

Title: Cavity Processing Experience at RRCAT



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Working Group : Cavity Processing and Testing

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650 MHz Cavity Processing experiences at RRCAT

- Two no.s of Single cell HB 650 MHz cavity (HB102 & HB104)
- Seven no.s of 5-cell HB 650 MHz cavity (HB501 – HB507) (Mid 2018 – Till Jun 2022)



HB501



HB502



HB503



HB504



HB505



HB 507

RRCAT Cavities in HB650 pCM at Fermilab



Three β 0.92 cavities (502, 504 and 506) supplied by RRCAT have been assembled in HB650 pCM at Fermilab

RRCAT-502

RRCAT-504

RRCAT-506

Courtesy: C. Grimm, Fermilab

650 MHz Cavity Processing at RRCAT



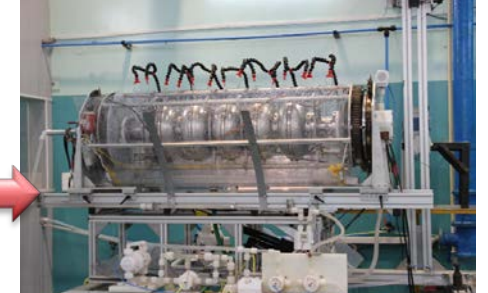
Optical Inspection



Bulk Electropolishing (~150 μ m)



Degassing/ N-Doping @ 800° C – 3 hrs



Light Electropolishing (~20 μ m)



Assembly in Class 10 cleanroom



HPR (UPW ~90 bar)



Ultrasonic M90 (50° C ~1 hr)

Electro-polishing Process

Bulk EP (*EB Welded Cavity received after Internal inspection*)

- Removal of damaged layer ~120 – 200 μm ; Improve surface smoothness; Elimination of sharp discontinuities

Parameters	Range
Voltage	15 – 18V
Current	175 – 225 A
Current oscillation range	~20 - 35A (peak to peak)
Cavity temperature	17 – 25°C
Removal rate	0.1 – 0.12 $\mu\text{m}/\text{min}$

Light EP (*Hydrogen degassed/ N- doped Cavity tuned to > 98% field flatness*)

- Removal of furnace contamination ~ 20 μm post Hydrogen degassing process
- Removal of nitride precipitate layer ~ 5 μm post N – doping process

Parameters	Range
Voltage	18V
Current	110 – 135 A
Current oscillation range	~35 A (peak to peak)
Cavity temperature	12 - 17°C
Removal rate	0.06 – 0.07 $\mu\text{m}/\text{min}$

Electropolishing Facility at RRCAT



Features:

- Temperature monitoring of each cell with 2 thermocouples.
- Uniformity in external cooling of each cell with dedicated flow at each cavity wall.

Thermal processing at RRCAT



Hydrogen degassing

Vacuum before heating $< 1 \times 10^{-7}$ torr

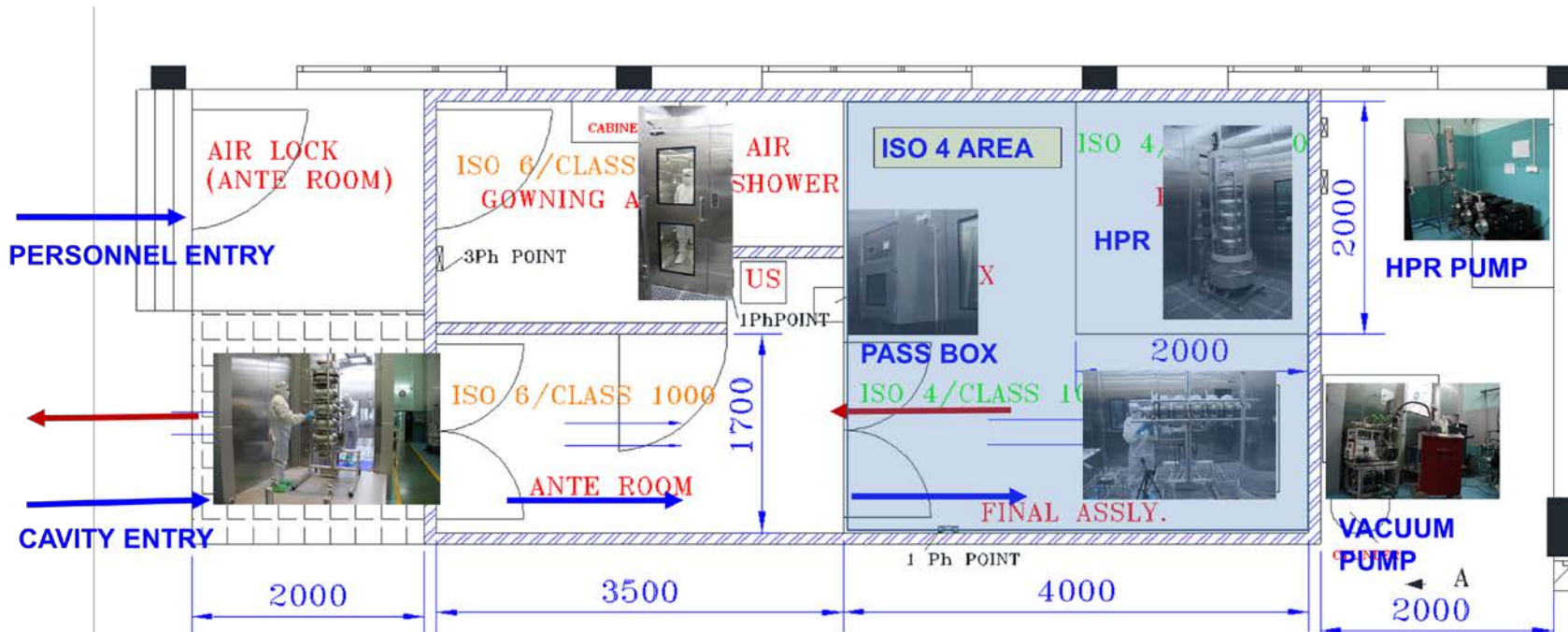
Heating @ $3^\circ\text{C}/\text{min}$ to 800°C (in vacuum)

Soaking for 3 hrs ($< 5 \times 10^{-6}$ torr)

Cooldown in vacuum to 50°C

Cleanroom Infrastructure at RRCAT

- ❑ All the cavity processing facilities are set up under one roof at RRCAT.
- ❑ After fabrication and electropolishing the cavities are rinsed at high pressure using ultrapure water and assembled in ISO class 4 cleanroom. For this a new ISO class 4 cleanroom facility has been set up at RRCAT.



Cleanroom Facility at RRCAT

CLEANROOM PARAMETERS

Parameter	Value
Cleanliness	ISO 4 and ISO 6
Air Change Rate	> 500 / hour
Operating Temp.	20 ± 2°C
Relative Humidity	50% ± 5%

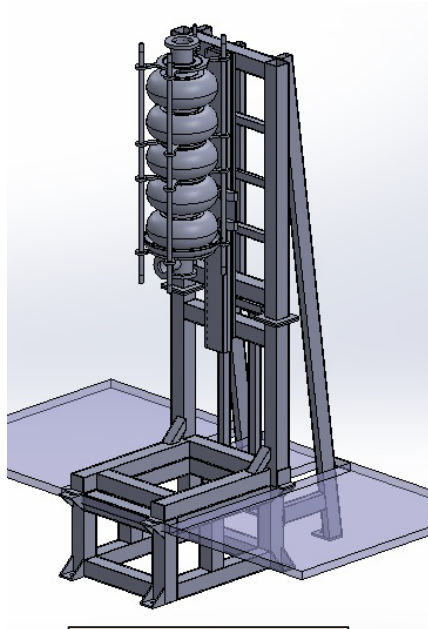
CLEANROOM FEATURES

Flooring	Perforated raised floor
	Static dissipative epoxy paint on building floor
Filters for ISO 4 Area	HEPA/ULPA filter banks inside a plenum box

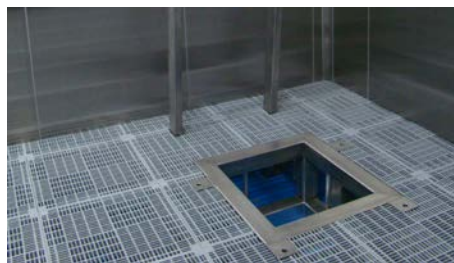


Thanks to Genfa Wu and Fermilab team for support during cleanroom construction

HPR Infrastructure



HPR Structure



Ultrapure water generation plant



Hydraulically actuated diaphragm Pump

PLANT PARAMETERS

Parameter	Value
<u>Ultrapure water Quality</u>	
Resistivity	: $\geq 18 \text{ M}\Omega\cdot\text{cm}$
TOC	: $< 20 \text{ ppb}$
Bacterial count	: $< 1 \text{ cfu}/100 \text{ ml}$
Flow Rate	800 LPH
Instrumentation	Online Resistivity
	Online TOC

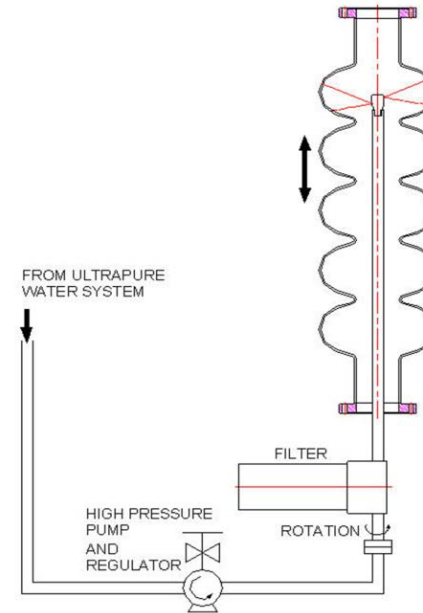
PUMP SPECIFICATIONS

Parameter	Value
Max. Pressure	105 bar
Flow rate	12 lpm
Pump head	Triplex-Sandwich diaphragm (PTFE)
Wetted parts	SS 316

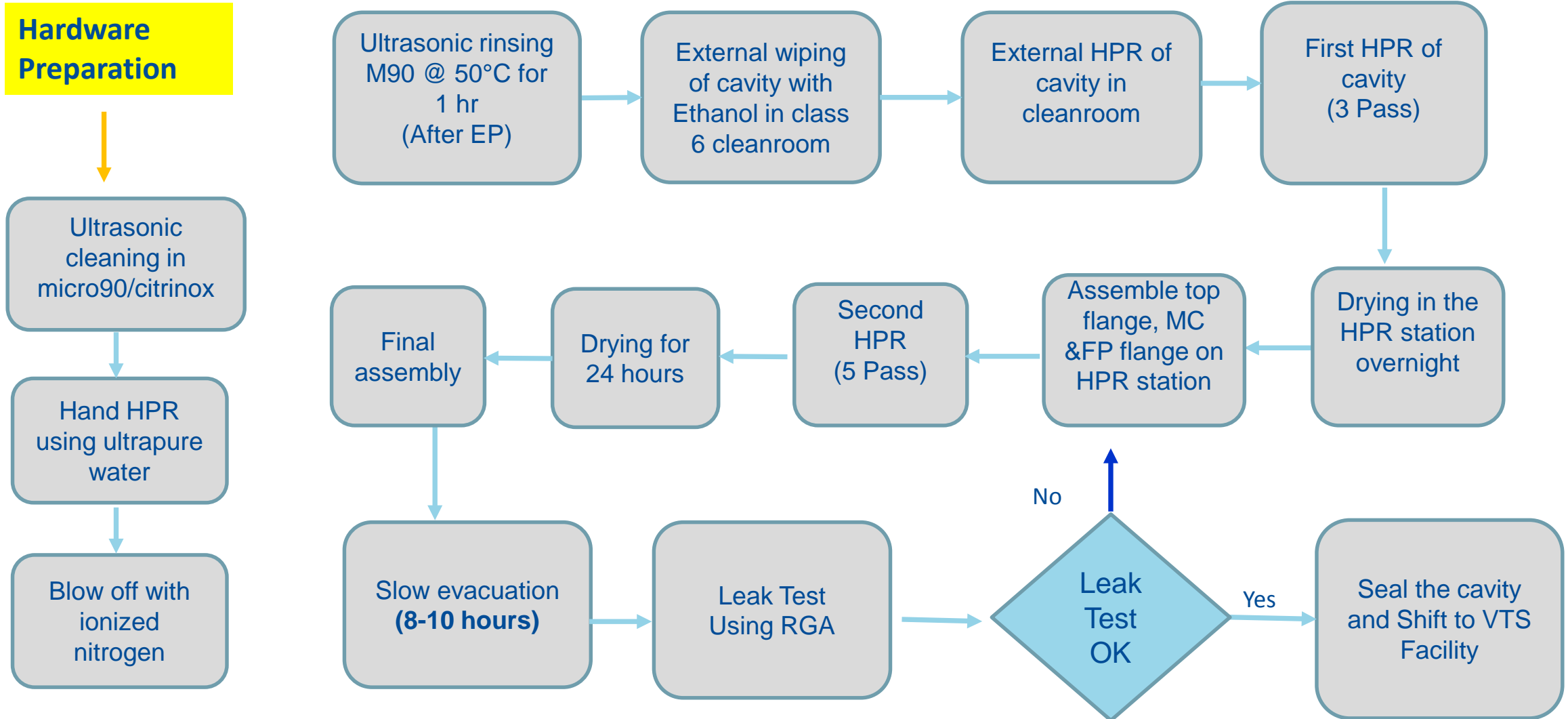
High Pressure Rinsing of Cavity

HPR Parameters for 5 cell HB650 cavity

Parameter	Value
Jet Pressure	90 bar
Wand Rotation	2 rpm
Cavity linear Translation	6 mm/min
No. of passes	3 + 5
Final filtration	0.05 μm
Nozzle type	40 fan jet
Nozzle material	SS 410
Cleanroom environment	ISO class 4



Cavity and Hardware Preparation in Cleanroom





Ultrasonic cleaning



Hand HPR

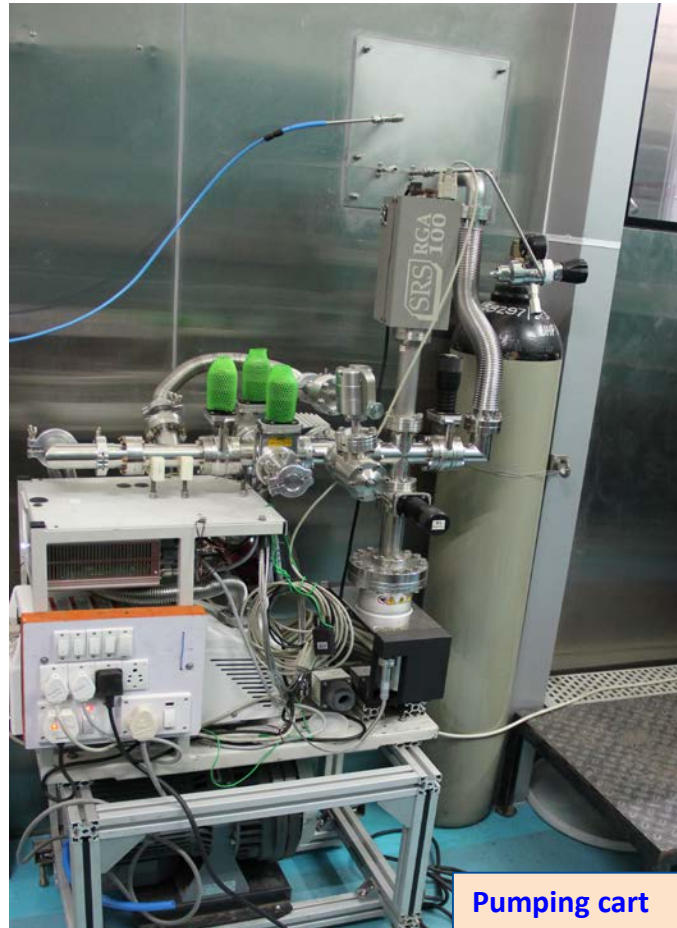


Hardware blow off using ionized nitrogen



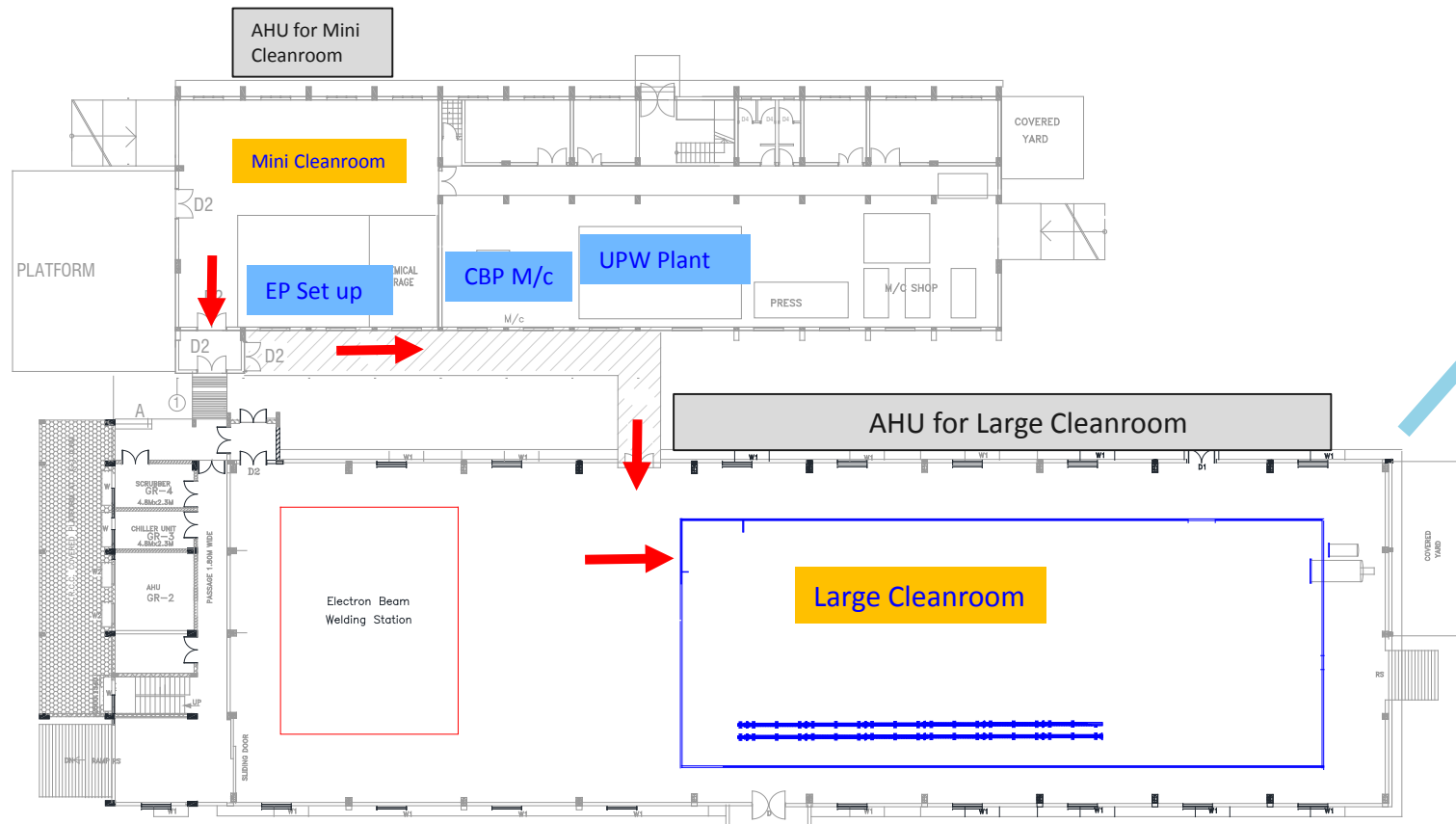
External rinsing of 5 cell 650 MHz cavity

Evacuation of Cavity



Slow evacuation of cavity is carried out using a fine control leak valve

Integrated cleanroom facility in cavity Processing Facility Building



Cleanroom under construction

An integrated cleanroom facility for HPR, cavity assembly, string assembly, tuning and high temperature hydrogen degassing

Total Area of cleanrooms: 600 m²

Area of ISO class 4 rooms: 140 m²

Thank you for your kind attention

