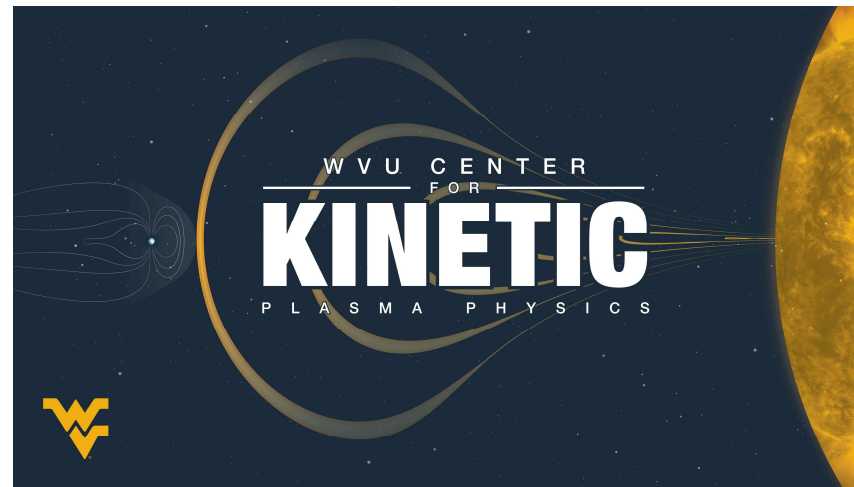


HELICON PLASMAS AND 3D THOMSON SCATTERING AT WEST VIRGINIA UNIVERSITY

Jacob E.A. Lord

Contributors: Sonu Yadav, Earl E. Scime, Peiyun Shi, Katey Stevenson
*West Virginia University Department of Physics and Astronomy
Center for KINETIC Plasma Physics*

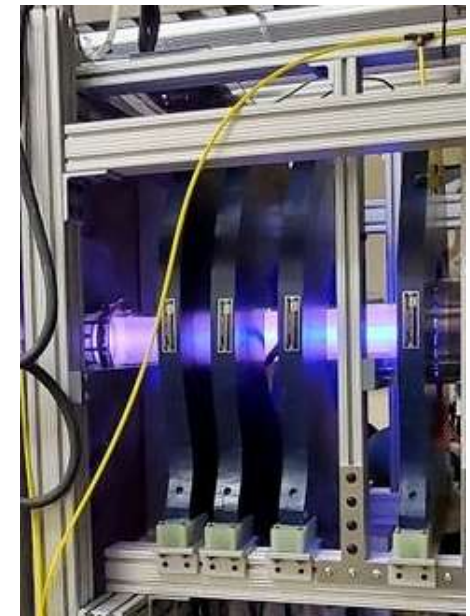
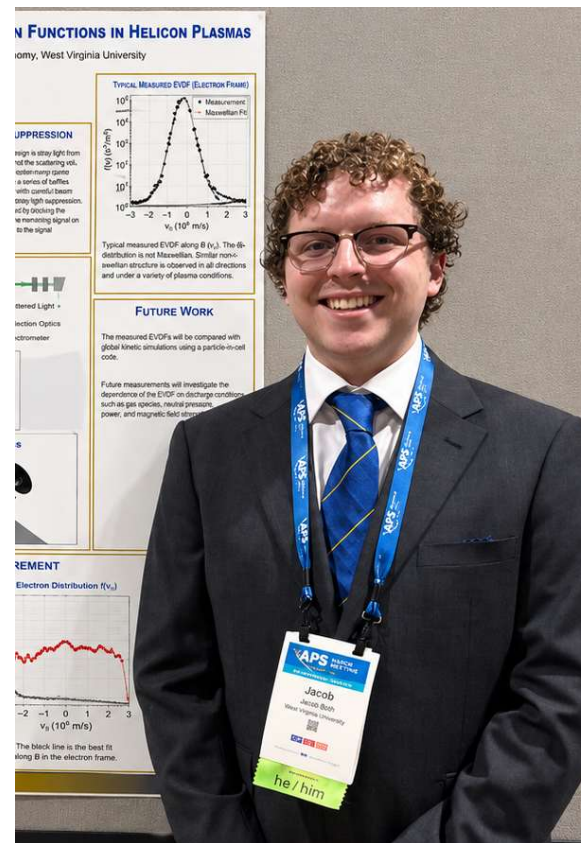


NORDITA Workshop
May 2026

Work supported by

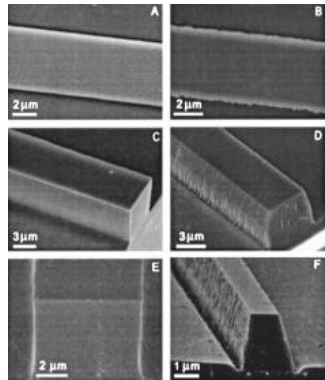
Research Overview

- Working on Experimental Space Plasma Physics under Professor Earl Scime
- A broad specialty of our lab is non-invasive plasma diagnostics
- My research Focus is on 3D Thomson Scattering in Phase Space using the PHASE Space MAPPING Experiment (PHASMA)
- Current project focusing on Electron Heating via wave particle interactions in Helicon Plasmas
- Future goals are to apply expertise in Thomson Scattering to Plasma diagnostics in Nuclear Fusion

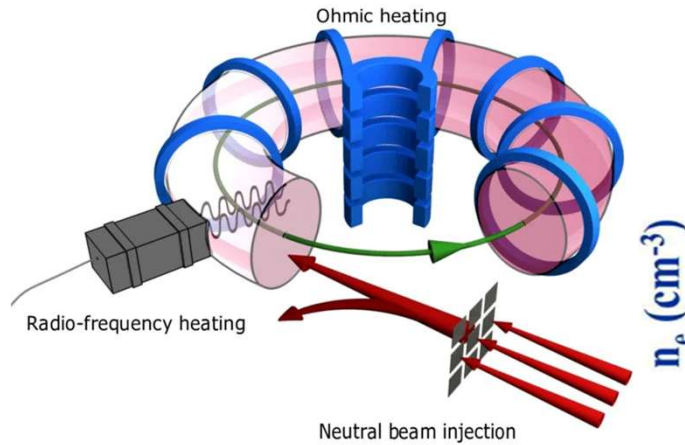


PHASMA running a Helicon Plasma in Argon

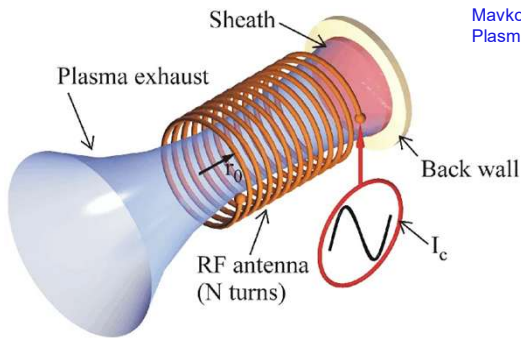
Overview of Helicon Plasmas and some Synergies



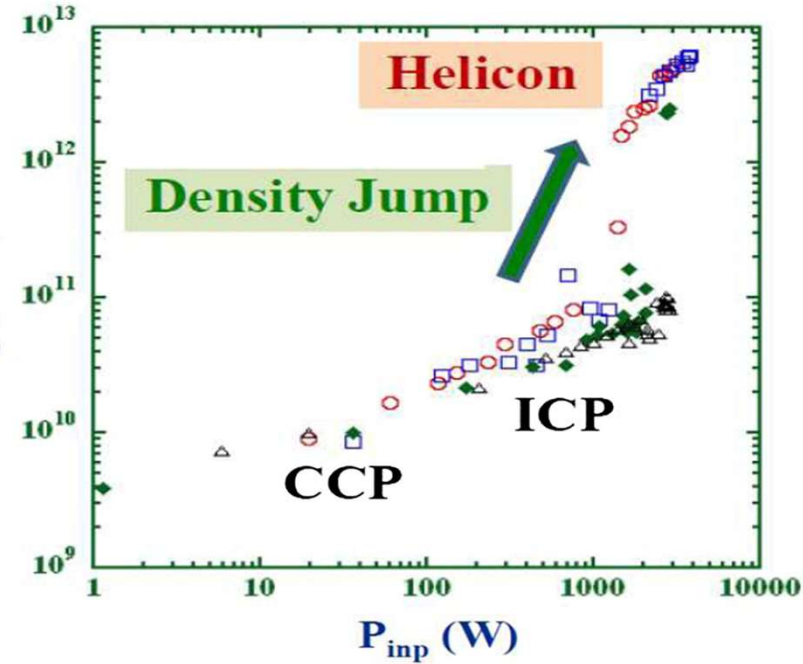
Helicon Plasma Etching of Silica:
 W. T. Li, D. A. P. Bulla, J. Love, B. Luther-Davies, C. Charles, R. Boswell; Deep dry-etch of silica in a helicon plasma etcher for optical waveguide fabrication. *J. Vac. Sci. Technol. A* 1 January 2005; 23 (1): 146–150. <https://doi.org/10.1116/1.1842114> .



Heating systems of Tokamak
 Mavkov, Bojan. (2017). Control of Coupled Transport in Tokamak Plasmas.



Helicon Plasma Thruster
 Ref: Bathgate, Stephen & Bilek, Marcela & Mckenzie, David. (2017). Electroless plasma thrusters for spacecraft: A review. *Plasma Science and Technology*. 19. 083001. 10.1088/2058-6272/aa71fe



Ref: Shinohara, S. "Helicon high-density plasma sources: physics and applications," *Advances in Physics* 3 1 (2018).

Thomson Scattering in 3D Phase Space on PHASMA

Incoherent vs Coherent Thomson Scattering

Shi, P., Multi Dimensional Incoherent Thomson Scattering Diagnostic System in PHASMA (2023), Internal Report, PL -061

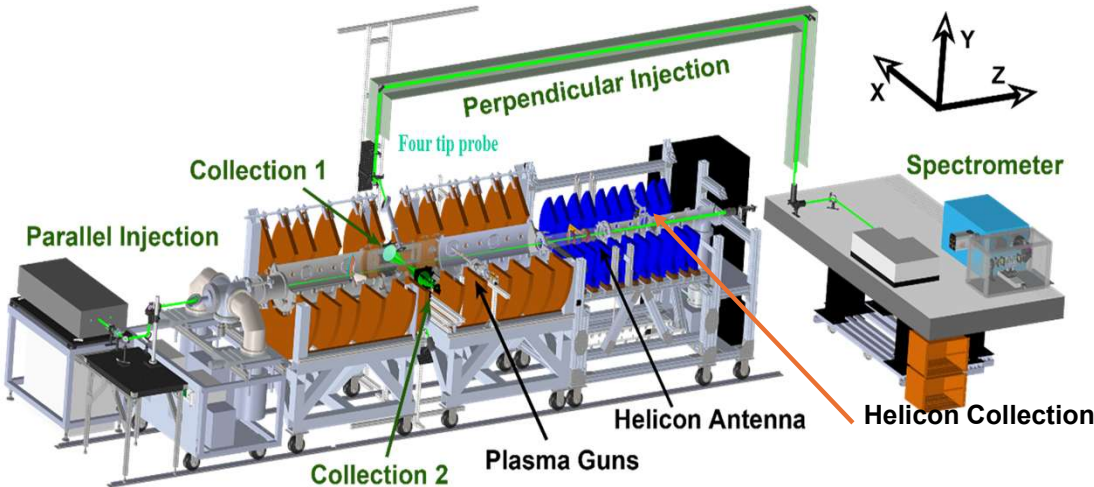
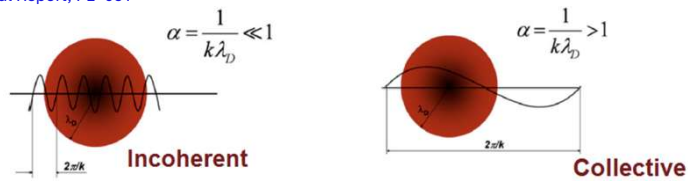
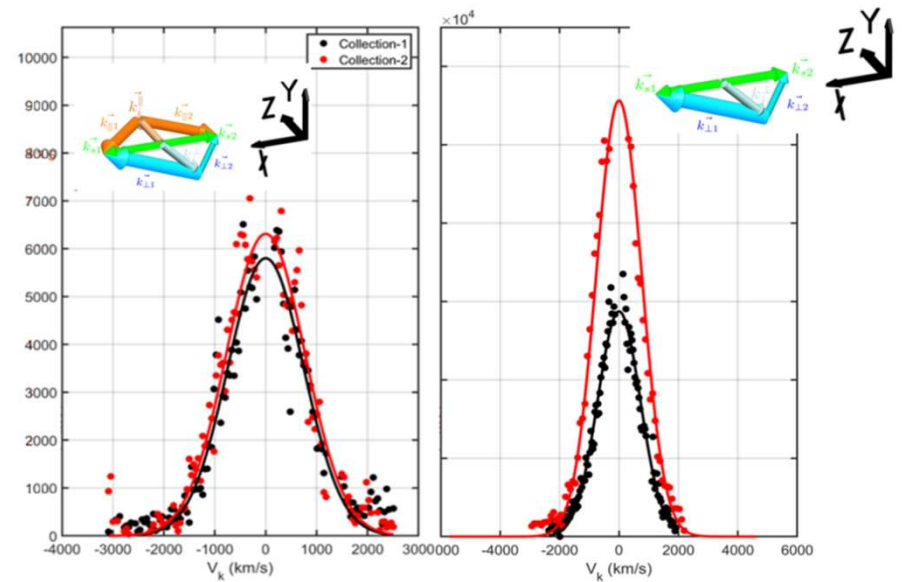


Image: CAD model of PHASMA showcasing 3D TS

Peiyun Shi, Earl E. Scime; Multi-dimensional incoherent Thomson scattering system in PHase Space MApping (PHASMA) facility. Rev. Sci. Instrum. 1 February 2023; 94 (2): 023501. <https://doi.org/10.1063/5.0133665>

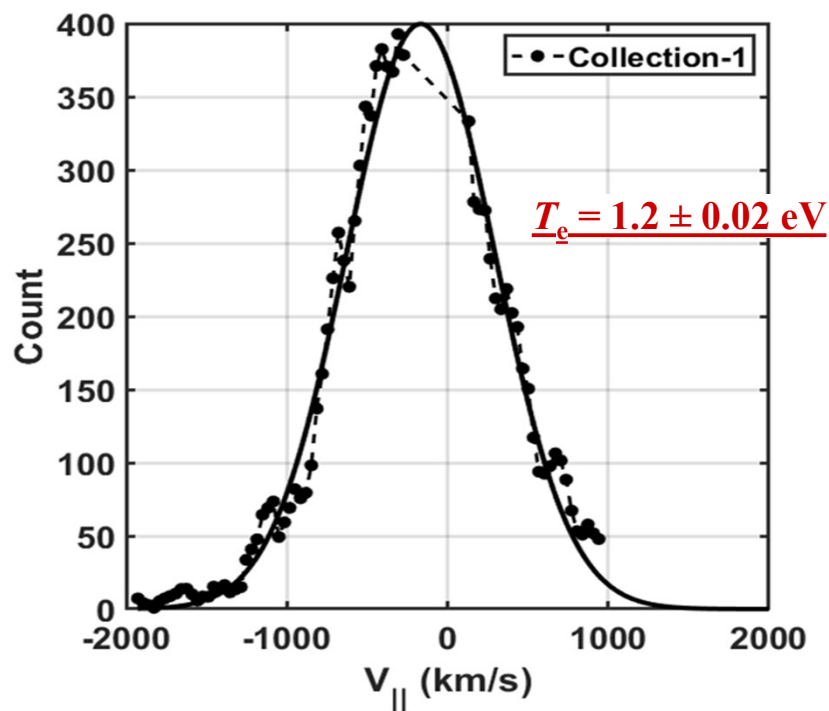
Parallel EVDF

Perpendicular EVDF

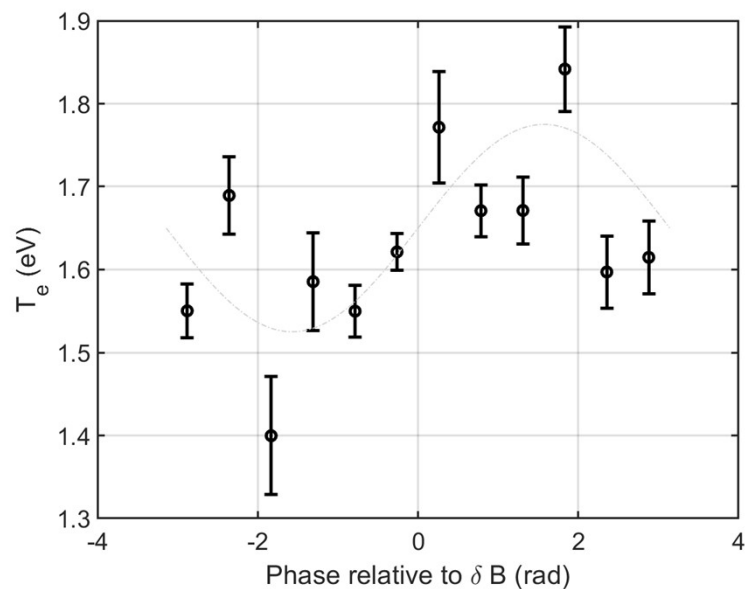


Ref: Earl E. Scime; Exploration of Kinetic Plasma Physics Through in-situ Phase-space Measurements in Laboratory Plasmas*. Plenary Talk for APS DPP 2025

Electron Heating of Helicon Plasmas



Preliminary measurements in blue core of helicon for:
 RF power = 1000W
 Magnetic field: 1000 G
 Pressure: 3.5×10^{-3} Torr



Preliminary phase sorted Parallel T_e data

Courtesy of Peiyun Shi circa August 2024

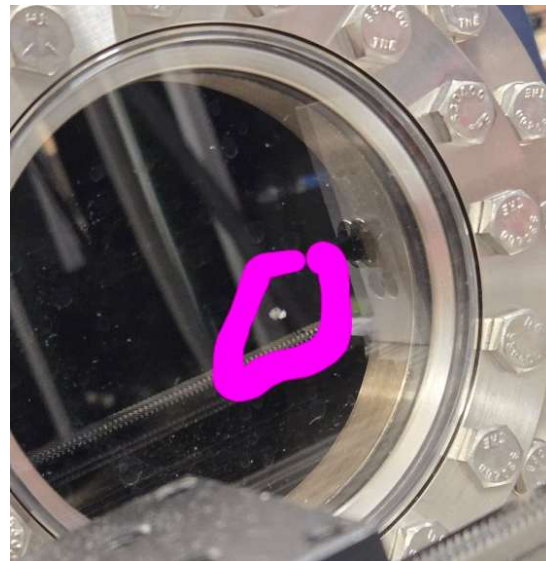
Slide 5

- GU1** Here can be a good place to relate your research to the kinetic physics of electro heating. Talk about your phase-angle-resolved TS measurements. You can cite previous measurements.
Guest User, 2026-05-22T19:06:27.351
- JL1 0** Sounds good. Previous measurements in our lab might be still just what you did I think. Unfortunately we've had some difficulty and yet to take data for phase resolved TS
Jacob Lord, 2026-05-22T19:12:49.517
- JL1 1** I could also refer to some of the phase resolved work by Jim Schroeder from "Laboratory measurements of the physics of auroral electron acceleration by Alfvén waves" <https://doi.org/10.1038/s41467-021-23377-5>
Jacob Lord, 2026-05-22T19:14:47.051

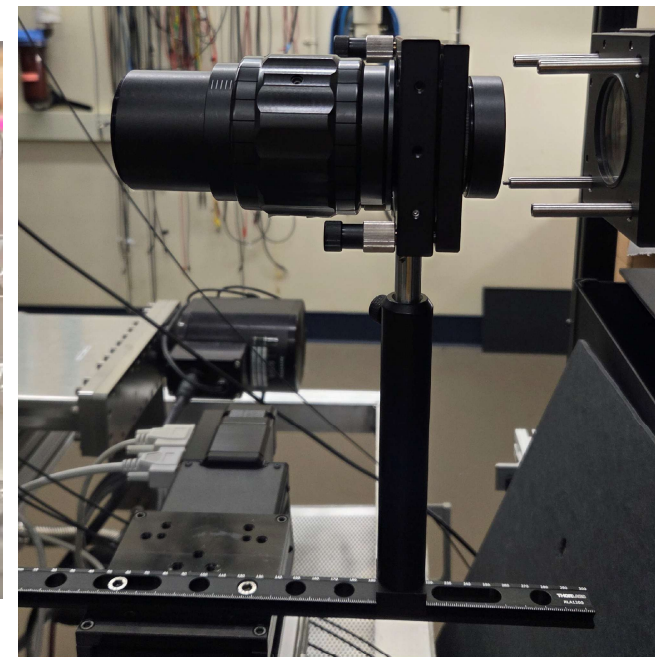
Setbacks

In short, big lasers can mean big problems

Why have I not brought fully
Phase resolved data with me?



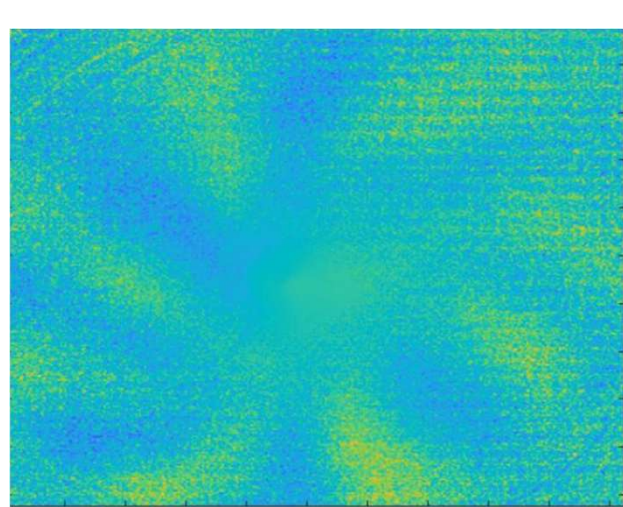
Hole drilled through UHV window



Injection Beam Expander

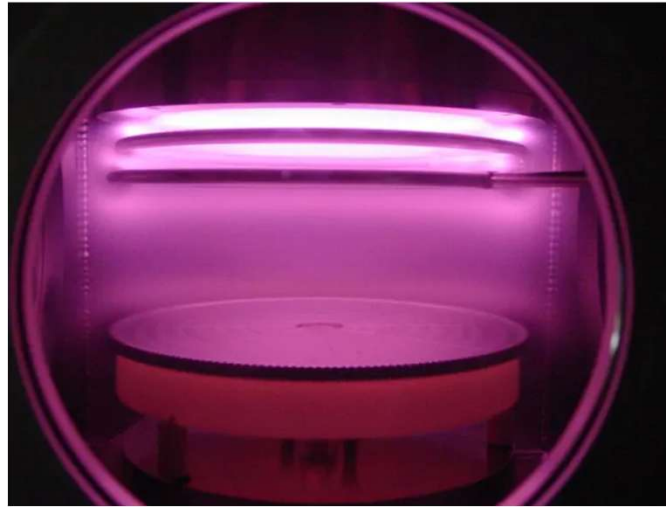
Significance to Plasma Community – Details of Synergies

Why must we keep track of electrons?



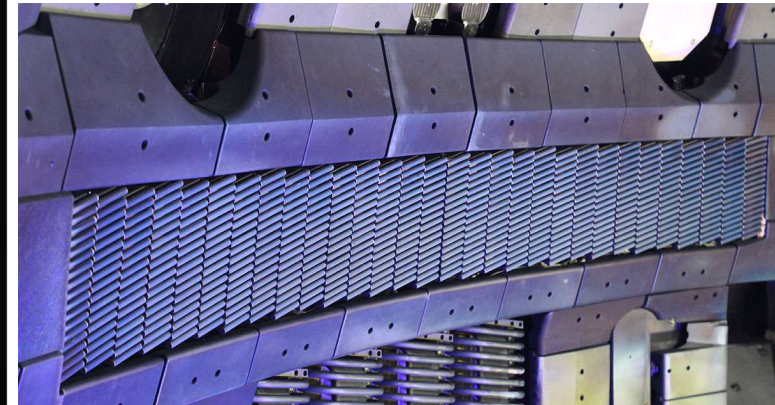
[Helicon Plasma density variations found via Proper Orthogonal Decomposition](#)

Ref: Bartolo, Gustavo E, et al. "Power Spectral Density Measurements of Turbulent Plasma and Flux Rope Merger with Fast Camera." 66th Annual Meeting of the APS Division of Plasma Physics, 2024, meetings-archive.aps.org/dpp/2024/np12/85/.



[Plasma Processing Chamber](#)

Ref: Lobo, Nadia. "Radio Frequency Power: Driving Modern Plasma Technologies." *Impedans*, 2 Aug. 2024, www.impedans.com/radio-frequency-power-driving-modern-plasma-technologies/.



[Helicon antenna on DIII-D](#)

Johal, Zabrina. "DIII-D Scientists at GA Develop New System to Improve Production of Fusion Energy." *General Atomics*, 23 Aug. 2021, www.ga.com/diii-d-scientists-at-ga-develop-new-system-to-improve-production-of-fusion-energy.

THANK YOU! – WORK MADE POSSIBLE THANKS TO THE FOLLOWING 8



The PHASMA Team: Gustavo Elias Bartolo, Tyler Blizzard, Dash Collier, Daniel Curtis, Vikram Dharodi, Erick Diaz, Mikal Dufor, Chloelle Fitz, Krishan Kumar, Jacob Lord, Greg Lusk, Ashley Marsico, Jacob McLaughlin, Makesi Pantor, Thomas Rood, Sam Stalnaker, Katey Stevenson, Ethan Thompson, and Sonu Yadav
Lab link: <https://sites.google.com/view/scimeresearchgroup/home?authuser=0>

& The Extended PHASMA Family (An Incomplete List)

Dr. Peiyun Shi – PPPL
Cuyler Beatty - LLNL
Dr. Mahmud Hasan Barbhuiya – Clemson U.
Dr. Paul Cassak – Clemson U.
Dr. David Caron – Coors
Dr. Tyler Gilbert – U. Wash
Dr. Tim Good – Gettysburg College
Miguel Henriquez – Aerospace Corp.
Dr. Greg Howes - U. of Iowa
Dr. Regis John – U. of Iowa
Jordan Lazo
Luke Neal – U. of Waterloo
Dr. John McKee – Micron
Michael Moran
Dr. Ripudaman Singh Nirwan – U. Wash
Dr. Mitch Paul – Riverside Research
Ethan Scime – AndyMark Inc.
Dr. Greg Severn – U. of San Diego
Dr. Fred Skiff – U. of Iowa
Dr. Jim Schroeder – Wheaton College
Dr. Prabhakar Srivastava – IPR India
Dr. Thomas Steinberger – West Virginia U.
Dr. Derek Thompson - SpaceX
Dr. Glen Wurden – LANL
Dr. Jongsoo Yoo - PPPL



Questions?