



# Power Deposition and Transport during HHFW Heating

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for the NSTX HHFW Group.

*NSTX Results Review*

*September 19, 2001*

# Outline



- HHFW modulation and two-laser Thomson scattering system to measure  $\Delta T_e(R)$ .
- Preliminary analysis of a high-performance HHFW discharge with indication of ITB.

# MPTS: Two Nd:YAG Lasers Operational



MPTS  
60 Hz, 10 channels  
 $Te(R)$ ,  $ne(R)$ ,  $nel$

MPTS LASER  
BEAMS

MPTS VIEWING  
OPTICS

HHFW ANTENNA

ORNL  
REFLECTOMETER

PUMP DUCT

NEUTRAL BEAM

CHERS OPTICS

CHERS, 17 channels,  
 $Ti(R)$ ,  $v\phi(R)$

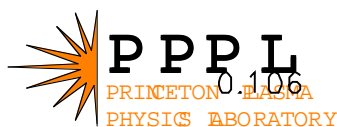
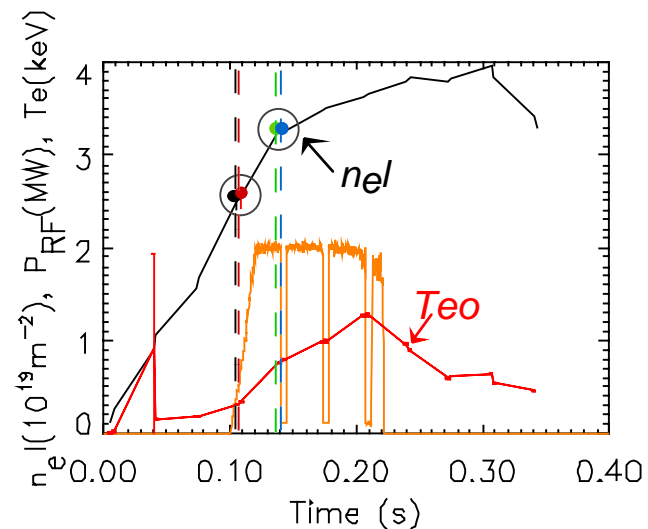
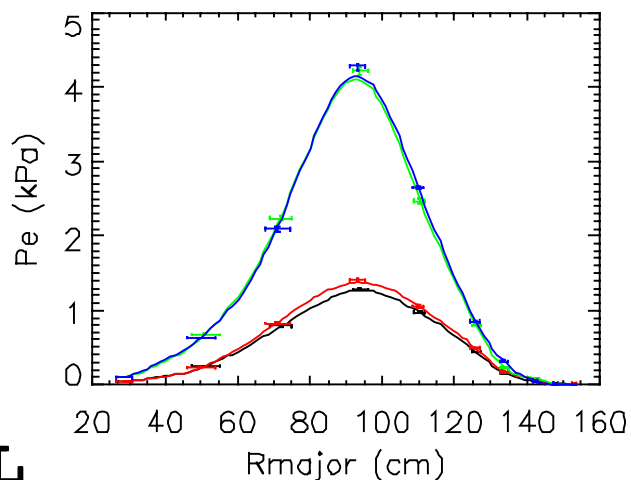
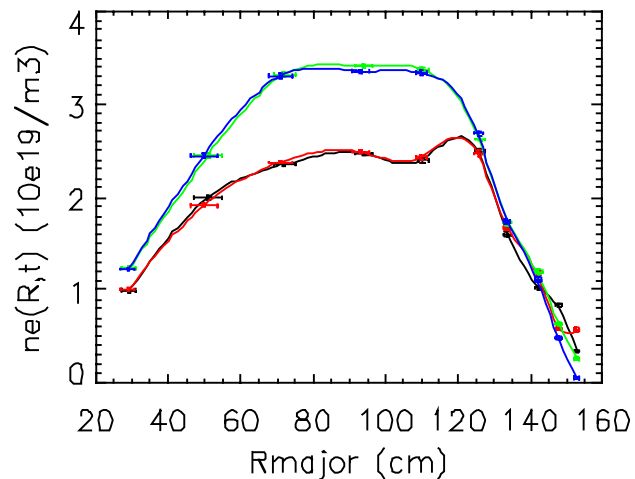
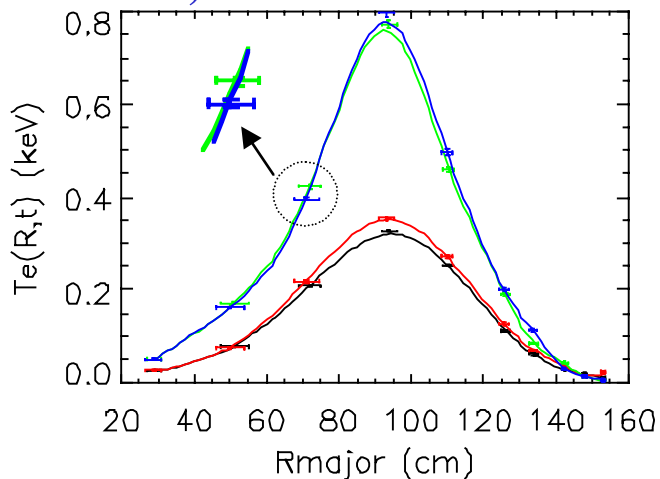


# Measure $\Delta T_e(R)$ with MPTS set to $\Delta t = 3$ ms



4.5 kG, 0.8 MA, He

105797



0.109

0.139

0.142

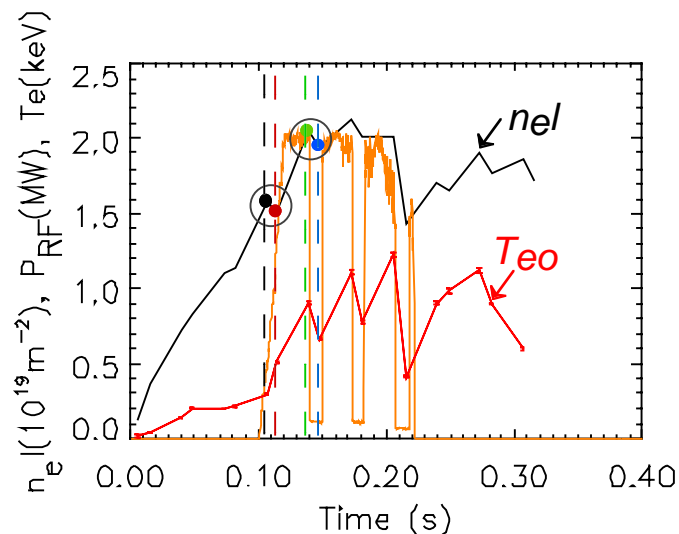
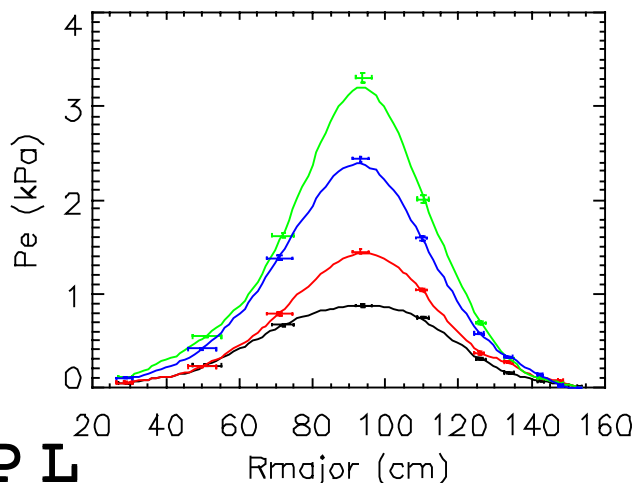
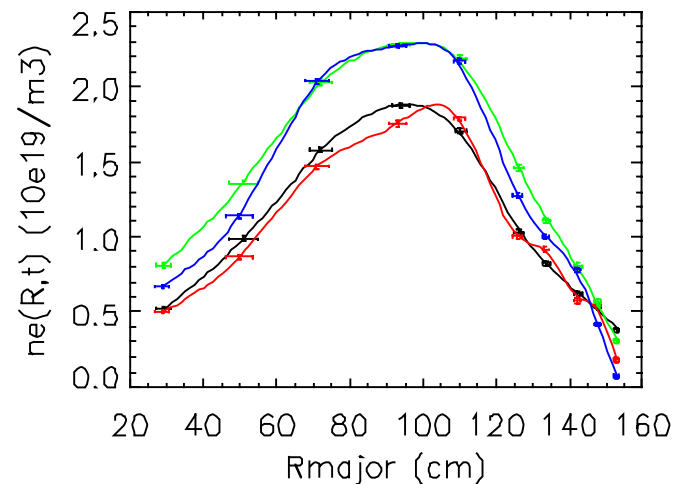
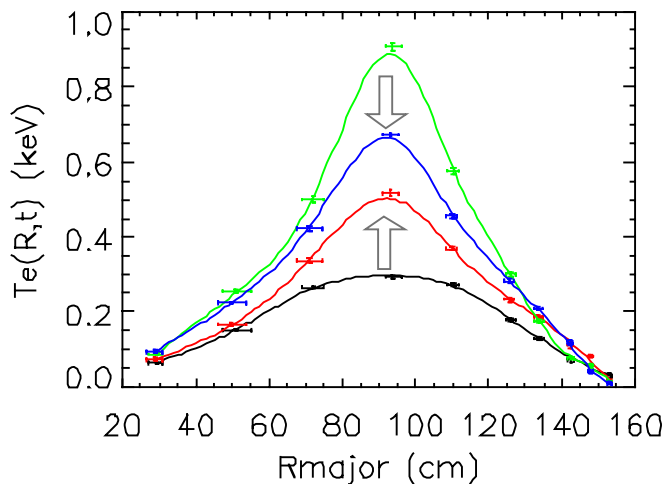
LeBlanc, NSTX\_RES\_REV, 19-Sep-00-4

# Measure $\Delta T_e(R)$ with MPTS set to $\Delta t = 9$ ms



4.5 kG, 0.8 MA, He

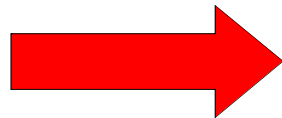
105800



# $\Delta T_e(R)$ Measurement Limitations



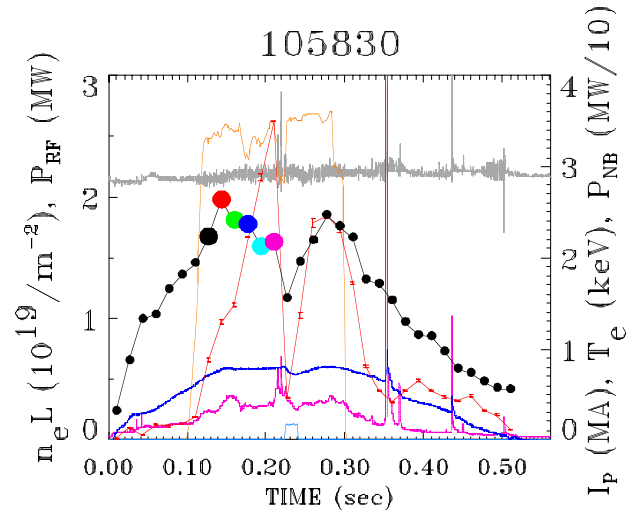
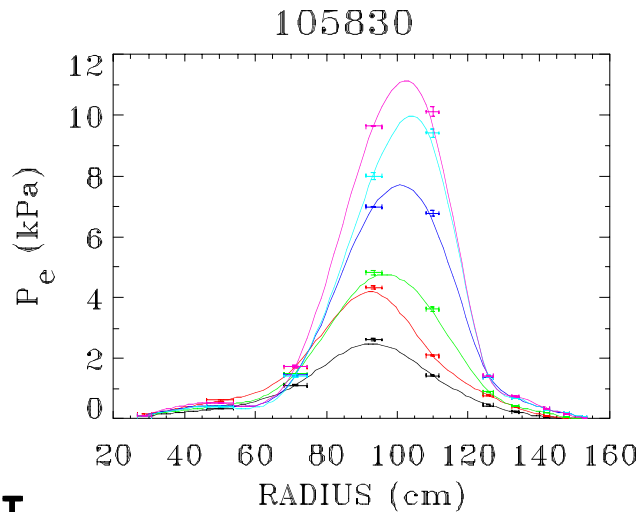
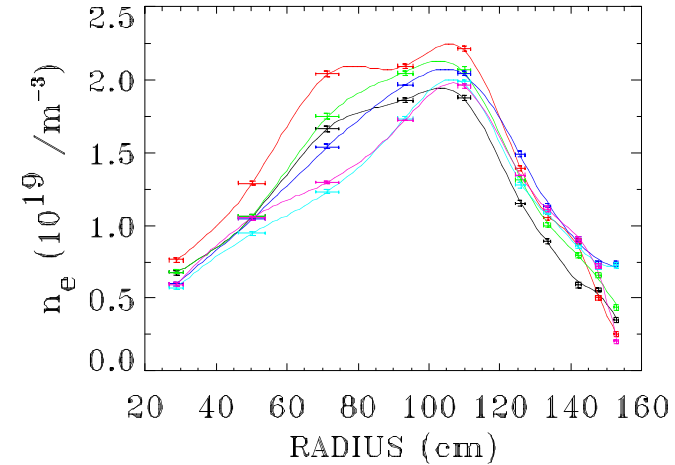
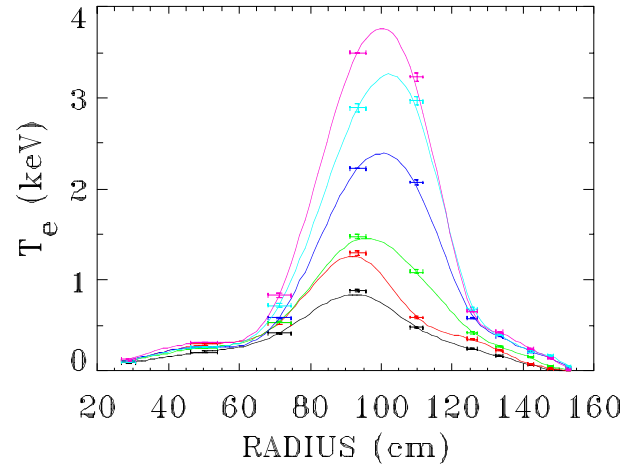
- Measurement limited by only 10 spatial channels.
  - Observed  $\Delta T_e(R)$  at the plasma center.
  - 20 spatial channels for 2002.
- Will try at lower ohmic power.
  - Present measurements were done at  $I_p = 0.8$  MA.
  - Will repeat at lower plasma current, e.g. 0.3 MA.
- Experimental observation could be partially caused by transport effects...



# A "Typical" Shot: 105830



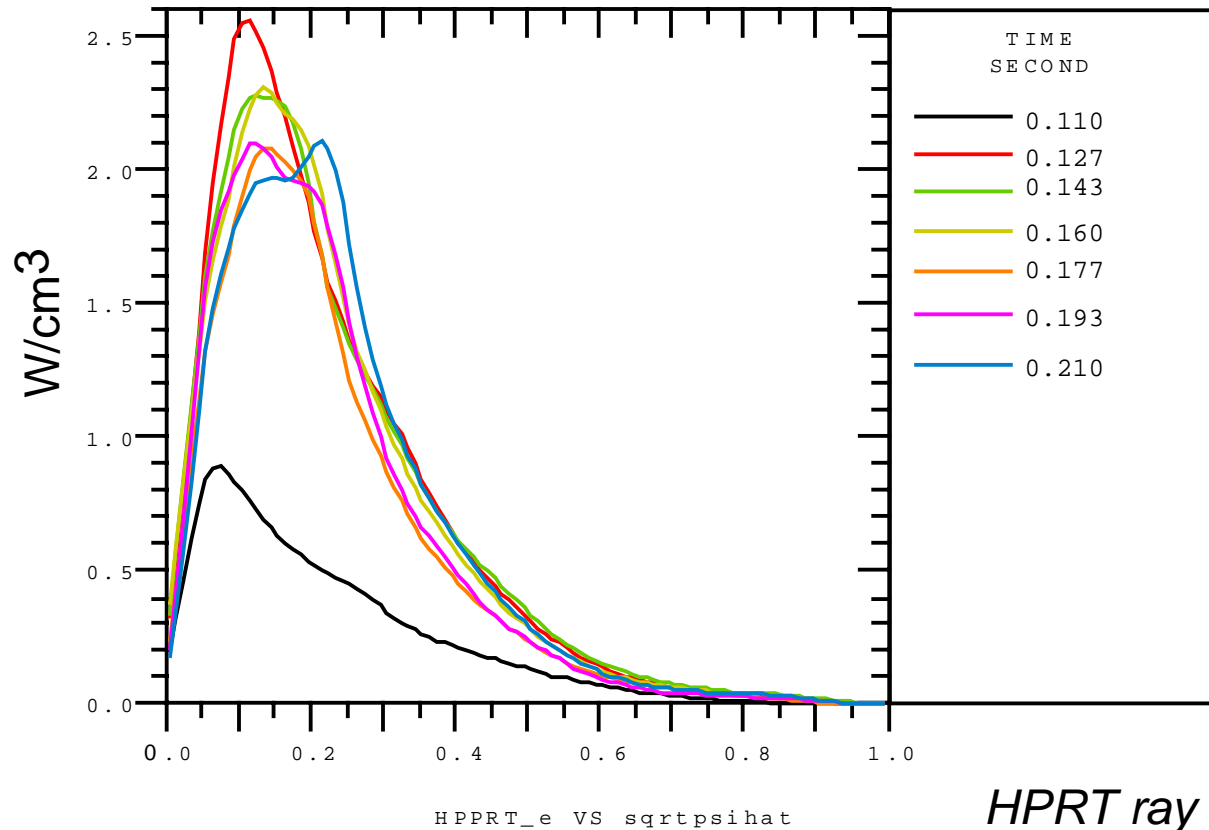
4.5 kG, 0.8 MA, D 105830



# Power Deposition Profile Computation



NSTX 105830  
SHOTDATE: 07Dec-1941 SMOOTHED.



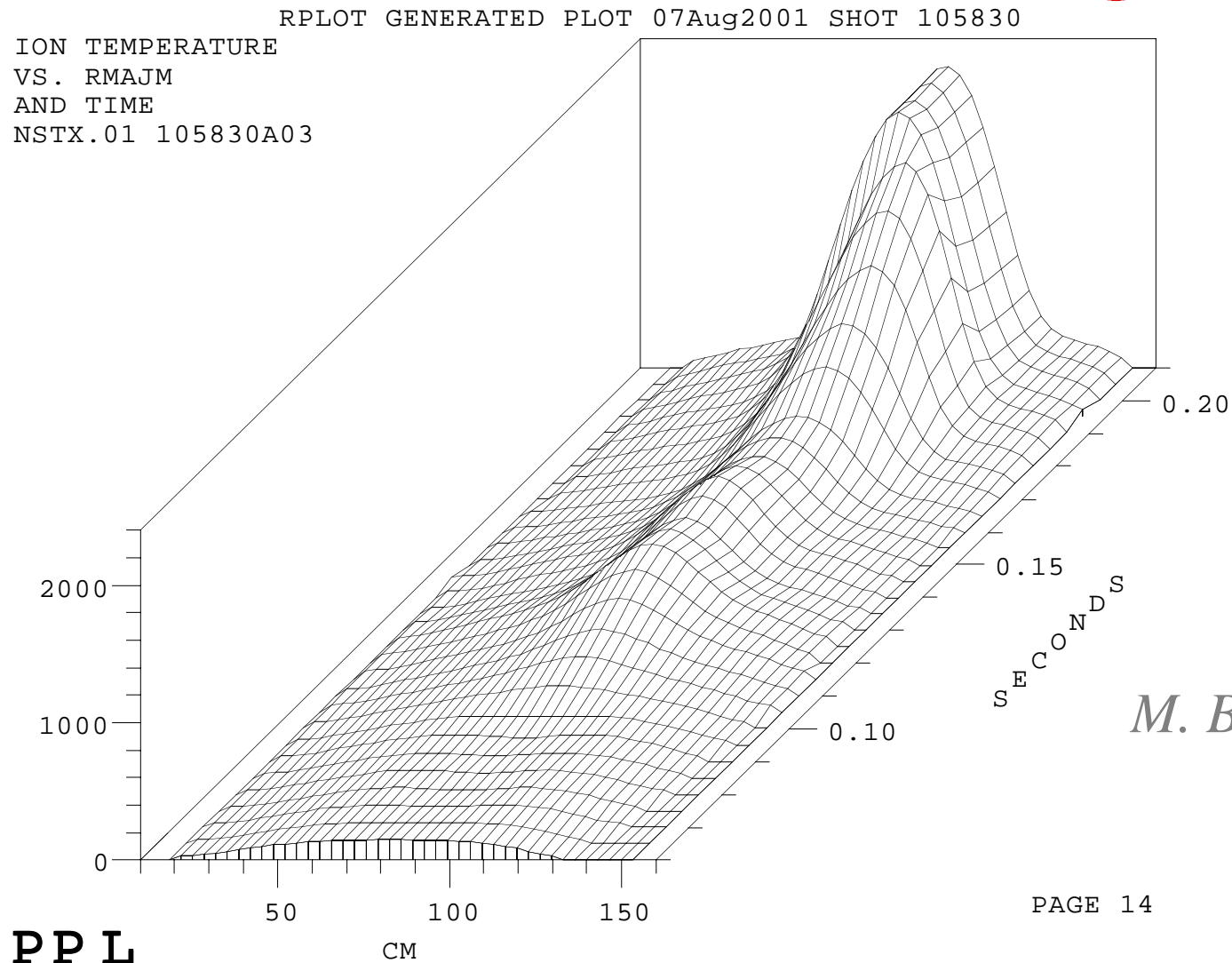
*HPRT ray tracing code*

*A. Rosenberg*

*J. Menard*



# Use XR Crystal Spectrometer and MPTS Data to Generate $T_i(R, T)$

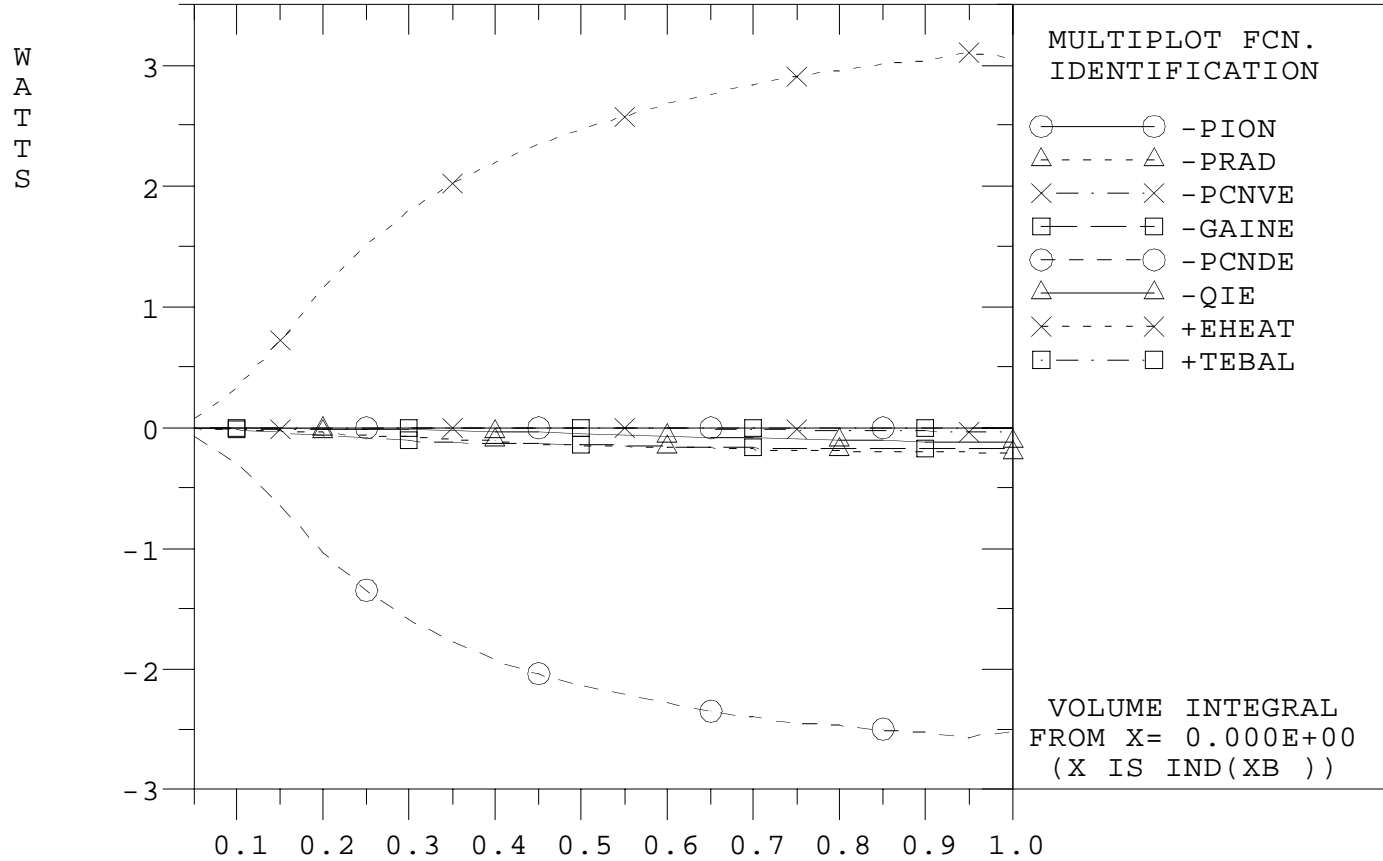


*M. Bitter*

# Electron Energy Balance Dominated by Conduction



NSTX.01 105830A03 PAGE 19  
 TIME = 2.0000E-01 SECONDS  
 x10<sup>6</sup>

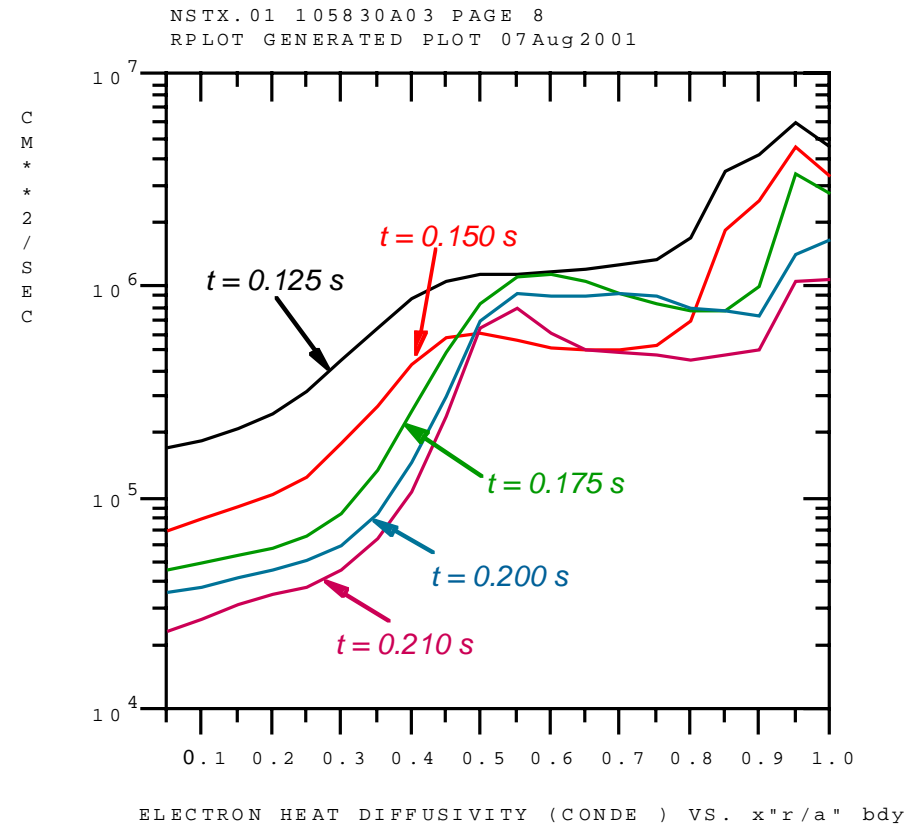


ELECTRON POWER BALANCE (EEBAL) VS x''r/a'' bdy (XB)

# TRANSP “Sees” a $\chi_e$ Drop



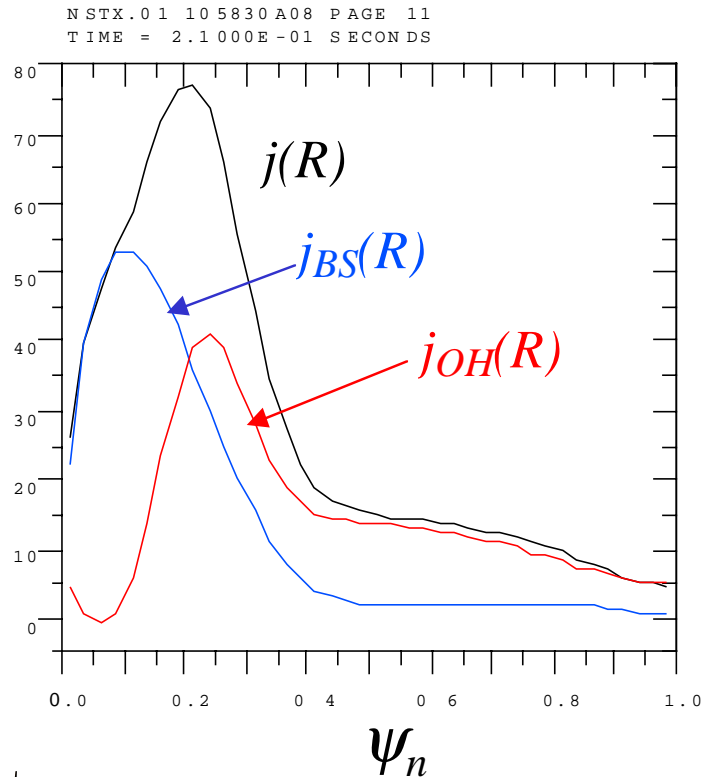
- Assume  $T_i(R,t) = T_{i0}(XR-XSTL) * T_e(R)$  MPTS shape.
- Get HHFW power deposition from HPRT.
- Power balance dominated by conduction.
- *Results are preliminary.*
- With thanks to M. Bitter, A. Rosenberg, and J. Menard.



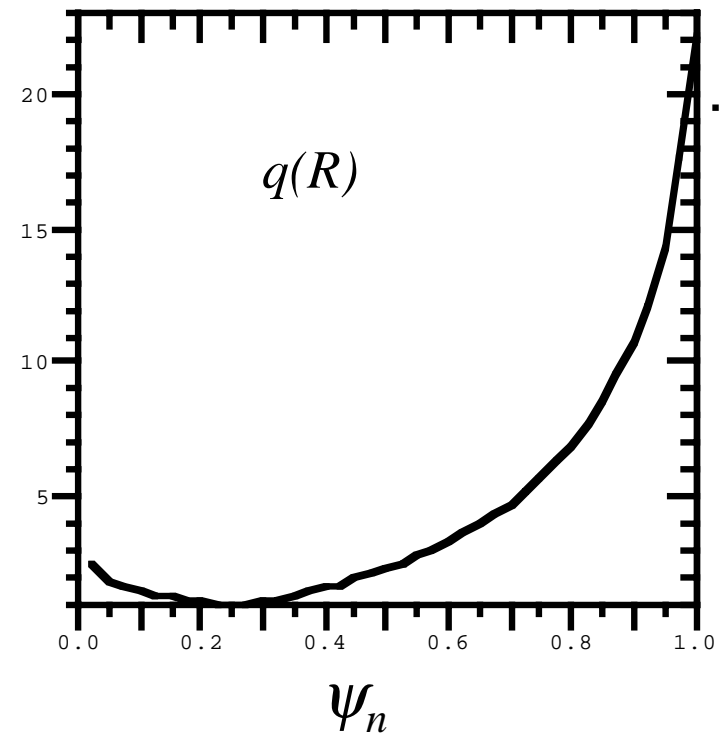
# Magnetic Diffusion Eqn Solved by TRANSP



- Inverted  $q$  profile
- $q_{min} = 1$  at  $\psi_n = 0.25$  just before MHD event.



$t = 0.21$  s RPLOT GENERATED PLOT 18Sep2001



# Preliminary Transport Analysis during HHFW



- High central  $T_e = 3.5$  keV in deuterium plasma.
- Little change in density.
- First-cut TRANSP analysis:
  - Internal transport barrier likely (MPTS data).
  - $\chi_e$  drops in core region.
  - Electron energy transport dominated by conduction
  - Inverted  $q$  profile.
  - $q_{min} = 1$  just before MHD event.
  - $q_{min}$  nominally aligned with  $T_e$  gradient.

# CONCLUSION



- More work needed to determine  $\Delta T_e(R)$  from Thomson scattering data.
  - Heating and transport effects appear convoluted.
- HHFW seem to have caused an internal transport barrier in deuterium plasma.
  - $\chi_e$  drops in core region.
  - Inverted  $q$  profile.
  - $q_{min}=1$  just before MHD event.