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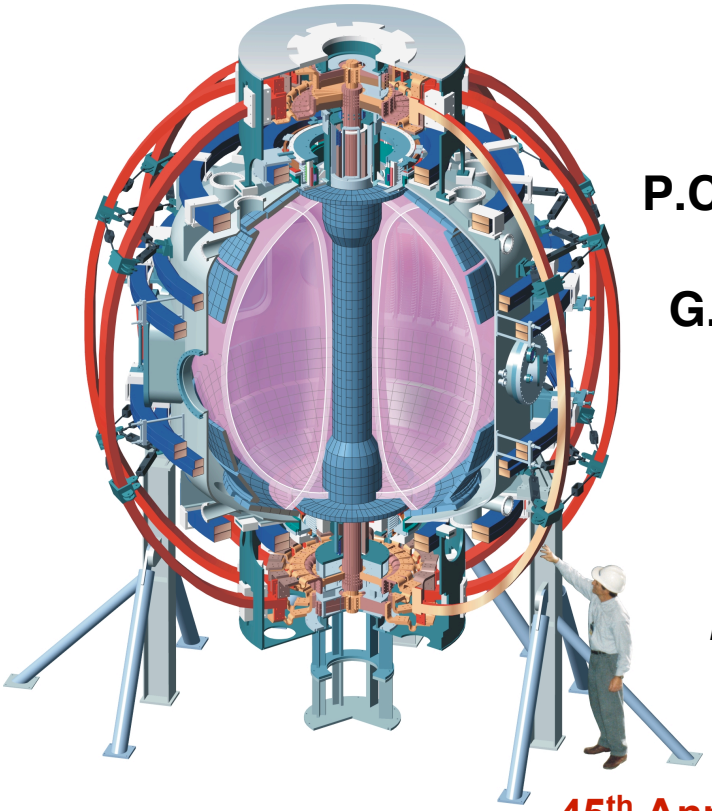
NSTX Electron Bernstein Wave (EBW) Research



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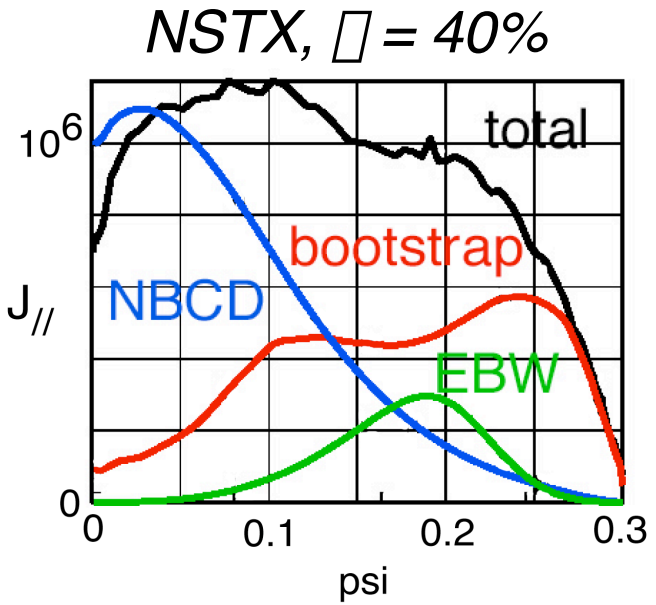
At High β, EBW Current Drive May Provide Critical Off-Axis Current



- ~100 kA of off-axis EBW CD needed for sustained β ~ 40% operation:
  - *challenge on ST due to large trapped particle fraction*

[C. Kessel, KO1.009, next talk]

- EBW heating & CD may also assist non-solenoid plasma startup
- Mode-converted thermal EBW emission used to measure $T_e(R)$ and investigate coupling of EBW to electromagnetic waves
- Modeling EBW coupling, power deposition and CD efficiency for planned multi-megawatt EBW heating & CD system for NSTX

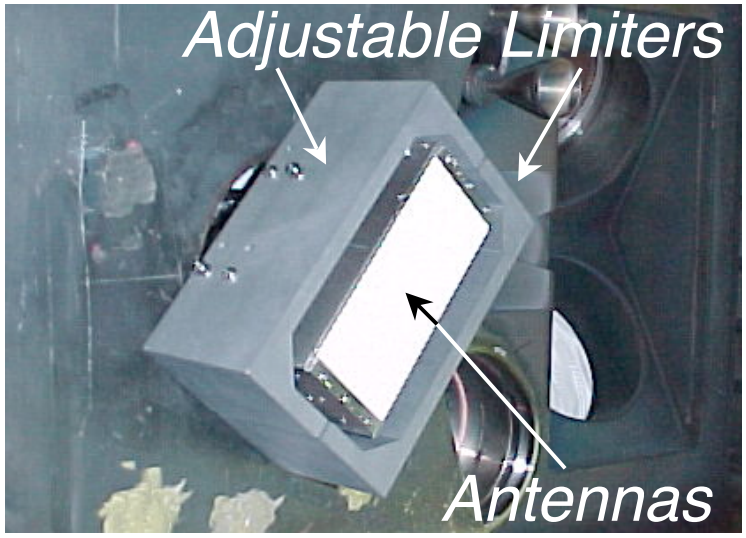
X-Mode & O-Mode EBW Antennas Installed on NSTX for $T_e(R)$ Diagnostic & EBW Coupling Studies

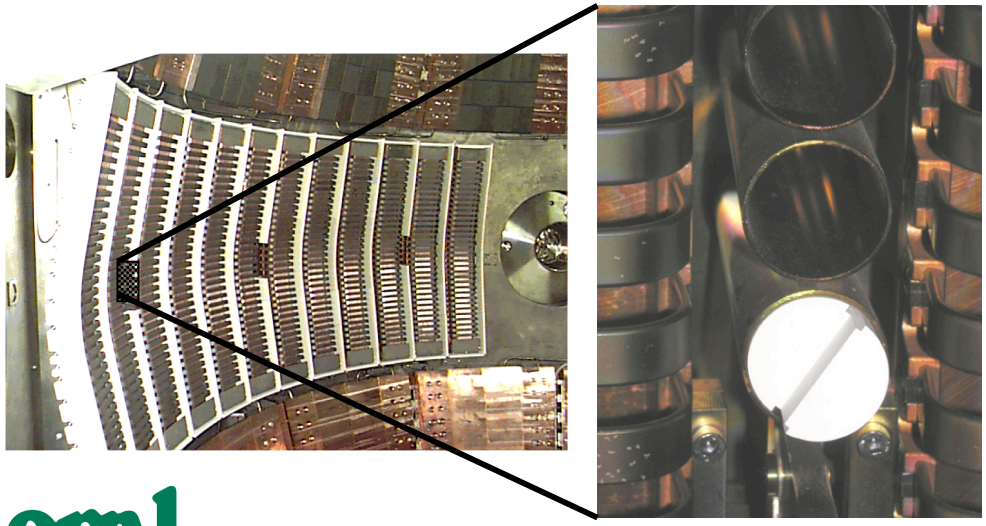
B-X Antenna

- Has adjustable limiters designed to achieve > 80% EBW coupling:
  - *similar antenna achieved ~ 100% coupling on CDX-U*

B-X-O Antenna

- Uses obliquely viewing, stepped wedge:
  - *also planning obliquely viewing, quad-ridged antenna*





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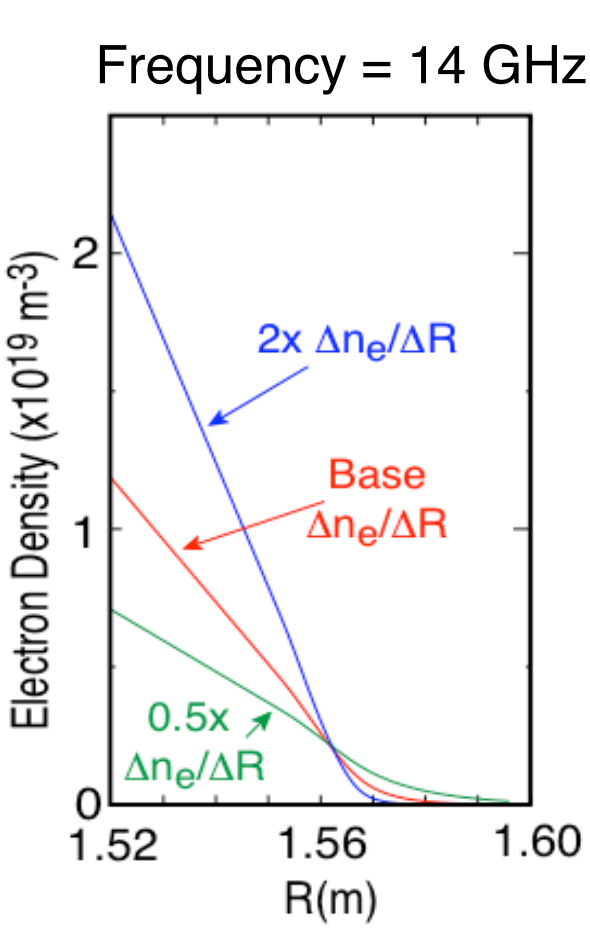
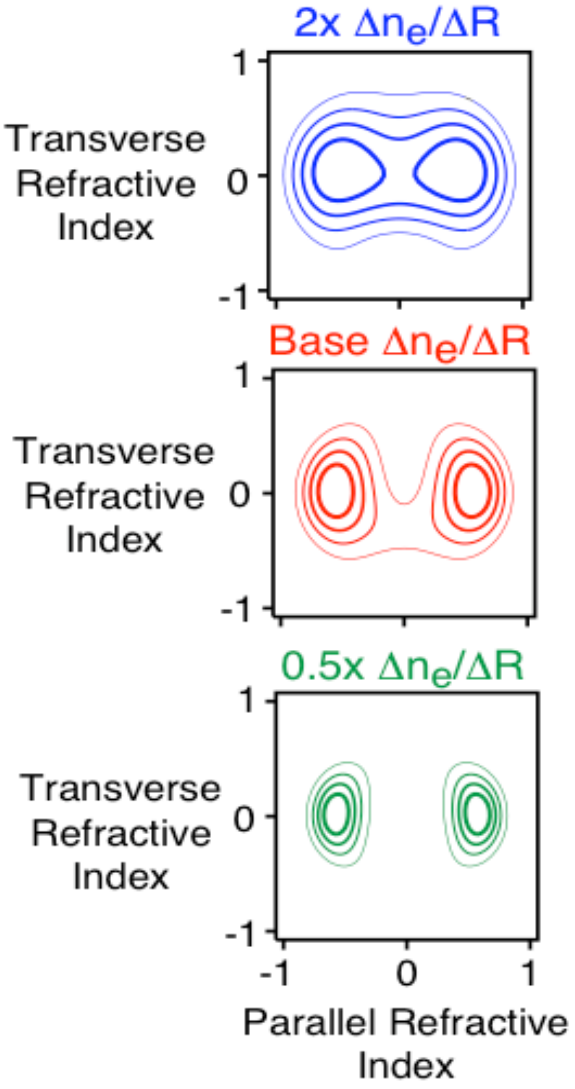
NSTX
NATIONAL SPHERICAL TORUS EXPERIMENT

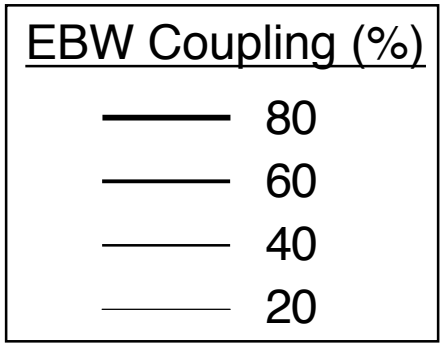
Oblique, "O-X-B", Launch Appears Resilient to Changes in Edge Density Gradient

- *OPTIPOL surveys EBW coupling - uses impedance matrix from GLOSI*





- Optimum $n_{//} \sim 0.55$; toroidal angle ~ 34° from normal to **B**
- Maxiumum EBW coupling efficiency obtained for near-circular polarization



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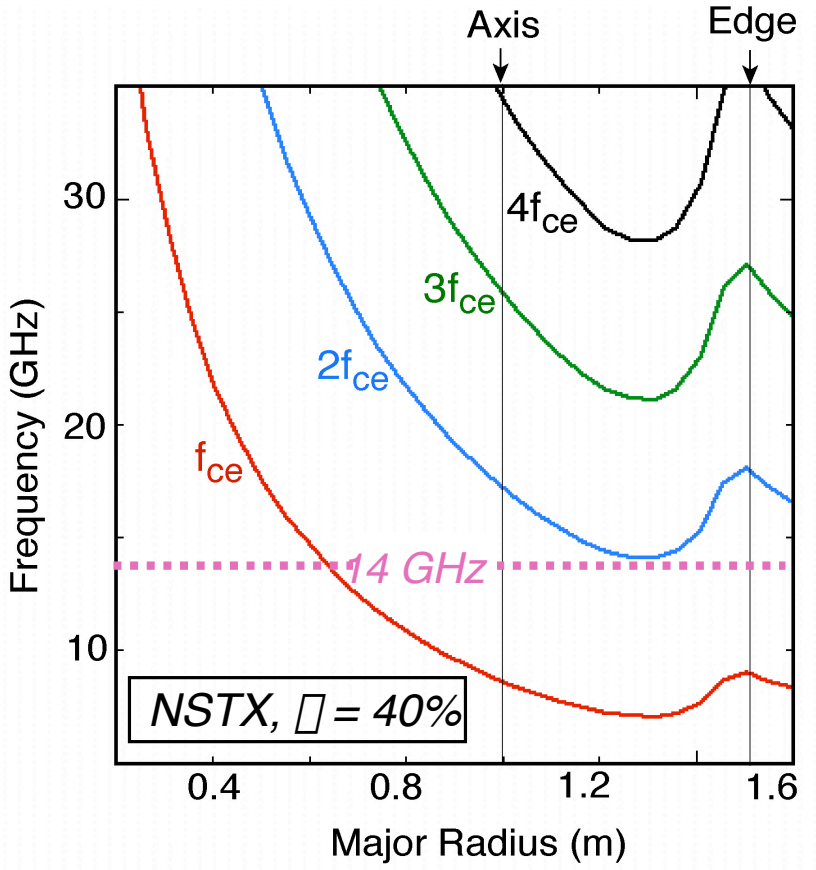
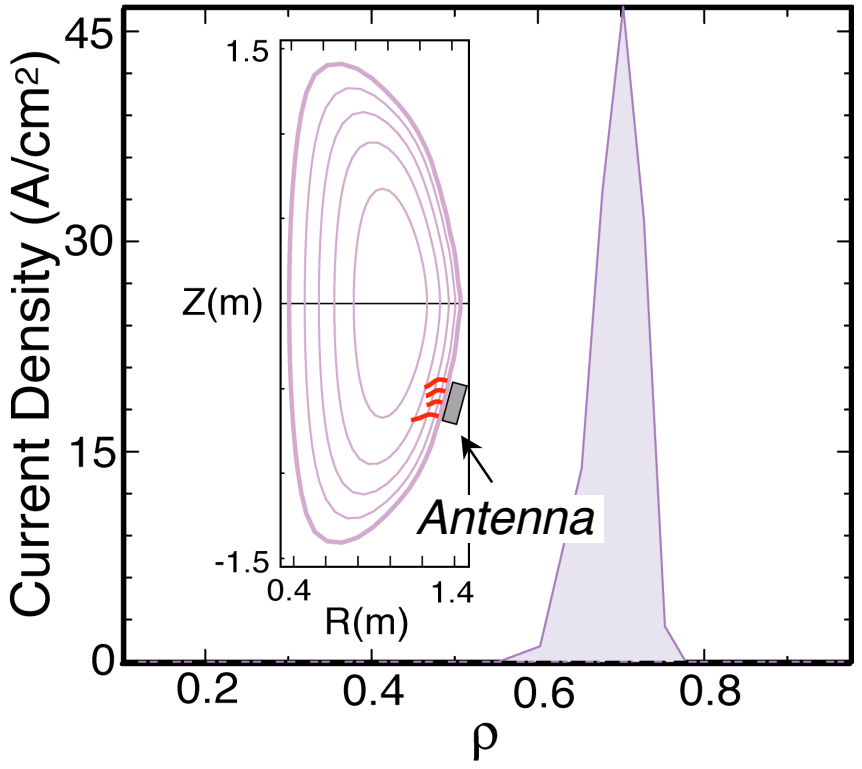
OPTPOL/GLOSI

NSTX National Spherical Torus Experiment

Fokker-Planck Modeling Indicates Efficient, Off-Axis, EBW Current Drive at □ = 40%



Frequency = 14 GHz
EBW Power = 3 MW
Total Driven Current =132 kA



CompX *GENRAY/CQL3D*

Normalized Off-Axis CD Efficiency, ζ_{ec}, in ST Compares Favorably to ECCD in Conventional Tokamak

$$\zeta_{ec} = \frac{3.27 \times I_p(A) \times R(m) \times n_e\,(10^{19} m^{-3})}{T_e(keV) \times P(W)}$$

*[C.C. Petty, AIP Proc. **595**, 275 (2001)]*

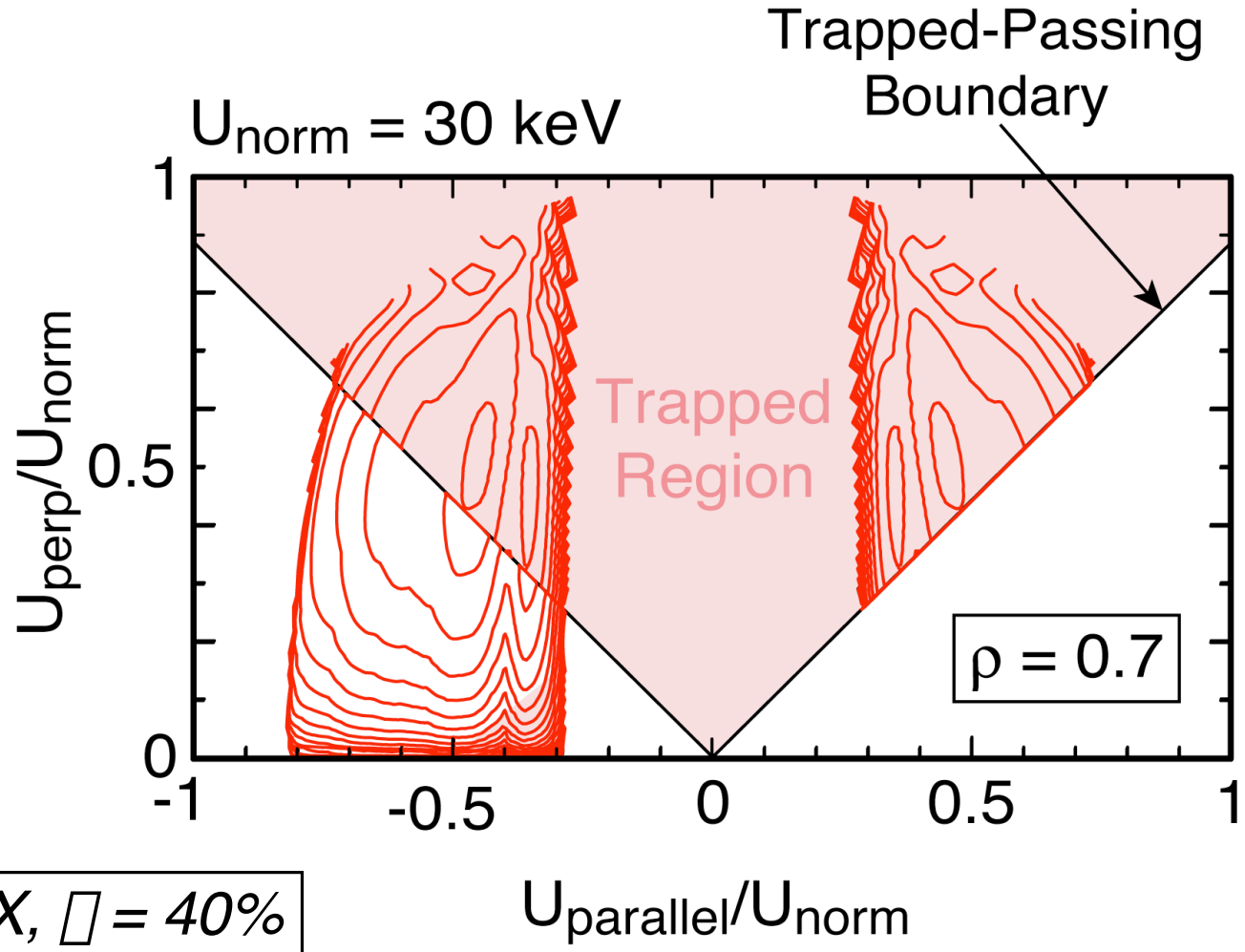
Results for EBW Frequency = 14 GHz

ρ	CD Efficiency (kA/MW)	ζ_{ec}
20%	22.6	0.65
30%	37.5	0.75
40%	44.0	0.69

- ζ_{ec} compares favorably to off-axis, ECCD on D-IIID where $\zeta_{ec} \sim 0.2$ at $\rho \sim 0.3$, with ζ_{ec} falling with increasing ρ

CompX *GENRAY/CQL3D*

Strong Diffusion Near Trapped-Passing Boundary Enables Efficient Ohkawa Current Drive



NSTX, β = 40%

CompX *GENRAY/CQL3D*

EBW Current Drive Possibly Critical to Sustained High β ST Operation

- New EBW emission antennas installed in NSTX for $T_e(R)$ and coupling studies in 2004:
  - *Demonstrate > 80% EBW coupling*
- Oblique, near-circularly polarized, launcher for efficient EBW coupling; resilient to changes in edge density gradient & field pitch
- Strong diffusion near trapped-passing boundary enables efficient off-axis, Ohkawa EBW CD in $\beta \sim 40\%$ plasmas
- ~ 3 MW EBW system planned to provide ~100kA off-axis EBW CD at $\beta \sim 40\%$ on NSTX by 2008:
  - *~ 4 MW of RF source power*
  - *steerable mirror launchers with polarization control*

ORNL Oak Ridge National Laboratory | MIT PSFC | **CompX** GENRAY/CQL3D | NSTX National Spherical Torus Experiment