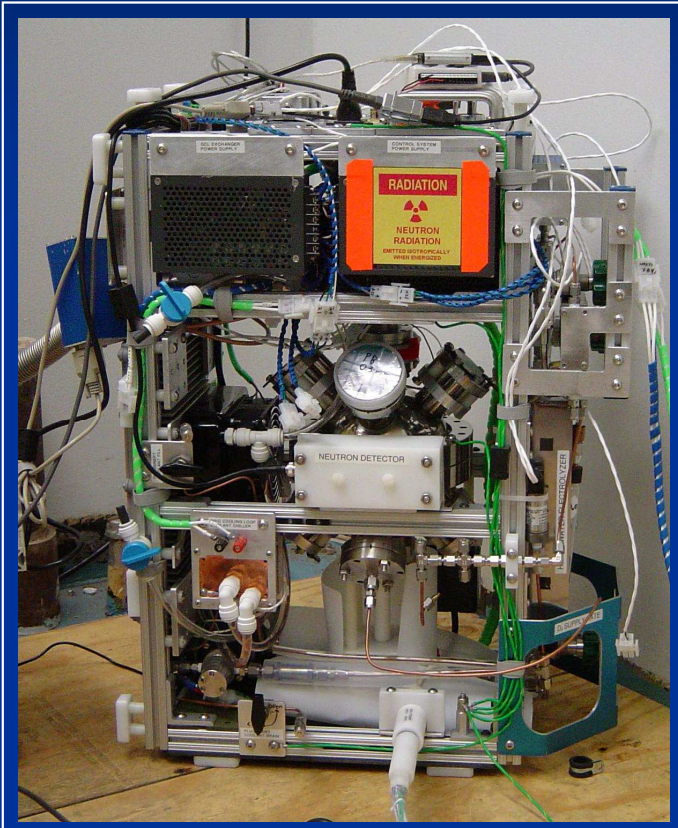
Inertial Electrostatic Confinement Fusion Liquid Cooled Ion Accelerating Grid

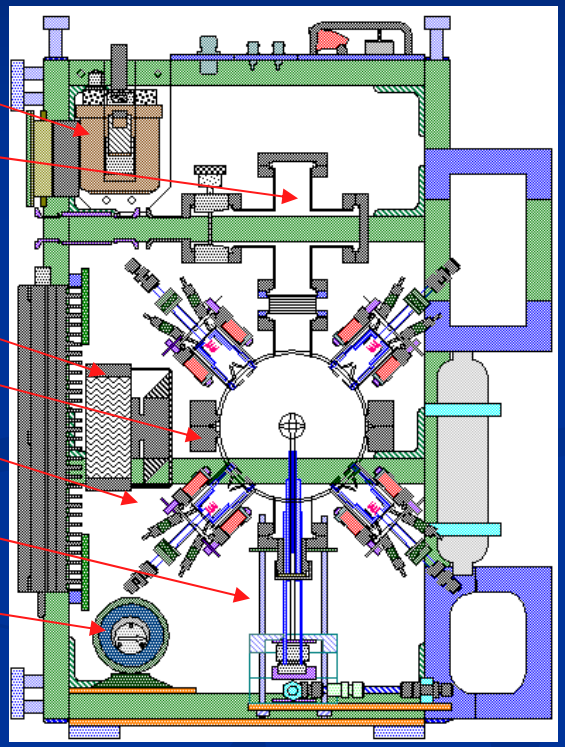
Andrew Seltzman. Georgia Institute of Technology, Dept. of Physics

IEC Fusion Reactor Design



Mark 3 IEC Reactor Core

Neutron Detector
Vacuum Hub
ECRF Drive Amplifier
Primary Cooling Radiator
Vacuum Envelope
ECRF Injector
Accelerating Grid System
Fluorinert Micropump

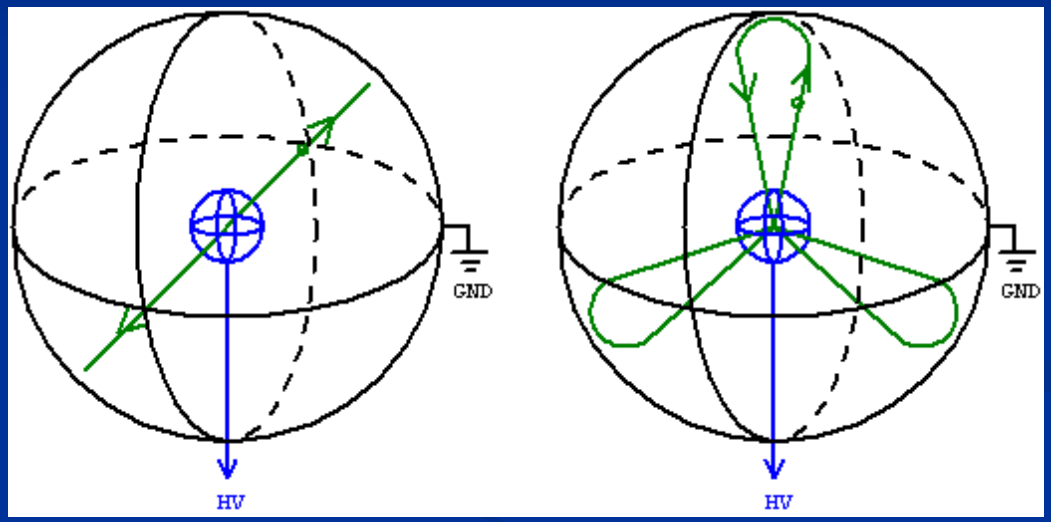


IEC Reactor Core Design

IEC Fusion Overview

Deuterium Fusion

- Central grid negatively biased
- Ions oscillate in electrostatic field
- Ions collide at focal point and fuse
- Fusion generated high energy neutrons and protons



Ion Trajectory

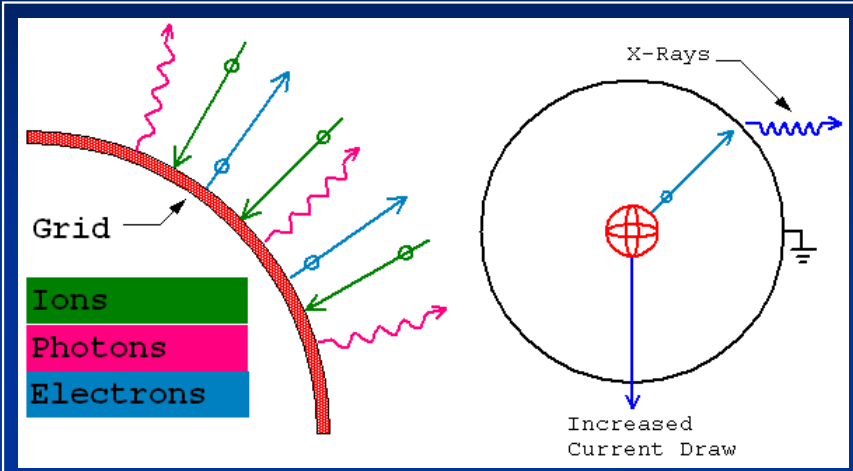
Problems With Conventional Design

Problem to be Solved:

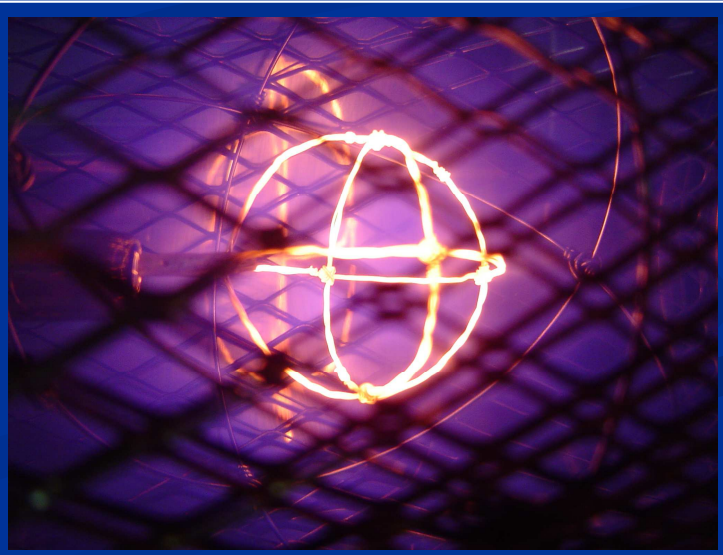
- Grid heating due to ion bombardment causes thermionic electron emission, thereby increasing reactor power draw and generating unwanted x-ray radiation.

Grid Heating

- A fraction of the accelerated ions collide with the grid heating it.
- A radiatively cooled grid will operate at high temperatures
- At high temperatures the grid emits a large thermionic electron current, generating a substantial power draw
- Emitted electrons are accelerated into the reactor shell where they generate bremsstrahlung x-rays.



Thermionic Electron Emission



Ion Bombardment Heating

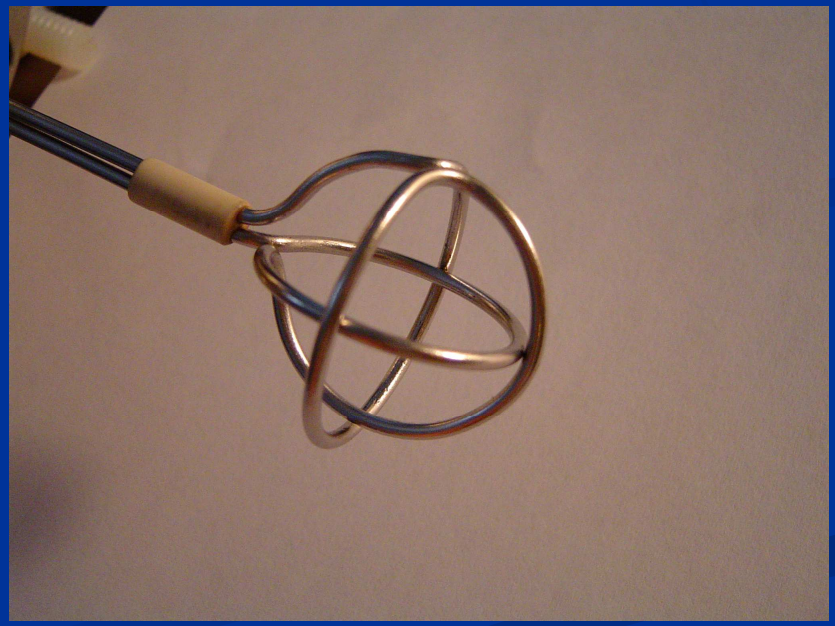
Design Enhancements

Solution:

- A liquid cooled ion accelerating grid remains cool at high operating power, allowing increased plasma density and higher operating efficiency by eliminating thermionic electron emission.

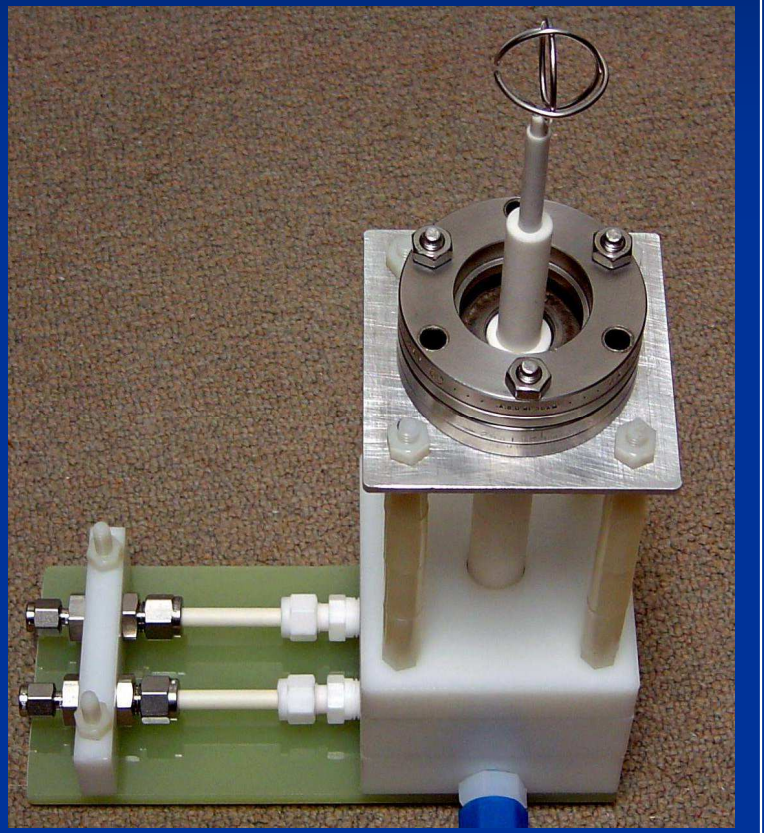
Cooled Grid Assembly

- Low operating temperature to reduce thermionic electron emission current.
- High voltage bias (-50kV)
- Three ring grid fabricated from 1/16” OD stainless steel tube
- Non-conductive Fluorinert coolant
- High flow rate (1ml/s at 80 PSI)
- Ceramic cooling system isolation
- Vacuum compatible alumina ceramic feedthroughs

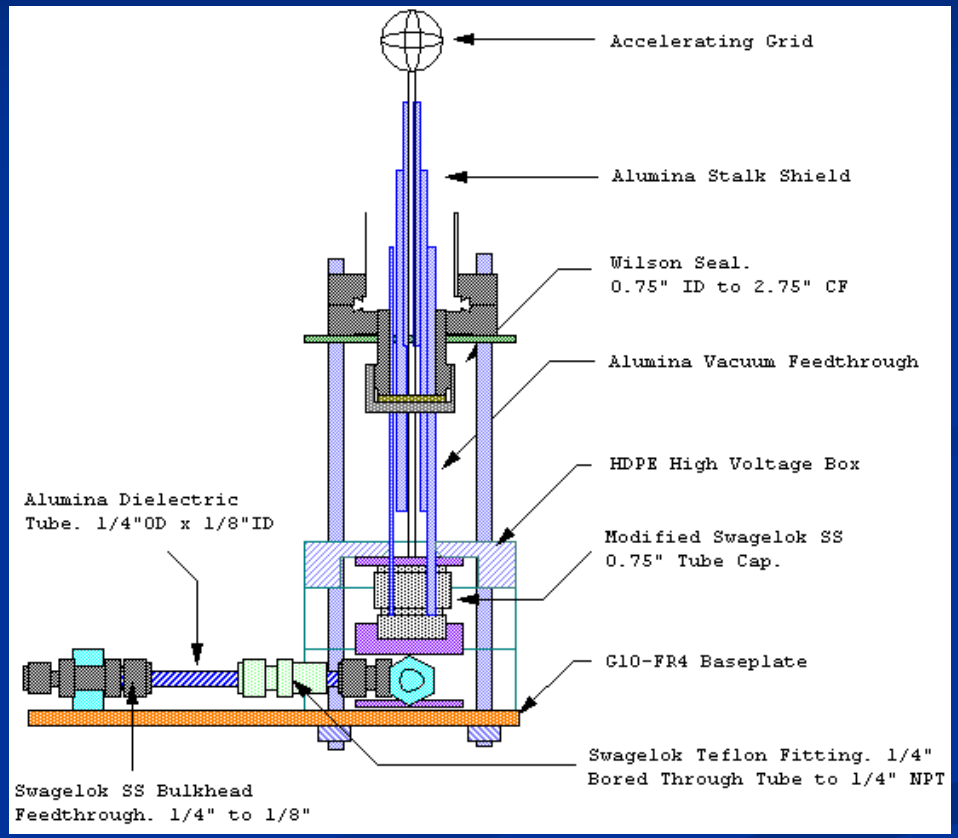


Cooled Grid

Cooled Grid Design



Ion Accelerating Grid

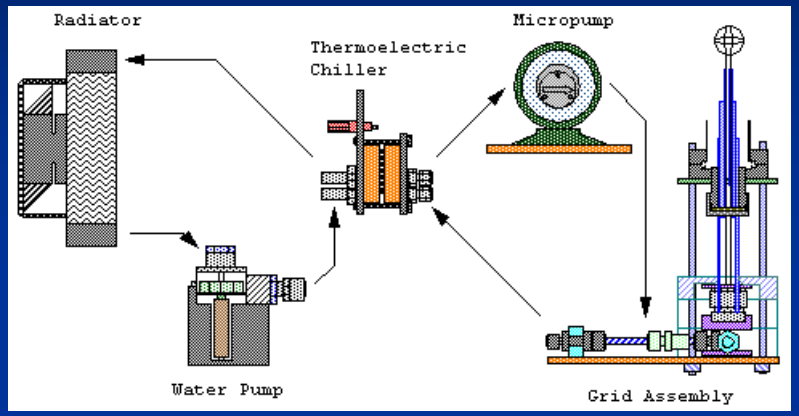


Grid Design

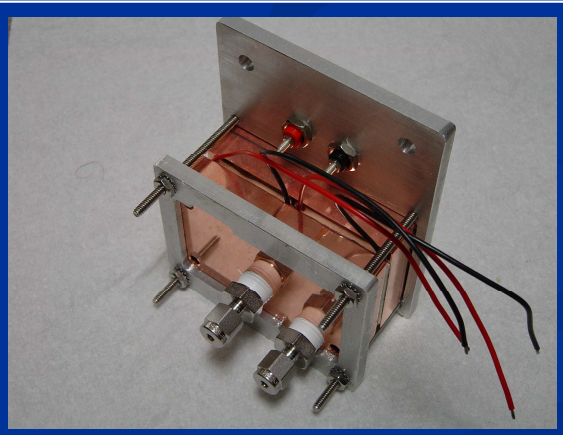
Grid Cooling System

Grid Cooling System

- Primary cooling loop radiator removes heat from water
- Water cooled Fluorinert chiller assembly
- Thermoelectric chiller assembly allows compact, high performance cooling of grid
- Fluorinert grid cooling loop



Grid Cooling System

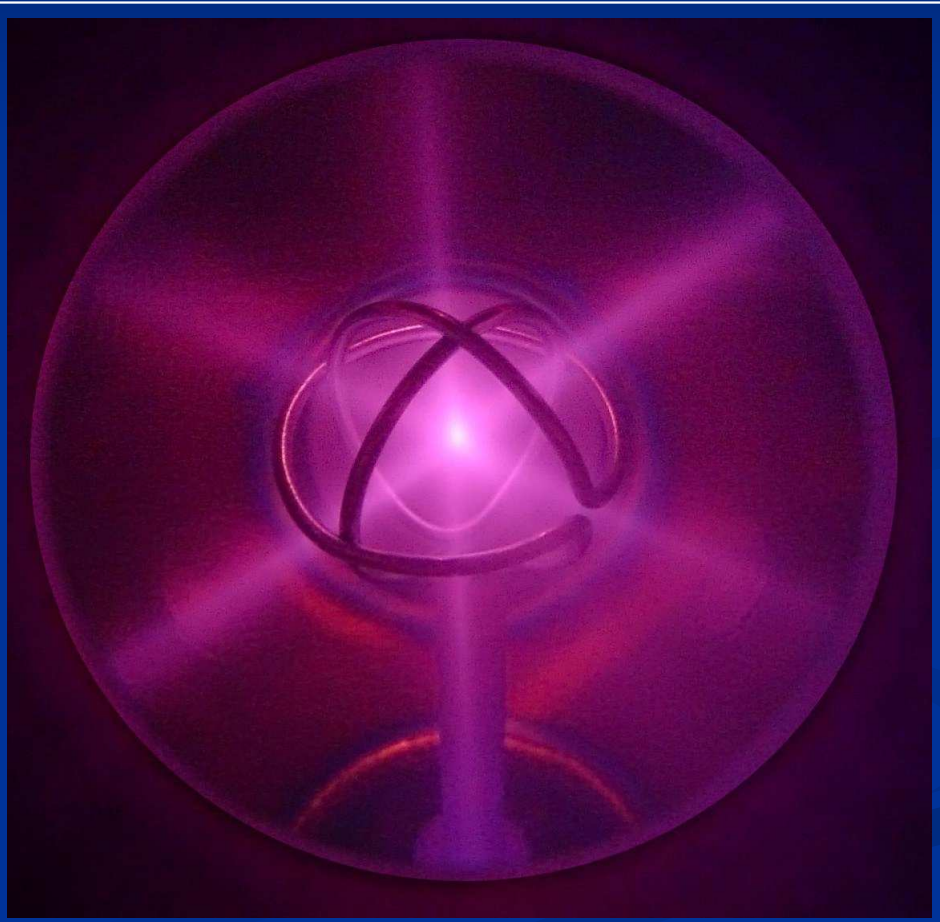


Fluorinert Chiller

Reactor Operation

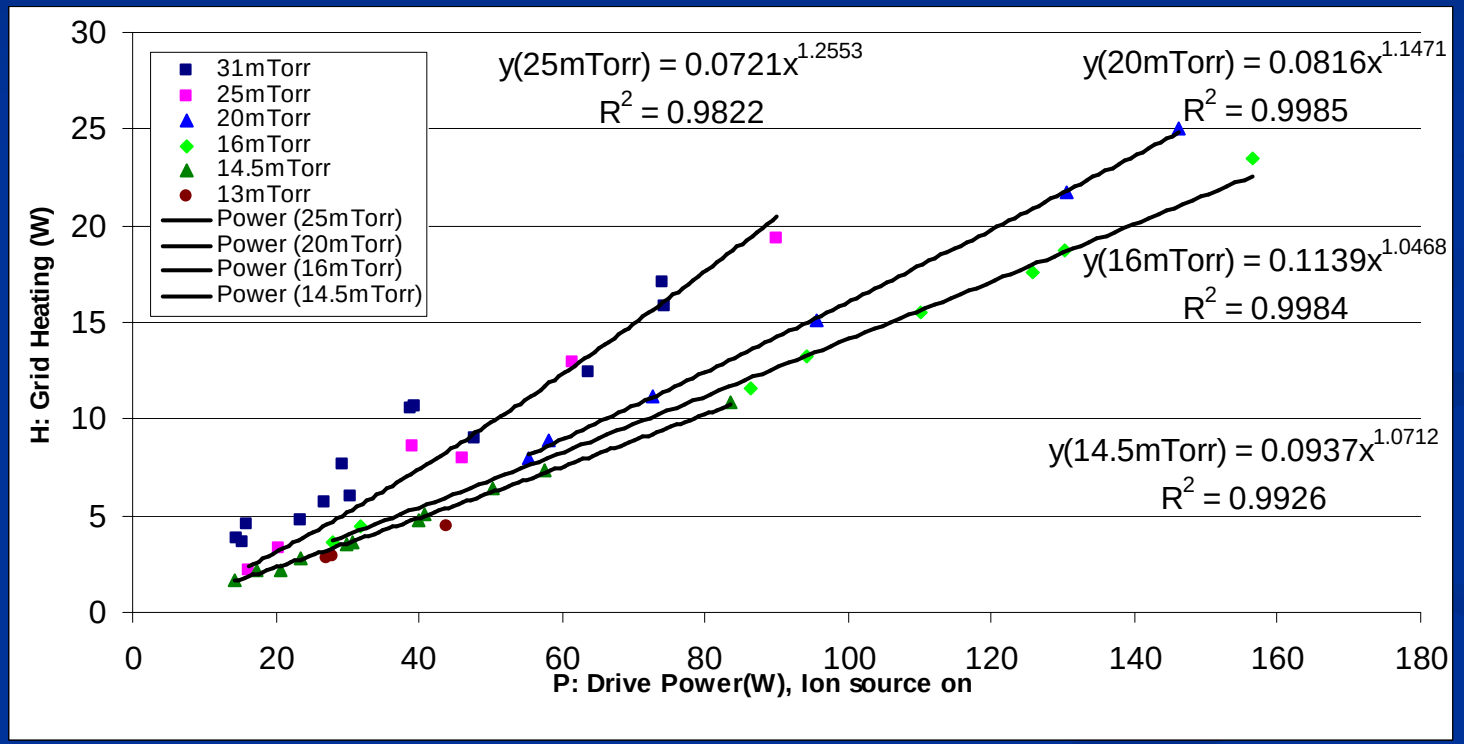
Reactor Operational

- Deuterium fusion detected via neutron generation
- Cooled grid remains below 45C at 155W drive power.
- Grid serves as diagnostic tool to determine fraction of drive power dissipated into grid heating

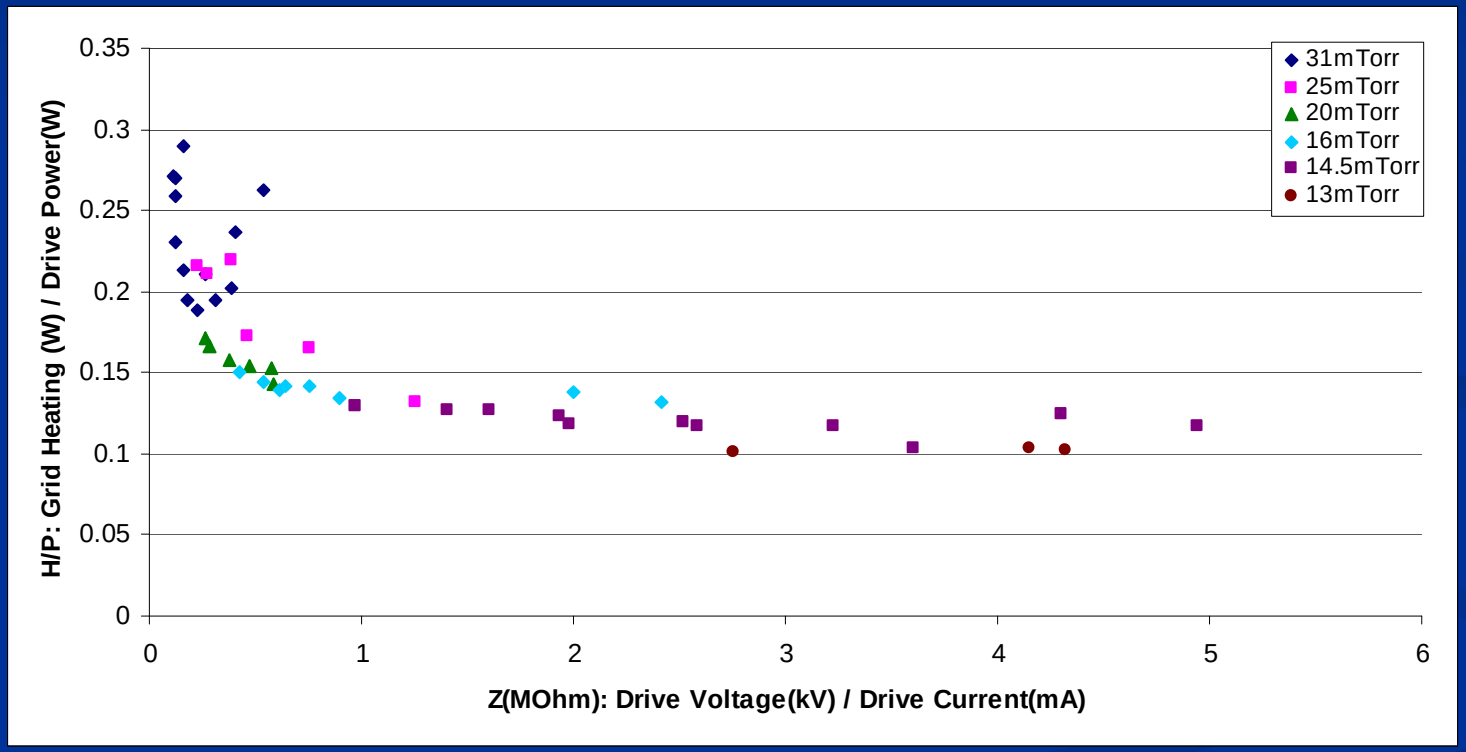


Deuterium Plasma: 13kV, 5mA, 16mTorr

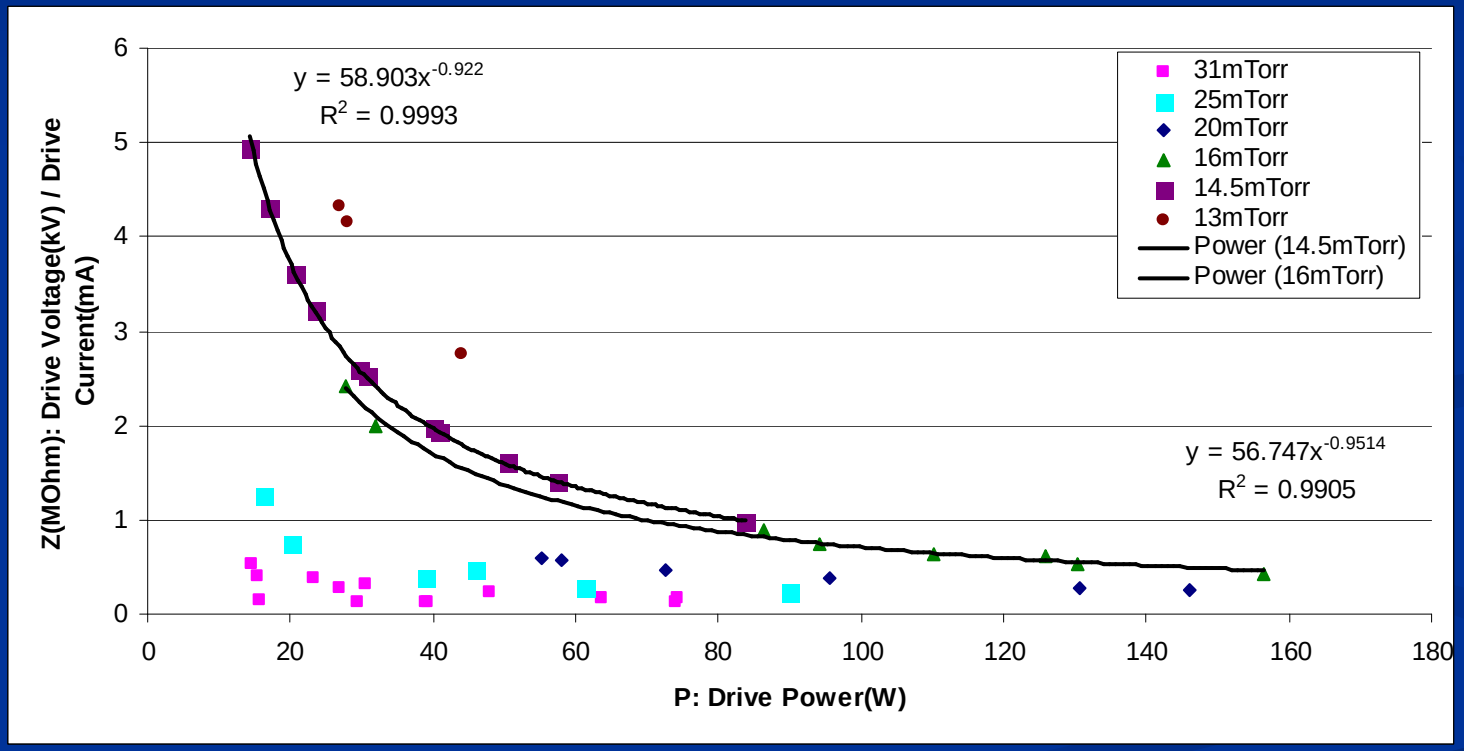
Grid Data: H vs. P



Grid Data: H/P vs. Z



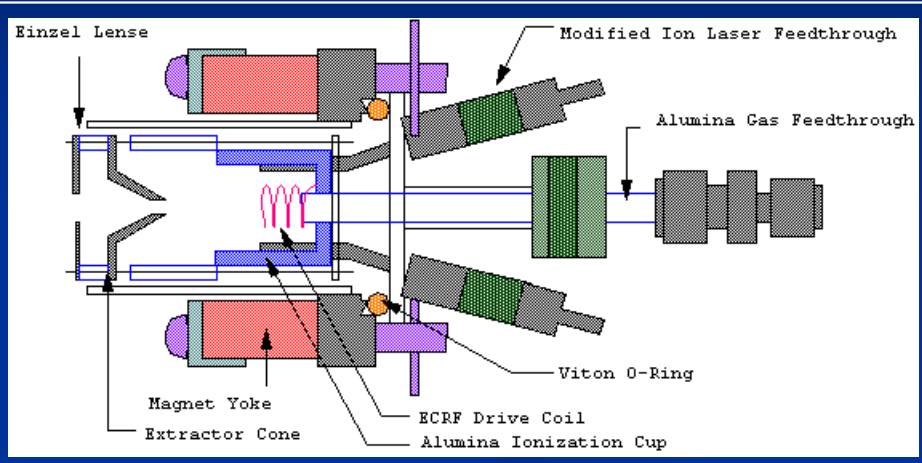
Grid Data: Z vs. P



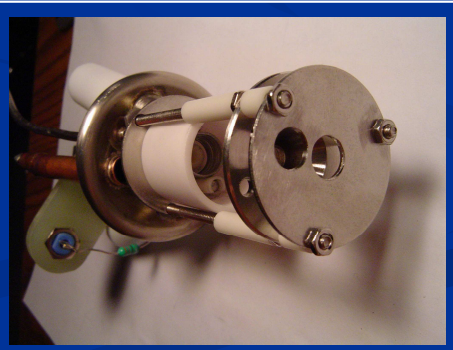
Future Work

ECRF Injector System

- RF drive system operational, Injector system in testing
- RF ionization of X-mode electron cyclotron resonance at 880MHz
- Provides low pressure stability
- Increases plasma density and energy while reducing ion-grid collisions

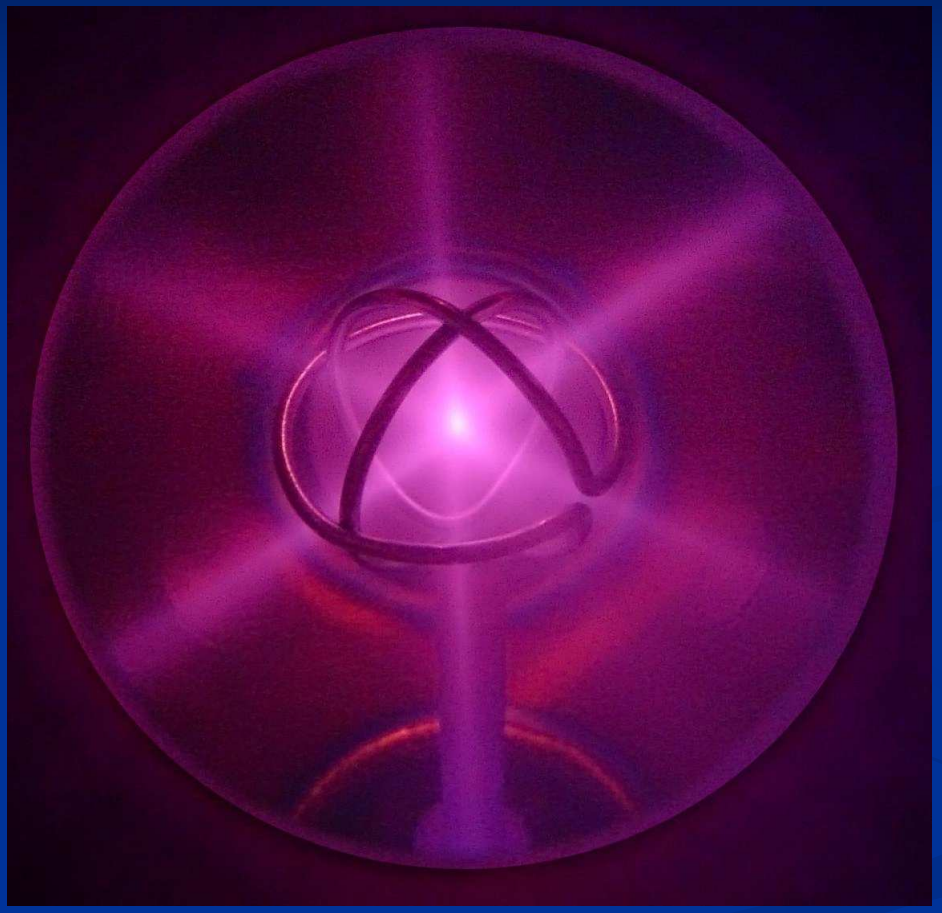


ECRF Ion Injector Design



ECRF Ion Injector Assembly

Questions?



Results and design documentation posted at:
www.rtftechnologies.org