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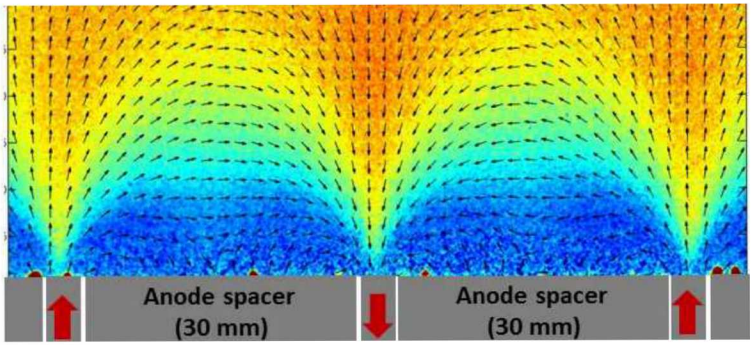
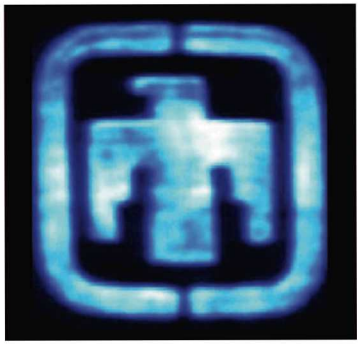
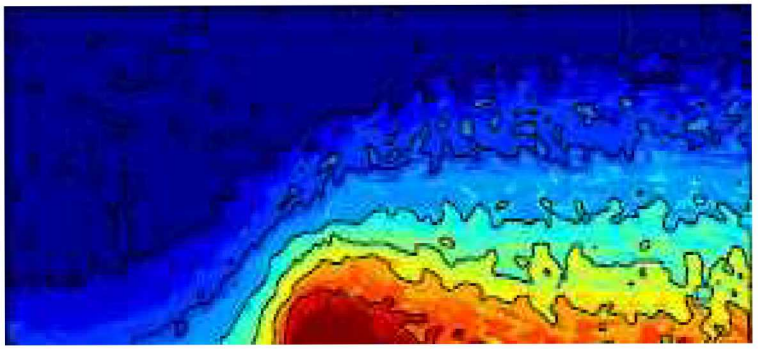






SANDIA COLLABORATIVE LOW TEMPERATURE PLASMA RESEARCH FACILITY (PRF)

73rd GEC

Friday October 9, 2020

Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Overview

Sandia National Laboratories

- The Sandia Low Temperature Plasma Research Facility (PRF)is a DOE FES funded effort to help facilitate low-temperature plasma science

  - Mission Statement:

To continually serve the low-temperature plasma community by providing it access to world-class capabilities and expertise to enable community members to further their research and to advance plasma science.

  - Approach:

Engage with potential collaborators to understand their mission and research goals and to help them identify, implement, and achieve solutions by providing access to the unique capabilities and expertise our Facility has to offer.

Key Personnel

- Ed Barnat (evbarna@sandia.gov)
  - Multi-dimensional interrogation of atomic species, electron densities and electric fields using linear and non-linear spectroscopies.
- Jonathan Frank (jhfrank@sandia.gov)
  - Imaging and gas-phase spectroscopy for high-speed, multi-dimensional measurements in plasmas and plasma-assisted reacting flows.
- Nils Hansen (nhansen@sandia.gov)
  - Interrogation of chemistries in reactive environments using high resolution mass spectroscopy.
- Matthew Hopkins (mmhopki@sandia.gov)
  - Computational modeling and simulation of non-equilibrium plasma phenomena.
- Christopher Kliewer (cjkliew@sandia.gov)
  - Ultrafast non-linear gas and surface phase spectroscopies.
- Benjamin Yee (btyee@sandia.gov)
  - Electrical and optical characterization.



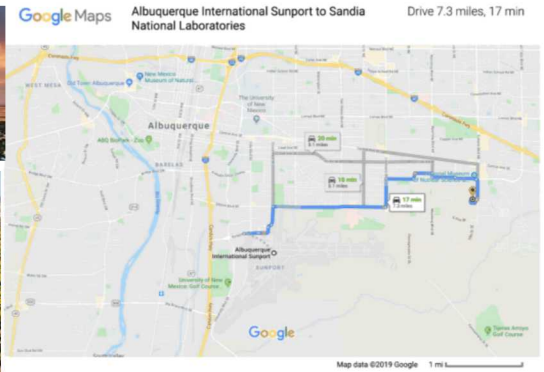



Our team offers a broad set of skills to serve the community.

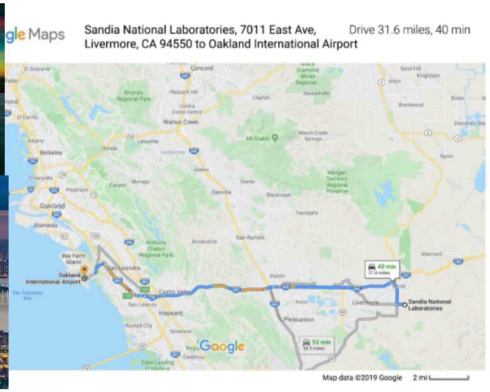
Access to the Facility

- Visitor infrastructure streamlining
  - Visitor badging, computer access, data sharing, safety documentation/training
    - Office space for visitors
    - Open network for visitors to access resources
  - Working from several existing examples of collaborator engagement at Sandia:
    - Previous Plasma Science Center (DOE FES funded)
    - Center for Integrated Nanoscience and Technology (CINT, DOE BES funded)
    - Combustion Research Facility (DOE BES funded)

Sandia New Mexico



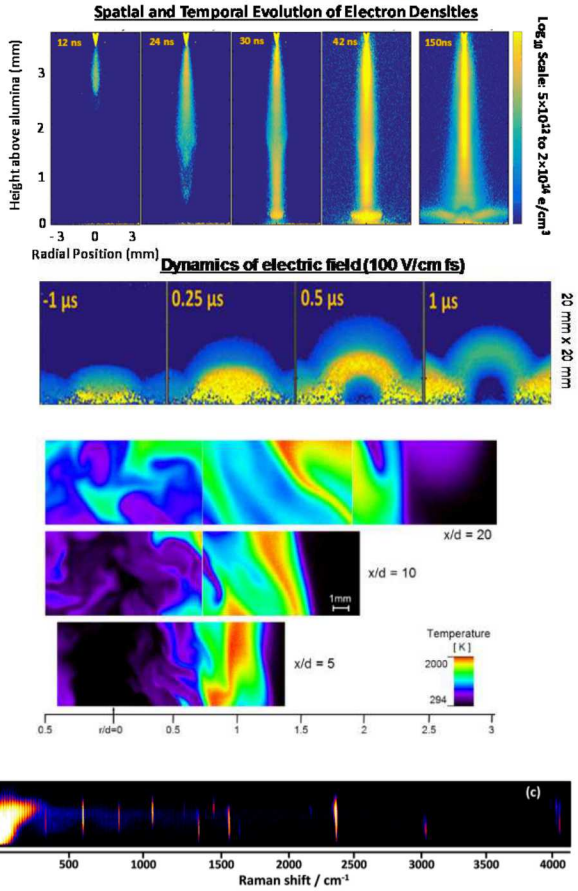
Sandia California

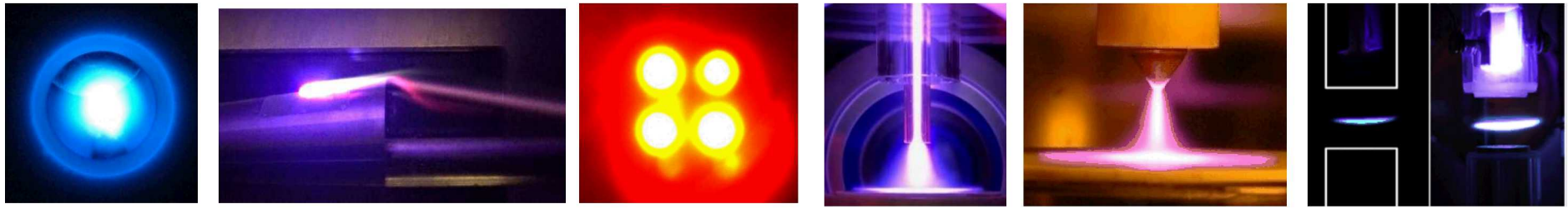


We will work with collaborators to ensure streamlined access to our sites

Differentiating Capabilities

- Multiple femtosecond, picosecond, nanosecond and CW lasers spanning < 190 nm and exceeding 10 μm for interrogating dynamic plasma and reactive environments.
  - LCIF for electron densities and LIF-Dip for electric fields.
  - 2D-CARS and SFG for gas and surface phase interrogation
  - Multi-pulse (10 kHz to 100 kHz) laser cluster for high speed LIF and Rayleigh
- High speed imaging capabilities from <200 ps gated cameras, multi-frame framing cameras and high-speed CMOS cameras.
- VUV and FTIR spectrometers for spectroscopy.
- High resolution tandem and molecular beam mass spectroscopy for interrogating gas phase chemistries occurring in multi-atmosphere environments.
- Broad range of plasma generating capabilities spanning vacuum to atmospheric pressures and beyond.



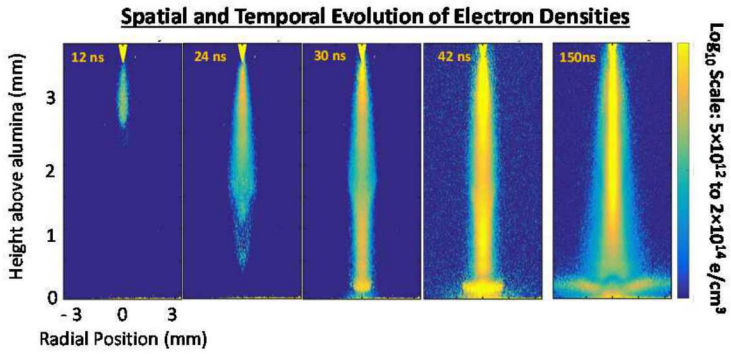


We offer extensive set of capabilities to address many challenges.

Employment of Capabilities

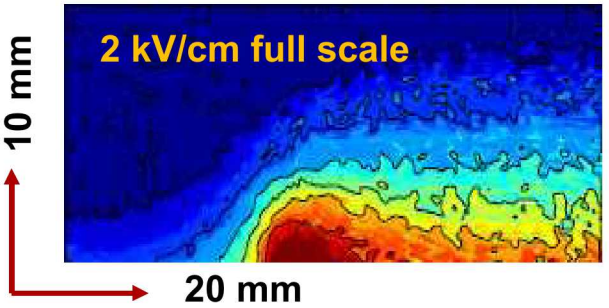
Sandia National Laboratories

Electron Properties
Thomson scattering
Laser-collision induced fluorescence (LCIF)
Microwave interferometry and resonant cavities
Langmuir probes and emissive probes



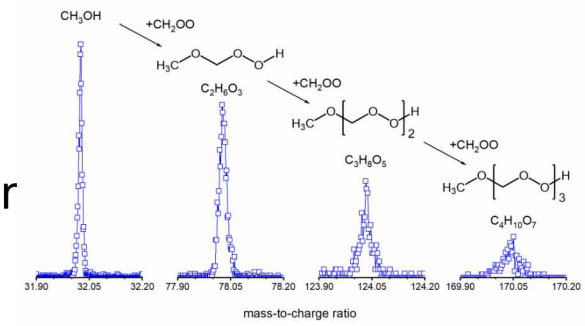
Electron densities measured by LCIF

Electric and Magnetic Fields
Electric field induced second harmonic (E-FISH) generation
Laser-induced fluorescence dip spectroscopy (LIF-dip)
RF Free field probes (D-dot, B-dot)



Electron fields measured by LIF-Dip

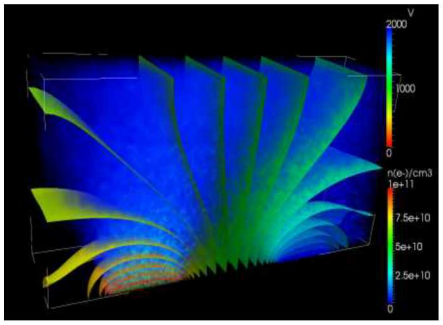
Molecular/Atomic Composition
Molecular beam mass spectrometry
Tandem mass spectrometry
Laser-induced breakdown spectroscopy (LIBS)
Surface sensitive sum frequency generation (SFG)
Surface sensitive polarization modulated reflection absorptior

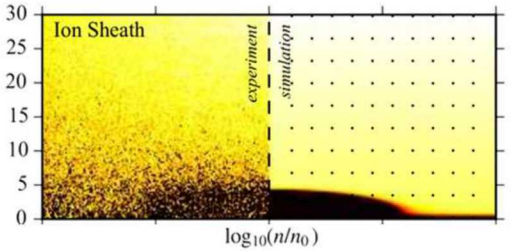


High-resolution mass spectroscopy

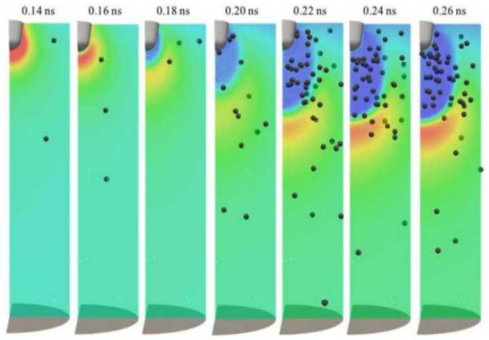
Theoretical/Computational LTP Capabilities

- Aleph and EMPIRE
  - Massively parallel LTP simulation capability employing PIC-DSMC methods, extensive chemistry (excitation, ionization, recombination), and photonic processes.
  - Extensively employed discharges in vacuum, low pressure, atmospheric pressure, and higher.
  - Current development interests are in surface material models and managing complex chemistry (e.g., collisional air).
  - EMPIRE is next generation capability under development, with electromagnetics and heterogeneous architecture support (e.g., GPUs).
- Aria is a multiphase fluid simulation capability being extended to highly collisional plasmas.





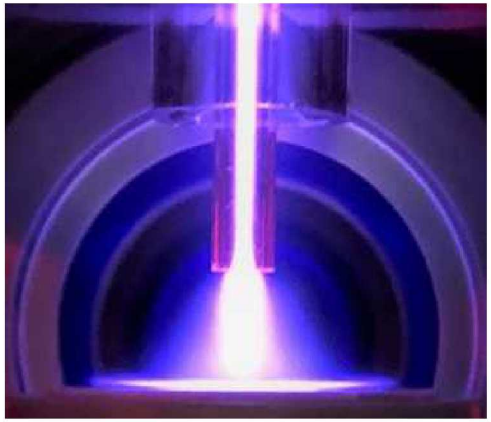
Ion densities for plasma-anode system



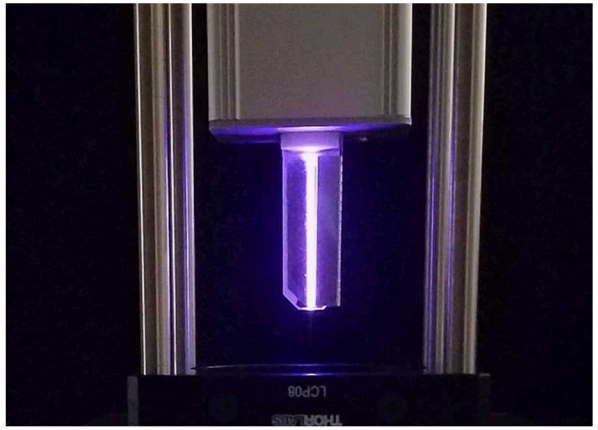
Examples of Interactions

- 2D Measurements Electron densities in Helium Jets
- 2D Measurements Atomic Oxygen Densities near interface
- Simulations on sheath Stability

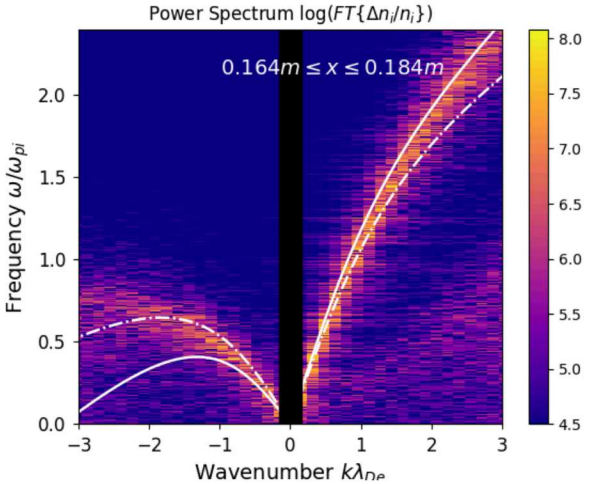
Humid Jet



APPJ



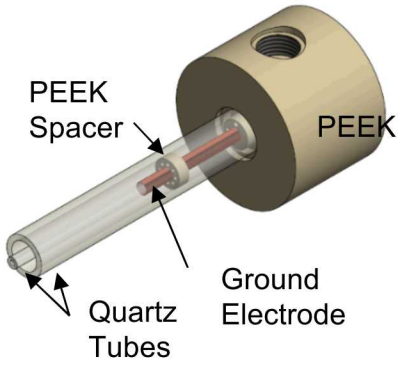
Ion Sheaths



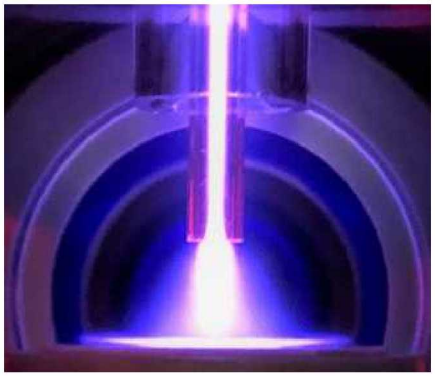
Electron Densities in humid jet

- Hosted Amanda Lietz, Ph.D. Student w/ Mark Kushner.
- Goals centered on measuring jet to benchmark simulations:
  - Utilize laser-collision induced fluorescence to map electron densities.
  - Provide dynamic n_e measurements for comparison with modeling of APPJs.

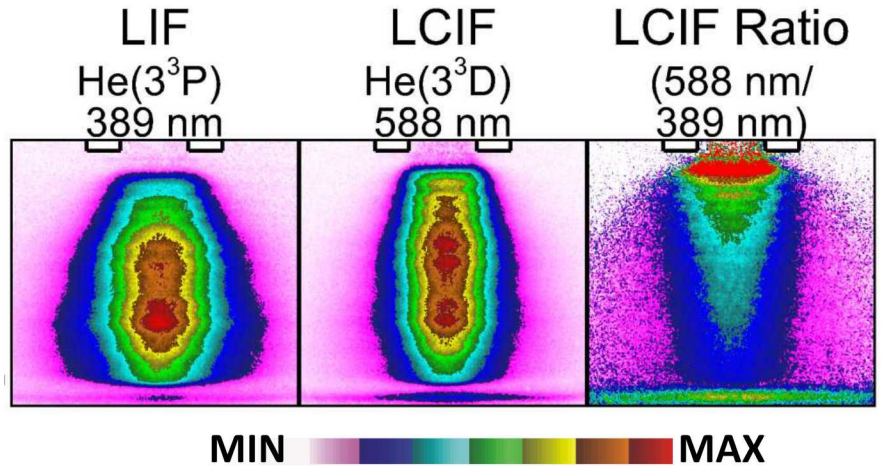
Concept



Implementation



Representitive results

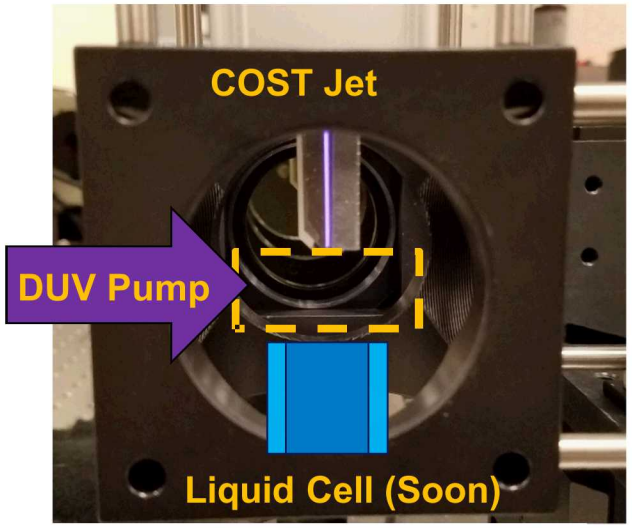


Laser-Collision induced fluorescence provided 2D map of electron densities

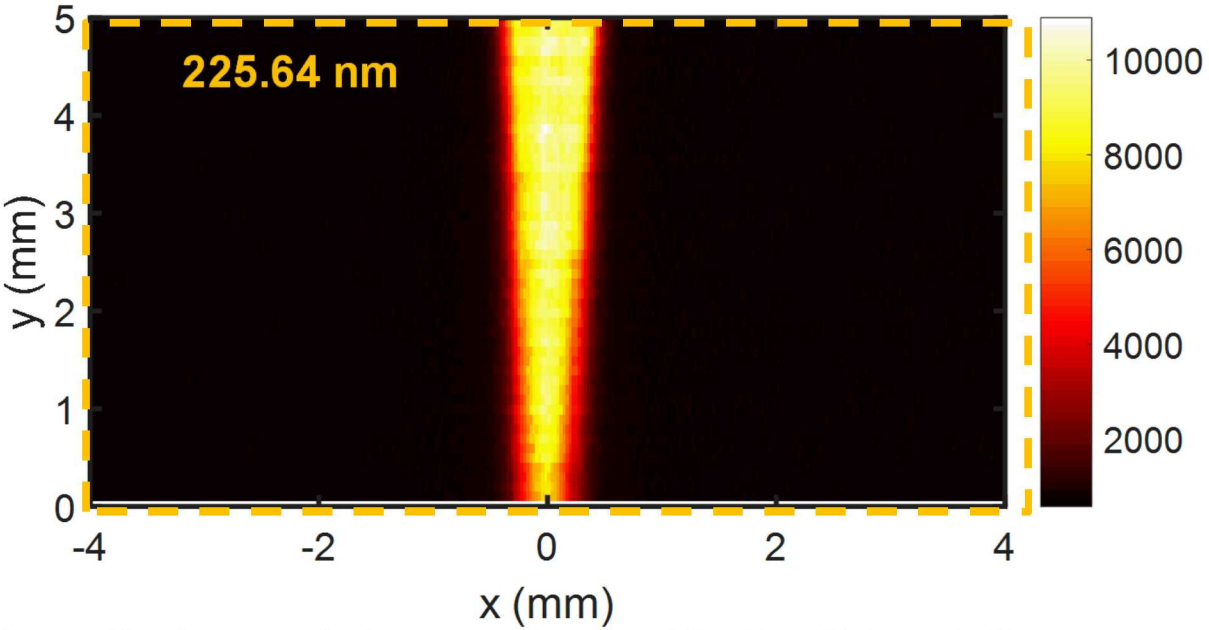
Atomic oxygen near liquid interface

- Hosting Brayden Myers, Ph. D. Student at North Carolina State University Studying with Katharina Stapelmann.
- Goal: Map atomic oxygen densities in APPJ as jet impinges liquid interface.
  - Project is in early stages, more results soon!

Setup



2D TALIF Signal from Atoic Oxygen

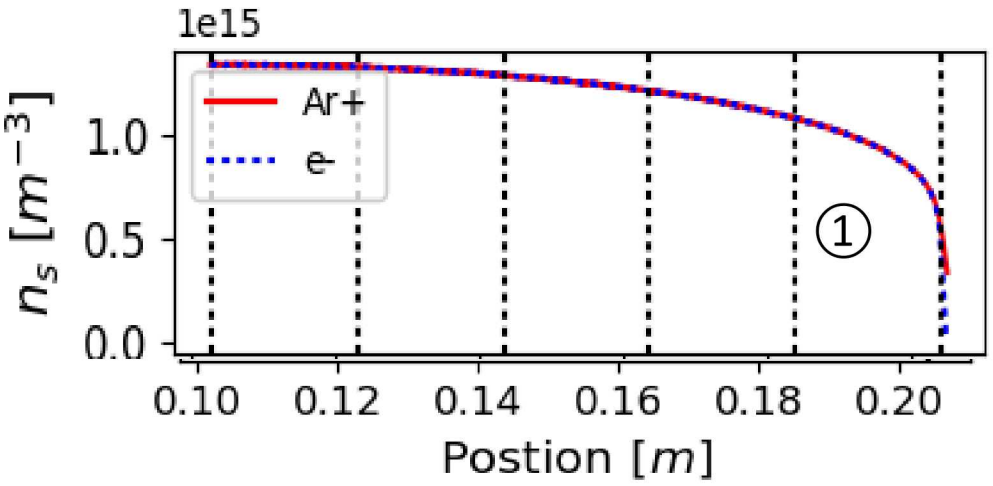


Implementation and preliminary data acquired with flexible platform

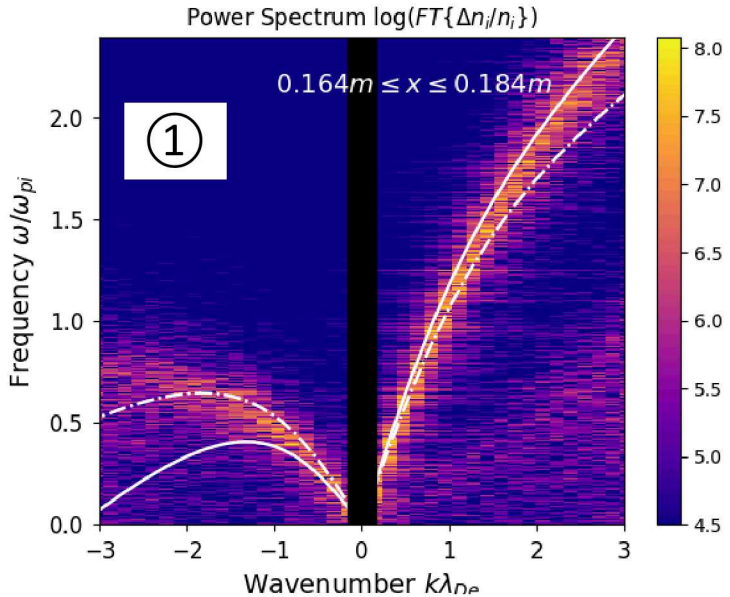
Simulations of Sheath Stability

- "Hosting" Lucas Beving (virtually), PH. D. Student at U. Iowa studying with Scott Baalrud
  - Using fully kinetic, 3D code to test and understand stability of presheaths that form at plasma boundary

Simulated Sheath Structures



Presheath Ion-acoustic waves

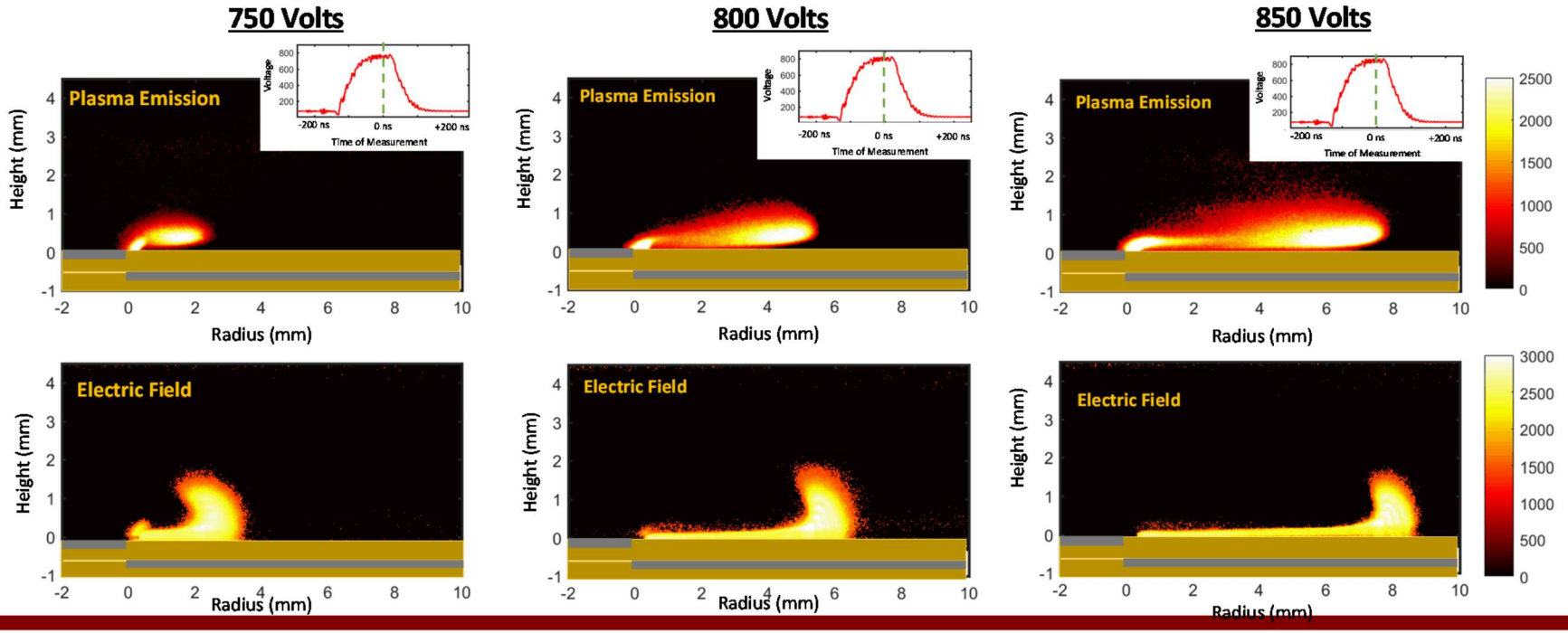


High performance computing tools enable access to richer phenomena

Establishing new capabilities

- Part of our mission is to execute internal research to help further PRF goals
  - Developing apparatus for in-situ diagnostics for in operando plasma-assisted catalysis (J. Frank)
  - Developing LIF-Dip for two-dimensional mapping of electric fields in collisional environments

Electric fields around surface ionization wave



Call For Proposals Open Soon

- Sandia National Laboratories and Princeton Plasma physics Labs have set schedule for user proposal solicitation and review
  - Open call for proposals: November 2, 2020
  - Close call for proposals: December 11, 2020
  - External Review: December 15, 2020-January 15, 2021
  - Internal Down select: January 22,2021
  - Report to DOE: January 29, 2021
- We strongly encourage engagement with our team prior to these calls
  - Better understand your questions.
  - Better match team members to achieve your goals.

How to Engage Our Team

- Website for more information:
  - http://wwwd.sandia.gov/prf
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  - Better understand your questions.
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- For more information please contact:

Dr. Edward V. Barnat (Lead PI)
evbarna@sandia.gov
Sandia National Laboratories
Applied Optical and Plasma Sciences
Phone: (505) 284-9828
Fax: (505) 844-5459

Thank you for your interest!

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Mission Statement and Approach

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