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MYKONOS AT SANDIA

A pulsed power driver for science and innovation

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2024 ZNetUS Workshop

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SAND2025-02527C

SUMMARY

- Sandia's Mykonos LTD based pulsed power driver delivers MA class current at 100ns rise-time to a small target chamber in support of pulsed power and HED science.
- The facility allows for hands-on, pulsed power, experimental training for students and staff along-side senior Sandia scientists in an environment that is more accessible than the Z Facility.
- In recent years we have supported students and research projects in areas of:
  - Pulsed Power Science, including plasma cleaning techniques
  - Electrothermal Instability Studies
  - Auto-magnetized liners for MagLIF fusion concept
  - Optical diagnostics, x-pinches and more
- We have recently established the Mykonos Academic Access Program (MAAP) that will grant outside University access to the facility as part of the ZNetUS network.

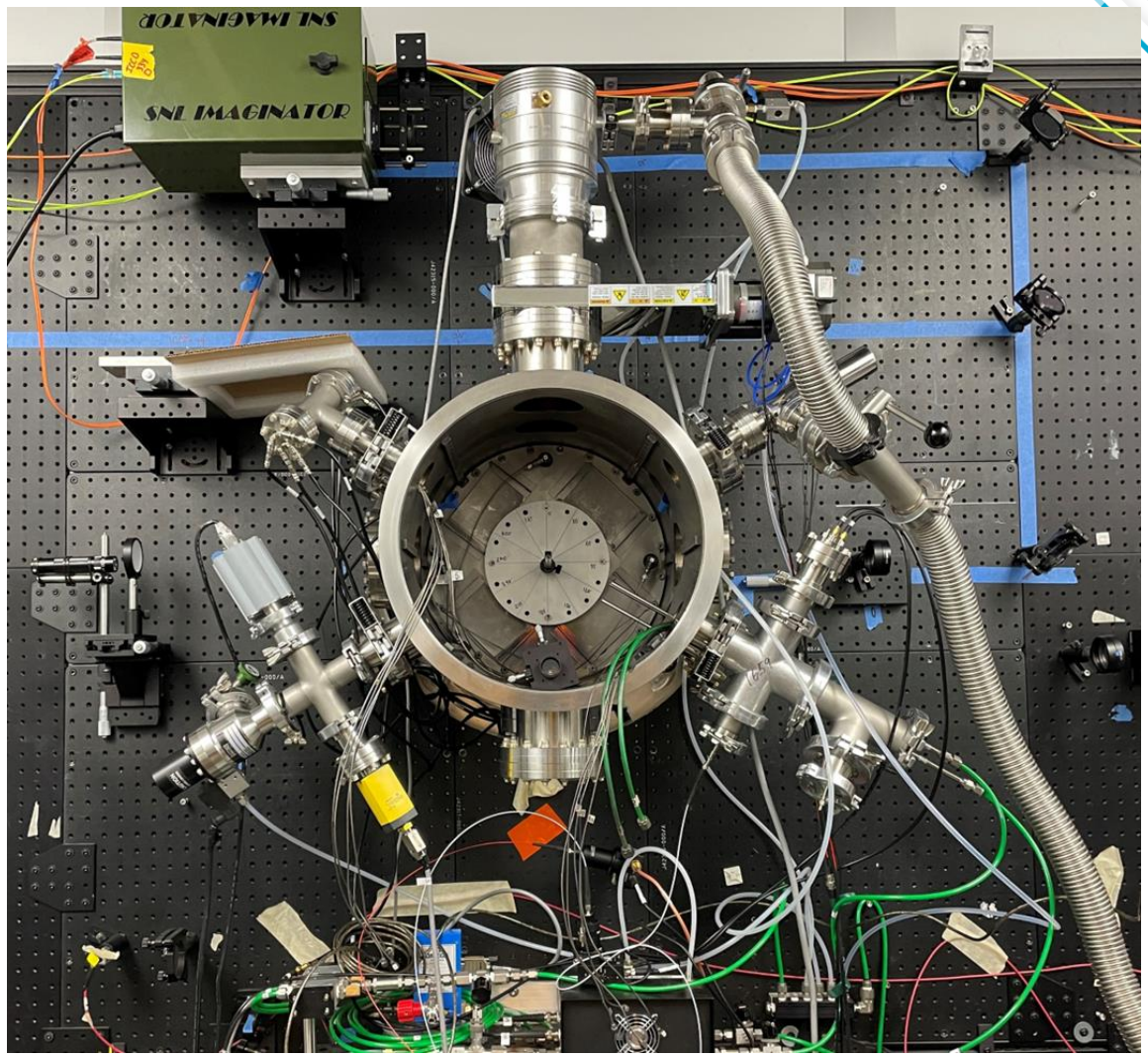
MYKONOS IS A FIVE CAVITY LTD PULSED POWER DRIVER

- Five LTD cavities (1.25 MA, 100 kV, 0.1 ohm) in series drive a water filled transmission line that linearly increases in impedance from 0.1 to 0.5 ohms.
- This is a rate of 1-3 shots/day, depending on load complexity.
- Mykonos is nominally 500 GW (1 MA, 500 kV) driver at 100 kV charge.
- Typically operated at: 0.85MA, 400kV at 80kV charge

[1] M. G. Mazarakis et al., "High-Current Linear Transformer Driver Development at Sandia National Laboratories," in IEEE Transactions on Plasma Science, vol. 38, no. 4, pp. 704-713, April 2010, doi: 10.1109/TPS.2009.2035318.

THE TARGET AREA PROVIDES A MULTITUDE OF DIAGNOSTICS

- Optical Diagnostics:
  - Four frame pulsed laser imaging system (0.5-ns pulsed laser, 5-ns frame width)
    - Shadowgraphy, Schlieren, Refractometry, Interferometry
  - ICCDs: 1ea. 4 frame, 2ea. Single frame (3-5ns exp.)
  - Long-distance Microscope assemblies (imaging of ~1mm phenomena)
  - Streaked Visible Spectroscopy (SVS)
  - Dispersion Interferometer (in commissioning phase)
  - Gated visible spectroscopy (1D spatial distribution)
  - VUV spectroscopic system (in progress)
- X-ray Diagnostics: Ultra-fast x-ray imager (UXI) and x-ray diodes
- Current and Magnetic Field sensors



MYKONOS PERFORMS ABOUT 250 SHOTS/YEAR FOR INTERNAL RESEARCH, ONGOING PROGRAM ACTIVITIES, AND NNSA MILESTONES

- In this presentation we will highlight four areas:
  - Studies of power flow and plasma cleaning
  - Optical diagnostic development for low density plasma measurement
  - Auto-magnetized liners for MagLIF fusion concept
  - Fundamental studies of the Electrothermal Instability (ETI)

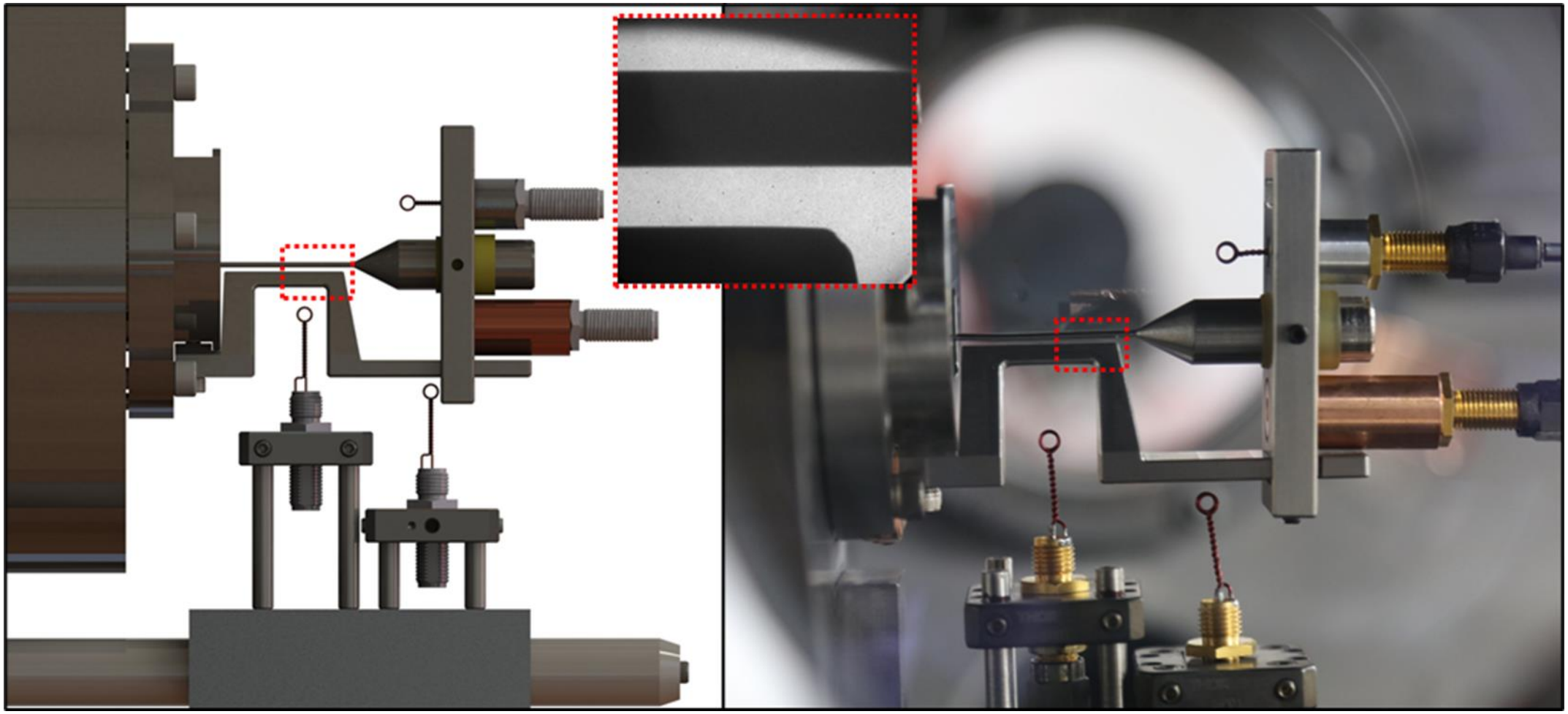
THE UNIVERSITY of NEW MEXICO

UC San Diego

UNIVERSITY OF MICHIGAN

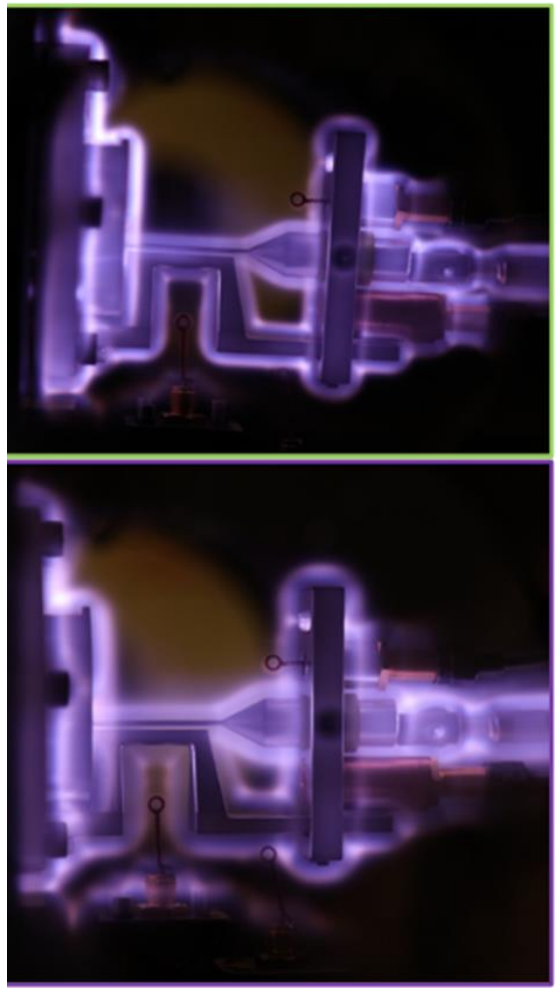
Imperial College London

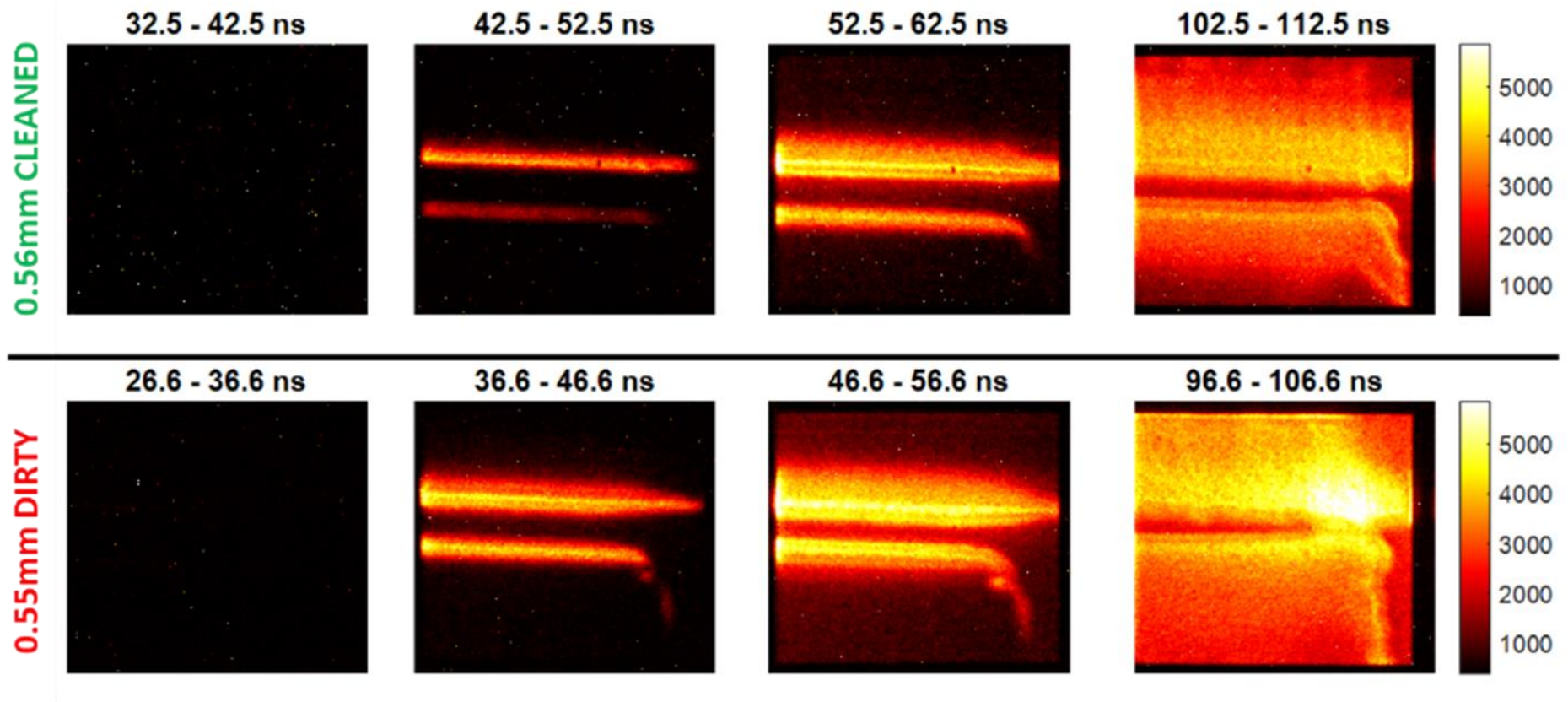
PARALLEL PLATE MITL ENABLES PLASMA EVOLUTION STUDIES AT LINEAL CURRENT DENSITIES SIMILAR TO Z



Side-view of an 0.5mm AK spacing, 2.1 MA/cm experiment. **Inset is the backlit magnification-4 field of view**, for one ICCD; the cathode and the bend of the anode knee are visible. Power flows to the right in all images.

THE IN-SITU CLEANING PROCESS IS PERFORMED UNDER VACUUM BEFORE THE ACCELERATOR DOWNLINE SHOT

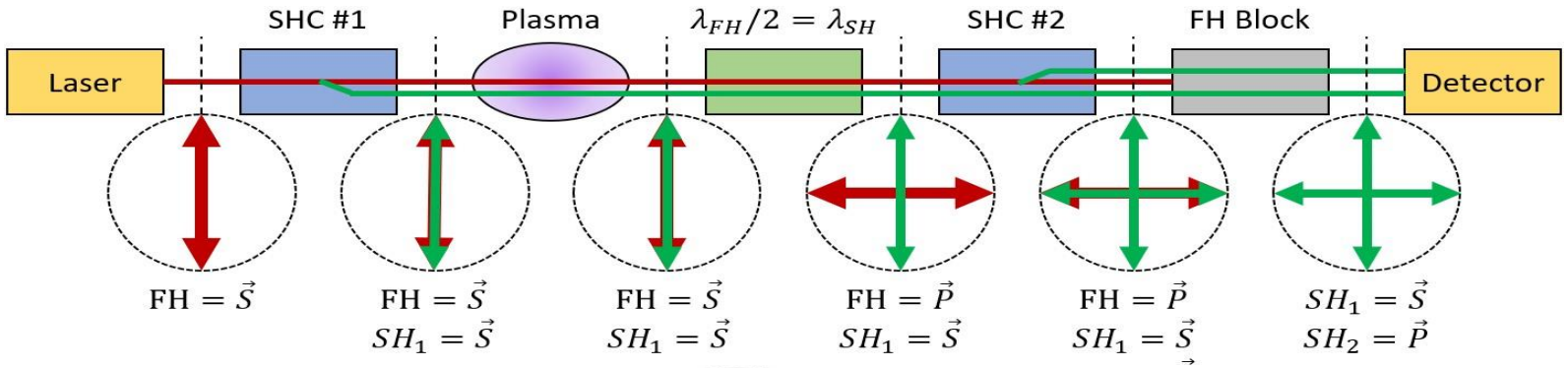


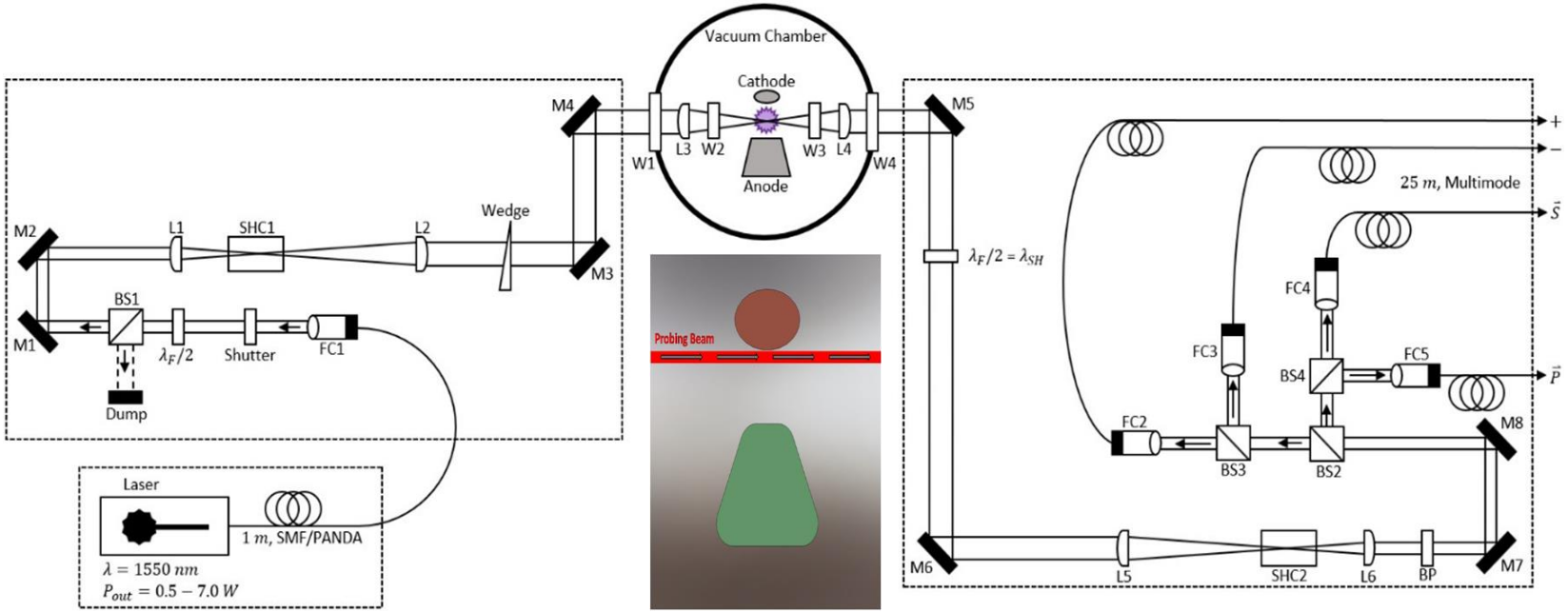


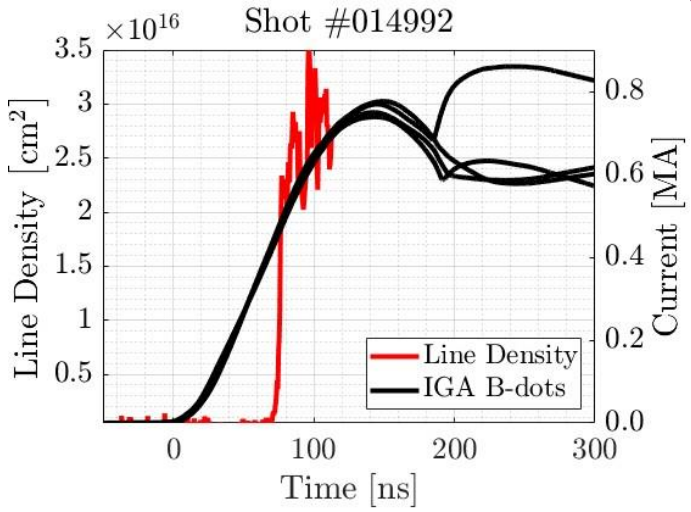
ICCD images show that in-situ plasma cleaning delays self emission and apparent gap closure by at least 15ns.

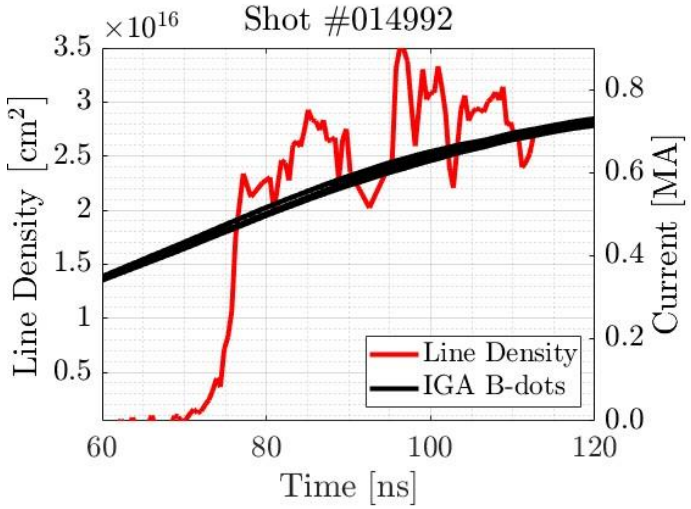
[2] Lamppa, Derek C., Simpson, Sean C., Hutsel, Brian T., Laity, George R., Cuneo, Michael E., & Rose, David V.. "Assessment of Electrode Contamination Mitigation at 0.5 MA Scale" https://doi.org/10.2172/1825219

A DISPERSION INTERFEROMETER HAS BEEN DEVELOPED FOR LOW ELECTRON DENSITY MEASUREMENTS IN POWER FLOW GAPS



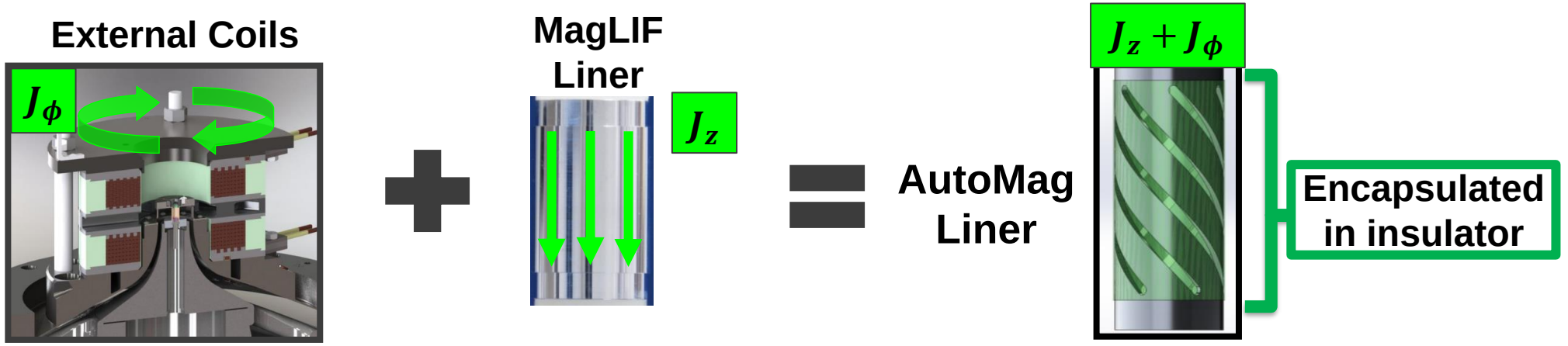






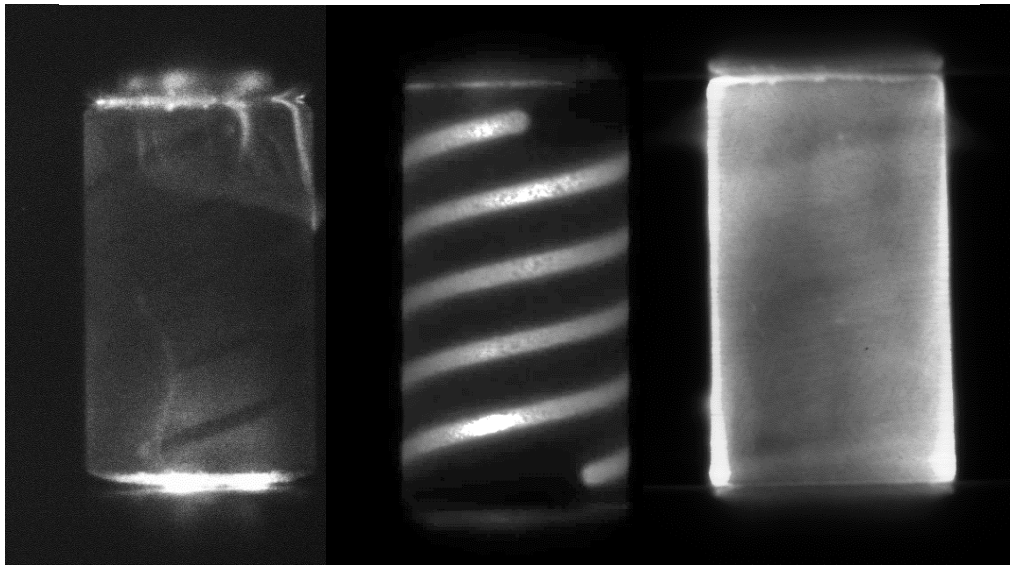
[3] N. R. Hines, S. Patel, D. Scoglietti, M. Gilmore, S. L. Billingsley, R. H. Dwyer, T. Awe, D. Armstrong, D. Bliss, G. Laity, M. Cuneo; A fiber-coupled dispersion interferometer for density measurements of pulsed power transmission line electron sheaths on Sandia's Z machine. *Rev. Sci. Instrum.* 2022; 93 (11): 113505.

EXPERIMENTS ON MYKONOS STUDIED AUTO-MAGNETIZATION AND DIELECTRIC BREAKDOWN



- Measured internal B_Z>90T
- Internal B-field depends on pitch angle
- Reduction scan of helical gaps to enhance induced electric field strength and promote earlier breakdown

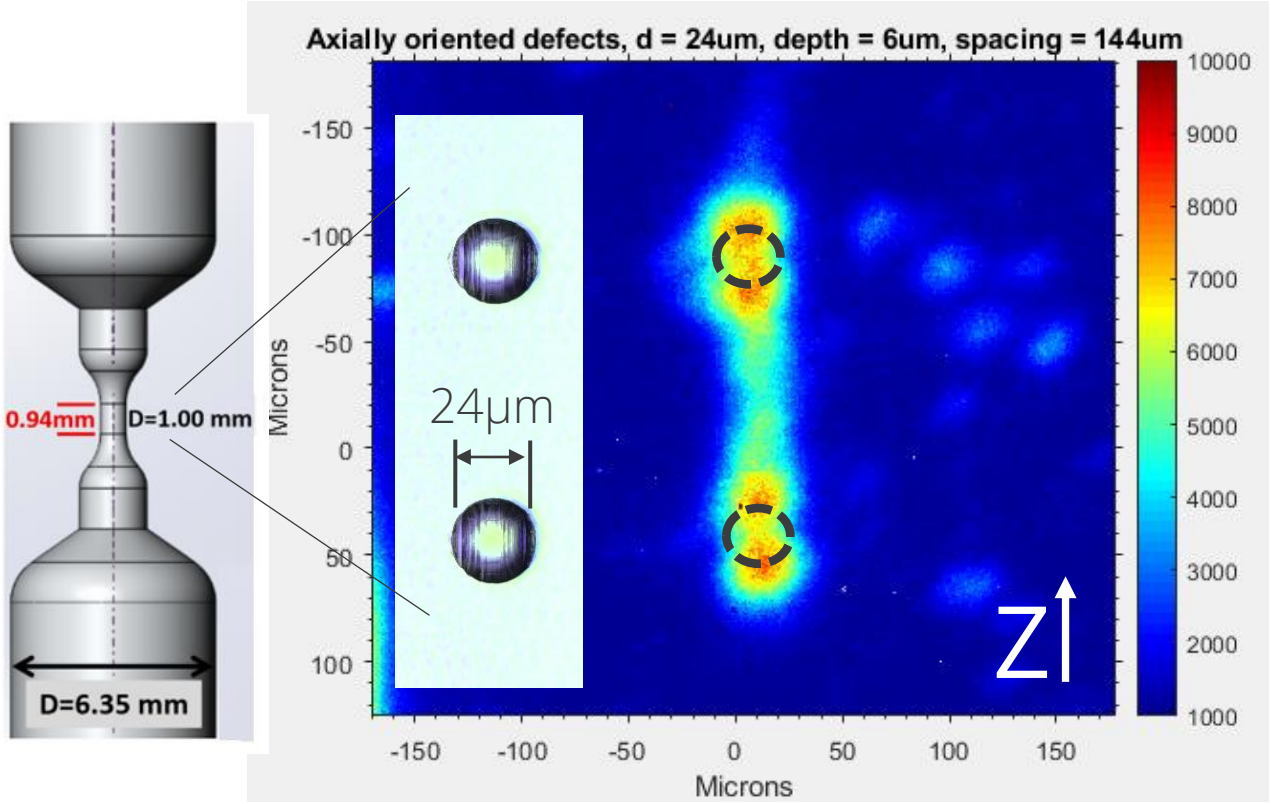
iCCD images of Mykonos experiments



[4] "Megagauss-level magnetic field production in cm-scale auto-magnetizing helical liners pulsed to 500 kA in 125 ns", G. A. Shipley, T. J. Awe, B. T. Hutsel, S. A. Slutz, D. C. Lamppa, J. B. Greenly, T. M. Hutchinson, Physics of Plasmas 25, 052703 (2018)
[5] "Implosion of auto-magnetizing helical liners on the Z facility", G. A. Shipley, T. J. Awe, B. T. Hutsel, J. B. Greenly, C. A. Jennings, S. A. Slutz, Physics of Plasmas 26, 052705 (2019)

ELECTROTHERMAL INSTABILITY (ETI) PLATFORM WAS DEVELOPED TO STUDY NON-UNIFORM HEATING FROM OHMICALLY HEATED METAL

- Instability growth and plasma formation on conductors could limit performance, decreasing transmitted energy efficiencies
- These growths may degrade efficacy of applications such as ICF, high pressure dynamic material properties experiments, and radiation effects science platforms
- Performed detailed studies on how engineered defects grow based on size, depth, distance to nearest neighbor, coated vs. uncoated sample, etc.
- Some results:
  - μm scale voids seed local overheating
  - Defect pairs exhibit collective behavior



[6] M. W. Hatch, T. J. Awe, E. P. Yu, B. T. Hutsel, and M. Gilmore, “2D and 3D surface perturbations effects on plasma formation on high-current-density-conductors”, for submission to Phys. Plasmas Nov. 17, 2023.

MAAP HAS PARTNERED WITH ZNETUS FOR SHOTS IN CY25

- We have joint the ZNetUS network to provide academic access to Mykonos for two four week campaigns in calendar year 2025.
- Each PI will partner with a senior scientist at Sandia for shot planning and execution.
- In partnership with the PI, Sandia will design and fabricate the targets.
- We are looking forward to hearing from you and welcoming you at our facility in 2025!
- ZNetUS contact for Sandia Labs: Jens Schwarz: jschwar@sandia.gov