Possible T&T research directions towards CTF

Presents D. Stutman

Johns Hopkins University

CTF based on flat profile, high T_e, T_i H-mode

35 MW

5 MW

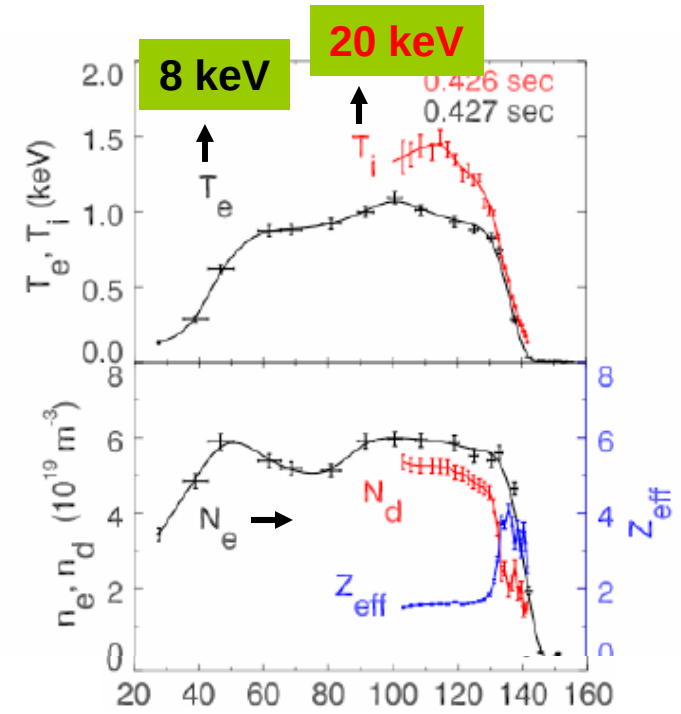
2.5 T

0.5T

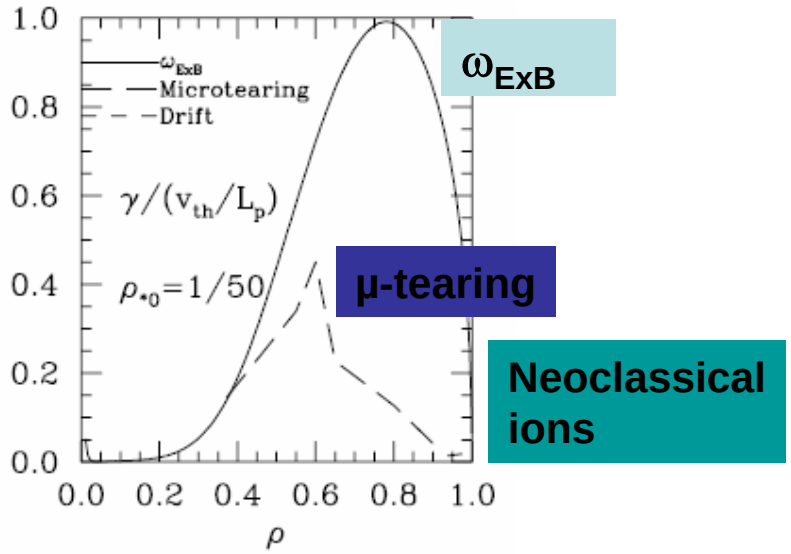
10 MA

1 MA

Peng et al



Kotschenreuther et al



ω_{ExB}

μ-tearing

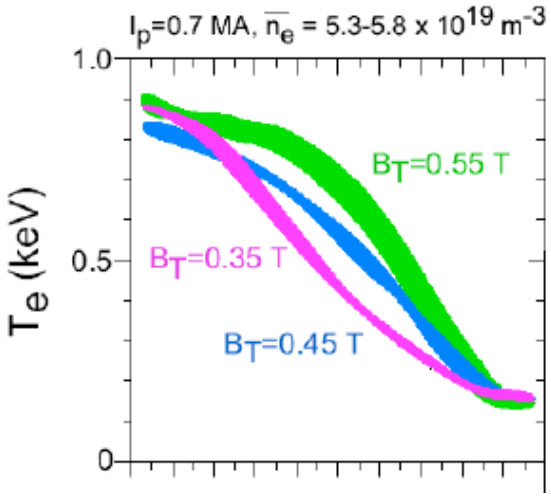
Neoclassical ions

- Flat, high T profiles, sharp pedestal for bootstrap current, macro and micro-stability
- τ_E scaling experiments suggest significant differences from large-A (S. Kaye)
- Assume ion transport will remain about neoclassical (large V_t, ExB in CTF)
- Focus T&T on H-mode core and pedestal (diagnostics, theory)
- Study electron transport vs. B_t, I_p, P_{heat}, q and ExB

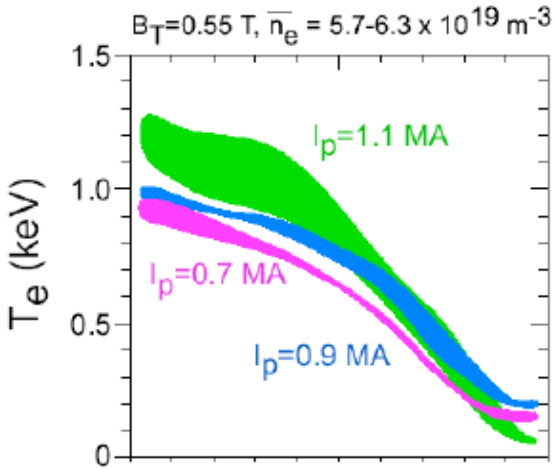
B_t and I_p effects (S. Kaye)

4 MW NBI

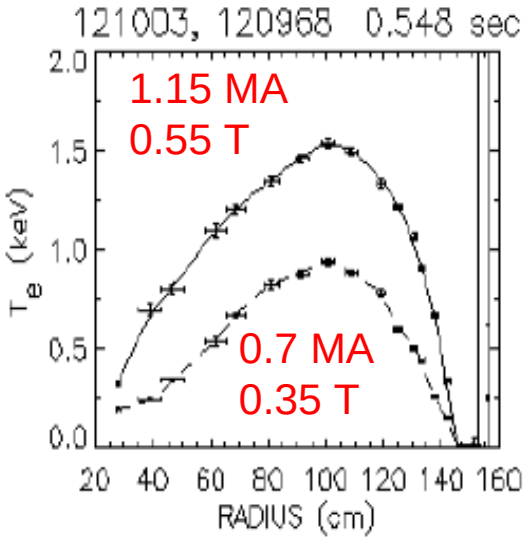
B_t scan at 0.7 MA



I_p scan at 0.55 T



I_p scan at fixed I_p/B_t

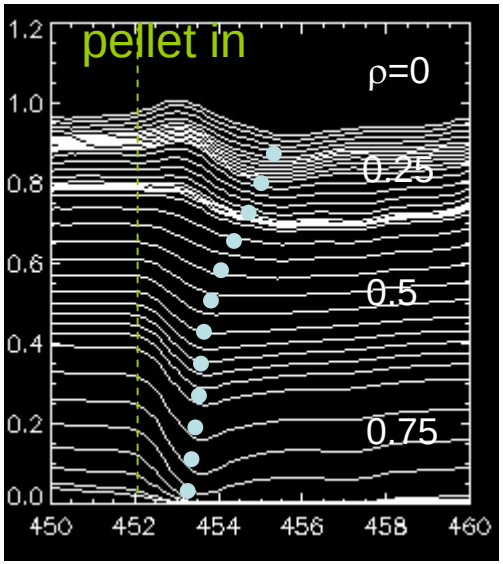


- Increasing B_t broadens region of high T_e, but $T_e(0)$ ~ const. (lesser effect at high I_p)
- Increasing I_p at fixed B_t improves, but mainly ion channel
- However, increasing both I_p and B_t can double T_e; why ?
- Very complex H-mode transport picture from equilibrium studies (L-mode better)
- Help from perturbative transport studies

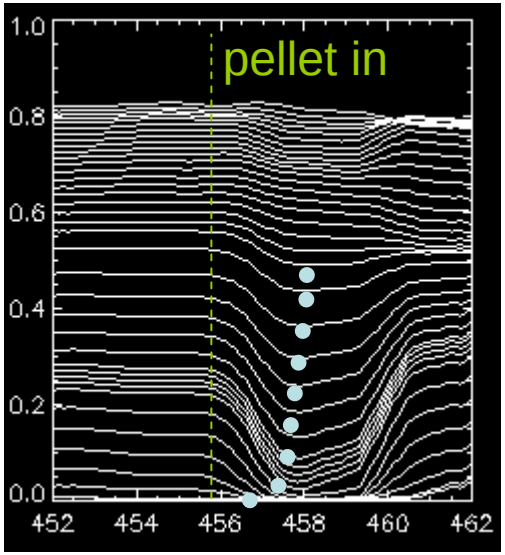
P_{heat} effects studied in perturbative experiments

T_e (keV)

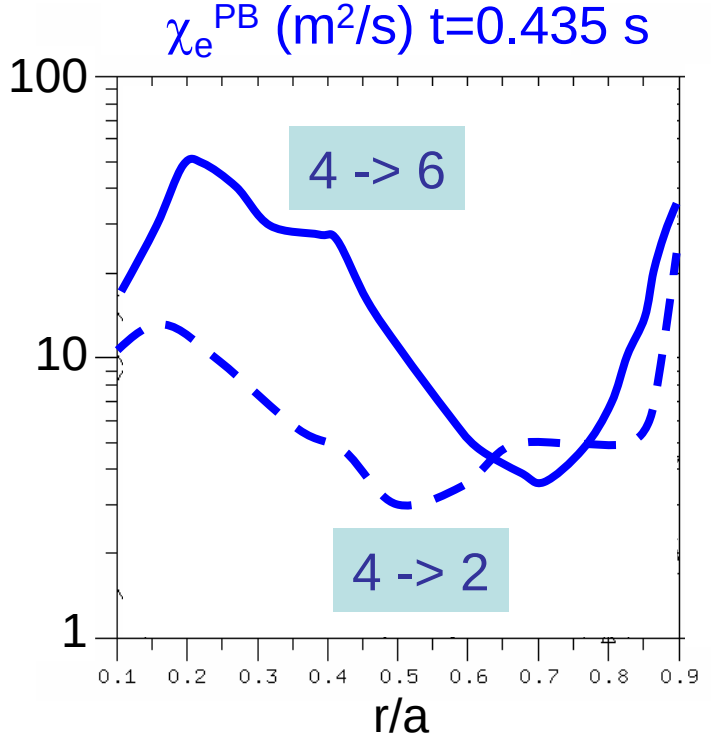
4 -> 6



4 -> 2

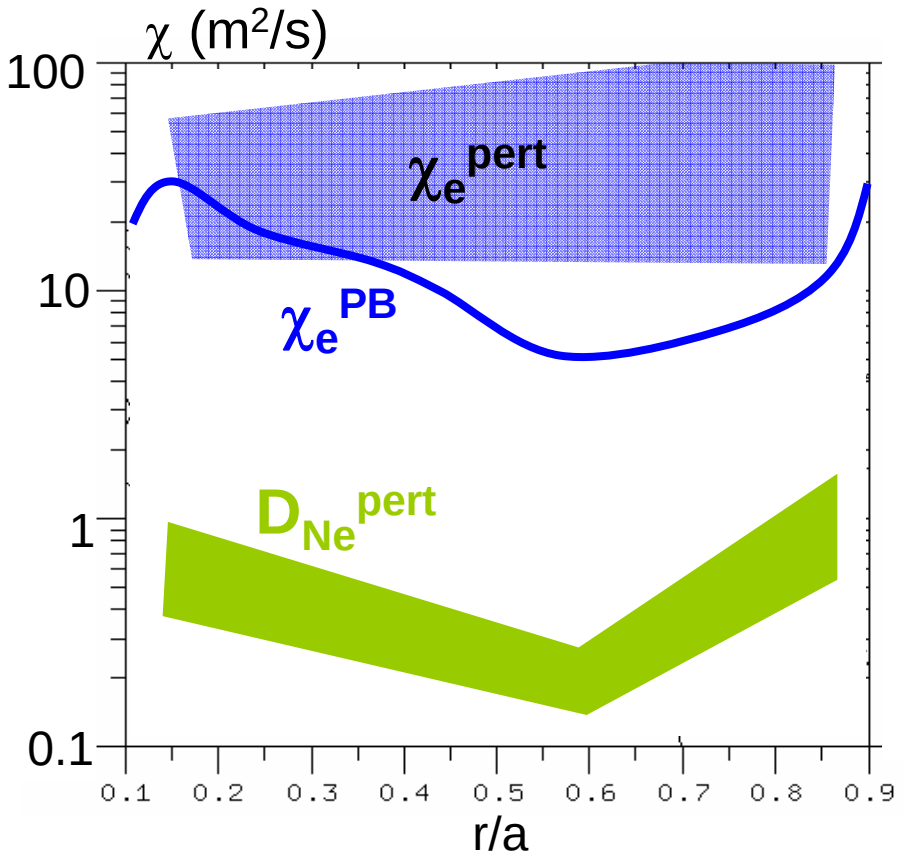


t (ms)



- Central electron transport degrades with P_{heat}
- Non-diagonal transport ($\nabla T_e/T_e$=ct.); heat flux ?
- Scaling with B_t and I_p (08)
- 'Overpower' the CTF for broad T_e ?
- Perturbative result supports/clarifies equilibrium picture

Perturbations suggests magnetic transport at high P_{heat}



$$D_{magn} \approx V_{ll} (\Delta B_r/B)^2 L_s$$

$$\Downarrow$$

$$D_i \approx \chi_i \approx \chi_e \sqrt{(m_e/m_i)}$$

$$\Downarrow$$

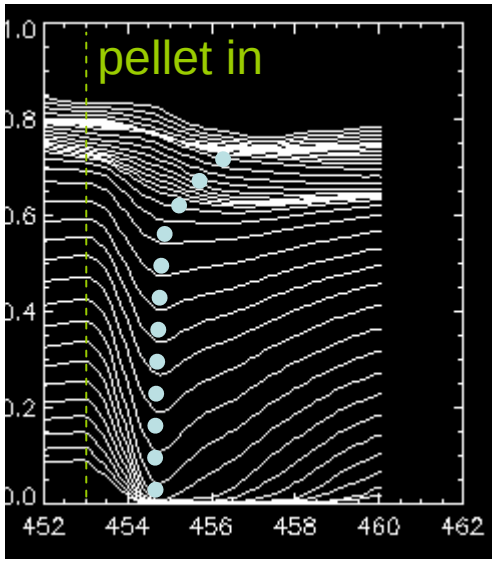
$$\chi_e / D_{Ne} \approx \mathcal{O}(10^2)$$

- About 10^2 gap between perturbed electron thermal and impurity diffusivity
- μ-tearing χ_e in the range of experiments (K. Wong)

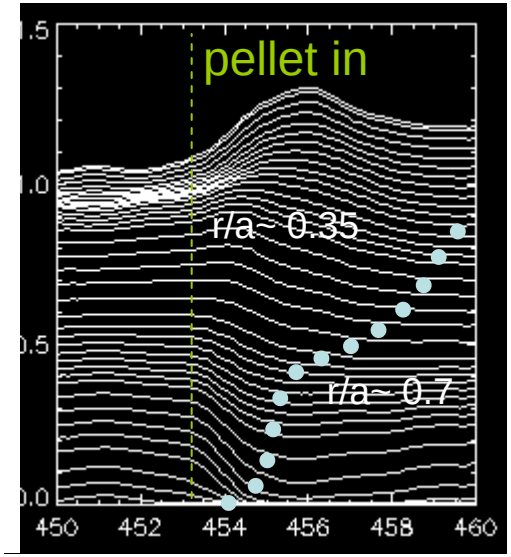
Strong q effects also revealed in perturbative experiments

T_e (keV)

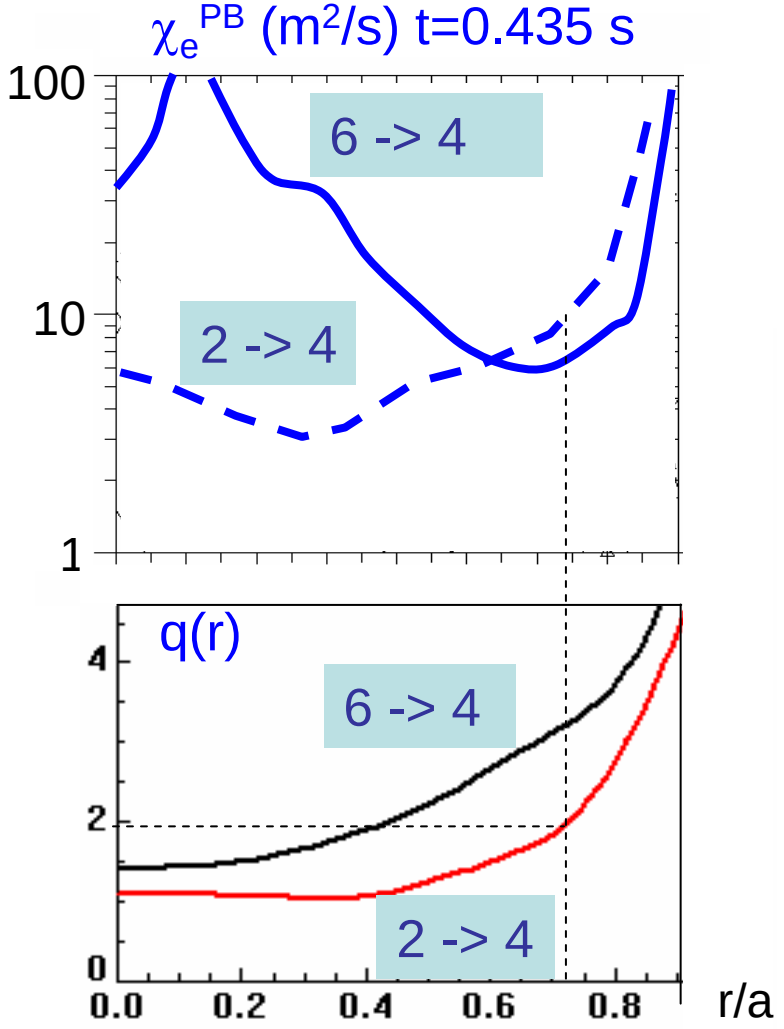
6 -> 4



2 -> 4

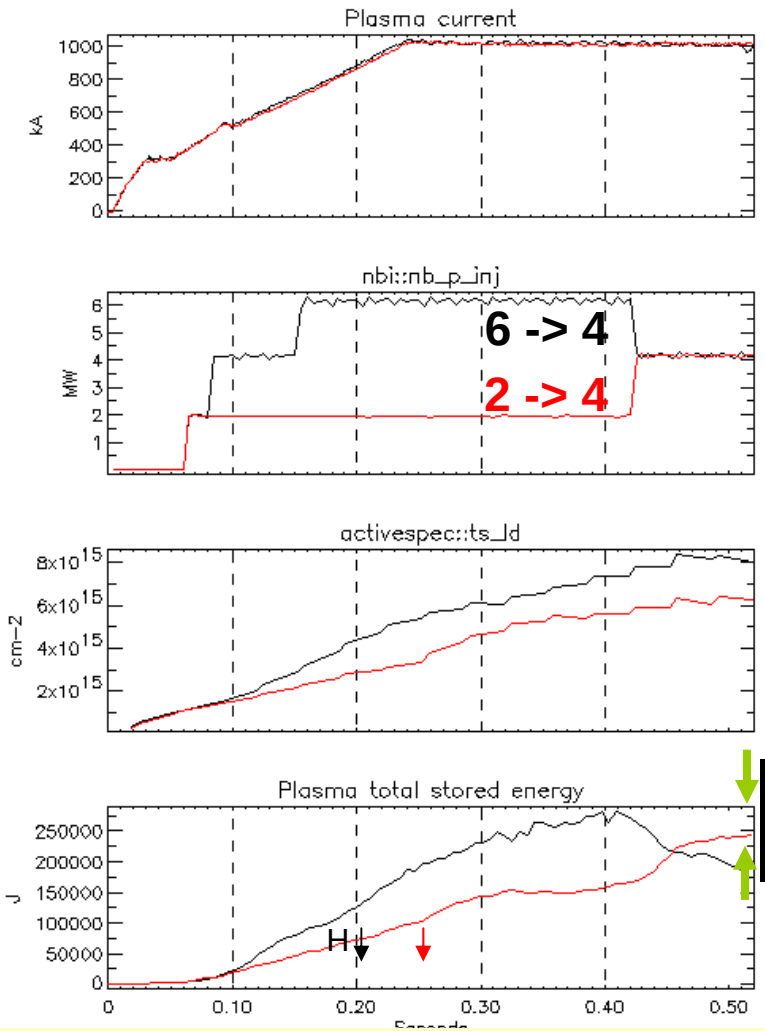


t (ms)



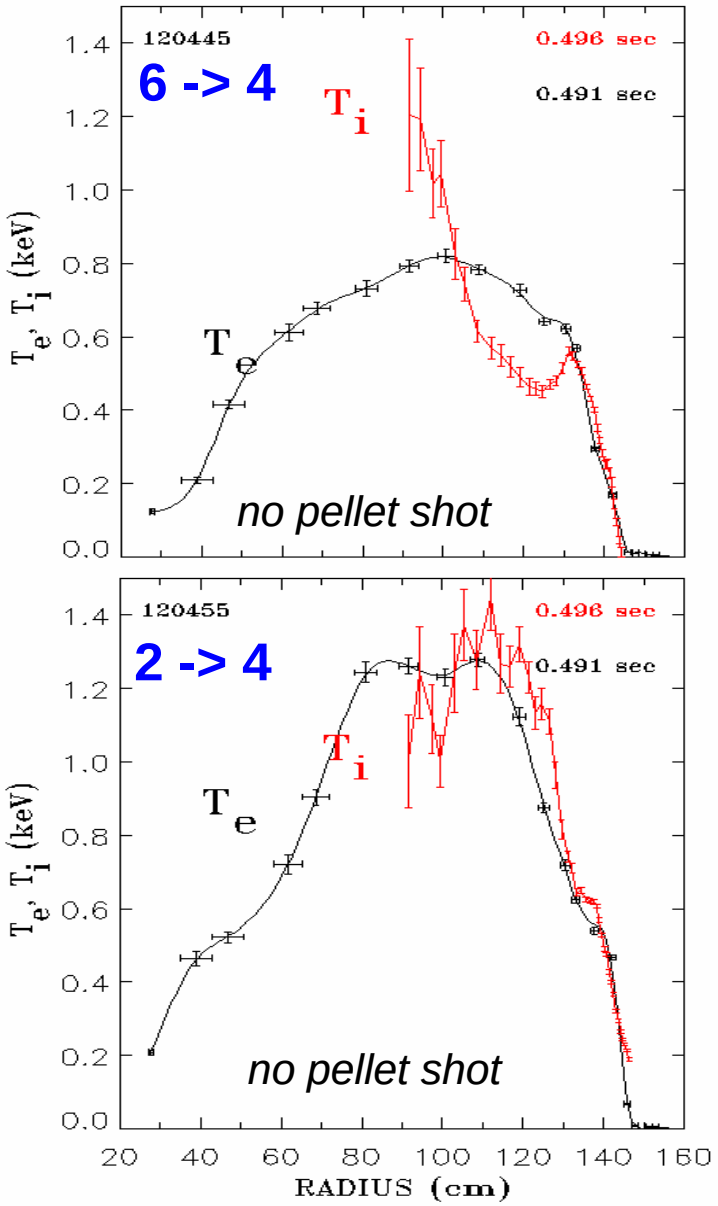
- Comparable magnetic shear
- Role of integer q-surfaces at large r/a (07)
- Synergy with equilibrium picture

Unusual perturbative effects seen also in T_i and rotation



ΔW_{tot}~50 kJ
ΔW_{el} ~13 kJ

t=0.5 s



- Unusual T_i profiles when power dropped
- Large difference also in rotation profiles

Proposed T&T research methodology

- Routine perturbative + equilibrium studies to resolve/understand scalings
- Use also I_p, B_t (?), heating profile (EBW), q, ExB perturbations
- New perturbative tools: high-Z TESPEL pellets, SGI, EBW, RWM coils
- Fast CHERS for T_i, V_t perturbations
- Add low-k n_e (n_z) fluctuations in H-mode core and pedestal
- Magnetic fluctuations (MSE ?), T_e fluctuations (EBW ?, USXR + TESPEL ?)
- Theory: unified treatment of ion and electron scales

  (prey-predator relation suggested by experiment)

JHU proposed T&T diagnostics

Pedestal/edge multi-energy SXR-VUV arrays for perturbative electron and particle transport

USXR-BES Telescope for low-k fluctuations at r < 0.3 (flat T_e)