



***MSFC  
Lunar Environment Test System (LETS)  
System Development***

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***Third Lunar Regolith Simulant Workshop***

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# *Presentation Outline*



- *MSFC LETS Chamber Status*
- *LETS Simulant Containment Box Development*
- *Tests Conducted in LETS To date*
  - ◆ *Simulant Dust Migration*
- *Summary*
- *Forward Work*



# *Lunar Surface Environment*



- ***Harsh Environment***
  - ◆ ***Temperature Extremes***
  - ◆ ***Charged Particle Radiation***
  - ◆ ***Meteoroid Bombardment***
  - ◆ ***Fine grain regolith (“dust”)***
  - ◆ ***Ultra-violet Radiation***
- ***Ground based testing of materials and systems is required to ensure safe and successful operations on the lunar surface***





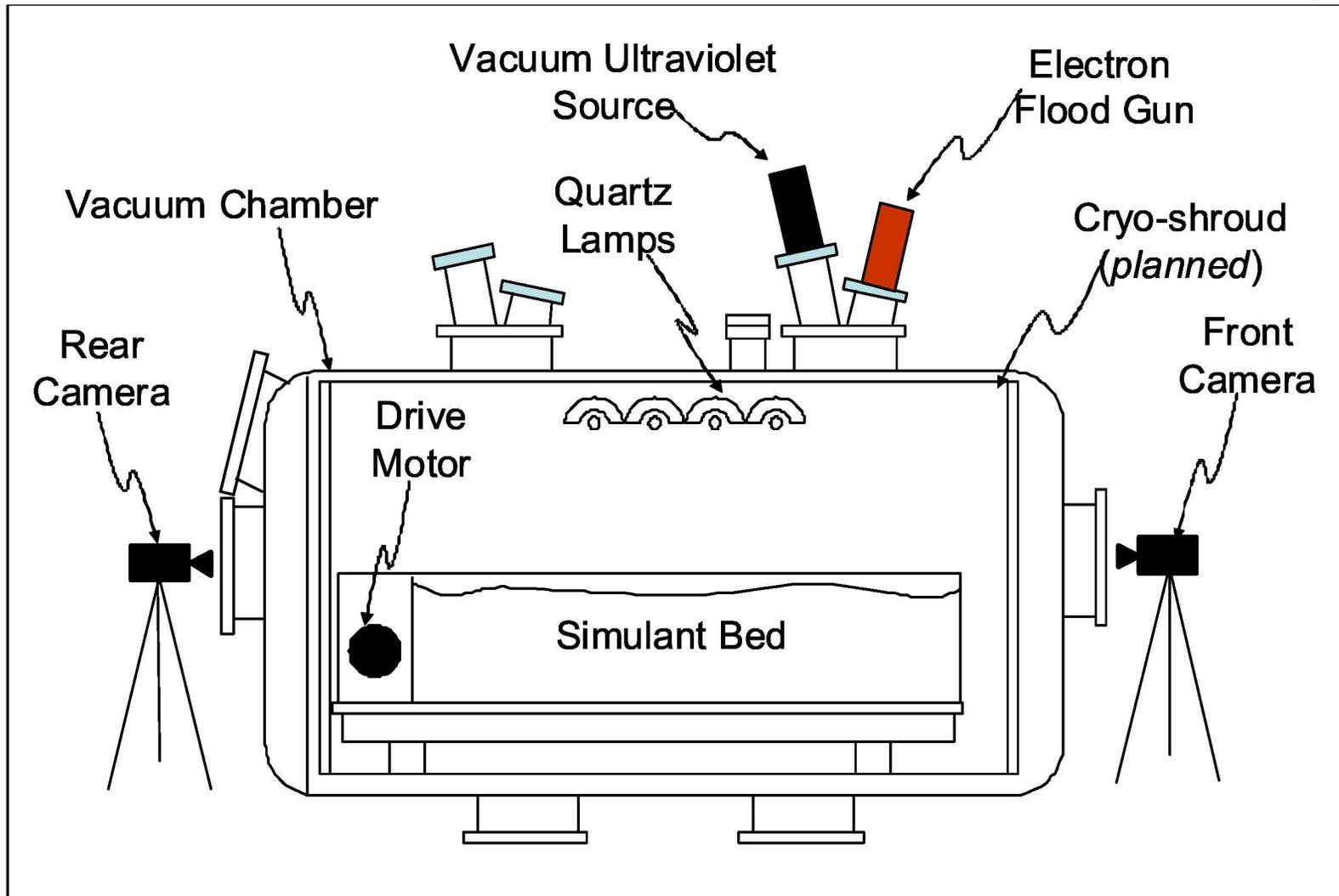
# MSFC Lunar Environment Test System (LETS) Development Status

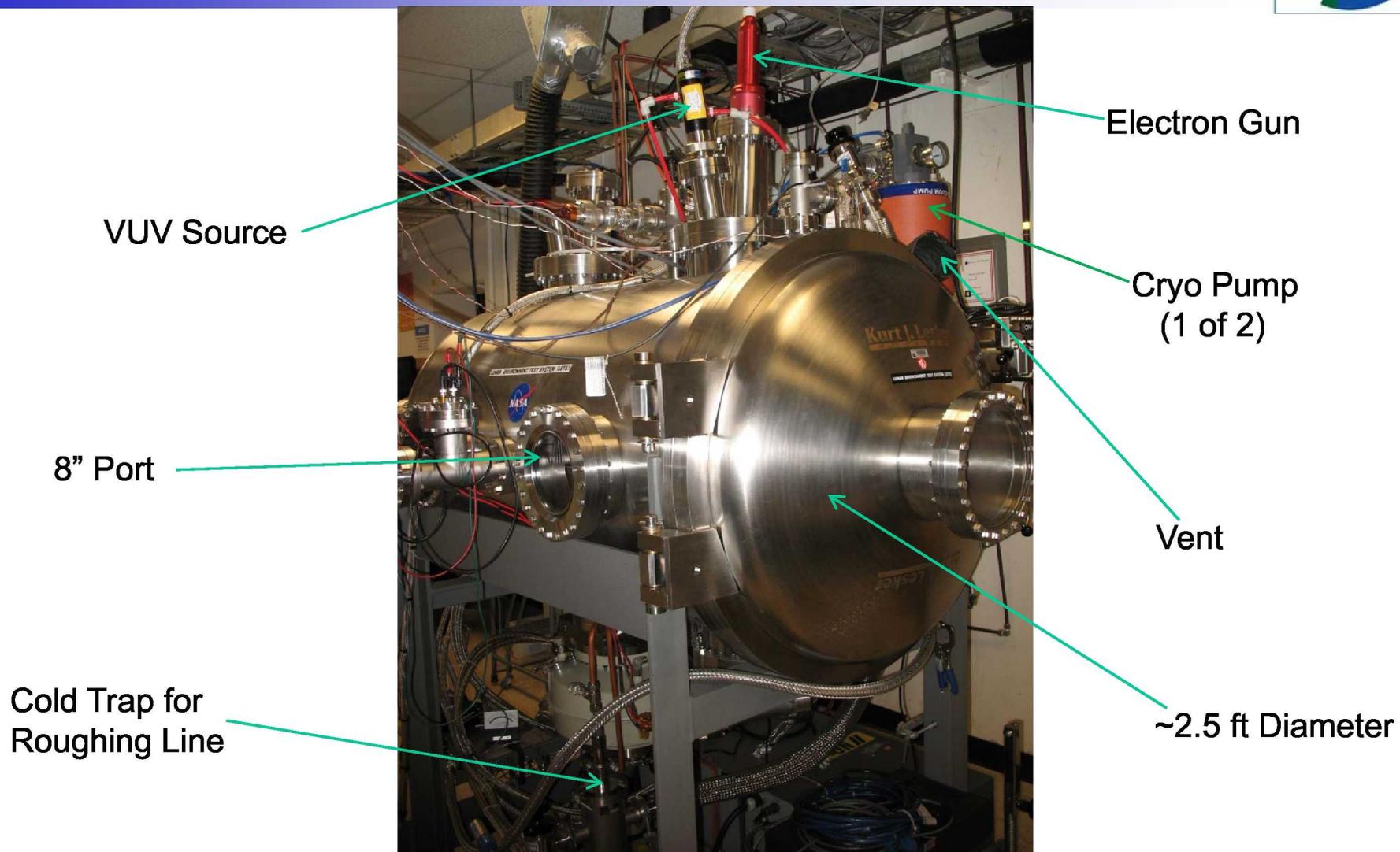


<i>Lunar Environment</i>	<i>Planned LETS Capability</i>	<i>Current LETS Capability</i>
<i>High Vacuum</i>	<i>Cryo-pumped vacuum chamber with base pressure of <math>1 \times 10^{-7}</math> Torr</i>	<i>Cryo-pumped vacuum chamber with base pressure of <math>1 \times 10^{-7}</math> Torr</i>
<i>Temperature Range -150 °C to +130 °C</i>	<i>Liquid Nitrogen (LN<sub>2</sub>) Cold Shroud (-190 °C), Quartz Lamp Array (+150 C)</i>	<i>System has quartz lamps installed and demonstrated to (+150 C). Cryo-Shroud in-house and being worked.</i>
<i>Solar Radiation</i>	<i>UV and Vacuum Ultraviolet Lamps</i>	<i>Vacuum Ultraviolet Lamps Installed and being used for charging of simulant.</i>
<i>Charged Particle Radiation (Solar Wind)</i>	<i>Electron Flood Gun and low energy proton source</i>	<i>Flood has been installed and used for simulant charging. Proton source under design in house.</i>
<i>Regolith (including fine particles)</i>	<i>Regolith Simulant (JSC 1a) 100 kg capacity</i>	<i>Lunar simulant bed completed. 75 kg in vacuum chamber at <math>1 \times 10^{-7}</math> Torr.</i>



# MSFC Lunar Dust Test Chamber



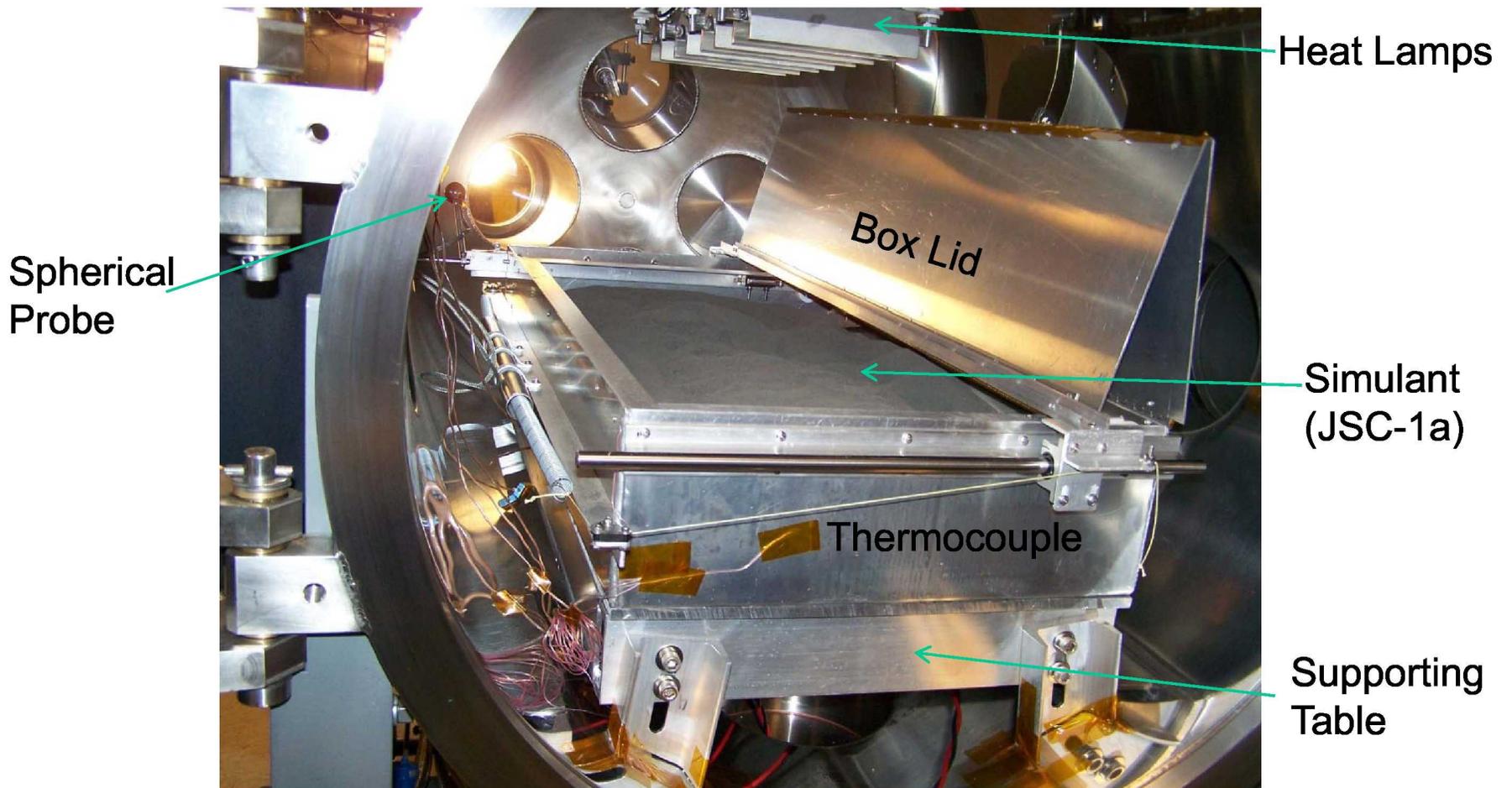




# Data Acquisition and Box Controller



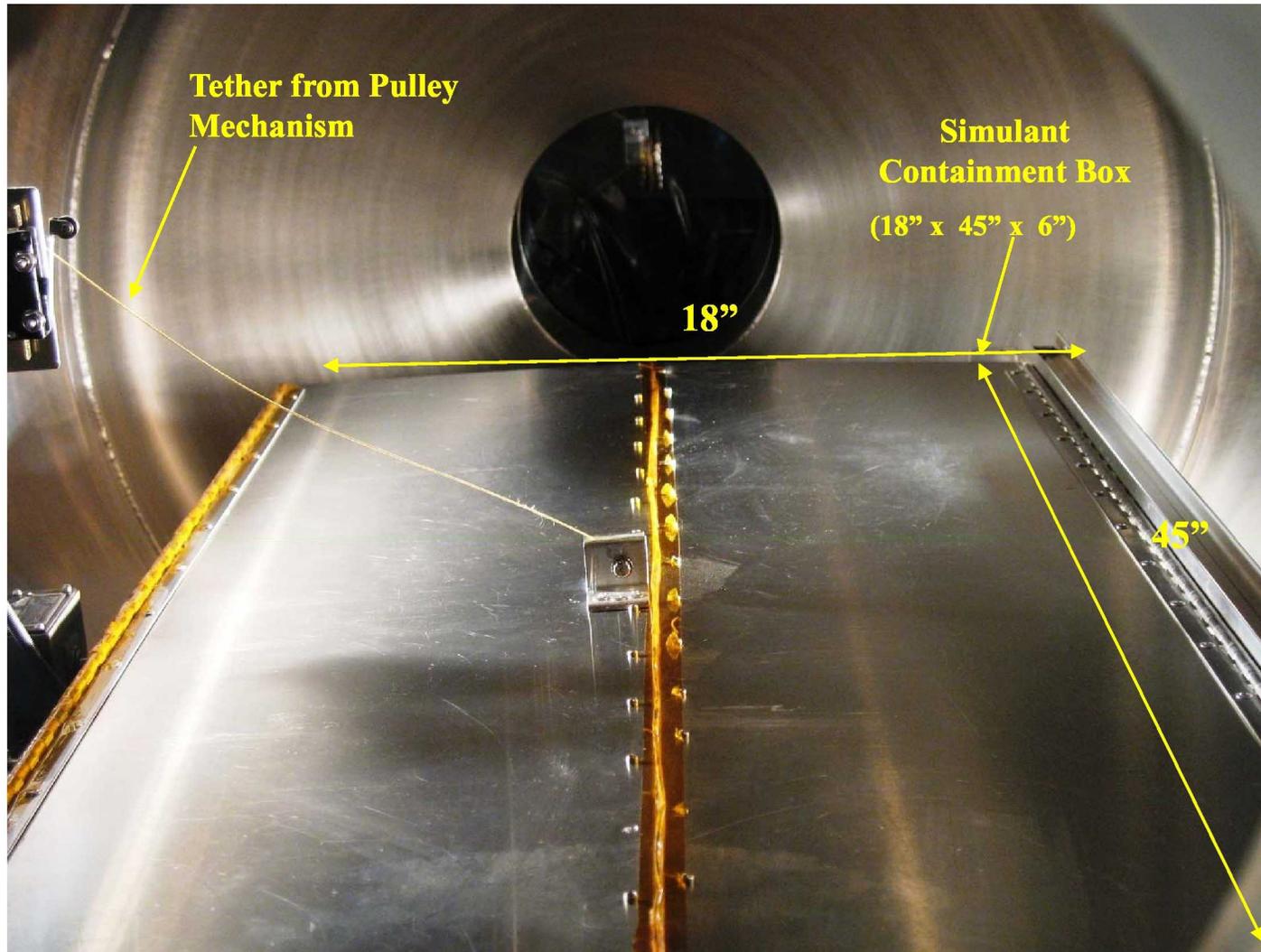
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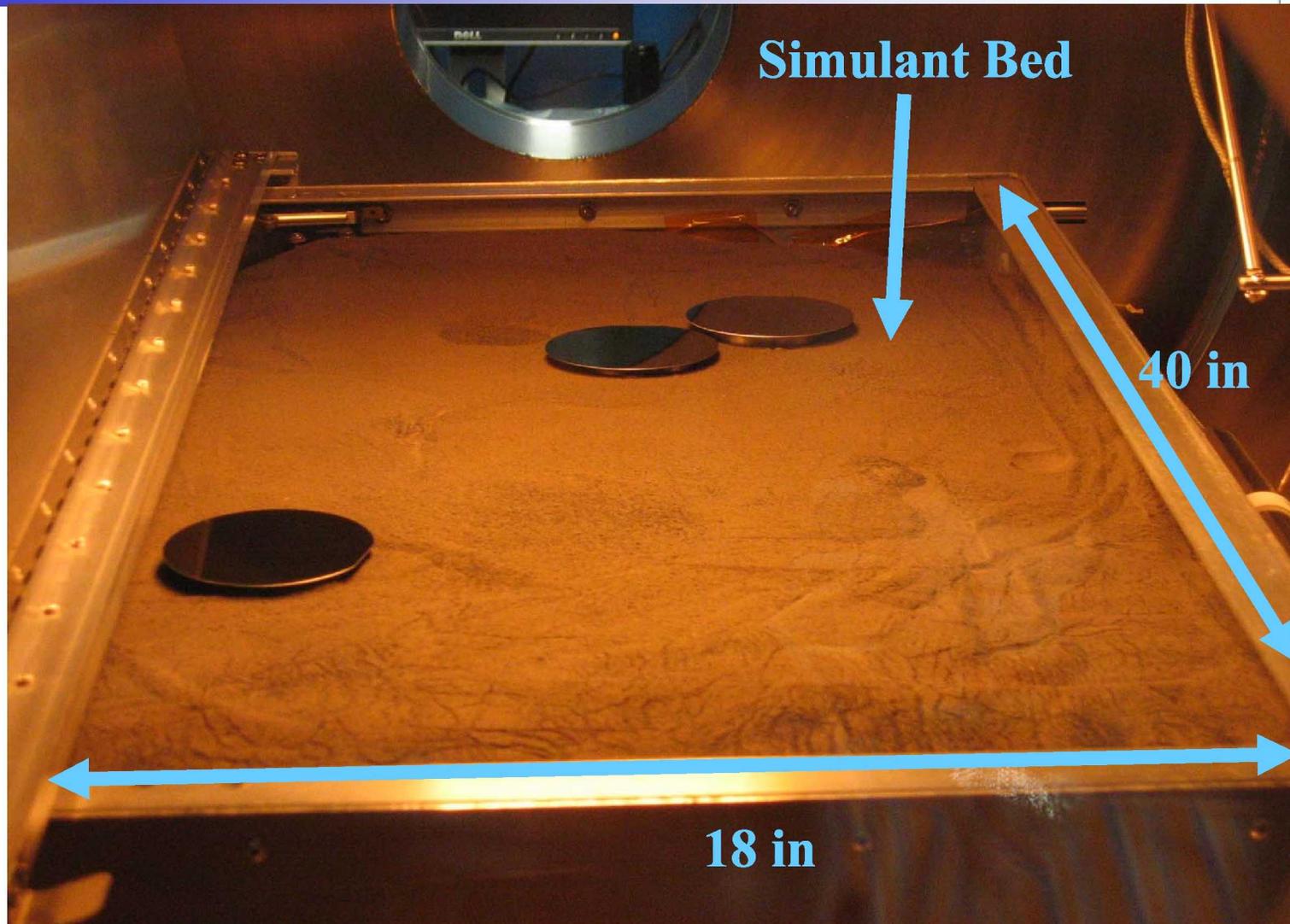
# Simulant Containment Box

(Lid Closed)





## *Simulant Bed in LETS*



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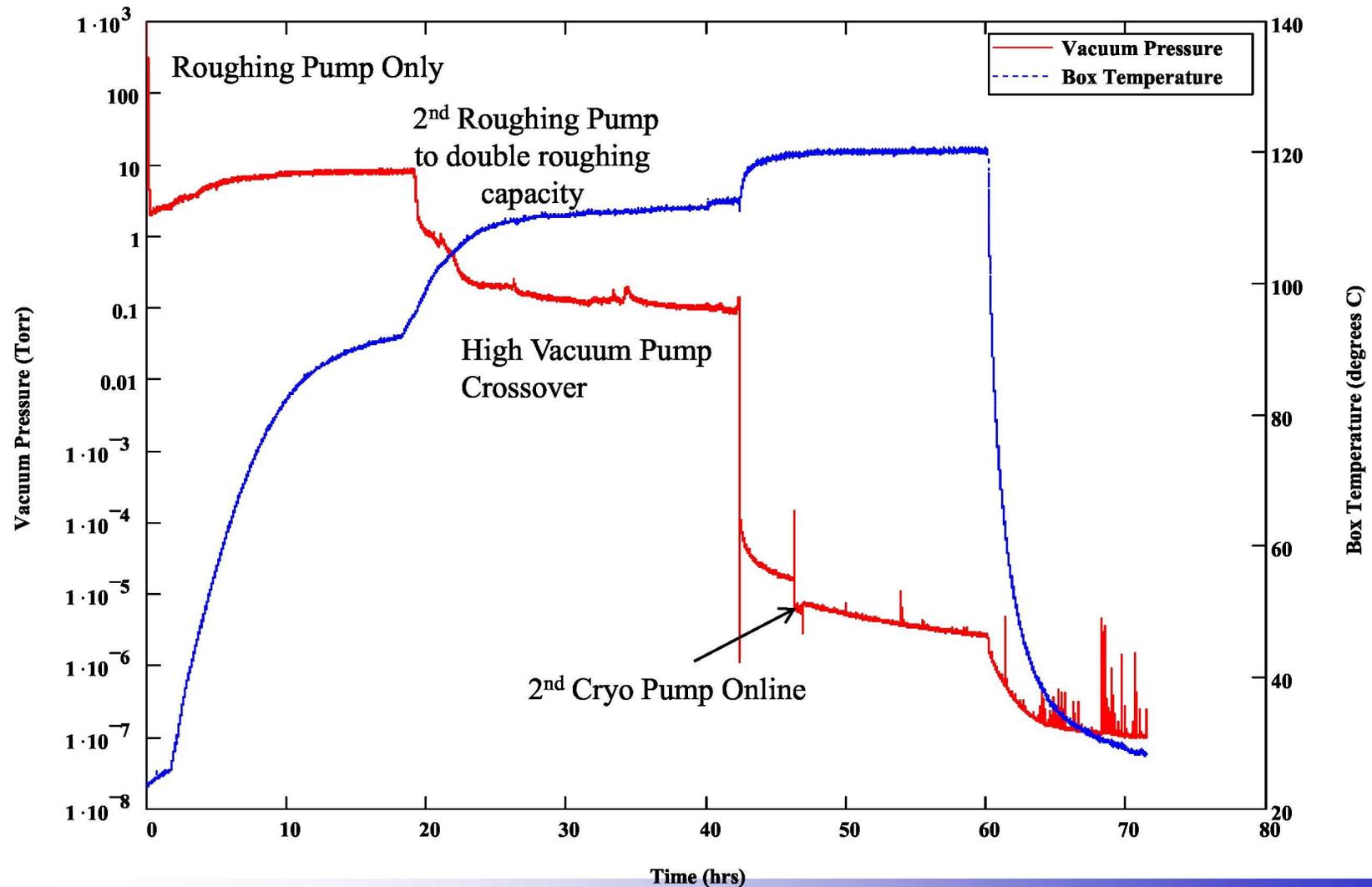
## *On-going Research*



- *Vacuum cycling of large quantities of JSC-1a lunar simulant*
- *Small dust particle migration due to vacuum cycling using optical fall out plates*
  - ◆ *Vacuum Cycles*
- *Vacuum Ultra Violet Radiation Charging*
- *Photoelectron emission of JSC-1a simulant (i.e. electrostatic charging)*
  - ◆ *A spherical Langmuir probe has been used to measure charging of simulant.*
  - ◆ *Fall out plates placed in regolith*
- *Optical detection of dust mitigation which is currently in design/setup phase.*



# First Pump Down with 25 kg of JSC-1a Simulant



## *Fall Out Plate Results*

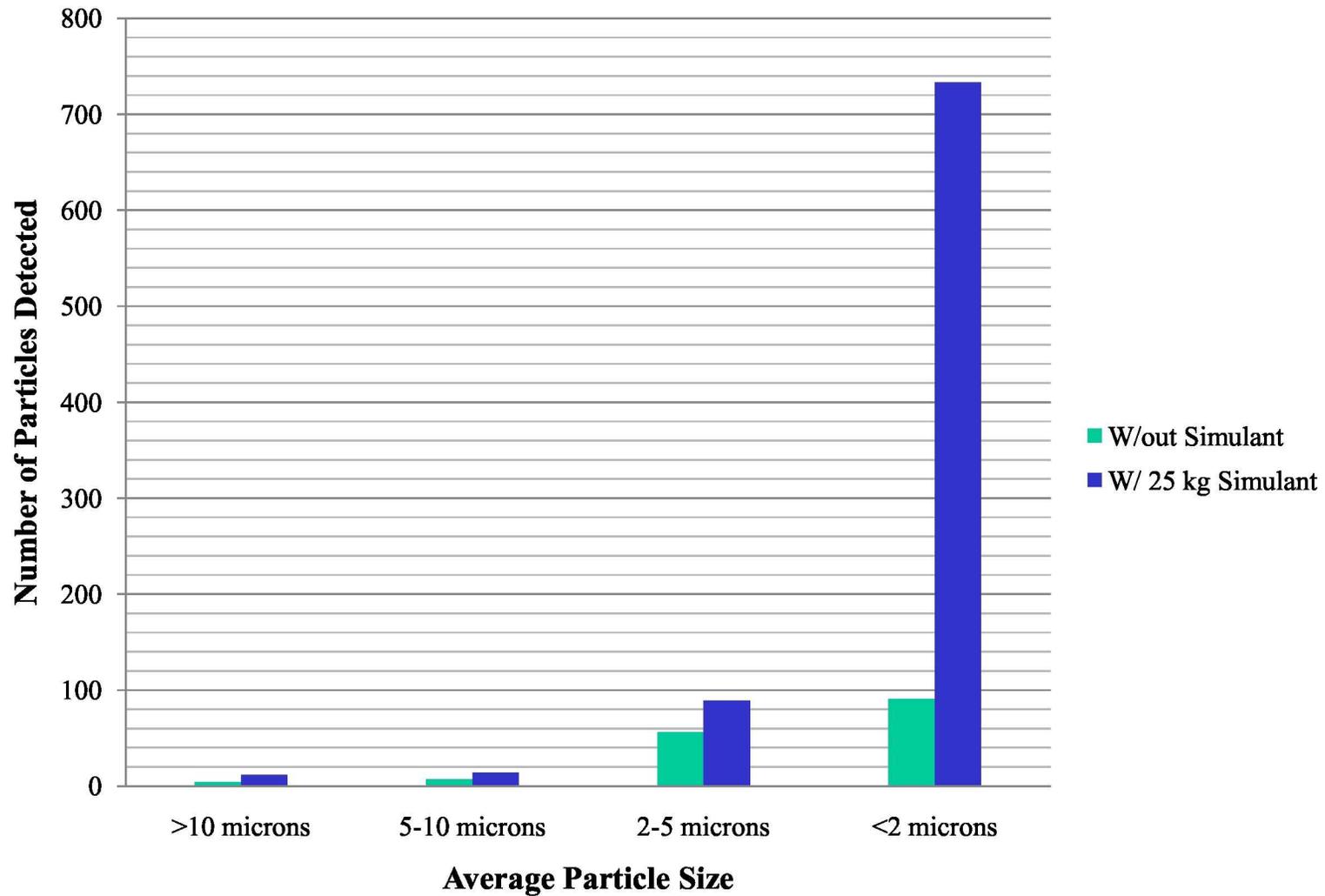
- *Three Fall plates were placed in the vacuum chamber around the regolith containment box to detect how much and what size of dust particles were leaving the containment box during the pump down cycle.*
- *Objective to determine how well simulant is contained in box.*
- *Fall Out Plate is 5 cm diameter.*
- *Each plate is examined by looking at 70 to 100 photographs taken across surface counting particles.*
  - *At 200 X capable of detecting particles less than 1 micron diameter.*
  - *Baseline measured without dust in containment box*



Typical Fall Out Plate



# Fall Out Plate Particle Count Results



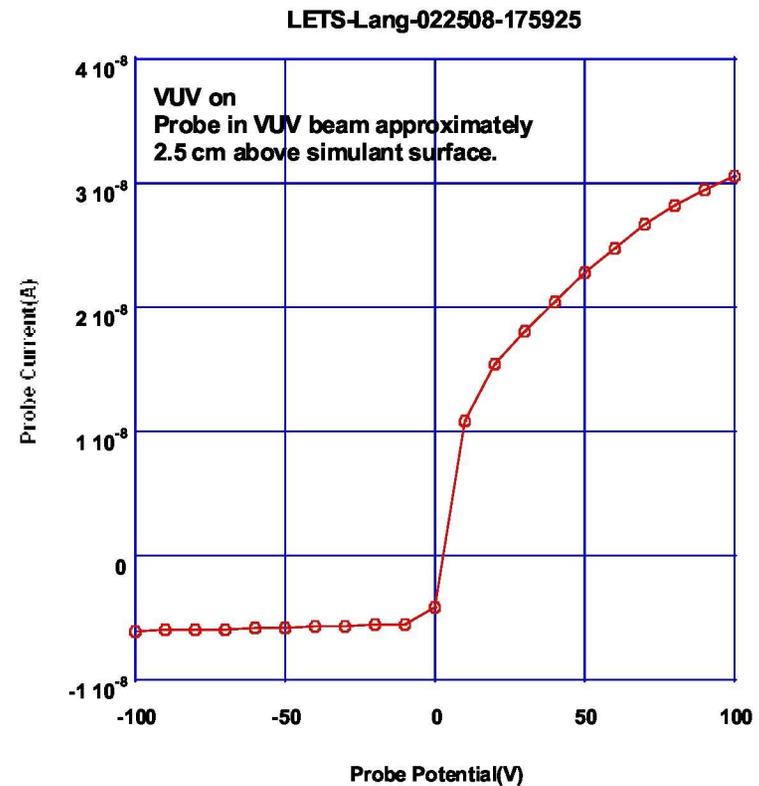
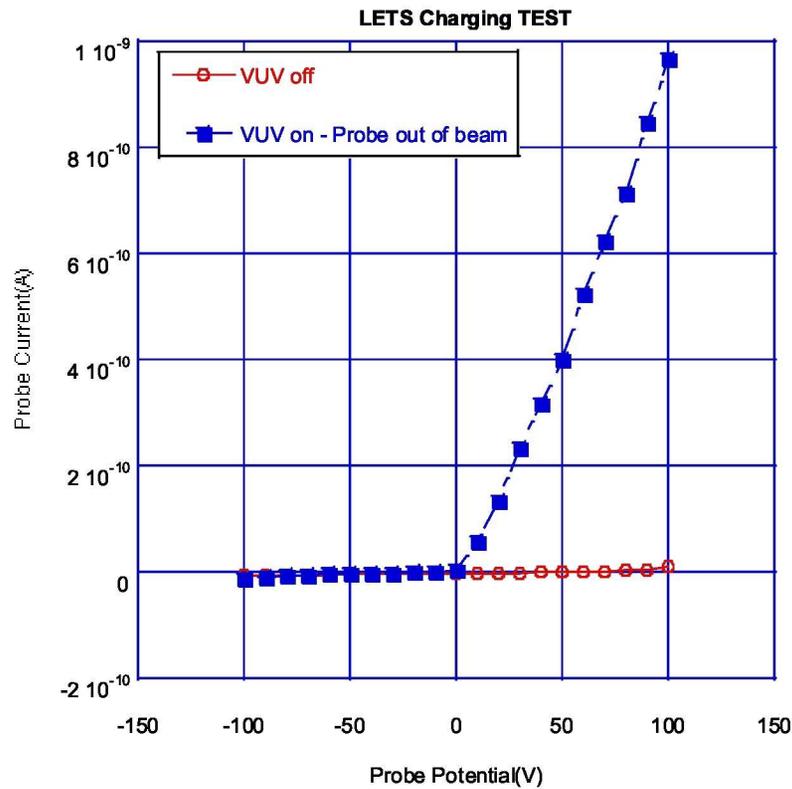


# *VUV Illuminated Area with Sphere*





# Examples of Simulant Photoelectron Emission

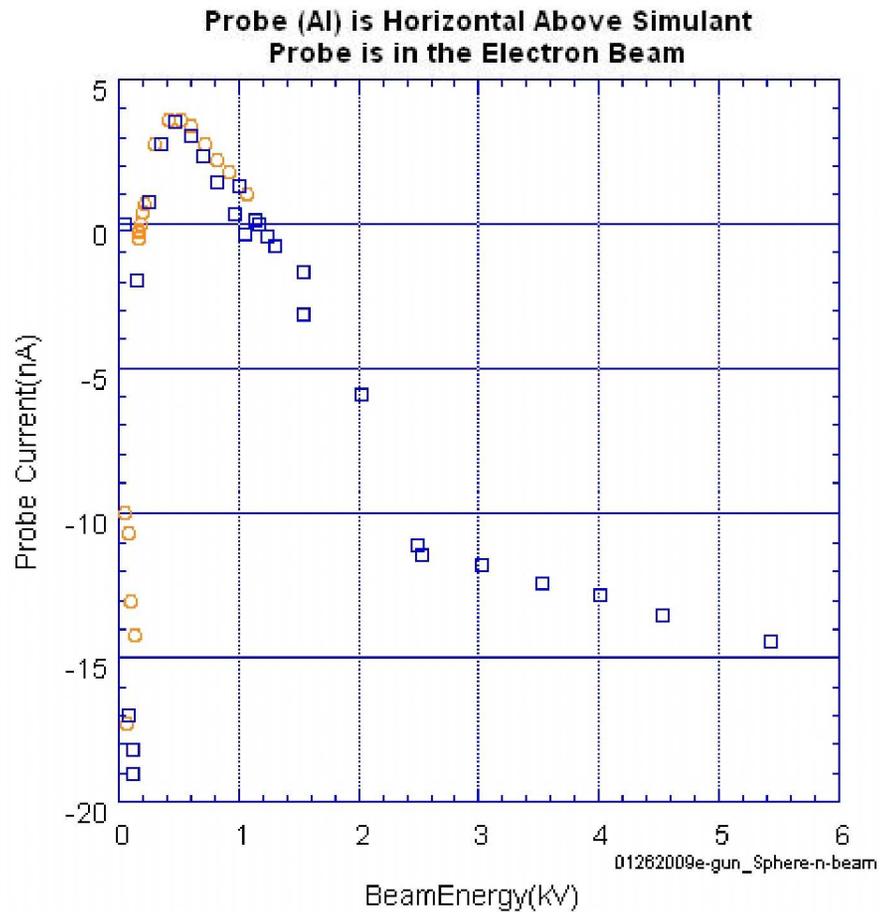




# Example of Simulant Secondary Electron Emission



- *Qualitative Measurement*





# Summary



- *Development of the MSFC Lunar Environment Test System is well underway.*
- *Primary system components including vacuum system, heat lamps and data acquisition are in place.*
- *Simulant containment box to house simulant and minimize dust migration has been completed and is operational.*
- *75 kg of JSC-1a simulant has been placed in containment box and pumped down to  $1 \times 10^{-7}$  Torr .*
- *Heating lamps have been tested, verified and have been used for simulant bake out.*
- *VUV lamp has been installed and is operational.*
- *Electron flood gun installed and is operational.*
- *Chamber is being used for dust testing, especially designed for electrostatic dust charging and migration of dust due to charging.*



## *Potential Testing in LETS*



- *Mechanism tests with simulant at temperature.*
- *Scientific experiments requiring tests in lunar simulant.*
- *Electrostatic charging experiments including triboelectric tests.*
  - ◆ *Simulant Compaction*
- *Mitigation tests of dust adherence to space suits.*
- *Dust charging mitigation testing.*



## *Forward Work*



- *Conduct dust migration measurements using the vacuum ultra-violet lamp and electron gun to charge the JSC-1a simulant.*
  - ◆ *Test are currently underway on the 75 kg of simulant*
- *Obtain and install Cryo-shroud - effort is ongoing.*
- *Designing test for mitigation of dust in a mechanism.*
- *Parallel effort to use a Particle Image Velocimetry (PIV) system to track dust migration real time – preliminary stage.*
- *Add Diagnostics: TQCM, Faraday cups, Trek Probes, translation stages, Residual Gas Analyzer*
- *Add additional JSC-1a simulant.*