Physics of Ohmically Heated H-mode Plasmas

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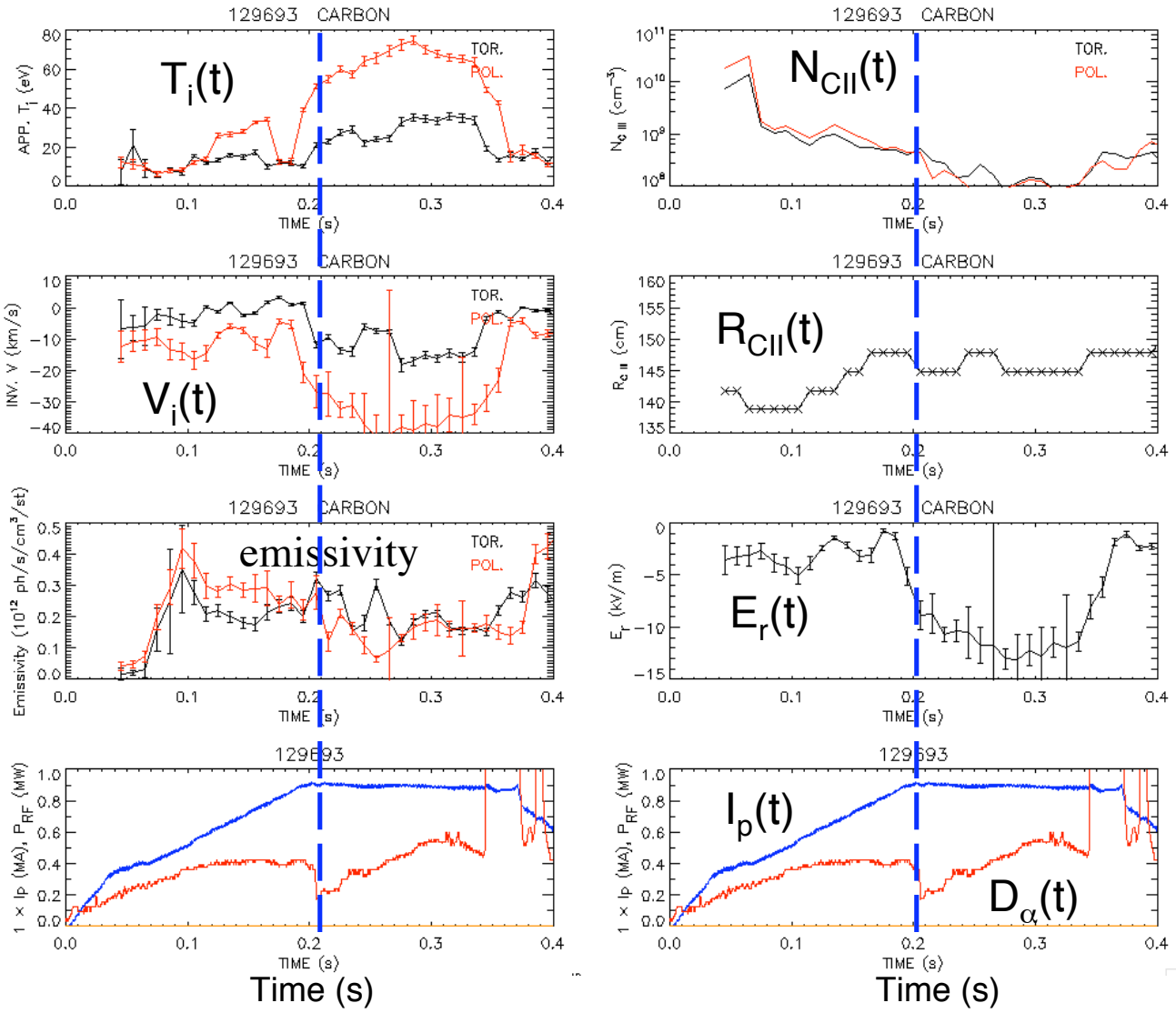
NSTX Results Review
Wednesday, August 6, 2008
Princeton Plasma Physics Laboratory
Princeton, NJ

Goal:

- To study H-modes in which core and edge turbulence can be measured. Also, to study H-modes created without use of external fast particle or momentum input in order to understand the fundamental physics of the L-H transition and the H-mode in general.

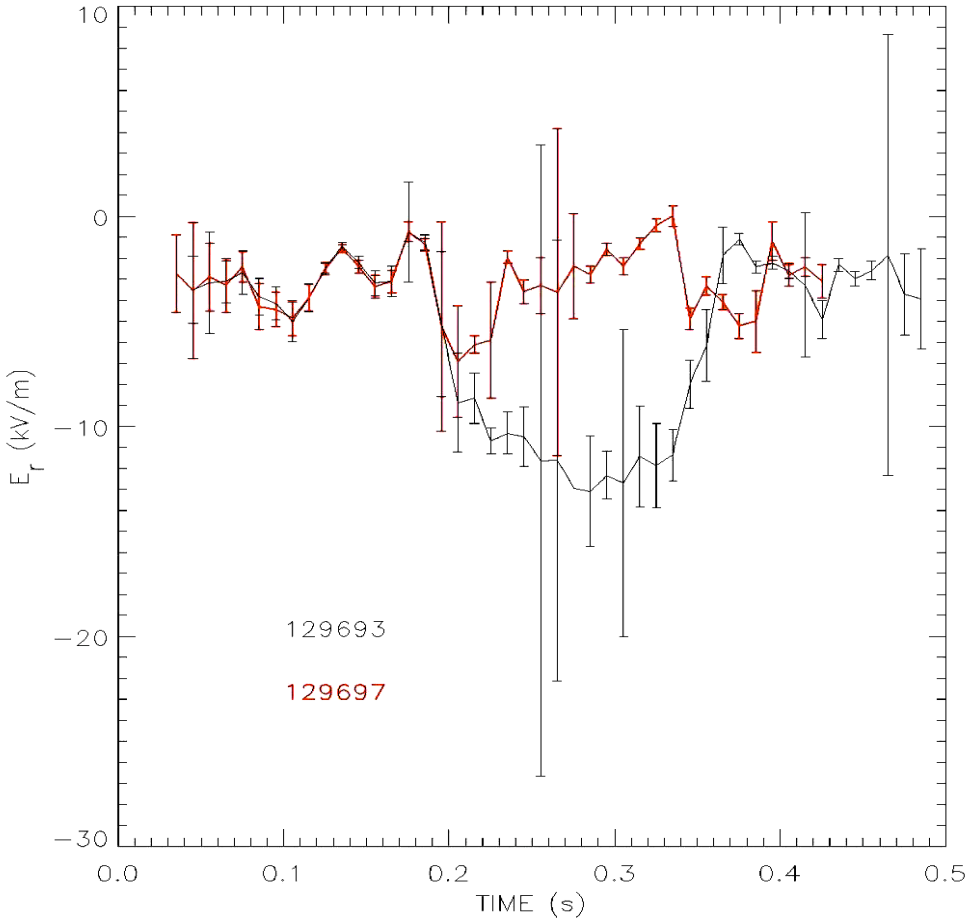
V_t, V_p, T_t, and T_p change at L-H Transition



Begin H-mode at 0.20 s, Velocity gradients increase

R. Bell

Er Increases by > 10 kV/m after L-H-mode Transition



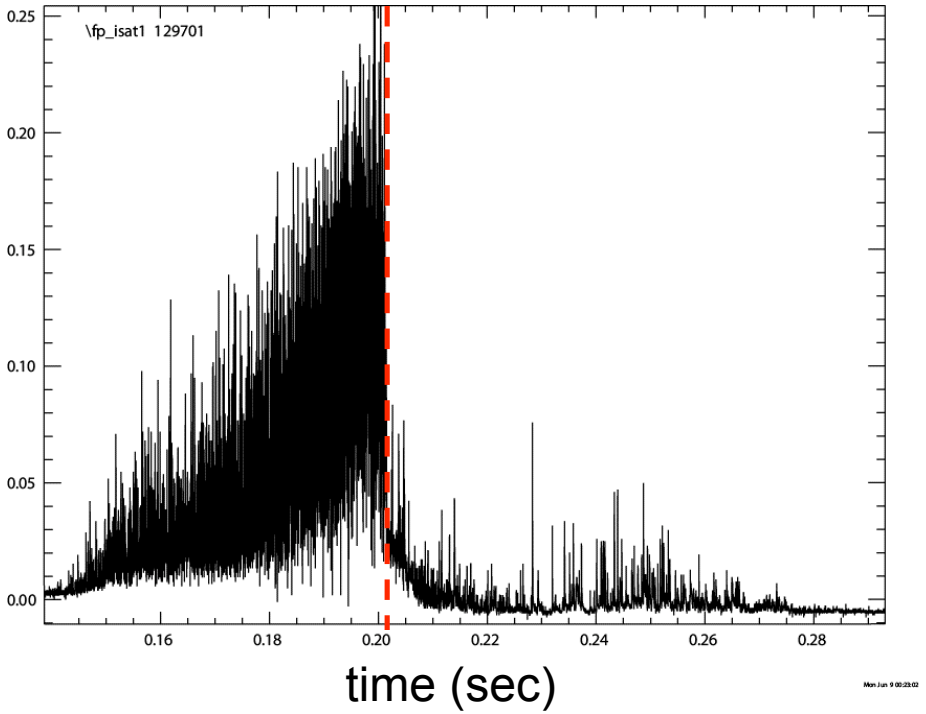
- Vpol increases by 30 km/s after L-H transition
- Ti and Te increase after transition

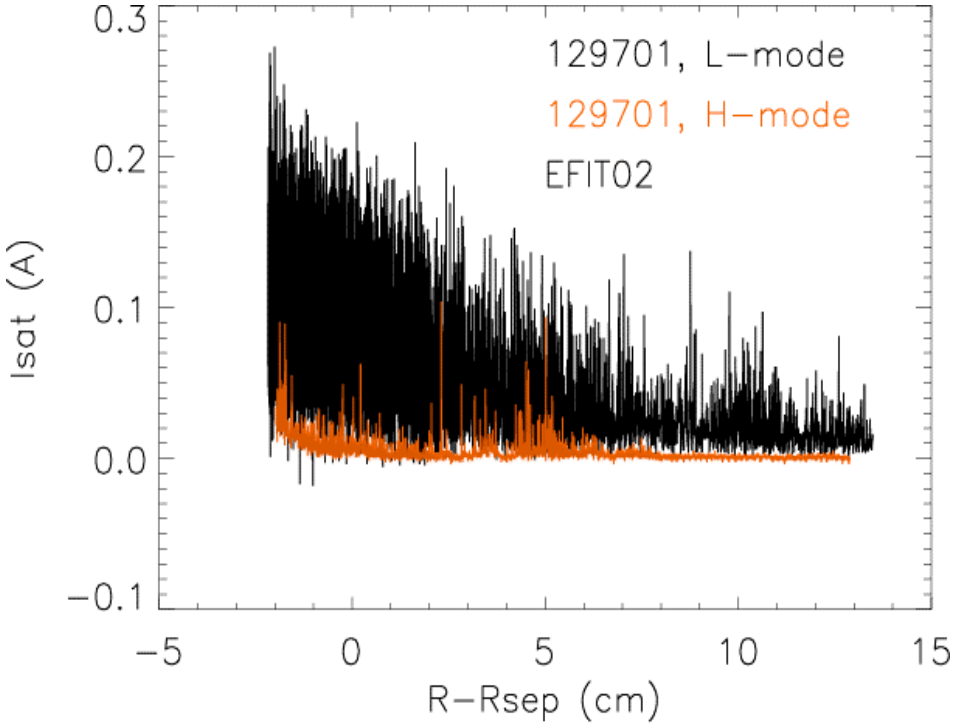
R. Bell

Isat Fluctuations Dramatically Reduced in H-mode

- Fast reciprocating probe data by J-W Ahn

L → H transition

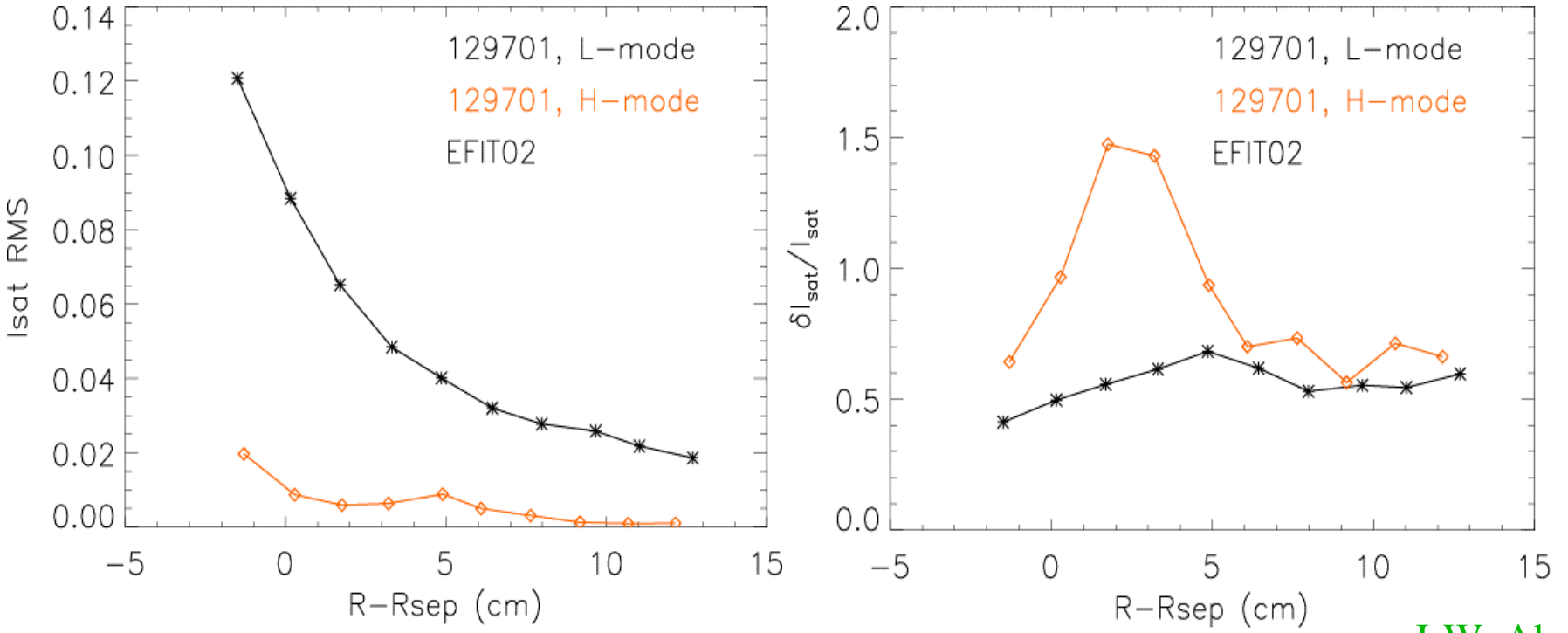




J-W. Ahn

- Probe plunge reached maximum distance at L-H transition time
- Isat amplitude dramatically reduced in H-mode compared to L-mode

RMS fluctuation level shows different trend in L- and H-mode



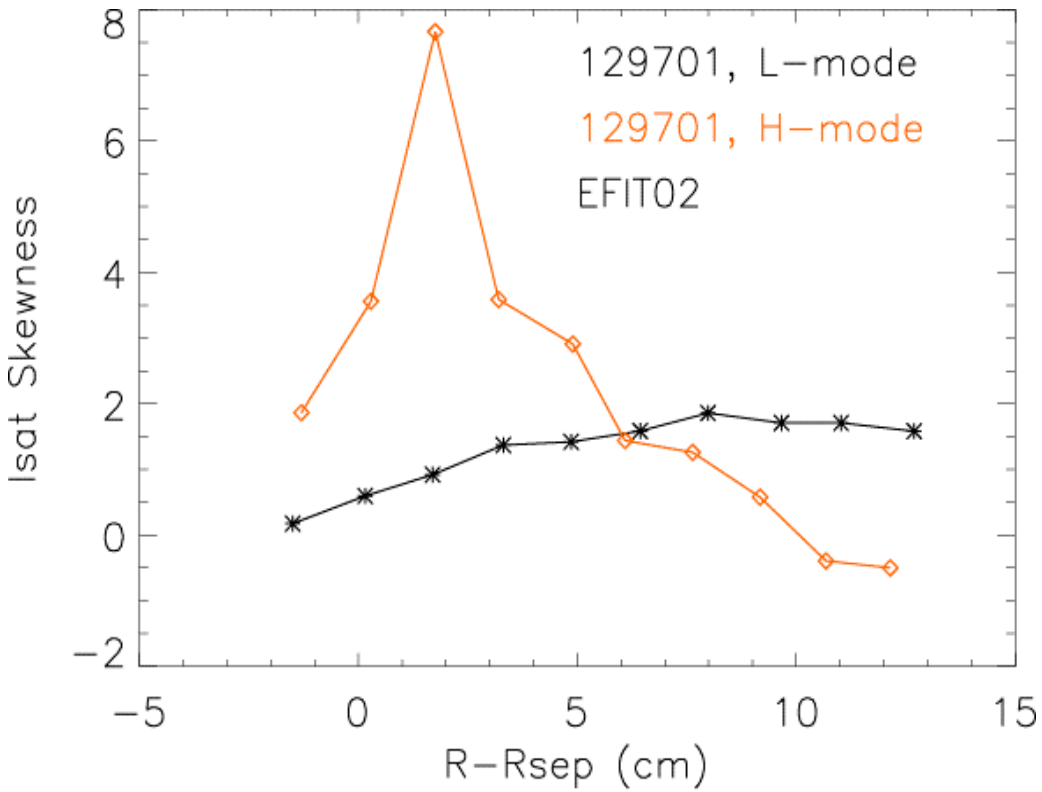
J-W. Ahn

- Isat RMS level peaked near separatrix in both L- and H-mode
- Isat RMS fluctuation level is indicated by $\delta I_{sat}/I_{sat}$

  L-Mode: Increases from separatrix into the SOL, then slightly decreases or saturates in the far SOL

  H-mode: Rapidly increases in the near SOL (R-Rsep up to 2-3cm), then drops and becomes saturated in the far SOL (R-Rsep ≥ 6-7cm)

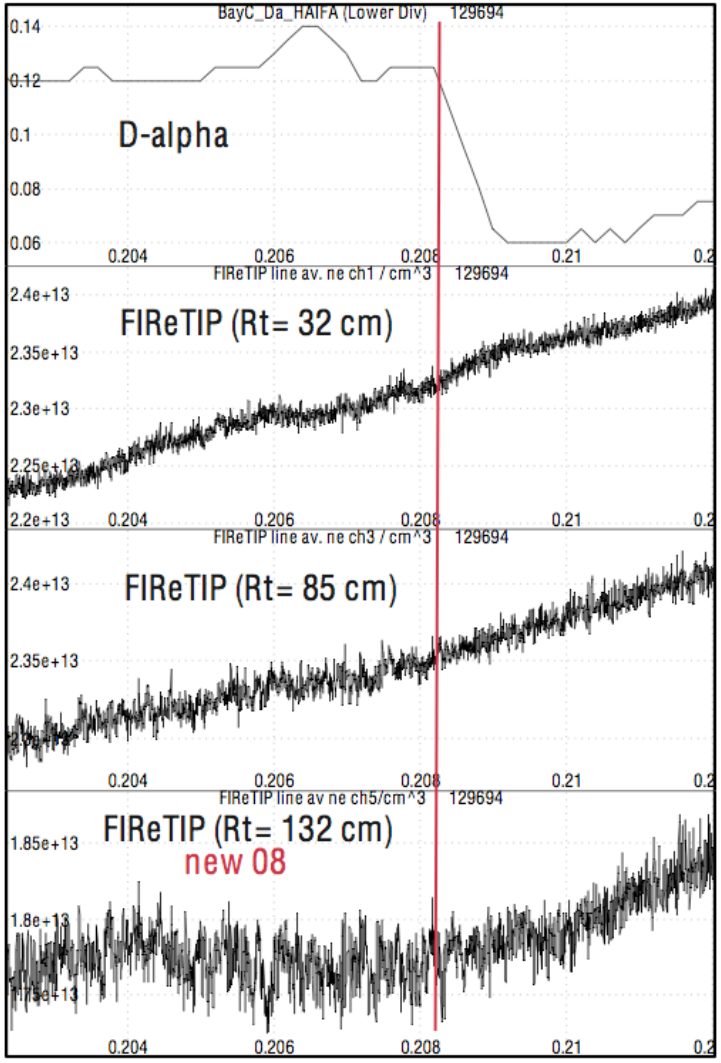
Isat Skewness Trend Similar to RMS Fluctuation Level



J-W. Ahn

- Skewness is indicative of fluctuations deviation from Gaussian
- L-Mode: Increases from separatrix into the SOL, slightly decreases in the very far SOL
  Positive over the whole SOL region
- H-mode: Rapidly increases in the near SOL and then drops in the rest of SOL
  Becomes negative in the very far SOL (R-Rsep~10cm)

FIReTIP density fluctuation change near plasma edge at theL/H transition (red line) of Shot 129694

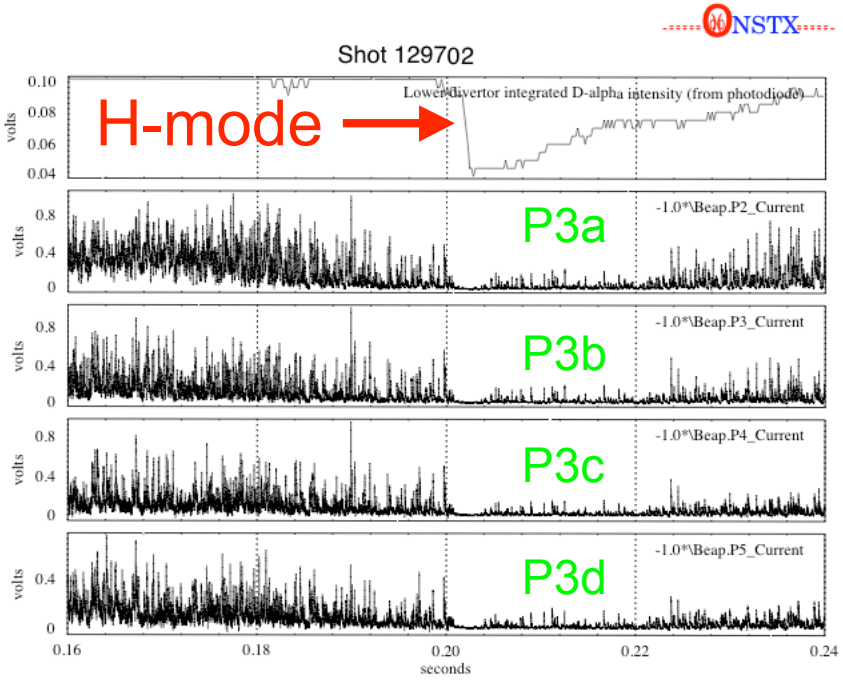


KC Lee

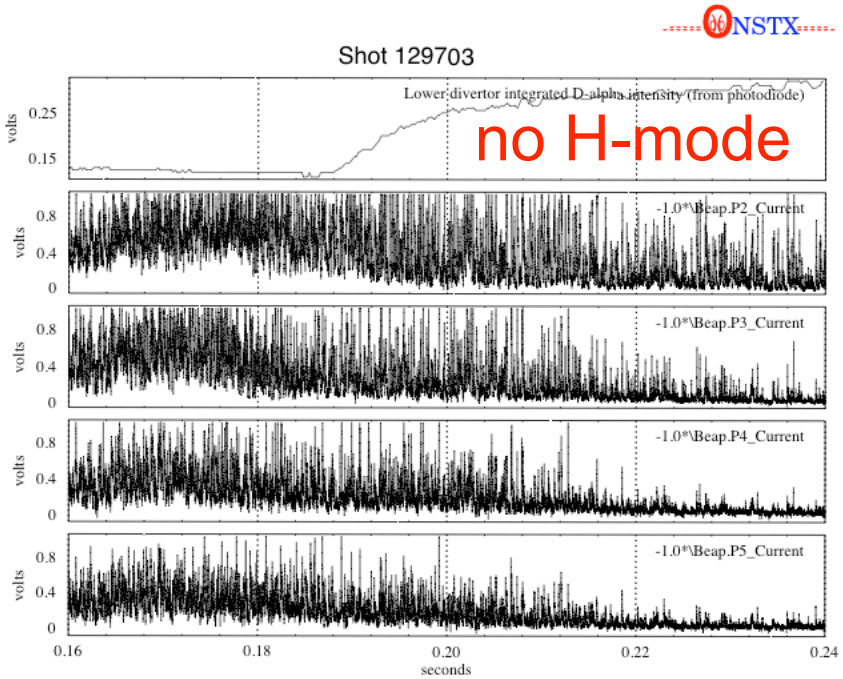
- New channel shows decrease in fluctuations at transition

Ohmic H-modes in BEaP Probes

- *Far-SOL midplane density goes down suddenly at H-mode*
- *Far-SOL density (and turbulence) can return during H-mode*
- *Far-SOL density was dropping slowly even without H-mode*



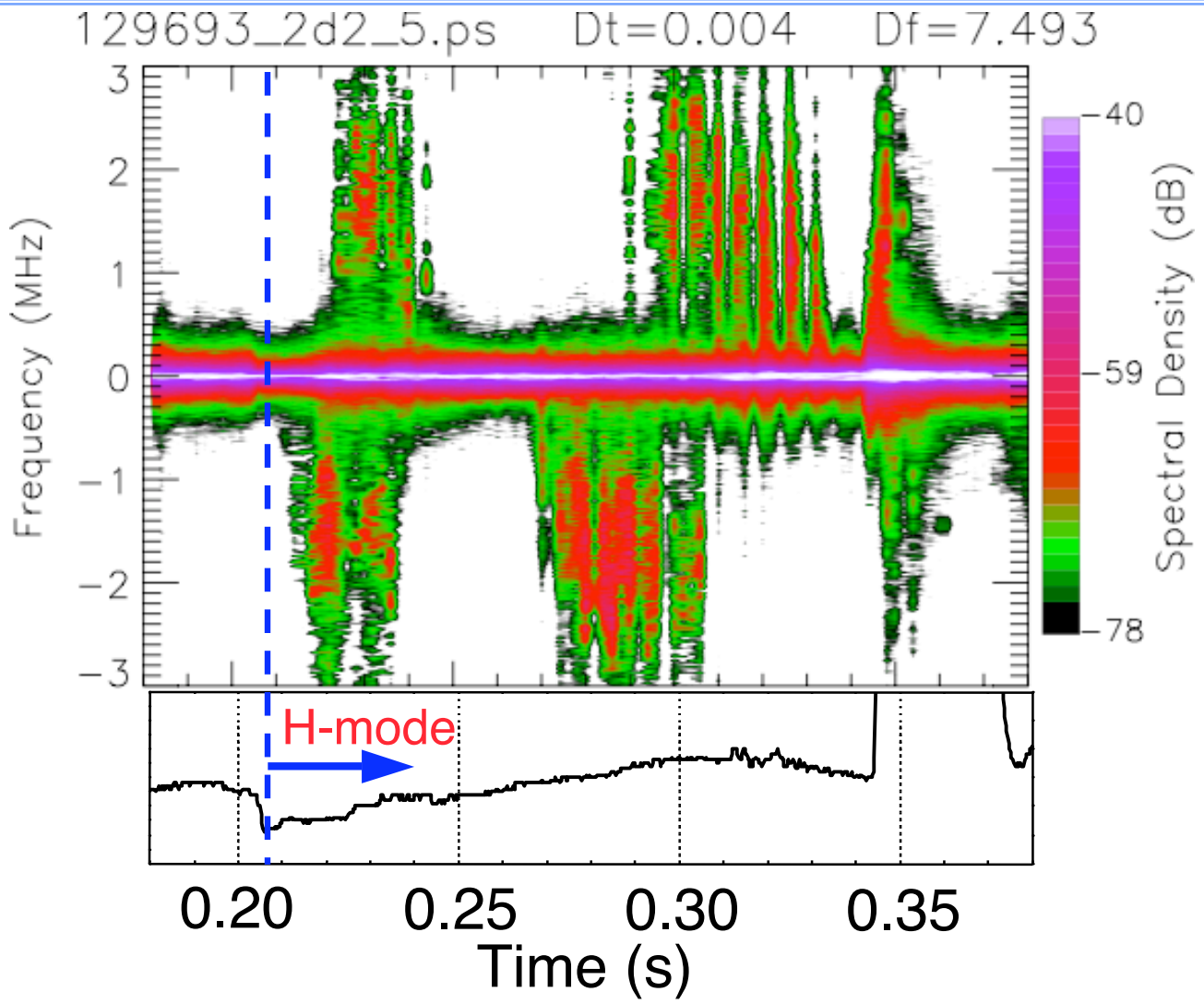
Time (s)



Time (s)

S. Zweben

High-k result for H-mode shot 129693

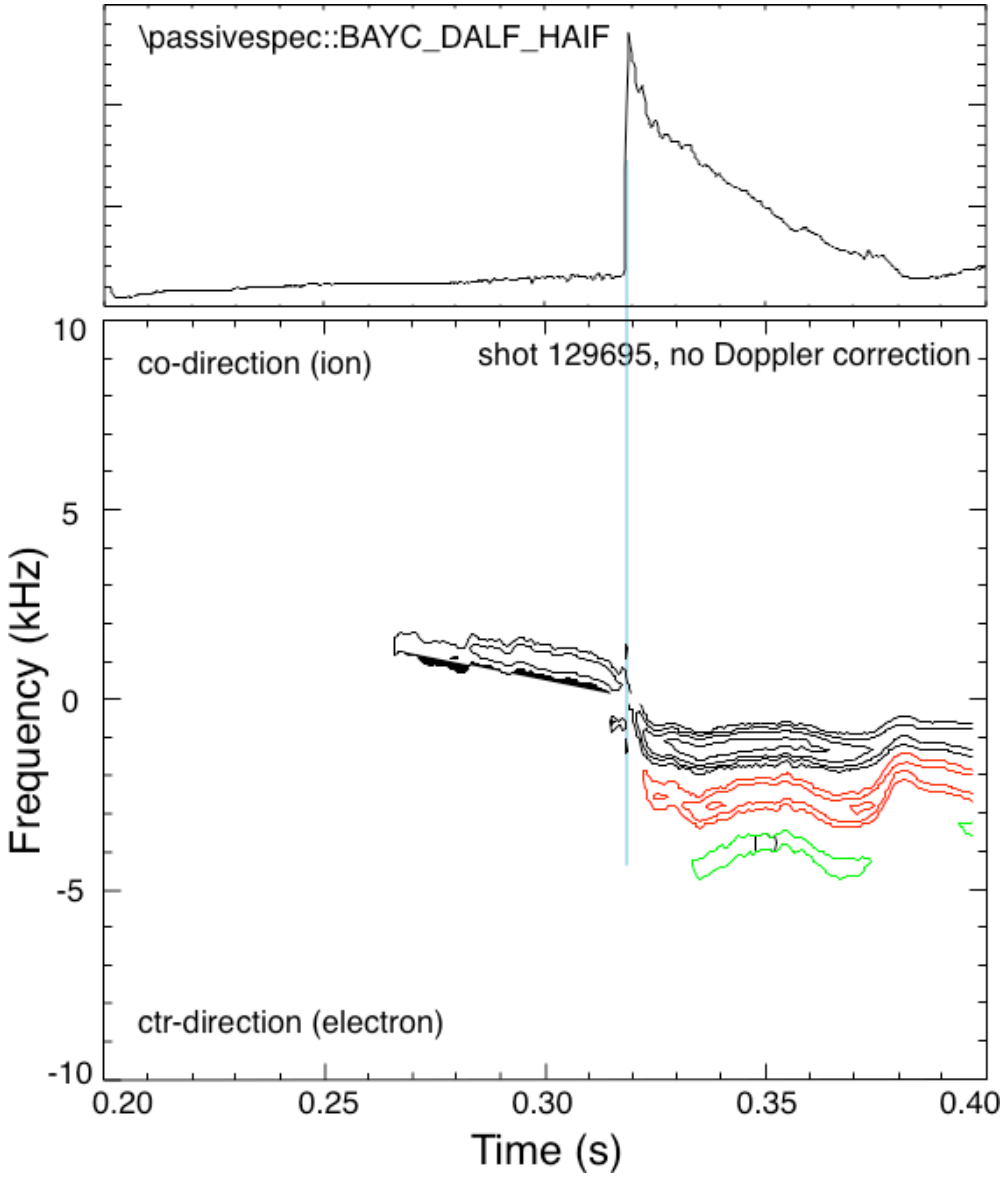


E. Mazzucato

Spectra of fluctuations at R=1.20 m (H-mode, t = 0.204 - 0.344 s)

MHD mode slows and reverses at L to H

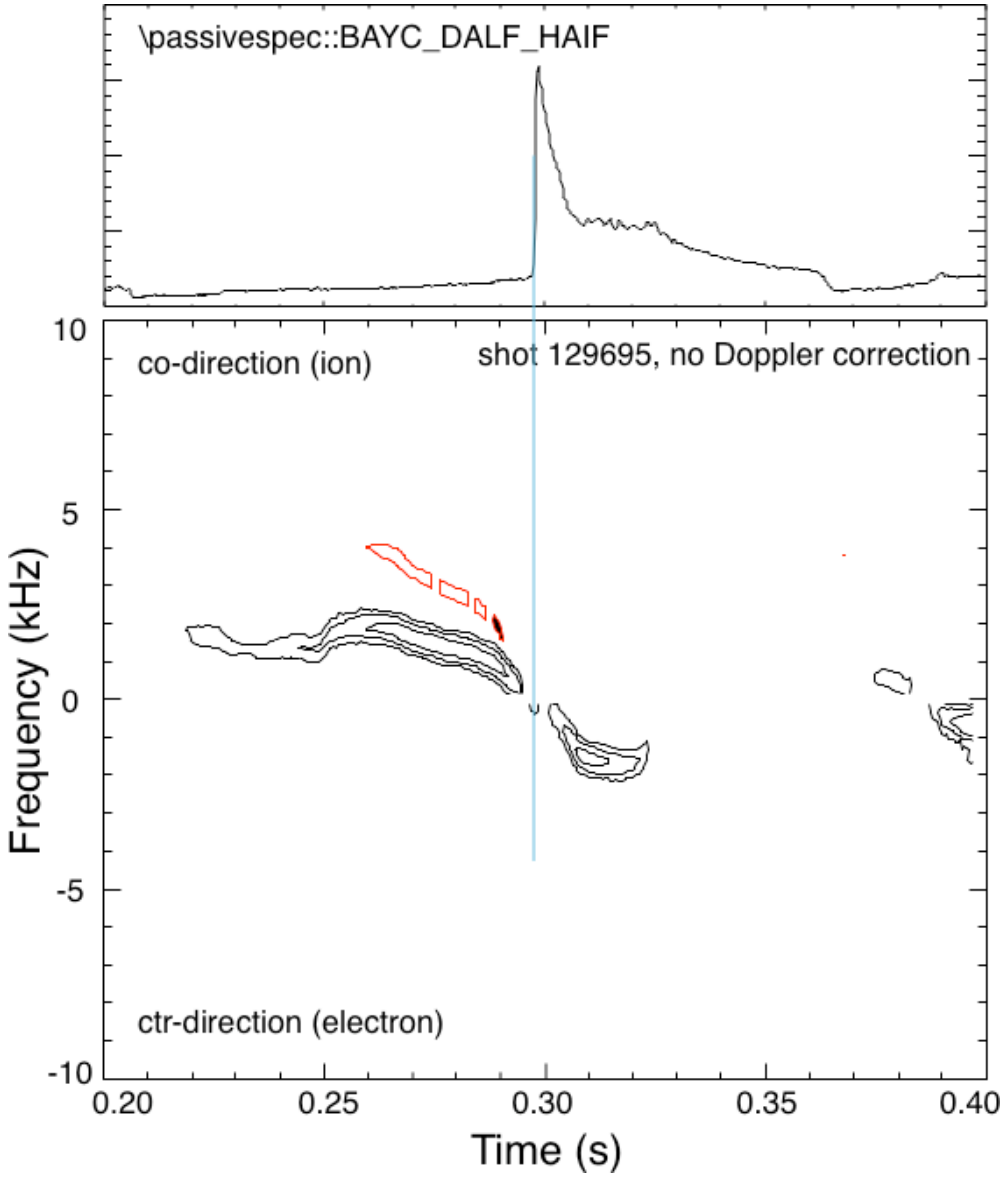
- Mode rotating in co direction during H-mode; typically without beams, MHD rotates in ctr (electron) direction.
- Mode doesn't lock when passing through zero-frequency - where are error fields?



E. Fredrickson

Similar behavior on other shots

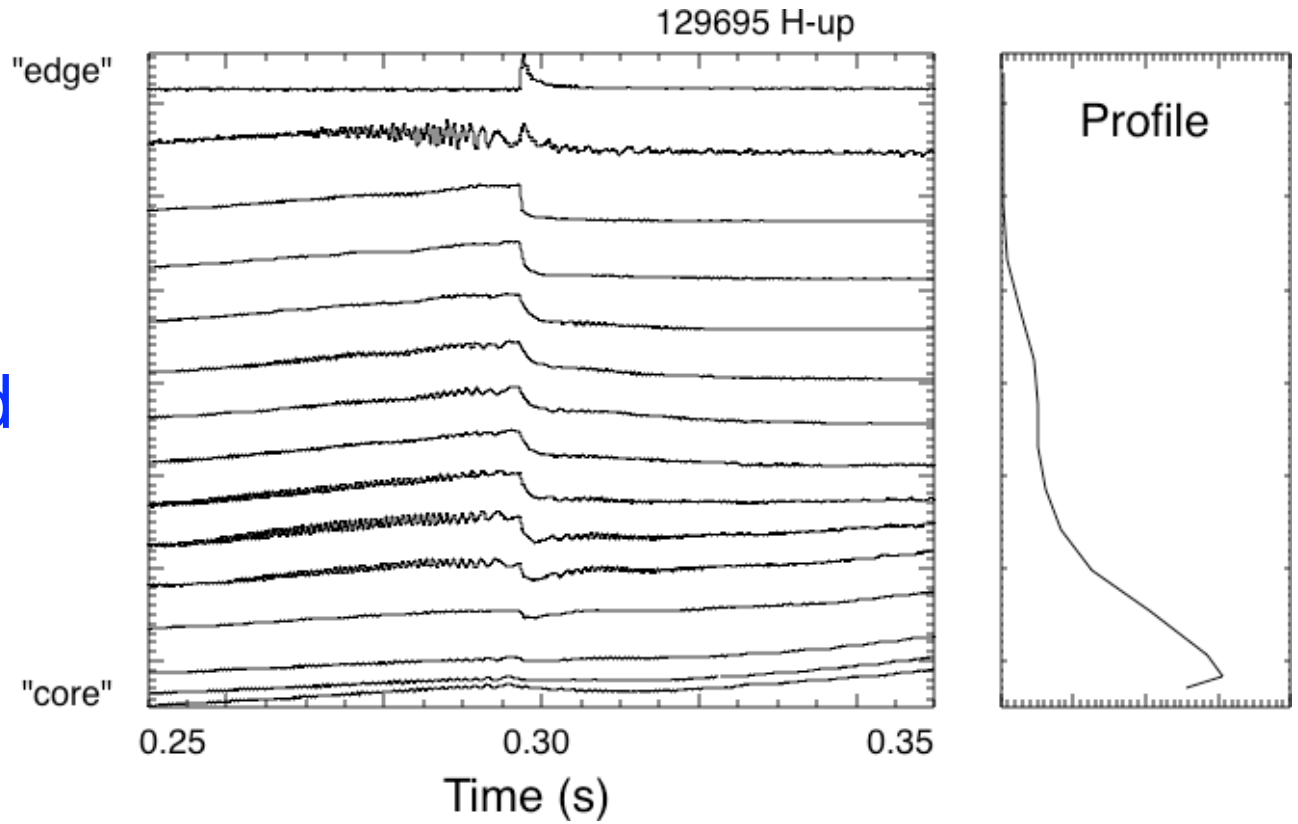
- Rate of frequency chirp increases as mode slows
- D-alpha suggests fairly violent event when freq = 0, but why?



E. Fredrickson

Soft x-rays show global reconnection occurs at the time frequency passes through zero

- Possibly core and edge mode coupled together?



E. Fredrickson

EXTRA

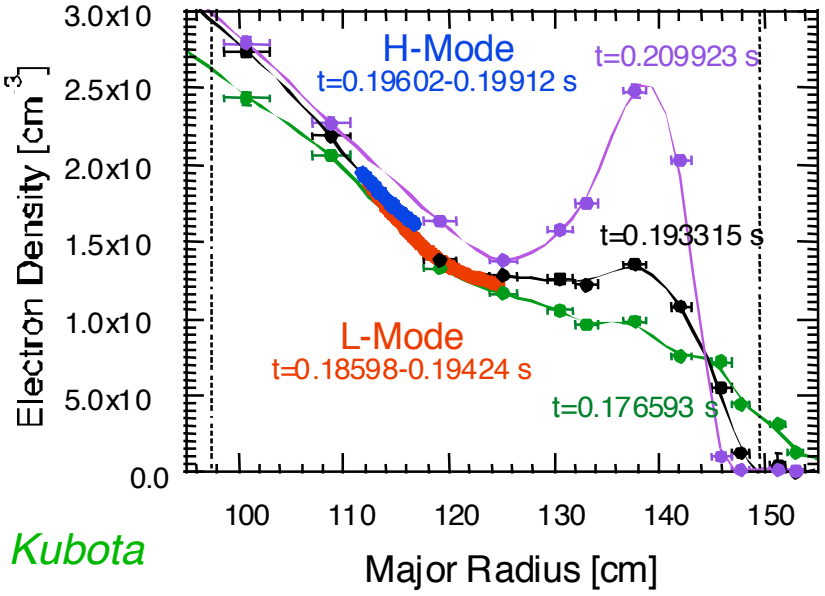
Shot list for XP-506 05Jun2008

Shot list for the run Thursday June 5, 2008 is given below.
The approximate H-mode ON (L-H-transition) and OFF times are also given:

129693 hmode 204-344 ms excellent shot *** (triple star)
129694 hmode 210-312 ms **
129695 hmode 206-297.7 ms **
129698 hmode 202-231 ms **
129699 hmode 200-230 ms
129700 hmode 200-228 ms
129701 hmode 201-318.3 ms **
129702 hmode 200-242 ms *
129704 hmode 210-235 ms
129705 hmode 206-229 ms

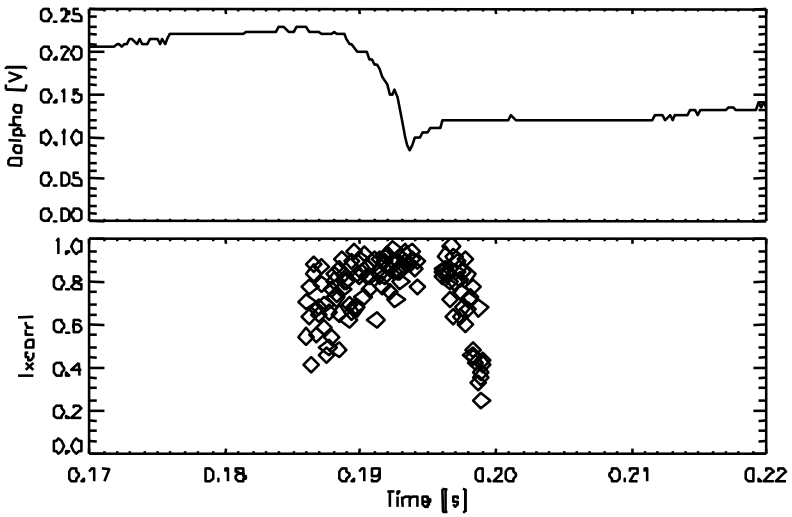
No Hmode comparison shots
129697 No hmode
129703 No hmode
H-mode from couple years ago
127256 hmode 190-300 ms

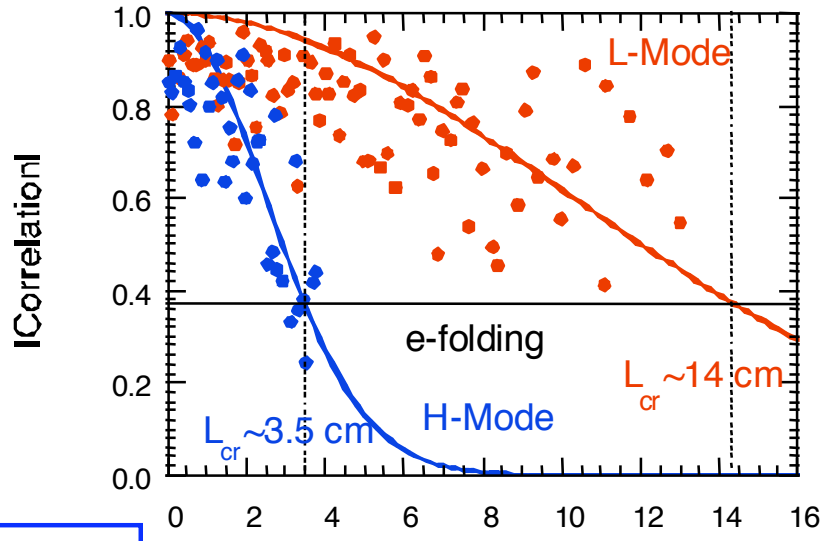
Correlation Length Decreases at L-H Transition



S. Kubota

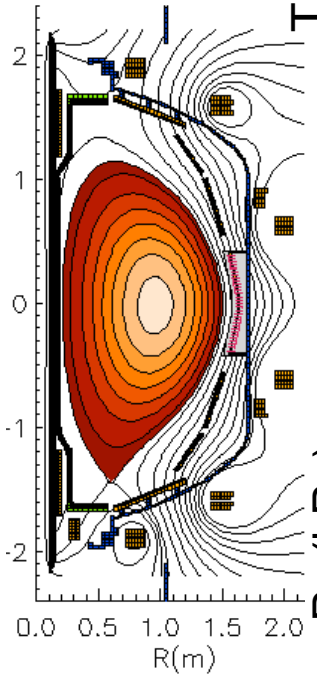
Time series of cross-correlation values near L-H transition.

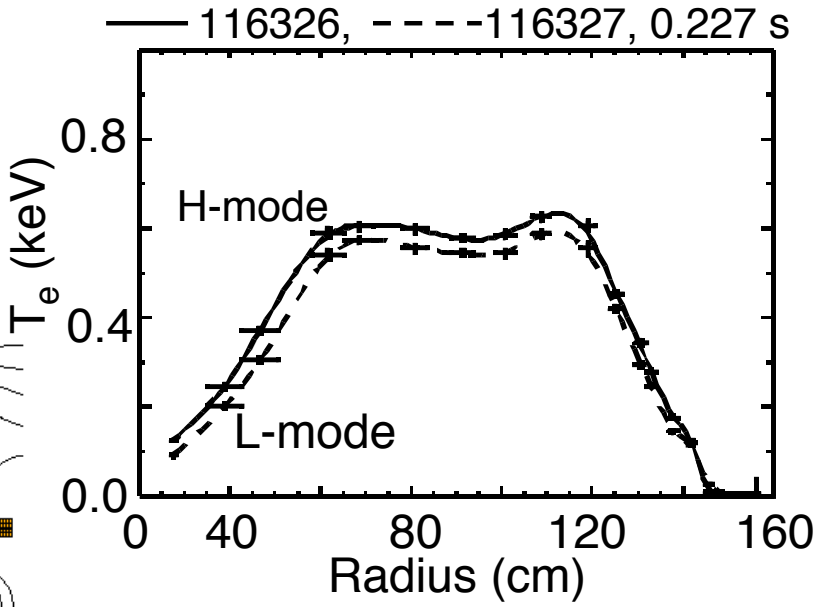


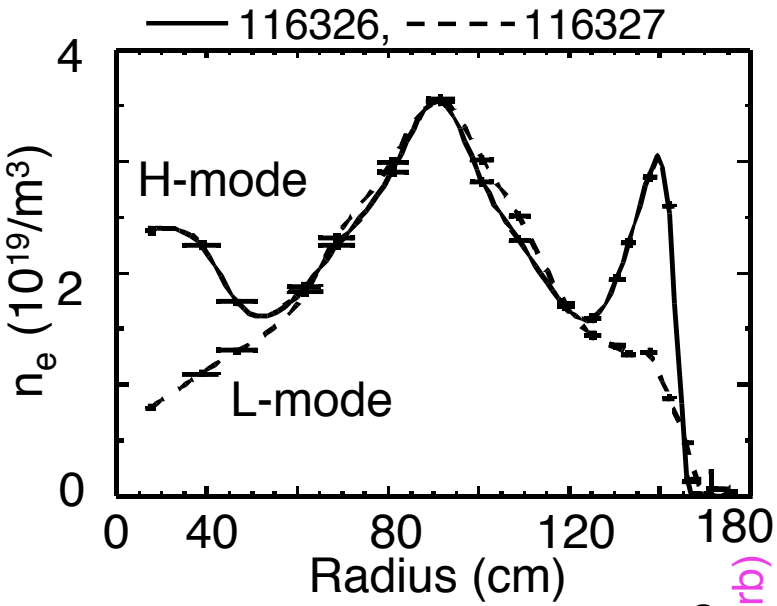


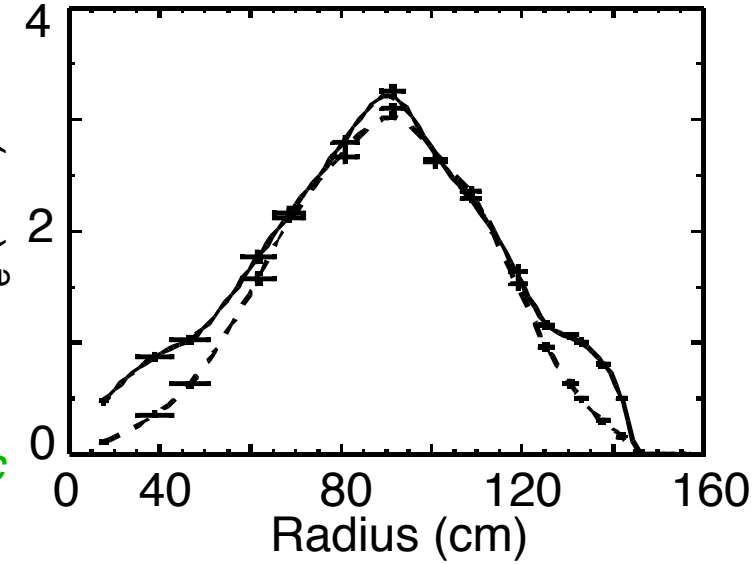
- Typical L_{cr} drops from ~10-20 cm to ~ 4-8 cm at the L-H transition.
- Eventual rise in edge density cuts off reflectometer signal
- For the 42 GHz channel, statistical properties of signal (amplitude histogram, complex spectrum) remain constant across transition, with turbulence properties close to axis changing little

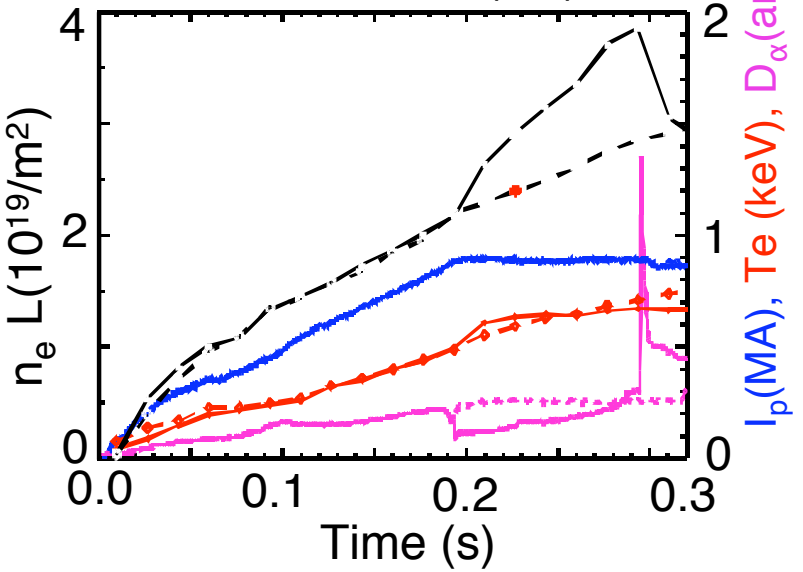
ELM-Free OHH-mode Obtained with LSN











B. LeBlanc

Model: E x B Flow Shear Breaks Turbulent Eddies to Transition to a Quiescent State

- Sheared ExB flow is expected to suppress turbulence leading to enhanced core confinement
- The ExB flow is determined from the zeroth order force balance equation for any species i:

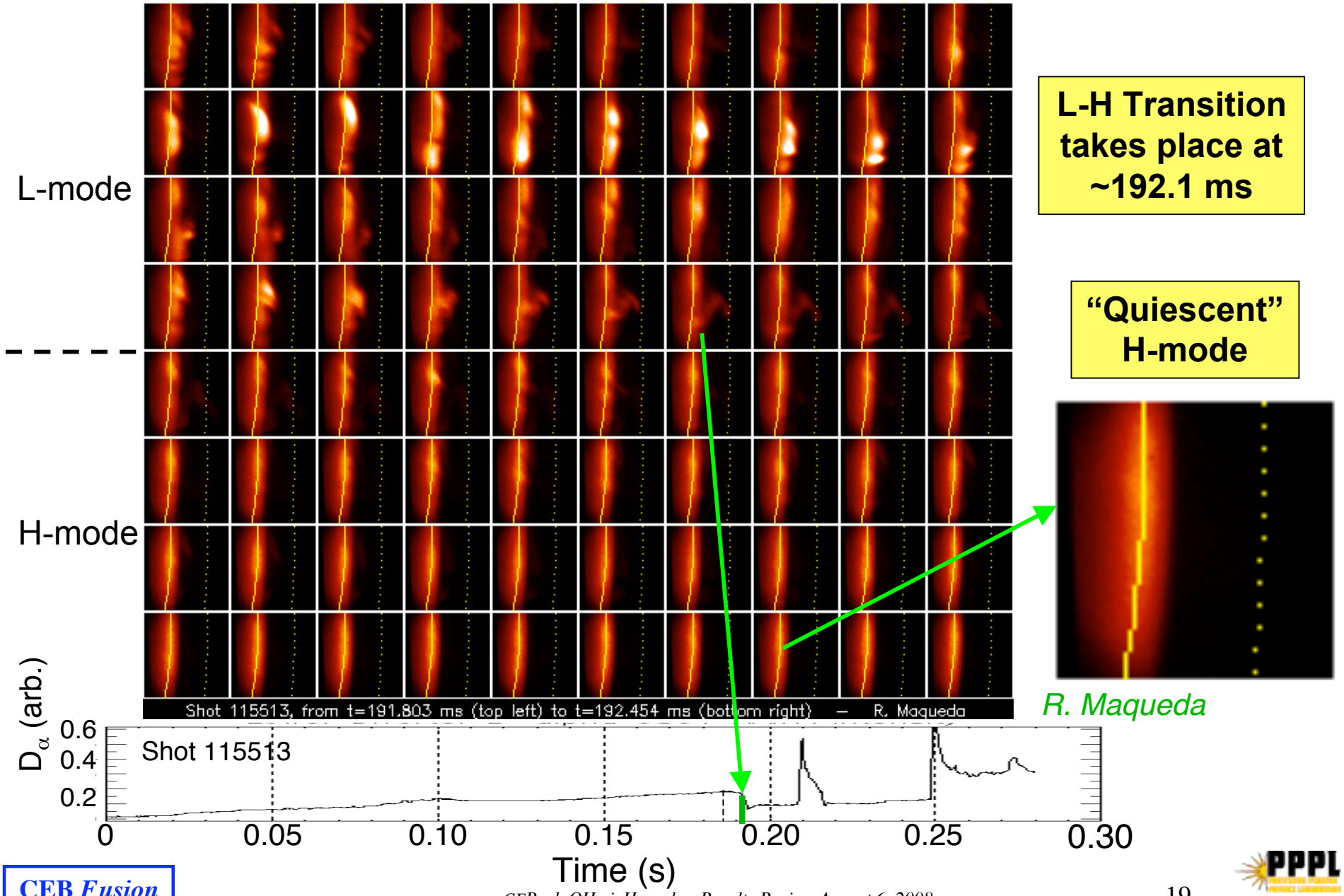
$$E_r = \frac{1}{Z_i e}\left[\frac{T_i}{n_i}\frac{dn_i}{dr} + \frac{dT_i}{dr}\right] - V_\theta B_\phi + V_\phi B_\theta$$

- E_r can be solved for by using measured profiles of:

  n_i, T_i, V_Φ: using charge exchange recombination spectroscopy (CHERS)

  B_θ from MSE, combined with TRANSP simulations

Gas Puff Imaging (GPI): L-H transition



L-H Transition takes place at ~192.1 ms

"Quiescent" H-mode

R. Maqueda

Turbulence/blob activity much lower During Ohmic H-mode than L-mode and NBI H-mode

- The characteristics of the H-mode turbulence and blobs present a continuum from a turbulence level just above that measurable (a "quiescent" H-mode) to that approaching L-mode level (an "active" H-mode), at least for brief periods of time.
- The level of activity correlates well with the pedestal n_e or P_e.