

The New National IFE Ecosystem

NIF & JLF User Group Meeting

Tammy Ma

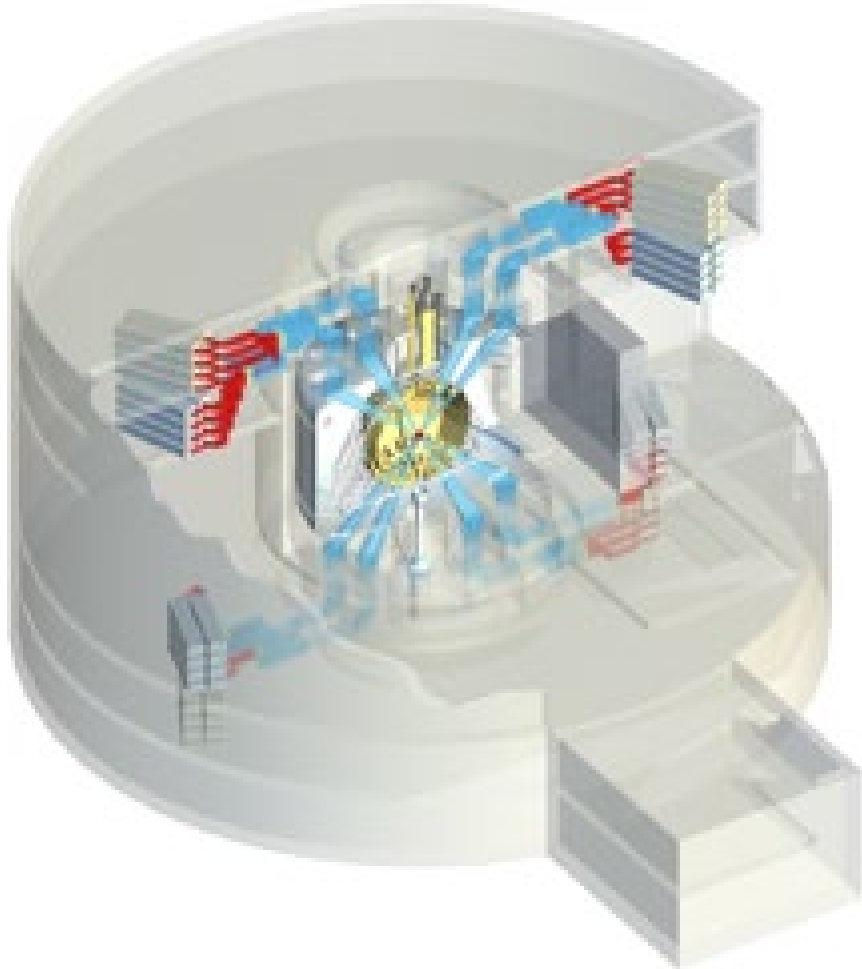
Lead, Inertial Fusion Energy Initiative
Lawrence Livermore National Laboratory

Feb 11, 2025

LLNL-PRES-833900

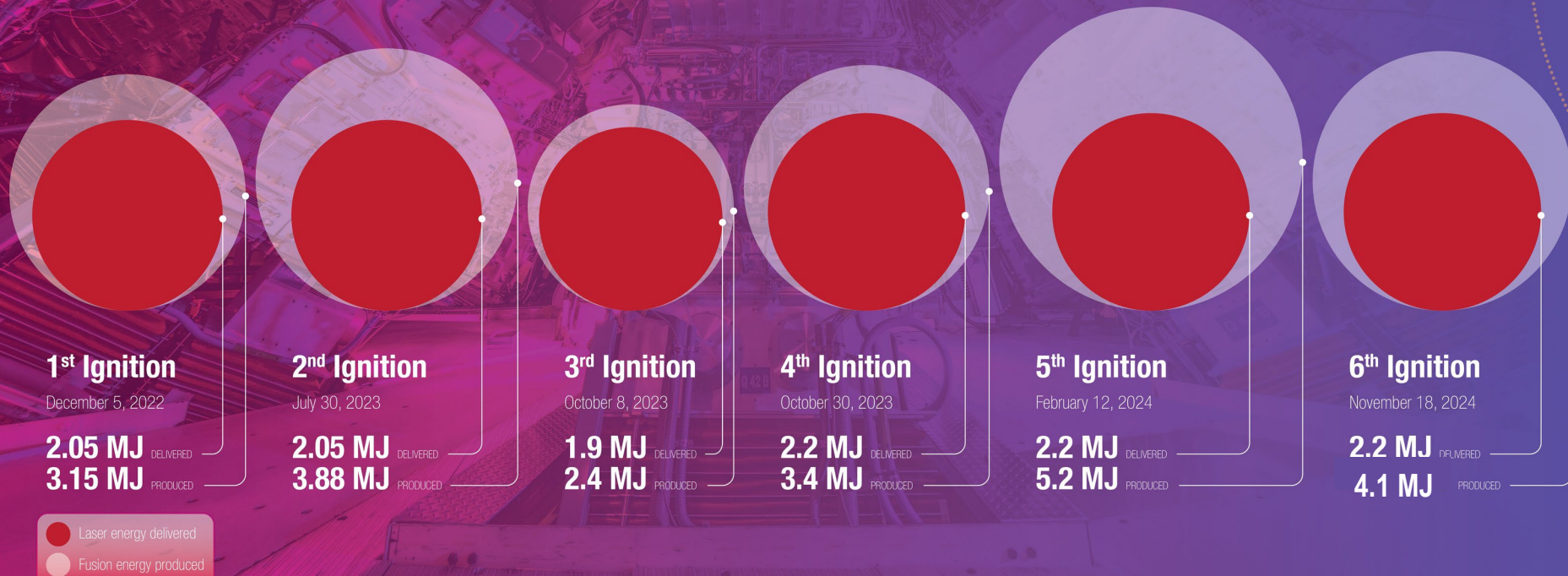
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Momentum from recent ICF success is directed towards building an IFE ecosystem and bridging the gaps to go from ignition to IFE

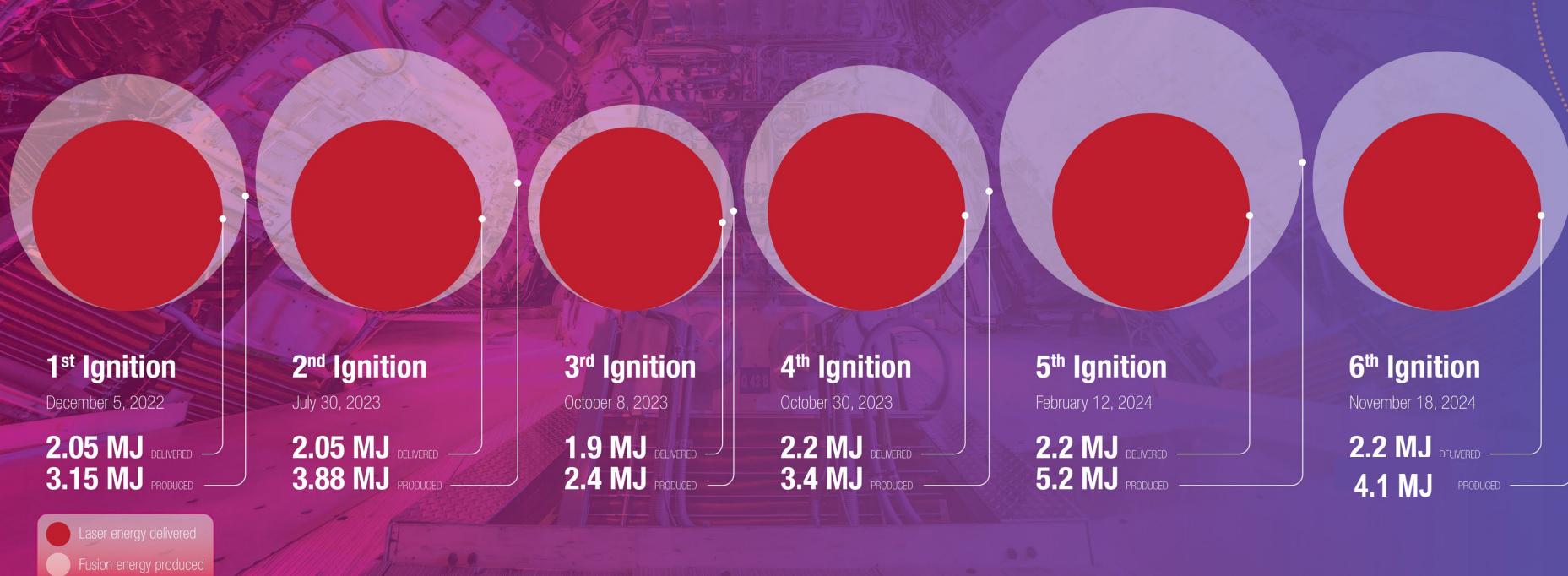


- The national IFE program is growing through DOE Office of Science programs: IFE-STAR, FIRE, more
- The IFE-STAR ecosystem coordinating structure has been established and is driving many activities
- A national IFE technology plan is getting assembled
- LD-FIRST integrated test facility and driver test facility in development with the community

Ignition has now been demonstrated 6x on the National Ignition Facility



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- Highest target gain demonstrated to-date: **2.35x**
- The scale of driver required for ignition, burn and gain has been uniquely established with ICF
- NIF is the only experiment that operates in burning and ignited plasma regimes — can be used to test IFE target designs and retire one of the most significant risks

IFE will require technology advances in many subsystems

Laser Driver

- kJ-level, rep-rated, 10-20% efficient lasers
- Economical diode scale-up

Final optics

- Survivability, laser damage thresholds
- High average power 3ω conversion

Chamber System

- First wall protection (buffer gas, liquid wall,...)
- Long lifetime radiation resistant materials

Recycling and waste

- Target materials
- Isotopic separation

Target Injection

- ~1-10 Hz at 50-200 m/s
- Tracking to lasers at <25 μm

Target Design and Fabrication

- High yield, high gain, survivable designs
 - Scale up to ~1M targets/day
- Production at ~\$0.25-0.50 each

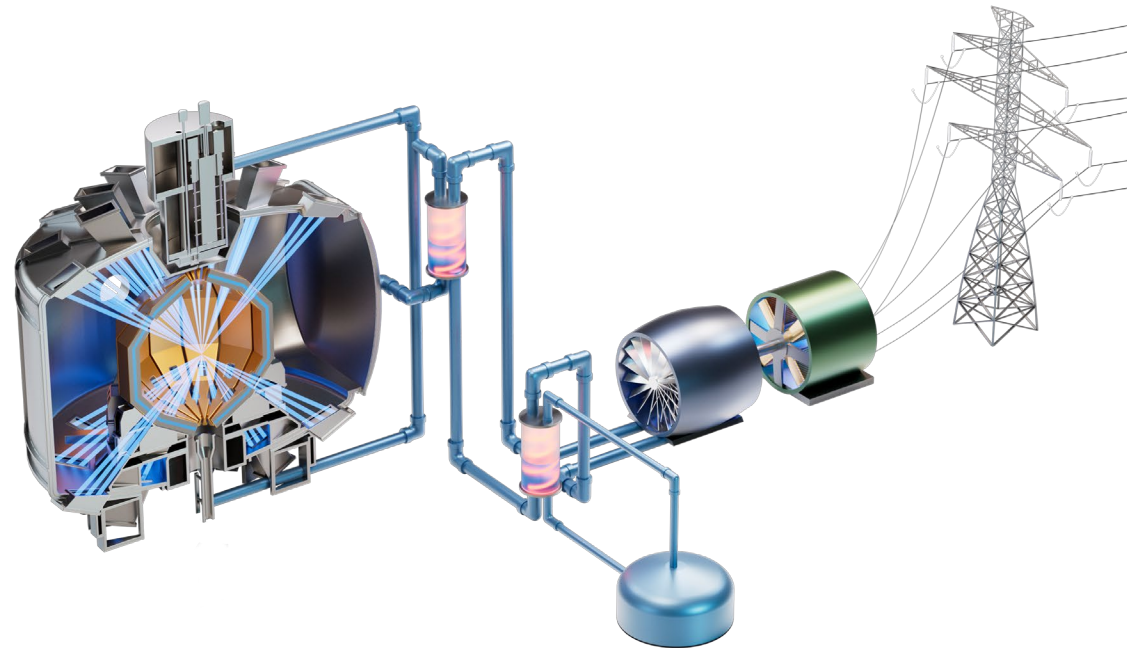
Tritium fuel cycle

- ~1 kg/day DT flowing through system
- Blanket and tritium breeding
 - Tritium recycling
- Materials constraints

System Engineering and Plant Operations

- System design and tradeoffs
 - Modularity and RAMI


(Reliability, Availability, Maintainability and Inspectability)



Each of these subsystems will need to be engineered with cost, operability, maintainability, and full system integration in mind in order for economical energy production

DOE-FES launched three IFE-STAR Hubs in 2023 to advance the S&T in key areas of IFE

DEPARTMENT OF ENERGY (DOE)
OFFICE OF SCIENCE (SC)
FUSION ENERGY SCIENCES (FES)



**INERTIAL FUSION ENERGY SCIENCE & TECHNOLOGY
ACCELERATED RESEARCH
(IFE-STAR)**

FUNDING OPPORTUNITY ANNOUNCEMENT (FOA) NUMBER:
DE-FOA-0003044

FOA TYPE: INITIAL
CFDA NUMBER: 81.049

FOA Issue Date:	May 8, 2023
Submission Deadline for Pre-Applications:	May 30, 2023, at 5 PM Eastern Time A Pre-Application is required
Pre-Application Response Date:	June 6, 2023, at 5 PM Eastern Time
Submission Deadline for Applications:	July 11, 2023, at 11:59 PM Eastern Time

Department of Energy

DOE Announces \$42 Million for Inertial Fusion Energy Hubs

DECEMBER 7, 2023



Tammy Ma
LLNL



Carmen Menoni
CSU



Dustin Froula
U Rochester

\$107M in FIRE Collaboratives were recently announced, with new awards in target injection and fuel cycle

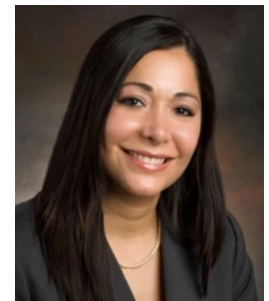


U.S. Department of Energy Announces Selectees for \$107 Million Fusion Innovation Research Engine Collaboratives, and Progress in Milestone Program Inspired by NASA

New Awards from DOE Will Support Acceleration of Commercial Fusion Energy Toward Viability



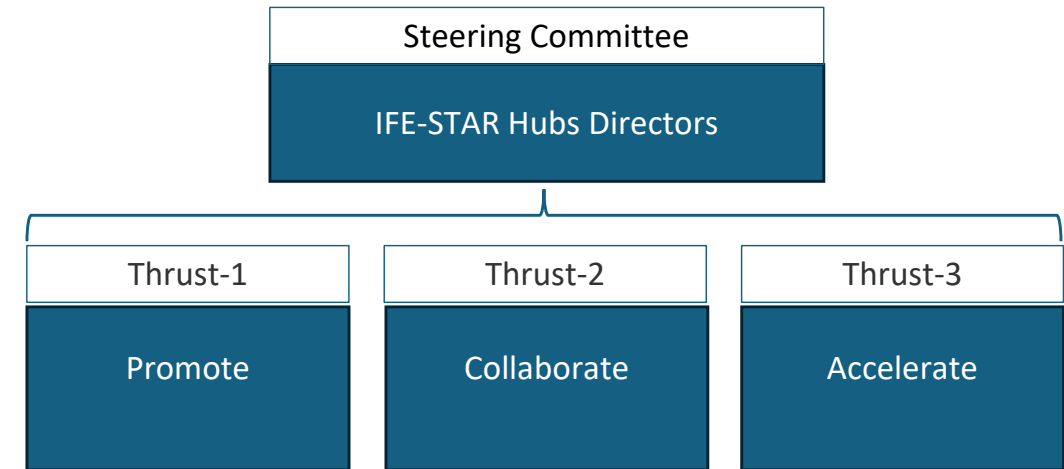
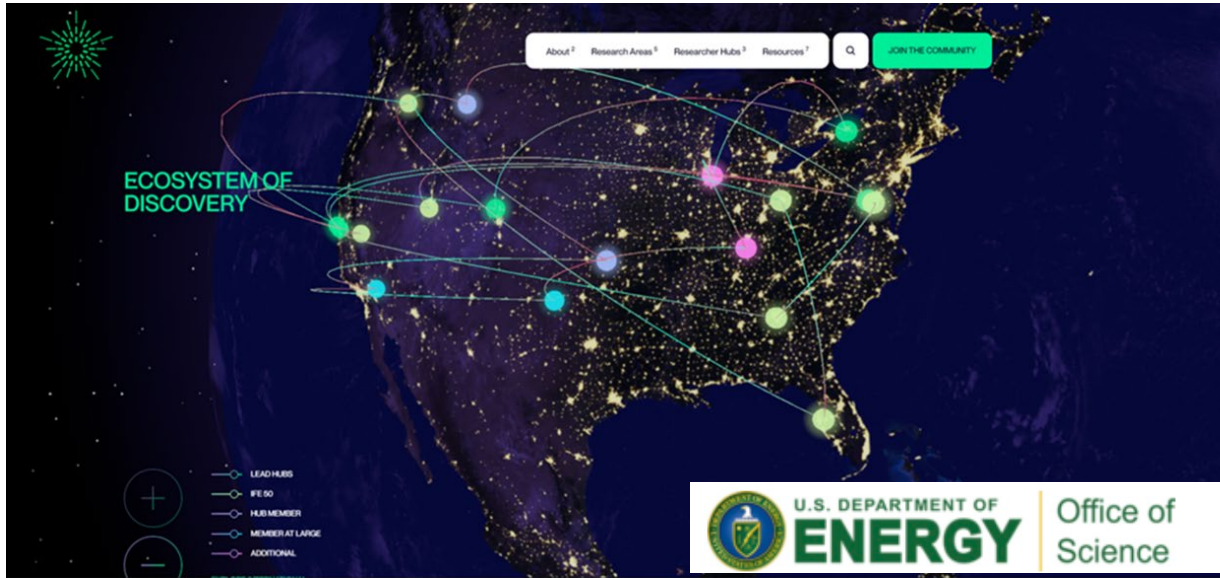
Neil Alexander
GA



Brenda Garcia-Diaz
SRNL

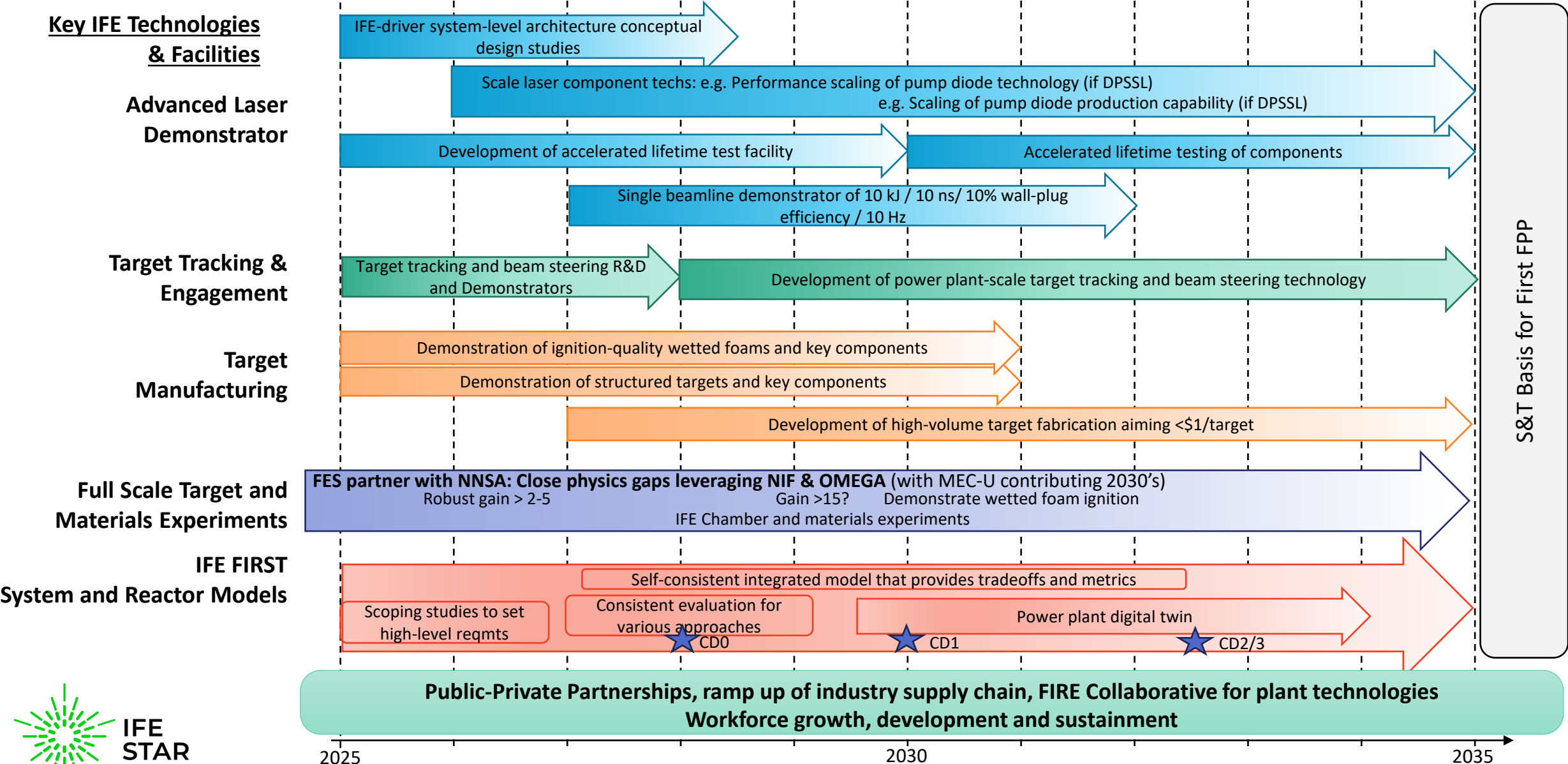


Three IFE STAR hubs are being organized into an ecosystem that will serve as the coordinating structure for the U.S. IFE program



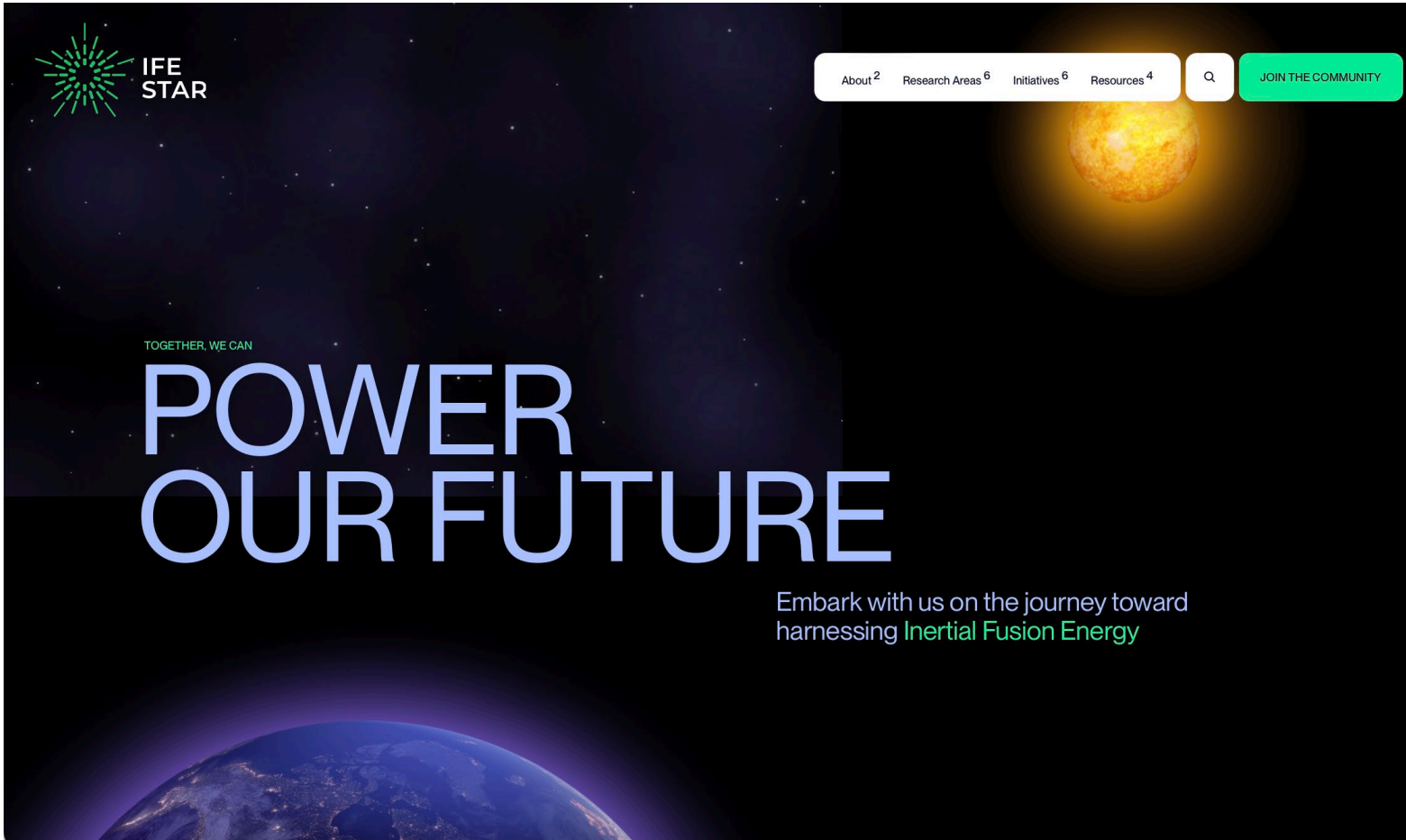
The IFE STAR Ecosystem requires a network that connects the nation, and which will include more partners such as FIRE centers and public-private partnerships

An aggressive, coordinated national technology plan to accelerate IFE is being assembled



requires far more definition, discussion, and input from many entities - very much a work in progress!

The IFE-STAR online platform is now live: <https://ifestar.org/>



The IFE-STAR website will provide up-to-date IFE information and serve as a convening location for:

- Introduction to Fusion and IFE (accessible to everyone)
- Summaries of priority research opportunities from the IFE BRN
- Information about the Hubs and other projects
- IFE publications, News, events,....
- An interactive FAQ and other resources

The IFE-STAR Ecosystem has kicked off a Summer Undergraduate Research Experience



- Common application site for undergraduate students looking for summer opportunities in IFE
- For 2025, 15 participating institutions
- >60 applications received
- In progress of matching students to internships

Brigham Young University, Provo, UT	Colorado State University, Fort Collins, CO	Ergodic, Seattle, WA	Focused Energy, Austin, TX
General Atomics, San Diego, CA	Lawrence Livermore National Laboratory, Livermore, CA	Leonardo Electronics US Inc., Tucson, AZ	Los Alamos National Laboratory, Los Alamos, NM
Massachusetts Institute of Technology, Cambridge, MA	Stanford Linear Accelerator Center (SLAC), Menlo Park, CA	Texas A&M University, College Station, TX	University of California, San Diego, San Diego, CA
University of Nebraska–Lincoln, Lincoln, NE	University of Rochester, Laboratory for Laser Energetics, Rochester, NY	Xcimer Energy, Denver, CO	

The upcoming IFE-STAR Conference will bring together the community and discuss the latest developments in IFE research

A promotional banner for the IFE-STAR 2025 Conference. The background is dark blue with a bright sun in the upper right corner. On the left, there is a green starburst logo with the text "IFE STAR" next to it. The main text "IFE-STAR 2025 Conference" is in large, bold, white letters. Below that, it says "April 7 - 11 • Breckenridge, CO" in a smaller white font.

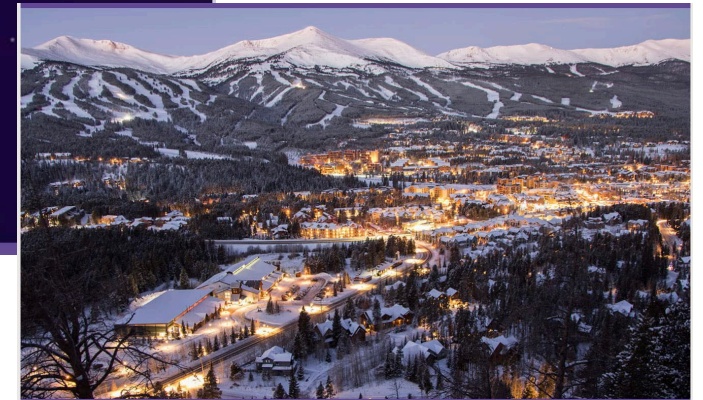
 IFE STAR

IFE-STAR 2025 Conference

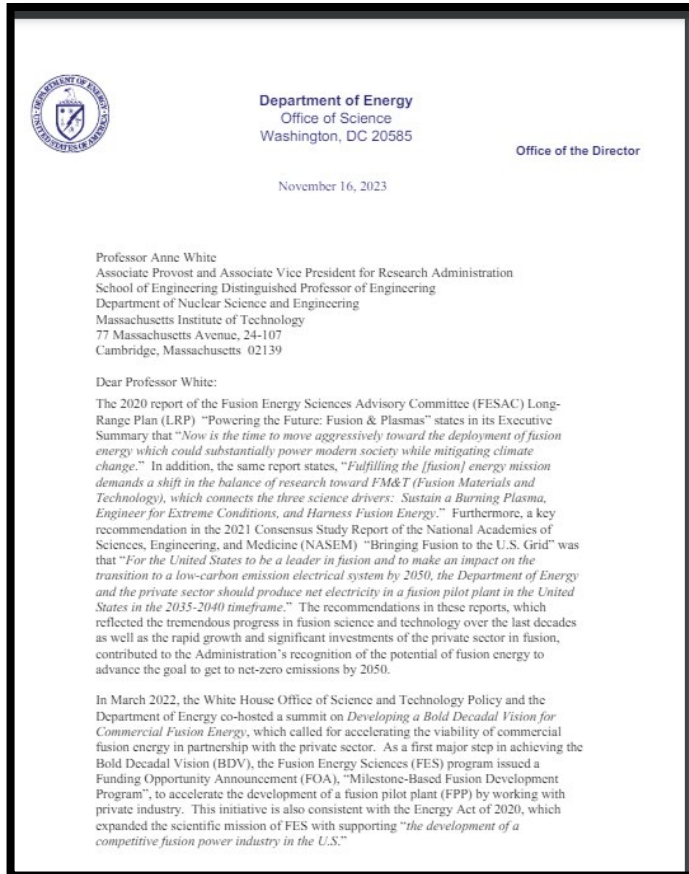
April 7 - 11 • Breckenridge, CO

<https://events.bizzabo.com/IFESTAR>

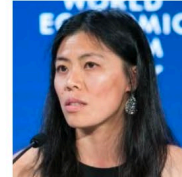
Abstract submission deadline: Feb 10, 2025
Early registration deadline: Mar 7, 2025
Registration closing: Apr 2, 2025



FES Decadal Plan Subcommittee has been reassessing the alignment of the FES program with the LRP and the BDV



Carlos Paz-Soldan
(Columbia), Chair



Tammy Ma
(LLNL), Vice-Chair



Arianna Gleason
(SLAC)



Brenda Garcia-Diaz
(SRNL)



Brian Grierson
(GA)



Carmen Menoni
(CSU)



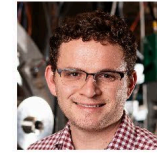
Chris Holland
(UCSD)



Cristina Rea
(MIT)



Davide Curreli
(U. Illinois)



Derek Sutherland
(Zap Energy)



Elizabeth Paul
(Columbia)



Katharina Stapelmann
(NCSU)



Lauren Garrison
(CFS)



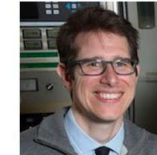
Luis Delgado-Aparicio
(PPPL)



Michael Porton
(Tokamak Energy)

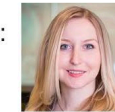


Paul Humrickhouse
(ORNL)



Rob Kolasinski
(SNL)

Ex-officio:



Anne White
(MIT)



Brian Wirth
(UTK)

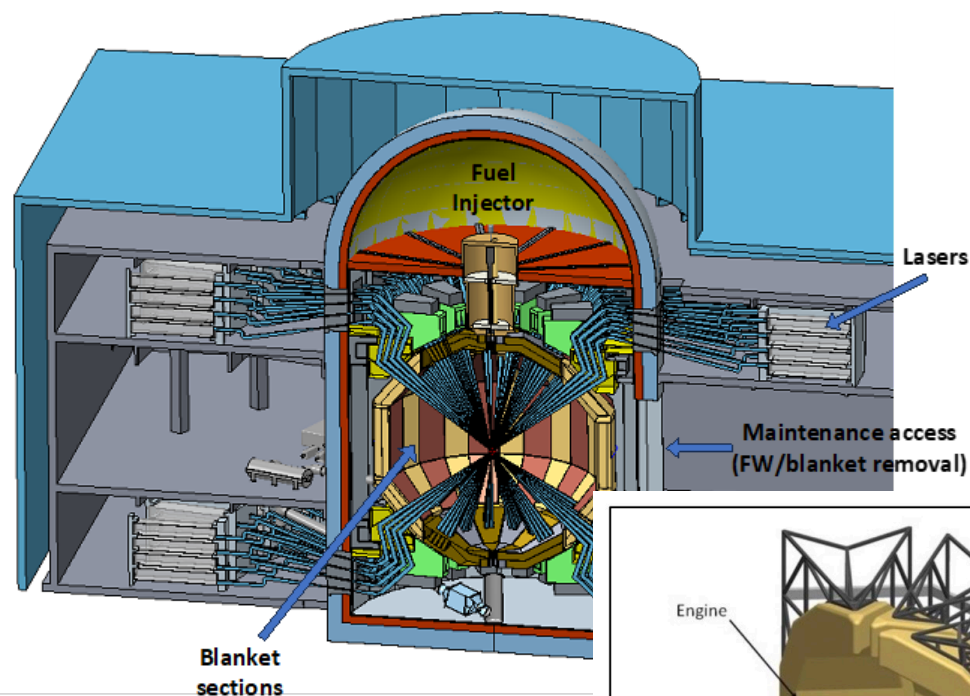


Sam Barish
(DOE Liaison)

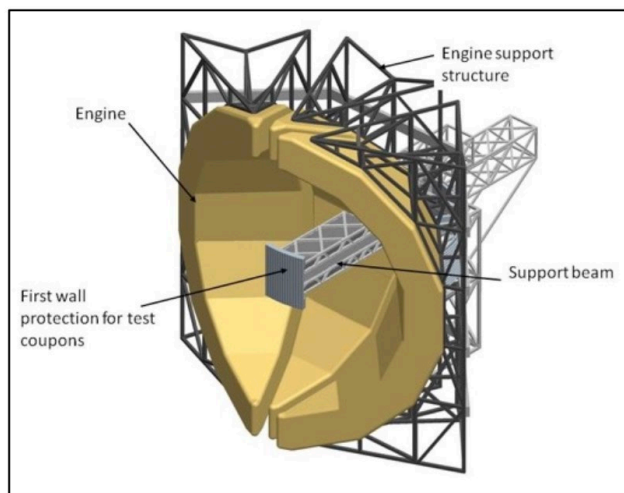
FESAC meeting will be announced soon, where the report will be deliberated and voted on by FESAC



Laser Driven Fusion Integration Research and Science Test Facility (LD-FIRST) in works with IFE community



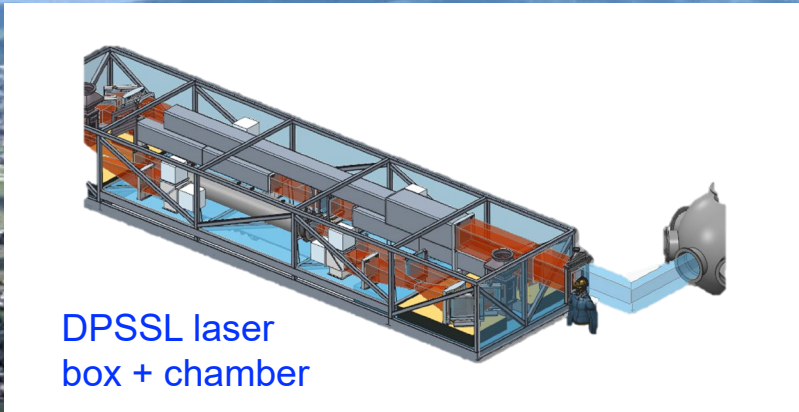
Nominal cross-section of LD-FIRST facility, leveraging LIFE designs



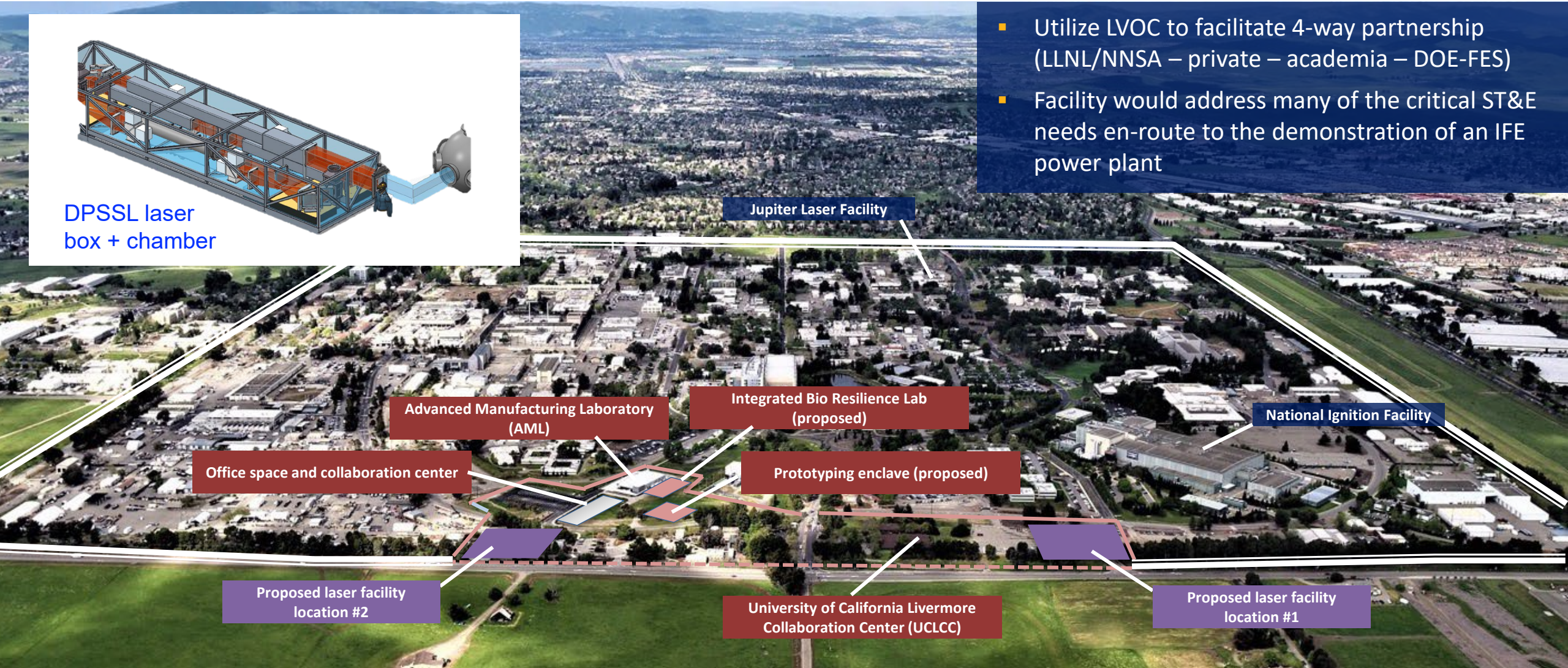
- Envisioned as an integrated test facility which encompasses the key research capabilities provided by many single purpose test facilities, serve as a full-scale testbed for technologies needed for MFE and IFE
- Laser-driven option for FIRST could be self-sustaining at \sim gain 15
- LD-FIRST (operating with DT) would address S&T gaps:
 - Full-scale testing of mats and components under integrated fusion conditions
 - Test the nuclear performance of candidate blankets operating at-scale
 - Test all aspects of the fuel cycle
 - Establish the basis for a robust concept of operations
 - Potentially close the power cycle
 - Provide tailorable irradiation rates w/ DPA/yr >10
- Likely will require a public-private venture
- Two community workshops held in 2024 to develop LD-FIRST needs and requirements

An LD-FIRST, on the path to an IFE FPP, will serve as a point design to guide R&D across the many IFE subsystems in development

We are exploring a public-private partnership Livermore Valley Open Campus facility to build a laser beamline demonstrator



- Utilize LVOC to facilitate 4-way partnership (LLNL/NNSA – private – academia – DOE-FES)
- Facility would address many of the critical ST&E needs en-route to the demonstration of an IFE power plant

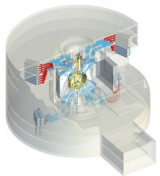
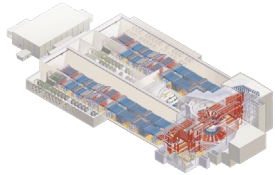
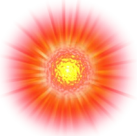


IFE is developing a highly coordinated national strategy to drive towards FPPs in the 2030's, founded on \$B's + 70 yrs investment in ICF



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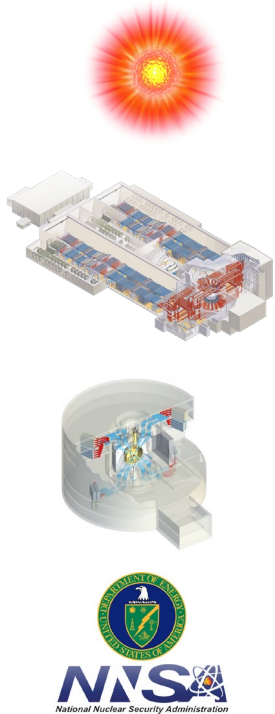
Foundations



- Robust, repeatable ignition
- At-scale facility (NIF) to study burning plasma and demonstrate concepts
- Multiple historical plant studies to build from
- \$B's investment in ICF

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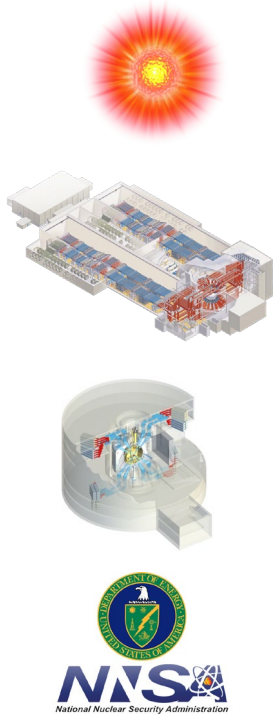
Going Forward



- Priority Research Opportunities as defined by 2022 IFE BRN
- Balanced mix of basic and applied research
- IFE-STAR Ecosystem developing a coordinated national IFE strategy
- Milestone program + PPP's focused on FPP development

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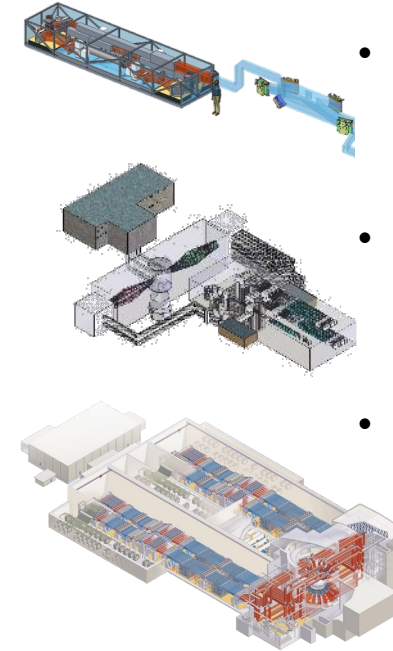
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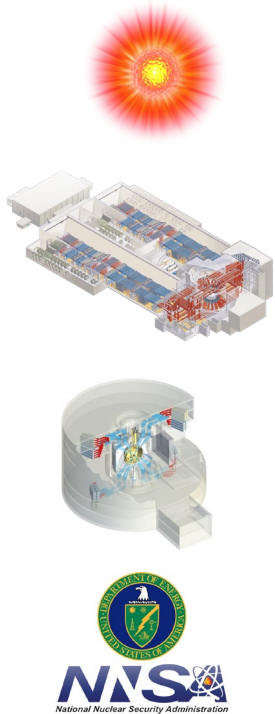
Future Facilities



- Component Test Facilities
- Demo + Integration Test Facility
- NIF Expanded Yield Capability + High-Yield Facility

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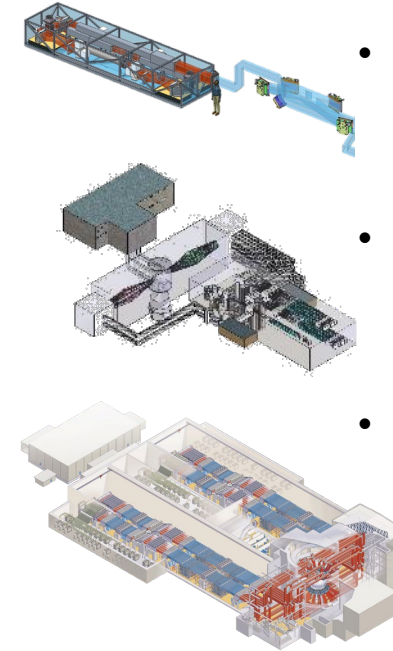
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We must move faster! Will need to find innovative ways to partner, pool resources, and develop critical mass of funding and effort to accelerate progress in key technologies

The success of IFE requires bringing together the many national efforts through coordination, advocacy, and collaboration

In 2024 we advanced the science, technology, and community of IFE:

- Ignition now achieved 6x on NIF
 - Only limited by target production and shot opportunities
- The STAR hubs are advancing the TRL of key IFE technologies
- The IFE-STAR ecosystem coordinating structure has been established
- An integrated, coordinated community-driven national IFE technology development plan toward an FPP will accelerate IFE and drive forward the IFE ecosystem
- LD-FIRST and driver test facility are in development with the community



We are building an ecosystem and bridging the gaps to go from ignition to IFE



**Lawrence Livermore
National Laboratory**