

Enhanced Transport of Energetic Ions due to Interaction with Microturbulence in DIII-D

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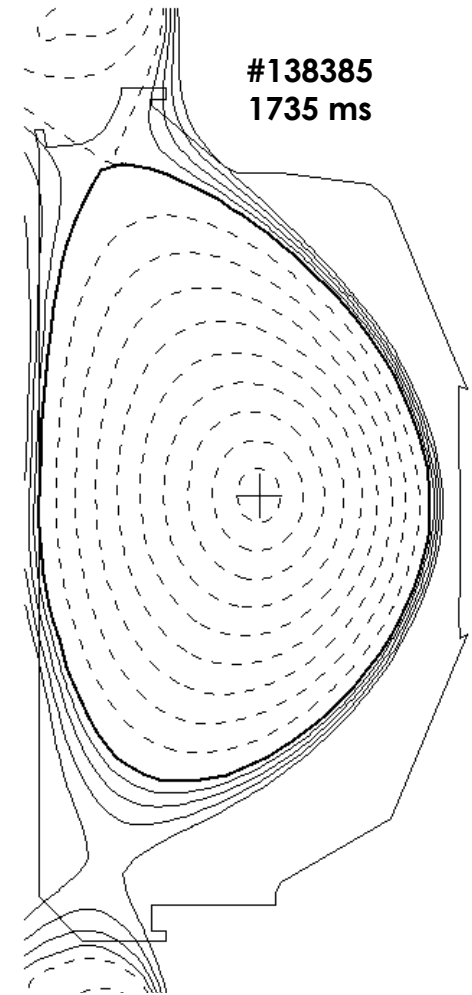
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Experiment Provides Opportunity for Comparisons with Theory and Simulation Predictions

- Energetic particles are better confined than thermal particles.
- Recent theoretical work [1-3] provides experimentally testable predictions of fast-ion transport due to interaction with microturbulence.
 - microturbulence: ion-temperature gradient (ITG) and trapped electron modes (TEM)
 - $D_{\text{fast}} \sim C(E/T_i) * D_i$, $C(E/T_i)$ is a measure of orbit averaging effectiveness
 - Passing orbits: $D \sim 1/E$, Trapped orbits: $D \sim 1/E^2$

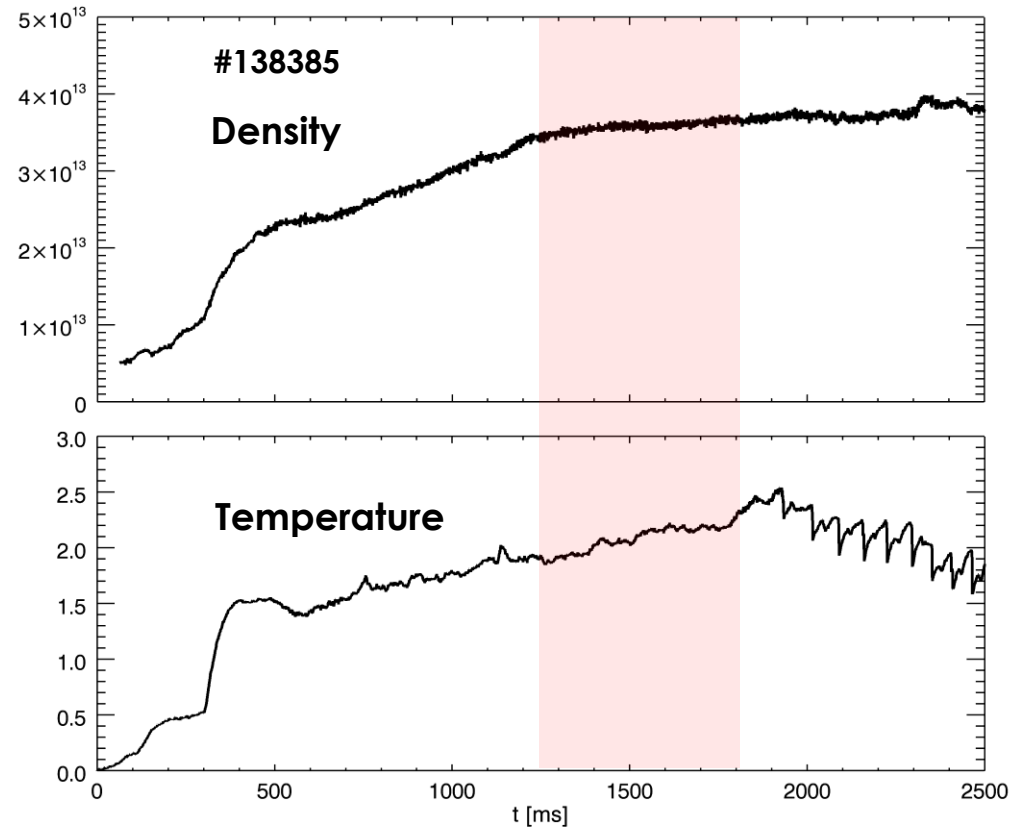
Optimizations for Both Fast-ion and Fluctuation Measurements are Incorporated into Shot Design

- **Fast-ion measurements**
 - neutral beam programming (FIDA, MSE)
 - $n_e < 5 \times 10^{13} \text{ cm}^{-3}$ (FIDA)
- **Fluctuation measurements**
 - separate neutral beam setup (BES requires 150 NB)
 - magnetic field, density (reflectometer, DBS, CECE)



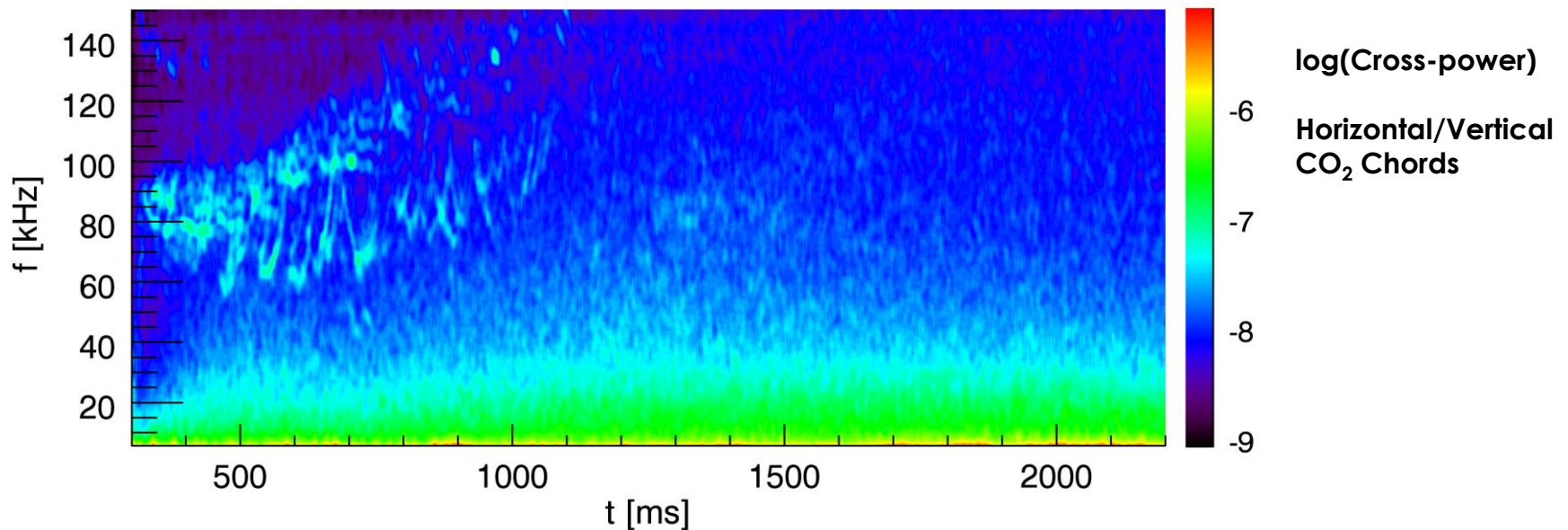
Extended Periods of FIDA Data Collected Prior to Sawtooth Oscillations

- **Near steady-state allows for long time averaging**
 - improves statistics
 - better profiles for code input
- **Sawtooth oscillations must be avoided**
- **Scan through different parameter spaces**
 - reduced beam voltage
 - tangential vs. perpendicular beam sources



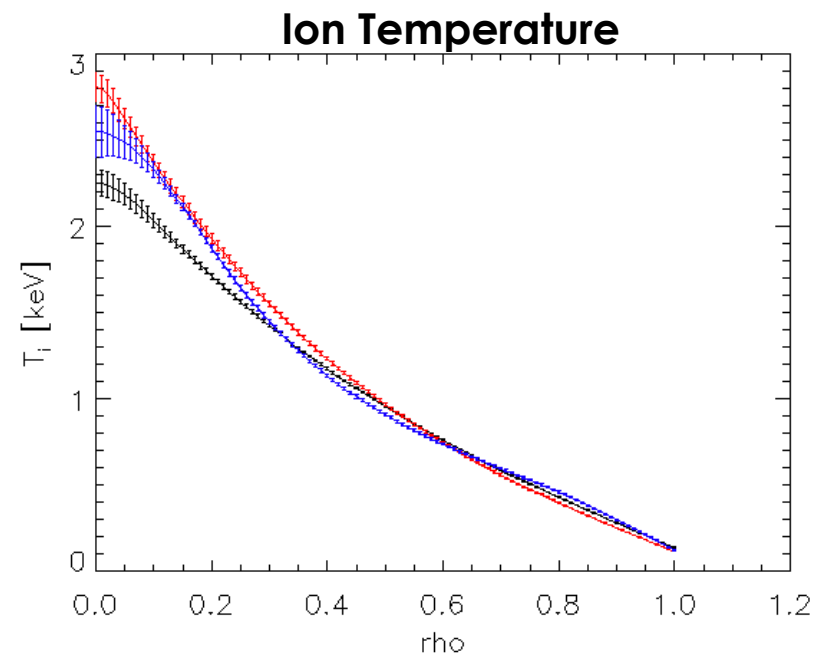
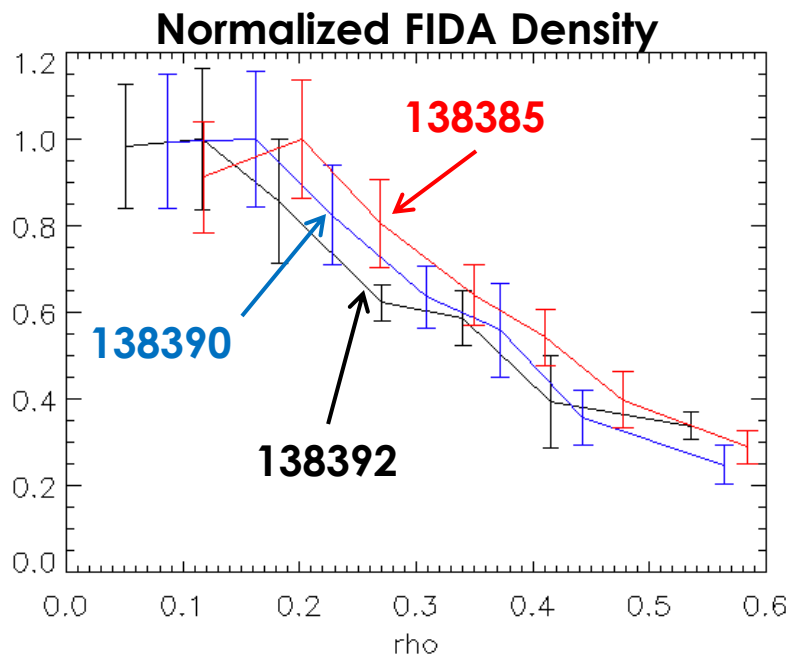
Energetic Particle Driven Modes are Largely Avoided

- EP-driven modes can cause significant transport
- Large amplitude EP-driven modes observed early
- Modes are significantly reduced in amplitude during times of interest



Fast-ion Density Profiles are Qualitatively Similar in Different Discharges

- **138385: Standard Case**
- **138390: Perpendicular neutral beams**
- **138392: Reduced neutral beam voltage**



Analysis in Progress

- **Fluctuation analysis will determine spatial scales and amplitudes of ITG/TEM**
- **TRANSP/FIDA simulation will determine whether measured FIDA spectra deviate from classical predictions**
- **GTC and TGYRO/TGLF will both utilize experimental profiles as input**
- **Codes will output fast-ion diffusivity**

References

- [1] C. Estrada-Mila, J. Candy, and R.E. Waltz, *Phys. Plasmas* **13**, 112303 (2006).
- [2] W. Zhang, Z. Lin, and L. Chen, *Phys. Rev. Lett.* **101**, 095001 (2008).
- [3] T. Hauff, M.J. Pueschel, T. Dannert, and F. Jenko, *Phys. Rev. Lett.* **102**, 075004 (2009).