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NSTX

Beta Scaling and Momentum Transport Studies in NSTX

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APS-DPP Meeting
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Orlando, Fla

This Talk will Feature Highlights of Two Studies

NSTX

- Dependence of energy confinement on beta
  - High priority ITPA task – important to success of ITER AT scenario
  - Previous results mixed
    - Early JET, DIII-D with strong shaping showed little or no degradation
    - JT-60U, AUG with weaker shaping showed strong degradation
  - NSTX operates over a large range of beta
    - Few up to 10's of %
  - Can perform beta scans with different plasma shapes

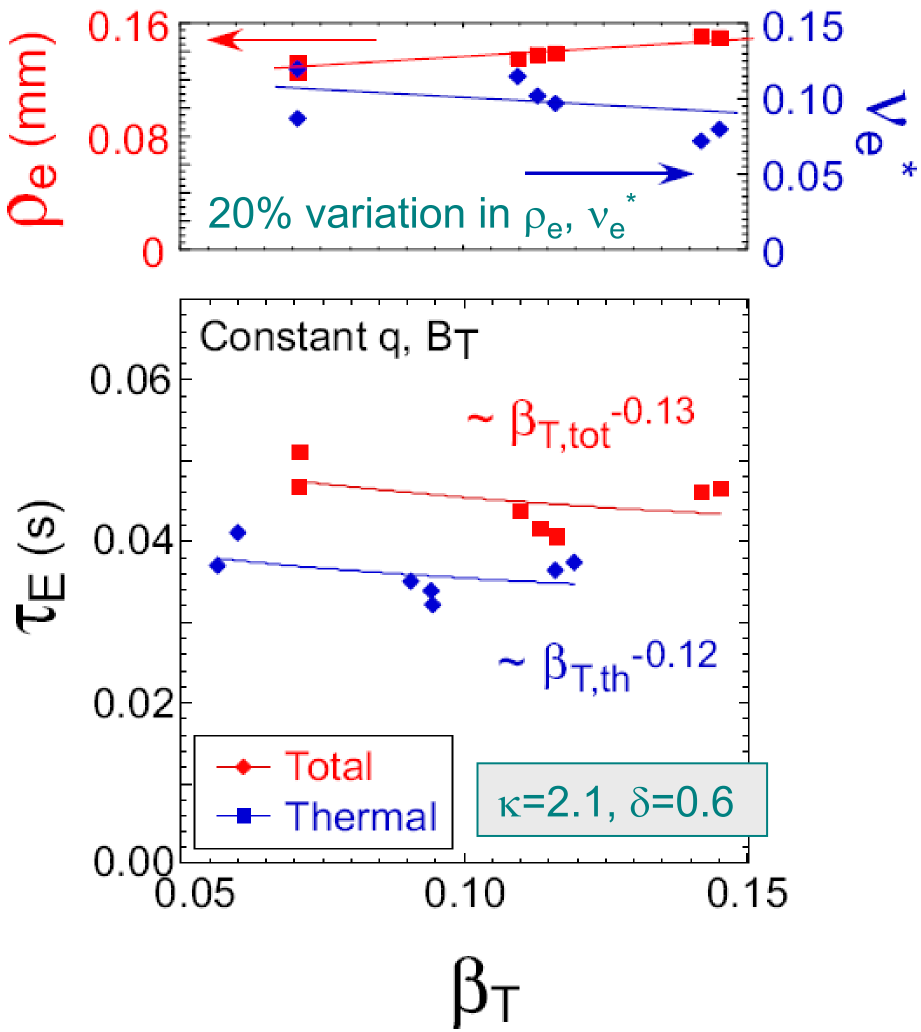
- Momentum transport
  - High rotation rates observed on NSTX (M~0.5)
    - ExB shearing rates large enough to suppress low-k microturbulence
  - Experiments to study steady-state momentum transport
    - Use perturbation technique with n=3 field application to separate χ_ϕ from v_{pinch} and compare to pinch theories

Dimensionless Parameter Scans Have Addressed the Beta Dependence of Confinement

NSTX

β-scan at fixed q, B_T (κ=2.1, δ=0.6)

- Factor of 2-2.5 variation in β_T across power scan (P_{inj}=2 to 6 MW)
- Small, Type V or no ELMs at all power at times of interest
- *Little degradation of τ_E with β for these conditions*
- β-degradation of τ_E found to be strong from statistical analysis of international H-mode database ($B\tau_{98y2}$~$\beta^{-0.9}$)



Test Shape Dependence of Confinement Degradation With Beta

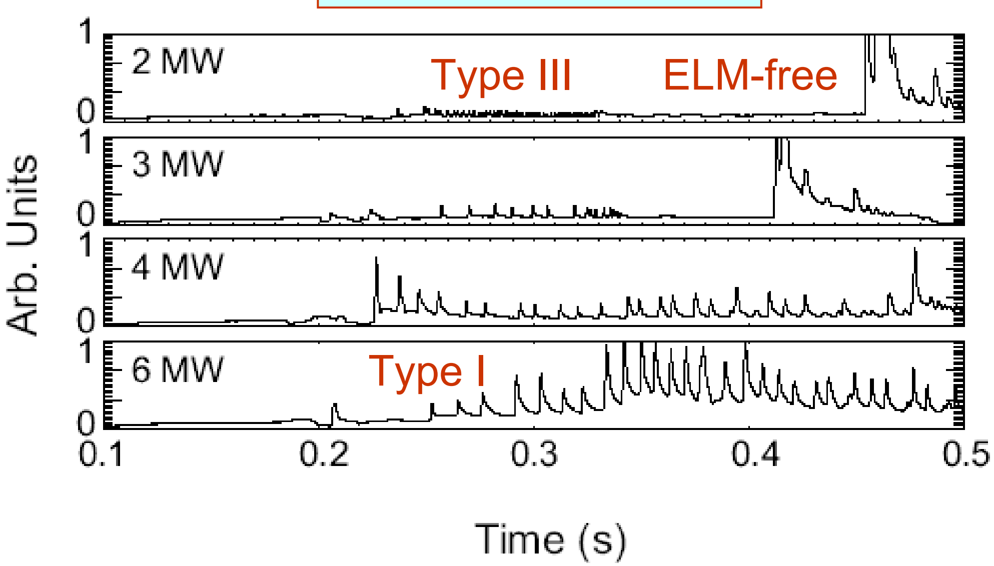
NSTX

- κ=1.8-1.9, δ~0.4 (fixed, q, B_T)
  - Power scan again used to produce variation of beta
  - ν_e*, ρ_e vary ≤ 20% across scan

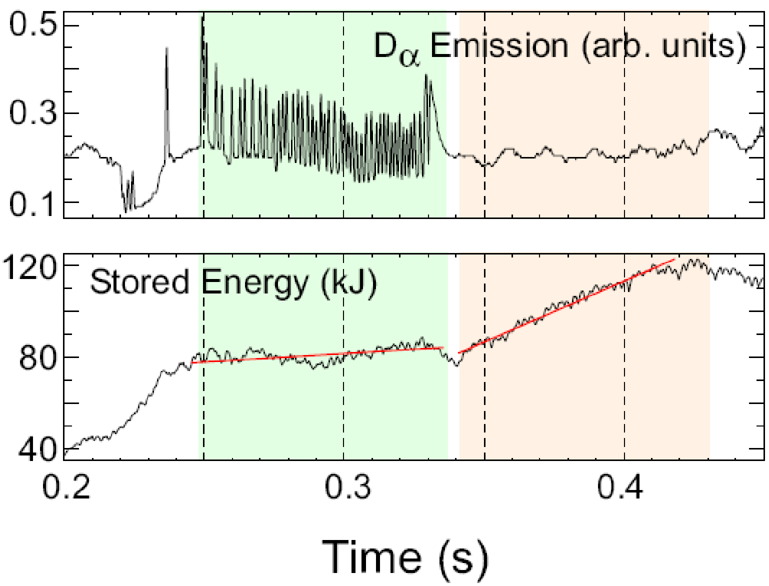
ELM severity increases with increasing power

- High frequency Type III ELMs at low power, Type I at high power

Type I: ΔW/W~7%

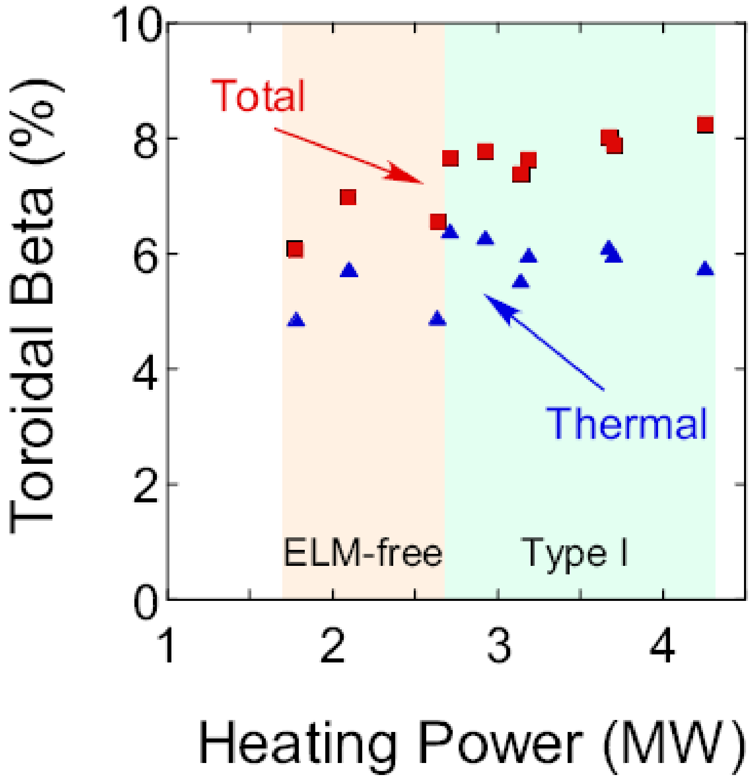


Type III → ELM-free

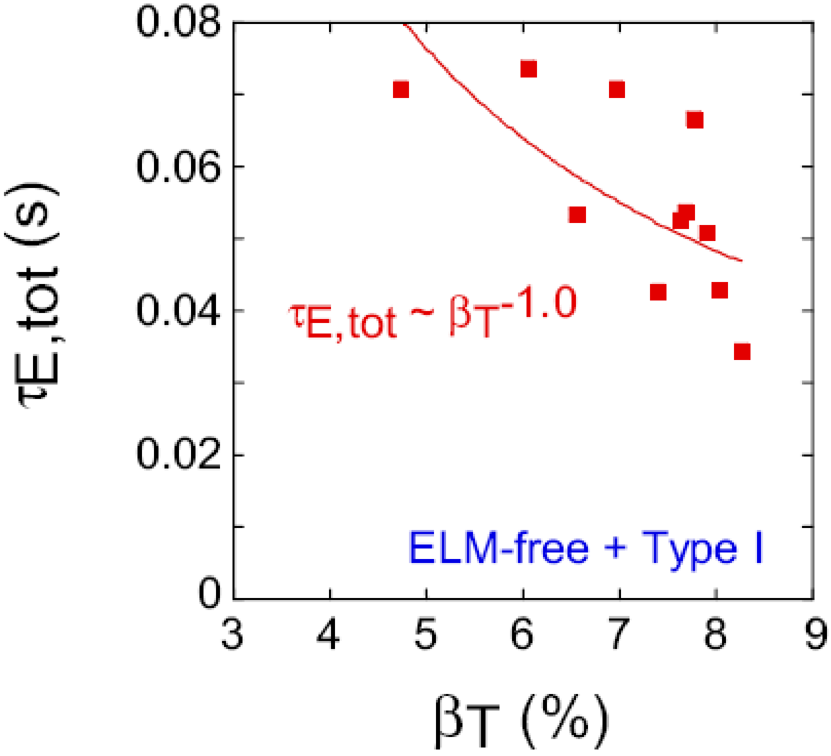


Type III ELMs severely degrade confinement

Beta Increases Weakly With Power For κ=1.8, δ=0.4 Plasmas



Strong degradation of τ_E



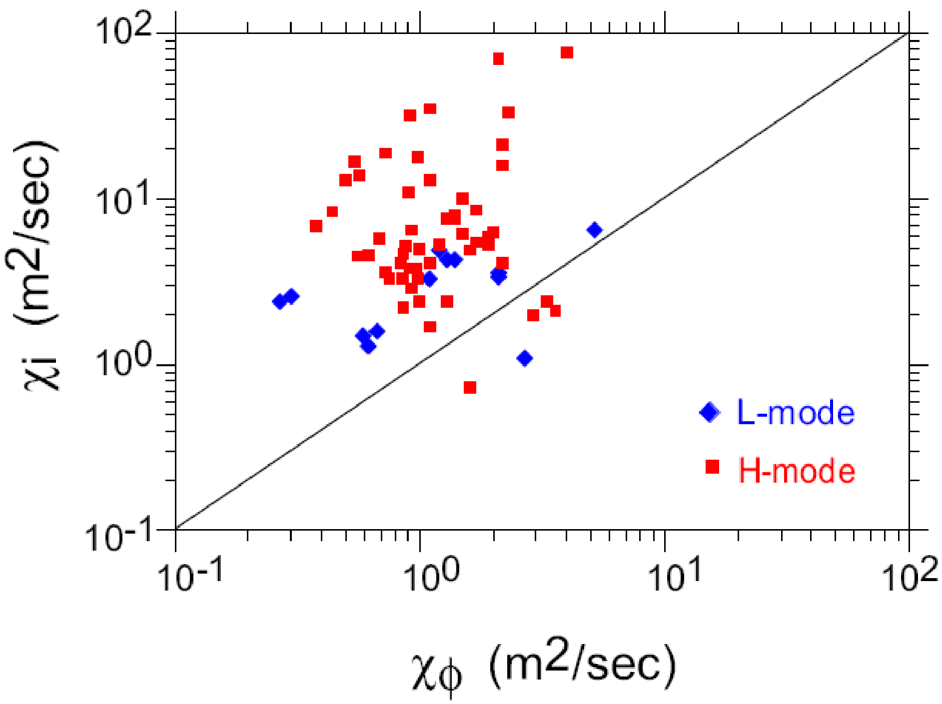
Beta scaling depends on plasma shape through pedestal stability/ELM behavior

Steady-State and Perturbative Momentum Confinement Studies on NSTX Have Started

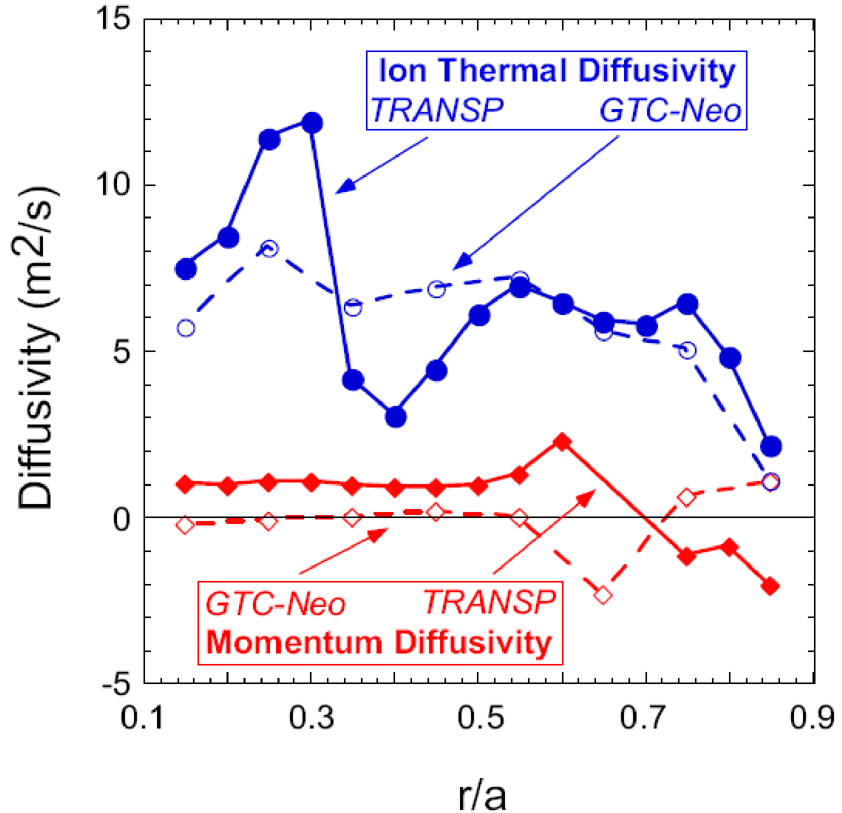
NSTX

Power Balance $\chi_\phi << \chi_i$

– χ_ϕ, χ_i decoupled



$\chi_i \sim \chi_{i,neo}$, $\chi_\phi >> \chi_{\phi,neo}$



$\chi_i \sim \chi_{i,neo}$ in many H-mode discharges

Is $\chi_\phi \sim \chi_{\phi,neo}$?

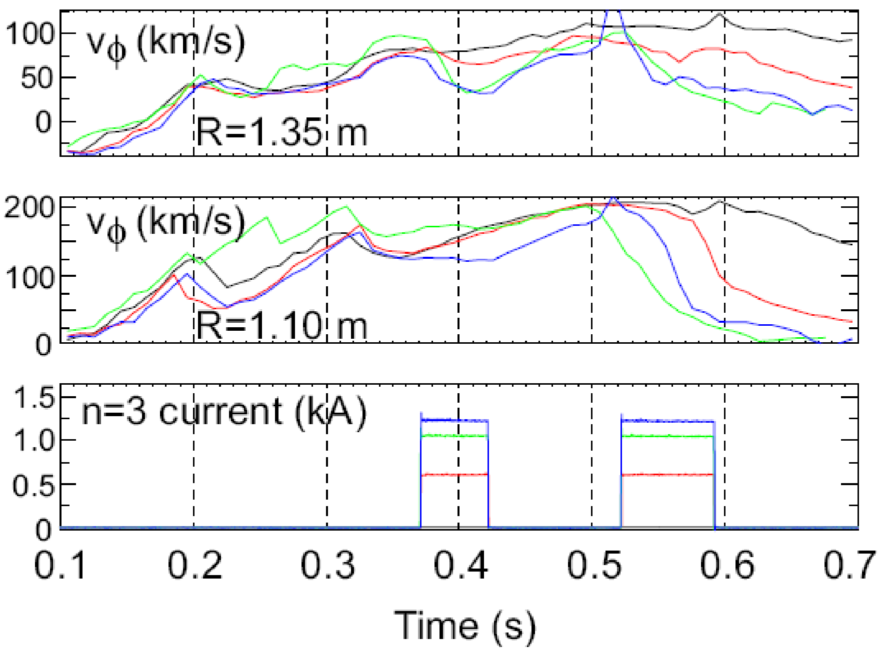
$\chi_{\phi,\,neo}$ can be negative due to ∇T_i drive

Perturbative τ_ϕ, χ_ϕ Can be Obtained from Transient Application of nRMP

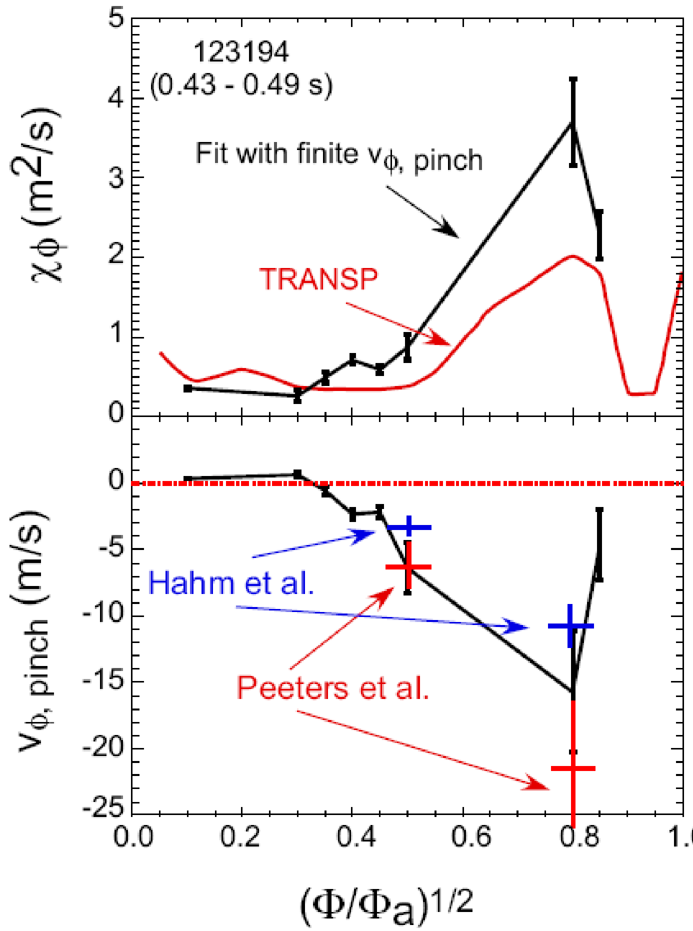
Application of non-resonant n=3 magnetic perturbation slows plasma

Plasma spins up when nRMP removed

Maximum nRMP torque at R~1.35 m



Significant inward pinch velocity



τ_ϕ ~ 150 ms >> τ_E (50 ms)

Inward pinch consistent with values from low-k turbulence theory

Summary

- Degradation of τ_E with β_T varies with pedestal stability in differently shaped plasmas
  - No degradation in strongly shaped plasmas
  - Strong degradation in more weakly shaped plasmas tied to edge stability/ELMs
- Steady-state power balance and perturbative analyses indicate long momentum confinement times (>100 ms) and $\chi_\phi << \chi_i$
  - Momentum diffusivity decoupled from ion thermal diffusivity
  - $\chi_\phi >> \chi_{\phi, neo}$
  - Strong inward pinch velocity inferred from perturbative analysis

What is source of momentum pinch in NSTX when low-k believed to be suppressed (higher-k electron modes)?

Related Presentations: Kaye et al., NM4.3 (Wed AM – miniconference), Davis et al, TP8.72 (Thurs AM – NSTX poster session)