High Speed Imaging of Edge Turbulence in NSTX

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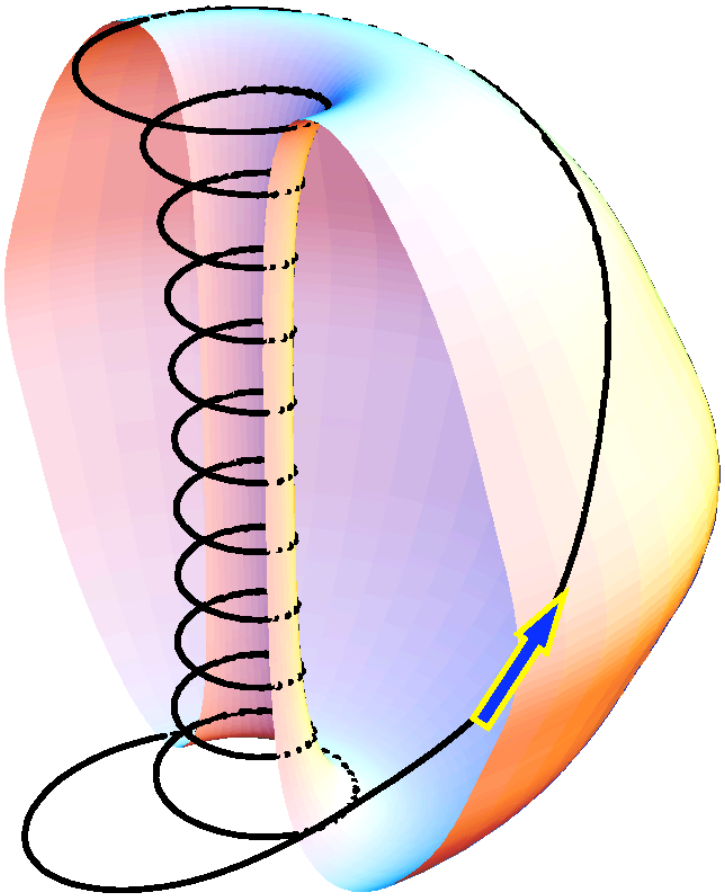
Outline

- NSTX
- Gas puff imaging diagnostic
- GPI image and time series analysis
- Summary
- Plans

NSTX



R = 85 cm

a = 68 cm

A = 1.25

I ≤ 1.5 MA

B ≤ 6 kG

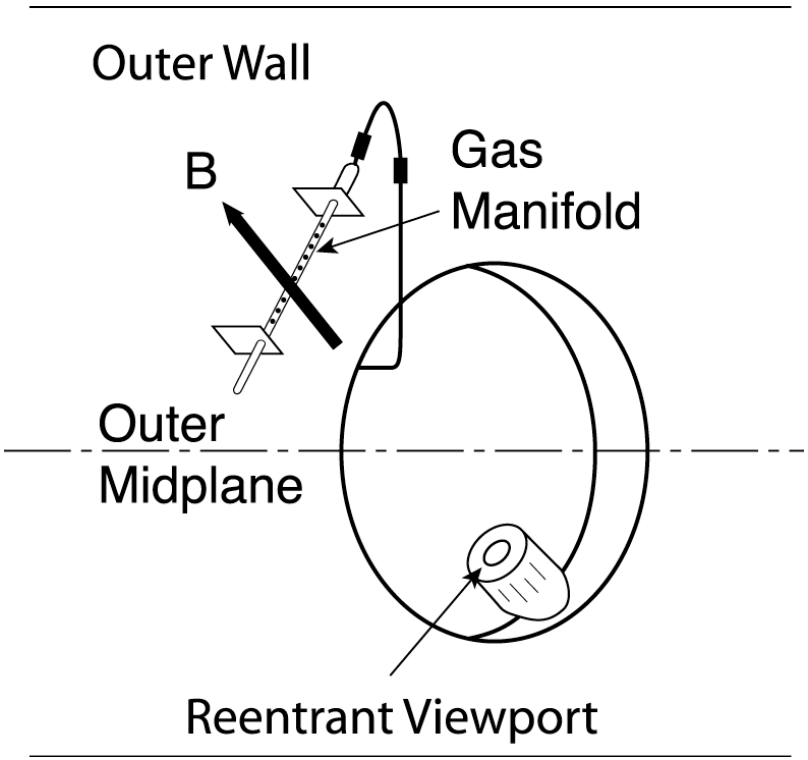
5 MW NBI

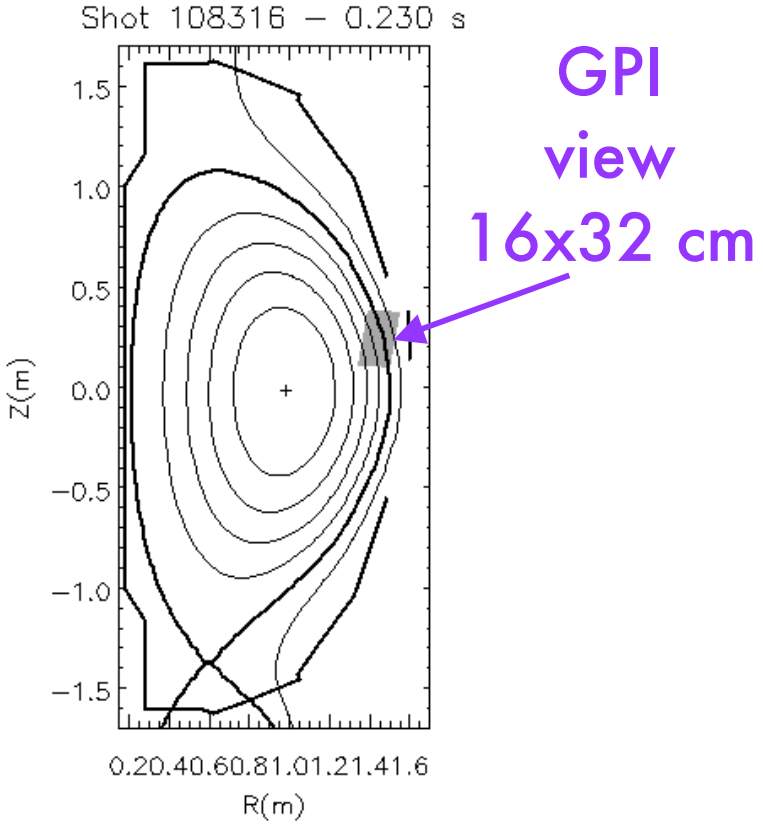
6 MW ICRH

$\beta_T \leq 35\%$

Gas Puff Imaging Diagnostic

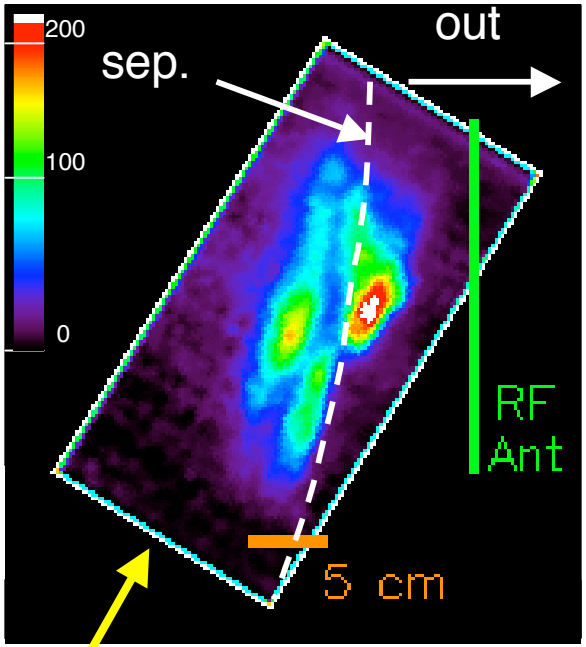
- Look at HeI(587.6 nm) from gas puff I $n_o n_e f(n_e, T_e)$
- View along B field line to see 2-D structure ⊥ B



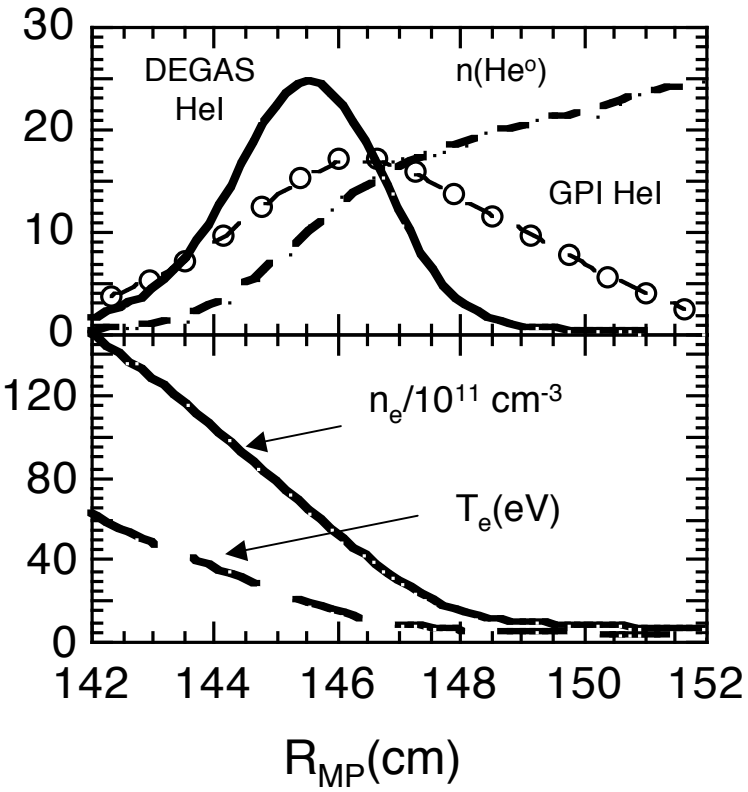


Typical GPI Image

- Use typically 10 μsec exposure time (τ_{ac} ≈ 40 μsec)
- Average HeI light intensity peaked near separatrix



PSI camera frame
80 x 160 pixels



GPI Diagnostic Interpretation

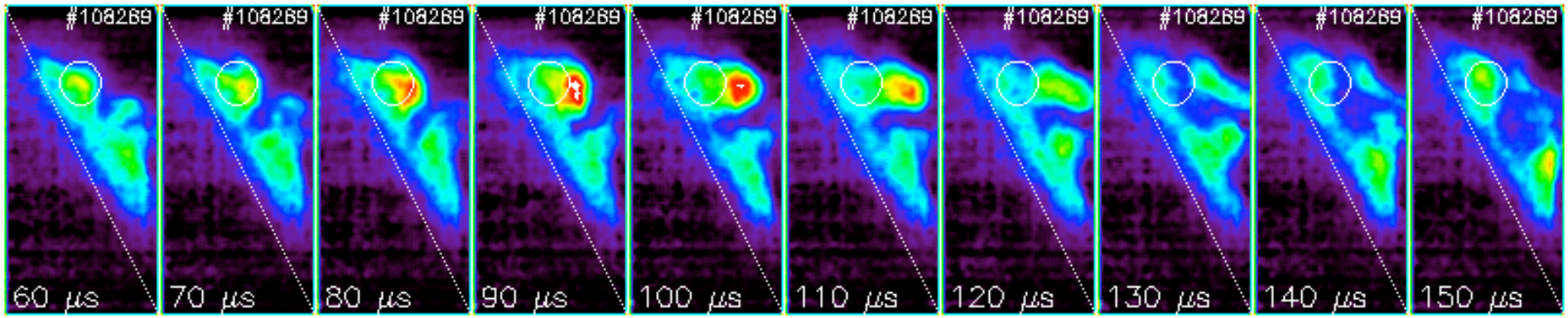
- HeI light emission "I" visible where $5\ eV < T_e < 50\ eV$
- I $n_e^{\alpha} T_e^{\beta}$, where $\alpha \approx 0.5$ and $\beta \approx 0.7$ near center of cloud
- Space-time structure of I similar to n_e, but $\tilde{I}/I \approx \alpha\, \tilde{n}_e/n_e$
- Fluctuation spectra of I similar to probe and reflectometer

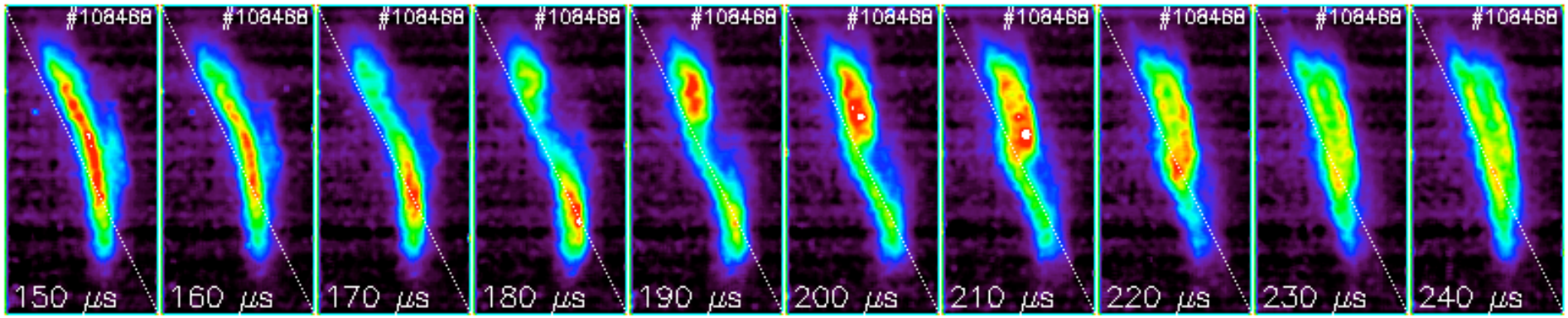
GPI light gives approximate structure of edge turbulence

High Speed Imaging of NSTX Edge

100,000 frames/sec at 10 μsec/frame for 28 frames/shot

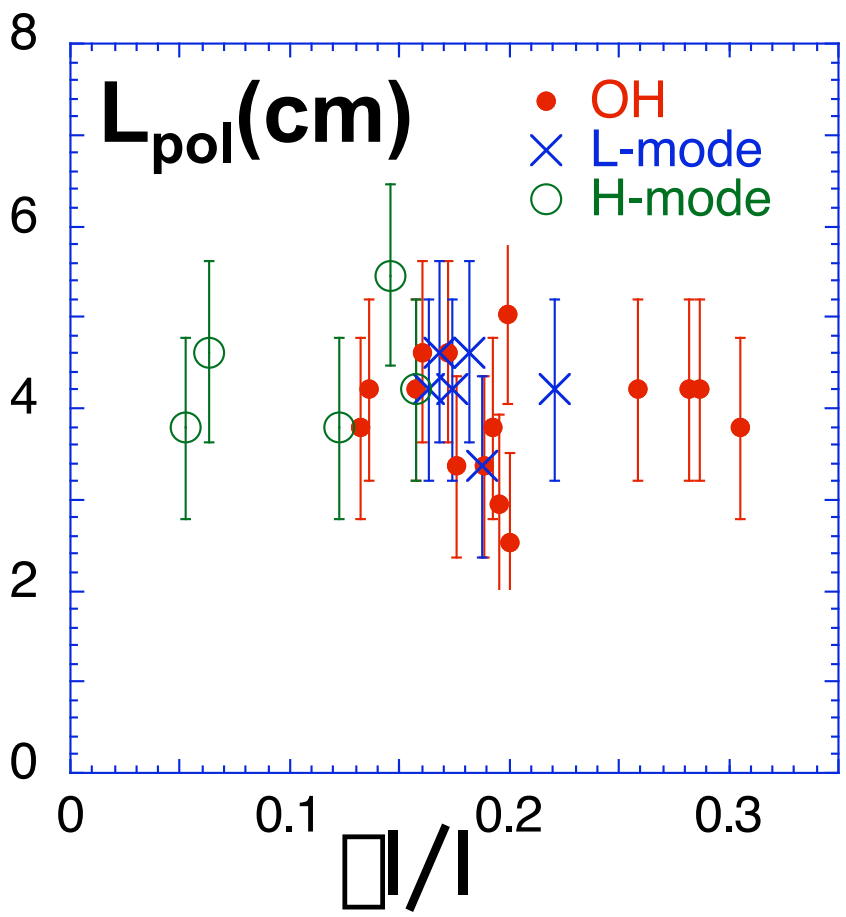
[Princeton Scientific Instruments PSI-4]

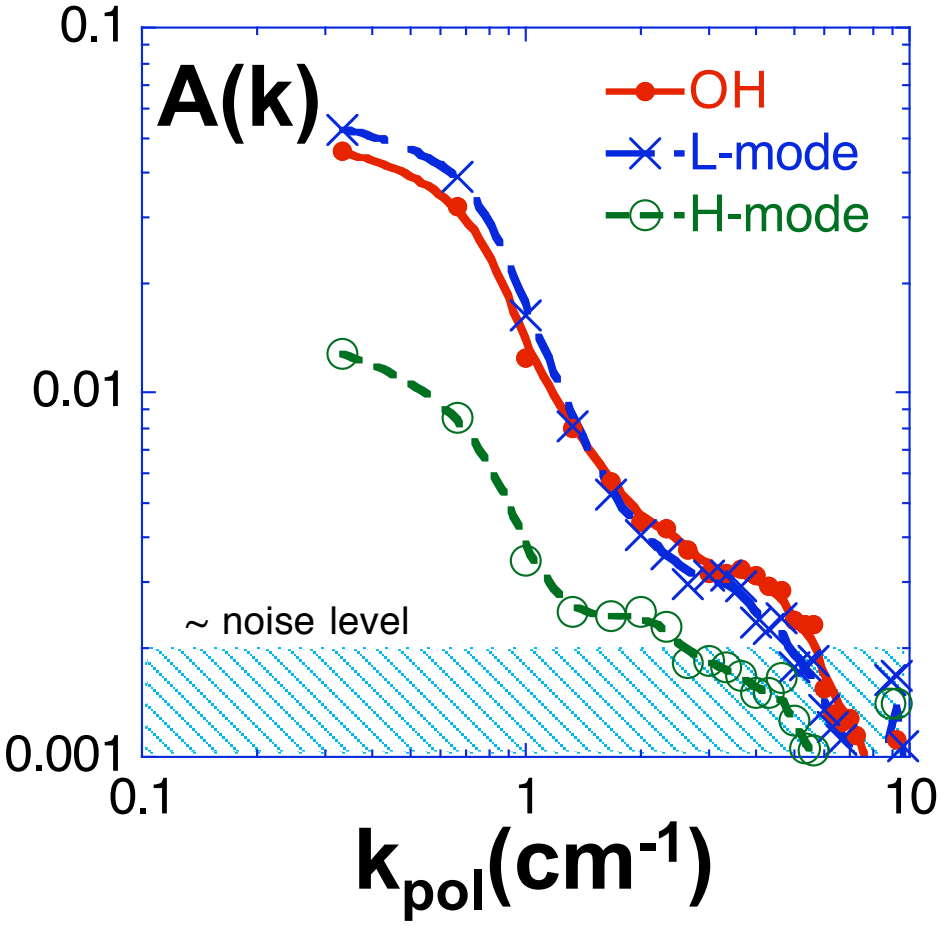




Poloidal Correlation Length and k-spectra

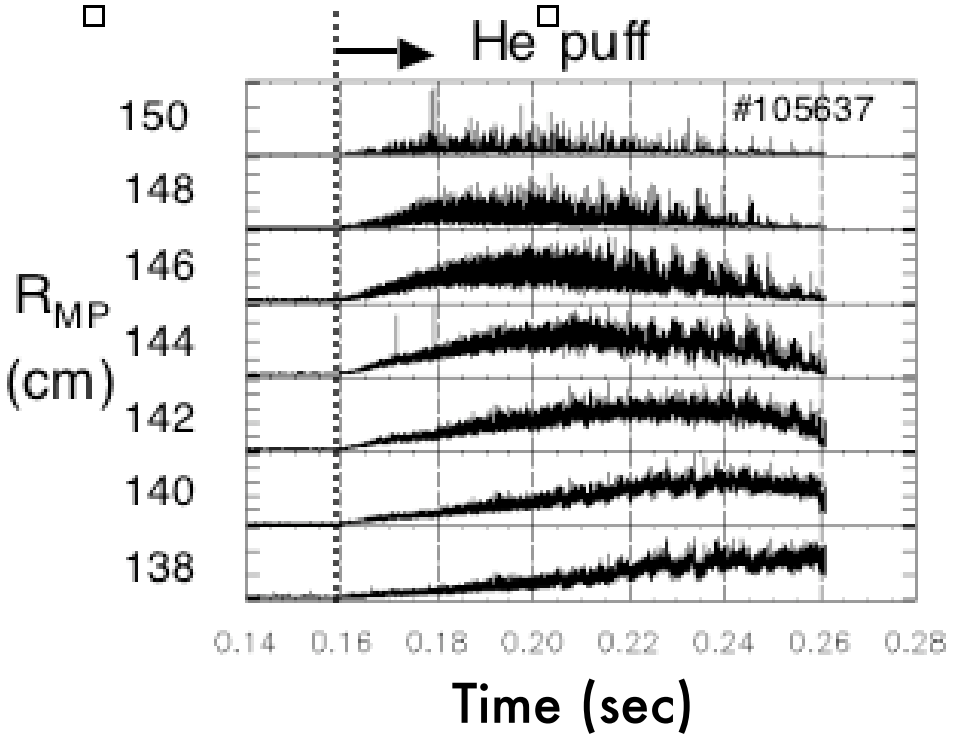
- $L_{pol} \approx 4$ cm or $k_{pol} \rho_s \approx 0.2$ (similar to other experiments)
- $\delta I/I$ lower in H-mode than L-mode (with much variation)

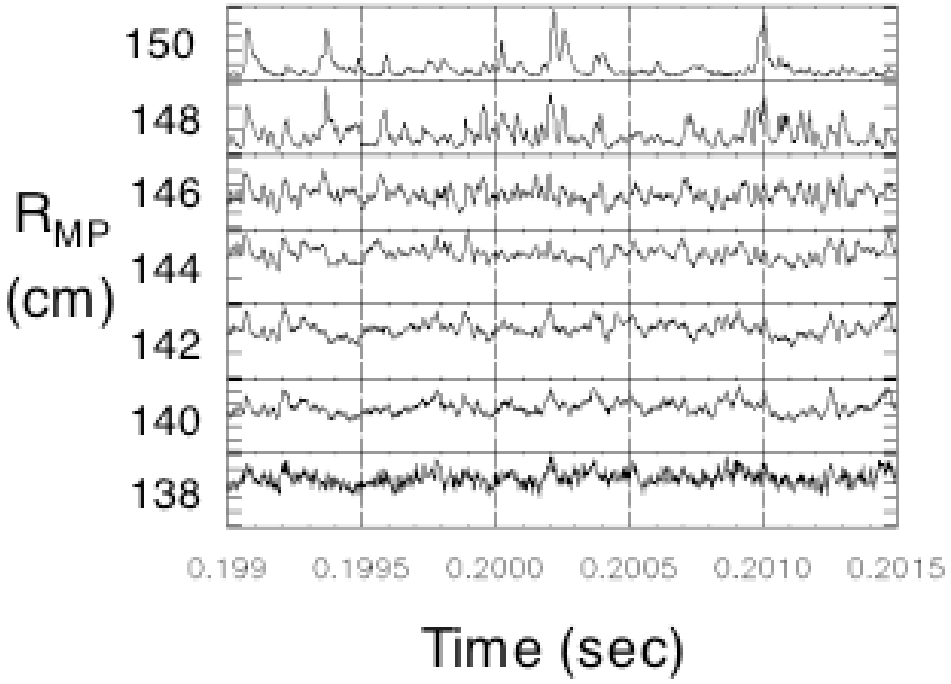




Time Series of GPI Light Fluctuations

- HeI digitized over 1.5 cm diam. chords through images
- Relative fluctuation level larger as R increases (≈ images)





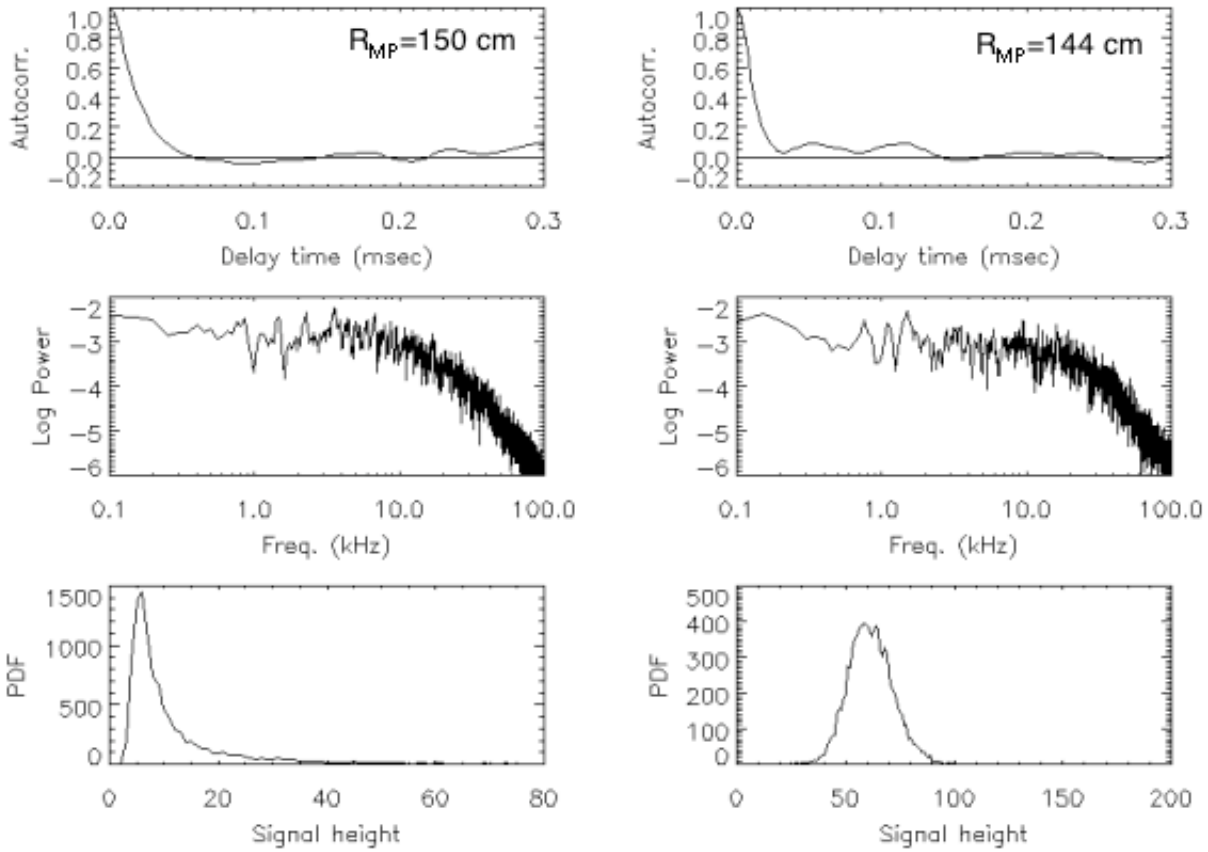
Statistical Analysis of Typical Chords

- Autocorrelation times typically 40 ± 20 μsec
- Frequency spectra broad over ≈ 0.1 - 100 kHz

Autocorrelation function

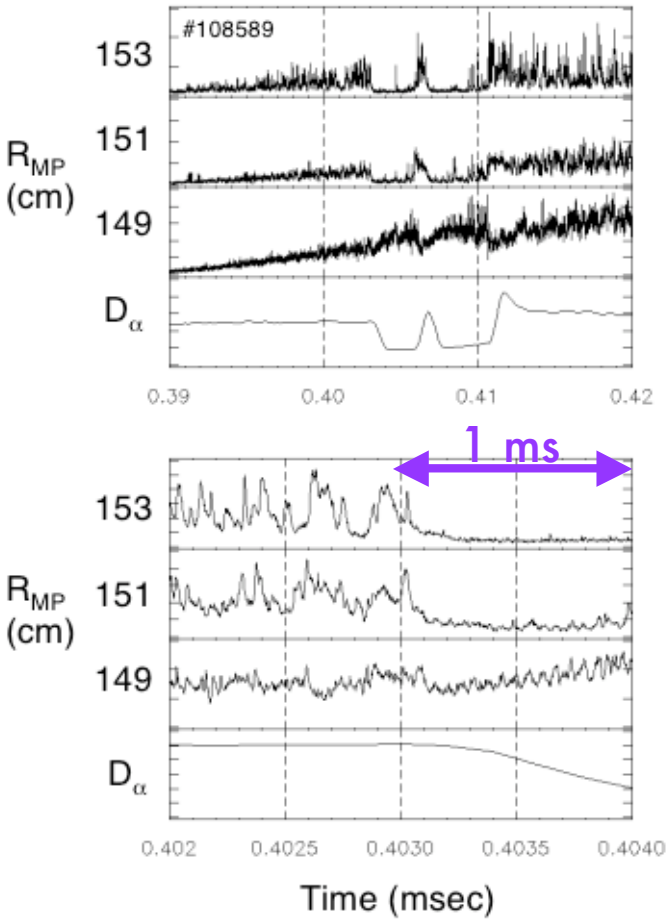
Frequency spectrum

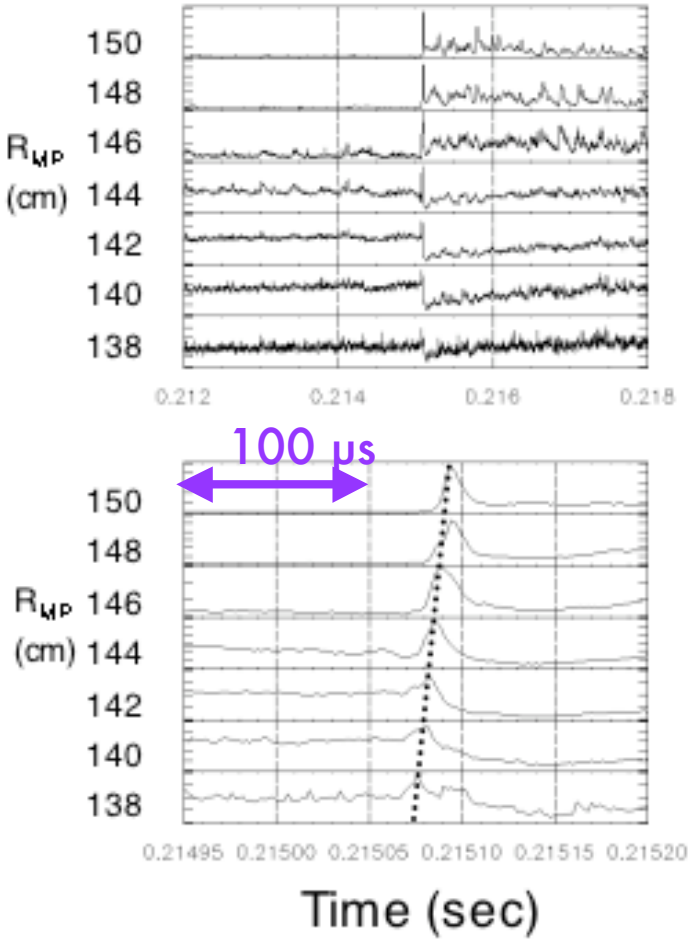
Probability distribution function



L-H and H-L Transitions

- L -> H in ≈ 100 μsec with obvious precursor
- H -> L in 30 μsec with outward radial pulse





Summary of Results So Far

- Images consistent with previous measurements
  - large fluctuation level in edge
  - broad frequency and k-spectrum
  - approx. isotropic structure ⊥ B
- Coherent structures seem to move through edge
  - "blob- like" look similar to DIII-D IPOs
  - "wave-like" look similar to EDA, QCM
- H-mode *generally* more quiescent than L-mode
  - considerable variation in behavior
  - transitions can happen very fast

Plans for Comparison with Theory

Using DEGAS-2 or neutral + atomic physics models:

- Compare GPI with BOUT simulations for H- and L-mode (Xu and Nevins)
- Compare motion of GPI "blobs" with blob model (D'Ippolito and Myra)
- Compare with other simulations…

Plans for Additional Measurements

- Capture H-mode transition with high speed camera
- Get better data on zonal flows in images and chords
- Examine turbulence nearer density limit
- Look during RF heating, e.g. co- vs. ctr. current drive
- Make systematic scans of q(a), rotation, Z_{eff}, etc.
- Make quantitative comparisons with other diagnostics