NSTX Confinement and Transport
- Contributions to Databases -

S.M. Kaye

PPPL, Princeton University

Princeton, N.J. 08543, USA

CD & Modeling ITPA

St. Petersburg, Russia

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Outline – NSTX Contributions to ITPA Databases

- L-H threshold data – already contributed

- 0D confinement
  - L and H-mode data
  - Global τ_E available
    - EFIT (magnetics only or electron p(r) + diamagnetic flux)
  - Working on thermal τ_E's
    - Beam ion loss can be significant (up to 40%)

- Profile data
  - Database of TRANSP results being assembled (NBI)
  - Checking consistency between magnetics and kinetics

Special thanks to R. Bell, C. Bush, B. LeBlanc, R. Maingi, S. Sabbagh

H-mode Operation is Routine
- "Steady-State" Achieved

NSTX

I_p = 0.8 MA

B_T = 0.5 T

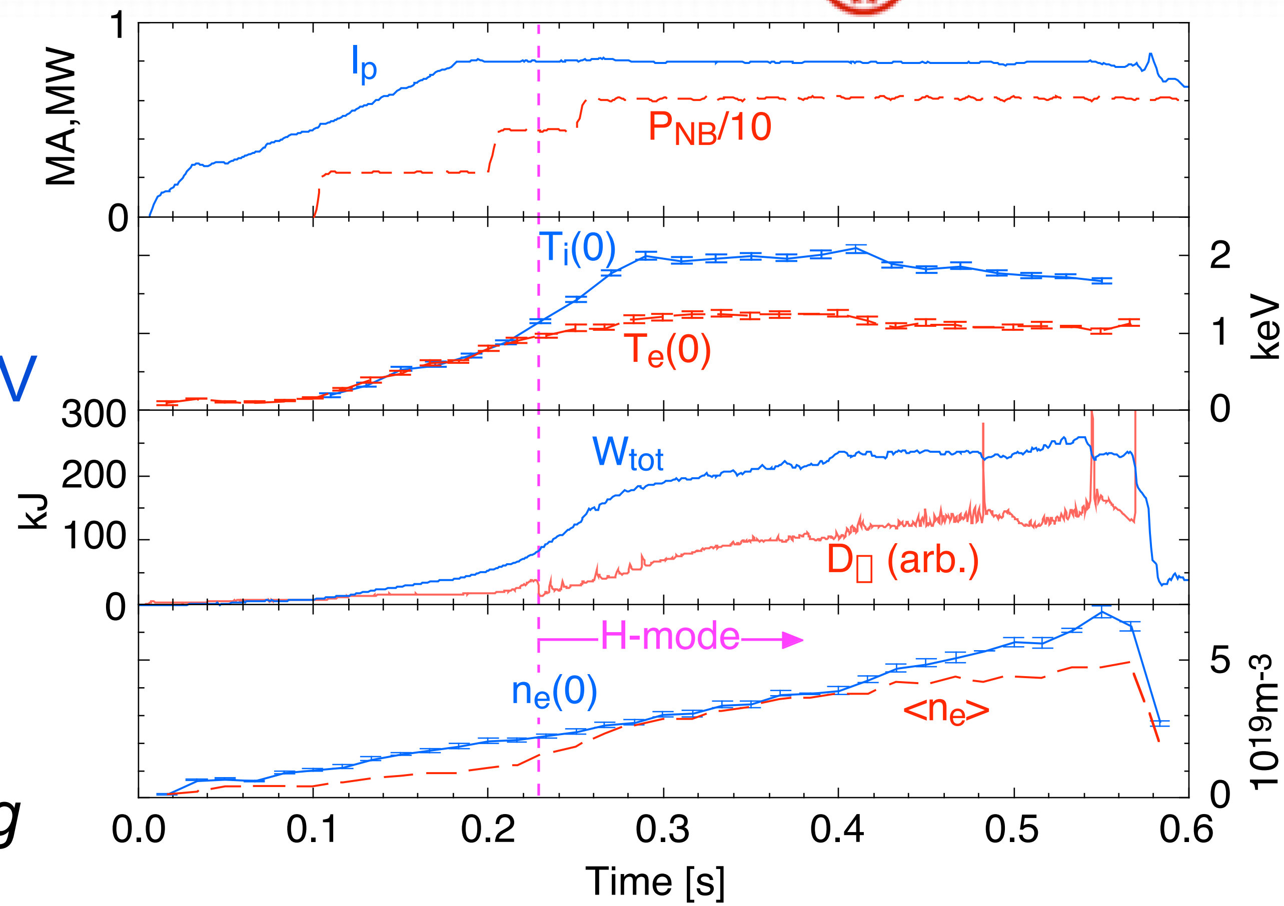
P_{NBI} = 6 MW

E_{NBI} = 80-100 keV

β_T = 18%

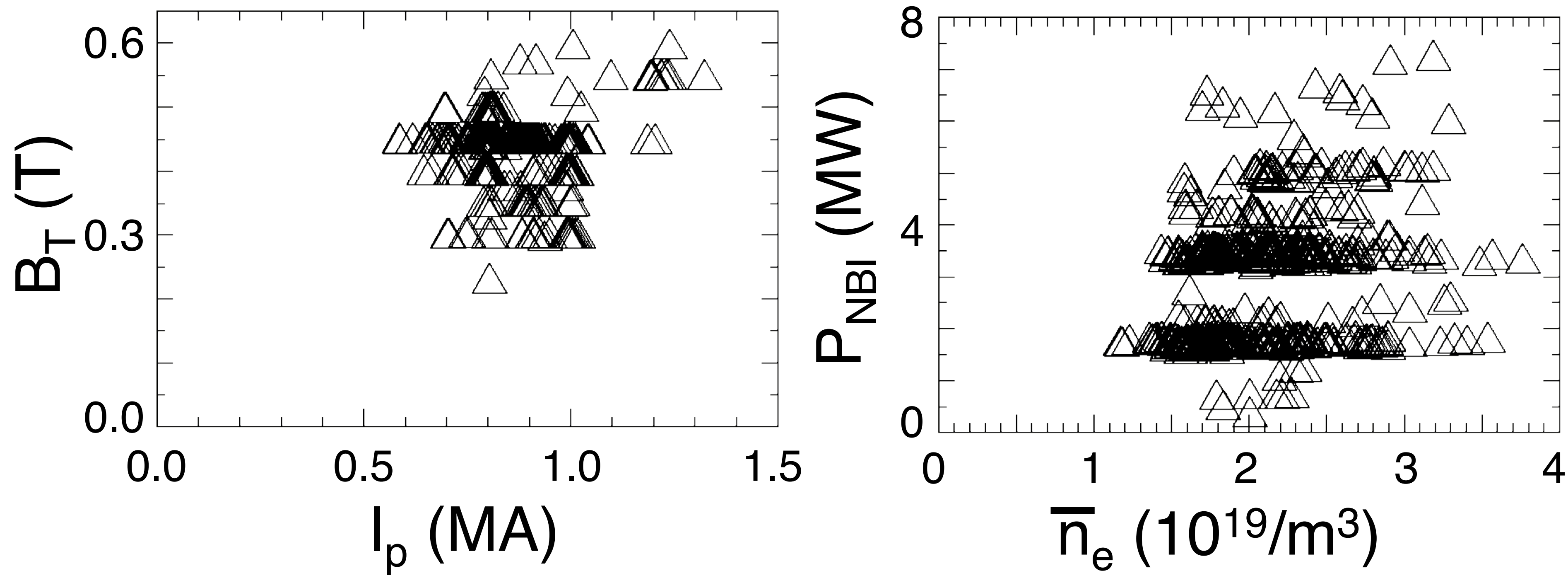
W = 0.25 MJ

Density profile broadens during H-mode



- β_T up to 35% and β_p up to 1.4 (highest β_N are H-modes)
- H-mode phase duration > 500 ms (with NBI)

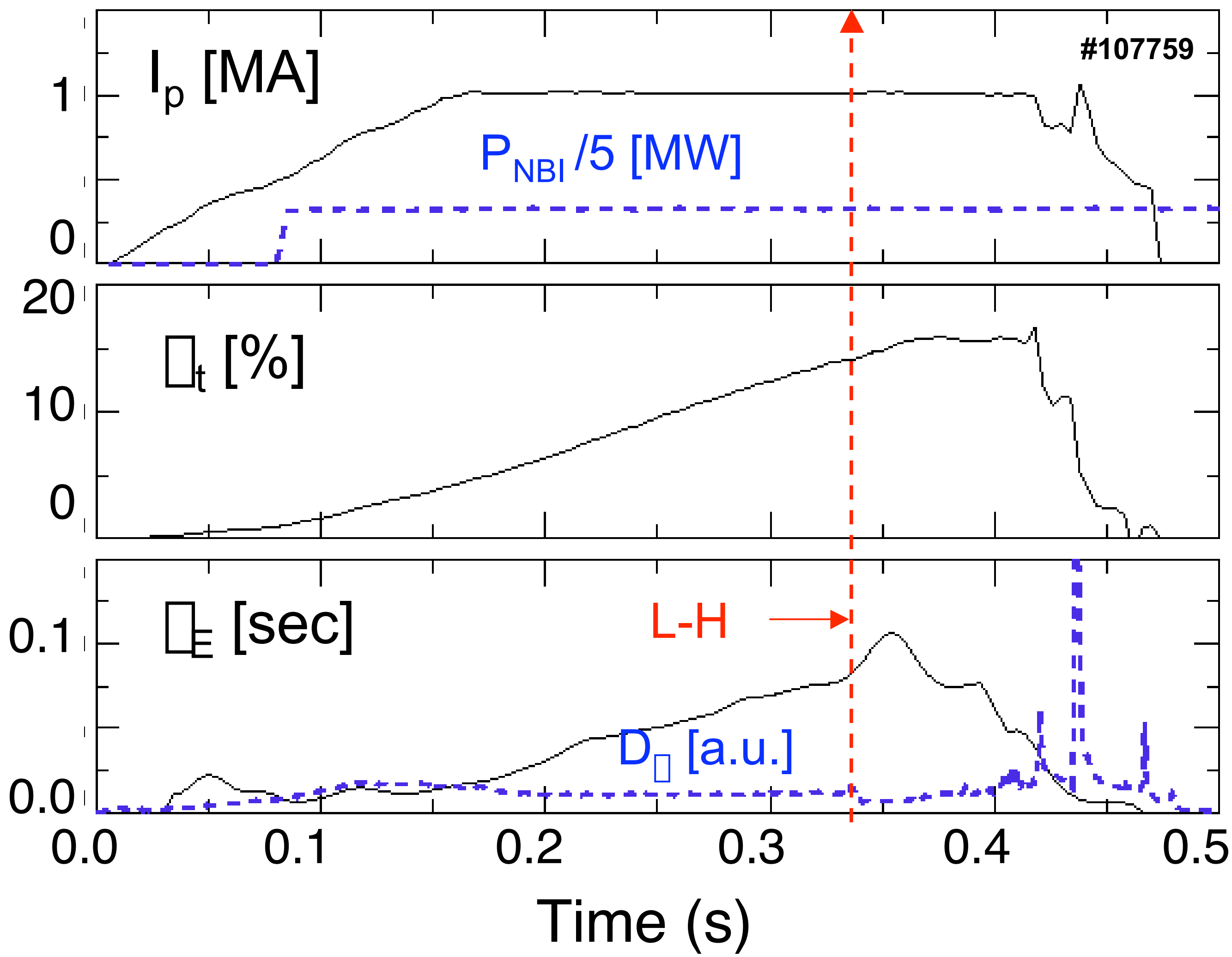
The NSTX H-mode Access Space is Wide



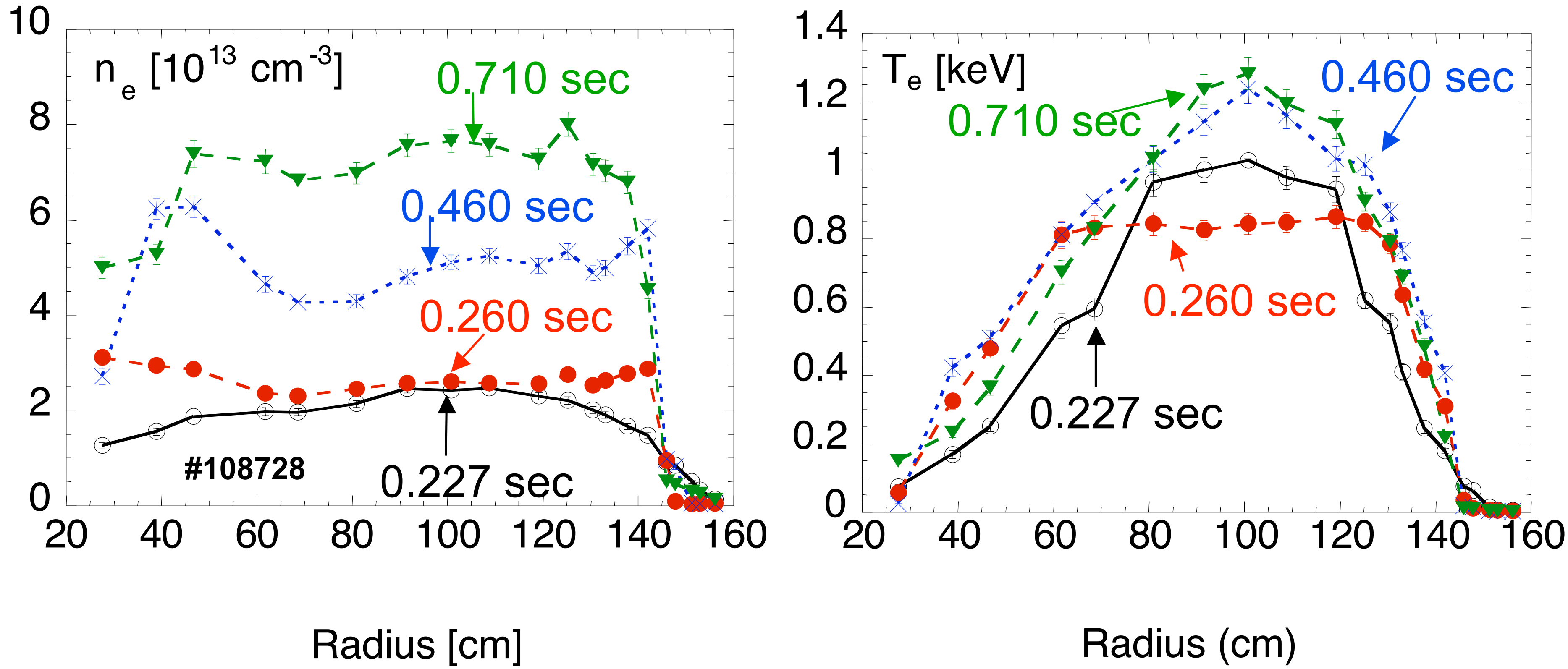
- Lower Single Null (LSN) & Double Null (DN) Divertor configurations
- Lowest threshold/most reproducible with HFS midplane gas injection

C. Bush, R. Maingi

Confinement Gain in Steady-state After the H-mode Transition is Often Modest



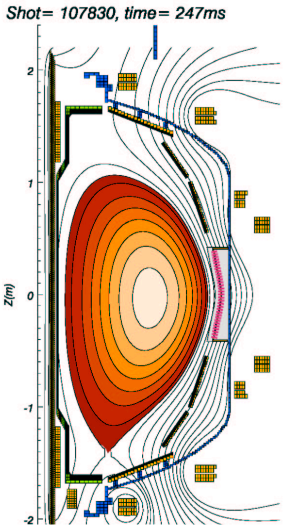
n_e and T_e Profiles Evolve Differently During Long H-mode

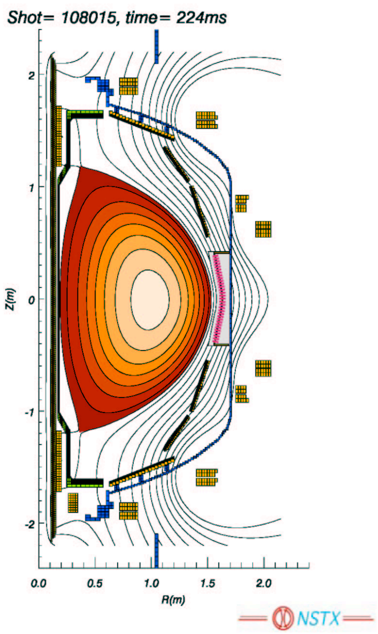


- n_e profile hollow after transition and fills in 300-500 ms
- T_e profile flattens initially and peaks later in time

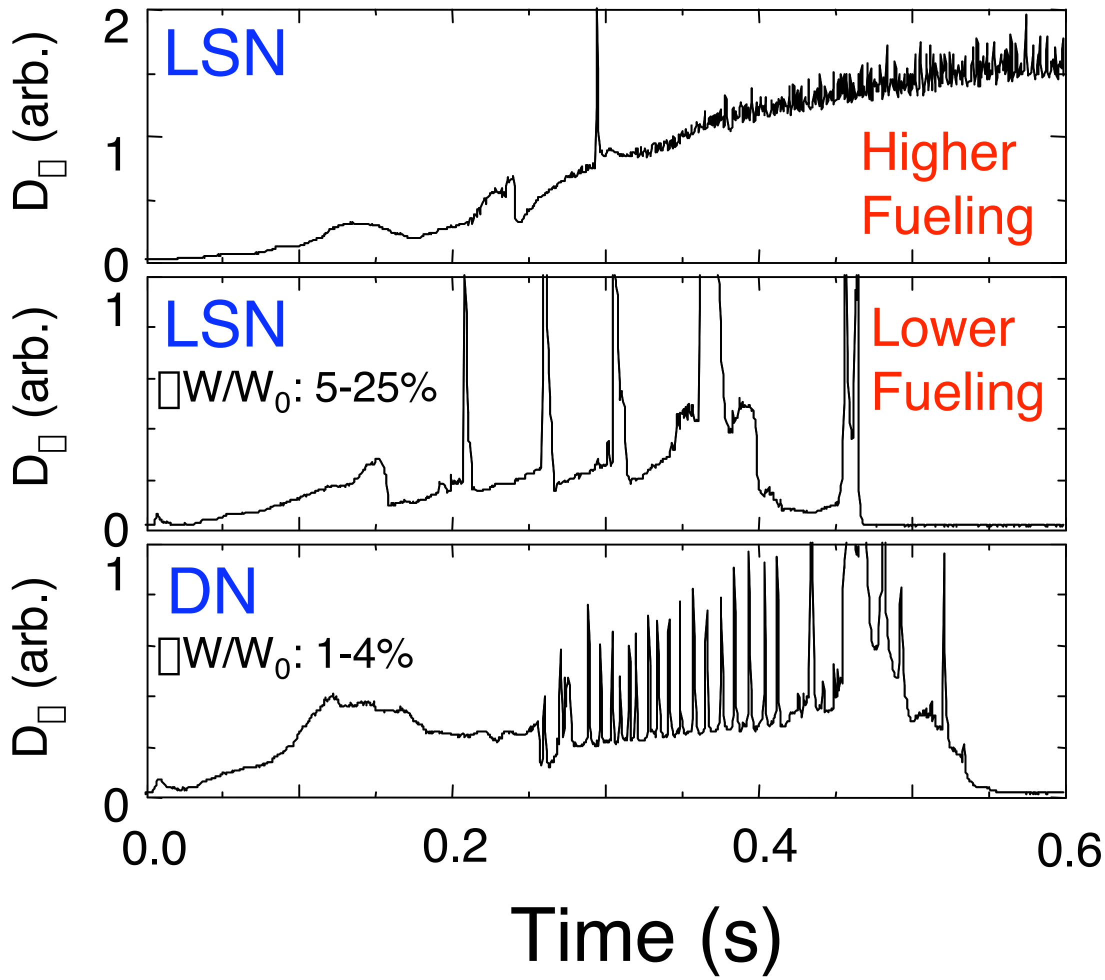
B. LeBlanc

ELM Behavior Depends on Operating Conditions





S. Sabbagh,
D. Gates



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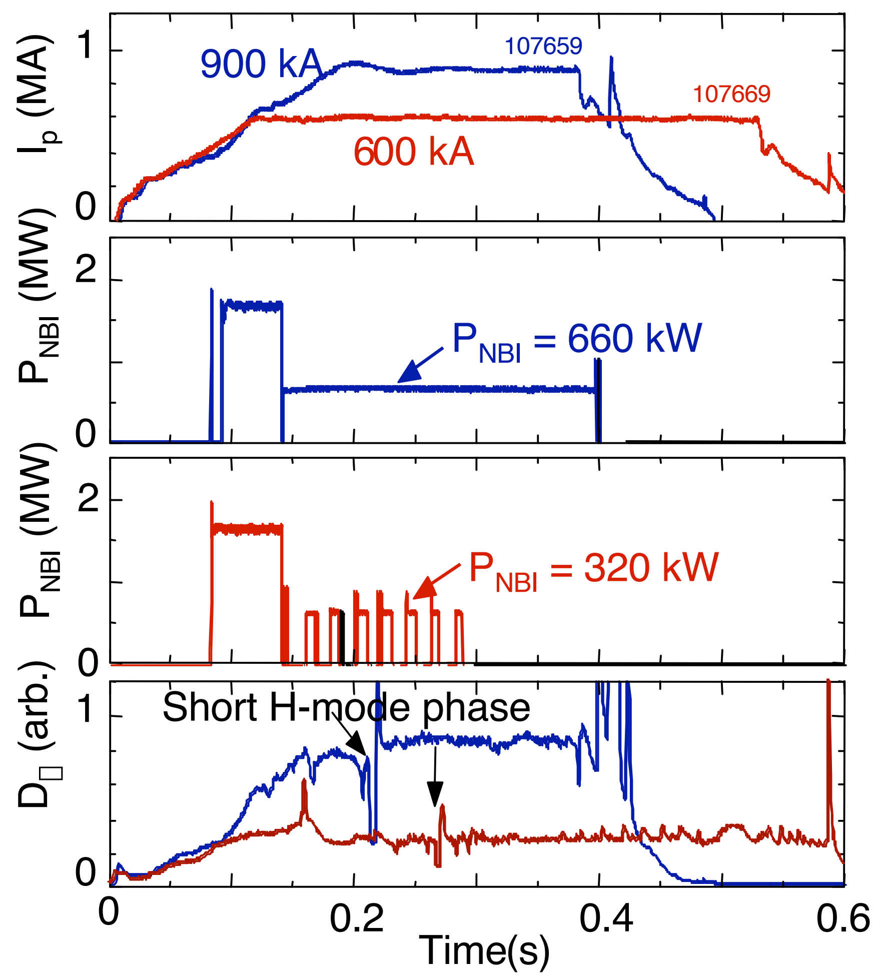
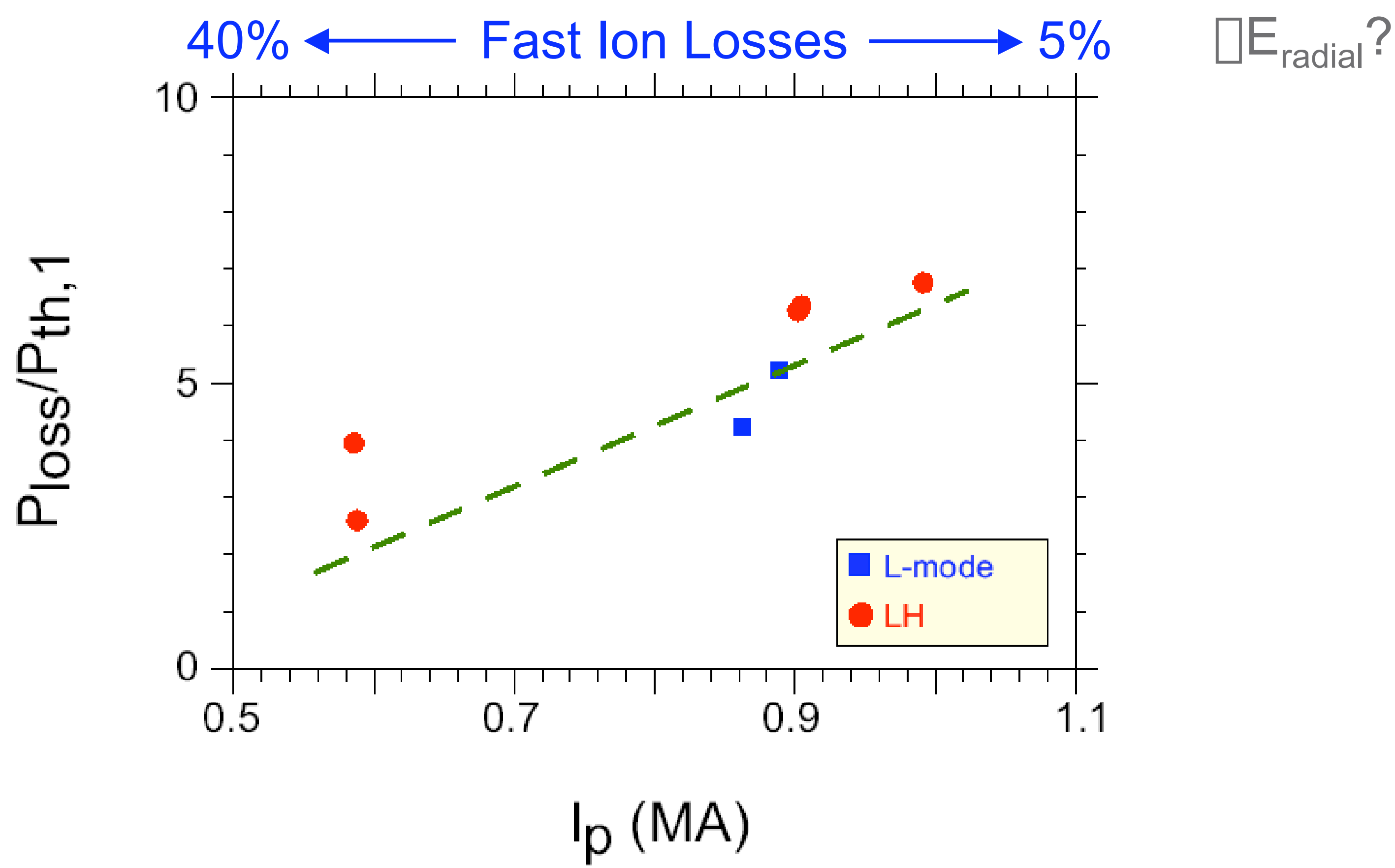
L-H Threshold Probed



Fast Ion Losses May Influence L-H Threshold

Possible I_p dependence of P_{thresh}

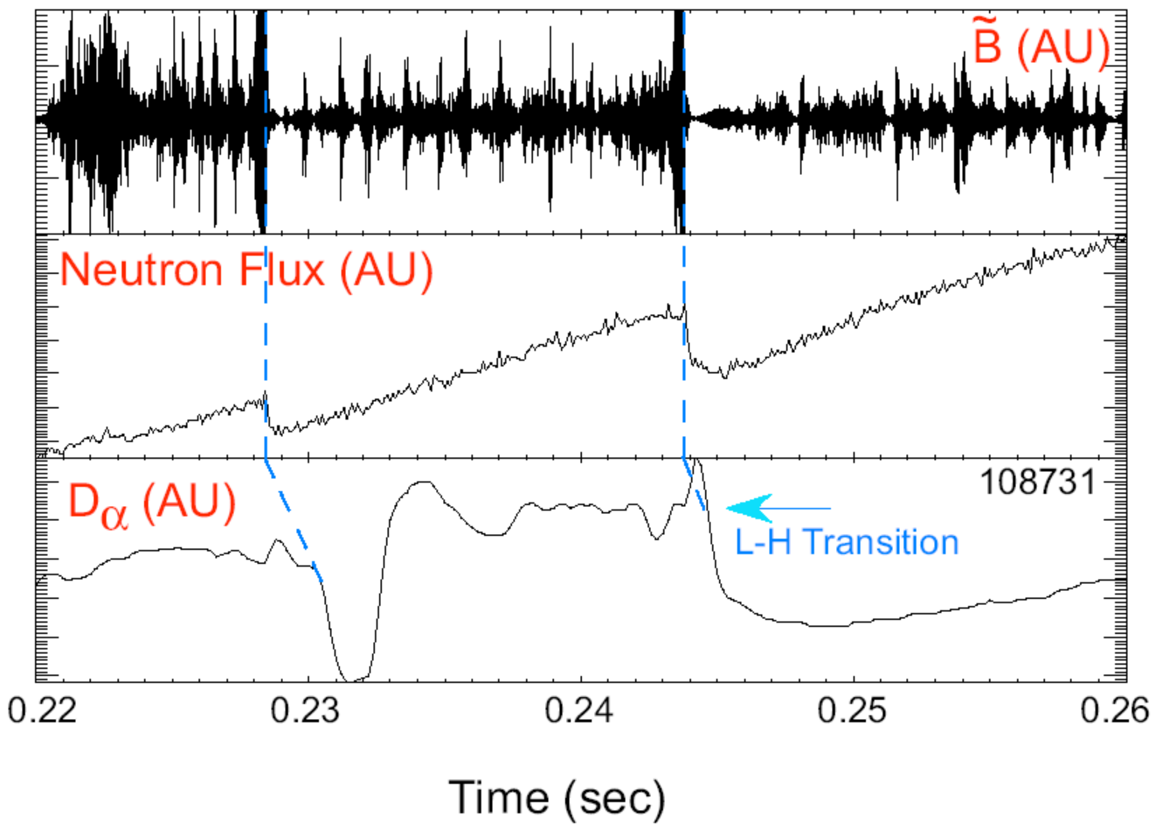


$P_{th,1} \sim n_e^{0.61} B_T^{0.78} a^{0.89} R^{0.94}$ (Snipes et al., IAEA 2002)

Bursty Fast Ion Loss May Induce Transition

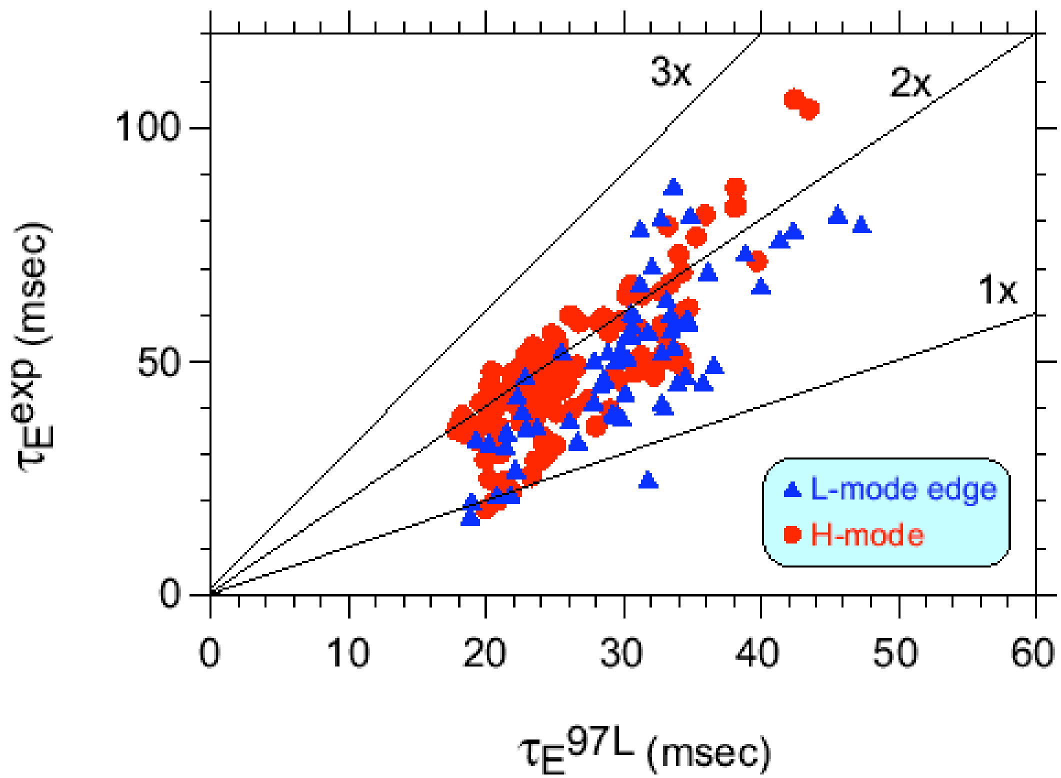
D_{α} fluctuations prior to L-H transition associated with bounce-precession fishbone bursts

L-H when significant fast ion loss (neutron drop) – E_{radial}?



Sawtooth-free

0D Confinement Enhanced Relative to Conventional R/a Scalings



- τ_E^{exp} from EFIT magnetics reconstruction
  - Includes fast ion component
- Quasi-steady conditions (i.e., 1 to 2 τ_E's)
- $H_{98pby,2}$ up to 1.5 (wrt global τ_E^{exp})

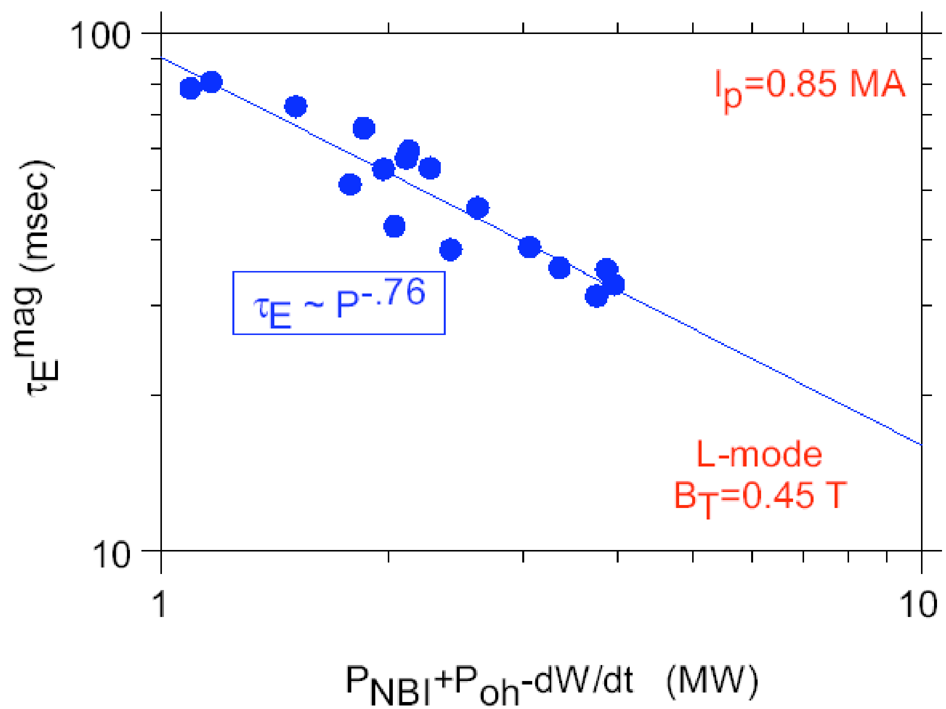
L-Mode Plasmas Have Parameter Dependences Similar to Those at Conventional R/a

- Slightly stronger power degradation

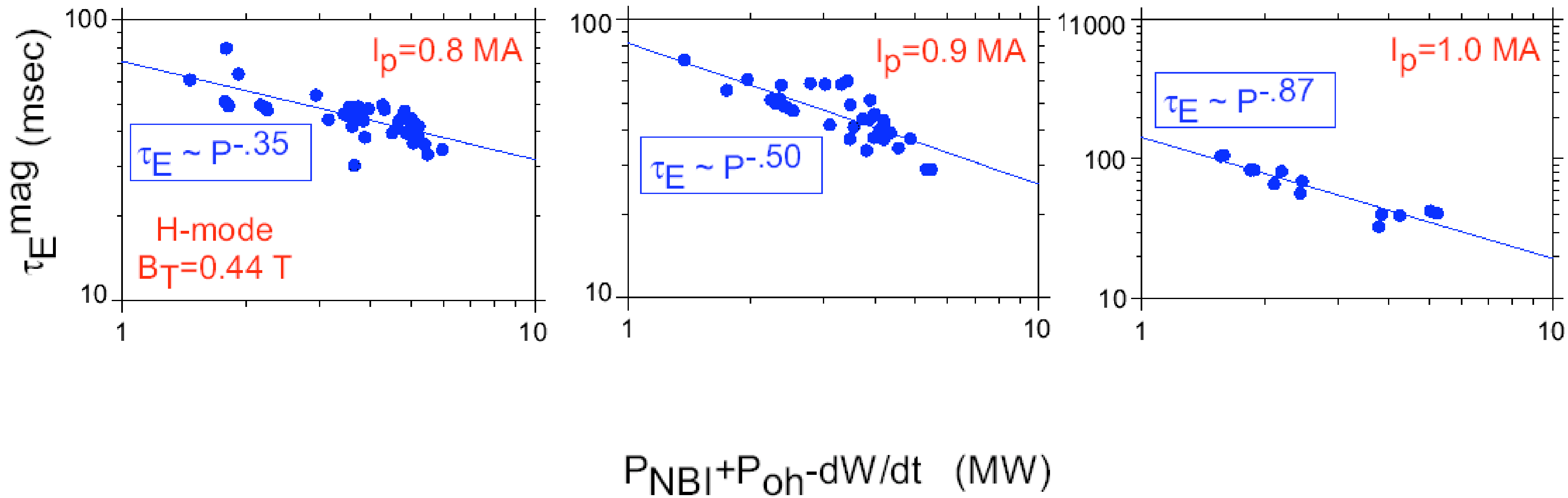
$\tau_E^{mag} \sim I_p^{0.76}\, B_T^{0.26}\, P_L^{-0.76}$

$\tau_E^{89P} \sim I_p^{0.85}\, B_T^{0.20}\, P_L^{-0.50}$

$\tau_E^{97L} \sim I_p^{0.74}\, B_T^{0.20}\, P_L^{-0.57}$

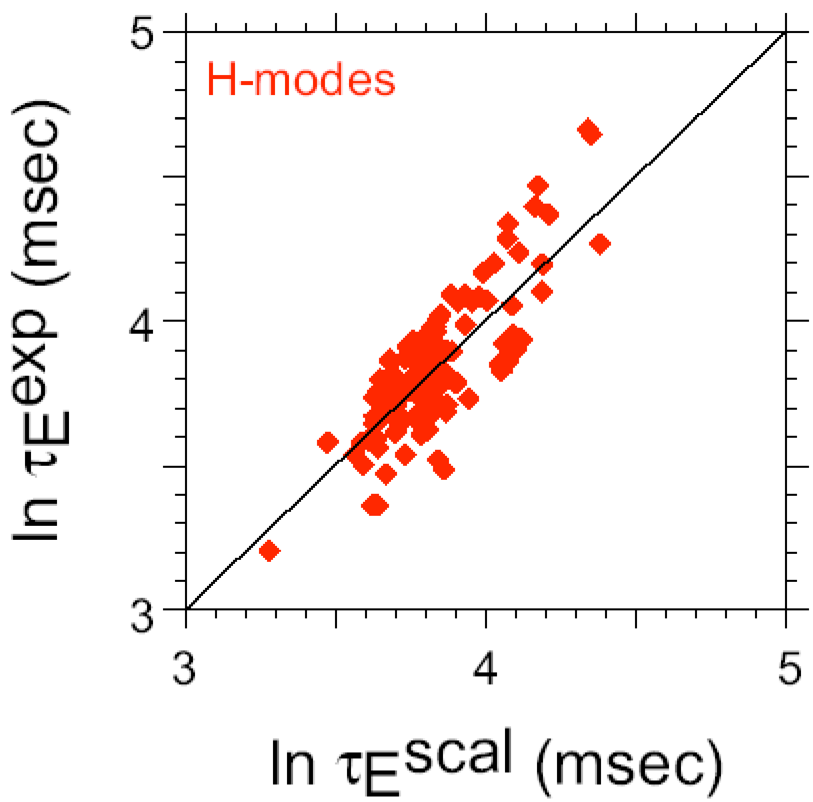


H-mode Power Degradation Depends on Plasma Current



H-mode Scaling Needs More Development - ELM Dependence, Non-Linearities

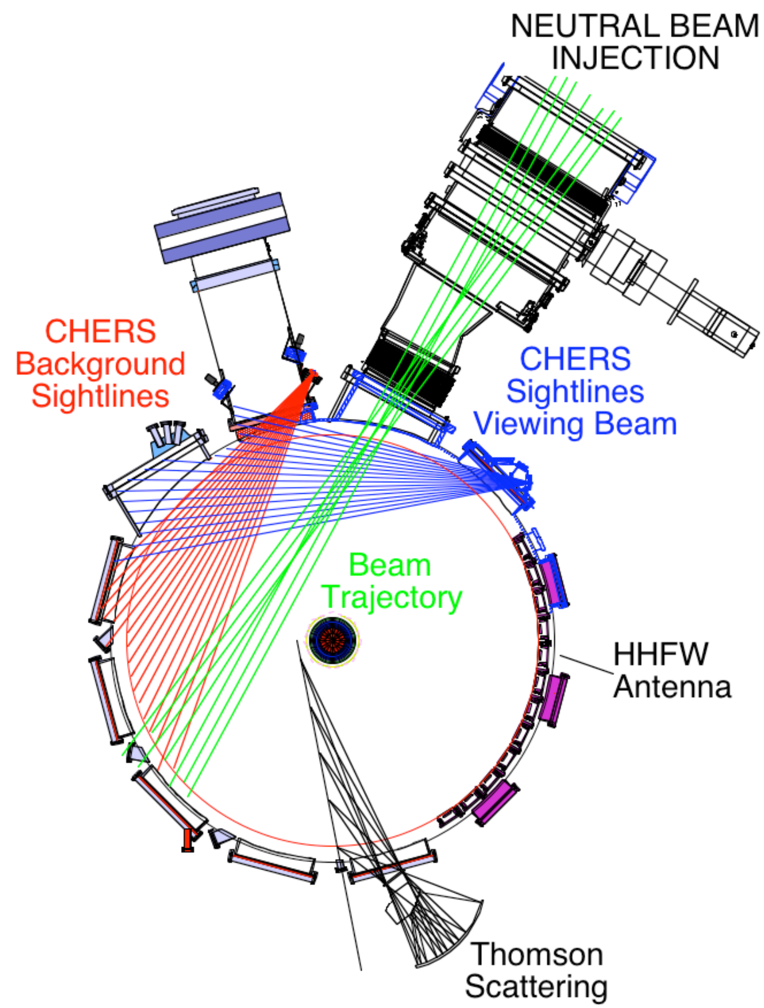
$\tau_{E,H} \sim I_p^{0.32} B_T^{0.90} P_{loss}^{-0.54}$



Dedicated scaling experiments planned

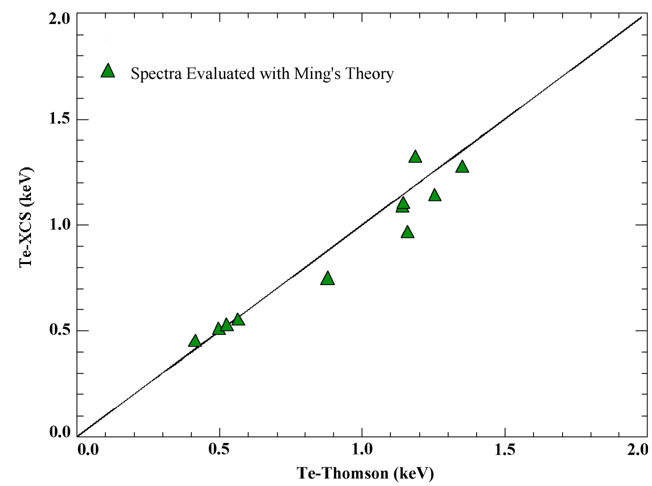
Time Dependent Kinetic Profile Measurements Allow Profile Analysis

- Thomson scattering
  - *$T_e(R,t)$, $n_e(R,t)$*
  - *60 Hz, 20 channels*
- Impurity charge exchange recombination spectroscopy
  - *$T_i(R,t)$, $v_\phi(R,t)$*
  - *17 channels, Δt = 20 msec*
- Bolometer
  - *$P_{rad}(R,t)$*, 16 channels
- Ultra soft x-ray arrays
  - 4 fans of 16 channels each

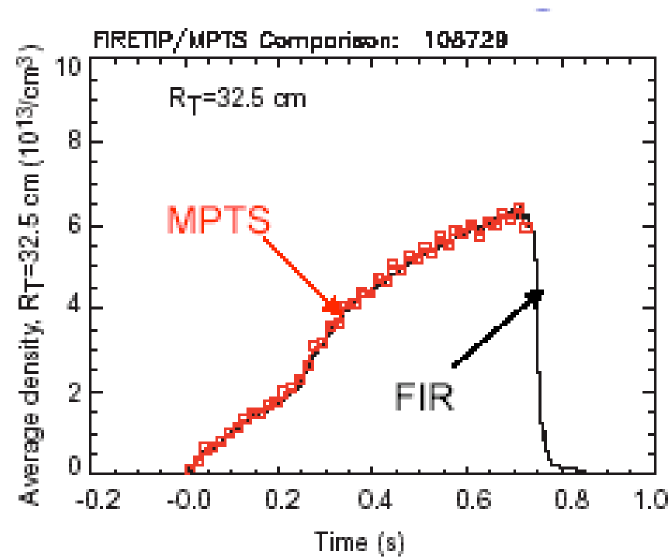


Kinetic Data Validated Where Possible

$T_e(0)$: XCS vs MPTS



n_e (0): FIR vs MPTS

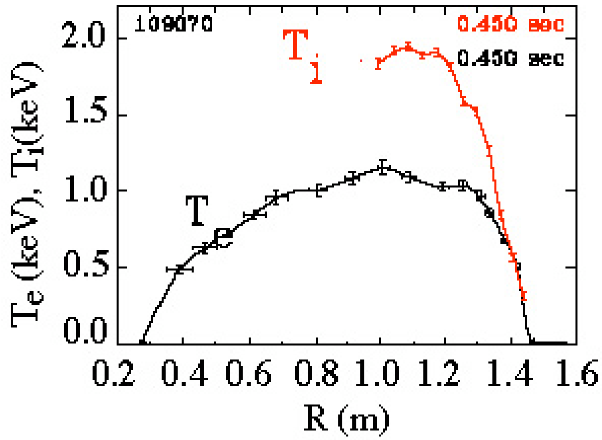


$T_i(0)$: XCS vs CHERS

R. Bell, M. Bitter, B. LeBlanc, K.C. Lee

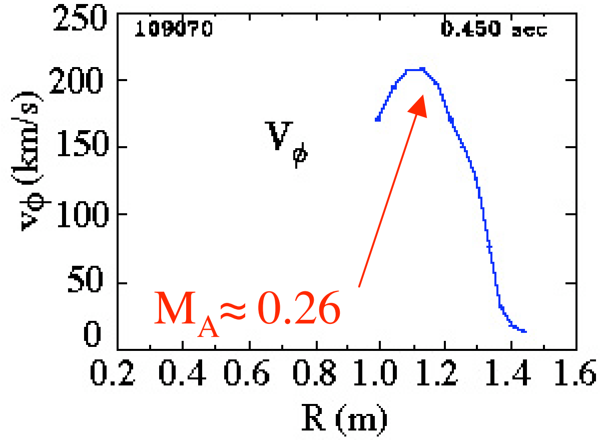
$T_i > T_e$ during NBI Indicates Good Ion Confinement

- Classical fast particle slowing down predicts predominant electron heating
  - 2/3 to electrons
  - 1/3 to ions



- $T_i = T_e$ in edge region

- High rotation associated with good ion confinement

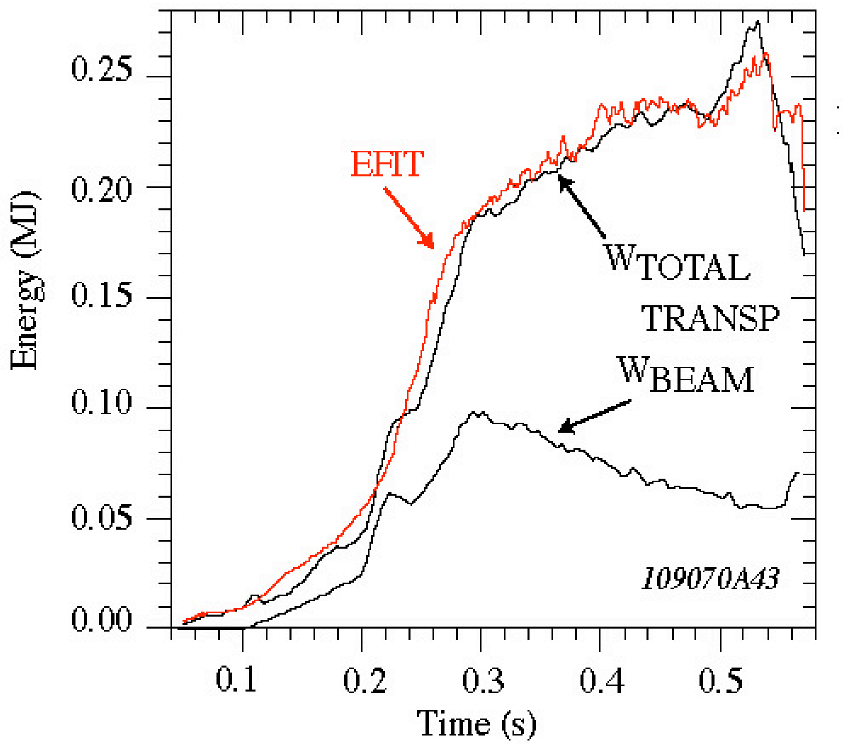


R.E. Bell

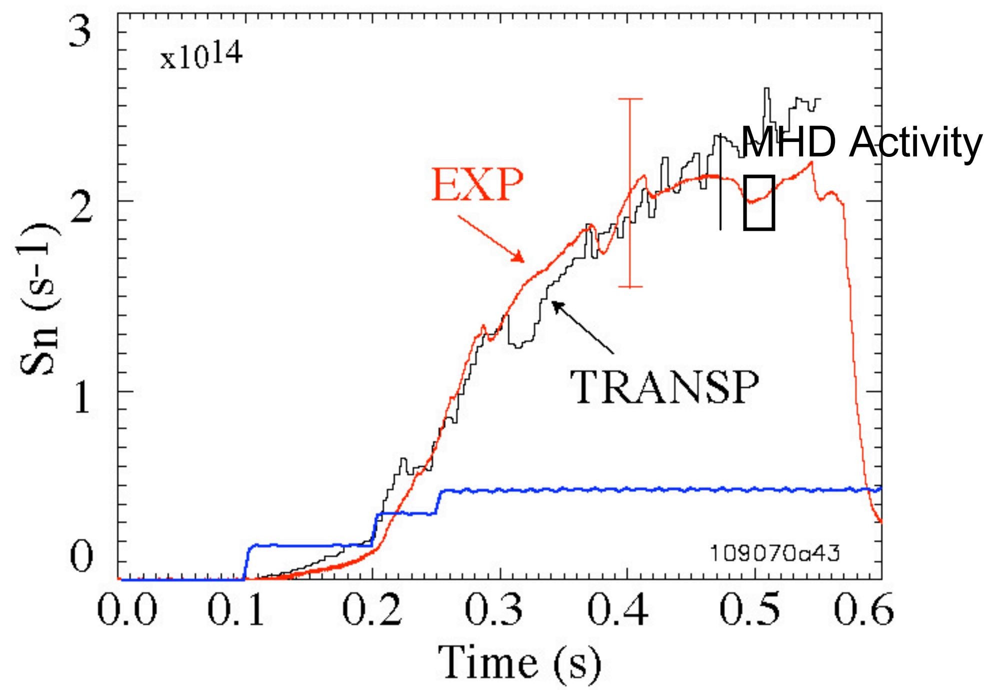
Global Parameters from Kinetic Analysis Agree With Those From Magnetic Analysis and Neutrons

NSTX

Stored Energy



Neutron Rate

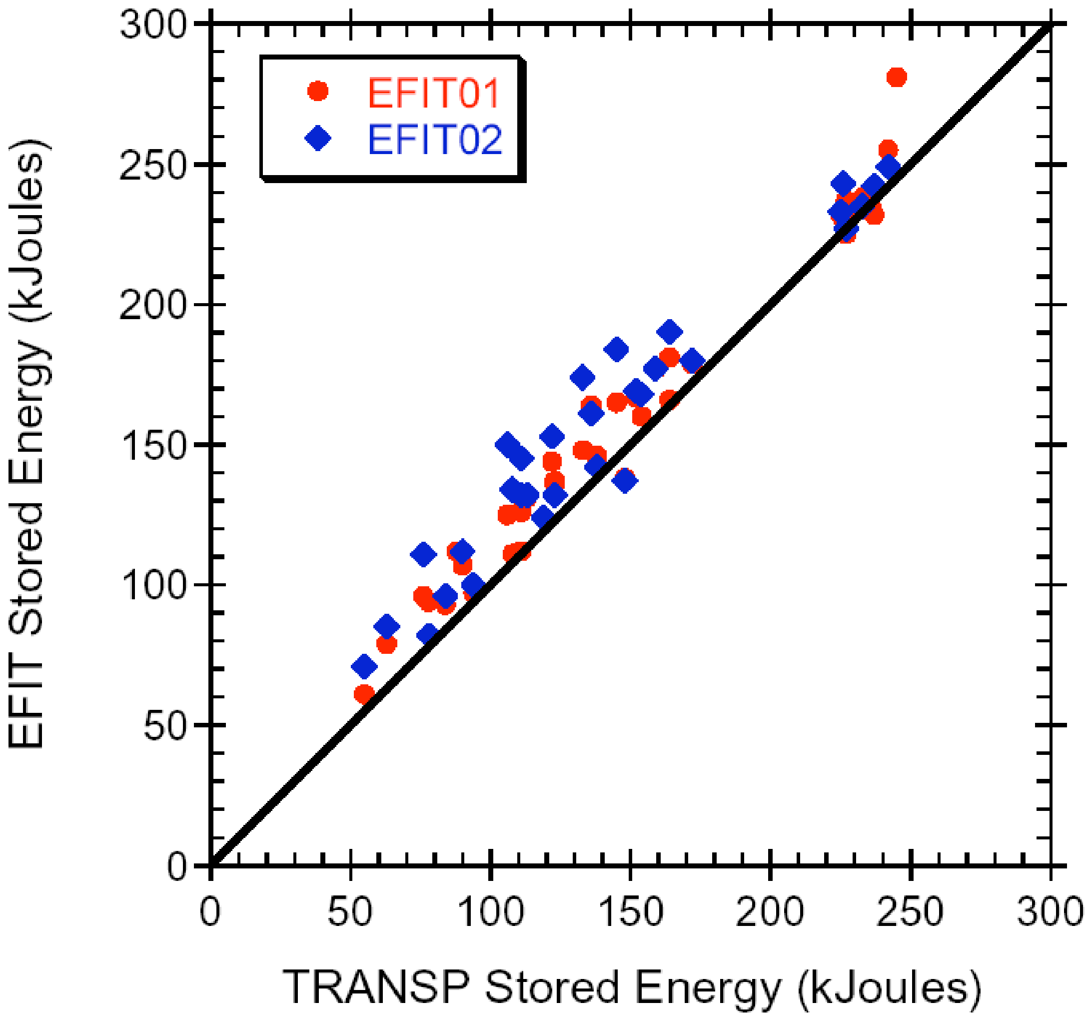


TRANSP assumes classical beam slowing down

S. Sabbagh, S. Kaye

A.L. Roquemore

Relatively Good Agreement Between Magnetics and Kinetics



EFIT01/TRANSP = 1.09 ± 0.08

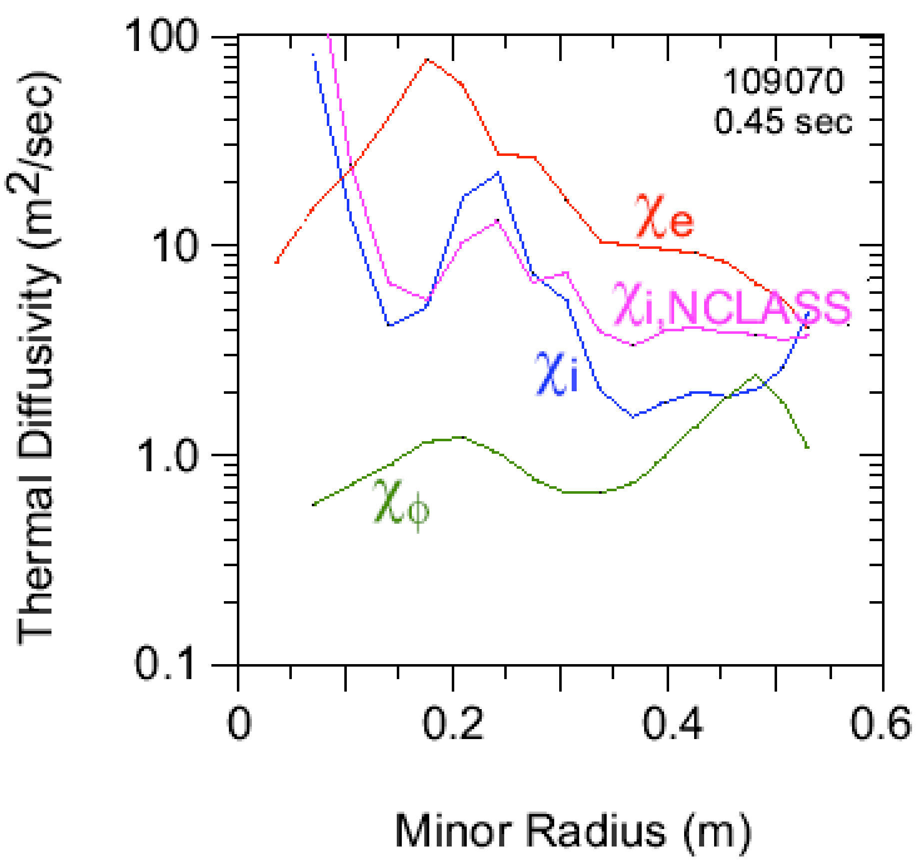
EFIT02/TRANSP = 1.15 ± 0.13

S. Sabbagh, S. Kaye

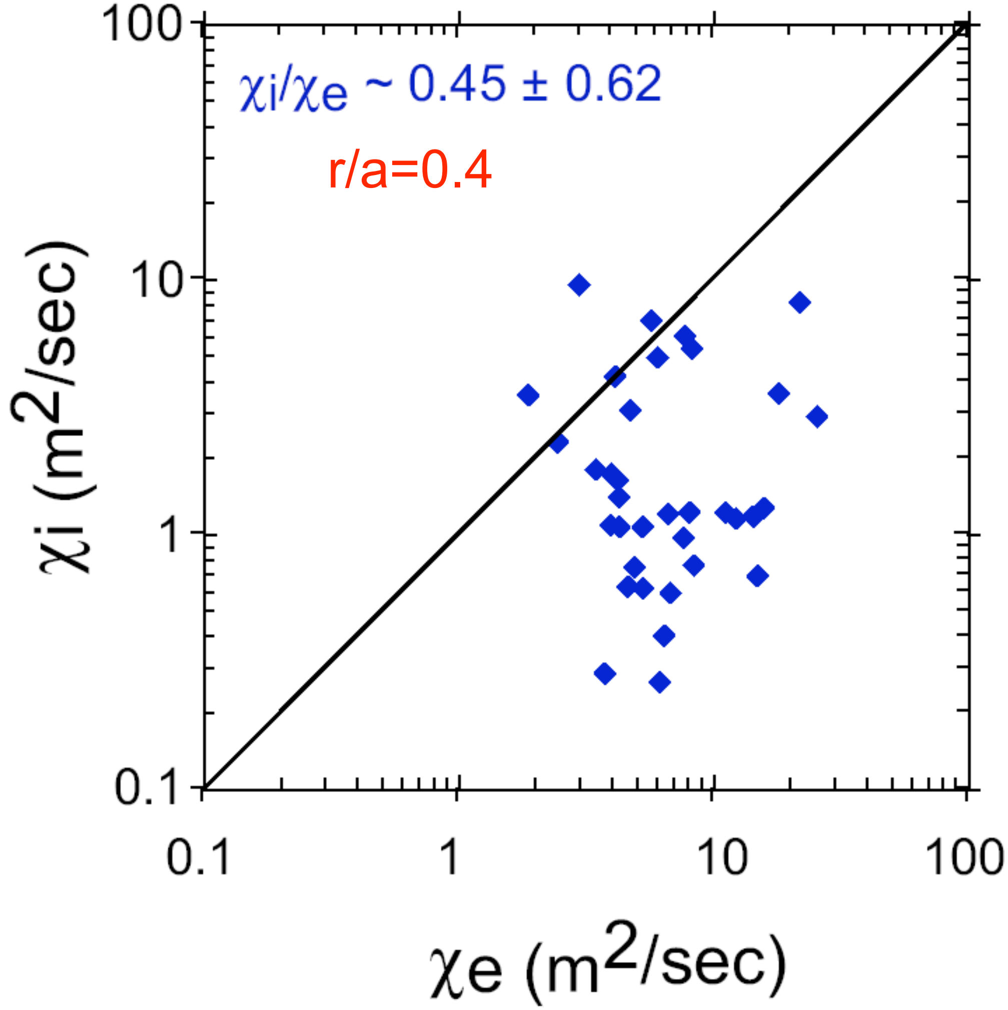
Low Ion Thermal Transport, High Electron Thermal Transport

NSTX

$\chi_i \approx \chi_i^{NC} < \chi_e$, χ_i^{NC} from NCLASS

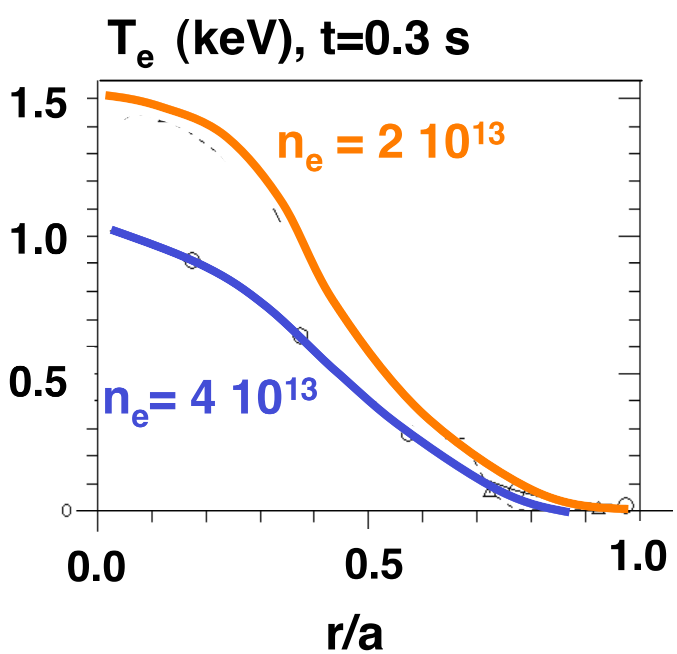


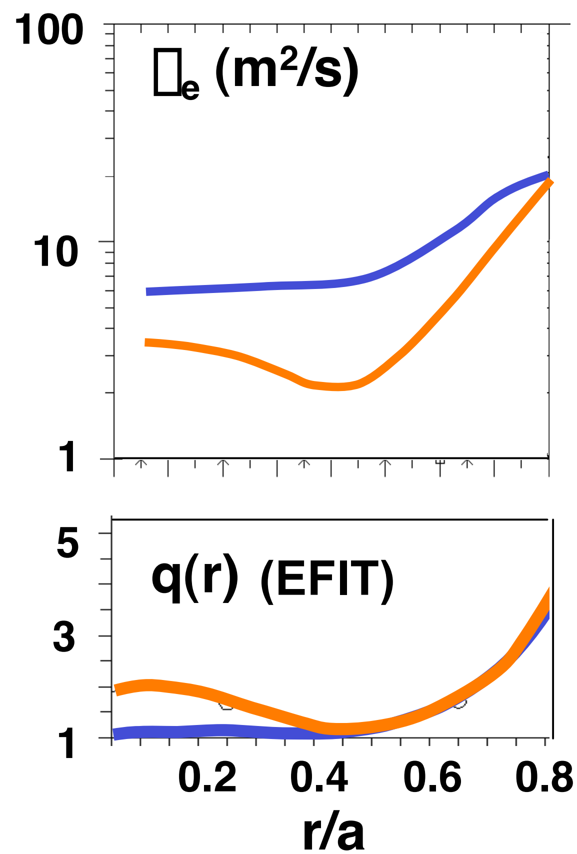
Electron Losses Dominant



Electron transport reduced when s < 0?

1 MA/4.5 kG/1.7 MW NBI ‘L-mode’

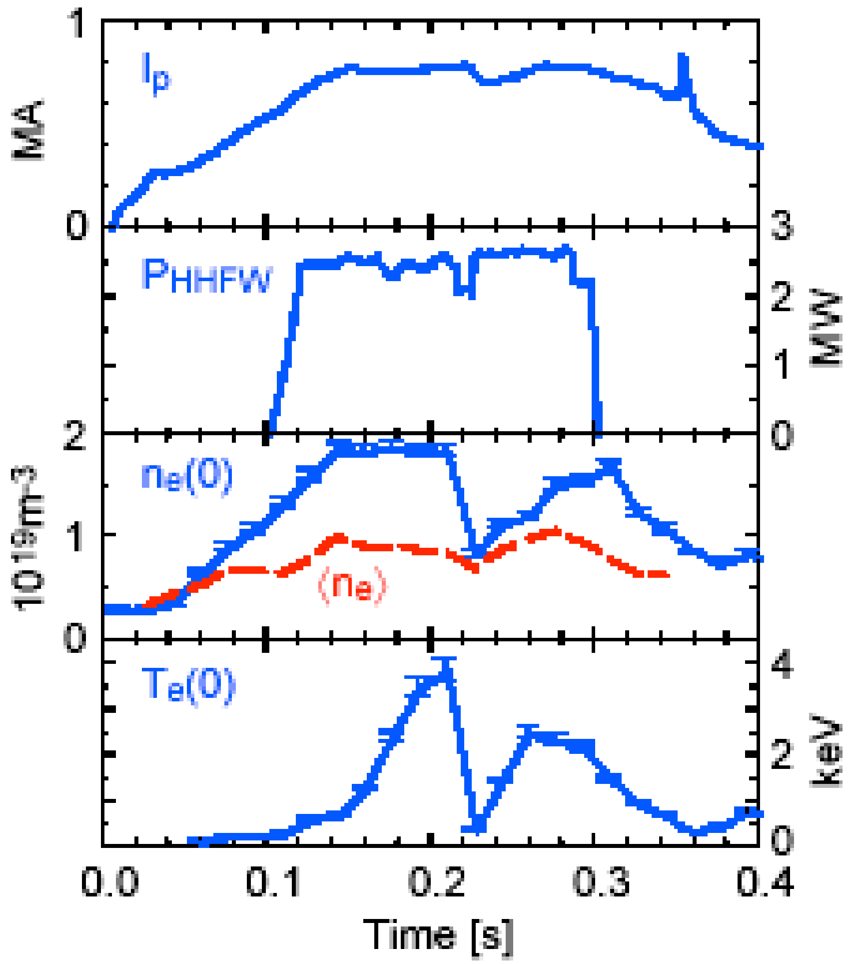


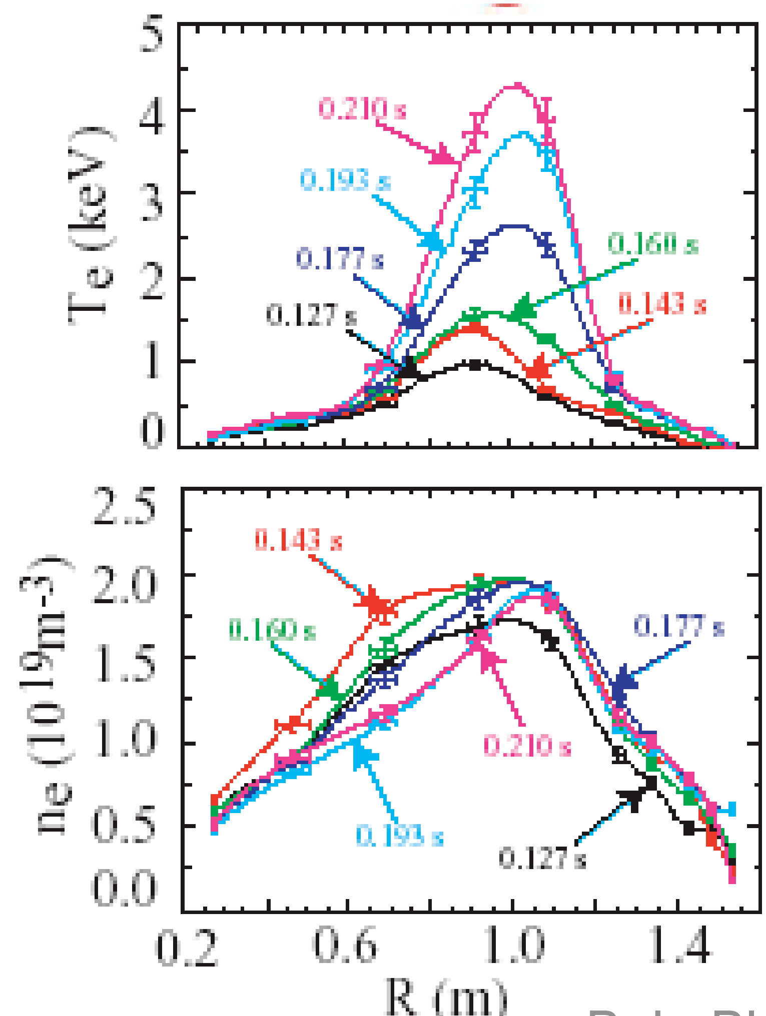


Shear reversal inferred from USXR, TRANSP

D. Stutman, S. Kaye, S. Sabbagh

Electron ITB Formation with HHFW in Low Density Deuterium Plasma

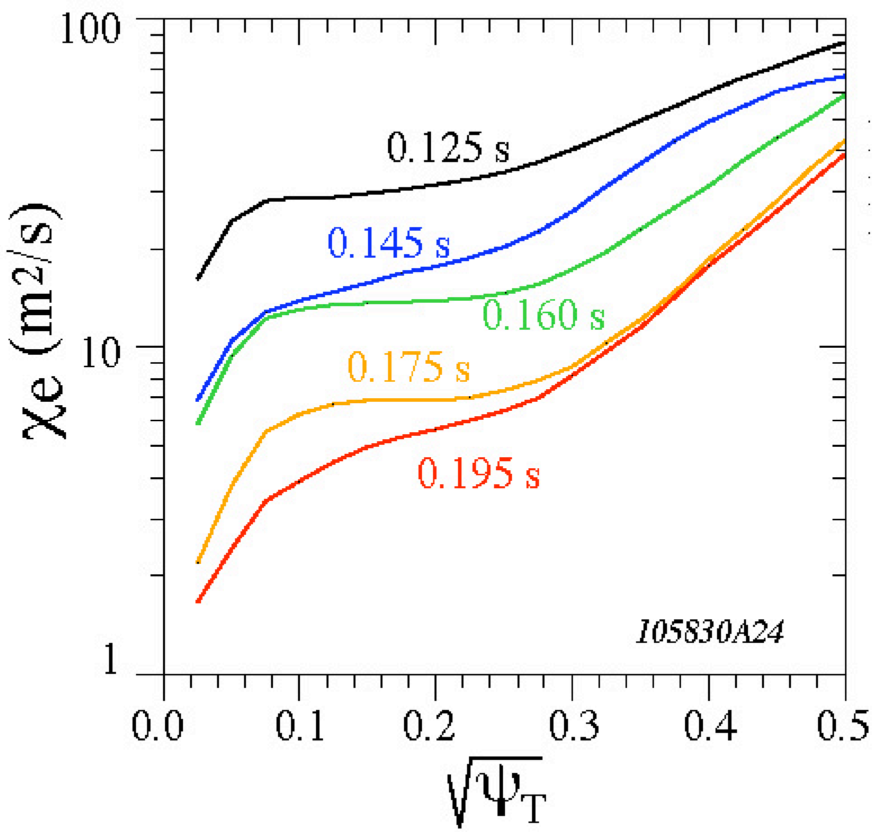




B. LeBlanc

Increase in T_e Corresponds to Decrease in χ_e

- Power deposition from ray tracing
- T_{io}(t) obtained from X-ray crystal spectrometer
- χ_e progressively decreases in the central region



B. LeBlanc, R. Bell, M. Bitter

Plans

- Dedicated L-H threshold study data submitted
  - Lower limit of P_{LOSS}
  - Additional data when new experiments performed
  - Explore possible R/a, I_p dependence

- 0D confinement data is being worked on
  - Global τ_E's available now
  - Fast ion energy content/loss can be significant
  - Corrections for fast ion content, loss require either
    - TRANSP run for each discharge submitted, or
    - Series of TRANSP “test” runs to develop parametric scalings (assuming scalings with I_p, B_T, n_e, shape, etc, independent)

Plans (cont'd)

- Profile data
  - Data validation a continuing effort
    - Expect further modifications to profiles, especially in outer regions
    - Check magnetics vs kinetics consistency
  - IDL scripts to extract data and create appropriate _0D, _1D, and _2D files written and submitted to C. Roach

- Programmatic issue – NSTX physicists would like to analyze/publish data before releasing