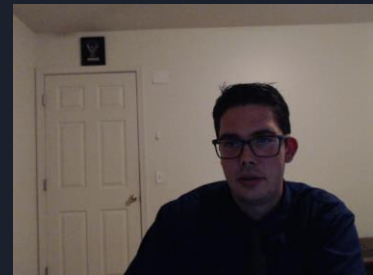




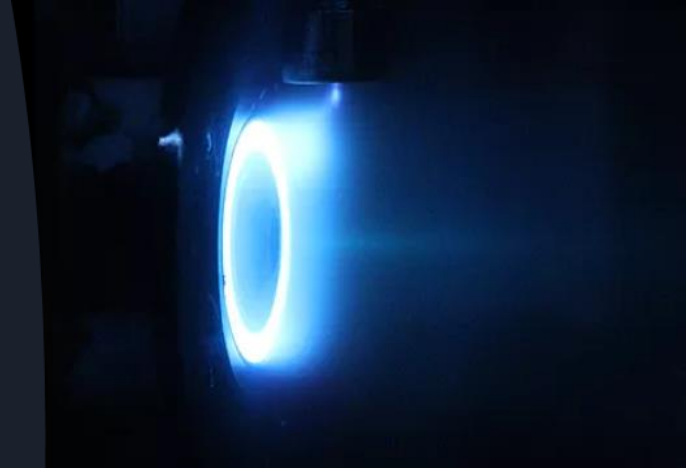
Charge Tracing for Determining Electrical Facility Effects on Electric Spacecraft Propulsion Systems

Joseph Backe
Tyler Bye



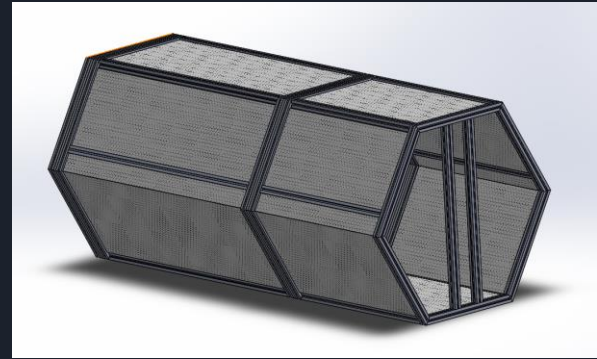
Hall Effect Thruster Background

- ❖ Components
 - Cathode
 - Anode
 - Electromagnets
 - Backplate
 - Channel
- ❖ Plasma Generation
 - Thrust
 - Xenon



Confinement Cage Background

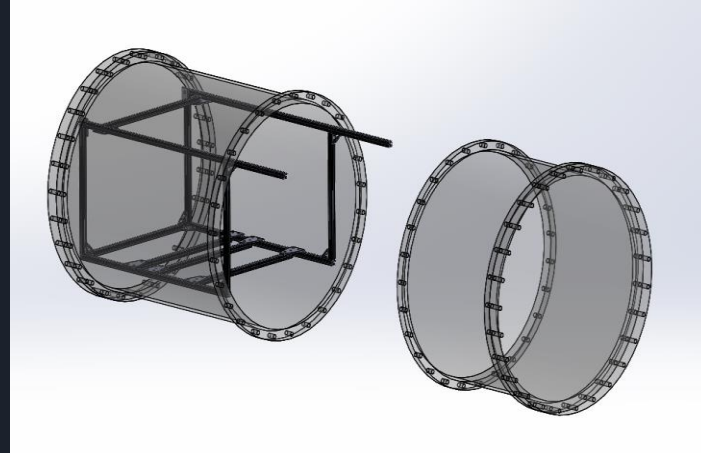
- ❖ Space vs Vacuum Chamber
 - Thrust Axis
 - Ion and Electron Interaction
 - Ambient Pressure
 - Plasma Plume Density
 - New Conduction Pathways
- ❖ Goal of confinement cage
 - Eliminate electrical anomalies in chamber



Vacuum Chamber

❖ Dimensions of Chamber

- 41" Diameter
- 68.19" Length
- 30.97" Length of beams



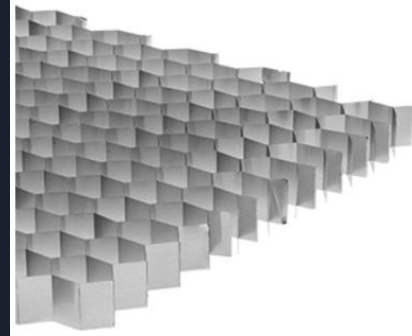
Struts

- ❖ 80/20 1in by 1in T-slot strut
 - Ring 1
 - 26" long
 - 30.31" max width
 - 27" tall
 - Ring 2
 - 36" long
 - 30.31" max width
 - 27" tall



Honeycomb Mesh

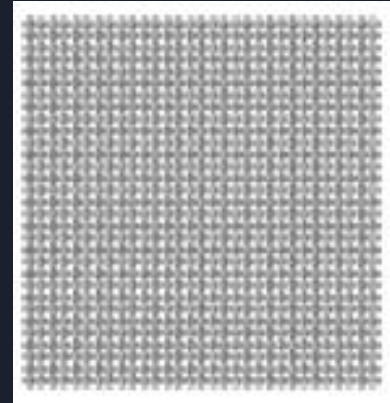
- ❖ Corrosion-Resistant 3000 Series Aluminum Honeycomb Cores
 - Cell size
 - 0.5" size
 - 0.75" thickness
 - Lines opening of rings 1 and 2



Fine Mesh

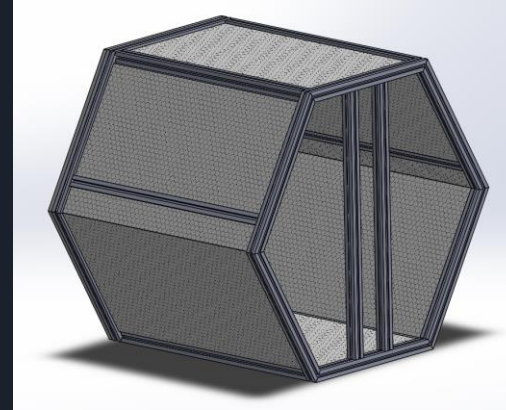
❖ Stainless Steel Wire Cloth

- Dimensions:
 - Opening size 0.02"
 - Wire diameter 0.013"
 - Open Area 37%
- Lines the inside of the confinement cage



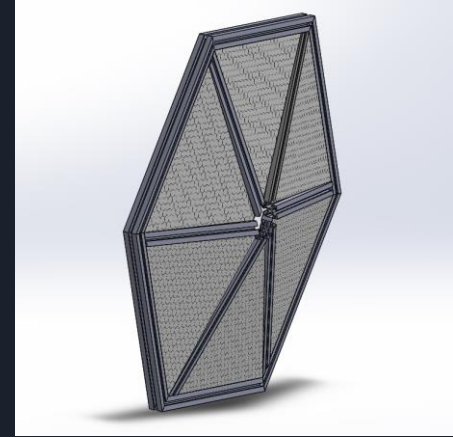
Back Wall

- ❖ Composed of two struts with adjustable horizontal location
- ❖ Back plate with adjustable vertical height
- ❖ Lined with mesh to prevent ion leakage



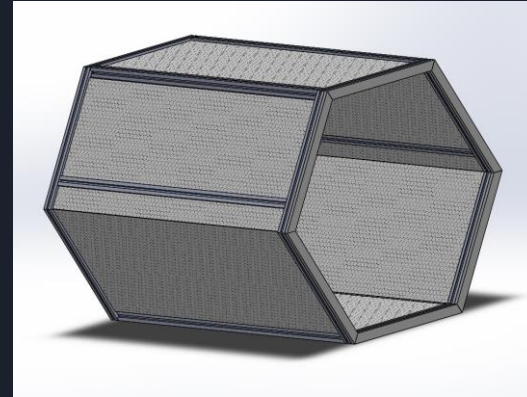
Beam Dump

- ❖ 10 degree angled hexagonal piece
- ❖ Prevents particle reflection towards thruster exit
- ❖ Made of struts and both meshes
- ❖ Small hole covered by acrylic to put a camera lens



Ring Separation Insulator

- ❖ Same Hexagonal Design as rings
 - 0.39" long
- ❖ Made of G-10 Fiberglass
- ❖ Prevents Ion leakage



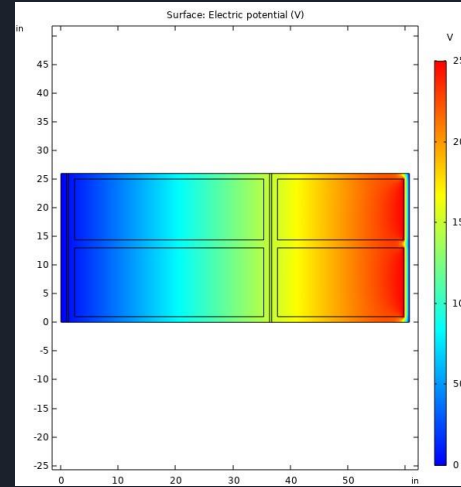
Experiment Setup

- ❖ COMSOL Multiphysics®
 - 2-Dimension Cross-Section
 - Differences from 3-Dimensional model
 - Electrostatics and Electric Current Toolboxes
 - Ground locations
 - Test Voltage 250V



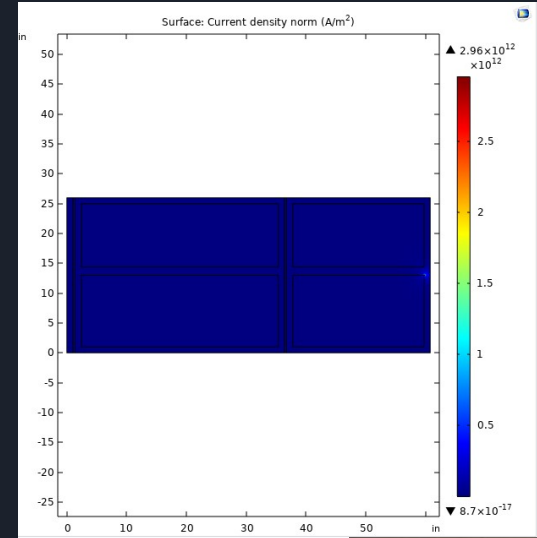
Electric Potential

- ❖ Decrease in potential approaching grounds
 - Zero potential at grounds
 - Maximum potential (250V) near thruster



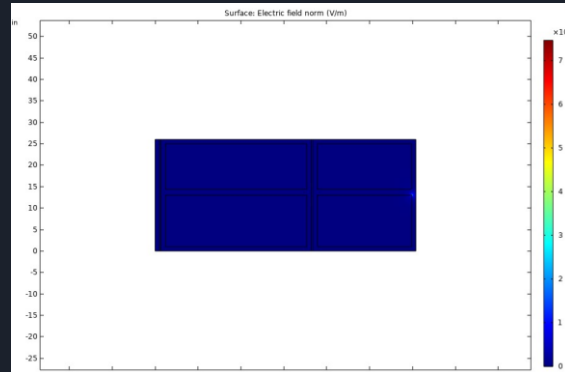
Electric Current Distribution

- ❖ Current density ranging 10^{-17} to 10^{-7} A/m²
 - Section dimensions are in square inches (low current)
 - 1 square inch = 0.0006 square meter
 - Minimal current allows minimal current leakage



Electric Field Distribution

- ❖ Electric Fields range from 10^{-24} to 10^{-4} V/m
 - Section dimensions are in inches
 - 1 inch = 0.0254 m
 - Minimal electric fields induced within confinement cage
 - Space conditions do not have electric fields





Conclusion

- ❖ Does the Confinement Cage fit within the chamber?
 - Yes
- ❖ Low current density and minimal electric fields
 - Parameters are met in simulation
 - Design works in simulation as a confinement cage





Future Improvements

- ❖ Better COMSOL Multiphysics® Simulation
 - New program to group
 - Will beams in vacuum chamber affect confinement cage circuits?
 - No particle tracing module at WMU
 - 2-Dimensional model is missing much of the air inside cage
 - Conductance of air \ll conductance of aluminum or steel



Constraints

❖ COVID-19

- Entirety of project was conducted during COVID 19
 - Limited access to lab and university
 - Extra time spent waiting for email correspondence
 - Remote login
 - Computer malfunctions and crashes





Acknowledgements

- ❖ Dr. Kristina Lemmer - Faculty Advisor
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- ❖ Christopher Boucher - COMSOL Multiphysics® Tutorials
- ❖ The many students within the ALPE lab who responded to emails concerning controller parameters and vacuum chamber information



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Questions?

