Quiet Periods in Edge Turbulence Preceding the L-H Transition in NSTX

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What triggers the L-H transition in NSTX ?

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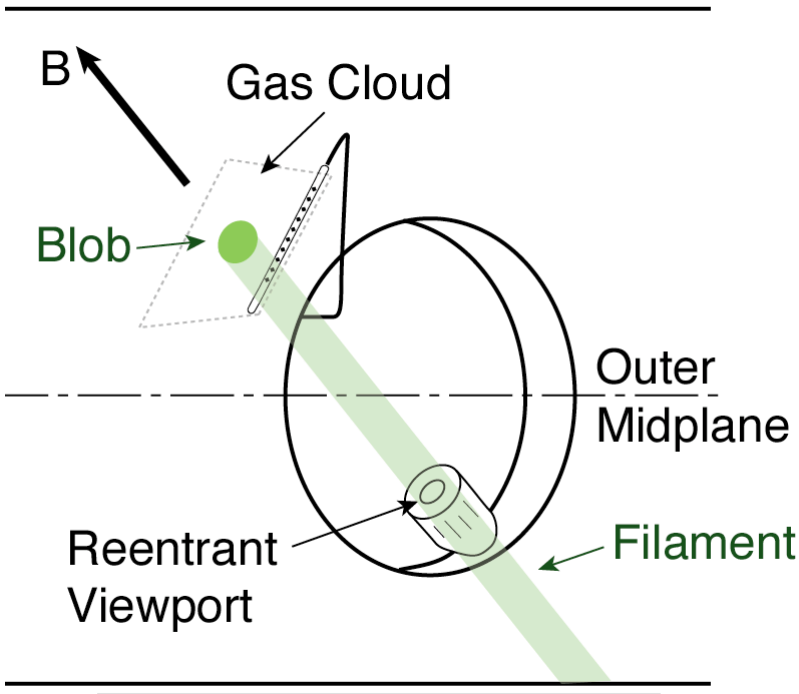
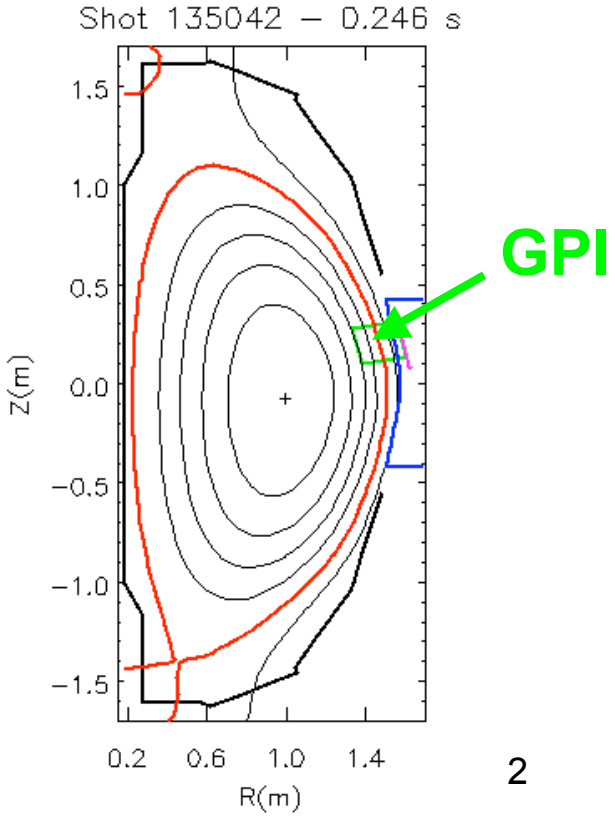
Gas Puff Imaging Diagnostic on NSTX

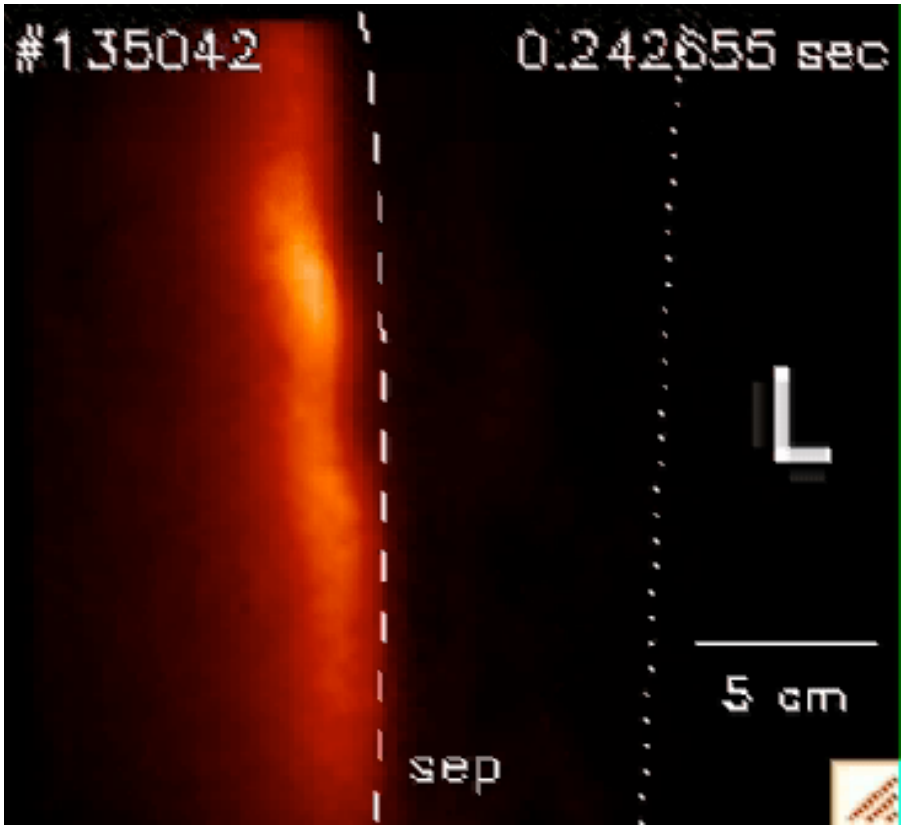
- Views D_α light along B to get 2D radial vs. poloidal view
- Turbulence structure and motion derived using $D_\alpha(n,T_e)$





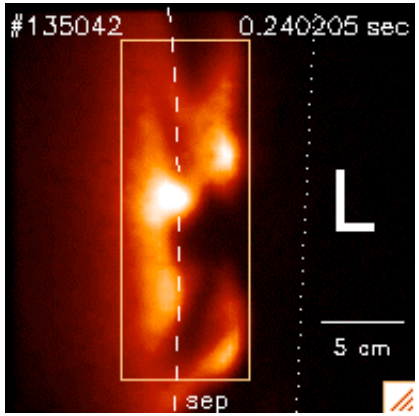
GPI Images Across L-H Transition

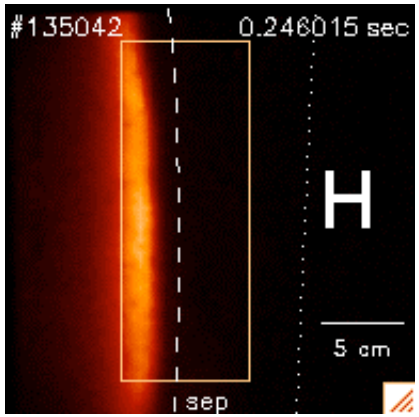
~50 μs/sec (285,000 frames/sec)



poloidal

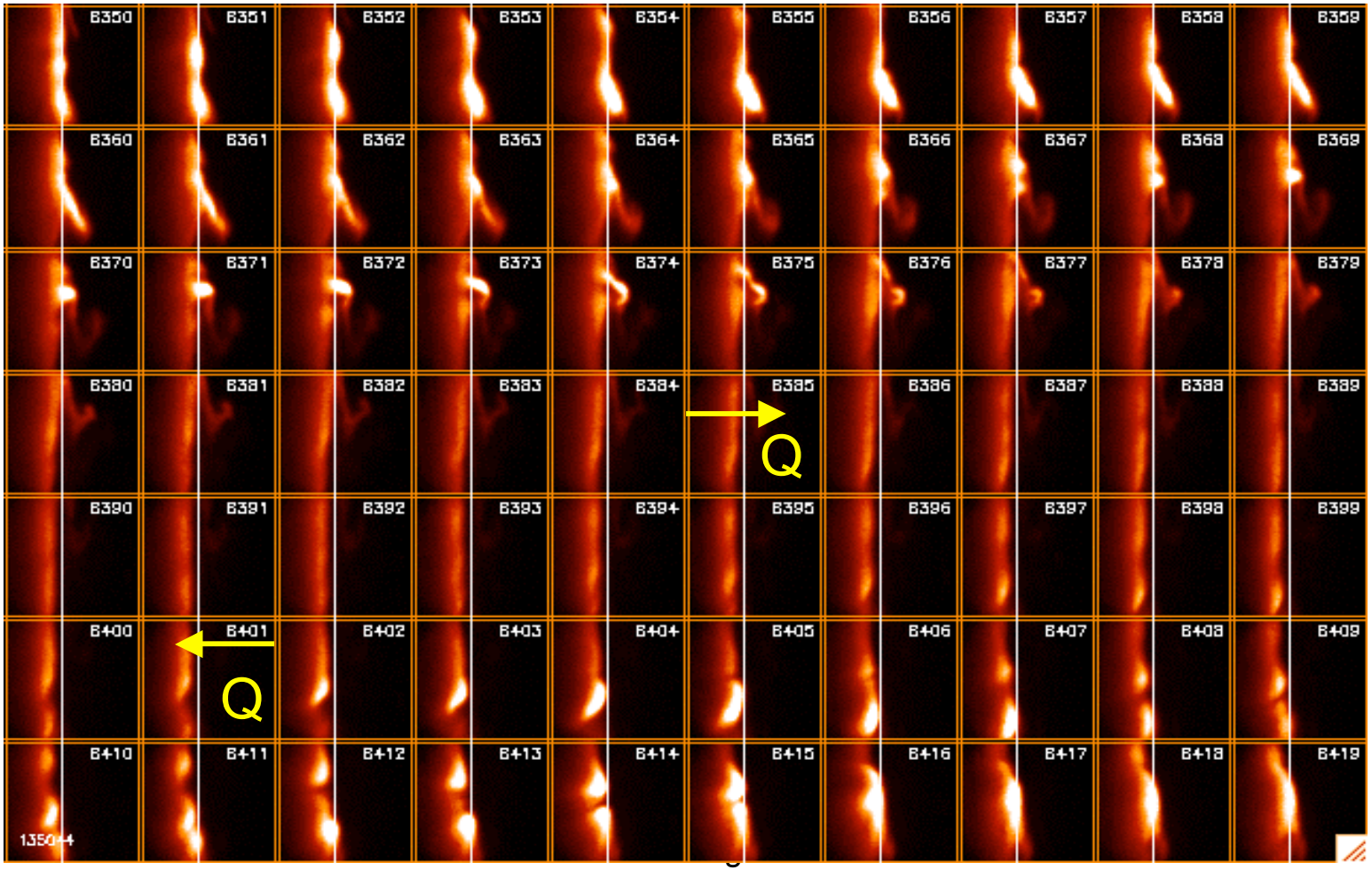
radial





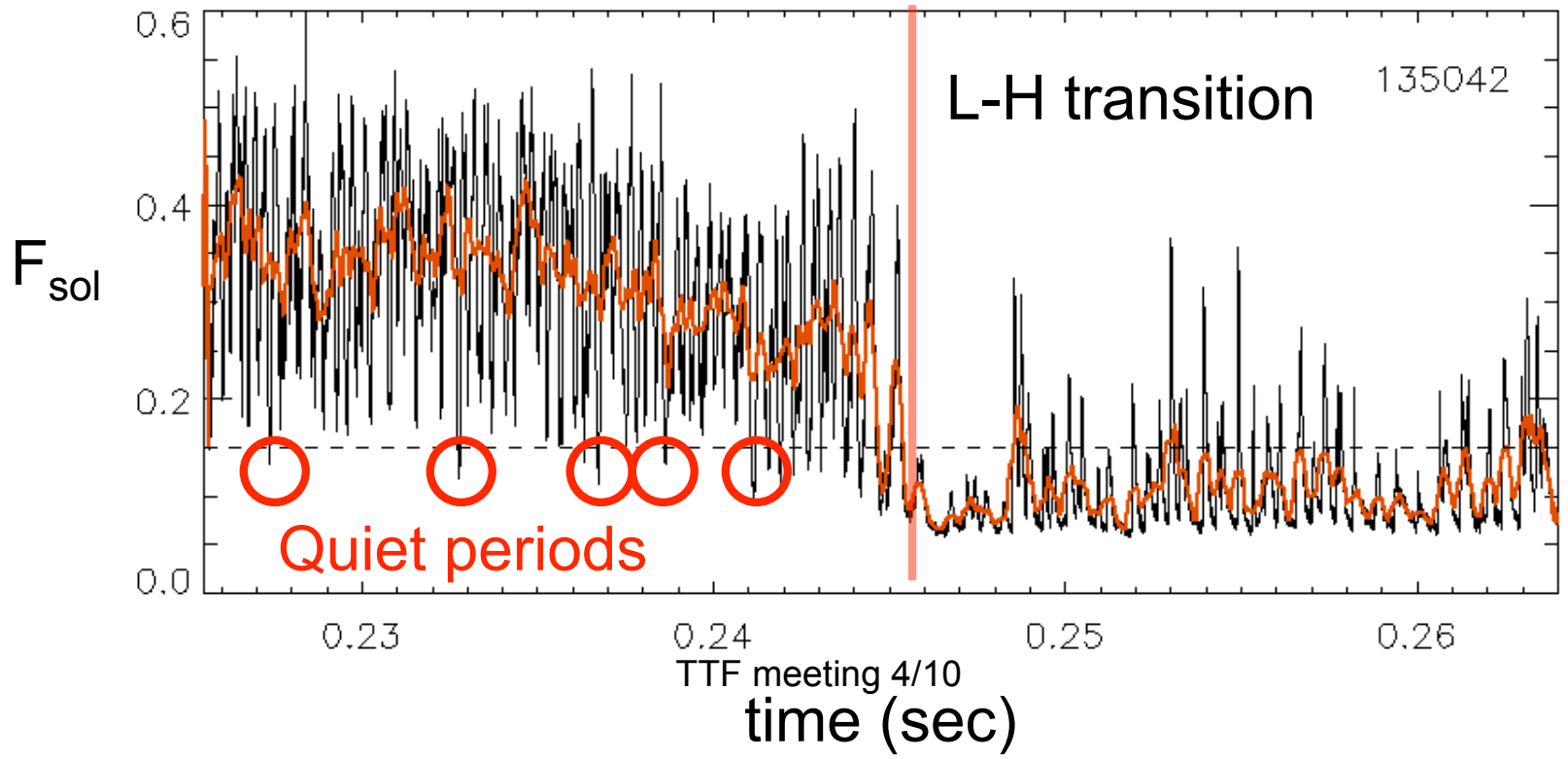
Quiet Periods Preceding Transition

- Sometimes GPI images in L-mode look like H-mode !



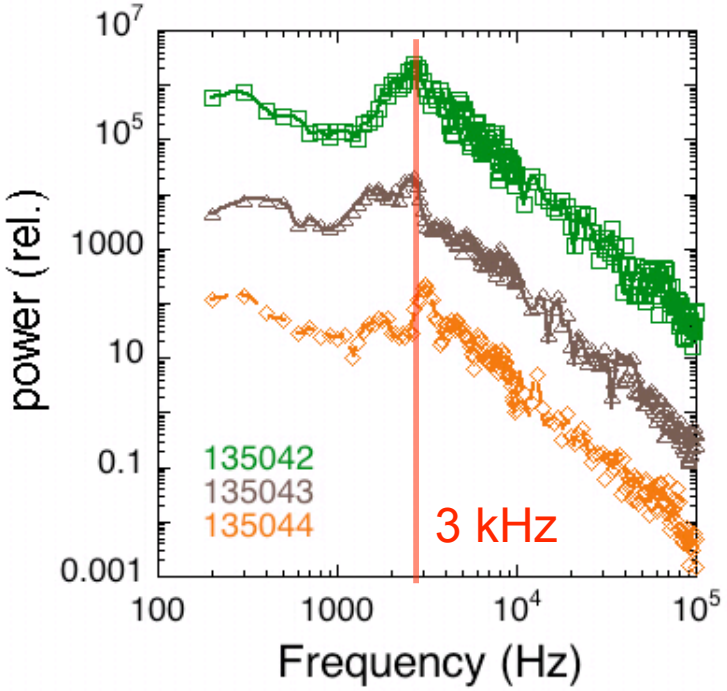
Define "Scrape-off Layer Fraction"

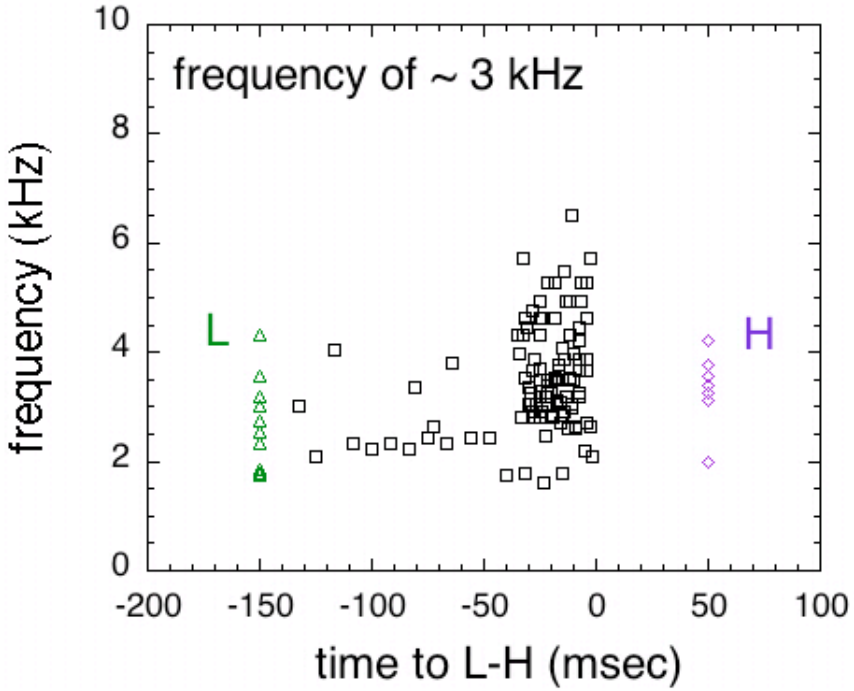
- F_{sol} = fraction of GPI D_α light located outside separatrix
- Measures "H-mode-ness", $F_{sol} \leq 0.15$ seen in H-mode
- F_{sol} determined by shape of n, T_e profiles near separatrix



Frequency and Extent of Quiet Periods

- F_{sol} frequency spectrum has a broad peak at f ~ 3±1 kHz
- Quiet periods extend ≥30 msec before L-H transition

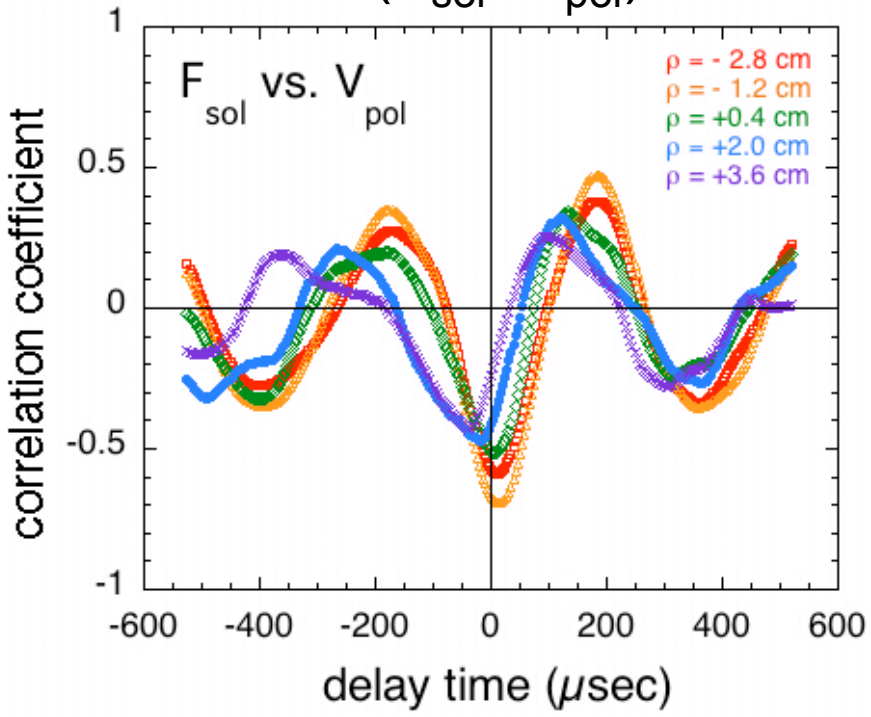




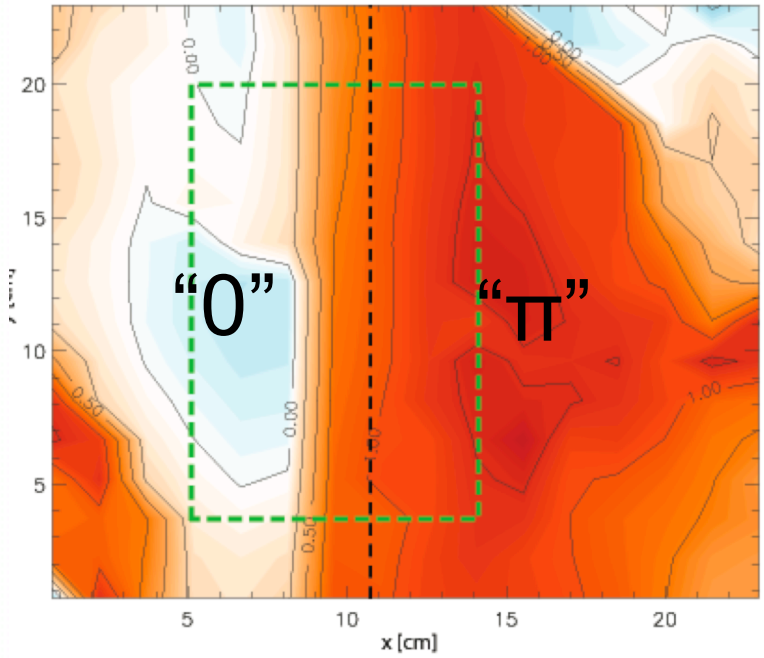
Quiet Periods vs. Poloidal Flow

- Poloidal flow V_{pol} measure from GPI turbulence motion
- F_{sol} and V_{pol} ~50% correlated within ±3 cm of separatrix

(F_{sol}, V_{pol})



Cross-phase vs. radius



Sechrest and Munsat

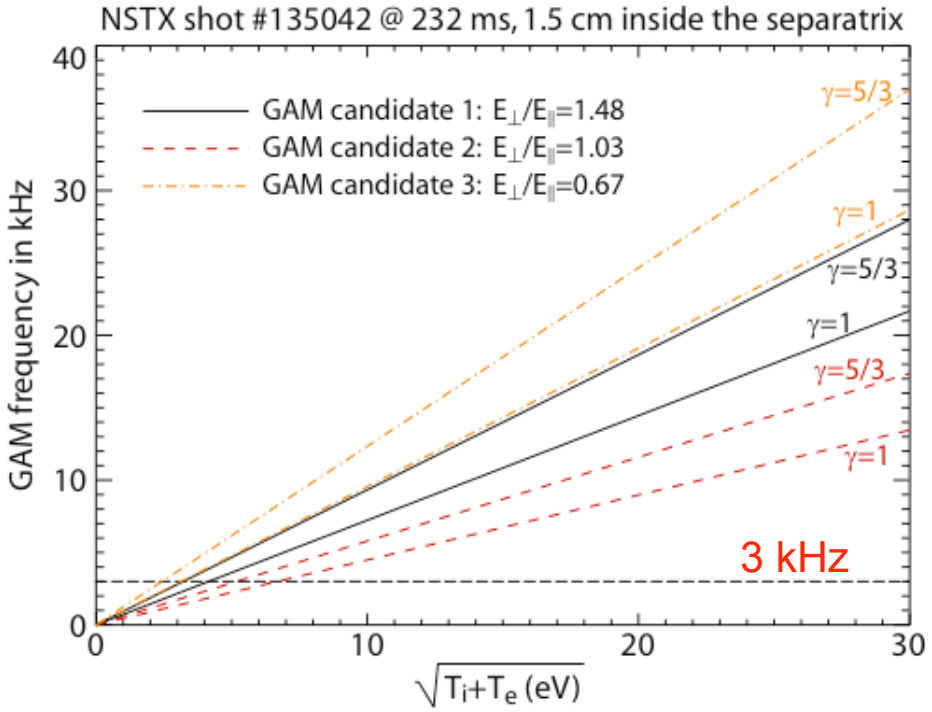
Geodesic Acoustic Mode (GAM) Analysis

R. Hager, K. Hallatschek, IPP Garching

- GAM expected roughly at f(Hz)= $(1/\pi R)\,[\gamma(T_i+T_e)/m_i]^{1/2}$ G

- linear simulations show three GAM candidates for NSTX #135042

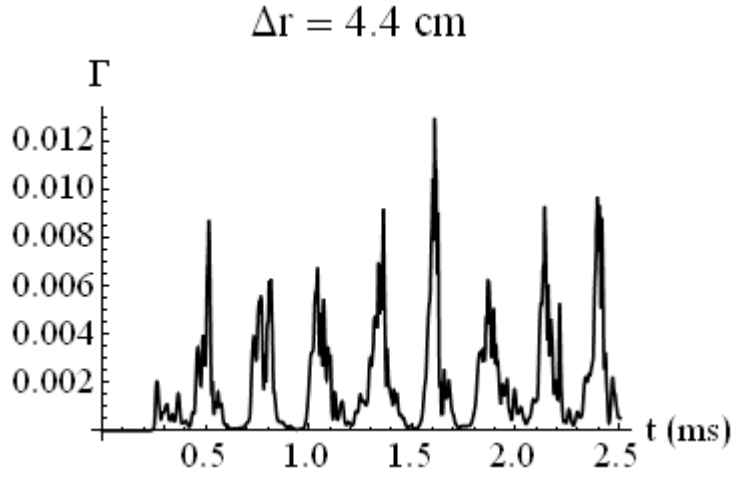
- nonlinear simulations show low frequency mode (red) excited at 3 kHz for $T_i+T_e \sim 40$ eV

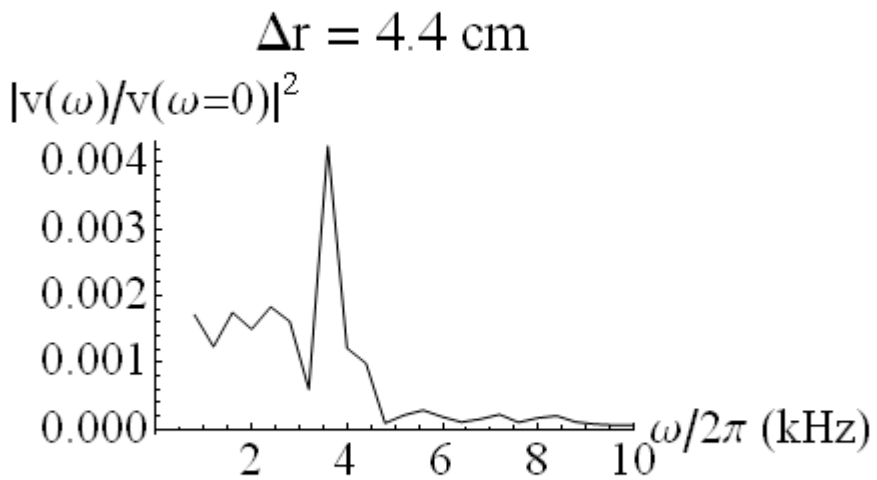


Edge Zonal Flow Analysis

D.A. Russell, Lodestar

- SOLT 2-D simulation of NSTX shows 'bursty' behavior in SOL quasi-periodic V_{pol} modulation at ~ 4 KHz
  (D.A. Russell et al Phys. Plasmas 16, 122304 (2009)





- Zonal flow also expected at f ~ ν_{ii}(R/a) ~ 3 kHz (Hahm)
  (assuming n=10^{13} cm^{-3}, T_i=50 eV, μ=2)

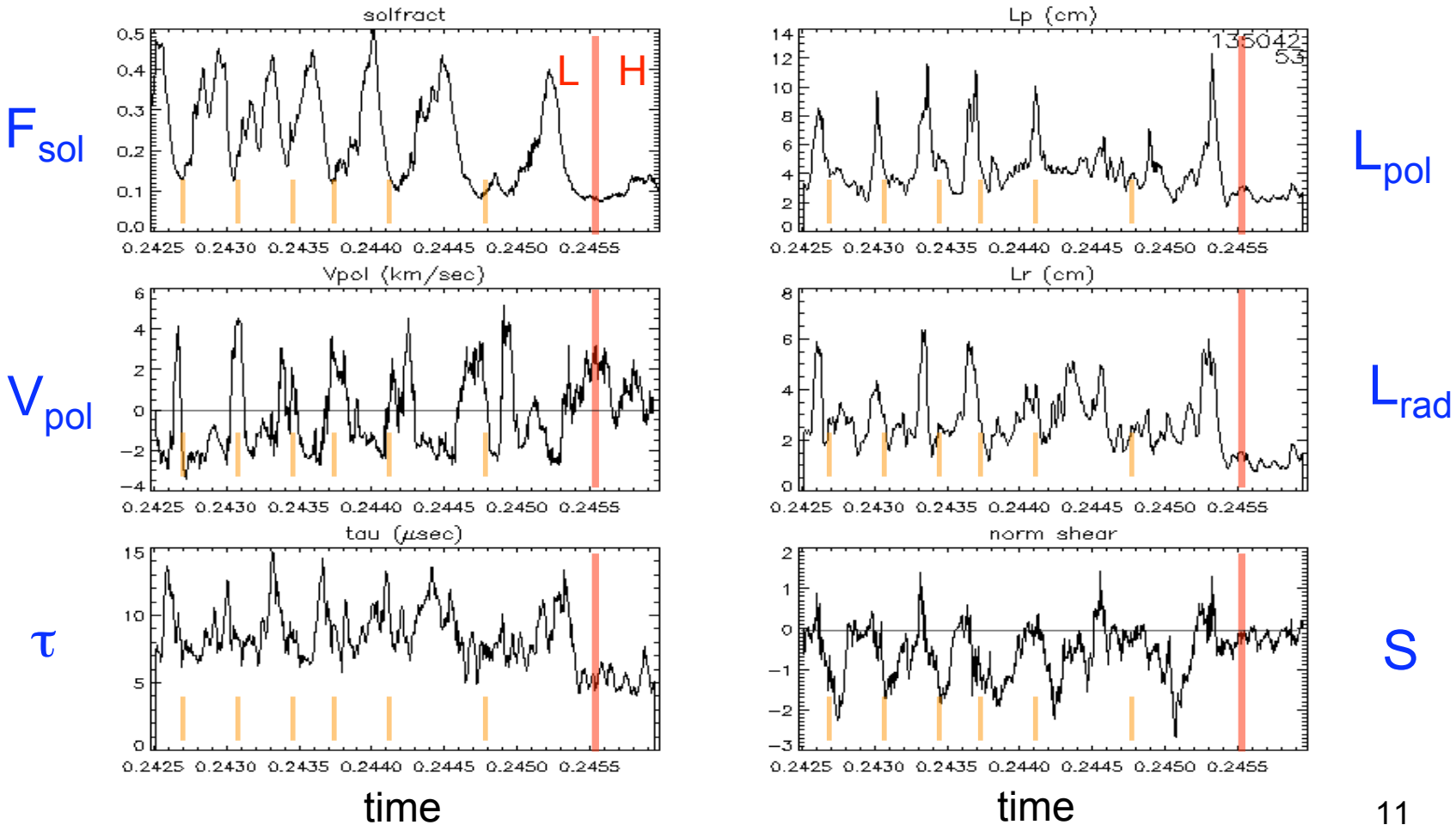
Estimate of Shear Flow from GPI

- Dimensionless shear: $S = (dV_{pol} / dr) (L_{rad} / L_{pol}) \tau$
- Scale lengths and times derived from correlation functions
- Poloidal velocity from delayed-time cross-correlations
- Average over ~40 μsec, and ~ 1.5 cm radial for dV_{pol} / dr
- $L_{rad} \sim 3$ cm, $L_{pol} \sim 4$ cm, $\tau \sim 8$ μsec, $dV_{pol}/dr \sim \pm 10^5$ sec^{-1}

=> $S \sim \pm$ 1-2 (interesting coincidence !?)

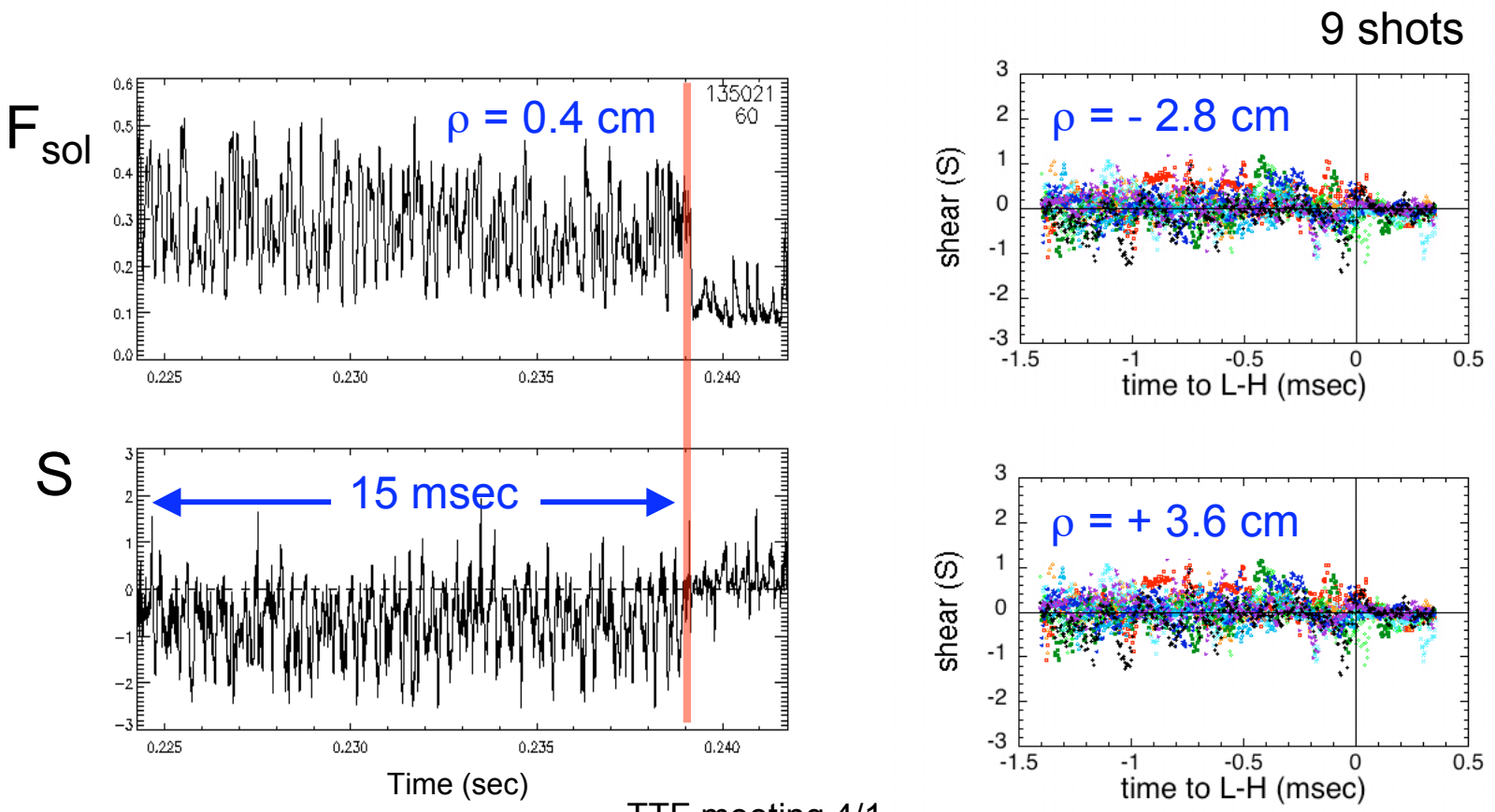
Shear Preceding Transition (ρ ~ 0)

- V_{pol} and S reverse sign during quiet periods (F_{sol} <0.2)



Shear Preceding Transition

- Turbulence shear S is not changing before L-H transition, so does not appear to trigger transition

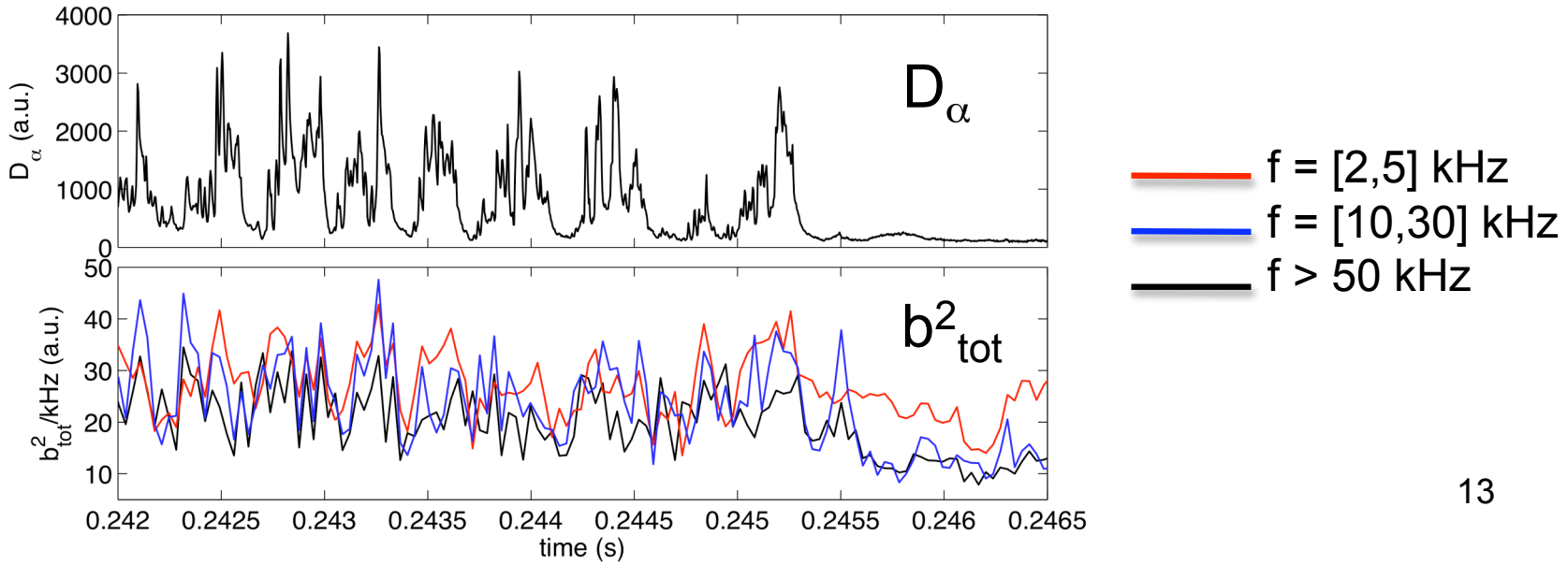


Nonlinear Bicoherence Analysis

F.M. Poli, U. Warwick

- Total bicoherence b^2_{tot} has minima during quiet periods in all frequency ranges until 2 ms before L-H transition

- Total bicoherence slightly increases ~0.5 ms before transition in the low- to intermediate- frequency range



Conclusions

- So far: "the role of turbulence in triggering the L-H transition must be considered open." [G.R. Tynan et al, PPCF (2009)]

- Possibilities:

  - L-H transition is triggered by slow or slight changes

  - the trigger is non-local, i.e. outside GPI field of view

  - creative data analysis might yet identify the trigger