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NSTX

Correlation of Edge Localized Modes and Electron Transport

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Correlation of Edge Localized Modes and Electron Transport

- **Motivation**

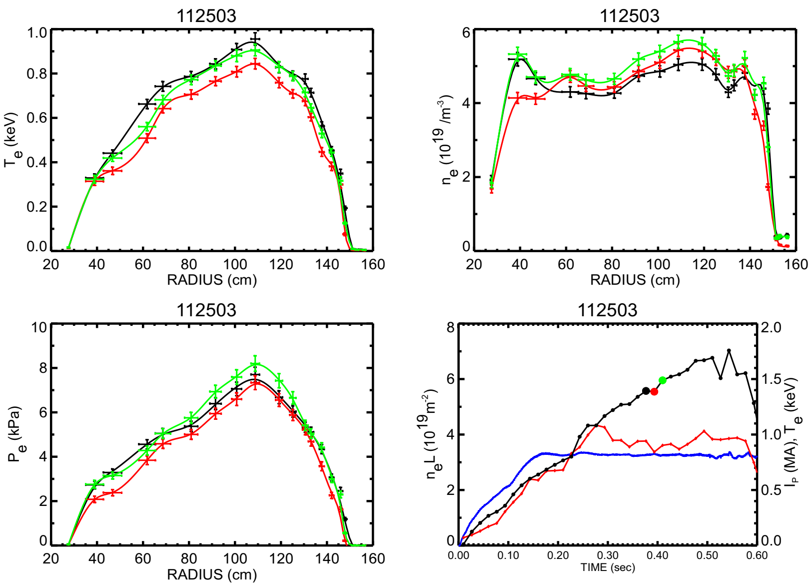
  - ELM phenomena on NSTX appears different from conventional tokamaks (e.g. ΔW_{tot}, perturbative penetration)
  - On NSTX, Type I ELM can perturb T_e profile with cold pulse reaching core on fast (~100's μs) time scales
  - Similar T_e perturbations have been recently observed with Li pellet injection into H-mode discharges

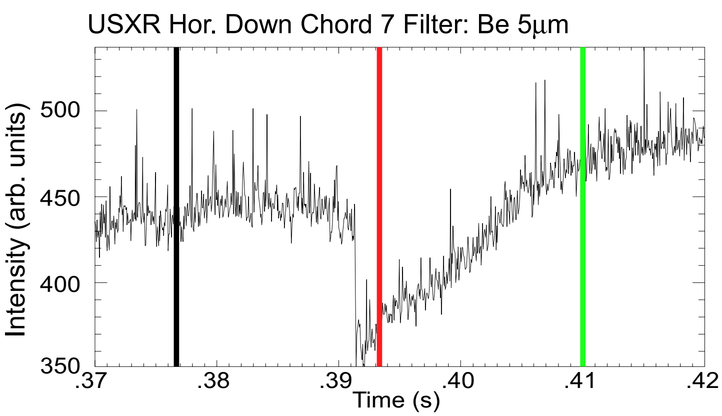
- **Goals**

  - Distinguish between the Type I ELM and resultant perturbation
  - Scale current to change electron transport and observe effect on cold pulse propagation
  - Inject Li pellets after ELM period to compare perturbations

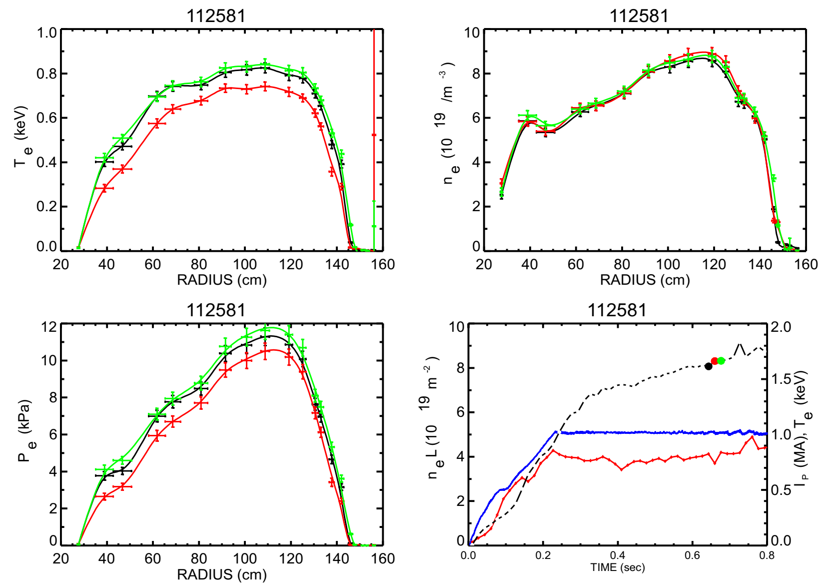
Type I ELMs Show Mixture of T_e, n_e Perturbation

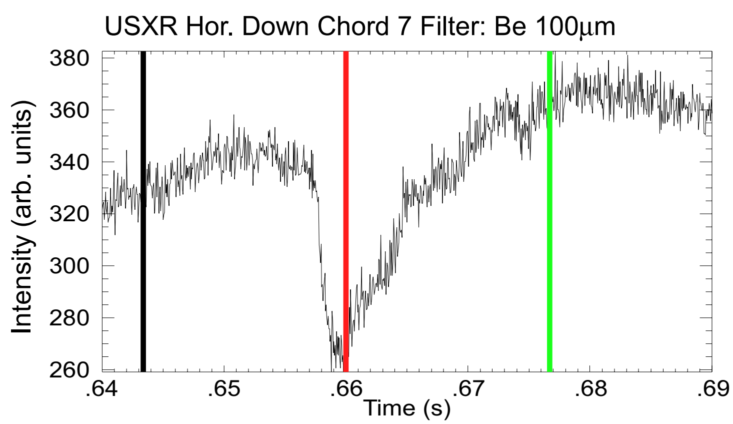
Combination T_e, n_e perturbation





Primarily T_e perturbation

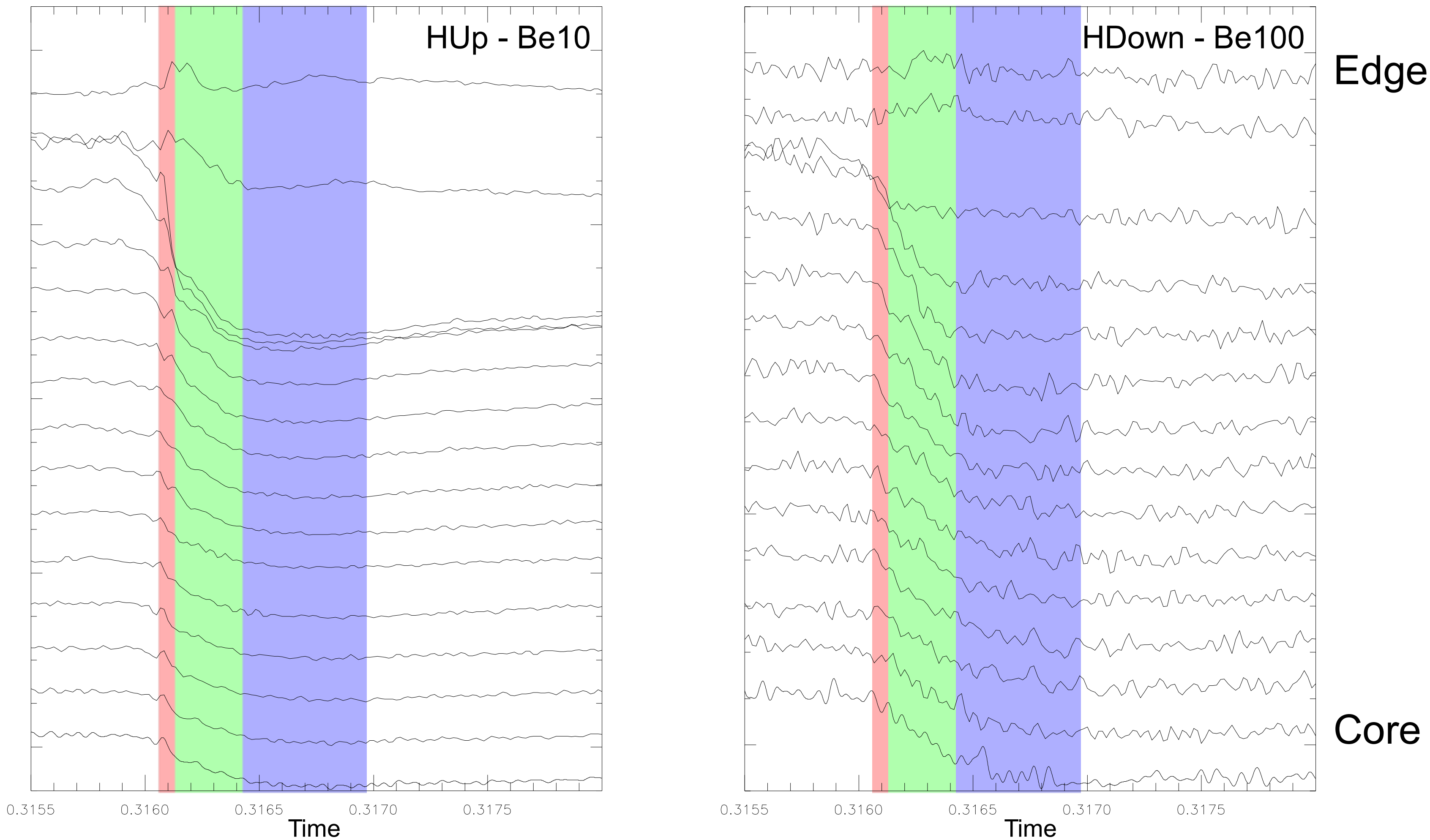




- In above cases, perturbation reaches core of plasma

ELM Perturbation Evolves on Different Timescales

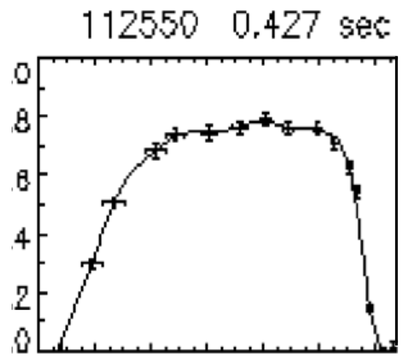
117414



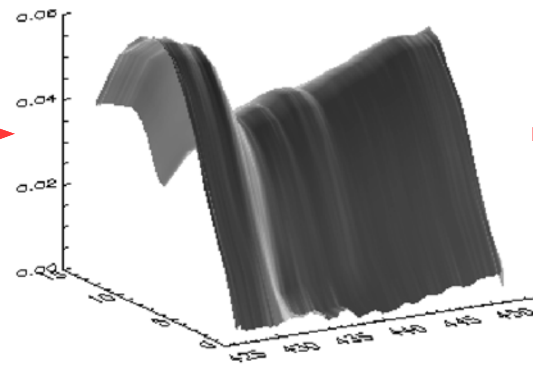
Fast edge crash	~50µs
Cold pulse propagation	~few 100µs
Te profile evolution	~0.5-3ms

Multi-color SXR Imaging Separates Δn_e, ΔT_e

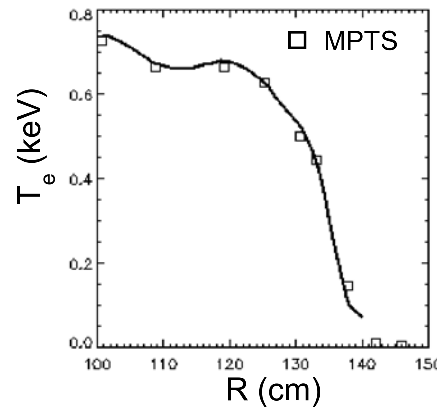
MPTS $T_e(R)$ @ .427s



$\frac{E > 1.4keV}{E > 0.4keV}$ intensity ratio



Post-ELM MPTS Comparison



- Use Be 100μm/Be 5μm ratios to propagate MPTS T_e profile
  - Use pre-ELM MPTS to fit model parameters (e.g., $n_e(R)$, $n_z(R)$, $T_e(R,t=t_0)$)
  - High / low energy USXR ratio T_e sensitive, n_e x n_z factors out
  - USXR spectrum modeled with C, O, and B coronal radiative coefficients and EFIT mapping
  - Good agreement between USXR 'prediction' and subsequent MPTS T_e profile

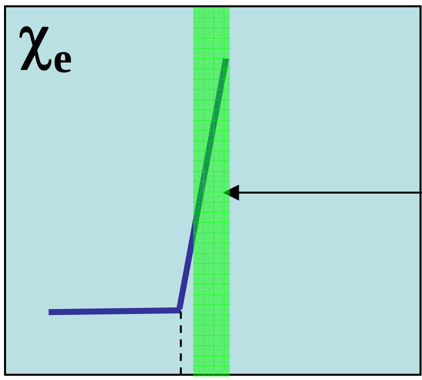
Critical gradient paradigm for electron transport

(Ryter 2001)

gyro-Bohm behavior

Critical gradient for TEM, ETG turbulence

$$\chi_e = T_e^{3/2}[\xi_0 + \mathcal{G}(\nabla T_e/T_e - (\nabla T_e/T_e)_c)]$$



$R/L_{Te} = R/(T_e/\nabla T_e)$

'Stiff transport'

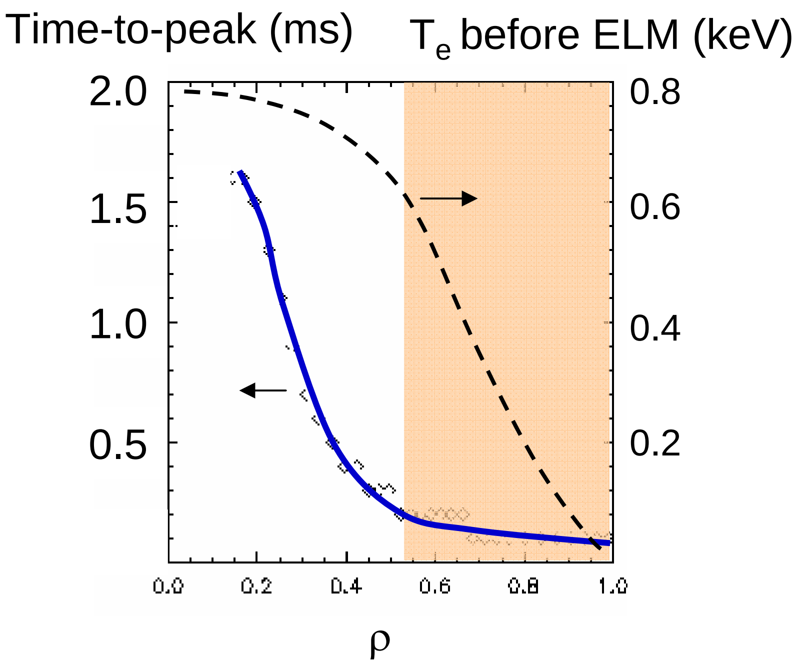
- $\nabla T_e/T_e\,(r) \approx (\nabla T_e/T_e)_c \approx$ const.
- $T_{core} \sim T_{edge}$
- $\chi_e^{pert} >> \chi_e^{PB}$

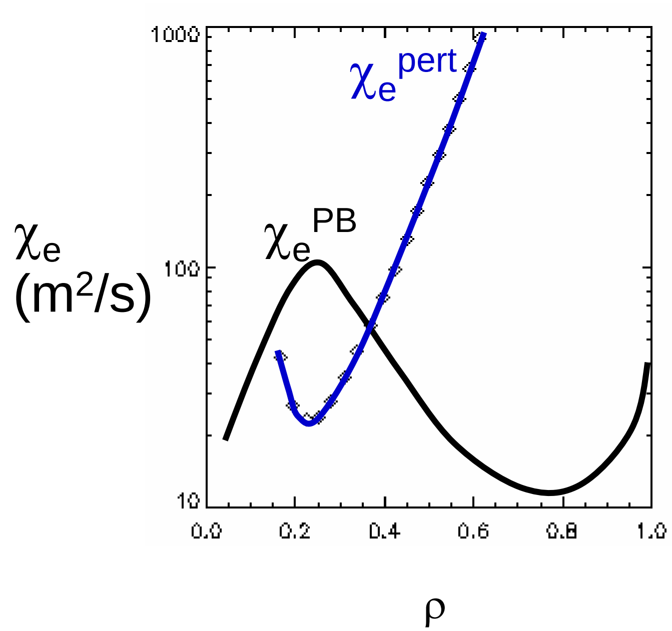
Three parameter model applied at JET using controlled T_e perturbations (Garbet, Mantica 2004)

$$\chi_T = \chi_s q^{\nu} \frac{T}{eB}\frac{\rho_s}{R}\left(\frac{-R\partial_r T}{T} - \kappa_c\right) H\left(\frac{-R\partial_r T}{T} - \kappa_c\right) + \chi_0 q^{\nu}\frac{T}{eB}\frac{\rho_s}{R}$$

χ_e^{pert} from ELM markedly different from χ_e^{PB}

Model from Inagaki *et al*, PPCF 04 (neglects ion damping)

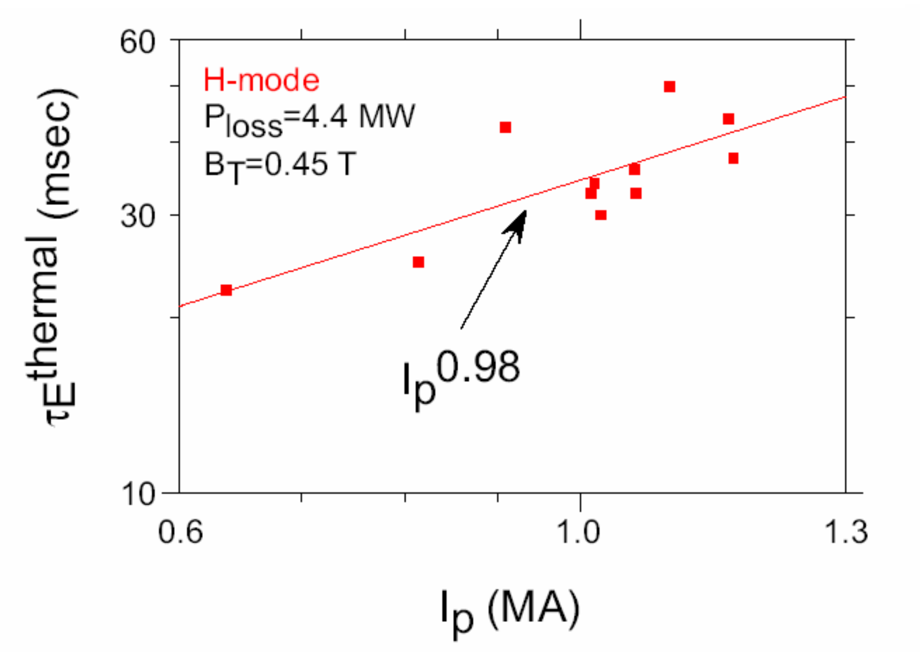


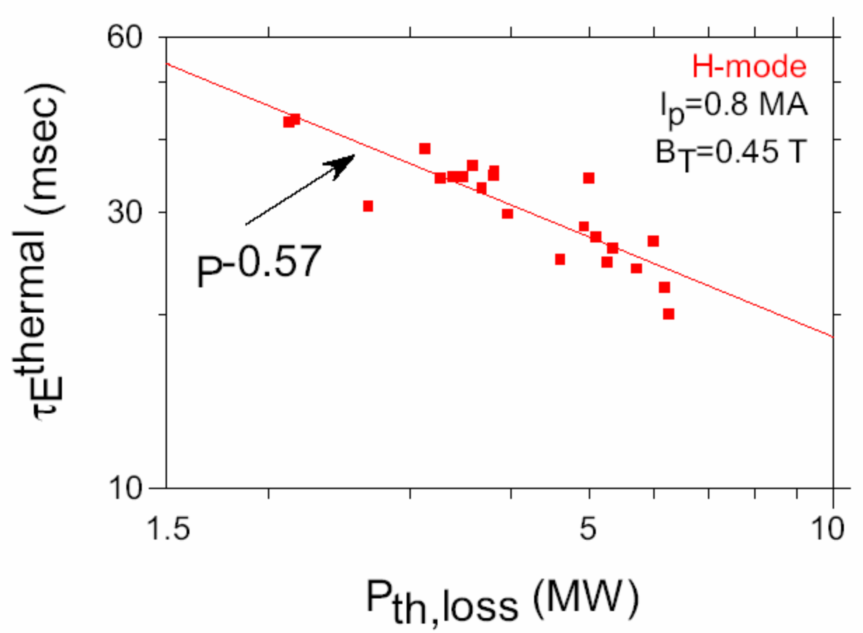


- Rapid perturbed transport in the T_e gradient region, decreasing inside

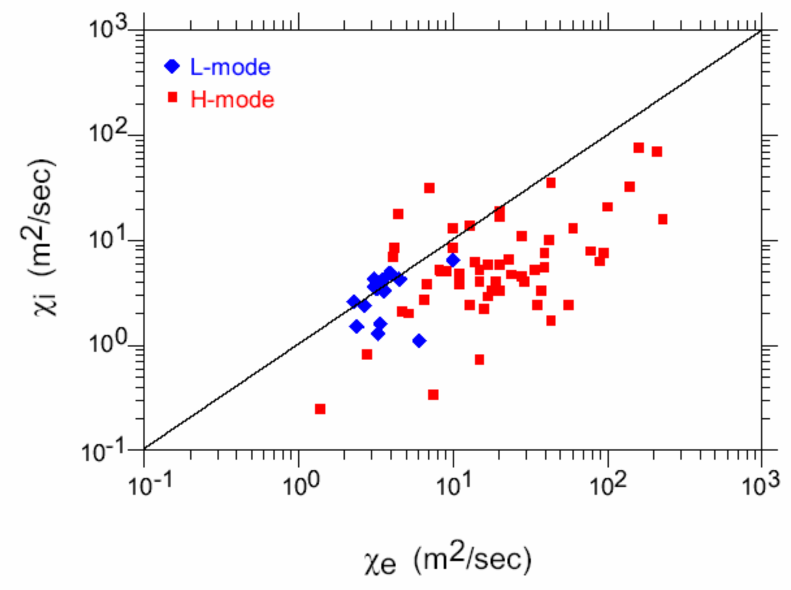
Thermal Electron Confinement Scales with Ip

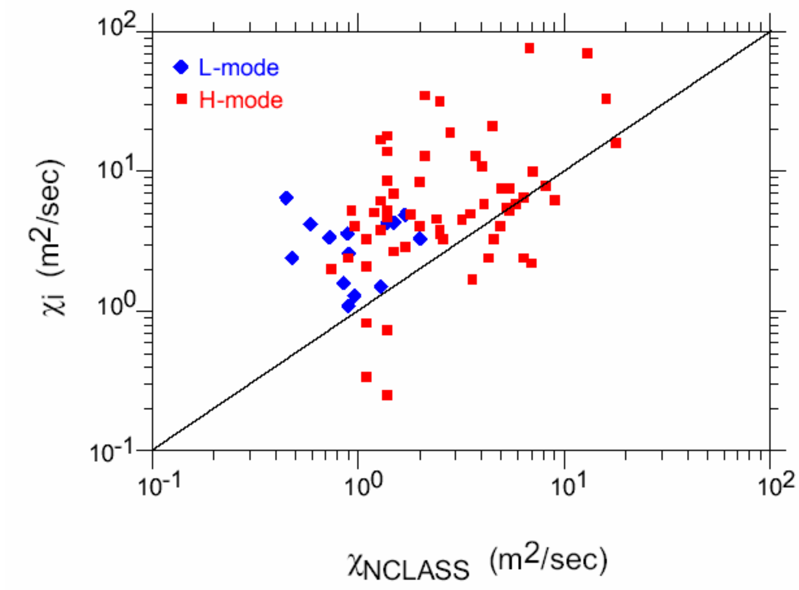
Thermal τ_E determined by TRANSP
(126 discharges 'TRANSPed")
~25% uncertainty on $\tau_{E,th}$





Electrons Dominate Heat Loss In H-modes





Energy confinement scales with Ip

Electron transport dominates energy confinement

→ Electron transport should scale with Ip

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Experimental Proposal

- Use ‘typical’ high power LSN H-mode plasma which exhibits desired Type I ELM phenomena (117410)
  - Large outer gap optimizes Tompson coverage of boundary
  - Add Li pellets after ELM period for comparison of perturbation
- Scan plasma current at fixed TF to change electron transport
- Scan plasma current at fixed q (time permitting)
- Diagnostics
  - USXR (multi-color)
  - MPTS (with edge resolution upgrade)
  - CHERS
  - Fast cameras for ELM imaging
  - MSE
  - Fast T_i
- Analysis
  - Multi-color analysis of ELM perturbation and cold pulse propagation
  - Fast EFIT reconstructions will account for change in plasma geometry
  - TRANSP calculations of equilibrium electron confinement
  - If diagnostic coverage permits, stability analysis and computation of eigenmode depths to isolate MHD effects

Shot Matrix

Base shot: 117410, LSN, 6MW, Ip ~.8MA

Ip	BT	# shots	comments
0.7MA	4.5kG	2	start current scan
0.8MA	4.5kG	2	if ELM timing repeatable, adjust TS time
0.9MA	4.5kG	2	
1.0MA	4.5kG	2	
1.1MA	4.5kG	2	
0.7MA	3.5kG	2	lower TF, same q as 0.9MA/4.5kG
0.8MA	4.0kG	2	intermediate TF, same q as 0.9MA/4.5kG
Total:		14	
additional high field shots: 1MA @ 5.0kG, 1.1MA @ 5.5kG x2 ea.			

- If more shot repetition is necessary (statistics or misfires) use coarser scan
- Li pellet will be injected after few ELM periods ~0.4-0.6s