

# *Cavity Fabrication at KEK- CFF*

KEK

Takeshi DOHMAE

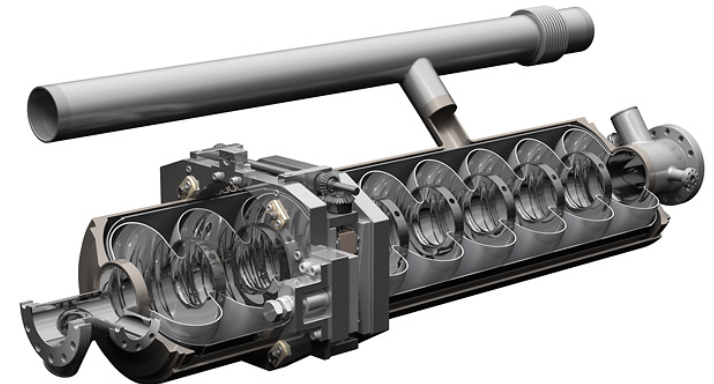


2019.3.December  
IHEP-KEK collaboration meeting

## *Current status of Cavity Fabrication Facility (CFF)*

Cavity Fabrication Facility (CFF) is working for ILC;

- Study for cost reduction in cavity fabrication
  - ✓ Try new materials (large grain Nb)
  - ✓ Mass production techniques
- Pass the Japanese helium vessel code (high pressure gas safety act.)
  - ✓ Buckling simulation
    - Tensile test in cryogenic temperature
  - ✓ Welding Procedure Specification
- Investigation on tuner
- Cooperation with companies
- Hydroforming cavity



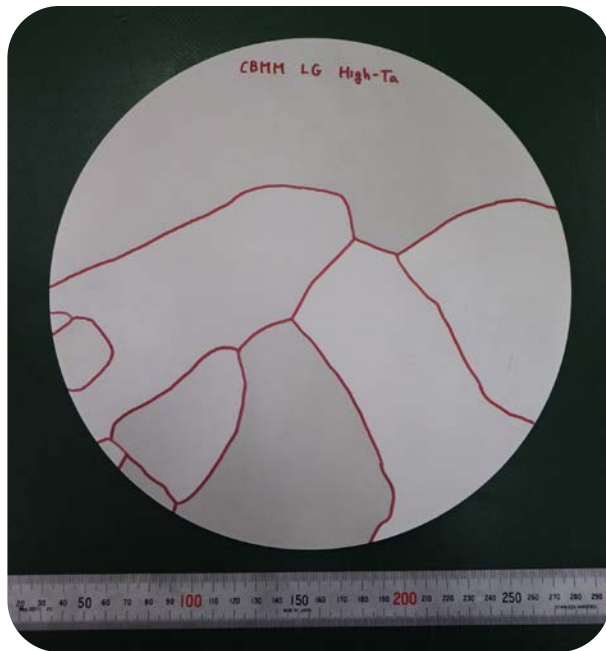
# ***Large Grain Nb***

# Large grain (LG) niobium for cost reduction

CBMM LG: RRR = 242-298, High-Ta contained (1034ppm)

※High-Ta contained Nb is cheaper than low-Ta contained Nb

CBMM  $\phi$ 260



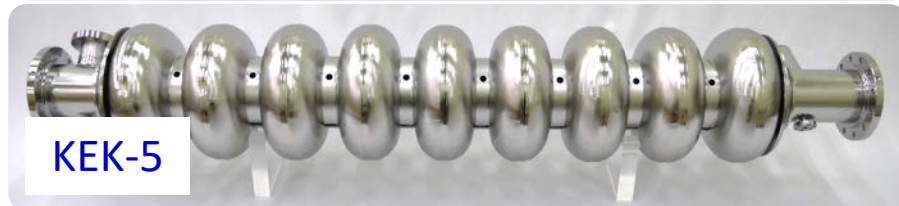
Completed  
in 2017

Extend to 9-cell

1.3GHz Tesla shape



Completed  
in 2019



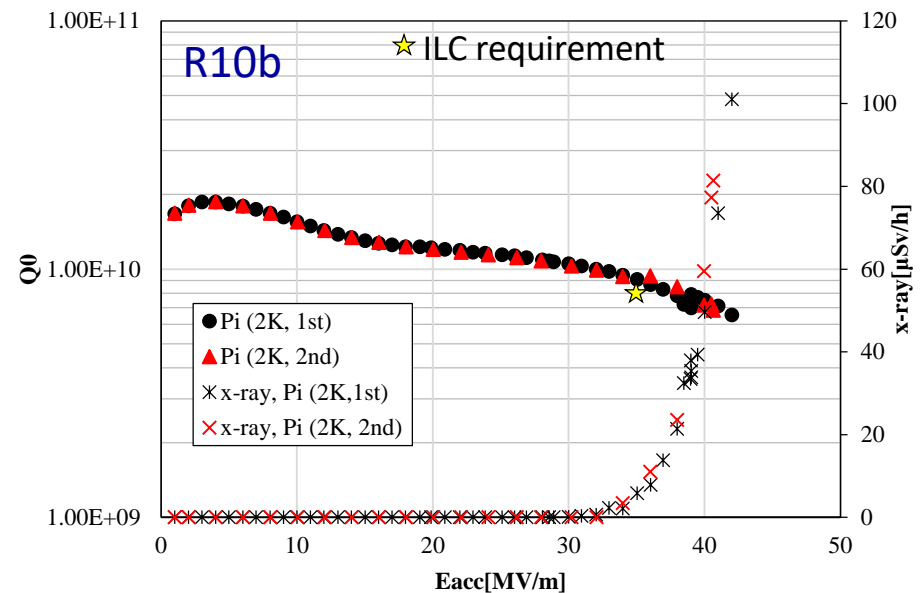
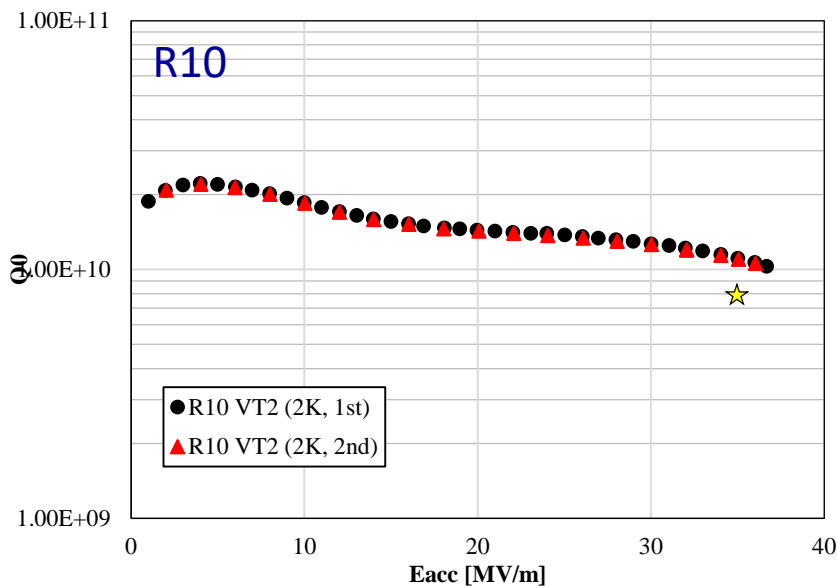
# CBMM LG: 3-cell cavity (reminder)

Two 3-cell cavities were fabricated.

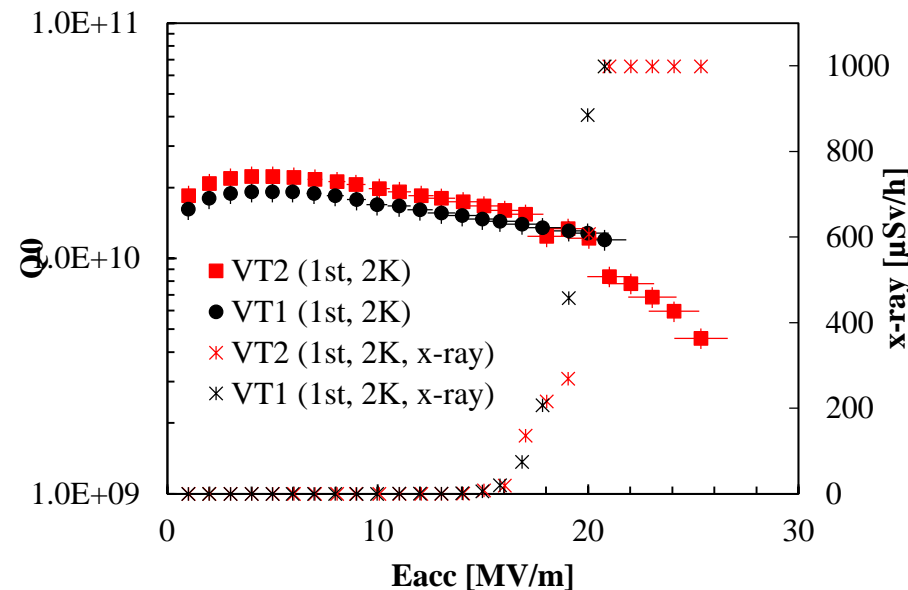
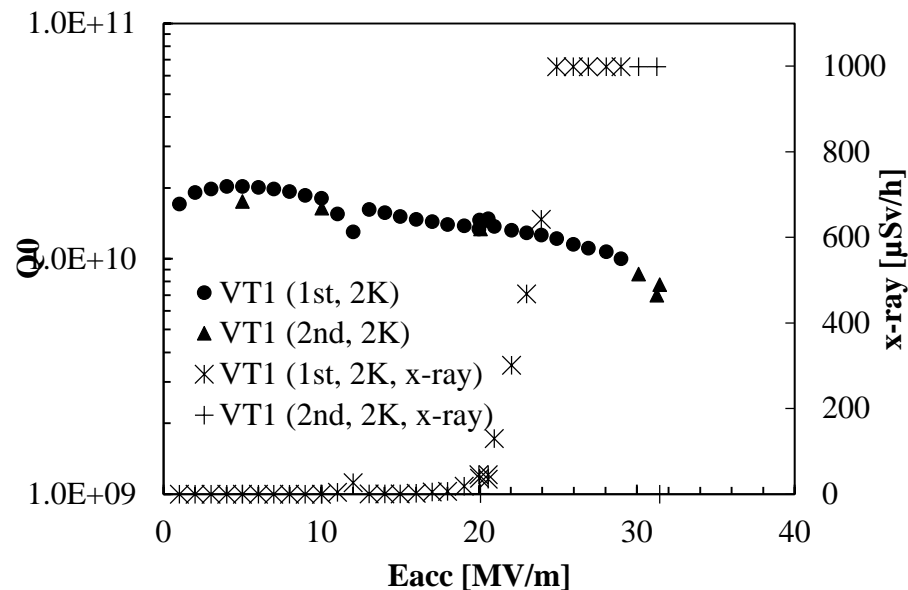
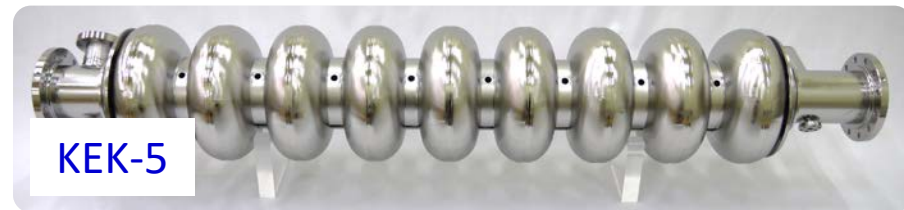
## Surface treatment (standard ILC recipe)

1. EP1 (100 $\mu$ m)
2. Annealing (750deg  $\times$  3hrs)
3. Tuning
4. EP2 (20 $\sim$ 30 $\mu$ m)
5. Assembly
6. Baking (120deg  $\times$  48hrs)

R10/R10b



# CBMM LG: 9-cell cavity

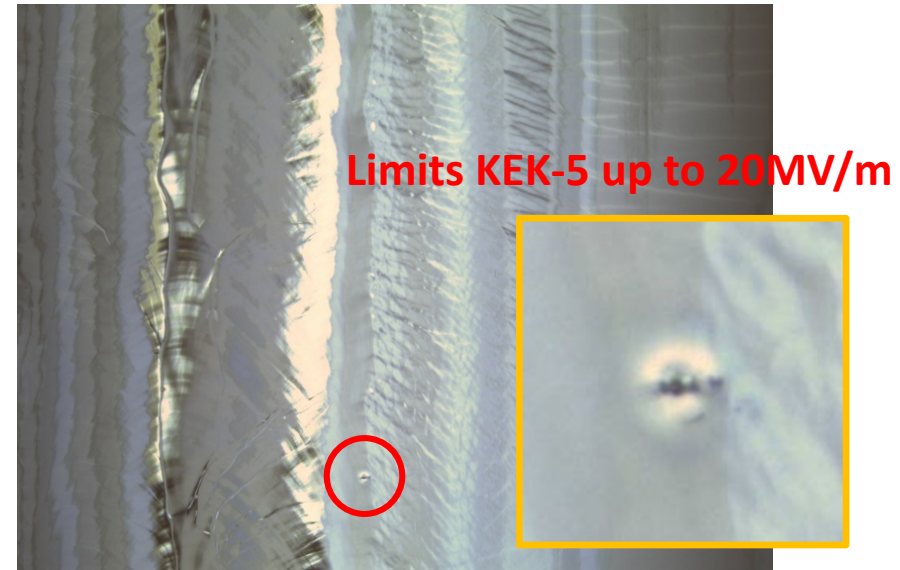
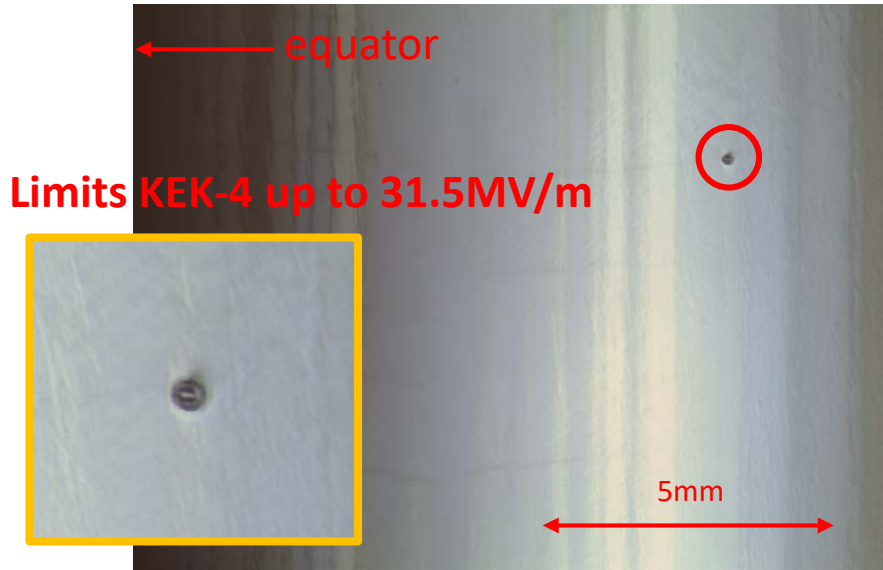


## Maximum gradients

	Cell1	Cell2	Cell3	Cell4	Cell5	Cell6	Cell7	Cell8	Cell9
KEK-4	40.0	40.9	>31.5	>31.5	>40.9	31.5	31.5	>40.9	>40.0
KEK-5	>34.4	32.9	30.3	33.4	35.9	>33.4	>30.3	>32.9	>34.4

→To be measured again

# Found defects



- ✓ Need to reconsider our fabrication process;
  - Welding procedure
  - Grinding procedure
- ✓ Observe material
  - Inner mechanical/thermal stress
  - Contamination

Increase yield ratio  
→ Most effective cost reduction

***Helium vessel code***



# High pressure gas safety act. (Helium vessel code)

Aiming to pass the high pressure gas safety act. by KEK.

- Current goal: FG cavity
- Future plan: LG cavity

Several items are necessary;

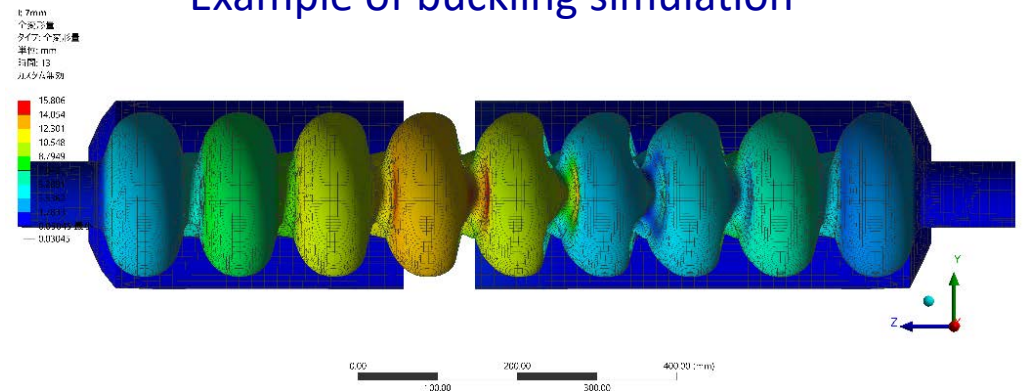
- Welding Procedure Specification (WPS)
- Buckling/stress simulation

→ Mechanical properties of materials

Example of WPS

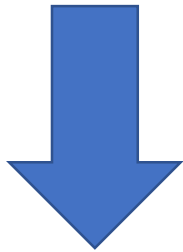


Example of buckling simulation

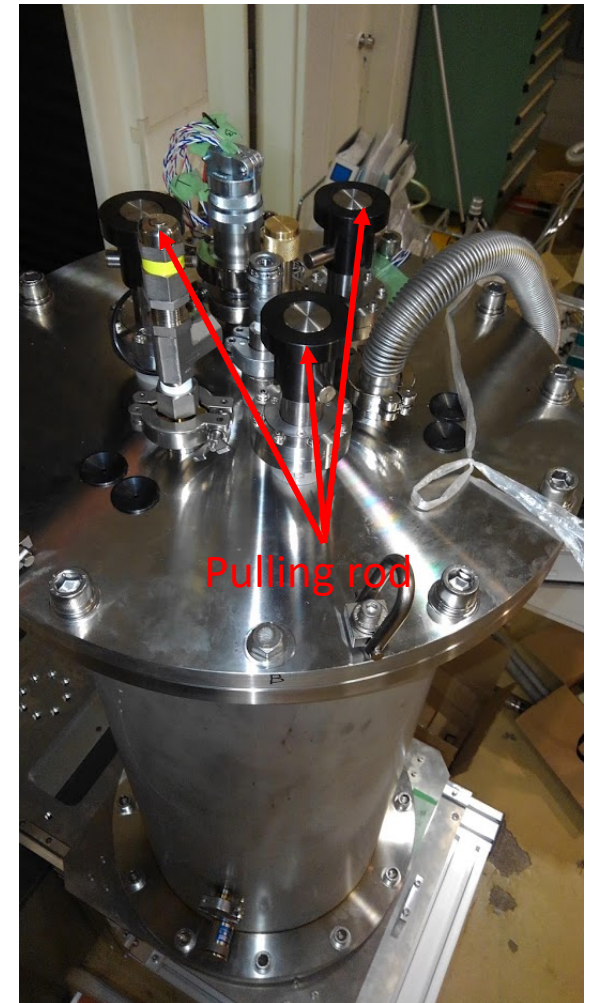


# Tensile test at cryogenic temperature

Measuring mechanical properties of LG is necessary to pass the helium vessel code.

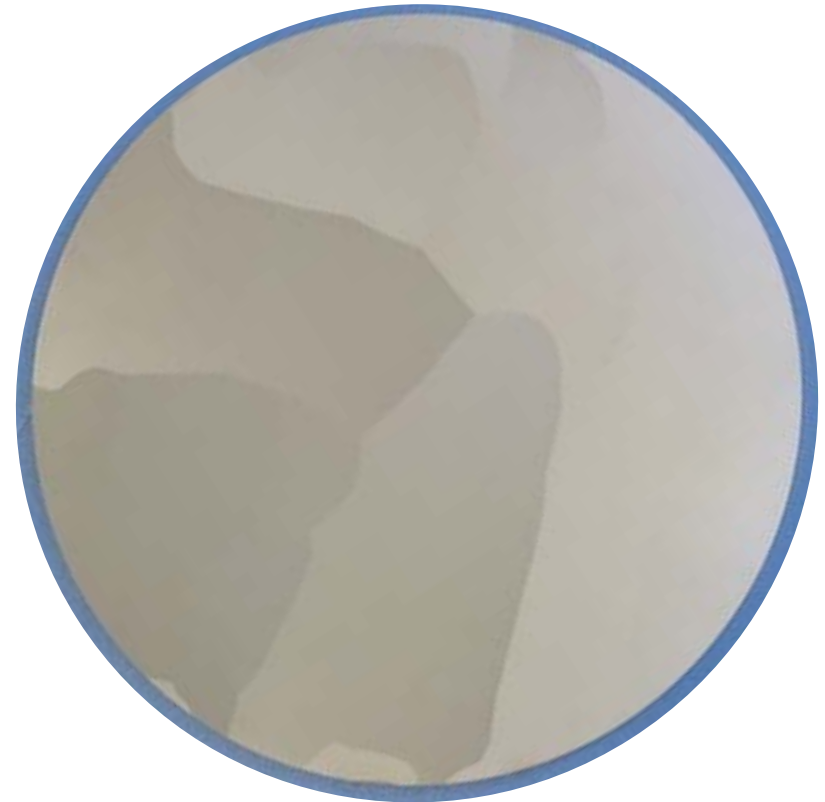
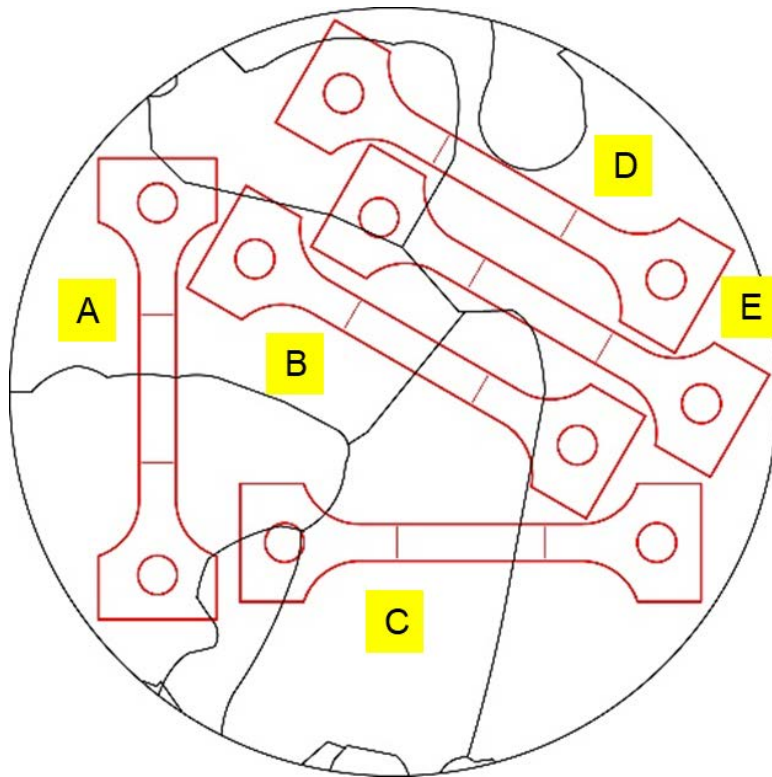


We are currently investigated tensile test system at cryogenic temperature.



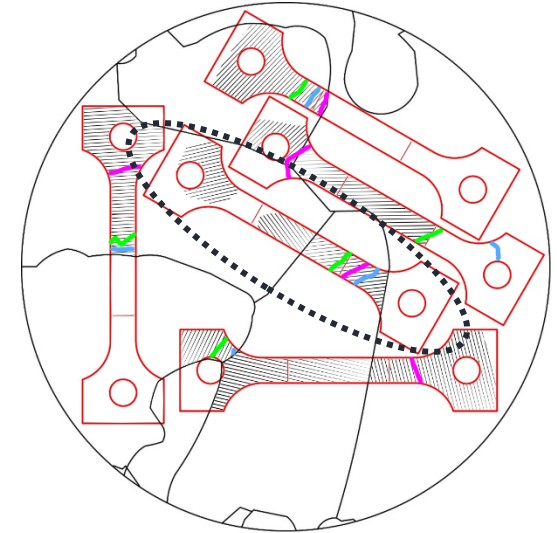
# Tensile test of LG slices at cryogenic temperature

3 discs which has similar grain alignment were used for the test.  
→Samples were cut considering grain alignment.

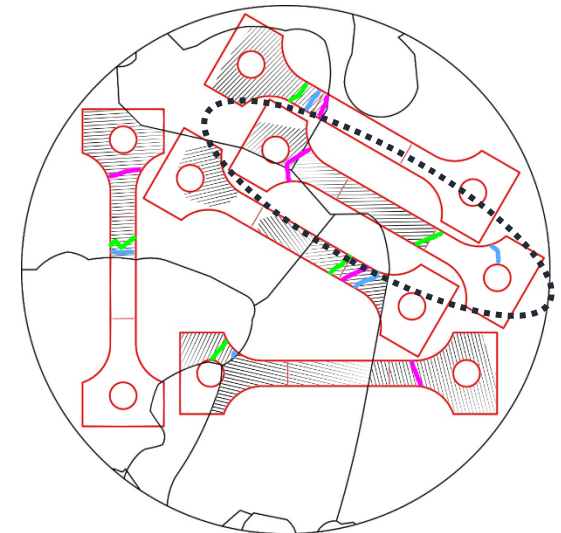


# Examples of tensile test results of LG

Broken at similar positions



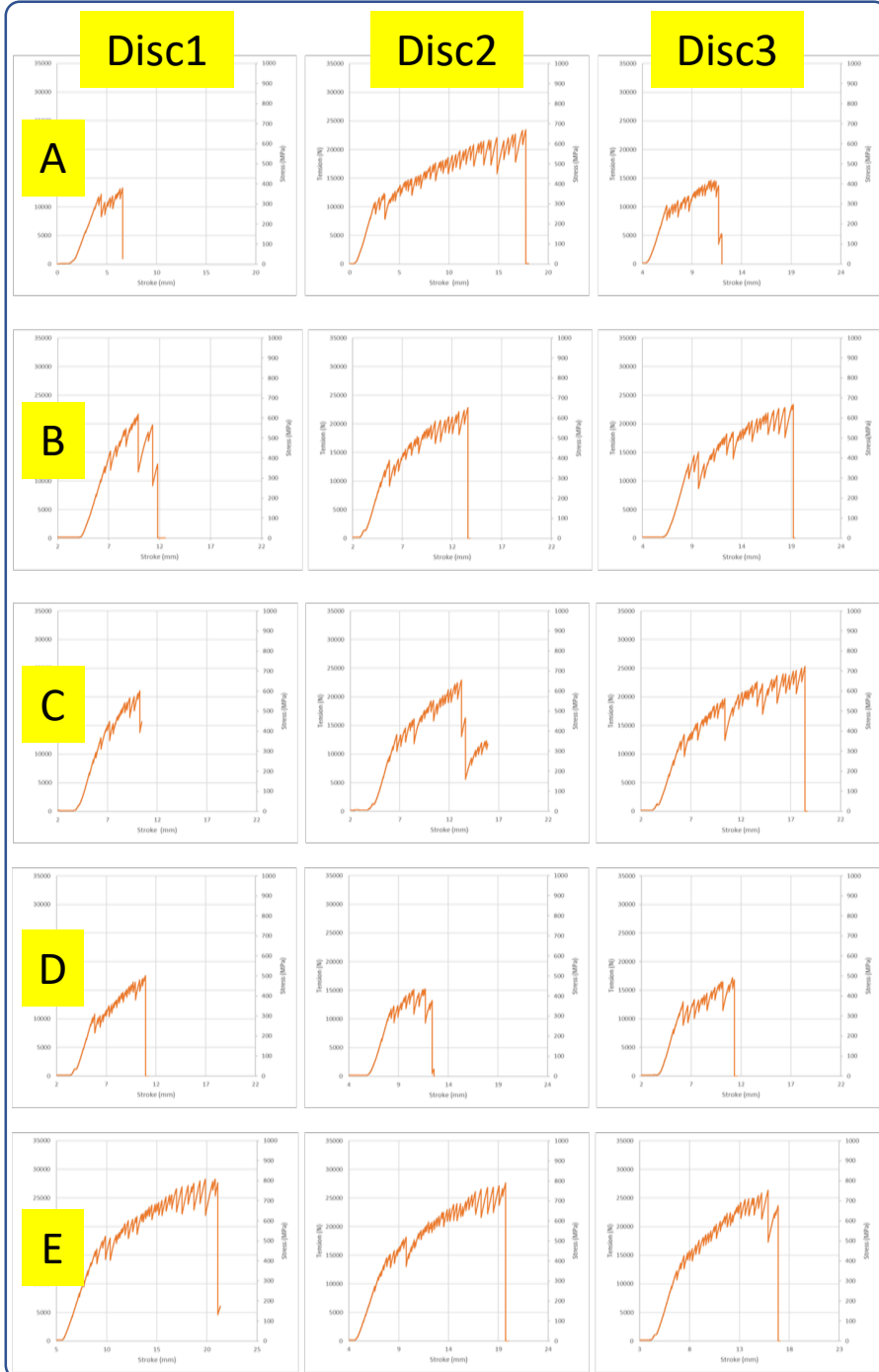
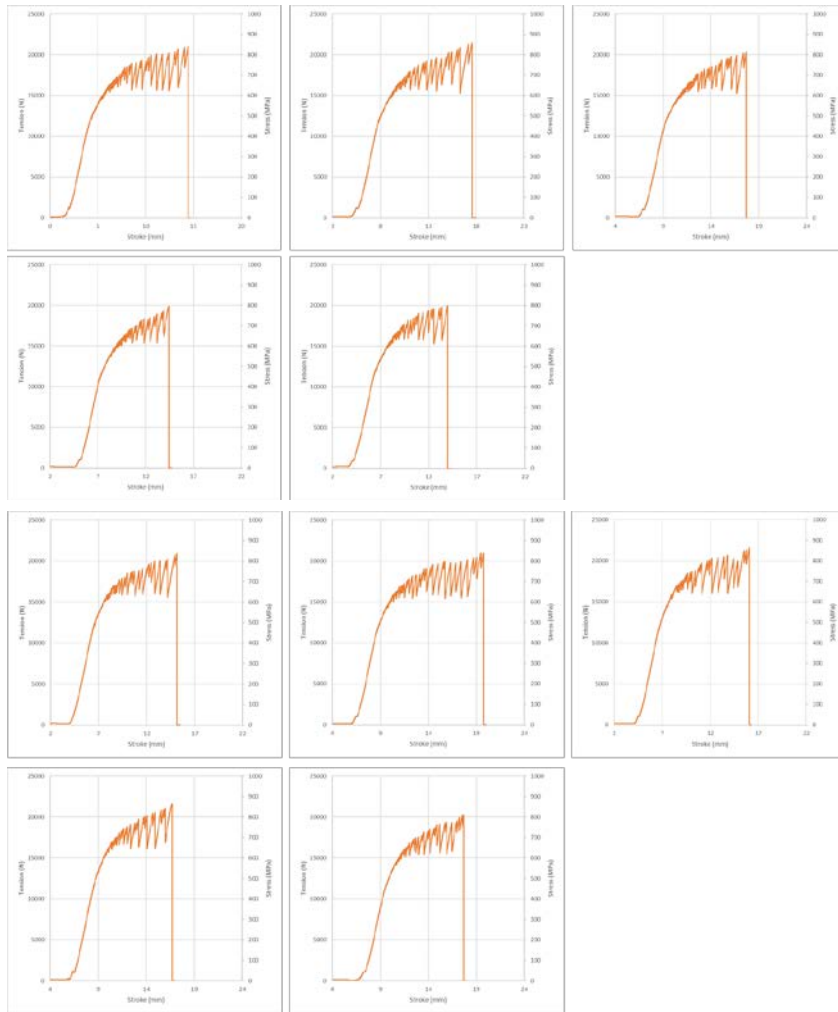
Broken at totally different positions



# LG and FG comparison

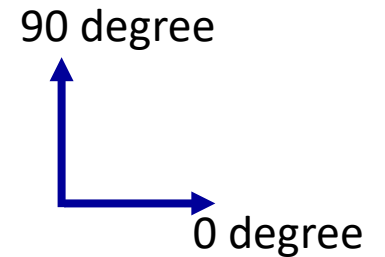
LG

FG



# Trend analysis

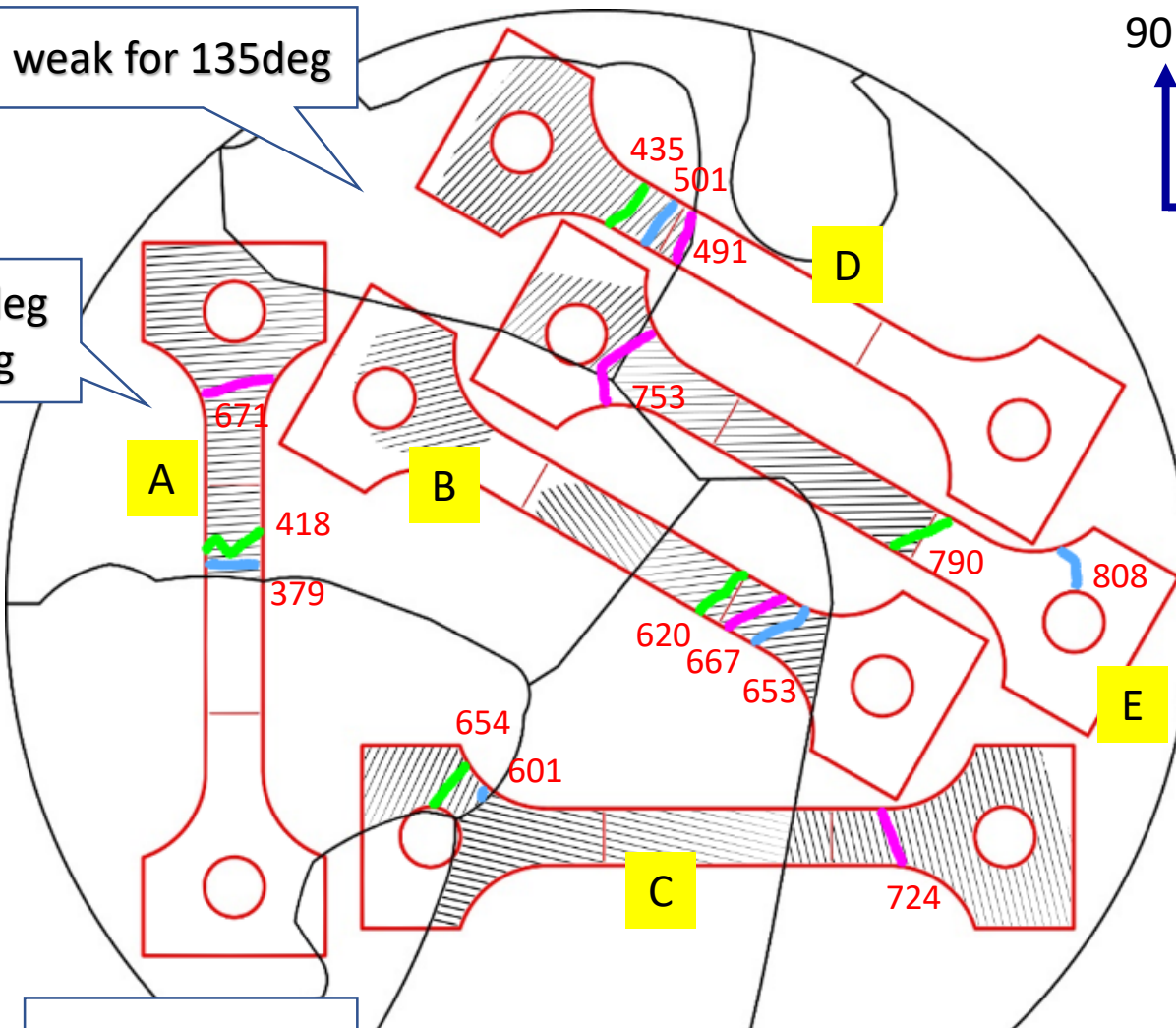
\*red number represents broken tension



weak for 135deg

strong for 135deg  
weak for 90 deg

strong for 0deg



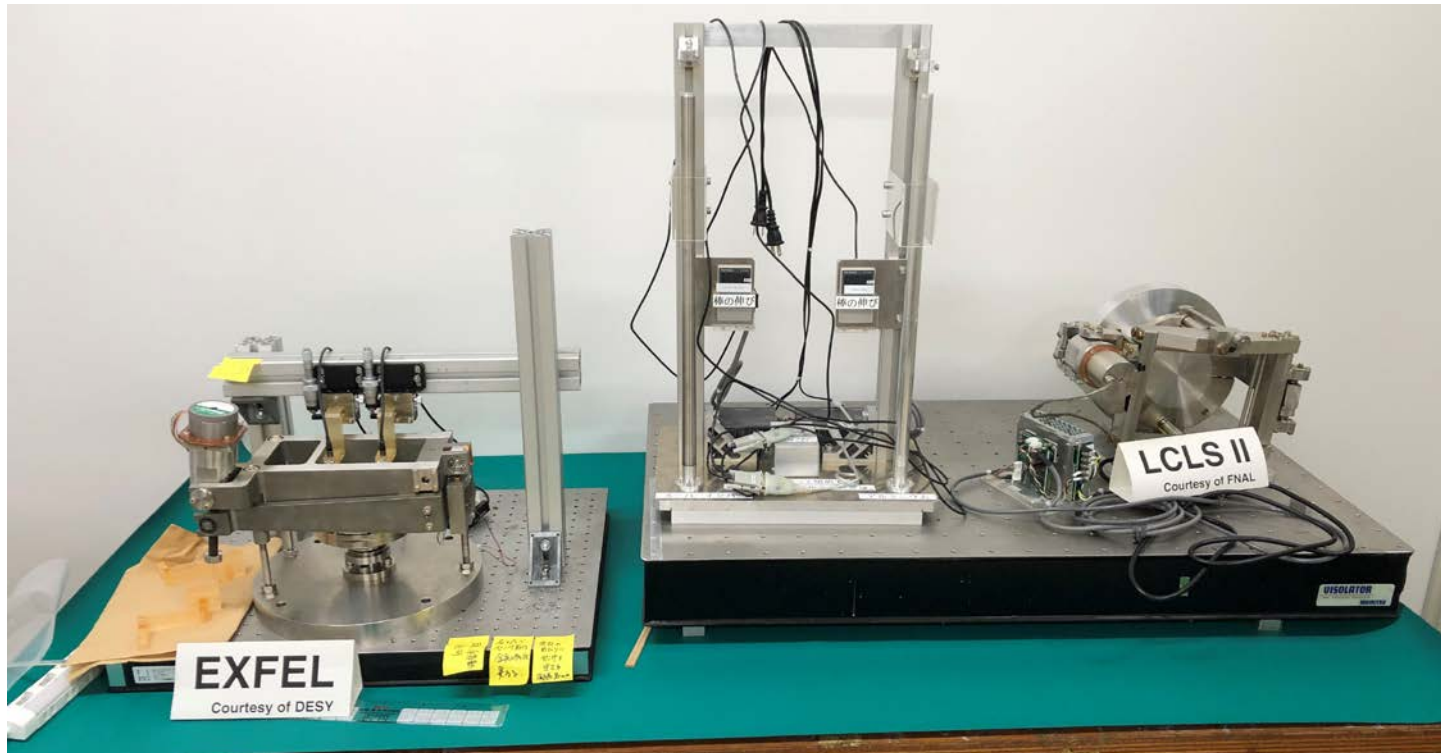
Crystal orientation affects to tensile strength  
→Cut samples considering orientation

# ***Investigation on tuner***

# Investigation on tuner

We had just re-started our investigation on tuner.

- Validating (playing) two tuners; X-FEL & LCLS II
- Investigating suitable tuner for ILC
  - Use the best of both tuner
- Finding new actuator



Investigated by M. Yamanaka



***Collaboration with companies***

# Collaboration with company

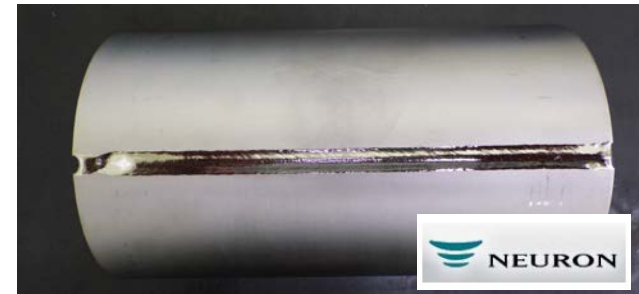
Collaboration is ongoing with several companies.



### HOM housing production



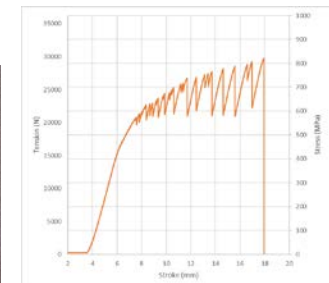
### Beam tube mass production



### Cavity fabrication



### Cryogenic tensile test of Nb production



Similar values as Tokyo Denkai were measured.

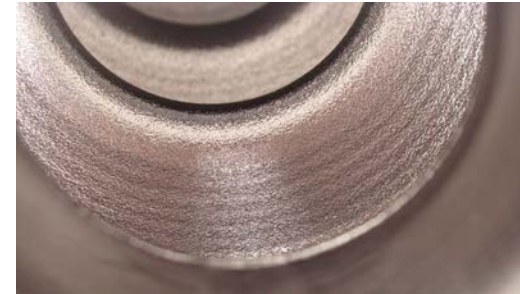
***Hydroforming cavity***

# Investigation on hydroforming cavity



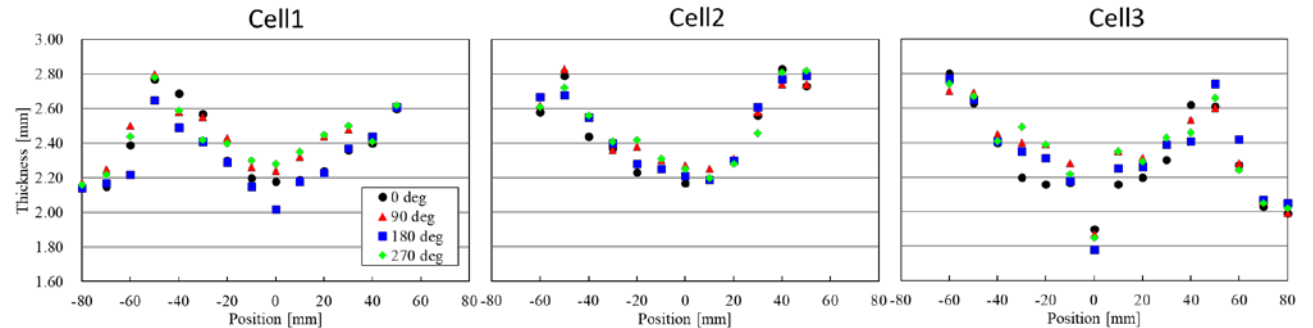
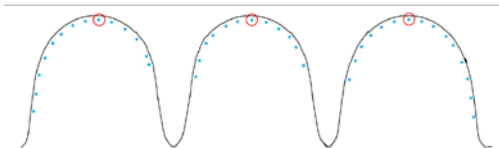
Measured after VT (~100μm EP)

Ra [μm]	U6	W3
Cell1	9.575	7.64
Cell2	9.435	9.07
Cell3	11.6285	9.23



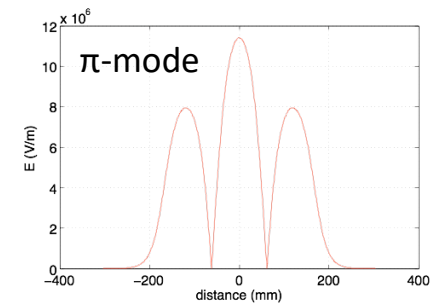
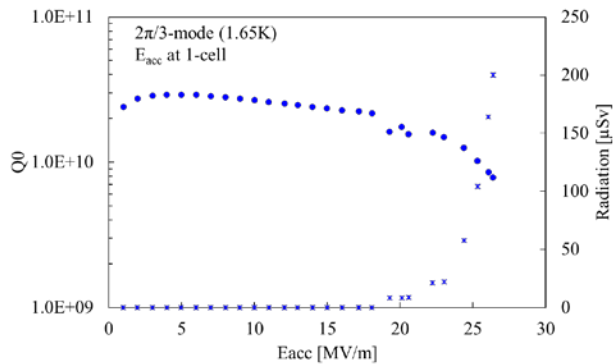
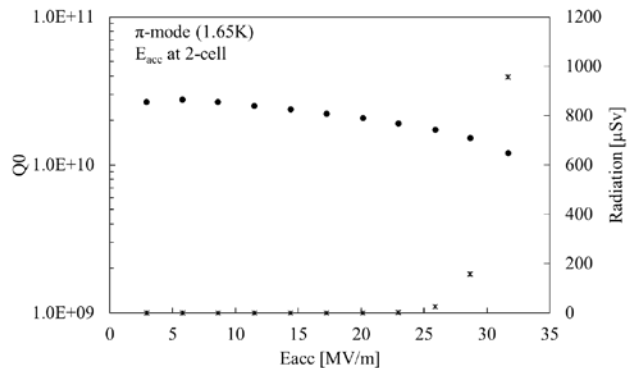
Cavity	Supplier	RRR	Tube size
W3	ATI	387-563	OD130 x ID123 x 800L
U6	ULVAC	353	OD138 x ID131 x 800L

Measured points

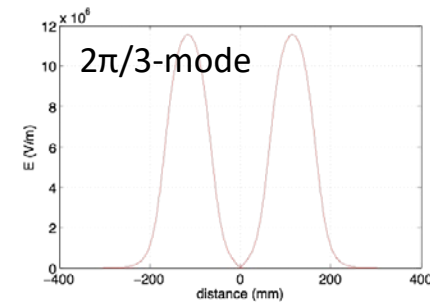
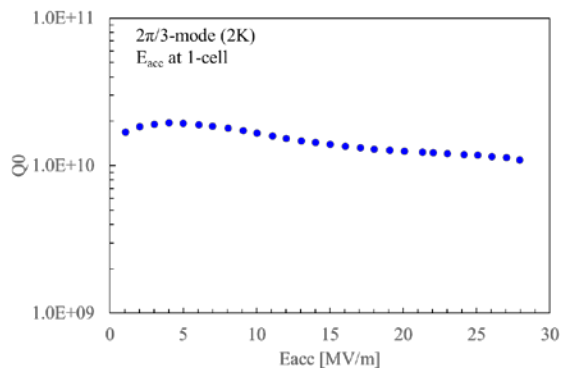
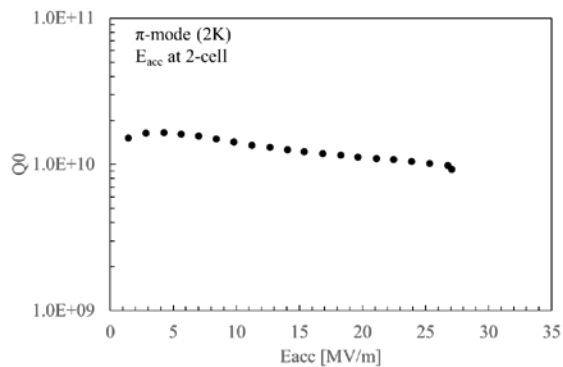


# Performance test results

W3



U6



E <sub>acc</sub> [MV/m]	Cell1	Cell2	Cell3
W3	> 26.4	31.7	26.4
U6	> 27.9	26.7	28.4

→Aiming to fabricate 9-cell cavity

# ***Summary***

# Summary

- Cost reduction investigation on material
  - Two 9-cell cavities were fabricated using CBMM LG
    - ✓ Insufficient results were obtained
      - To be measured again
    - ✓ Some defects were found
      - Reconsider fabrication process
      - Observation of material itself
- Helium vessel code
  - ✓ Aiming to pass with FG cavity (on going)
  - ✓ Planning to pass with LG cavity
    - Measurement of mechanical property is necessary
      - Tensile test system in cryogenic temperature was investigated
      - further strategy will be necessary for the measurement
- Investigation on tuner
  - Just started
- Cooperation with companies