EBW Coupling at 8-40 GHz for L- and H-Mode Plasmas

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Wave-Particle ET Meeting

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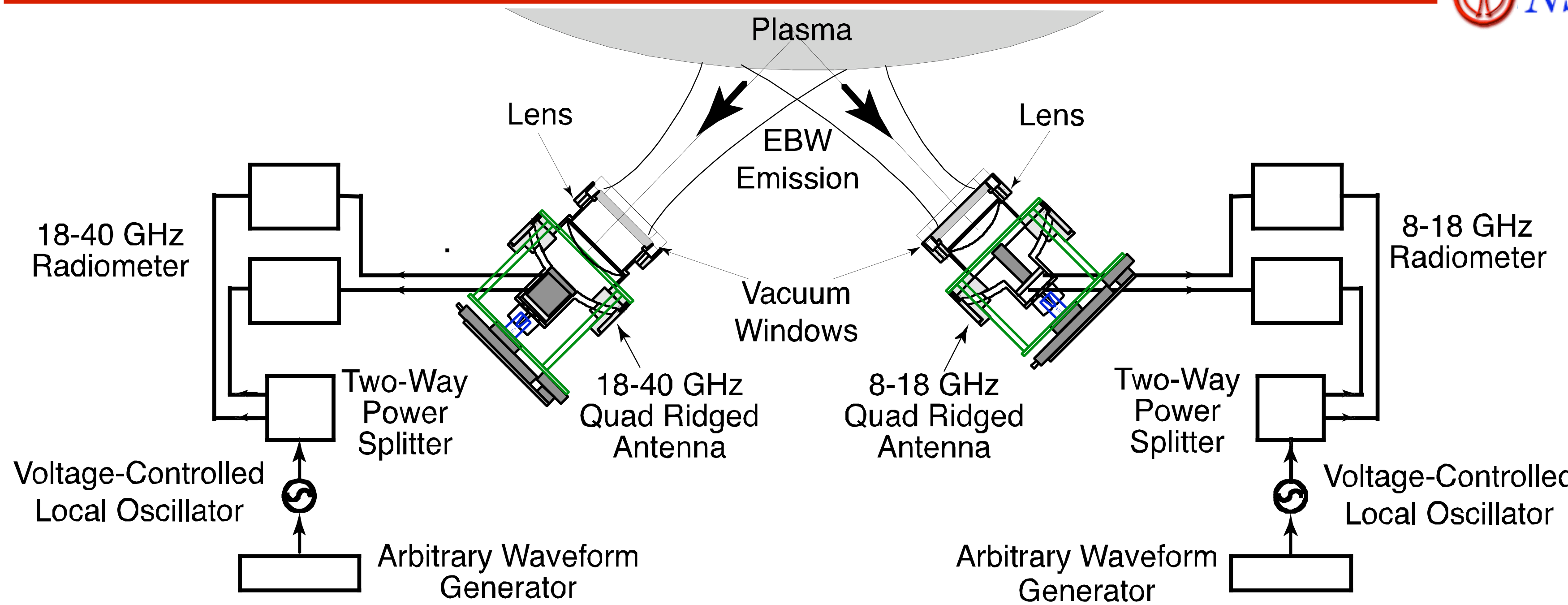
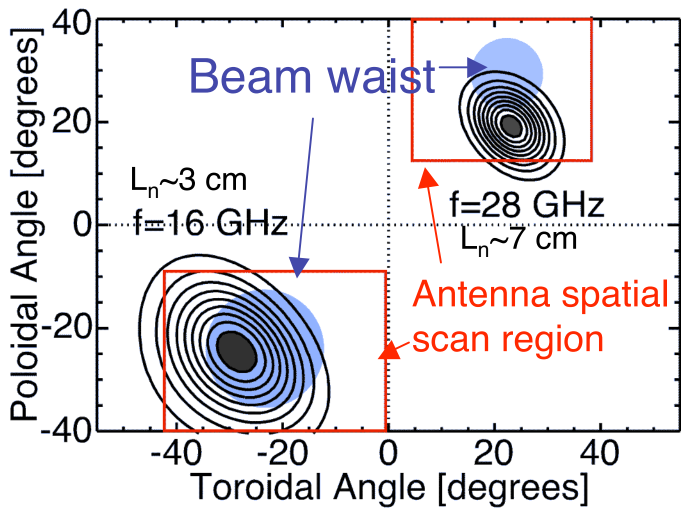
Goal for 2007: Understanding EBE in L- and H-Mode Plasmas

- Study H- & L-mode coupling physics with improved diagnostics
- Investigate variation of EBW coupling on plasma shape, I_p, z, etc.
- Compare to EBE simulation with kinetic model EBW collisional damping
- Outline-
  - Diagnostic overview
  - L-mode results and run plan
  - H-mode results and run plan

Remotely Steered EBW Antennas Allow Angular Mapping of f_{ce} & 2 f_{ce} B-X-O Coupling Window

NSTX





- ±10° scan in poloidal and toroidal directions
- Acceptance angle:
  8-18 GHz antenna ~ 22°
  18-40 GHz antenna ~ 14°

L-Mode Results and Plans for NSTX 2007 Run Campaign

Strong f_{ce} Emission Observed During L-mode Scan

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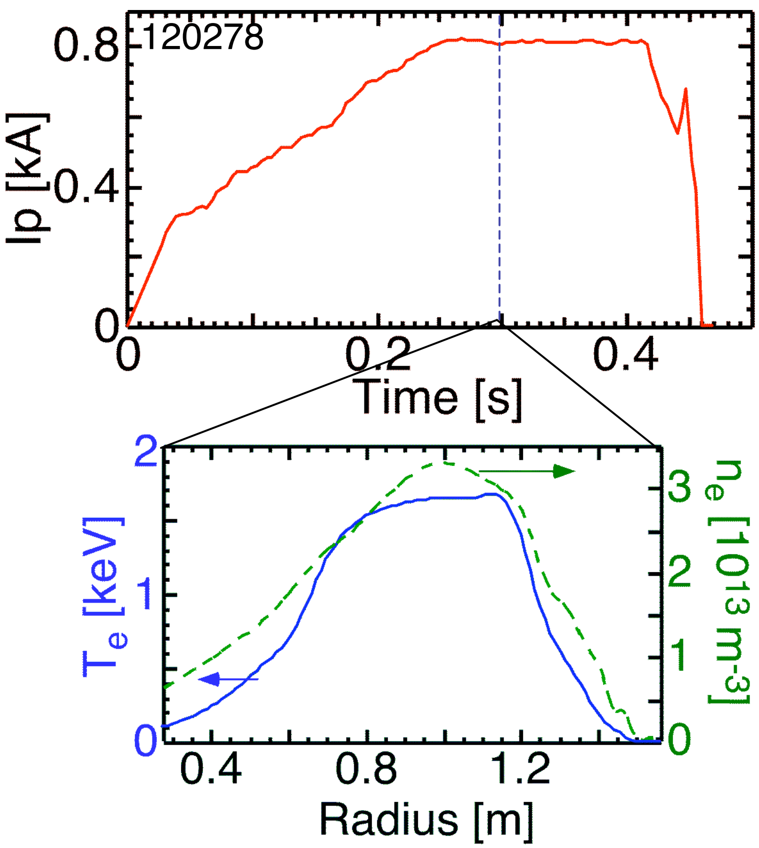
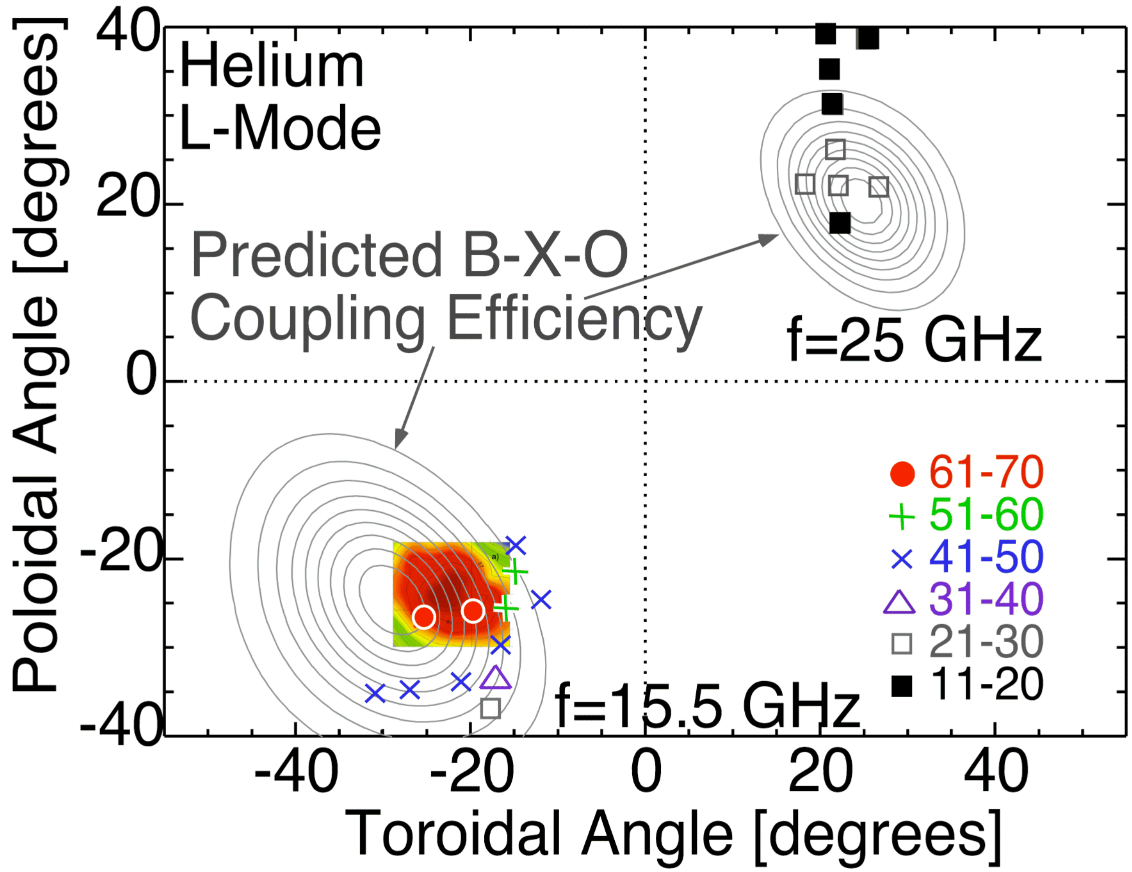
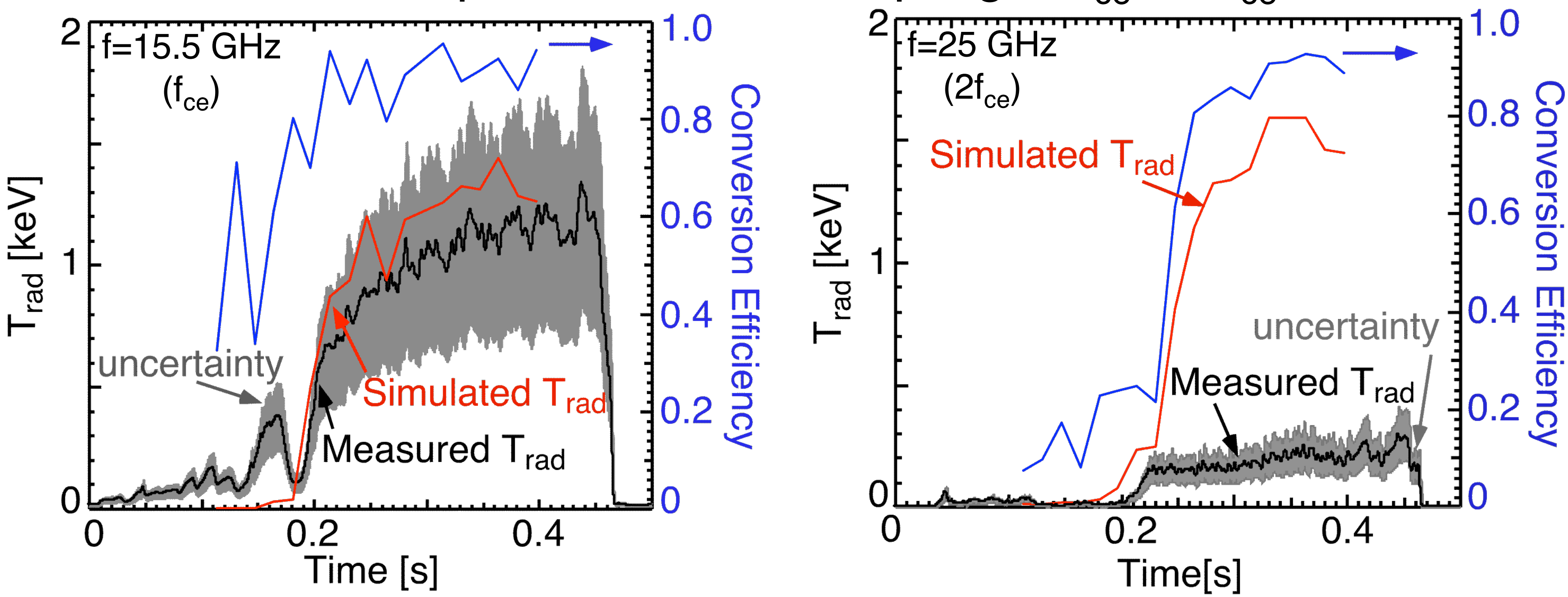
- Target plasma I_p=0.8 MA, $T_e(0)$~1.6 keV, n_e~3x10^{13} m^{-3}
- Discharge repeated to obtain B-X-O coupling map





L-Mode B-X-O Emission Data from 2006 Run Agrees Well With Modeling at f_{ce}, but not $2f_{ce}$

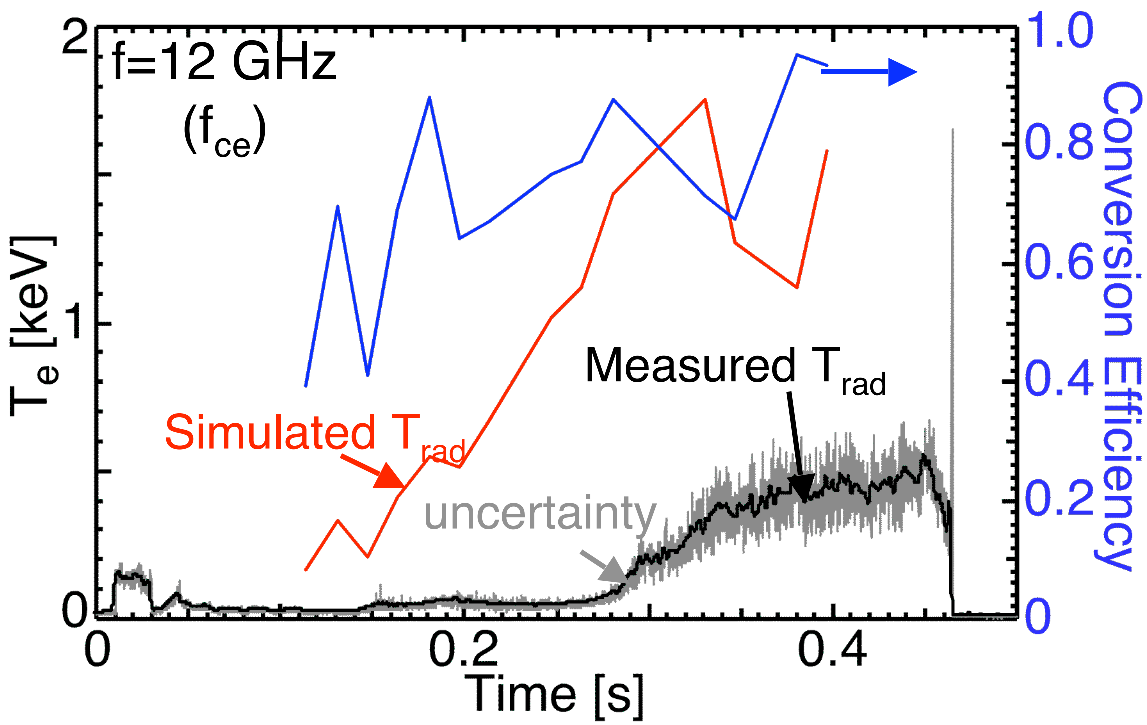
- Measure ~70±20% f_{ce}(=15.5 GHz) coupling, but only ~25±10% $2f_{ce}$ coupling
- EBW simulation predicts ~90% coupling at f_{ce} & $2f_{ce}$

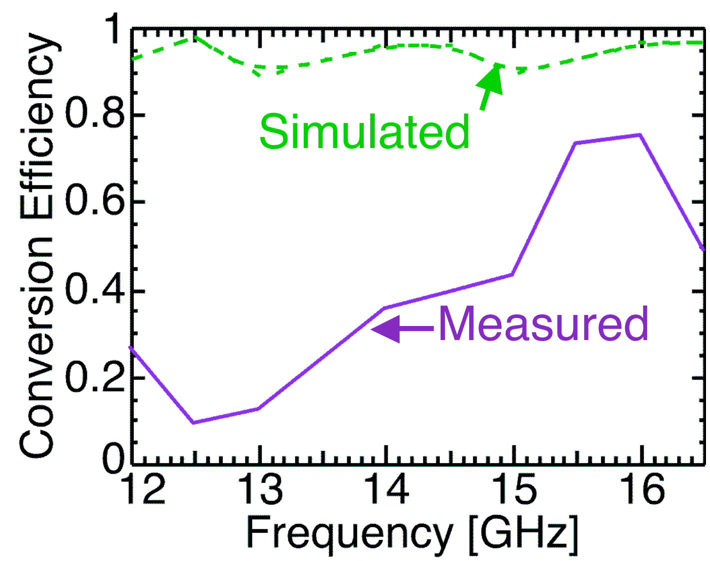


→ Possible causes: large Doppler broadening effects resulting in off-axis damping, EBW damping at conversion layer, problems with EBW simulation

Significant Disagreement Between Measured and Simulated Coupling for Most f_{ce} Frequencies

- Measured coupling efficiency ~26% for f_{ce}=12 GHz; simulation predicts 60-80%
- Similar observation made for f_{ce}<15.5 GHz





- Possible causes - large Doppler broadening, collisional damping, problems with EBE code

$T_e(R)$ from 2006 EBE Data Disagrees with Thomson Scattering

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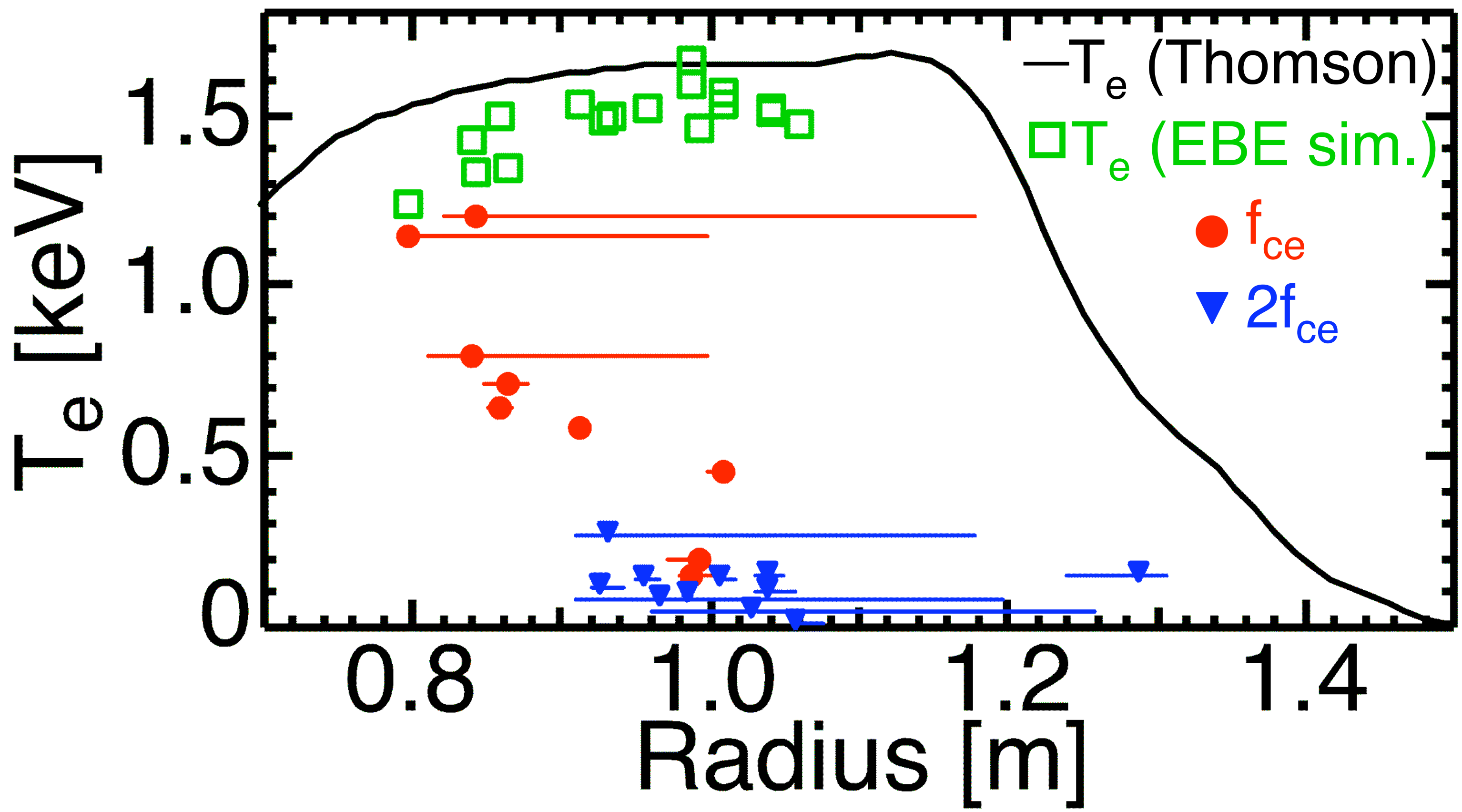
- $T_{rad}(R)$ profile for 120278, t=0.398s
- Ray damping location obtained from EBE simulation code
- Average T_{rad} from EBE used in calculation
- Bars show max. and min. damping location from 41-ray case



Three Main Objectives will Provide Further Understanding of B-X-O Coupling Physics

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- To investigate collisional effects on B-X-O mode coupling
  - Local gas puff injector installed in front of antennas
- To investigate the effects of plasma parameters on B-X-O mode coupling
  - rtEFIT will be used to vary I_p, κ, vertical position
- To measure Te(R) using thermal EBW emission
  - Increase frequency range from 12-18 GHz to 8-18 GHz will provide more radial information

L-Mode Run Plan for 2007 Campaign

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- Modeling and data mining
  - Update B-X-O modeling code to include off-axis magnetic field information
- Piggyback
  - Identify target discharge, I_p~0.8-1MA, B_t~0.4-0.55T
- Run Plan (40 shots = 1.5 days)

5 - shot development

5(2) - gas puffs

2 - Li pellet injection shots

10(5) - parameter scans

3 - reflectometer shots

5 - low I_p ohmic shots

H-Mode Results and Plans for NSTX 2007 Run Campaign

EBE Characteristics During H-Mode from 2006 Run Campaign

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- Burst emission
- Decaying emission
- H-mode with H-L back transition

2006 Scan of H-Mode Window Indicates Very Low Emission

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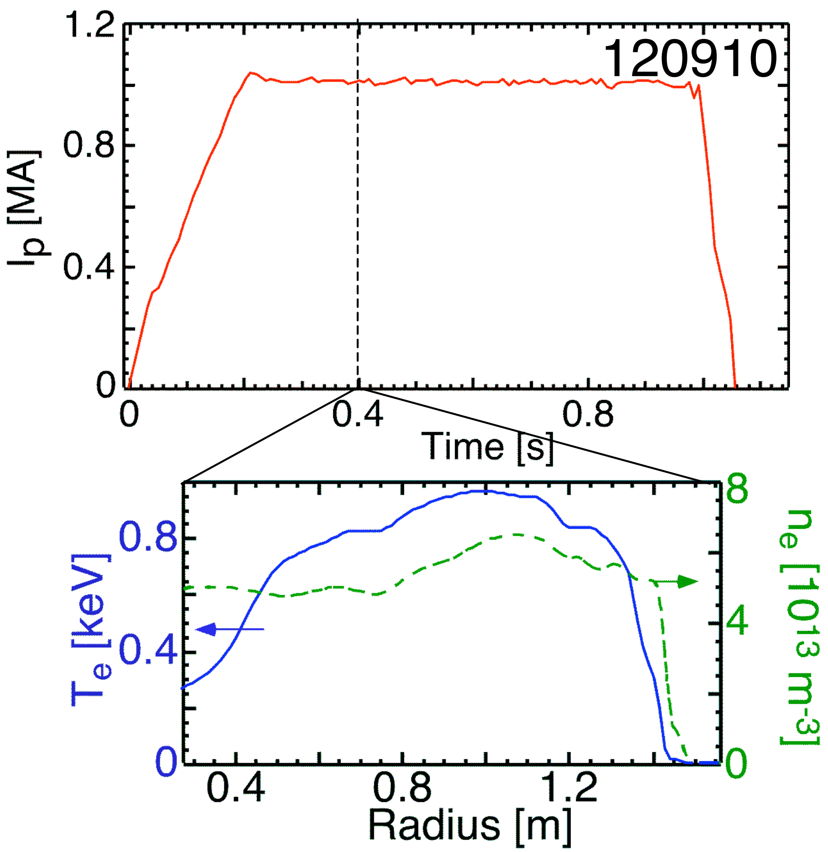
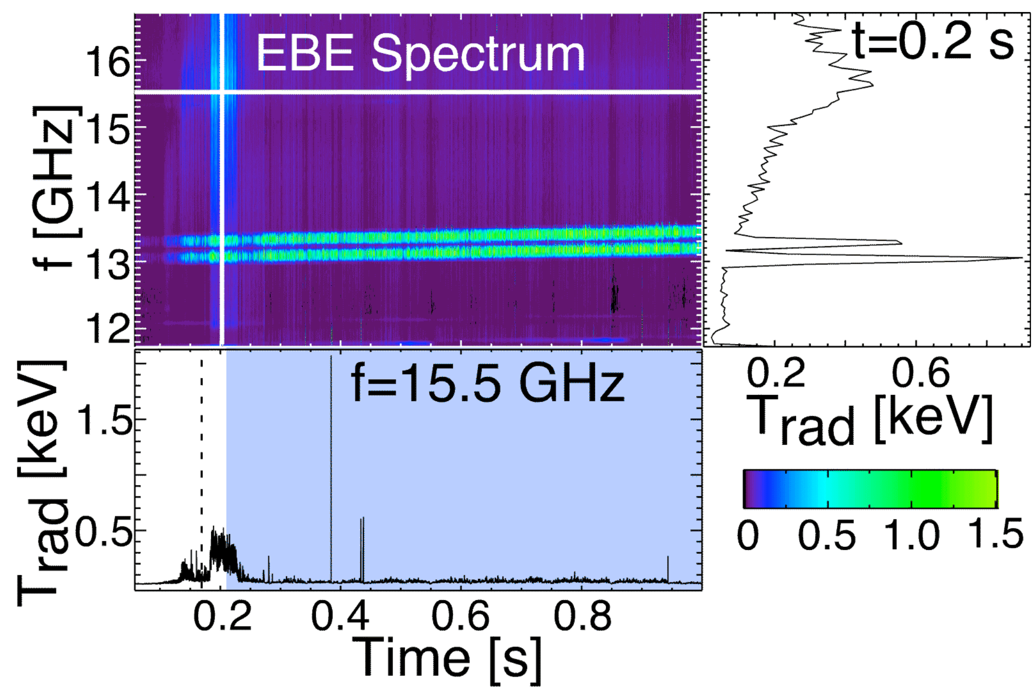
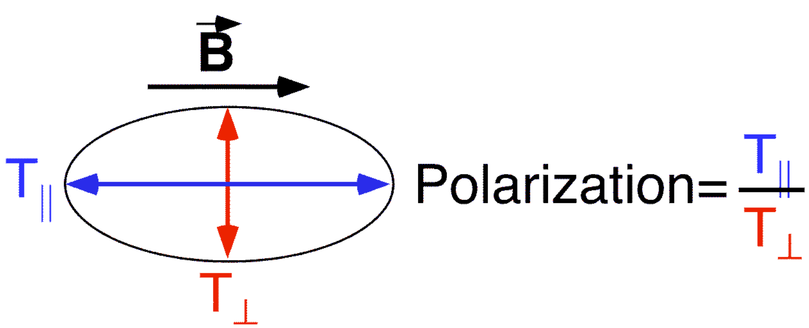
- Target discharge: I_p~1MA, $T_e(0)$~0.9 keV, $n_e(0)$~5e^{13} m^{-3}
- Burst of emission observed shortly after L-H transition

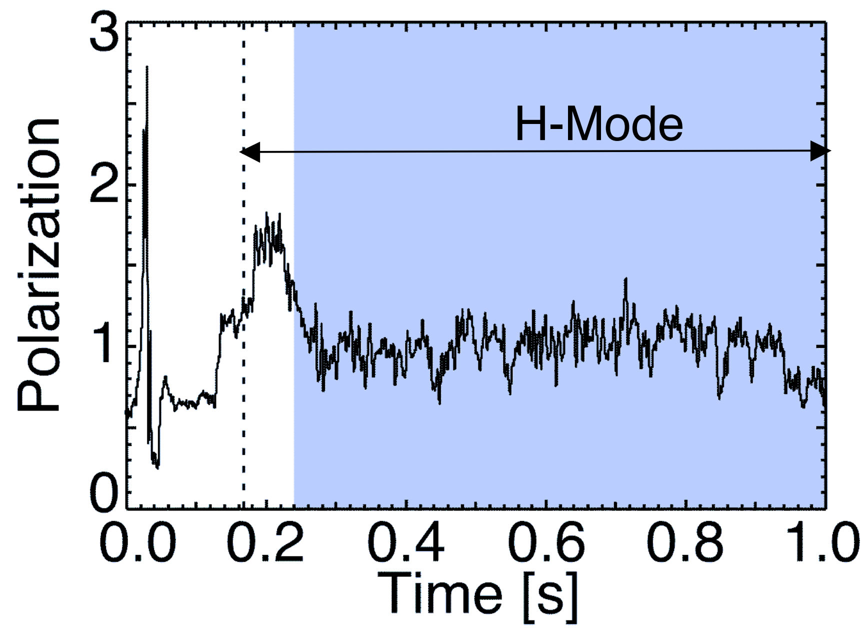




Very Low B-X-O Coupling Measured During H-mode Plasmas in 2006

- <10% coupling efficiency measured during I_p flattop (after emission burst)
- Emission unpolarized after t~0.25s, indicating diagnostic measuring scattered emission





→ Possible causes: collisional damping, edge bootstrap current effects

Slowly Decaying EBE H-Mode Shot Observed

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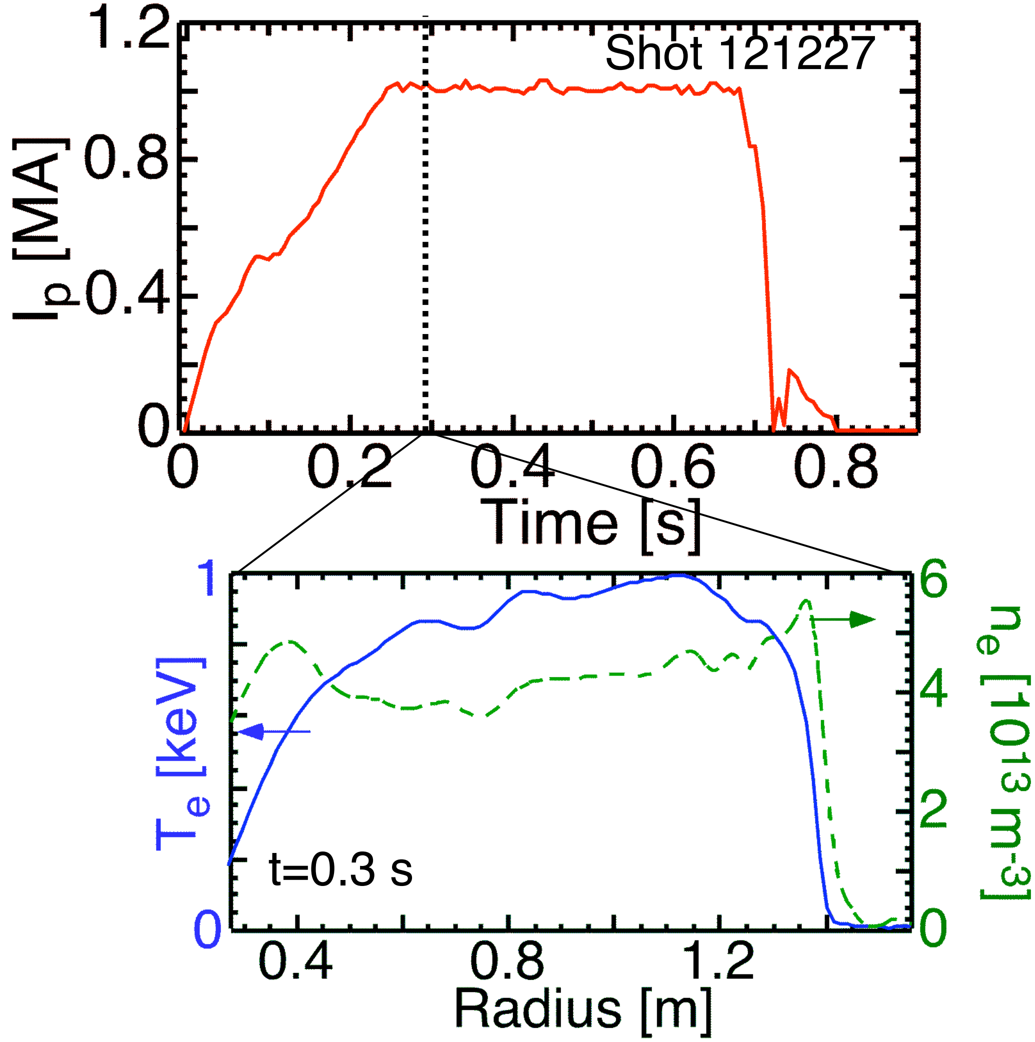
- Discharge characteristics: I_p=1MA, $T_e(0)$~1keV, $n_e(0)$~4e10^{13} m^{-3}



Slowly Decaying EBE H-Mode Shot Observed (con't)

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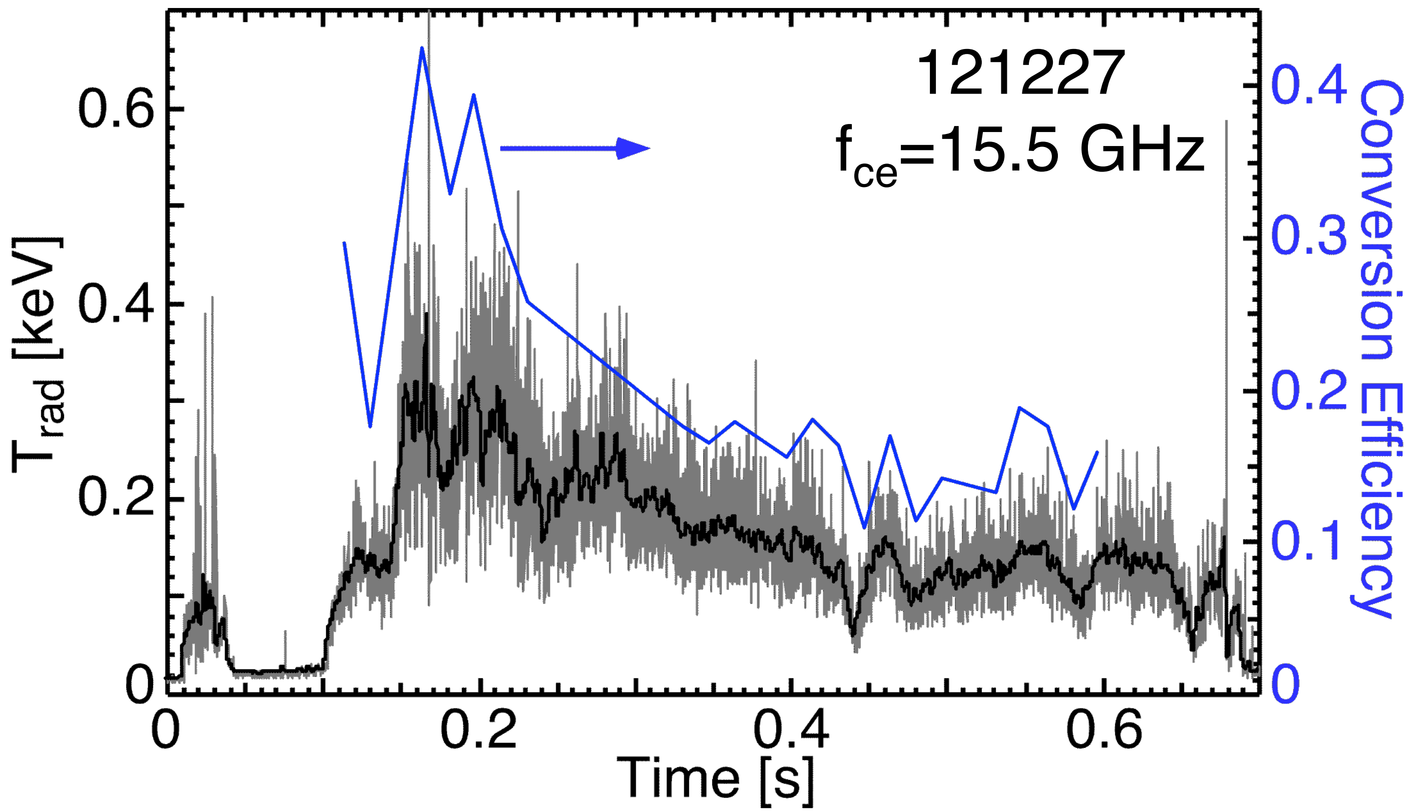
- Emission slowly decays during discharge
- Coupling efficiency drops from 40% to 15%
- Antenna pointing direction not optimized



- Similar to refraction effects observed on MAST
  - "Prospects of EBW Emission Diagnostics and EBW Heating in Spherical Tokamaks", V.F. Shevchenko, et. al.

Data Mining Suggests Reduced Emission May be Coupled to Z-Position

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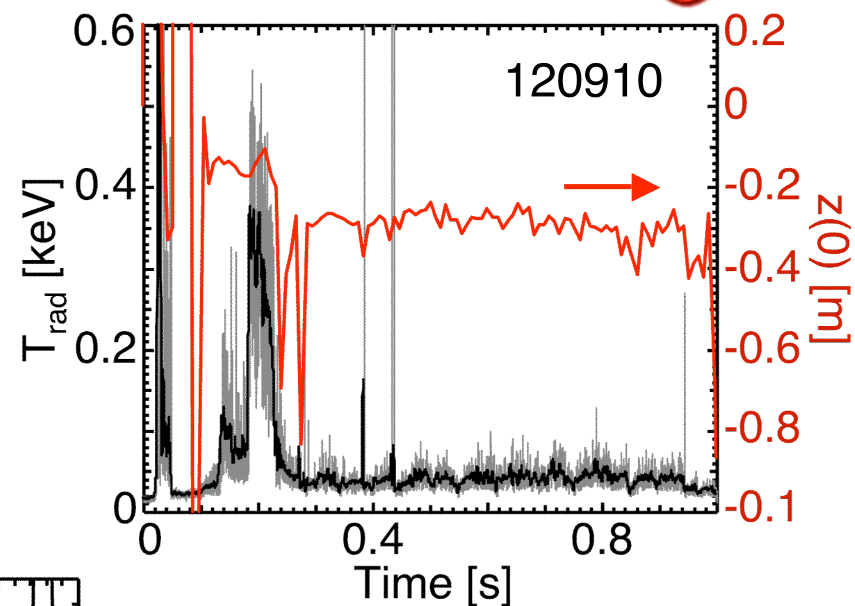
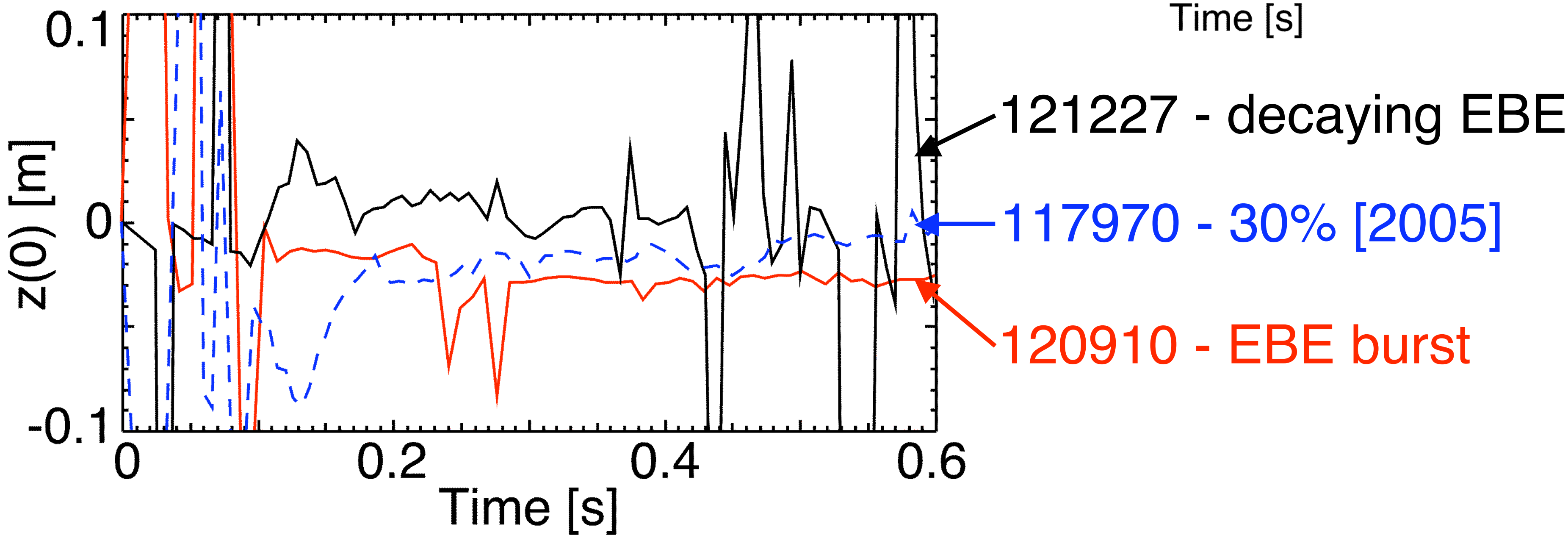
- Emission burst occurs for z(0)>-0.2 m and decays when z(0)<-0.2 m

- Possibly similar to results observed during EBW heating experiments on TCV





H-L Transition May Provide Insight to Understanding B-X-O Coupling in H-Modes

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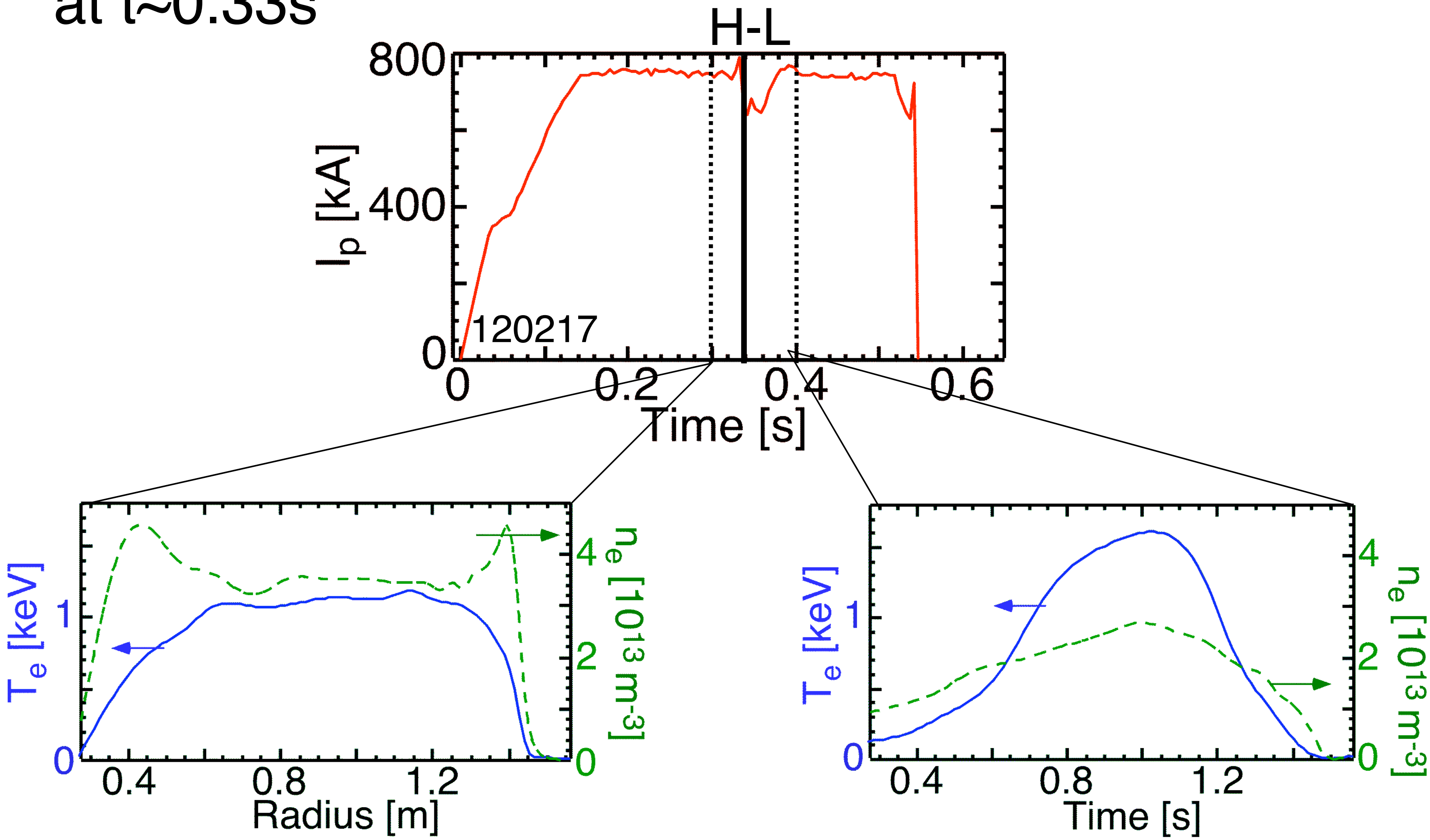
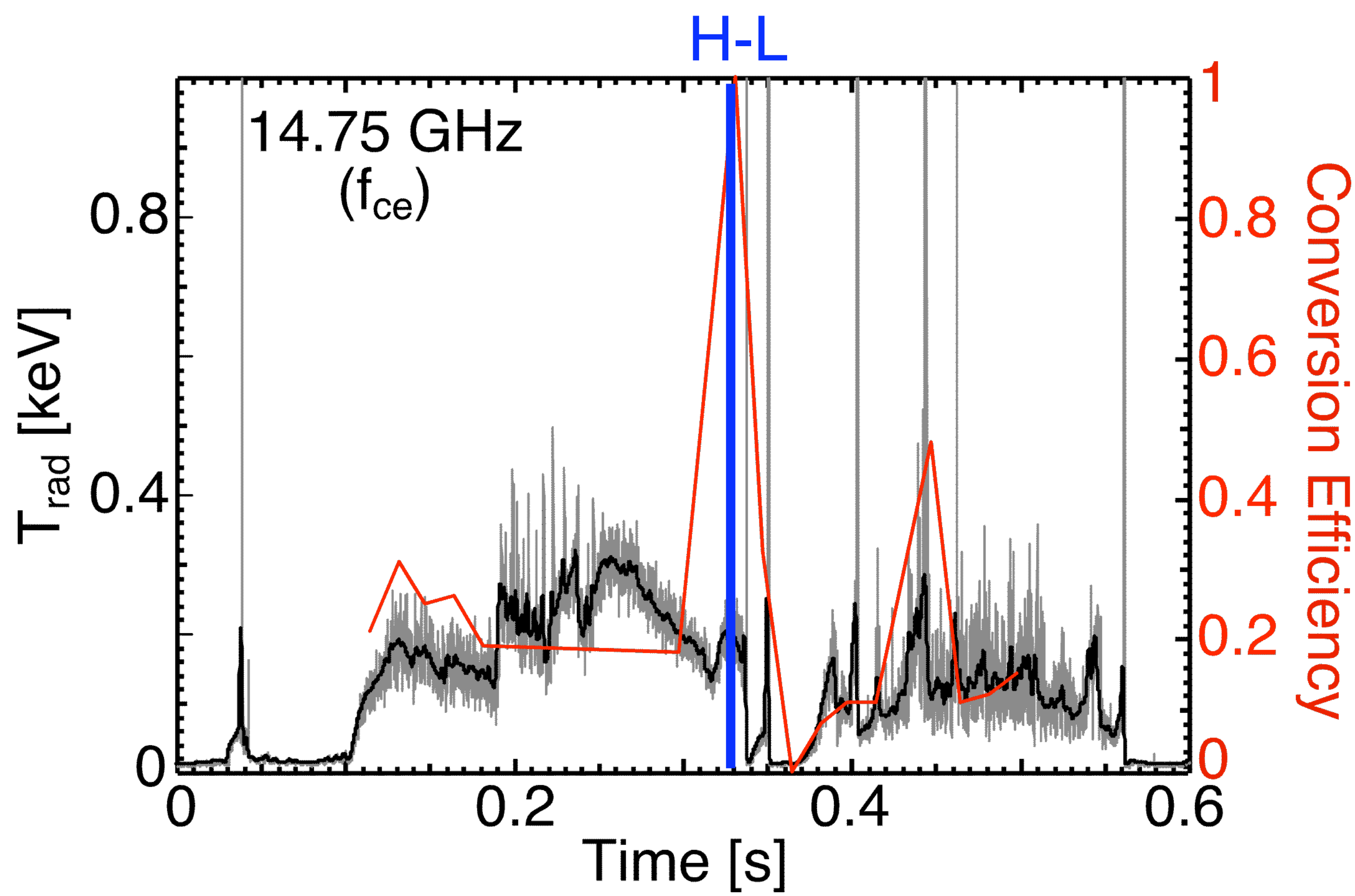
- Discharge characteristics: I_p~750 kA, H-L transition at t~0.33s



H-L Transition May Provide Insight to Understanding B-X-O Coupling in H-Modes

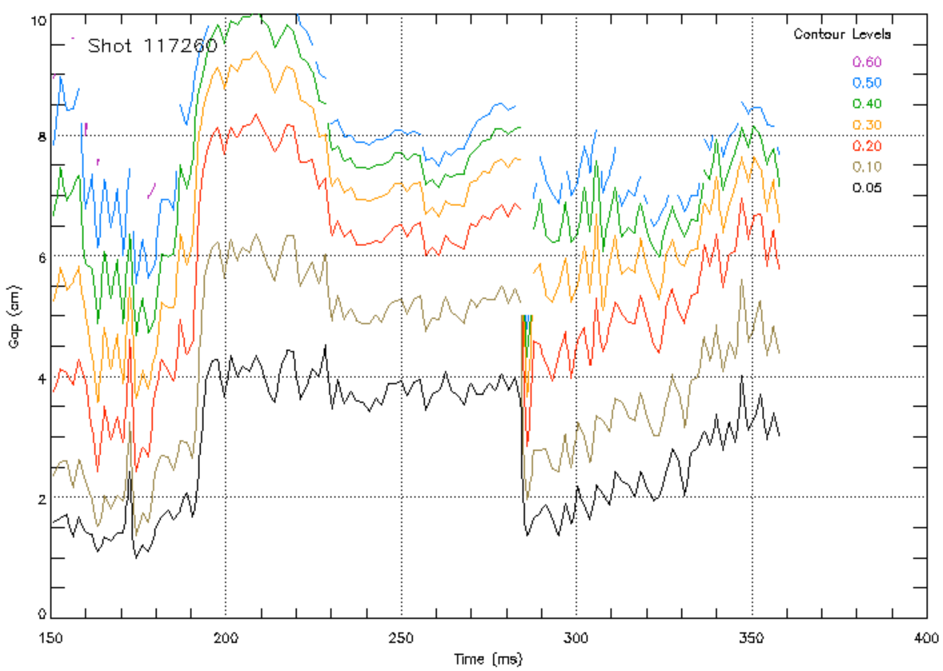


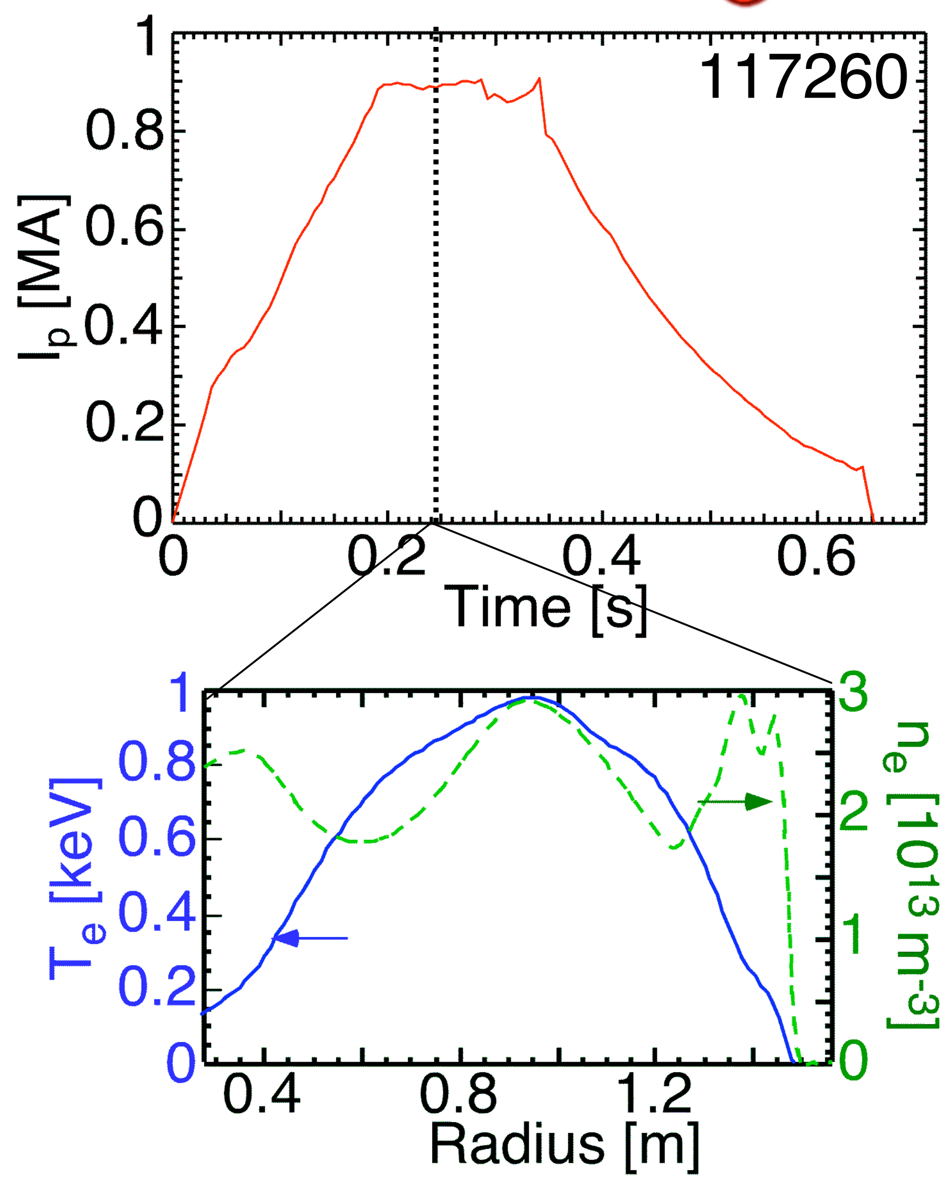
- Event at t=0.35 s kills B-X-O emission

→ For 2007 develop disruption-free discharge with H-L transition for bursting H-modes

Quiescent H-Mode from Previous Run
Good Target Discharge

- Fluctuation free edge
- Steep edge gradients
  - Improve B-X-O coupling





Low EBE During H-Mode will be Investigate During 2007 NSTX Run Campaign

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- Investigate collisional effects on B-X-O mode coupling
  - Li pellet injection will be used to modify edge T_e and change collisionality at B-X-O mode conversion layer
- Investigate effects of plasma parameters on B-X-O coupling
  - May help in understanding of B-X-O coupling physics
- Bootstrap current from pressure gradient at H-mode pedestal may change field pitch at UHR:
  - Pitch may be large enough to move B-X-O emission window outside antenna acceptance angle
  - Install wide acceptance angle spiral antenna to detect EBE outside acceptance angle

H-Mode Run Plan 2007 Campaign

NSTX

- Modeling and data mining
  - Create database of H-mode emission and z(0) and other plasma parameters
- Piggyback data
  - Look for stray emission using wide angle antenna
  - Identify either quiescent H-mode or bursting emission H-mode for current target plasma
  - Look for H-modes with high edge T_e
- Run plan (50 shots = 2 days)

10(5) - shot development for quiescent H-mode target plasma

5 - data shots for reflectometer and fast recipricating probe

5 - Li pellet injection to condition edge during discharge

5 - shot development for bursting emission H-mode discharge

5 - vary vertical position and other plasma parameters to increase emission

5(2) - introduce early H-L transition during I_p flattop

15 - plasma shaping scan to increase edge T_e

Extra Slides

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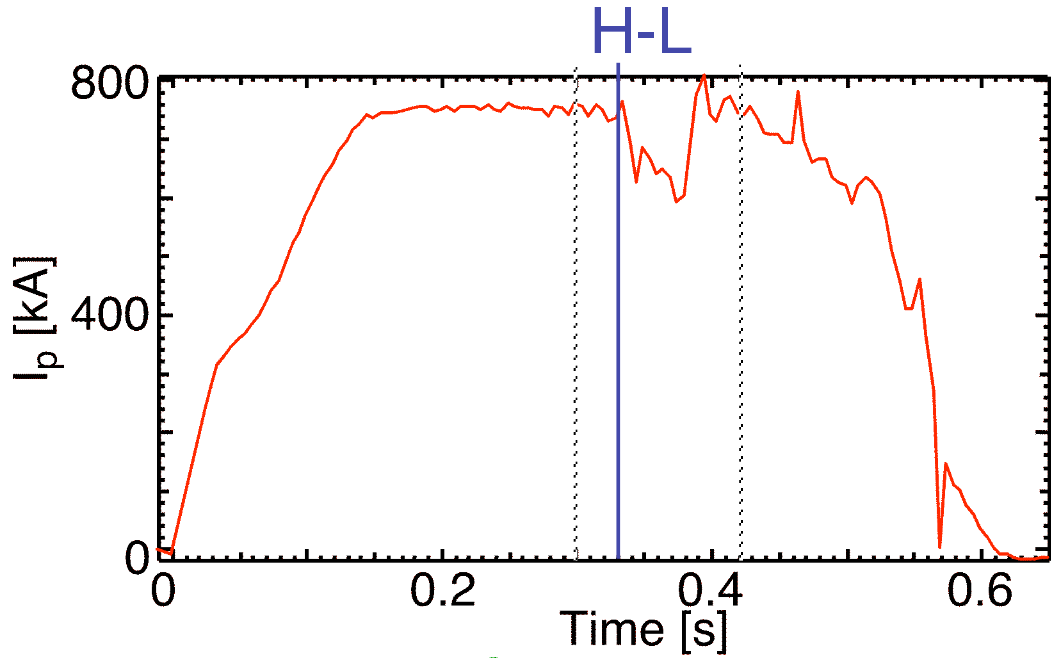
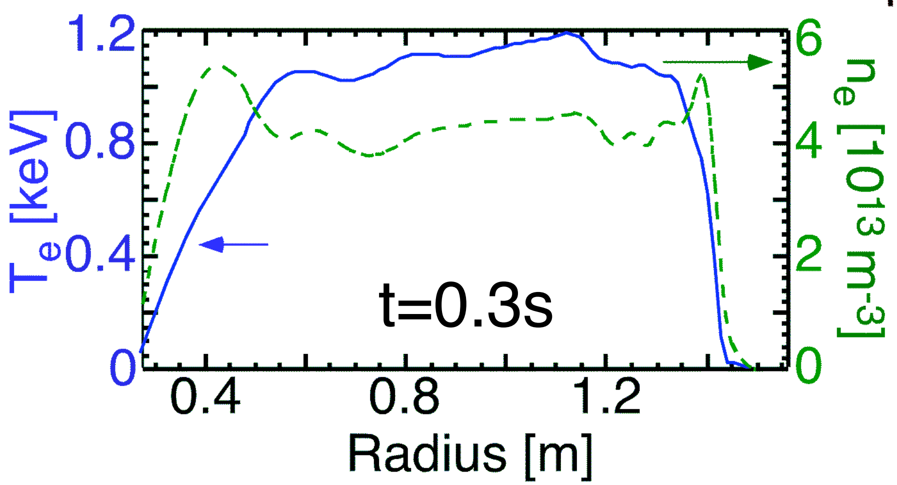
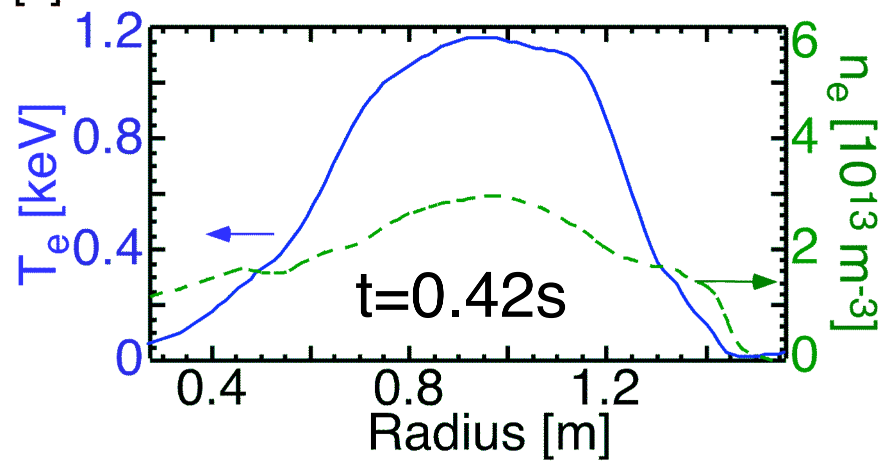


H-L
800
400
0
I_p [kA]
0
0.2
0.4
0.6
Time [s]



1.2
0.8
0.4
0
T_e [keV]
6
4
2
0
n_e [10^{13} m^{-3}]
t=0.3s
0.4
0.8
1.2
Radius [m]



1.2
0.8
0.4
0
T_e [keV]
6
4
2
0
n_e [10^{13} m^{-3}]
t=0.42s
0.4
0.8
1.2
Radius [m]