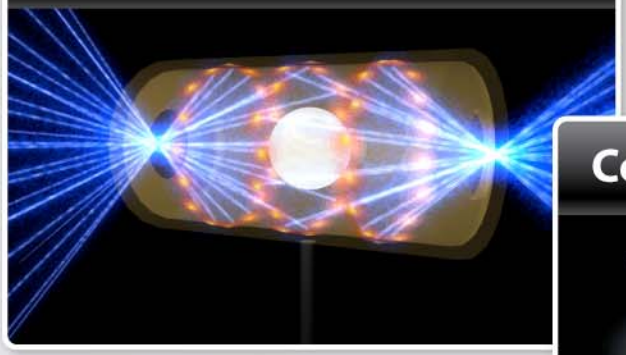


NIC is organized into integrated product teams (IPTs)

Commission laser

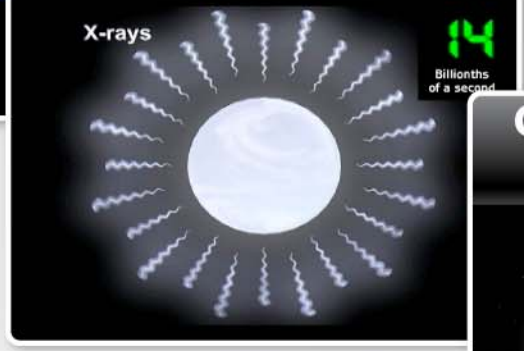
Laser Drive

Commission hohlraum



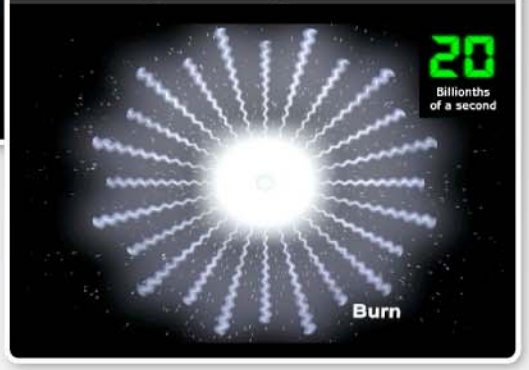
X-Ray Drive

Commission capsule

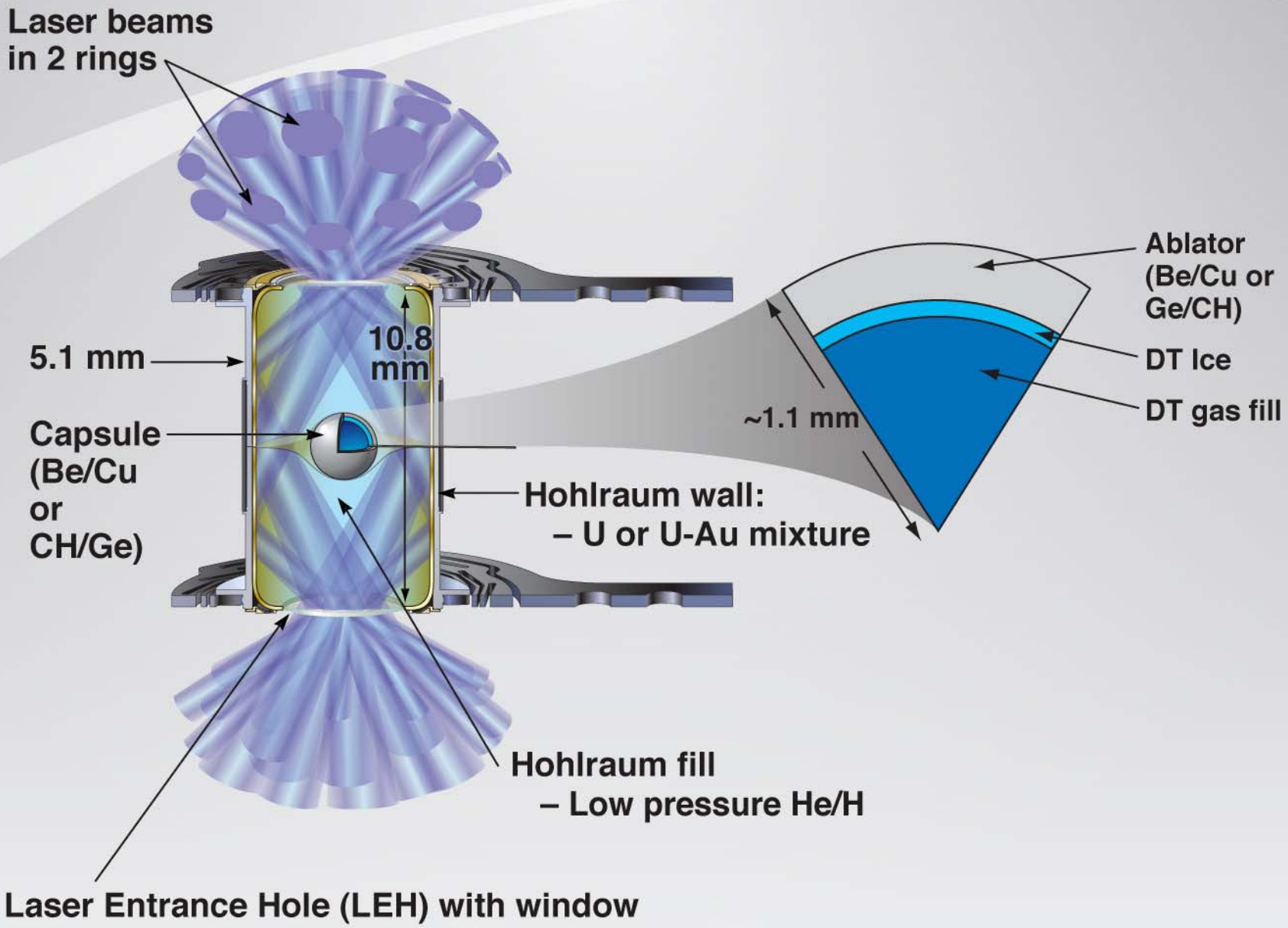


Hydro Drive

Commission layered target implosions



Ignition Point Design



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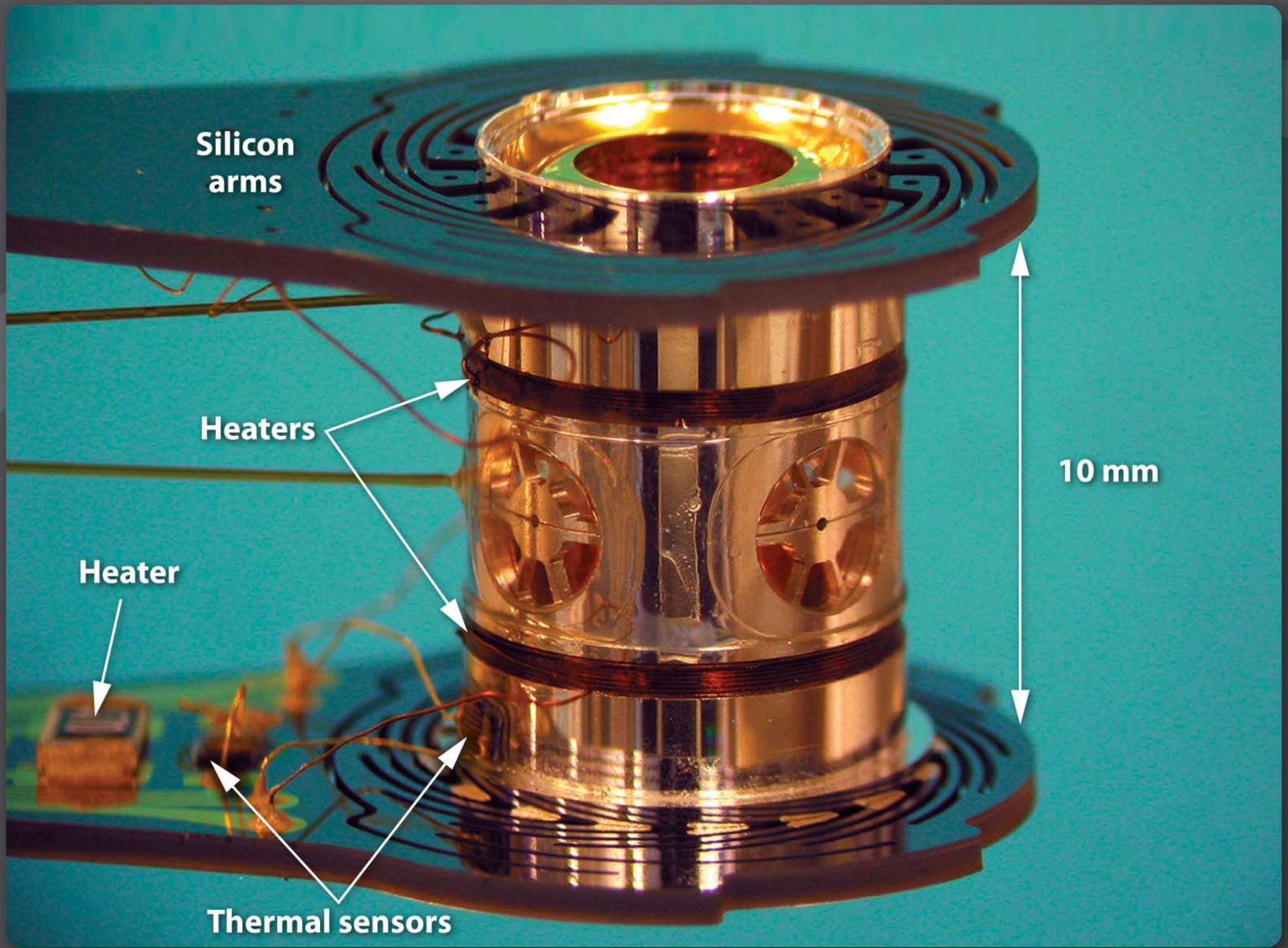
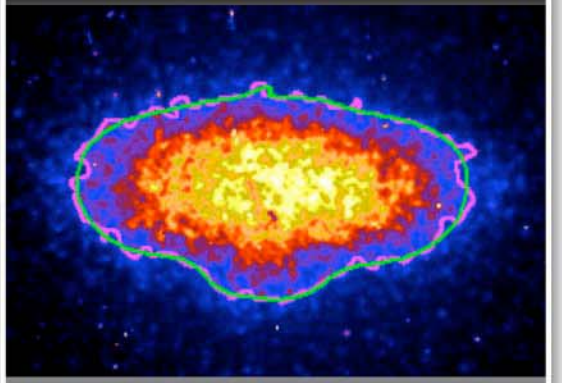
Moses, Fusion Power Associates


Silicon arms
Heaters
Heater
Thermal sensors
10 mm

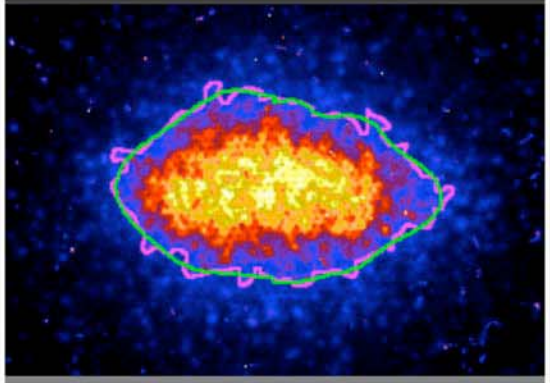
Capsule implosions in cryogenic gas-filled hohlraums have shown good symmetry at 270 eV

Wednesday, Sept. 2



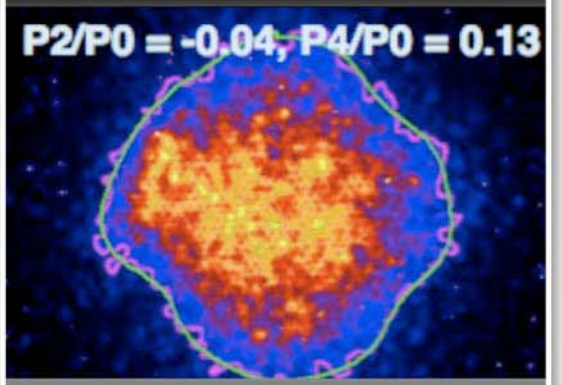
1st cryo implosion

Thursday, Sept. 3



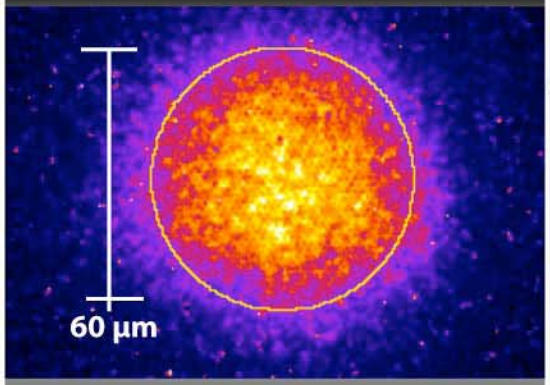
2nd cryo implosion

Friday, Sept. 4



3rd cryo implosion

Saturday, Sept. 5



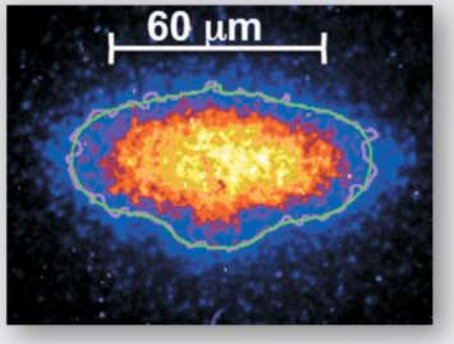
4th cryo implosion

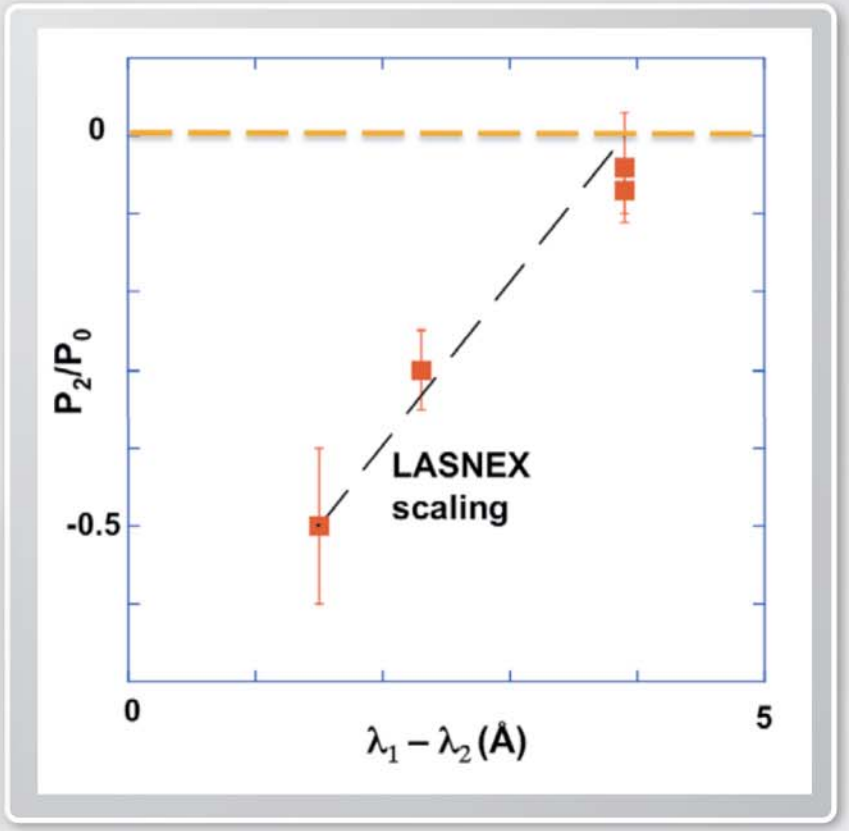
- Initial capsule diameter: 1.8 mm
- Emitting region 33x smaller than capsule diameter
- Consistent with 10-15 mass compression
- Very symmetric implosion P2 ~7%

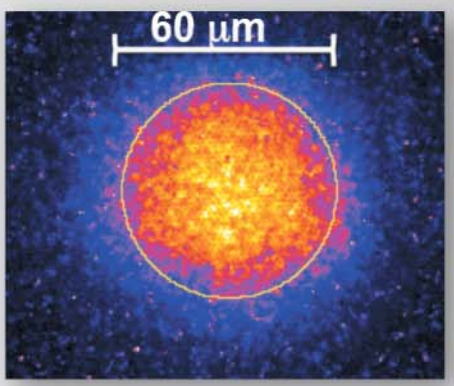
Implosion symmetry has been achieved by tuning the wavelength of the outer cone

- A two-color tuning allowed us to bring an initially "pancake" implosion to round without changing the laser cone fraction

P2/P0 = -0.5,
P4/P0 = 0.3

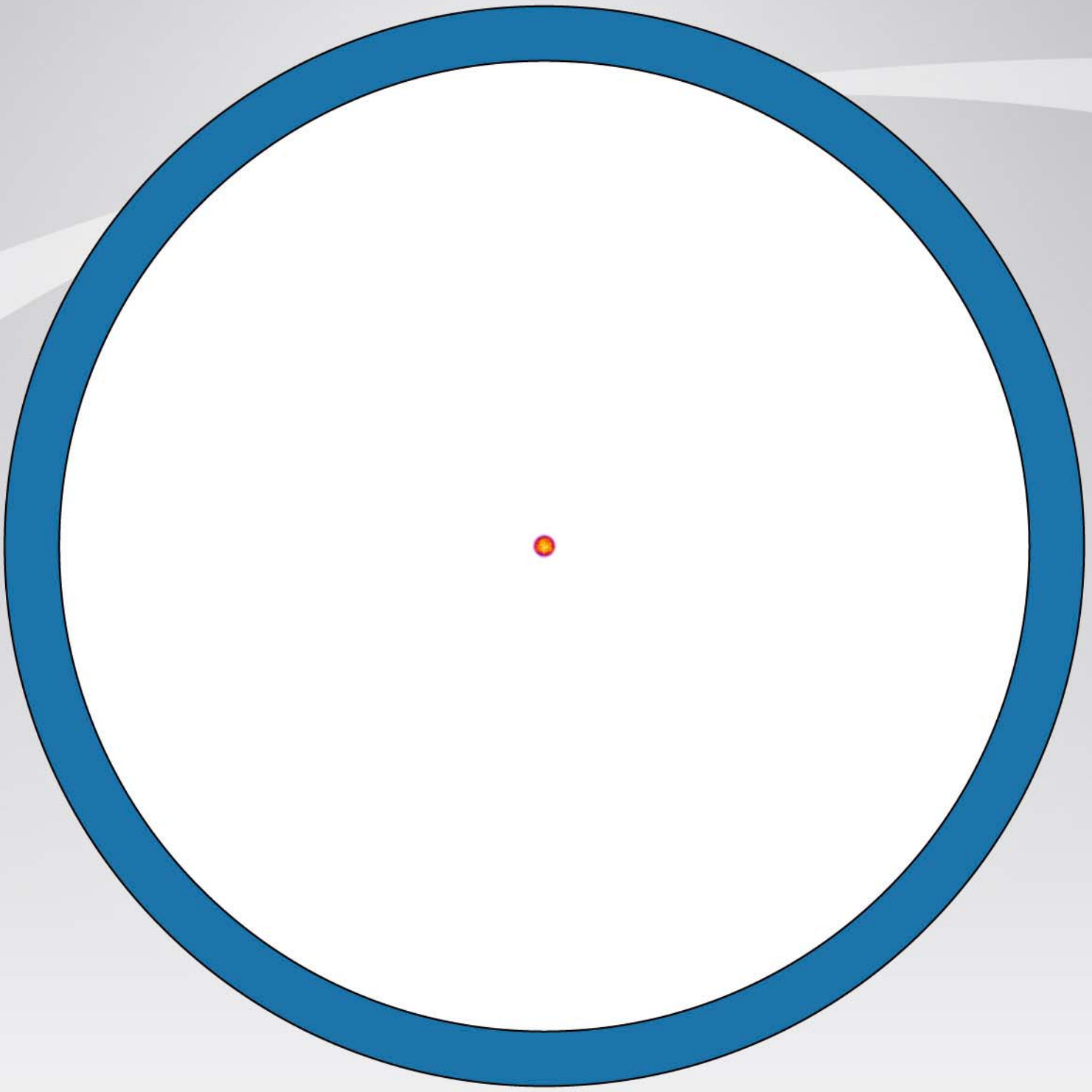


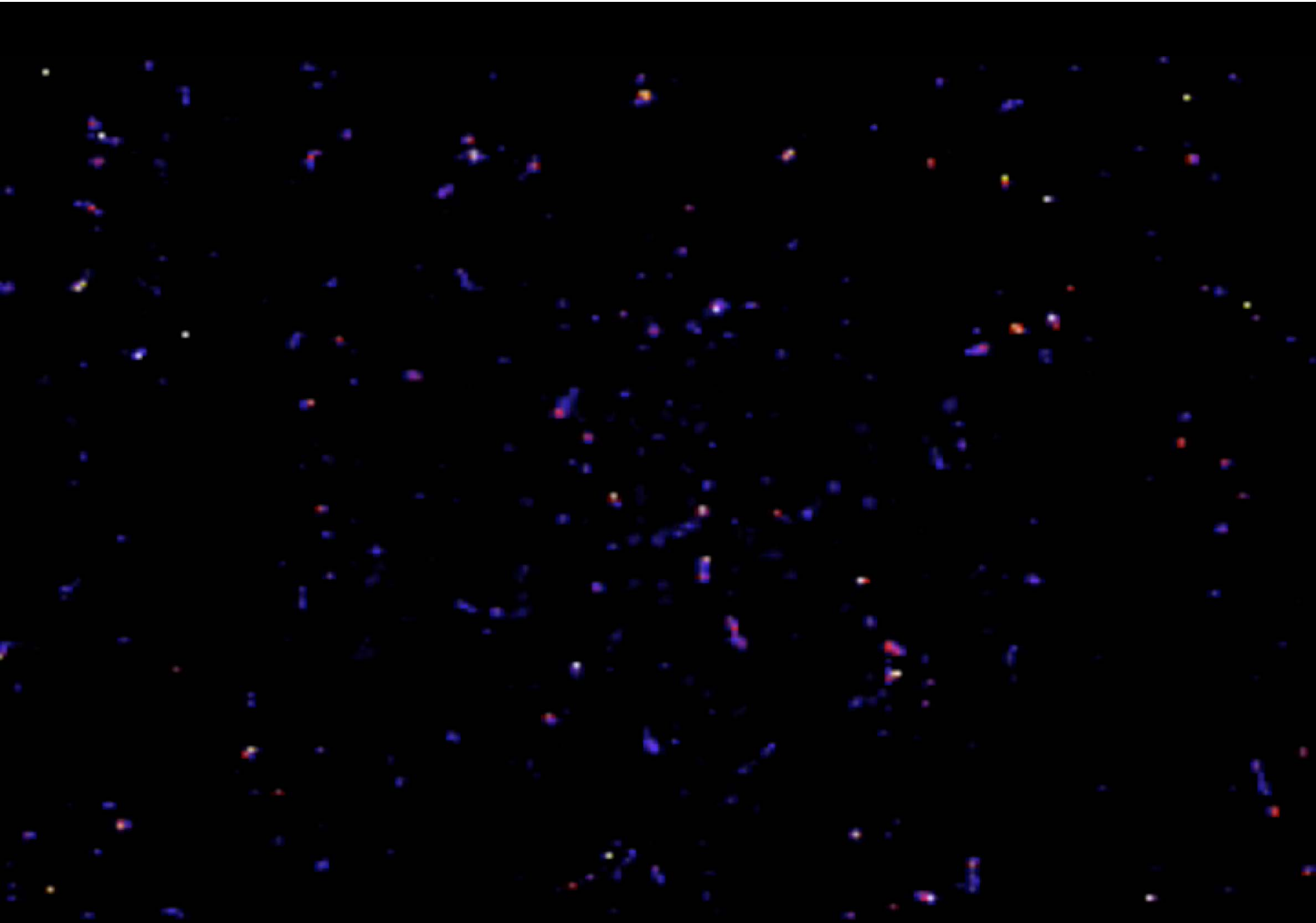




P2/P0 = -0.07,
P4/P0 = -0.03

This change in symmetry has been predicted by LASNEX calculations that include crossed beam transfer in the laser entrance hole area





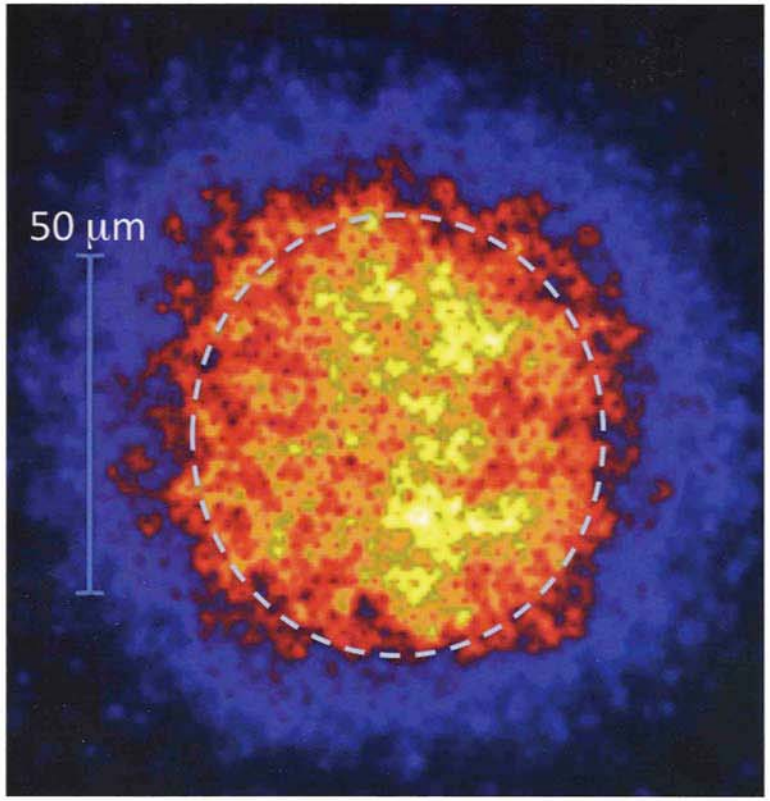
BULLETIN

OF THE AMERICAN PHYSICAL SOCIETY

51st Annual Meeting of the Division of Plasma Physics

November 2–6, 2009

Atlanta, Georgia



November 2009

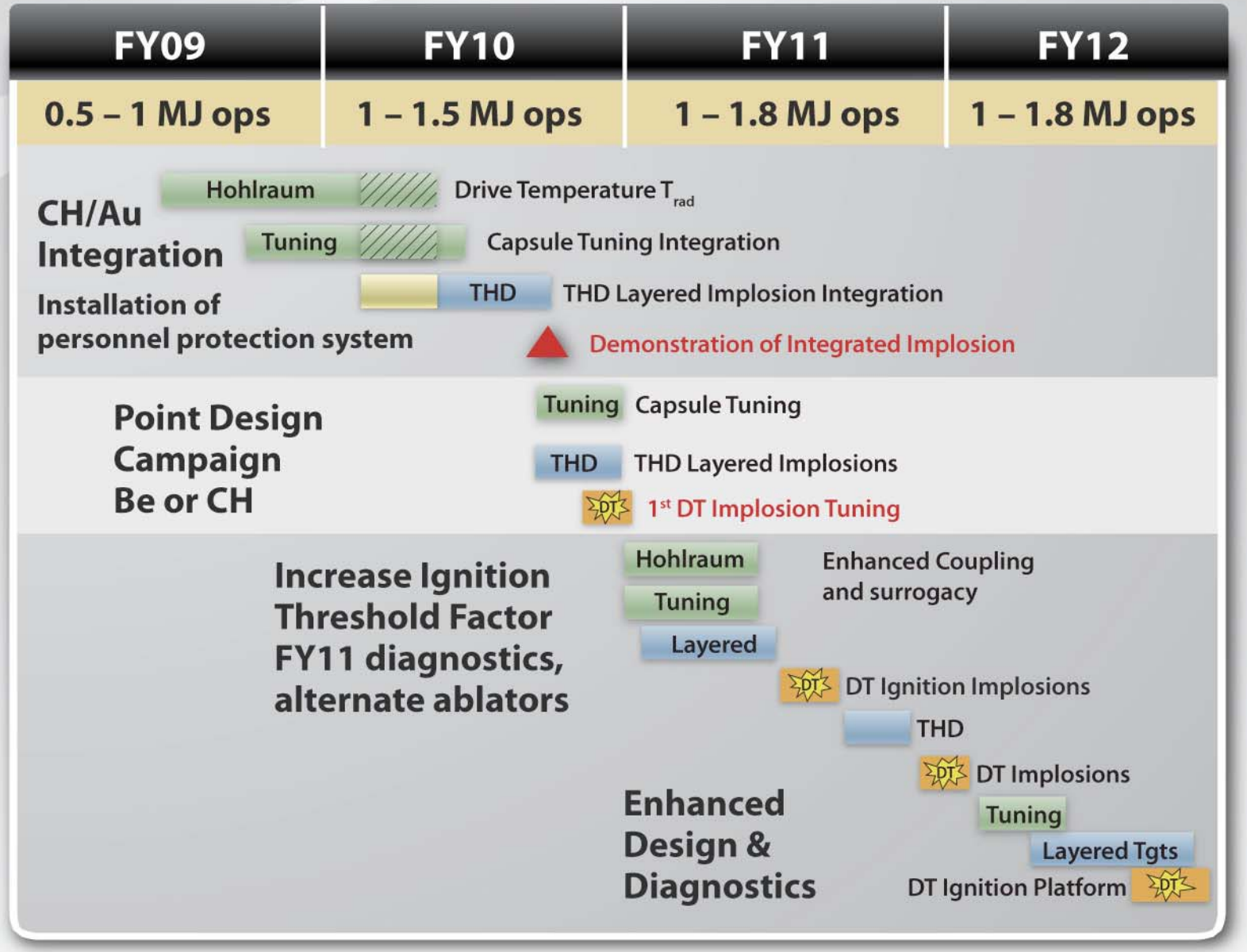
Volume 54, No. 15

APS physics

LLE nTOF 4.5 installed 6/09

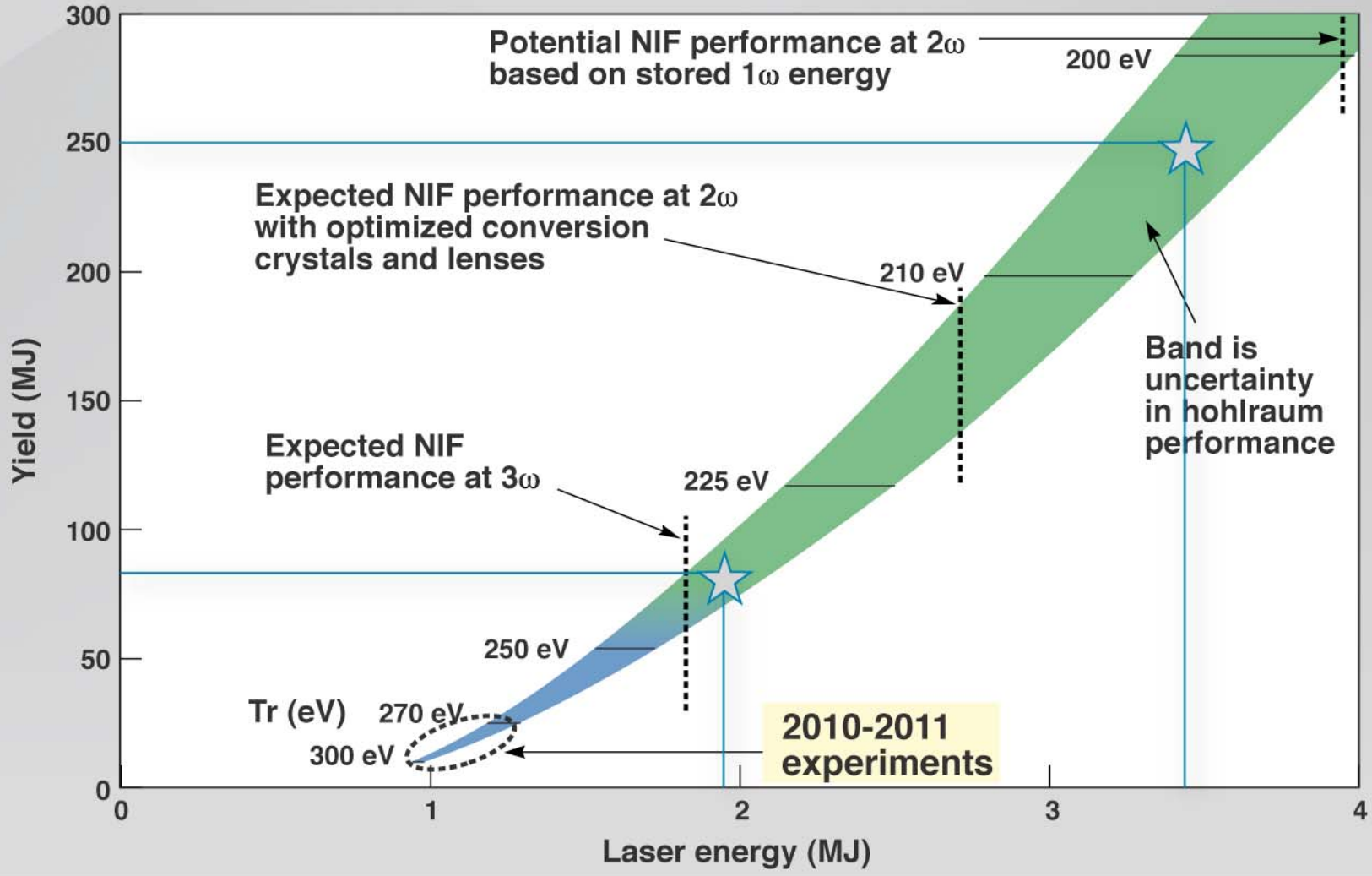
- Yield
- Bang-time
- Core Temp
- Downscattered neutrons

The NIC goal is to develop a robust burning plasma platform by the end of 2012



Ultimately, yields well in excess of 100 MJ may be possible on NIF

Yields versus laser energy for NIF geometry hohlraums



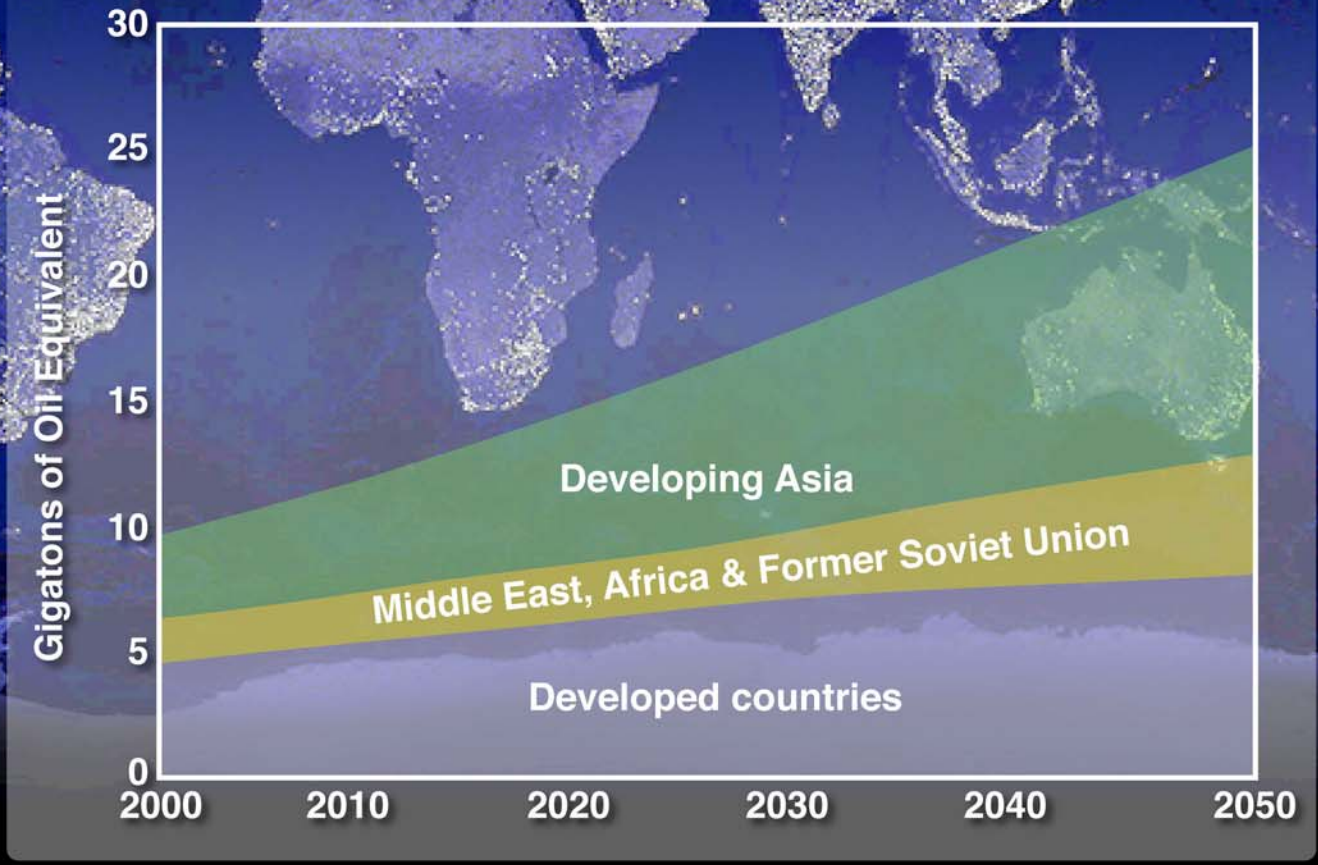
Achieving ignition on NIF can be a defining moment for the world's energy future

Clean energy: Humankind's challenge

Global Factors

- Population increase
- Developing countries
- Resource depletion
- Climate change

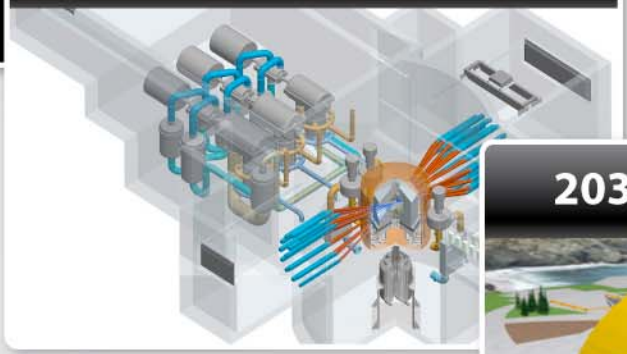
This challenge must be resolved and solved today



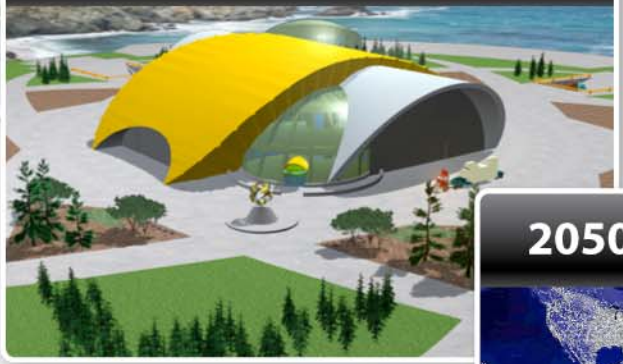
LIFE Roadmap

2010 NIF Ignition

2020 LIFE Prototype



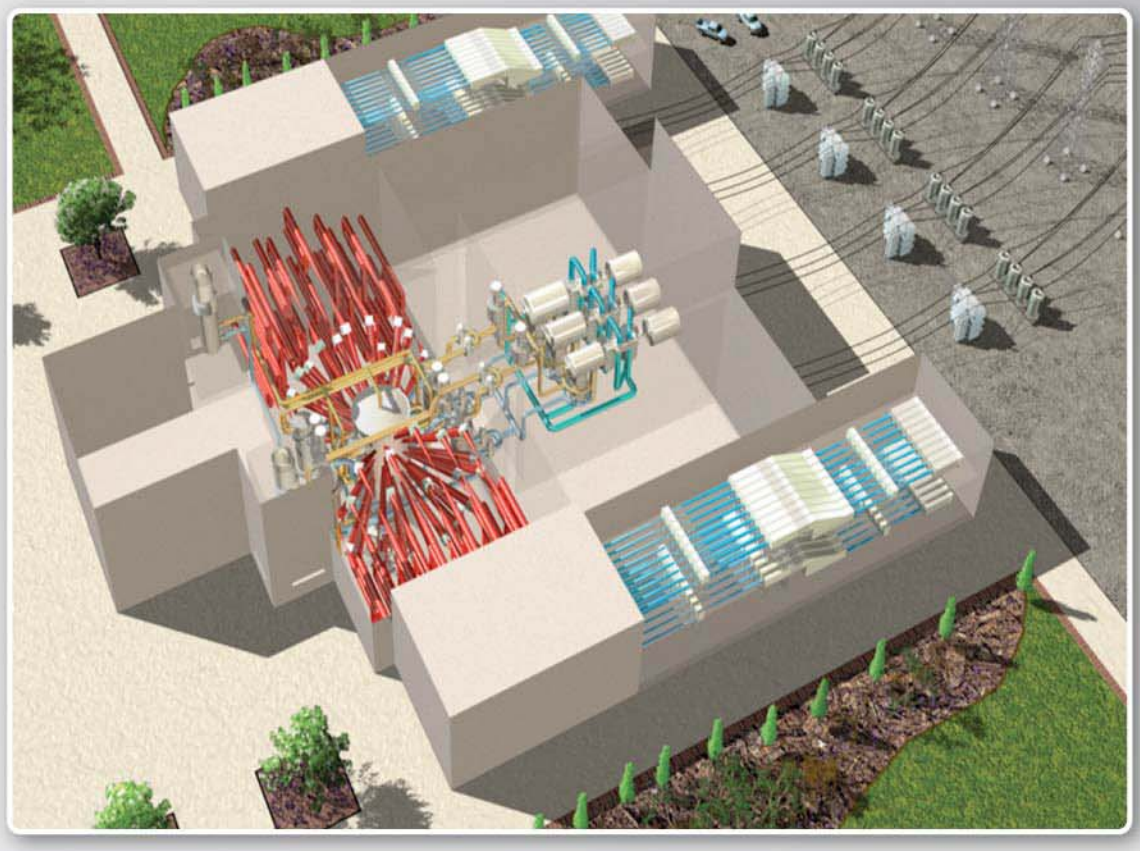
2030 LIFE Commercial



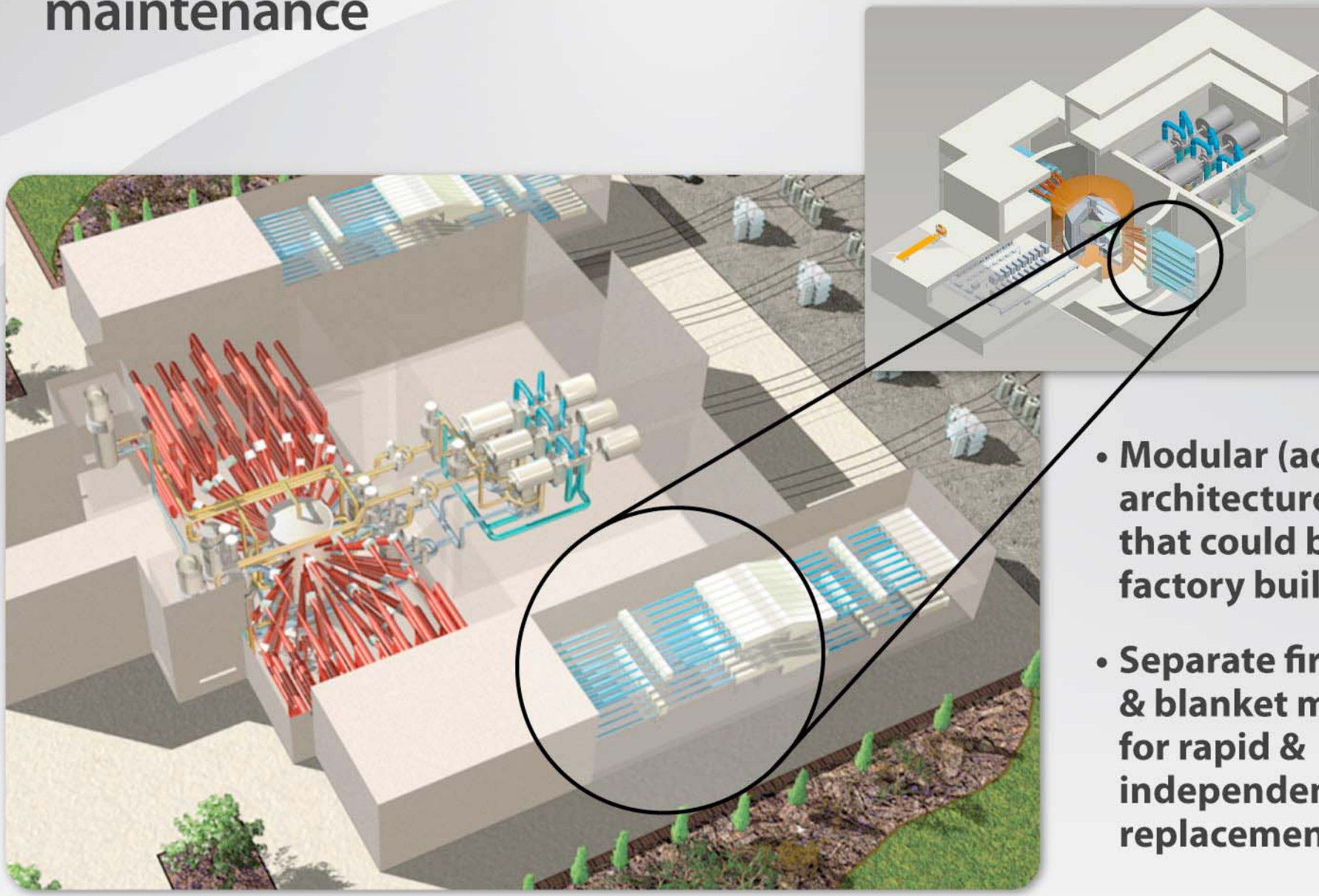
2050 Fleet Incorporated

LIFE is a credible extension of NIF, ignition on NIF, and ongoing developments in the nuclear industry

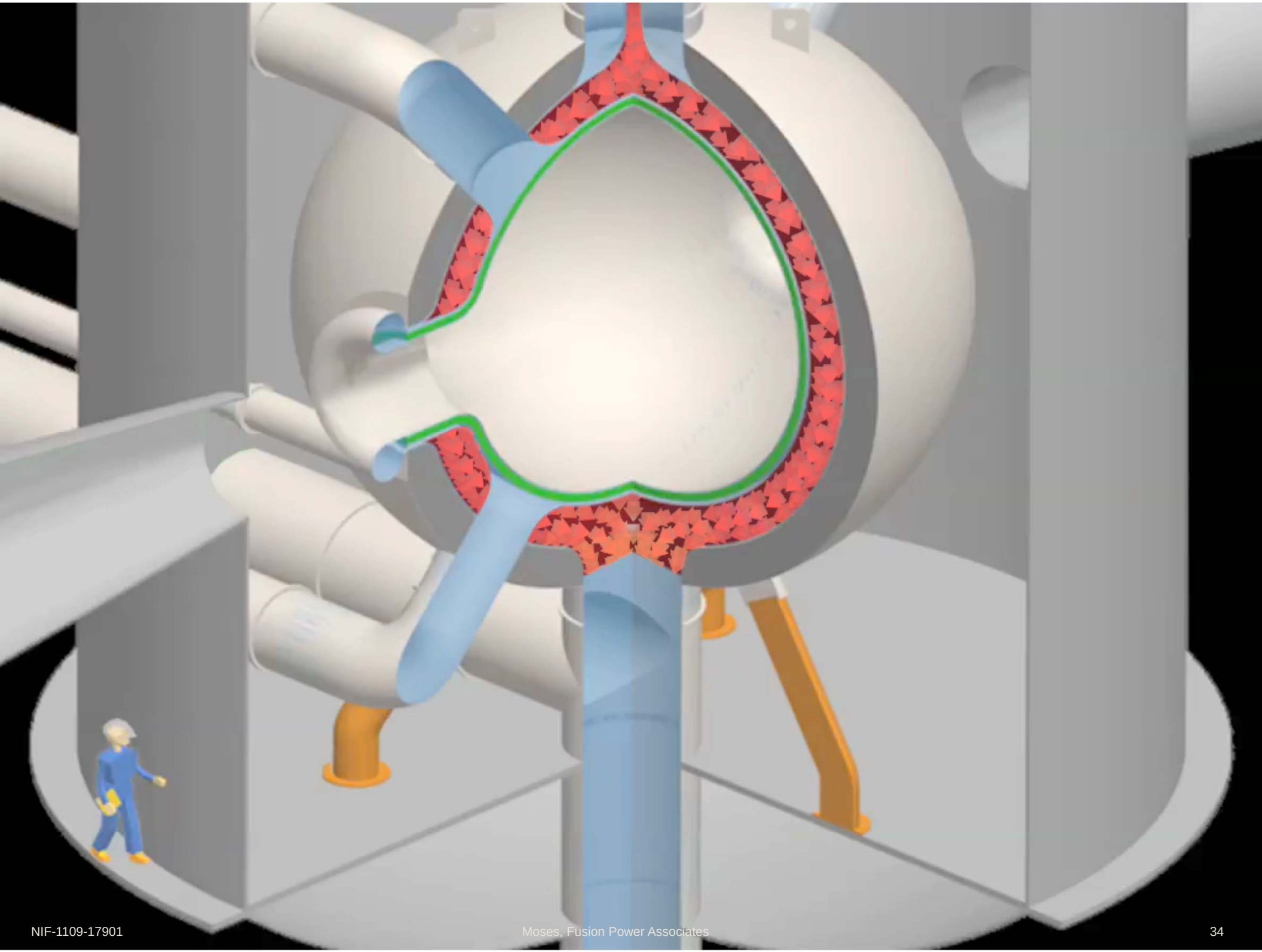
- NIF-like fusion performance
- NIF-based lasers
- Mass produced NIF-like targets
- Target injection and engagement
- Fusion environment
  - Protecting first wall
  - Laser beam propagation

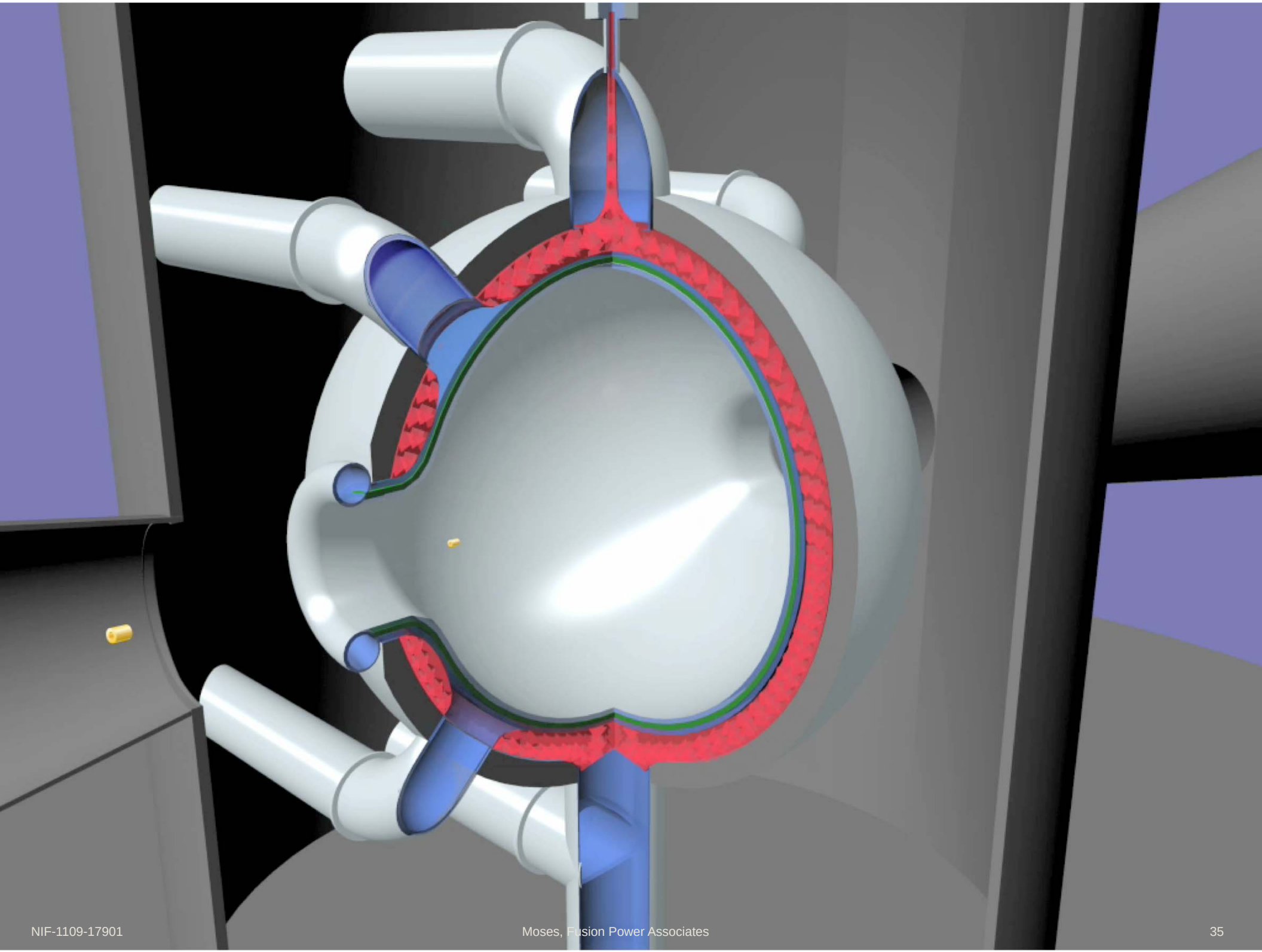


Advanced lasers and modular systems make the facility compact and enable rapid construction and maintenance

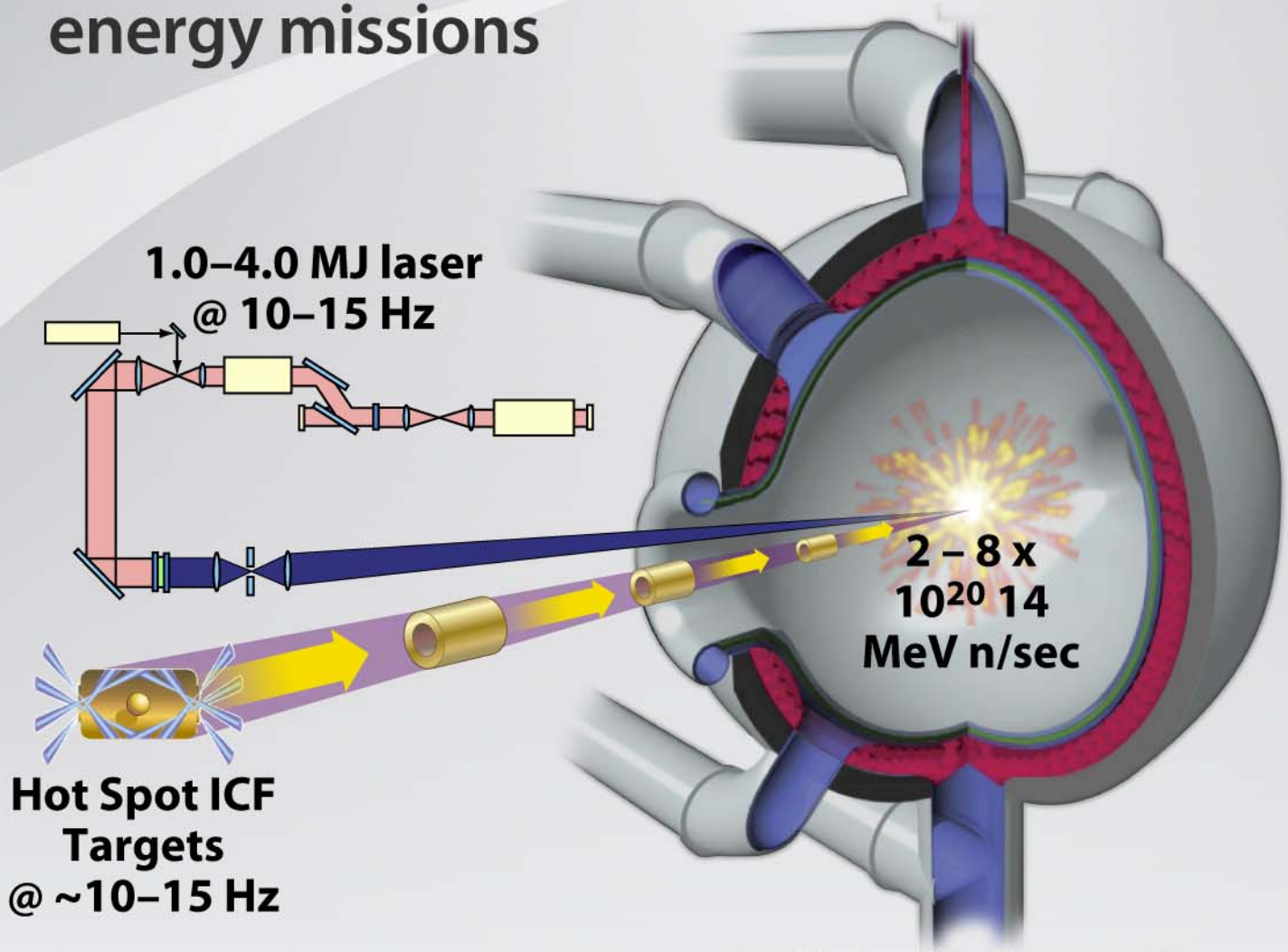


- **Modular (advanced architecture) lasers that could be factory built**
- **Separate first wall & blanket modules for rapid & independent replacement**





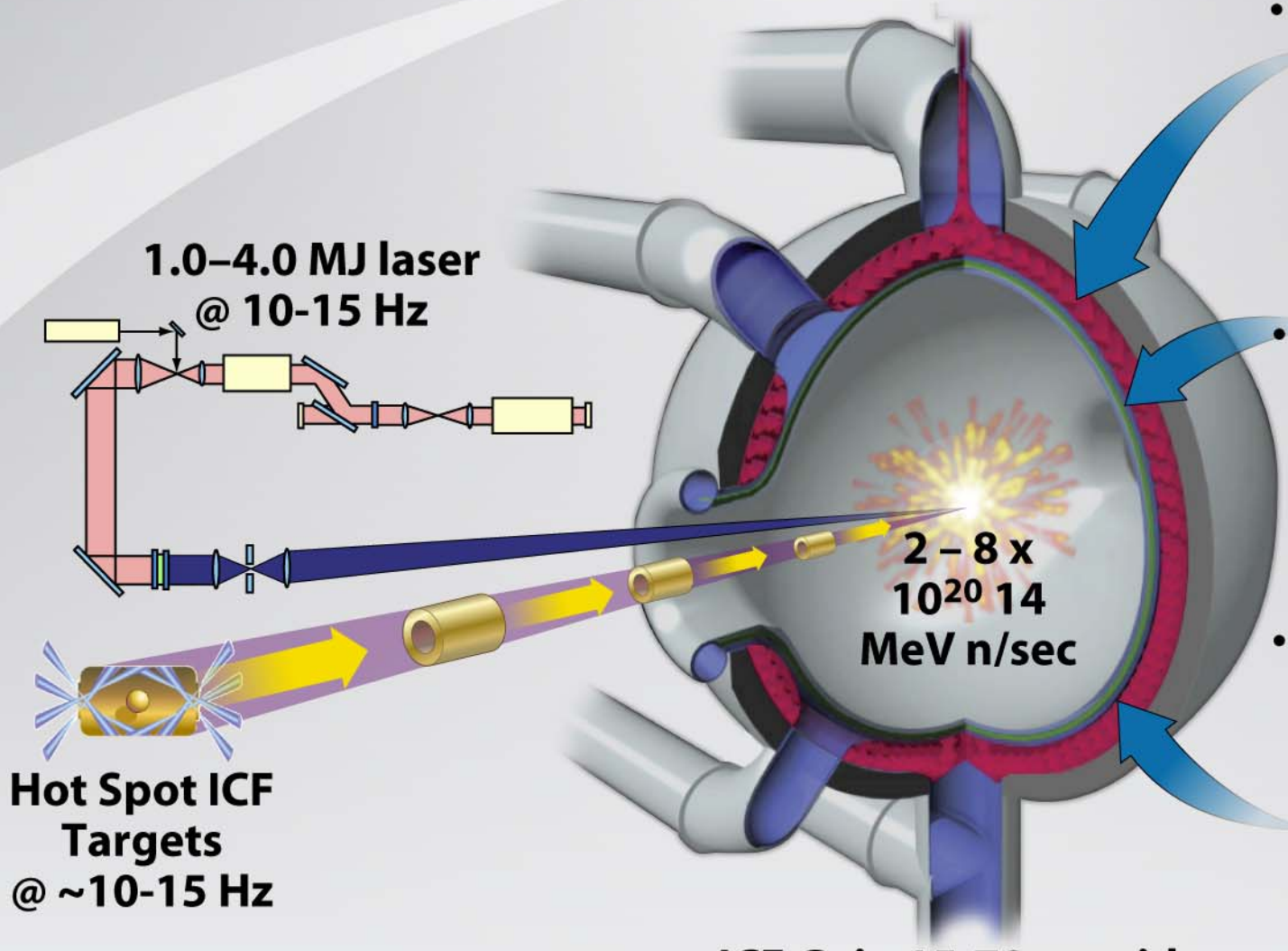
LIFE – a Laser Inertial Fusion Engine provides a point source of 14 MeV neutrons for a variety of fusion-based energy missions



Blanket to provide energy specific missions

ICF Gain 15-70 provides 150–1750 MW fusion

Different LIFE blankets provide unique energy systems



LIFE blankets options

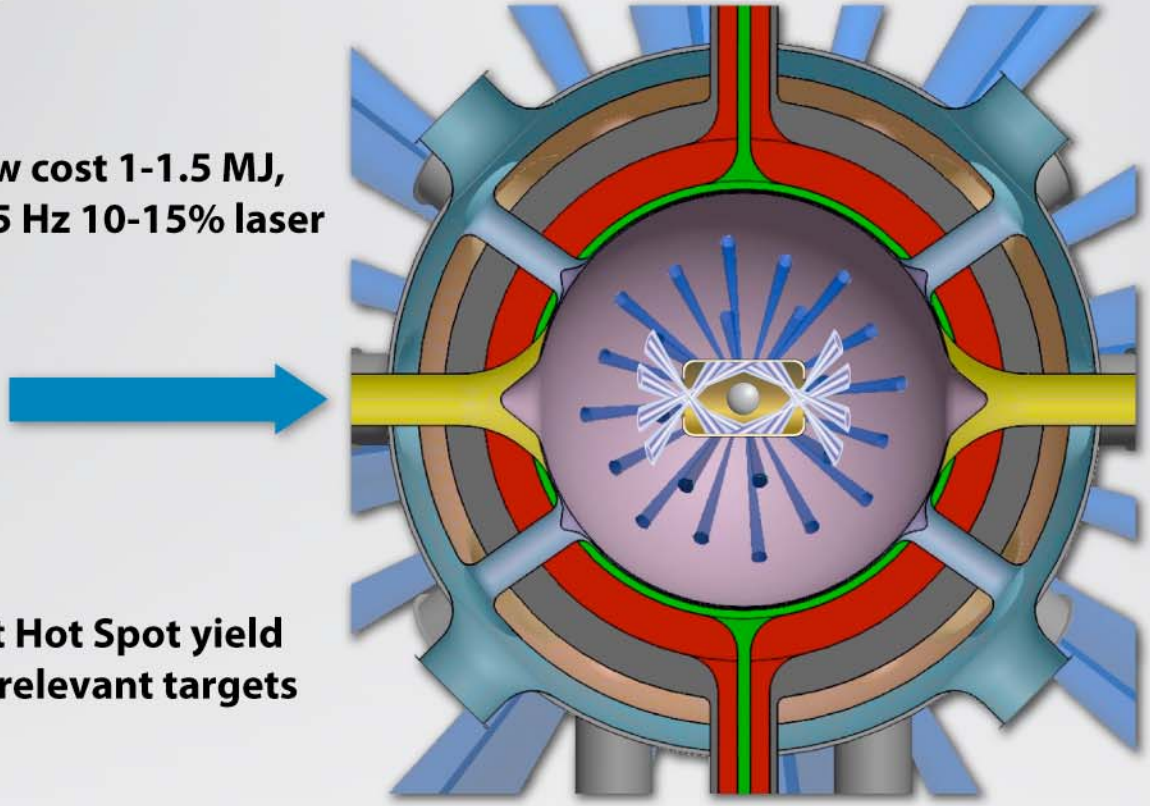
- Li-based salt to make electricity and produce T for other LIFE-based missions (pure fusion-base case)
- Coolant with U, DU or TH pebbles for Once-Through Closed Energy Production (> 99% burn-up)
- Coolant with fertile or fissile pebbles for Once-Through Closed Waste Burning (> 99% burn-up)
  - SNF
  - WG – Pu, HEU

LIFE systems face several scientific and technological challenges

Target production at 15 Hz @ ~ 30¢ each

Target injection and tracking

Low cost 1-1.5 MJ,
10-15 Hz 10-15% laser

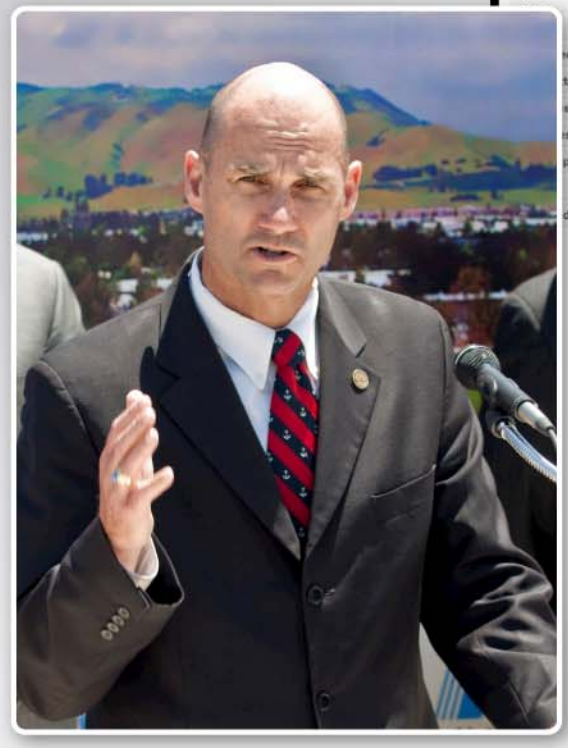


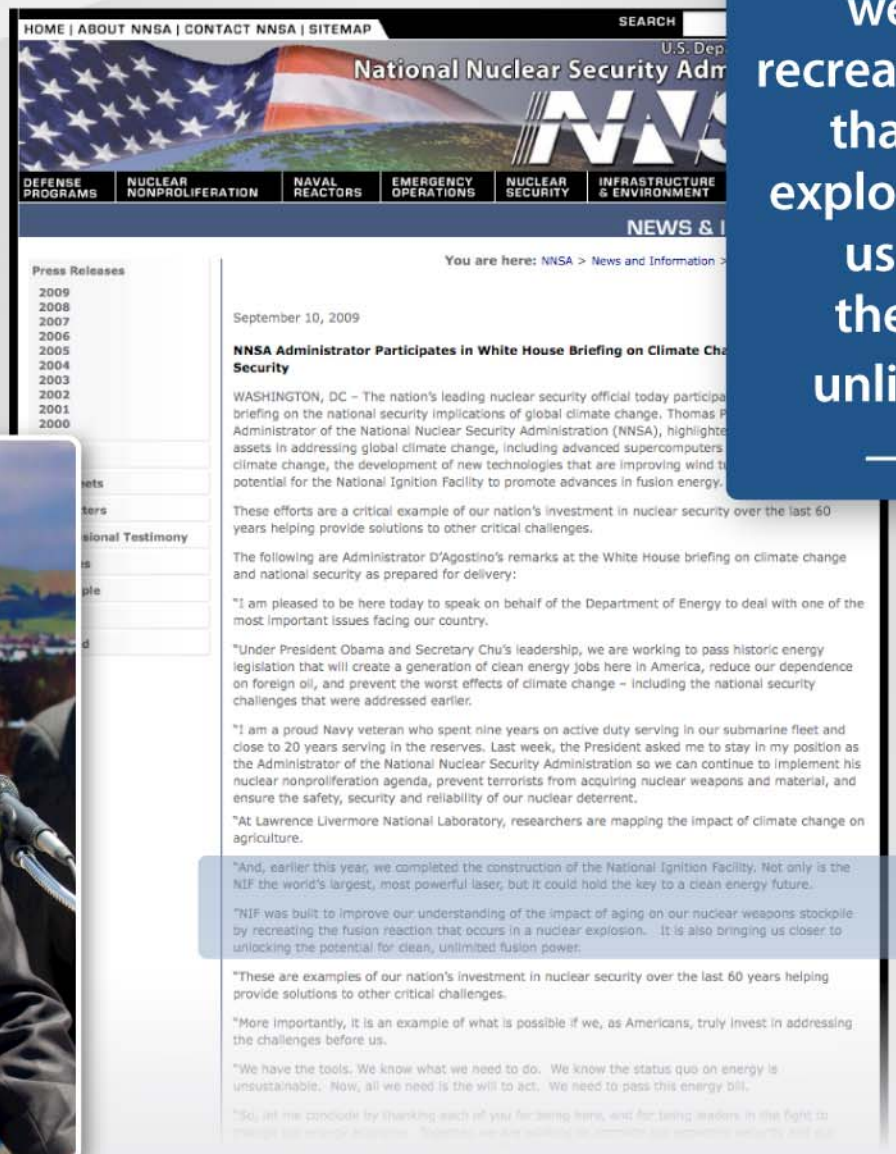
Manage fusion environment: final optics, 1st wall, chamber clearing

Robust Hot Spot yield w/LIFE-relevant targets

99% burn-up of fuel without re-fabrication or reprocessing

Tom D'Agostino at the White House Sept 10, 2009

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National Nuclear Security Adm

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sional Testimony

September 10, 2009

NNSA Administrator Participates in White House Briefing on Climate Cha Security

WASHINGTON, DC – The nation's leading nuclear security official today participa briefing on the national security implications of global climate change. Thomas P Administrator of the National Nuclear Security Administration (NNSA), highlighte assets in addressing global climate change, including advanced supercomputers climate change, the development of new technologies that are improving wind t potential for the National Ignition Facility to promote advances in fusion energy.

These efforts are a critical example of our nation's investment in nuclear security over the last 60 years helping provide solutions to other critical challenges.

The following are Administrator D'Agostino's remarks at the White House briefing on climate change and national security as prepared for delivery:

"I am pleased to be here today to speak on behalf of the Department of Energy to deal with one of the most important issues facing our country.

"Under President Obama and Secretary Chu's leadership, we are working to pass historic energy legislation that will create a generation of clean energy jobs here in America, reduce our dependence on foreign oil, and prevent the worst effects of climate change – including the national security challenges that were addressed earlier.

"I am a proud Navy veteran who spent nine years on active duty serving in our submarine fleet and close to 20 years serving in the reserves. Last week, the President asked me to stay in my position as the Administrator of the National Nuclear Security Administration so we can continue to implement his nuclear nonproliferation agenda, prevent terrorists from acquiring nuclear weapons and material, and ensure the safety, security and reliability of our nuclear deterrent.

"At Lawrence Livermore National Laboratory, researchers are mapping the impact of climate change on agriculture.

"And, earlier this year, we completed the construction of the National Ignition Facility. Not only is the NIF the world's largest, most powerful laser, but it could hold the key to a clean energy future.

"NIF was built to improve our understanding of the impact of aging on our nuclear weapons stockpile by recreating the fusion reaction that occurs in a nuclear explosion. It is also bringing us closer to unlocking the potential for clean, unlimited fusion power.

"These are examples of our nation's investment in nuclear security over the last 60 years helping provide solutions to other critical challenges.

"More importantly, it is an example of what is possible if we, as Americans, truly invest in addressing the challenges before us.

"We have the tools. We know what we need to do. We know the status quo on energy is unsustainable. Now, all we need is the will to act. We need to pass this energy bill.

"So, let me conclude by thanking each of you for being here, and for being leaders in the fight to

"NIF was built to improve our understanding of the impact of aging on our nuclear weapons stockpile by recreating the fusion reaction that occurs in a nuclear explosion. It is also bringing us closer to unlocking the potential for clean, unlimited fusion power."

— NNSA Administrator

DOE has announced the National Academy of Science study of fusion energy future

“The National Ignition Facility is a marvel, and while the Laboratory will achieve ignition, we need to think about what we should be doing in a year or two from today."

“ Steve Koonin is already heading up an effort at DOE for inertial fusion energy R&D planning. DOE should assume ignition success in that planning, and not wait for NIF ignition to start such planning.”

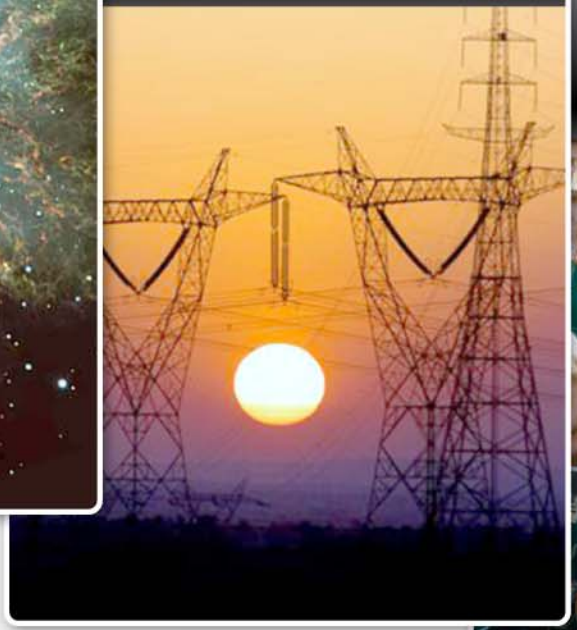
- Stephen Chu U.S. Secretary of Energy

NIF missions

Ensuring Global Stability & Global Security

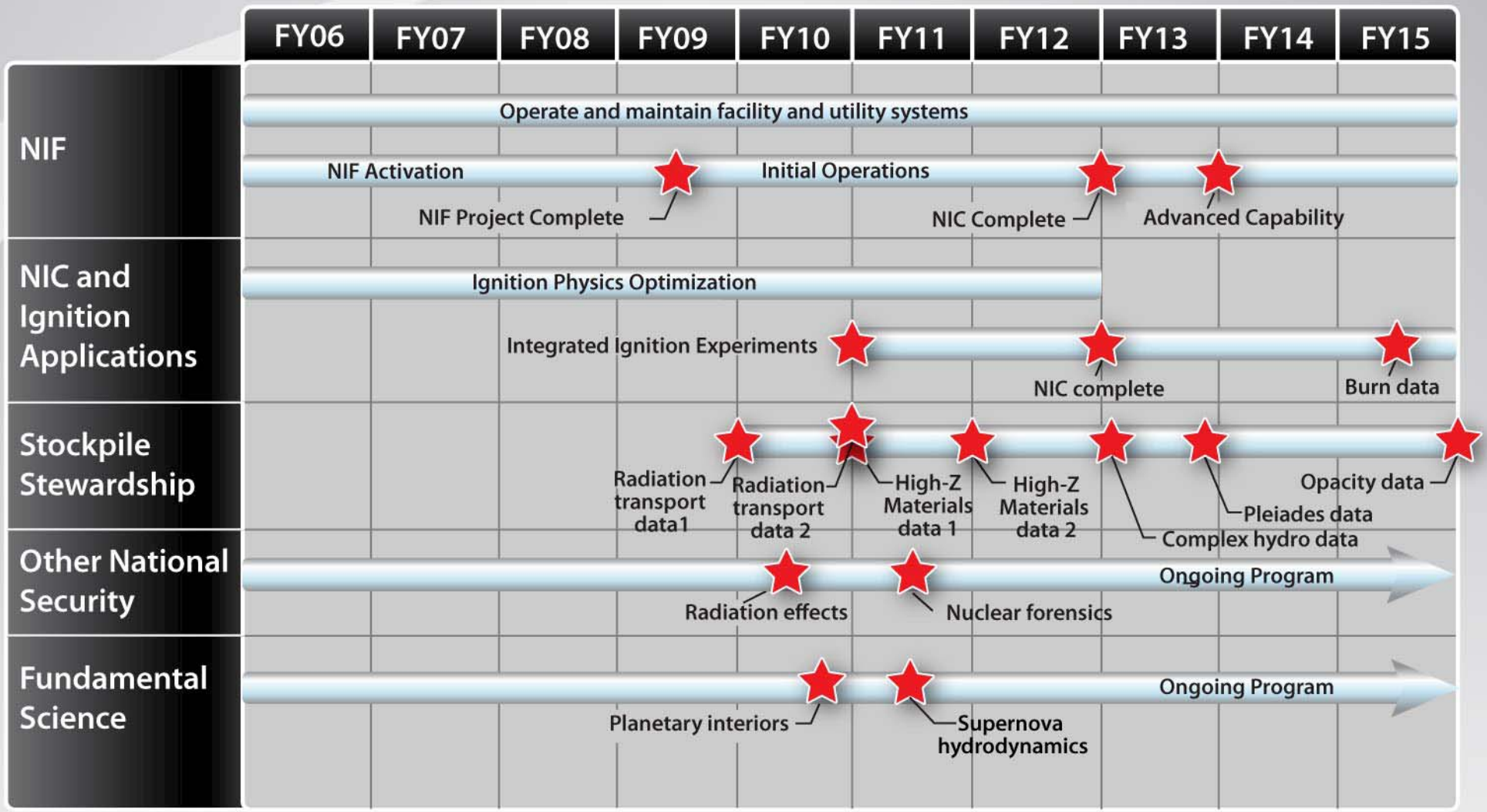
Advancing Frontier Science

Enabling Clean Energy



Building Future Generations of HED Scientists

NIF will provide a unique experimental platform for multiple missions



NIF is operational, conducting experiments and acquiring great data