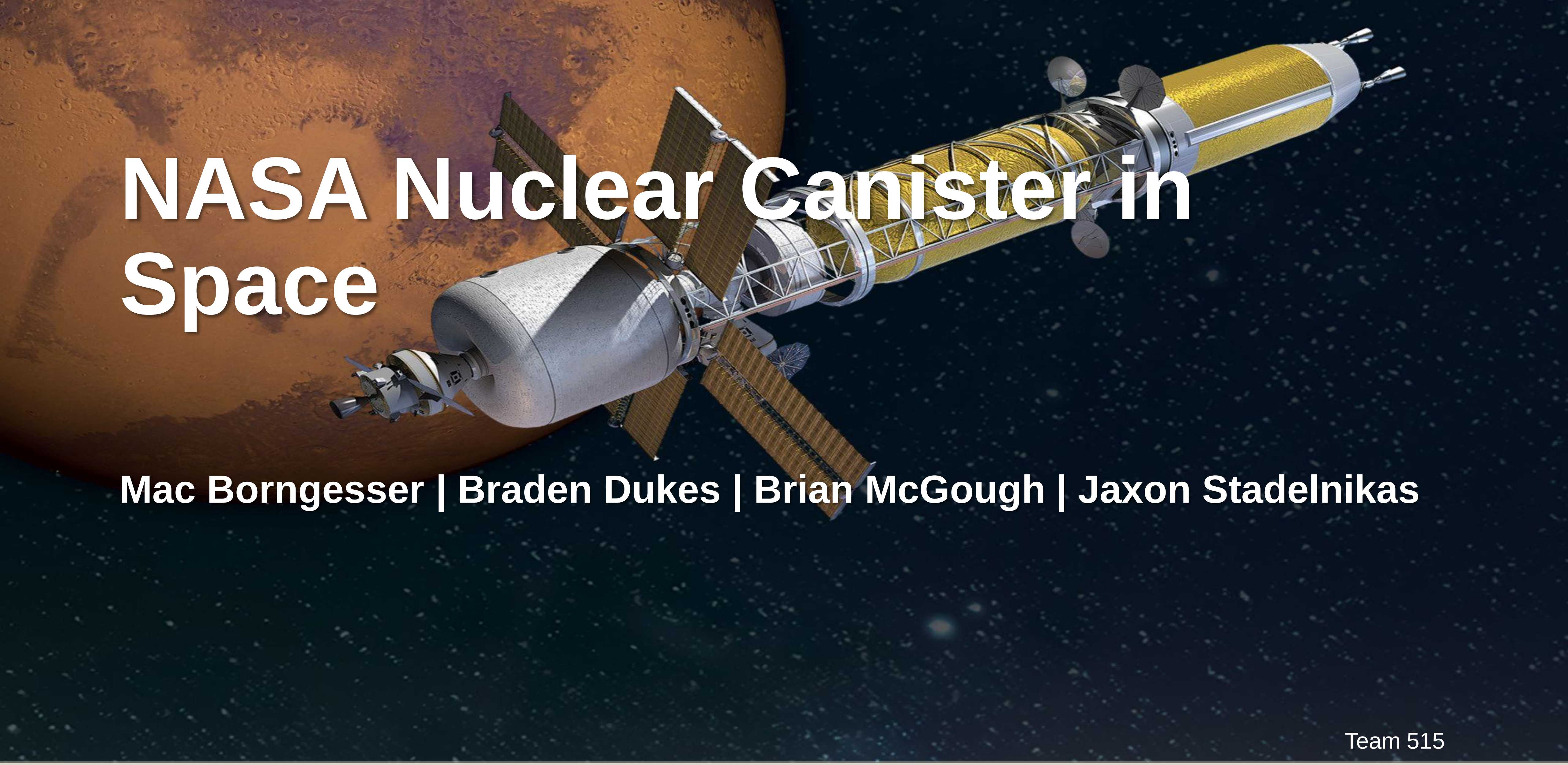
NASA Nuclear Canister in Space



Mac Borngesser | Braden Dukes | Brian McGough | Jaxon Stadelnikas

Team 515

Team Introductions

McAnarney Borngesser
Aeronautics Engineer

Braden Dukes
Materials Engineer

Brian McGough
Aeronautics Engineer

Jaxon Stadelnikas
Aeronautics Engineer

Sponsor and Advisor

+

Engineering Sponsor
Marvin Barnes
NASA Marshall Space Flight Center

Academic Advisor
Eric Hellstrom, Ph.D.
FAMU-FSU College of Engineering

Braden Dukes

Objective

The objective of the project is to develop and test a canister to go into Big BUSTER and the SIRIUS module to test nuclear fuel compounds for thermal nuclear propulsion systems in the Transient Reactor (TREAT).

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Project Background

NASA plans on going to Mars

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Nuclear Thermal Propulsion engines are very efficient

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Further research can improve efficiency of NTP engines

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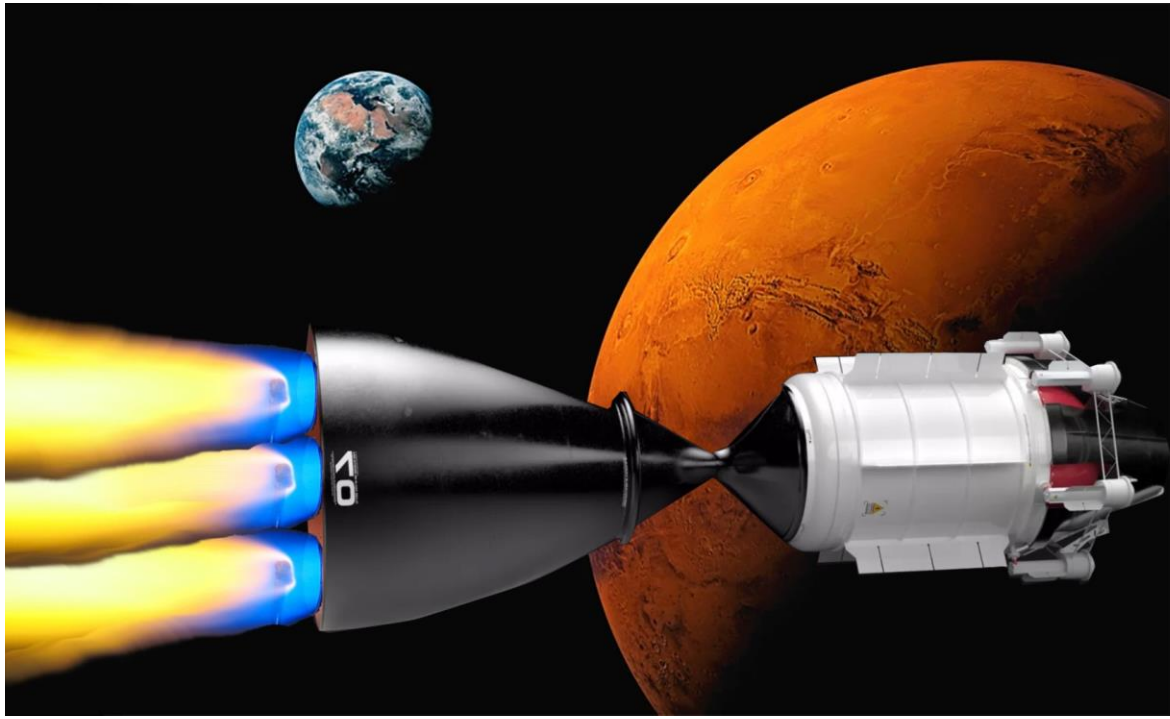
Develop a component for Big BUSTER and the SIRUIS module to test different fuels for NTP engines.



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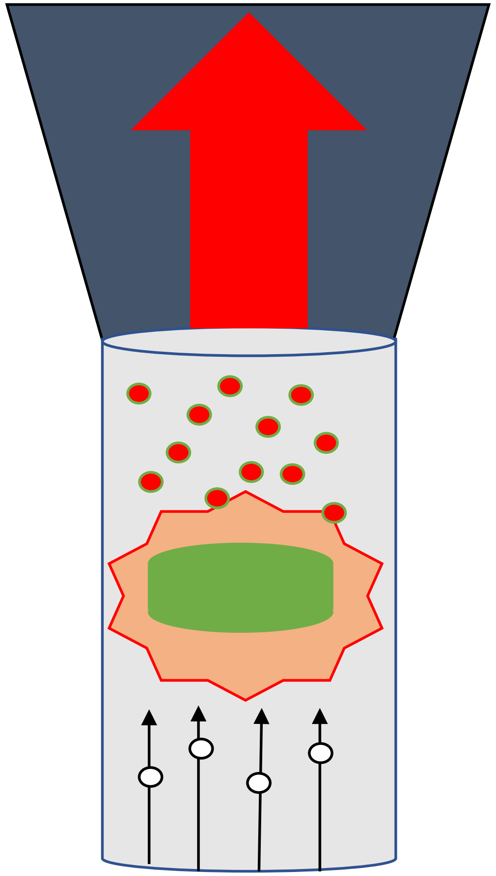
Nuclear Thermal Propulsion

Uses a uranium core to superheat liquid hydrogen to produce thrust.

Has a higher specific impulse than chemical rockets meaning that it can produce more thrust while weighing less.

The more heat generated by the uranium core the more specific impulse the engine can have.



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Assumptions

Big BUSTER and SIRIUS will function according to the specifications given by NASA

Weight will not be a constraining factor

Temperature range will not exceed 3000K

Radiation containment is done by Big BUSTER and the TREAT Reactor, not the canister

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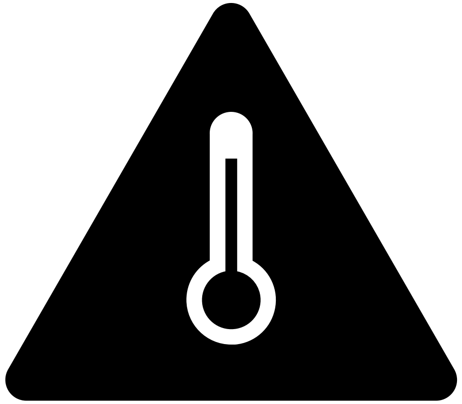
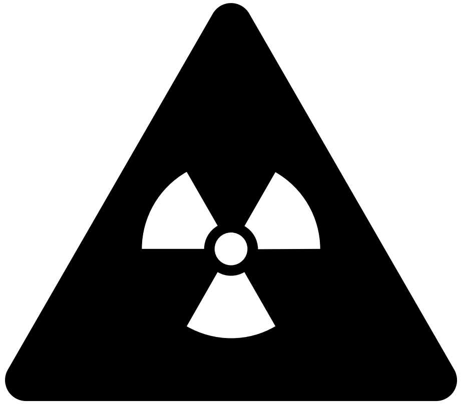
Key Goals

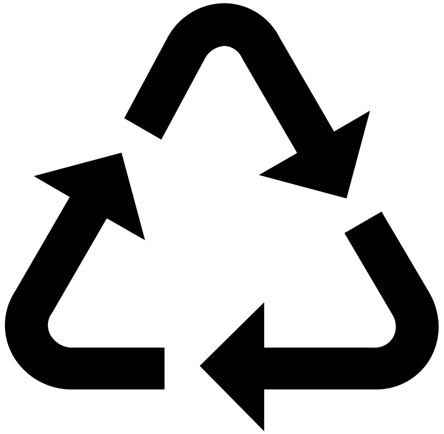
Temperature Resistant



Resist Effects of Radiation on the Canister



Reusability



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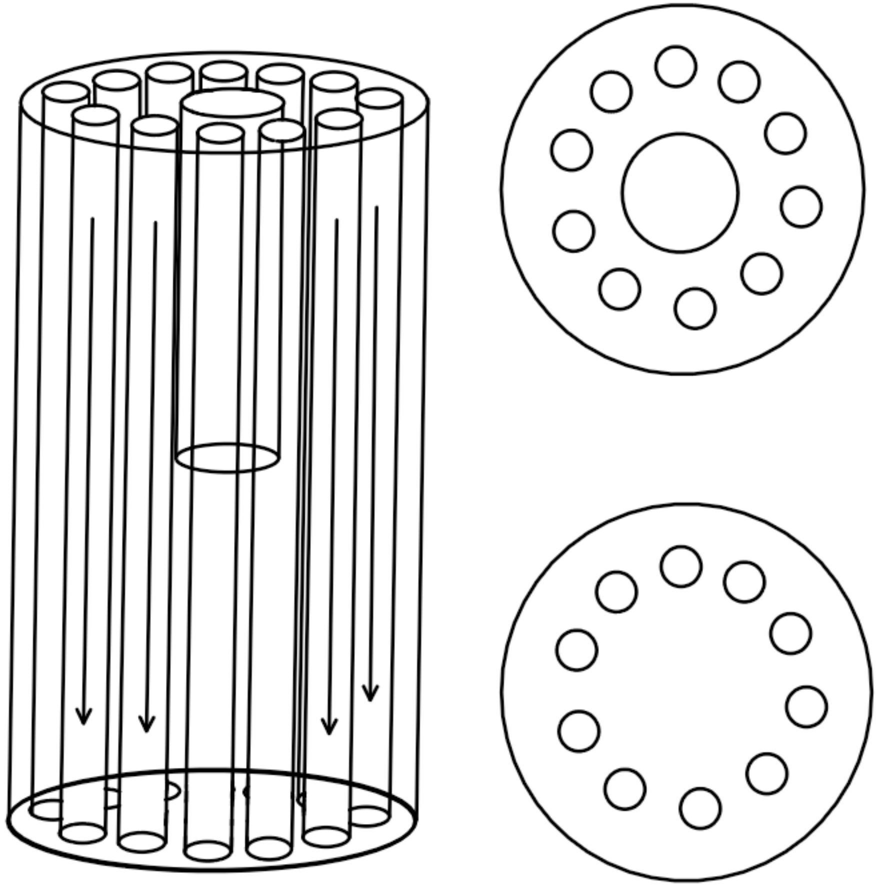
Concept 1

Base metal of Tungsten

Straight path for hydrogen to flow



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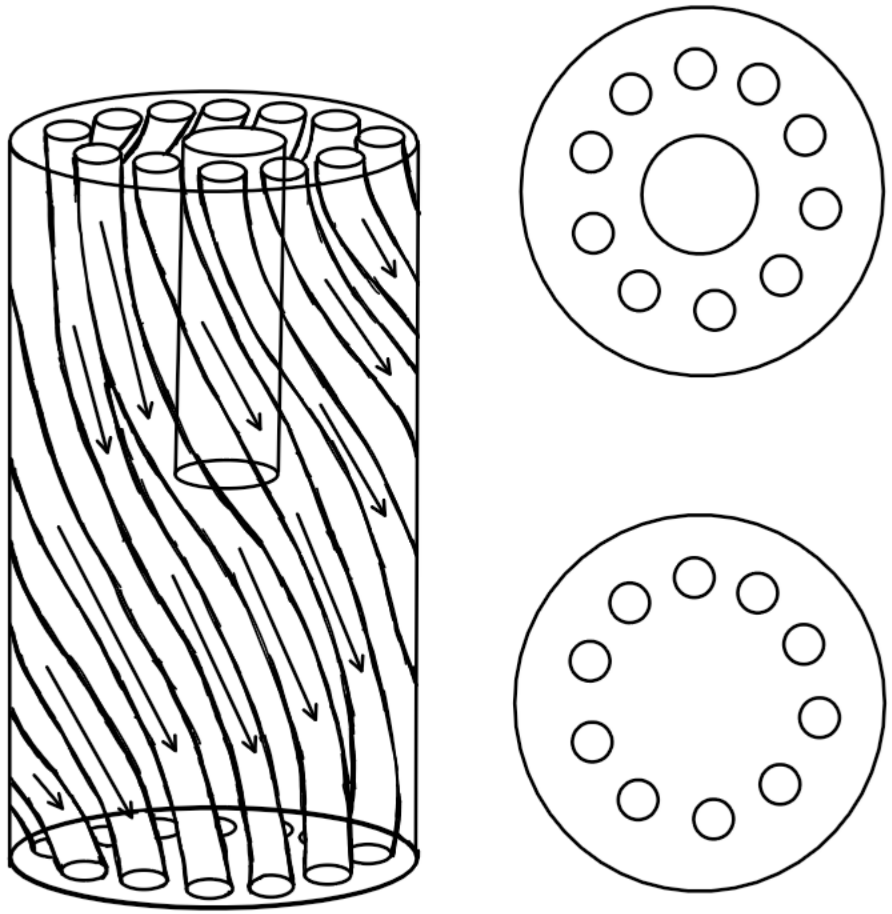
Concept 2

Base metal of Tungsten

Spiral path for hydrogen to flow



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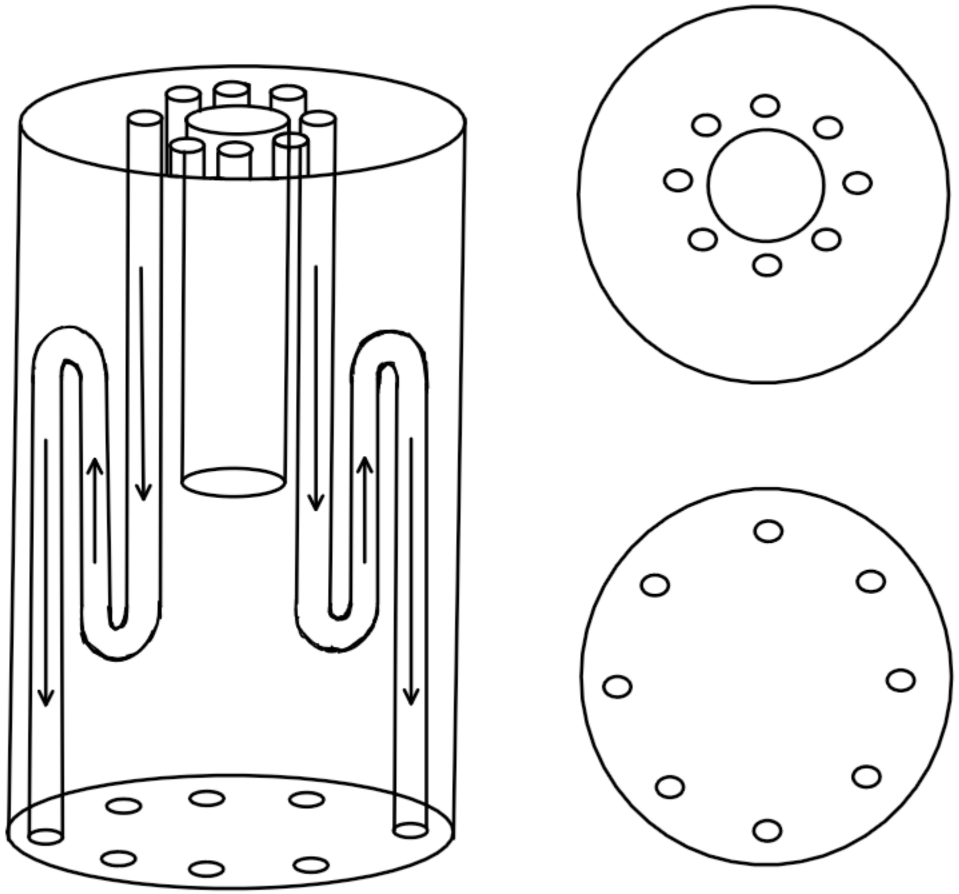
Concept 3

Base metal of Tungsten

Triple pass path for hydrogen to flow



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Concept Selection

Selected concept: Concept #1

Tungsten Base Metal Straight Paths

- Best suited for the project
- Integrates well with existing design

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Proposed Design

- Zirconium Carbide coated Tungsten
- 7.62cm (3in) diameter
- 0.635cm (0.25in) diameter flow channels [x28]
- 35.56cm (14in) length
- Pressure fitted variable size center hole adaptable to different uranium configurations

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Alternate Designs 1

Middle partition divides flow to test direct interaction of hydrogen and uranium.

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Alternate Designs 2

Similar to the first alternate, differentiated by isolated channels to test multiple fuels.

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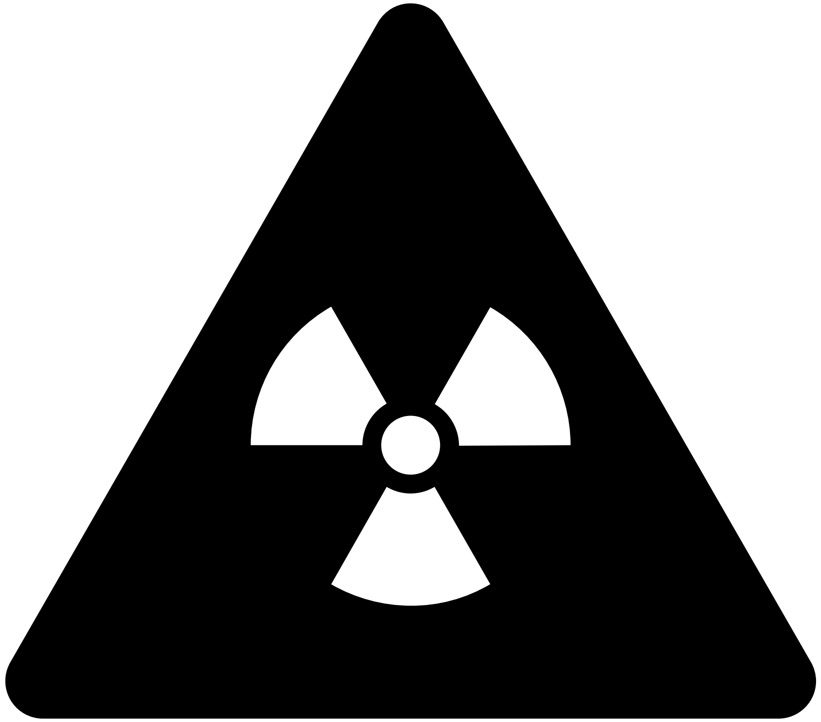
Experimental Design

Due to cost and resources an experimental design has been developed for testing.



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Proposed Design

74 $4f^{14}5d^{4}6s^{2}$
W
Tungsten
183.84

99.99% Pure Tungsten

1 $1s^{1}$
H
Hydrogen
1,008

Hydrogen Propellant

92 $5f^{3}6d^{1}7s^{2}$
U
Uranium
238.029

Uranium Fuel

Experimental Design

13 $3s^{2}\,3p^{1}$
Al
Aluminium
26.982

Aluminum 6061

18
Ar
Argon
39.948

Argon Propellant

Heating Element "Fission Product"

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Base Material

Aluminum 6061 has a similar thermal conductivity to that of tungsten ($\approx 170 \frac{W}{mK}$)

Aluminum 6061 is readily available and easily machinable fitting into the budget allowing for a full scale test.

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Propellent

18
Ar
Argon
39.948

- Argon is a noble gas allowing for use of ideal gas law.
- Argon is nonreactive making it safer to work with.
- Argon is also abundant in the atmosphere making it easier to obtain.

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Fuel

Uranium is too dangerous, and we do not have the proper facilities to store and test.

The heating element can screw into our canister keeping it secure.

The heating element can reach high temperatures in a concentrated area.

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Prototype

7in tall 3-D printed "mock" canister

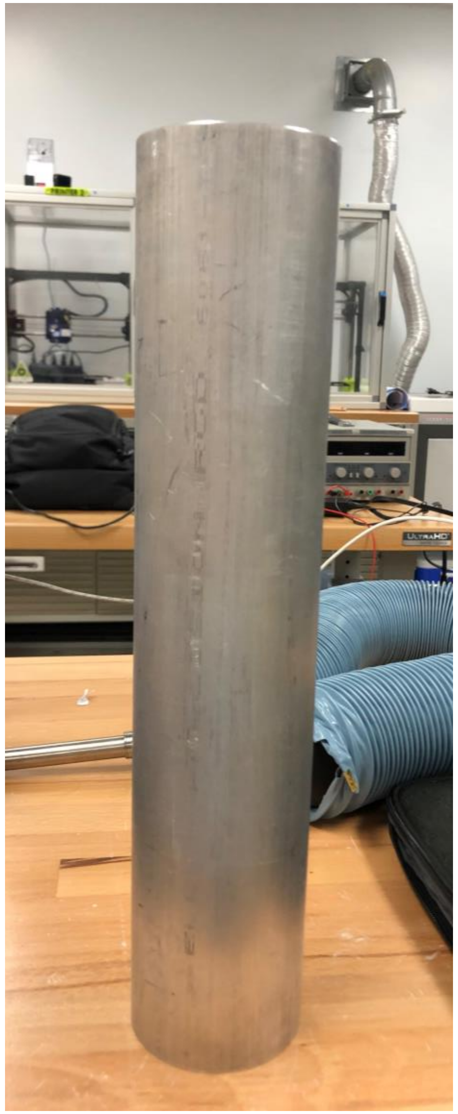
- 3.81cm (1.5in) diameter
- 28 flow channels
  - 0.316cm (0.125in) diameter flow channels

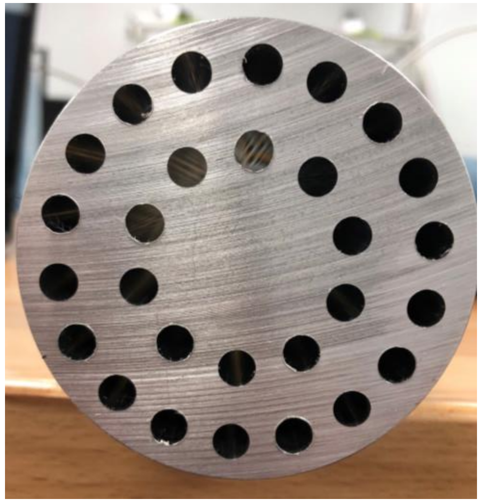
Brian McGough

Prototype

Aluminum 6061 14in machined canister

- 7.62cm (3in) diameter
- Heating element
- 28 flow channels
  - 0.635cm (0.25in) diameter flow channels





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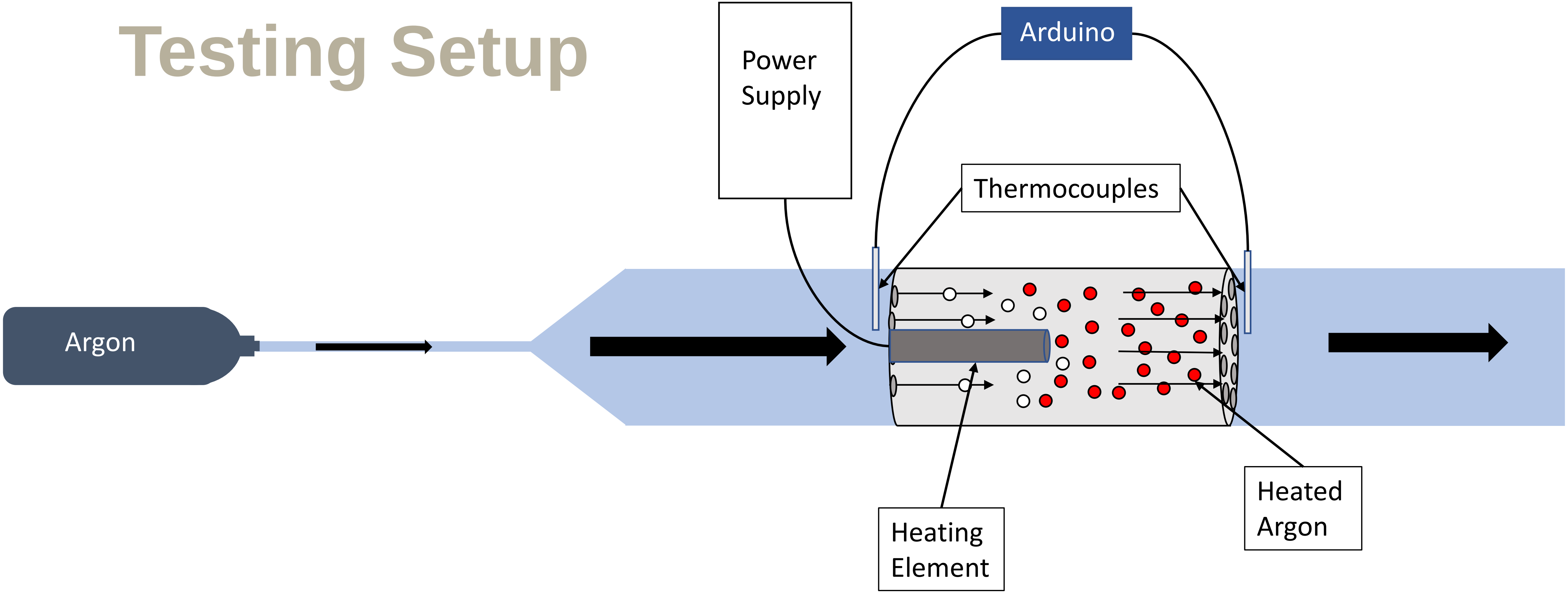
Testing Setup



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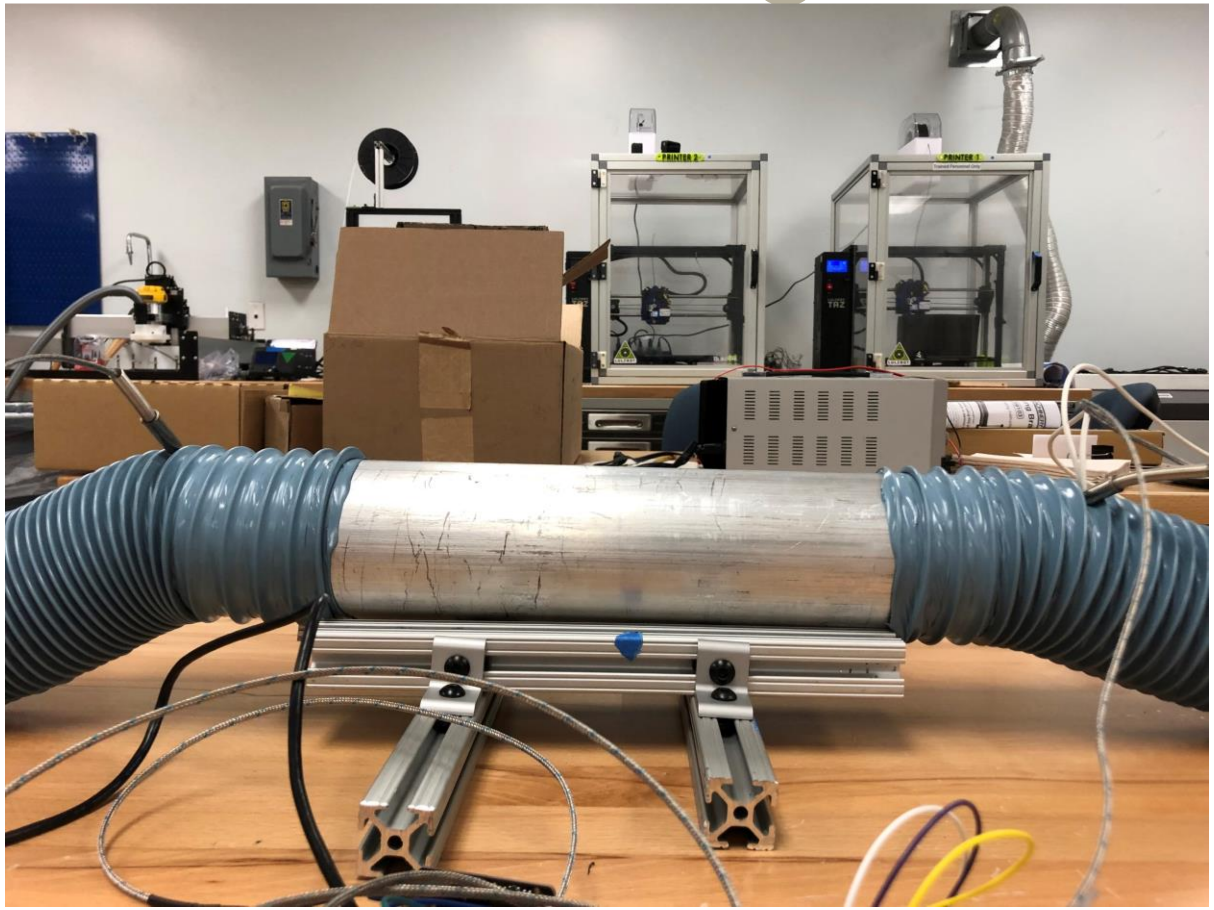
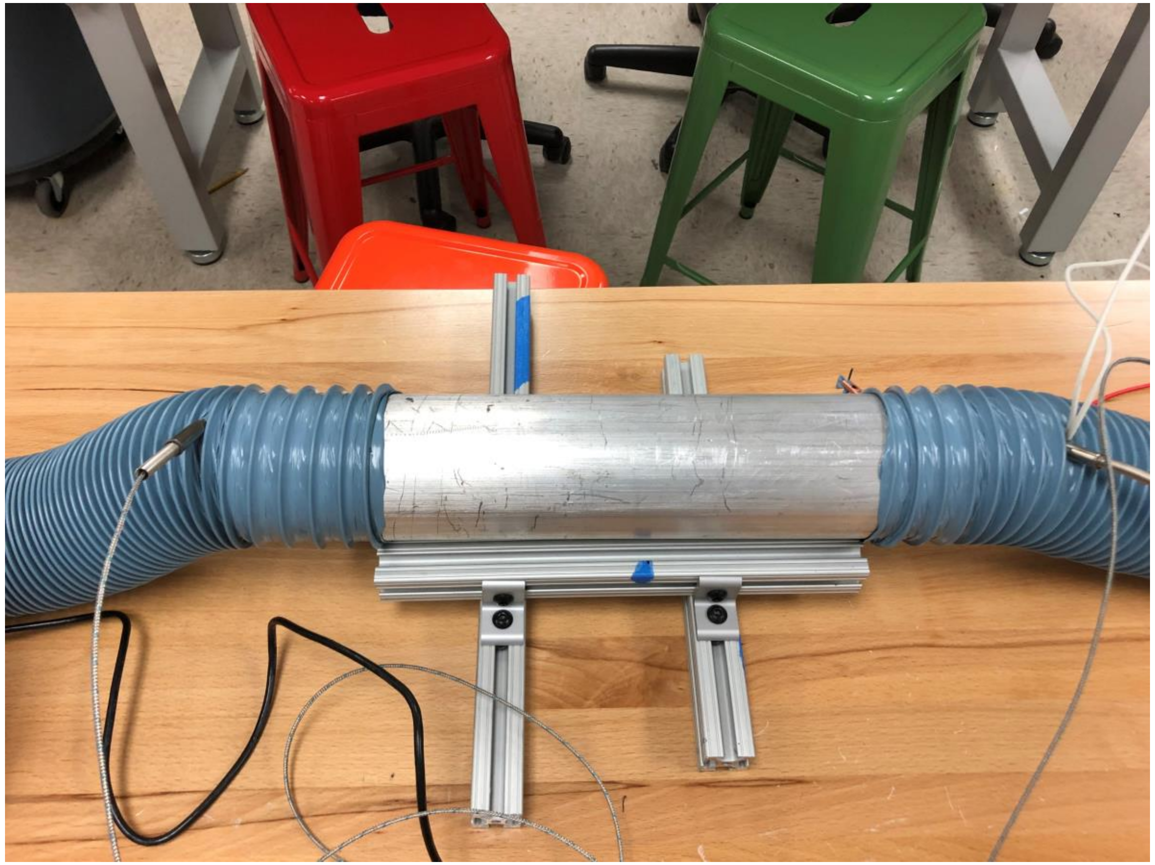
Part Testing





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Validation

- Use the ideal gas law to calculate pressure and mass flowrate
- Then velocity at the entrance and exit can be calculated
- The results will then be scaled for higher temperatures

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Future Work

Testing

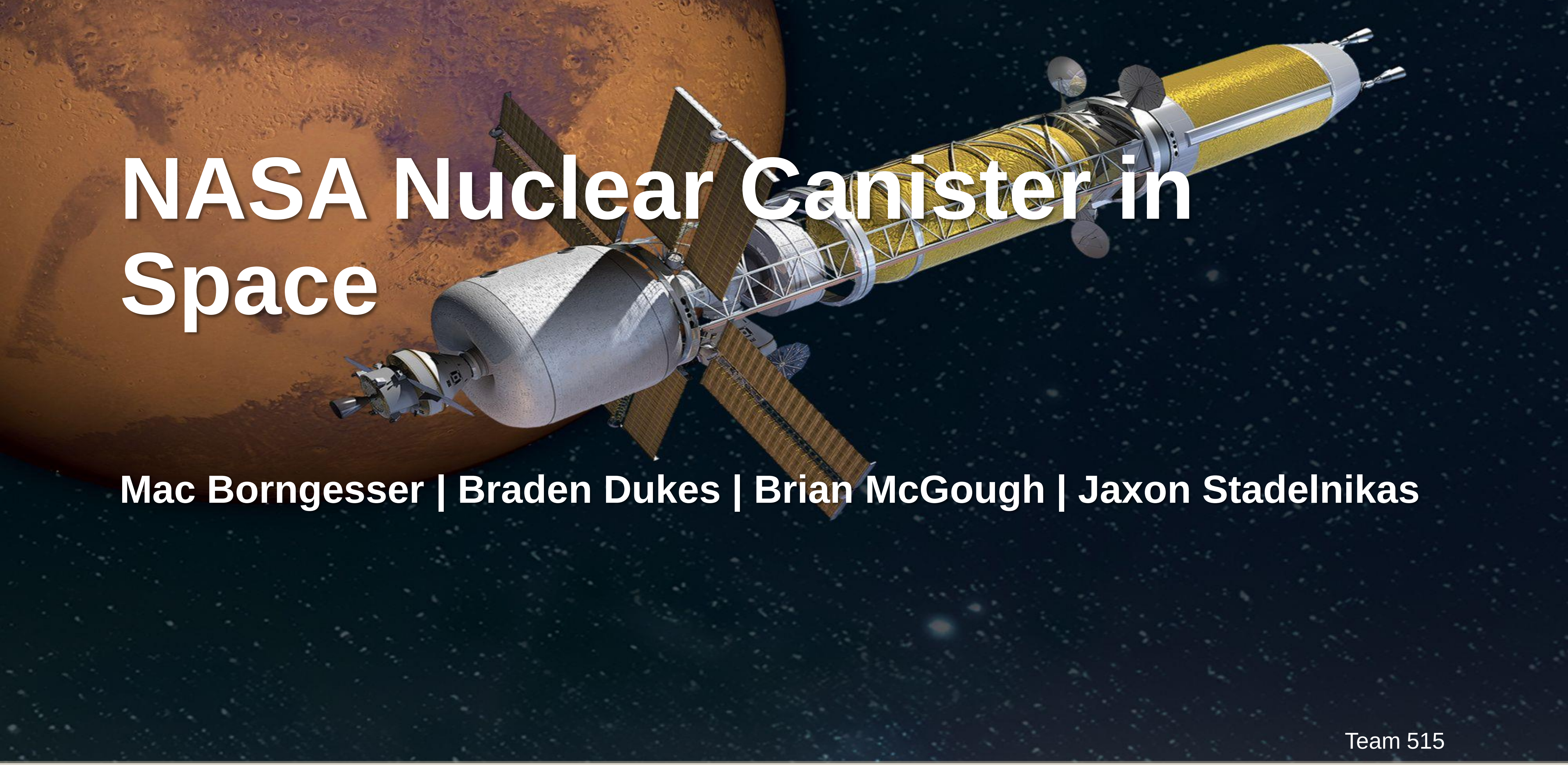
- Final Assembly
- Perform Experiment

→

Validation

- Confirming and comparing with expected results

Brian McGough



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