

OFF-AXIS ECCD: RESULTS AND ISSUES

by

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with

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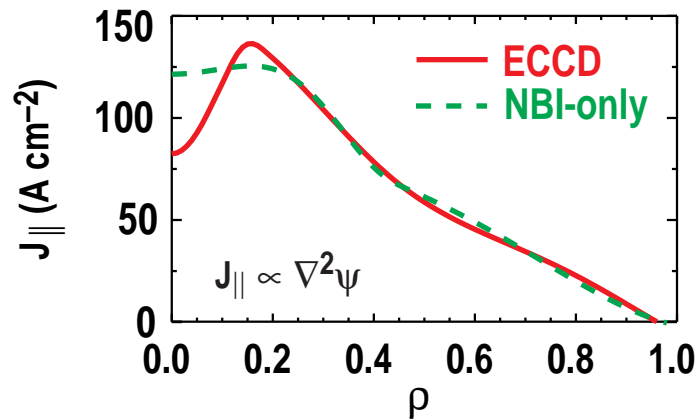


OUTLINE

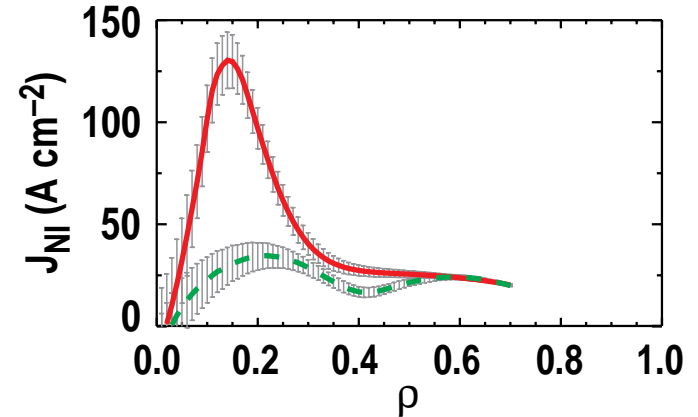
This talk addresses the following questions

- **Results:** Does the ECCD system on DIII-D drive current where we want it to?
- **Issues:** Is RF heating and current drive consistent with maintaining an internal transport barrier?

LOCALIZED CURRENT DRIVE IS CLEARLY MEASURED

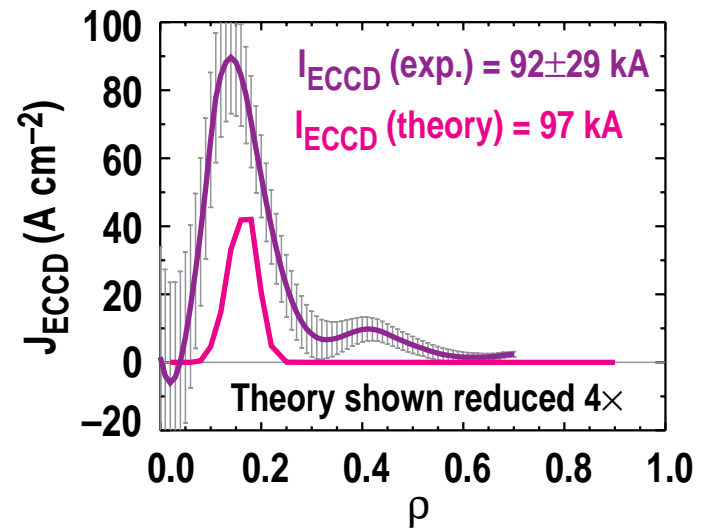
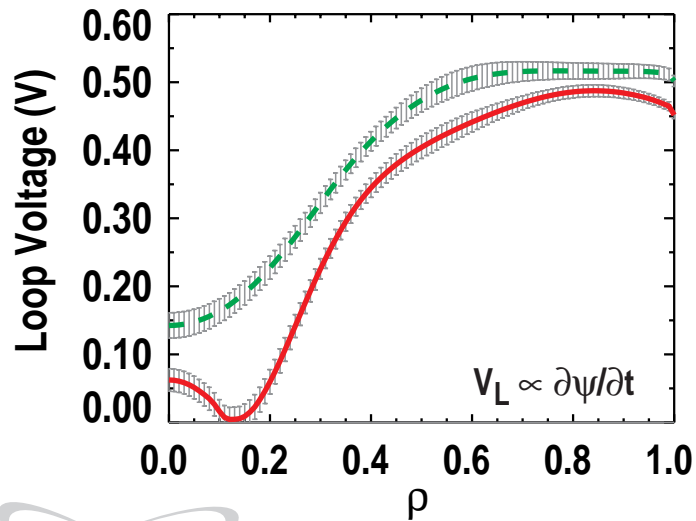


J_{\parallel} and loop voltage obtained from magnetic reconstructions with high resolution motional Stark effect spectroscopy (MSE)

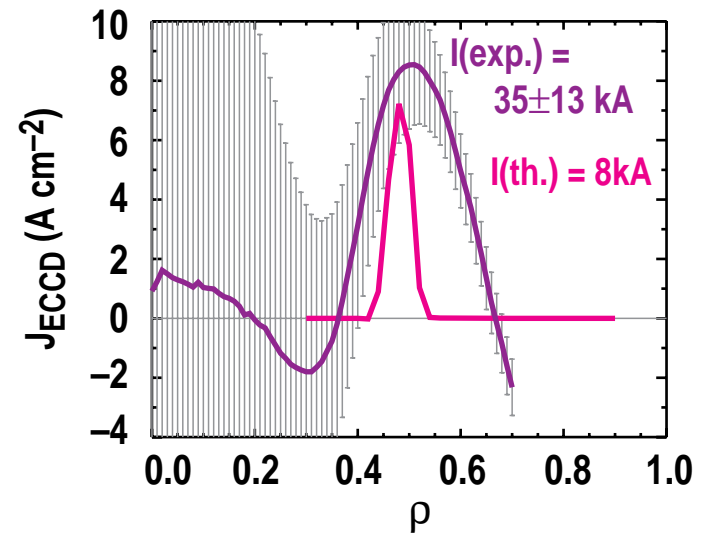
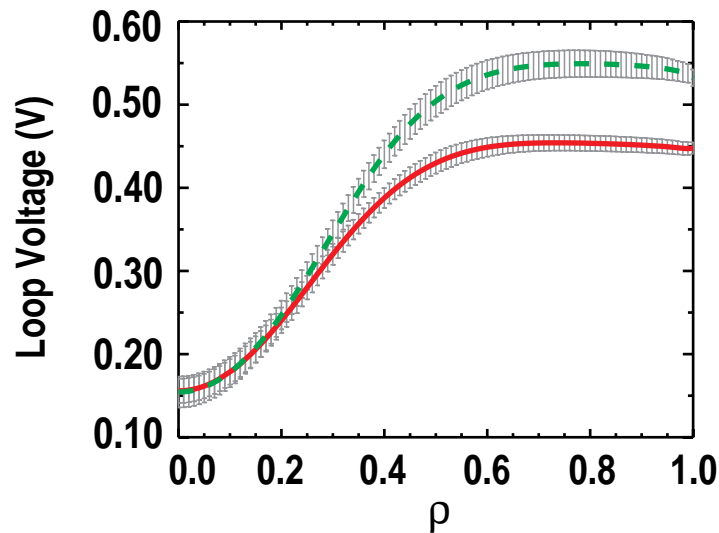
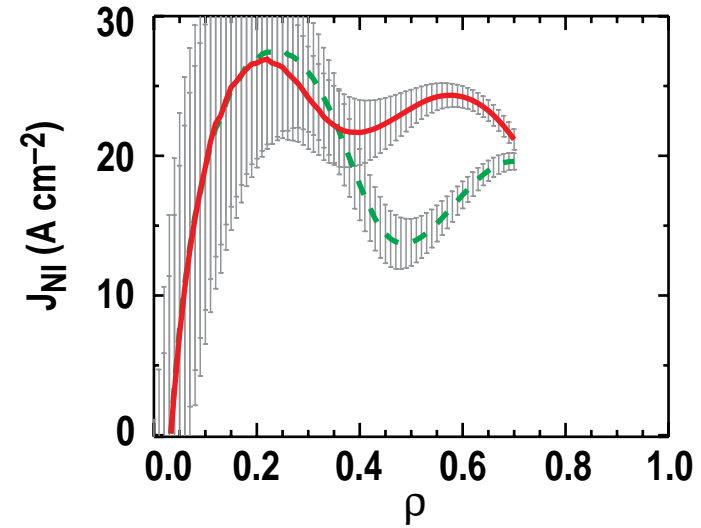
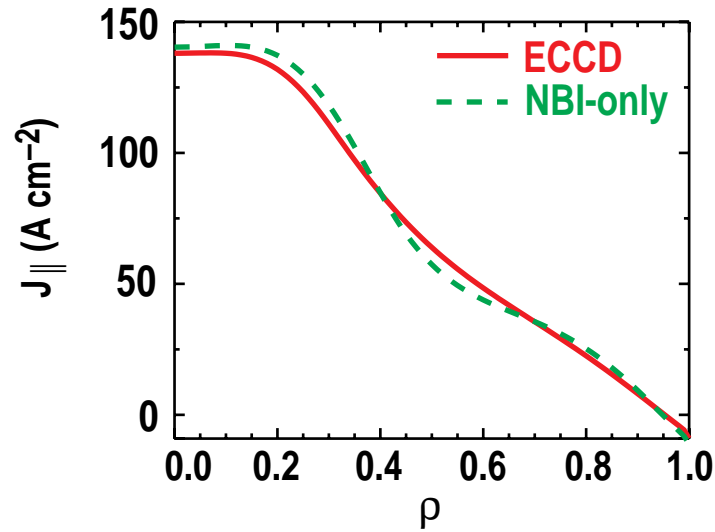


Assumption of neoclassical resistivity gives $J_{NBI} \equiv J_{\parallel} - \sigma E_{\parallel}$

Comparison of ECCD case with NBI-only fiducial separates ECCD from bootstrap and NBCD



SIGNIFICANT CURRENT IS MEASURED AT THE HALF RADIUS



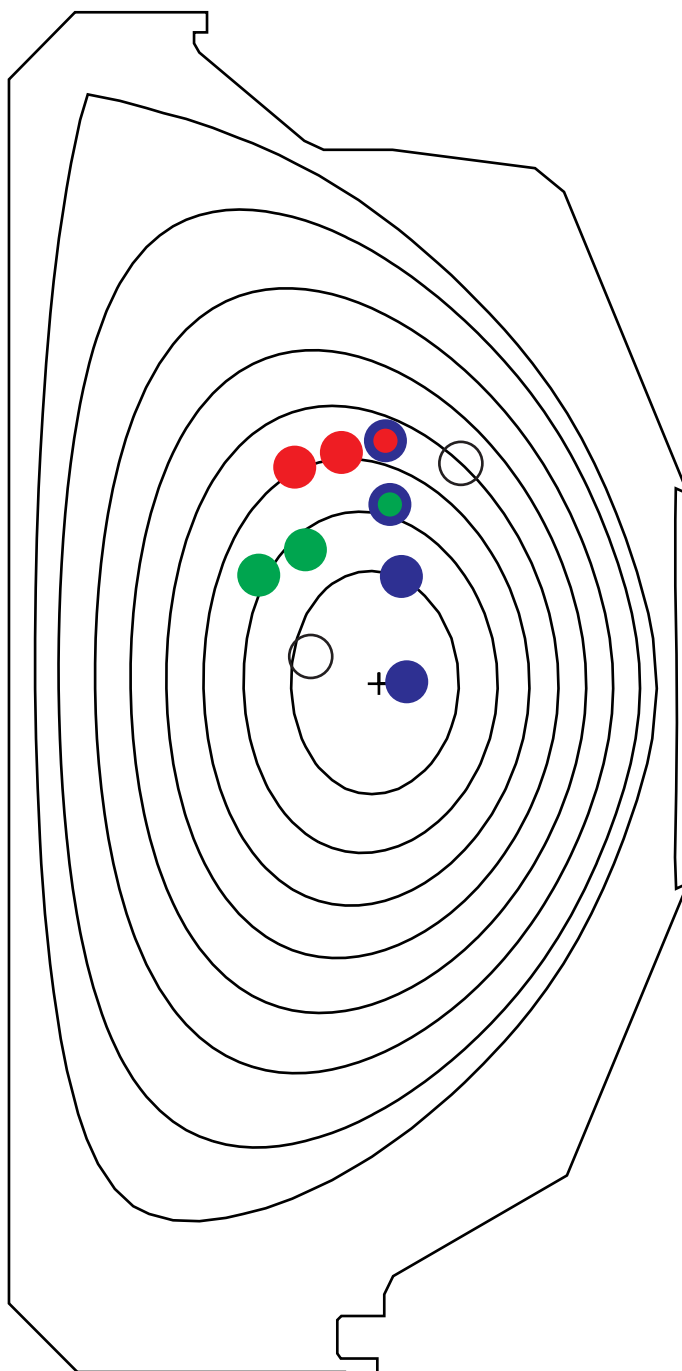
RADIAL AND POLOIDAL SCANS HAVE BEEN OBTAINED TO TEST THE EFFECTS OF TRAPPED PARTICLES

$P_{\text{ECH}} = 0.95\text{--}1.14 \text{ MW}$
 $\bar{n} = 1.66\text{--}1.85 \times 10^{13} \text{ cm}^{-3}$
 $q_{95} = 5.95\text{--}6.33$

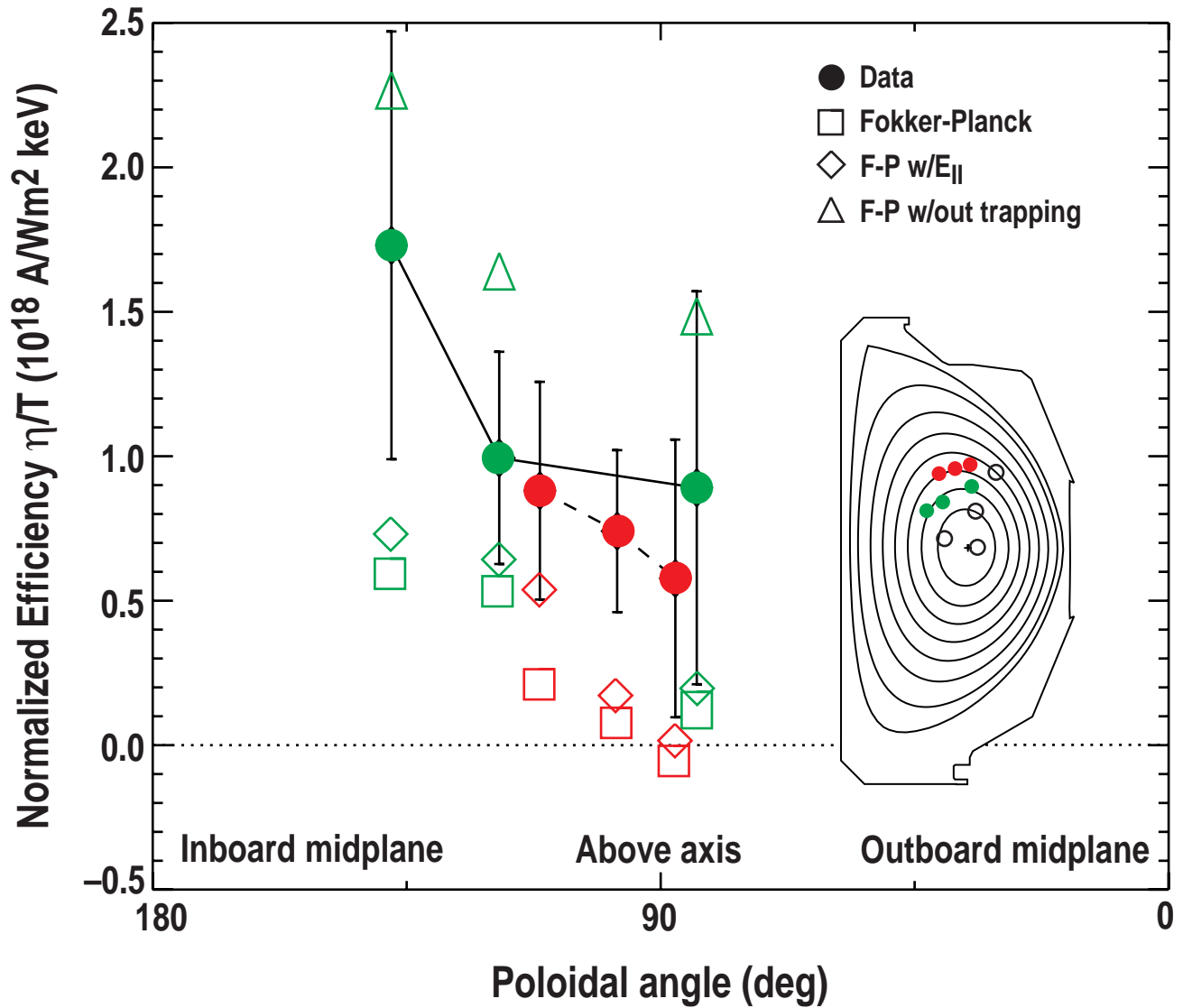
Radial Scan

Poloidal Scan $\rho = 0.34$

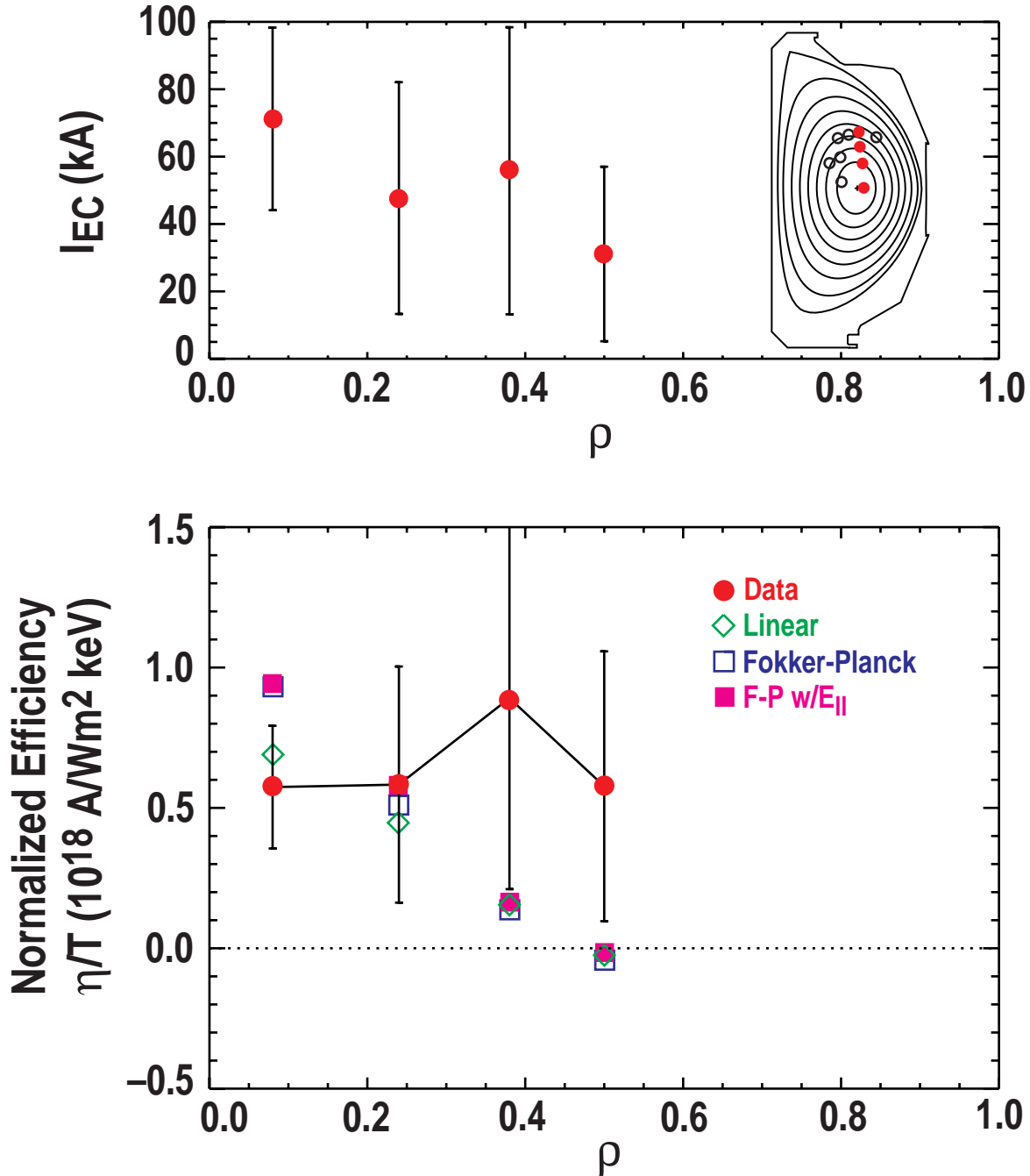
Poloidal Scan $\rho = 0.47$



POLOIDAL SCANS SHOW REDUCED TRAPPING EFFECT AND SYSTEMATIC INCREASE IN EFFICIENCY TO HIGH FIELD SIDE



NORMALIZED CURRENT DRIVE EFFICIENCY DOES NOT DROP WITH RADIUS AS EXPECTED FROM THEORY

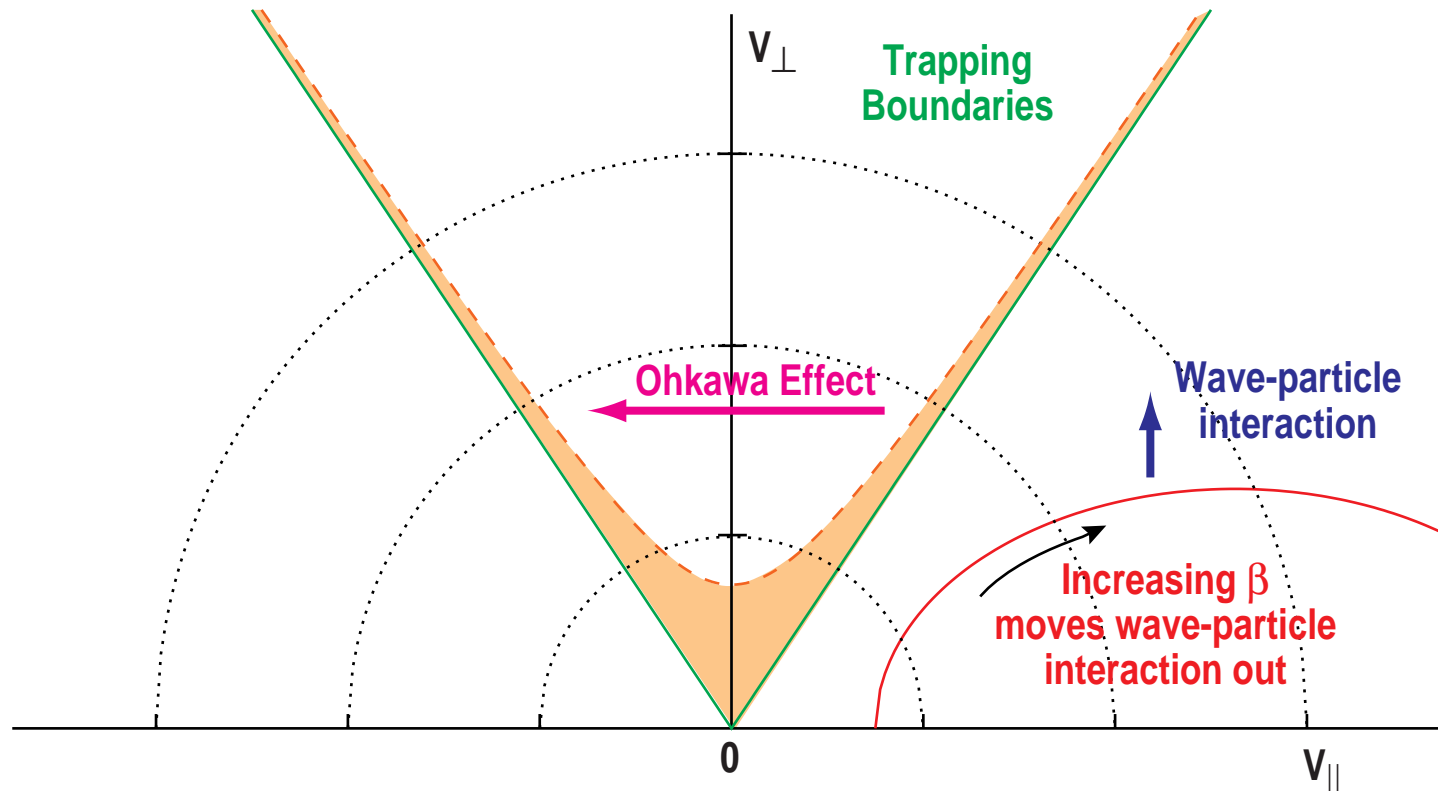


ISSUES

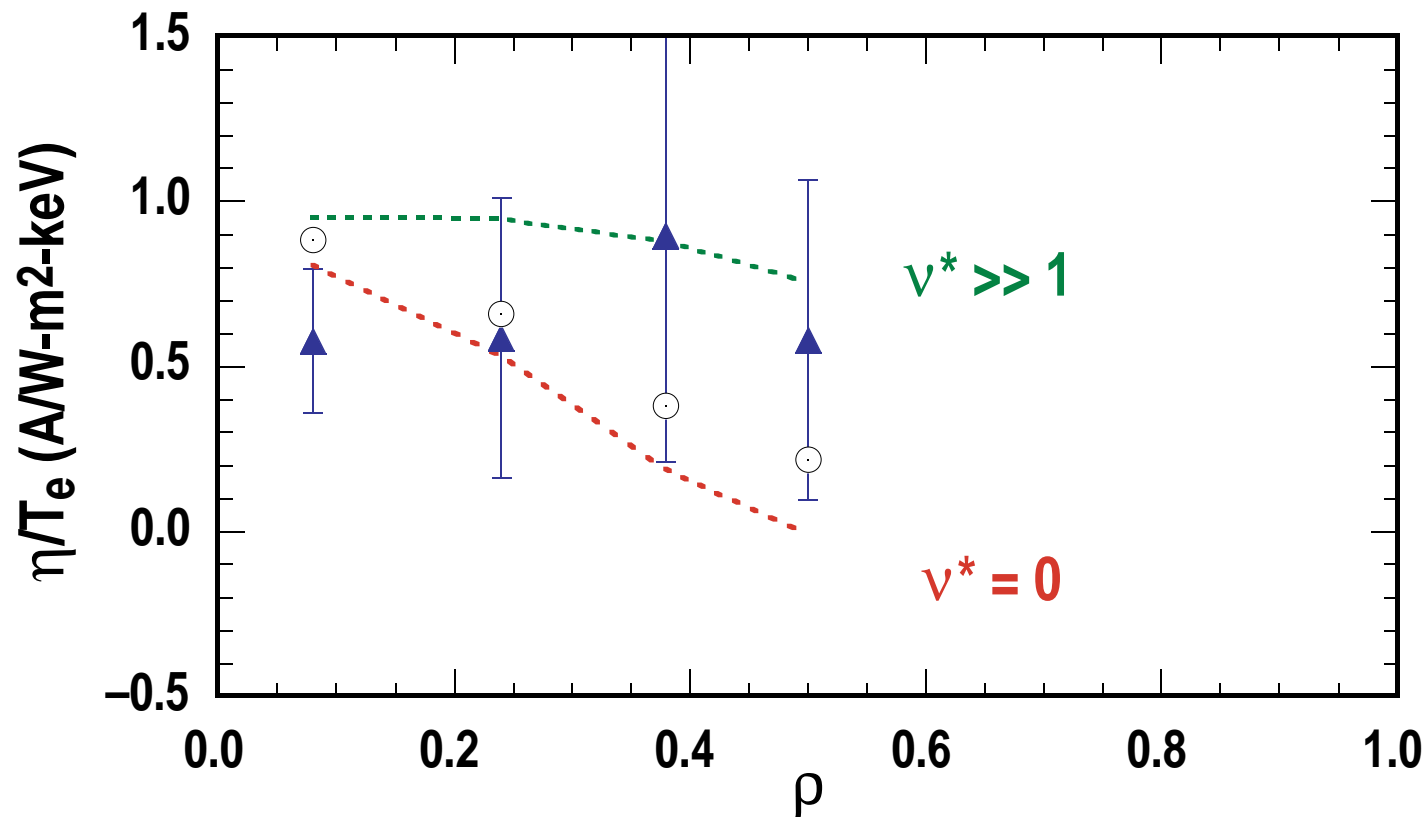
1. Why is the effect of trapped electrons significantly less than expected from theory?

- Bounce-averaged Fokker-Planck calculation gives a conservative estimate of ECCD
- Collisionality effectively reduces trapped electron fraction, increasing current drive efficiency
- Analytical interpolation of ECCD efficiency between collisional and collisionless limits improves agreement between theory and experiment for off-axis cases
- Work on a 3-D Fokker-Planck calculation of ECCD including collisionality effects is in progress

SCHEMATIC OF EFFECTS OF FINITE COLLISIONALITY AND HIGHER β ON ECCD



VELOCITY SPACE INTERPOLATION OF ECCD EFFICIENCY IMPROVES AGREEMENT WITH EXPERIMENT FOR STRONG TRAPPING



ISSUES (Continued)

2. Why is the measured ECCD radial profile broader than expected from theory?
 - Numerical simulation of poloidal magnetic flux evolution during ECCD planned to determine “instrumental resolution” of current drive analysis

3. Can sufficient particle control be obtained in plasmas with strong internal transport barriers to keep density below ECH cutoff density?
 - Density control experiments planned using top pump in ELMing NCS plasmas
 - Electron cyclotron wave propagation through H-mode edge plasma will also be studied

4. Are the planned ECCD systems for DIII-D sufficient to control the current in Advanced Tokamak plasmas?
 - Covered in Murakami’s talk on self-consistent AT scenario modeling

ISSUES (Continued)

5. Can strong internal transport barriers be maintained during strong electron heating?

- Usually $T_i \gg T_e$ obtained in conjunction with high performance (exceptions are plasmas with extremely peaked density profiles)
- Both $E \times B$ shear and $T_i/T_e \gg 1$ are stabilizing for ion temperature gradient mode
- RF heating and current drive allow us to study internal transport barriers formed by $E \times B$ shear with $T_i = T_e$ and weak density gradients
- See Greenfield's talk on electron transport in DIII-D NCS discharges

CONCLUSIONS

This talk addresses the following questions

- **Results:** Does the ECCD system on DIII-D drive current where we want it to?
- **Issues:** Is RF heating and current drive consistent with maintaining an internal transport barrier?