Progress toward divertor experiments on the Compact Toroidal Hybrid

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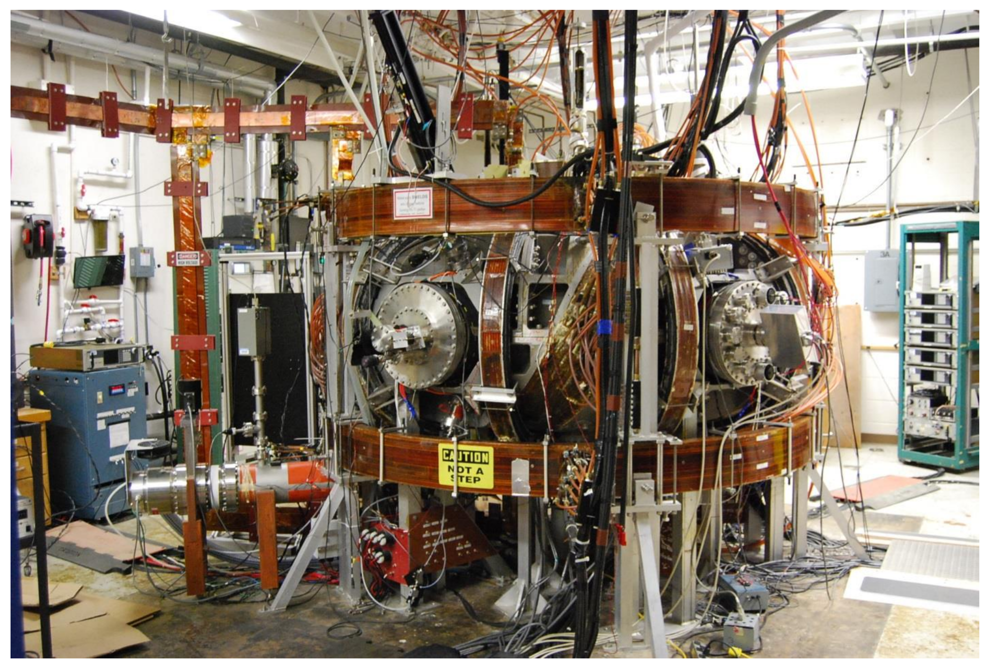

CTH parameters

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}	≤ 15 kW ECRH ~ 200kW OH	I_p	≤ 80 kA
	~ 150 kW 2^{nd} Harmonic x-mode (under construction)		
Vacuum transform 0.02 – 0.35		<β>	≤ 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 calculations using the EMC3-EIRENE code that guide the placement and design of experimental island divertor plates.
- Plasma generation and heating will be accomplished with a 200kW, 28 GHz gyrotron system under construction; operation will be at 2^{nd} harmonic.
- ECRH power absorption for two launch positions is modeled using the TRAVIS code.

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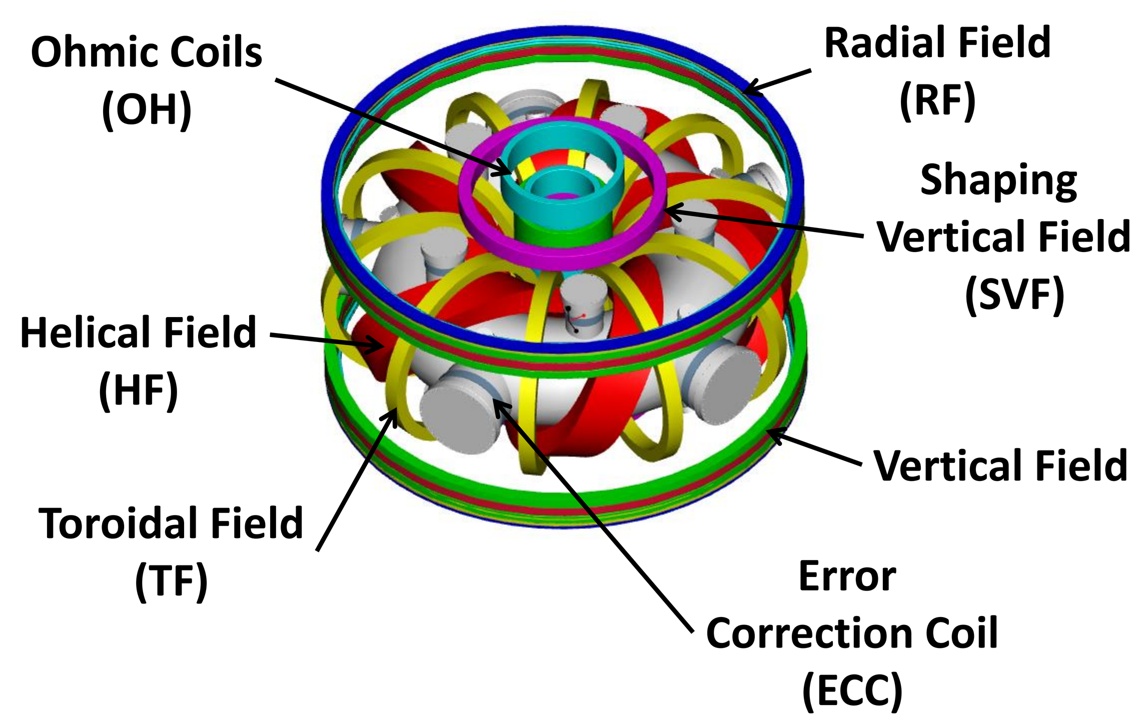
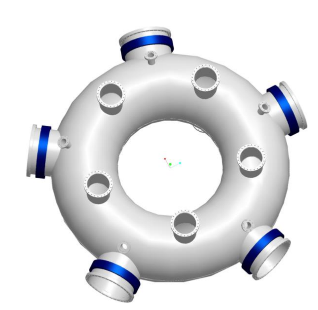
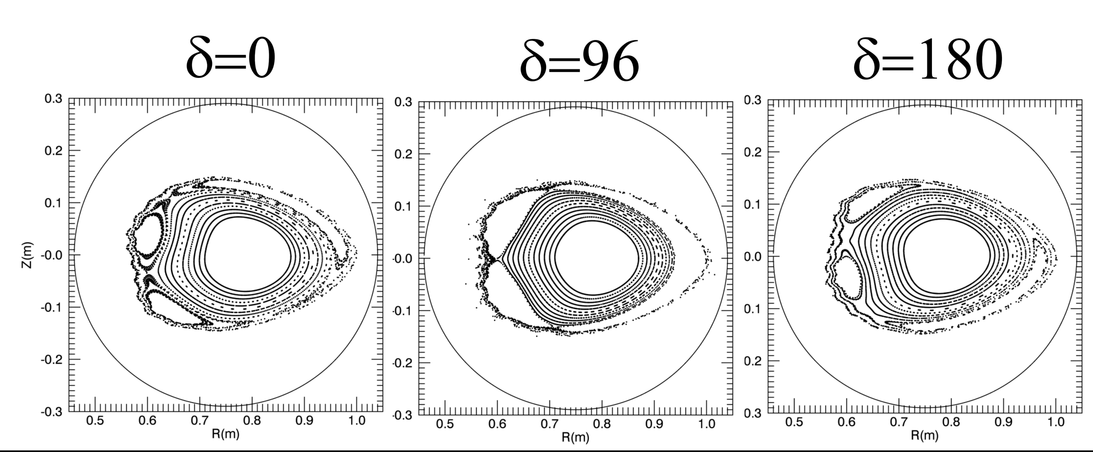
CTH has a flexible coil set that allows for exploration of multiple magnetic field configurations





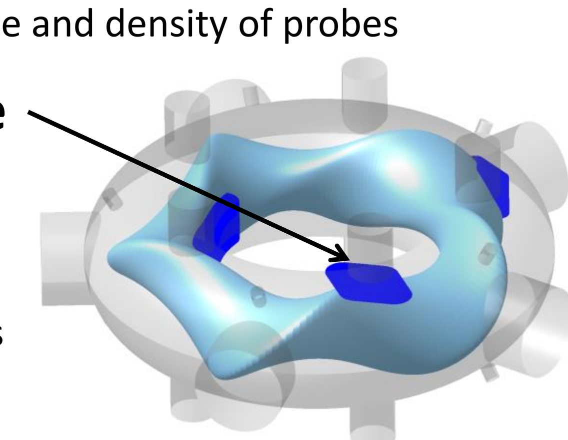
Symmetry breaking islands are generated with error correction coils. Shown below is an example m/n = 1/3 island near the edge.



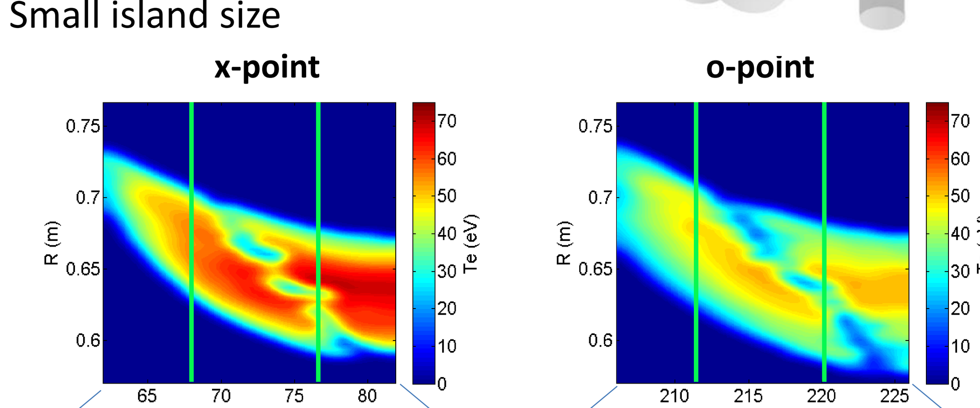
EMC3-EIRENE modeling

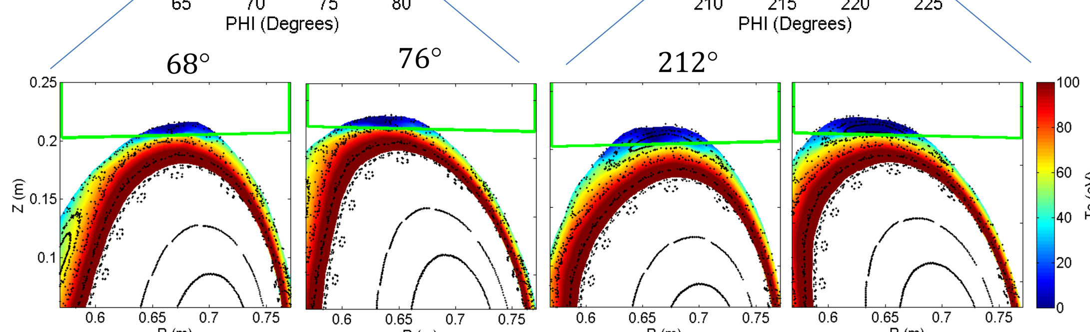
- Used to predict particle and energy fluxes to plates inserted into island regions of the plasma
- Used to determine size of plate and density of probes

Top Plate



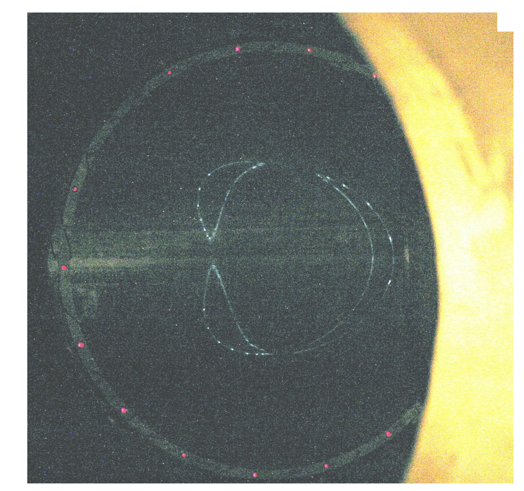
- Plate could be inserted and retracted with a linear motion feedthrough
- Could be imaged with cameras viewing from lower ports
- Small island size

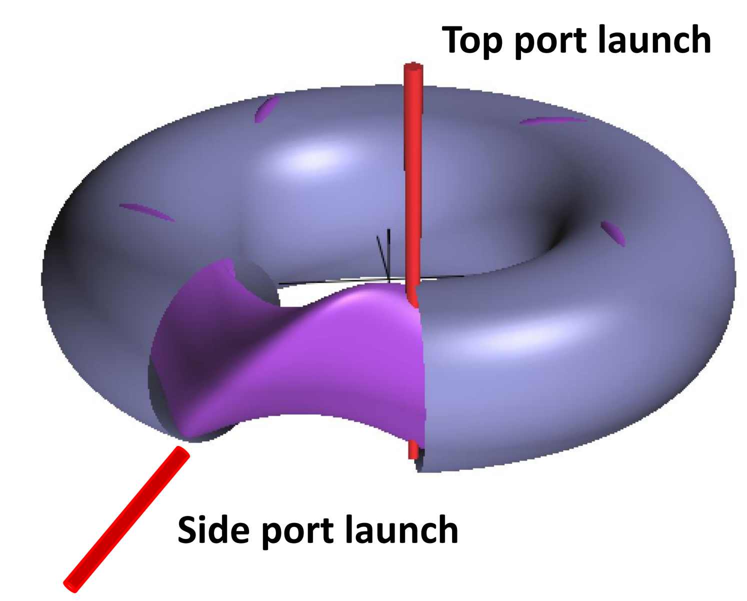




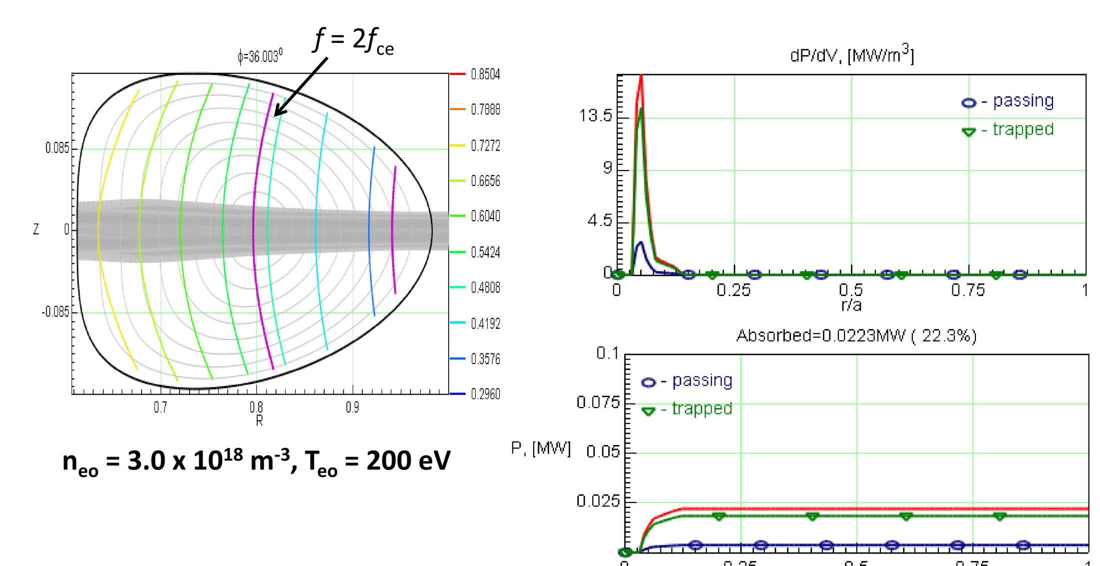
TRAVIS modeling

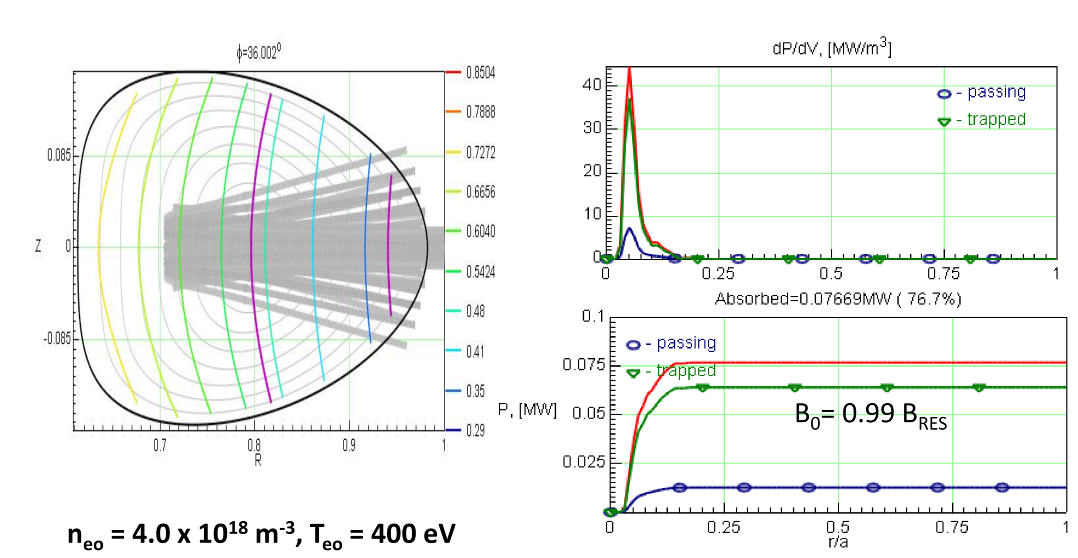
- TRAVIS is an electron cyclotron wave ray tracing codes for non-axisymmetric toroidal equilibria
- 3D stellarator equilibrium modeled with VMEC
- Necessary because 3D geometry of stellarator equilibrium has strong impact on ray trajectories and absorption; magnetic field geometries vary with toroidal angle

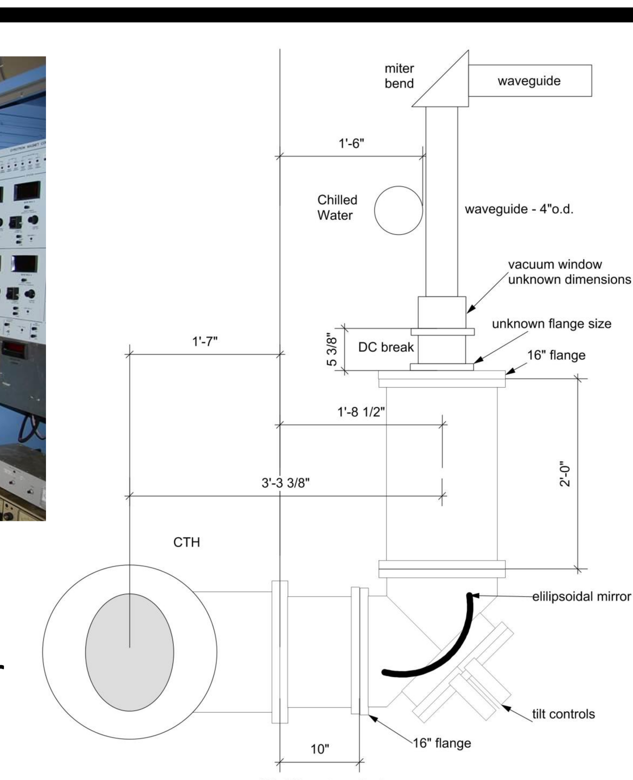




I. Launch through side-port into radial B-gradient



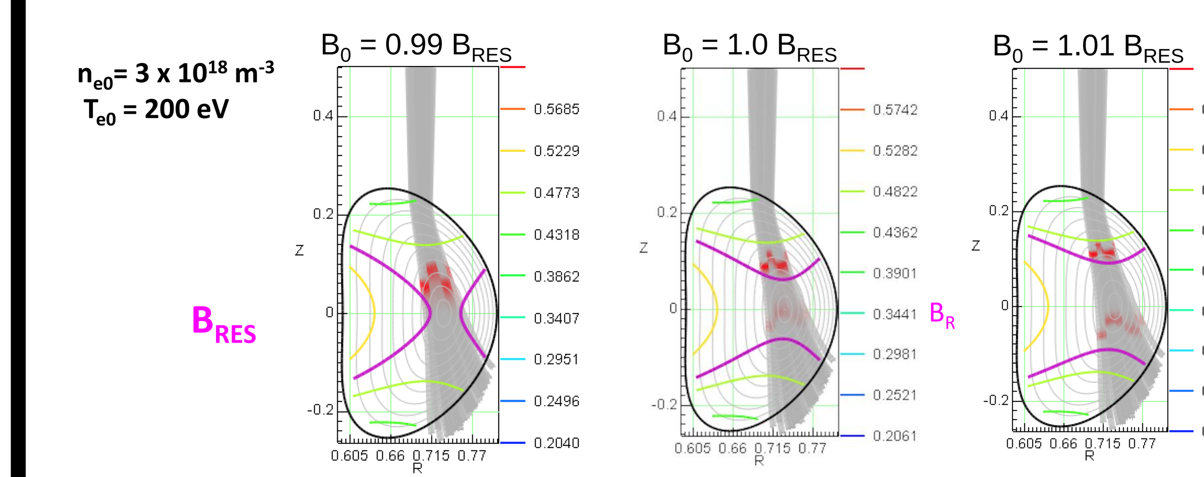




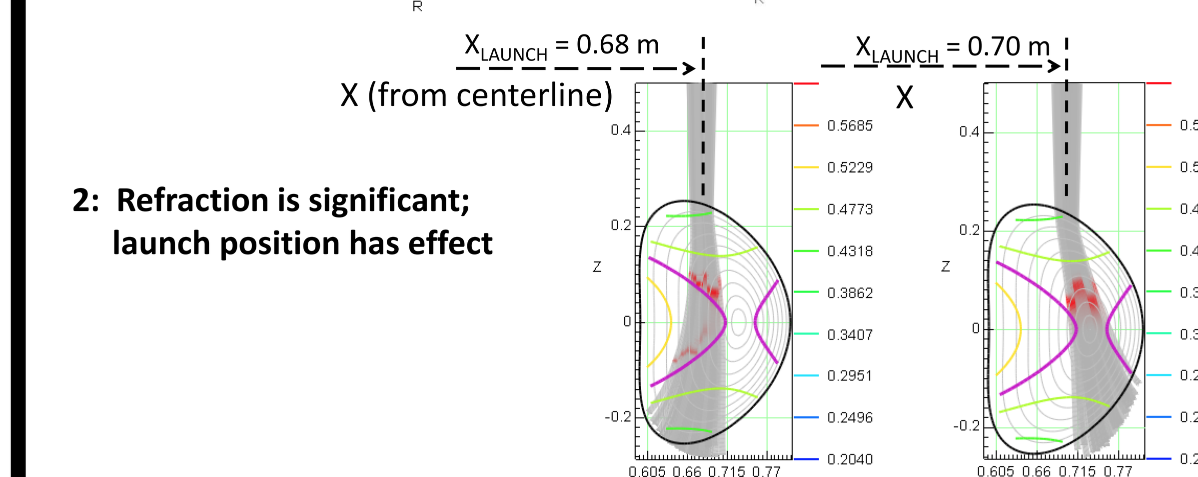
200kW, 28GHz Gyrotron (above) and designed beam hardware for side-launch configuration (right).

II. Launch through vertical port into saddle structure

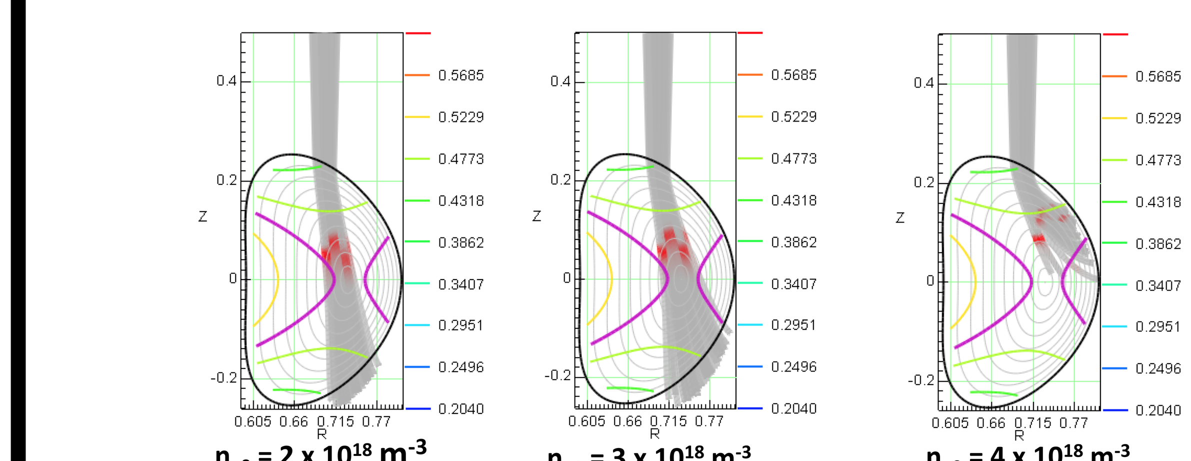
1. Breadth of resonance makes its location sensitive to magnetic field strength



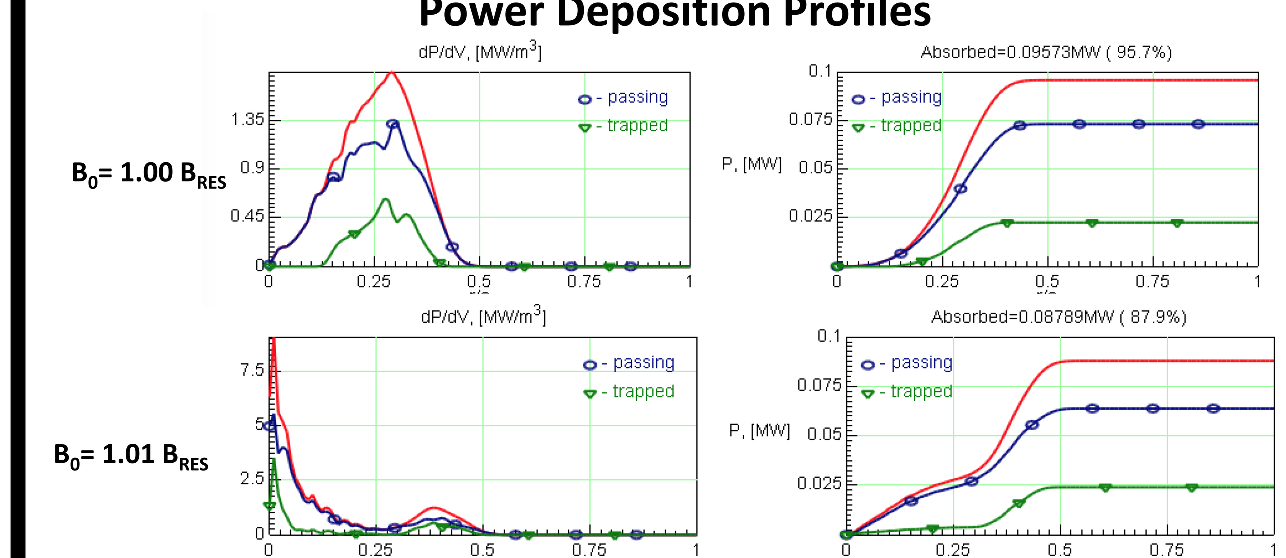
2: Refraction is significant; launch position has effect



3: Top-launched beams will undergo greater refraction due to the non-normal incident angle, and may limit effective heating to density n_{eo}≤ 0.3 x10^{19} m^{-3}.

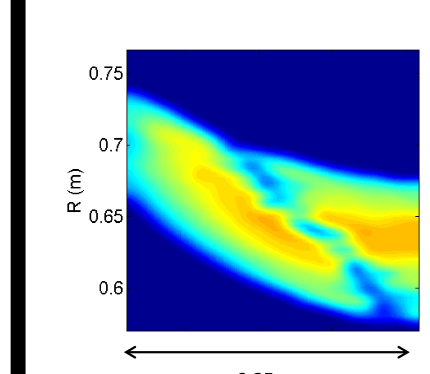


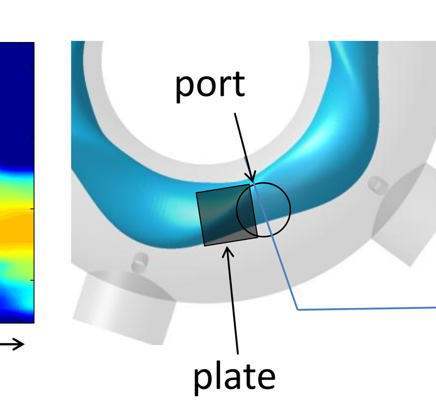
Power Deposition Profiles

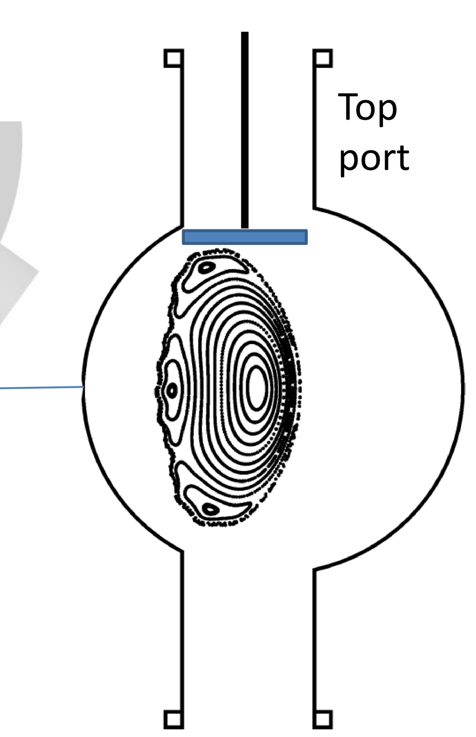


- Predicted deposition within inner half
- Most power absorbed on passing particles

Plate Design







- Square plate, 20cm x 20cm
- Covers area of high particle flux
- Located in region where flux surfaces have peak vertical extent
- Fitted with an array of langmuir type probes