

Cavity Fabrication status

9th July 2024

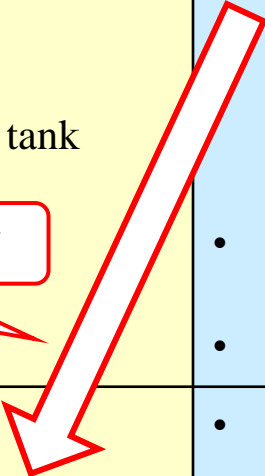
LCWS2024 SRF-session

Takayuki SAEKI (KEK iCASA)

**Relationship between MEXT-ATD and ITN
&
Global collaboration
&
License agreement and NDA to be updated**

MEXT-ATD (done by KEK as domestic program)		ITN (as Time-critical work packages) (done by global collaboration for ILC)	
Cavity	<ul style="list-style-type: none"> Nb material preparation Production HPGS Establishment of surface treatment Clean assembly VT Equipment of helium tank 	<ul style="list-style-type: none"> 1-cell cavity: fundamental research 9-cell cavity <ul style="list-style-type: none"> HPGS Purchasing SC material Industrial production with globally shared contracts VT and further effort Clean room work procedure (robotics) Quality control/assurance 	<p>Necessary Nb material sent from KEK</p> <p>WPP-1 (Cavity Industrial-Production Readiness)</p>
Cryomodule incl. ancillaries	<ul style="list-style-type: none"> Production HPGS Clean assembly/Installation Cold test at CM bunker 	<ul style="list-style-type: none"> Finalization of envelope drawing including tuner, coupler, SCQ HPGS 	<p>WPP-2 (Cryomodule design)</p>
Infrastructure	<ul style="list-style-type: none"> Cryogenics CM test bunker Cold mass hanger Rail system for cavity string 		
Crab cavity		<ul style="list-style-type: none"> Prototype production VT Design of CM 	<p>WPP-3 (Crab cavity)</p>

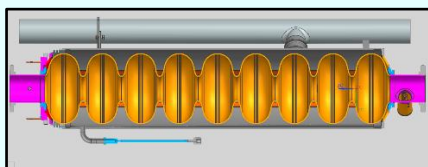
Two cavities sent from oversea before CY2027



Each Step of MEXT-ATD program (JFY2023-2027)

Production

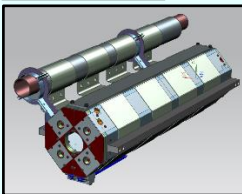
L-band SC 9-cell cavity



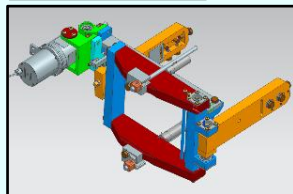
Power coupler



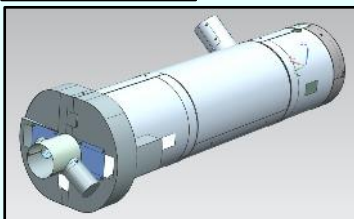
SCQ magnet



Frequency tuner



Magnetic shield

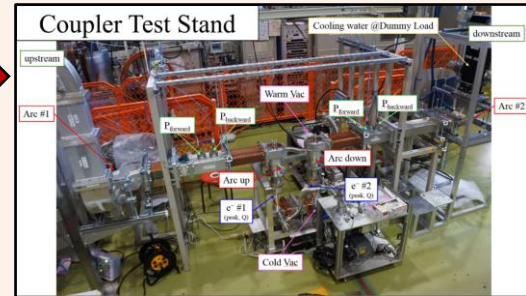


Component Test



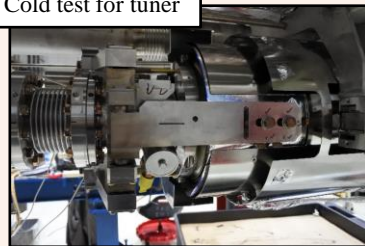
Vertical test for cavity

High power test for coupler



Coupler Test Stand

Cold test for tuner

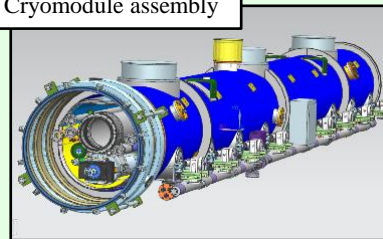


Installation

Demagnetization of cryo-vessel



Cryomodule assembly



Preparation

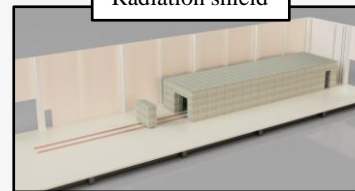
Cryogenic



CM assembly hall

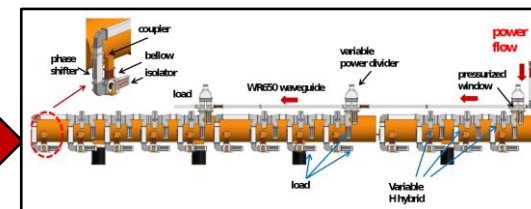


Radiation shield



CM Test

Waveguide assembly



Installation into bunker



Cold test at bunker



Global collaboration on SRF for MEXT-ATD/ITN

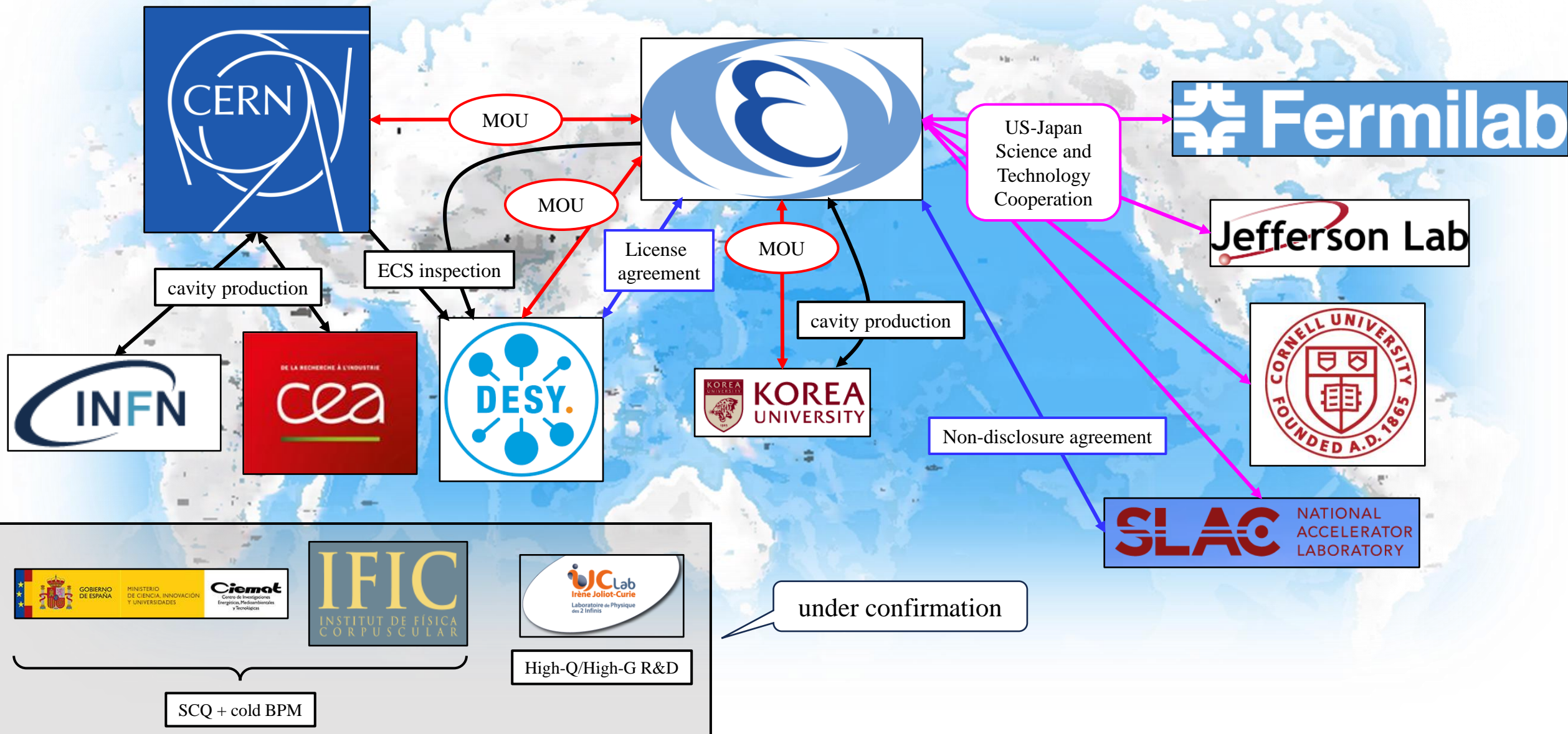
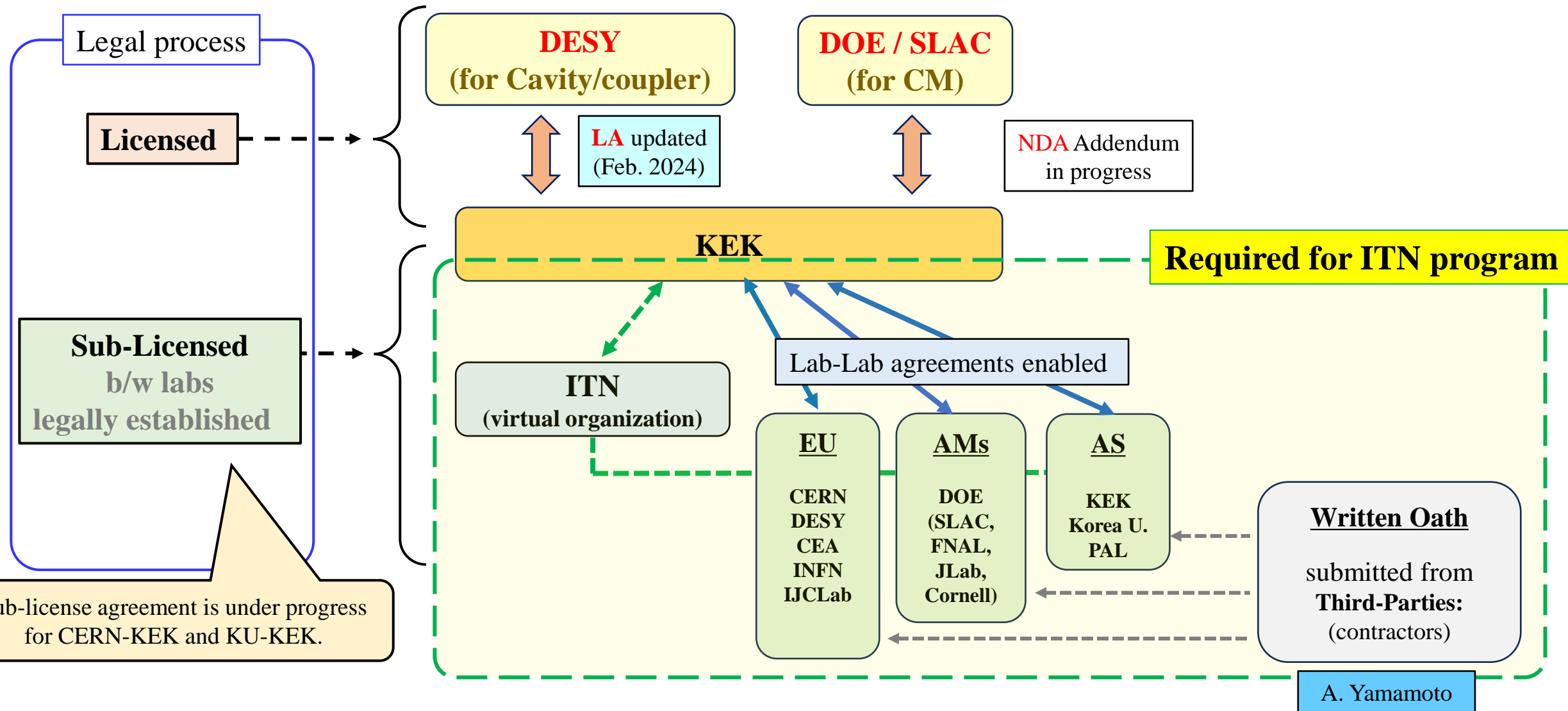
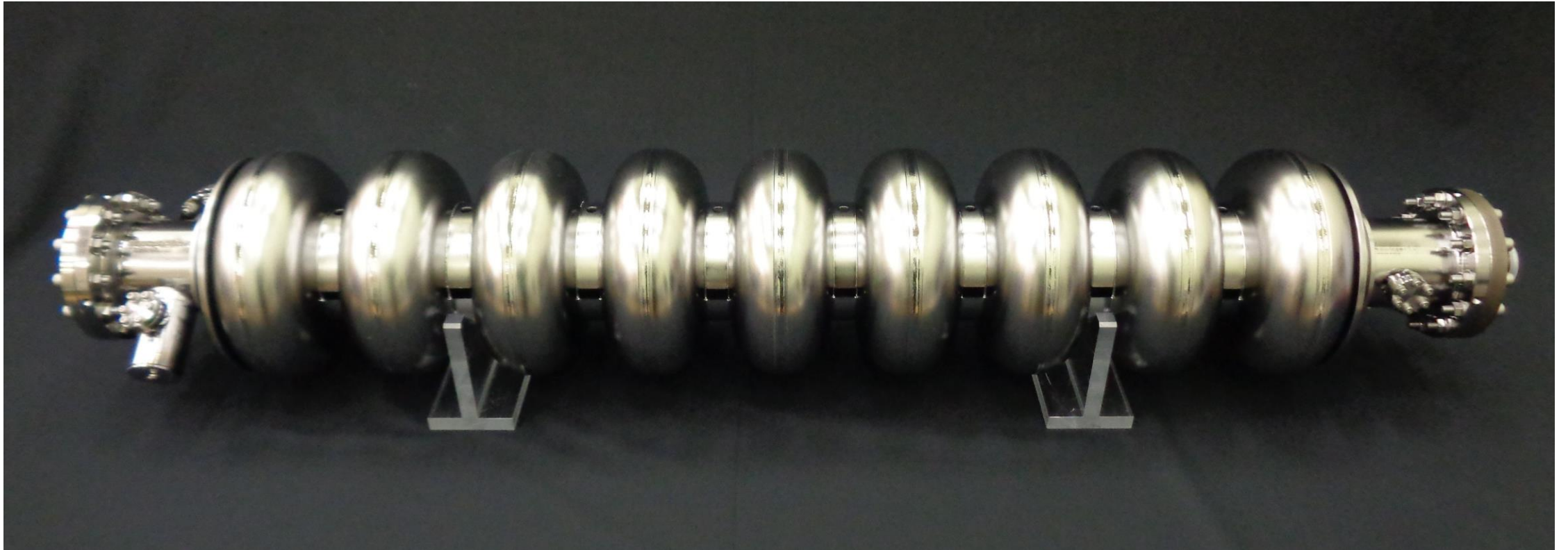


Image of License Agreement (LA) and NDA updates for ITN

(based on the License Agreement between DESY and KEK, and NDA between SLAC and KEK)



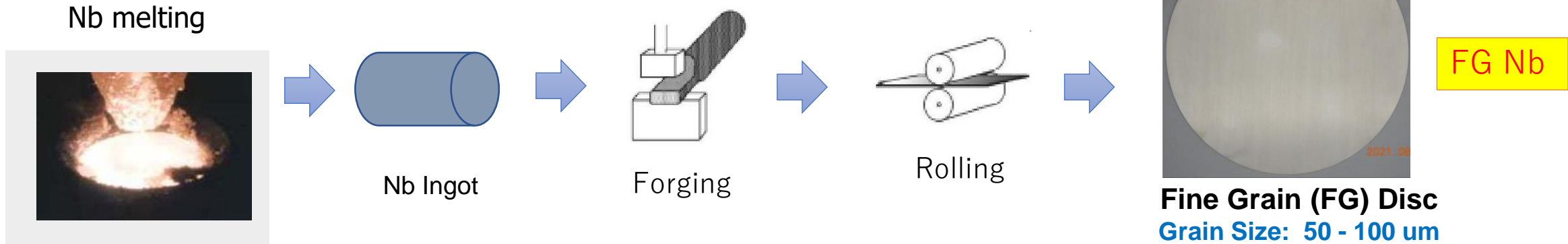
Cavity Fabrication status



Fine-Grain Nb 9-cell cavity

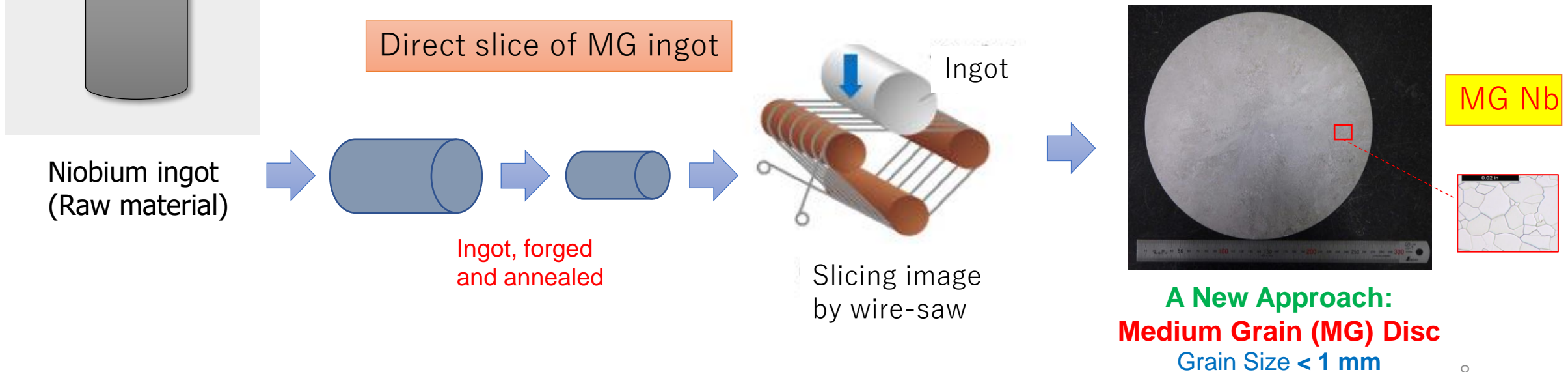
Manufacture methods of Fine-Grain / Medium-Grain Nb discs

Fine Grain Nb fabrication

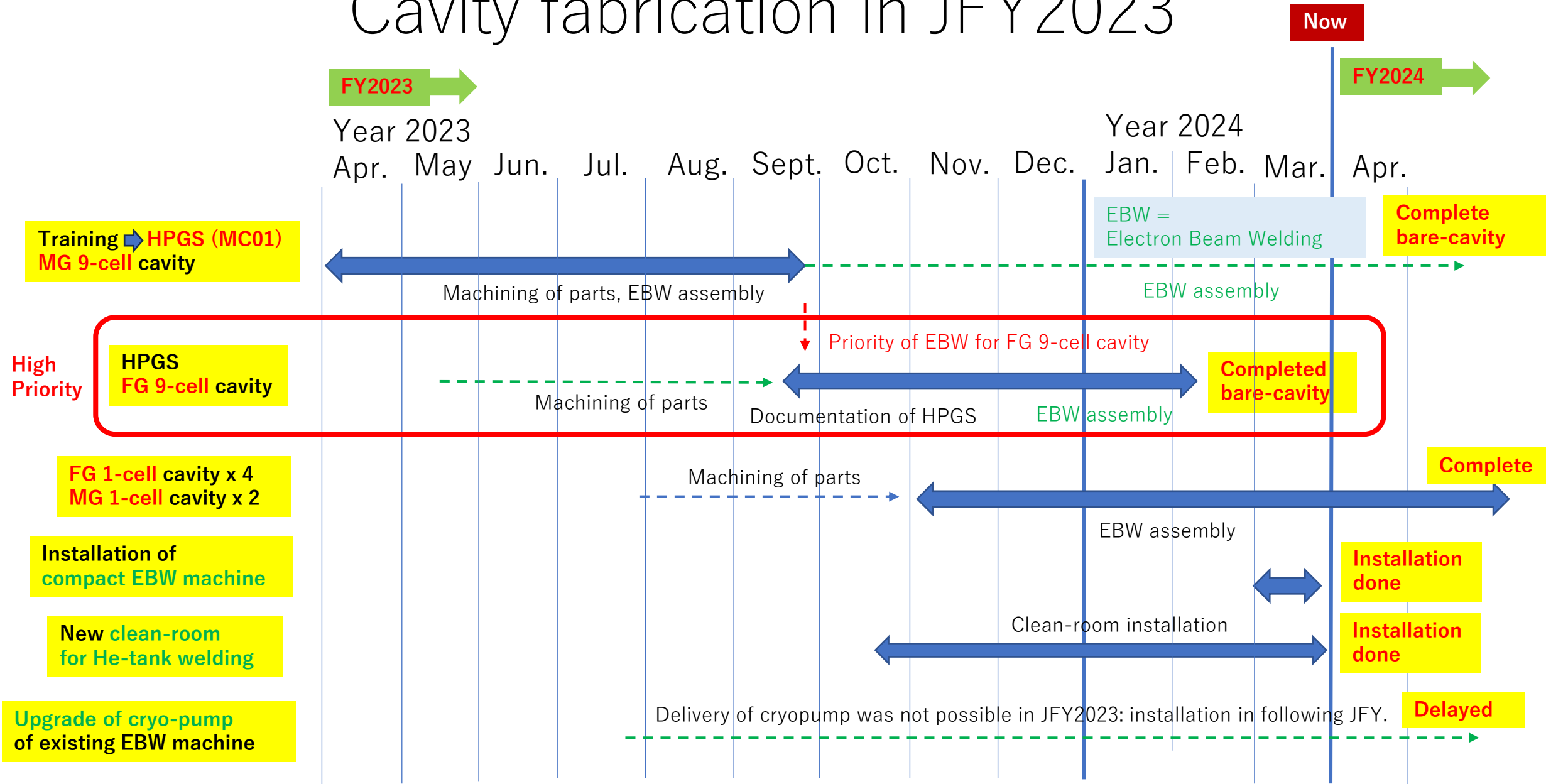


- Aiming for clean, mechanically stable, and cost-effective SRF cavity production.

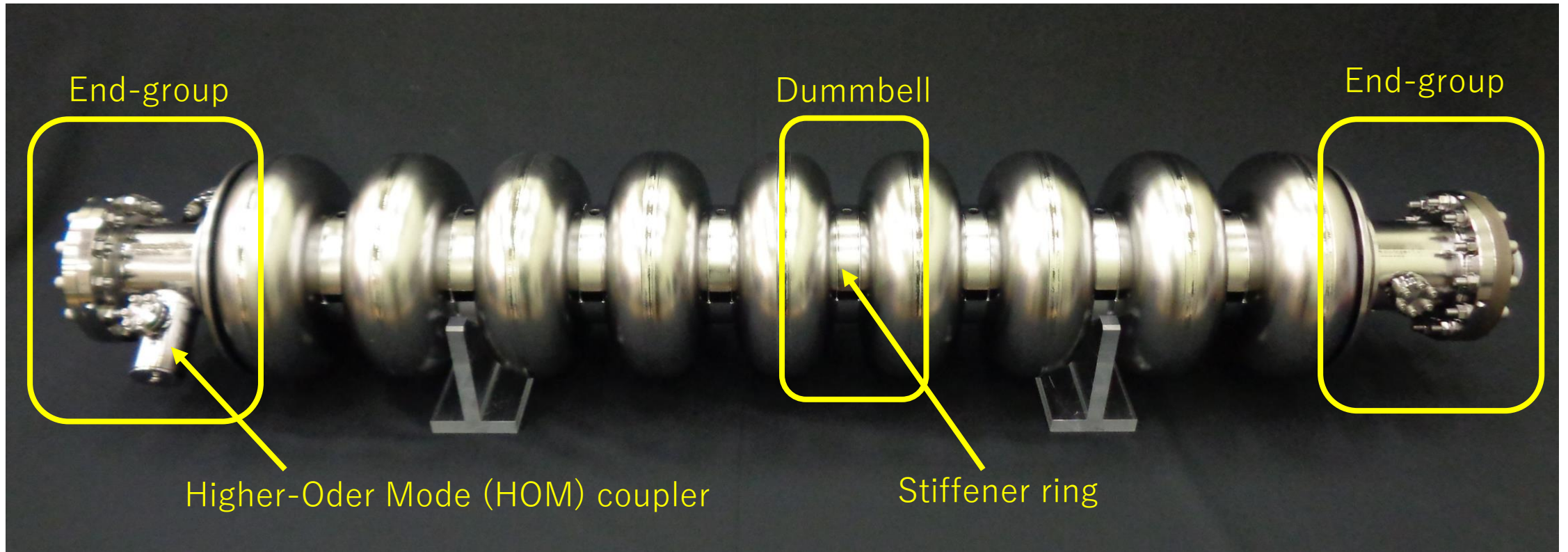
Direct slice of MG ingot



Cavity fabrication in JFY2023

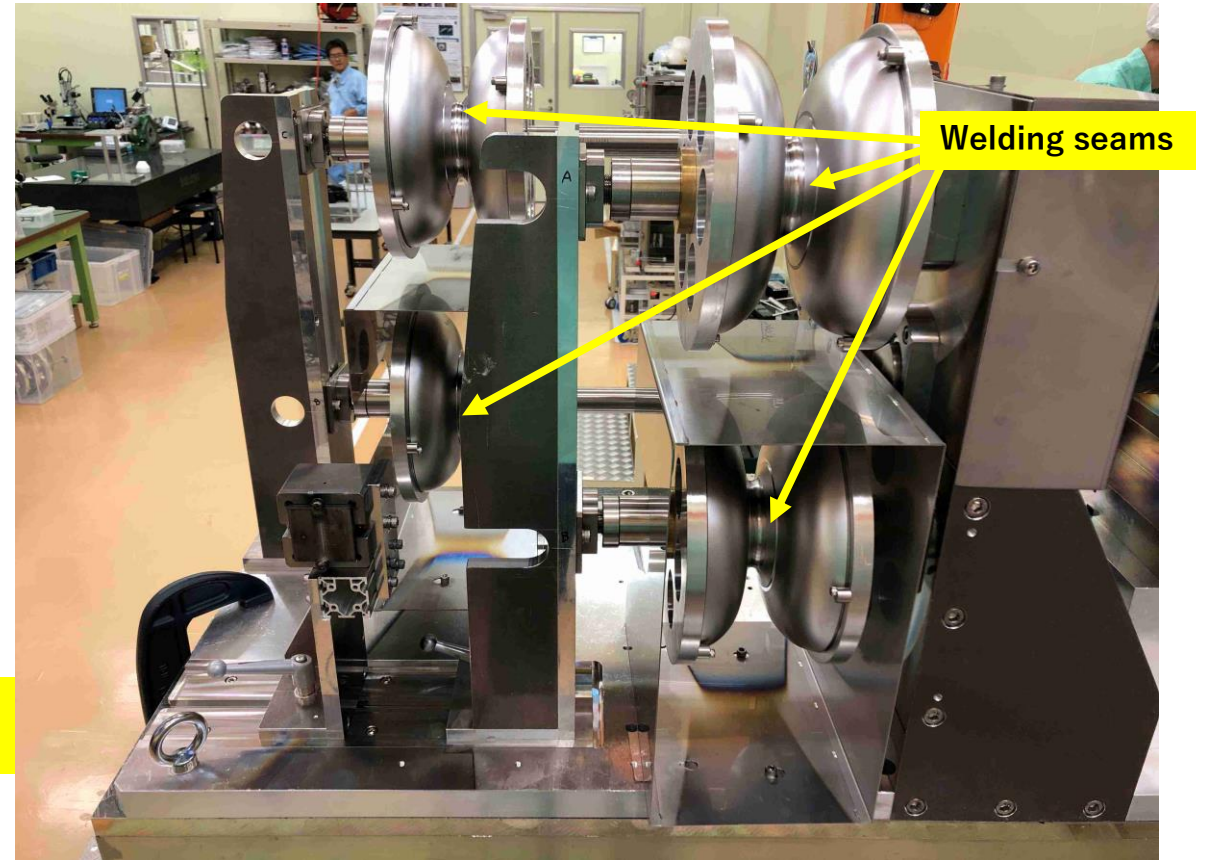
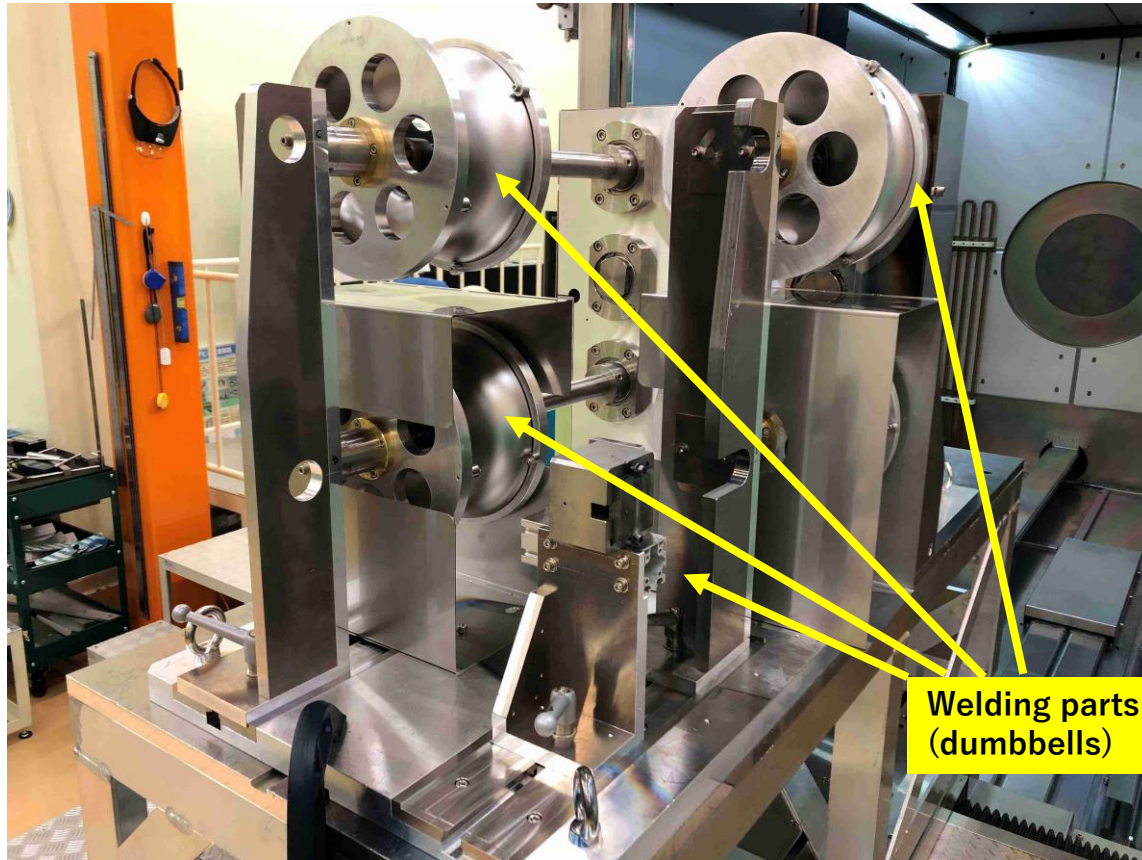


Cavity Fabrication



Fine-Grain Nb 9-cell cavity

Dumbbell EBW (on 20 Spt. 2023)



Electron Beam Welding (EBW) is done by following 4 steps. 1) setting parts inside vacuum chamber and pumping the vacuum chamber (more than one hour), 2) welding the seams by electron beam, 3) cooling the welded parts in the vacuum chamber (about 40 minutes), 4) breaking the vacuum chamber and taking out the parts. Pumping and cooling takes about two hours. So multiple-part fixture is necessary for efficient welding.

Multiple-part fixture for HOM parts.



At maximum, four HOM parts are EBW-assembled at once.

FG-Nb 9-cell cavity: EBW assembly



2-Dumbbell x 5 EBW was done (9-11 Jan)
(4 + spare 1)



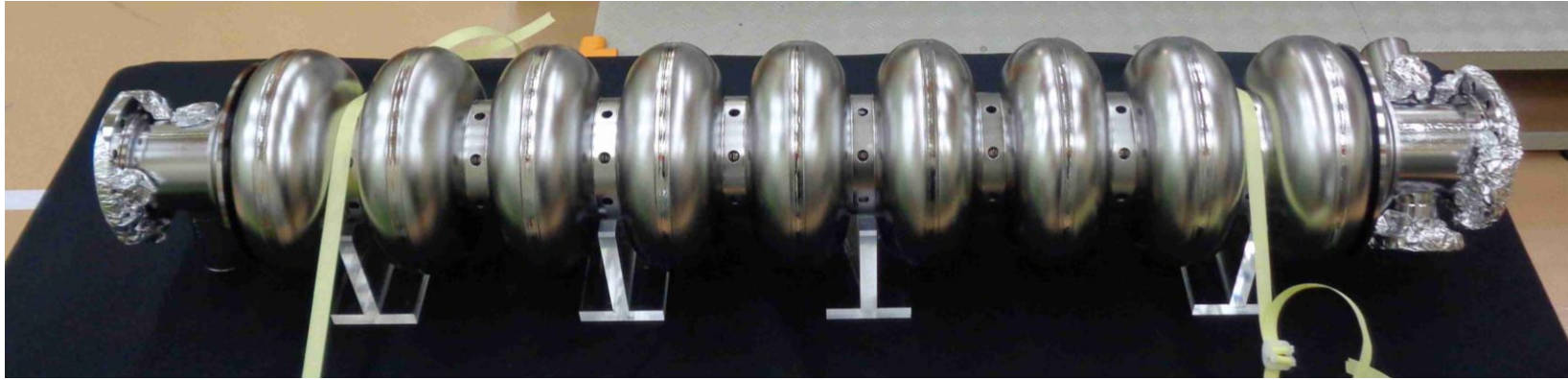
(End-cell + Beam-Tube) x2
EBW was done (24 Jan).
Coupler-flange
EBW was done (24 - 25 Jan).



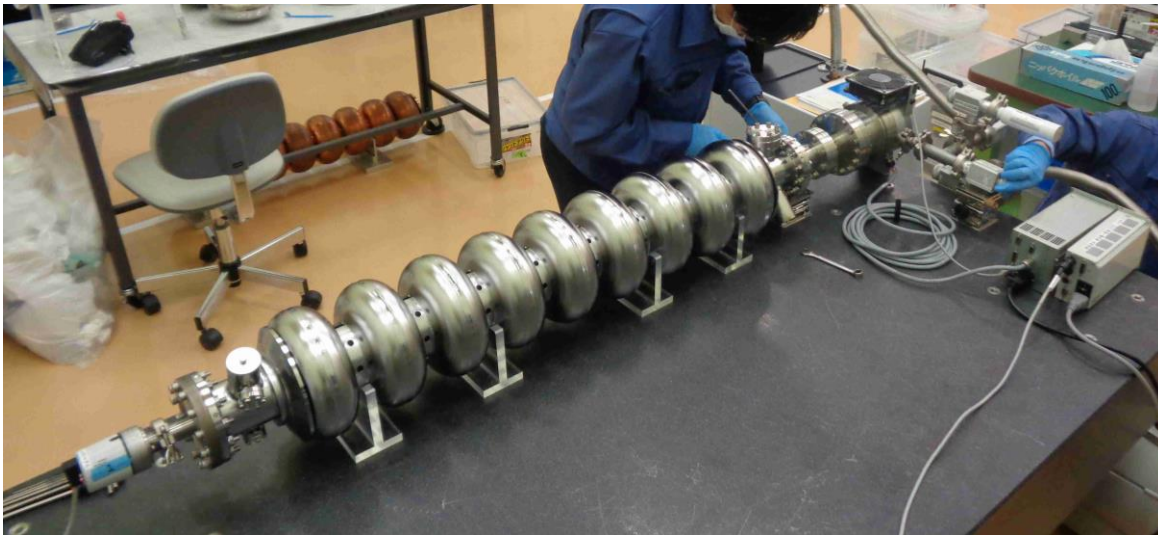
9-cell cavity assembly (31 Jan - 2 Feb):
The equator-seam of cell x 5 was done.

9-cell cavity assembly
was finished on 2 (Fri.) Feb. 2024

Fabrication of FG 9-cell cavity completed



Final EBW assembly was done(2 Feb. 2024)

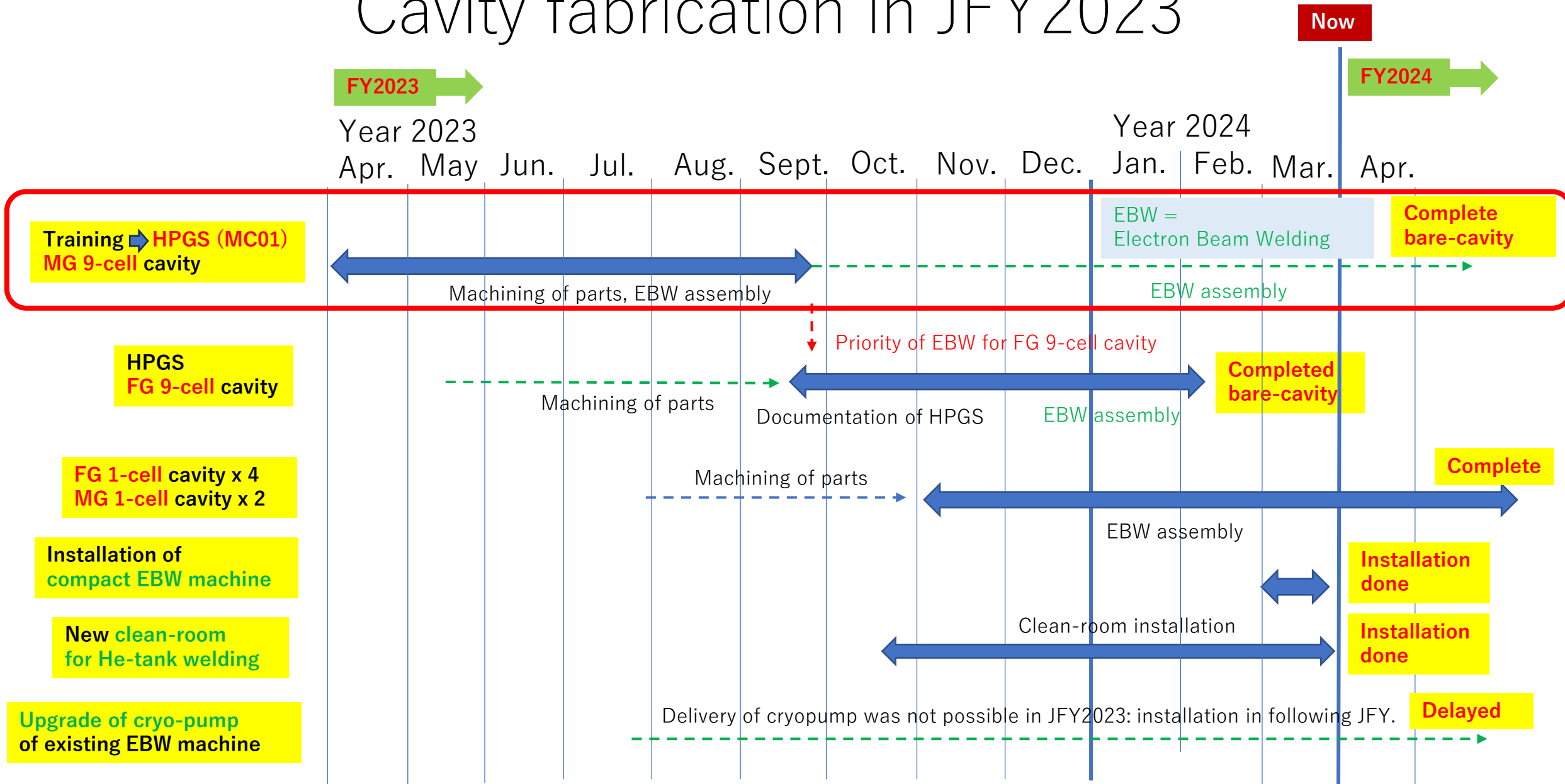


2 (Fri.) Feb : No leak in the leak tests



3-D dimension measurement was done (19 Mar.)

Cavity fabrication in JFY2023



Fabrication of MG 9-cell cavity

MG-Nb (Grain-size < 1 mm)



Fabrication of MG-Nb 9-cell cavity is the first time in the world.

EBW-assembled all dumbbells

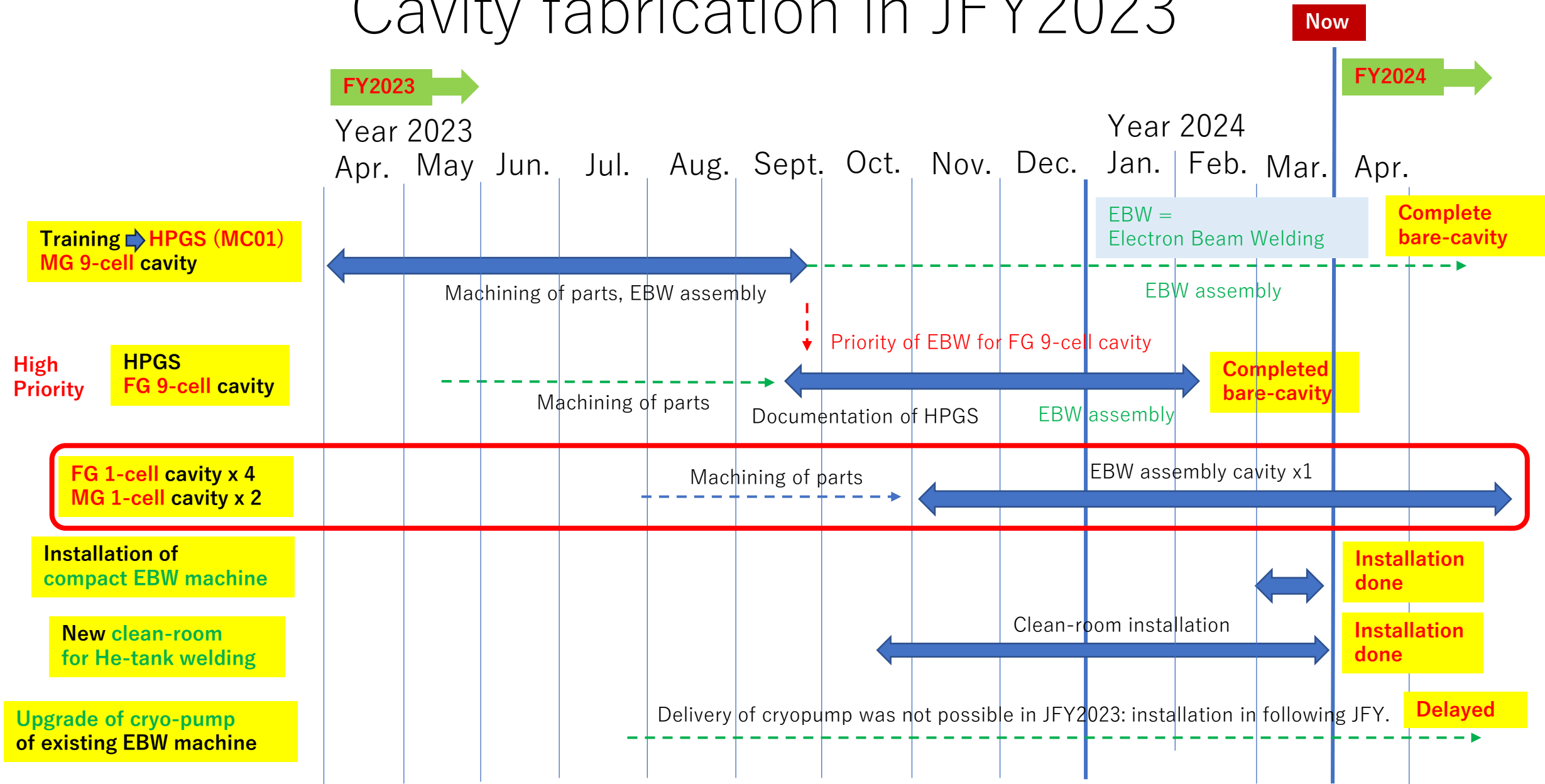


End-group assembly is scheduled in 2024.

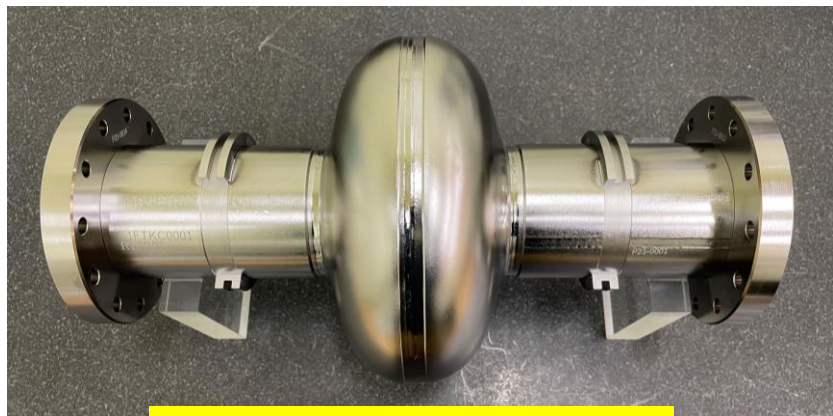
End-group parts of four 9-cell cavities will be EBW-assembled at once by using multiple-part fixtures efficiently.

Cavity fabrication will be finished in FY2024.

Cavity fabrication in JFY2023



FG-Nb single-cell cavities
(R1FC01, R1FC02) completed



R1FC01(Nickname)



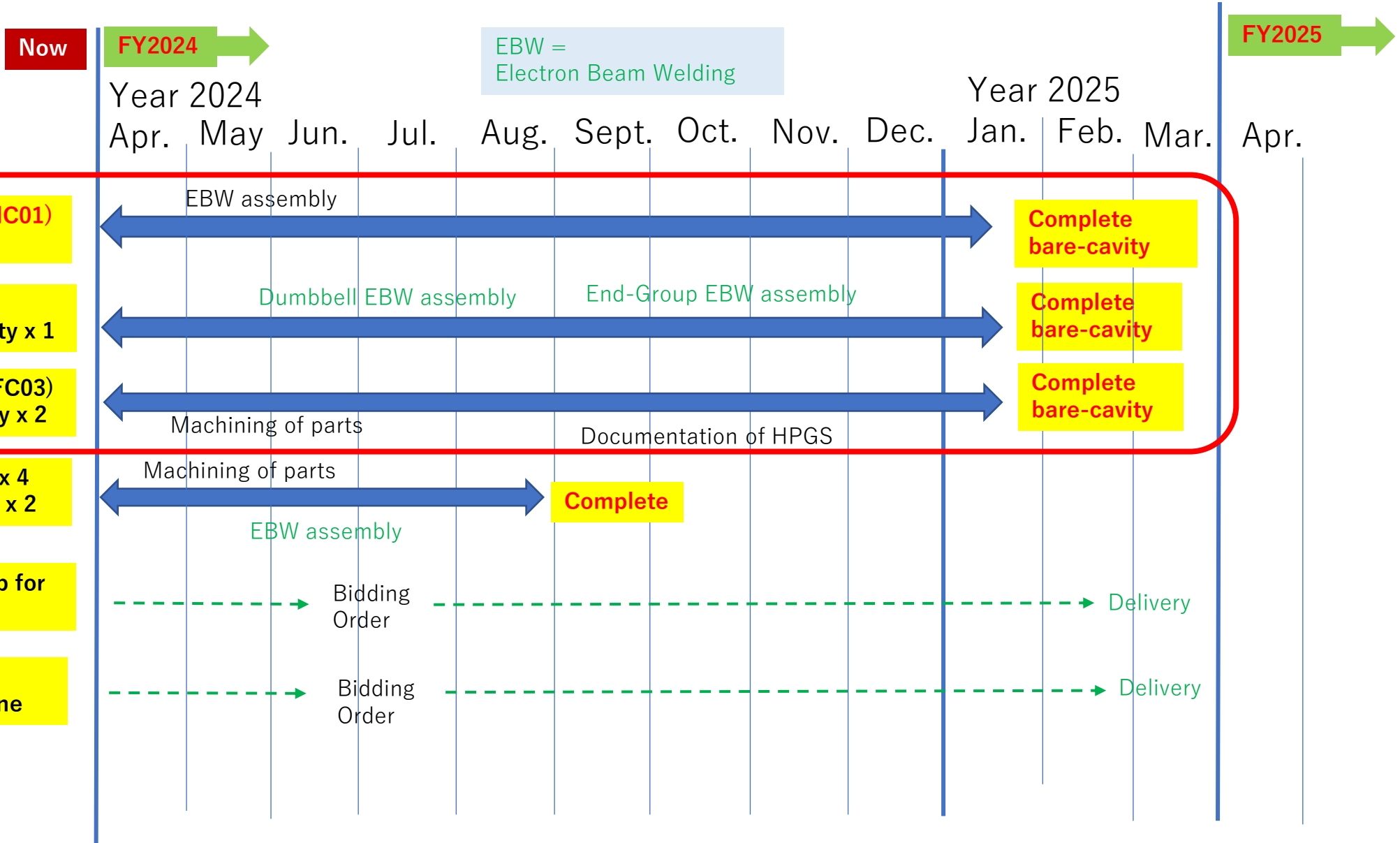
R1FC02(Nickname)

FG-Nb single-cell cavities
(R1FC03, R1FC04)
EBW assembly ongoing



Final assembly in the end of July.

Plan of cavity fabrication in JFY2024



FG-Nb / MG-Nb material of 9-cell cavities

MG-Nb disks x 68: Eddy current scan was done at DESY
Scanned MG-Nb disks delivered at KEK on 21st June.
Dumbbells of MC02 are made of the scanned MG-Nb disks.



DESY : Eddy Current Scanning (ECS)

MG-Nb disks x 68: Eddy current scan was done at DESY

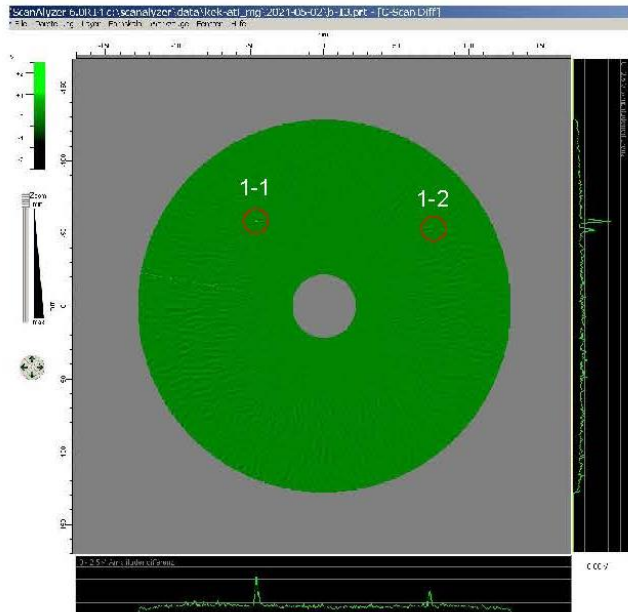
Quality Inspection Report

eddy current test

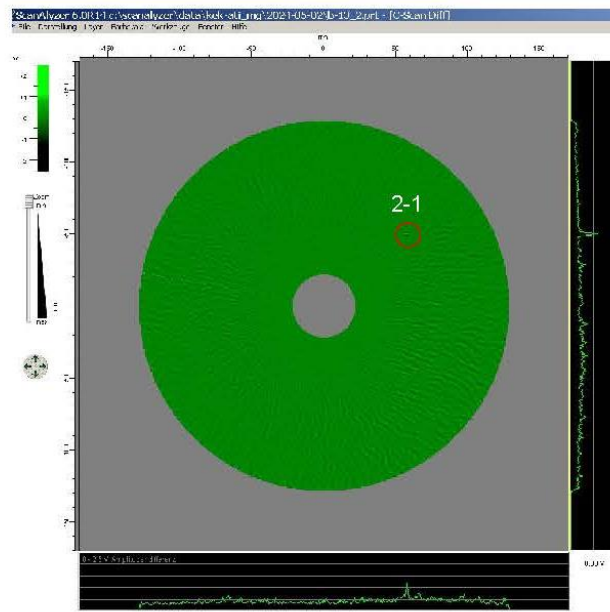
Nb-disc: B-13

An example of ECS

Scan image side 1



Scan image side 2



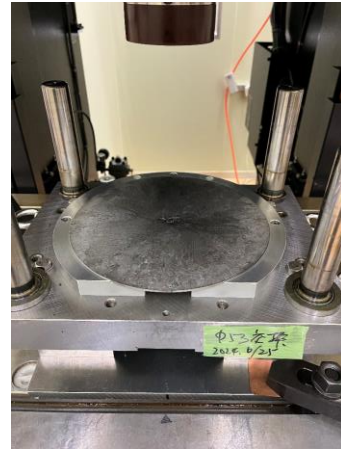
- ECS signals detected on both sides of the disc.
- Areas have been prepared for further analyses.

64 disks /68 disks are usable
For cavity fabrication.

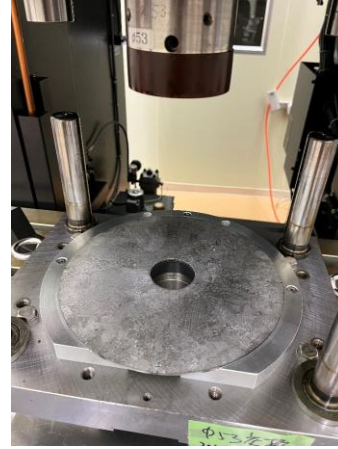
Center hole of MG-Nb disk was cut out.



Thickness measurements



Before cutting out.



After cutting out.

9-cell cavity (MC02) MG-Nb center half-cell



16 half-cells were press-formed.

Press forming of half-cells (MG-Nb disks)



Before press forming



After press forming

5-year plan of cavity fabrication at KEK

	JFY 2023	JFY2024	JFY2025	JFY2026	JFY2027
MG-Nb procurement	Bidding not successful	Use stocked MG-Nb			
FG-Nb procurement	For all cavities				
1-cell cavities (KEK-made) FGx4, MGx2	FGx1	FGx3, MGx2			
9-cell cavities (KEK-made) FGx4	1	2	1		
9-cell cavities (KEK-made) MGx2	(1 training cavity) ----->	1	1		
9-cell cavities (Industry) MGx2			2		
Cryomodule assembly					
Cryomodule evaluation					

Performance tests (vertical tests)
He-tank welding



Total number of cavities:

1-cell cavities: 6 (FGx4, MGx2)

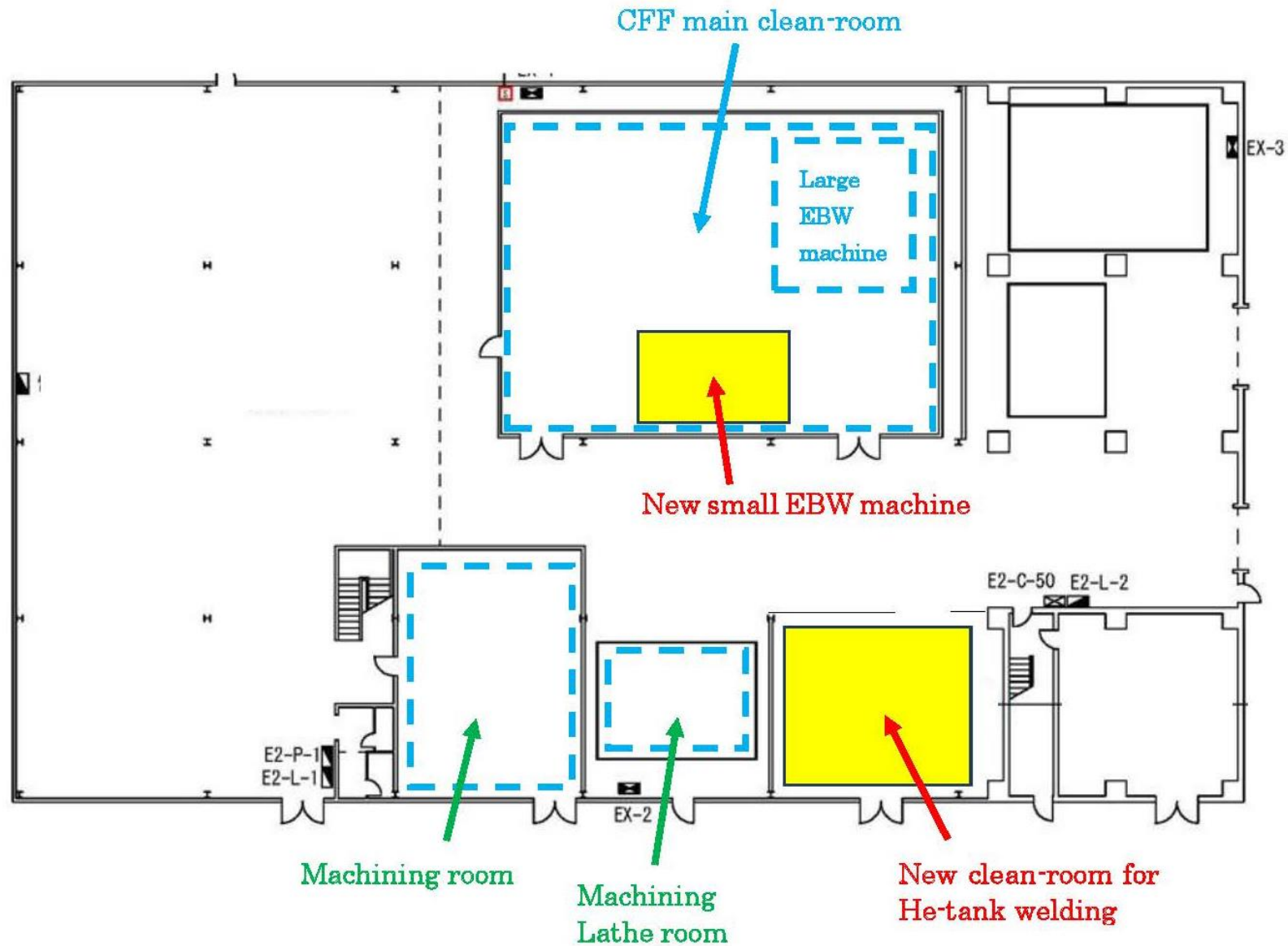
9-cell cavities: 8 (FGx4, MGx4), and we hope some cavities from EU/US/Asia.

All 9-cell cavities are complied with **High Pressure Gas Safety (HPGS) code** except 1 training MG 9-cell cavity.

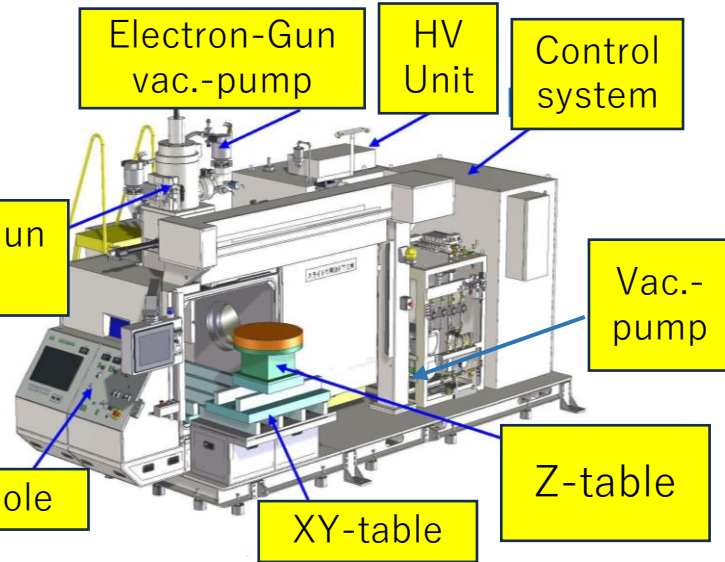
In JFY2027, Cryomodules (CM) with cavities will be tested at COI building (KEK).

International contributions:
We hope some cavities from EU/US/Asia.

Cavity Fabrication Facility (CFF) at KEK



Update of cavity fabrication facility



New compact Electron Beam Welding (EBW) machine was installed in JFY2023 for EBW assembly of end-parts of cavity.

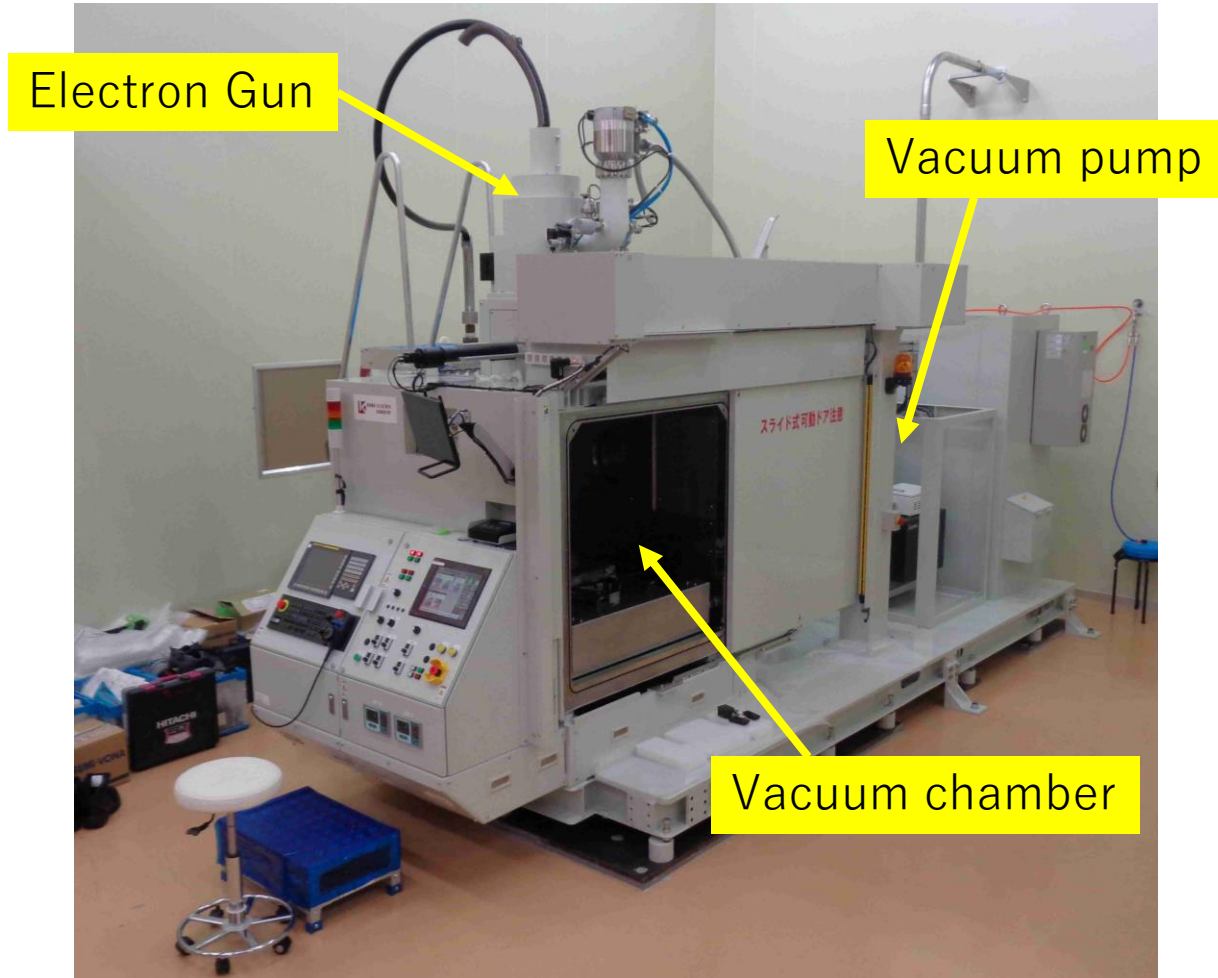


Clean-room is expanded for the He-tank TIG-welding process in JFY2023.



The update of cryo-pump of existing Electron Beam Welding (EBW) machine was delayed to following JFY because the cryo-pump delivery was delayed.

New small EBW machine was installed in CFF



The existing large EBW machine can be used for assembly of large parts.

On the other hand, this **new small EBW machine** can be used **assembly of End-Group** which is rather small.

The existing large EBW machine and new small EBW machine can be used in parallel. This makes us **more efficient fabrication of cavity**.

15 Mar 2024: Delivery of new small EBW machine at CFF/KEK.

25 Mar 2024: Commissioning has been finished successfully.

New Clean Room for He-tank welding.



Currently, He-tank welding and EBW assembly are done at the same place. Hence it is impossible to perform both works at once. Now new He-tank welding clean-room make is possible to work both works in parallel.

Upgrade of control system of large EBW is planed in FY2027.



- Large EBW machine was purchased in 2012.
- The control system of large EBW machine is obsolete and the control program has many limitation.
- Upgrade of control system of large EBW machine enable us to perform the EBW of cavity parts and cavity assembly more efficiently.

Summary of FY2023 – FY2024

- Two types of Nb materials are used for cavity fabrication: One is Fine-Grain (FG) Nb and the other is Medium-Grain (MG) Nb.
- We fabricated one (bare) FG-Nb 9-cell cavity complied with High-Pressure Gas Safety (HPGS) code successfully. Good progress of cavity fabrication in FY2023.
- We are fabricating one (bare) MG-Nb 9-cell cavity and continue in FY2024.
- We fabricated two FG-Nb 1-cell cavity successfully (two more in July 2024).
- We will fabricate two (bare) FG-Nb 9-cell cavity complied with High-Pressure Gas Safety (HPGS) code in FY2024.
- We will fabricate one (bare) MG-Nb 9-cell cavity complied with High-Pressure Gas Safety (HPGS) code in FY2024.
- We purchased new small EBW machine for more efficient cavity-fabrication.
- We constructed a new clean-room for He-tank welding. We can perform He-tank welding in parallel to EBW cavity-assembly. Good progress of facility upgrade in FY2023.

Summary of 5-year plan

- We will fabricate four (bare) FG-Nb 9-cell cavity complied with High-Pressure Gas Safety (HPGS) code in total by FY2025.
- We will fabricate two (bare) MG-Nb 9-cell cavity complied with High-Pressure Gas Safety (HPGS) code in total by FY2025.
- We will weld He-tank for all eight 9-cell cavities by FY2026. New He-tank welding clean-room is used efficiently.
- We will install a new cryopump and new control system for existing large EBW machine.
- We will install a new small EBW machine with a cryopump and will use it for more efficient cavity-fabrication.