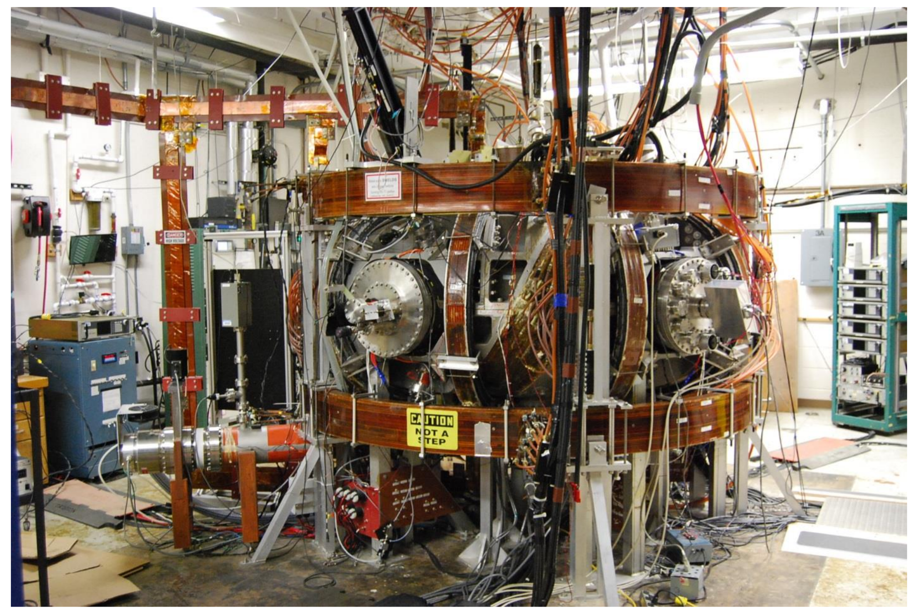
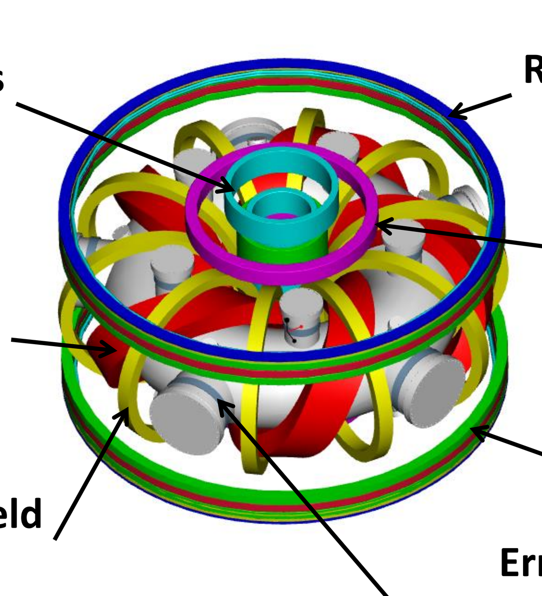


CTH parameters

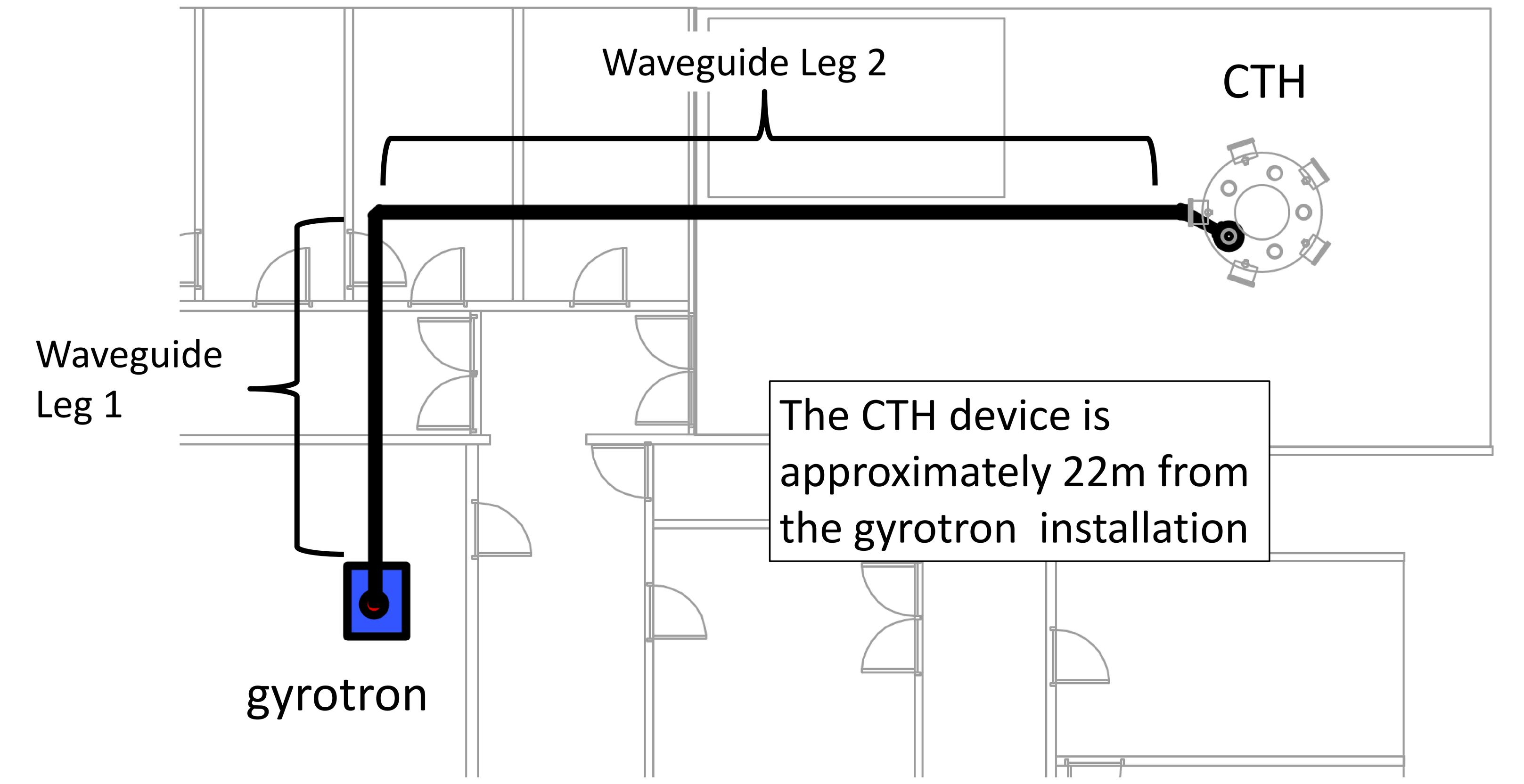
5 field periods		discharge duration ~0.1s	
R_o	= 0.75 m	n_e	$\leq 5 \times 10^{19}$ m^{-3}
a_{vessel}	= 0.29 m	T_e	≤ 200 eV
a_{plasma}	≤ 0.2m		
B_o	≤ 0.7 T		
P_{input}	≤ 15 kW ECRH ~ 200kW OH	I_p	≤ 80 kA
	~ 150 kW 2nd Harmonic x-mode (under construction)		
Vacuum transform 0.02 – 0.35		$\langle\beta\rangle$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

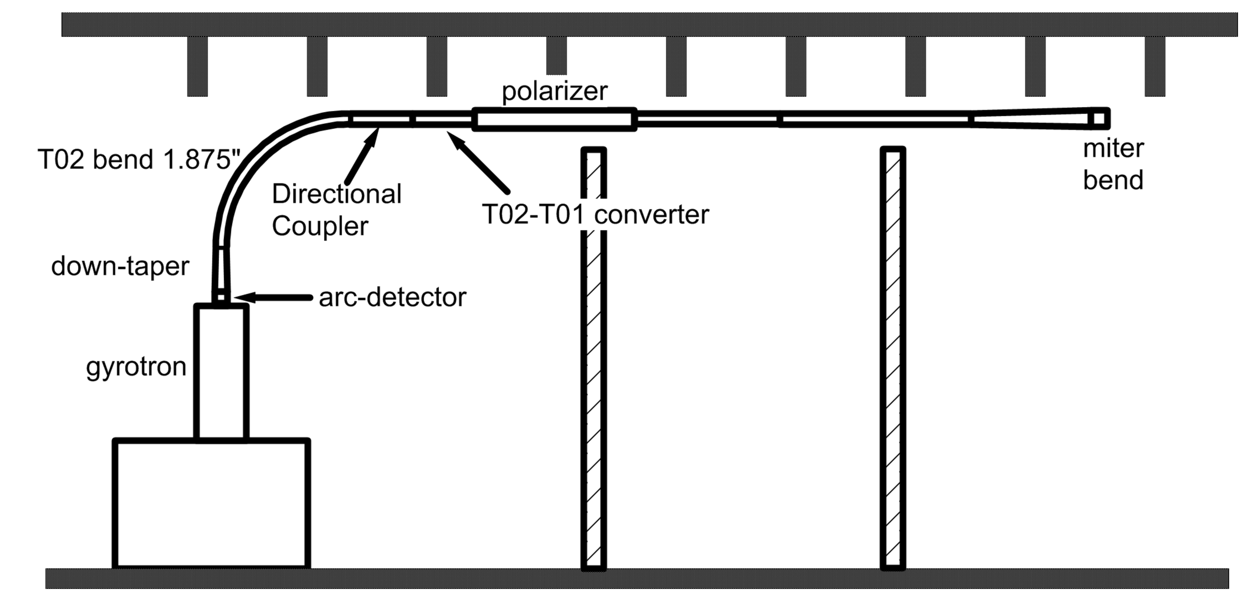
CTH has a flexible coil set that allows for exploration of multiple magnetic field configurations



VGA-8050M pulsed gyrotron oscillator 200kW - 28GHz 75ms pulse width

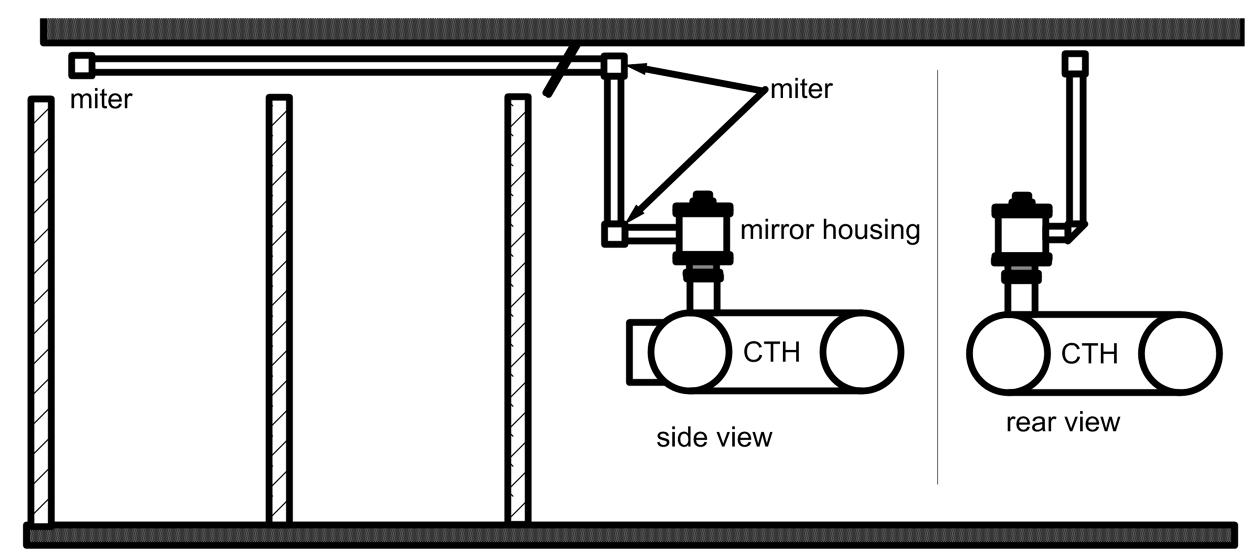
Waveguide path and components





Waveguide Leg 1

- Measure forward and reflected power with directional coupler
- Convert T02 mode to T01
- Polarize beam
- Transition to corrugated waveguide



Waveguide Leg 2

- Main transmission leg - 15m
- waveguide is corrugated for low loss transmission of the linearly polarized HE11 mode with a Gaussian-like antenna pattern
- Miter bends used to route power to final mirror

Overview

- The CTH laboratory is installing a 200 kW, 28 GHz gyrotron for plasma heating at 2nd harmonic.
- Target plasma generation is done with 10kW, 17.65 GHz and 18 GHz klystrons operating at the fundamental.
- ECRH power absorption for two launch positions is modeled using the TRAVIS[1] code.
- The waveguide path from the gyrotron to the CTH device is shown as well as a conceptual design for the final beam launcher.

Motivation

- CTH is installing a gyrotron system to generate plasmas more relevant for studying divertor physics.
- 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.

References and acknowledgements

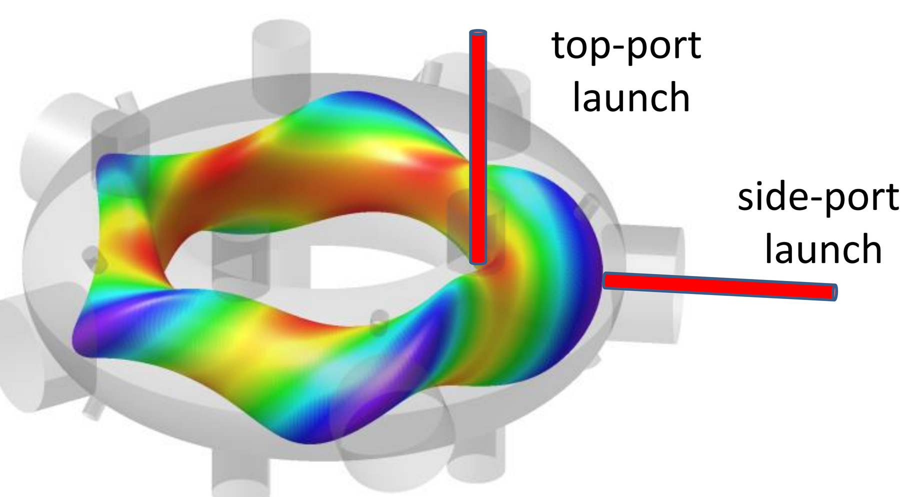
[1] Marushchenko et al., *Comput. Phys. Commun.* **185**, 165 (2014)

Supported by US DOE Grant DE-FG02-00ER54610

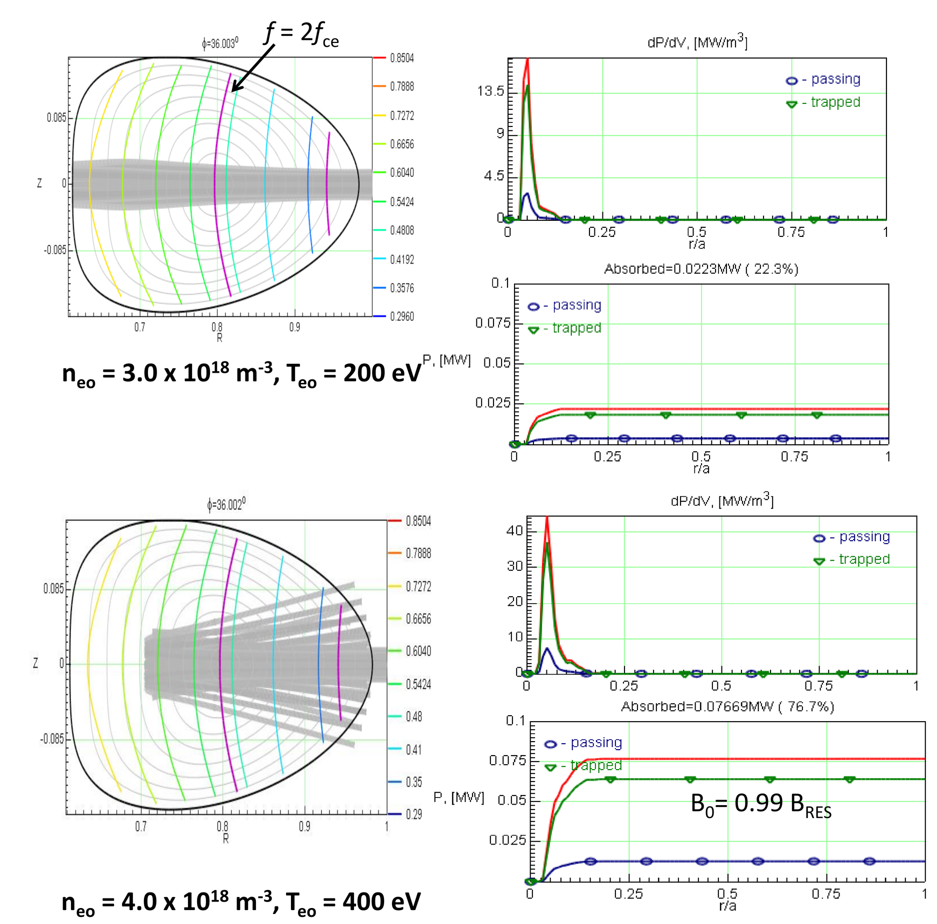
The CTH laboratory is grateful to Max Planck IPP-Greifswald for permission to use the TRAVIS code, to ORNL for the loan of the 28 GHz gyrotron, and to the HSX laboratory of the University of Wisconsin for the loan of RF transmission line components.

TRAVIS modeling used to determine launch position

- 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
- X-mode, 2nd harmonic assumed for all modeling

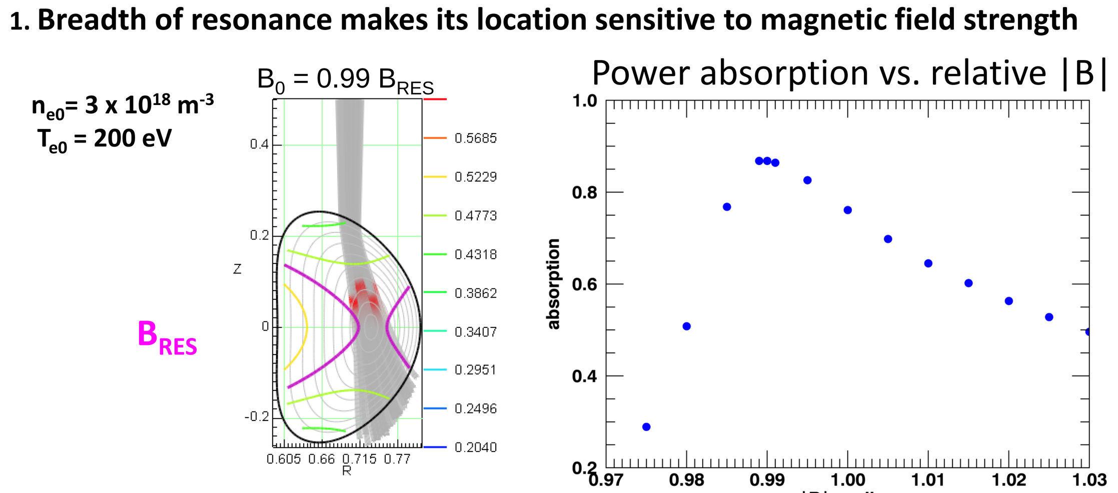


I. Launch through side-port into radial B-gradient

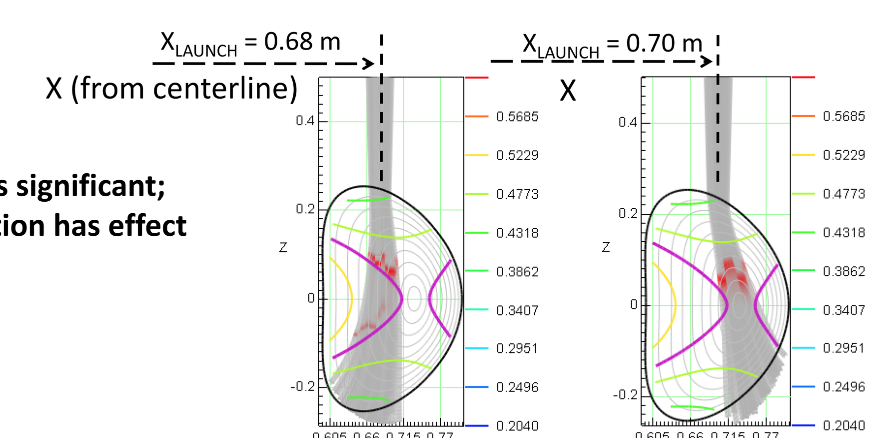


II. Launch through vertical port into saddle structure

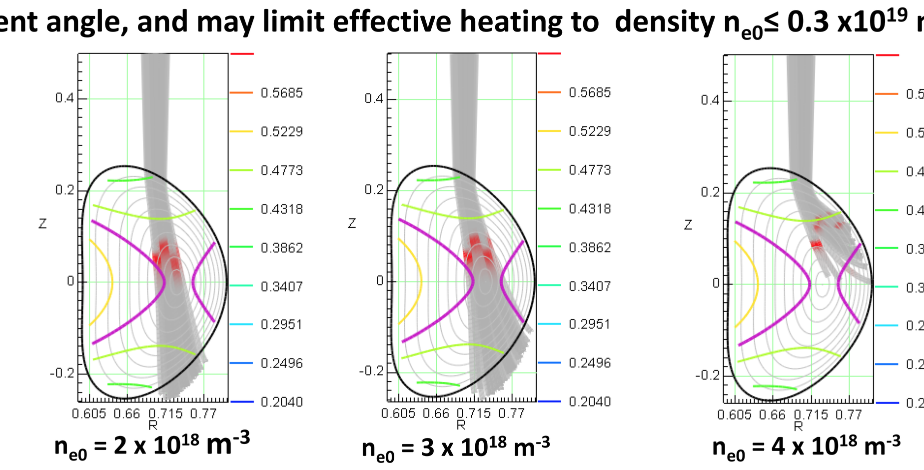
1. Breadth of resonance makes its location sensitive to magnetic field strength



2: Refraction is significant; launch position has effect

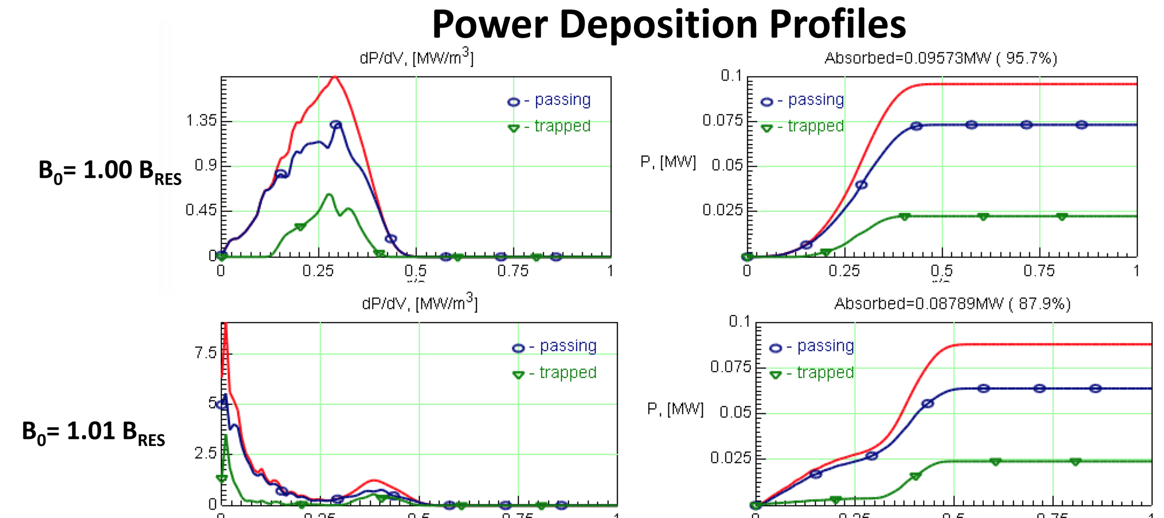


3: Top-launched beams will undergo greater refraction due to the non-normal incident angle, and may limit effective heating to density $n_{e0} \leq 0.3 \times 10^{19}$ m^{-3}.

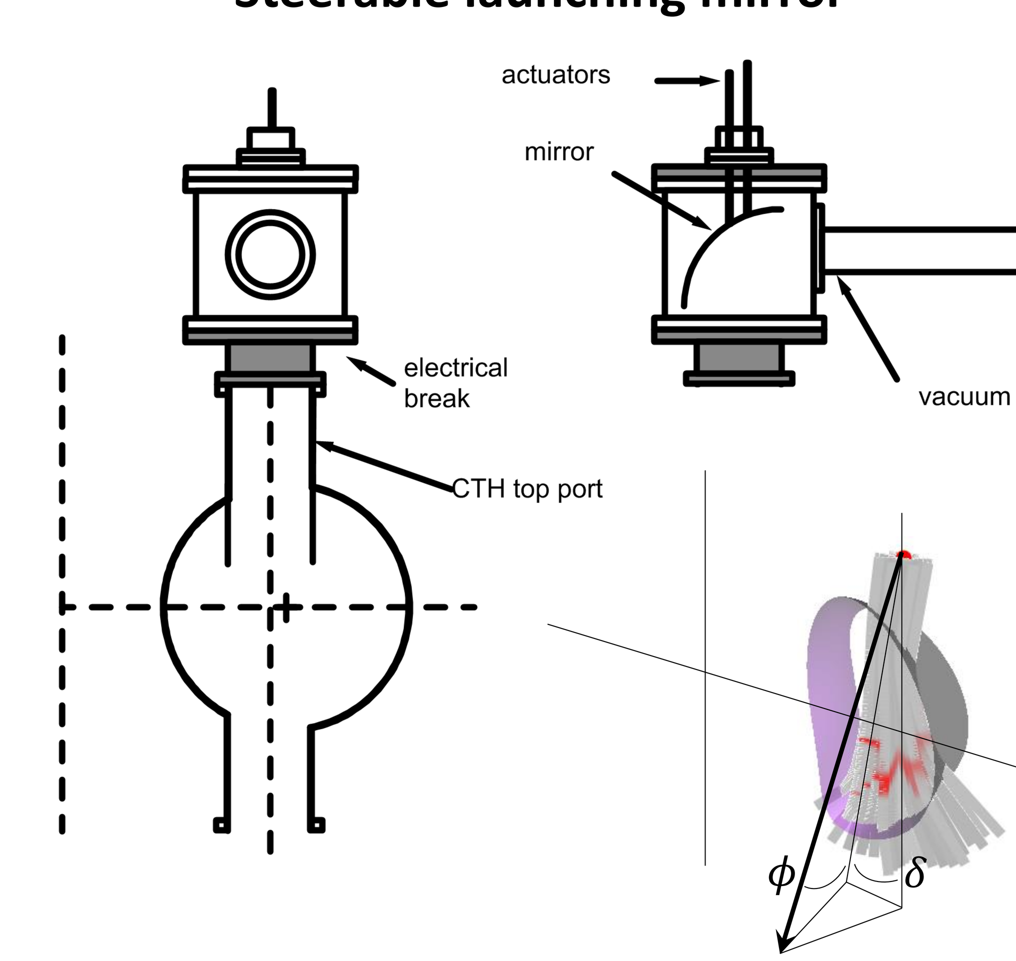


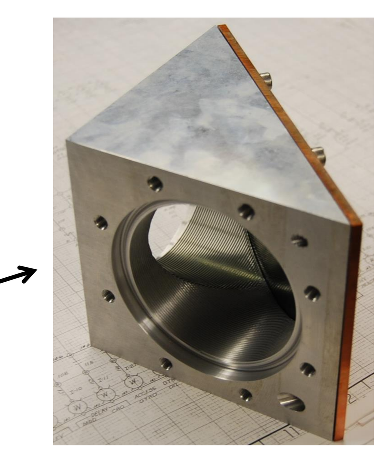
- Predicted deposition within inner half
- Most power absorbed on passing particles

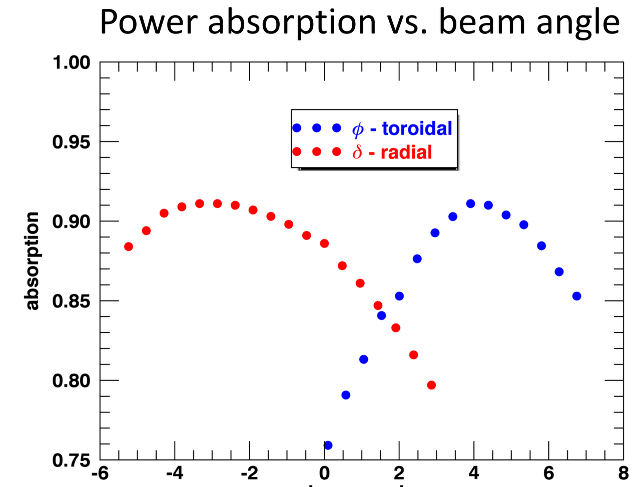
Power Deposition Profiles



Steerable launching mirror







- Beam steering will be necessary to achieve optimal power absorption