Engineering perspectives on quadrants

(1/2) Experience on our first quad (Higo)
(2/2) Perspective on quad (Higashi)

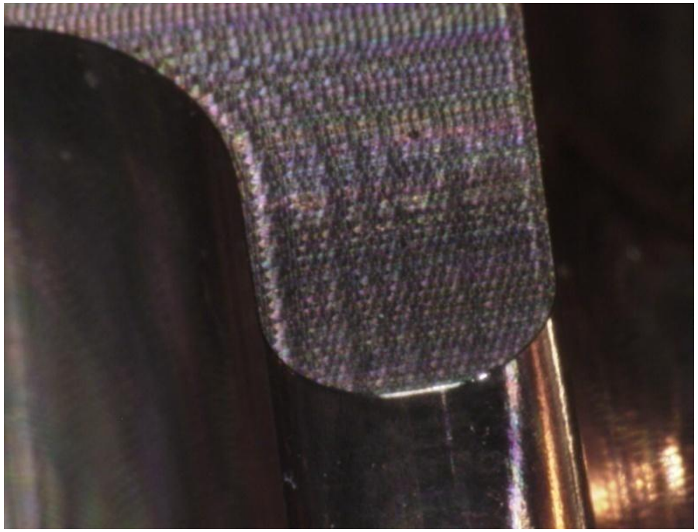
CLIC09, Oct. 12-16

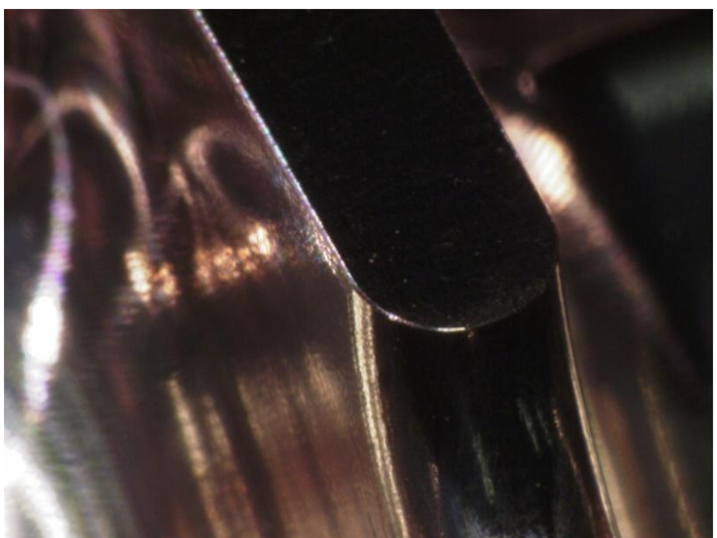
T. Higo (KEK)

Contents

- Quadrant
  - Fabrication of quads
  - Surface treatment
  - Assembly of four quads
  - Tuning
  - Vacuum chamber
- SiC material

KEK's version: 50 micron chamfer





Made of CuZr without heat treatment.

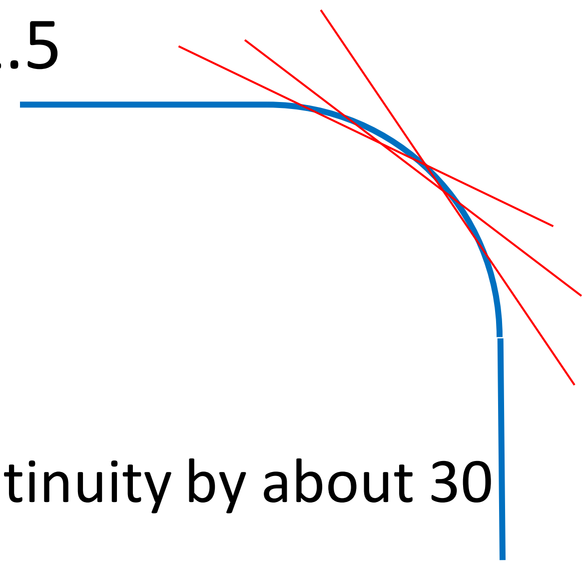
50 micron rounding: shape with angles and bumps.

Reference planes were formed by milling in a few micron level without re-chucking for shaping cells.

Assembly was done within ten micron level.

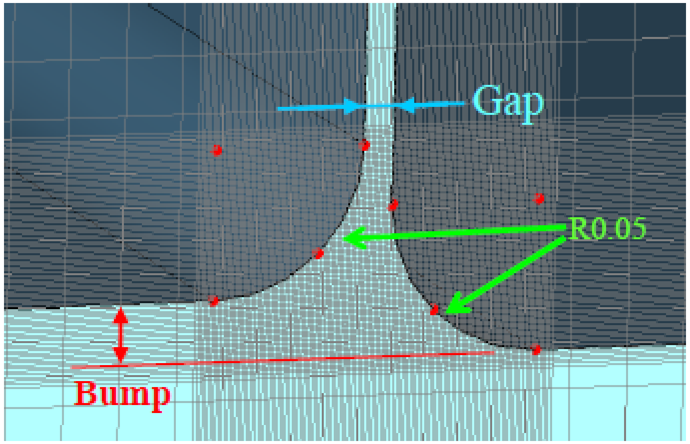
Possible cause of high dark current
Field enhancement due to round chamfer

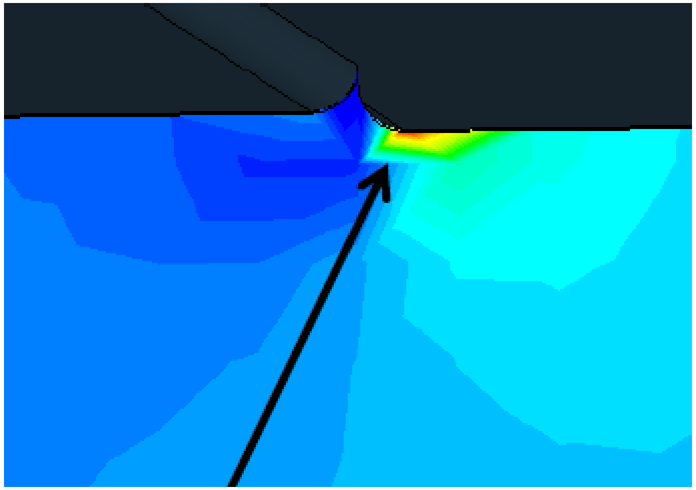
- Simulation of field enhancement
  - 1.4 ~ 1.6 at radius
  - with gap<radius/5, step<radius/2.5
- Only a few tool passes
  - to shape 50 micron radius
  - with radius tool of 2mm
    - If three passed → tangential discontinuity by about 30 degree
    - Can be relaxed by such as EP in future



Electric field enhancement in a shallow channel with round chamfer

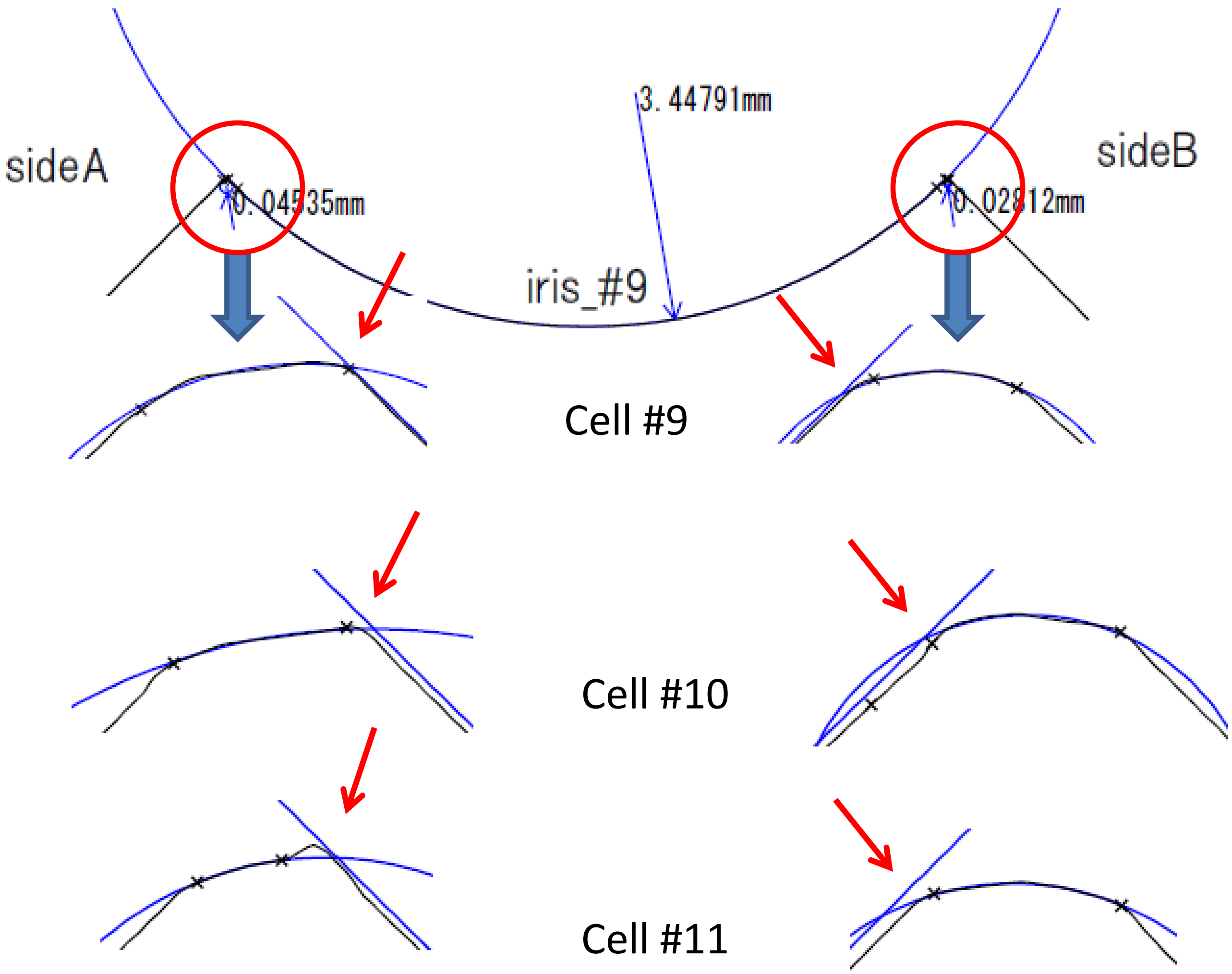
Calculation done by T. Abe by CST MS. Waveguide field.





Gap (micron)	Bump (micron)	Emax / Enominal
0	0	1.39
0	20	1.57
10	20	1.58

Detailed shape at R0.05 chamfer



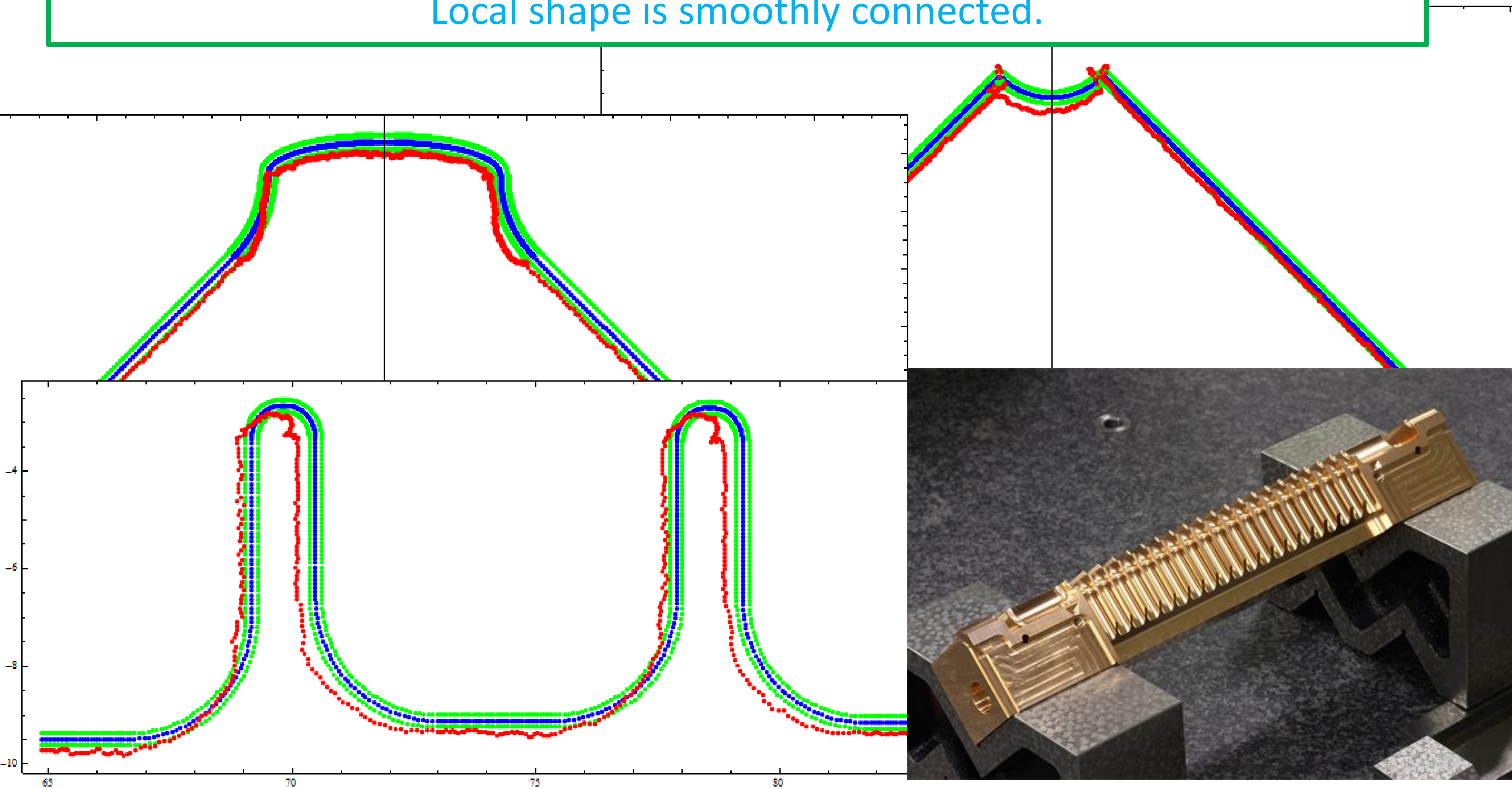
Only 2~3 tool passes over R0.05 90deg rounding.

Not tangential connection from smooth surface. 30-40 degree edge emerges.

Sharp edges or bumps exist at the rim.

Production of quadrant Q1-1

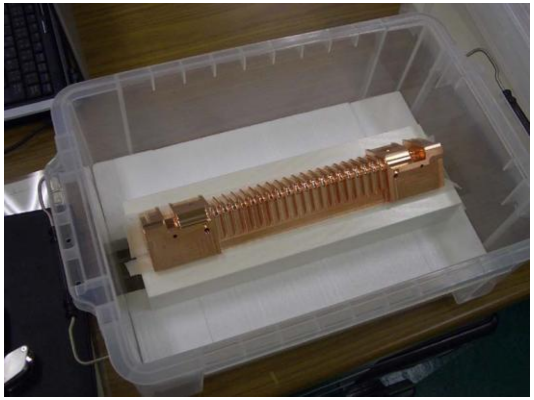
Green lines are ±2.5 microns.
Followings shows worst part out of four measured areas along the axis.
Local shape is smoothly connected.



Cleaning: no etching

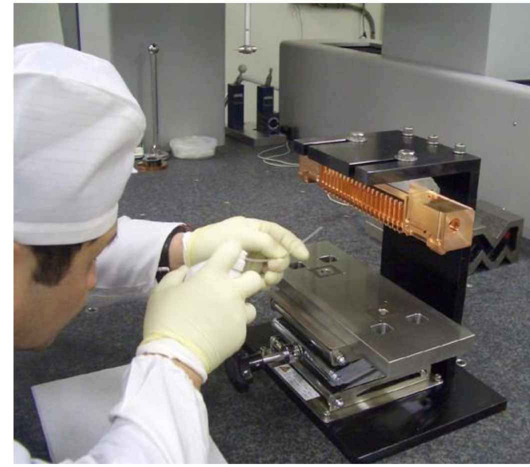
- Alcohol bath
  - with ultra-sonic vibration for 5 minutes.
- Acetone bath twice
  - with ultra-sonic vibration for 5 minutes.
- Nitrogen blow
- Storage in a deccicator
  - Initially filled with nitrogen gas.
  - Storage for more than a month.

Assembly

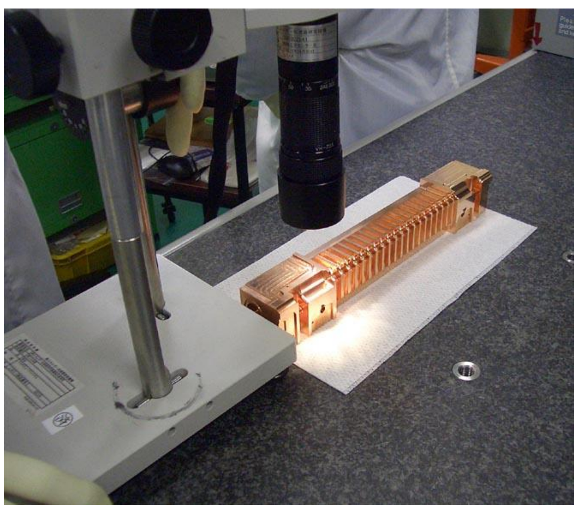


Carry and storage

First hanging

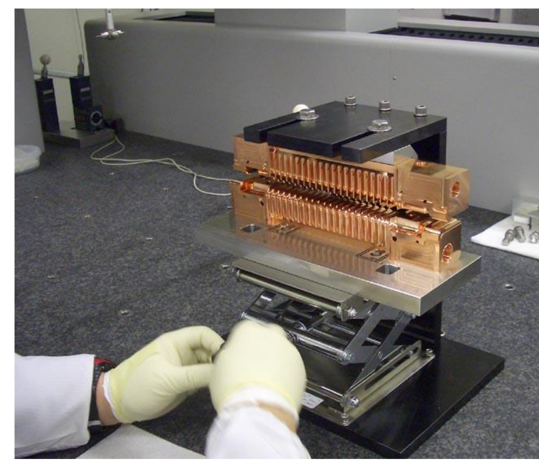


Prepare next quad approach

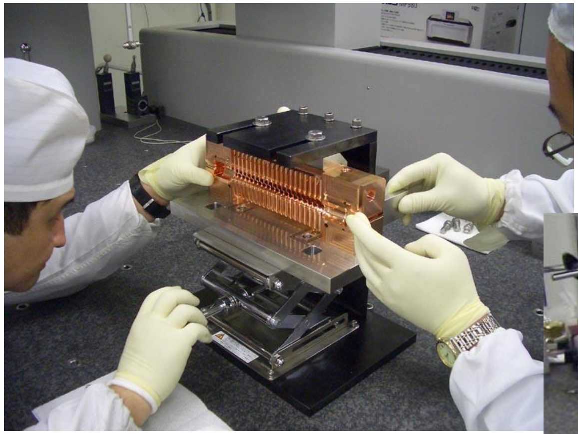


Edge inspection

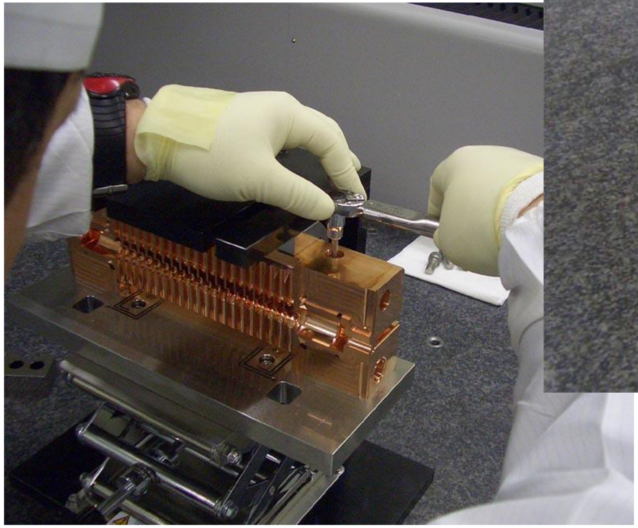
Check ball diameter



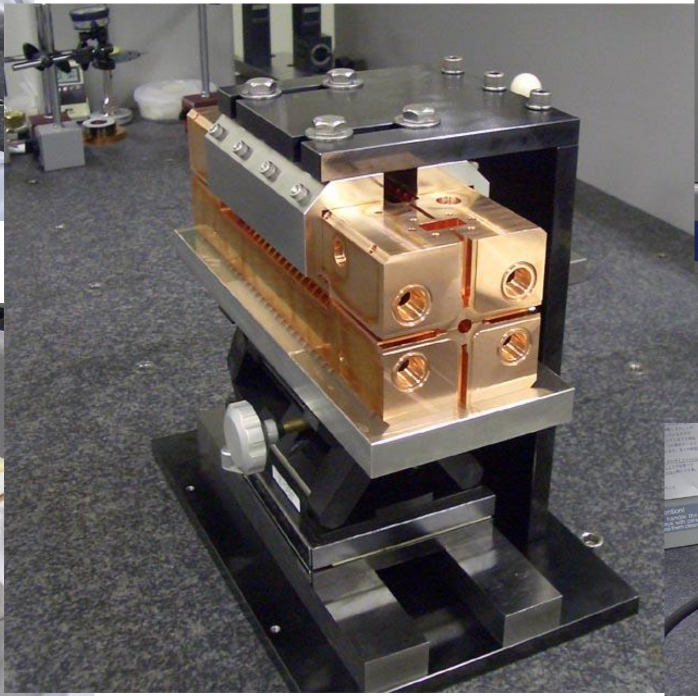
Second hanging



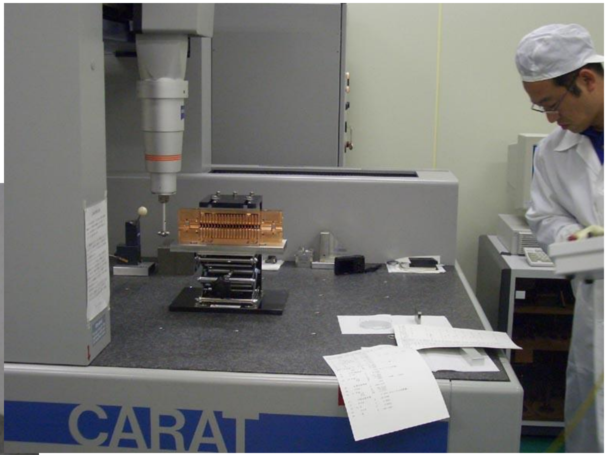
Fine adjustment



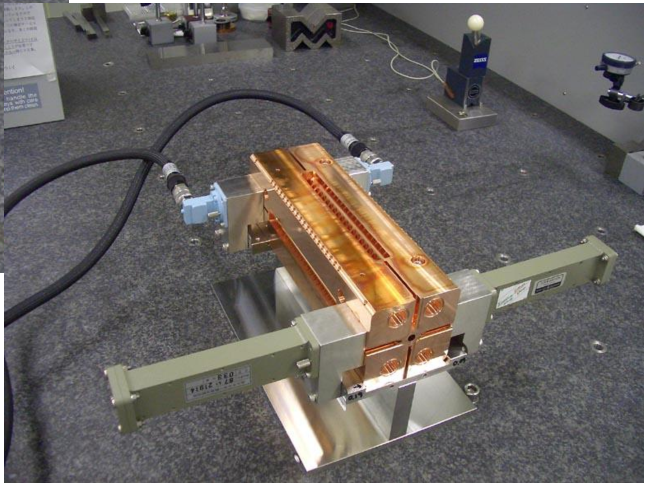
Fixing by bolt



Completion of stack



Alignment checking



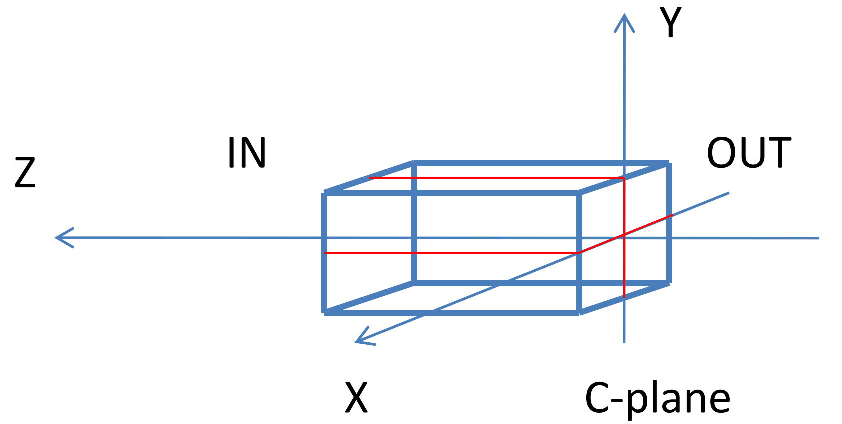
RF setup

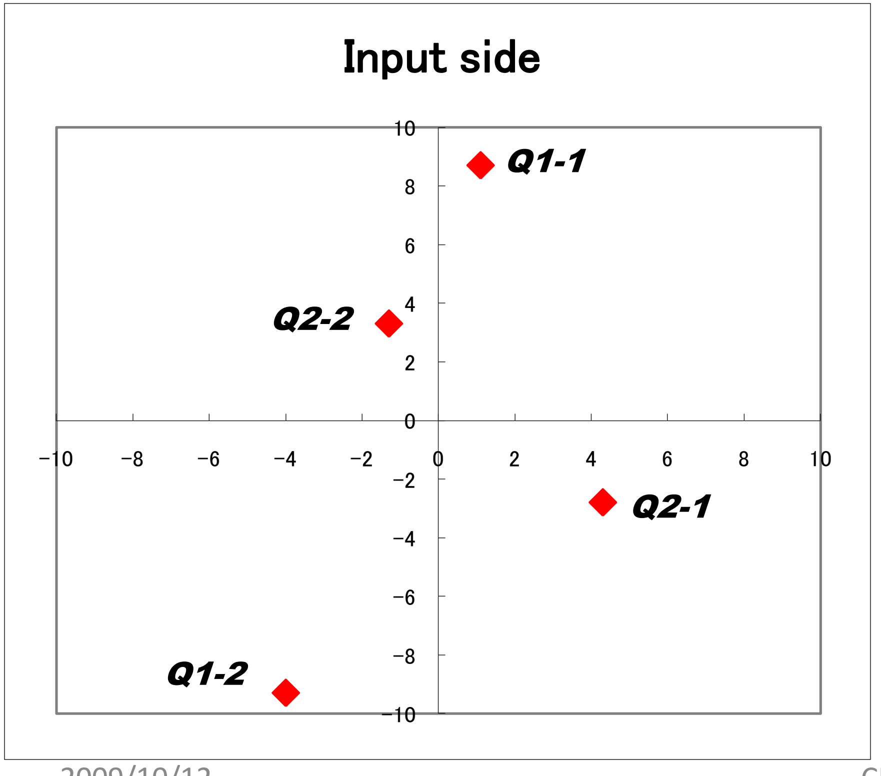
Manual adjustment before final pressing, without ball and groove mechanism. Misalignment: within ten microns.

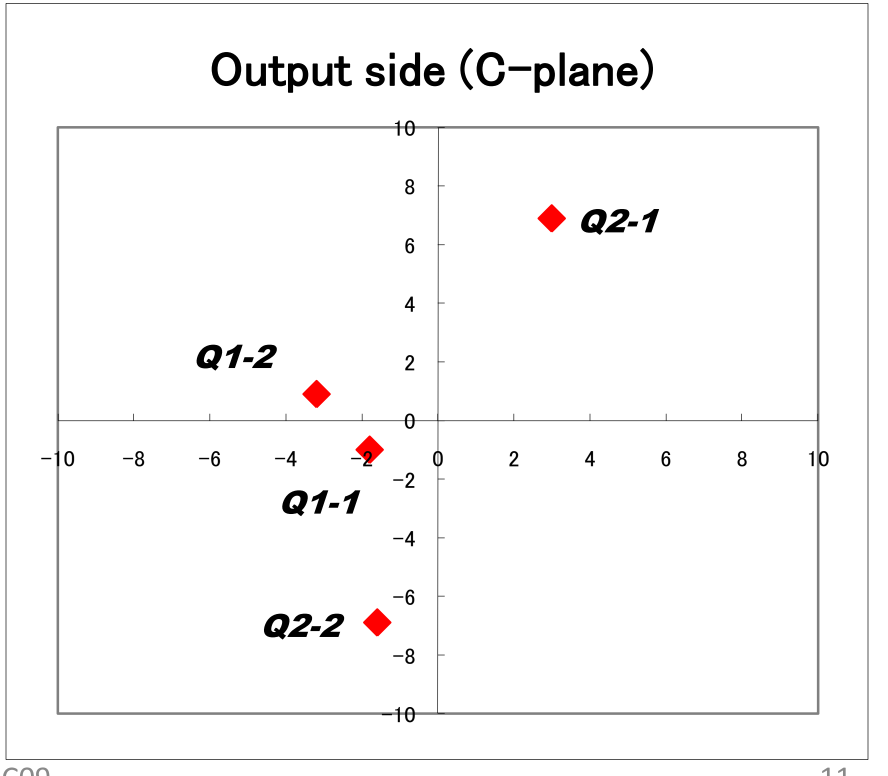
Reproducibility: a few microns.

Final alignment

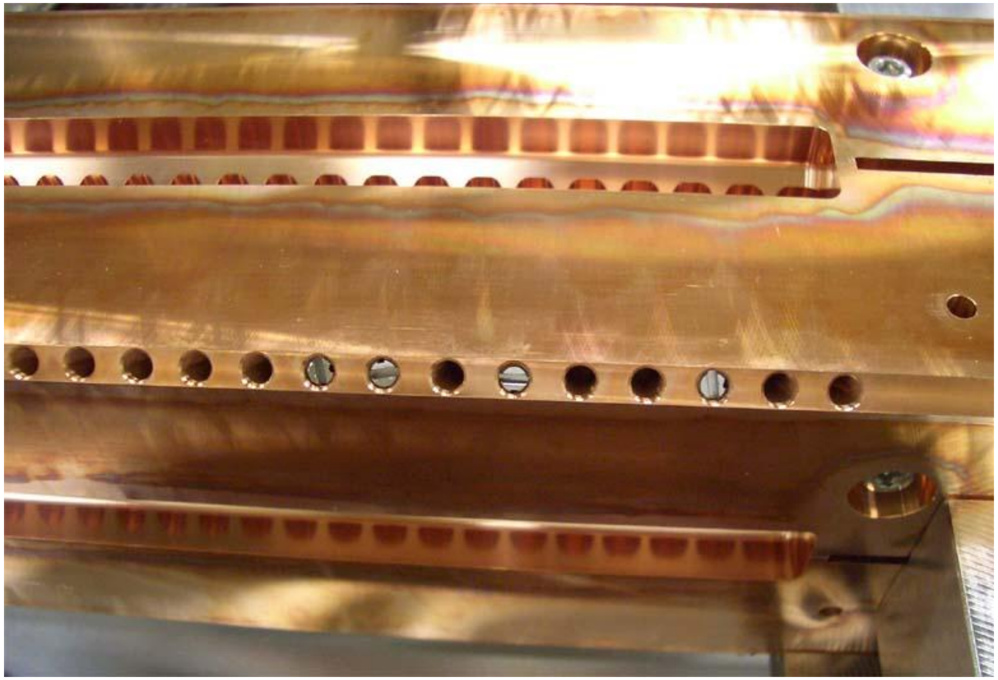
Misalignment of each quadrant
w.r.t. the average of four quadrants
(units are in micron)

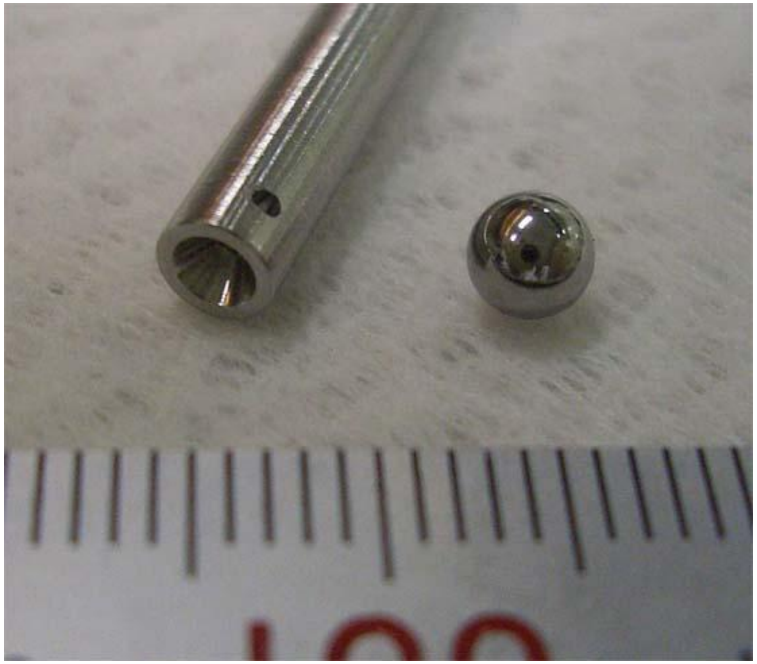






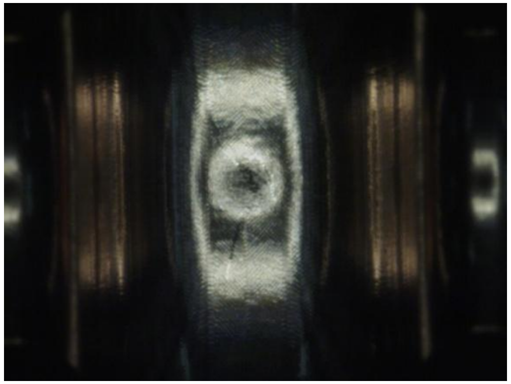
Elastic tuning with a ball being kept push



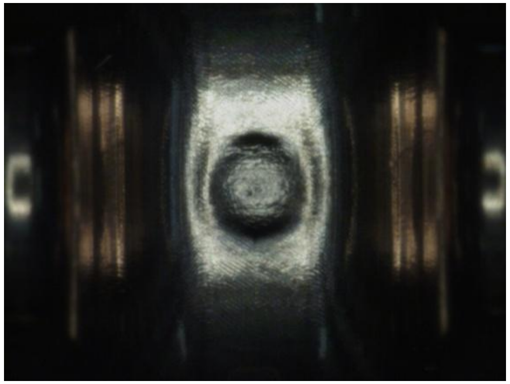


4mm stainless ball pushed by minus watch driver.
Pushing by turning with Higo's hand full force.
Elastic deformation kept, meaning that the tuning pins are kept pushing the balls.

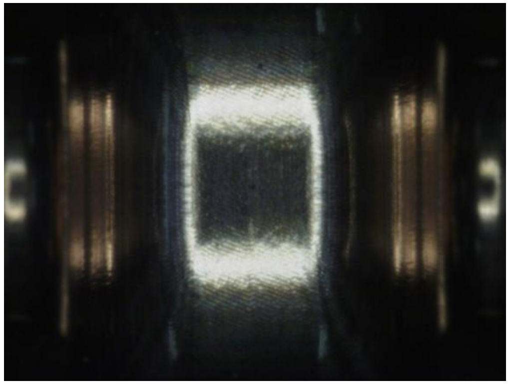
Notice: Deformed cavity wall



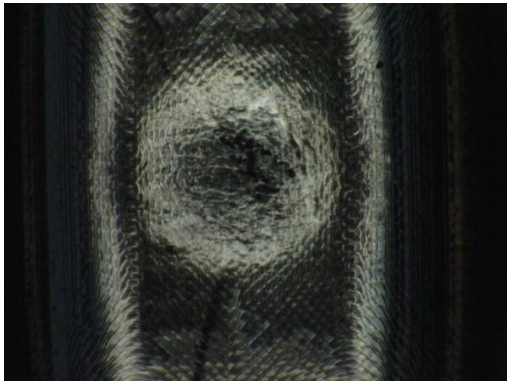
Cell 3(×35)



Cell 8(×35)

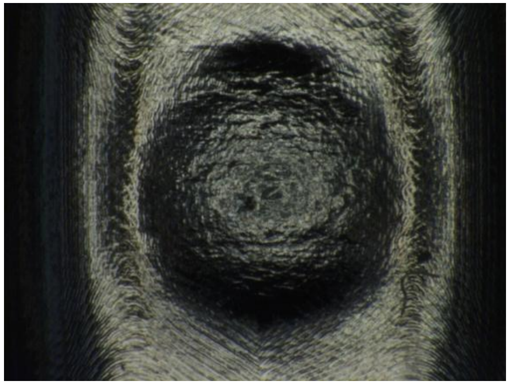


Cell 10(×35)



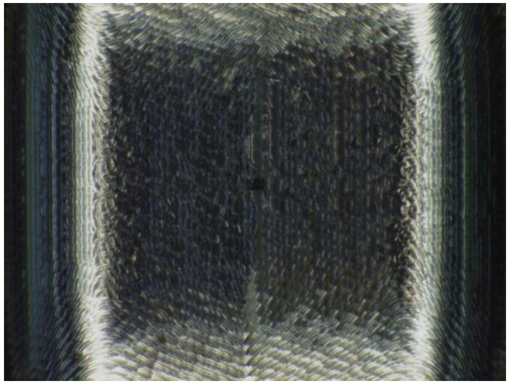
Cell 3(×100)

Cell3 deformation：0.053mm



Cell 8(×100)

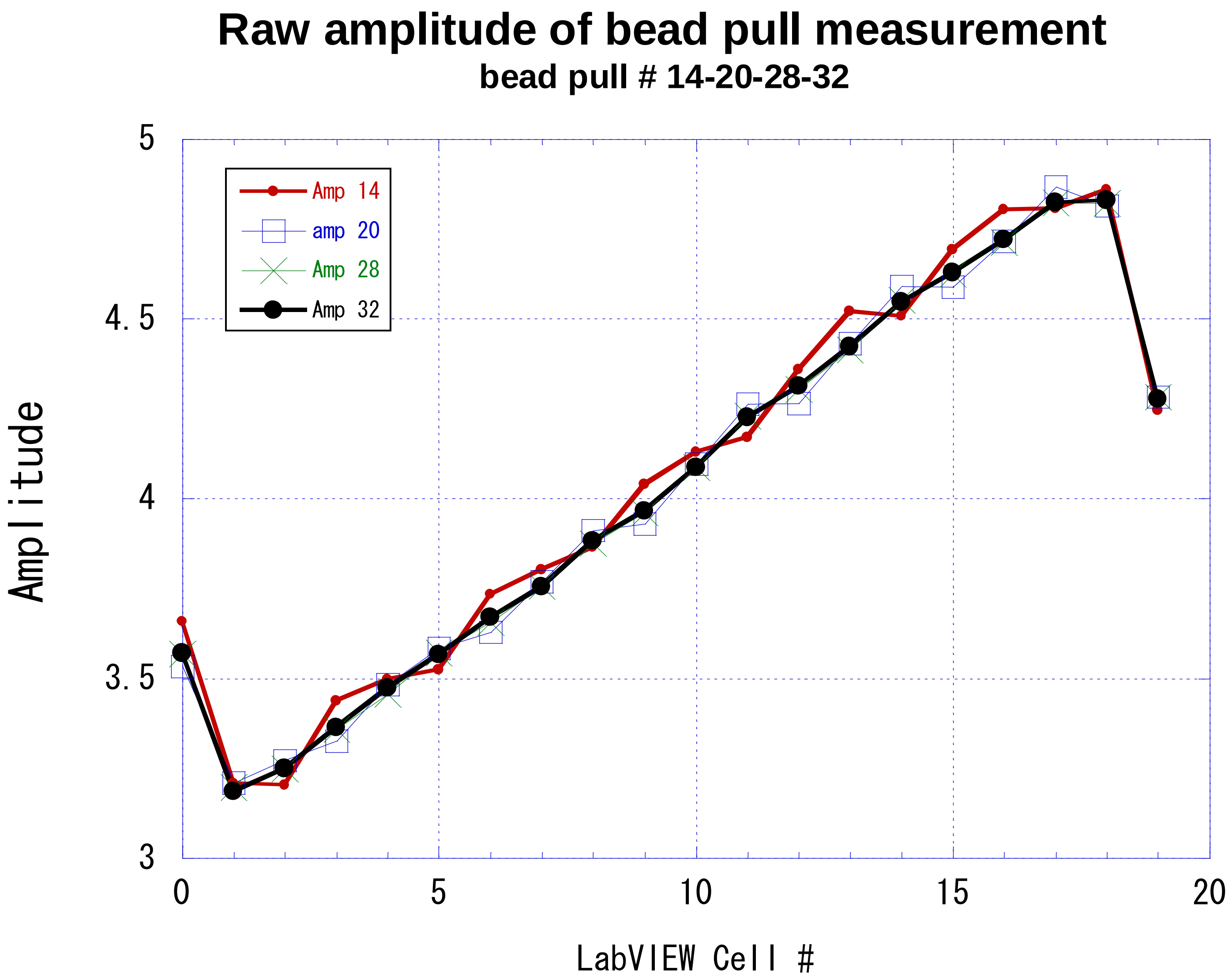
Cell8 deformation：0.167mm



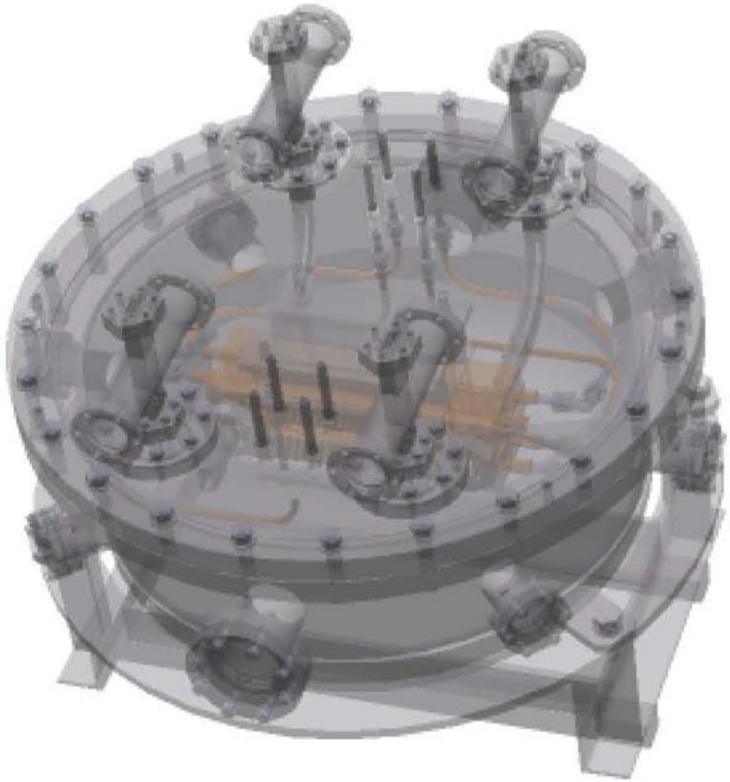
Cell 10(×100)

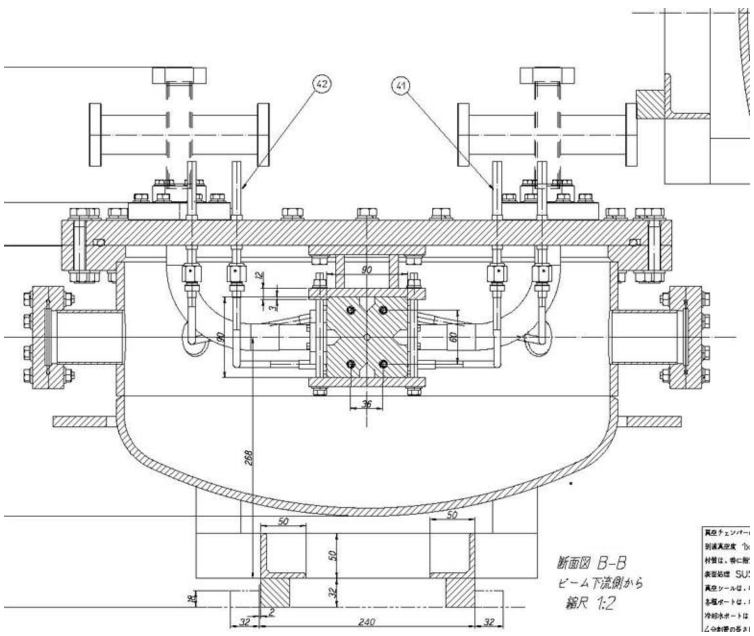
Cell10 no tuning

Field smoothness after tuning good.



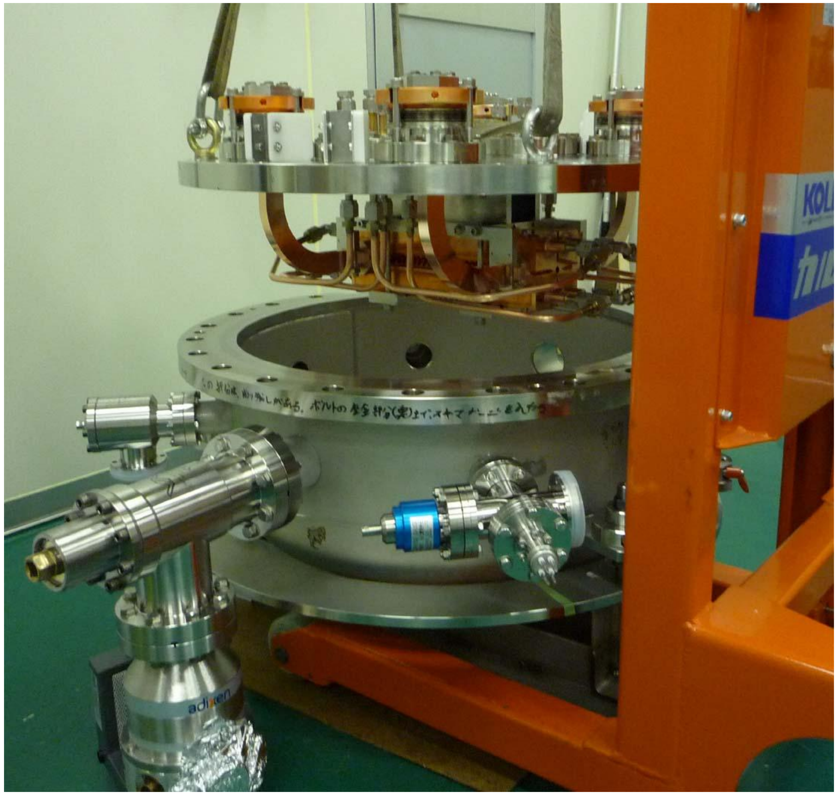
Vacuum chamber design

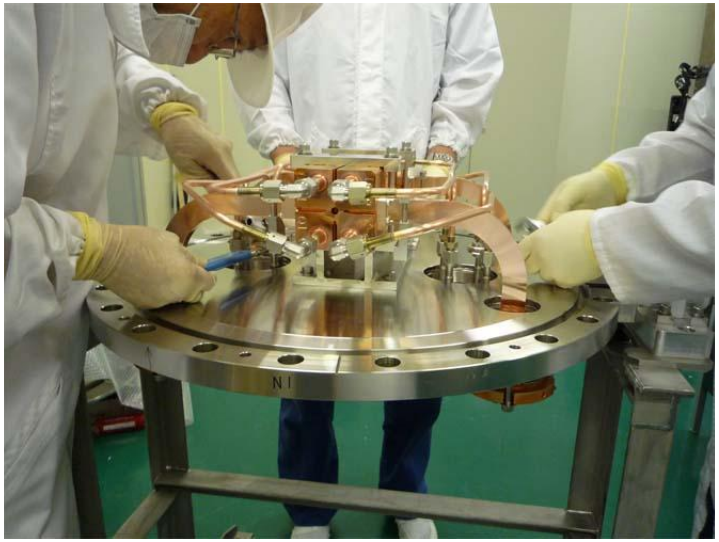




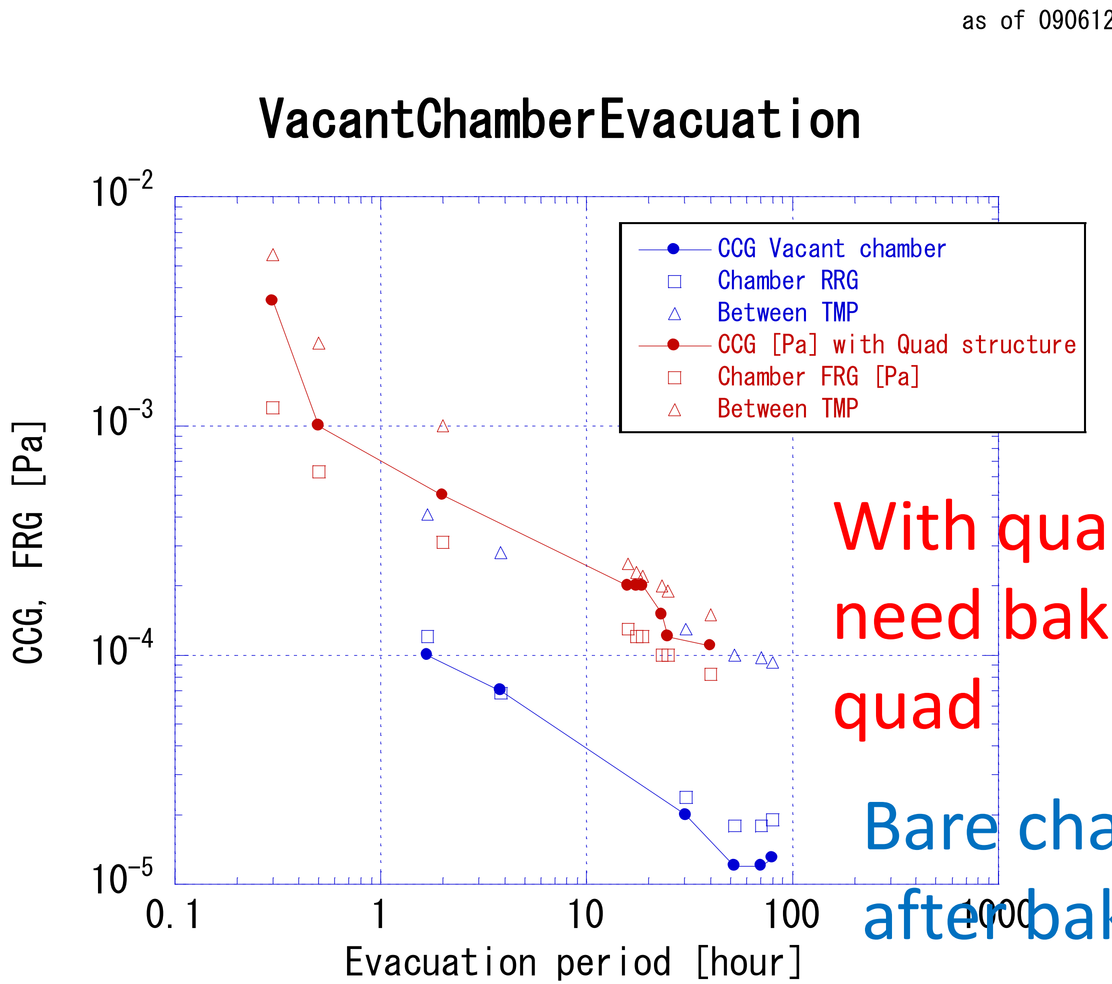
U-tight seal (round metal gasket)
VCR connector for cooling water connection
Thin H-bend being vac sealed with bellows
Vac evacuation from CF114 mounted on chamber with IP 70l/s and from WR90 at just 0.5m from structure

Installation into chamber





Evacuation with quad structure

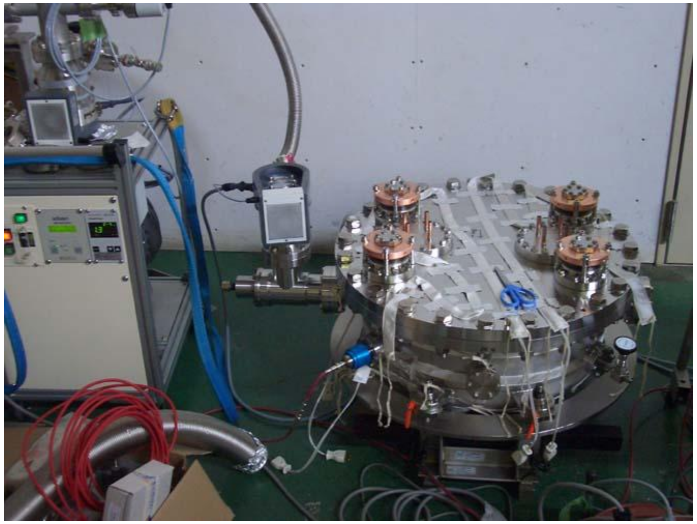


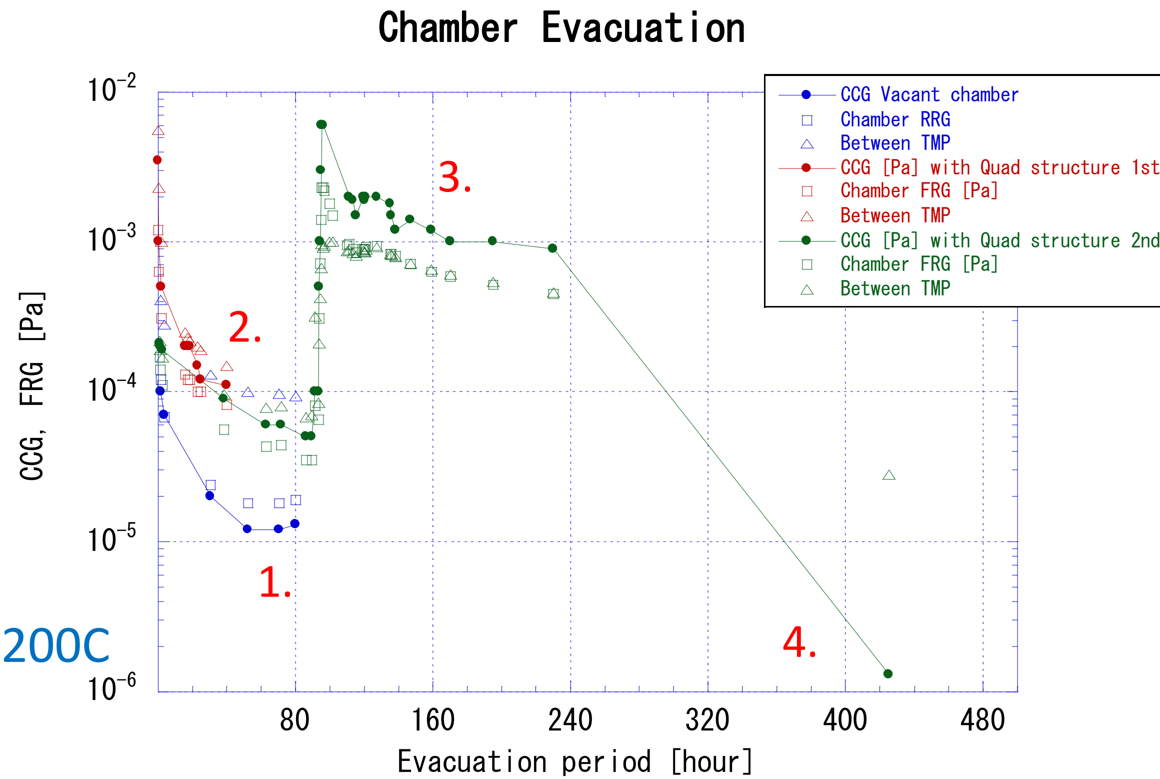
With quads → need baking of quad

Bare chamber after bake OK

First installation to Nextef but,

as of 090622





1. Firstly baked without quads at ~200C
   → Reached 10^-5Pa
2. Quad into chamber → 10^-4Pa
3. Then baked with quads ~200C → Reached 10^-6Pa
4. Moved to Nextef but the

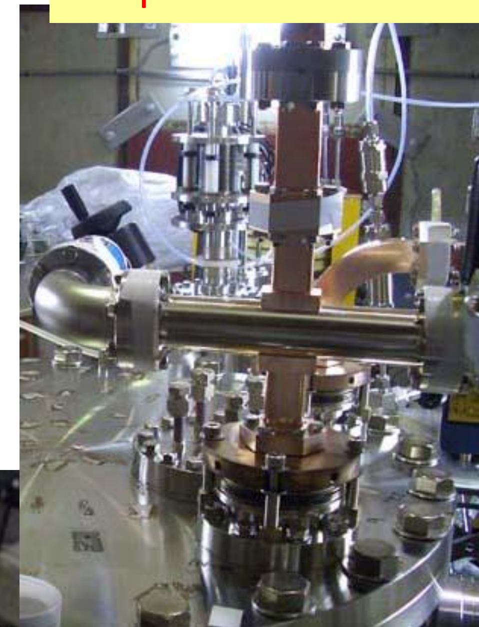
stuck gaskets prevent quad from connection to waveguide

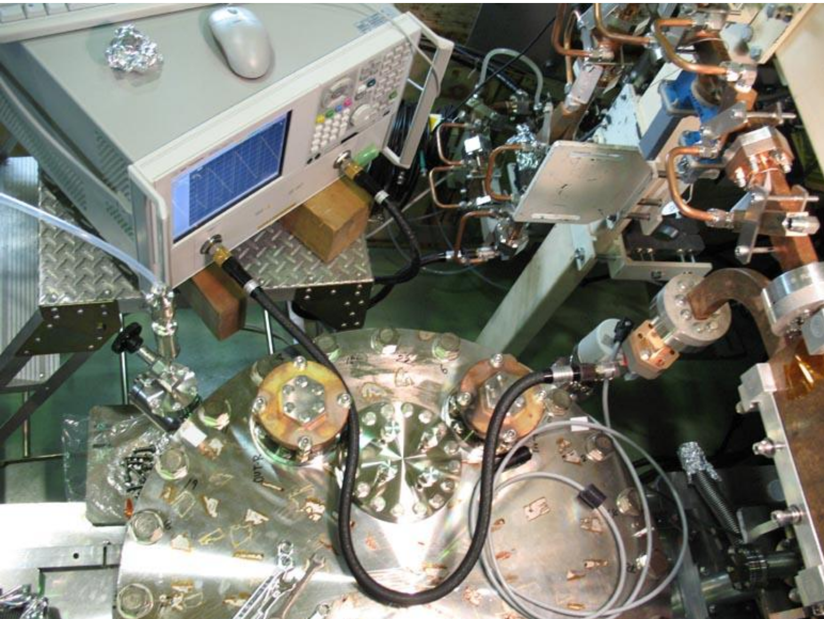
→ Removed gaskets by oil-less milling with cutting flange surface

→ Reinstalled into chamber without baking.

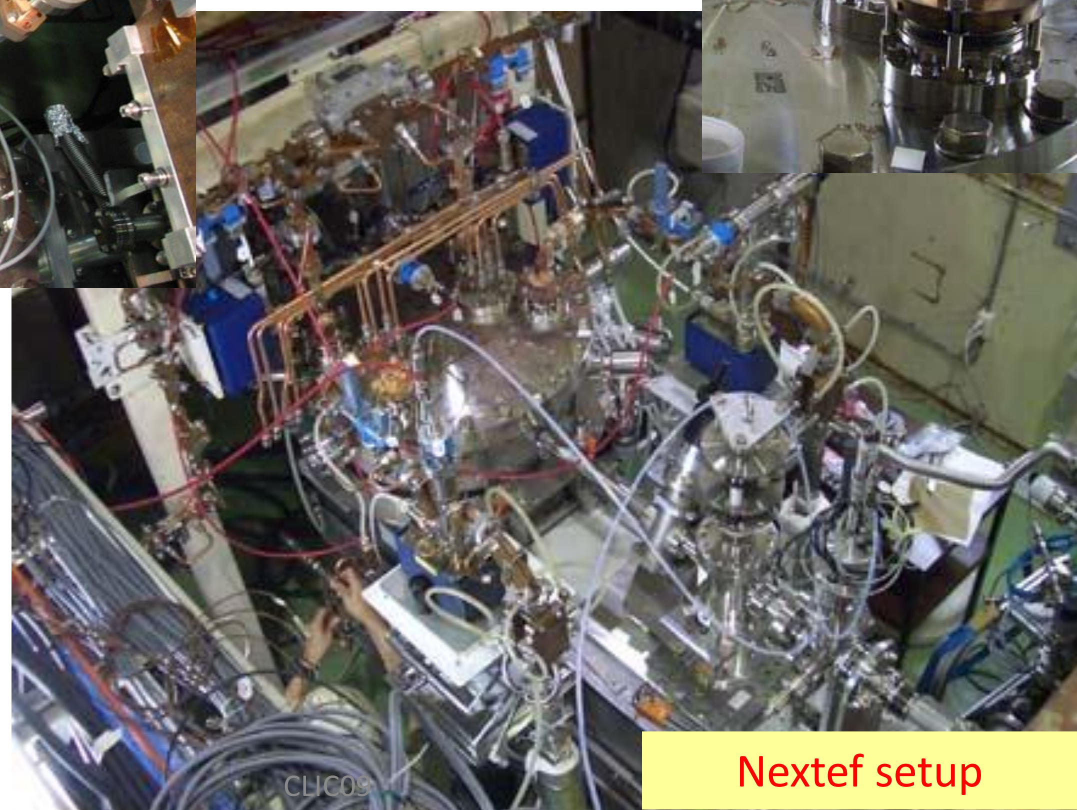
Installed into Nextef

Input connection





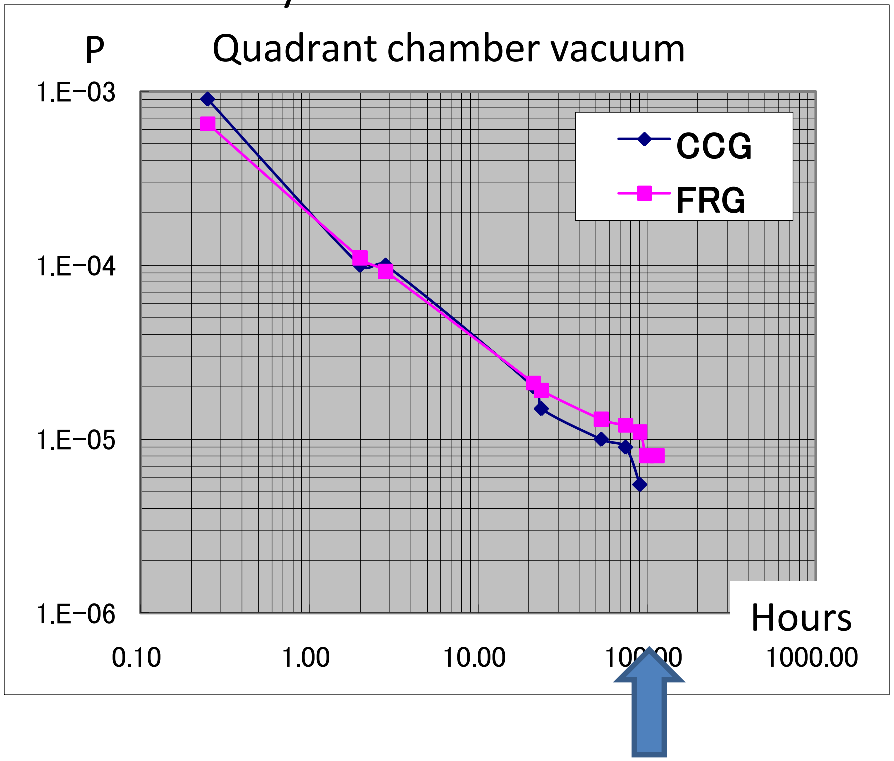
3dB phase check



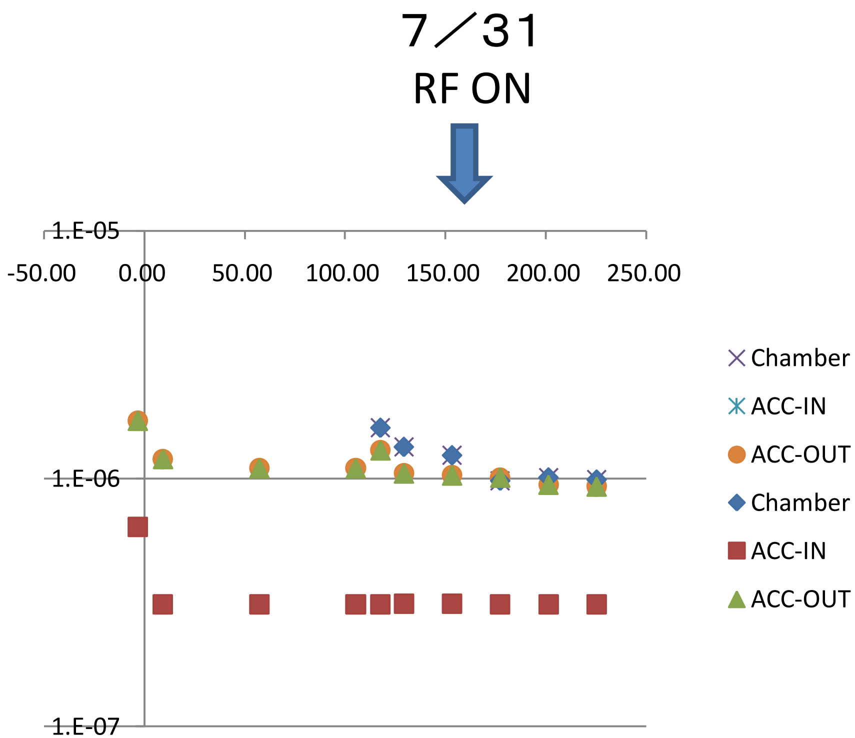
Nextef setup

Evacuation of quad at Nextef

Evacuation July 17-24



Evacuation with IP



Evacuation with TMP through CF114
Prepare IP with baking, while evacuation by TMP through ICF70

Reached 10^-6Pa with IP
→ Then RF-ON

Vacuum of quad

- Base pressure reached 10^{-6}Pa
  - Nearly one order of magnitude worse than T18_Disk (a few 10^{-7}Pa)
  - Taking good vacuum conductance from gauge to RF pass, vacuum level inside is estimated to be close to T18_Disk
- Gas activity with RF
  - Should carefully be studied to see what is happening inside due to RF and sometimes breakdowns
  - We may get some hint to understand breakdown

Hitachi's second try of quad fab.

- Hitachi engineer tried again a quad test production.
- It reached the similar level as those of Quad#5.
- Milling done with 3D milling machine but adding another rotational motion.

- Company engineers are interested in the quad production.
- They are watching our perspective.

Conclusion to pass to Higashi's talk

- First Quad by KEK was now in high power test.
- Many features are still in question
  - responsible for the poor high gradient property?
- However, we want to use it as our education to understand breakdown.

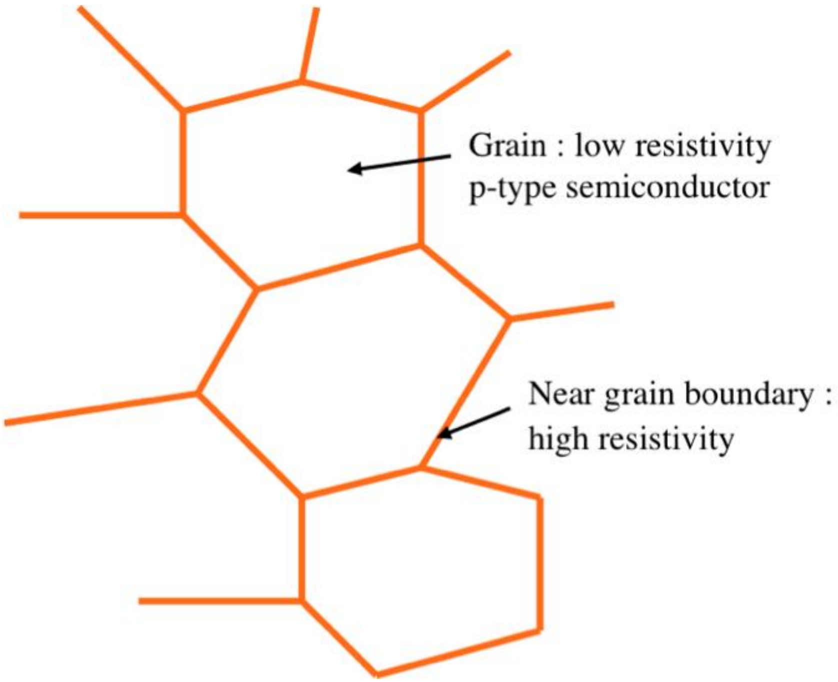
- Quad approach:
  - We need to establish high gradient first,
  - Taking mass production perspective in mind.
  - → Higashi

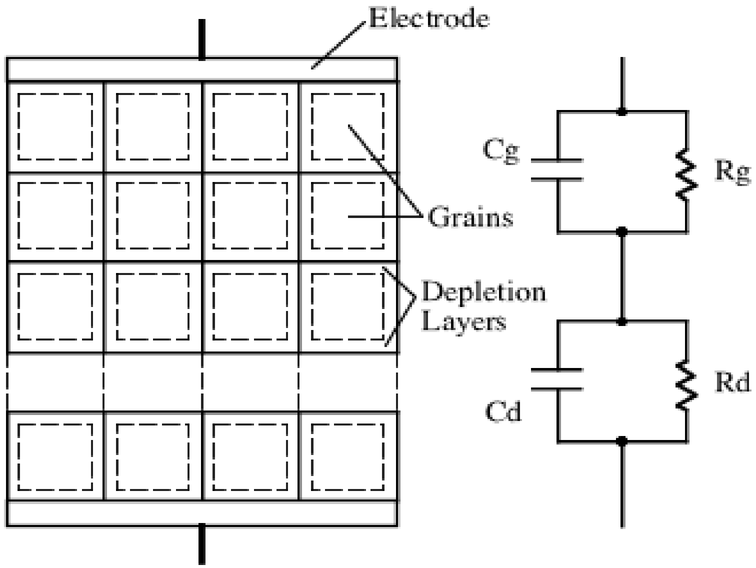
Some information on Lossy material

- SiC being studied by Y. Takeuchi
  - Based on material for HOM absorber of KEKB 500MHz cavity
    - SuperB chose low current/low emittance design
    - No extra funding for higher frequency development
  - Tried tuning to higher frequency
    - By changing doping amount
  - Mostly by two companies
    - Covalent and Hitachi chemical

Y. Takeuchi (KEK)

Adjustment of the permittivity of SiC ceramics





Schematic Model of SiC Ceramics

Two-layer Model and Equivalent Circuit

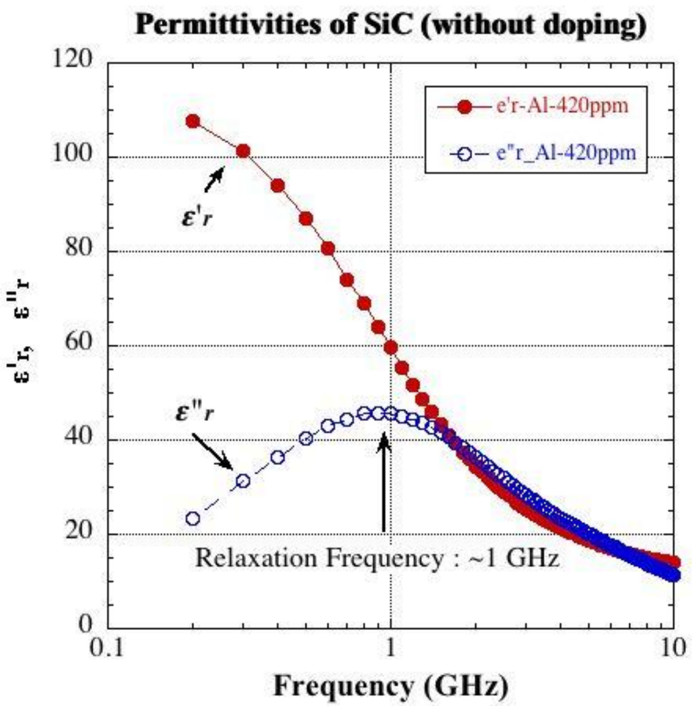
By doping Al-compound, we have tried to increase the carrier concentration in the grain. >>>>> The relaxation time (~ CdRg) will change.

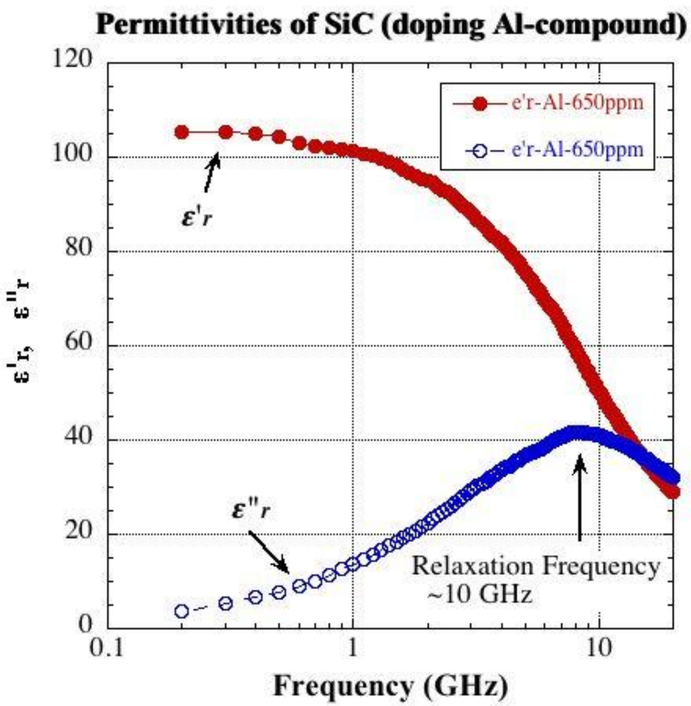
Y. TAKEUCHI (KEK) and M. ANDO (Covalent Materials Corporation)

Y. Takeuchi (KEK)

Results of the doping (preliminary)

Covalent work in collaboration with KEK.





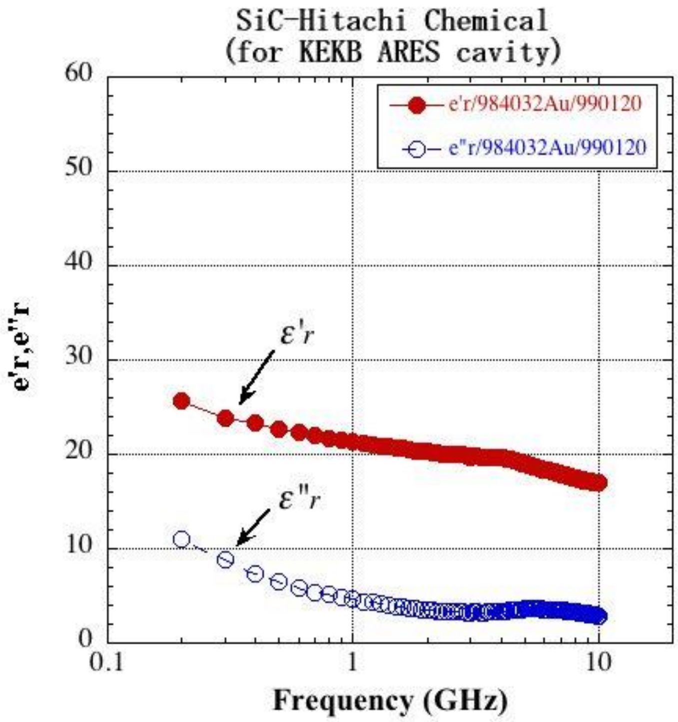
Al : 420 ppm(wt)
Relaxation time τ ~1.6x10^{-10} sec
Resistance 19 MΩ (1 cm)
* Relaxation frequency = $1/(2\pi\tau)$

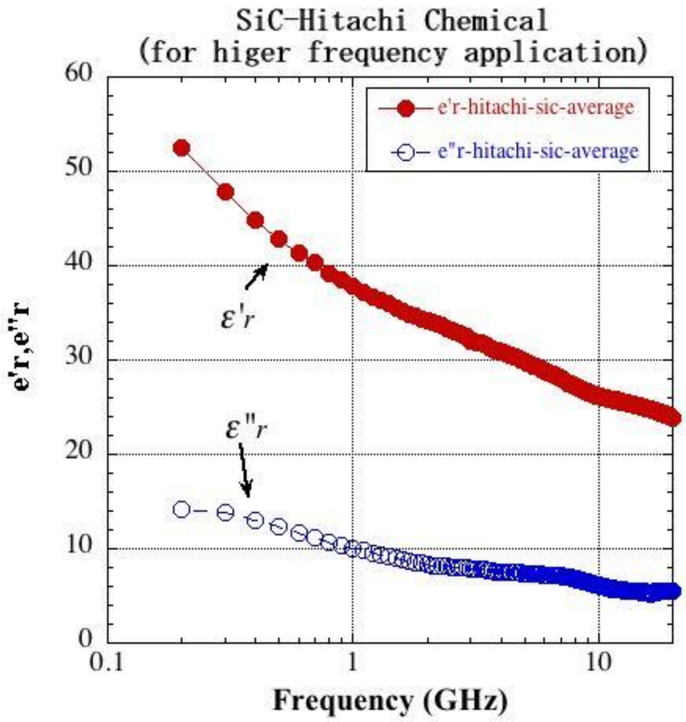
Al : 650 ppm(wt)
Relaxation time τ ~1.6x10^{-11} sec
Resistance 0.8 MΩ (1 cm)

Y. Takeuchi (KEK)

SiC ceramics for higher frequency produced by HITACHI CHEMICAL

Hitachi Chemical did try and KEK measured.





For KEKB ARES cavity → Developed to higher frequency

For further info on SiC

- Please contact Takeuchi for further info in general.
- You can directly contact Covalent or Hitachi Chemical, for technical info and for production capability.

- KEK may make for accelerator structure use, depending on the success of TD24.
- If more for PETS
  – probably better to control production process by those who make PETS with the actual production company.