Search for Edge Zonal Flows in Alcator C-Mod

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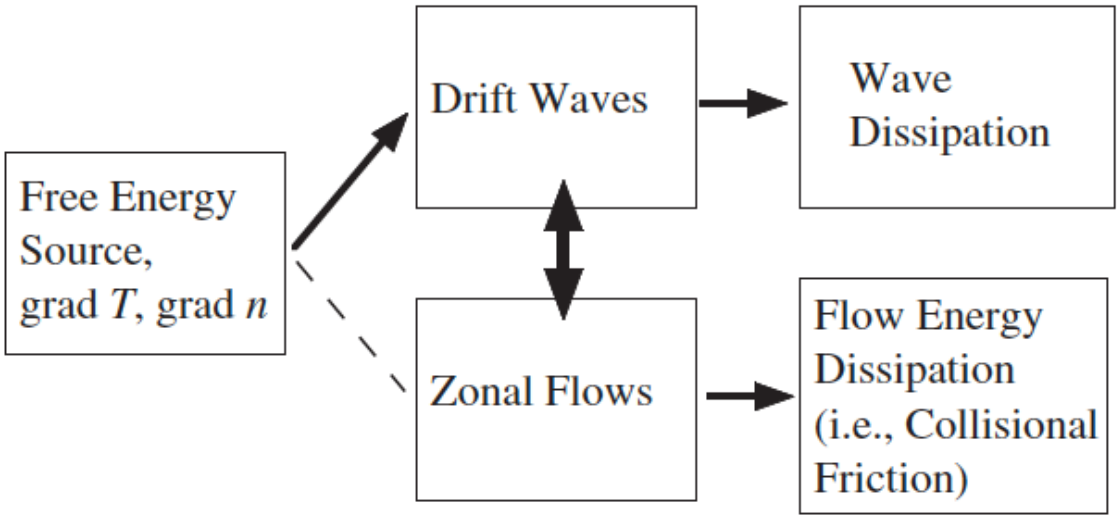
- Motivation
- Methods
- Results

Significance of Zonal Flows

- Zonal flows are m=0 fluid flows, generally with small radial correlation length and low frequency (f < drift waves)
- Zonal flows can reduce energy in drift wave turbulence, and so reduce turbulent radial transport (in theory)



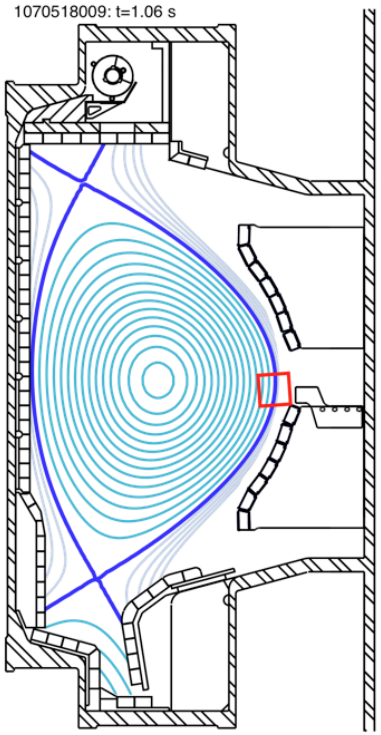
Theory review -
Diamond et al, PPCF '05

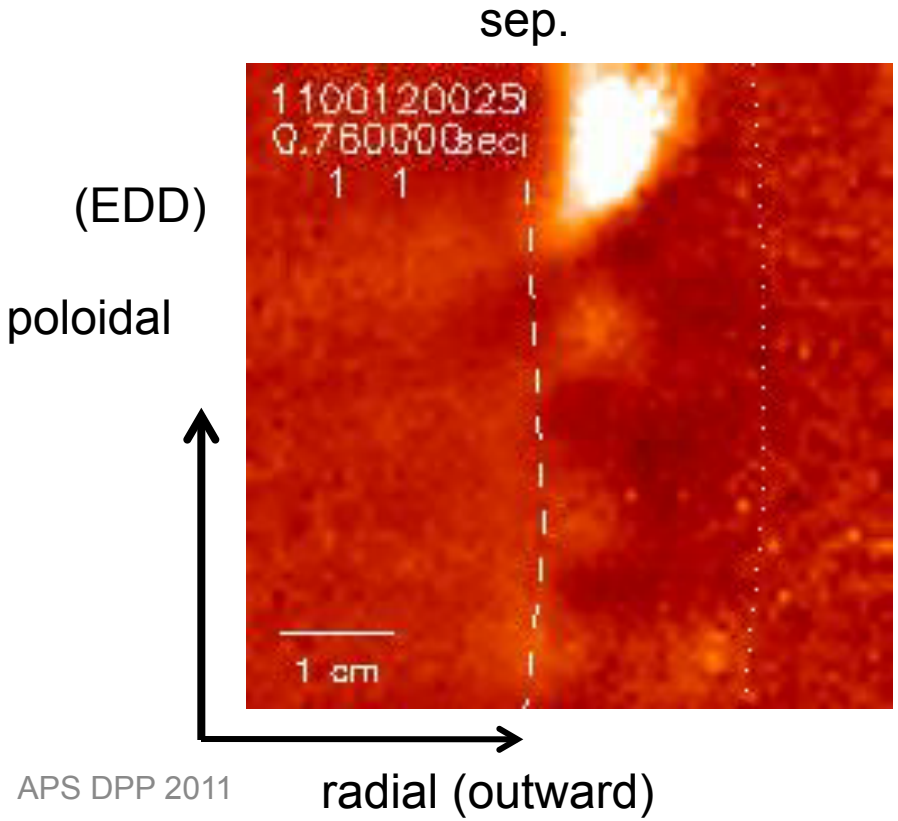
Experimental review –
Fujisawa NF '09

Drift wave review -
Tynan et al PPCF '09

Edge Turbulence Imaging in Alcator C-Mod

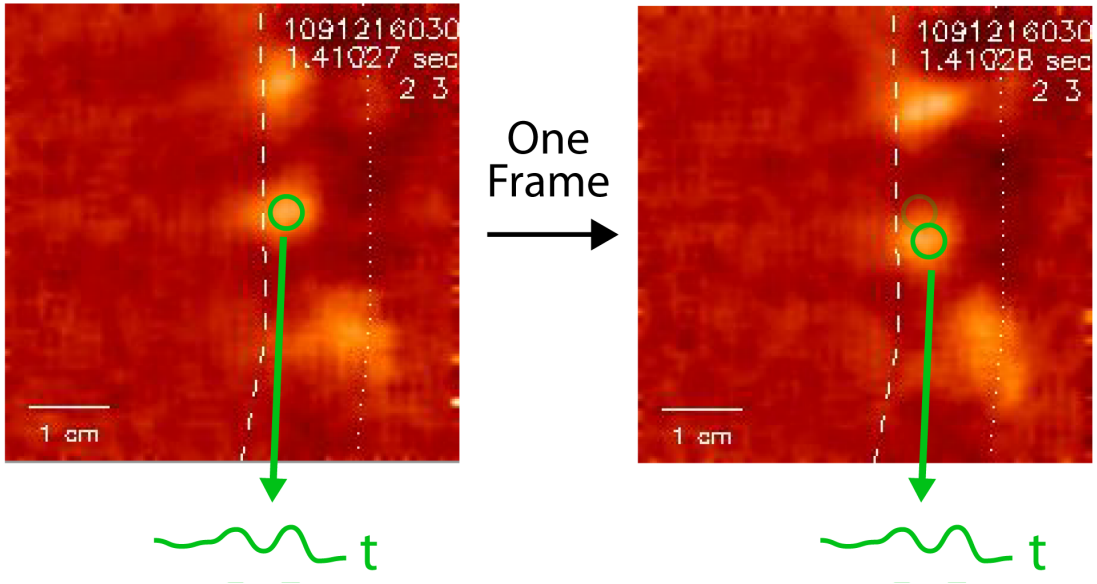
- Gas puff imaging diagnostic using D_2 puff in field of view
- Viewing area along B ~ 6 cm radially x 6 cm poloidally
- Camera imaging 64x64 pixels at 400,000 frames/sec





Method to Evaluate Turbulence Velocity

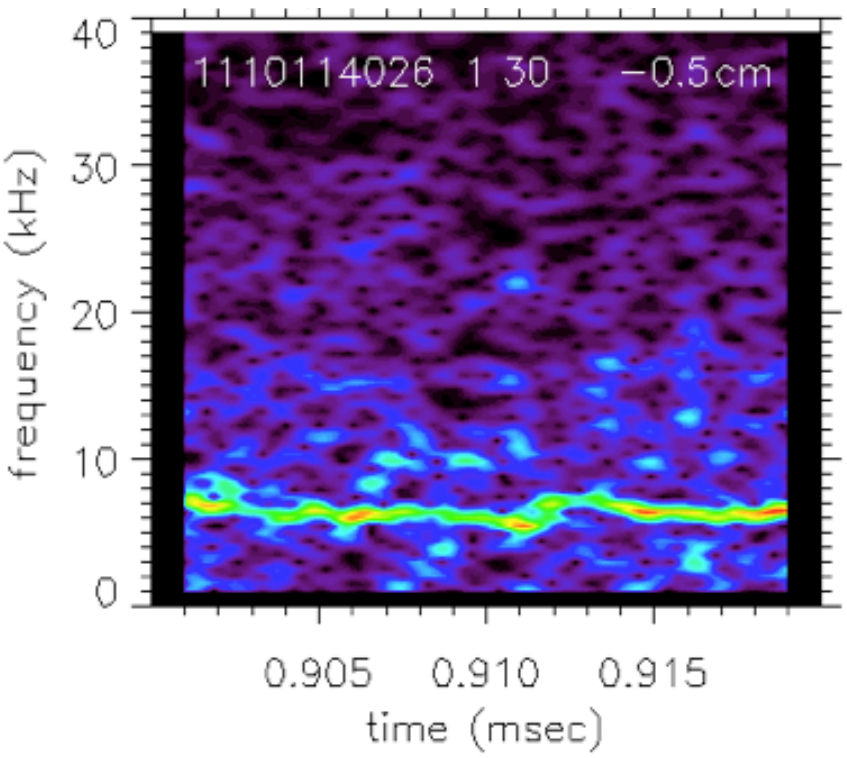
- Use 2-D cross-correlation to find V_{pol} of turbulence in ~ 25 μs
- Average V_{pol} over poloidal field of view (~ 5 correlation lengths)
- Assume V_{pol} of turbulence is the same as poloidal ExB flow velocity (as in BES in DIII-D, Doppler reflectometry in AUG)



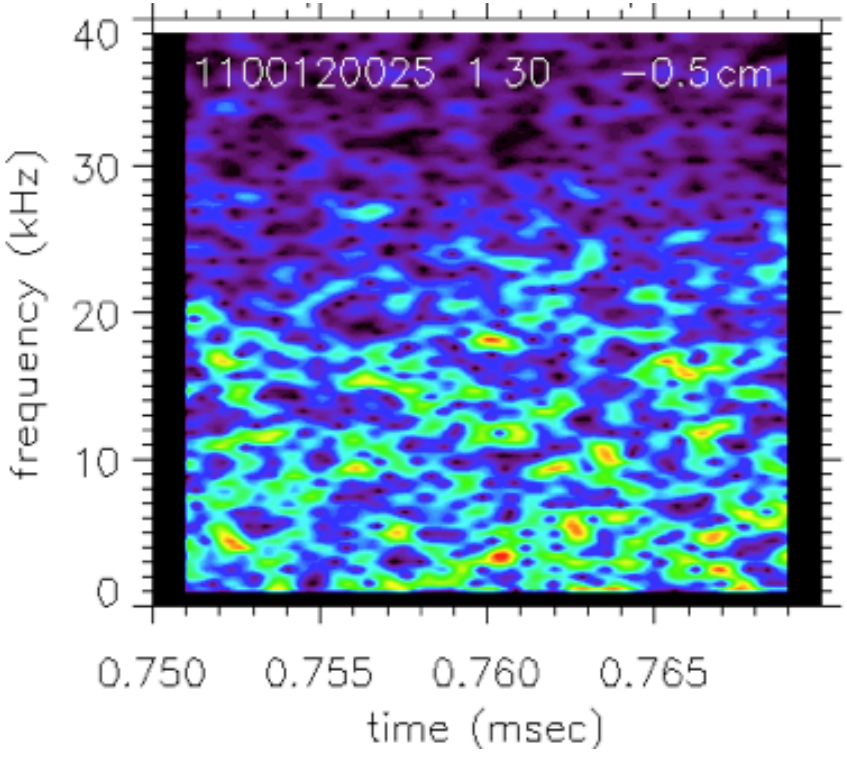
Poloidal Velocity Frequency Spectra

- For some ICRF cases see coherent mode at ~6-7 kHz
- More often broadband, intermittent spectra ~1-20 kHz

coherent mode with ICRF

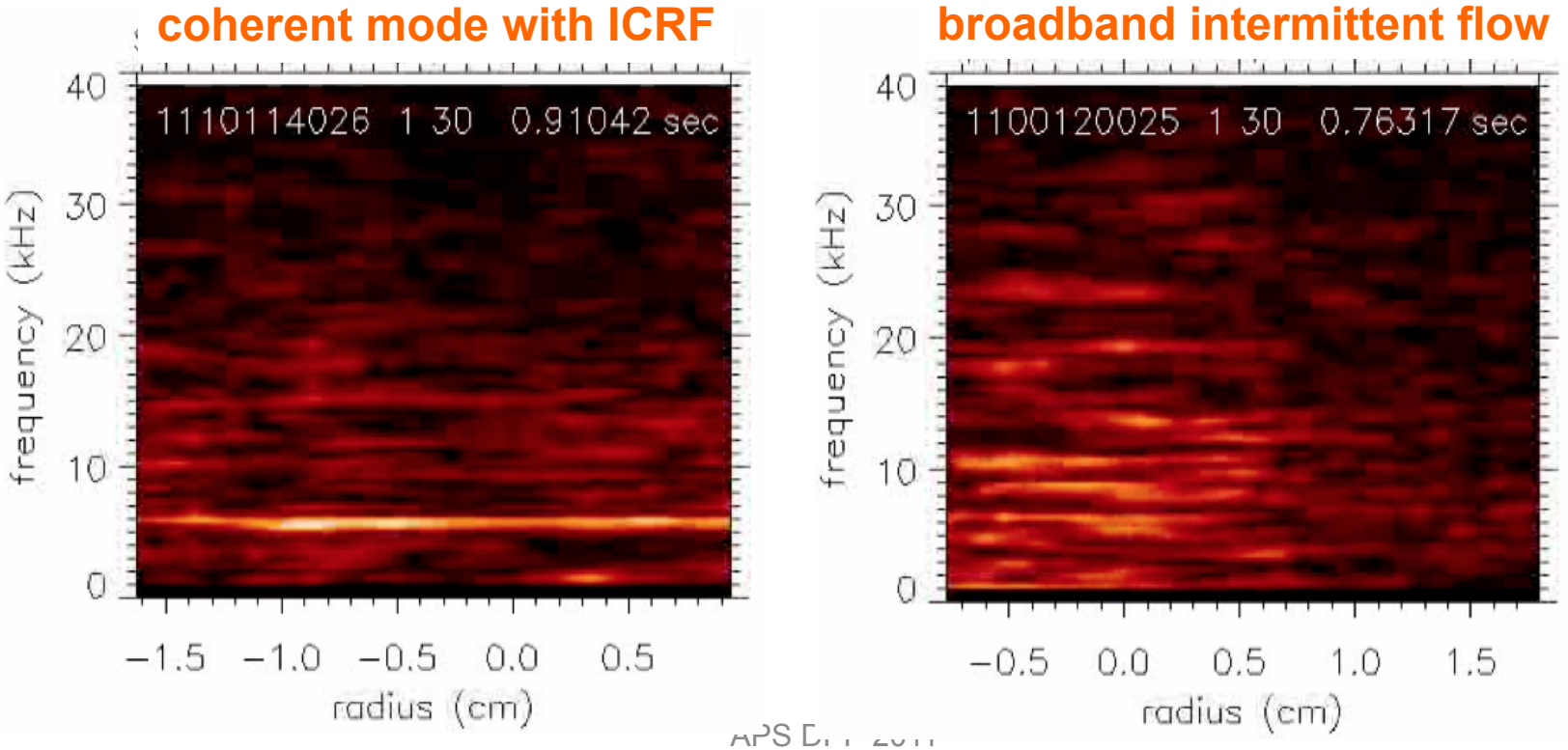


broadband intermittent flow



Radial Profile of Poloidal Velocity Spectra

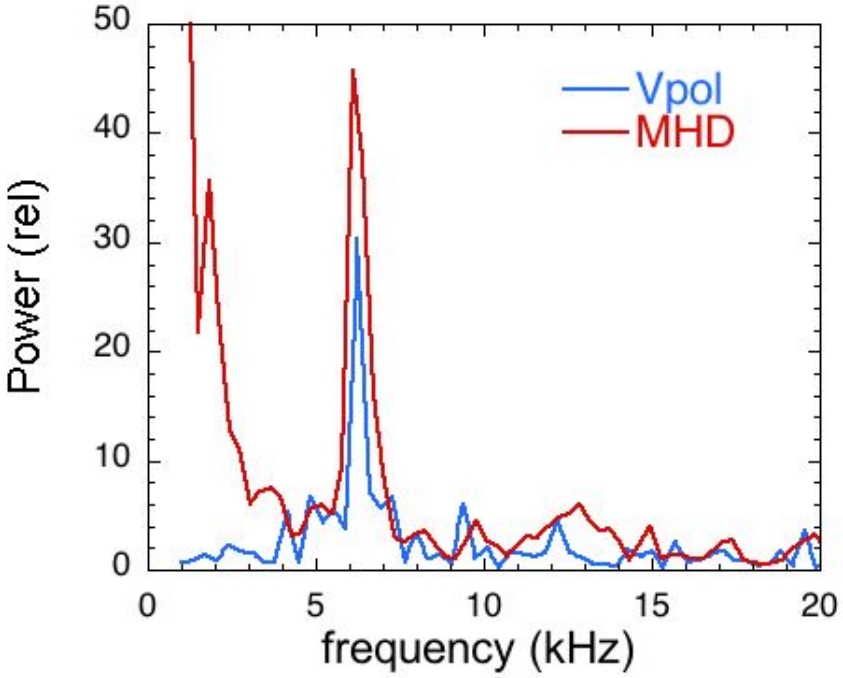
- Spectra of coherent mode extends over -1.5 cm < $\rho \leq$ 1.0 cm
- Spectrum of broadband features within ± 1 cm of separatrix



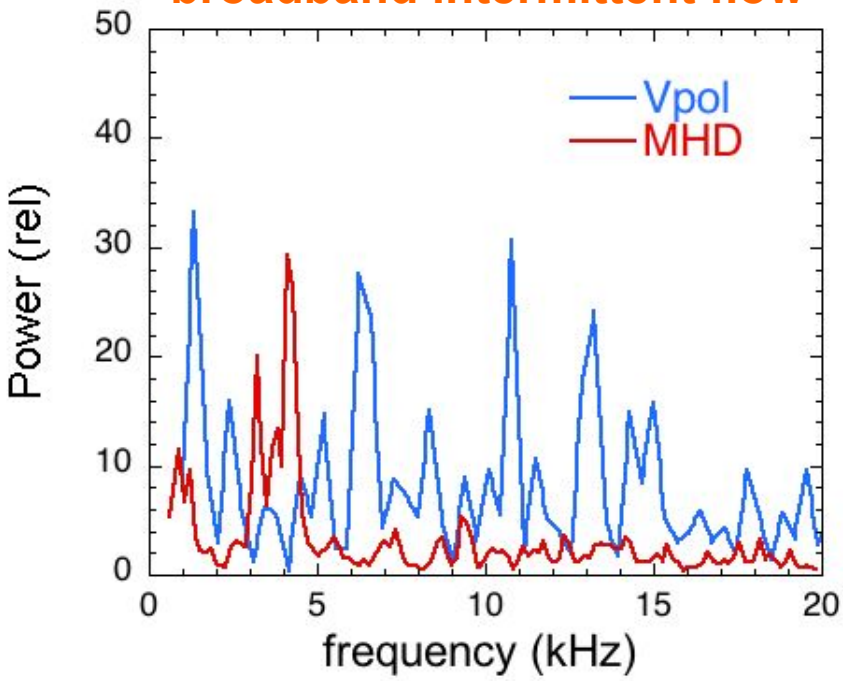
Correlation with Magnetic Fluctuations

- Coherent V_{pol} mode is correlated with B-dot from coils
- This magnetic mode seems to have n=0 like zonal flow

coherent mode with ICRF

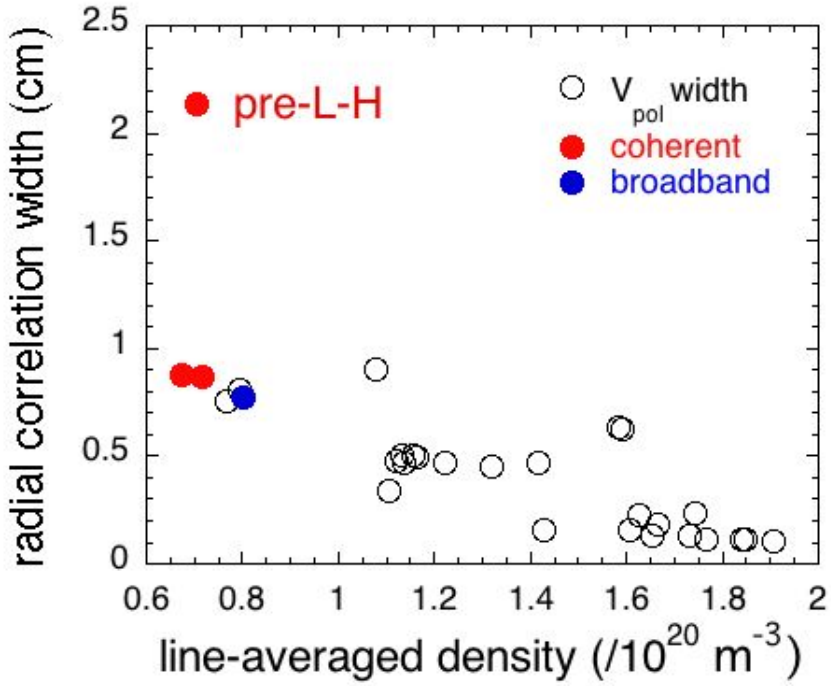


broadband intermittent flow



Poloidal Velocity Fluctuations vs. Density

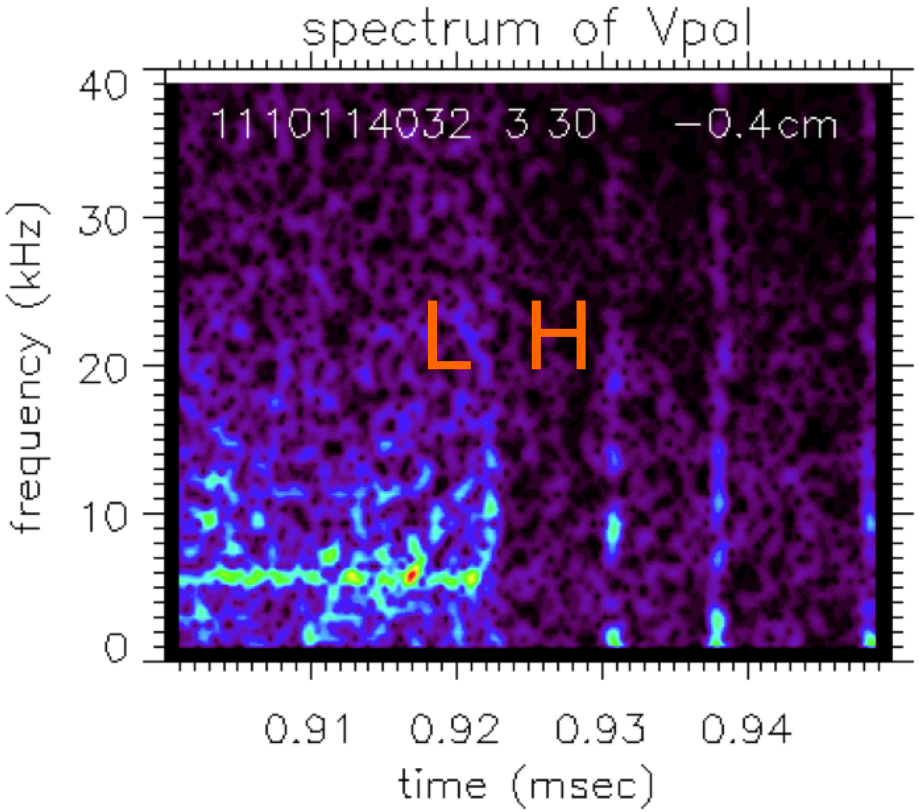
- Magnitude of poloidal velocity fluctuations does *not* vary in a simple way with line-averaged density, B, or power
- But radial correlation width of V_{pol} decreases with density



radial correlation width of V_{pol} (FWHM)

Poloidal Velocity at L-H Transition

- Coherent mode in V_{pol} disappears at L-H transition at all radii, at least in the *one shot* obtained so far



spectrum of V_{pol} just inside separatrix just before L-H transition

Theoretical GAM Frequency for C-Mod

- From a fit to GAM eigenfrequency for various plasma shapes

$f = G\, c_s/(\pi R)$ with $R = R_o + r$, and $c_s = [\gamma(T_i+T_e)/m_i]^{1/2}$

where $G \sim (2^{-1/2})\,(2/(1+\kappa)\,(1+1/(2A^{2/3})\,(1+1/(4q^2))$

- For C-Mod A=3, κ=1.6, q=3, $T_e=T_i$=50 eV, γ=4/3 and m_i=2

$$\Rightarrow \quad f_{GAM} \sim 20\ kHz$$

- But radial profile of observed oscillation *does not* follow the radial profile of $T_e^{1/2}$ within $\rho = \pm$ 0.5 cm (T_e~35-350 eV)

Summary of C-Mod Results

- Coherent zonal-like flows or GAMs at ~6-7 kHz seen in edge of some ICRF shots, with correlated magnetic fluctuations
- More commonly, see broadband, intermittent poloidal velocity fluctuations with radial correlation decreasing with density
- Coherent velocity fluctuations disappear at the L-H transition

Experiments next year will investigate whether the coherent mode is related to ICRF-driven “E-GAMs”