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The Enhanced Pedestal H-mode in NSTX

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Rajesh Maingi

Oak Ridge National Laboratory

M.G. Bell 2), R.E. Bell 2), E.D. Fredrickson 2), D.A. Gates 2), S.M. Kaye 2), B.P. LeBlanc 2), F. Levinton 3), J.E. Menard 2), S.A. Sabbagh 4), H. Yuh 3), and the NSTX Team

1) Oak Ridge National Laboratory
2) Princeton Plasma Physics Laboratory
3) Nova Photonics
4) Columbia University

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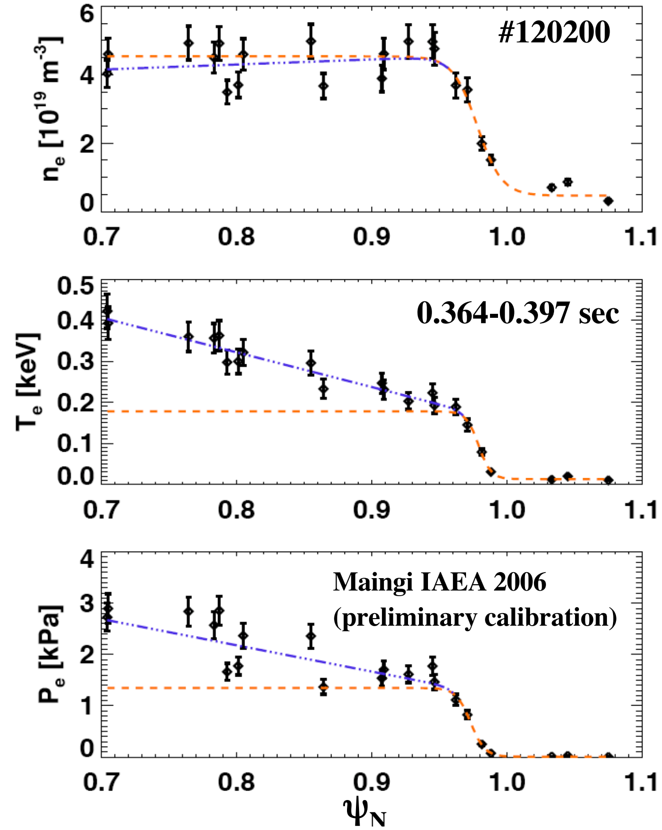
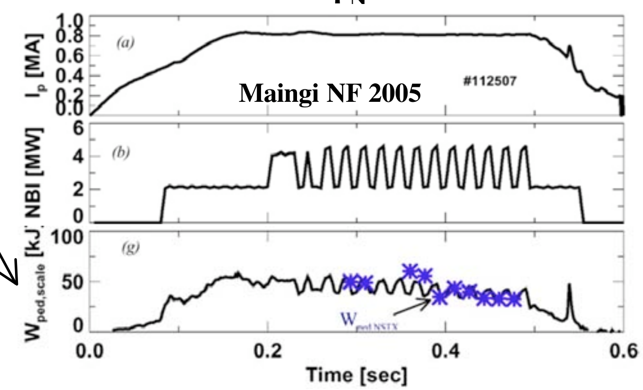
Motivation

- Typical $T_{e,i}^{ped}$ ~ 100-300 eV and P_e^{ped} ~ 1-3 kPA
- NSTX data agree roughly with Guzdar PoP 2005 scaling for T_{ped}:

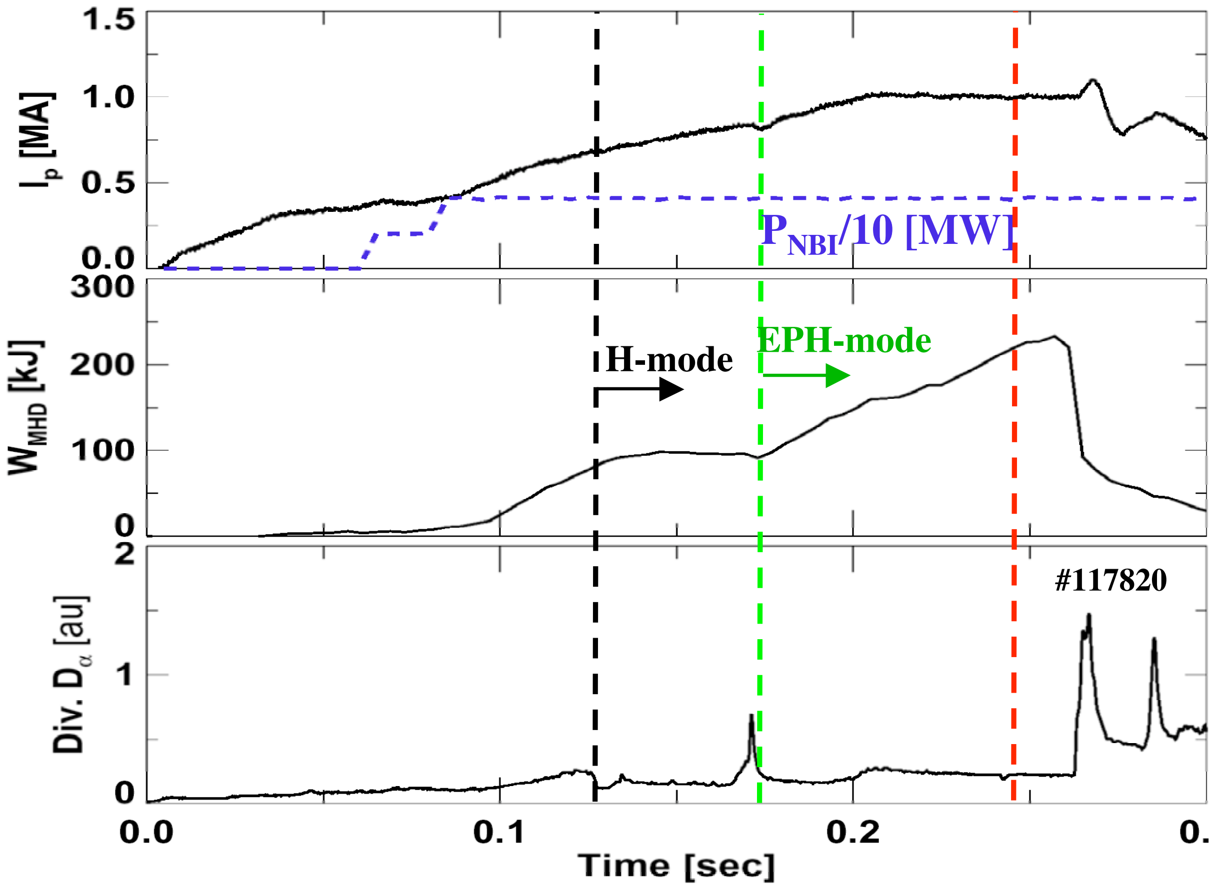
  $T_e^{ped}+T_i^{ped} \sim B_t^2/(q^2R(n_e^{ped})^{3/2})$~R/a

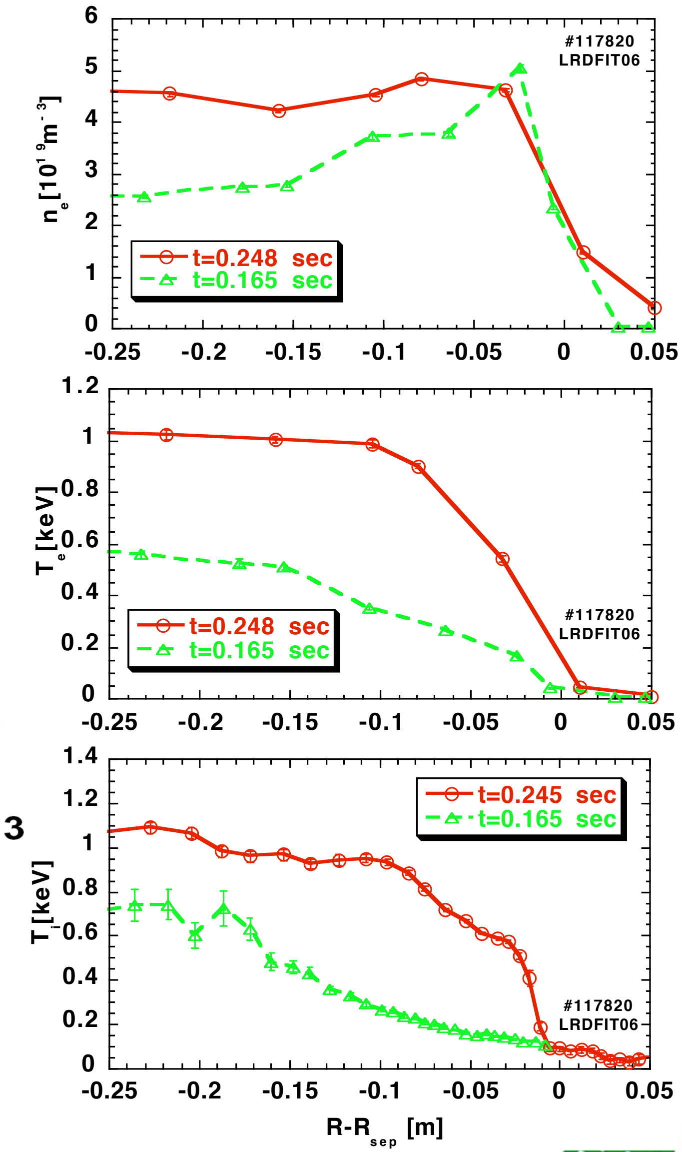
- NSTX data agree with Cordey's NF '05 two term model for W_{ped} scaling
- New Enhanced Pedestal H-mode (EPH) observed with $T_{e,i}^{ped} \leq 650$ eV, $P_e^{ped} \leq 8$ kPa, with a pedestal in to $\psi_N \sim 0.8$, with pedestal $\nu_e^* \sim 0.1$
- Similarities with VH-mode in DIII-D





Transition to an Enhanced Pedestal H-mode enables pedestal $\nu_{e,ped}^* \sim 0.1$ in NSTX



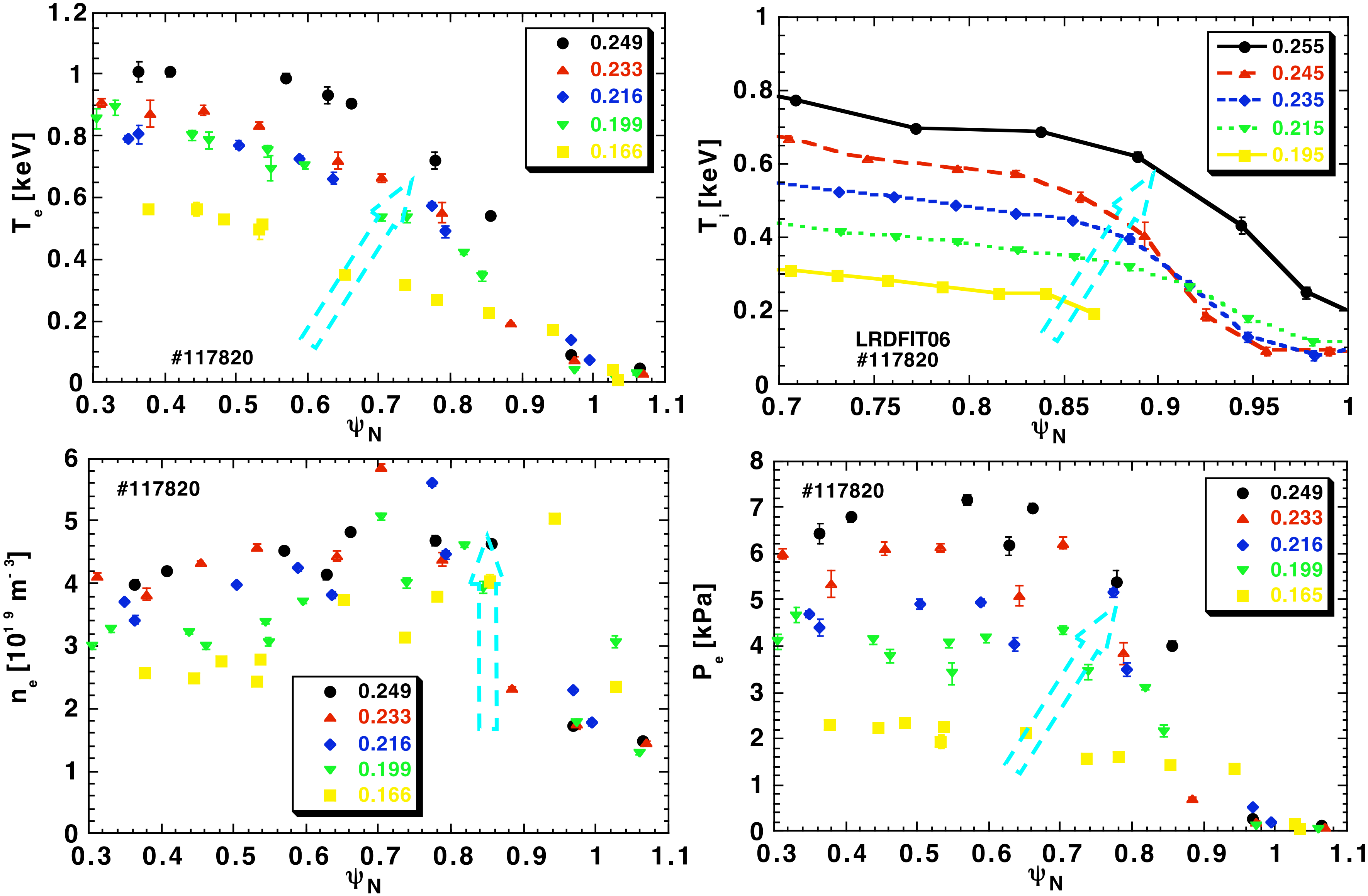


- Pedestal $\nu^*_e \sim 0.5$-1 in normal H-mode
- Hypothesize that extreme reversed shear restricts $\beta_N \leq 4.5$ in this discharge

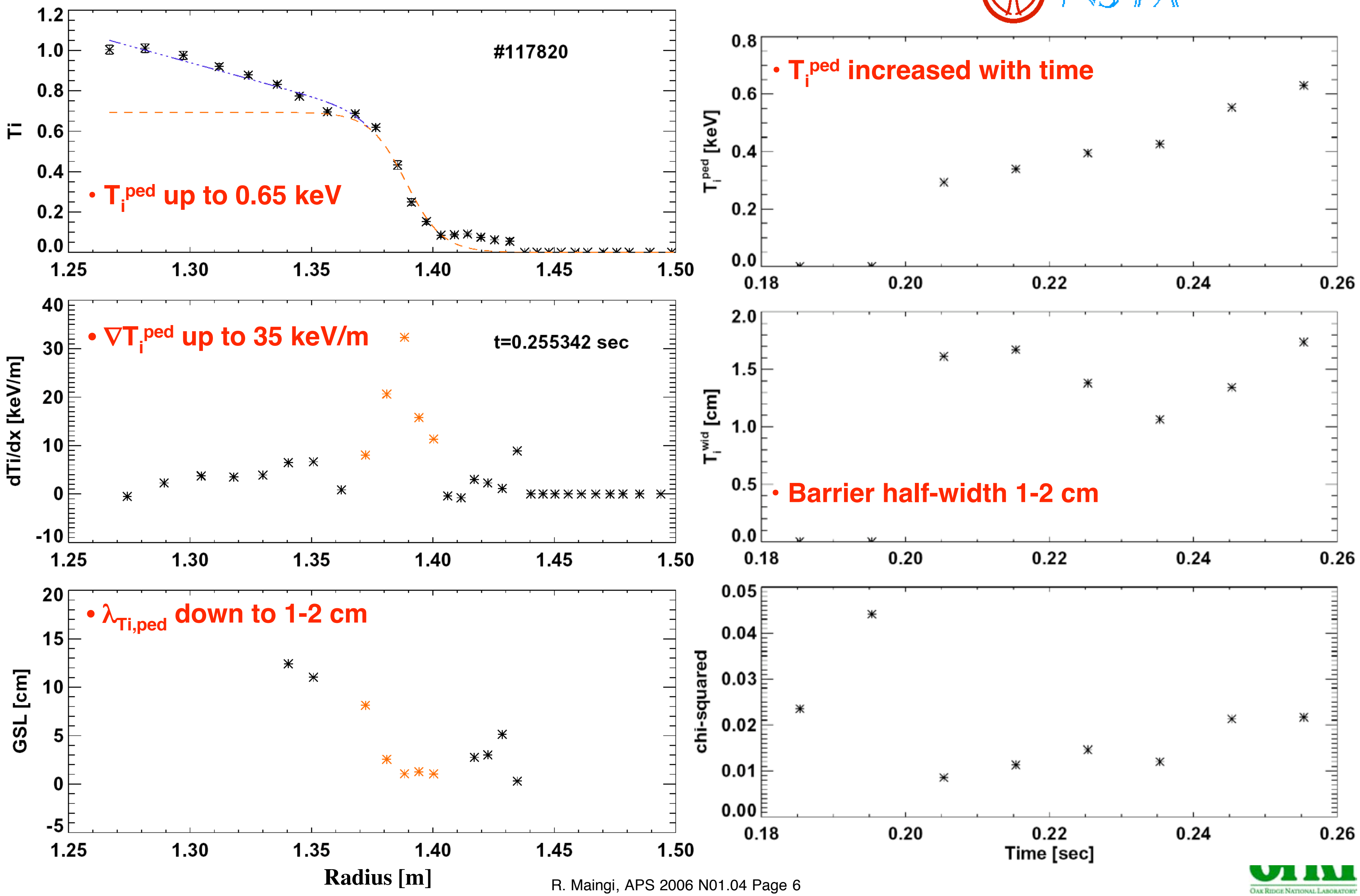
Enhanced Pedestal H-mode Characteristics

- A second transition to enhanced confinement and high pedestal T_e, $T_i \leq 650$ eV
- $H_{H89P} \sim 2.6\text{-}2.7$ due to high dW/dt
- Triggered after global MHD mode
- Apparent power threshold: between 2 and 4 MW
- Common feature: edge v_ϕ develops large gradient
- Some of these discharges had low/no current density over inner 15cm, in which case $\beta_{N,max} \sim 4\text{-}4.5$

Edge and core T_e, T_i, and P_e increase rapidly after EPH-mode transition

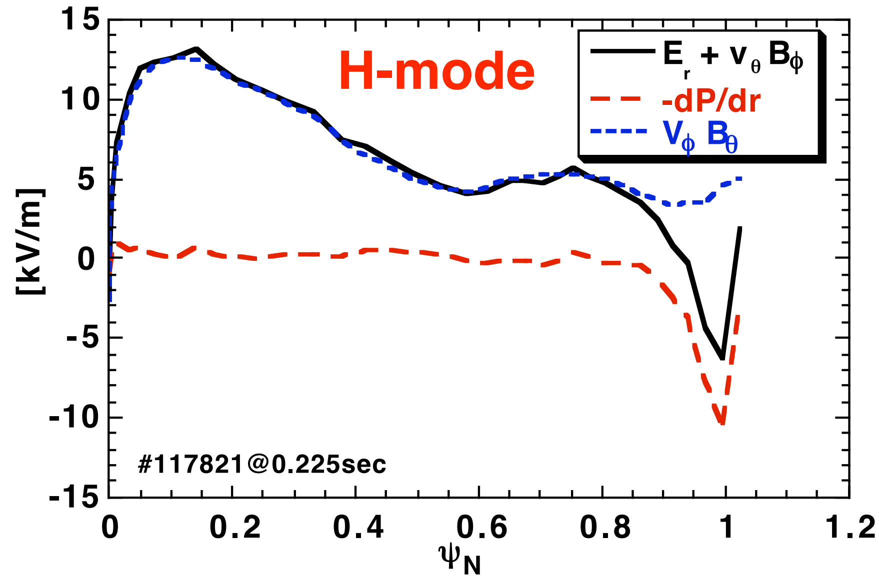


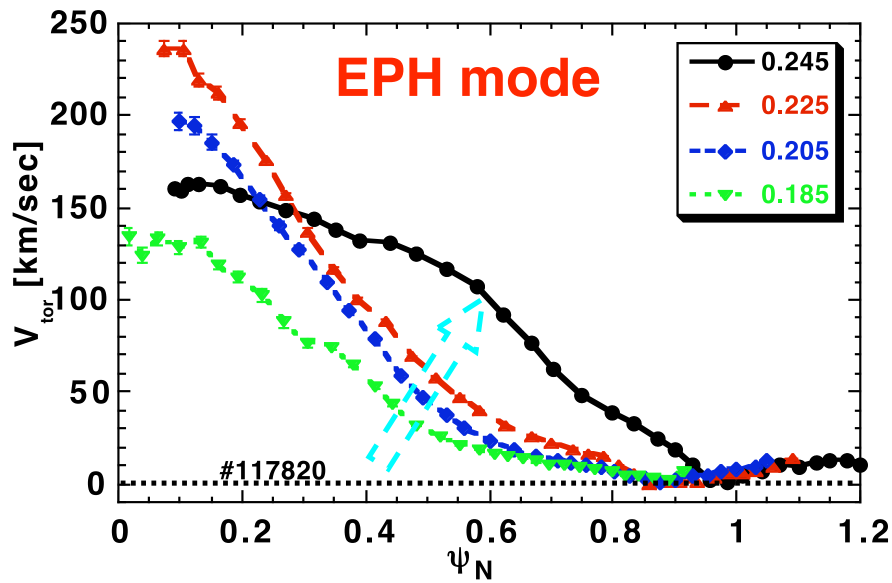
Pedestal T_i from tanh fits increased with time

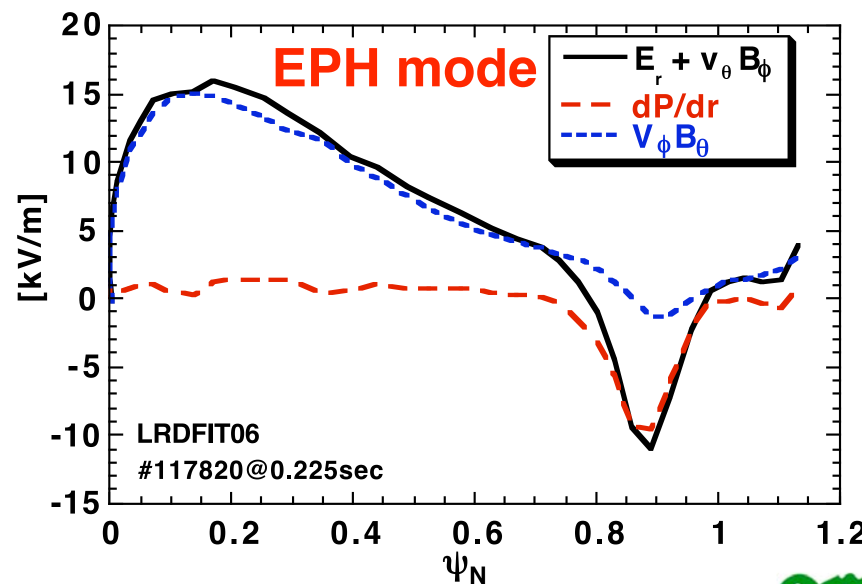


Changes in v_ϕ accompany high $T_{e,i}^{ped}$ in Enhanced Pedestal H-mode

- First order radial force balance: $E_r + v_\theta B_\phi = v_\phi B_\theta + \nabla P_c / 6eN_c$
- EPH mode has $v_\phi \sim 0$ near separatrix, probably due to drag from an island, such that ∇P term dominates v_ϕ over large region
- Large ∇v_ϕ indicative of large E_r'
- v_θ will be measured this year





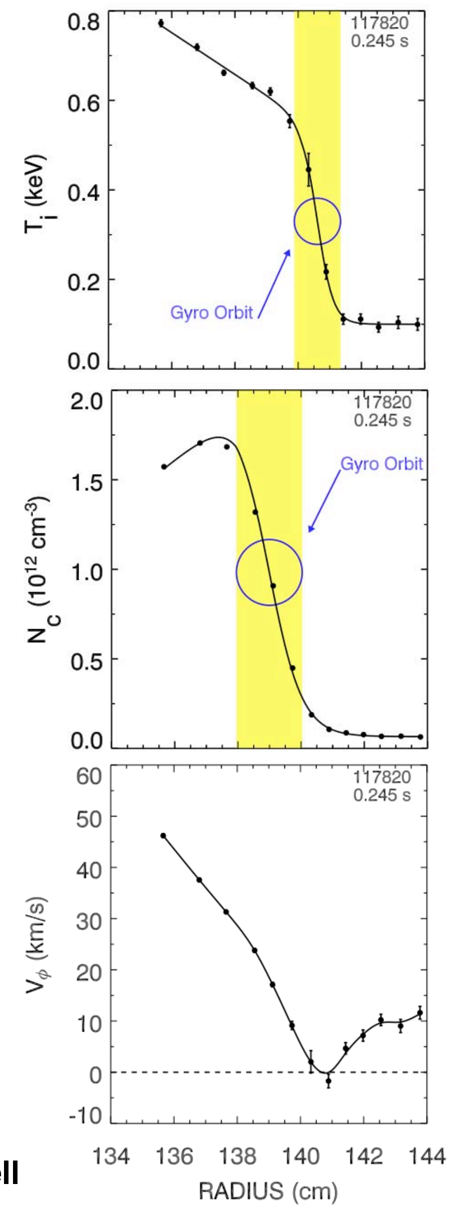


Enhanced Pedestal H-mode barrier width size comparable to gyro-diameter

NSTX

- Edge scale lengths for both T_i and n_C approach the gyro-diameter during EPH-mode
- Ion gyroradius $\rho_i \sim 0.7$ cm relative to |B|, owing to combination of local $T_i \sim 350$ eV and and |B| ~ 0.35 T at outer midplane
  - ➢ Approaching or at the fundamental limit on the gradient scale length?
- Note that ion poloidal gyroradius 100% higher, i.e. $\rho_i \sim 1.4$ cm

✓ *Basic transport physics can be studied in EPH-mode, owing to large gyro-diameter and good spatial resolution of plasma profiles*

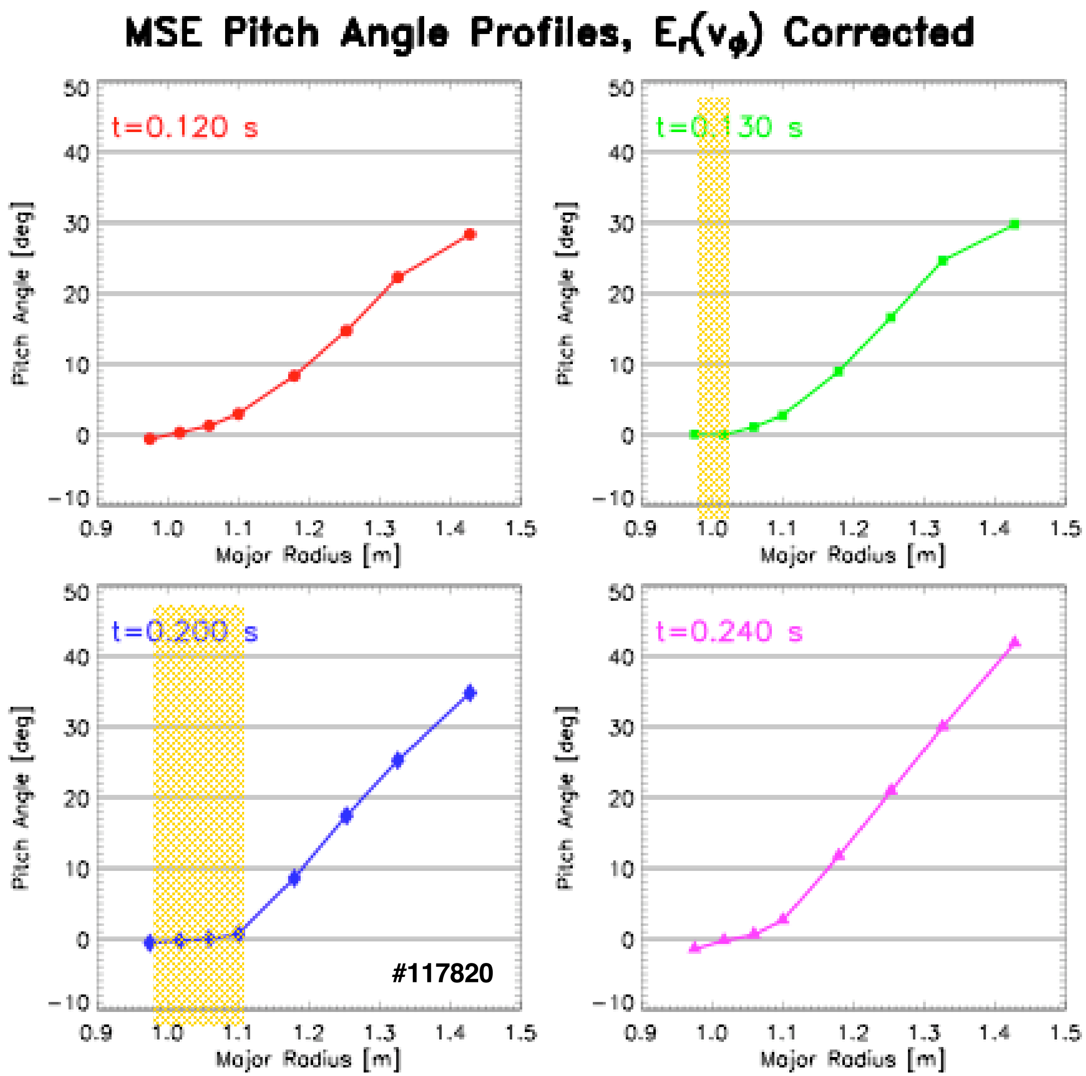


R. Bell

MSE Shows Evidence for Formation of "Current Hole" in Certain EPH-mode Discharges

NSTX

- At 0.12 s current profile is hollow but central current density is finite
- Small region of almost zero current density forms at 0.13 s
- Expands to about 15 cm diameter by 0.20s
- Central current density becomes positive again by 0.24 s



F. Levinton, H. Yuh

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Summary

- A second transition to enhanced confinement and high pedestal T_e, $T_i \leq 650$ eV observed in certain discharges
- Triggered after global MHD mode
- Common feature: edge v_ϕ develops large gradient and region of large E_r' penetrates further into the core than normal H-mode, similar to VH mode (*Burrell PoP 1994*)
- T_i gradients approaching fundamental limits?
- Termination thought to be related to ideal MHD instability due to extreme central reversed shear

Backup

Transition to Enhanced Confinement follows MHD