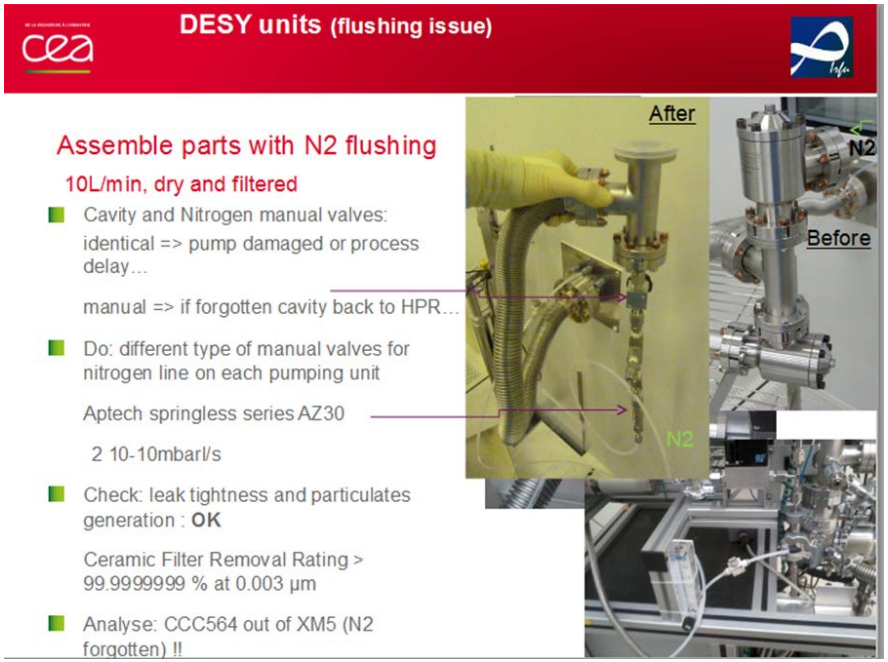
Agenda for assembly in cleanroom session

- Is a beamline purge system necessary during assembly?
  - What beamline purge system is being used and how does this compare to XFEL?
  - Should a study of the beamline purge use be carried out to understand the correct flow to be used and particle migration?
- Differences in assembly techniques for string assembly at FNAL and JLab and possible correlations to CM performance
- Issues identified during pCM assembly that need to be improved –path forward, lessons learned
- Hardware cleaning techniques at each lab
- Copper plated beamline components

Beamline purge

- The maximum venting flow is based on data (Zapfe SRF2007): 3L/min for N2
- The purging flow is based on DESY experience: 10L/min (depending on cavity port aperture)
- Videos from the DESY cleanroom showed that with this purging flow rate, cavities are protected from particles, metallic fibers to migrate/fall into the beamline during assembly
- At Saclay for the XFEL CMs assembly in the cleanroom, 10 liter / minute dry, filtered nitrogen flow was used. Backfill to atmospheric pressure was done through the corrugated flex hose with 3 liter / minute flow. Purge was done through a flexible line which is connected with a tee to the right angle valve of a cavity

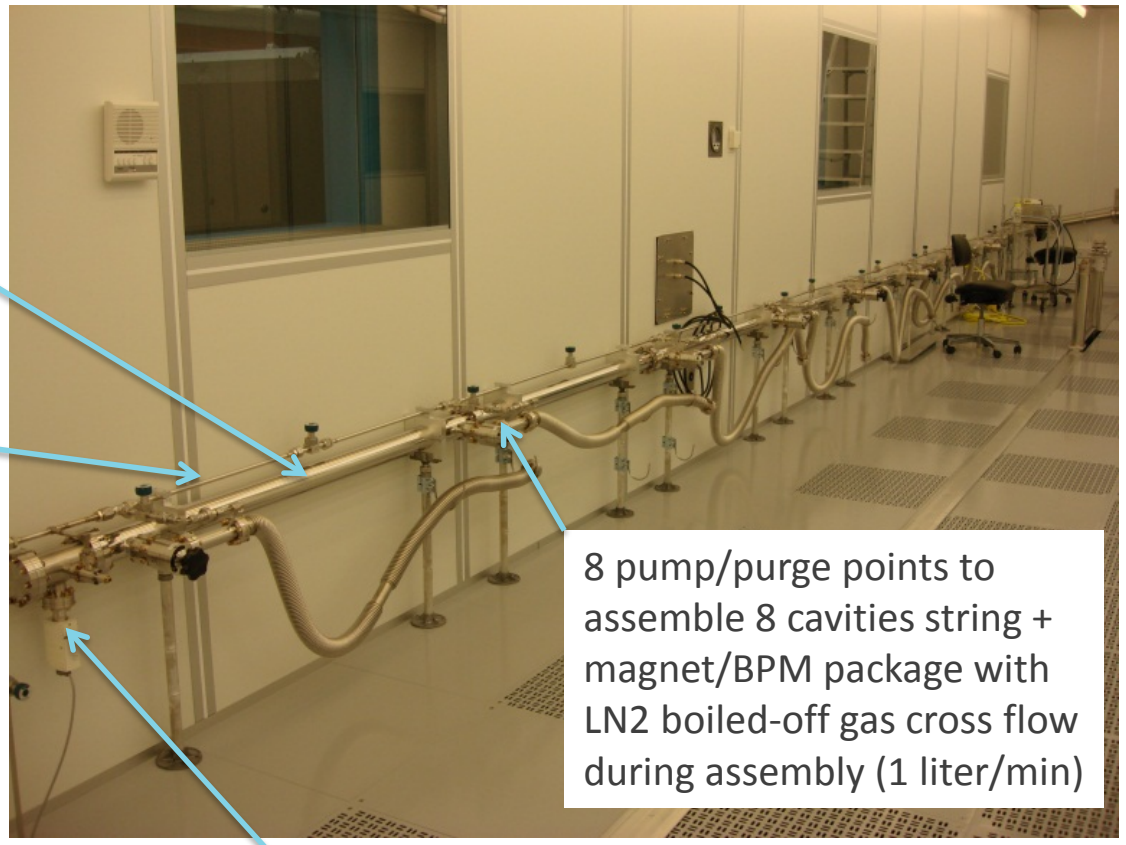
TTC topical clean room assembly 2014: https://indico.in2p3.fr/event/10347/timetable/#20141113.detailed



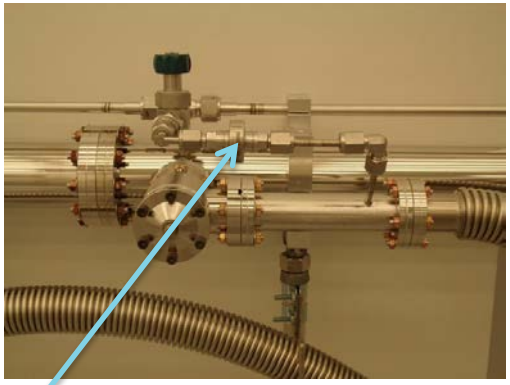
Fermilab CAF cleanroom Vacuum / Purge / Backfill Manifold

3 inches diameter 304 electro-polished SS vacuum header

1/2 inches diameter 304 electro-polished SS backfill/purge line which also goes under the raised floor



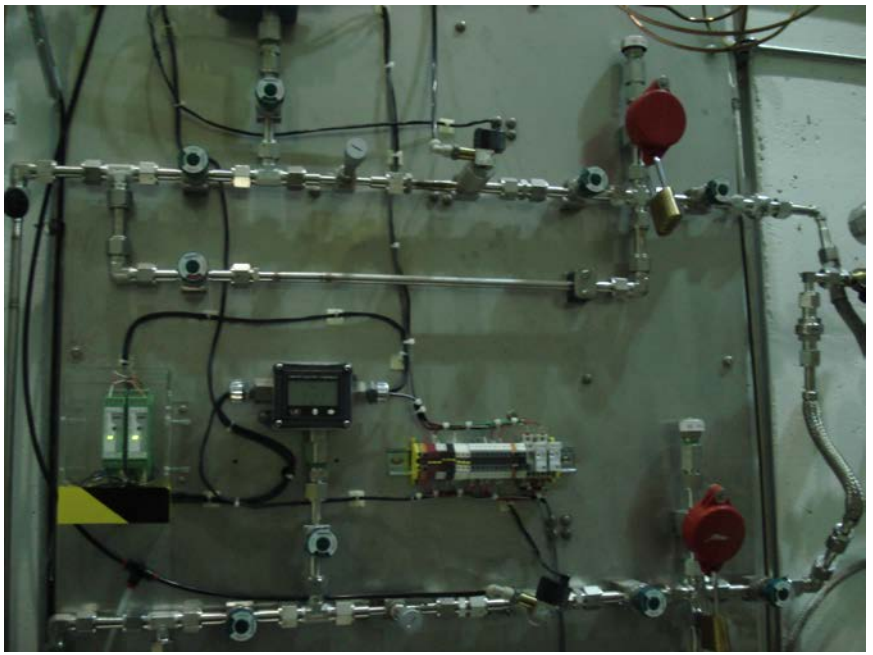
8 pump/purge points to assemble 8 cavities string + magnet/BPM package with LN2 boiled-off gas cross flow during assembly (1 liter/min)



Nitrogen in-line and point of use filters: Mott Defender series sintered all metal (0.03 micron)

Vacuum gauge and calibrated leak

CAF Boiled-off Gas Dewars and Manifold



Upgraded dewars for the anticipated LCLS-II throughput:

- 300 liters LN2 dewar for cavity backfill and purge
- 1000 liters LN2 dewar with volumizer for Class 10 WS1 and Sluice area blow guns
- 1000 liters LN2 dewar with volumizer for Class 10/100 WS0 and UHV cleaning area blow guns

Gas manifold for the cavity backfill and purge operations:

- Filter, relief valve, solenoid valve, needle valve, pressure transducer

Set values: Backfill the cavity beamline to 1050 mbar abs pressure with 1 liter / minute flow rate. Purge will start immediately when the pressure transducer senses less than 50 mbar gauge and will stop when it reaches to 50 mbar gauge slightly above atmospheric pressure.

Recommendation noted about flow rate variability from a fixed orifice needle valve depending to the inlet pressure

JLab cleanroom

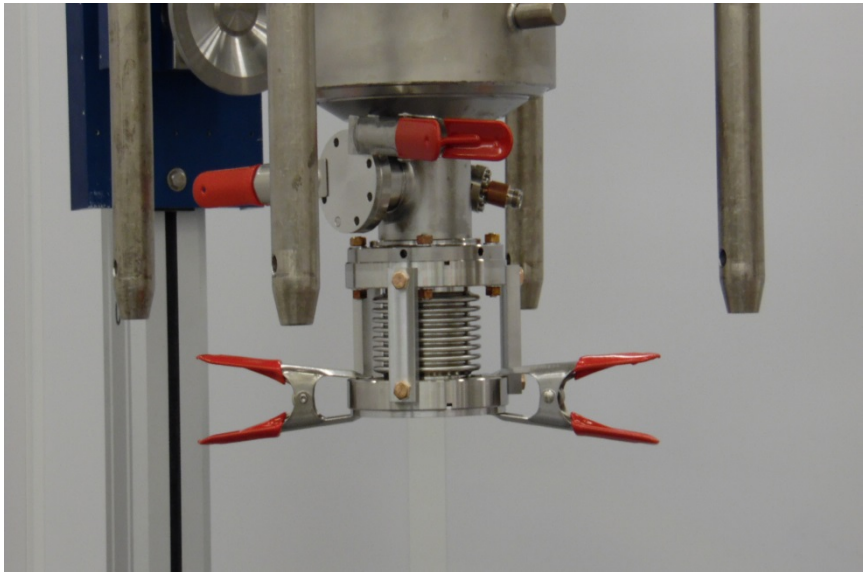
- Slow venting of the qualified cavity beamline before cavity beampipe and FPC flange blank peripherals disassembly and HPR
- If needed, slow venting of the cavity string after a leak check to repair leaks
- No purge is setup and used in the cleanroom

String Assembly Differences

- Cavities receive HPR at JLAB after high power test and prior to string assembly
- FPC bodies at JLAB are not installed and leak checked prior to installing cavity on lollipop system
- JLAB does not use a purging system during string assembly.
- After string completion cavity string is pumped down and leak checked. The goal is to pump the string only this one time during the entire cryomodule assembly.
- Sub-assemblies and bellows are completed using different procedures (slides to follow)

String Assembly Differences (cont.)

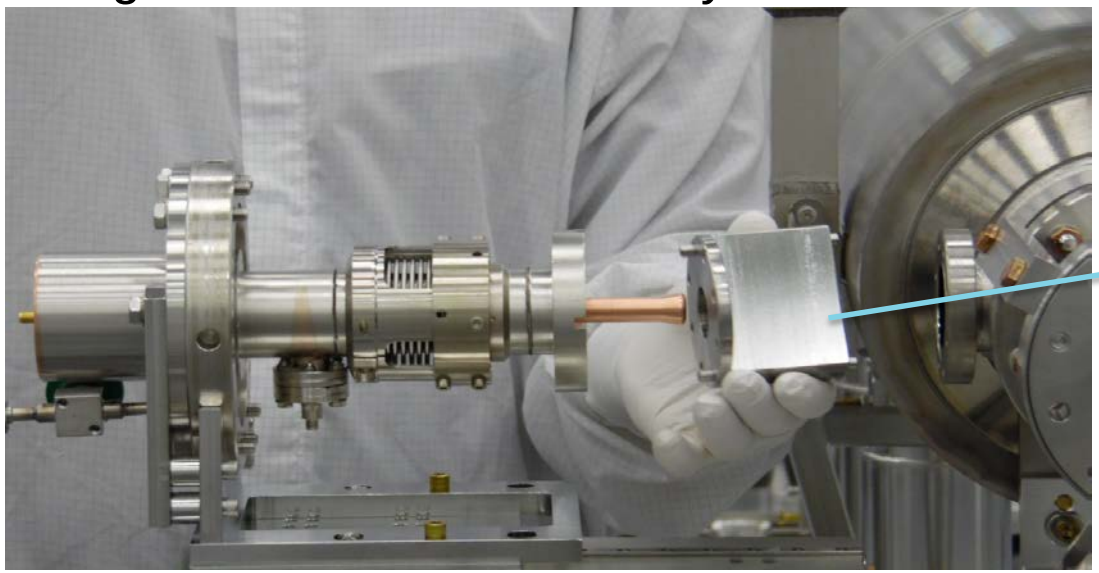
- Bellows are attached to upstream cavity in a vertical position prior to placing cavities on the lollipop system
- Bellows alignment fixtures are different at the two labs. JLAB uses a stiffener system that is placed on bellows prior to attachment on upstream cavity



Extensive studies were done to choose the plate, gasket and spring clamp for the minimum particle generation

String Assembly Differences (cont.)

- Although the FPC alignment tooling is similar, the procedures for aligning FPC to cavity flange are different
- Alignment blanks are installed on cavity and FPC prior to installation in tooling. The alignment is performed, blanks removed, gasket inserted and finally assembled

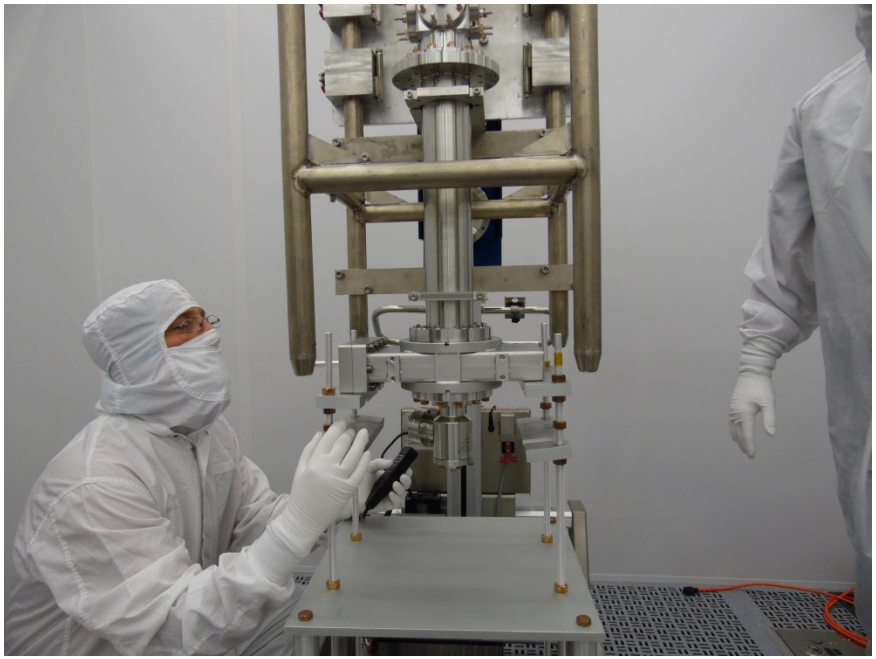


Recommendation noted to clean this tooling after each string assembly

Better process control and quality assurance checks to eliminate the alignment problems encountered during assembly of pCM

String Assembly Differences (cont.)

- BPM sub-assembly at JLAB is completed vertically prior to placement on lollipop system
- Leak check performed on sub-assembly and it remains under vacuum until ready for attachment to cavity #8



Modified for ProdCM string assembly, it will be done in horizontal configuration

String Assembly Differences (cont.)

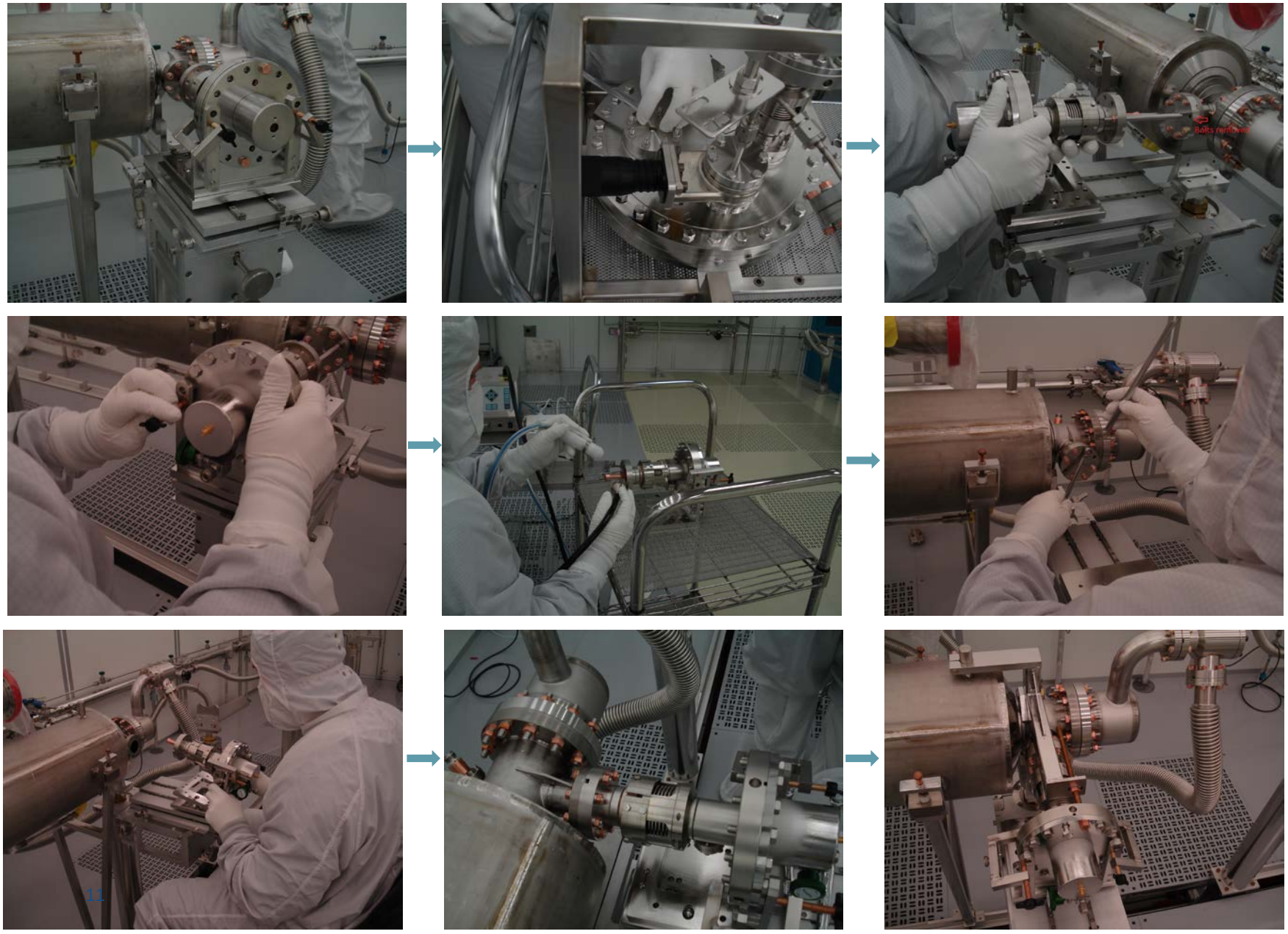
- Leak checks are similar with differences in the type of detectors being used.
- JLAB uses Residual Gas Analyzers with calibrated leaks to calculate MDL. FNAL use leak detection system with automatic MDL calculation.

Recommendation noted for use of torque wrenches for LCLS-II strings assembly in the cleanroom

Over-torqueing of the fasteners to fix a leak is noted. DESY recommendation shall be reviewed further

pCM at WS0

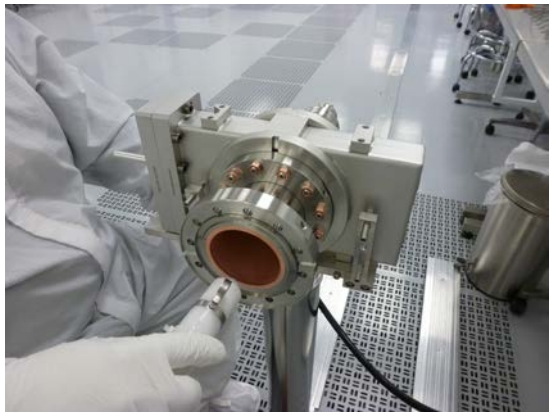
Recommendation noted to use the JLab design
Delrin clip to hold the gasket

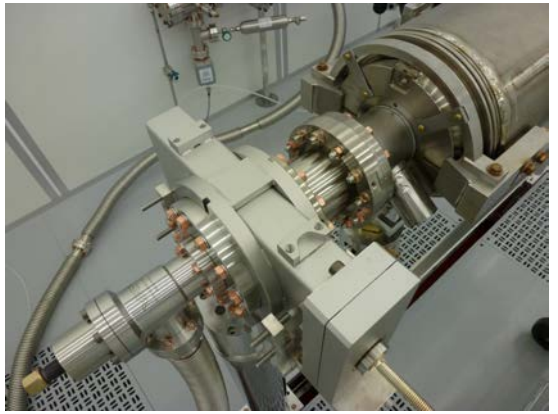


String Assembly-I (WS1)

- Align 8 cavities for string assembly
- Gate Valve (GV1) to Cavity #1 Assembly:
  - Check the particle free cleanliness of the GV and clean as needed
  - Sub-assembly of the GV peripherals
  - Installation to the cleanroom post and flex hose assembly
  - Alignment to the cavity beam line flange
  - Assemble the gate valve to the cavity

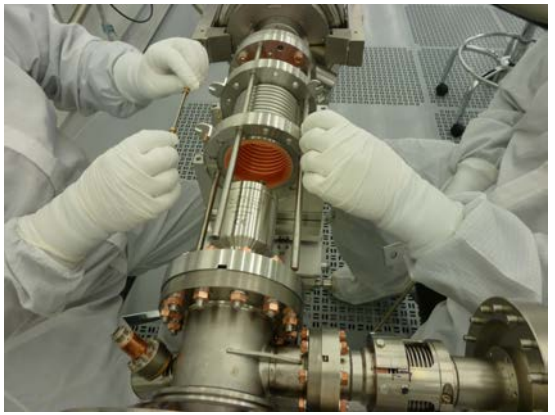
Recommendation noted that gate valve is opened and closed several times at JLab during particle free cleaning with ionized nitrogen

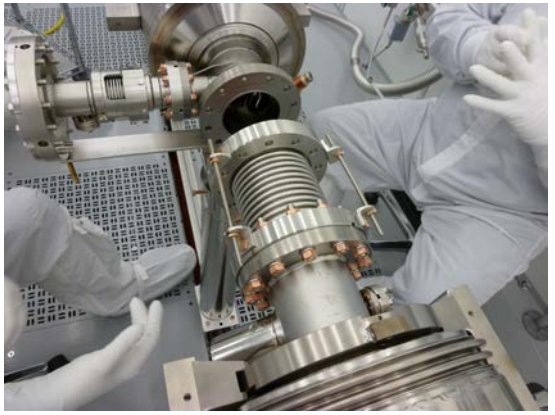


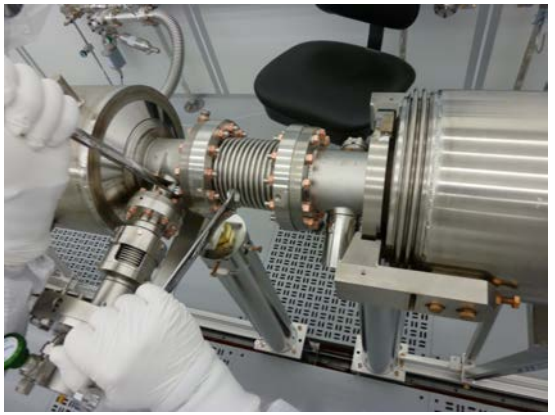


String Assembly-II (WS1)

- Cavity to Cavity Assembly with the interconnect bellows:
  - Assemble flex hose to the cavity Pump down and Leak check
  - Backfill
  - Align the interconnect bellows to the cavity field probe end beampipe flange
  - Assemble with PFFA
  - Align the bellows to the cavity coupler end beampipe flange
  - Assemble with PFFA



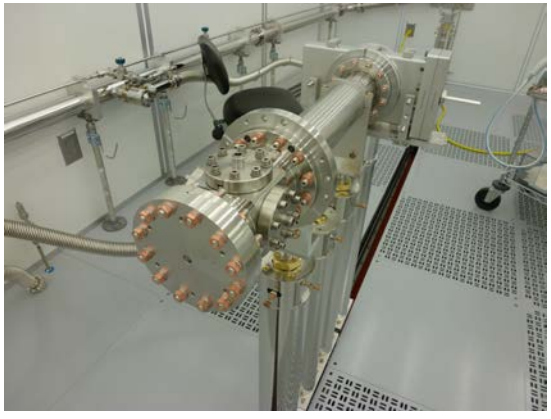




String Assembly-III (WS1)

- BPM+Magnet Spool Tube+GV2 assembly and leak check
- BPM/Magnet package subassembly to the 8 cavities string
- Pump down the fully assembled cavity string, bag the bellows, leak check. Backfill
- Roll out of the cleanroom to WS2

Alignment pins currently are not used at neither labs



Particle free UHV Cleaning at CAF, Fermilab

- Cleaning Procedures for stainless steel, titanium, copper and niobium components
- Wash/rinse in the ultrasonic baths (1 Stoelting, 3 Branson) with DI water (Crossbow).
- Dry under the Class 10 hood
- Transport into the Class 1000 ante clean room
- Blow clean with ionized nitrogen while monitoring the particulates count in the Class 100 sluice area
- Transport into the Class 10 assembly area

General UHV Cleaning Procedure at CAF

1. Simple Green, 3% solution, 20 minutes
2. DI water rinse
3. Micro90, 2% solution, 15 minutes
4. DI water rinse
5. 99.9% pure Isopropyl alcohol rinse
6. Blow dry with boiled off liquid nitrogen gas
7. Leave under Class 10 cleanroom hood to dry thoroughly

UHV cleaning procedure at JLab

- Parts are wiped down with Micro 90 first if needed. Parts are then put in Ultra Sonic tanks with 1% to 2% Micro added for 50 minutes and 130 F.
- Parts are separated by material.
- After Ultra Sonic the parts are triple rinsed.
- Parts are then laid out in the laminar flow hood to dry
- After hardware is dry it is blown off and bagged in Class 1000 cleanroom

Hardware Cleaning Techniques in Cleanroom (Class 10)

- Air Force ionized nitrogen guns for spraying parts
- Lighthouse particle counters at all stations
- No use of the ionized nitrogen spray anywhere near an open cavity
- All sub-assemblies sprayed before assembly onto a cavity or string
- All parts, fasteners, blanks, valves and sub-assemblies sprayed with ionized nitrogen IAW CP-L2PRO-CST-CHEM-CLN-ION
  - Spec 1-particle counts zero on all scales except 0.3µ can be 0 or 1
  - Spec 2-particle counts ≤ 1/s on the 1µ scale

Noted that only the deemed critical fasteners are blown cleaned to Spec 1. Remainder of the fasteners are blown cleaned in Class 1000 cleanroom by the chemical group

Copper plated Beamline Components QA Goals

- No outgassing! No flaking!
- Analysis by Andrei Lunin:

Noted that project needs to develop standardized acceptance criteria for the plating imperfections to reduce the subjectivity

Heat Loads Per Cavity*, [mW]

Beam Line Component	Copper Plated				No Plating	
	+5 mm		1st groove only			
	RF	Wake	RF	Wake	RF	Wake
Flange at 105 mm	76	16	95	18	150	20
Flange at 140 mm	1.4	16	1.6	18	2.6	20
Bellow, 5 conv. L= 100 mm	2	20	2	20	100	300
Total	130		155		600	

*Accelerating gradient: 16.5 MV/m

Workflow

1. Lesker fabricates the beamline components
2. JLab performs leak check and surface roughness measurements (only on flanges)
3. Nomura Plating performs copper plating and conducts post plating QC steps
4. Components deemed to be accepted by Nomura are shipped to partner labs
5. Partner labs perform incoming QC:
    1. Visual QC
    2. Fix the flange surfaces scratches
    3. Leak check
    4. Copper plating visual check pre and post cleaning