NSTX

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Radiative divertor with impurity seeding in NSTX

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Acknowledgements:
NSTX Team

NSTX Results Review
Princeton, NJ
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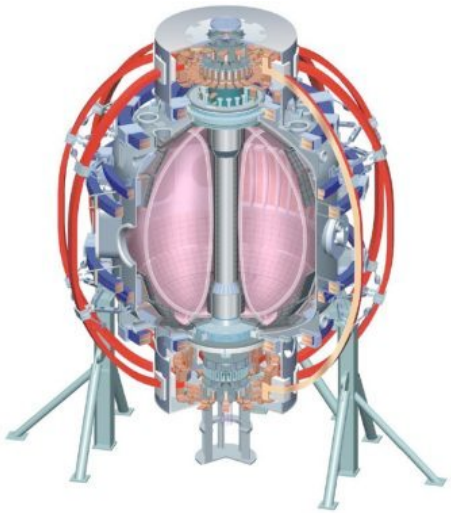

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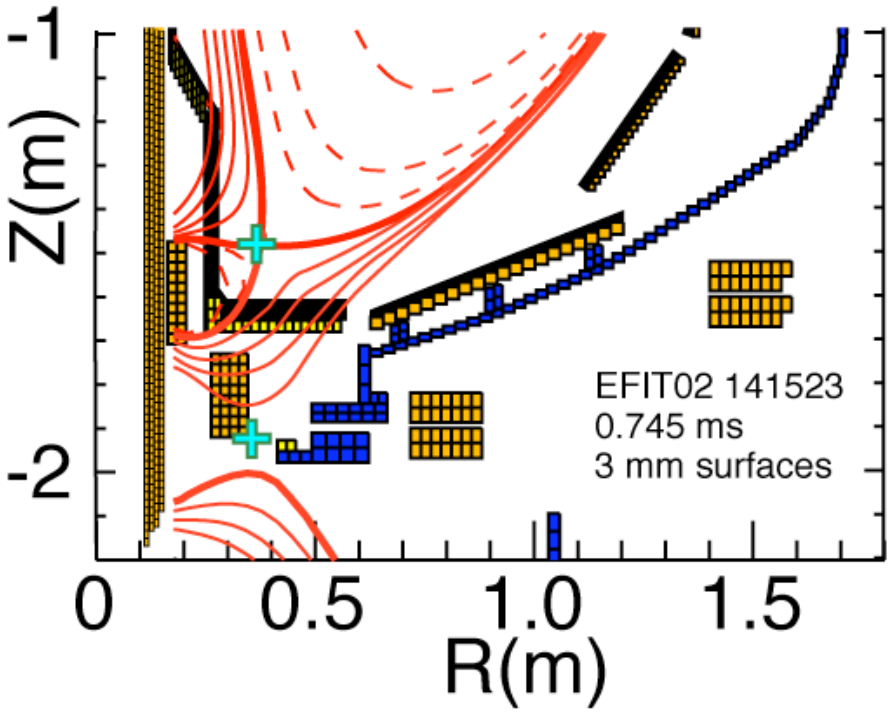
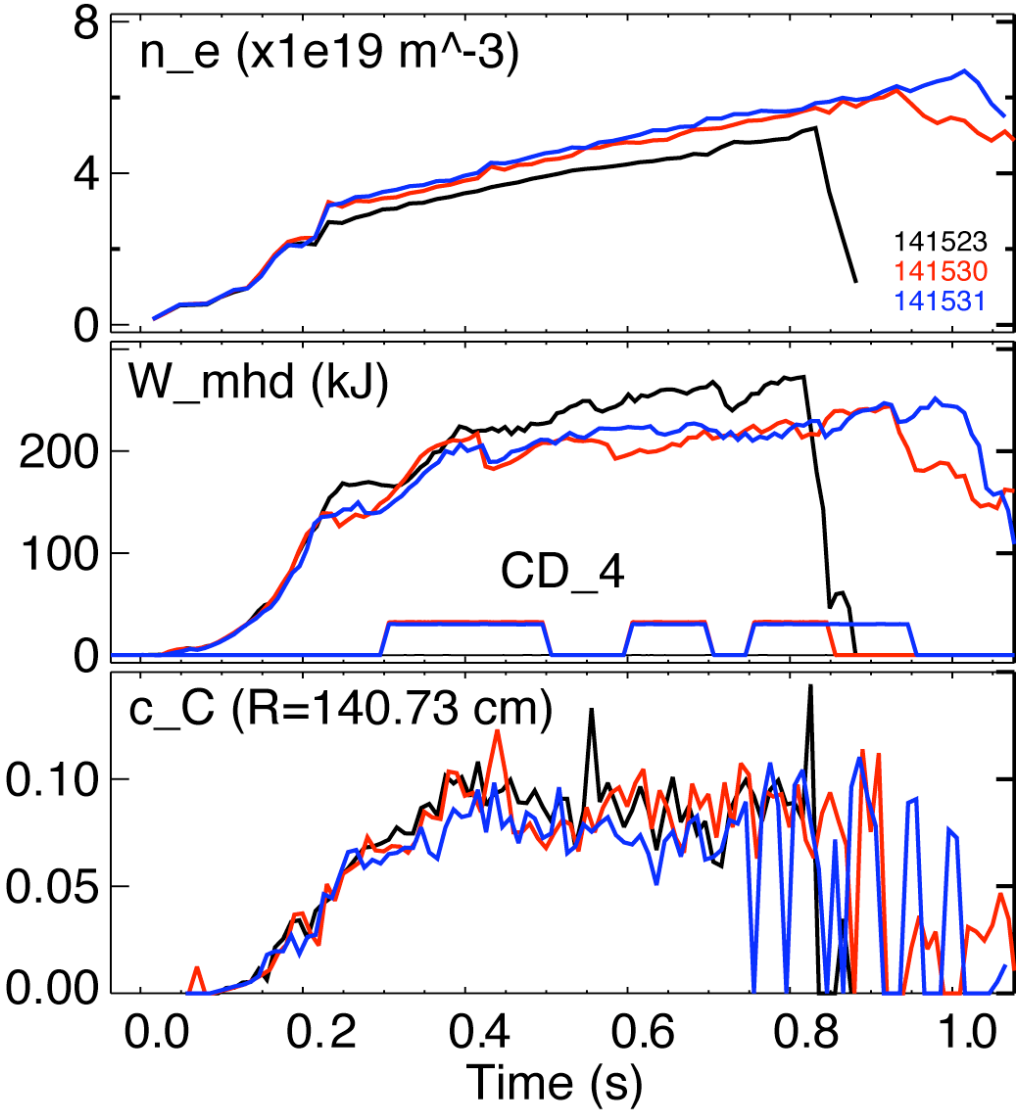
Use of impurity seeding provided an opportunity to study NSTX-U-relevant radiative divertor

- Radiative divertor experiments used D_2 injection to demonstrate peak heat flux reduction in NSXT with carbon radiation
- A significant divertor peak heat flux reduction will be needed in NSTX-U, probably not possible with low Z impurities
- Reduced density LITER operation reduces radiated power due to extrinsic impurity seeding
- Control aspects of radiative divertor
  - Identify divertor quantities that can be monitored and used as actuators for feeding into PCS to regulate impurity injection

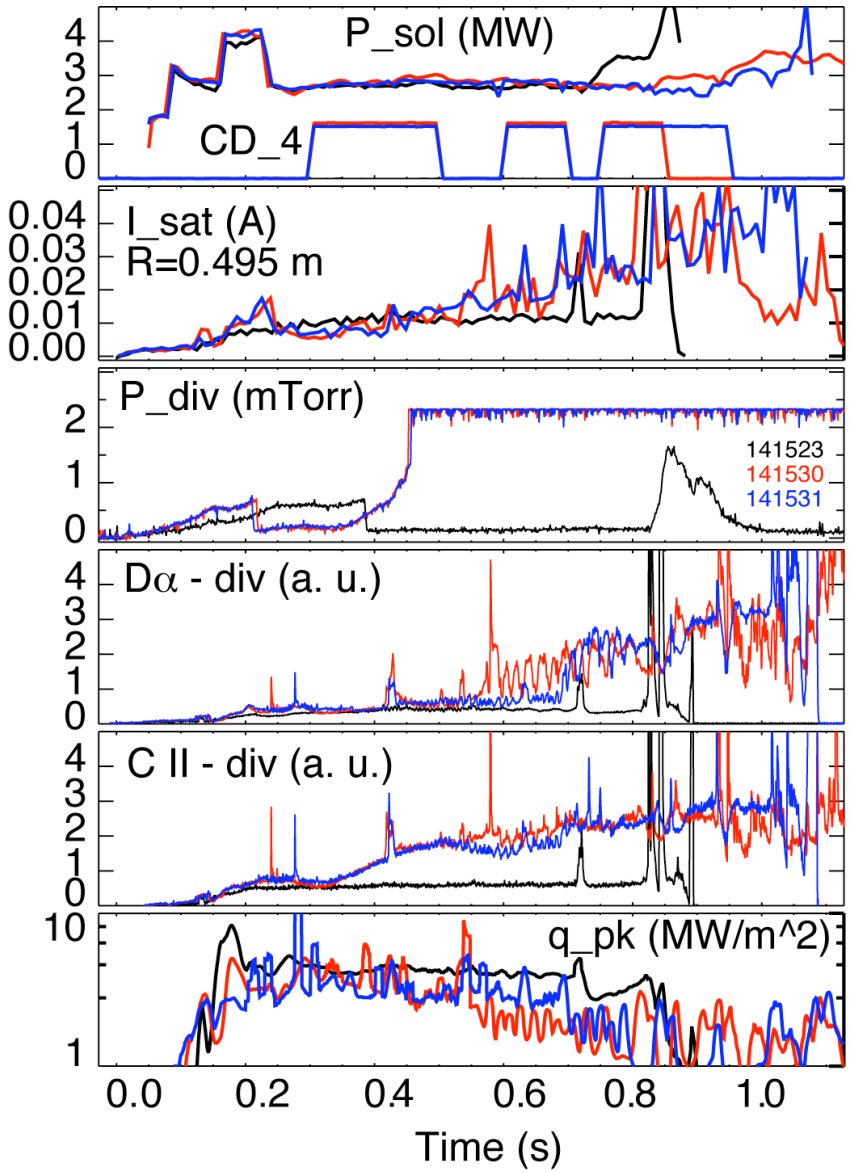
First demonstration of divertor peak heat flux reduction with impurity seeding in NSTX



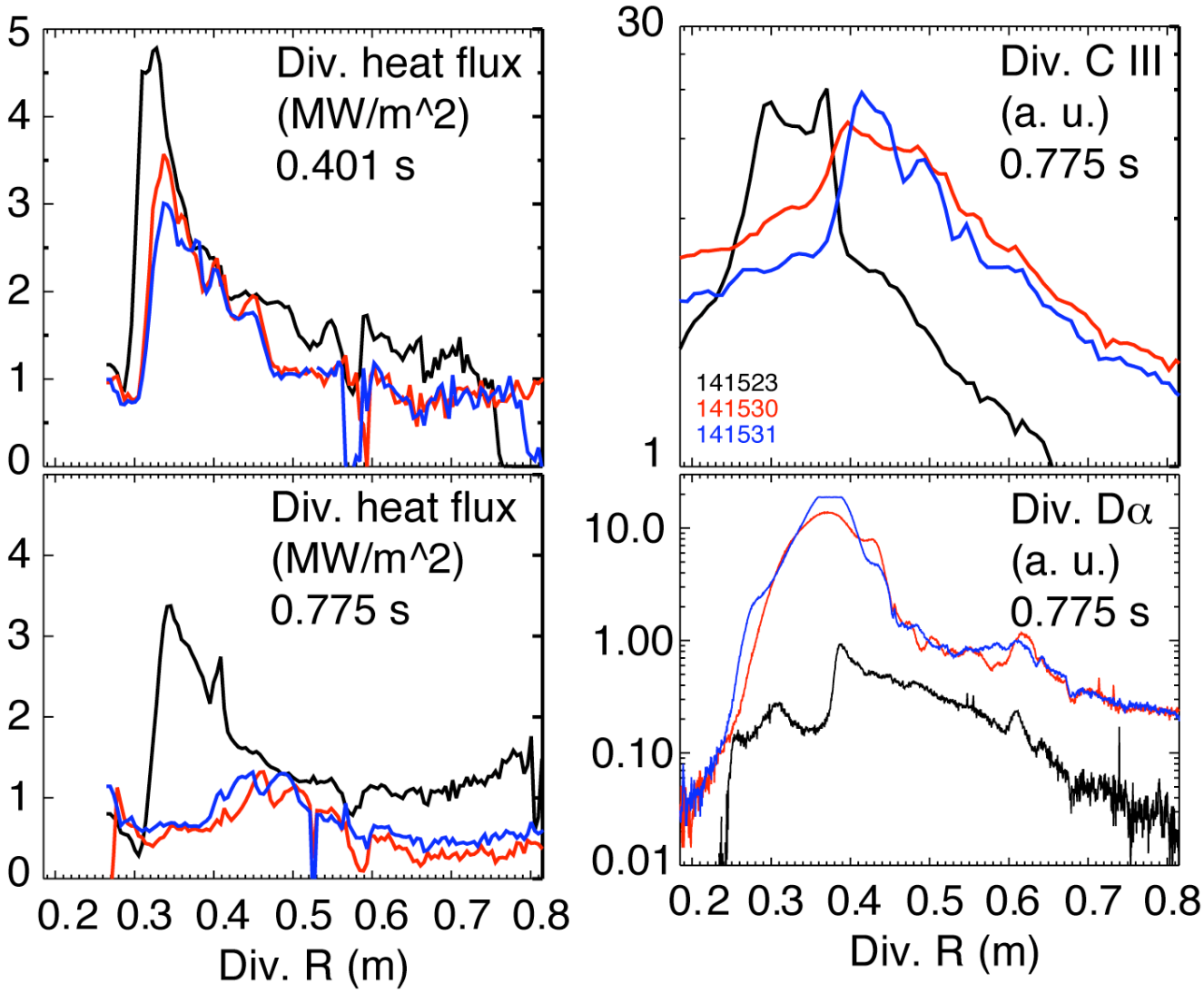


- I_p=0.9 MA, P_{NBI} = 4 MW
- δ=0.85, κ=2.3, f_{exp}~20
- P_{SOL} = 3 MW
- Marginal performance degradation

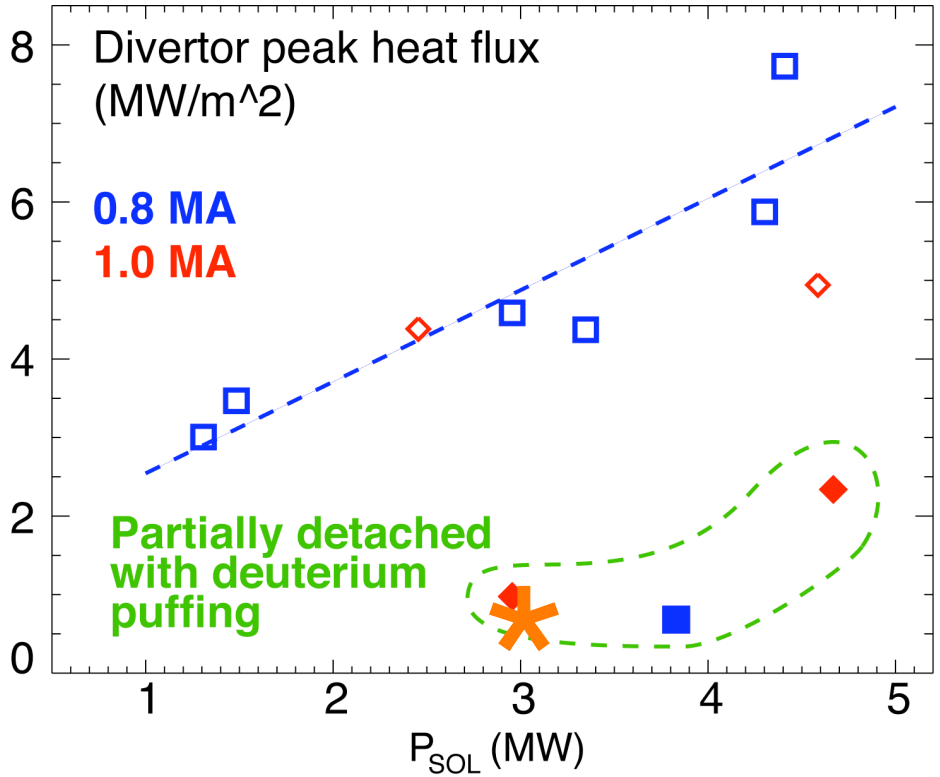
Divertor peak heat flux reduced by up to 80 %, clear signs of partial detachment observed



Divertor profiles confirm partial strike point detachment with increased radiation



Radiative divertor with CD_4 seeding appears to reduce divertor heat flux as good as PDD with D_2

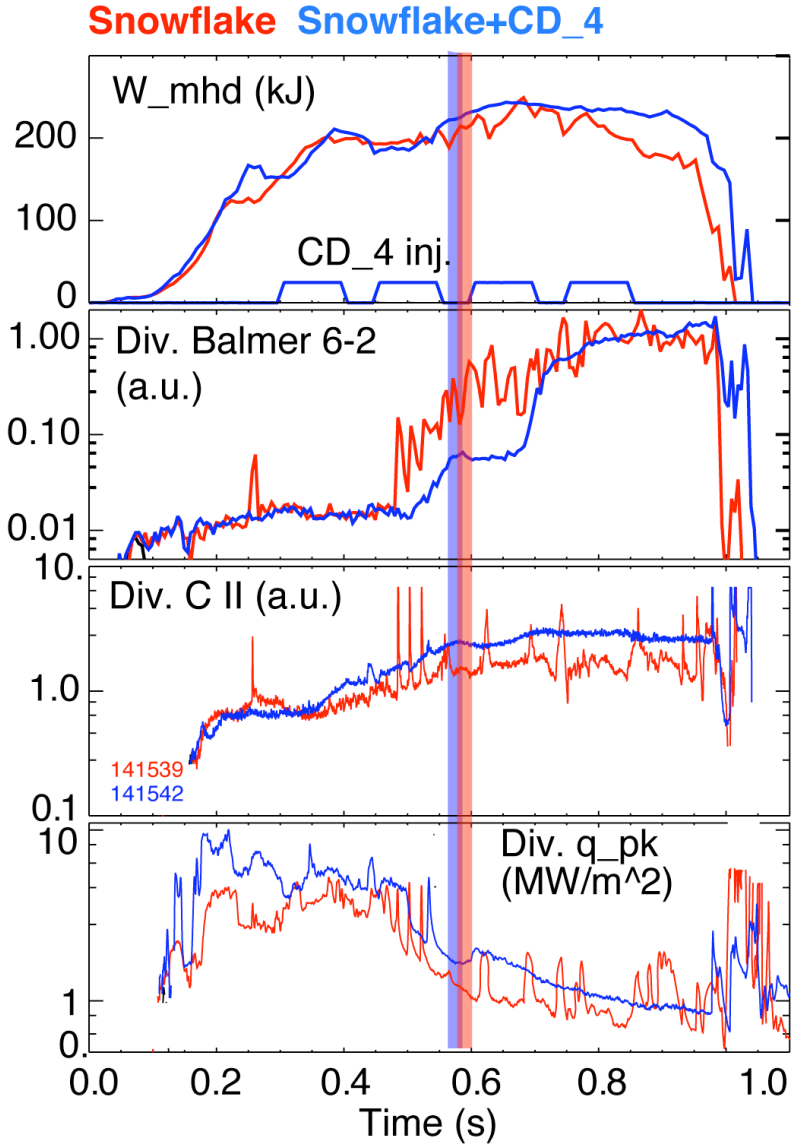


- Radiative CD_4 divertor (*): P_{SOL}~3-4 MW, q_{peak}~0.5-1.0 MW/m^2

V. A. Soukhanovskii et. al, PoP 16, 022501 (2009)

Snowflake divertor with CD_4 seeding leads to increased divertor carbon radiation

- I_p=0.9 MA, P_{NBI}=4 MW, P_{SOL}=3 MW
- Snowflake divertor (from 0.6 ms)
  - Peak divertor heat flux reduced from 4-6 MW/m^2 to 1 MW/m^2
- Snowflake divertor (from 0.6 ms) + CD_4
  - Peak divertor heat flux reduced from 4-6 MW/m^2 to 1-2 MW/m^2
  - Divertor radiation increased further



Conclusions and Future plans

- First demonstration of impurity-seeded radiative divertor provided very encouraging results
  - Marginal core plasma performance degradation
  - Significant peak heat flux reduction

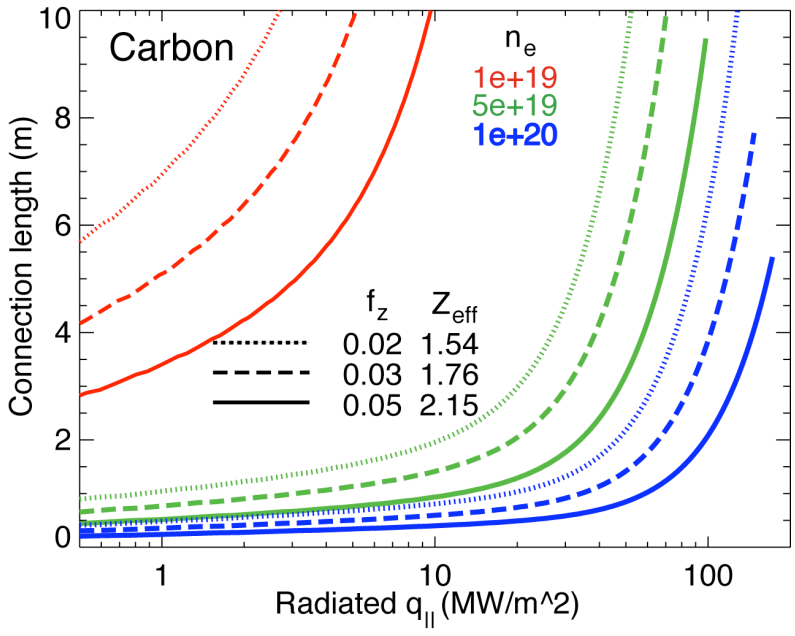
- Continue with these studies in FY2011-2012
  - Optimize CD_4 PDD performance for 1.2 MA, 6 MW
  - Develop feedback control of radiative divertor
  - Combine radiative divertor with snowflake and X-divertor
  - Demonstrate and optimize for NSTX-U shape and performance

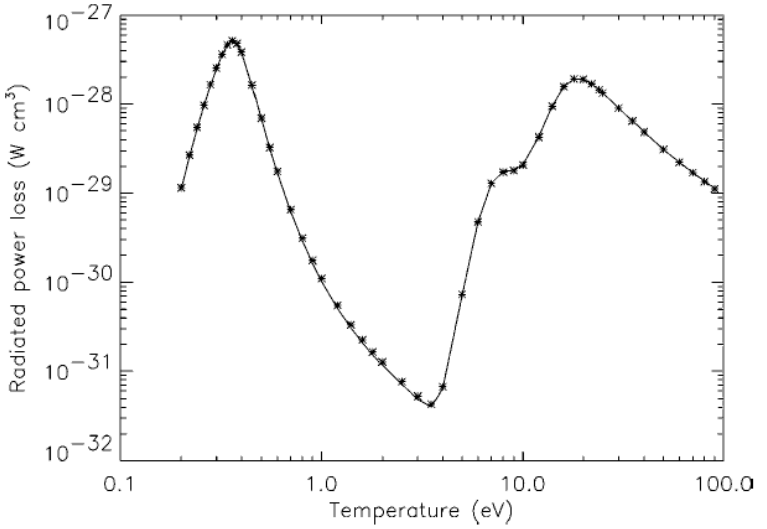
Impurity radiation role is to be clarified in radiative divertor experiments

- It is marginally possible to radiate the necessary fraction of $q_{||}$ with intrinsic carbon in NSTX
- Lithium and helium can play an important role in divertor power balance
  - Helium - energy expensive (first I.P. 24.6 eV), radiates at 1-10 eV
  - Lithium – highly radiative at T_e < 1-3 eV
- In PDD experiments in FY 2006-2008
  - Radiated power was due to D, He, Li, C
  - He and C were main contributors

$$q_{||} = -\kappa_0 T_e^{5/2} \frac{\partial T_e}{\partial x}$$

$$\frac{\partial q_{||}}{\partial x} = -n_e n_z L_Z(T_e)$$





Previous NSTX radiative divertor experiments with neon demonstrated that the divertor was too cold for efficient neon radiation