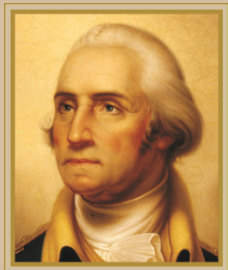


# Thruster Subsystem Design for the Ballistic Reinforced Communication Satellite (BRICSat-P)



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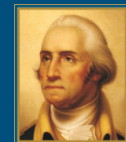
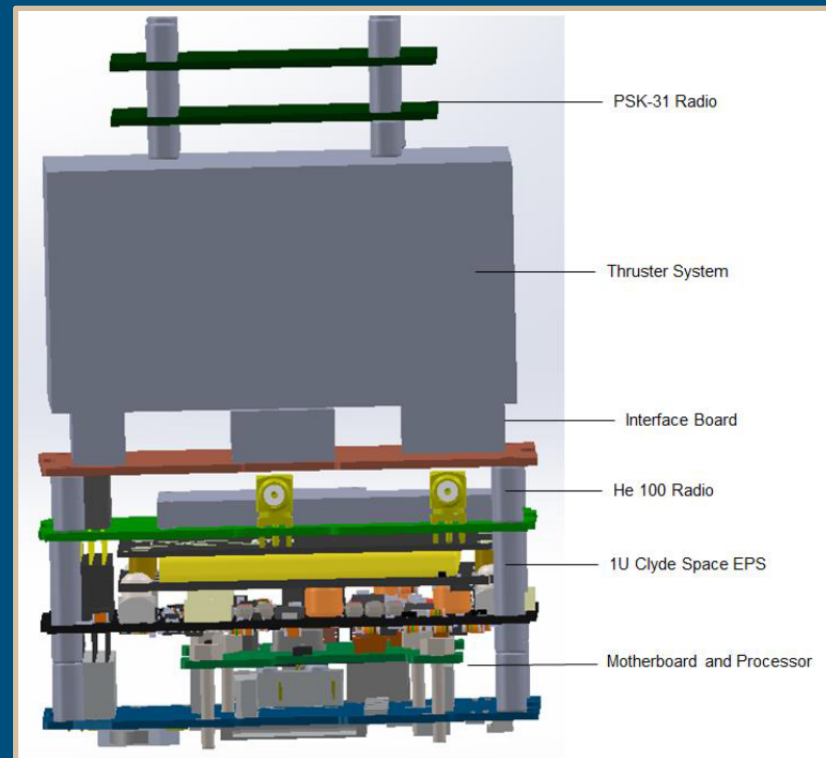
**Presented By:**  
Joseph Lukas

**Team Members:**  
George Teel  
Samudra Haque  
Alexey Shashurin  
Professor Michael Keidar



# USNA Mission

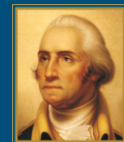
- BRICSat-P 2015 launch
- 500 km: Attitude control, orbit change, & deorbit
- Subsystem fits in 6 cm x 10 cm x 10 cm area





# Success Criteria

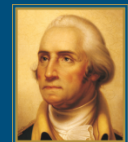
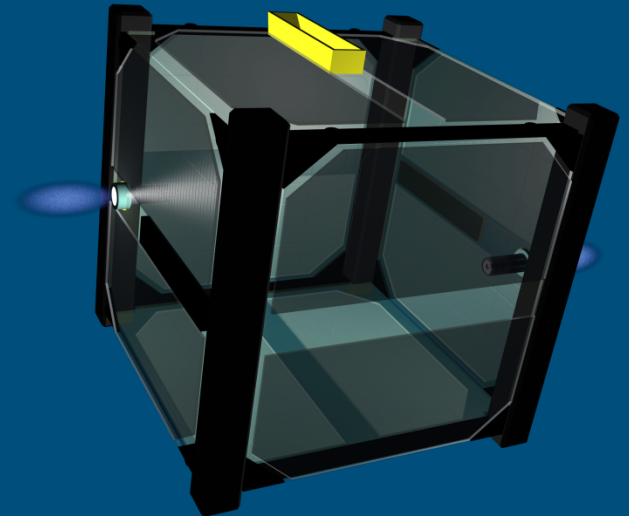
- Initial and repeatable firing
- BRICSat rotation of 6 rpm
- Stable spin and de-spin





# Propulsion Requirements

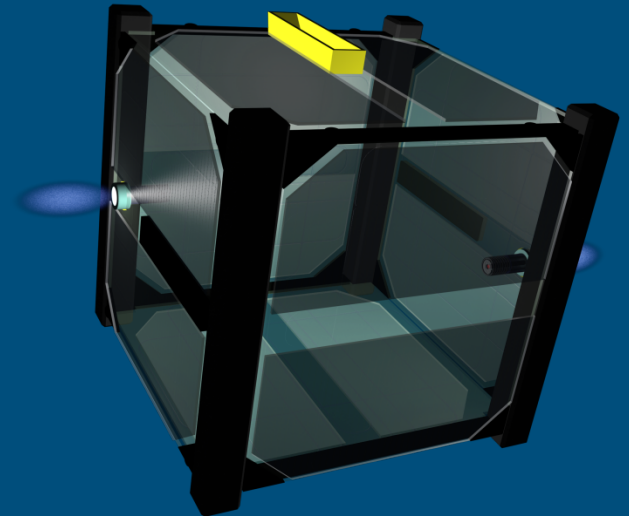
- **Electric propulsion that is...**
  - Low-cost
  - Reliable and simple
  - No pressurized tanks
  - Power efficient
  - Scalable and modular
  - Safe for the satellite



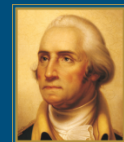


# Propulsion Requirements

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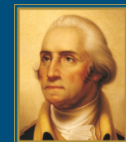
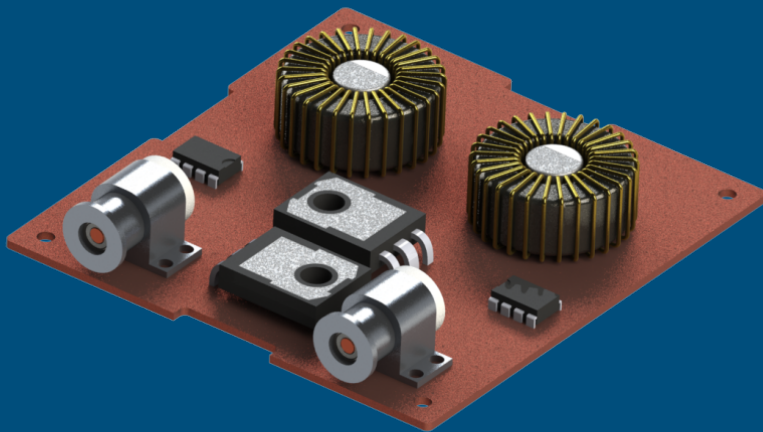
**Solid Propellant**





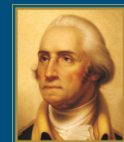
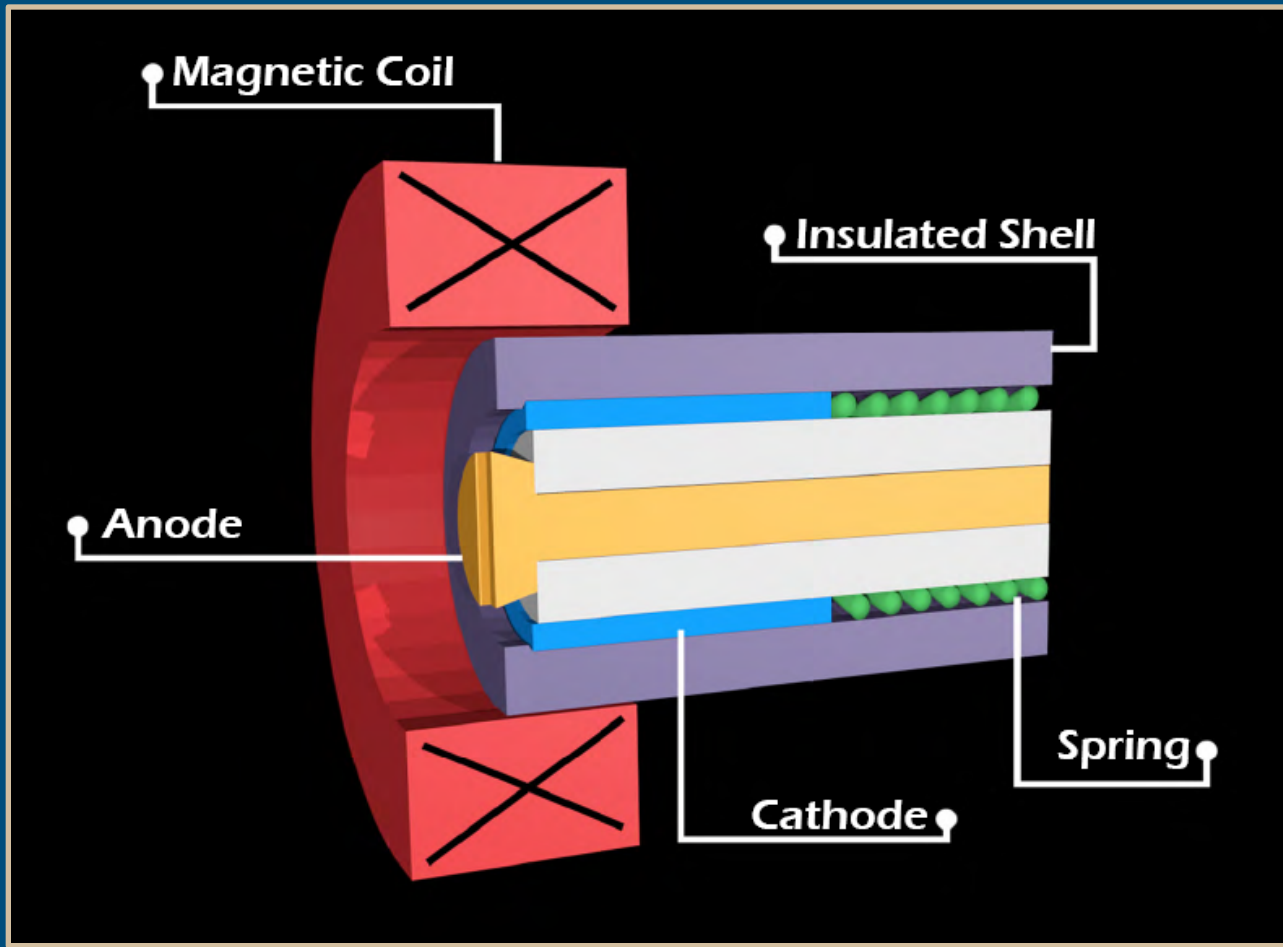
# Micro-Cathode Arc Thruster ( $\mu$ CAT)

- Generation III



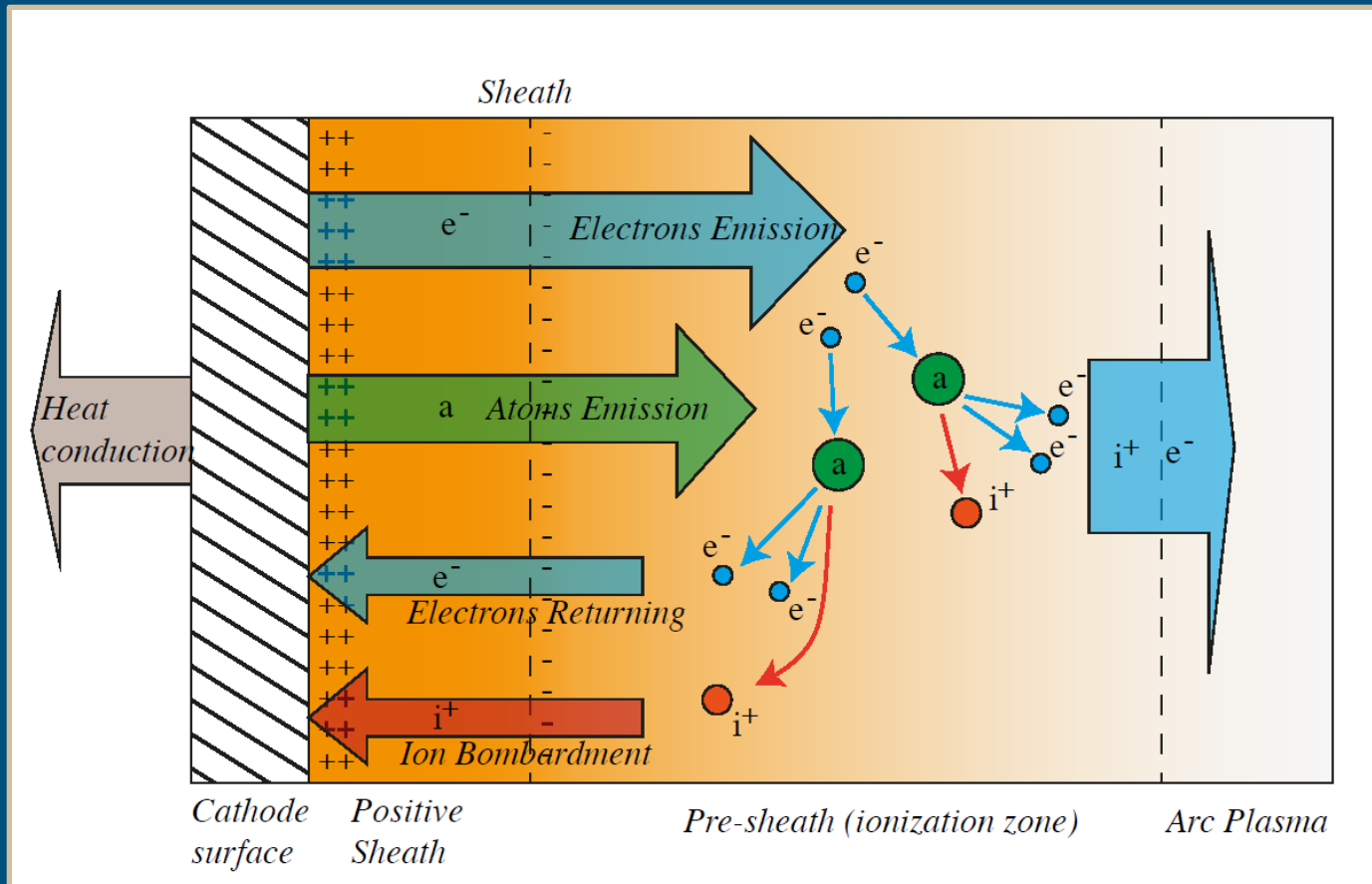


# Thruster Head Components





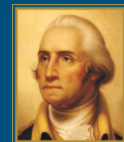
# How It Works







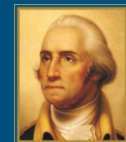
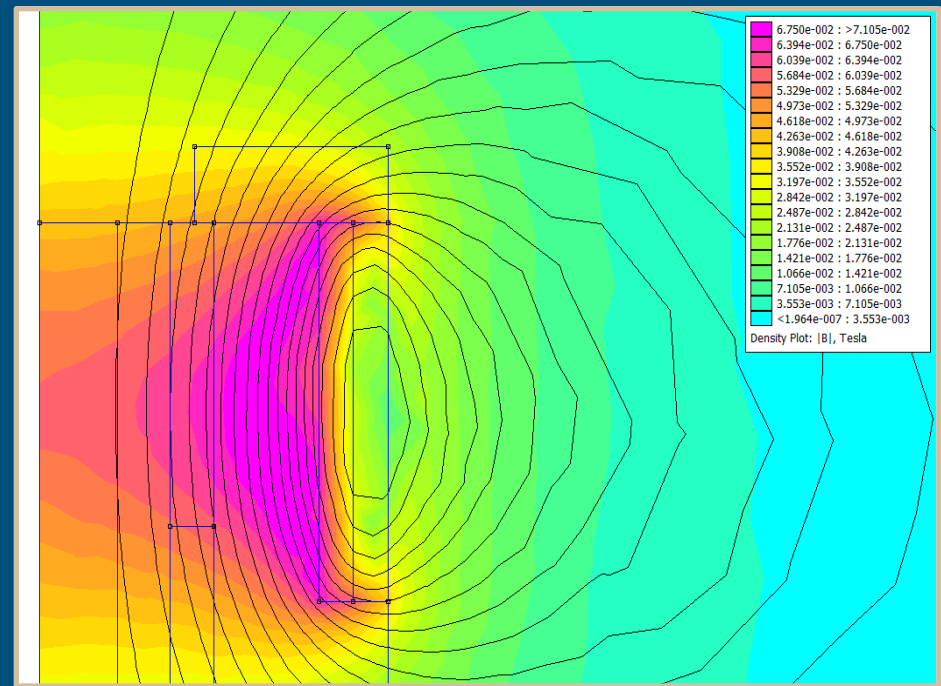
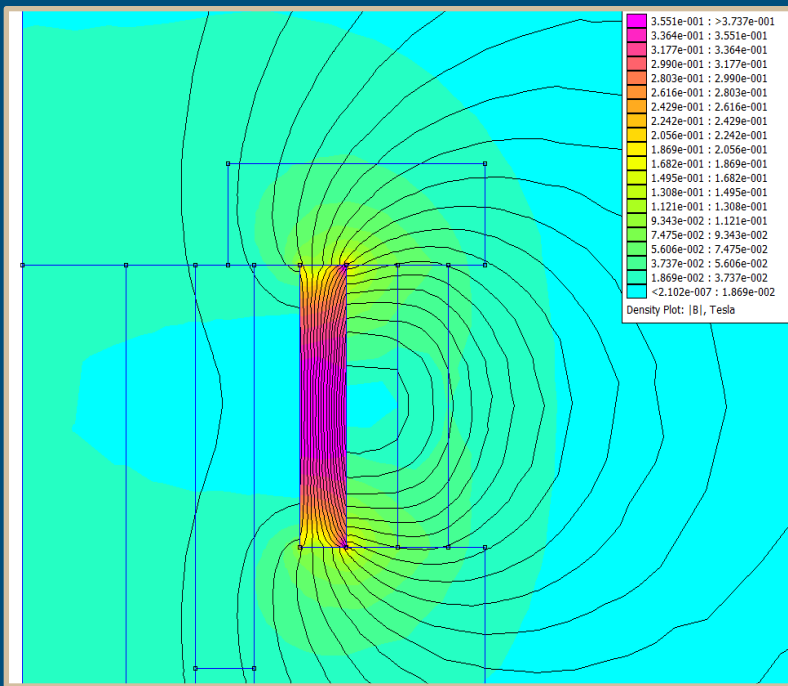
# Arc Discharge – 20 Hz



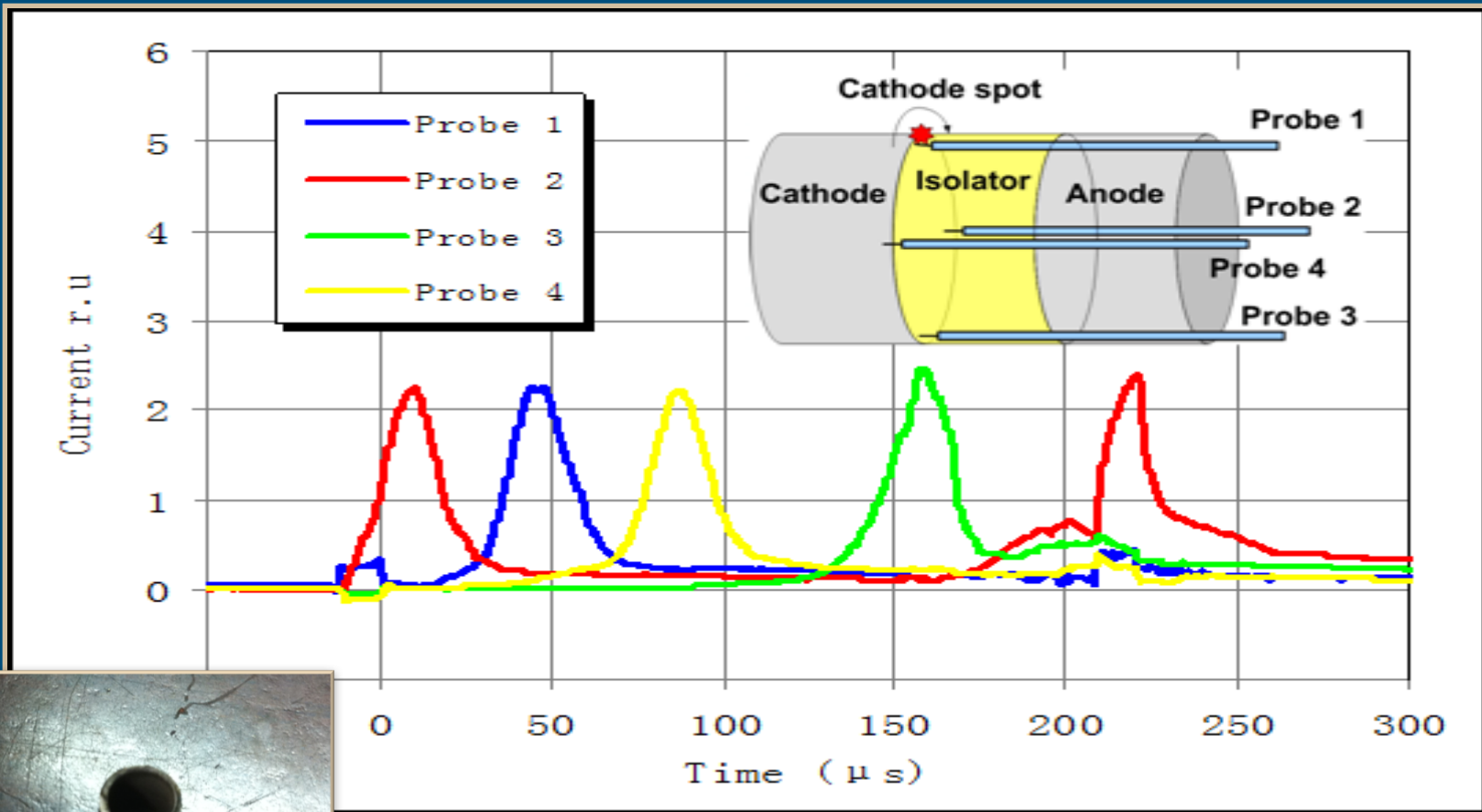


# Magnetic Field

- Without and with a magnetic field

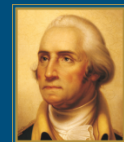
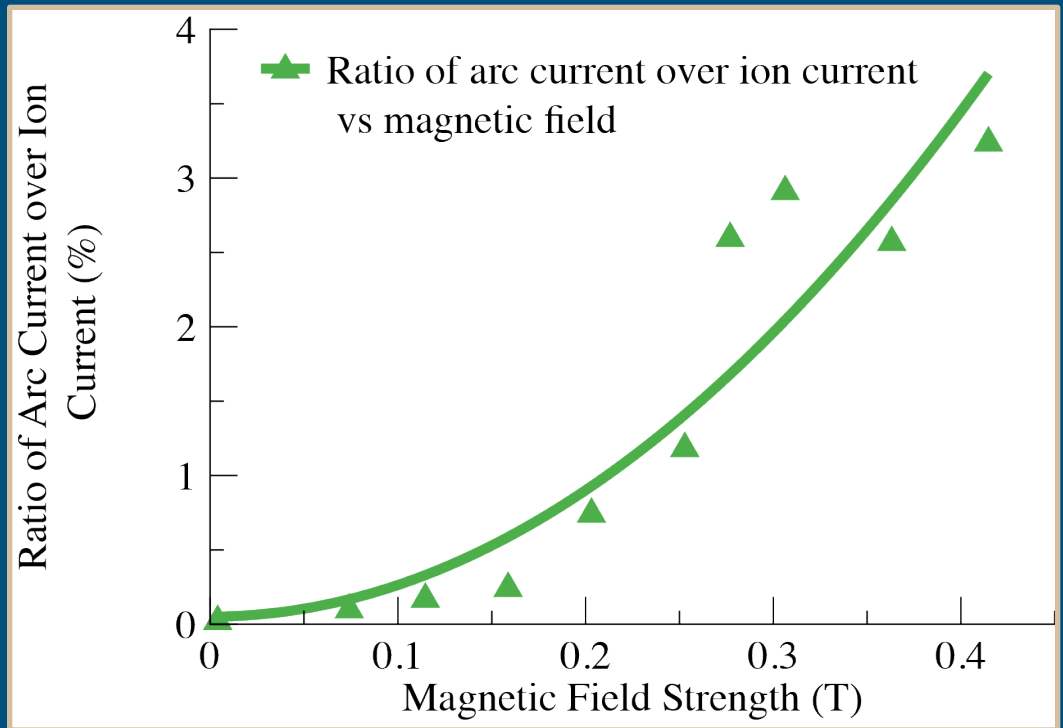
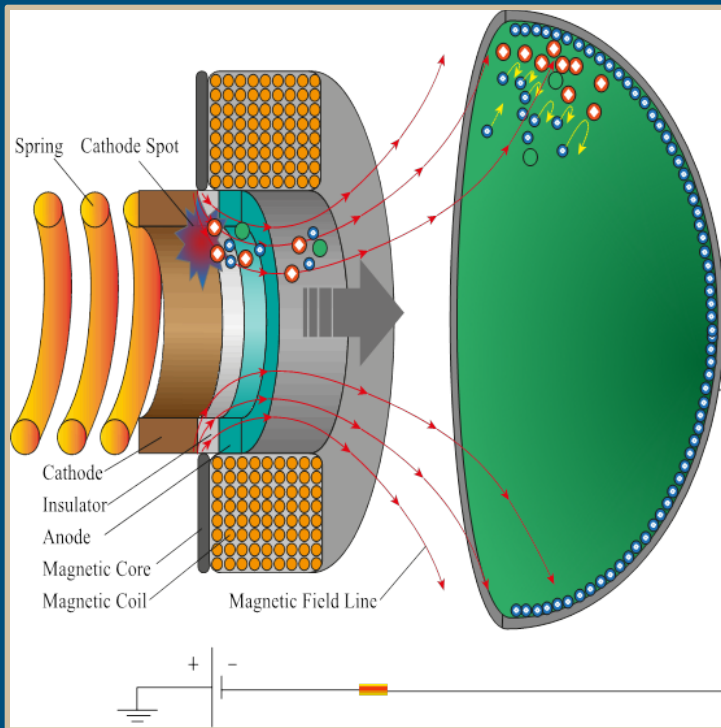


# Uniform Erosion



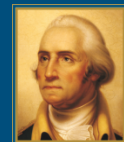
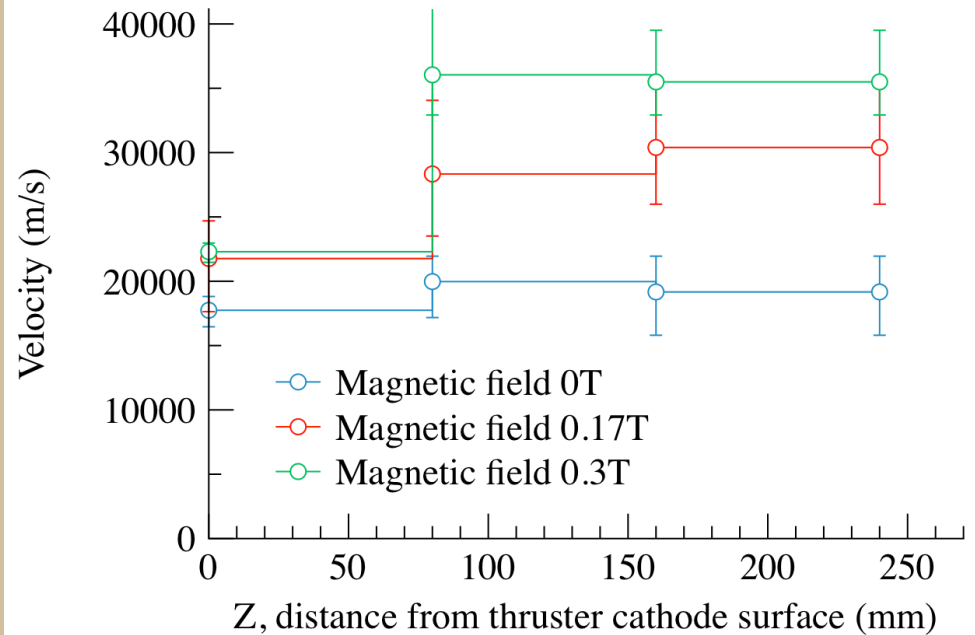
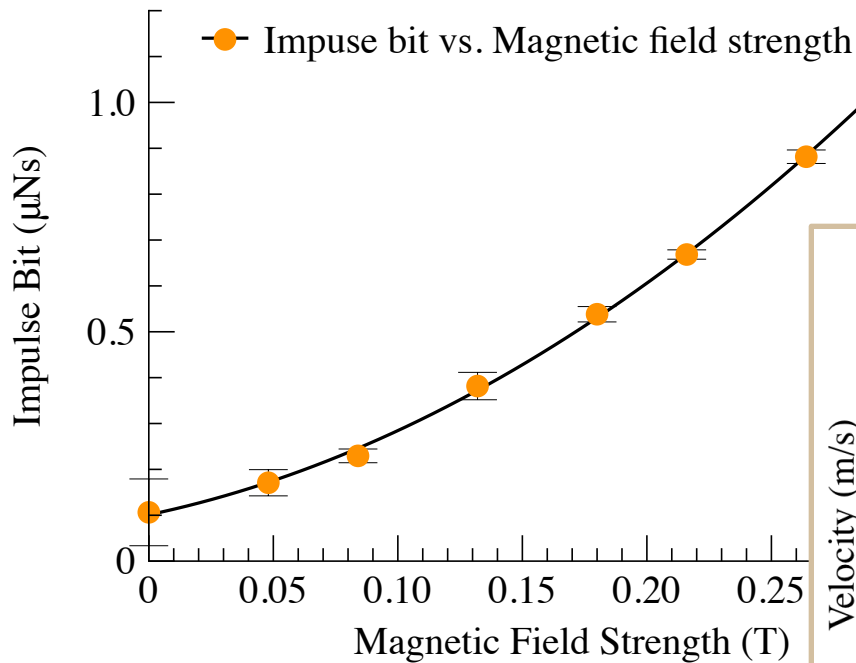


# Ion Current





# Impulse Bit and Velocity





# Development

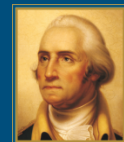
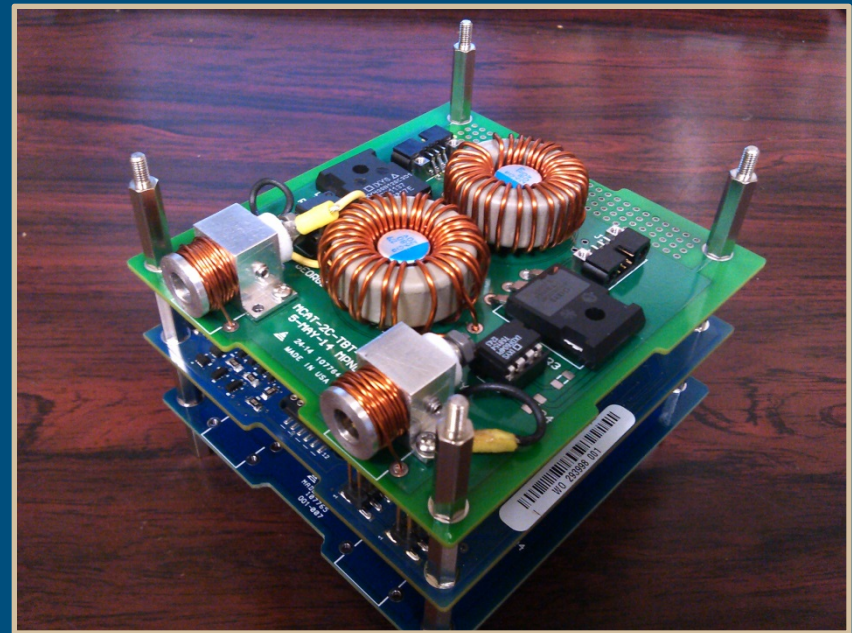
- **Left to Right:**
  - $\mu$ CAT Concept, Generation I, Generation III





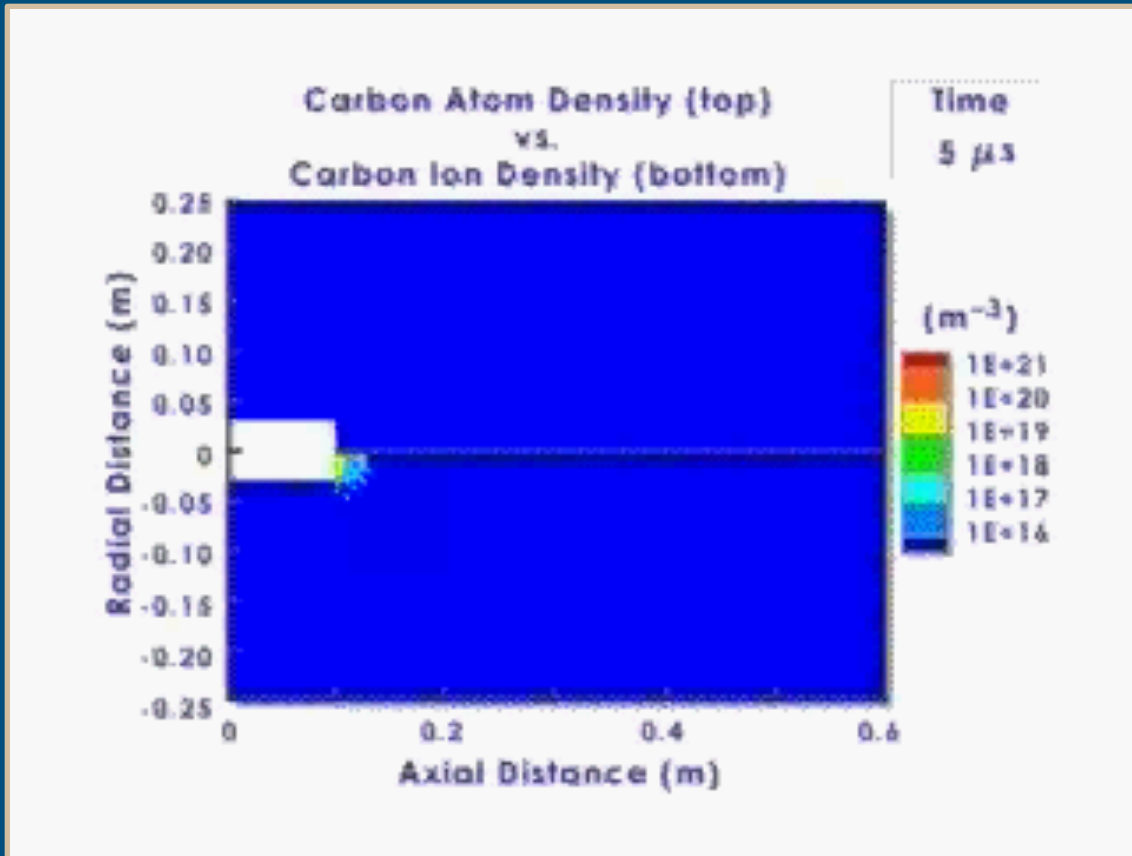
# Subsystem Properties

- **Impulse bit:**
  - 1 mN-s/pulse
- **Operating Frequency:**
  - 1 - 50 Hz
- **Specific Impulse ( $I_{sp}$ ):**
  - 2000 - 3000 s
- **Avg. power/pulse:**
  - < 0.1 Watts
- **Thrusters + PPU mass:**
  - < 150g





# Contamination

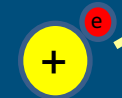


Fast  
Ion

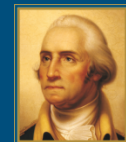
Slow  
Neutral



Slow  
Ion



Fast  
Neutral

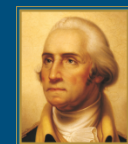
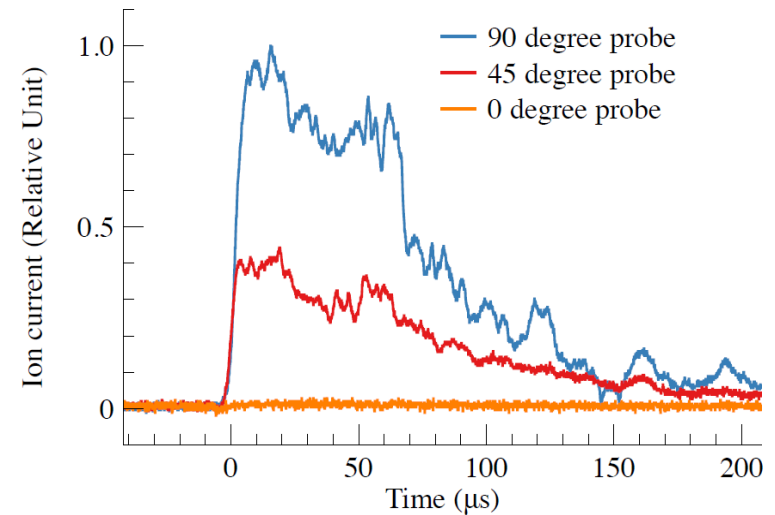
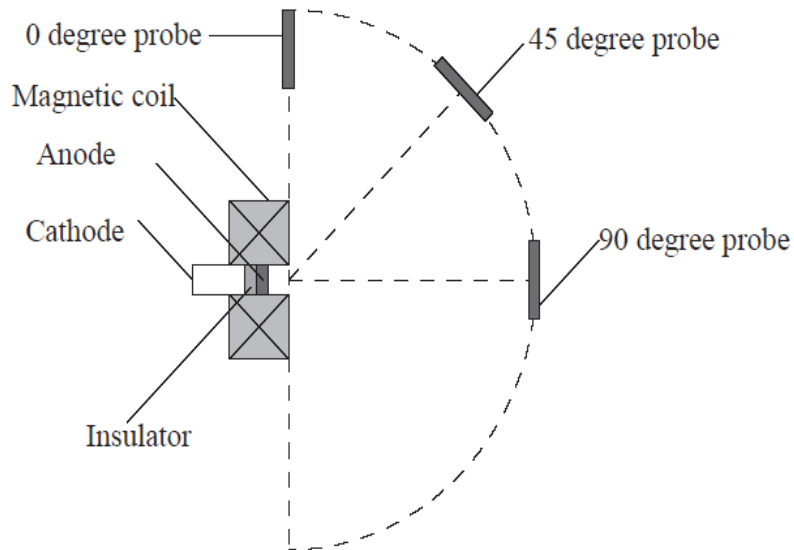






# Contamination

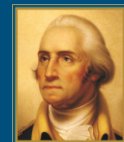
- Experimental setup and results





# Current Developments

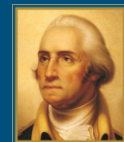
- **Single bus operation**
- **Component miniaturization**
- **Mass reduction**
- **Array/cluster operation**
- **EMI and RFI investigation**



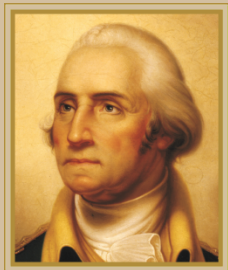


# Conclusions

- **Scalable electric propulsion**
- **Mission customizable**
- **No contamination**
- **Compact propulsion option for CubeSats**
- **Researching further optimizations**



# Questions?



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