Study of a High-Power, Magnetized Plasma Jet with a Magnetic Probe Array and High Frequency Wave Probe

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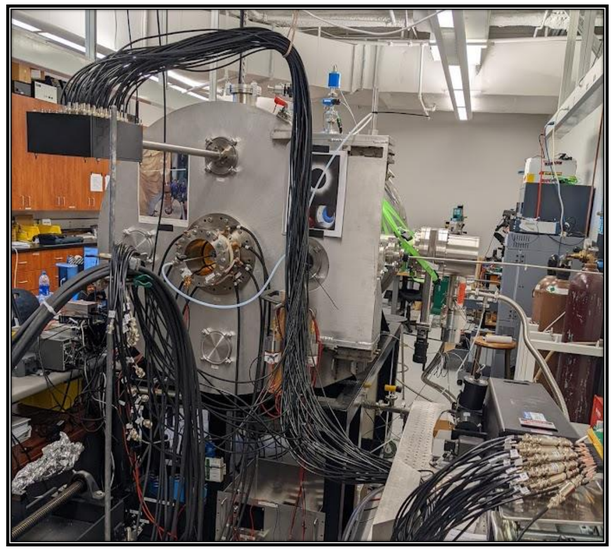
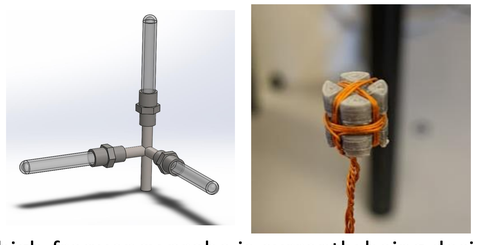
SCAN ME

Data Collection

View of the Experimental Setup (July 2022)



High-Frequency Polarization/Wave Vector Sensor



The high-frequency probe is currently being designed and constructed. The sensing cluster here is not the exact architecture that will be used in the final setup.

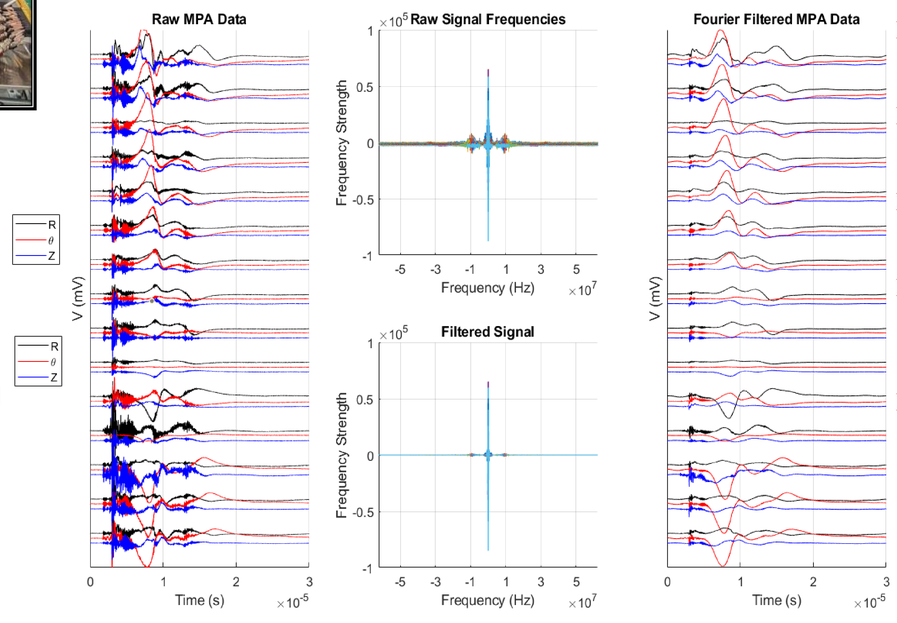
- HF probe used to find plasma wave polarization and direction of travel.
- Design inspired by Ref [3].
- Design allows for reliable electrostatic interference filtering.
- Wave vector may indicate dominant magnetic field topology in environment.

Abstract

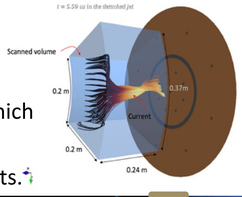
Presented is a method to observe magnetic field characteristics in a three-dimensional volume as well as high frequency waves generated by a pulsed plasma source. This source will produce a plasma jet that exhibits instabilities and magnetic reconnection [1] inside Embry-Riddle's two meter long, cylindrical plasma chamber. Magnetic reconnection is a process by which a portion of magnetic field energy is transferred into kinetic or thermal energy of plasma [1]. By observing the topology of the magnetic field at distinct locations over many pulses with the magnetic probe array, a three-dimensional vector space can be constructed for the plasma as it evolves over time. The magnetic field observations will be performed with a calibrated magnetic field probe array (MPA) as described in reference [2]. Design and calibration methodology for the high frequency array is motivated from instruments described in reference [3], although key differences are present. By interpreting these data over system parameter variations, the construction of an empirical model will be suggested for the plasma behavior, and heating of the plasma jet will be studied. This study will investigate fundamental plasma physics and applications, such as the drivers and patterns of reconnection and may lead to improved fusion energy generation and pulsed plasma propulsion.

Data Analysis

Magnetic Probe Array (MPA) Data Processing Workflow and Information

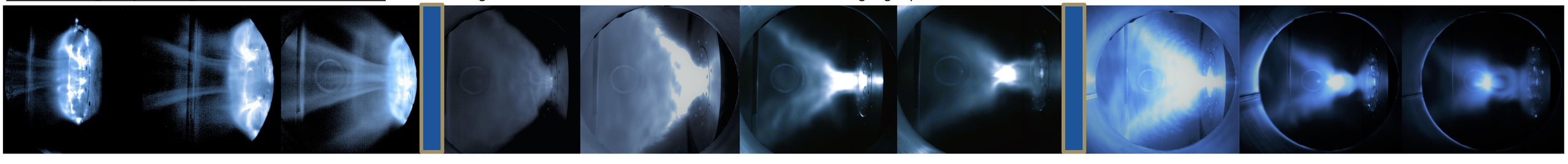


- MPA used for magnetic sensing of sub-10kHz plasma phenomenon.
- Fourier filtering is used as a countermeasure to electrostatic noise.
- 3-D magnetic video can be made by stitching data from many shots
- Current density and magnetic helicity can be observed from resulting vector space.
- Provides both qualitative and quantitative information on magnetic reconnection in the plasma.



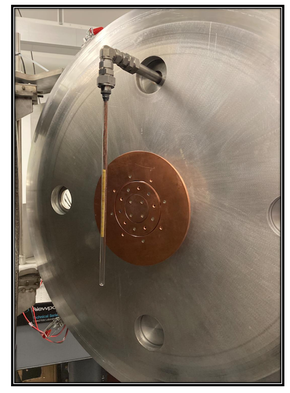
➢ Above, data from the MPA is processed. To the right is a possible output from the MPA [2], which shows how the magnetic fields can be used to deduce energy levels within the plasma jet.

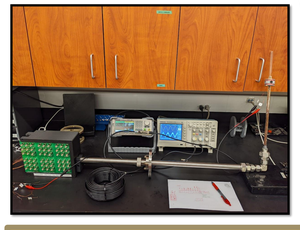
A Series of Images Representing the Evolution of Our Jet Profile: Each set of images shows how our results have become more desirable with ongoing improvements.



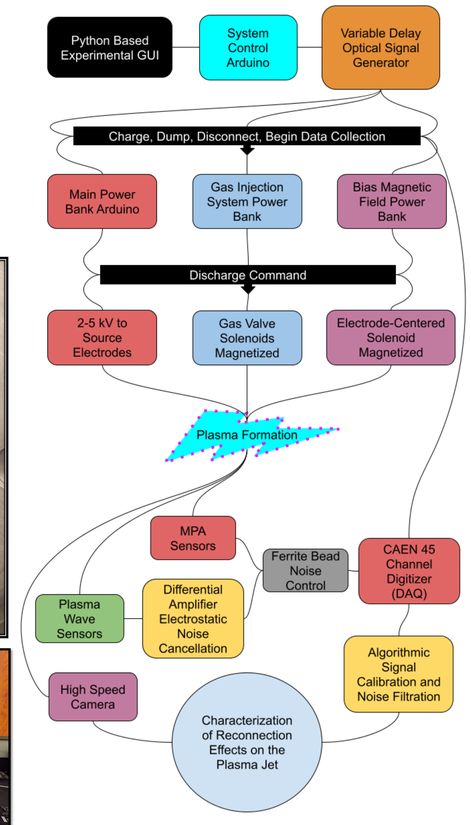
Experiment Details

The pulsed system is very sensitive to timing. Three power banks must fire at exact repeatably, to enable a reliable experiment.





Experimental Flowchart



References

[1] Seo, B., Wongwaitayakornkul, P., Haw, Magnus. A., Marshall, Ryan S., Li, Hui, and Bellan, Paul (2020) Determination of macro to microscale progression leading to a magnetized plasma disruption, Physics of plasmas, 27, 022109.
[2] Moser. (2012). Dynamics of magnetically driven plasma jets: An instability of an instability, gas cloud impacts, shocks, and other deformations. ProQuest Dissertations Publishing, Physics of Plasmas.
[3] Everson, Pribyl, Constantin, C., Zylstra, A., Schaeffer, D., Kugland, N. L., & Niemann, C. (2009). Design, construction, and calibration of a three-axis, high-frequency magnetic probe (B -dot probe) as a diagnostic for exploding plasmas. Review of Scientific Instruments, 80(11), 113505–1135058. https://doi.org/10.1063/1.3246785