FY04 Plans for HHFW H & CD Modeling with CURRAY

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Three Tasks in Support of HHFW Campaign

- Continue to analyze HHFW CD discharges and compare with MSE measurements

- Complete coupling of CURRAY to TRANSP
  - Evaluate $j_{fw}(E_{dc})$ and $\partial j_{fw} / \partial E_{dc}$ for transient simulations

- Investigate thermal and energetic ion damping at high beta and/or low $k_{||}$

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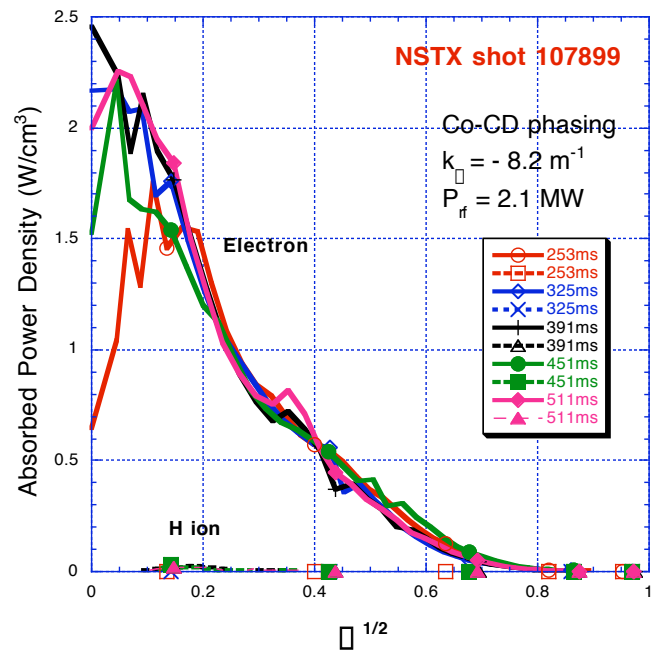
Analysis of HHFW CD Shots

- Will continue to analyze HHFW CD shots and compare with MSE measurements.
- Investigate trapping effect for off-axis CD and diamagnetic effects at high β.
- Add effect of E_{dc} to CD efficiency and assess regimes of importance.
- Do a comprehensive benchmarking with full wave codes (AORSA or TORIC).
- Compare with CQL3D/GENRAY to elucidate the significance of quasilinear effects on electron damping and current drive, and determine the parameter regimes of validity for the adjoint approach in CURRAY.

Typical CURRAY results



Transient CD Modeling with CURRAY/TRANSP

- CURRAY has been incorporated as a subroutine in TRANSP. The combined package has been used in modeling HHFW heating discharges in NSTX.

- However, work is needed to complete incorporation of the current drive package:
  - Need to evaluate $j_{rf}(E_{dc})$ and $\partial j_{rf}/\partial E_{dc}$ for modeling transients during rf turn-on.
  - Propose to calculate a table of j/p ($\square$,$\square$,w,E_{dc}) making use of an existing adjoint code (Karney &Fisch) with nonzero E_{dc}.
  - Follow procedure by Ignat on LHCD in LSC, for the fast branch and assuming Maxwellian distribution.

This can be a time-consuming task.

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Modeling of Thermal and Energetic Ion Absorption of HHFW at High β and/or Low $k_{||}$

- Accurate modeling of absorption by thermal ions and beam energetic ions becomes critical as plasma β is increased and $k_{||}$ is lowered for efficient CD.
- Both ray tracing codes and full wave codes predict enhanced ion absorption in these regimes, contrary to experimental observations to date.
- This warrants an in-depth look at the present ray tracing models, together with detailed, comprehensive benchmarking with full-wave codes over a wide parameter range (ion β, $k_{||}$, thermal and energetic ions).

  Good agreement between ray tracing and full wave codes provides confidence with predictions based on transport simulations with ray tracing.

- The ray codes and full wave codes agree quite well at low β discharges with or without energetic ions. CURRAY and HPRT results deviate at high β and low $k_{||}$.
  Need comparison with full wave codes (AORSA) at high β and/or low $k_{||}$.

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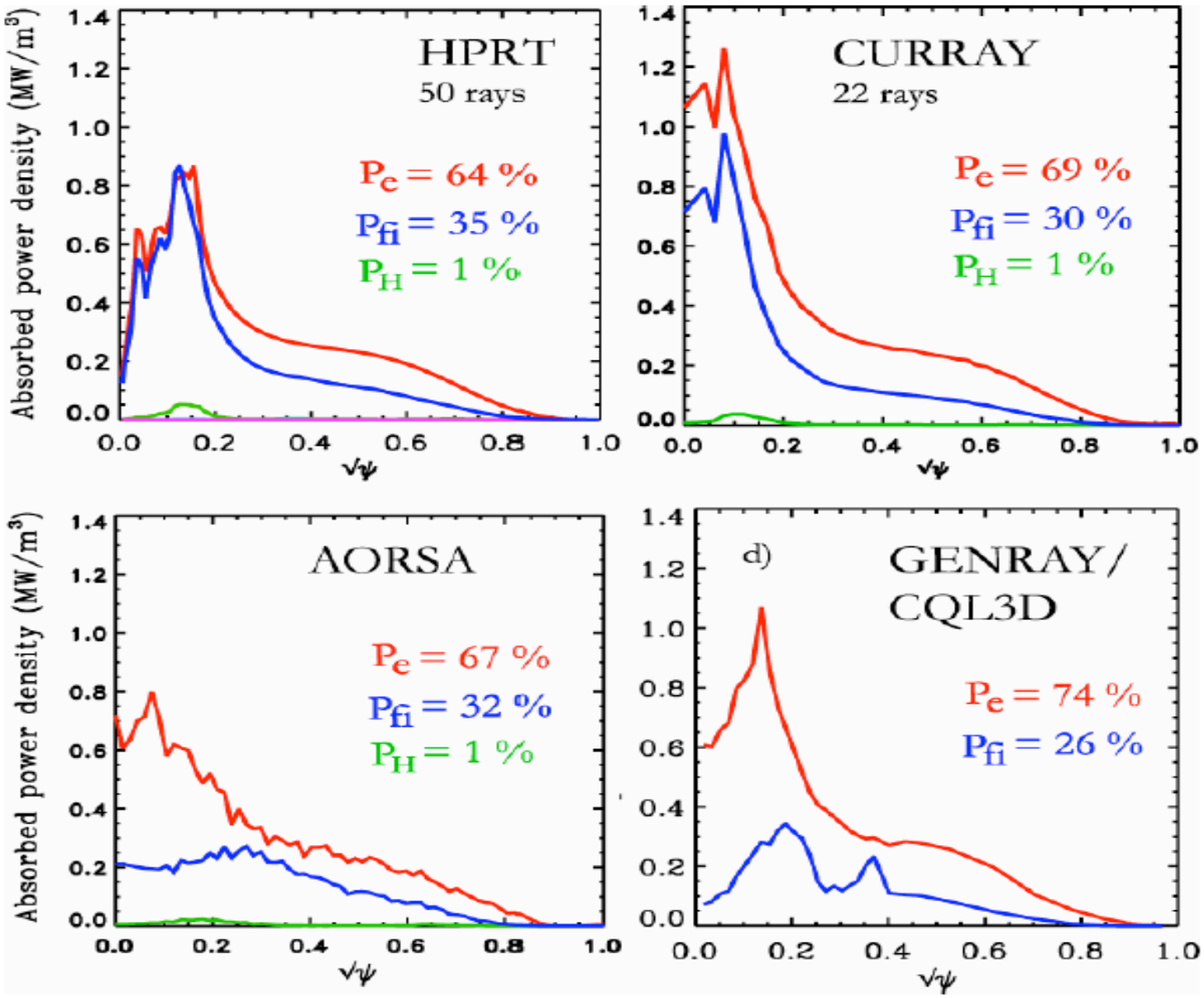
Reasonable Agreement between HPRT, CURRAY, AORSA, and GENRAY/CQL3D for $N_{\square} = 24$, Shot 108251

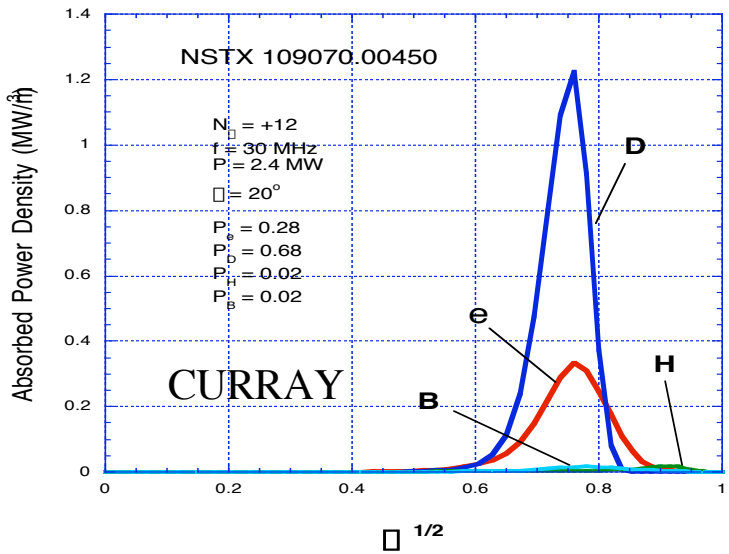


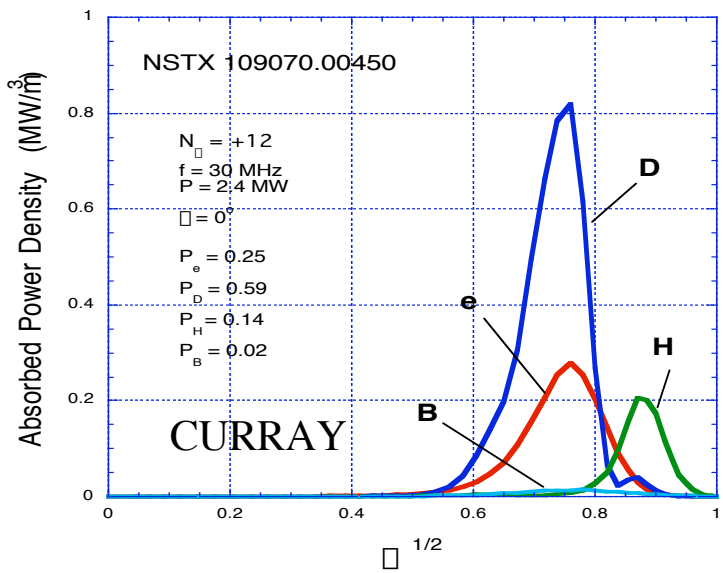
$\square = 5$ %
$T_i/T_e = 2$

From Rosenberg, APS/DPP03 Conference.

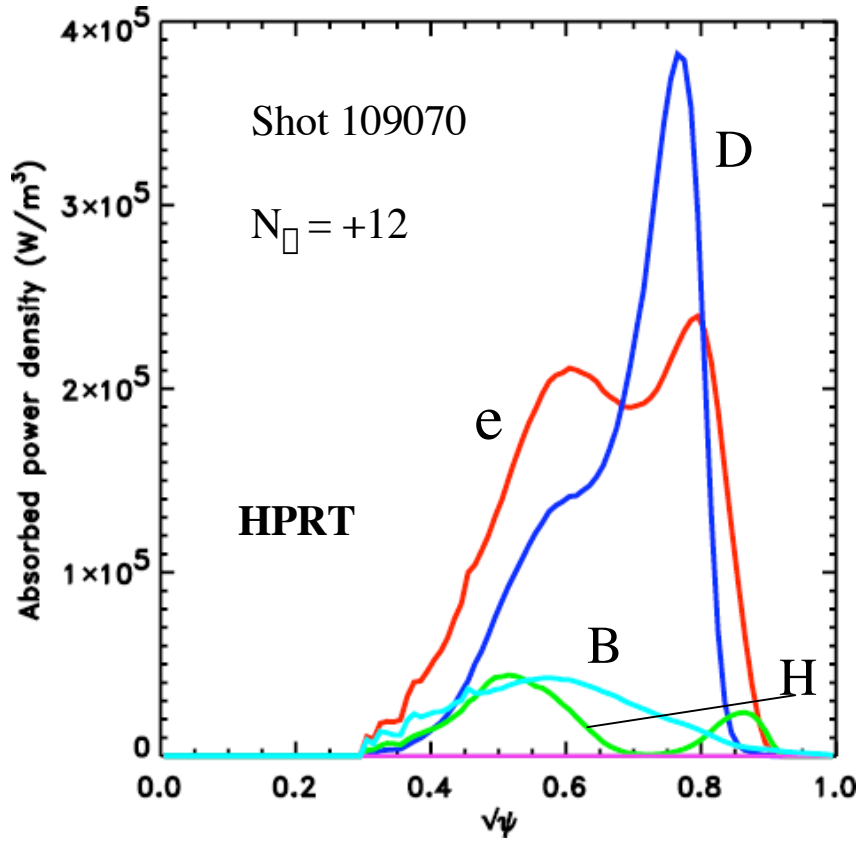
CURRAY and HPRT Results Differ at Low $k_{||}$, High □ -- Shot 109070

- From CURRAY, wave penetration is found to depend on poloidal location of antenna.

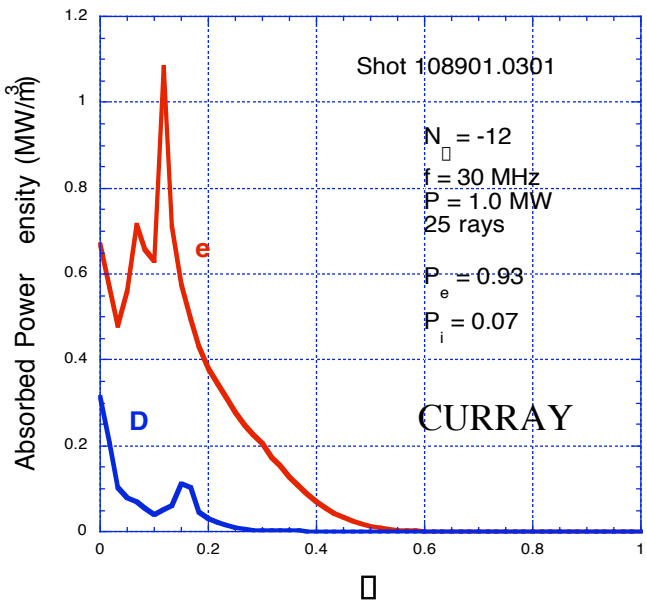
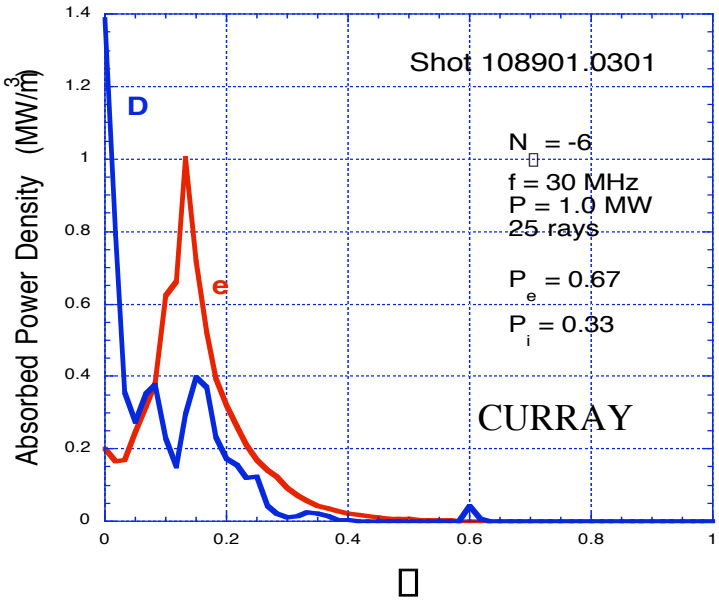
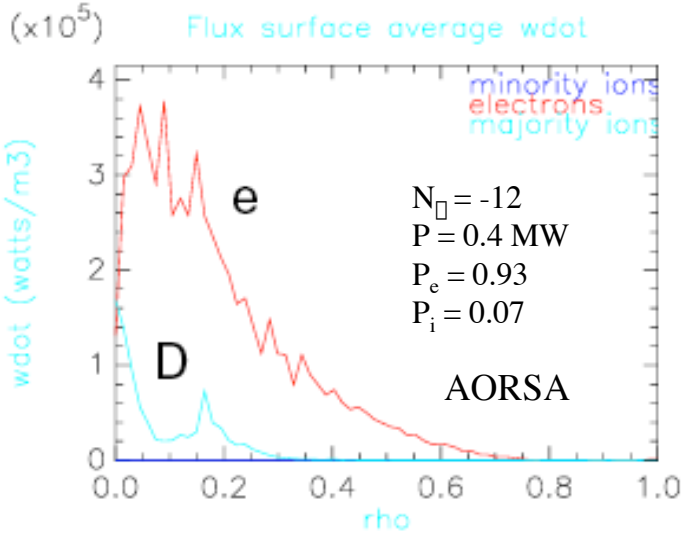
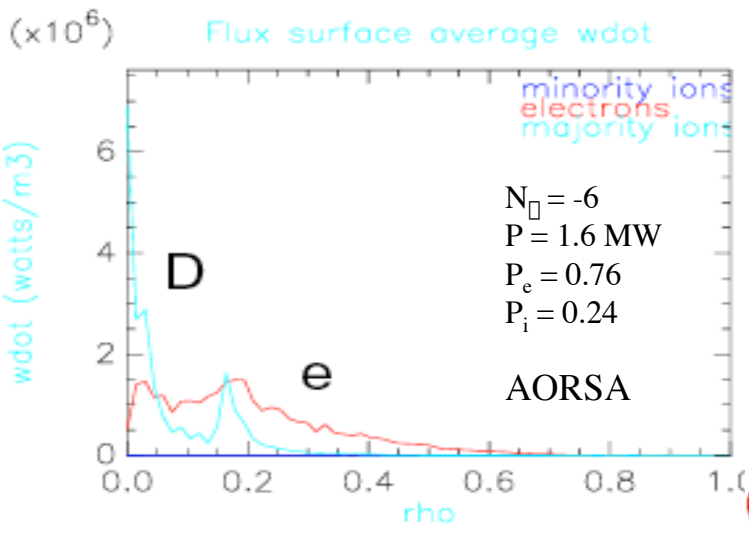




□ = 16%
$T_i/T_e = 2$



Reasonable Agreement between CURRAY and AORSA for Case with Thermal Ions Only, Shot 108901

$\square = 3\%$

$T_i/T_e = 1.6$