MLI Pressure Sensor
Design Review 4

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Introduction

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Treasurer

Project Recap

Presenter: Jordan Eljaiek

Background Information

- Pressure sensor must interfere as little as possible with its surroundings while measuring residual gas within a multi-layer radiation blanket.
- NASA Marshall Space Flight Center (MSFC)
- Advisors:
  - Jim J. Martin, James W. Smith
  - Dr. Wei Guo

Multi-Layer Insulation (MLI)

- Cryogenic tanks use multi-layer insulation blankets to protect from thermal radiation during time in space
- Composed of 30 or more layers of alternating Double Aluminized Mylar and polyester fabric mesh placed in a cryostat.

Figure 1: Multi-layer insulation blankets

MLI Pressure Sensor

- Develop a pressure sensor that can measure the vacuum within interstitial areas.
- After vacuum, if residual gas still remains between each layer, sensor should read a pressure reading different than the pressure reading within the vacuum chamber.

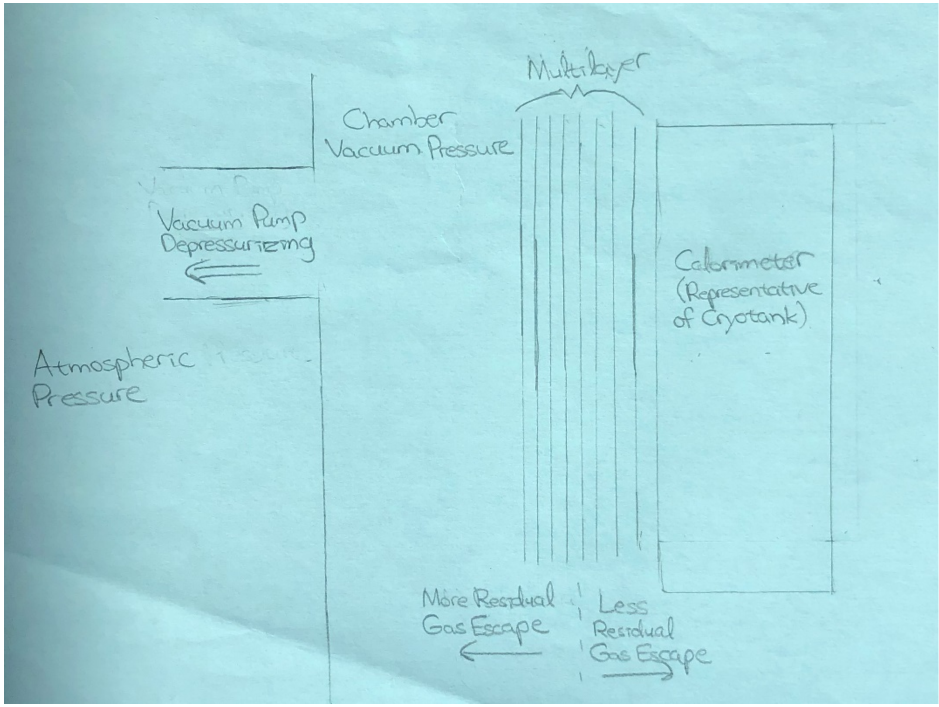

Figure 2: Pressure Gradient Illustration

Project Constraints

1. Measure from 760 torr to 10e-4 torr.
2. Operate at temperatures as low as 77K.
3. Sample at least once every second.
4. Avoid interference with MLI components.

Hot-Filament Ion Gauge

Operation

- A stream of electrons is emitted from cathode.
- If there is gas present, electrons will strike molecules and knock out electrons, creating a larger current.
- Pressure is proportional to the amount of gas present.

Why Hot-Filament Was Chosen

- The ion filament sensor works at extreme vacuum pressures down to 10e-3 torr.
- There is no mechanical dependency on strain that could be interrupted by temperature changes.
- Additional benefits include minute size, high sampling rate, and high resolution.

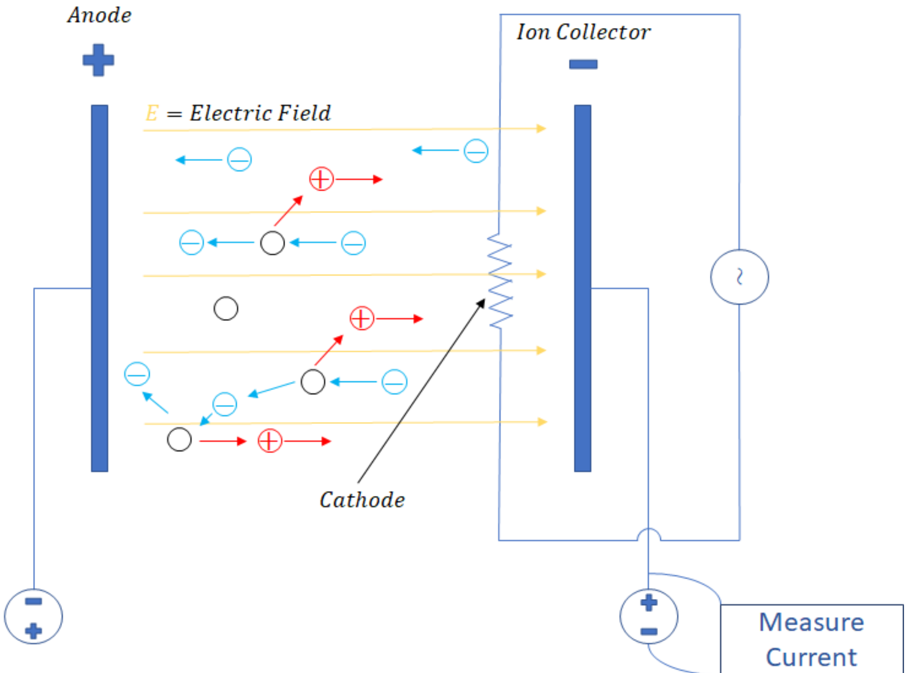

Figure 3: Schematic of Ion Filament Design.

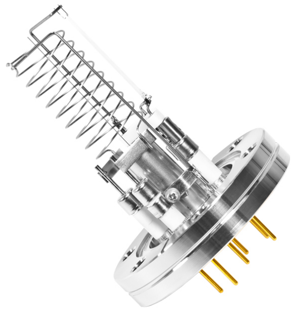

Figure 4: Standard Industry Ion Gauge.

Transition to Cold Cathode Gauge

- The Hot-Filament ion gauge met the constraints of the project scope.
- Operating temperature of the filament would release too much local heat into the measured area.
- The filament typically operate in a temperature range from 1,800ºC to 2,500ºC.
- Such high, concentrated heat would increase the pressure in the measured area.

Scope Alteration

- Originally Scope:
  - Measure from 760 to 10e-4 torr.
- New Altered Scope:
  - Measure from 10e-3 to 10e-5 torr.
- Pressure in the blanket typically will get to at least 10e-3 torr.
- The Pirani gauge is utilized for approximately 760 to 10e-3 torr.

Cold Cathode Ion Gauge (CCG)

Benefits	Disadvantages
Generates a minimal amount of heat.	Cost valuable time to switch focus.
Typically measures higher vacuum with more accuracy.	More complicated physics to research and design around.
Requires less parts.	

Electric Field in an CCG

- Electric field and magnetic field work together to trap electrons.
- Anode has a positive charge whereas the cathode has a negative charge.
- Electrons will be emitted and accelerated from the cathode to the anode.
- High initial voltage difference (at least 2,000 V) across the anode and cathode will produce a plasma.
- The plasma will complete the circuit and act as a resistor.
- Ionized molecules will be attracted to the cathode and will neutralize.

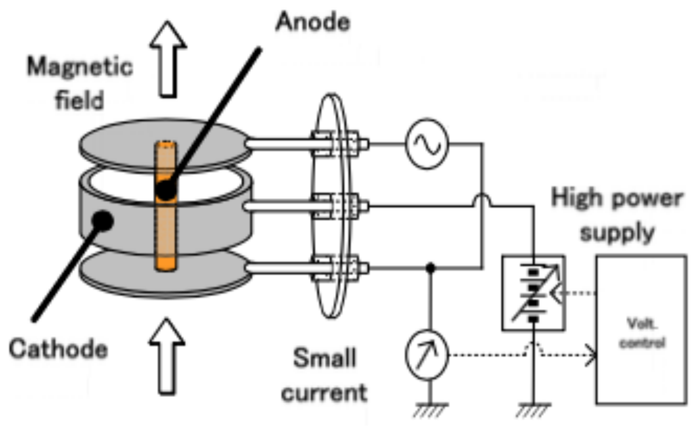

Figure 5: Diagram of Cold Cathode gauge theory.

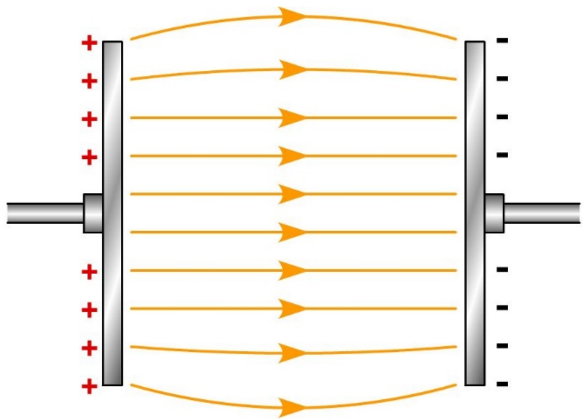

Figure 6: Behavior of electrons between plates.

Magnetic Field in a CCG

- Magnetic field typically used is 1-2 kG.
- Magnets are oriented so that the field it parallel to the orientation of the anode (perpendicular to the electric field).
- Will increase the path-length of electrons and thus the probability that they will collide with molecules and ionize them.

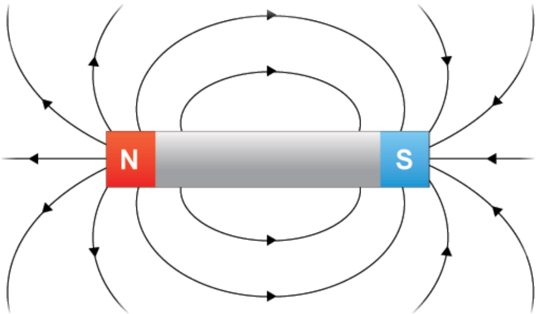

Figure 7: Magnetic field behavior.

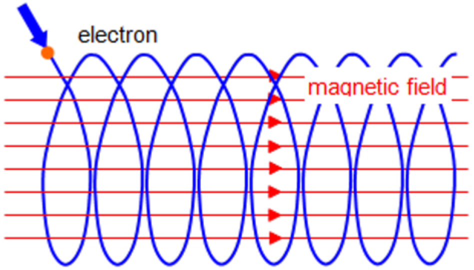

Figure 8: Behavior of an electron around a magnetic field.

Gauge Design, Reference Gauge & Supporting Hardware

Presenter: Qinjie Chen

Design Features

- Inverted magnetron ion gauge provided by NASA.
- Will utilize the tungsten anode and diode.
- Our design will mimic cross section of this sensor.
- We will likely lose sensitivity but not enough to make the data measured useless.

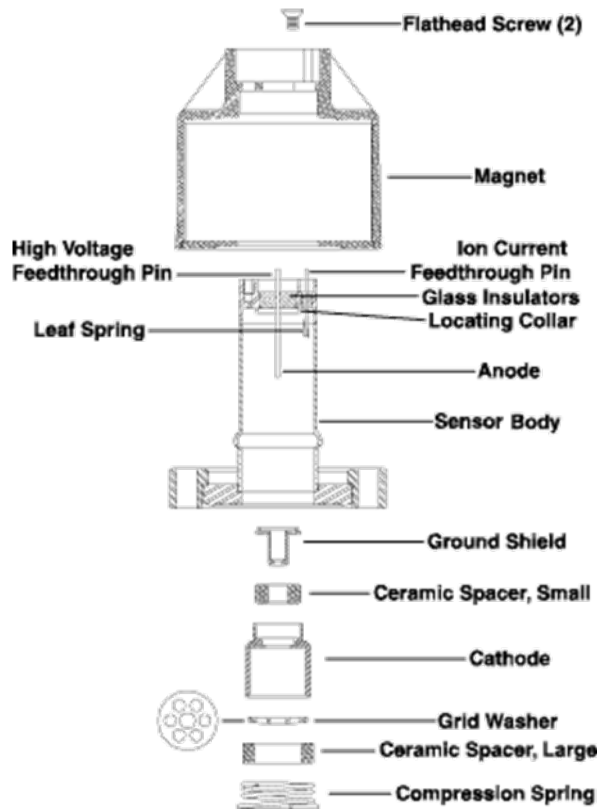

Figure 9: Exploded view of gauge supplied by NASA.

Design Features

- Two cathodes used to double plasma length.
- Anode utilized for electron distribution.
- Two Neodymium magnets orientated to create a magnetic field.
- Wire soldered to anode provides voltage.
- Wire soldered to cathode returns current reading.

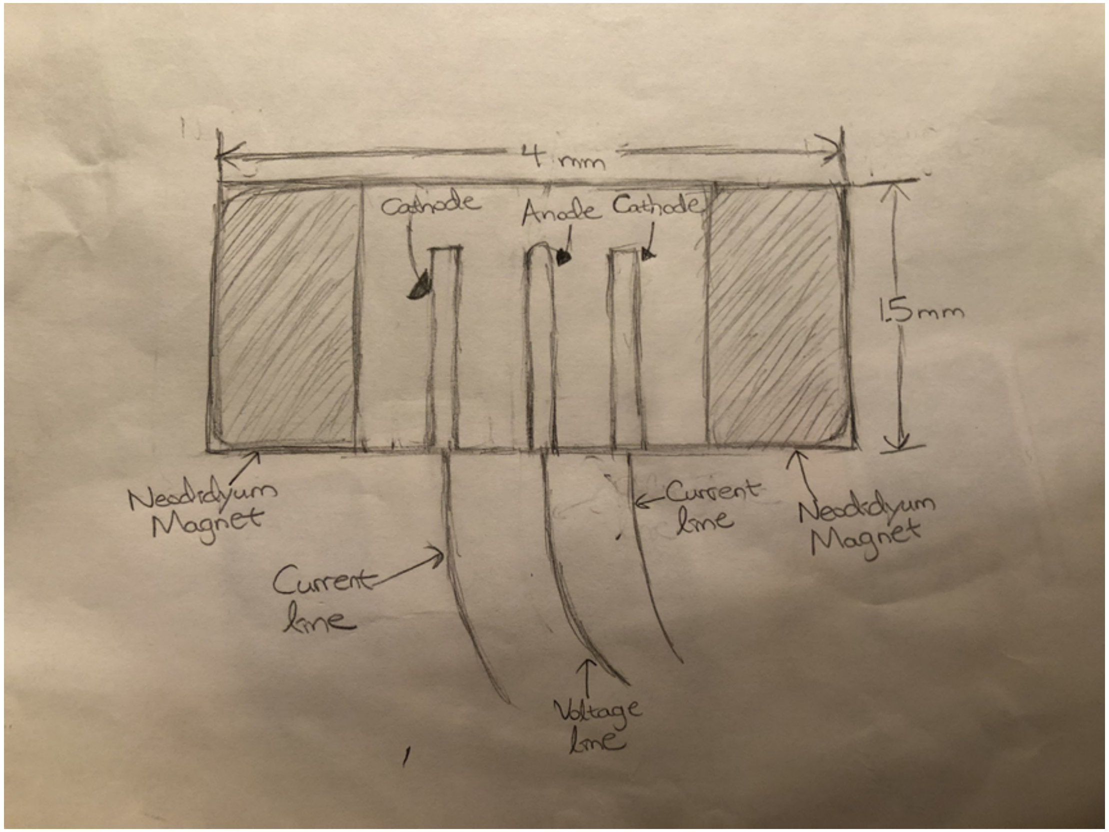

Figure 10: Schematic of the ion gauge assembly.

Pirani Thermal Conductivity

- A Pirani gauge, supplied by NASA will be used as a reference gauge.
- Utilizes the thermal conductivity of gases.
- Operates on a Wheatstone bridge platform.
- One filament exposed to atmosphere, other filament remained in vacuum.
  - Filament's sensitivity to pressure change shows in its resistance fluctuations.
- Bottom two resistors set equally to one another.
- Voltage across Wheatstone bridge will correlate with pressure reading.

Pirani Diagram

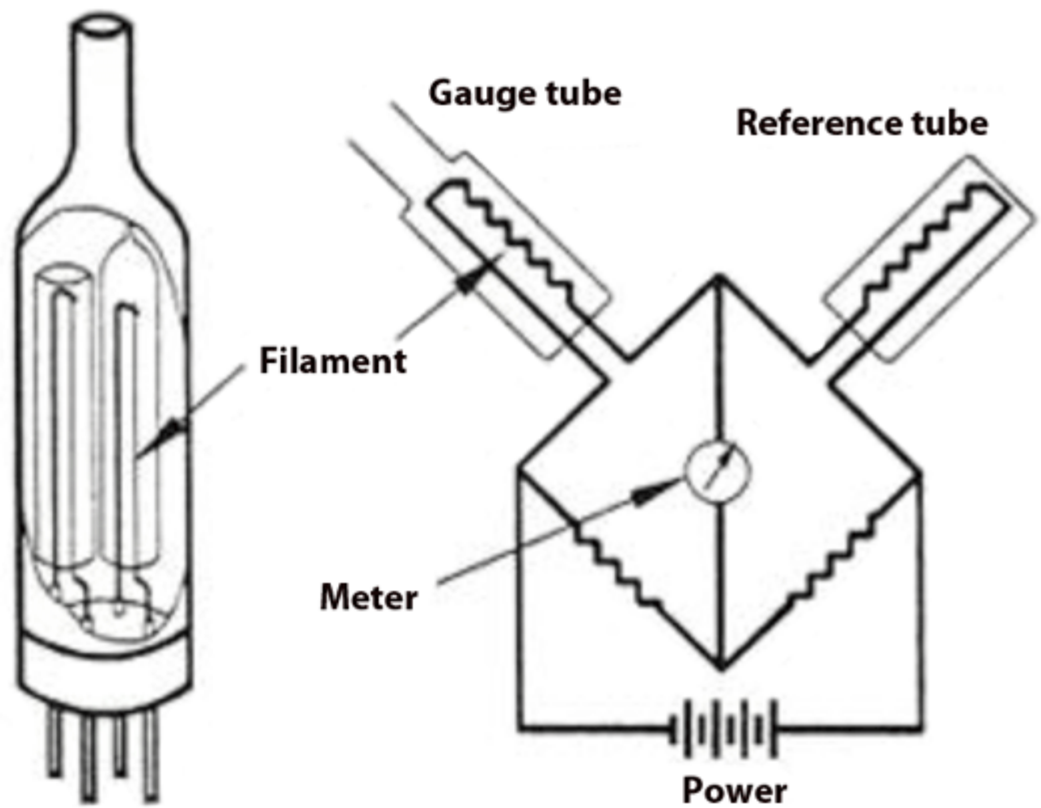

Figure 11: Pirani Thermal Conductivity Wheatstone

Design Features (Cont.)

- Cold Cathode Ion Gauge connected to reliable DC Voltage box.
- CCG Meter is responsible for supplying voltage to the anode.
- Able to achieve at most 300 V.

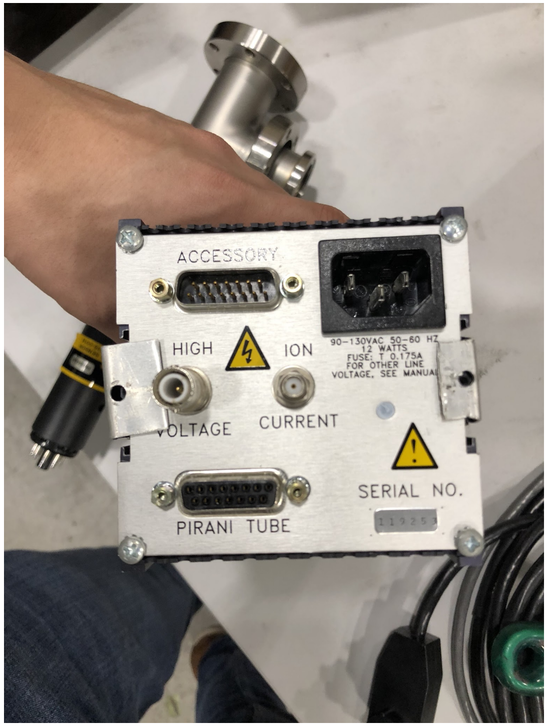

Figure 12: Power supply and analog data collector.

Design Features (Cont.)

- Cold Cathode Gauge Meter is connected to the Voltmeter and LabVIEW GBIB-USB-HB (DAQ Box)
- The Voltmeter will read the amount of voltage.
- Will convert from analog data to digital data.
- GBIB-USB-HB responsible for transferring the voltage reading.
- GBIB-USB-HB is connected to a laptop with LabView.
- Proper calibration will be ensured with a reference pressure reading from a Pirani gauge.

Figure 13: Voltmeter for data conversion.

Testing Chamber & Part List

Presenter: Benjamin Hallstrom

Vacuum Test Chamber

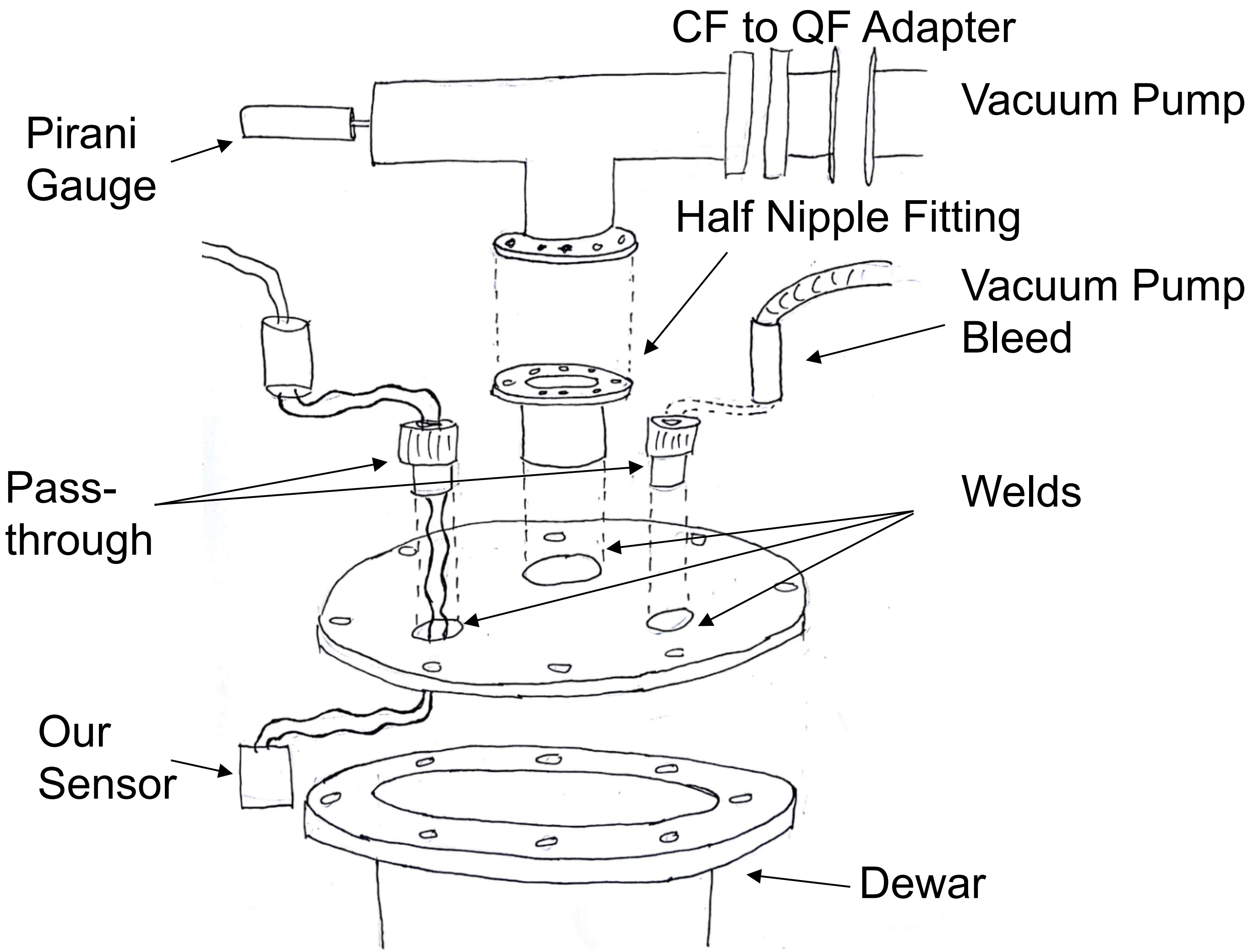

Figure 14: Vacuum Test Chamber

Vacuum Test Chamber

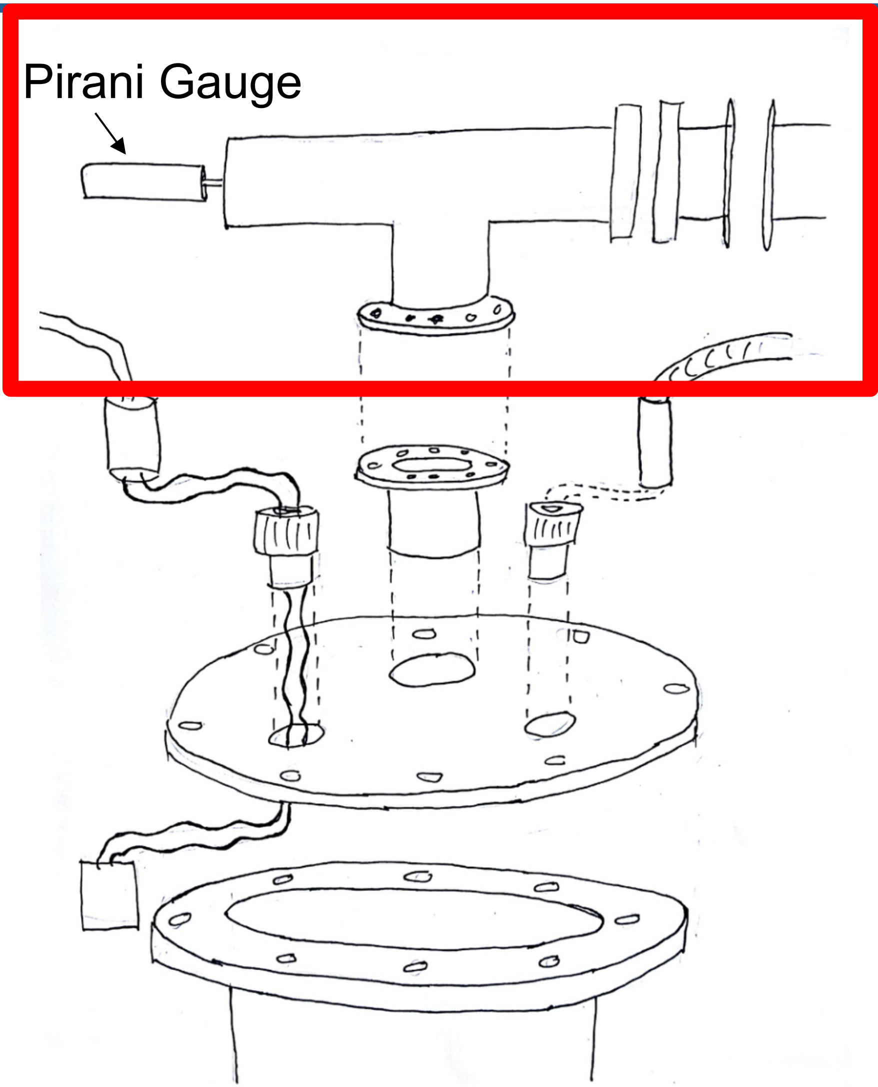

Figure 14: Vacuum Test Chamber

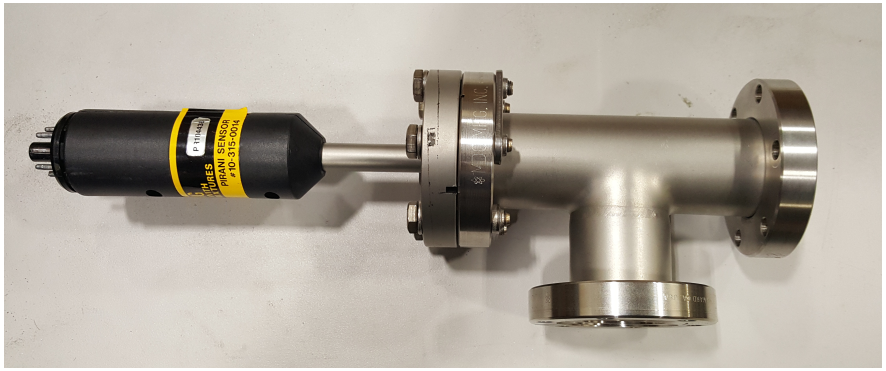

Figure 15: Pirani Gauge and T-bar connection supplied by NASA

Vacuum Test Chamber

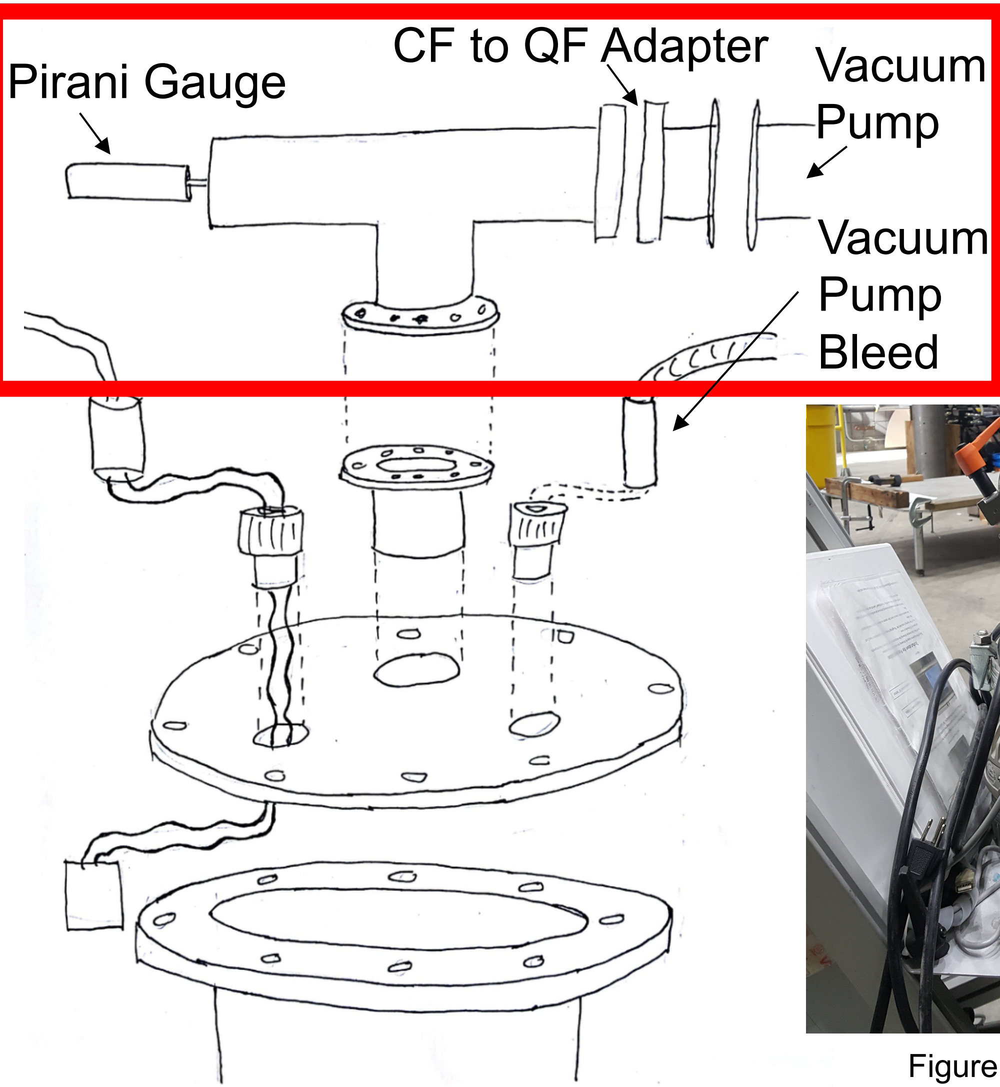

Figure 14: Vacuum Test Chamber

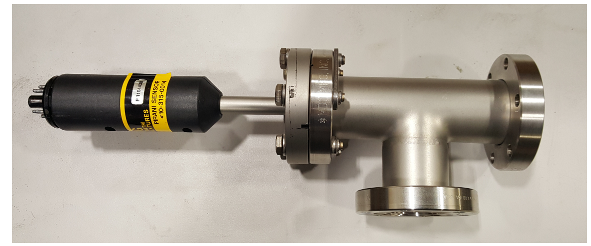

Figure 15: Pirani Gauge and T-bar connection supplied by NASA

Figure 16: CF/KF adapter

Figure 17: Vacuum Pump

- 2 ¾" Conflat Flange (CF)
- KF-25, KF-40, or KF-50.

Vacuum Test Chamber

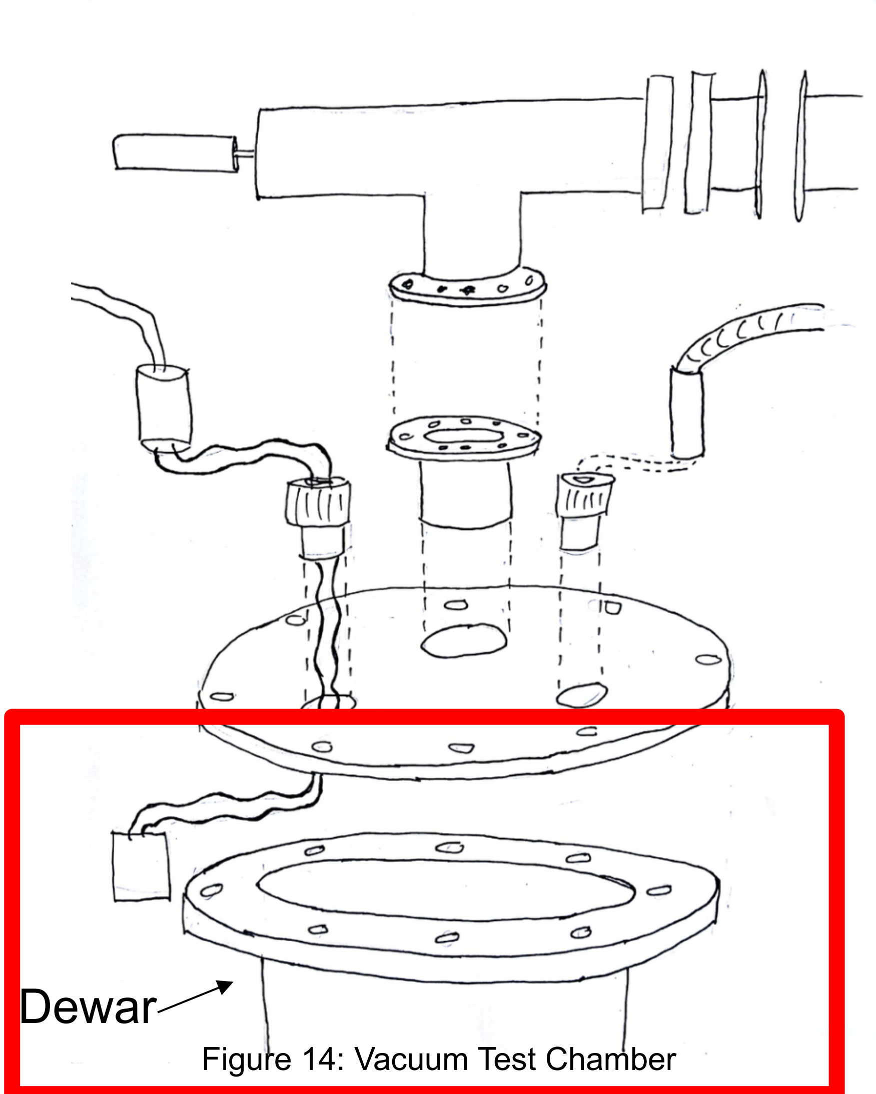

Figure 14: Vacuum Test Chamber

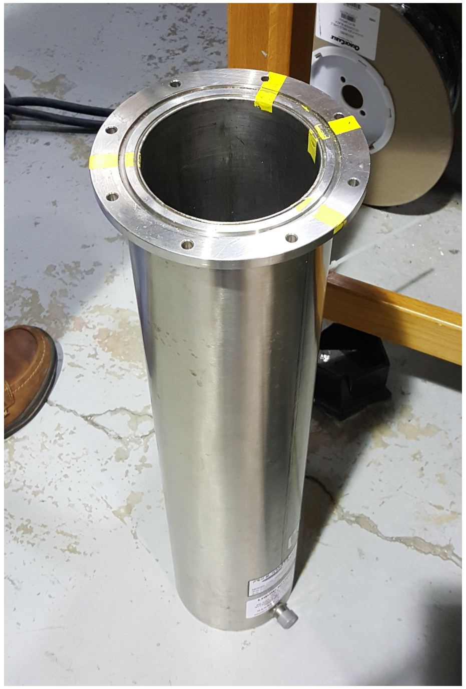

Figure 18: Dewar

- ID 4 ½'"
- OD 7"
- Depth 24"
- 6 3/8" Bolt Pattern
- ¼" Bolts

Vacuum Test Chamber

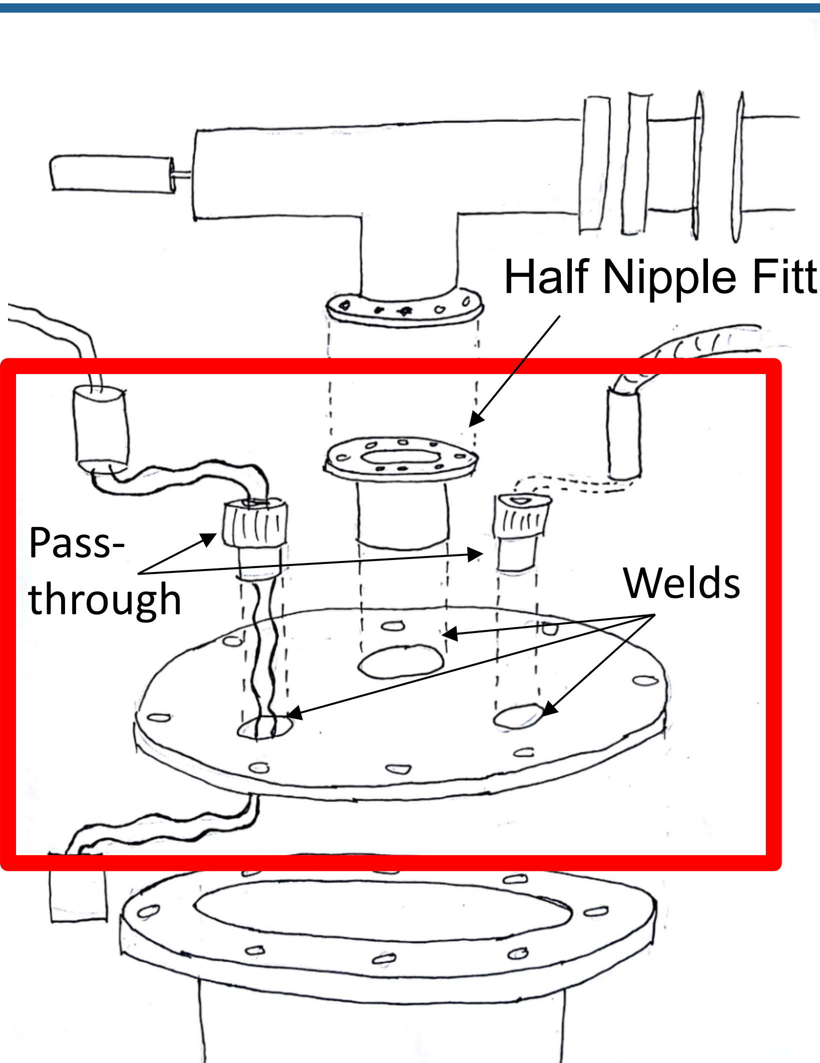

Figure B1: Vacuum Test Chamber

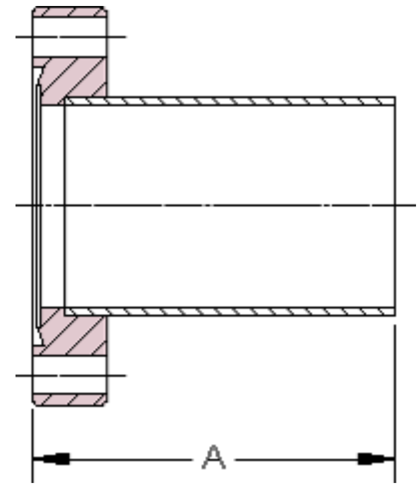

Figure B6: CF Half Nipple

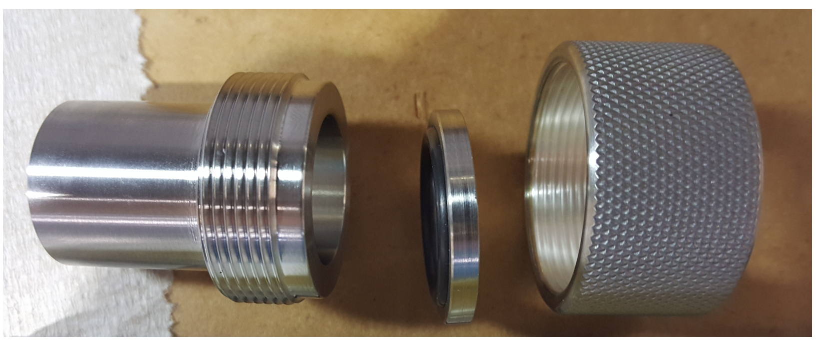

Figure B7: Passthrough

Overall Parts List

Table 1: Parts List

Part	Quantity	Source
Pirani Gauge	1	NASA
T-Bar w/ CF Fitting	1	NASA
Copper Gaskets	3	NASA
Dewar	1	Borrow from MS&T at NHMFL
CF to KF Adapter	1	Borrow from MS&T at NHMFL
Vacuum Pump	1	Borrow from MS&T at NHMFL
Top Plate	1	Purchase and machine
Top Plate CF Adapter	1	Purchase
Top Plate Ultra Torr Passthrough	2	Purchase
Neodymium Magnets	2	Purchase
Thermal-Resistant Wire	1 spool	Purchase
Tungsten Rods	2	Purchase
Gauge Assembly Box	1	3D Print

Conclusion & Timeline

Presenter: Jordan Eljaiek

Timeline

Table 2: Timeline

	Major Tasks	Project Completed By: April 12, 2018													
1	Determine the Necessary Components and Materials	●													
2	Iterate CAD Designs		●	●	○	○									
3	Research Part Costs/ Create Bill of Materials				●	●									
4	Buy/Order Parts					○									
5	Build Prototype of Cold Cathode Ion Gauge						○	○	○						
6	Determine Where to Borrow LabView/ Modify Block Diagram for LabView					●				○	○				
7	Determine How to Acquire Supporting Hardware					●				○					
8	Final Testing/Prototyping										○	○	○		
		21-Jan-18	28-Jan-18	4-Feb-18	11-Feb-18	18-Feb-18	25-Feb-18	4-Mar-18	11-Mar-18	18-Mar-18	25-Mar-18	1-Apr-18	8-Apr-18	15-Apr-18	22-Apr-18

- Proactively securing hardware and other means to test device.
- Part list & Bill of Materials has been created.
- By Friday (2/23/18) we will have ordered all of the necessary parts.
- While parts are on the way, we will assemble the hardware and test chamber that has been secured.
- Need to CAD and submit drawings for the gauge assembly box to be printed.
- Machine Top Plate.

Conclusion

- What we have accomplished since last presentation:
  - Acquired parts and means to vacuum test chamber capable of pressures below 10e-6 torr.
  - Adapted to project scope modifications and temperature constraints.

- Moving forward:
  - Ordering Parts
  - Building test chamber
  - Machine top plate
  - Send CAD model of gauge box to be printed
  - Setting up hardware
  - Testing pressure sensor and relating the readings to the reference gauges

References

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- The I-Mag CCG Sensor. Retrieved from https://www.mksinst.com/docs/UR/423Rebuild.aspx
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