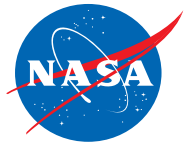
NASA's Aerosol Sampling Experiment Summary

Marit E. Meyer
Researcher in Spacecraft Indoor Air Quality & Fire Safety
NASA Glenn Research Center
Cleveland, OH



Outline

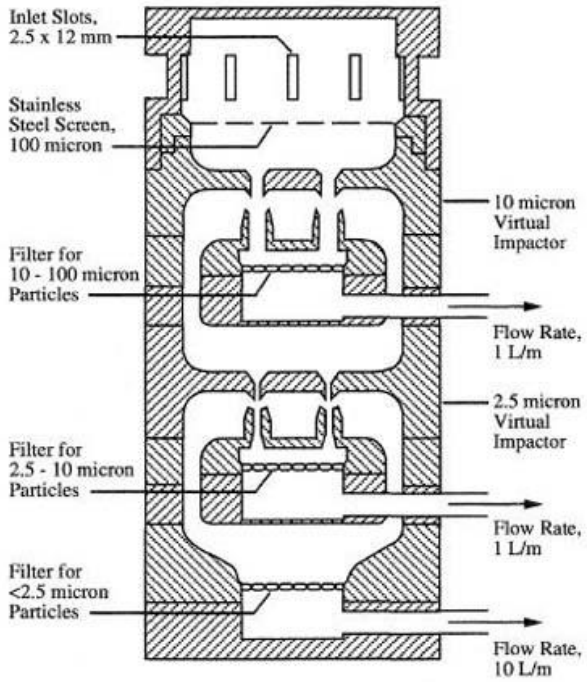
- Background
  - Previous aerosol sampling experiment in space
  - International Space Station
- Aerosol Sampling Experiment
  - Objectives
  - Two Samplers
    - Thermophoretic
    - Passive
- Summary

Aerosol Measurements on Space Shuttle

- Instruments developed by Particle Technology Laboratory at the University of Minnesota
- Space Shuttle Columbia experiments 1990 and 1991

Aerosol Measurements on Space Shuttle

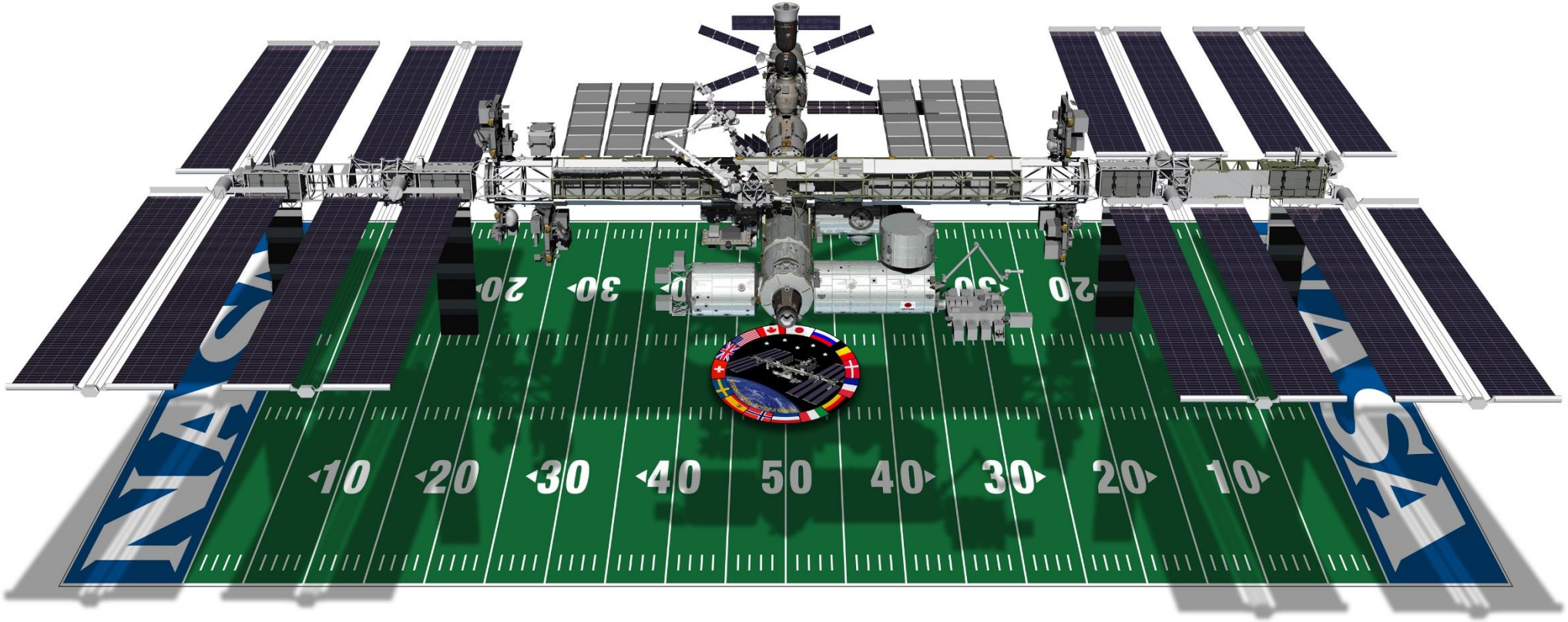
- Shuttle Particle Sampler (SPS) – Multi-stage impactor and filtering system for size distributions, XRF & microscopy
- Shuttle Particle Monitor (SPM) - Nephelometer (photometric detection of scattered light) for time-resolved mass concentration
- RJ Lee Group performed automated SEM and EDS



- 5 people on STS-32 Columbia
- 71.5 m^3 Habitable Volume
- Sampled day 2 and 7 of the 11 day mission
- Average concentration: 56 µg/m3
- ***'Clean' by indoor air quality standards***
- No measurements < 1 µm (1000 nm)
- Space Shuttle retired in 2011
- Cannot use this data for current spacecraft

International Space Station (ISS)

- 388 m^3 Habitable Volume
- Continuously occupied for 14 years
  - More than 200 people from 15 countries, typically 6 crewmembers at a time

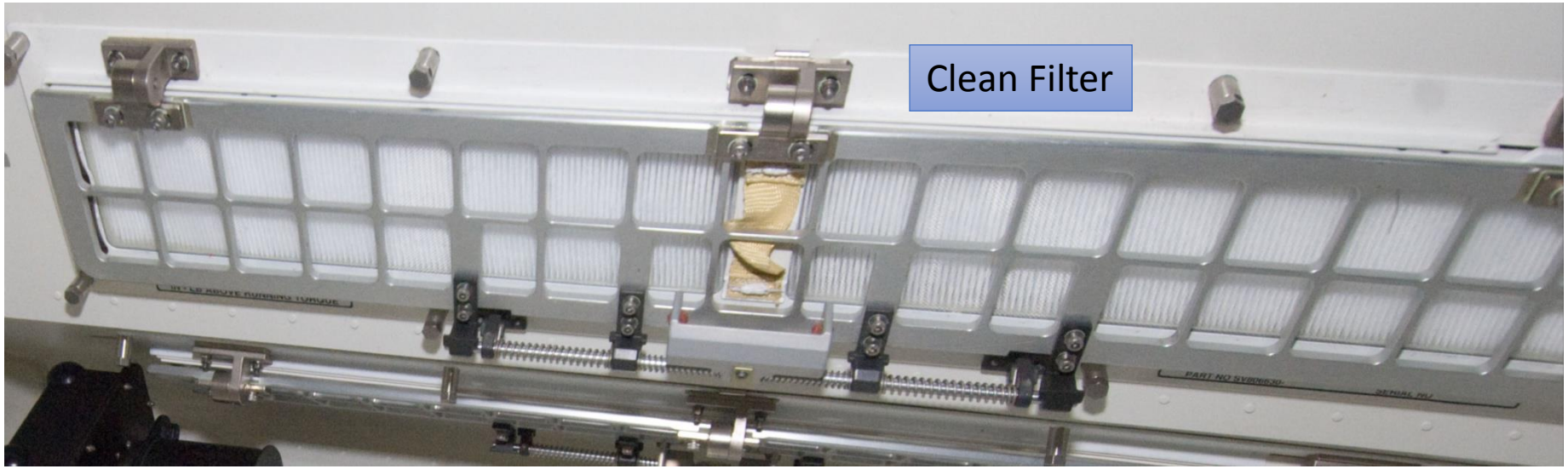


Aerosols on ISS

- On Earth, our air quality is improved by gravitational settling of large partices
  - On ISS, all particles remain airborne until deposited on surfaces or on filters of the air handling system
- Dust and particle-laden air has been a recurring complaint of the crew as they have experienced nose and eye irritation as well as allergies
  - Indicates high concentrations of inhalable particles

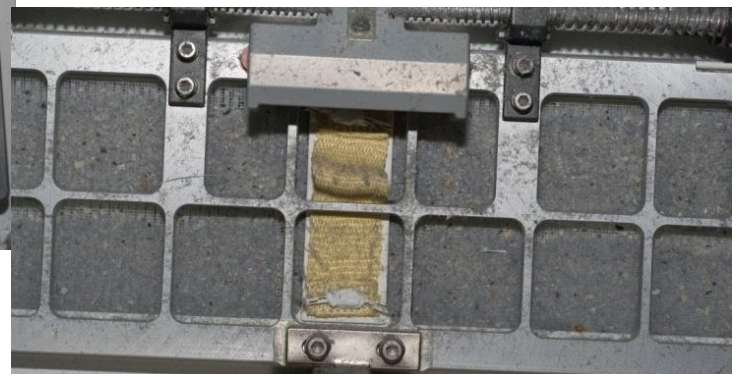
Aerosols on ISS

- Airborne debris samples have been returned from ISS, but without the necessary delicate handling or not on appropriate collection substrates for quality microscopic analysis of individual particles
- There is currently no particle measurement capability on ISS to provide data
- Particle control technology is HEPA level filtration



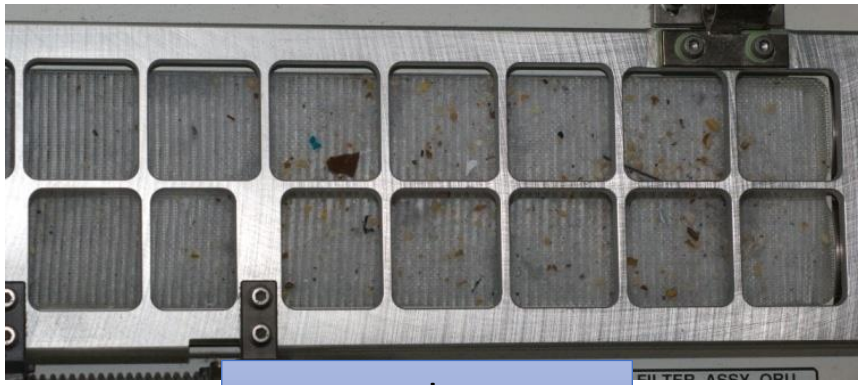
12 days accumulation

Node 3
Hygiene & Exercise
Location



8 days accumulation

8 days accumulation



Node 1
Temporary Storage
Location

Weekly chores on ISS

Aerosol Sampling Experiment

- Funded by NASA Advanced Exploration Systems Life Support Systems Project (AES LSS)
- Obtain quantitative data on airborne particles in multiple ISS locations and associated with different activities
- Sample particles and return to Earth for microscopic analysis
    - Estimate average number concentration, size distributions
    - Particle morphology and chemical composition
    - Measurement range: a few nanometers to 100's of micrometers
  - Simple experiment gives long-duration average data
  - Low cost and low risk

Collect Airborne Particles on ISS

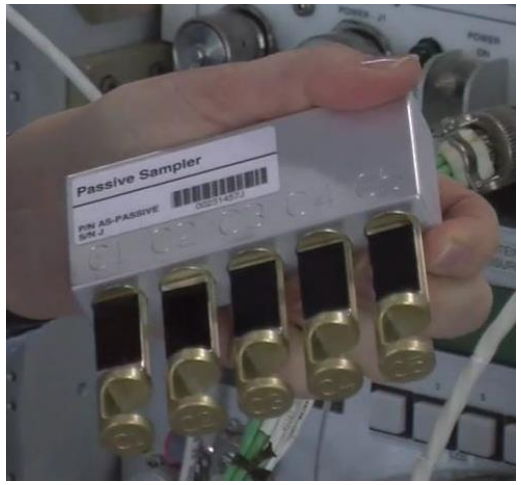
- Two different samplers
  - Collect a larger size range of particles
  - Some redundancy

Thermophoretic Personal Sampler, TPS100

Commercial Off-the-Shelf (COTS)

Collect particles from 10 nm to ~10 µm

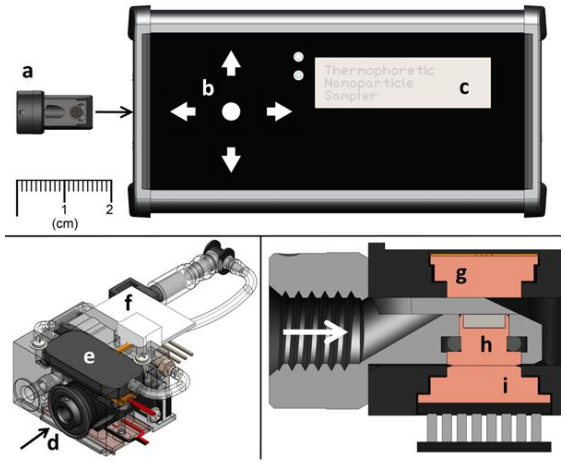
Passive Aerosol Sampler (PAS)

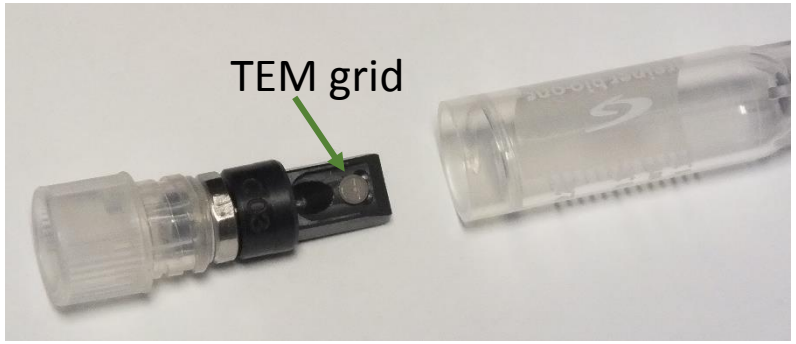


Passive sampler custom designed for ISS

Collect particles up to 500 µm & larger

Thermophoretic Personal Sampler (TPS)



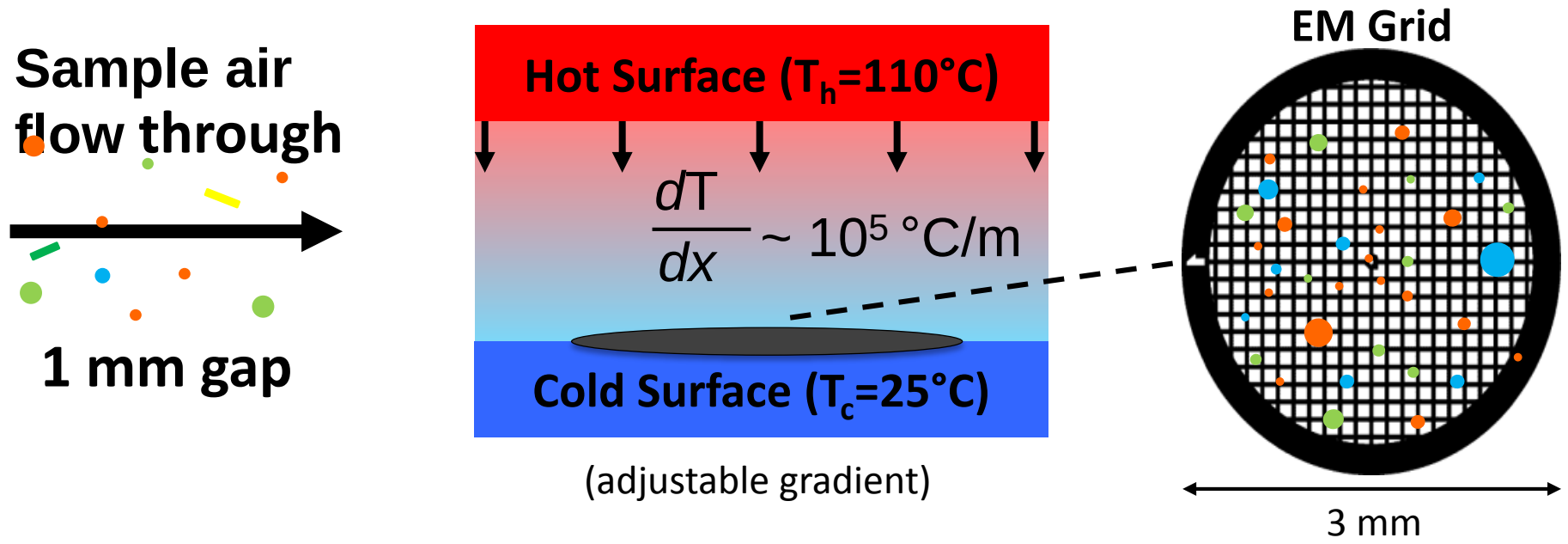


Loading a TPS sample cartridge

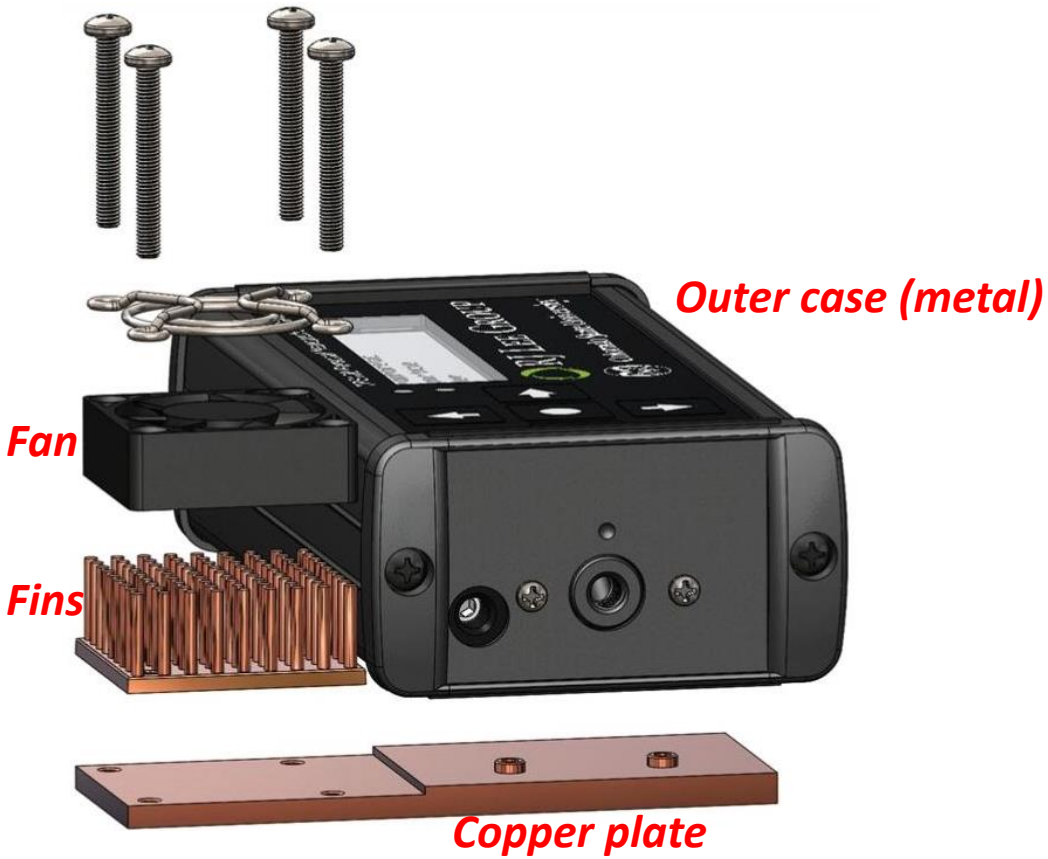
Active sampling:

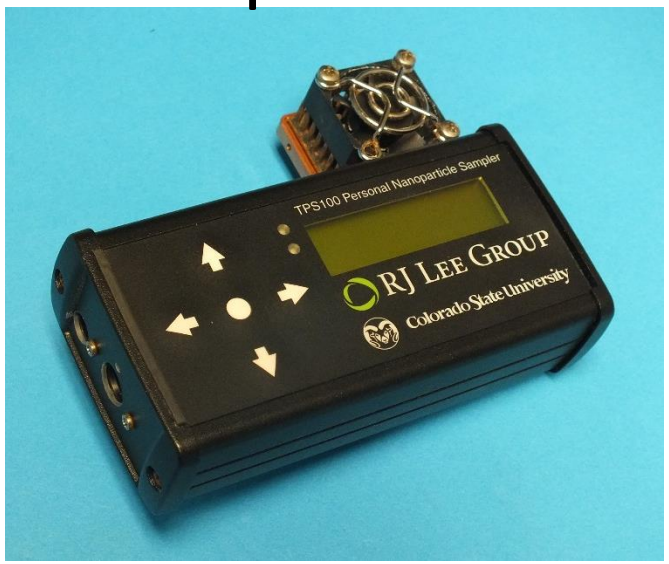
- **Contains pump, heater, cooler, circuit cards, battery**
- **Collection substrate (TEM grid) is housed in removable inlet cartridge**
- **Procedure:**
  - **Charge for ~4 hours, load cartridge, attach to wall panel (Velcro), sample for 6 hours, remove cartridge, stow**
- **Fly two units for redundancy, less crew time for simultaneous sampling in two locations**

Thermophoretic Collection

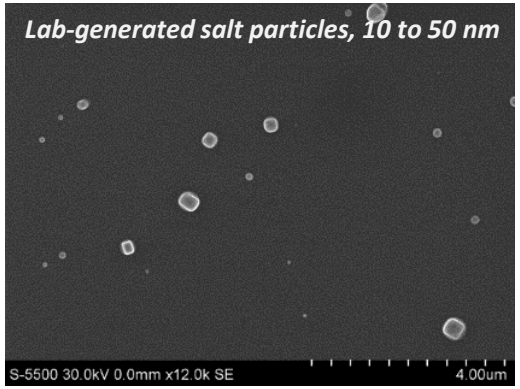


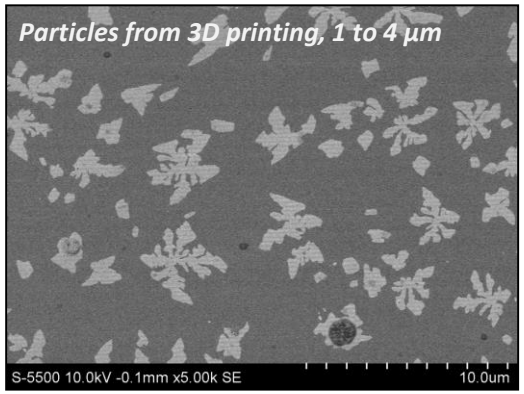
Thermal Solution for Active Sampler



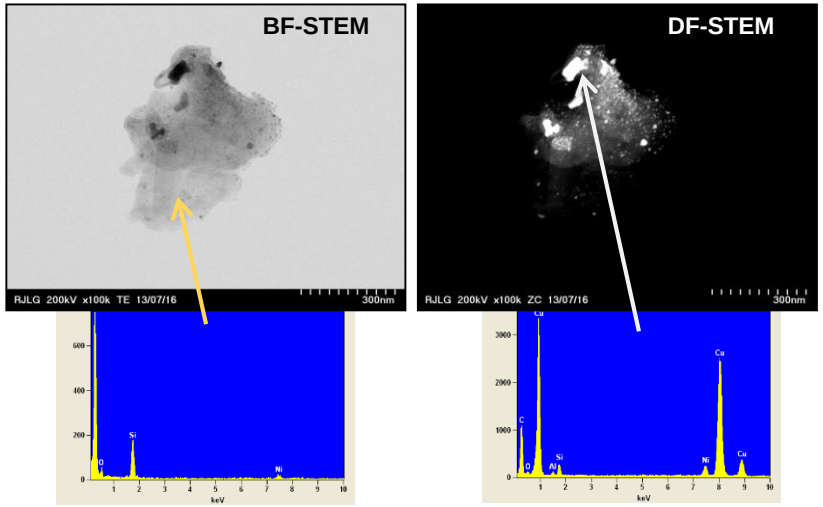


Example Data from Microscopic Analysis of Particles Collected by TPS





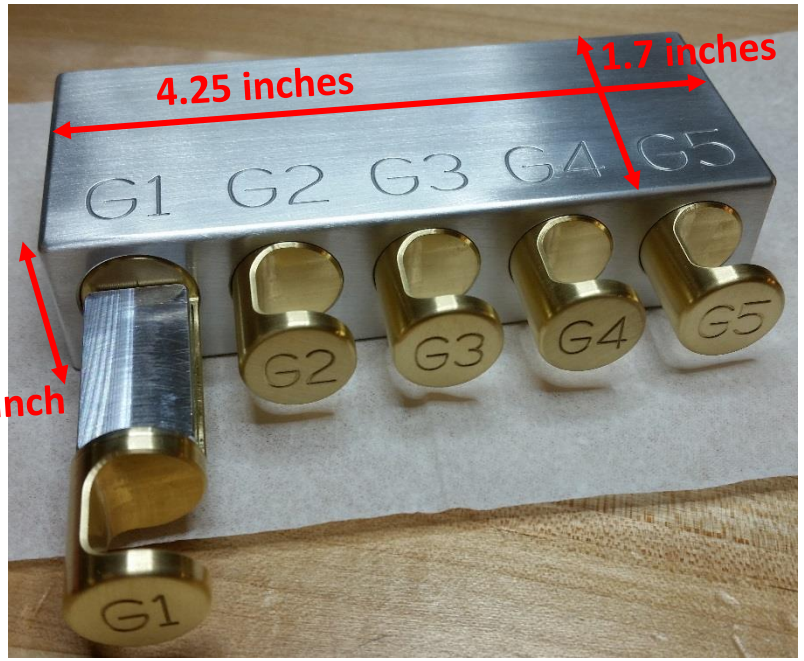
Below: Two images of a particle from a small electric motor and the chemical compositions of different portions of the same particle



- Identify particle morphology
  - Shape
  - Coated or multi-component particles
  - Agglomerates
- Chemical composition
  - Elemental speciation
- Potentially identify sources of individual particles
  - Lint from clothing
  - Skin flakes
  - Metal particles from exercise equipment

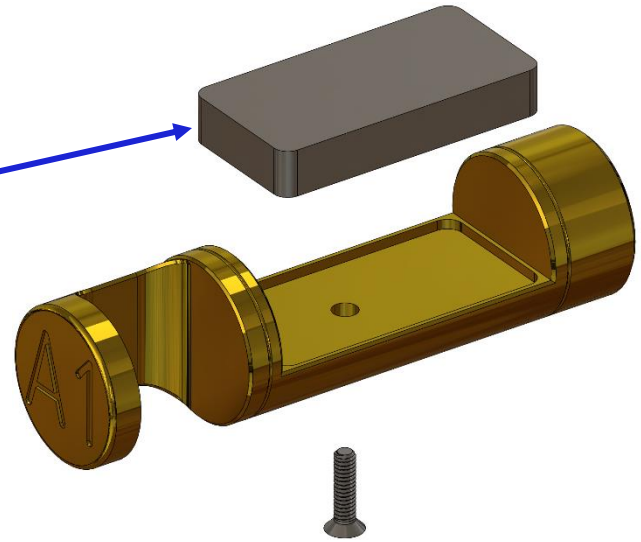
Custom Passive Sampler

- **Aluminum** outer case with **brass** ‘drawers’
- Mounted with Velcro near air intakes of the ISS ventilation system to take advantage of incoming ‘dirty’ air flow

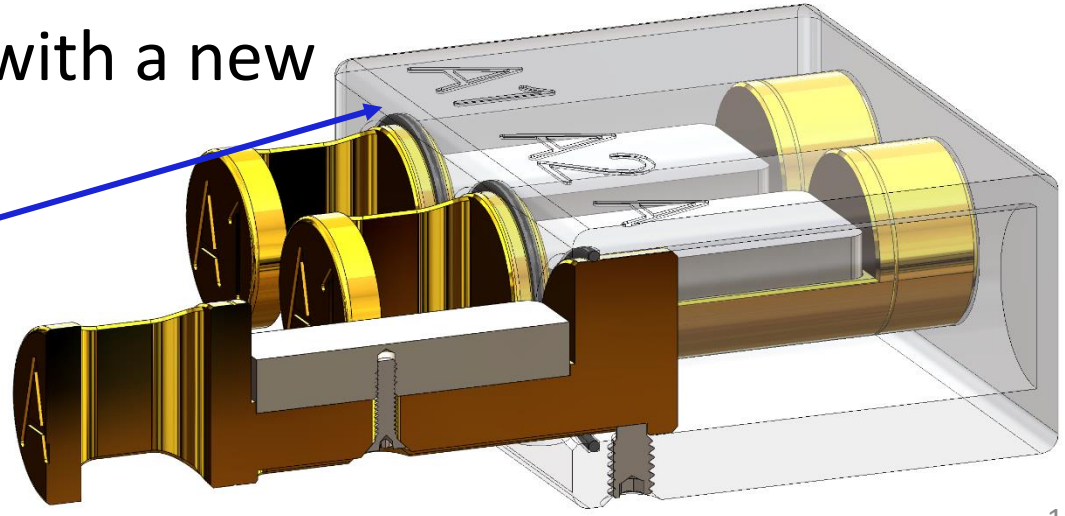


Passive Sampler

- 2-way sticky carbon tape on 29 mm x 15 mm collection surface (aluminum block)
- Each drawer compartment is individually bored to eliminate cross-contamination between samples
- Collection plate samples can be archived for potential future analysis
- Units can be cleaned and re-used with a new aluminum block

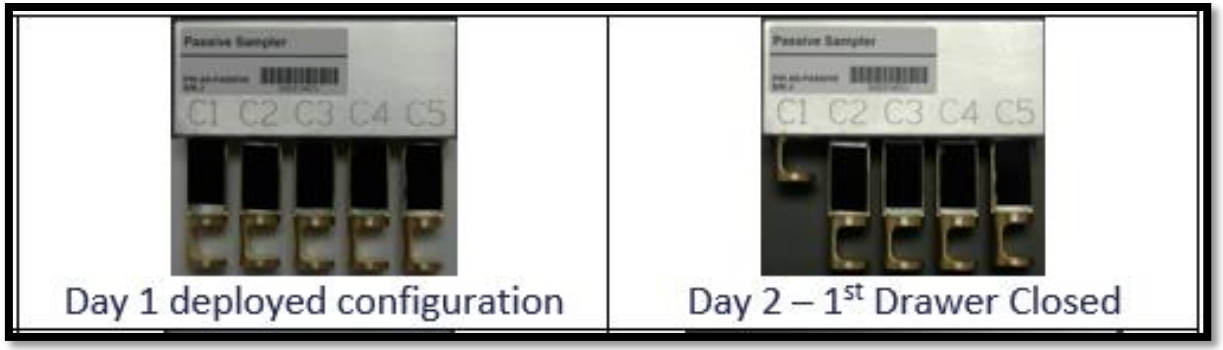


Carbon tape pieces & 5 o-rings are the only non-metal parts



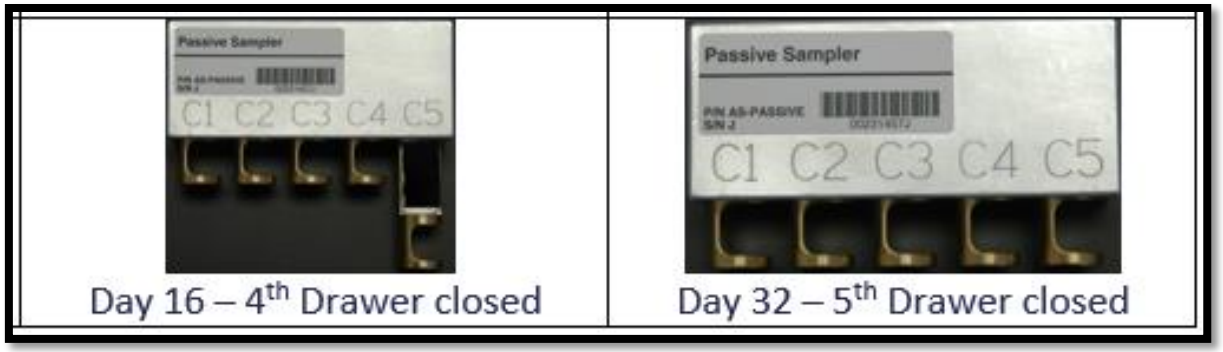
Passive Sampler

- Crewmembers close the drawers incrementally
- After 2 days, 4 days, 8 days, 16 days, and 32 days
- Goal is to obtain at least one long-term sample with optimal particle coverage for microscopic analysis
  - Not too few particles, and not too many particles (overlapping or touching each other)



Day 1 deployed configuration | Day 2 – 1st Drawer Closed

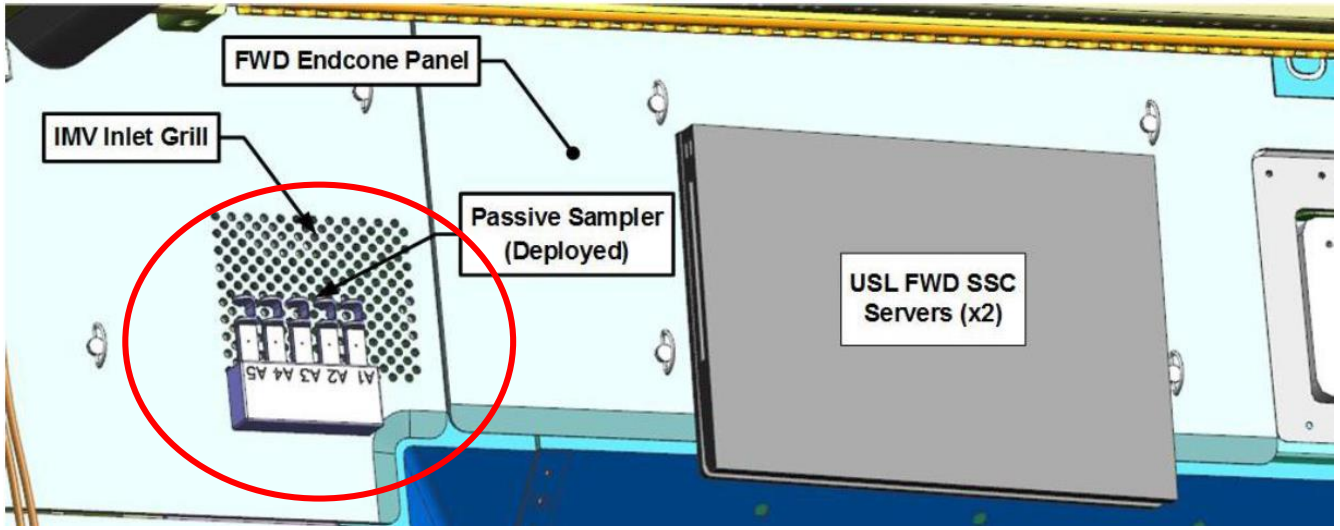
Day 4 – 2nd Drawer closed | Day 8 – 3rd Drawer closed

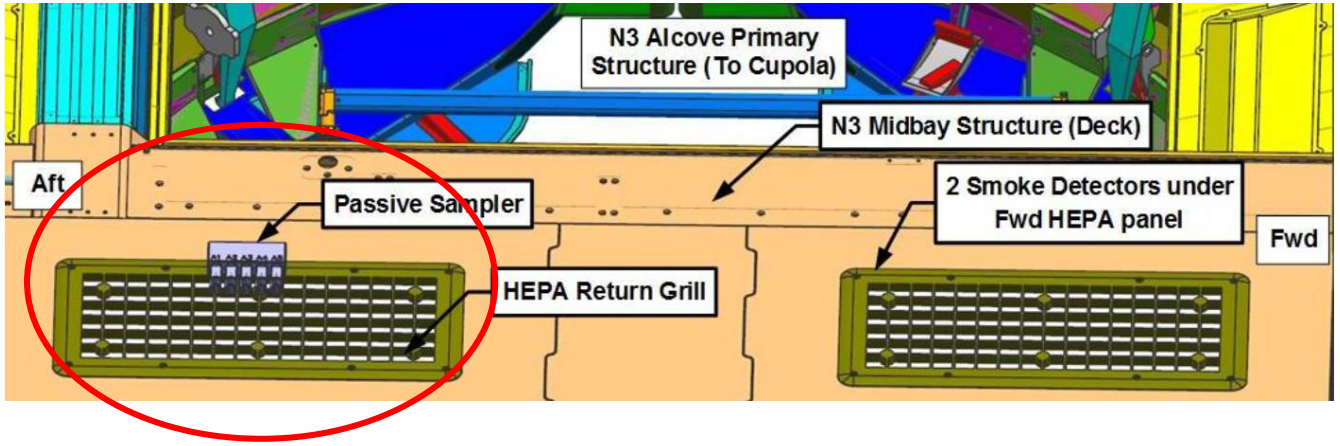


Day 16 – 4th Drawer closed | Day 32 – 5th Drawer closed

Passive sampler locations on air return grills

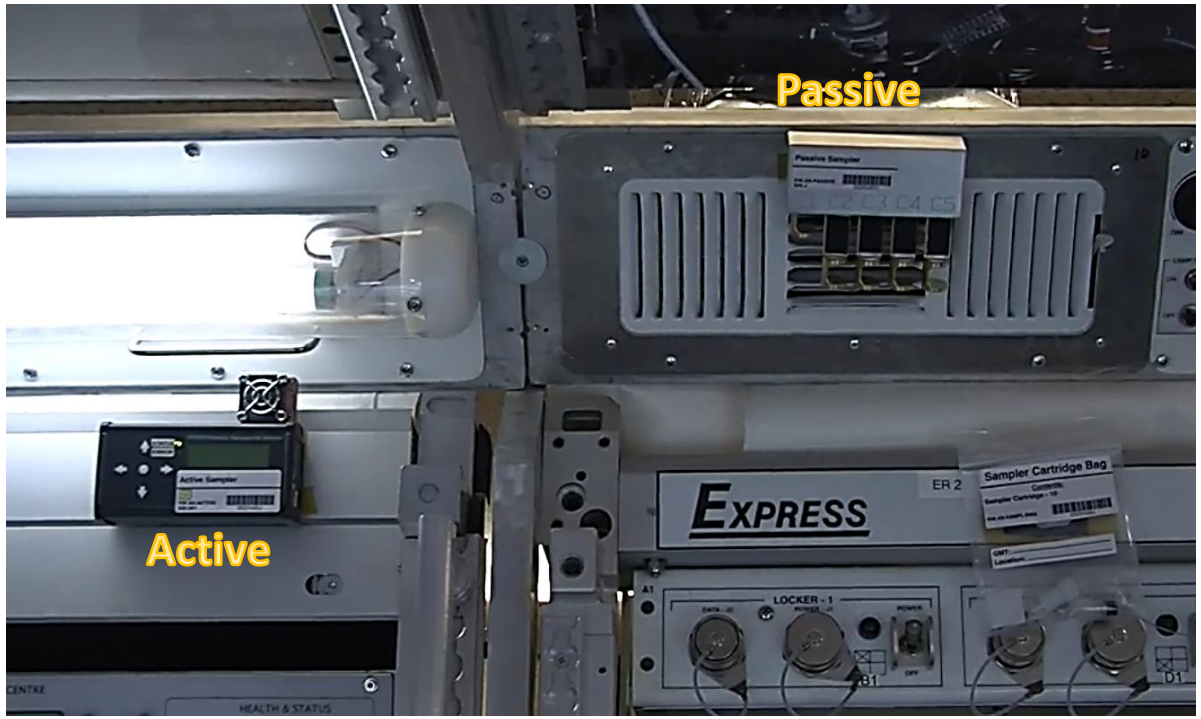
Deployed in 7 locations and collecting for 32 days





Active Sampling Sessions

- Two are deployed 4 times within two feet of passive samplers
  - Sample the same air and collect different size ranges of particles
  - 8 total samples
- During exercising
- When a cargo vehicle arrives and docks to ISS



Summary

- Goal of sampling experiment is ***data:***
  - Validate ISS inventory of aerosol sources
  - Input for particulate monitor development for long-term manned missions
  - Understanding background aerosol signature is important for the next generation smoke detector design
- Analysis after return to Earth
- RJ Lee Group will perform the sample analyses
- Results will ultimately improve air quality in spacecraft
  - Fundamental for future long-term manned space missions