Spontaneous Rotation and Momentum Transport in OH and RF H-modes

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Transport and Turbulence 5-Year-Planning Workshop
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Princeton Plasma Physics Laboratory
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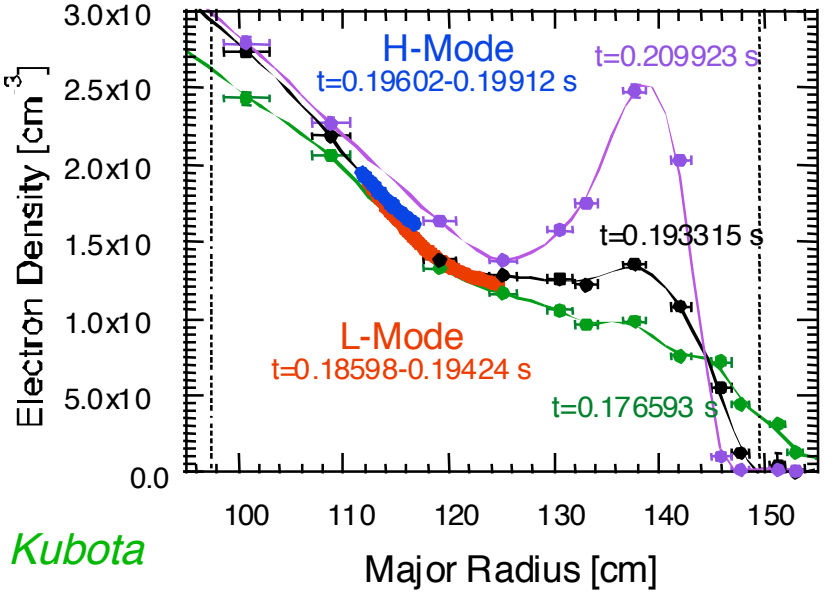
The Proposal is Composed of:

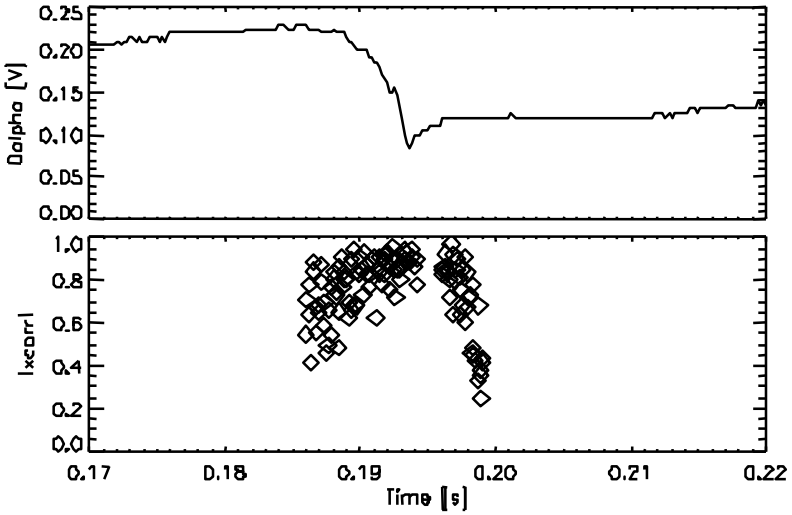
- Ohmic H-modes, RF H-modes, NBI H-modes, Counter Injection, Diagnostics
- Unique Physics from OHmic H-mode
  a) Reduction of correlation length (by > 4x)
     1. But need definitive experimental data
  b) Need reflectometer core n_e fluctuation data
     1. Are fluctuations reduced in core by h-mode barrier?
     2. Is turbulence trapped in core when H-mode barrier is triggered?
  c) NSTX can provide aspect ratio scaling of spontaneous velocity (for ITPA database)
- Beam blips for momentum transport experiments in quiescent OHmic and RF H-modes

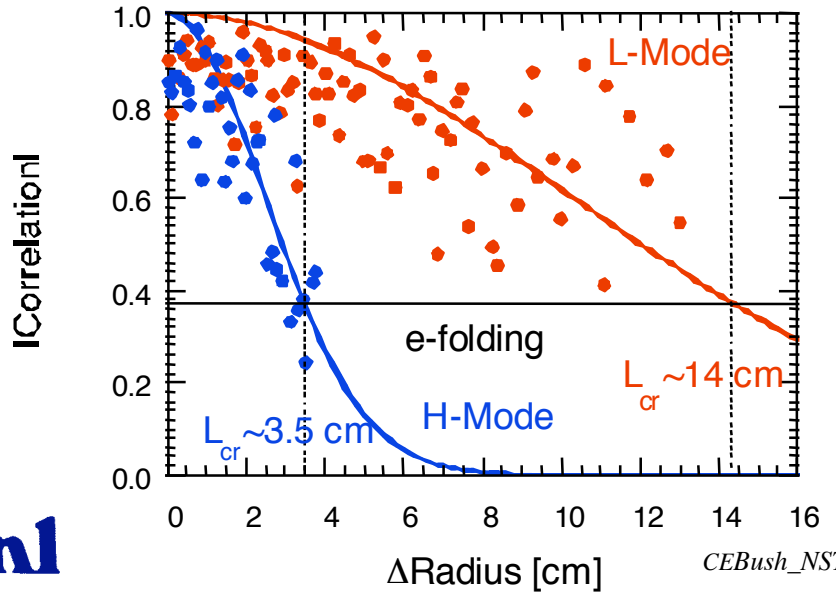
Correlation Length Decreases at L-H Transition



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

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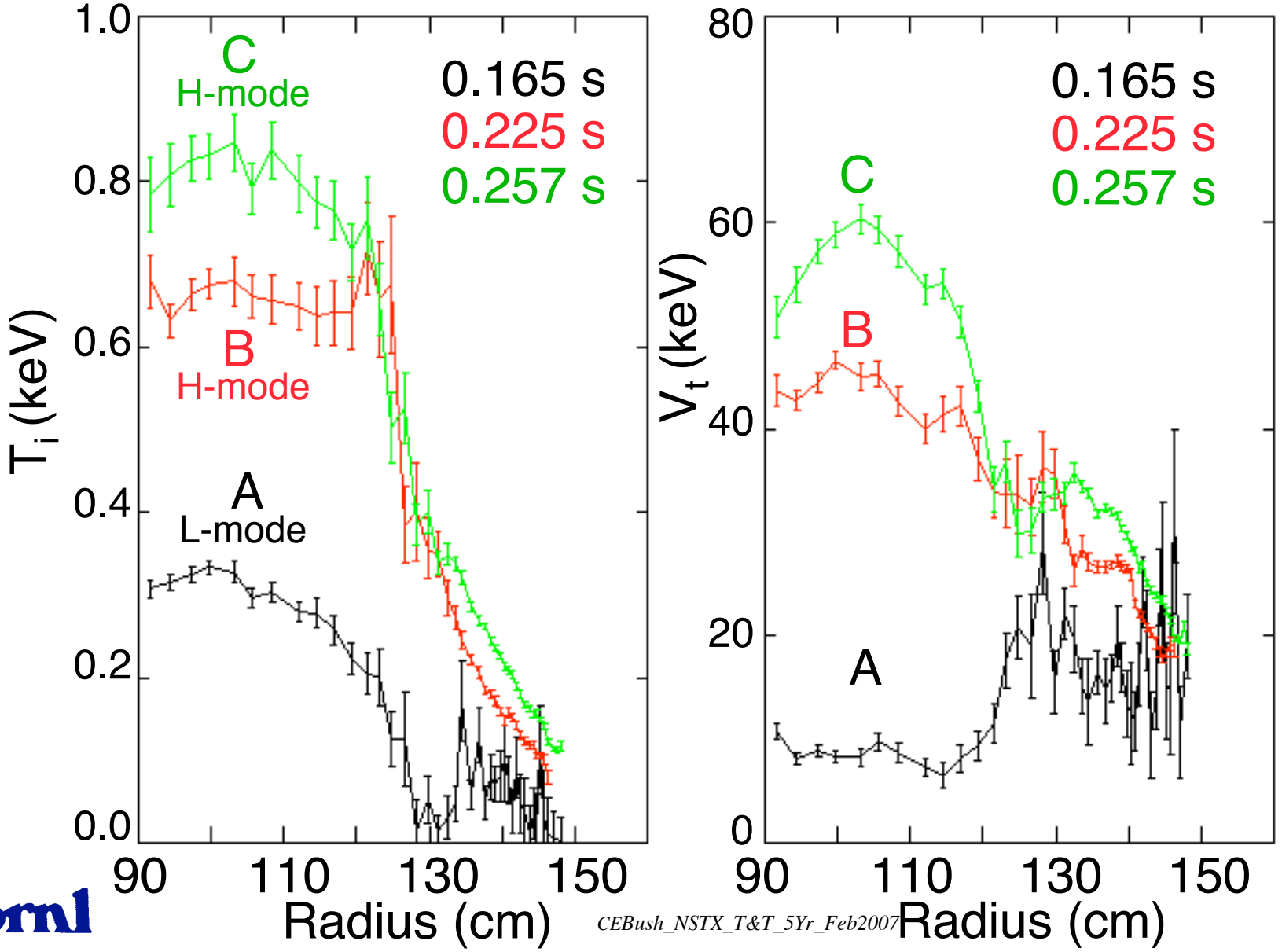
Ion Internal Transport Barrier Develops with NBI into Ohmic H-mode Target



R. Bell

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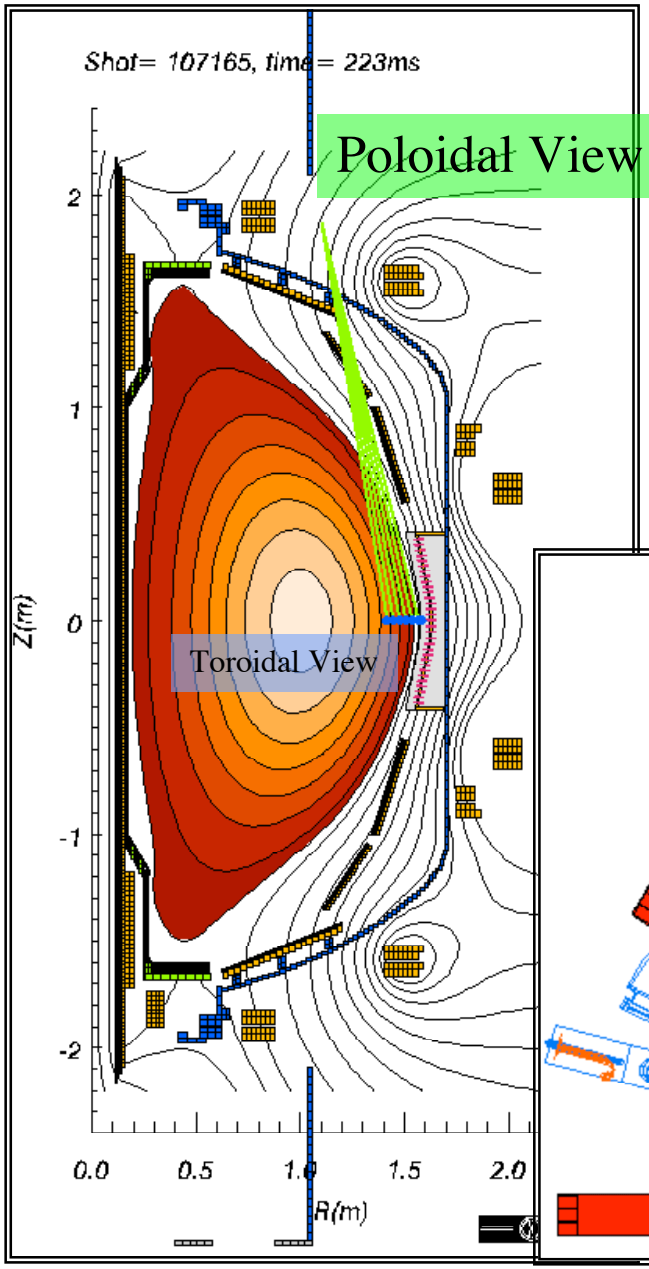
(continued)

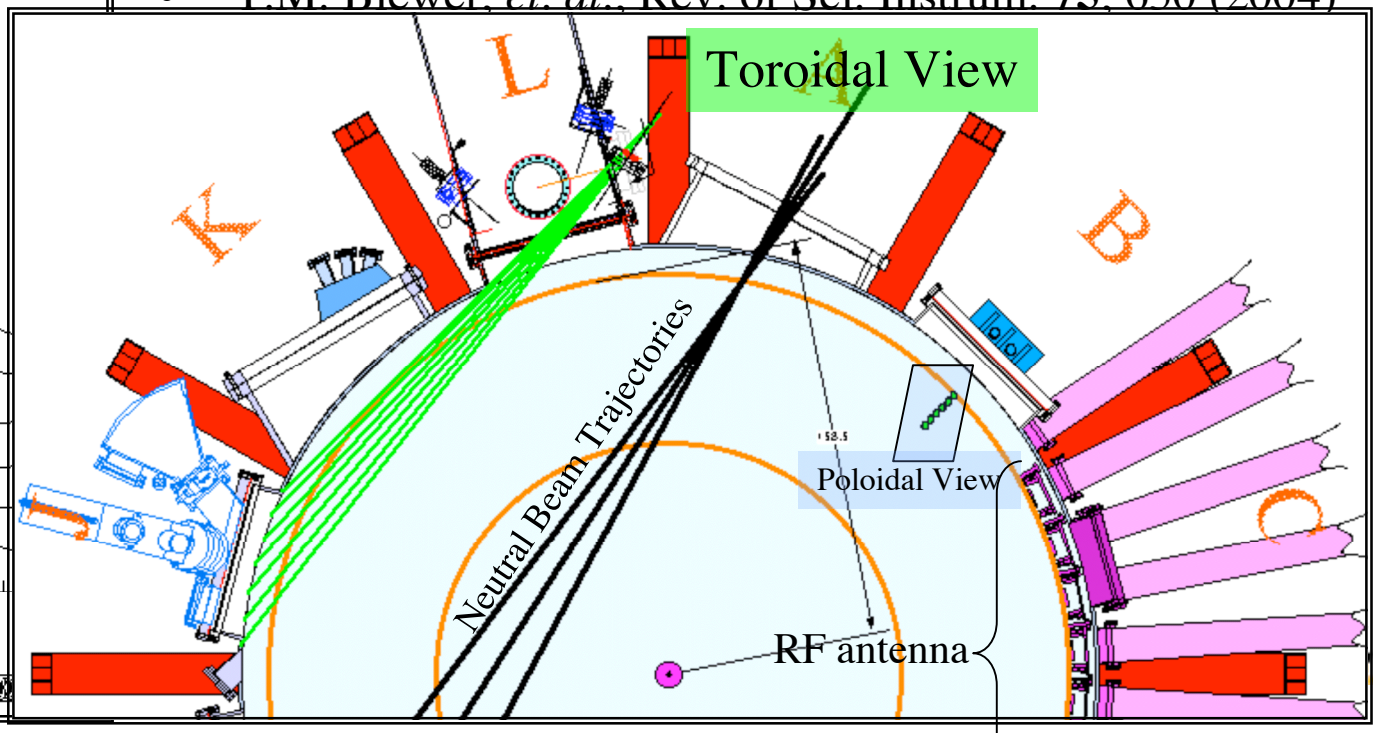
- New diagnostics and diagnostics upgrades
  - a) Use new features of microwave reflectometer
    1. Simultaneous measure of edge and core fluctuations and turbulence
    2. Measure V_θ
  - b) New X-ray crystal system to measure T_e, T_i, V_θ (similar to Manfred's C-mod system)
    1. Are fluctuations reduced in core by h-mode barrier?
    2. Is turbulence trapped in core when H-mode barrier is triggered?
  - c) New edge rotation diagnostic - with better spatial resolution
    1. For better profiles of T_i, V_θ, V_ϕ ==> E_r and ExB shearing rate
- Counter NBI
  - a) Again momentum and spontaneous velocity in Ohmic and RF
  - b) Pthreshold studies with counter injection
    1. With new and upgraded diagnostics as above

The Edge Rotation Diagnostic (ERD)

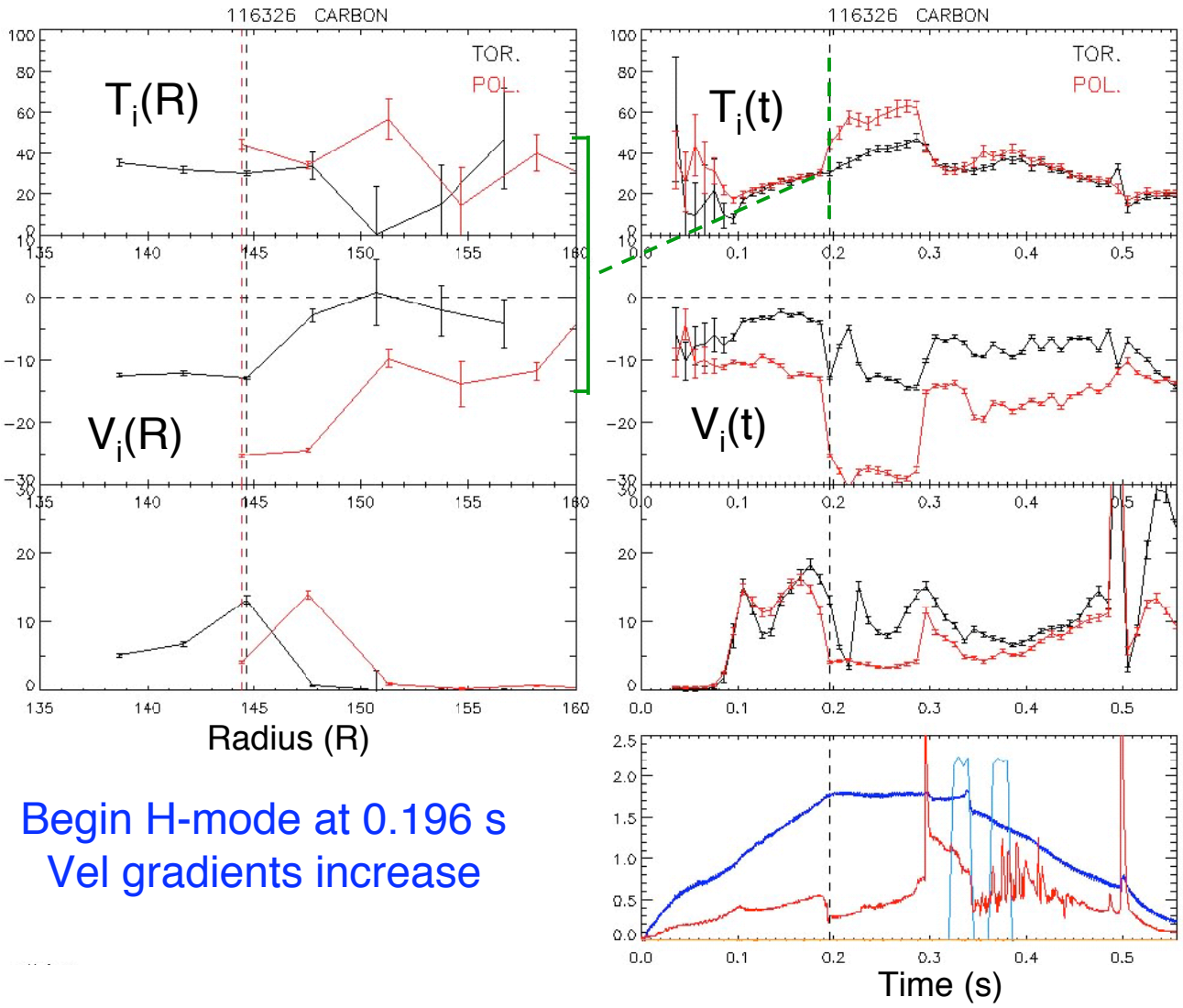


- 10 ms time resolution
- 7 toroidal and 6 poloidal sightlines cover 140 to 155 cm at the outboard midplane.
- Sensitive to intrinsic emission light of C III, C IV, and He II.
- Measures velocity, temperature, and brightness of edge ions.
- Spectral resolution of 0.22 Å/pixel with 75 μm slits.
- T.M. Biewer, *et. al.*, Rev. of Sci. Instrum. **75**, 650 (2004)

T. Biewer



$V_t(R)$ and $V_p(R)$ change at L-H Transition



Begin H-mode at 0.196 s
Vel gradients increase

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(continued)

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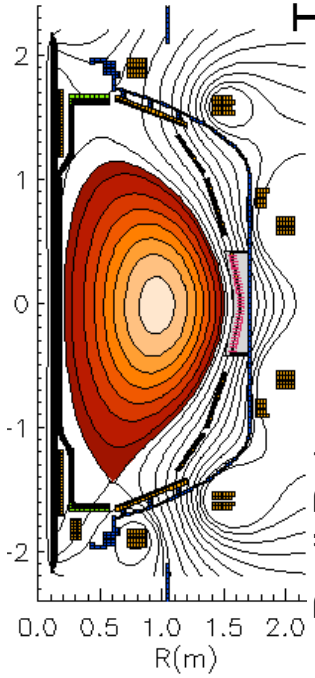
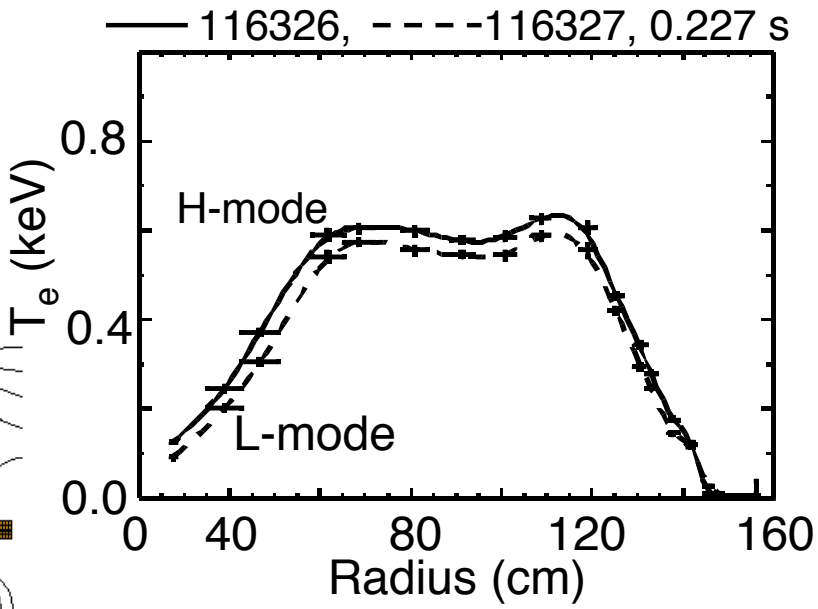
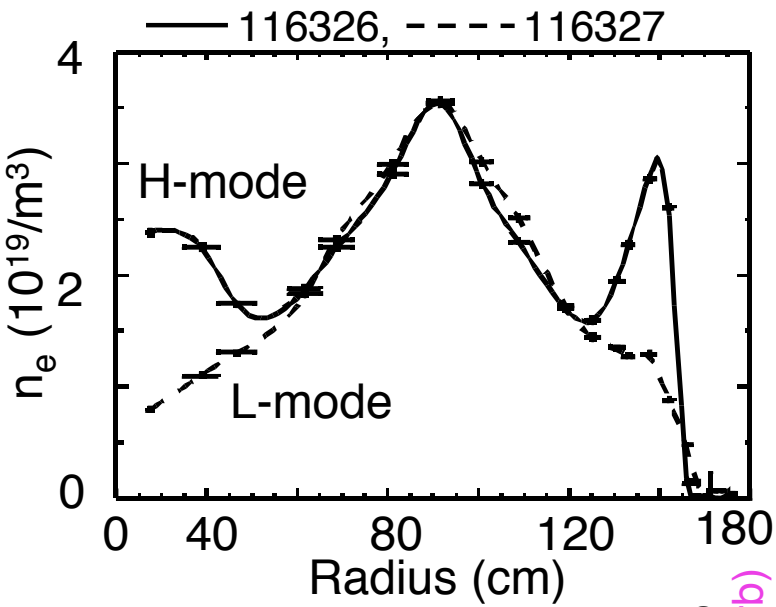
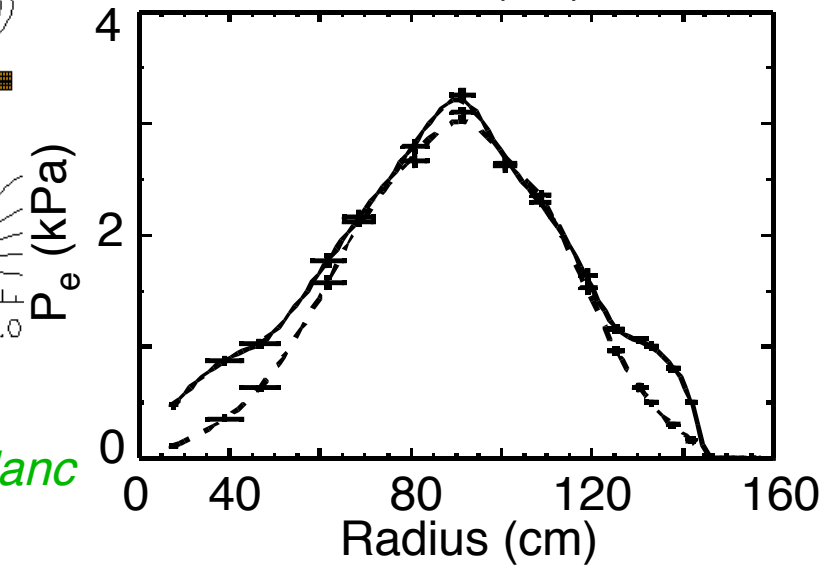
EXTRA

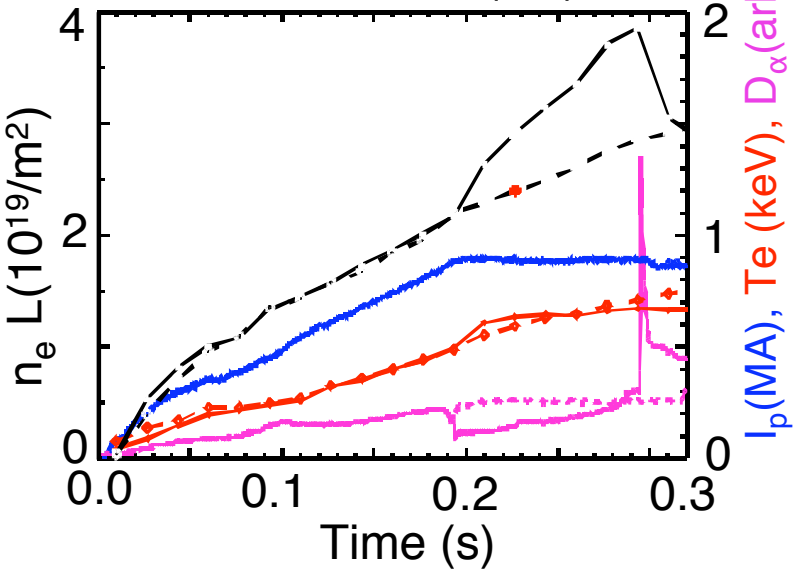
ELM-Free OHH-mode Obtained with LSN











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:

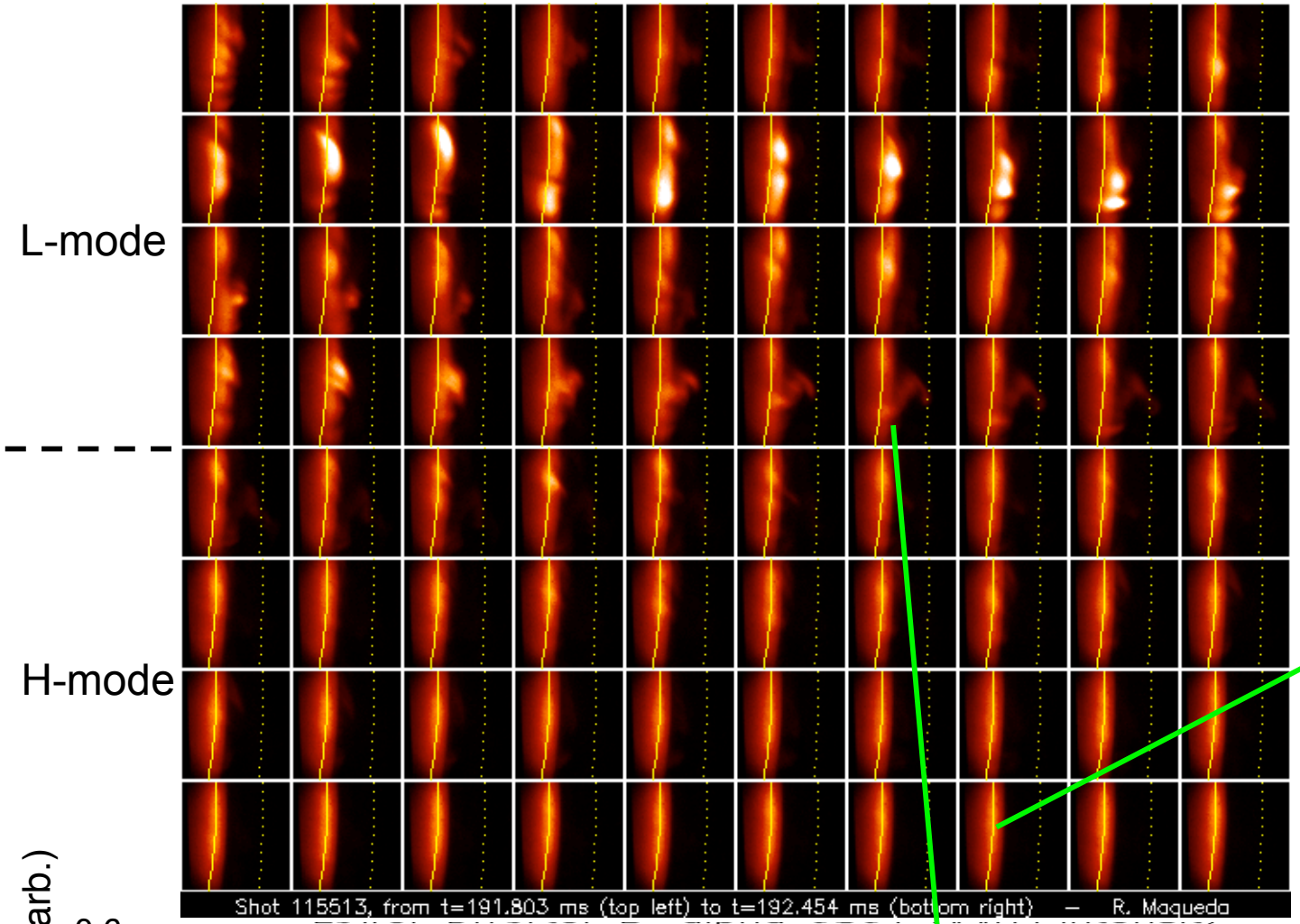
$$E_r = \frac{1}{Z_i e}\left[\frac{T_i}{n_i}\frac{dn_i}{dr} + \frac{dT_i}{dr}\right] - V_\theta B_\phi + V_\phi B_\theta$$

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

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

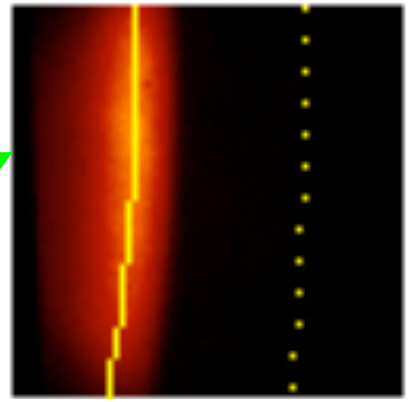
  B_θ from MSE, combined with TRANSP simulations

Gas Puff Imaging (GPI): L-H transition

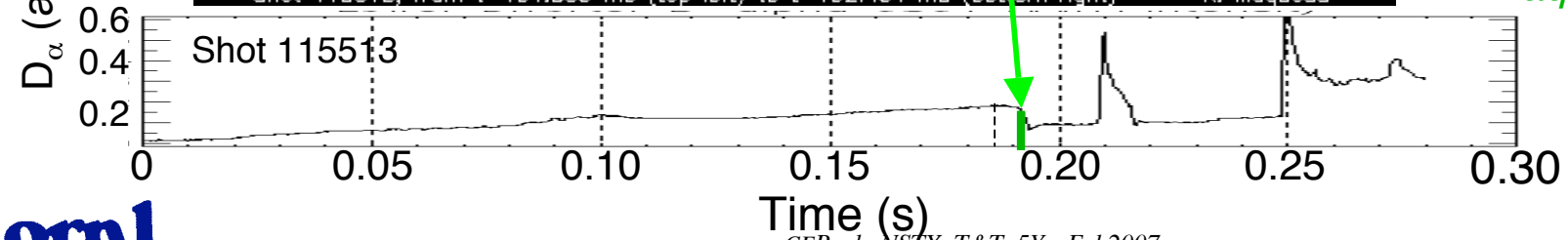


L-H Transition takes place at ~192.1 ms

"Quiescent" H-mode



R. Maqueda



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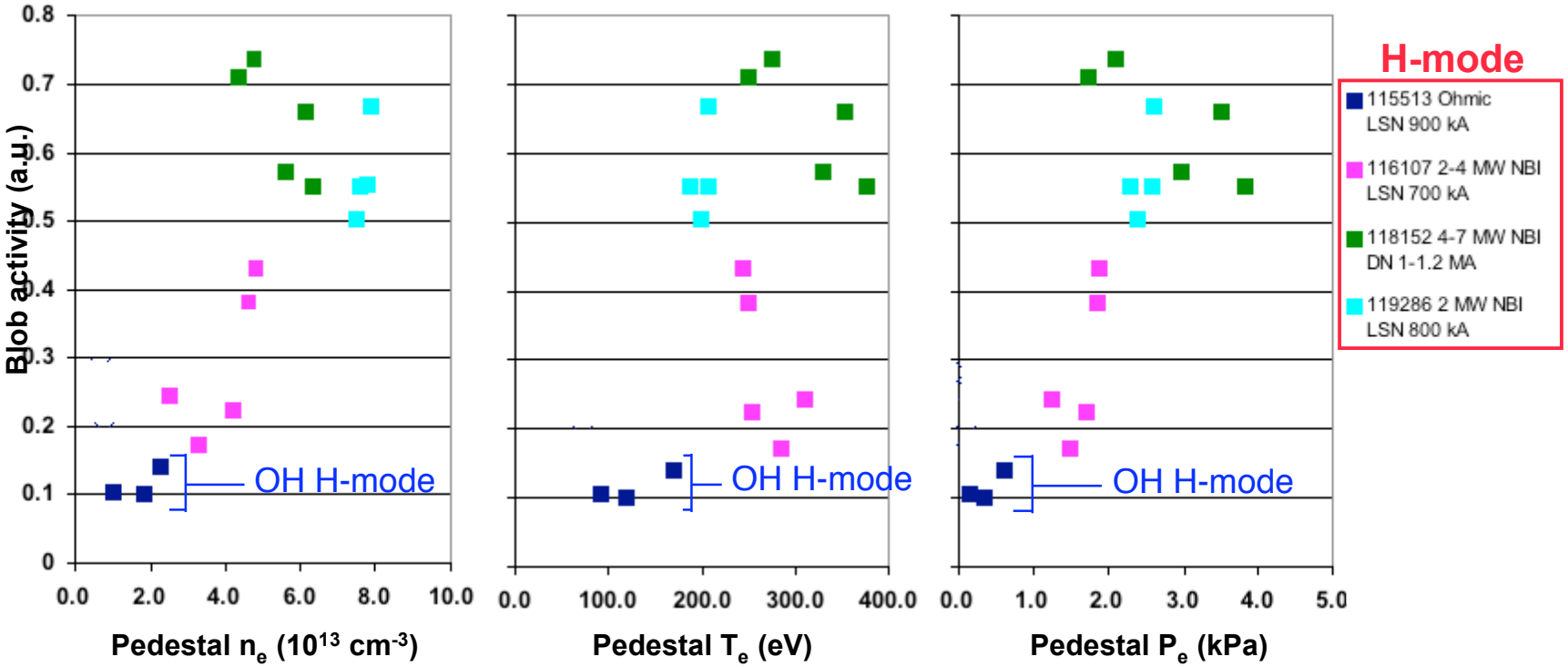
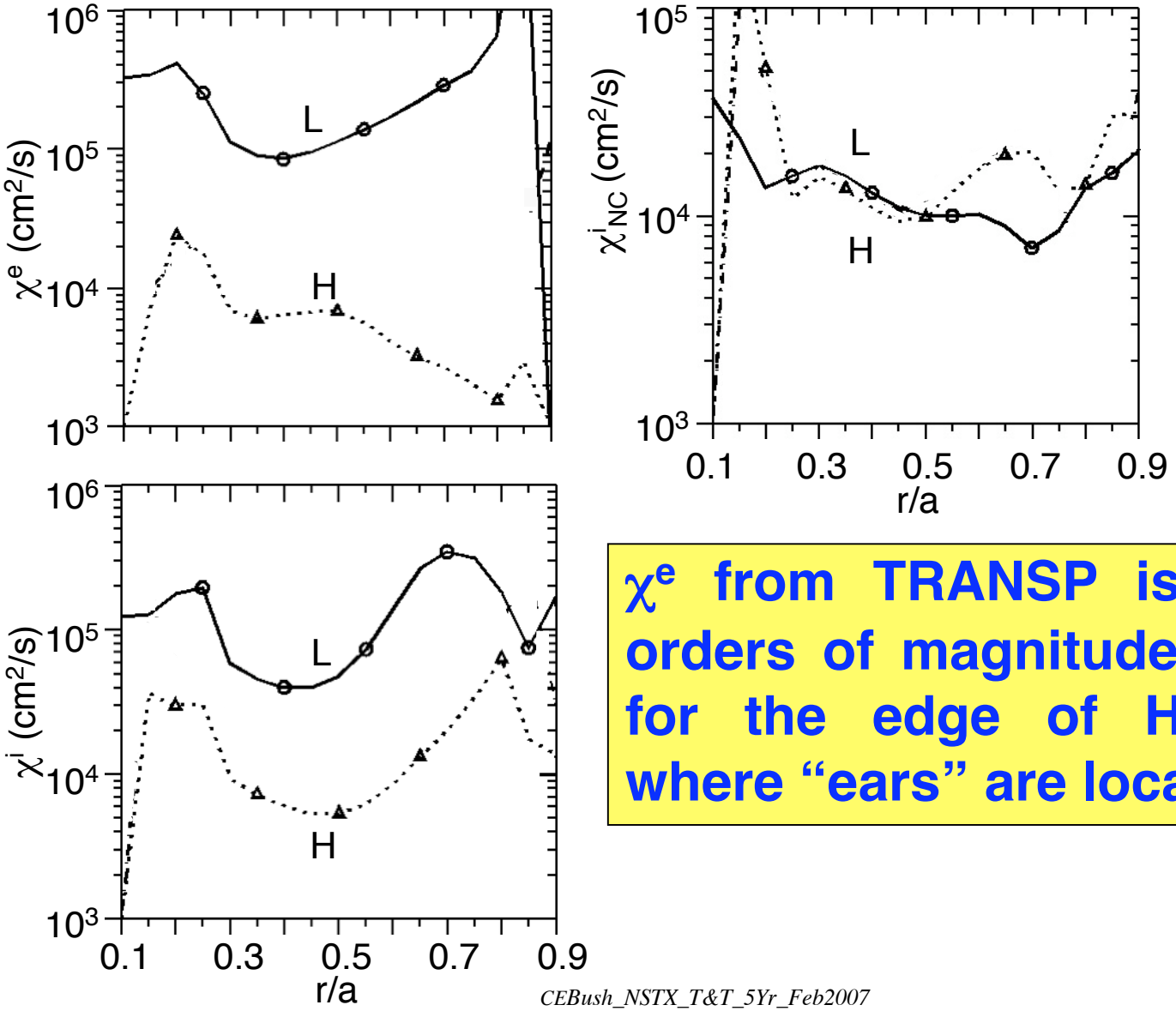
Turbulence/blob activity much lower During Ohmic H-mode than L-mode and NBI H-mode

- 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.

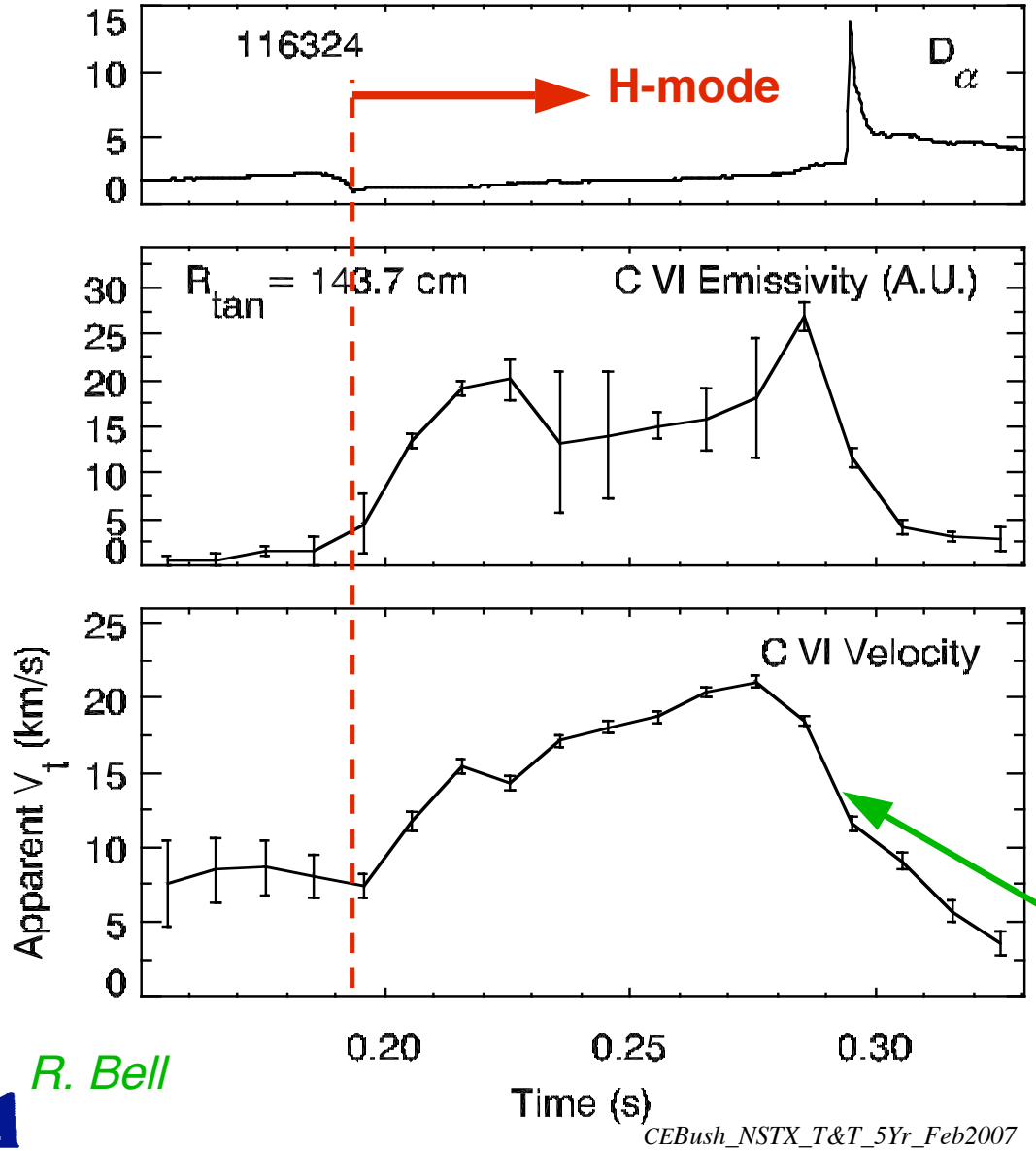


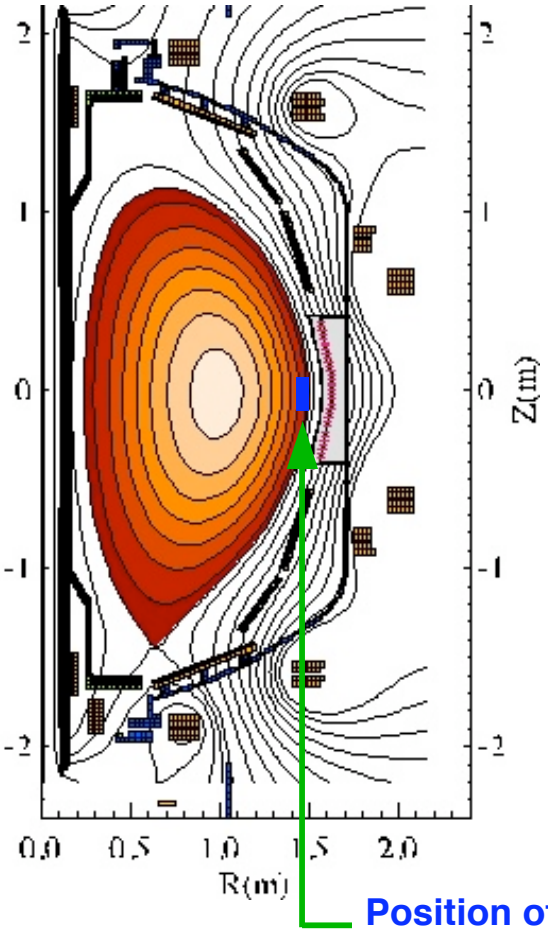
Electron (Ion) Heat Diffusivity, χ^e (χ^i) Lower during OHH-mode with NBI Blip



χ^e from TRANSP is two orders of magnitude lower for the edge of H-mode where "ears" are located.

C VI Emissivity and Toroidal Velocity Increase at Plasma Edge in Ohmic H-mode on NSTX





C VI Edge Toroidal Velocity, V_t, Increases During H-mode

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