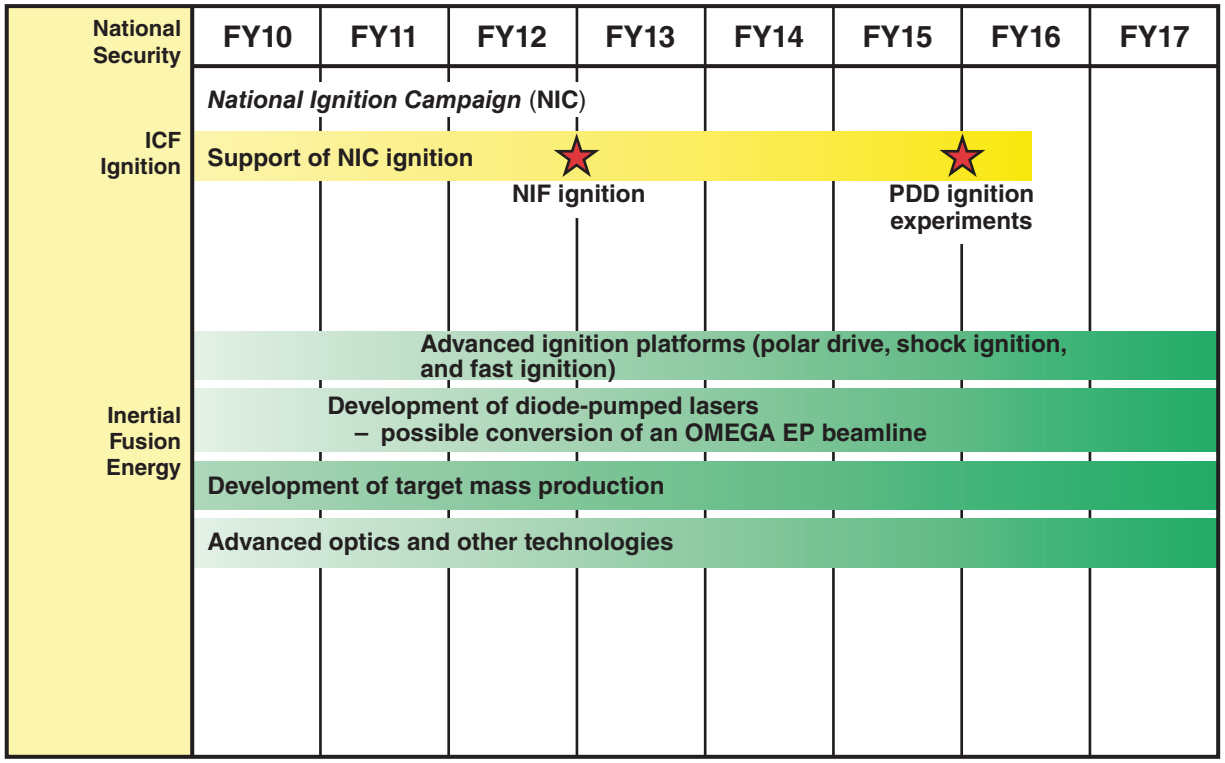
The University of Rochester's Laboratory for Laser Energetics' Role in Inertial Fusion Energy Development



J. M. Soures for R. L. McCrory
University of Rochester
Laboratory for Laser Energetics

31st Fusion Power Associates
Annual Meeting and Symposium
Fusion Energy: Focus on the Future
Washington, D. C
1–2 December 2010

Summary

LLE will play a major role in a national IFE program

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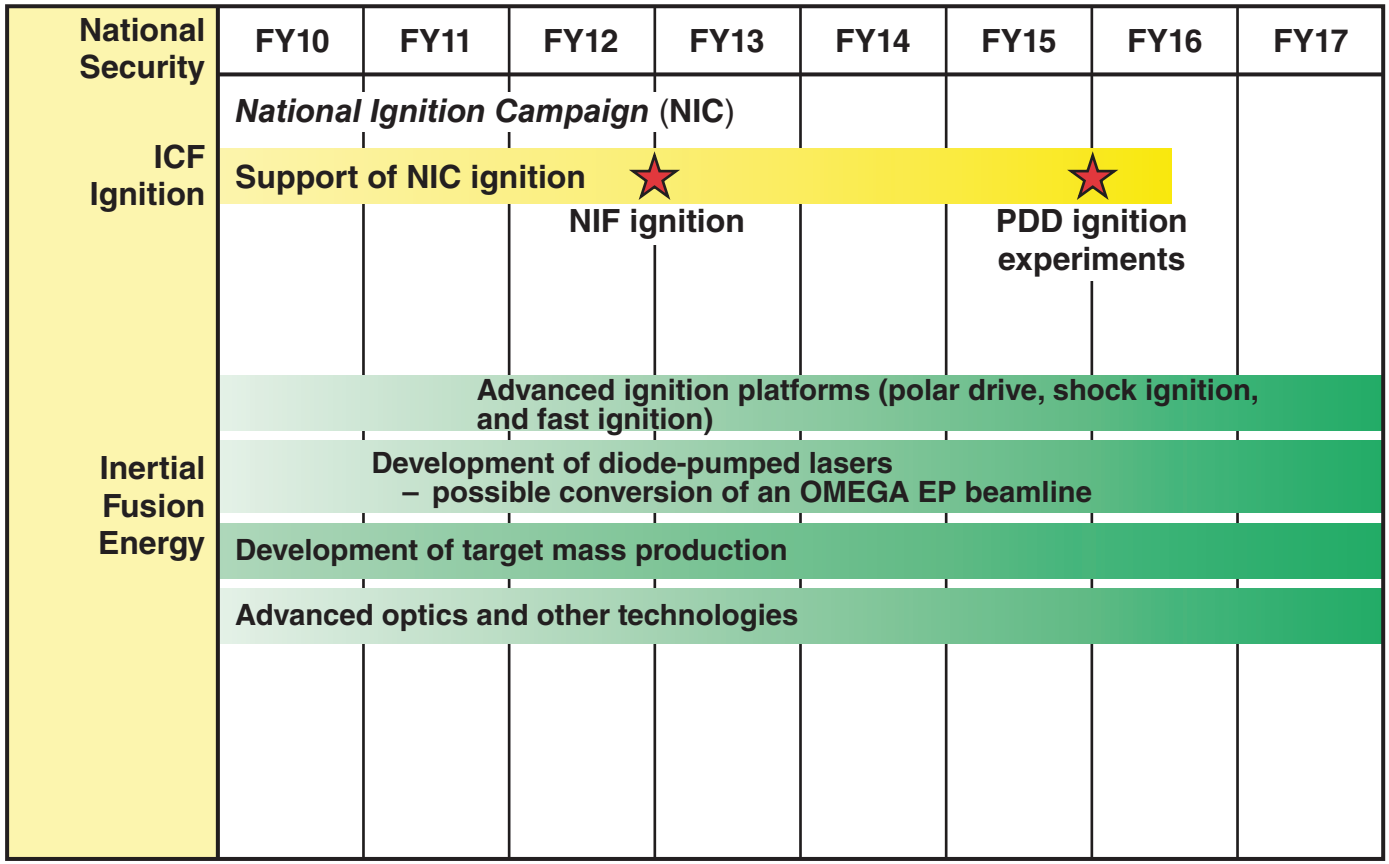
- LLE is developing advanced ignition designs (polar drive, shock ignition*, and fast ignition*) that may provide higher gains than the baseline NIF indirect-drive design
- LLE will make major contributions to IFE technologies, including
  - target-fabrication techniques
  - development of tritium handling systems
  - advanced optical materials and coatings
  - potential to convert an OMEGA EP beamline to diode pumping
- LLE is working with the other ICF sites to develop a consensus plan to present to the NAS IFE study

LLE favors a fast-paced IFE timeline and will be working with the other participants to define it further.

*See R. Betti talk

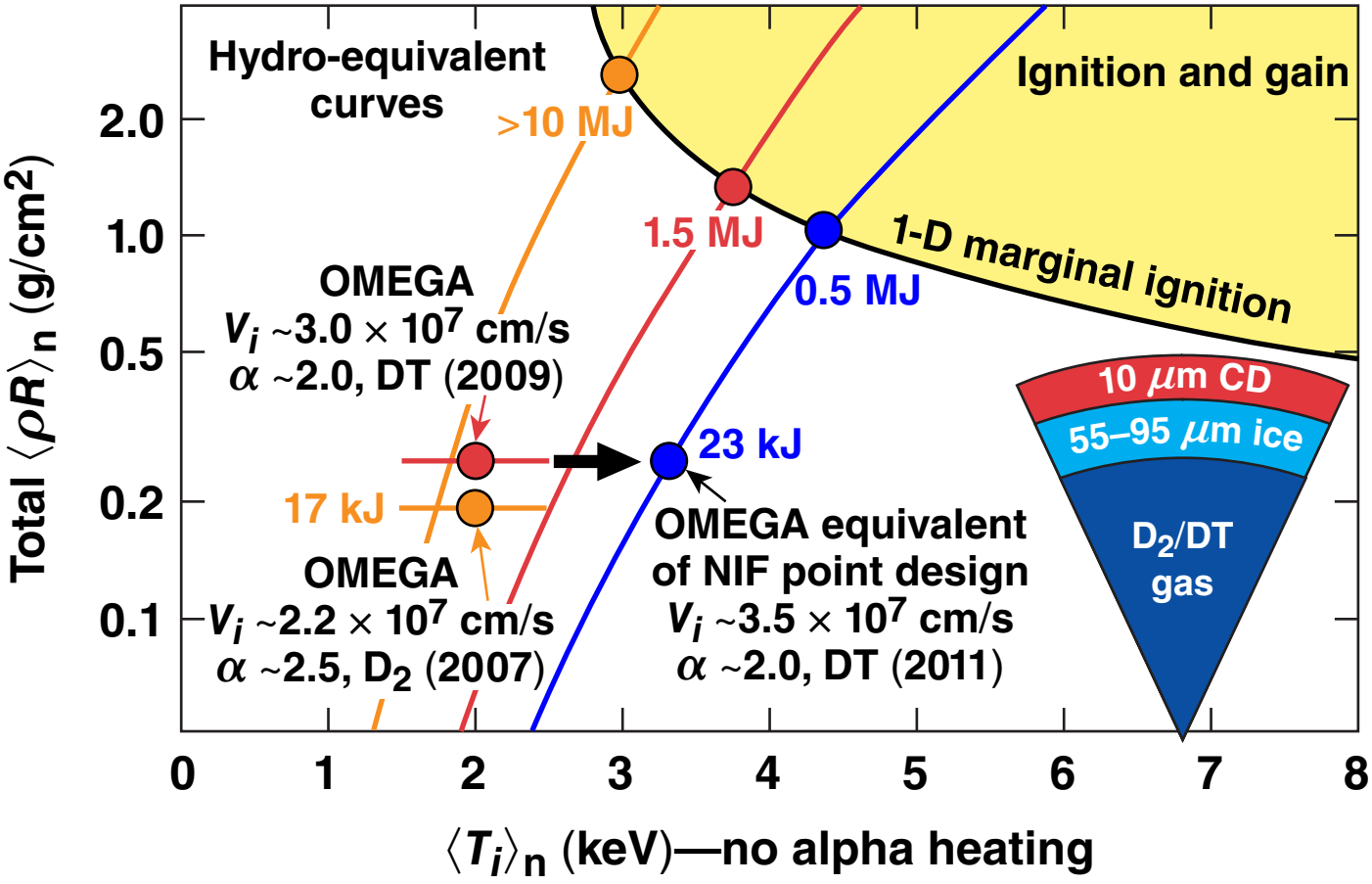
LLE's IFE research program will focus on advanced ignition concepts after NIF ignition



Advanced-ignition concepts may also benefit the SSP.

OMEGA Experiments

OMEGA experiments are on a path to demonstrate scaling to NIF polar-drive ignition

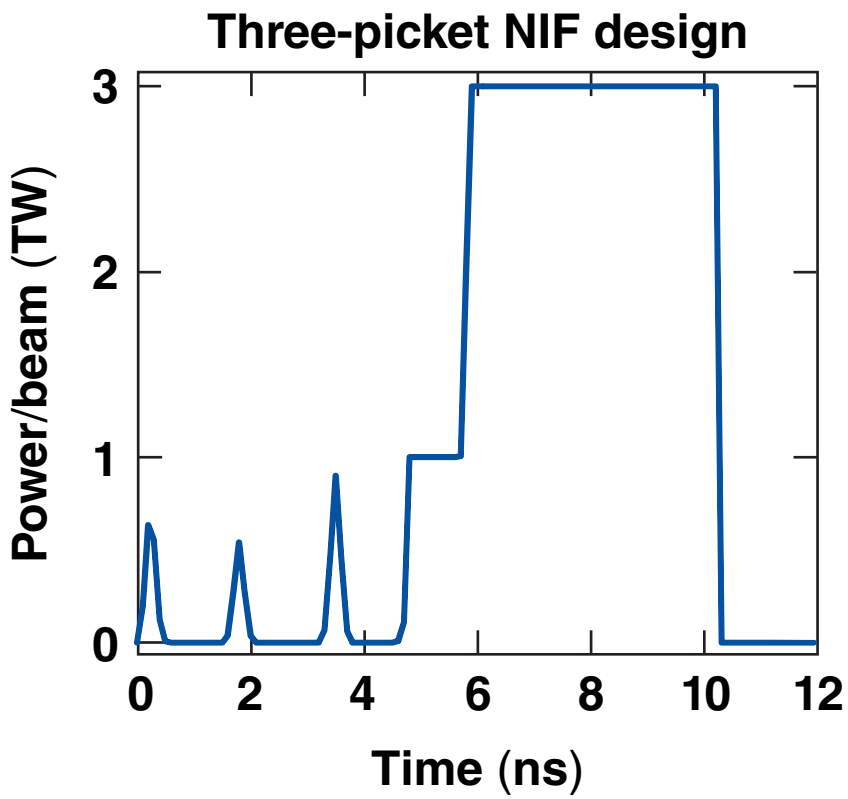


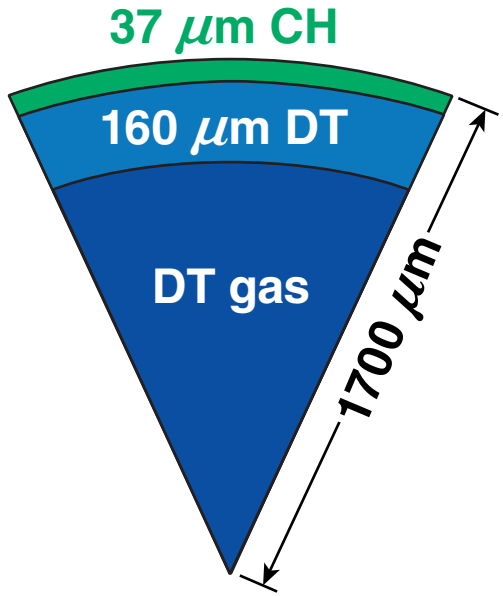
E18409d

R. L. McCrory *et al.*, Phys. Plasmas 15, 055503 (2008).

A new LLE ignition design uses a multi-picket, multishock drive instead of the continous low-intensity foot

$Gain_{1\text{-}D} = 48$

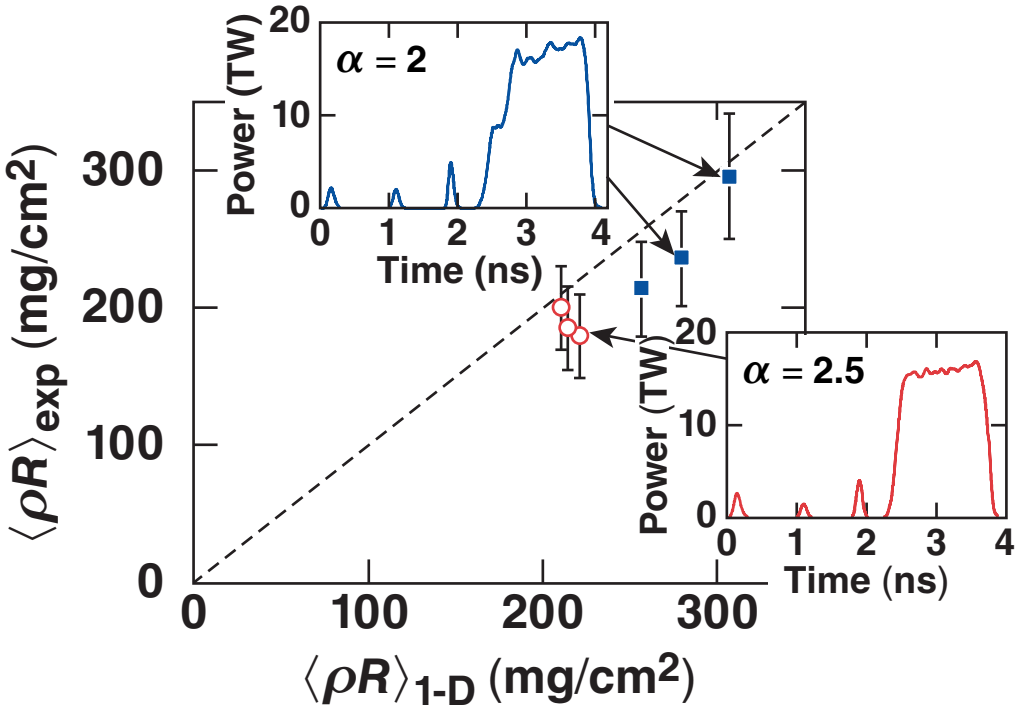


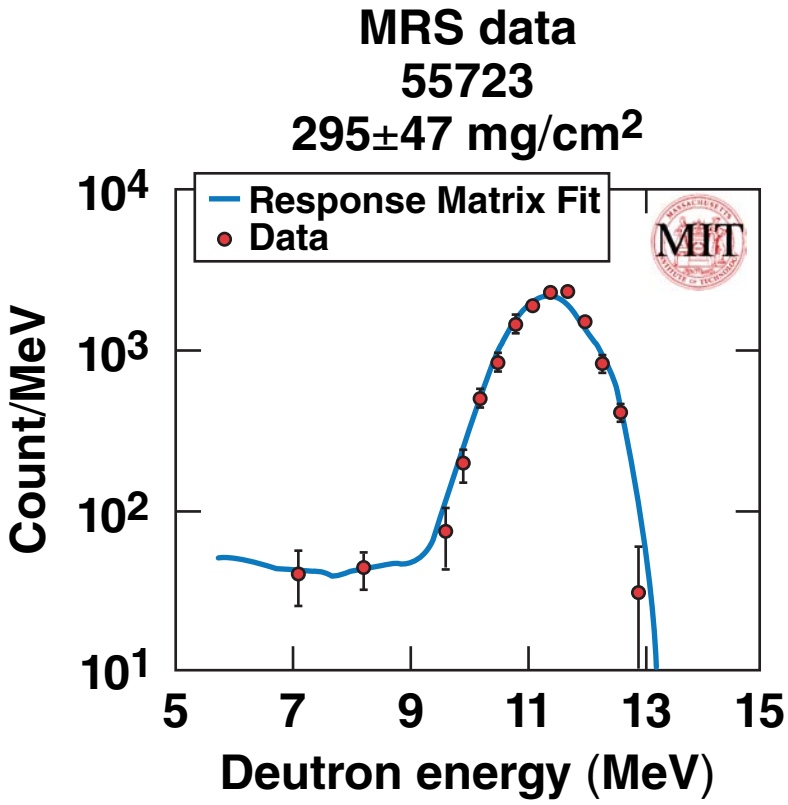


The multiple-picket design is easier to tune for shock coalescence.

V. N. Goncharov *et al.*, submitted to Physical Review Letters

Shock-tuned, triple-picket designs demonstrated near 1-D compression up to $\langle \rho R \rangle$ ~300 mg/cm^2





LLE has conducted over 100 cryogenic DT-target implosions on OMEGA.

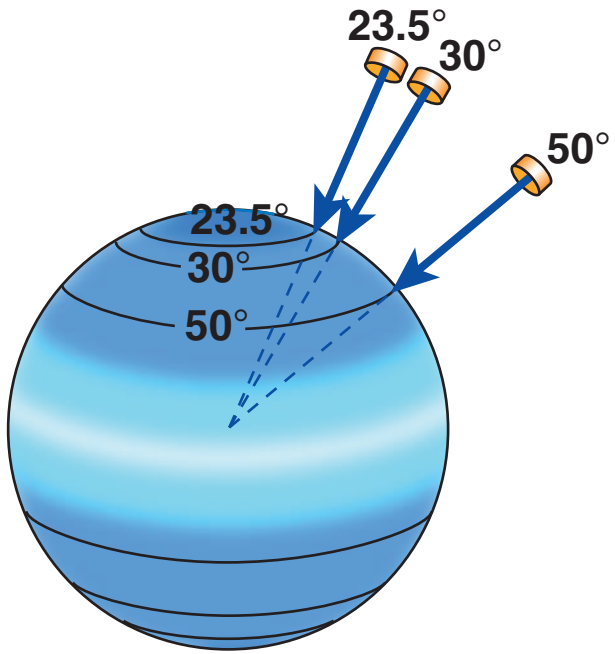
TC8896d

Polar Drive

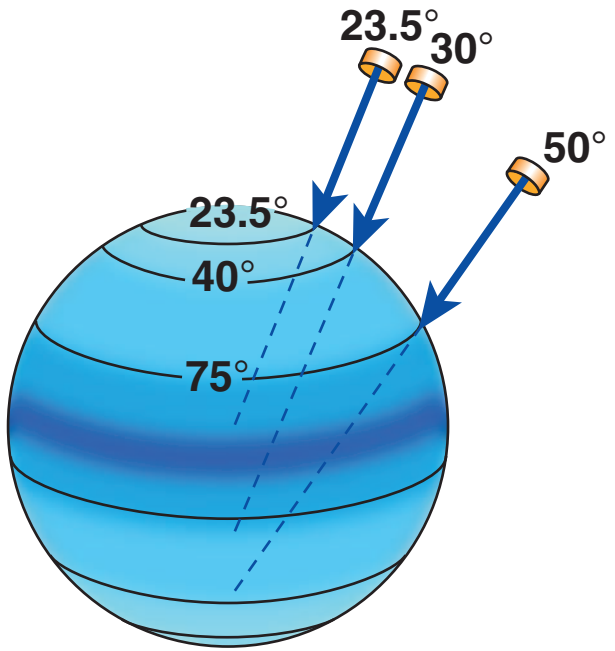
LLE proposed polar drive in 2003 to allow direct-drive implosions on the NIF without moving the beams

UR LLE NIC The National Ignition Campaign

Pointing for x-ray drive



Repointing for polar drive*



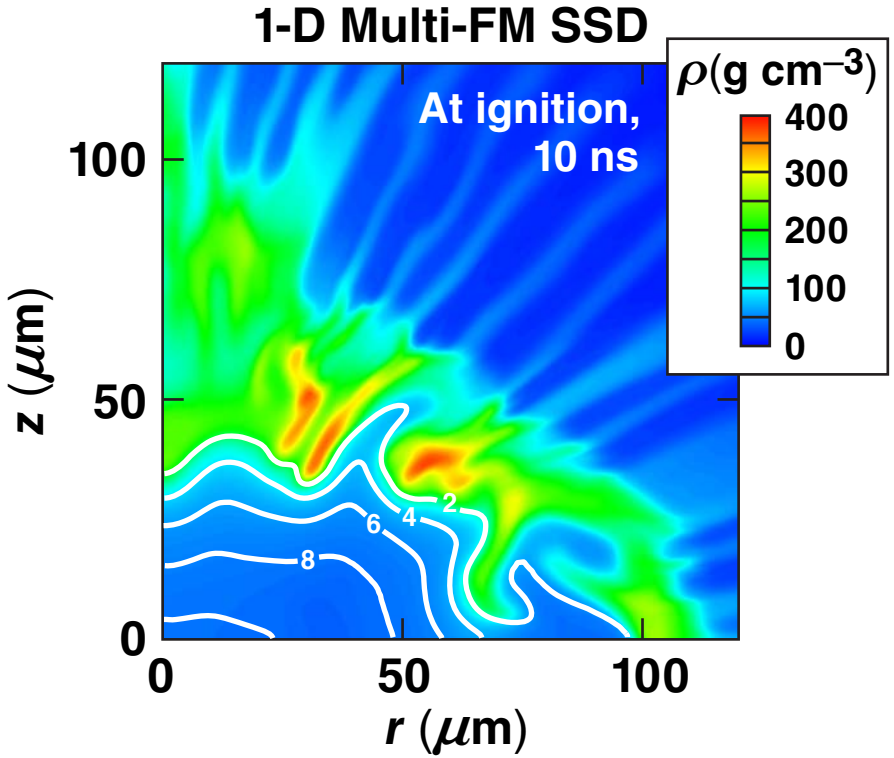
Polar drive provides

- **Ignition alternative**
- **Diagnostic qualification on the NIF**
- **HED platform for the NIF**

*S. Skupsky *et al.*, Phys. Plasmas 11, 2763 (2004).

The triple-picket PD design with target and beam nonuniformities and Multi-FM beam smoothing achieves a 2-D gain of 19

- A 1-μm ice roughness is included in these calculations, as well as single-beam imprint, 8% rms power imbalance, 30-ps rms beam mistiming, and surface roughness



The long-term plan is to validate polar-drive ignition on the NIF to offer a higher-gain target option for IFE.

IFE Target Fabrication

LLE is developing an IFE target-fabrication process that uses a microfluidic "lab-on-chip" approach to manipulate fluid droplets and transport targets

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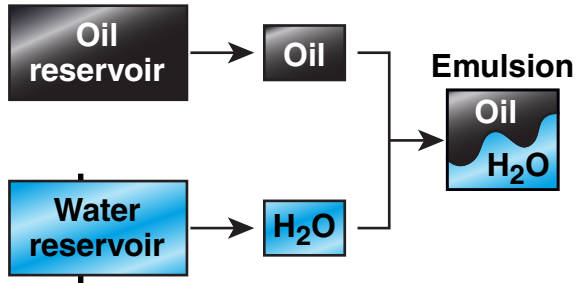
Step 1

Dispense fluids and combine them to make an oil–water emulsion

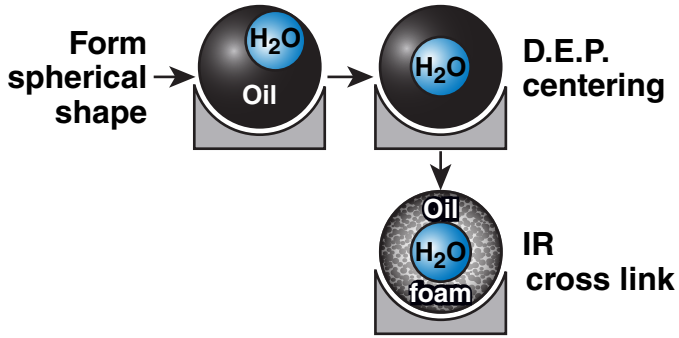
Demonstrated



Step 2

Center the emulsion using an electric field and polymerize the shell

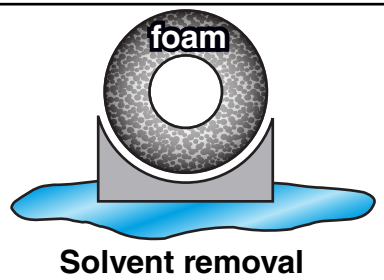
In Progress



Step 3

Remove fluid from the polymerized shell

Evaluating techniques other than critical-point drying



Step 4

Dispense DT droplet and add to the foam shell

Demonstrated with D_2

Step 5

Add Ne/Ar/Xe overcoat

Planning experiments

Step 6

Layering: mass production

Conceptual Step

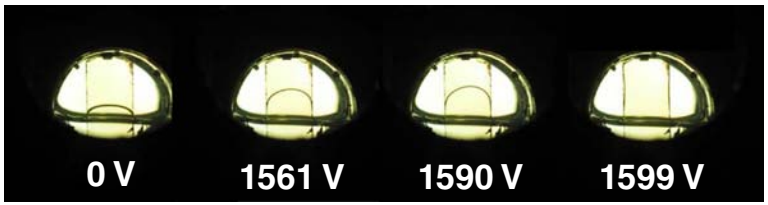
Step 7

Target injection and survival

Preliminary data

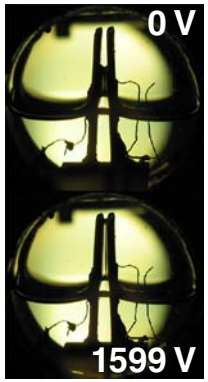
Target production and filling time could be significantly reduced with the "lab-on-chip" approach.

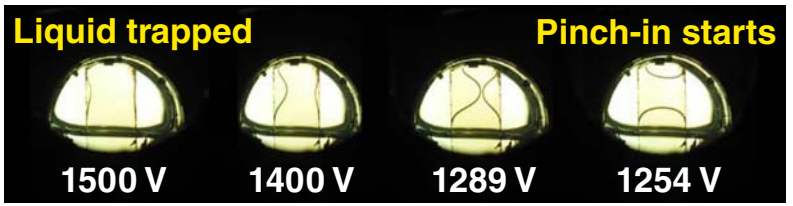
We have demonstrated the feasability of using the dielectrophorectic force to move cryogenic fluids



1. An electric field elevates a column of liquid D_2

Rotated 90°

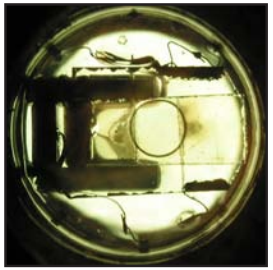




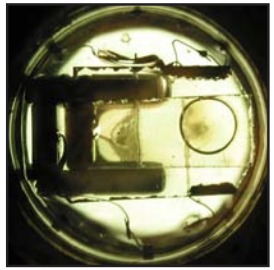
2. Lowering the voltage leaves a trapped volume of D_2

3. The D_2 droplets can be moved laterally

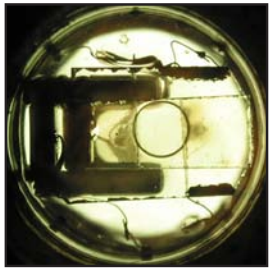
14-μL D_2 droplet



Electrodes de-powered



1.8 KV on the rightmost electrode



Electrodes de-powered

This is a first demonstration of dielectrophoretic behavior in a cryogenic liquid.

Tritium Handling

Using microfluidics to fuel targets simplifies the primary fuel cycle by handling cryogenic DT only once

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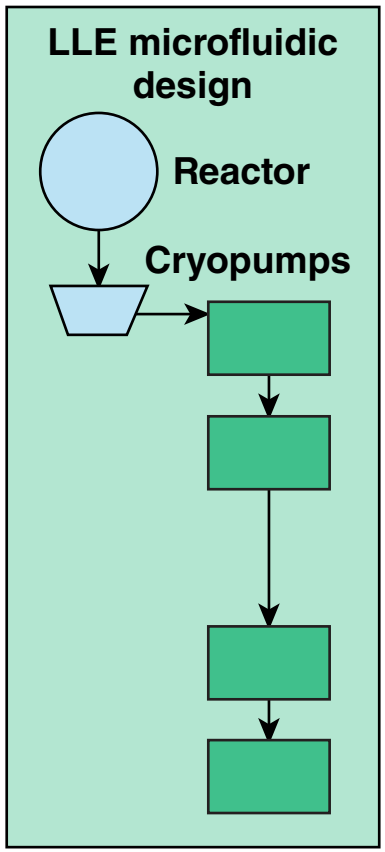
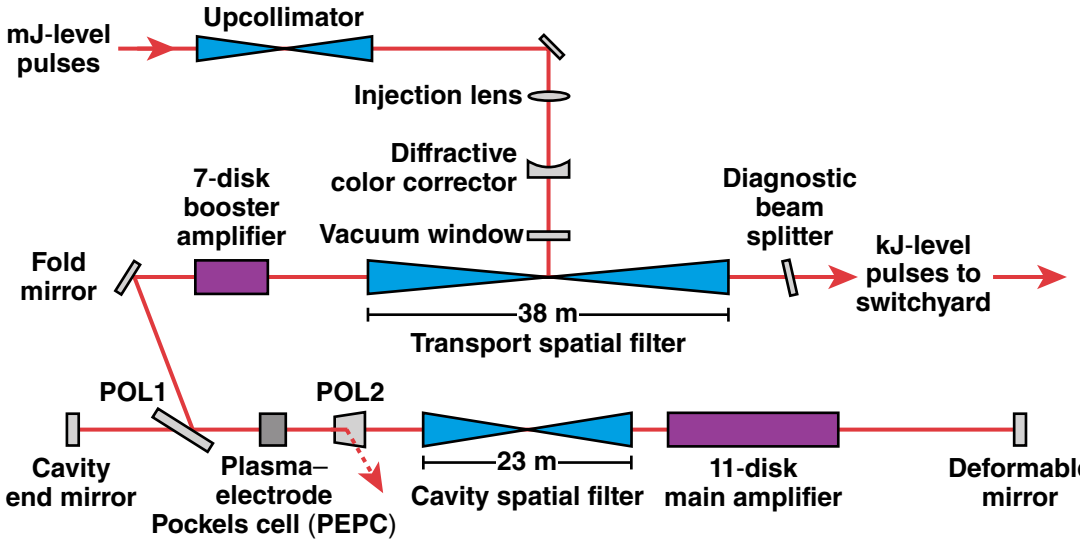
- Reduces tritium inventory
- Reduces ^{3}He accumulation in targets
- Fewer steps
- Simplified DT handling
  - eliminate the need for high pressure
  - increased reliability
  - reduce equipment footprint



IFE Driver Development

The open architecture of an OMEGA EP beamline would allow it to be converted to diode pumping

- An OMEGA EP beamline is NIF-scale unbundled
- An OMEGA EP beamline could be converted to a full-scale IFE prototype by diode pumping
- Advantages
  - building and infrastructure exist
  - amplifiers are modular so a diode-pumped module could be developed offline
  - existing OMEGA EP target chamber would allow for full-scale tests of target injection and tracking



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