Bare and Partially Dressed Cavity Preparation for Cold Test Validation

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on behalf of
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With inputs from
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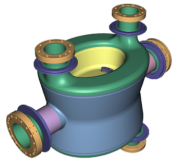
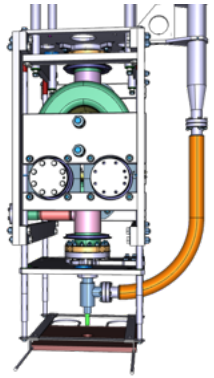
and Eric's BE-RF-PM Team
Eric Montesinos, Sebastien Calvo, Emile Grospelier, Antoine Boucherie, Frida Eriksson

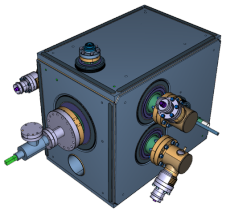
Outline

- **Bare cavity reception**
  - Mount frame
  - Degrease
  - HPR
  - Clean room assembly (follow T. Jones talk)



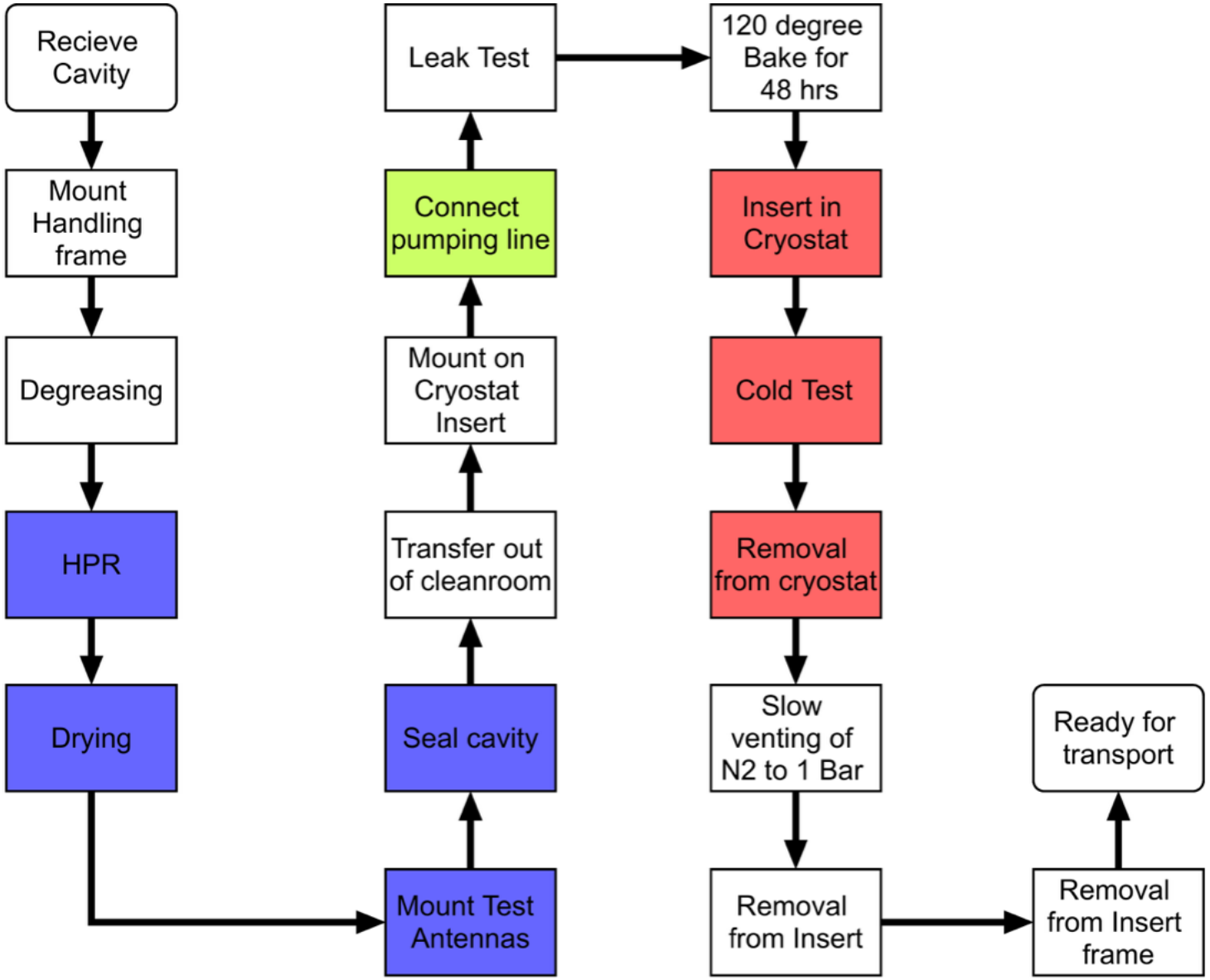


- **Bare cavity test**
- **Cavity + He tank reception**
  - Degrease
  - Clean room assembly of HOMs and field antenna (follow E. Montesinos' talk)

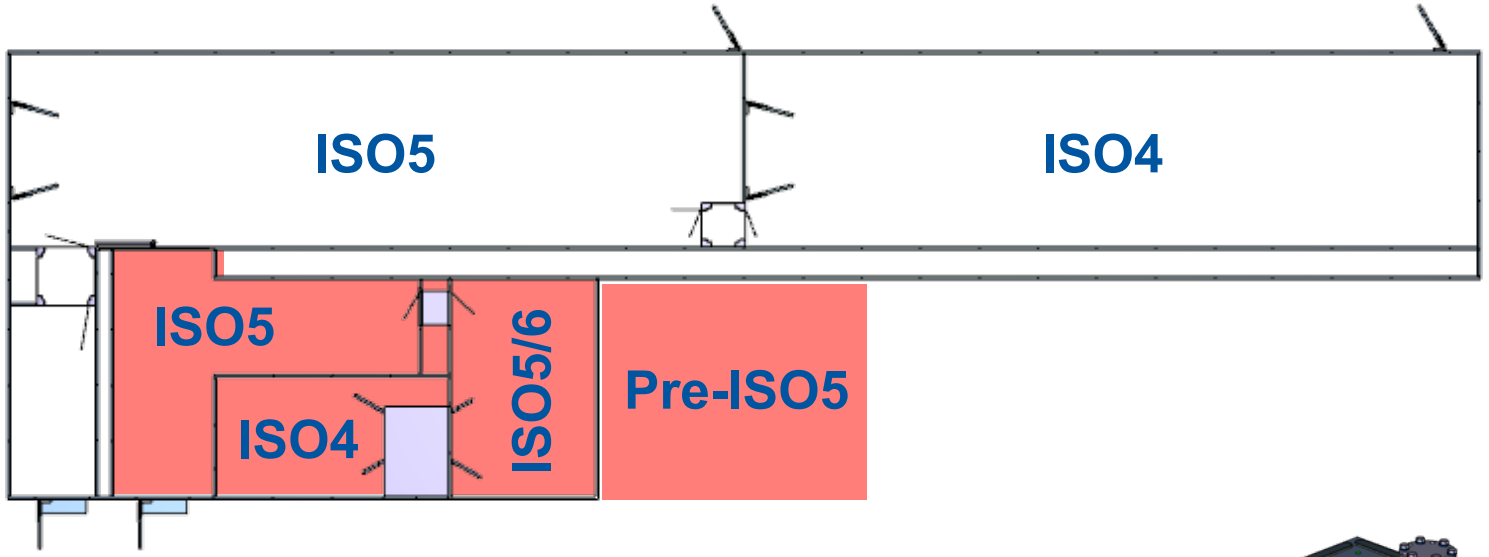


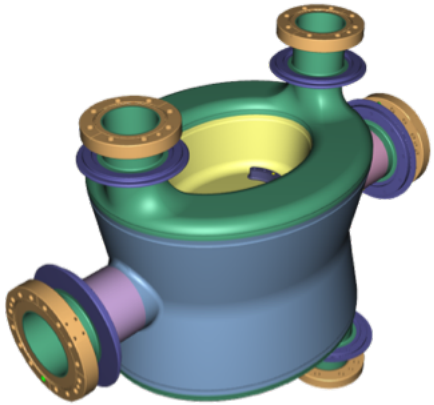
- **Partially dressed cavity test**
- **Back to clean room**
  - Hand-of for FPC mounting (follow E. Montesinos' talk)
- **Send to string assembly** (follow A. Macpherson's talk)

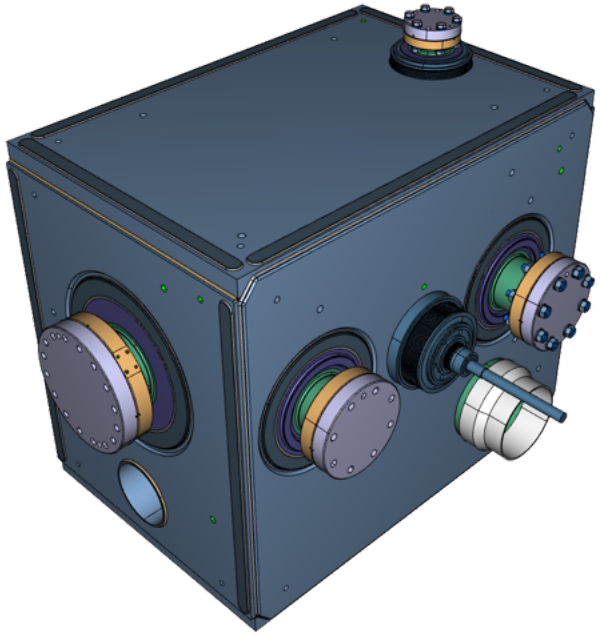
Bare Cavity Workflow



Bare Cavity Preparation and Validation



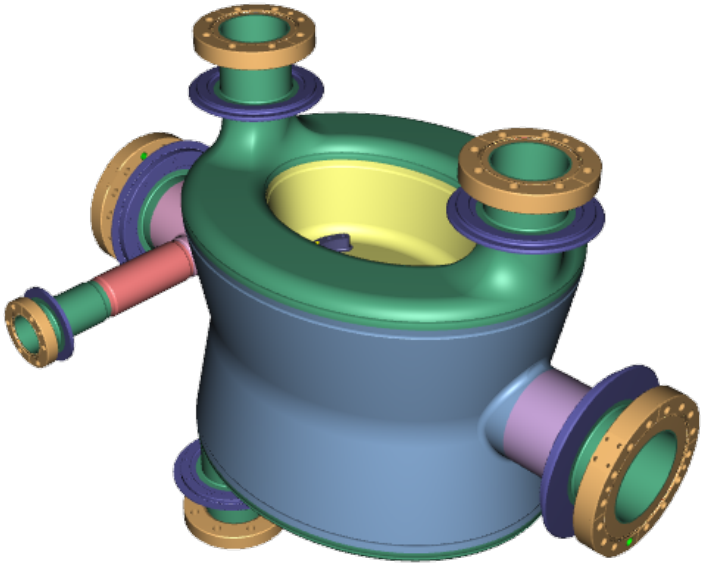


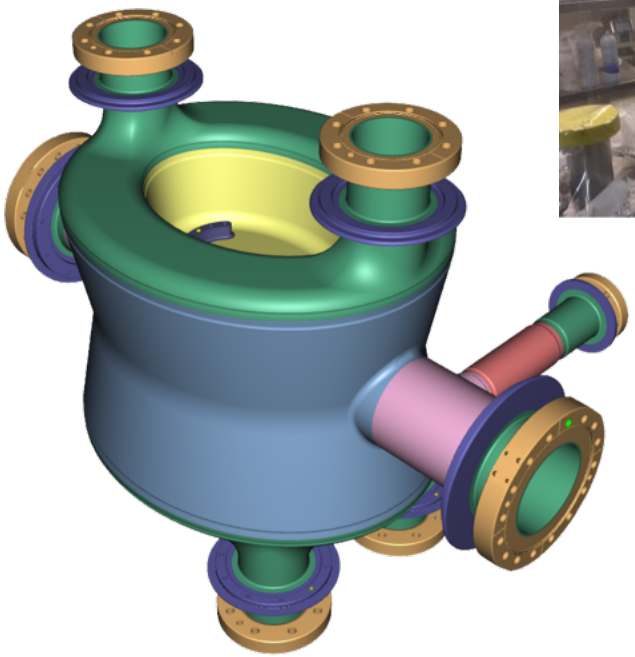


- See talks by E. Montesinos

Bare Cavity Reception

- **Delivery by internal transport to the SM18**
  - PVC caps + plastic bagged
  - Handling and mounting done in Pre-ISO5 area



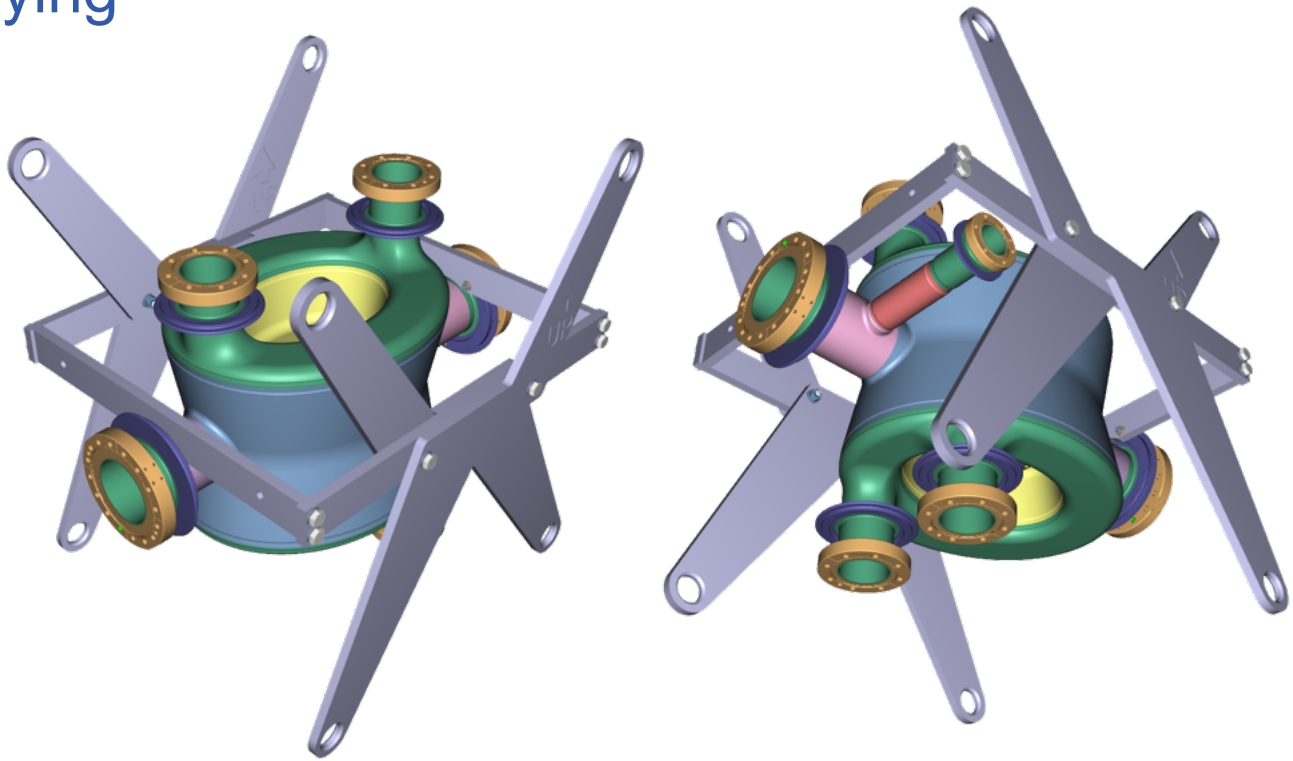


Reception in Pre-ISO5

Handling Frame Mounting

- **Customised interface**
  - Transporting
  - Handling
  - Drying

Mounting in Pre-ISO5



- **Plastic bagged and transported to BAT 857**

Degreasing

- **Cleaning steps**
  - 4 hours submerged detergent
  - 1 hour in ultrasound at 55 C
  - Low pressure UPW rinsing
  - Immersion in demineralised water
  - Cleaning with propanol
  - Drying with clean nitrogen

Degreasing in BAT 857

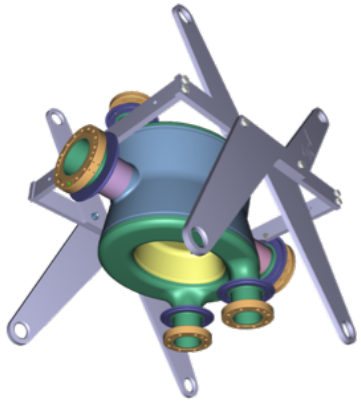
- **Shipping preparation steps**
  - Clean PVC flange mounting (no-aluminium) with stainless steel bolts (w/o silver coating)
  - Double plastic bag filled with nitrogen

- **Transport back to SM18**

Reception Post-Degreasing

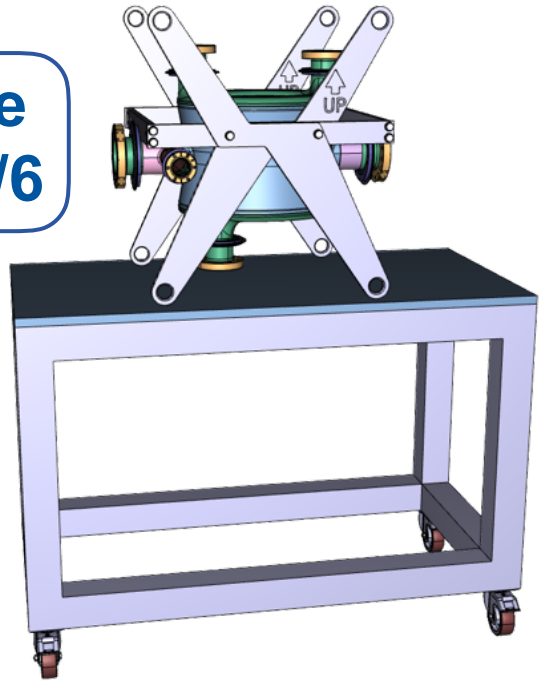
- **Reception of double bagged cavity**
  - Removal of plastic bags
  - Blow with ionised nitrogen

Receive in Pre-ISO5



- **Move to ISO5/6 area**
  - Blow with ionised nitrogen
  - Removal of PVC caps
  - Second Blow with nitrogen following the corresponding particle counts criteria (see T. Jones talk)

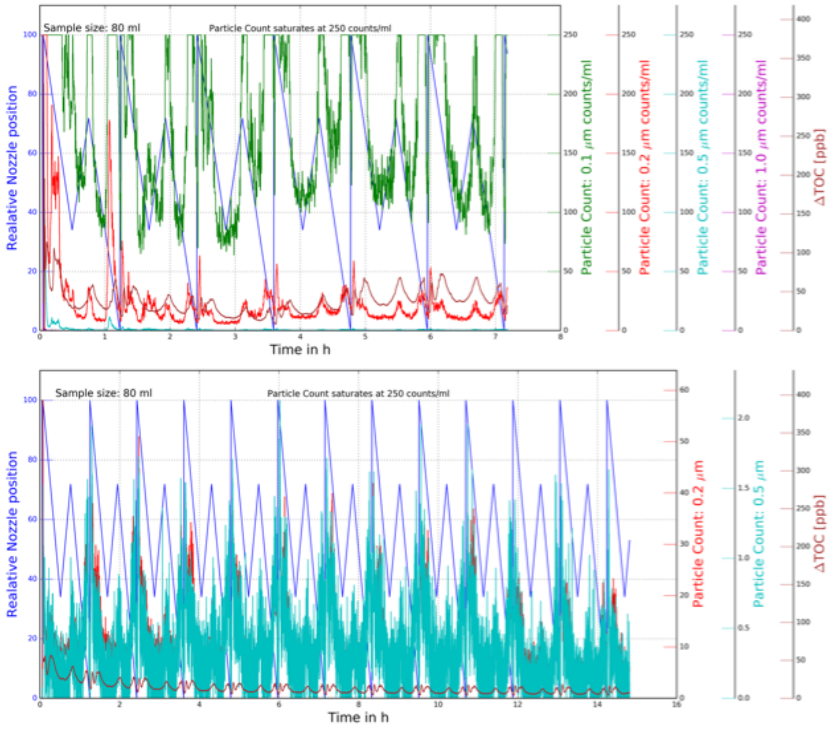
Prepare in ISO5/6

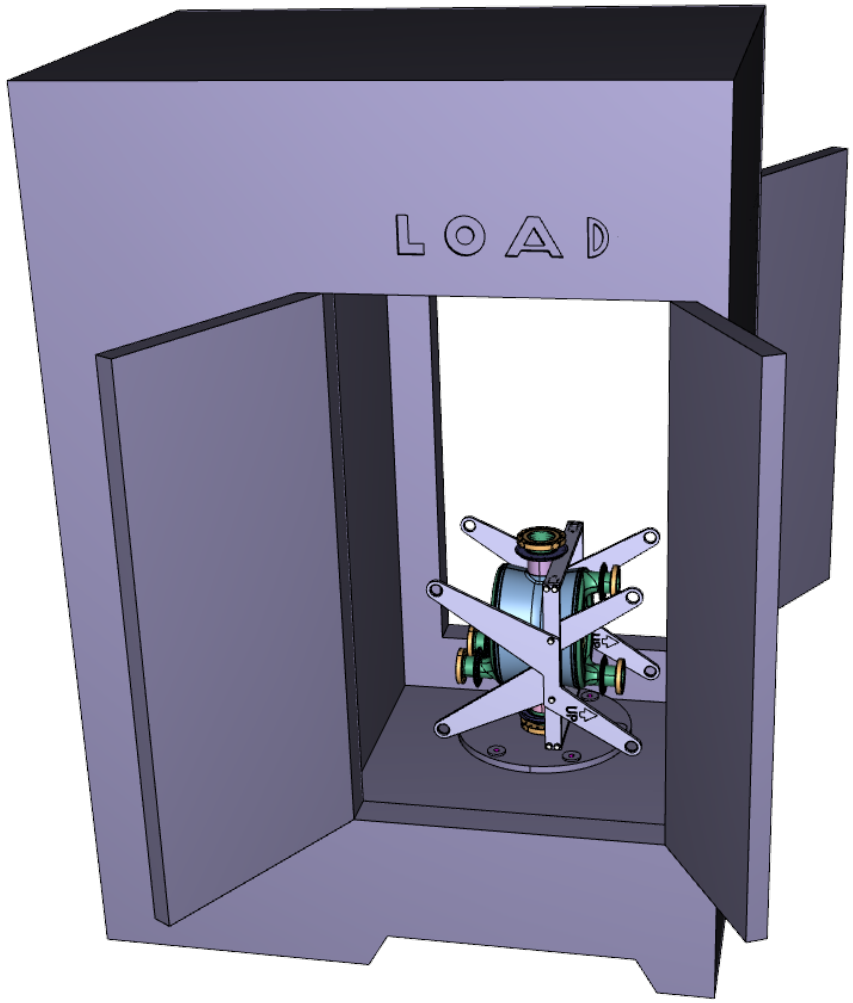


High Pressure Rinsing

- **Mount into HPR cabinet**
  - Low pressure rinse
  - HPR at >60 bar for ~14 hours (based on counters' lectures)

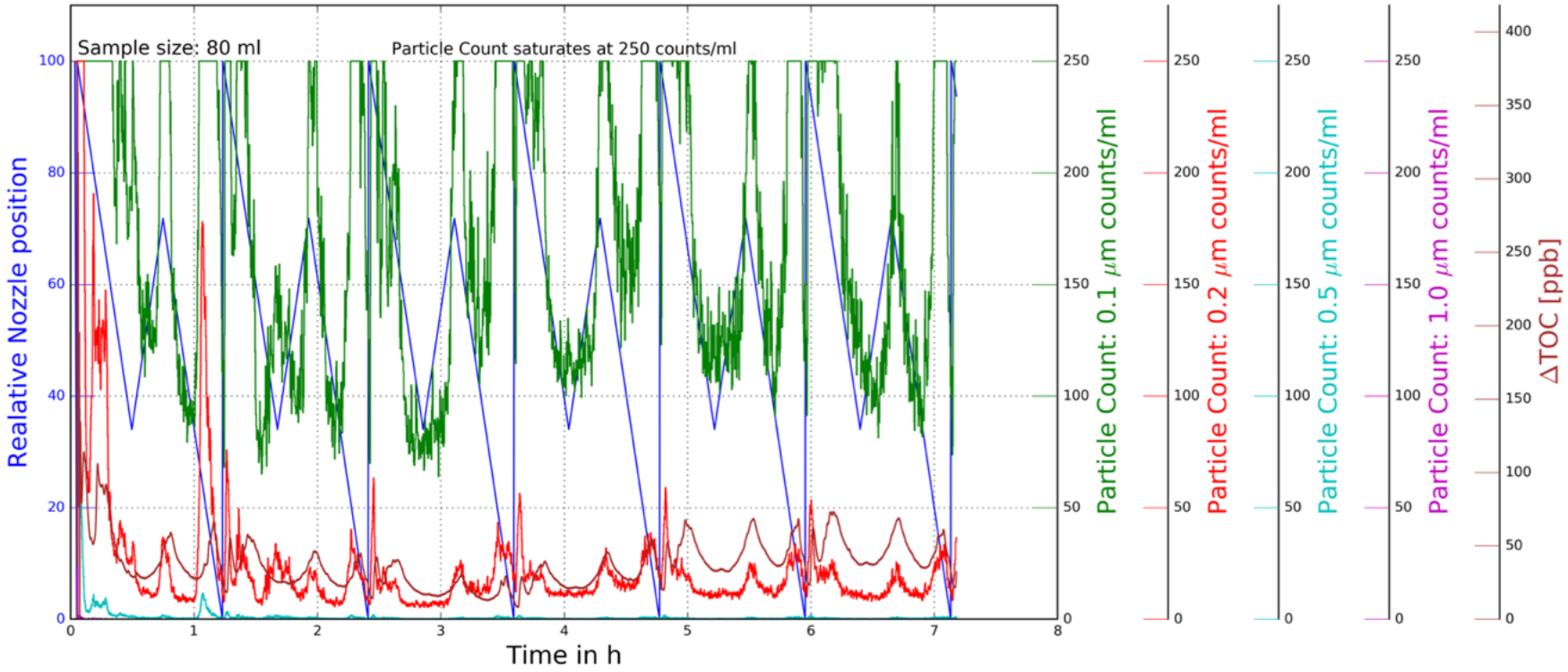
HPR ISO5/ISO4





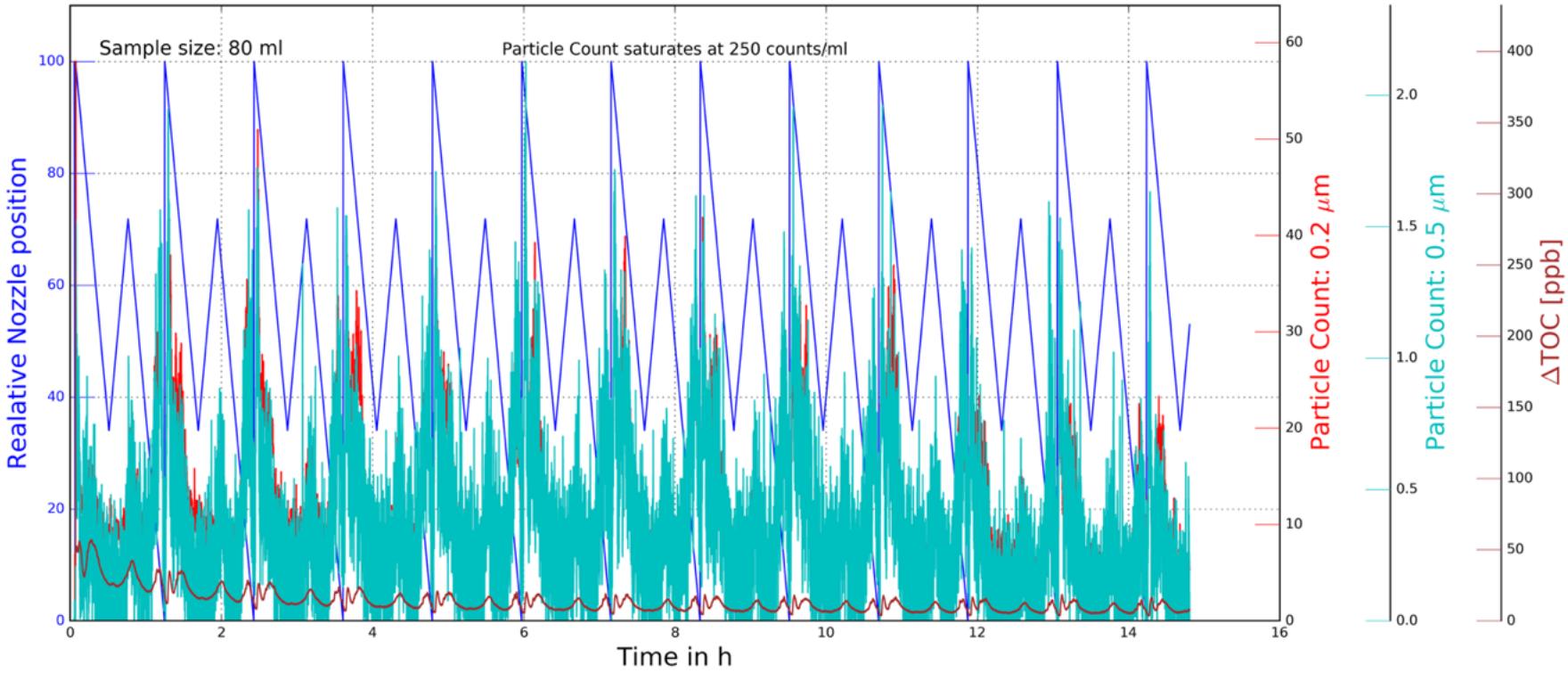
High Pressure Rinsing

- DQW PoP 1st rinse



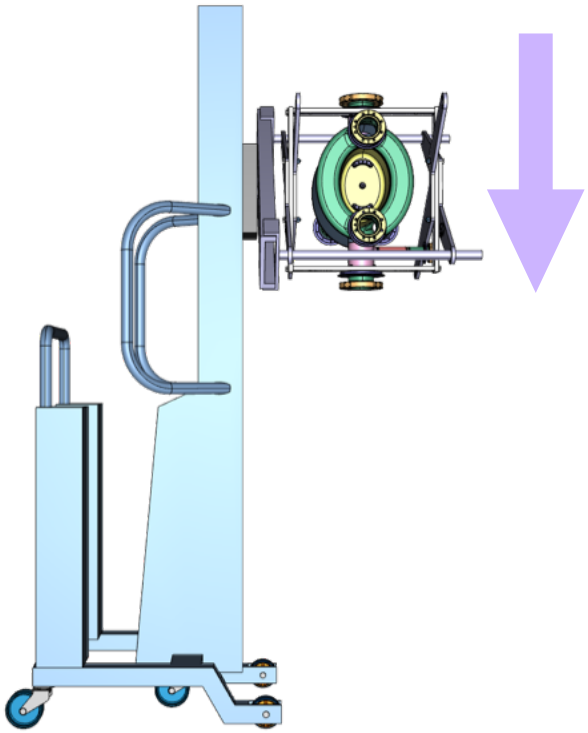
High Pressure Rinsing

- DQW PoP 2nd rinse

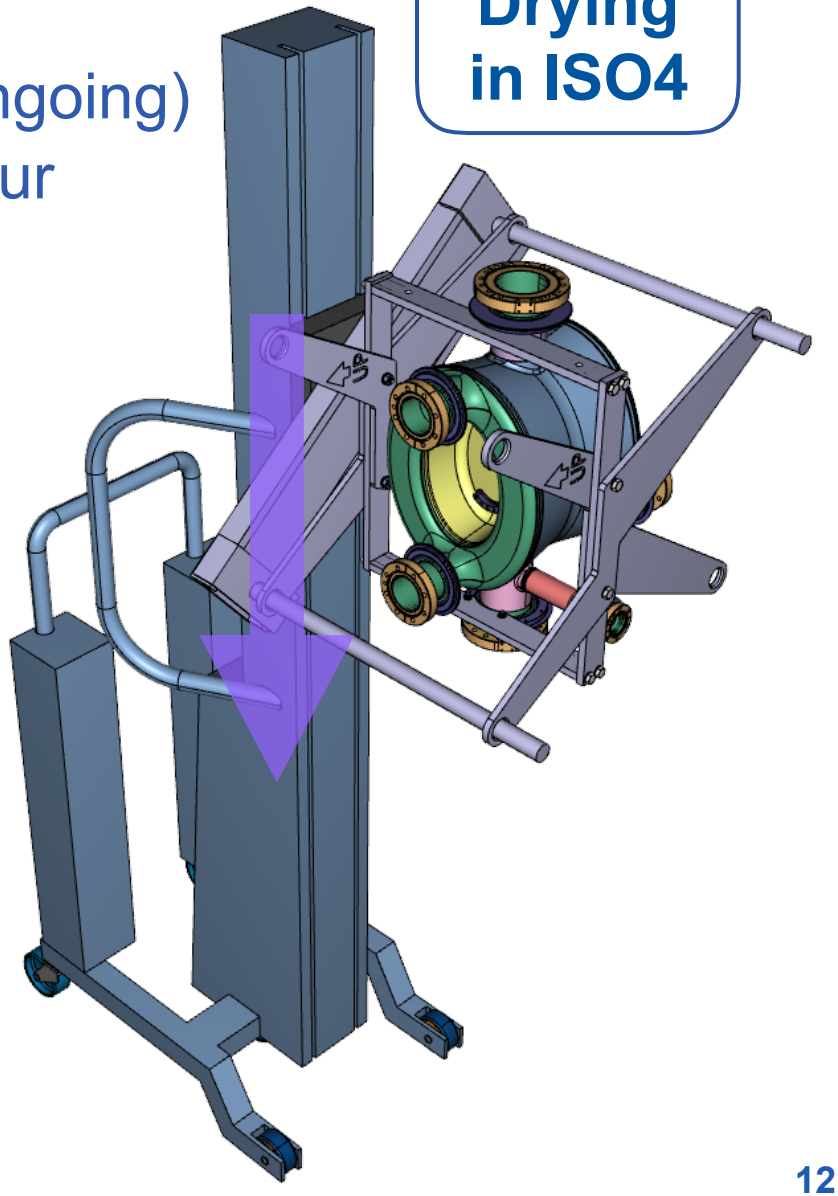


Clean Room Cavity Handling

- **Handling/drying robot**
  - Commercially made (order ongoing)
  - Min 1 turn/day, Max 1 turn/hour
- **Drying for 12 hours**
  - Under laminar flow



Drying in ISO4



Clean Up Assembly Components

- **All steps described by T. jones**

ISO5/6

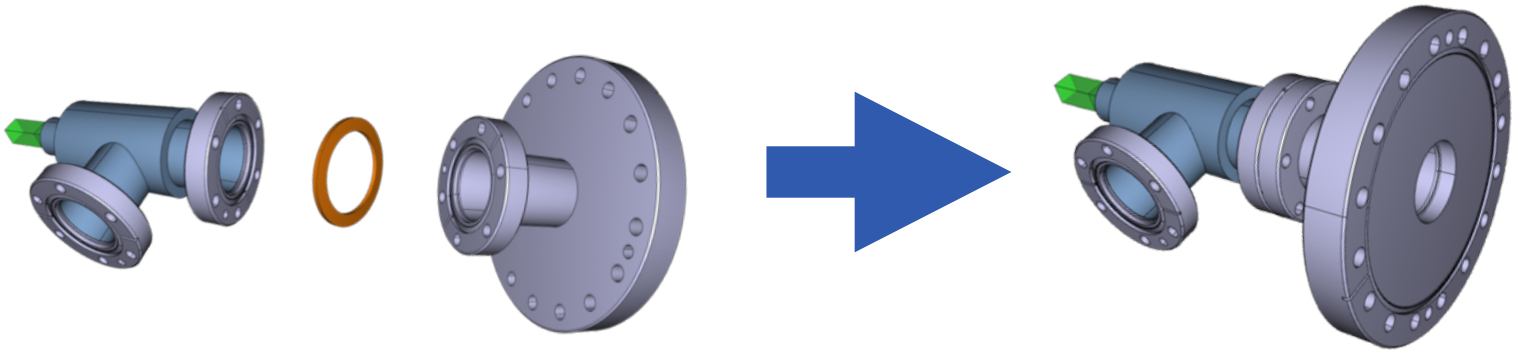
↓

ISO4

- Move to ISO5 using SAS
- Move to IS04

Pre Assemblies I

- **In ISO4**
  - Blow with ionised nitrogen following the corresponding particle counts criteria
  - Pre assembly components

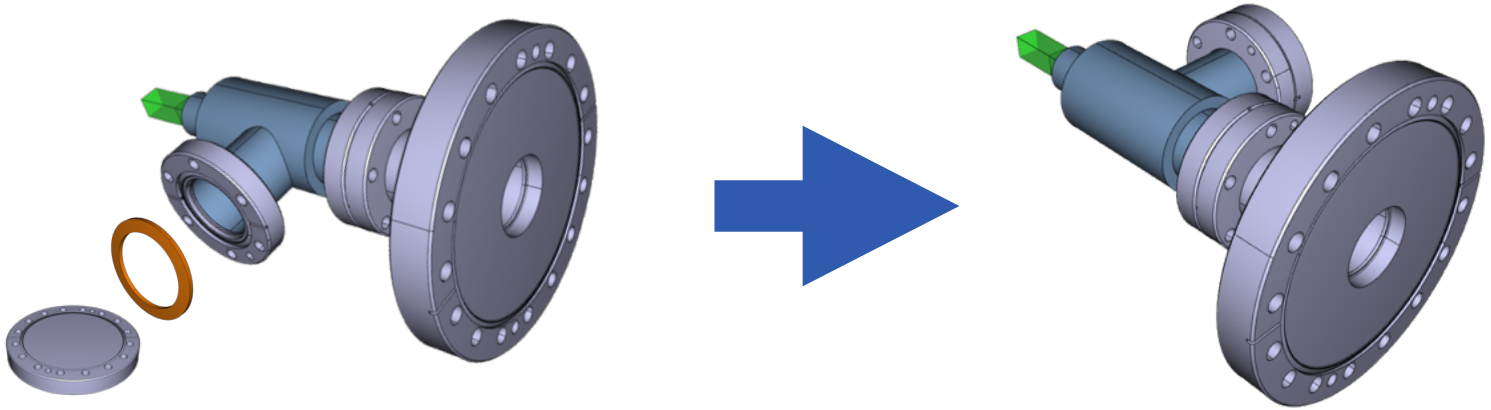


  - Blow with ionised nitrogen following the corresponding particle counts criteria

ISO4

Pre Assemblies II

- **In ISO4**
  - Pre assembly components



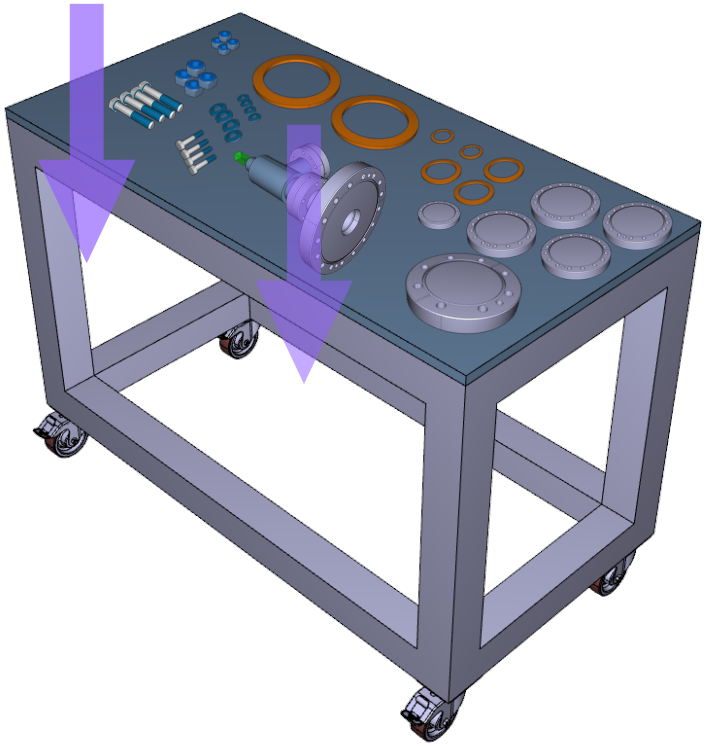
- Blow with ionised nitrogen following the corresponding particle counts criteria

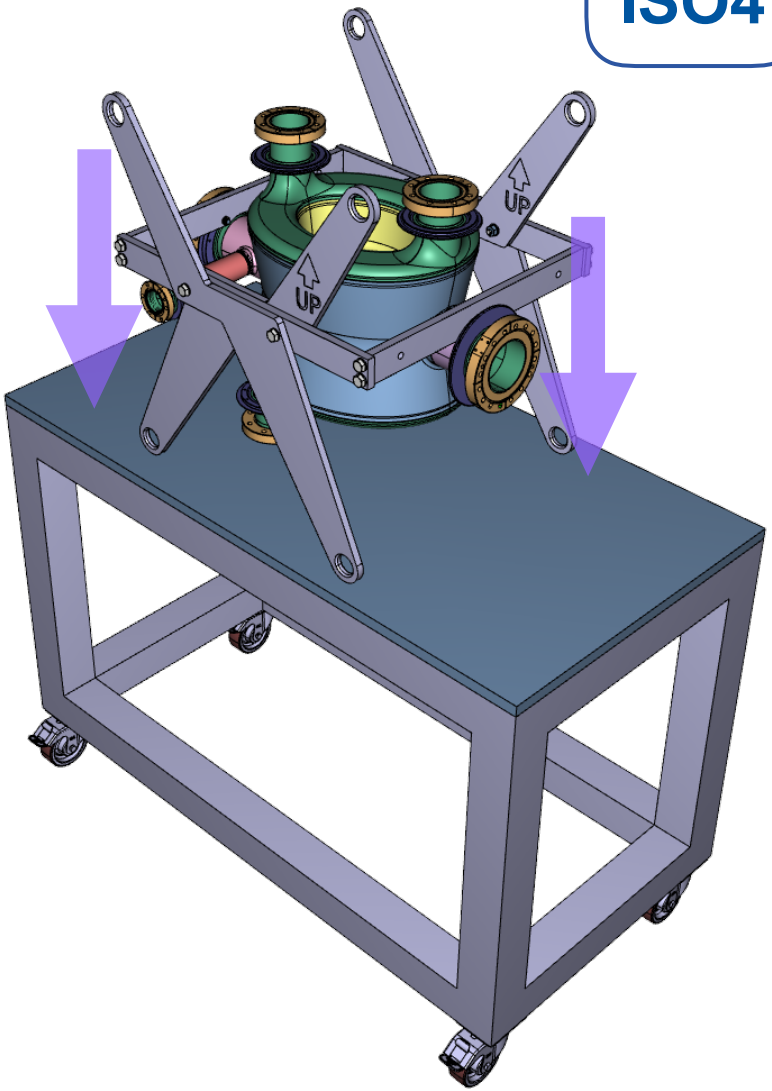
ISO4

Clean Room Assembly (Bare Cavity) I

- **Clean assembly**
  - Parts and pre-assemblies ready
  - Under laminar flow
  - Systematic sequence

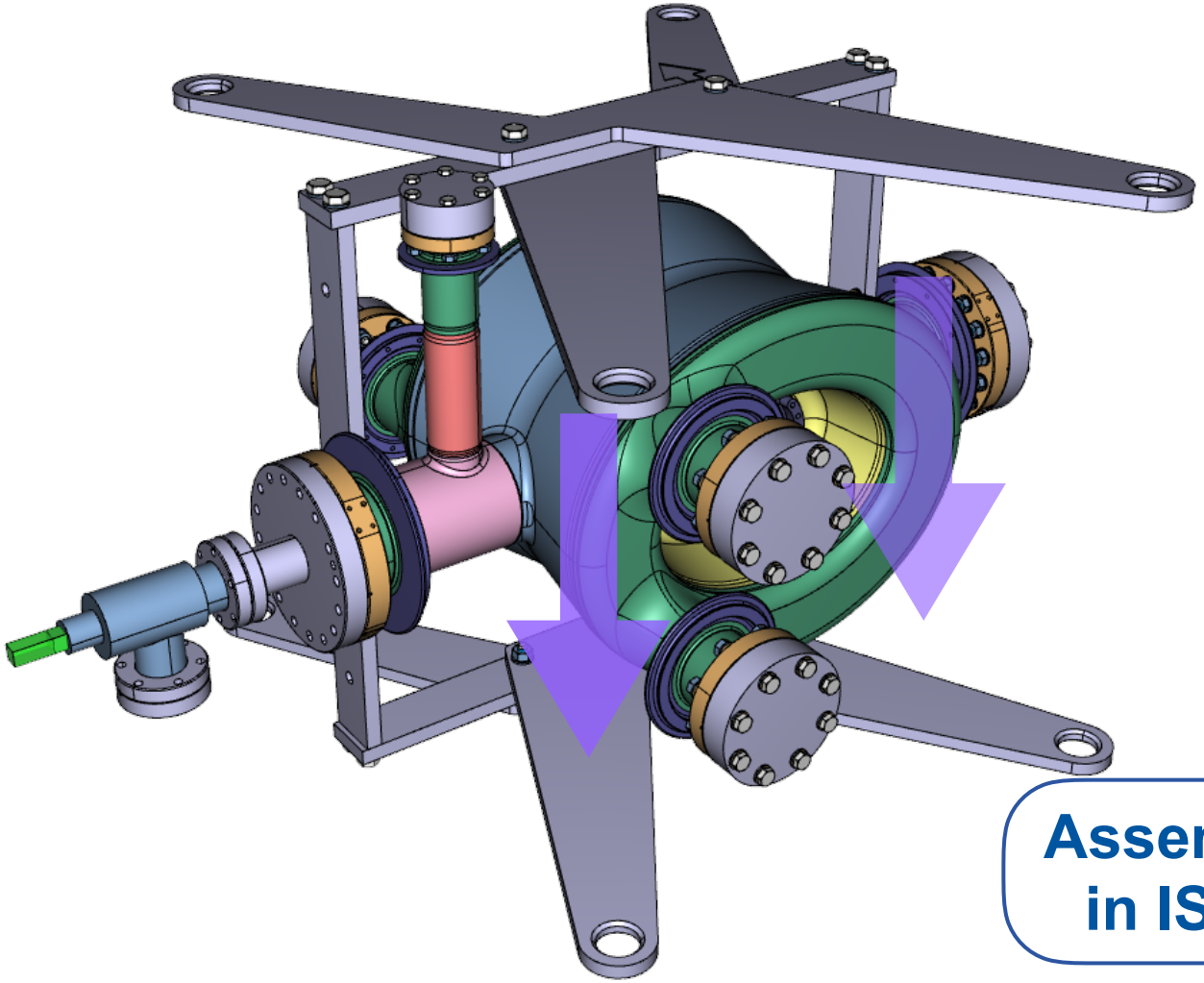
ISO4





Clean Room Assembly (Bare Cavity) V

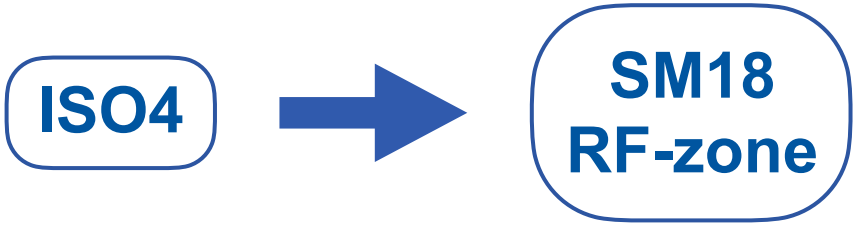
- All the sequence under laminar flow

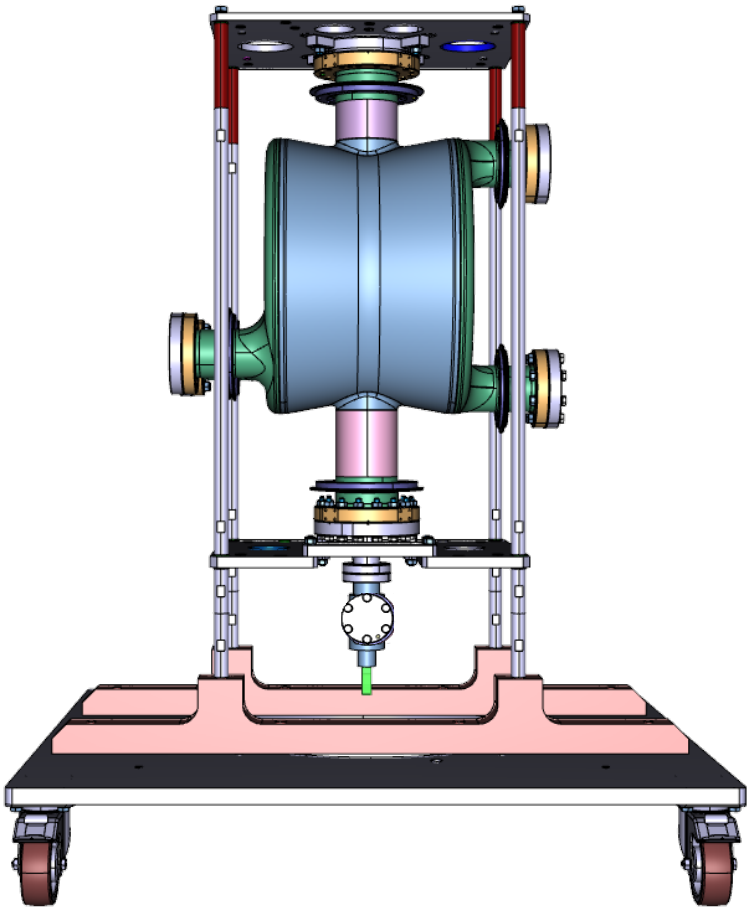


Assembly in ISO4

Leaving the Cleanroom for Insert

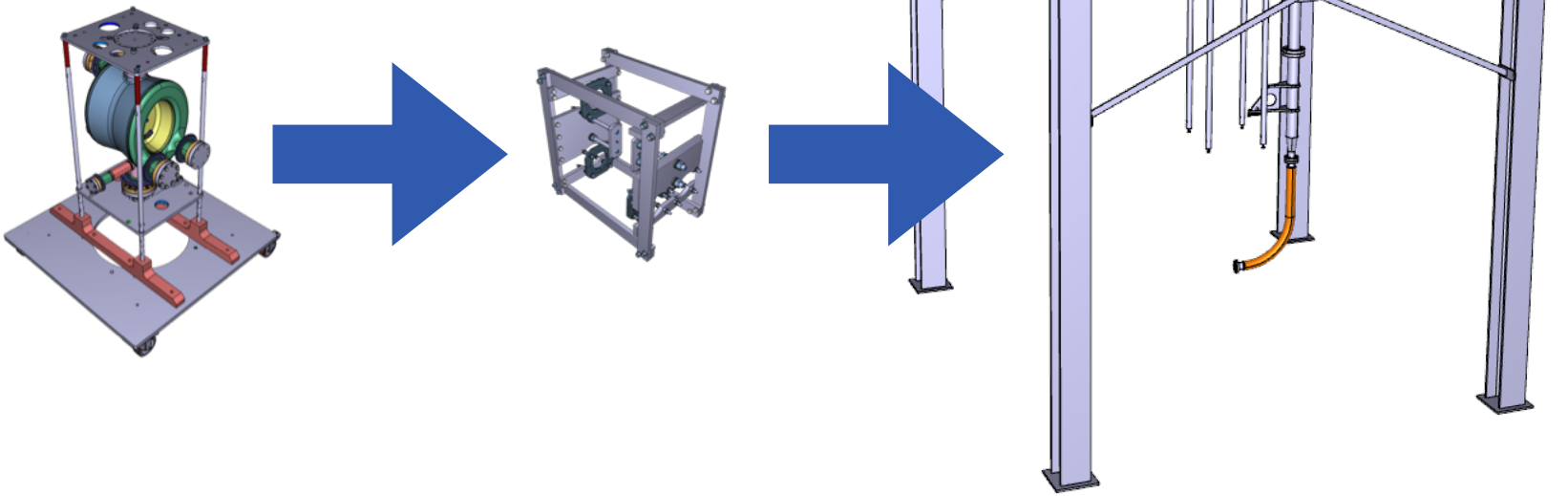
- **Leave cleanroom**
  - Mount on chariot
  - Remove handling frame
- **Move to rf-zone**
  - Install stiffening frame
  - Install onto insert
- **Leak check capabilities in ISO5**
  - More vacuum line connections but cleaner environment
- **Leak check in rf-zone**
  - Less vacuum line connections but dirtier environment





Insert Installation

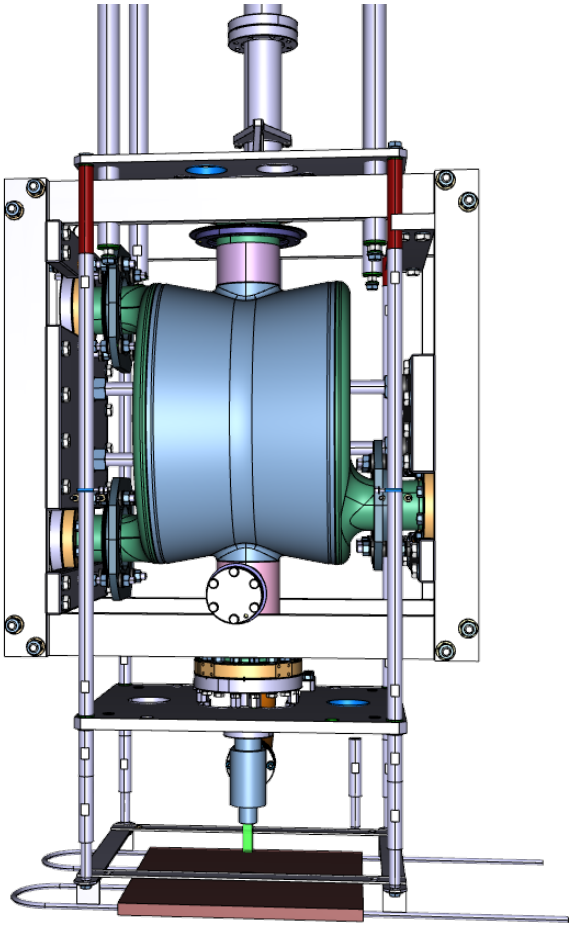
SM18
RF-zone

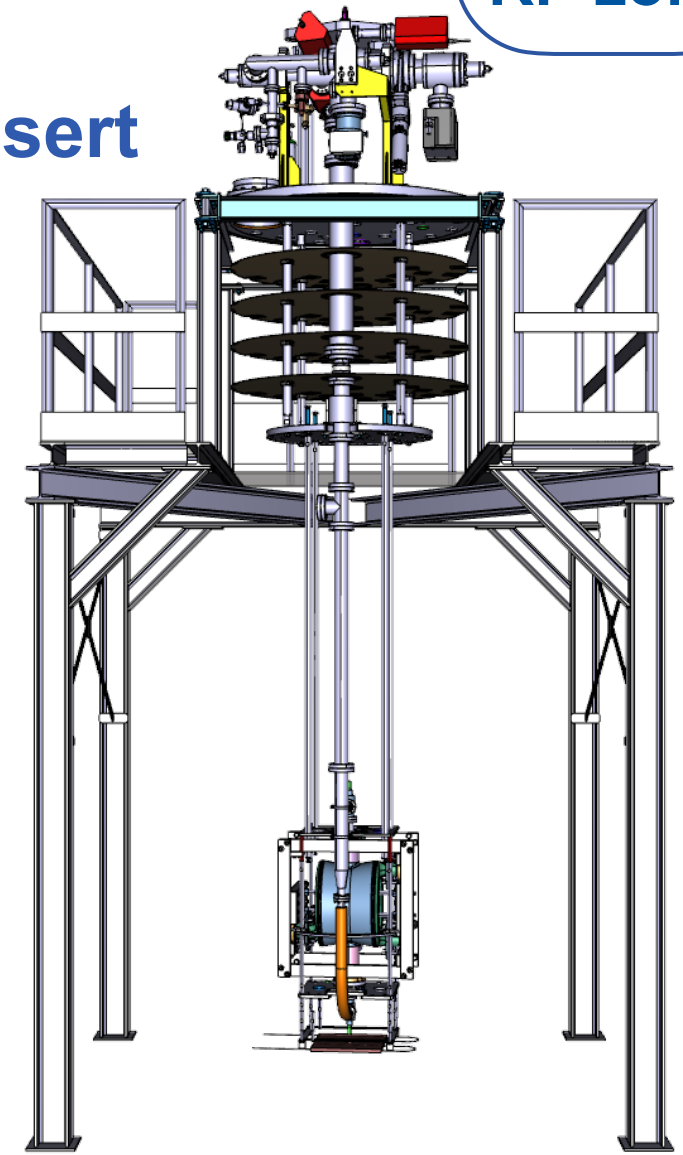


Insert Installation

SM18
RF-zone

- Remove from chariot
- Mechanically mount onto insert

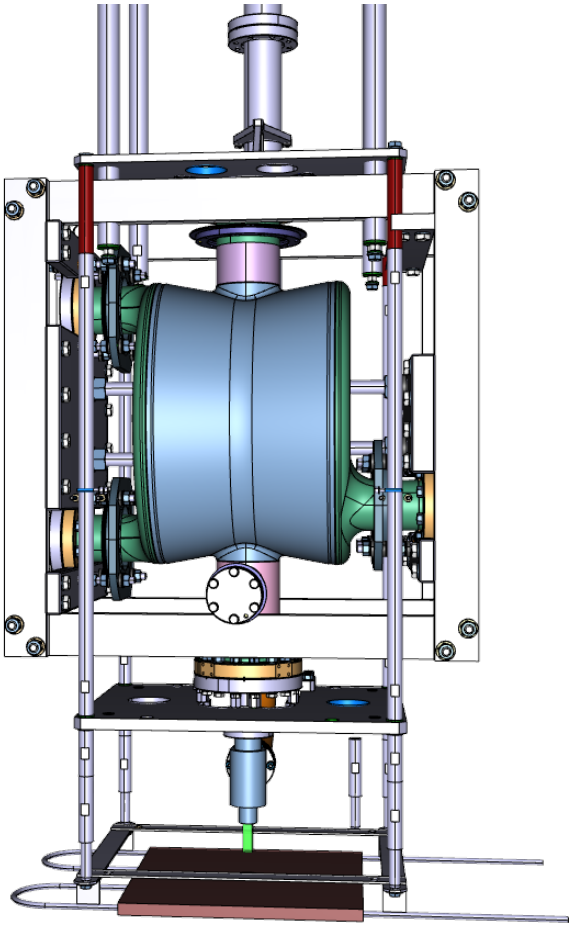




Insert Installation

SM18
RF-zone

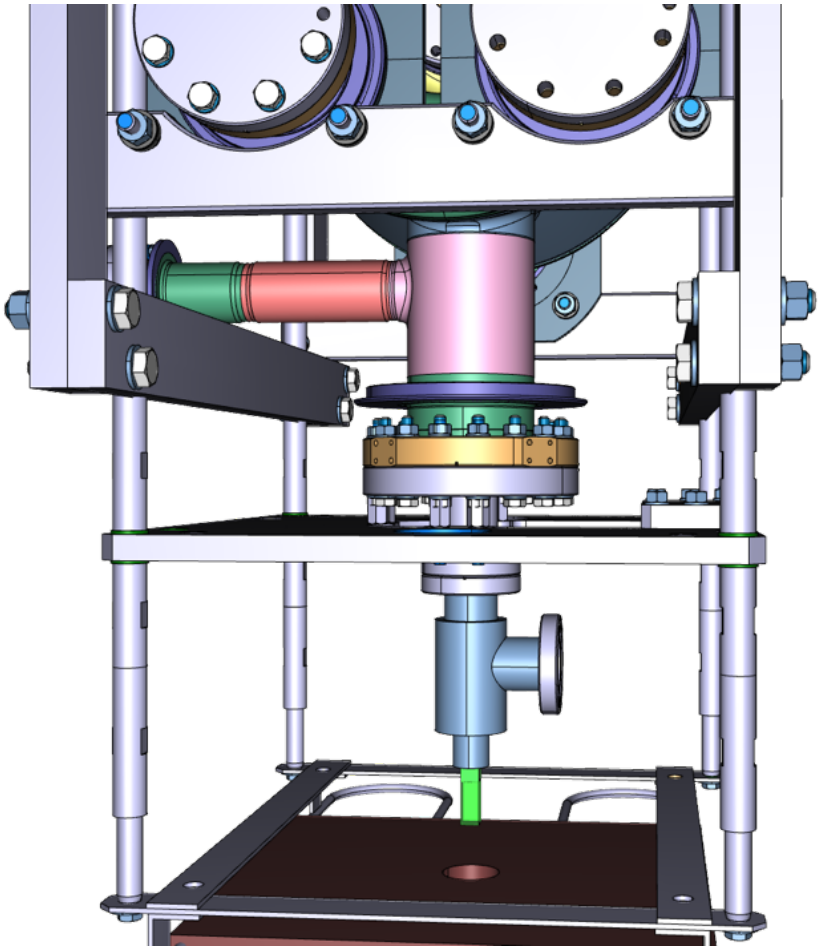
- Remove from chariot
- Mechanically mount onto



Insert Installation

SM18
RF-zone

- Use of portable cleanroom
- Reduced area of risk to 1 connection



Insert Installation

SM18
RF-zone

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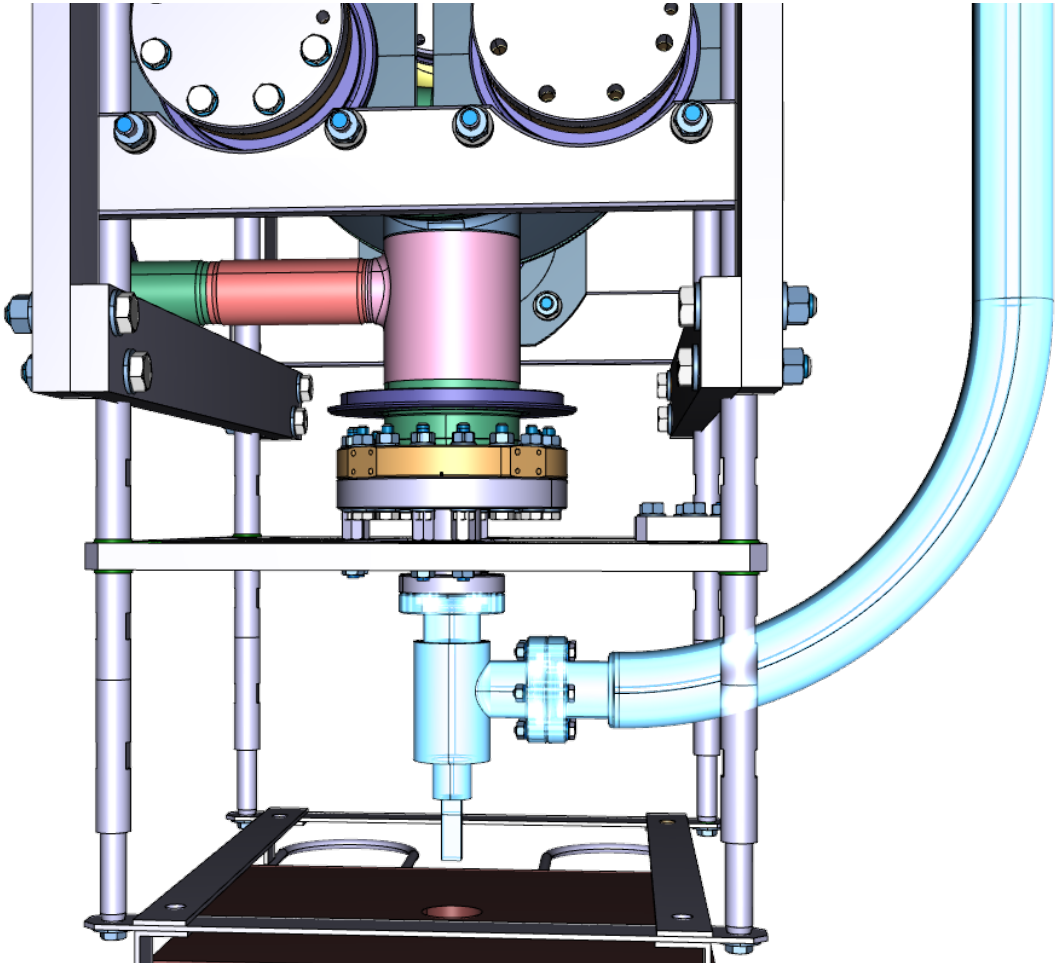


Present Vacuum Line Connection

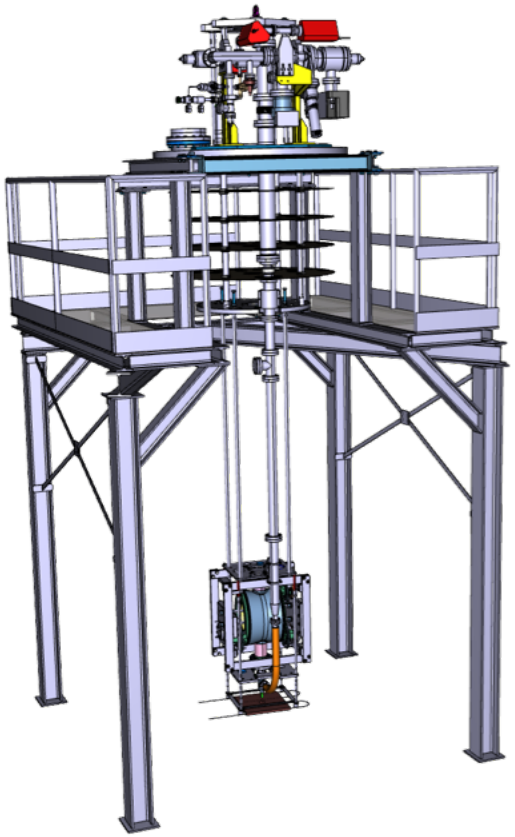
SM18
RF-zone

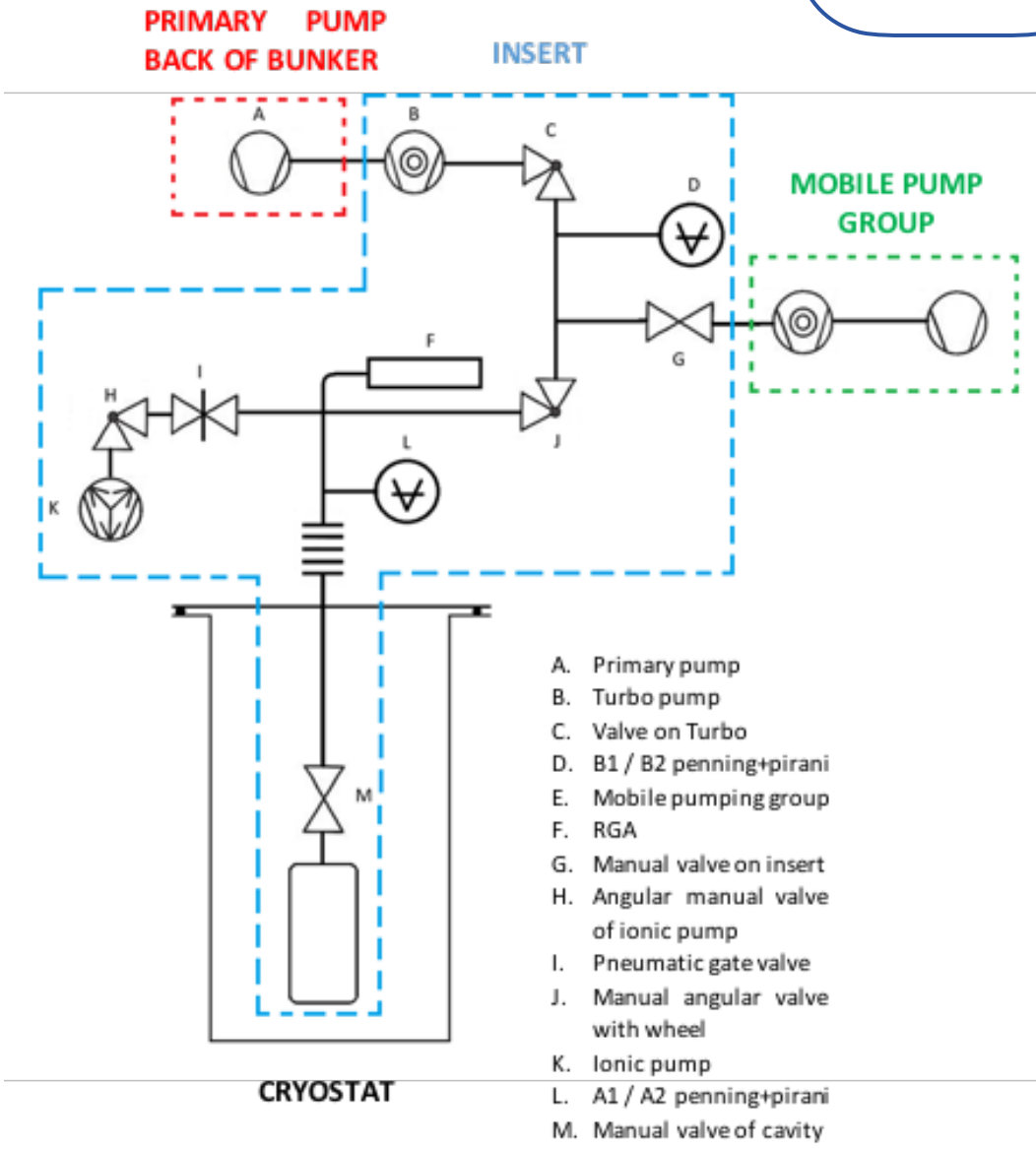
- **Use of portable cleanroom**
  - New closed portable cleanroom will be available
  - Laminar flow
- **Reduced area of risk to 1 connection**
  - A second valve is considered for isolating vacuum line
  - Cleaning of line in parallel to cavity preparation
  - Line is kept in clean conditions after test

Leak Check

SM18 RF-zone

- **Vacuum diagram**
  - Pumping groups
  - Vacuum sectors





Leak Check

SM18
RF-zone

- **Cleaning and opening of flanges**
- **Connection of vacuum line**
  - Valve on cavity remains closed
  - Valve on the insert vacuum line remains closed

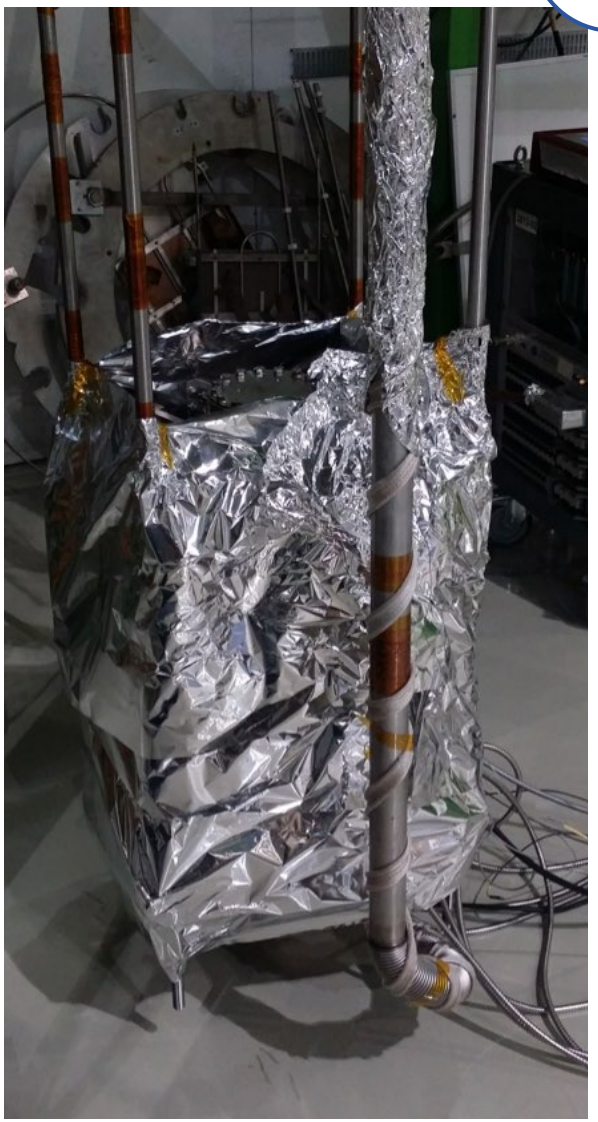
Laminar flow

- **Cleaning of insert vacuum line**
  - Open vacuum line valve
  - Standard 3-rinse cycle on pumping line with filtered N_2 0.05 um
  - Take reference RGA mass scan, it requires pressure < 10^{-6} mBar
    - If pressure is not attained, perform an 8 hours bake out
  - Flush with N_2 to ~1 Bar
  - Slowly open cavity valve
  - Pump to < 10^{-6} mBar with pumping at 2 l/min using mobile group
  - Continuous opening, 1 turn in 10 sec
- **Leak Detection Check**
  - Bag areas around flanges and blow helium inside
  - Leak detection on pumping line, acceptance level < 2 x10^{-10} mbar l/s
  - Repeat RGA mass scan
- **End of leak check**
  - Close and disconnect mobile group
  - Lower insert into cryostat and connect primary pump

Bake Out

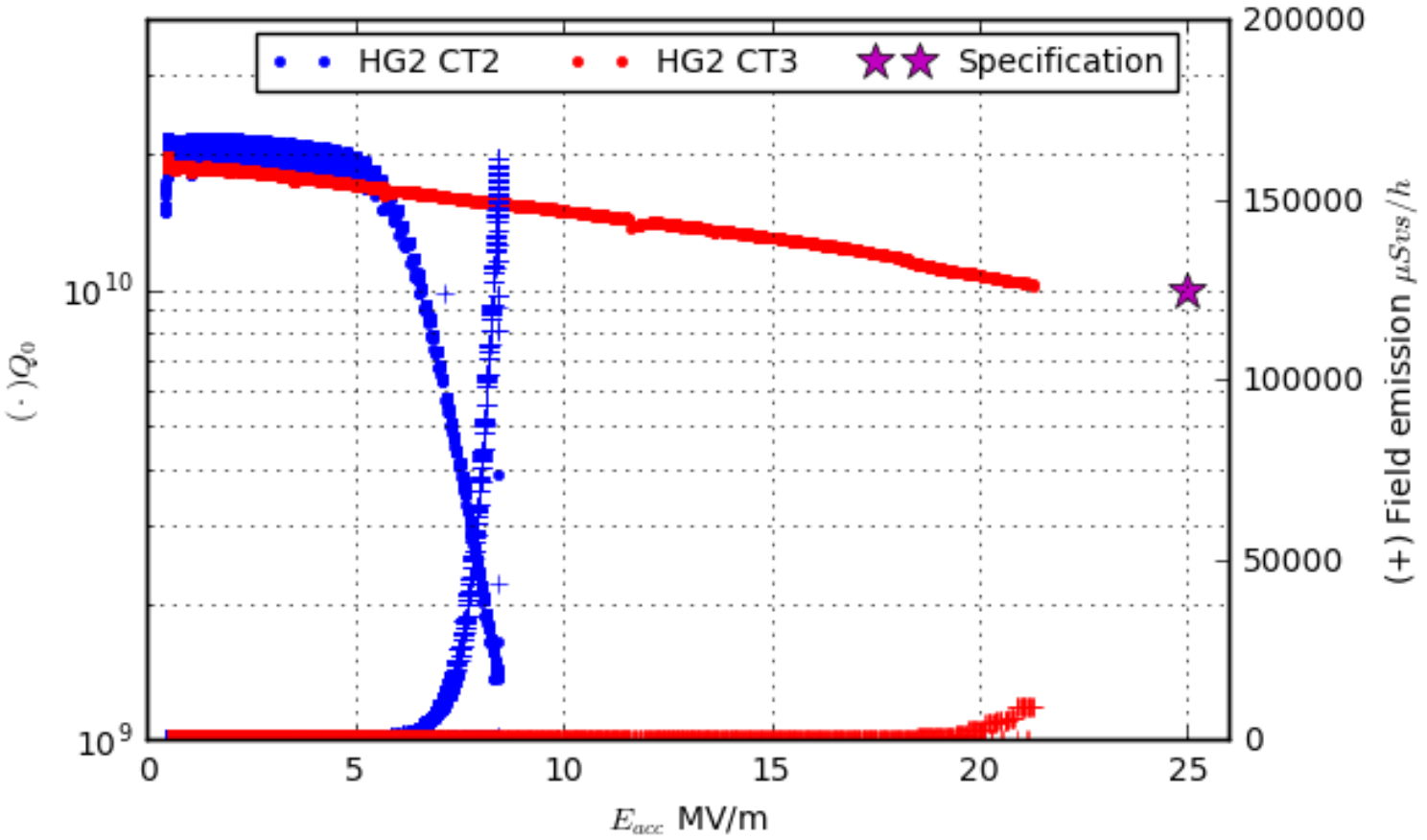
SM18
RF-zone

- **120 C for 48 hours**
  - Active pumping
  - Continuous RGA mass scan
- **Mainly to remove water and degassing**
- **Reduces multipacting**



Testing Experience in the SM18

- **Bad vs Good preparation and handling**
  - Tests of 5 cell High Gradient before/after improving preparation and handling procedures



Testing Experience in the SM18

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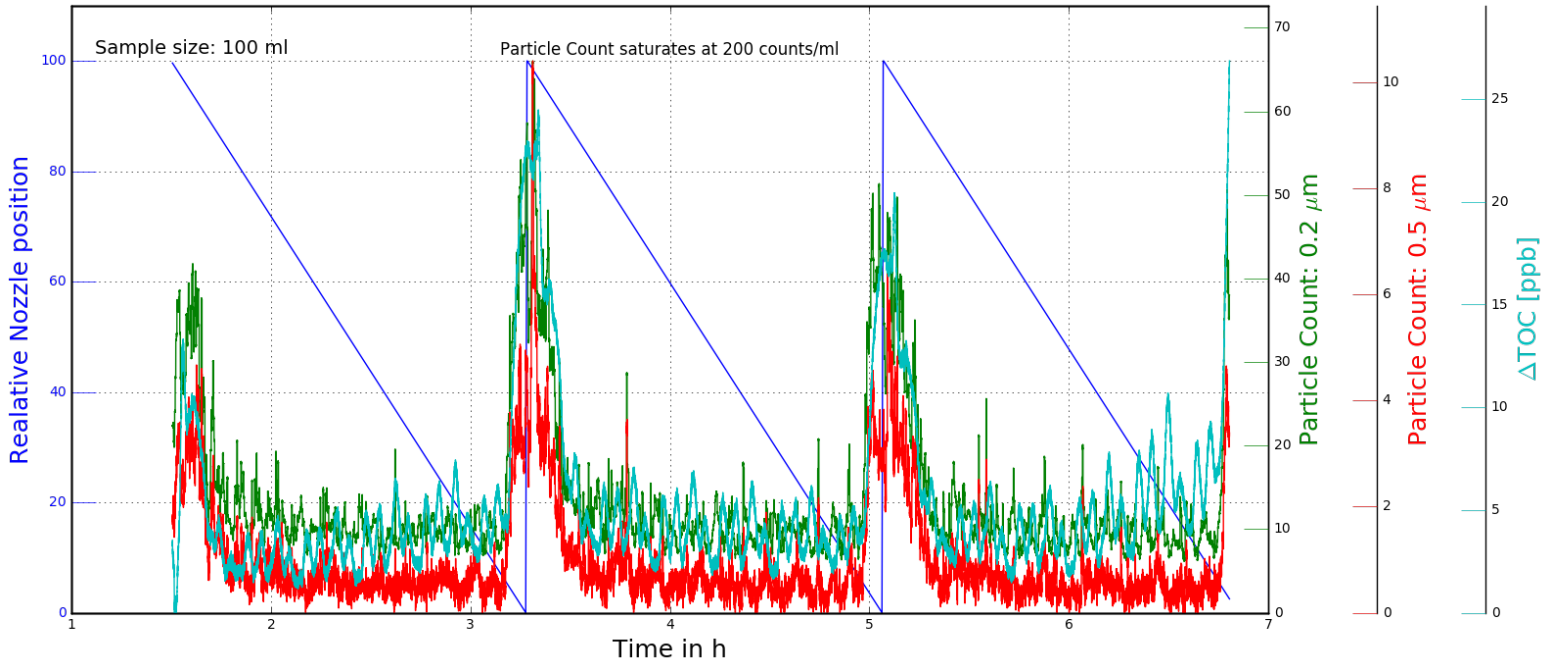
- **Bad**



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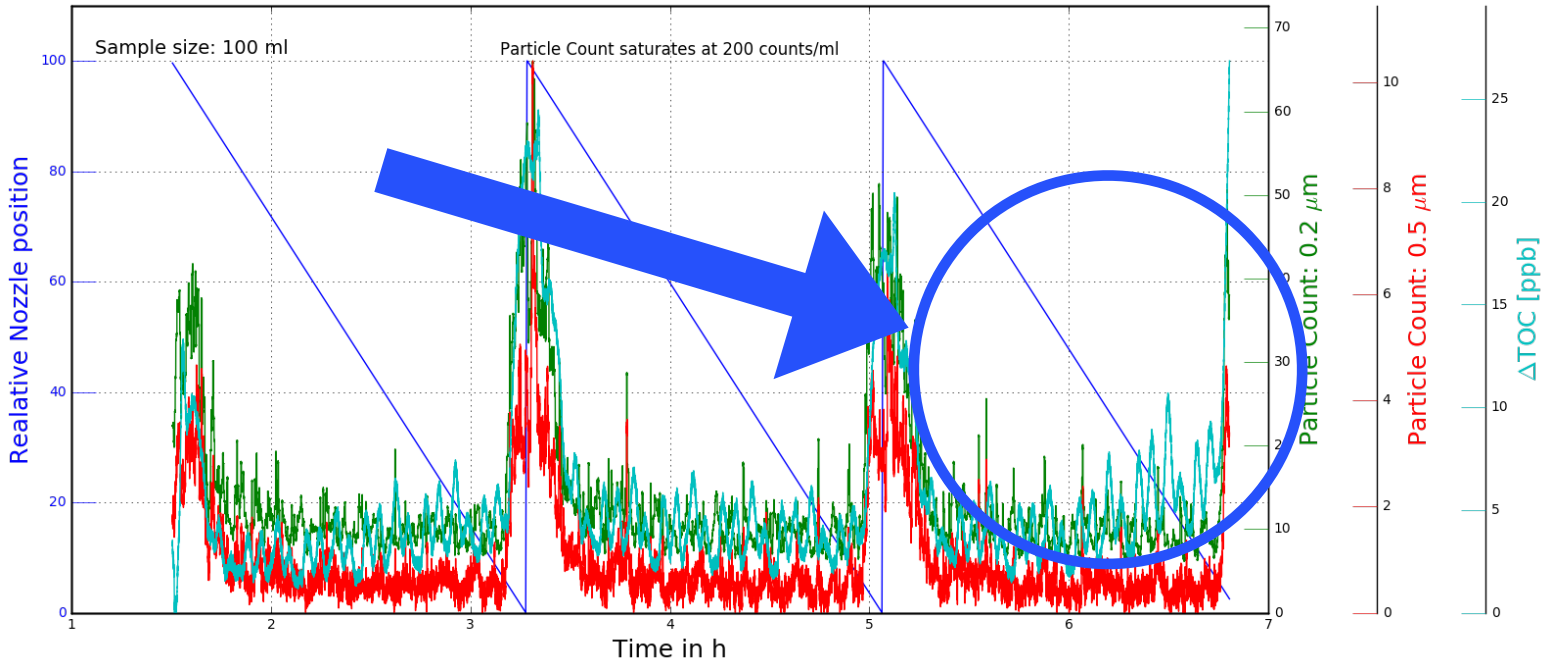

Testing Experience in the SM18

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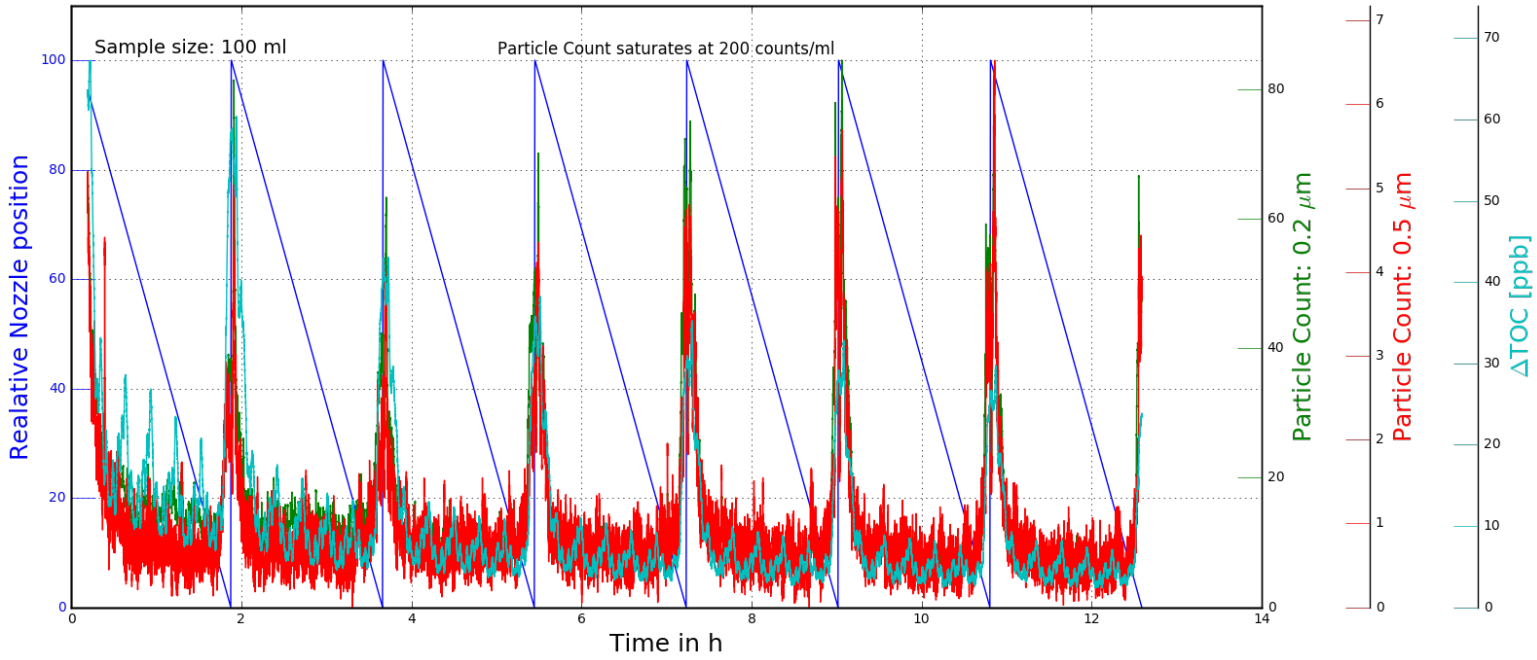
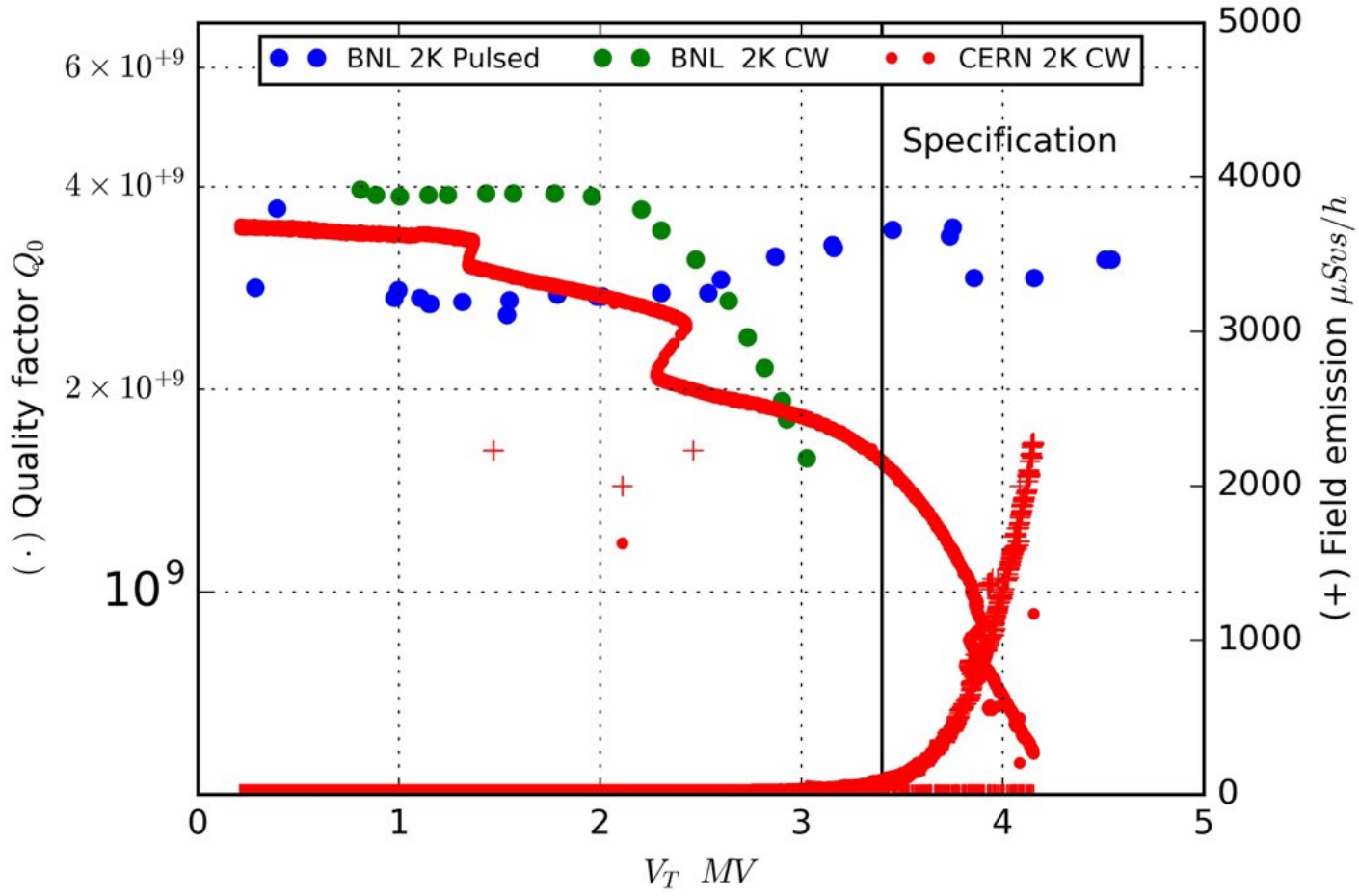
- **Good**



Testing Experience in the SM18

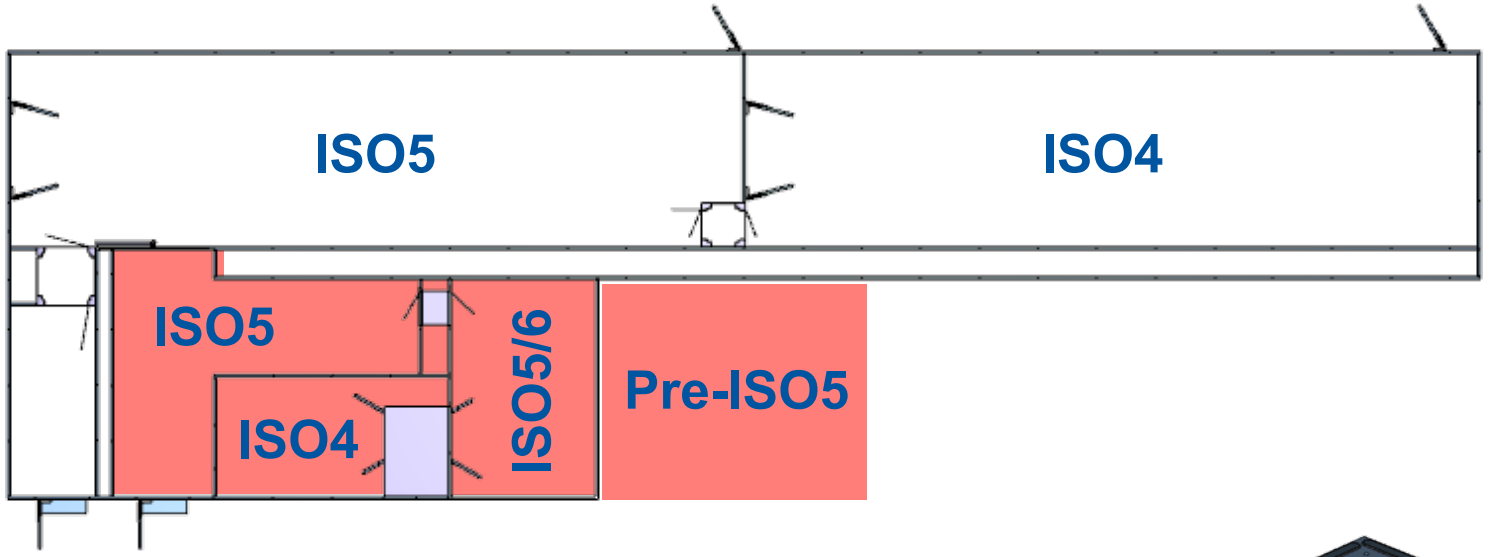
- DQW-PoP test results comparable to BNL

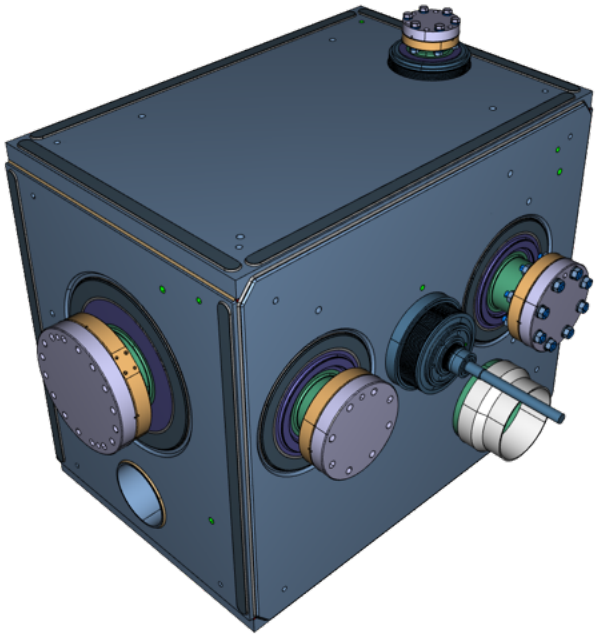


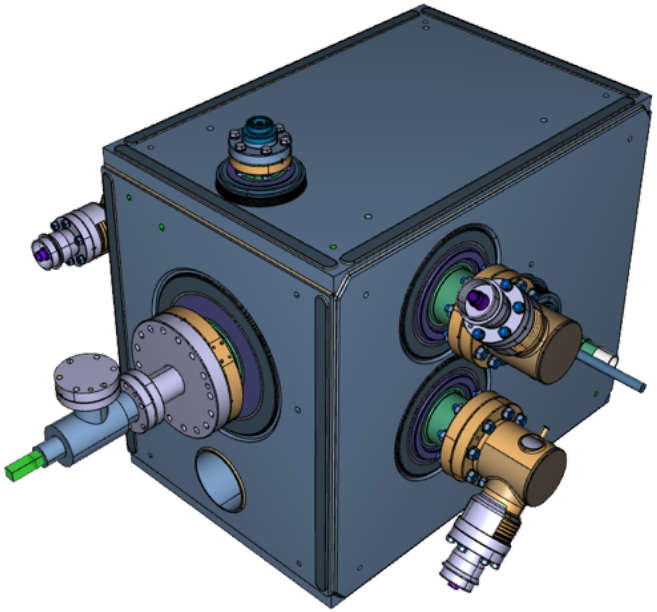
Post Test and He Tank Welding

- **Bare cavity test goals**
  - Frequency measurements
  - Take to specifications (Q_0~ 10^{10} and V_T= 3.4 MV)
- **Cavity**
  - Filled with filtered N_2 0.05 um to 1 atm
  - Stay sealed at all times until back to ISO4
- **Insert vacuum line**
  - stays sealed under 1 atm of N_2 0.05 um
- **Dismounting of cavity from the insert**
- **Stiffening frame removed**
- **Cavity is transported to the workshop**
- **He tank is leak is welded**
  - And leak checked by the workshop team
- **Cavity with He tank is sent back to the SM18**

Part. Dressed cavity Prep. and Validation



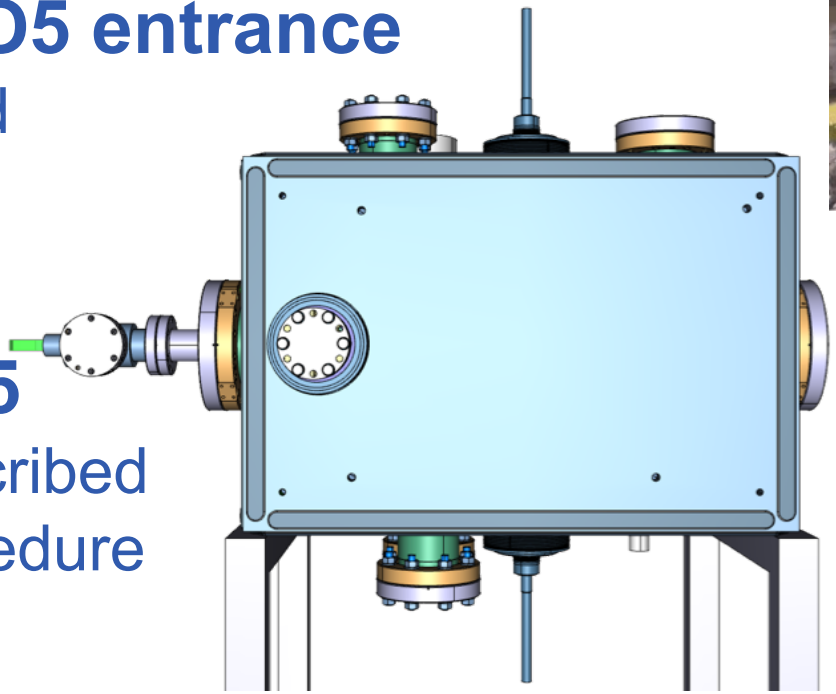




- See talks by E. Montesinos

Cavity + He Tank Reception

- **Delivery by internal transport to the SM18 pre-ISO5 zone**
  - Arrives sealed, nitrogen filled at 1 atm
  - It is wiped with propanol
  - Blowed with ionised nitrogen
  - Double bagged
- **Move to ISO5 entrance**
  - De-bagged
  - Wiped
  - Blowed
- **Enters ISO5**
  - Apply described ISO5 procedure

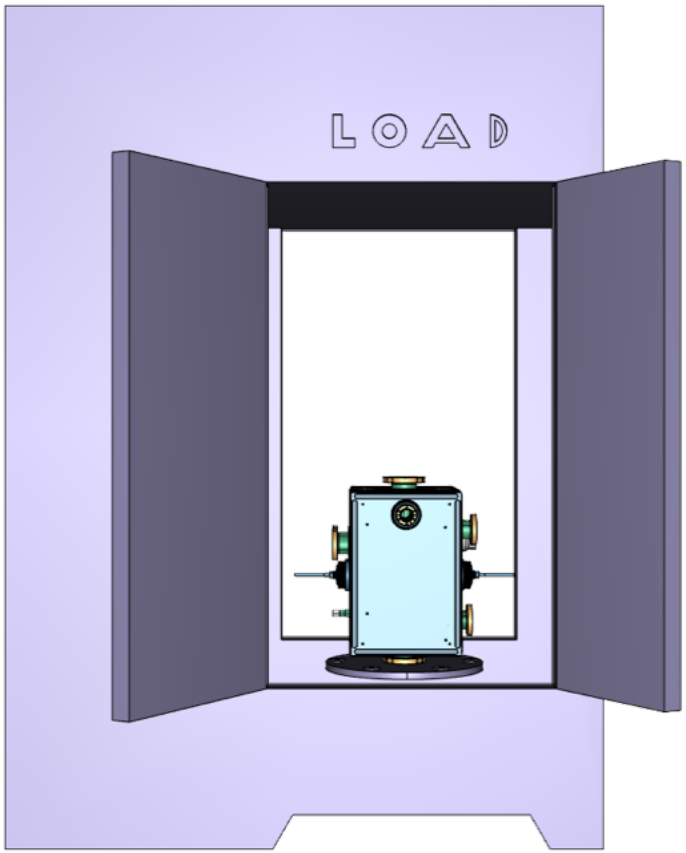


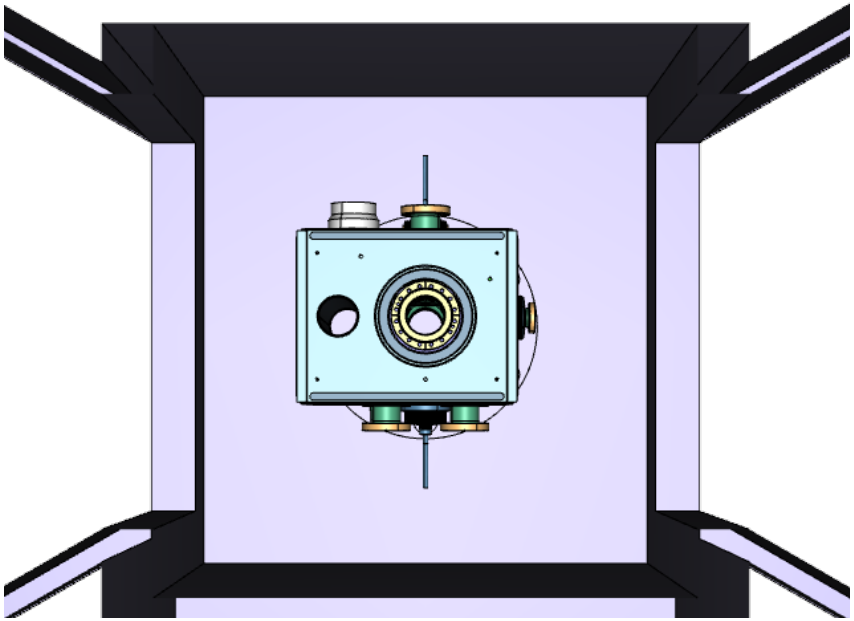
Reception in Pre-ISO5

Cavity + He Tank Preparation

- **HPR of cavity + He tank is optional**
  - Can be done if bare cavity showed radiation during testing

ISO5/ISO4

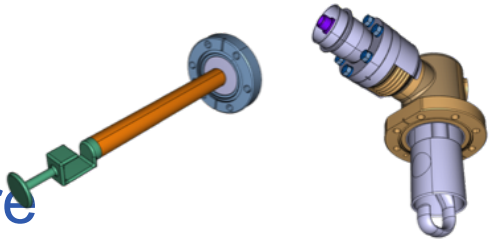


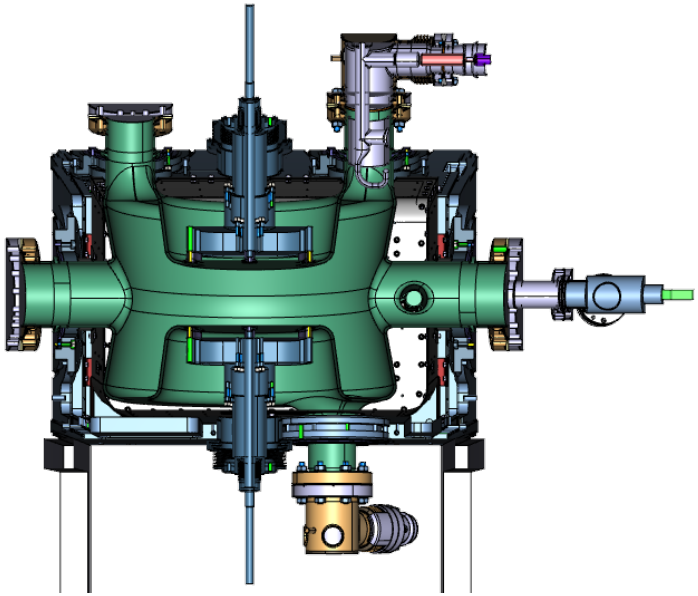


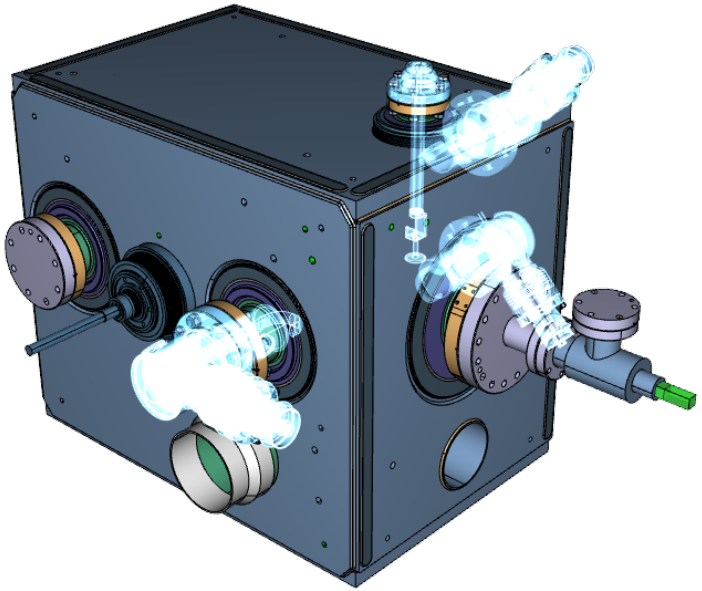
Clean Room Assembly (Part. Dressed Cavity)

- **Cavity + He tank is moved to ISO4**
- **Mounting of HOMs couplers and RF field antenna**
  - Done by E. Montesinos' team (see dedicated talk)
  - One-by-one with nitrogen overpressure

ISO4

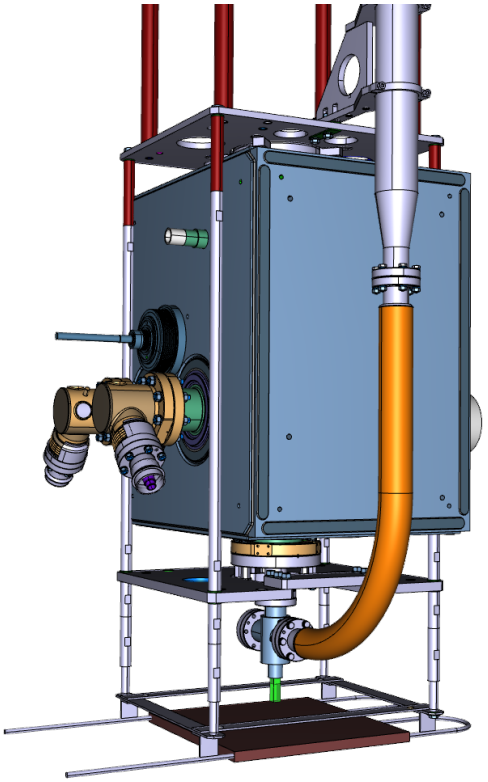




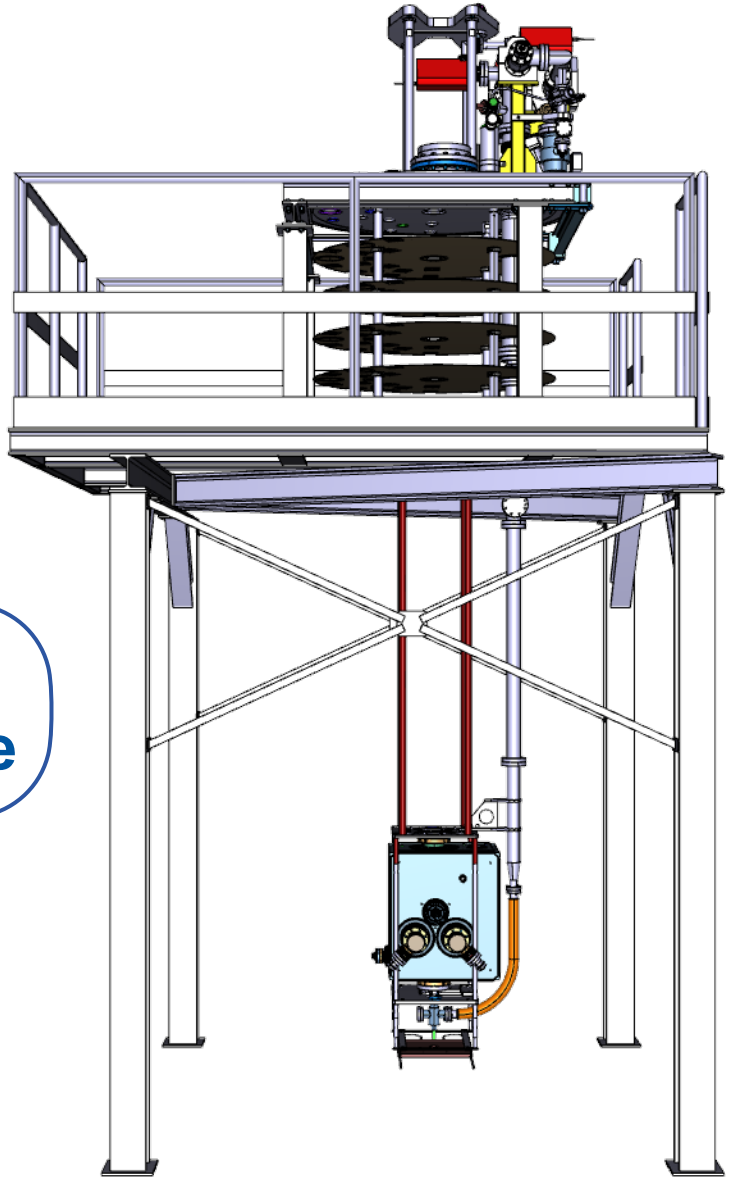


Part. Dressed Cavity Insert Installation

- Mounting into insert
- Vacuum line connection and leak check procedure similar to bare cavity



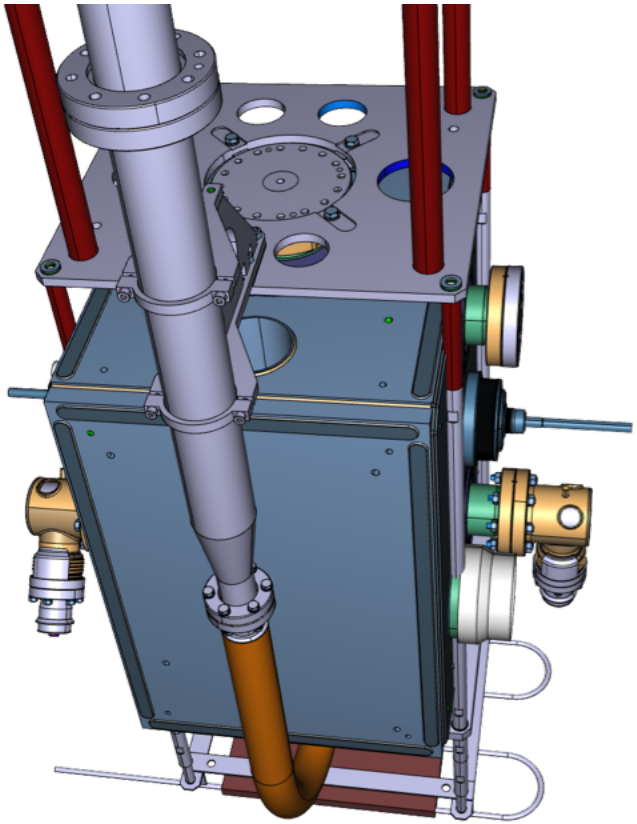
SM18
RF-zone

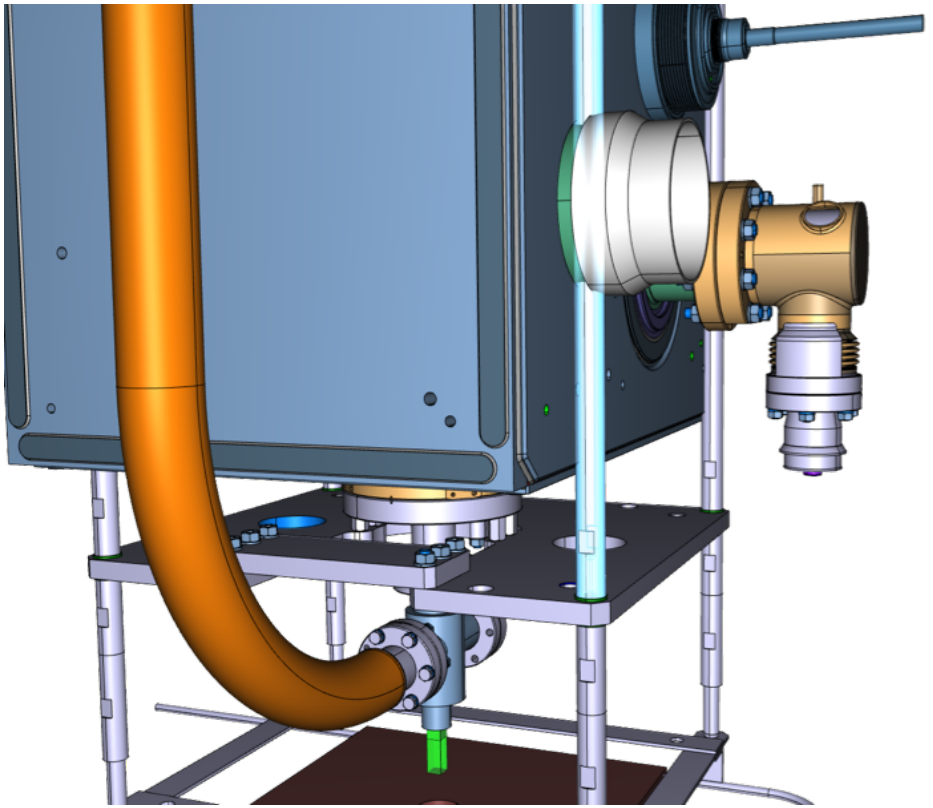


Part. Dressed Cavity Insert Installation

- A few interferences between the insert and the He tank are under correction

SM18
RF-zone





Part. Dressed Cavity Validation

- **Test goals**
  - Frequency measurements
  - HOMs measurements
- **Post test steps**
  - Cavity is filled with filtered N_2 0.05 um to 1 atm and sealed
  - Insert vacuum line stays sealed under 1 atm of N_2 0.05 um
  - Dismounting of partially dressed cavity from the insert
  - Cavity is transported to the pre-ISO5 area
    - Wiped with propanol, blowed, and double bagged
  - Cavity is moved to ISO5 entrance
    - De-bagged, wiped with propanol, and blowed
  - Cavity is moved to ISO5 area
    - Blowed with ionised nitrogen to particle counter specifications
  - Cavity is moved to ISO4 for mounting of FPC

Leak Check Summary

- **Bare cavity**
  - On the insert after cleaning insert's vacuum line
    - Stays under 1 atm of nitrogen after the test until it is back from He tank welding and in the ISO4 again for mounting of HOM couplers and rf field antenna
  - Possibility to leak test inside ISO5 area
- **Partially dressed cavity**
  - On the insert after cleaning insert's vacuum line
    - Stays under 1 atm of nitrogen after the test until it is back in the ISO4 for mounting of FPC
  - Possibility to leak test inside ISO5 area
- **We would like recommendations of these steps from the reviewers**

Summary

- Standard test preparation for bare cavity
- Cold test to take bare cavity up to specifications

- Welding of He tank with leak check

- Cavity + He tank reception

- Mounting of HOM couplers and rf field antenna

- Cold test of partially dressed cavity
- Back to clean room

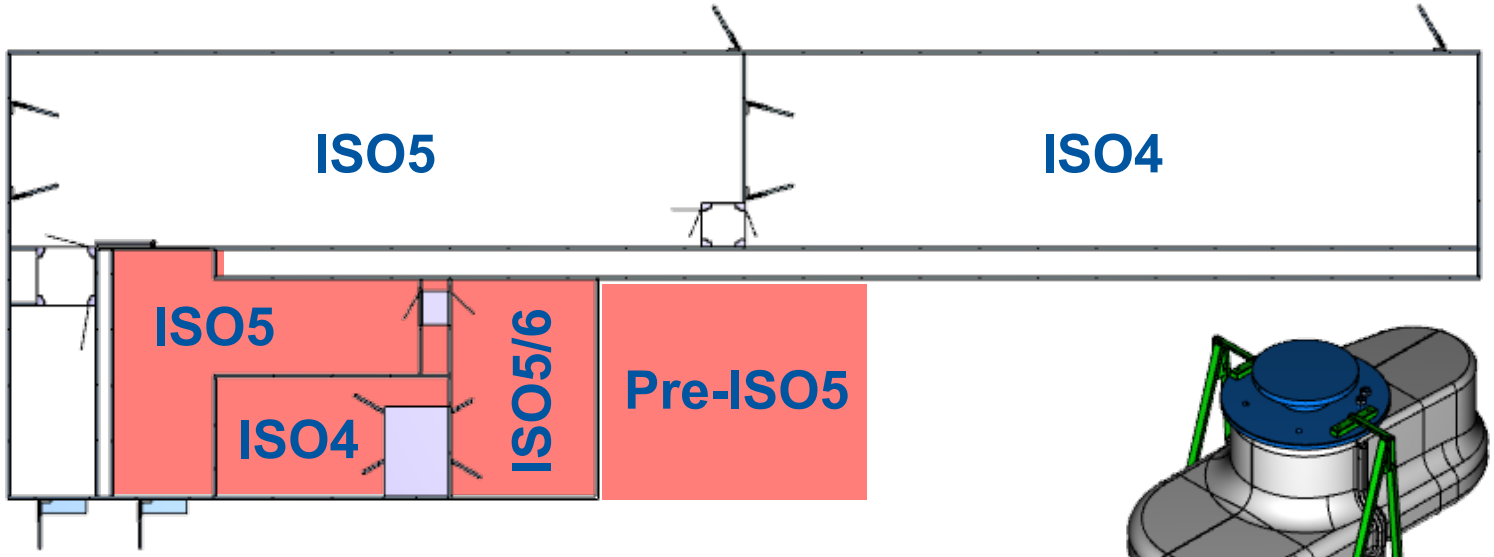
- Remove test probes and mount of FPC

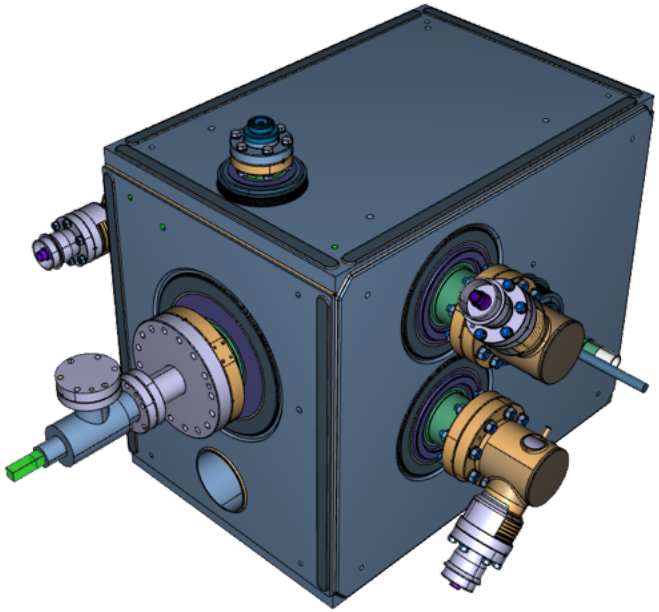
- Send to string assembly

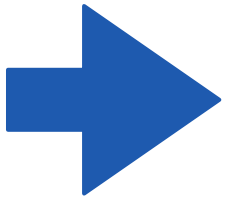
Team's colour code taken from general workflow

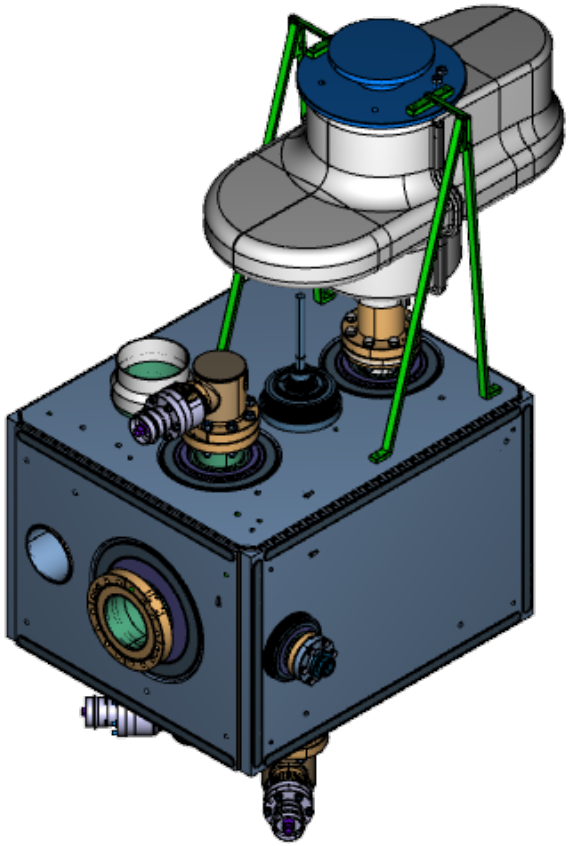

CERN

Dressed Cavity Preparation



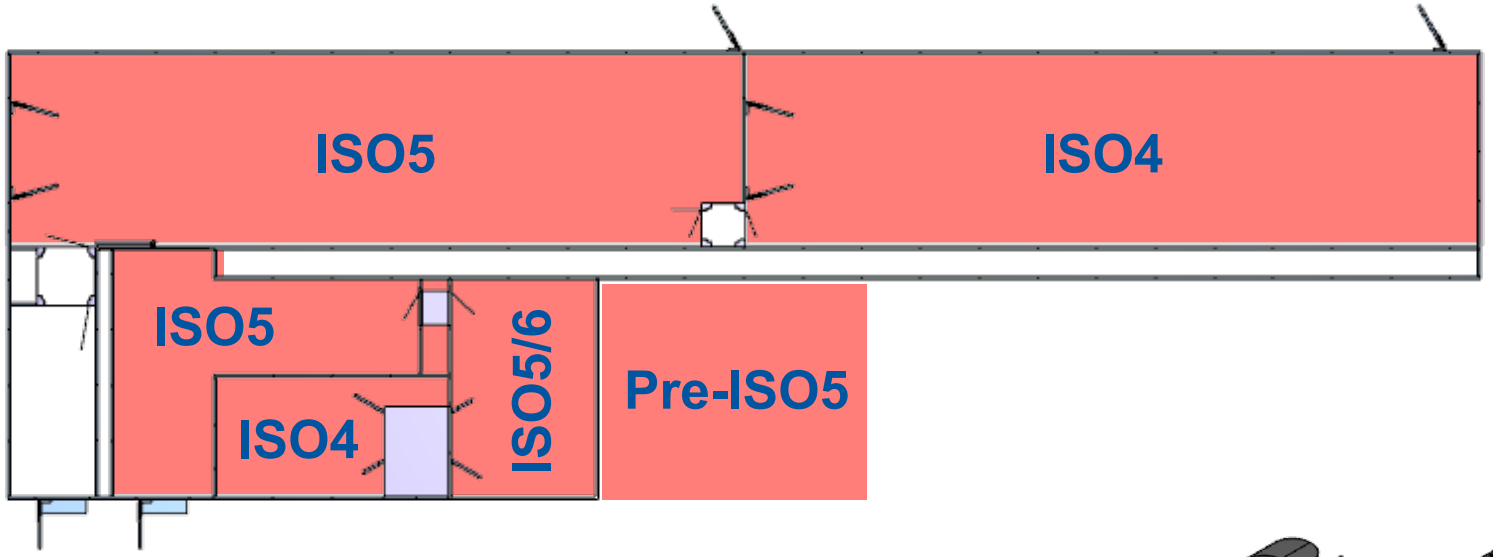


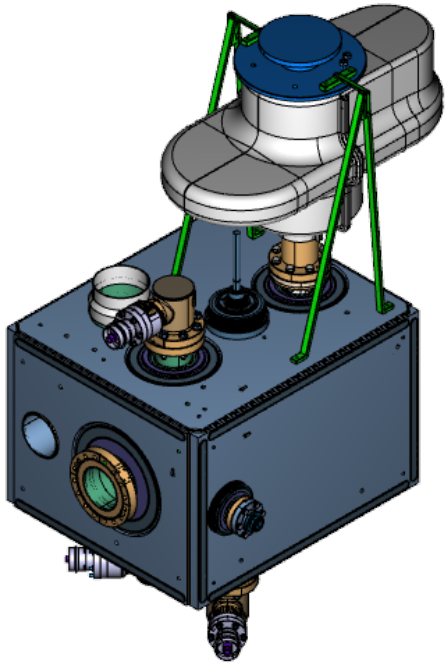


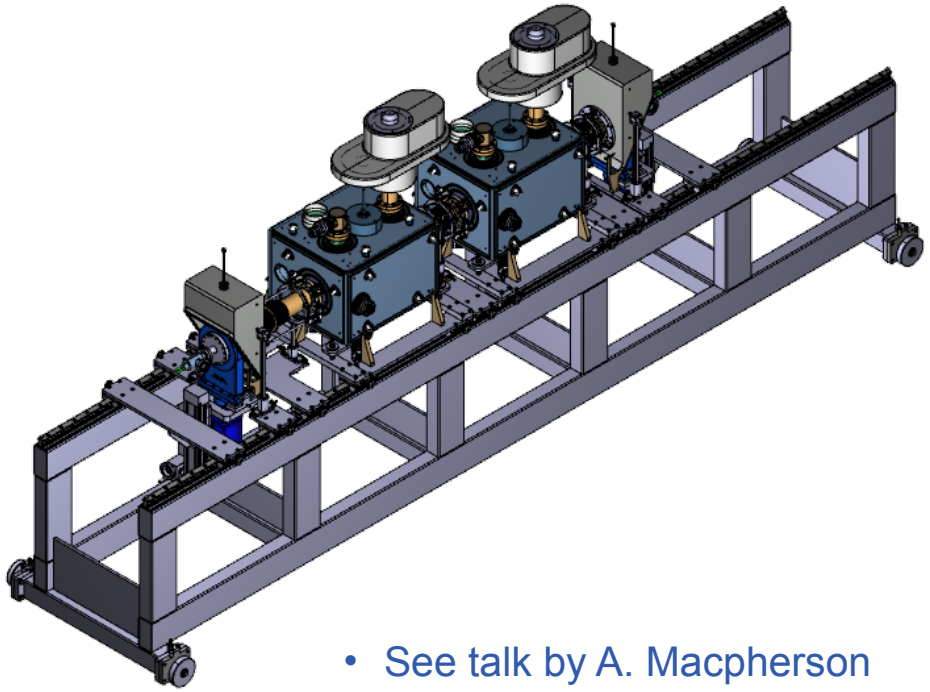


- See talks by E. Montesinos

String Assembly

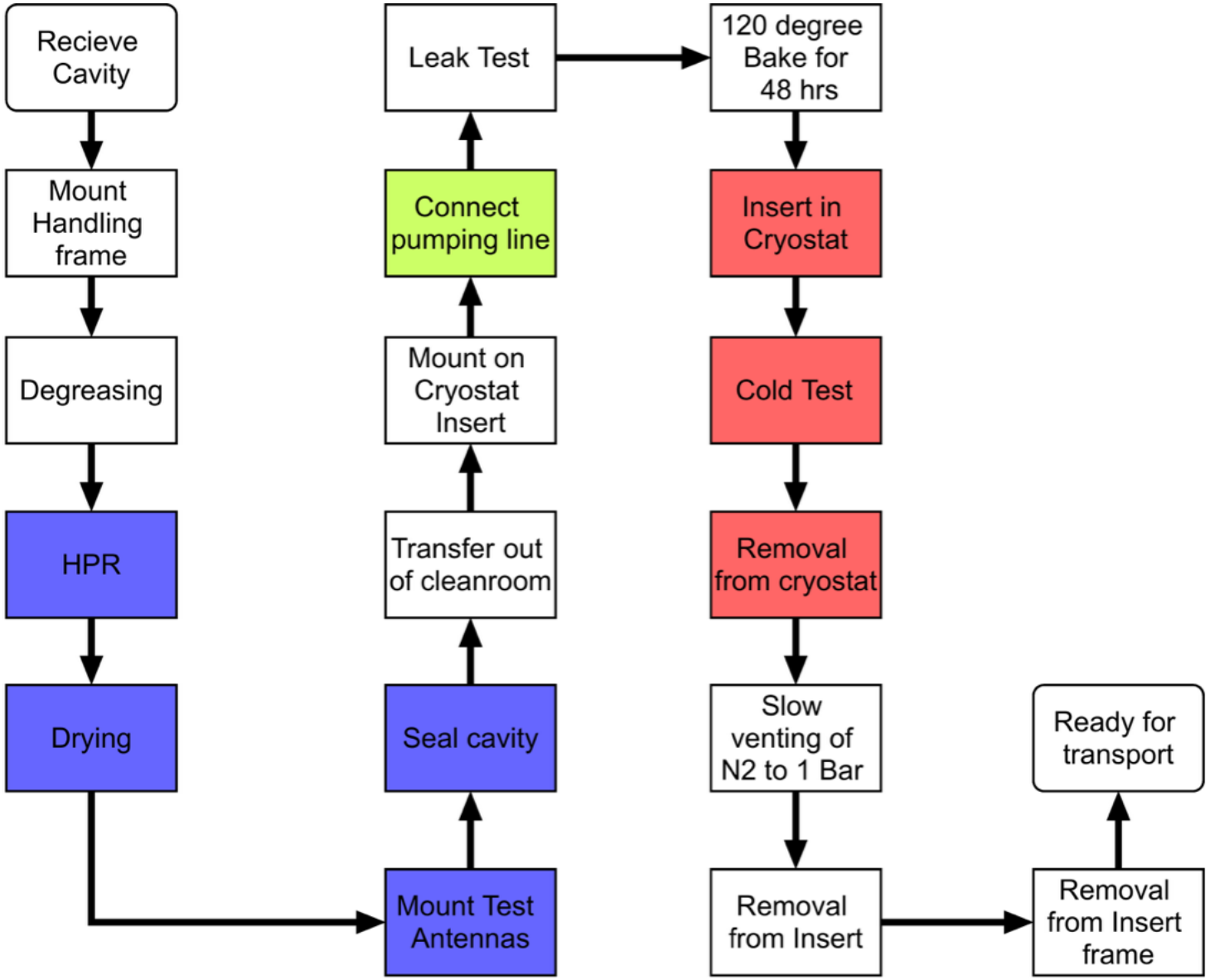




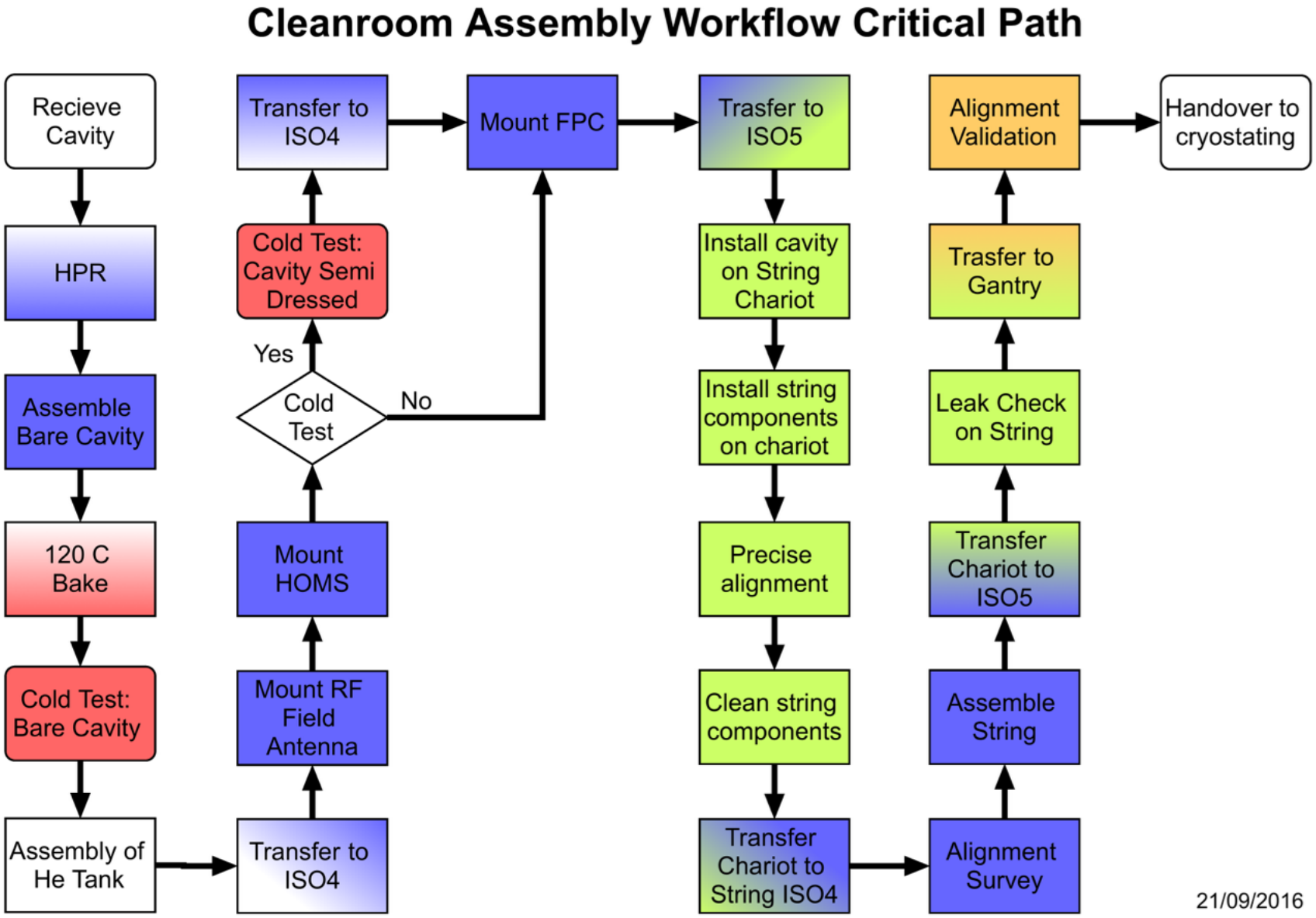


- See talk by A. Macpherson

Workflow

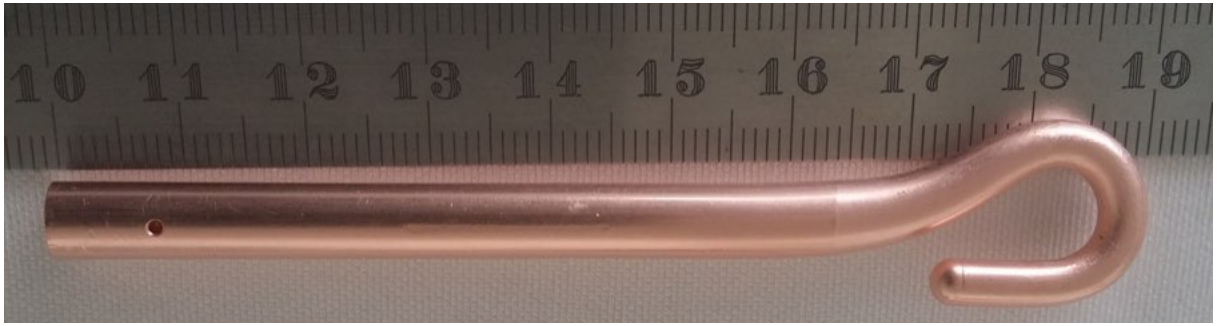

Recieve Cavity
Mount Handling frame
Degreasing
HPR
Drying
Mount Test Antennas
Seal cavity
Transfer out of cleanroom
Mount on Cryostat Insert
Connect pumping line
Leak Test
120 degree Bake for 48 hrs
Insert in Cryostat
Cold Test
Removal from cryostat
Slow venting of N2 to 1 Bar
Removal from Insert
Removal from Insert frame
Ready for transport

Critical Path



DQW-PoP Test Antennas

- **Fundamental Power Coupler**
  - Inductive coupler (Cu hook)



- **Field Probe**
  - Capacitive coupler (Cu rod)

SRF beamline component cleaning

4. Required particle count should be less than given ISO thresholds
   - Threshold are given by ISO-14644-1 Cleanroom standards

Class	maximum particles/m³						FED STD 209E equivalent
	≥0.1 µm	≥0.2 µm	≥0.3 µm	≥0.5 µm	≥1 µm	≥5 µm	
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

   - For blow-off in ISO4, the threshold for >0.5 um is 352 cnts/m^3
     - Assuming a particle counter flow rate of 50 LPM
       threshold(>0.5um) = (352/1000) * 50 = 17.6 counts/min
   - For ISO4, require no counts for particle sizes above 1um.

5. If any counts during the blow-off process exceed threshold
   => blow-off repeated until all counts are below threshold
   - If acceptable blow-off not achieved, replace or re-cleaned piece

Exception:
Bellows are difficult to clean to the required level usi
   - If needed, clean by repeated filling & flushing with propanol.

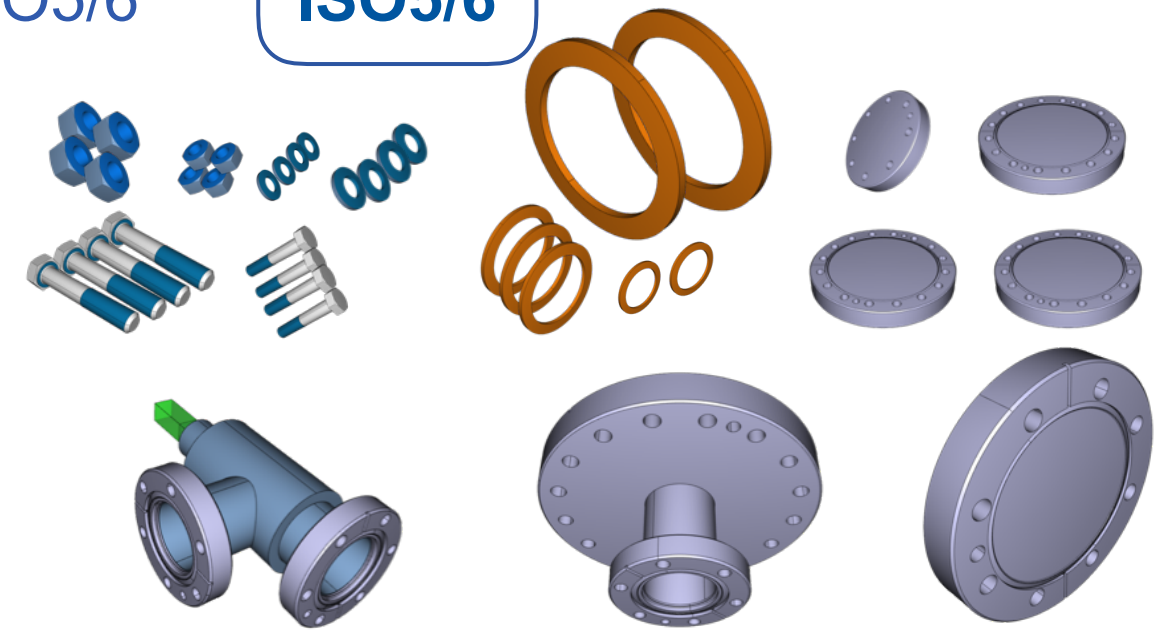
T. Jones Talk

Clean Up Assembly Components I

- **Degrease at SM18**
  - Ultrasound with detergent for 30 min at ~50 C
  - Dip/rinse with UPW
  - Dip in alcohol
  - Blow with ionised nitrogen
  - Move to ISO5/6

Pre-ISO5

ISO5/6



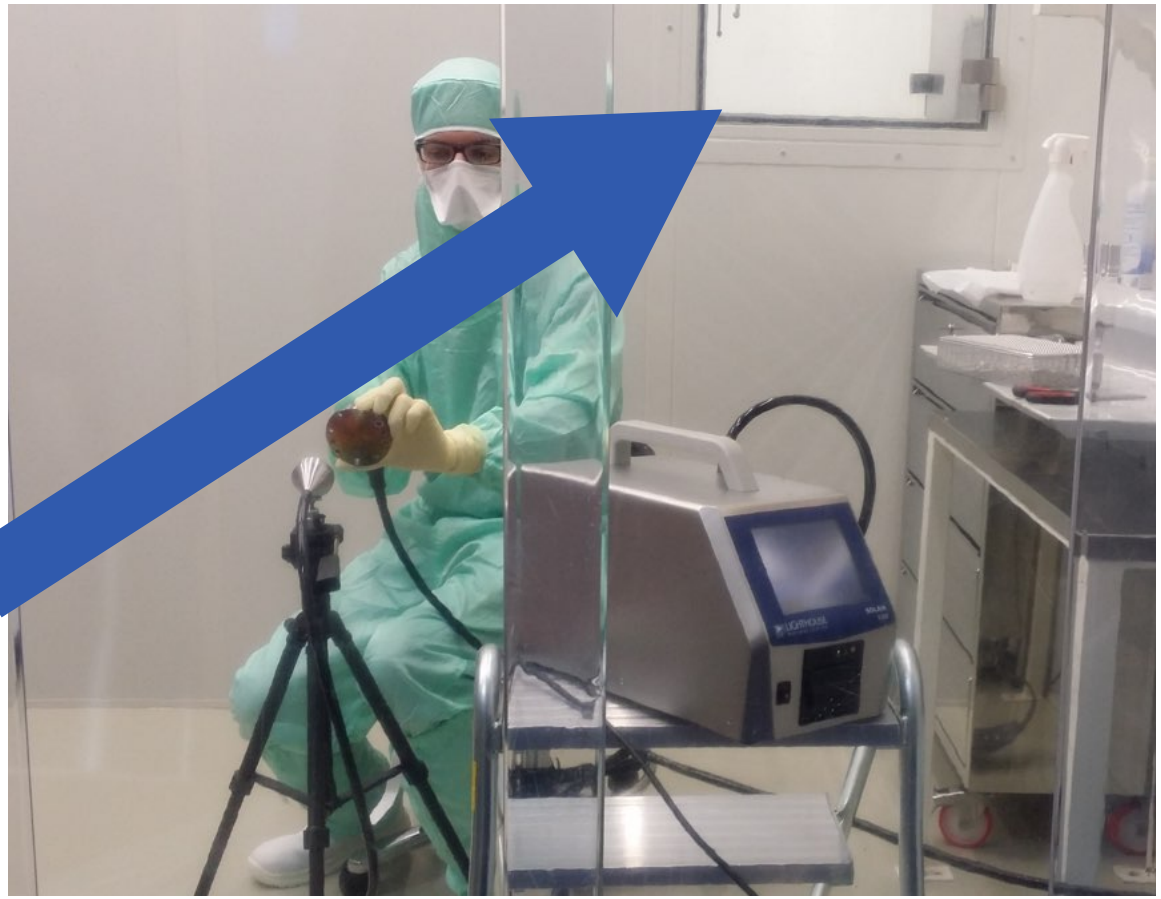
Clean Up Assembly Components II

- Blow with ionised nitrogen following the corresponding particle counts criteria

ISO5/6

↓

ISO4

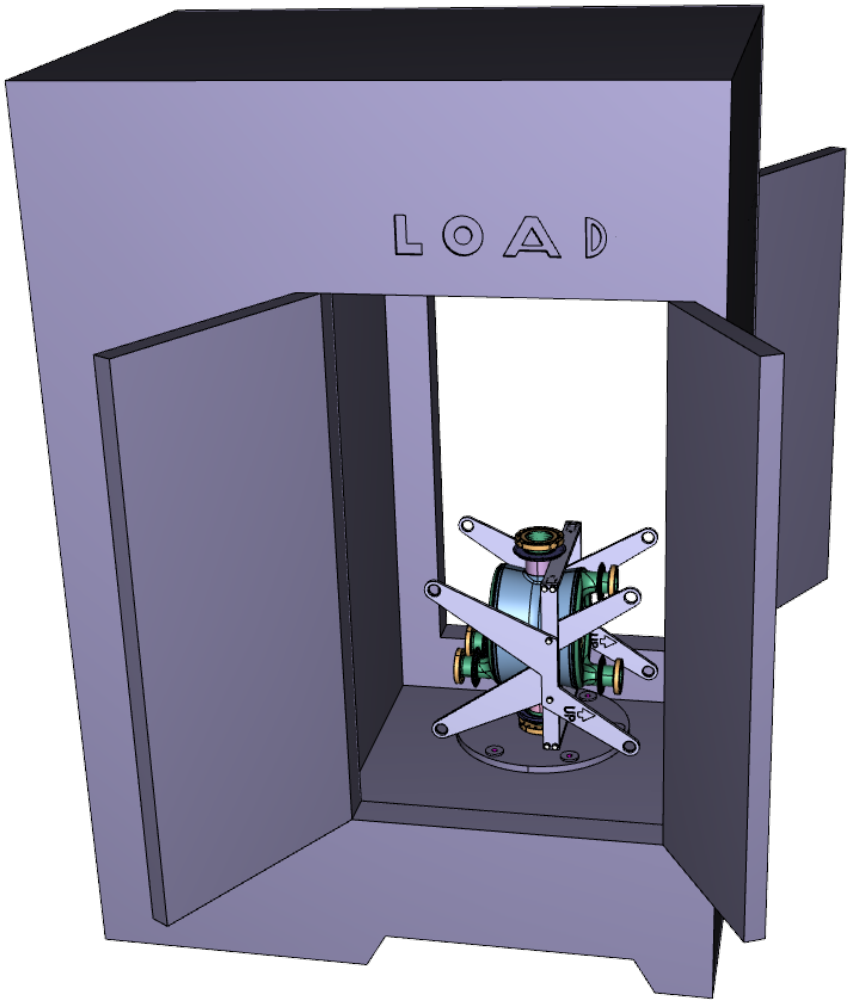


- Move to ISO5 **using SAS**
- Move to IS04

DQW HPR Parameters (PoP example)

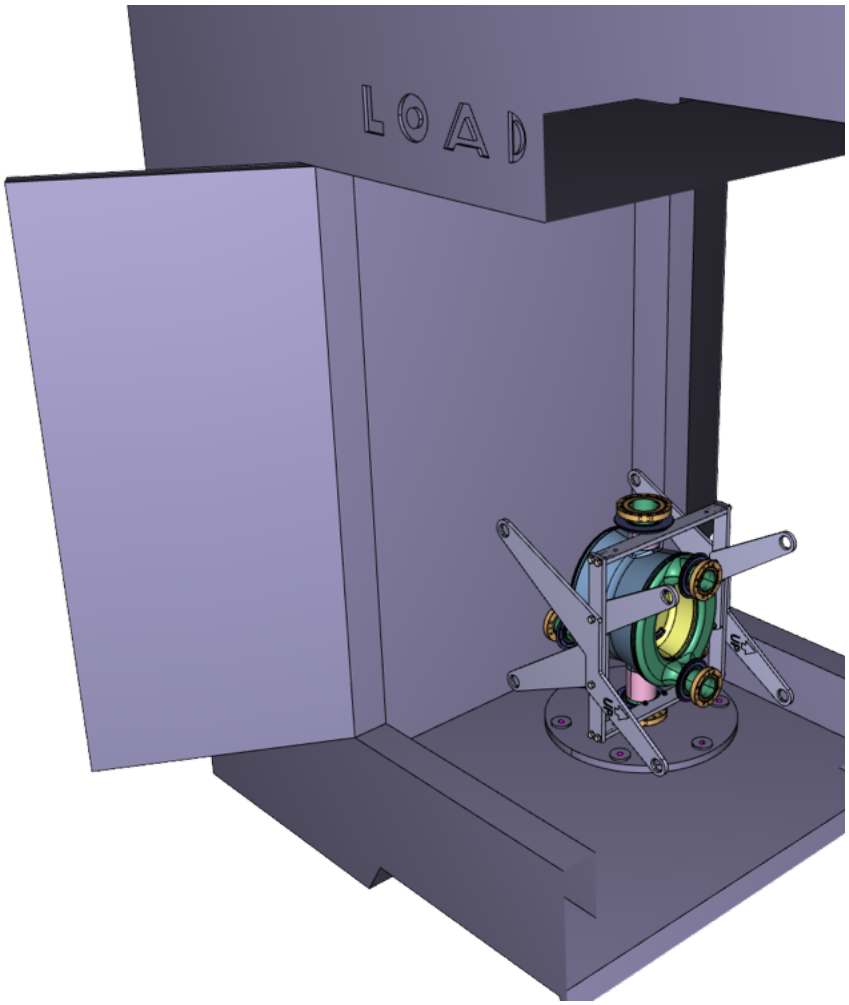
Parameter	Value	Unit
Pre Rinse	Enabled	-
Rinse Cycles	7	units
Post Rinse	disabled	-
Rotation speed	4	RPM
Wand Speed during rinsing	0.2	mm/s
Wand Speed during Pre-rinsing	10	mm/s
Wand Speed during Pos-rinsing	10	mm/s
Top of cavity	343.00	Cnt
High Limiit	1.0	mm
Low Limit	550.0	mm
Stroke Lenght	200.0	mm
Stroke cycles	0	units
Contrntated Position 1	250.0	mm
Contrntated Position 2-10	0.0	mm

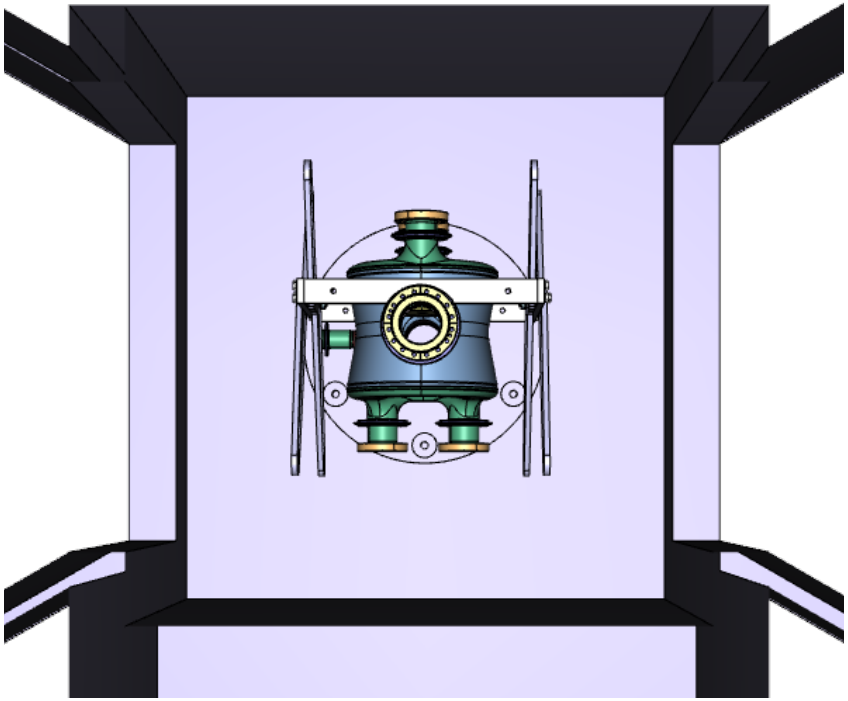
HPR ISO5/ISO4



High Pressure Rinsing

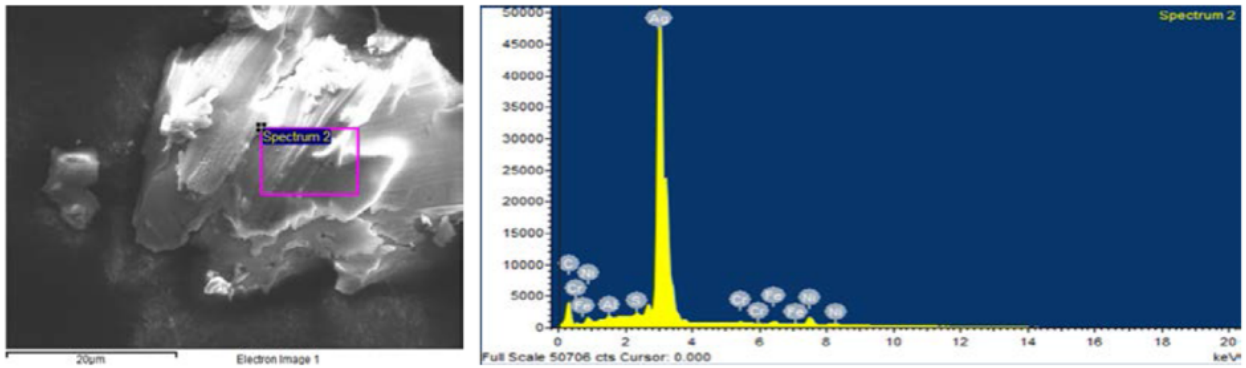
HPR
ISO5/ISO4





HPR Cabinet Residual Analysis

- **Statically attached particulate on cavity**
  - A total number of 40 particles from five samples (corresponding with different sampling locations and dates) were analysed by EDS technique
  - The particles majorly present in the dust were rich in Fe, Cr, Ni and Mn (probably from **stainless steel parts**), independently of the sample. **Metallic chips of Ag, Al and Nb** were also found. That can be explained by the fact that the cavity is made out of Nb and the flanges from stainless steel. Moreover, flanges are connected with cavity by screws made of stainless-steel with coating silver
  - In addition to this, other isolated particles were also found as oxides of Ca and Si (most probably **$CaCO_3$** and **SiO_2**), carbon (**C**), zirconium (**Zr**), titanium (**Ti**) or lead-tin particle (**Pb-Sn**)

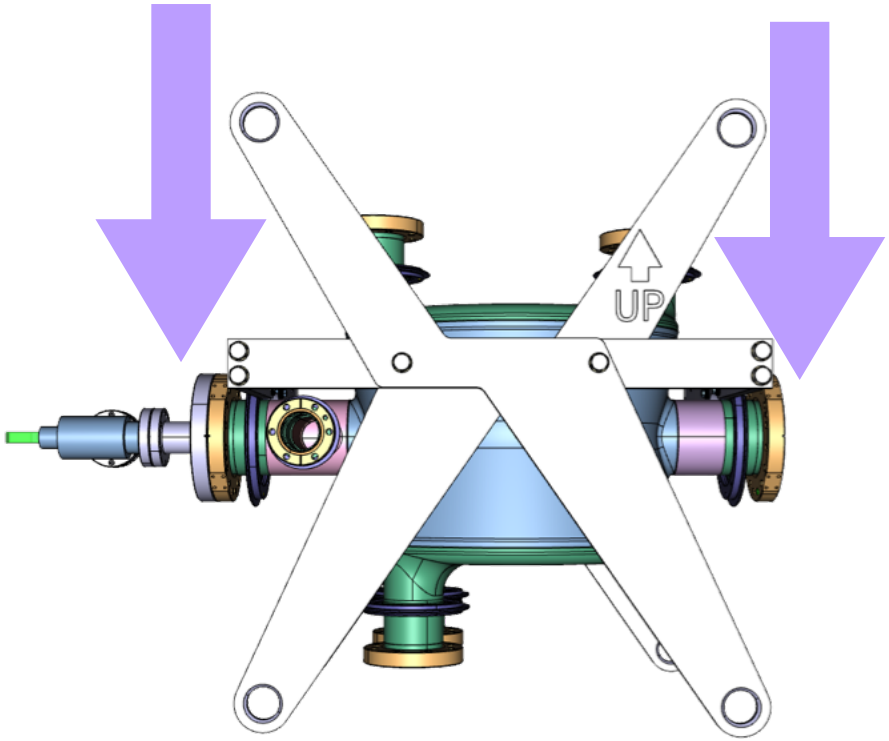


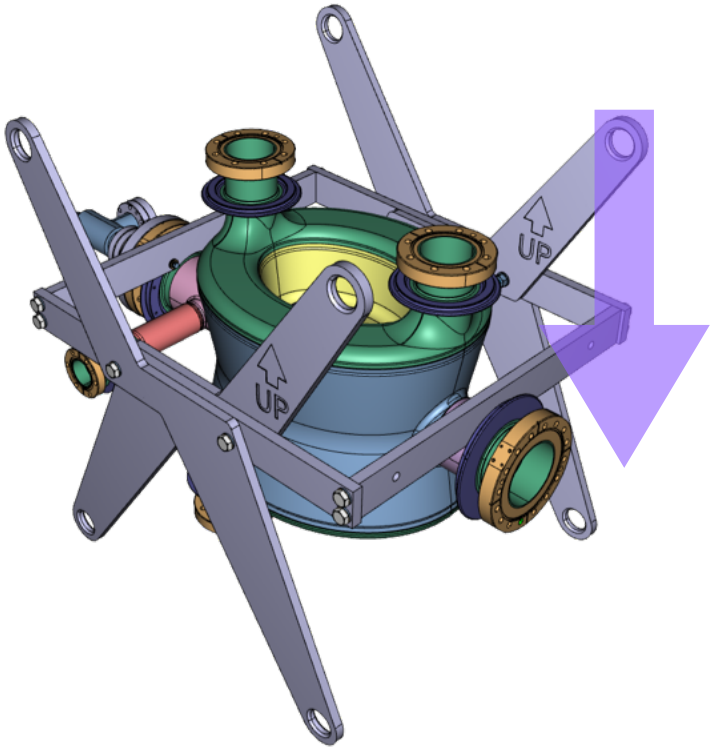
- **Study made by Ana Teresa Perez Fontenla (EN-MME-MM) and Katarzyna Turaj (BE-RF-SRF)**

Clean Room Assembly (Bare Cavity) II

- All the sequence under laminar flow

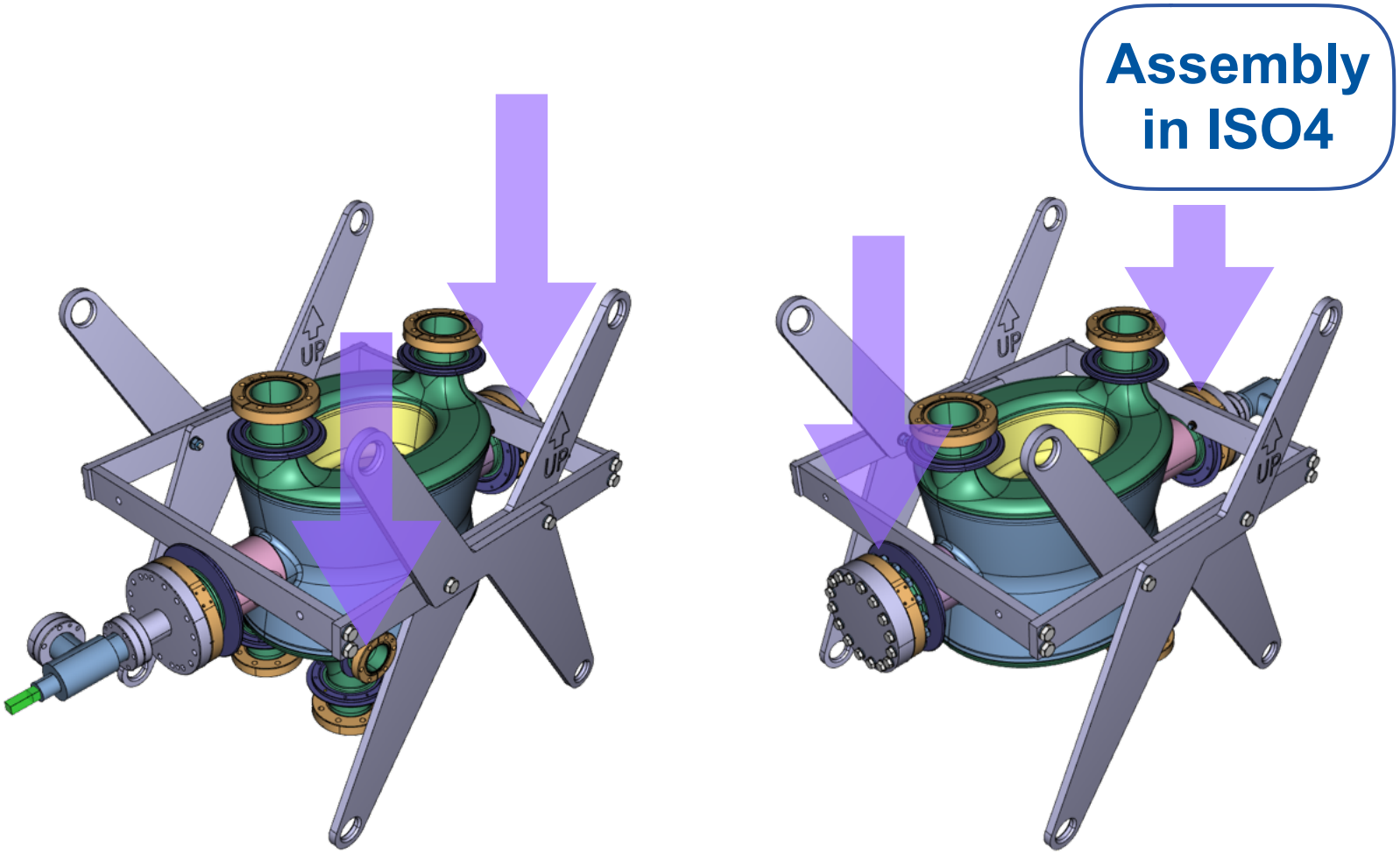
Assembly in ISO4





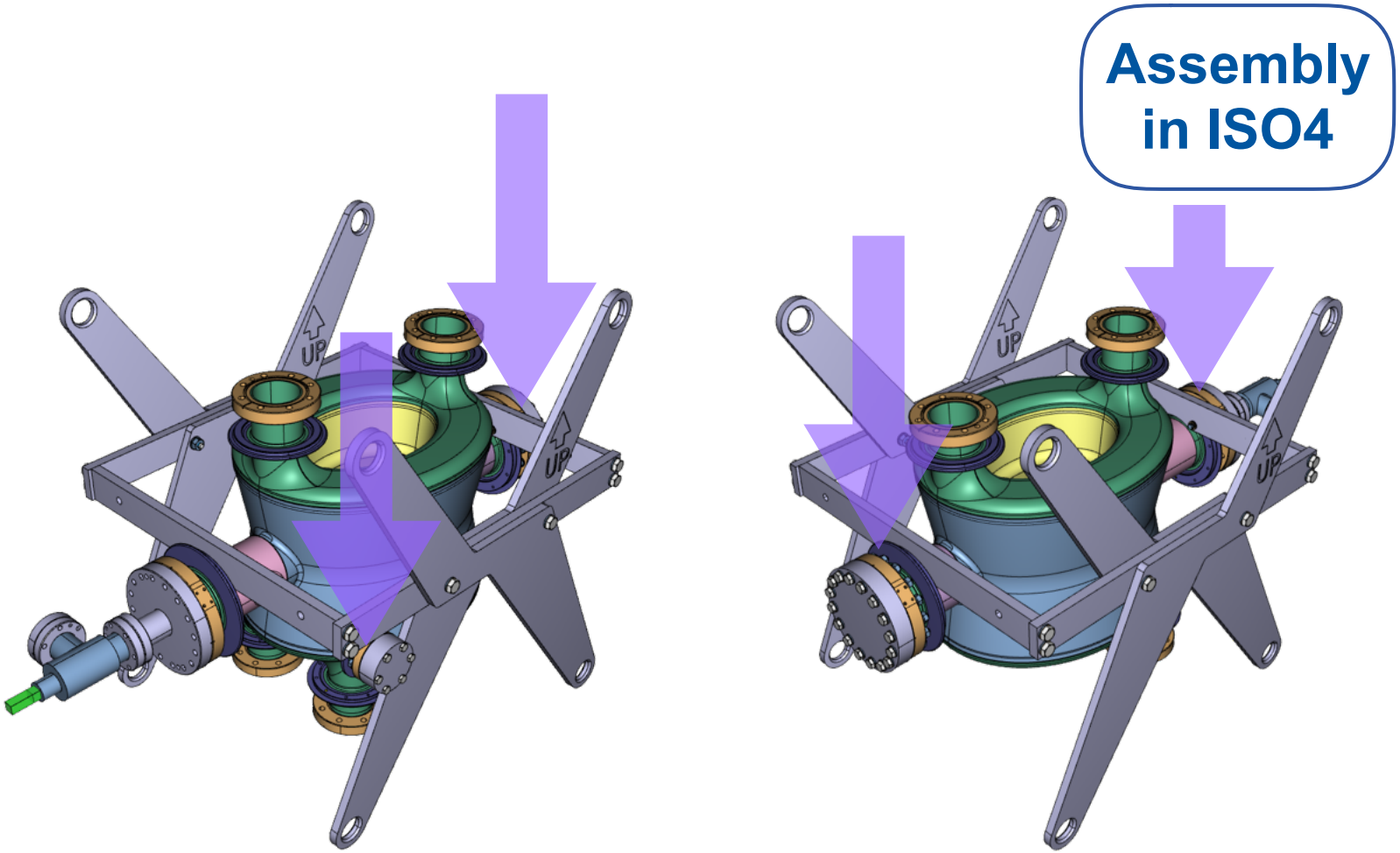
Clean Room Assembly (Bare Cavity) III

- All the sequence under laminar flow



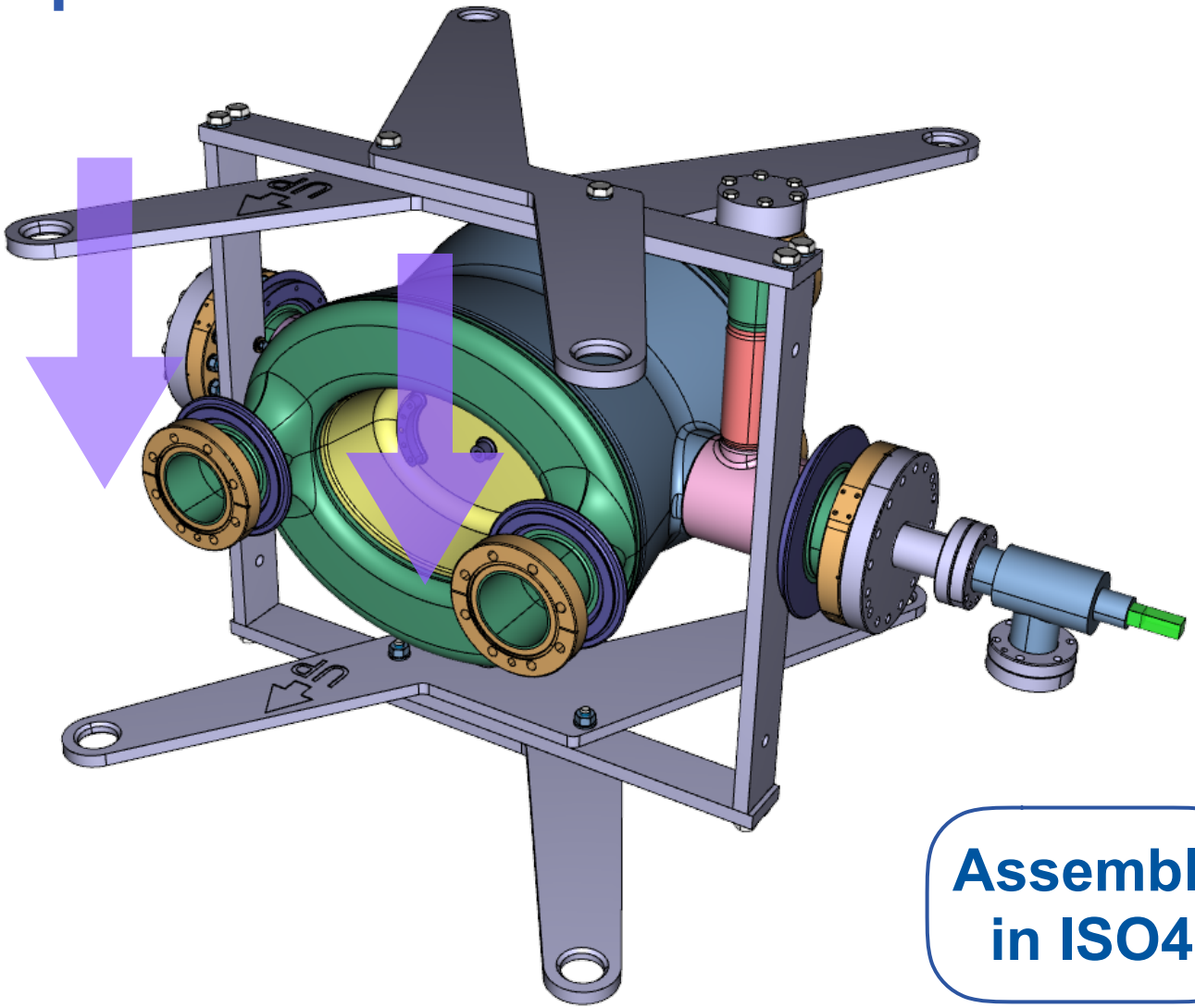
Clean Room Assembly (Bare Cavity) III

- All the sequence under laminar flow



Clean Room Assembly (Bare Cavity) IV

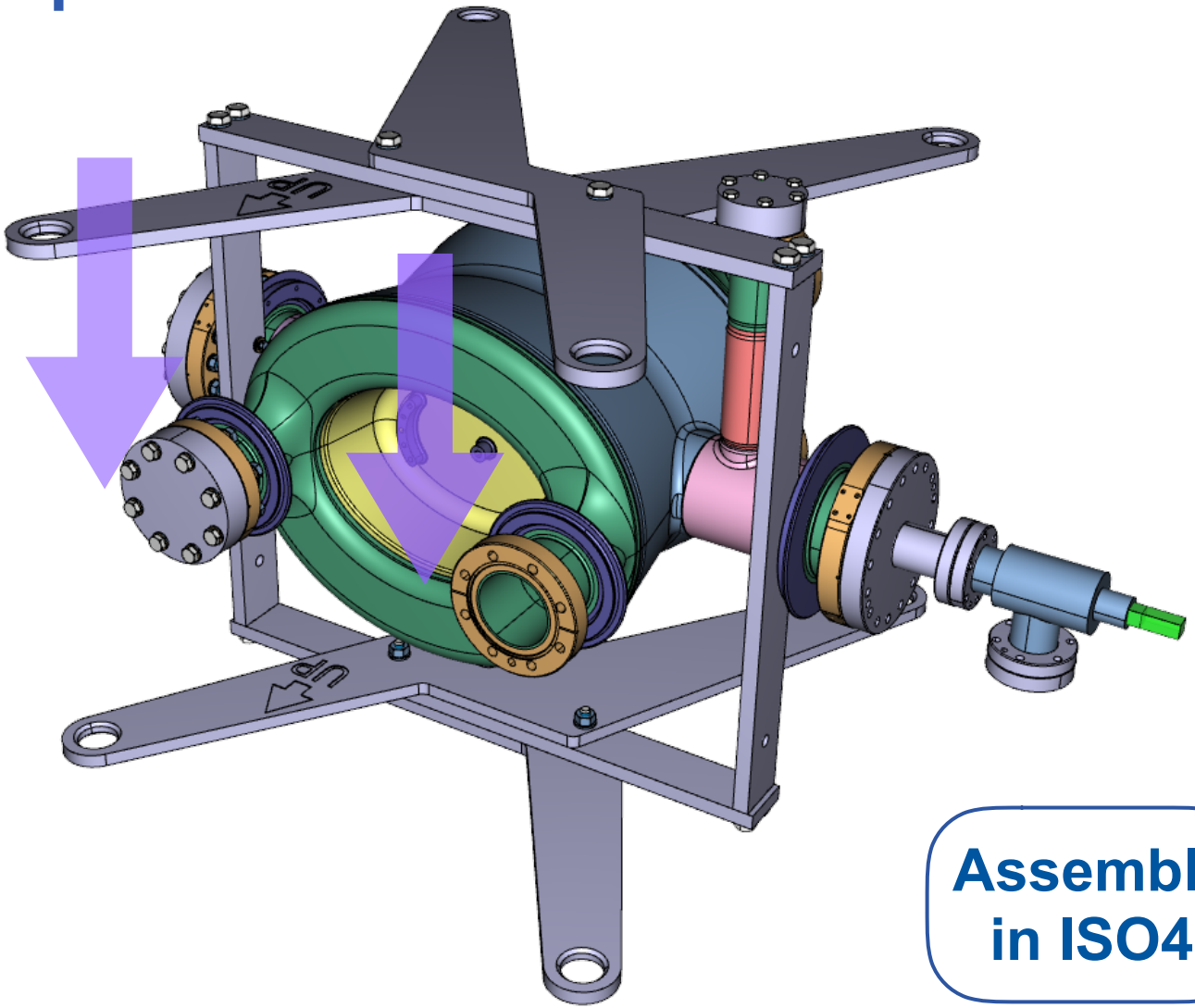
- All the sequence under laminar flow



Assembly in ISO4

Clean Room Assembly (Bare Cavity) IV

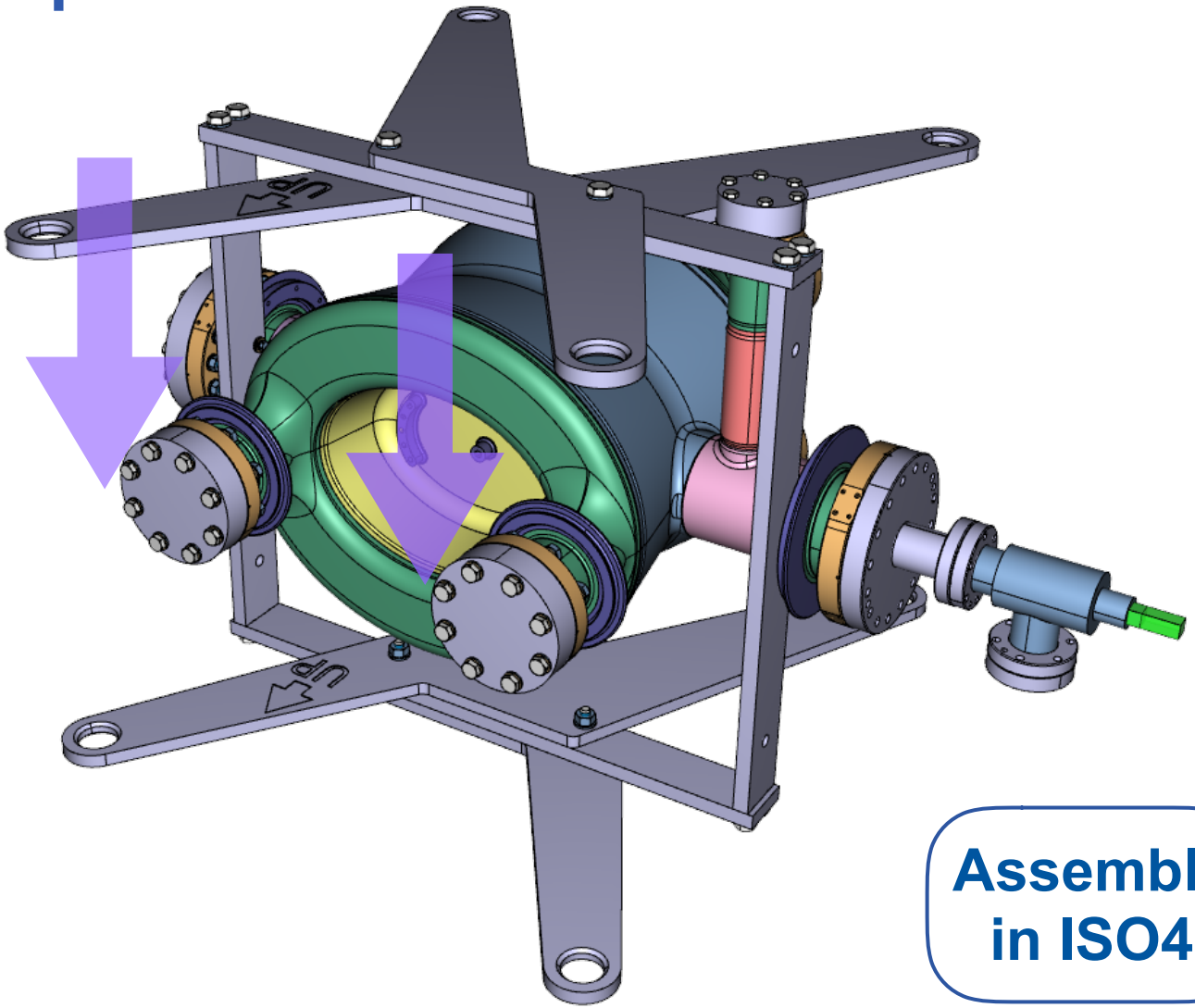
- All the sequence under laminar flow



Assembly in ISO4

Clean Room Assembly (Bare Cavity) IV

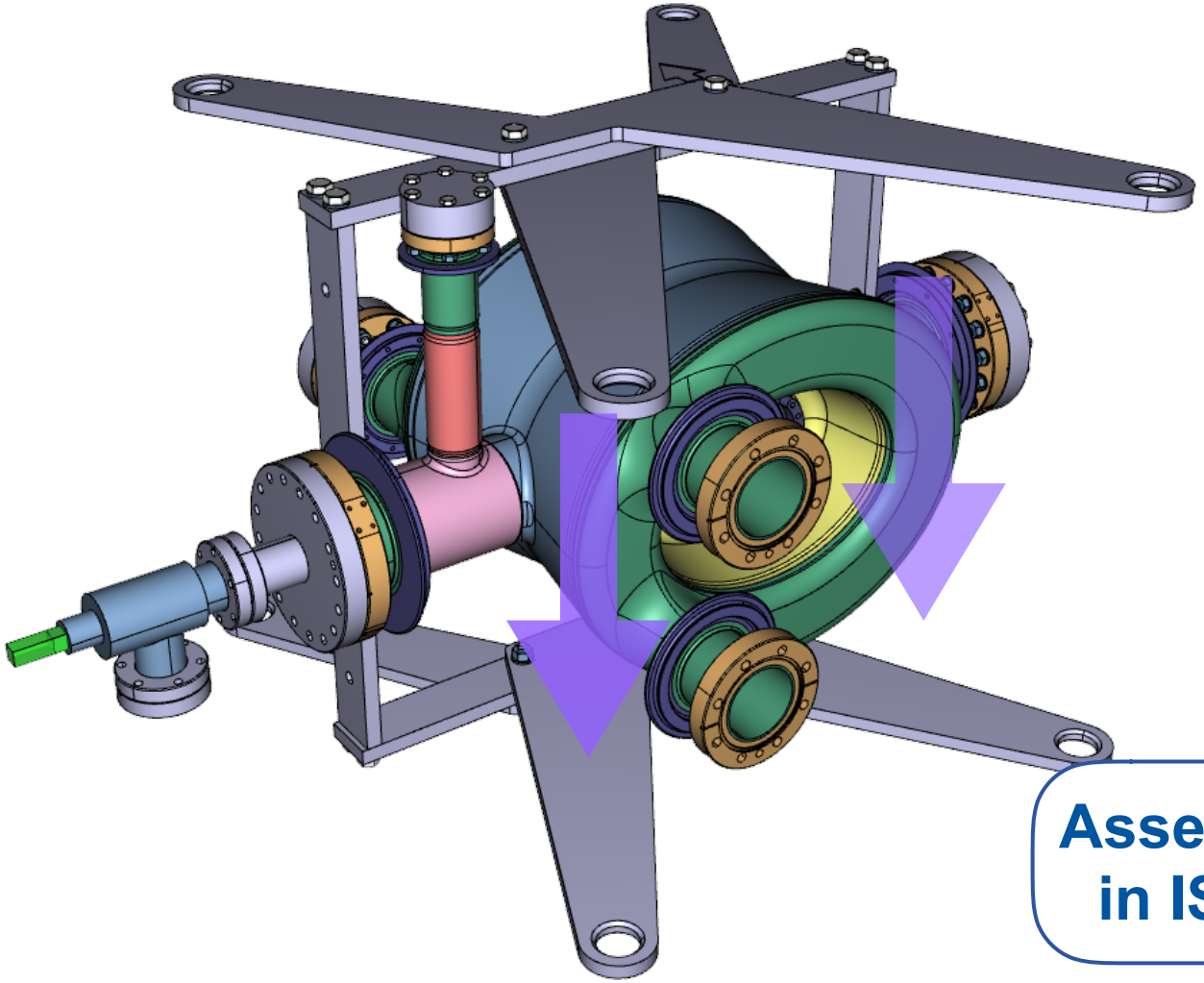
- All the sequence under laminar flow



Assembly in ISO4

Clean Room Assembly (Bare Cavity) V

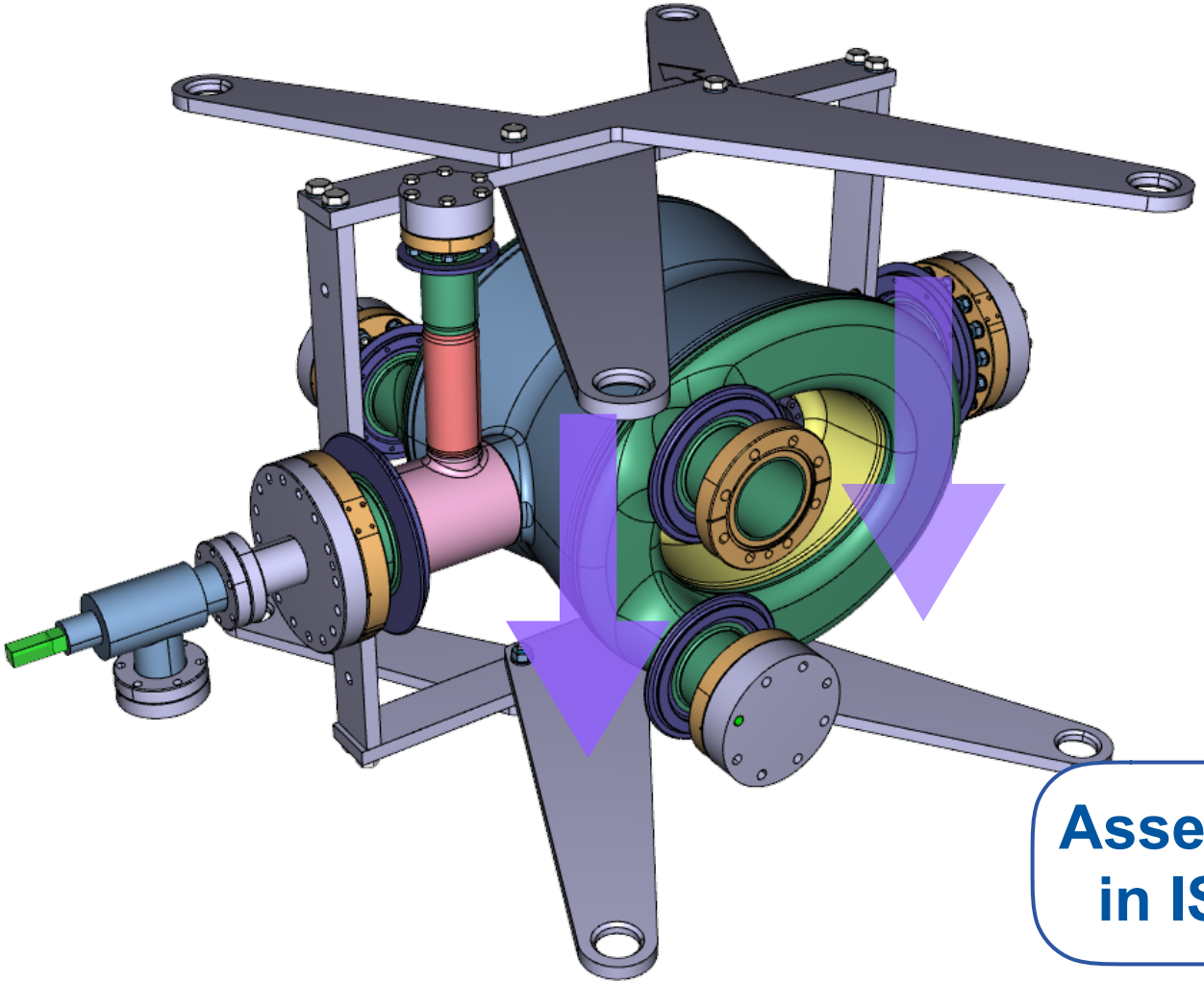
- All the sequence under laminar flow



Assembly in ISO4

Clean Room Assembly (Bare Cavity) V

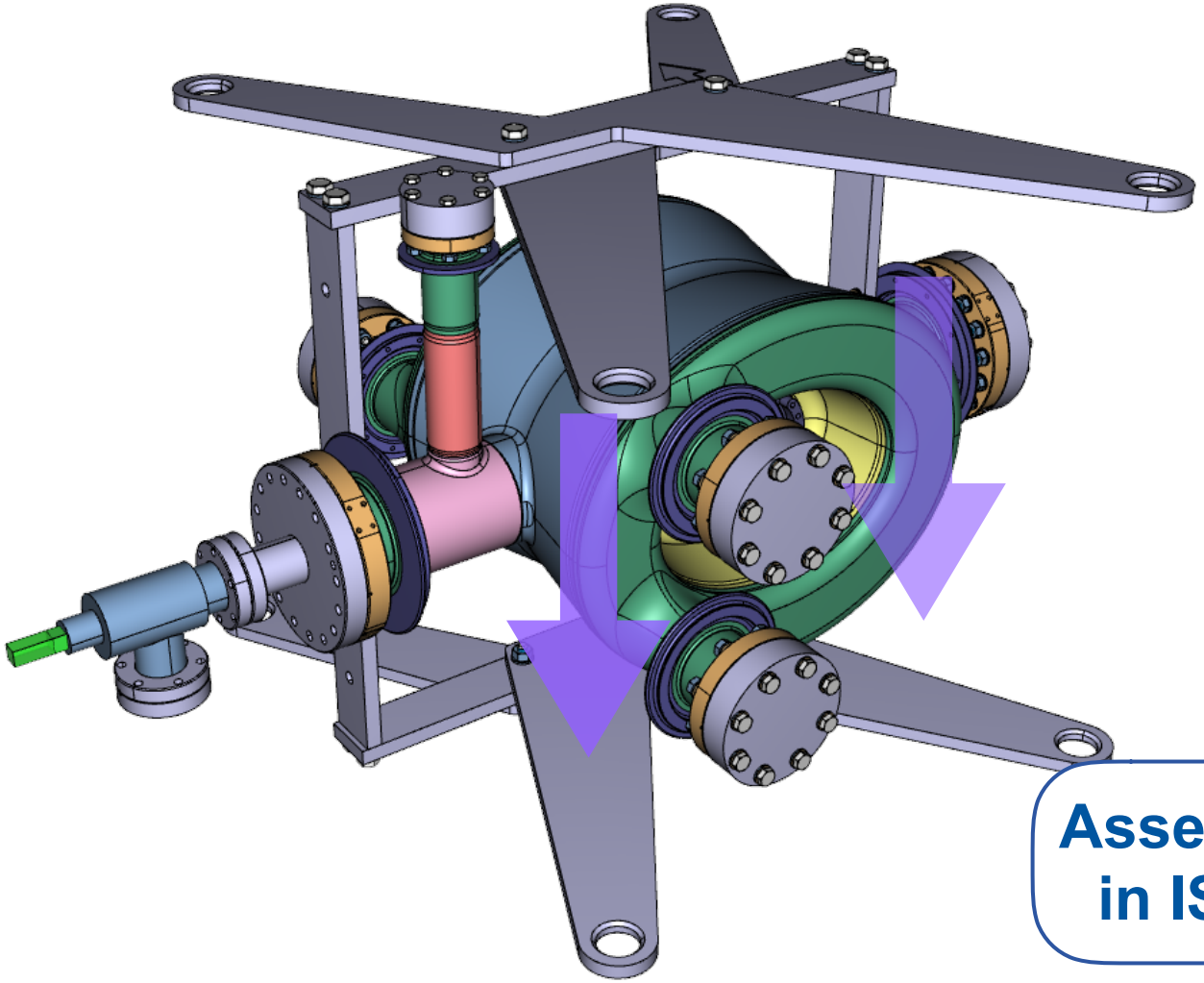
- All the sequence under laminar flow



Assembly in ISO4

Clean Room Assembly (Bare Cavity) V

- All the sequence under laminar flow



Assembly in ISO4

Part. Dressed Cavity Insert Installation

- A few interferences between the insert and the He tank are under correction

SM18
RF-zone