National Ignition Facility Update

2026 NIF/JLF User Group Meeting

Gordon Brunton
National Ignition Facility Director

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LLNL-PRES-2015651

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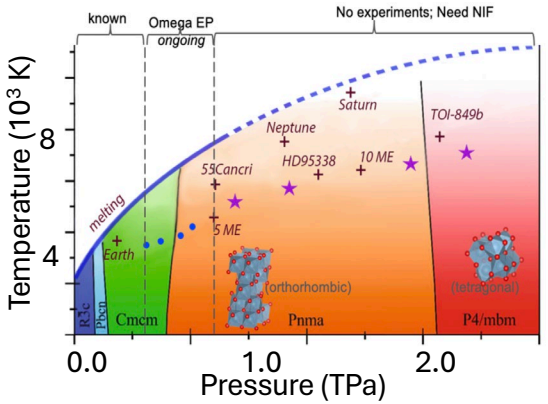
Lawrence Livermore National Laboratory

NIF had a year of many highs and a few challenges, but we continue to deliver for all users

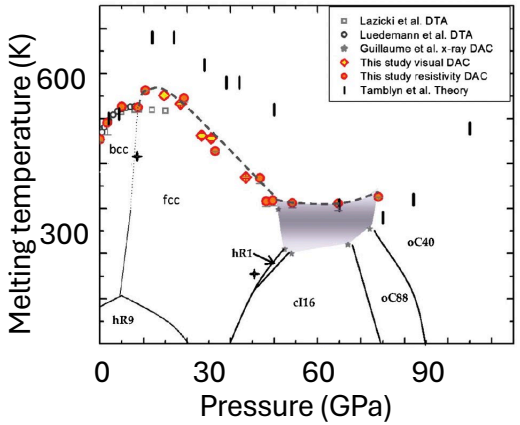
- Achieved two highest ignition target gains in FY25, including a new record yield
- Completed the first-of-a-kind yield stockpile modernization experiment on NIF
- Managing increased optic damage, resulting in a temporary laser energy limit and a focused recovery effort
- Executing essential NIF sustainment refurbishments, required a shift to midweek maintenance
- Making strong progress on the NIF EYC upgrade, with project funding starting this year
- Continuing to push NIF's scientific and capability frontiers, reflected in major publications and awards

The 2026 Discovery Science projects span planetary science, laboratory astrophysics, nucleosynthesis and electron screening in stellar interiors

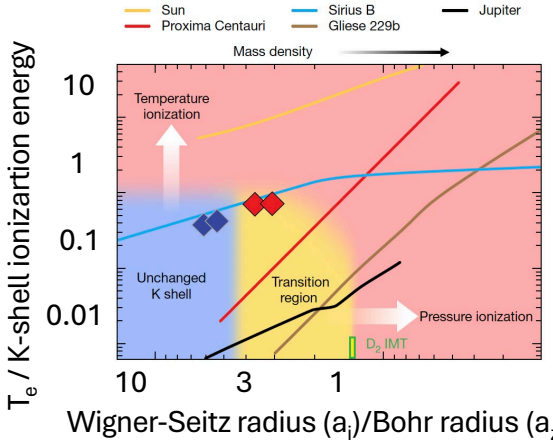
Al2O3 (alumina) crystal structures at multi-TPa pressures
Terry-Ann Suer (UR LLE)



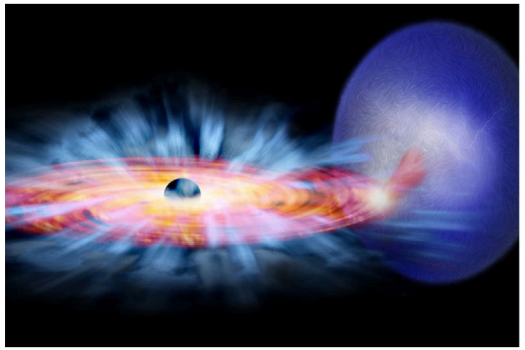
Lithium multi-shock EOS
Shanti Deemyad (Univ. Utah)



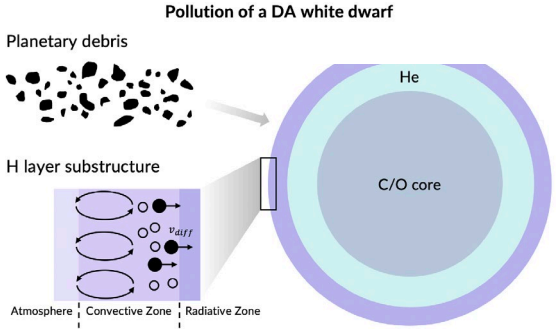
Sirius B white dwarf science
Tilo Döppner (LLNL)



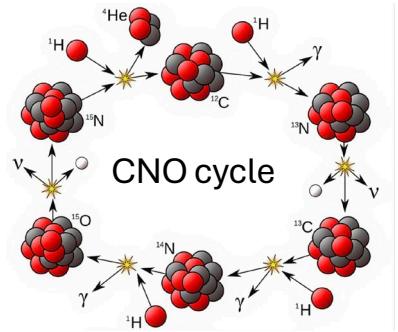
Iron photoionized plasmas relevant to black-hole accretion disks
Roberto Mancini (UNR)



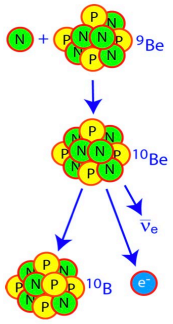
Ionization state of mid-Z traces for white dwarf astrophysics
Willow Martin (Stanford)



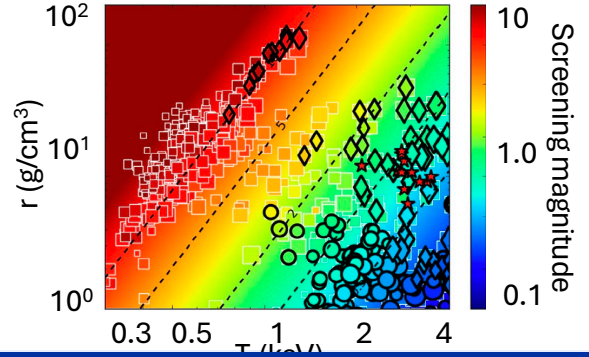
Stellar nucleosynthesis: CNO cycle in massive stars
Andrew Lanzrath (MIT)



Neutron capture in plasma, for generating the heavy nuclei
Brian Appelbe (Imperial College)



Plasma electron screening relevant to stellar nucleosynthesis
Daniel Casey (LLNL)



We continue to be impressed by the quality of DS proposals covering a wide range of fundamental science

NIF's priorities over the next decade strive to expand mission value while growing the next generation HED scientists and engineers

- **Execute HED science and ignition applications**
  - Deliver robust NIF operations through the 2040s
  - Execute robust applications of multi-MJ yields

  2.2 MJ laser
  <5MJ yield

  2026

- **Increase ICF performance with improved sensitivity understanding**
  - Enable higher yield compatibility of current NIF capabilities
  - Understand performance sensitivities to increase target gains

  2.2 MJ laser
  10+MJ yield

  2026

- **Maximize NIF performance to expand applications at higher yields**
  - Deliver an Enhanced Yield Capability (EYC) on NIF
  - Design, develop, and test EYC ignition platforms and applications on NIF

  2.6 MJ laser
  30+MJ yield

  2032

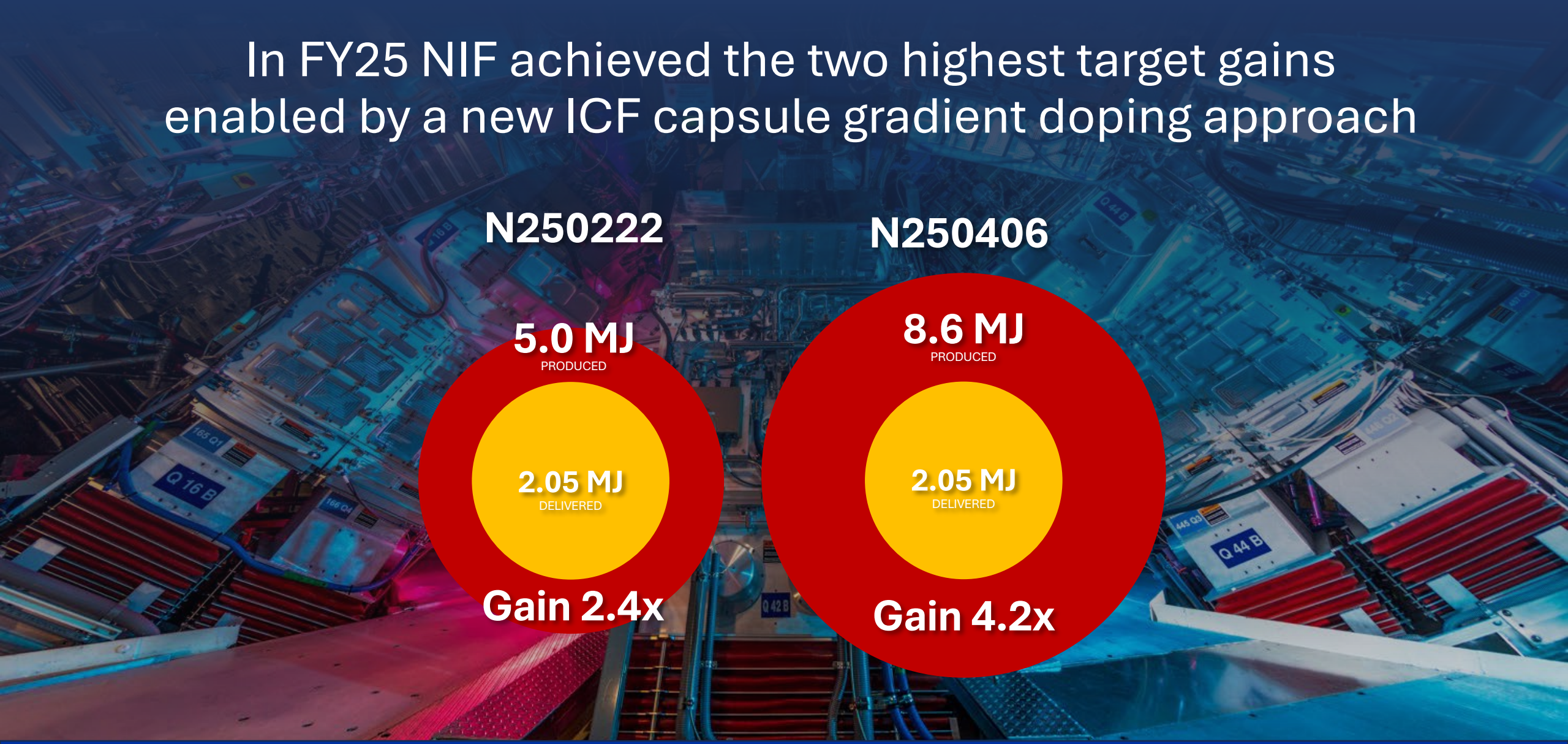
- **Prepare for next-gen high yield facility**
  - Develop high yield ignition applications to close stockpile capability gaps
  - Improve maturity of science and technology supporting high yield applications and next-generation HED capability

  ? MJ laser
  200+MJ yield

  204x

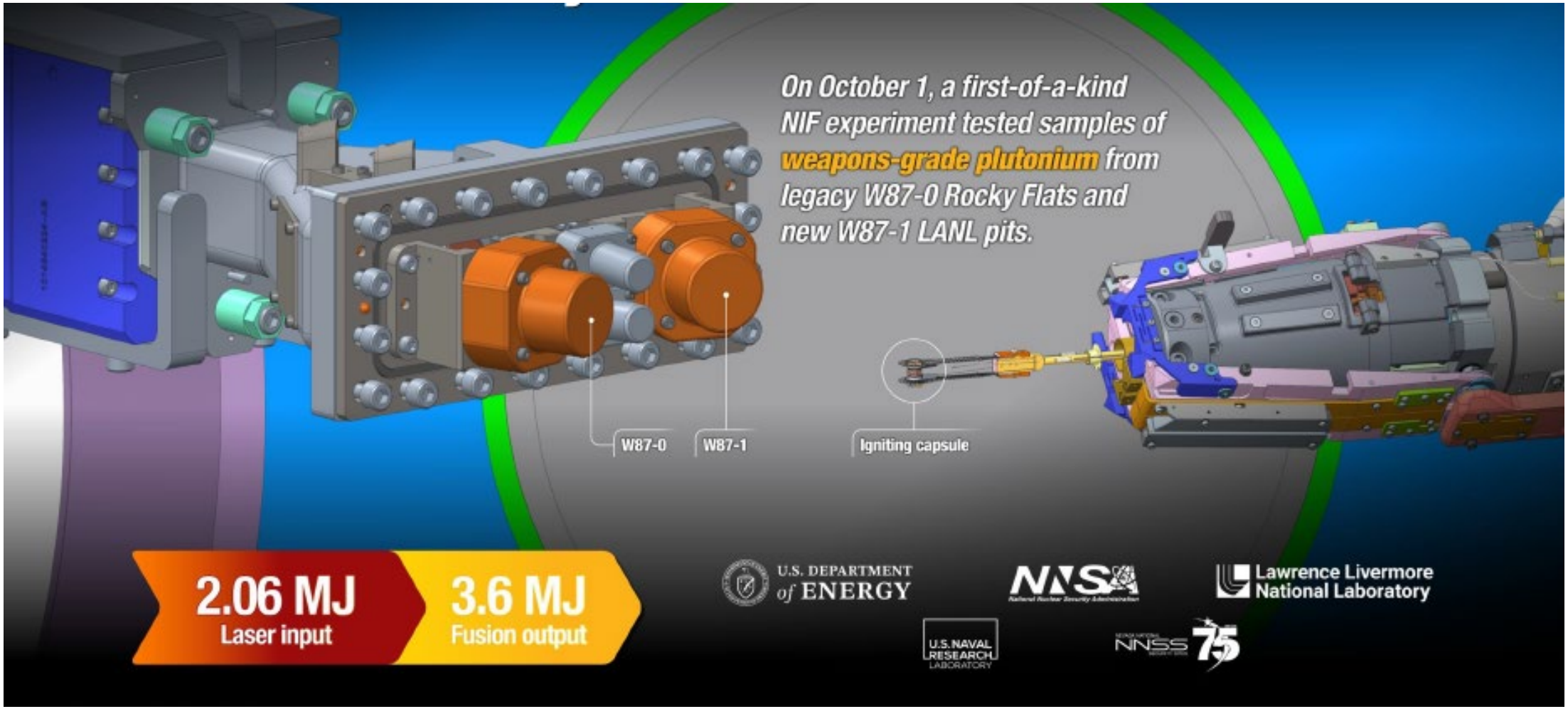
It is an exciting time for NIF and its users and expanding its performance opens many new opportunities

In FY25 NIF achieved the two highest target gains enabled by a new ICF capsule gradient doping approach



The new capability appears more forgiving to mix instabilities
and most ICF experimental campaigns are now favoring this capsule type

We successfully applied ignition yields on a recent shot to support the W87-1 survivability certification



Several years of preparation across many teams enabled this first-of-a-kind capability on NIF

The most critical NIF sustainment projects are underway and good progress is being made to address degradations and obsolescence risks

Partially Commenced

Injection Laser

- High Fidelity Pulse Shaping
- Beam-based Spot Blockers
- Diode-pumped Multi-pass Amplifiers
- 3ω Power Sensors

Amplifiers

- Debris Elimination & Refurbishment
- Pulsed Power Replacements
- Transport and Handling Equipment

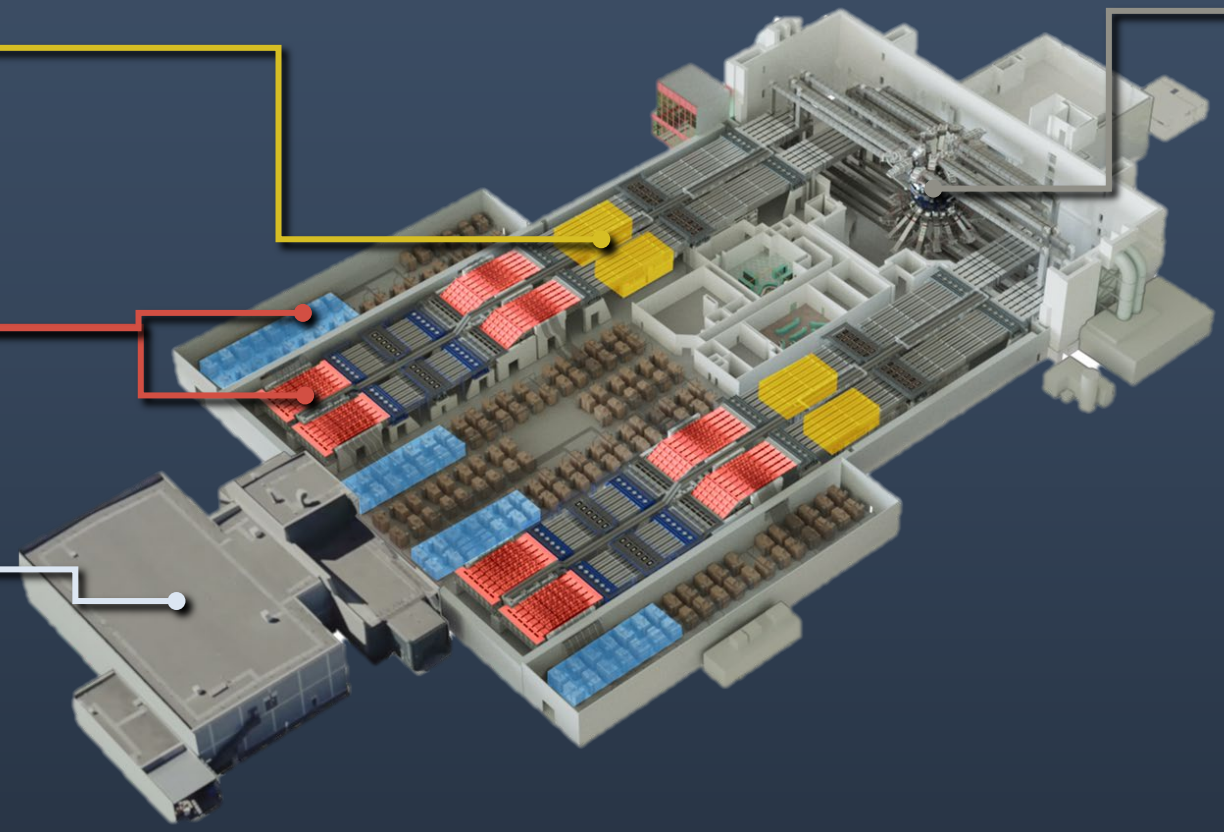
Optics Processing

- Equipment Refurbishments

Target Fabrication

Separate LLNL facility

- Equipment Replacements
- Data/ Processing Equipment
- General Atomics Equipment



Target Area

Final Optics

- Final Optics Refurbishment
- Debris Induced Damage Mitigation
- Blue Blockers
- Optic Installation Platforms
- Vacuum Phase Plate Exchange

Alignment and Optics Inspection

- Final Optics Damage Inspection
- Chamber Interior Viewing System
- Target Alignment System

Other

- Chamber Entry Lift Refurbishment
- Polar Diagnostic Insertion Mechanism
- Target Line Replaceable Unit

Controls and Data Systems

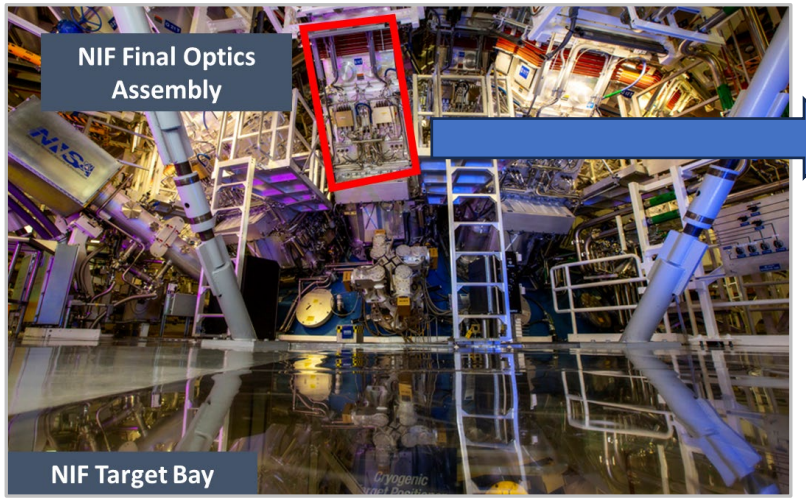
Facility wide effort

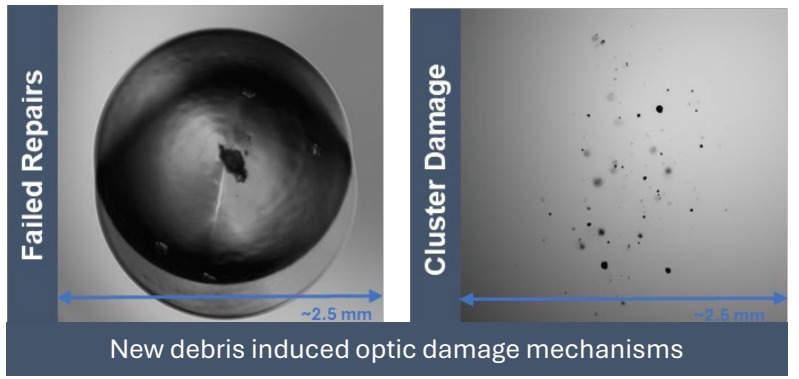
- Industrial Controls Replacements
- Facility Controls Replacements
- Embedded Controller Replacements
- Laser System Controls Replacements
- Alignment and Optics Inspection Controls
- Data Archive Replacement

We expect to complete all refurbishments by FY31, funding dependent

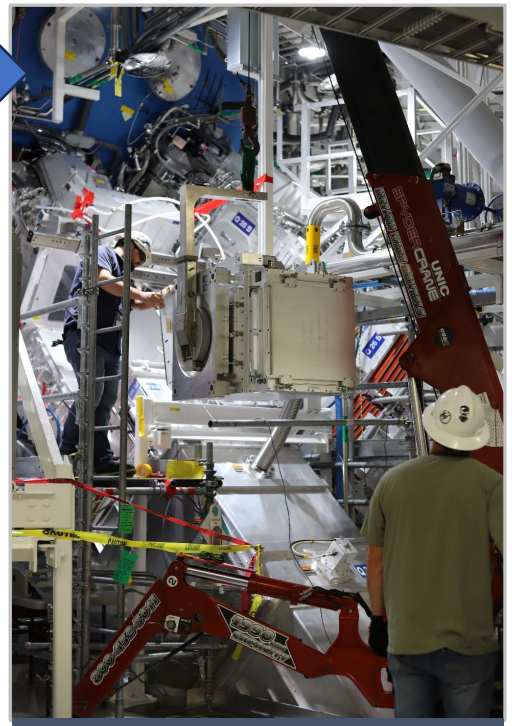
Delays in NIF sustainment funding have resulted in inability to address key risks in the necessary timeframe

- Risk of excessive damage on NIF final optics been realized
- Temporarily reduced maximum NIF energy to 1.9MJ until we address degradations
- Damage mechanisms are understood and we have demonstrated solutions
- Halfway through refurbishing 32 worst offending beamlines in FY26 to restore performance to 2.05MJ starting Q4





New debris induced optic damage mechanisms



Integrated Optics Assembly removal

A restoration to 2.2MJ operations will be assessed, based on damage levels, in FY27

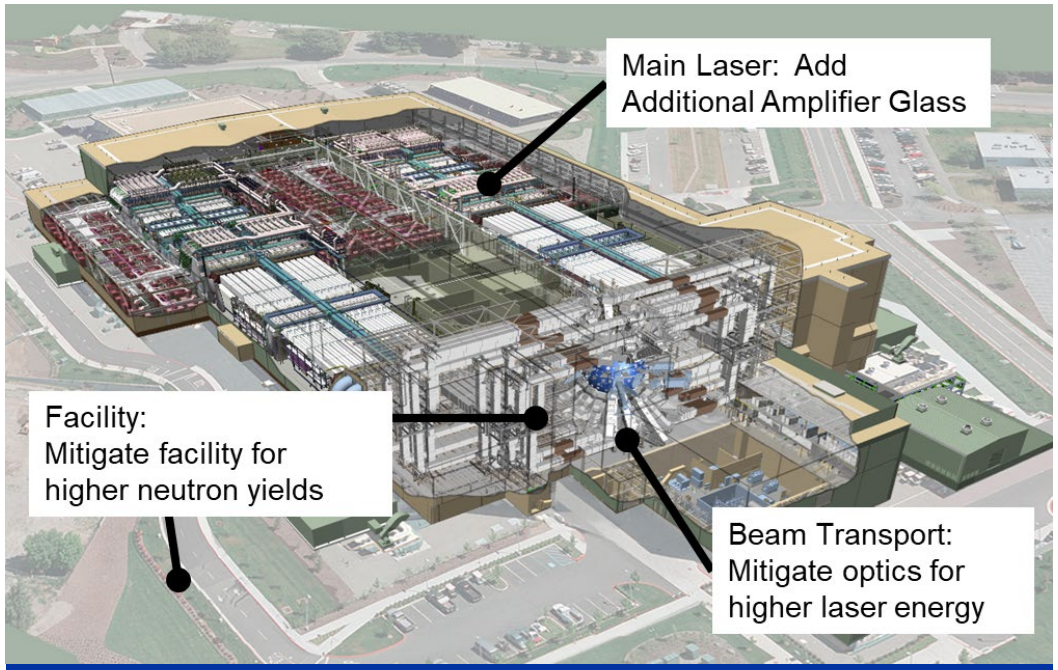
Successfully completing NIF sustainment refurbishments necessitated a shift to mid-week maintenance

- Refurbishing Integrated Optics Modules (IOM) in weekly maintenance periods demands a robust schedule
- Each exchange to-date required off-hours engineering expertise to address issues and minimize shot week disruption
- After initial 32 IOMs are refurbished in Q3 we intend to continue with the remaining 160 over the next few years
- Amplifier refurbishments will also begin in FY27 and we anticipate the same level of support needed, at least initially

Hoisting & Rigging IOM into place

We will reassess annually a return Fri/Sat maintenance as our processes mature

In FY26 we will commence the Enhanced Yield Capability (EYC) project to upgrade the NIF to its maximal performance



Enhanced Yield Capability Scope

- Modest upgrades required using existing designs and established supply chains
- Laser energy increase from 2.2 MJ to 2.6 MJ and expanded applications of yield
- Project commencement approved by NNSA and DOE approval imminent
- Funding for EYC begins in FY26
- With the necessary funding levels, EYC will begin operating in 2032

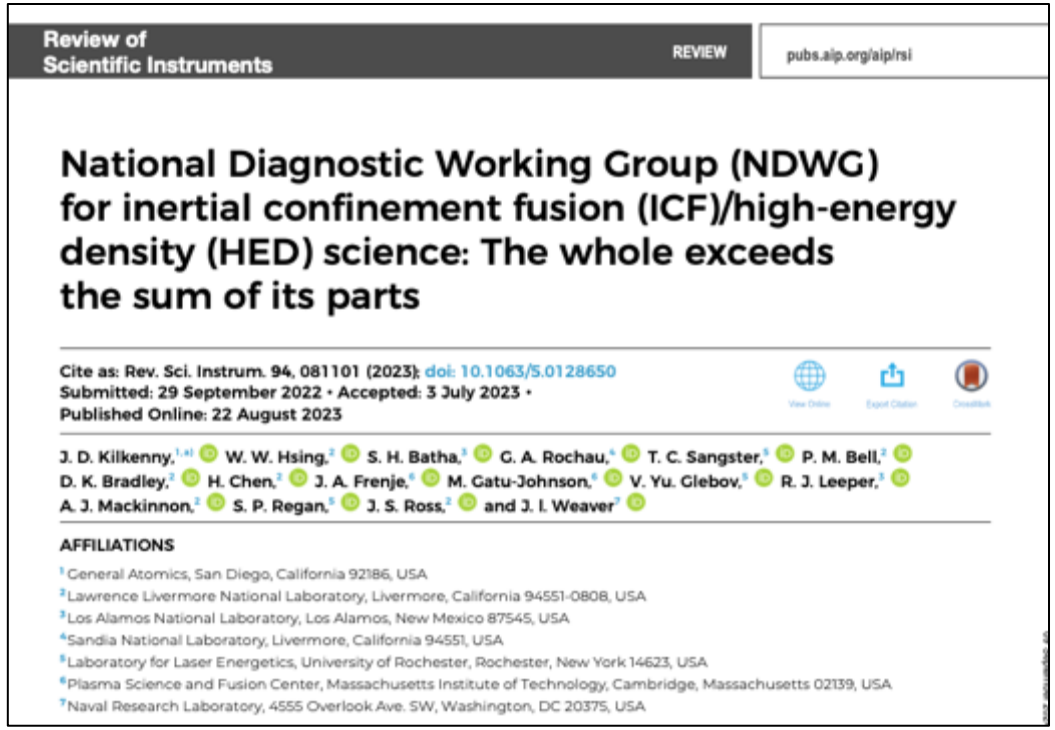
With EYC performance we anticipate achieving fusion yields >30MJ

NIF's diagnostics are developed in collaboration with the HED diagnostic community through the NDWG

Participants of the ninth meeting of the NDWG held in September 2014 with ~117 attendees.

National Diagnostics Working Group (2022)

Hosted by Sandia National Laboratories, Albuquerque, New Mexico



Review of Scientific Instruments — REVIEW — pubs.aip.org/aip/rsi

National Diagnostic Working Group (NDWG) for inertial confinement fusion (ICF)/high-energy density (HED) science: The whole exceeds the sum of its parts

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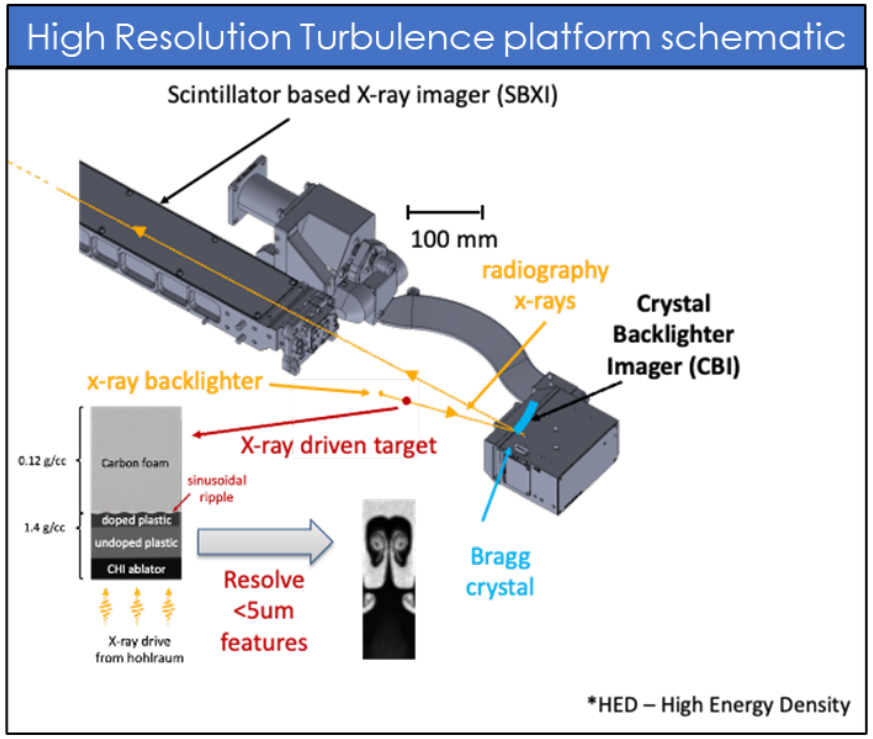
NIF's diagnostics continue to be impactful in many areas of HED *

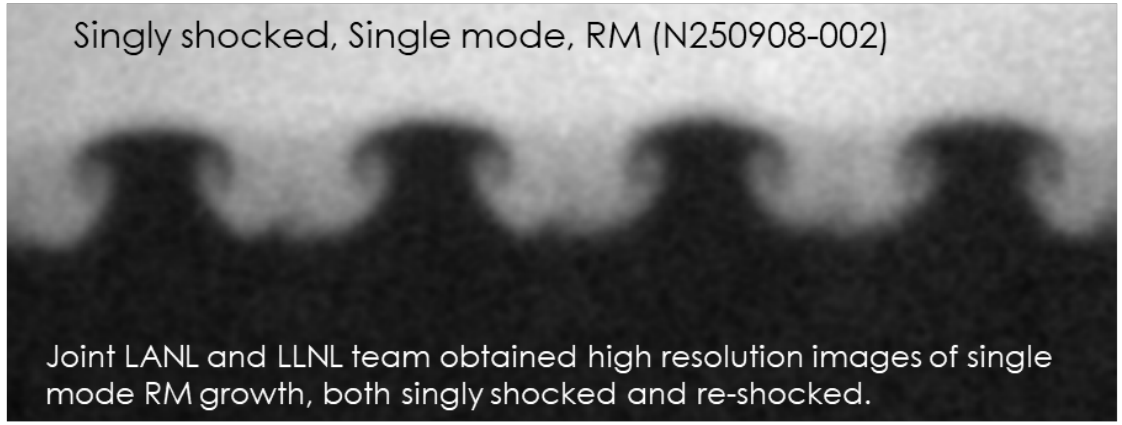
* Ignition, EOS of materials at high pressures, rad transport, hydro instabilities, survivability, nuclear cross sections... etc

We all continue to benefit from the NDWG input to guide the highest value diagnostic advancements on NIF

A new High Resolution Turbulence diagnostic has enabled the highest resolution levels of hydrodynamic instabilities



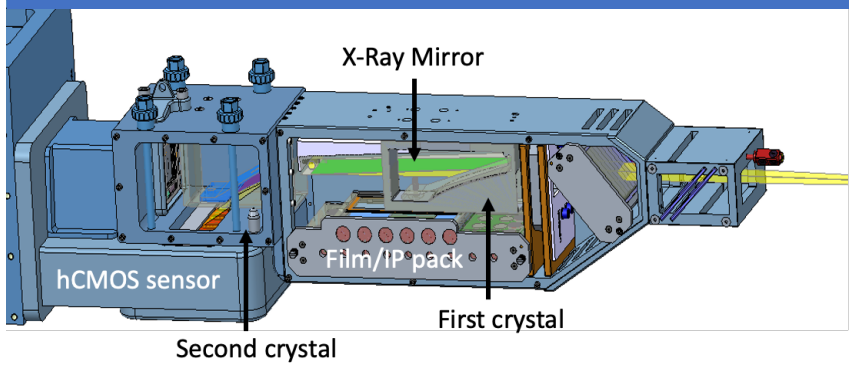
Item	Requirement	Measured	Check
Resolution at scintillator	< 25 μm	11 μm	✓
Field of View on scintillator	6 x 6 mm	11 x 11 mm	✓
DQE	> 3%	30%	✓
SNR	>15	30	✓



HRT is providing the highest precision of Rayleigh Taylor Instabilities ever achieved on NIF experiments

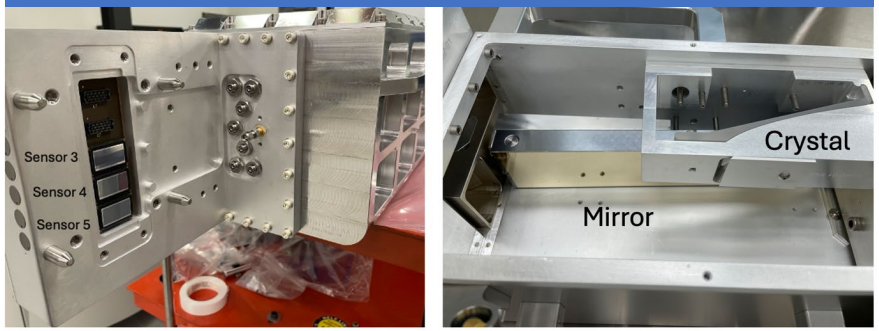
A new time-resolved Opacity Spectrometer has been successfully commissioned on NIF

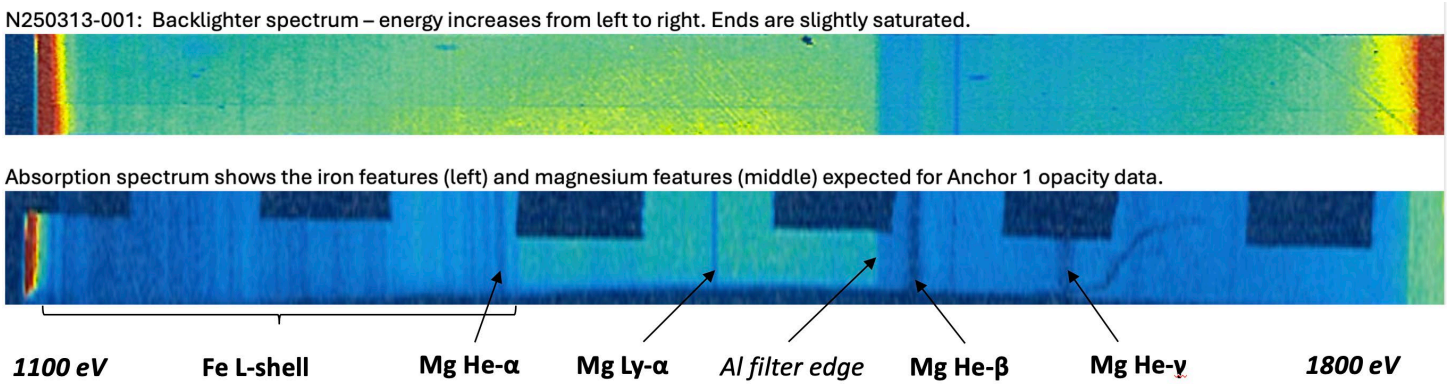
OPSPECTR schematic



- Accurate X-ray opacities with quantified uncertainties are critical for radiation-hydrodynamic simulations, but experimental data to validate opacity models are very sparse
- NIF opacity experiments are checking unexpected results from prior Z measurements. Time-gating helps to reduce backgrounds which limited previous NIF capabilities

OPSPECTR components

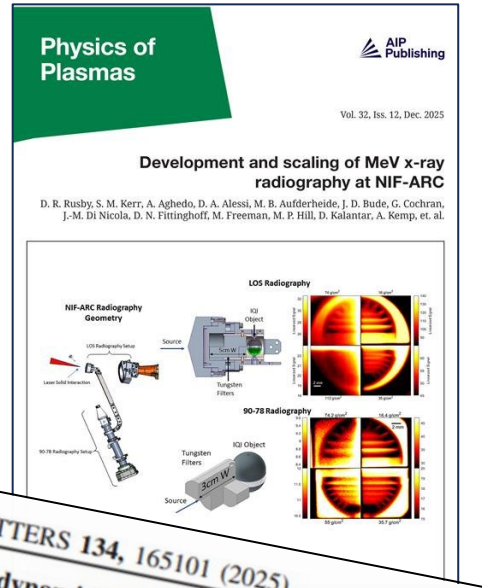


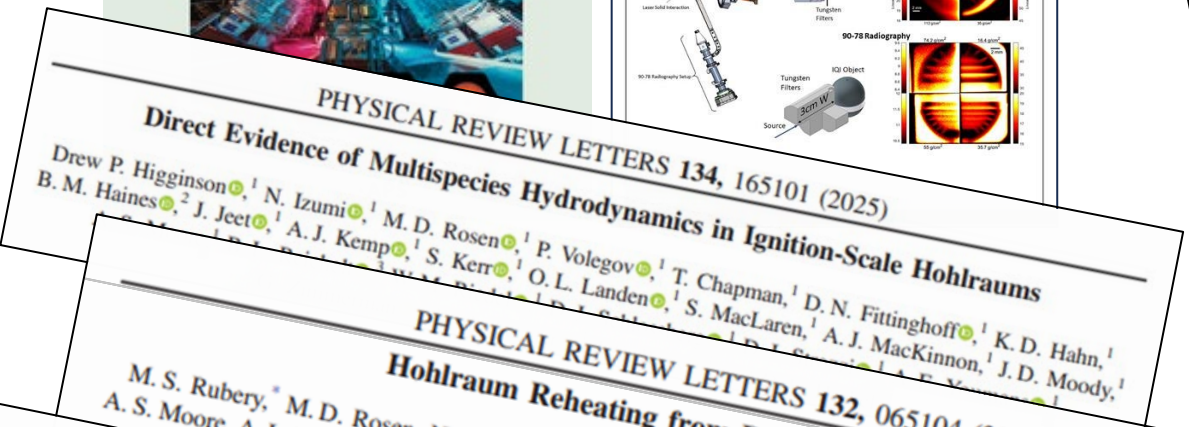


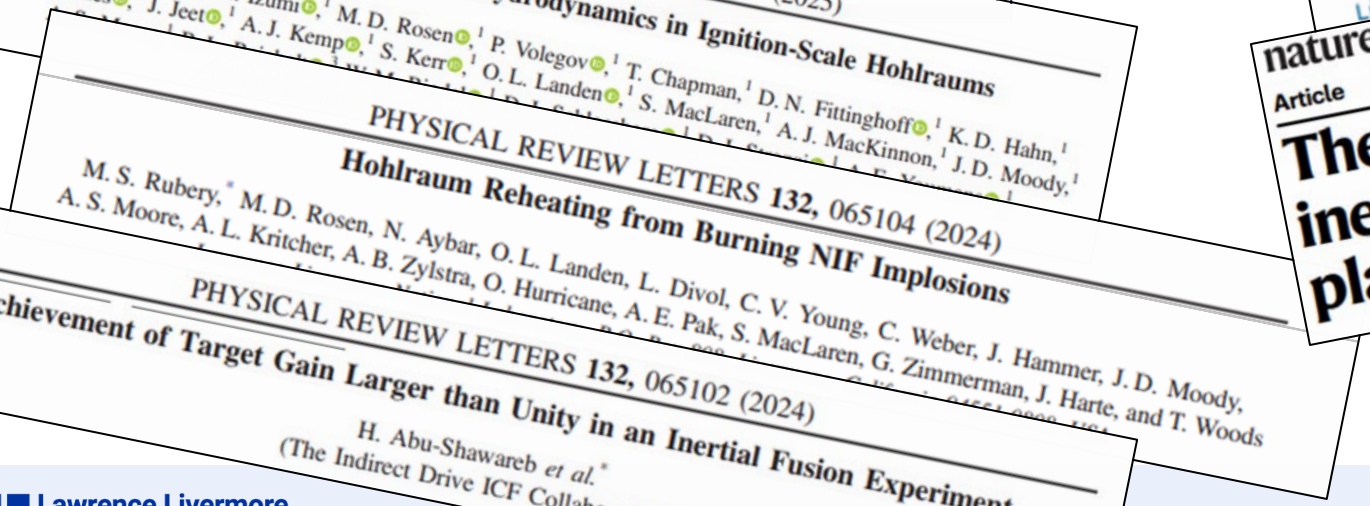
Data from NIF shot, with iron and magnesium opacity spectral features identified.

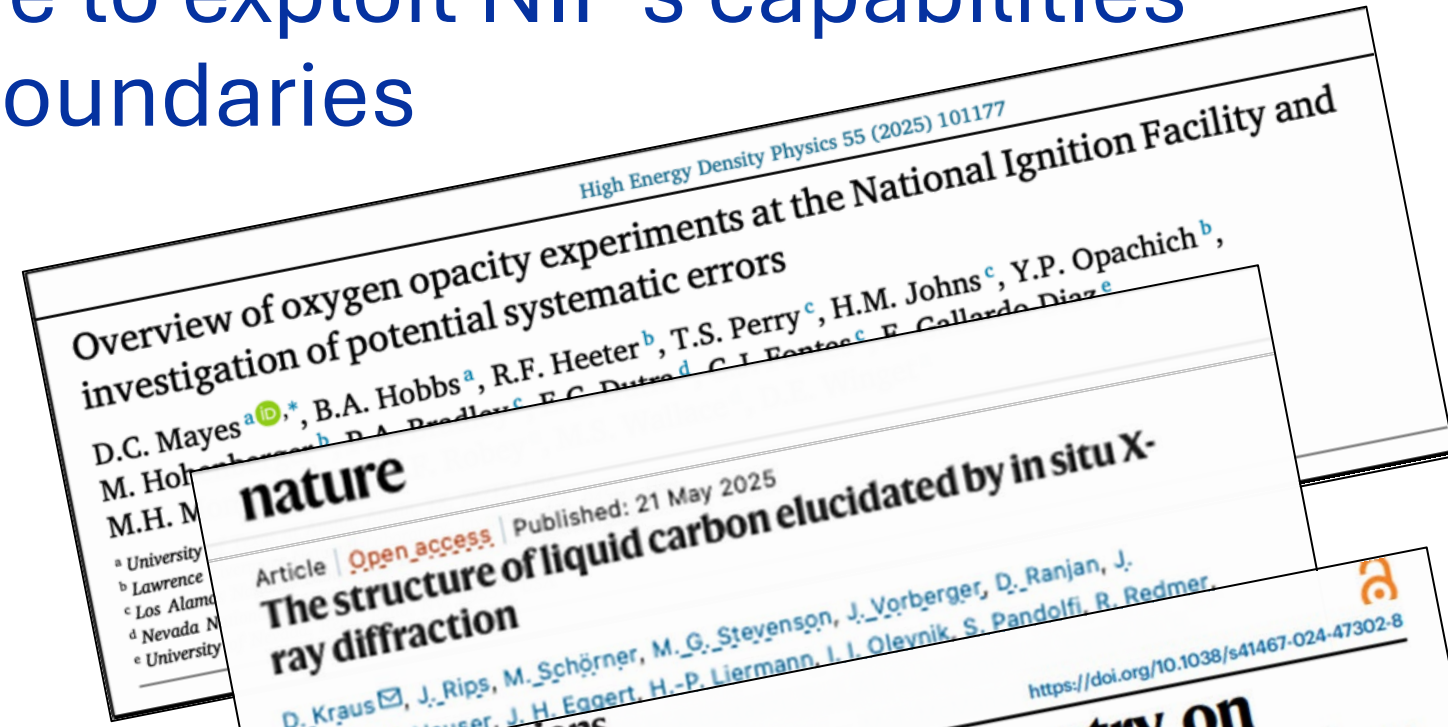
This capability enables NIF to measure opacities more accurately and at more extreme conditions

HED scientists continue to exploit NIF's capabilities to push the scientific boundaries









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Livermore scientific staff have had a highly productive year and received many high-profile awards and honors

LLNL physicist Hye-Sook Park receives Edward Teller Award

NIF target innovator Abbas Nikroo awarded the Fusion Power Associates 2025 Distinguished Career Award

Robin Benedetti and the NIF FIDDLE team received a 2025 R&D 100 award

Kelli Humbird, Tomi Akindele and Holly Carlton were awarded the Presidential Early Career Award for Scientists and Engineers

Charles Yeamans has won the Nuclear Fusion Award, announced in 2025 by the IAEA

David Alessi Named Senior Member of Optica

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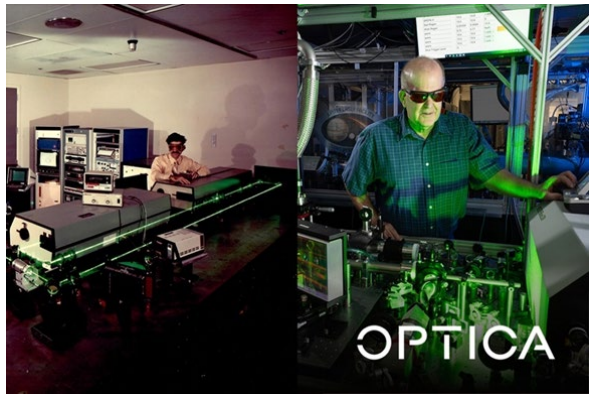
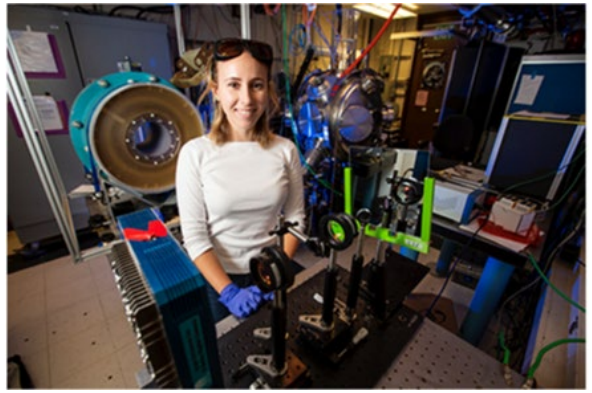
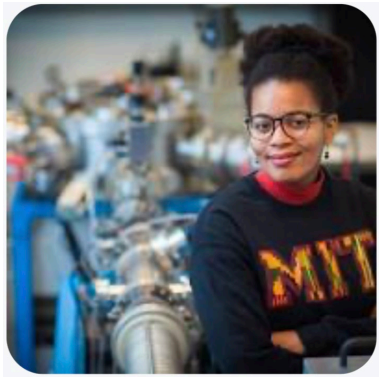


Mark Henesian (left) and Brent Stuart (right) were elected as Optica fellows

2025 Director's Institutional Operational Excellence Award for enabling first weapons grade plutonium experiment on NIF



Elizabeth Grace received award for developing the STRIPED FISH and SAPPHIRE diagnostics on NIF



Raspberry Simpson has won a 2025 NIF Igniter Award for helping to drive world-class innovation and brings out the best in our workforce to meet the challenges of our national security missions

I look forward to another outstanding year of achievements and recognition for our teams

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- Continuing to push NIF's scientific and capability frontiers, reflected in major publications and awards

Thank you all for the amazing support, contributions and results you achieve on NIF!

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