Some Technology Challenges for a Facility Handling Samples from Mars

Presentation to:

European Curation of
Astromaterials Returned from
Exploration of Space

April 2016

MERRICK® & COMPANY

Problem Statement

A Systems Engineering and Operational Requirements Study for

A Mars Sample Receiving Facility

NASA/JPL 2003

NASA/CP—2002-211842

NASA

A DRAFT TEST PROTOCOL
FOR DETECTING POSSIBLE BIOHAZARDS IN
MARTIAN SAMPLES RETURNED TO EARTH

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October 2002

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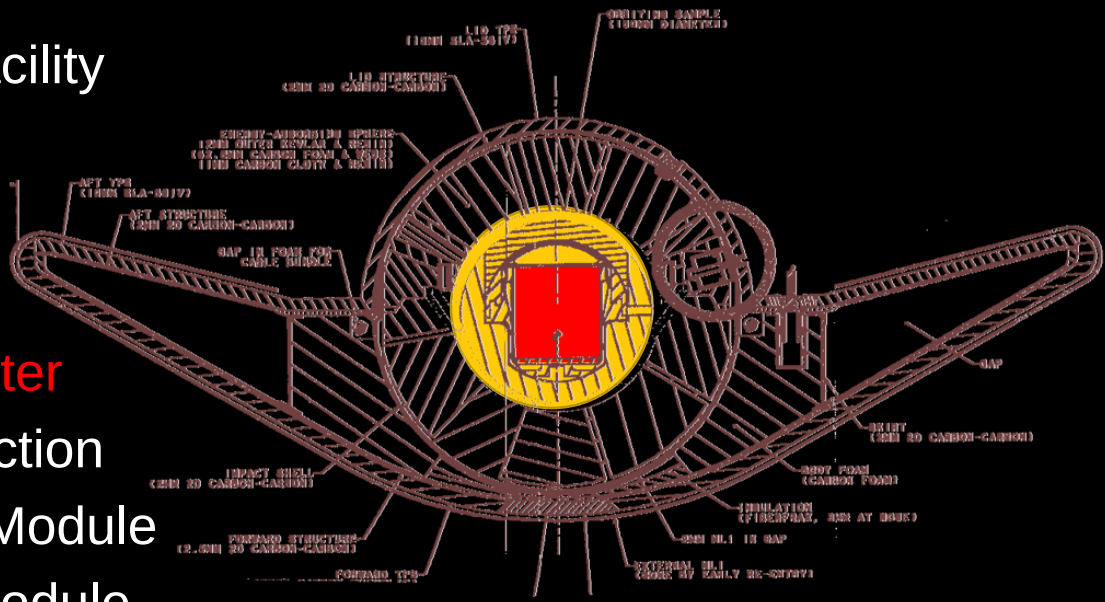
Acronyms

- SRF Sample Receiving Facility
- EEV Earth Entry Vehicle
- CV Containment Vessel
- OS Orbiting Sample
- SRC Sample Return Canister
- BH/LD Biohazard / Life Detection
- MCM Mobile Containment Module
- FCM Fixed Containment Module
- AL “Airlock”
- RTP Rapid Transfer Port



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Problem Statement

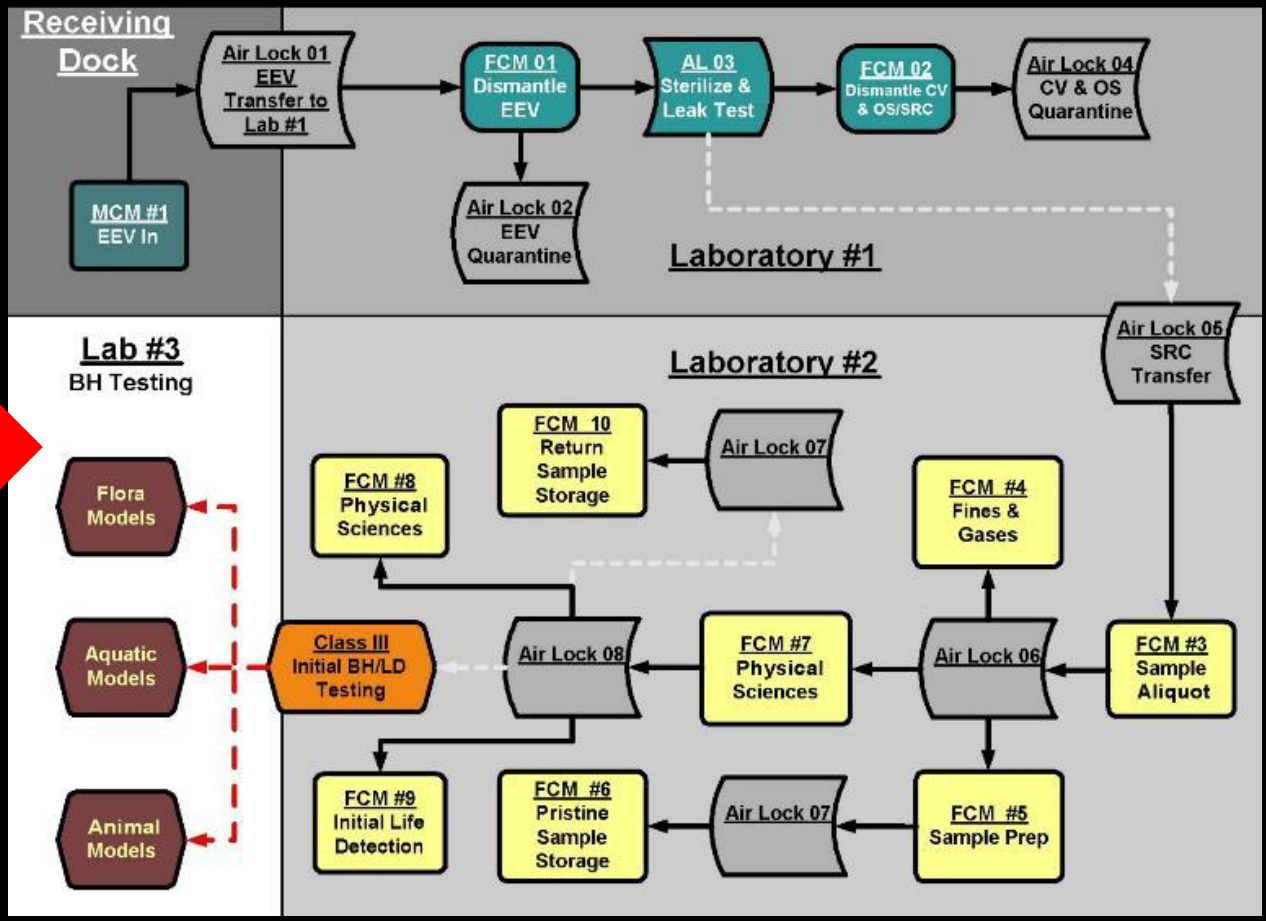
- A Draft Test Protocol
  For Detecting Possible Biohazards In Martian Samples Returned To Earth…."*Follow the Sample" / "Follow the Waste"*


NASA/CP—2002-211842

NASA

A DRAFT TEST PROTOCOL
FOR DETECTING POSSIBLE BIOHAZARDS IN
MARTIAN SAMPLES RETURNED TO EARTH

October 2002



Facility Concept – Planetary Protection Levels

PPL-type	Biocontainment	Cleanliness	'Ambient' Conditions	Used For:
PPL-α	Maximum (BSL-4)	Maximum	Mars-like (pristine); *Although at 1 atm w/inert gas environment.*	Incoming container and materials; some preliminary tests; sample bank/storage; some Life Detection
PPL-β	Maximum (BSL-4)	Maximum	Earth-like	Life Detection; some Physical/Chemical; TBD
PPL-γ	Maximum (BSL-4)	Moderate	Earth-like	Some Biohazard testing, some Physical/Chemical processing, and animal testing
PPL-δ	Strict BSL-3-Ag	Ambient	Earth-like	Some Biohazard testing; 'post-release' tests TBD

Table 1. Anticipated laboratory conditions and PPL categories. Note: Levels of cleanliness associated with each PPL are TBD and should be defined explicitly well in advance of sample return

Facility Concept

	Lab 1	Lab 2	Lab 3
Function	Receive EEV, Remove CV from EEV, Remove SRC from CV – conduct testing of all the devices to scientifically prove containment and preservation of sample integrity	Receive SRC. Sample Aliquot, Initial P/C Processing. Initial life detection and biohazard testing. Possible preservation and storage based on BH.	Receive apportioned samples. Additional BH and LD testing capabilities. Culturing/ amplifying samples.
Containment Level	CDC/NIH BMBL BSL3	CDC/NIH BMBL BSL4 Cabinet Lab	CDC/NIH BMBL BSL4 Suit Lab
Containment Enhancements	HEPA filtration, effluent retention and decontamination , pass-through autoclave. Carbon filter exhaust.	Pressure decay testing of secondary barrier systems. Carbon filter exhaust.	Pressure decay testing of secondary barrier systems. Carbon filter exhaust.
Contamination Control / Cleanliness	Room cleanliness of ISO 8 class 100K.	Room cleanliness of ISO 7 class 10K. Containment Modules will be attaining a ISO 4 Class 10 particulate cleanliness throughout.	Room cleanliness of ISO 8 class 100K. While room is occupied the cleanliness will be better than 100K due to good microbiological practices, use of BSCs, HEPA filtered supply air and wearing BSL4 suits.
Primary Containment	Class III biological safety cabinet for all processing and quarantine of containers. ISO 4 Class 10 particulate cleanliness as process approaches CV. Cabinets are "free of terrestrial organic material.	Double-walled, research grade nitrogen filled containment modules. Class III biological safety cabinet for some BH/ LD testing using bio/flora models.	Class III biological safety cabinet for some BH/ LD testing using bio/flora models (pass thru to Lab 2) Class II cabinets.

Concepts of (HIGH) Biocontainment

Containment Barriers

- Primary - BSC's, personnel protective gear, containment equipment
- Secondary - Room, systems
- Tertiary – Processes and Containment around systems

Access Control and Separation

Redundancy and Reliability

Barrier Minimization

Decontamination Systems/ Methodology

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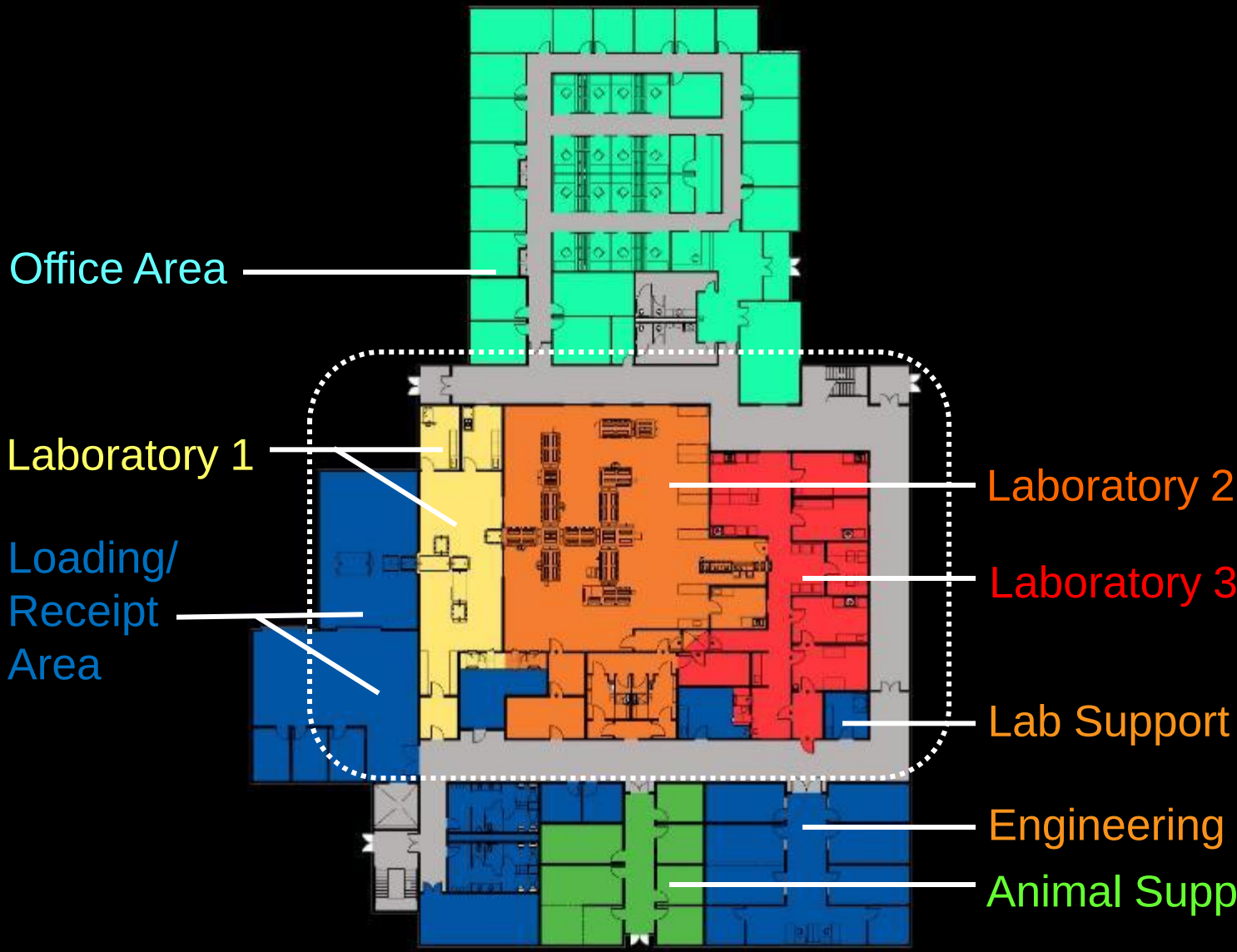
Facility Concept



A Mars Sample Receiving Facility

Merrick/Flad/AEI/Southwest Biocontainment

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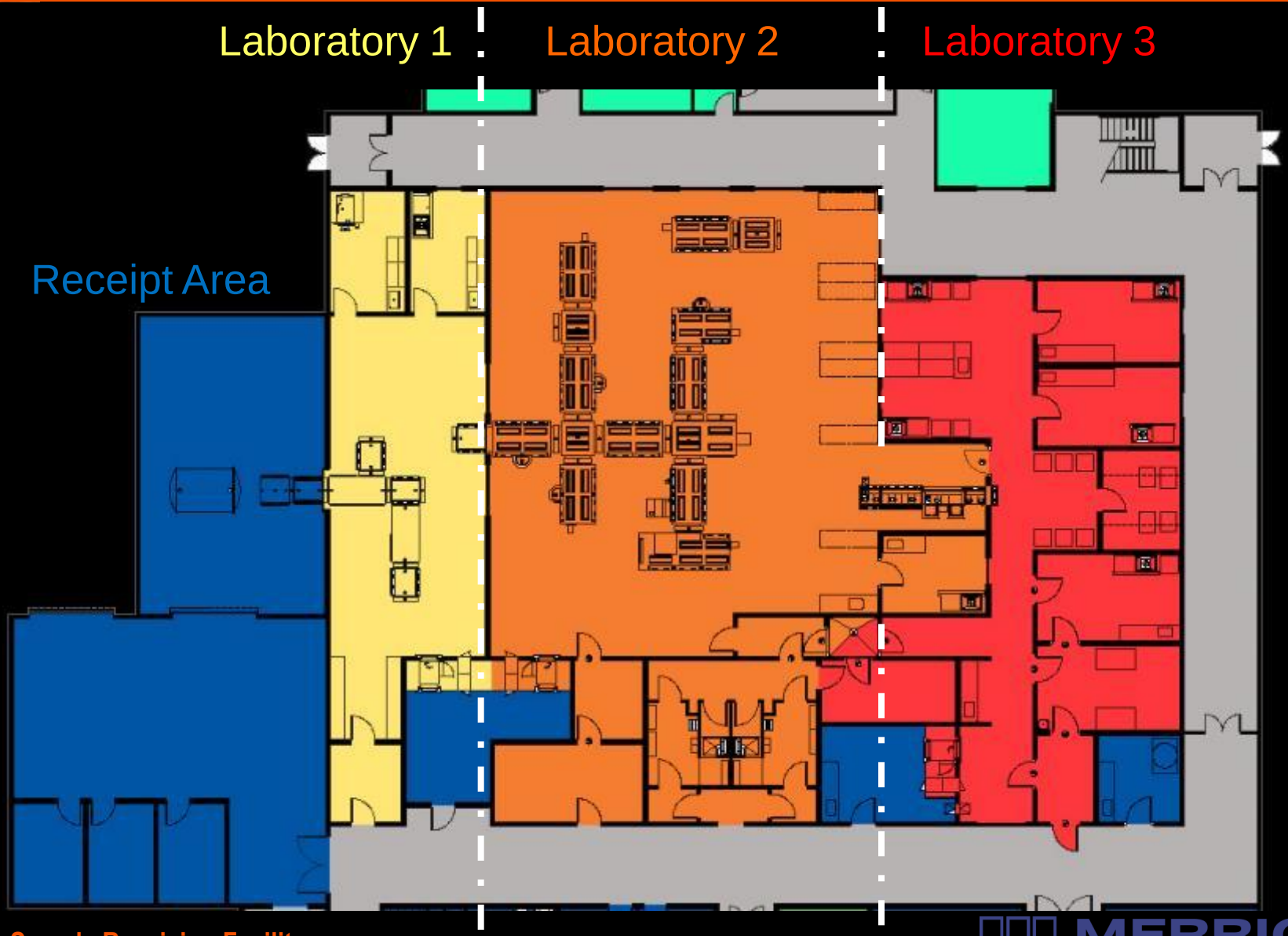
Facility Concept



A Mars Sample Receiving Facility

Merrick/Flad/AEI/Southwest Biocontainment

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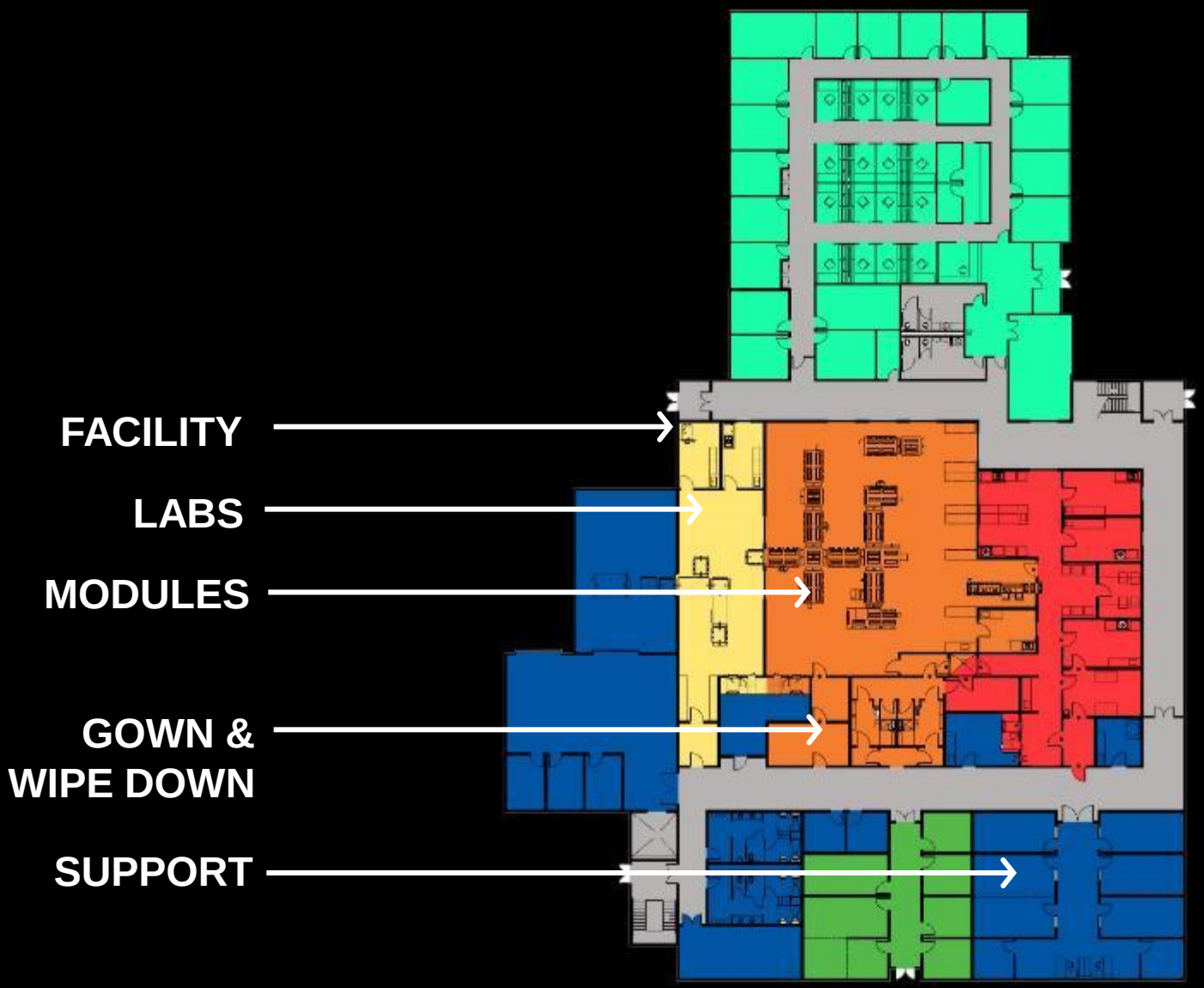
Contamination Control



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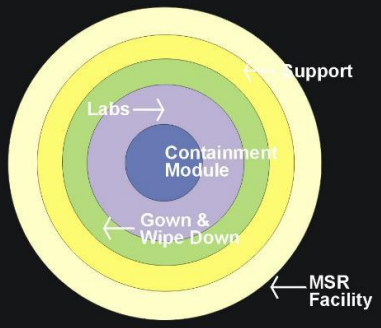
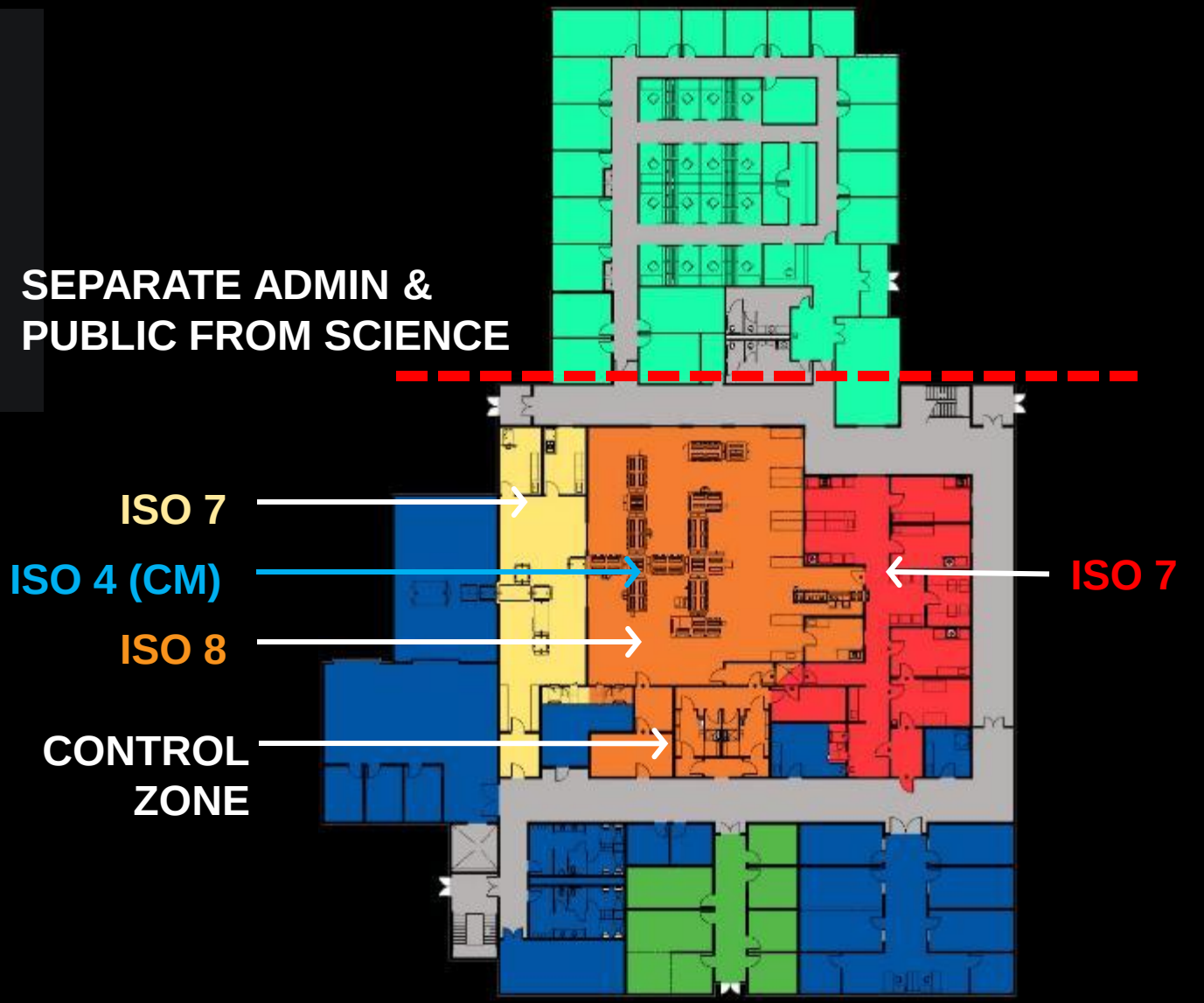
Contamination Control



ISLANDS OF CLEANLINESS
ISO 14644 Concept of Segregation

SEPARATE ADMIN & PUBLIC FROM SCIENCE



A Mars Sample Receiving Facility
Merrick/Flad/AEI/Southwest Biocontainment

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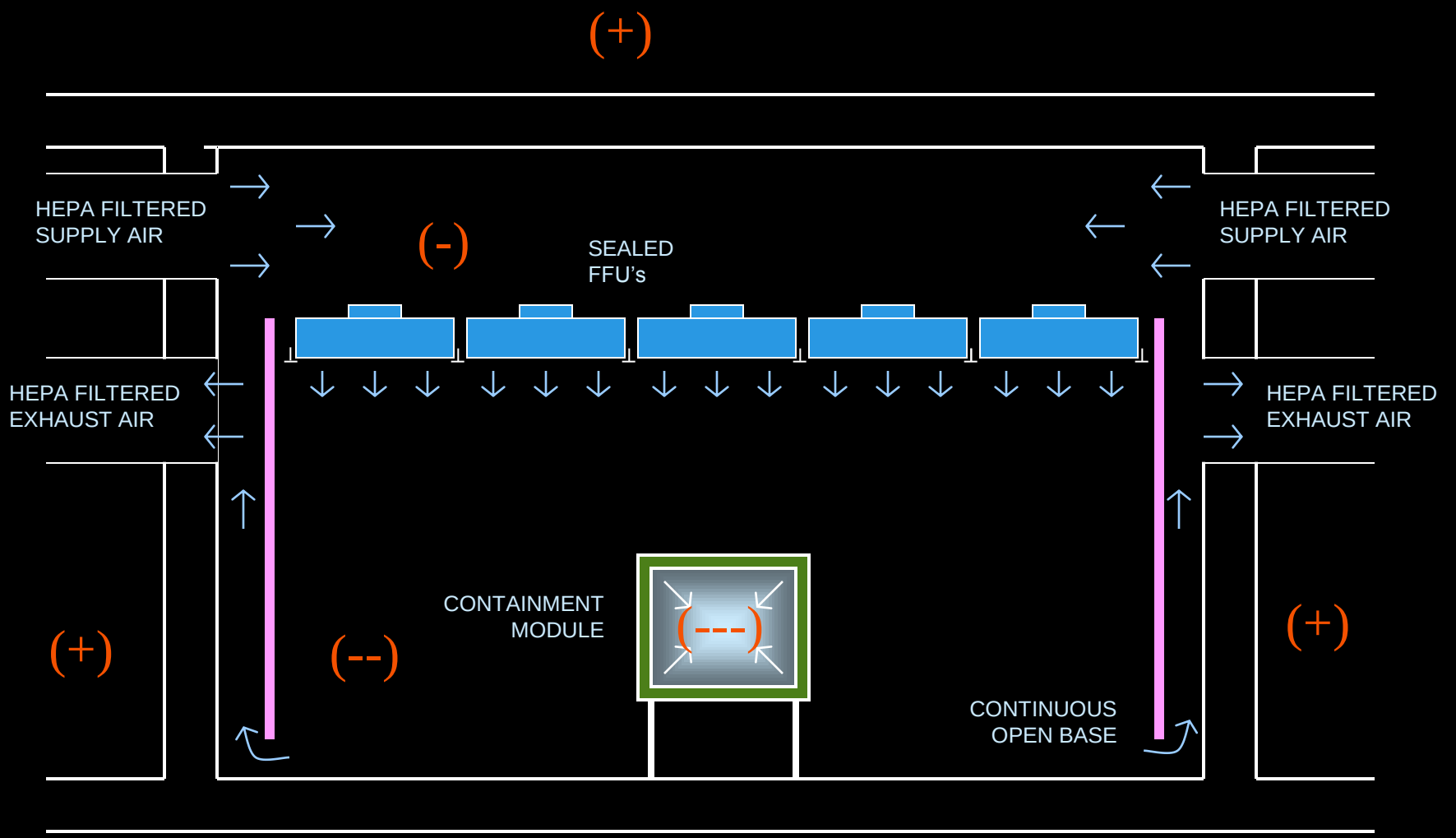
Contamination Control



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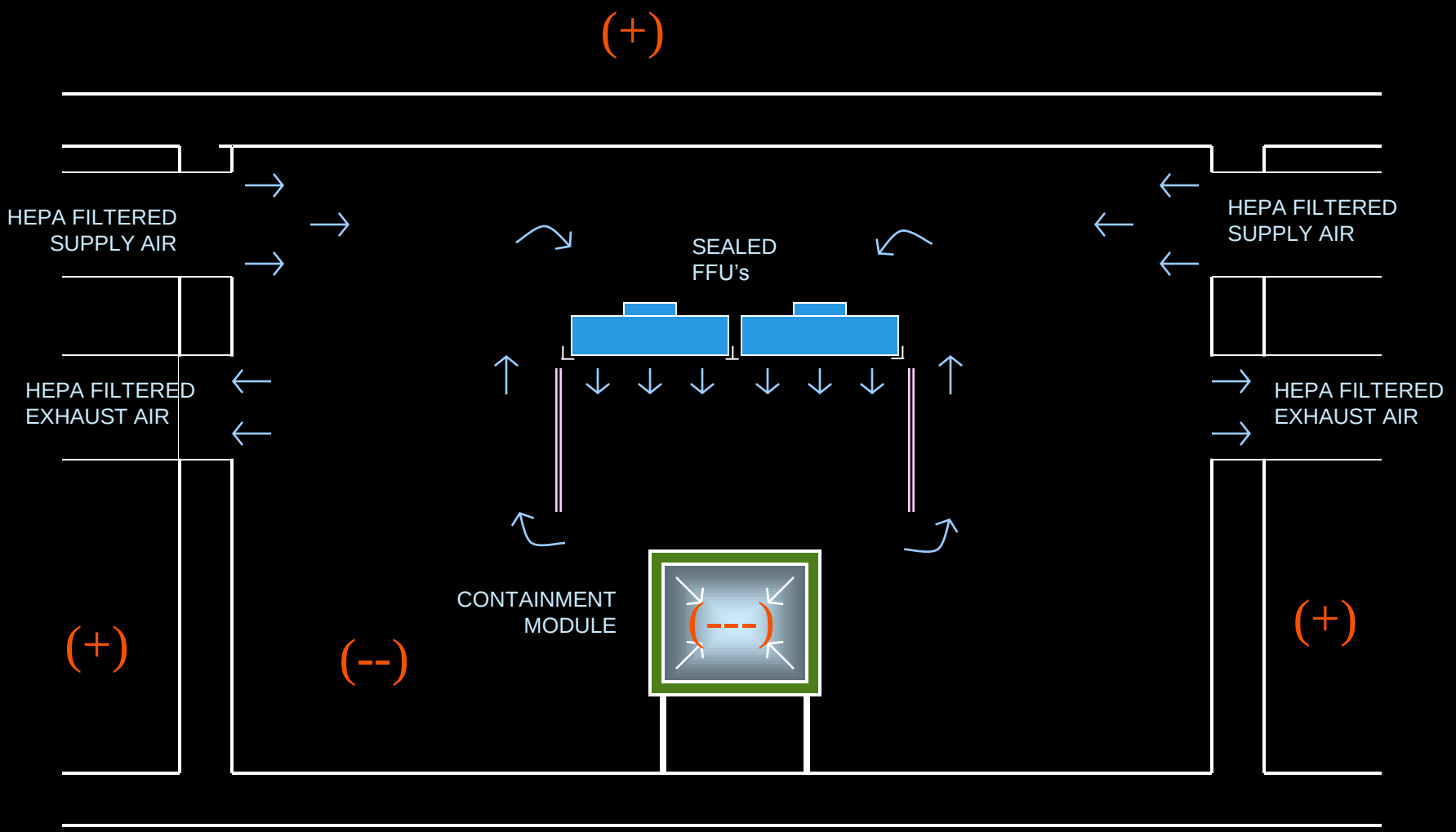
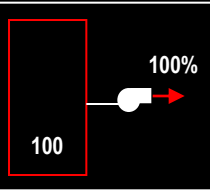
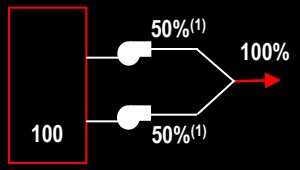
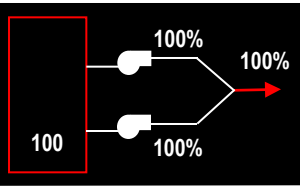
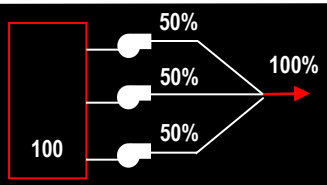
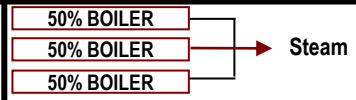
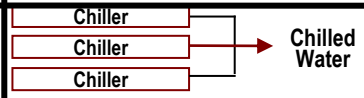
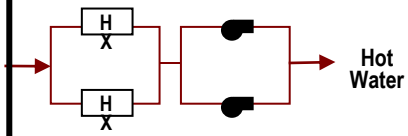
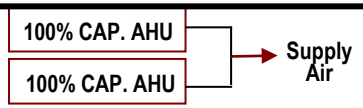
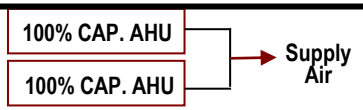
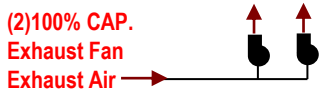
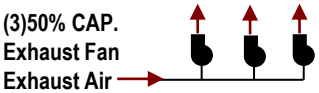
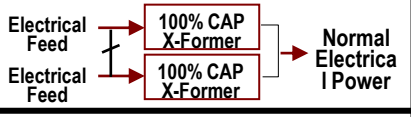
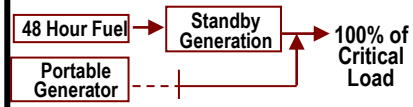
Contamination Control



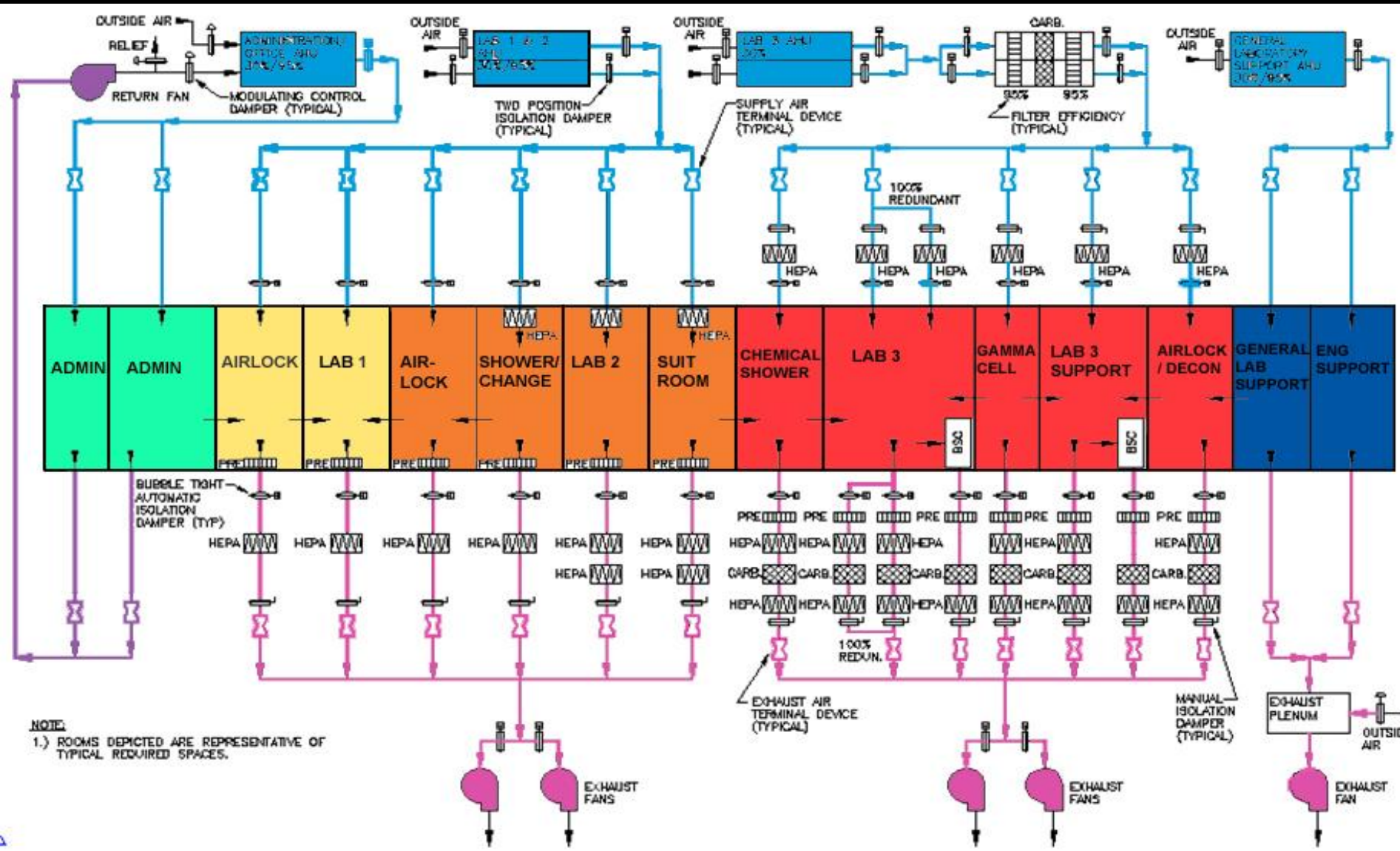
Redundancy

Usage	Configuration	Description	Nomenclature
Office Buildings		One piece of equipment serves load.	No Redundancy
Typical Research Building	 (1) Option for 60%, 70%, etc.	n pieces of equipment serves load.	n
Critical Environments		Equipment capable of serving 200% of load.	2n
Critical Environments		n pieces of equipment plus 1 standby piece of equipment.	n+1

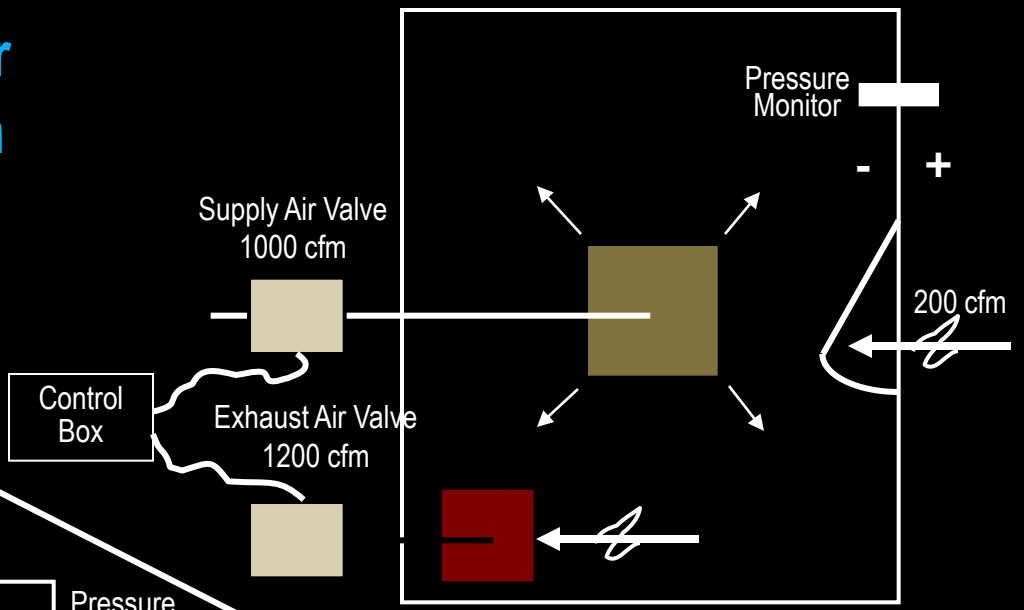
Engineering Systems

Steam	Configuration	Description	Redundancy
Steam		3 boilers each sized at 50% of building load.	N+1
Chilled Water		3 chillers each sized for 50% of building load.	N+1
Heating Hot Water Heat Exchangers/Pumps		2 heat exchangers and 2 pumps sized at 100%.	2n
Lab Supply Air		2 complete air handling units sized at 100%. (1 standby unit.)	2n
Vivarium Supply Air		2 complete air handling units sized at 100%. (1 standby unit.)	2n
Lab Exhaust		2 exhaust fans sized at 100%. (each running at 60%)	2n
Vivarium Exhaust		3 exhaust fans sized at 50%. (1 standby unit.)	n+1
Normal Power		Double ended switchgear with 2 feeds from utility (2 transformers). Backup of critical loads by standby generator.	2n
Standby Power		Single diesel generator set with 48 hour fuel supply and connection for a portable generator.	n+1

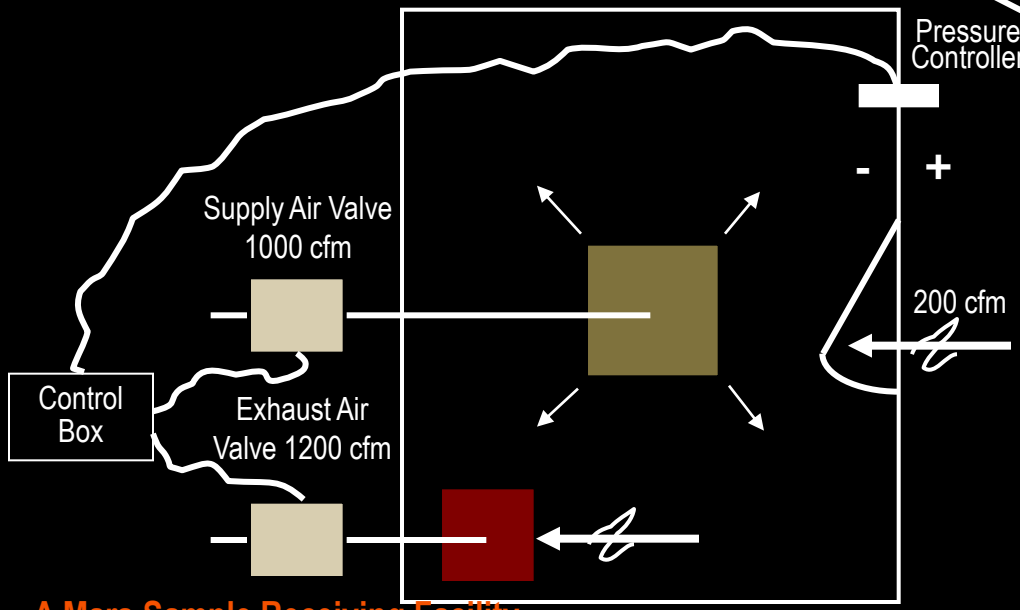
Engineering Systems



Air Flow Control Via Air Flow Tracking With Monitoring

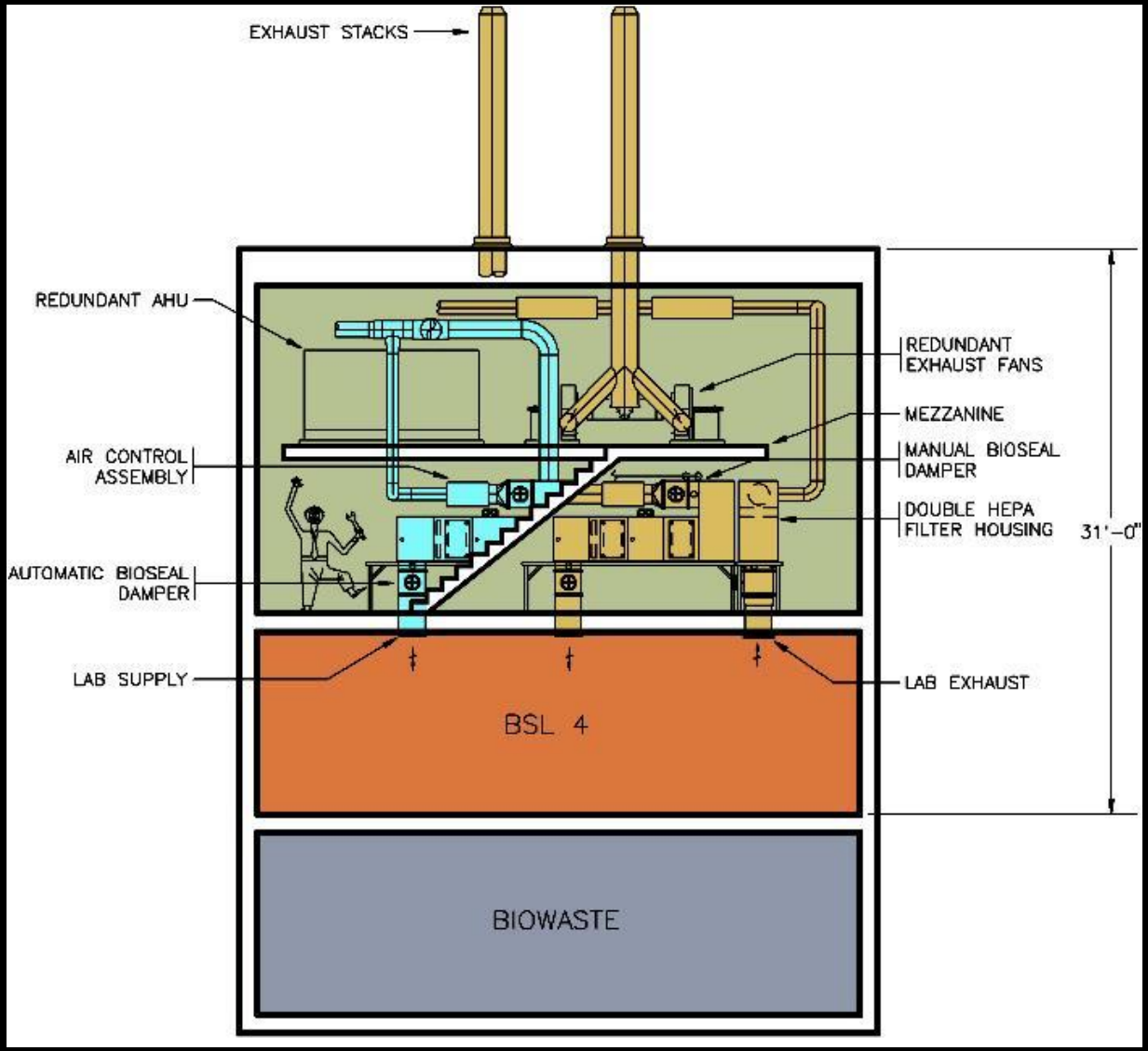


Air Flow Control via Active Pressure Control



Engineering Systems

- Area Net-to-Gross ratios are 3:1 to 4:1
- Air handling and extract systems
- Filtration systems
- Waste Decontamination systems
- High Purity Gas systems
- Breathing Air systems
- Back-up power systems
- Suit Decon systems



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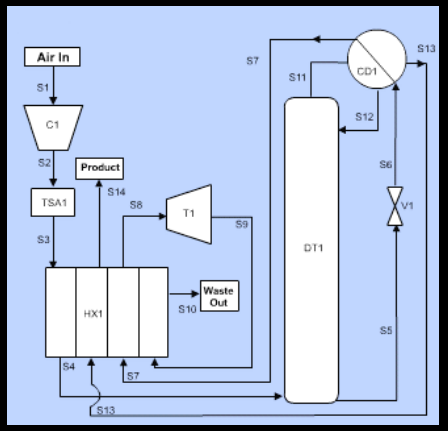
High Purity Inert Gas Production and Delivery

- Ultra High Purity – Grade 8 (99.999999% Pure) Nitrogen achievable with cryogenic distillation
- Available in on-site plants as small as 10,000 SCFH or 167 SCFM
- Plant consists of filters, compressors, molecular sieves, heat exchangers, distillation columns, cryogenic pumps, vacuum jacketed piping and vaporizers.
- High purity GN2 distribution system consists of 316L seamless tubing, valves and fittings with mechanical or Teflon seals.
- Tubing, fittings and valves will be electropolished or passivated to meet ultra-high purity standards.



BSL4 Positive Pressure Suits

BSL4 Positive Pressure Suits


DATA SHEET

DELTA PROTECTION | BSL 4-2 | REF : 848 021 T

DESCRIPTION

USES

SUPPLEMENTARY INFORMATIONS

This pressure suit can be used in any type of laboratory where there is a high risk of biological or particulate contamination, accordingly the suit offers:

- An excellent protection factor (> 100 000).
- Easy to put on and take off.
- Comfort (good ventilation, low noise < 70 dB, wide sleeves).
- Wide field of view.
- Very good mechanical strength (abrasion, piercing, tearing…).
- Light weight (overall weight: 3.6kg).

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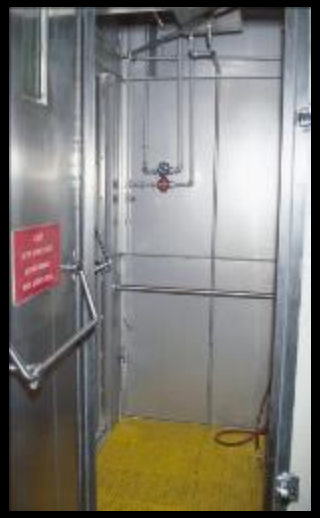
BSL4 Suit Breathing Air Systems

- The suits have in-coming HEPA filtered air and allow the air to leave the suits into the room without backflow.
- The suits have air supplied by multiple breathing air compressors that add humidification
- Emergency backup breathing air cylinders for additional safety.

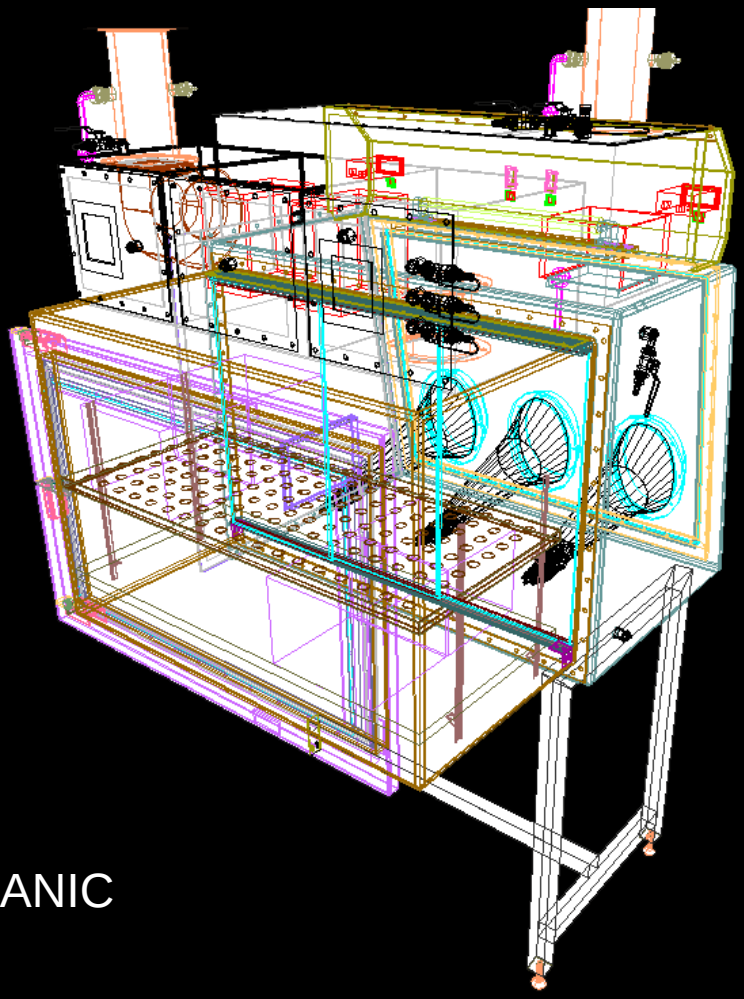
BSL4 Suit Chemical Shower

- The chemical shower has multiple spray nozzles that atomizes a spray inside the tight double door room to ensure the suits are fully disinfected upon egress
- Advancements in nozzle design and placement.
- The chemical shower combines both chemical and water rinses
- Chemicals used include Paracetic Acid, Quaternary Ammonia – Lysol , Microchem.



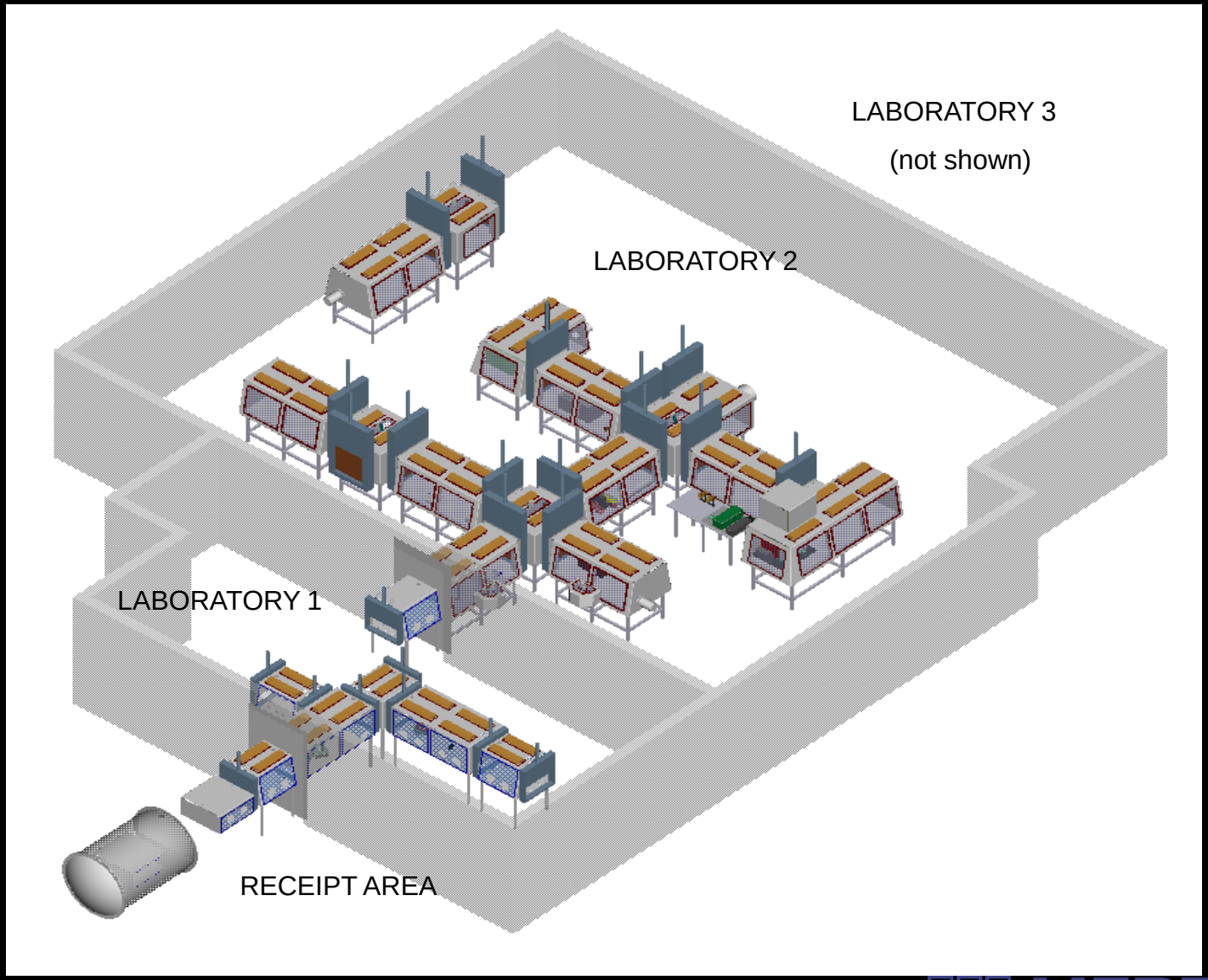
Containment Modules

Costs - PPL-α
Containment Modules
Approximately
US$47,400 per linear foot

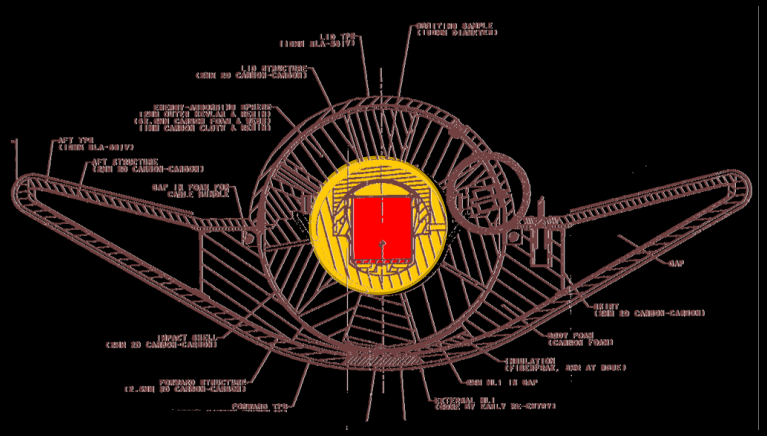


- Double wall construction
- N2 Gas environment
- FREE OF TERRESTRIAL ORGANIC MATERIAL

Receipt Area, Laboratories 1 and 2

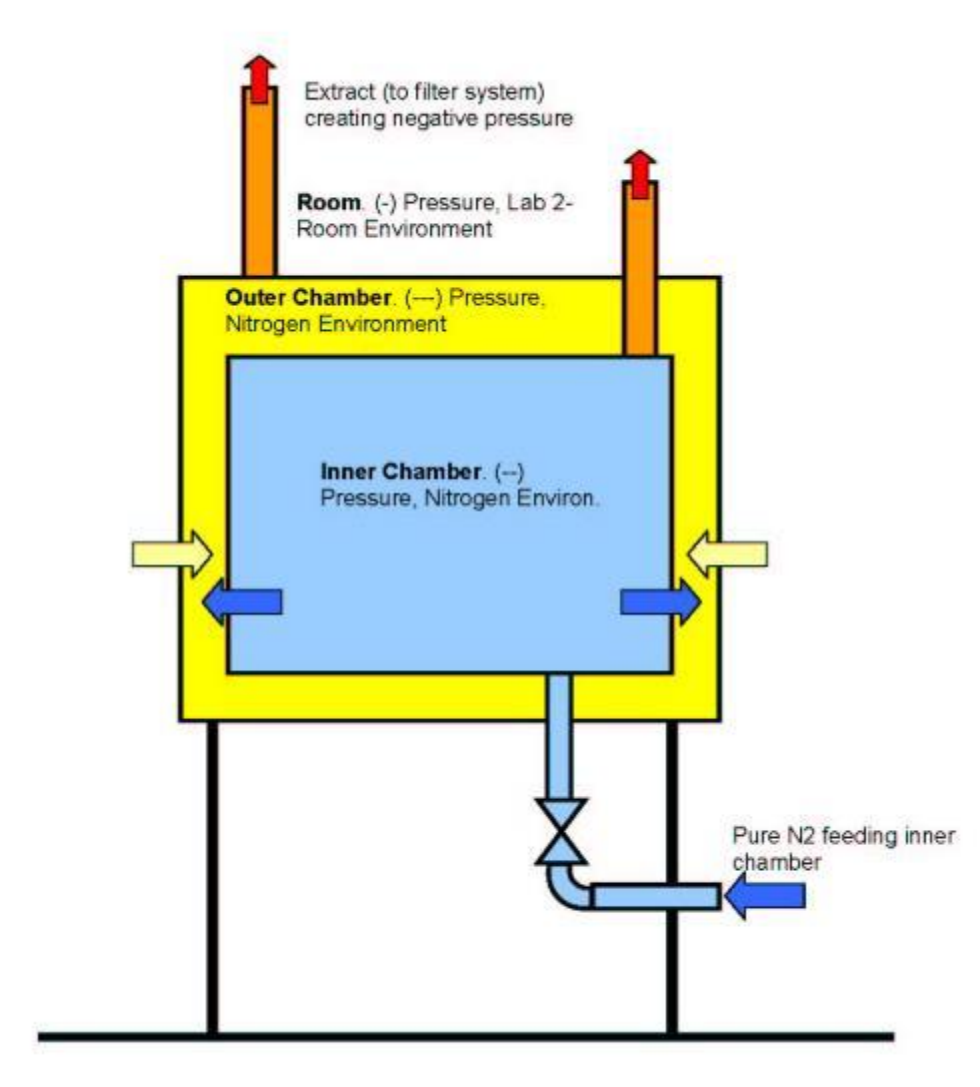


Overview – Containment Modules



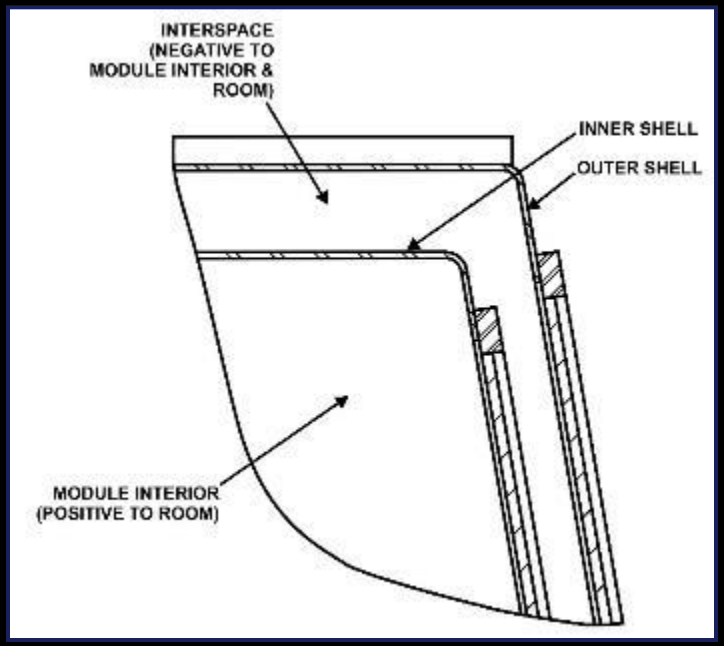
- Receipt Area
  - Single Shell SS
  - Air Environment, Negative to Surroundings
- Laboratory 1 – EEV/CV Disassembly
  - Single Shell SS
  - Air Environment, Negative to Room
  - Manual Operations through specialty gloves
  - Material transfers: RTPs and Airlocks
- Laboratory 2 – SRC Opening, P/C, Initial BH/LD Testing
  - Specialty Double Shell SS w/ Negative Pressure Shell
  - Nitrogen Environment, Negative to Room
  - Concepts developed: Module, Ventilation Control, Double-Glove Gloveport
  - Robotic Operations with Gloves used in maintenance/off-normal activities
  - One Single Shell SS, Air Environment, Negative to Room
  - Material transfers: RTPs and Airlocks
- Laboratory 3 – Extended BH Testing
  - Single Shell SS
  - Air Environment, Negative to Room

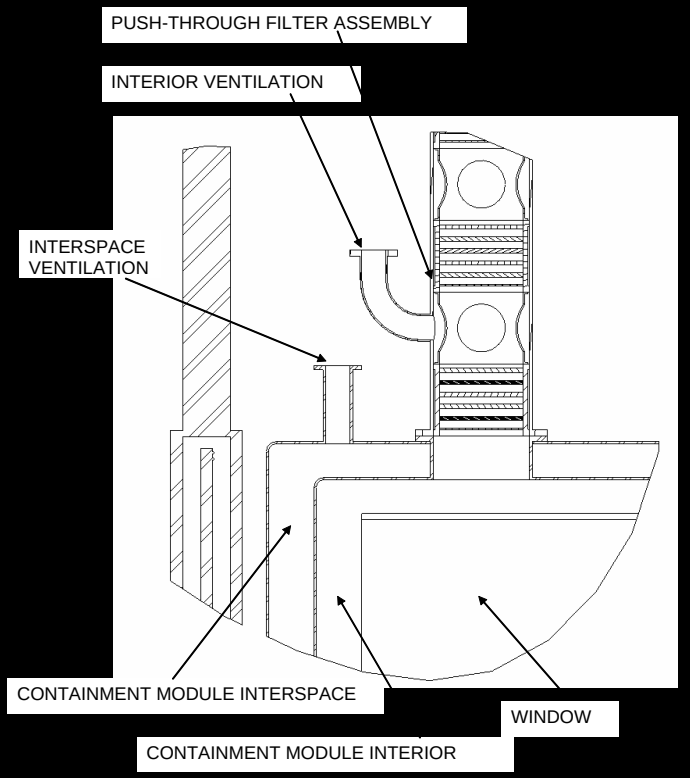
Double Containment Module Ventilation



Double Shell Containment Module

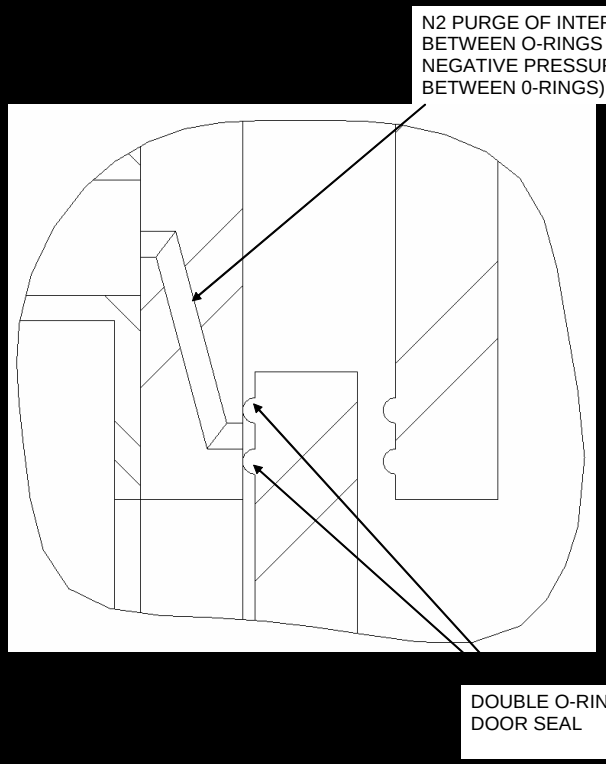
- Double Shell Module Construction
  - Double shell in areas of potential leak paths or permeation
  - ‘Negative’ Pressure outer shell



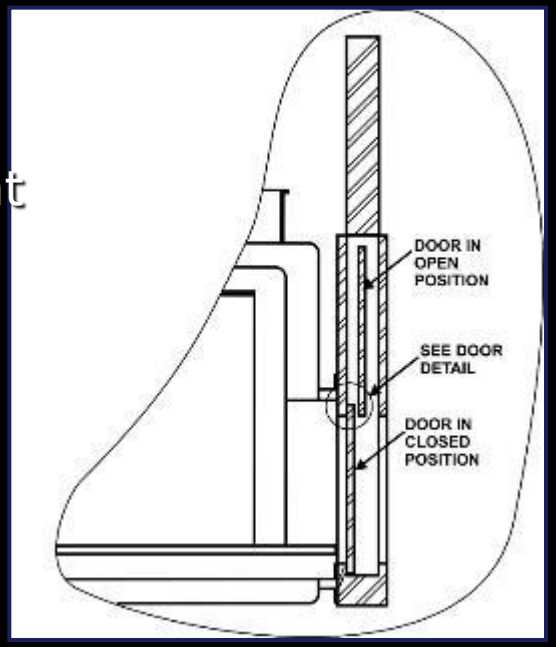


- Standard construction techniques
- Some special materials

Double Shell Containment Module



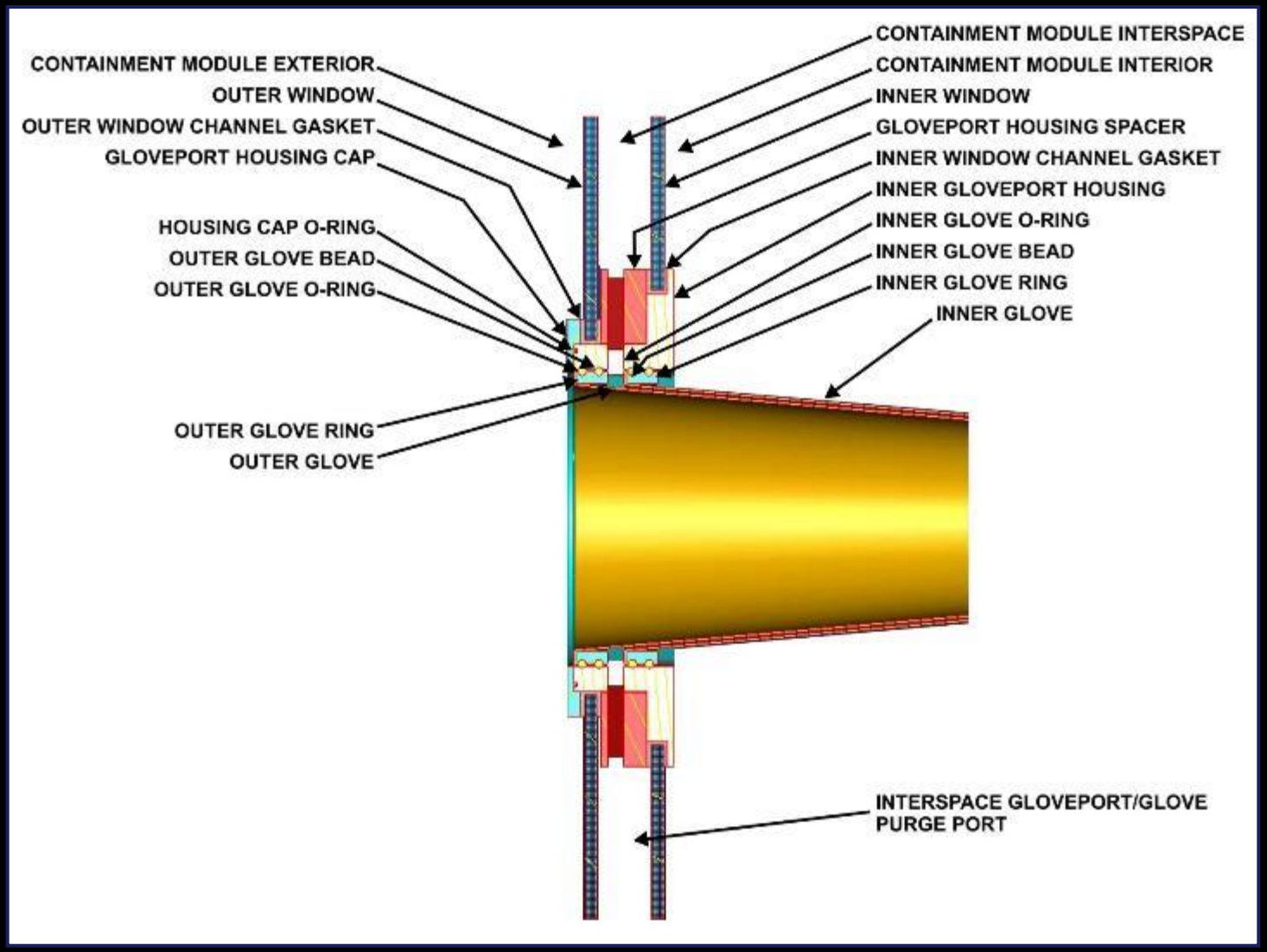
Door operations require development



Doors

- Dual O-rings with Nitrogen purge to maintain negative shell pressure, enclosed door plate

Double Glove Gloveport Concept



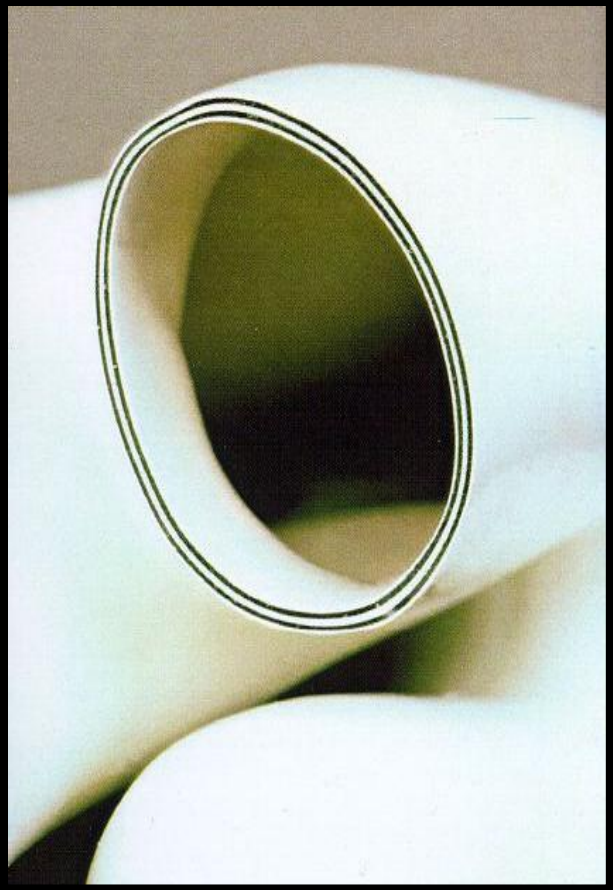
Patent Pending

Containment Module Challenges

- Material Compatibility
  - gloves, gaskets, seals, filters, windows
- Operations in Modules
  - Robotic Operations
- Cleaning/Sterilization
  - Three Stage Approach
  - Drainage
- Module Security
  - Electronic Interlocks
  - Mechanical Interlocks
- Integration of Equipment and Instrumentation
  - 'working' portion of instrument inside module
  - support equipment external to module

Outstanding Technology

- Material Compatibility / Technology
- Double Containment Module Prototype
  - RTP
  - Penetrations
  - Ventilation
  - Double Glove Gloveport
- Filter
- Gloves
  - Further Testing
  - New Material (custom design)
  - Integrity Barrier
    - Development at LANL/North
    - Gloves Puncture Detection
    - Puncture Self-Repair
    - 3 - 5 layers – conducting layers separated by insulating layers



Laboratory Challenges

- Selection of Equipment Made to:
  - Meet Draft Protocol
  - Containment module and laboratory space requirements
  - Instrument integration
  - Actual configuration depends on final analysis and process requirements
- Limited Off-the-Shelf Equipment
  - assure material compatibility
  - integration with sample transfer/containment module
  - minimize/eliminate sample loss/hold up
  - cleanliness/sterilization requirements

Thanks

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