Pedestal Height Scalings and Initial Turbulence Analysis in NSTX

A. Diallo

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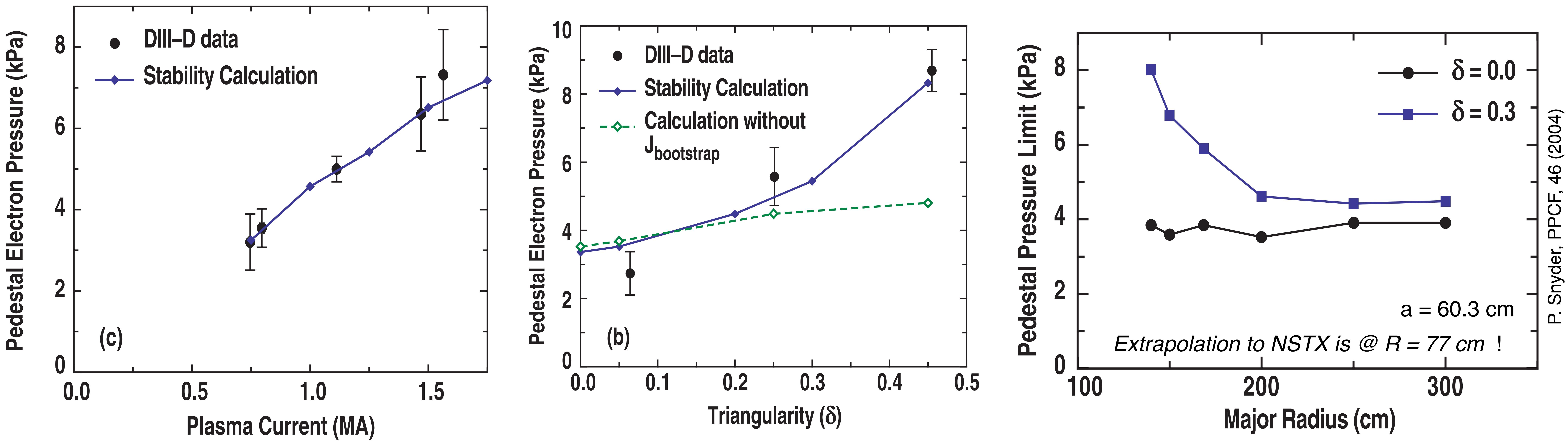
Motivation

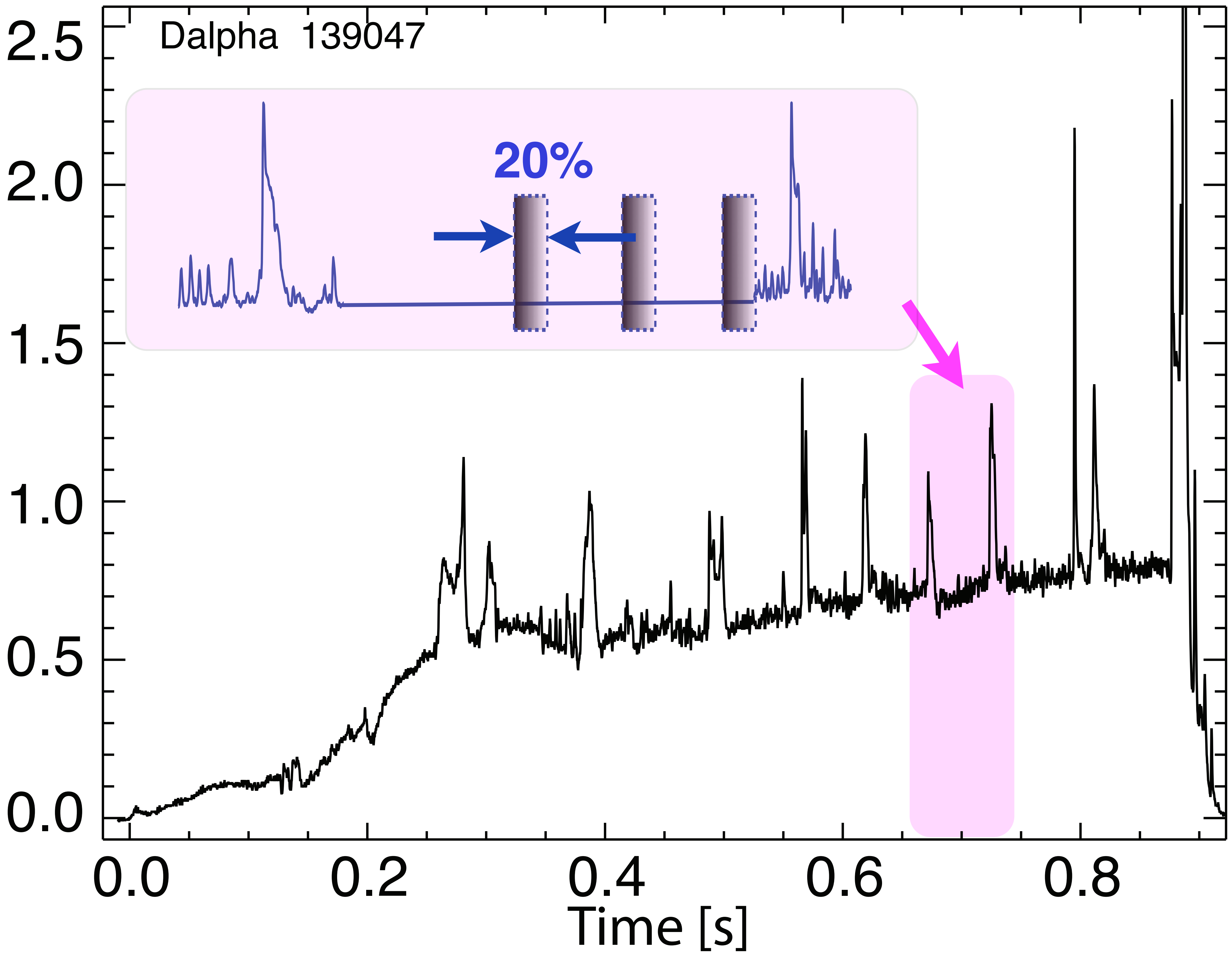


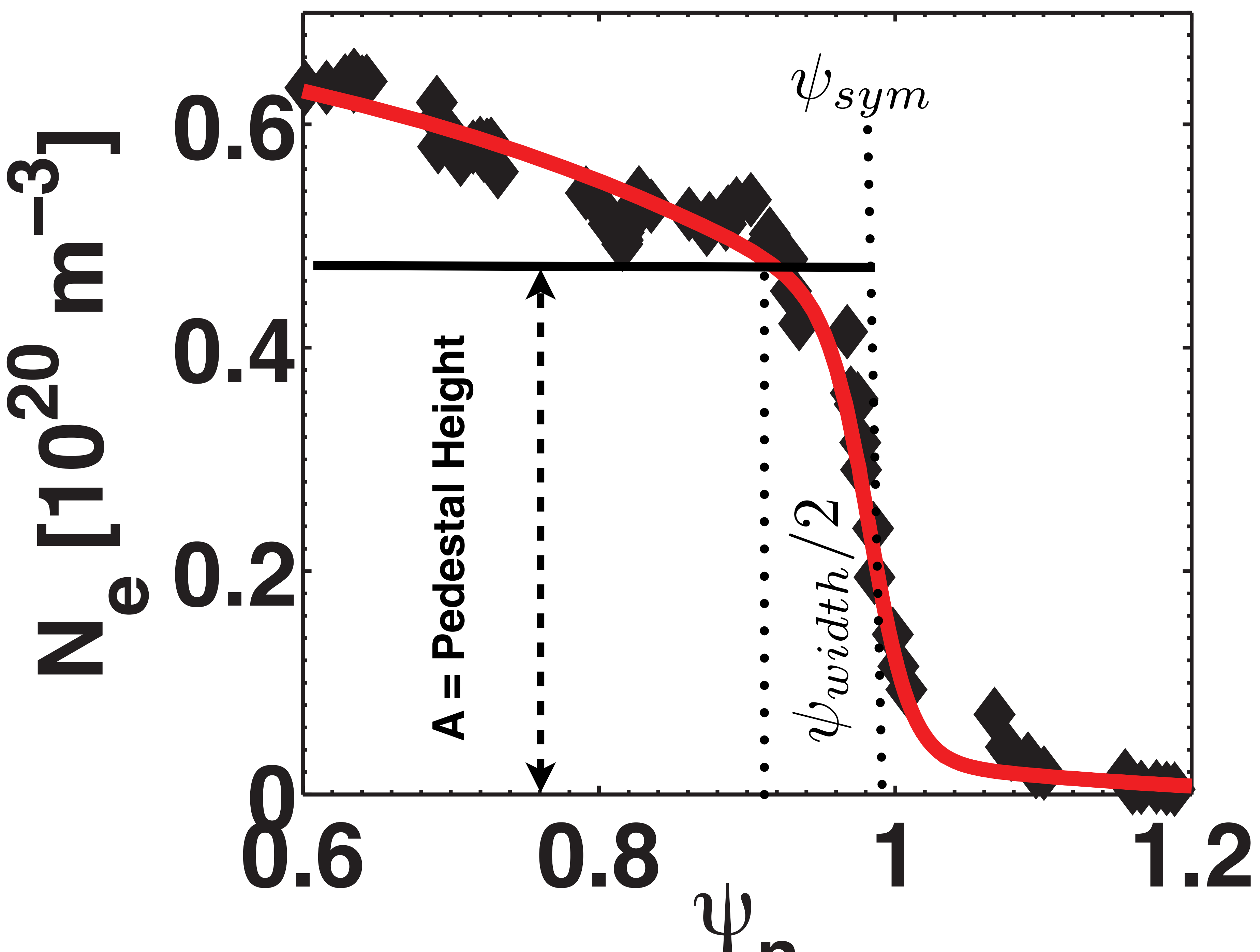
- ELITE modeling simulating DIIID discharges show the pedestal height trends with triangularity and plasma current (Ip)
- Extension of the triangularity trends to NSTX has yet to be established.

Understand the pedestal structure prior to the onset of ELMs as a function of key plasma parameters

- Investigation of the plasma current and shape scalings
  - Pedestal component has a strong dependence in Ip [J.Hugh,Phys. Plasma 9,2019, (2002)]
  - Shaping is known to have strong effect in MHD stability
- Assess the edge fluctuations during the multiple stages on an ELM ELM cycle.
  - Density fluctuations through reflectometry
  - Velocity fluctuations through GPI

Composite radial profiles of density, temperature and pressure synced to Type I ELM cycle



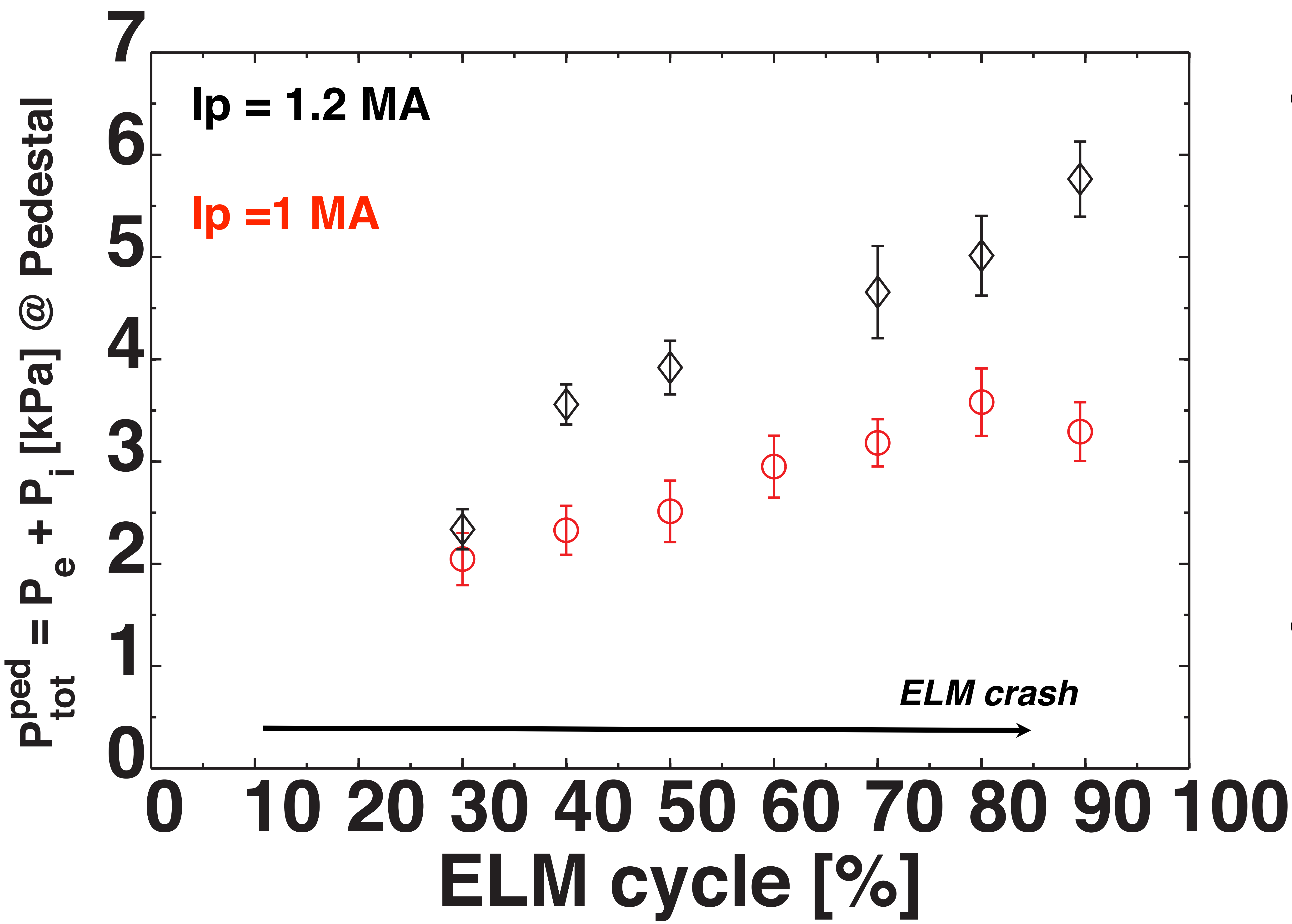


$$N(\psi) = A \tanh\left(\frac{\psi_{sym} - \psi}{\psi_{width}}\right) + offset$$

R. Groebner and T. Osborne PoP **5** 1800 (1998)

- N_e and T_e profiles fitted using modified tanh function
  - Ion profiles fitted with splines (no clear pedestal)
- Fits done in discrete windows throughout ELM cycle

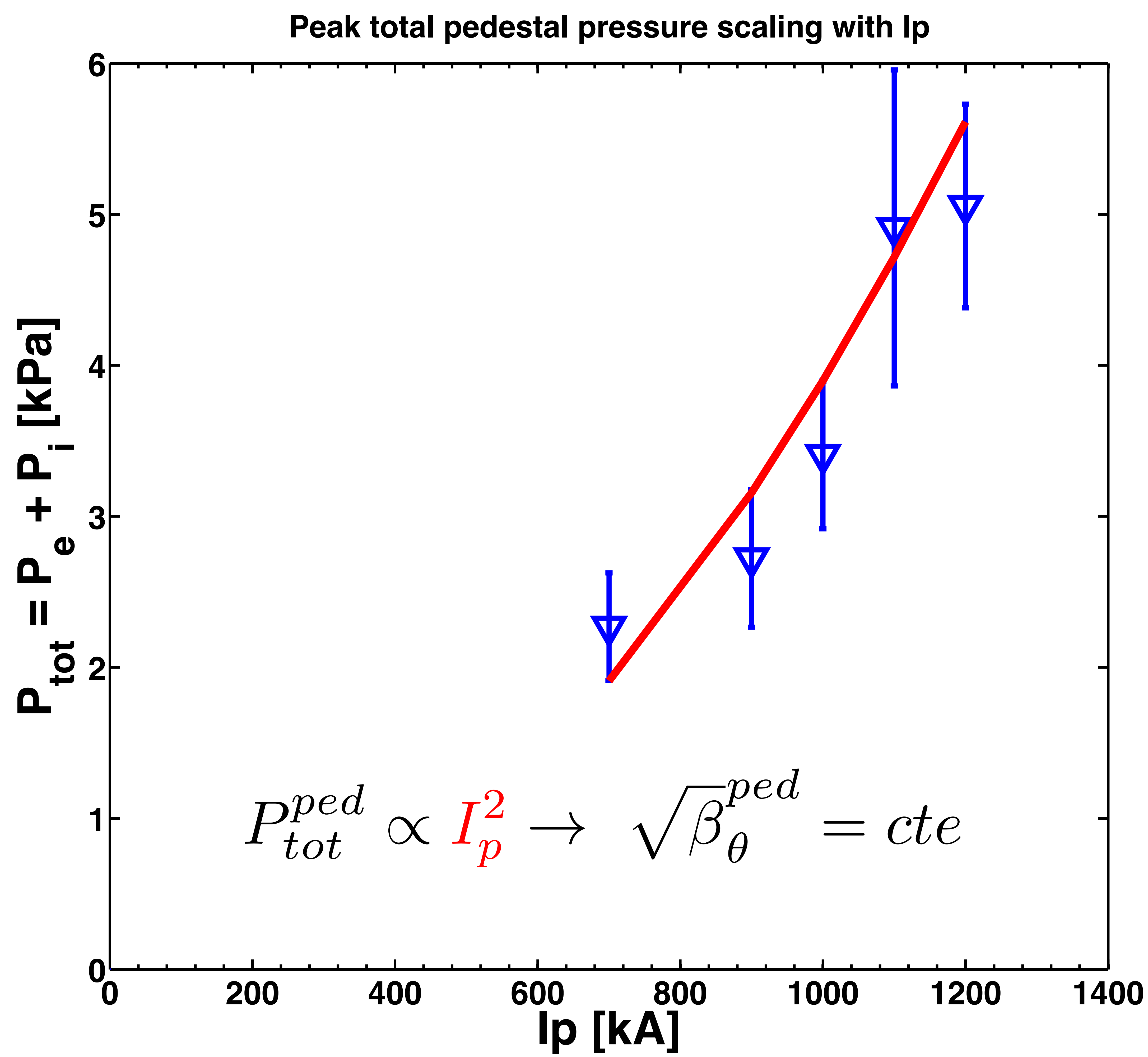
Pedestal height builds up during an ELM cycle



- Pedestal pressure increases by a factor ~ 3 before the ELM crash
  - No clear saturation at high Ip
  - Saturation late in cycle at lower Ip
  - In contrast to rapid saturation within first 20-50% of ELM cycle observed in AUG and DIIID

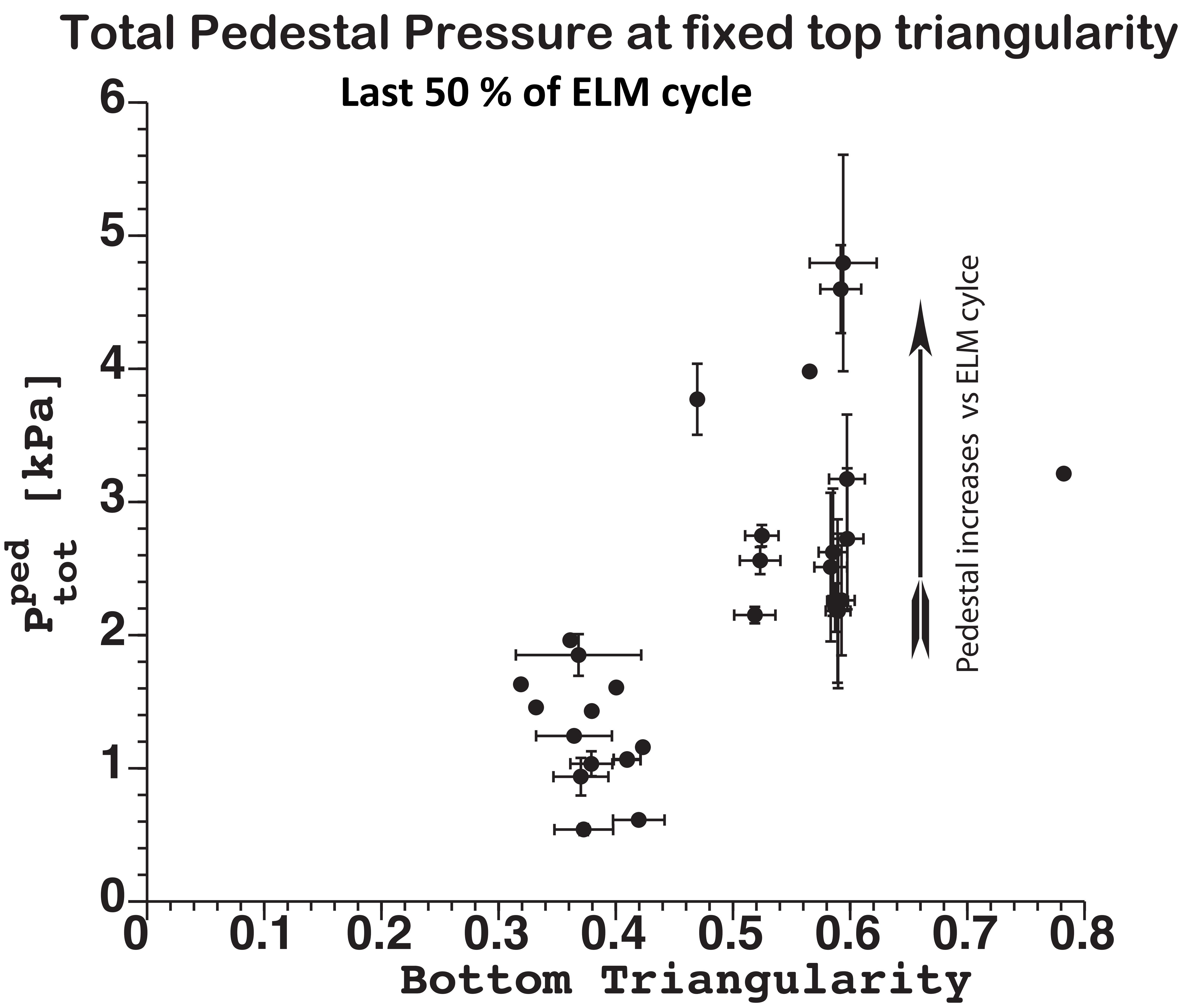
    (Maggi, Nucl. Fusion 2010 & Zohm, PPCF 2010)
- Pedestal pressure increases with Ip

P_{tot}^{ped} increases quadratically with Ip, but at constant β_θ^{ped}



Consistent with higher R/a, e.g. DIIID, C-MOD,and AUG [Osborne,PPCF 42 2000, Hughes, PoP 13 (2006), Suttrop,PPCF, 42 2000]

Pedestal pressure height increases with bottom triangularity



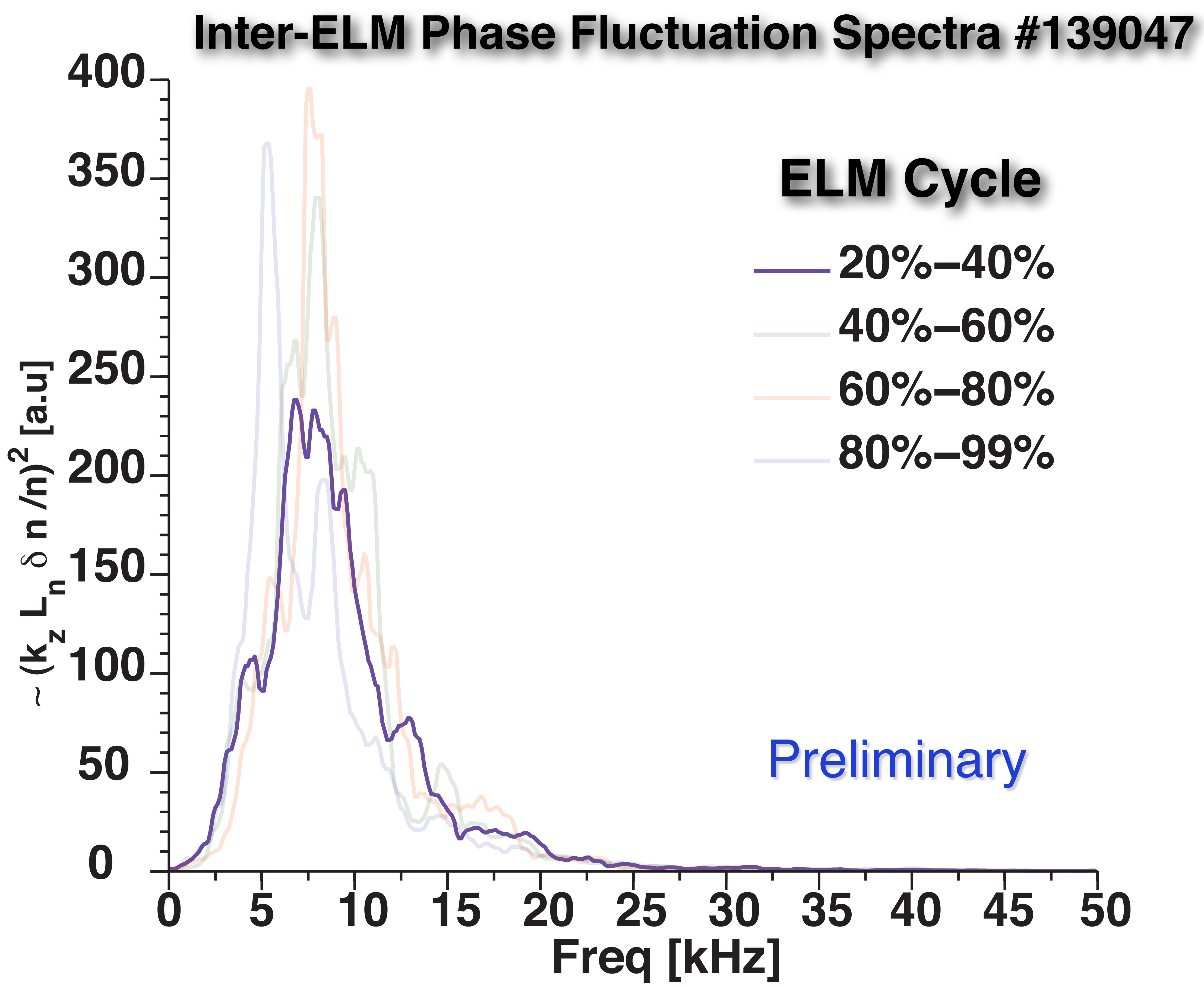
- Ip=0.8 MA, PNBI=4 MW, Bt=0.45 T, drsep~ - 0.5 cm
- density and temperature pedestals both increase
- Similar to DIII-D
  [Osborne,PPCF 42 2000]

Understand the pedestal structure prior to the onset of ELMs as a function of key plasma parameters

- Assess the edge fluctuations during the multiple stages on an ELM ELM cycle.
  - Density fluctuations through reflectometry
  - Velocity fluctuations through GPI

Density fluctuations at the top of the pedestal increase continuously during ELM cycle and "cascade" to low frequency just before ELM crash

- Phase fluctuations from reflectometry ~$k_z L_n \delta n/n$ at the top of the pedestal
- Increase of initial mode
  - e.g., at 7.5 kHz
- Mode activity late in ELM cycle
  - e.g., 5 kHz
- Modes are electrostatic, no evidence in Mirnov signals



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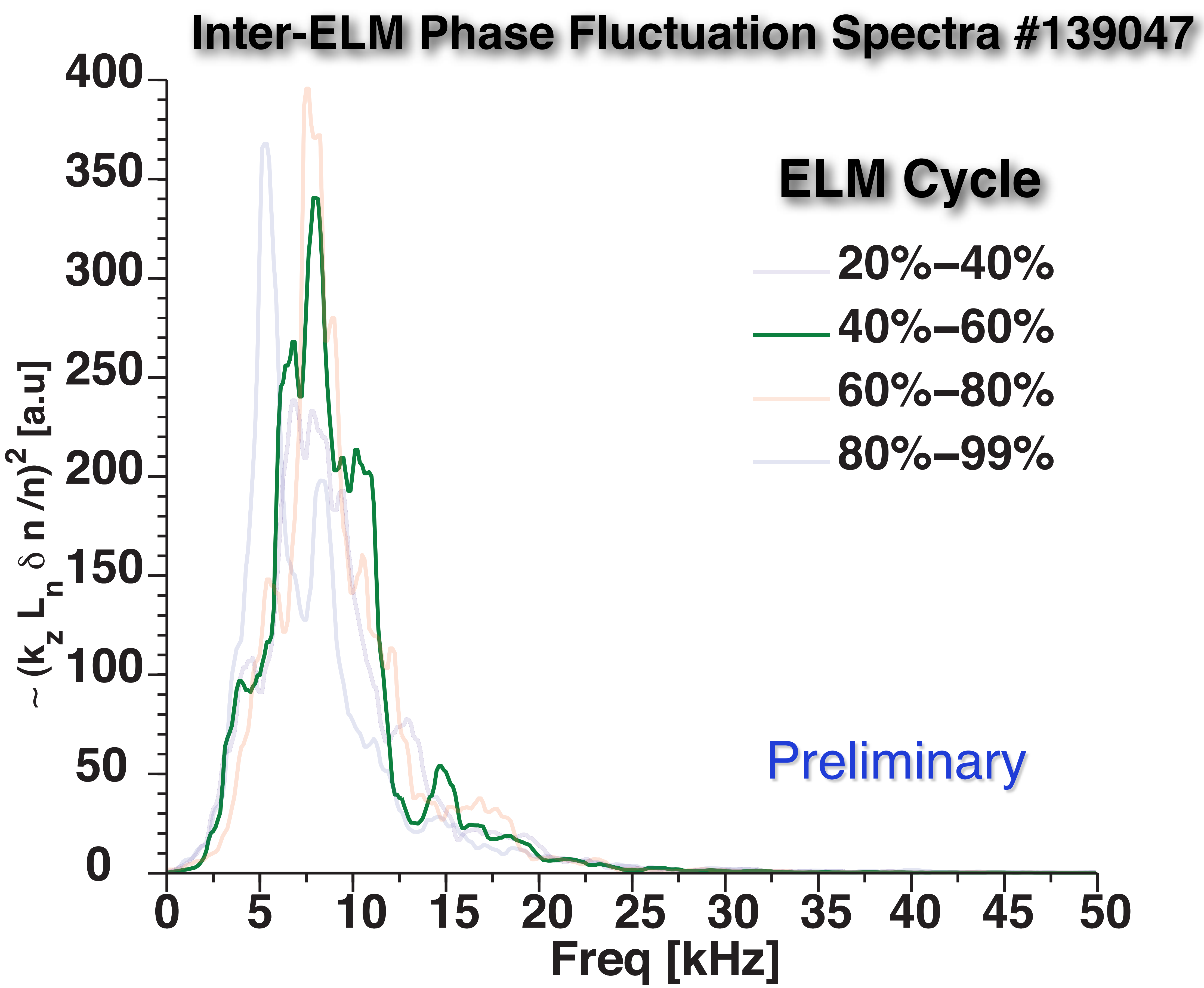

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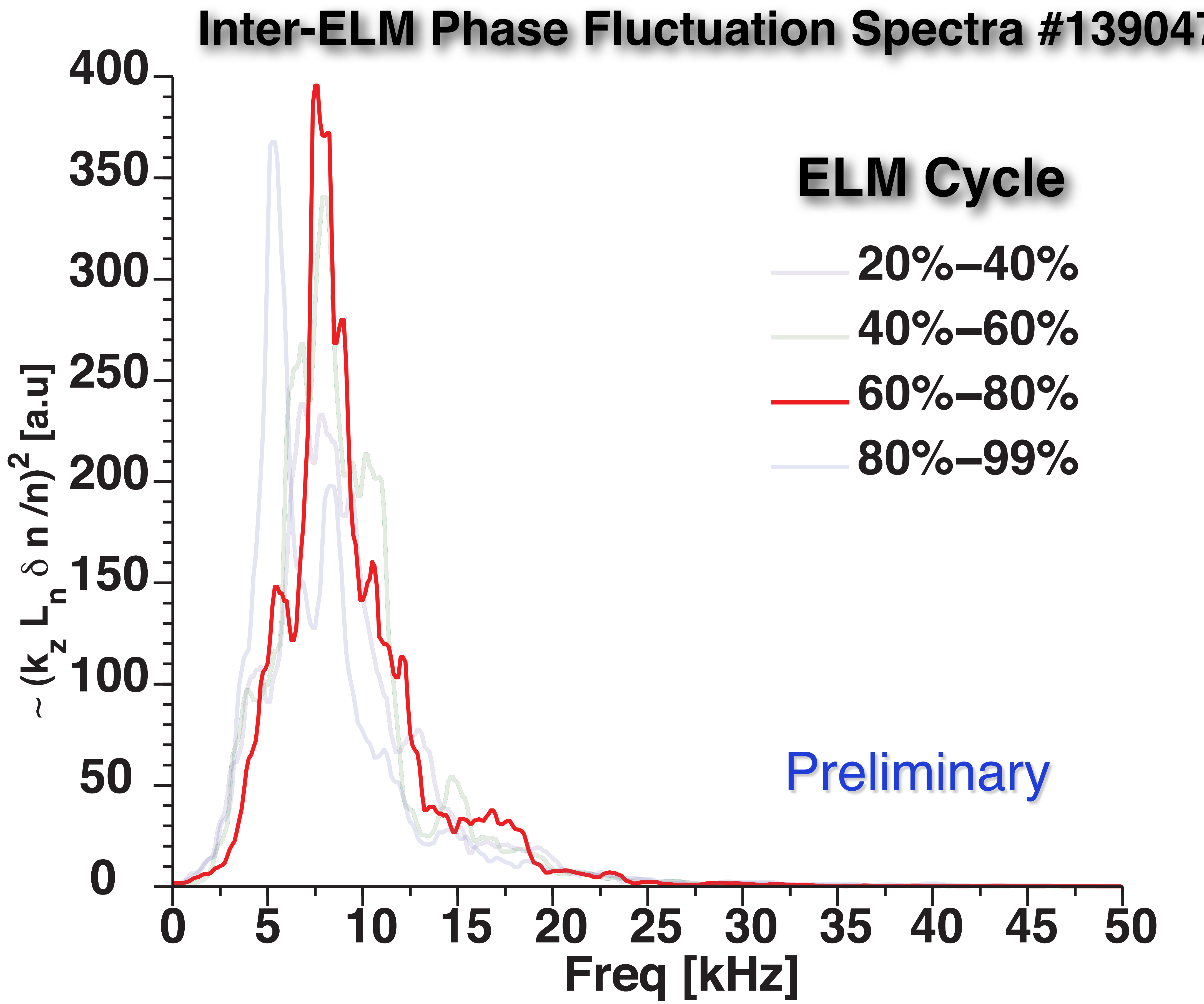

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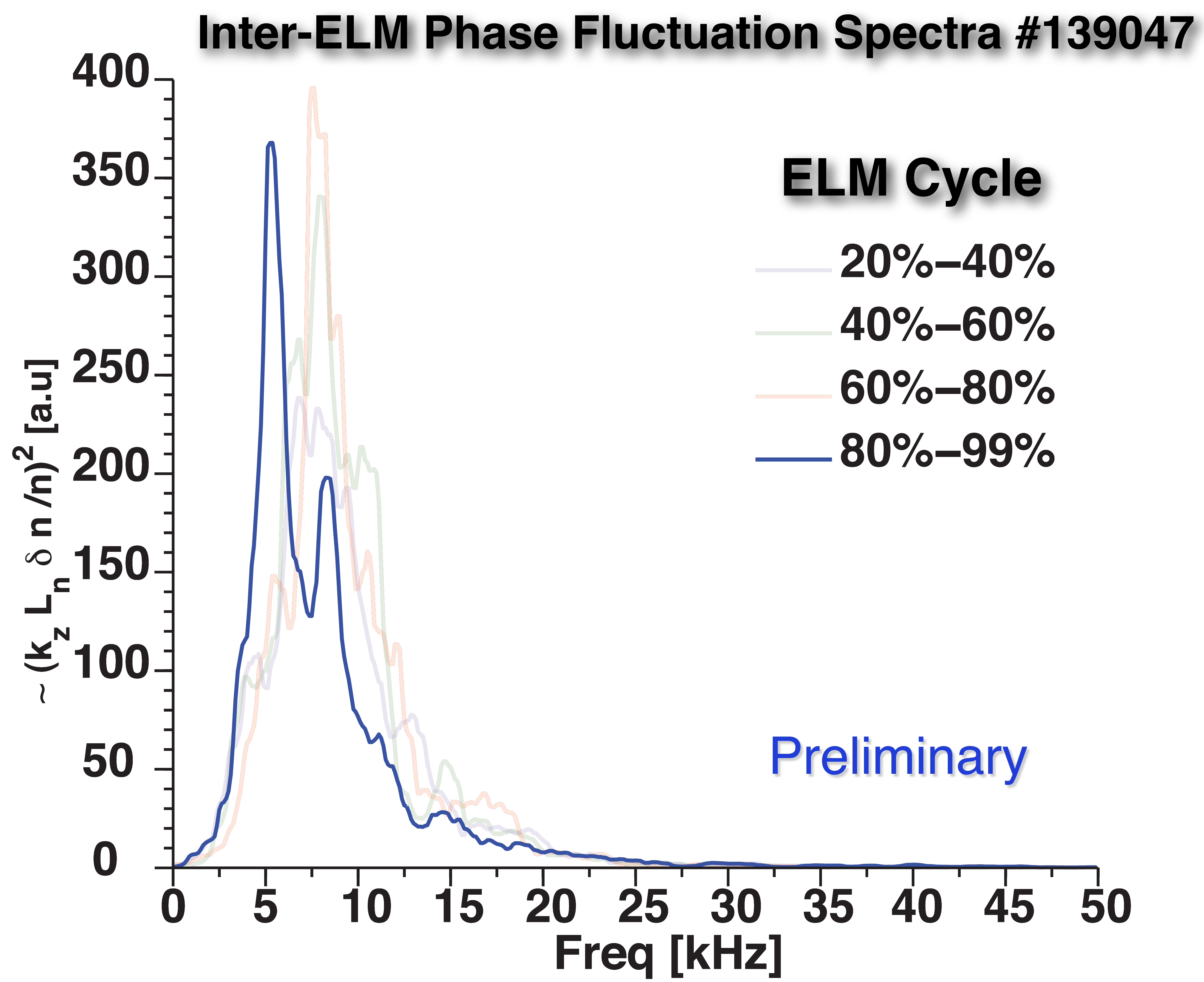
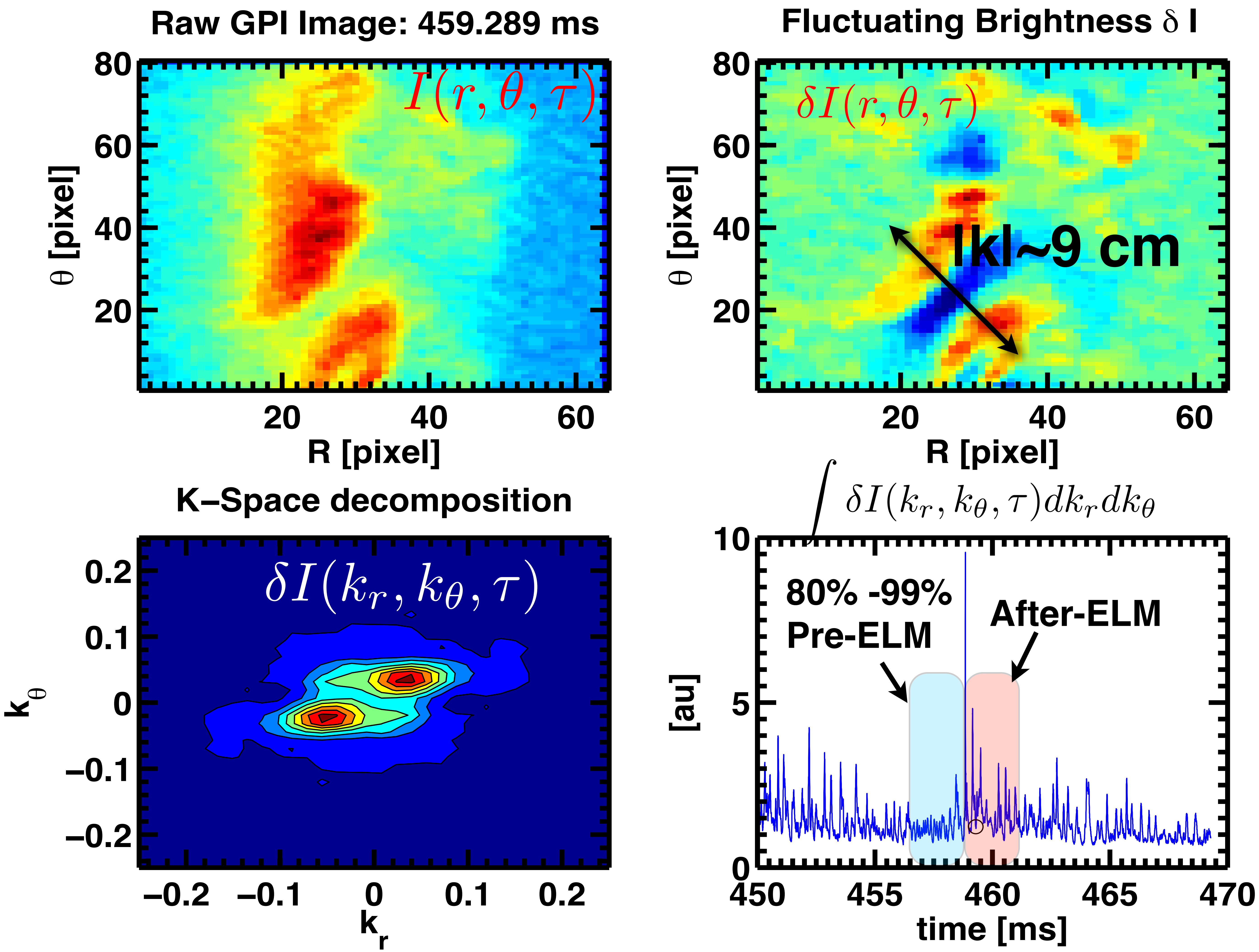


Assuming the advection of the gas puff, the velocity fluctuations in the region of steep gradient

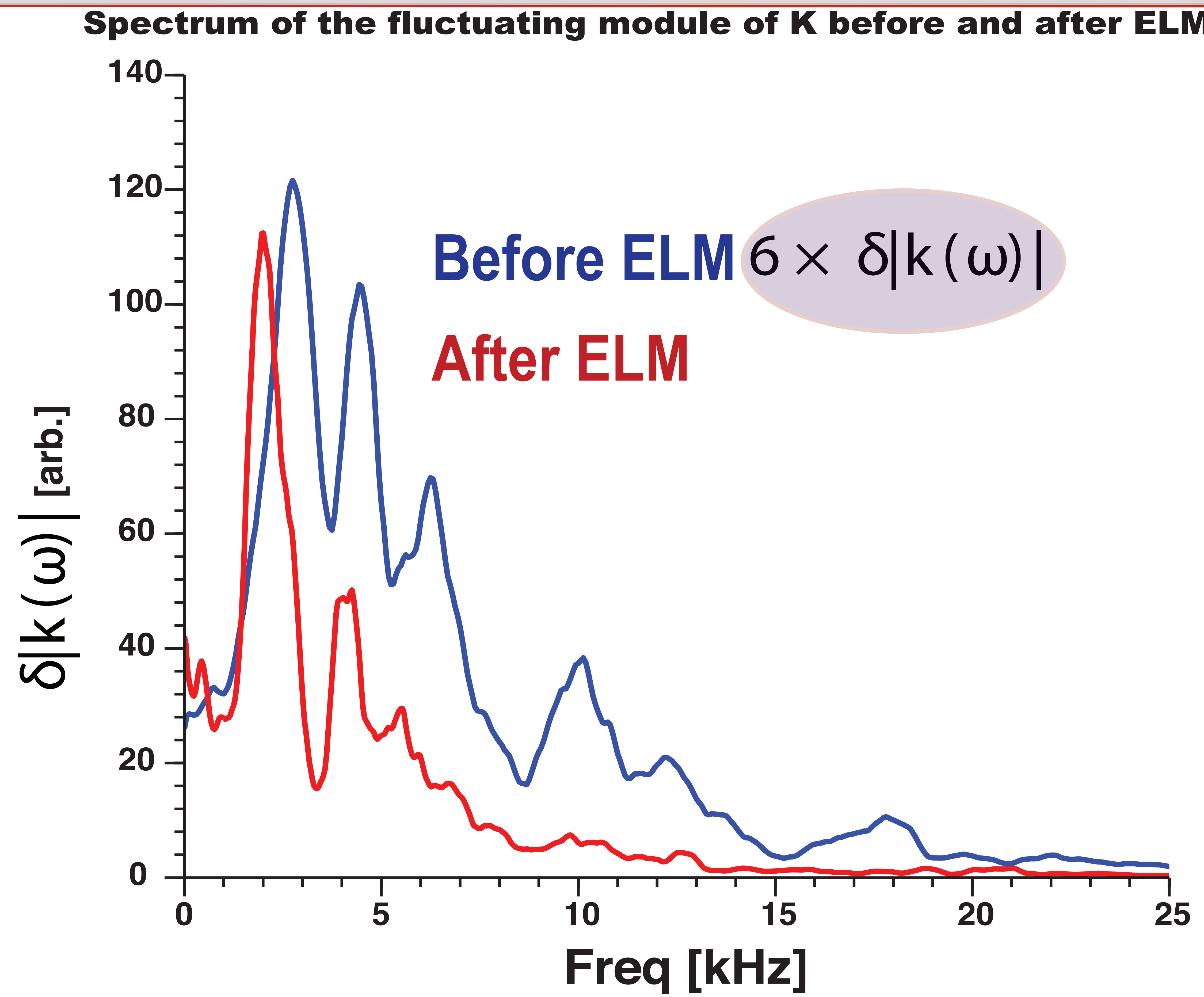


- Step 1: subtract *spatial* DC component
- Step 2: GPI brightness fluctuations are projected into K-space.
- Step 3: Evaluate |**K**| in the camera frame of reference
  - equivalent to the module in the advected frame of reference

- the fluctuation of |K| is correlated with the velocity fluctuations.

Y. B. Zel'dovich Sov. Phys. Dokl ,27 (1982)
A. Diallo PRL, 101 (2008)

Velocity fluctuation is higher after ELM than just before ELM



- Observation of coherent velocity fluctuations similar to recent observations by Zweben PoP (2010).
- RMS fluctuation is a measure of the velocity gradient which is shown to increase after the ELM crash.

Summary and future directions

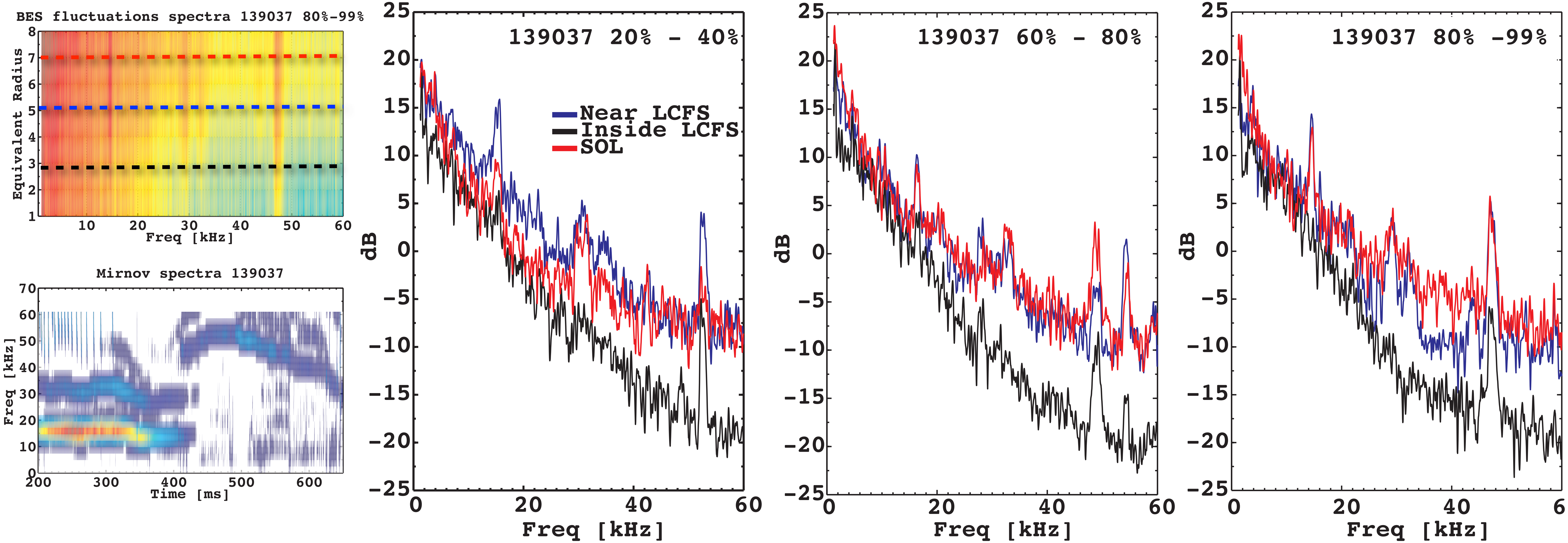
- We observe $P_{tot}^{ped} \propto I_p^2$,which is consistent with higher aspect ratio tokamaks
- We observe P_{tot}^{ped} increases with triangularity: similar to DIII-D
- We show that the pedestal pressure build ups continuously during an ELM cycle, with saturation only at lower plasma currents near the end of the cycle
  - appears to be in contrast with AUG and DIII-D

- Pedestal top density fluctuations increase during ELM cycle, with a frequency "cascade" to lower frequency just before the ELM crash
- Velocity fluctuations peak just after ELM crash, and die away slowly in the inter-ELM cycle

✦ FY11: extra 7-8 edge Thomson channels being implemented

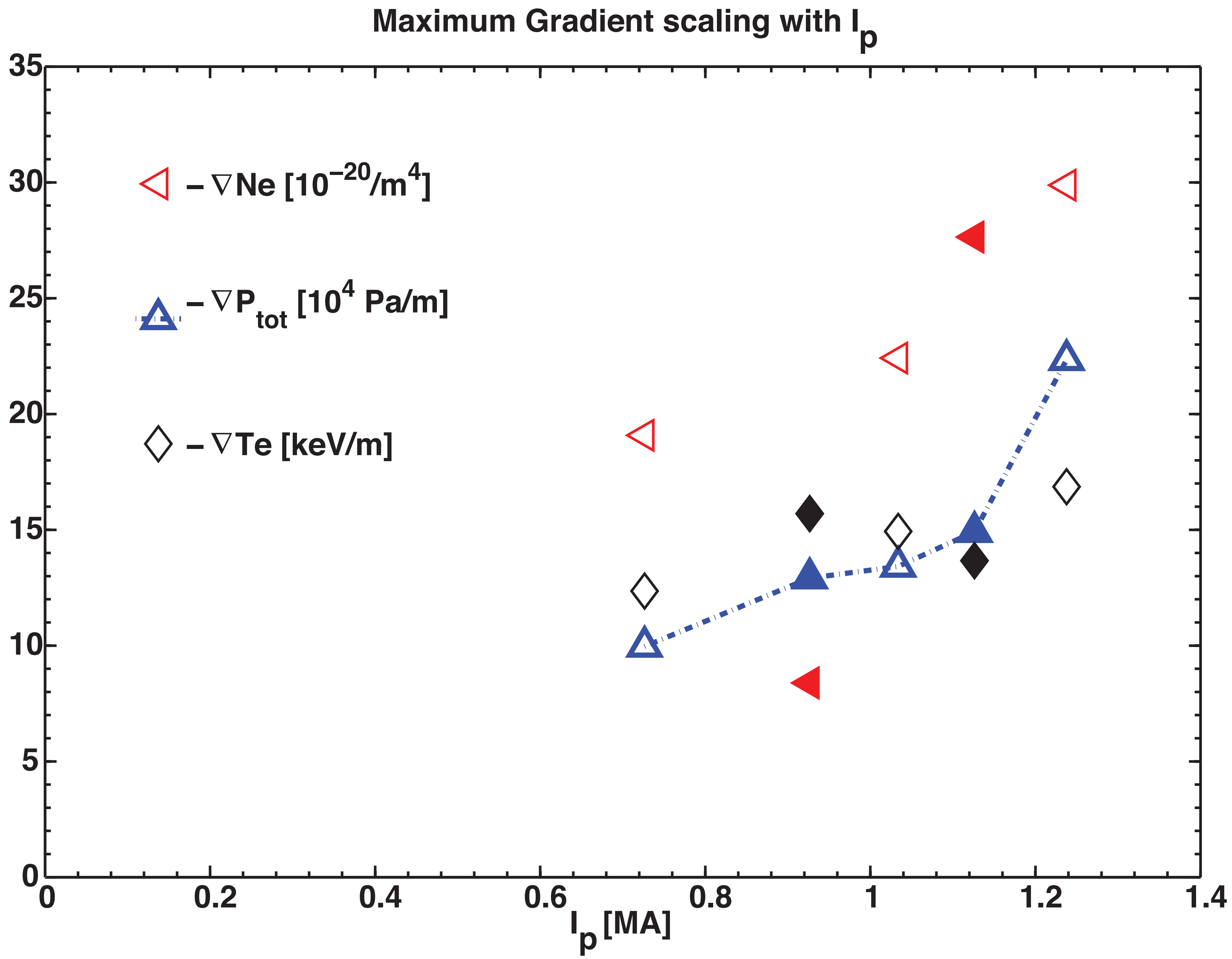
Backup Slides

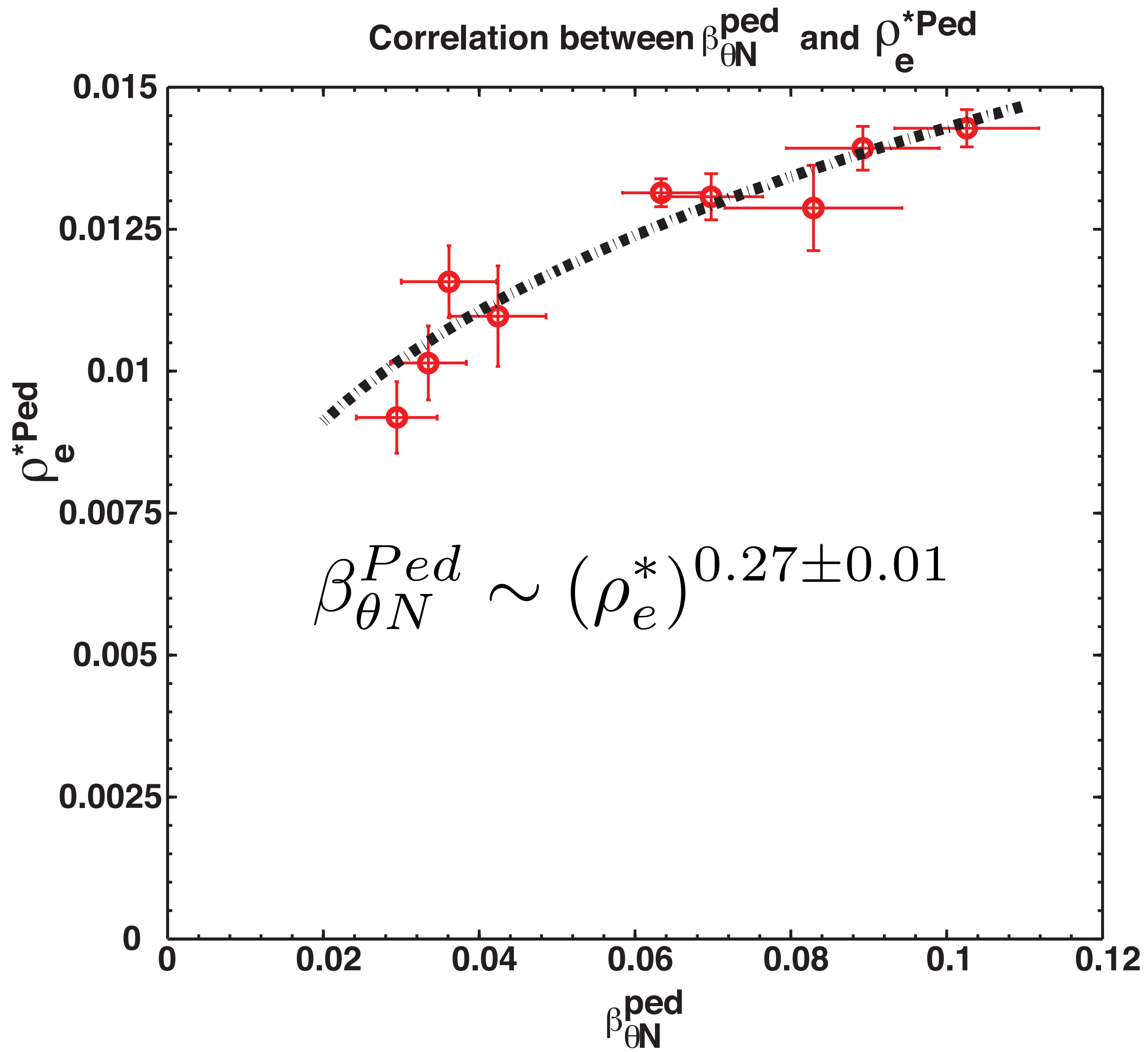
Inter-ELM fluctuations from BES indicate generic changes in fluctuations spectra during the ELM cycle with no signature of modes correlated with the pedestal buildup



Inter-ELM density fluctuation through BES enables the localization of fluctuation peaks detected on Mirnov coils but no clear signature of modes correlated with the pedestal structure.

Dominant contribution of the density gradient in the critical pressure gradient and weak correlation of the ρ_e^* with normalized beta poloidal

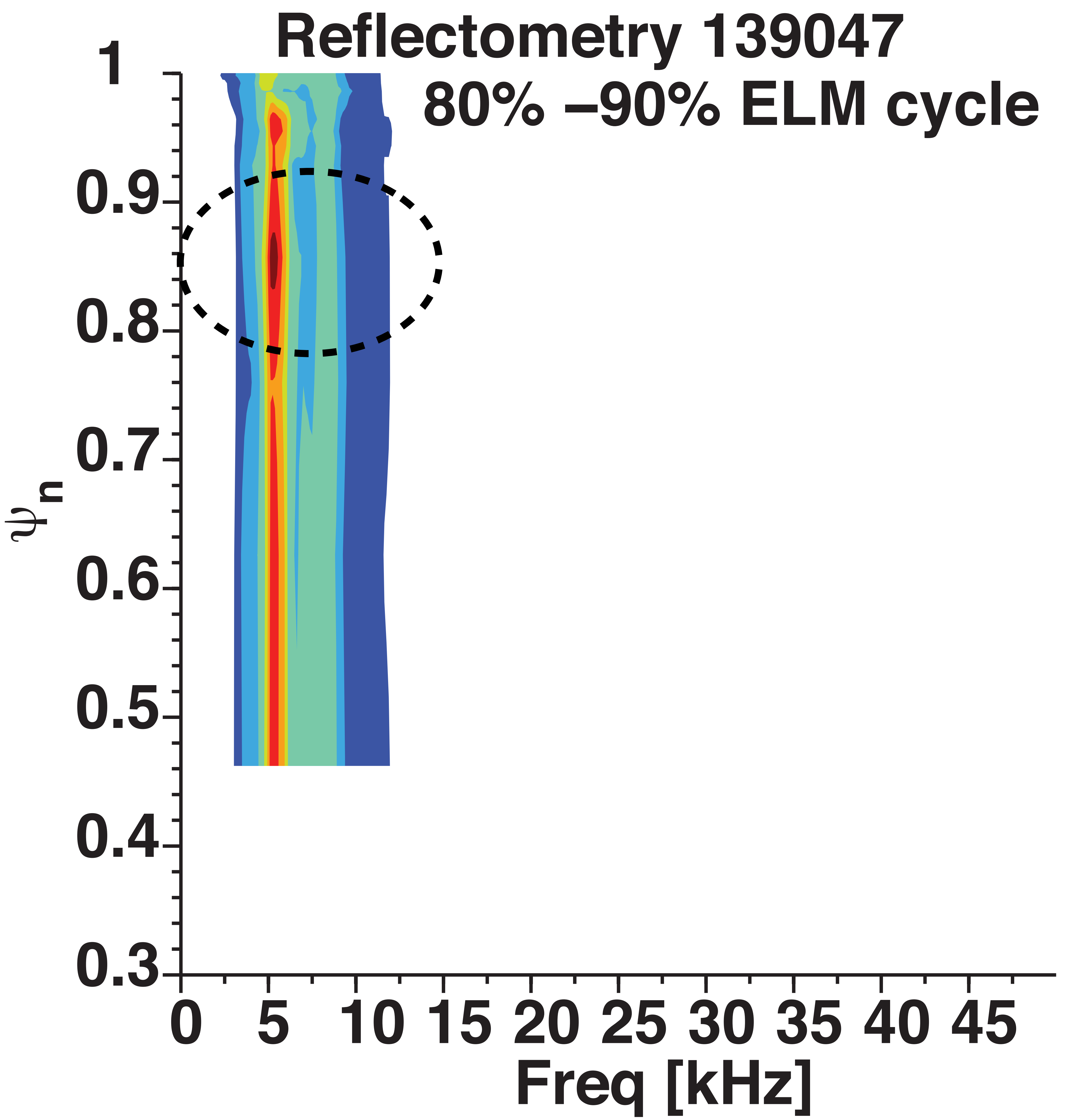




The pressure gradient scales with Ip at constant toroidal field and the density gradient increases much faster than temperature gradient.

Correlation between the normalized poloidal beta with ρ_e^* evaluated at electron pedestal temperature is weaker than similar scaling in MAST.

Mapping the reflectometer signals to normalized flux coordinates allow for better targeting of density fluctuation at the pedestal top



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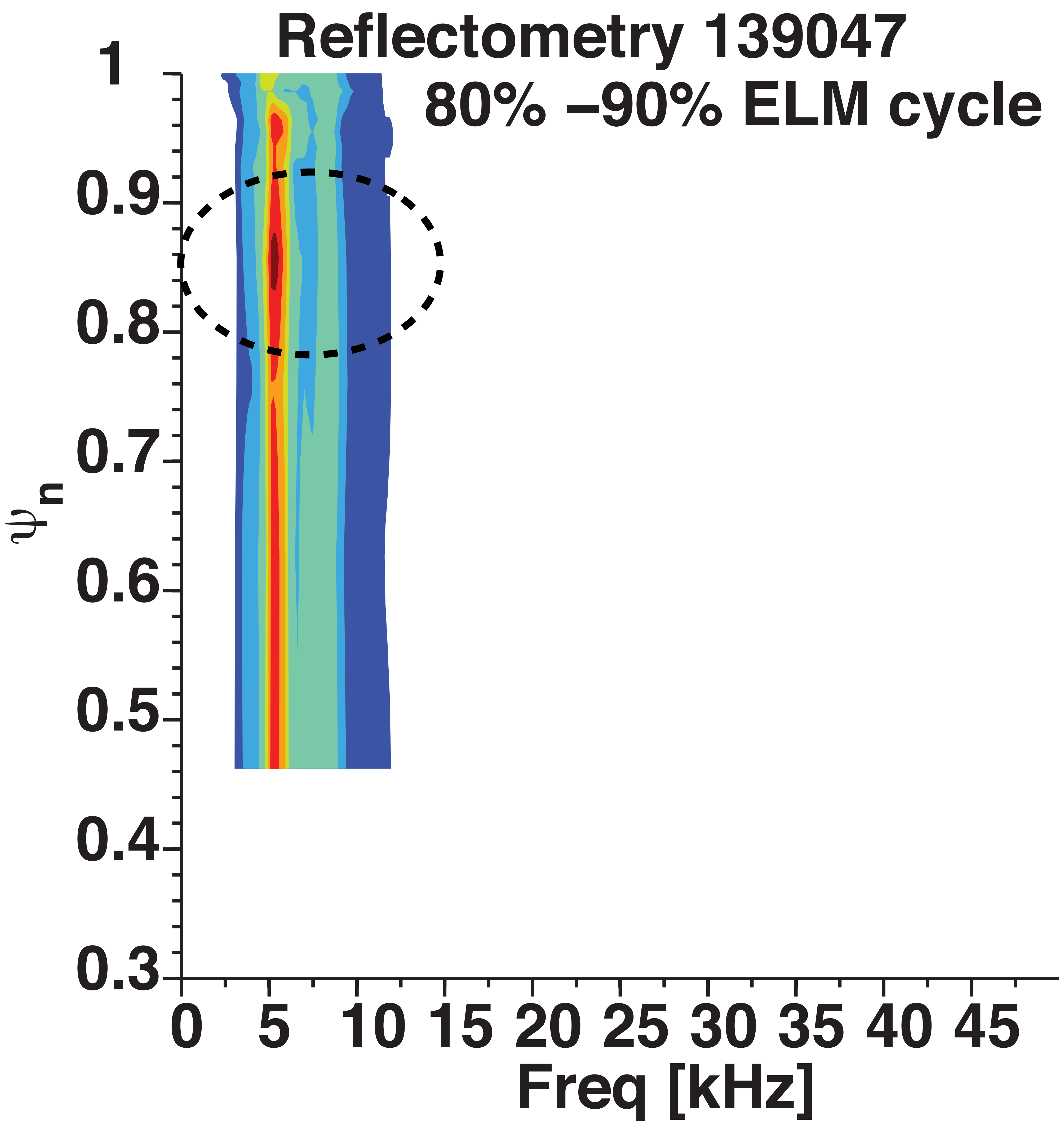

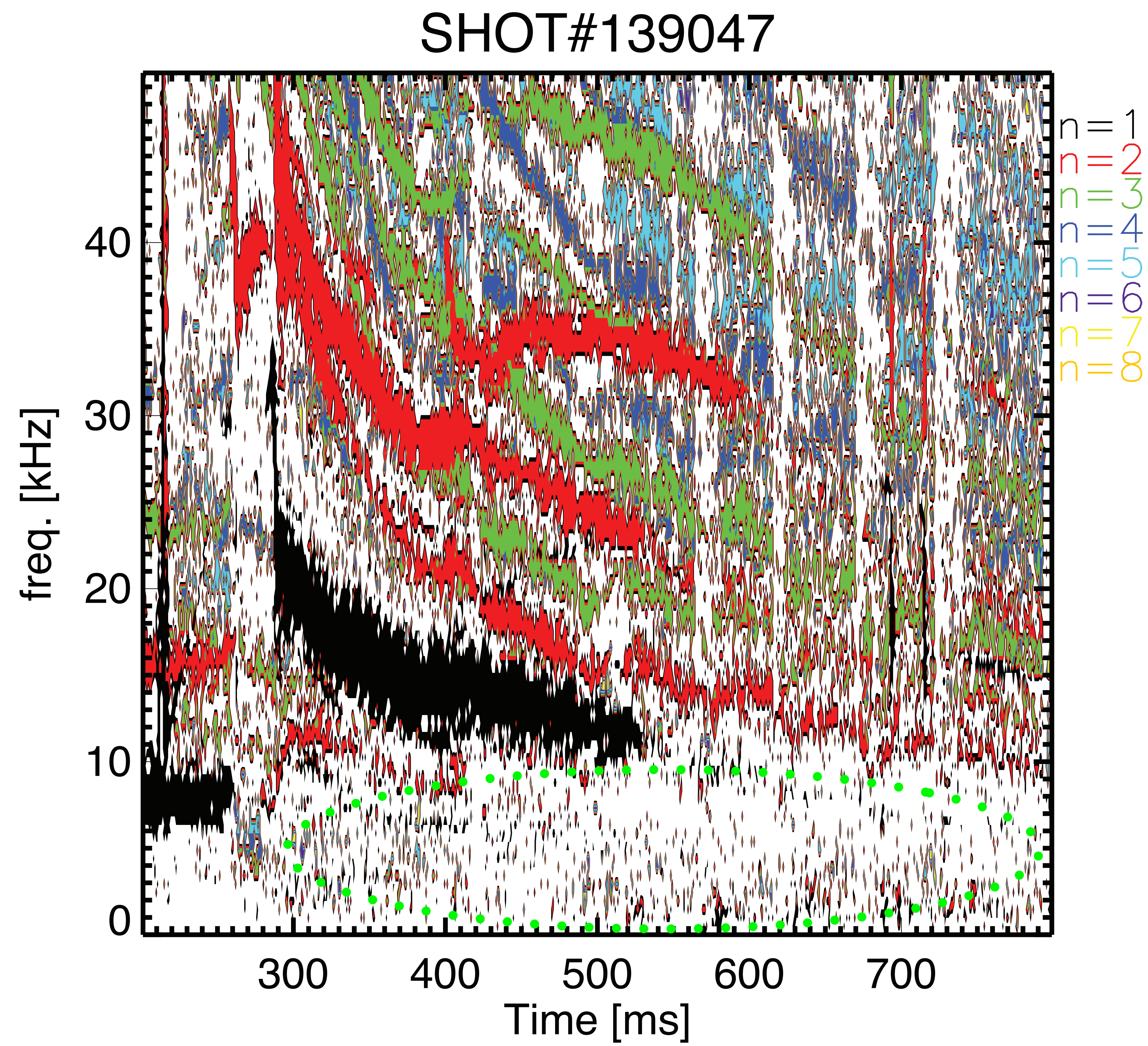

Wave activity before ELM crash, cannot discern them from intrinsic MHD activity already present