COLLEGE OF ENGINEERING
NUCLEAR ENGINEERING & RADIOLOGICAL SCIENCES
UNIVERSITY OF MICHIGAN

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Laser Gate Experiment for Increasing Energy Coupling Efficiencies in Magnetized Liner Inertial Fusion (MagLIF)*

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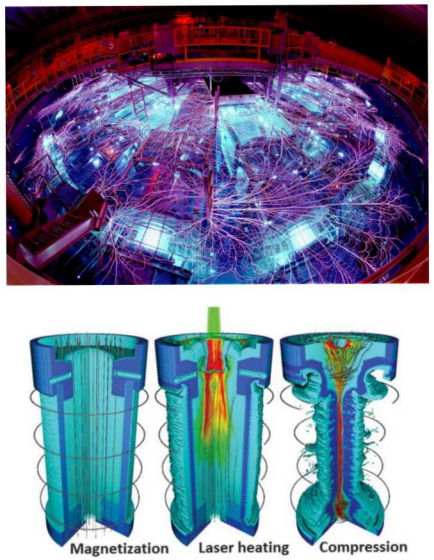
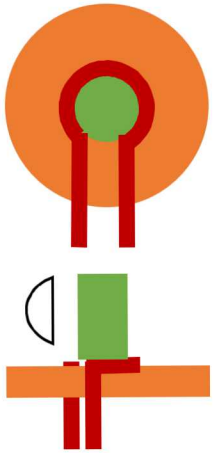
Outline of today's talk

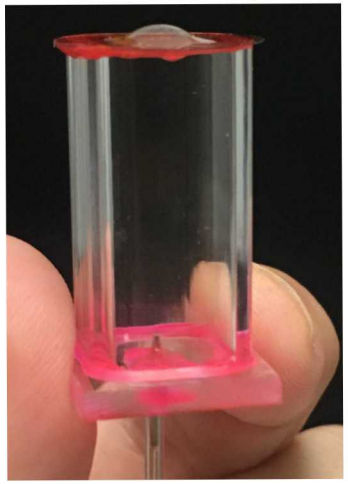
Z Machine and MagLIF



Laser Gate Concept

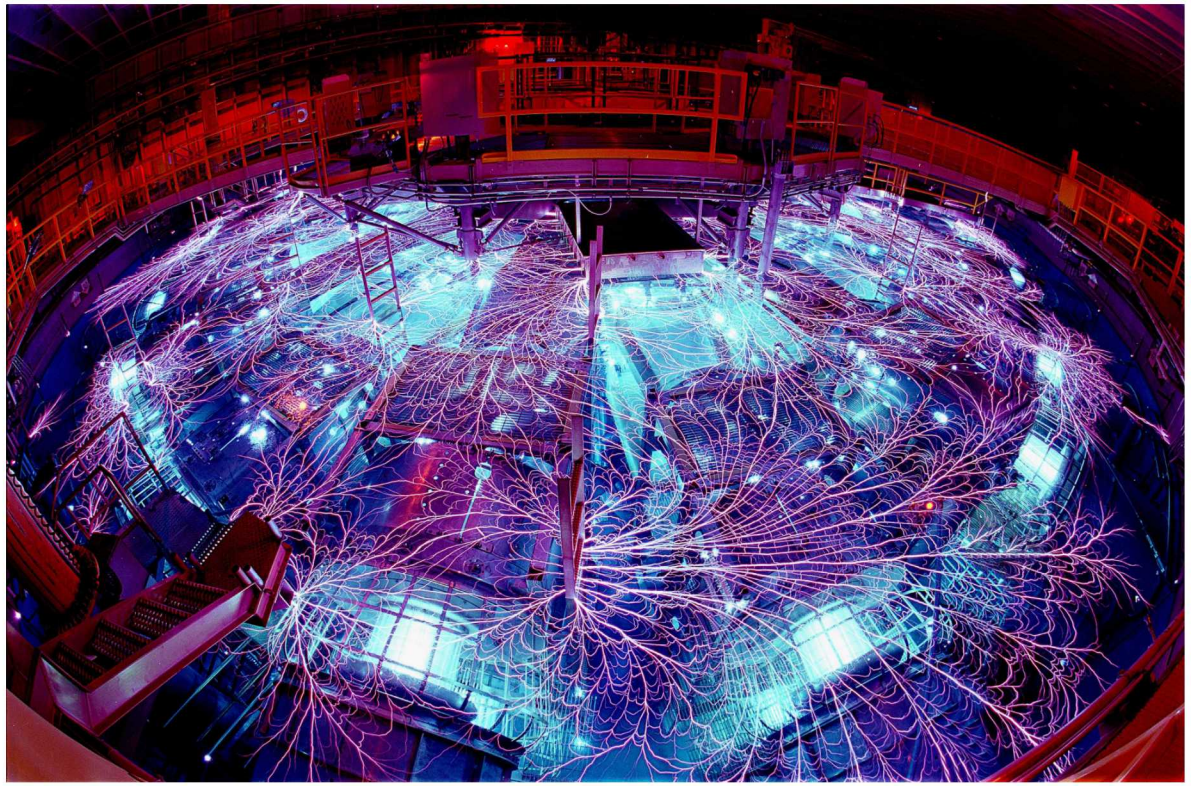


Experimental Setup



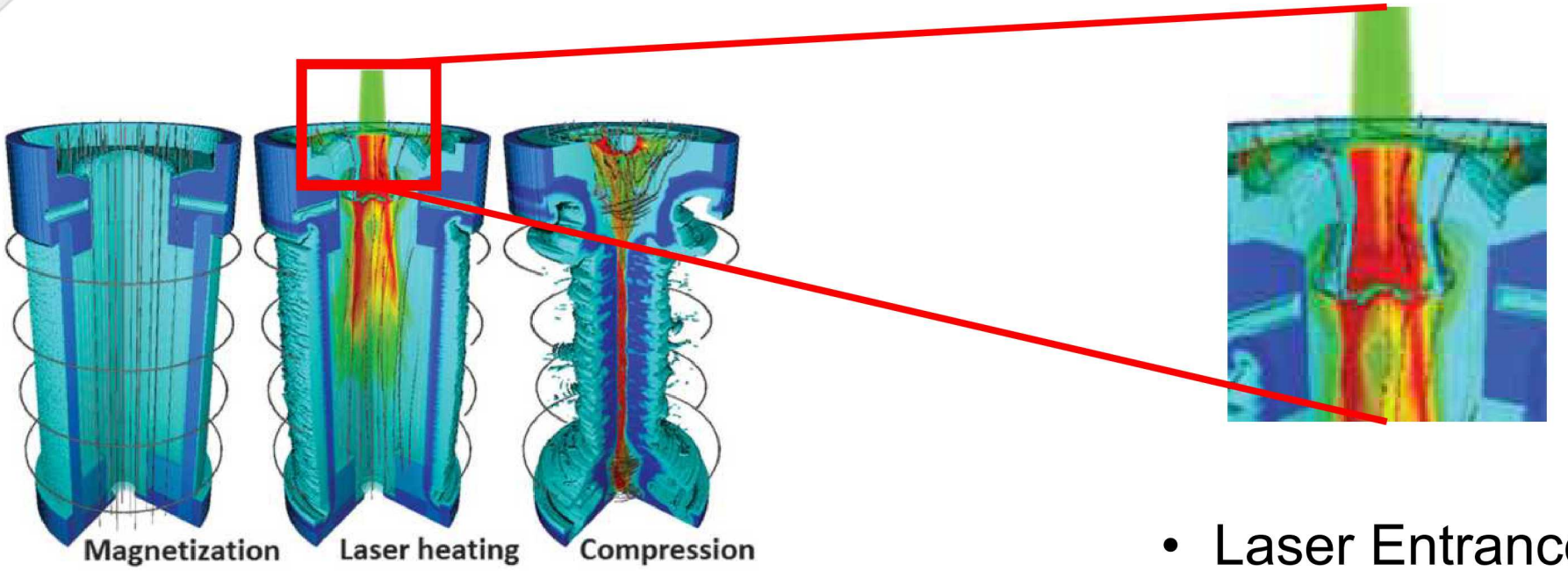
Results

Important Experiments on the Z Machine



- 22 MJ stored energy
- 3 MJ delivered to the load
- 26 MA peak current
- 100’s Mbar drive pressure
- 100 - 1000 ns pulse length

3 Stages of MagLIF



Magnetized Liner Inertial Fusion

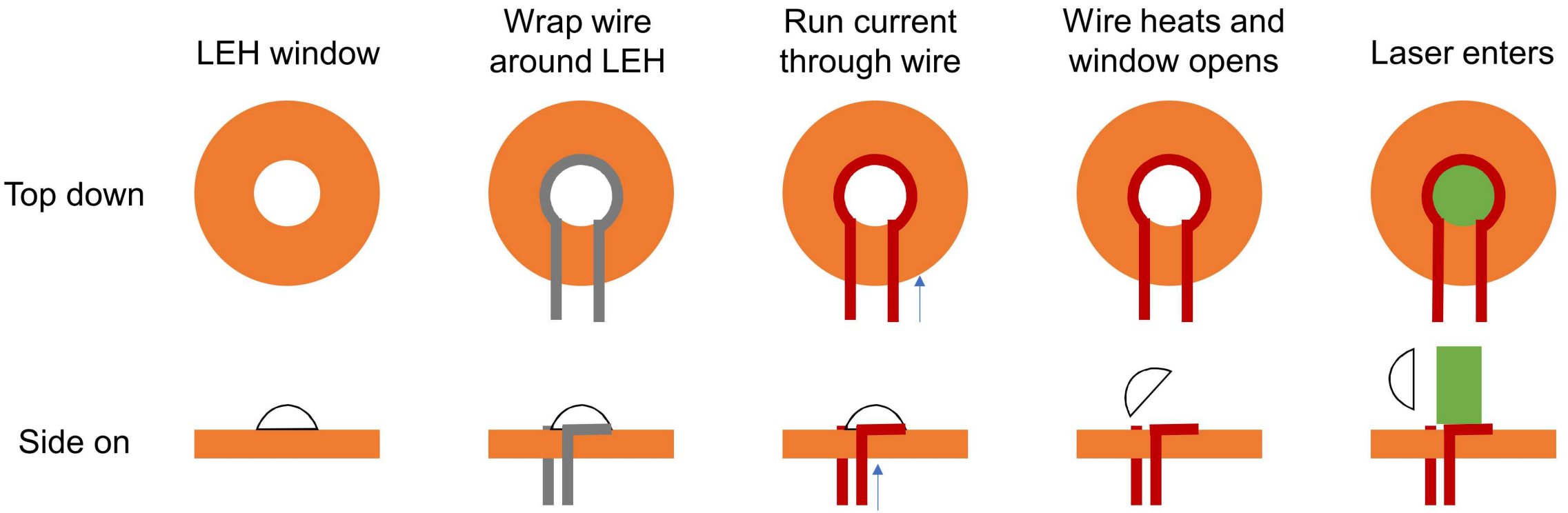
- Laser Entrance Hole (LEH) Window
- Losses occur coupling laser energy to fuel

Sources of energy coupling losses

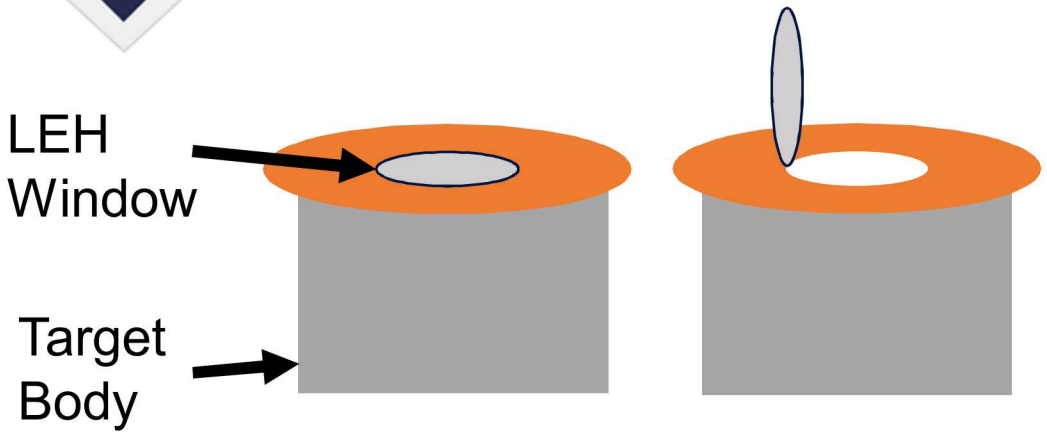
- Energy to ablate the window material
- Window material mixing with fuel
- LPI (Laser plasma interactions)

Laser Gate concept

- To eliminate fuel window mix and laser plasma interactions (LPI)
- Remove window early in time proposed by Steve Slutz



Estimating window opening time



$$t = \left(\frac{5\,\pi}{4}\right)^{1/2} \left(\frac{\rho\,\Delta_z\,R}{P}\right)^{1/2} s$$

- Rigid disk
- Constant Pressure
- Rotating about point
- Open at 90°

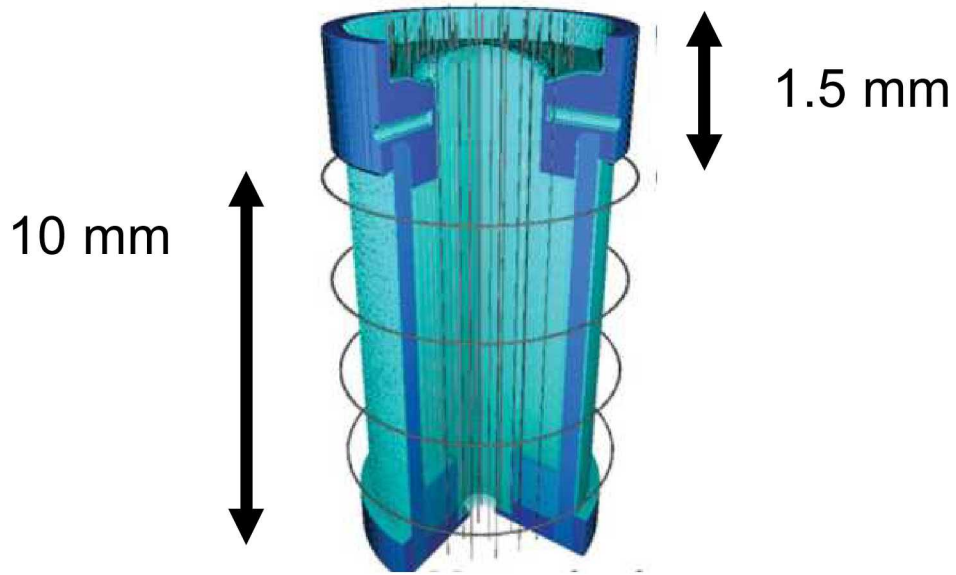
ρ = Window Density (kg/m^3)

Δ_z = Window Thickness (m)

R = Window Radius (m)

P = Fuel Pressure (Pa)

Target design for correct timing



- Time for window to open

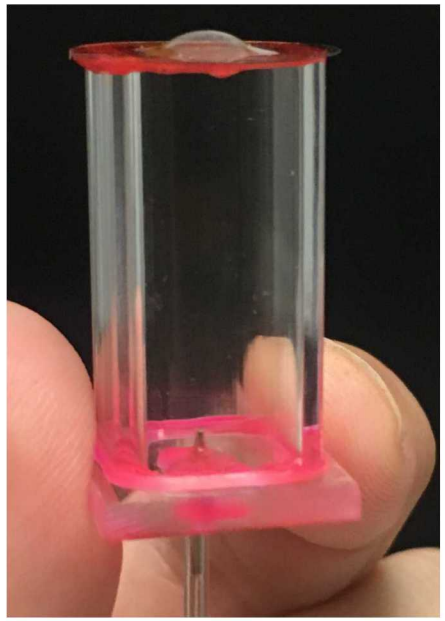
  ~ 3.4 μs
- Time to bottom of cushion

  ~ 1.6 μs
- Time to bottom of target

  ~ 12.5 μs

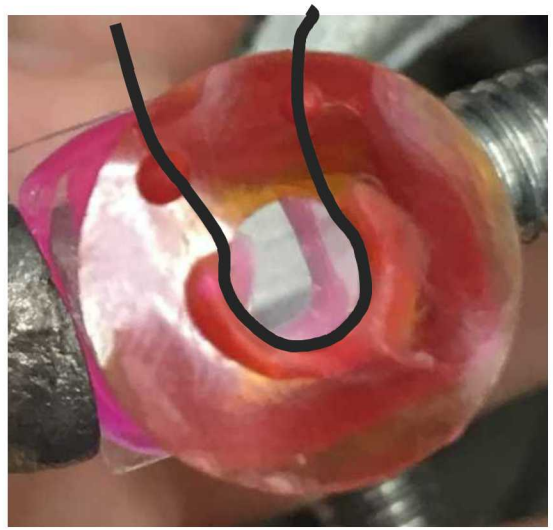
- About double cushion height to account for escaping gas
- Cushion height of 3.2 mm accounts for loss in window opening time

In house target design and fabrication



- 3 μm mylar window
- Polyimide washer
- 1.25 x 1.25 x 2.5 cm

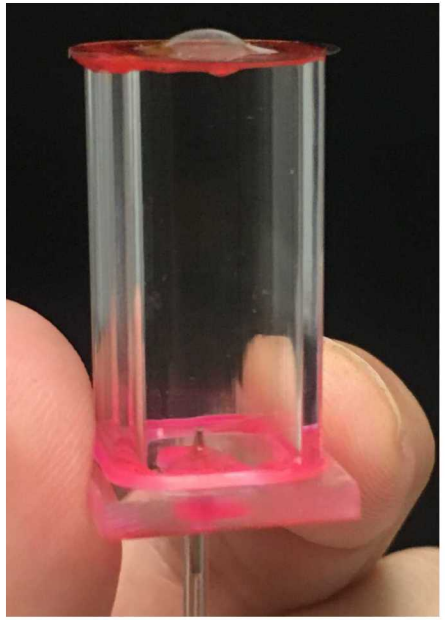
- Compressed air
- 2 atm (30 PSI) fill pressure
- Square cross section for easier imaging



- 0.1 mm wire
- Attached to pulser
- Used to locally melt LEH window

Timings for our targets

25 mm



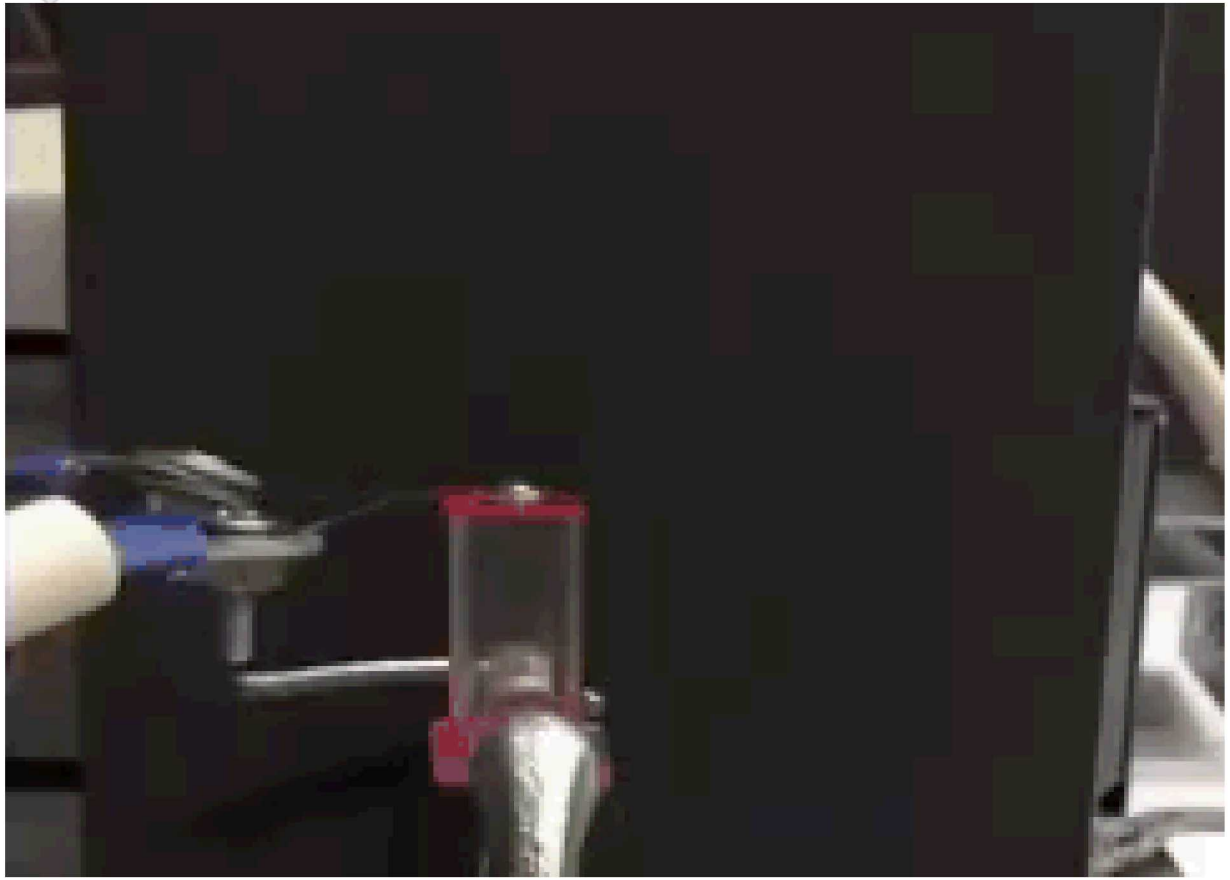
- Time for window to open:

  ~ 14 μs

- Time for rarefaction wave to reach bottom of target:

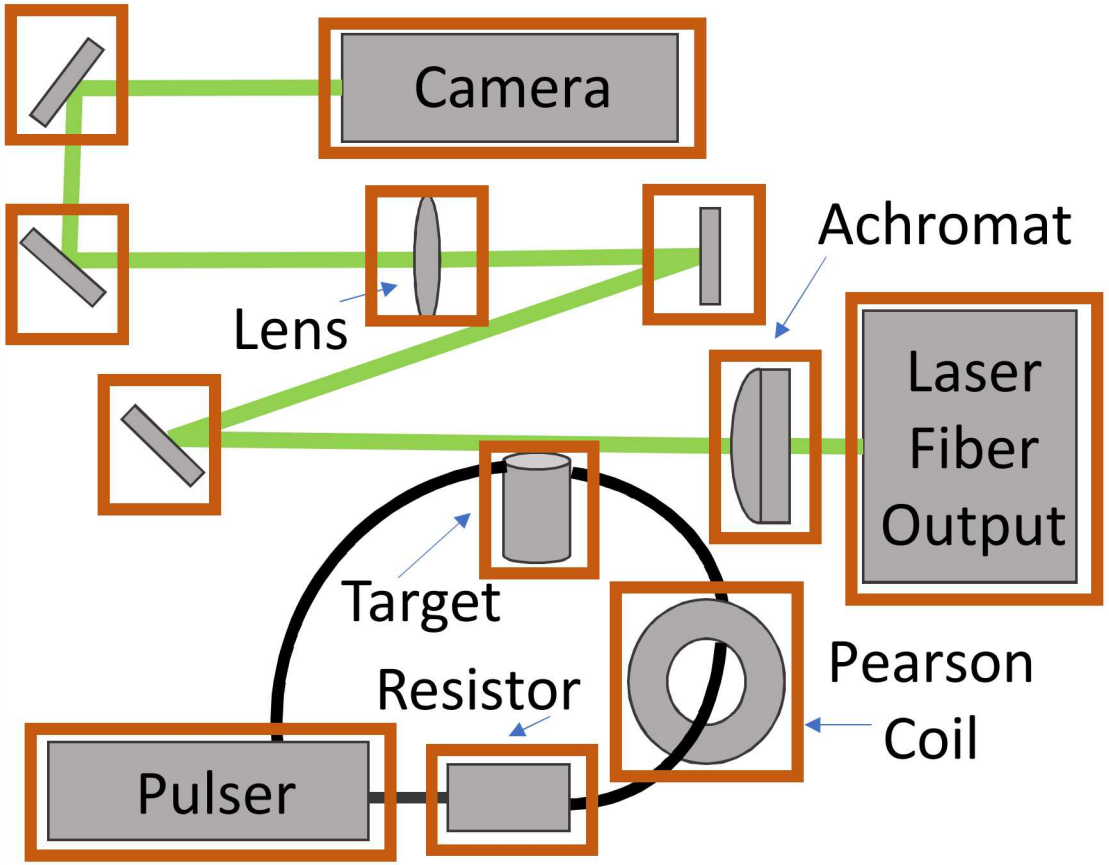
  ~ 74 μs

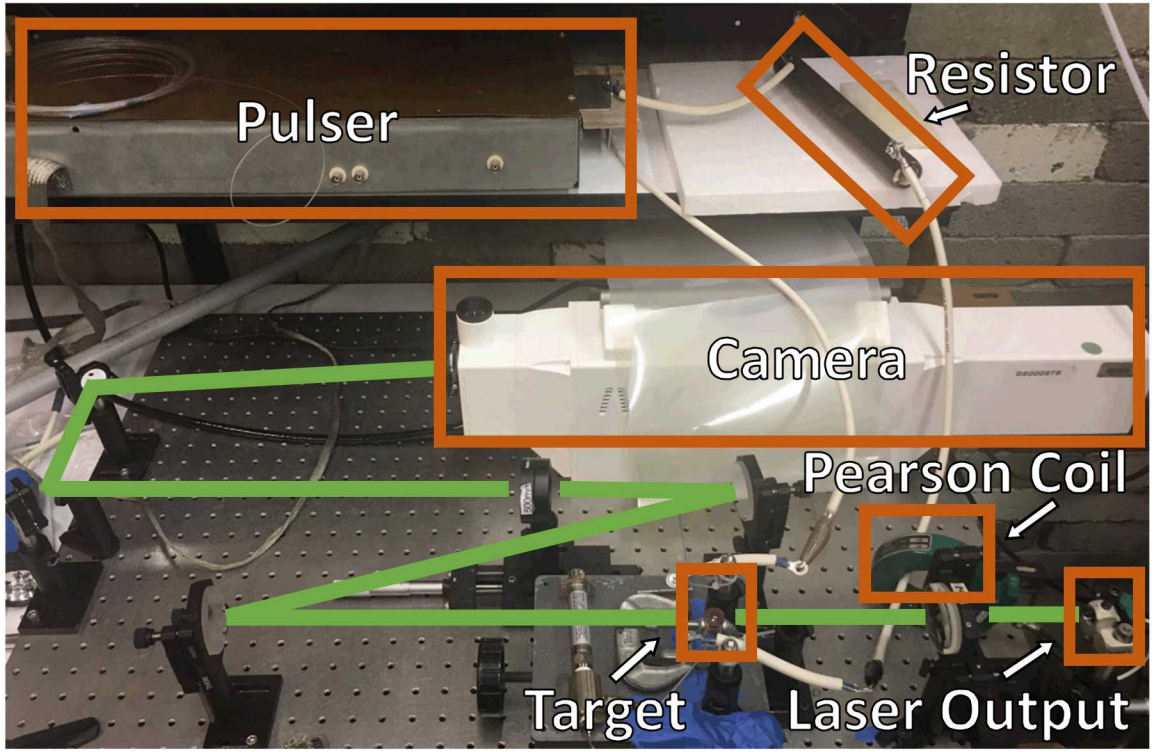
Proof of concept window opening video



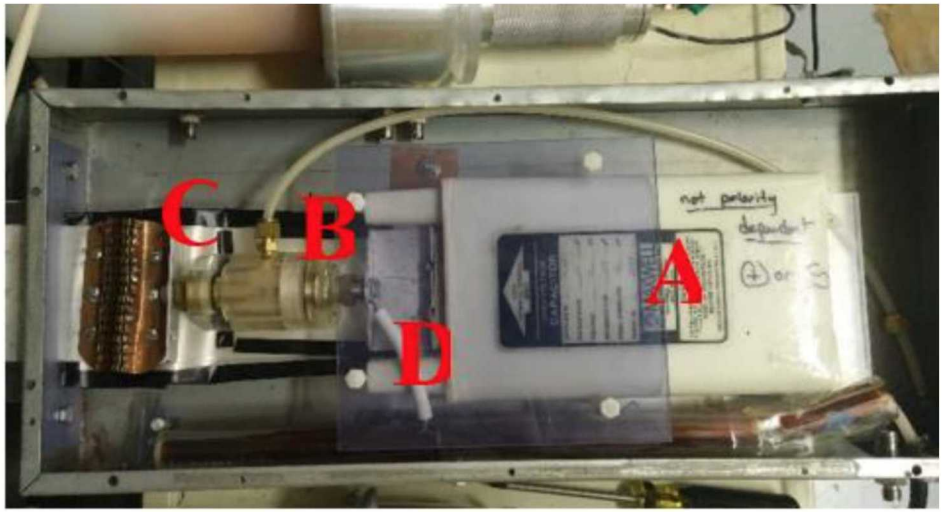
- Filmed on iPhone slow motion camera
- 4 ms frame resolution
- Shows window opening out of potential laser path

New CW experimental setup

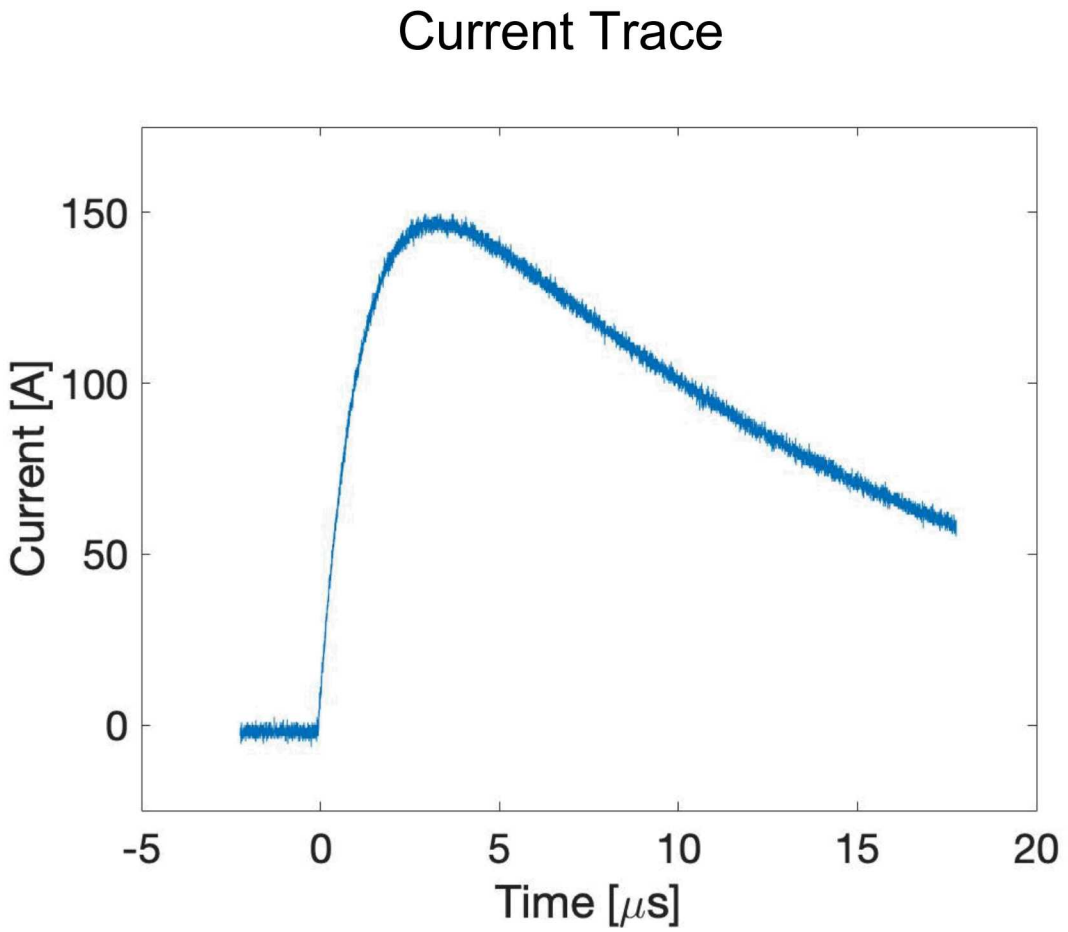




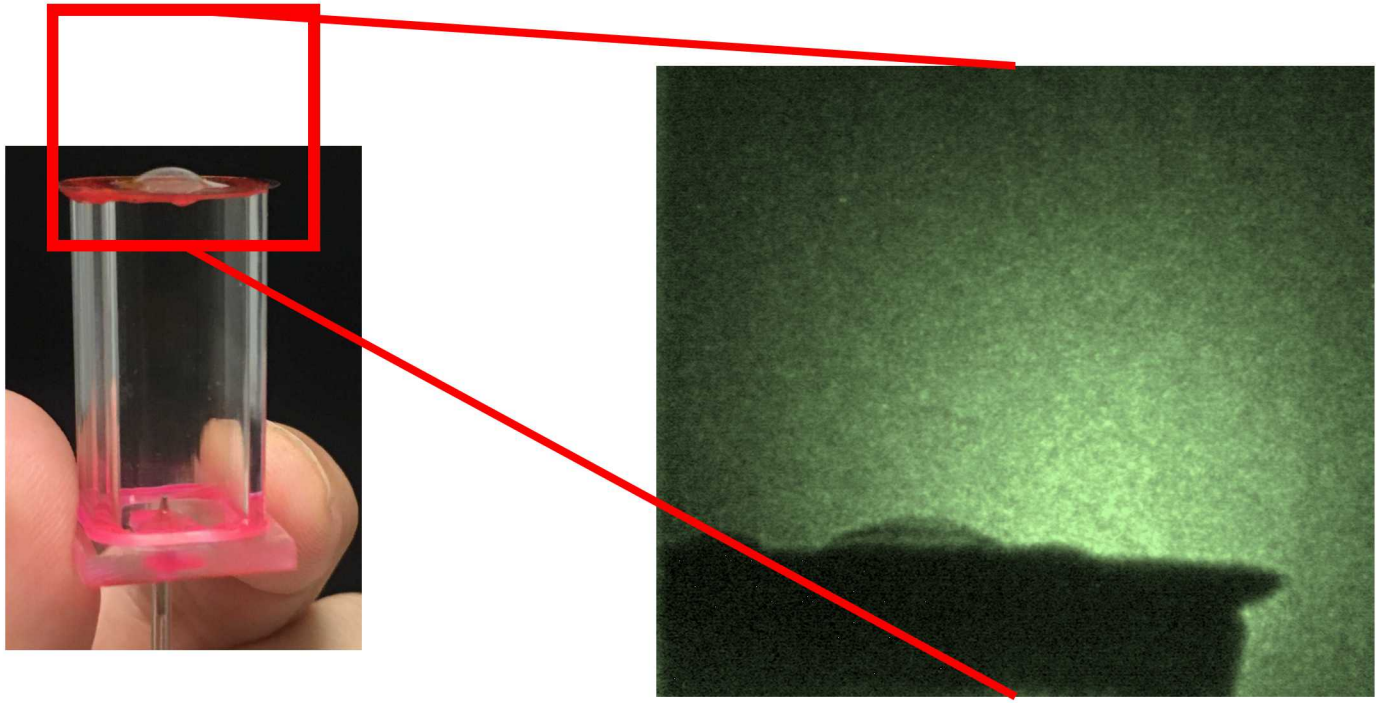
Pulser device driving the current



A. 240 nF capacitor (13 kV)
B. Spark gap switch
C. 0.83 Ω resistor array
D. High voltage input from power supply



Backlit Fast Framing Camera Images



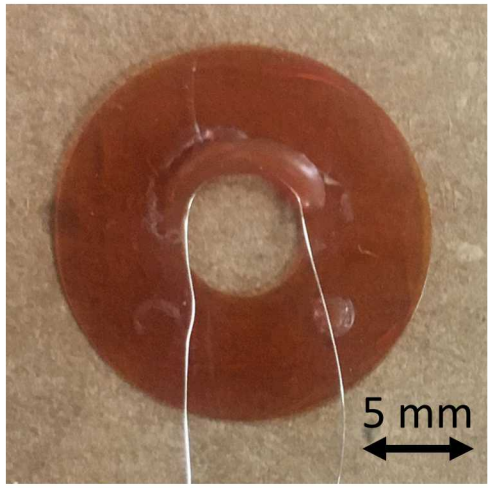
LEH Window Opening

- 10 μs frame resolution
- Window opening out of potential laser path on order of expected time scale

Ongoing Work at Sandia

- Built LEH targets more similar to Sandia parameters
- Vacuum chamber test facility experiments

Michigan

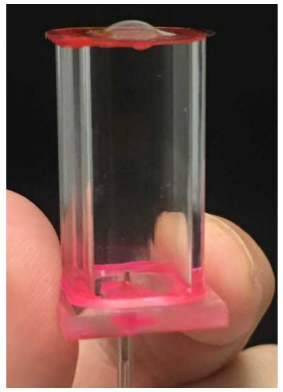


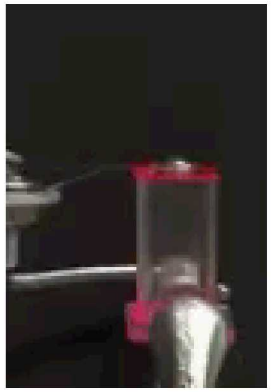
Sandia

	UofM	Sandia
Pressure (atm)	2	4-8
LEH Radius (mm)	2.6	1.1
Fuel Type	Air	D_2
Washer	Sharp Corner	Beveled

Conclusions and Future Work

- Target design and fabrication
- Preliminary window opening out and away
- Wire version of laser gate can remove window
- Transition target design to Sandia parameters





- Study rarefaction wave
- NNSA Laboratory Residency Graduate Fellowship

Questions?