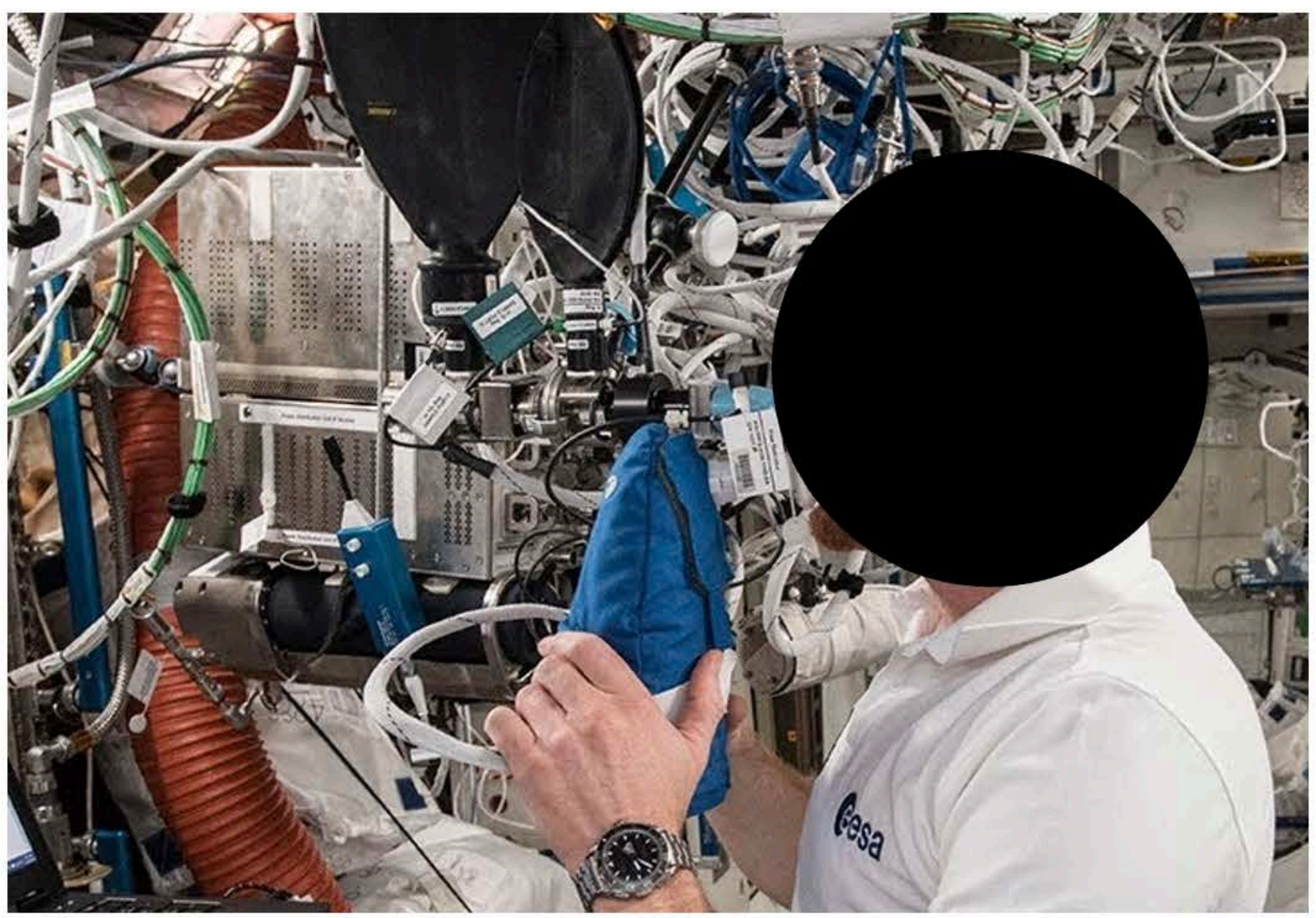
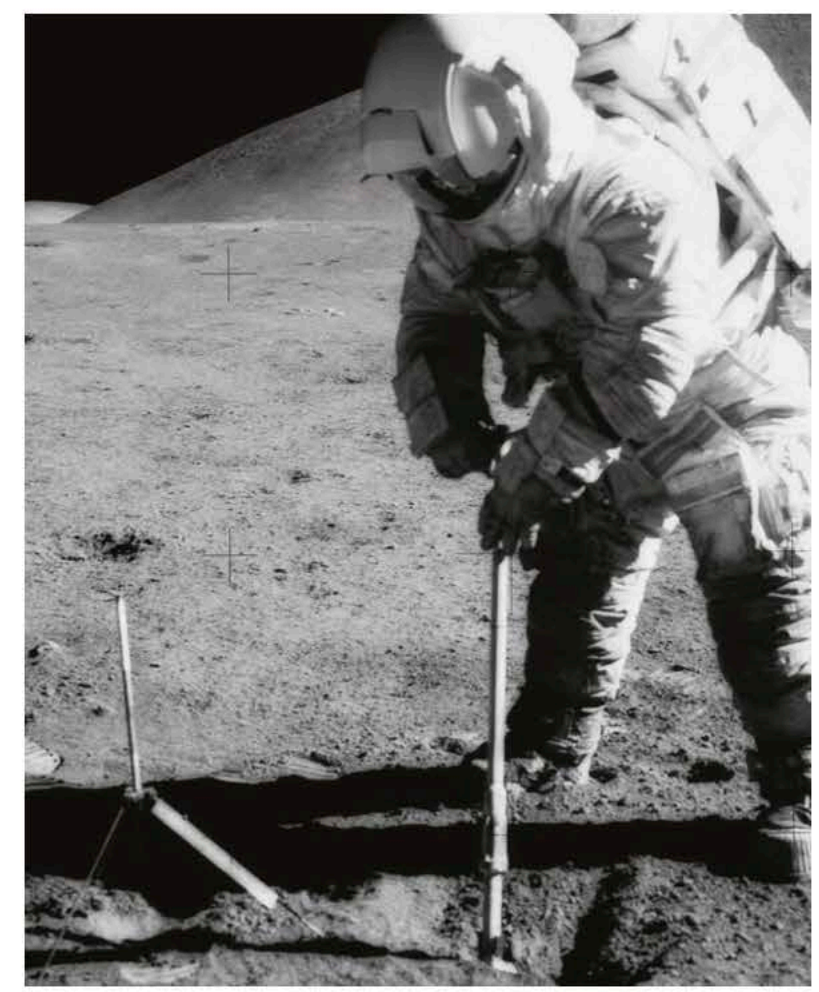
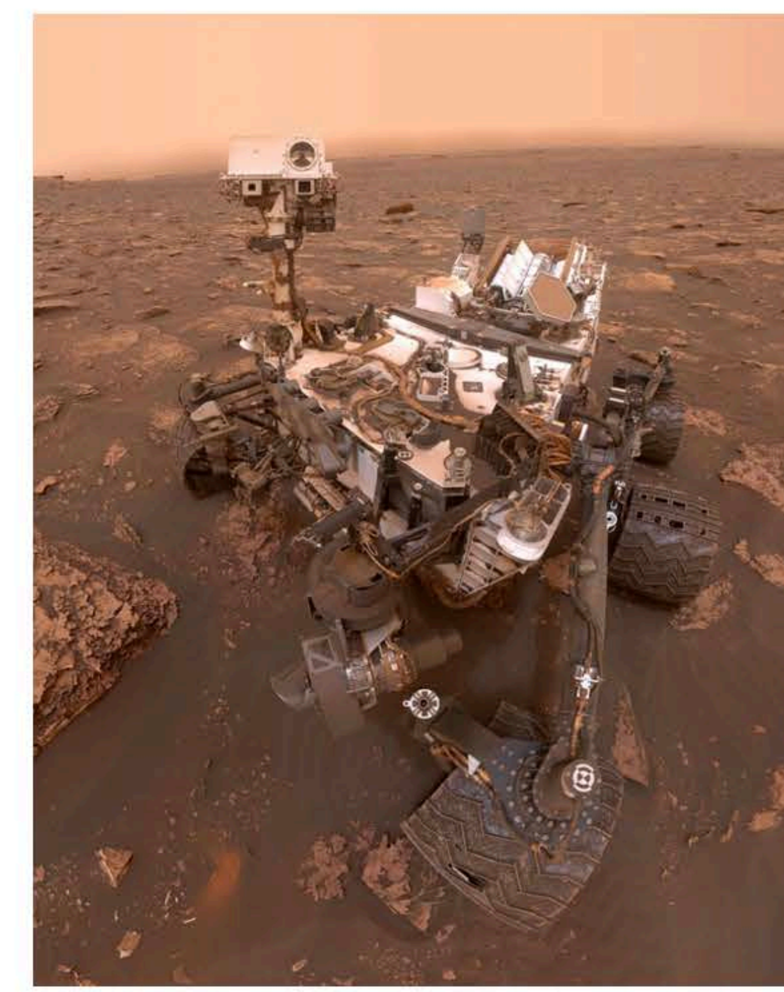
Lung health in space

This presentation

- Airway Monitoring – *lung health (ISS experiment)*
- Celestial dusts – *toxicity on human lungs (lunar dust and lunar and Mars simulants)*







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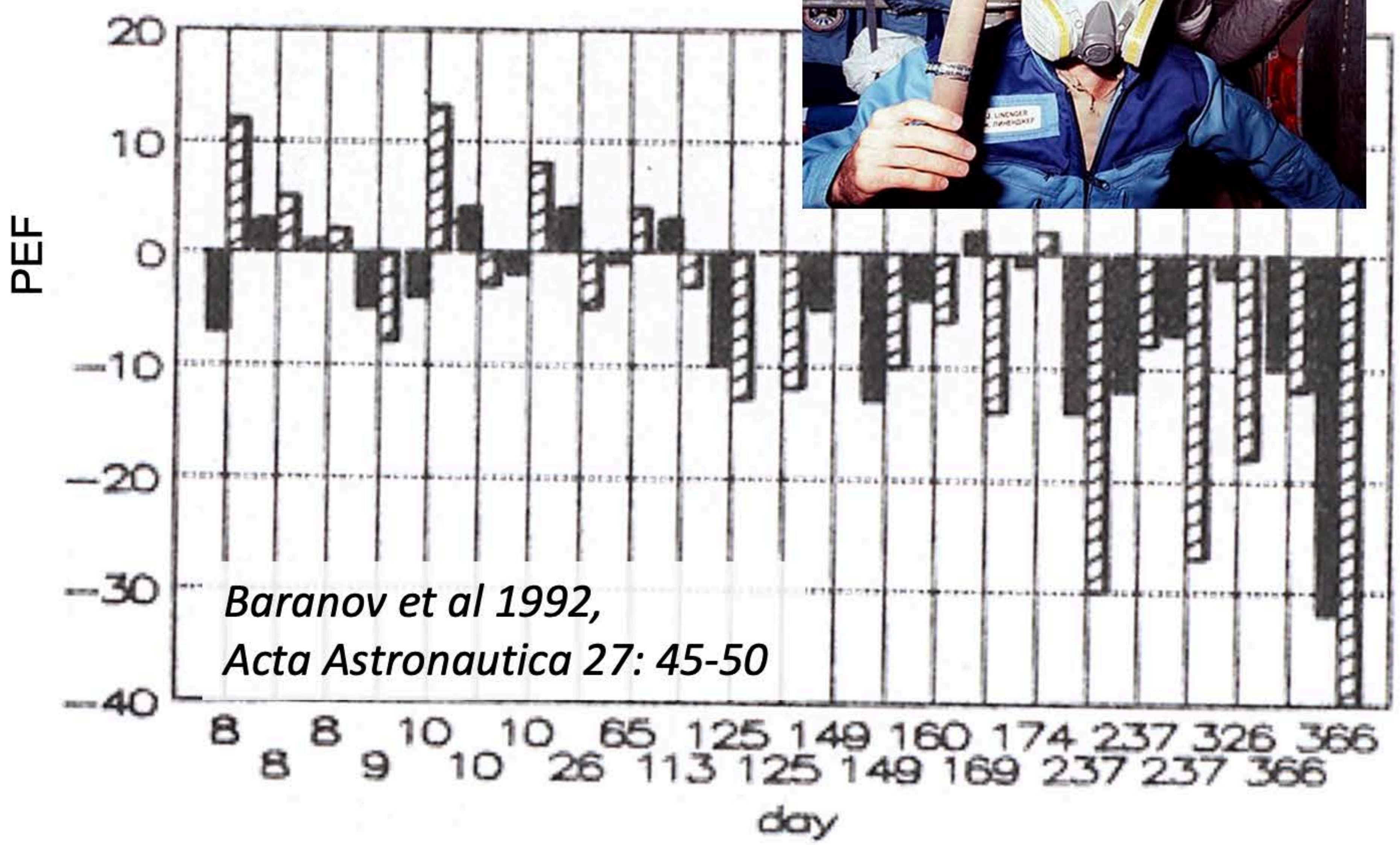
Science Background – ”Airway Monitoring”

- Lung health in space and on earth: increase our knowledge on monitoring airway inflammation.
- <u>In space</u>: airway inflammation could be a challenge due to inhalation of free-floating particles and toxic dust.
- <u>On earth</u>: main cause of airway inflammation is asthma.

Airway inflammation can be diagnosed by monitoring increased levels of exhaled nitric oxide (NO).

Gene Cernan, Apollo 17, ©NASA

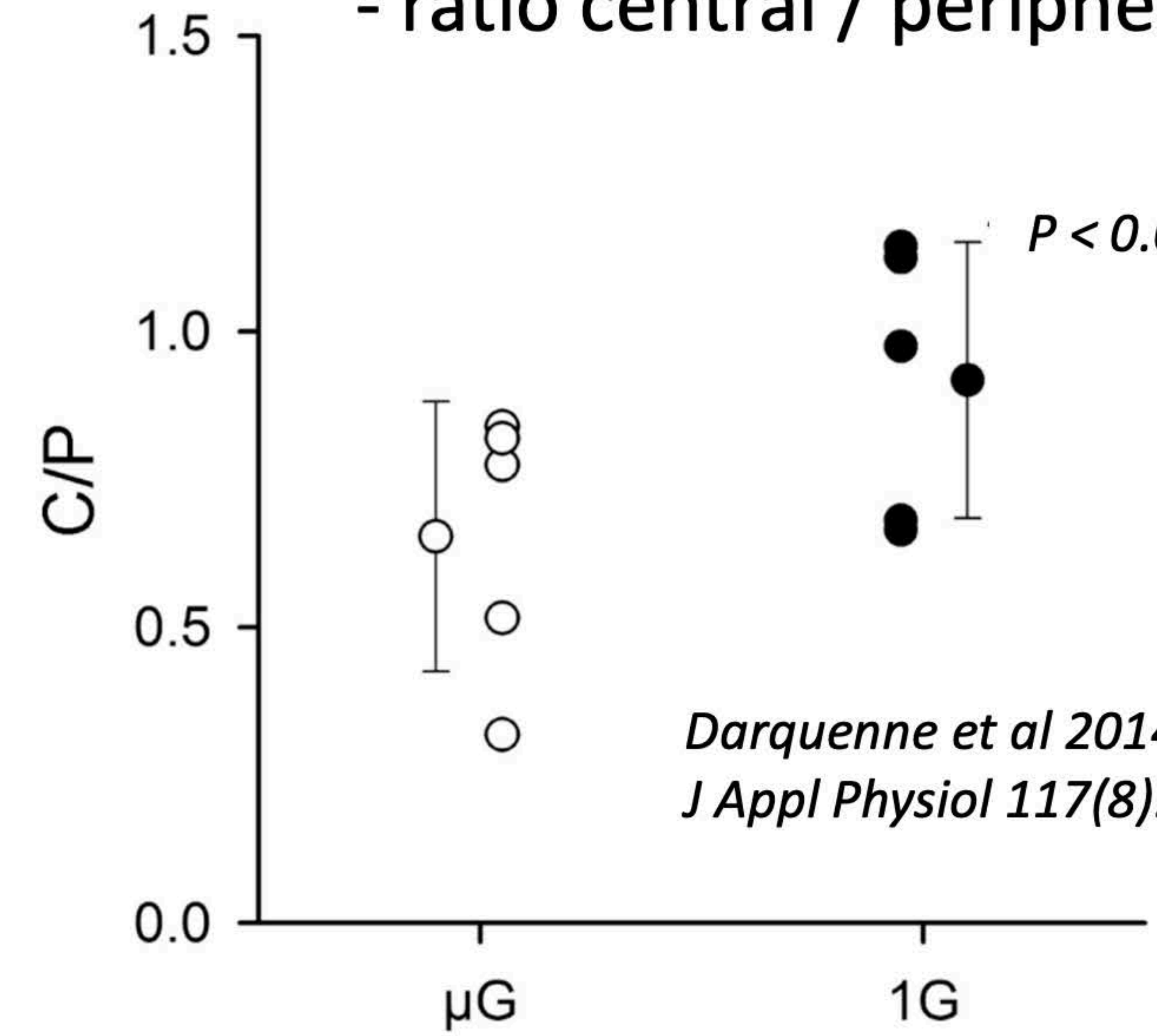
Inhalation of particles in micro-G



Baranov et al 1992,
Acta Astronautica 27: 45-50

Decreased lung function on MIR, probably due to inhalation of particles

Particle deposition in rat lung:
- ratio central / peripheral

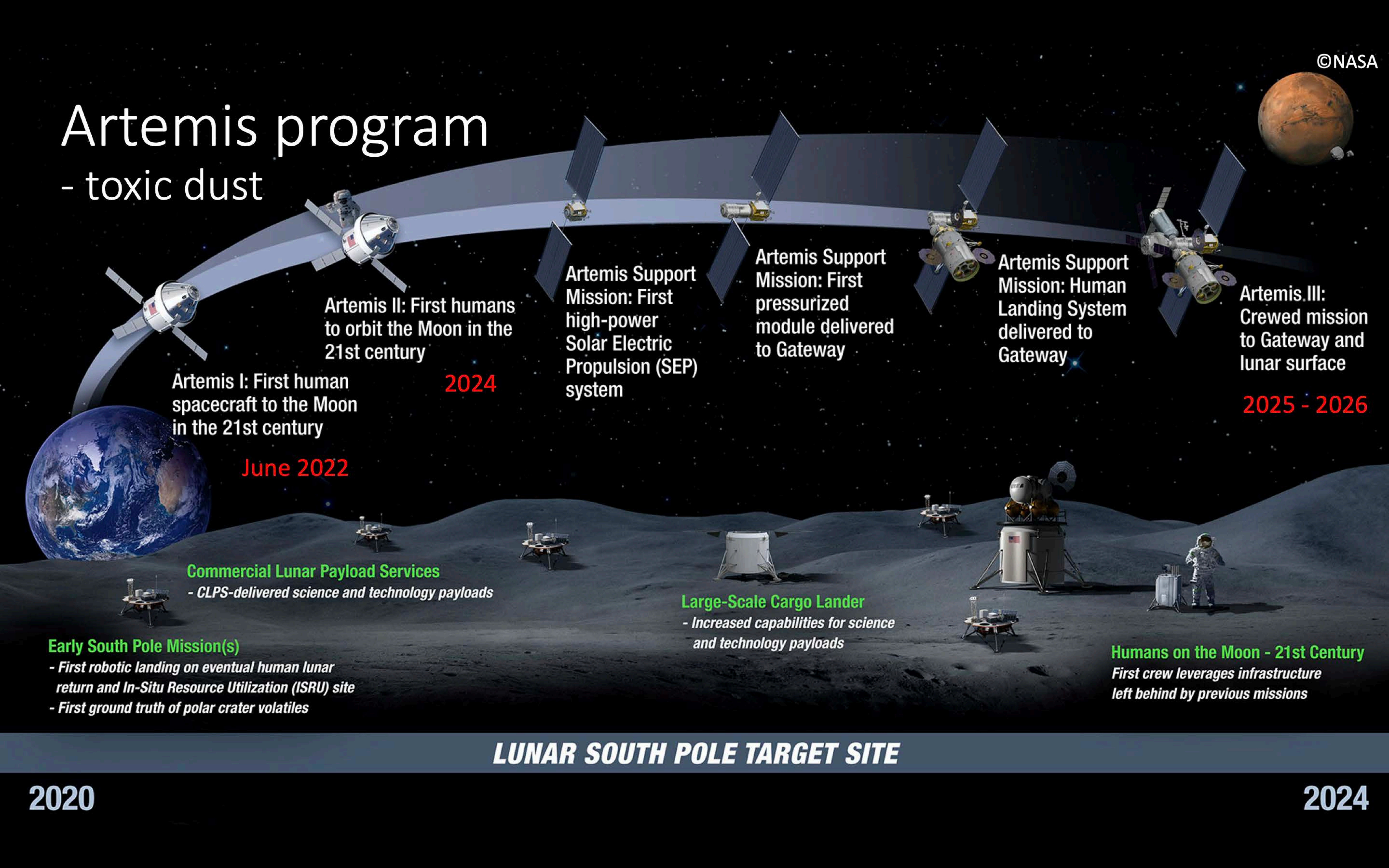


Darquenne et al 2014,
J Appl Physiol 117(8):880-6

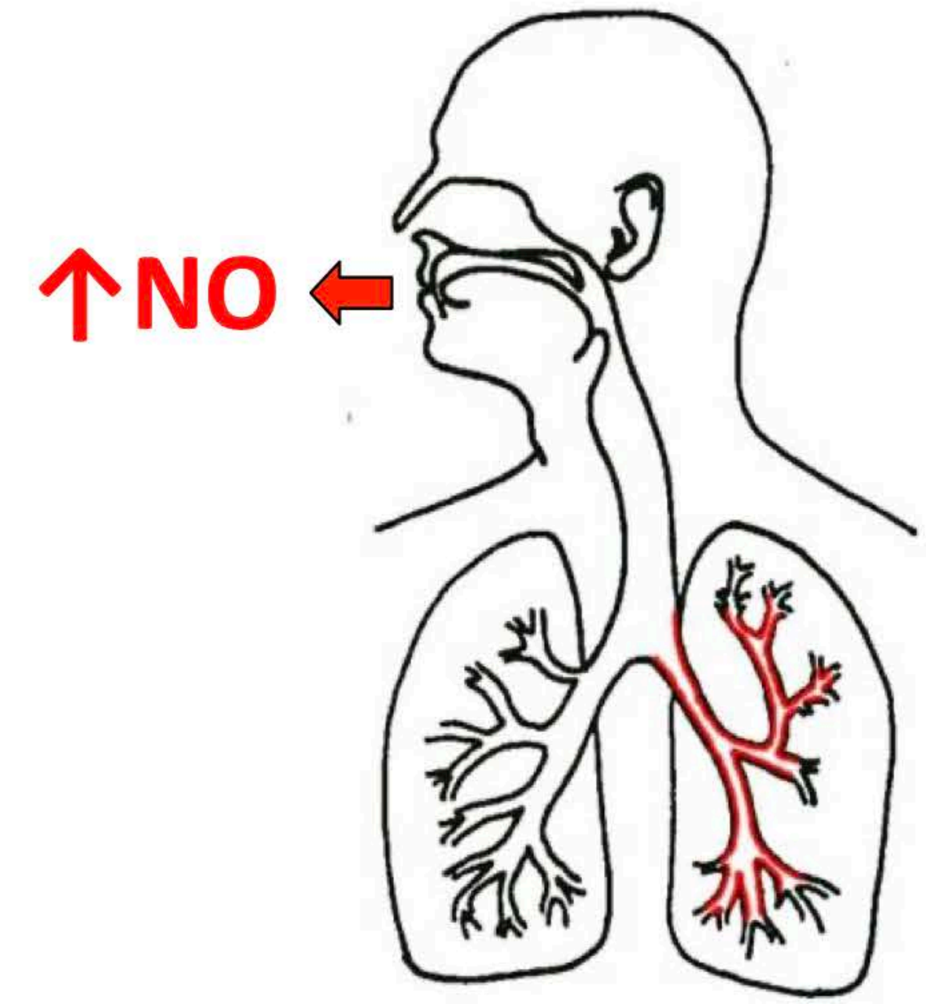
In μ-G: - decreased total deposition
- increased peripheral deposition
→ *slower clearance*

inhalation of particles → <u>airway inflammation</u> → <u>exhaled NO ↑</u>

Artemis program
- toxic dust



Nitric oxide (NO)



- Nitric Oxide (NO) present in vehicle exhaust, cigarette smoke, and **exhaled** air
- Endogenously produced NO has many functions in the human body
- Exhaled NO can be used as an indicator of airway inflammation (biomarker), clinically used to monitor (eosinophilic) asthma

→ Exhaled NO, a tool for monitoring lung health in space and on earth

Objectives and methods

1. Basic research

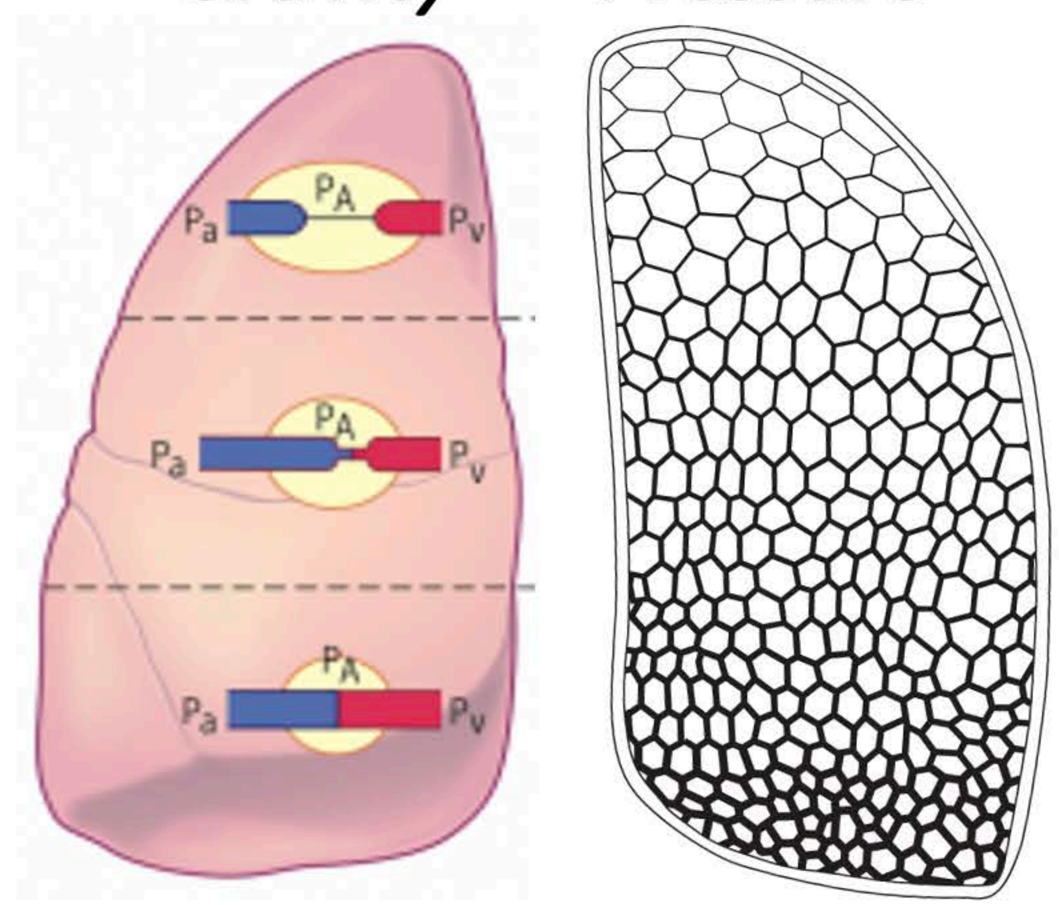
We alter gravity and gas density to pinpoint the site of NO formation

→ improve diagnostic value of exhaled NO

→ improve drug design

Blood | **Gas**

Gravity | *Pressure*



2. Space medicine

Future space vehicles / planetary habitats operate at reduced pressure & reduced / zero gravity

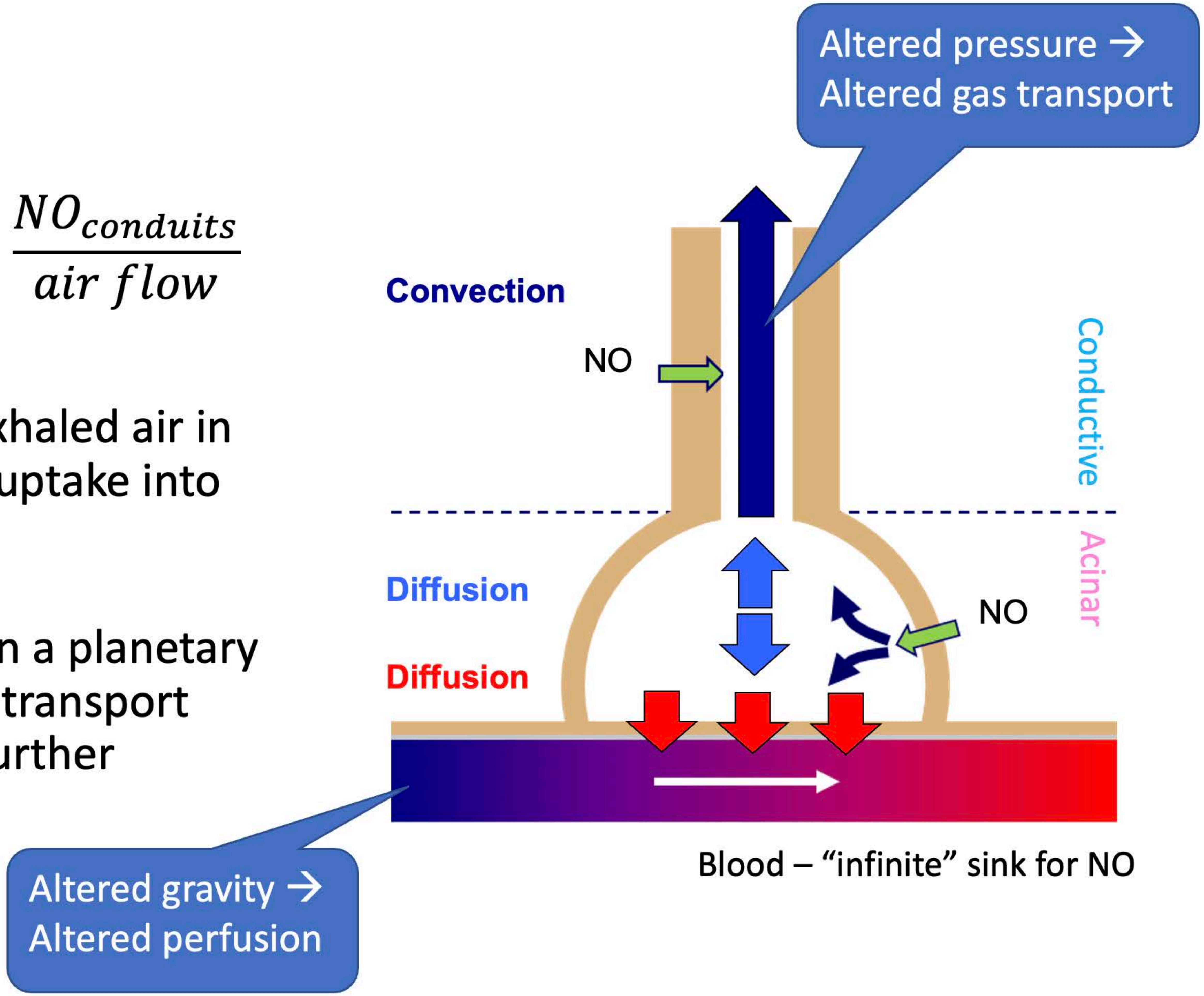
→ lay the baseline for use of exhaled NO in space, important for space exploration

Methods: Exhaled NO was determined in 10 (11) astronauts before and during a six month stay at ISS, at normal (1000 hPa) and reduced atmospheric pressure (700 hPa - 3000 m alt.)

Hypotheses

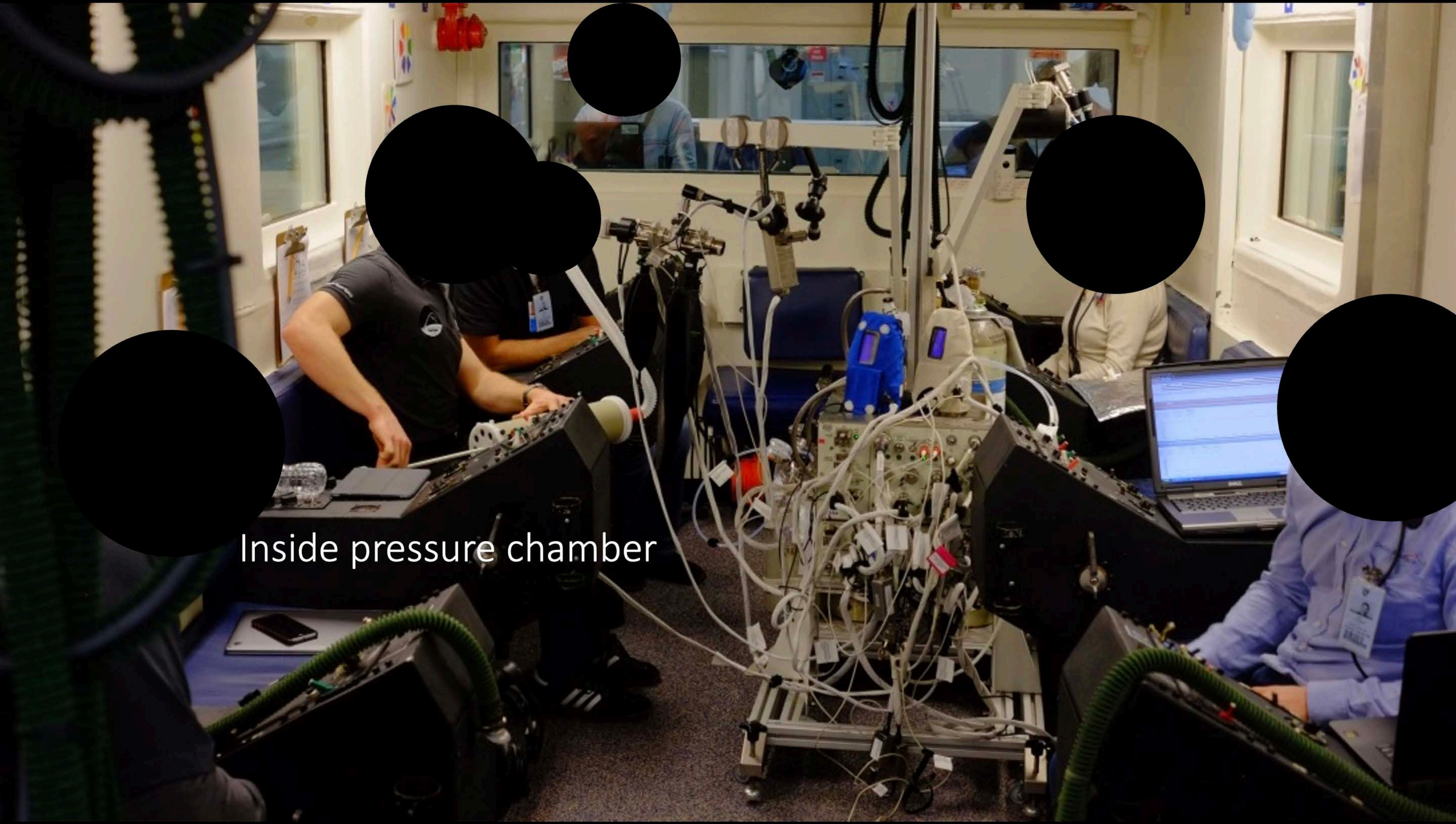
$$NO_{exhaled} = NO_{alveolar} + \frac{NO_{conduits}}{air\ flow}$$

- Hypothesis 1: Less NO in exhaled air in micro-G due to enhanced uptake into the blood
- Hypothesis 2: The thin air in a planetary habitat promotes diffusive transport and reduces exhaled NO further




Pressure
chamber
NBL
Neutral Buoyancy
Laboratory
NASA / JSC

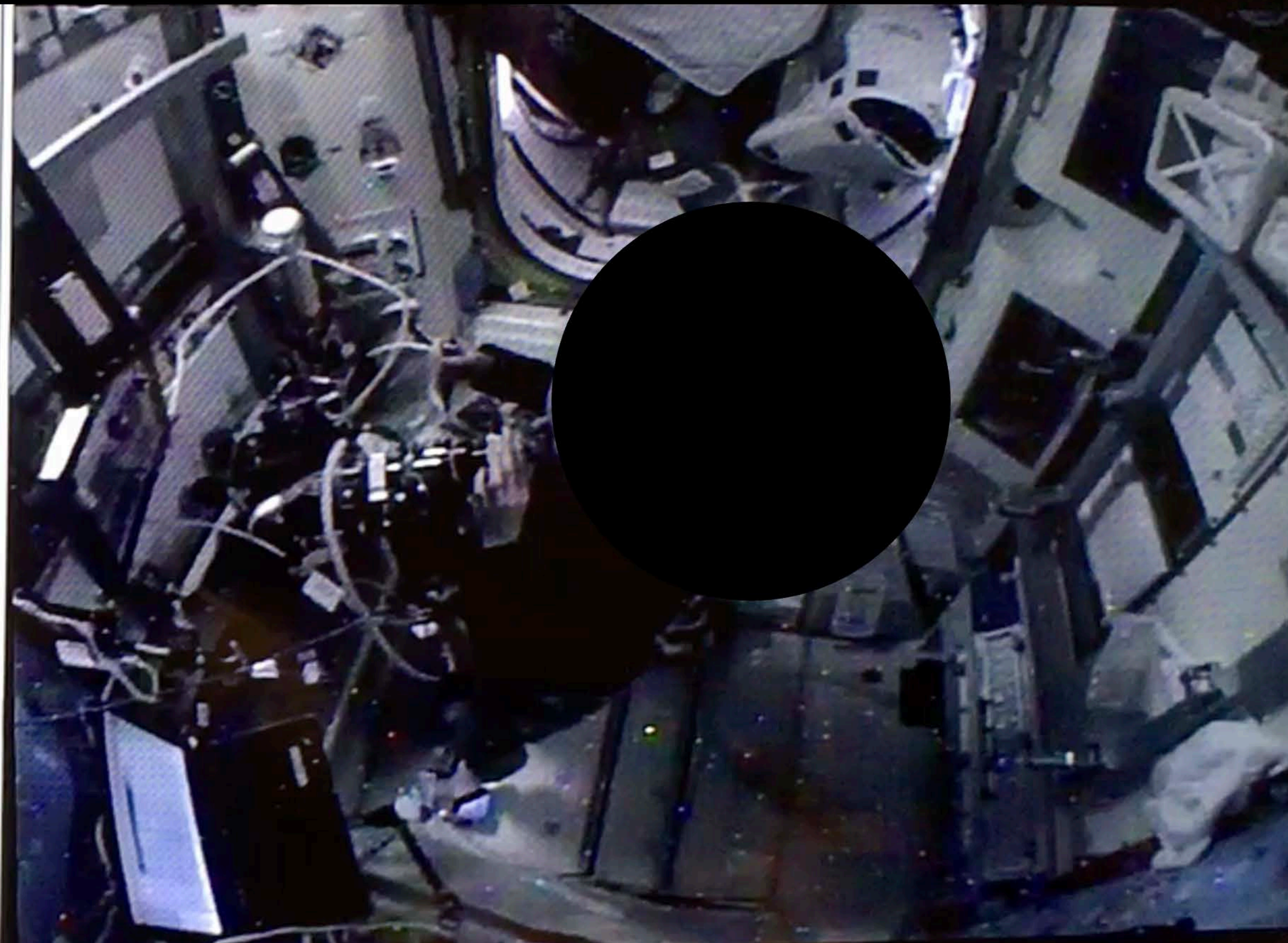

©NASA
US Airlock



Inside pressure chamber


©NASA
Measure:
- *exhaled NO (PE_{NO})*
- *NO formation*

Measure: gas transport (DL_{NO} – lung diffusing capacity of NO)



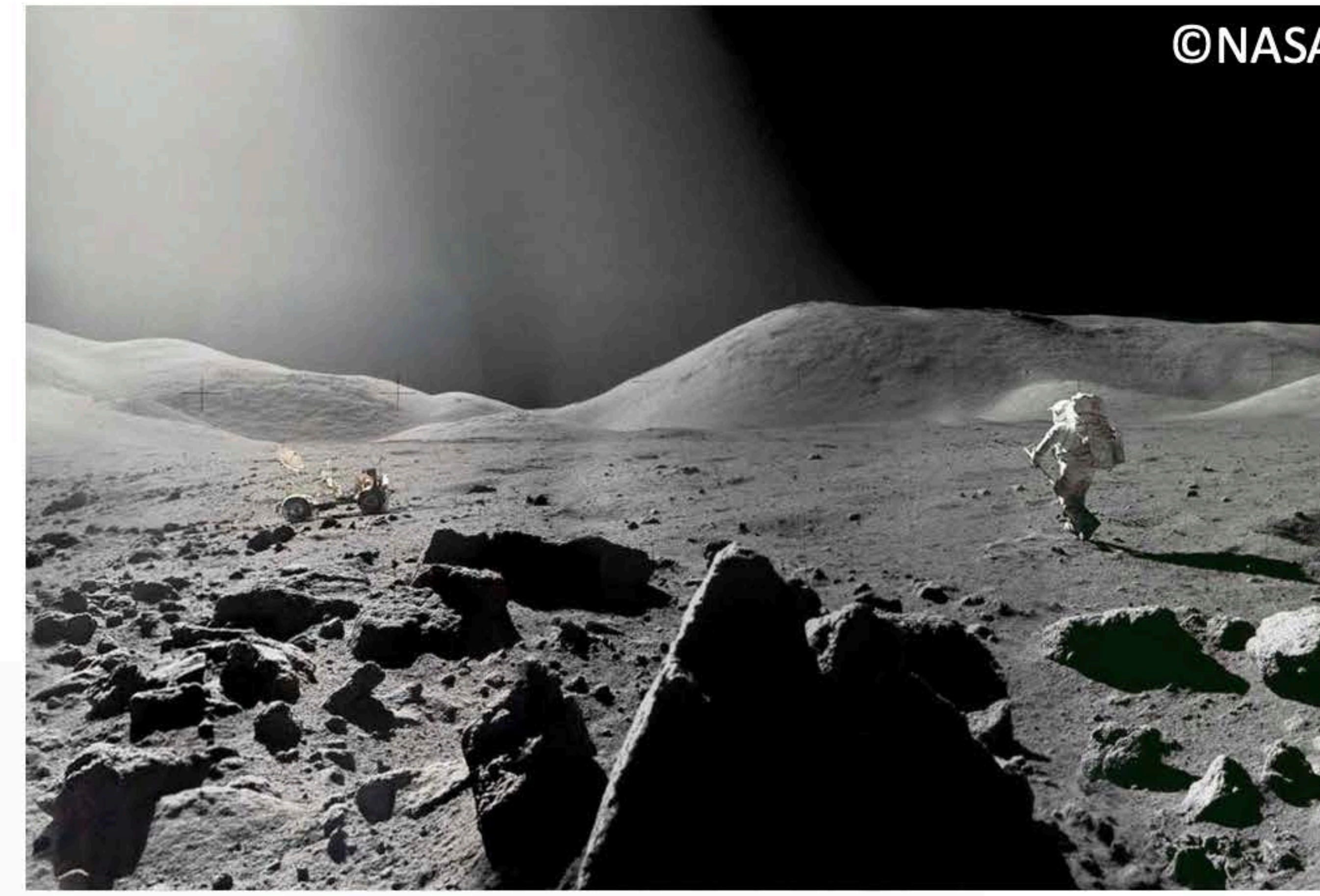
Key findings at normal pressure

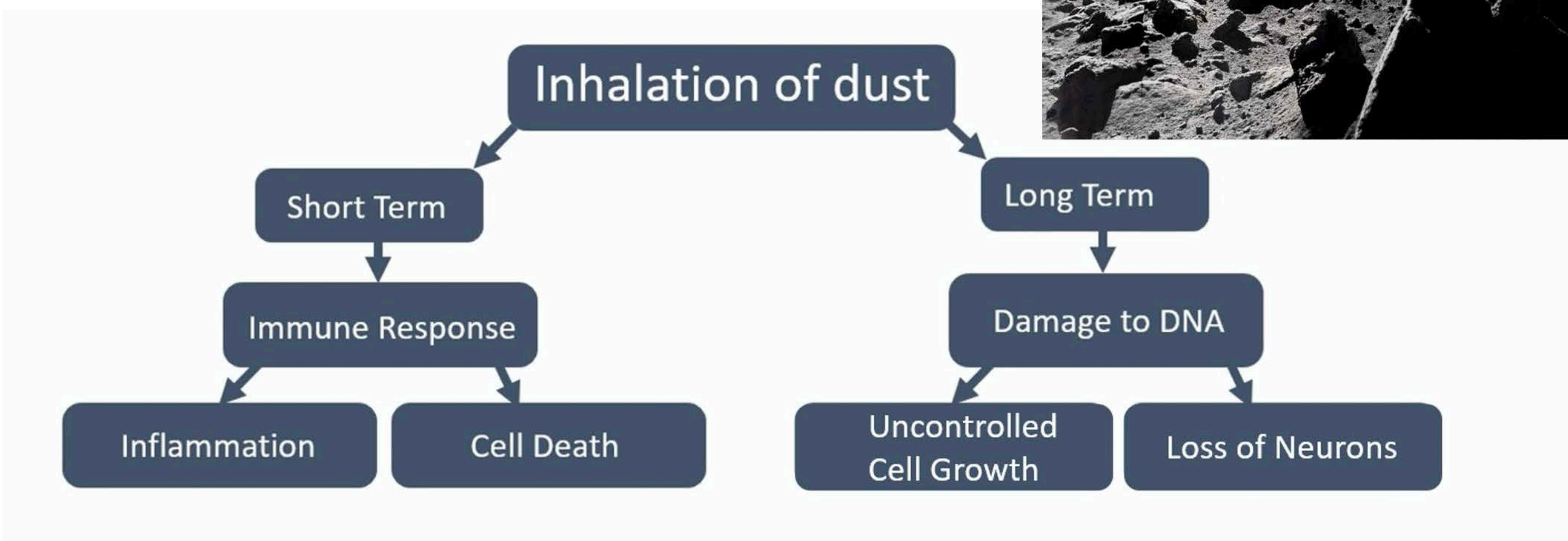
Key findings at reduced pressure

(@700 hPa, 30% reduction of pressure and gas density)

Toxicity of celestial dusts

Possible health effects



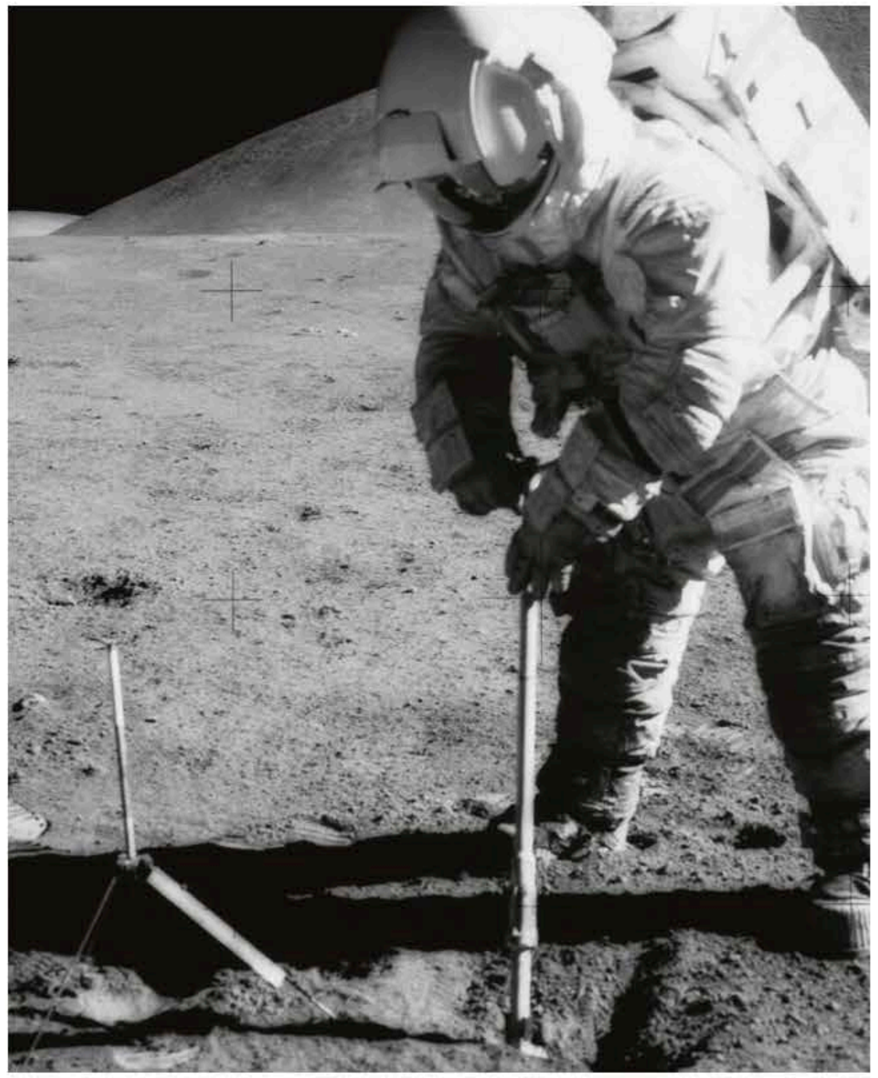


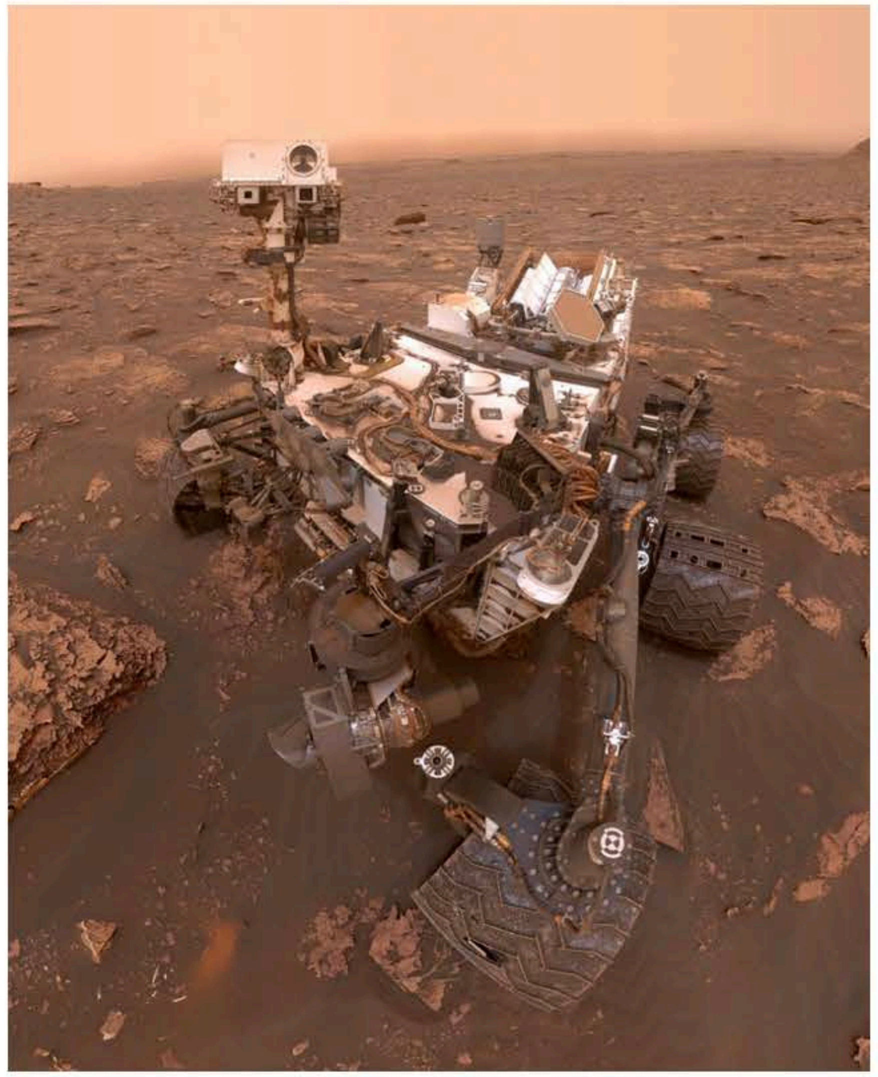
https://news.stonybrook.edu/newsroom/press-release/general/2018_05_04_lunar_dust/

Toxicity of celestial dusts

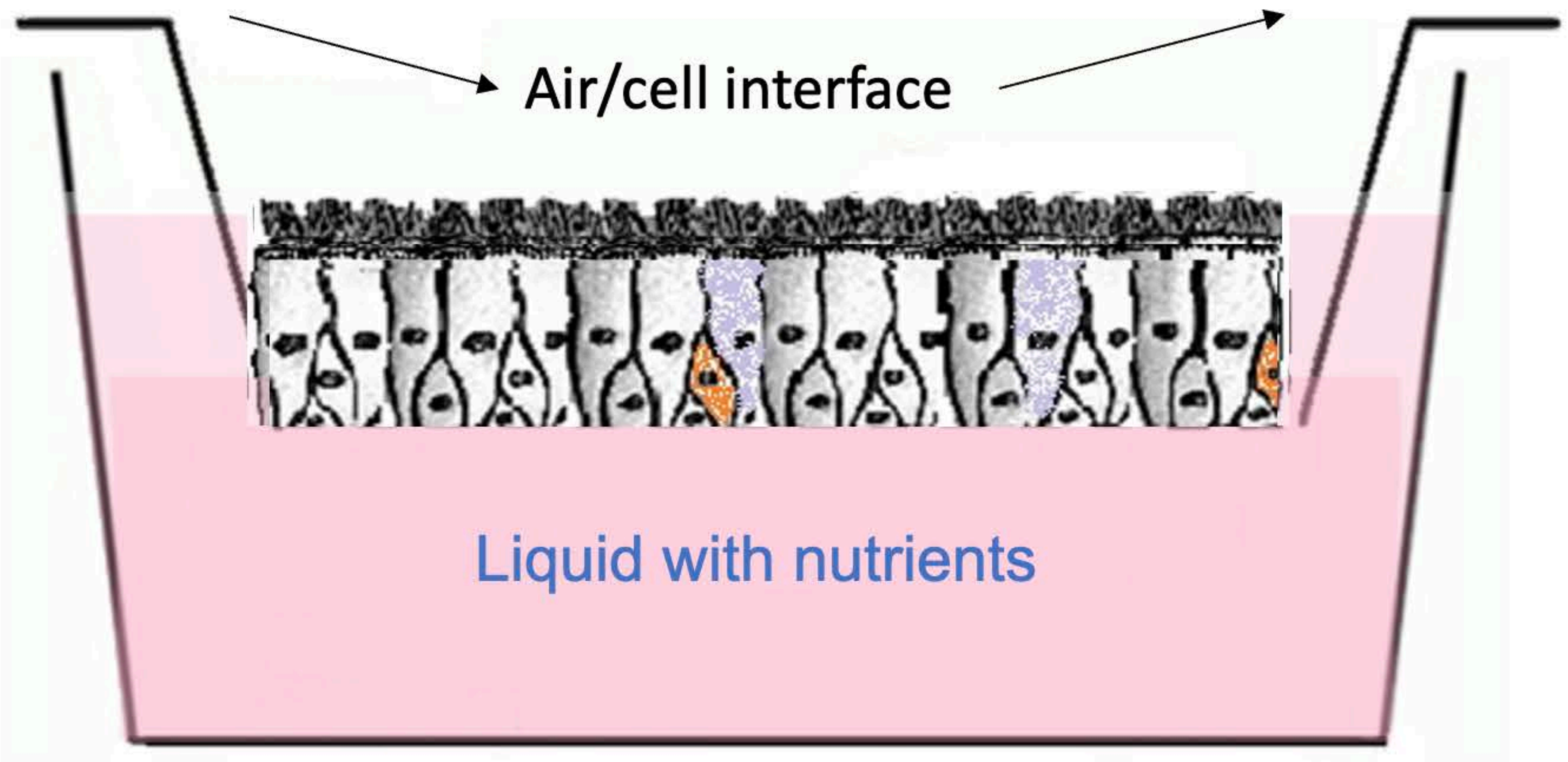
T3CD: ESA Topical Team on the Toxicity of Celestial Dusts

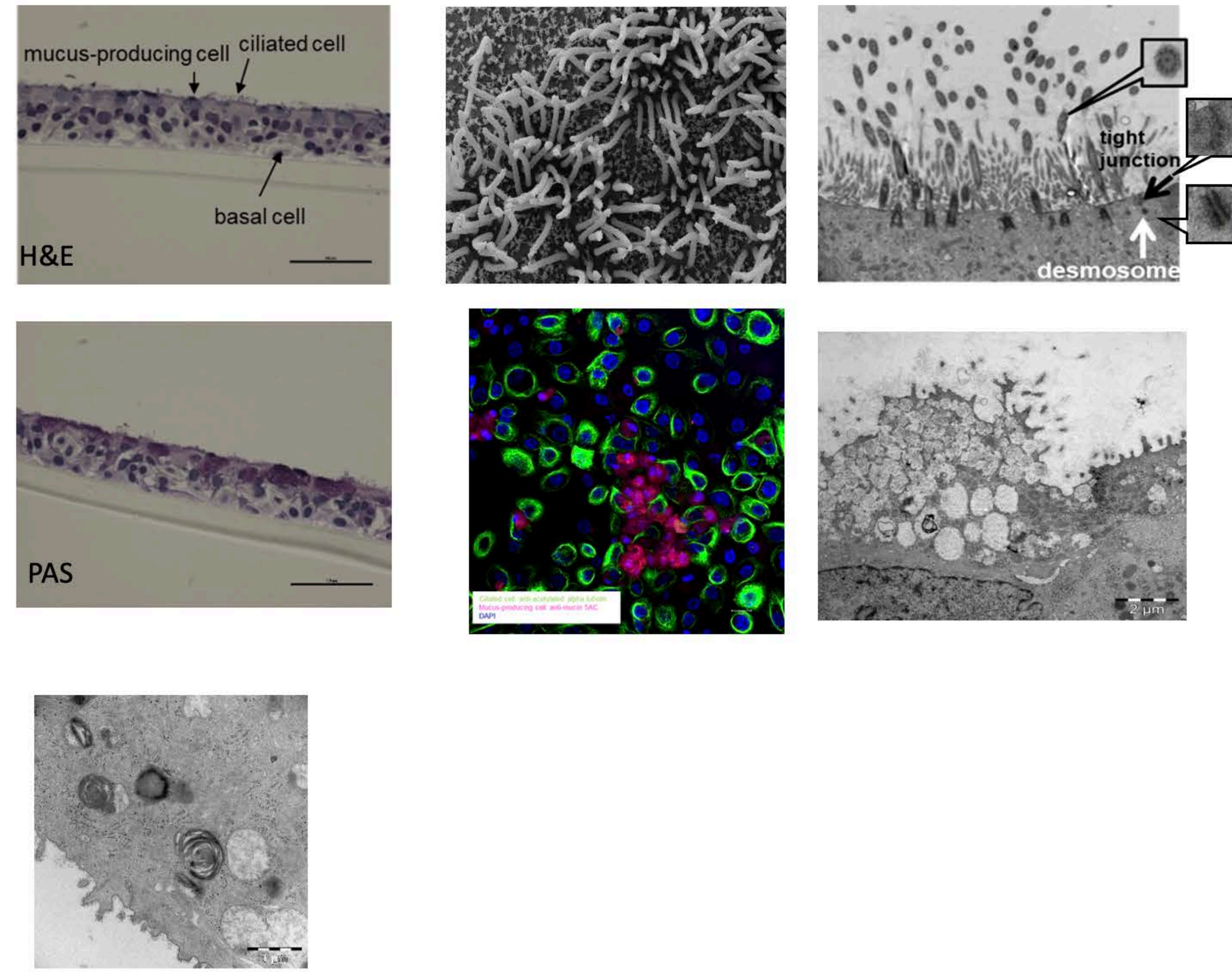
- **Material:**
  - Dust simulants (JSC-1, <u>JSC-1 Mars</u>, etc)
  - Actual lunar dust (TBD)
- **Activation of surface reactivity**
  - Milling
  - Radiation
- **Toxicity**
  - Chemical reactivity
  - Effects on cell cultures and animals
  - Kinetics of deactivation in humidified oxygen mixtures





Bronchial epithelial human cell culture on an air-liquid interface



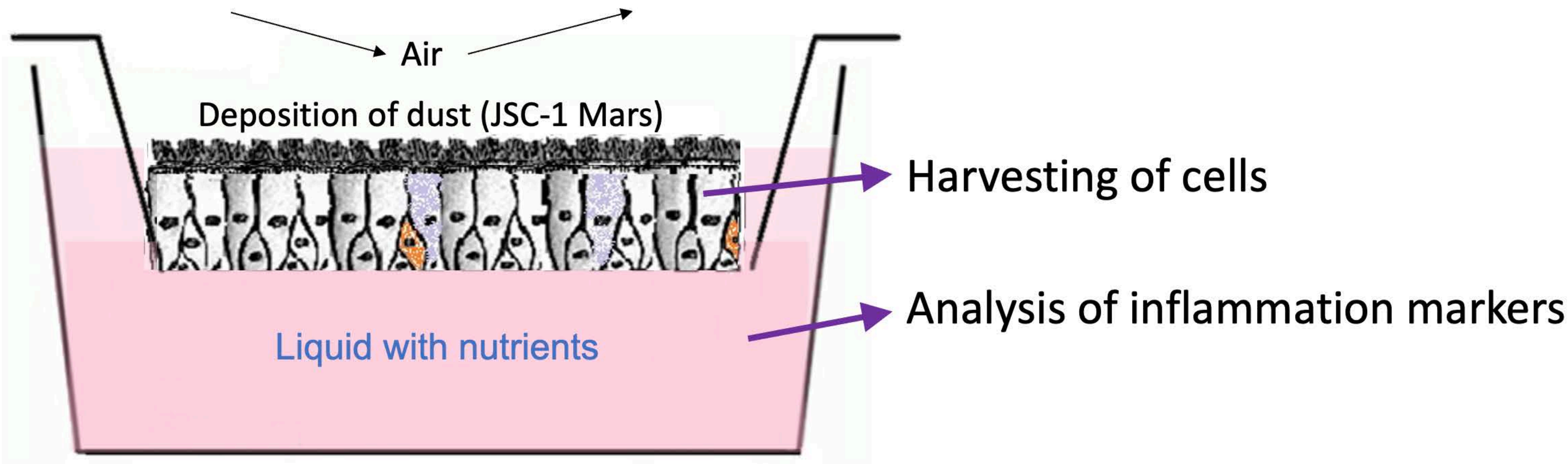


<u>PBEC: primary bronchial epithelial cells</u>

- Basal cells (stem cells)
- Mucus producing cells (goblet cells)
- Ciliated cells

Palmberg et al 2022

Bronchial epithelial human cell culture on an air-liquid interface



Palmberg et al 2022

Conclusions – Toxicity of celestial dusts

Palmberg et al 2022

Science team – Airway Monitoring

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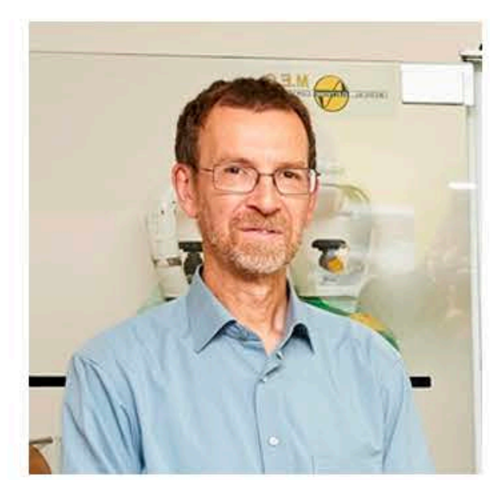

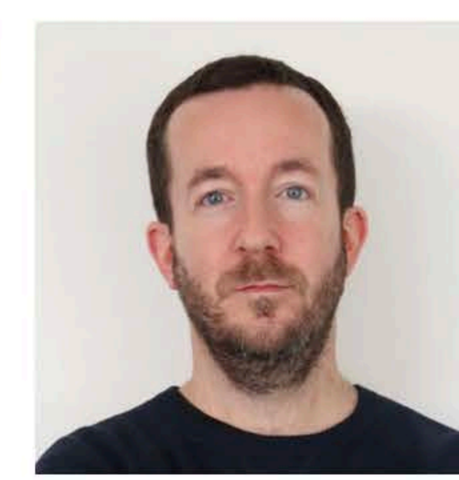

Science team – Toxicity of Celestial Dusts (T3CD)

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7. Vrije Universiteit Amsterdam, the Netherlands.

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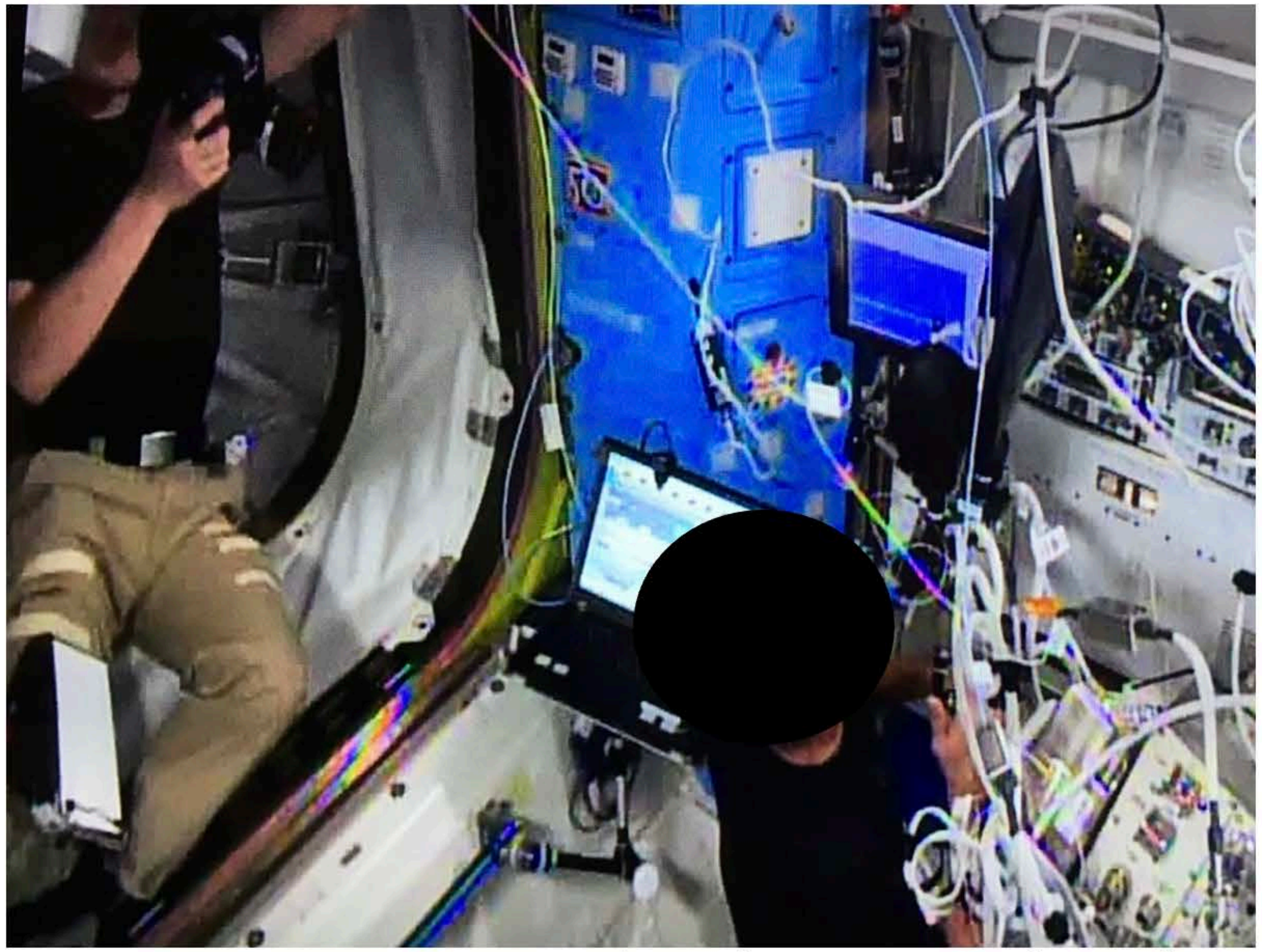
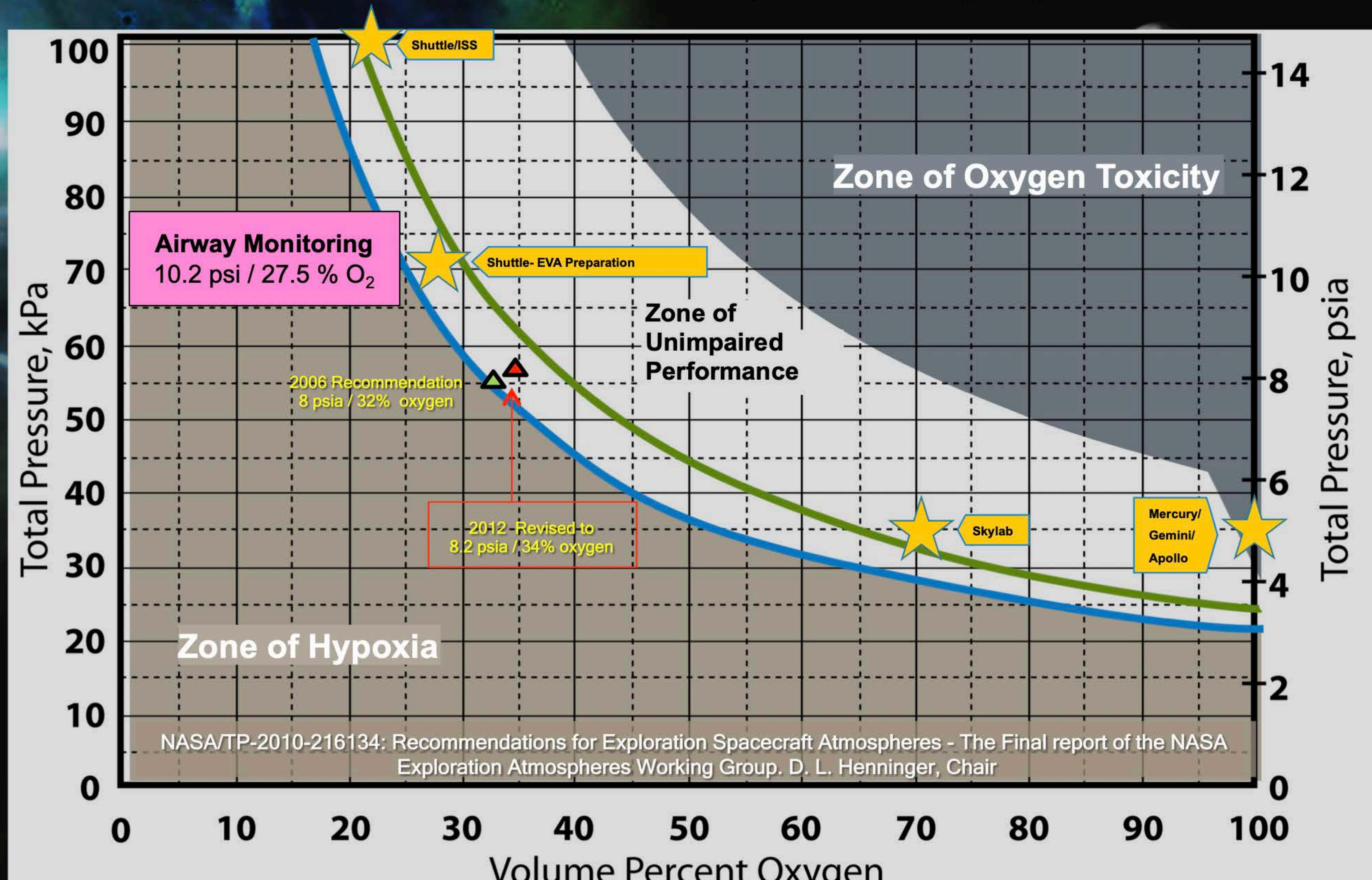


Tests at reduced pressure aboard ISS

A History of HSF: Habitable Atmospheres Employed in the Past



NOTE:

This chart has been revised from a previous presentation to include Nitric Oxide Experiment parameters

Historical Designs

Normoxic (Sea Level) Equivalent Alveolar Oxygen

1829 m (6000 ft.) Equivalent Alveolar Oxygen

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