

# The fabrication of the 1.3 GHz single-cell cavity using niobium materials with varied grain sizes

Junho Han, Heesu Park, Seonghoon Kang, Yongil Kim, ByeongRok Ko, Eun-San Kim

**14-Nov-2024**

**Presented by Junho Han**

**(Kiswire Advanced Technology Co., Ltd.)**

## Acknowledged



## Collaborated by



Dr. Han, Junho  
Mr. Park, Heesu  
Mr. Yongil Kim



Prof. Kim, Eun-San  
Prof. Ko, Byeong-Rok



Dr. Kang, Seonghoon

# Contents

- ❖ **Background of R&D**
- ❖ **Introduction of KAT**
- ❖ **1.3 GHz single-cell cavity**
- ❖ **Summary & Future Works**

# Background of R&D

## 1.3 GHz single-cell cavity fabrication

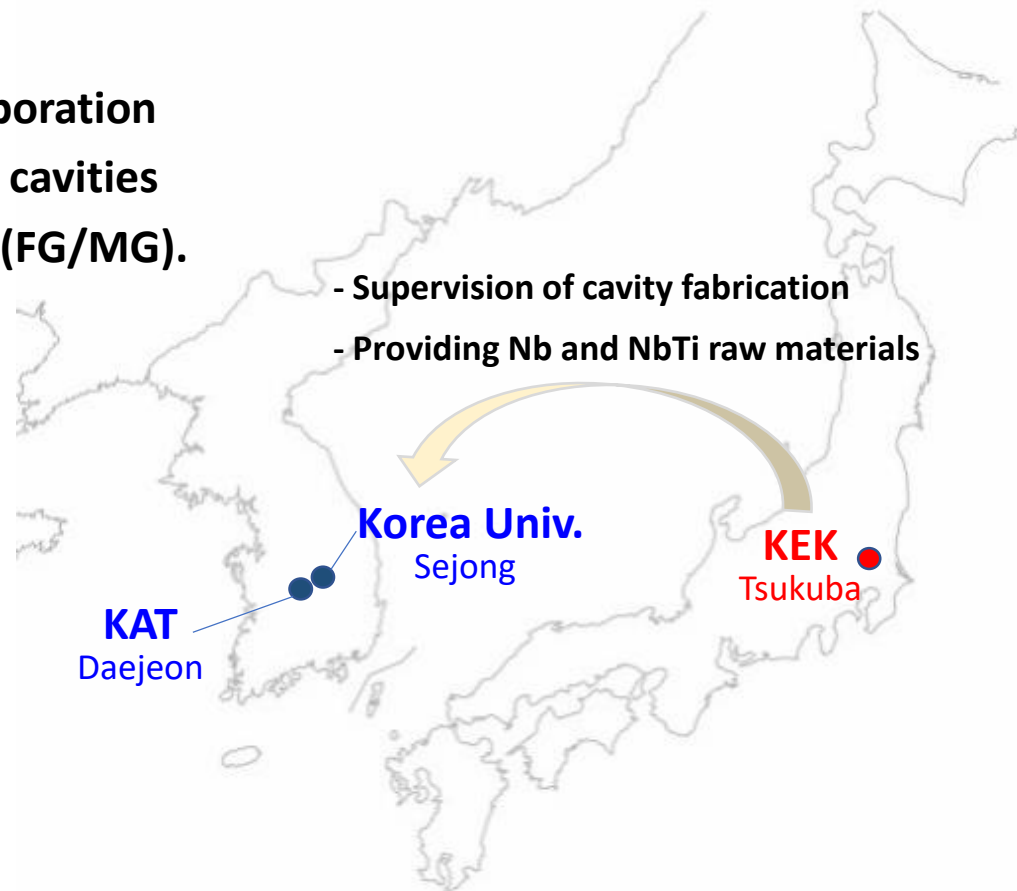
As an activity for the GLOBAL COLLABORATION for ITN,

**KEK(JPN)** and **Korea Univ.(KOR)** are proceeding the collaboration for the fabrication of 1.3 GHz 9-cell cavity.

KAT Co., Ltd. has participated in the collaboration for manufacturing two 1.3 GHz single-cell cavities with the different grain size Nb materials (FG/MG).

\* FG : fine grain size

\* MG : medium grain size



# Contents

- ❖ Background of R&D
- ❖ **Introduction of KAT**
- ❖ 1.3 GHz single-cell cavity
- ❖ Summary & Future Works



Wire Connects the World

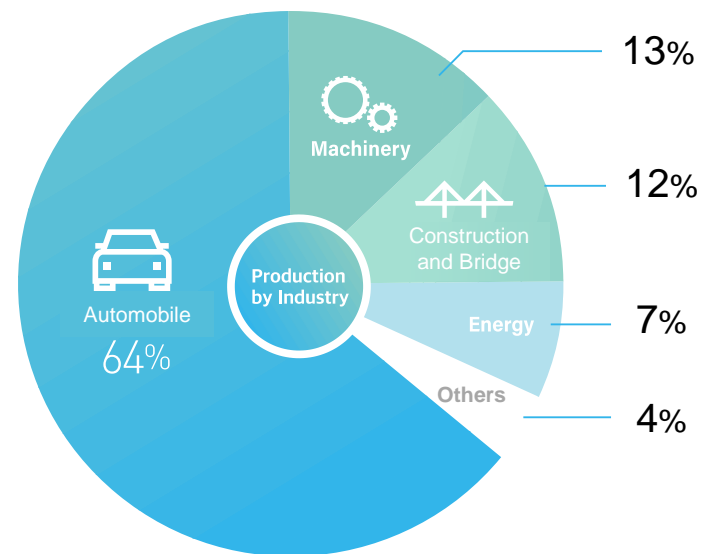


KAT is the branch company of Kiswire

## Kiswire, Global Specialty Wire Company

Founded in 1945, Kiswire manufactures specialty steel wire products for a diverse range of industries including automotive, bridge, energy, construction and electronics. Kiswire exports to customer in over 80 countries.

Establishment	1945	Headquarters	Busan, Korea
Export countries	80	Annual total production capacity	1,200,000t
Worldwide employees	6,000	Annual sales	2.1 B USD (FY 2023)



KAT is a global leading superconducting wire company, located at Daejeon/South Korea.

Established in 2004 as a wholly owned subsidiary of Kiswire, KAT specializes in high-performance superconducting wires, including  $\text{Nb}_3\text{Sn}$ ,  $\text{NbTi}$ , and  $\text{MgB}_2$ . These wires are utilized in fusion reactors such as K-STAR, ITER and DTT project. KAT has been also developing the High-Jc  $\text{Nb}_3\text{Sn}$  wire for the FCC project in collaboration with CERN.

Additionally, from 2018 to 2022, KAT supplied the cryomodule prototypes and cryostats to RAON and RIKEN, respectively. From 2021 to 2023, KAT successfully fabricated and tested the 1.5 GHz 3<sup>rd</sup> harmonic superconducting cavity for new Synchrotron light source.



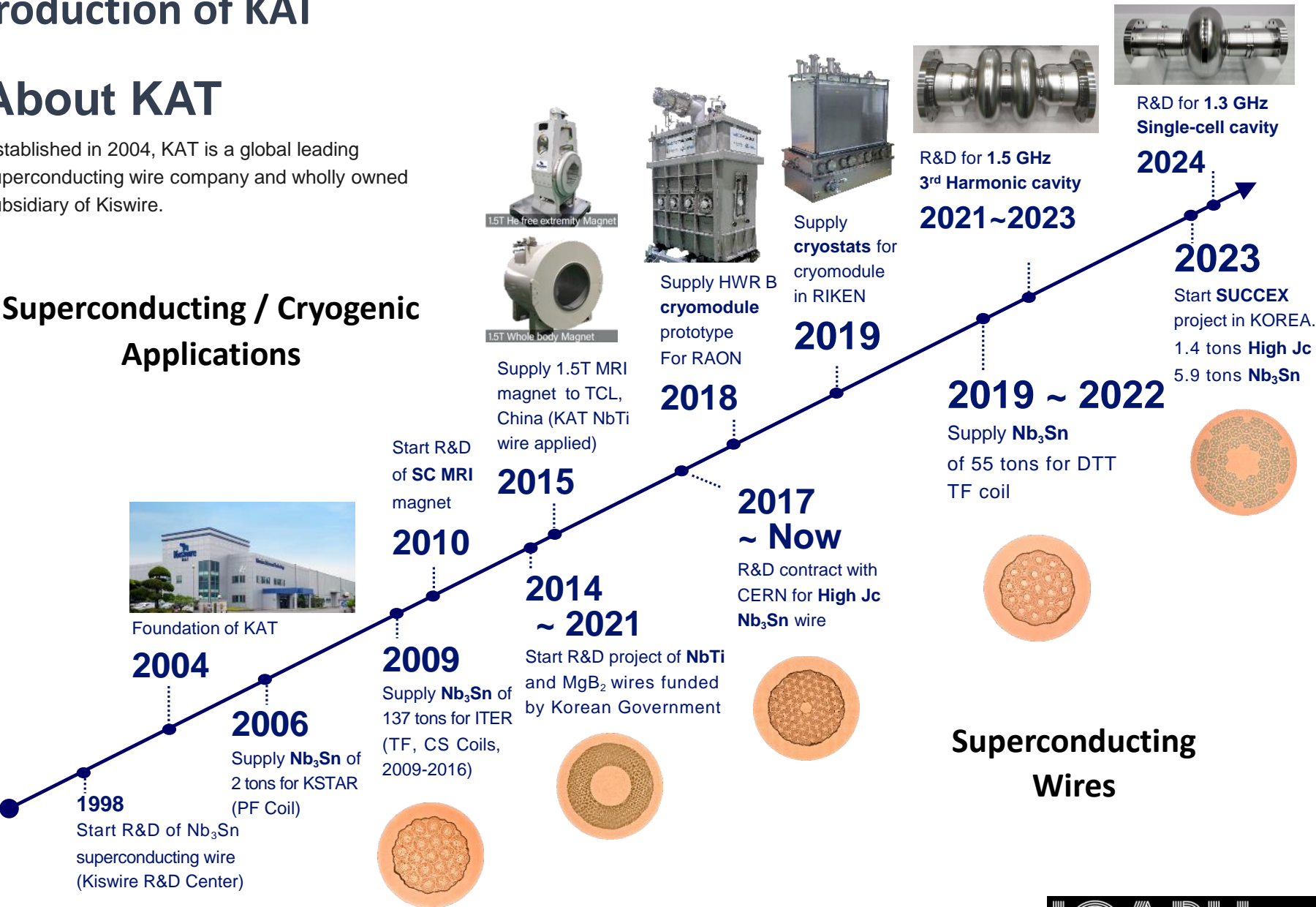


# Introduction of KAT

## About KAT

Established in 2004, KAT is a global leading superconducting wire company and wholly owned subsidiary of Kiswire.

## Superconducting / Cryogenic Applications



# Introduction of KAT

## Superconducting Cryomodule



### RAON HWR B Cryomodule Prototype (2018, IBS/Korea)

- Cavity, coupler, tuner were supplied by IRIS
- Cryostat design and manufacturing by KAT
- Cryomodule assembly including clean room work by KAT





# Introduction of KAT

## Superconducting Cryomodule



### RIKEN QWR Cryomodule Cryostat (2019, MHI-MS)

(vacuum vessels, thermal shields, and other parts)

- KAT has manufactured the vacuum vessels and thermal shields and the helium leak test and pressure tests according to the Japanese Industrial standard.
- Those cryostat parts have been supplied to MHI-MS and assembled as the cryomodule.
- The cool-down process has been conducted in 2020 successfully.

# Introduction of KAT Superconducting Cryomodule



## RAON SSR2 Cryomodule R&D Prototype Assembly (2022, RAON/Korea, Collaboration with IHEP/China)

- The cryomodule assembly work has been done by collaboration of IHEP and KAT in RAON.
- In 2024, KAT plans to participate in the SSR2 cryomodule mass production prototype in collaboration with IHEP.



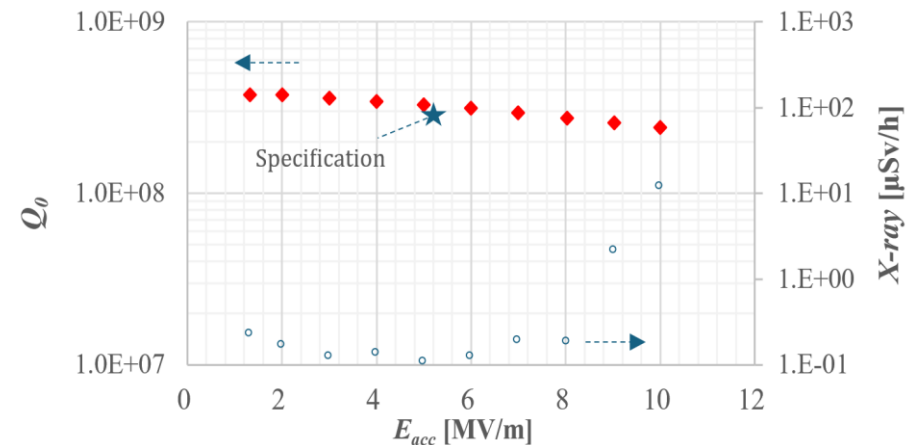
# Introduction of KAT Superconducting Cavity



## 1.5 GHz 3<sup>rd</sup> Harmonic Cavity Prototype for the Synchrotron Light Source

(2023, Collaboration with Korea Univ.)

- The cavities have been fabricated by KAT with the technical advices by Korea University.
- The vertical test of the cavity has been conducted utilizing the infrastructure of SARI-SSRF/China, and the test results met the targeted specifications.



Vertical test results of  
the 1.5 GHz 2-cell 3rd harmonic cavity at 4 K

# Introduction of KAT

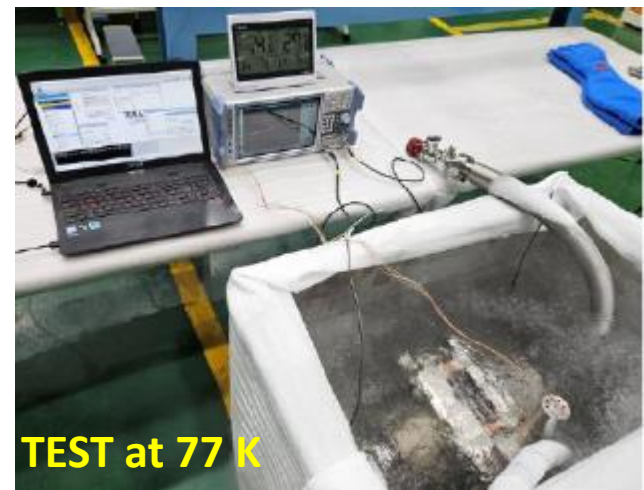
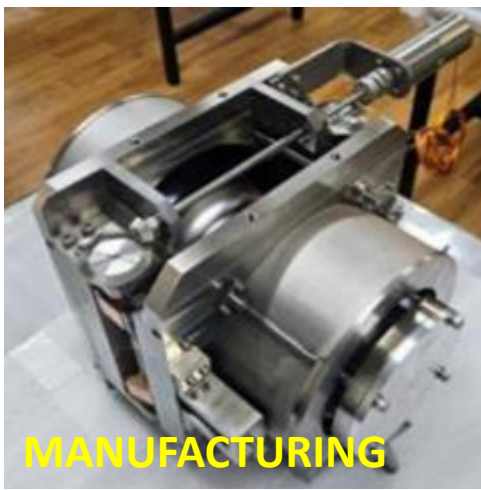
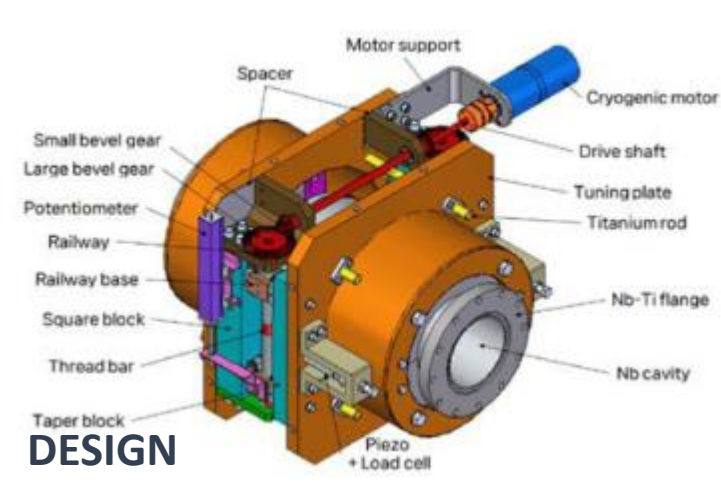
## Frequency Tuner for Superconducting Cavity

### Frequency Tuner for 1.5 GHz 3<sup>rd</sup> Harmonic Cavity Prototype

(2023, Collaboration with Korea Univ.)

- The tuner has been designed, manufactured, and tested by KAT with the advices by Korea Univ.
- The performance test of the tuner has been conducted at the liquid nitrogen temperature successfully.

Parameters	Unit	Required @ 77K	Measured @ 77 K
Tuning range	kHz	$\geq 500$	532
Tuning sensitivity	Hz/step	$\leq 3.0$	1.0



# Contents

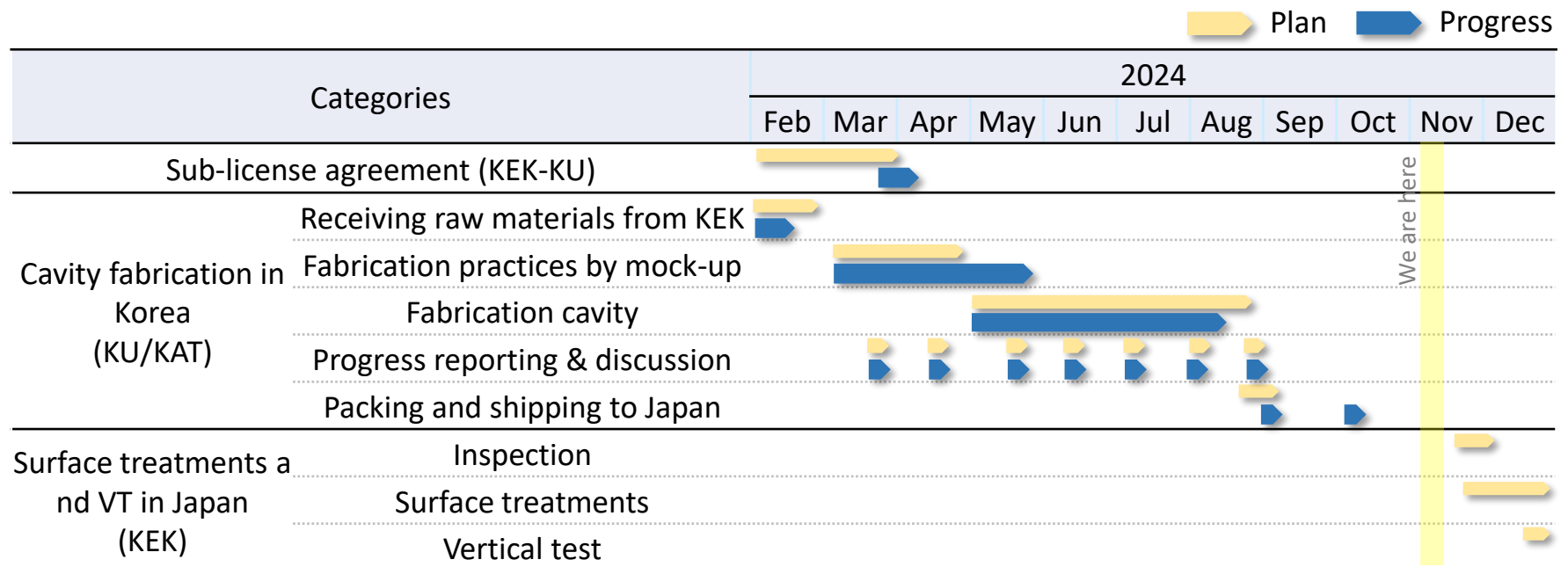
- ❖ Background of R&D
- ❖ Introduction of KAT
- ❖ **1.3 GHz single-cell cavity**
  - Objectives and Schedule
  - Cavity Design and Raw Materials
  - Parts Fabrication
  - Electron Beam Welding
- ❖ Summary & Future Works



# 1.3 GHz single-cell cavity

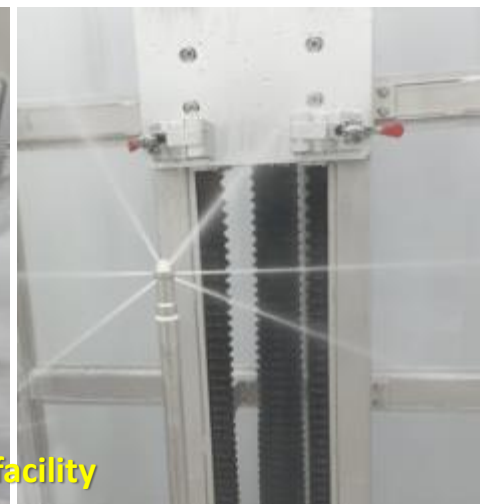
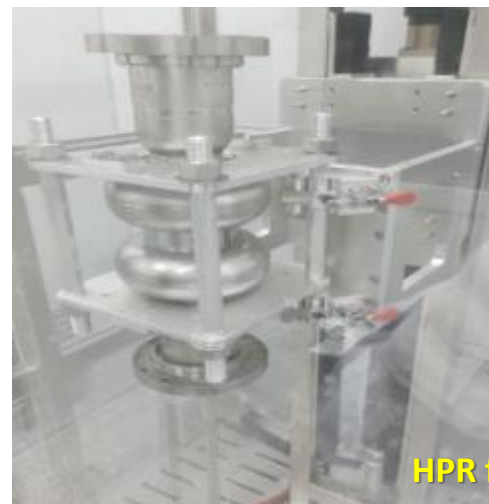
## Objectives and Schedule

- Objectives
  - : Verification of cavity fabrication process in Korea by utilizing different Nb raw materials
    - Fabrication two 1.3 GHz single-cell cavities (1 FG cavity/1 MG cavity) in Korea
    - Surface treatment and vertical test of cavities by KEK in Japan
- Schedule
  - The 1.3 GHz single-cell cavities have been shipped to Japan successfully.
  - The surface treatments and vertical test of cavities will be conducted by KEK.



# 1.3 GHz single-cell cavity

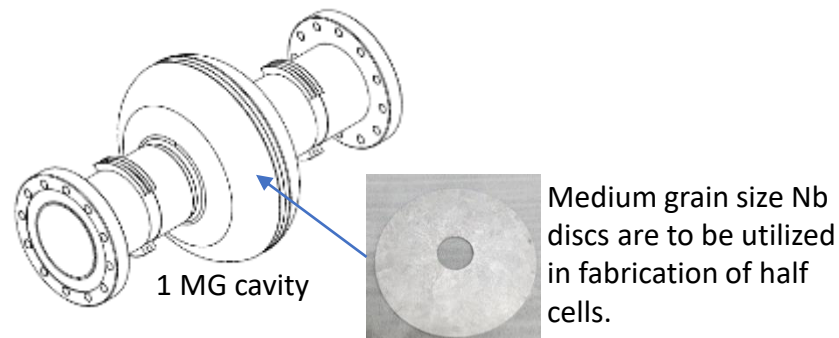
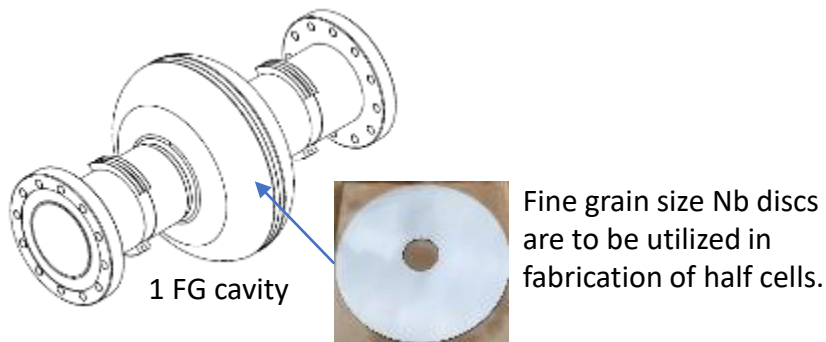
Cavity fabrication infrastructure in KAT



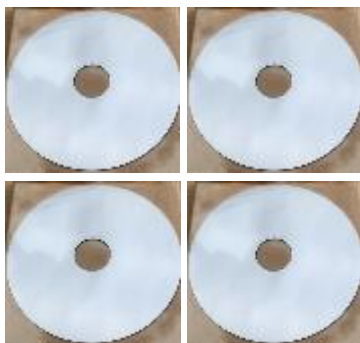
# 1.3 GHz single-cell cavity

## Cavity Design and Raw Materials

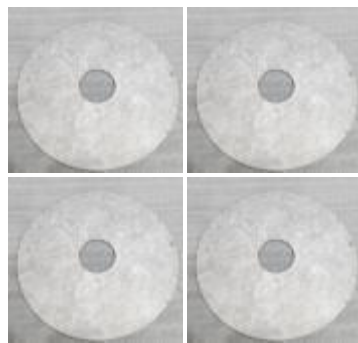
- Cavity Design
  - The typical 1.3 GHz single-cell cavity
  - Two cavities with same geometry, but different grain size Nb materials on the cell



- Raw Materials



Fine grain size Nb discs  
(4 pcs)



Medium grain size Nb discs  
(4 pcs)



Nb tubes  
(4 pcs, fine grain)



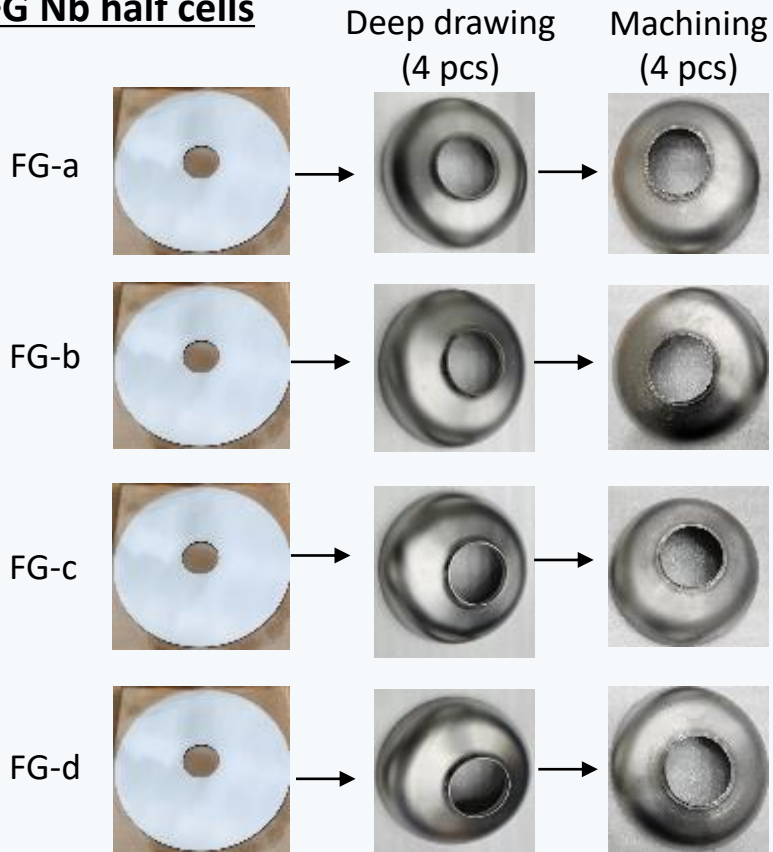
Nb billets  
(2 pcs, low RRR)

# 1.3 GHz single-cell cavity

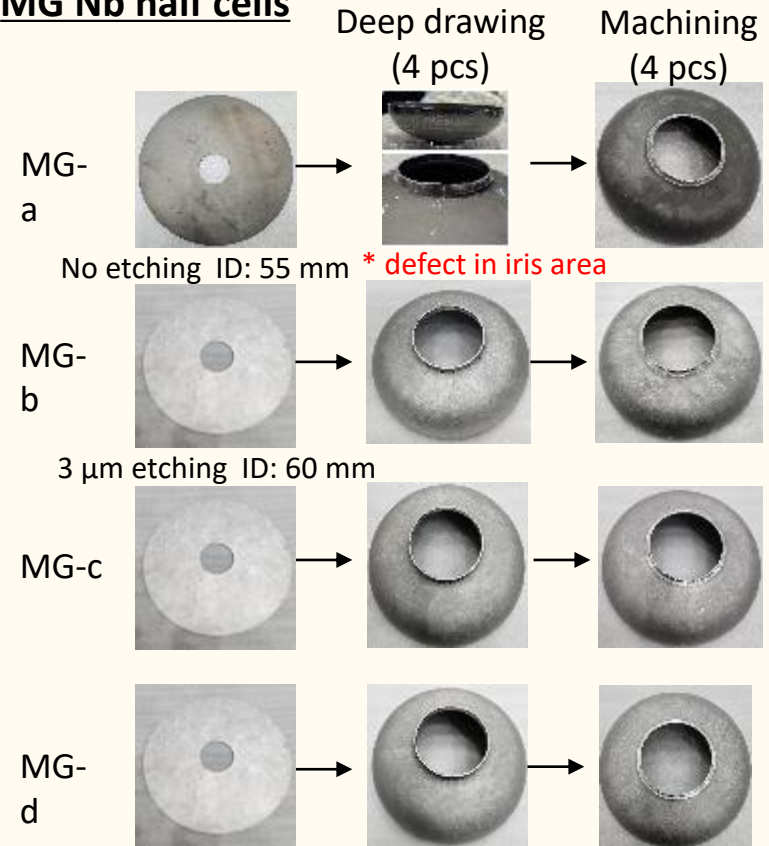
## Parts Fabrication

- Half cell fabrication
  - Totally 8 half cells have been fabricated.
  - One of MG half cell had a defect at iris area during deep drawing process.

### FG Nb half cells



### MG Nb half cells



※ The deep drawing of half cells has been done by collaboration with KIMS (Korea Institute of Materials Science)



# 1.3 GHz single-cell cavity

## Parts Fabrication

- Other parts fabrication
  - Tubes and fixture rings have been fabricated.

### Nb Tubes



Beam tubes (4 pcs)



Beam tubes with fixture rings  
(4 pcs)



### Nb billets



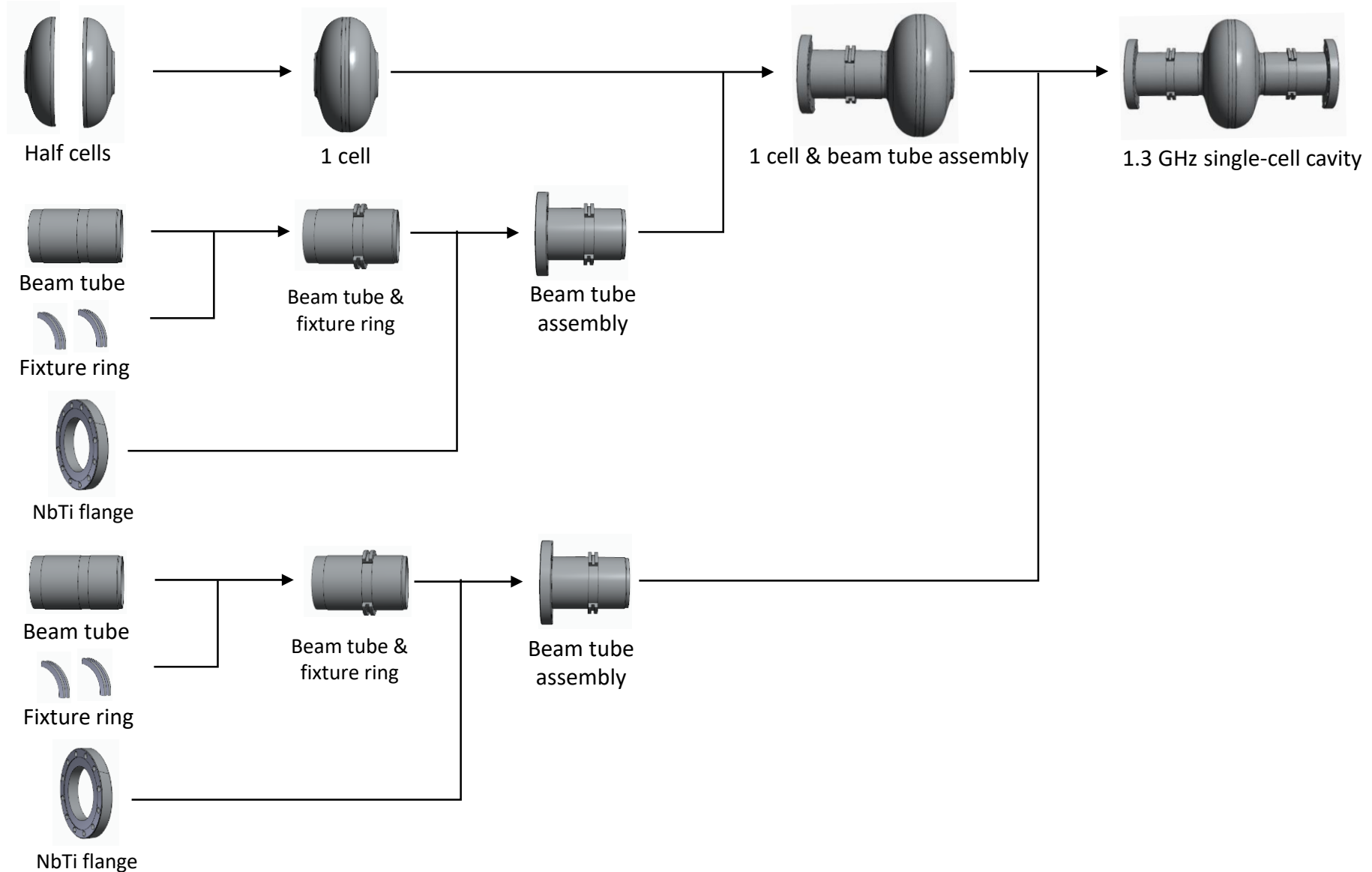
Fixture rings (8 pcs)

EBW



# 1.3 GHz single-cell cavity

## Electron Beam Welding (EBW) Plan



# 1.3 GHz single-cell cavity

## Electron Beam Welding (EBW)

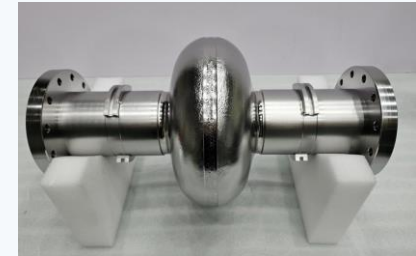
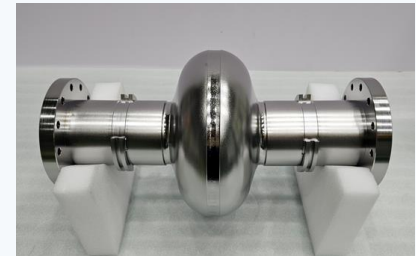
- Before starting EBW for two 1.3 GHz single-cell cavities (1 FG cavity and 1 MG cavity) with provided Nb materials by KEK, we have practiced the EBW process to check the EBW quality.
- After checking the EBW conditions, the EBW process were performed for the two 1.3 GHz single-cell cavities (1 FG cavity and 1 MG cavity)



Equator / Iris  
EBW practices



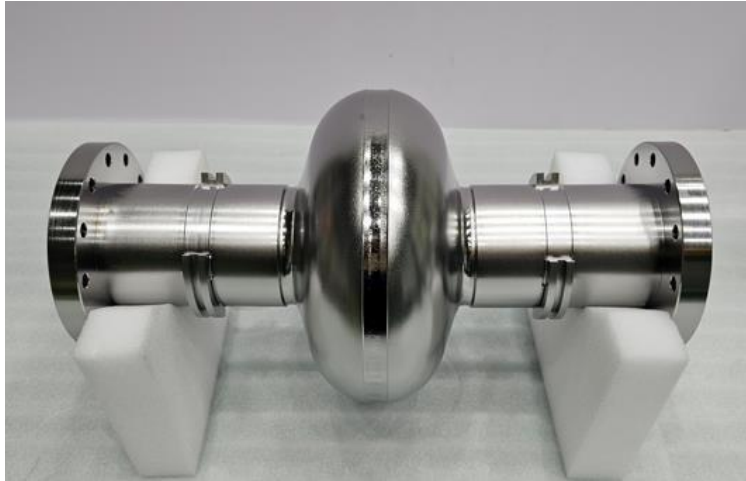
Cells / Beam tube / Flange  
EBW



1.3 GHz single-cell cavities

# 1.3 GHz single-cell cavity

## Fabrication Status Summary



1.3 GHz FG single-cell cavity



1.3 GHz MG single-cell cavity

- Two cavities have been assembled by the EBW process. (14-Aug-2024)
- Resonant frequency check, helium leak test are conducted in 19<sup>th</sup> Aug for two cavities.

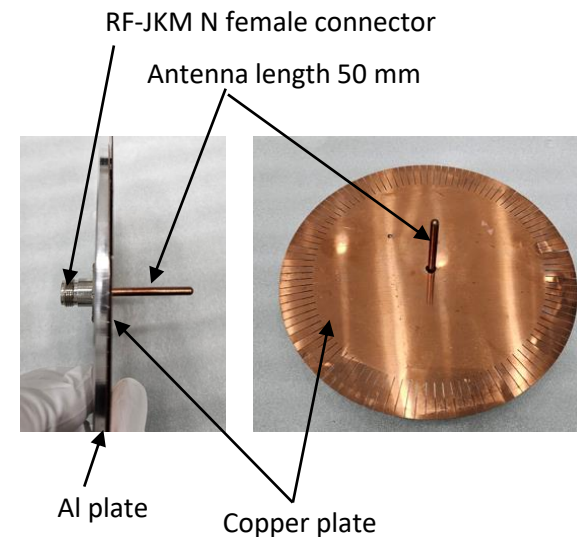
	FG single-cell cavity	MG single-cell cavity
Resonant Freq.	1.298588 [GHz]	1.299351 [GHz]
Leak Rate	< 0.5E-12 [mbar-L/sec]	< 0.5E-12 [mbar-L/sec]

※ Two mock-up cavities are fabricated in advance to exercise the fabrication process.

# 1.3 GHz single-cell cavity

## Frequency and Leak Rate

- Configuration of Resonant Frequency Measurement



Resonant frequency measurement jig

### Device & Environments in measurement

Device	Network analyzer	ZNL20 (ROHDE&SCHWARZ)
	Input & Pick up coupler	RF-JKM N female connector
		*Antenna : Copper, Length 50 mm
Environments	Temperature	25 °C
	Humidity	60~62 %

# 1.3 GHz single-cell cavity

## Frequency and Leak Rate

- Configuration of Helium Leak Test



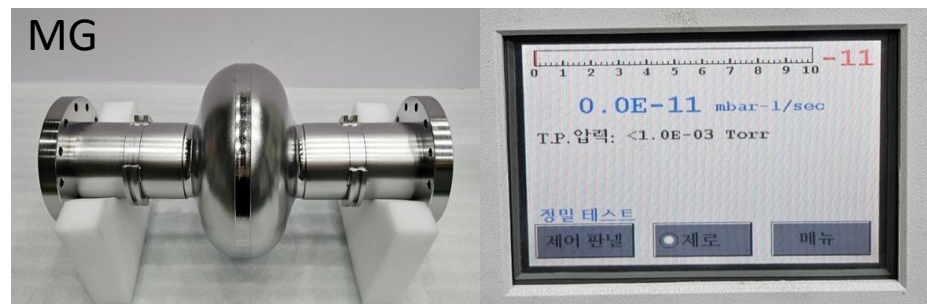
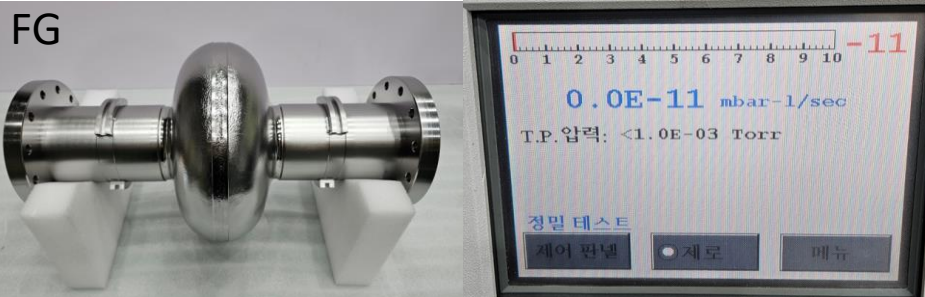
### Device & Environments

Detector Agilent, He Leak Detector

Temperature 25 °C

Humidity 60~62 %

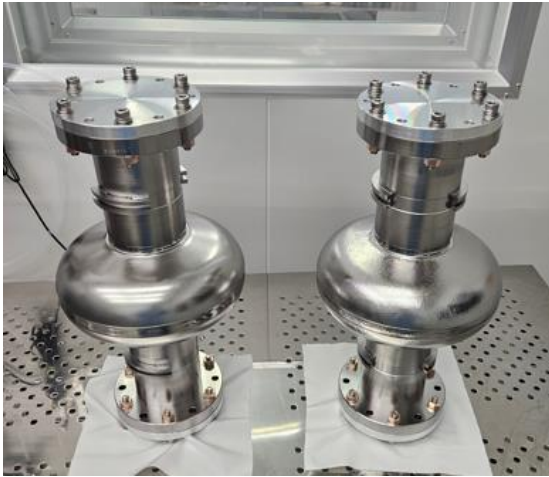
- Helium Leak Test Results : No leak found in both cavities





# 1.3 GHz single-cell cavity

## Packing



① Flanges of cavity were covered with Al flange



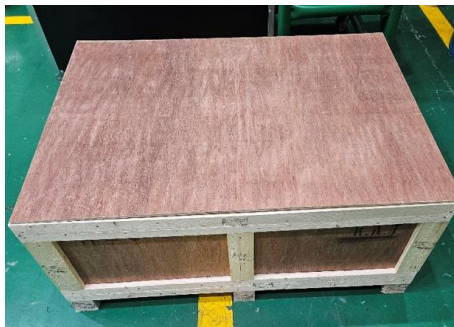
② Cavities were packed with clean shielding bag.



③ Cavities were packed with plastic carrier.



④ Plastic carriers were packed with wooden box



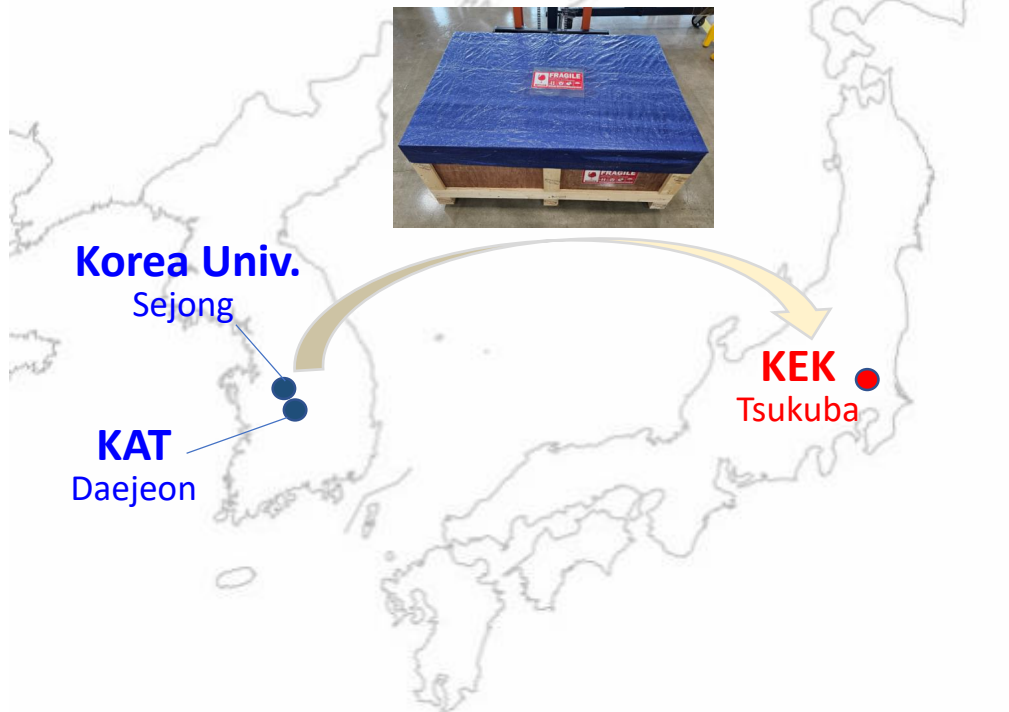
⑤ The wooden box was sealed by the plastic cover and shipped to KEK/Japan



# 1.3 GHz single-cell cavity

## Transportation

- The cavities were transported from Korea Univ. to Japan.
- We are waiting for the cavities to arrive at KEK.
  - KAT(Departure : 03-Sep) → Korea Univ.(Arrive : 03-Sep)
  - Korea Univ.(Departure : 12-Sep) → KEK(Arrive : 02-Oct)
- KEK invited KU and KAT people for participating the inspection, surface treatment, and vertical test of two cavities. (Mid of Dec 2024)



# Contents

- ❖ Background of R&D
- ❖ Introduction of KAT
- ❖ 1.3 GHz single-cell cavity
- ❖ **Summary & Future Works**

# Summary & Future Work

- As the activity of global collaboration for ITN, the collaborative R&D (KEK, KU, and KAT) of 1.3 GHz single-cell cavity has been started in Feb 2024.
- KEK supplied the Nb and NbTi raw materials to KU/KAT, and two 1.3 GHz single-cell cavities have been fabricated successfully in Aug 2024.
- We have continued the regular technical meeting for checking the progress and technical issues.
- The 1.3 GHz single-cell cavities have been shipped to Japan successfully. The surface treatments and vertical test of cavities will be conducted by KEK with participating KU and KAT people.

\* ITN : ILC (International Linear Collider) Technology Network

\* KU : Korea University

