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Divertor heat flux reduction in NSTX

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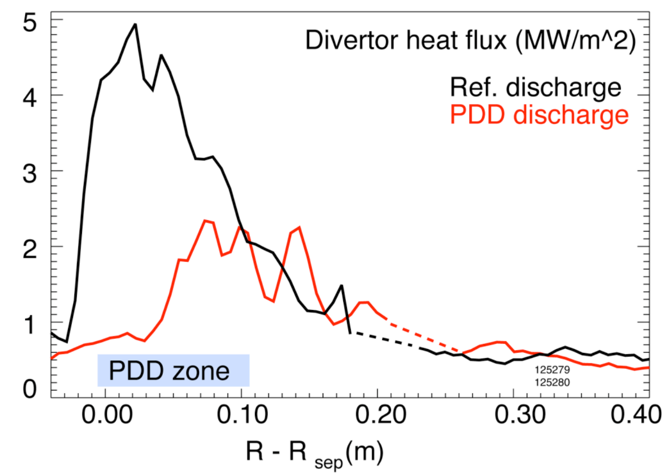
Experiments in NSTX demonstrated possibilities of divertor peak heat flux reduction in many ways

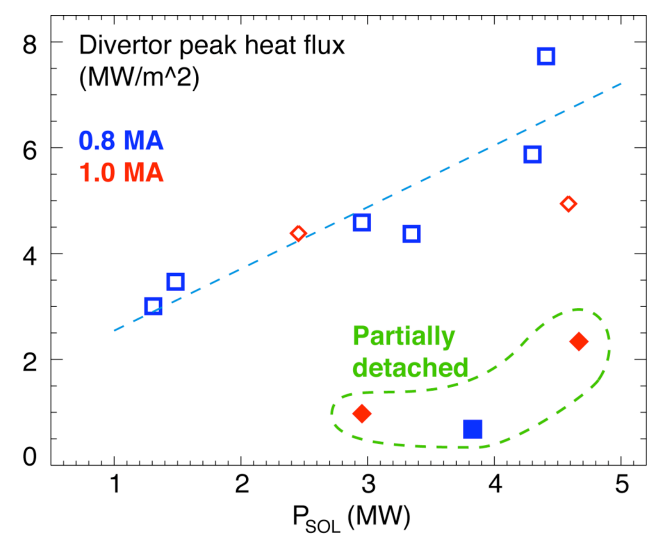
- **Divertor heat flux mitigation solutions:**
  - ✓ Poloidal flux expansion at outer strike point (OSP)
    - Particularly well suited for STs, reduced q_{peak} by up to 50 % in NSTX
  - ✓ Strike point sweeping (Plasma stability and control issues?)
  - ✓ Radiative divertor
    - reduced q_{peak} by up to 60 % in NSTX with D_2 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} (15 - 40 MW/m^2) for future devices (NHTX, ST-CTF)**
  - Combinations of solutions may work

Summary of FY 2007 radiative divertor results

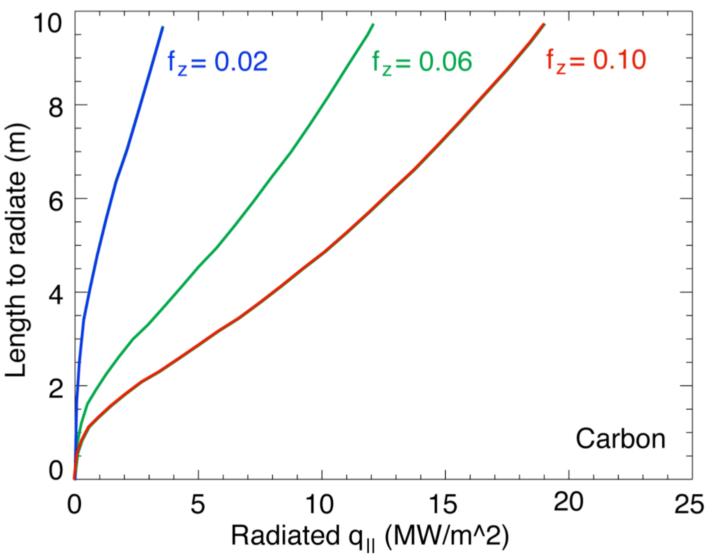
- Significant divertor **peak heat flux reduction** has been demonstrated in highly shaped high-performance H-mode plasmas in NSTX using **divertor magnetic flux expansion and radiative divertor** simultaneously with **high core plasma performance**
  - Good synergy of high performance small ELM H-mode regime with PDD



- Learnt detachment characteristics and limitations
  - Detachment achieved only with additional D_2 injection, or with additional low Z intrinsic impurities
  - 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



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



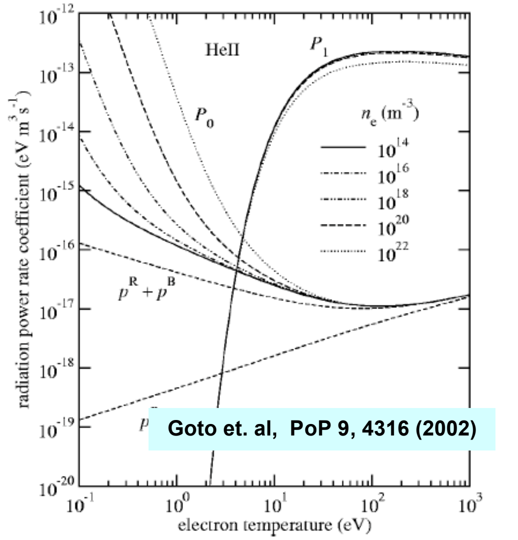
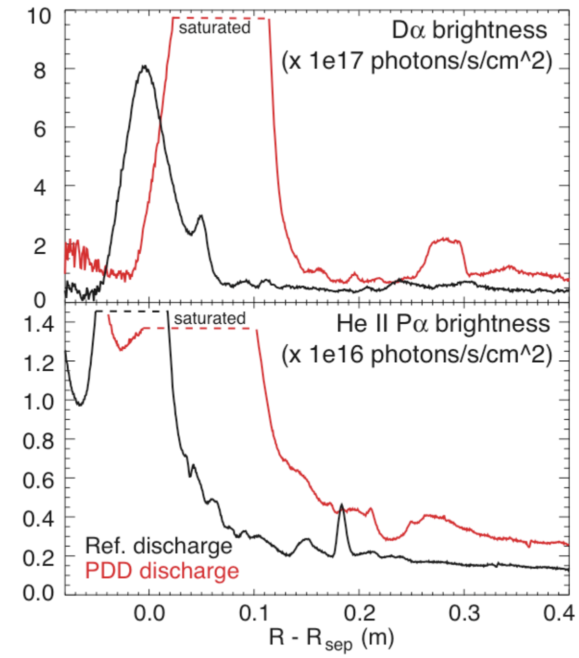


FIG. 14. T_e dependences of P_0 and P_1 for several n_e values for ionized helium.



- It is marginally possible to radiate the necessary fraction of $q_{||}$ with intrinsic carbon in NSTX
- Helium can play an important role in divertor power balance
  - Energy expensive (first I.P. 24.6 eV)
  - 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 divertor (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 (still mostly scoping studies)
  - 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/or CD_4 injections (**10-15 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 (κ = 2.2-2.3, δ = 0.65-0.75, *drsep* ~ 5-10 mm)
  - Repeat in balanced DN shots (extra time?)

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
  - New divertor gas injector (Bay C)
  - Highly-shaped configuration for FY 2008

- Needed diagnostics:
  - IR cameras (upper/lower divertor heat flux)
  - Bolometers (core plasma and new divertor bolometers)
  - Dα, Dγ, C III divertor 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