

# Divertor heat flux reduction in NSTX

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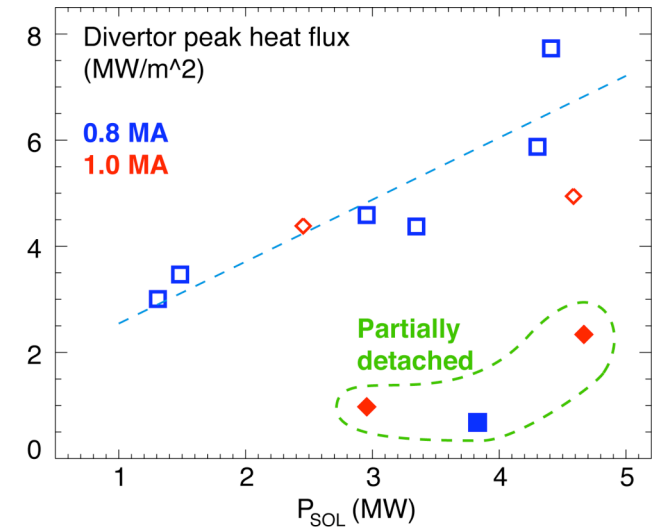
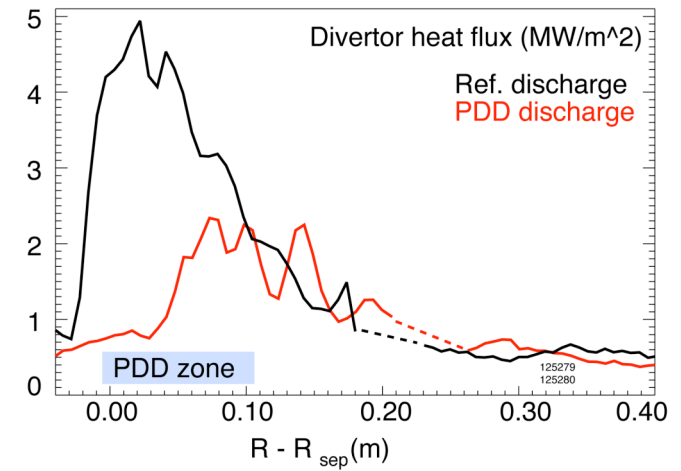
# Experiments in NSTX demonstrated possibilities of divertor peak heat flux reduction in many ways

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- **Divertor heat flux mitigation solutions:**
  - ✓ Poloidal flux expansion at outer strike point (OSP)
    - Particularly well suited for STs, reduced  $q_{peak}$  by up to 50 % in NSTX
  - ✓ Strike point sweeping (Plasma stability and control issues?)
  - ✓ Radiative divertor
    - reduced  $q_{peak}$  by up to 60 % in NSTX with D<sub>2</sub> injection (next slide)
  - ✓ Radiative mantle
    - reduced  $q_{peak}$  by up to 50 % in NSTX (w/ neon) albeit confinement degradation
  - Divertor materials and geometry (plate tilt, closure, number of divertors...)
- **These solutions must be compatible with good core plasma performance (H-mode confinement, MHD, ELM regime, density)**
- **Solutions must scale to very high  $q_{peak}$  for future devices (NHTX, ST-CTF)**
  - Combinations of solutions may work

# Summary of NSTX radiative divertor results

- Significant divertor **peak heat flux reduction** has been demonstrated in highly shaped high-performance H-mode plasmas in NSTX using **divertor magnetic flux expansion and radiative divertor** simultaneously with **high core plasma performance**
  - Good synergy of high performance small ELM H-mode regime with PDD
- Learnt detachment characteristics and limitations
  - Detachment achieved only with additional  $D_2$  injection
  - PDD regime onset is abrupt. High radiated power, neutral pressure, volume recombination rate are measured
  - PDD properties appear to be similar to those observed in tokamaks
- A number of questions remained
  - Role of extra low Z impurities in detachment
  - MARFE formation



# Impurity radiation role is to be clarified in radiative divertor experiments in FY 2008

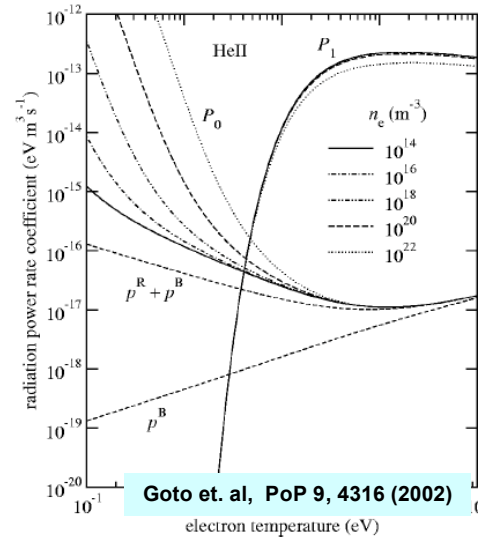
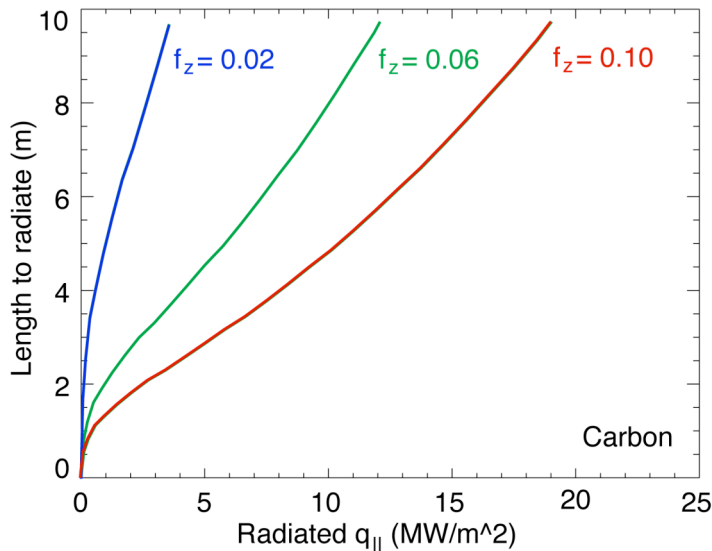
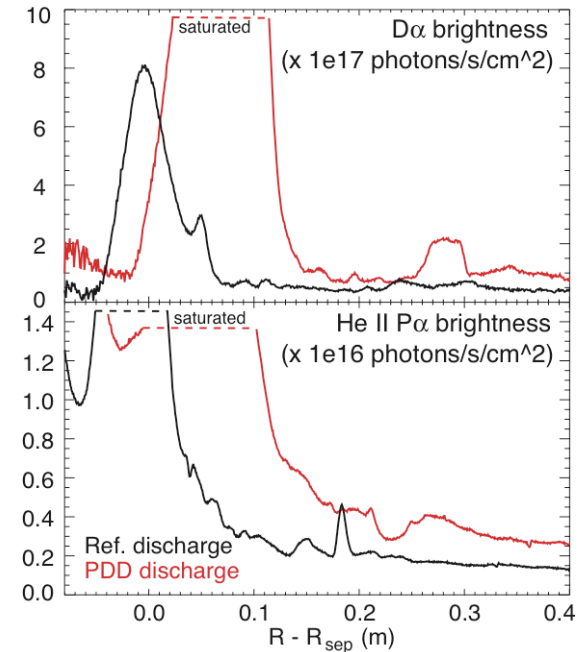


FIG. 14.  $T_e$  dependences of  $P_0$  and  $P_1$  for several  $n_e$  values for ionized helium.



- It is marginally possible to radiate a large fraction of  $q_{||}$  with intrinsic carbon in NSTX
- Helium can play an important role in divertor power balance
  - Energy expensive
  - Radiates at 1-10 eV
- In FY 2007 experiment
  - Radiated power was due to deuterium, lithium, helium, and carbon
  - He and C were main contributors

# FY 2008 radiative divertor experiment is likely to complete radiative divertor studies in NSTX

- Lithium coating experiments (FY 2008 - 2009) and liquid lithium module (FY 2009) will shift emphasis of divertor research to lithium work
- Lithium experiments make radiative divertor work difficult due to uncertainties in divertor  $q_{peak}$  and  $P_{rad}$  measurements, and possible different divertor transport regimes
- Experiment execution plan
  - Obtain highly-shaped reference shot and reproduce PDD conditions at three  $I_p$ ,  $P_{NBI}$  values (esp. 1.2 MA, 6-7 MW)
  - Use new divertor gas injector with  $D_2$  at 100 - 160 Torr l/s (**5-10 shots**)
  - Use He and  $CD_4$  injections (**10 shots**)
  - Operate GPI and divertor fast camera in PDD shots to elucidate on Lodestar blob theory and turbulence measurements
  - Adjust  $drsep$  and outer gap values to obtain MPTS pedestal measurements ( $\kappa = 2.2-2.3$ ,  $\delta = 0.65-0.75$ ,  $drsep \sim 5-15$  mm)
  - Repeat in balanced DN shots (**5 shots**)