Facility for Payload Cleaning and Assembly and for Curation of Returned Genesis Solar Wind Samples

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THE BIG PICTURE

- **JSC Curation Supported Genesis Mission from Beginning to End**
- **Transitioned to Long Term Curation and Providing Samples for Researchers**

Mission & Science Team Support

- Early Sample Hardware Requirements & Inputs
- Advocate for the Scientific Integrity of the Collected Samples
- Coordination with ALL Mission Partners
- Contingency Planning for Surface Operations to Science Sample Recovery on Earth (Genesis Mission Contingency Plan Heritage)
- Science Payload Recovery Operations

Flight Hardware Cleaning

- Procedure Development for Precision Cleaning
- ISO Class 4 Precision Cleaning Laboratory
- Precision Cleaning for Flight Hardware & Assembly Tools
- Cleaning Verification and Analysis

Flight Hardware Clean Assembly

- ISO Class 4 Assembly Cleanroom Lab
- Precision Cleaned Assembly Tools & Specialized Tooling
- Hardware Testing in Clean Environment
- Final Hardware Close-Out and Sealing for Flight
- Genesis Science Canister Assembly & Sealing Heritage

Flight Hardware Design Support

- Material Selection to Reduce Contamination
- Hardware Geometry Selection to Ensure Cleanability for Reducing Contamination
- Containment and Seals Selection for Long-Term Preservation
- Ensure Science Goals & Requirements are Met
- End-to-End Sample Containment Strategy for Contamination Control:
  Hardware Cleaning & Assembly – Sample Acquisition – Containment & Seals – Long-term Storage – Earth Opening/Extraction

Curation facilities play an important role in all of these functions!

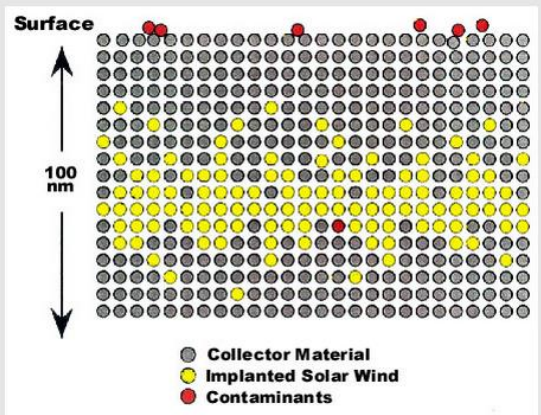
Archival & Documentation

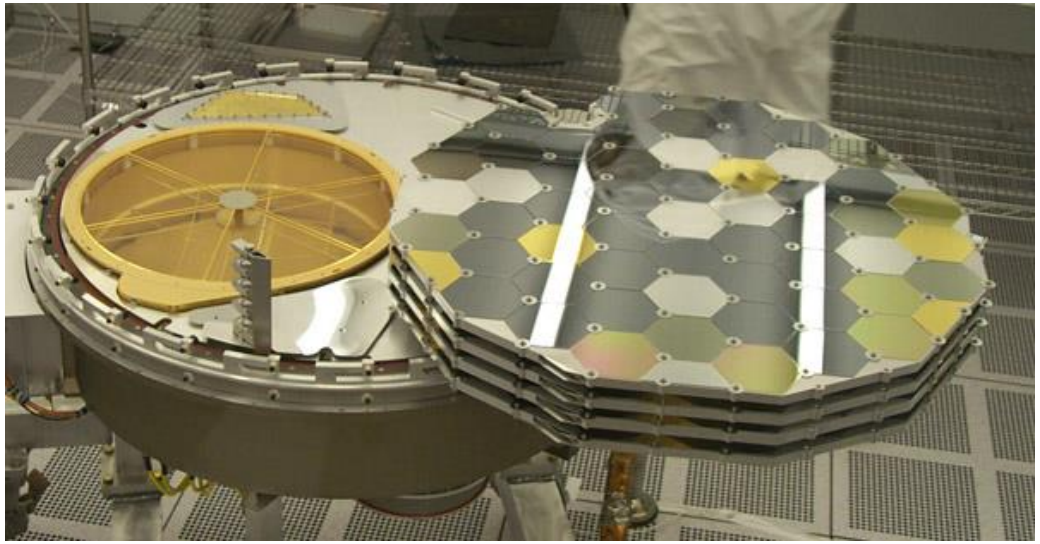
- Material Reference Coupon/Witness Plate Archival from Precision Cleaning Through Assembly & Sealing for Flight
  - Environmental (structure, maintenance, airborne samples)
  - Cleaning process reference material
  - Payload material reference coupons
- Documentation & Contamination Control Plan – Procedures, Transport/Track & Database Development
- Testing, Analysis & Archival for Future
- Well-established Preflight and Flown Hardware Archive Facilities in ISO class 4 to 7 cleanrooms
- Proven Long-term Storage in Inert Glovebox & Desiccator Environments

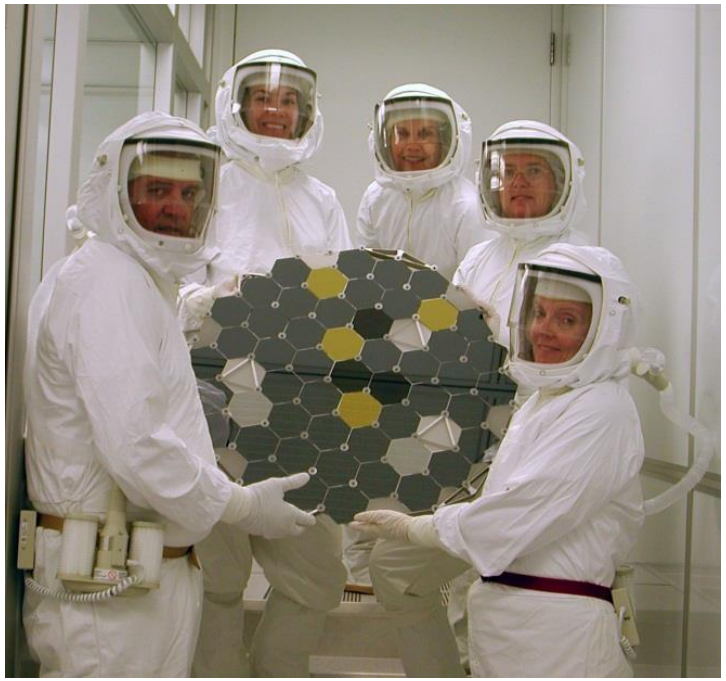
FACILITY FOCUS: Purpose

RETURN SAMPLES CONTAINING CAPTURED SOLAR WIND ATOMS FOR LABORATORY MEASUREMENT

- Collector Materials are “containers” which will capture and hold solar wind



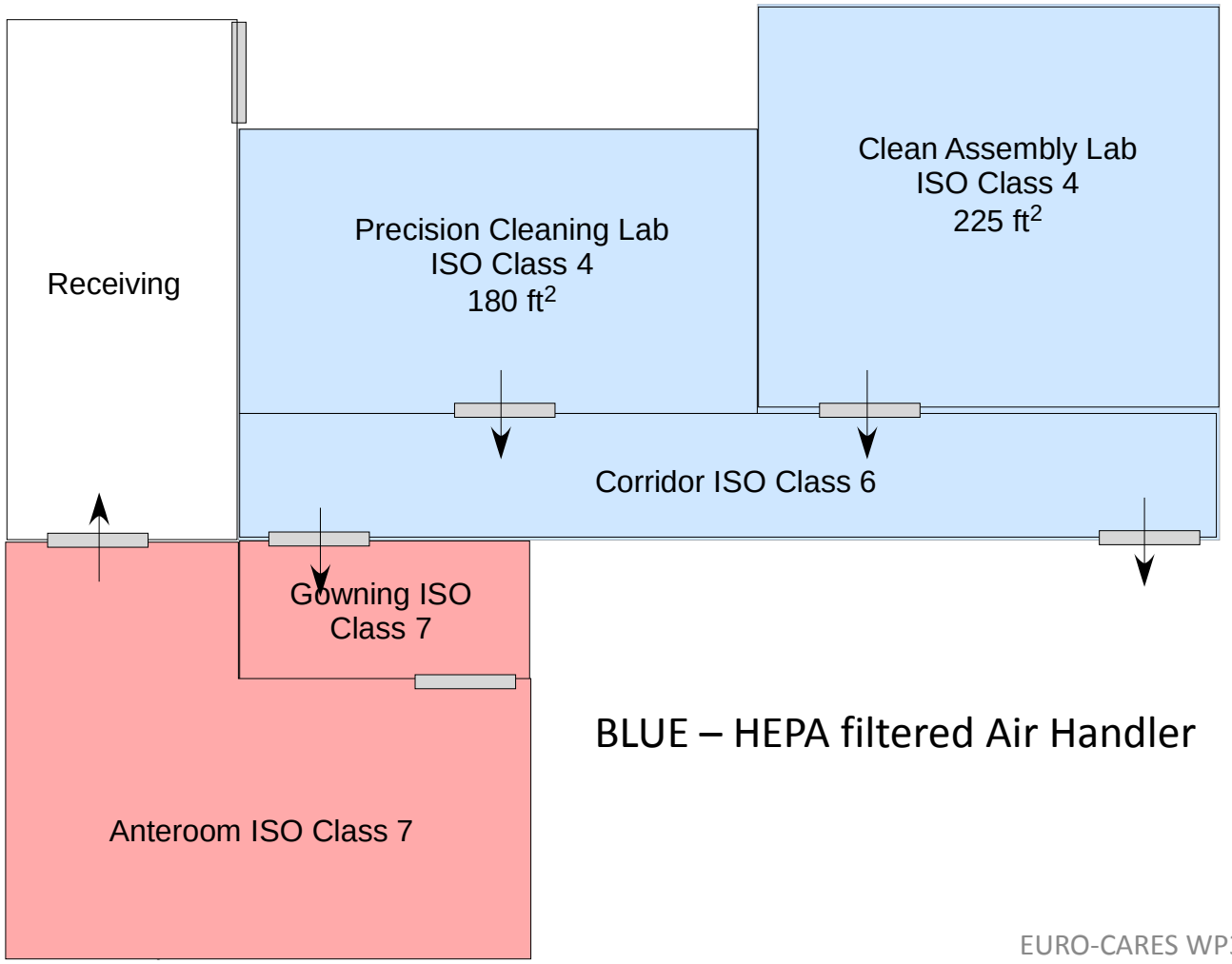




- Must be pure enough
  - Solar wind fluence is low
  - Design goal is signal to noise ratio >100, critical requirement SNR >10
- Must be clean enough
  - Surface contamination < 2 year SW fluence for any element
  - If some surface contamination does occur, there must be methods for removing it

FACILITY FOCUS: Overview of a retrofit laboratory

AIR HANDLERS ARE CRITICAL FOR MAINTAINING DIFFERENTIAL ROOM PRESSURES



BLUE – HEPA filtered Air Handler

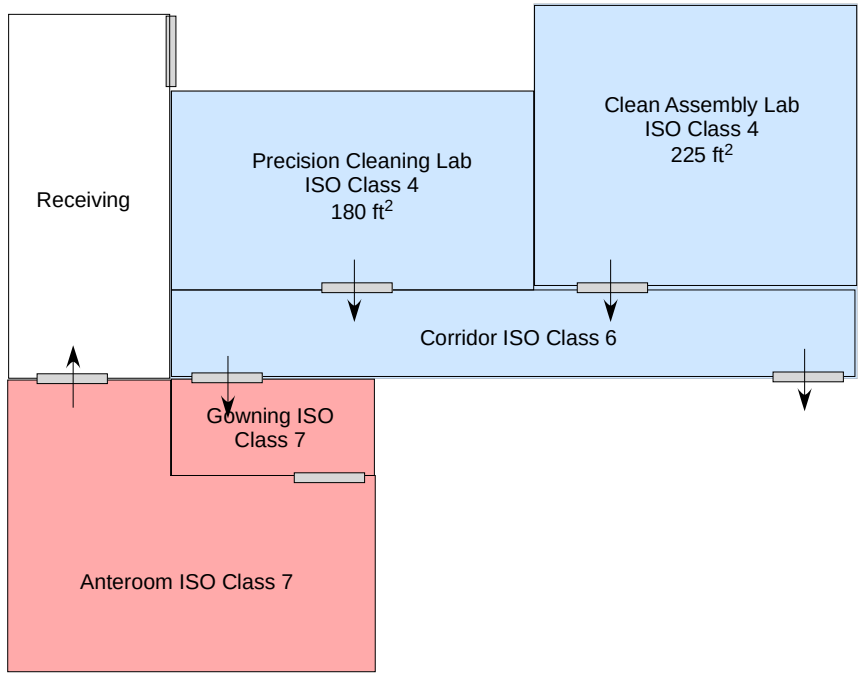
Facility Capabilities

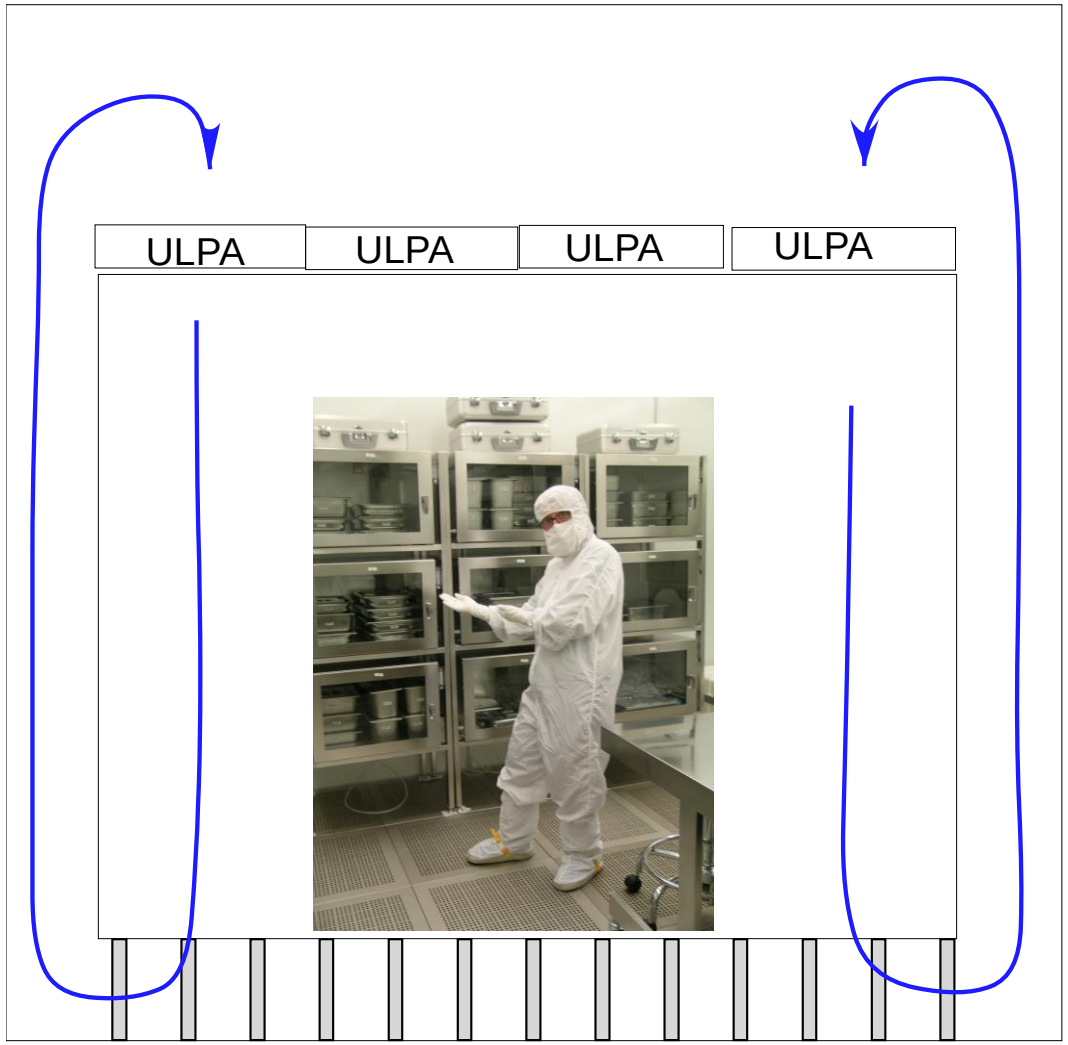
- Two ISO Class 4 Positive Pressure Cleanrooms
- Maintained to ISO 14644 Specifications
- ULPA Fan Filter Unit Air Filtration
- Laminar Air Flow from Ceiling to Floor
- Raised Floor Air Recirculation
- Facility is currently used by Genesis Curation

List of Current Equipment

- Ultrapure Water (UPW) System: E-1 Grade or better (ASTM D5127-13) & UPW Heater
- Gaseous Nitrogen System: Boil-off grade C LN_2 (MIL-PRF-27401G) & GN2 Heater
- GN_2 storage desiccators
- 72 kHz Ultrasonic UPW Cascade Tank and Baths
- 1 MHz Megasonic Pulse UPW Cleaning
- Liquid Particle Counters (> 1 µm)
- Optical Automated Scanning Microscopes
- Stereomicroscopes
- FT-IR with Continuum Microscope
- UV-Ozone Cleaner
- Clean tools for handling and assembly

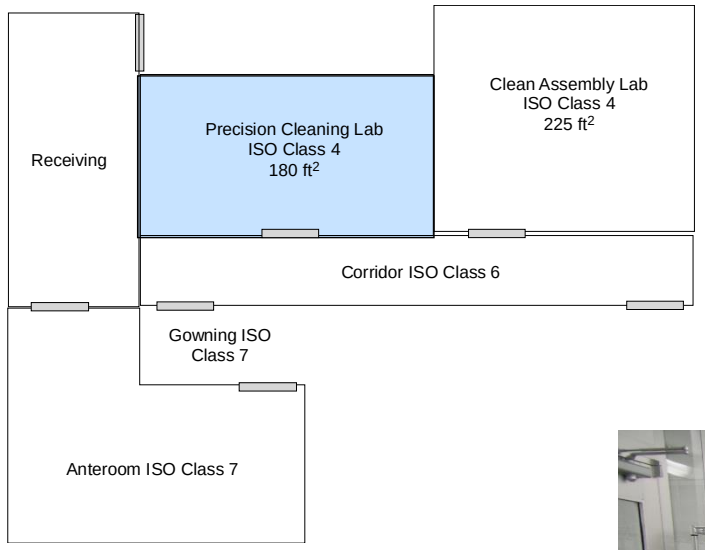
FACILITY FOCUS: ISO Class 4, a drop-in room



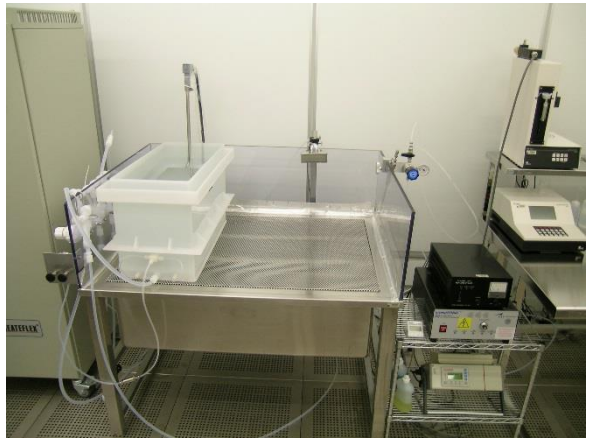


SHOWN IN BLUE
Vertical laminar flow
100 fpm ULPA (<0.12 μ)
Fed by HEPA air handler (<0.3 μ)
Total ULPA coverage ceiling
Total floor air flow holes

FACILITY FOCUS: ISO Class 4 Ultrapure water precision cleaning



Ultrasonic cascade bath

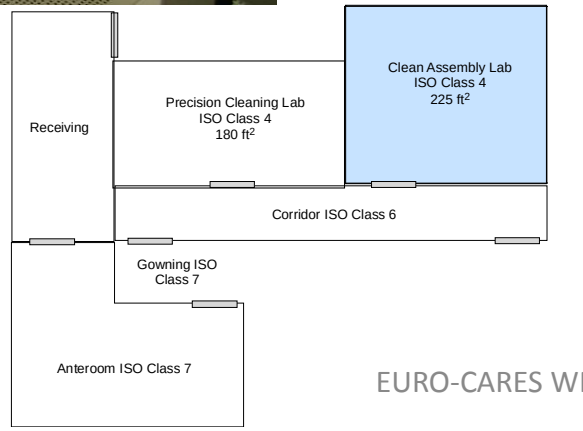


Megasonic spin cleaner

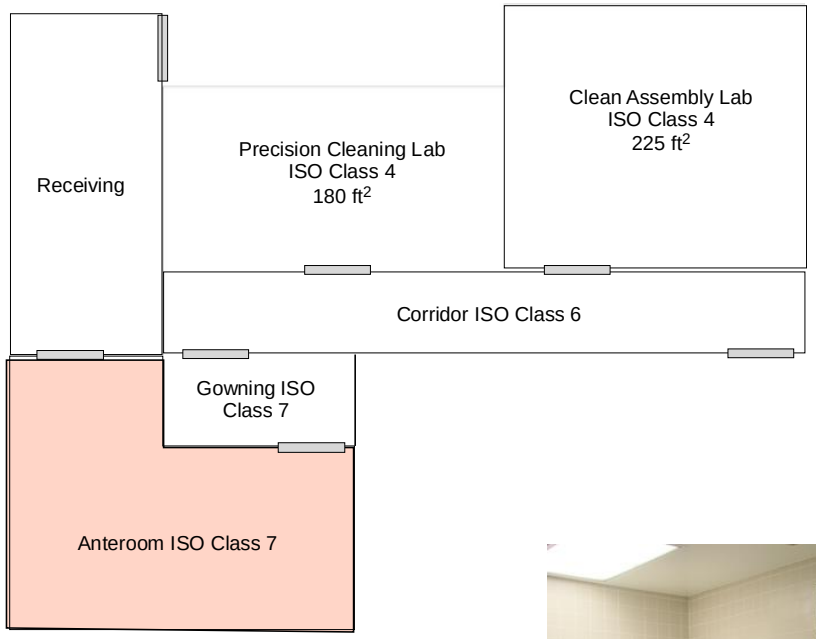
FACILITY FOCUS: ISO Class 4 sample characterization & nitrogen storage

Microscope, FT-IR, ellipsometer, scanning optical microscope

Nitrogen purge sample storage



FACILITY FOCUS: ISO Class 7 entry room

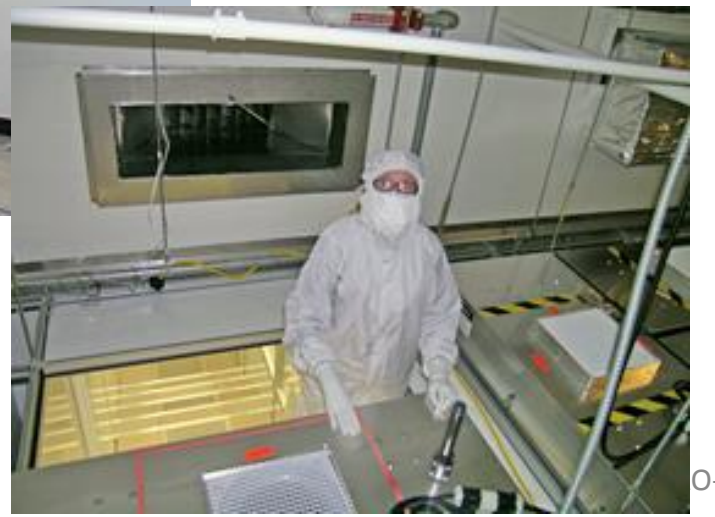


HEPA filtered storage cabinet, flow bench

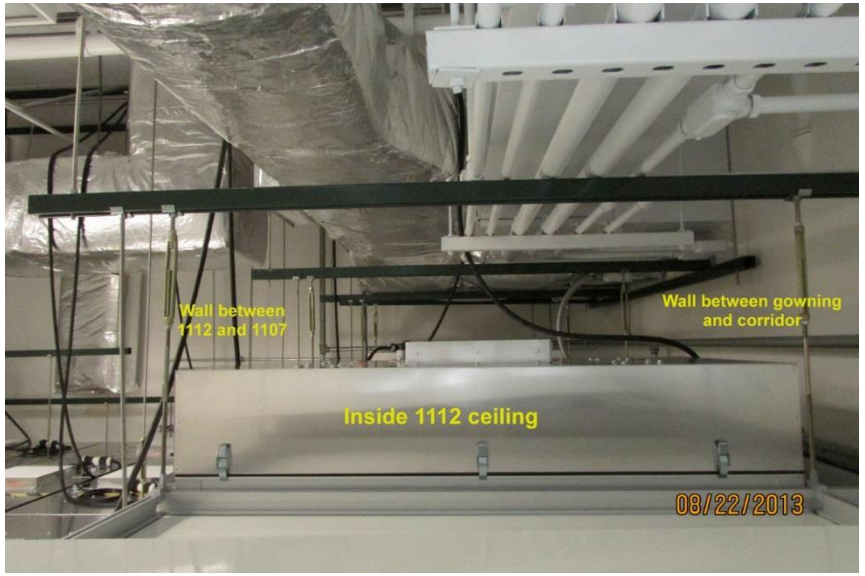
FACILITY FOCUS: construction, subfloor

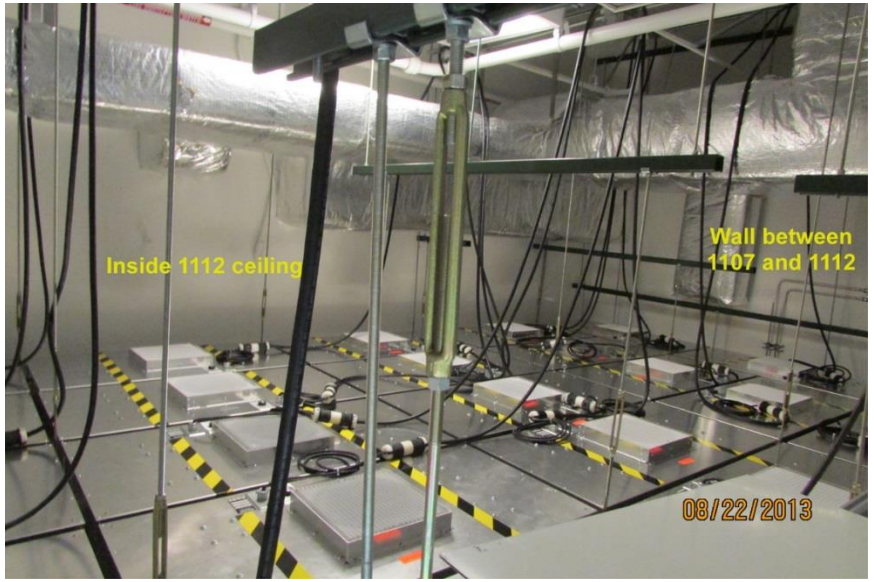
Incipient Fire Detection
UPW
Nitrogen gas

FACILITY FOCUS: Construction, hanging the ULPA filter units



Above the ULPA
Fan Filter Units

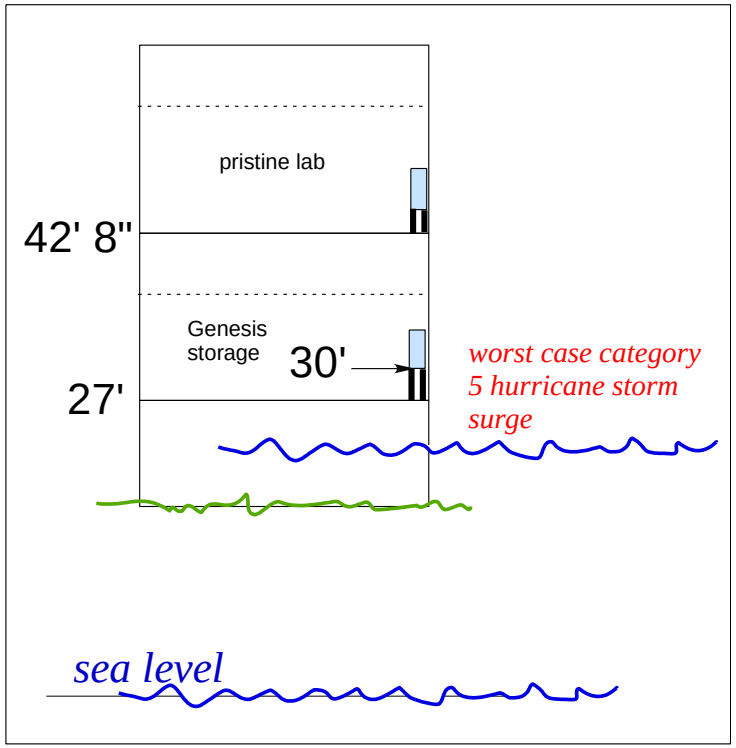




FACILITY FOCUS: Remote sample storage

- Store a subset of the collection at a remote location
- Static nitrogen storage

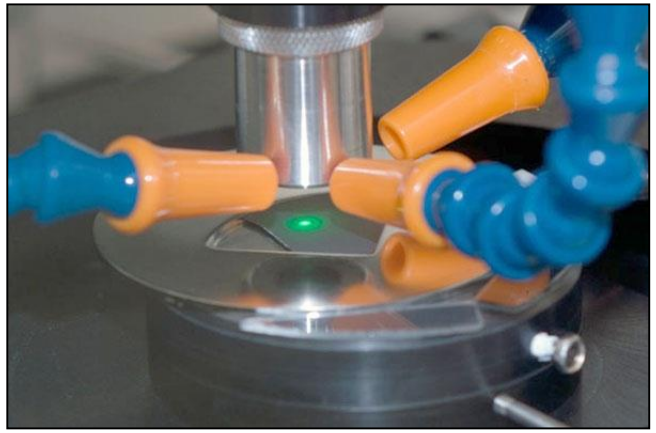
FACILITY FOCUS: Hurricane readiness storage



Samples not currently being worked are stored in upstairs vault during hurricane season. Kept in rolling desiccators purged with nitrogen. Moving process practiced annually.

FACILITY FOCUS: Separate laser scribing subdivision

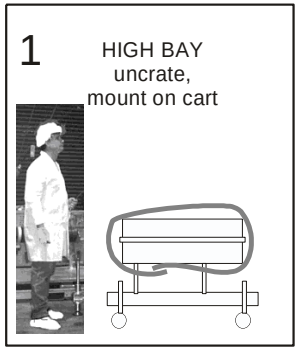
Laser scriber for subdividing large samples. Set up Inside laminar flow clean tent.

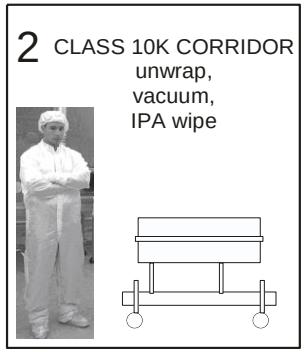


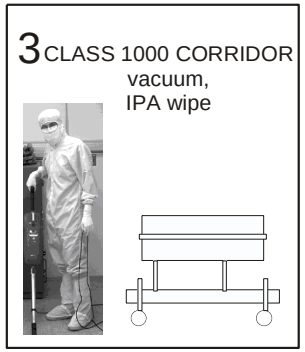
FACILITY FOCUS: Sample receiving as planned

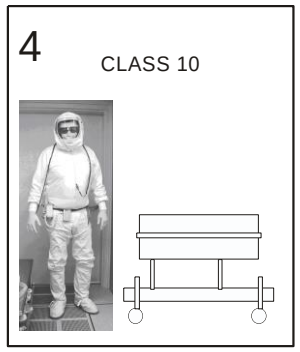
- Set-up cleanroom in hangar at UTTR
- Put nitrogen purge on science canister
- Ship to JSC

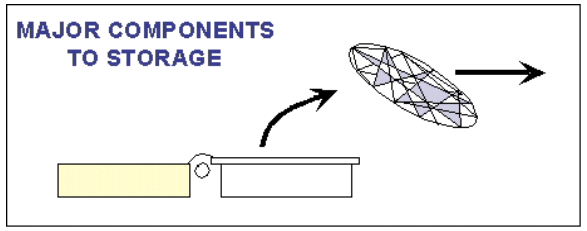
Arrival at JSC

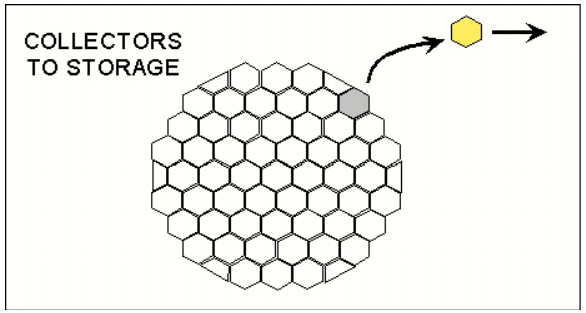




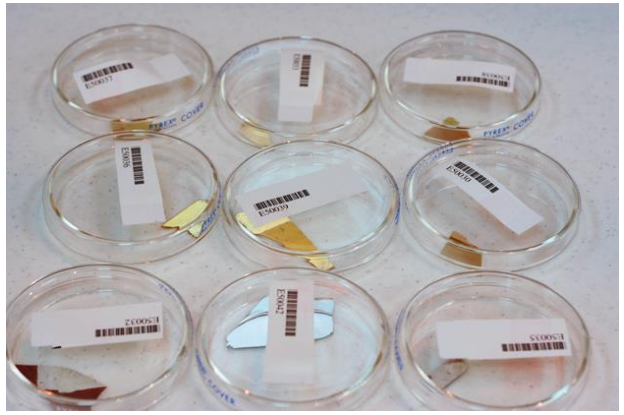








FACILITY FOCUS: Sample recovery as happened



UTTR dilution cleanroom was used! More than 10,000 collector fragments were imaged and packaged in less than one month.

Contingency supplies already in place included 1000's of prenumbered containers.

FACILITY FOCUS: Initial receiving at JSC

JSC ISO Class 4
Nitrogen storage,
room air handling

EXAMPLES: Things we did right and lessons learned

PAYLOAD CLEANING AND ASSEMBLY

- Clean assembly wearing HEPA filtered suits
- Minimization of organic material inside the payload
- Cleaning with ultrapure water (UPW) using ultrasonic & megasonic energy
- Bare aluminum is not easily cleaned without alteration (oxide formation)
- Airborne particle and UPW monitoring

DURING RECOVERY OPERATIONS IN UTAH

- Assets were in place to handle worse case scenario (hard landing)

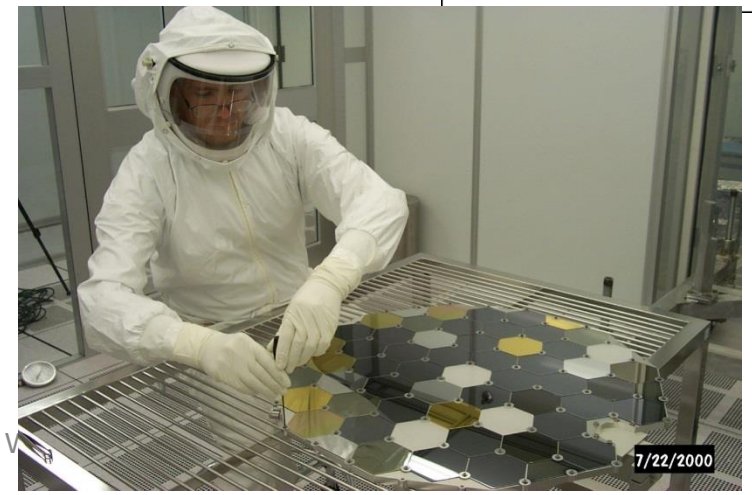
CURATION OF RETURNED SAMPLES

- Competing air handlers
- Ability to clean solar wind sample substrates using megasonic UPW

EXAMPLE, did right: Clean Payload Assembly & Function Testing

- ISO Class 4, personnel wearing fully enclosed suits with HEPA filters
- Strict protocols, JPL QA: example – fasteners not touched by gloved hands, installed using tweezers
- Cultural differences - team worked well together

During assembly, fasteners were handled with tweezers, not gloved fingers.



EXAMPLE, did right: Clean Payload Assembly & Function Testing

- ISO Class 4 for cleaning and assembly
- New cleaning techniques – megasonic energized UPW
- Verification methods: particle count rinse water, optical inspection, witness coupon measurement (XPS) to validate process
- Measurement of airborne molecular contamination (semi-annually), particle counts (weekly)
- Continual monitoring of UPW quality: resistivity 18.2 MΩ, TOC ,5 ppb. UPW chemical & biological analyses (semi-annually or as needed). Ion concentration low parts/trillion
- Material and personnel access controlled

EXAMPLE, did right, but could have been better: Minimize organics

- Tight control of amounts applied – tiny amounts RTV applied with dental pick, Braycote applied with 2-mm brush
- Mechanism lubricants isolated to vent to outside of canister
- “Brown stain” polymerized RTV-like material, 50A thick

EXAMPLE, did right: High level cleanliness using UPW

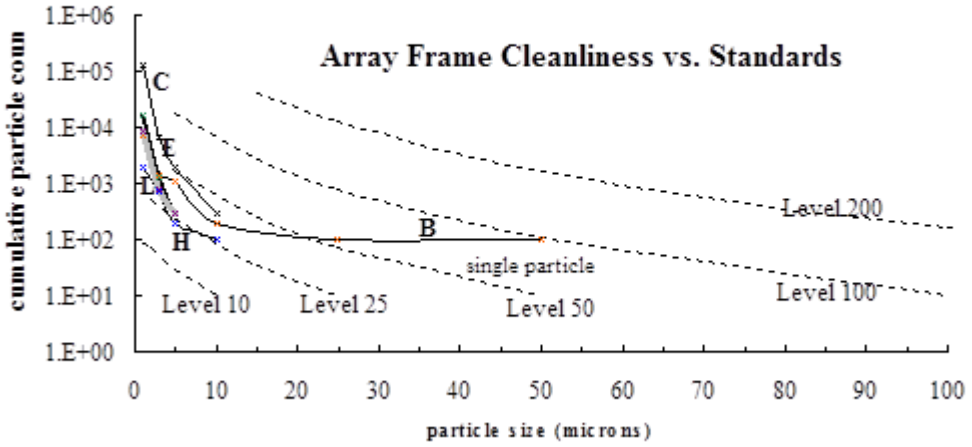


Fig. 4-10. *A stream of megasonically energized UPW generated by a portable wand is used to clean the canister base.*

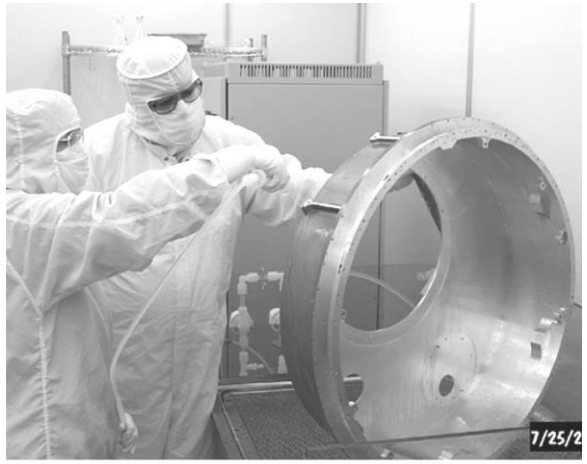


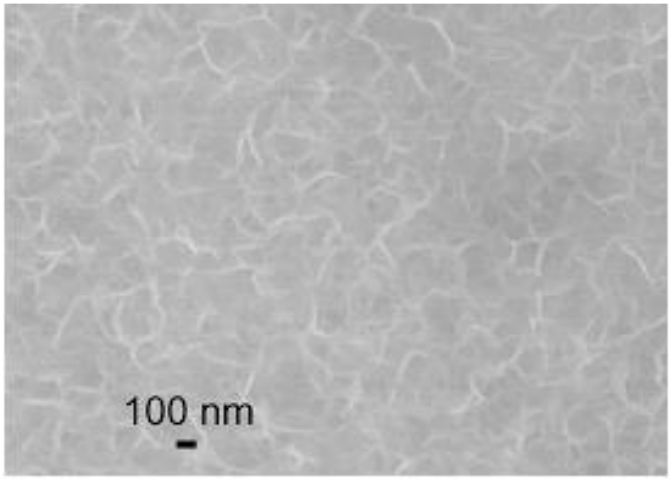
Fig. 4-9. *Canister base is rinsed with ultrapure water (UPW)*

Megasonic energy on UPW head

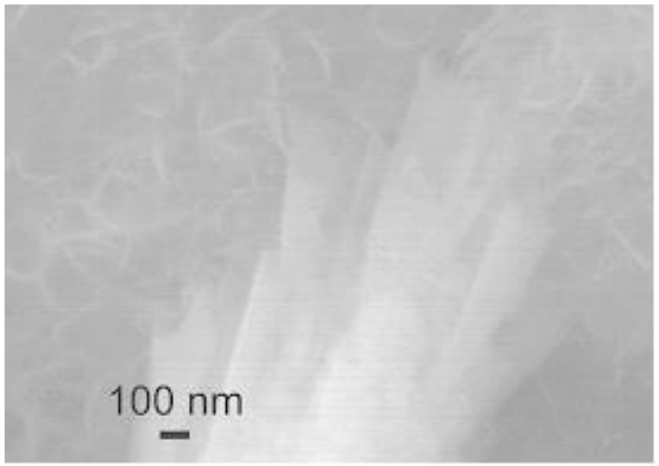
Ultrasonic energy in bath

EXAMPLE, lesson learned: Cleaning bare aluminum results in oxide formation

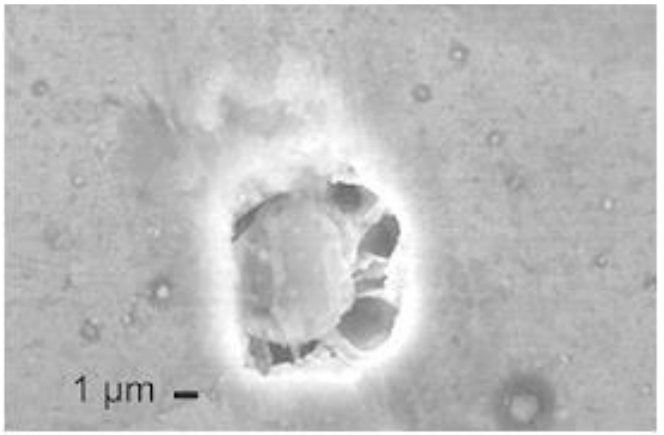
Has implications for difficulty of CLEAN and STERILE for aluminum spacecraft parts



The wrinkled texture of hydroxides (boehmite?) resulting from UPW cleaning of aluminum 6061 at 75°C for 30 min. Scale bar is 100 nm.

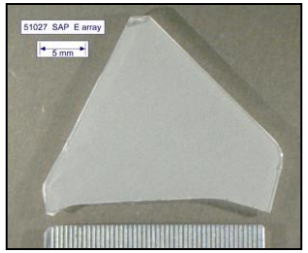


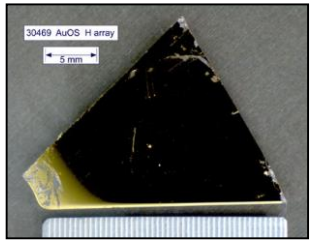
The needle laths (bayerite?) radiating from single point. The view is from same coupon in fig. 4-5. Scale bar is 100nm.

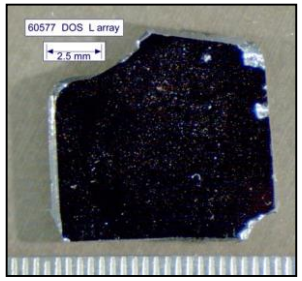


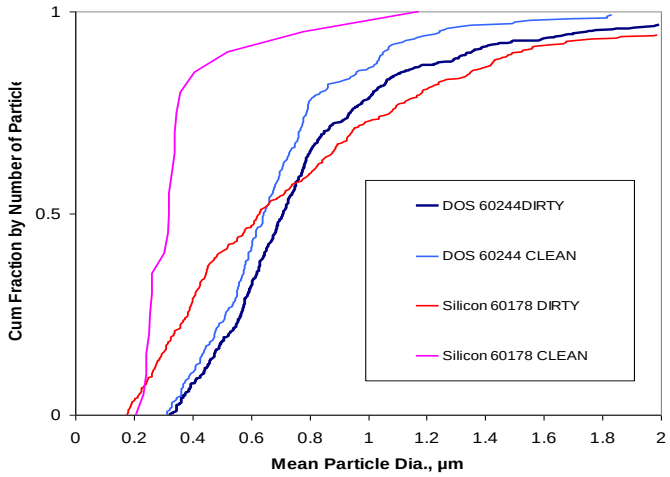
Erosion pit around inclusion in aluminum 6061 cleaned in UPW at 50°C for 30 minutes. Scale bar is 1 µm.

EXAMPLE, did right: Developed technique for cleaning SW sample substrates with UPW









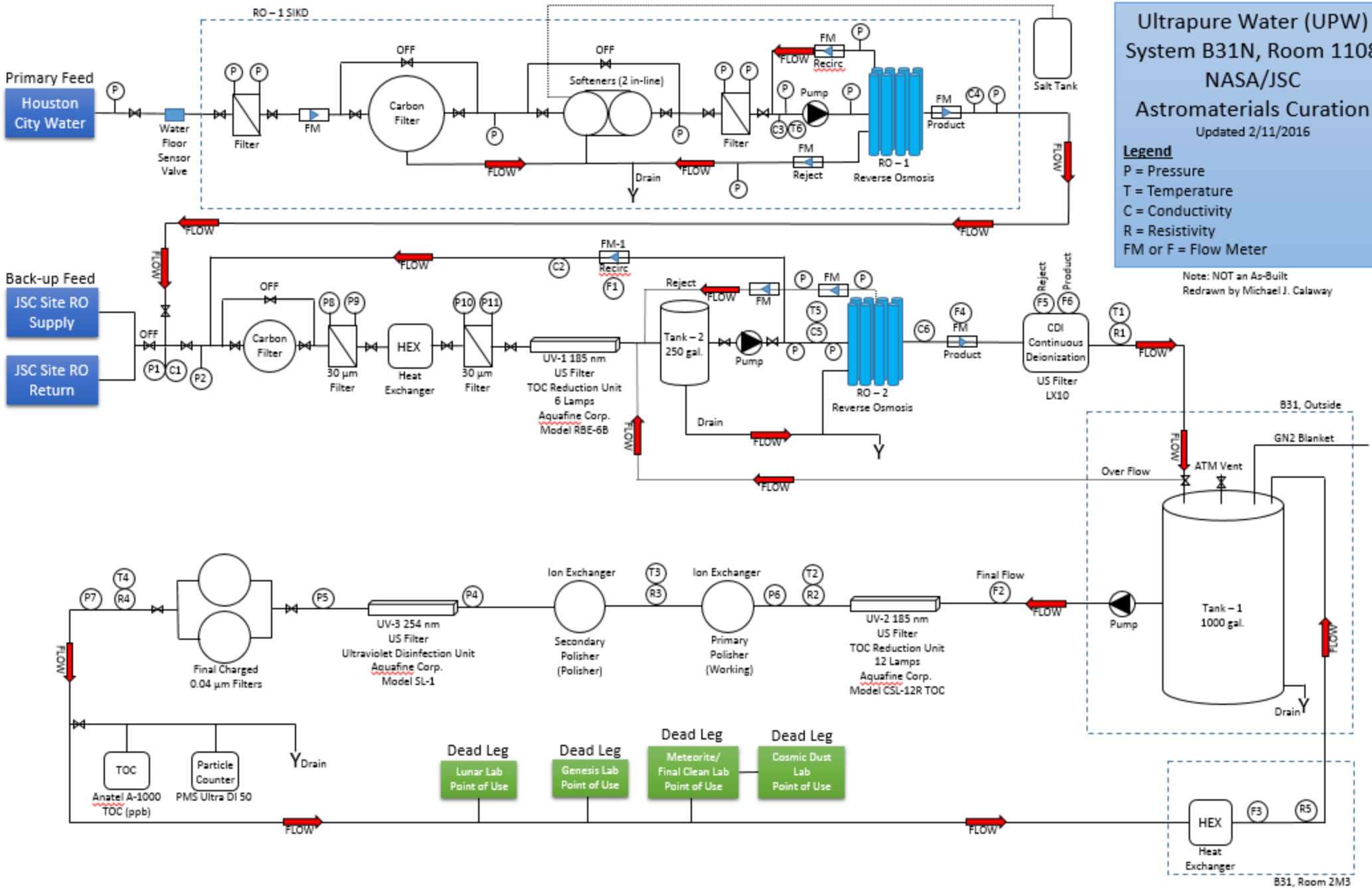
Ultrapure Water (UPW) System B31N, Room 1108 NASA/JSC Astromaterials Curation

Updated 2/11/2016

Legend

P = Pressure
T = Temperature
C = Conductivity
R = Resistivity
FM or F = Flow Meter

Note: NOT an As-Built
Redrawn by Michael J. Calaway



THE BIG PICTURE: facility going forward…..

- **JSC Curation Supported Genesis Mission from Beginning to End**
- **Transitioned to Long Term Curation and Providing Samples for Researchers**

- Secure, storage under nitrogen cover gas
- Regular monitoring of airborne particulates, UPW chemistry
- Sample characterization in ISO Class 4 room using microscopes and analytical instruments
- Cleaning of sample substrates with UPW
- Maintenance of extensive reference material collection
- Providing researchers with appropriate solar wind samples and reference materials

Genesis Lab was a 1998 retrofit laboratory inside of the 1978 lunar sample building. A new, long-term facility plan needs core utilities better located for easy maintenance and upgrade. A receiving facility, for samples requiring strict containment, also needs laboratory instruments located for easy maintenance and upgrade.