

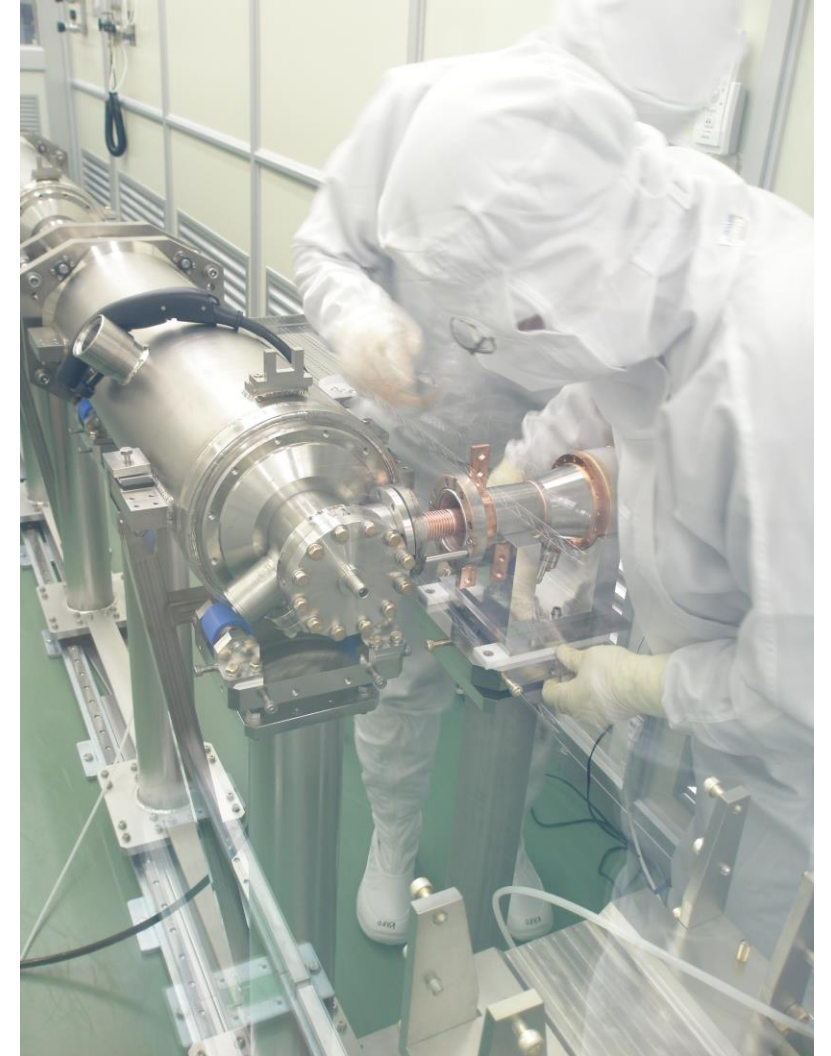


The status of robotic clean assembly in KEK

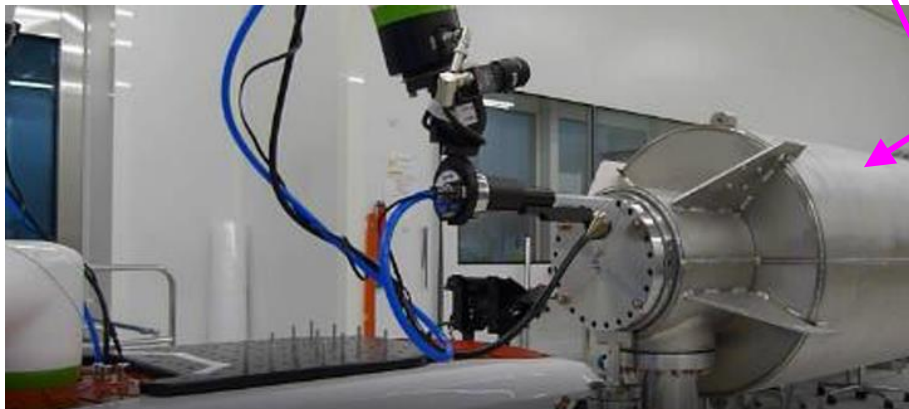
Tomohiro Yamada
KEK Accelerator Laboratory

On behalf of the KEK robotics group

Conventional clean assembly



Transformation: Human to Robot



CEA-IRFU

Semiconductor
Factory (KUKA)
<https://www.kuka.com/>



Importance of utilizing robotics

The introduction of robotics in clean room assembly will give us following benefits.

□ For SRF cavity:

- Preventing dust from entering the cavity prevents degradation of cavity performance.
- Perfect routine work by the robot promises high yield on cavity performance.

□ For human

- Workers no longer have to listen to loud noises when air-blowing, handle heavy components, and repeat boring routine works.

□ For accelerator project

- Since robots work in place of humans, labor costs can be reduced, ultimately lowering the cost of building accelerators.
- Robots can work 24 hours a day, 7 days a week, 365 days a year, which helps to shorten the workload.

KEK's target



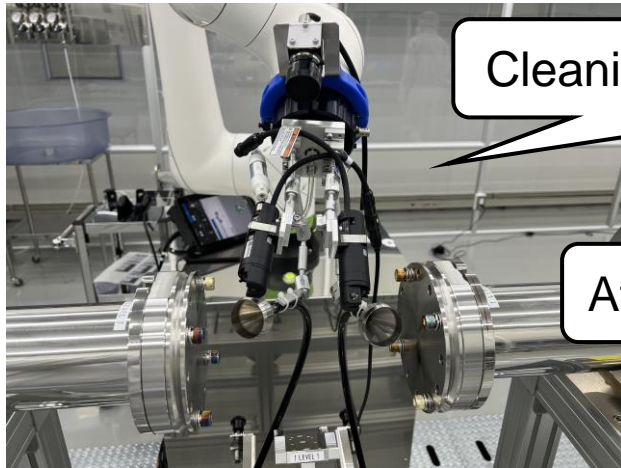
- MEXT-ATD: Fabrication and test of ILC-type CM by 2028 March
- Robots will be utilized for string assembly.

Research and development items in robot use in the cleanroom	CY2024				CY2025				CY2026				CY2027				28
	JFY2024				JFY2025				JFY2026				JFY2027				
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Integration of the robot, particle counter and ion-gun	■	■															
Air blowing for the cavity end group	■	■	■	■													
Flange exchange, Coupler installation, Bellows installation					■	■	■	■	■								
Relative positioning	■	■	■	■	■	■	■	■	■	■	■						
<i>String assembly</i>													■	■			
<i>CM assembly</i>													■	■			
<i>CM tests</i>															5	■	

KEK's status on Robotics



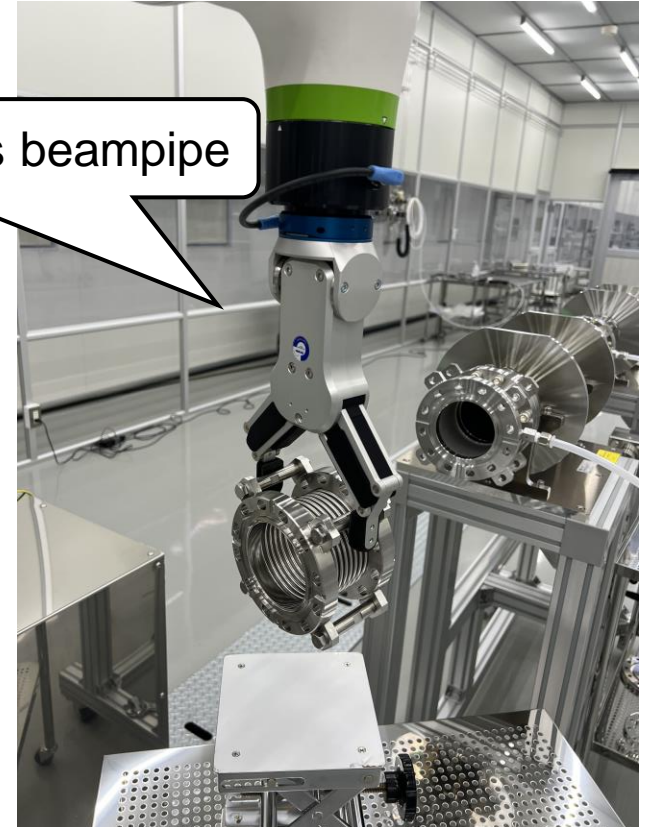
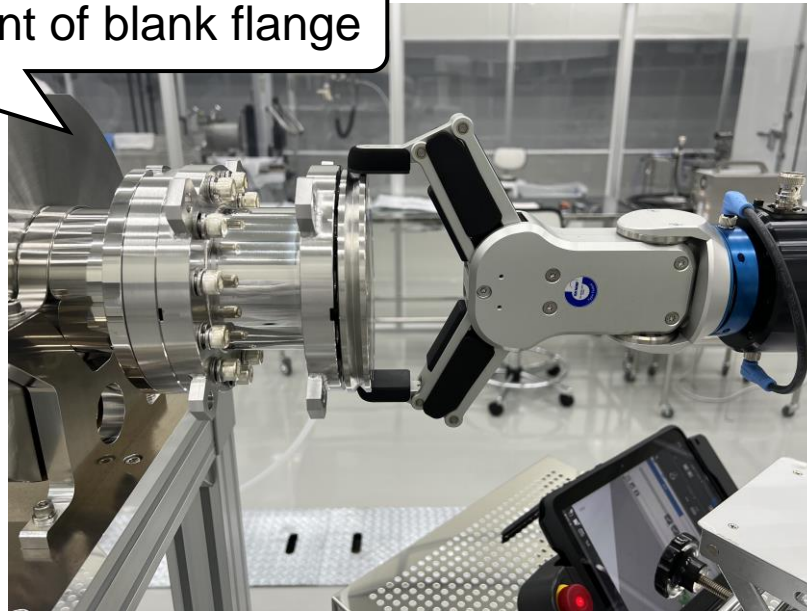
- KEK introduced a robot in 2022.
- It is still in the demonstration phase and not yet for actual use.



Cleaning by multi-ionized guns

Attachment of blank flange

Attachment of bellows beampipe

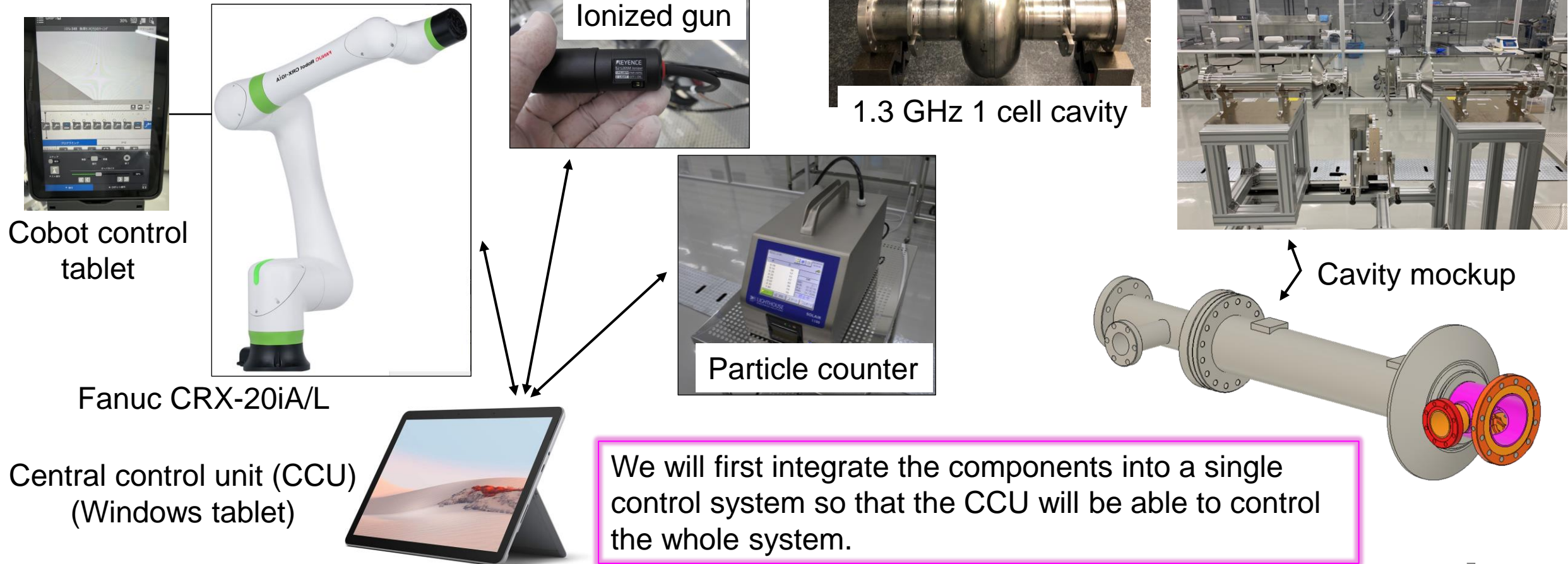


Research plan in JFY2024 - 1



Target: with 1 cell cavity, air blowing, flange exchange, etc...

Key components:



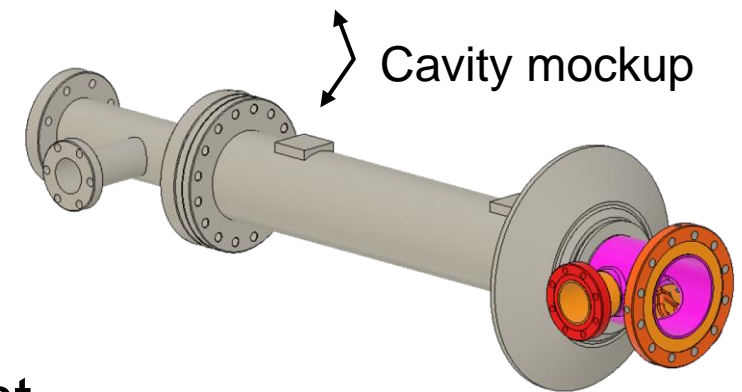
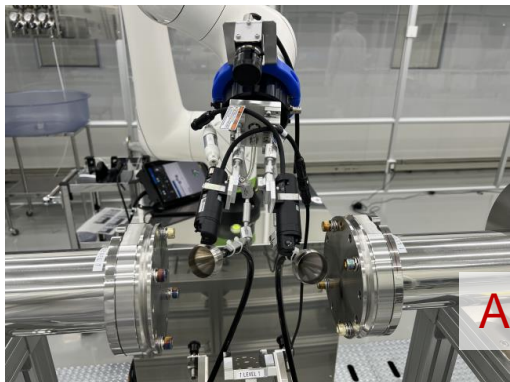
Research plan in JFY2024 - 2



Target: with 1 cell cavity, air blowing, flange exchange, relative positioning etc...

R&D topics

- How to grab an ionized air gun,
- How to teach trajectory of movement to the robot around cavity end group,
- How to grab components for assembly.



Validation method

- Assembly of 1 cell cavity with a robot for cavity RF test,
- Evaluation of Field Emission.

Future plan in JFY2025 & 2026



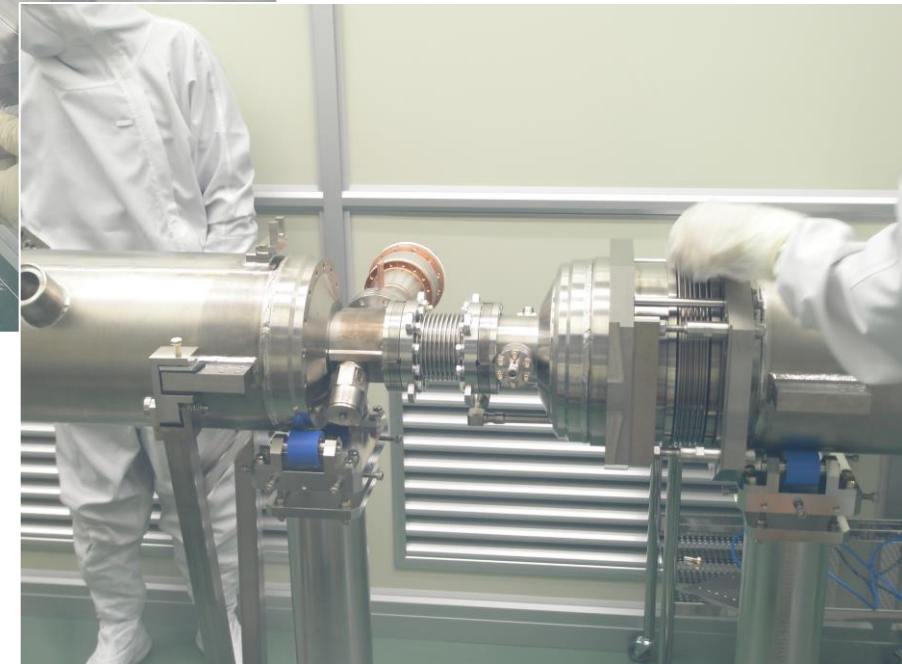
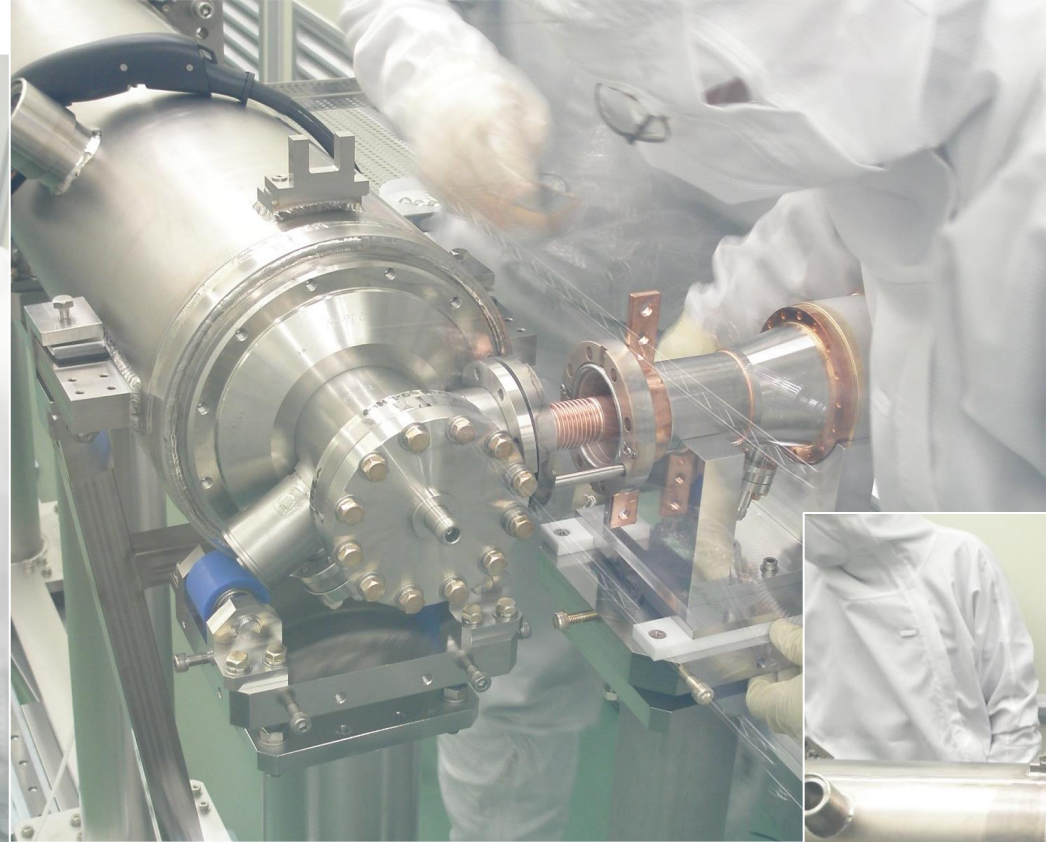
Target: with 9 cell cavity, flange exchange, coupler installation, bellows installation etc...

R&D topics

- How to handle a coupler by robot,

Research and development items in robot use in the cleanroom	CY2024				CY2025				CY2026				CY2027				28
	JFY2024				JFY2025				JFY2026				JFY2027				
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Integration of the robot, particle counter and ion-gun	■	■															
Air blowing for the cavity end group	■	■	■	■													
Flange exchange, Coupler installation, Bellows installation					■	■	■	■	■								
Relative positioning	■	■	■	■	■	■	■	■	■	■	■						
<i>String assembly</i>													■	■			
<i>CM assembly</i>														■	■		
<i>CM tests</i>																■	

Coupler installation



Future plan in JFY2025 & 2026



Target: with 9 cell cavity, flange exchange, coupler installation, bellows installation etc...

R&D topics

- How to handle a coupler by robot,
- How to insert an inter-cavity bellows and touch both side flanges,

Research and development items in robot use in the cleanroom	CY2024				CY2025				CY2026				CY2027				28
	JFY2024				JFY2025				JFY2026				JFY2027				
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Integration of the robot, particle counter and ion-gun	■	■															
Air blowing for the cavity end group	■	■	■	■													
Flange exchange, Coupler installation, Bellows installation					■	■	■	■	■								
Relative positioning	■	■	■	■	■	■	■	■	■	■	■						
<i>String assembly</i>													■	■			
<i>CM assembly</i>														■	■		
<i>CM tests</i>															■	■	

Inter-cavity bellows installation



Future plan in JFY2025 & 2026



Target: with 9 cell cavity, flange exchange, coupler installation, bellows installation etc...

R&D topics

- How to handle a coupler by robot,
- How to insert an inter-cavity bellows and touch both side flanges,
- Towards string assembly, confirmation of robotic assembly after movement to the next cavity position

Research and development items in robot use in the cleanroom	CY2024				CY2025				CY2026				CY2027				28
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Integration of the robot, particle counter and ion-gun	■	■															
Air blowing for the cavity end group	■	■	■	■													
Flange exchange, Coupler installation, Bellows installation					■	■	■	■	■								
Relative positioning	■	■	■	■	■	■	■	■	■	■	■	■					
<i>String assembly</i>													■	■			
<i>CM assembly</i>														■	■		
<i>CM tests</i>																■	

Validation method

- Assembly of 1 cell cavity with a robot for cavity RF test,
- Evaluation of Field Emission.



Summary



- KEK has taken aim on the cavity string assembly starting at January 2027.
- The robot will be utilized as much as possible for the string assembly. For that,
 - In JFY2024, R&D on air blowing and flange exchange with 1 cell cavity,
 - In JFY2025 & 2026, R&D on coupler and bellows installations with 9 cell cavity,
 - Validation of each R&D will be done by evaluating Field Emission at RF test.
- KEK's robotics R&D will be also supported and accelerated by US-Japan and France-Japan (FJPPN) programs.

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