



Fabrication and performance of LG cavities

IHEP-KEK meeting
2020/12/9

Takeshi DOHMAE

Current activities at KEK/CFF

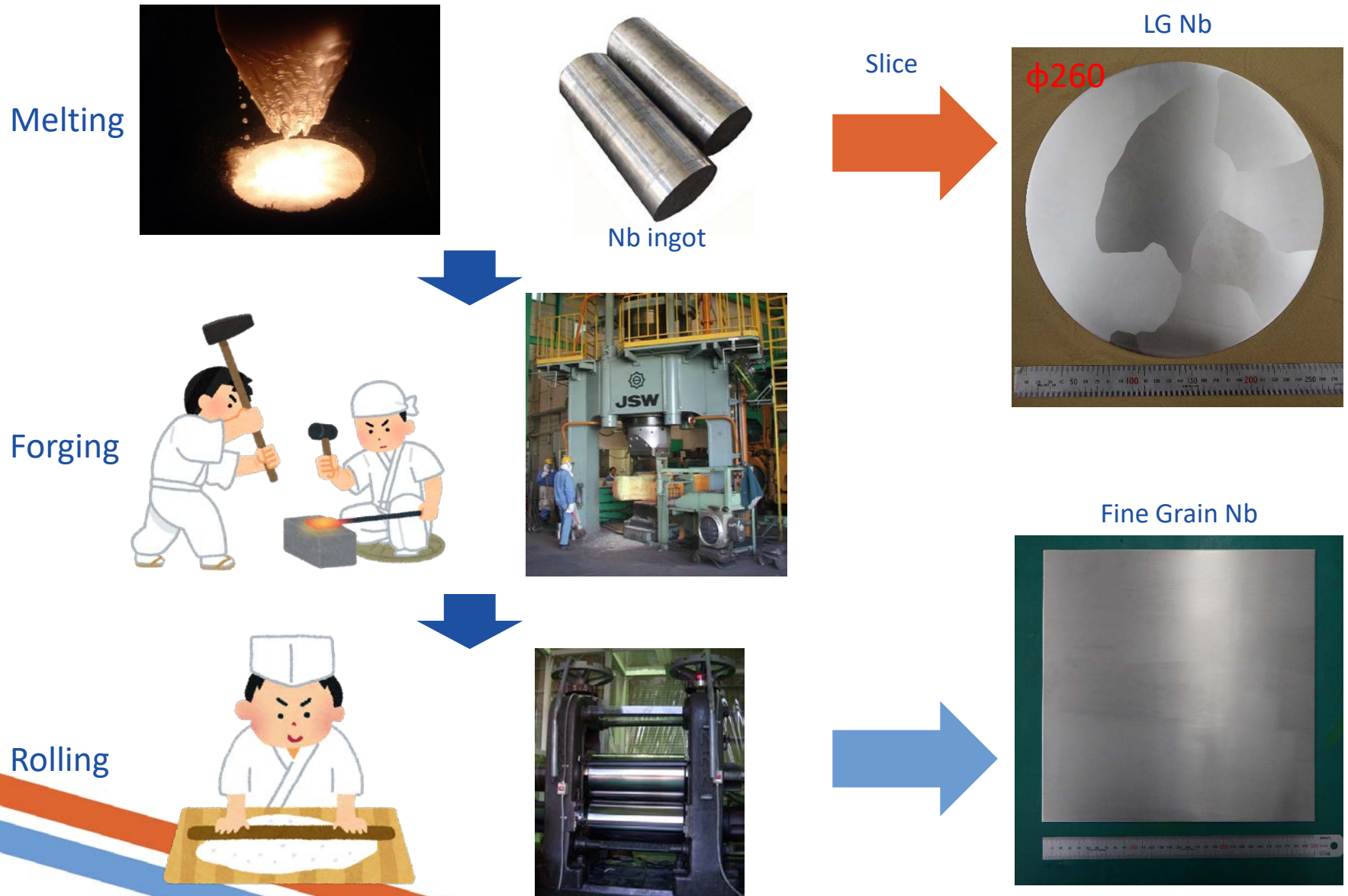
Cavity Fabrication Facility (CFF) at KEK is currently;

- Working for cost reduction on cavity fabrication
 - Reduce the cost for material: Large grain (LG) Nb
 - Reduce the cost for fabrication
- Working for high pressure gas safety act (He-tank of cavity)
 - Step1. Pre-application for evaluation criterion
 - Step2. Application for equipment test
- Collaborating with other lab and company
 - Inner welding of cavity (with CERN and TECHMETA)
 - Challenge of new technologies



Today's topic

LG niobium production

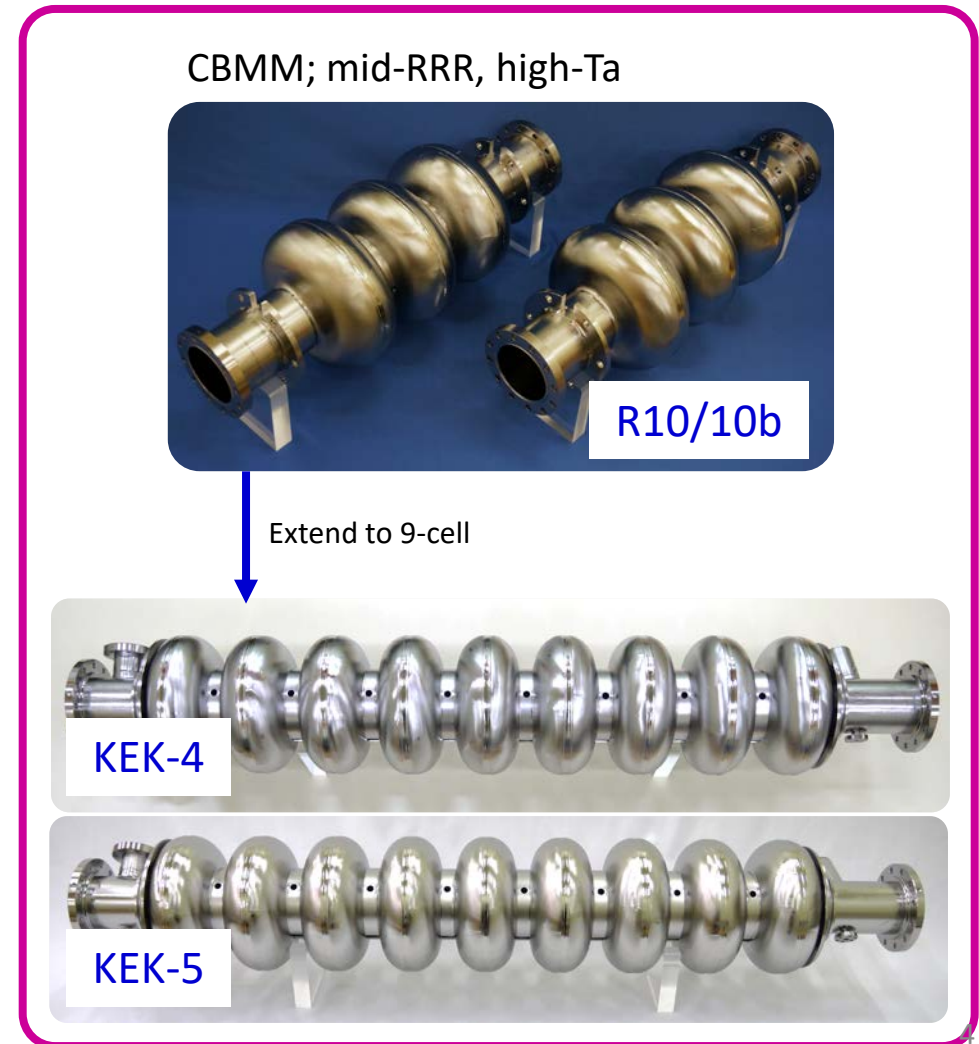
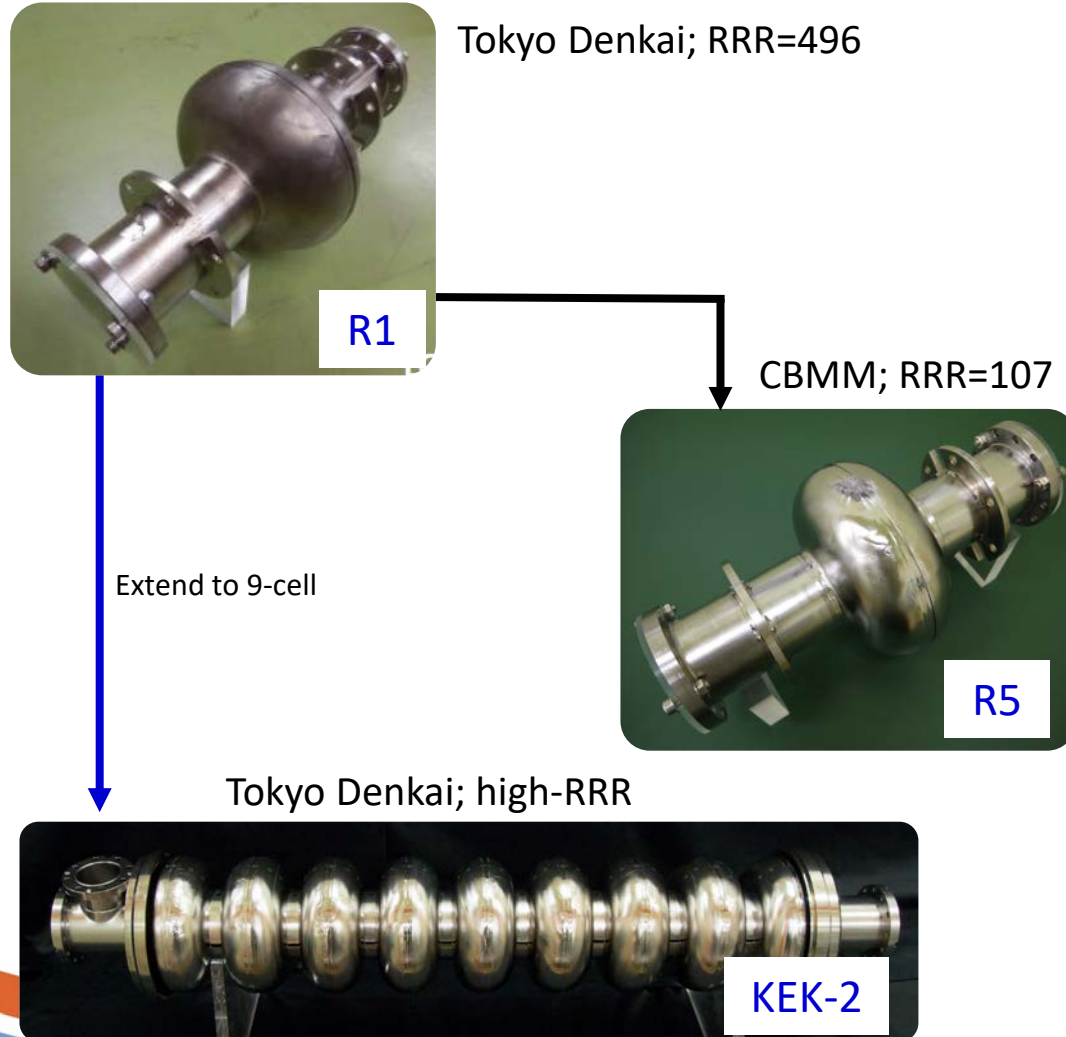


Forging and rolling steps can be skipped for LG Nb production.

Large cost reduction can be expected using LG Nb.

LG Nb cavities fabricated in KEK

Aiming at cost reduction

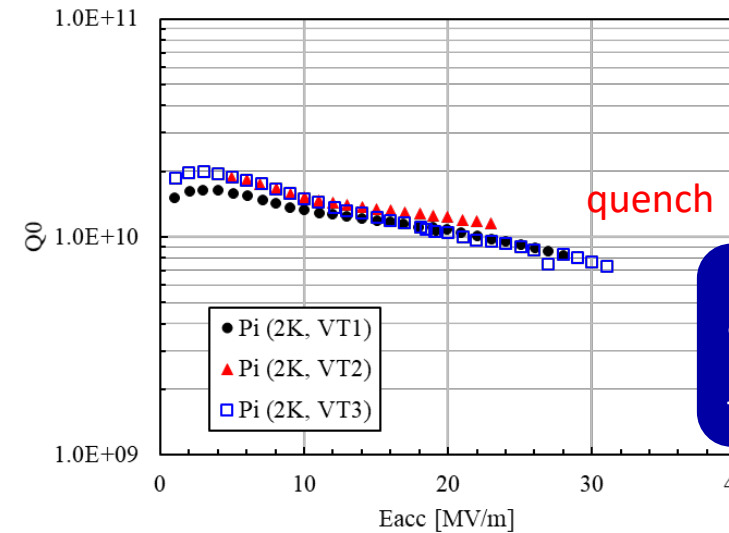
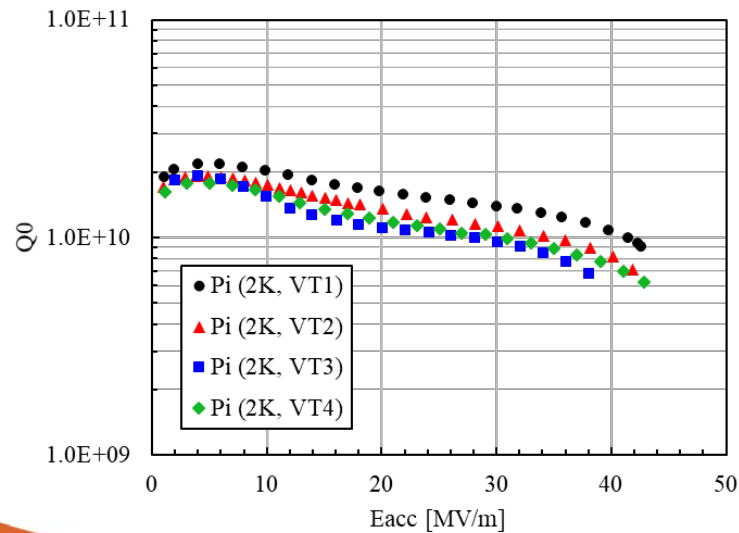
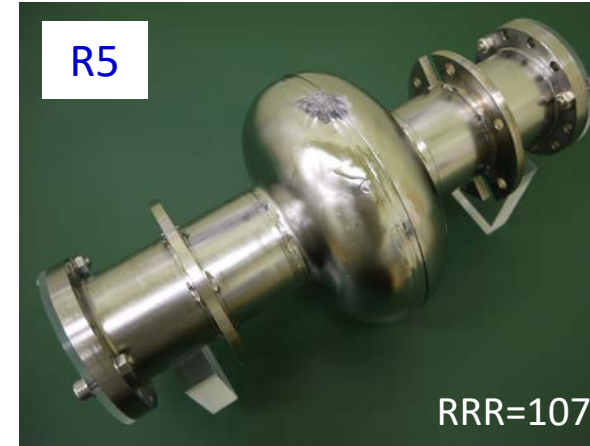


Performance test

- **Surface treatment (before test)**
 1. EP1 (100 μ m)
 2. Annealing (750 (800) deg \times 3hrs)
 3. Tuning
 4. EP2 (20 \sim 30 μ m)
 5. Assembly
 6. Baking (120deg \times 48hrs)
- **Measurement environment**
 - ✓ Vertical cryostat filled with liquid He
 - ✓ Remaining magnetic field : 5 \sim 10mG
 - ✓ No magnetic cancelation. (except R10)



Different RRR LG Nb

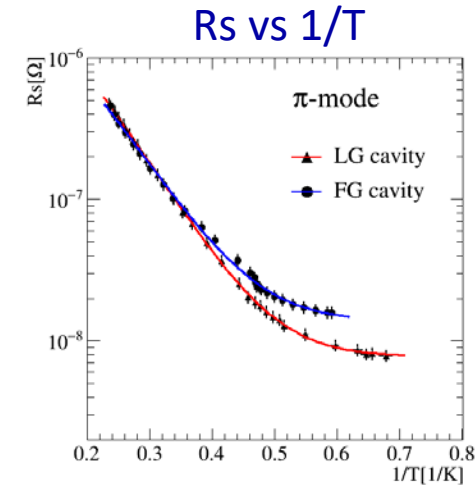
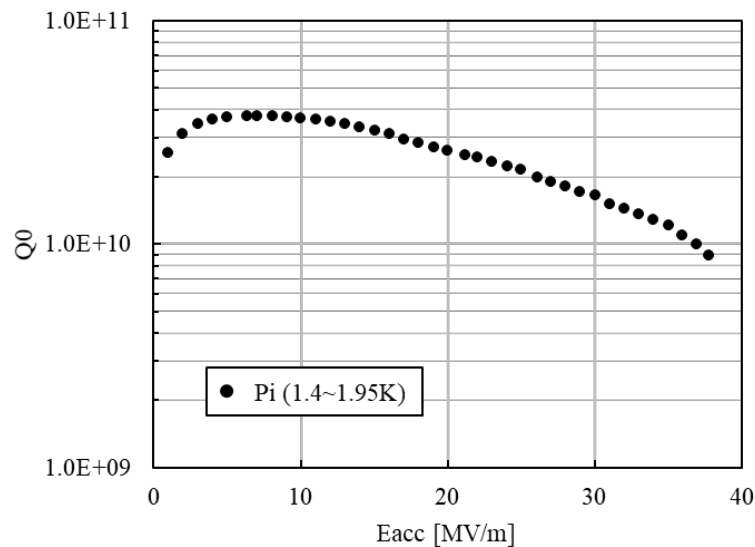


Measured again at Jlab
P. Dhakal
TUP012

"Fabrication and evaluation of superconducting single-cell cavities manufactured using different materials and methods", Hiroataka Shimizu *et al.*, 2017

Achieved to high gradient with hi-RRR LG Nb, but not with lo-RRR

9-cell cavity made by high-RRR LG Nb



- Achieved high gradient
→ more than 40MV/m at most of cells
- Residual resistance is lower than FG
→ higher Q-value is expected
→ further study necessary with good magnetic environment

Maximum gradients at each cell

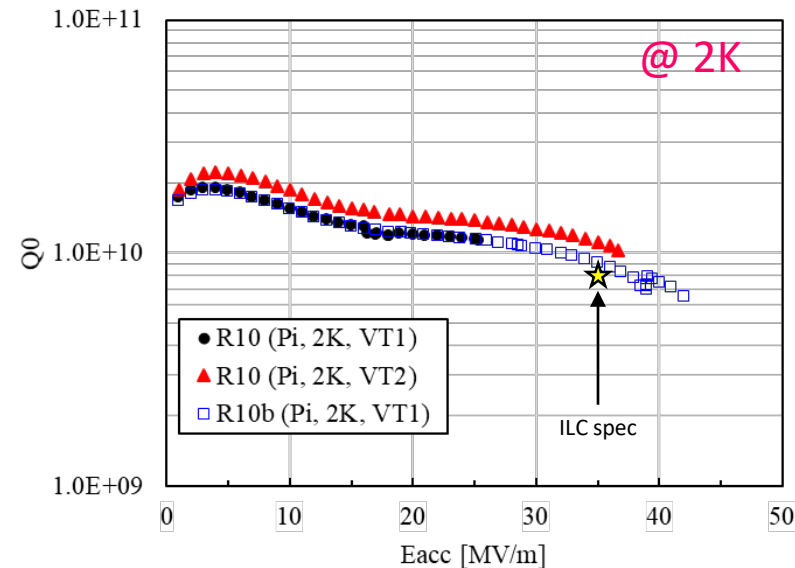
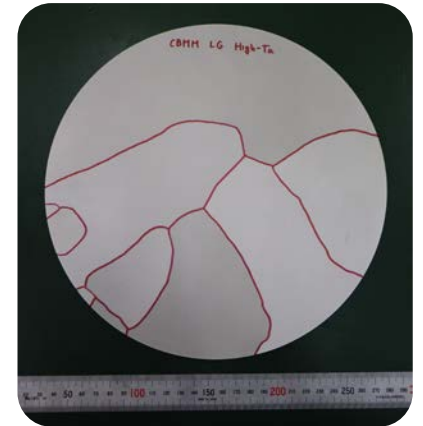
Cell#	1	2	3	4	5	6	7	8	9
E_{acc}	>45	40.4	39.6	>44.7	>42.7	>44.7	>39.6	>40.4	>45

Current activities on LG Nb



Two 3-cell cavities were made using CBMM LG Nb.

- ✓ $RRR(\rho(300K)/\rho(Tc)) = 242-298$
- ✓ High Ta contained (1034ppm)



Two 3-cell cavities satisfied ILC spec.



Two 9-cell cavities were fabricated using same material.

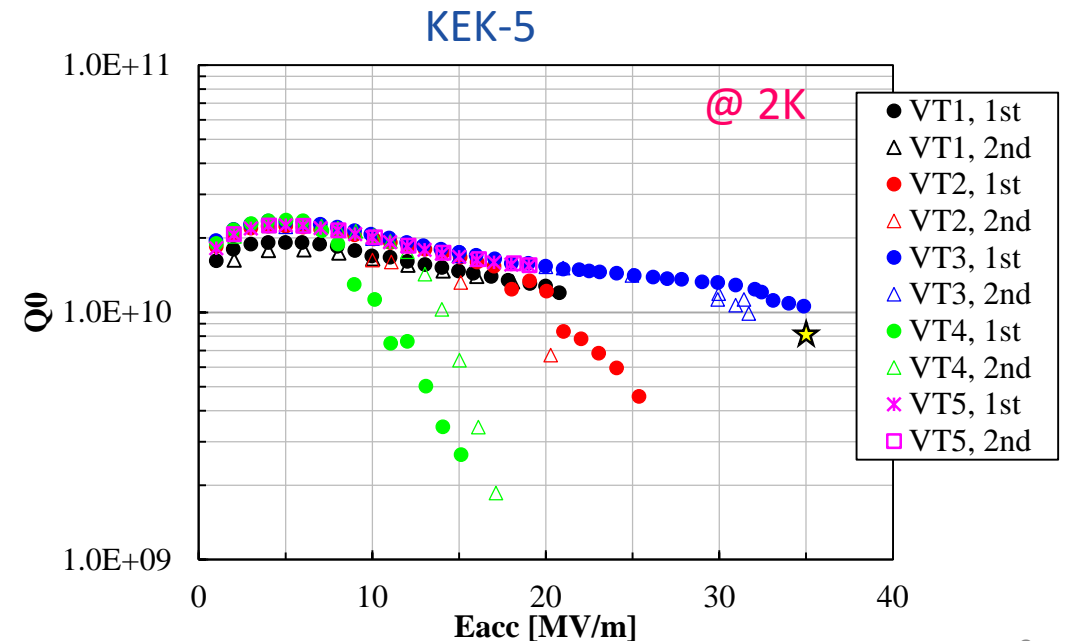
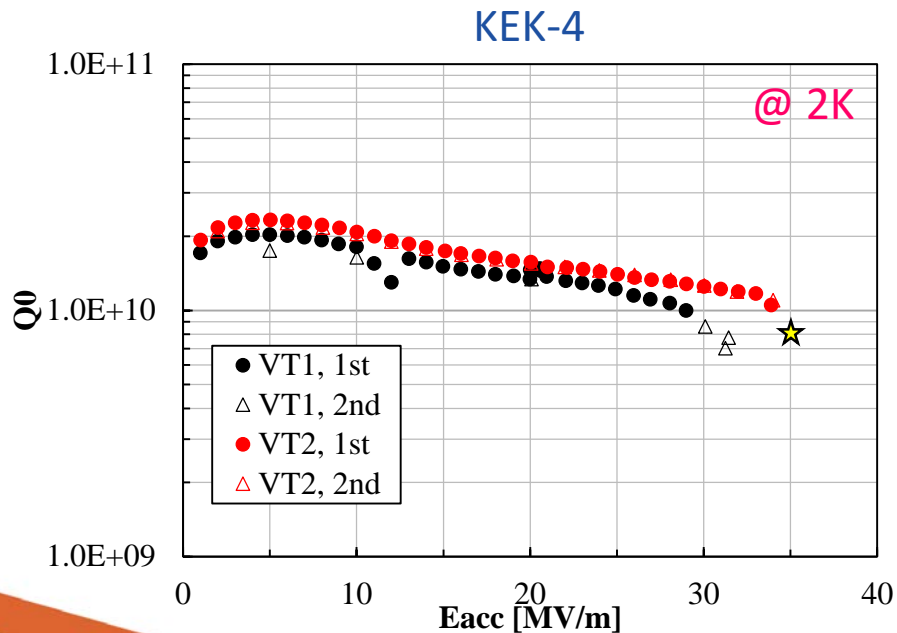
9-cell cavity made by LG Nb



Two 9-cell cavities were fabricated using same LG Nb as previous page (CBMM mid-RRR, hi-Ta contained).



Two of them have not achieved ILC spec.



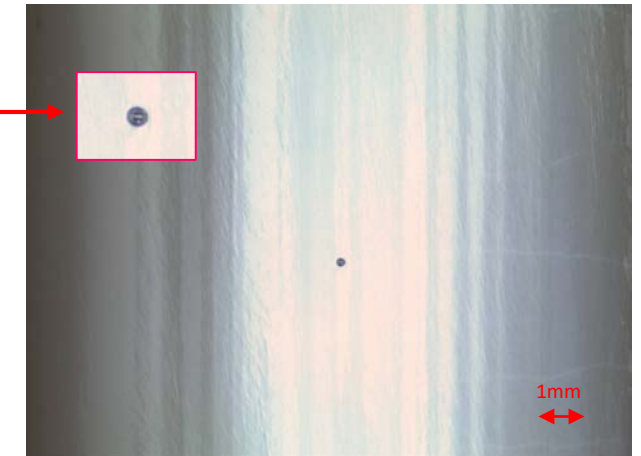
Summary of KEK-4/5

KEK-4	E_{acc}	Reason
VT1	31.5 MV/m	Quench by the defect
VT2	34 MV/m	Quench (no defects were found)

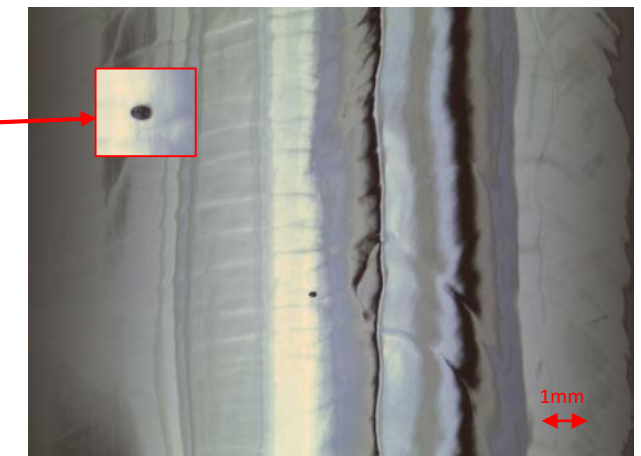
KEK-5	E_{acc}	Reason
VT1	20 MV/m	Quench by the defect
VT2	25 MV/m	Power limitation due to heavy x-ray radiation
VT3	32 MV/m	Quench by the defect
VT4	17 MV/m	Power limitation due to heavy x-ray radiation
VT5	19MV/m	Quench by the defect

- If any defects are found near the quench position, they are removed by local grinding. Then, measurement is done after 20-30 μ m EP.

Defect found near the quench position of VT1 (KEK-4)



Defect found near the quench position of VT5 (KEK-5)



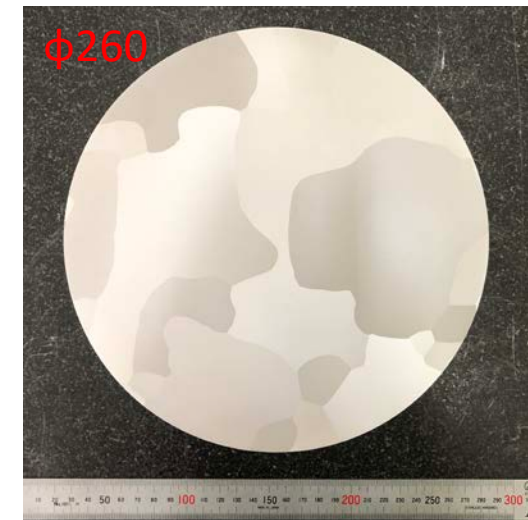
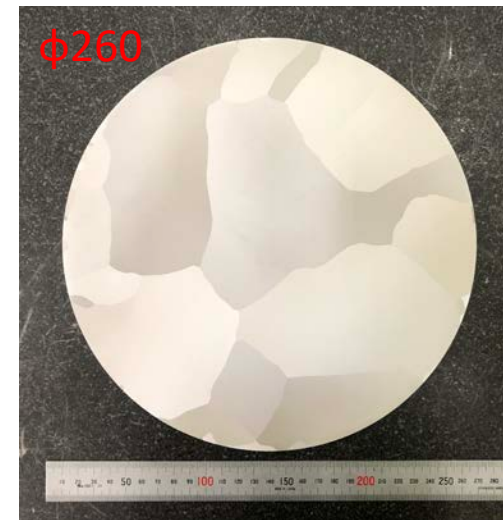
New LG Nb is ready from ULVAC

ULVAC enabled to produce $\phi 300$ ingot.

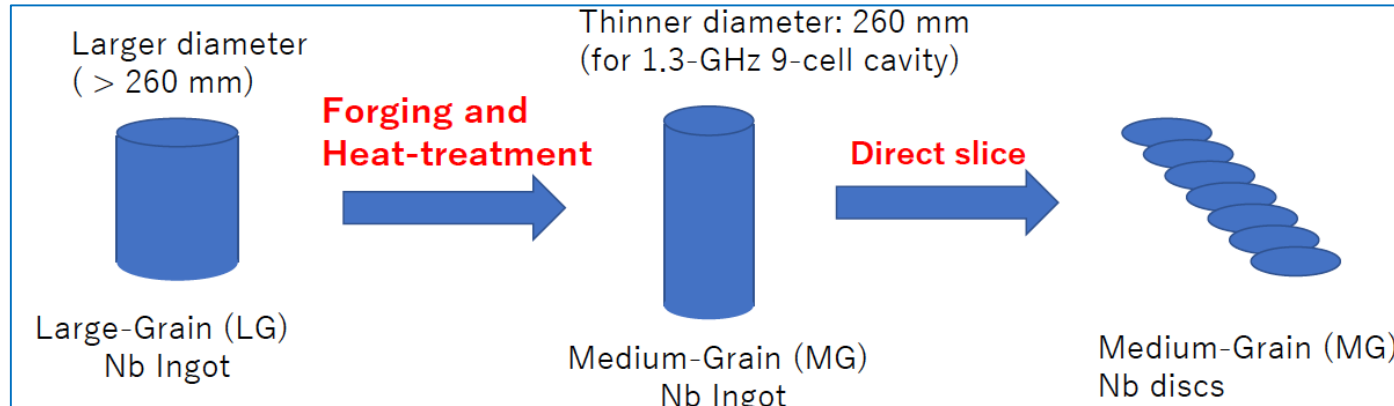


- Two ingots made by different Nb sources were delivered.
- Sliced by Japanese company.
- Four 3-cell cavities made by each ingot is now under fabrication.

ULVAC



A new Fabrication Approach for Nb Disc directly sliced from Forged Ingot



Uniformly pressed at KEK

- Aiming to realize **clean** surface and **medium grain** mechanical characteristics, in cooperation with **ATI**, and
- SRF cavity fabrication and RF test to be examined at KEK



See more: a report at AWLC-2020, by T. Saeki,
<https://agenda.linearcollider.org/event/8622/timetable/#20201021>

Summary

KEK/CFF has been investigating 1.3GHz elliptical cavity made of LG Nb for cost reduction.

- Several single/3/9-cell cavities were fabricated by several kinds of LG Nb.
 - ✓ Single-cell and 9-cell cavity with high RRR LG Nb
 - Achieved > 35MV/m
 - ✓ 3-cell and 9-cell cavities with mid RRR & high Ta contained LG Nb
 - Achieved > 35 MV/m with 3-cell but not with 9-cell
- New LG Nb from ULVAC is now ready.
- Challenging new material.