Modeling of Island Divertor Plates in the Compact Toroidal Hybrid

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CTH Compact Toroidal Hybrid

Introduction

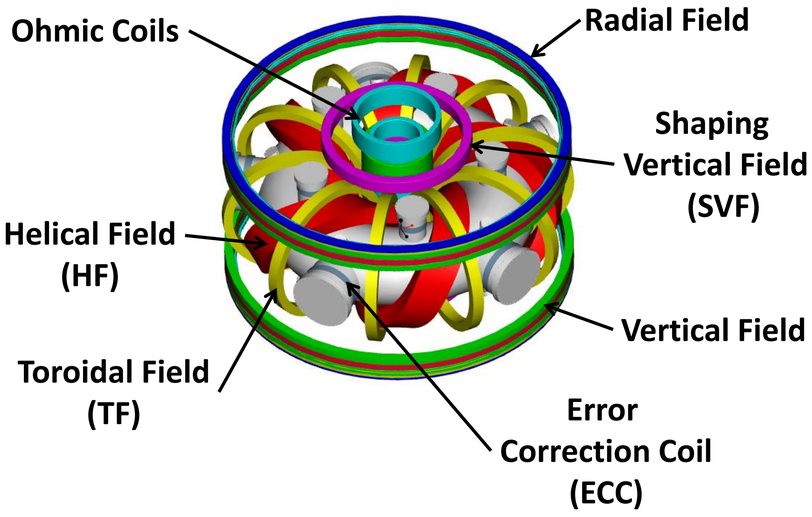
- Edge island divertors can be used as a method of plasma particle and heat exhaust in high performance, long pulse length stellarators.
- Computational studies of the power loading on these structures and its relationship to the long connection length scrape off layer physics are underway on the Compact Toroidal Hybrid (CTH) experiment.
- We report the results of connection length studies for divertor plates to be installed in CTH and initial calculations using the EMC3-EIRENE code[1,2], with **three potential divertor plate locations** relative to the island structure.
- Plasma generation and heating will be accomplished with a 200kW, 2.4GHz gyrotron system that is under construction; operation will be at 2nd harmonic.
- A poloidal field coil is used to adjust the shear of the rotational transform profile, and hence the size of edge islands, while five error coils producing an n=1 perturbation giving further size and phase adjustment. For the studies conducted, a magnetic configuration with a large n=1, m=3 magnetic island at the edge is generated.

Special thanks to : Aaron Bader – University of Wisconsin
Yuhe Feng – IPP Greifswald
Sam Lazerson – PPPL

This work is supported by U.S. Department of Energy Grant No. DE-FG02-00ER54610

[1] Feng Y, Sardei F and Kisslinger J 1999 *J. Nucl. Mat.* **266–269** 812
[2] Reiter D 1984 *Technical Report* J¨ul-1947, KFA J¨ulich, Germany

CTH Magnet Coils

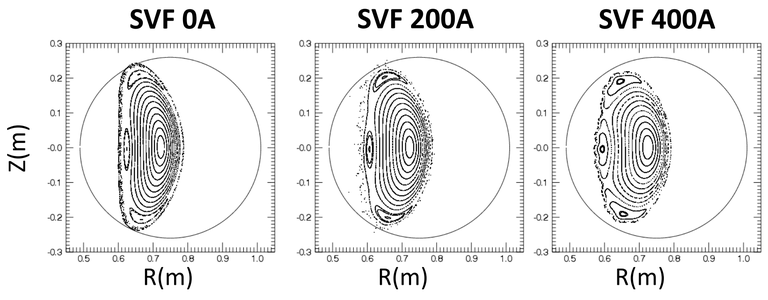


CTH parameters

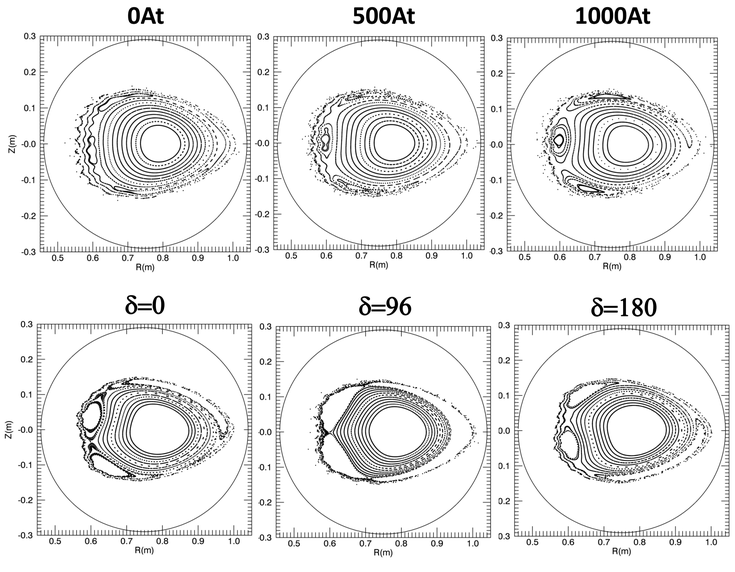
5 field periods	**discharge duration ~0.1s**
R_o = 0.75 m	n_e ≤ 5 x 10^{19} m^{-3}
a_{vessel} = 0.29 m	T_e ≤ 200 eV
a_{plasma} ≤ 0.2m	B_o ≤ 0.7 T
P_{input} ≤ 30 kW ECRH ~ 200kW OH	I_p ≤ 80 kA
Vacuum transform 0.02 – 0.35	<β> ≤ 0.5%

CTH has a flexible magnetic geometry

- The SVF Coil set is used to modify the magnetic shear and island width.



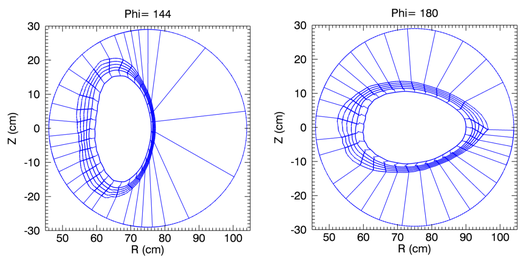
- The ECC coils are used to add an n=1 perturbation to modify the magnitude and phase of the 1/3 magnetic islands.



EMC3-EIRENE Grid and Parameters

Power Input = 50kW
n_e = 4 x 10^{18} m^{-3}
$D_\perp$ = 1.0 m^2s^{-1}
$\chi_e = \chi_i$ = 3 m^2s^{-1}

Grids shown are 1/16 actual density



Inboard Plate

- While moving this plate is possible, connecting actuators and signal lines is difficult compared to other locations.
- Viewable with infra-red cameras located at side ports

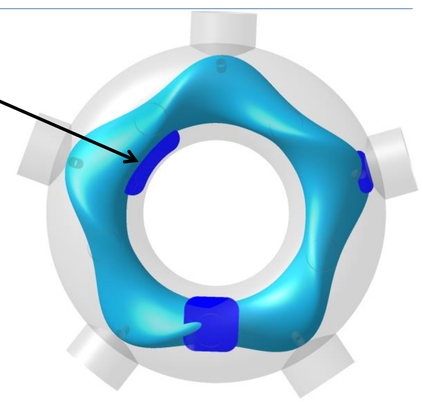
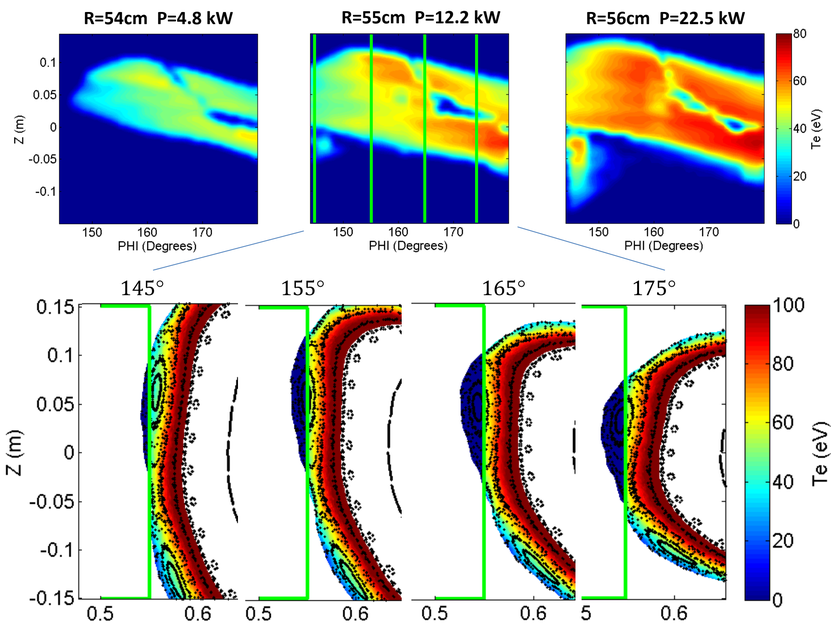


Plate Temperatures

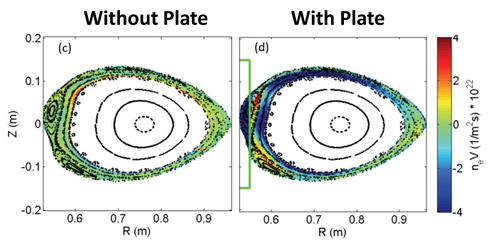
- The plate is positioned at three major radial positions
- Plotted are the temperature contours at the plate
- As the plate is moved toward the core, more power is deposited on the plate



- Surface of section plots superimposed with temperature contours at four toroidal locations on the front face of the inboard plate.

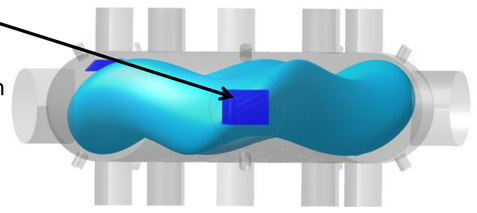
Flows

- EMC3-EIRENE predicts induced flows when the inboard plate is inserted into the edge island.

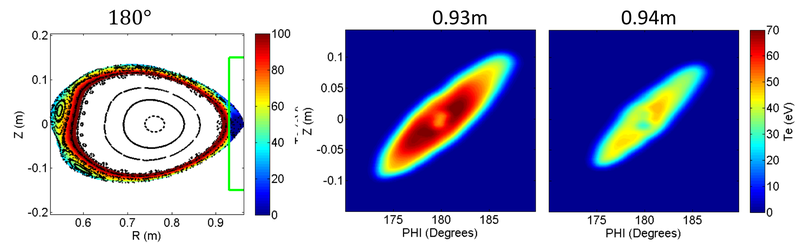


Outboard Plate

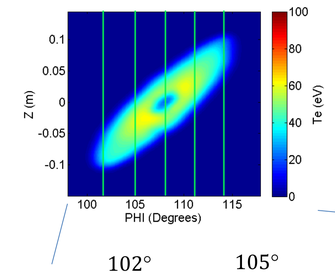
- Plate could be inserted and retracted with a linear motion feed-through.
- Not easily viewable with cameras



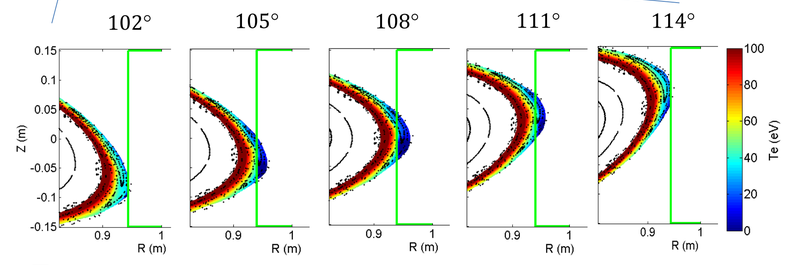
x-point location



o-point location



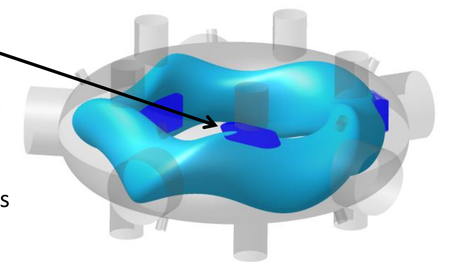
- Similar temperature and power deposition patterns on outboard plates near x and o-points suggest that the deposition is dominated by the background magnetic field configuration.

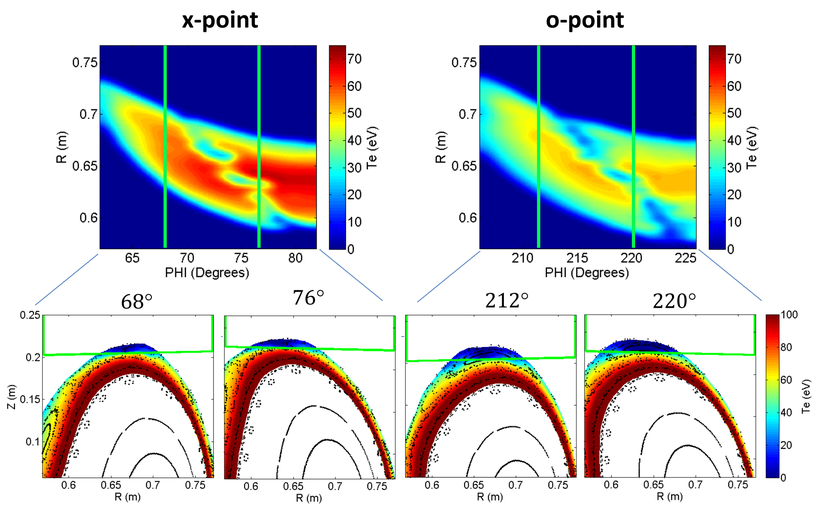


- Surface of section plots superimposed with temperature contours at five toroidal locations on the front face of the outboard plate.

Top-port Plate

- Plate could be inserted and retracted with a linear motion feed-through.
- Could be imaged with cameras viewing from lower ports

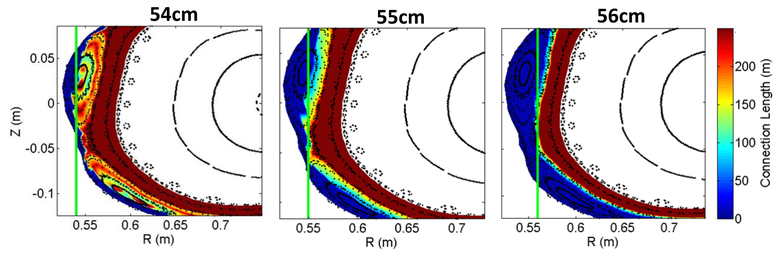




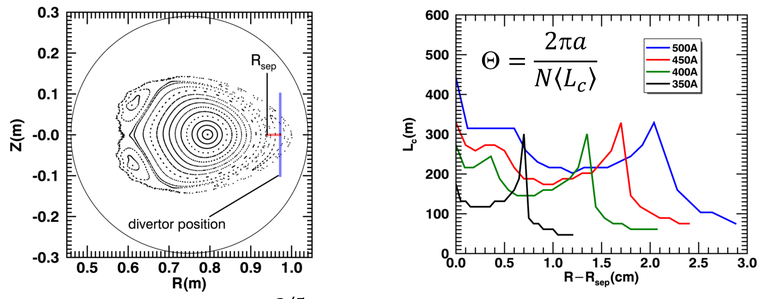
Connection Length Studies

- Connection lengths calculated with EMC3-EIRENE and field line following codes have the same order of magnitude.
- The flexibility of the CTH system allows access to parameter space where the parallel transport effects can dominate the perpendicular effects or visa versa.

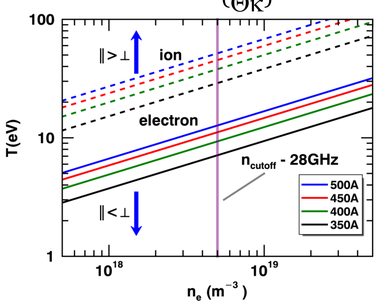
Results from EMC3-EIRENE, inboard plate



Results from IFT, outboard plate



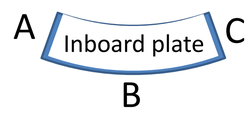
$$T = \left\{\frac{\chi n}{\Theta \kappa}\right\}^{2/5}$$

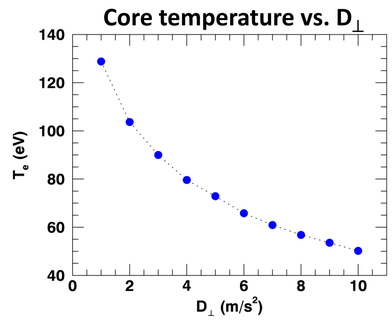


- $\langle L_c \rangle$ is calculated for each magnetic field condition and related to the field line pitch through the local rotational transform, λ.
- Perpendicular conduction will dominate for cold CTH ions.
- Parallel and Perpendicular conduction effects will compete in CTH, and the boundary is adjustable.

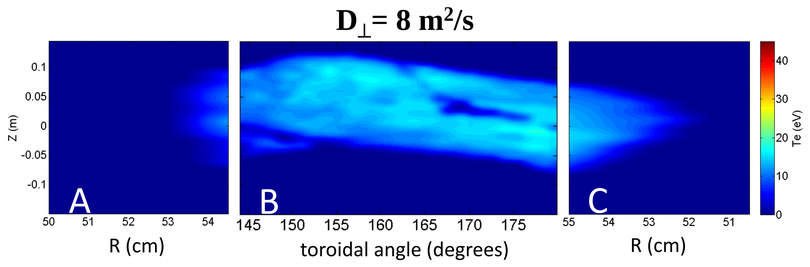
Diffusivity ($D_\perp$) Scan Results

- Inboard plate located at 55cm
- χ is fixed at 3 m^2/s
- As $D_\perp$ increases, the core temperature decreases
- Sides of inboard plate also receive power flux





$D_\perp$= 8 m^2/s



$D_\perp$= 2 m^2/s