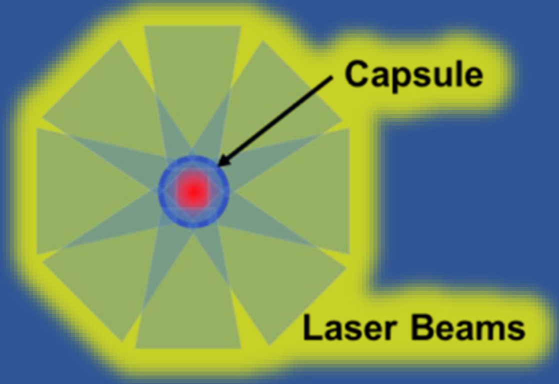
Stephen Obenschain
LaserFusionX Inc.

Fusion Power Associates Meeting
8 December 2022



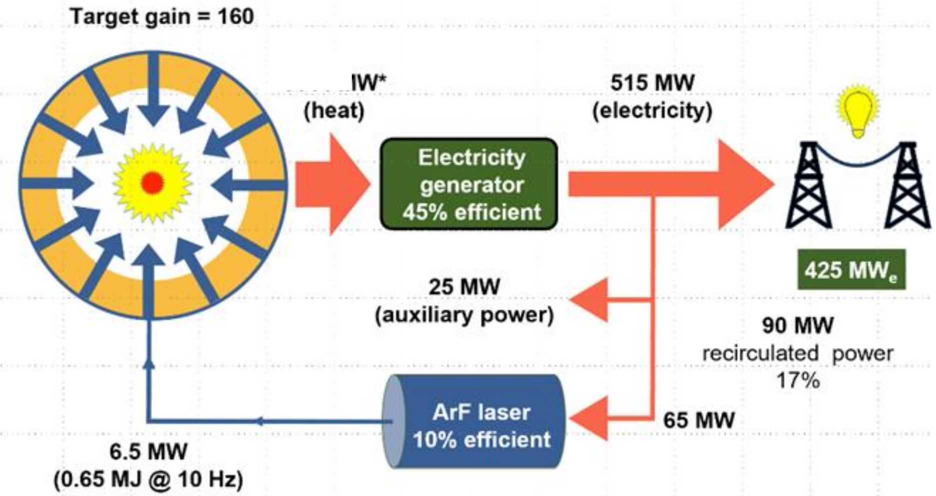
- **The deep ultraviolet broad-bandwidth light from the argon fluoride (ArF) laser could enable much smaller lower-cost laser-fusion power plants than was previously thought to be feasible.**
- **Simulations by researhers at the Naval Research Laboratory have indicated that ArF's 193 nm light could enable high gain (>100) direct drive implosions with less than 1 MJ***
- **LaserFusionX Inc. has been formed to advance this attractive approach to laser fusion energy in the private sector.**

*NRL laser fusion work supported primarily by the U.S. Department of Energy

Advantages of ArF direct drive approach to IFE

- Less laser energy required to reach gain required for power production.
- 193 nm broad-bandwidth light suppresses LPI and thereby enables higher drive pressure for implosions.
- Large ArF systems projected to have 10% electrical efficiency.
- Well developed physics base via National inertial fusion program
- High energy robust ArF systems needed for IFE can be developed

Notional ≈ 500 MWe ArF power plant



Power flow in the power plant. The high target gain could enables efficient electrical power production at 0.65 MJ laser energy.*

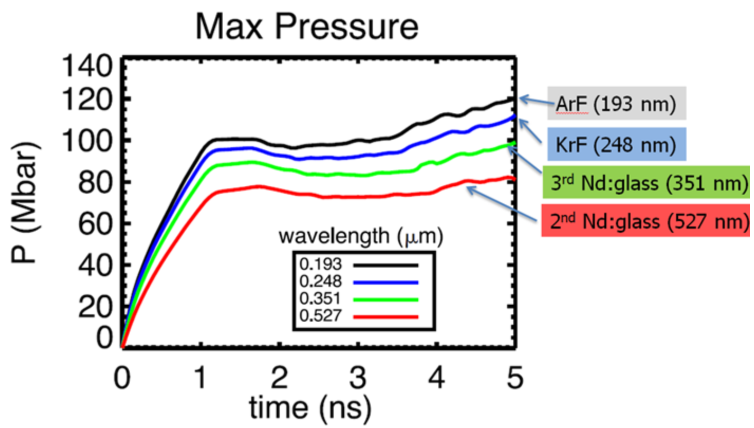
*1/3rd of that already demonstrated on the National Ignition Facility,

Physics advantages of ArF light for direct-drive implosions

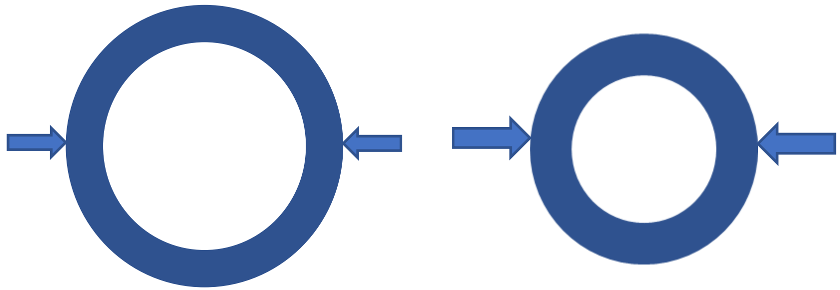
193 nm light penetrates to higher plasma density resulting in higher mass ablation rate and higher ablation pressure at a given intensity.

Suppression of Laser Plasma Instability by ArF's short wavelength allows higher laser intensity on target which further boosts the max pressure – allowing use of thicker-walled smaller radius targets that are more stable against hydrodynamic instability.

NRL hydrocode and LPSE simulations are quantifying the effects of ArF light on laser target interactions



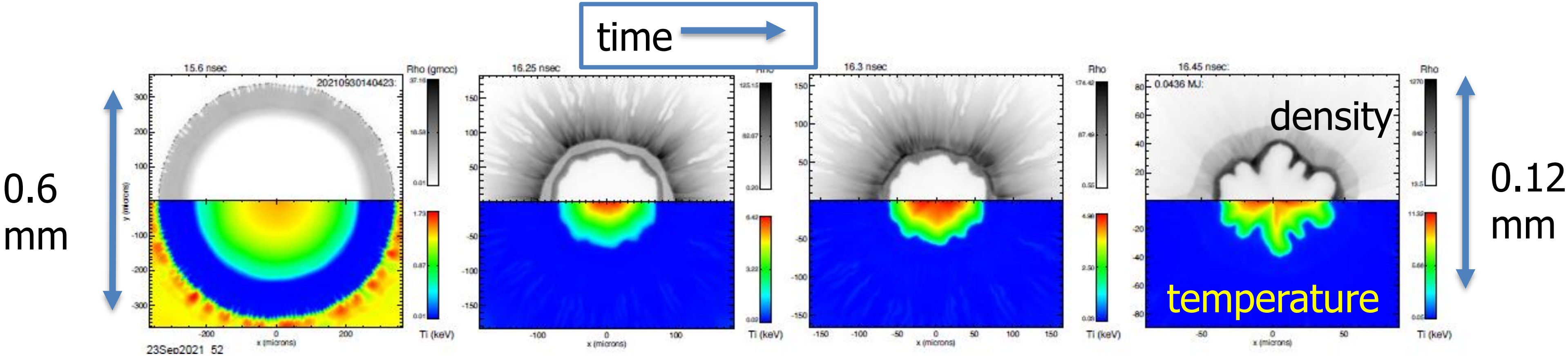
Higher drive pressure allows use of lower aspect ratio targets



NRL 2D simulations indicate an ArF laser can achieve target gains (>100) needed for laser fusion power plant with much less laser energy than achieved by NIF

NRL PPD

Sample NRL 2D simulation of a **410 kJ ArF** driven shock ignited implosion



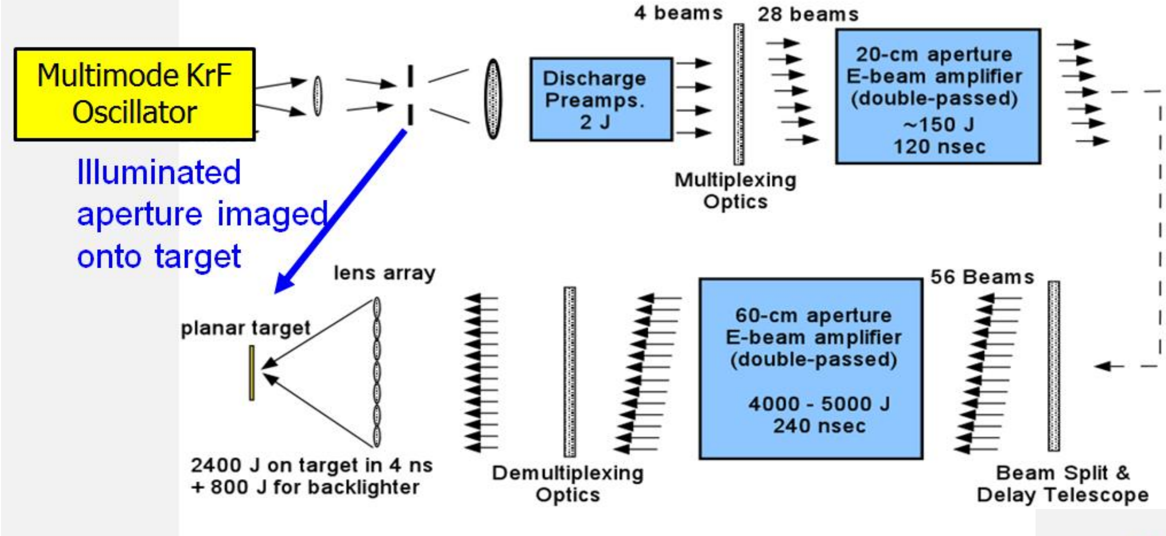
• 160x gain including effects of target imperfections
• 148x gain adding effects of laser imprint @ 5 THz bandwidth

A. Schmitt DPP 2021

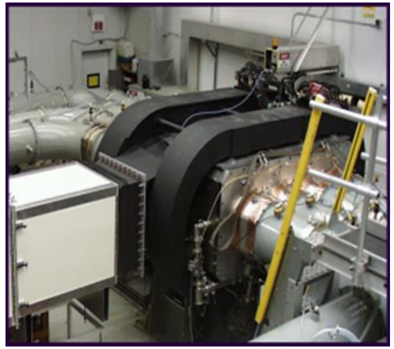
The NRL Nike krypton fluoride (KrF) laser demonstrated that large electron beam pumped excimer laser systems could be built & operated

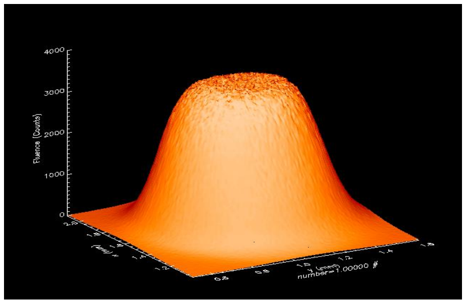
NRL PPD

Nike: Aperture in the front end is imaged through the amplifier system to target

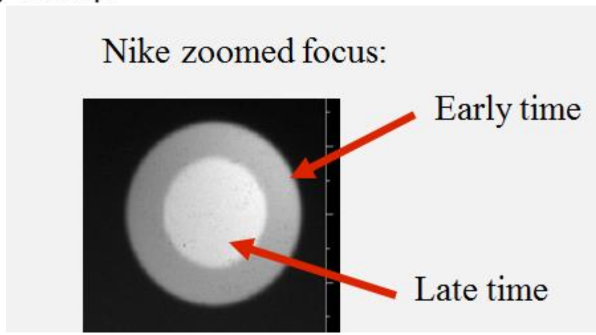


Nike 60-cm aperture 5-kJ amp





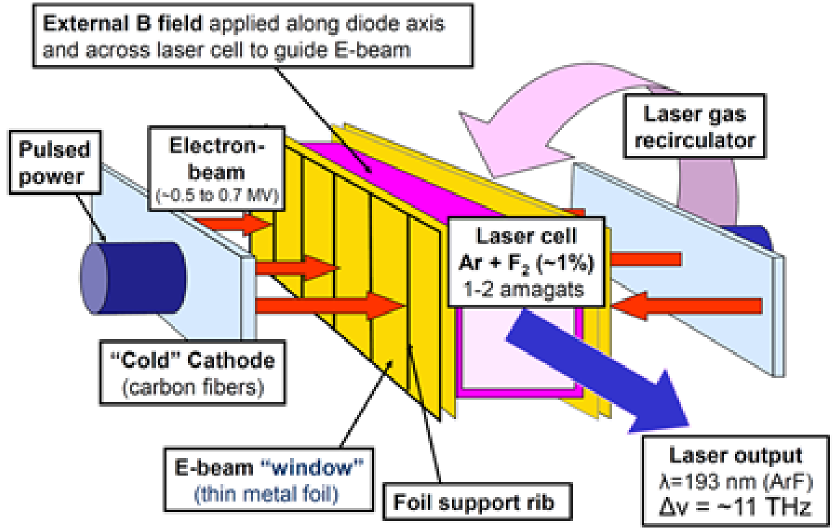
Time averaged laser spatial profile in target chamber



NRL has advanced the basic S&T of the electron beam pumped ArF laser

NRL PPD

NRL Electra Facility

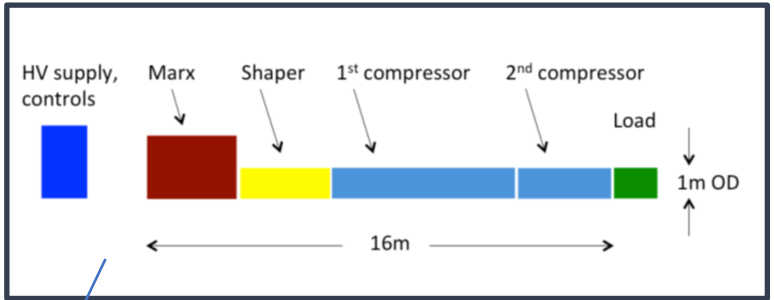


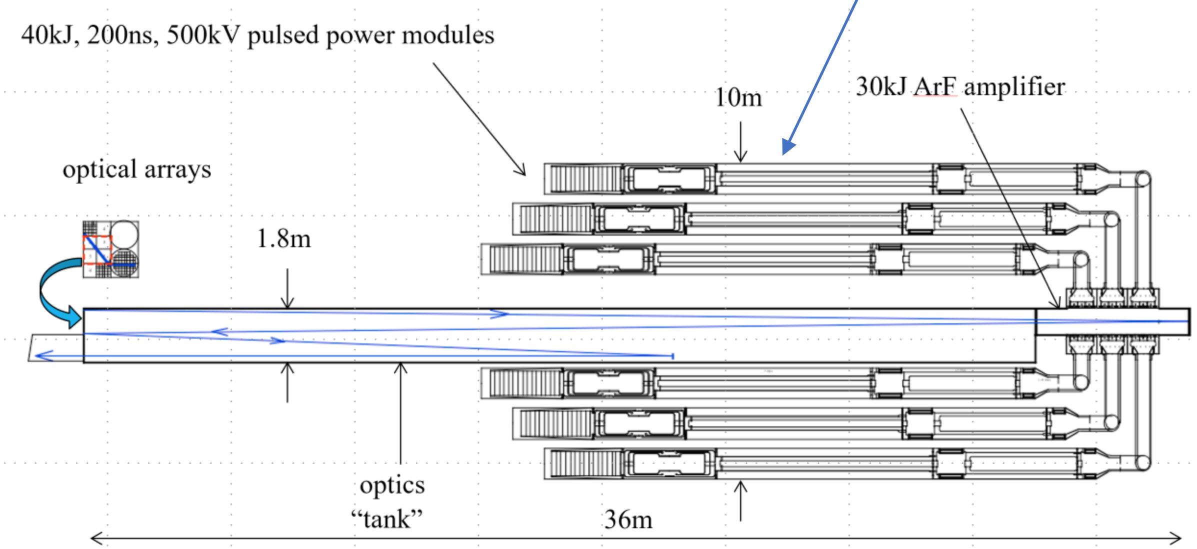
ArF laser use by lithographic industry has advanced 193 nm optics.

- Demonstrated 5 pulse per second operation with similar KrF operation
- Converted to ArF to advance basic electron-beam pumped ArF S&T
- World record ArF energy (200J)

Conceptual design for a high energy high-rep-rate ArF amplifier needed for a laser fusion power plant

All solid-state switched (silicon & magnetic) pulse-power module



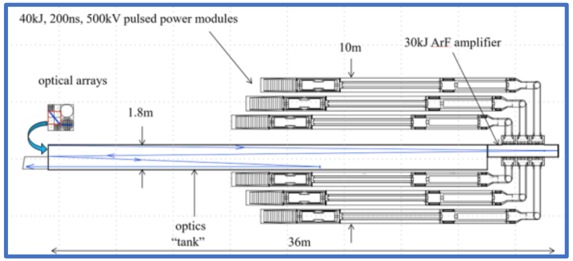


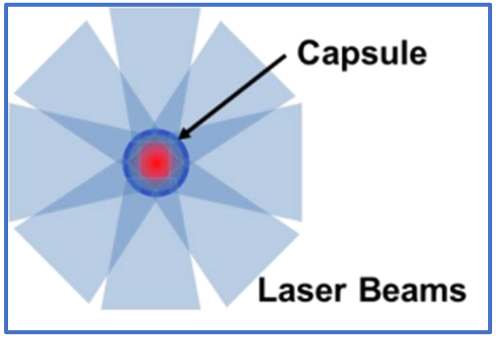
ArF laser gas cell
90 cm x 90 cm aperture

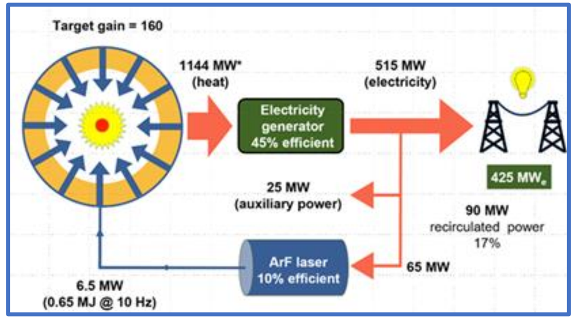
M. McGeoch. Plex LTD

30-kJ 10-pulse-per-second 90-cm aperture ArF amplifier

Development path to ArF laser IFE pilot plant/ IFE test facility







- **Develop and DEMO ~30 kJ ArF laser beamline.**
- Test ArF laser target interaction physics @ 30 KJ
- Develop auxiliary technologies (100 shot/day target fab)
- Studies to define and reduce COE

- **High-gain ArF direct drive implosion facility**
- Operating at 100 shots/day
- DEMO high gain (>100x)
- Develop 10 pulses/second ArF beamline
- Develop all other pilot plant technologies
- Design pilot power plant

- **500 MWe pilot power plant / Inertial Fusion Test Facility**
- Develop and test operating procedures
- Advance and test materials and components
- Breed tritium fuel from lithium
- DEMO net power generation

Path forward to IFE

- The combination of the high fusion gain from a ArF direct drive laser system and low cost target fabrication could provide a practical source of fusion power.

- We will need long lived reaction chambers – short term threat from alphas (HAPL program identified potential solutions) and longer term threat from neutron atomic displacements and activation of first wall.

- Cost studies indicate that laser system will be only about 30% of cost for an IFE power plant. Can be drive down the cost of the other nuclear and balance of plant components?

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