中国科学院近代物理研究所
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The design of an automated high-pressure rinsing system for SRF cavity and the outlook for future automated cleanroom on strings assembly

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Cleanroom automation

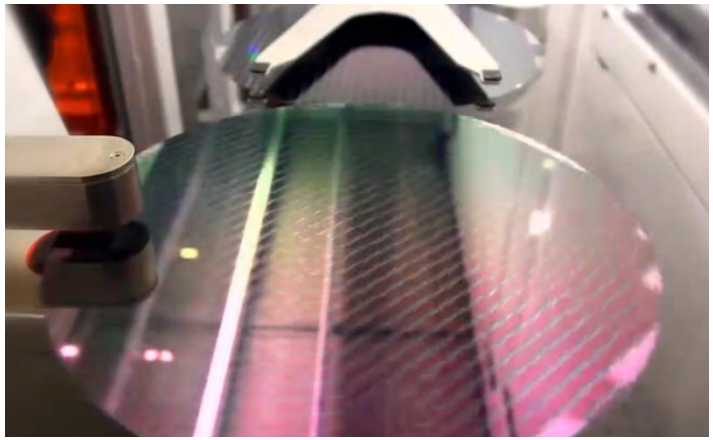
Photovoltaic industry

Semiconductor industry

Pharmaceutical industry

Automatic production line in cleanroom could increase the production yield.

The cleanliness can reach ISO Class 1.

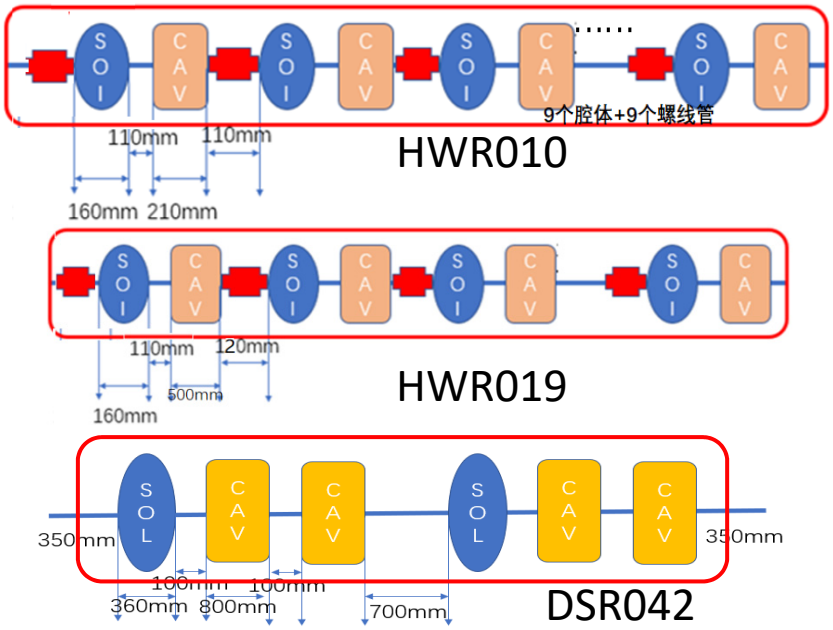


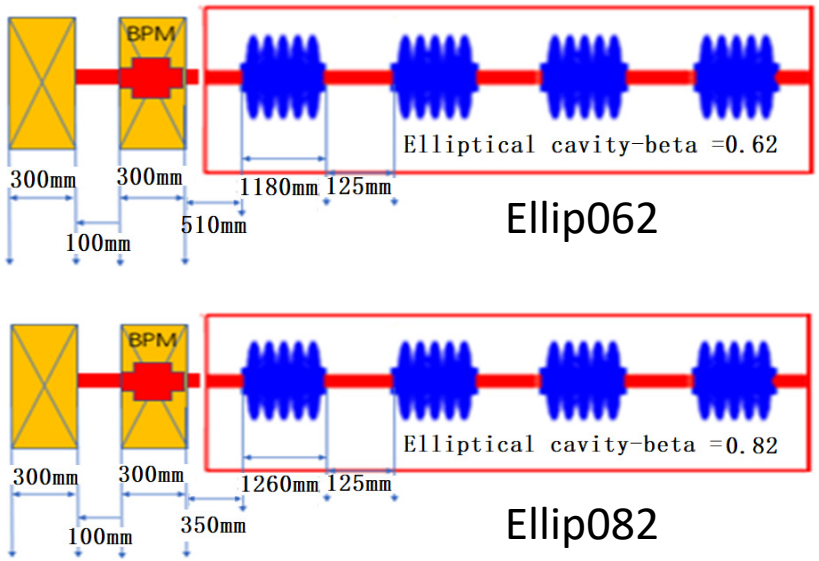
Outline

- 1. automation experience in IMP
  - 1.1 overweight cavity
  - 1.2 cleanliness in the strings assembly
  - 1.3 reducing labor cost
- 2. full automated HPR system
- 3. outlook for full automatic cleanroom for CIADS project

The problem of overweight cavity

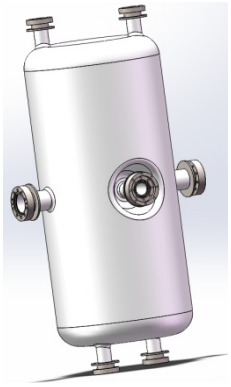
Cavity	Quantity of cavities	Quantity of strings
HWR010	9	1
HWR019	24	4
DSR042	40	10
Ellip062	40	10
Ellip082	24	4





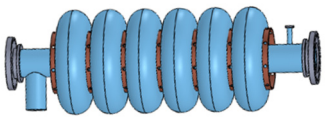
The problem of overweight cavity

Cavities type	Weight with helium vessel	Ports number
HWR010	~50kg	8
HWR019	~180kg	8
DSR042	~180kg	8
Ellip062	~140kg	4
Ellip082	~140kg	4



HWR019

DSR042



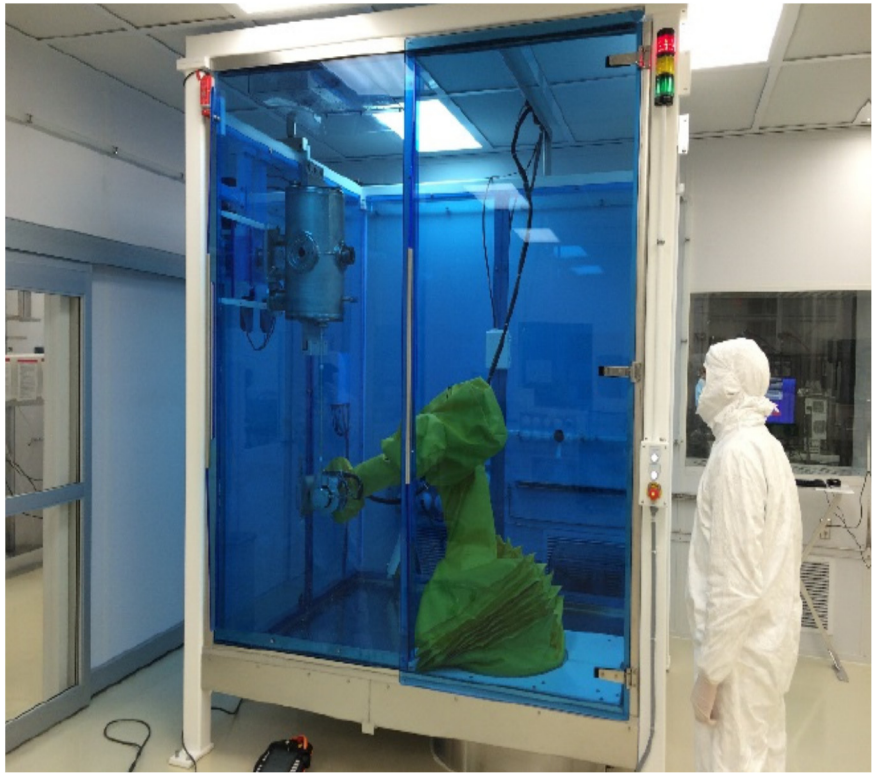
Ellip062

The weight of HWR019, DSR042, Ellip062 and Ellip082 is over the maximum permissible weight to be carried by an adult.

In 1967, the 'International labor Conference' gave a suggestion of maximum permissible weight to be carried by one worker. The weight is 50kg.

The robot applied in FRIB

Robot HPR system in FRIB: the first robot application in SRF cleanroom. Which gave us a new orientation for cleanroom automation.

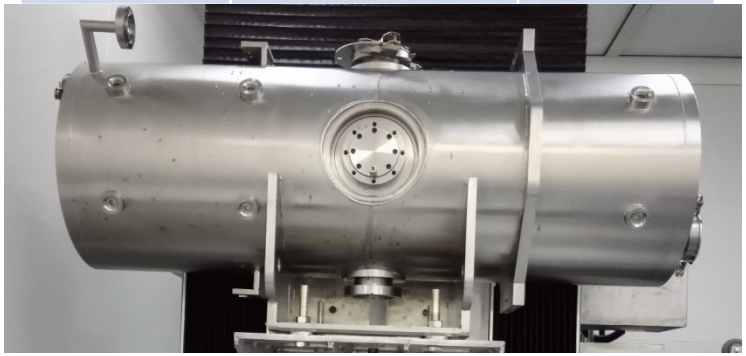


I. Malloch, et al. "Design and implementation of an automated high-pressure rinse system for FRIB SRF cavity processing" in proc. LINAC2016, East Lansing, MI, USA. Paper TUPRC024.

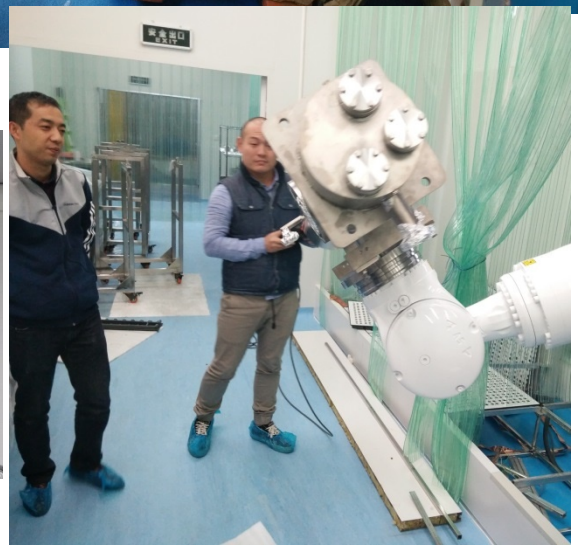
Robot application in IMP cleanroom

In 2017, in order to solve the problem in post process and cleanroom assembly of HWR015 cavities in IMP, a robot had been introduced in IMP cleanroom.

Cavity type	Weight with helium vessel	Ports number
HWR015	~120kg	8



HWR015 cavity



Parameter of the robot:

Cleanliness: ISO4 & ISO5

Rated payload: 210 kg

Pose repeatability: ±0.06mm

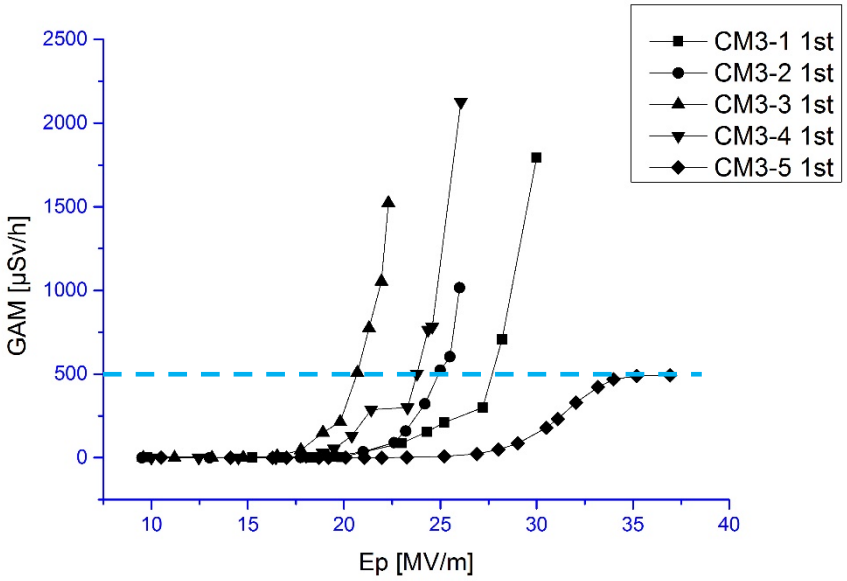
Number of axes: 6

Robot application in IMP cleanroom

In March 2018, the first robot assisting strings had been assembled in cleanroom.
This strings is used to replace the first CM3 which has been assembled in March 2017.

Robot application in IMP cleanroom

Cavity online RF result compared between CM3 1st and CM3 2nd
All cavities in CM3 1st and CM3 2nd have similar FE onset in vertical test.



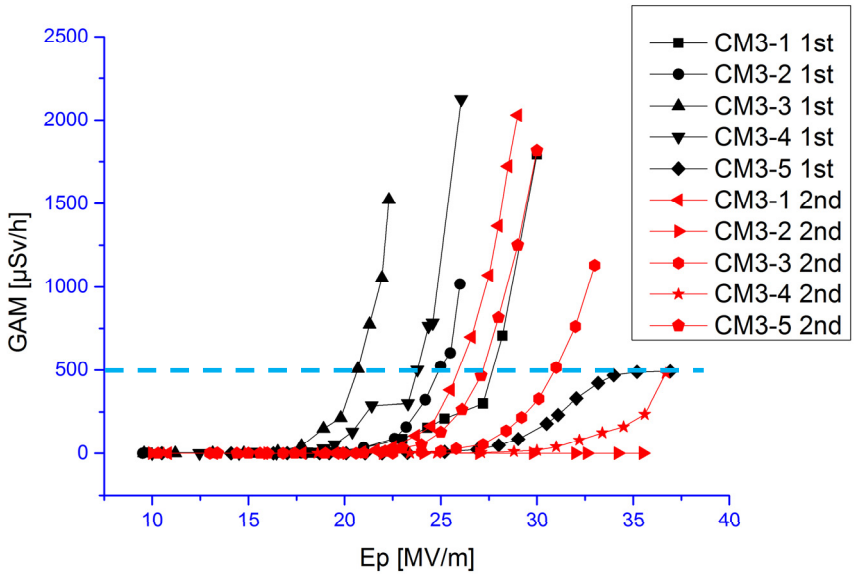
Cavity number	FE Onset (1st)	GAM<500 μSv/h(1st)	FE Onset (2nd)	GAM<500 μSv/h(2nd)
CM3-1	23MV/m	28MV/m	21MV/m	26MV/m
CM3-2	19MV/m	25MV/m		36MV/m
CM3-3	16MV/m	20MV/m	25MV/m	31MV/m
CM3-4	18MV/m	24MV/m	29MV/m	36MV/m
CM3-5	26MV/m	36MV/m	22MV/m	27MV/m
Average	20.4MV/m	26.6MV/m	24.2MV/m (4 cavities)	31.2MV/m

CM3 1st

- Hard alignment between flange to flange
- Assembled 5 times due to vacuum leak
- 3 operators needed on assembly and disassembly for HPR process

Robot application in IMP cleanroom

Cavity online RF result compared between CM3 1st and CM3 2nd
All cavities in CM3 1st and CM3 2nd have similar FE onset in vertical test.



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CM3 1st

- Hard alignment between flange
- Assembled 5 time um leak
- 3 operators n sembly and disassem process

contaminated

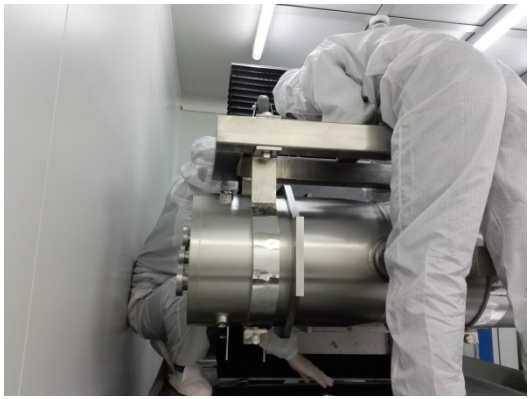
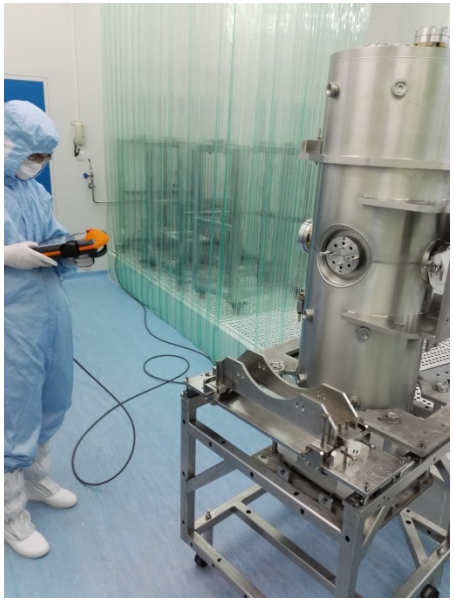
improvement

Improved by robot assisting

CM3 2nd

- Easy alignment between flange to flange with robot assisting
- Assembled only one time
- 1 operators needed on assembly and disassembly for HPR process

Robot application in IMP cleanroom

	Without robot		With robot	
HPR		At least ***3 operators*** in cleanroom for cavity loading and alignment		Only ***1 operator*** needed in cleanroom
Cavity moving		At least ***3 operators*** in cleanroom with special frame.		Only ***1 operator*** needed

Robot application in IMP cleanroom

The advantage of robot assisted in cleanroom (based on HWR015 cavities:

- labor saving (for one cavity)

Process	Operators (nomal)	Hours (nomal)	Operators (with robot)	Hours (with robot)	Hours saved
HPR	3	8	1	8	16
Cavity moving	3	1	1	1	2

- Benefit for cleanliness

Most particles in cleanroom are coming from operators. Thus less operators can reduce the contamination risk of cavities in cleanroom.

Conclusions

1. Robot assisting can better solve the problem of “over weight” which is caused by heavy cavities.

2. Robot assisting could not reduce the cavities RF performance compared with former process.

3. Robot assisting can save labors in cleanroom

What are the next steps ?

1. Full automated HPR system
2. Automated assembly

An automatic production line for SRF cavity strings.

Outline

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The design of automated HPR system

Based on robot technology, full automated HPR system is feasible.

Step	Robot assisting	Full automated
Cavity loading on HPR system	Manually	Manually
Launch wand rotating and pump	Manually	Automatic by control system
Ports change and alignment	Assisted by robot and visually aligned	Automatic by robot and aligned by control system
Process end and drying	Assisted by robot	Automatic by robot

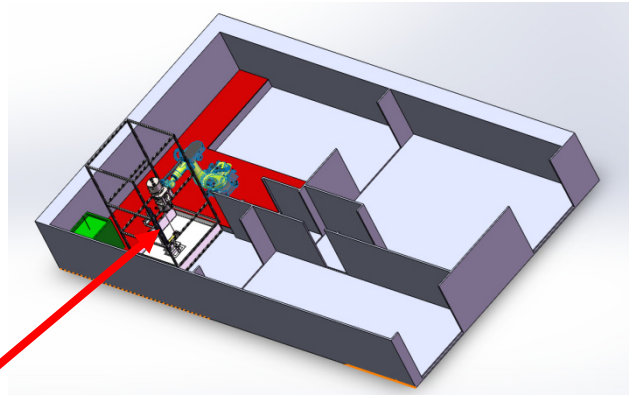
Process	Operators (robot assisting)	Hours (robot assisting)	Operators (full automated)	Hours (full automated)	Hours saved
HPR	1	8	1	1	7
Cavity moving and drying	1	1	0	0	1

The design of automated HPR system

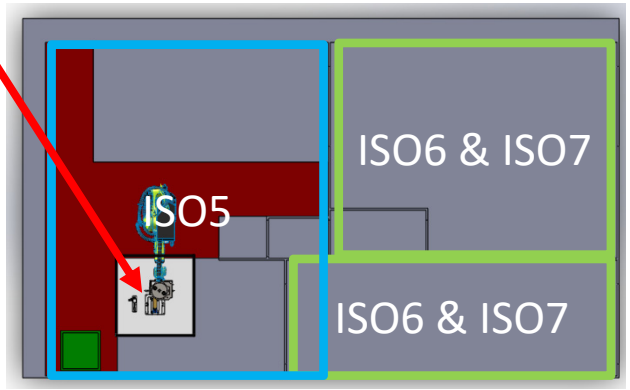
Some of main design goals for the automated HPR system:

- Rated payload: >200 kg
- Ingress protection: IP67
- Cleanliness: ISO class 5
- Stroke of wand: 1300 mm
- Length of wand: 1400 mm
- Diameter of wand: 12 mm
- ***Cavity type: Suit for all cavity type with ports diameter greater than 25mm***

The first version design of this system has been finished in mid-June.



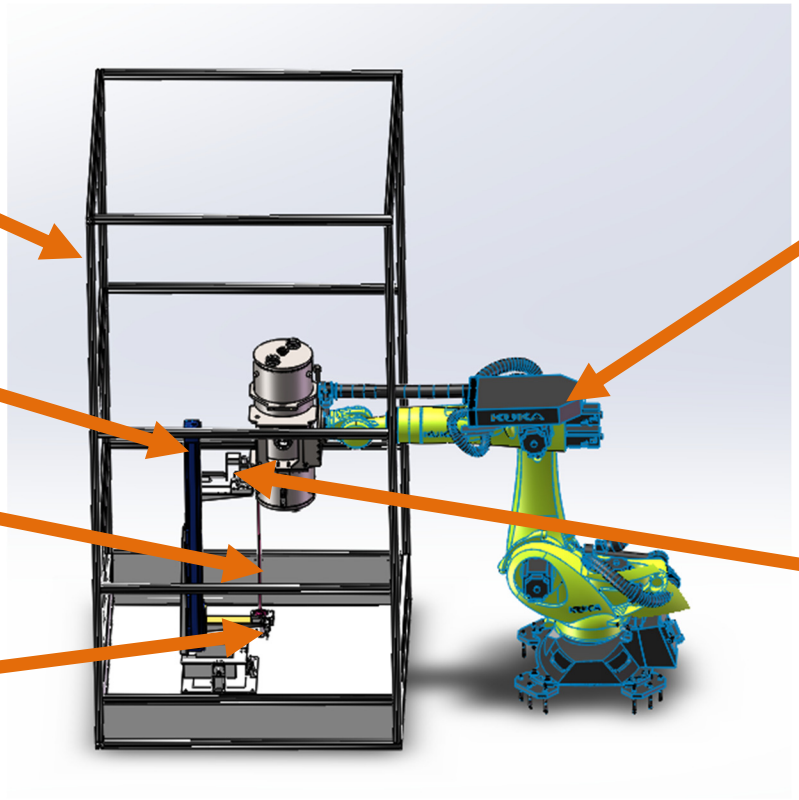
Automated HPR system



The layout of IMP cleanroom and the position of automated HPR system

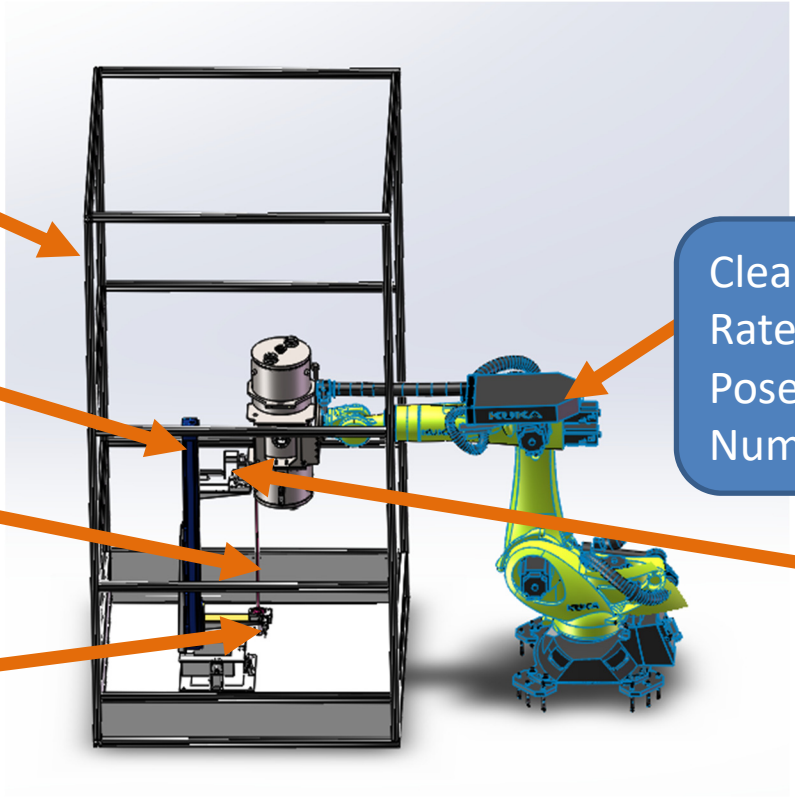
The design of automated HPR system

The detail design of automated HPR system



The design of automated HPR system

The detail design of automated HPR system



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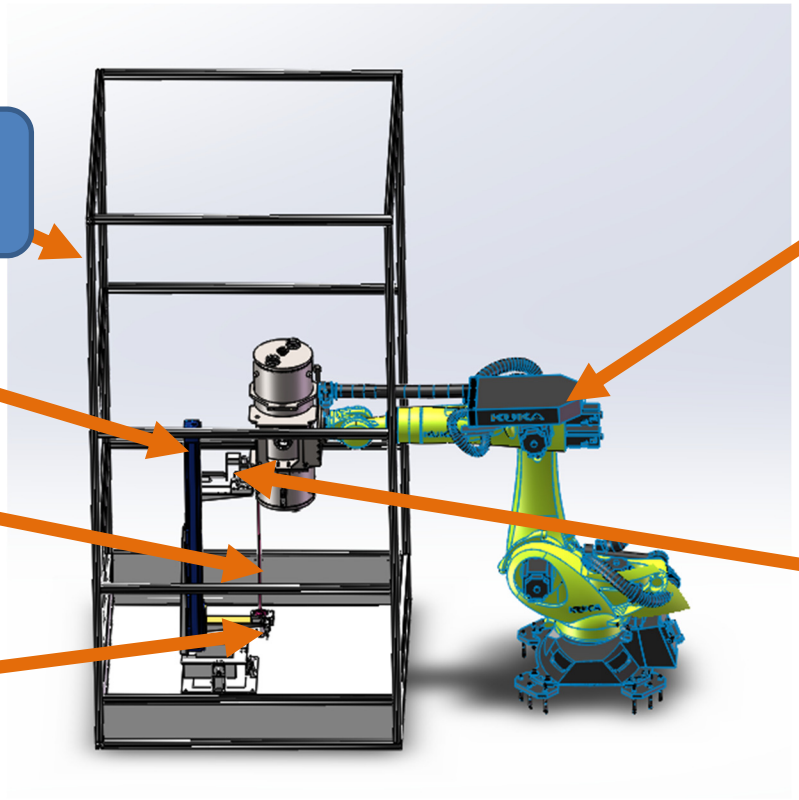
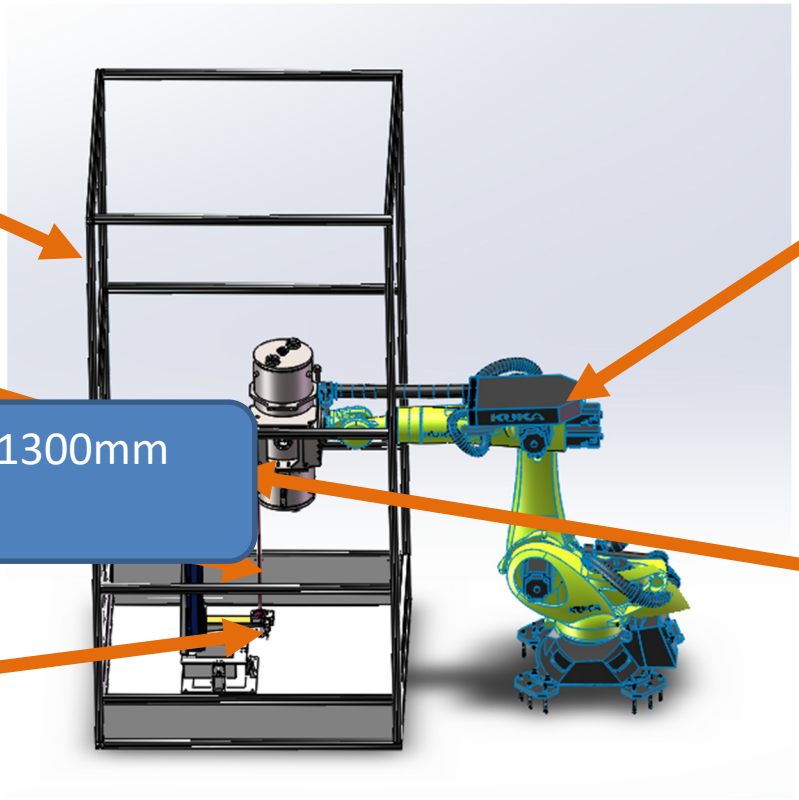


The design of automated HPR system

The detail design of automated HPR system



Water shelter frame

Linear motion system

Stroke length, maximum: 1300mm
Ingress protection: IP67

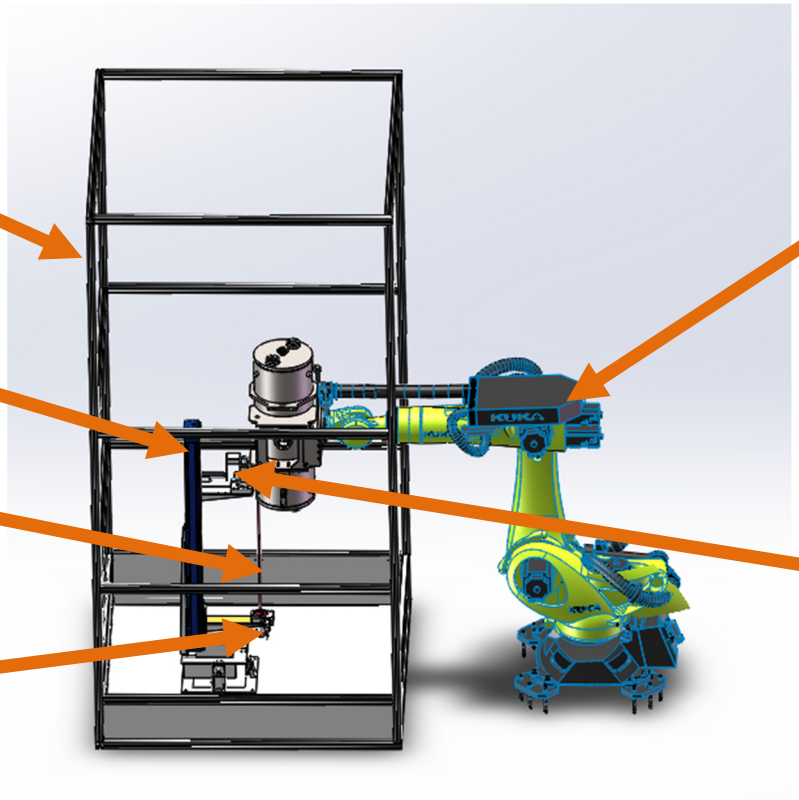
Rotary water feedthrough

Cleanroom robot

Alignment system

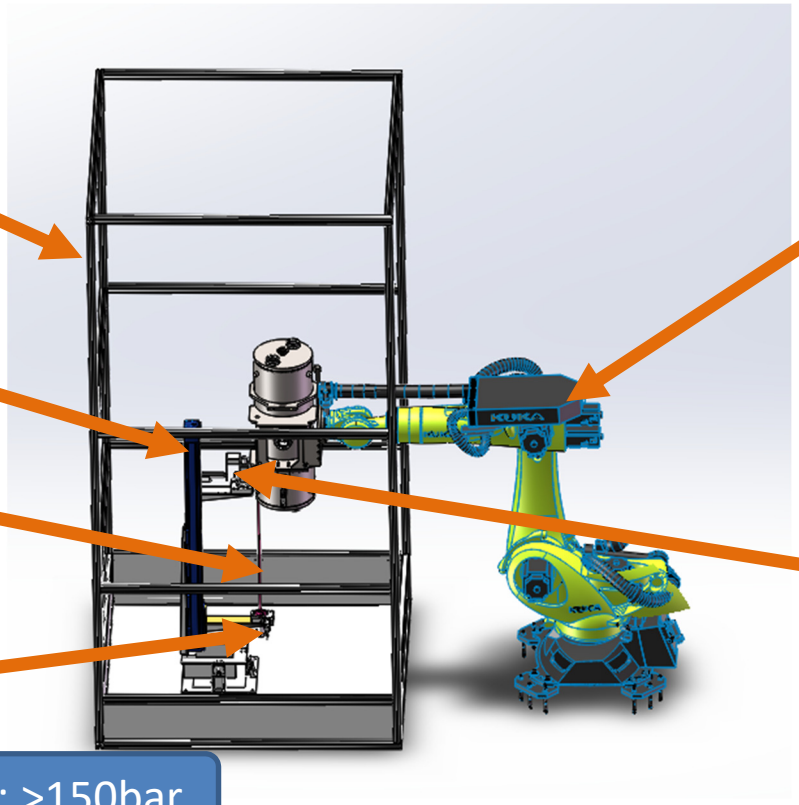
The design of automated HPR system

The detail design of automated HPR system



The design of automated HPR system

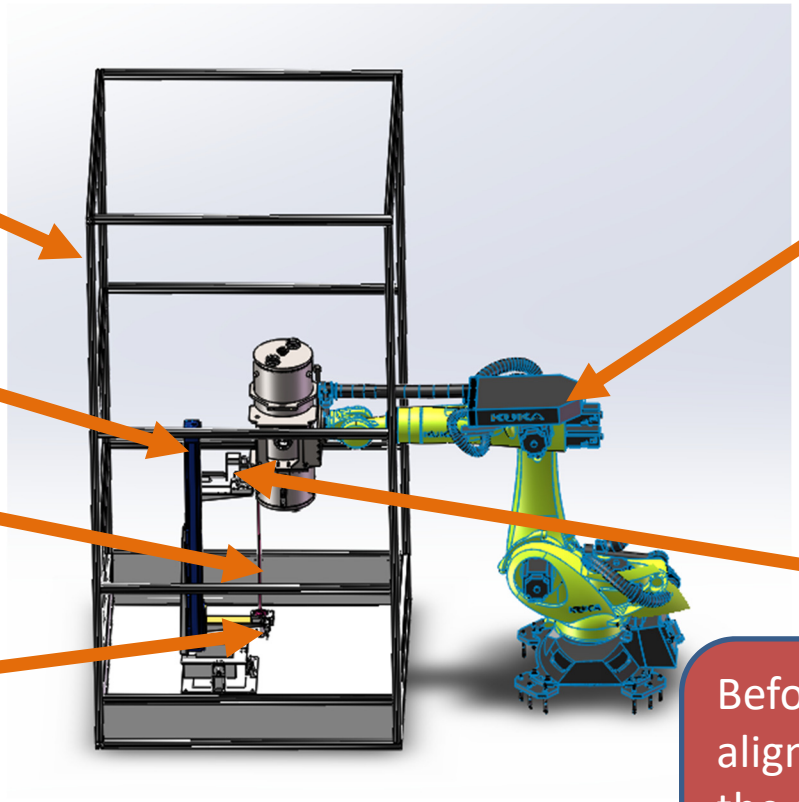
The detail design of automated HPR system



Maximum water pressure: >150bar

The design of automated HPR system

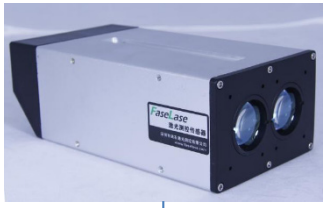
The detail design of automated HPR system



Before every process, alignment system will check the status of cavity which could avoid cavity damage by spray wand.

The design of automated HPR system

The control system design of automated HPR system



alignment system

HMI

communication

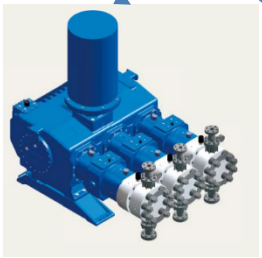
PLC

robot

pump

Servo motor (wand rotation)

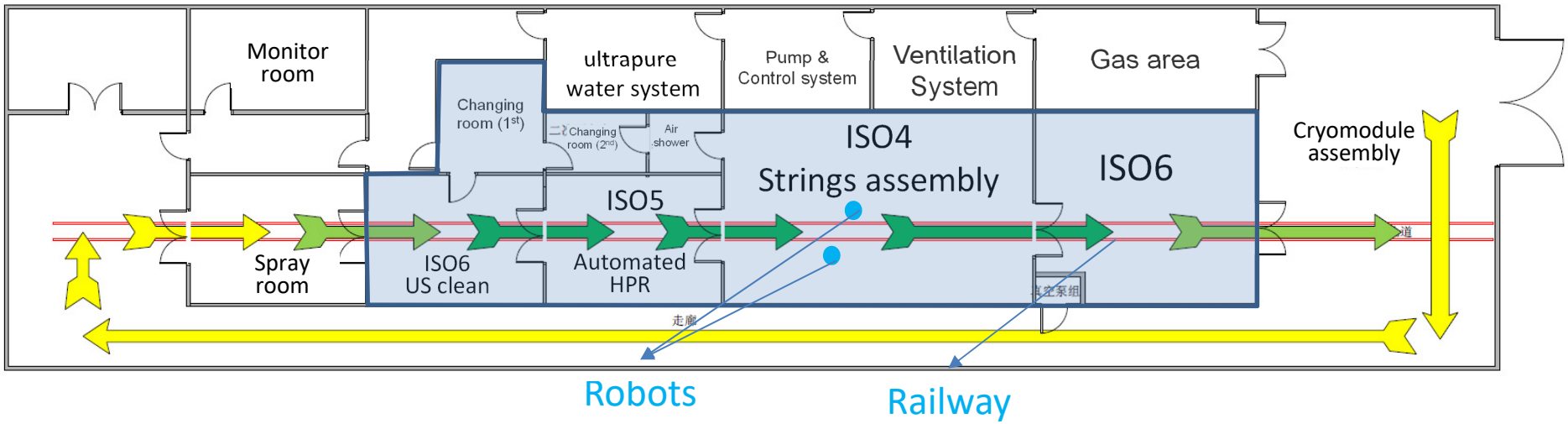
Servo motor (wand lift)



pump

valve

The new automatic cleanroom for SRF cavities



- The cavities will enter cleanroom from one side and become strings to other side.
- An automatic railway will be used for carry cavities and other components.
- A special facility will assist operator to move the cavity into ultrasonic cleaner.
- For HPR process, an automated system will finish it without operators.
- For strings assembly, two robots will assist operators to finish cleanroom alignment and assembly.

Operators needed in cleanroom

Step	Nomal cleanroom	Automated cleanroom
US clean	2	1
HPR	3	0
Strings assembly	3	2

Only 3 operators needed in the whole cleanroom process


Thank you!