Reflectometry and Interferometry Measurements of Density Profiles and Fluctuations in NSTX

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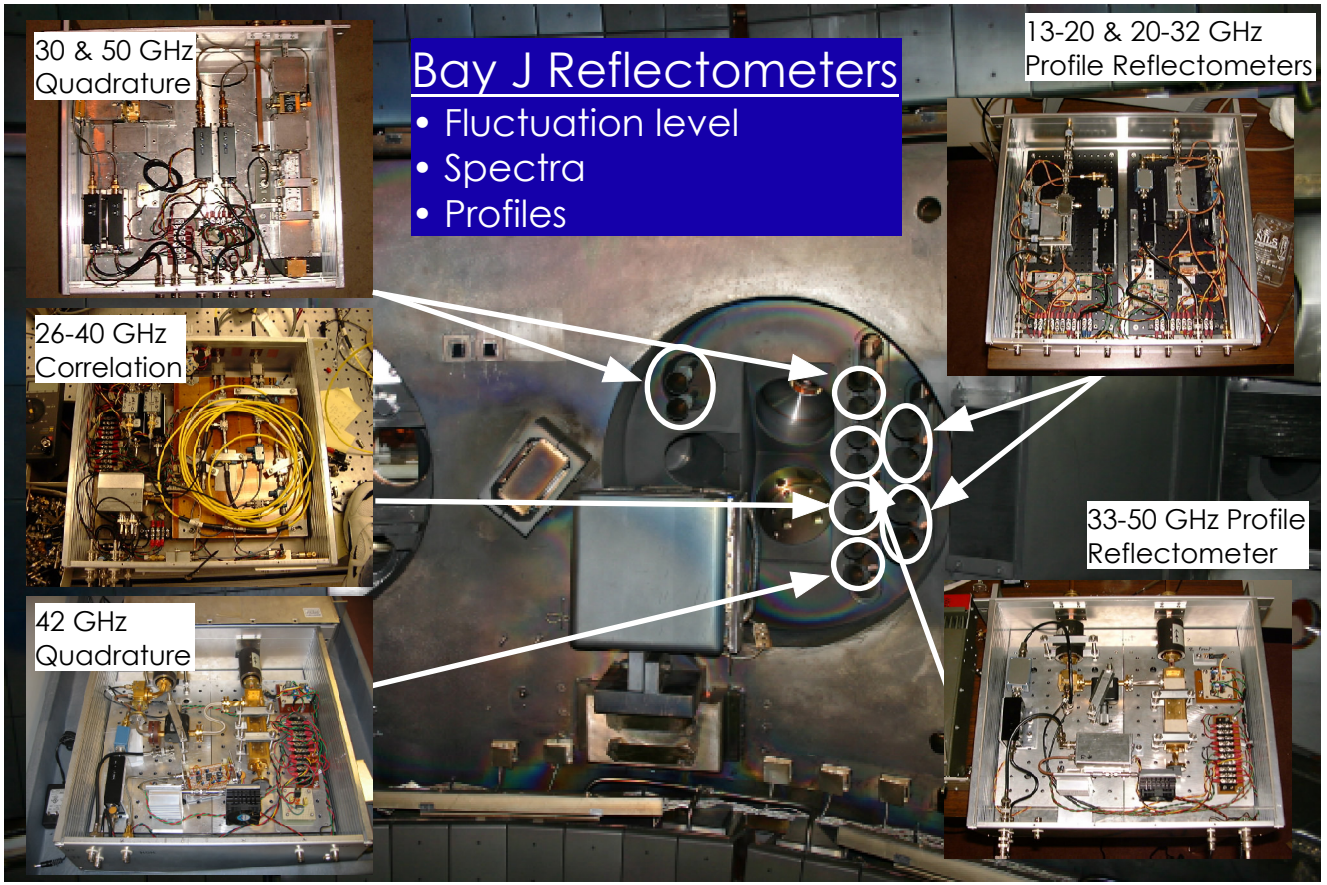
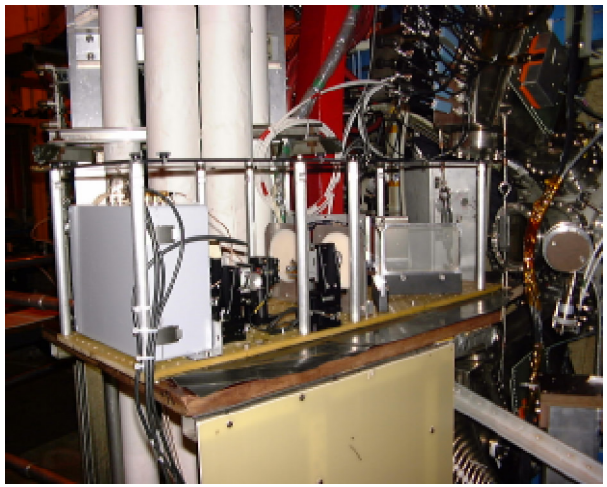
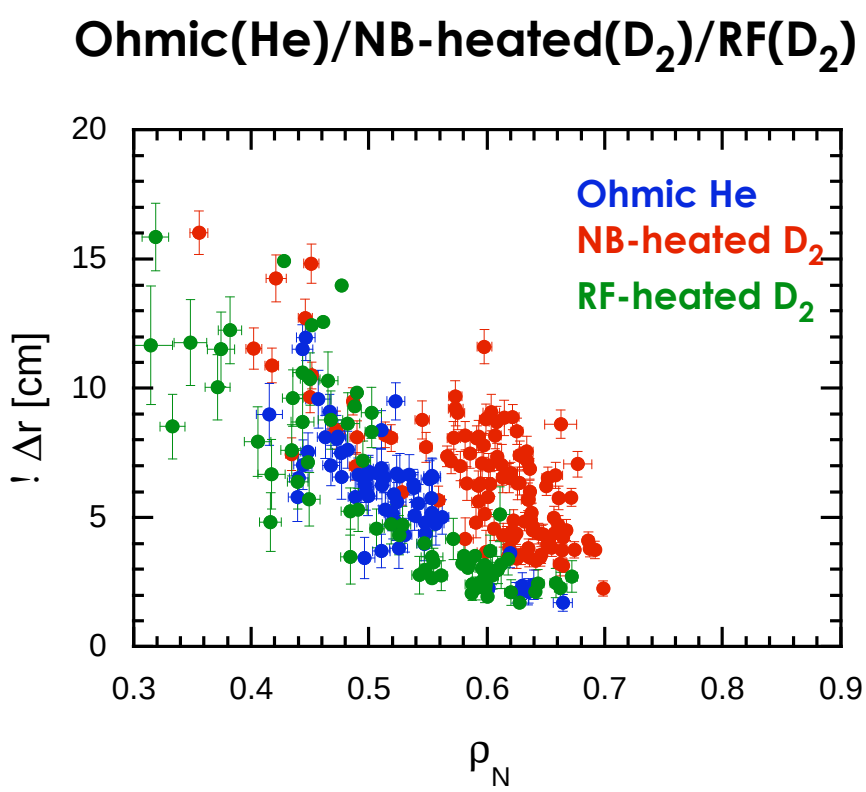


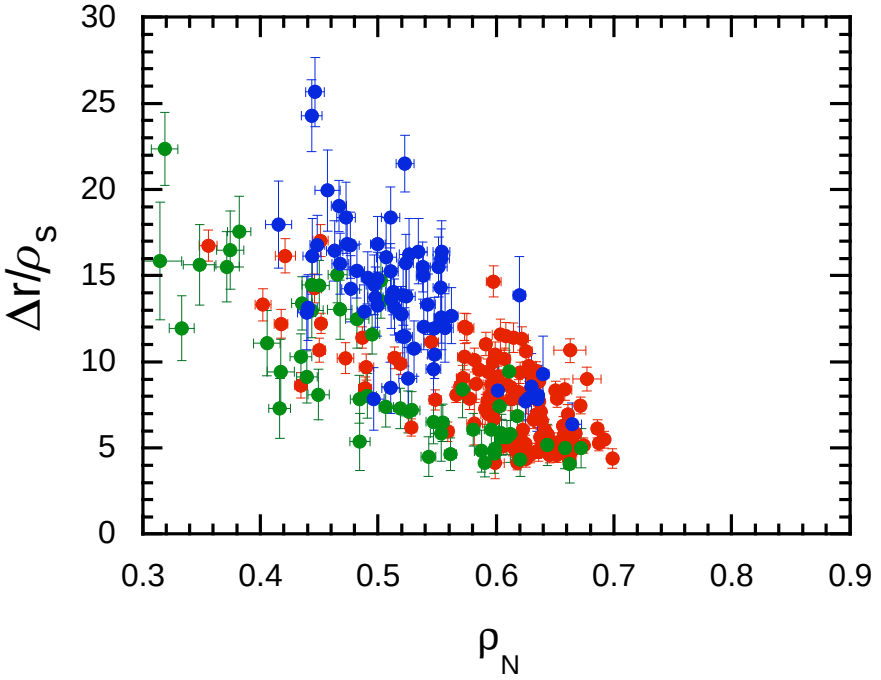
Bay G Interferometer
- Radial line density
- Operating routinely

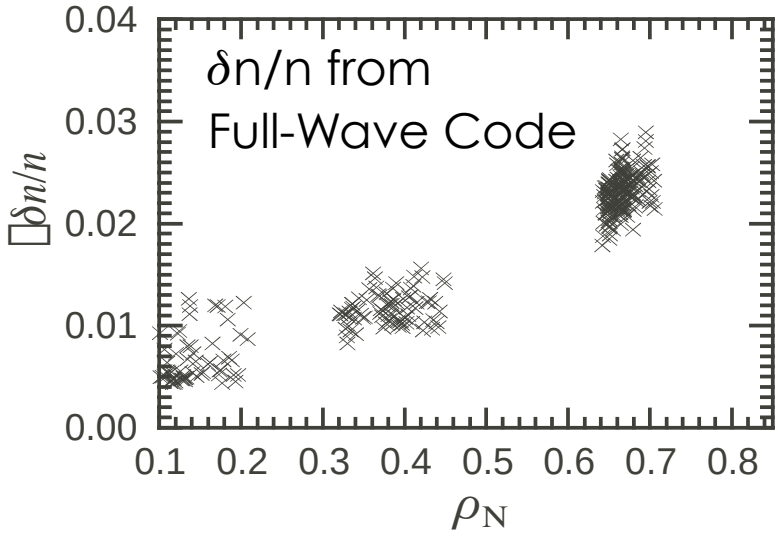


- **Array of microwave diagnostics for density measurements.**
- **Turbulence measurements in a variety of plasmas.**
- **Full-wave simulations for reflectometer response to modeled turbulence.**

Δr Compared in a Variety of Plasmas



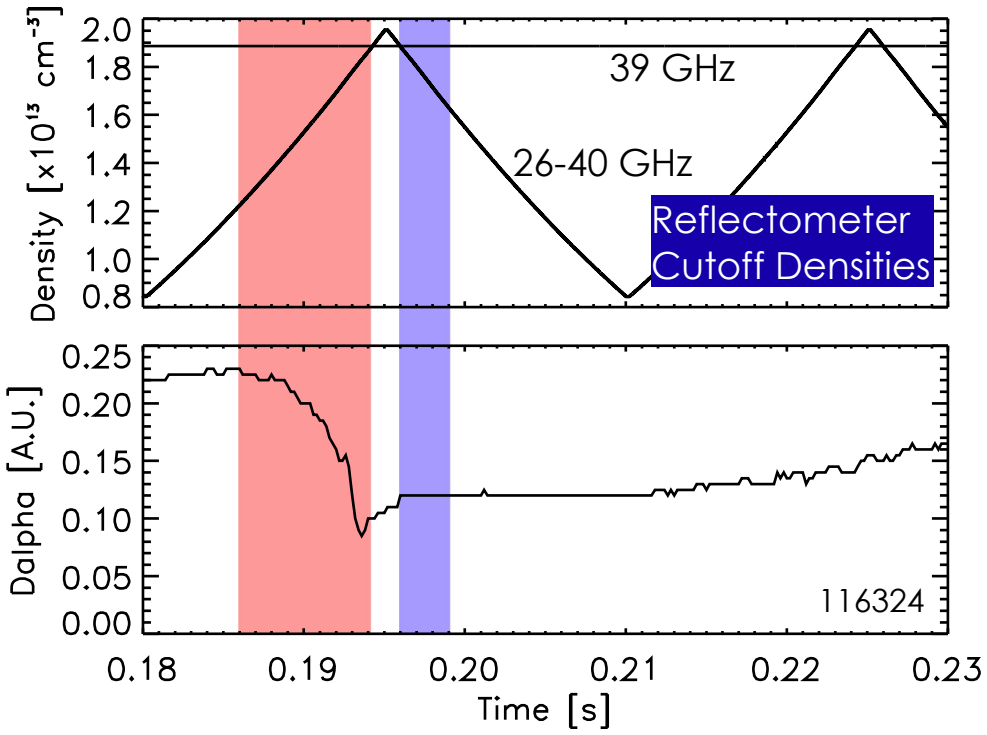


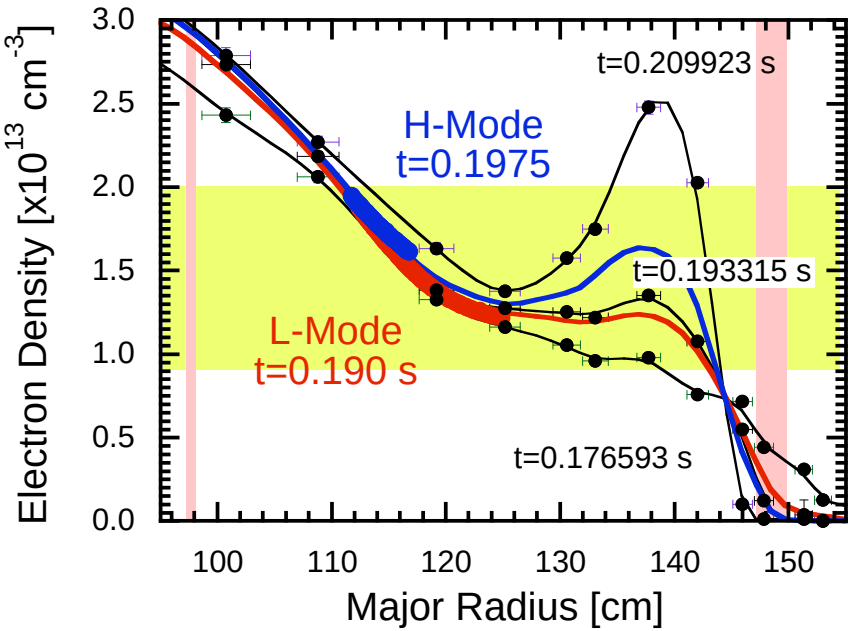


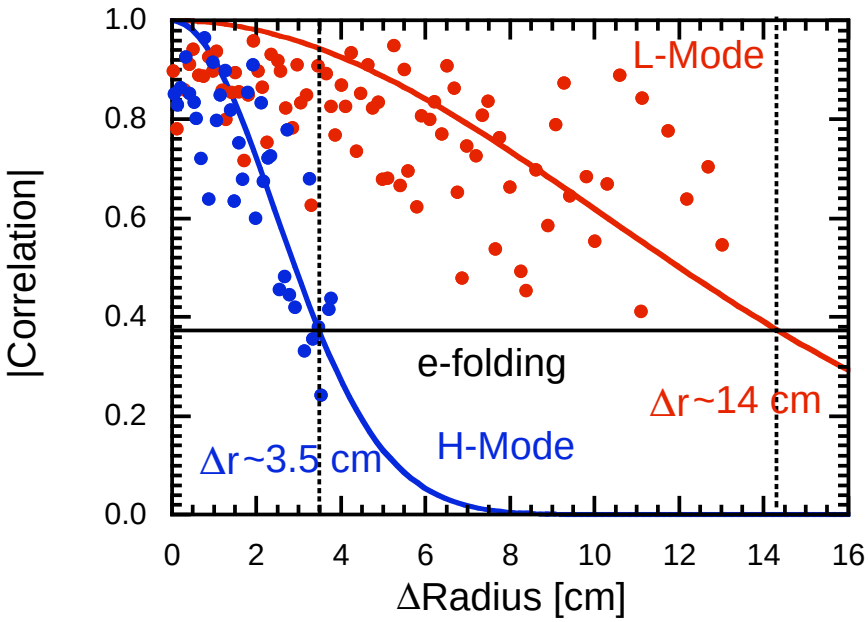
- Ohmic (He), RF- & NB-heated L-modes.
  - Δr~15 cm are seen irrespective of heating method.
  - AEs are missing in RF and ohmic He case; rules out turbulence due to fast particle-driven modes.

Correlation Length Reduced by ~1/2 in Ohmic H-Modes

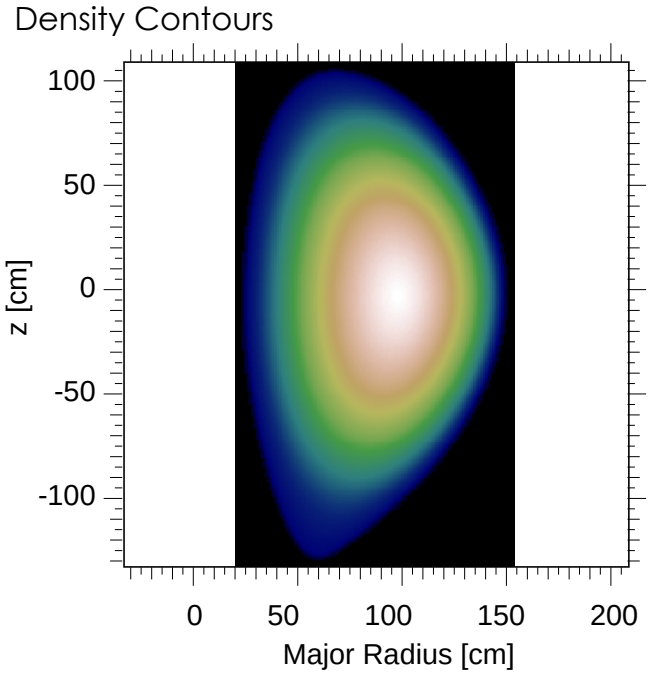
- Core measurement of ohmic H-mode discharges around L-H transition.
- ~5-10 ms window for single Δr measurement before rise of edge density ear.
- Other turbulence properties remain constant in core.
- **Typical Δr change from ~14 to ~7 cm.**
- **Δr decrease consistently seen.**

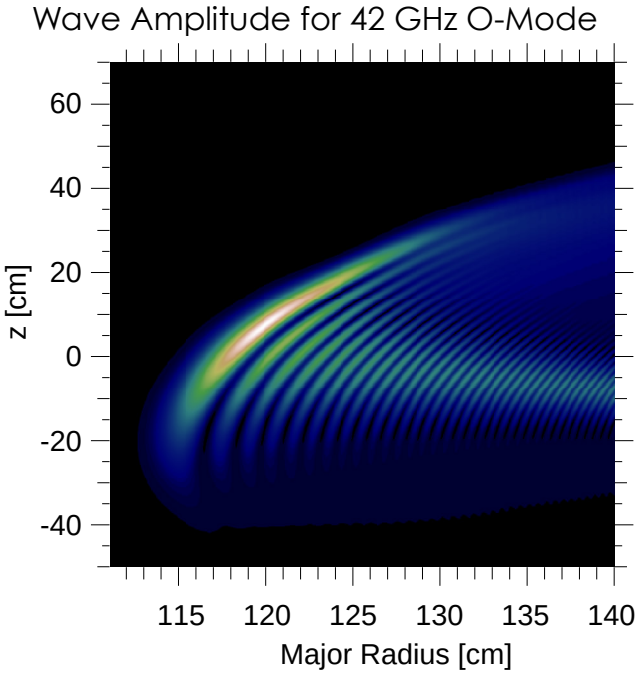


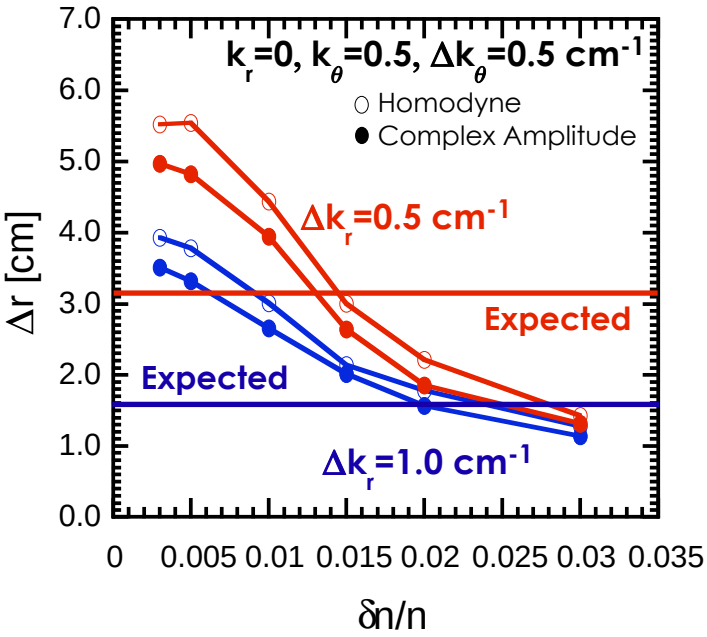




Modelling of Reflectometer Response To Turbulence Using Full-Wave Codes (Collaboration with G. Kramer)





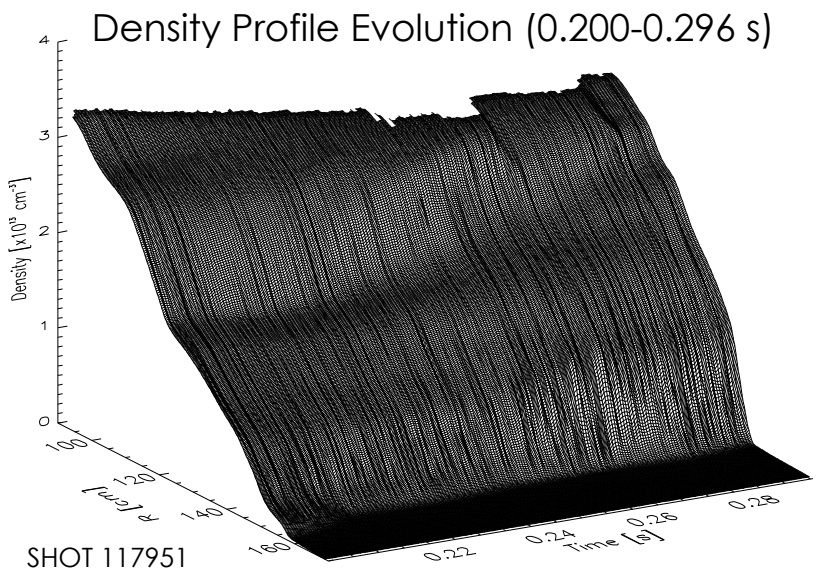


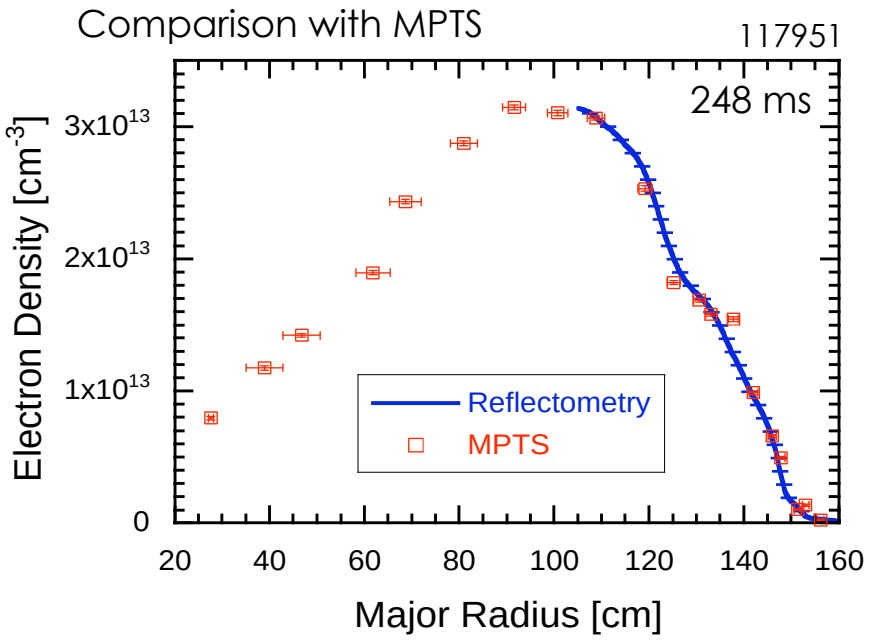
- Model complex reflectometer response to turbulence (δn/n, Δr, k) in 1-D and 2-D.
- Full-wave codes: **PPPL 2-D code FWR2D. UCLA 1-D FDTD code.**
- Turbulence model: superposition of sinusoids with random phase and obeying

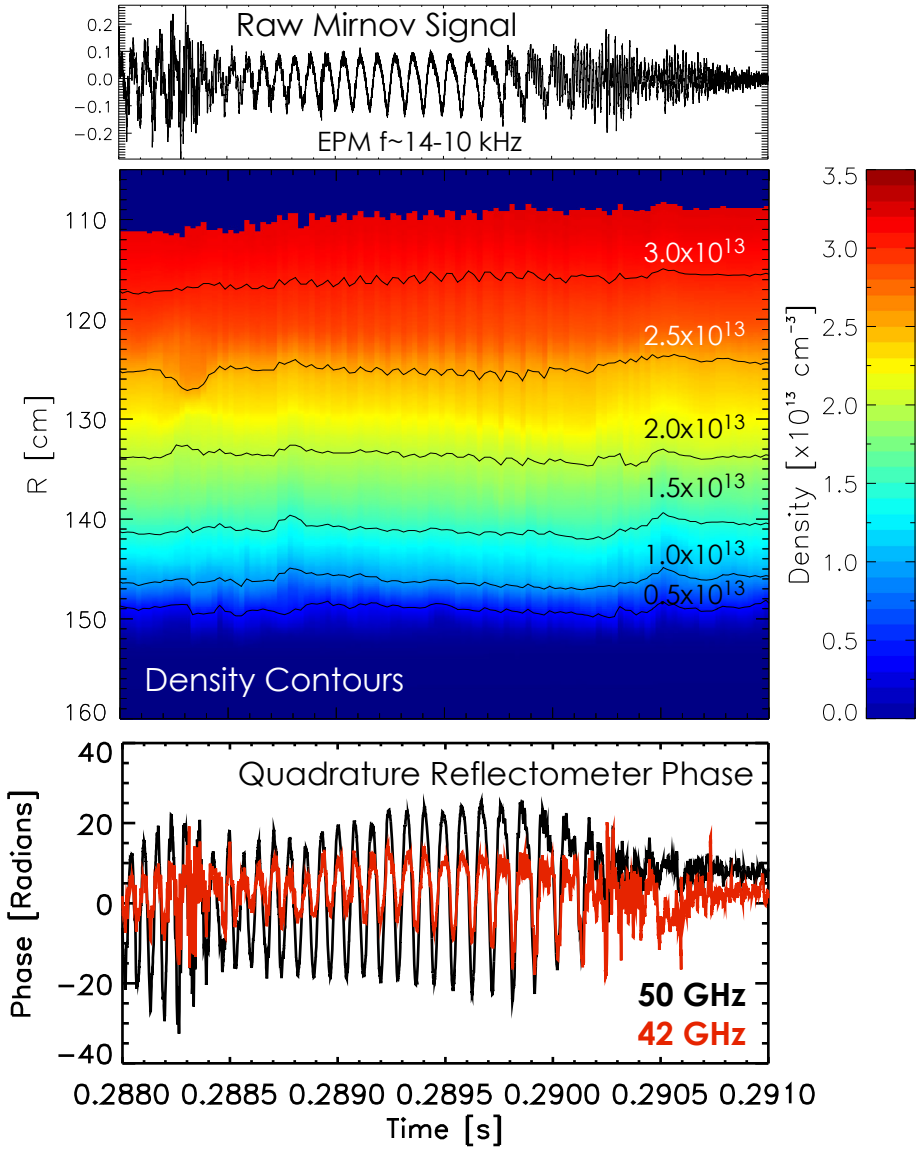
$$\frac{1}{n^2}\langle \tilde{n}_1 \tilde{n}_2 \rangle = \left(\frac{\tilde{n}}{n}\right)^2 \exp\left(-\left(\frac{\Delta t}{\tau}\right)^2\right) \exp\left(-\left(\frac{(\boldsymbol{x}+\boldsymbol{v}t)\cdot\Delta\boldsymbol{k}}{2}\right)^2\right) \cos(\boldsymbol{x}\cdot\boldsymbol{k})$$

- **Main result: Δr can vary strongly with δn/n and k spectrum.**
- Corroboration of code/turbulence model with experiments is still limited. Definitive test to be performed on DIII-D including detailed comparison with BES.

Fast Profile Measurements With 25 μs Resolution

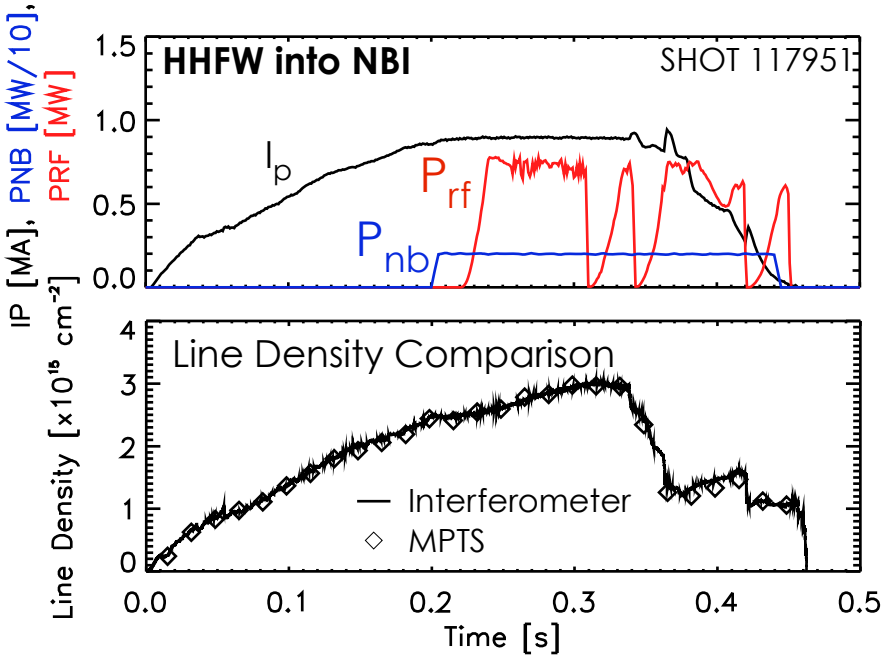


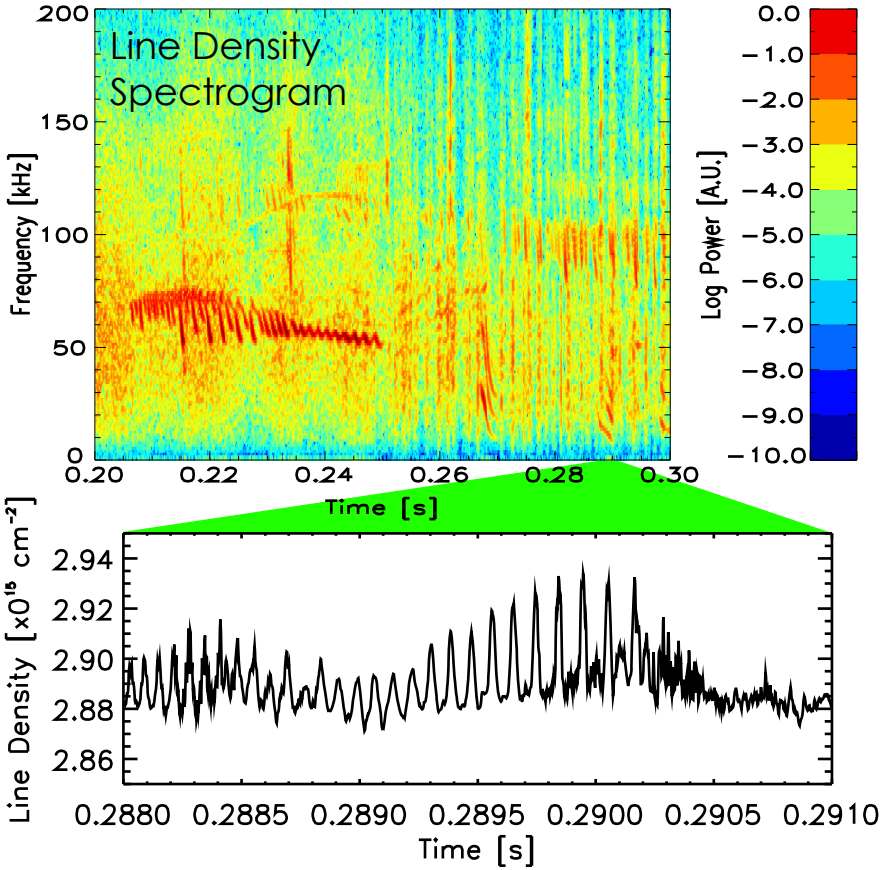


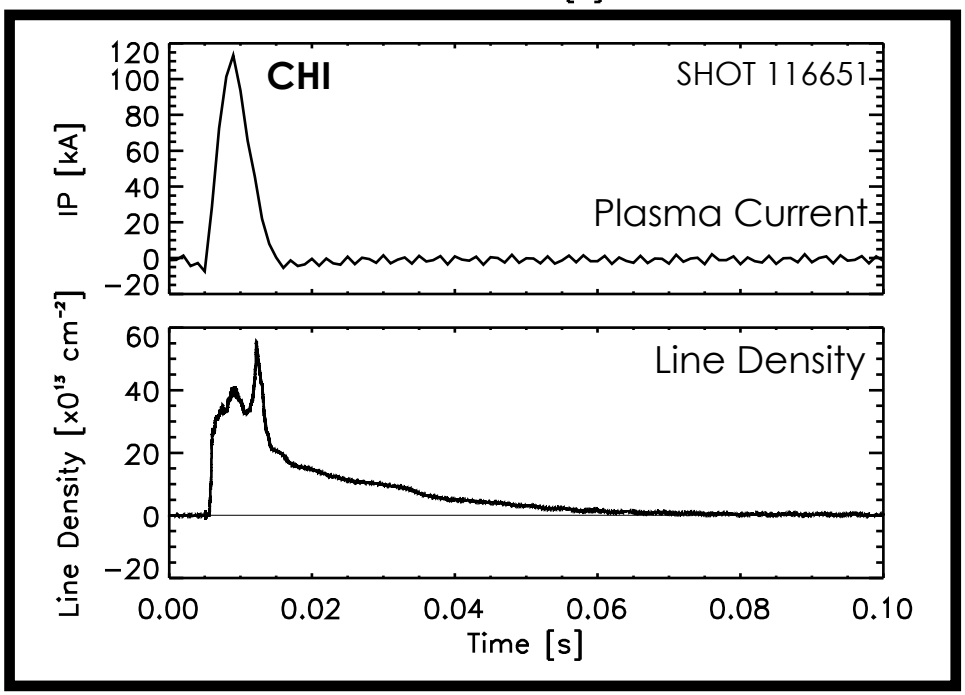


- **Radial mode structure is visible.**

1mm Interferometer Provides Time-Resolved Line Density







- Valuable for studying coherent modes and turbulence.
- Can provide constraint on fluctuation levels at midplane.
- Data partially available on tree. Need to start looking at this.

Summary and Future Work

- Reflectometry and interferometry making full use of assigned NSTX ports for time-resolved local and line-integral measurements of electron density.
- Correlation measurements in a variety of discharges:
  - Δr vs ρ_N profiles are resilient.
  - δn/n from full-wave codes.
  - Big change seen for Ohmic H-modes; radial correlation lengths decrease by ~1/2.
- 1-D & 2-D FW with turbulence model used to simulate reflectometer response.
  - Δr is sensitive to δn/n and k_r spectrum.
  - Comparison with experiment and other diagnostics is still ongoing to assess validity of these calculations.
- For FY06 and onward:
  - Time-resolved poloidal and radial correlation measurement capability. **Radial propagation, poloidal correlation lengths and flows.**
  - Quantitative estimates of **radial structure and amplitude** of Alfven eigen-modes. Combination of multiple quadrature systems to use single pair of midplane horns. Boost repetition rate of profile reflectometers.
  - Improved time response for 1 mm interferometer (use of heterodyne).