Role of magnetic field, current and integer q-surfaces in NSTX electron transport

D. Stutman, K. Tritz, L. Delgado, M. Finkenthal

Johns Hopkins University

S. Kaye, M. Bell, R. Bell, B. LeBlanc

PPPL

R. Maingi

ORNL

F. Levinton, H. Yuh

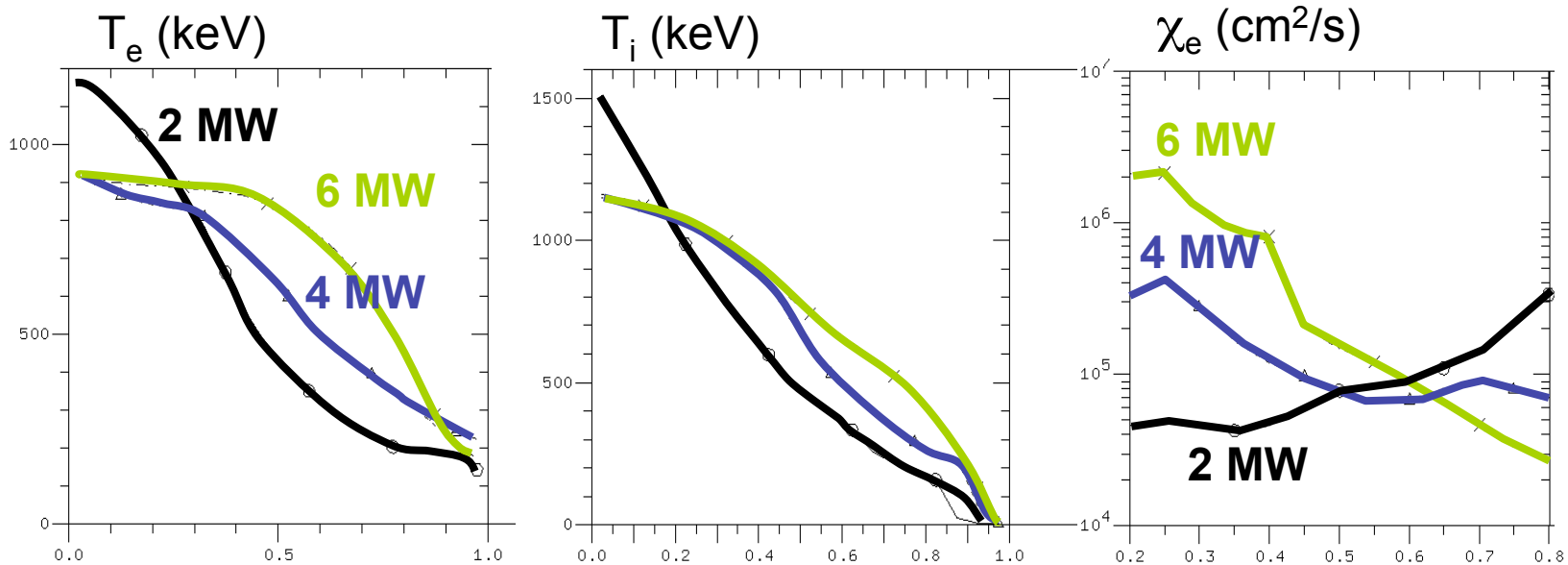
Nova Photonics

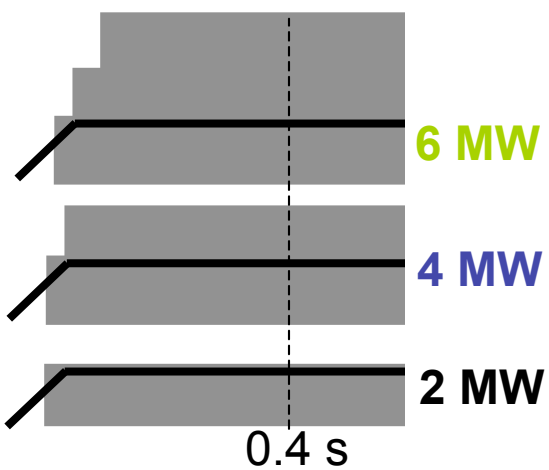
M. Austin

GA

Unusual broadening of $T_{e,i}$ with P_{NB} in NSTX H-modes

1 MA, 4.5 kG, early heating, ELM-free/small-ELM H-modes, t=0.4 s

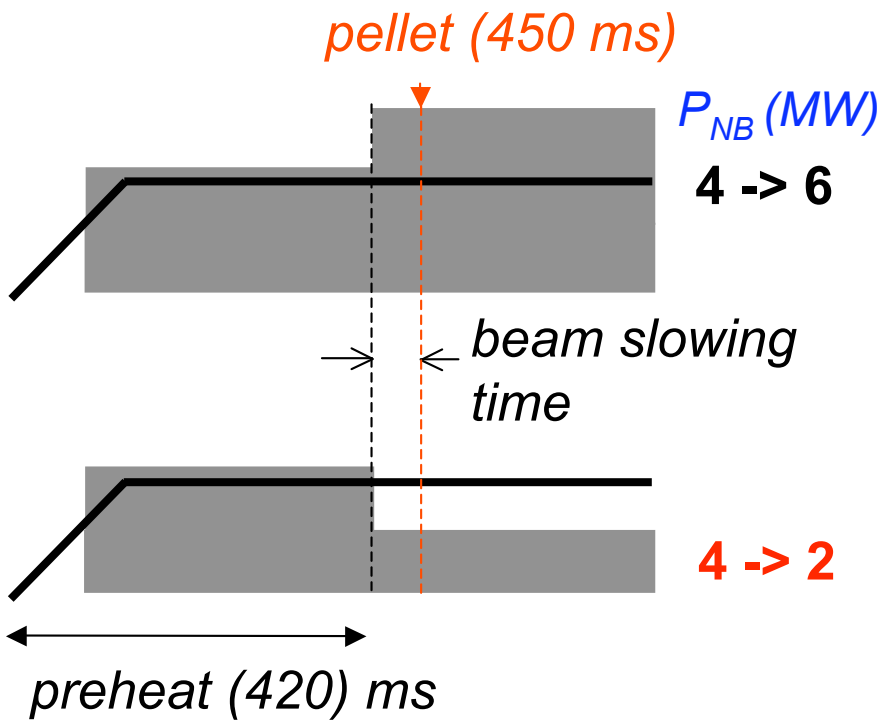




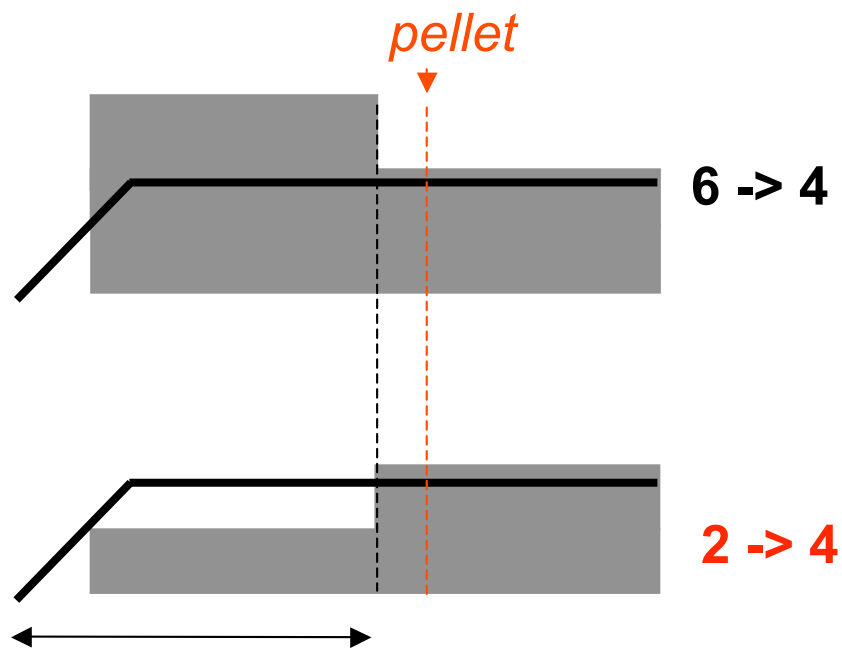
- **With early heating at high beam power most of the thermal gradient at r/a > 0.6**
- **Effect due to large change in χ_e**
- **Important issue for next step ST**

Effect studied through P_{NB}, pellet perturbations (XP612)

I) P_{NB} change at fixed q



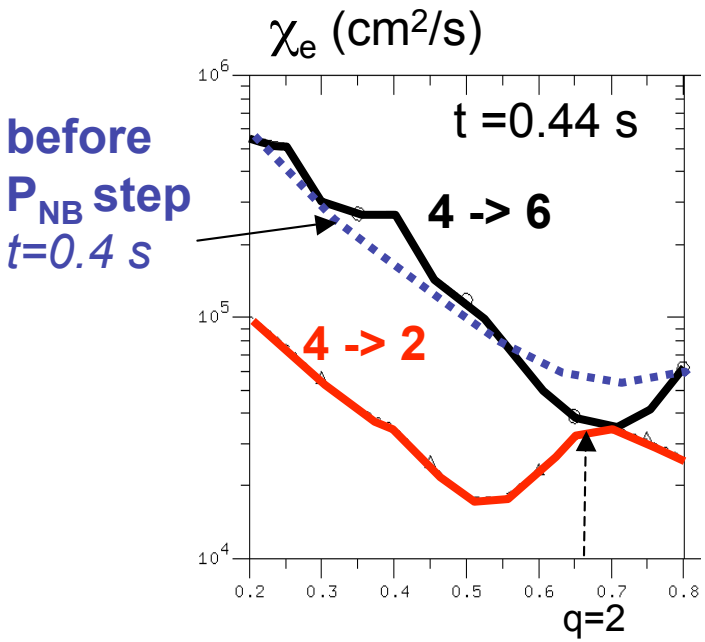
II) q change at fixed P_{NB}



- **Preheat to 'freeze-in' q-profile -> step P_{NB} and perturb with pellet**
- **'Frozen-in' q-profile varied by varying preheat power**
- **Study both ΔP_{NB} and pellet perturbations**

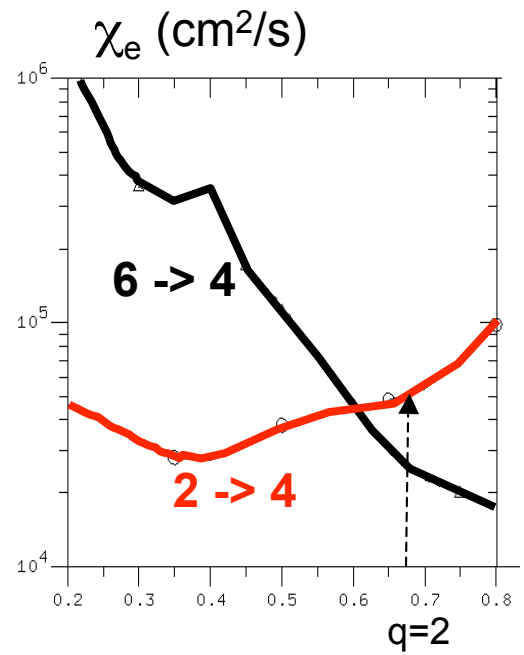
Results motivate further study

P_{NB} change at fixed q



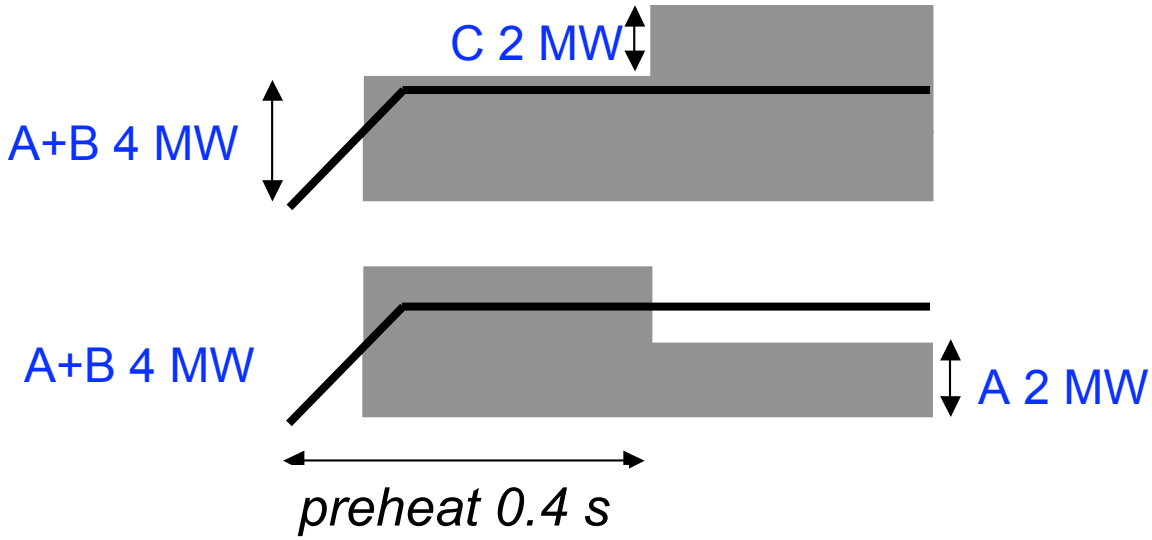
- **Large χ_e decrease at P_{NB} drop**
- **Very low critical gradient in NSTX (~ 0.25 keV/m)**
- **Scaling with B_t, I_p?**

q change at fixed P_{NB}



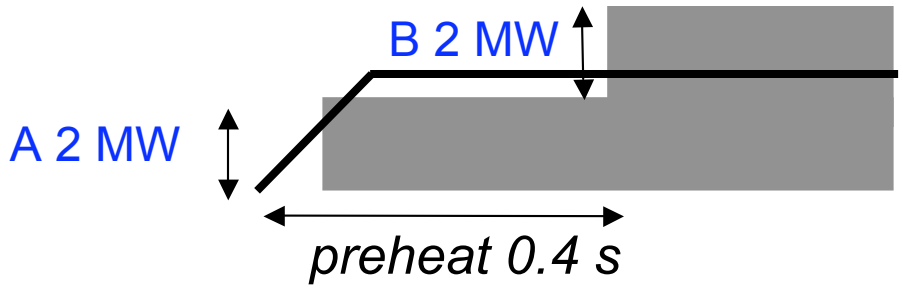
- **Large χ_e decrease inside q=2**
- **Also T_e modulations at q=1, 2 in NCS L-mode (zonal flows)**
- **Role of integer-q surfaces ?**

Part I: B_t, I_p scaling of transport change with P_b



- **Use recipe from XP 612 for P_b change at fixed-q**
- **Use P_b step/drop as main transport perturbation (MPTS+SXR for 1 ms T_e, CHERS at 5 ms ?)**
- **Do B_t and I_p scan at fixed I_p/B_t :**
  - **0.4 T / 0.9 MA**
  - **0.45 T / 1 MA (reference)**
  - **0.55 T / 1.2 MA**
- **Pellet perturbation later in the shot (after 3 CHERS frames)**
- **Try also RF modulation?**

Part II: Role of integer q-surfaces in NSTX transport



- **Goal I: Validate effect in H-mode (ITPA TP-8.2)**
- **Use recipe from XP 612 to 'freeze-in' q and step P_b to perturb transport**
- **Scan I_p at two fields to vary radii and value of integer-q surfaces**

  0.45 T : 0.9 / 1 / 1.2 MA

  0.55 T : 0.9 / 1 / 1.2 MA

- **Goal II: Verify role of collisionality (effect seen at low n_e so far)**
- **Density scan in 1 MA, 2 MW, H-mode**

  $\langle n_e \rangle$ = 2 / 3 / 4 x10^{13}

- **Time permitting, repeat in 2 MW NCS L-mode**

12 shots x 2 = 1 run day

Suggested ITPA relevant experiments (TP-8.2, M. Austin *et al*)

1) Validate effect in H-mode (where difficult to see in small $\rho*$ devices)

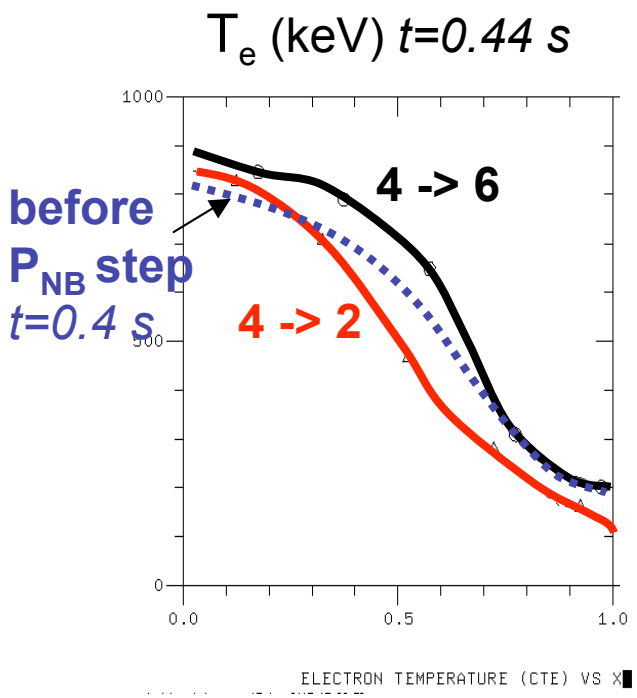
2) Verify role of collisionality (mostly seen at low n_e so far)

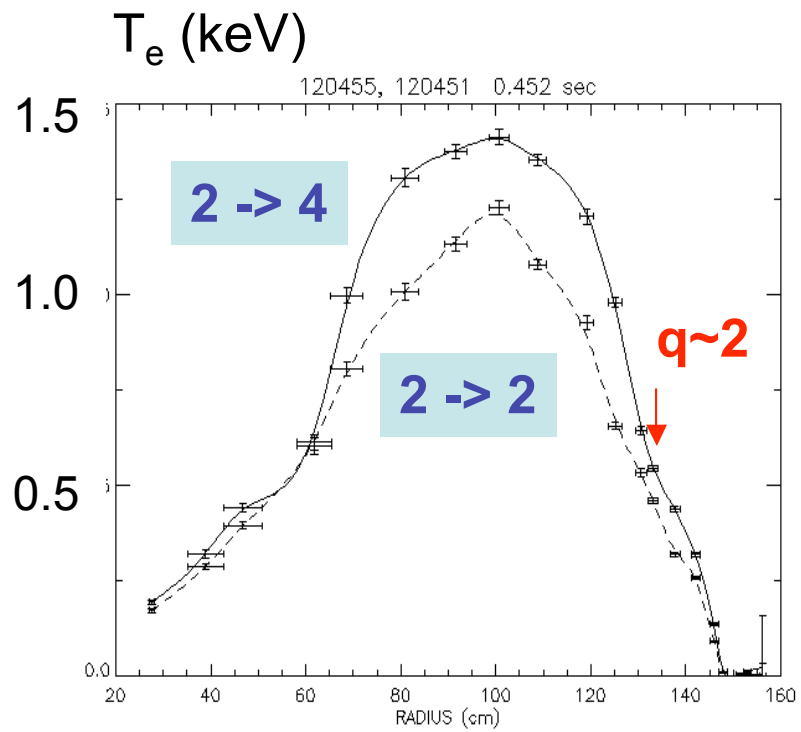
3) Compare effect in discharges with more/less negative shear

4) Measurements of interest:

- **correlate equilibrium and perturbed χ with integer-q**
- **SXR diagnostic of fast changes in the T_e profile**
- **changes in poloidal rotation**
- **low-k fluctuations in the core**

P_b step /drop makes useful T_e profile perturbation

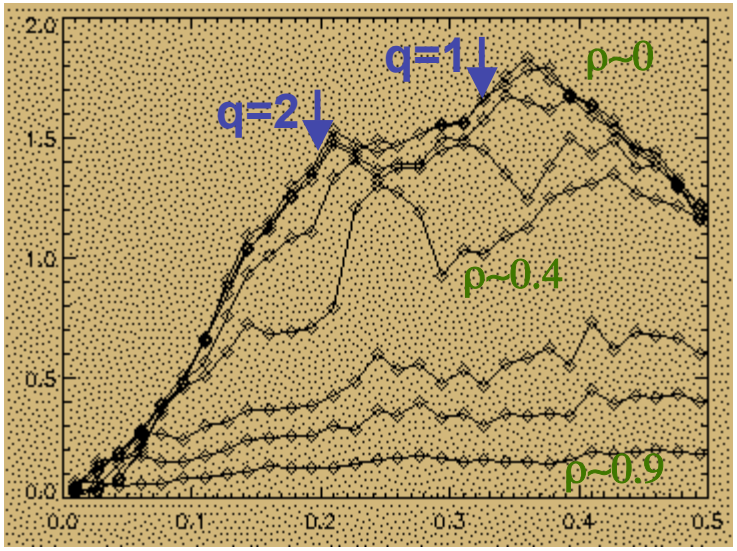




Role of integer-q also evident in low n_e/NCS L-mode

2 MW L-mode (112989)

inboard T_e (keV)



t (s)

- **Step T_e changes when q approaches integer q-surfaces, as in DIII-D**
- **Zonal flow/magnetic geometry model (M. Austin *et al* PoP 2006)**
- **Possibly fundamental explanation why electron confinement improves**