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Thermal Electron Bernstein Wave Emission Measurements on NSTX

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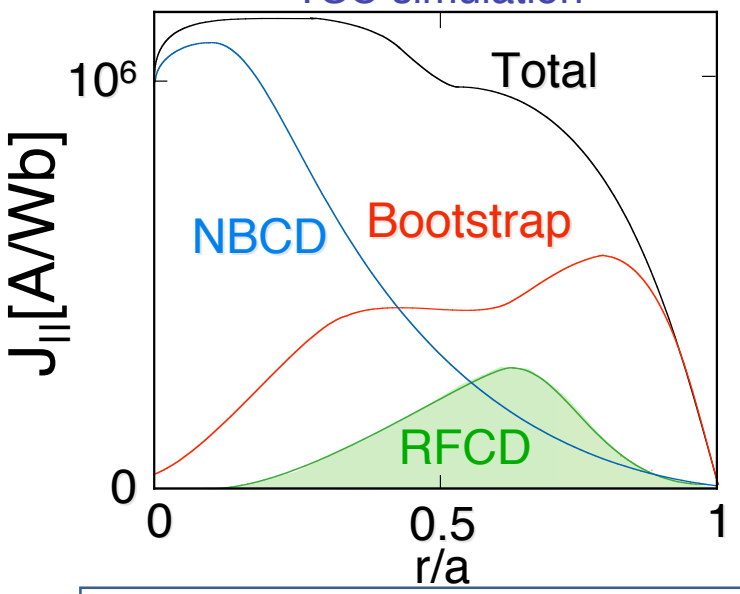
Oct. 30-Nov. 3, 2006
Philadelphia, PA

Modeling Predicts EBW Can Provide Needed Current for Non-Inductive Scenarios

- EBW must provide ~100 kA of off-axis current
- Possible across wide range of β at both f_{ce} & $2f_{ce}$

NSTX, β_t = 42%, β_{pol} = 1.6
B_t = 0.34 T , I_p = 1 MA

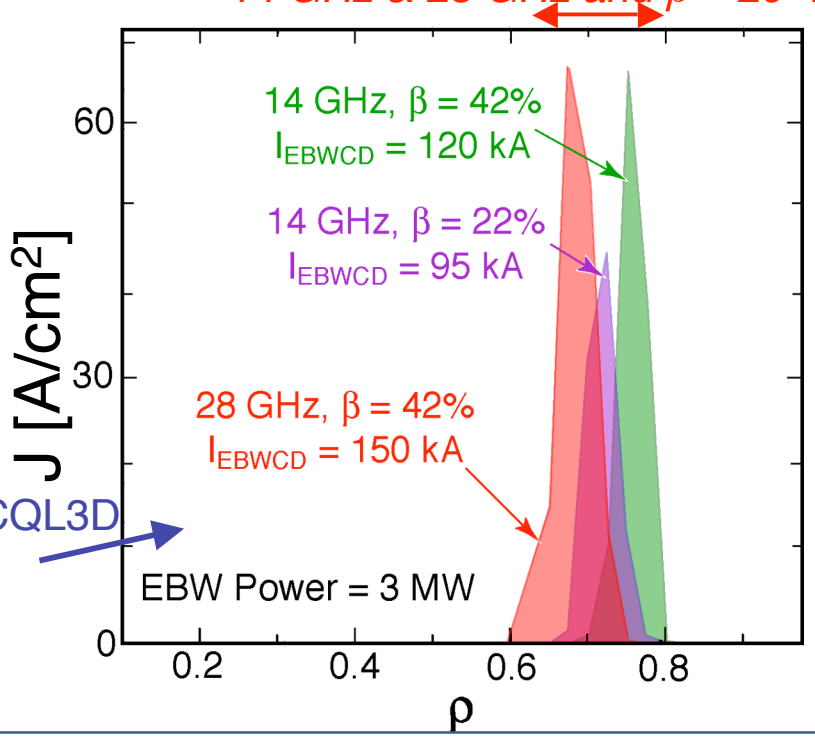
TSC simulation



C. Kessel, et al ., Nucl. Fusion **45**, 814 (2005)

GENRAY/CQL3D Modeling

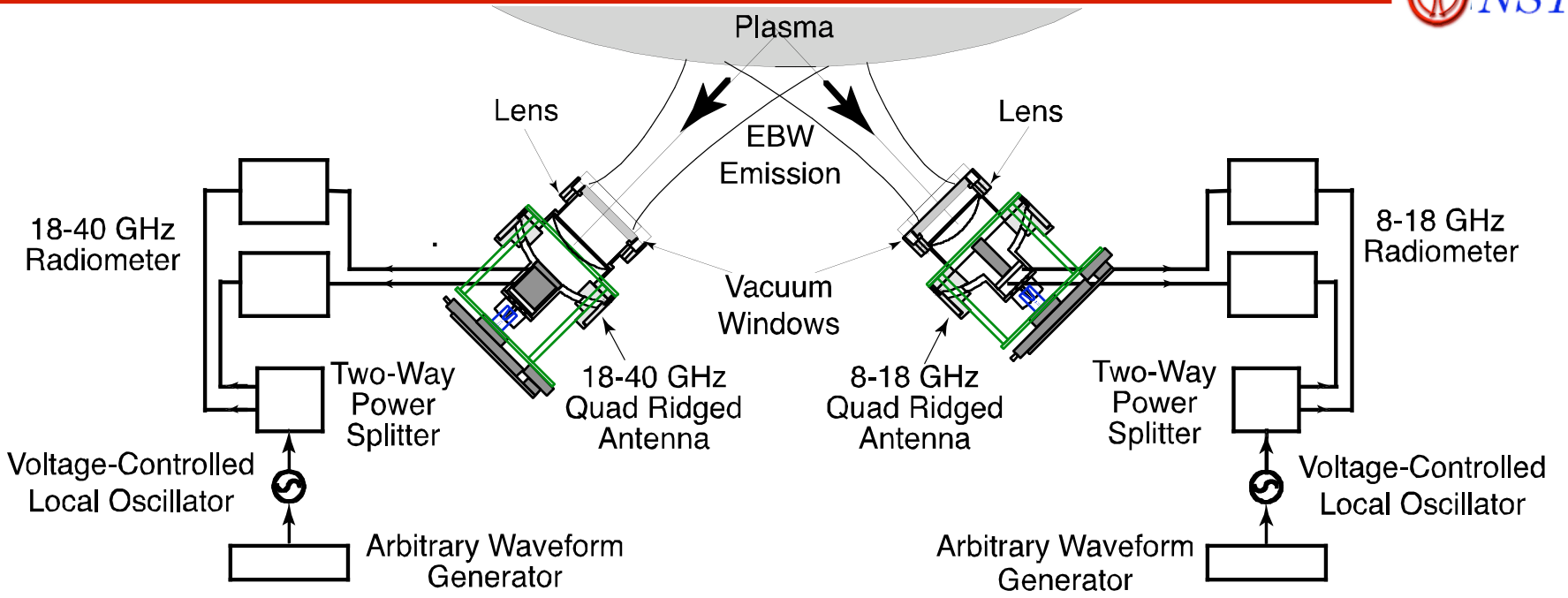
Deposition similar for 14 GHz & 28 GHz and β = 20-40%

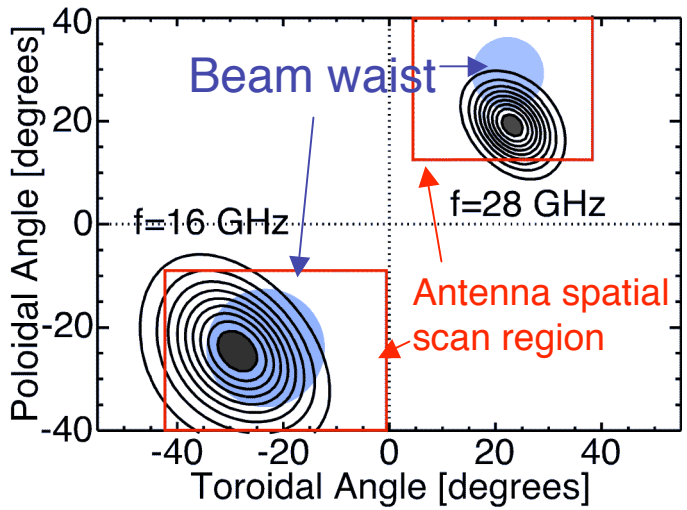


G. Taylor, et al ., Phys. Plasmas **11**, 4733 (2004)

Need efficient coupling of RF power to EBWs; assess oblique O-X-B coupling by measuring B-X-O emission (EBE)

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

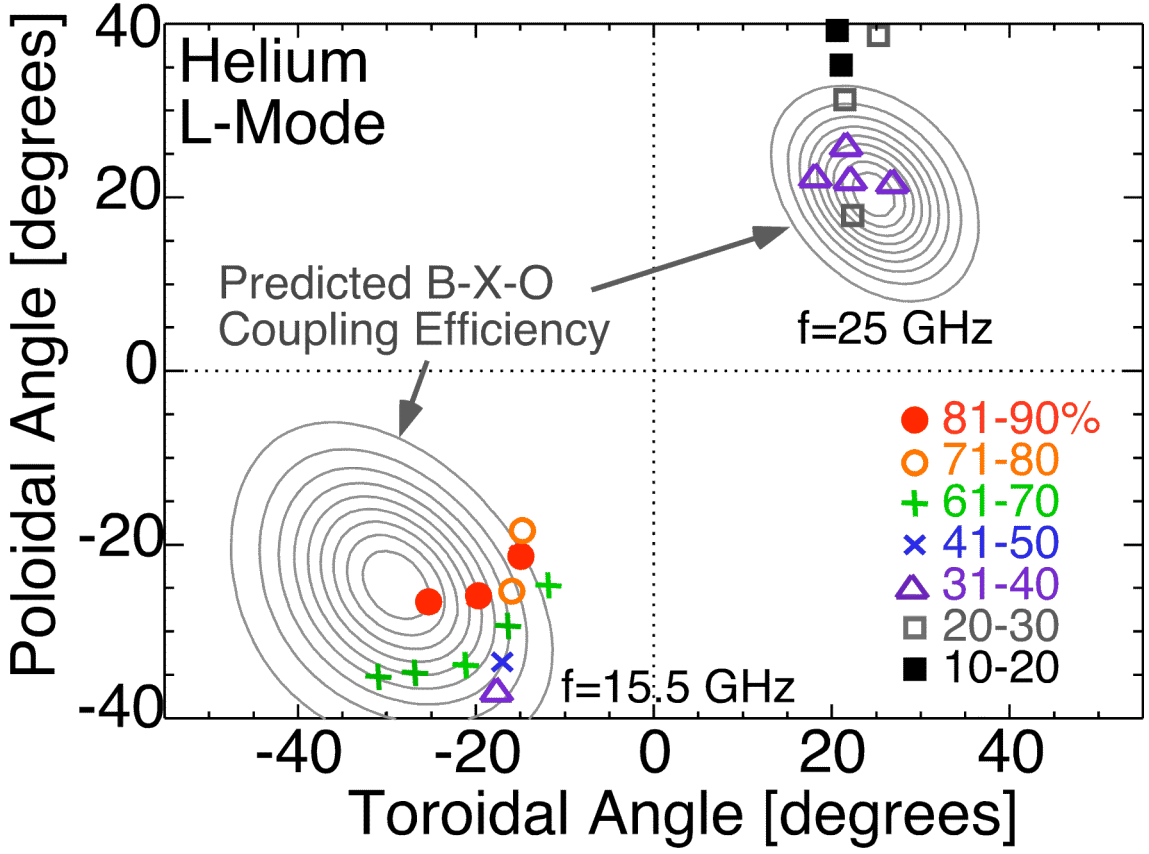




- ±10° scan in poloidal and toroidal directions during L-mode and H-mode EBE experiments
- Acceptance angle:
  - 8-18 GHz antenna ~ 22°
  - 18-40 GHz antenna ~ 14°

Antenna Steering Scan Provides Good Coverage of L-Mode B-X-O Emission Window

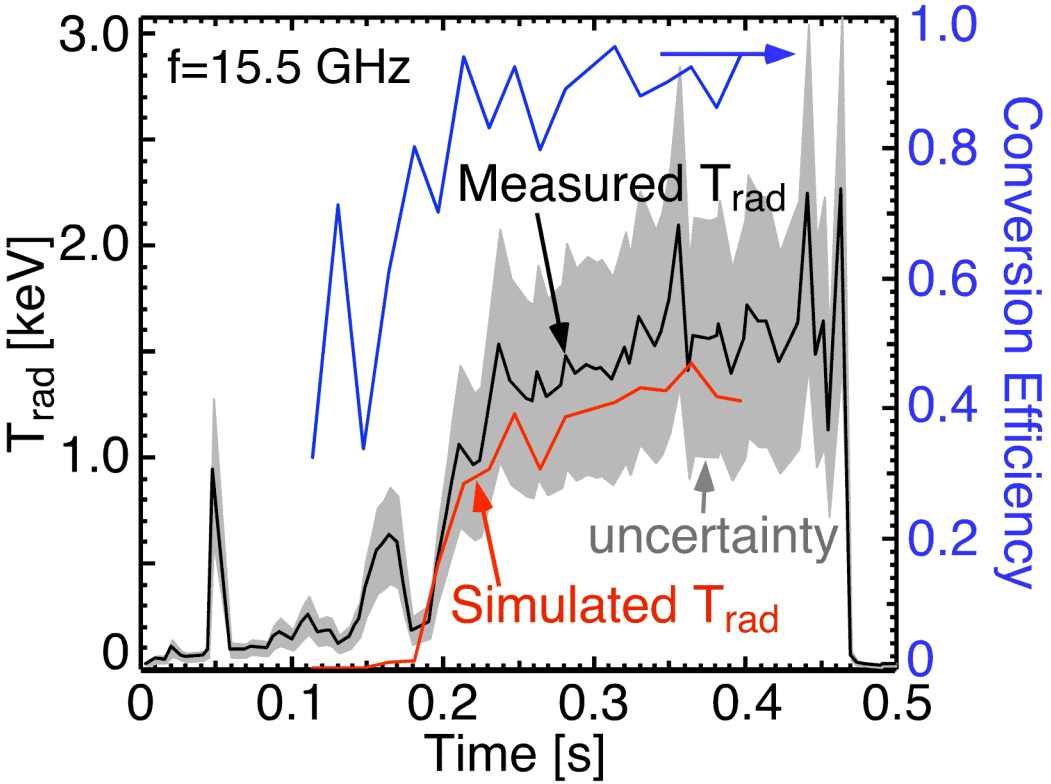
- To calculate B-X-O coupling efficiency:
  - Ray damping location obtained from GENRAY
  - Compare T_e from Thomson scattering at ray damping to T_{rad} from EBE diagnostic
- Magnetic field pitch (~40%) determines location of window
- Density scale length determines width of window

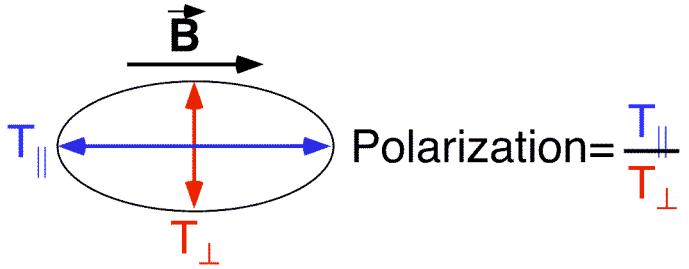


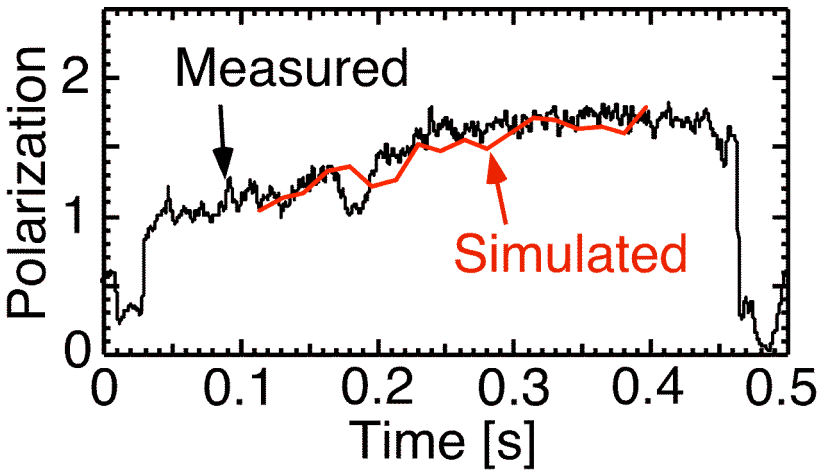
Edge information scarce; may account for discrepancy between experimental and calculated B-X-O coupling map

L-Mode f_{ce} B-X-O Coupling Measurements Agrees with Simulated Results

- Simulated results from EBW ray tracing & mode conversion model
  - Inputs are EFIT magnetic equilibrium, measured T_e & n_e
- At peak emission angle, $T_{||}/T_{\perp}$~1.6 for measurement & simulation

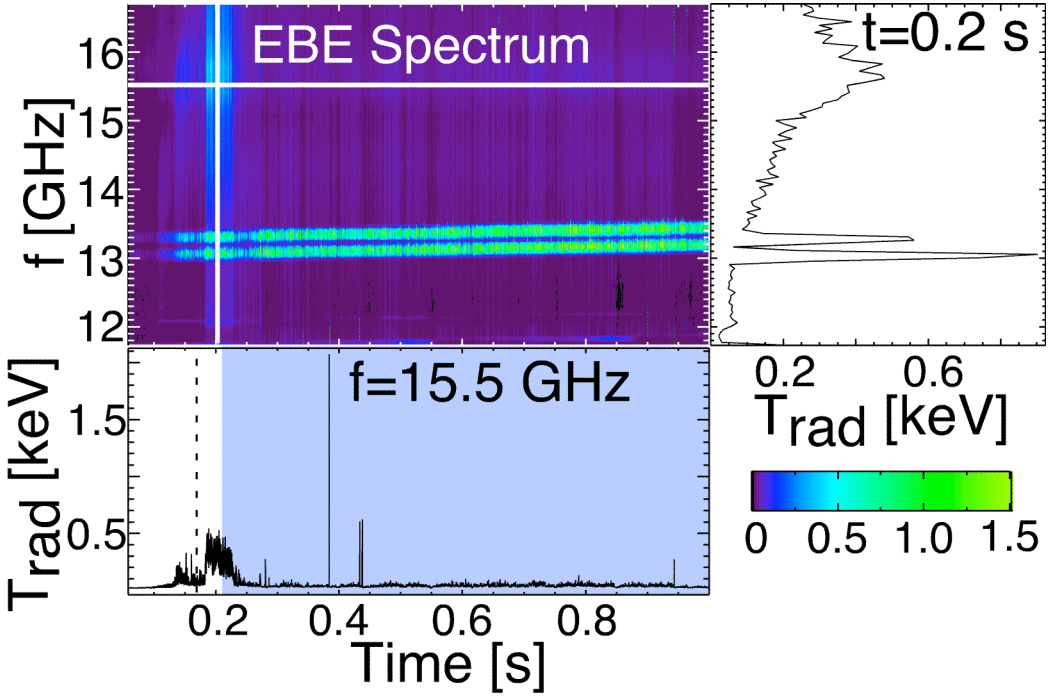


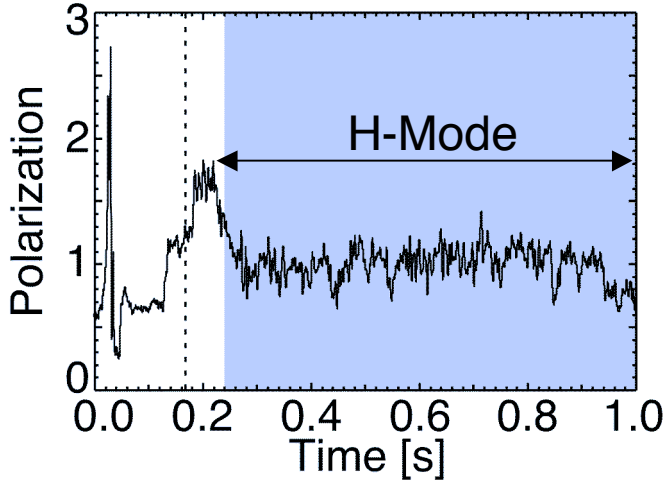




Scan of H-Mode B-X-O Window Indicates Very Low Emission

- During EBE burst at t=0.2s:
  - B-X-O coupling f_{ce}~60% & $2f_{ce}$~20%
  - $T_{||}/T_{\perp}$~1.7; agrees with simulated results
- During I_p flattop in H-mode scan:
  - <10% B-X-O coupling for all frequencies
  - $T_{||}/T_{\perp}$ falls to <1, indicating diagnostic measuring scattered emission





Low EBE During H-Mode will be Investigated During 2007 NSTX Campaign

- Low T_e at mode conversion (MC) layer may cause EBW collisional loss:
  - Adding gas injector to change collisionality at MC layer
  - Adding kinetic model to EBE simulation, currently using WKB approximation
- 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
  - Include H-mode edge current in equilibrium used by EBE simulation
  - Install wide acceptance angle spiral antenna to detect EBE outside acceptance angle

Summary

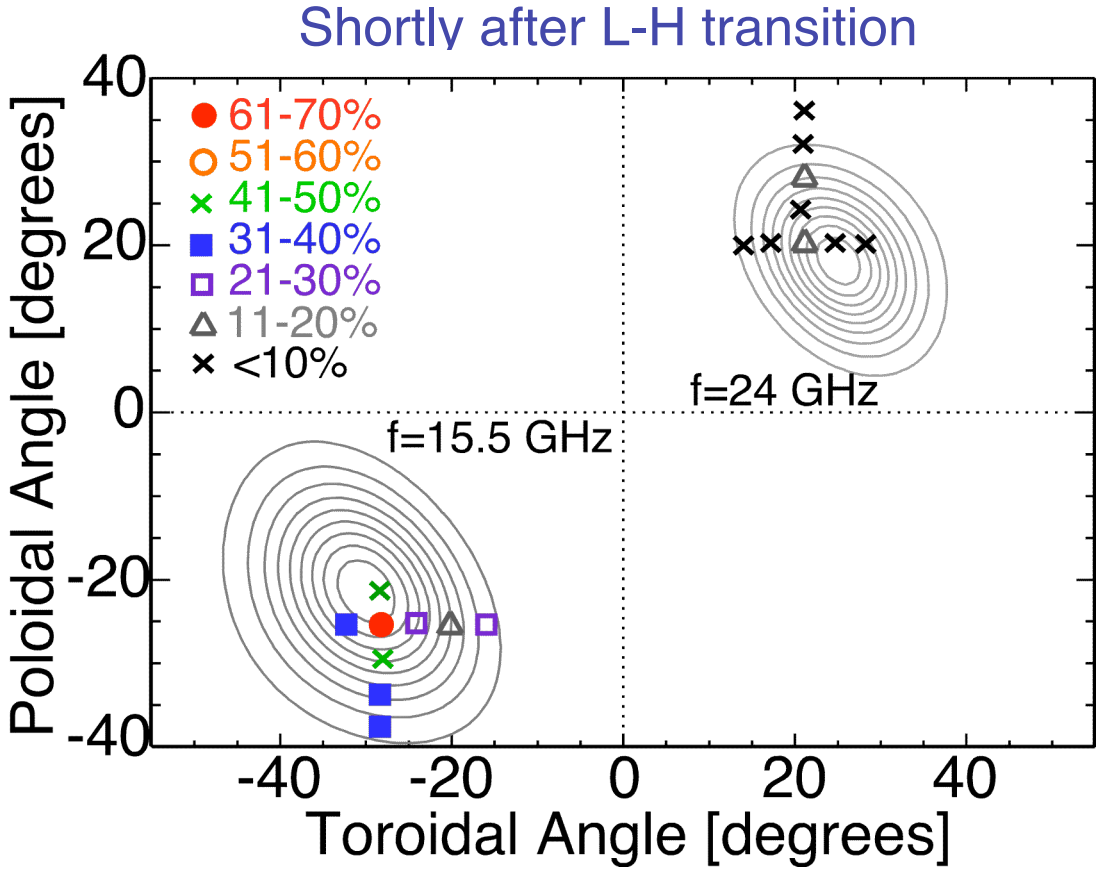
NSTX

- New EBW emission diagnostic operational on NSTX
  - Provides emission measurements of 8-40 GHz - up to 3rd EC harmonic
  - Remotely steerable quad-ridged horn antennas provide detailed information on B-X-O coupling physics
  - May also provide $T_e(R, t)$
- EBW emission data will provide coupling efficiency and polarization information for a heating and current drive system
- L-mode f_{ce} B-X-O conversion efficiencies of ~90% observed; ~40% EBW coupling for $2f_{ce}$
- <10% EBW coupling observed during I_p flattop in H-mode plasmas
- See QP1.00025 (this afternoon) for more details

Supporting Slides

Angular Scan of H-Mode B-X-O Window Indicates Very Low Emission Levels

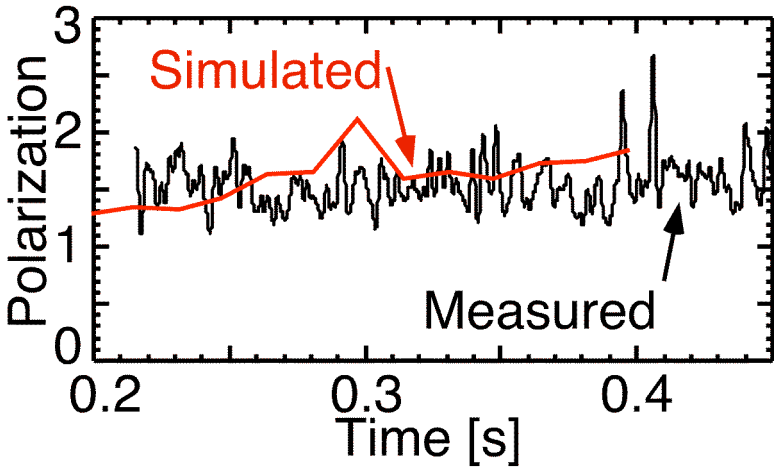
- Fundamental B-X-O conversion efficiency reaches ~60-70% during burst of emission before I_p flattop
- Harmonic B-X-O conversion efficiency <20% during burst of emission
- During I_p flattop, B-X-O mode conversion efficiency for all frequencies <10%

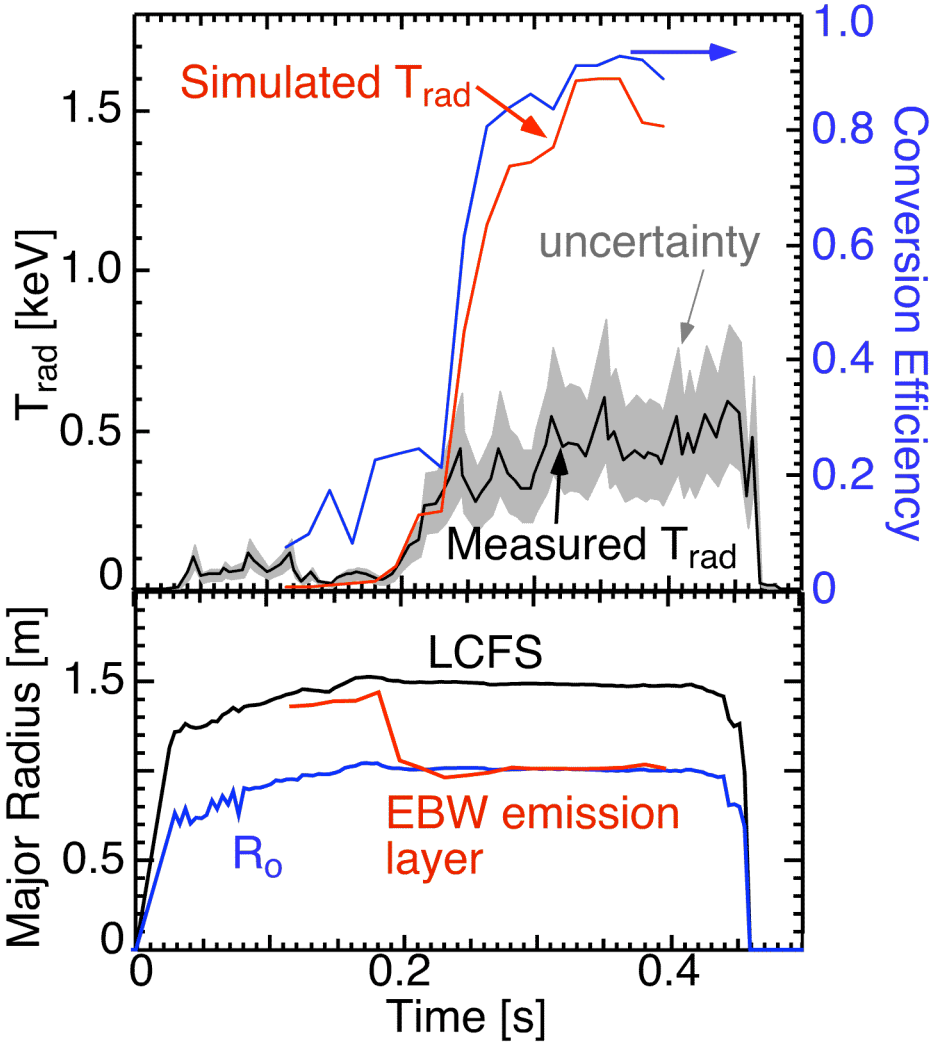


L-Mode $2f_{ce}$ Measured T_{rad} Significantly Lower than Simulated T_{rad}

NSTX

- Experimental B-X-O coupling efficiency ~30-40%; simulated B-X-O coupling ~90%
- EBW T_{para}/T_{perp}=1.6 for both experimental measurements and simulated results





→ Cause of discrepancy uncertain