Simulations of NSTX with a Liquid Lithium Divertor Module*

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NSTX Results Review 2008

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Calibrate UEDGE Input Parameters Using NSTX Data

NSTX

- Simulate shot 128339 @ 0.35 s.

- Solve equations for n_i, T_e, T_i, $u_{\|}$,

  - Set core b.c. using Thomson scattering: $n_e = 4.3 \times 10^{19}$ m^{-3}, and $T_e = 130$ eV.

  - Classical transport along field lines & anomalous across flux surfaces.

  - Adjust $D(\psi)$, $\chi_e(\psi)$, $v(\psi)$ to match midplane profiles.

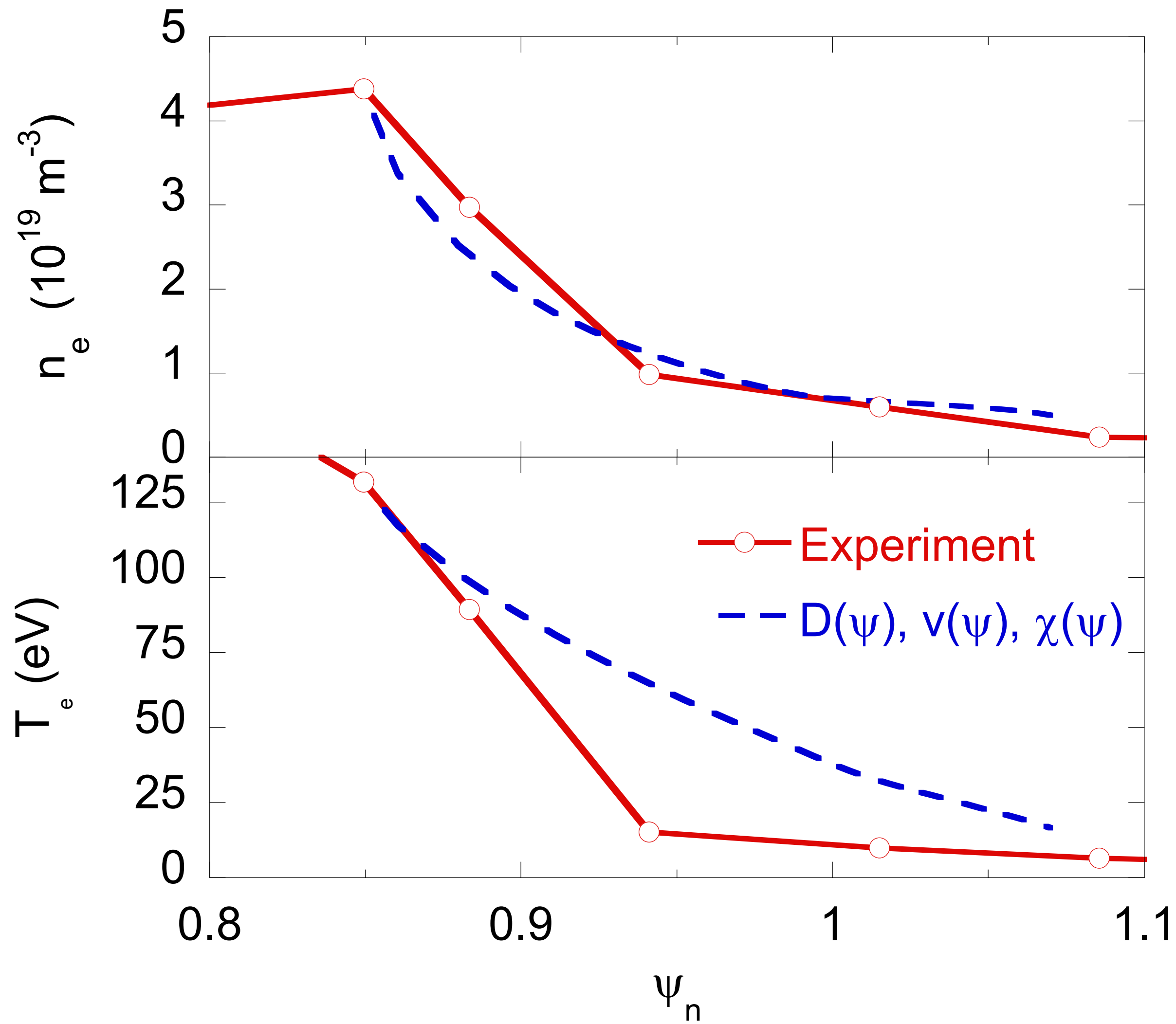
- And to match power flowing in from core: $P_{\text{in}} = 1.7 – 1.8$ MW.

- Particle input:

  - Lump external fueling into core particle source,

  - Require magnitude consistent with center stack gas puff (400 A) $+$ NBI (18 A).

Use Midplane Profiles to Set Transport Coefficients

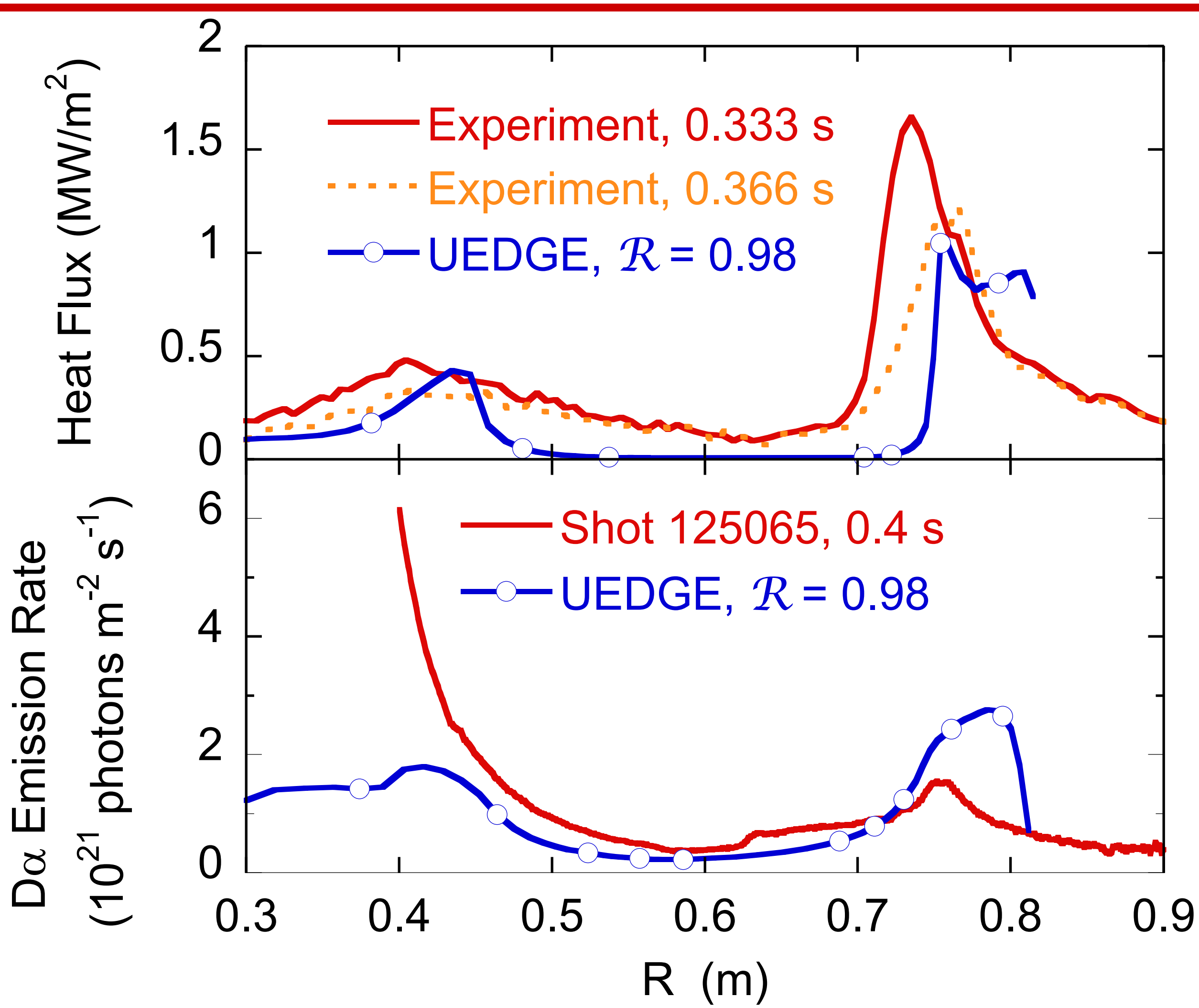


- $D(\psi)$ = 0.04 (core) → 0.1 (wall) m^2/s,
- $v(\psi)$ = 0 → 30 m/s,
- $\chi(\psi)$ = 1.5 → 35 m^2/s.

- Core power: P_e = 0.98, P_i = 0.82, = 1.8 MW total,
- D+ current from core: 440 A; D current to core: 142 A.

Divertor Profiles Reasonable with Nominal Pumping

NSTX



- Improving D_α agreement requires much more complex approach.

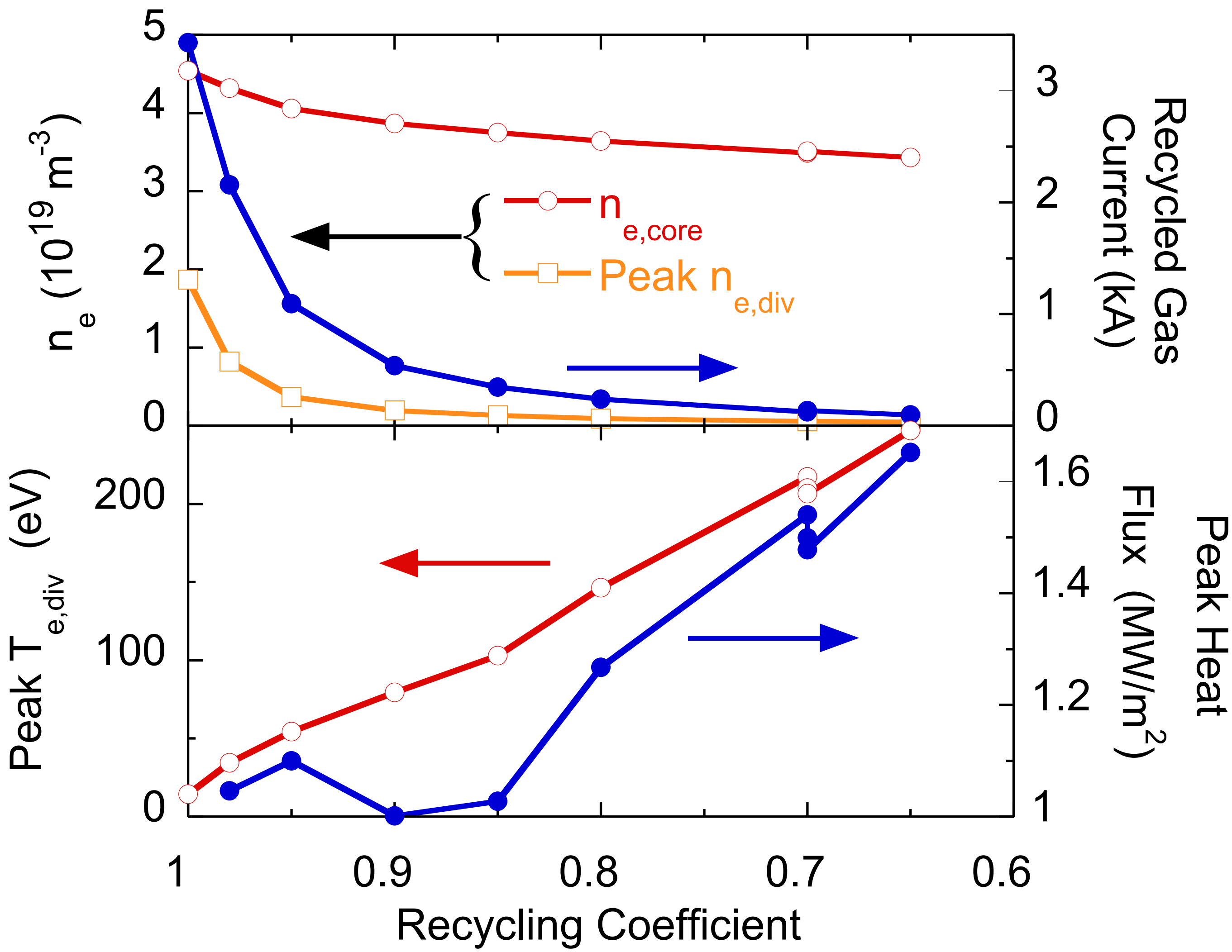
Simulate Effect of LLD as Reduction in Recycling

- Theoretical lower limit = 0.1 – 0.3,
  - Actual values higher due to variations in coatings & surface contamination.
  - Don't know *a priori* $\Rightarrow$ do scan.

- First change $\psi_n = 0.85$ boundary condition from specified n & T to specified particle flux & power,
  - Fix these & transport model as recycling varied.

- Introduce LLD as reduction in $\mathcal{R} \equiv \mathcal{R}_{od} = \mathcal{A}_{od}$,
  - Lower limit: $\mathcal{R} = 0.65$ set by ability of UEDGE to converge.

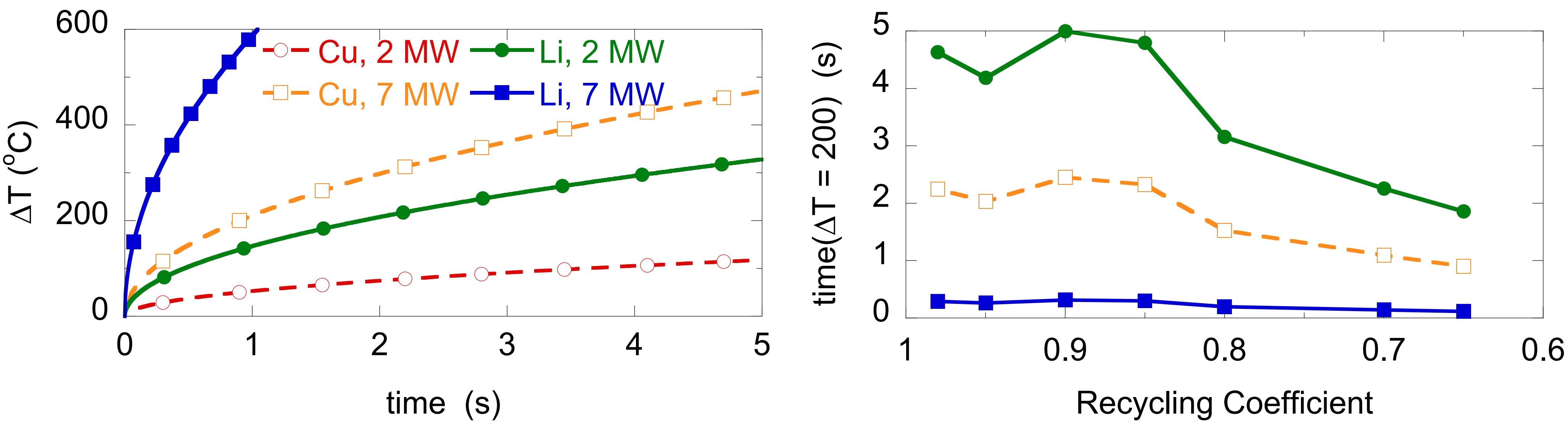
Scan of Recycling Coefficients will Feed into Future Work



- Will compare core density with 0-D particle balance calculations.
- Peak divertor n_e & T_e impact lithium transport.
- Total current drops 40 x,
  - Compare with 3 x drop in D_α in CDX-U $\Rightarrow$ Difficult to approach theoretical minimum recycling in practice.

Li Temperature Limit Could Be Reached at Maximum Input Power

NSTX



- Simple calculation for illustrative purposes,
  - Should instead feed heat flux data into Zakharov's 3-D calculations.
- ΔT from 200 °C shown for $\mathcal{R}$ = 0.65 case.
- Consider LLD thermal properties to be like pure Cu or Li
- Present 2 s discharges OK for 1.8 MW Li.
- But, pulse length restricted at 7
  - Especially if Li coating thick.

Discussion

NSTX

- Simulation of existing & recycling scan will be used to check 0-D particle balance calculations,
  - Were utilized in selecting LLD radius & width.
- Use UEDGE profiles & thermal analysis to compute reflection, sputtering, evaporation of lithium,
  - Surface models based on coupled REDEP/WBC, TRIM-SP, & MD simulations.
- Self-consistent erosion / redeposition simulation $\Rightarrow$ net flow of Li away from surface,
  - Feed flux back to UEDGE $\Rightarrow$ Li distribution in core & SOL.