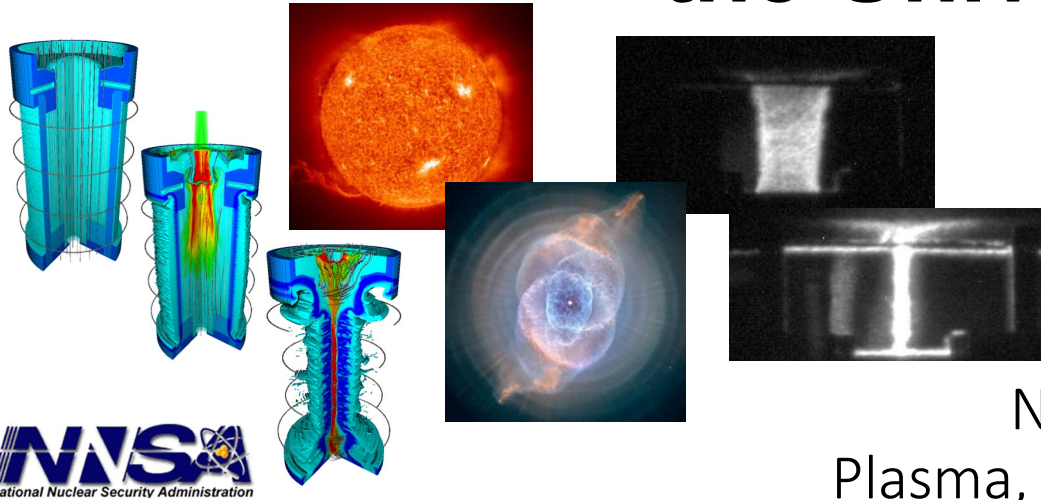




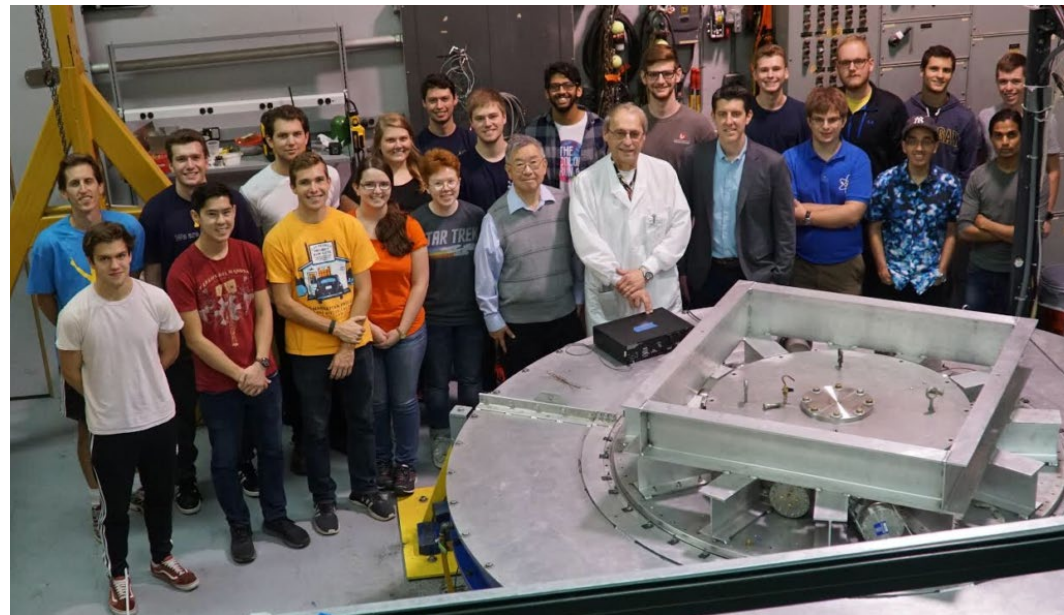
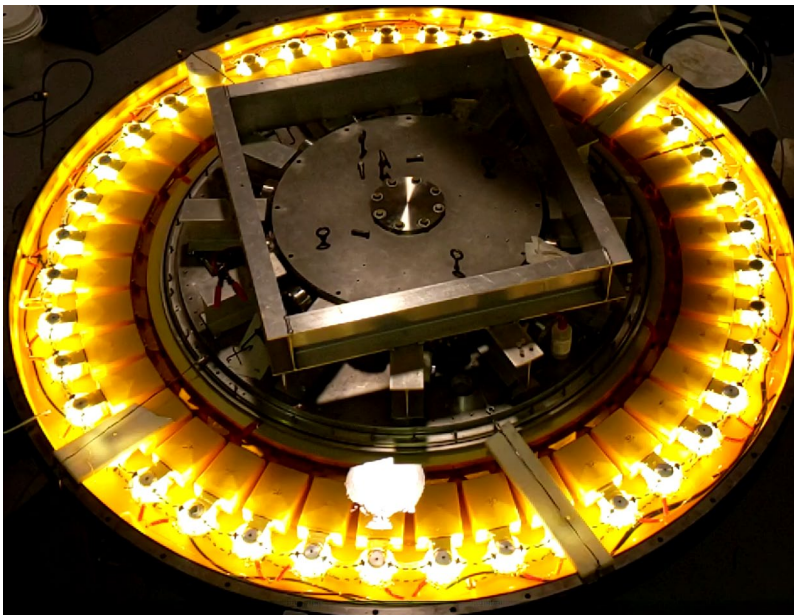
The MAIZE Pulsed Power Facility at the University of Michigan



Nick Jordan

Assoc. Research Professor
University of Michigan

Nuclear Engineering Department
Plasma, Pulsed Power, & Microwave Lab



MAIZE is a Linear Transformer Driver (LTD)

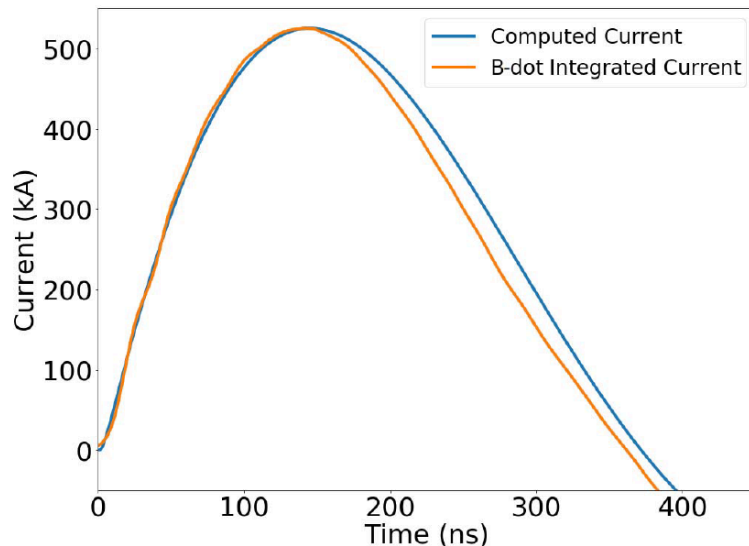
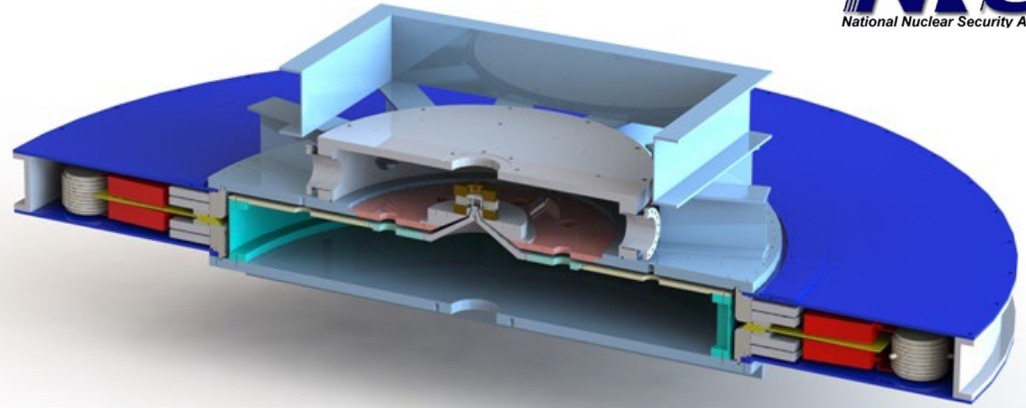
~0.5–1 MA in 100–250 ns

~100–200 kV (~0.1 ohm)

~10 kJ, 0.1 TW

~3-m-diameter cavity

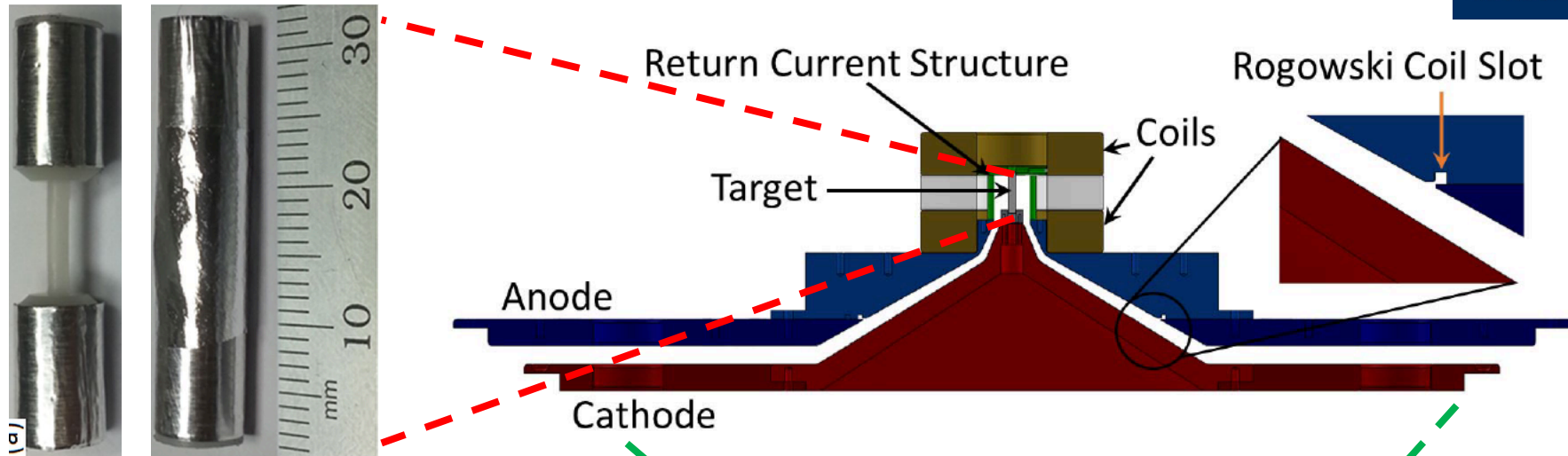
- Developed at High Current Electronics Institute in Tomsk, Russia
- First 1-MA LTD in the US (2007)
- **Part of ZNetUS user network & NNSA MACH & CHEDAR Centers**



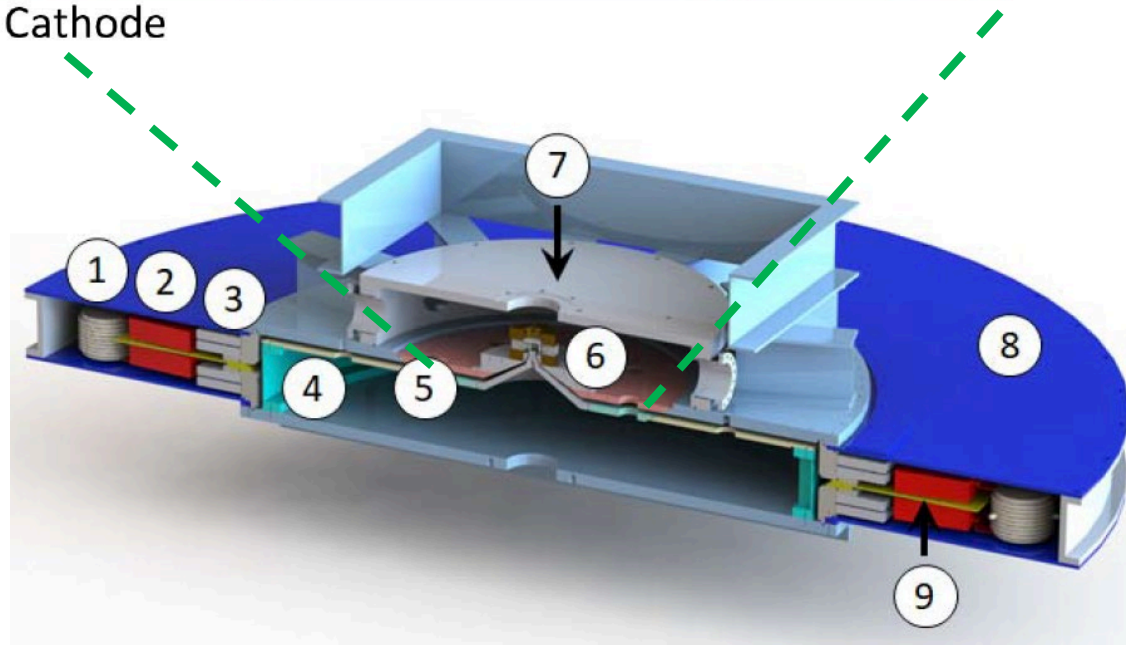
Many upgrades over the past 6 years to improve performance & reliability:

- New low-inductance conical power feeds
- 40 new L3 switches (latest model: 50264)
- New oil filtration system
- New trigger wire routing
- Solid-state charging resistors
- Trigger inductors
- Rebuilt trigger generator
- New gas line configuration
- Stronger switch purge system
- Switched to Zero Air from Matheson Tri-Gas, Inc.

Many load platforms and capabilities

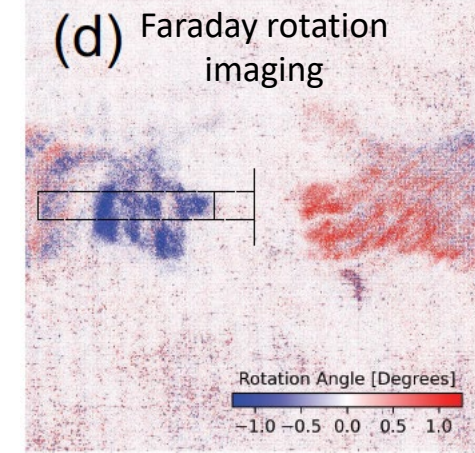
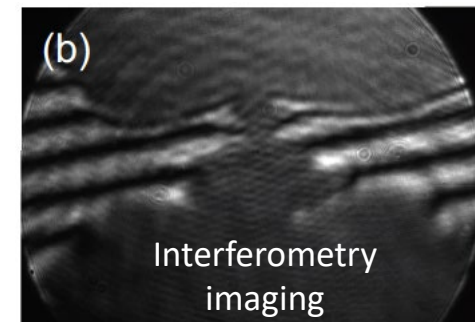
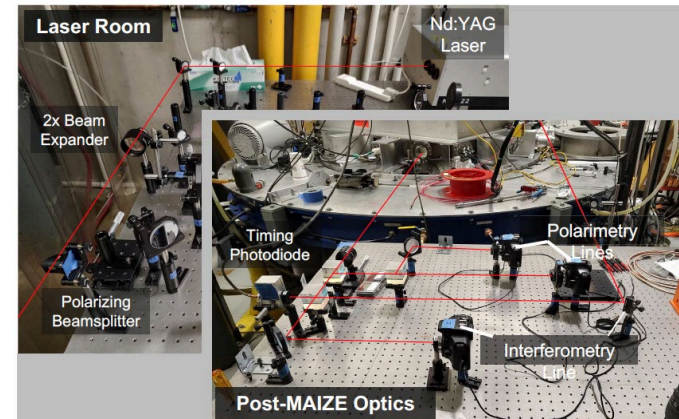


- Imploding thin-foil liners
- Applied B_z capability
 - Up to 2T uniform over cm scale sizes
- Gas-puff z-pinch (D2, Ar, etc)
 - Convertible to Dense Plasma Focuses (DPFs)
- Wire-array z-pinch:
 - Planar (UNR), conical (UM/Kuranz), dual exploding (MIT)
- Standard and hybrid X-pinch
 - CD2 fibers (CTU)
- Post-hole convolute / MITL loads
- Ablative rod plasmas (UR)
- Field-reversed configurations (FRCs)
- *Many creative platforms enabled by 3D printing!*



Diagnostics Available:

- 12-frame laser shadowgraphy or 12-frame visible-light self-emission imaging
- 2-frame MCP for self-emission imaging in XUV
- Laser interferometry imaging
- Laser Faraday rotation imaging
- Time-integrated x-ray pinhole camera
- X-ray slit step-wedge camera for photon energies
- Time-gated, fiber-coupled visible-light spectroscopy
- Micro B-dot probes
- Load current Rogowski coil and B-dot probes
- Silicon diodes and photo-conducting diamond (PCD) detectors with various filters for x-ray power
- Bolometer for total soft x-ray yield
- Bubble detectors for total neutron yield
- Beryllium activation probe for neutron yield
- Neutron time-of-flight (nToF) for neutron timing/energies
- 3D printing for custom setups
- Vacuum chamber ports and floor space available for user-supplied diagnostics





Recent PhD student
Joe Chen (Now a
Sandia postdoc)

Low-density plasma (LDP) to modify and suppress helical MRTI in magnetized liner implosions

Applied LDP layer mitigates MRTI growth in gas-on-liner (GoL) experiments

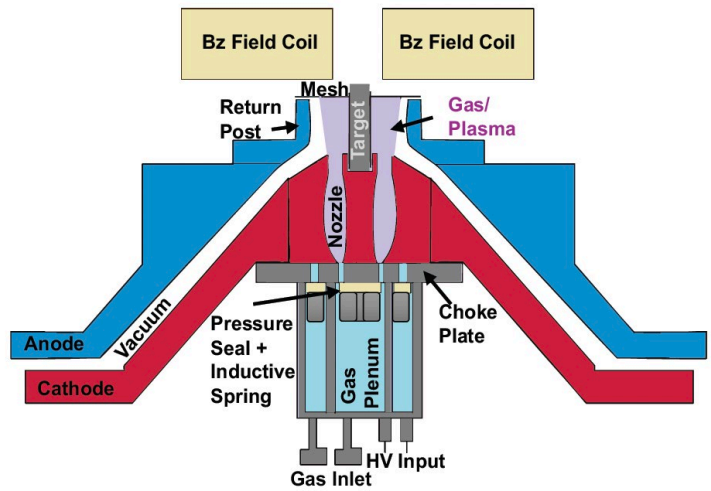
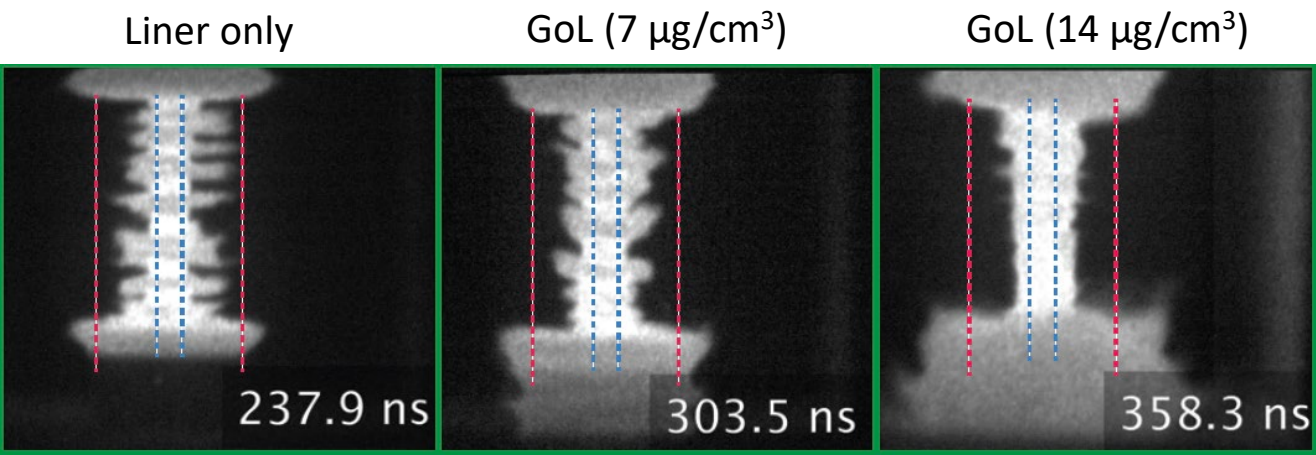


FIG. 1. Cross-sectional drawing of experimental hardware.

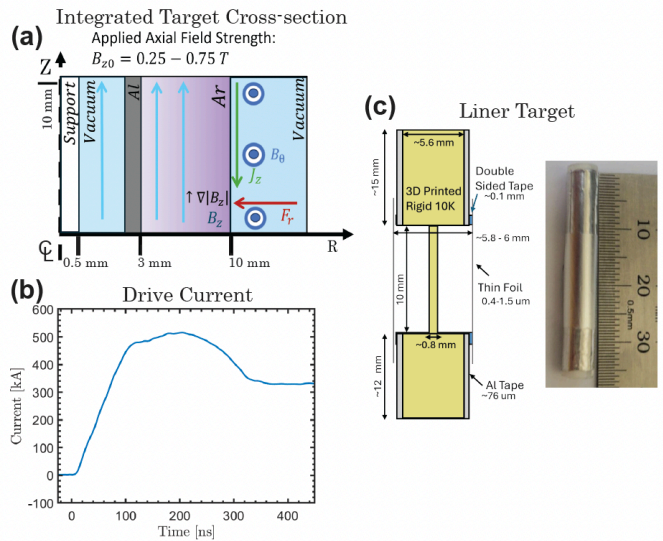


FIG. 2. (a) Cross-sectional drawing of a fully integrated MGoL target. (b) Typical drive current generated by MAIZE for a GoL/MGoL target. (c) Technical design and photograph of a thin-foil liner target.



Recent PhD student
Joe Chen (Now a
Sandia postdoc)

Low-density plasma (LDP) to modify and suppress helical MRTI in magnetized liner implosions

- The MRTI growth was further mitigated by applying B_{z0} in magnetized gas-on-liner (MGoL) experiments
- The combination of LDP + B_{z0} reduced instability amplitudes by 45%–80% relative to baseline cases

	Liner	MGoL
Liner	0.75 T	0.25 T

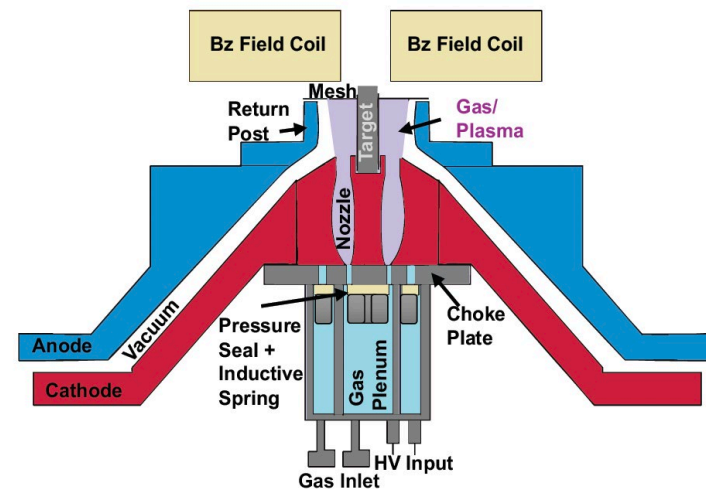
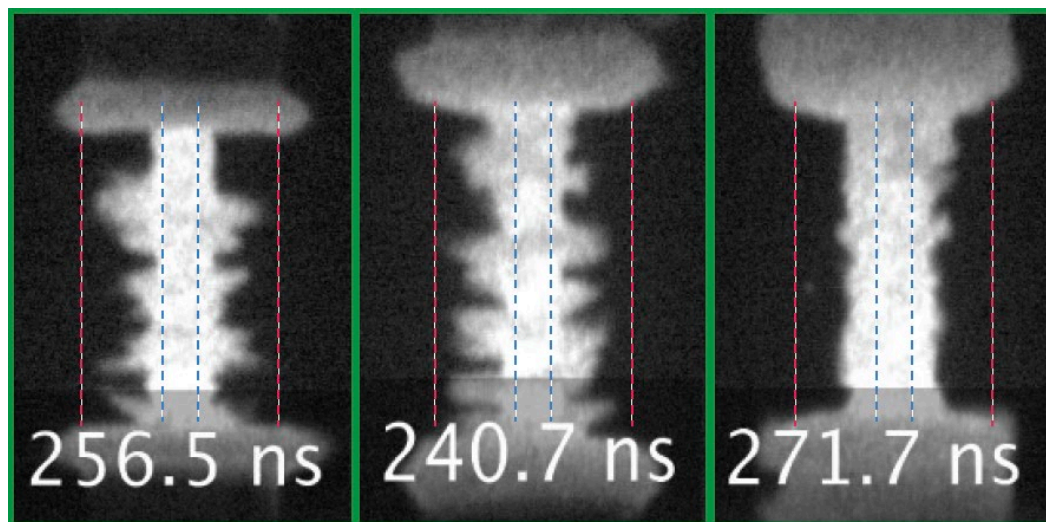
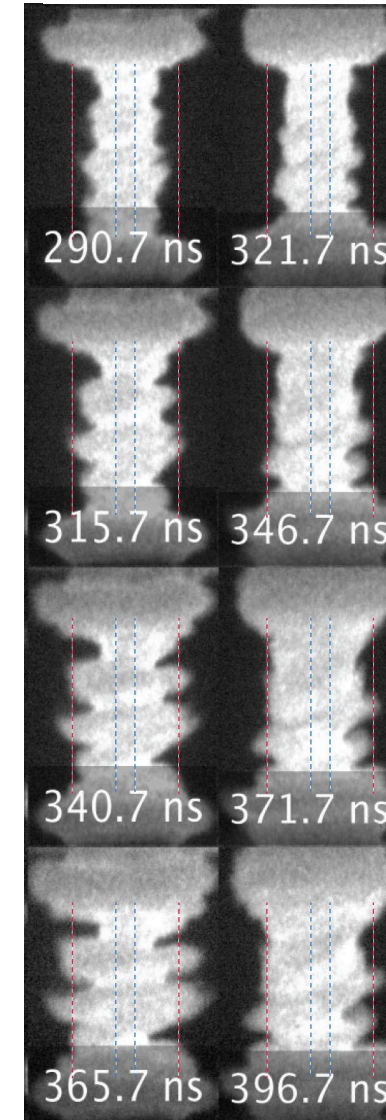


FIG. 1. Cross-sectional drawing of experimental hardware.

Low-density plasma (LDP) to modify and suppress helical MRTI in magnetized liner implosions

- Also demonstrated that an axially magnetized LDP layer compressing onto the outer surface of a thin-foil liner results in larger helical instability pitch angles in the subsequent thin-foil liner implosion (relative to an axially magnetized case without an applied LDP layer).
- The pitch angles observed with an axially magnetized LDP layer were 22° – 35° (with $B_{z0} = 0.25$ T).
- The pitch angles measured for the axially magnetized baseline case with no LDP layer were only about 8° , despite using 3x the initial axial magnetic field strength ($B_{z0} = 0.75$ T).

Liner	MGoL
0.75 T	0.25 T

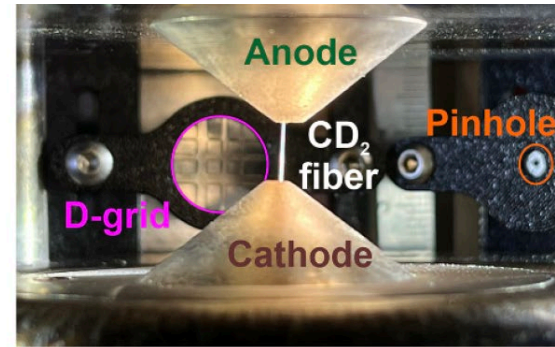
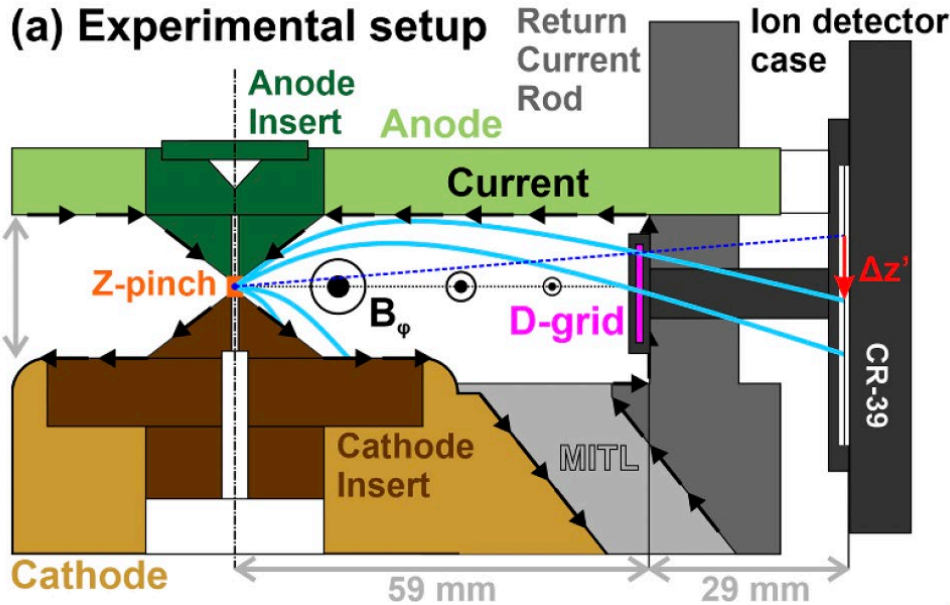


Recent PhD student
Joe Chen (Now a
Sandia postdoc)

X-pinch mysteries & applications with CTU

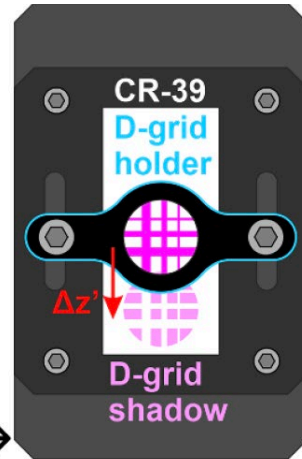


Initial setup from Munzar *et al.*, PPCF (2024).



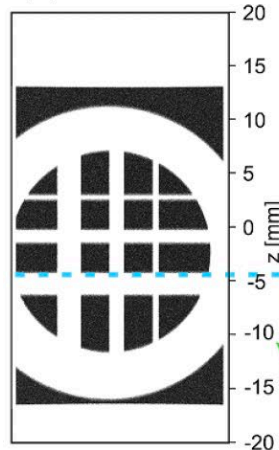
(b) Side-on view ↑

(c) Ion deflectometer →

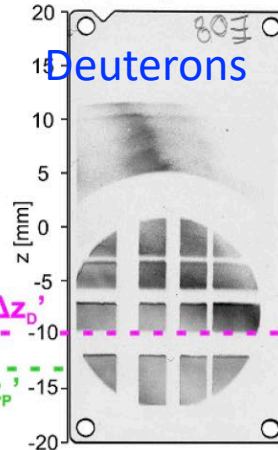


Both fusion protons
and accelerated
deuterons detected
due to use of CD_2
fibers
DD neutron yields $\sim 10^8$

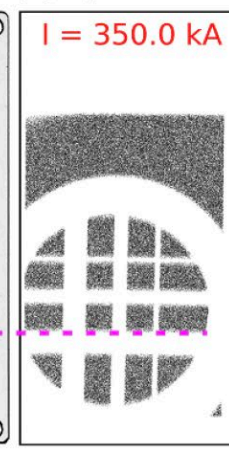
(c) Reference



(d) Exp. data



(e) Synth. data

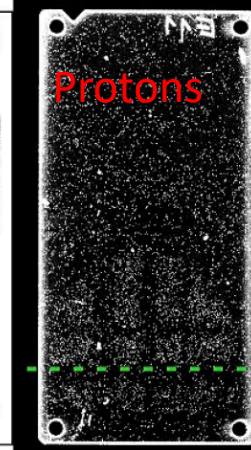


Shot 3010

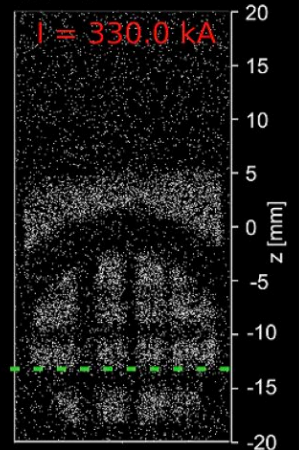
Deuterons

Shot 3012

(f) Exp. data



(g) Synth. data



Protons

X-pinch mysteries & applications with CTU

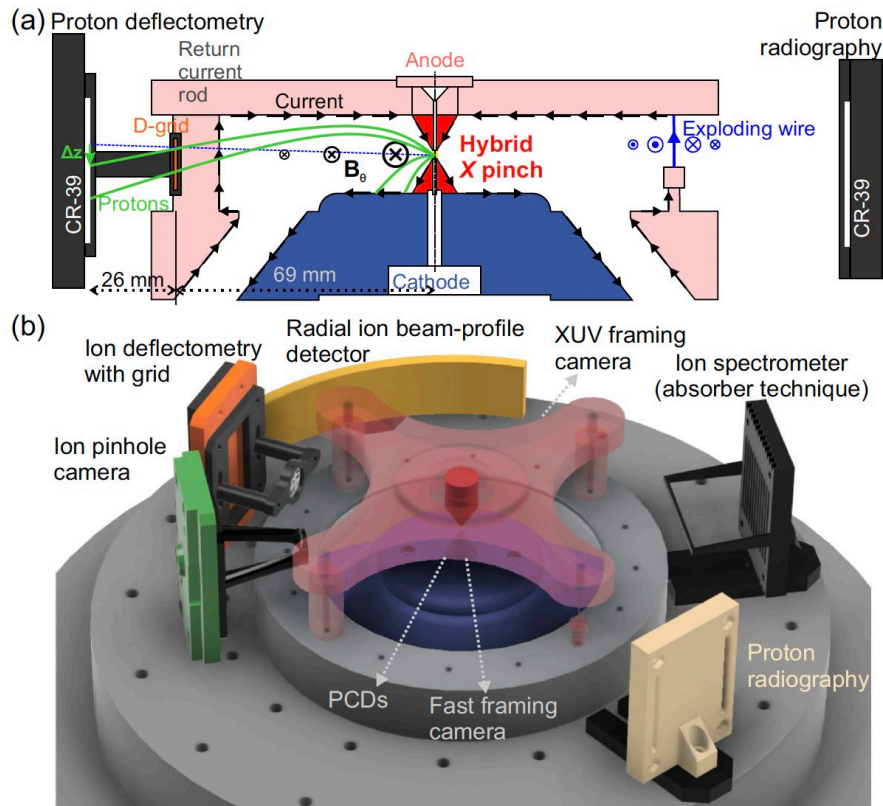
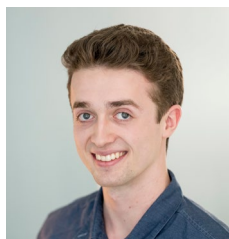


FIG. 1. Schematics of (a) the hybrid X pinch and (b) the in-chamber diagnostics on MAIZE. The same set of ion detectors is used on XP.

Klir *et al.*, PRL (2026). doi: [10.1103/qdgp-tydj](https://doi.org/10.1103/qdgp-tydj)



PhD Student Landon Tafoya (at LANL)
LRGF fellow studying neutron imaging diagnostics

- Remove fusion protons and accelerated deuterons by using CH_2 fibers
- This leaves only accelerated protons
- Use accelerated protons as a source to study exploding wires with proton radiography

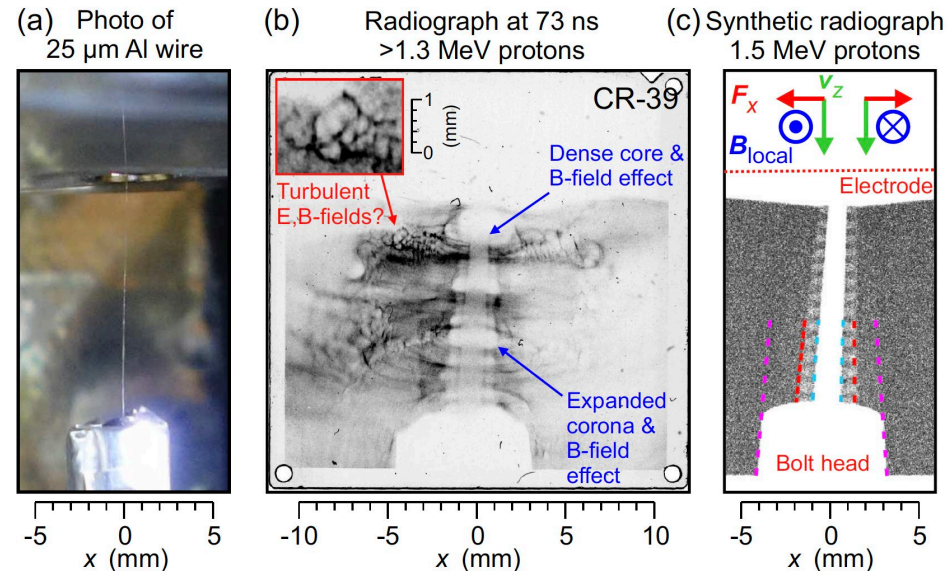


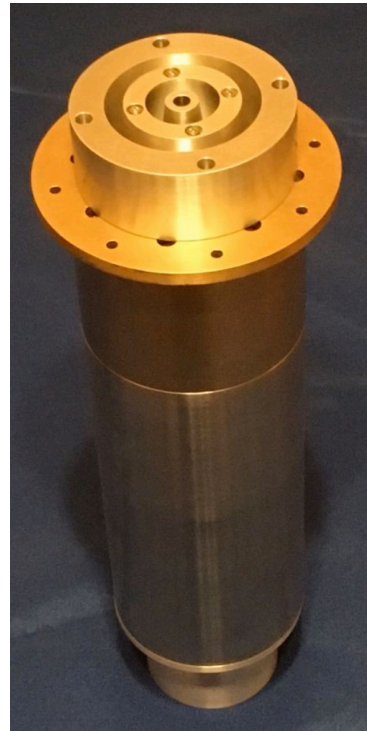
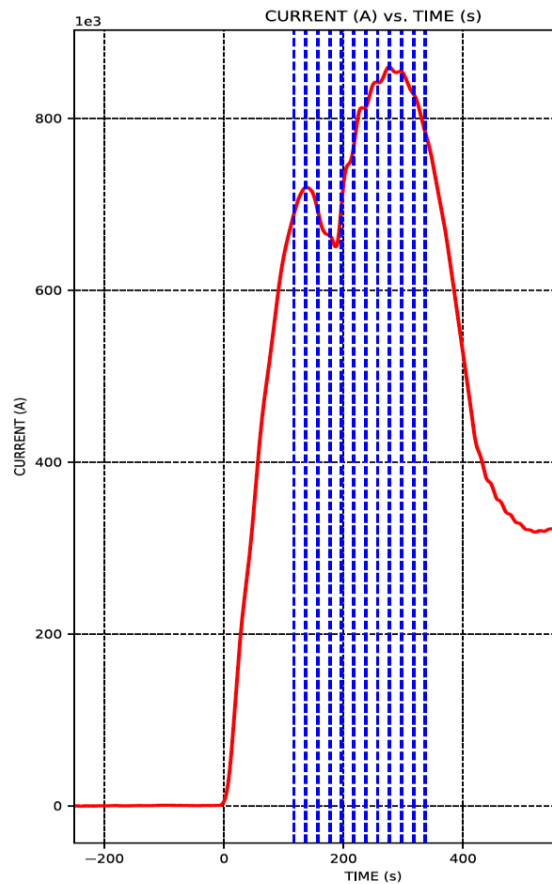
FIG. 5. (a) Preshot photograph, (b) experimental, and (c) synthetic X-pinch-driven proton radiographs of the $25\ \mu\text{m}$ Al wire in MAIZE shot no. 3369. A $20\ \mu\text{m}$ Al foil is used to absorb protons with energies below $1.3\ \text{MeV}$. Spatial scales correspond to the plane of the wire.



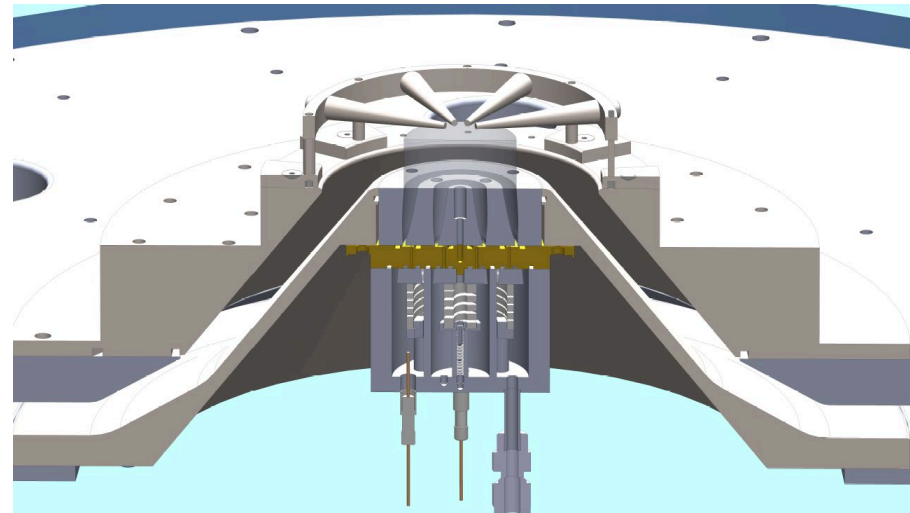
Recent PhD Student
Dr. Akash Shah
(Now at Zap Energy)

Deuterium gas-puff z-pinches on MAIZE

- Triple-shell gas-puff system developed w/ Alameda Applied Science (Mahadevan Krishnan)
- DD fusion neutron yields of $\sim 10^8$ measured with bubble detectors and Be probe
- **>30 shots per day demonstrated on MAIZE!**



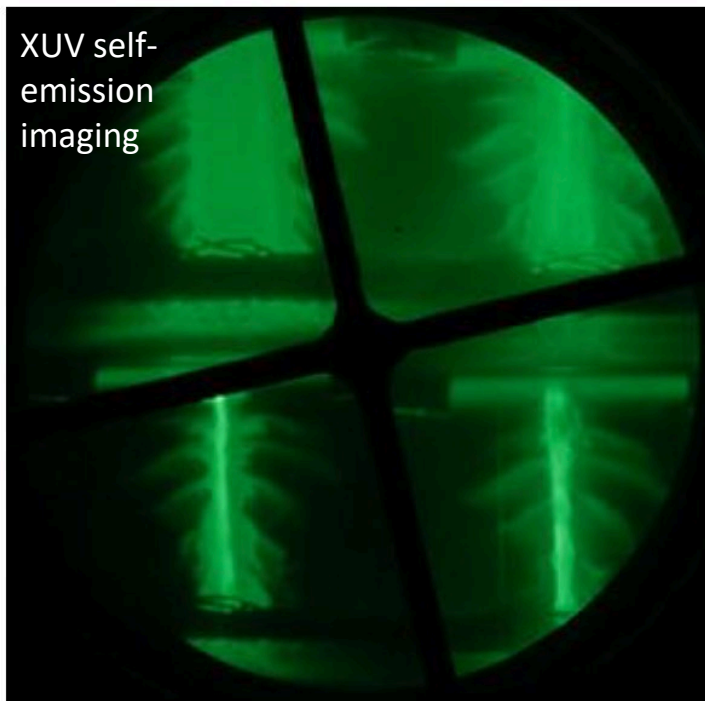
MAIZE's triple-shell
gas-puff nozzle



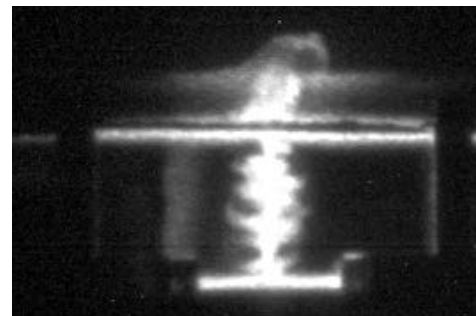
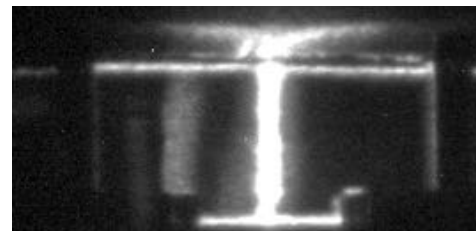
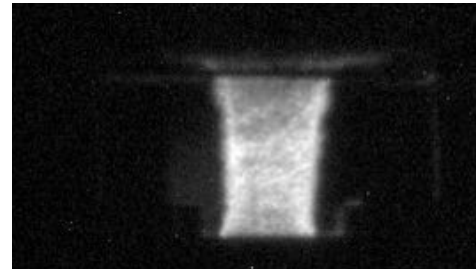
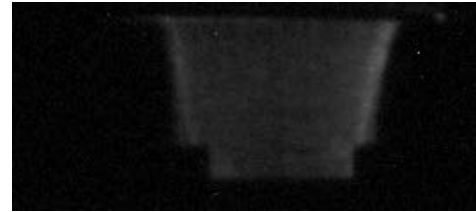
Conical gas-puff power feed

Argon gas-puff z-pinches on MAIZE

- Total X-ray yields up to 820 J measured for pure Ar implosions (bolometer)
- At ± 60 kV charge, 5.8 kJ stored in caps, giving a wall-plug efficiency of 14%
- Pre-ionization available
- Argon onto D2 demonstrated



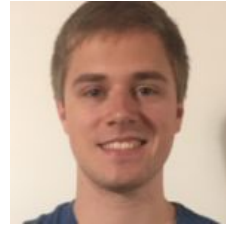
Visible-light self-emission imaging



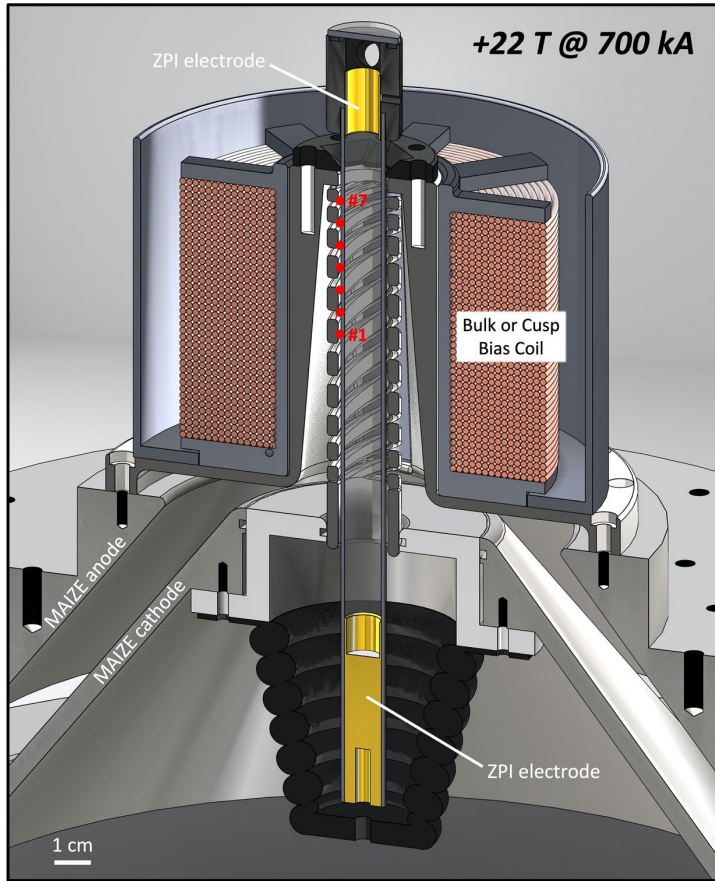
Recent PhD Student
Dr. Akash Shah
(Now at Zap Energy)

A. Shah et al.
IEEE TPS, 2024.
doi: [10.1109/TPS.2024.3436054](https://doi.org/10.1109/TPS.2024.3436054)

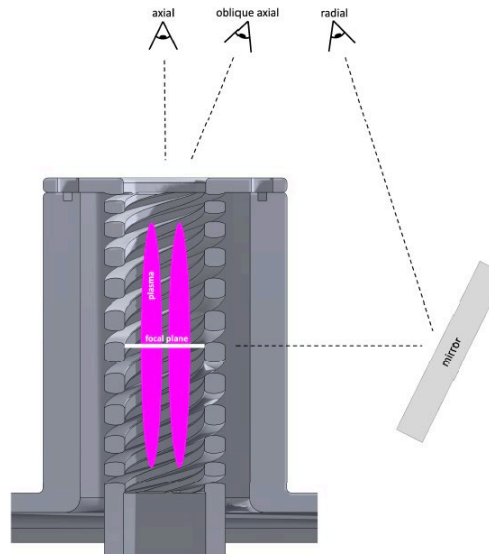
FRC platform on MAIZE (for potentially preheating and pre-magnetizing MagLIF fuel)



Recent PhD Student
Dr. Brendan Sporer
(now at TAE)



Simultaneous side-on and top-down self-emission imaging with fast 12-frame visible light camera



- 3D printed fast reverse coil and housing for slow bias coil (wound in-house)

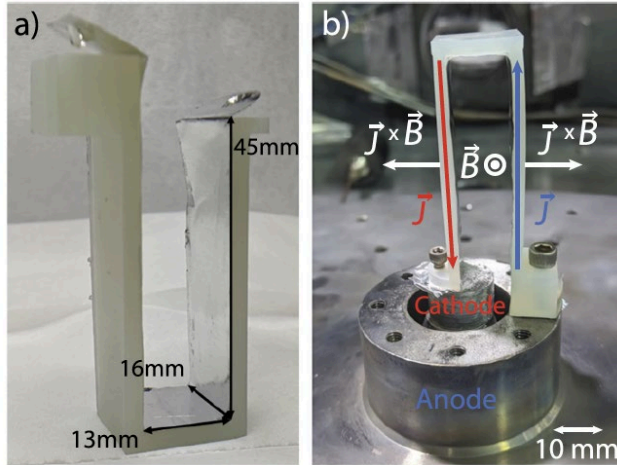
B. Sporer et al., PoP, 2025. doi: [10.1063/5.0286778](https://doi.org/10.1063/5.0286778)



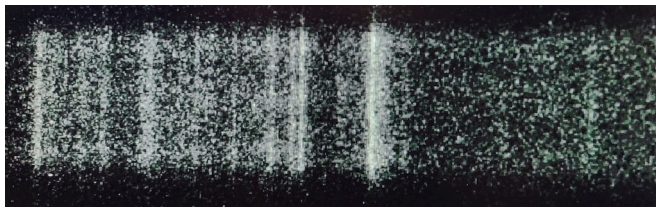


Recent PhD student
Trevor Smith (Now
a Sandia postdoc)

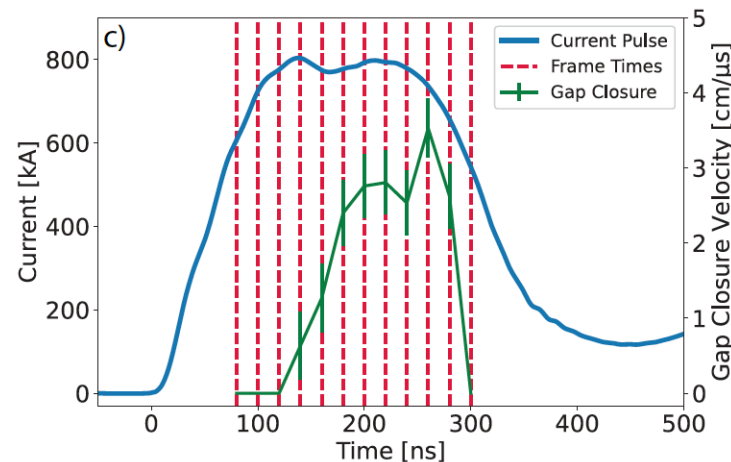
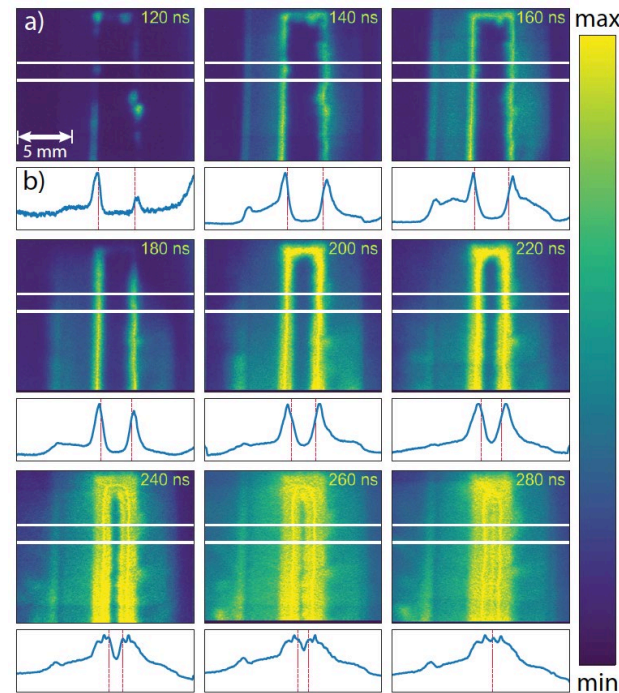
Power flow studies: Thin-foil platform to image plasmas in A-K gaps



- Studying coronal plasma formation, gap closure, and current shunting
- Using spectroscopy (visible & VUV) + models to understand constituents, ionization states, temperatures, densities, etc.



- From 50-um Al foil
- Main prominent line is 465 nm (Al-II)

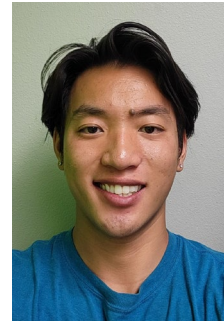
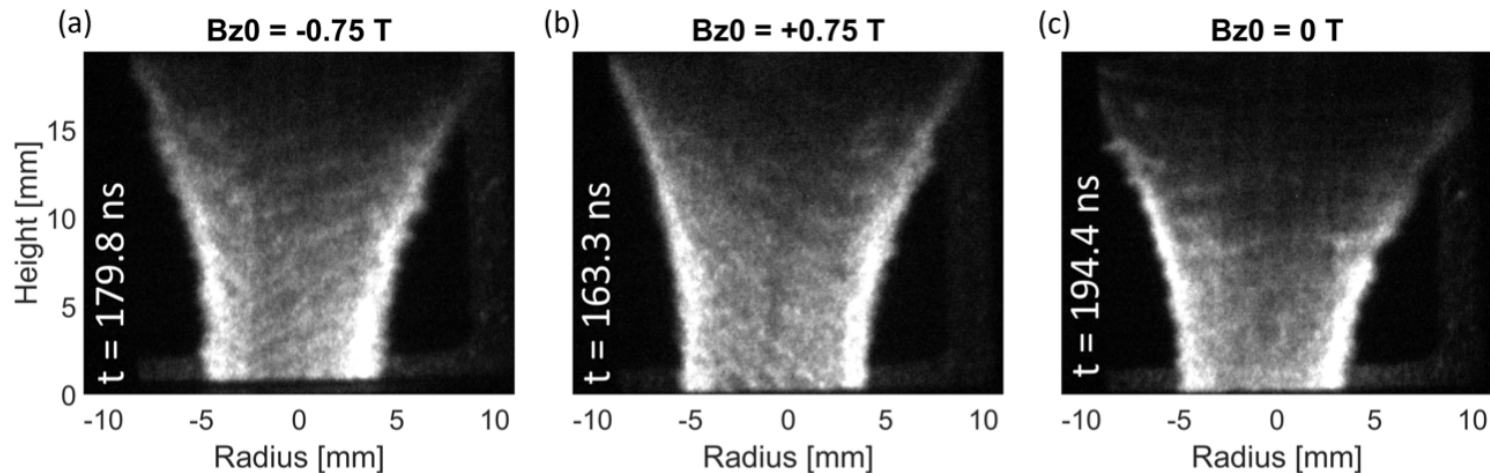


T. J. Smith *et al.*, Rev. Sci. Instrum. **92**, 053550 (2021).

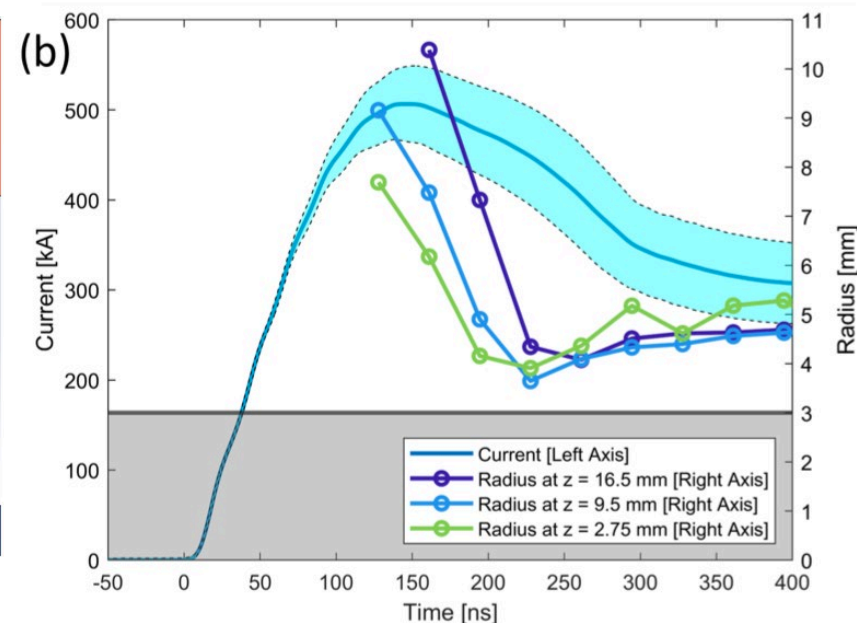
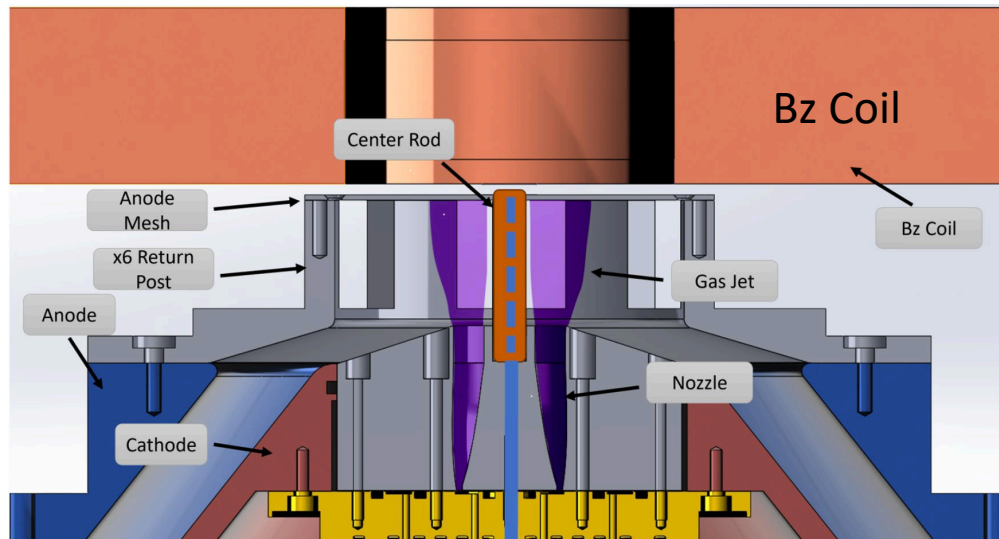
Concluding Remarks

- Many platforms and diagnostics available on MAIZE
- High shot rates possible (e.g., >30 shots/day with gas-puff loads)
- 3D printing (metals and dielectrics) is enabling creative experimental design
- ZNetUS collaborators welcome!
- Our goals for MAIZE's participation in ZNetUS are to:
 - Grow the pulsed-power community
 - Expose students to new diagnostics and techniques
 - Increase the depth and diversity of research investigated on MAIZE
- UMich will support users with consultation on the experimental design as well as onsite support during the shot campaigns.
- The consultation will likely include an SNL-like design review process that looks something like:
 1. An initial kick-off meeting/experimental objectives review (EOR) for introducing team members and sketching out ideas (~16 weeks before shots)
 2. An initial design review (IDR) for evaluating preliminary designs and collecting feedback (~14 weeks before shots)
 3. A final design review (FDR) for approving final designs for fabrication (~12 weeks before shots)
 4. A shot-readiness review to ensure all hardware and diagnostics are available and ready (~2 weeks before shots)
 5. A post-shot review to ensure the integrity, distribution, and correct interpretation of all data collected, including in any publications generated (~2 weeks after the shot campaign and as needed)
- For questions, email: mcbrider@umich.edu
- Thank you for your time!

Gas-puff-on-rod experiments with pre-applied B_z (for seeding helical MRT instability in dense liners)



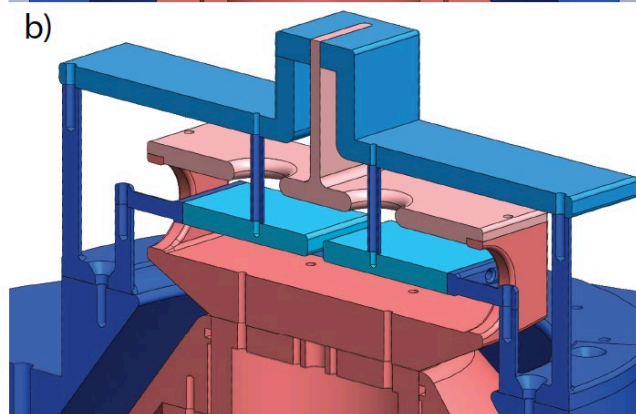
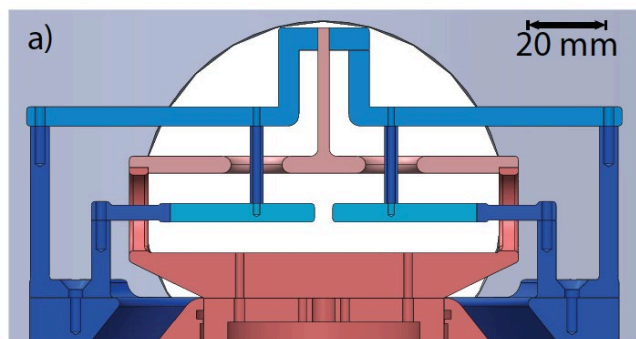
Recent PhD student
Joe Chen (Now a
Sandia postdoc)



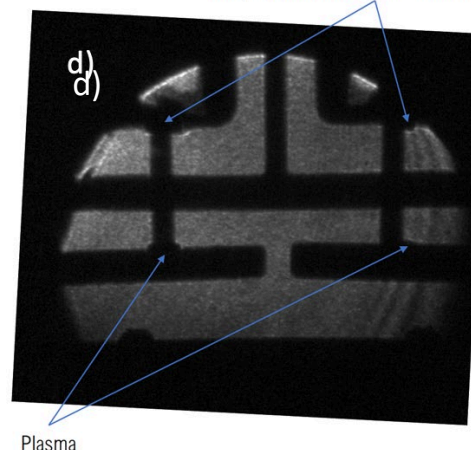
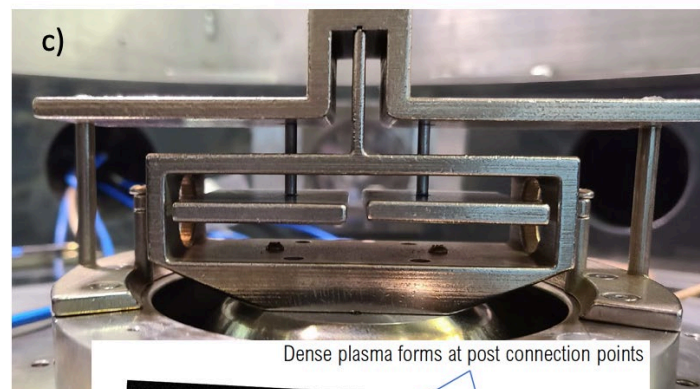


Recent PhD student
Trevor Smith (Now
a Sandia postdoc)

“Print-a-lute” for studying plasma flow through post-hole convolute structures with side-on imaging & spectroscopy



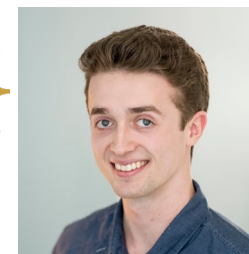
3D printed in solid metal



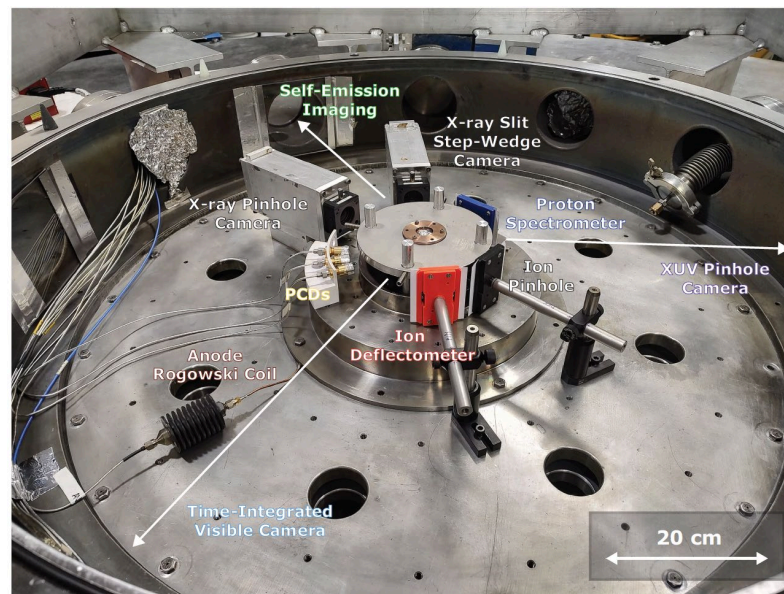
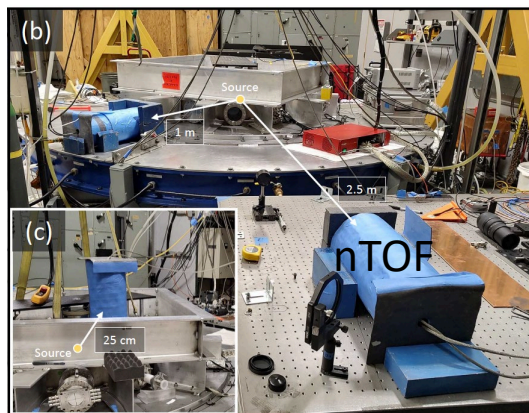
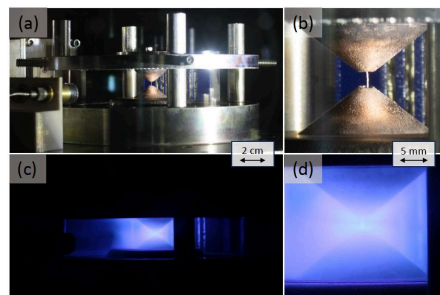
- Want to directly image plasma dynamics in convolute structure and test code predictions (e.g., CHICAGO)
- Initial experiments reveals high stress points where plasma is sourced in the anode-post connections



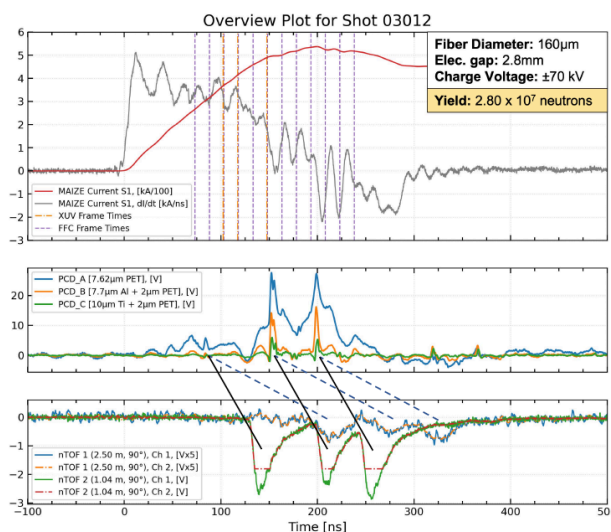
Recent PhD Student
Dr. George Dowhan
(now postdoc at NRL)



PhD Student
Landon Tafoya
(at LANL)



- With Daniel Klir and Karel Rezack from the Czech Technical University (CTU)
 - Interested in ion accel. mechanisms
- CD2 fiber from NRL
- DD neutron yields $\sim 10^8$
 - On par with D2 gas-puff z-pinch!
- Interesting fluence anisotropy detected with radial > axial, perhaps due to hybrid electrodes and scattering environment
- Radial ion beam detected with CTU's ion deflectometers



G. Dowhan et al.
IEEE TPS, 2025.
doi: [10.1109/TPS.2025.3565461](https://doi.org/10.1109/TPS.2025.3565461)