



LASER GATE EXPERIMENT FOR REDUCING ENERGY COUPLING LOSSES IN MAGNETIZED LINER INERTIAL FUSION (MAGLIF) *



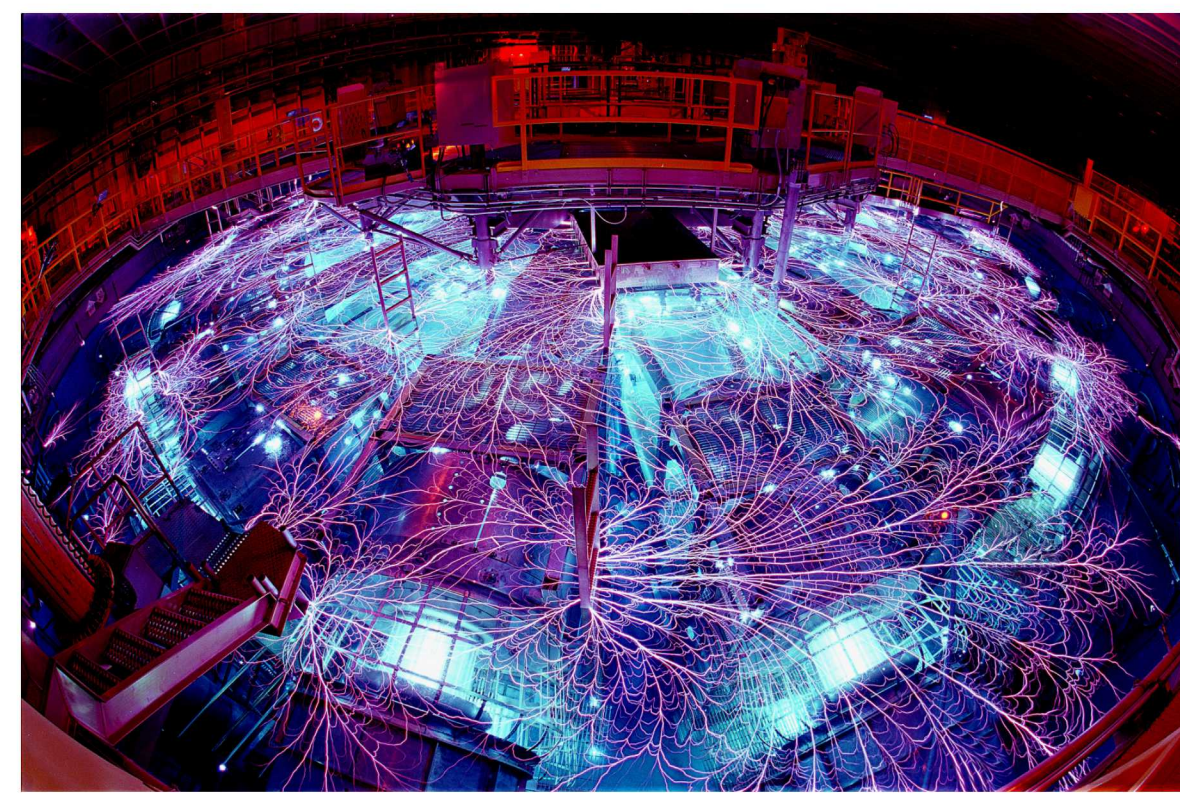
First Year LRGF

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1: University of Michigan 2: Sandia National Laboratories 3: Imperial College London

Motivation

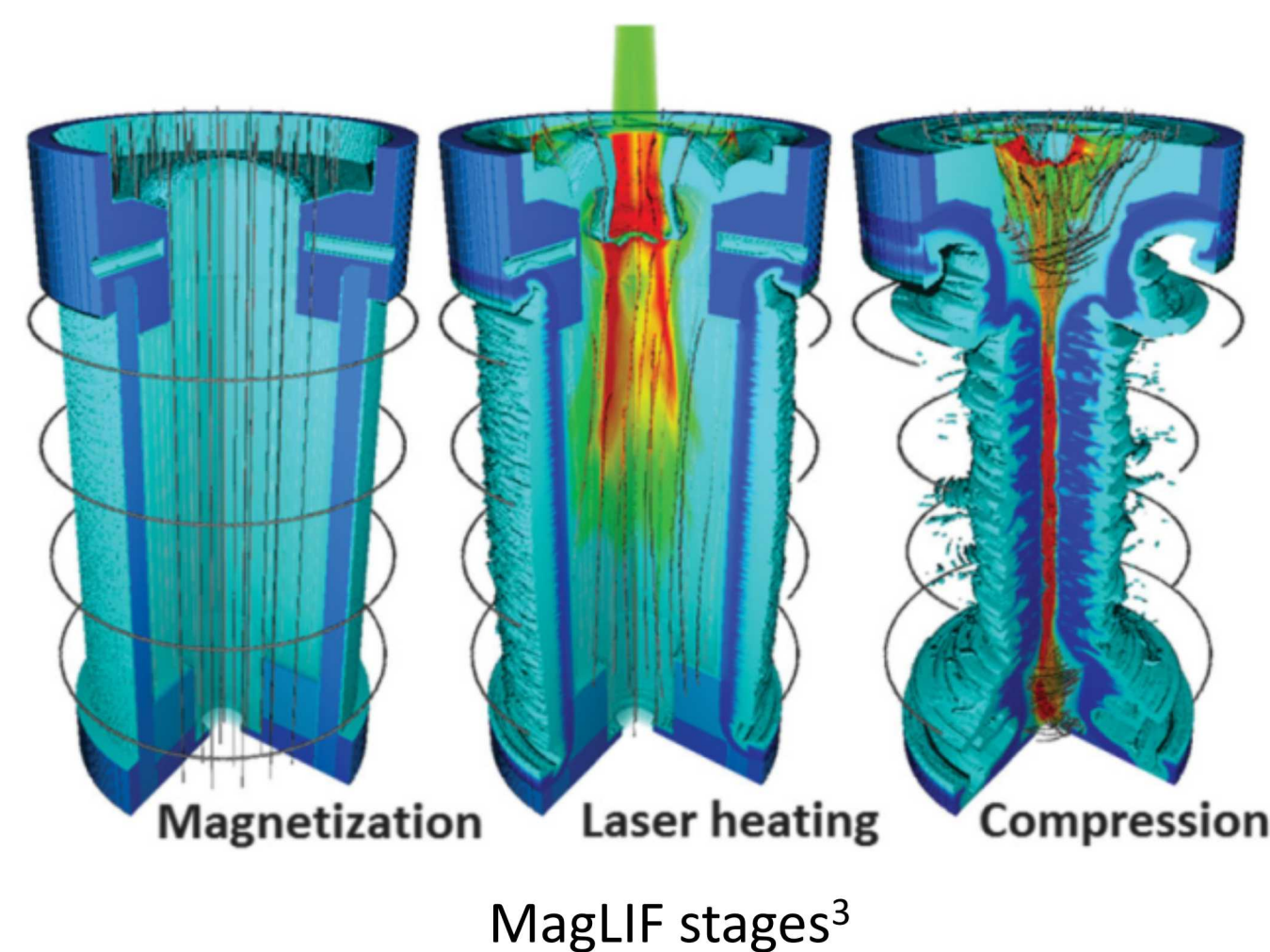
- Achieve ignition for clean energy and stockpile stewardship applications
- Magnetized Liner Inertial Fusion (MagLIF) is a pulsed power version of inertial confinement fusion (ICF) studied at Sandia's Z Machine
- Losses in fusion gain from laser energy absorption, and fuel-window mix originating at the Laser Entrance Hole (LEH)
- Mitigate losses and fuel-window mix to increase yield for MagLIF



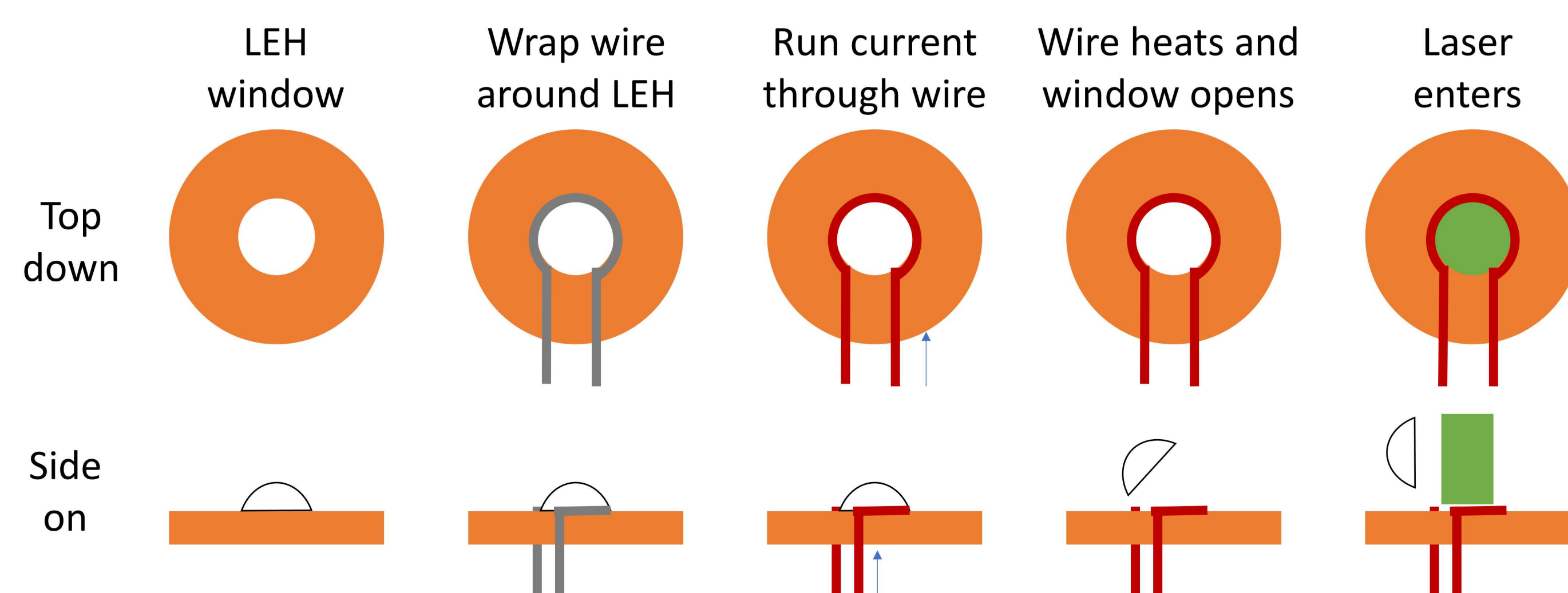
Z Machine at Sandia¹

Background

- 3 stages of MagLIF:
 - Magnetization
 - Laser heating
 - Compression
- LEH window keeps fuel inside of target until laser heating stage
- Need to remove LEH window from path between laser and fuel
- Weaken LEH window and it opens out and away from laser path



Laser Gate Concept



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

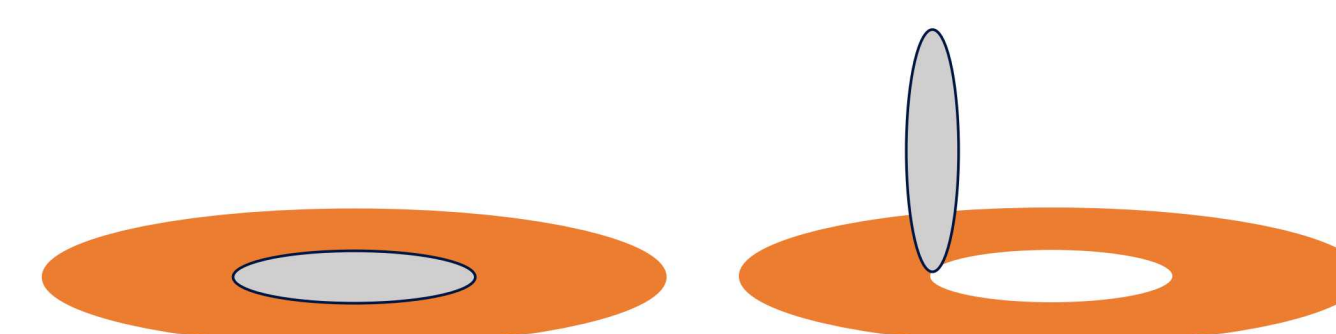
Objectives

- Reduce possible LPI losses by removing window early in time²
- Design and build pressurized MagLIF targets in house
- Image LEH window opening to verify pulsed method
- Study fuel escaping from target (Schlieren Photography)

Will the Timing Work?

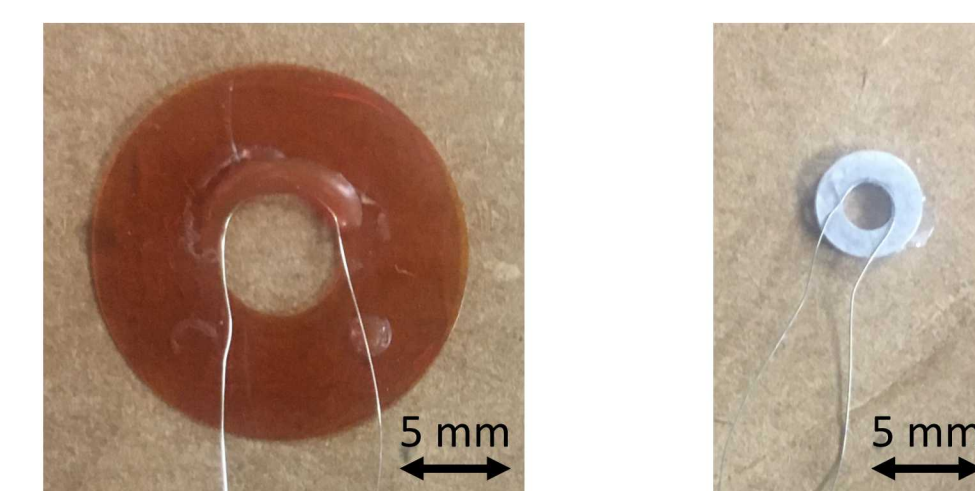
$$t = \left(\frac{5\pi}{4}\right) \left(\frac{\rho \Delta_z R}{P}\right)^{1/2} s$$

ρ = Window Density R = Window Radius
 Δ_z = Window Thickness P = Fuel Pressure



- Thin disk rotating on edge point
- Open when window is at 90°

Michigan **Sandia**



Targets shown at same scale size

Parameters	Michigan Targets	Sandia Targets
Gas Type	Air	Deuterium
Window Thickness (μm)	3	3
Window Radius (mm)	2.6	1.1
Pressure (atm)	2	8
Beveled?	No	Yes
Sound Speed (m/s)	343	923
Target Length (mm)	25.4	10
Opening Time (μs)	14.3	4.7
"Empty" Time (μs)	74.1	10.8

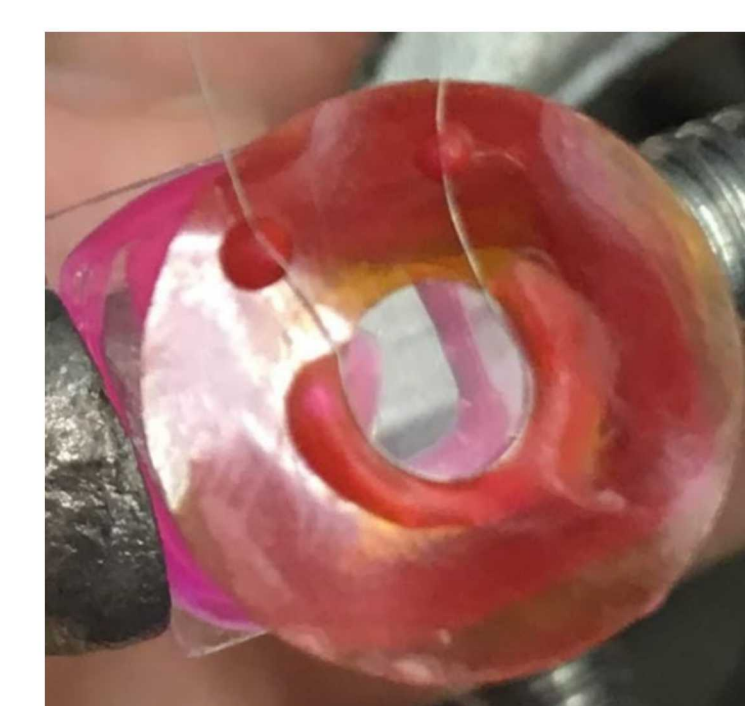
System Design

Target Design



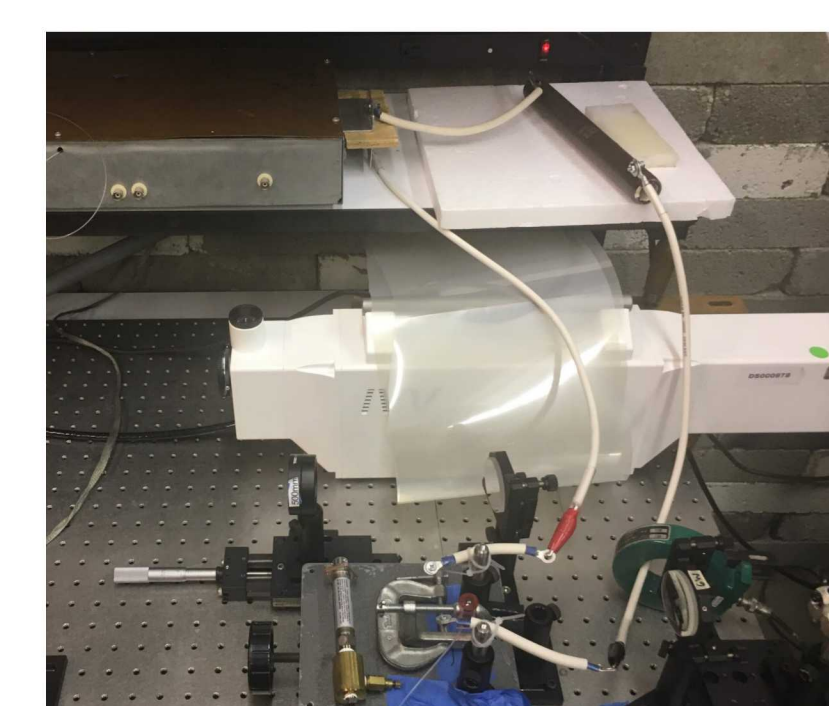
- 0.5" x 0.5" x 1"

Nichrome Wire



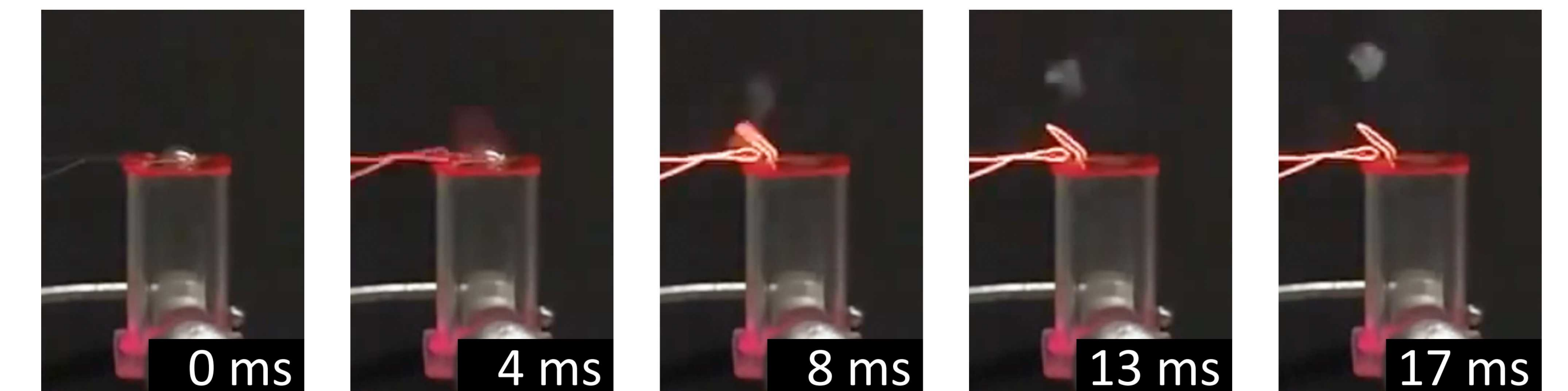
- 0.1 mm wire
- Melt LEH perimeter

Camera/Laser



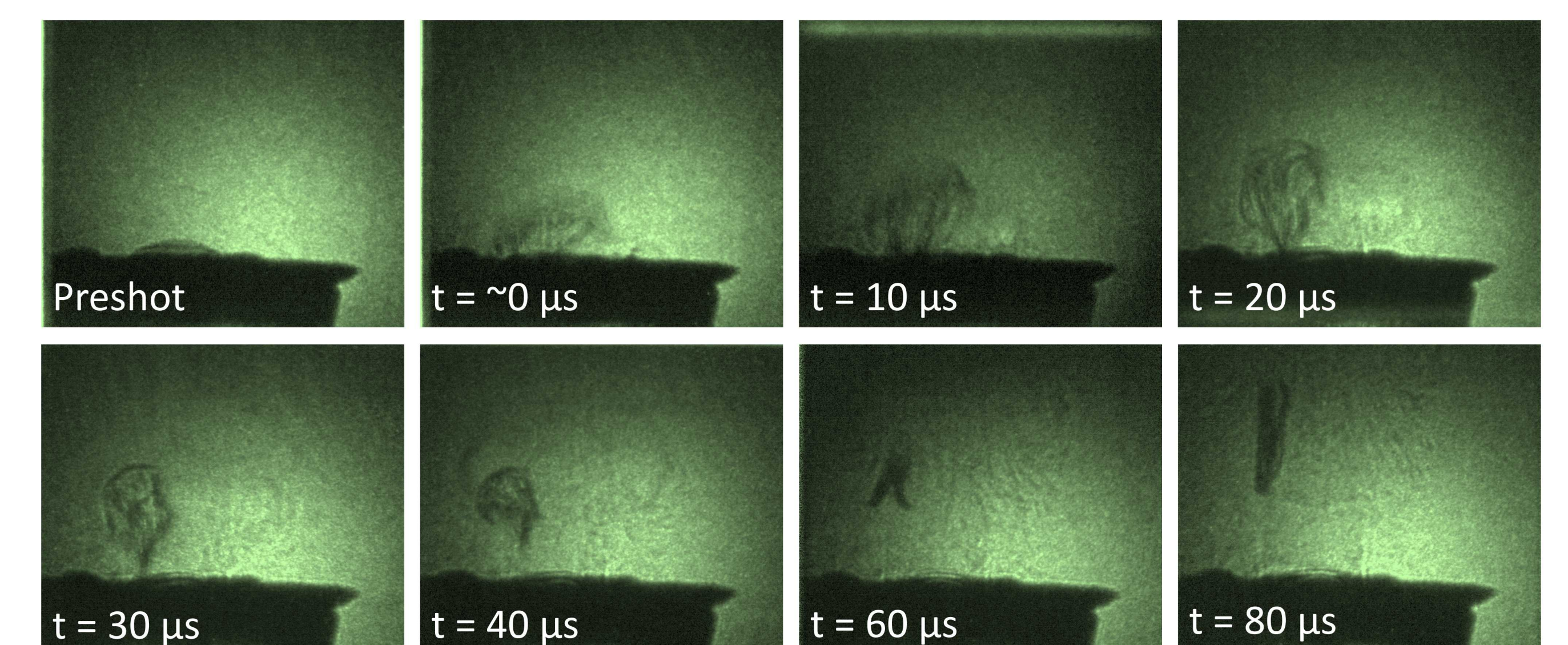
- 12 frame camera
- 6 W continuous

Slow Motion Video Opening



- Removal of window out and away from laser path
- Preliminary proof of concept, finer timescale needed

Laser Backlit Opening



- Filmed on fast framing camera with laser backlight
- Window opening out of laser path on order of expected time scale
- Window rides along edge of escaping gas column

Conclusions

- Designed and built targets
- Imaged window opening
- Proved Laser Gate concept

Future Work

- Study escaping fuel gas
- Determine density gradients
- Transitioning to Sandia

References

- [1] Image taken from www.sandia.gov/z-machine
 [2] S. A. Slutz, et al., Phys. Plasmas **24**, 012704 (2017); S. A. Slutz, personal communication (2017)
 [3] M. R. Gomez et al., PRL **113**, 155003 (2014)

Acknowledgments

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