Reproducing the Enhanced Pedestal H-mode in NSTX

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ISD Group Meeting

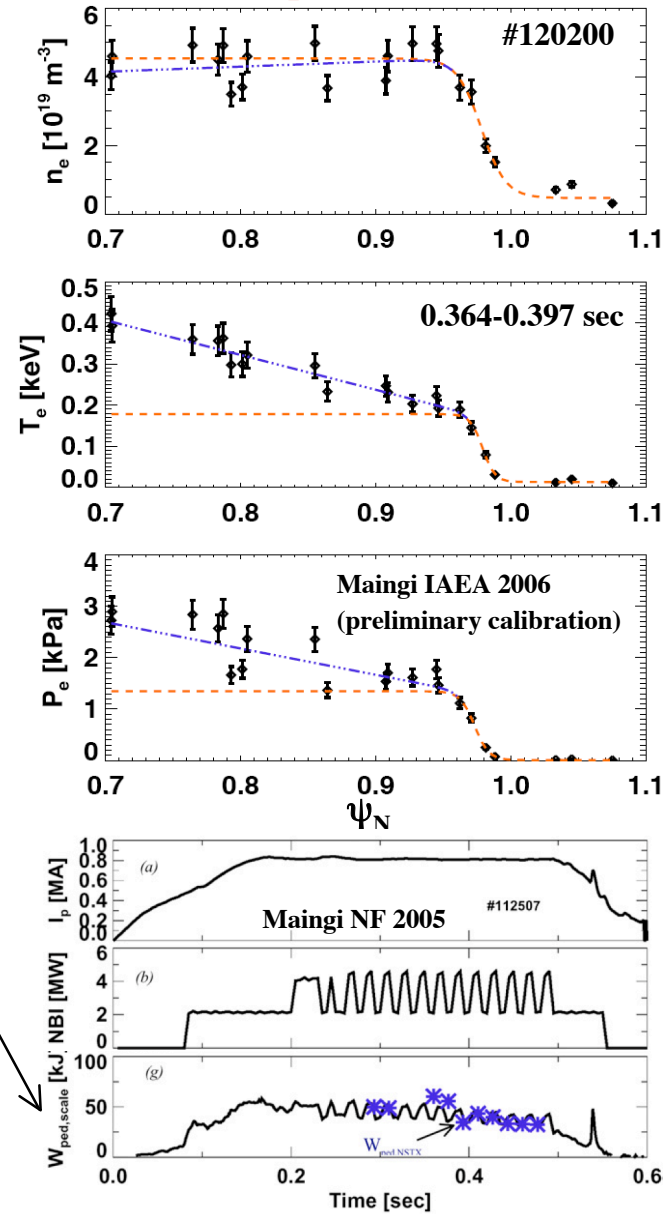
Princeton, NJ

June 1, 2007

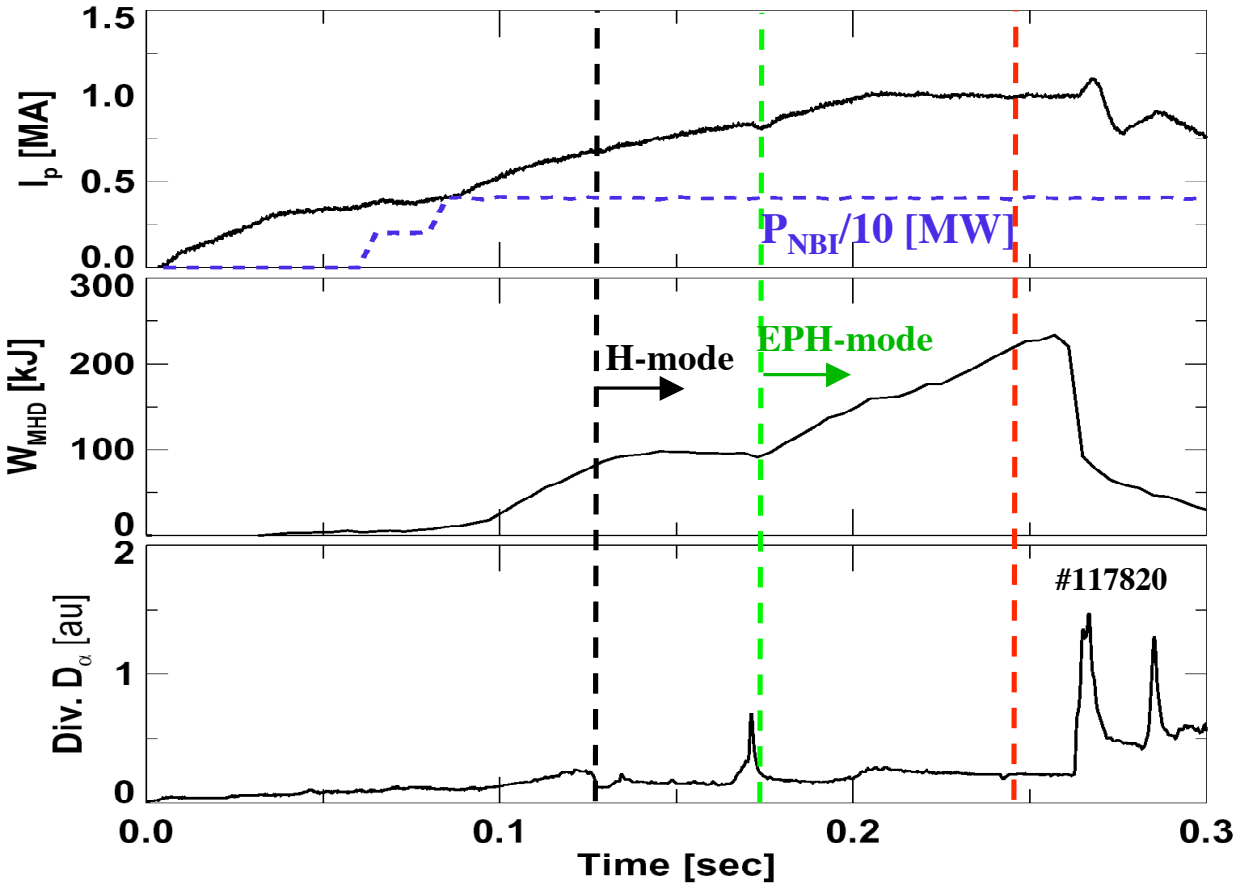
Motivation

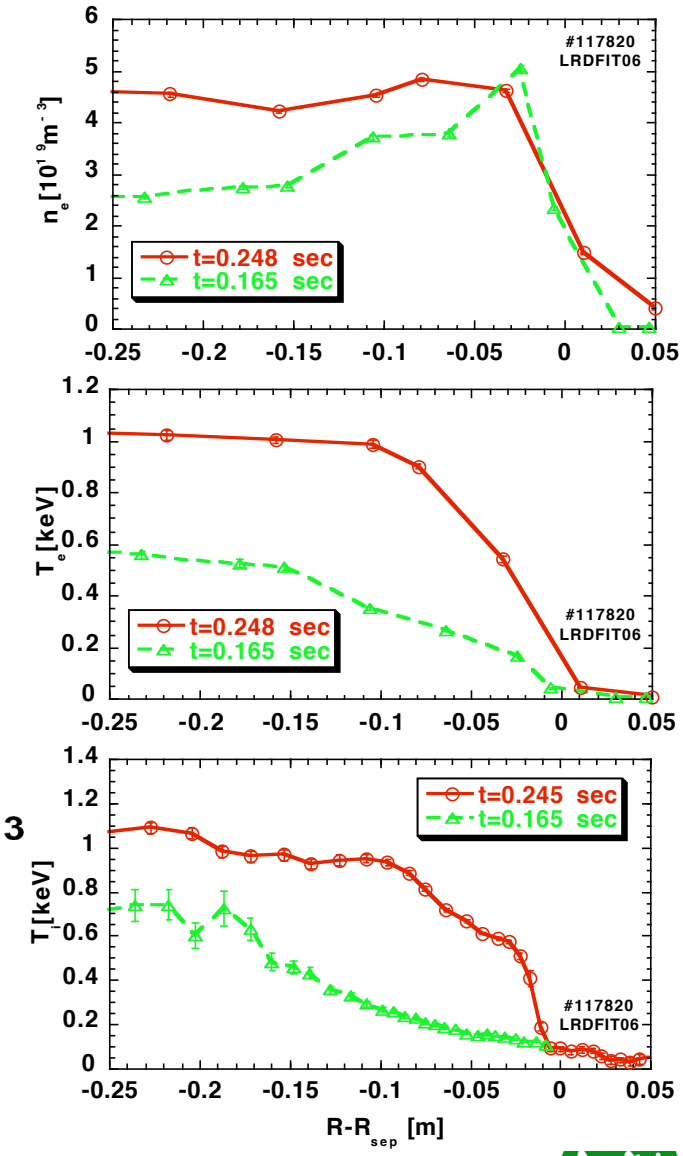
- Typical $T_{e,i}^{ped} \sim 100\text{-}300$ eV and $P_e^{ped} \sim 1\text{-}3$ kPA
- NSTX data agree roughly with Guzdar PoP 2005 scaling for T_{ped}:

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



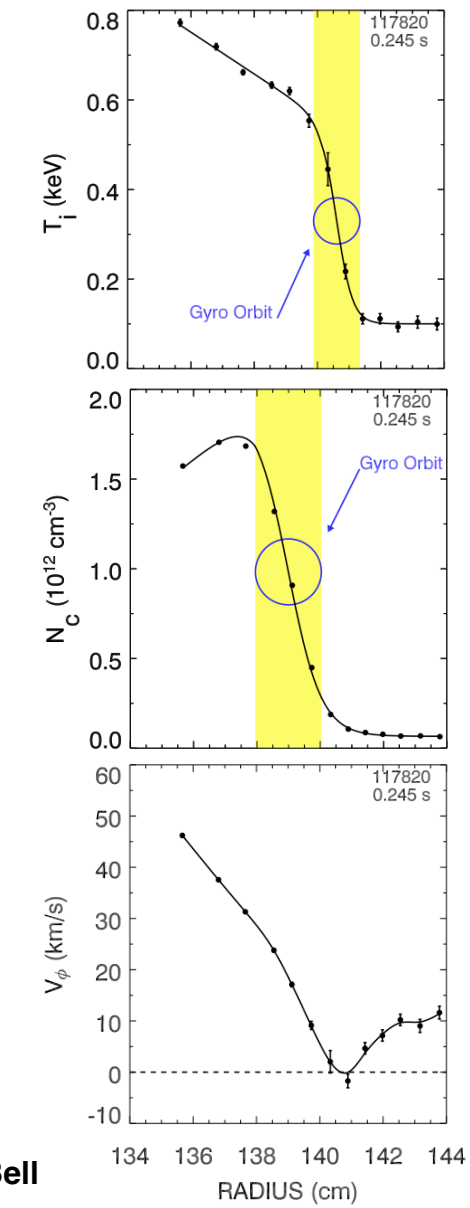


- Pedestal $\nu^*_e \sim 0.5$-1 in normal H-mode
- Hypothesize that extreme reversed shear restricts $\beta_N \leq 4.5$ in this discharge

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

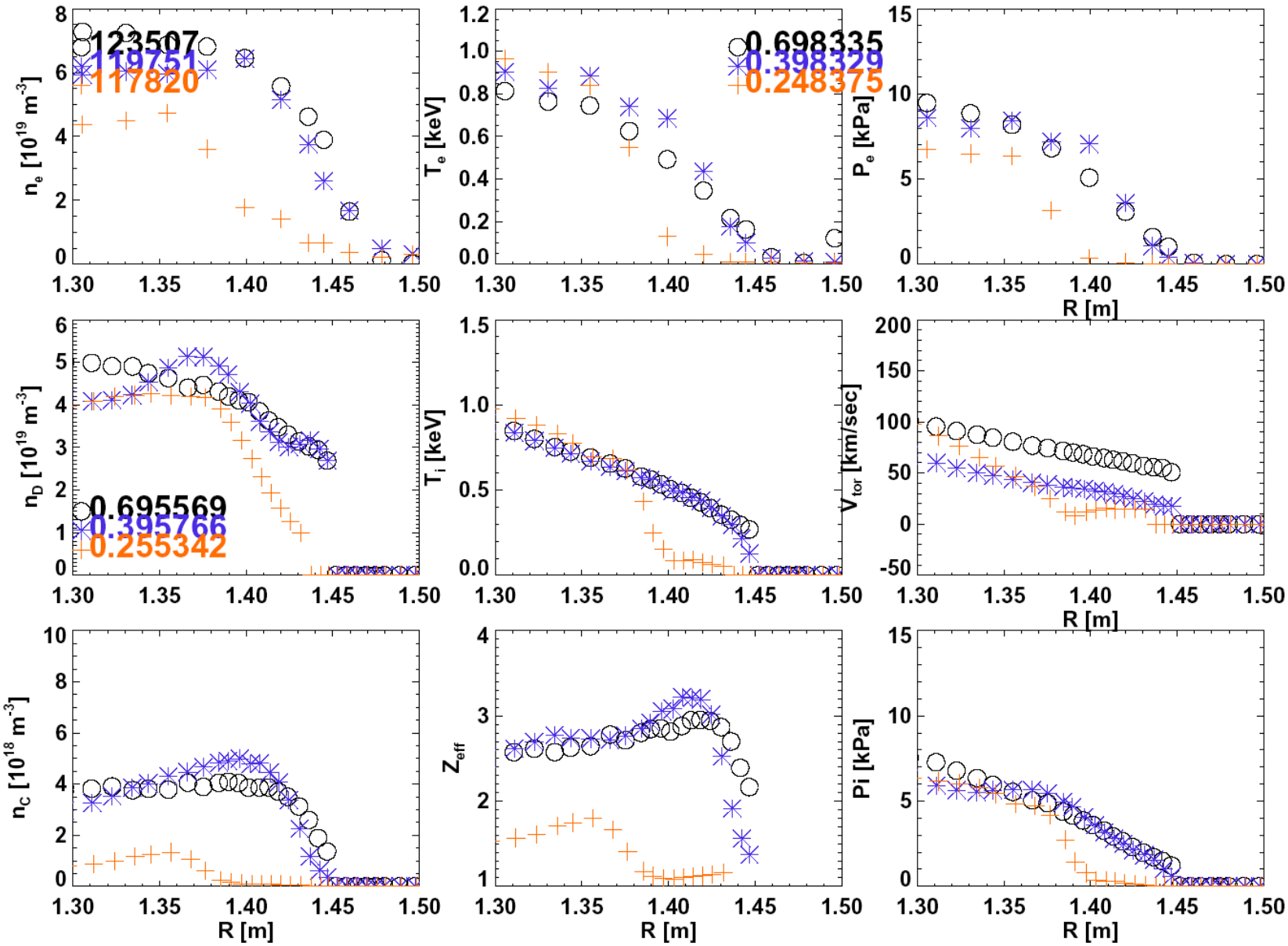
- Edge scale lengths for both T_i and n_C approach the gyro-diameter during EPH-mode
- Ion gyroradius $\rho_i \sim 0.7$ cm relative to |B|, owing to combination of local $T_i \sim 350$ eV and and |B| ~ 0.35 T at outer midplane
  - ➢ Approaching or at the fundamental limit on the gradient scale length?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

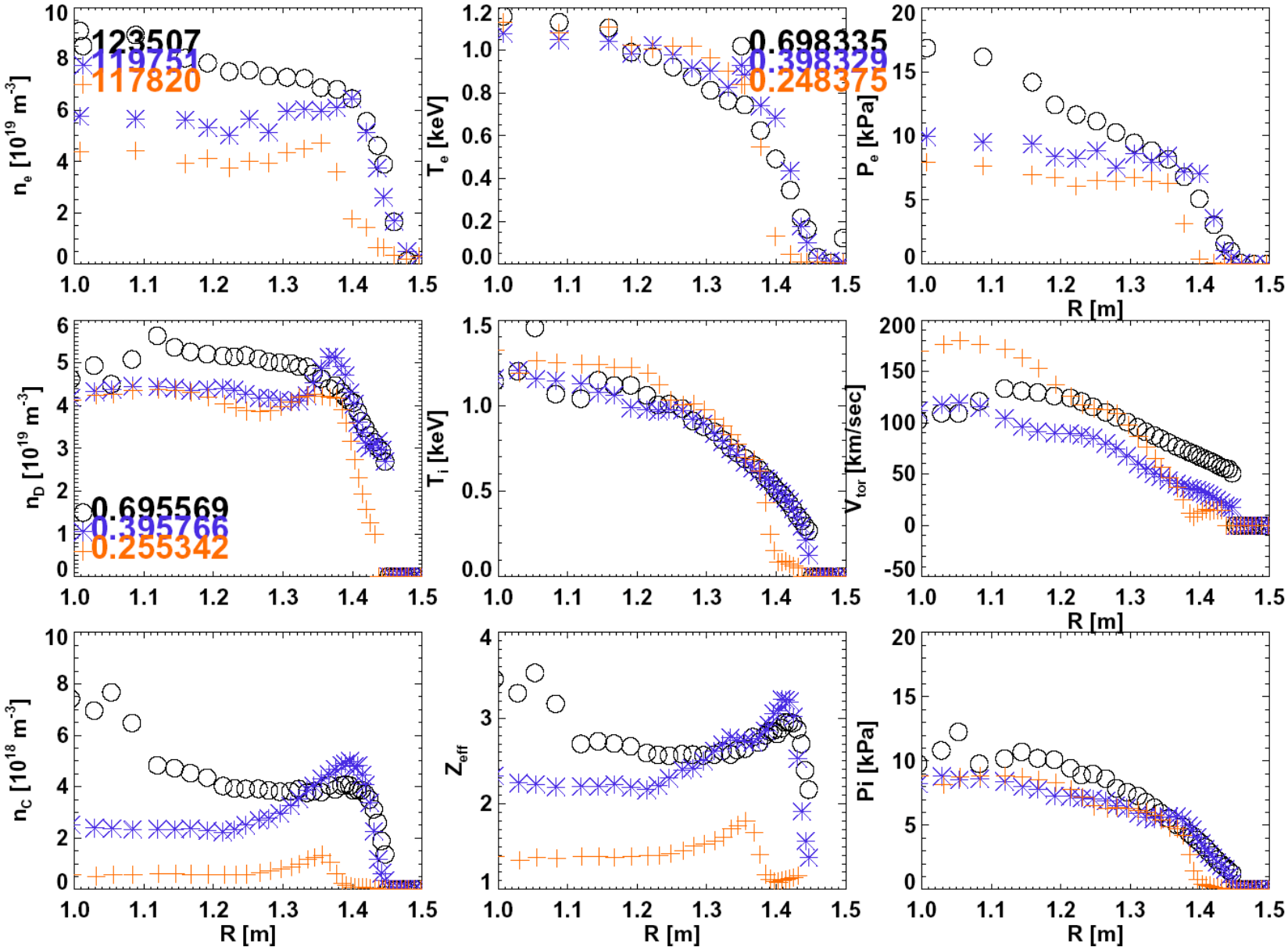


R. Bell

Edge Gradients Stronger in EPH mode than in High Performance Lithium enhanced discharges



High Performance Lithium enhanced discharges have better core performance than EPH mode



Proposal (0.5 day)

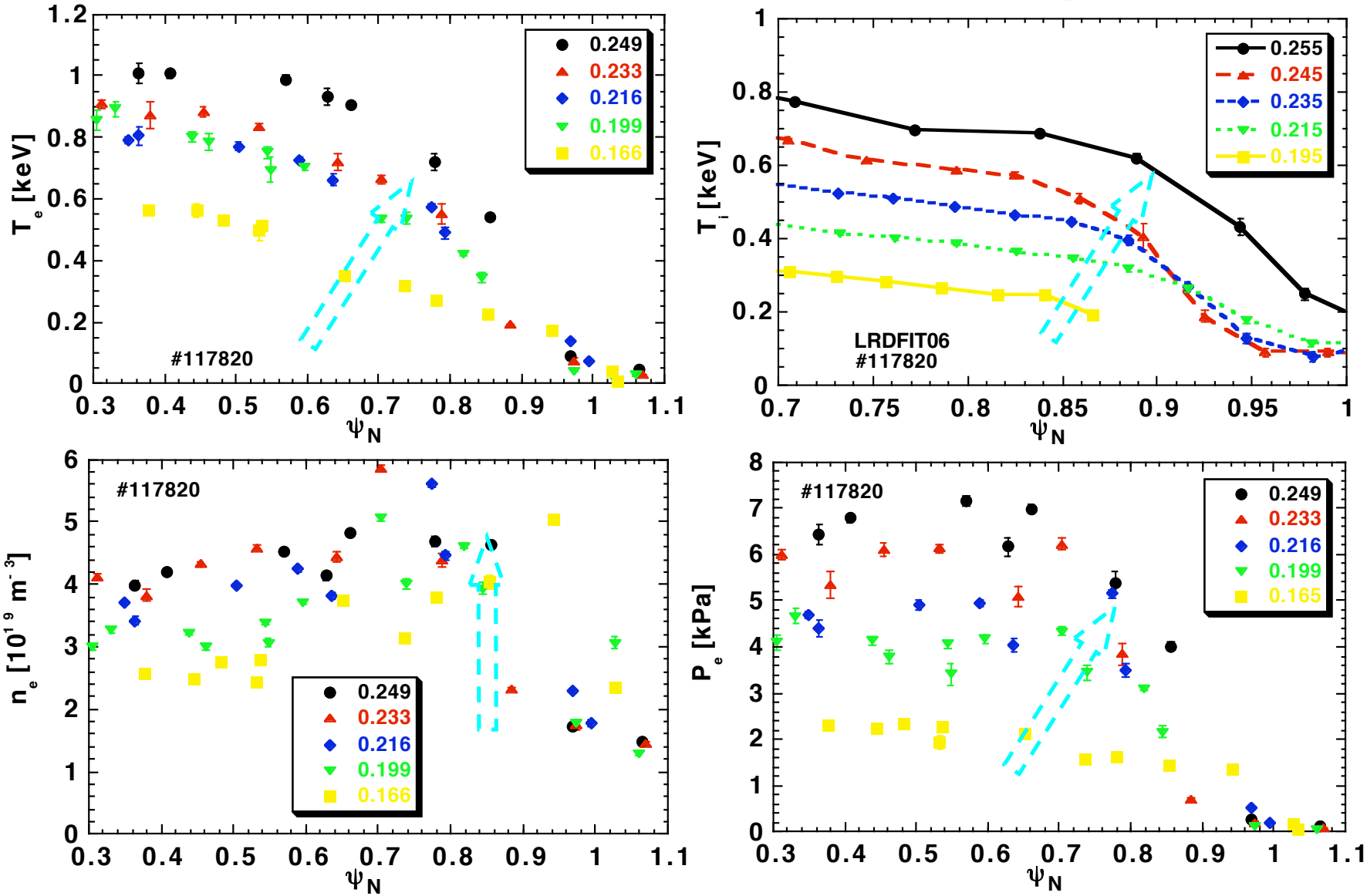
1. Reproduce EPH discharges e.g. #119751 or #117820 and optimize outer gap for best Thomson and CHERs resolution of gradients (9-11 cm?)

2. Avoid current hole with changes to I_p ramp and NBI timing

- New data will accelerate development of poloidal CHERs analysis software, despite not being able to measure all E_r terms

Backup

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

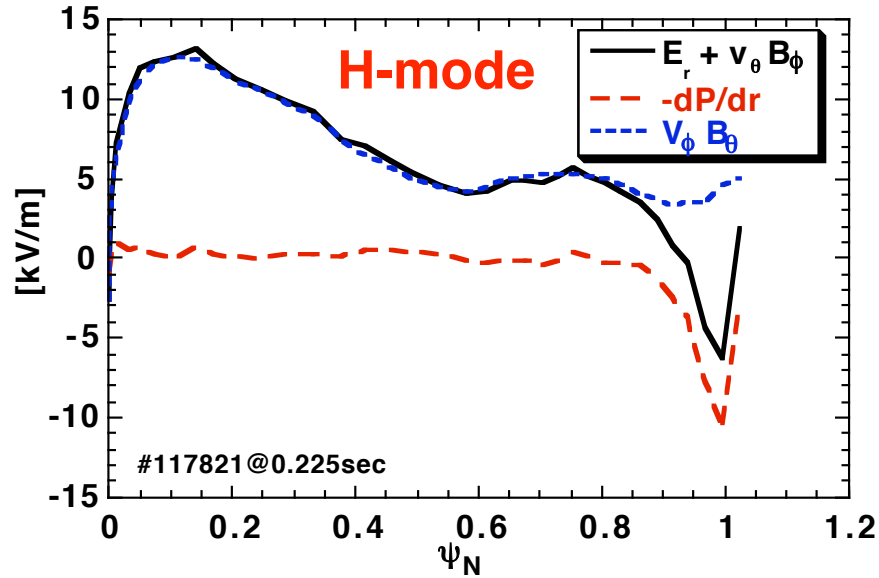


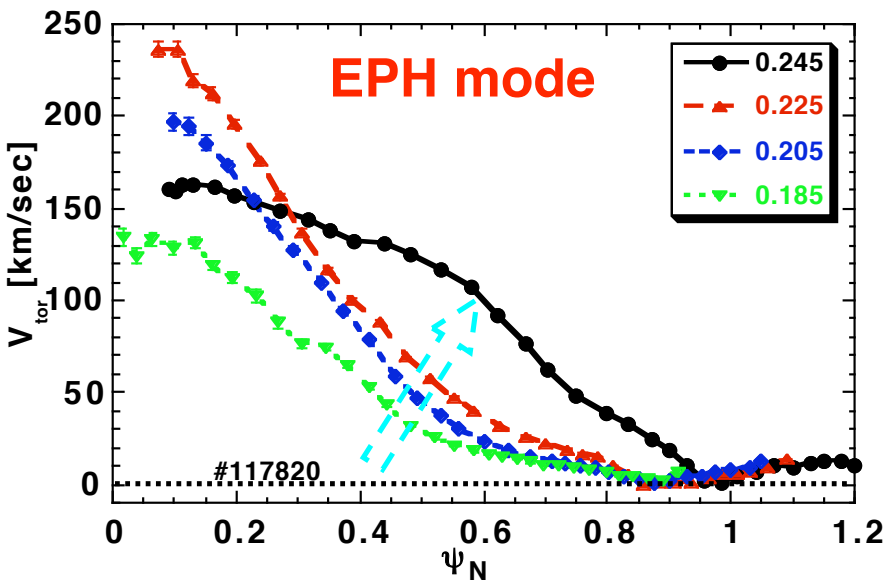
Enhanced Pedestal H-mode Characteristics

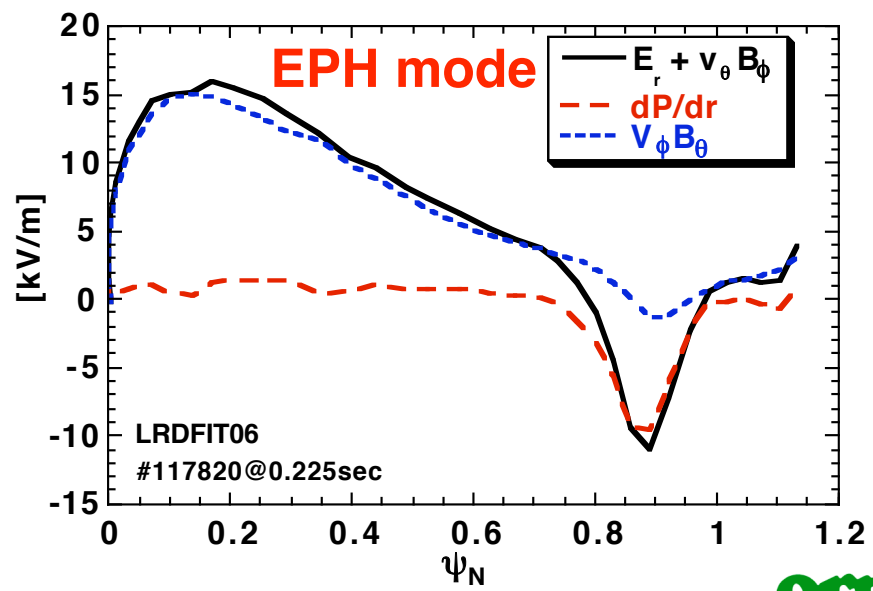
- A second transition to enhanced confinement and high pedestal T_e, $T_i \leq 650$ eV
- $H_{H89P} \sim 2.6\text{-}2.7$ due to high dW/dt
- Triggered after global MHD mode
- Apparent power threshold: between 2 and 4 MW
- Common feature: edge v_ϕ develops large gradient
- Some of these discharges had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

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

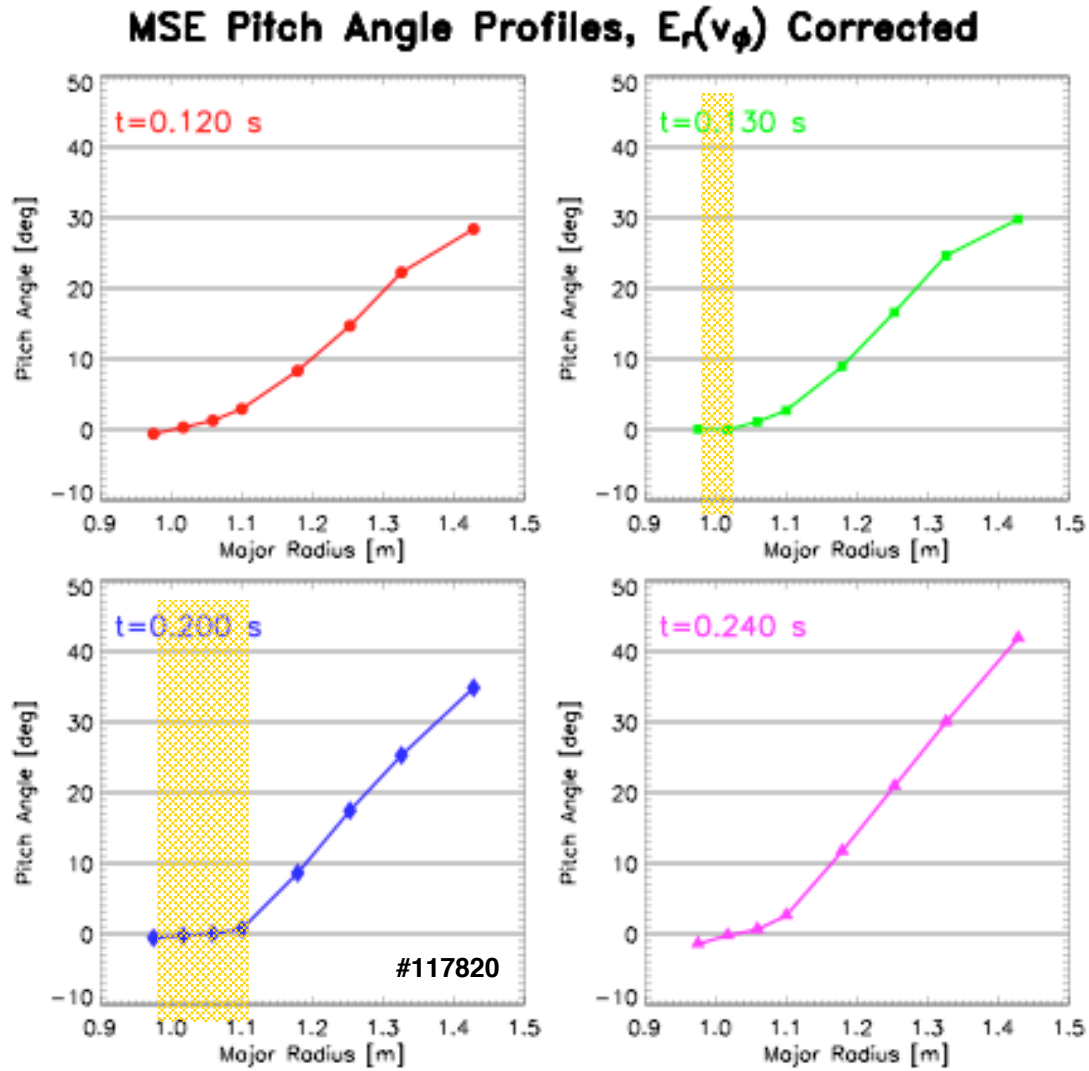






MSE Shows Evidence for Formation of "Current Hole" in Certain EPH-mode Discharges

- 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



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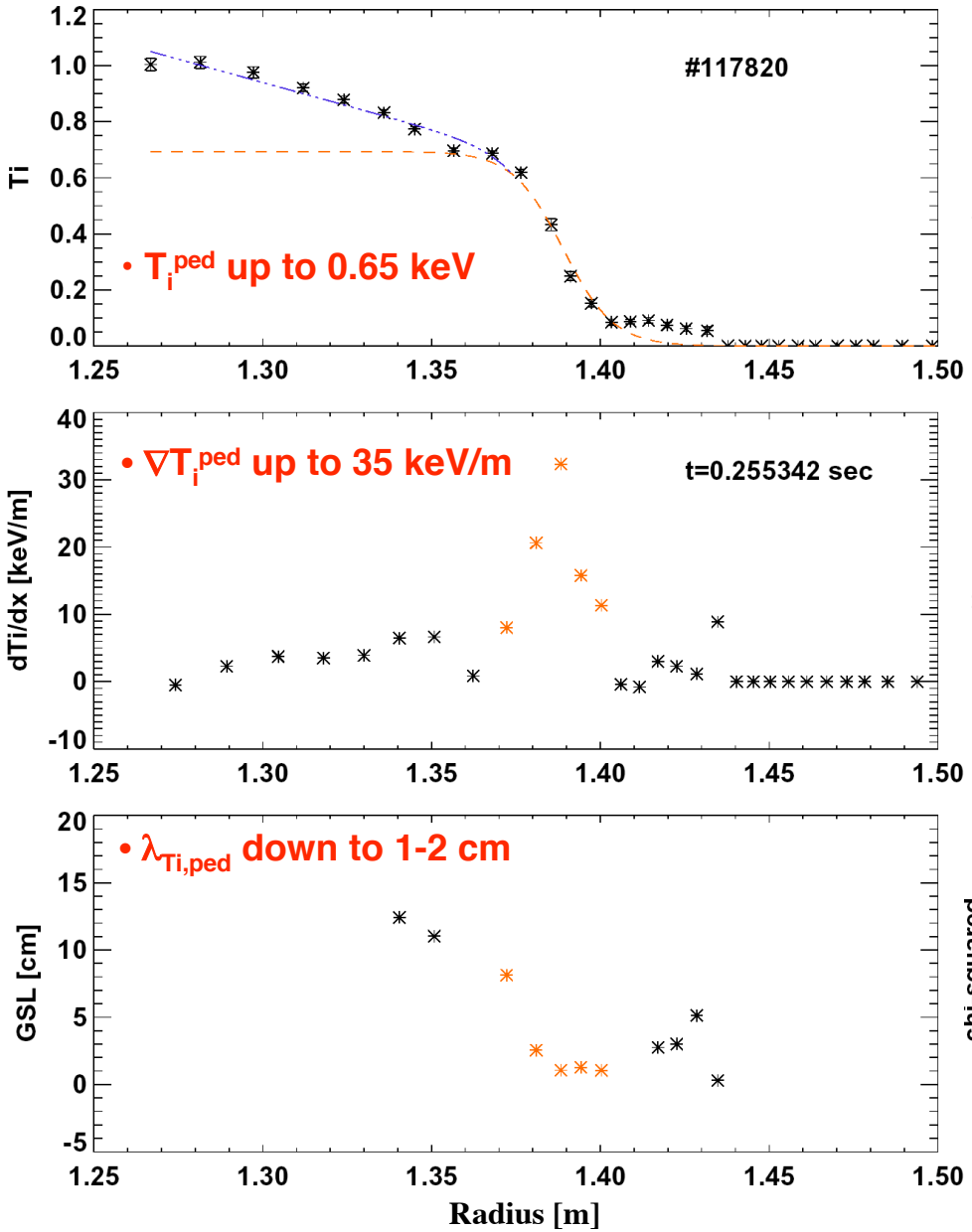
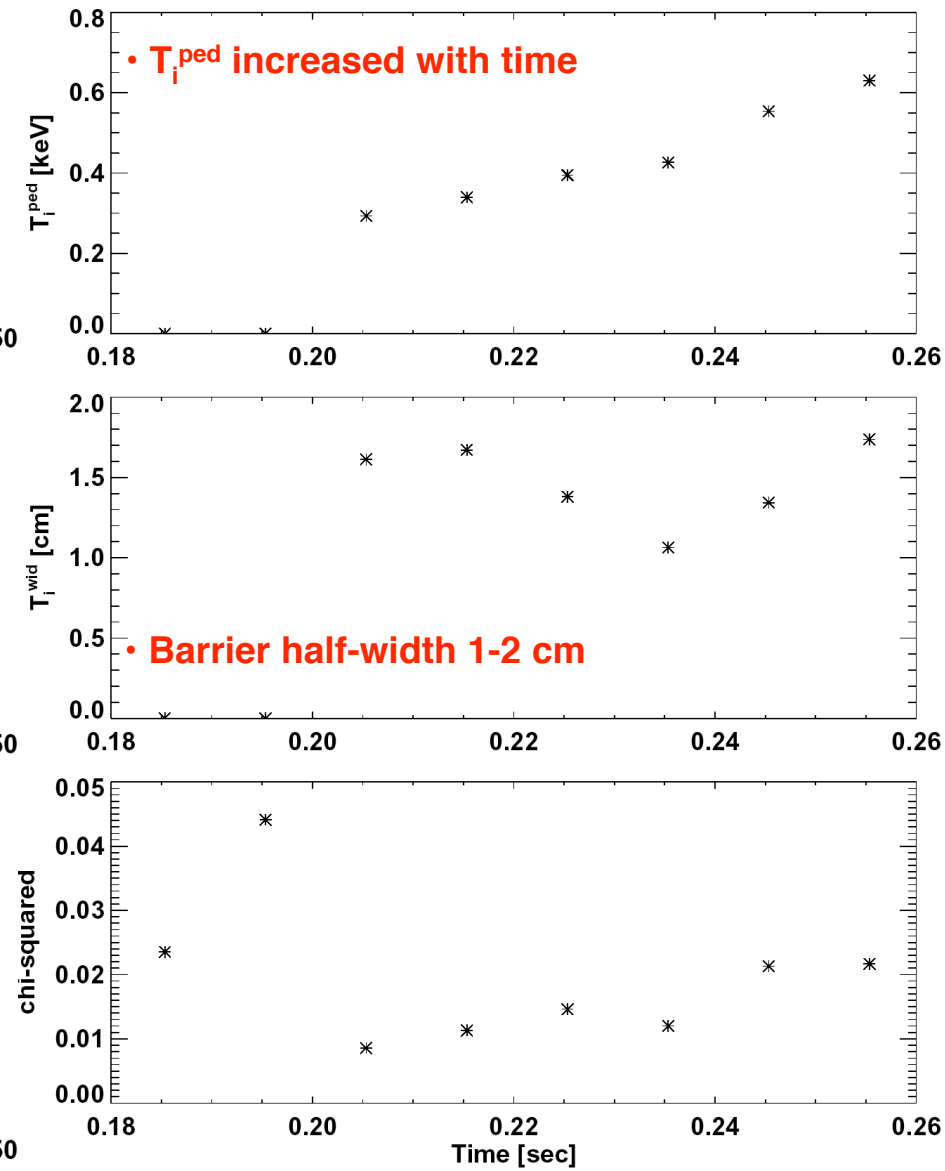
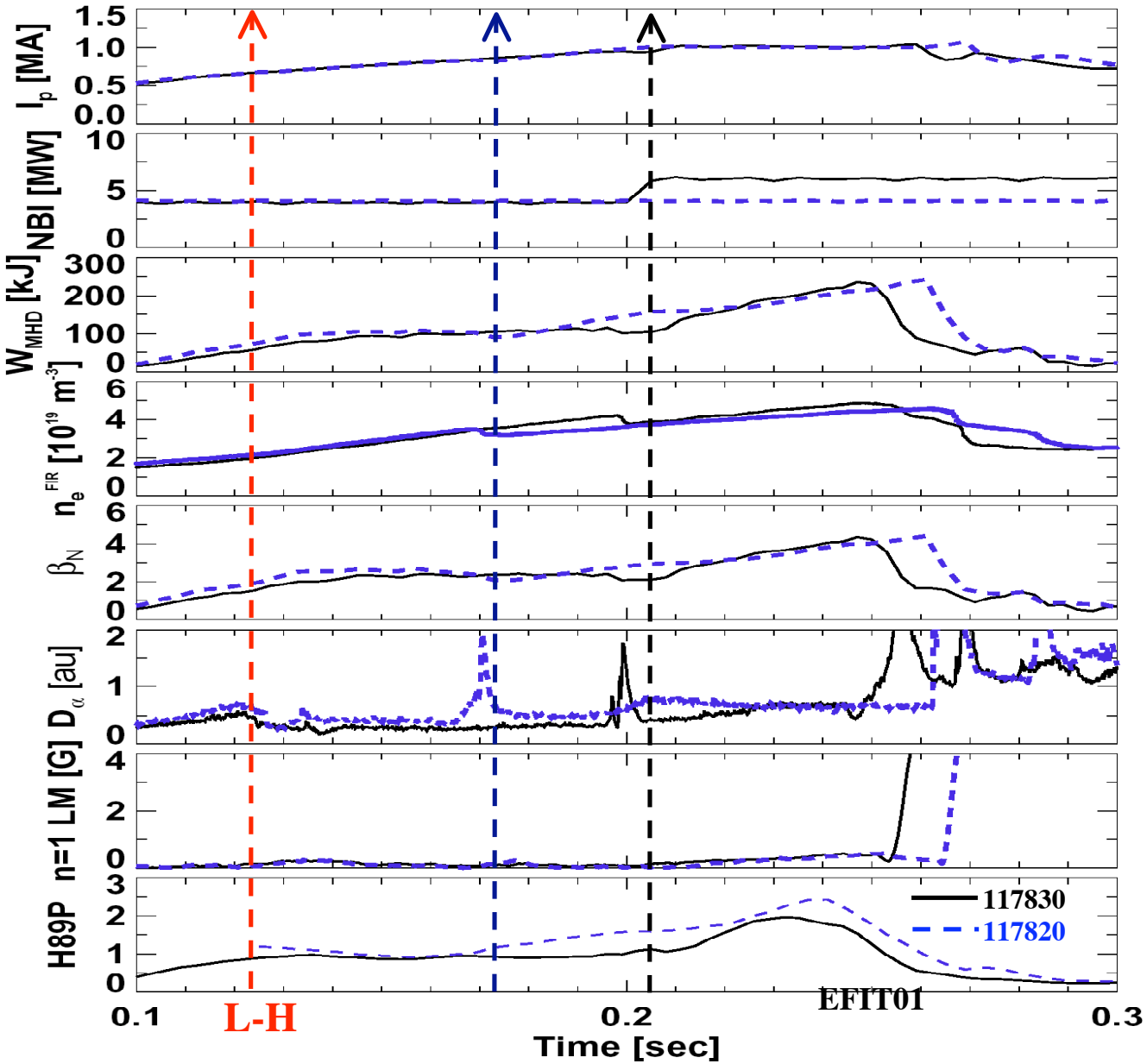
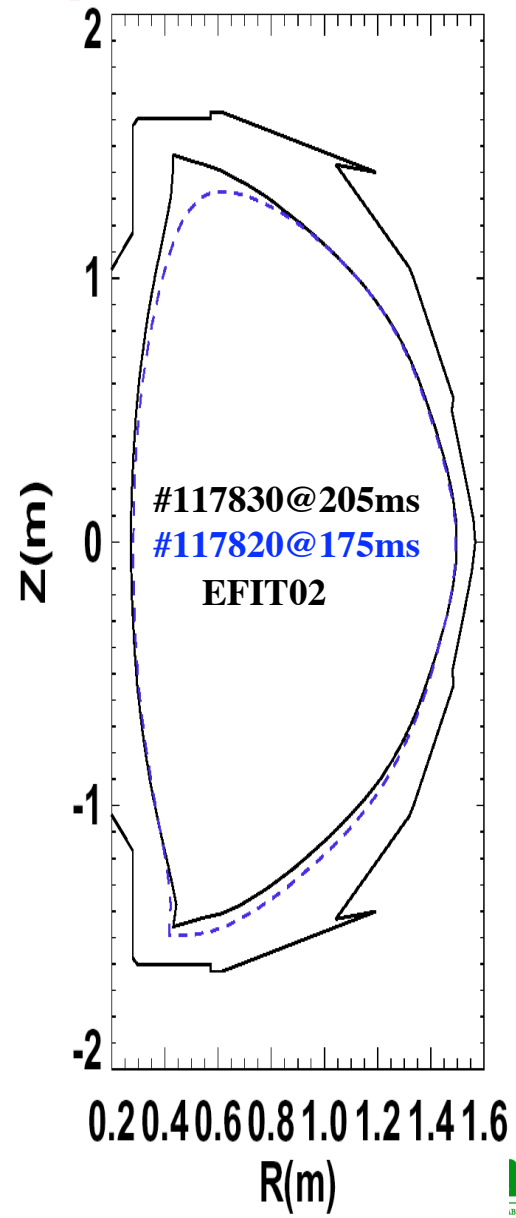
Pedestal T_i from tanh fits increased with time





Transition to Enhanced Confinement follows MHD