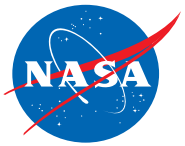

A Scroll Filter System for In-Situ Resource Utilization CO_2 acquisition of the Martian Atmosphere

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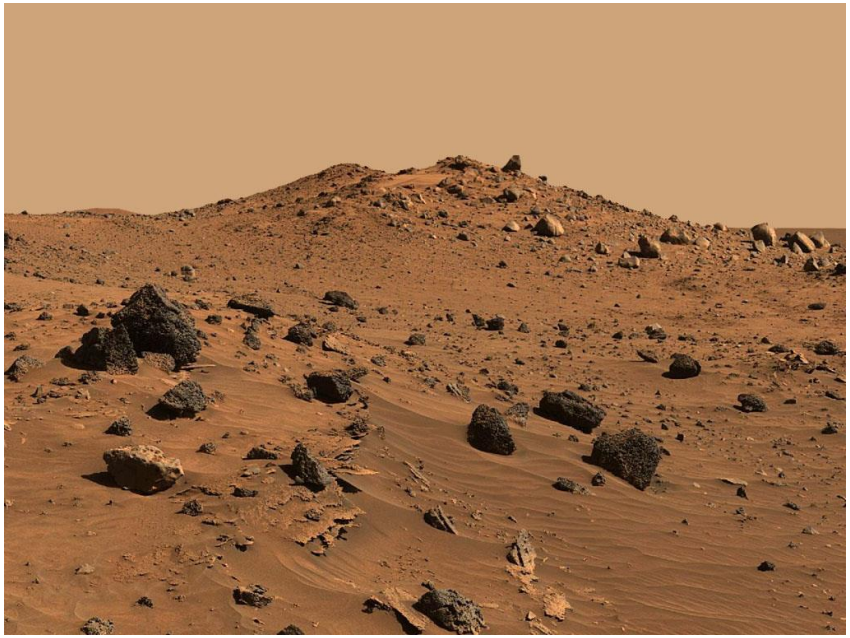
NASA Glenn Research Center

Space Resources Roundtable, Golden, CO, June 11-14, 2019

Resource Utilization and Atmospheric Acquisition

- Surface missions to Deep-Space destinations will have to rely on In-Situ Resource Utilization (ISRU) technologies
- Dramatically reduce launch mass of human exploration missions, and create a self-sustaining infrastructure.

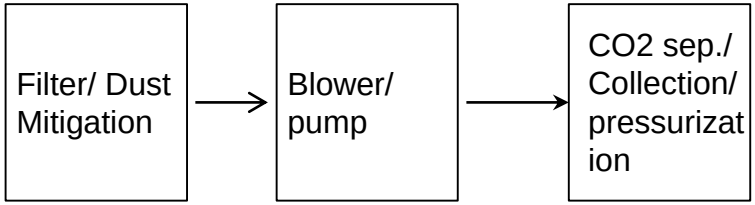


Resource Utilization and Atmospheric Acquisition

- Technology Roadmap Area 7.1

  Resource Acquisition to collect and pre-process the ‘raw’ resources, both naturally occurring and discarded, or un-needed components brought from Earth;

  Processing and Production to convert the raw resources into consumables for propulsion, power, and life support



Martian Dust Properties

- Limited particle size data, in particular little known of fine particles
- Mission data: Interferometric spectroscopy, spectrometers, spectroscopic cameras, video observations, infrared imaging, solar path obscuration (Pathfinder, Mariner 9, Viking, Phobos, MER)
  - Indirect measurement
  - Do not resolve fine particles well

Size Distribution and Concentration

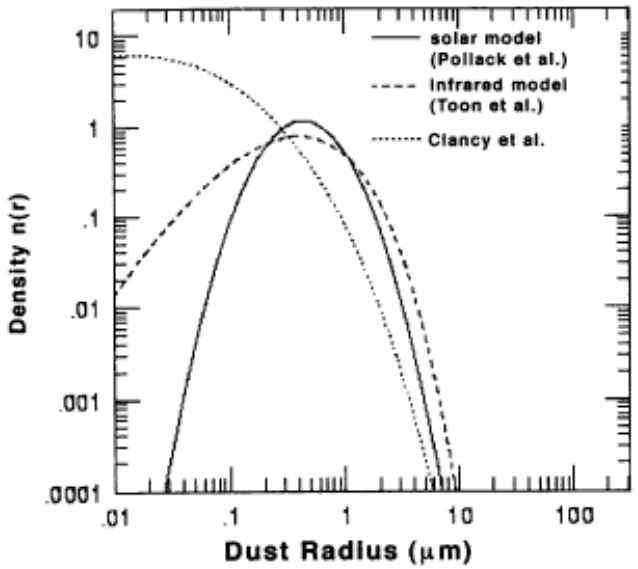
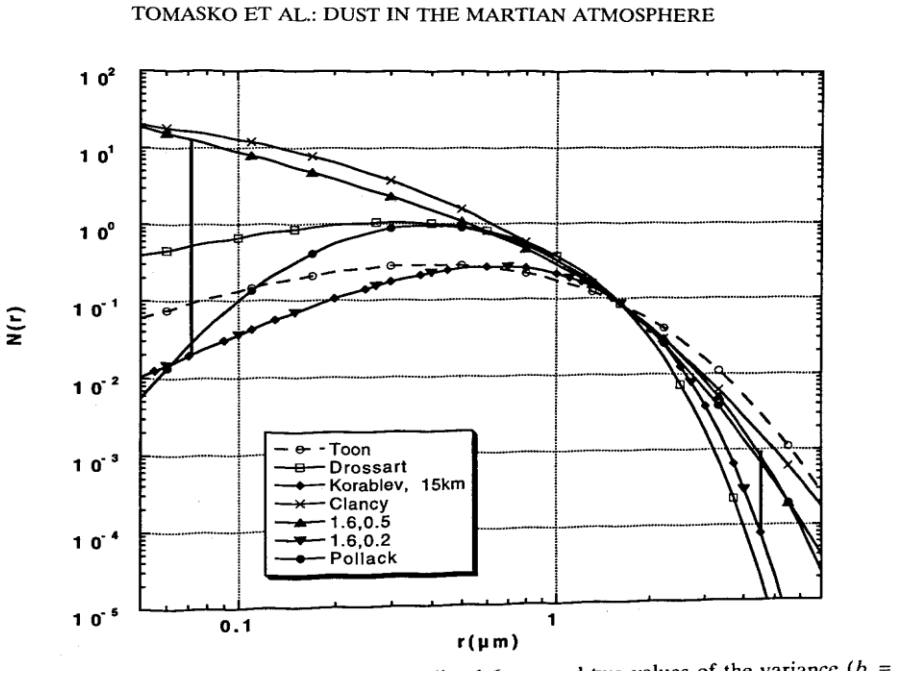
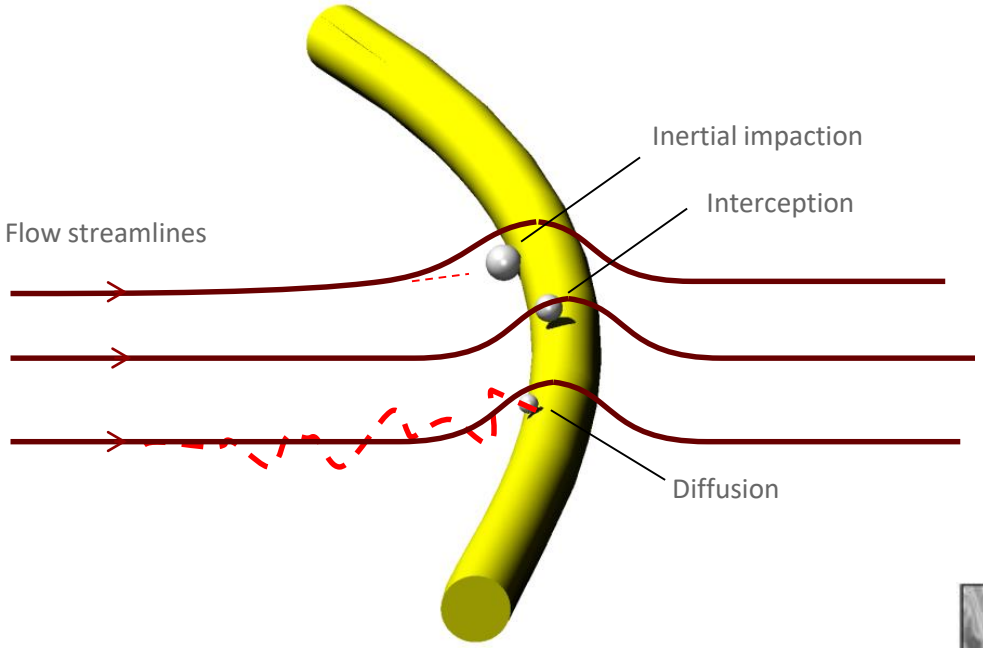


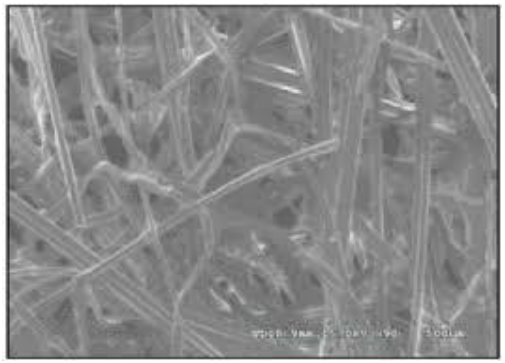
Figure 3-9. Relative Size Distribution of Airborne Dust Particles. Radius of dust particle is in micrometers.[3-12 3-13 3-14] Note the large disagreement for the smallest particles.



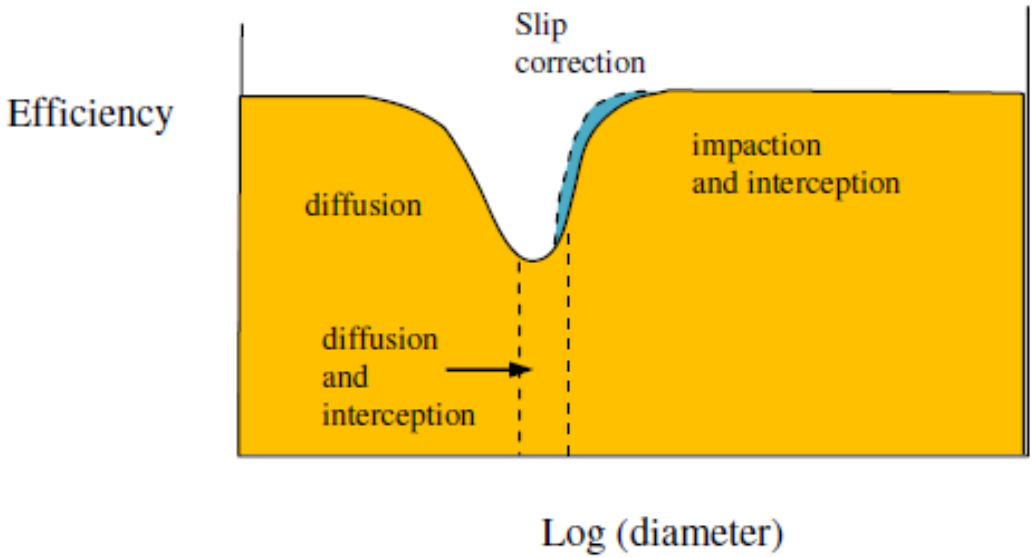
Alexander, Mars Transportation Environment Definition Document , 2001.

Media filtration
Capturing mechanisms on Fibers





Filter Efficiency



Slip effects:

Knudsen number *kn*, given by mean free path, λ, and characteristic length, L_{char}

$$kn = \frac{\lambda}{L_{char.}}$$ (λ~ 3 µm @ 7 Torr)

Kn < 0.001 (no slip boundary)
0.001<kn<0.1 (slip boundary)

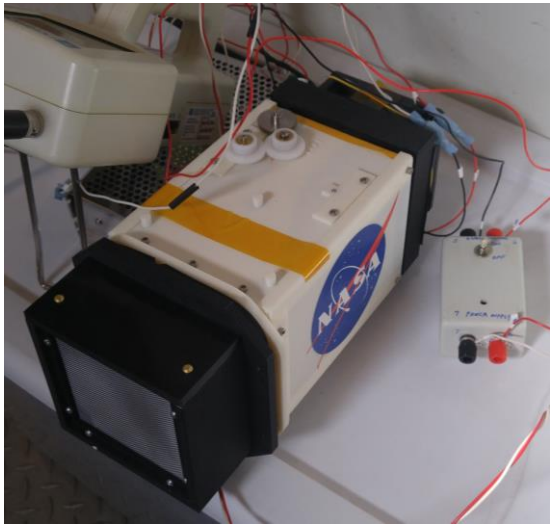
Drag force

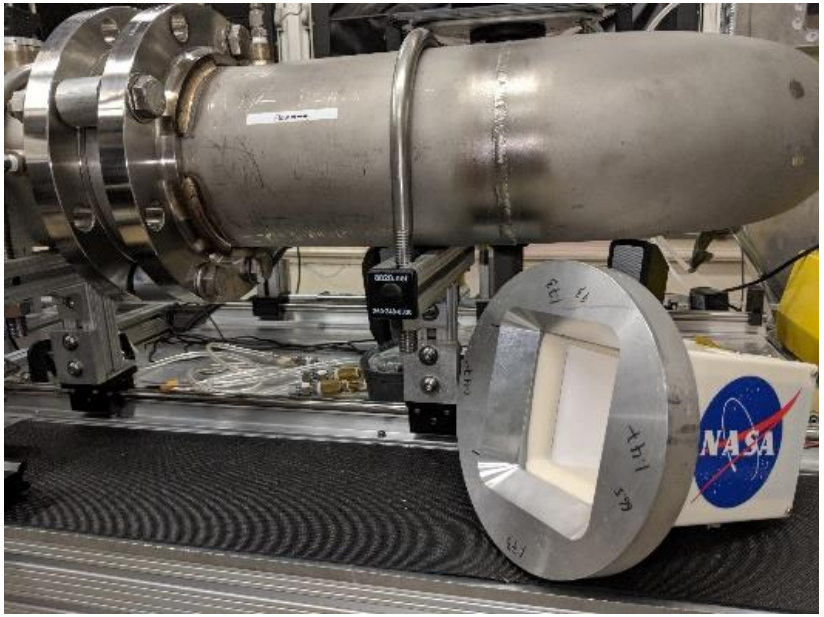
$$F_D = \frac{3\pi\eta d_p v_p}{C_C}$$

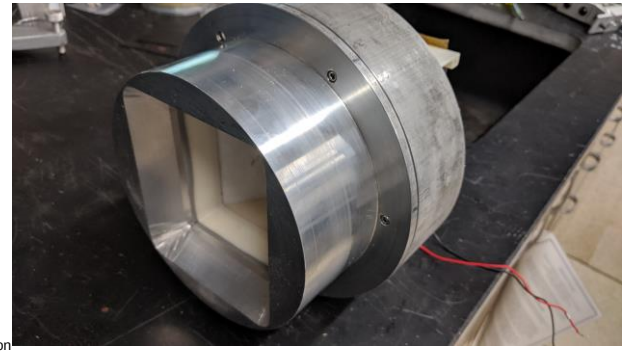
$C_C \sim 2 \; to \; 3 \; @ \; 7 \; Torr$

Scroll Filter

- Uses any grade of filter media (from high efficiency – i.e. HEPA – to medium efficiency – pre-filtration)
- Built-in pleated structure
- Scrolling mechanism allows hands-free (automated) media changes.
- Modular – facilitates added pre-filter components such as baffles, impactors and pre-filter media



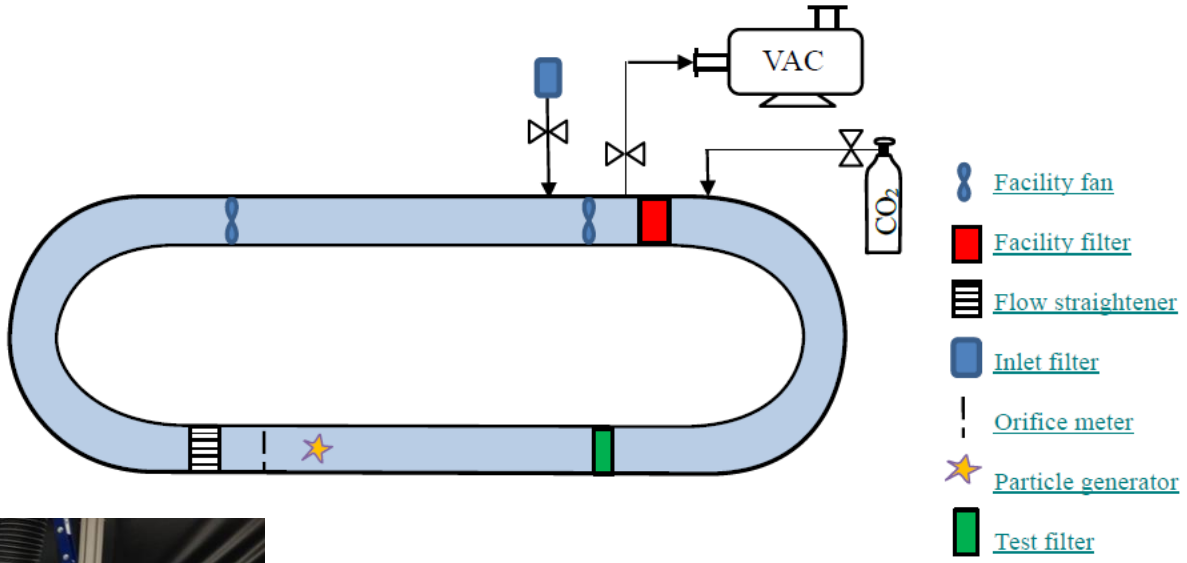




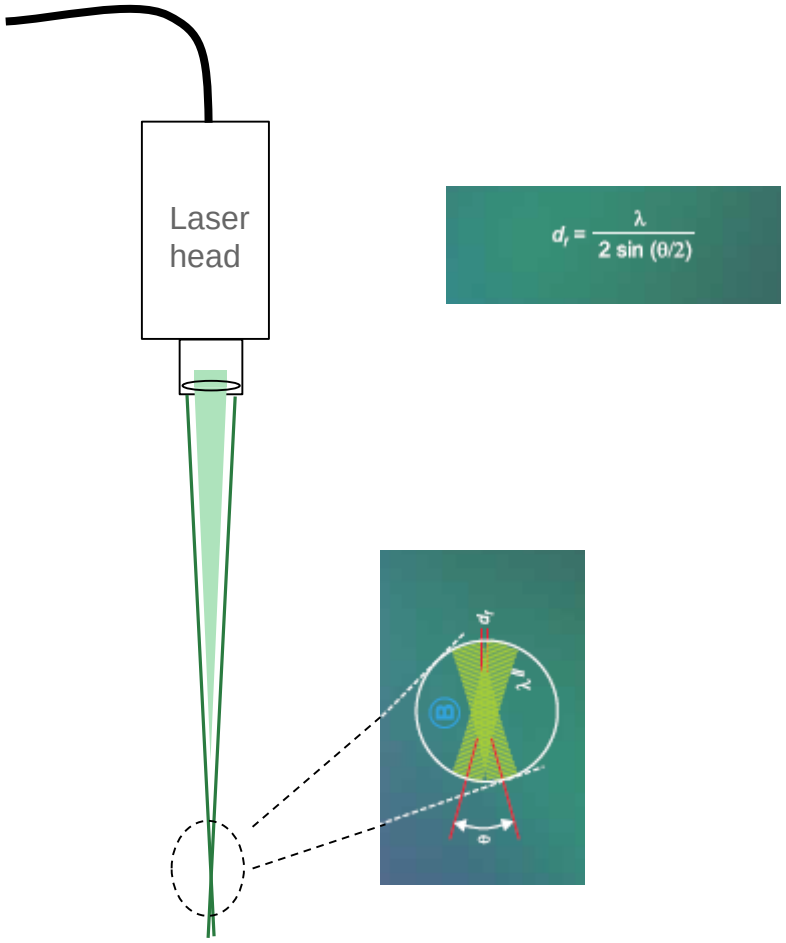
Test methods

- HE media (supplied by H&V)
  - 61% collection efficiency
  - Δp: 44 Pa @ 5 cm/s, 1 atm.
- Differential pressure transduce: pressure drop across filter
- Challenge aerosol
  - Internal aerosol generator
  - JSC-Mars 1 Martian simulant
- Light sheet imaging
- Particle penetration, P
  - LDA (counts, velocity) upstream and downstream of the filter.
  - Filter samplers upstream and downstream of the filter

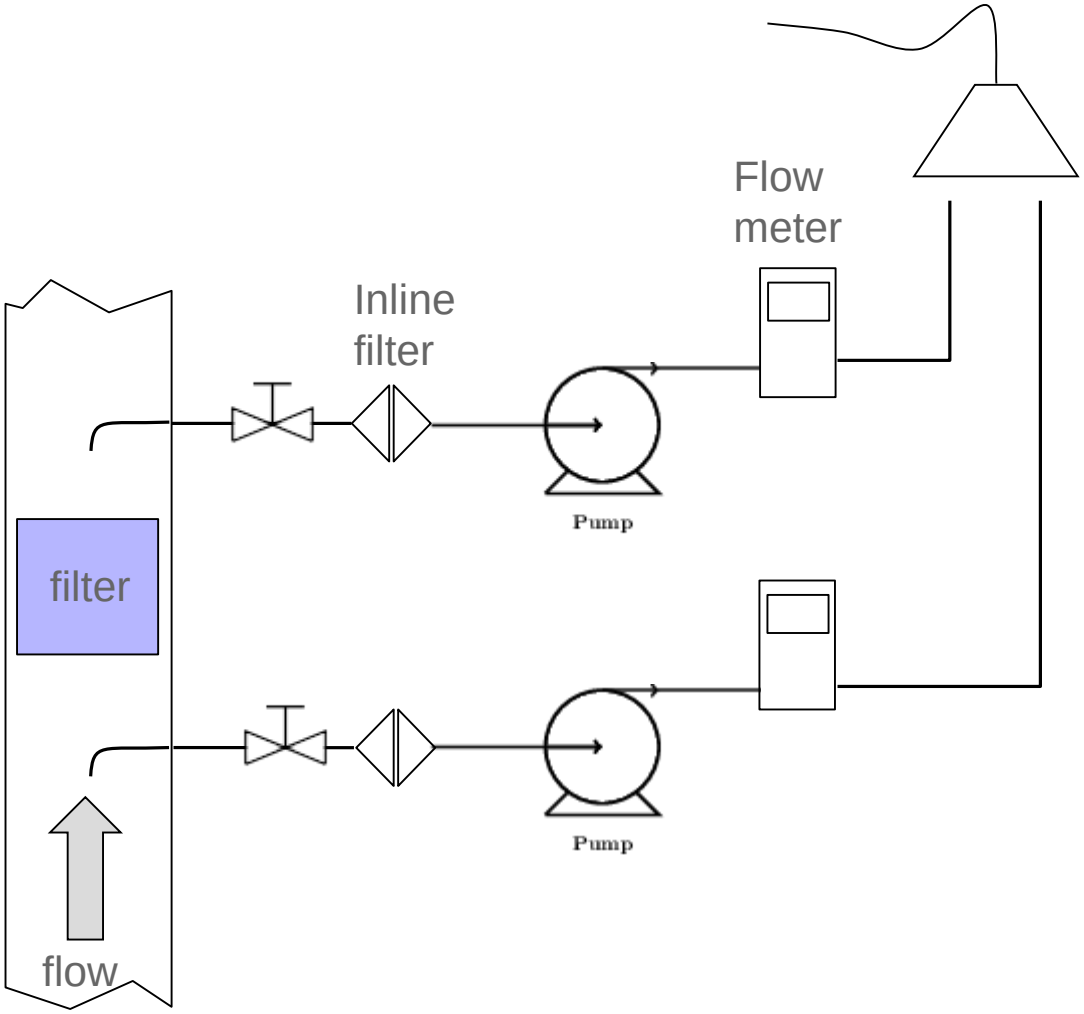
Particle Flow loop



Laser Doppler Anemometry

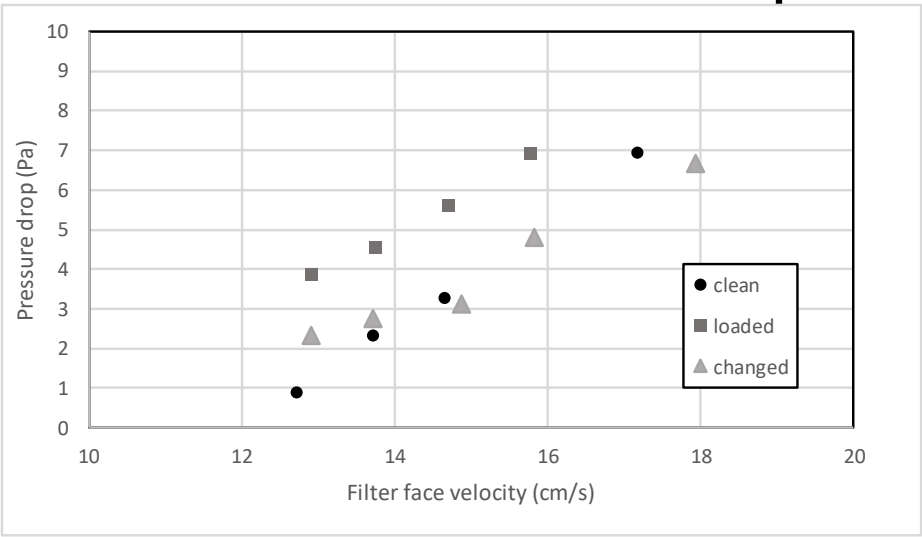


Particle Sampling

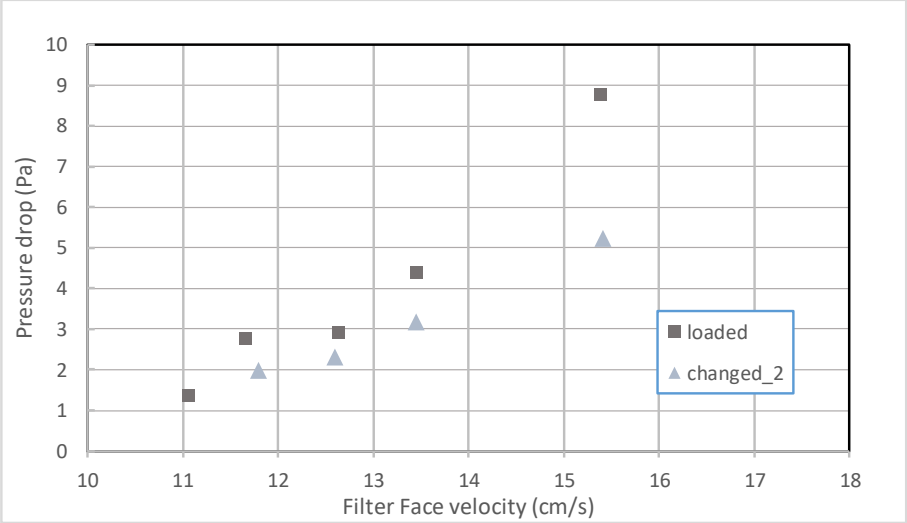


Results
(preliminary)

Filter Pressure Drop

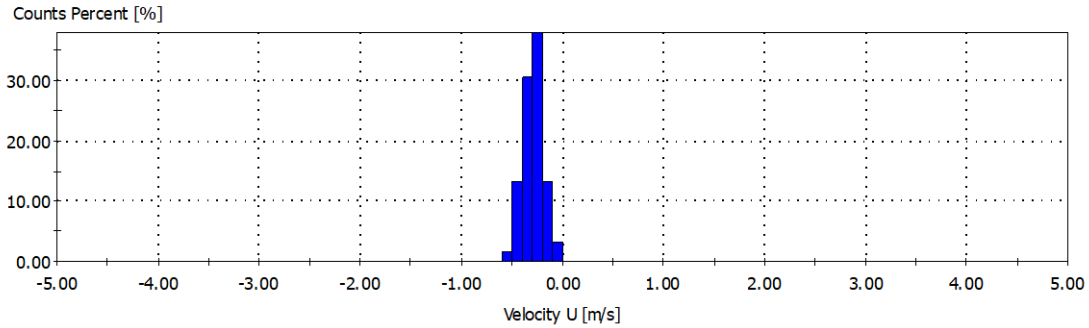


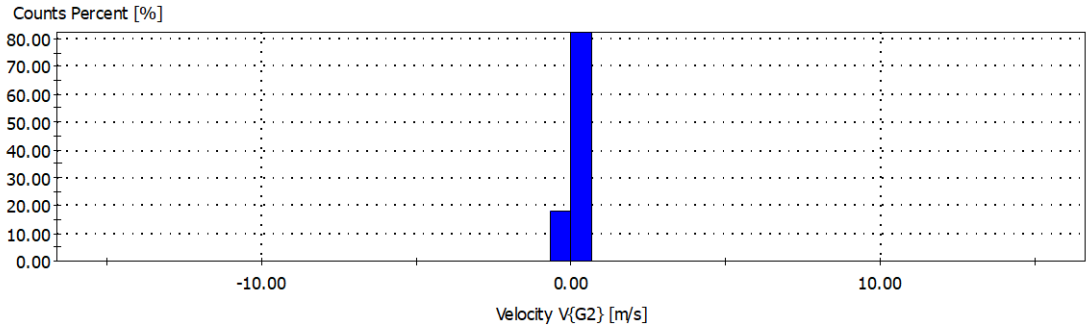
7 Torr



5 Torr

Velocity Histograms at upstream station (7 Torr, 121 particle counts)





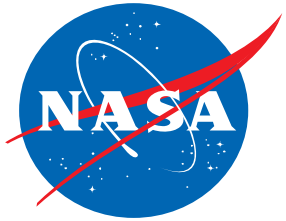
Filter samplers

Sampler	sampling time (min)	original mass (mg)	new mass (mg)	Δm (mg)	Conc µg/cm^2/min
Upstream	30	38.4	47	8.6	56.5
Downstream	30	38.3	38.3	-0.1	0

±0.1 mg

Conclusions

- Test methods in simulated Martian conditions using light sheet imaging, Laser Doppler Anemometry, particle sampling are being developed to establish methods of determining filter performance under these conditions.
- Pressure drop data indicated a increase in pressure drop with loaded filter, and a recovery of original pressure drop when media was changed out.
- LDA was used effectively to quantify particle counts upstream and downstream of the filter to measure particle penetration and filter collection efficiency
- Particle sampling provided estimates of particle concentrations upstream and downstream indicated nearly complete collection efficiency of the scroll filter.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