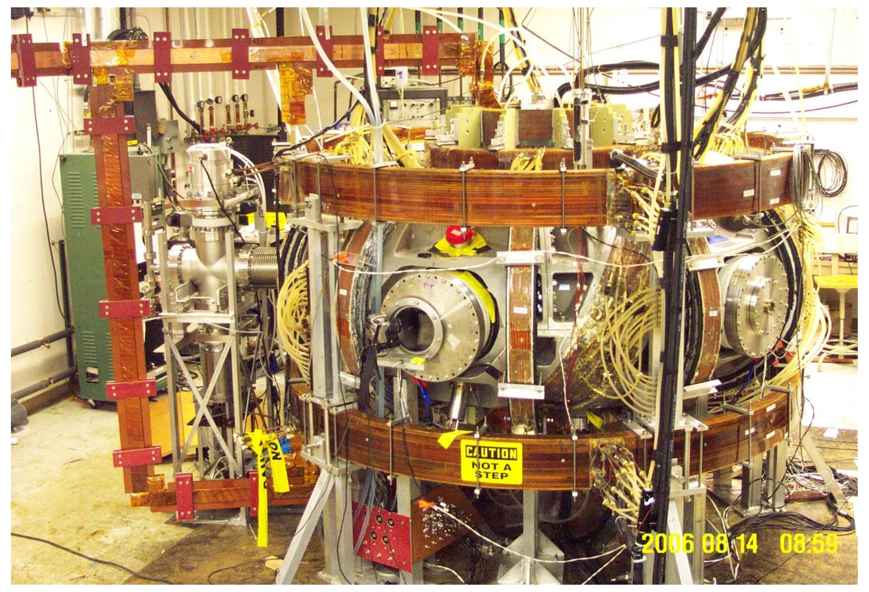


CTH parameters

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%

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.
- Knowledge of the detailed power loading on these structures and its relationship to the long connection length scrape off layer physics is a new Compact Toroidal Hybrid (CTH) research thrust.

Overview

- Modeling results are shown for connection lengths determined by following vacuum field lines from the stagnation plane to the divertor and from those starting and terminating on the plate itself.
- For future experimental work CTH will be operated as a pure stellarator with no plasma current.
- The CTH vacuum rotational transform can be varied from ɫ(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.
- For the studies conducted, magnetic configurations with large 3,1 and 4,1 magnetic islands at the edge are generated.
- Connection lengths are shown for scans of the SVF current, ECC current, and position of the divertor plate locations relative to the island structure.

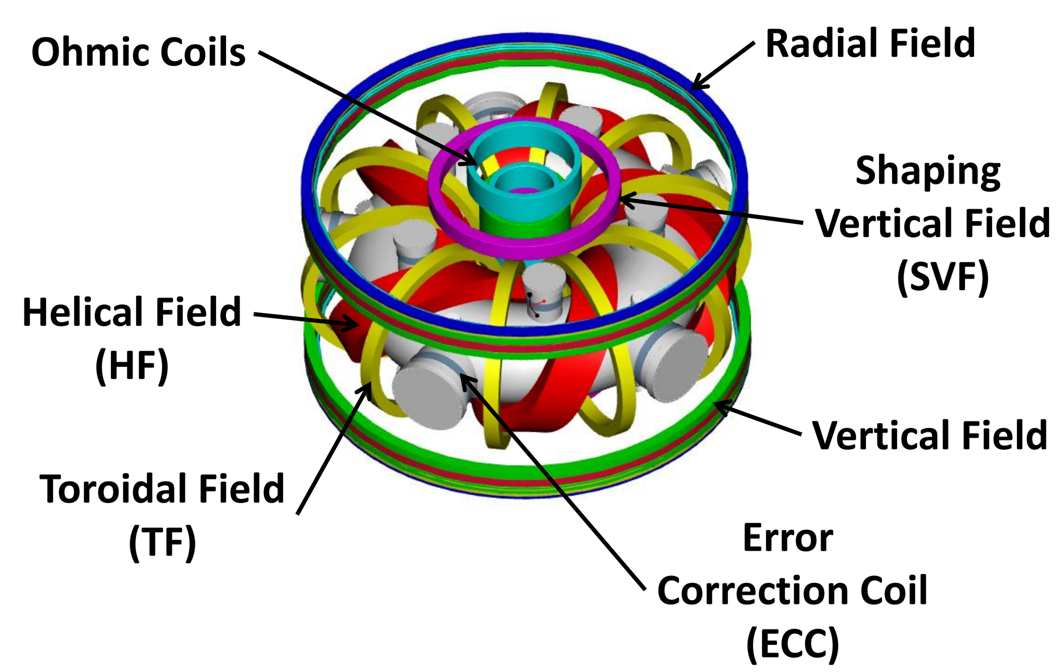
References

[1] Y. Feng, M. Kobayashi, T. Lunt, and D. Reiter, *Plasma Phys. Control. Fusion*, **53** (2011) 024009

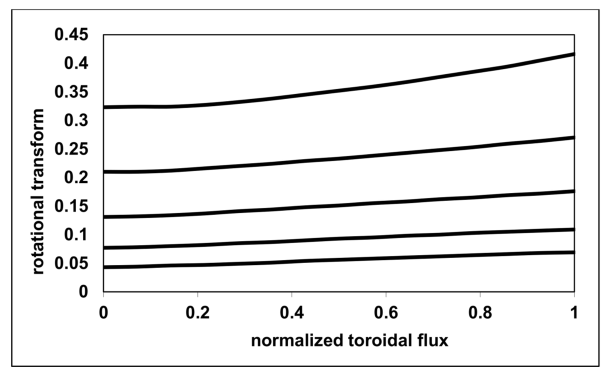
[2] P. Stangeby, *The Plasma Boundary of Magnetic Fusion Devices*, IOP Publishing (2000)

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

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

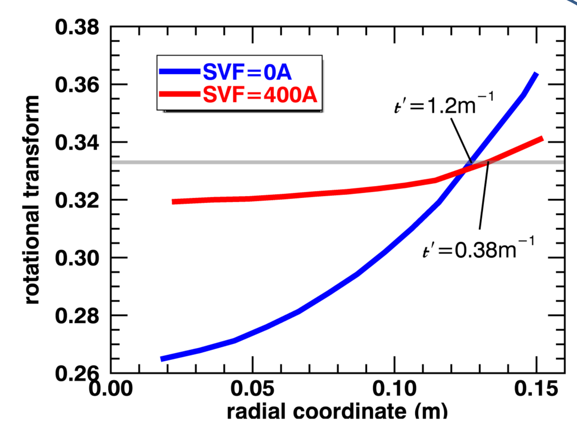


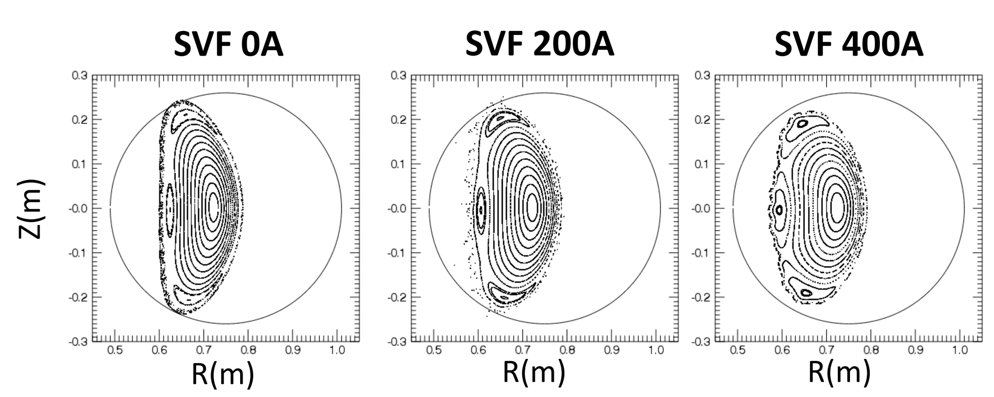
I_{TF}/I_{HF} ratio modifies rotational transform profile

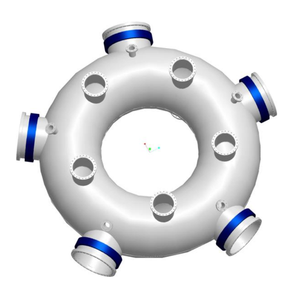


SVF Coil modifies shear/island width

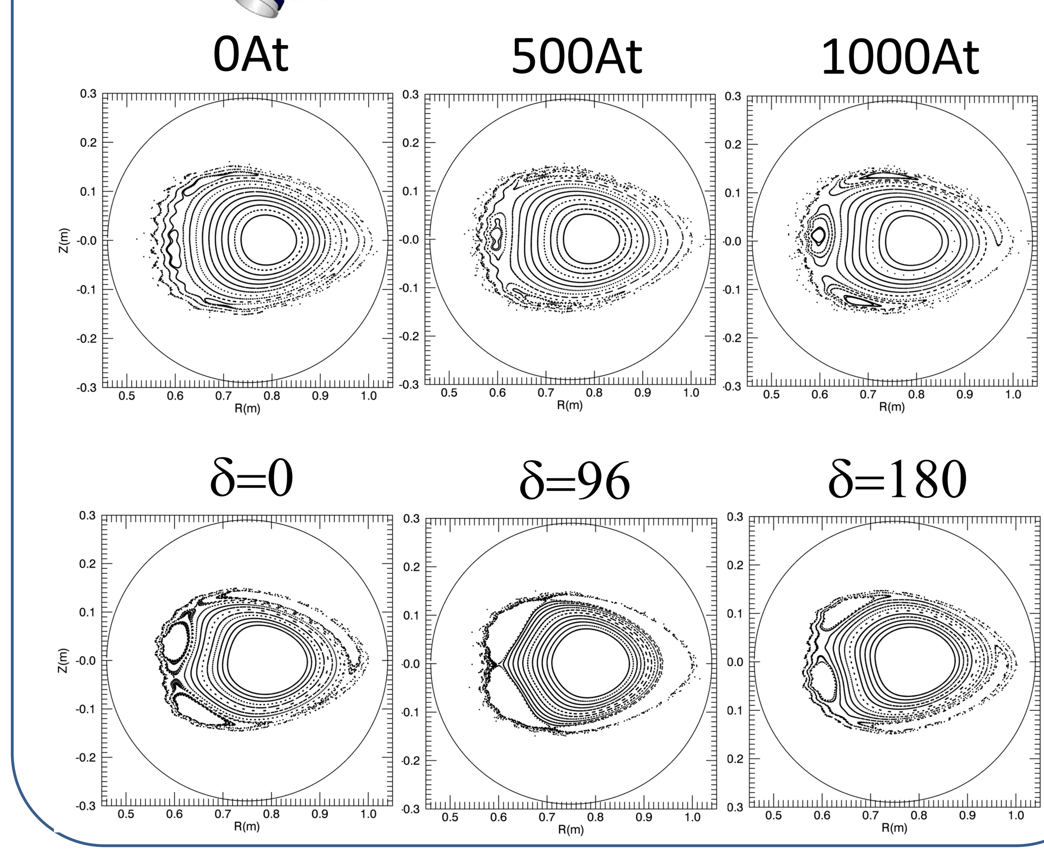
$r_{island} \propto \sqrt{R_o b_{mn}/n ɫ'}$



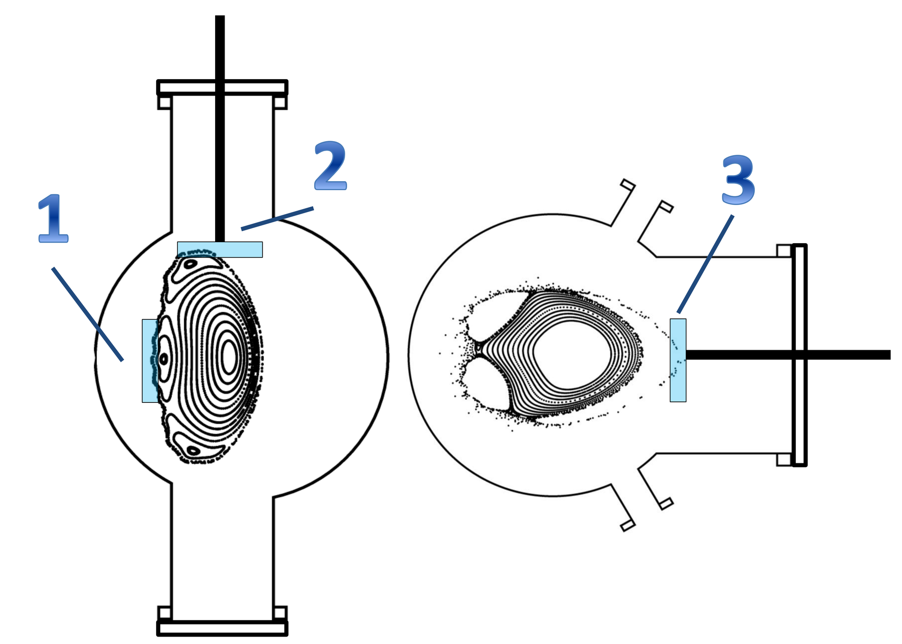




Magnitude and phase of islands can be modified by applying an n=1 perturbation using ECC

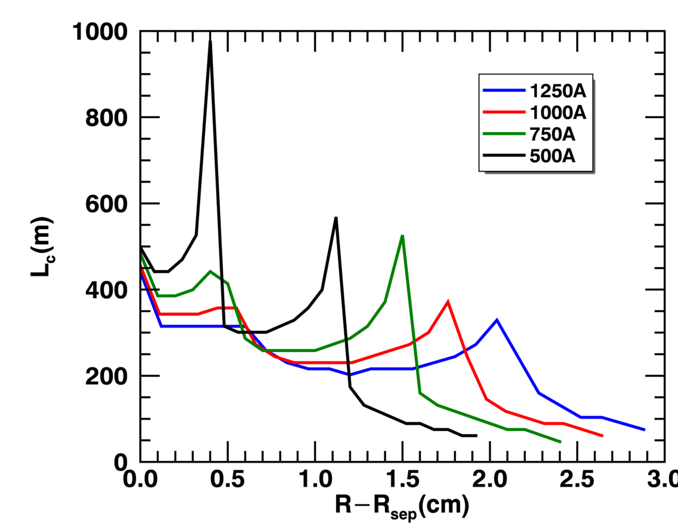


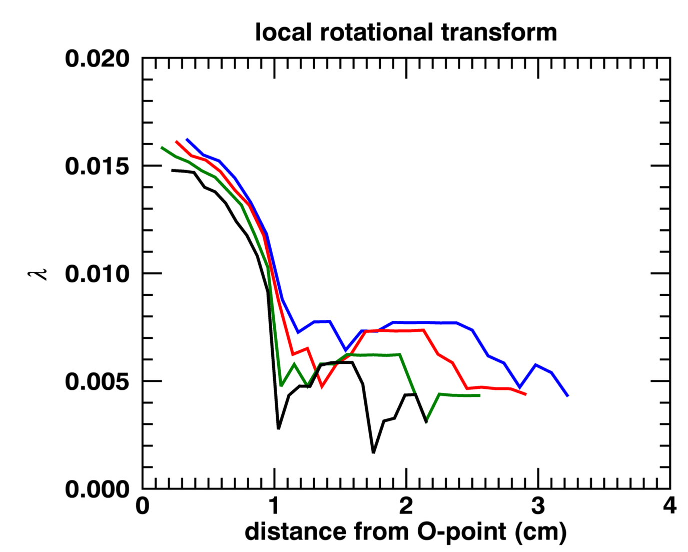
Possible divertor/diagnostic positions



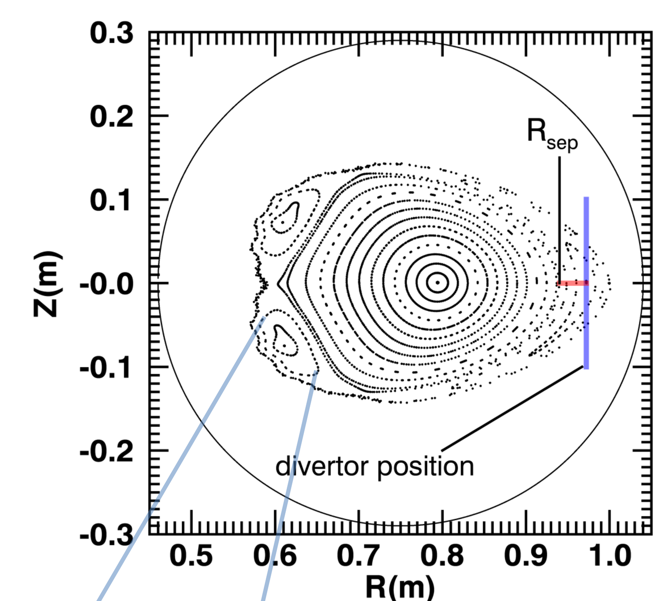
1. Full field period – inner mid-plane
   - fixed position – all position control would be with fields
   - limited camera access
2. Full field period – top port
   - movable
   - camera access from lower port
3. Half field period – side port
   - movable
   - no camera access

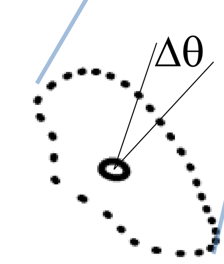
Connection Length is modified by n=1 perturbation





- Connection length measured from stagnation plane (red) to the divertor (blue)

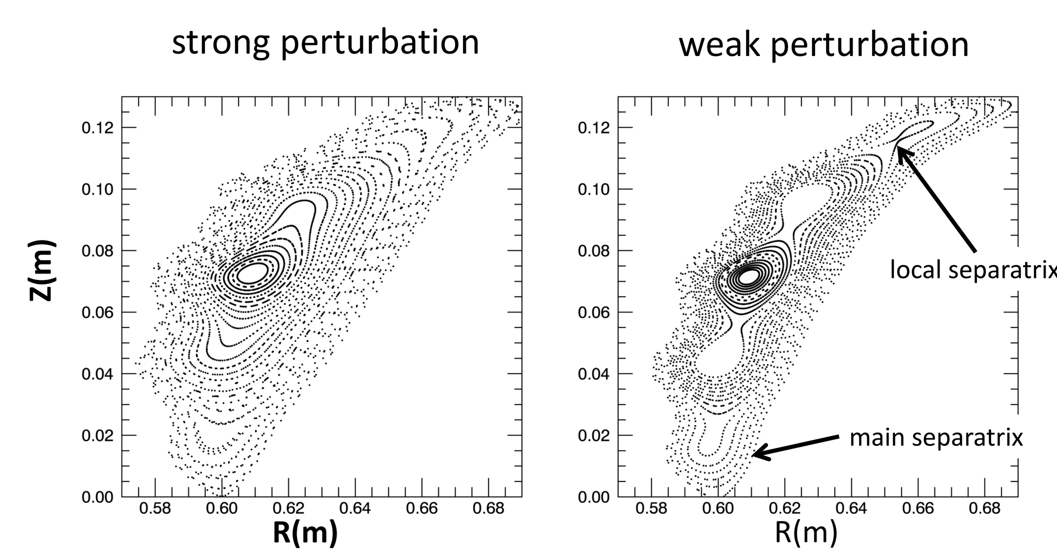




$\lambda = \left\langle \frac{\Delta\theta}{2\pi} \right\rangle$ Local rotational transform

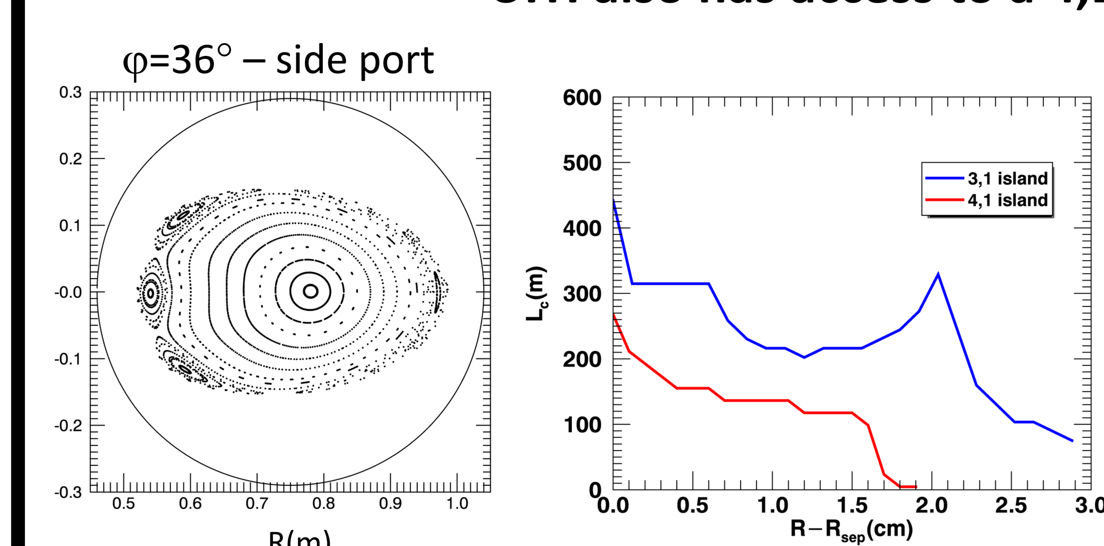
$\Theta = \frac{\lambda a}{R_o}$ Field line pitch

$L_c = \frac{2\pi R_o}{N\lambda}$ Connection Length



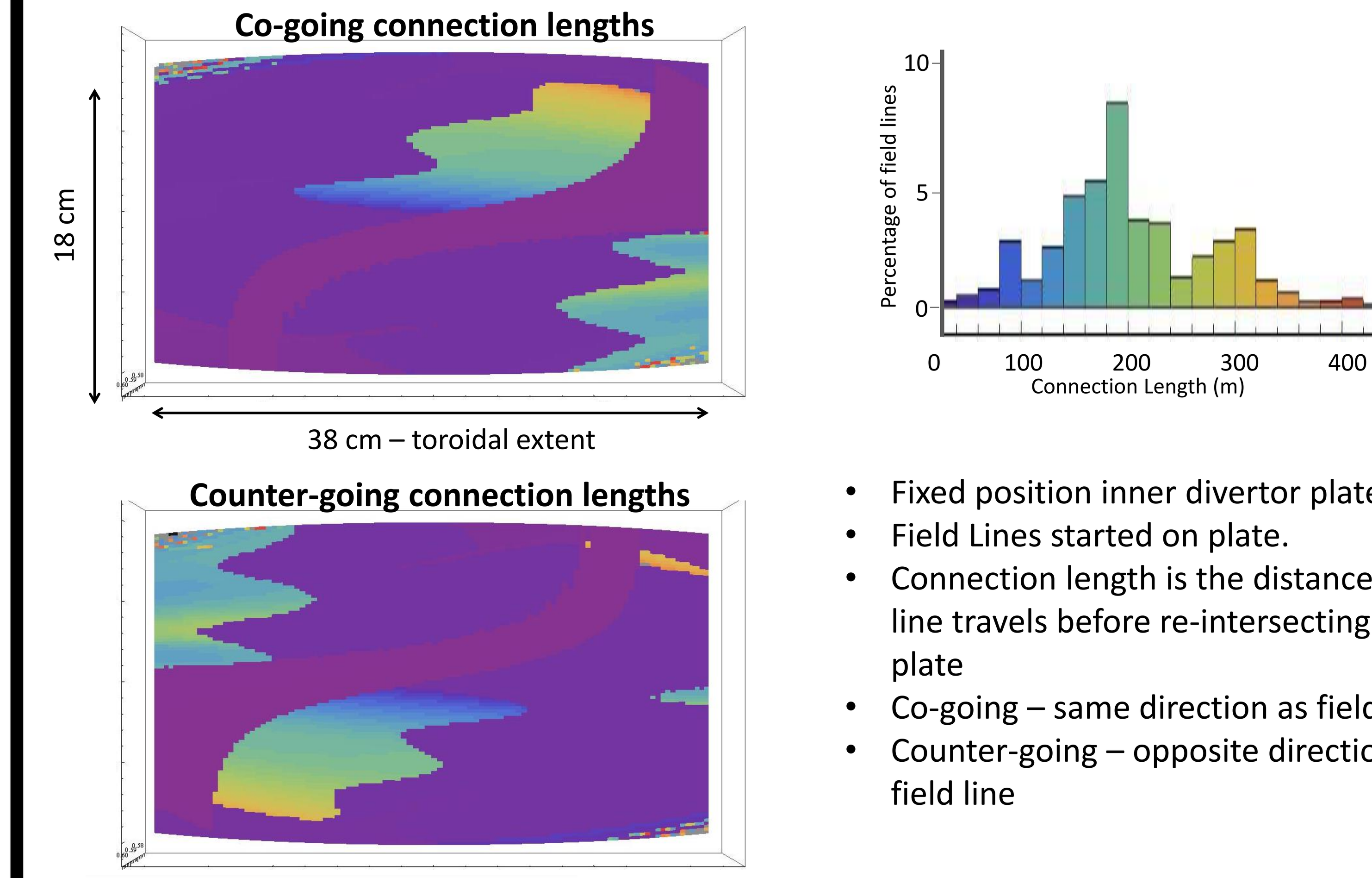
- Influence of local separatrix surfaces causes longer than expected connection lengths.
- Local separatrix is more prominent with weaker field perturbation

CTH also has access to a 4,1 island

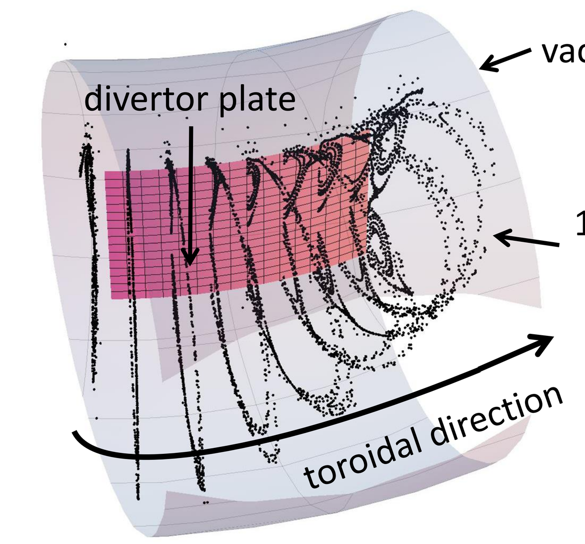


- Connection lengths calculated with maximum SVF and ECC currents for both field settings.
- 1/4 island width is not as large as the 1/3 island
- Lower transform is operationally easier to obtain.
- Have same access and controllability as with the 1/3 island.

Modeling of 2D divertor plates



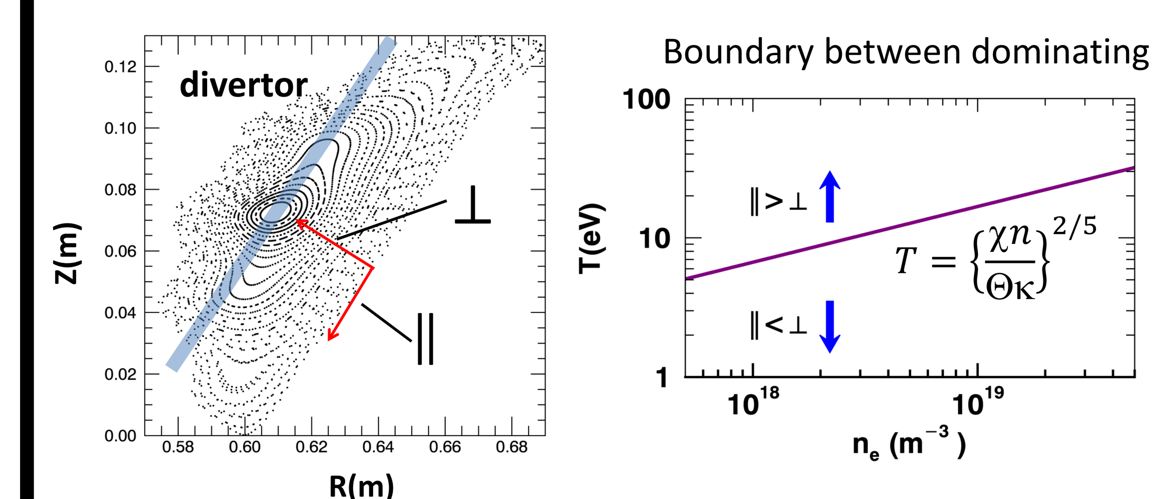
- Fixed position inner divertor plate
- Field Lines started on plate.
- Connection length is the distance field line travels before re-intersecting the plate
- Co-going – same direction as field line.
- Counter-going – opposite direction as field line



3D view of divertor plate and 1/3 magnetic island structure

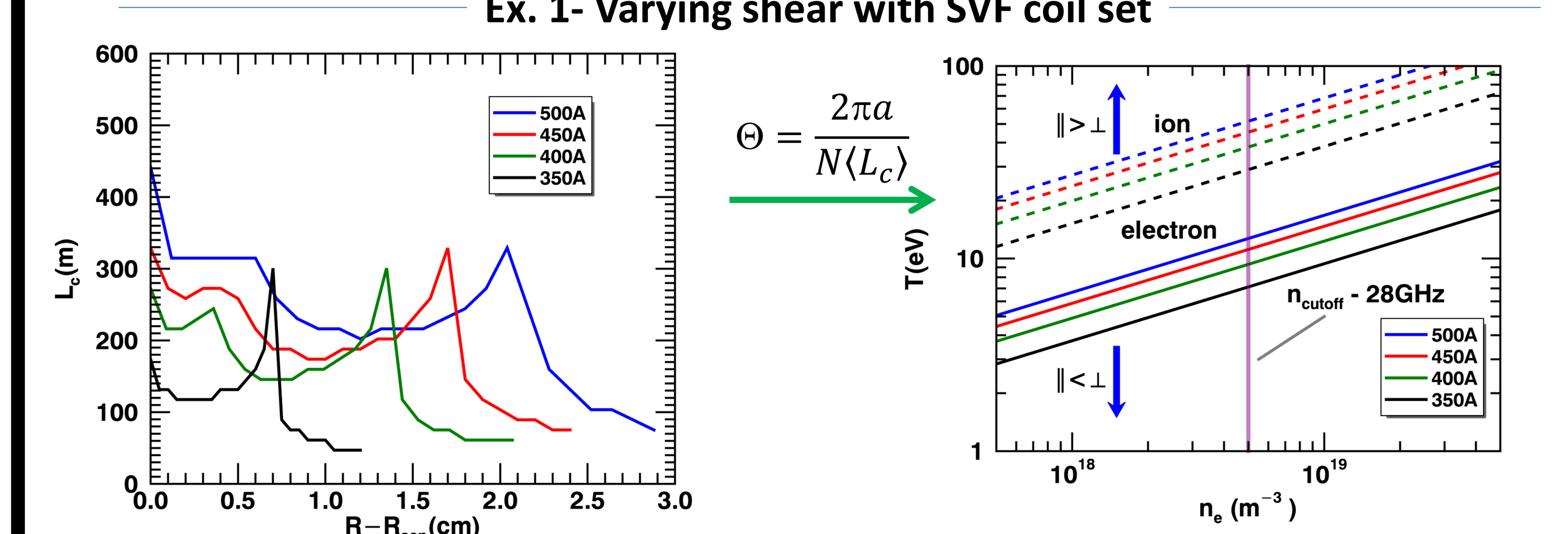
- Island structure rotates clockwise in toroidal direction
- One island o-point is leaving divertor surface in the upper right corner

Modeling indicates that CTH will have experimental access to parameter spaces where parallel or perpendicular transport effects dominate



χ - perpendicular thermal diffusivity ≈ $2m^2s^{-1}$
κ - parallel conductivity coefficient κ_e≈2000, κ_i≈2000 (Stangeby[2])

Ex. 1- Varying shear with SVF coil set



- $\langle L_c \rangle$ 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.

Ex. 2 - Moving divertor position