ASTROMATERIALS RESEARCH & EXPLORATION SCIENCE

New Dry Fractionation Methods

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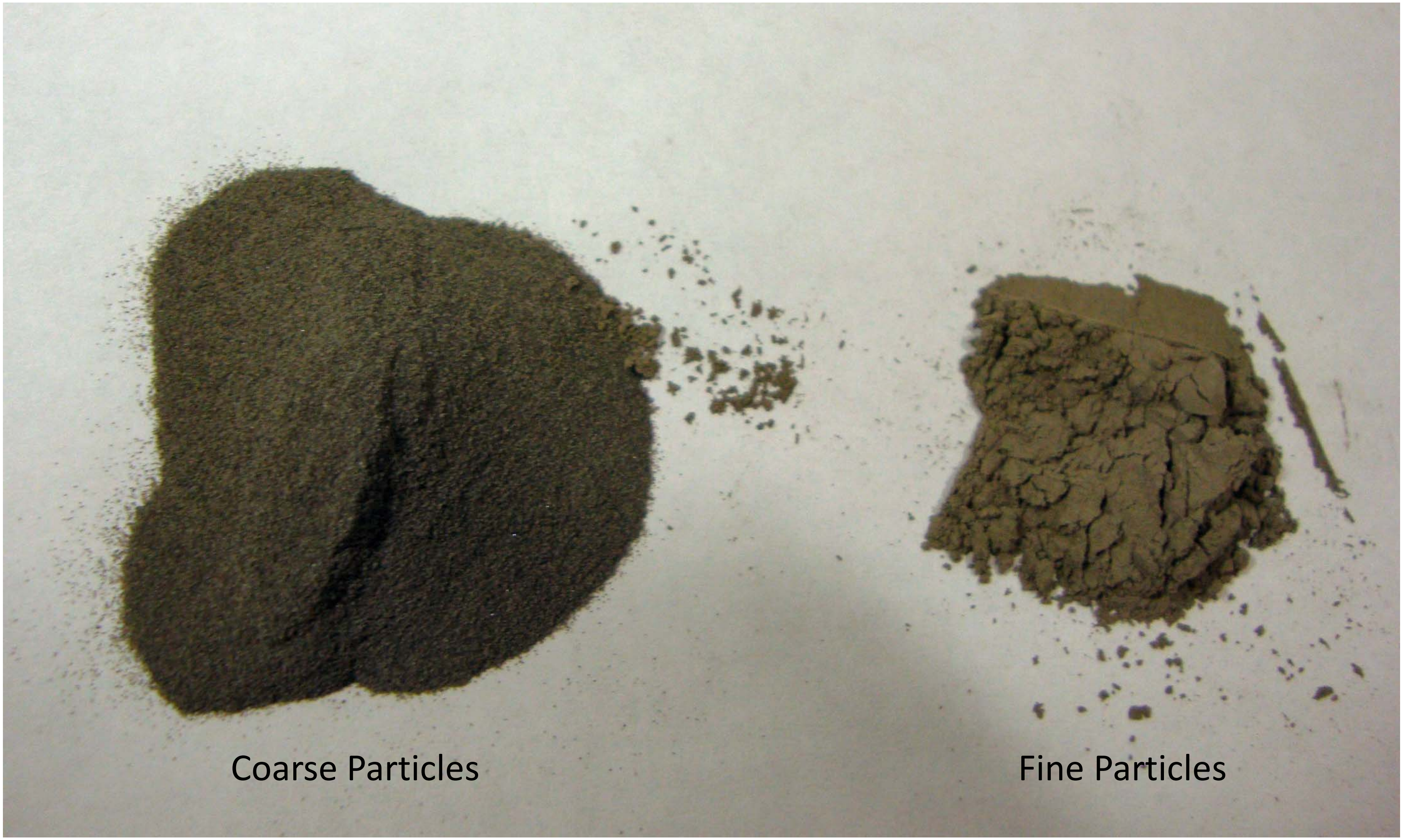
Dry Fractionation Optimization



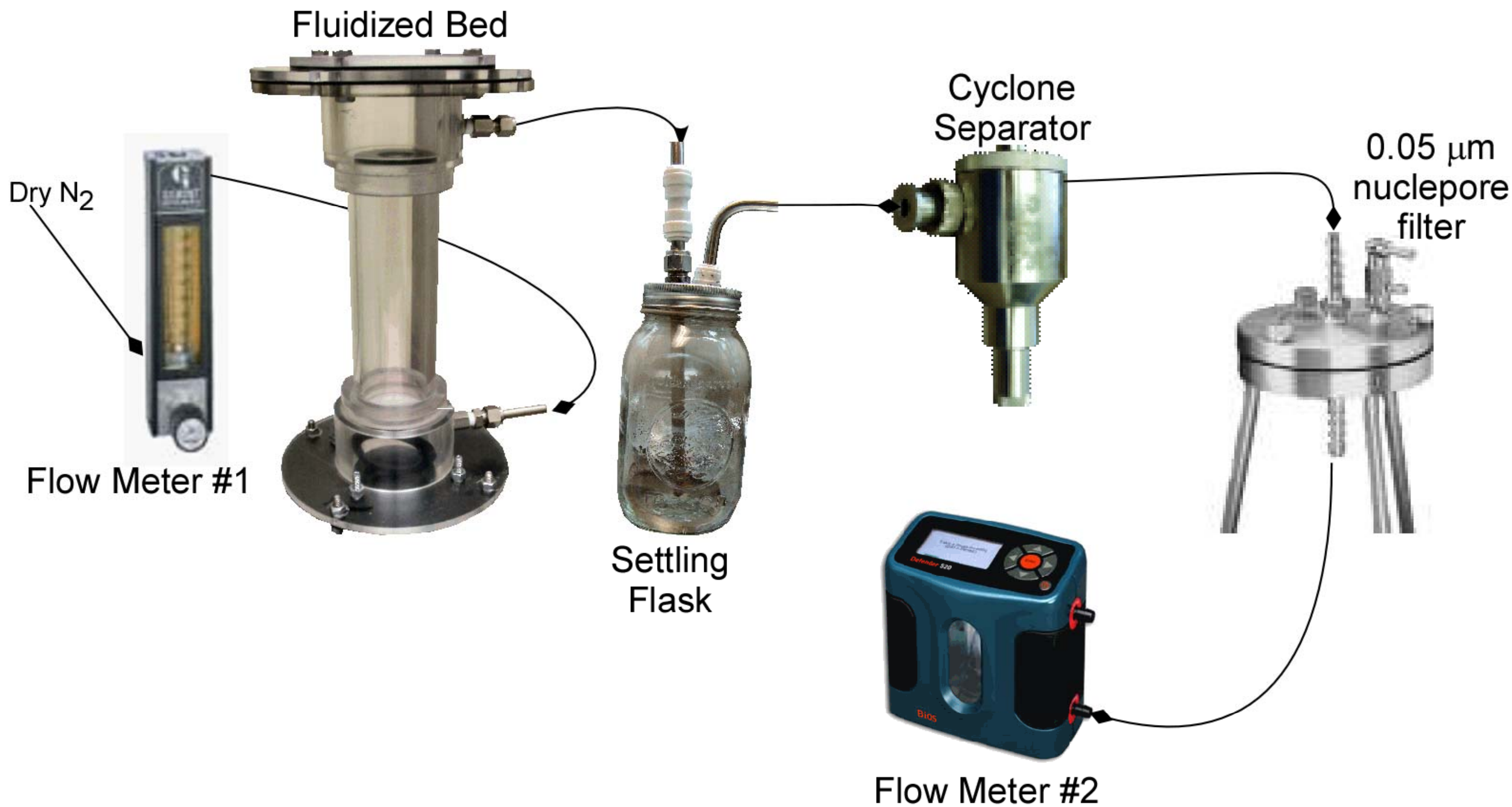
We Cannot Waste Any Dust

- Mechanisms exist that can be used to separate particles for inhalation toxicology studies.
- However, because lunar dust is a priceless national treasure, we cannot afford to use a method that results in loss of material.
- Our dust separation system incorporates some traditional methods, while preventing the dust from being contaminated or changed in reactivity properties, and also minimizing losses.

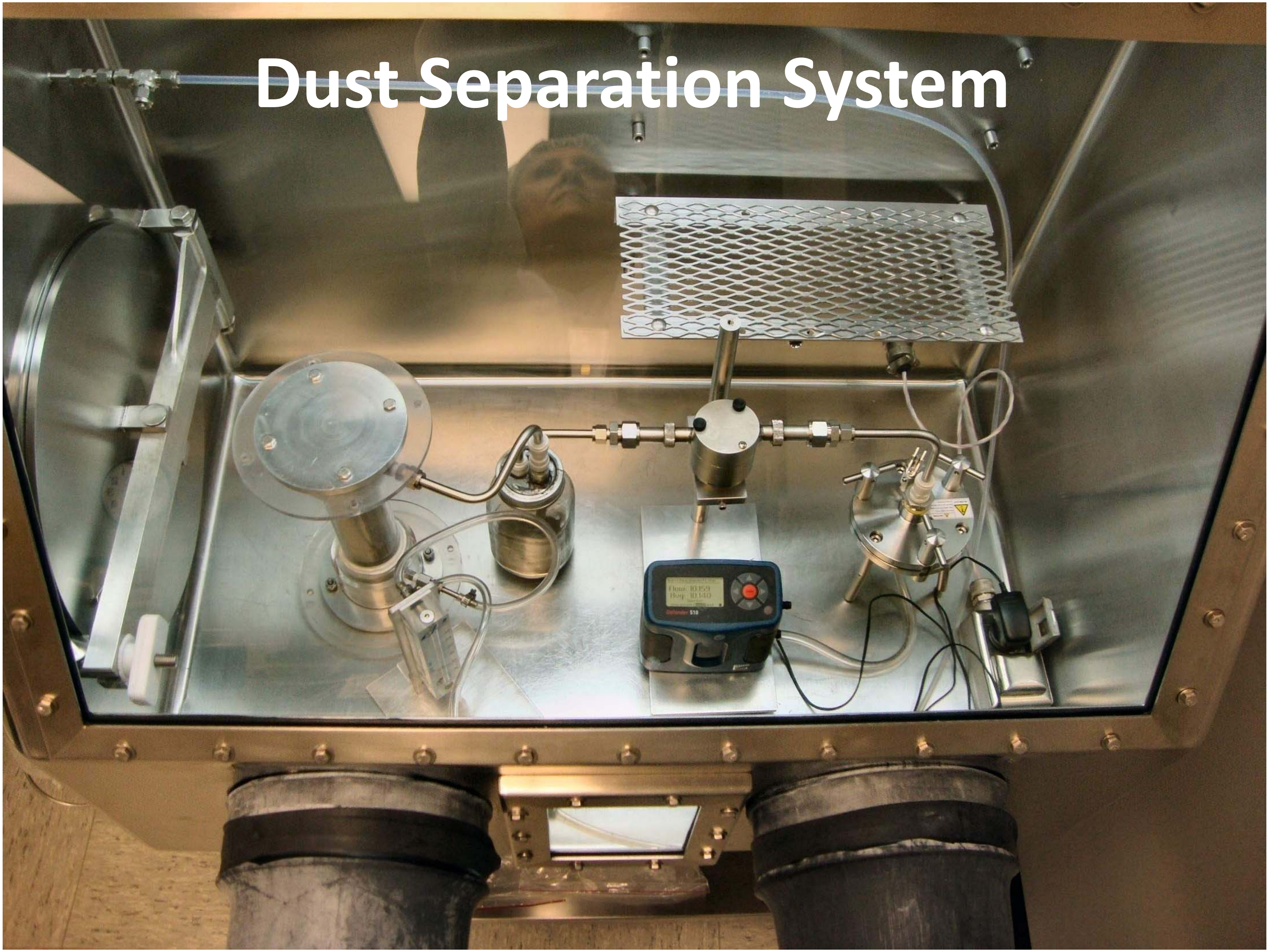
Stainless Steel filter holder

Metal tubing (copper or stainless steel) has least amount of dust adhesion of all tubing types tested.

Dust Separation System Components and Flow Path

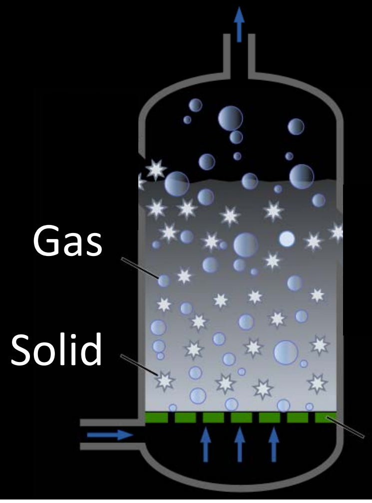


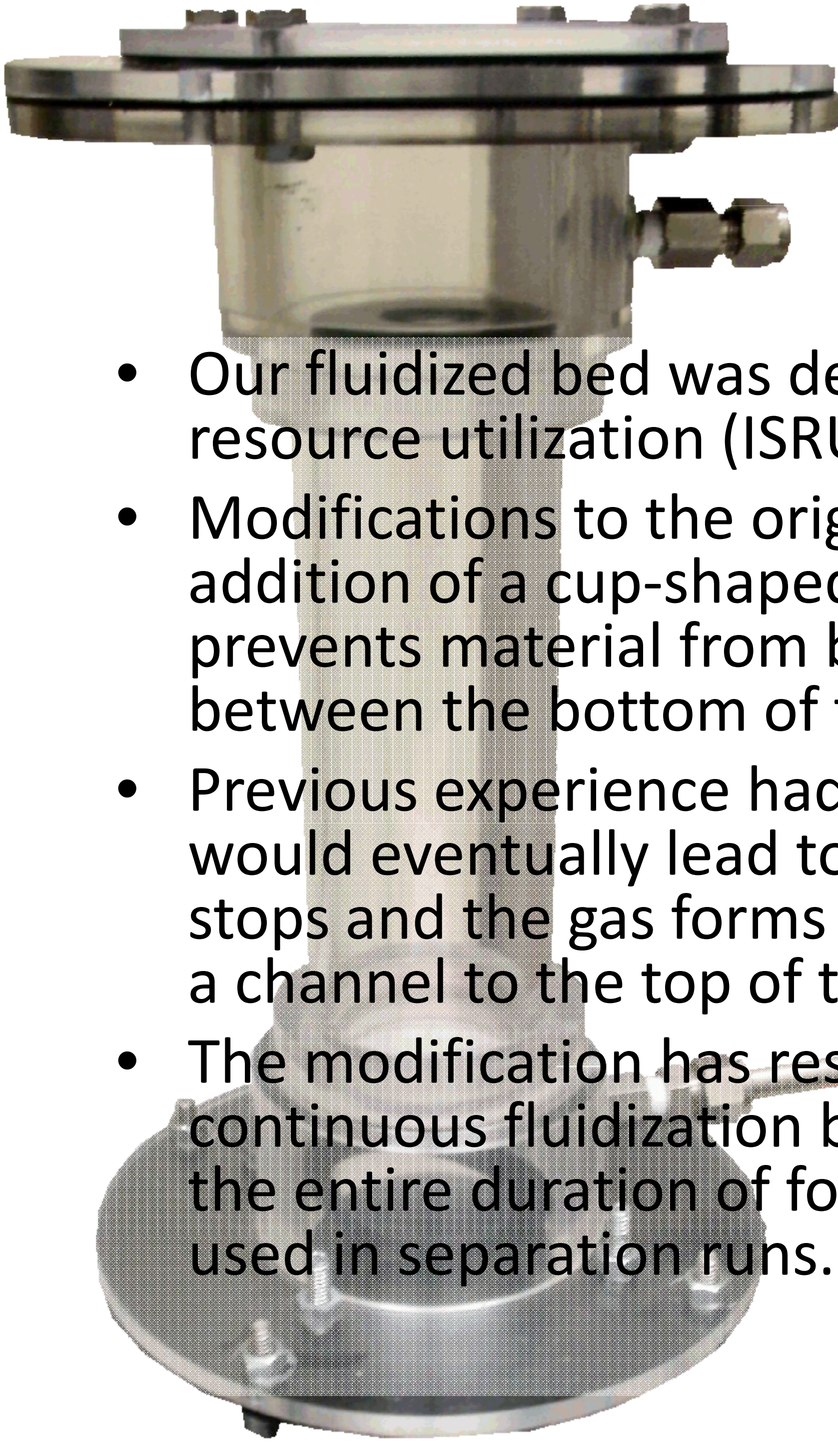
Dust Separation System



Fluidized Bed

- Because dry sieving is not very effective at releasing the respirable dust particles that are adhered to larger grains, we selected a fluidized bed as the first stage in our system. The fluidized bed thus becomes an enhanced elutriation system
- Fluidized beds are most commonly used for chemical processing, but the principal of operation makes them a useful option for a dust separation system.
- The “bed” is the mass of particulate material which is contained by the system. Fluidization refers to the fact that gas (or liquid) passes through the material from below, causing the particulate matter to behave like a fluid. The gravitational pull on the particles is offset by the fluid drag that pulls them upward, and the particles remain in a semi-suspended condition.





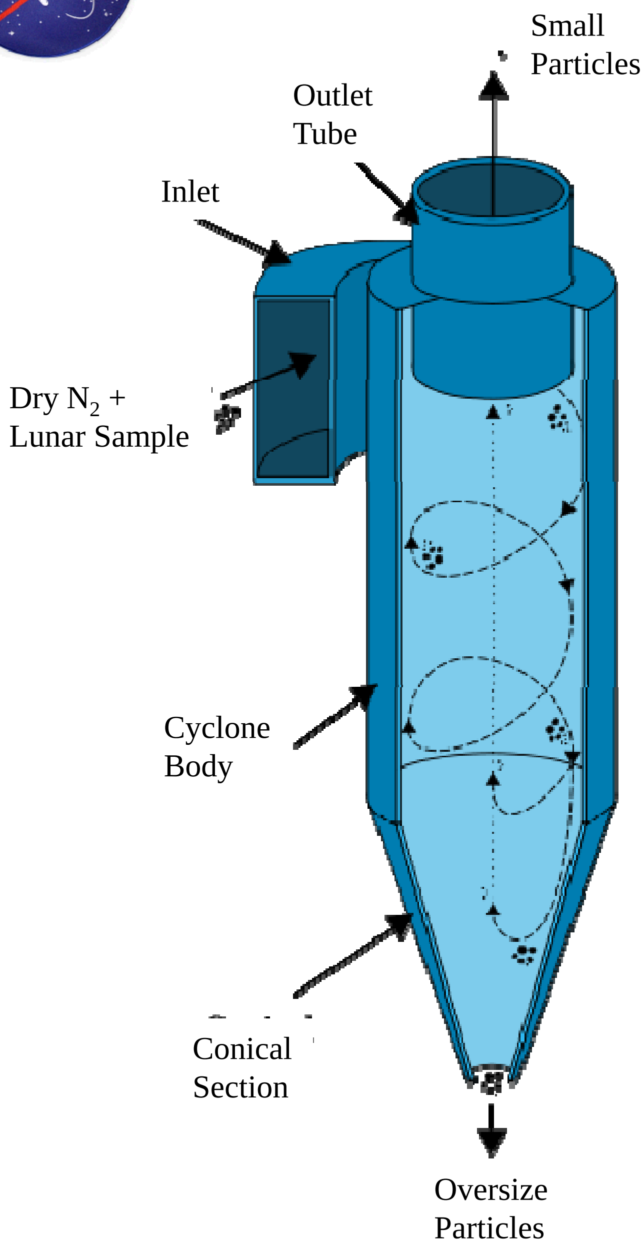
Fluidized Bed

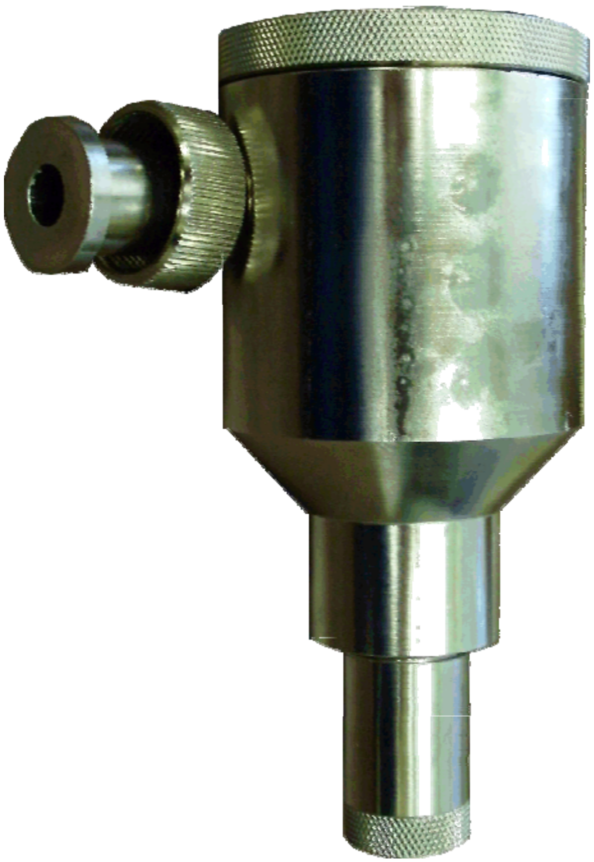
- Our fluidized bed was developed at JSC for use as an *in-situ* resource utilization (ISRU) demonstration unit.
- Modifications to the original component include the addition of a cup-shaped filter holder at the bottom, which prevents material from being caught in the corner space between the bottom of the bed and its floor.
- Previous experience had shown us that these “dead” spots would eventually lead to channeling, in which fluidization stops and the gas forms a channel to the top of the bed.
- The modification has resulted in continuous fluidization behavior for the entire duration of four hours used in separation runs.

Settling Flask/Impactor

- Following the fluidized bed is a settling flask, in which the input is directed via a tube to the bottom of the flask.
- The settling flask presents a large volume to the air stream of the separation system.
- The sudden expansion of size at the flask reduces the speed of the dust-filled airstream and thus heavier particles will settle out.
- Smaller particles will remain in the air stream and flow around the tube.
- These smaller particles then drift upwards in the air stream to the top of the flask, and are carried out to the next component—the cyclone.

Cyclone


Small
Particles
Outlet
Tube
Inlet
Dry N_2 +
Lunar Sample
Cyclone
Body
Conical
Section
Oversize
Particles



Filter

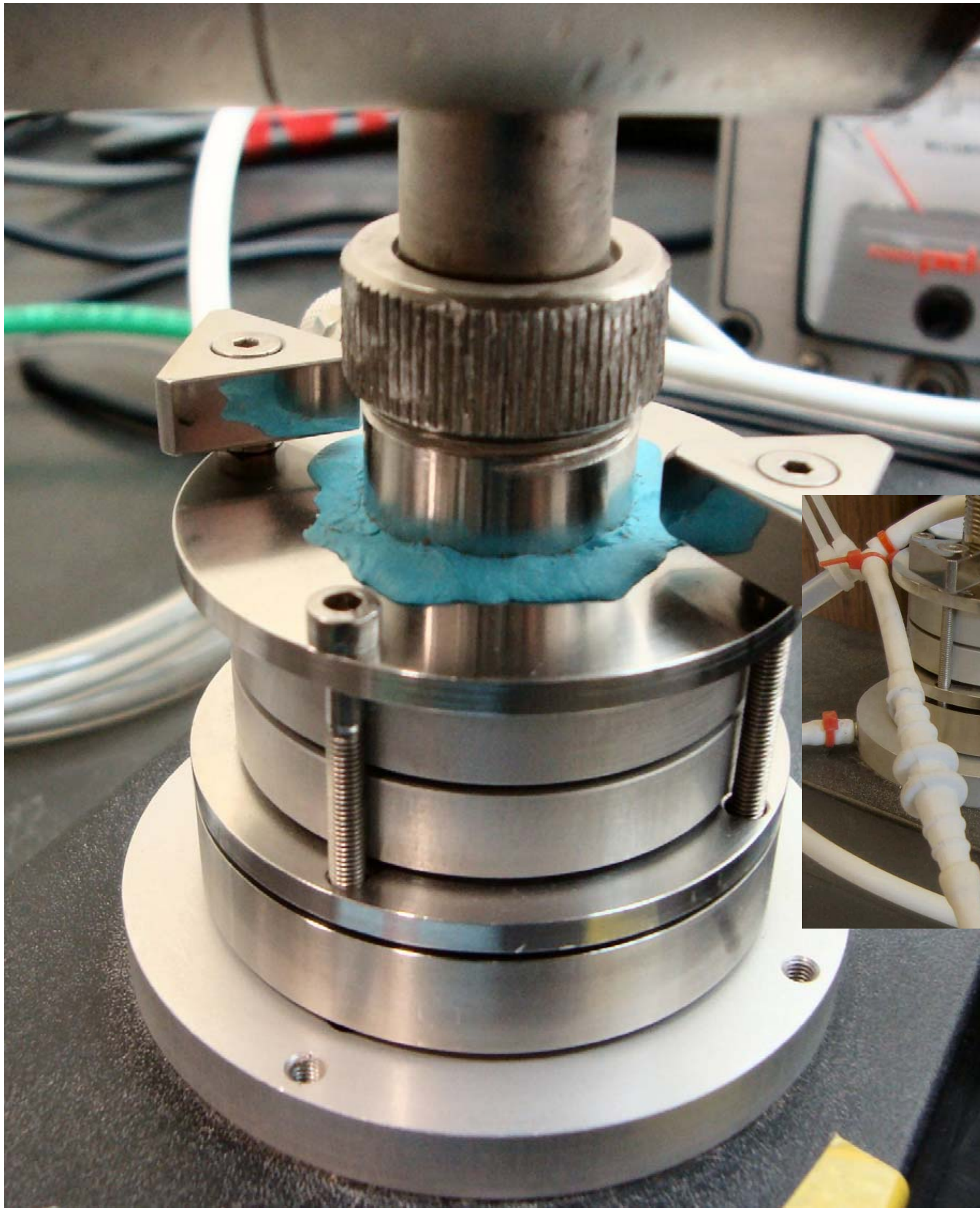
- The membrane filter is the final component in the system, and is the point at which the product dust is collected.
- Filters are one of the most efficient methods of separating dust from a gas stream, with collection efficiencies of more than 99% for very fine particulates.
- Cellulose or paper filters cannot be used because (a) it is difficult to remove the dust from them after collection; and (b) scraping material from this type of filter results in fibers in the dust.
- Instead we use a membrane filter with a pore size of 0.05 μm.
  - We have found these filters to be robust—a single filter is used throughout a four-hour system operation.
- In spite of their high efficiency in capturing dust, filters do not perform well in separating various particle sizes from one another—all particles of almost any size are trapped on the filter.
  - This is why the filter is used only at the end of the separation system, after we have removed the oversize particles from the gas stream.

Membrane filter removal inside glove box.

Example of dust collected by the membrane filter.

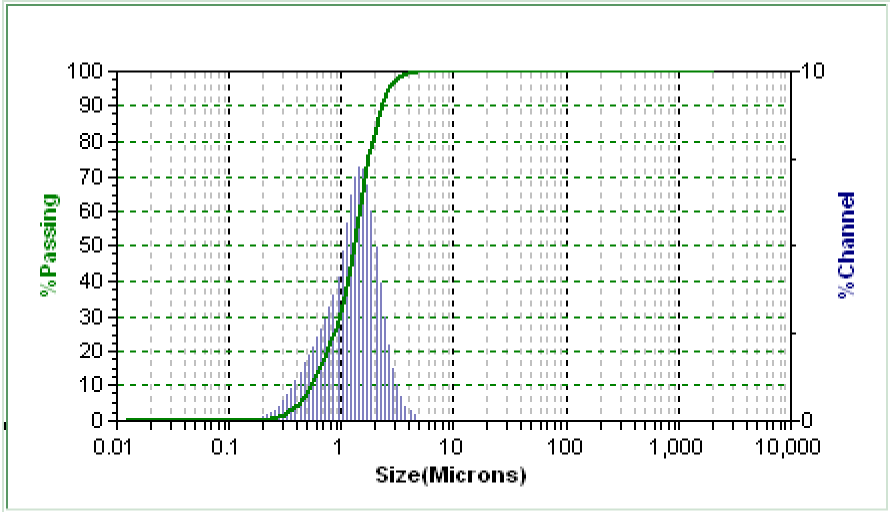
Separation of Ground Dust

- Grinding lunar soil into dust did not provide particles that were small enough to be mouse-respirable (1.7 μm)
- Two types of grinding were tried
  - Jet-Mill grinding (D50 = 2.848 μm)
  - Ball-Mill grinding (D50 = 5.13 μm)
- An additional separation system for small amounts of material was assembled to further separate the ground lunar soil.

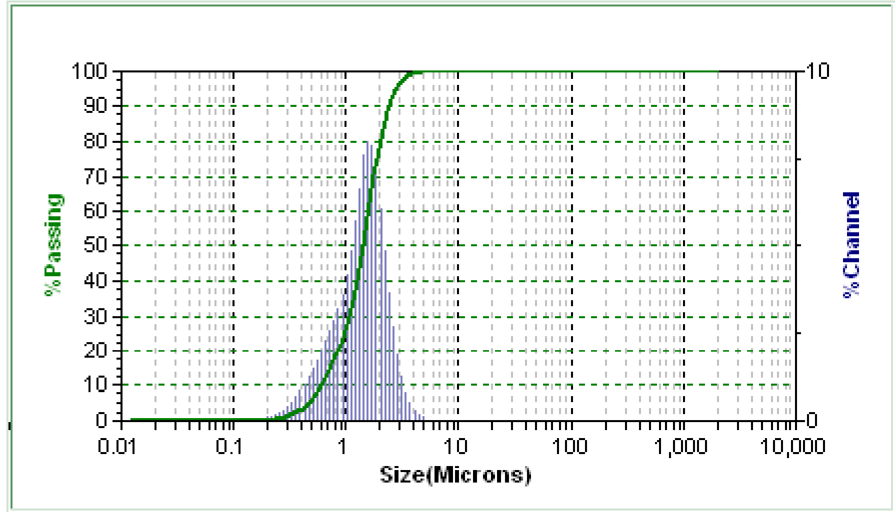


Separation System for Small Amounts of Lunar Material

Results



Jet-Mill-Ground, then separated: (Rec. # 1741)
Median = 1.300 um; St. Dev = 0.673



Ball-Mill-Ground, then separated: (Rec. # 1737)
Median = 1.427μm; St.Dev. = 0.689 (IPA)

Natural Dust: (Rec. # 675)
Median = 1.448 um; St. Dev = 0.717