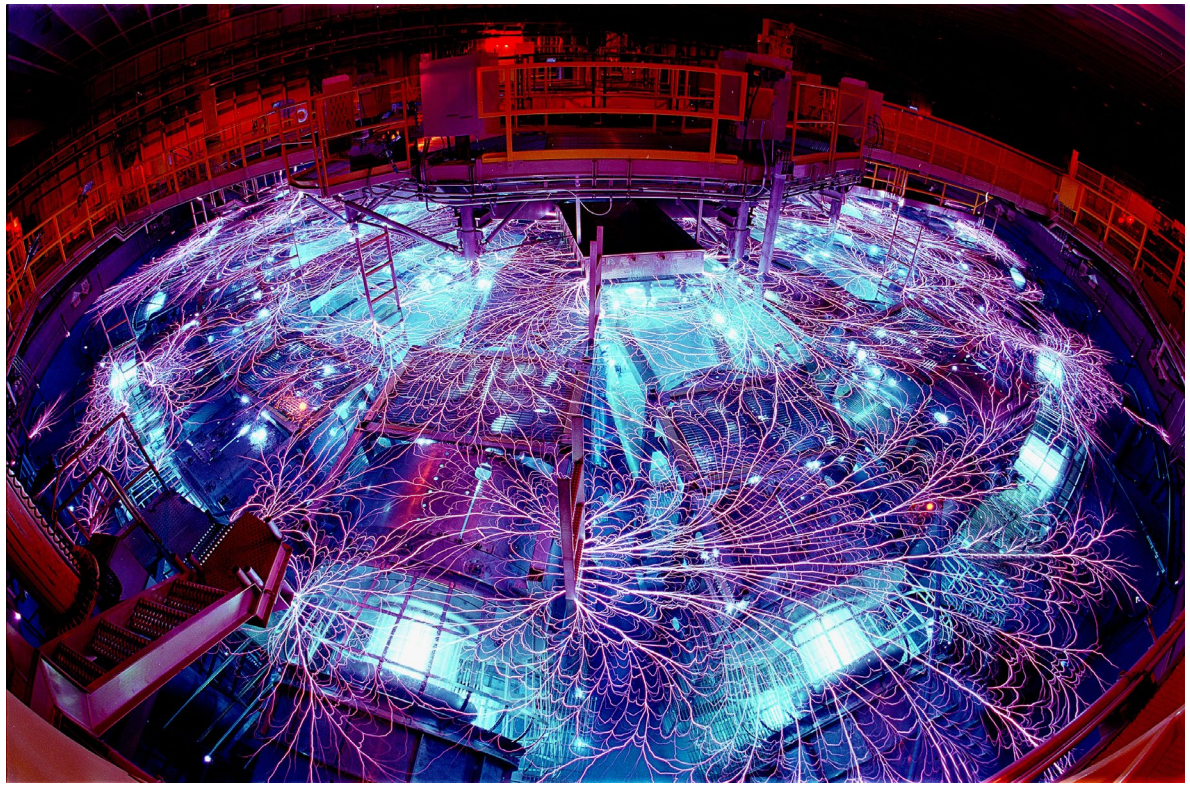
COLLEGE OF ENGINEERING
NUCLEAR ENGINEERING & RADIOLOGICAL SCIENCES
UNIVERSITY OF MICHIGAN

Analysis of Laser Preheating Stage of MagLIF to Increase Laser Energy Coupling and Validate Simulations

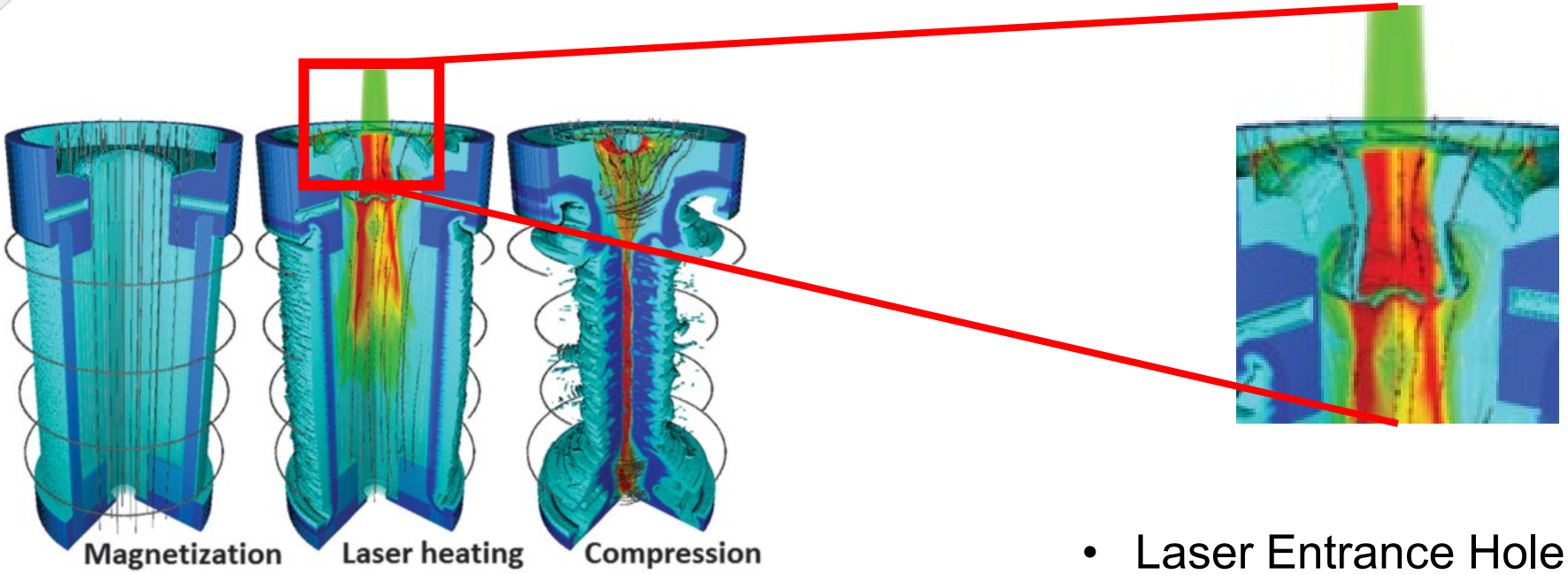
Stephanie Miller
6/22/2022

Important Experiments on the Z Machine



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

3 Stages of MagLIF

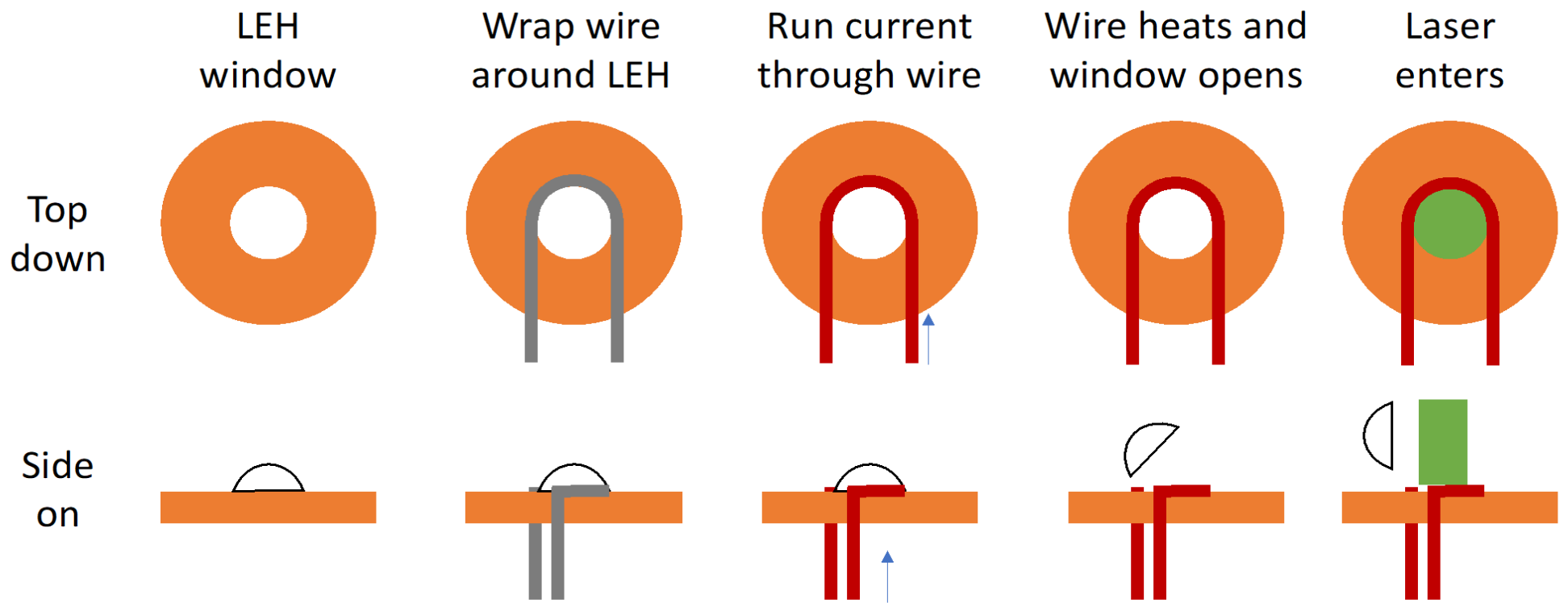


Magnetized Liner Inertial Fusion

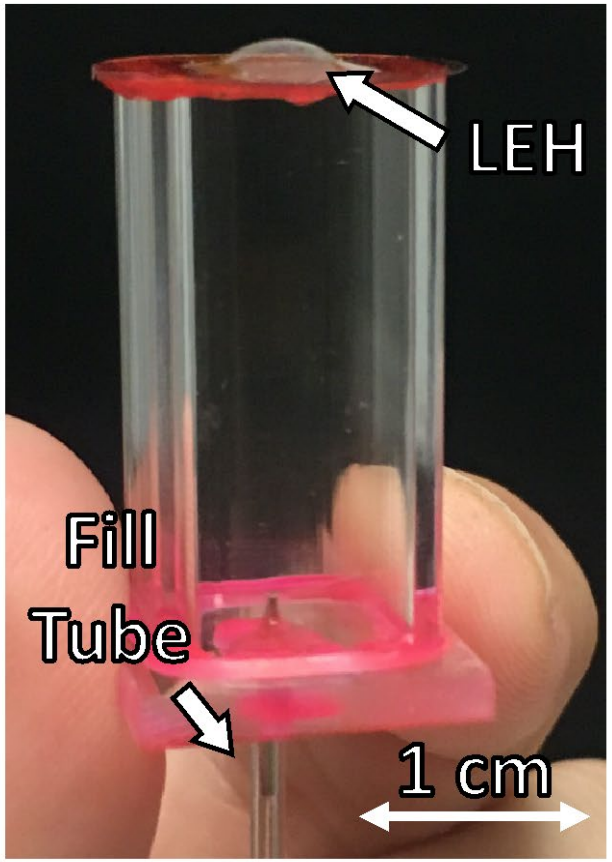
- Laser Entrance Hole (LEH) Window
- Losses occur coupling laser energy to fuel

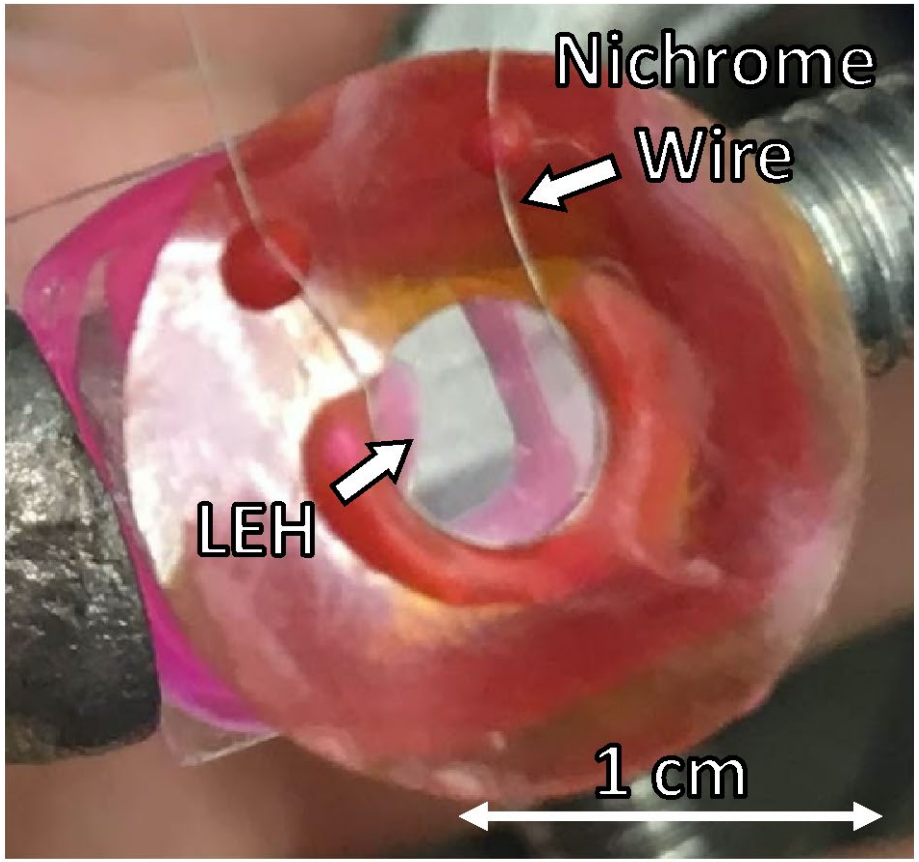
Laser Gate concept of window removal

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



In house target design and fabrication

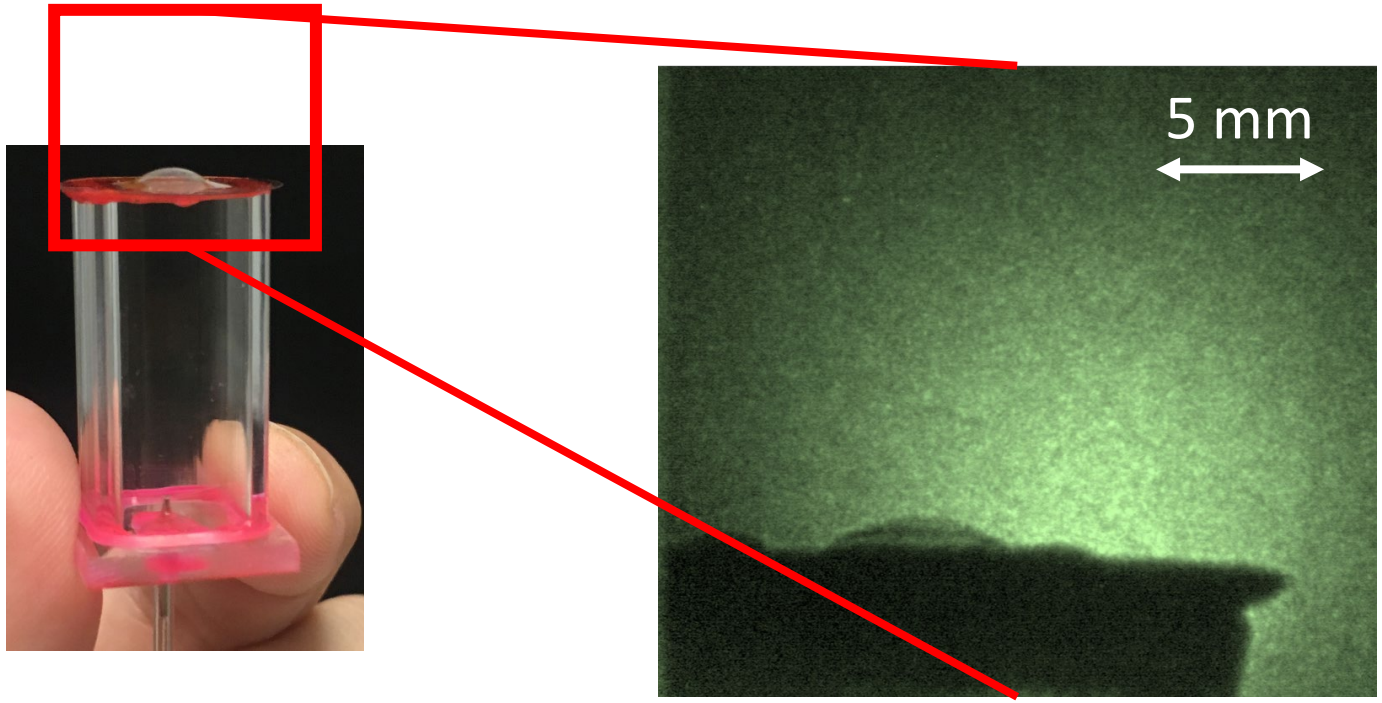




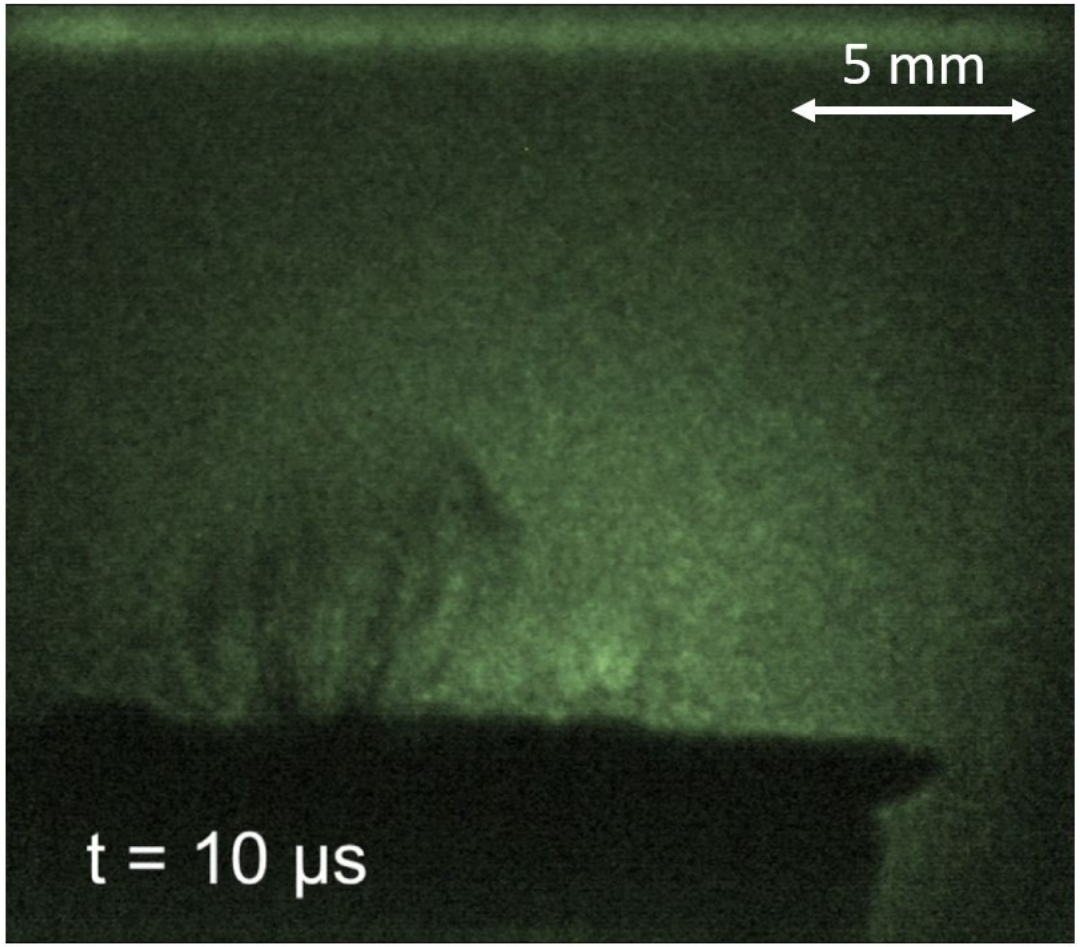
Proof of concept window opening video

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

Backlit Fast Framing Camera Images



Window opening video



- Filmed on fast framing camera with laser backlight
- 10 μs frame resolution
- Window opening out of potential laser path on order of expected time scale

I'm published

A pulsed-power implementation of "Laser Gate" for increasing laser energy coupling and fusion yield in magnetized liner inertial fusion (MagLIF)

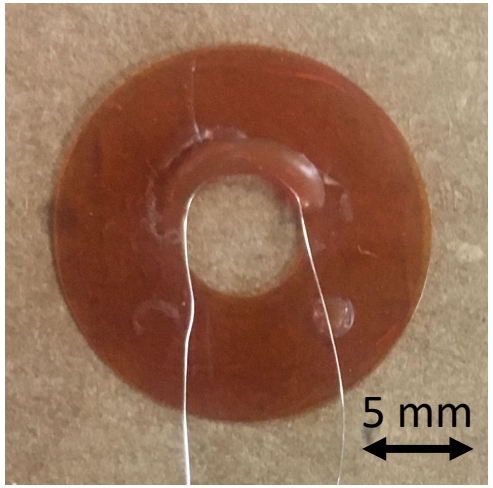
Cite as: Rev. Sci. Instrum. **91**, 063507 (2020); https://doi.org/10.1063/1.5139663
Submitted: 21 November 2019 . Accepted: 28 May 2020 . Published Online: 18 June 2020

S. M. Miller, S. A. Slutz, S. N. Bland, S. R. Klein, P. C. Campbell, J. M. Woolstrum, C. C. Kuranz, M. R. Gomez, N. M. Jordan, and R. D. McBride

Transition to MagLIF scaling

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

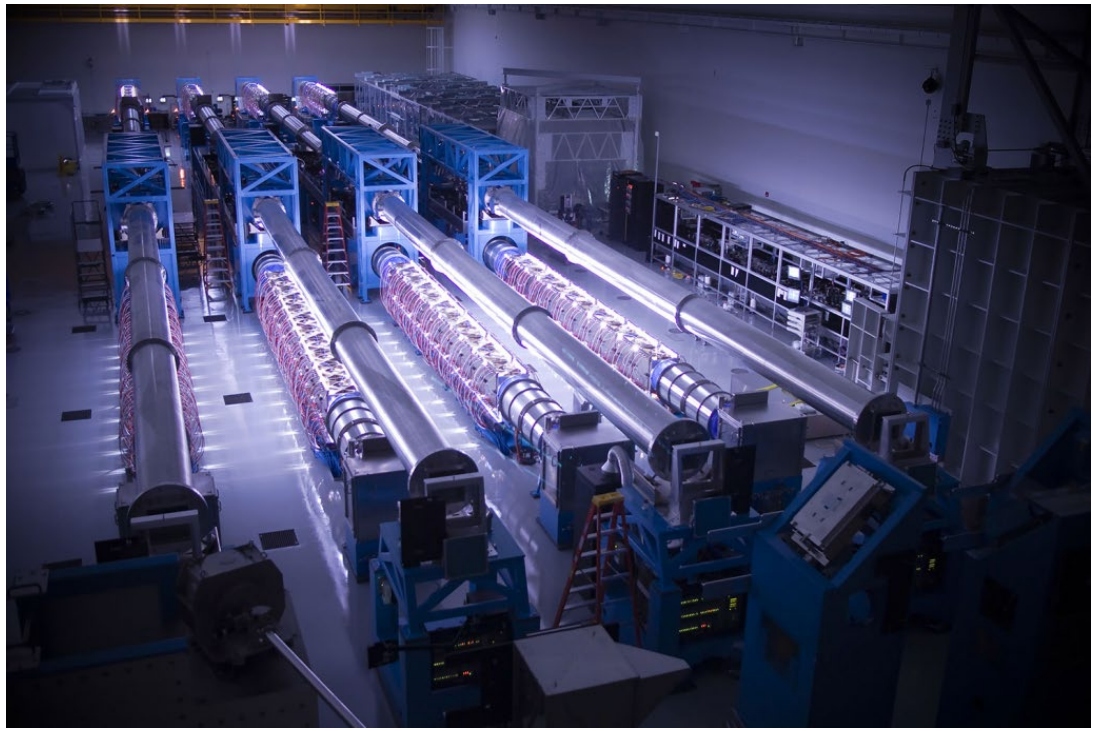
Michigan



Sandia

	UofM	Sandia
Pressure (atm)	2	6
LEH Radius (mm)	2.6	1.1
Fuel Type	Air	He
Washer	Sharp Corner	Beveled
τ_{open} (μs)	14.3	3.4

Second Residency Omega Experiments

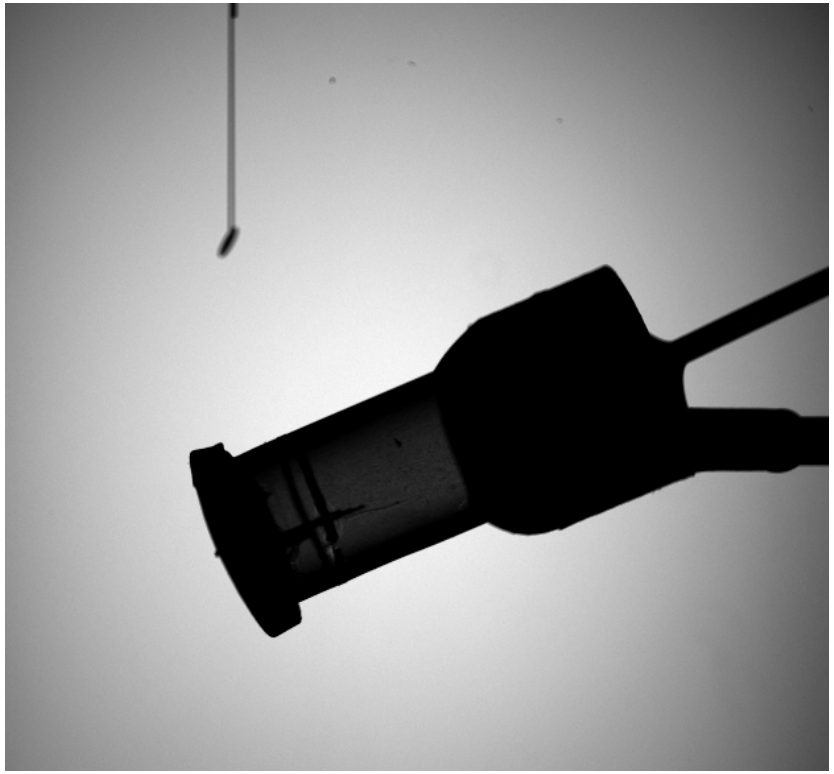


- More shots a day than z
- Radiography diagnostic platform
- Increased collaboration efforts

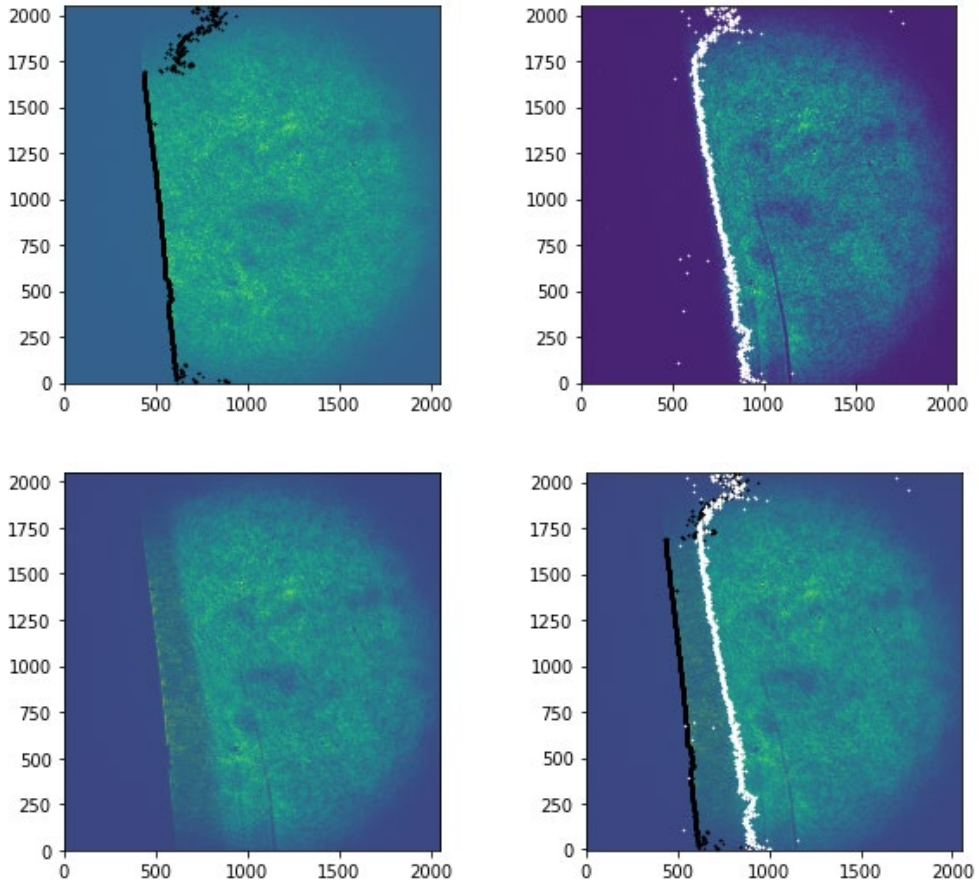
- Ride along in January 2022
- Full shot series May 2022

Omega experimental objectives

- Study wall movement for code validation
  - Wall movement times
  - Wall material density tracking
- Develop new MagLIF radiography platform
- Boost collaboration efforts

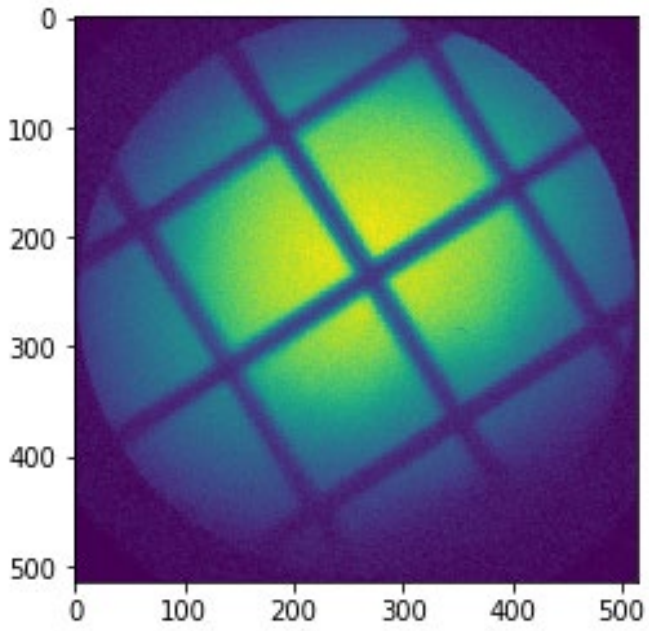


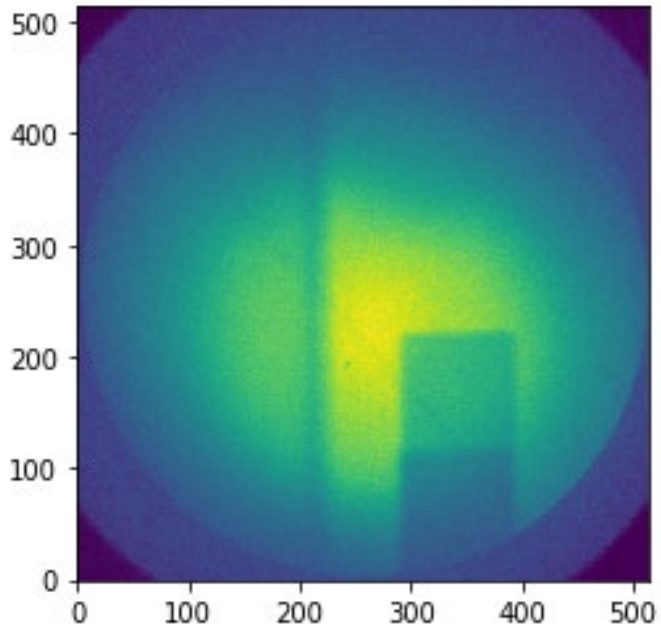
Tracking outer wall movement in time



- 4 ω probe data show shadowgraphy images of wall edge
- Pre and post shot at 4 different times after laser deposition
- Captured beginning of movement

Radiography images for density profiles

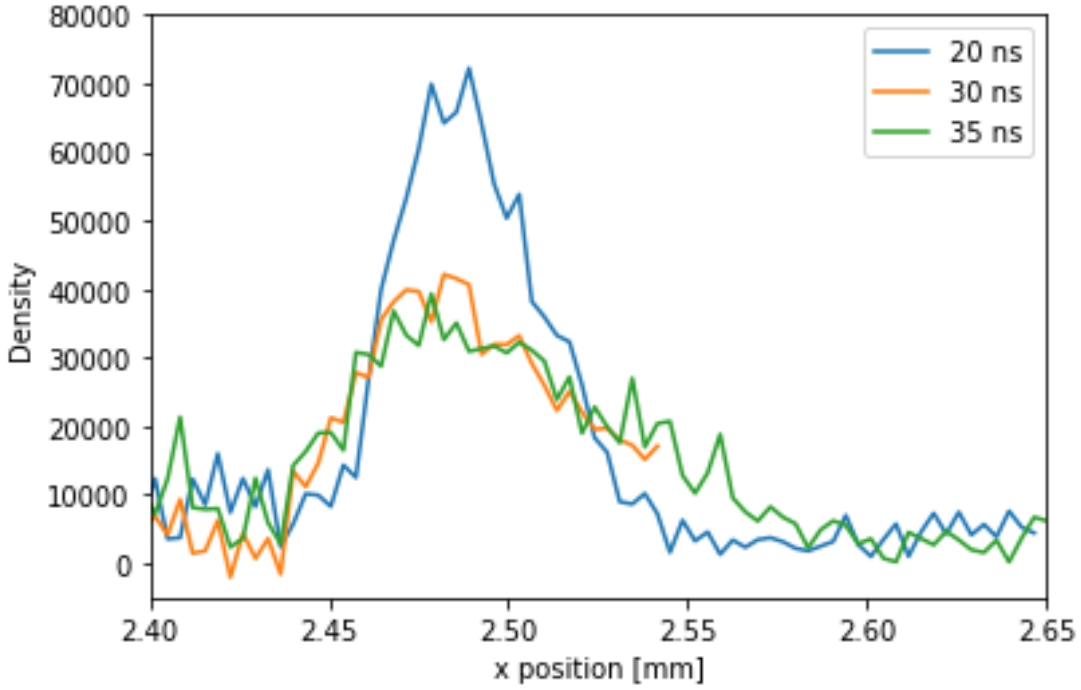




- Resolution shot
- Understand background profile
- Assess resolution capabilities

- Target shots
- See wall density at points in time
- Fiducial for position and transmission

Analyzing wall density profiles



- Spherical crystal imager to capture radiographs (images of wall surface)
- Compare to simulated data to validate models

What's Next?

- NGFP NA 10.1
- Moving to DC
- Defending my PhD

Thank you's

- Matt Gomez
- Dave Ampleford

- Facilities
- Education

- Ryan McBride
- Carolyn Kuranz

- Mentorship
- Other Students

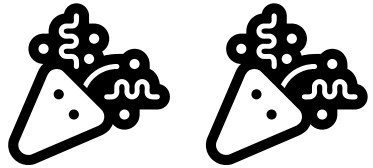
- Kris Moran
- Krell

- Funding
- Conferences

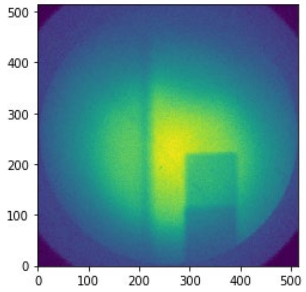
Conclusions

- Demonstrated Proof of Concept

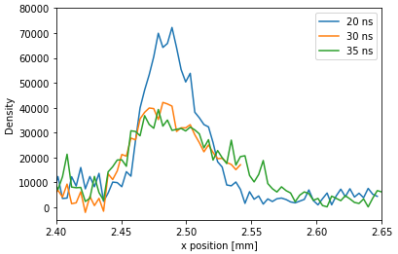
- Published Paper



- Conducted omega campaigns



- Comparing to simulations



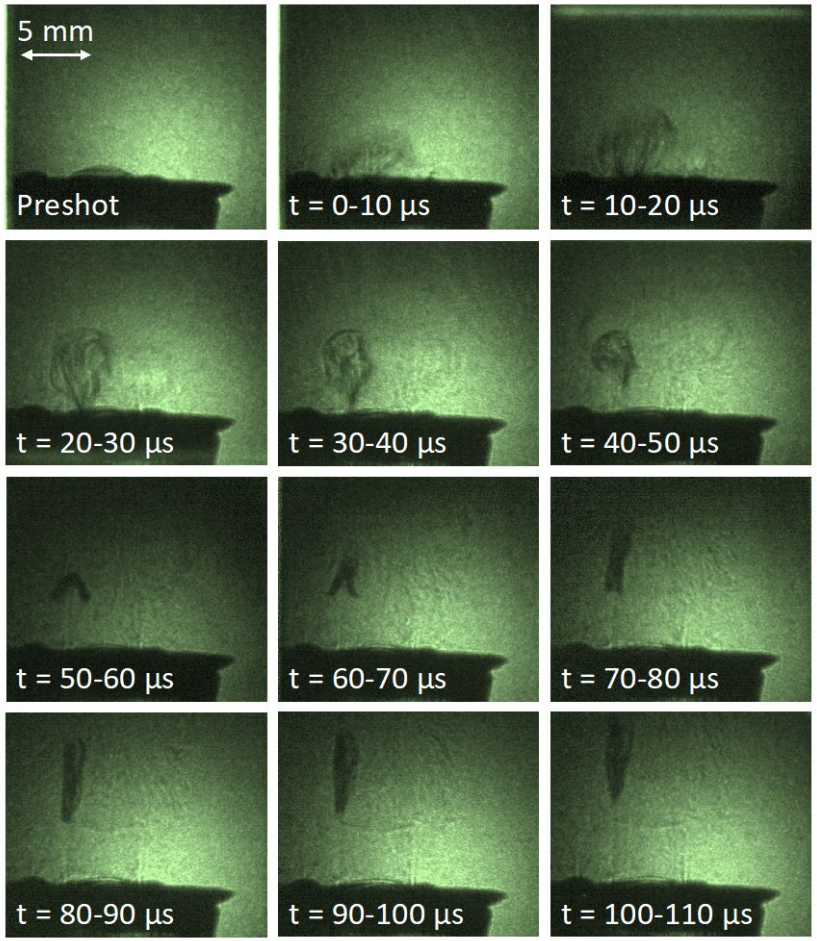
- Moving to DC tomorrow!!

National Nuclear Security Administration

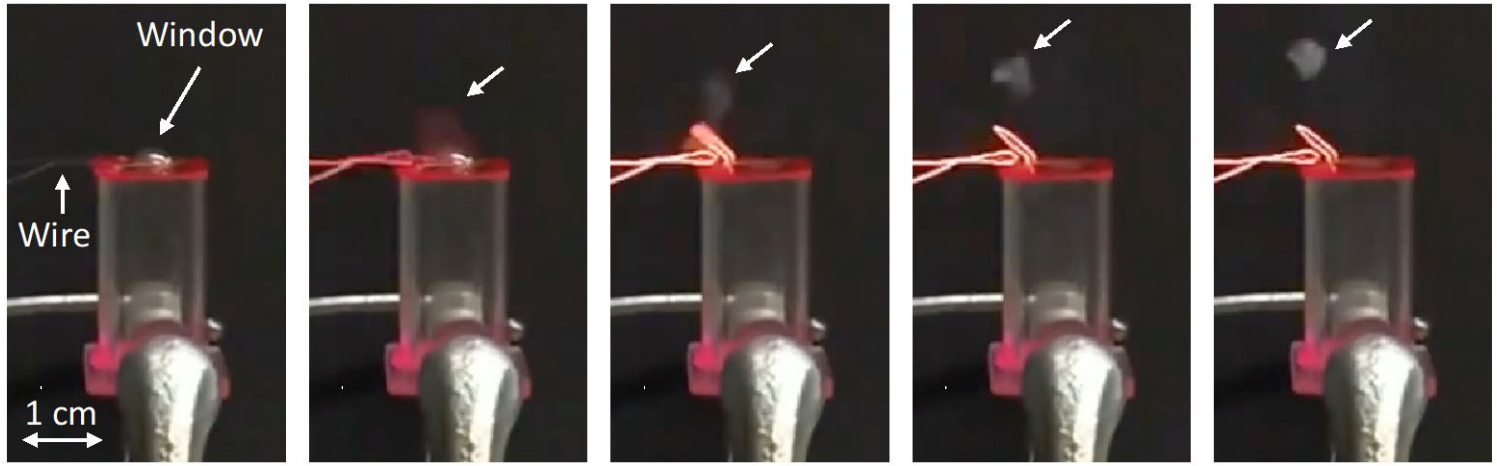
- Graduating ...

QUESTIONS ?

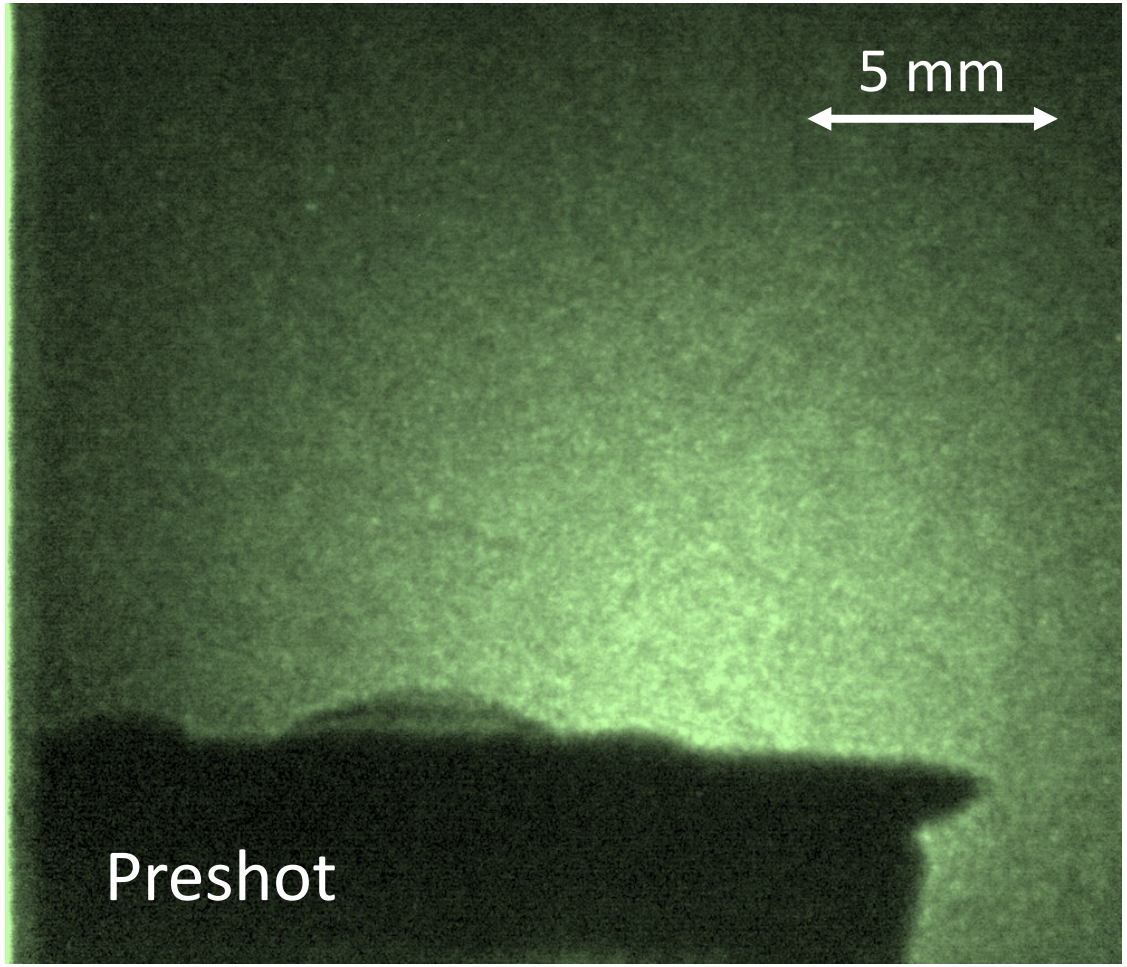
Green- paper


5 mm
Preshot
t = 0-10 µs
t = 10-20 µs
t = 20-30 µs
t = 30-40 µs
t = 40-50 µs
t = 50-60 µs
t = 60-70 µs
t = 70-80 µs
t = 80-90 µs
t = 90-100 µs
t = 100-110 µs

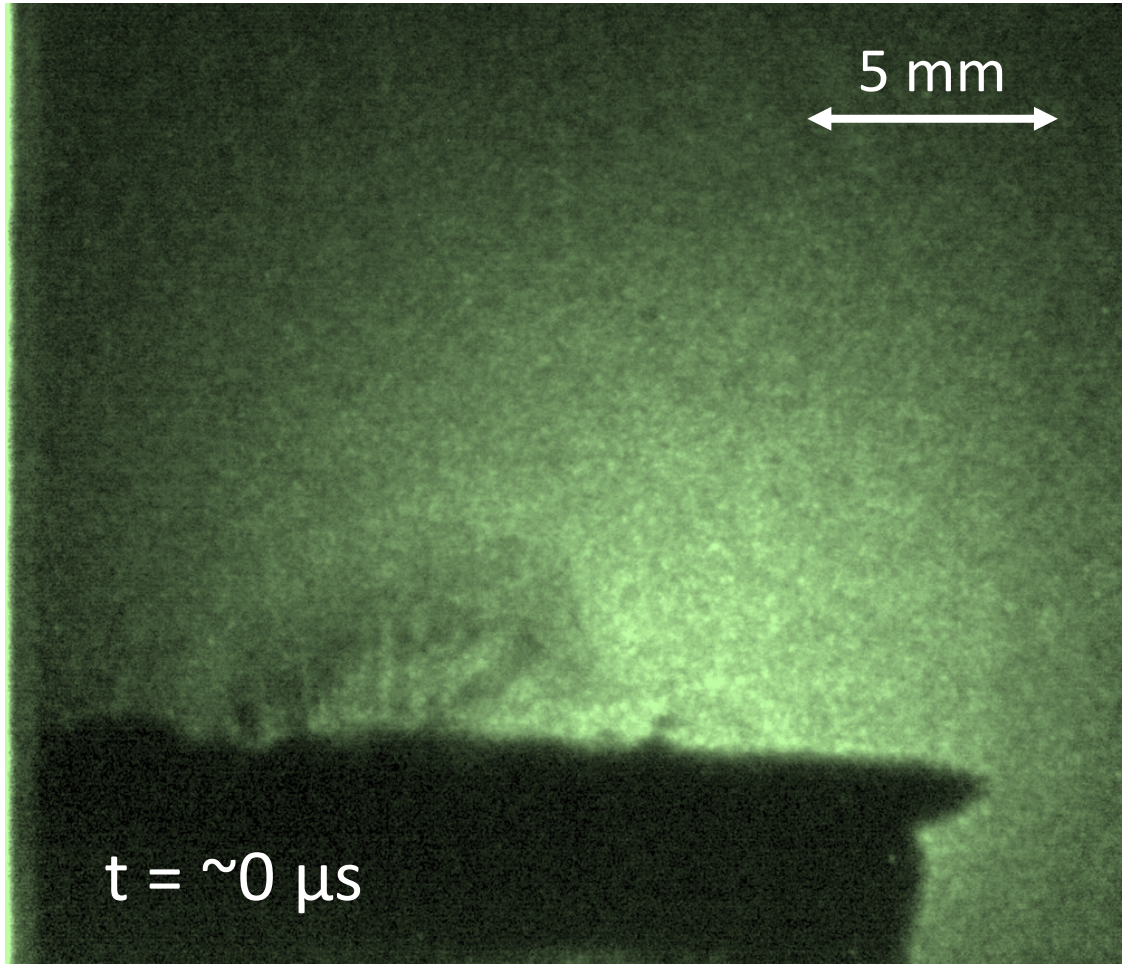
iphone- paper



Window opening

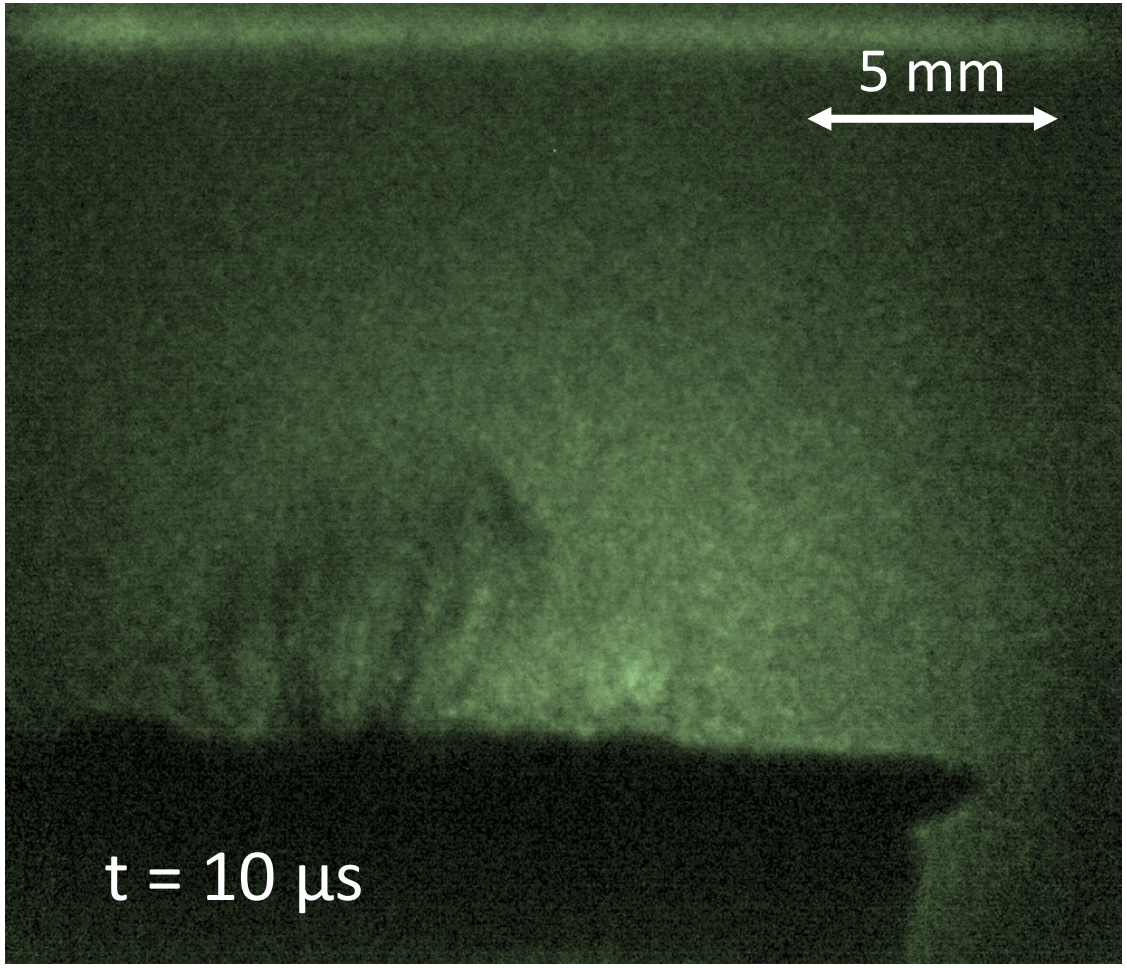


Window opening



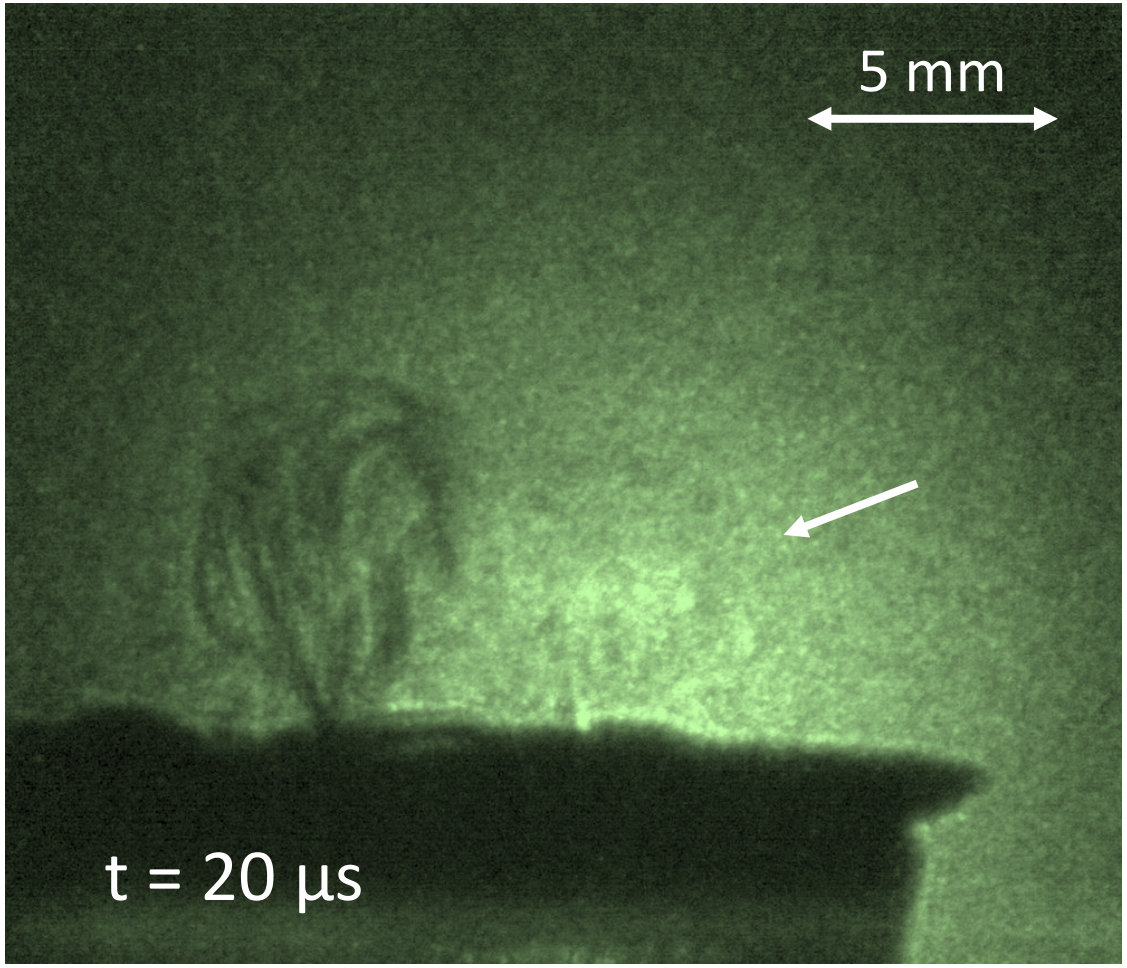
- Window begins opening

Window opening



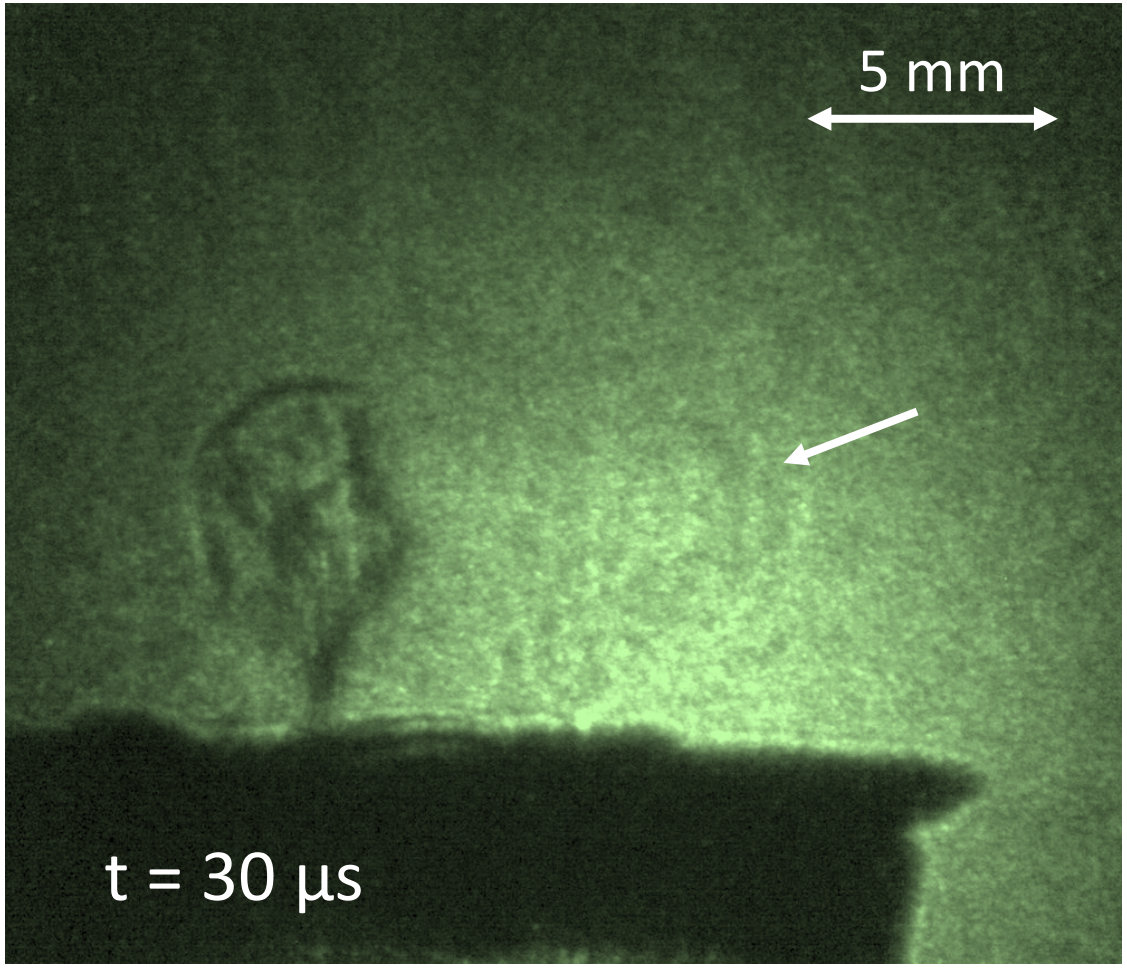
- Hinges to preferred side

Window opening



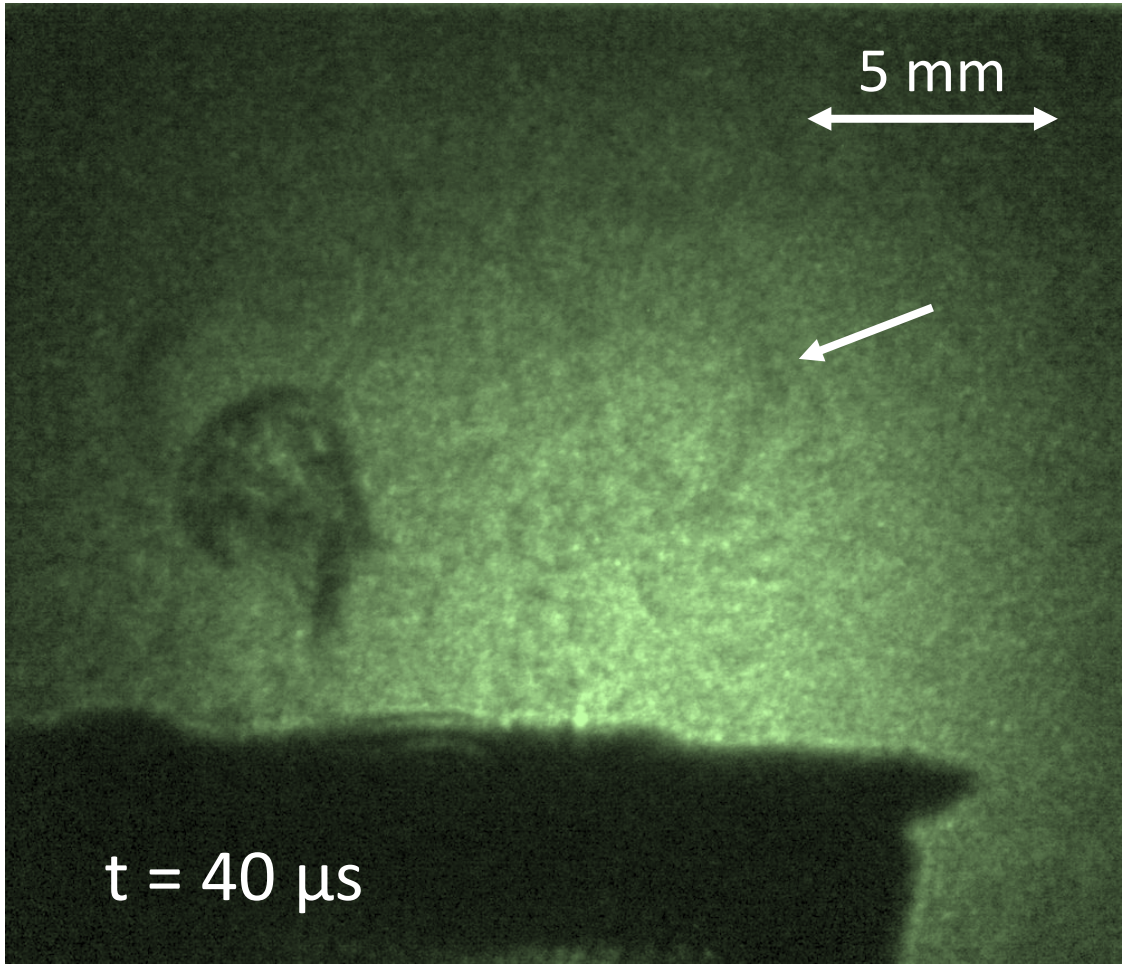
- Mushroom cloud formation

Window opening



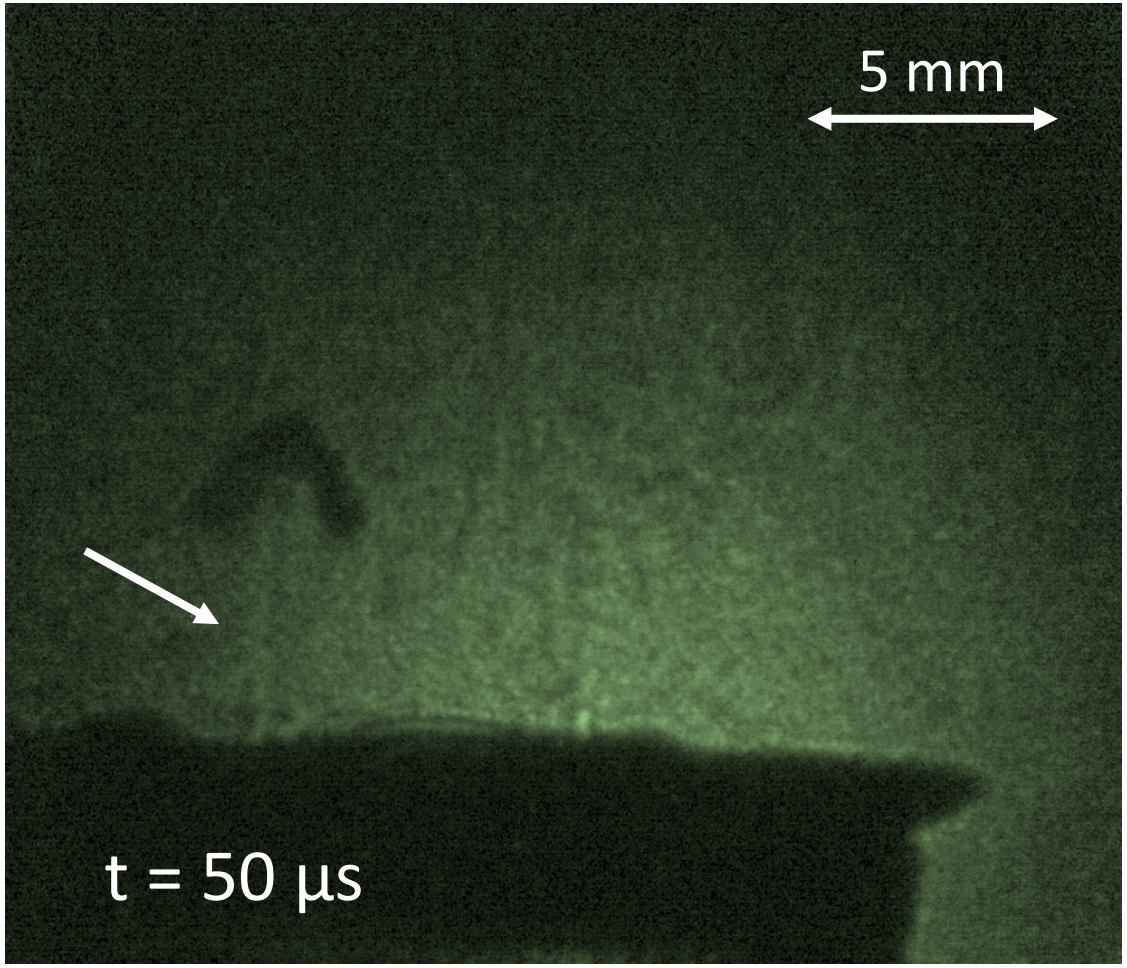
- Mushroom Cloud

Window opening



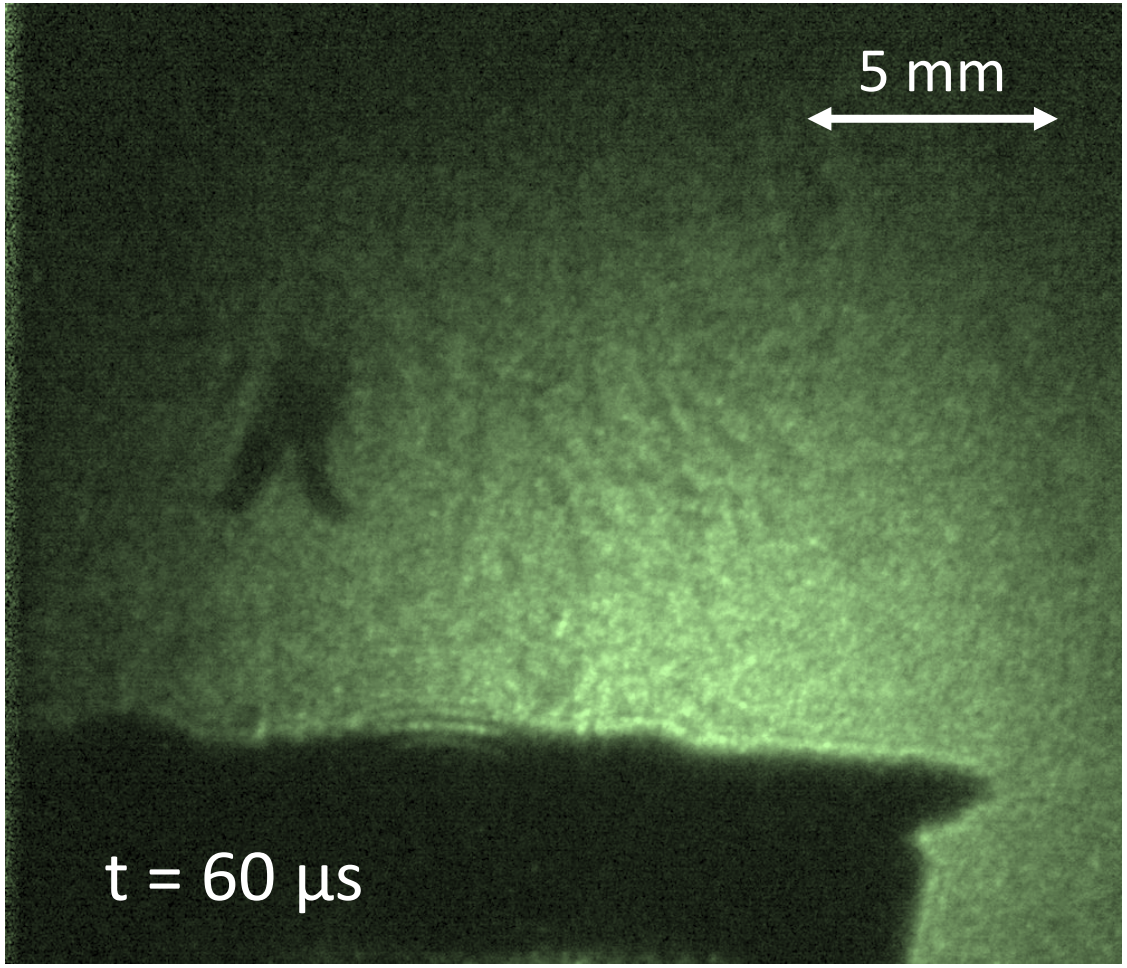
- Mushroom Cloud

Window opening



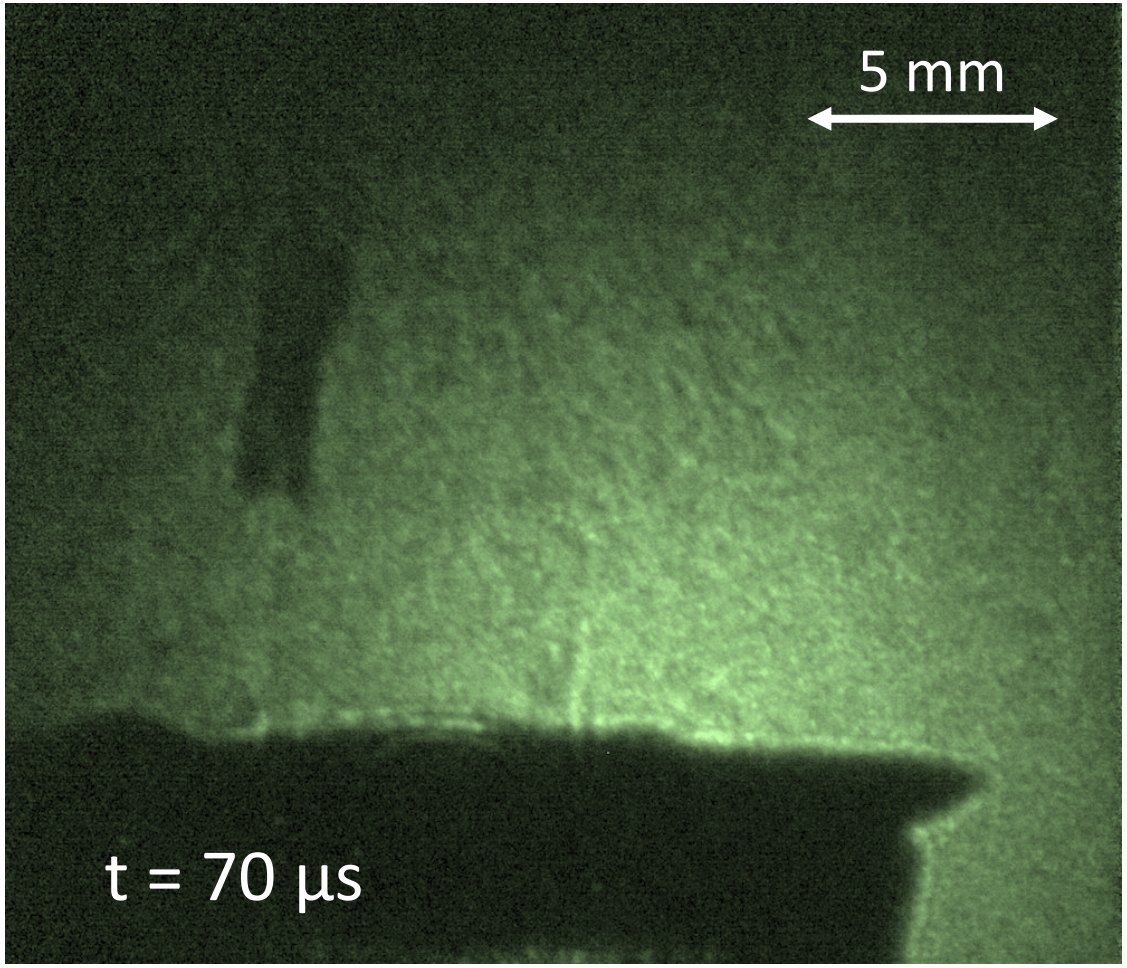
- Window on edge of gas jet

Window opening



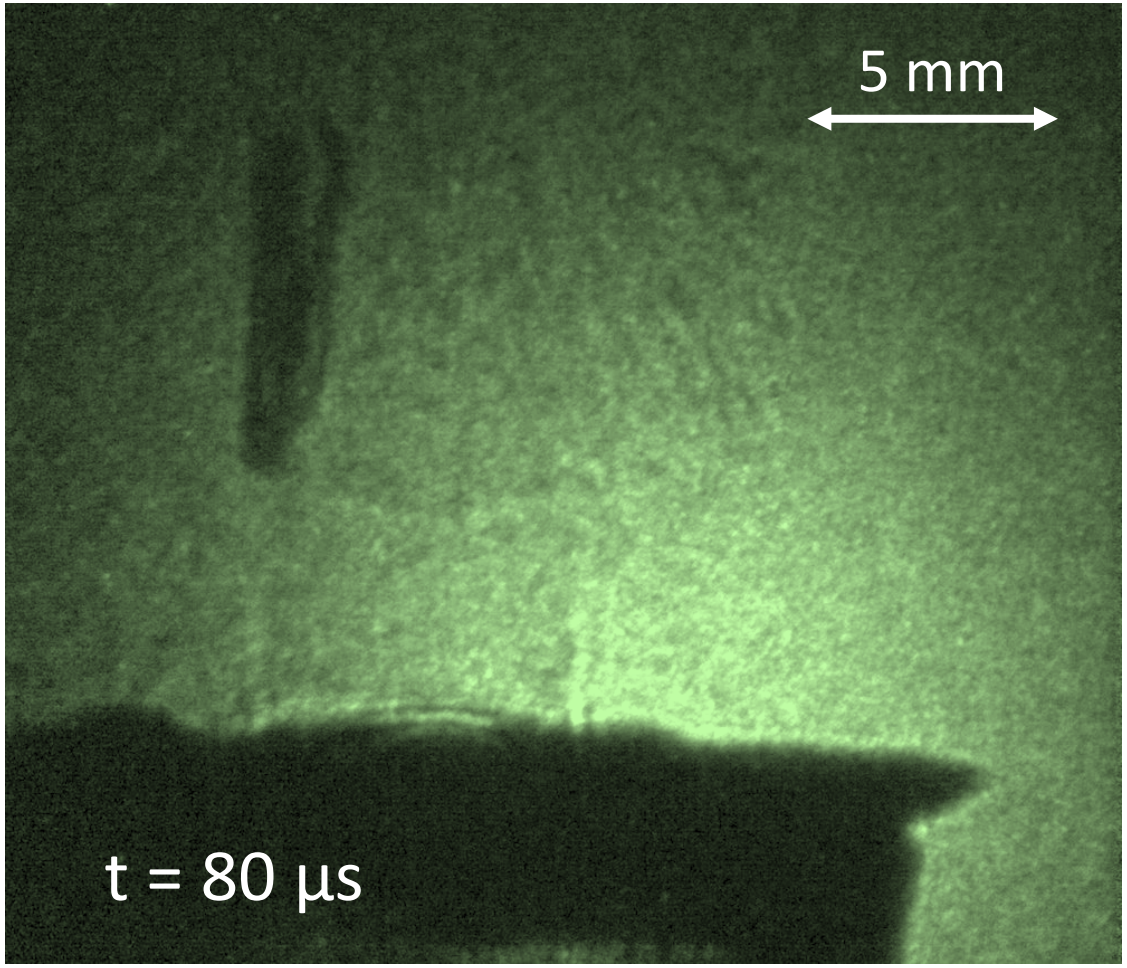
- Window rides along edge of gas jet column

Window opening



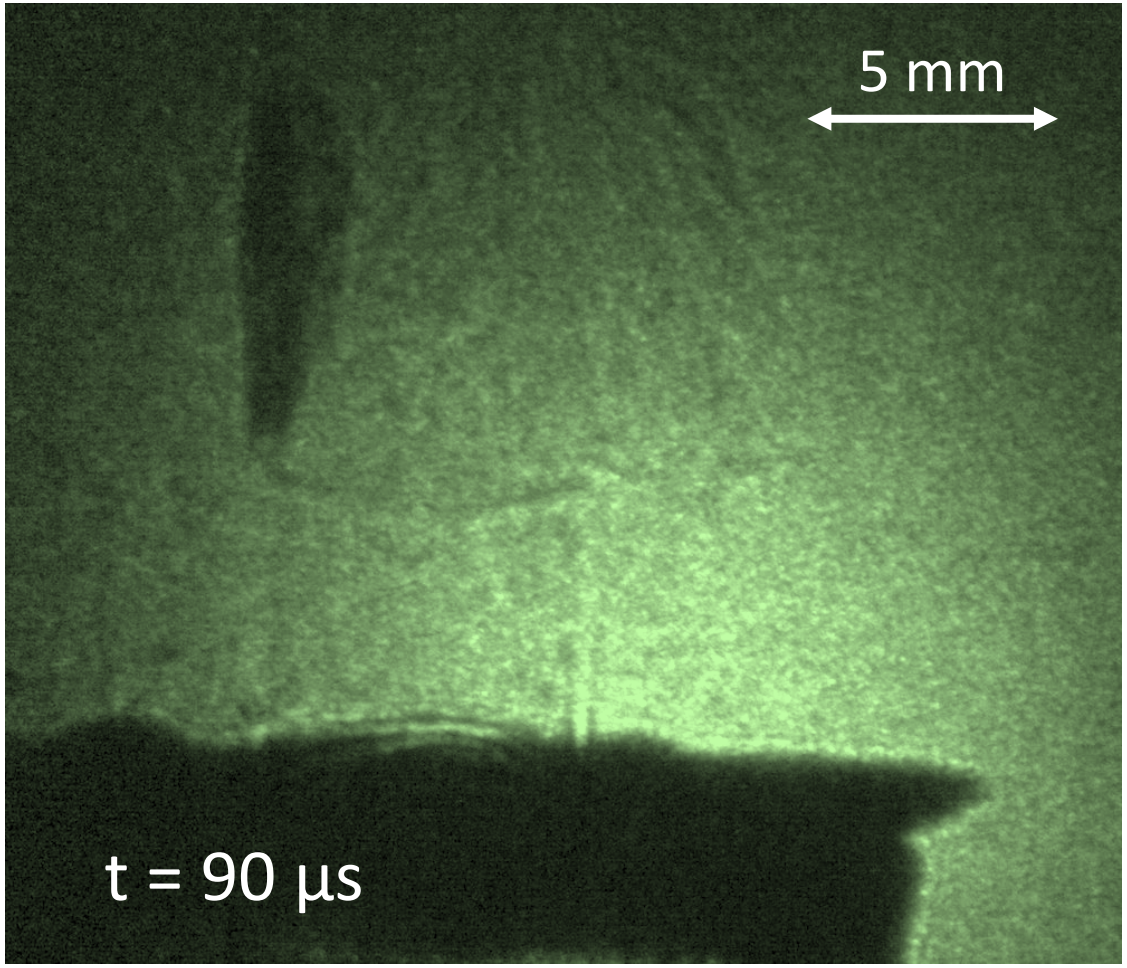
- Window rides along edge of gas jet column

Window opening



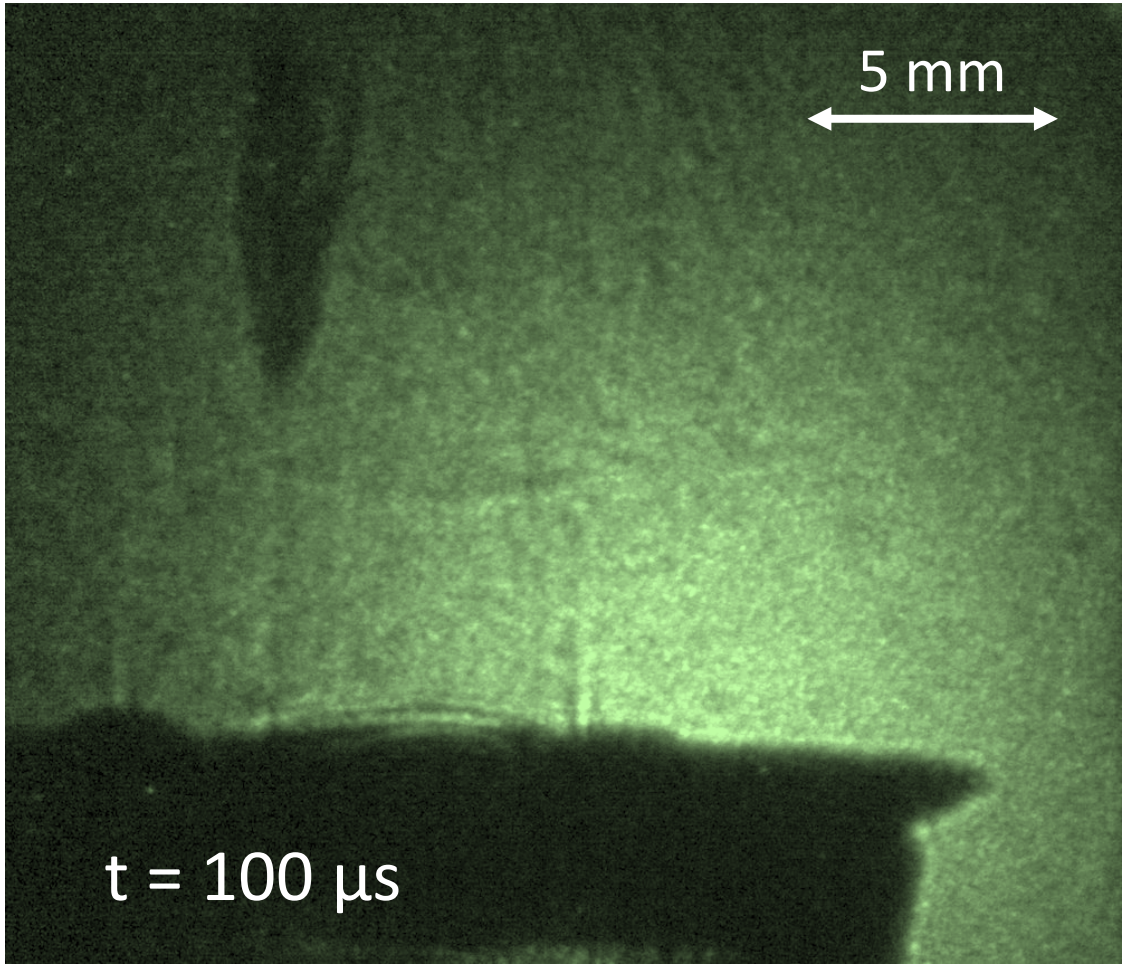
- Window rides along edge of gas jet column

Window opening



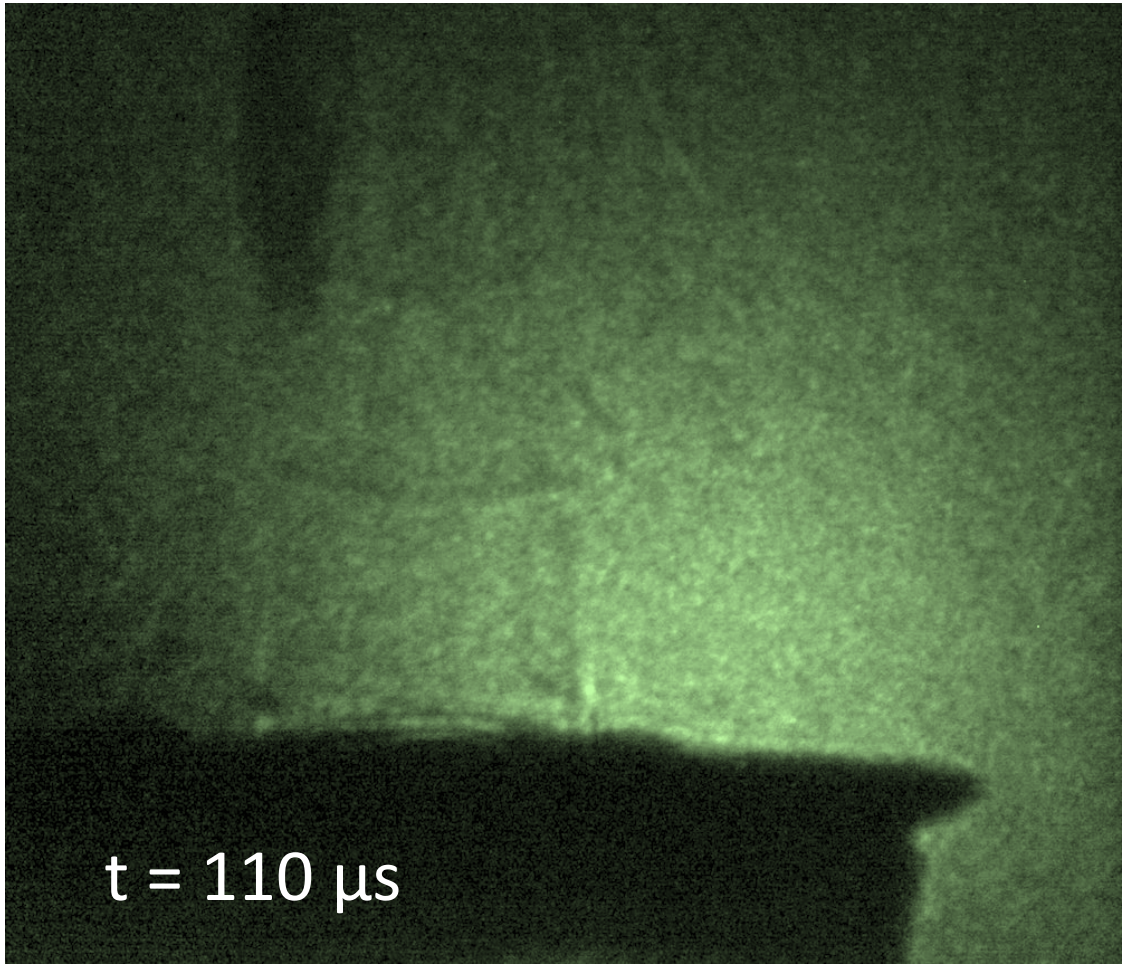
- Window rides along edge of gas jet column

Window opening



- Window rides along edge of gas jet column

Window opening



- Window remained intact
- No wire movement shown