Turbulence and Flow Interactions in the NSTX Edge

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NSTX CMTFO

- Context provided by Predator-Prey models

- Observations of edge reminiscent of DW-ZF interaction

- Motivation for future studies of L-H physics

P-P Models identify important interactions

Evolution of Turbulence:

Evolution of ZF Shear:

Evolution of profile:
(grad P)

Mean Flow Shear:

P-P Models identify important interactions

Evolution of Turbulence: $$\partial_t E = EN - a_1 E^2 - a_2 V^2 E - a_3 V_{ZF}^2 E$$

Evolution of ZF Shear: $$\partial_t V_{ZF} = b_1 \frac{E V_{ZF}}{1 + b_2 V^2} - b_3 V_{ZF}$$

Evolution of profile: (grad P) $$\partial_t N = -c_1 EN - c_2 N + \underline{Q}$$

Input Power

Mean Flow Shear: $$V = dN^2$$

Kim and Diamond, PRL 2003

P-P Models identify important interactions

Evolution of Turbulence: $$\partial_t E = EN - a_1 E^2 - a_2 V^2 E - a_3 V_{ZF}^2 E$$

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Evolution of profile: (grad P) $$\partial_t N = -c_1 EN - c_2 N + Q$$

Mean Flow Shear: $$V = dN^2$$

- DW-ZF interaction

Kim and Diamond, PRL 2003

P-P Models identify important interactions

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Evolution of profile: (grad P) $\partial_t N = -c_1 EN - c_2 N + Q$

Mean Flow Shear: $V = dN^2$

- ZF-DW interaction
- Mean Flow Shear effects

Kim and Diamond, PRL 2003

P-P Models identify important interactions

Evolution of Turbulence: $\partial_t E = EN - a_1 E^2 - a_2 V^2 E - a_3 V_{ZF}^2 E$

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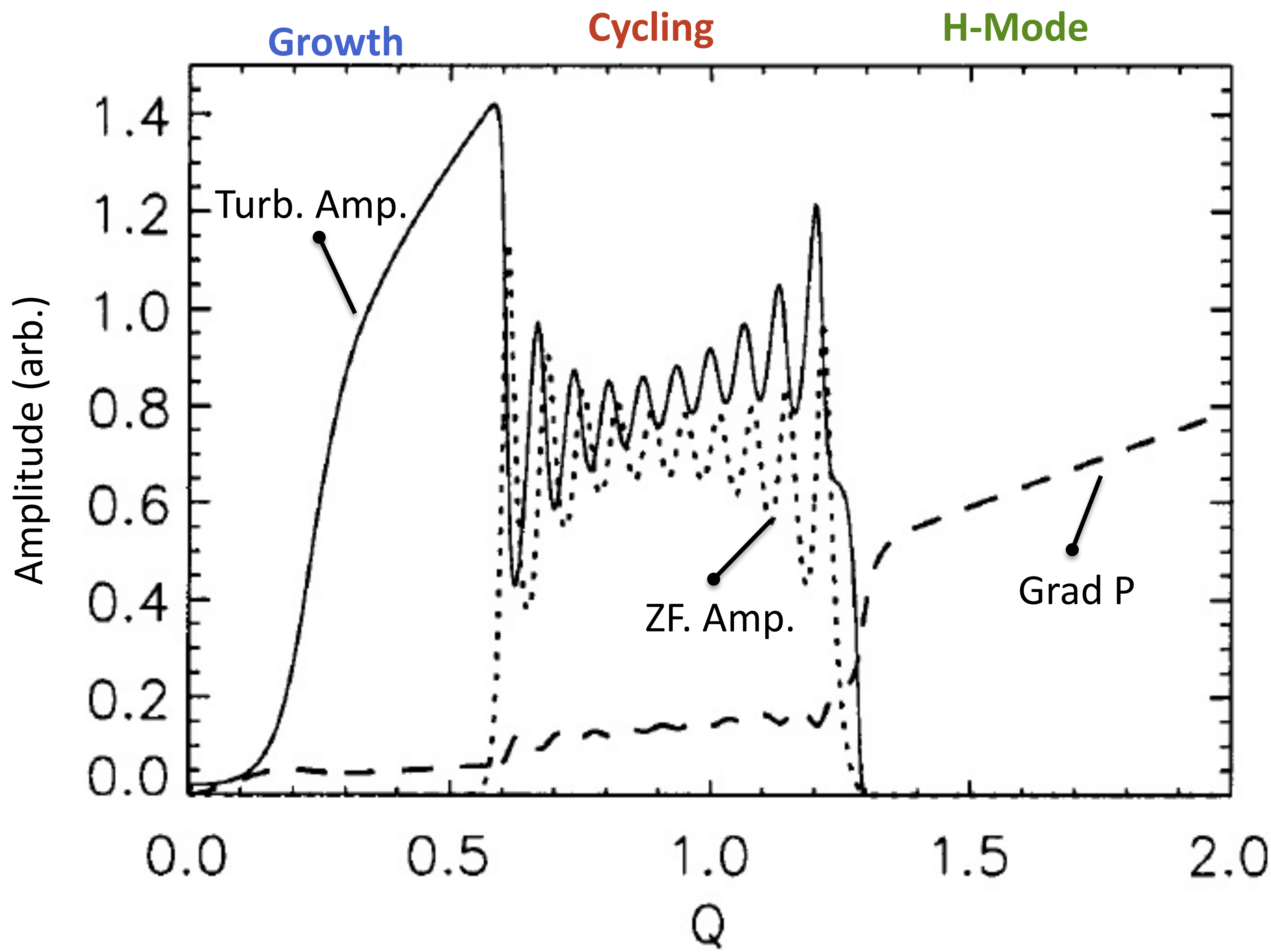
Evolution of profile: (grad P) $\partial_t N = -c_1 EN - c_2 N + Q$

Mean Flow Shear: $V = dN^2$

- ZF-DW interaction
- Mean Flow Shear effects
- Control parameters: Turbulence drive and ZF damping

Kim and Diamond, PRL 2003

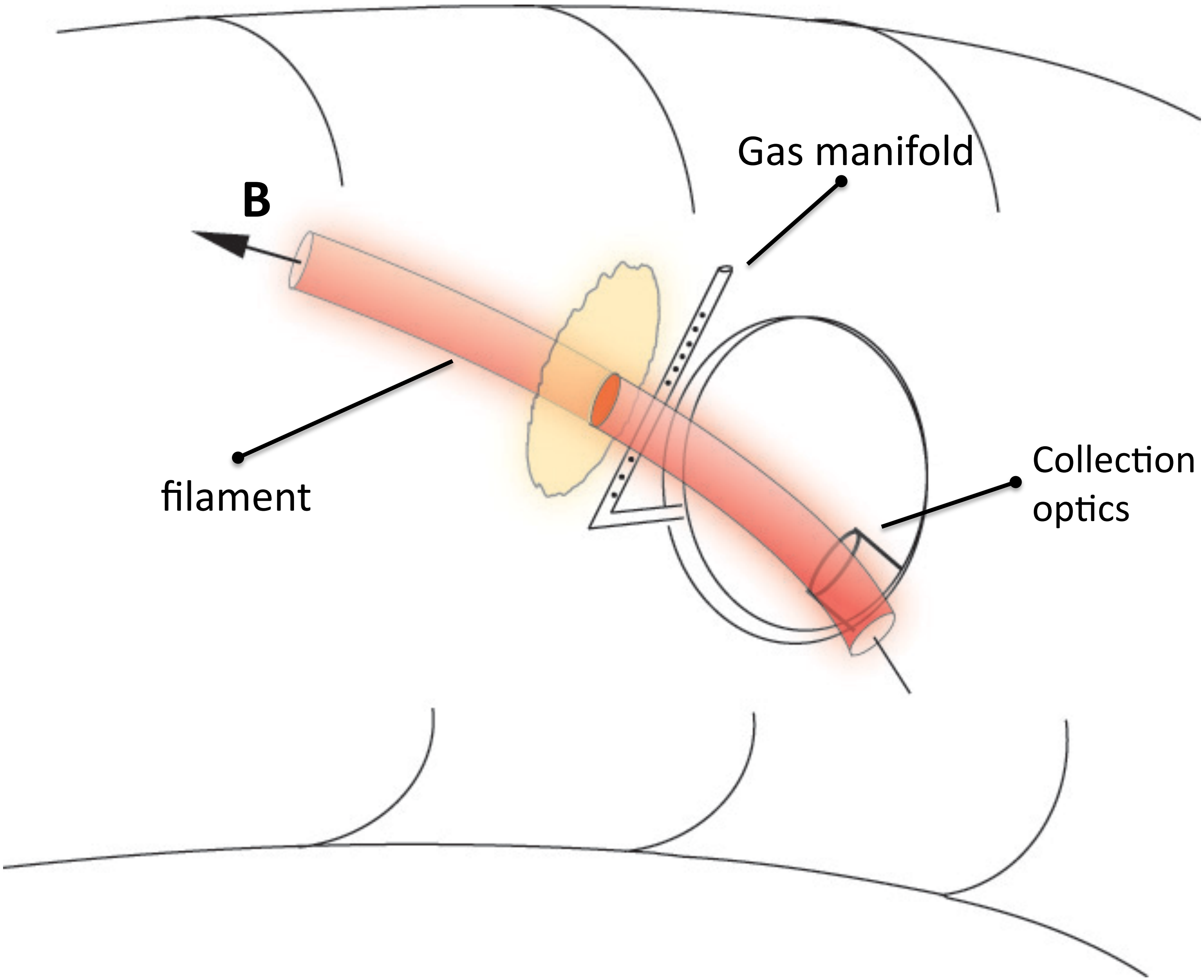
P-P Models qualitatively describe behavior



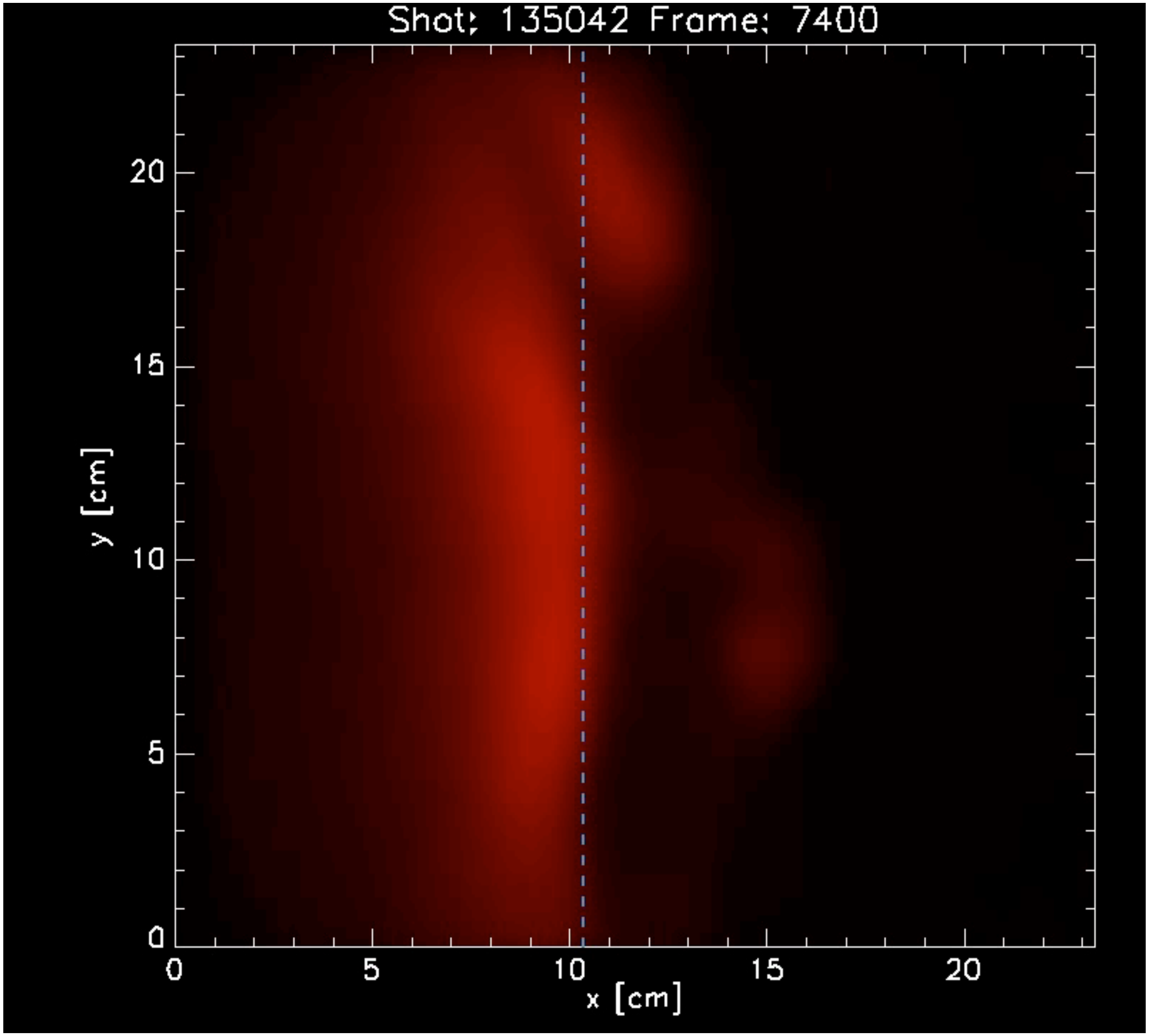
Kim and Diamond, PRL 2003

- How can we make measurements of the DW-ZF interaction?
- How can we study the dynamics of the interaction?
- What role does the mean shear play?
- Experimentally, how can we alter the dynamics?

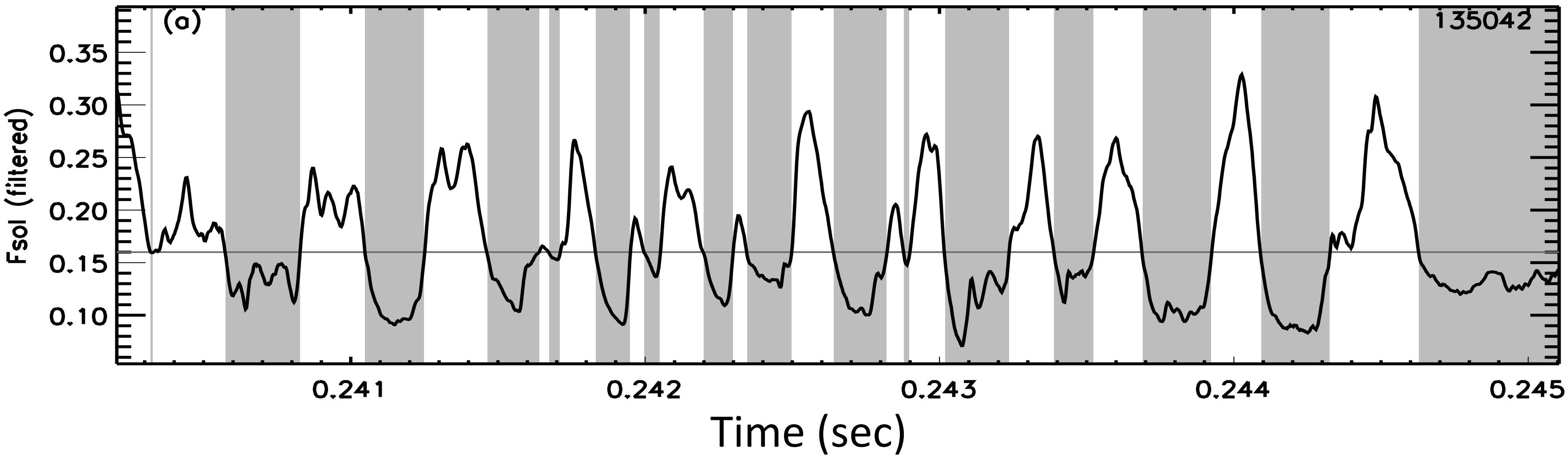
GPI measurements



GPI measurements

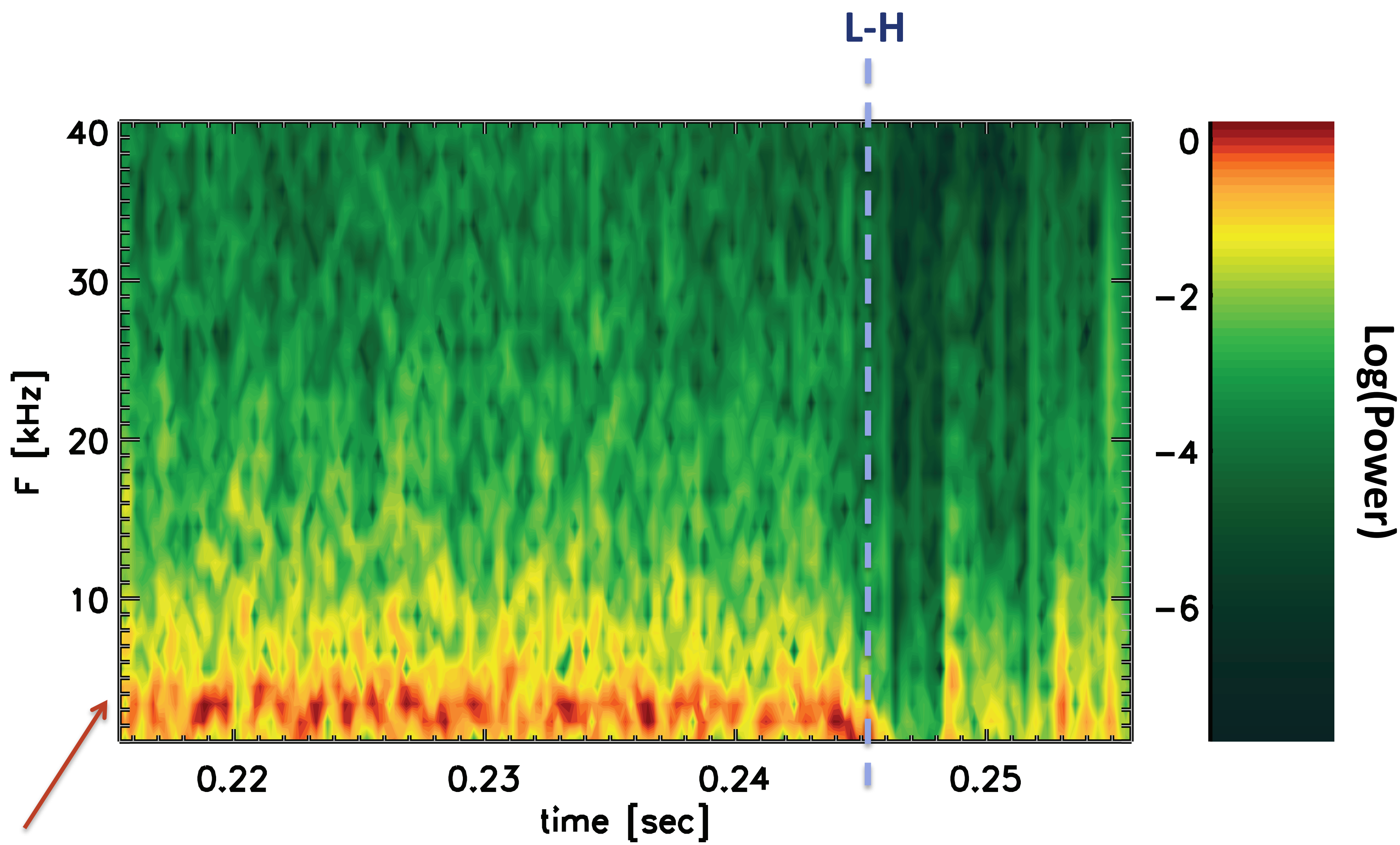


F_{SOL} bursting similar to limit-cycle behavior



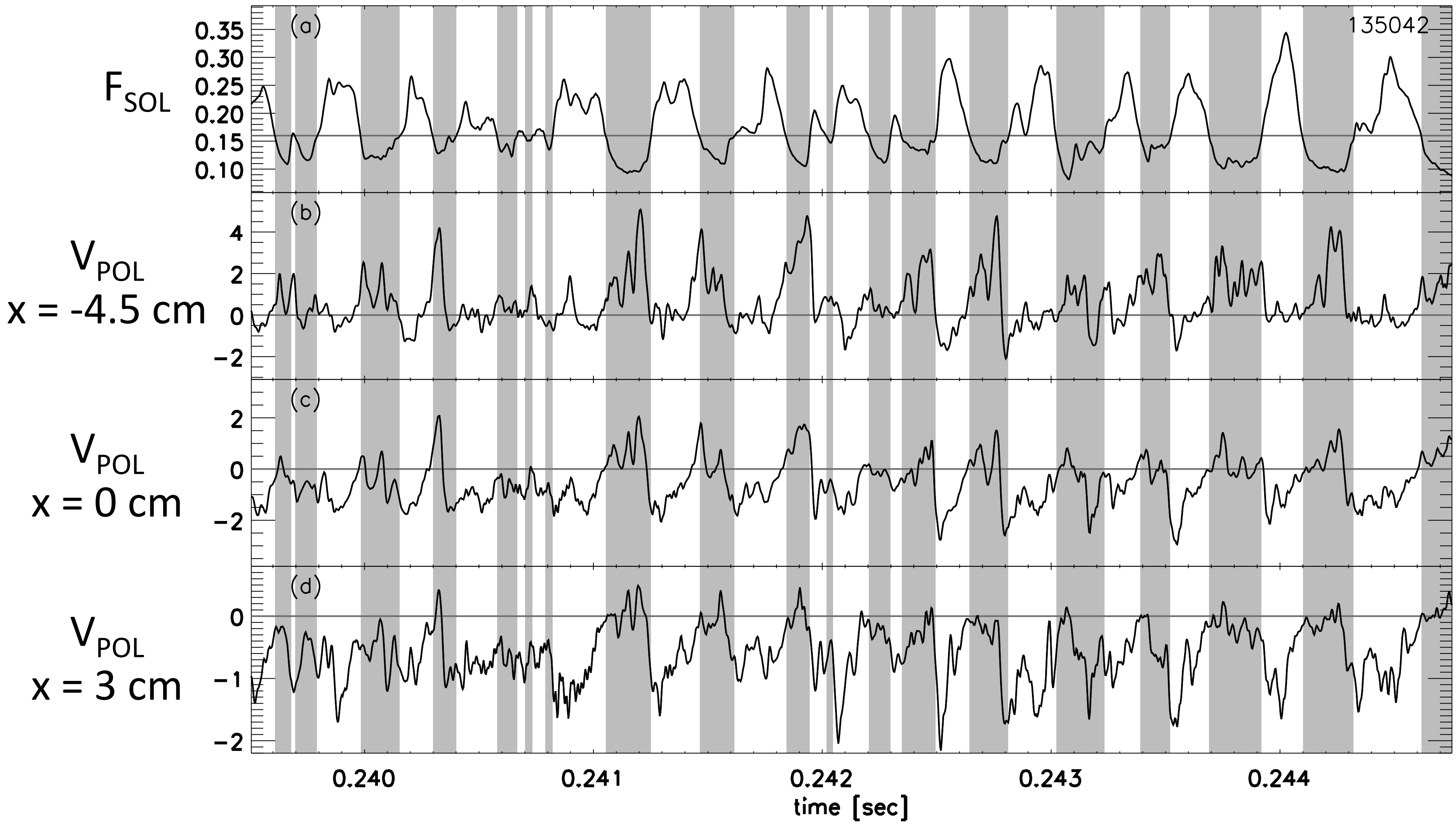
- **F_{SOL}** defined as D_{α} light contained in SOL
  - Proxy for level of transport into SOL
- High **F_{SOL}** -> turbulent, bursty edge
- Low **F_{SOL}** -> quiescent edge

Turbulence bursts are quasiperiodic



3 kHz quasiperiodic bursting

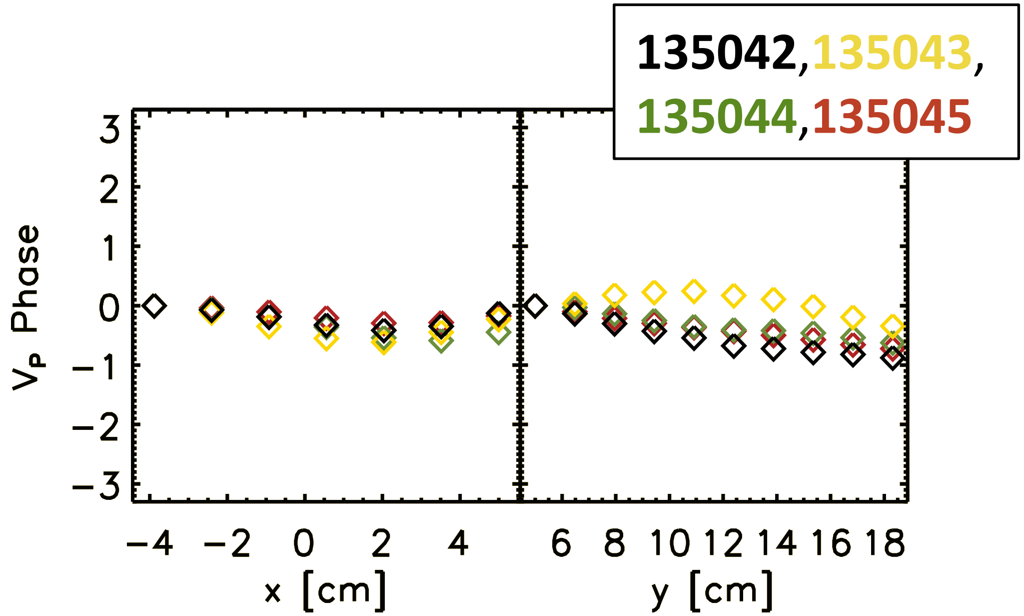
Activity correlated with poloidal velocity



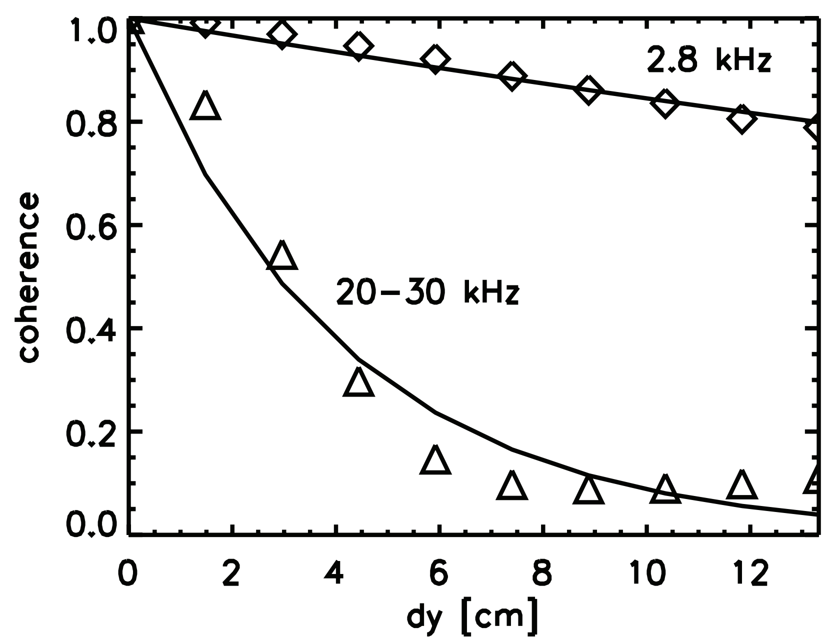
- V_{POL} vs. F_{SOL} correlation = -.6

V_{POL}: Munsat, RSI 2006

V_{POL} Fluctuations are long wavelength

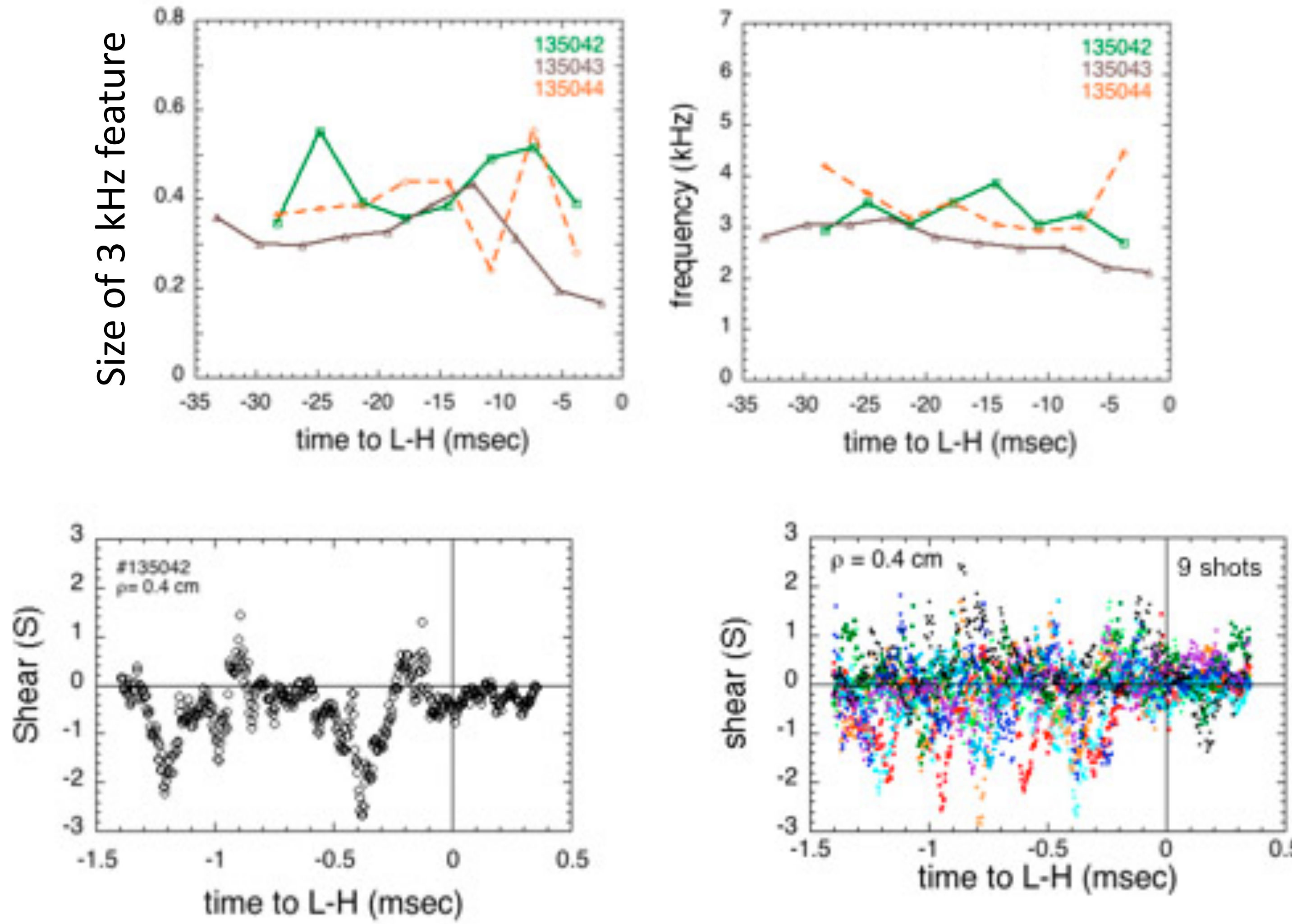


- λ_{POL}(3kHz) ~ 1 m
- Correlation lengths
  - 3kHz ~ 56 cm
  - Turbulence ~ 4cm



- Reminiscent of DW-ZF interaction
  - Quasiperiodic turbulence oscillations
  - Turbulence correlated with V_{POL}
  - V_{POL} Fluctuations exhibit ZF-like behavior

No systematic changes preceding L-H



Zweben, PoP 2010

- Recap of results
  - Captured L-H with GPI with P_{IN} >> P_{LH}
  - quasiperiodic turbulent bursts in NSTX edge correlated with ZF-like V_{POL} fluctuations
  - No precursor or systematic variations preceding L-H transition found
- Looking forward…
  - New XP to Probe the dynamics near the L-H threshold
  - Long Distance Correlations
  - Continue to develop GPI analysis techniques
    - Feature extraction, shape analysis

Thank you…

- We would like thank the whole NSTX team for their support.
- This work was supported by US DOE Contracts #DE-FG02-08ER54995, DE- SC0001966, and DE-AC02-09CH11466.

Thank you for your attention

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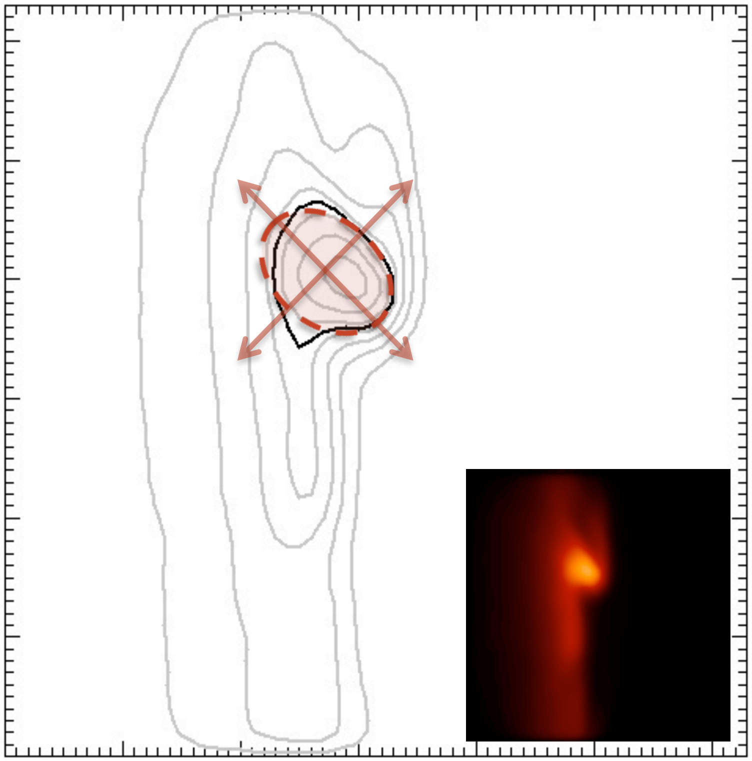
GPI prime application for DIP techniques

- Current techniques
  - Velocity extraction
  - Correlation analysis
  - Fourier analysis

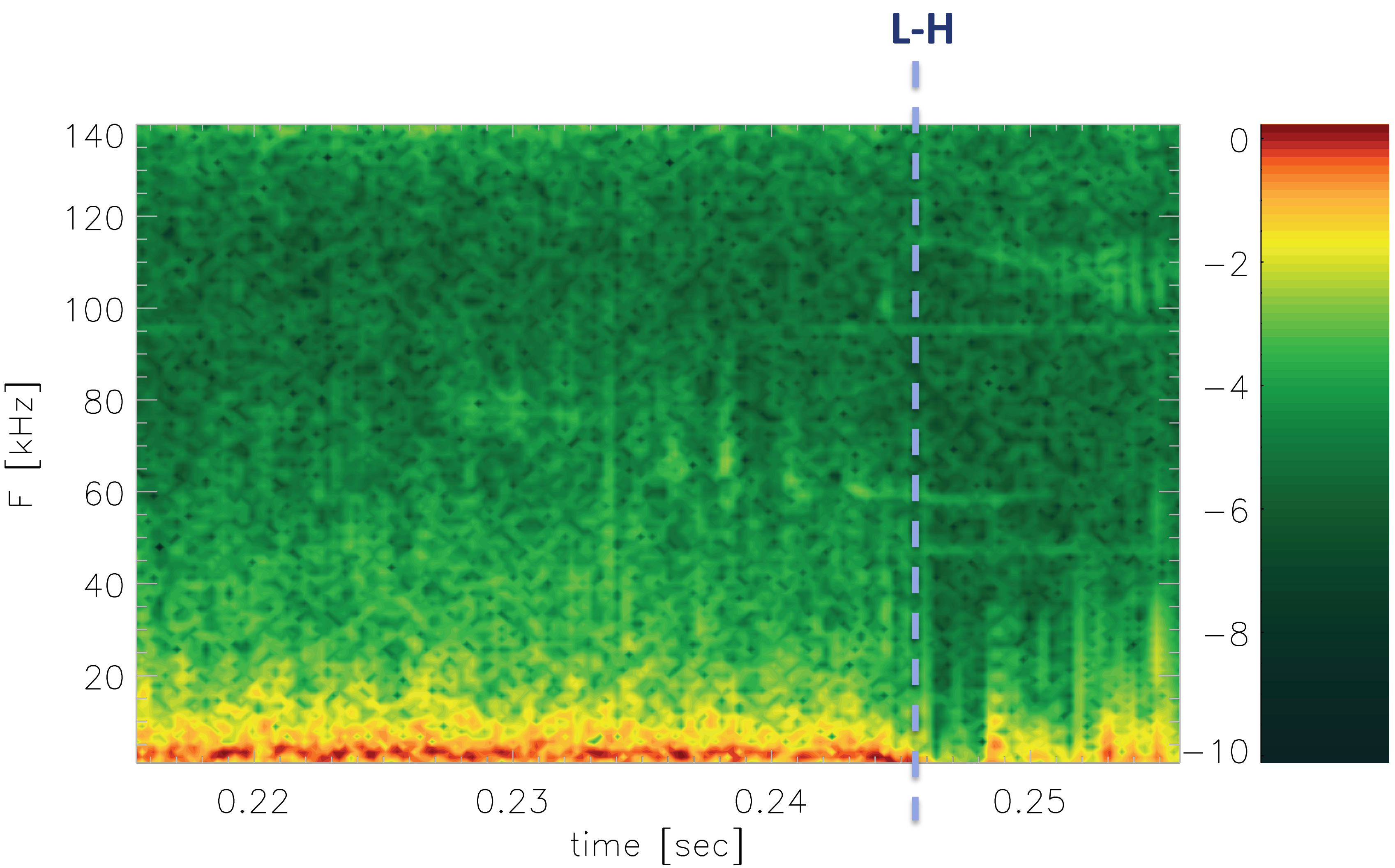
- Further digital image processing
  - feature extraction (blobs)
  - Shape analysis



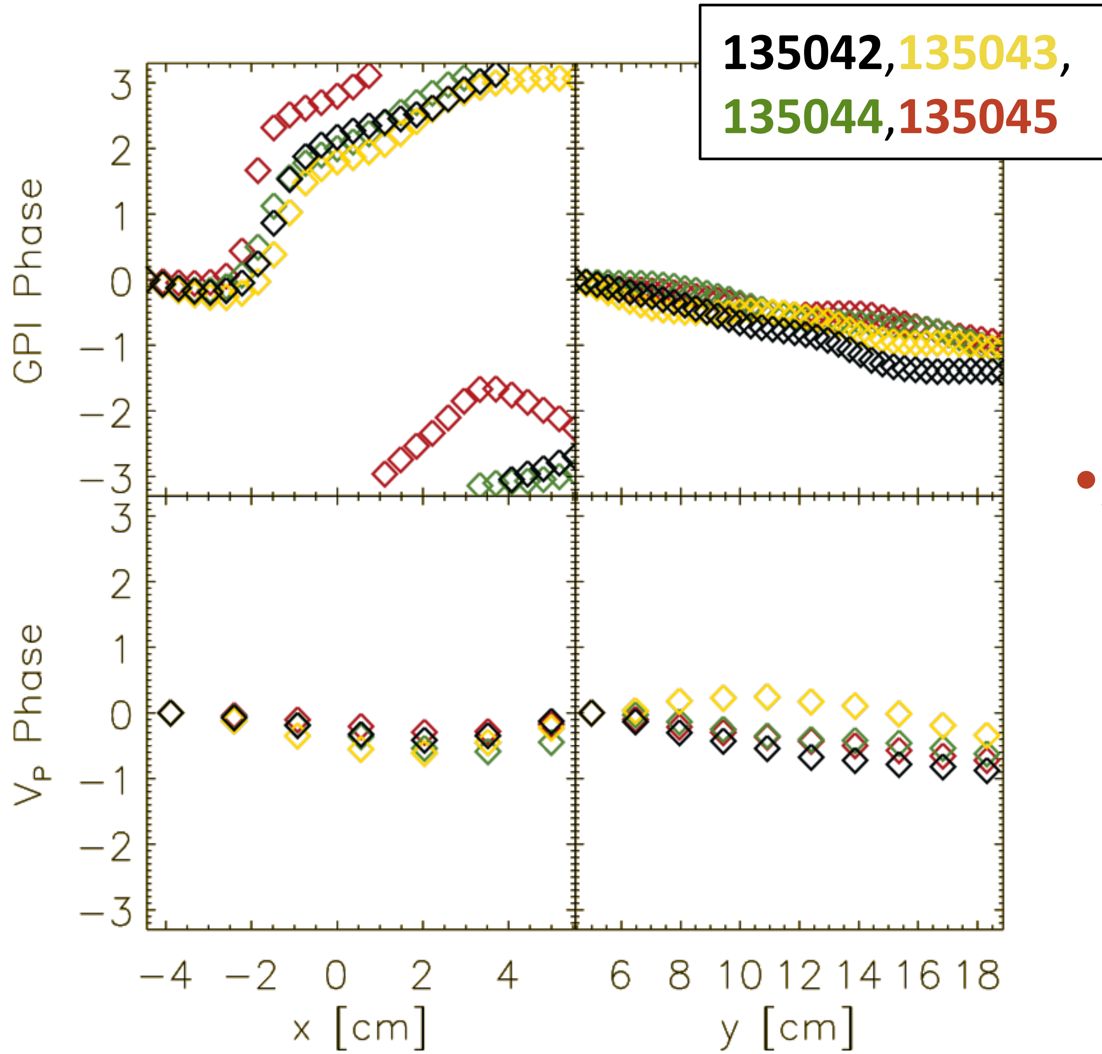
Results motivate future transition studies

- Previous study
  - Input power >> threshold
  - No clear changes preceding L-H
- Study dynamics near L-H power threshold
  - DW-ZF Limit-cycle
- Long Distance Correlations
  - Cross-diagnostic measurements

Turbulence bursts are quasiperiodic

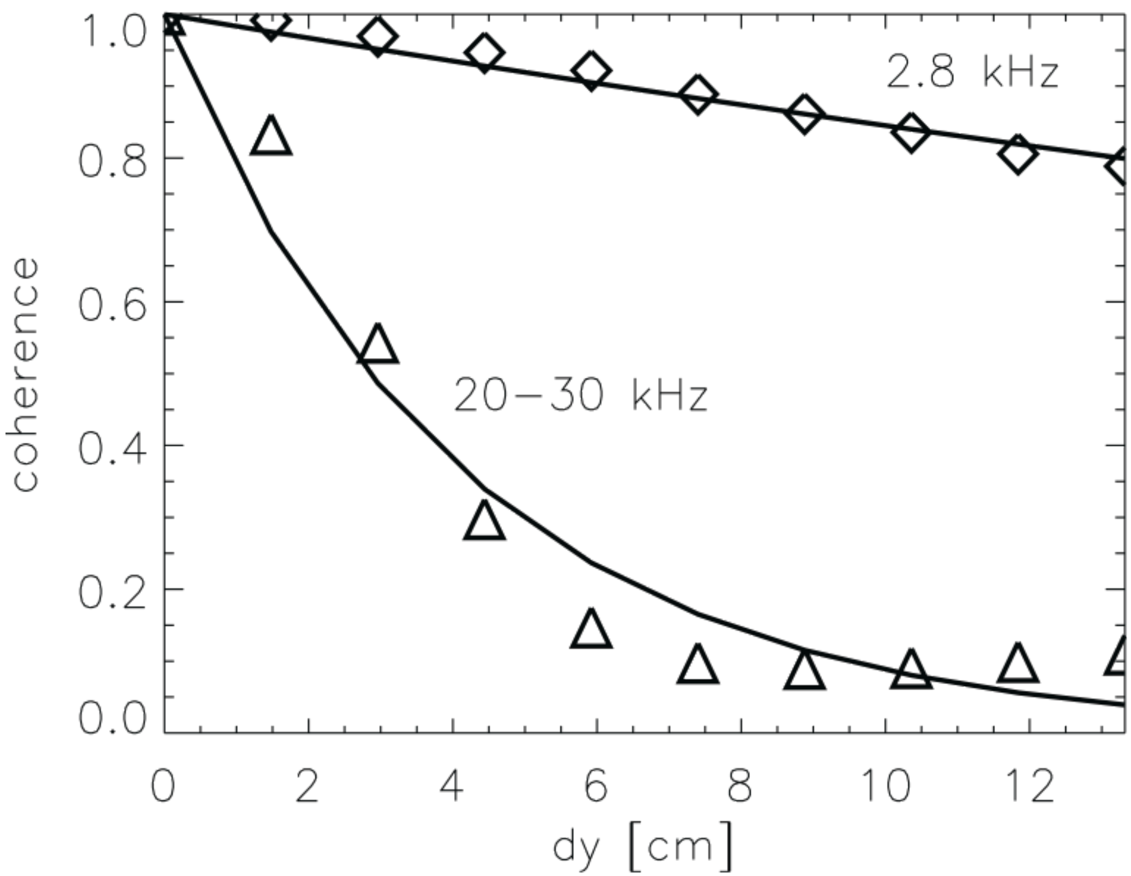


V_{POL} Fluctuations are long wavelength



- λ_{POL}(3kHz) ~ 1 m

V_{POL} Fluctuations maintain coherence



- 3 kHz correlation length ~ 56 cm
- Turbulence correlation length ~ 4 cm