Scaling experiments of perturbative impurity transport in NSTX

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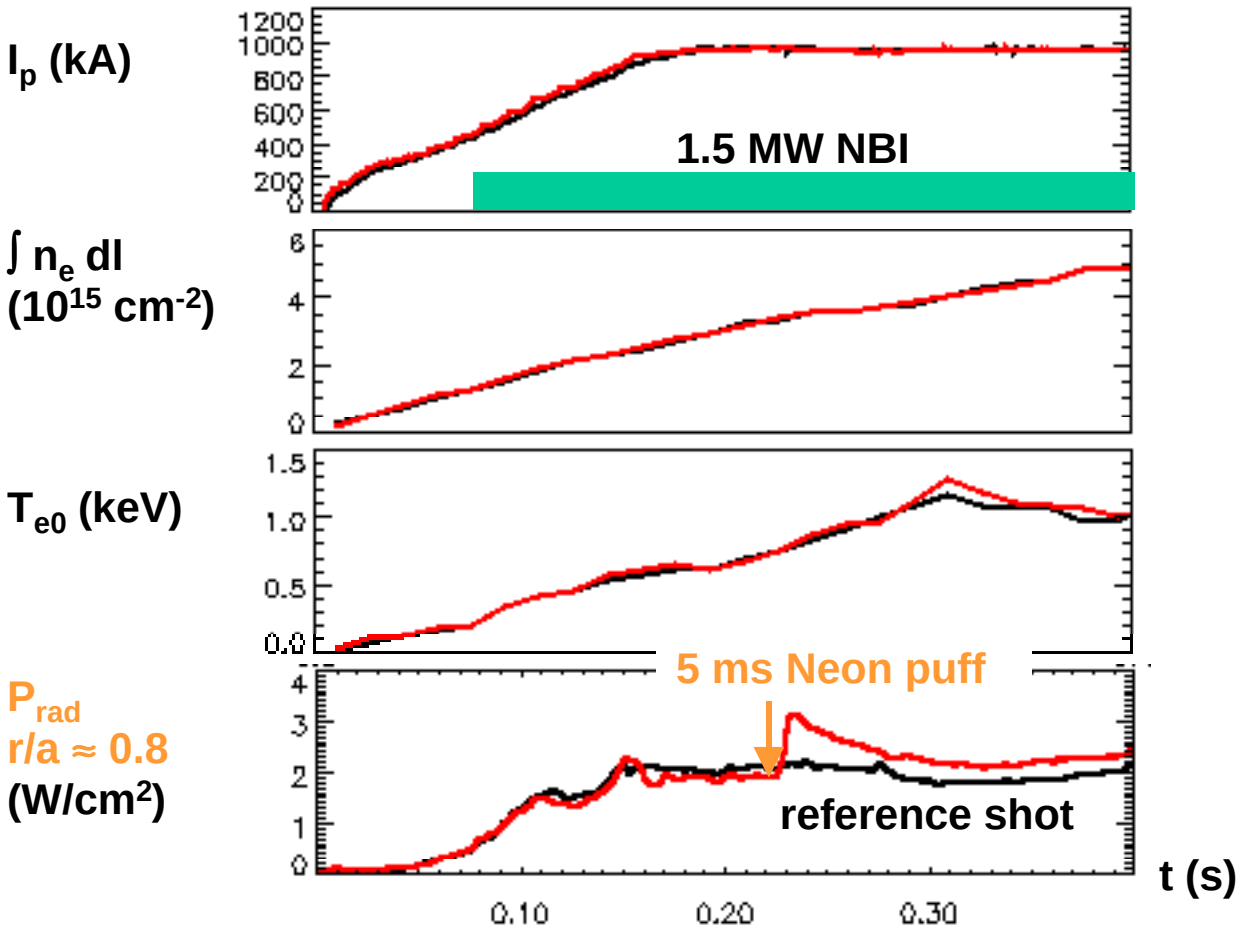
Motivation

- 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

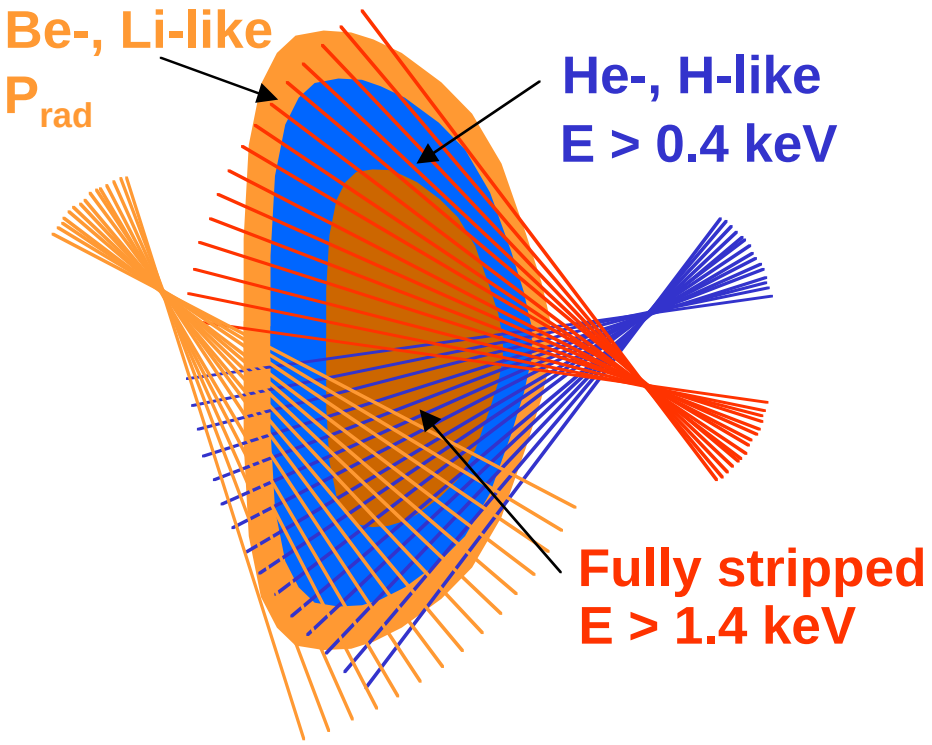
- Brief, non-perturbing Neon puff into beam heated discharges
- Ultrasoft X-ray (USXR) imaging + high resolution spectroscopy
- Atomic physics + transport modeling

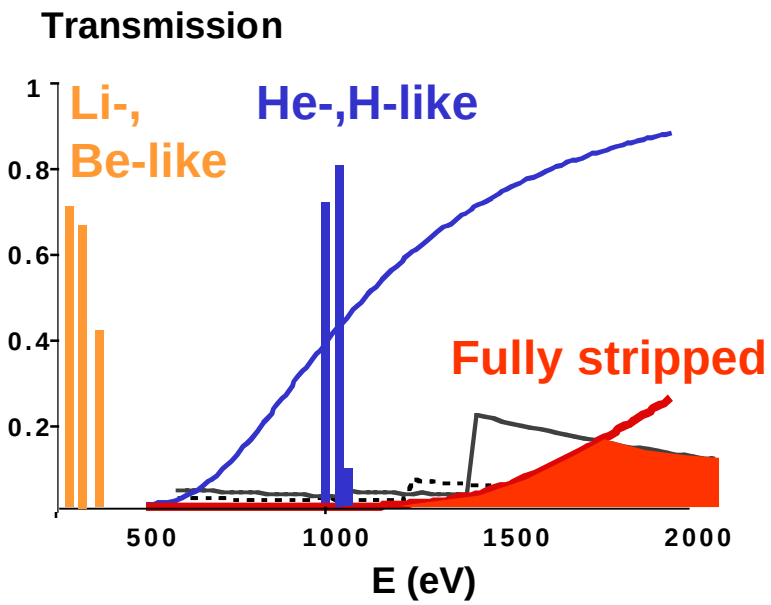
Injection experiments



- 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

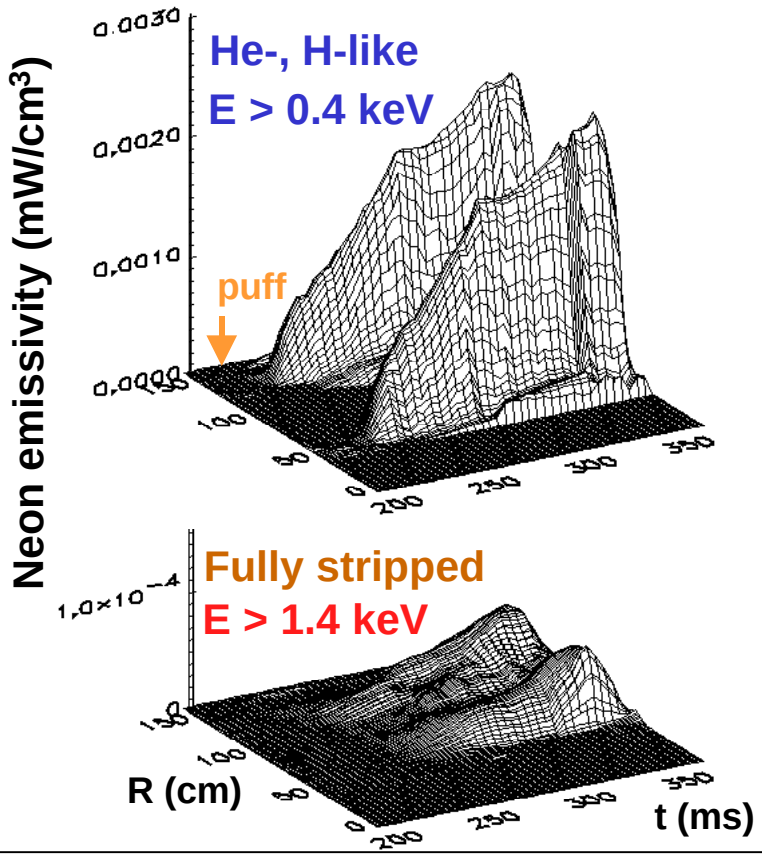
USXR diagnostic

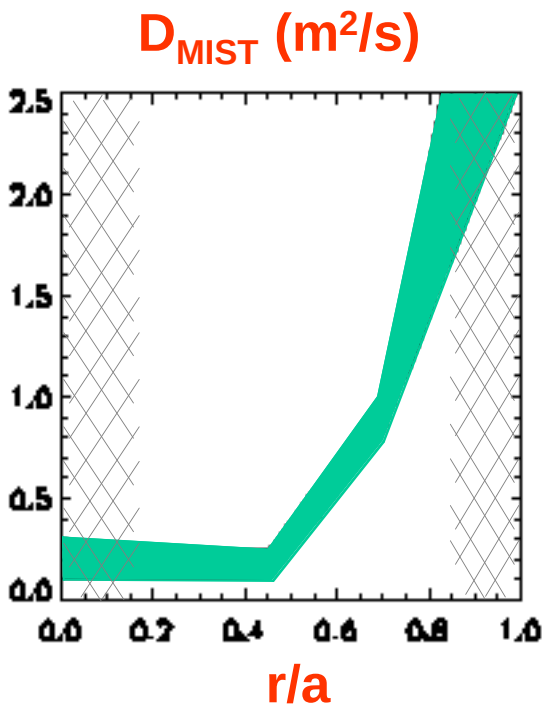




- Three diode arrays for peripheral, mid and core Ne charge states
- Neon contribution from consecutive, reproducible shots
- Average emissivity from the up/down profiles (symmetric)
- Inclusion of peripheral charge states (P_{rad}) improves D, V estimate

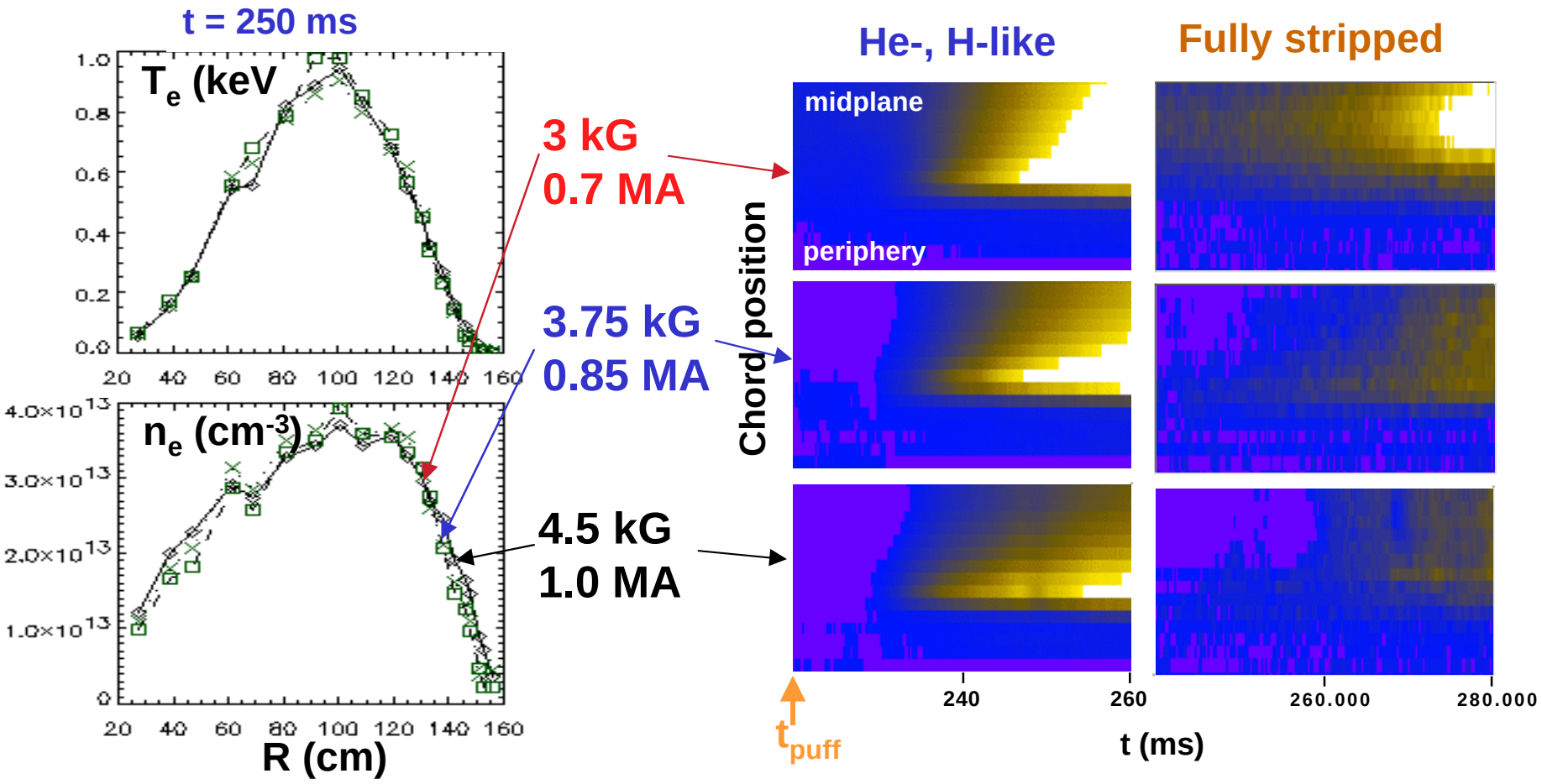
Neon penetration at 4.5 kG/1 MA





- Slow core penetration despite fast rise in peripheral Neon density
- Best fit modeling (MIST) indicates core D in the neoclassical range
- No significant pinch velocity (V < 0.5 m/s)
- 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 reveals strong effect



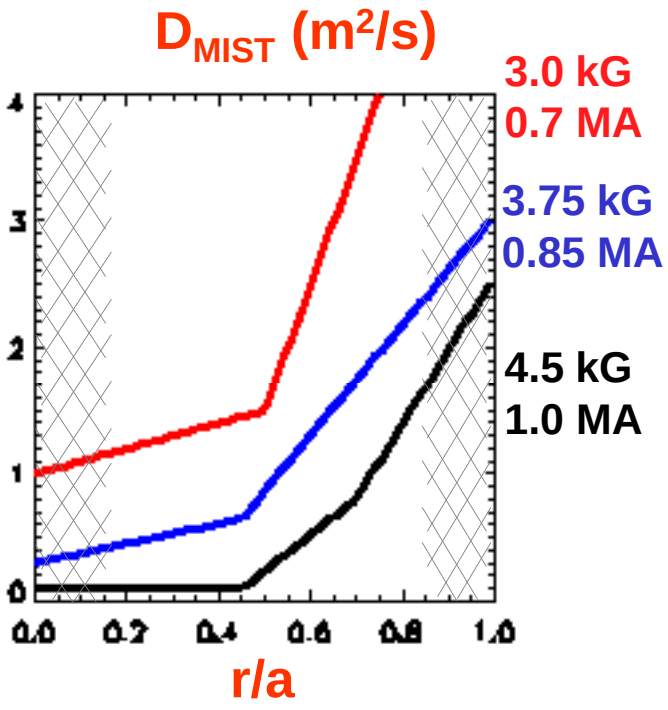
- Both peripheral and core charge states penetrate less at higher field, despite very similar electron profiles

Neon diffusion decreases at higher field

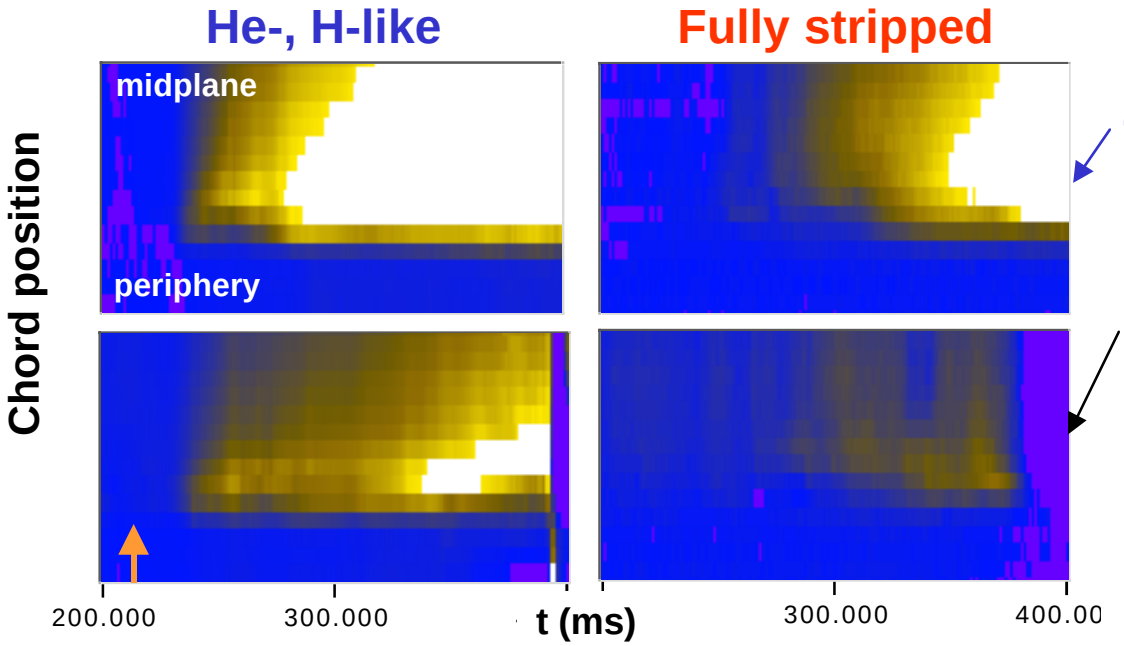
- Peripheral turbulence correlation length also strongly decreases
  (see following talk by M. Gilmore)

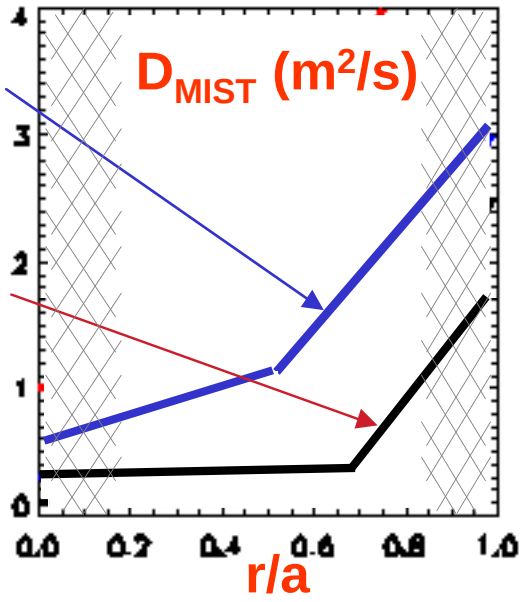
- Comparable effect also observed with B_t scaling at fixed I_p

- Note that B_t/I_p is 'true' ρ^* scaling in a ST:
  - since $B_{t\,in} >> B_{t\,out}$, varying B_t or I_p separately, changes ρ^*_{in} and ρ^*_{out} in different proportions



Large D decrease for only 20% I_p increase





- Turbulence correlation length also decreases with I_p (M. Gilmore)
- Threshold effect around 1 MA ?

- **Global confinement:** W_{tot} and τ_E *do not* scale with I_p/B_t

  $W_{electron}/W_{tot}$ '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
- $\chi_i \lesssim \chi_{i\ neoclassical}$, while $\chi_e >> \chi_i$
- Ion power balance:

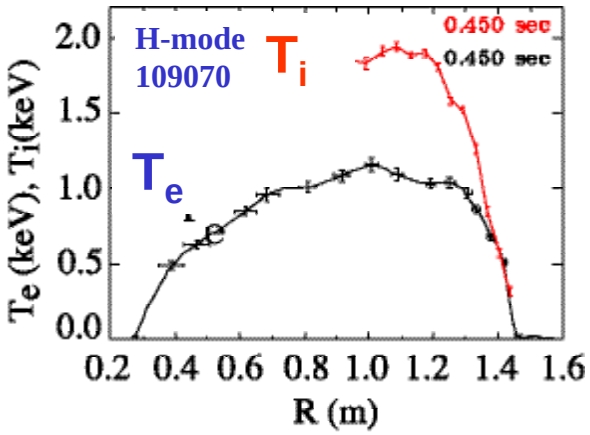
$$P_{conduction} = P_{input} - \frac{dW_i}{dt} - Q_{i-e}$$

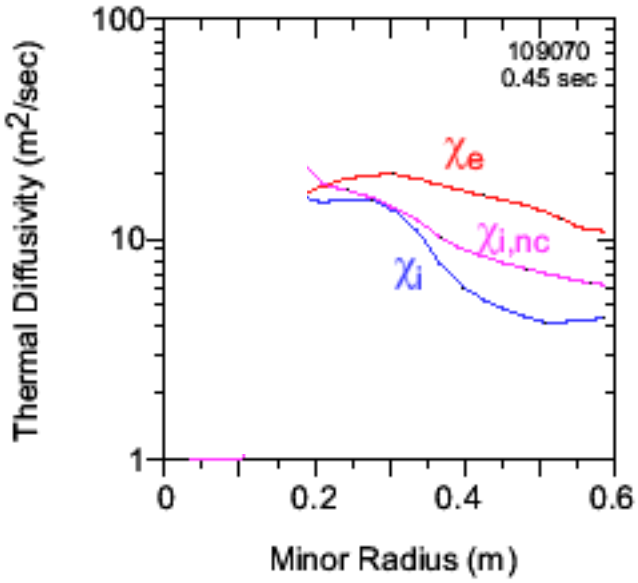
$P_{conduction} \rightarrow 0$

$\Downarrow$

thermal ion profiles governed in fact by the balance between P_{input}, $Q_{i\text{-}e}$ and χ_e

R. Bell, PPPL





S. Kaye, PPPL

Summary

- Sensitive technique for perturbative transport developed
- Further evidence of 'naturally' low particle transport in the NSTX core
- Initial scaling experiments suggest both particle transport and ion turbulence decrease with ρ^*
- Global confinement and ion energy content do not scale similarly; negligible ion and large electron conduction a probable reason
- I_p scaling hints at threshold effects