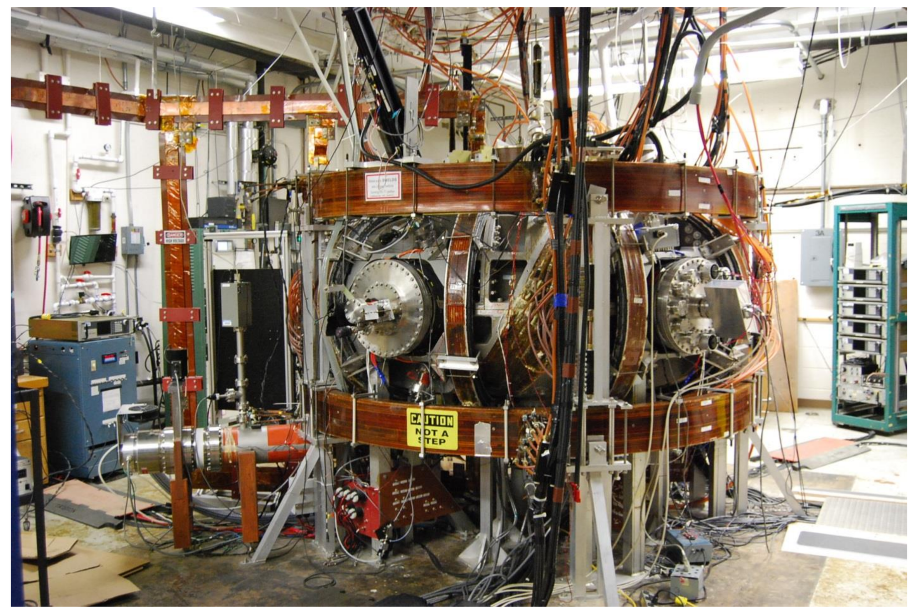


CTH parameters

5 field periods		discharge duration ~0.1s	
R_o	= 0.75 m	n_e	$\le 5 \times 10^{19}$ m^{-3}
a_{vessel}	= 0.29 m	T_e	$\le$ 200 eV
a_{plasma}	$\le$ 0.2m		
B_o	$\le$ 0.7 T		
P_{input}	$\le$ 15 kW ECRH ~ 200kW OH	I_p	$\le$ 80 kA
	~ 150 kW 2nd Harmonic x-mode (under construction)		
Vacuum transform 0.02 – 0.35		$\langle\beta\rangle$	$\le$ 0.2%

Motivation

- Divertors isolate the confinement core from regions where the plasma and structural surfaces interact.
- Divertors in stellarators can make use of magnetic island structures at the edge of the confinement region; these structures are device-dependent
- In long pulse length stellarator experiments, edge island divertors can be used as a method of plasma particle and heat exhaust, e.g. W7-X.
- 3D divertors generated by an edge magnetic island structure have substantially different physics properties from 2D poloidal divertors; Knowledge of the detailed power flow and loading on 3D divertors and its relationship to the long connection length scrape off layer physics is a new Compact Toroidal Hybrid (CTH) research thrust, and a component of the US collaborative effort with W7-X.

Overview

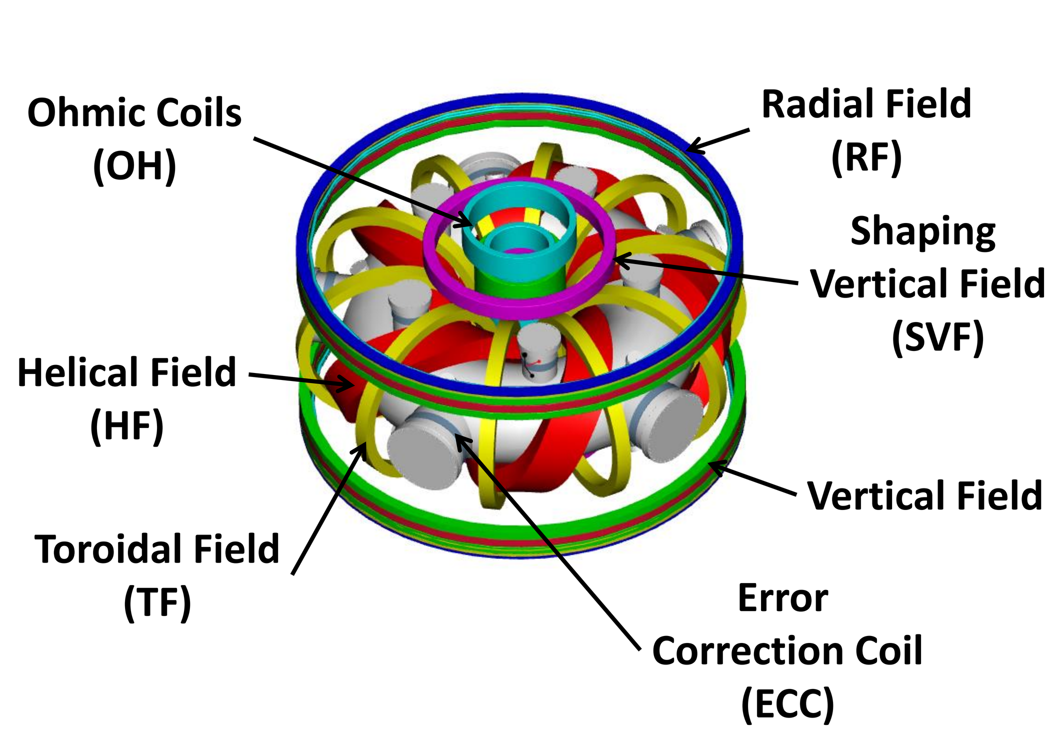
- We report the results of initial calculations using the EMC3-EIRENE code[1,2], using three potential divertor plate locations relative to the island structure.
- CTH will be operated as a pure stellarator with no plasma current. Plasma generation and heating will be accomplished with a 200kW, 28 GHz gyrotron system under construction; operation will be at 2nd harmonic.
- The CTH vacuum rotational transform can be varied from $\iota(a)$=0.02 - 0.35 by adjusting the ratio of currents in the helical and toroidal field coils.
- The shaping vertical field (SVF), poloidal coil set is used to adjust the shear of the rotational transform profile, and hence the size of edge islands.
- The magnitude and phase of islands can be adjusted with a set of five error correction coils (ECC) that produce an n=1 perturbation.

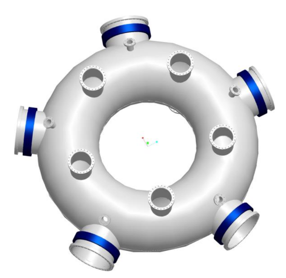
Special thanks to : Yuhe Feng – IPP Greifswald
Jeremy Lore – ORNL
Sam Lazerson – PPPL

References
[1] Y. Feng, M. Kobayashi, T. Lunt, and D. Reiter, *Plasma Phys. Control. Fusion*, **53** (2011) 024009
[2] P. Stangeby, *The Plasma Boundary of Magnetic Fusion Devices*, IOP Publishing (2000)

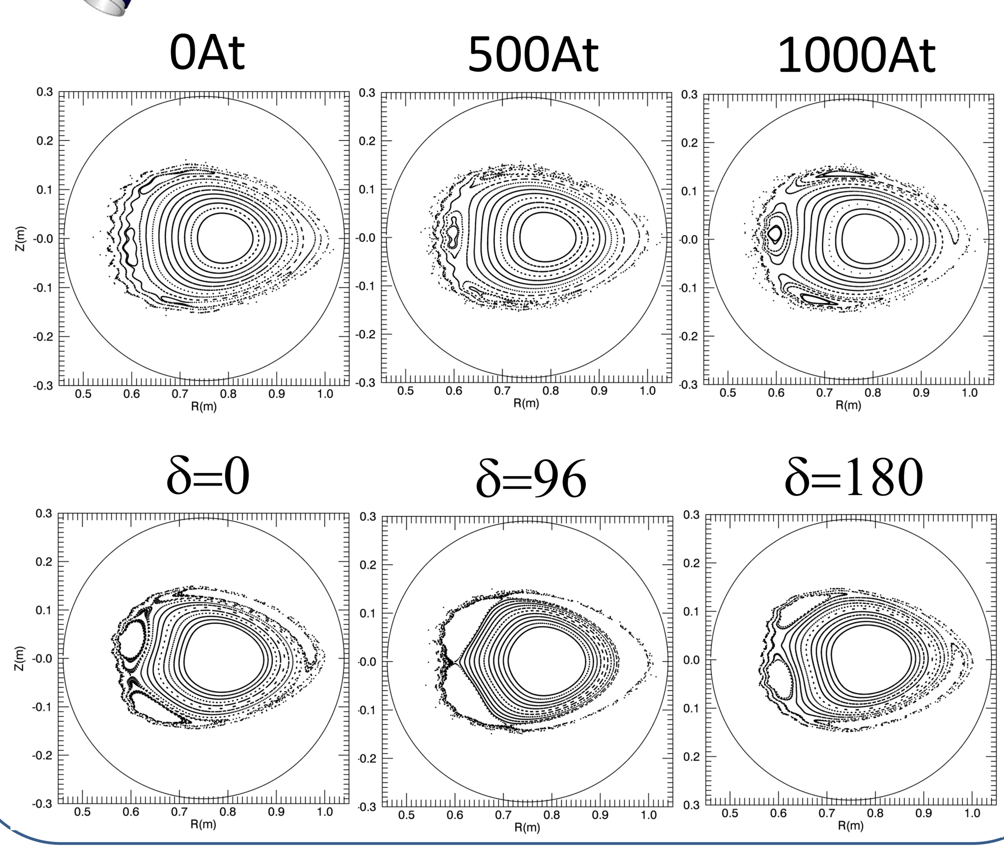
*Supported by US DOE Grant DE-FG02-00ER54610

CTH has a flexible coil set that allows for exploration of multiple magnetic field configurations

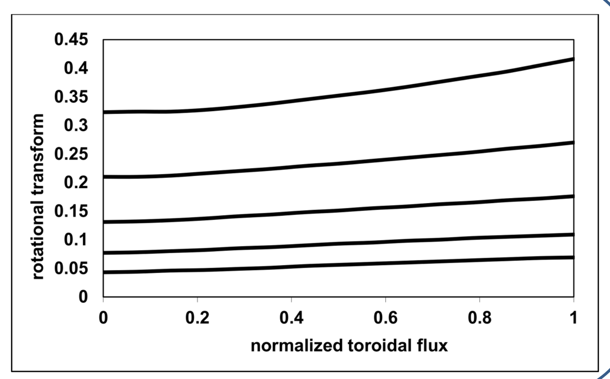




Symmetry breaking islands are generated with error correction coils. Shown below is an example m/n = 1/3 island near the edge.

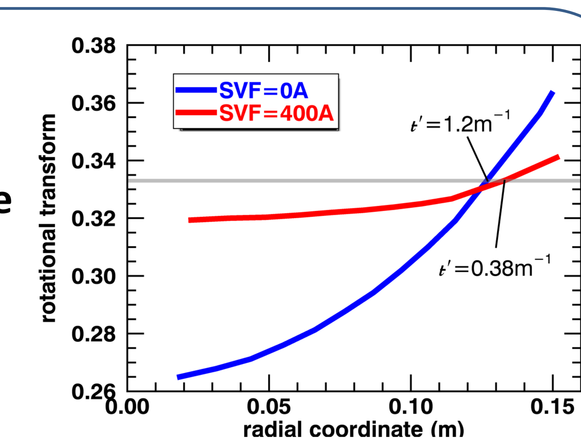


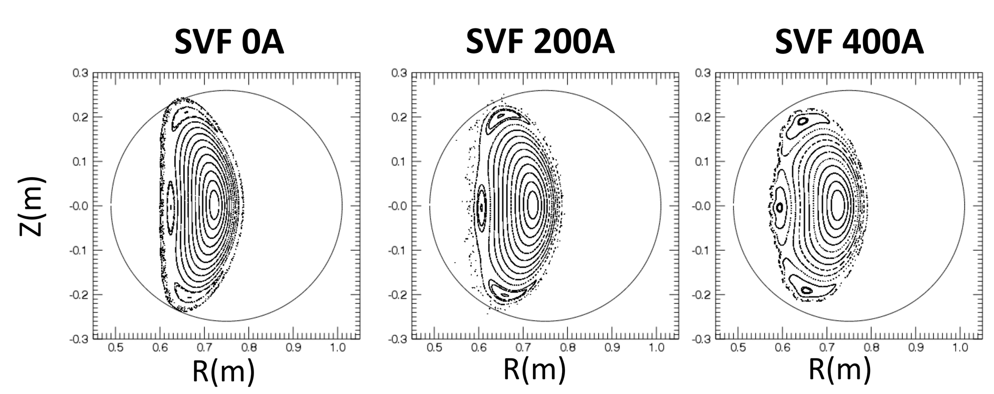
The rotational transform profile, $\iota(r)$, is modified by changing the ratio and direction of currents in the TF and HF coils.



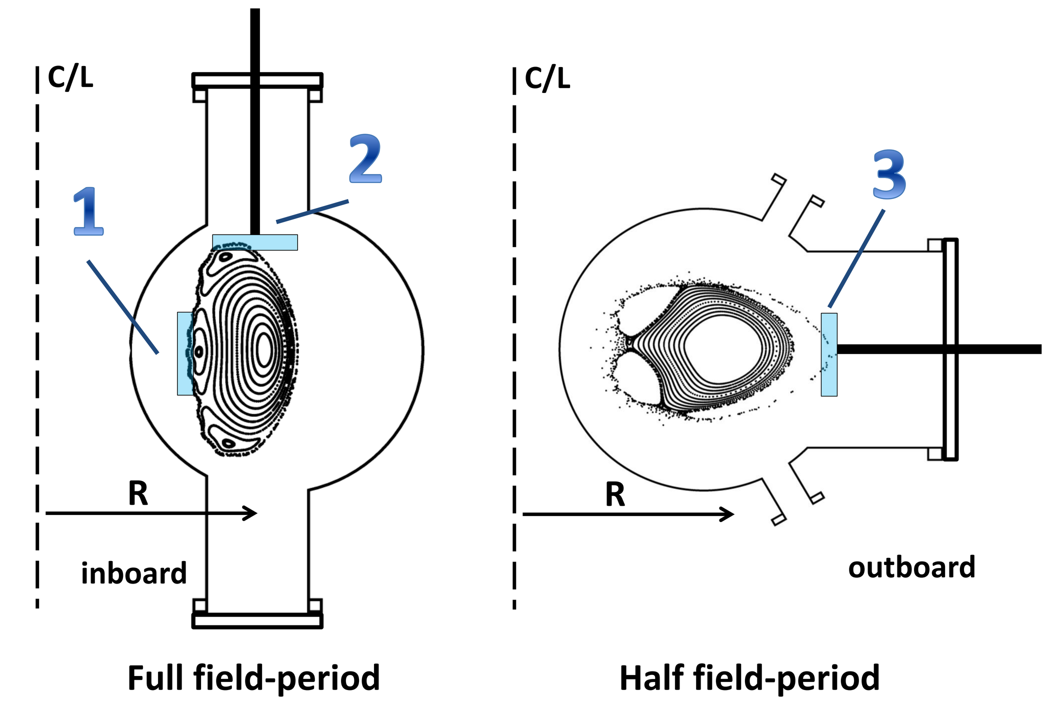
The SVF Coil modifies the magnetic shear profile, $\iota'(r)$, and hence the width of the magnetic island, Δr.

$$\Delta r_{island} \propto \sqrt{R_o b_{mn}/n\iota'}$$



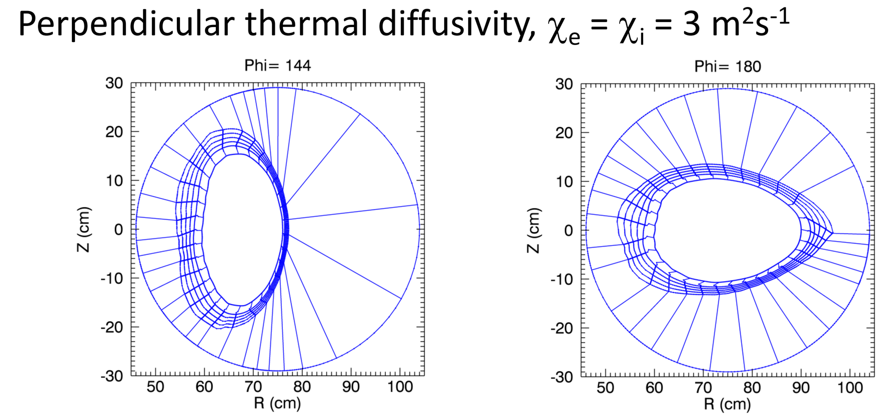


With magnetic island width and phase control, we explore three divertor-like structures using the EMC3-EIRENE code.



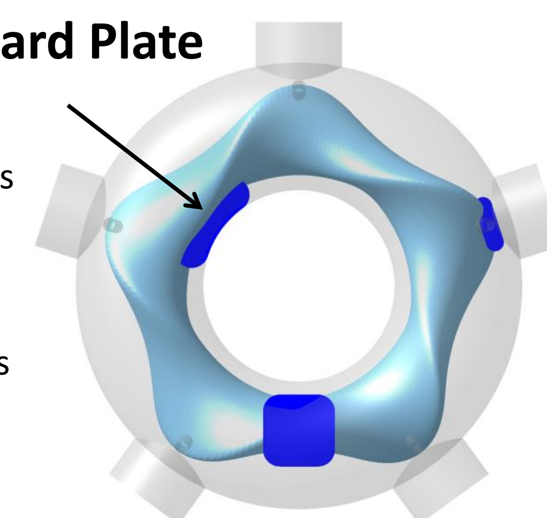
For these studies EMC3-EIRENE is used to model the temperature distribution at the divertor-like plate.

Power input at core = 50kW
Core electron density, n_e = 4 x 10^{18} m^{-3}
Perpendicular particle diffusivity, $D_\perp$ = 1.0 m^{2}s^{-1}
Perpendicular thermal diffusivity, $\chi_e = \chi_i$ = 3 m^{2}s^{-1}



Computational grids shown at 1/16 actual density

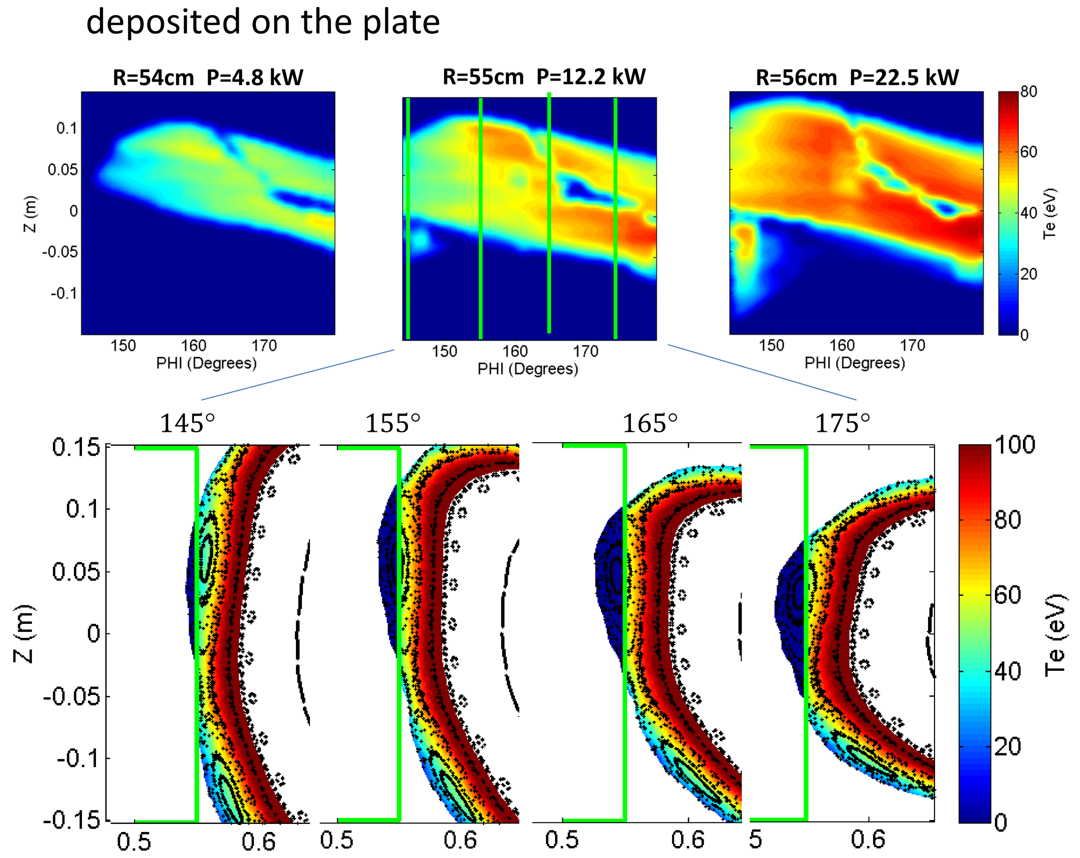
1 Inboard Plate



- 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
- Moderate island size

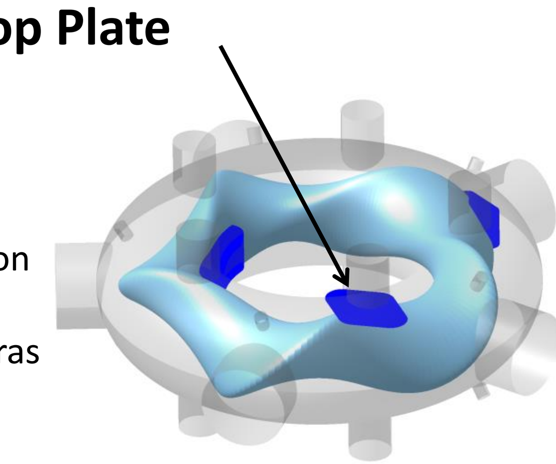
Plate Temperatures

- 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



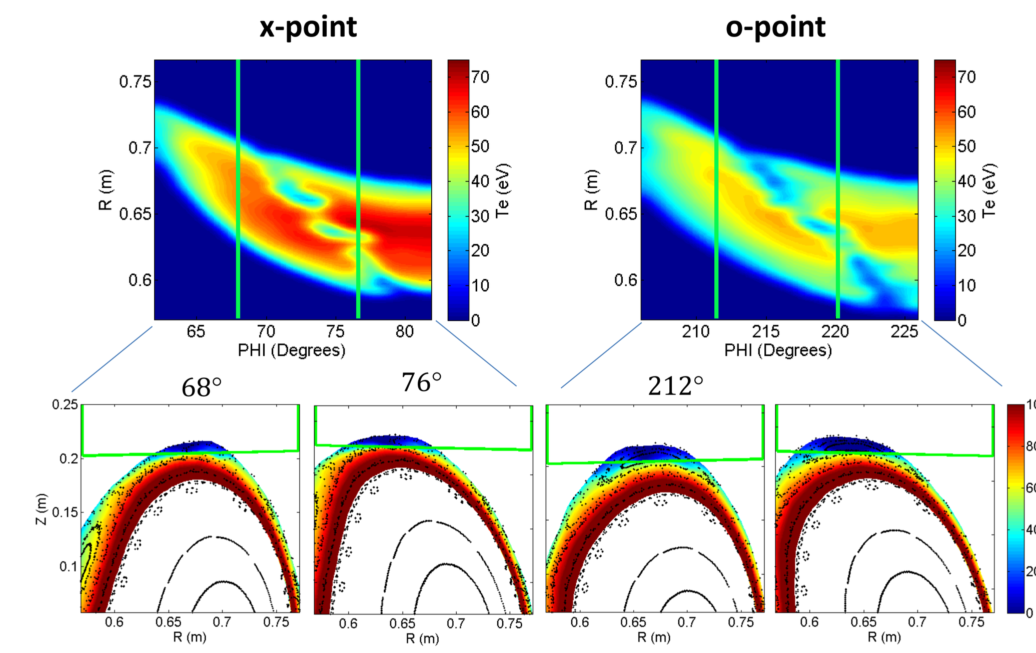
- Surface of section plots superimposed with temperature contours at four toroidal locations on the front face of the inboard plate.

2 Top Plate



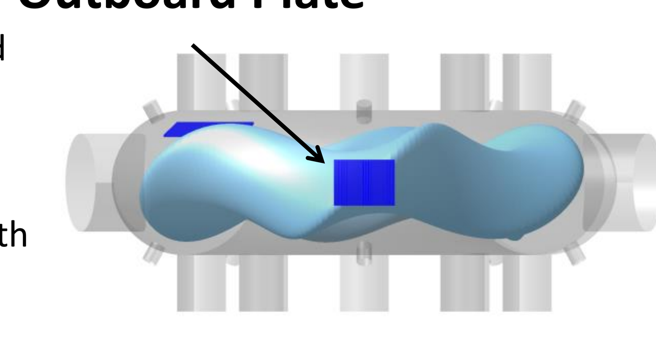
Top-port Plate

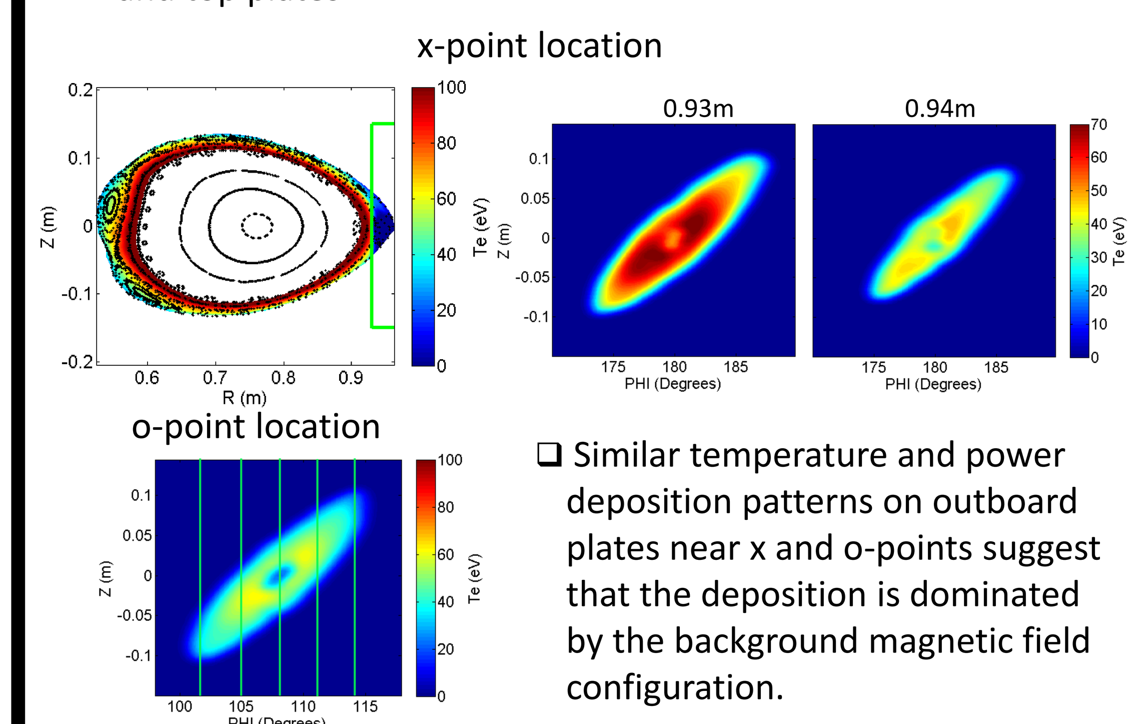
- Plate could be inserted and retracted with a linear motion feedthrough
- Could be imaged with cameras viewing from lower ports
- Small island size



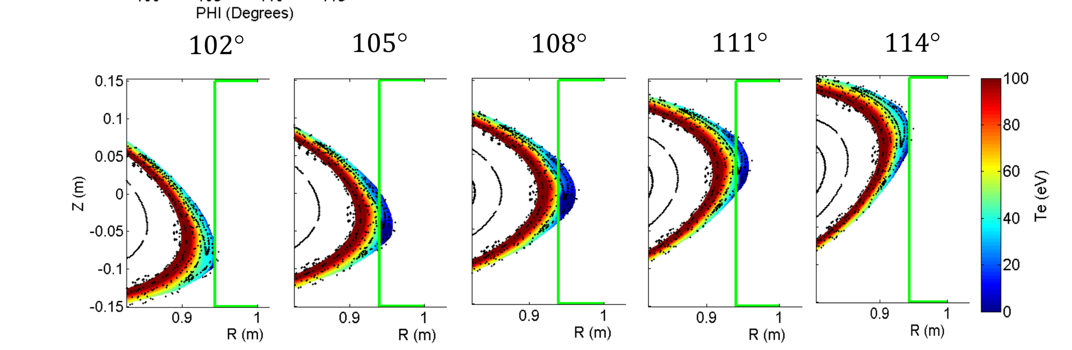
3 Outboard Plate

- Plate could be inserted and retracted with a linear motion feedthrough
- Not easily viewable with cameras
- Largest island width compared to inboard and top plates

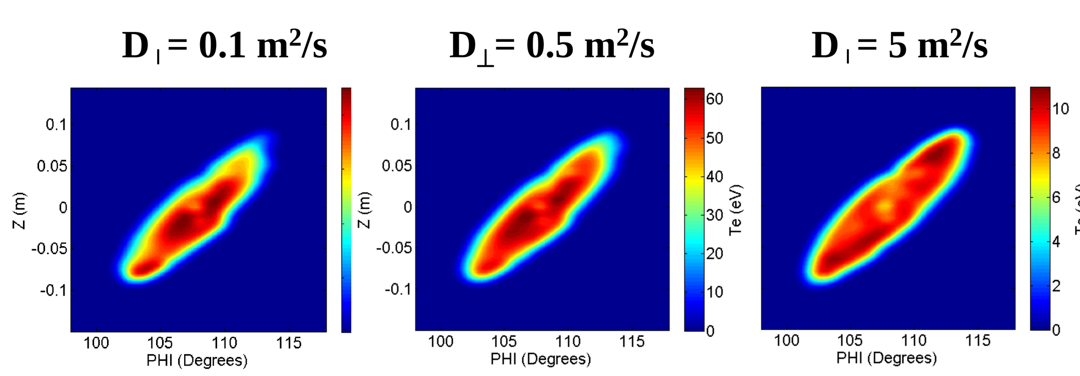




- Similar temperature and power deposition patterns on outboard plates near x and o-points suggest that the deposition is dominated by the background magnetic field configuration.



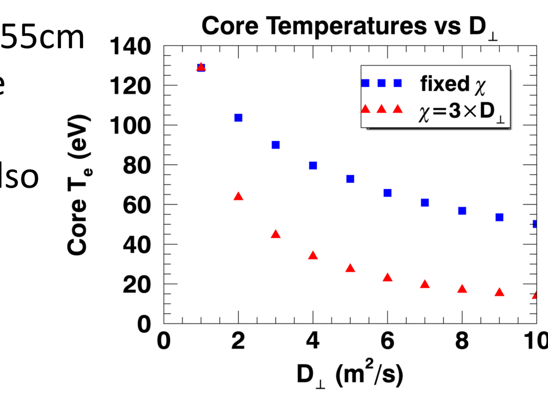
- Surface of section plots superimposed with temperature contours at five toroidal locations on the front face of the outboard plate.

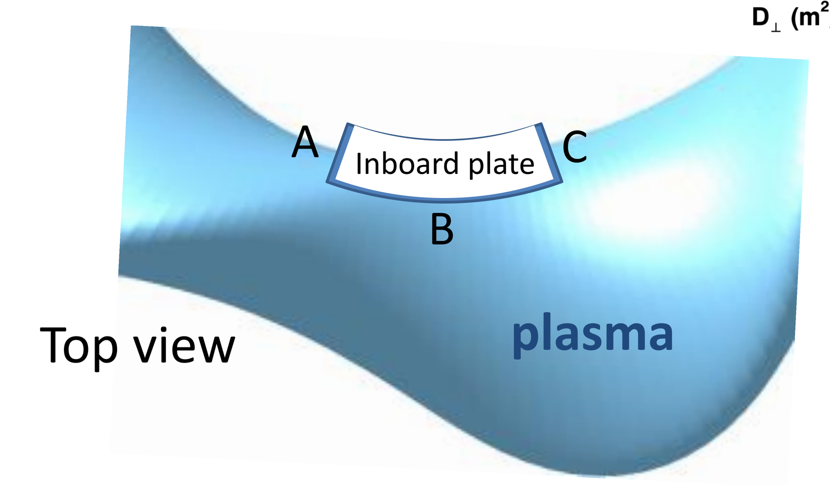


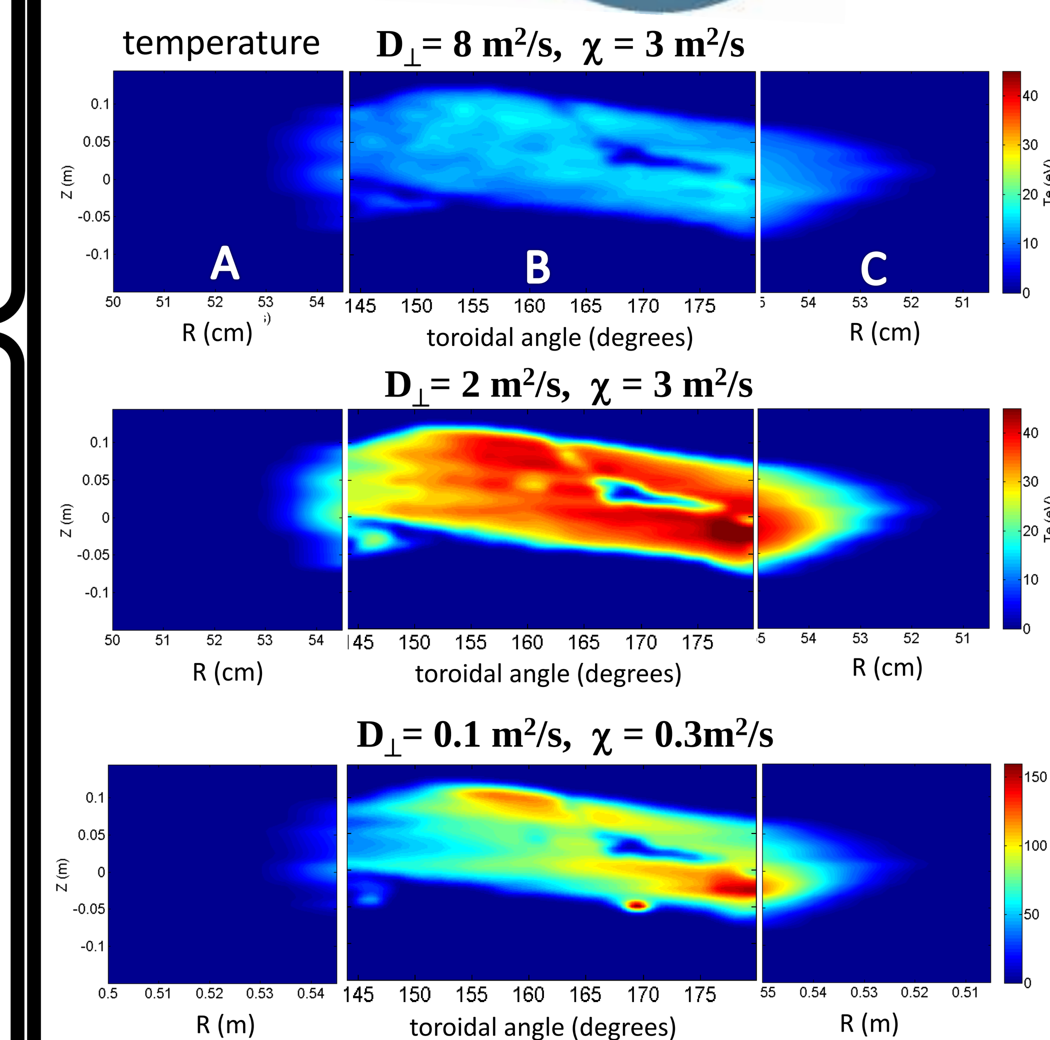
- Diffusivity scan with χ = 3 $D_\perp$ shows slightly broadened and lower temperature distribution as $D_\perp$ is increases. Note the different temperature scales. All plots are at R=0.94m.

Diffusivity ($D_\perp$) Scan Results

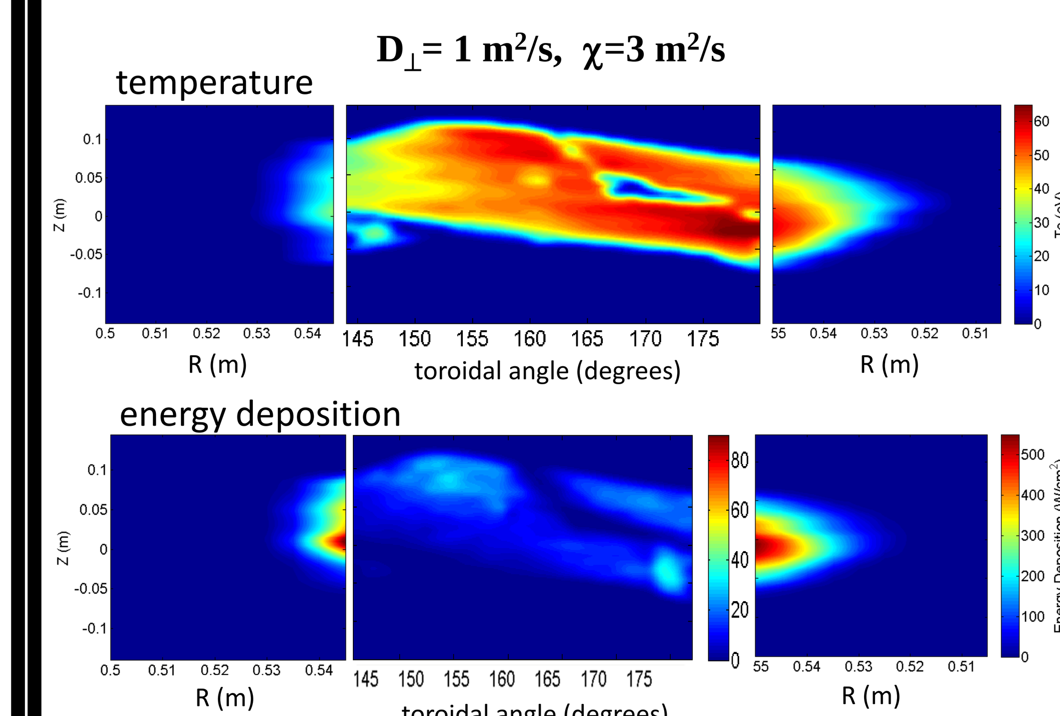
- Inboard plate located at 55cm
- As $D_\perp$ increases, the core temperature decreases
- Sides of inboard plate also receive power flux



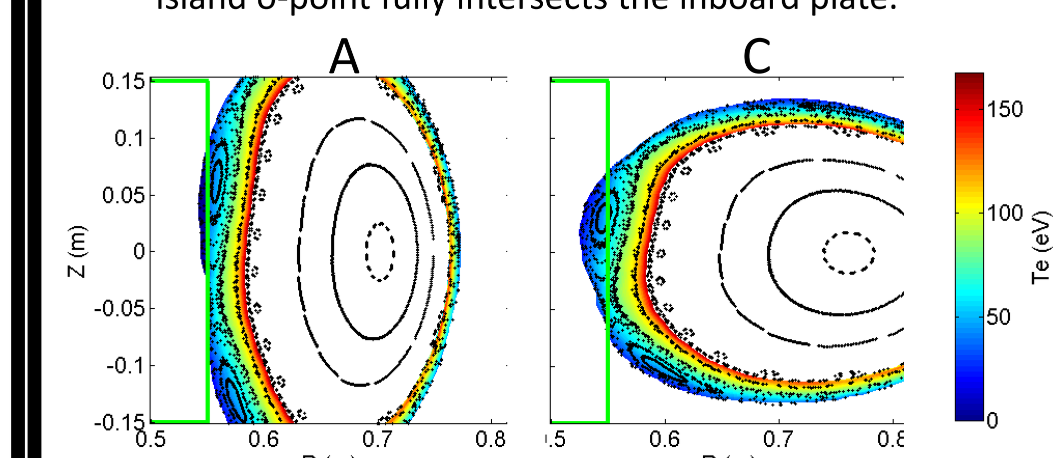




- Overall temperature decreases as $D_\perp$ increases
- Temperature pattern is more localized as $D_\perp$ decreases



- Energy deposition is highest on the 'C' panel where the island o-point fully intersects the inboard plate.



- The inboard plate/magnetic island intersection is not symmetric at the 'A' and 'C' plates.