Monitoring Impurities and Hydrogen Isotopes in the C-2W Field-Reversed Configuration Fusion Device

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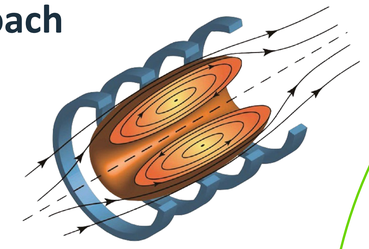
Introduction

- C-2W, TAE Technologies' fifth-generation field-reversed configuration (FRC) fusion device, uses strong magnetic fields to confine a superheated plasma, forcing hydrogen atoms to fuse and generate energy
- TAE's ultimate goal is to develop proton boron-11 fusion, in which naturally abundant boron is used to generate large amounts of energy with no greenhouse emissions or neutron radiation

Benefits of TAE's Approach

- Compact linear design
- No meltdown risk
- Not weather-dependent
- Virtually unlimited fuel (hydrogen and boron)
- Does not generate nuclear waste

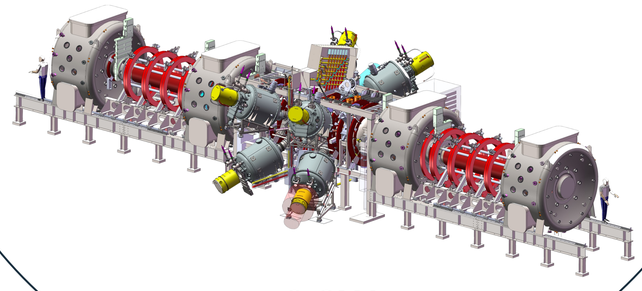


Field-reversed configuration (FRC)

Research Highlights

TAE Technologies' field-reversed configuration (FRC) fusion device, C-2W, has a suite of spectroscopic systems that provide important information about:

plasma parameters
particle transport and confinement time
impurity concentrations
device performance

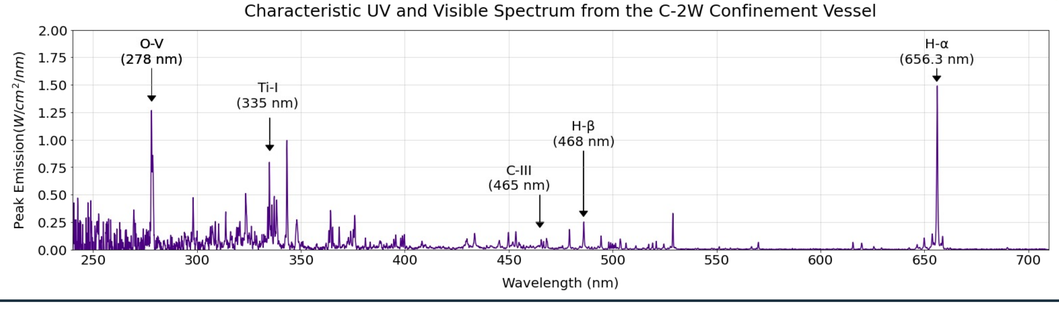


C-2W

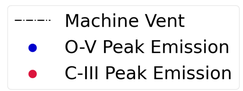
Methods

- Survey spectrometers measure time-resolved spectra from the core, fueling sections, and divertors in order to understand the evolution of the plasma composition
- A suite of 10 survey spectrometers are currently deployed on C-2W (200 nm – 1100 nm)
- A high-resolution spectrometer is currently installed in the gas fueling flange to measure hydrogen isotope fractions

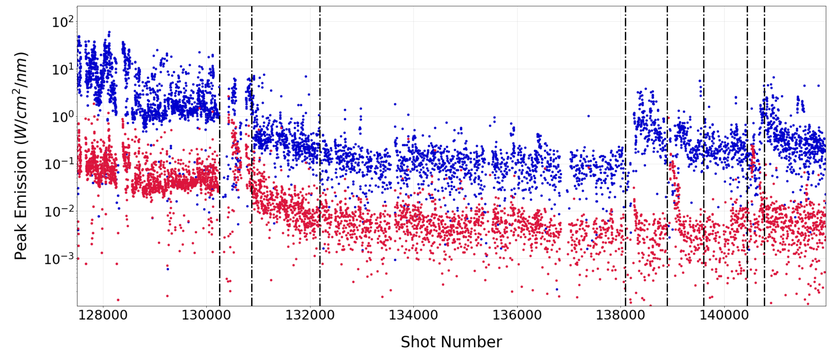
Characteristic UV and Visible Spectrum from the C-2W Confinement Vessel



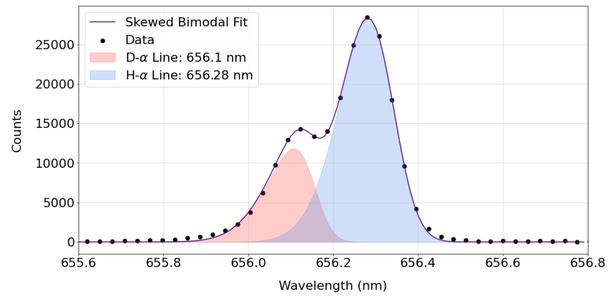
Results



Impurity Trends in the C-2W Confinement Vessel (March 2020 to August 2022)



Fueling Flange Hydrogen and Deuterium Balmer Alpha Spectrum



Discussion and Conclusion

- The line intensities of the different impurity charge states can be used as proxies for impurity concentration
- O-V and C-III are important emission lines that can be used to infer machine cleanliness and performance
- Impurity emission generally trends downward after machine vents, as impurities are slowly purged via plasma cleaning of the walls
- Hydrogen and deuterium isotope fractions in the fueling flange can be used in conjunction with measurements in the core to study fueling, particle confinement, and transport in C-2W
- By tracking the time-evolution of impurity and hydrogen isotope line emission, we are able to better understand machine performance and C-2W's ability to generate stable FRC plasmas, taking us one step closer toward a commercial, grid-ready fusion energy power plant.

Bibliography

1. H. Gota *et al.*, Nucl. Fusion **61**, 106039 (2021)