Status of Electron Bernstein Wave Research on NSTX and CDX-U

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NSTX Results & Theory Review
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Recently Completed Detailed Study of EBW to X-Mode Conversion on CDX-U

- Limiter shortened L_n from ~5 cm to ~5 mm, resulting in an order of magnitude increase in measured B-X conversion (C_{BX}) to > 95%

- Emission strongly X-mode polarized and emitted locally from ECE resonance layer

- High time resolution measurements of L_n with Langmuir probe array show correlation between L_n and EBW T_{rad} fluctuations

- Large fluctuation in conversion efficiency due to both L_n fluctuations and refraction:

  - fluctuations due to refraction should be much smaller on NSTX

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EBW Research on NSTX Focused on Achieving Improved B-X Conversion

- C_{BX} typically < 5% during NSTX L-Mode plasmas
- Need to achieve C_{BX} > 80% as a prerequisite for EBW heating and current drive on NSTX
- C_{BX} increases to 10-15% during H-Mode when L_n shortens from 3-4 cm to ~1.5 cm at B-X conversion layer
- Attempt to reproduce CDX-U experiments with local limiter shortening L_n on NSTX next year
- Results from experiment using HHFW antenna tiles to shorten L_n this year were very encouraging:

  - achieved $C_{BX} \leq 50\%$

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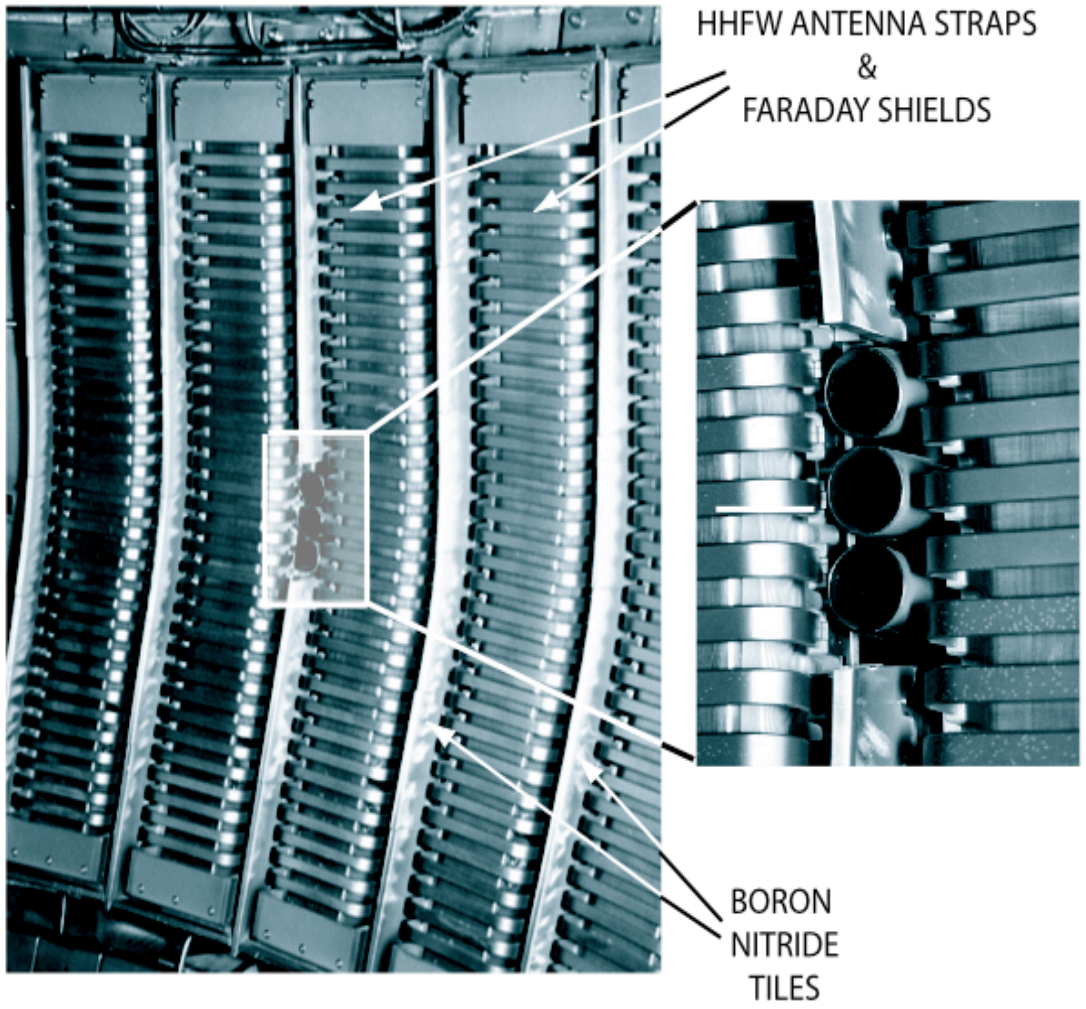
Enhance EBW Conversion to X-Mode by using Tiles in HHFW Antenna to Shorten L_n in Scrape Off



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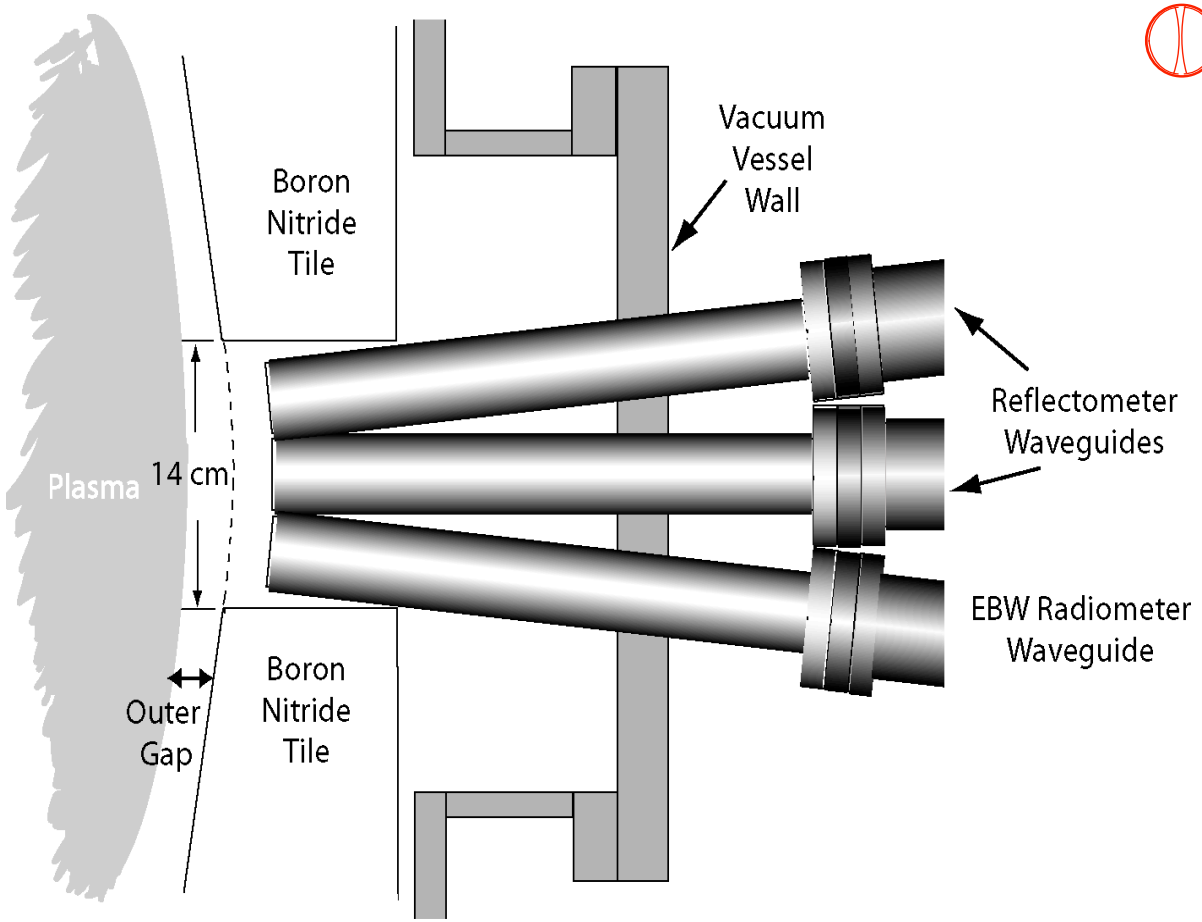
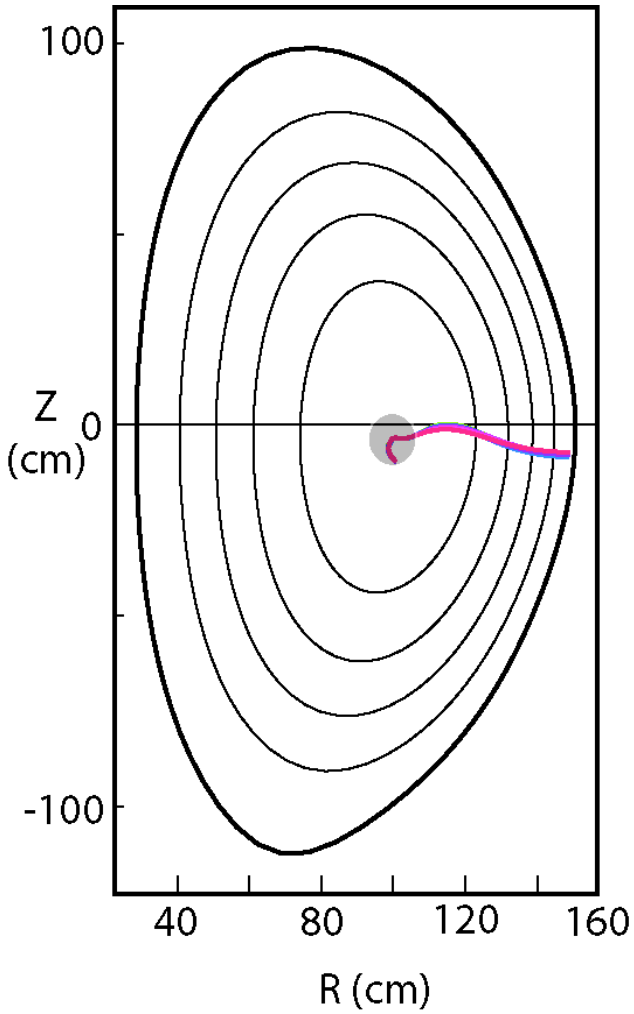
Reduce Outer Gap between LCFS and Boron Nitride Tiles to Shorten L_n in Scrape Off

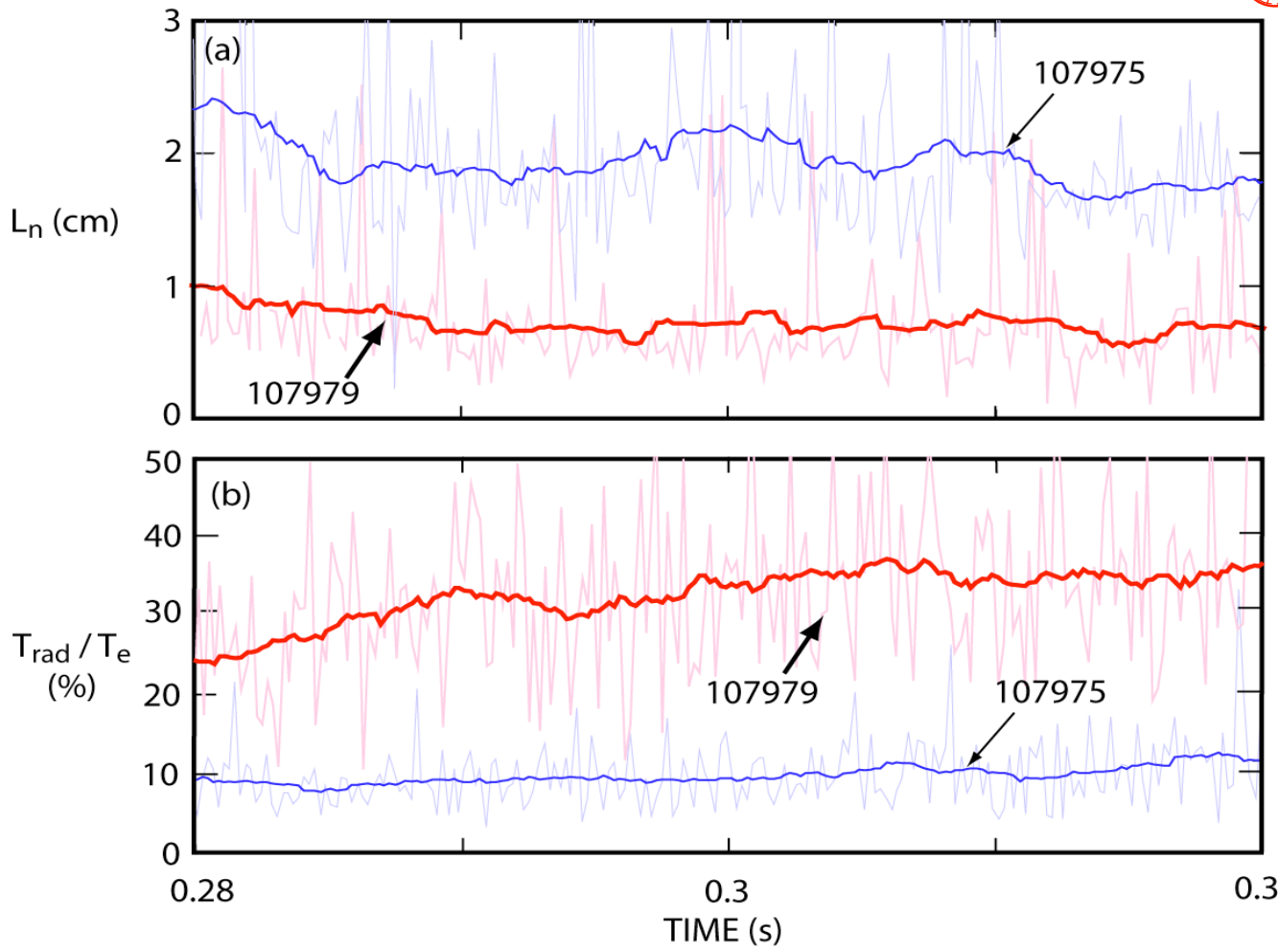


- Measure L_n with ORNL X-Mode Reflectometer

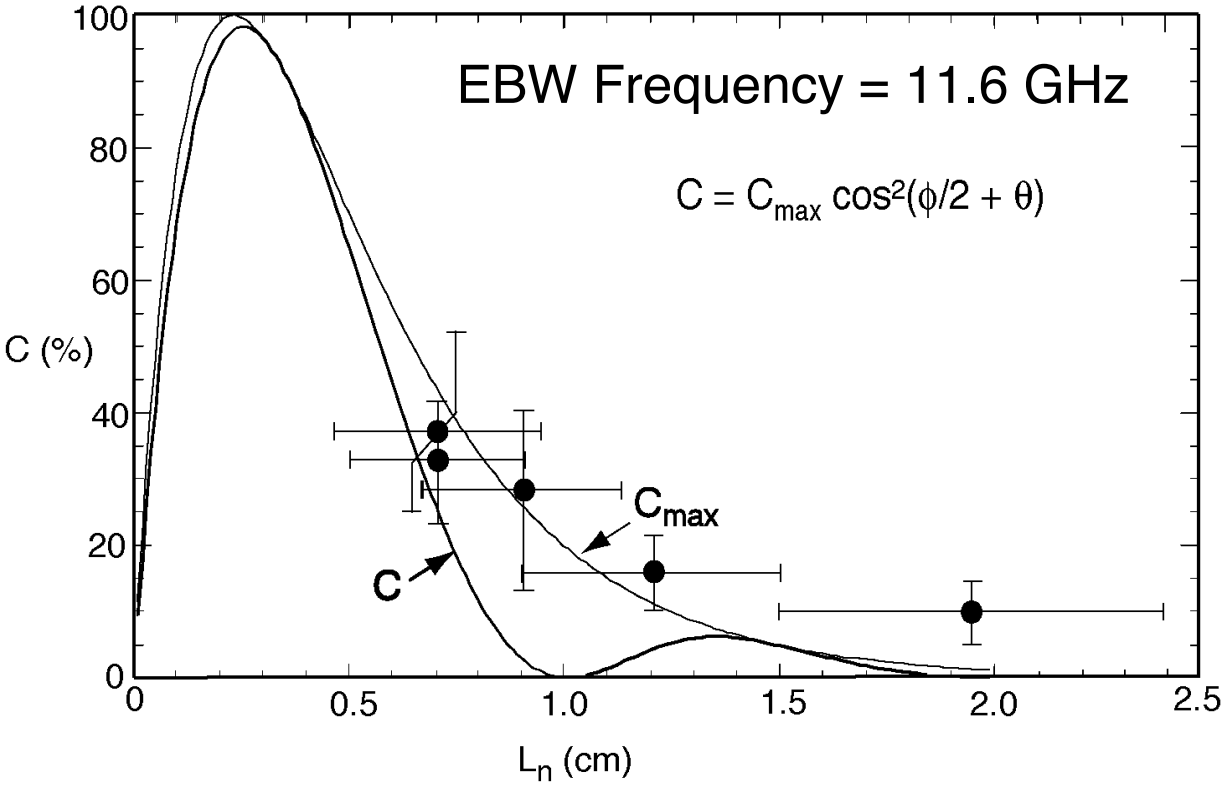
EBW Ray Tracing Shows 11.6 GHz EBW Emission From Axis



11.6 GHz EBW T_{rad}/T_e Increases with Decreasing L_n in Scrape Off

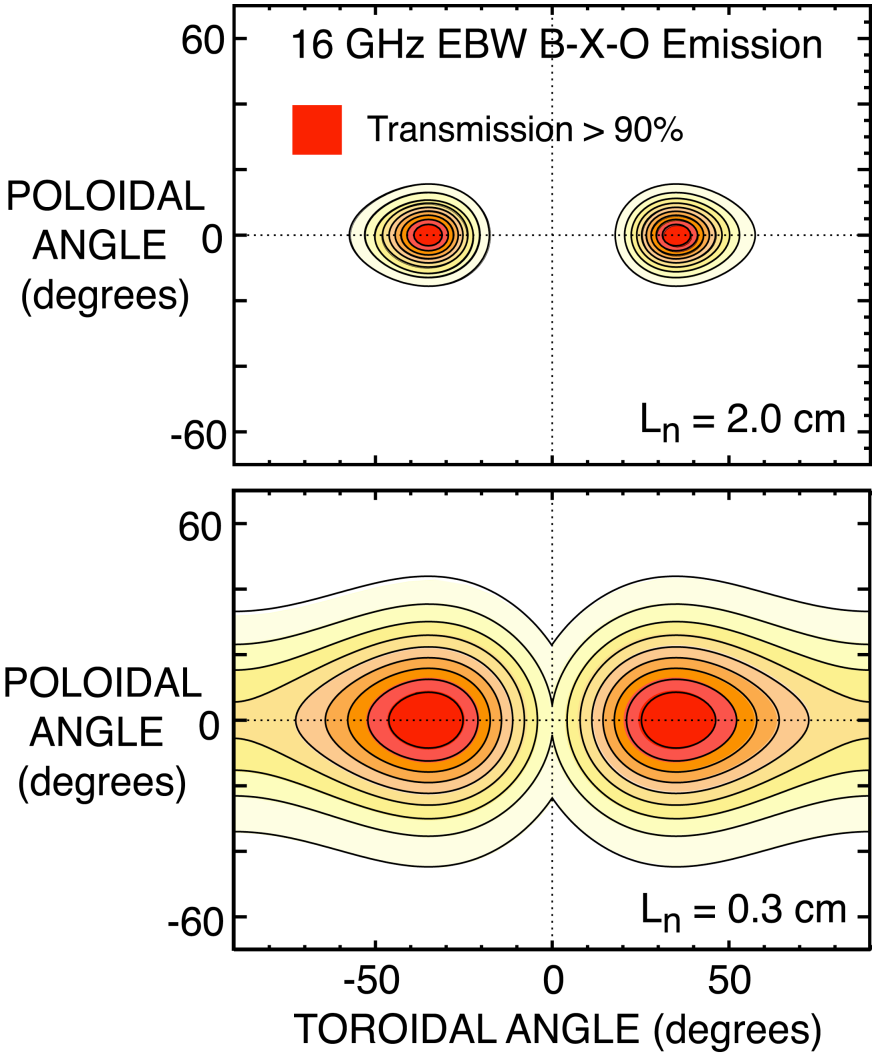


Increased B-X Conversion with Decreased L_n Agrees Well with C_{max} Dependence



- Dependence of EBW T_{rad}/T_e on L_n does not show effect of predicted phase factor
- Observed dependence on C_{max} probably result of finite $n_{//}$ acceptance of antenna

Local Limiter May Also Widen B-X-O Transmission Window By Shortening L_n at the O-Mode Cut-off



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- Will install B-X, in-vessel, antenna this fall
- ORNL may install B-X-O antenna between HHFW straps in October

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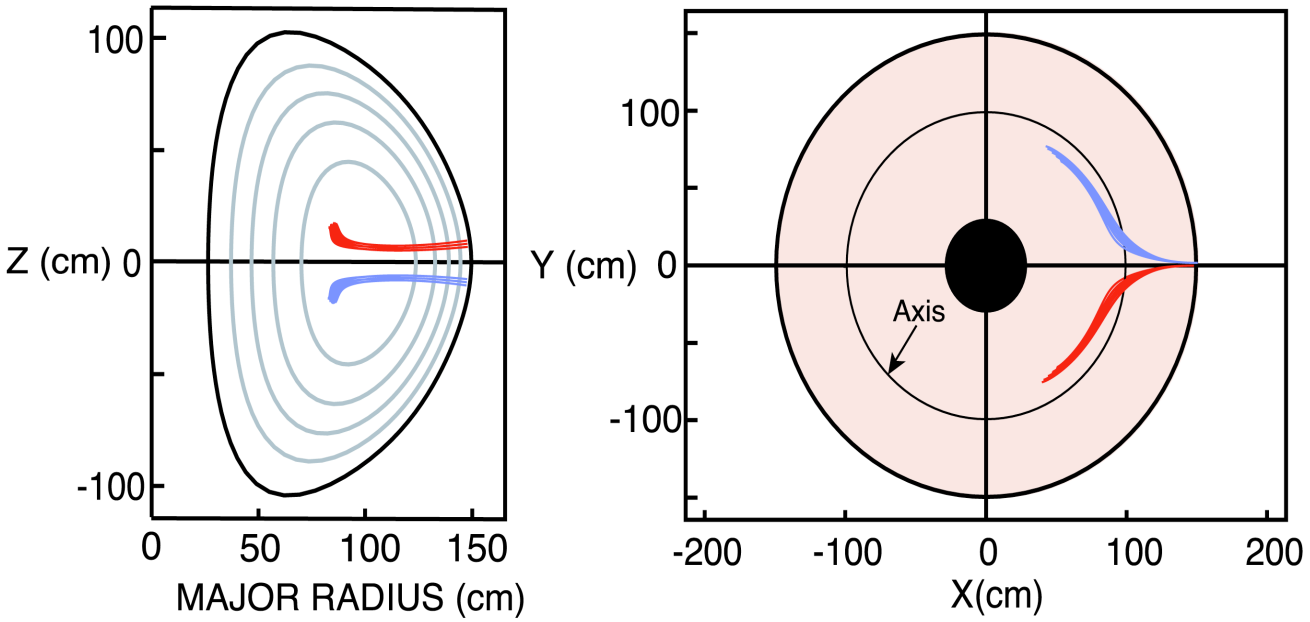
Modeling EBW Heating & Current Drive for a Range of NSTX Scenarios including □□ 10-40% and Startup

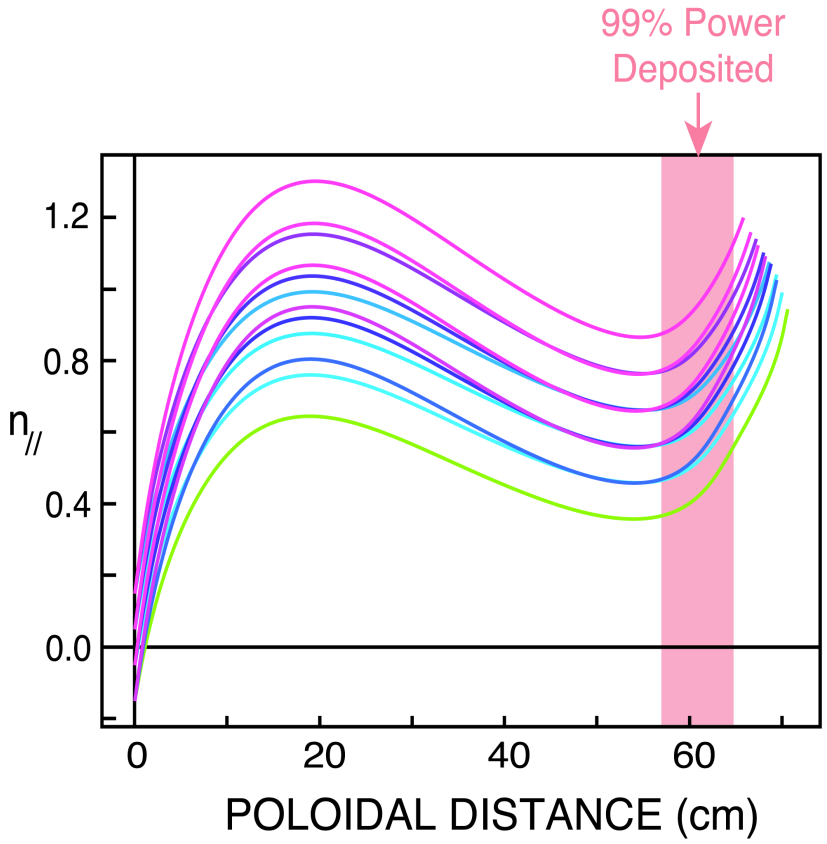
EBW Frequency = 12 GHz, $-0.25 < n_{//} < 0.25$, 10 cm pol. length
Launched 10 deg. above mid-plane
Launched 10 deg. below mid-plane
NSTX $\beta = 12\%$, $n_{eo} = 2 \times 10^{19} m^{-3}$, $T_{eo} = 1$ keV



- EBW Current Drive Direction Changed via Poloidal Launch Angle

At □ = 10-20%, Significant $n_{//}$ Upshift from Launch to Deposition, with Good Damping Localization

NSTX



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CompX

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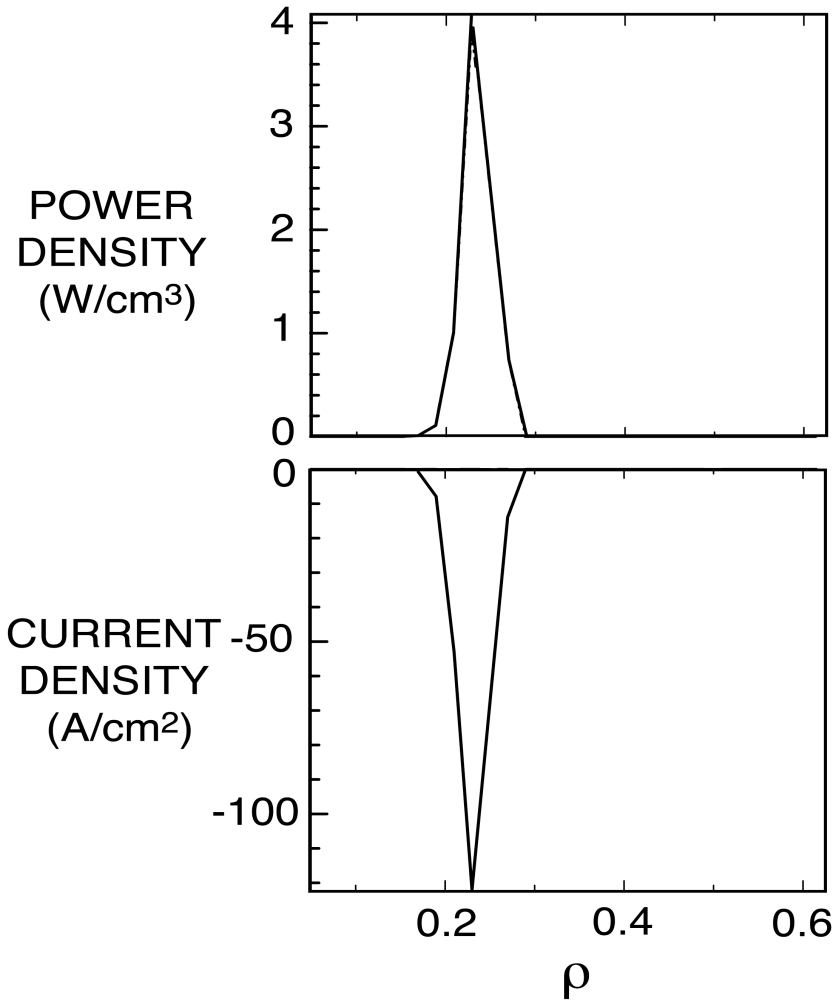
Normalized EBWCD Efficiency Comparable to ECCD at □□ 10-20%



- □ = 12% NSTX plasma with n_{eo}=3x10^{19}m^3, T_{eo}=1 keV EBW current drive efficiency is ~ 0.1 AW^{-1} with 1 MW

CompX

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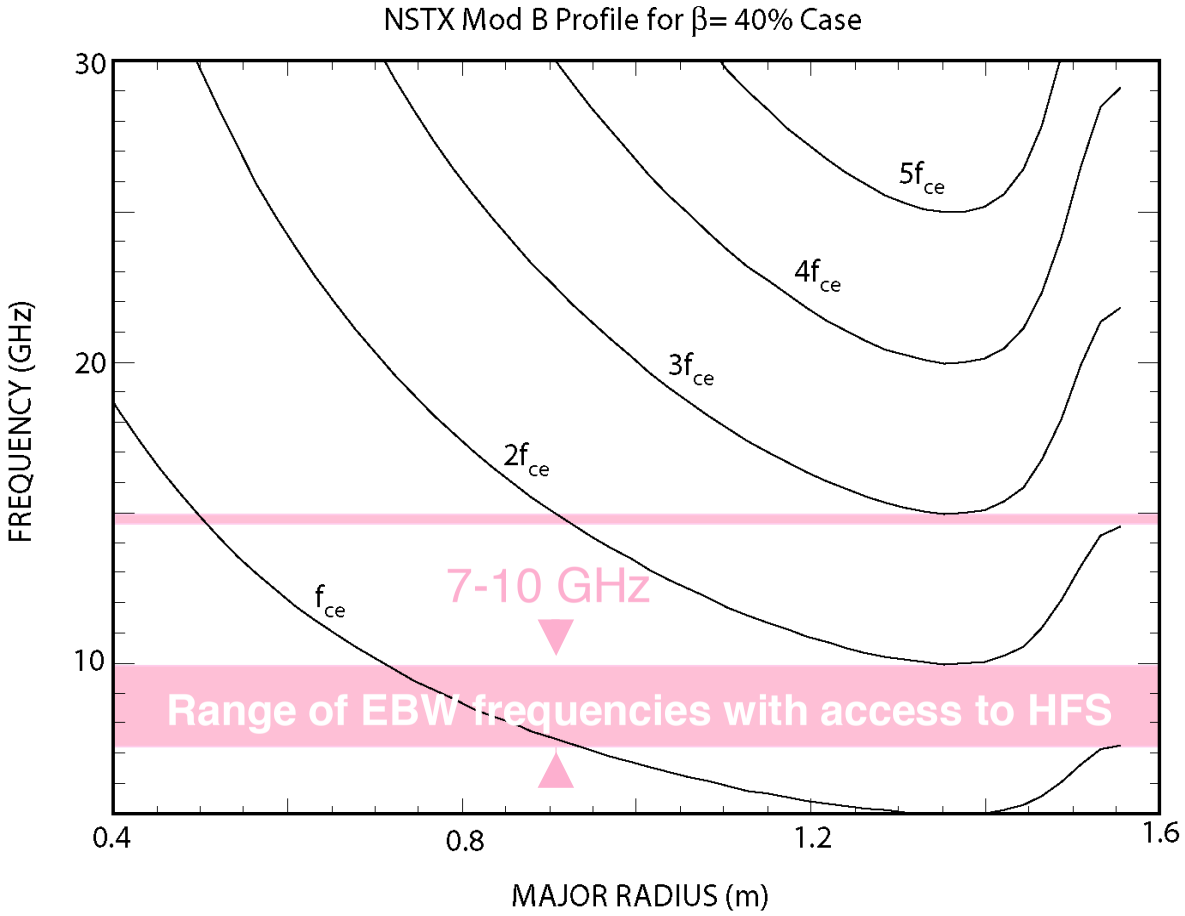
Only Fundamental EBW Provides Access to High Field Side of □ ~ 40% NSTX Plasmas



- Also may be able to drive current at large major radius

Investigating Large Major Radius EBW Deposition to Stabilize NTMs in $\beta \sim 40\%$ NSTX Plasmas