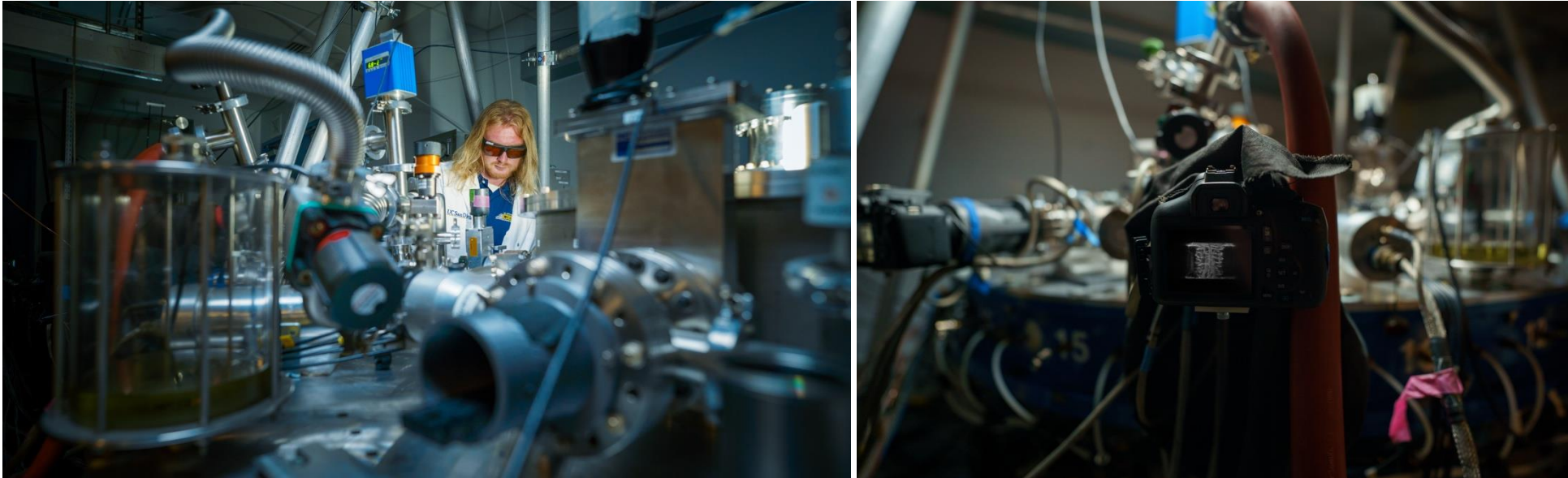


Compact Experimental System for Z-pinch and Ablation Research (CESZAR)

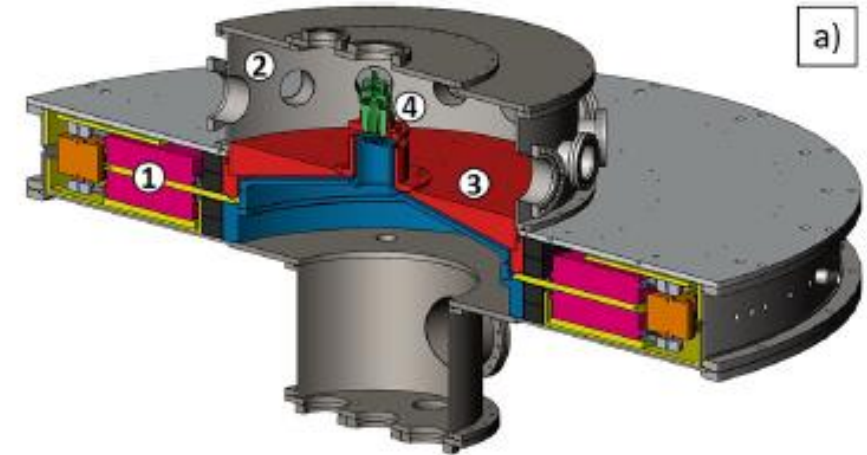


Farhat Beg
Center for Energy Research, UC San Diego
ZNetUS Workshop
August 10-11, 2026
Albuquerque, New Mexico

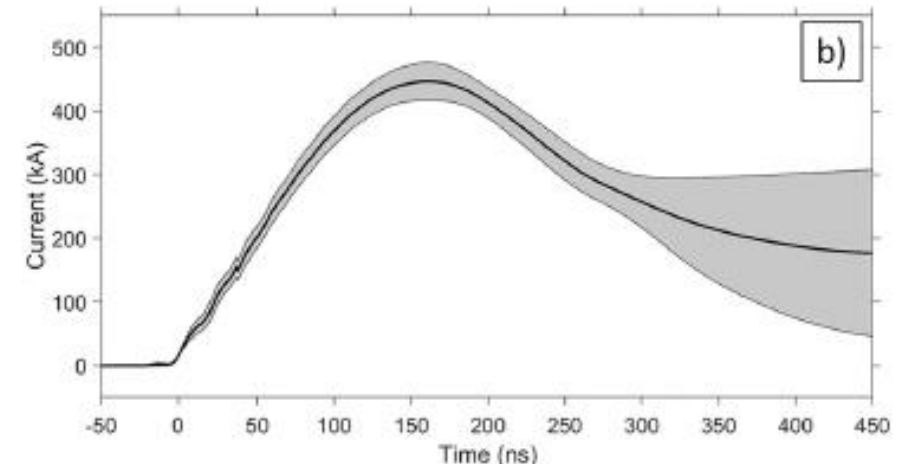
Compact Experimental System for Z-pinch and Ablation Research (CESZAR)

- CESZAR is a 20-brick Linear Transformer Driver (LTD) cavity that produces ~ 0.5 MA current with a rise time of 200 ns to a bipolar voltage +60 kV for a stored energy of 4.18 kJ.
- The current output is 500 ± 40 kA with a 160 ns rise time.
- 5-10 shots/day with gas puffs.

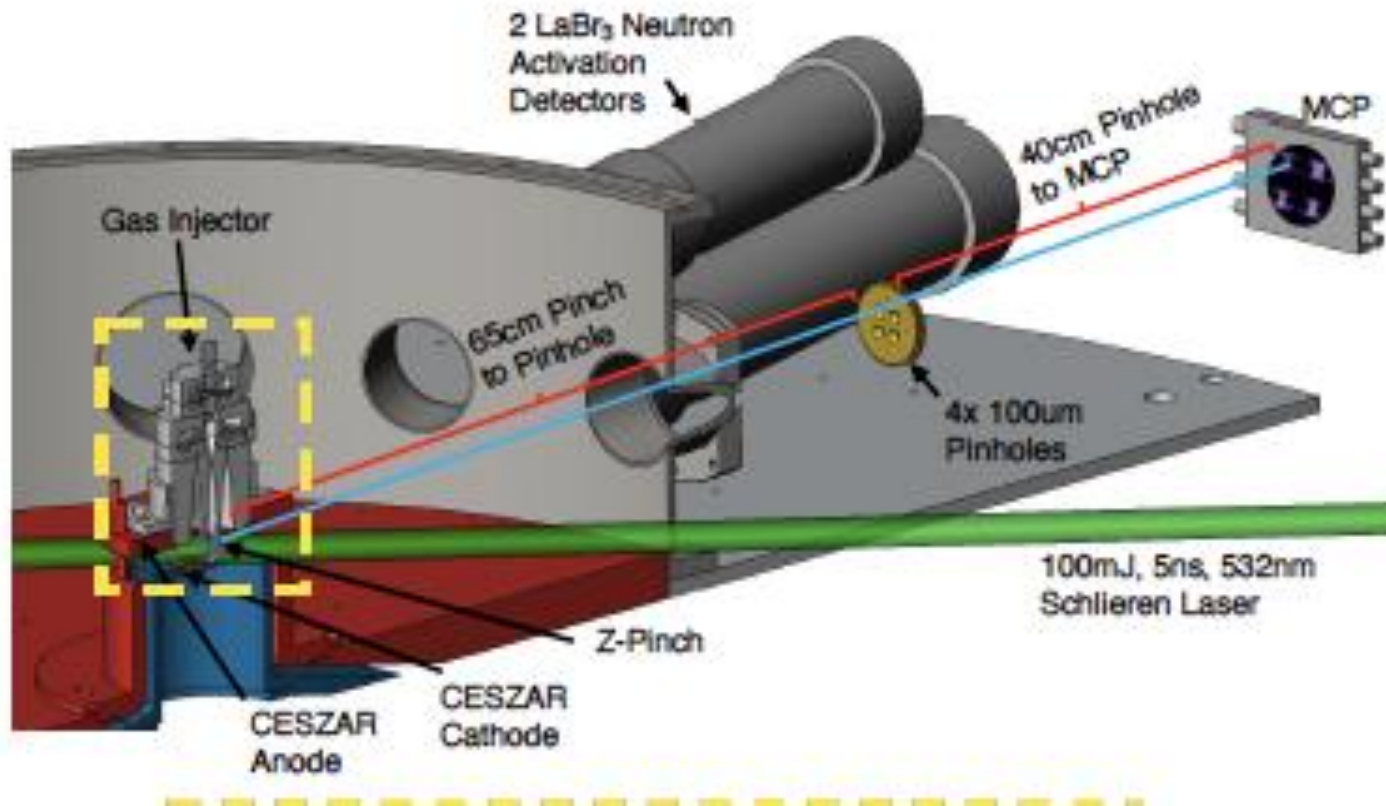
F. Conti *et al.*, *Physical Review Accelerators and Beams* **23**, 090401(2020)
 R.D. McBride *et al.*, *IEEE Transactions on Plasma Science* **46**, 11 (2018)



16 August 2023 19:27:28



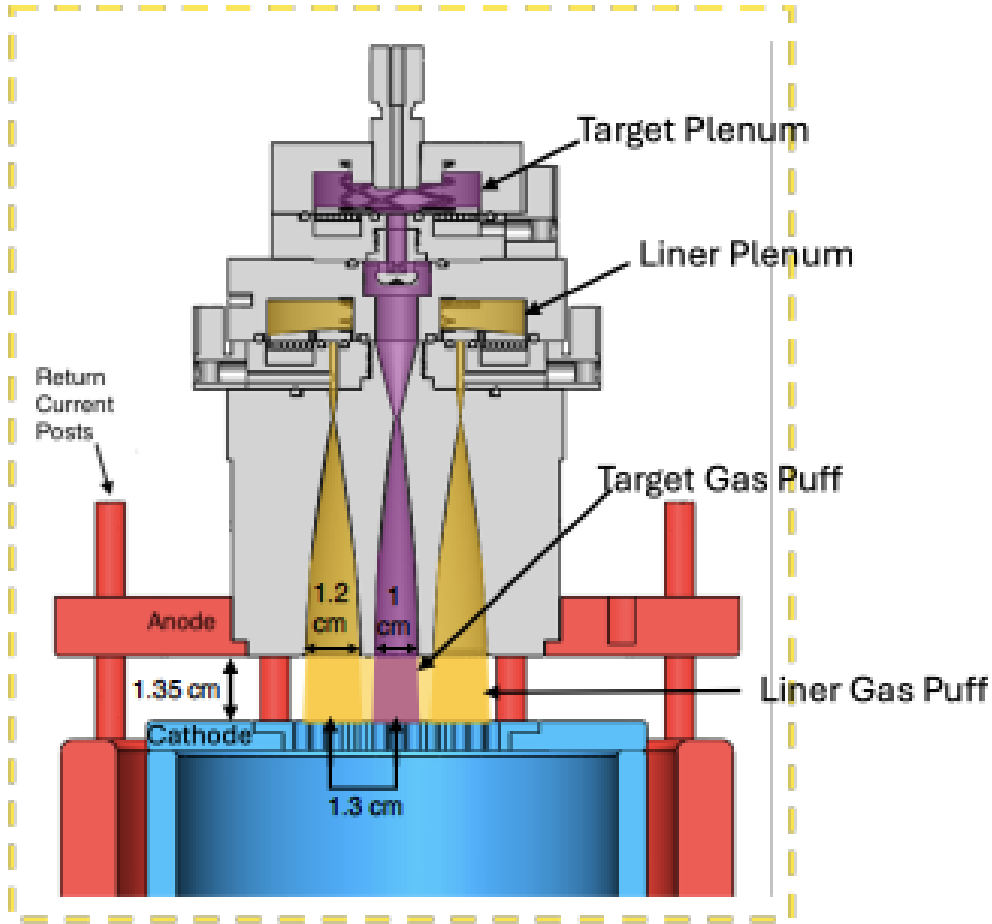
Diagnostics to measure implosion dynamics



- 1) Load (gas puff)
- 2) B-dot probes
- 3) Time-gated visible spectrometer
- 4) Laser schlieren imaging
- 5) XUV spectrometer
- 6) Soft X-rays photodiodes
- 7) Time-integrated X-ray pinhole camera
- 8) Two time-gated XUV pinhole camera
- 9) Hard X-rays photodiodes
- 10) Neutron activation counters and TOF detectors
- 11) Polarization spectroscopy

A. E. Youmans *et al.*, IEEE Transactions on Plasma Science **52**, 4833–4841 (2024).

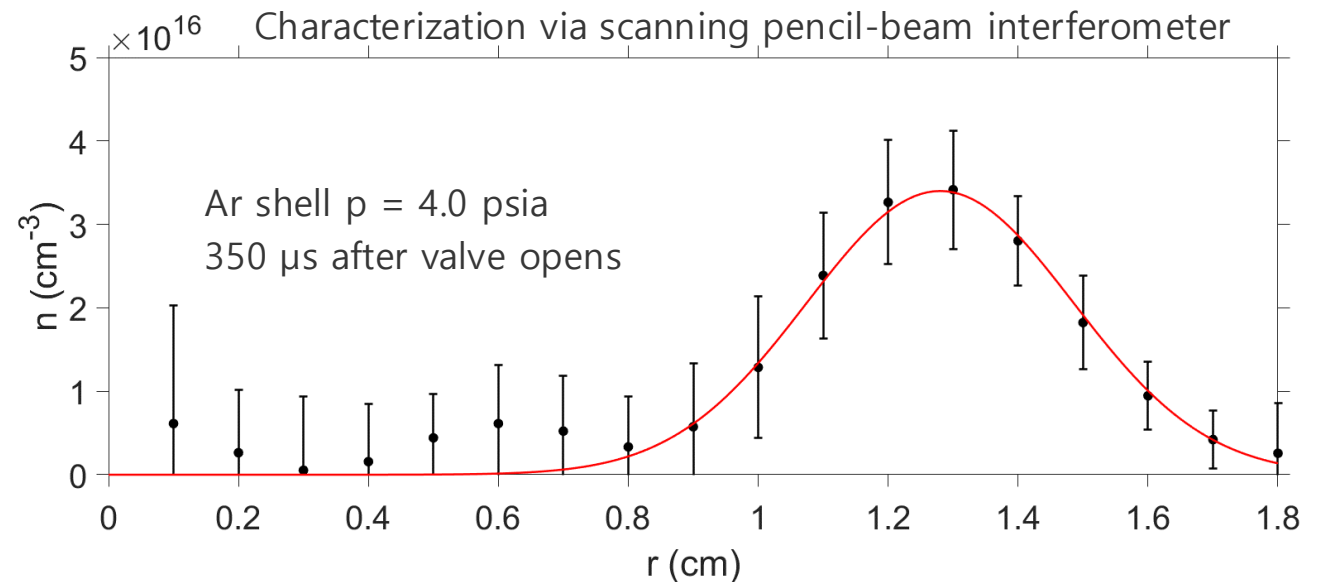
Gas puff injectors and characterization



Single, hollow shell

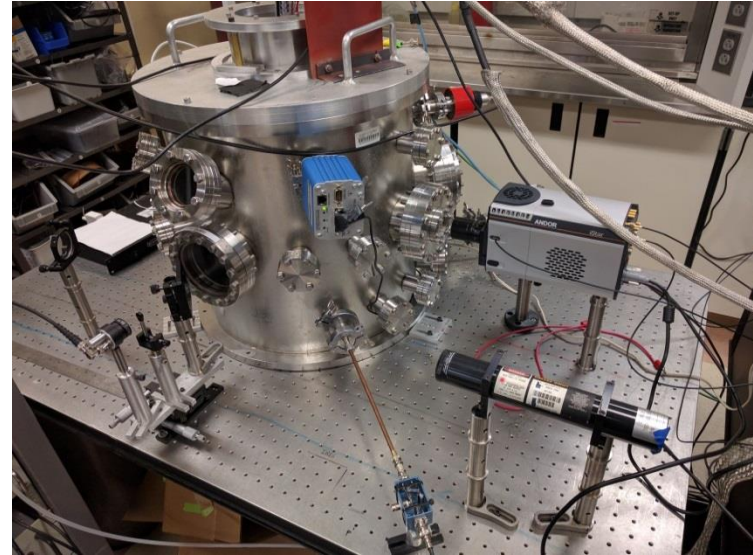
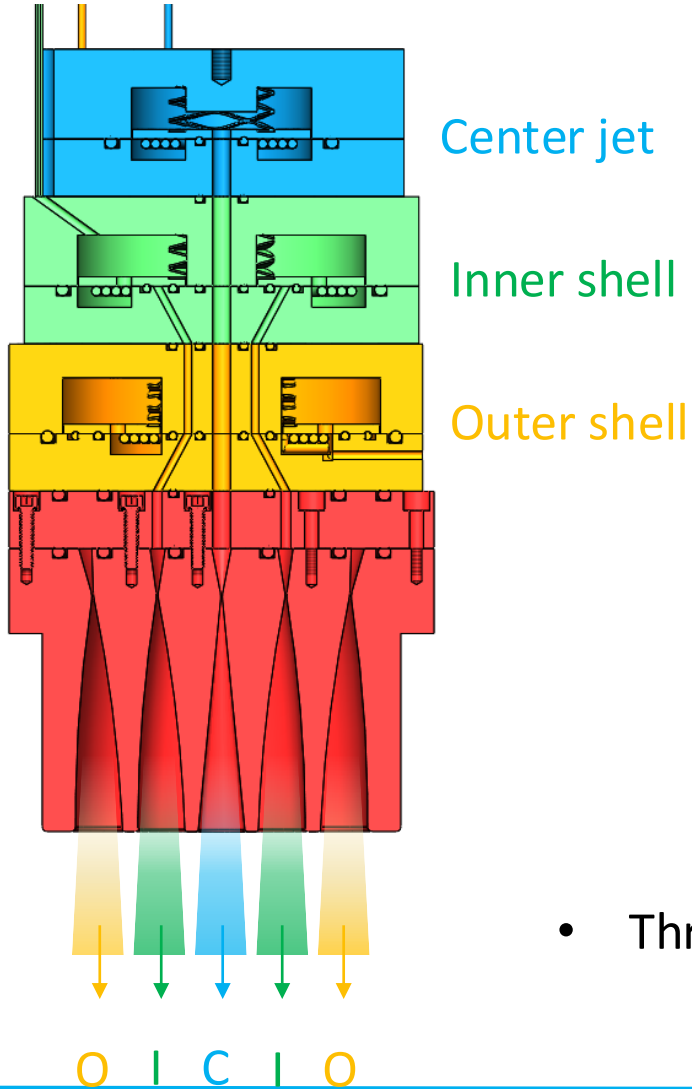
(baseline for multi-shell, multi-species)

- $R_0 = 13 \text{ mm}$
- $\text{FWHM} = 6 \text{ mm}$
- $\rho_0 \sim 2 \mu\text{g}/\text{cm}^3$
- $M/L \sim 10 \mu\text{g}/\text{cm}$



F. Conti et al., *IEEE Transactions on Plasma Science* **46**, 3855 (2018).

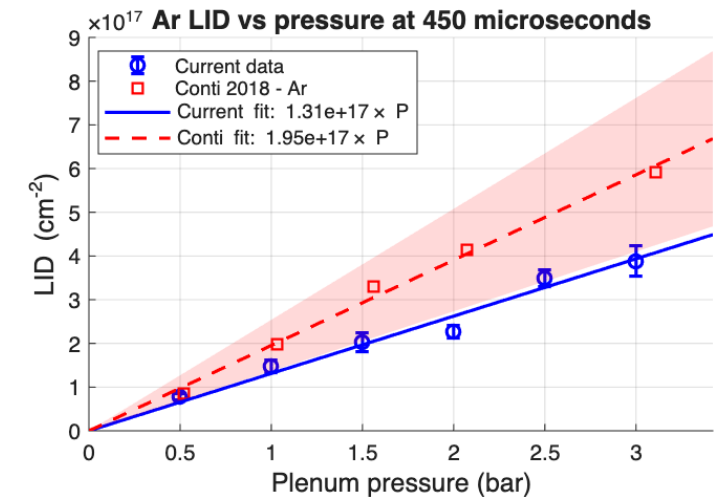
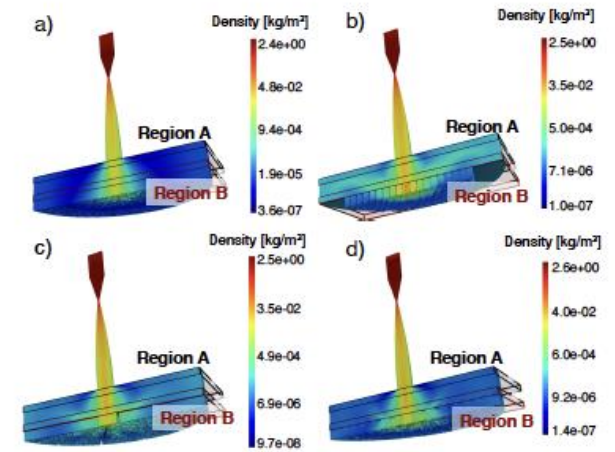
Design and construction of triple gas injector is completed



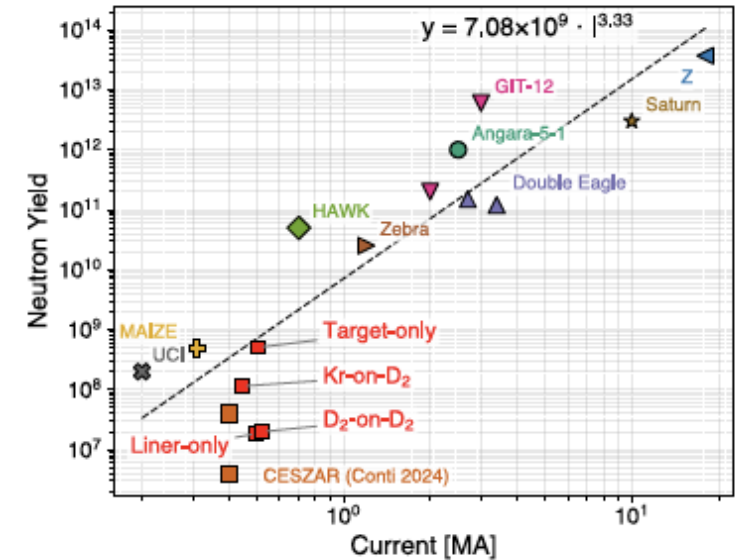
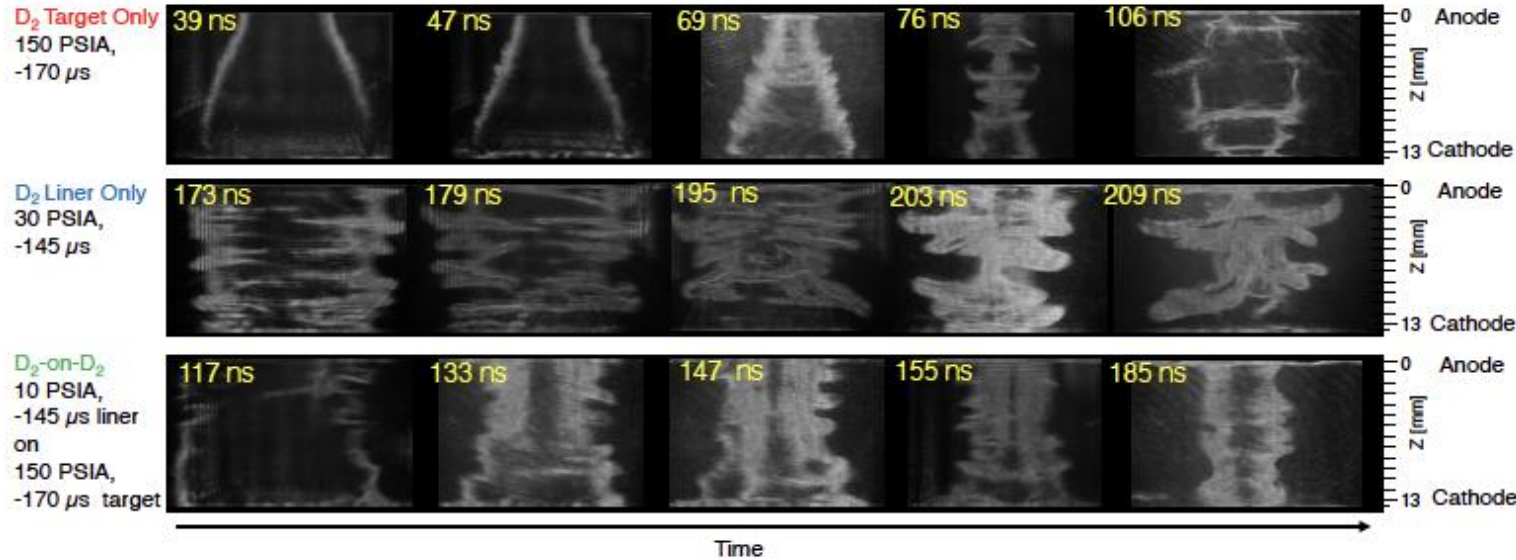
Test stand for jet characterization

- Three fully independent valves for flexibility

Design guided by CFD simulations



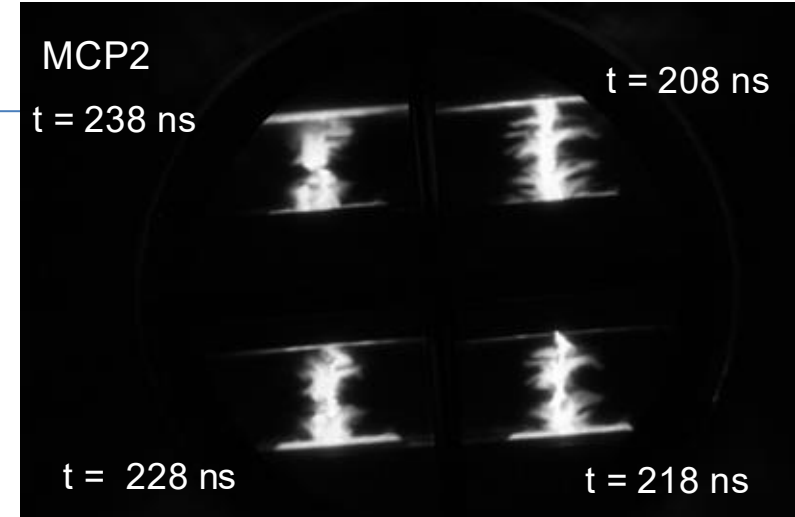
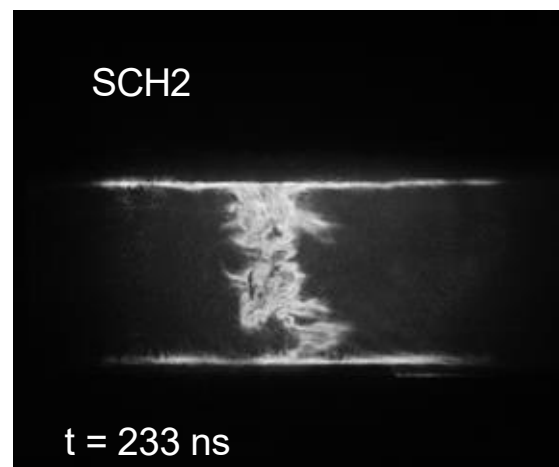
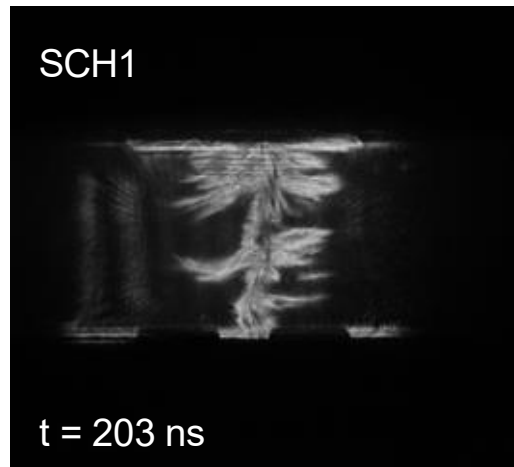
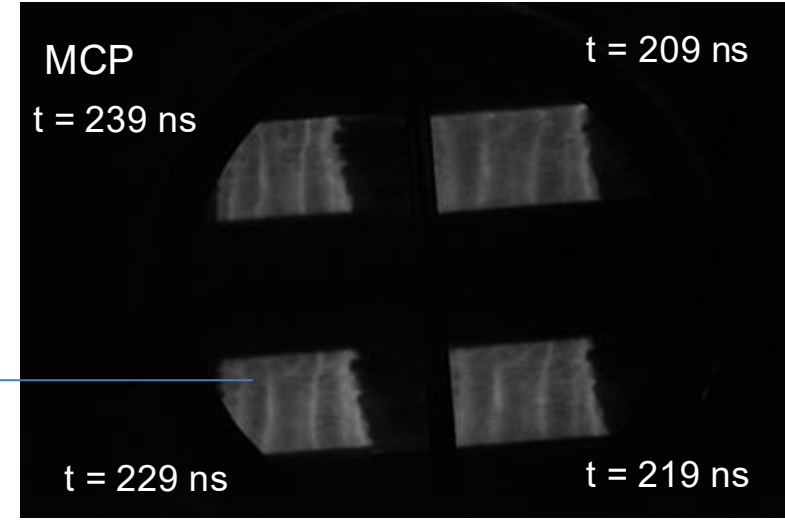
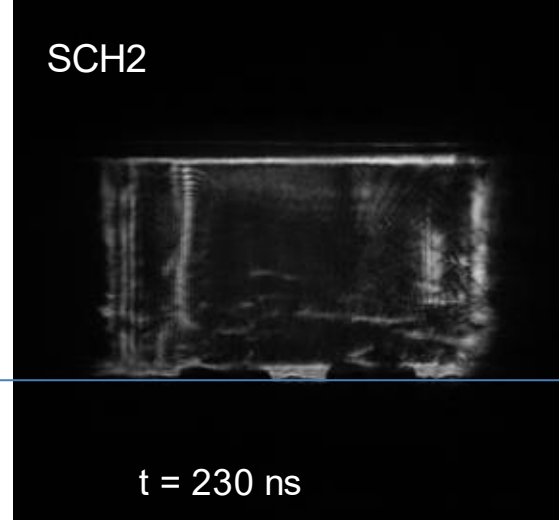
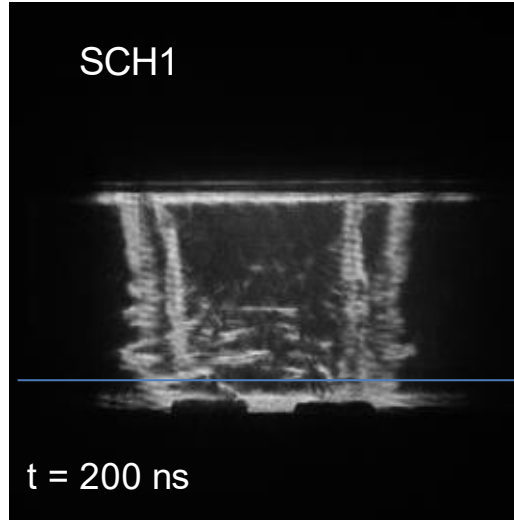
Deuterium gas puff experiments



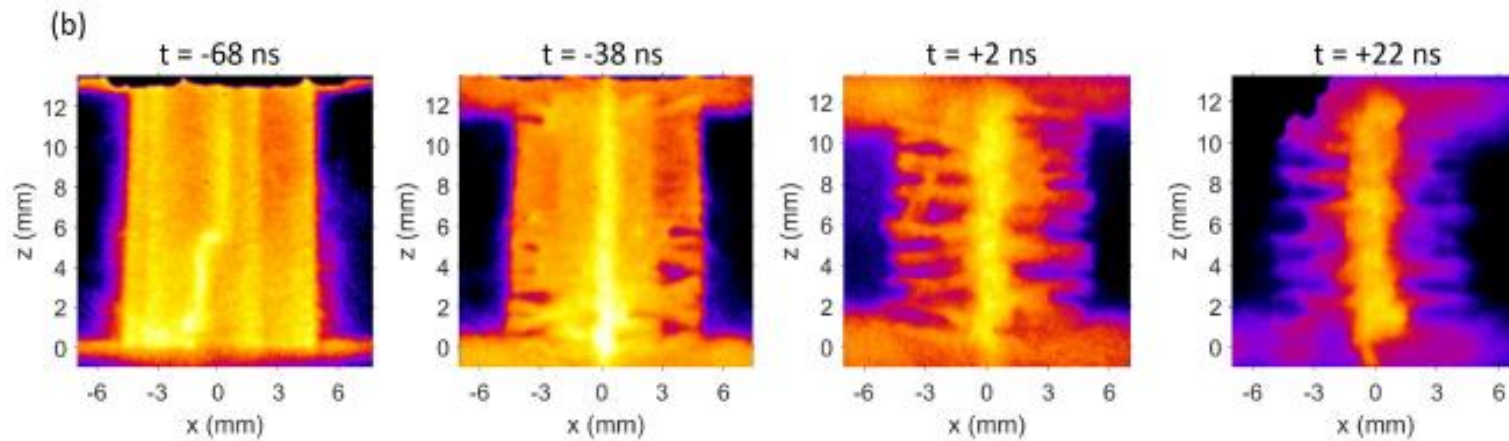
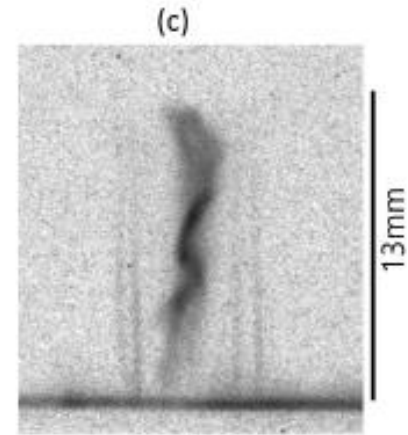
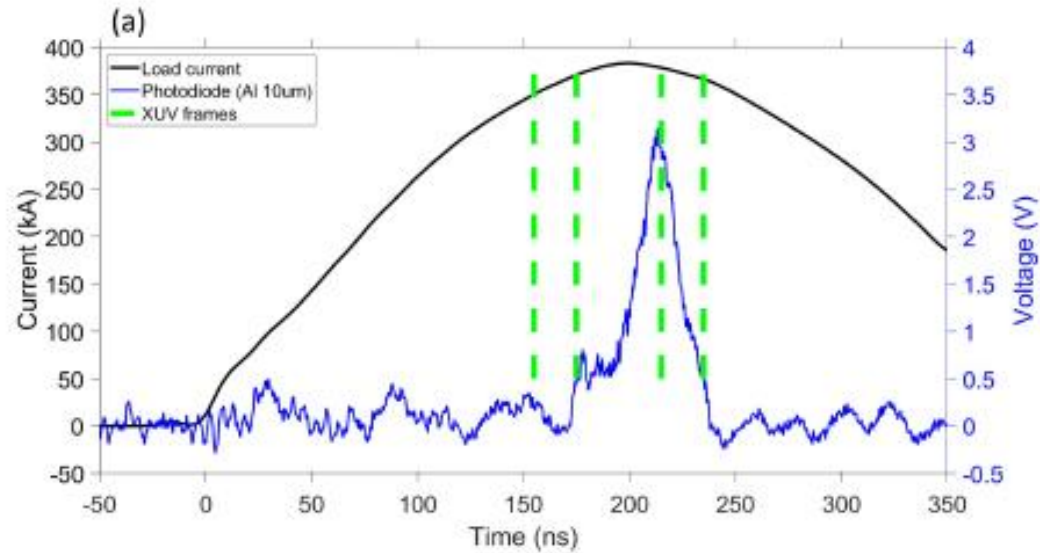
- D₂ liner-only demonstrated significant growth of the MRT instability, which was successfully mitigated by the addition of a target along with the liner.
- Neutron yields in the D₂ liner-only and D₂-on-D₂ configurations were very similar and below those of the target-only case.
- Kr-on-D₂ approached yields closer to target-only values; however, it is possible that these came from shots that behaved very similarly to target-only shots due to low liner mass or insufficiently ionized Kr gas.

O.Yang *et al.*, J. Applied Physics (under review)

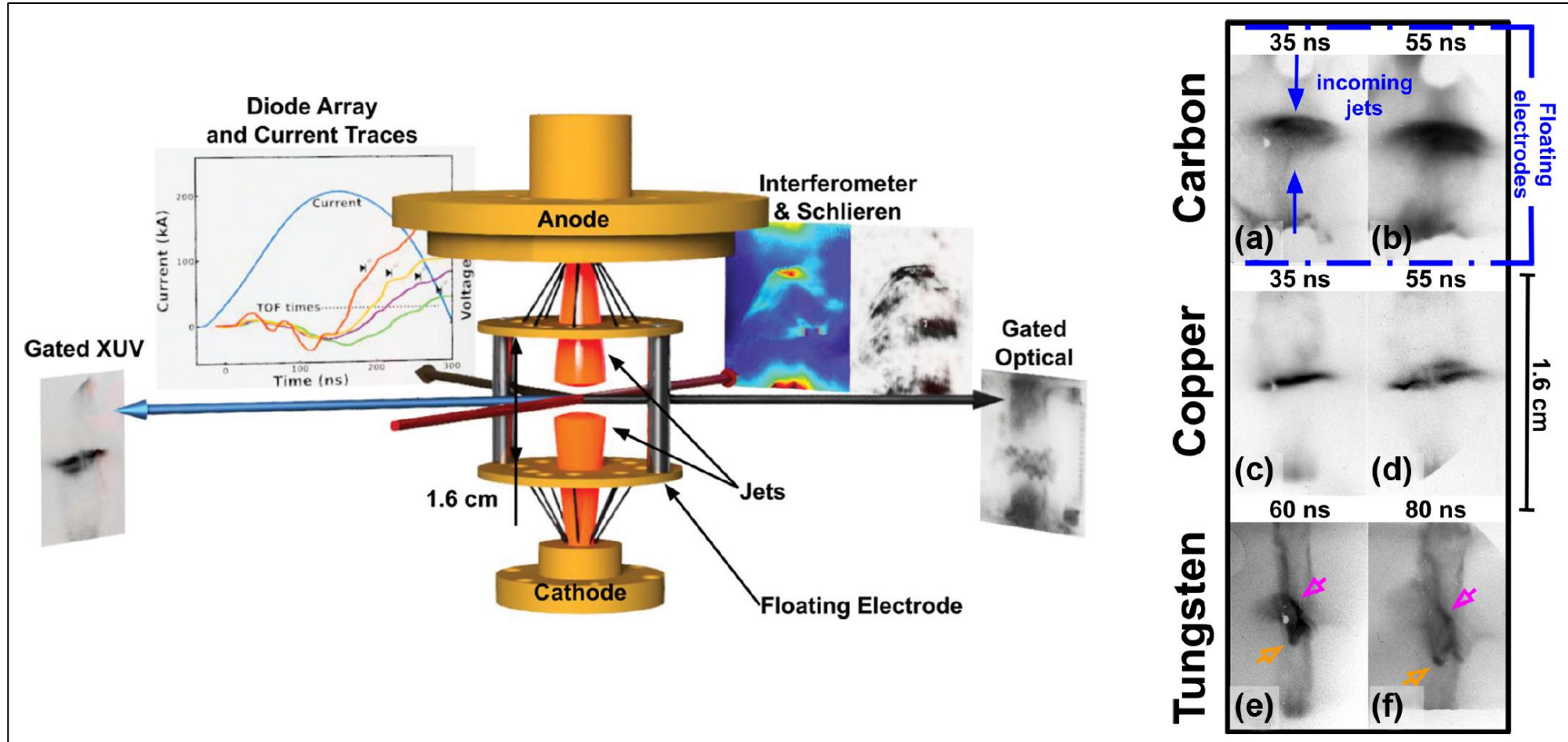
Single argon gas puff shows shock generation



Wire array experiments

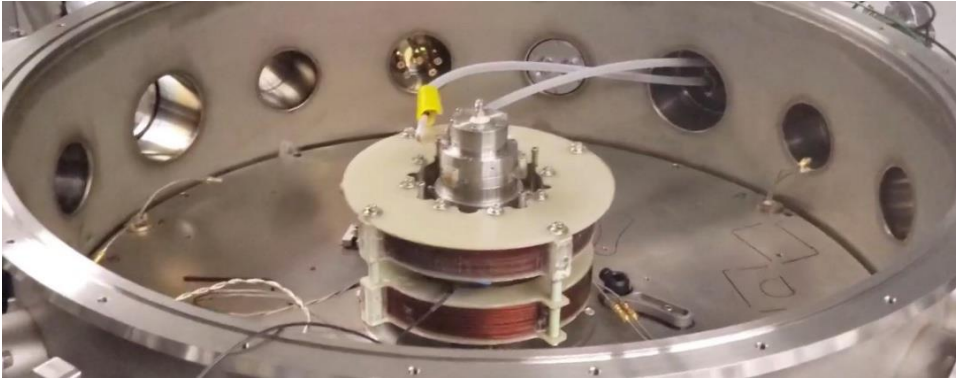


Conical Wire experiments



Axial magnetic field capability is also available

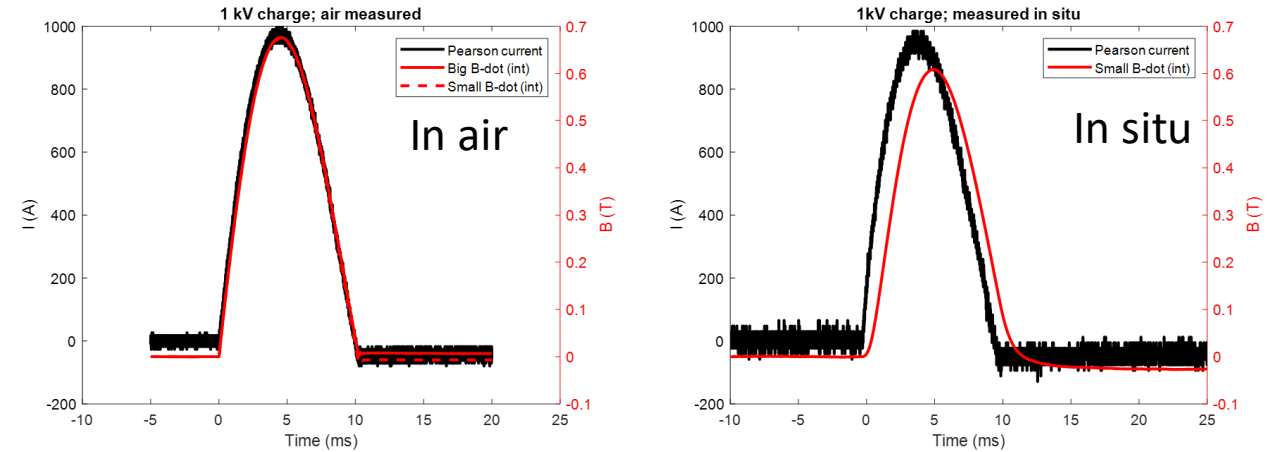
Coil inside the CESZAR chamber



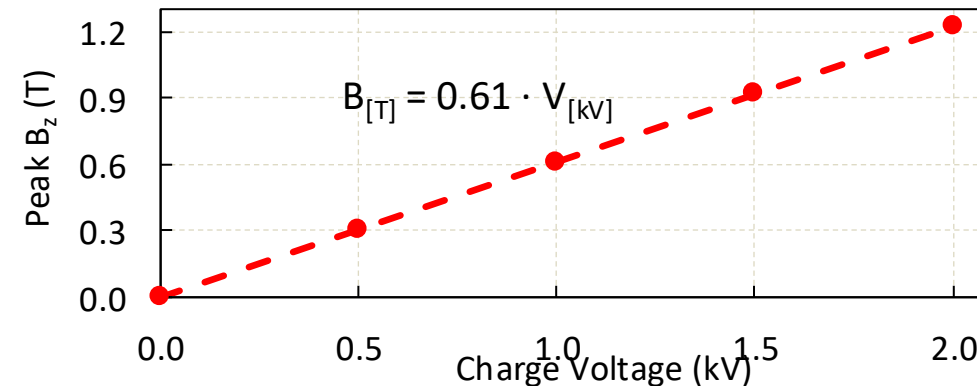
- 190 mm ID, 60 turns per coil
- 5 ms quarter-period
- Max V = 2 kV, E = 10 kJ
- Max $B_z = 1.2$ T ($B_{st} \sim 0.3$ T)

N. Aybar *et al.*, *Physics of Plasmas* **30**, 062706 (2023).
 N. Aybar *et al.*, *IEEE Transactions on Plasma Science* **50**, 2541-2547 (2022).
 N. Aybar *et al.*, *Physical Review E* **103**, 053205 (2021).

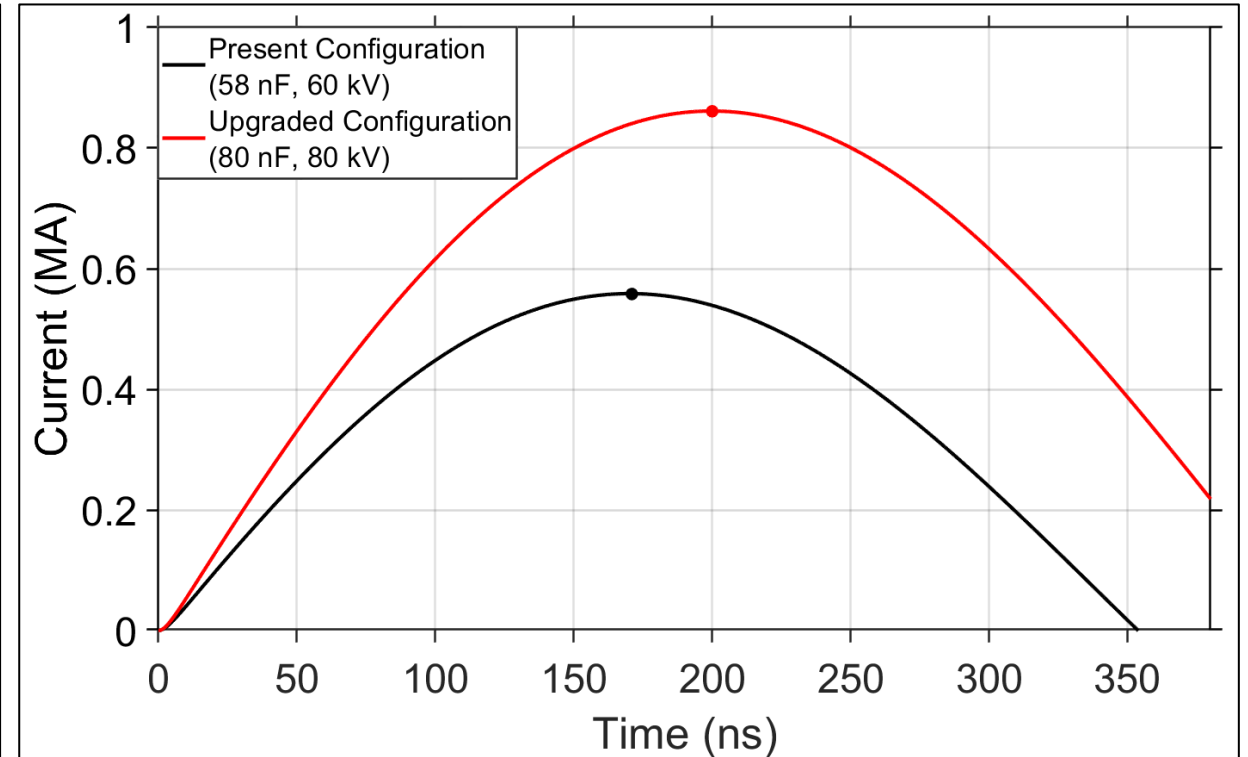
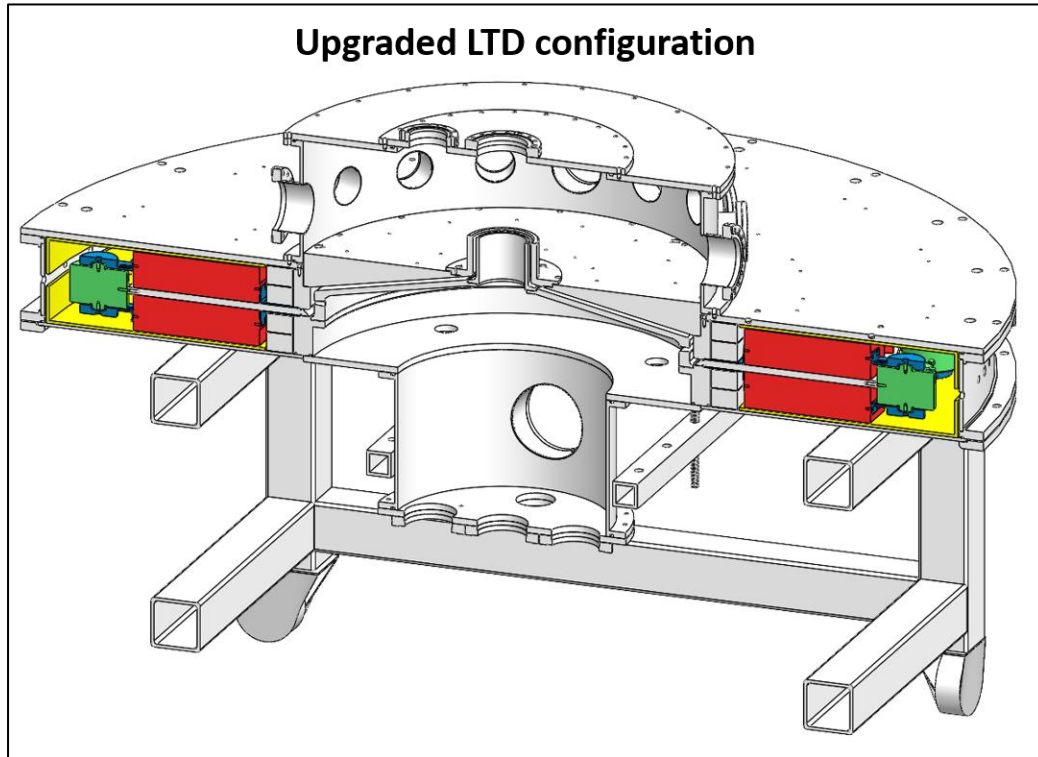
In air vs in situ characterization:
small difference due to B diffusion through metal



Peak B_z vs charge voltage



Machine upgrade



- Our plan is to upgrade the machine to 0.8 MA by the end of the year and to 1.5 MA by the end of next year.

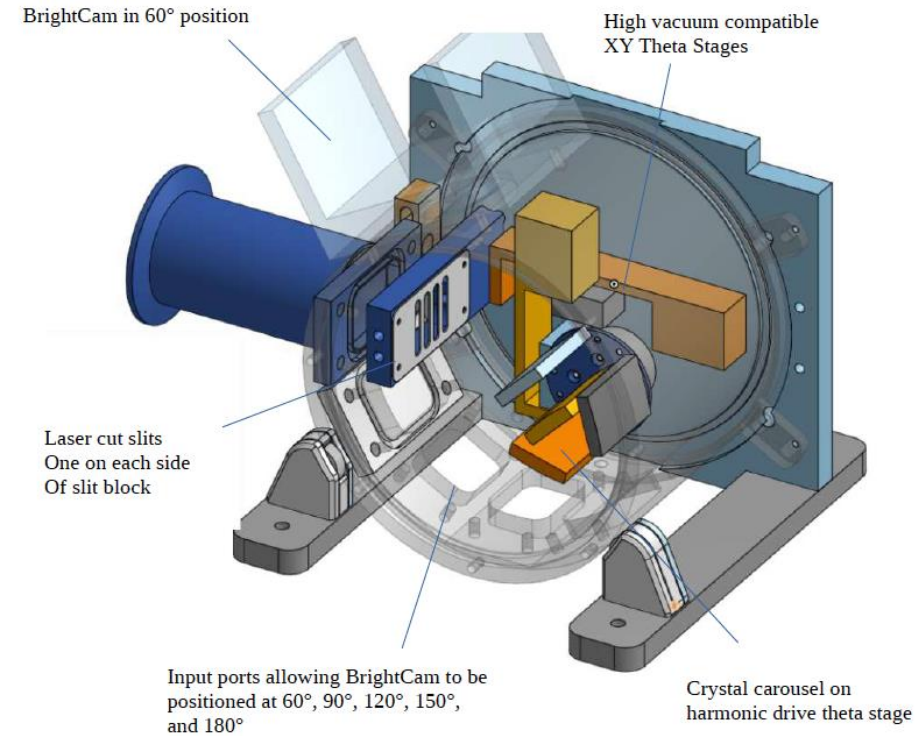
New Diagnostics: Optical Streak Camera



FEATURES

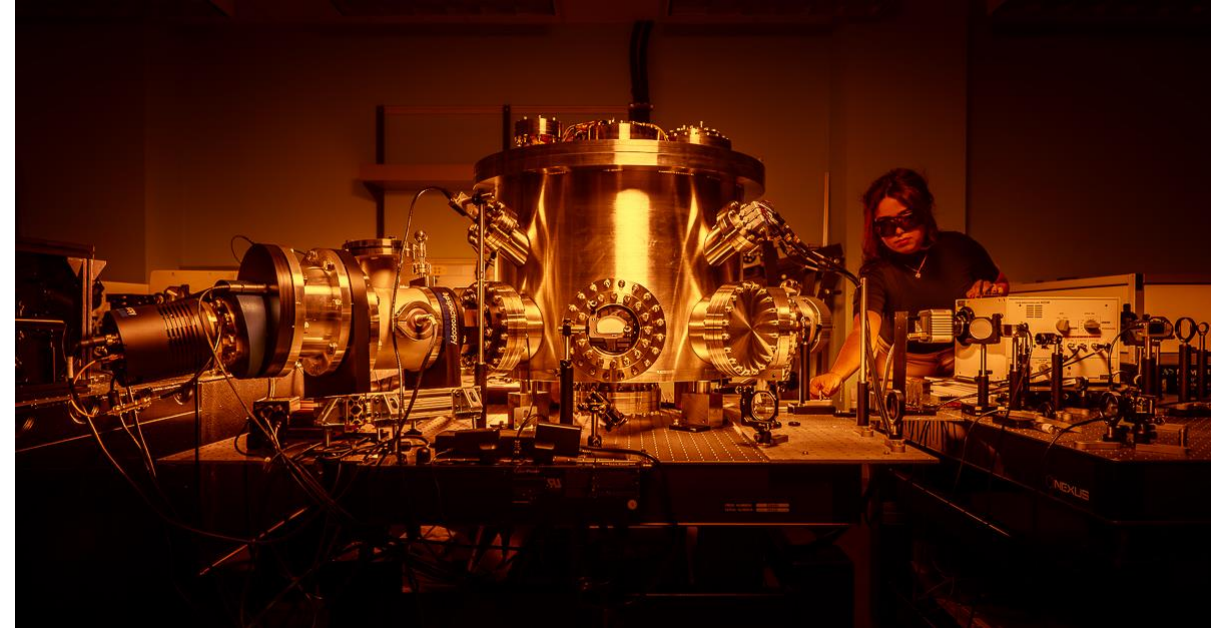
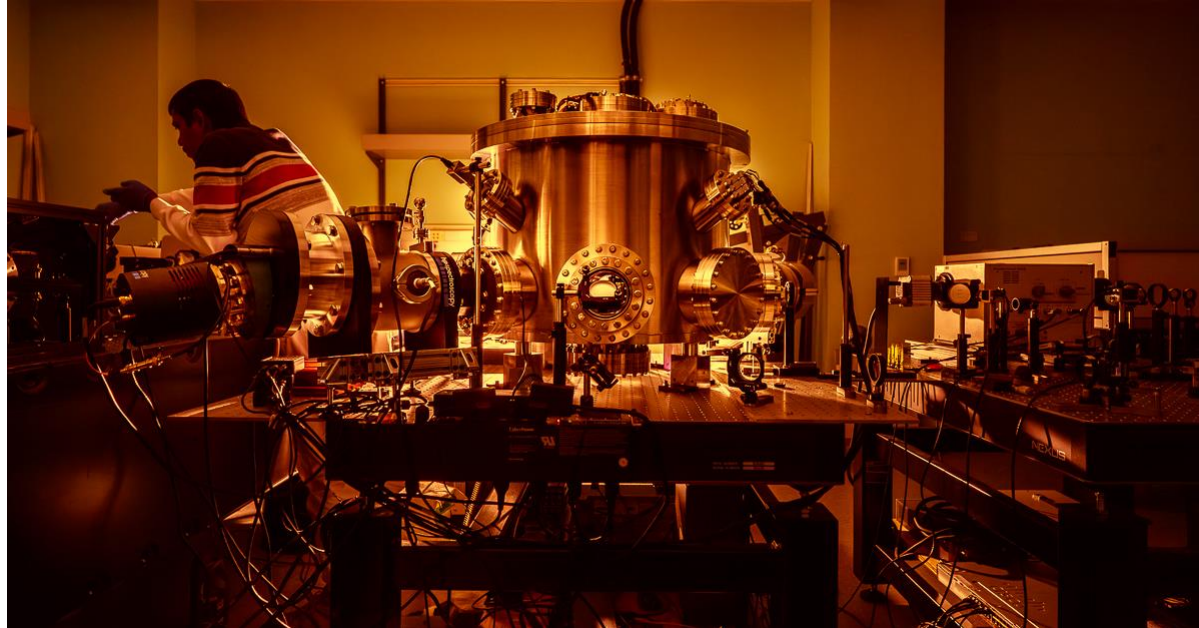
- Designed for single sweep operations
- Covers a wide time range from 500 ps to 1 ms (using both fast and slow sweep plug-in units)
- Temporal resolution
Fast sweep unit: Better than 10 ps
Slow sweep unit: Better than 100 ps
- Simultaneous measuring time, position (or wavelength) and light intensity
- High sensitivity (single photoelectron detectability)
- High-speed gate function

New Diagnostics: Time resolved XUV/X-ray spectrometer and calibration source

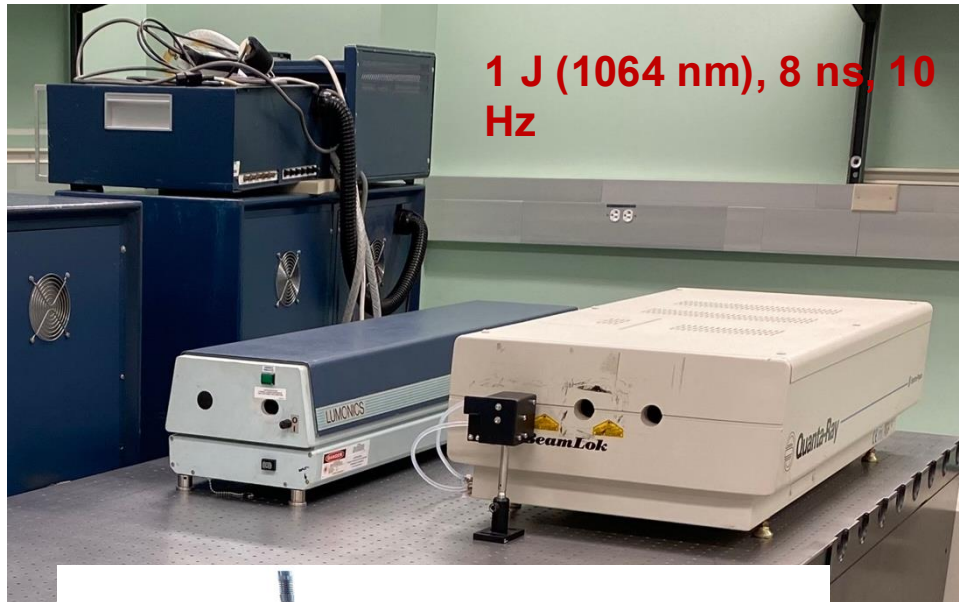


- Spectrometer with multiple crystal to cover line from neon to krypton
- X-ray calibration source for X-ray detectors

New Capability



Some of these lasers will be coupled to the CESZAR



40 J, 5-12 ns



35 mJ, 35 fs

Summary

- The CESZAR generator can be used for a variety of loads and diagnostics testing.
- Wide variety of diagnostics are available.
- Machine will be upgraded to 0.8 MA by the end of the year.
- We have a new laser facility next door. We plan to integrate some of the lasers with CESZAR.
- The facility provides ample of opportunities for hands-on experience to train students.

**The access to the facility is supported by the
Department of Energy, National Nuclear Security
Administration under the Support for ZNetUS
contract number 89233125CNA00039.**