Two-Dimensional Characterization of ELM Precursors in NSTX

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Overview:

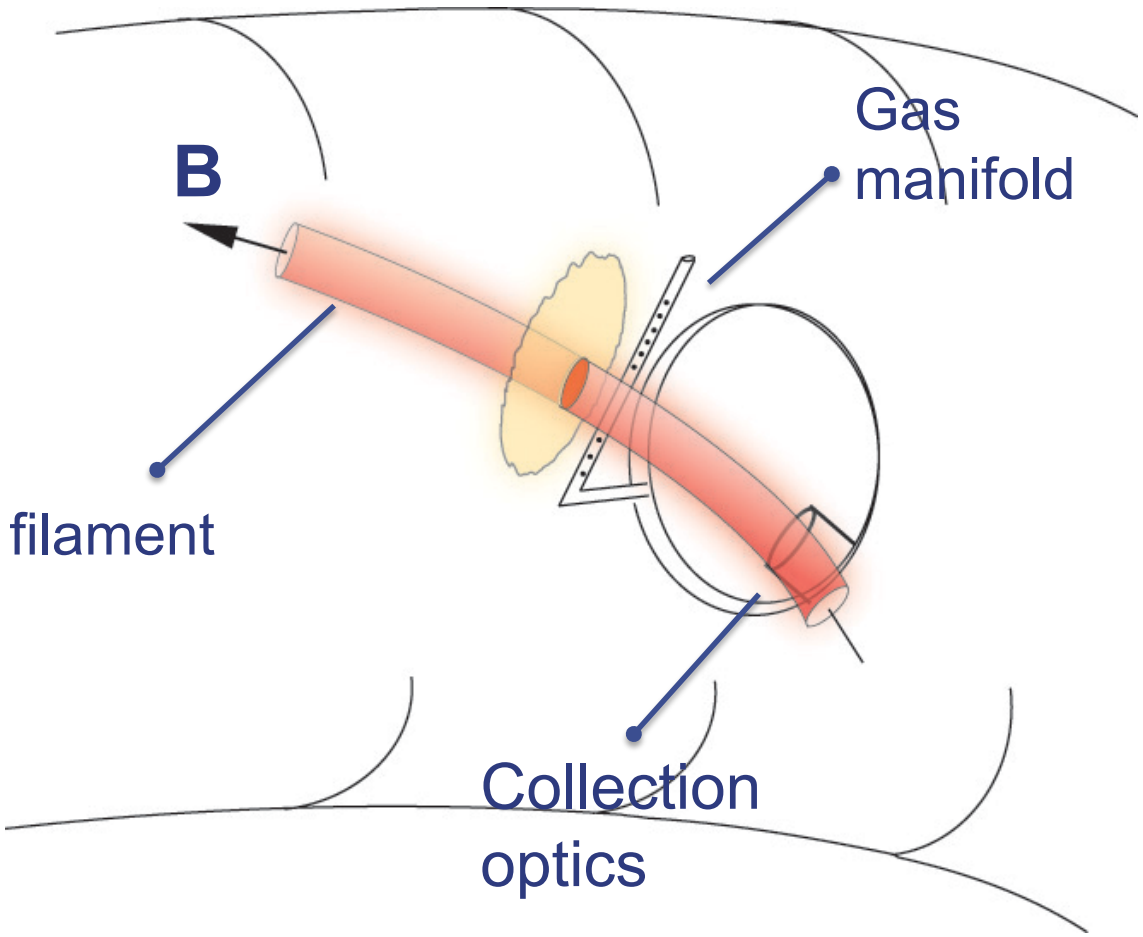
- RF heated, near L-H threshold plasmas
  - Small ELMs, but ELM type unclear
- ELM precursors imaged with Gas Puff Imaging(GPI)
- 2D Evolution of precursor through filamentation/crash

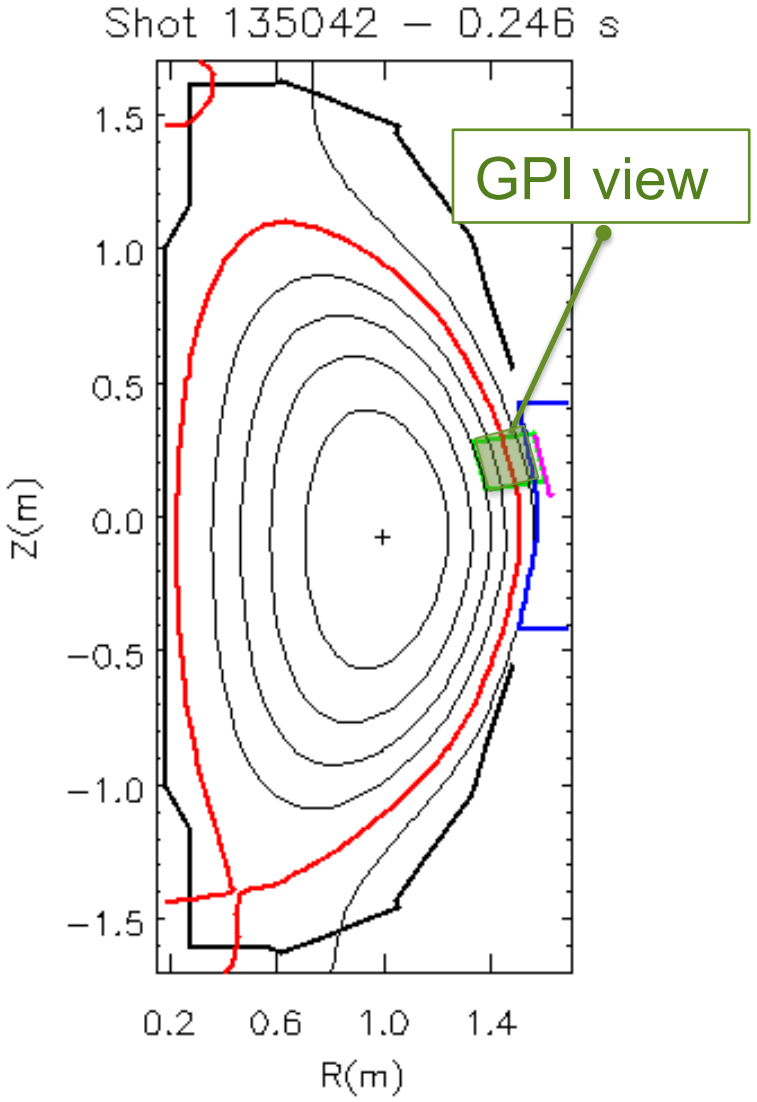
Sechrest et al. Nuclear Fusion, publication pending

Outline:

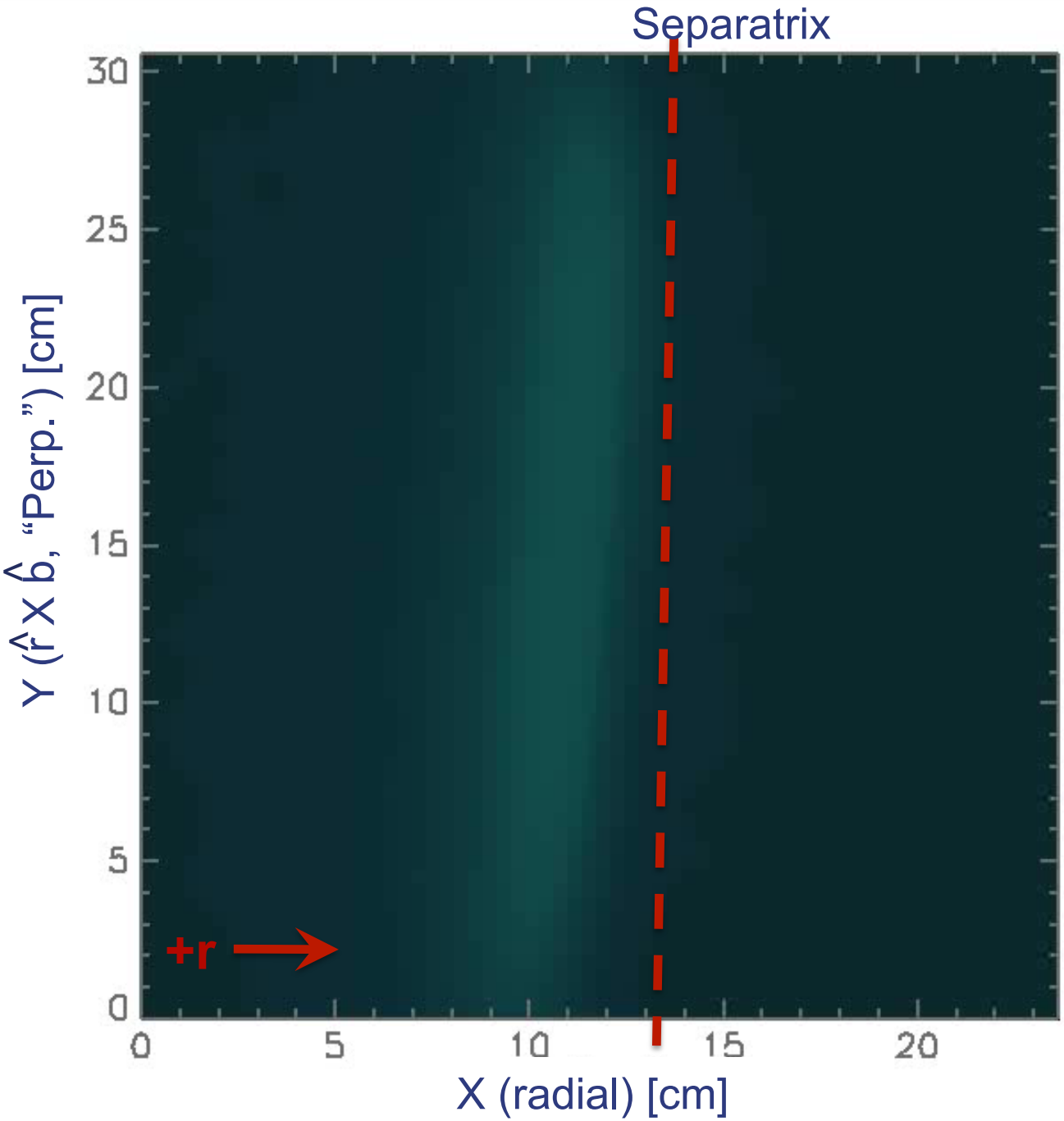
- GPI Observations
- Precursor mode Characterization
- Perturbation of H-mode edge

Gas Puff Imaging

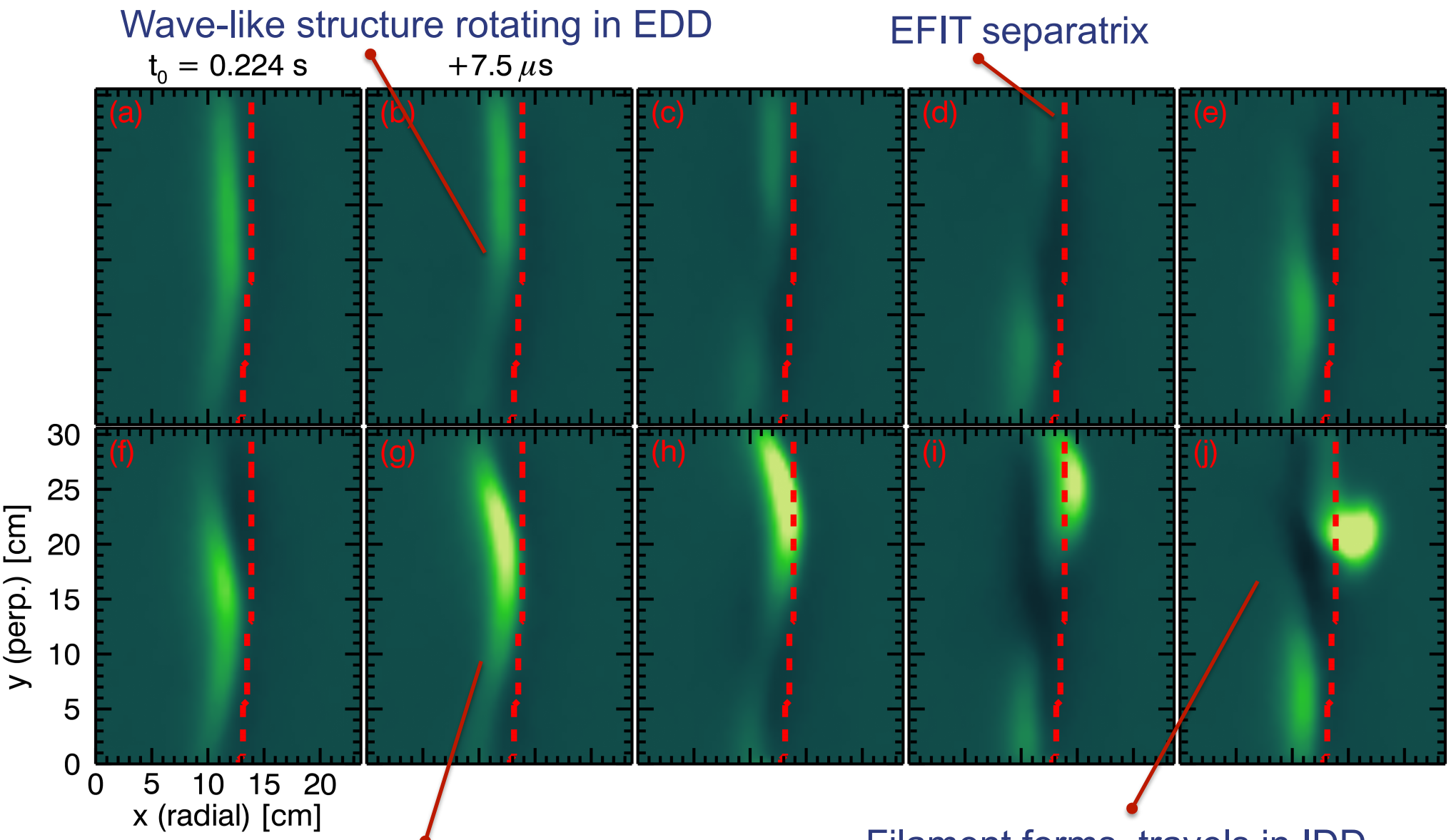




ELM Precursors captured by GPI



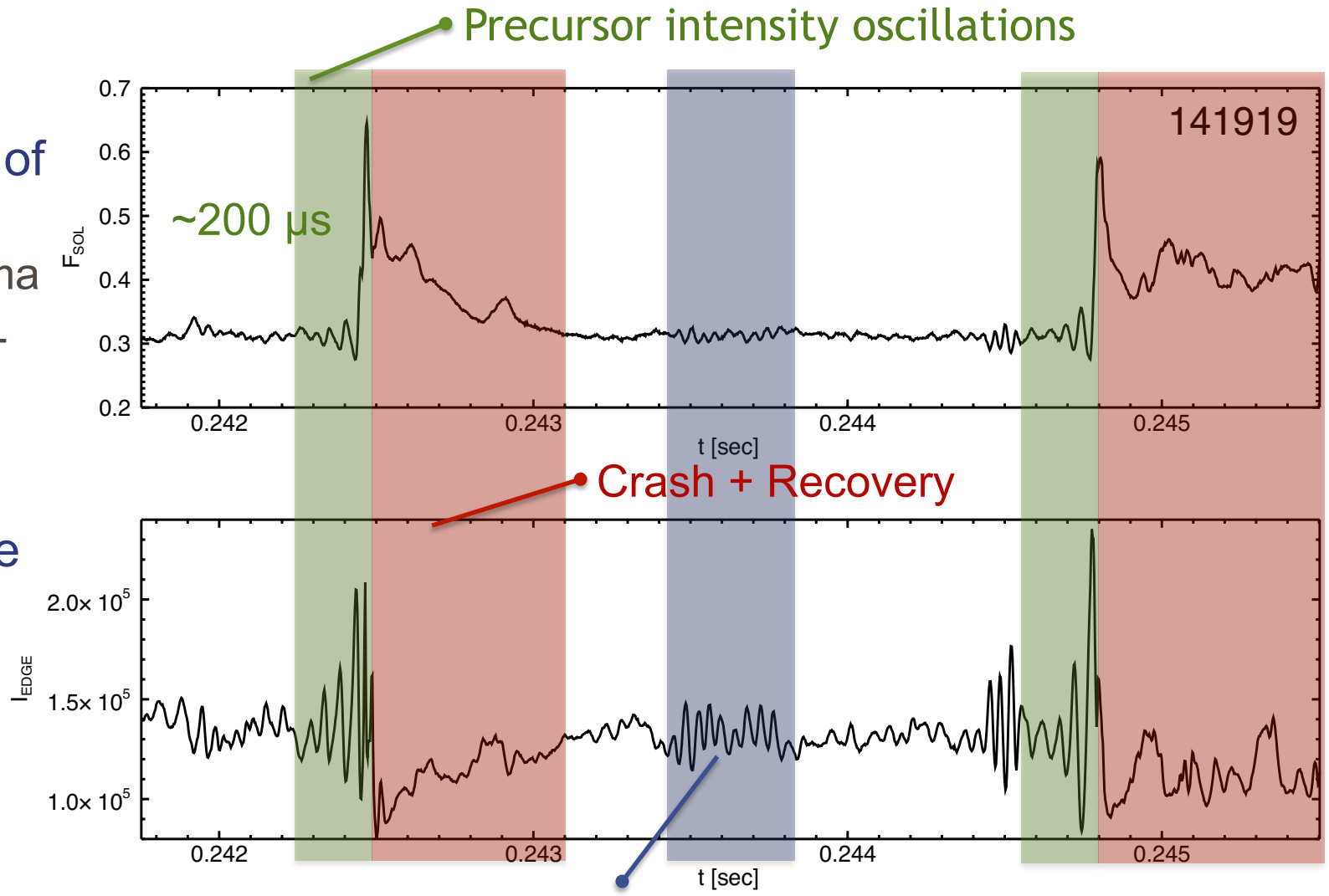
Evolution of precursor to crash observed



Precursors are short-lived and growing

F_{SOL} = fraction of light in SOL
- Indicates plasma ejected into SOL

I_{EDGE} = integrate Intensity just inside LCFS



Precursor Characteristics:

- Short-lived, Coherent fluctuations
  - 200 microsec duration
  - Frequencies between 20-30 kHz
- Finite Ky
  - Wavenumbers from imaging: Ky = 0.05-0.2 cm^{-1}
- Exhibit magnetic signature
  - Intensity fluctuations strongly correlated with Magnetics
  - Intermediate Toroidal mode #'s : n = 5-10
- What are precursor oscillations?
  - Mode number suggests Peeling-Ballooning
  - Peeling or Ballooning type edge deformation

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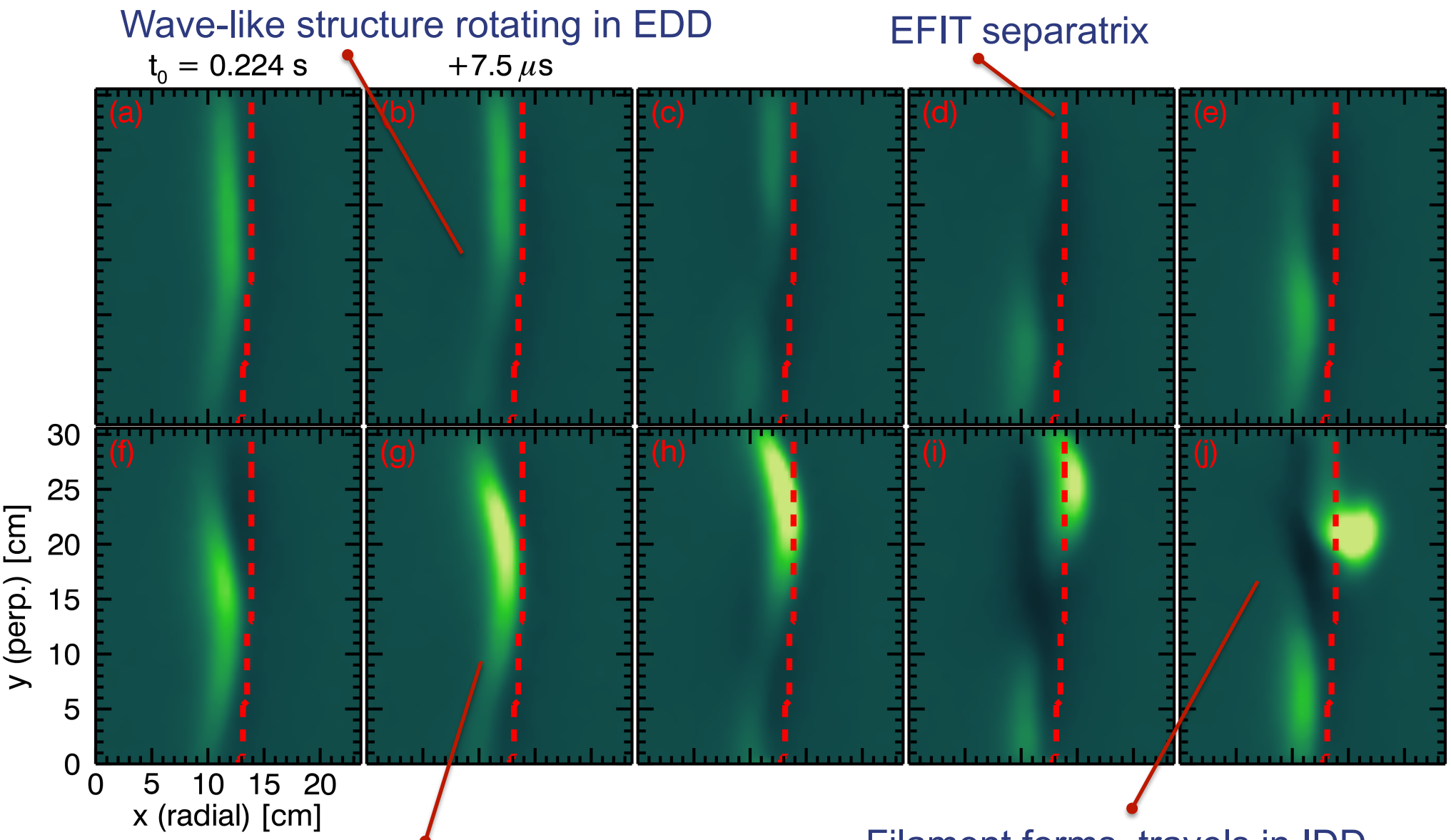
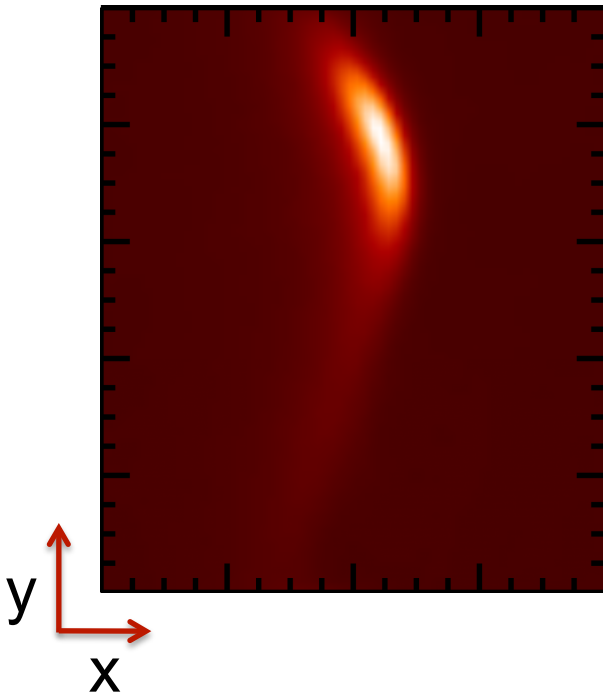
How can we quantify this?

Evolution of precursor to crash observed



Quantifying the edge deformation



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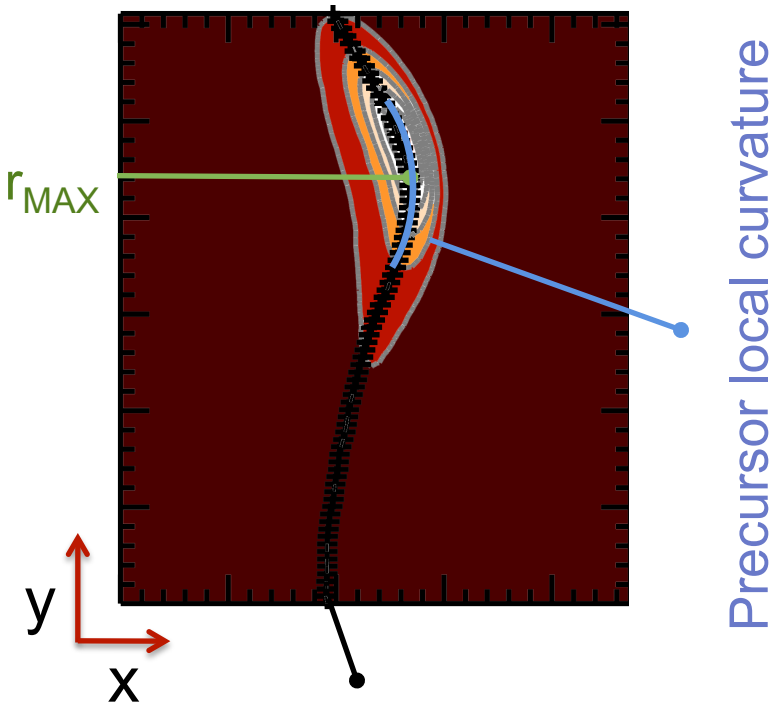
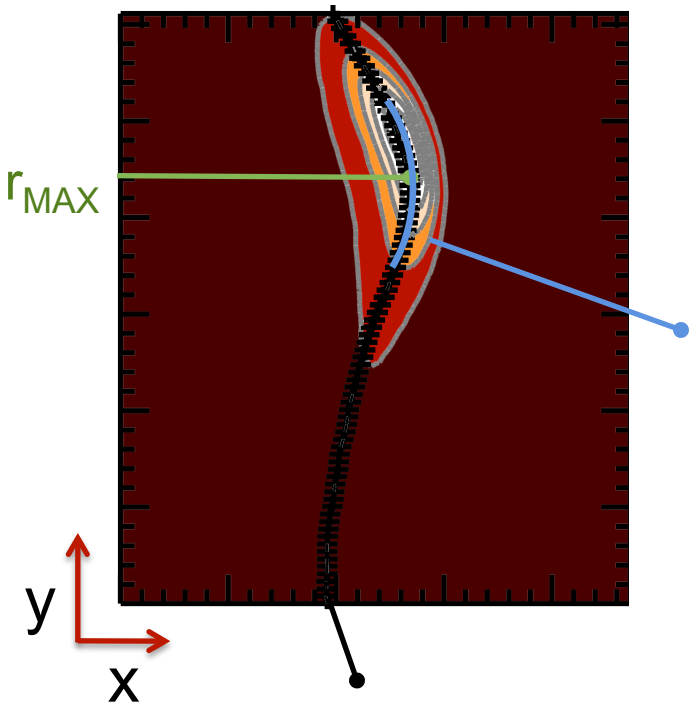


"edge" = x(y)
(weighted intensity average in x)

$$\kappa = \frac{x''}{(1 + x'^2)^{3/2}}$$

Quantifying the edge deformation



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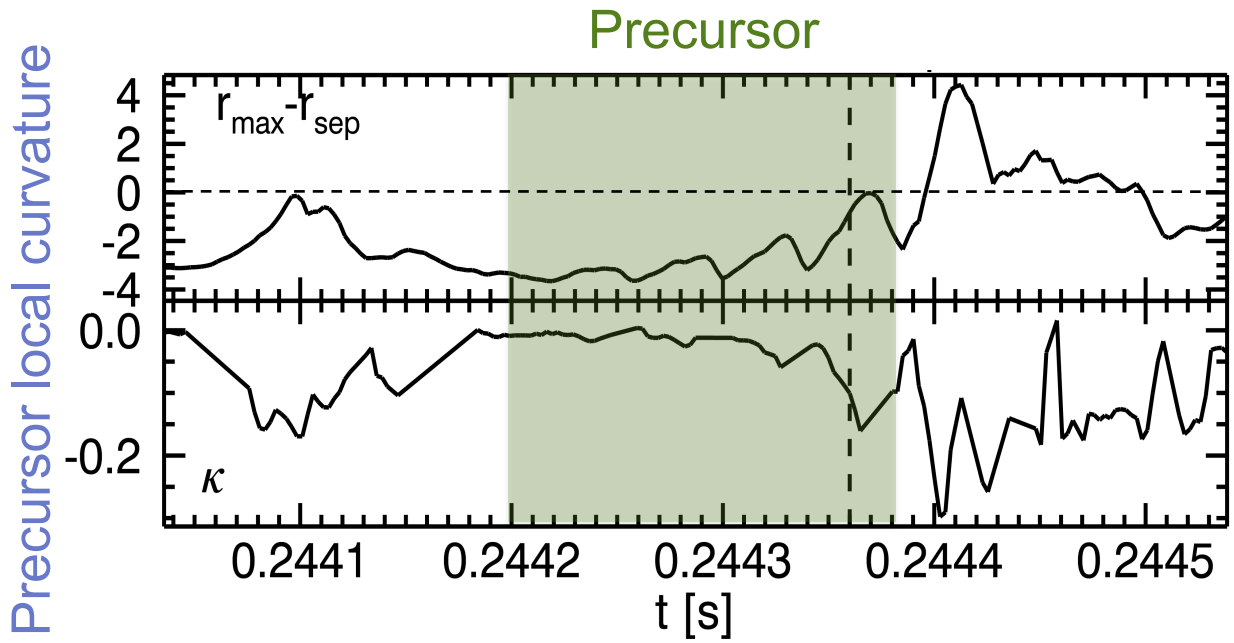
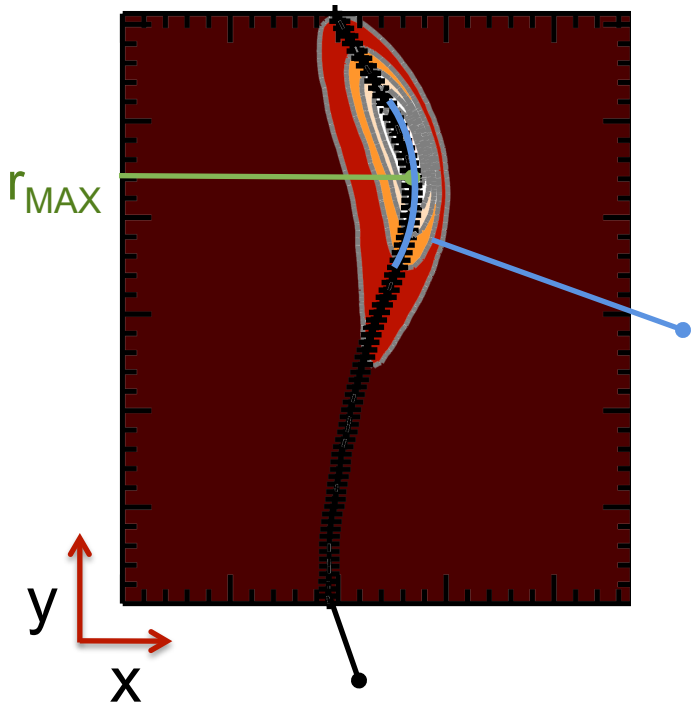


ELM precursors exhibit strong curvature



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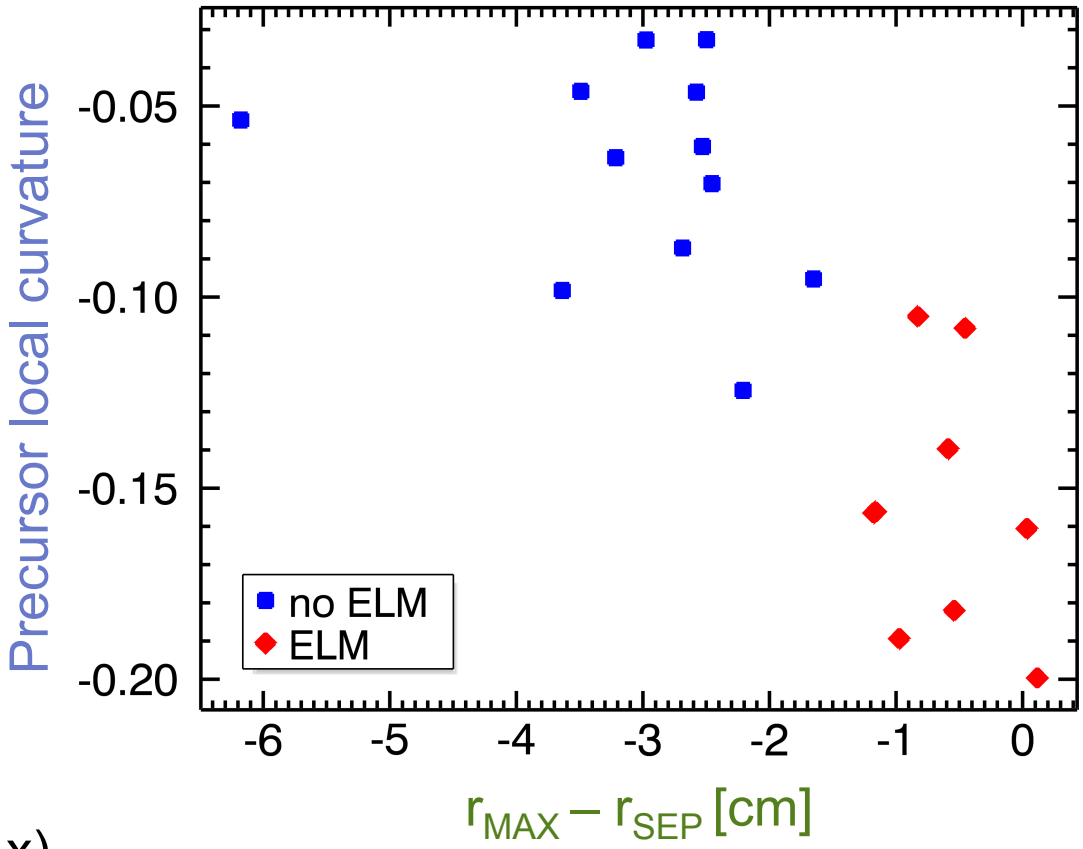

Summary

- Precursor Mode Characteristics
  - Short-lived and coherent
  - Finite Ky
  - Correlated with magnetics
  - Intermediate toroidal mode #'s
- Precursor edge deformation
  - ELM events exhibit Strong negative curvature
  - Max radial excursion approaches EFIT separatrix position
- RF vs. OH vs. NB
  - Precursors most prevalent in RF shots
  - Observed in OH shots
  - Not observed in NBI shots

Thanks for your attention.

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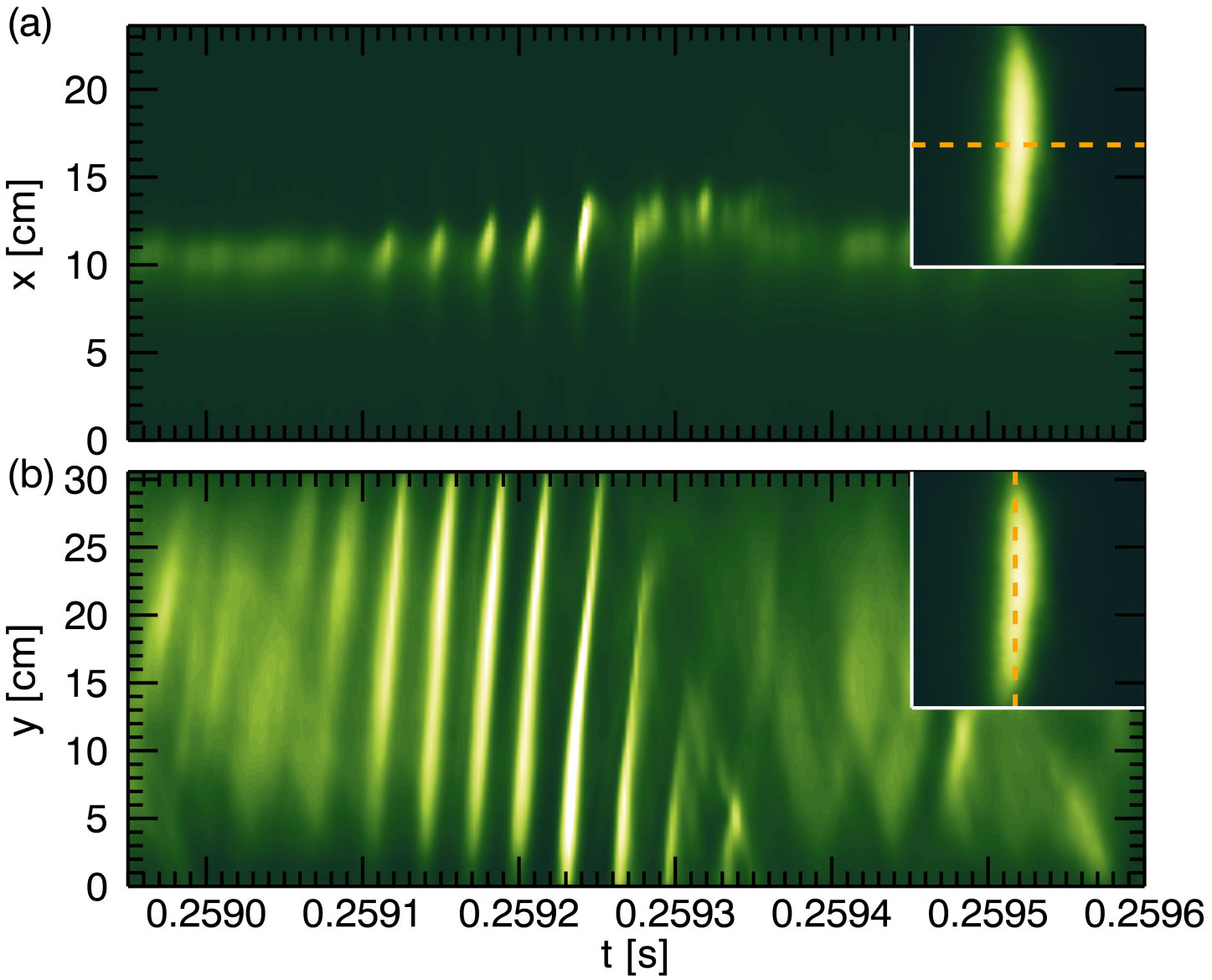
Coherent Intensity Fluctuations

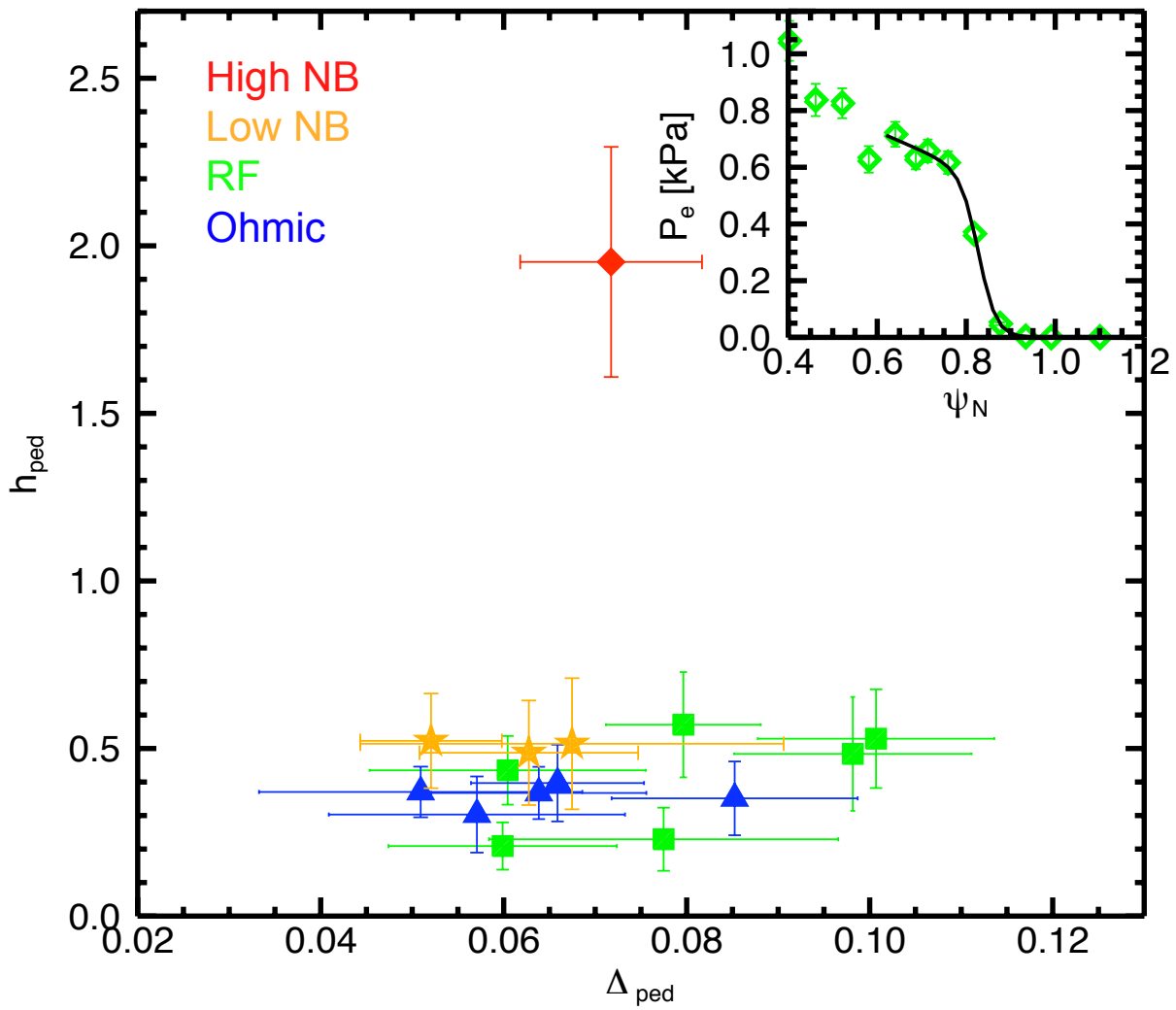


Unresolved issues

- ELM type
  - Dithers, etc. complicate identification
  - Ballooning characteristics, intermediate n
- Underlying Instability
  - Occur under what conditions?
  - Ballooning-like character
    - Edge pressure important?

Precursors prevalent only in RF cases

- Precursor Occurrence
  - Mostly in RF cases
  - Some in Ohmic
  - None in NBI cases
- Pedestal Params
  - No clear dependence on heating
- Toroidal Flow Effects?
  - Insufficient data

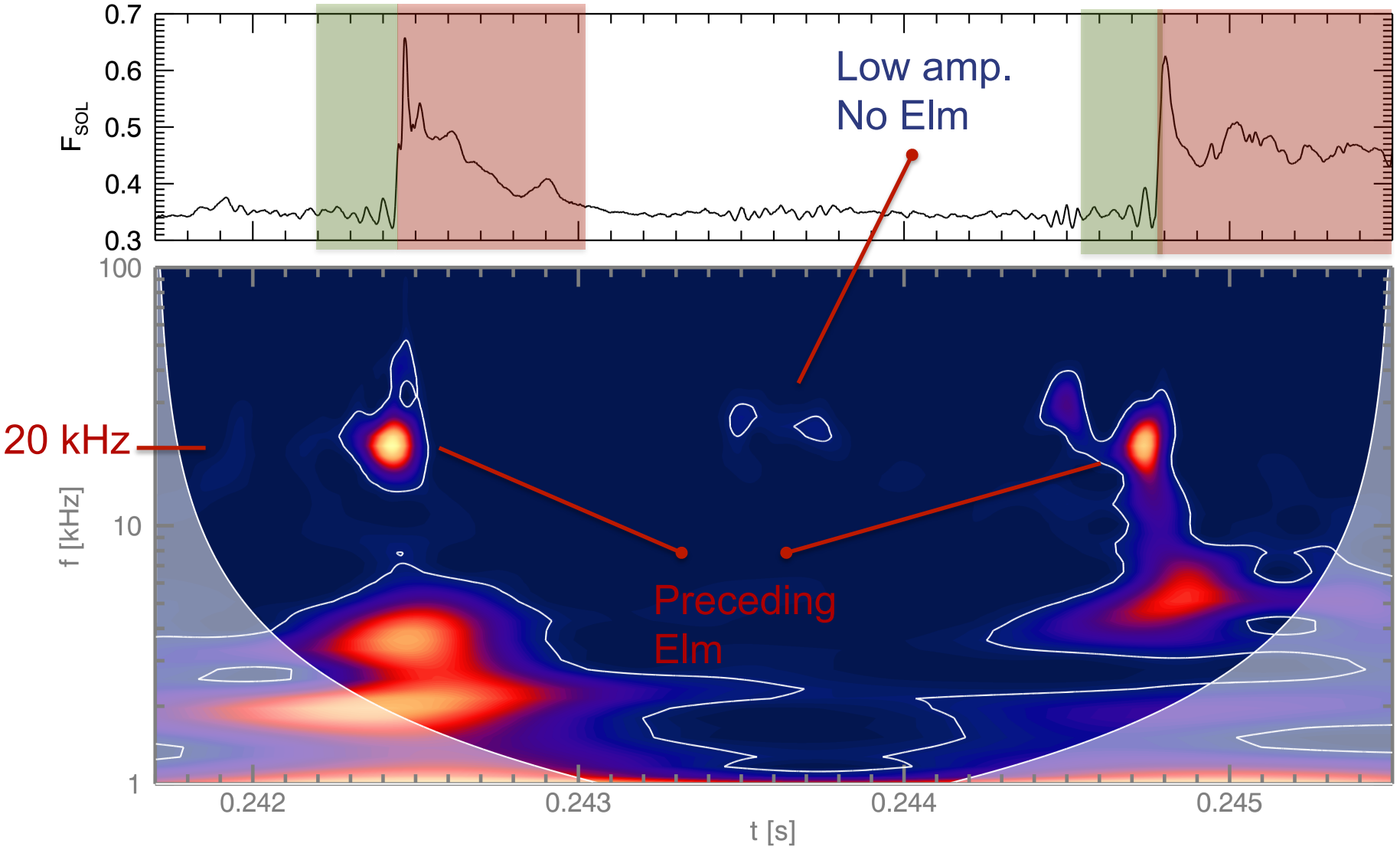


Unresolved issues

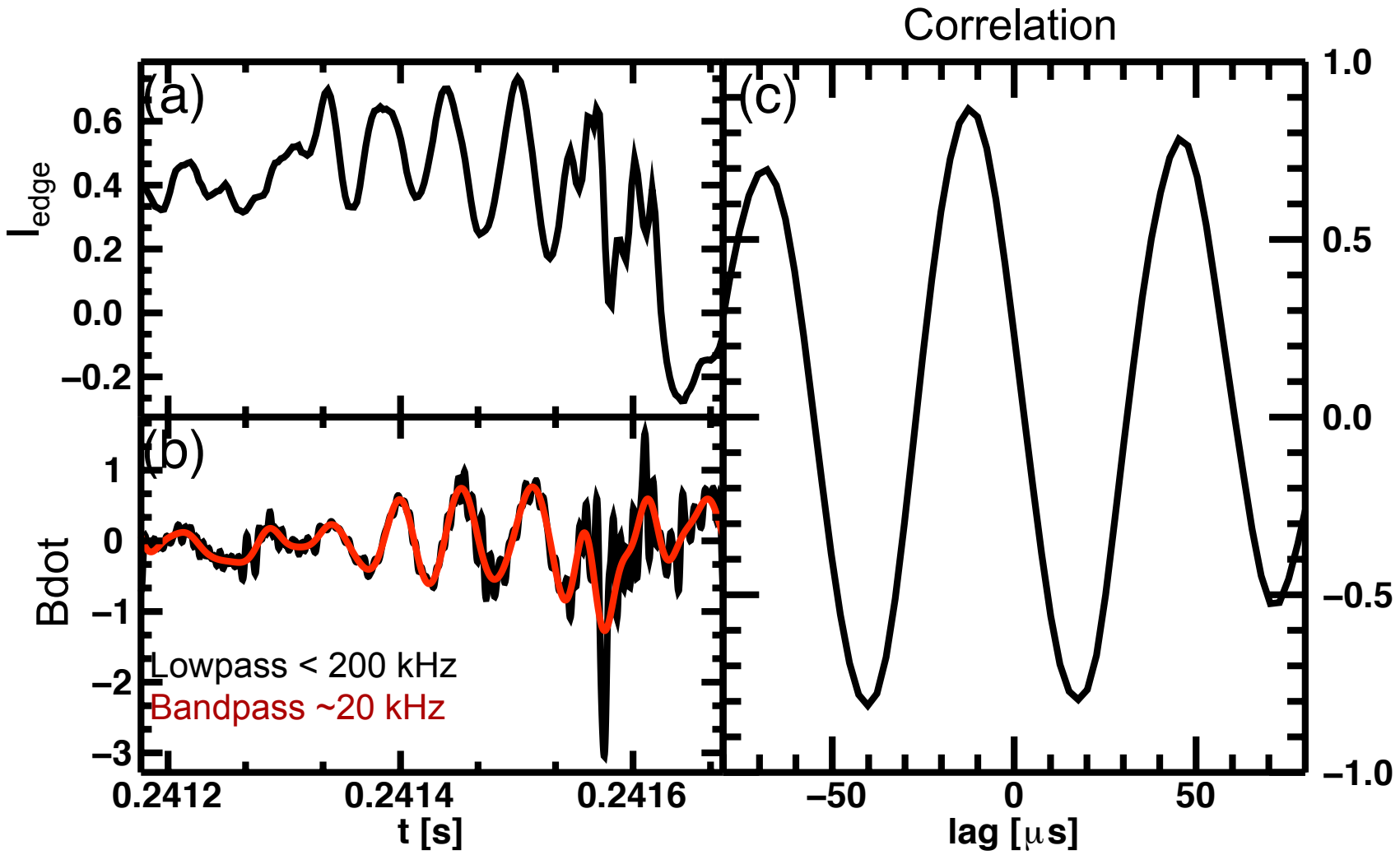
- ELM type
  - Dithers, etc. complicate identification
  - Ballooning characteristics, intermediate n
- Occurrence rate highest in RF cases
  - No precursor seen in NBI plasmas?
  - V_{tor} important?
- Underlying Instability
  - Peeling – Ballooning?

Precursor mode at 20-30 kHz

Continuous Wavelet Transform of Edge Intensity



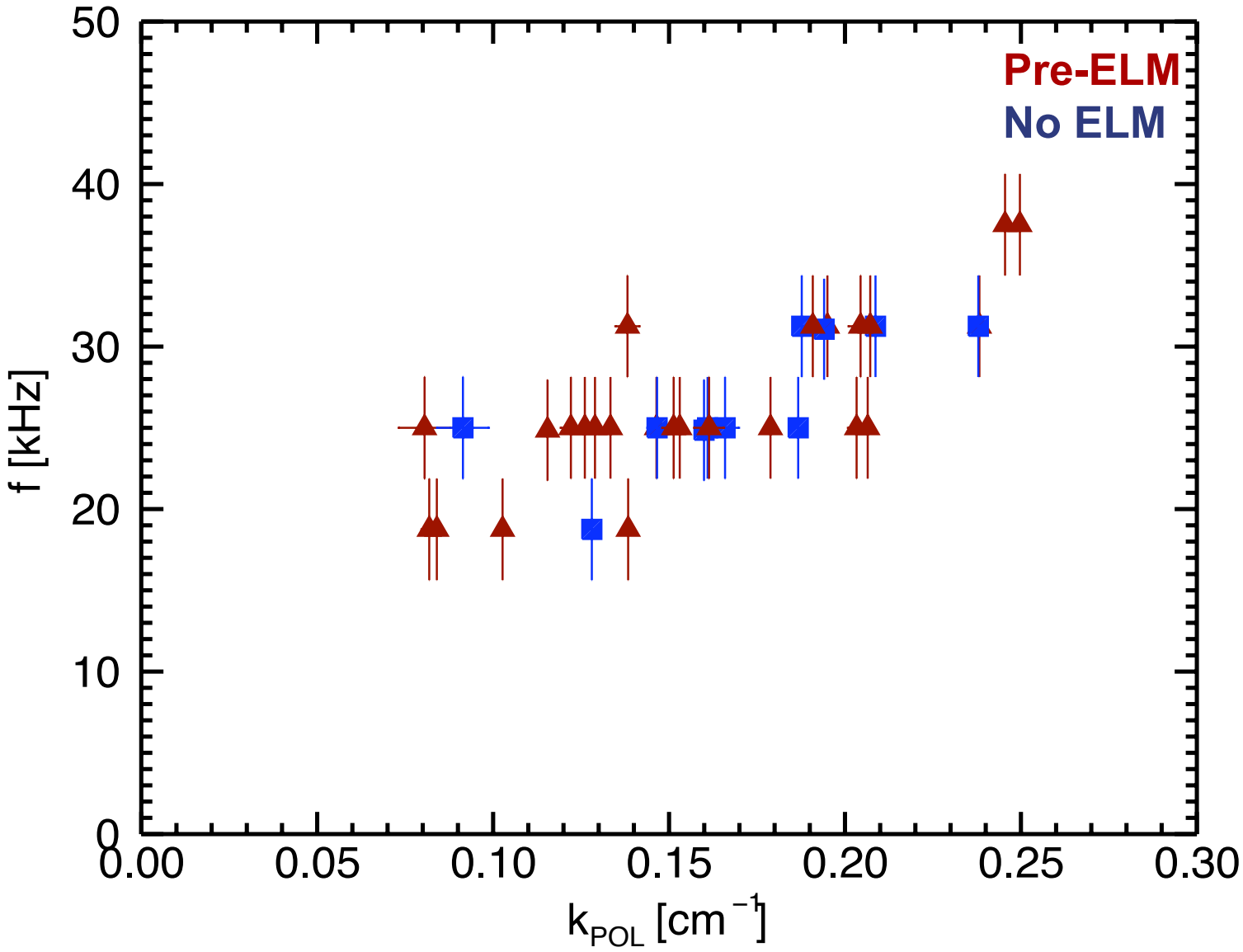
Low-F magnetics correlated with edge intensity



- Strong Correlations, R > 0.8
- Fluctuations appear to be electromagnetic
- n ~ 5-10 estimated from coil array

Typical Wavenumbers of 0.1-0.2 cm^{-1}

windowed FFT during periods with edge fluctuations



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