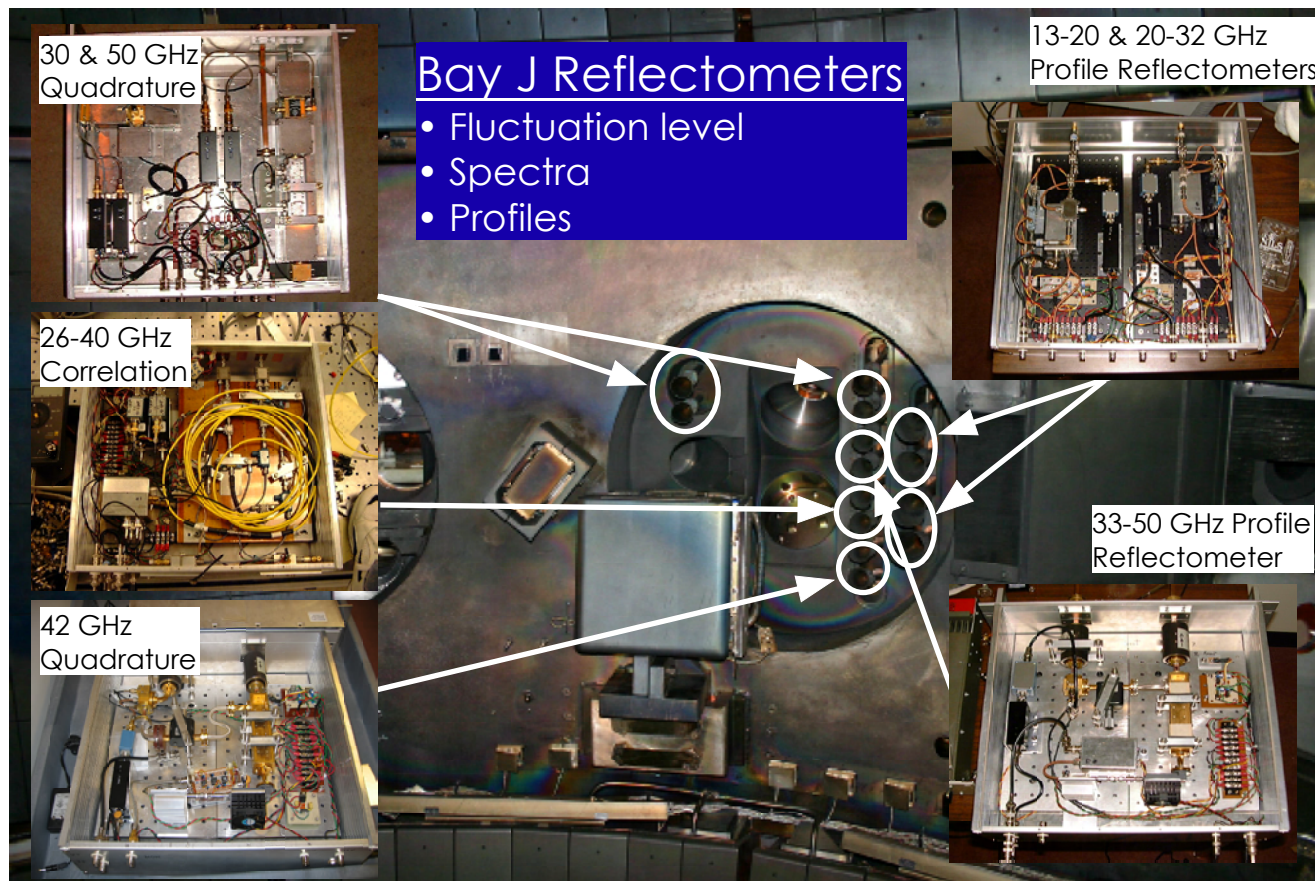


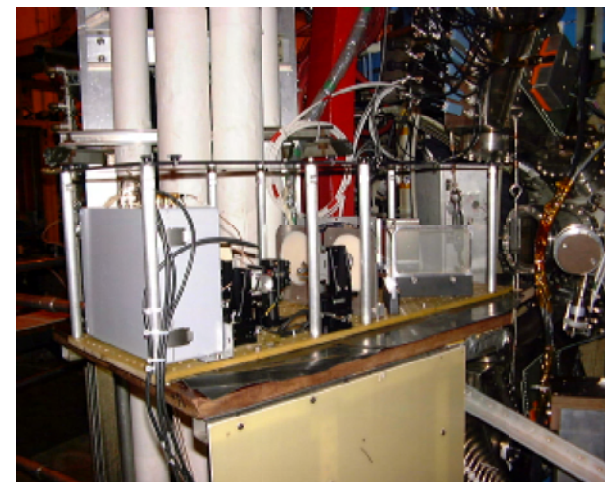
Reflectometry and Interferometry Measurements of Density Profiles and Fluctuations in NSTX

S. Kubota, W.A. Peebles, N.A. Crocker, D.R. Mikkelsen, C.E. Bush, G.J. Kramer, R.E. Bell, S.M. Kaye, B.P. LeBlanc & the NSTX Team



Bay G Interferometer

- Radial line density
- Operating routinely

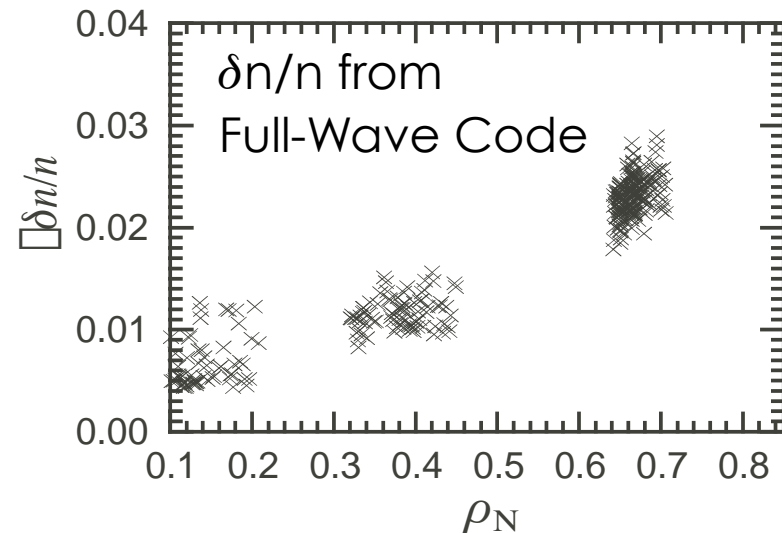
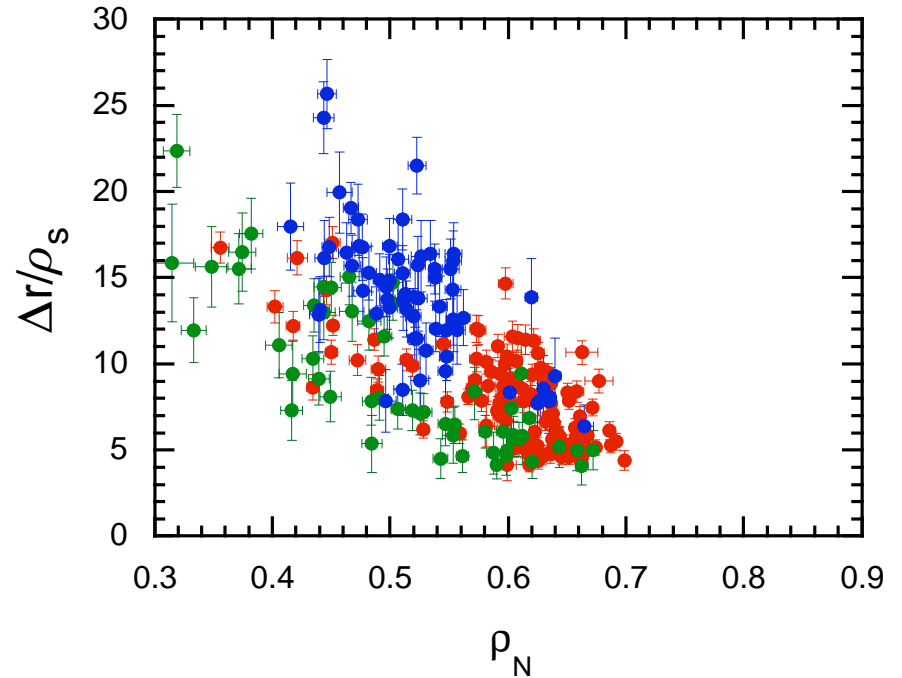
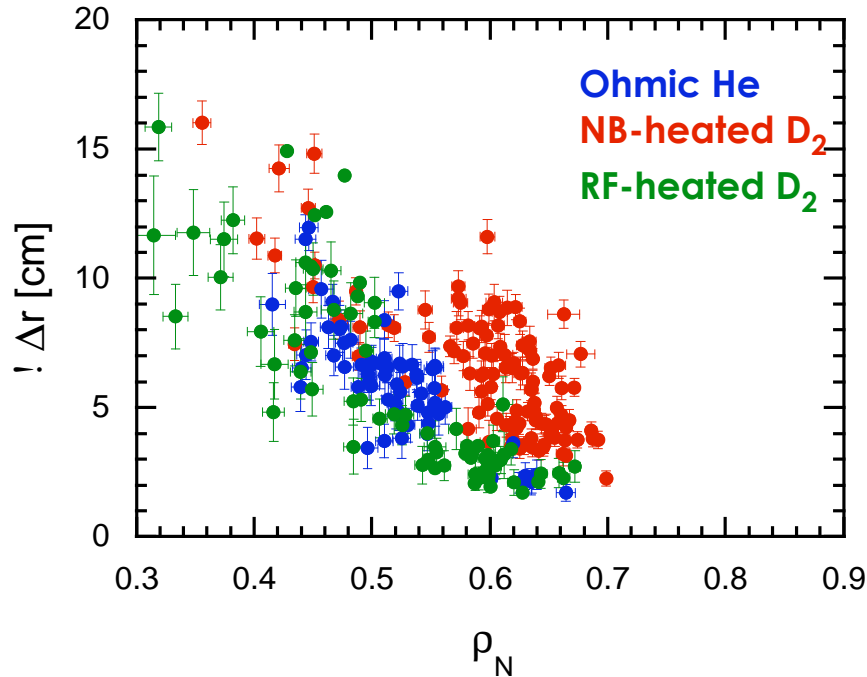


- Array of microwave diagnostics for density measurements.
- Turbulence measurements in a variety of plasmas.
- Full-wave simulations for reflectometer response to modeled turbulence.

Δr Compared in a Variety of Plasmas



Ohmic(He)/NB-heated(D₂)/RF(D₂)

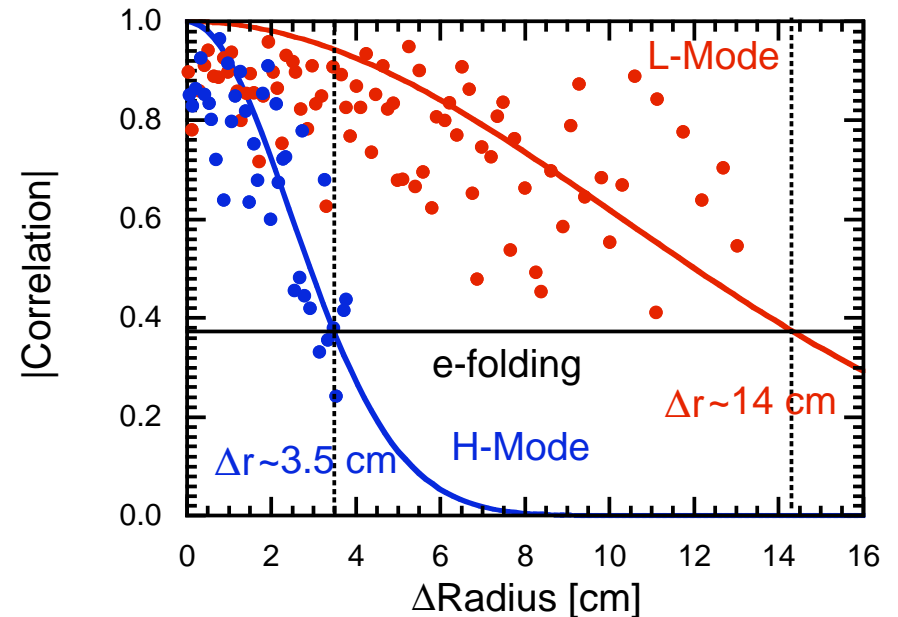
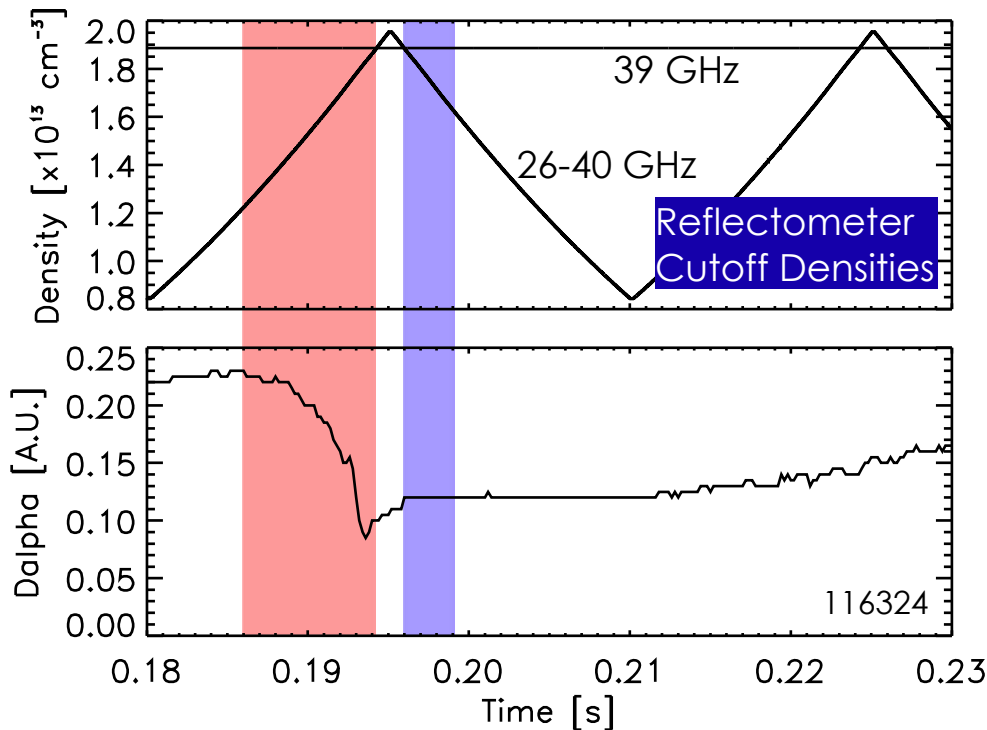
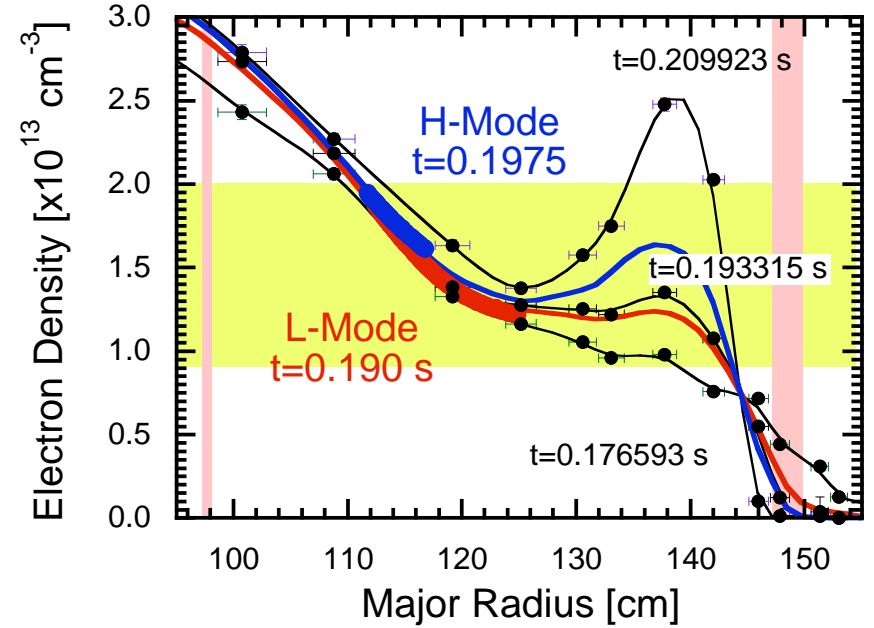


- Ohmic (He), RF- & NB-heated L-modes.
 - $\Delta r \sim 15$ cm are seen irrespective of heating method.
 - AEs are missing in RF and ohmic He case; rules out turbulence due to fast particle-driven modes.

Correlation Length Reduced by $\sim 1/2$ in Ohmic H-Modes



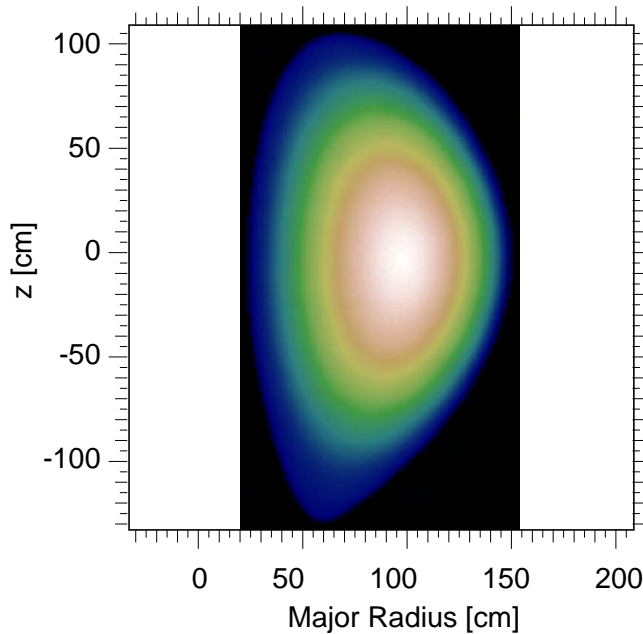
- Core measurement of ohmic H-mode discharges around L-H transition.
- ~ 5 - 10 ms window for single Δr measurement before rise of edge density ear.
- Other turbulence properties remain constant in core.
- **Typical Δr change from ~ 14 to ~ 7 cm.**
- **Δr decrease consistently seen.**



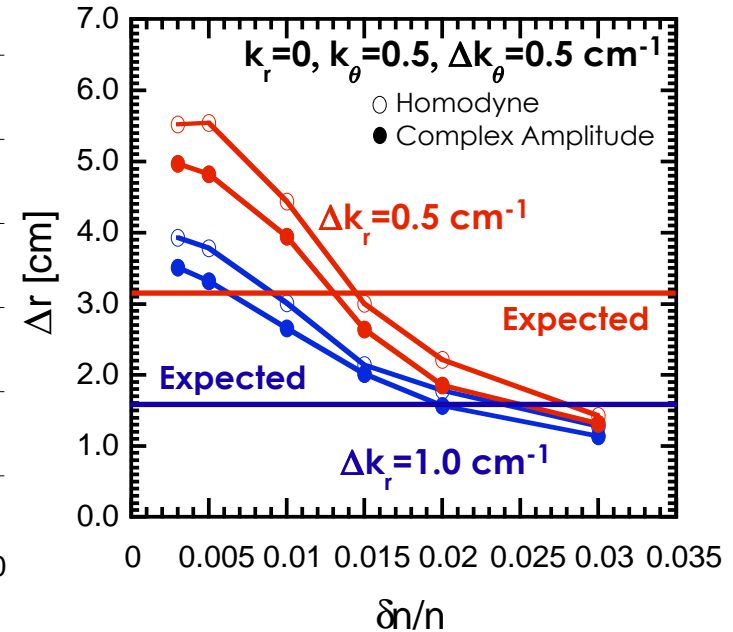
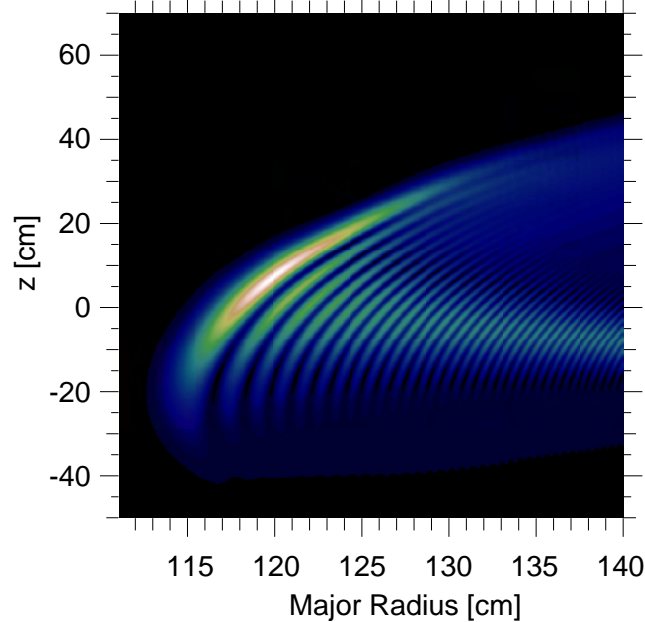
Modelling of Reflectometer Response To Turbulence Using Full-Wave Codes (Collaboration with G. Kramer)



Density Contours



Wave Amplitude for 42 GHz O-Mode

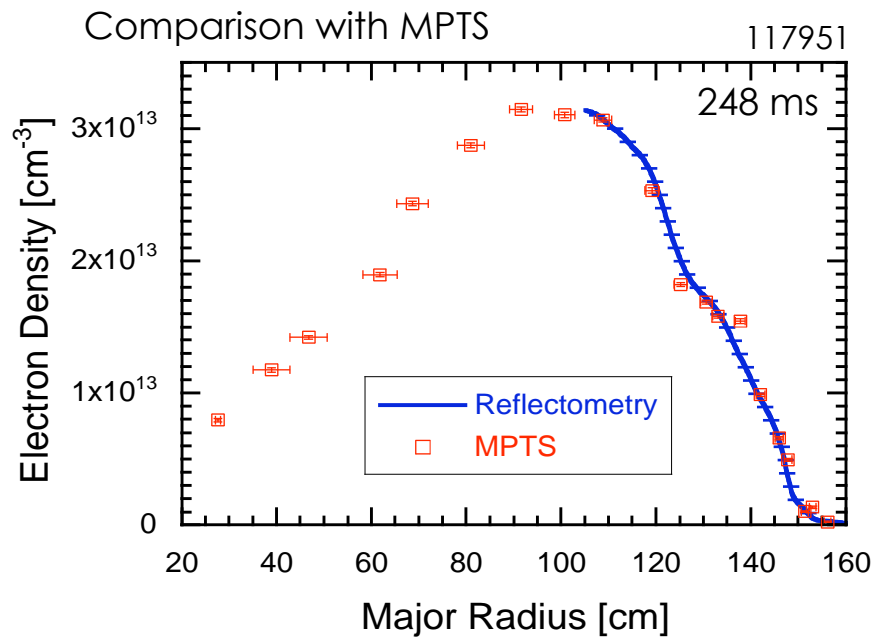
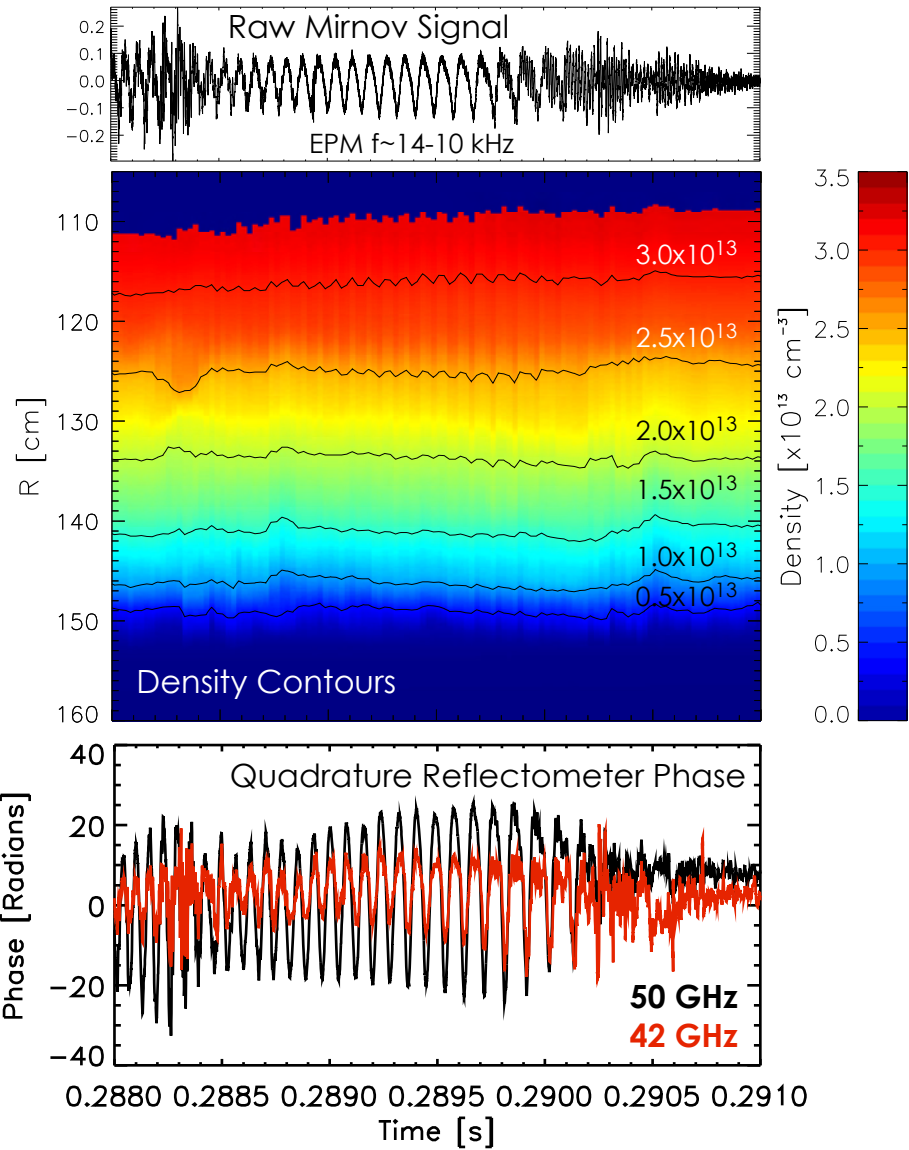
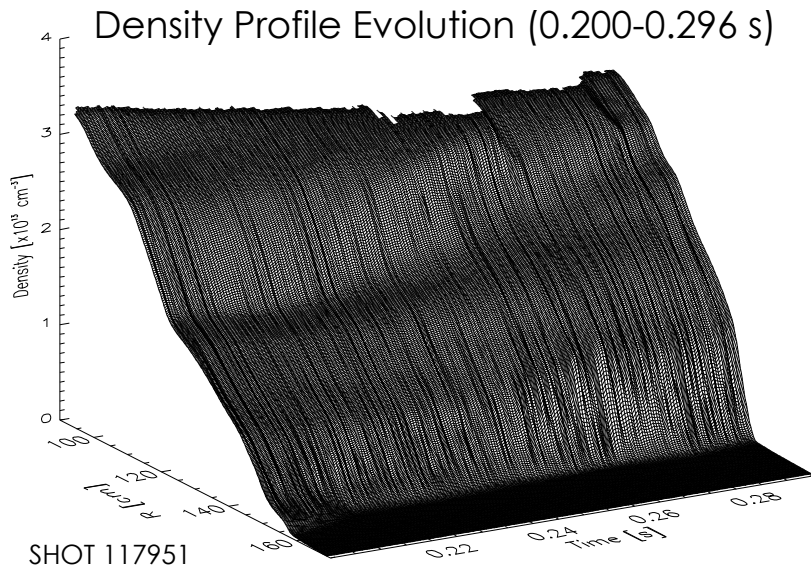


- Model complex reflectometer response to turbulence $(\delta n/n, \Delta r, k)$ in 1-D and 2-D.
- Full-wave codes: **PPPL 2-D code FWR2D. UCLA 1-D FDTD code.**
- Turbulence model: superposition of sinusoids with random phase and obeying

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

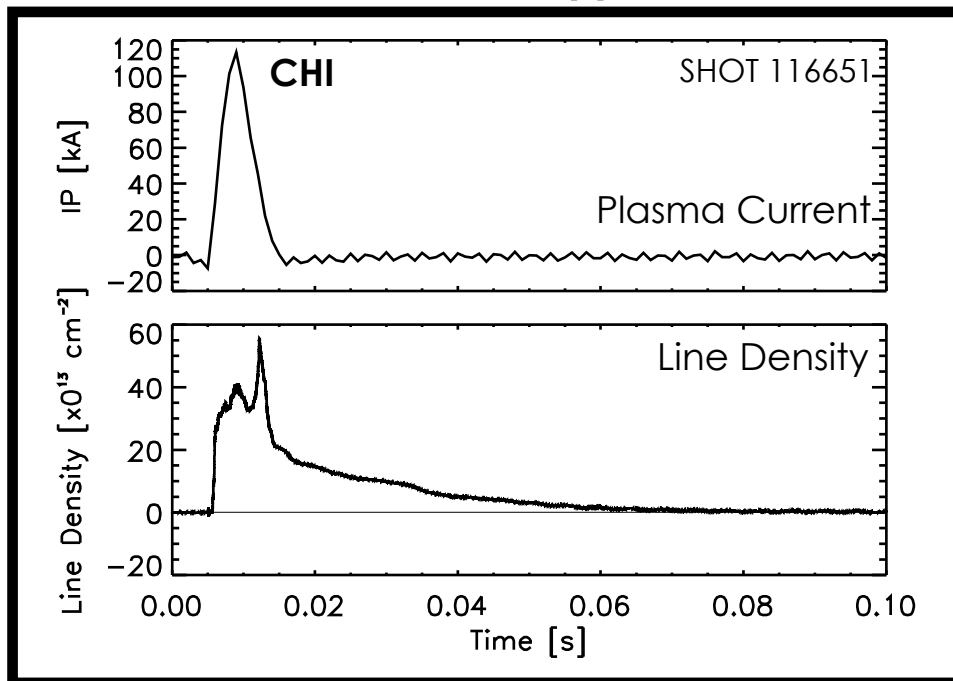
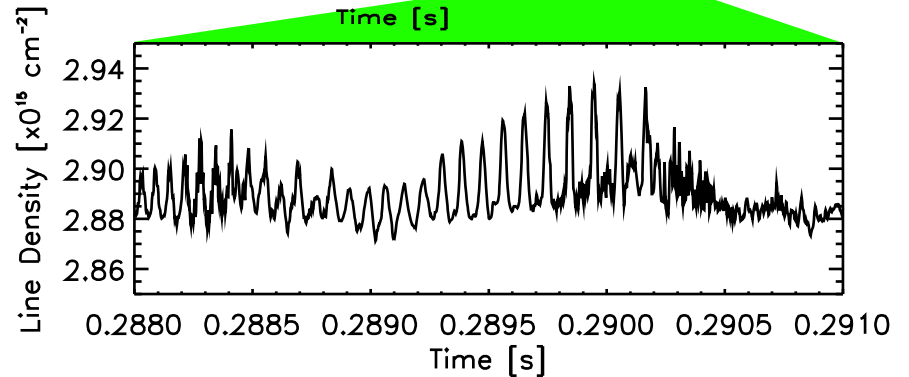
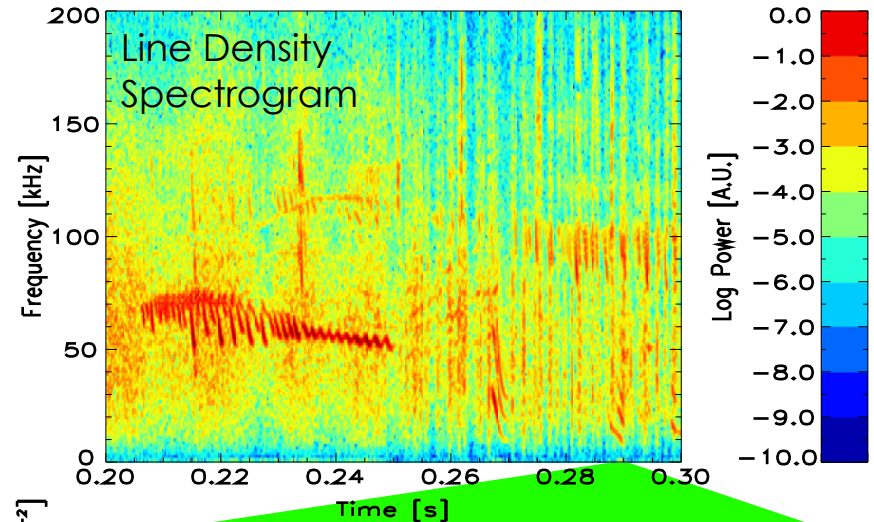
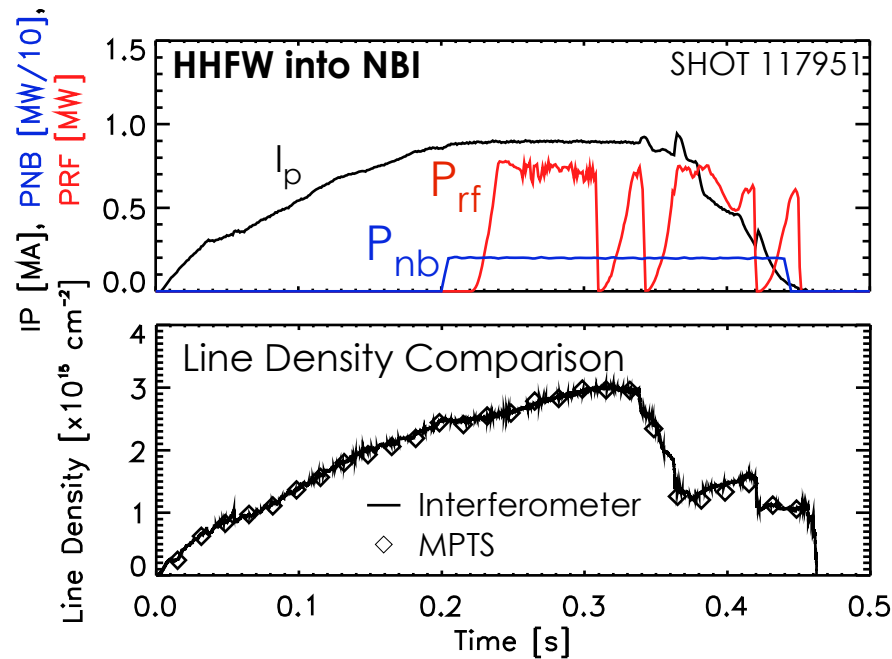
- **Main result: Δr can vary strongly with $\delta n/n$ and k spectrum.**
- Corroboration of code/turbulence model with experiments is still limited.
Definitive test to be performed on DIII-D including detailed comparison with BES.

Fast Profile Measurements With $25 \mu\text{s}$ 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.
 - $\delta n/n$ from full-wave codes.
 - Big change seen for Ohmic H-modes; radial correlation lengths decrease by $\sim 1/2$.
- 1-D & 2-D FW with turbulence model used to simulate reflectometer response.
 - Δr is sensitive to $\delta n/n$ 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 Alfvén eigenmodes. 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).