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

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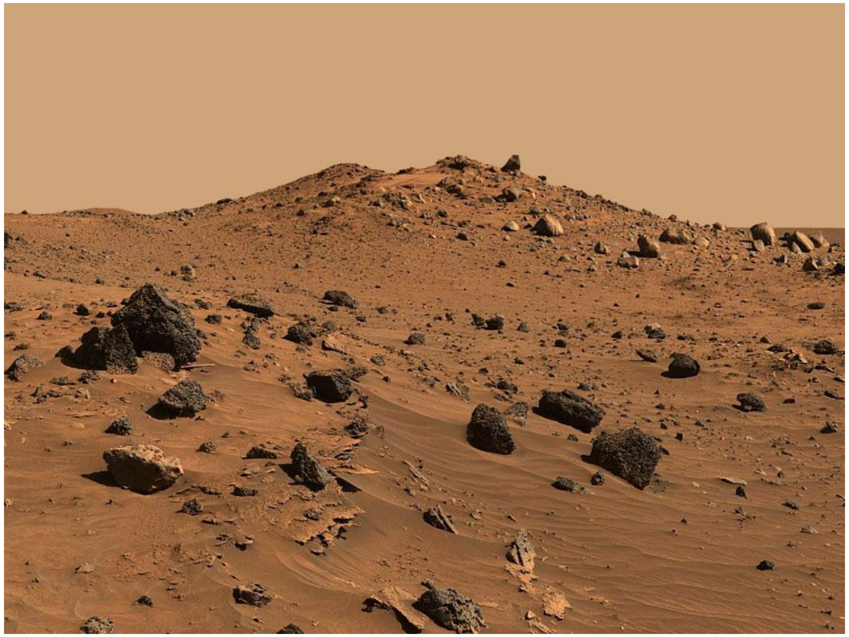
Space Resources Roundtable, Golden, CO, June 11-14, 2019

# 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.

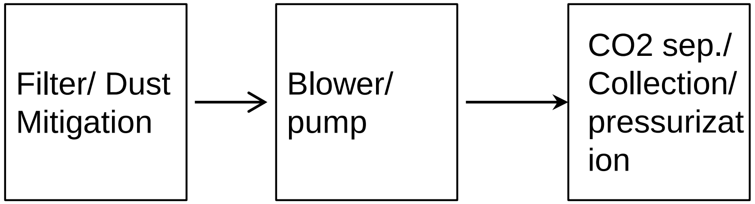


# Resource Utilization and Atmospheric Acquisition

- 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

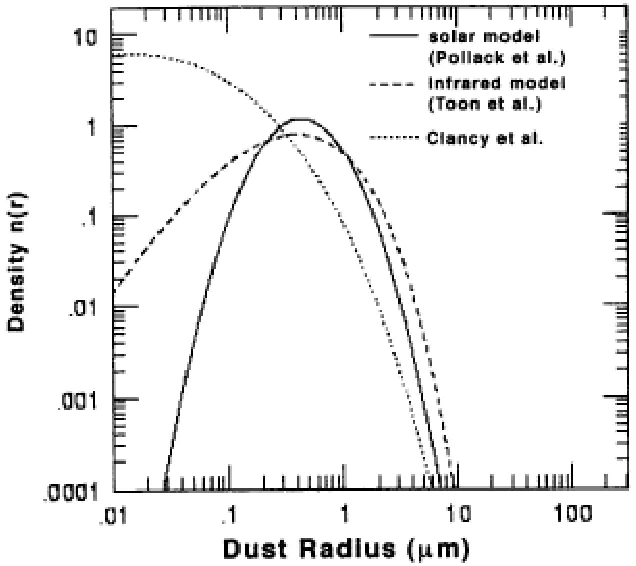
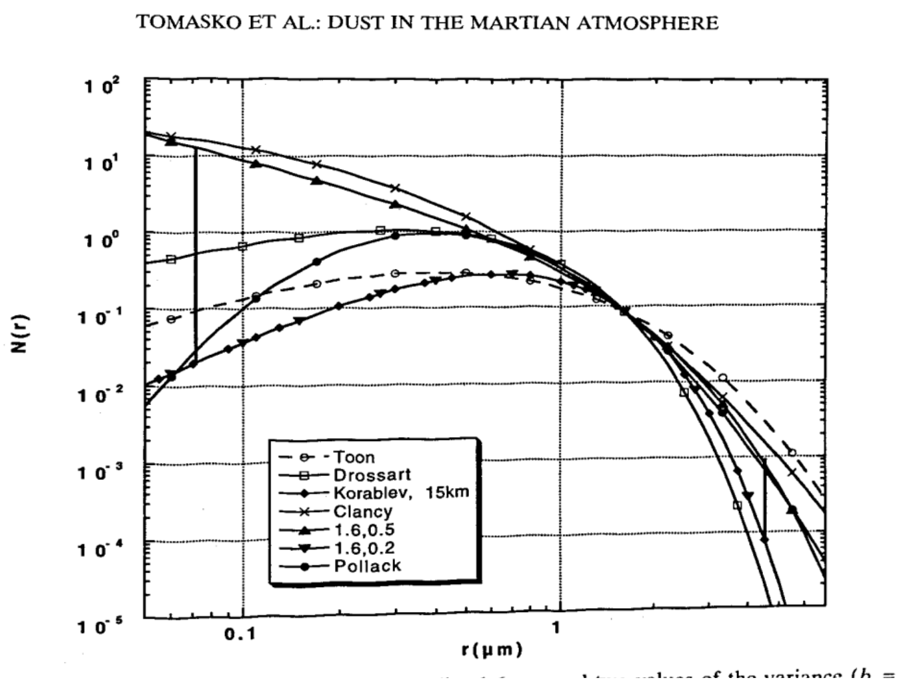
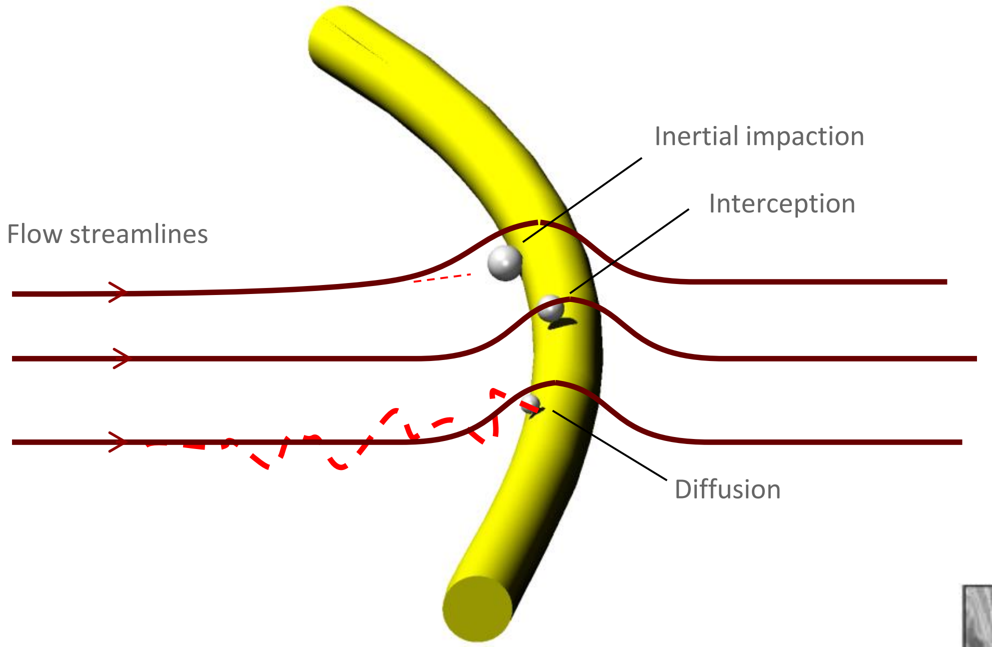


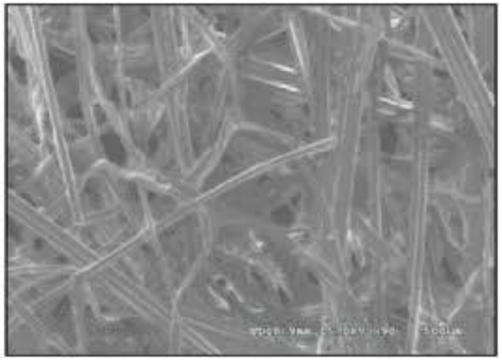

**Figure 3-9. Relative Size Distribution of Airborne Dust Particles.** Radius of dust particle is in micrometers.[3-12 3-13 3-14] Note the large disagreement for the smallest particles.




*Alexander, Mars Transportation Environment Definition Document , 2001.*

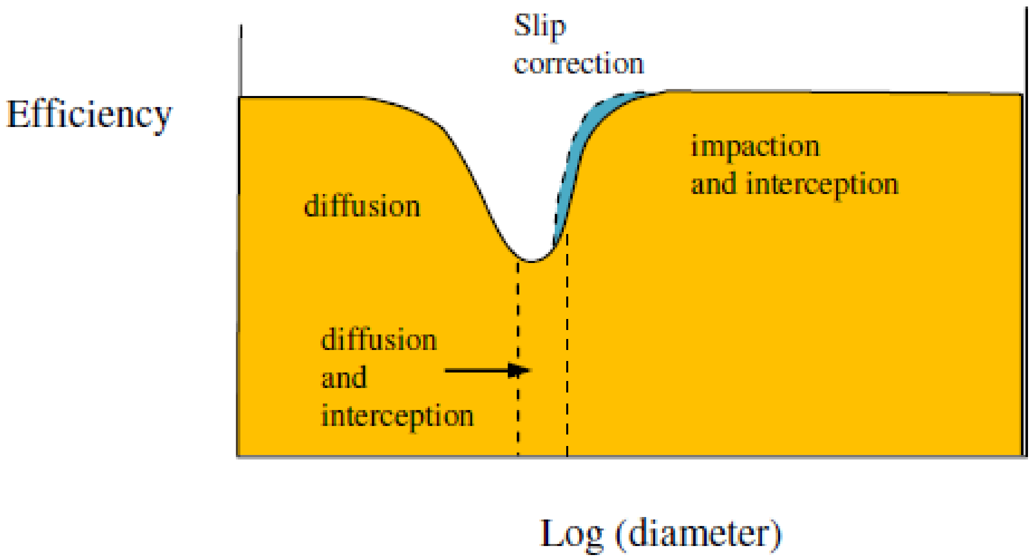
# Media filtration
# Capturing mechanisms on Fibers



# Filter Efficiency






Slip effects:

Knudsen number *kn*, given by mean free path, $\lambda$, 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)

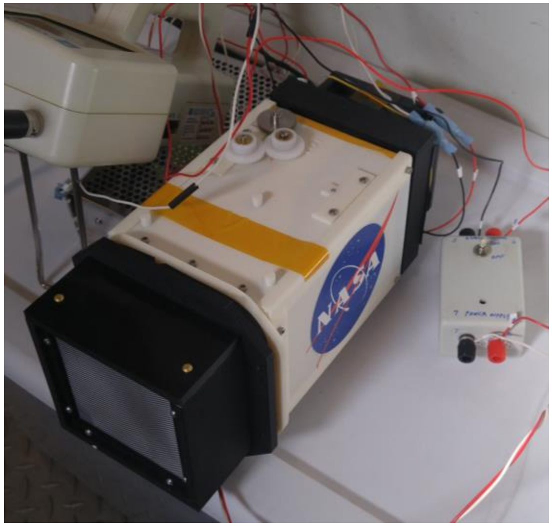
Drag force

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

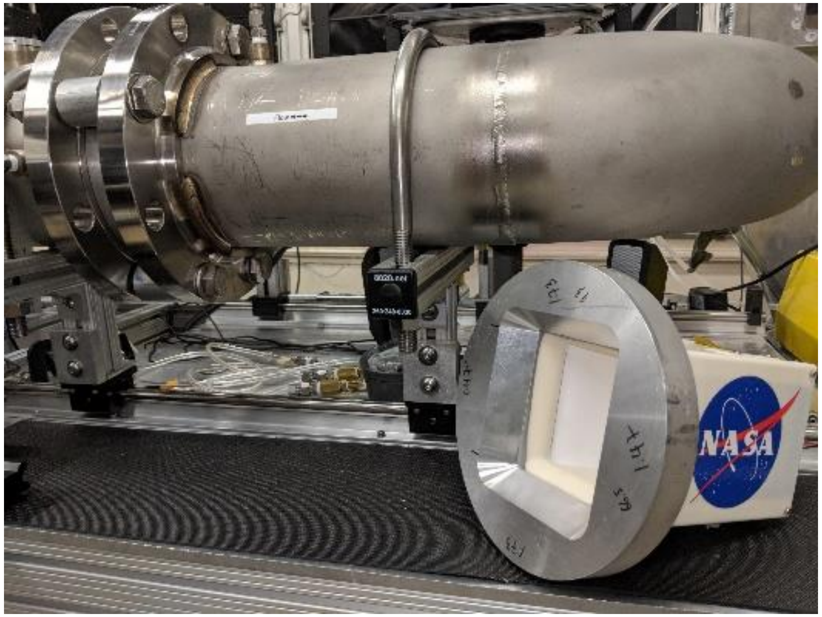
$$C_C \sim 2\ to\ 3\ @\ 7\ Torr$$

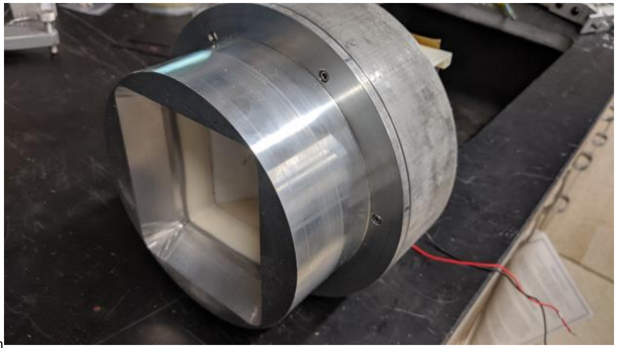
# Scroll Filter





- 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



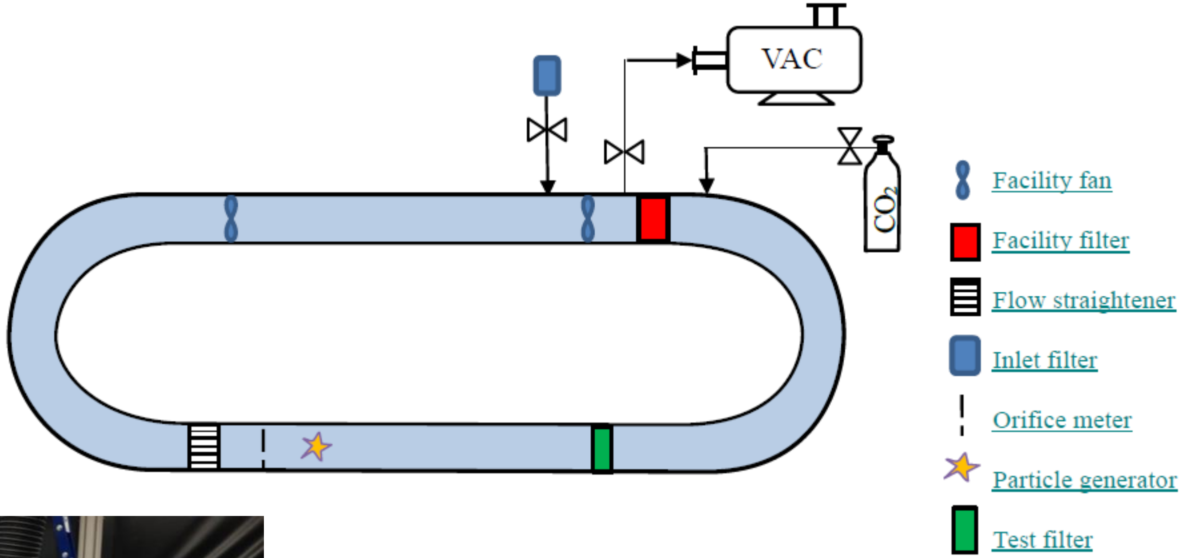


# Test methods

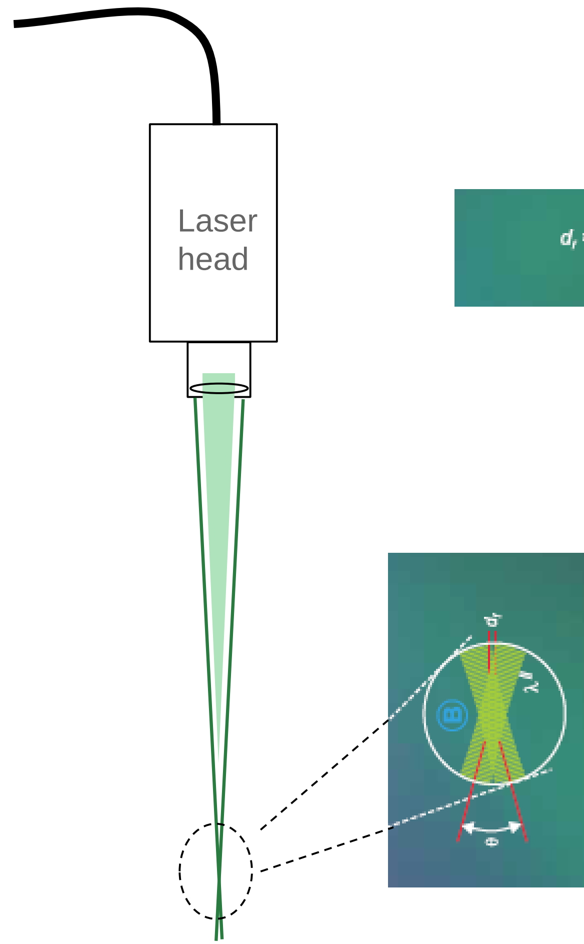
- HE media (supplied by H&V)
  - 61% collection efficiency
  - Δp: 44 Pa @ 5 cm/s, 1 atm.
- Differential pressure transduce: pressure drop across filter
- Challenge aerosol
  - Internal aerosol generator
  - JSC-Mars 1 Martian simulant
- Light sheet imaging
- Particle penetration, P
  - LDA (counts,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

# Particle Flow loop





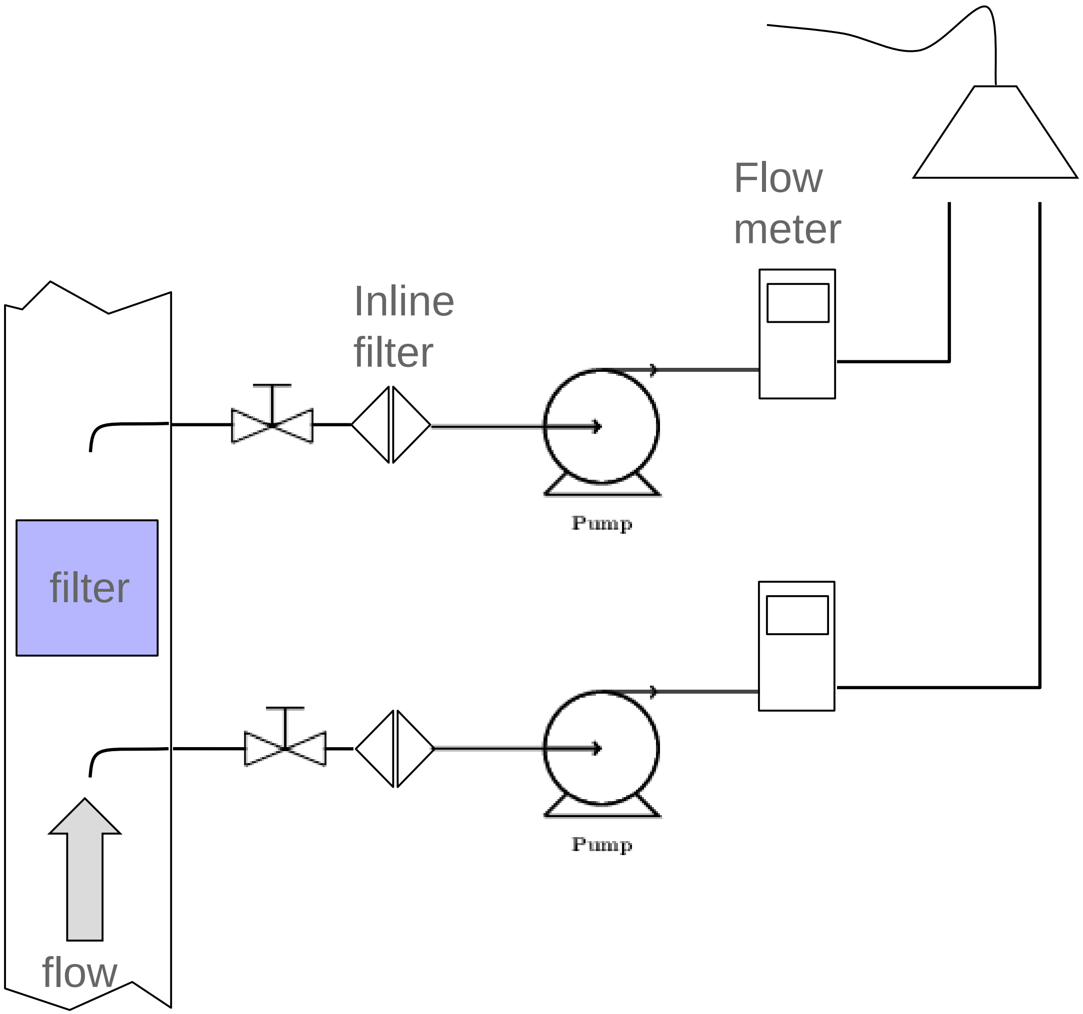

# Laser Doppler Anemometry




$$d_f = \frac{\lambda}{2 \sin(\theta/2)}$$

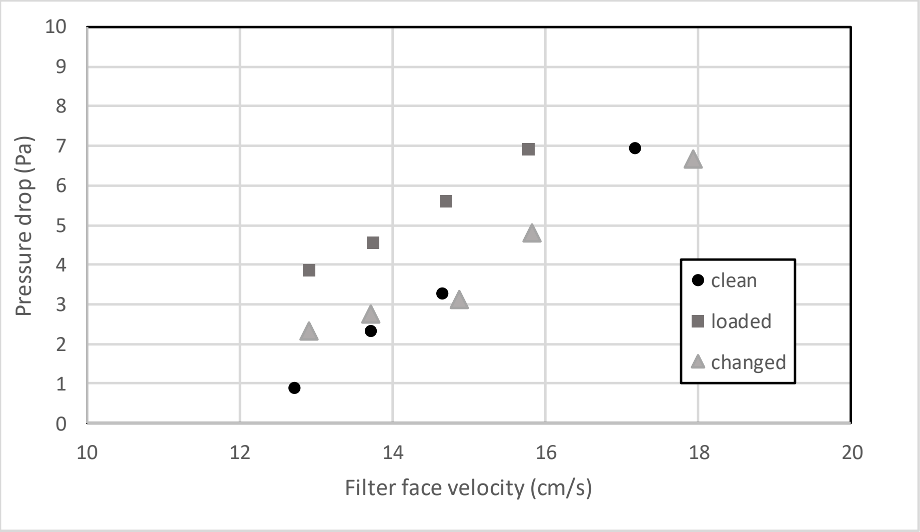
# Particle Sampling



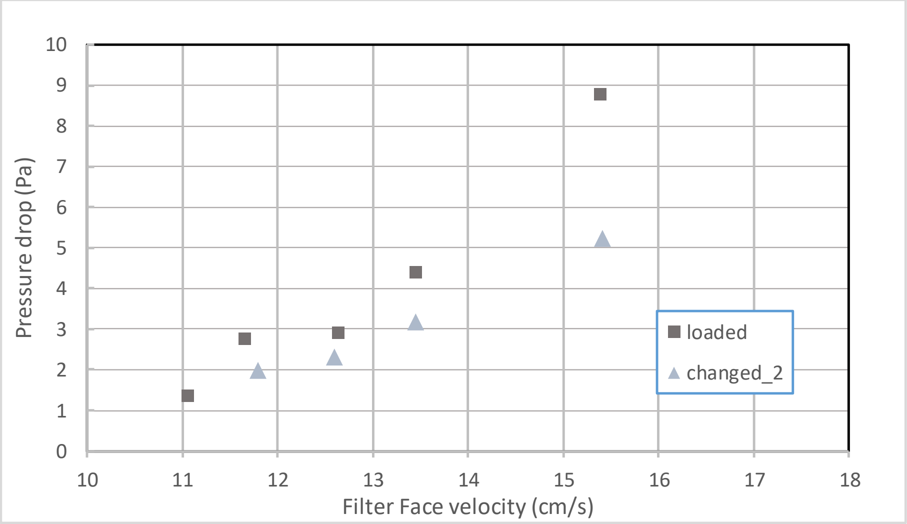


# Results
# (preliminary)

# Filter Pressure Drop

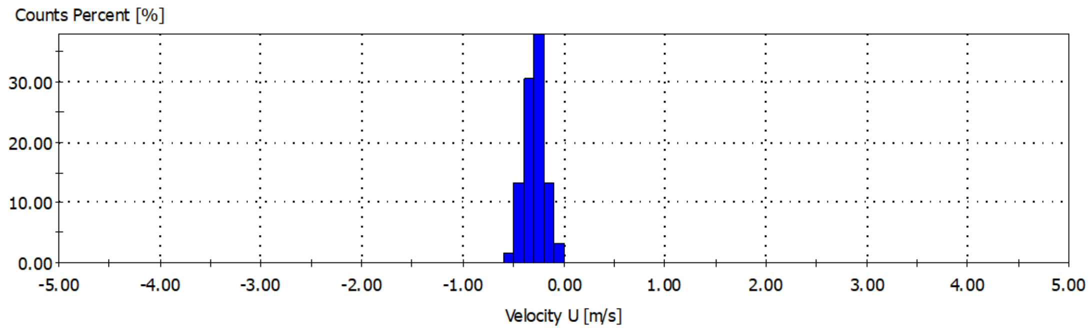


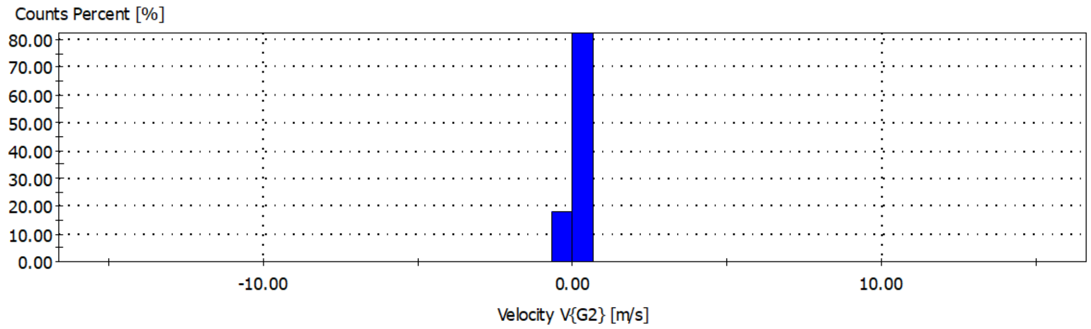

7 Torr




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.