Characterization of the High-Harmonic Fast-Wave Driven H-mode Plasmas in NSTX

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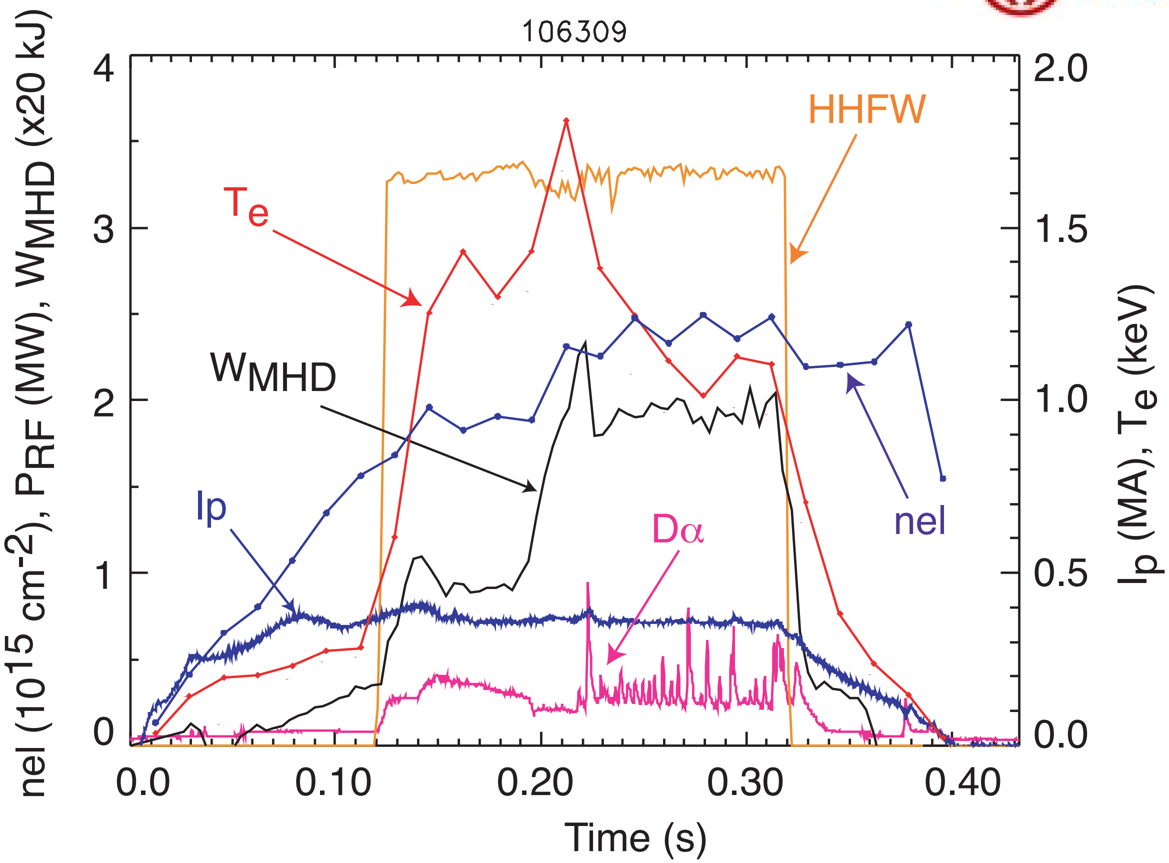
HHFW Driven H-mode Plasmas

- Readily obtained when HHFW provides sole auxiliary heating
- Limited data set, but
  - So far observed for $I_p \leq 0.6$ MA and $k_{//} = 14$ m^{-1}
  - LSN configuration
  - Typically need > 2 MW
  - Stored energy doubling observed in good cases
  - Kinetic profile H-mode signatures observed
  - $\tau_E \leq \tau_{pby2}$

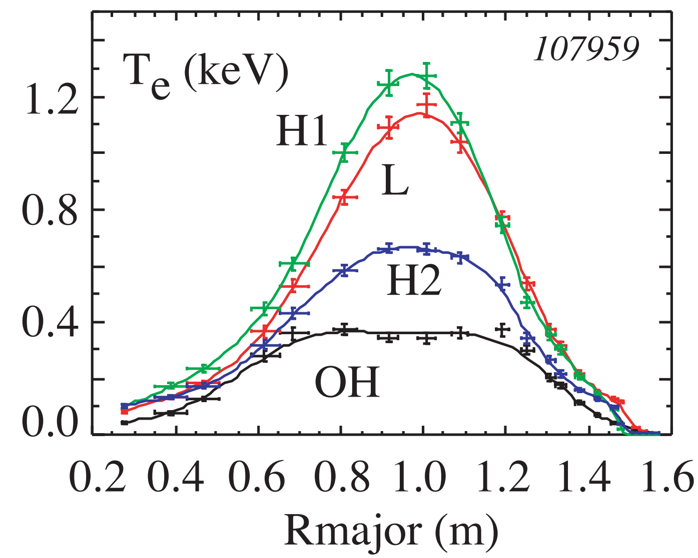
Long Lasting HHFW H mode
$I_p = 0.5$ MA, $B_T = 0.45$ T

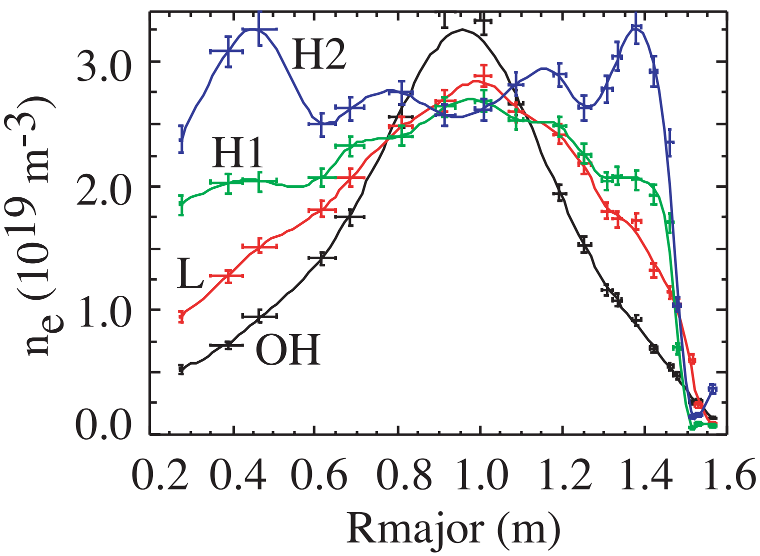


- H mode doubles stored energy
- 40% bootstrap current
- Quiescent, then Elmy
- Drop in W_{MHD} during Elms

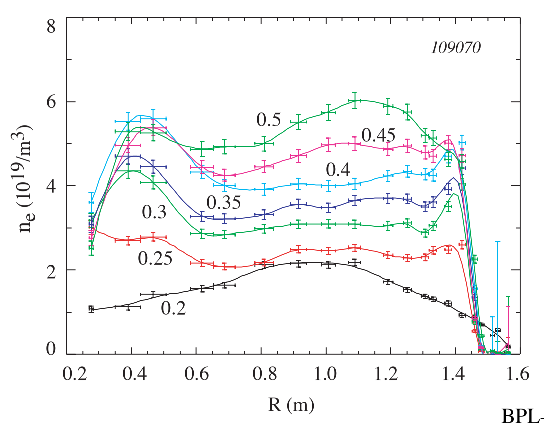
HHFW H-mode Profiles

Time Slices OH, L, H1 and H2





- T_e pedestal observed
- Large edge n_e gradients with "ears'
  - Also observed in NBI H mode ->



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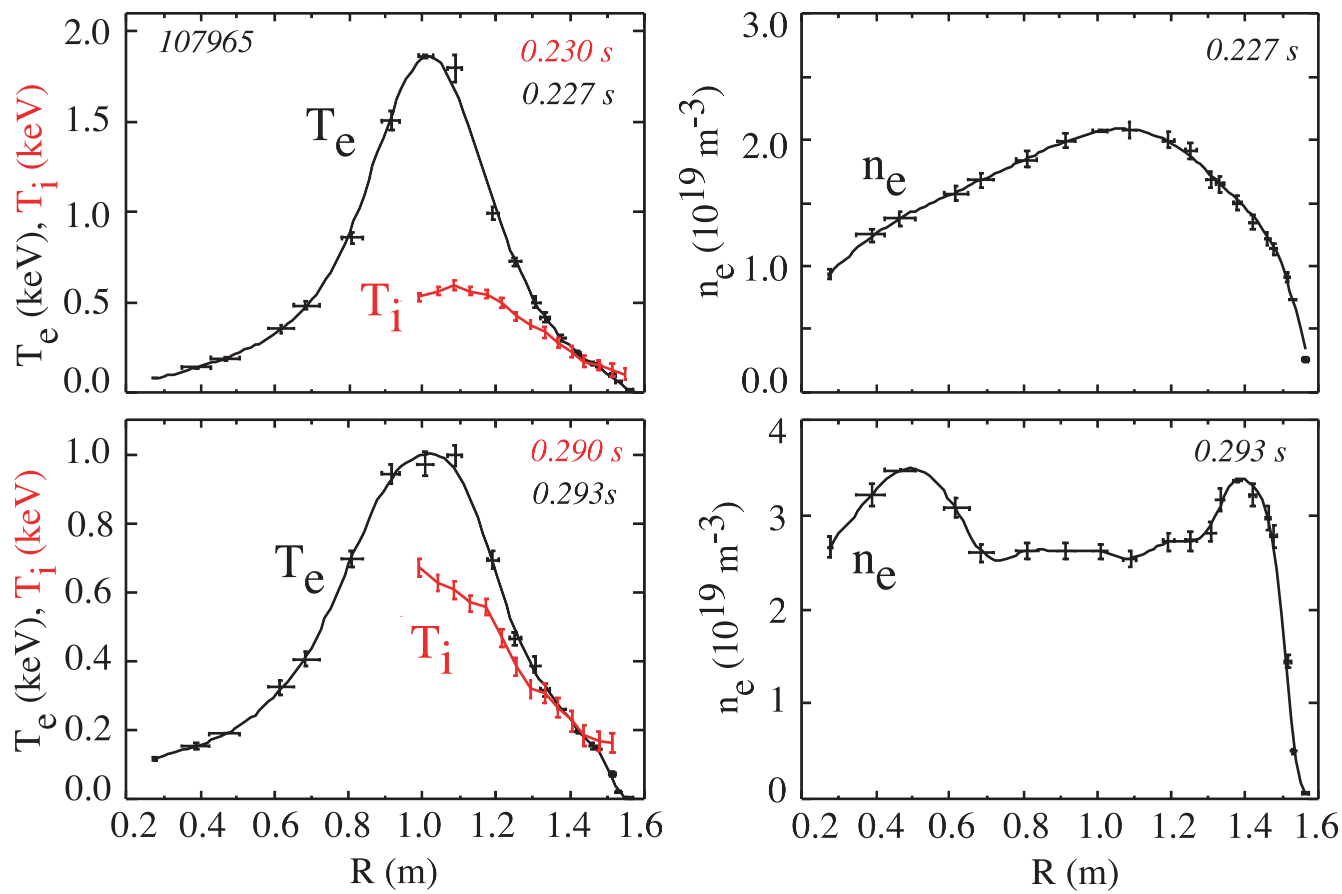
T_i, T_e and n_e Profiles during L and H phases

L Mode

H Mode



T_i from ICHERS, R.E. Bell

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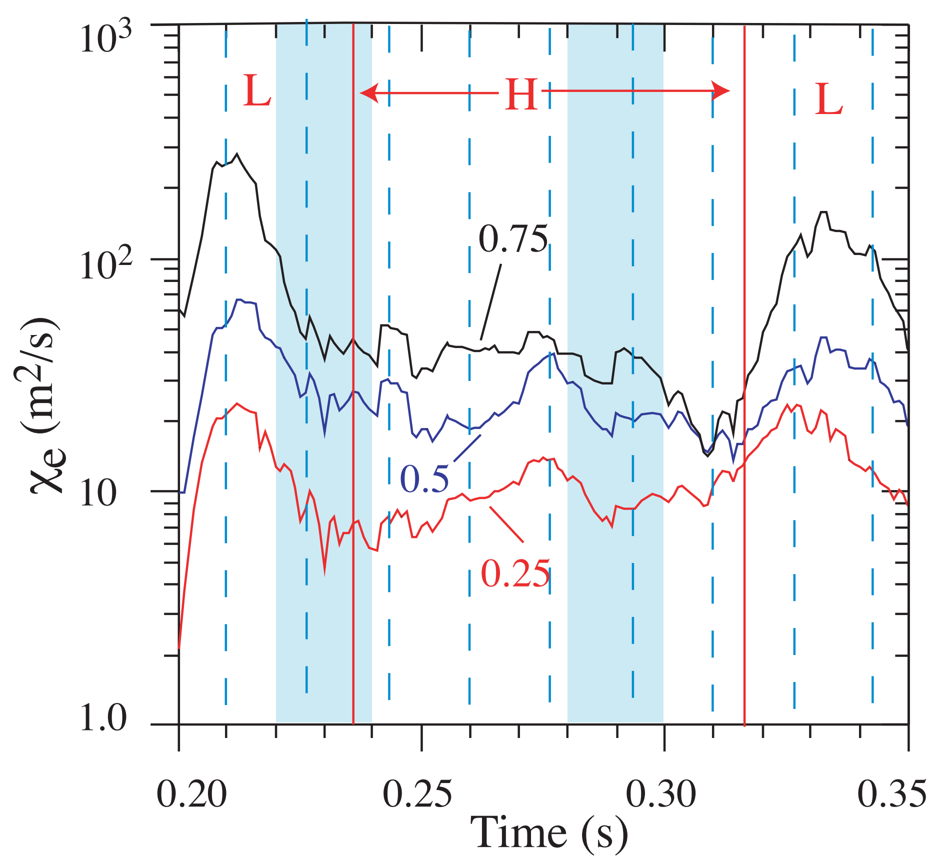
Drop in χ_e Observed during H Phase

- χ_e time evolution for three normalized toroidal flux values
- Dotted lines mark MPTS times
- Light blue areas mark ICHERS measurements.
- Red lines mark H-mode forward and back transitions



Remarks

- The transition is produced without external torque drive and provides grounds for comparative study with NBI driven H mode.
- Combination of H-mode bootstrap current drive with HHFW current drive makes a good candidate for long plasma duration.

Conclusion and Request

- H-mode plasmas obtained with HHFW heating
  - Limited data set, $k_{//} = 14\ m^{-1}$, $I_p \le 0.6$ MA
  - Kinetic profile effects observed
  - χ_e drops during H-phase
  - $\tau_E \le$ ITERPby2
- Need to do a systematic study of HHFW H mode
  - Establish HHFW operational H-mode envelope
    - TF, Ip, push density up, LSN, and DND
  - Study threshold issues
  - Develop HHFW as a tool for NSTX long pulse
    - Investigate current drive phasing

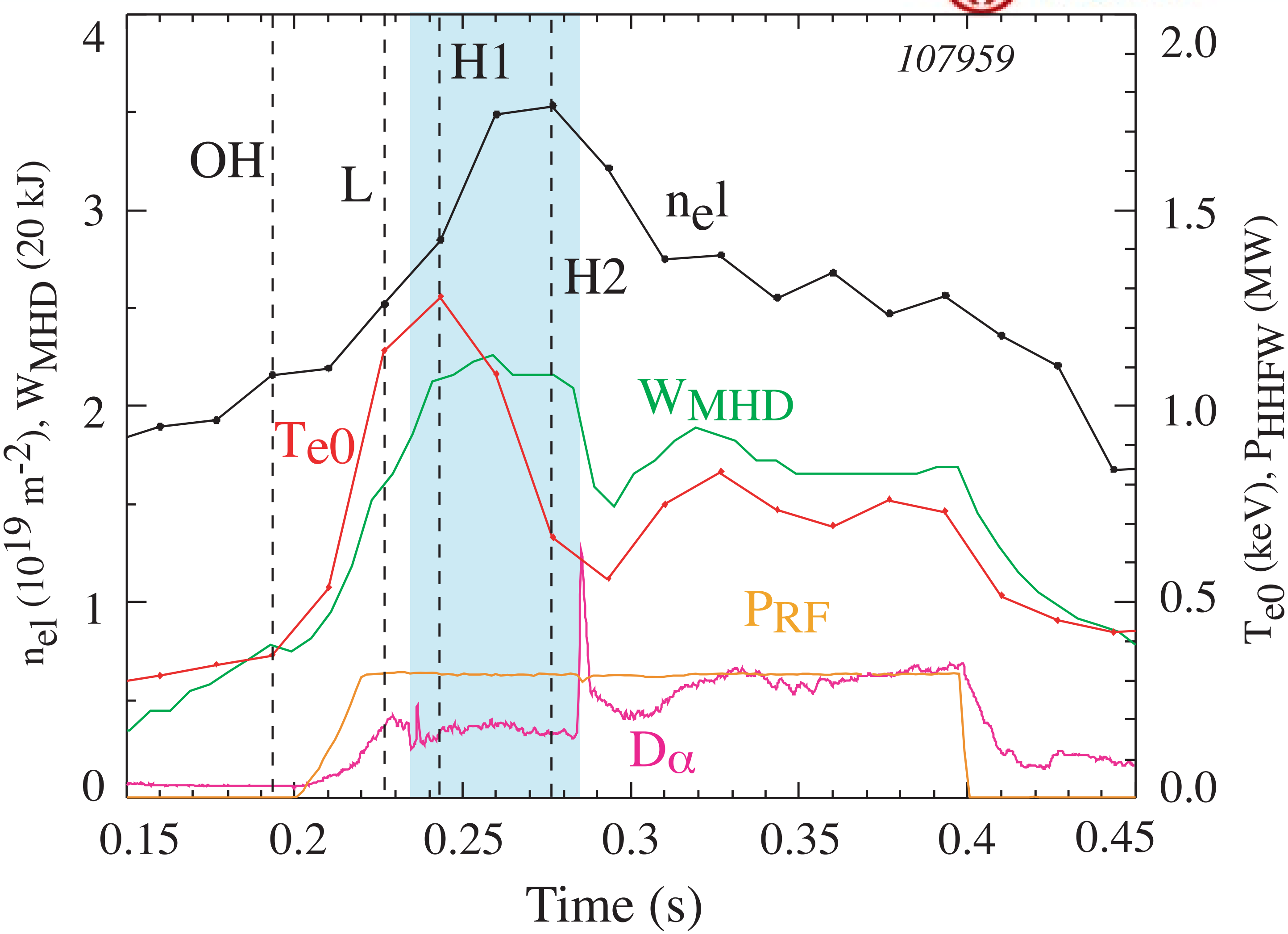
END OF TALK

Outline

- HHFW driven H-mode plasmas
  - – Parameters and profiles
  - – CURRAY implementation into TRANSP
  - – Electron thermal diffusivity time evolution

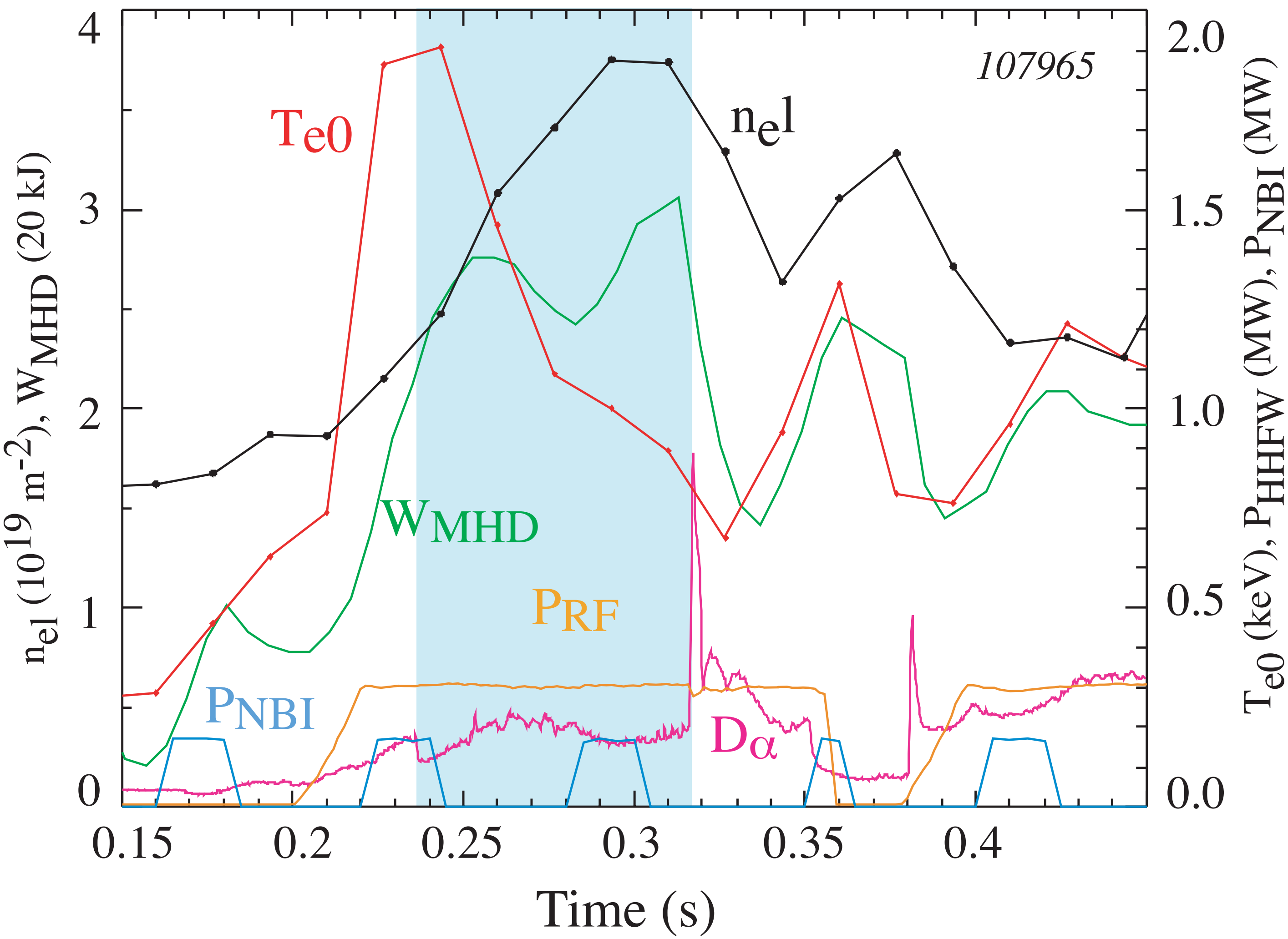
HHFW Driven H Mode Kinetic Documentation

Select Time Slices OH, L, H1 and H2



HHFW H-Mode Plasma

Document T_i Profile with Beam Blips



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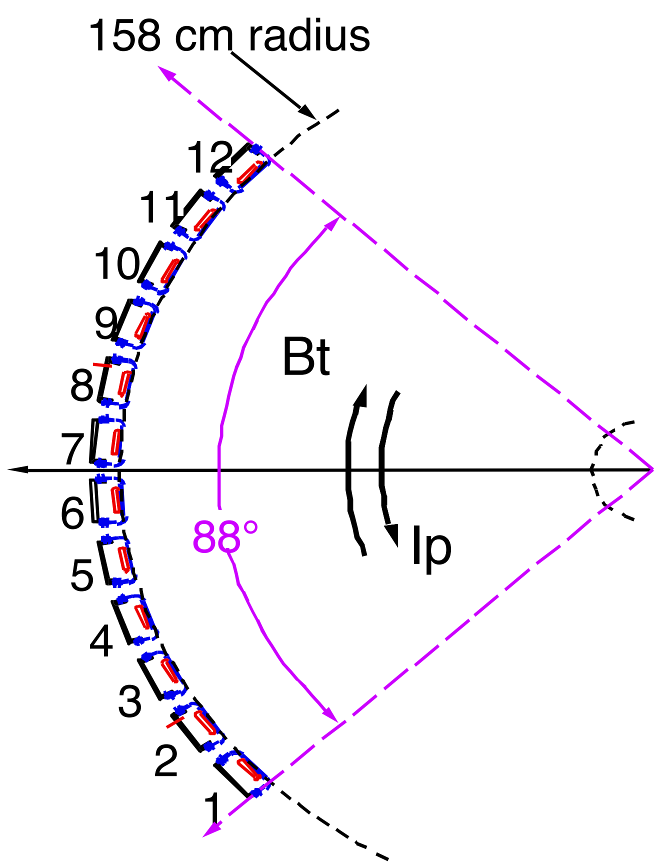
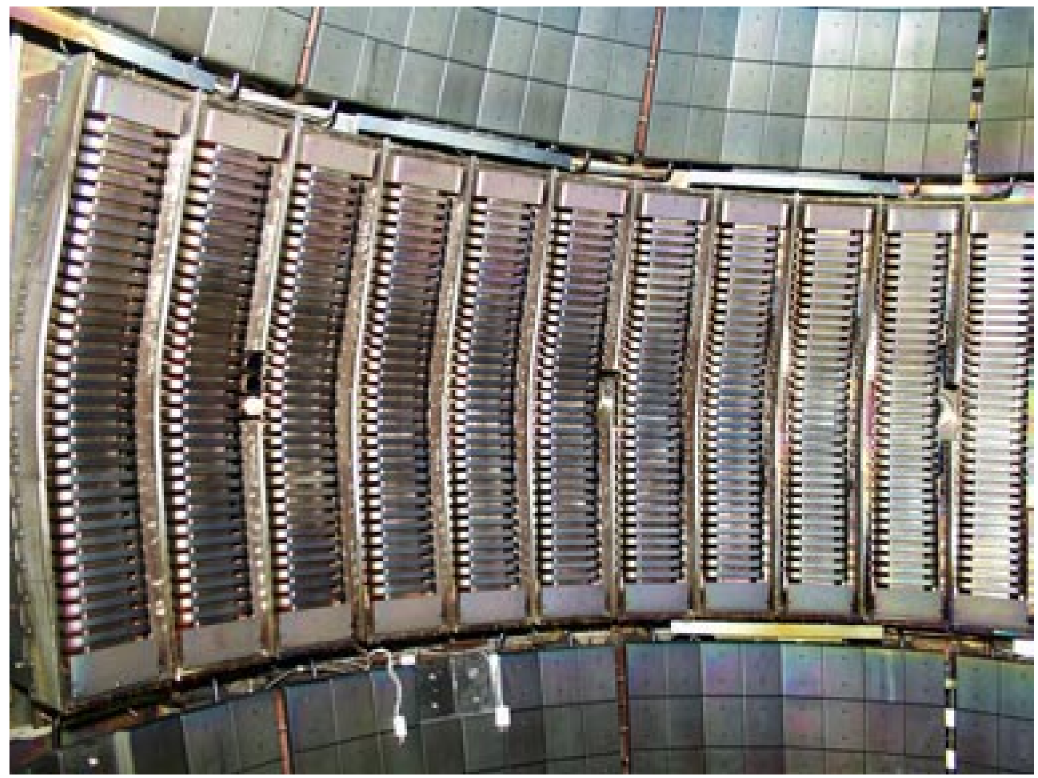
12-Element Antenna Array

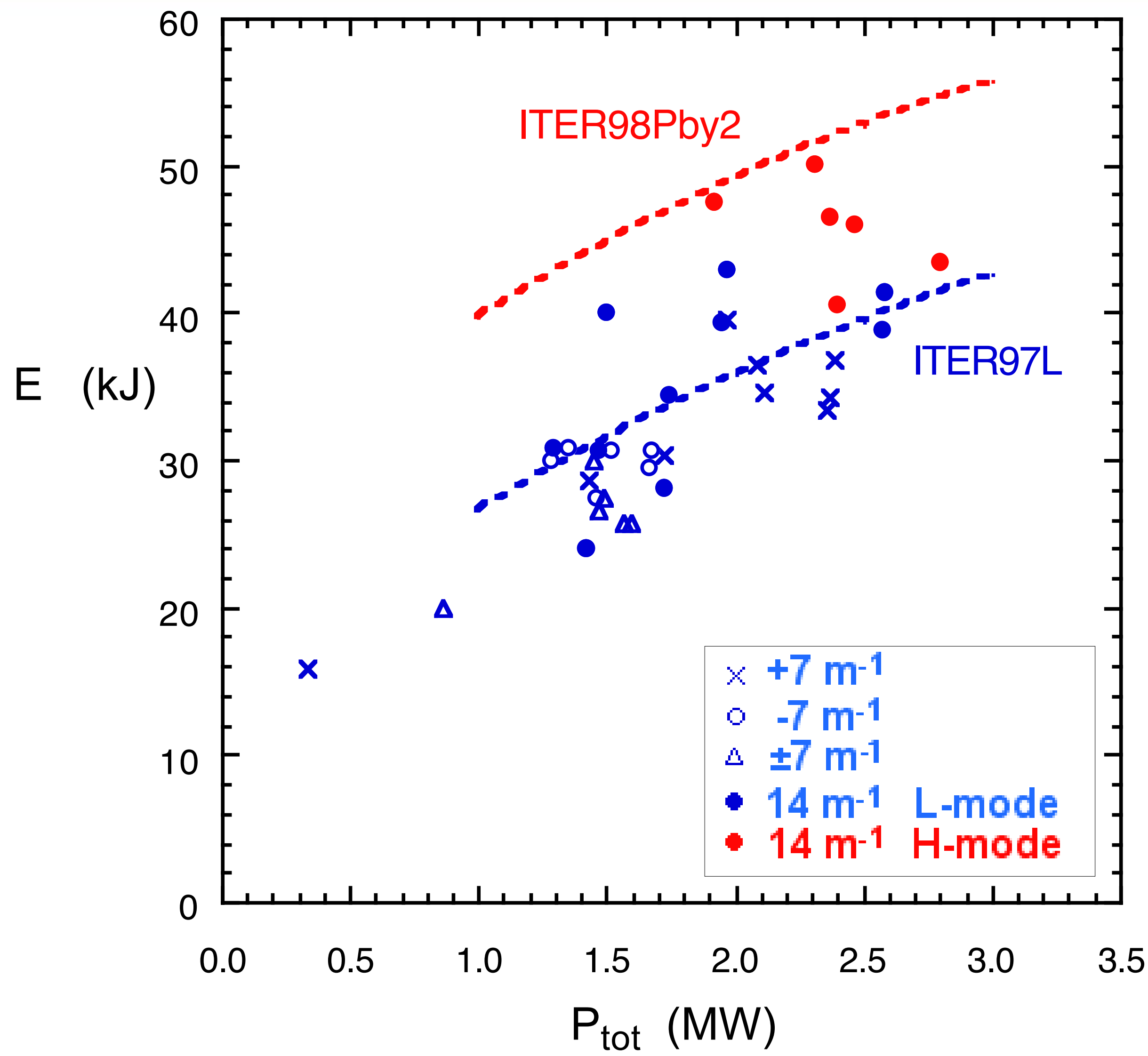
Top view of midplane section



NSTX antenna: Boron-nitride limiters surround each element. Carbon tiles on top and bottom passive plates are also visible.



HEATING WITH HHFW FOLLOWS PREDICTIONS OF CONVENTIONAL SCALING



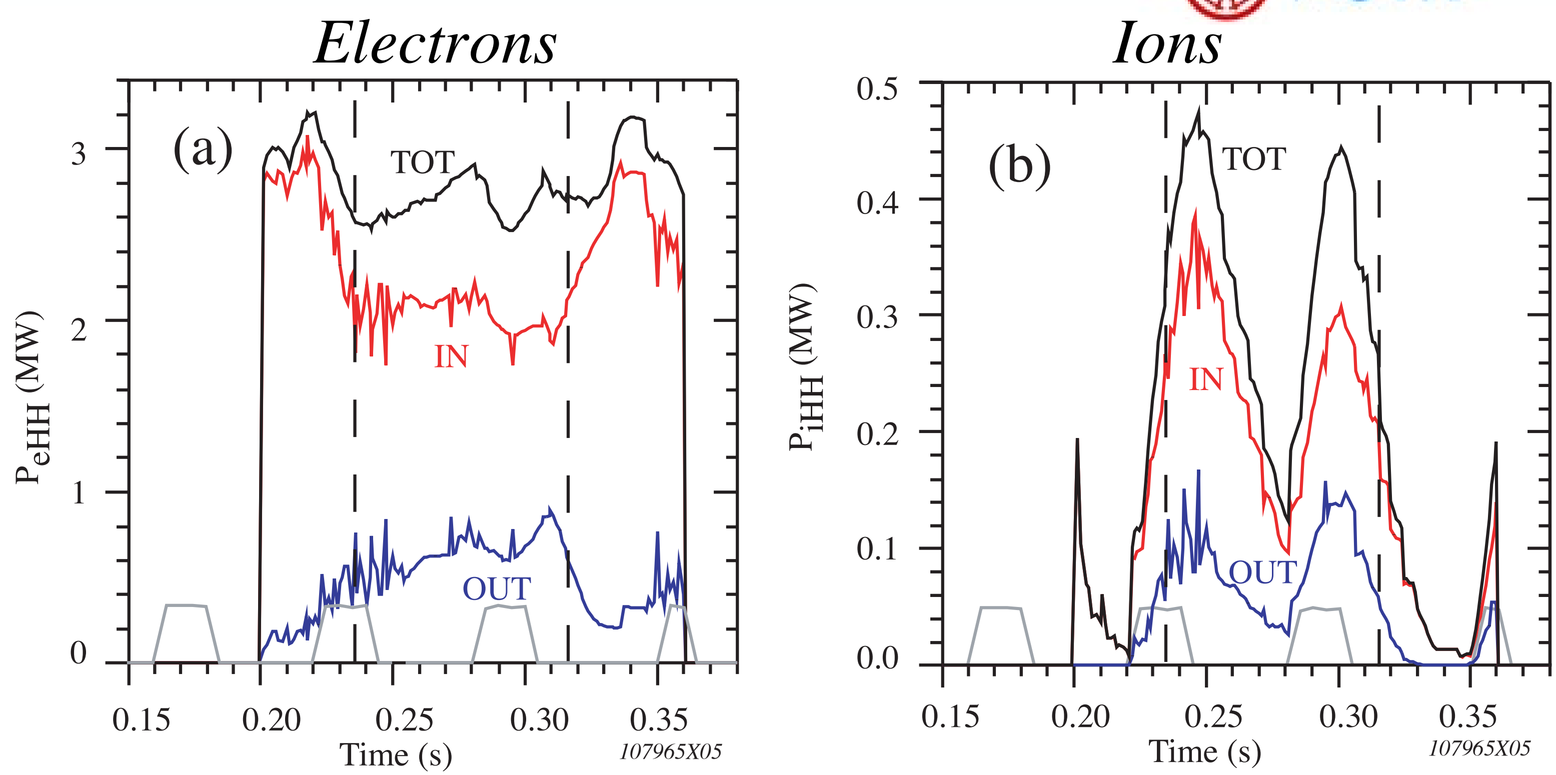
I_p= 500 kA
B_T= 4.5 kG
$\langle n_e \rangle$ =1.5 x10^{19} m^{-3}

H mode defined by appearance of edge pedestal

P.M. Ryan

D.W. Swain

Integration of CURRAY[1] Power Deposition into TRANSP Provides Factual Time Evolution



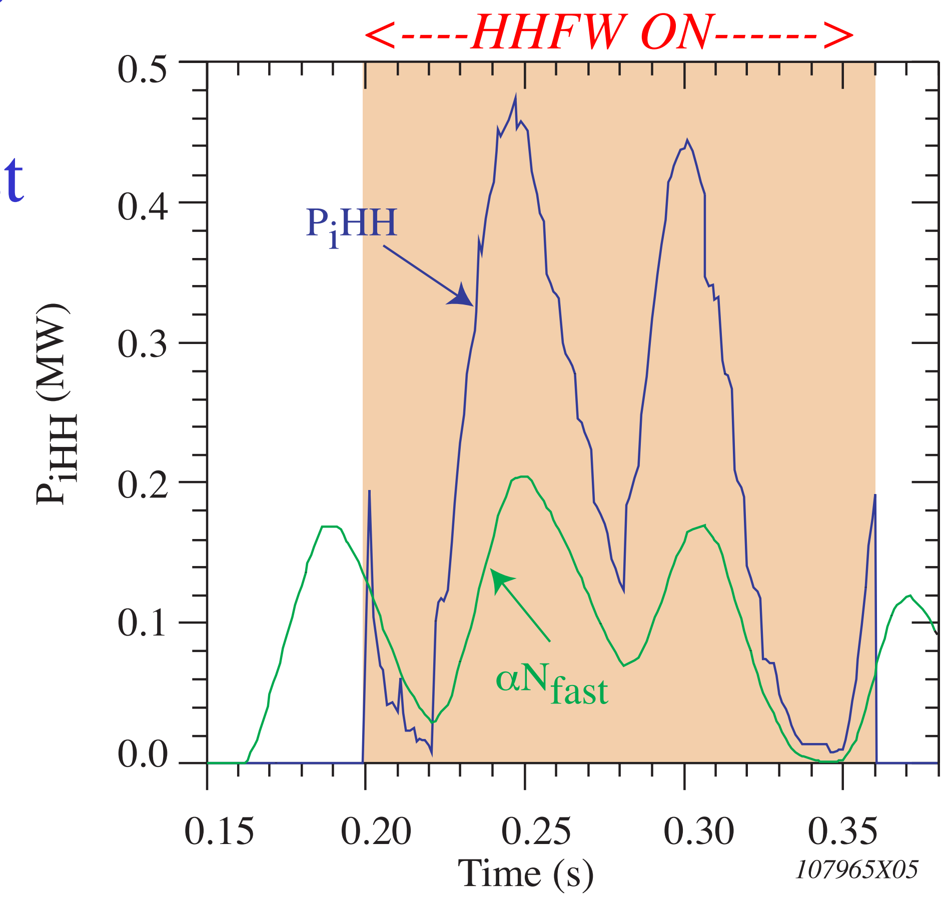
- Total power (TOT), inner radial half(IN) and outer radial half (OUT)
- Electron absorption moves out during H mode (within dashed lines)
- Ion power absorption caused by fast particles

[1]Mau, T.K.,*el*., R. F. Power in Plasmas, 14th Topical meeting, AIP proc. 595, (2001) p.170

HHFW Ion Heating Dominated by Fast Ions

- Power absorption occurs in presence of fast ions
- P_{iHH} is modulated by fast particle population.
- Power absorption at the HHFW onset is due to fast ions generated by NBI blip starting at 0.16 s

CURRAY/TRANSP Output



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