Mars Sample Receiving Facility Research and Development

to Enable Preservation, Safe Containment, and Scientific Research of Martian Samples on Earth

NASA RAMA Tiger Team For MSR SRF Formulation

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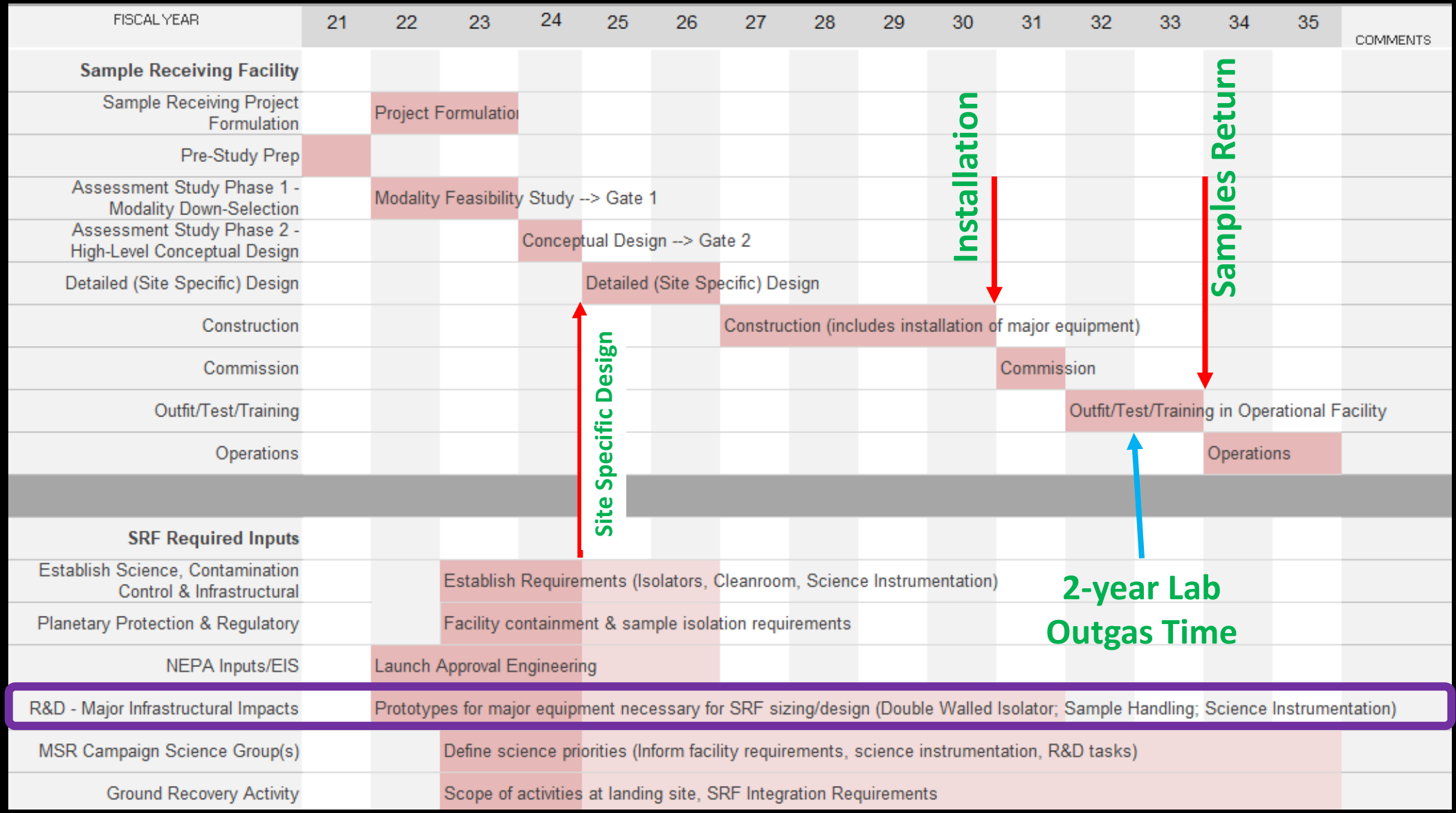
44th COSPAR Scientific Assembly
Section B4.4, #18
Athens, Greece
July 21, 2022: 10:45 (15 min.)

Notional MSR Sample Receiving Facility Schedule

Critical R&D FY23-24 To Inform FY25 Site Specific SRF Design



Mars Sample Return Project (SRP) to Critical Site Specific Design FY25

NASA/ESA MSPG2 Science

SSAP/ Planetary Protection

NASA/ESA MOSDT SRF OPS Scenario

Adv. Planning RAMA/Tours Report

U.S. BSL-4 Regulatory CDC/BMBL; etc.

U.S. EPA NEPA

SRF MSAS Study Modality Options Design/Construction Cost/Schedule

Establish SRP & Level 1 REQ

SRF R&D Technology Development

Translate Mars 2020 Mission CC REQ for Geologic Sample to Engineering REQ for SRF

FY25

SRF Cost and Schedule Estimates

Possible Use Of Existing BSL-4 Feasibility

Fixed, Hybrid, Modular Construction Feasibility

Down Select And Conceptual Designs

Finalize Construction Modality

SRF Requirements for Site Specific Design

Material Testing:
- **BSL-4 Suits**
- **Cleanroom Garments**
- **Construction Materials**

Finalize Parameters:
- **Isolators**
- **Cleanrooms**
- **Precision Cleaning**
- **Sterilization**

Critical Testing

SRF Requirements for Site Specific Design

Critical R&D

Finalize FY23 Implementation Parameters

Finalize FY23 Contamination Control

Size, Configuration, and Interfaces:
- **Isolators (DWI, BSC-III, etc.)**
- **Sample Handling (Robotic, Mechanical, etc.)**
- **Instrument (Sample Introduction)**

Finalize Science CC REQ.; Translate to Engineering CC REQ.

FY23 & FY24

Site Specific Design Phase

R&D Required Information before FY25

- Isolator/DWI R&D: Size, configurations, interfaces, connections, gas, and utilities.
- Develop, Fabricate, and BMBL certifed a working DWI prototype based on ESA DWI breadboard experience
- Materials Selection: R&D Testing of Construction Materials, biosafety suits, and cleanroom garments.
- Sample Sterilization Parameters
- Precision Cleaning and sterilization of cleanrooms and DWI R&D
- Existing BSL-4 Environment Cleanliness: Inorganic, Organic, and Biological baseline measurements
- XCT/Magnetometer Tube Container and Analysis Feasibility R&D: Inside or Outside BSL-4 Containment
- Gas Extraction and Analysis Feasibility: Inside or Outside BSL-4 Containment
- Sample Tube Head-gas puncture/extraction
- Sample Tube Cutting/Opening
- Sample handling interfaces (robotic, mechanical, etc.); Isolator size and configuration parameters
- Instrumentation Interface R&D: foot-print and utility accommodation of each instrument

Mars 2020 Mission Contamination Control Requirements to Samples

Inorganic: 1% of average concentration of 23 elements and 0.1% of the average concentration of 12 elements found in SNC meteorites

Organic: Total Organic Carbon <10 ppb baseline with Tier 1 compounds <1 ppb (Tier 2 <10 ppb)

Biological: Each sample comprising the collected cache will have a less than 1:6667 probability of containing a terrestrial (i.e., Earth) microbe (dead or alive).

These requirements will feed forward to MSR SRF Contamination Control Requirements

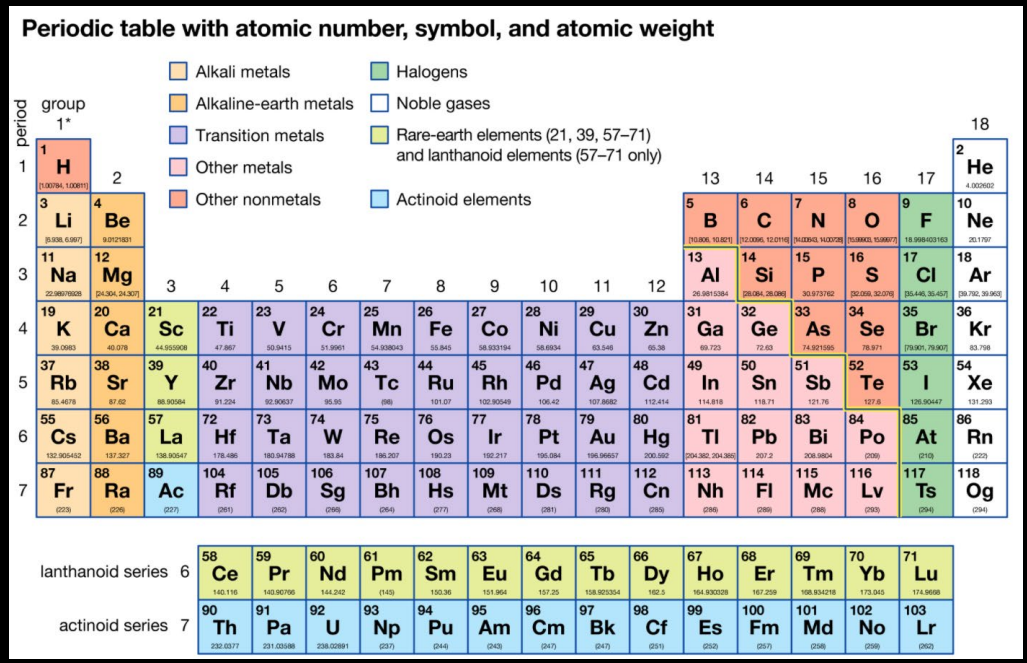
Mars 2020 Contamination Control Engineering Requirements During ATLO

- Sample Intimate Hardware is Level 50 cleanliness for particulates per IEST-STD-CC1246E
- Sampling Intimate Hardware set TOC < 100 ng/cm^2
- Interior Sample tubes set at **TOC < 0.3 ng/cm^2** (in order to make the <10 ppb max requirement for TOC during ATLO)

For Total Organic Carbon (TOC)
Mars 2020 needed to be 1,667 times "cleaner" than OSIRIS-REx Mission set at TOC < 500 ng/cm^2 .

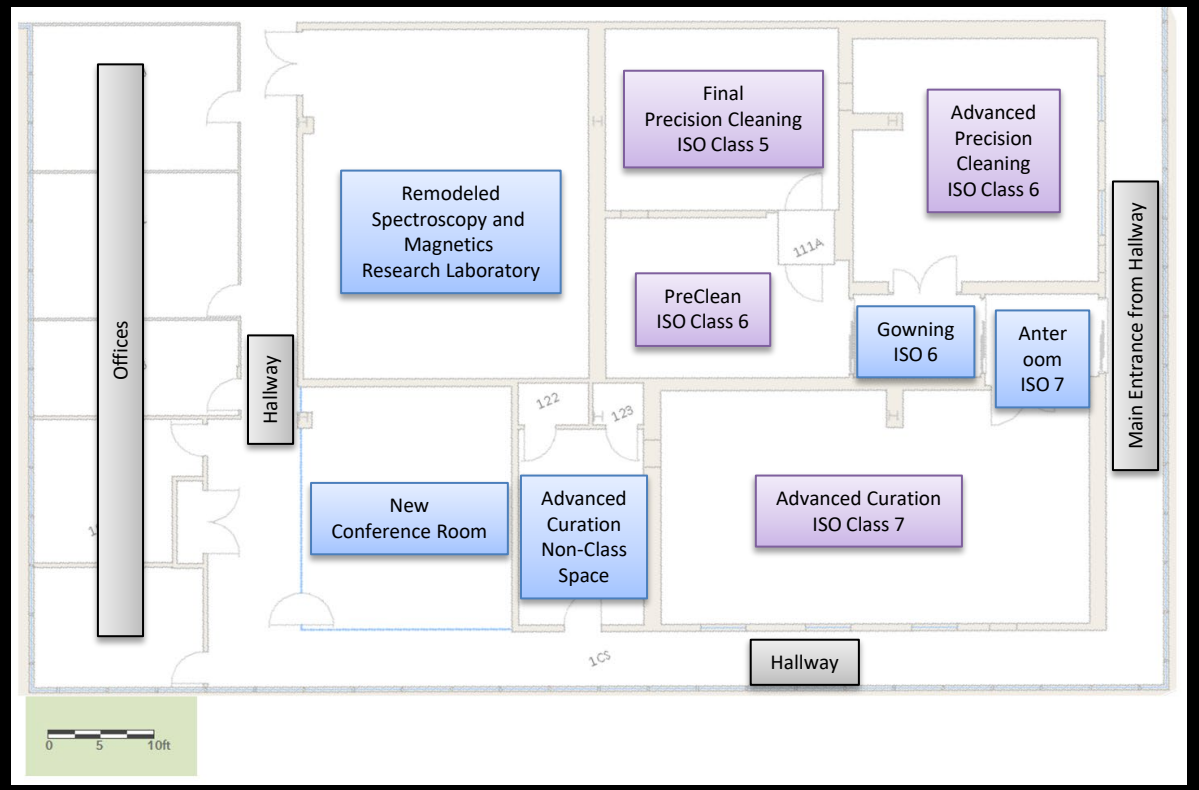
The Importance of Material Selection for

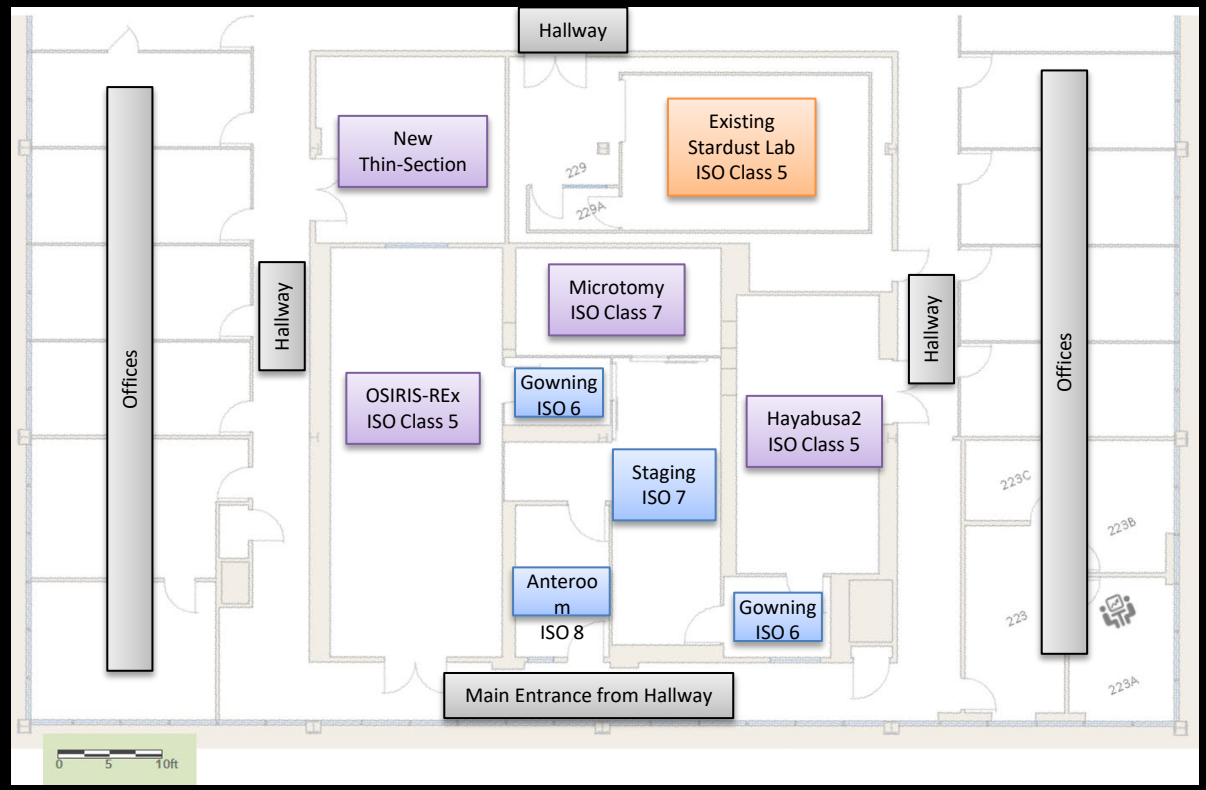
- *Cleanroom Construction Materials*
- *Isolator, Glovebox, and Desiccator Materials*
- *Sample Handling, Equipment, and Supplies*
- *Primary, secondary, and tertiary sample containers*
- *Everything that enters a curation lab*

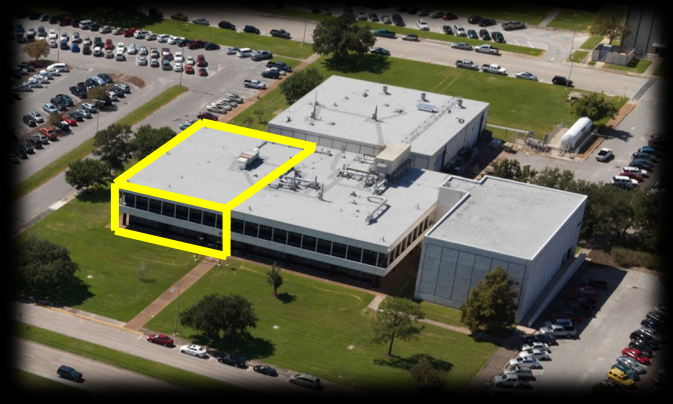


While sample return missions focus on certain chemical compounds and signatures, samples are eventually allocated for measurements of almost the entire period table

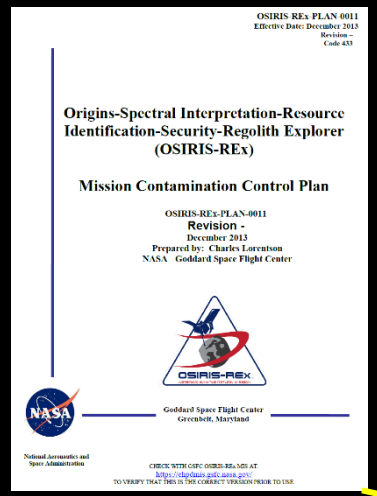
NASA JSC Bldg. 31 1st and 2nd Floor Curation Cleanroom Lab Renovations 2019-2021







A Decade of Planning and Testing to Reduce Organics . . .


OSIRIS REx PLAN 0011
Effective Date: December 2013
Revision –
Code 433

Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-REx)

Mission Contamination Control Plan

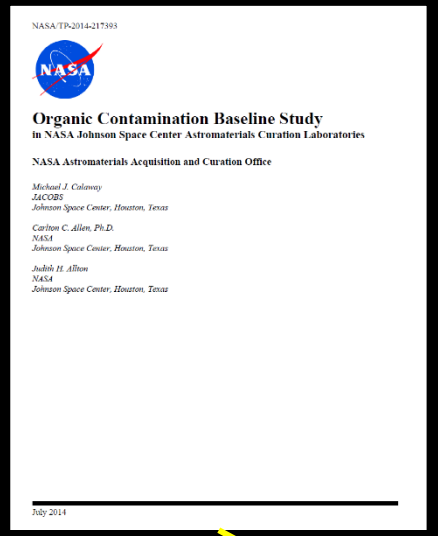
OSIRIS-REx-PLAN-0011
Revision -
December 2013
Prepared by: Charles Lorentson
NASA Goddard Space Flight Center

OSIRIS-REx

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and Space Administration

CHECK WITH OSPC OSIRIS-REx MIS AT
http://ospkms.gsfc.nasa.gov/
TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE


NASA/TP-2014-217393

Organic Contamination Baseline Study
in NASA Johnson Space Center Astromaterials Curation Laboratories

NASA Astromaterials Acquisition and Curation Office

Michael J. Calaway
JACOBS
Johnson Space Center, Houston, Texas

Carlton C. Allen, Ph.D.
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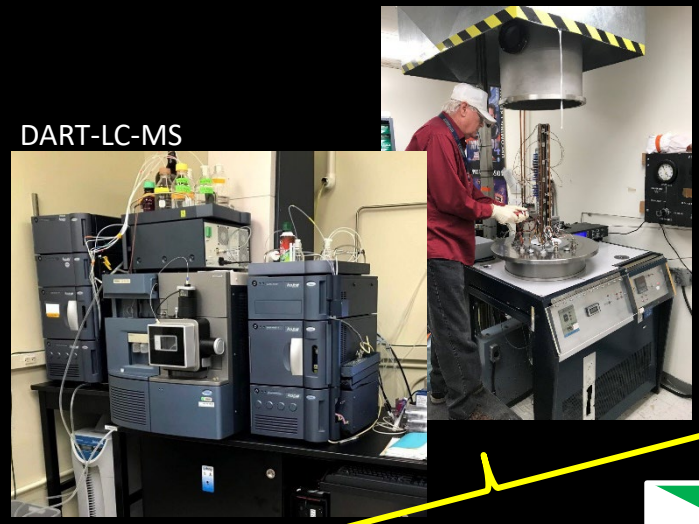
July 2014

DART-LC-MS



ASTM E-595
Outgassing

OSIRIS-REx
CC Plan

NASA JSC Organic Baseline Historical Research
2011

NASA JSC Baseline Cleanroom Tests
2012

Baseline Glovebox Tests
2013

Organic Baseline Report
2014

Continue Curation/ CC Planning
2015

Material Test Planning
2016

Material Testing
2017

Material Selection Lab Design
2018

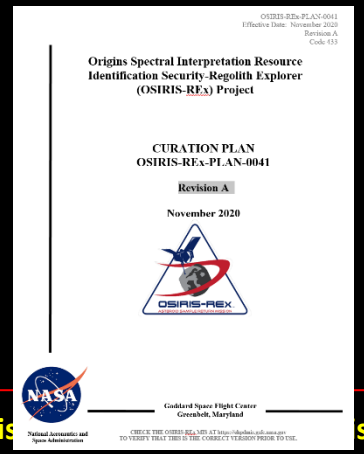
Lab Construction Begins
2019

Impromptu Material Testing
2020

Lab Construction Ends
2021

OSIRIS-REx
2023 Return to Earth

Planned 2-years
For Cleanroom to Outgas


OSIRIS-REx-PLAN-0041
Effective Date: November 2020
Revision A
Code 433

Origins Spectral Interpretation Resource Identification Security-Regolith Explorer (OSIRIS-REx) Project

CURATION PLAN
OSIRIS-REx-PLAN-0041

Revision A

November 2020

OSIRIS-REx

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and Space Administration

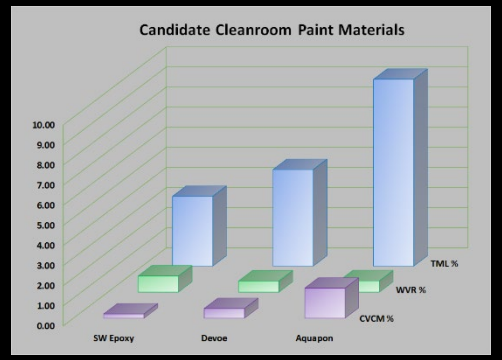
CHECK THE OSIRIS-REx MIS AT http://ospkms.gsfc.nasa.gov/
TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE

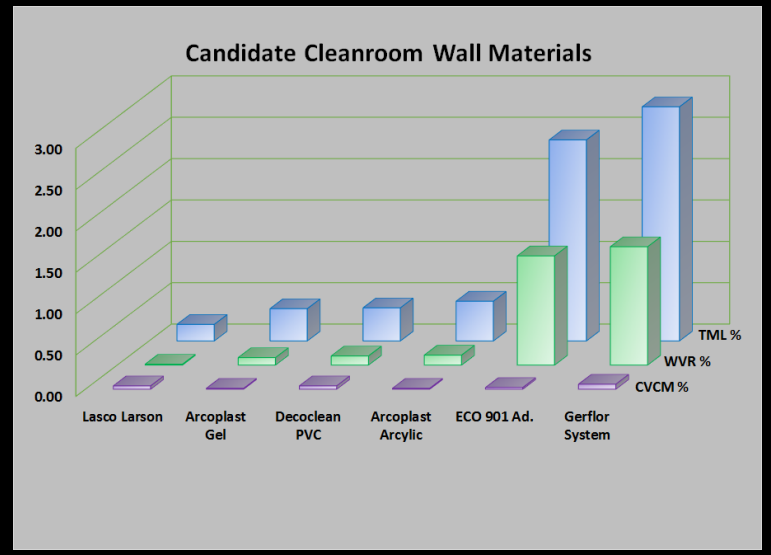
Material Selection for Cleanrooms

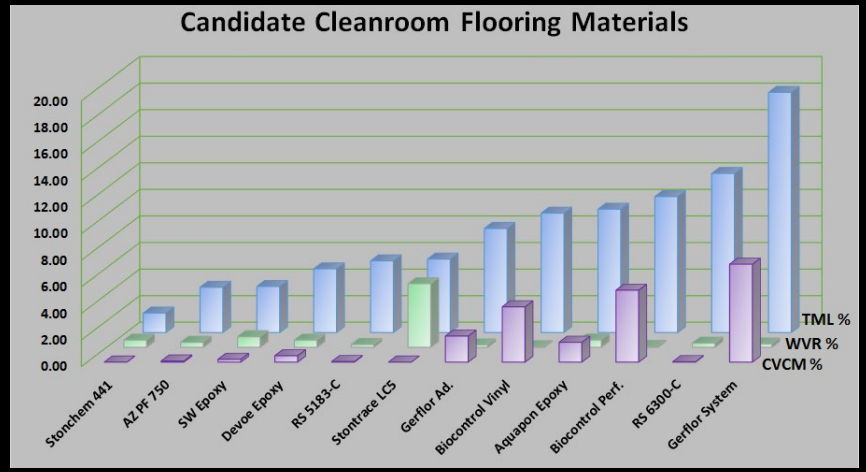
- Material Chemical Composition: Spec. Sheets, Safety Data Sheets, etc.
- Material Mechanical Properties, including particulate shedding
- Material Outgassing:
  - NASA MAPTIS Material Database Outgassing Reports
  - ASTM E-595, DART-LC-MS, and/or ISO 16000-6/7
- Functional for Engineering Application
- Cost and Schedule
- Prohibited and Preferred Construction Materials List

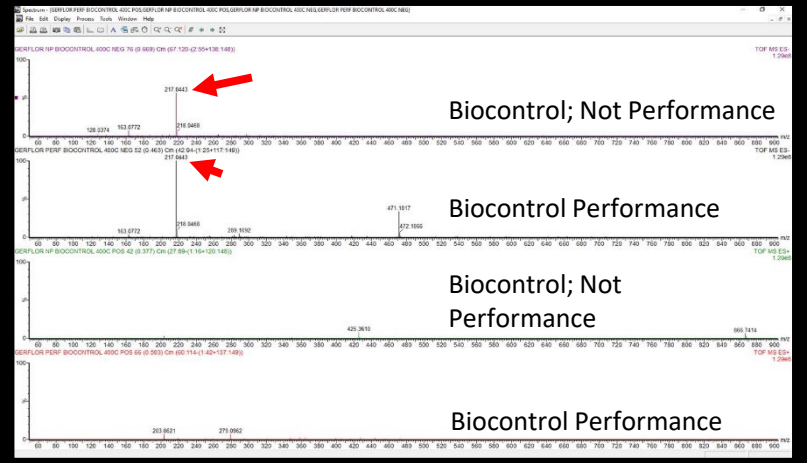
Controlled Construction Materials

- HVAC (Ducting, Filters, Motors, etc.)
- Fan Filter Units (FFU) with ULPA Filters
- Walls, Ceiling, and Flooring
- Plenum clean air surfaces (paints)
- LED Lighting
- Electrical and IT/Security
- Fire Protection
- Monitoring and sensors









Custom Fan Filter Unit Example

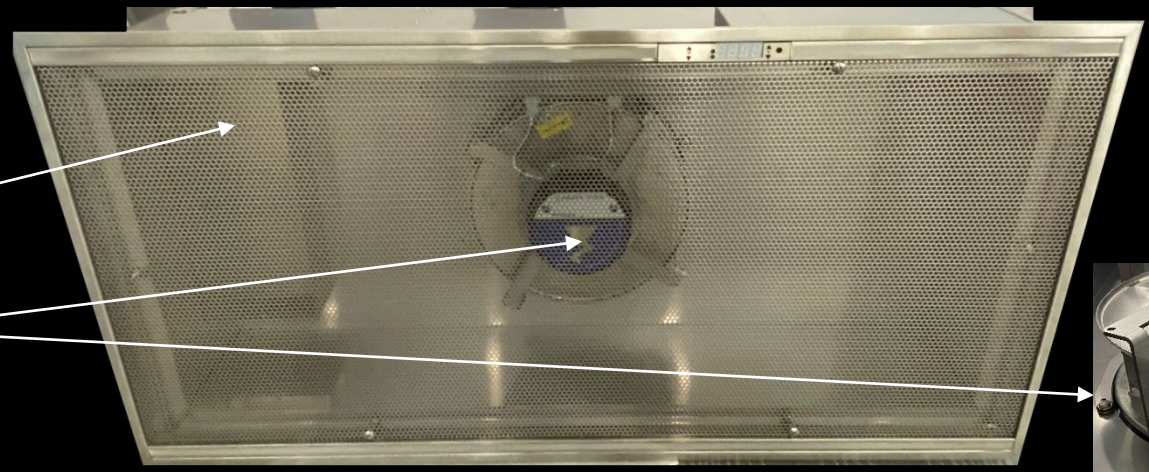
Nailor 304 stainless steel diffuser shell, electrical box, LED driver (all bolts, screws, hangers are 304SS)

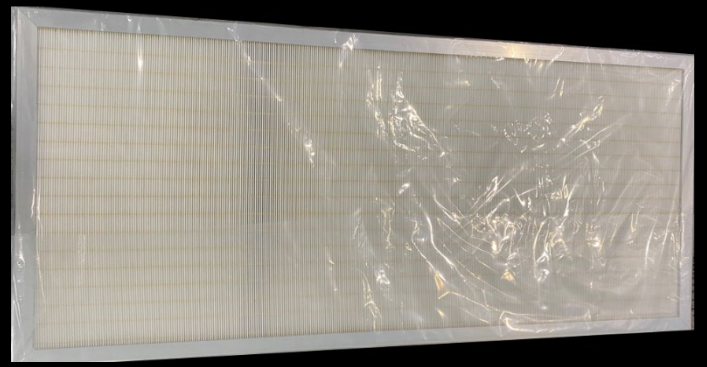
Custom variable speed motor with an untreated aluminum impellor

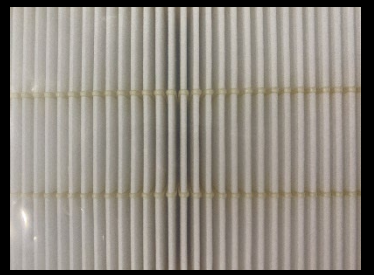
Gasket: traditional gel seal with a new silicone gel seal (DOWSIL CY 52-276 gel) that met the low outgassing requirement that was researched and tested by Kondoh Industries

Kondoh Industries Cambridge Giga Master ULPA Filter
<0.05 ng/cm^2/24 hours Organics (lowest on market)
low boron

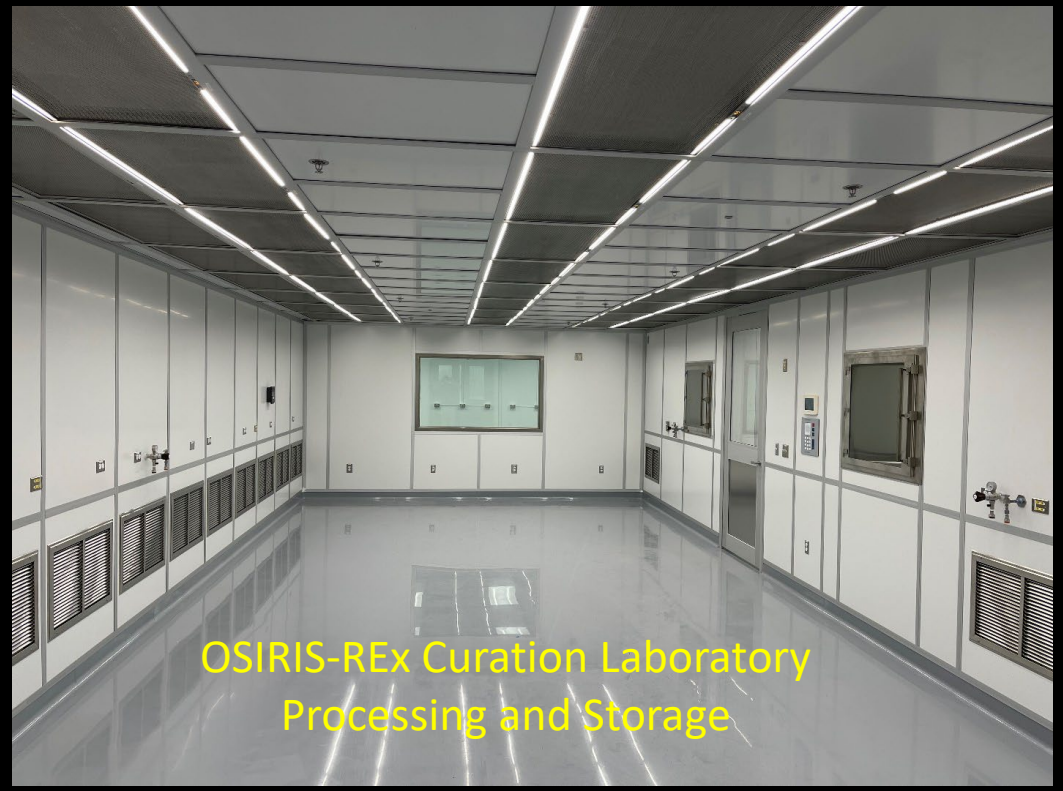
LED dimmable lighting fully sealed in stainless steel, PTFE, and polycarbonate lens with low outgassing epoxy
No Trace of Silicone

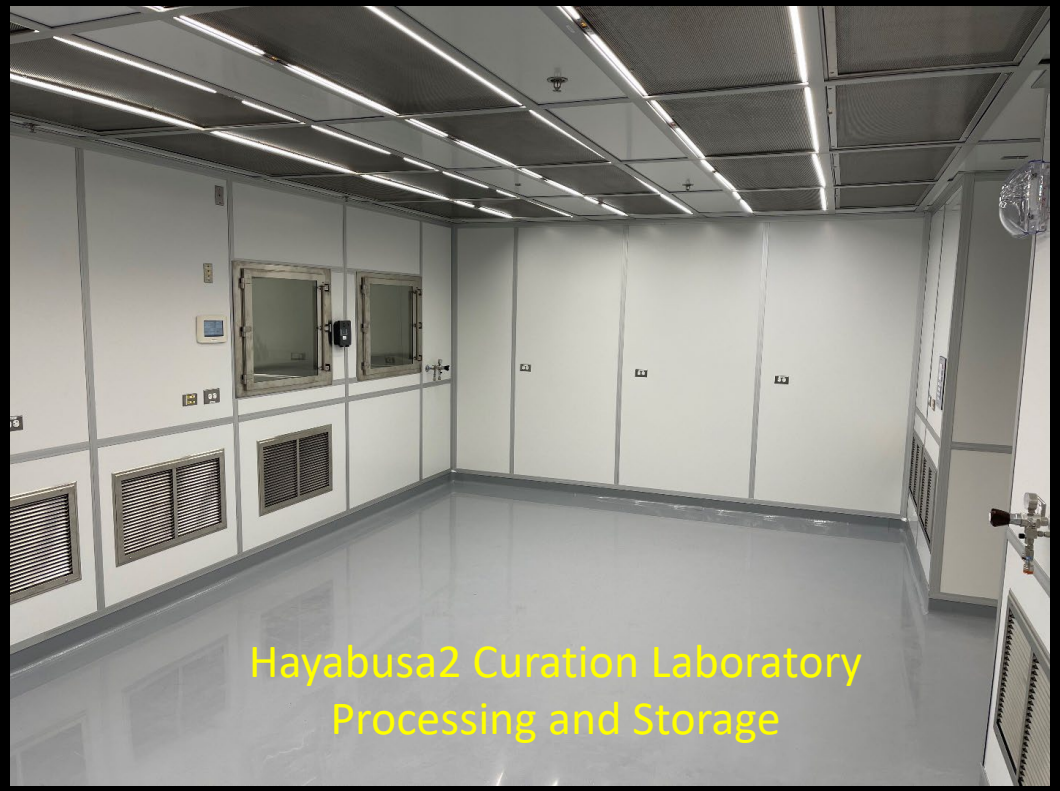






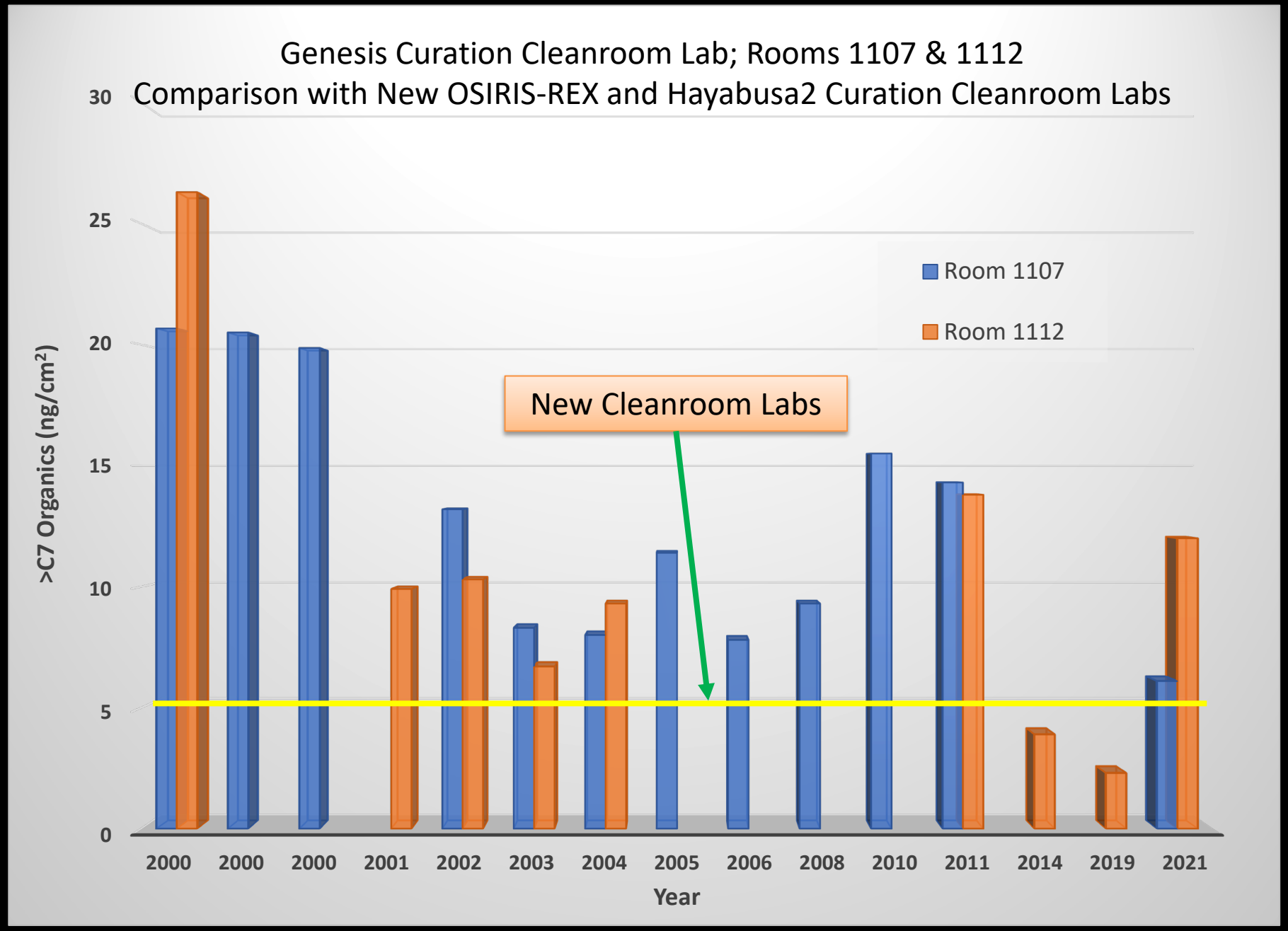
NASA JSC OSIRIS-REx and Hayabusa2 Constructed Cleanrooms





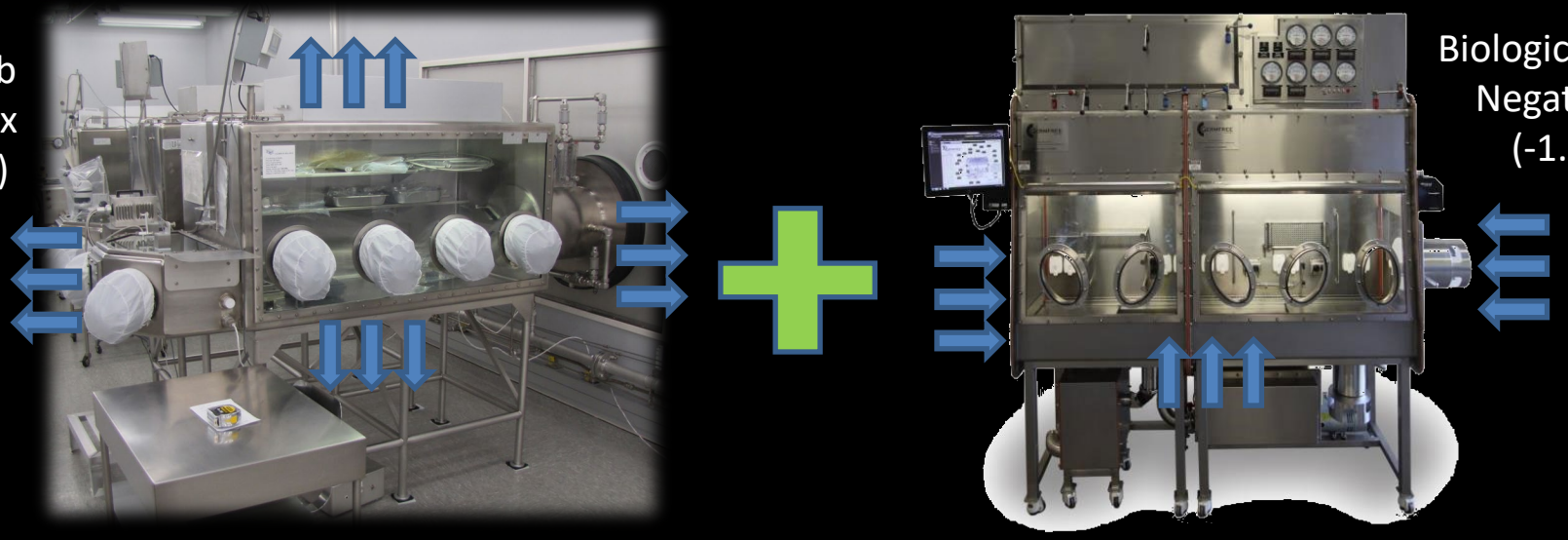
New Cleanroom Achieved
Below 1 ng/L
Airborne Organics
(6 hour exposure)

New Cleanroom Achieved
Below 5 ng/cm²
Nominal Surface Organics
(24 hour exposure)



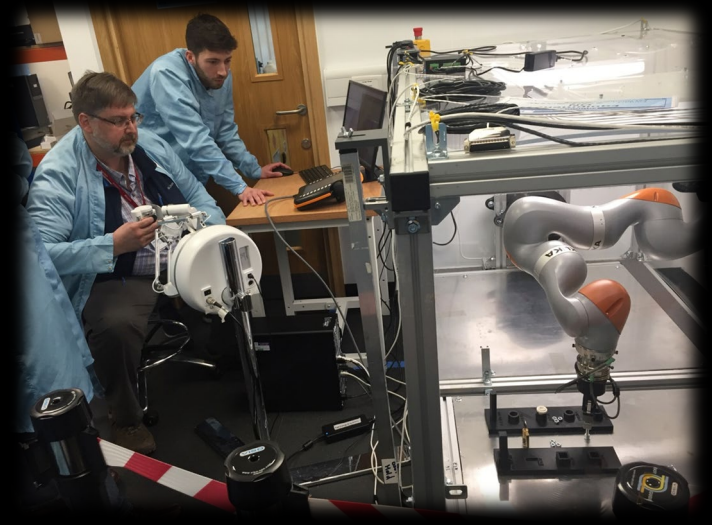
Integrate Positive Pressure and Negative Pressure Regimes

NASA JSC Apollo Lunar Lab
Positive Pressure Glovebox
(+1.00 inH2O or +250 Pa)



Biological Safety Cabinet (BSC-III)
Negative Pressure Glovebox
(-1.00 inH2O or -250 Pa)

ESA Funded Double Walled Isolator Breadboard and Robotic Manipulation

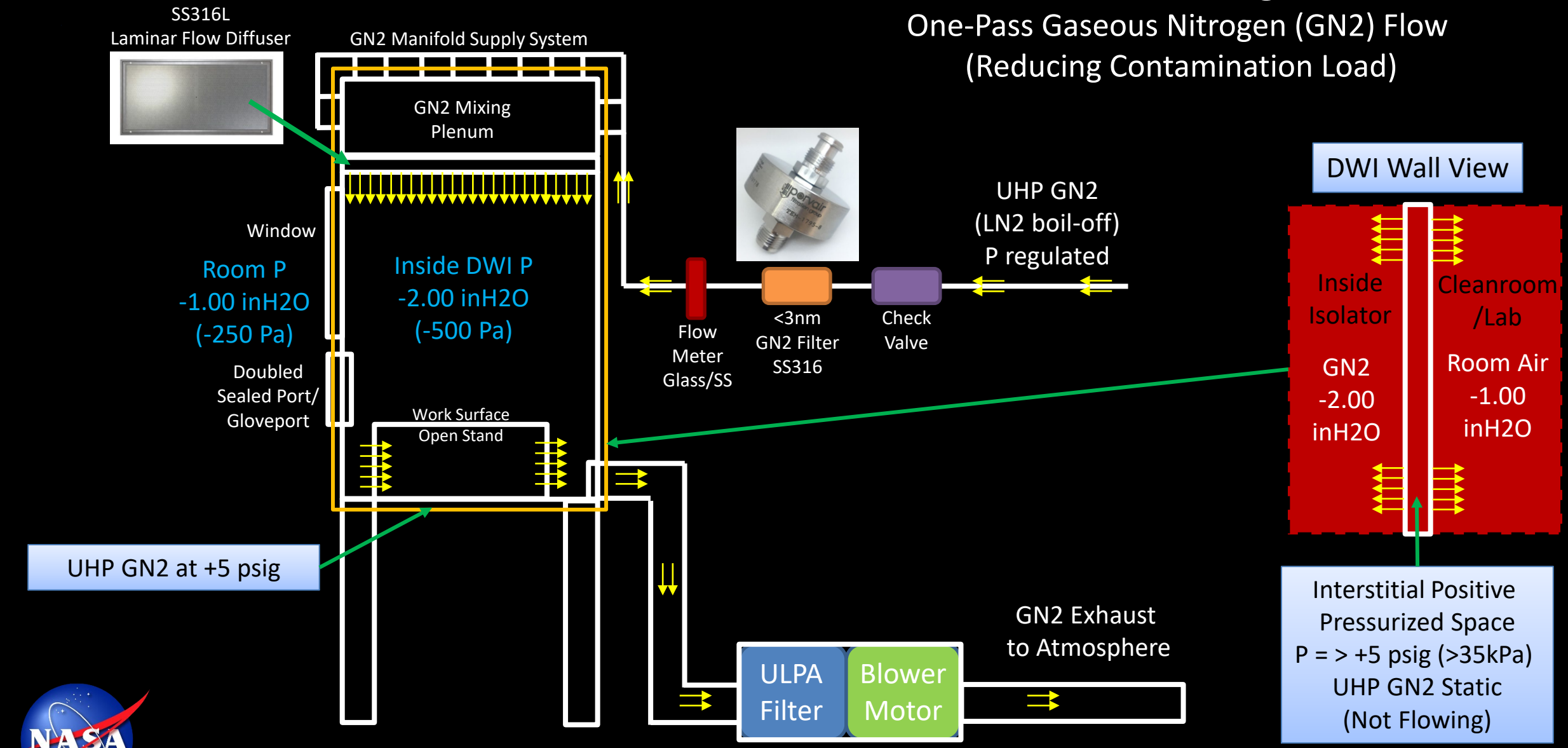


Double-Walled Isolator (DWI) Concept

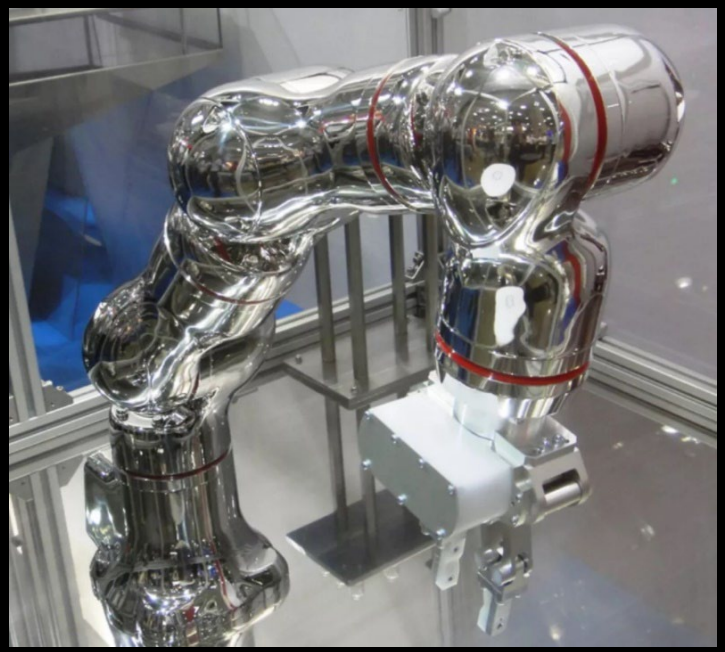
Combined Positive & Negative Pressure

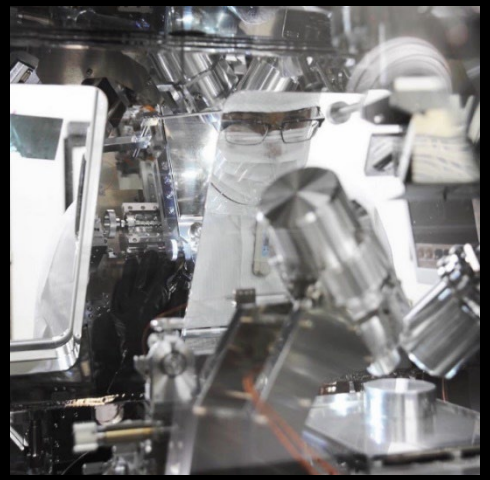
One-Pass Gaseous Nitrogen (GN2) Flow
(Reducing Contamination Load)

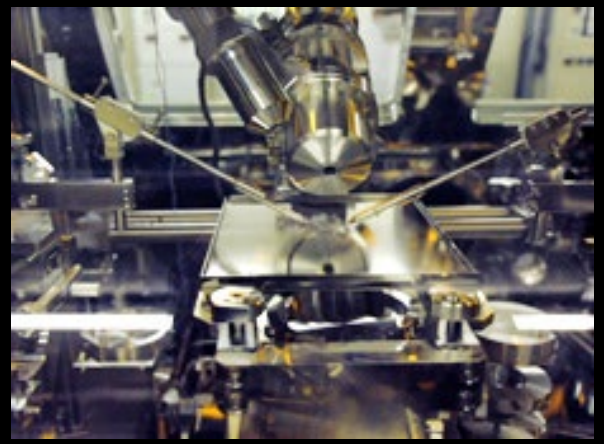
NOTIONAL

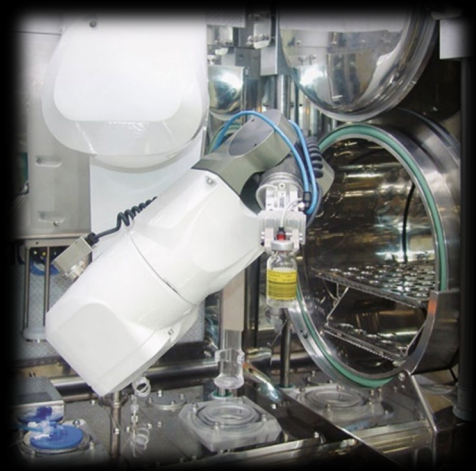


Human, Mechanical, and Robotic Sample Manipulation Inside Isolators

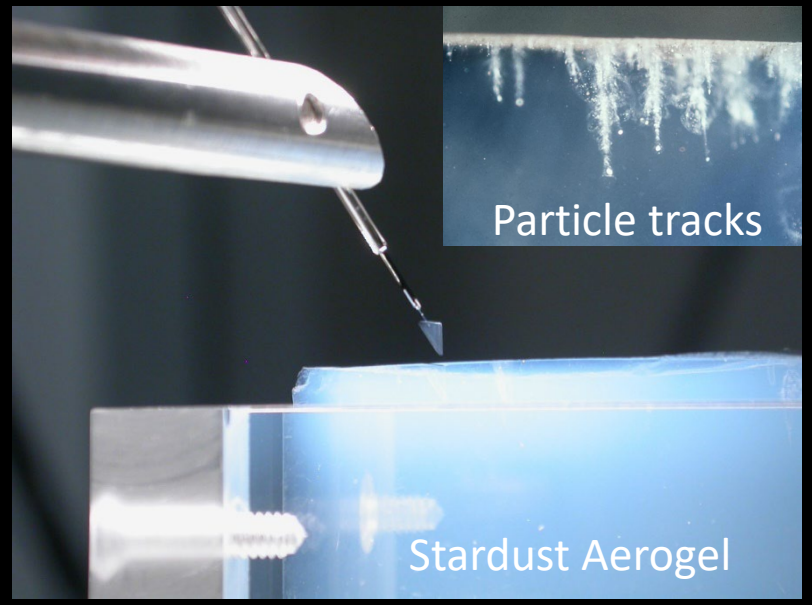


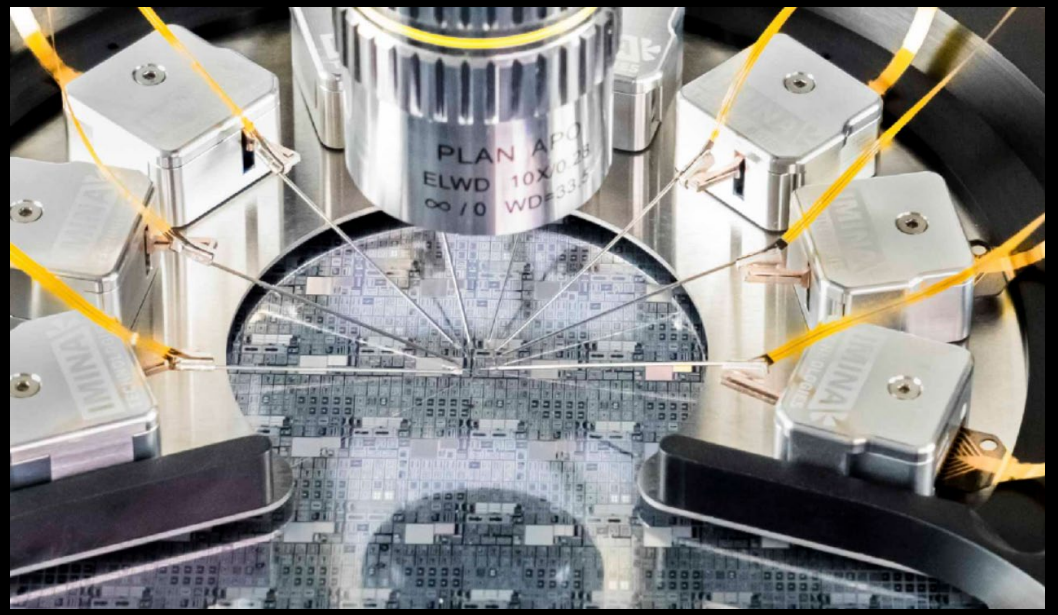


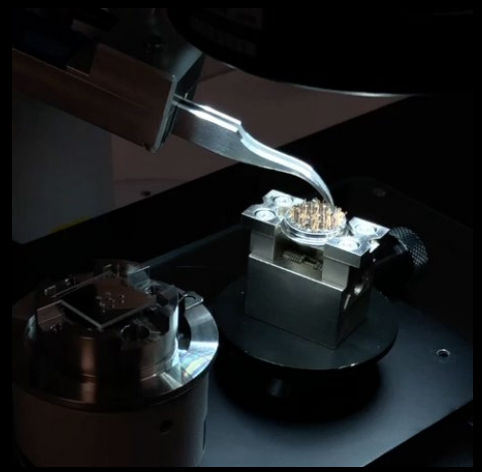


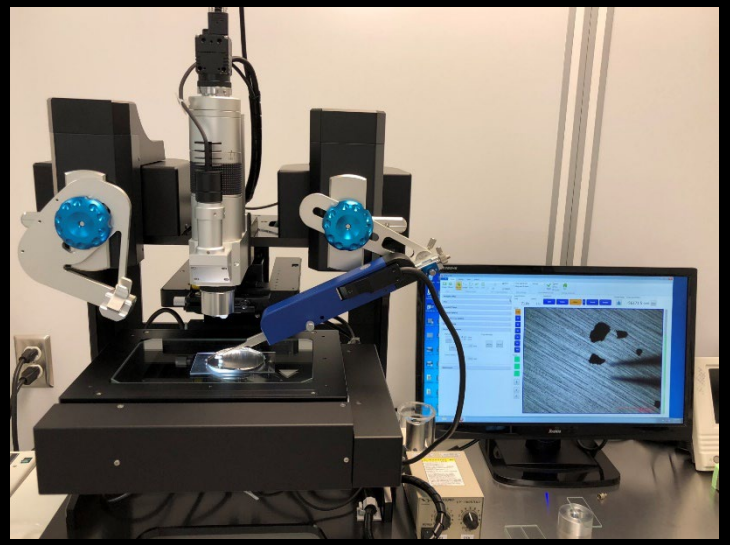


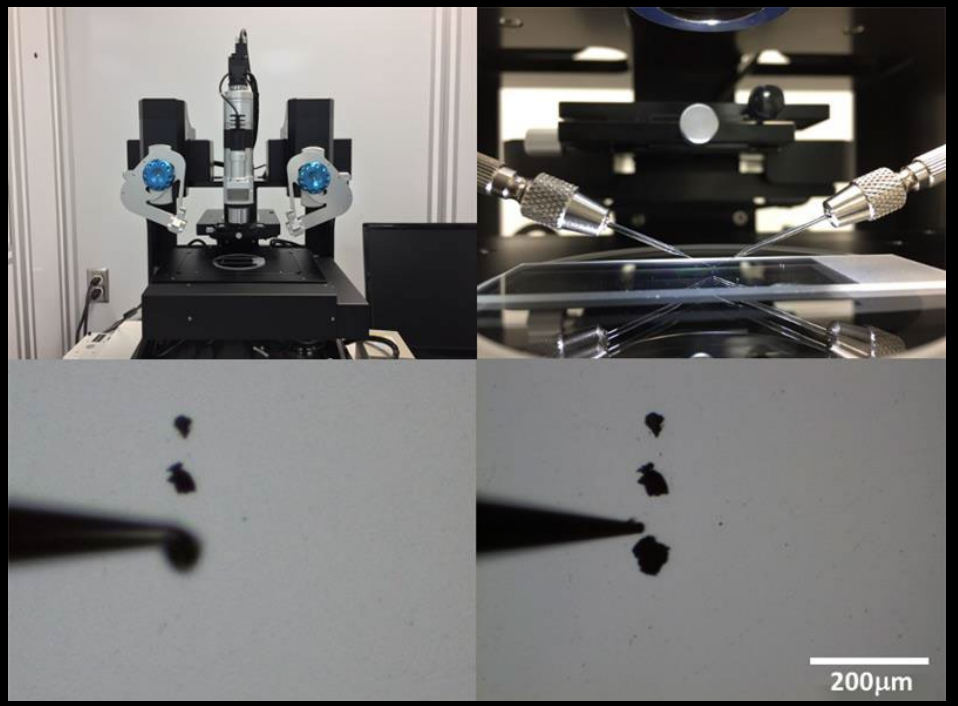
Robotic and Mechanical Micromanipulators







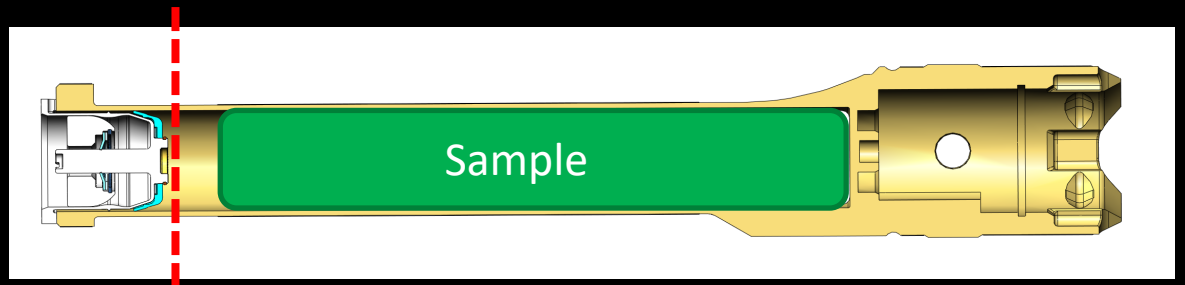


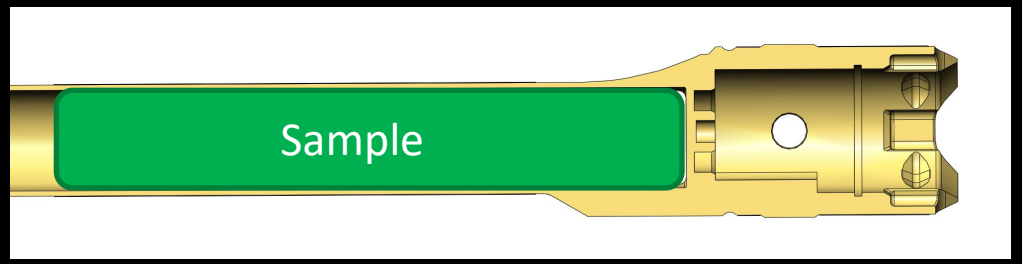


Sample Tube Opening Trades FY22

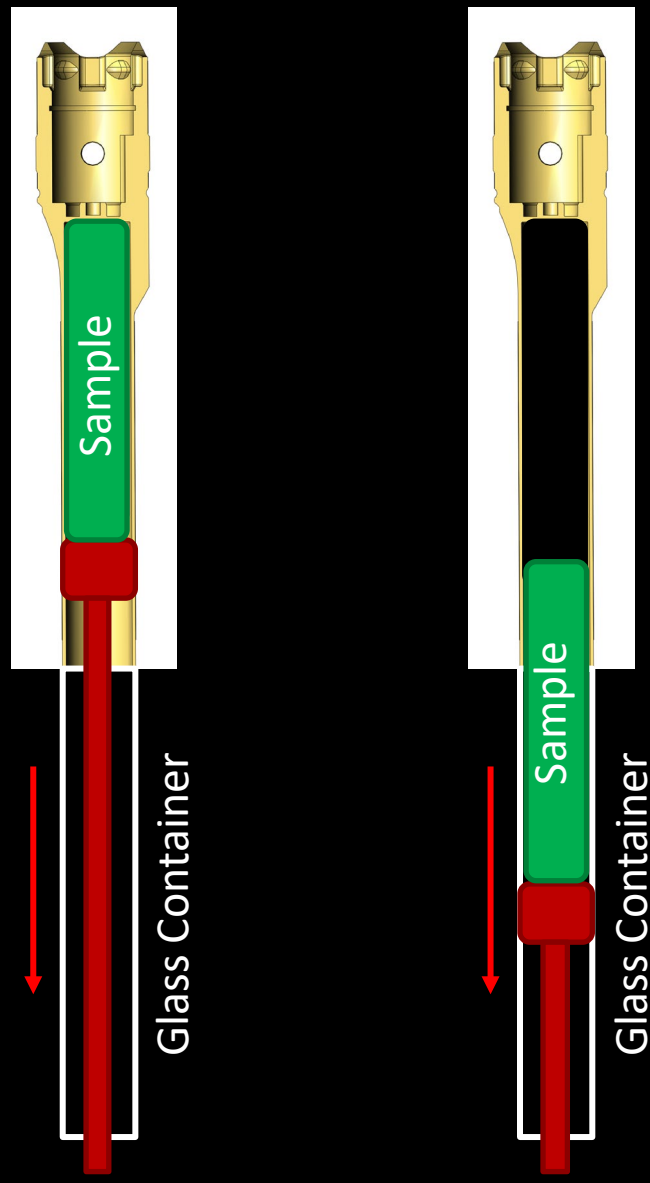
ALL NOTIONAL

Pipe Cut Sample Tube at Sealed End



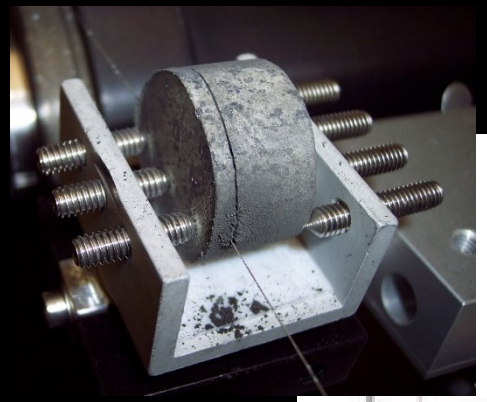


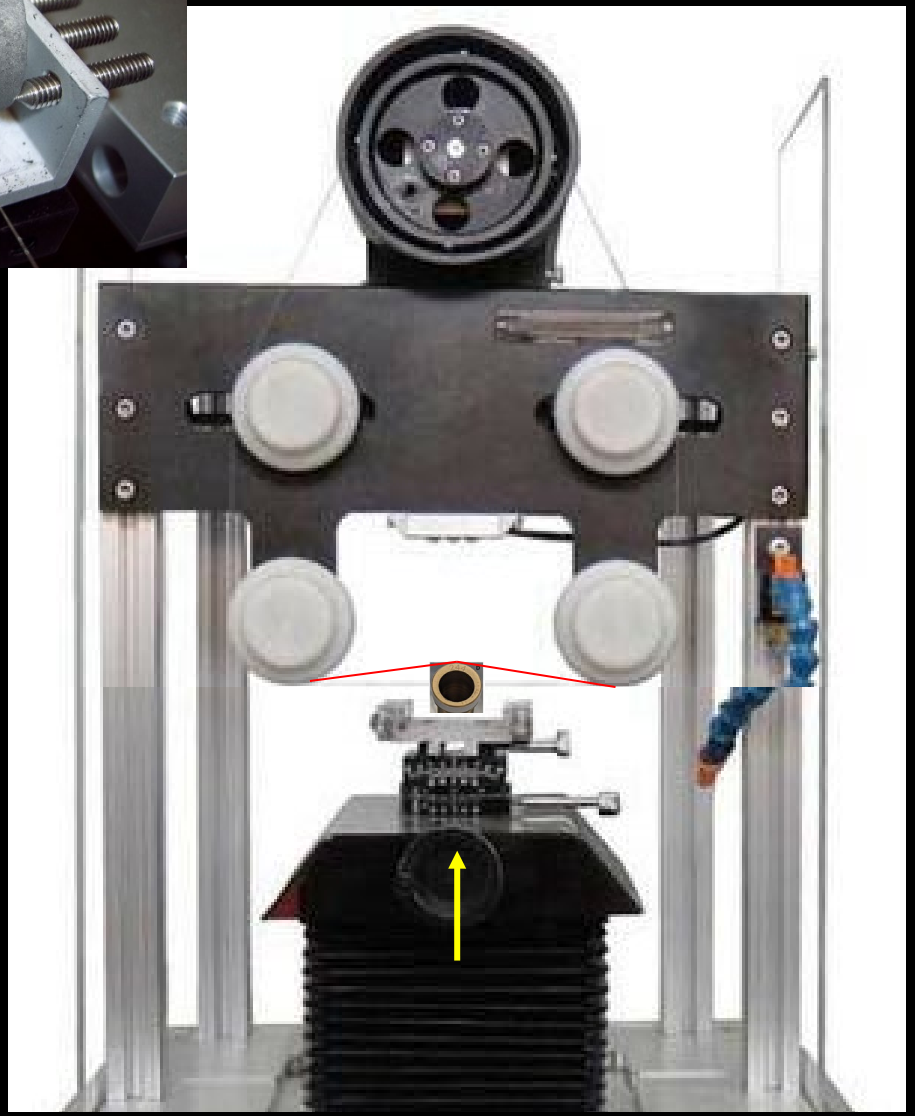
Use gravity and Control Sample being placed into new glass/SS clam shell container



Sample Tube Opening Trades FY22

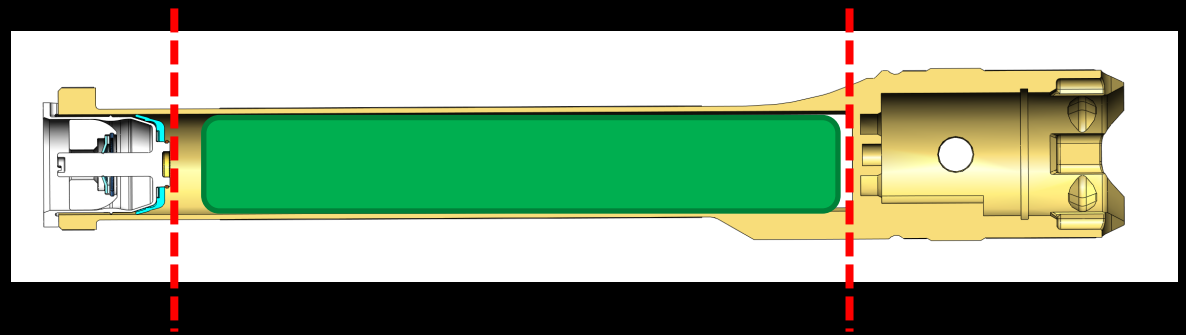
Precision Diamond Wire Saw Tube Cut
Dry Cut (Diamond Impregnated Wire)
Spool Length (like band saw) 60-120m

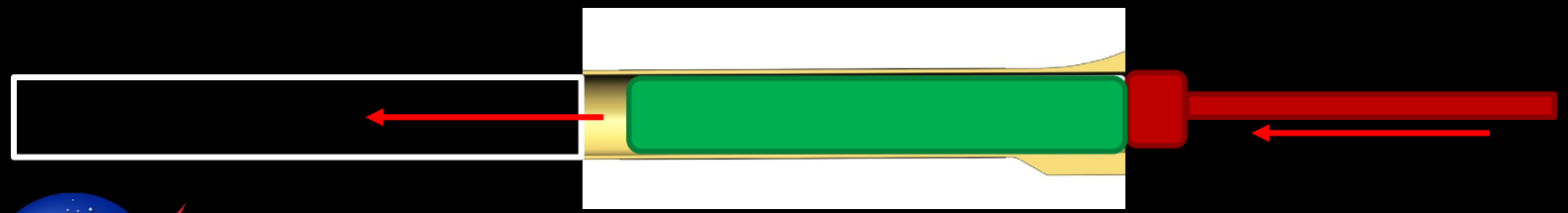




Wire Saw through both sides at once

ALL NOTIONAL

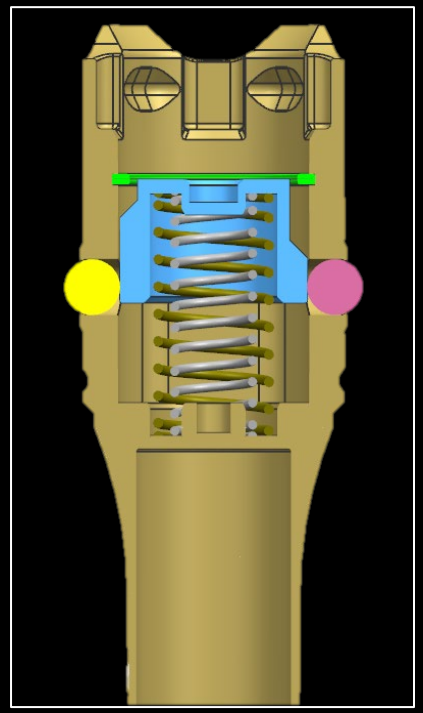


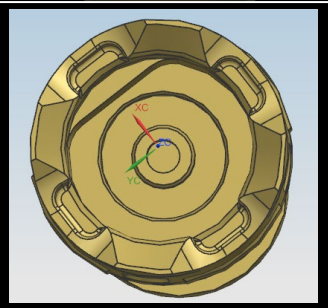


Push Sample into new glass/SS clam shell container

MSR Sample Tube Gas Extraction Trades – Crown Puncture

Remove Tube Gripping Hardware





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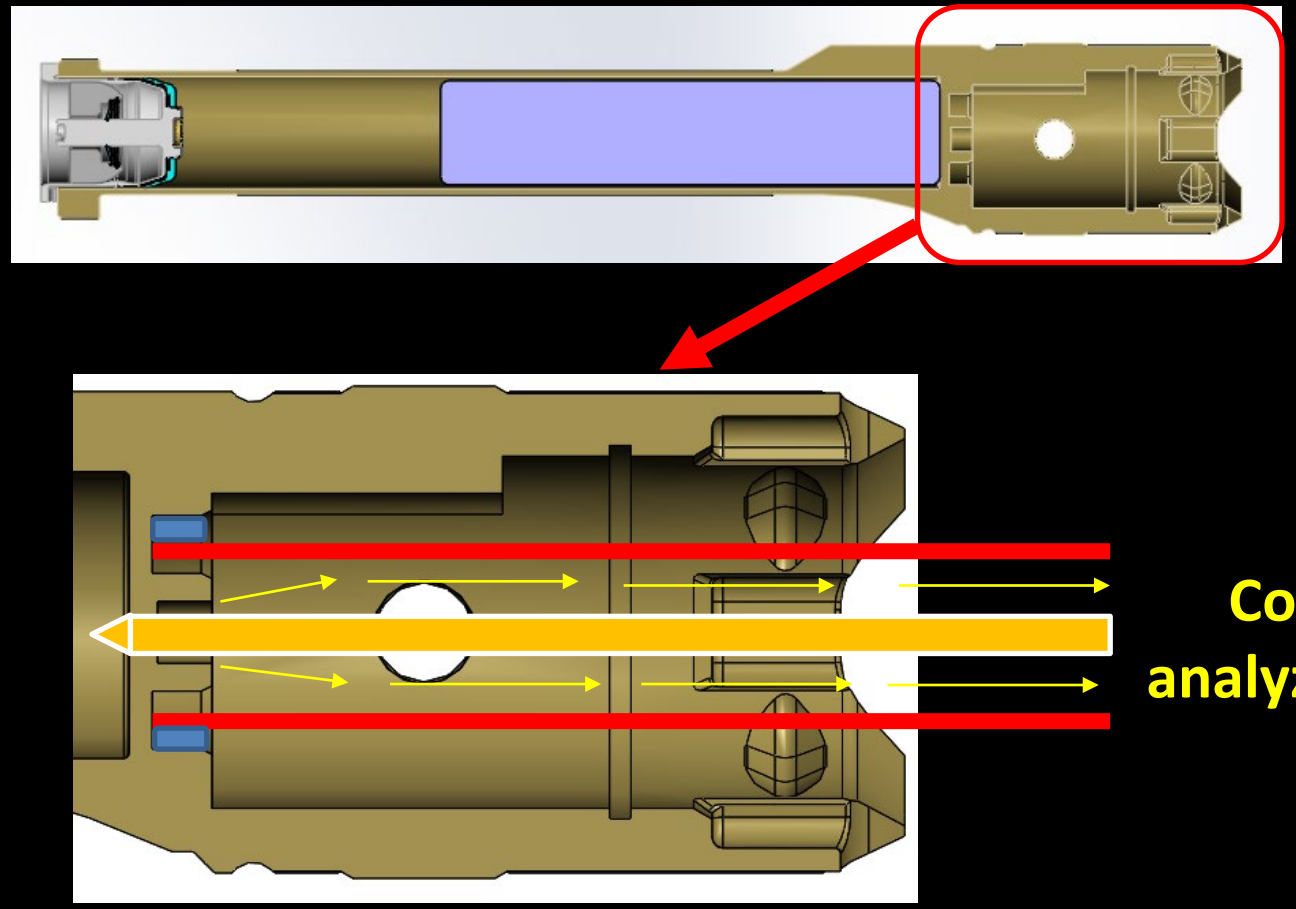

Collect and analyze Head-gas

Key Takeaways

- Finalizing Engineering Contamination Control and Planetary Protection Requirements for the MSR SRF is critical for commencing site specific design in FY2025
- Finishing R&D tasks in FY23 & FY24 is critical for commencing site specific design in FY2025
- DWI BMBL certified prototype and configurations with operational scenarios is a top priority
- Material selection is important for lowering cleanroom organic loads as evident from the recent construction of the Hayabusa2 and OSIRIS-REx Cleanroom Laboratories at NASA JSC
- Precision cleaning and sterilization of cleanrooms, DWI, and tools/equipment methods as well as sample sterilization R&D will be important for sizing facility
- Human, Mechanical, and Robotic Sample Manipulation are all in the trade space