Cleanroom Practices and Introduction to Cavity Assembly

Ari Palczewski

USPAS Course:
SRF Technology: Practices and Hands-On Measurements

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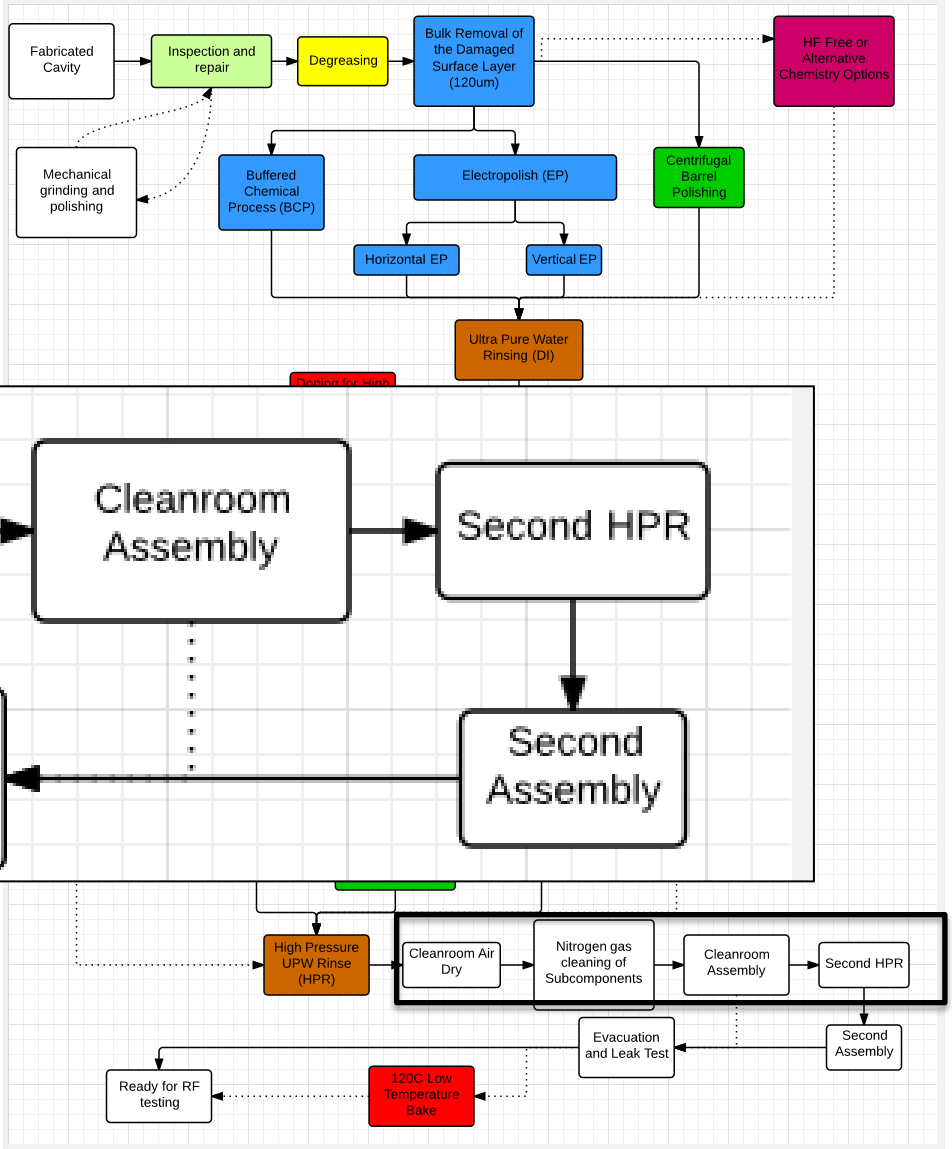
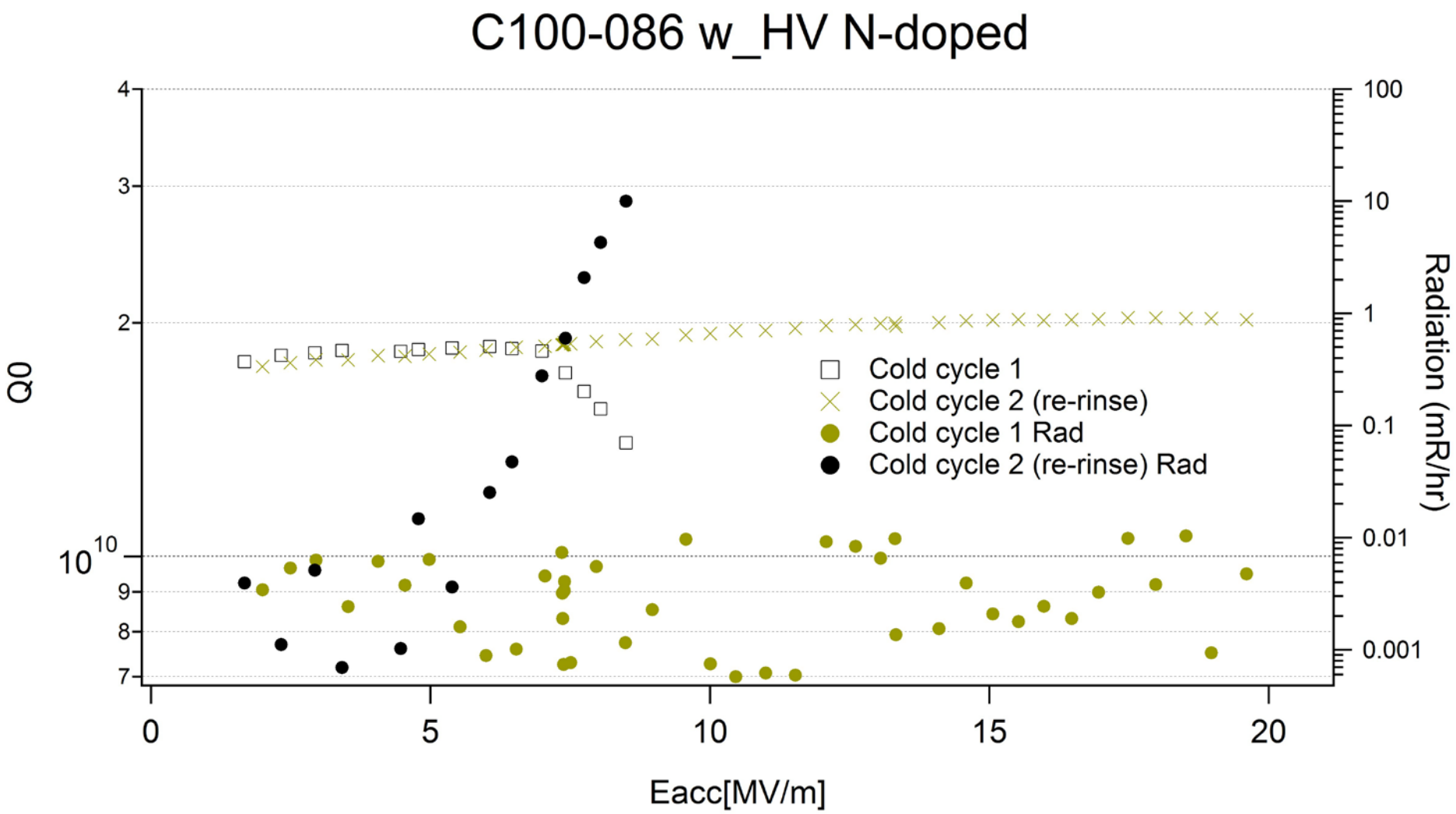
Cavity preparation – final steps

Back to John's Talk – 9T SRF cavity preparation



Why do we care RF measurement? – clean vs. dirty cavity



Outline

- What is a Cleanroom?
- History of Cleanrooms
- Cleanroom specifications
- Particle counters
- Cleanroom suits and why we need them
- Gowning procedures
- JLab's Cleanrooms
- Cleanroom consumables
- Parts cleaning procedure
- Introduction to cavity assembly
- JLab Cleanroom safety (keep out zones)
- Cleanroom lab preparation

What is a Cleanroom

Wiki

A cleanroom is an environment with a low level of environmental pollutants such as dust, airborne microbes, aerosol particles, and chemical vapors.

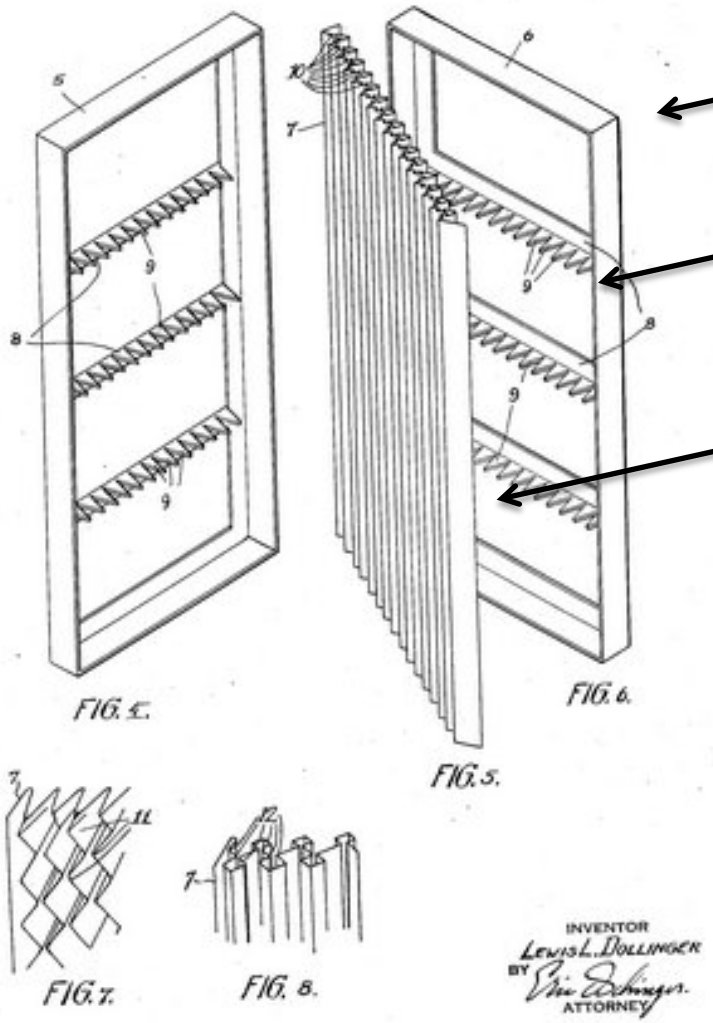
From ISO standard

A room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation, and retention of particles inside the room and in which other relevant parameters, e.g. temperature, humidity, and pressure, are controlled as necessary.

Cleanroom is only defined for room and air, it is your job not to mess it up as you are the dirtiest thing in the room and the items you bring into the room are the next dirtiest

History of Cleanrooms – first air filter

Patent for "Air Filter"



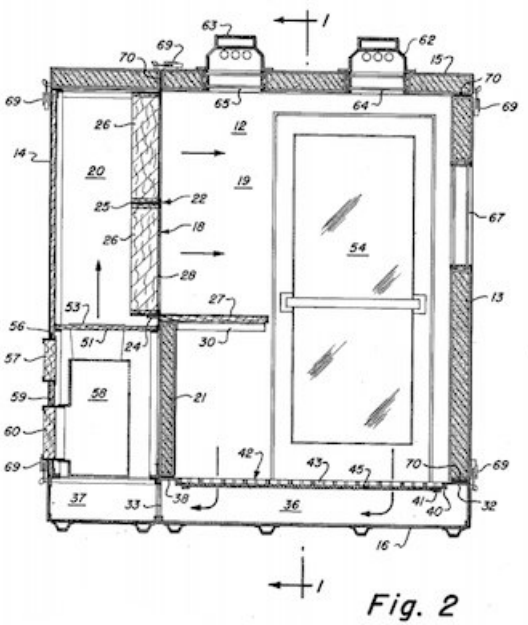
Staynew Filter Corporation of Rochester, NY, was granted in March 1935

Both are actually quite close to modern HEPA/ULPA filter – paper-like material – first actual HEPA filter was made in the 1950's

History of Cleanrooms – first modern Cleanrooms

Courtesy of Sandia National Laboratories

Willis Whitfield with a mobile Cleanroom in the 1960s.



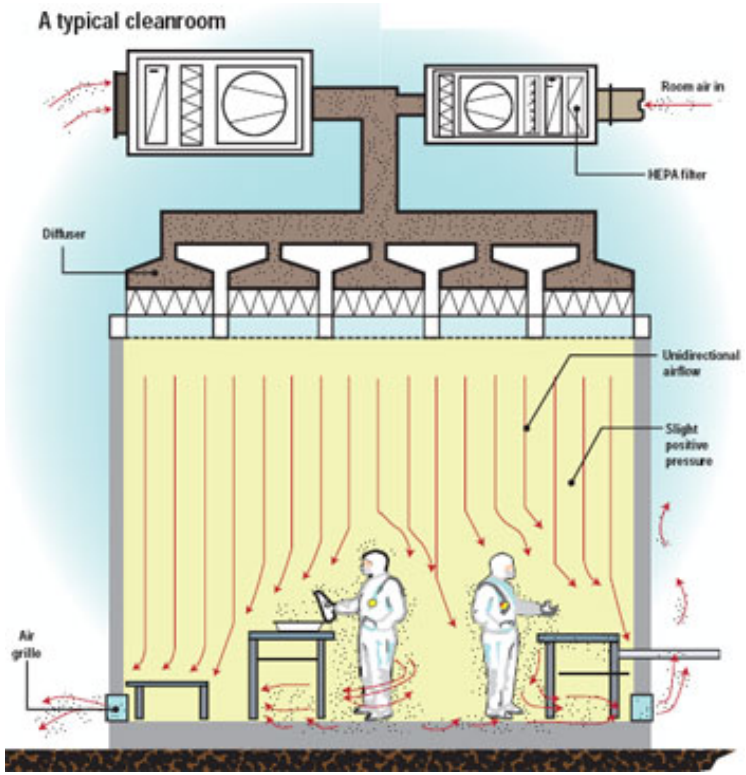
Equivalent to modern day ISO ~5/6 – 1000 times better than ever before

Needed a way to make better nuclear weapons (switches/ circuits ect.)

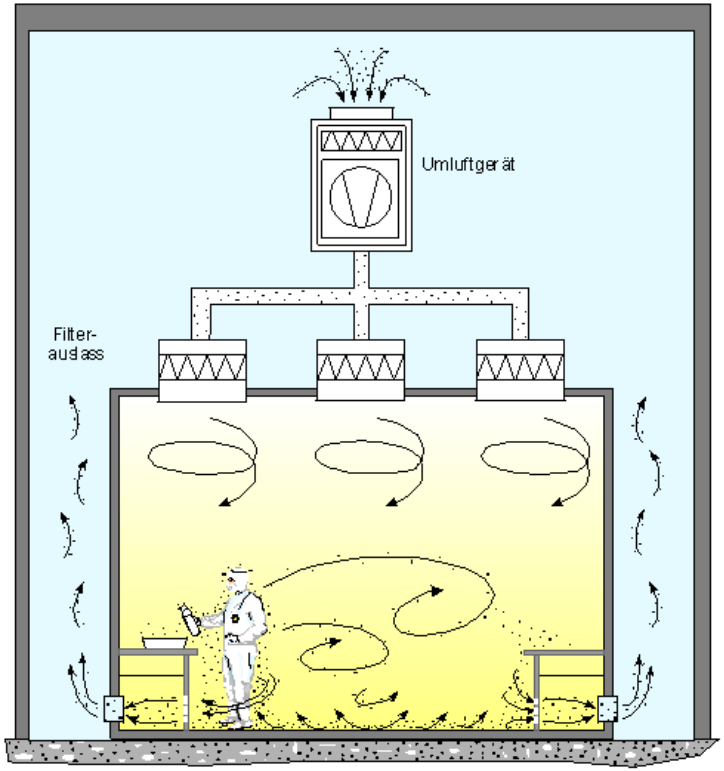
“First Laminar flow” design – although air change out (air speed was rather low)

Types of Cleanrooms

Laminar flow room



Turbulent flow room



Limited to ISO 6 applications, used where large amount of particles are produced

Cleanroom Classifications

Class	ISO 14644-1 Standards maximum particles/m³						FED STD 209E
	≥0.1 µm	≥0.2 µm	≥0.3 µm	≥0.5 µm	≥1 µm	≥5 µm	equivalent
ISO 1	10	2.37	1.02	0.35	0.083	0.0029	
ISO 2	100	23.7	10.2	3.5	0.83	0.029	
ISO 3	1,000	237	102	35	8.3	0.29	Class 1
ISO 4	10,000	2,370	1,020	352	83	2.9	Class 10
ISO 5	100,000	23,700	10,200	3,520	832	29	Class 100
ISO 6	1.0×10^6	237,000	102,000	35,200	8,320	293	Class 1,000
ISO 7	1.0×10^7	2.37×10^6	1,020,000	352,000	83,200	2,930	Class 10,000
ISO 8	1.0×10^8	2.37×10^7	1.02×10^7	3,520,000	832,000	29,300	Class 100,000
ISO 9	1.0×10^9	2.37×10^8	1.02×10^8	35,200,000	8,320,000	293,000	Room air

Only for very specialized application and usually very small are Micro electric manufacturing (usually mini environments and robots only)

Accelerator assembly

Pass-through, gowning as well as clean parts

US FED STD 209E cleanroom standards (Cancelled in 2001) (0.5µm/ft^3)

- Hair 50-150µm
- Pollen 7 -100µm
- Dust 0.1-100µm
- Sneeze particles 10-300µm
- Bacteria 1.0-10µm
- Maximum Human vision ~10's µm

Particle counters @ JLab

0.3, 0.5, 0.7, 1.0, 3.0, 5.0, 7.0, 10.0µm, 25µm
1.0 CFM (28.3 LPM)
Temperature and humidity sampling
Remote logging
8000 count data storage
Remote hose for local counting

Lighthouse Solair 3100

0.3, 0.5, 0.7, 1.0, 3.0, 5.0, 7.0, 10.0µm
0.1 CFM (28.3 LPM)
Temperature and humidity sampling
3000 count data storage

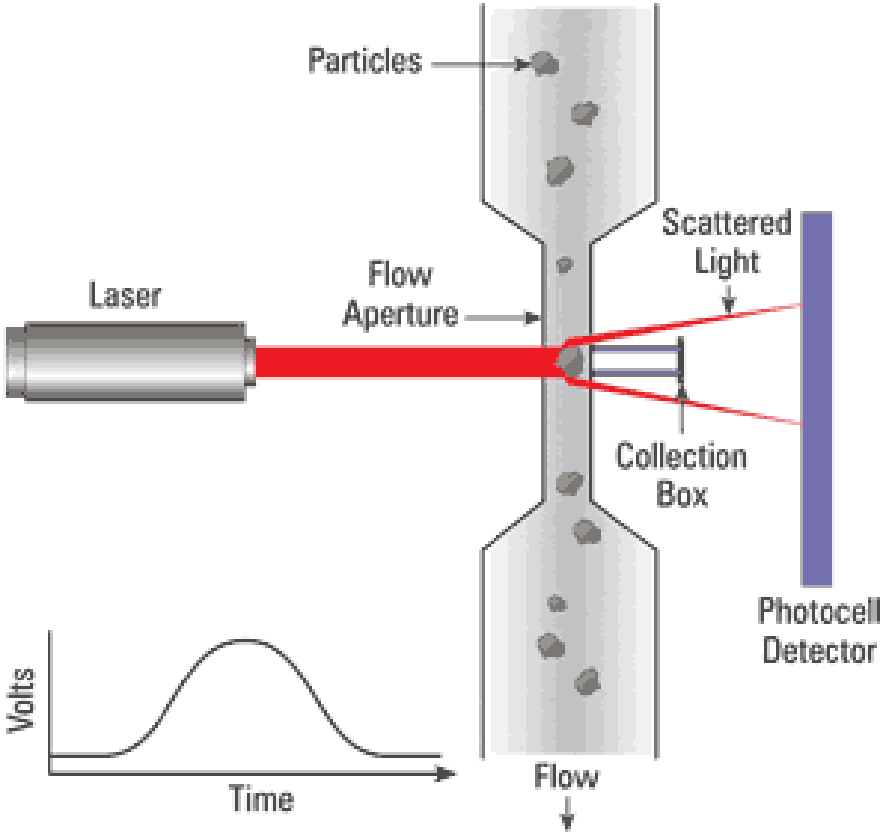
Lighthouse Solair 3100

0.3, 0.5 µm
0.1CFM (2.83 LPM)
Remote sampling to logging computer for real-time Cleanroom monitoring

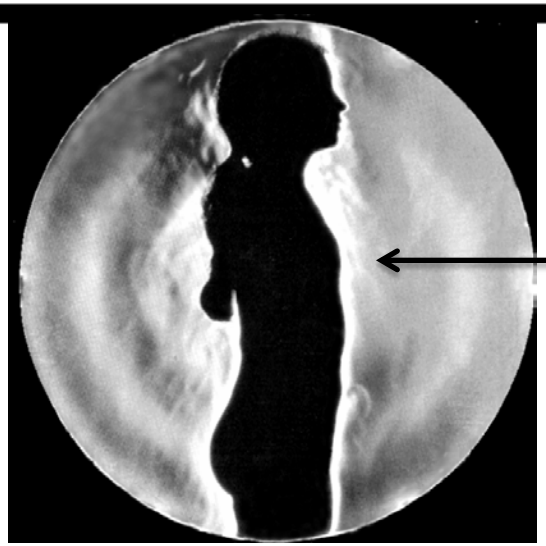
Lighthouse remote 3014

How particle counters work (Laser/light)

1) Vacuum pump pulls particle through aperture
2) Laser light is blocked by the incoming particle
3) Scattered light is detected by a photo-detector (camera)
4) The pulse width and intensity for a each particle is recorded
5) Data is converted into counts/size



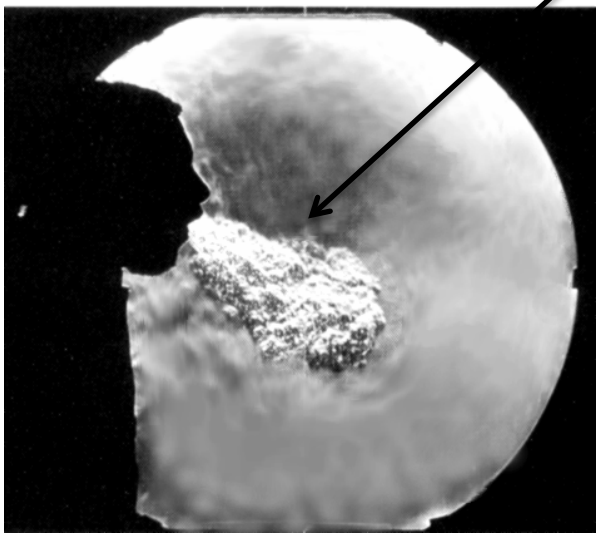
Why we wear Cleanroom suits



Full-Scale Schlieren Flow Visualization stills – body flow examples (differential diffraction images)

Vertical flow from human micro-environment (100K particle per minute)

Open mouth cough in standard room (wear a mask)
Cough produces over 1M particles



Fully suited person in Cleanroom

This is why we never lean over parts

Reference: Flow Visualization VII, ed. J. P. Crowder, Begell House, NY, Sept. 1995, pp. 2-13

Cleanroom suits - JLab

All users in production Cleanroom must wear full “Bunny suit”

All suits are clean to ISO-4 standards

Suits are double bagged (large single bag and smaller item bags)

Suits are made out of 99%/1% Polyester/carbon (carbon is added as a drain for static charge build up)

Suits are changed out at least one a week, with extra change outs when contamination is detected (user discretion)

Cleanroom protocol – before entry

- Wash and dry hands thoroughly in rest room - you should probably use the facilities as well
- Check Shoes for dirt, dirty shoes are not allowed
- Use shoe cleaner to remove dust from shoes and then step on sticky pad until no new dirty is being removed from shoes.
- Only 1 person is allowed in the entry way at a time
- External doors are not allowed open when gowning door and/or curtain is open

Gowning room door
And isolation curtain

Cleanroom protocol - Entry Procedure

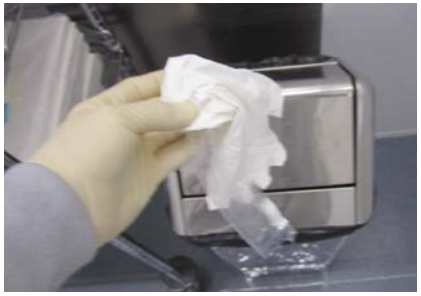
- Pick out two disposable Cleanroom boot covers from the bin on the floor
- Sit on SS bench in entry way and place first cover on left foot. After cover is on, move left foot around bench without touching the “dirty” side of the Cleanroom floor
- Place cover on right foot and move it to clean side of floor
- Don facemask with soft side in (if you don’t you will be very uncomfortable)
- Don Cleanroom Bouffant (hair net), making sure all hair is covered (over or under ears is fine)
- Don inner latex gloves -- from this point on you are not allowed to touch any part of your clothes
- Move through curtains to gowning selection area and pick out boots, gown and hood. (FYI I wear an XL for all parts - shoes (size 11), 5’11” 190lbs)

Cleanroom protocol –gowning demo

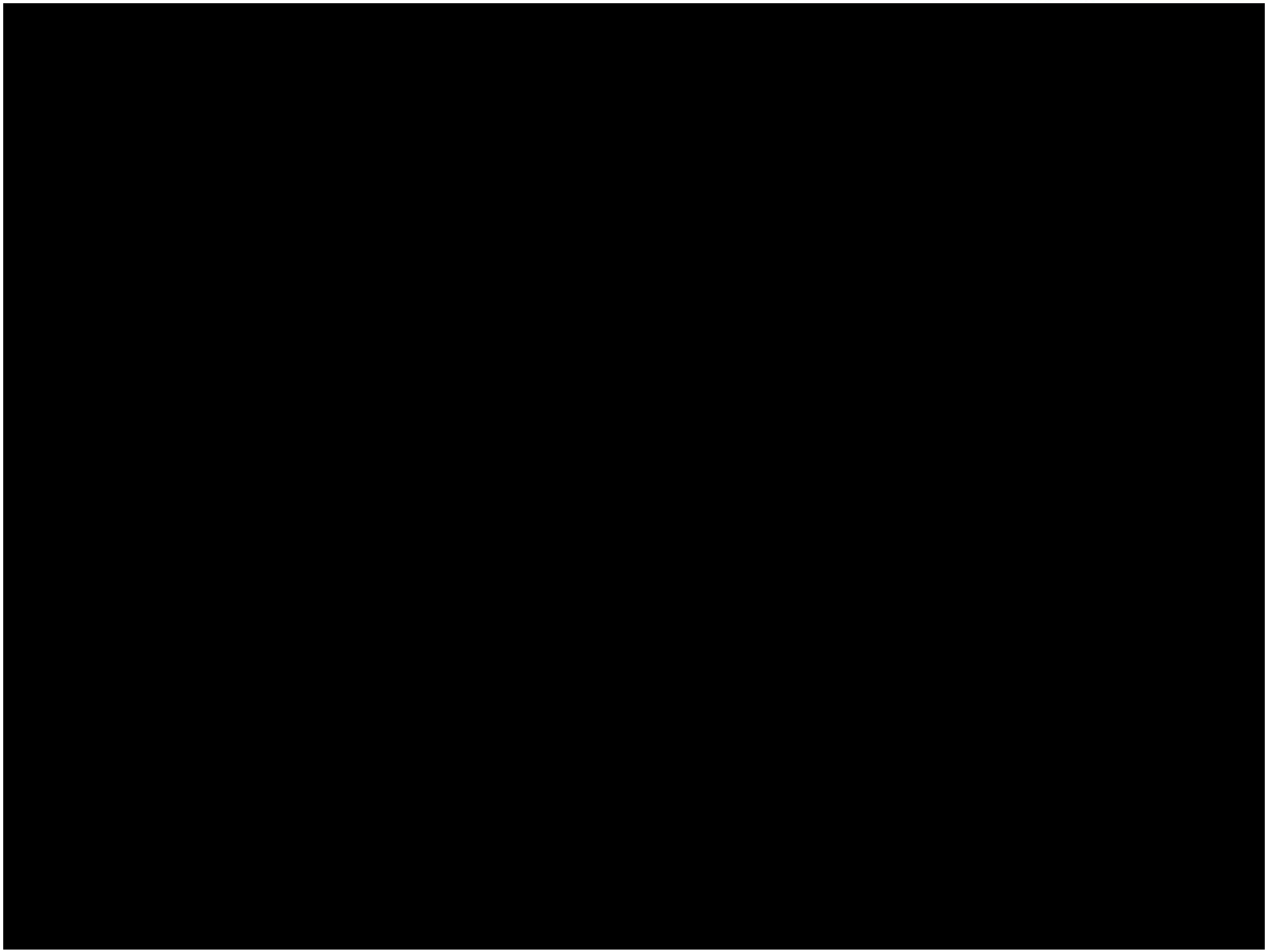
Watch me!

Cleanroom protocol – Un-gowning

- Remove outer glove and dispose of – do not let inner glove touch trash
- Remove booties and do not allow covers to touch floor
- Remove hood by pulling inside out
- Remove covers without letting then touch floor (legs are difficult, arm most important)
- Hang on designated rack with booties and head over buttoned to suit



Best Cleanroom practices – movement



Film to only be used inside JLab for training purposes

Cleanroom consumables – wipes example

100% polyester double-knit wipers
Manufactured in ISO 3 Cleanroom (no hand touch)
Laser edge cut/melted (sealed)

Vertex™ Dry Wipers

Performance and Contamination Characteristics

Property	Typical Value	Test Method*
Absorbency		
Sorptive capacity	350 mL/m²	1,TM20
Sorptive rate	0.3 seconds	1,TM20
LPC		
≥0.5 µm	7.4 x 10^6 particles/m²	1,TM22
Particles and fibers		
Particles 0.5–5.0 µm	2.1 x 10^6 particles/m²	1,2,TM22
5.0–100 µm	48,600 particles/m²	1,2,TM22
Fibers >100 µm	290 fibers/m²	1,2,TM22
Nonvolatile residue		
IPA extractant	0.02 g/m²	1,TM1
DIW extractant	0.01 g/m²	1,TM1

Property	Typical Value	Test Method*
Ions		
Lithium	ND	1,TM18
Bromide	ND	1,TM18
Potassium	<0.03 ppm	1,TM18
Ammonium	ND	1,TM18
Chloride	<0.02 ppm	1,TM18
Fluoride	ND	1,TM18
Magnesium	<0.02 ppm	1,TM18
Phosphate	ND	1,TM18
Calcium	<0.05 ppm	1,TM18
Sodium	<0.08 ppm	1,TM18
Sulfate	<0.12 ppm	1,TM18

Note: The data in these tables represent typical analyses of these wipers at the time of publication. These are not specifications. Values are reported in ppm (parts per million). Detection limit <0.009 ppm. Quantification limit of 0.009 ppm.

***Test Methods**

1 – IEST-RP-CC004.3, 2004; www.iest.org.
2 – ASTM E2090-06, 2006; E2090-06, ASTM International; www.astm.org.
TM – Texwipe Test Method available upon request. Visit www.texwipe.com or contact Texwipe Customer Service at + 1-336-996-7046.

Cleanroom consumables – wipes JLab

TX1009/TX4009 wipes

100% continuous-filament polyester/Nylon

ISO Class 5 laundered

Edges are not sealed – do not let part touch edges (new edge sealed wipes are on order)

TX 2009 Beta wipes

Only used for pre-cleaning dirty/contaminated parts

Wiping in the Cleanroom will produce particles

Used only by chemistry staff for BCP

All other uses in Cleanroom are prohibited – ISO 6 compliant only

Cleanroom paper - JLab

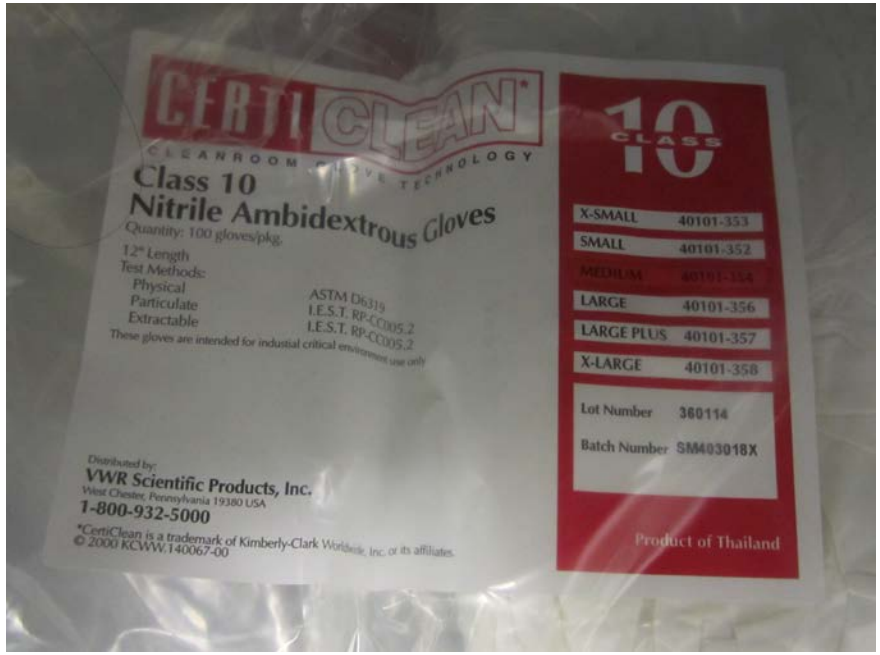
TexWrite® MP10
100% synthetic cleanroom bond paper,
Cellulose free

No outside paper allowed unless laminated and cleaned! – see Chem lab for Cellulose particle counts

Cleanroom consumables – gloves

Inner gloves are ISO 5/class 100 latex
-thin and flexible compared to over gloves
Come double bagged from manufacture

Outer gloves are ISO 4/class 10 Nitrile
Come double bagged from Manufacture

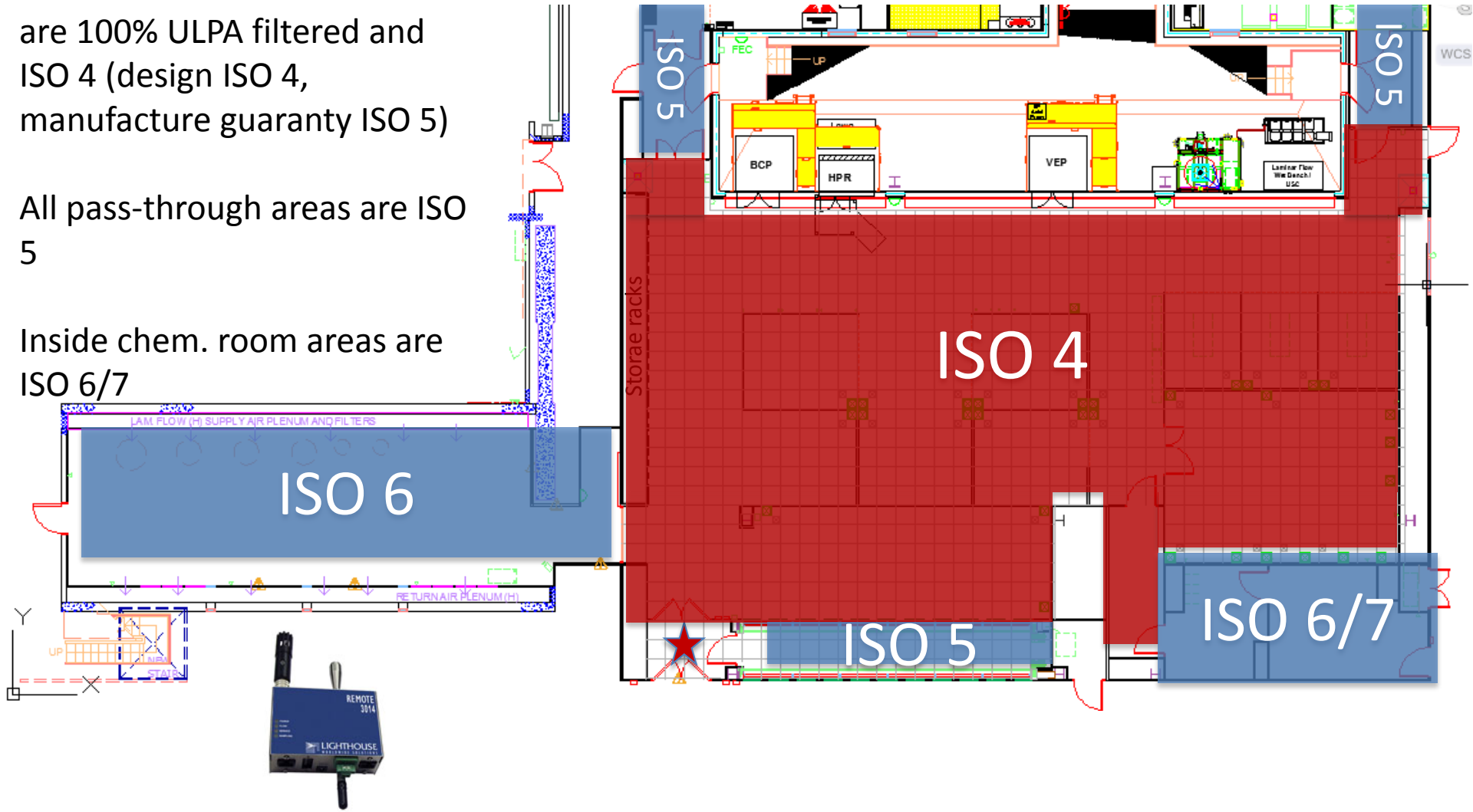


JLab Cleanroom – Overhead view

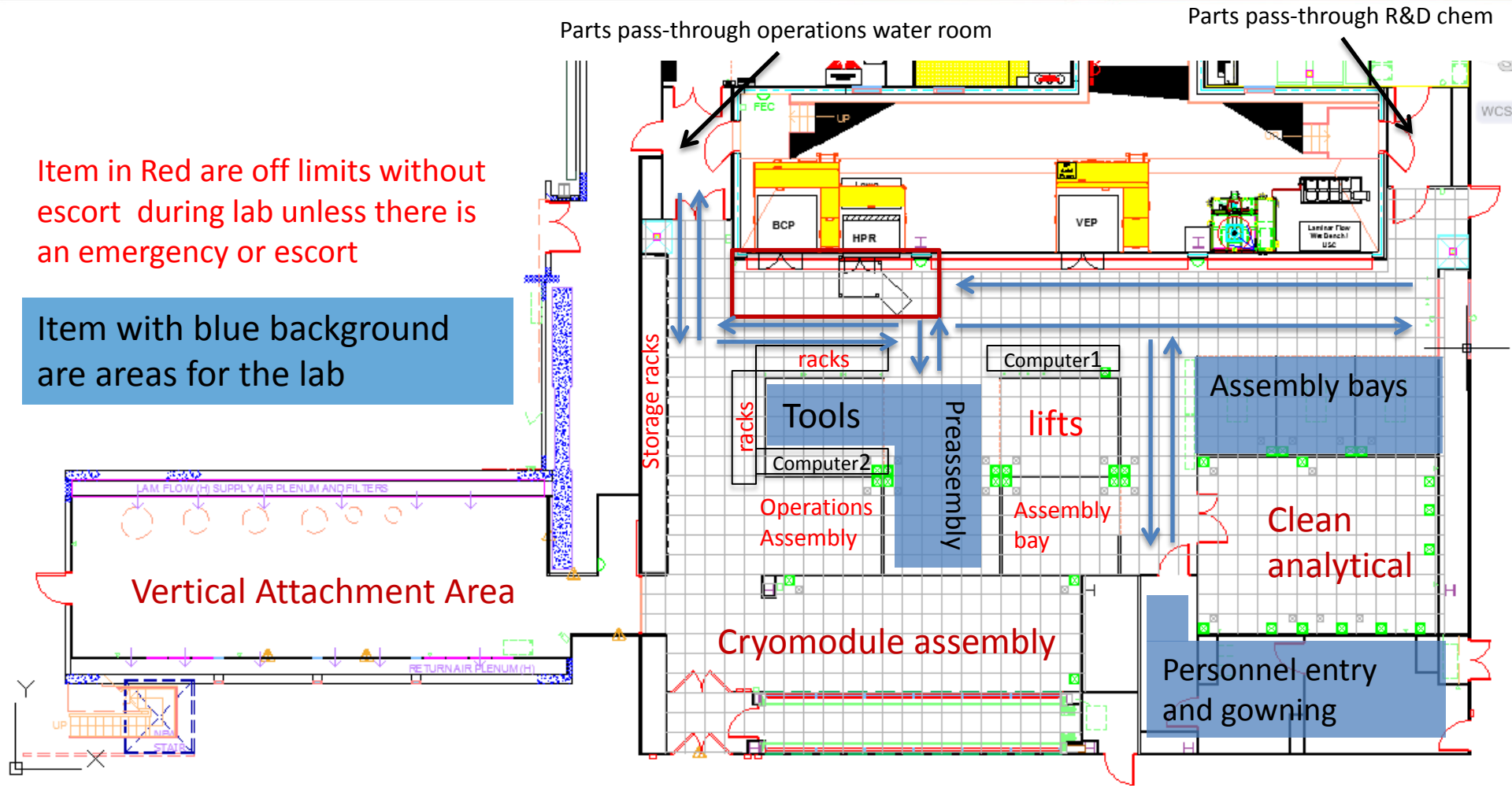
All main areas of Cleanroom are 100% ULPA filtered and ISO 4 (design ISO 4, manufacture guaranty ISO 5)

All pass-through areas are ISO 5

Inside chem. room areas are ISO 6/7



Jlab cleanroom – Overhead view



JLab Cleanroom – Overhead view

Parts pass-through R&D chem

Parts pass-through operations water room

Emergency exits
7 available

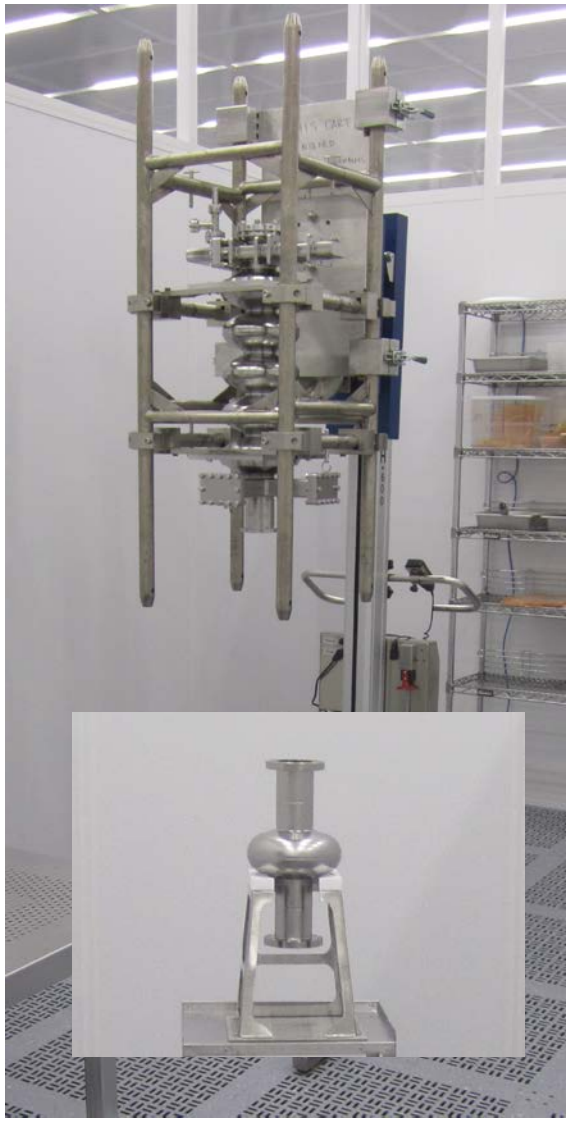
Cleaning of parts before entry

- All parts are cleaned to remove all grease, particles, and possible other forms of contamination.
- Ultrasonically cleaned (See Chem lab) for 30 minutes in detergent and then rinsed with ultra pure water.
- Dried in flowhood and/or blow dry with filtered ionized nitrogen
- Bagged in antistatic Cleanroom bags
- Bagged parts are placed in pass-through
- Larger parts are not bagged but dried in pass-though or ISO 6 area

Clean-room load lock entry (for parts)

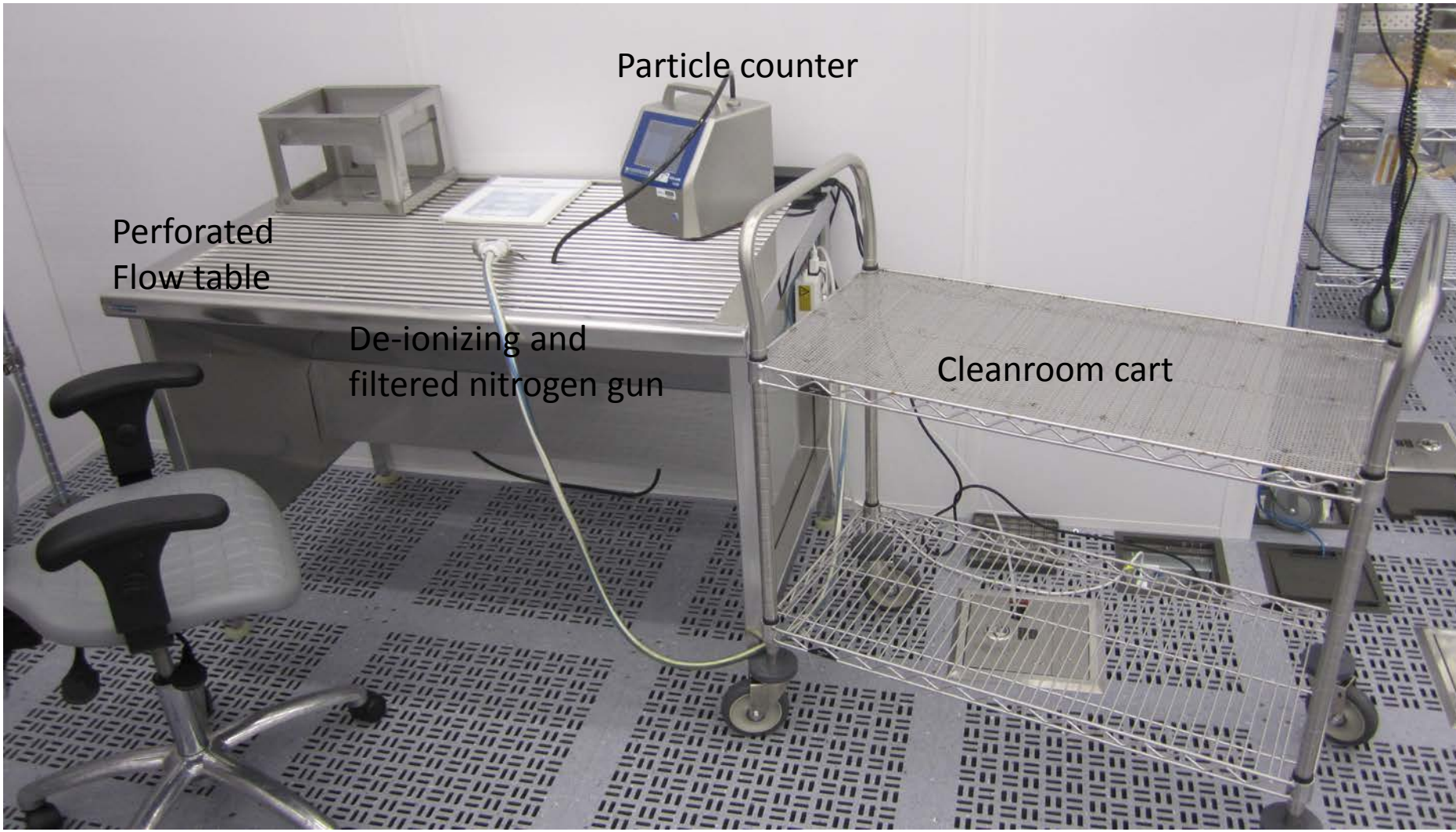
- All personal entering load lock must wear bouffant, facemask, shoe cover, gloves and them lab coat, and put on in the order listed. Lab coat should not be touched by ungloved hands (or dirty gloves)
- Once shoe covers are on you are not allowed to stand on floor, only sticky mat
- Entry is only allowed when inner Cleanroom doors are closed and load lock in unoccupied
- Spend as little time as possible in load lock

Introduction to cavity assembly - Cavity drying



- Single cell cavities are allowed to dry a minimum of 3 hours before assembly
- Multi-cell cavities are dried overnight (12 hours min. before assembly)
- All possible ports on the cavity are open for drying
- For final assembly, only bottom port is left open

Introduction to cavity assembly – blow off station



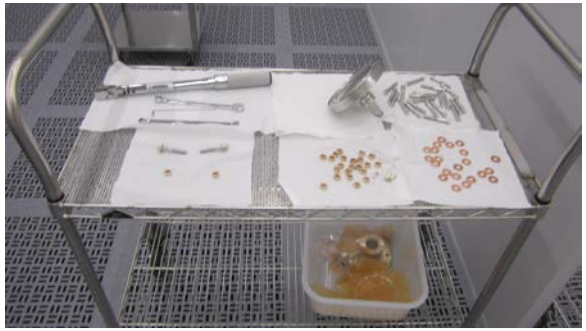
Dry Nitrogen cleaning specifications

1. Zero counts on all scales except 0.3 µm which can be zero or 1 in 5 seconds (half cycle). (~ISO 4)
   - Glove before any particle test of final assembly
   - All assembly parts after pre-assembly
   - All blank-off plates
   - Hand tools on all flat surfaces before final assembly
   - Initial two bolts/nuts/washers for first connection
   - Cleanroom blow-off bench before beginning any assembly
2. 1 count per second or less on the 1 µm scale
   - Individual parts before pre-assembly
   - hand tools at connection points
3. No blow off
   - Parts previously cleaned and bagged, taken directly out of bag which will not see cavity (unless initial two bolts are perceived as dirty)
   - New wipes taken directly out of bag for assemblies

Nitrogen parts cleaning steps





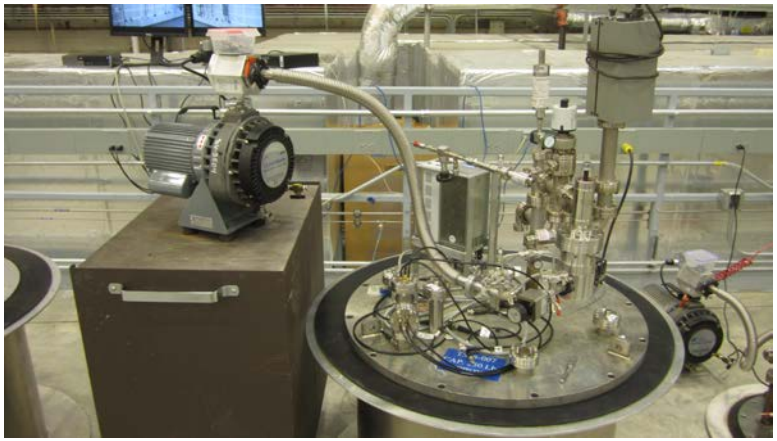


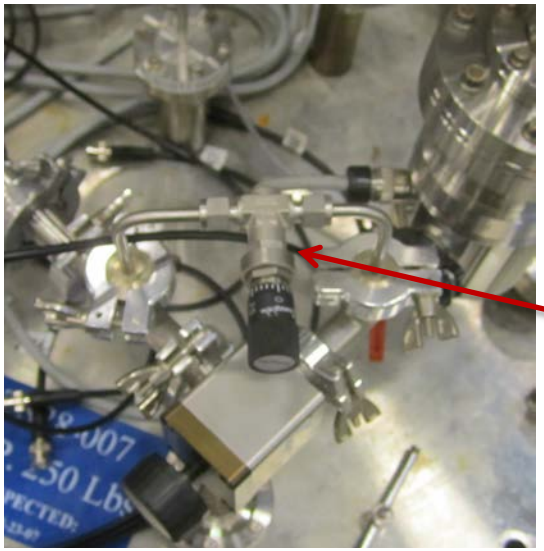
- All parts must be on Cleanroom wipe (avoid parts rubbing)
- All parts that “see” cavity must be facing up and cleaned last
- Only initial final assembly bolts (2 per flange) are cleaned to spec 1

Cavity assembly general steps (single cell)

1. Find cavity in assembly bay
2. Cover top of cavity with blank
3. Attach bottom flange assembly
4. Flip cavity
5. Uncover bottom flange
6. Assemble bottom flange of cavity

Cavity attachment/Slow pump down





Slow pump down in SRF is established as
A way to evacuate a cavity from atmosphere in a manner that does not transport particles which may be present in the cavity or the pumping system

Pressure drop rate in cavity set to
5 torr per minute
for TESLA shaped cavity after water barrier is gone.
~ 0.1 liter per minute

Same criterion is relevant for any needed clean bleed-up of a cavity.
Needle valve to keep gas flow in cavity below laminar flow (i.e. particle movement)

http://lss.fnal.gov/archive/test-tm/1000/fermilab-tm-1768.pdf to calculate flow in any geometry for dry cavity

Pressurized nitrogen flow – DESY/XFEL (side subject)

DESY pressurizes their string during assembly so that particles do not fall into the cavity as the string is horizontal, not vertical assembly.

99.9999 Nitrogen, EP SS tube, inline filters and real time particle counting

https://indico.in2p3.fr/event/10347/session/9/contribution/36 - more details on subject

How to prep the day of and before entering – no I'm not kidding

- Shower (not bath) the day of working in Cleanroom
- Brush teeth in morning, and rinse mouth before entering Cleanroom, shave if possible
- Clean hands and especially brush nails the morning of Lab
- If you have cuts, re-bandage and tape before entering
- Before entering Cleanroom – wash face, hands and go to bathroom
- Do not wear makeup of any kind or perfume/cologne – deodorant is fine
- No lotion/hand creams etc.
- Do not wear jewelry, take off all rings
- Wear non-knit clothing (no fuzzy sweater, hoodies, etc.) wear closed-toe shoes, pants and comfortable shirt. (We will spend ~5 hours in a bunny suit)
- Clean your shoes - no visible dirt
- Do not plan on bring phones etc. into Cleanroom, I like to empty my pockets – you can't use them anyways.

JLab Cleanroom Safety

- During a emergency
  - Follow my lead, we will exit through gowning area if there are no signs of smoke etc.
  - In the event of smoke etc. will exit though the farthest exit from the event.
- Solvents in Cleanroom
  - During lab we will be using acetone, methanol and alcohol in small squirt bottles (I will be doing any refills necessary for small bottles).
- Acids in Cleanroom
  - All acids are off limits to student (and me for that matter)
  - Do not touch BCP or VEP tool for any reason.
  - In the event the BCP tool is in operation you are not allowed with 10 feet of tool when doors are open by chem. tech. or 3 feet when operating (red flashing light)
- High Pressure rinse tool
  - You are not allowed on HPR platform or in front of control for any reason
  - If operator is using HPR tool, you are not allowed to go by platform, and not allowed within 10 feet
- Ladder and back-tech lifts
  - All are off limits without training, (there should be no reason to use then during the lab anyway)

Loose ends and Homework before lab

- See me before end of day if you have claustrophobia, breathing issues, latex allergies, or any other health concern about prolonged time in a over suit.
- Read over supplied single cell assembly procedure before the day of our lab.
- Please inform me if you have a cold the day before the lab.
- Questions?

Backup

- Backup

Cleanroom Lab daily Schedule

11:00 suit up
11:15 Cleanroom tour and safety
11:30 check suits and nitrogen blow of stations for contamination
11:40-12:20 contamination tests
12:32-12:30 leave Cleanroom
12:30 to 1:30 - lunch
1:30 suit up
1:40 check suits for particle contamination
1:50 Prep station for assembly
2:00-3:00 blow off parts
3:00-4:00 cavity assembly
4:45-5:10 cavity disassembly
5:00-5:30 wrap-up
5:30 bus departure

Off limits location in Cleanroom

- Production assembly booth
- Chemical tool storage racks
- Clean analytical
- Any assembly bay which contains a cavity except the two we will be using during the class (this is the same for any person, unless they are directly involved in an assembly)

Items needed

- 17 Cleanroom suits
- 2 assembly bays for entire week
- 2 HPR cavity each day, done in AM (RDT sets)
- Blow off table available from 10:30 to 4:30
- Two sets of cavity hardware each day and associated gaskets
- Two dedicated Cleanroom carts
- Hand help particle counter – 2 if possible
- 8 Cleanroom notebooks and pens
- 32 pre-cleaned glass slides
- Extra consumables in Cleanrooms
- Parts bagged in morning
- Cleanroom compatible alcohol