An Initial Look at
HHFW Absorption by D and He Ions in NSTX

T.K. Mau
University of California, San Diego

NSTX Physics Meeting

August 14, 2000

Plasma Assumptions

- NSTX plasma is described by EQDSK equilibrium at various beta levels.

- The density and temperature profiles are assumed as:

$$T(\psi)/T_o = 0.95\ (1-\psi^2) + 0.05$$
$$n(\psi)/n_o = 0.75\ p(\psi)T_o/[p_o T(\psi)] + 0.25$$
$$T_i(\psi)/T_{io} = T_e(\psi)/T_{eo}$$
$$n_i(\psi)/n_{io} = n_e(\psi)/n_{eo}$$

- The ion species mixture is : 96%D(He), 4%(Oxy) giving Z_{av} = 1.28 (D) , 2.24 (He), and Z_{eff} = 2.75 (D), 2.86 (He).

- Ion beta is give by

$$\beta_i = f_i\ \beta / [\ Z_{av}\ (T_e/T_i) + 1\ ]$$

where f_i is ion species concentration.

$$n_i/n_e = 0.75\ (D),\ \ 0.43\ (He)$$

HHFW Calculation Model

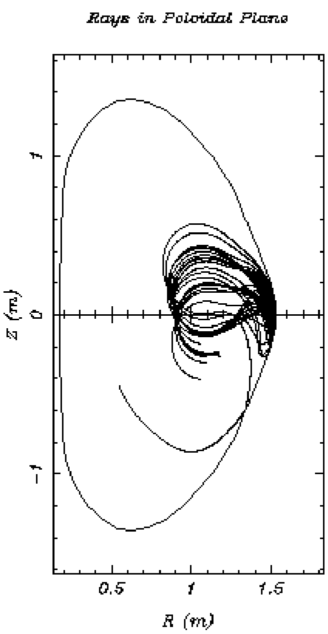
- The CURRAY ray tracing code is used.
- Wave propagation :
  - Cold ions ($k_x \rho_i << 1$), thermal electrons
  - Mode conversion not included
- Wave absorption:
  - Linear electron landau, harmonic ion resonance
  - Full thermal effects included in E-field polarization factors in damping decrement
- Launched wave spectrum:
  - single $N_{||}$
  - antenna current ~ $\cos[k_o a(\theta-\theta_o)]$
  - rays started along antenna poloidal extent at $\psi = 0.99$
- For NSTX analysis here,

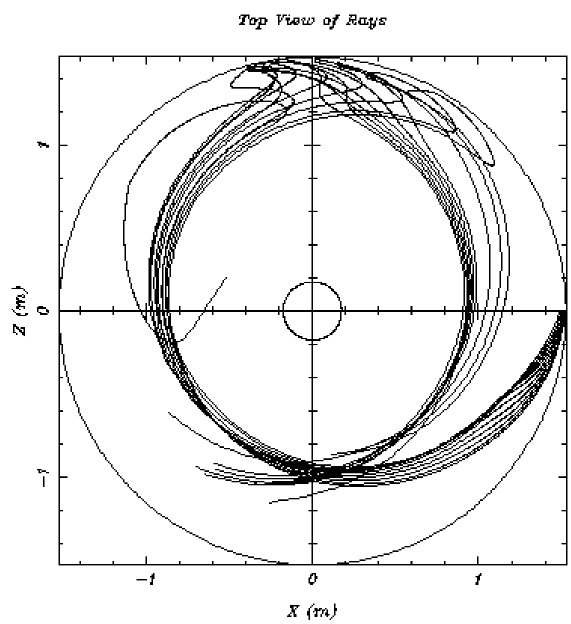
  $f = 30$ MHz
  $N_{||} = 11$ [$k_{||} = 7\ m^{-1}$]
  No. of rays used = 11

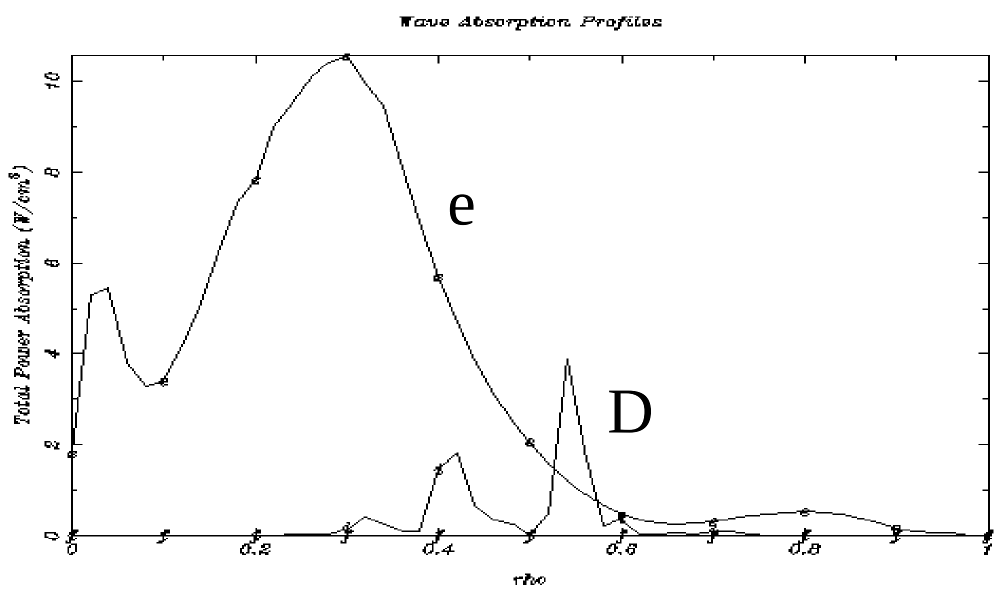
Typical Ray Tracing Results at Low β

- NSTX case with β = 10%, T_{eo} = 1 keV, T_{io} = 0.75 keV, and D plasma.

- 10.2% of power is absorbed by D ions, occuring where $k_x \rho_i$ is peaked.

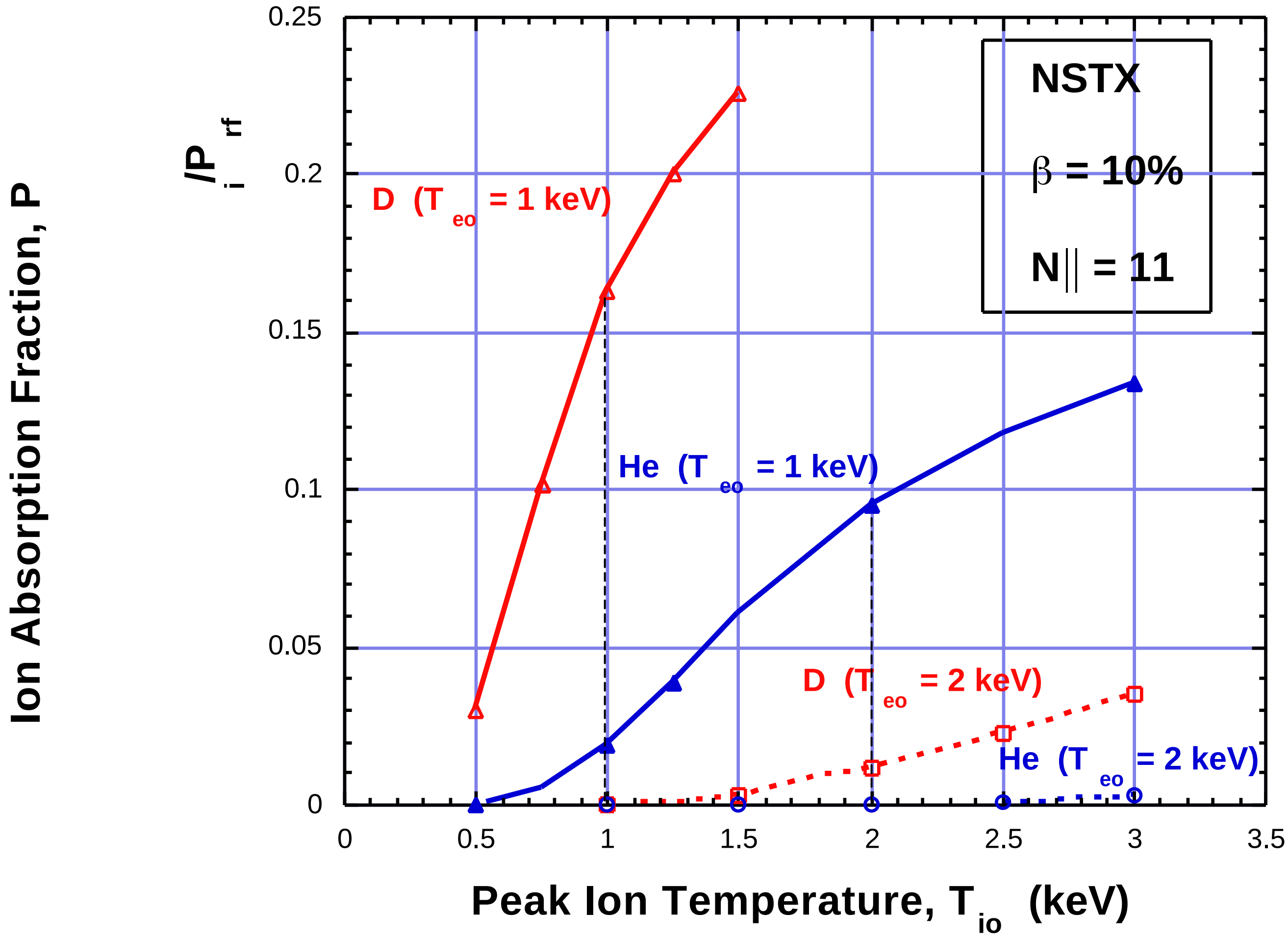






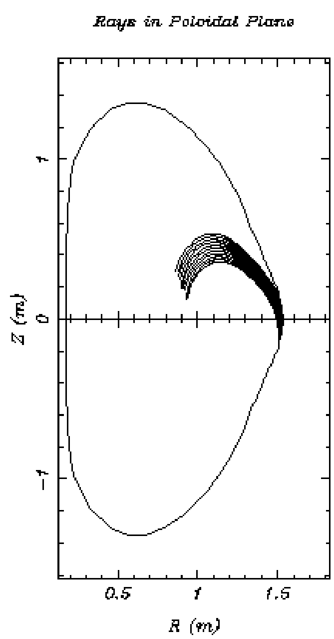
D Absorption is Much Stronger Than He Under Assumed Conditions, β = 10%

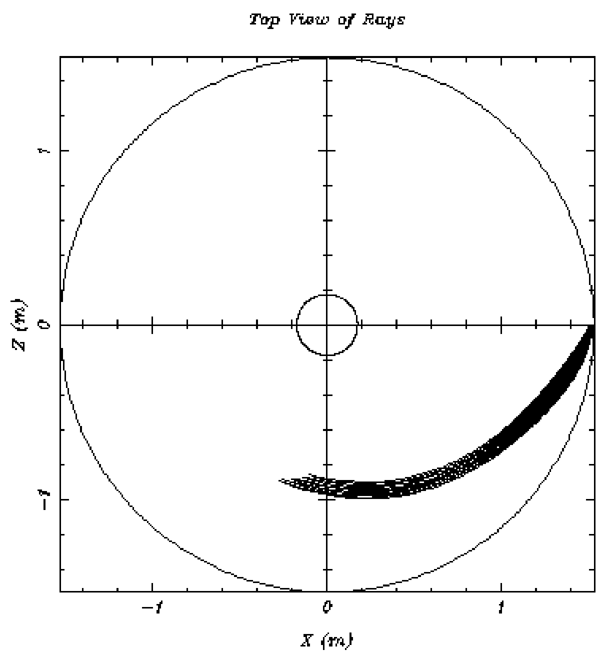
- $P_D >>> P_{He}$ at same T_i
- $P_D (T_i) > P_{He} (2T_i)$
- At same β, higher T, low n leads to weaker ion absorption, and vice versa.

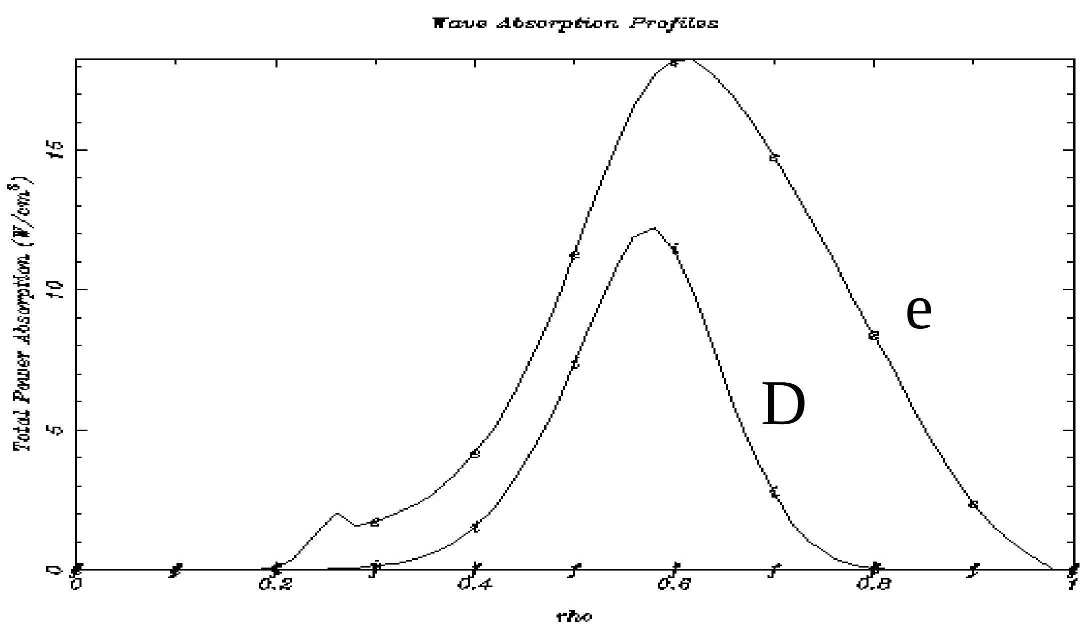


Typical Ray Tracing Results at High β

- NSTX case with β = 25%, T_{eo} = 4 keV, T_{io} = 5 keV, D-plasma.
- Total single-pass absorption; 29% P_{rf} absorbed by D-ions. $k_x\rho_i < 2$.



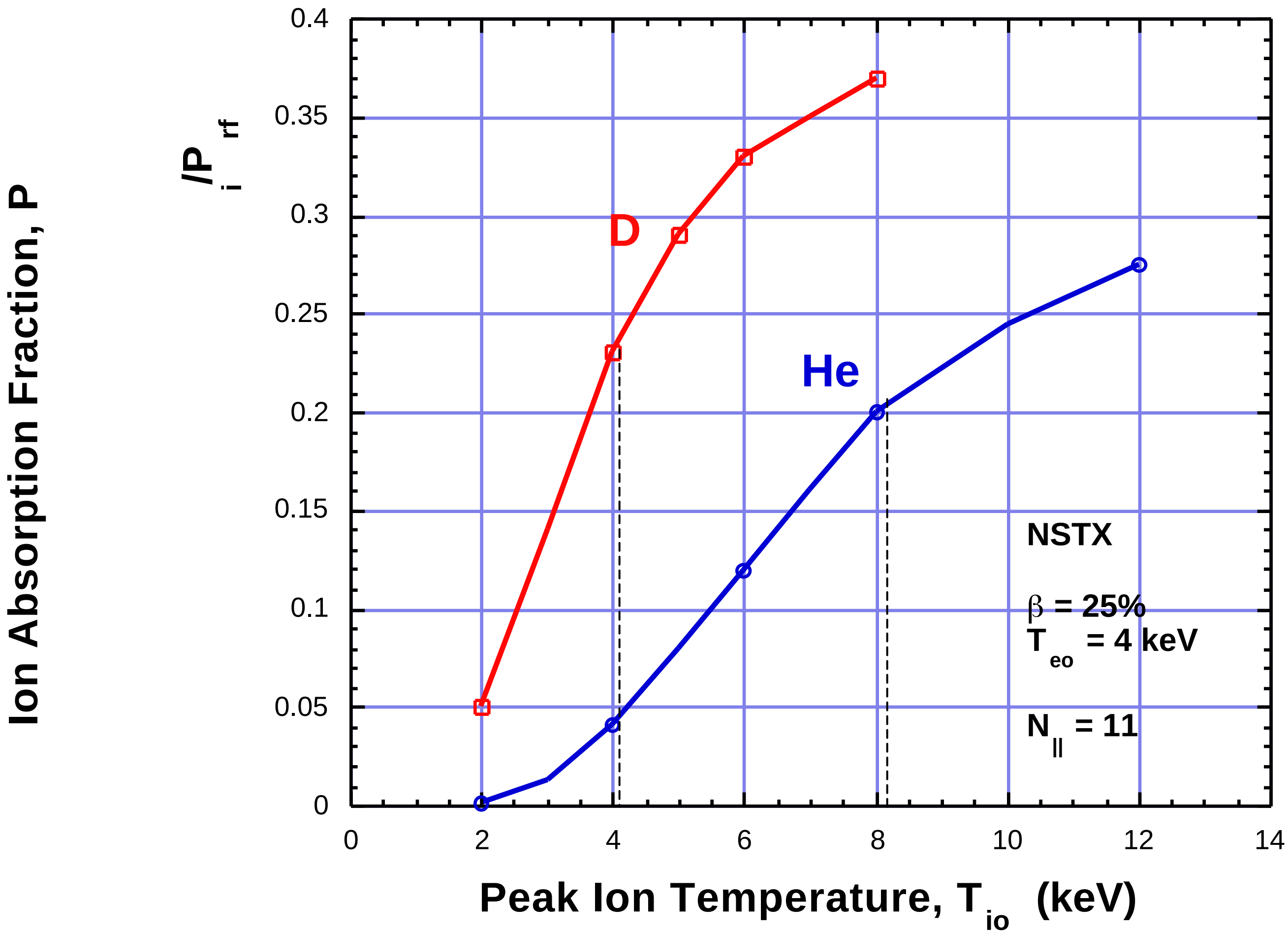




D Absorption is Much Stronger Than He at Same T_i Under the Assumed Conditions β = 25%

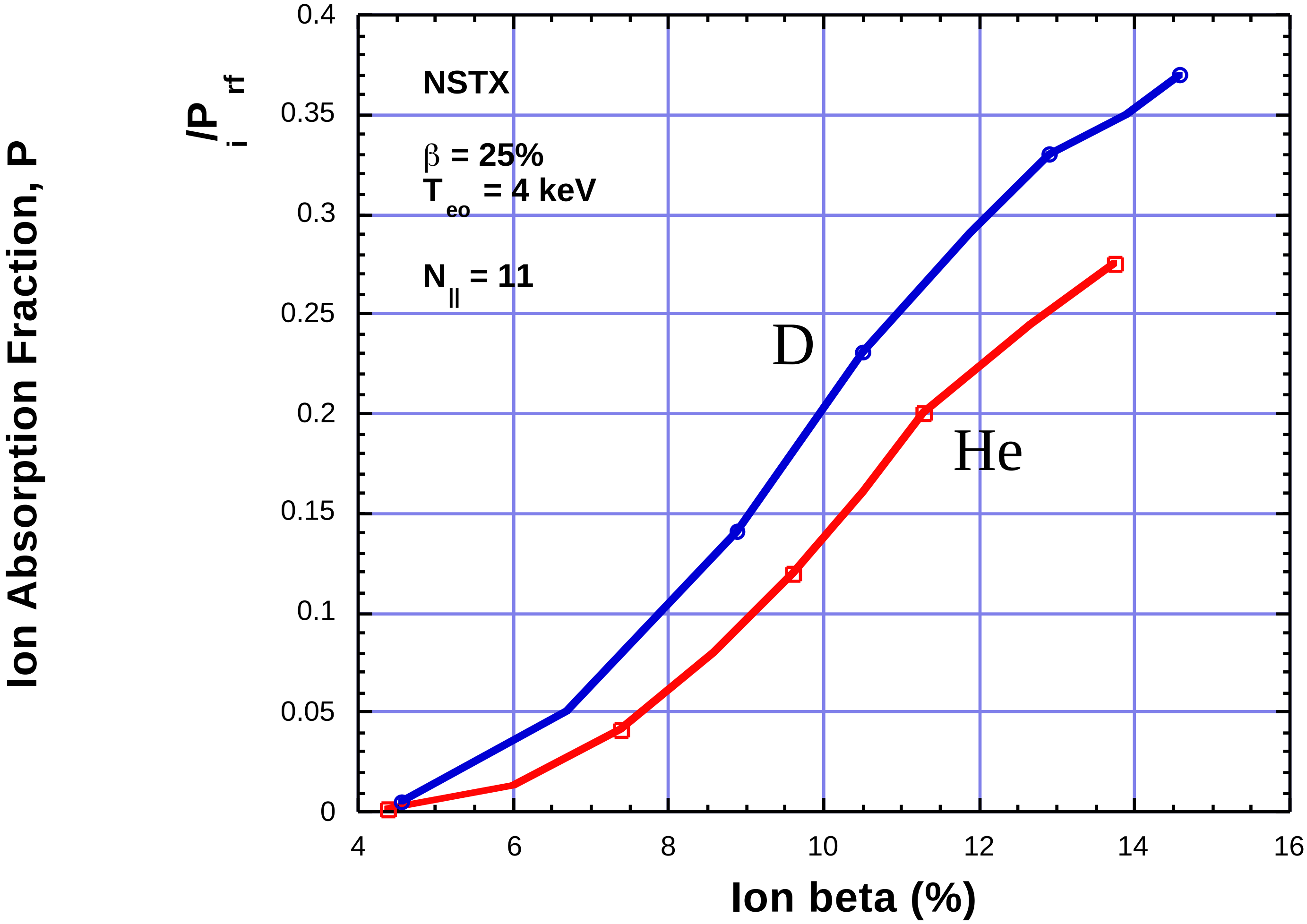
$$P_D \gg P_{He} \quad \text{at same } T_i$$

$$P_D(T_i) > P_{He}(2T_i)$$



D Absorption is Stronger Than He Under the Assumed Conditions β = 25%

$P_D > P_{He}$ at same ion beta.



SUMMARY

- Initial calculations indicate that HHFW interaction with He is much weaker than with D for the same plasma β.

- Operating at higher T and lower n results in much weaker ion absorption for the same plasma β.

- The results also indicate that

  $P_D (T_i) > P_{He} (2T_i)$

  $P_D > P_{He}$ at same ion beta

  which deviate from prediction. Reasons may be fixed β assumption and profile effects.

- The quantity $k_x \rho_i$ exceeds unity near the region where ion damping is strongest. Need to check ray paths with full kinetic geometric optics code.

- A complete scanning of parameter regimes, including $N_{||}$, is being carried out to obtain detailed understanding of the results.