A Beam Emission Spectroscopy Density Fluctuation Diagnostic for NSTX

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Outline

- **Motivation for a BES System on NSTX**
- **BES Measurement Capabilities**
- **Radial Localization Considerations**

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THE UNIVERSITY of WISCONSIN MADISON

MOTIVATION TO IMPLEMENT A BES SYSTEM ON NSTX

- **Stability to low-k fluctuations predicted for ST plasmas**(C. Bourdelle)
- **Very low (near neoclassical) ion confinement observed in some regimes**
- **BES system would complement existing fluctuation diagnostics and provide added capabilities to measure long-wavelength density fluctuations**
- **Opportunity to compare and contrast turbulence behavior in ST and Tokamak**
  - Extend dimensionless scaling studies (Aspect ratio, β)
- **Longer-Term: Contribute to the validation of turbulence simulations**
- **Also measures xAE,NTM Mode structure, ELM, Pedestal dynamics**

Linear Growth Rate Calculation

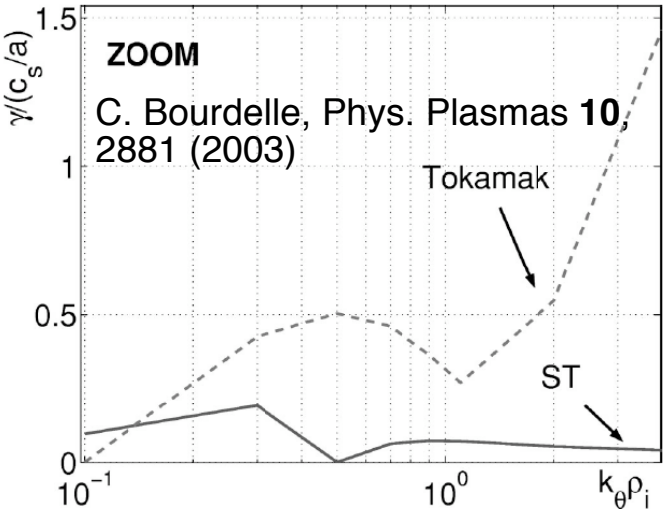


FIG. 8. Enlargement of Fig. 7 in the low $k_\theta \rho_i$ zone for the tokamak-like case, dashed line, and the ST-like case, solid line.

B. LeBlanc, Nucl. Fusion **44**, 513 (2004)

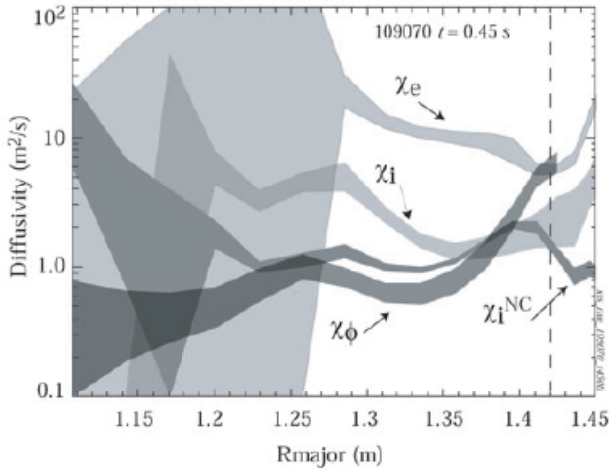


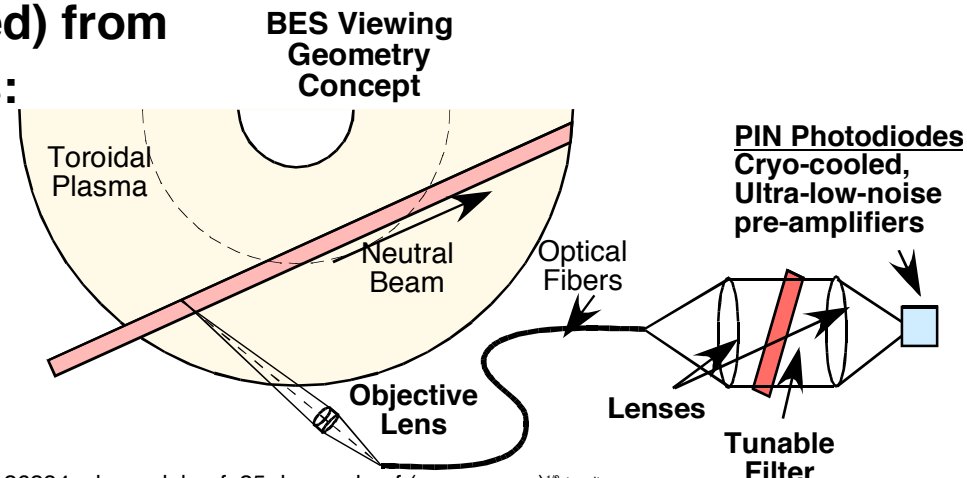
Figure 7. Experimental thermal diffusivity profiles against major radius R during high power NBI heating: electron thermal, χ_e, ion thermal, χ_i, and momentum, χ_ϕ. Neoclassical calculation of ion thermal diffusivity, χ_i^{NC}.

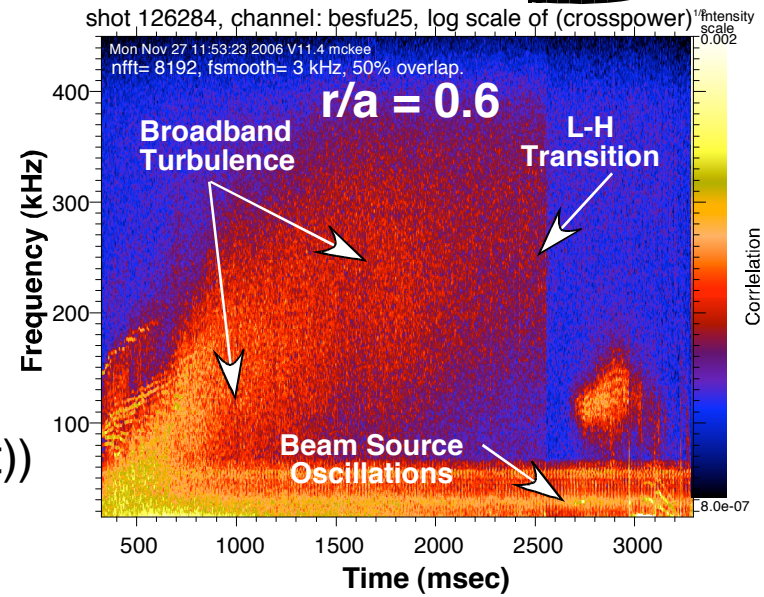
BES Measures Spatio-Temporal Characteristics of "Long-Wavelength" ($k_\perp \rho_I < 1$) Density Fluctuations

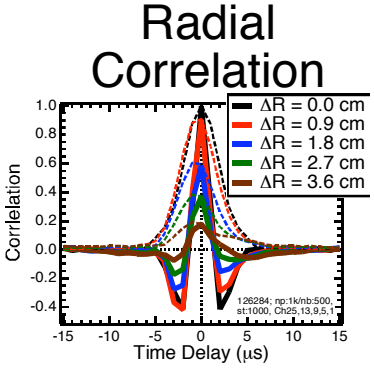
- **Measures intensity of D_α (Doppler-shifted) from collisionally-excited neutral beam atoms:**
  - Relate *I* to *n* (via atomic physics)
  - Core, edge & SOL
  - ΔR, $\Delta Z \sim 1$ cm,
  - Multi-channel (R,Z) ==> 2D imaging

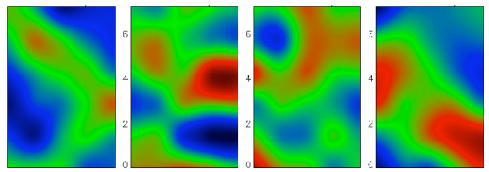
Turbulence Properties Measured:

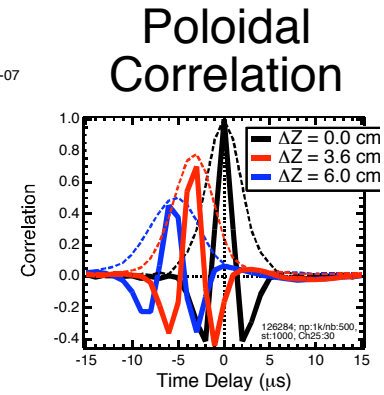
- Local Turbulence Spectra
- Fluctuation amplitude ($\tilde{n}/n$)
- Correlation Lengths: $L_{c,r}$, $L_{c,\theta}$
- Decorrelation Time, τ_c
- Poloidal advection, v_θ
- Eddy structure via imaging
- Time varying poloidal flows ($\tilde{v}_\theta(t)$) (Zonal Flows, GAMs)
- Bispectra, phase coherence (nonlinear: energy transfer)
- Velocity Field ($\mathbf{v}(r,\theta,t)$ via velocimetry











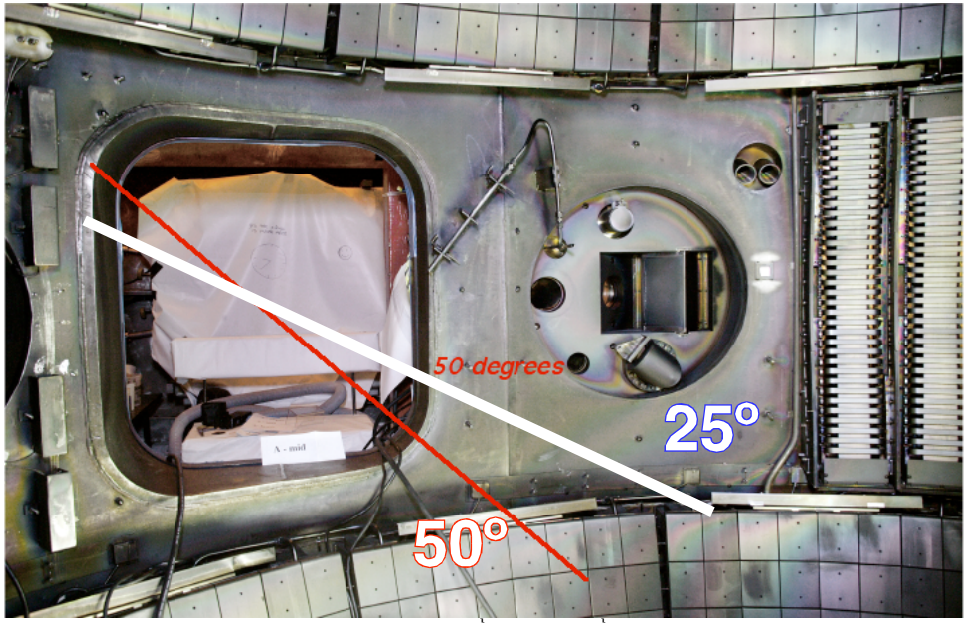
Radial Localization & Spatial Resolution

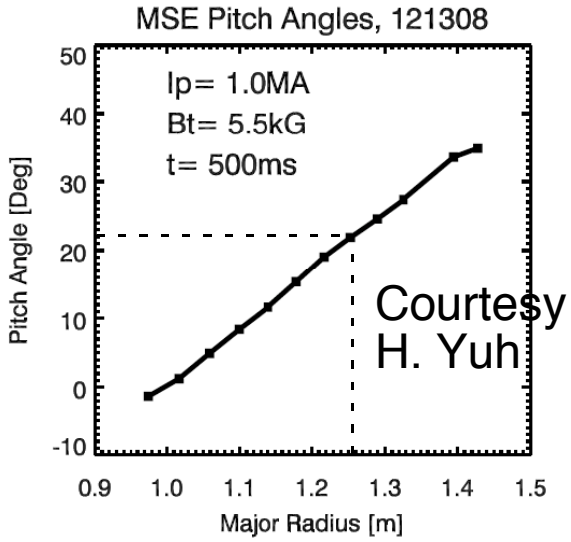
- **High T_I, low B_T ==> Large ρ_I, $L_{c,r}$**
  High spatial resolution and wavenumber sensitivity, $L_{c,r}$: 2-20 cm
  (S. Kubota, APS-06, S. Zweben, GPI)

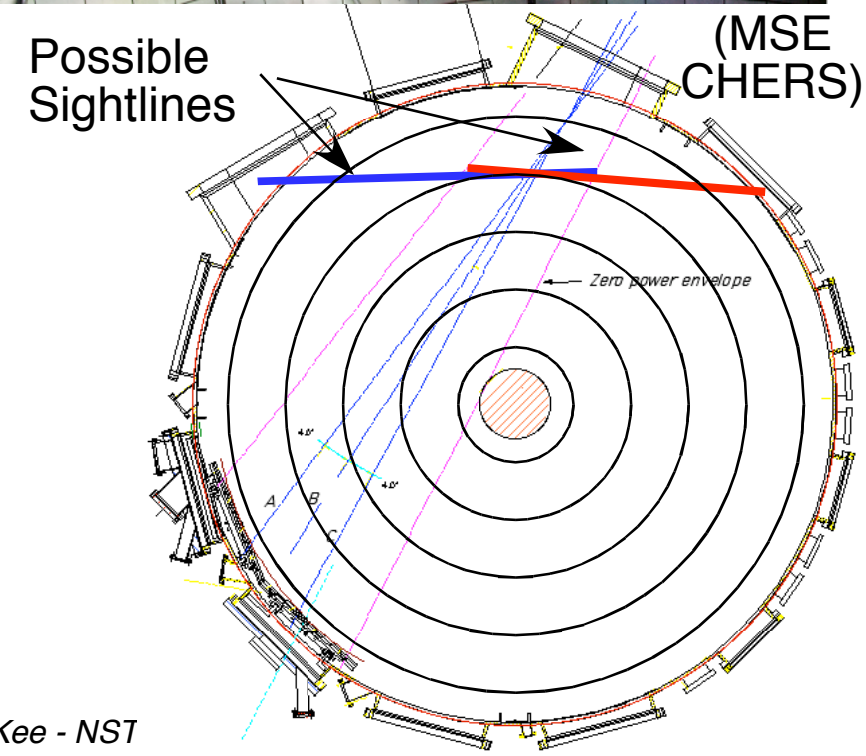
- **Spatial resolution and radial coverage will depend sensitively on local magnetic field pitch angle:**
  - *Target r/a=0.5-0.75*
  - *Pitch angle, $\theta \approx 20°$-30°*
  - *Optical sightline a challenge*

- **Carbon edge lines near 658 nm?**
  - *Counter-viewing geometry (like DIII-D)*

- **3 NB Sources**







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