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Radiative divertor with impurity seeding and with LLD

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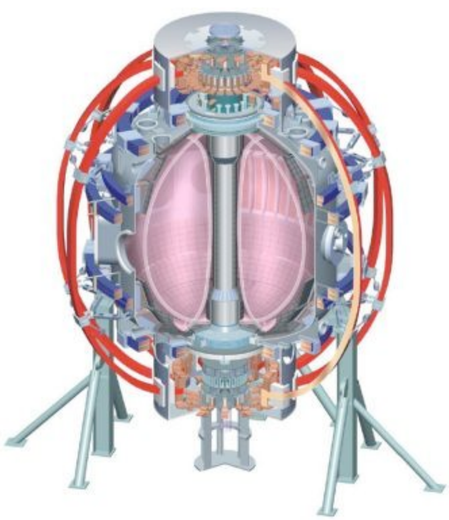
and NSTX Team

Boundary Physics TSG Meeting
Princeton, NJ
16 July 2010



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Use of impurity seeding will provide an opportunity to study reactor-relevant radiative divertor

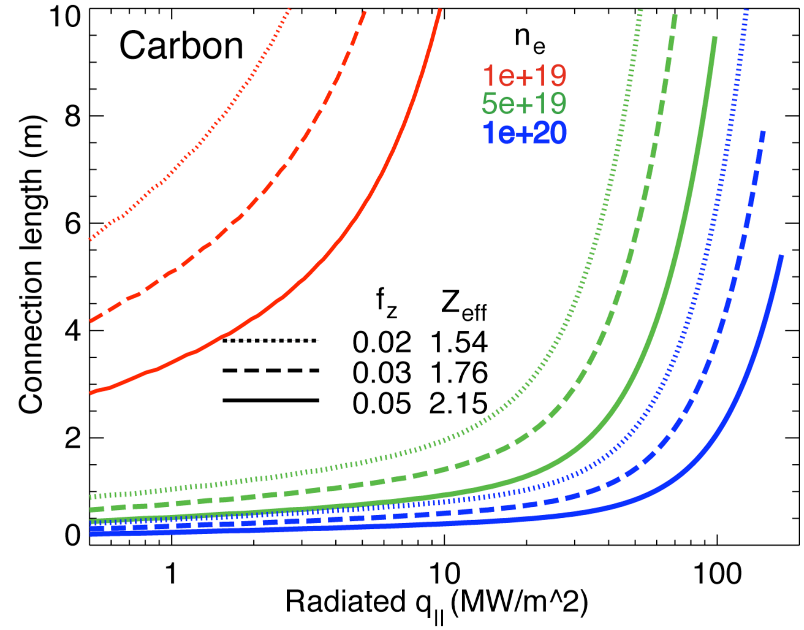
- Radiative divertor experiments used D_2 injection to demonstrate peak heat flux reduction in NSXT with carbon radiation
- A significant divertor peak heat flux reduction will be needed in NSTX-U, probably not possible with low Z impurities
- Reduced density LLD / LITER operation will reduce radiated power due to extrinsic impurity seeding – is radiative divertor possible at all?
- Need to learn control aspects of radiative divertor
  - Identify divertor quantities that can be monitored and used as actuators for feeding into PCS to regulate impurity injection
- Additional emphasis – consider joining ITPA DSOL-20 "Transient divertor re-attachment"
  - ITER will run with partially detached divertor (PDD)
  - Study possible fault conditions – loss of PDD regime
  - Dynamic / transient experiment – how intrinsic carbon can replace extrinsic impurity radiated power due to loss of impurity seeding

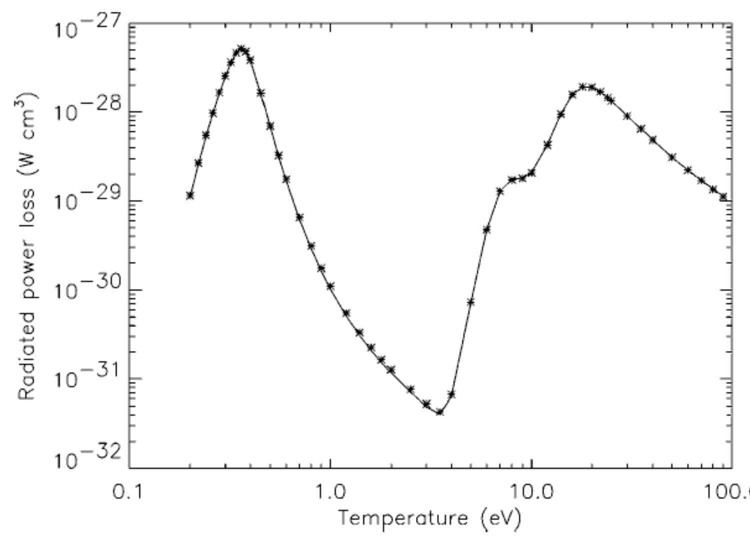
Impurity radiation role is to be clarified in radiative divertor experiments

- 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

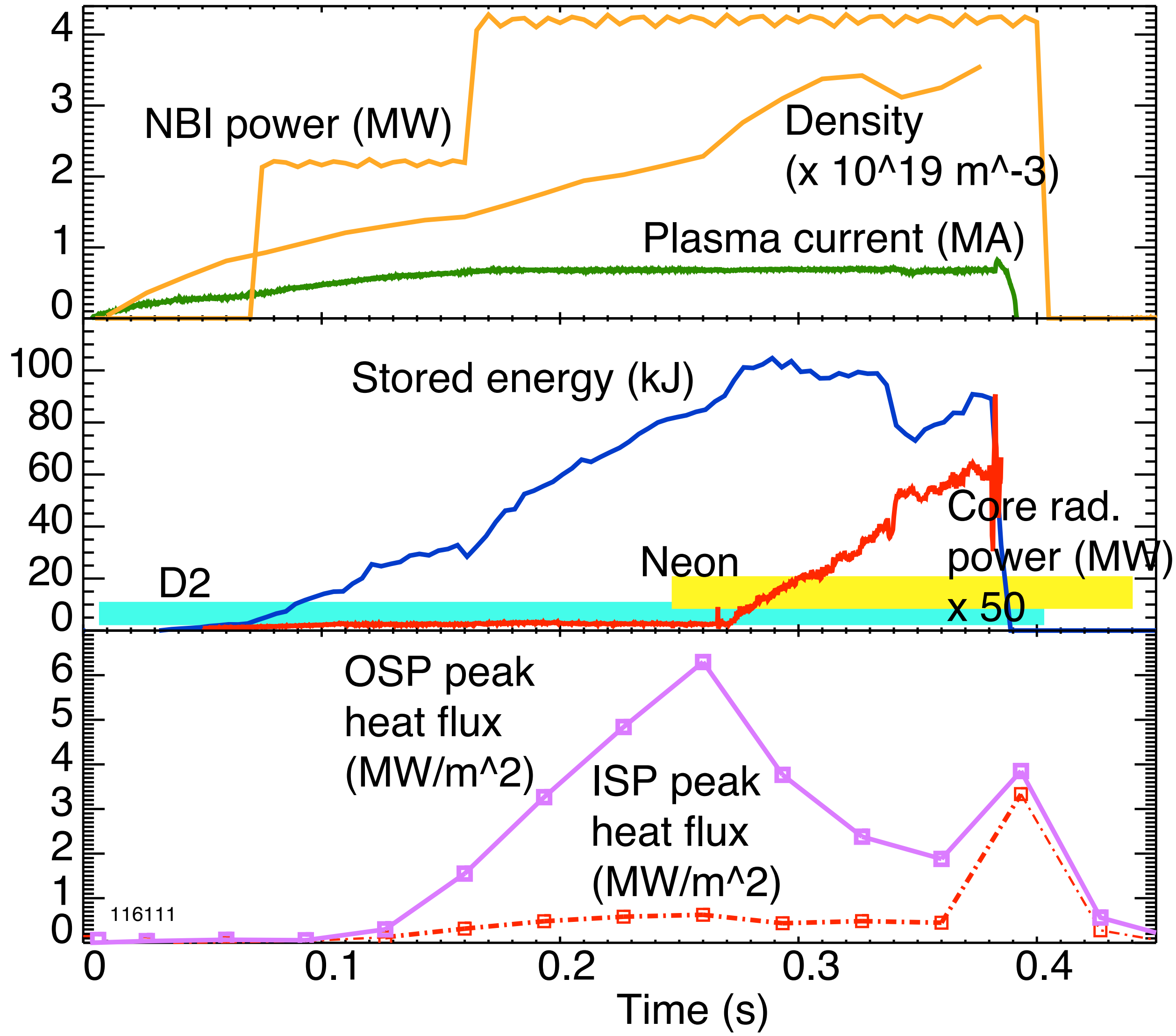
$$q_{||} = -\kappa_0 T_e^{5/2} \frac{\partial T_e}{\partial x}$$

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





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



Radiative divertor with impurity seeding – complete XP605, XP708, XP814 (1 run day)

- High κ, δ LSN plasmas with I_p = 0.8 - 1.2 MA, P_{NBI} = 4-5 MW (β-limit permitting)
- LITER to be used in part I, warm LLD to be used in part II, to study compatibility of radiative divertor with LLD pumping
- He, Ne, or CD_4 to be injected in the divertor region
  - Neon may be a good candidate in the LLD with higher T_e
- Study divertor conditions as a function of impurity injection rate
- Measurements of pedestal profiles and pedestal stability calculations to understand impact of radiative divertor on core and pedestal plasma

Multiple diagnostic measurements will be needed to elucidate on radiative divertor physics in NSTX

- Machine capabilities:
  - Low Z_{eff}, low H/D
  - Reliable H-mode access
  - B_t up to 5.5 kG
  - Divertor gas injector (Bay E)

- Needed diagnostics:
  - Two-color IR camera
  - Bolometers (core plasma and new divertor bolometers)
  - Dα, Dγ, C III, C IV cameras
  - Neutral pressure gauges (incl. 3 lower div. Penning gauges)
  - Divertor Langmuir probes
  - MPTS, CHERS, ERD (n_e, T_e, n_c)
  - Spectroscopy (D I Balmer series, impurities)
  - Gas puff imaging