Investigations of Electric Propulsion Systems at ERAU Prescott

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My Team

- Current group of students working on Electric Propulsion (EP) Projects
  - 2 Space Physics Majors, 1 Aerospace Eng. Major
- Designed arcjet thruster based on contemporary designs
  - In the process of optimizing design and operating parameters
- Designing/simulating miniature Hall-effect Thruster

ARIZONA SPACE GRANT NASA

Motivation for Project:

Arcjet Thruster

ERAU already has teams working on the following rocket propulsion types:

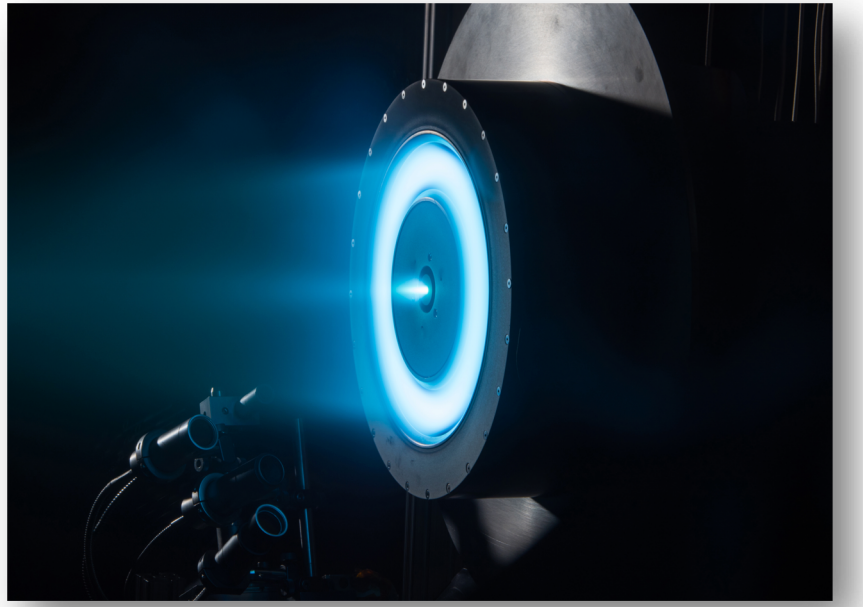
- Solid
- Liquid
- Hybrid

NO groups focusing on in-space propulsion

Most rudimentary form of EP: Electrothermal

- Good place to start?

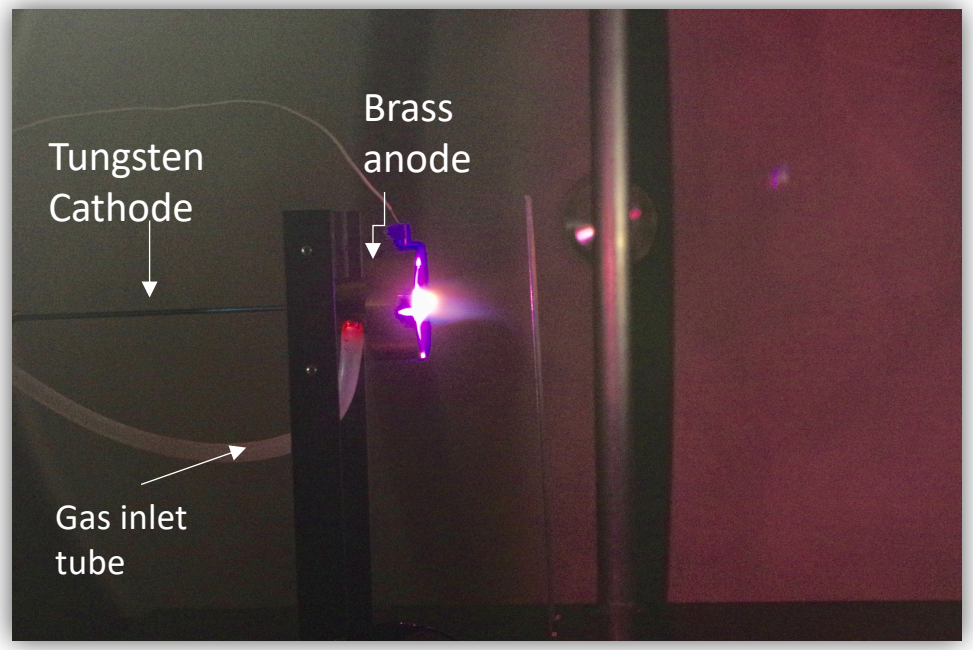
Source: https://crowdfunding.erau.edu/project/1159



Source: https://crowdfunding.erau.edu/project/1159

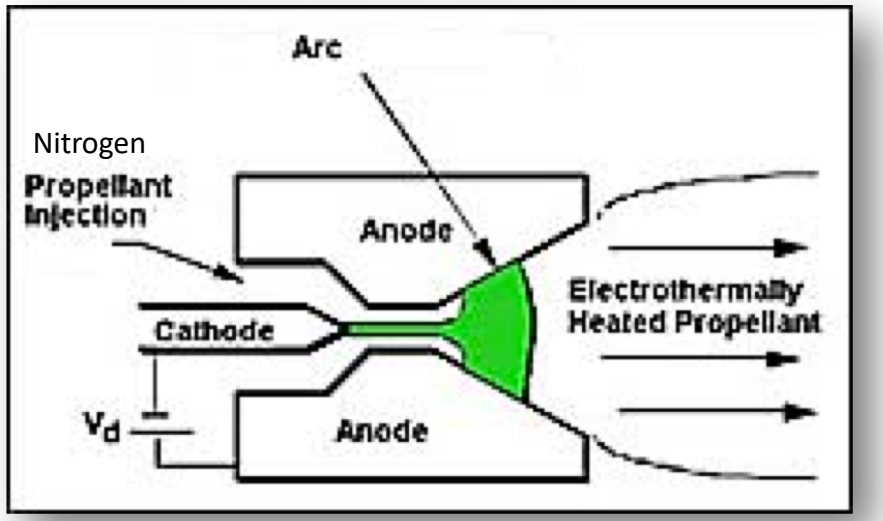
Thruster Operation Principles

- We utilize a type of electrothermal thruster known as an ***arcjet***
  - Arcjets work by passing a plasma discharge through a propellant gas to heat it, then expand that heated gas through a diverging nozzle[1]



Phase I Arcjet

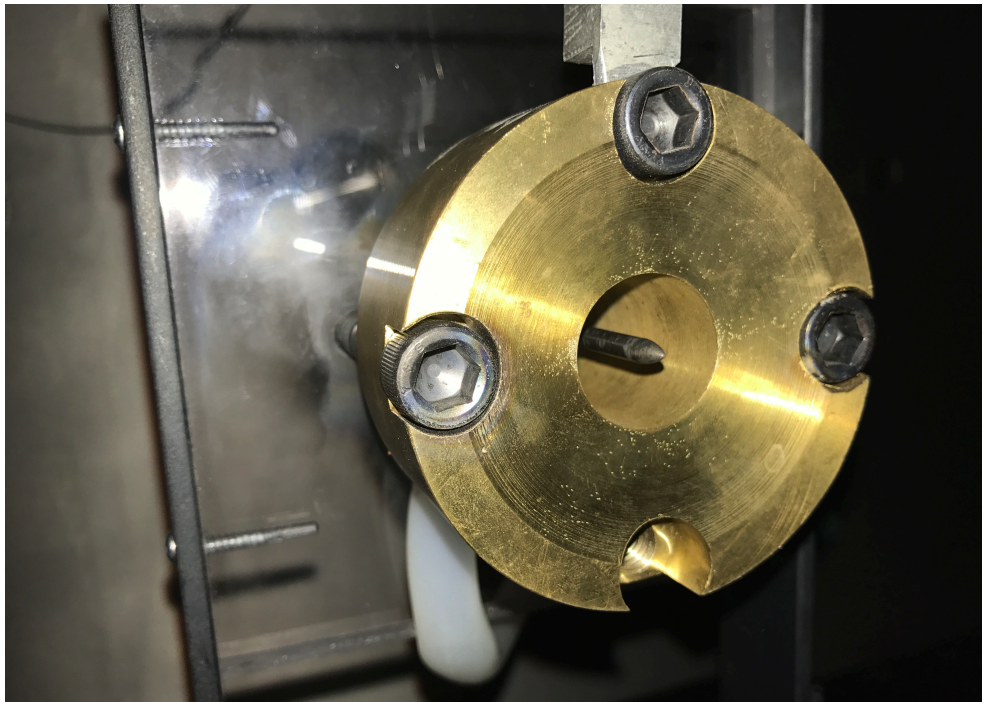
Our arcjet utilizes Nitrogen as propellant, since it is easily stored and virtually harmless for students to work with.

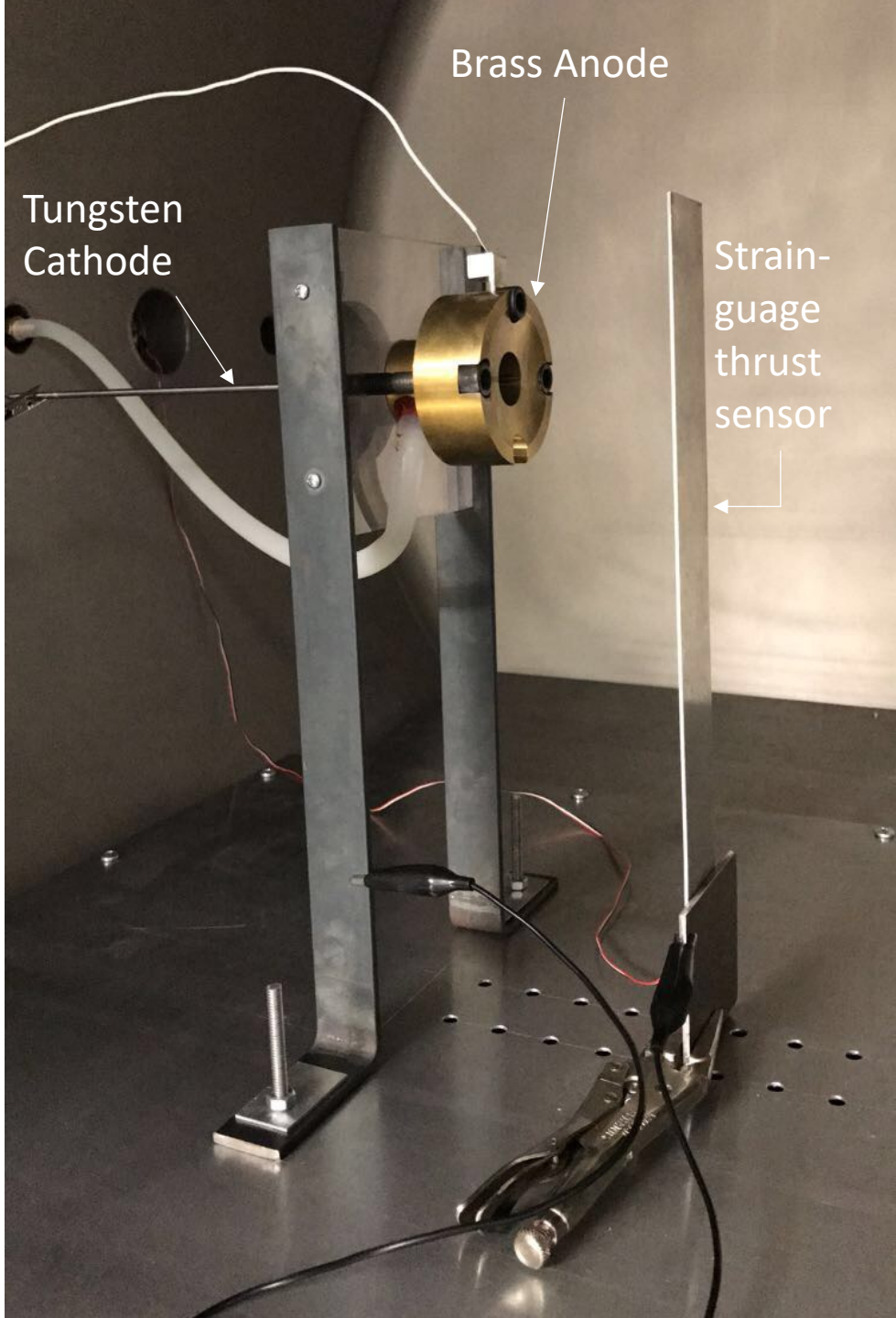


Source: http://www.waynesthisandthat.com/images/arcjet%20schematic.jpg

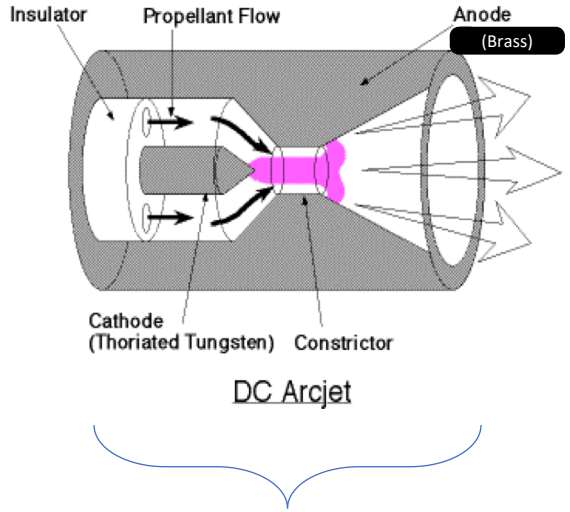
Initial Arcjet Design

- First design utilized open discharge “chamber”
  - No nozzle section
  - Allowed for easy troubleshooting in early testing

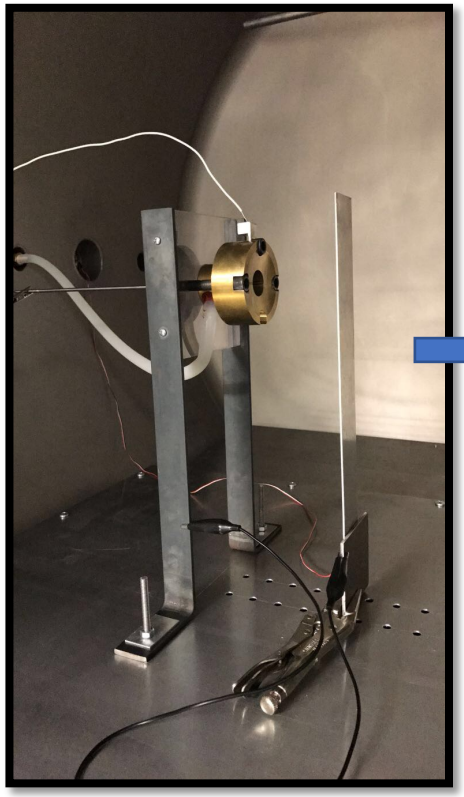




Arcjet Upgrade



Initial Design



Added constrictor section and diverging nozzle

New Design

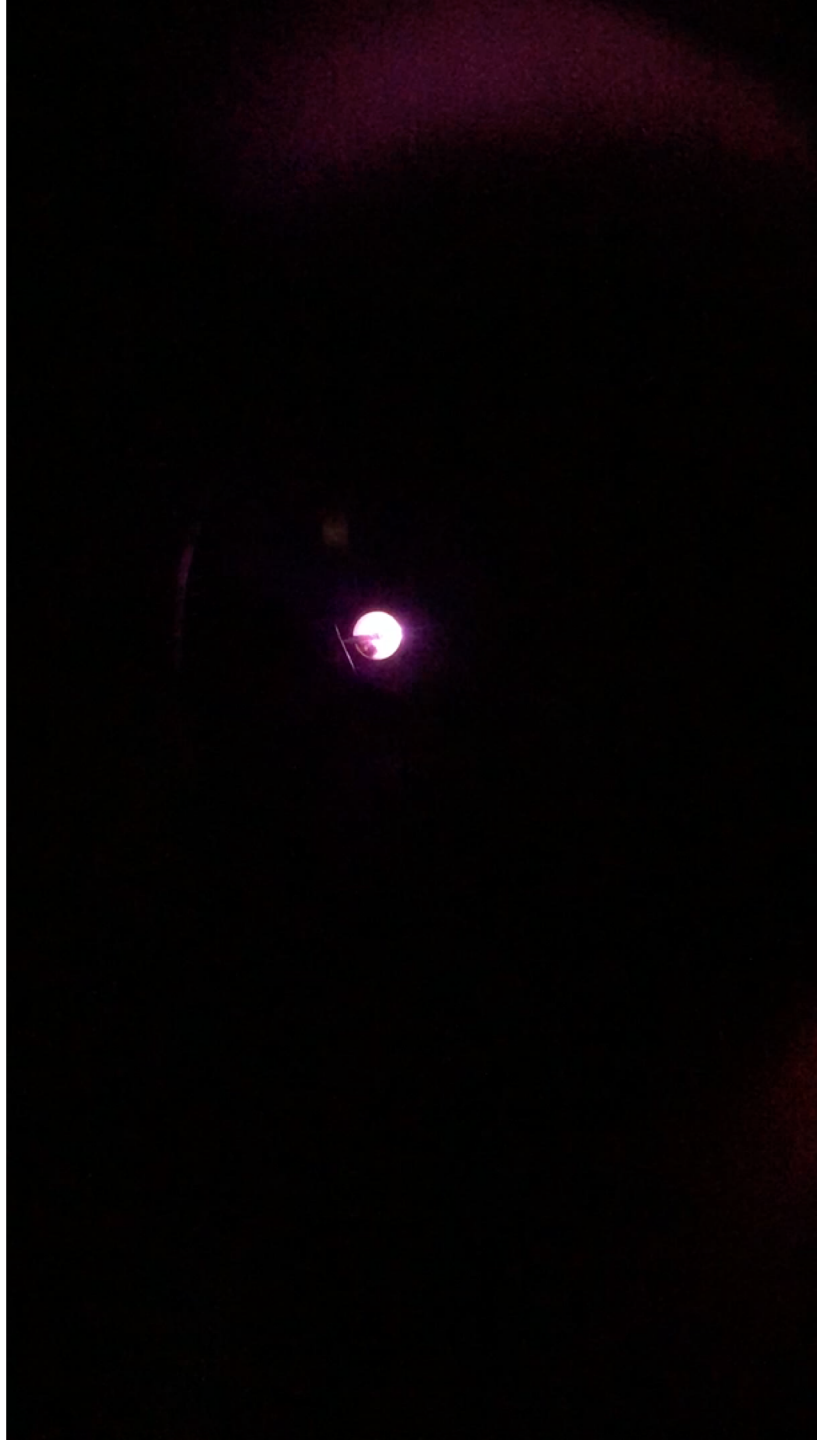
Technical Difficulties

- After new design, faced issues with electrical grounding
- Easier for arc to travel from bolts to mounting stand than through constrictor

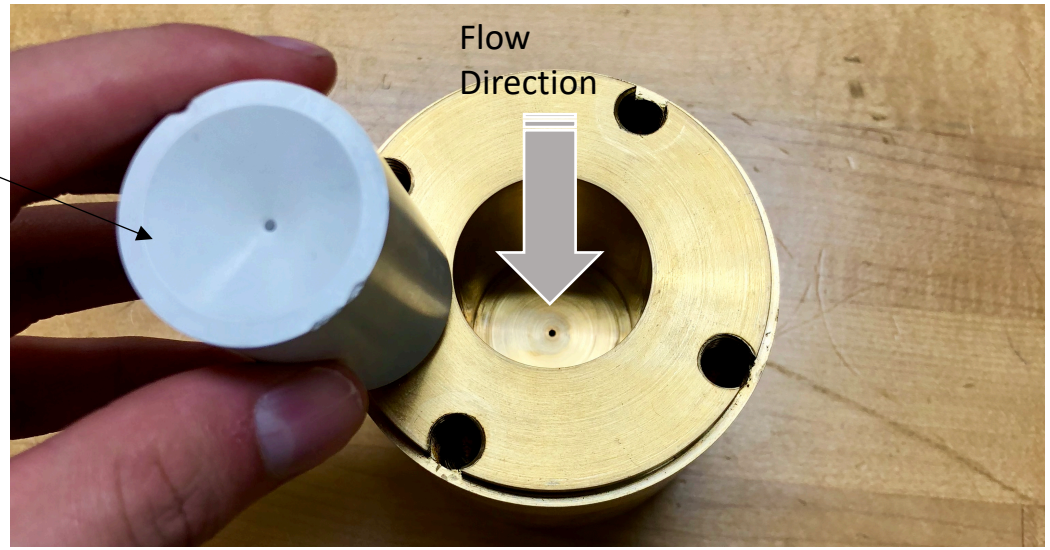
This is NOT ideal

Operational Success

- Isolated entire ground plane for successful tests
- Conducted tests without Boron Nitride insulator section
  - Heat dissipation issues immediately noticeable
- Note the swirling, stabilized plasma sheath around the cathode
- Bright, focused plume



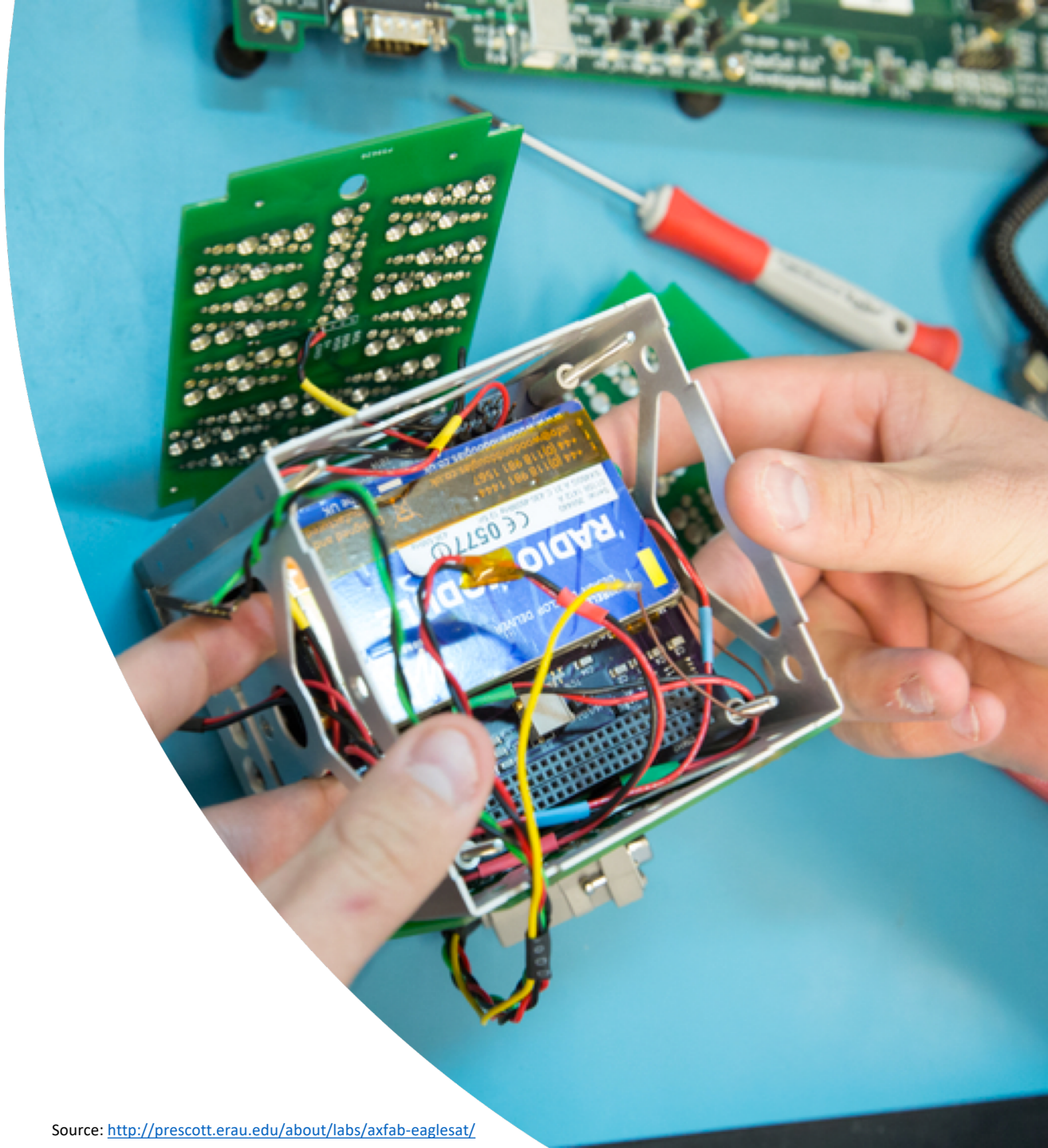
Boron Nitride Insulator (removed)



Motivation for Project:

Hall-Effect Thruster

- ERAU Prescott's prized project: EagleSat
  - Undergraduates construct CubeSat that is launched into space (launched aboard Delta II rocket in Nov.)[3]
- My dream for the project:
  - A student-built satellite with student-designed/built propulsion system
  - Could be used for satellite orbit drag correction
- I'd like to see this be realized via a miniature Hall-Effect Thruster (HET)

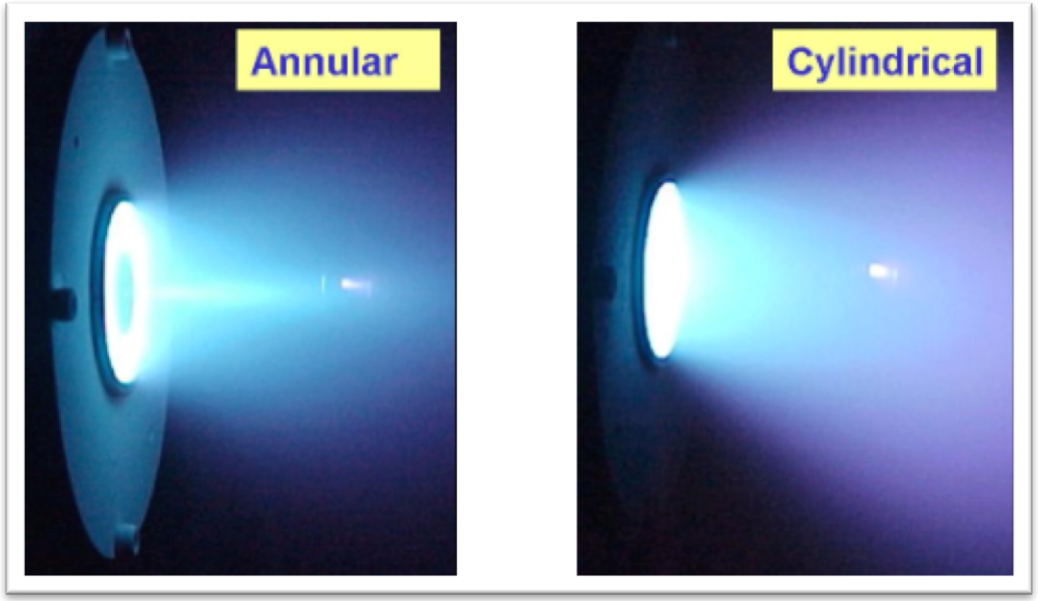


Source: http://prescott.erau.edu/about/labs/axfab-eaglesat/

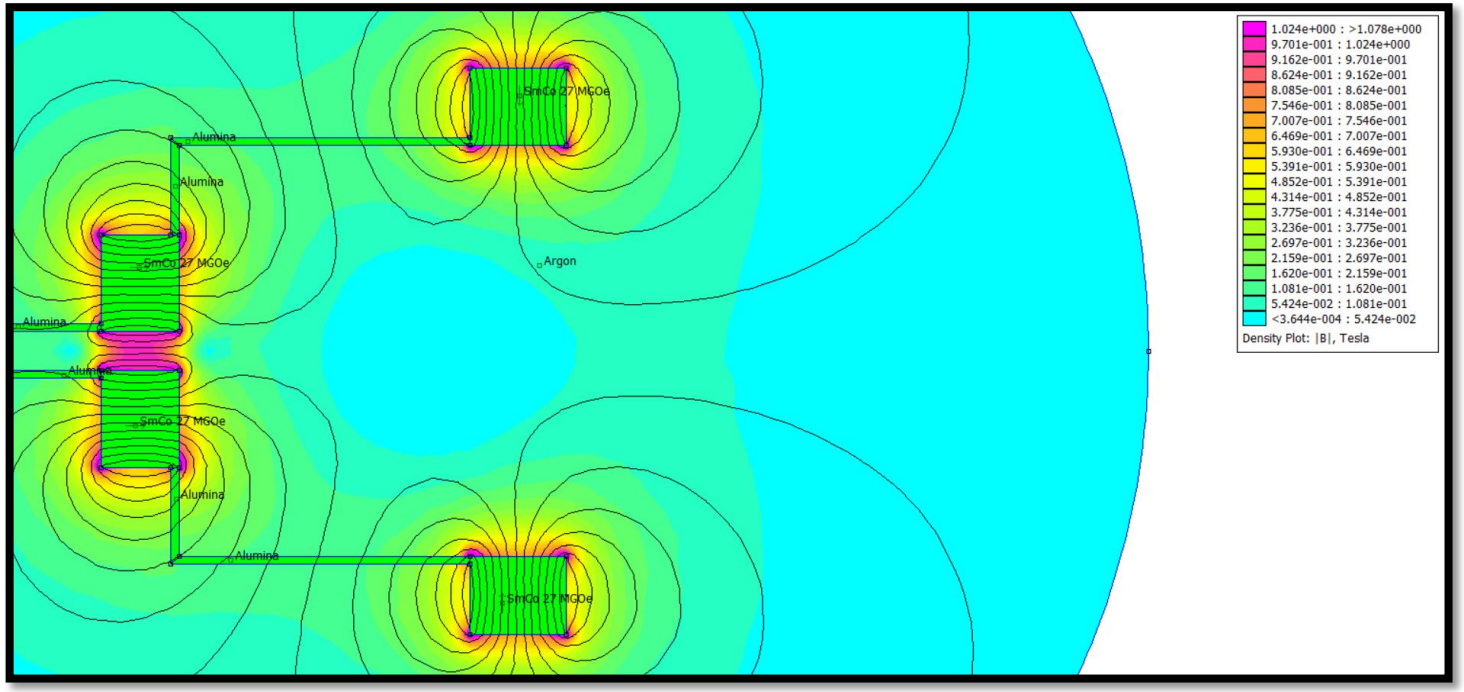
HET Design Progress

- Leaning towards a cylindrical HET design
  - Would use permanent SmCo magnets
  - Reduces power requirements & weight

- My team has used FEMM[1] to simulate the magnetic field strength of a possible thruster design
  - Performed this simply to demonstrate capabilities, and visualization purposes

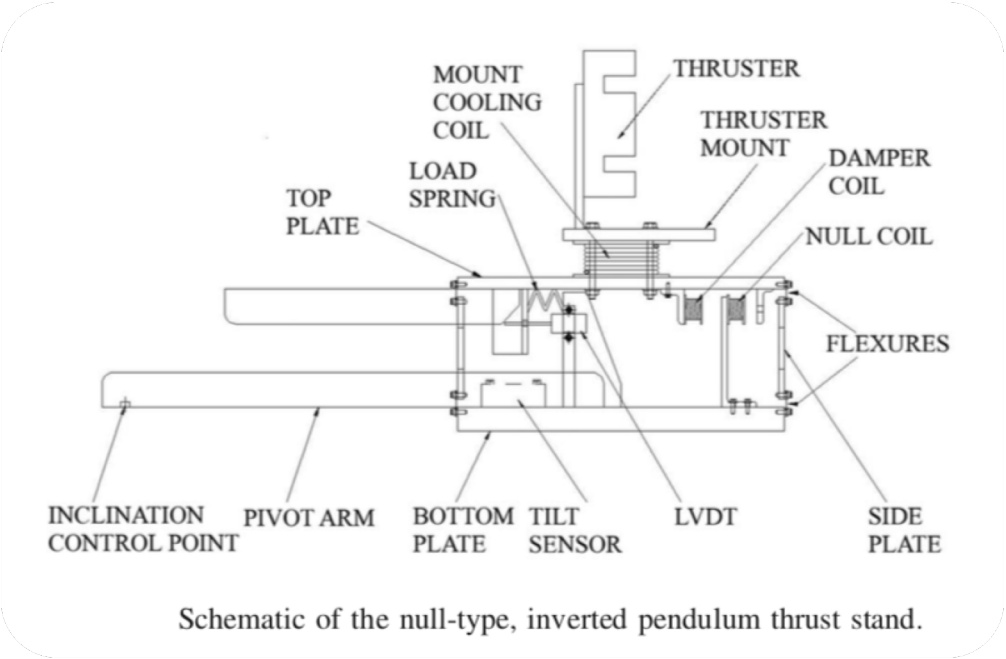


Source: https://htx.pppl.gov/cylindricals.html



Future Directions

- Nearing initial thrust measurements with the arcjet
- Focusing on the design and construction of a highly-sensitive inverted pendulum thrust stand[4]
- Would like to also obtain sensors/equipment for plume diagnostics



Schematic of the null-type, inverted pendulum thrust stand.

References

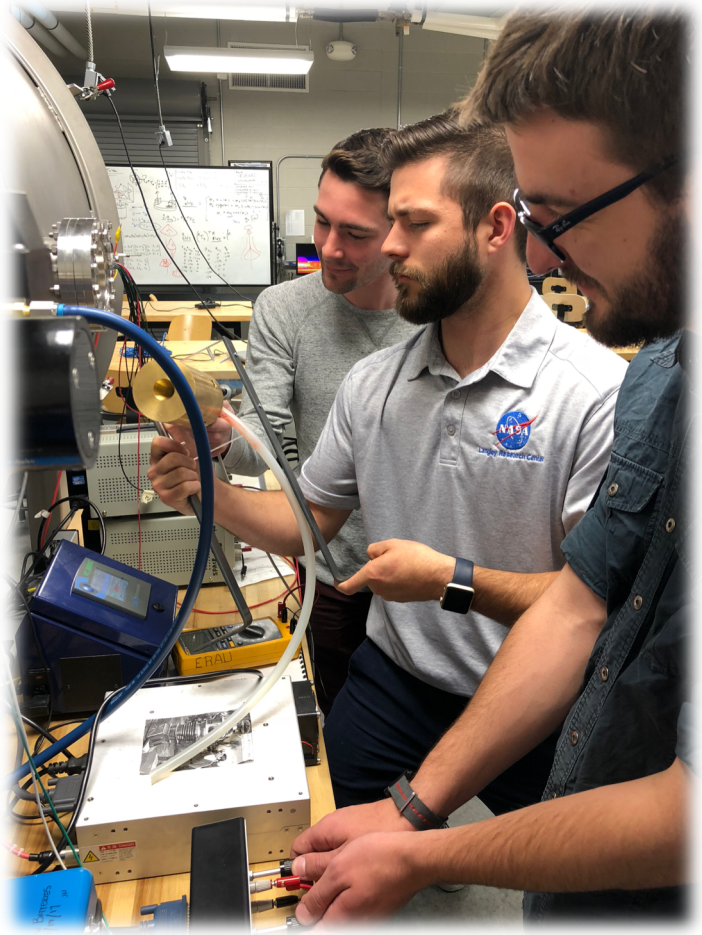
[1] *Finite Element Method Magnetics: HomePage*Available: http://www.femm.info/wiki/HomePage.

[2] Jahn, R. G., *Physics of Electric Propulsion*, Mineola, NY: Dover Pub., 2006.

[3] Kadah, J., "Embry-Riddle Prescott Selected by NASA for Future Satellite Launch," *Embry-Riddle Newsroom,* Available: https://news.erau.edu/headlines/embry-riddle-prescott-selected-by-nasa-for-future-satellite-launch/.

[4] Xu, K. G., and Walker, M. L. R., "High-power, null-type, inverted pendulum thrust stand," *Review of Scientific Instruments*, vol. 80, May 2009, p. 055103.

QUESTIONS?



Source: http://www.americaspace.org/wp-content/uploads/2012/08/Aerojet-EP-Satellites-rev-3-08.jpg