



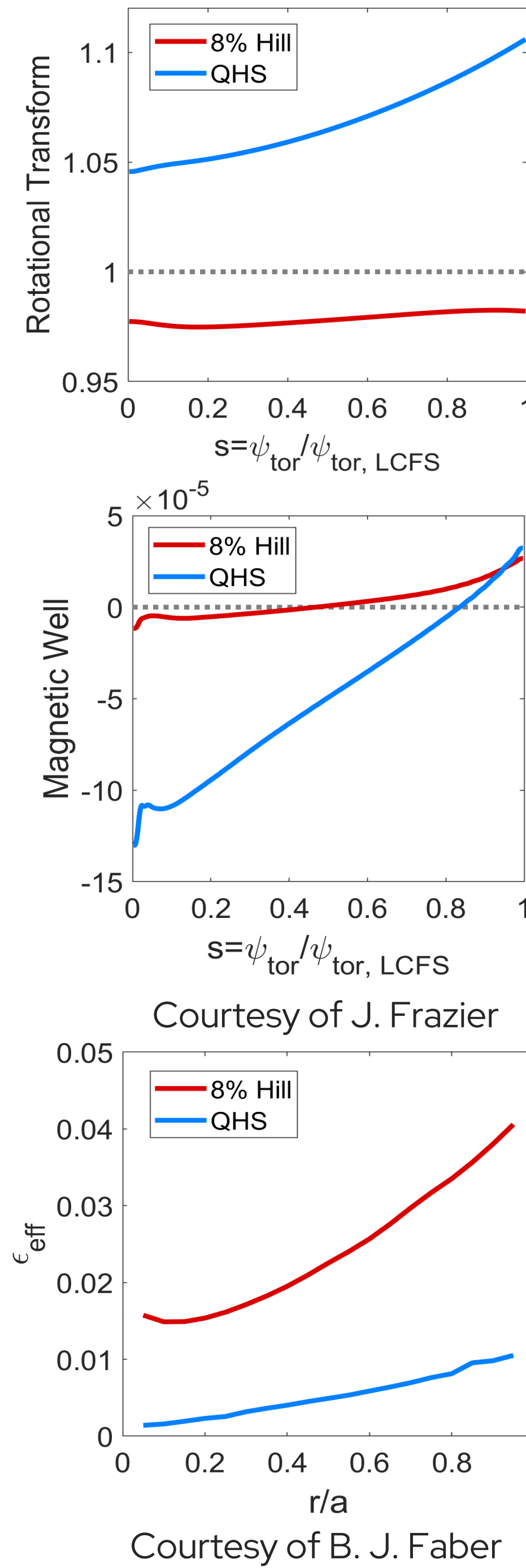
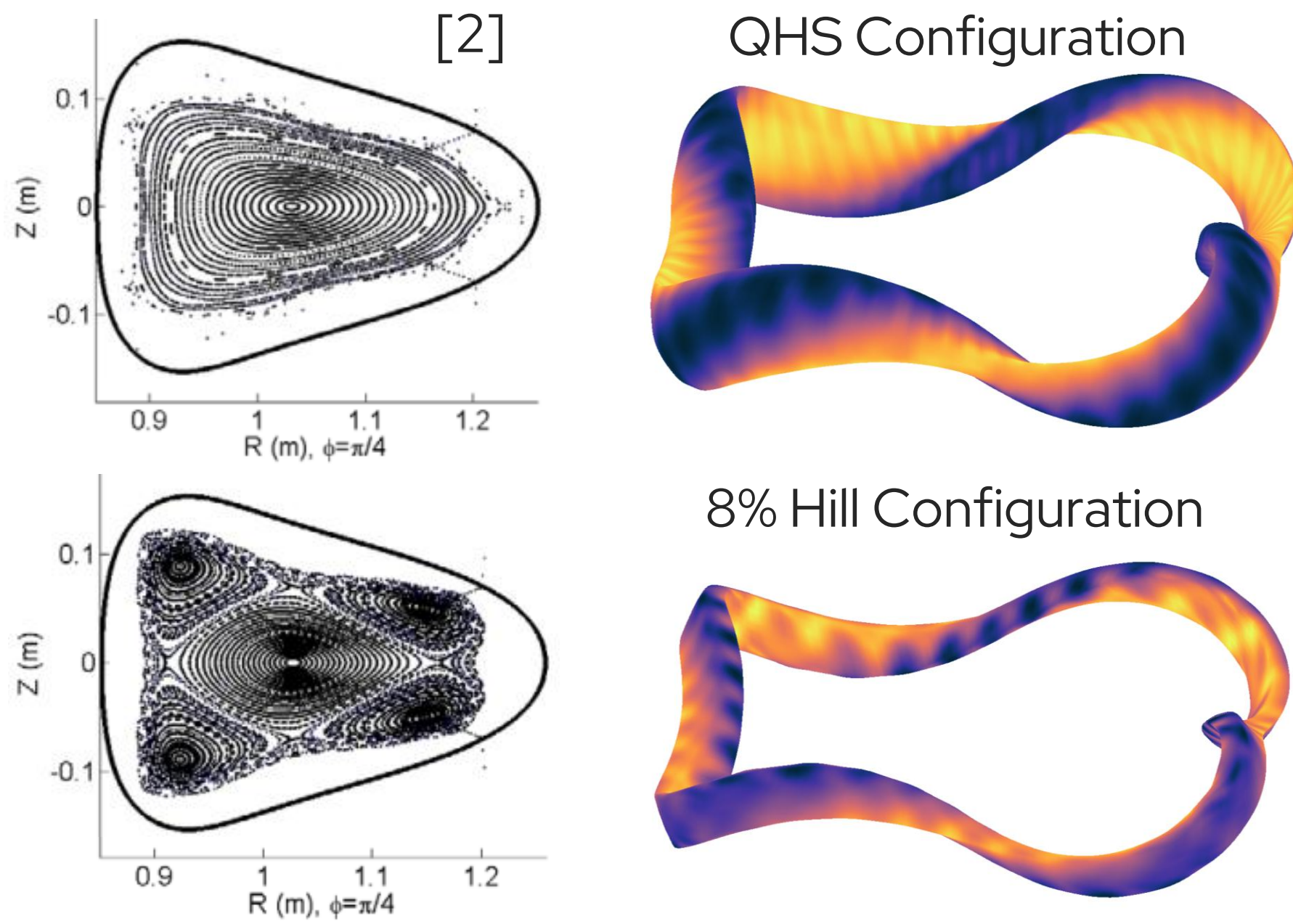
Experimental investigation of magnetohydrodynamically unstable stellarator configurations in the Helically Symmetric eXperiment

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Impact of Magnetic Geometry on MHD Stability

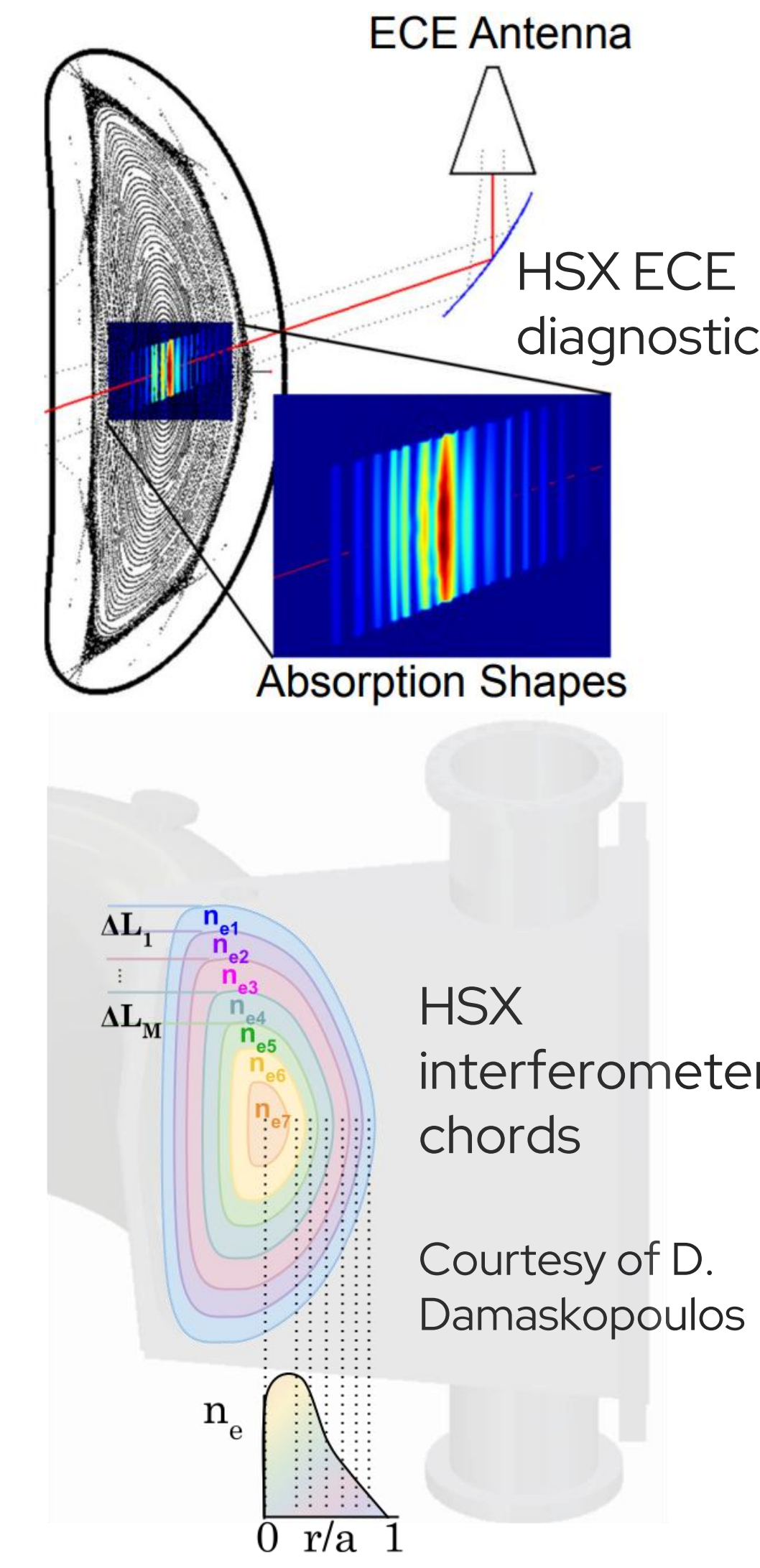
- Magnetohydrodynamic (MHD) modes can impact confinement due to macroscopic evolution on short time scales¹
- MHD instabilities are not well studied experimentally in quasi-symmetric configurations
- Validation of MHD simulation codes predicting modes is needed in unstable quasi-symmetric configurations



Diagnostic Measurement Techniques

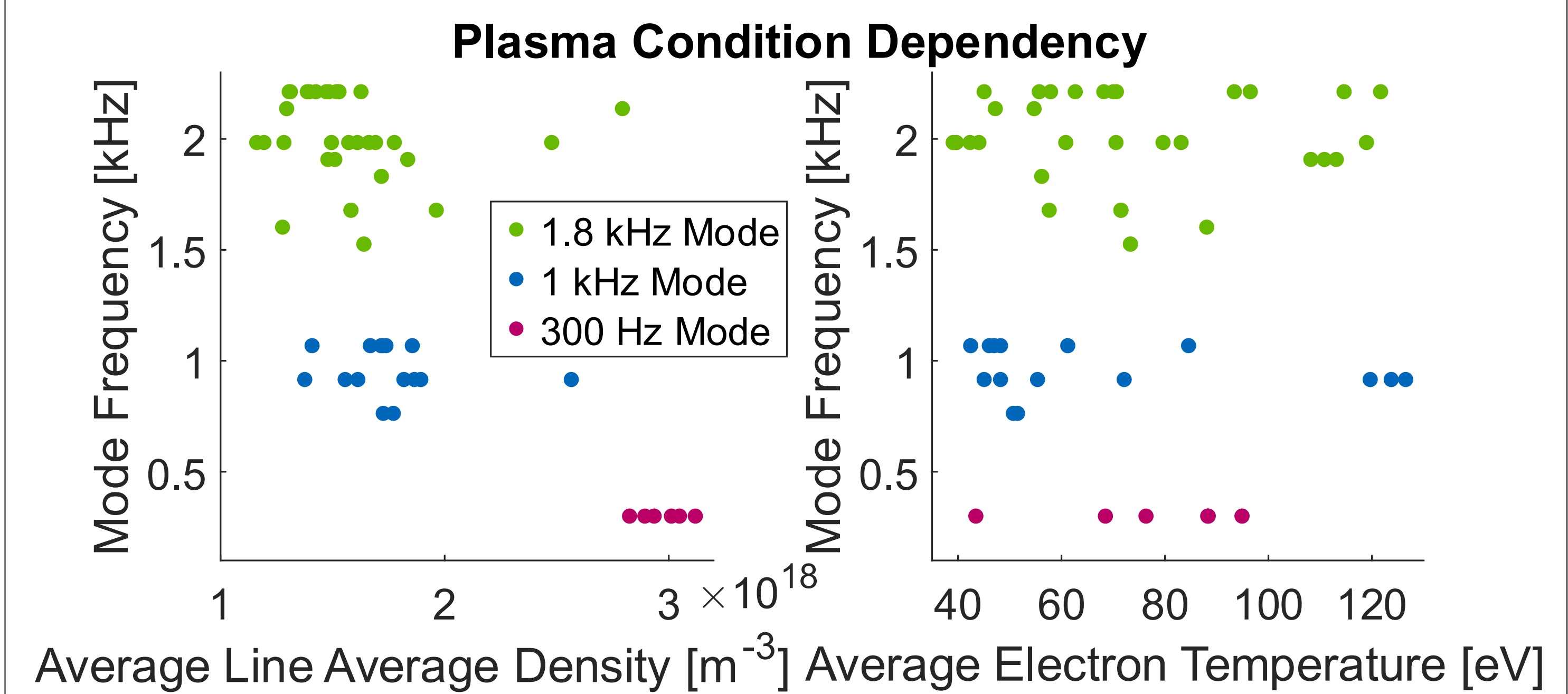
- Twenty Mirnov coils on HSX allow for spatially resolved magnetic fluctuation observation in poloidal and toroidal orientations
- Electron Cyclotron Emission (ECE) measures electron temperature at given positions along a radial chord
 - The HSX ECE system measures eight radial locations along a line of sight
- Interferometer measures line-averaged density along chords through the plasma
 - The 7 channels of the HSX interferometer give spatially resolved measurements

$$V = -NA \frac{dB}{dt}$$



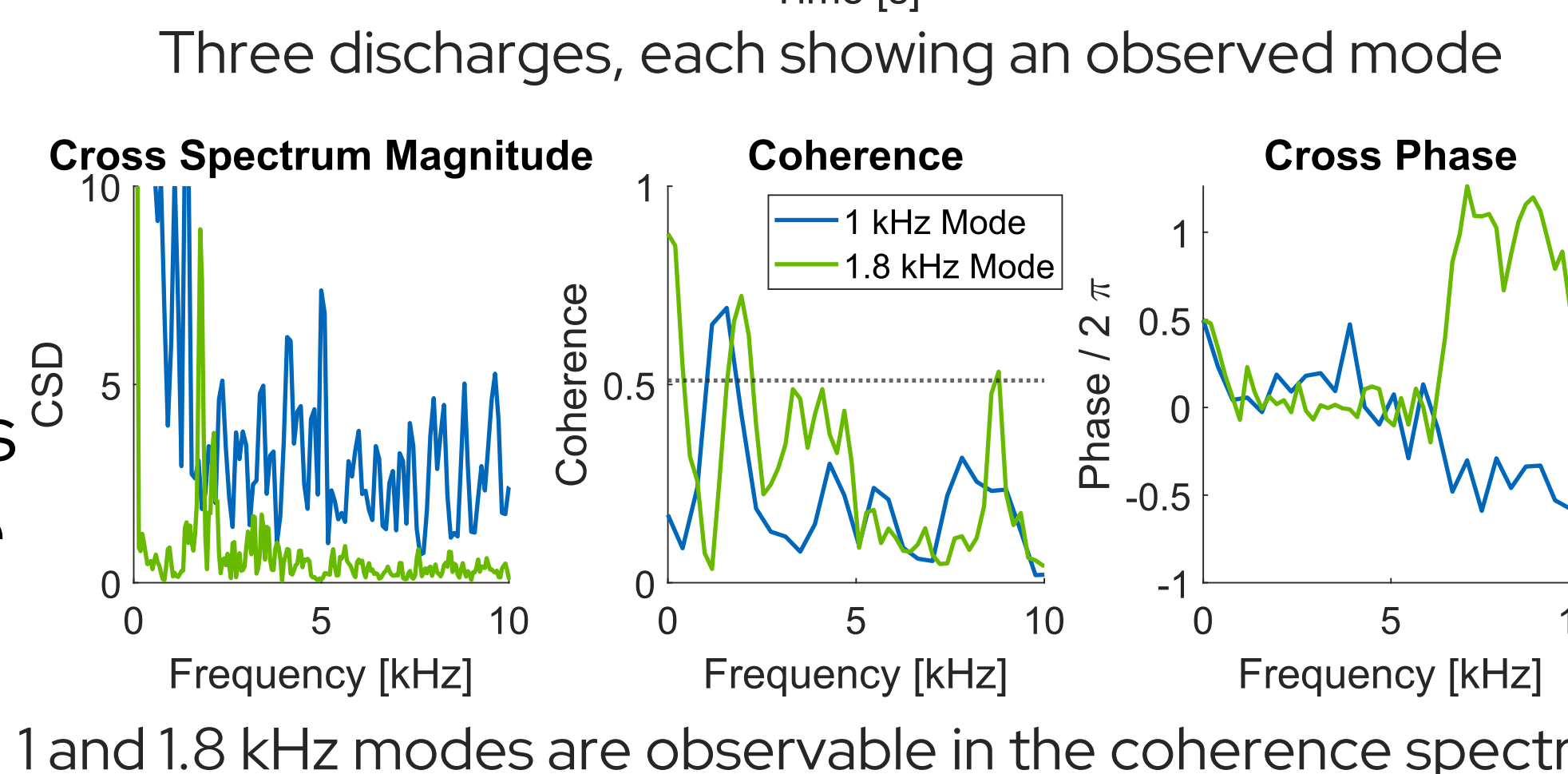
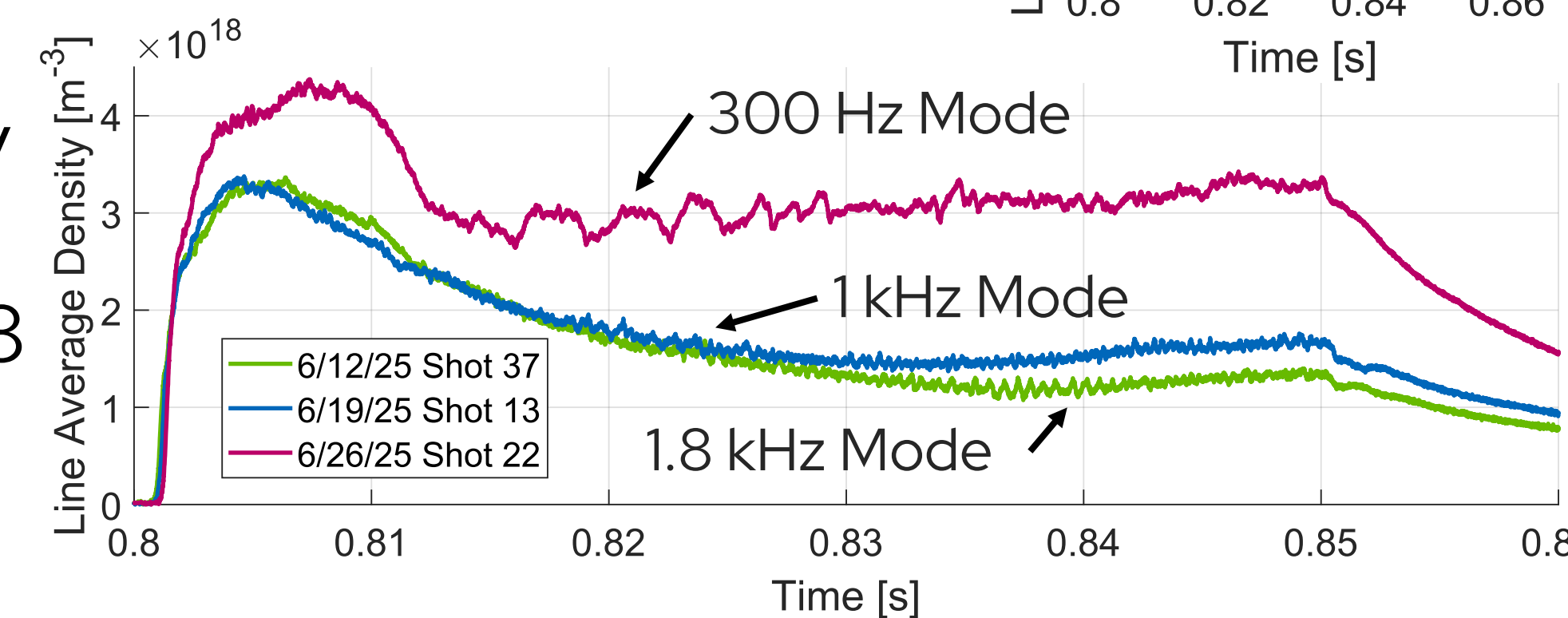
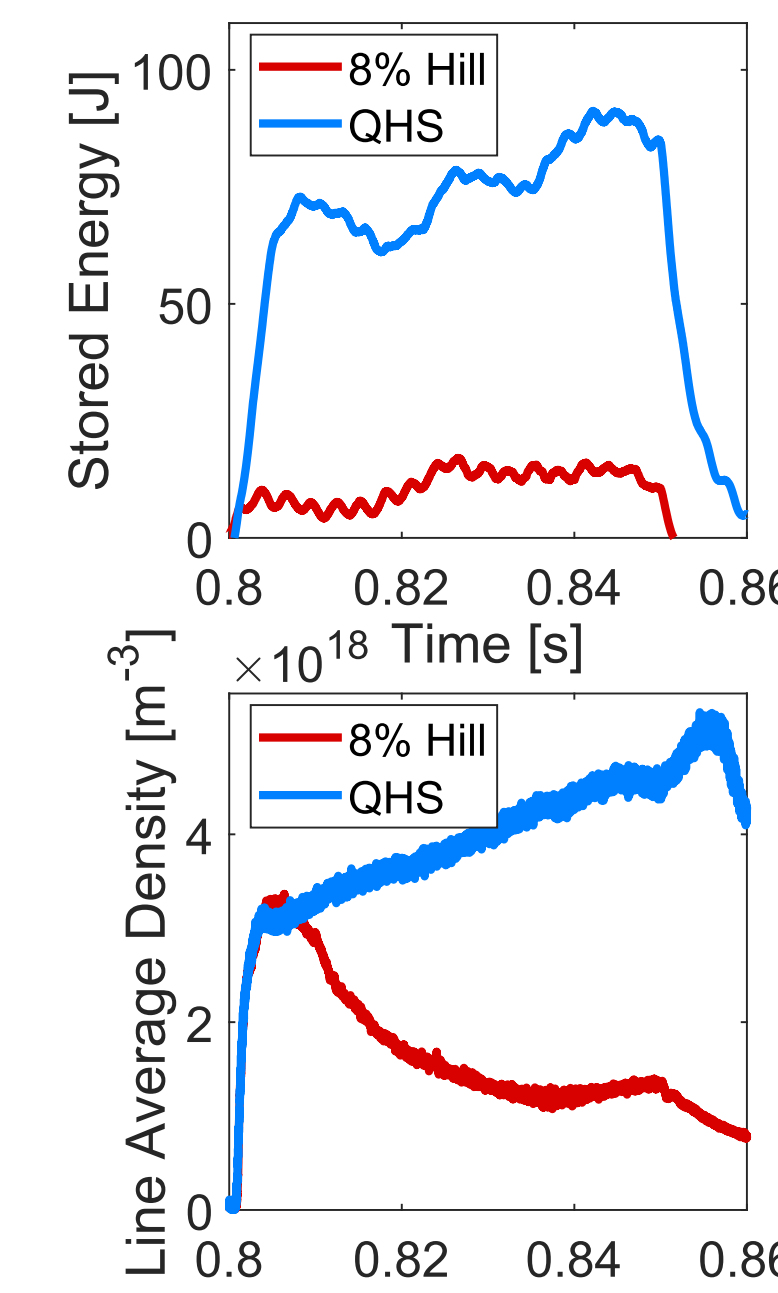
Modal Dependency on Density

- Each mode shows a correlation to the temperature and density of the discharge
- Potential mode origins can be identified by tracking the mode frequency and comparing to the average line average density and average radiated temperature of the shot
- The 1 kHz mode generally appears at a narrow density range, the 1.8 kHz mode appears across a wide range of densities
- The 300 Hz mode is only observed when the plasma reaches a line average density of at least $3 \times 10^{18} \text{ m}^{-3}$
- All 3 modes appear at a range of radiation temperatures



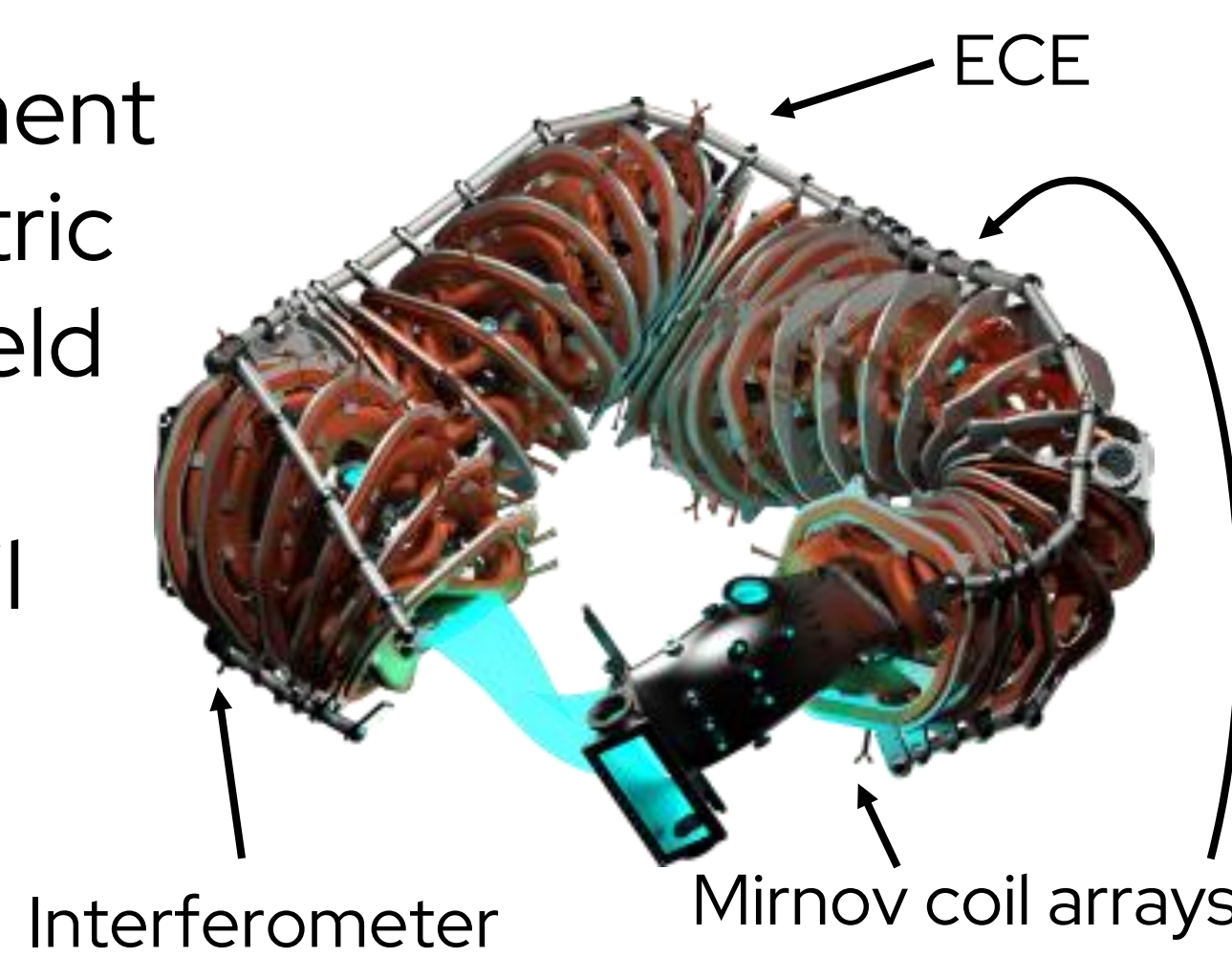
Characterization of Low Frequency Modes

- 8% hill configuration shows significantly lower stored energies and densities despite similar heating power and fueling
- 300 Hz, 1 kHz, and 1.8 kHz modes present in 8% hill but not in the QHS configuration
- All three modes appear in the line average density, electron radiation temperature, and magnetic fluctuations
- Coherence is significant between density and magnetic signals for the 1.8 kHz and 1 kHz modes



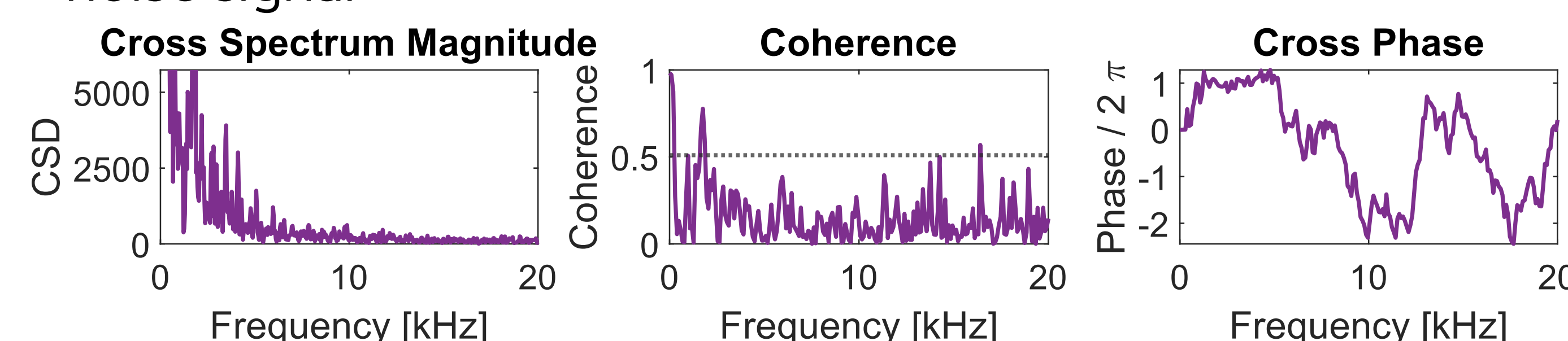
Helically Symmetric eXperiment

- The Helically Symmetric eXperiment (HSX) is a quasi-helically symmetric (QHS) stellarator with 48 main field coils and 48 auxiliary coils
- Auxiliary coils add to the main coil field, providing access to altered configurations, such as the 8% magnetic hill configuration



Signal Correlation Analysis

- Coherence analysis is used to identify modal activity
- A spike in coherence above about 0.5 is significant over the noise signal



Conclusions and Future Work

- A magnetic hill configuration generated global modes observable in temperature, density, and magnetic fluctuations, which is consistent with MHD activity
- Additional measurements of the density and temperature profiles of the 8% hill configuration will allow for categorization of the types of observed MHD activity
- Exploration of MHD simulation codes for experimental validation will give more insight into the nature of the modes

References

- [1] M. Schlutt, Investigation of 3D Effects in Stellarator Configurations Using Extended MHD, University of Wisconsin - Madison, 2012.
- [2] S. P. Gerhardt, Measurements and Modeling of the Plasma Response to Electrode Biasing in the HSX Stellarator, University of Wisconsin - Madison, 2004.
- [3] G. Weir, Electron Heat Transport Experiments in a Quasi-Helically Symmetric Stellarator, University of Wisconsin - Madison, 2014.