Dust Shaker Design & Fabrication

UMBC Dusty Plasma Lab
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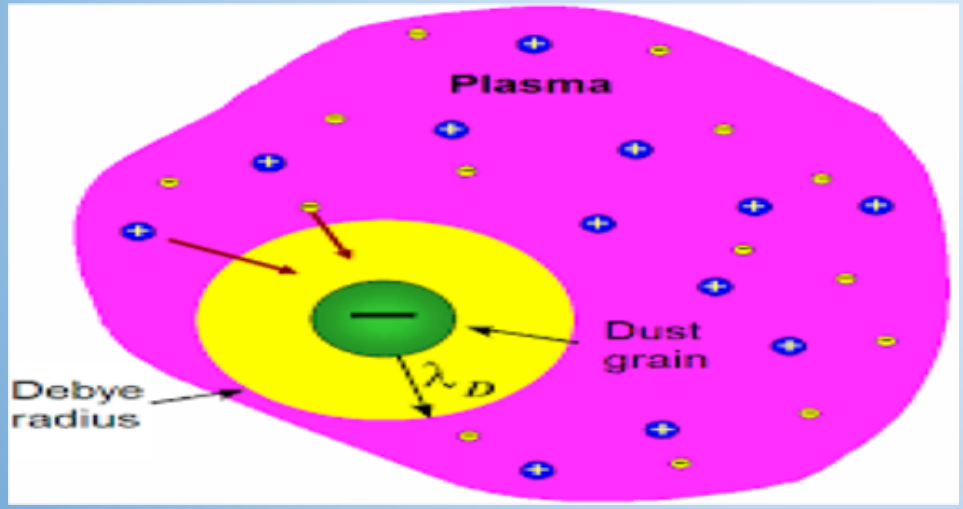
What is dusty plasma?

Small, solid particles of dust with electrons attached to their surfaces

- **Negatively charged by surface electrons**
- **Repelled by other dust**
- **Attracted by positive ions**



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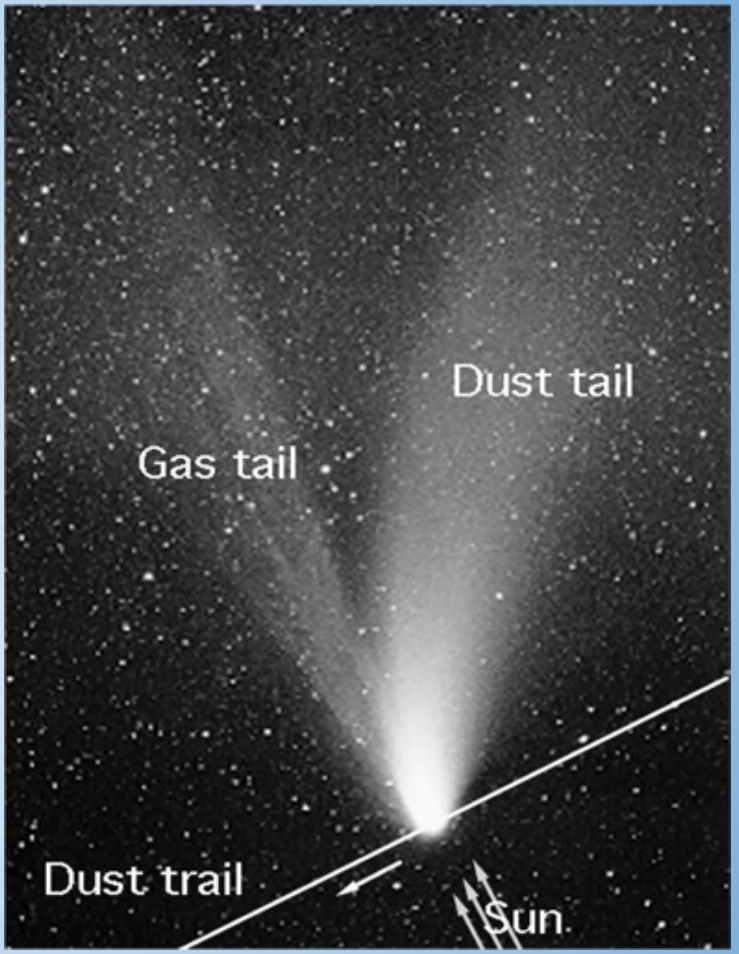

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Relevance/Applications to Space & Industry

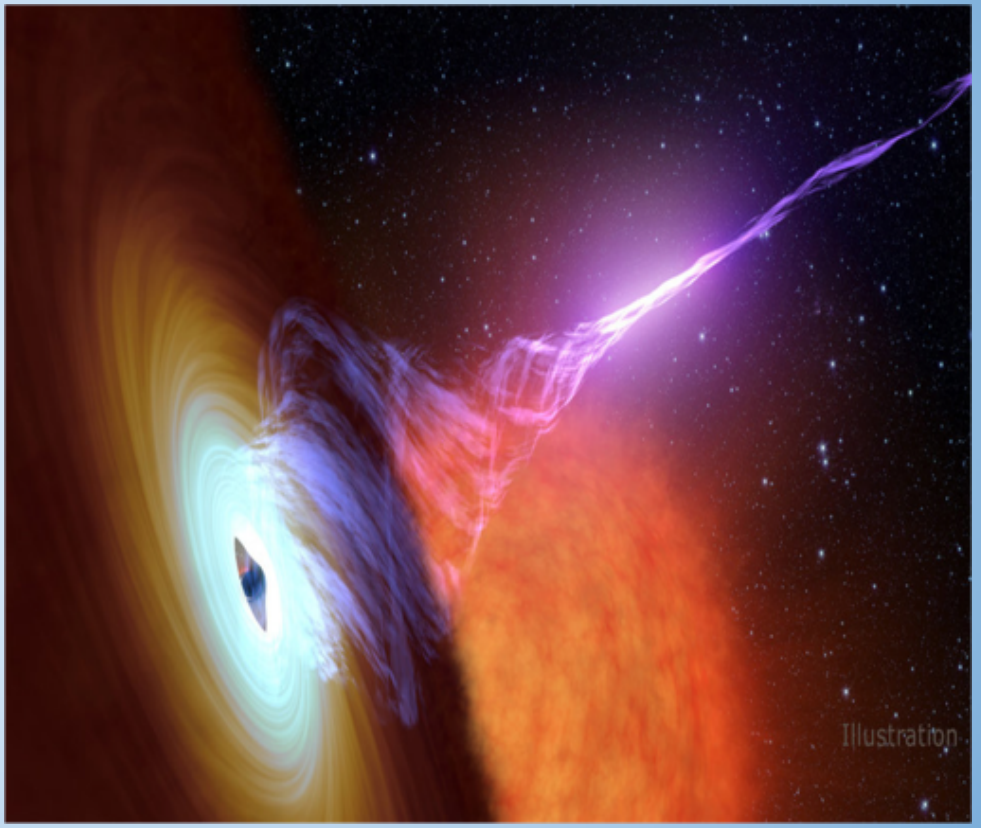
Accretion Disks -
Clouds of dust, gas and plasma around stars, planets and black holes

Nuclear fusion process for energy production

Plasma used in microchip production

Dust interactions in super-high-speed space crashes and planet formation

Noctilucent clouds - atmospheric electromagnetic phenomena



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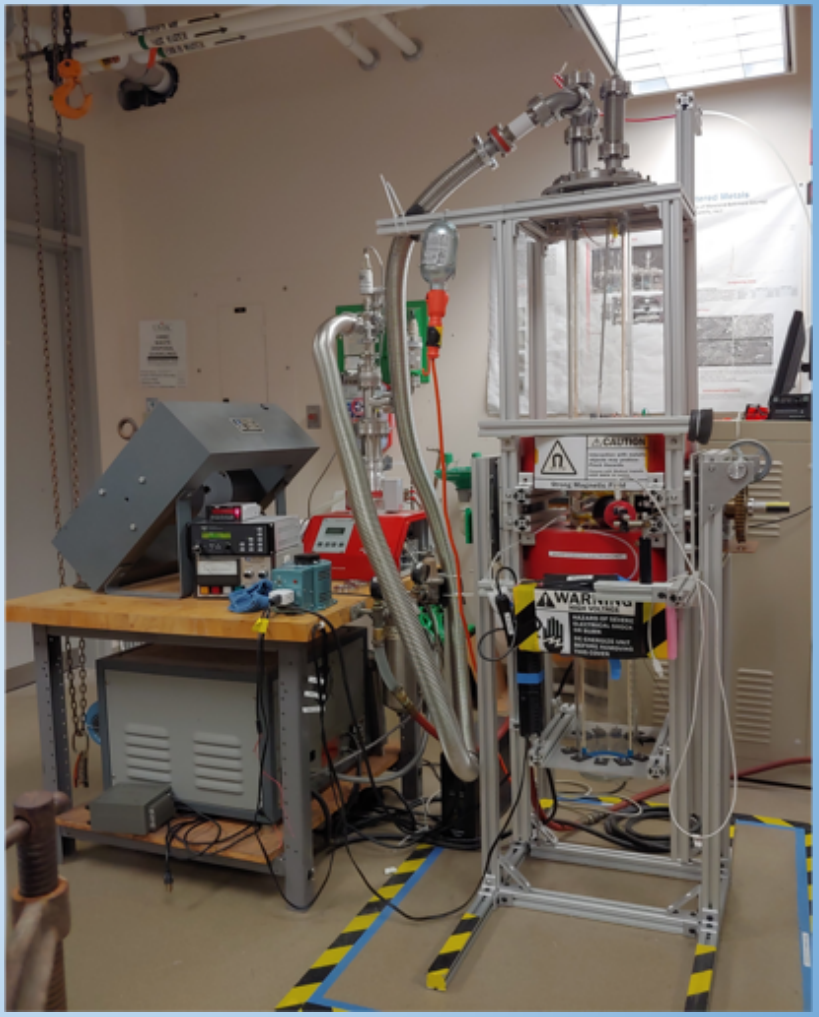
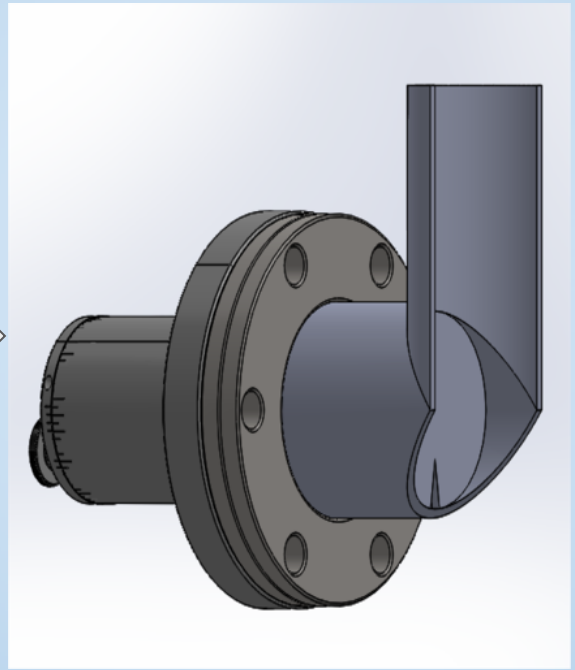
Research Background

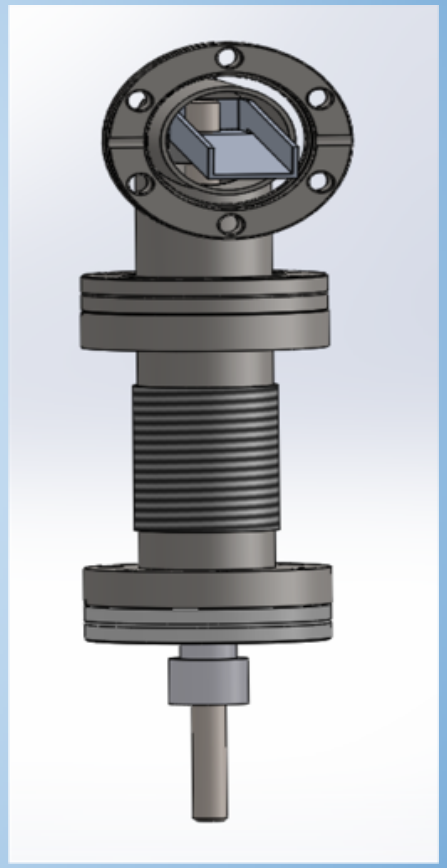
UMBC Dusty Plasma Laboratory (DPLX)
Dr. Carlos A. Romero-Talamas

Research focuses on studying strongly magnetized and unmagnetized dusty plasmas



Project Description: Vacuum Material Dispenser AKA Dust Shaker Design & Fabrication





Challenges

1. Conventional motors cannot be used in vacuum due to significant outgassing
2. Vacuum motors are far more expensive
3. Transferring motion from outside the vacuum chamber to inside is difficult
4. Device must be capable of dispensing a reproducible amount of dust
5. Device must be easily refillable - all the dust must be stored within the system before it pumps down to vacuum
6. Device must be compatible with overall system and other devices within the system

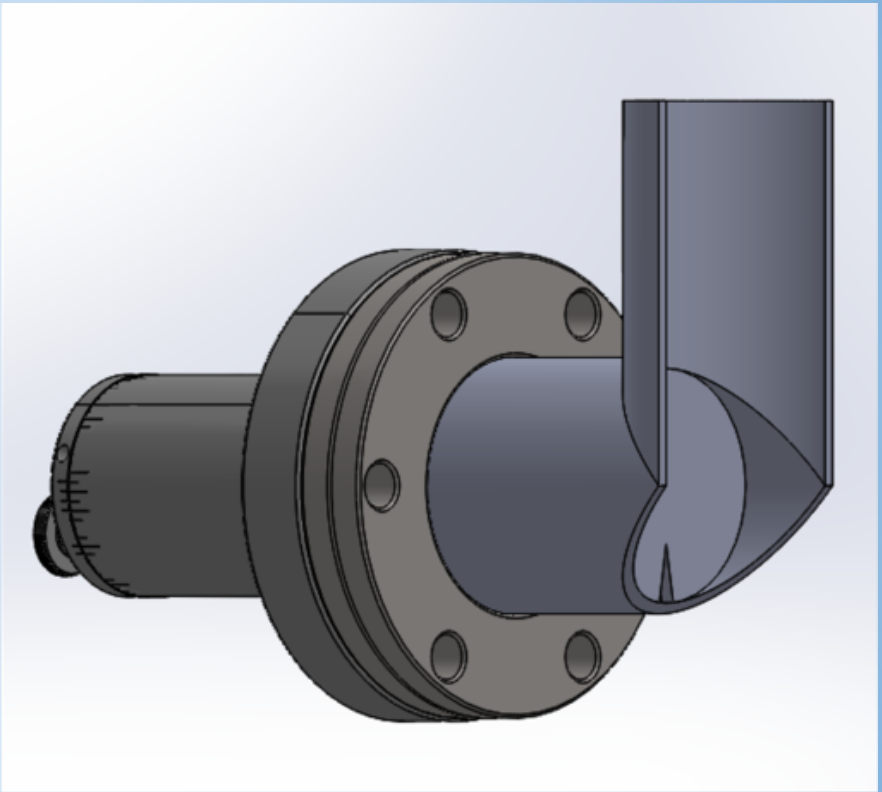
Preliminary Design - Rotating Drum Shaker

Based on a pepper-mill concept

Rotary Vacuum Feedthrough powered with DC motor

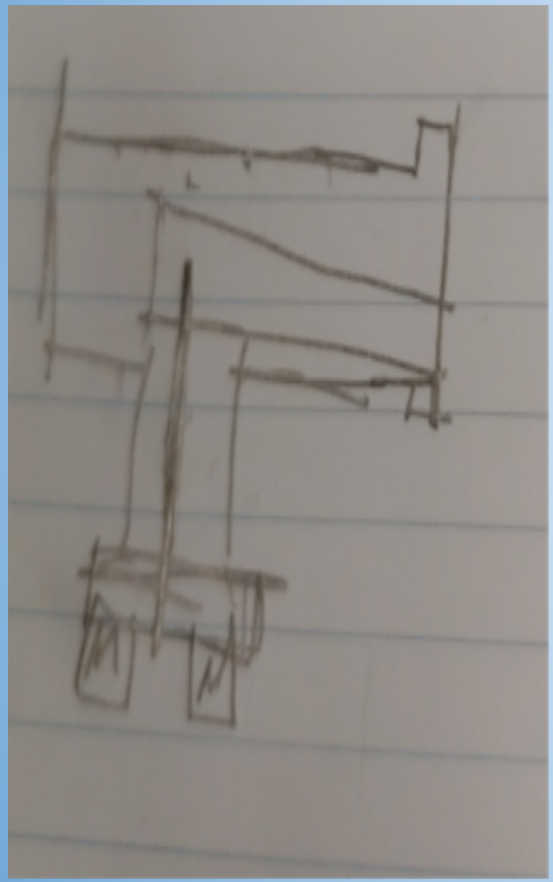
Gravity-powered dispensing mechanism: Dust drum rotates on the shaft and aligns each cycle with the hole on the T-chamber cap to release dust into the test tube

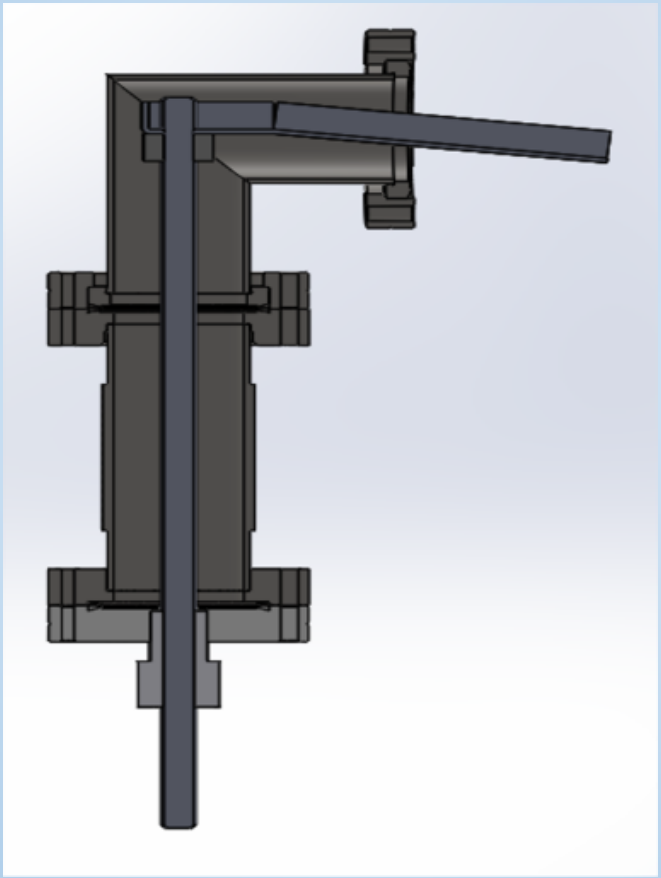
Flow-rate controlled passively by hole dimensions and actively by rotation rate



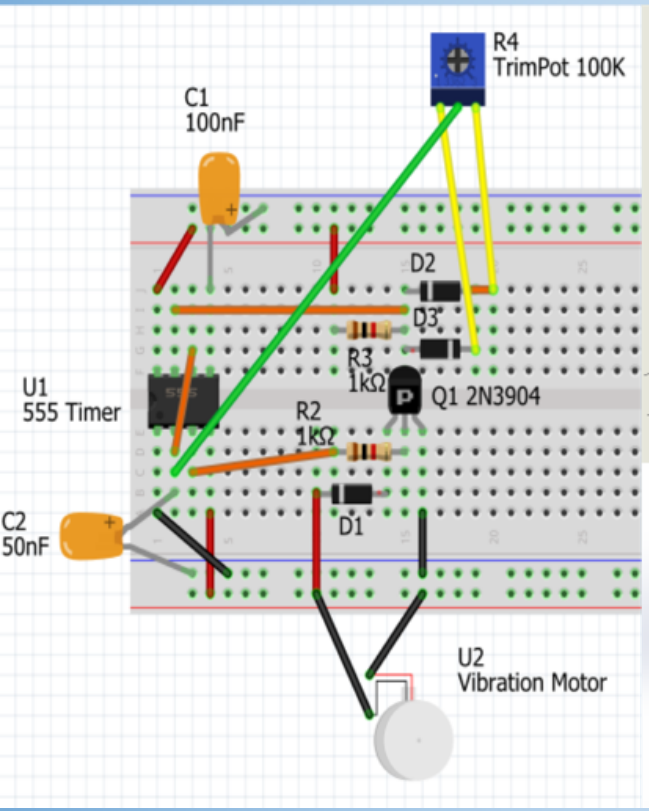
Design fails with Manufacturing (Couldn't be built)

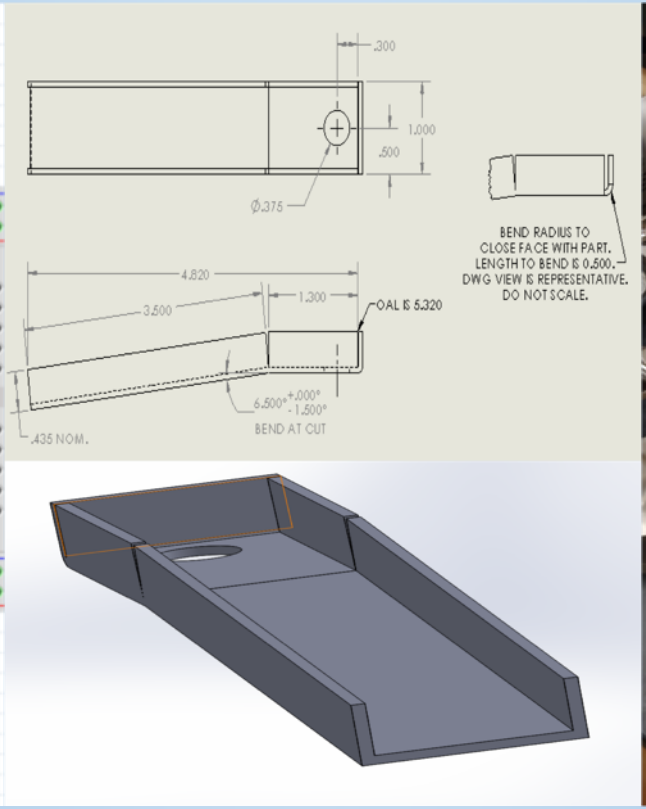
Current Design - Vibrational Ramp Shaker





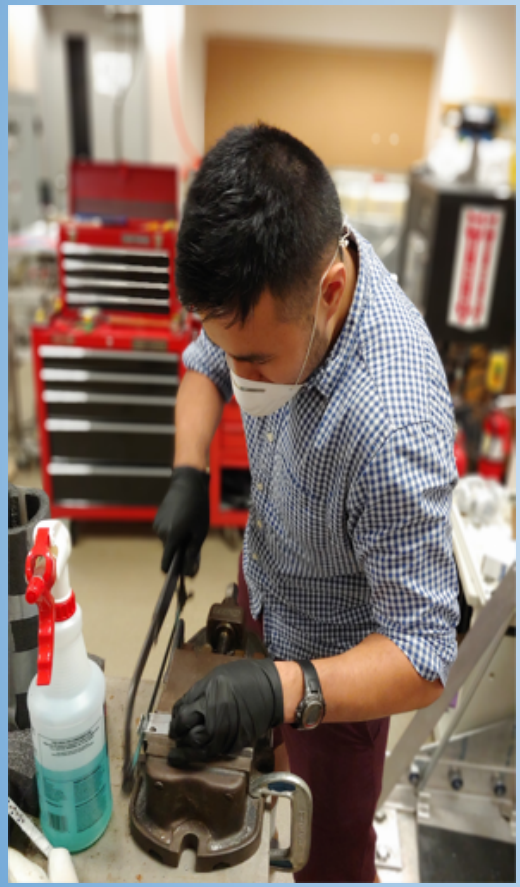
System Components

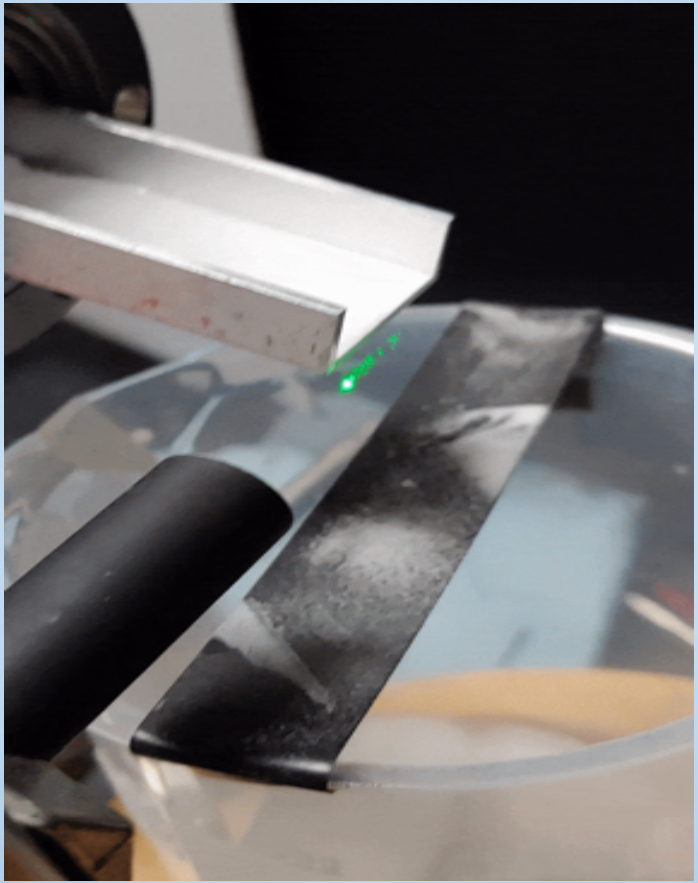




DC Motor Controller Circuit (555) **Vibration Ramp** **Test Setup**

Results and Future Goals





In-vacuum testing and full system assembly

Characterization of flow rate and voltage/potentiometer settings

Design and manufacture of a 3-D printed vibration motor mount

Review of scientific instruments articles

Acknowledgements & References

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Atkinson, N., "How Black Holes Shoot Out Lethal Plasma Jets Is Becoming Clearer," *Seeker* Available:https://www.seeker.com/space/astrophysics/how-lethal-plasma-jets-shoot-out-from-black-holes-is-becoming-clearer.

Carballido, A., Carmona-Reyes, J., Hyde, T., and Educational Outreach and Research, "Dusty plasma in the universe and in the laboratory," *The Conversation.* Available: https://theconversation.com/dusty-plasma-in-the-universe-and-in-the-laboratory-53862.

"Dusty plasmas in space," *Department of Physics and Astronomy* Available: https://www.physics.uu.se/research/astronomy-and-space-physics/research/fundamental/dusty-plasma/.

Appendix A: System Requirements (1/2)

- **Dust Shaker System Requirements:**
  - **1. The shaker shall dispense dust in a reproducible method**
    - **1.1. The shaker shall be capable of dispensing up to ___ dust/rotation**
    - **1.2. The shaker shall dispense the same volume of dust within a 5% tolerance**
  - **2. The shaker shall fit within the test tube chamber**
    - **2.1. The shaker shall be no larger than x_x_x inches**
    - **2.2. The shaker shall not interfere with the operation of other equipment in the chamber**
  - **3. The shaker shall be powered by a DC motor**
    - **3.1. The DC motor shall be capable of producing ___ RPM**
    - **3.2. The DC motor shall produce ___ N-m of torque**

Appendix A: System Requirements (2/2)

- **Dust Shaker System Requirements:**
  - **4. The DC motor system shall fit on a shelf outside of the T-Connection**
    - **4.1. The shelf shall not interfere with the gas piping or surrounding systems**
    - **4.2. The shelf shall support the DC motor's weight**
      - **4.2.1. The shelf shall support 7 pounds**
    - **4.3. The shelf shall connect directly to the T-Connection**
  - **5. The gear-shaft system shall accommodate the dust collector and electrical wiring systems within the T-connection and test tube chamber opening**
    - **5.1. The gear-shaft system will be composed of a**
  - **6. The system shall be capable of operating in a vacuum environment**
    - **6.1. The material shall not be susceptible to outgassing**
    - **6.2. The motor shall not operate inside of the vacuum to avoid plasma interference from magnetism**

Design dies with Manufacturing (Couldn't be built)

Press-fit?

Drum rotation if perfectly fit

Refillability

Challenges

Conventional motors cannot be used in vacuum due to significant outgassing

Vacuum motors are far more expensive

Transferring motion from outside the vacuum chamber to inside is difficult

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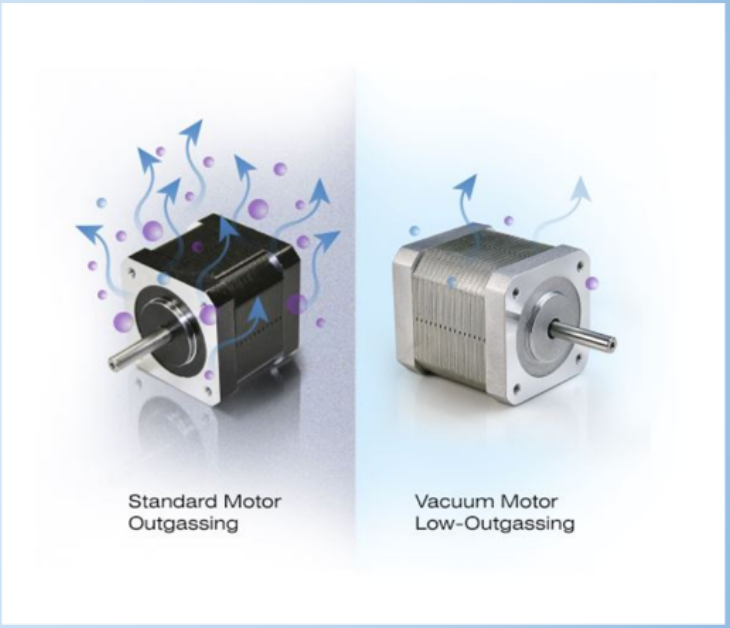

https://www.linengineering.com/wp-content/uploads/2017/11/OutGassing.jpg