

Fabrication of TESLA-shape 9-cell Cavities at KEK for studies on mass-production with industries

ID: MOBB2

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- Summary

New Budget was approved by “Ministry of Education, Culture, Sports, Science and Technology of Japan” (MEXT) in 2012

Title of new budget :

“New Project for Creating a Market for EARTH-CLEANER Products in Collaboration with Industries and Laboratories/Universities.”

Location of Organization : KEK

Collaboration with Following Industries :

**Mitsubishi Heavy Industry (MHI), Hitachi, Toshiba
Mitsubishi Electronics, Kyocera, Fujikura, etc.**

Abstract of New Budget Plan

In order to keep the earth sustainable, we need to solve the serious problems such as “Pollution of the earth”, “Warming of the earth”, “Energy Crisis”, “Natural Resources Shortage”, etc. Here, the situation created the needs for “New Energy Network System”, “Integration of Power Plant and Water/Air Cleaner” and so on, which clean the environment of the earth. The new project by the budget utilize the Superconducting Accelerator and Quantum Beam Technology, and create a new market for these **“EARTH CLEANER”** products. Finally, the goal of the project is to challenge the realization of **global/sustainable environment on the earth.**

COI: Center-of-Innovation Building at KEK

2012 supplementary-budget: model facility for ILC assembly & Testing



Construction of new COI building



Picture of construction site in the end of 2014.

COI =
Center of Innovation

Superconducting Accelerator Promotion Center / Center of Innovation (COI) Building

Construction was finished
in Jan. 2015.



Existing STF
building



New COI
building

North-east area



Vertical test area

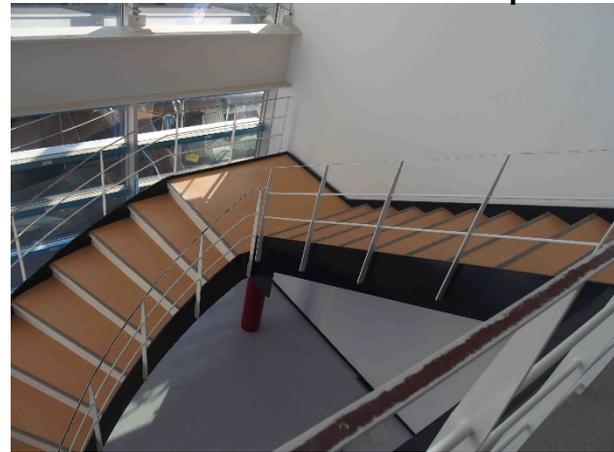


Jan. 2015.

Control room



Entrance hall steps



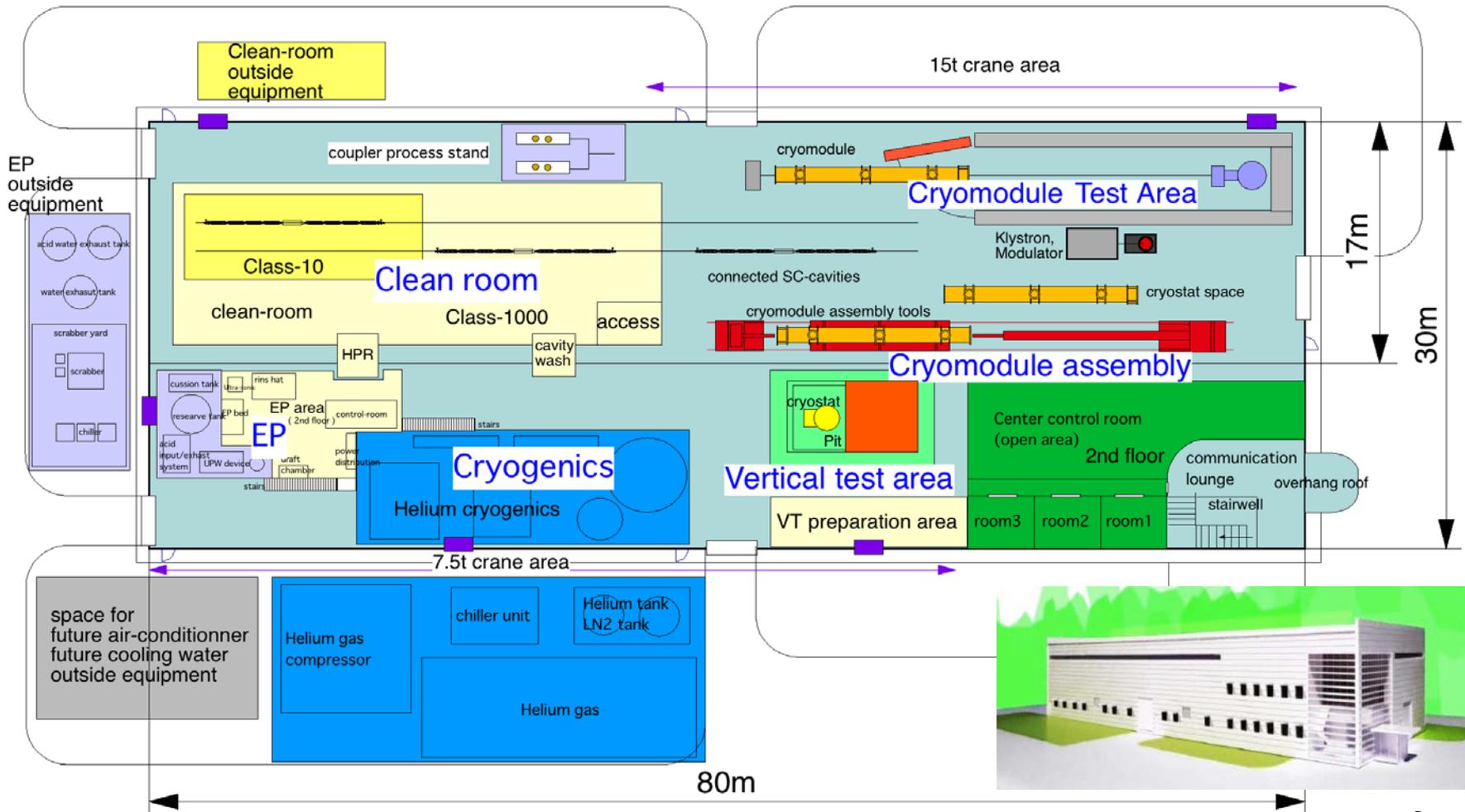
Panorama view of exp. hall



New SRF facilities : promotion of superconducting accelerator utilization

Facility lay-out plan of the new COI building (80m x 30m)

Superconducting Accelerator Development Hall



SC cavity inspection & process, vertical test, cryomodule assembly, cryomodule test

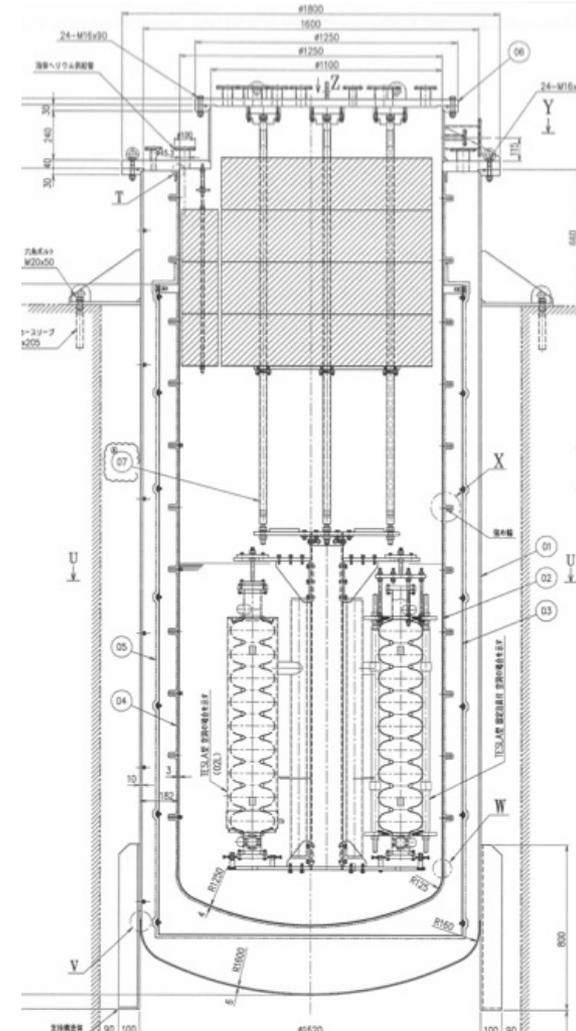
Vertical Test (VT) Facility

4-cavity Vertical Test Stand,
referencing VT facility at AMTF / DESY
aiming at mass-production of cavities.



Photo of VT facility at AMTF/DESY
(Courtesy of Prof. Hans Weise.)

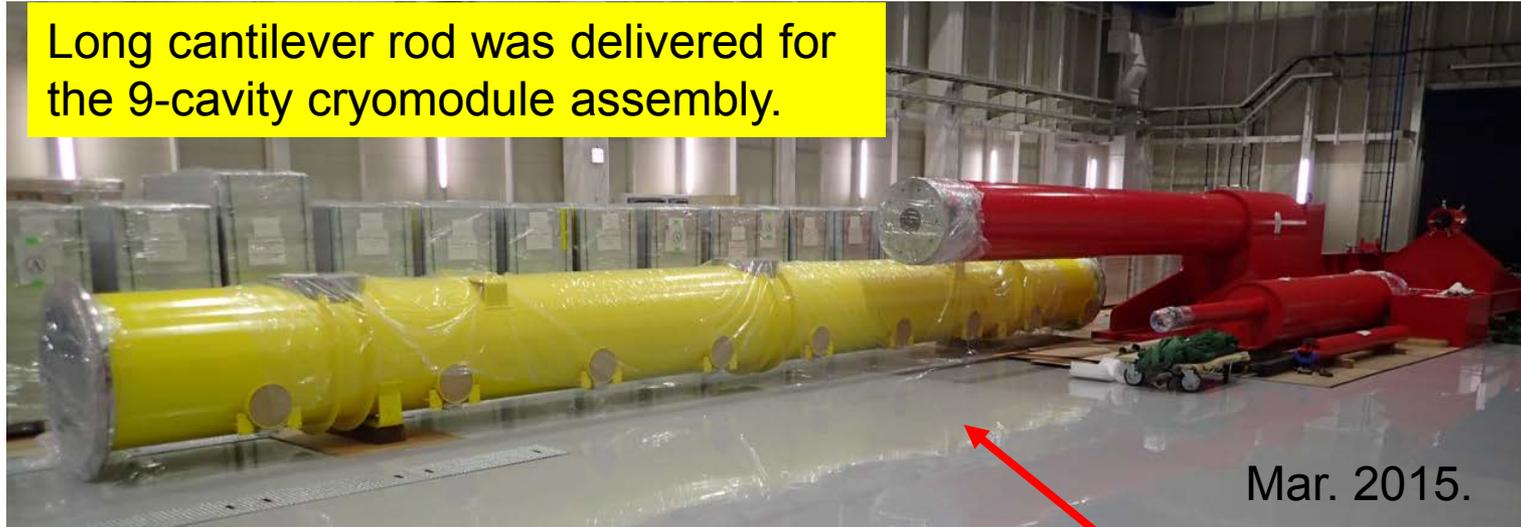
Cryostat for vertical test



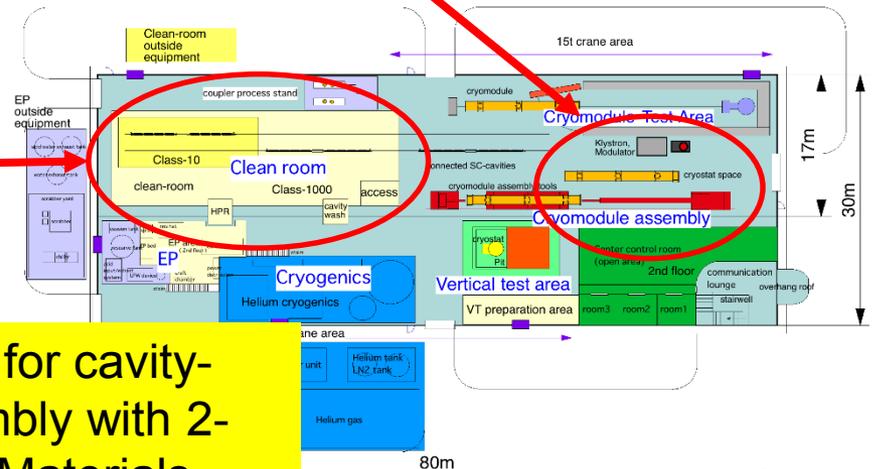
Designed by KEK and MHI
referencing the VT facility at
DESY/AMTF.

New SRF facilities : Cryomodule assembly

Long cantilever rod was delivered for the 9-cavity cryomodule assembly.



Superconducting Accelerator Development Hall



Clean-room for cavity-string assembly with 2-rail system. Materials were delivered

New SRF facilities : Electro-Polishing (EP) Facility

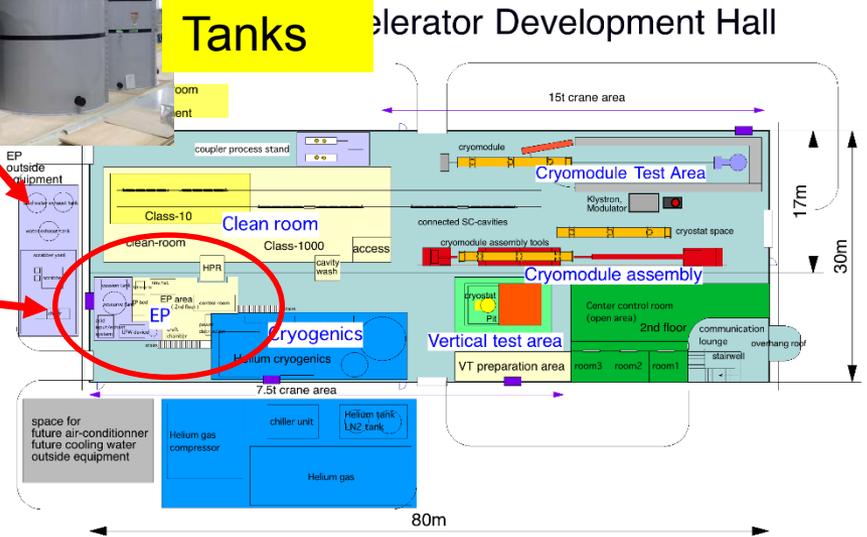


Cathode insertion tool.

EP bed is usable both for Horizontal EP and Vertical EP (2 ways). This enables the direct comparison of HEP and VEP processes.



Waste Tanks



Manufacturer is MHI

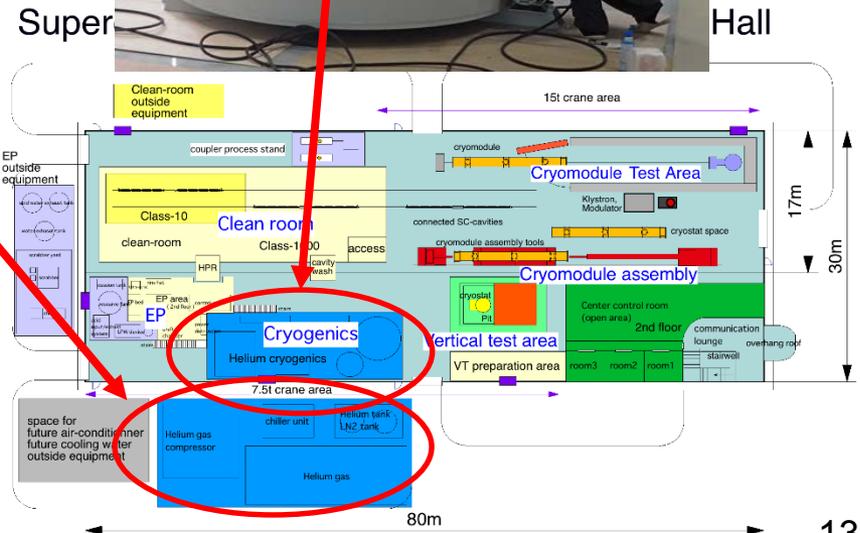
EP area is used for Vertical EP (VEP) experiments

New SRF facilities : Cryogenic system

He compressor parts were delivered.



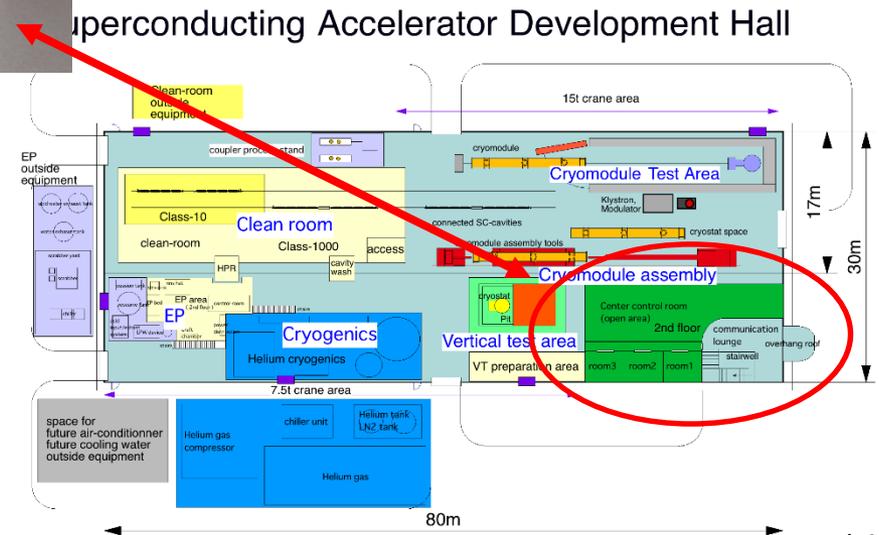
He refrigerator
(250 L/h, 500 W at 4.4 K)



New SRF facilities : Control room and offices



Control room, meeting room,
offices for researchers and
industry staff.



Motivation for fabrication of TESLA(Euro-XFEL)-shape cavity at KEK

- We had no experience of fabrication of TESLA(Euro-XFEL)-shape cavity at KEK. (Only KEK-original 9-cell cavities.)
- The new SRF facilities are aiming the mass-production of cryomodule referencing the Euro-XFEL production.
- We need TESLA(Euro-XFEL)-shape cavities for the commissioning of these new facilities of COI building.
- Also, we should have an experience of High-Pressure-Gas code process for TESLA (Euro-XFEL)-shape cavity, because we might import significant numbers of TESLA-shape cavities if ILC is approved for Japanese site.

Fabrication of TESLA(Euro-XFEL)- shape cavities

- We ordered four TESLA(Euro-XFEL)-shape cavities to industrial vendors by the Center-of-Innovation (COI) budget in 2013.
- These four cavities are only for the commissioning of facilities and are not complying with the High Pressure Gas code.
- Two TESLA(Euro-XFEL)-shape cavities were fabricated by Mitsubishi Heavy Industries (MHI).
- Two TESLA(Euro-XFEL)-shape cavities were fabricated by Toshiba.
- Both vendors successfully delivered the cavities.

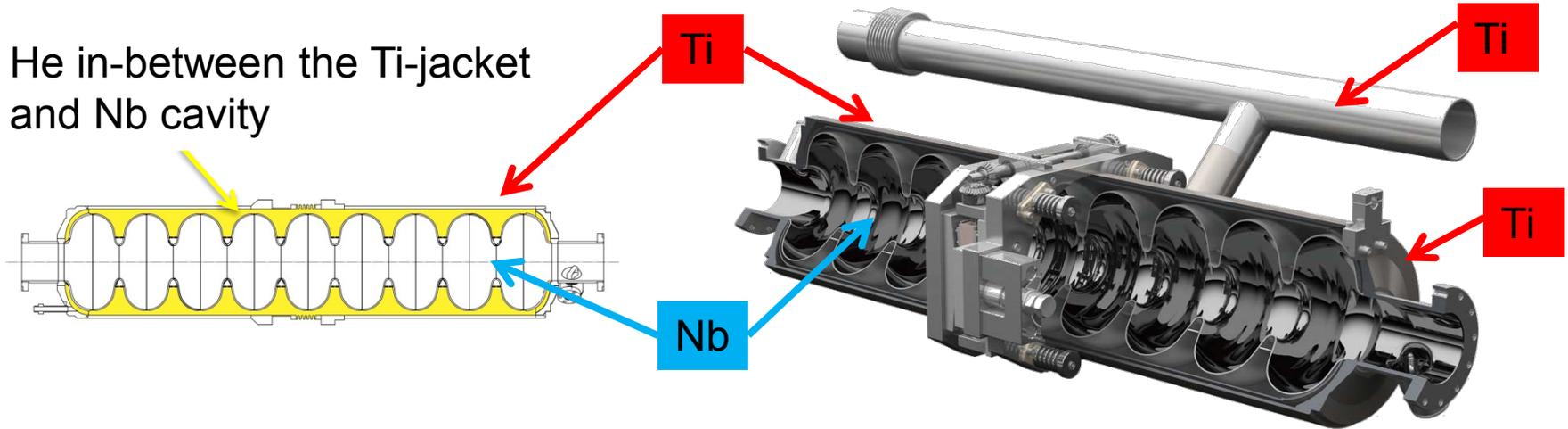
Fabrication of two TESLA(Euro-XFEL)-shape cavities by Mitsubishi Heavy Industry (MHI)



Fabrication of two TESLA(Euro-XFEL)-shape cavities by Toshiba



Japanese High-Pressure Gas safety act



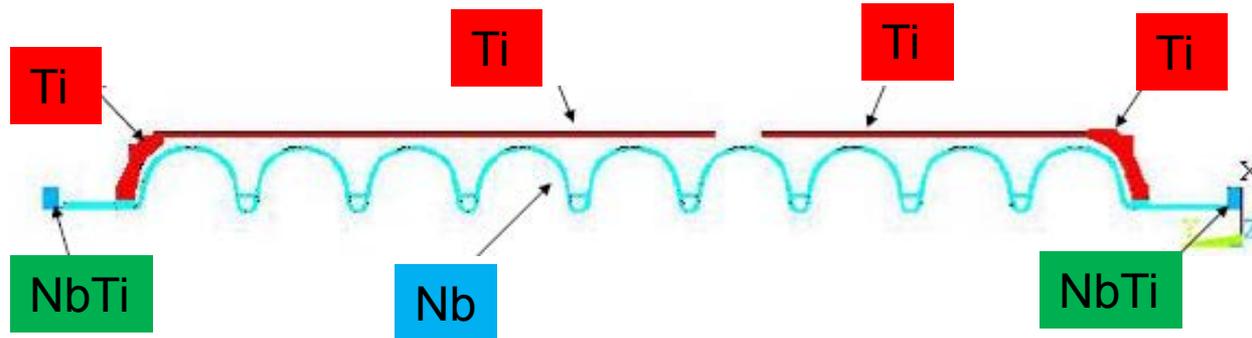
If we use the cavities in accelerators in Japan, vendors must fabricate cavities complying with **Japanese High-Pressure Gas (J-HPG) safety act**.

In case of ILC in Japan, a significant fraction of cavities might be imported from foreign vendors. KEK should guide foreign vendors for the procedures of J-HPG safety act.

But, we (KEK) has no experience of TESLA-shape cavity fabrication complying with J-HPG safety act.....

Japanese High-Pressure Gas safety act

Fabrication of cavities complying with Japanese High-Pressure Gas (PHG) code needs several steps.

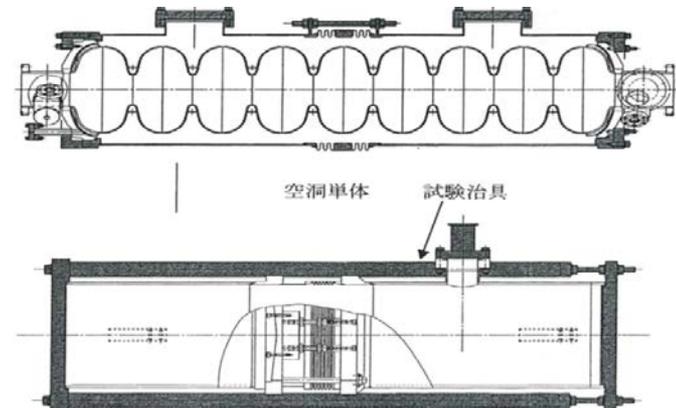


(Simulation step) We must confirm the strength of liquid-He pressure-vessel by analysis with simulation and declare the welding details of Nb cavity and Ti jacket to the authority. In addition, we must perform series of pressure tests and report the results to the authority.

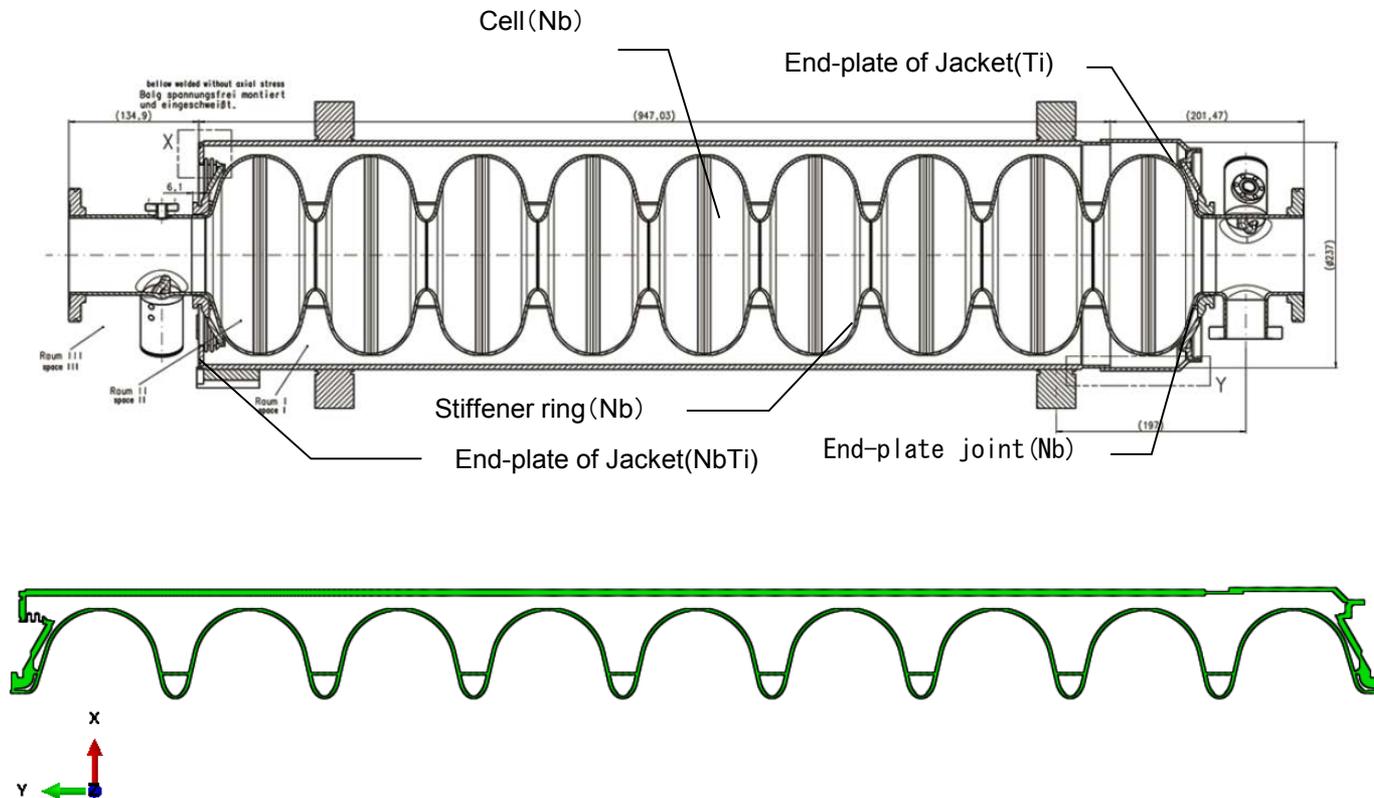
(Pressure test step) Bare 9-cell cavity (pressure-test with water)

(Pressure test step) Only He jacket (pressure-test with water)

(Pressure test step) Cavity + He Jacket after welding.



Simulation analysis of TESLA-shape cavity in collaboration with Toshiba



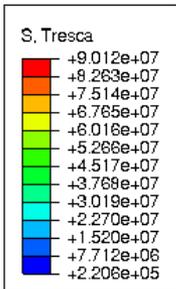
Simulation analysis of stress distribution at operational temperature and pressure with TESLA(Euro-XFEL)-shape cavity

Simulation analysis of TESLA-shape cavity in collaboration with Toshiba

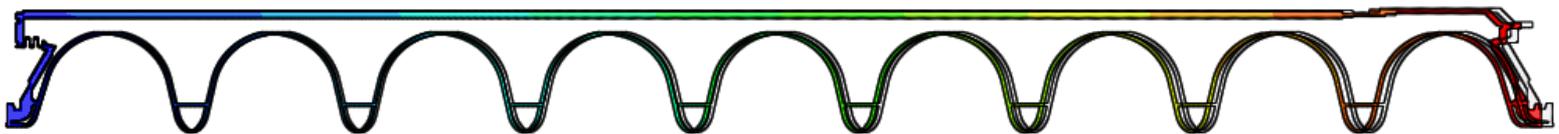
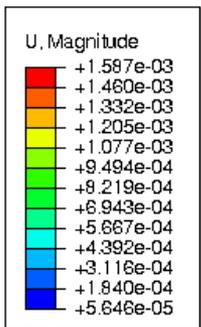
Example of simulation :
T = 2 K, Pressure = 0.2 MPa

Preliminary

Unit in MPa



Stress distribution



Displacement x 5

Unit in m

Simulation analysis of TESLA-shape cavity in collaboration with Toshiba

Example of simulation results:
T = 2 K, Pressure = 0.2 MPa

Preliminary

		Peak stress in MPa	Acceptable limit in MPa
Cavity	Cells (including end-cells)	10	39
	Equator	3	39
	Iris	7	39
	Joint to stiffener ring	9	78
Jacket	End-plate of jacket (joint to cavity)	11	39
	Conical disk	72	90
	Joint to bellows	39	127.5
	Joint to bellows (fixed side)	29	127.5
	Jacket cylinder	75	127.5
	Bellows	41	255



Peak stresses are below the acceptable limits of the J-HPG safety act.

Experimental plans by using TESLA(Euro-XFEL)-shape cavities

- It will take more than one year to complete the assembly of facilities in COI building.
- The four TESLA(Euro-XFEL)-shape cavities can be used for some R&D experiments until the completion of COI facilities.
- One TESLA-shape cavity was already sent from KEK to Cornell university to use it for Vertical EP (VEP) R&D experiments.

Vertical EP experiment is ongoing in collaboration with Cornell university



BCP (100 um) at Cornell university

In the end of 2014, one TESLA-shape cavity was sent from KEK to Cornell university (F. Furuta and G. Hoffstaetter) for the Vertical EP R&D experiments.

Bulk BCP (total 100 um, flipped cavity after 50 um etch) was done at Cornell university for the surface preparation before VEP experiments.

- BCP acid solution;
 $\text{HNO}_3:\text{HF}:\text{H}_3\text{PO}_4=1:1:2$.
- Removal rate $\sim 1\mu\text{m}/\text{min}$.
- DIW cooling shower for outside surface.
- Kept temp. 15degC during process.

Degassing/annealing at 800 °C for 2 hours followed.

Now the 9-cell cavity is waiting for VEP R&D experiments.

Summary

- New Center-of-Innovation (COI) building was completed in January 2015. Various components for new SRF facilities are already delivered in the new COI building.
- TESLA(Euro-XFEL)-shape cavities are needed for the commissioning of the new SRF facilities in COI building.
- Fabrication of four TESLA(Euro-XFEL)-shape cavities were ordered to industrial vendors (MHI and Toshiba) and the four cavities were successfully delivered.
- We will go through the process of Japanese High Pressure Gas (HPG) safety act with TESLA(Euro-XFEL)-shape cavity to guide foreign vendors.
- Simulation analysis of stress distribution in TESLA(Euro-XFEL)-shape cavity was done in collaboration with Toshiba. The preliminary results show the TESLA-shape cavity might comply with the Japanese HPG safety act.
- One TESLA-shape cavity was sent to Cornell university for the Vertical EP R&D experiments.