“COMMERCIALIZING LASER FUSION ENERGY TO SAVE OUR PLANET”

Expectations from research on inertial confinement fusion “Recent progress for commercializing IFE based on a novel high energy and efficiency OEC laser”

Shuji Nakamura
CEO of Blue Laser Fusion Inc.

Jubilee of Sustainability by ARPA Umbria
Assisi, Italy, March 21-22, 2025

Company overview

Founded on November 4th, 2022, US company

US and Japan sites

- Headquarters: Palo Alto, CA (Silicon Valley)
- CA Office & Facility: Goleta, CA (Santa Barbara)
- Japan entity: Tokyo office, Osaka lab

World renown team of innovation experts

- Target modeling and fabrication
- Laser beam combination & optical enhancement cavity
- Target injection & chamber design

Experienced growth stage commercialization team

- Gov program & commercial business development
- Site planning for power plant design & construction
- IP, legal, regulatory & export compliance

Shuji Nakamura, Ph.D
CEO, Co-Founder
Board Member

Hiroaki Ohta, Ph.D
CTO, Co-Founder
Board Member

Richard Ogawa, Esq.
General Counsel, Co-Founder
Board Member

FUSION INDUSTRY ASSOCIATION

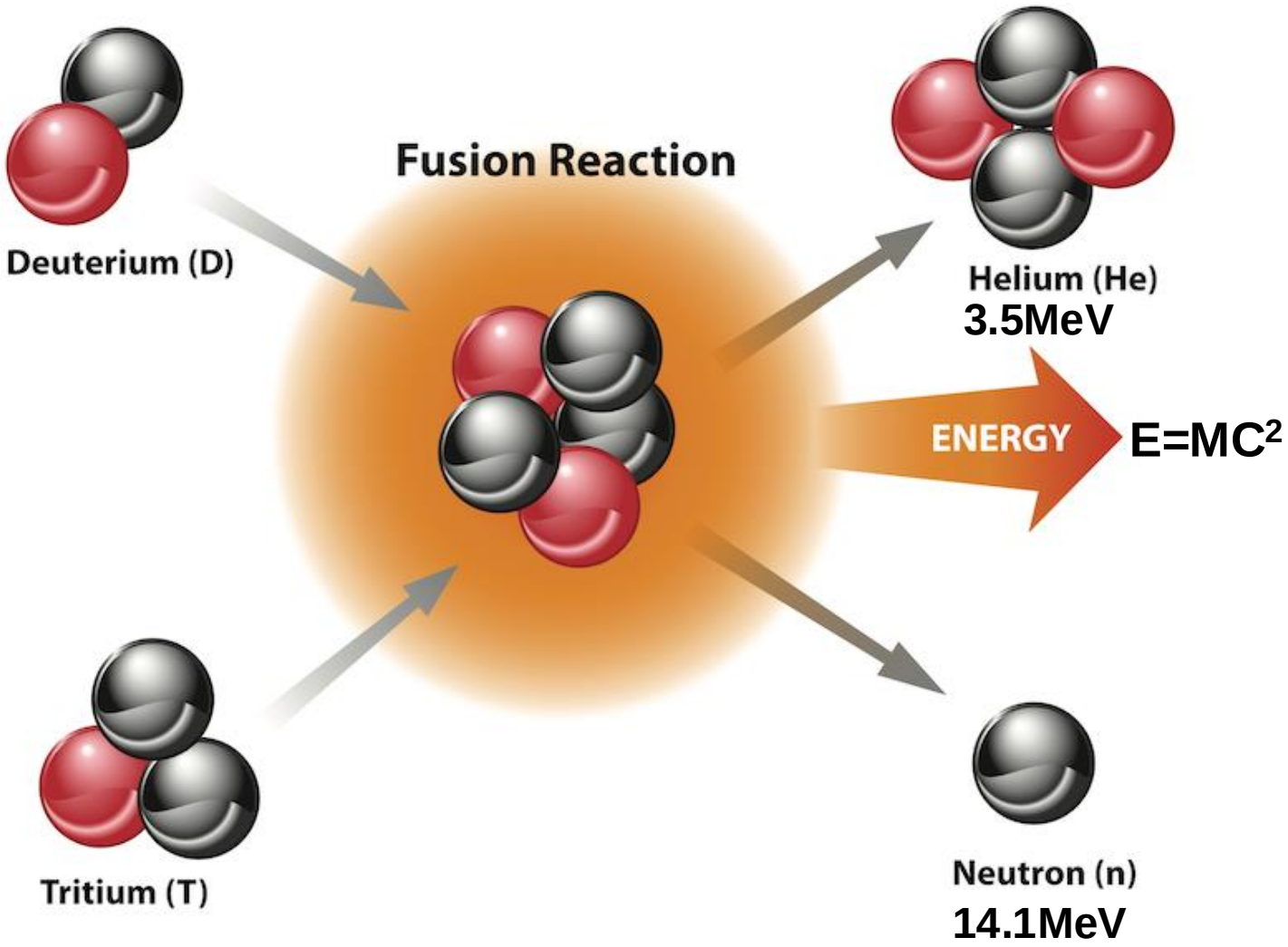
Company member

Japan Fusion Energy Council (J-Fusion)

Founding member

Pursuing $1T market for fusion energy with breakthrough laser innovation

Conventional DT Nuclear Fusion



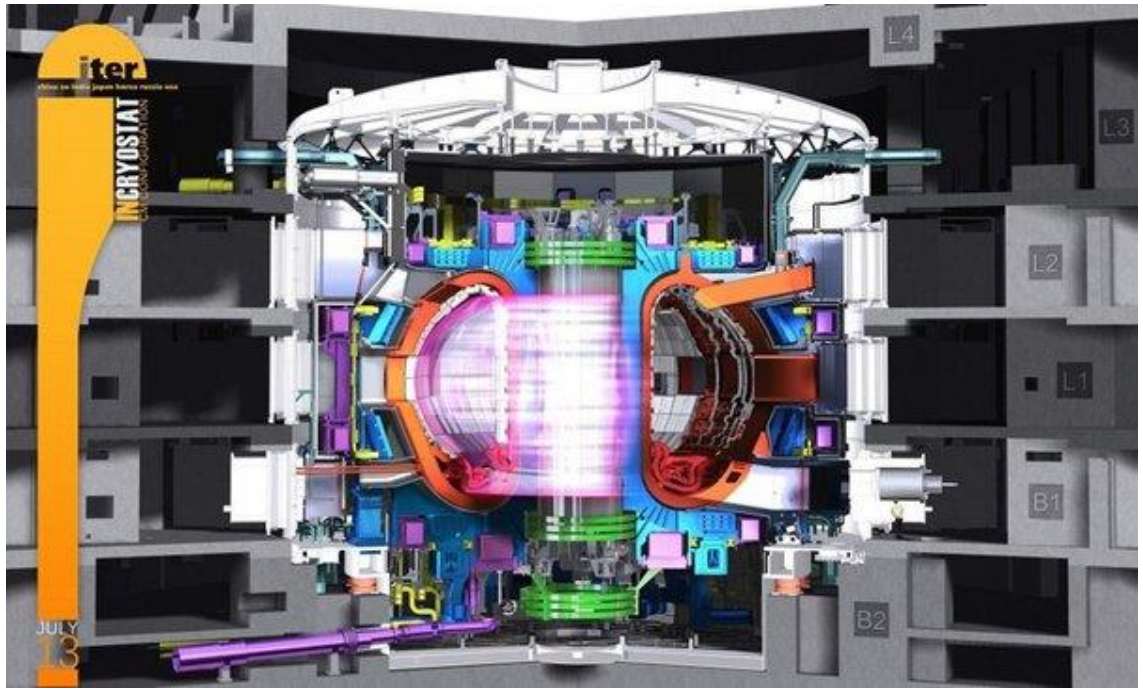
Unlimited Energy

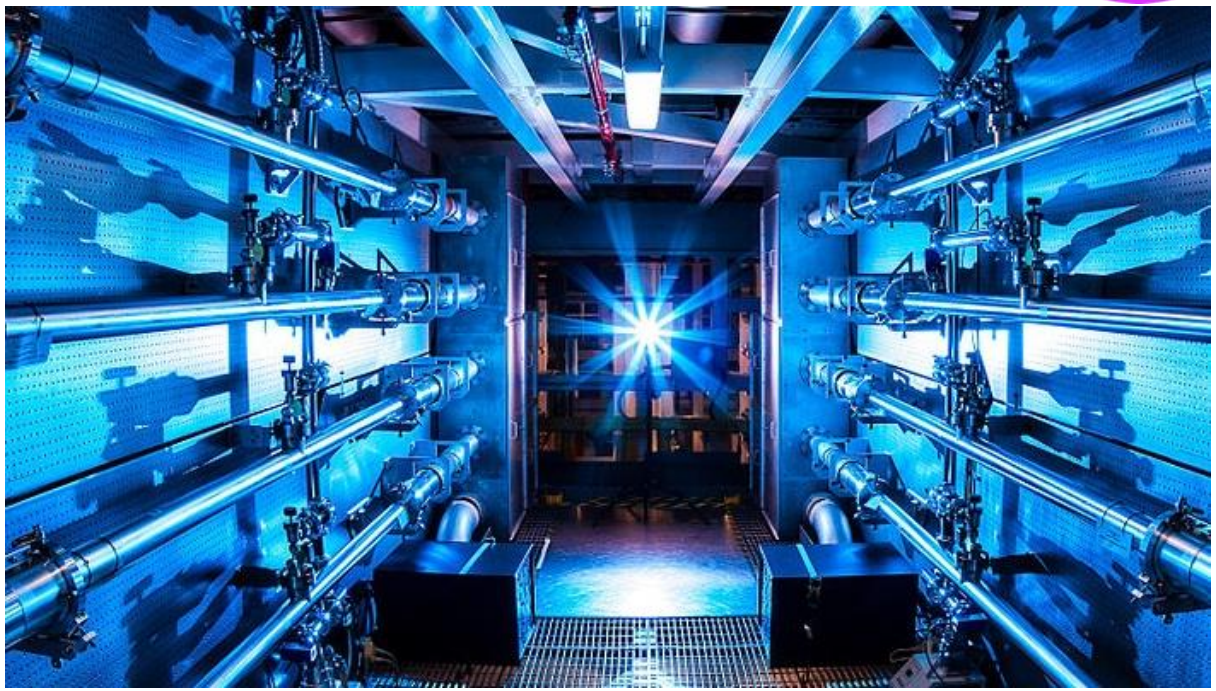
Sustainable and Safe

No Carbon Emissions

Ultimate Energy Source (no more candidates!)

Magnetic Confinement vs Laser Inertial





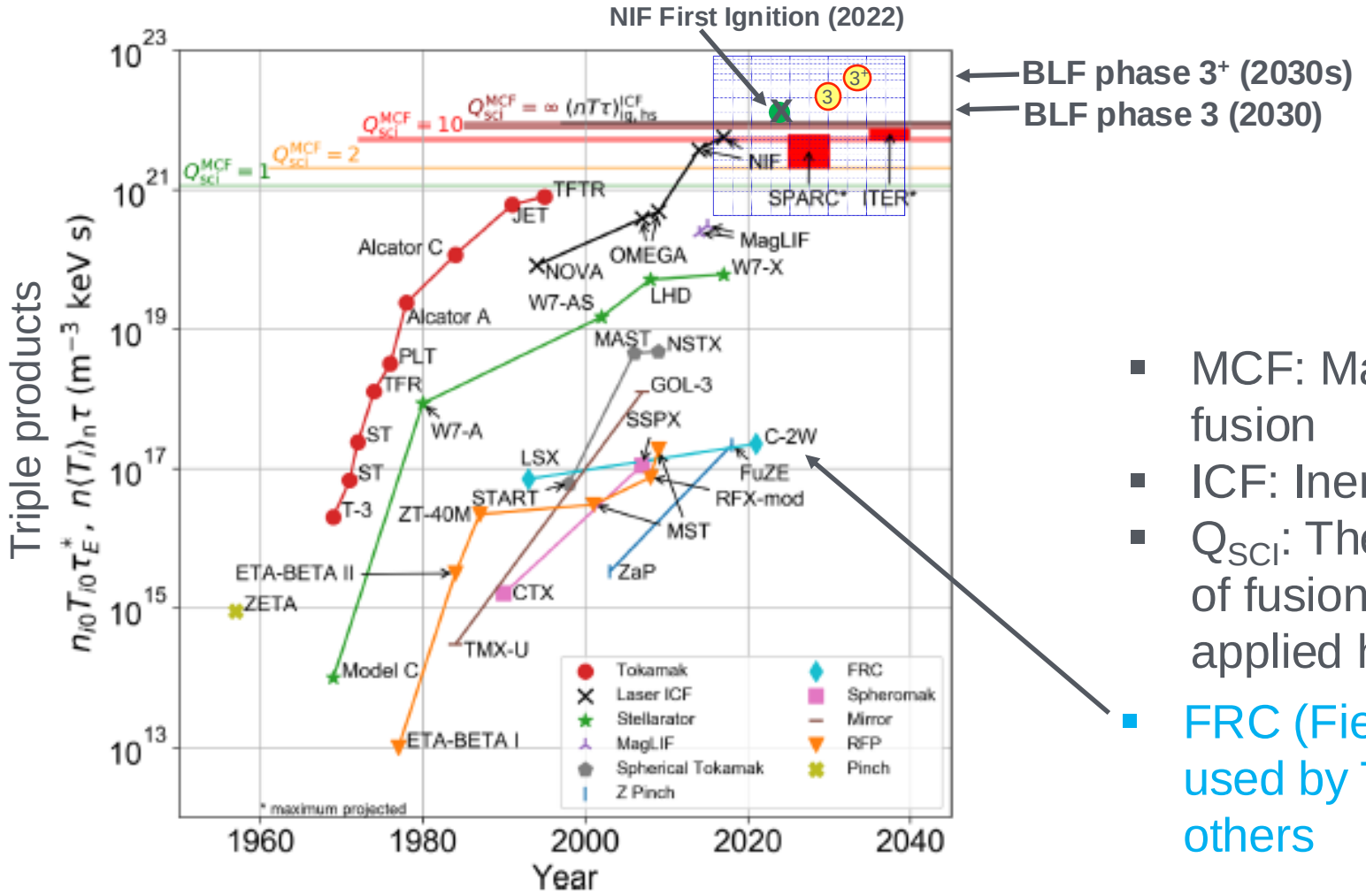
Magnetic confinement: High temperature plasma confined by magnetic field for > 1 second time scale, e.g., ITER.

Inertial Fusion: Fusion fuel compressed by implosion triggered by laser at nanosecond time scale

Both satisfy Lawson criteria: density x time = $n\tau \geq 10^{14}$ s/cm^3

Triple products: density x time x temperature(100MK)=$n\tau T \geq 10^{22}$ s/cm^3

Inertial Confinement Fusion (ICF) (Laser Fusion) is most promising



- MCF: Magnetic Confinement fusion
- ICF: Inertial Confinement Fusion
- Q_{SCI}: The scientific gain. The ratio of fusion power to externally applied heating power
- FRC (Field Reverse Configuration) used by TAE, Helion Energy and others

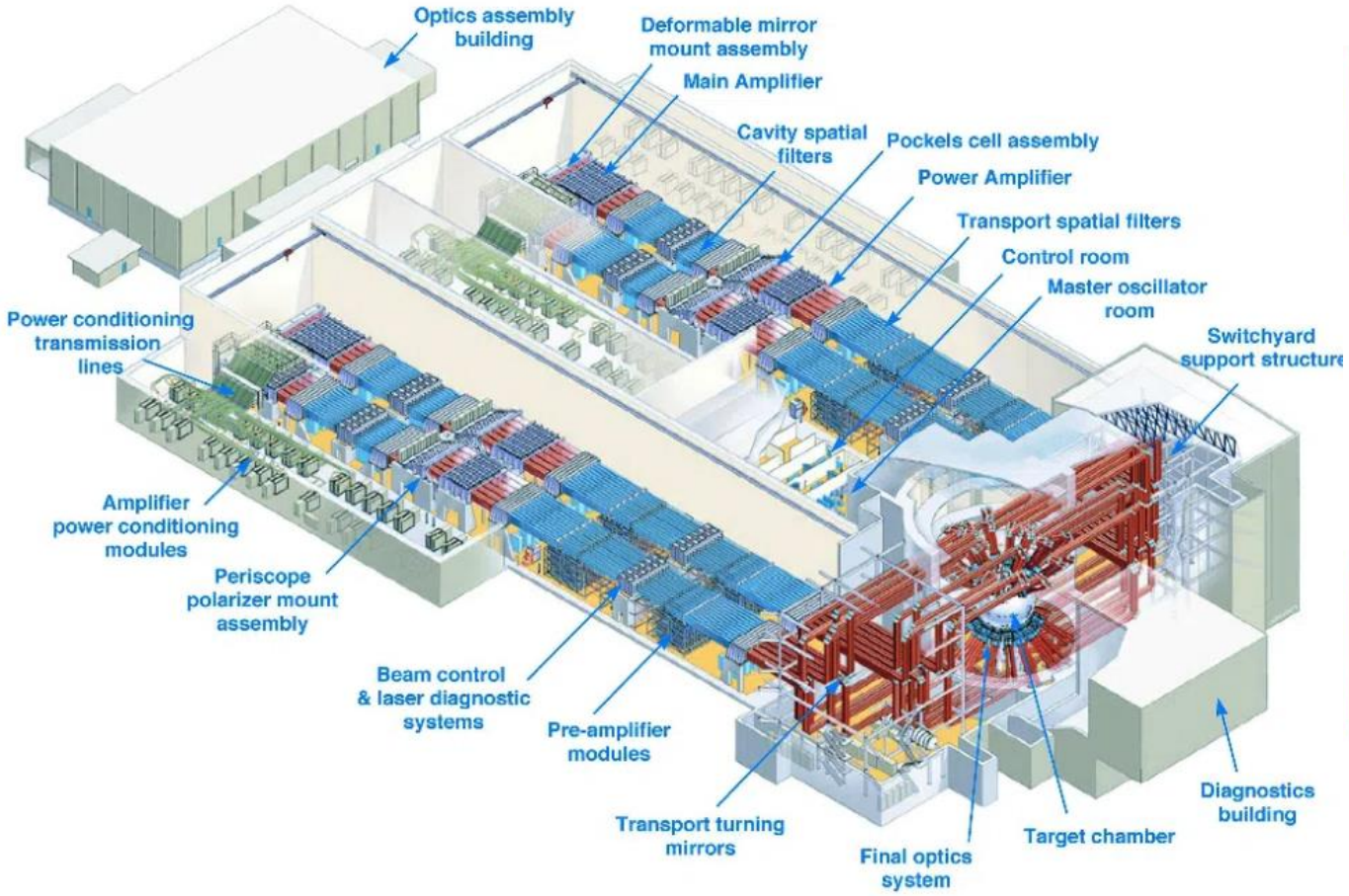
Phys. Plasmas 29, 062103 (2022); doi: 10.1063/5.0083990

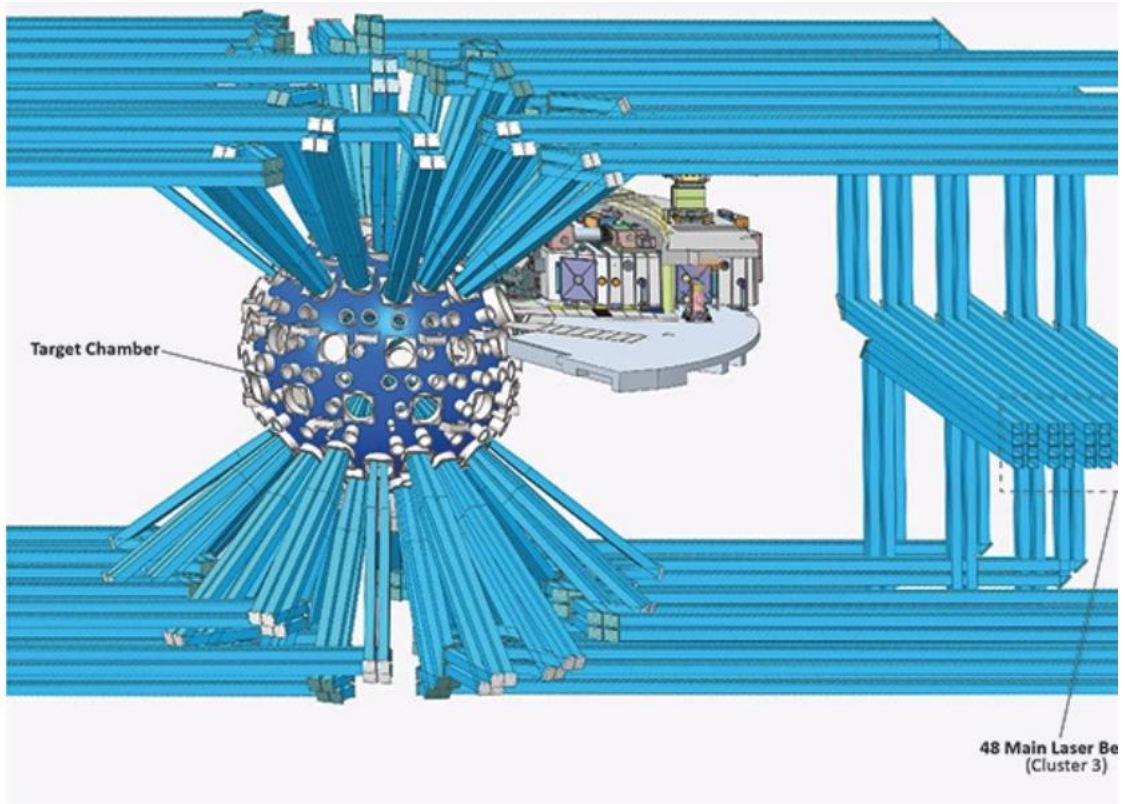
Laser Nuclear Fusion of Lawrence Livermore National Laboratory (LLNL)-National Ignition Facility (NIF)

192 Laser beams with each laser beam of 10KJ pulse

Reference : Lawrence Livermore National Laboratory

Modular lasers which are easily replaced with new lasers





Commercializing On-demand, Renewable Clean Energy

Nuclear Fission

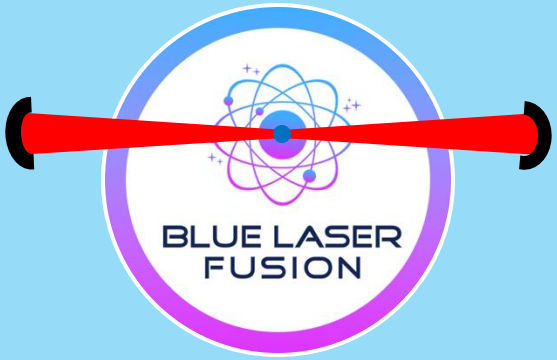
- ✓ Proven ignition approach
- X Safety & regulatory
- X Ideal energy solution

Magnetic Fusion

- X Proven ignition approach
- ✓ Safety & regulatory
- X Ideal energy solution

LLNL NIF Laser Fusion

- ✓ Proven ignition approach
- ✓ Safety & regulatory
- X Ideal energy solution
  - X Laser effic: 0.5% @ 2MJ
  - X Repetition rate: <1 shot/day



Blue Laser Fusion

- ✓ Proven ignition approach
- ✓ Safety & regulatory
- ✓ Ideal energy solution
  - ✓ Laser effic: 10-15% @ 10MJ
  - ✓ Repetition rate @ 1-10 Hz

High efficiency OEC laser & target innovations with a proven IFE approach

Breakthrough at Lawrence Livermore National Laboratory (LLNL)

National Ignition Facility (NIF) of LLNL produced more energy out from fusion than laser energy in. 2.05 MJ of energy in resulting in 3.15 MJ of fusion energy output (12/13/2022)

Laser Inertial Fusion (LIF)

- 1st Ignition: December 13th, 2022
- 2nd Ignition: July 30th, 2023
- Ignition in four out of its last six attempts[1)]

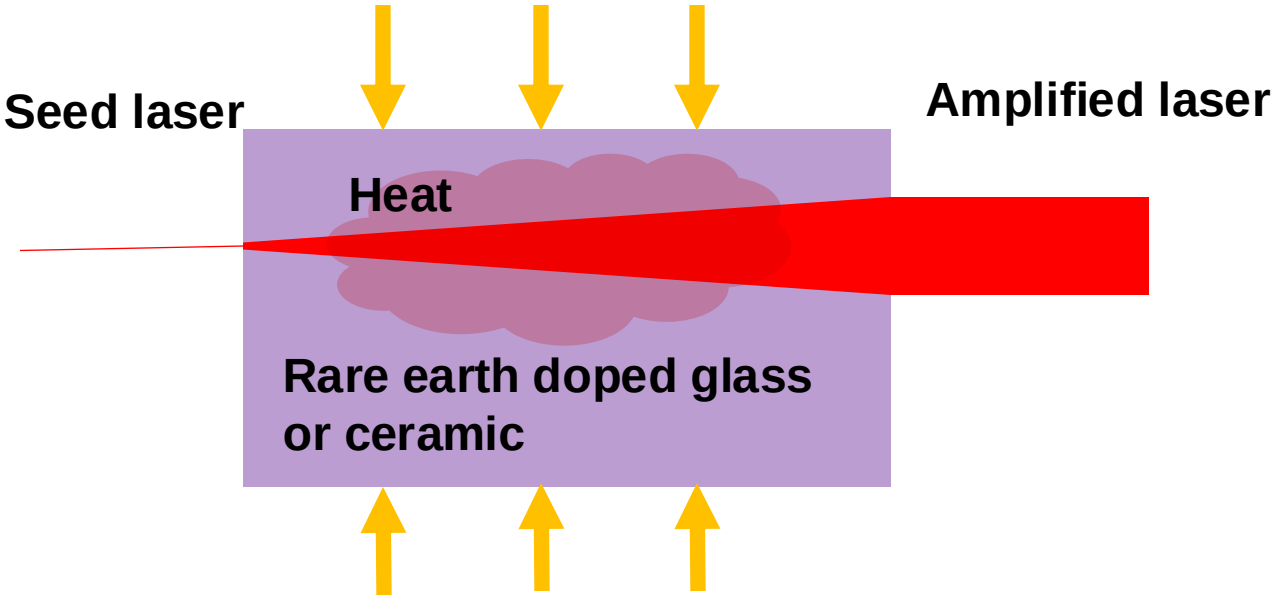
1) Nature news, 15 December 2023,"US nuclear fusion enters new era: achieving 'ignition' over and over"

Magnetic Confinement Fusion (MCF)

- No ignition and no real gain have been reported.

How to amplify the Solid-State (Glass or Ceramic) laser

This method cannot be used for continuous pulses due to heat issues



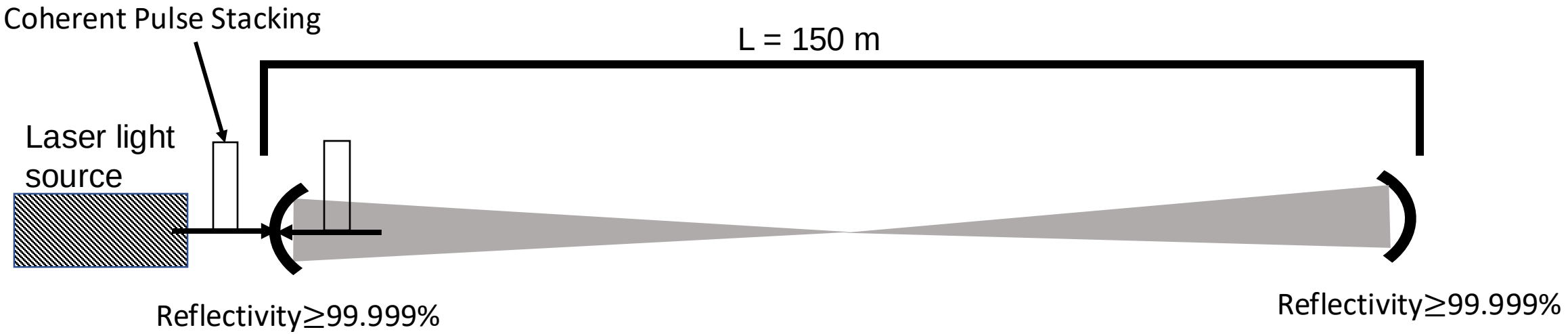
Glass amplifiers used by LLNL-NIF

Referred from Lawrence Livermore National Laboratory

BLF's Pioneering Revolutionary Invention of OEC!

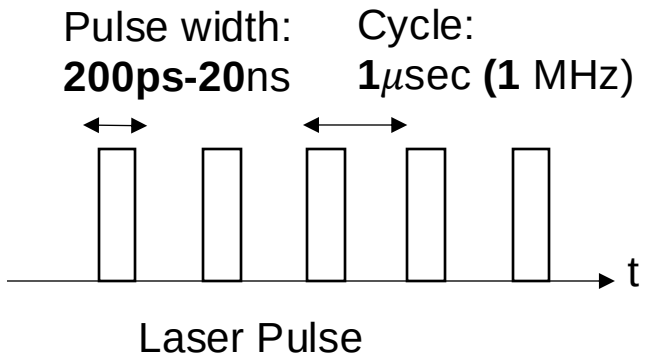
- Novel Optical Enhancement Cavity (OEC) Laser
  - Enables continuous laser firing: 1 shot/day →10 shots/sec
  - Laser WPE: 0.5%→ ≥ 10%
- Fuel Target (DT) for shock ignition
  - High gain≥100

Novel Optical Enhancement Cavity (OEC) for Laser nuclear Fusion



Pulse Train:

$f_{rep}=\frac{C}{2L}$=1 MHz



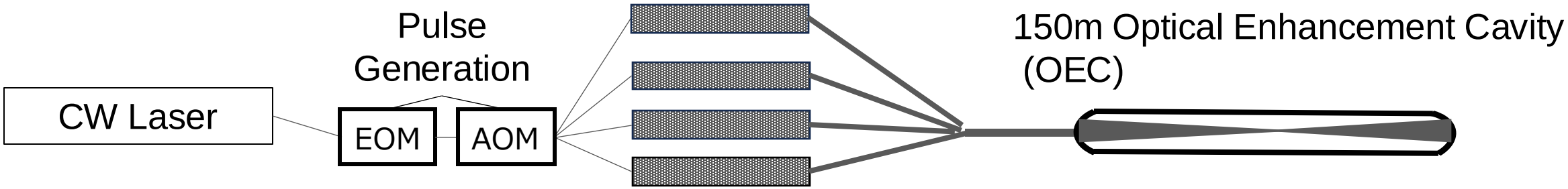
Coherent pulse stacking amplification:

1 MHz, 100 mJ → 10 Hz, 4 KJ

1 MHz, 100 mJ → 1Hz, 10 KJ

3-Stage kJ class pulsed laser with a repetition rate of 1~10Hz

Divided pulse amplification



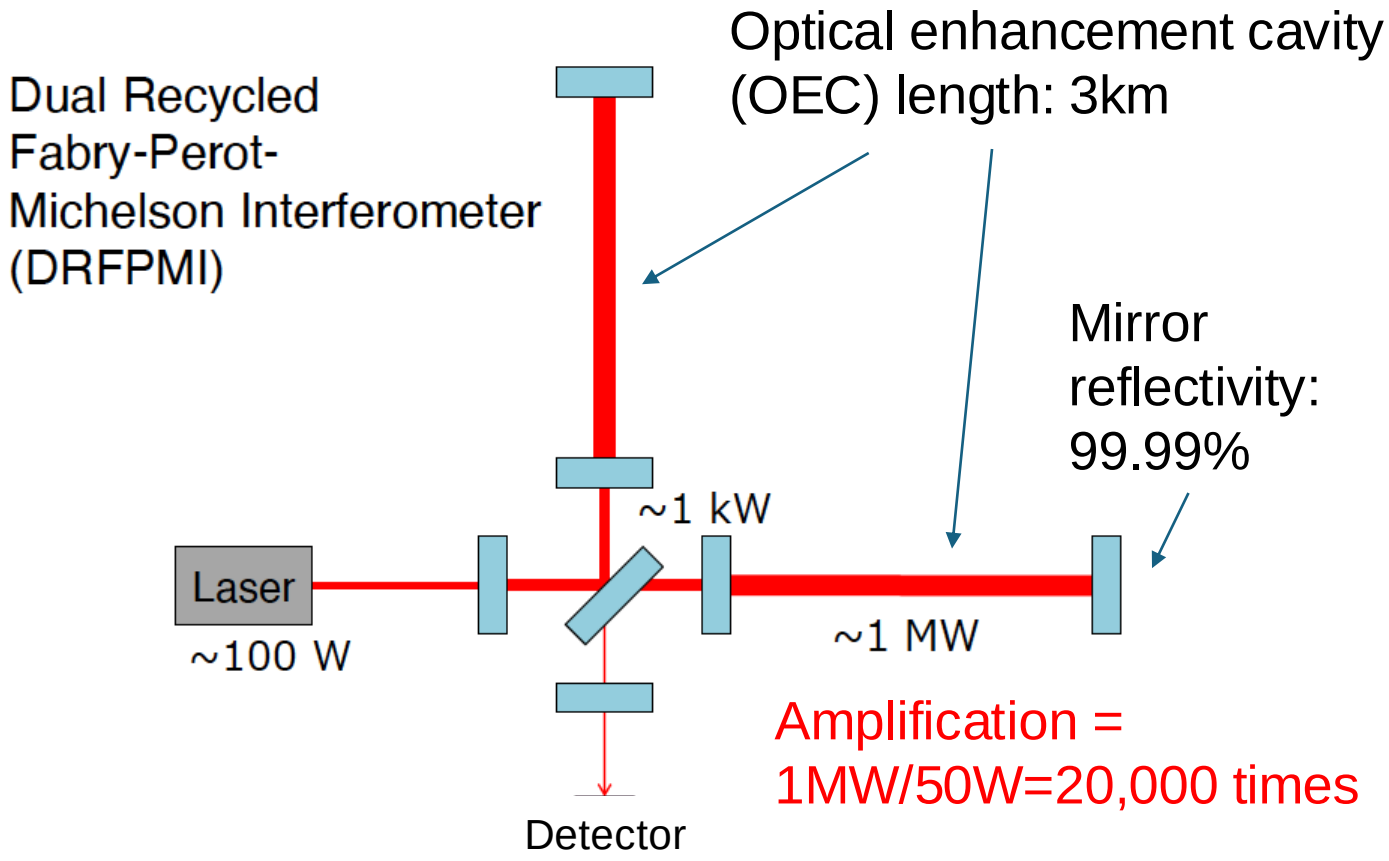
Coherent Beam Combining (CBC)

High efficiency stacking and storage of laser pulses x 100,000 times

- Capable of amplifying ns, MHz frequency pulses
- High power of 100kW~300kW

BLF's OEC Laser approach: Proven in LIGO Gravity Detection

Interferometer configuration

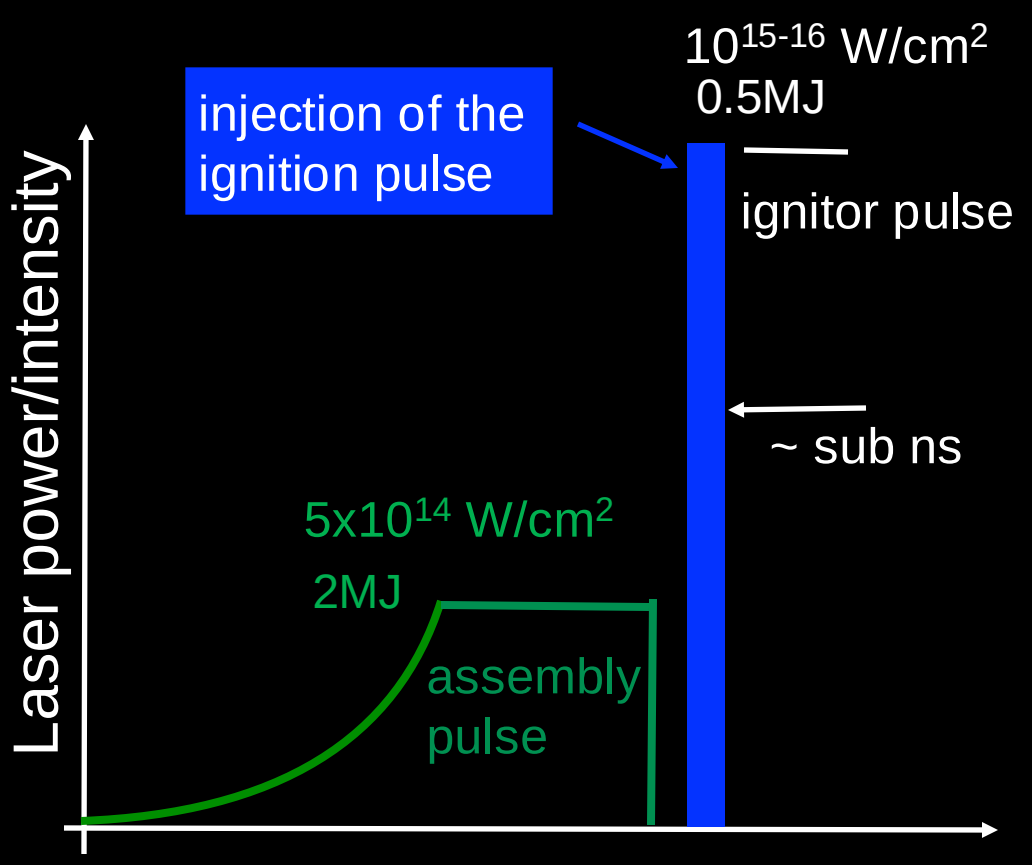


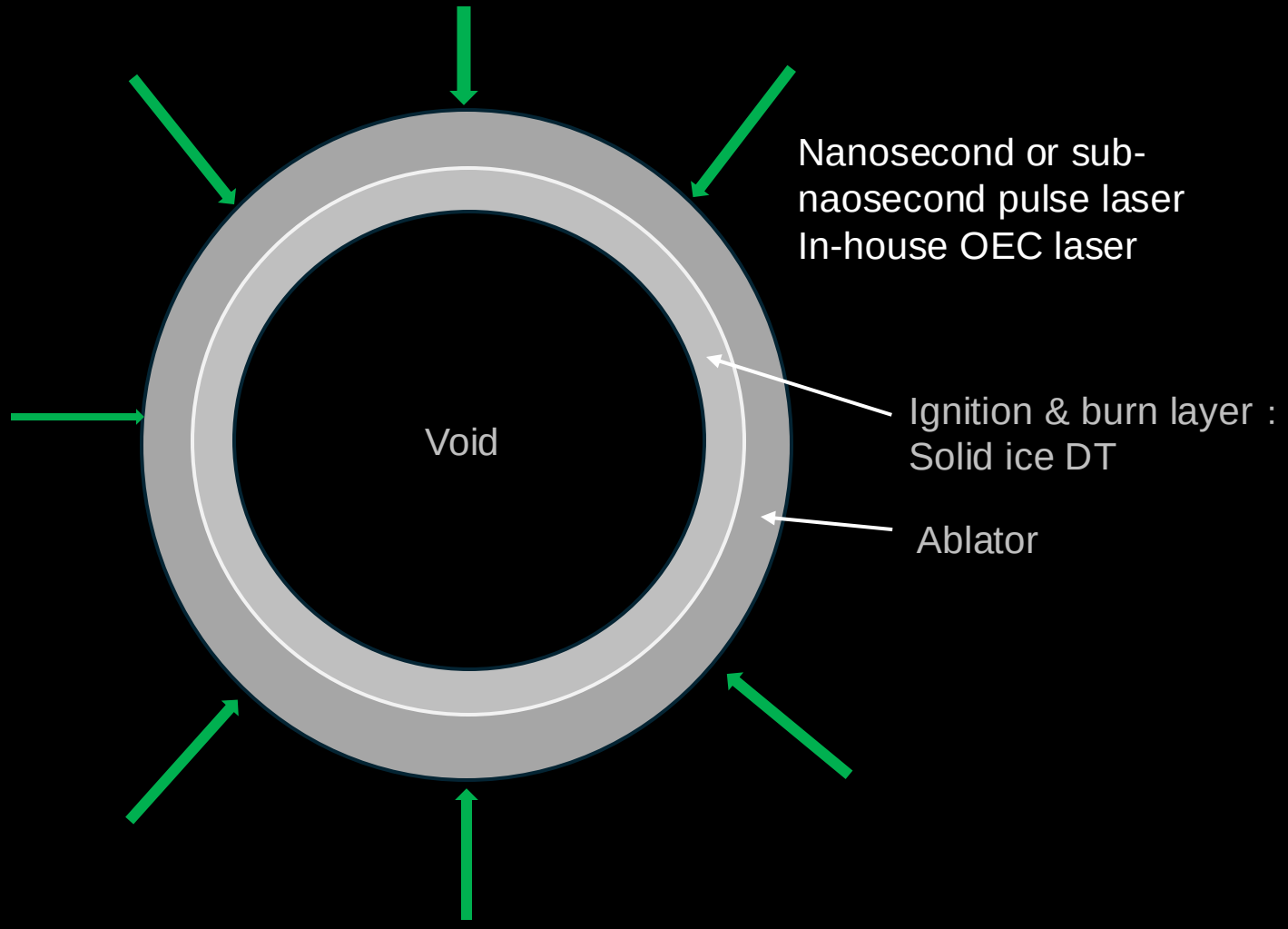
Amplification = 1MW/50W=20,000 times

Virgo, Italy
3km OEC Laser Interferometer

Shock Ignition Method

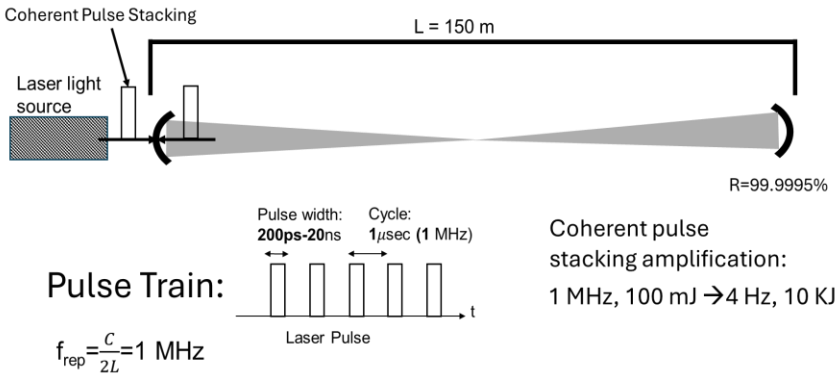
- **Target (DT)**
- **First Phase**
- **Ignition and gain of 100**





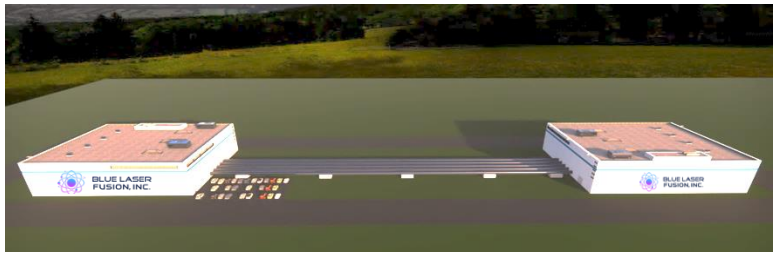
3/18/2025
15

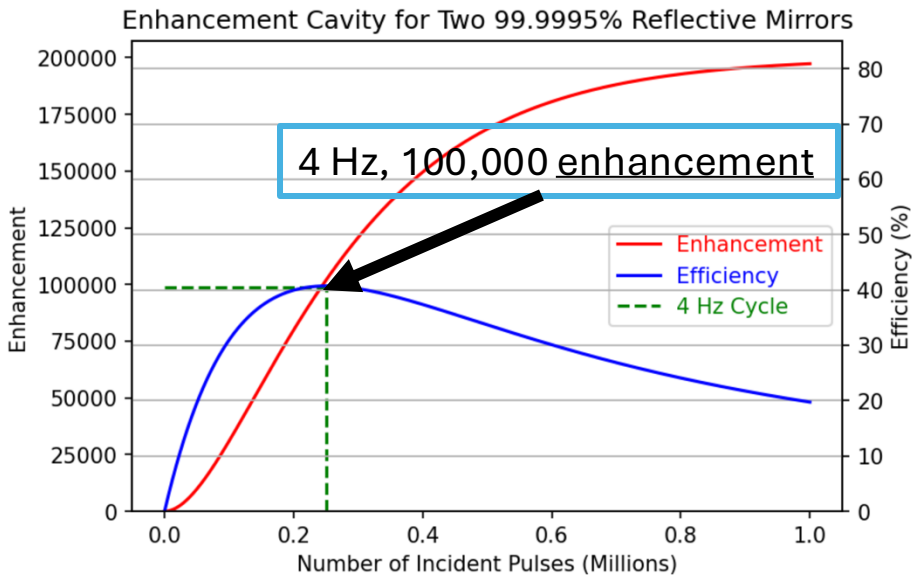
OEC pulse stacking & scaling

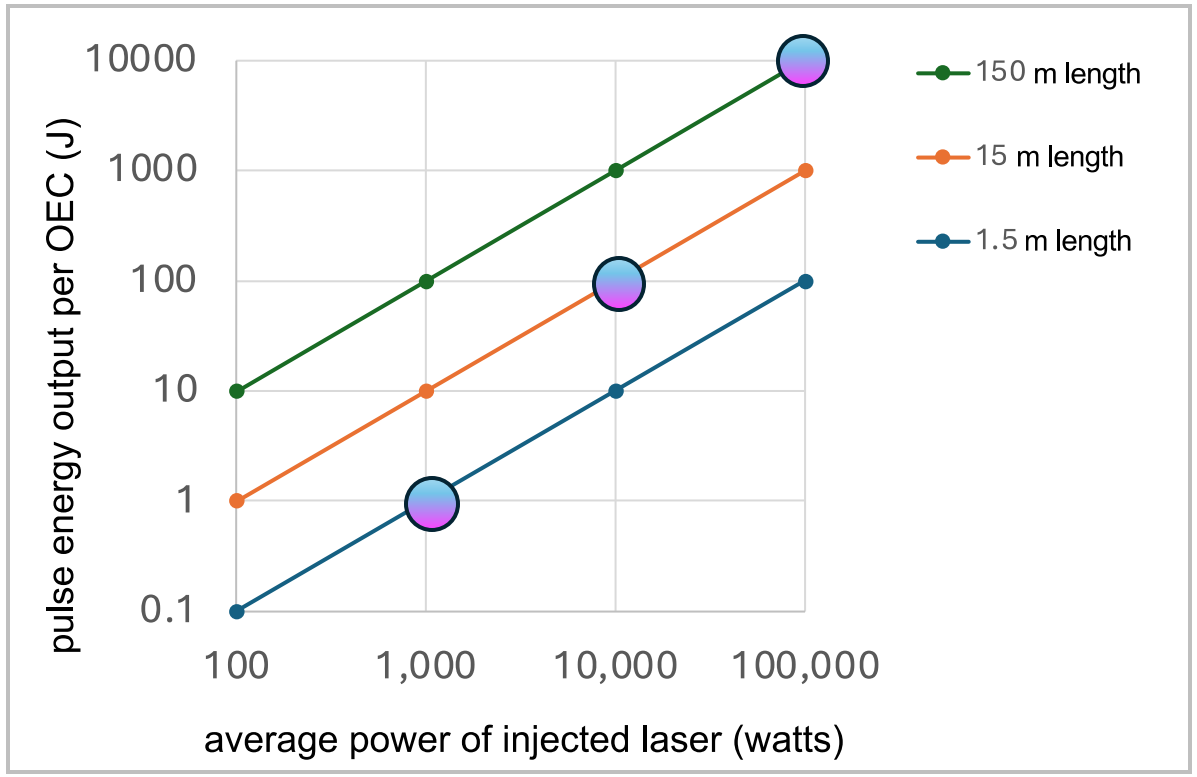


Coherent pulse stacking amplification:

1 MHz, 100 mJ →4 Hz, 10 KJ







Breitkopf, S., Eidam, T., Klenke, A. *et al.*, "A concept for multiterawatt fibre lasers based on coherent pulse stacking in passive cavities," Light Sci Appl 3, e211 (2014). https://doi.org/10.1038/lsa.2014.92

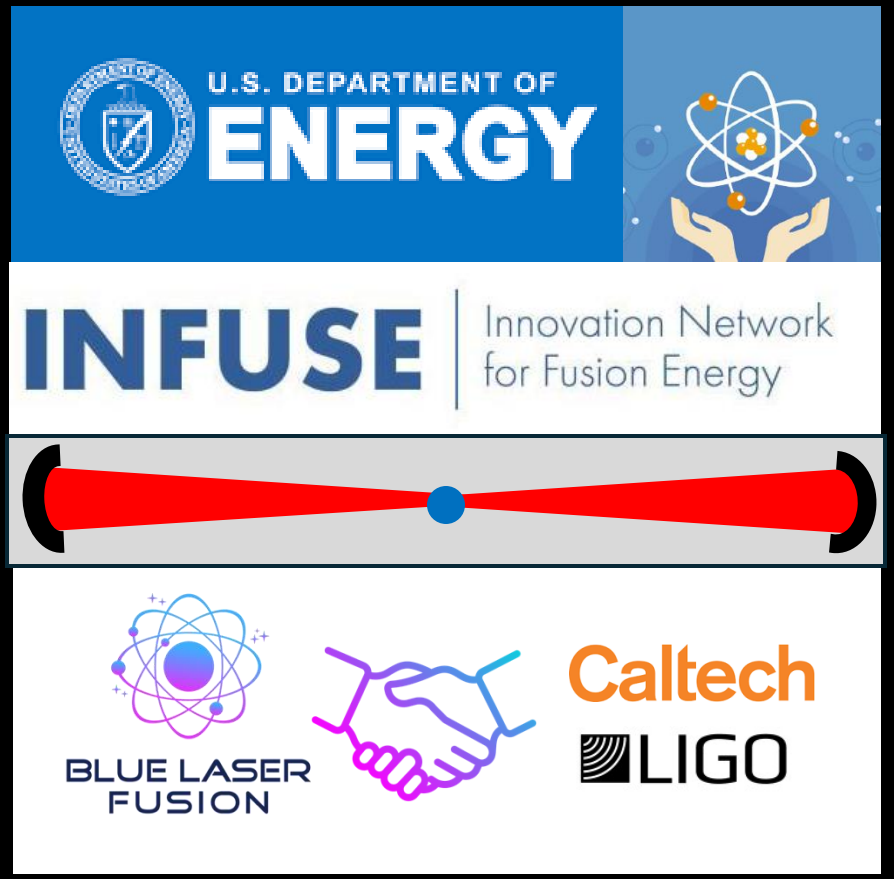
Blue Laser Fusion DOE INFUSE Project with Caltech

US DOE Innovation Network for Fusion Energy (INFUSE) program

- $4.6M program, awarded to projects with enabling & innovative fusion technologies to help move toward the ultimate goal of economical fusion energy
- Accelerates fusion energy development in the private sector by funding public-private to partnerships & collaboration between business & national labs or universities
- Overarching objective is to ensure the nation's energy, environmental & security needs

Blue Laser Fusion / CalTech was the only laser architecture award in 2024

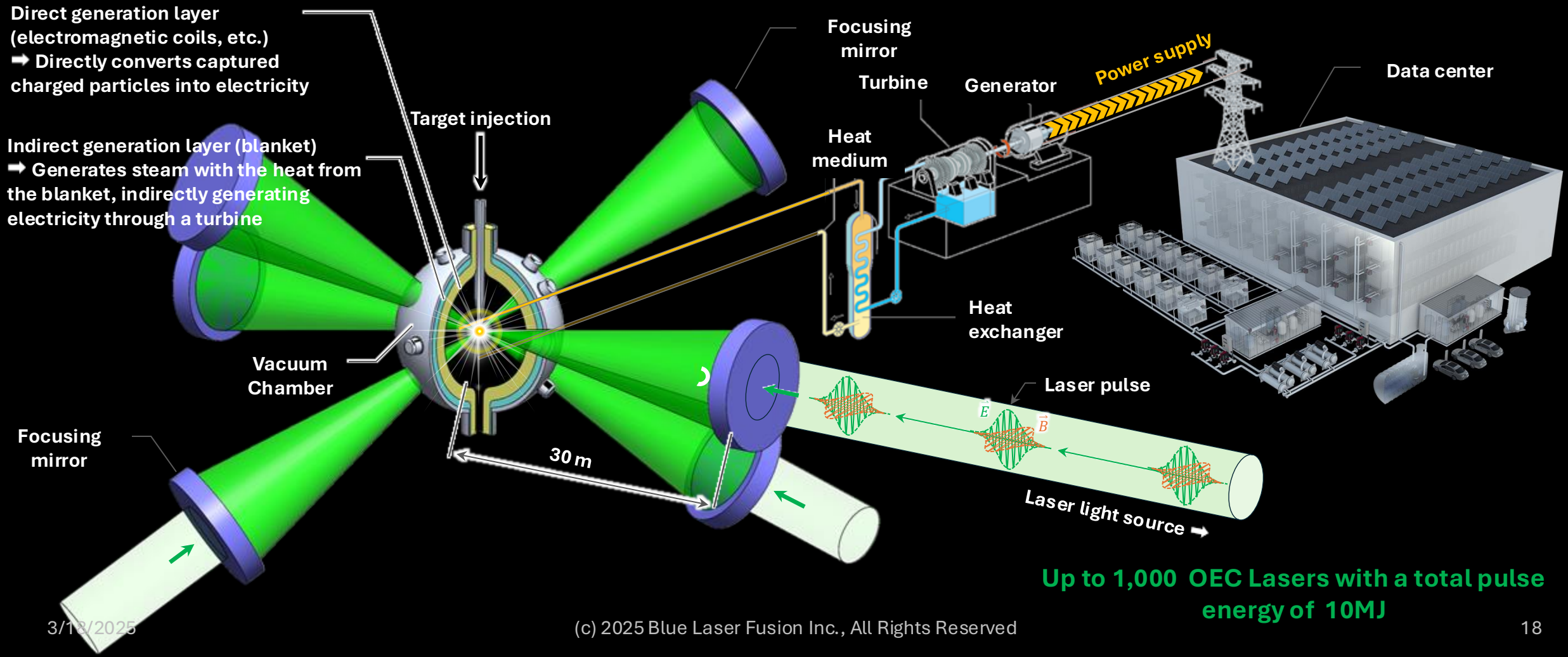
- Validates BLF's novel approach of OEC lasers for fusion
- Project: "High Energy Pulsed Laser Amplification Using Optical Enhancement Cavities"
- https://infuse.ornl.gov/awards/high-energy-pulsed-laser-amplification-using-optical-enhancement-cavities/



DOE INFUSE award for Blue Laser Fusion to cooperate with Caltech on OEC lasers for fusion.

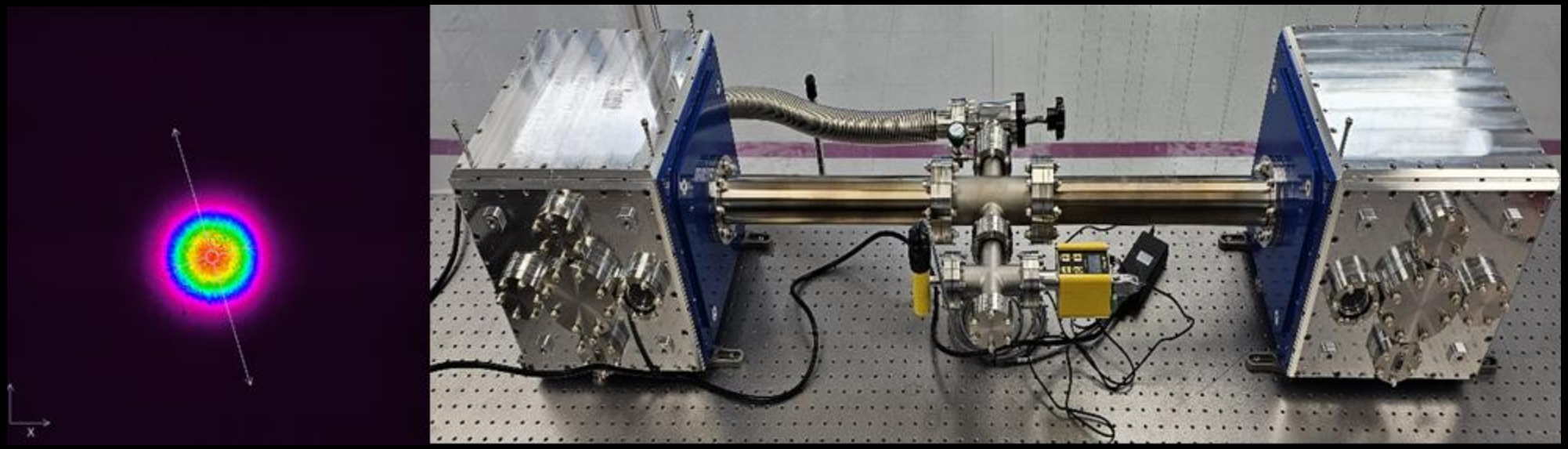
BLF's OEC Fusion Reactor

Innovative high-performance pulse source (CBC laser) light is accumulated between two pairs of mirrors, enhancing intensity to achieve fusion (OEC Fusion Reactor method).



Up to 1,000 OEC Lasers with a total pulse energy of 10MJ

OEC Laser with 58,000x Optical Enhancement



- 58,000x OEC laser operating in Blue Laser Fusion facility in Goleta
- 1.5 m prototype: 1 W injected power →58 kW inside the OEC
  Currently integrating CBC with pulsed OEC
- Goal: 150 m OEC injected with a 100 kW laser to achieve 10 kJ, 4 Hz

15 m OEC under construction in Goleta

- Construction of the 15 m OEC vacuum chamber to be completed and locking of the cavity begins in March, 2025

Site planning roadmap

Site planning underway for pilot facilities

- US: California, Utah, and TVA discussions running
- Japan: Osaka
- EU: Partnership with RSE Italy

<u>Phase 1 ongoing</u>
15m OEC laser, 1 kJ
(BLF Goleta facility)

Proof of concept 1/10th scale OEC laser

<u>Phase 1 site planning</u>
150m OEC laser, 10 kJ
(Central California, then Italy, Japan)

Full scale OEC laser, surpass LIGO energy

<u>Phase 2 site planning</u>
Small scale pilot
5x150m OEC laser 50kJ
Research target chamber
(Central California, then Italy, Japan)

Surpassing LLE Omega, small scale pilot

<u>Phase 3 site scouting</u>
Full scale pilot plant, Ignition, then GW class
500 x 150m OECs 10MJ IFE target chamber
Power to grid
(Central CA, UT, TVA, etc, then Italy, Japan)

Surpassing LLNL NIF gain, full scale pilot

Site Partner Update: Italy and the EU

BLF has signed an MOU with RSE, Italy's Energy Research Company

- Phase 1) Analytical and simulation inertial fusion energy (IFE) reactor
- Phase 2) Construct a prototype small-scale IFE reactor
- Phase 3) Construct a full-scale IFE pilot power Plant

RSE S.p.A., Ricerca sul Sistema Energetico

- Italy's energy research institution, controlled by the Italian Ministry of Economy & Finance via GSE S.p.A.
- Focused on the entire energy sector, supply chain, strategic projects at national & European level, experimental and applied perspective
- Themes of innovation, efficiency with interface between policy makers, business & citizens, both economic and social

RSE we move rsearch

BLUE LASER FUSION, INC.™

PRESS RELEASE

Fusion Energy
Agreement between RSE and BLUE LASER FUSION (USA)

The Memorandum of Understanding was signed in Rome during a two-day international discussion on innovation and the role of research and technology transfer in the energy transition. Guest of honor: Nobel Prize winner Shuji Nakamura.

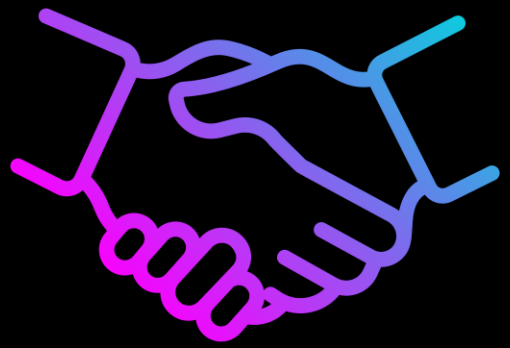
Rome, 06.11.2024 – An agreement was signed in Rome on 4 November between RSE and the American company Blue Laser Fusion (BLF) to initiate joint research and development activities on the world's first commercial-scale inertial fusion energy (IFE) power plant.

The agreement was quoted as proof of Italy's commitment to this technology in the Prime Minister's **Giorgia Meloni** speech which was presented this morning by the Undersecretary to the Presidency of the Council, **Alfredo Mantovano** at the inaugural ministerial event of the World Fusion Energy Group at the Ministry of Foreign Affairs and International Cooperation. The activities will be carried out in three phases: a first analytical one, a second to build a prototype of a small-scale commercial inertial fusion energy (IFE) reactor ("Small-scale Fusion Pilot Reactor") and a the third, concluding one, to launch a prototype of a larger-scale commercial IFE reactor ("Full-scale Fusion Pilot Power Plant").

Let’s collaborate

Contact us!
Or, reach out to me at:
tcohen@bluelaserfusion.com

- **Supply chain**
  - **Laser components**
  - **Optics with high damage and high/low reflectivity coatings**
- **Simulation**
- **Partnering on government programs**
- **Direct funded projects**
- **Internships, consultants and full-time positions**



“COMMERCIALIZING LASER FUSION TO SAVE OUR PLANET”

THANK YOU