Scaling experiments of perturbative impurity transport in NSTX

D. Stutman, M. Finkenthal

Johns Hopkins University

J. Menard, E. Synakowski, B. Leblanc,R. Bell, S. Kaye, V. Soukhanovskii, D. Darrow

Princeton Plasma Physics Laboratory

C. Bourdelle

CEA, Cadarache

M. Gilmore

University of California, Los Angeles

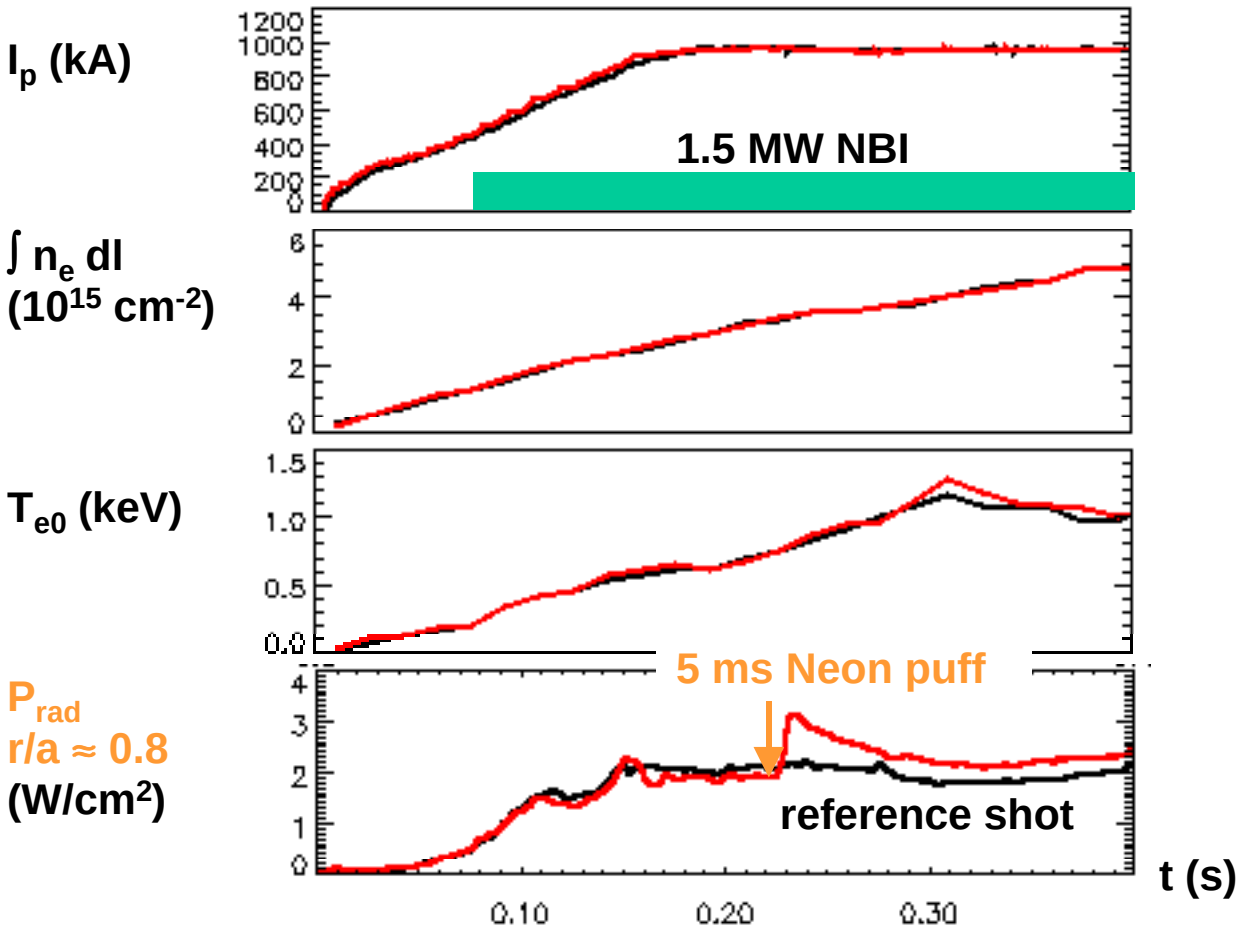
Motivation

- Field and momentum input effect on impurity transport in NSTX
- Part of larger experiment aimed at dimensionless scaling
- Impurity transport is <u>independent</u> probe of the ion channel:
  - χ_i from power balance still uncertain (*D. Gates invited talk*)
  - electron channel strongly dominates

Tools

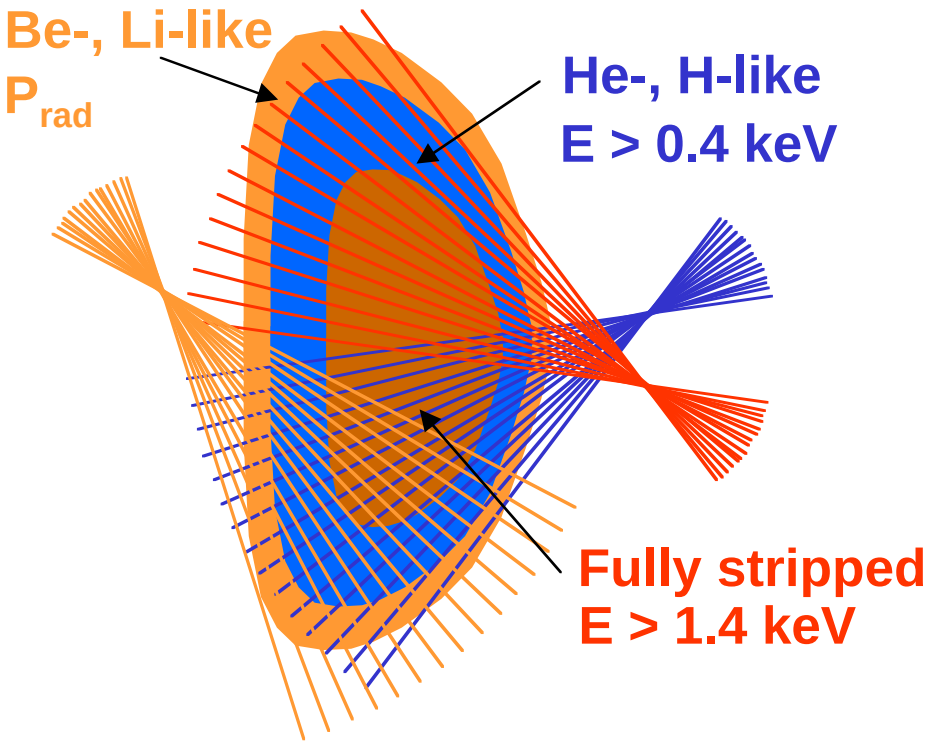
- Brief, non-perturbing Neon puff into beam heated discharges
- Ultrasoft X-ray (USXR) imaging + high resolution spectroscopy
- Atomic physics + transport modeling

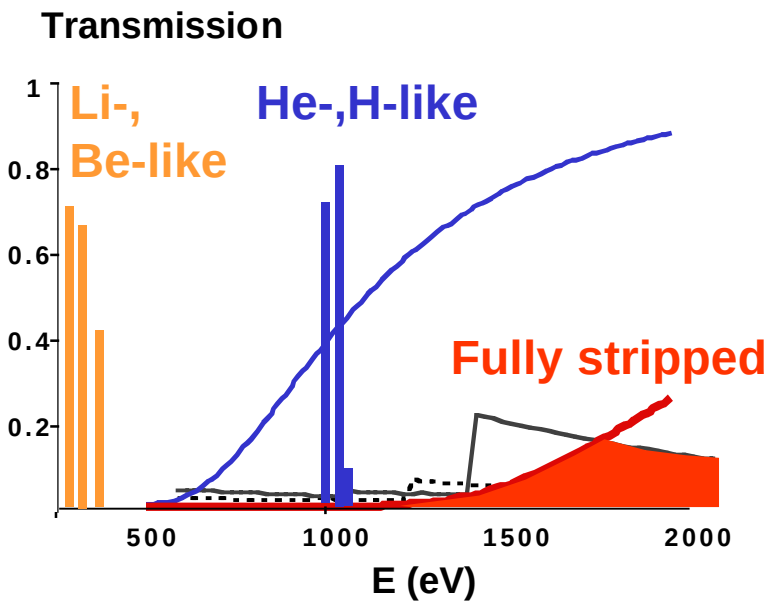
Injection experiments



- Neon injected in L-mode, MHD-free ($q_0 > 1$), DND discharges
- Injection is non-perturbing ($n_{Ne}/n_e \approx 0.5\%$)
- Fast puff enhances contribution of diffusive term

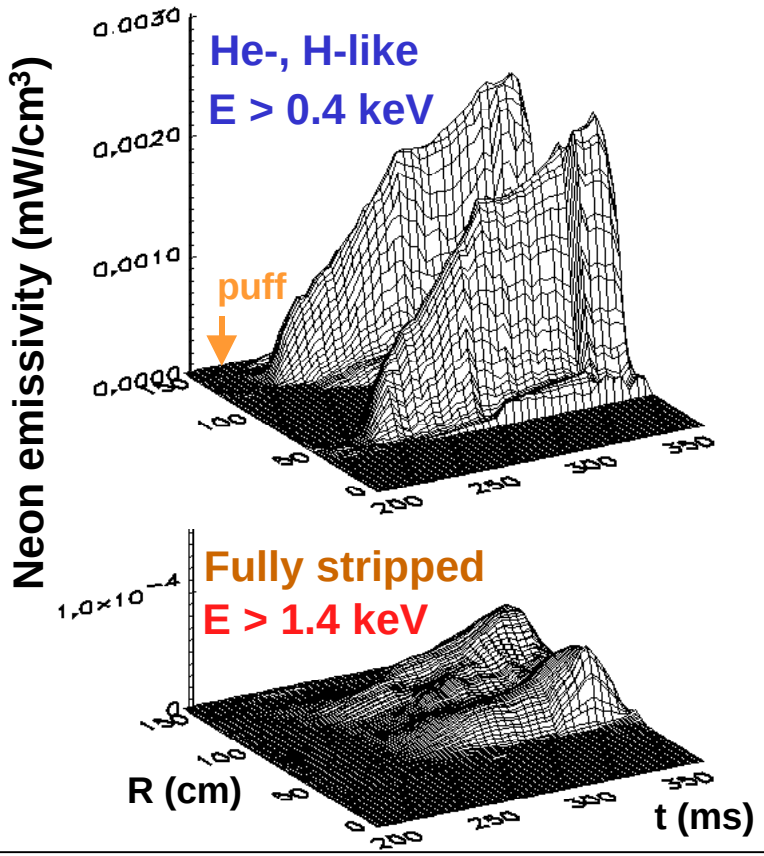
USXR diagnostic

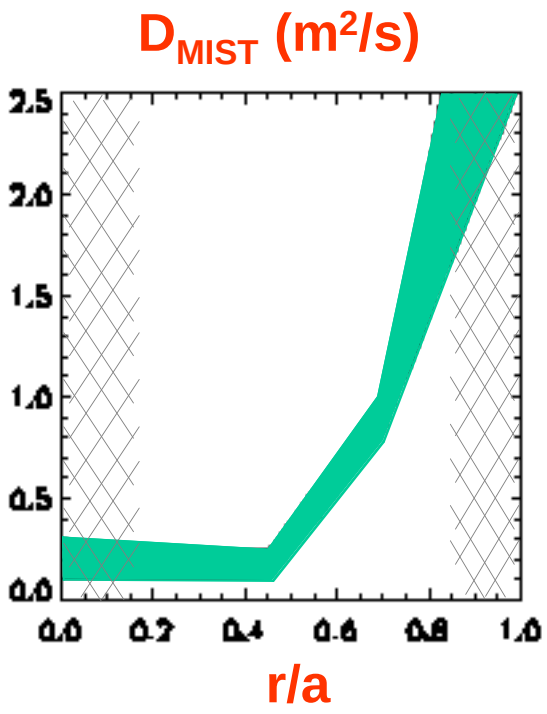




- Three diode arrays for peripheral, mid and core Ne charge states
- Neon contribution from consecutive, reproducible shots
- Average emissivity from up/down profiles (symmetric)
- Inclusion of peripheral charge states (P_{rad}) improves D, V estimate

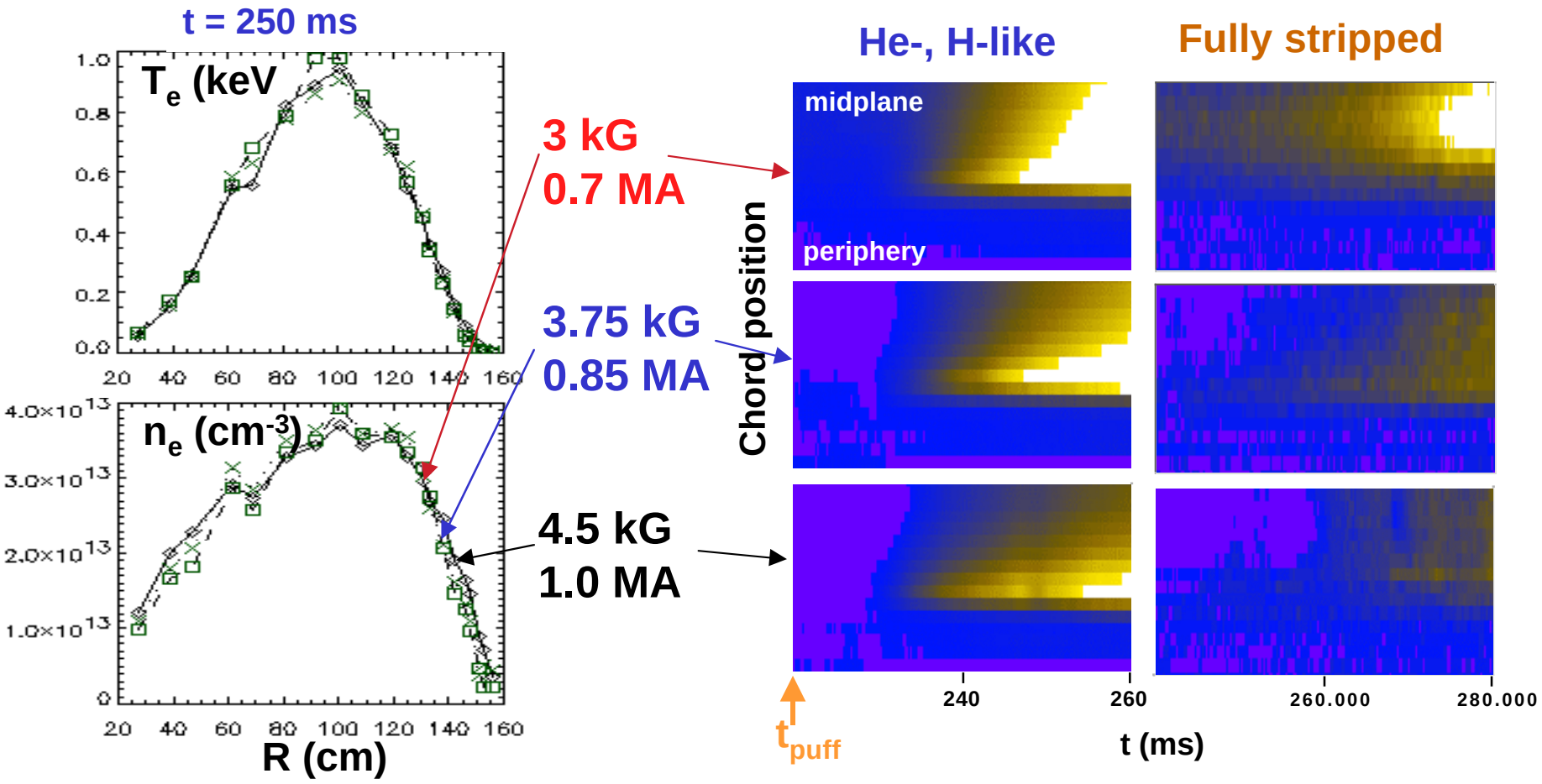
Neon penetration at 4.5 kG/1 MA





- Slow core penetration despite fast rise in peripheral Neon density
- Core D (MIST) in the neoclassical range
- Pinch velocity V ≈ 0
- Microstability computations predict ITG turbulence intrinsically suppressed in NSTX and *not* ExB shear effect (C. Bourdelle NF 02)

B_t scan at fixed B_t/I_p and n_e reveals strong effect



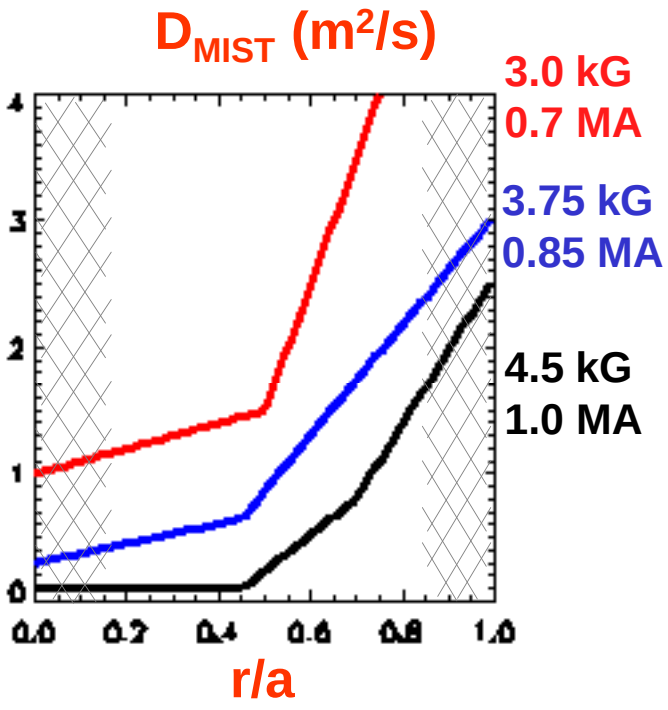
- Both peripheral and core charge states penetrate less at higher field despite very similar electron profiles

Ne diffusion decreases significantly at higher field

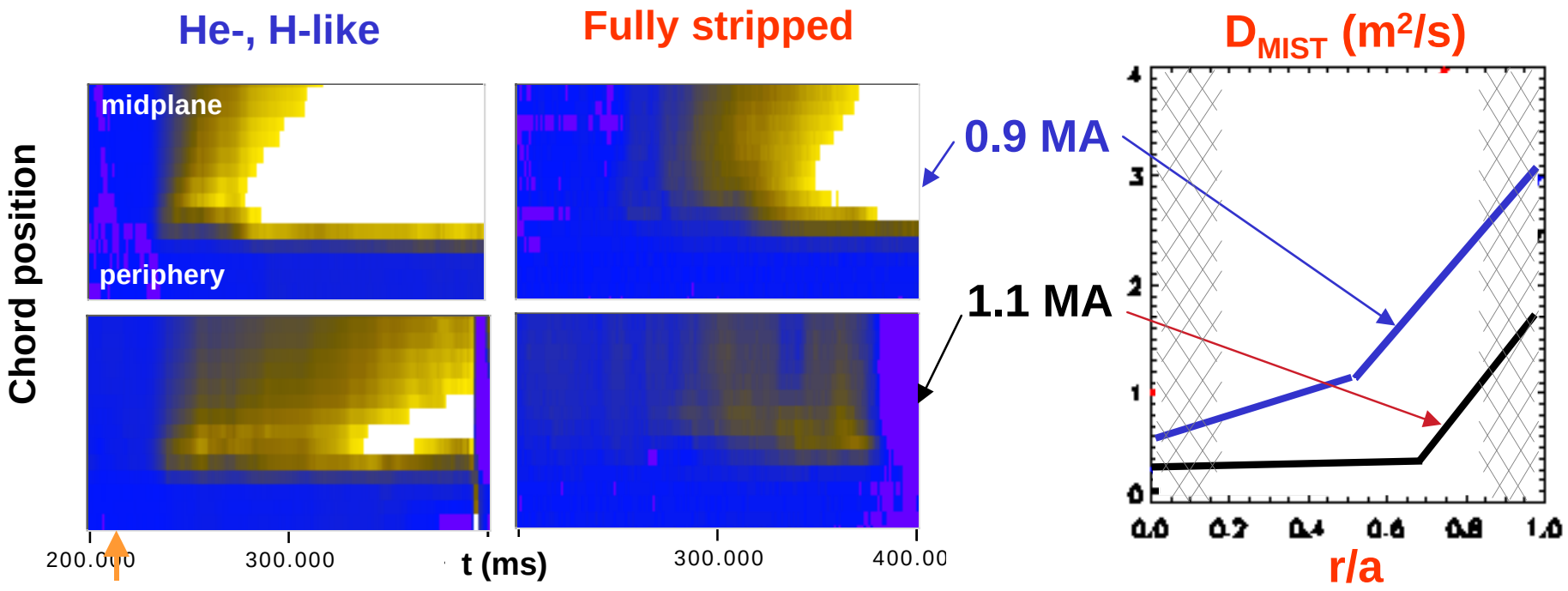
- Peripheral turbulence correlation length also strongly decreases
  (see following talk by M. Gilmore)

- Comparable effect also observed with B_t scaling at fixed I_p

- Note that B_t/I_p is 'true' $\rho*$ scaling in a ST: since $B_{t\ in} >> B_{t\ out}$, scaling only B_t or I_p changes ρ_{in}, ρ_{out} in different proportions



Significant decrease in D with only 20% I_p increase



- Turbulence correlation length also decreases with I_p (M. Gilmore)
- Threshold effect ? MHD ?
- W_{tot} and τ_E *do not* scale with I_p/B_t however
- Also, $W_{electron}/W_{tot}$ 'frozen' at ≈ 0.35-0.40
- Changes in Neon transport and edge turbulence not accompanied by changes in $W_{th\ ion}$, T_i profiles ? (T_i data in progress)

Possible explanation

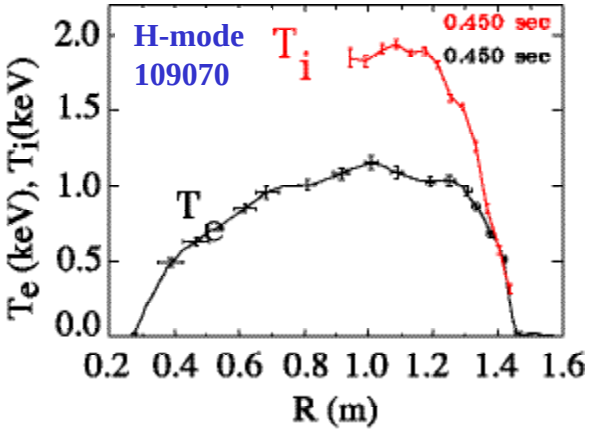
- $T_i > T_e$ in beam heated NSTX discharges
- Estimated $\chi_i \leq$ neoclassical, while $\chi_e >> \chi_i$
- Ion power balance:

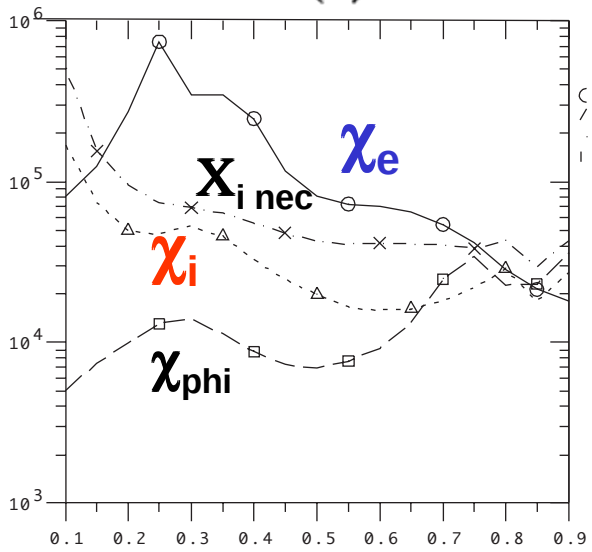
$$P_{cond} = P_{in} - \frac{dW_i}{dt} - Q_{ie}$$

0

⇓

thermal ion profiles governed in fact by the balance between P_{in} (anomalous ?), Q_{ie} and χ_e





To be replaced with P_{Cond} graph

Summary

- Neon technique is sensitive to transport changes
- Further evidence of ‘naturally’ low particle transport in the NSTX core
- Initial scaling experiments suggest particle transport and ion scale turbulence decrease with ρ^*
- Global confinement and ion energy content do not scale similarly; negligible ion and large electron conduction loss possible reason
- I_p scaling data hints at threshold effects