Heating, Confinement and Stability Studies in NSTX

M.G. Bell

presented for the

NSTX Research Team

APS-DPP Annual Meeting
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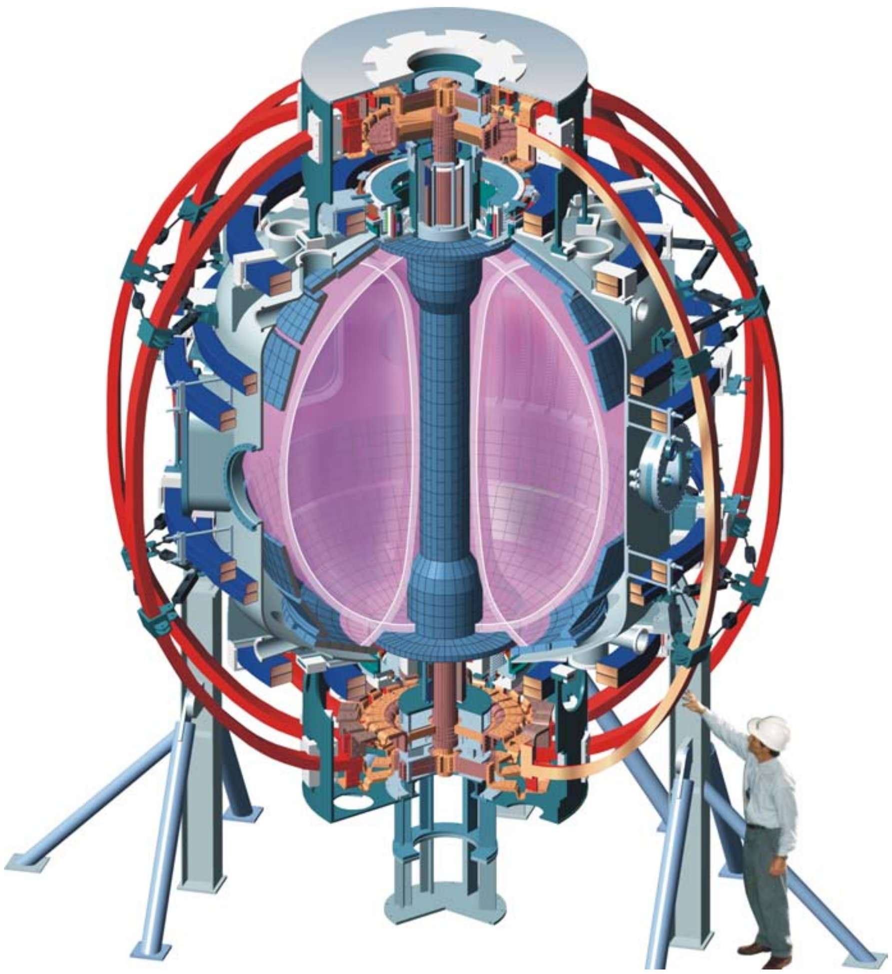
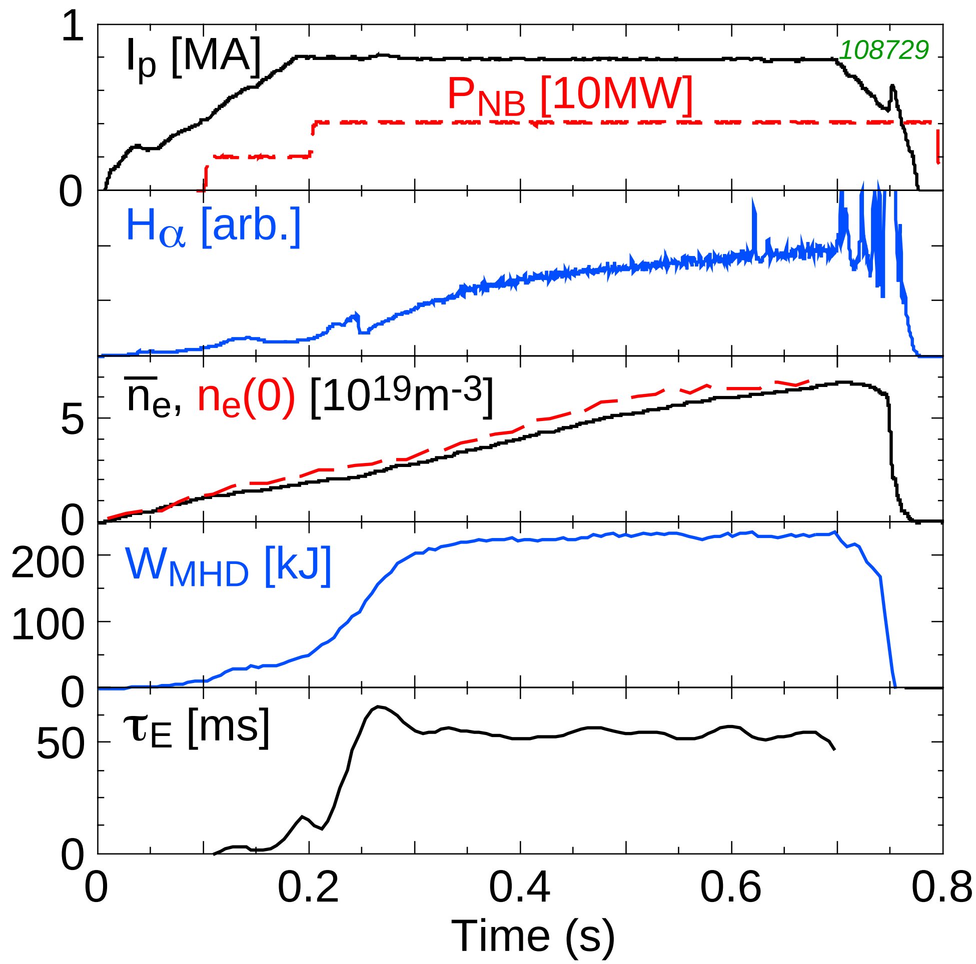
Experimental Capabilities Were Improved for 2002 Campaign



Capabilities *(this year)*	
PFC bakeout	***350°C***
Gas fueling	***HFS***
Aspect ratio	1.27
Elongation	2.5
Triangularity	***0.8***
Plasma Current	1.5MA
Toroidal Field	***0.6T***
NBI ***(100kV)***	***7 MW***
HHFW (30MHz)	6 MW
- full antenna phase control	
Pulse Length	***1s***
Reduced PF error field	

High-Field-Side Gas Injection Improved Reproducibility and Longevity of H-mode



- HFS injector gives large initial flow then continuing lower flow
  - contributes to density rise
- LFS fueling with rate similar to HFS produces
  - Delayed transition
  - Shorter H phase
- Can also get H-mode by loading walls with D_2 gas
- Confinement similar in all cases

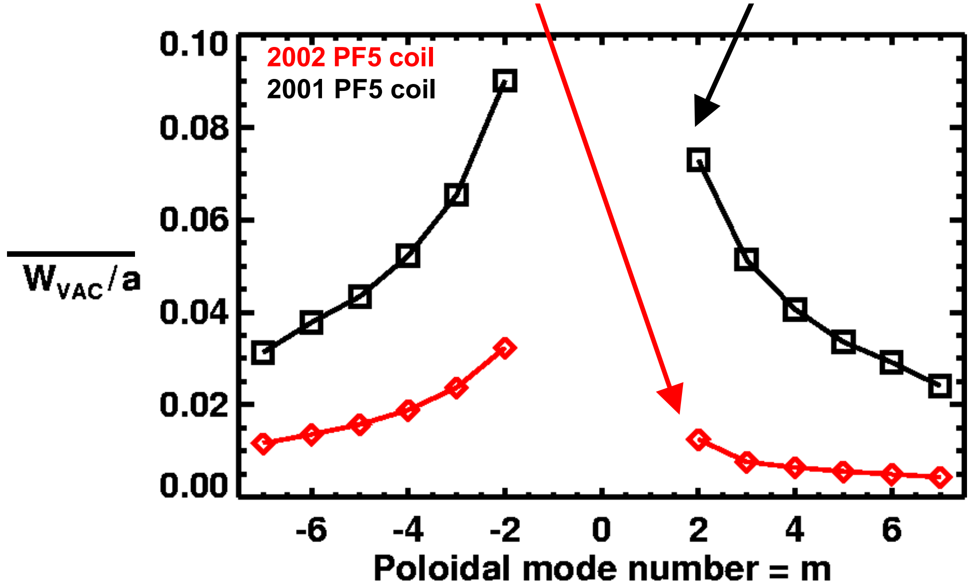
R. Maingi, C. Bush

Several Factors Contributed to Sustained Higher β Operation

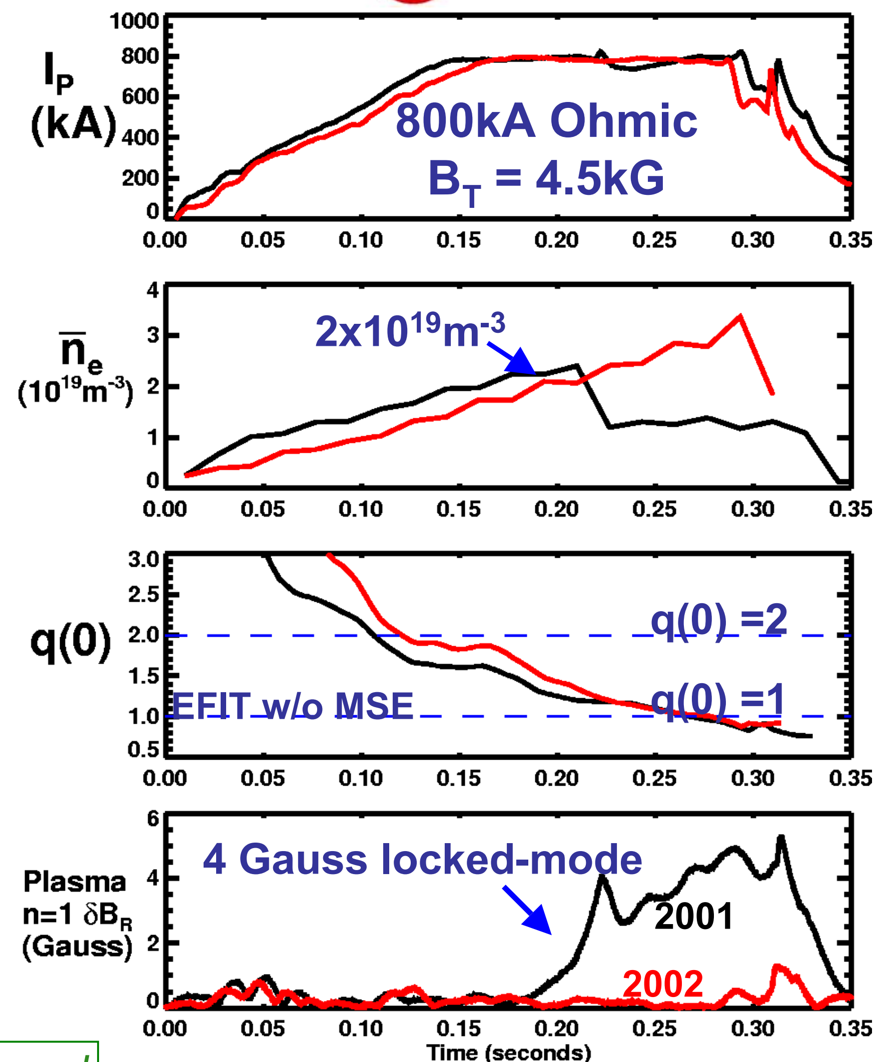
- Reduction of static error field
  - Reduced incidence of locked modes at low β
  - Reduced rotation damping
- Maintaining $q_{min} > 1$ for longer
  - Previous high-β plasmas collapsed when $q_{min} \leq 1$
  - Higher initial T_e & purity increased conductivity
- H-mode broadened profiles

Reshaping & Realignment of Outer PF Coil Reduced Error Field & Mode Locking

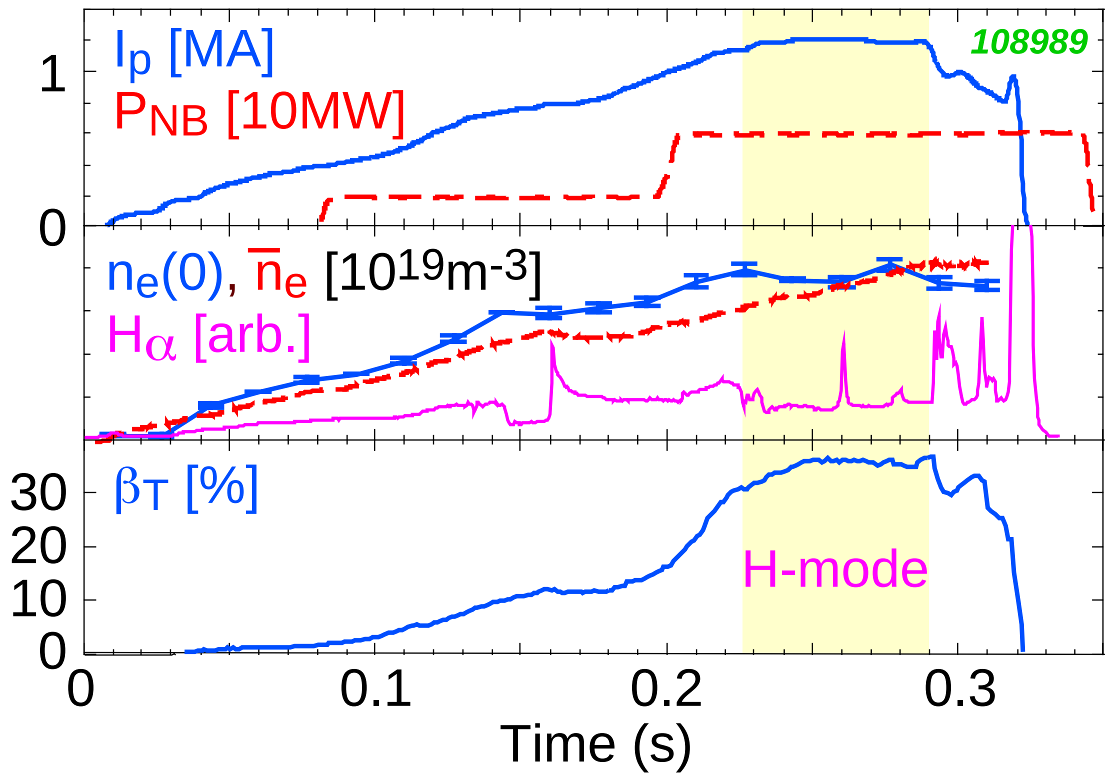
- PF5 (vertical field) coils found to generate large n=1 δB_r
- Coils re-shaped prior to '02 run
- Vacuum island widths now ***reduced to < 1cm*** (from ~5cm)

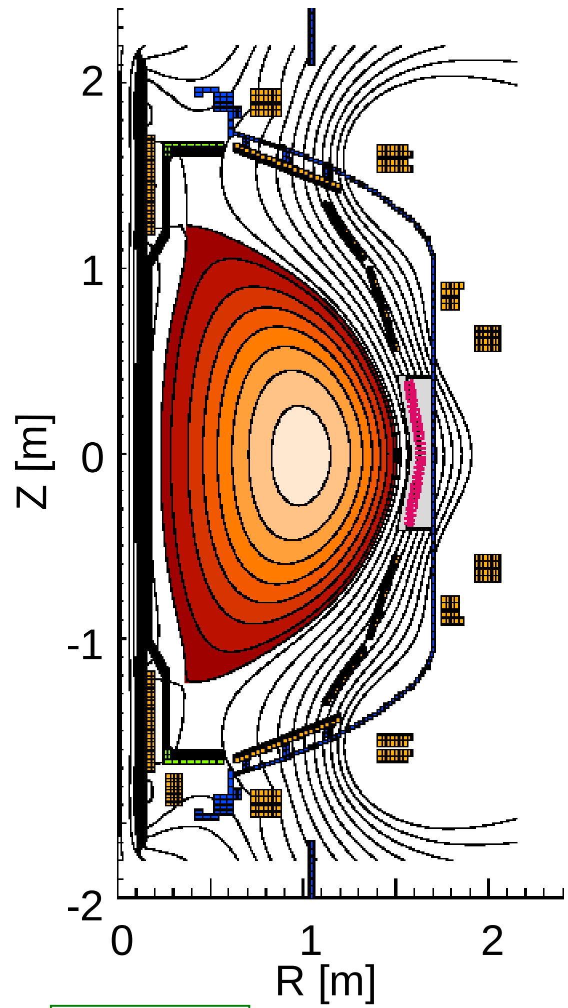


(NSTX operates with m > 0 resonant)



Achieved Substantial Progress in β_T

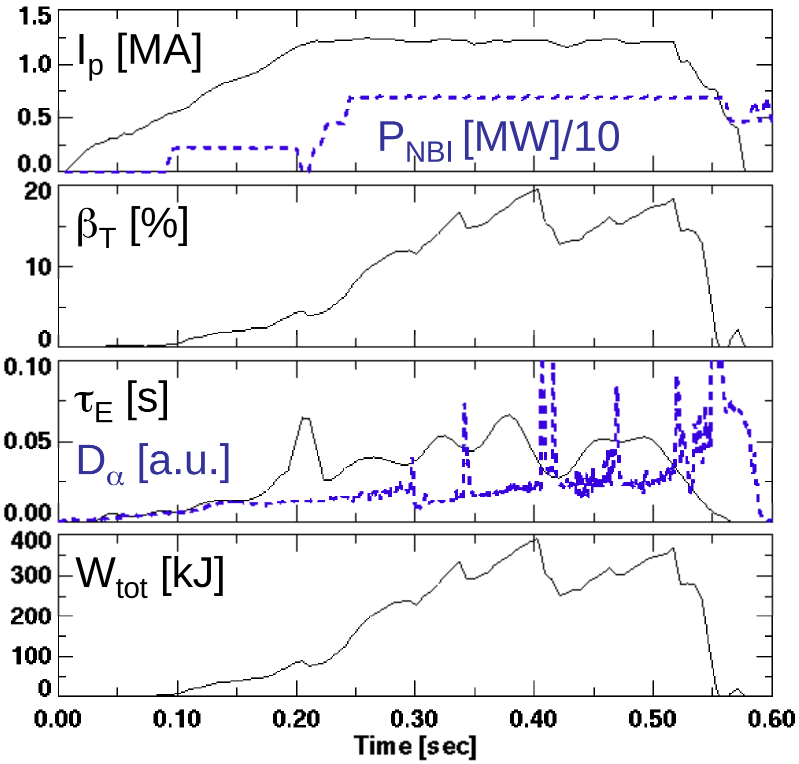


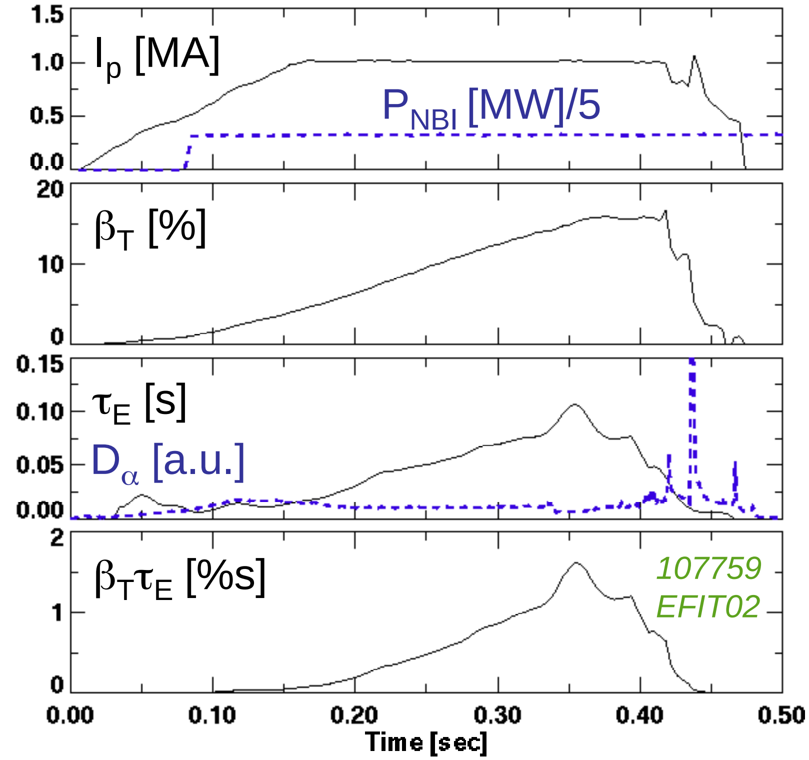


- β_T = 35% (EFIT with ϕ_{dia} and p_e profile)
- B_T = 0.3T, A = 1.4, κ = 2.0, δ = 0.8
- l_i = 0.6, $q_0 \approx 1.4$

D. Gates

Highest Stored Energy and $\beta_T \times \tau_E$ Achieved at Higher Toroidal Field





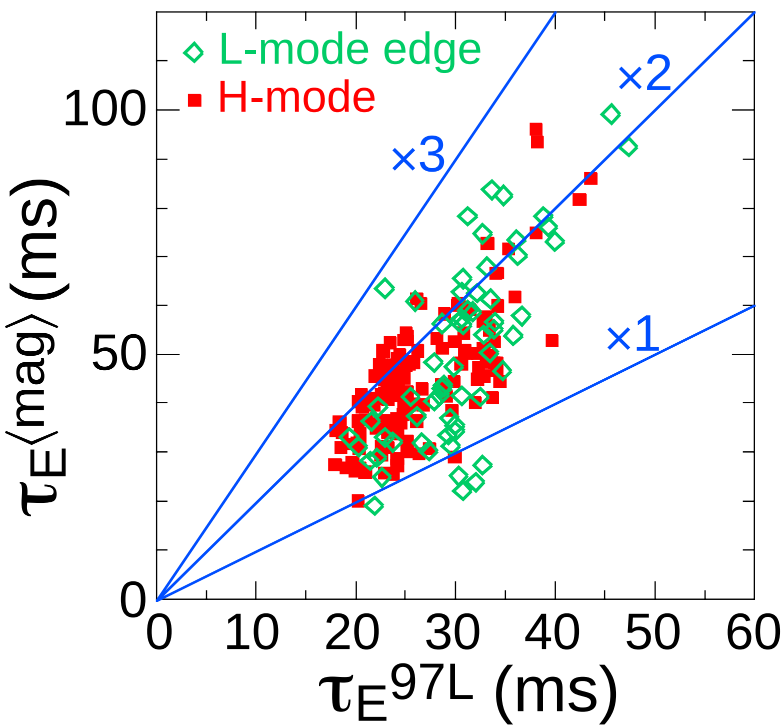
- W_{tot} = 390kJ
- B_T = 0.55T, β_T = 20%
- $\beta_T \times \tau_E$ = 1.2%·s
- B_T = 0.4T
  - Also achieved $\beta_N \times H_{89L} > 12$ for $8 \times \tau_E$
  - Higher B_T extends pulse (at lower β)

D. Gates , R. Maingi

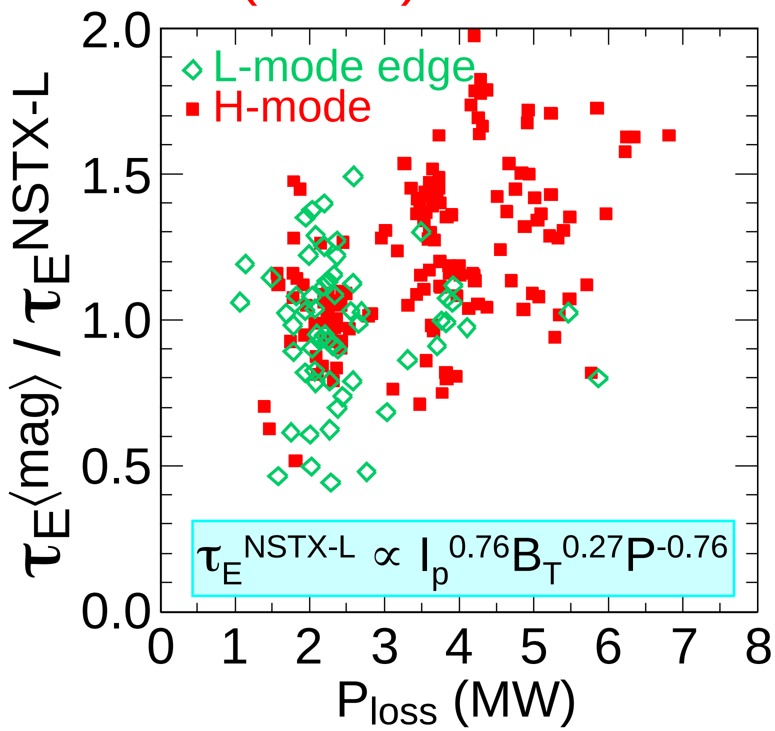
Global Confinement with NBI Continues to Exceed Standard Tokamak Scalings

NSTX

Both L and H -mode plasmas can exceed ITER-97L scaling



Weaker power degradation in H-mode ($\sim P^{-0.5}$) than L-mode

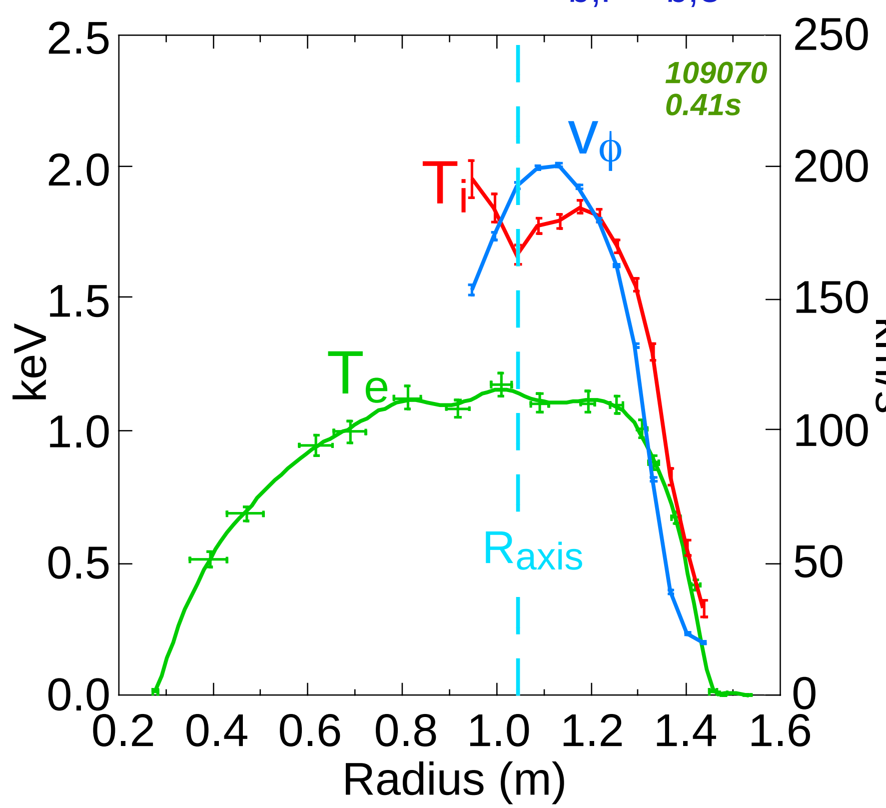


- Confinement times from EFIT determination of W_{tot}
  - Times near peak W_{tot}; include NB *injected* and Ohmic power

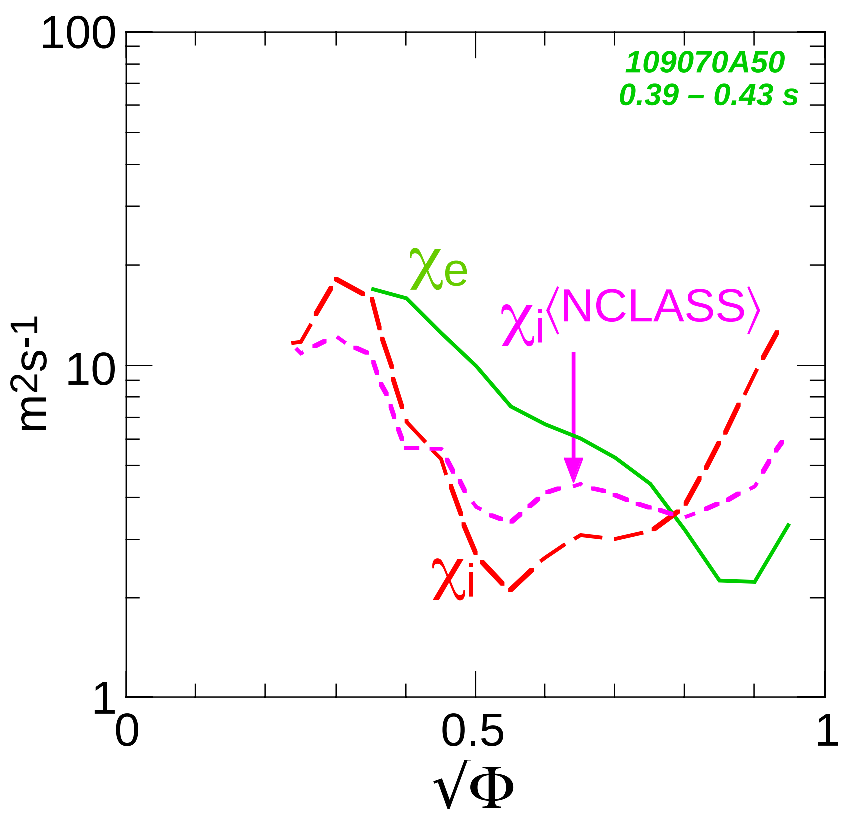
S. Kaye

Profile Analysis Confirms Low Ion Transport and Shows Unusual Features

$T_i > T_e$ throughout core
although classical $P_{b,i}/P_{b,e} \approx 0.7$



$\chi_i \sim \chi_I^{\langle NCLASS \rangle} < \chi_e$
Diffusivities decrease with r/a



- In some discharges T_i locally exceeds $\chi_I = 0$ prediction

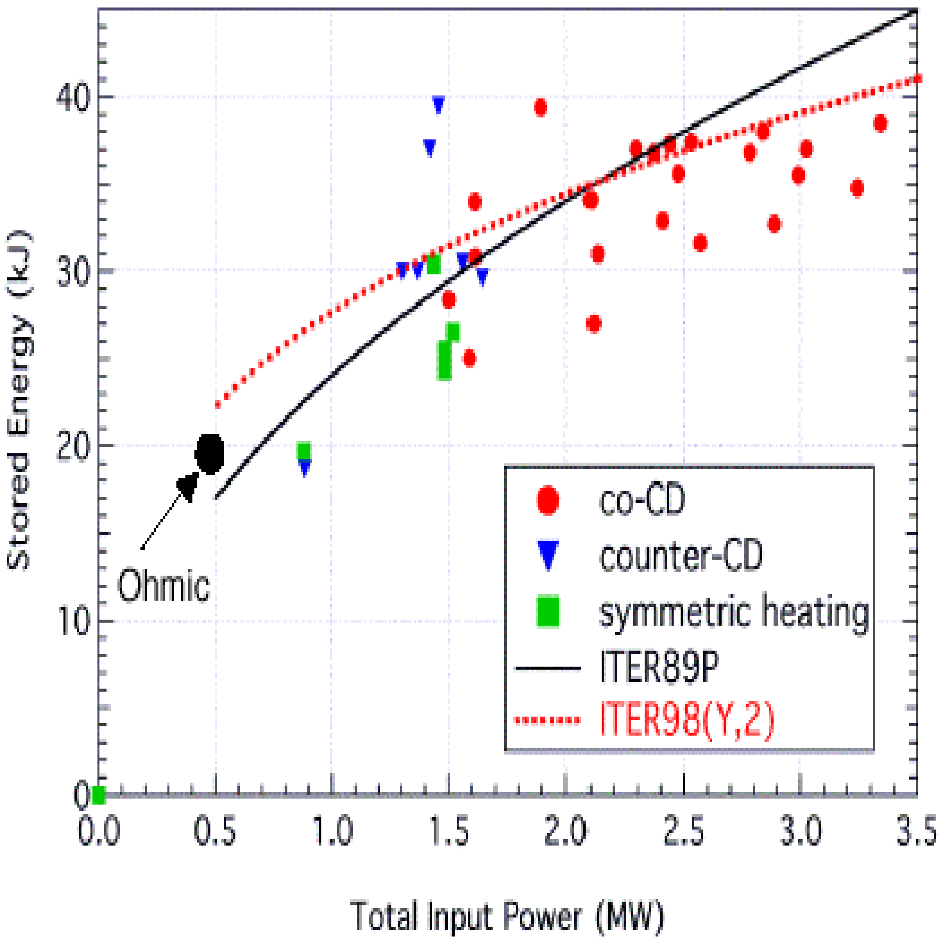
S. Kaye, D. Gates

Summary

- New facility and diagnostic capabilities added
  - Routine H-mode operation
- Significantly increased β
  - β_T, β_N, β_P, $\beta_T\tau_E$, $\beta_N H$, W_{tot} reached new levels
- Good global confinement observed with NBI heating
  - H-modes have more favorable power dependence
  - Single parameter dependences remain to be determined
- Ion confinement appears to be very good

Following talks will elaborate on several of the interesting trends in NSTX performance

HHFW Heating Not Yet as Effective as NBI



- Compare measured plasma energy increase with ITER scaling for plasma conditions

  I_p=0.5MA, B_T=0.45T, H=1
- Current-Drive antenna phasings ⇒ $\mathbf{k}_{||} \approx \pm 7\text{m}^{-1}$; Heating phasing ⇒ $\mathbf{k}_{||} \approx 14\text{m}^{-1}$
- Heating quite variable
- Power was limited by lower antenna standoff
  - feedthroughs now improved

P. Ryan