Recent Progress in Superconducting Cavity Production

Eiji KAKO
(KEK, Japan)

Outline

- Cavity fabrication process
- Cavity high gradient performance
- Activities of cavity fabrication
- Summary

- **Cavity fabrication process**
- Cavity high gradient performance
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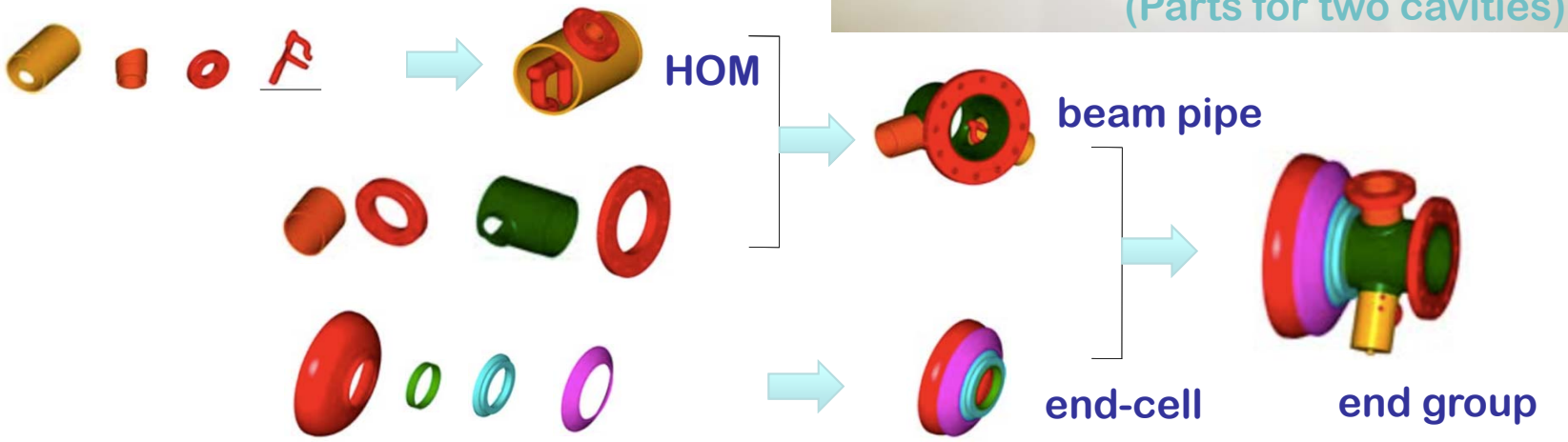
Cavity fabrication process (1)

EBW of dumb-bell

(2 half-cells + stiffening rings)

(8 dumb-bells / cavity)

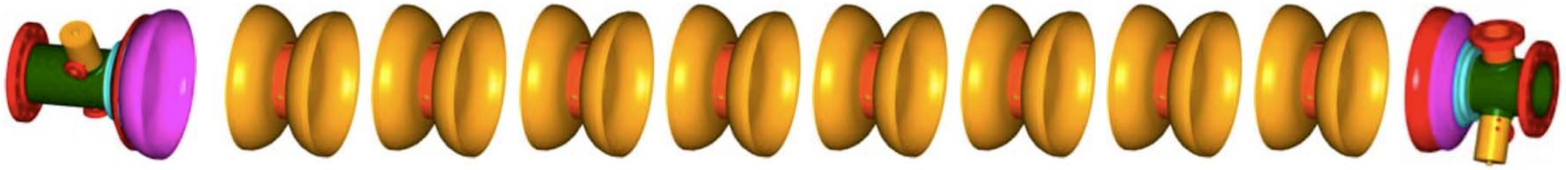
EBW of end-group parts



(2 end-groups / cavity)

Cavity fabrication process (2)

EBW of 9-cell cavity (end group + 8 dumb-bells + end group)



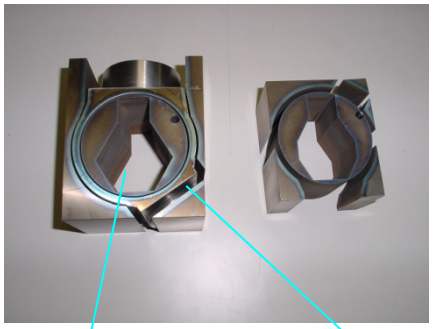
Welding of Helium jacket

(Ti vessel + Ti bellows)

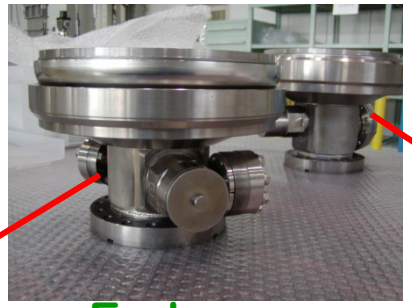
Quality of electron beam welding is essential for cavity fabrication.

Smooth surface of inner welding seems at equator is most important.

Cavity Fabrication Process (3)



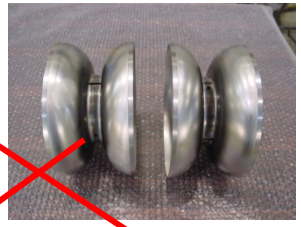
HOM coupler

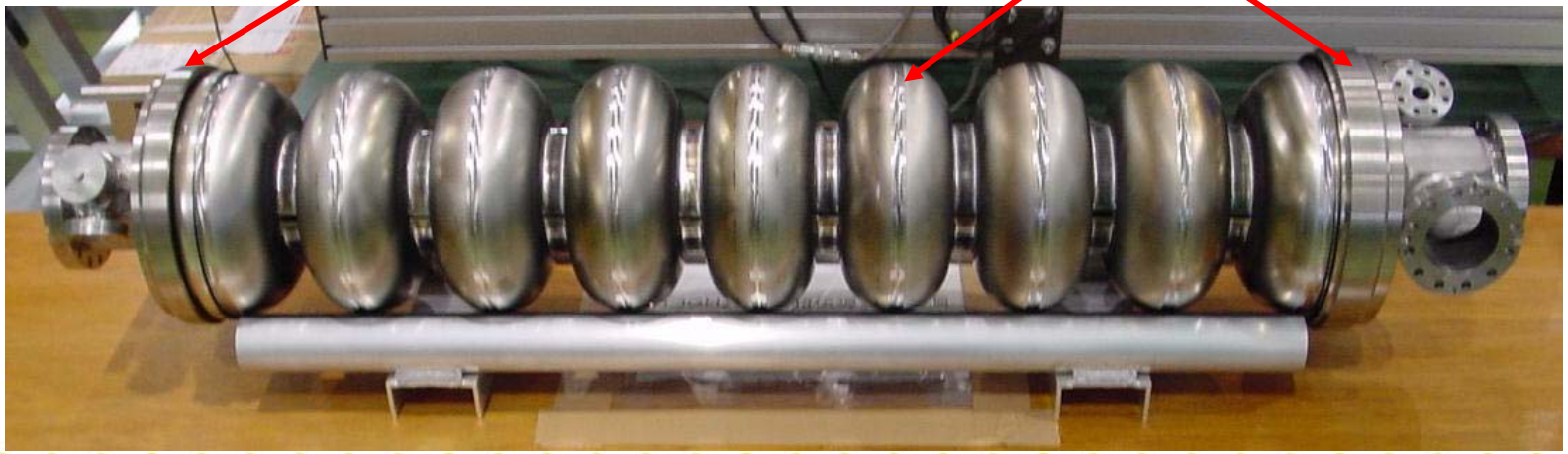


End-groups

Center-cells

(Tokyo Denkai ; RRR~300 Nb)

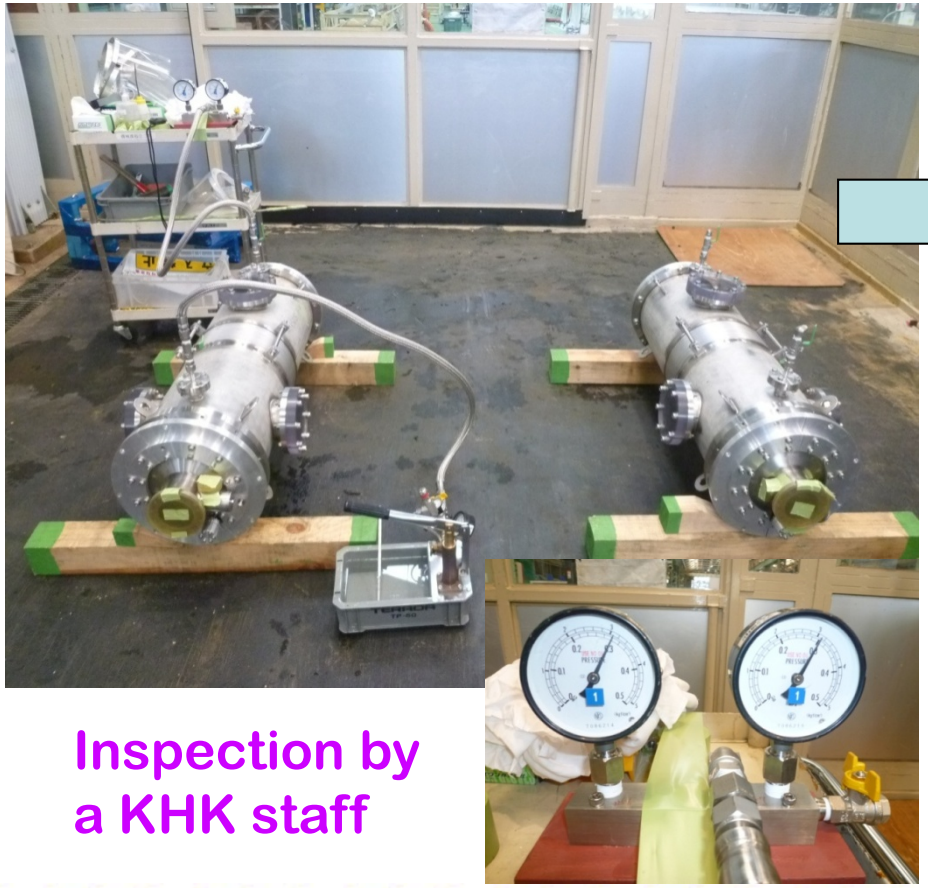




High Pressure Gas Safety Regulation (1)

Nb Cavity

at 1.5 times of design pressure
(test with water : 0.3 MPa)



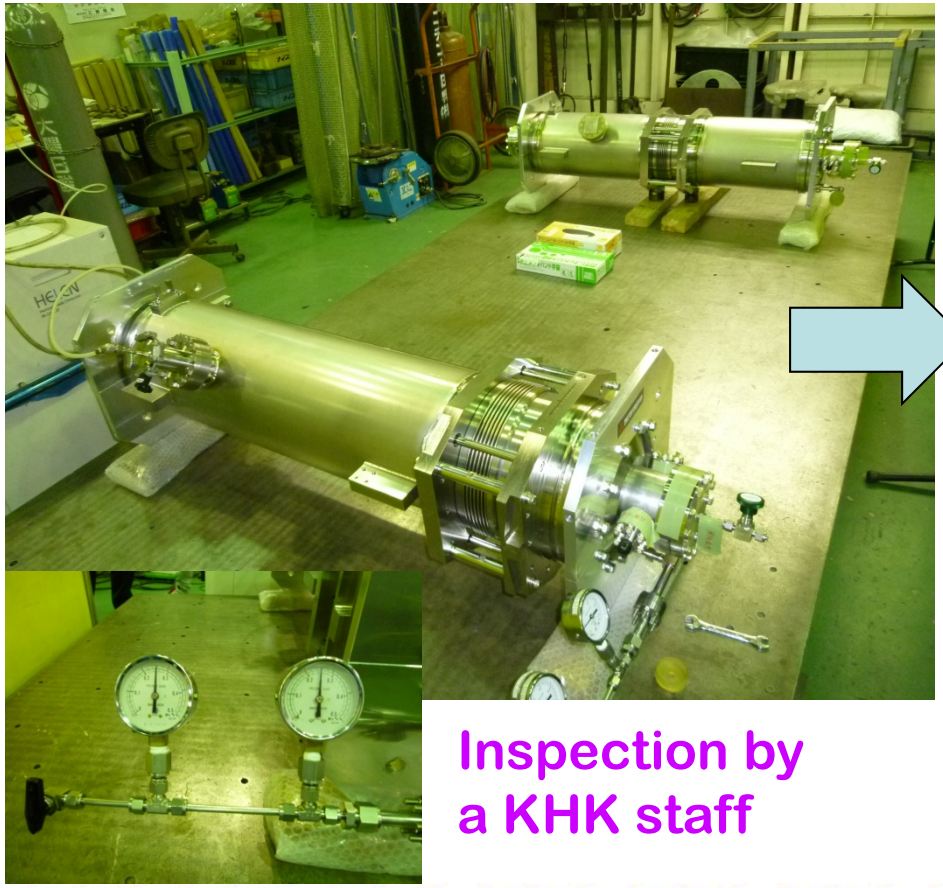
Inspection by a KHK staff

Vertical test of 9-cell cavity

High Pressure Gas Safety Regulation (2)

Cavity unit with Jacket

at 1.25 times of design pressure
(test with He gas : 0.25 MPa)



Inspection by
a KHK staff

Cavity string assembly

- Cavity fabrication process
- **Cavity high gradient performance**
- Activities of cavity fabrication
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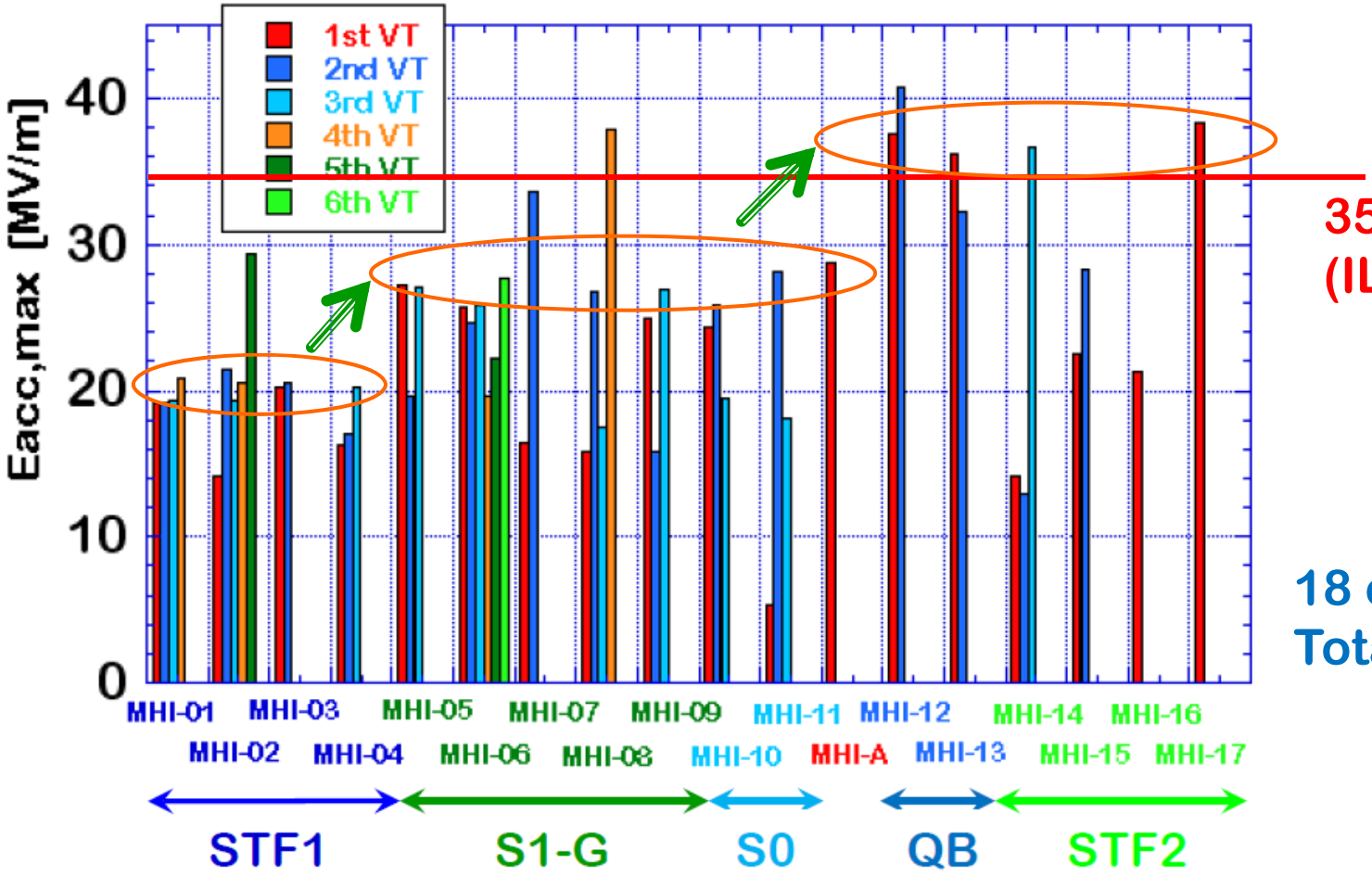
Cavity performance in VT at KEK

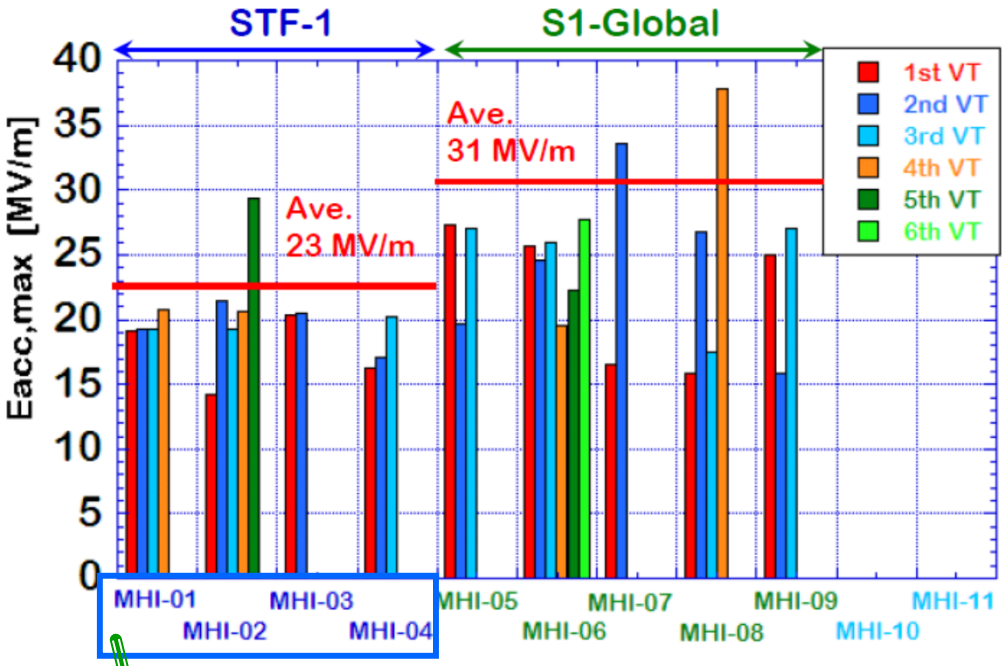
Twenty-three 9-cell cavities fabricated by MHI for 7 years, (2005~2011)

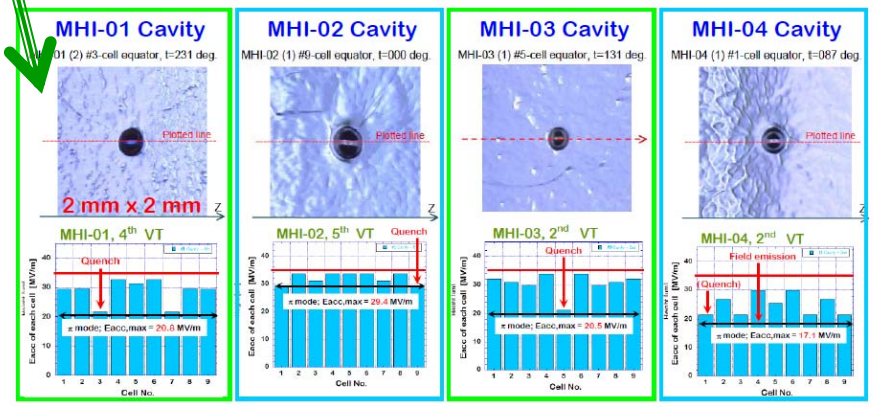


35 MV/m
(ILC target)

18 cavities tested.
Total 50 VTs.

Improvement of cavity performance (1)





Average Eacc,max in final VT ;
23 MV/m → 31 MV/m
(Gain = + 8 MV/m)

Improved items :

- **Cavity fabrication,**
  - . Thickness of EBW face
  - . CP of EBW face in each steps
  - . Wide parameter region of EBW
  - . Clean environment of EBW devise
  - . Clean room for assembly of jigs
  - . Inspection of EBW seam by camera
  - . Careful inspection of inner surface
- **Surface preparation,**
  - . Construction of new infrastructure at STF (EP, HPR, clean room,.....)
- **Diagnostics/Inspection,**
  - . T-mapping . Kyoto-camera

Surface Preparation Process at STF

Pre-tuning
fo adjustment

EP-II (20 μm)

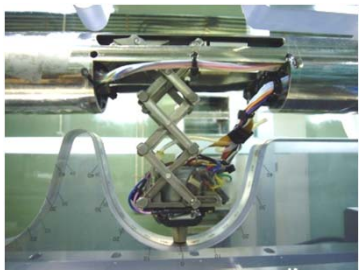
Hot bath rinsing
Degrease
(H_2O_2, C_2H_5OH)

HPR

Assembly
(class 10)

+ Anneal at 750°C
+ EP-I (100 μm)
preEP (5 μm)

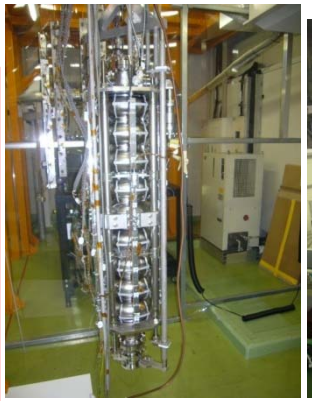
Infrastructure at STF



Local grinding
of defects

Inspection of
inner surface

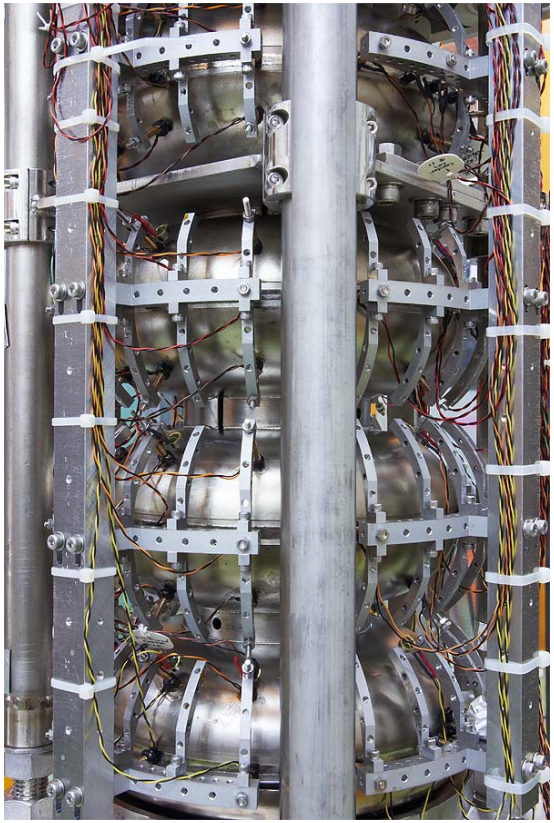
Vertical test
with T-map



Hanging
stand

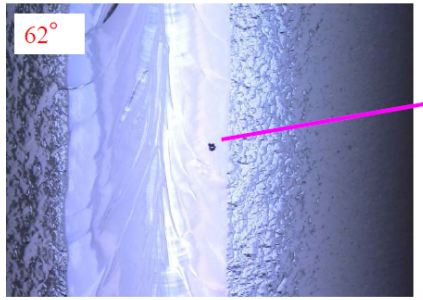
Baking
(class 1000)

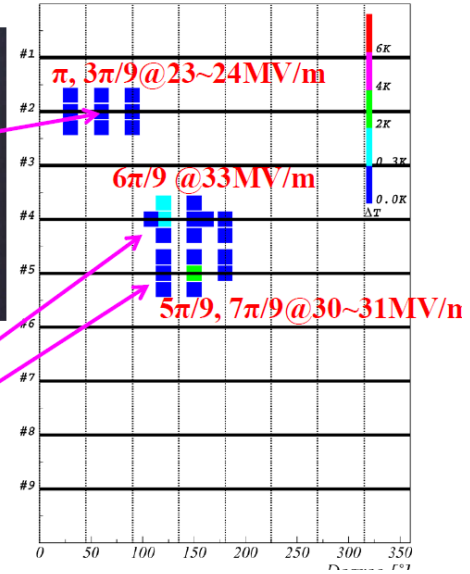
T-mapping and Surface inspection



396 carbon resistors
182 PIN photo diodes
8 second sound sensors
Radiation monitor
Electron probe

MHI-15 Cavity

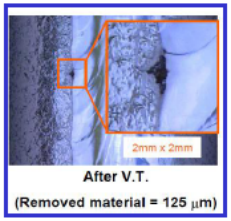


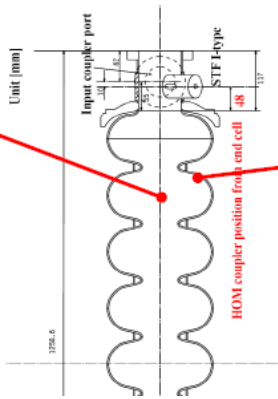


Nothing was found!

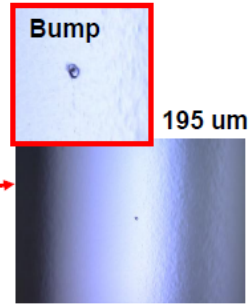
MHI-08 Cavity

Quench at 16MV/m





2 mm x 2 mm



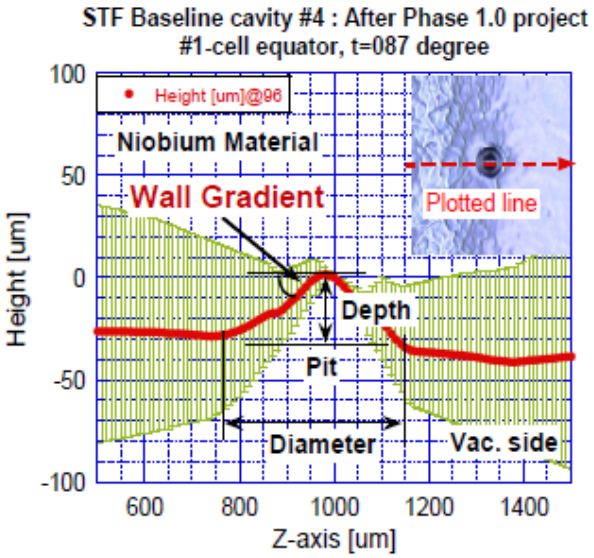
195 um EP

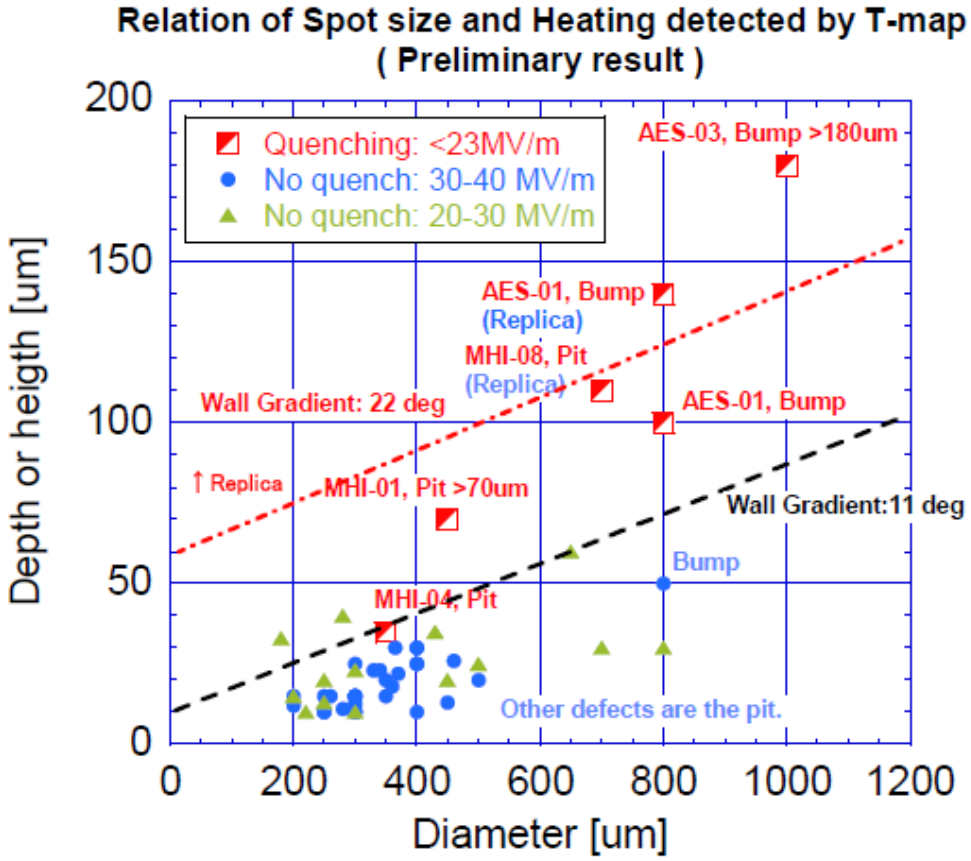
Quench at 27 MV/m

by Y. Yamamoto (KEK)

Size of defects and Quench fields

by K. Watanabe (KEK)





Found defects: 60 defects at outside weld area and on the EBW seam at equator

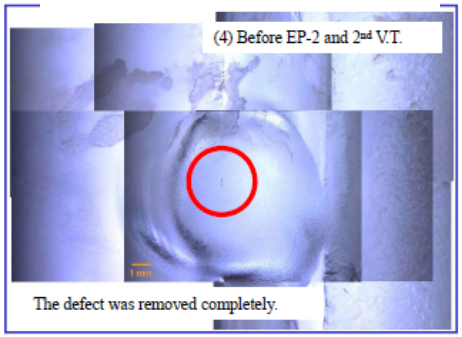
（13 cavities, 103 cells）(Quenched defect: 6 defects, Poor EBW)

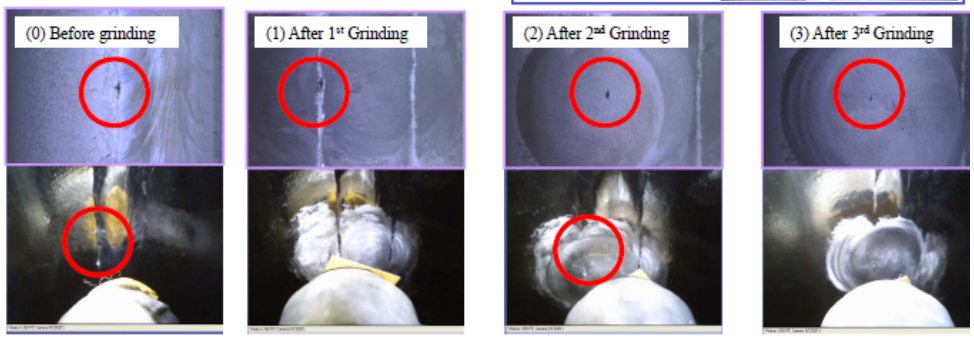
Improvement of cavity performance (2)

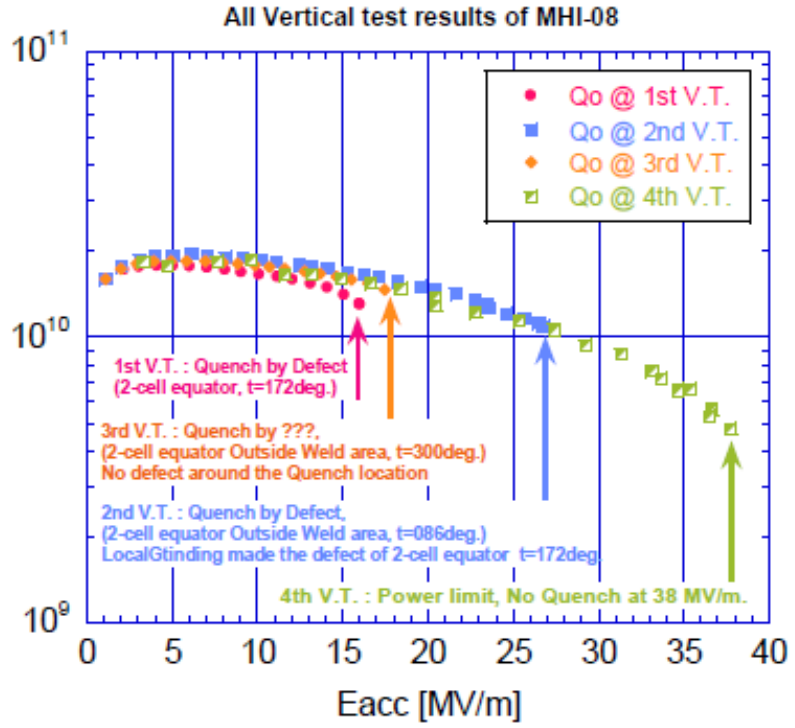
Repair by Local Grinding

by K. Watanabe (KEK)

MHI-08 Cavity



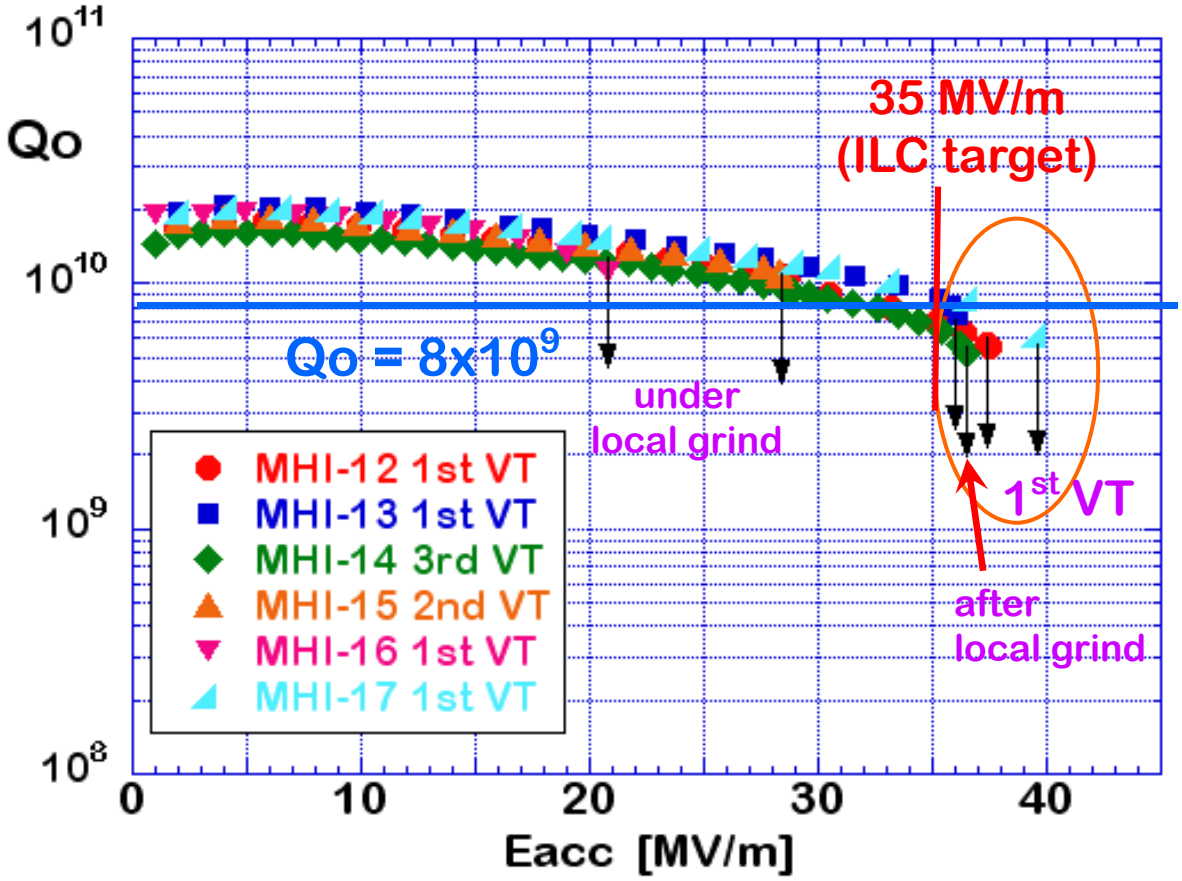




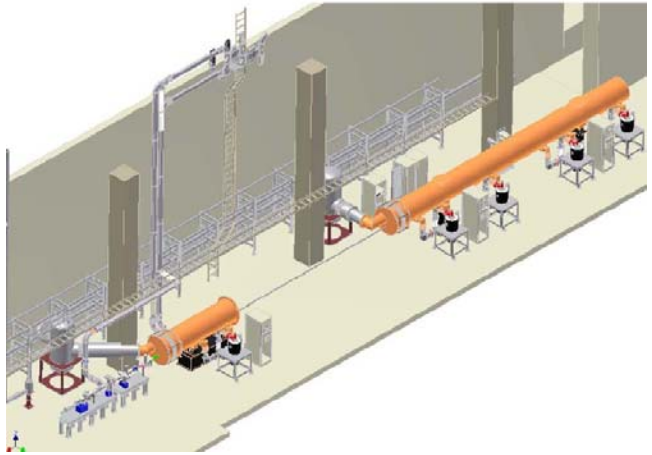
So many defects did not find on cavity surface. Only one or two defects like pits or bumps cause a quench and limit cavity performance.

Eacc of 38 MV/m was achieved in 4th VT after local grinding.

Recent cavity performance of STF-2 cavities



STF-2 Project



11 cavities were fabricated for STF-2.

2 cavities (MHI-12,13) for capture cryomodule.

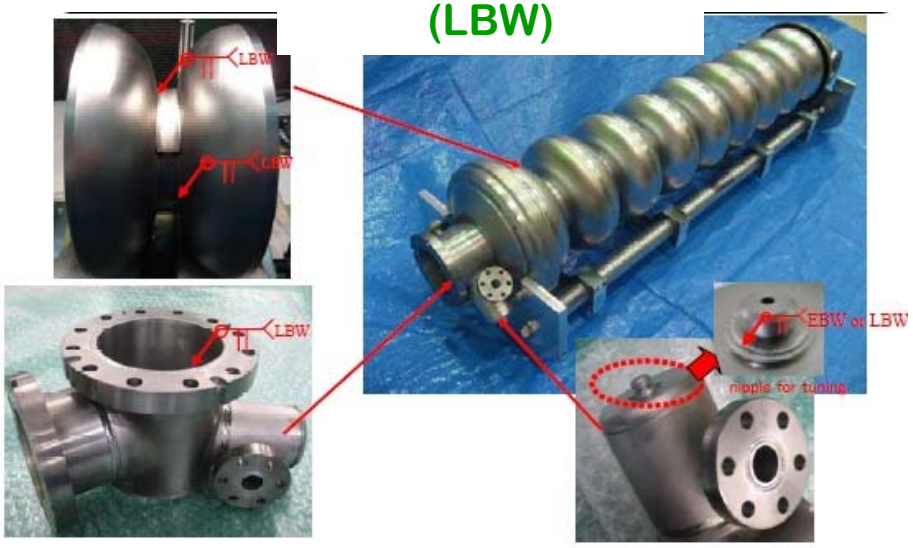
9 cavities (MHI-14~22) for ILC-type cryomodule.

Beam operation will be started in 2013.

- Cavity fabrication process
- Cavity high gradient performance
- **Activities of cavity fabrication**
- Summary

Cavity fabrication activities at MHI

MHI-A 9-cell cavity (LBW)



MHI-B 2-cell cavity (seamless dumbbell)

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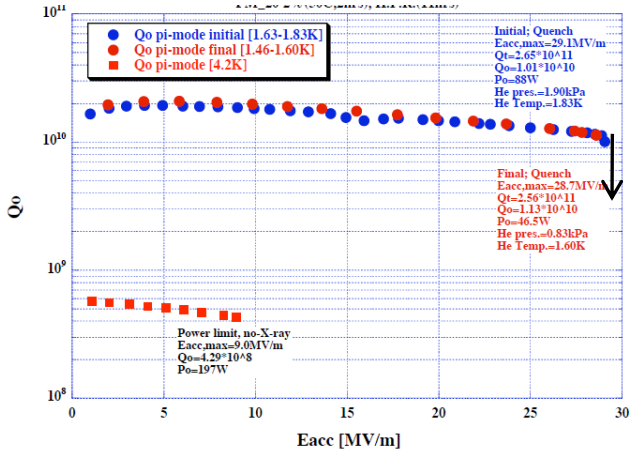
by K. Sennyu (MHI)

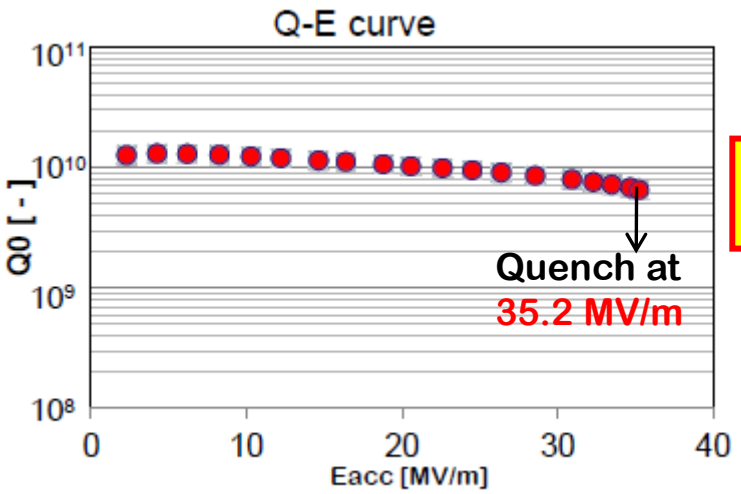


Quench at 28.7 MV/m

Cavity fabrication activities at Hitachi

HITACHI
Inspire the Next

Completed HIT-01 cavity

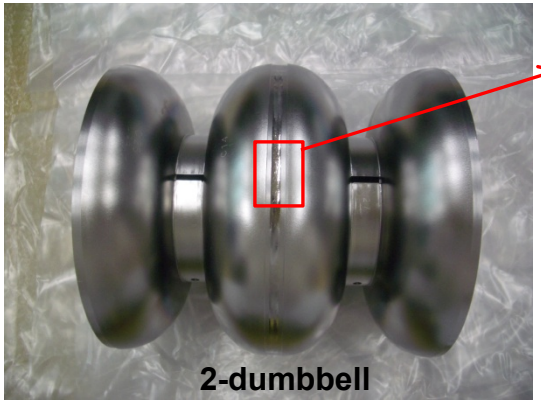


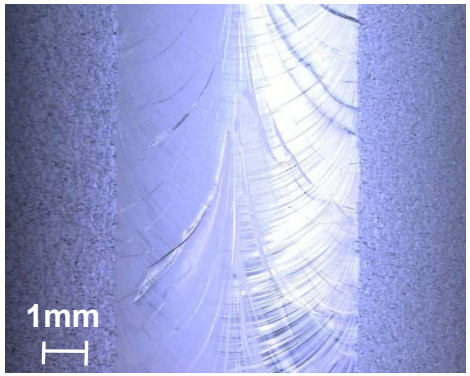
HITACHI
Inspire the Next

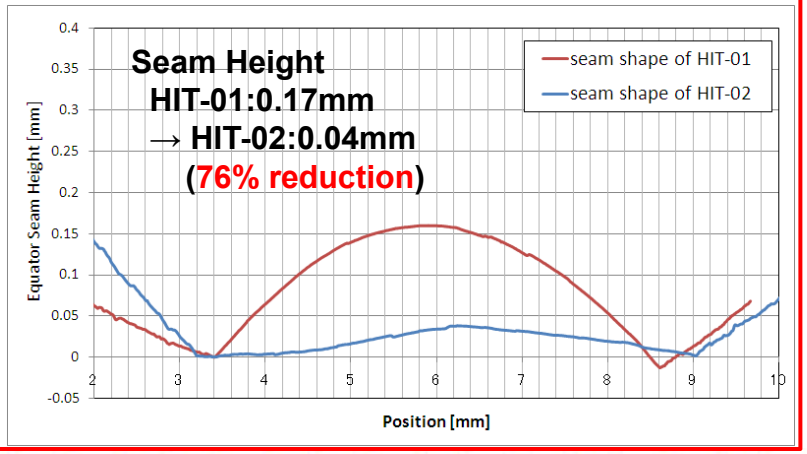
by T. Watanuki
(Hitachi)

Current status of HIT-02 cavity with HOM couplers

Improvement of equator welding seam



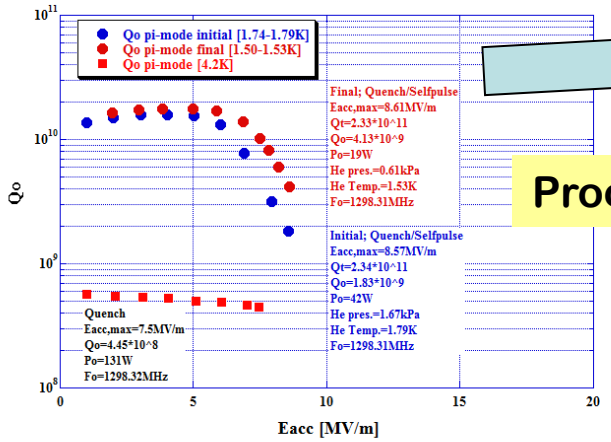




Cavity fabrication activities at Toshiba

First 9-cell cavity fabrication (TOS-01 cavity)

Vertical test results of first 9-cell cavity.



Process optimization

TOSHIBA
Leading Innovation

by T. Ohta (Toshiba)

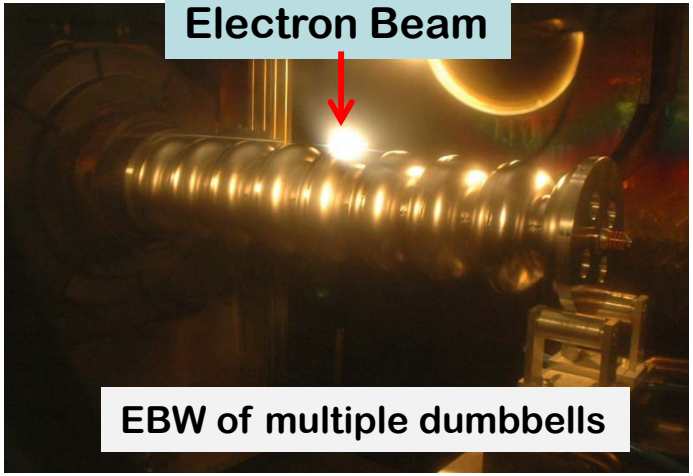
Beam Tube

End group (coupler side)

Fabrication of second 9-cell cavity (TOS-02)

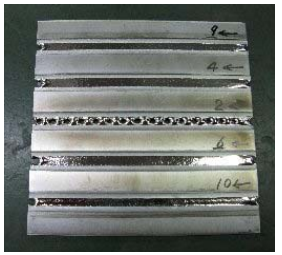
Cavity fabrication activities at KEK

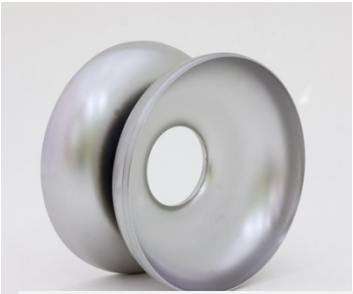
EB Welding at TOSEI co. Ltd.



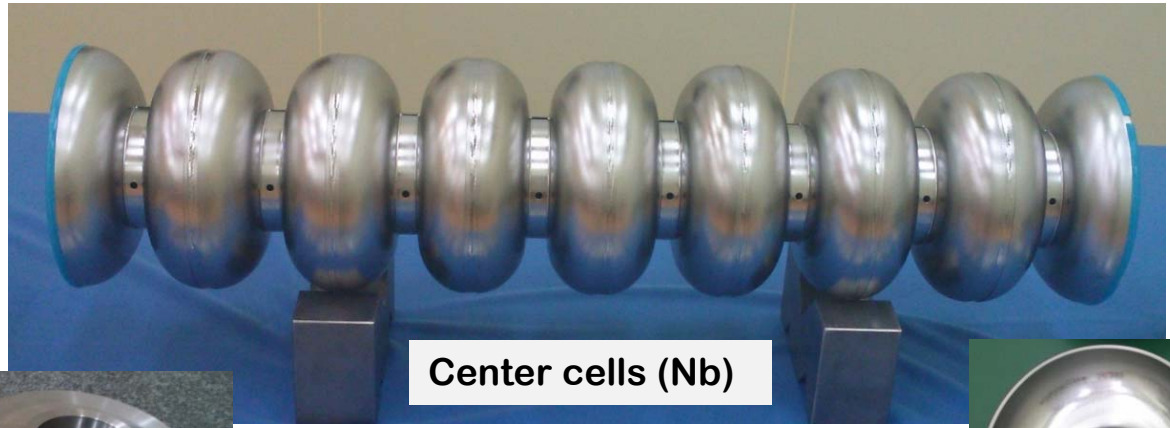
KEK

by T. Saeki (KEK)





Dumb-bell (Nb)



Beam-pipes (Nb)

Fabrication of KEK-00 cavity

Cavity Fabrication Facility (CFF) at KEK

Pilot Plant for cavity fabrication

Clean room 19 m x 14 m x 5 m H

Cleanness ISO 5 to 6

KEK

by K. Ueno (KEK)

EBW machine

60 ~150 kV

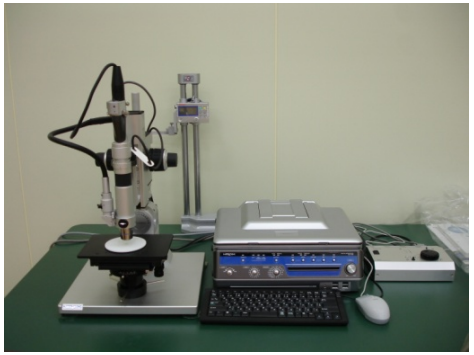
0 ~100 mA

15 kW

Vertical lathe

Press machine

CP room, Draft chamber

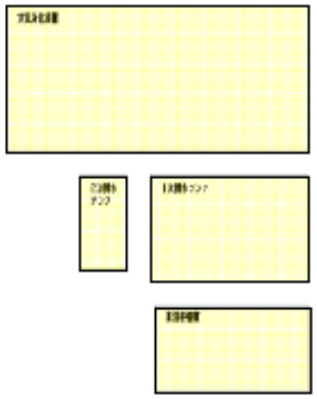


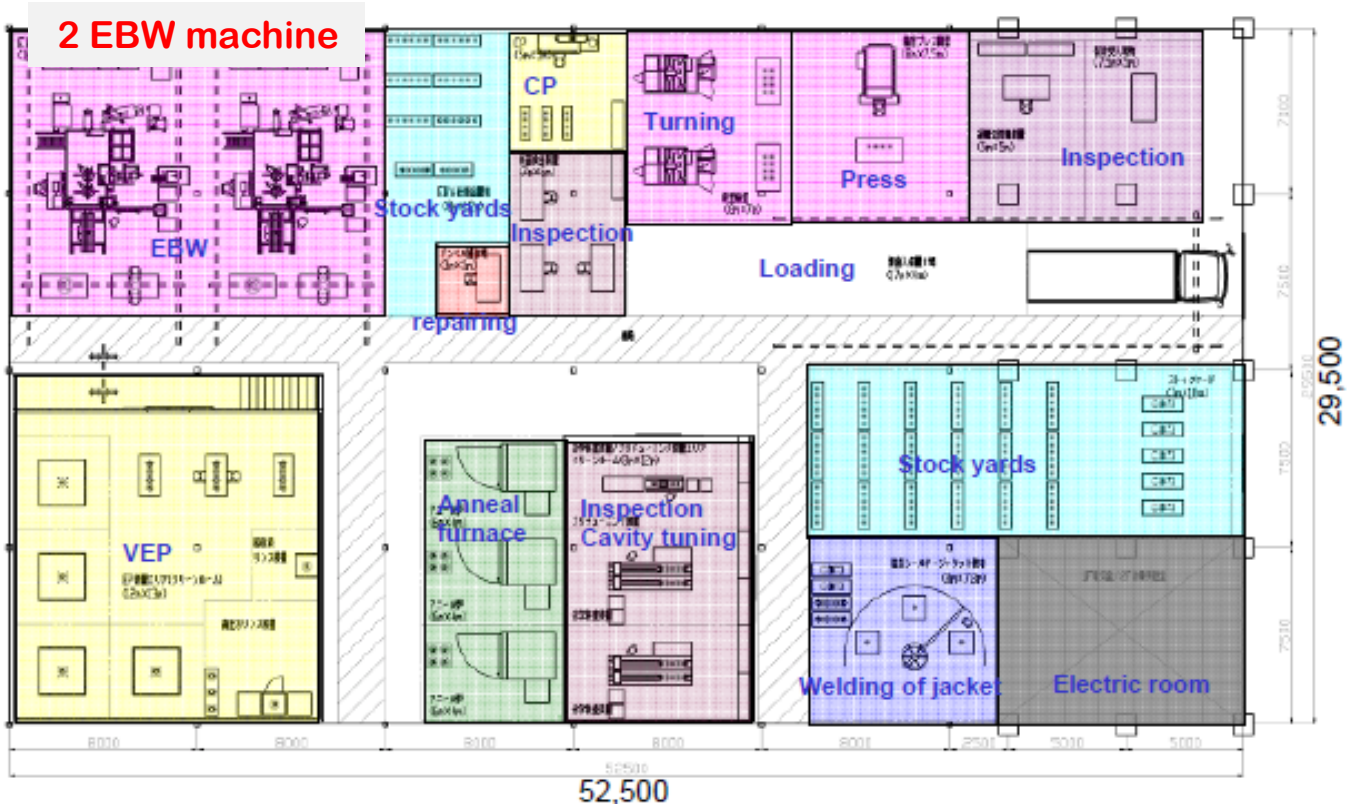
3D inspection equipment for Nb surface

Fabrication of KEK-01 cavity

Mass production model of cavity fabrication

•KEK's R&D facility (52.5mX29.5m)





Simulation results;
540 cavities / year
54 workers
(2 shifts, 16h / day)

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by S. Ishii (MHI)

KEK

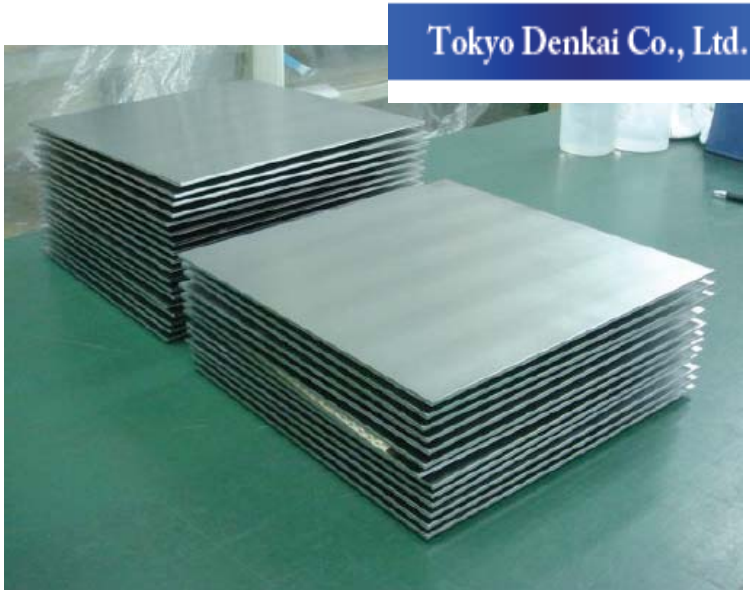
by A. Yamamoto (KEK)

- Cavity fabrication process
- Cavity high gradient performance
- Activities of cavity fabrication

In addition to ……,

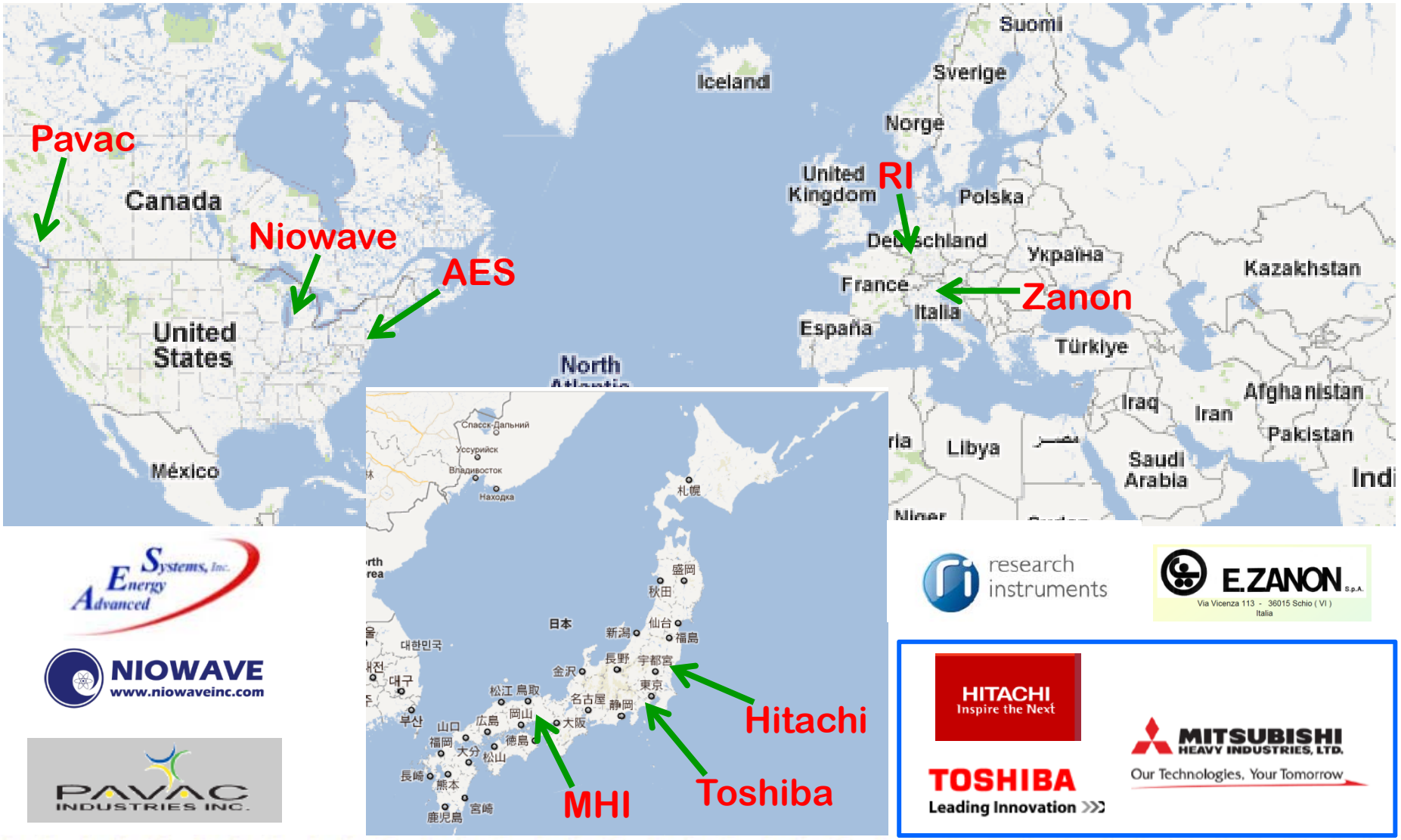
- Summary

Production of Superconducting Cavities



For 3GeV-ERL (at KEK)	5,000 Nb sheets (Total; 4.2 ton)	250 cavities / 3 years
For XFEL (at DESY)	12,000 Nb sheets (Total; 10 ton)	600 cavities / 3 years (+ α cavities)
For ILC (?somewhere)	340,000 Nb sheets (Total; 280 ton)	17,000 cavities / 6 years

Vendors for cavity production in the world



Energy Advanced Systems, Inc.

NIOWAVE www.niowaveinc.com

PAVAC INDUSTRIES INC.

research instruments

E.ZANON S.p.A. Via Vicenza 113 - 36015 Schio (VI) Italia

HITACHI Inspire the Next

TOSHIBA Leading Innovation

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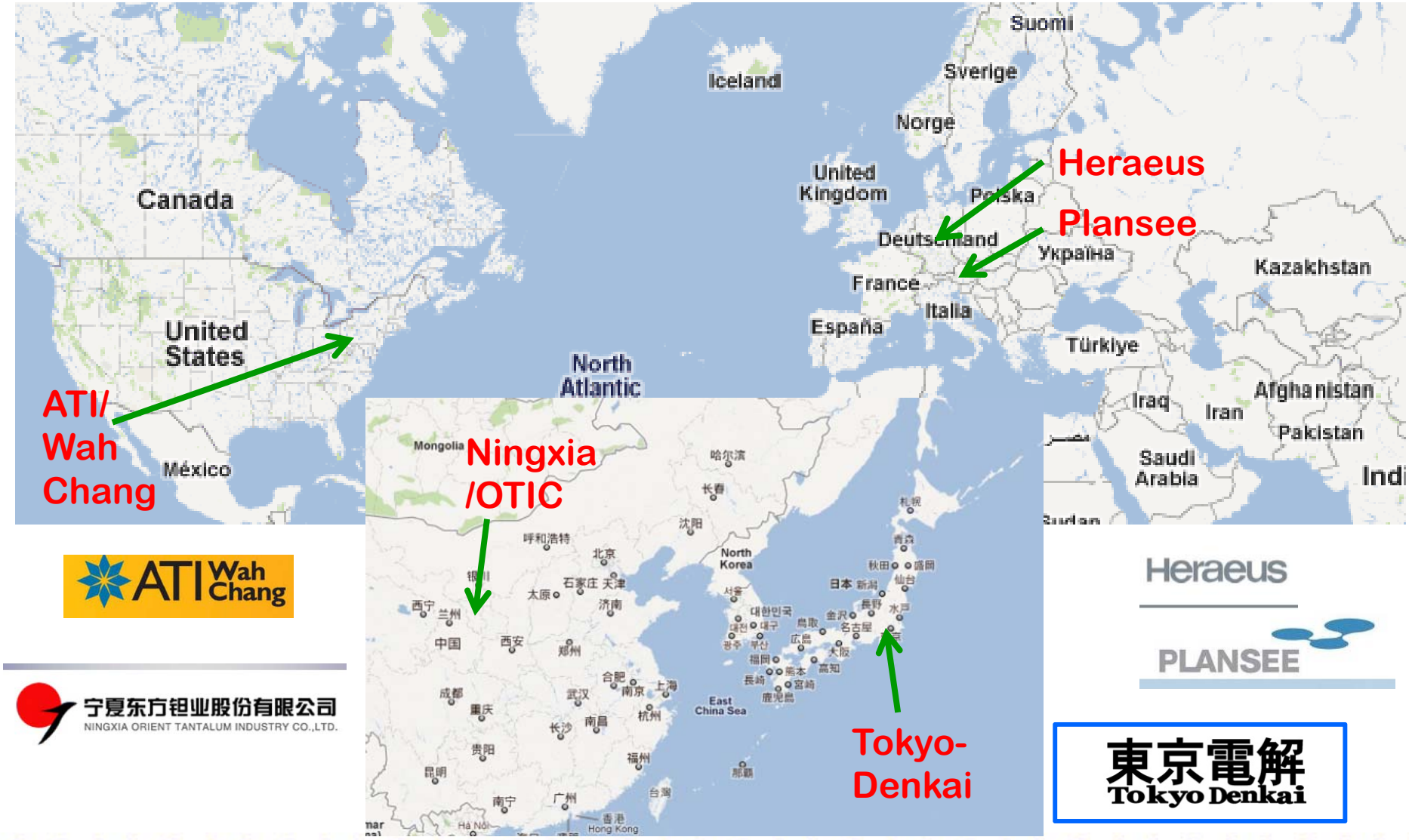
Suppliers for high purity Nb in the world



ATI Wah Chang

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NINGXIA ORIENT TANTALUM INDUSTRY CO.,LTD.

Heraeus

PLANSEE

東京電解
Tokyo Denkai

SUMMARY

- High gradient performances of 1.3GHz 9-cell cavities have been improving with steady progress of cavity production technologies by vigorous R&D efforts.

- Next further requirements are cost reduction and mass production of 1.3GHz 9-cell cavities for future accelerators.

Acknowledgements

Special thanks go to

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K. Ueno and A. Yamamoto (KEK)

Thank you for your attentions !