



Crab Cavity Development

KEK

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MHI

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KEKB

Crab Crossing Scheme

KEKB Superconducting Crab Cavity

RF Performance Test

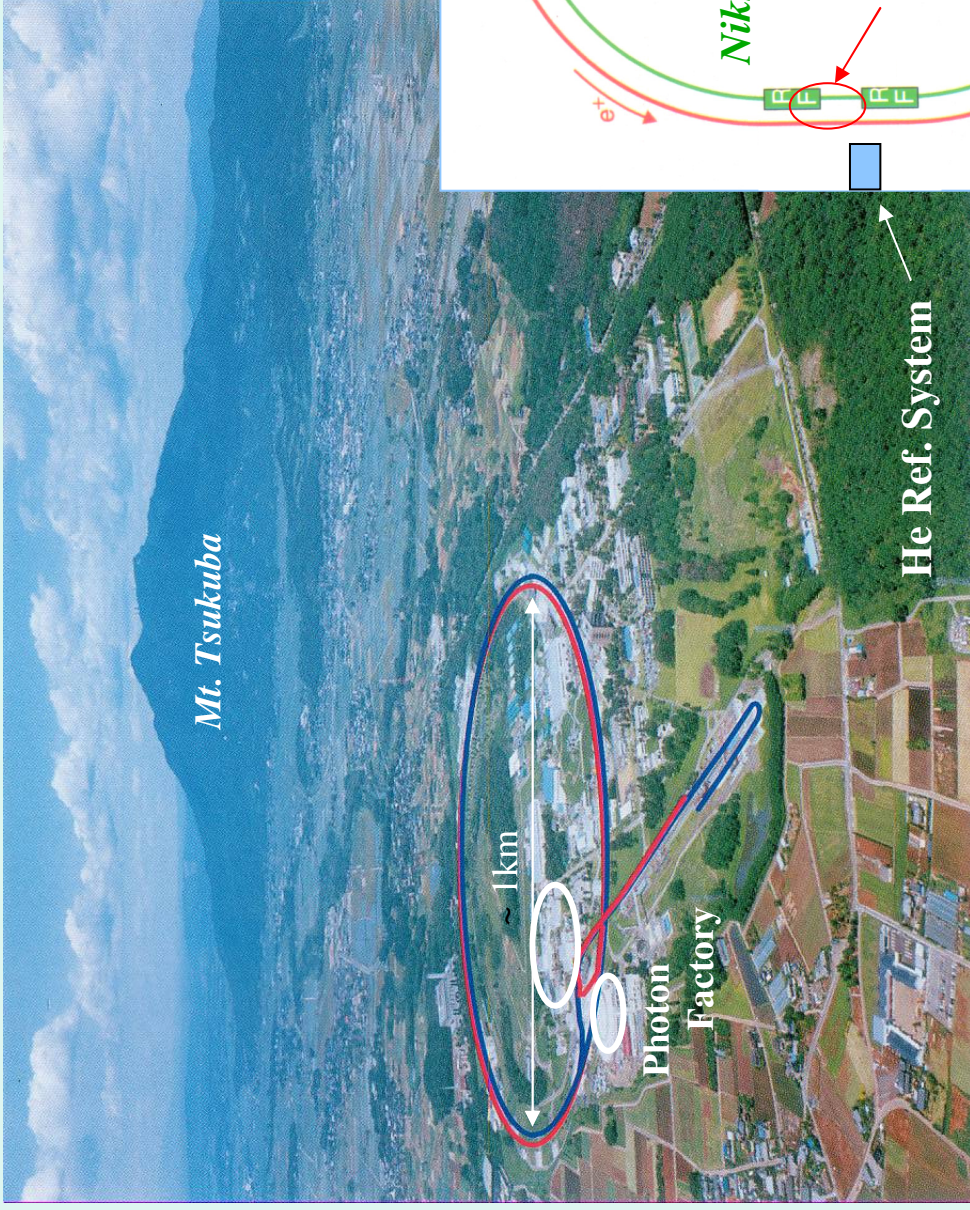
Cryostat for KEKB Crab Cavity

RF Absorber

Input Coupler

Summary

KEKB Electron-Positron Collider



KEKB

LER 3.5 GeV

HER 8.0 GeV

RF freq. 508.9 MHz

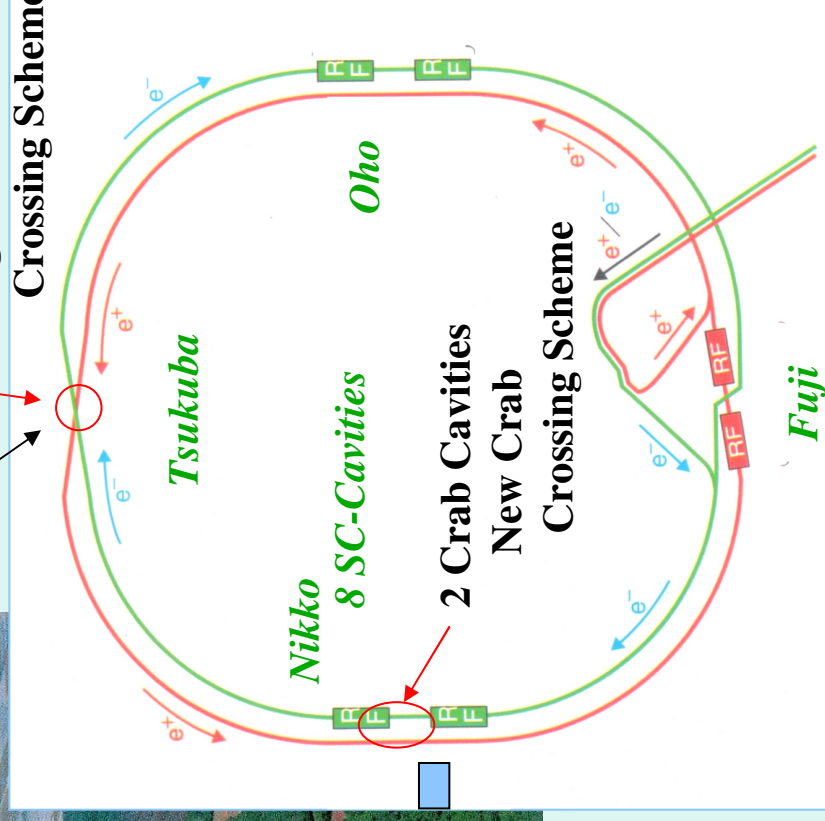
Cross. Ang. 2 x 11 m rad.

Collision Point

4 Crab Cavities

Original Crab

Crossing Scheme



Beam Current

1.8 A LER

1.3 A HER

1300 bunch

L_{Peak} 15/nb/s

Integral L 1000/pb/day

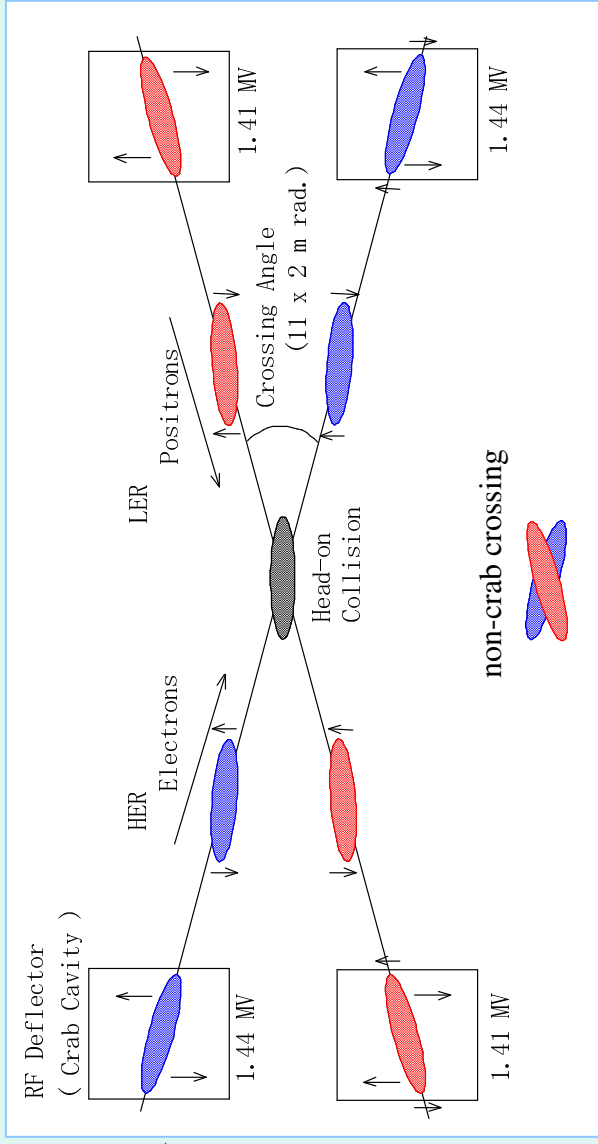
Integral L 470/fb

5 Years Operation

KEKB Crab Crossing

The crab crossing scheme allows a large crossing angle collision without introducing any synchrotron-betatron coupling resonances. 1, 2)

- 1) R.B.Palmer, SLAC-PUB-4707,1988
- 2) K.Oide and K.Yokoya, SLAC-PUB-4832,1989



4 Crab Cavities
at Colliding Section

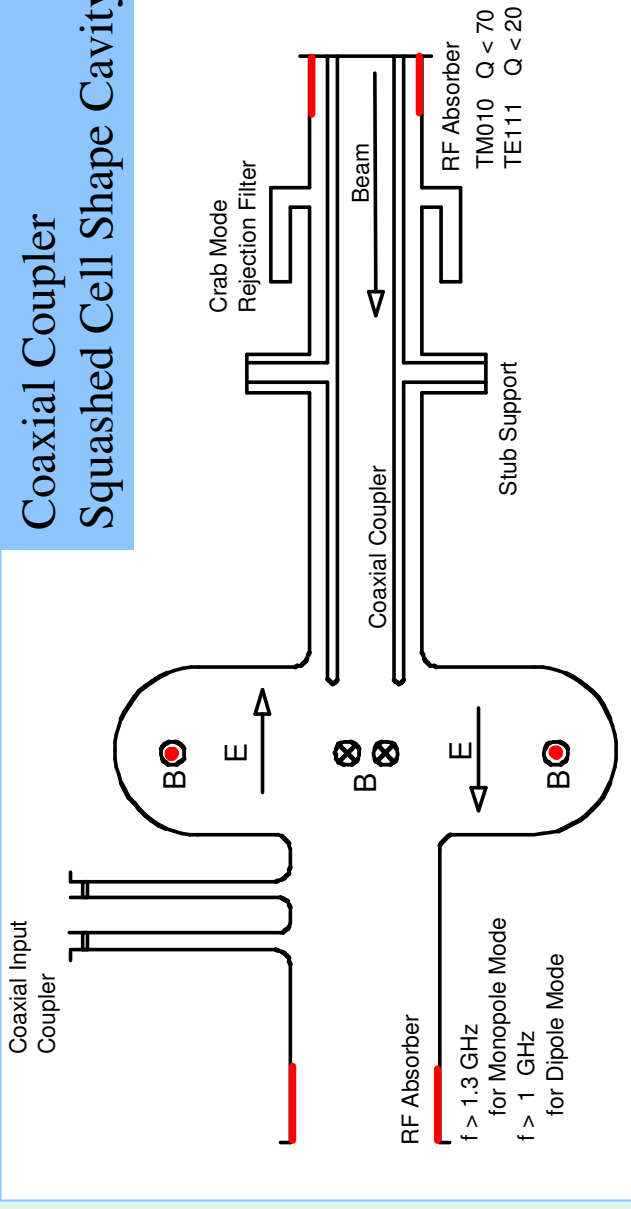
New Crab Crossing Scheme

2 Crab Cavities
at “Nikko” Section Beam-bunch wiggle around the whole ring!

Advantage: We can use existing cryogenic system for Acc. S.C. cavities

Conceptual Design of KEKB Crab Cavity

Top View



Crab Kick

Coaxial Coupler

Squashed Cell Shape Cavity

TM110 B-field 1.44 MV

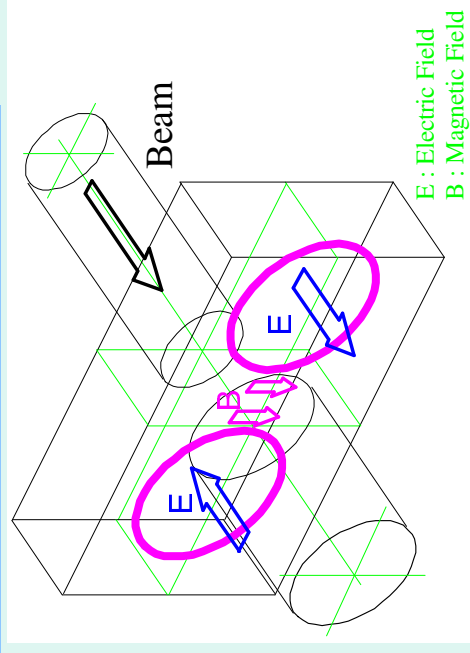
TM010, TE111

TM110*

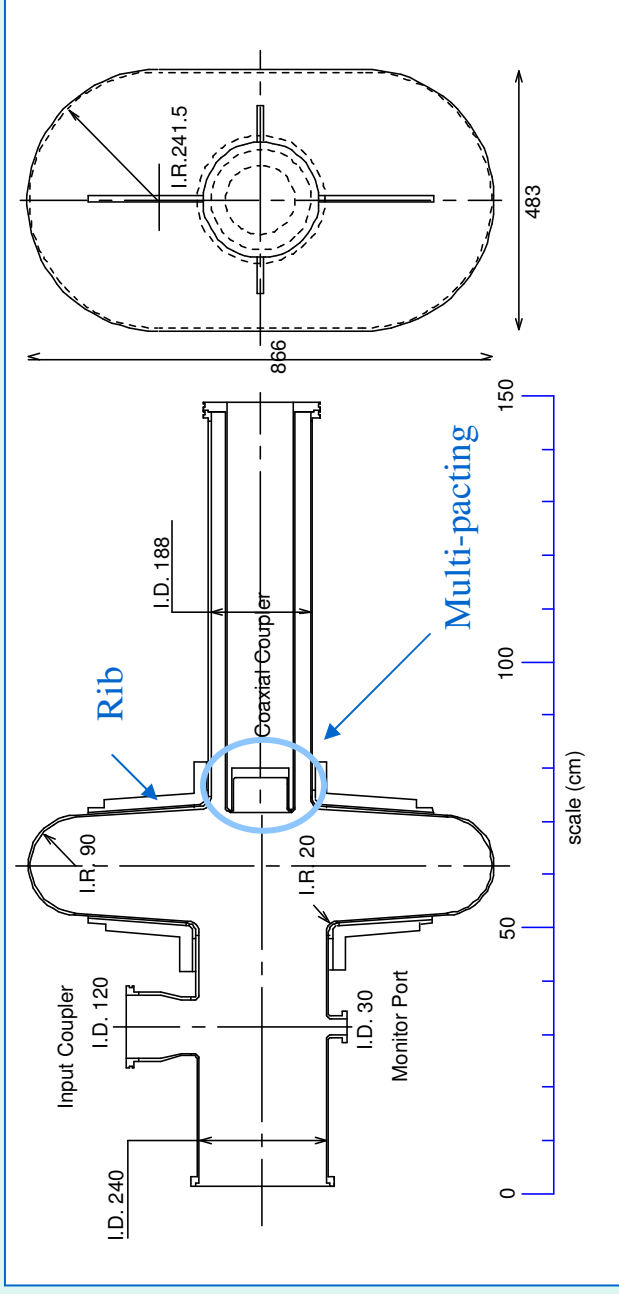
⇒ The squashed cell shape cavity scheme was studied extensively by Akai at Cornell in 1991 and 1992 for CESR-B under KEK-Cornell collaboration.

We adopted this design as “base design”!

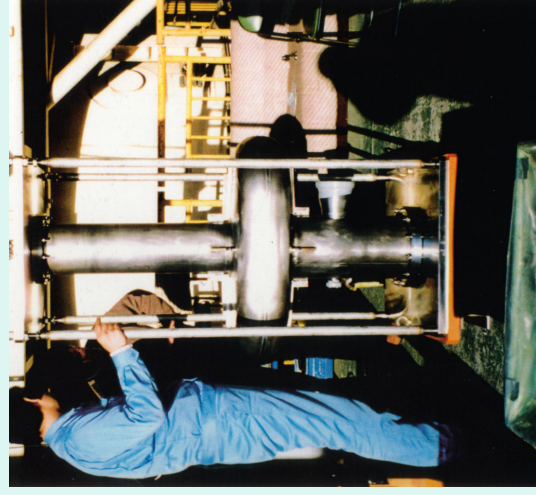
Squashed Cell Shape Cavity




KEKB Superconducting Crab Cavity



Frequency	501.7 MHz
R / Q	46.7 Ω
G	220
Esp / Vkick	14.4 MV / m / MV
Hsp / Vkick	Oe / MV



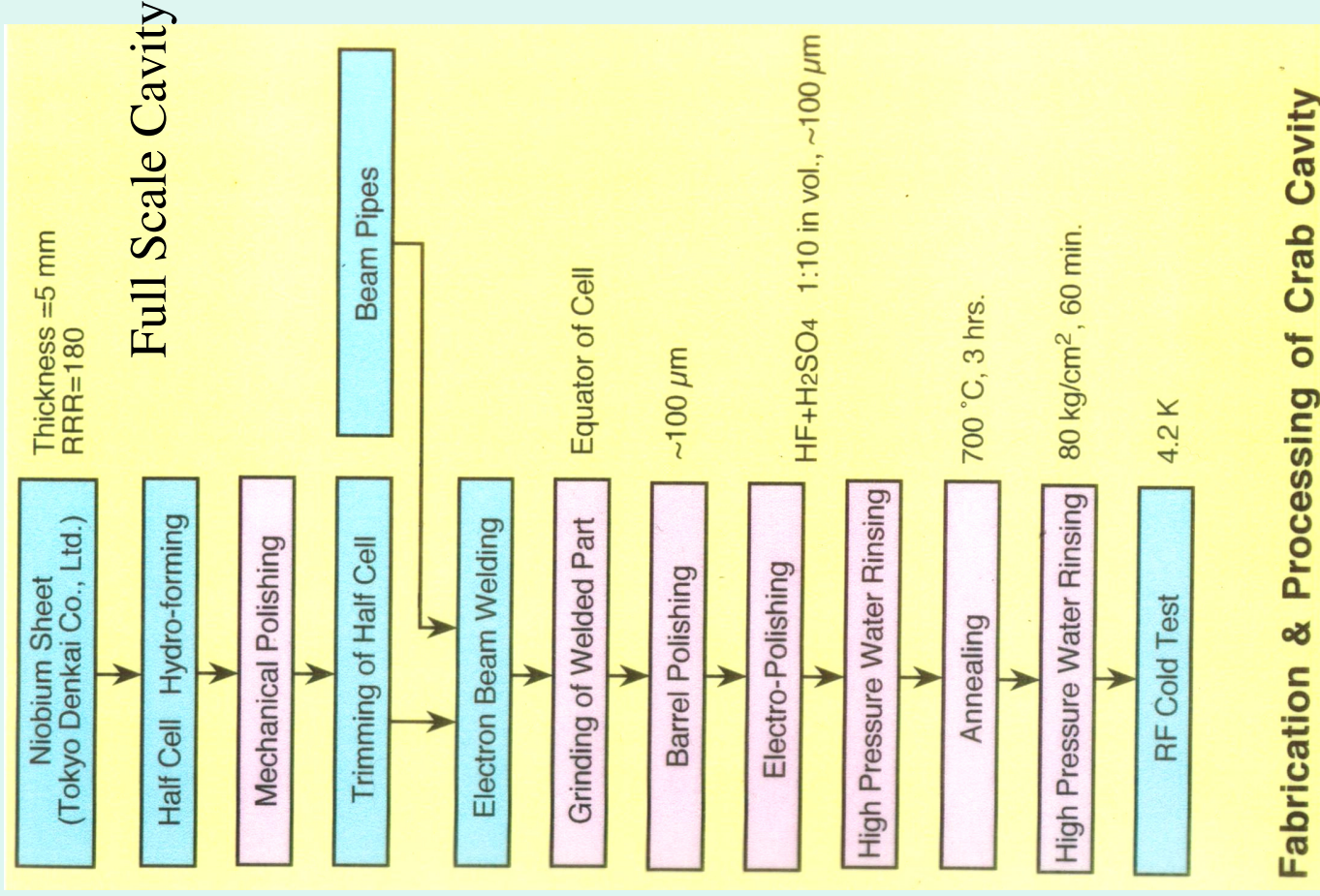
 Non-axial Symmetric Structure
 Thickness of 4.5 mm Nb Cavity
 Reinforced by Ribs

Simplified Nb Coaxial Coupler

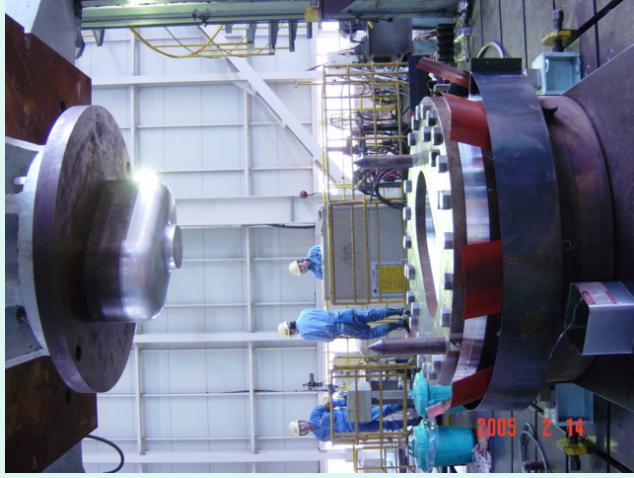
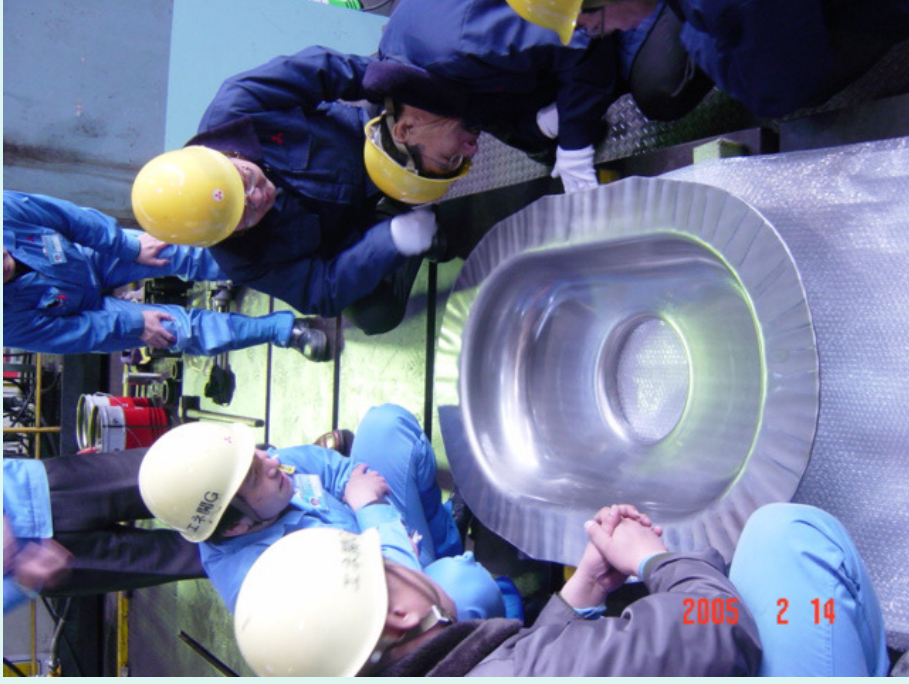
Fabrication of Crab Cavity

- 1) 1/3 scale model 1.5 GHz
3 Nb cavities
1 Cu cavity
1 sus cavity
- 2) Full scale model 500MHz
2 Nb cavities
2 Cu cavities
1 sus cavity

3) KEKB Crab Cavity 509MHz
2 Nb cavities
under fabrication



Crab Half-Cell Forming at MHI



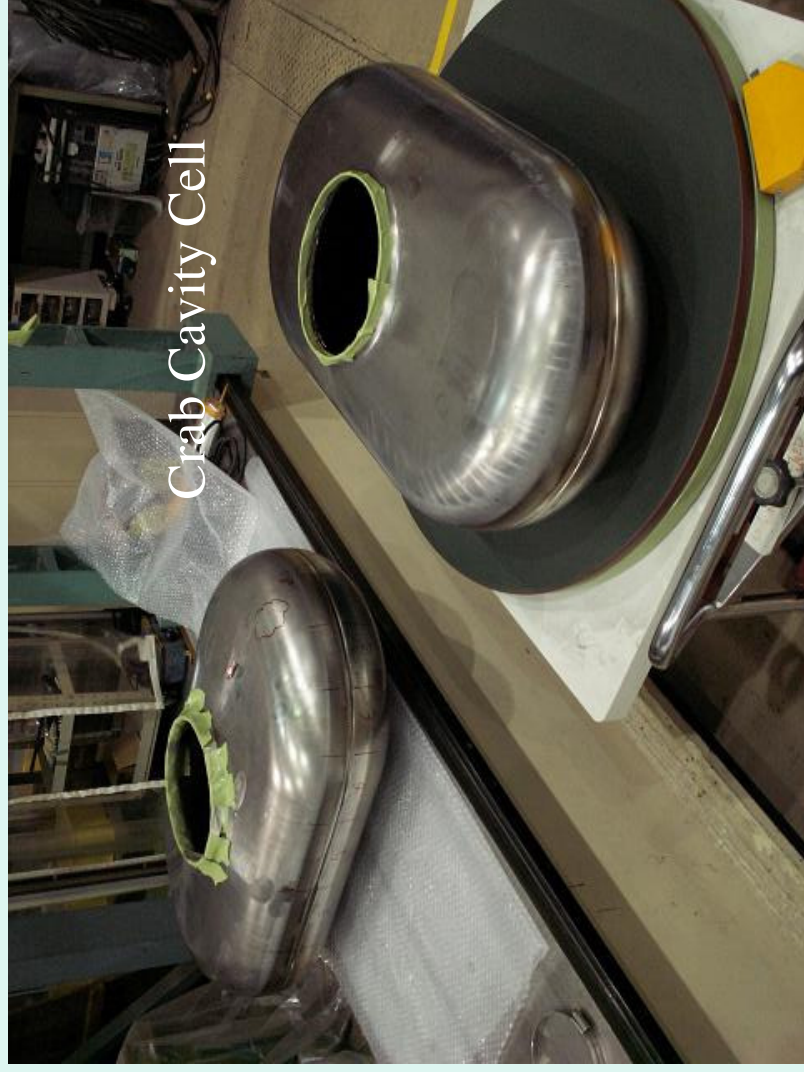
Forming of 4 Half-Cells for Crab # 1 and # 2
Finished on Feb. 14, 2005 at Mitsubishi Heavy Industries, LTD. Kobe

After forming, the shape was checked.
The dimension of the cavity was measured by 3-D
measurement system.

Crab Cavities for HER & LER



Small Beam Pipe

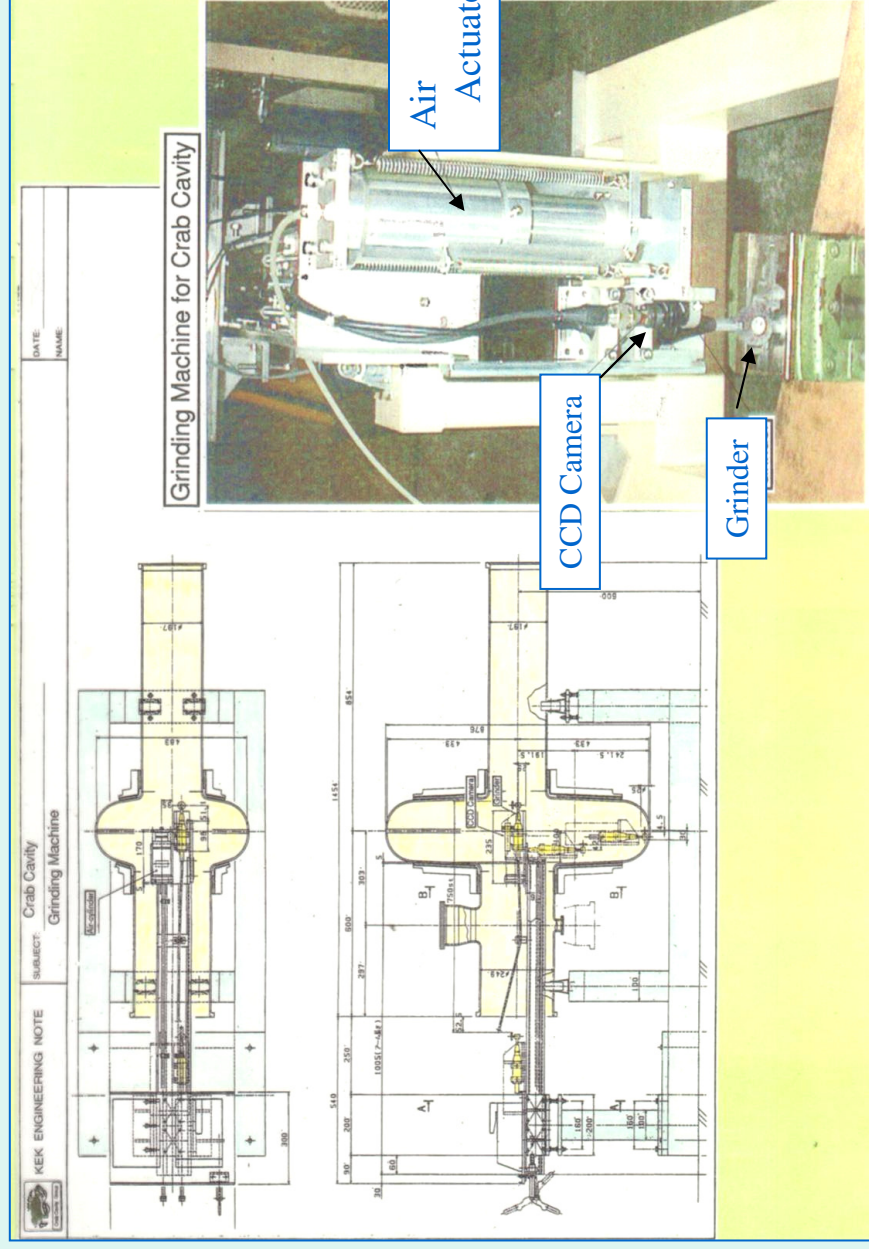


Crab Cavity Cell

Large Beam Pipe

Grinding Machine

Grind the welding part of equator by using specially designed grinding machine.



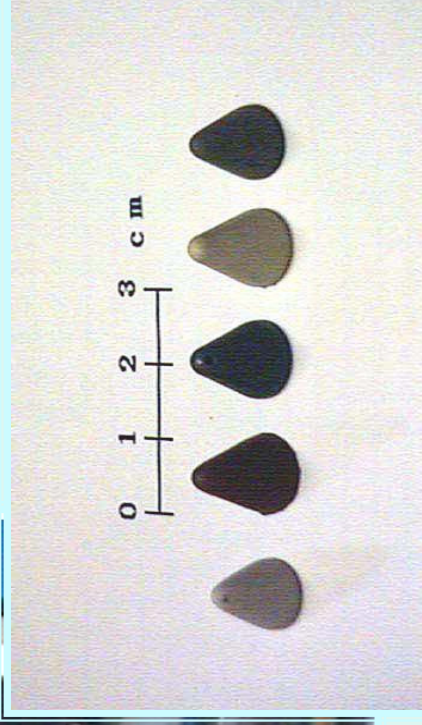
- 1) Position of grinder is controlled by air actuator
- 2) Grinding process can be monitored by CCD camera

Barrel Polishing



Rough
Medium
Fine

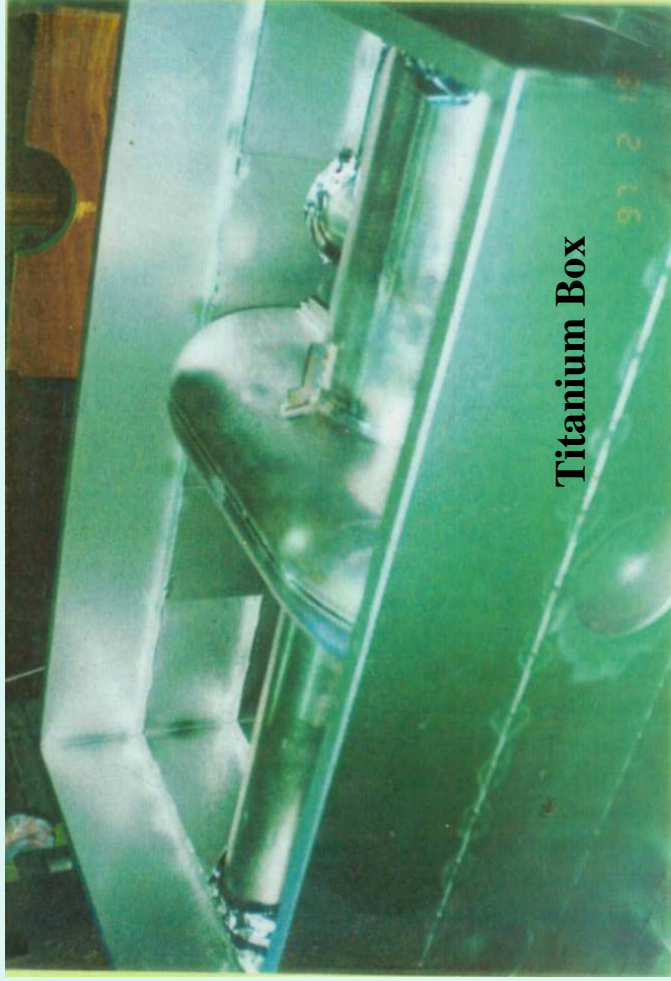
~114 hr



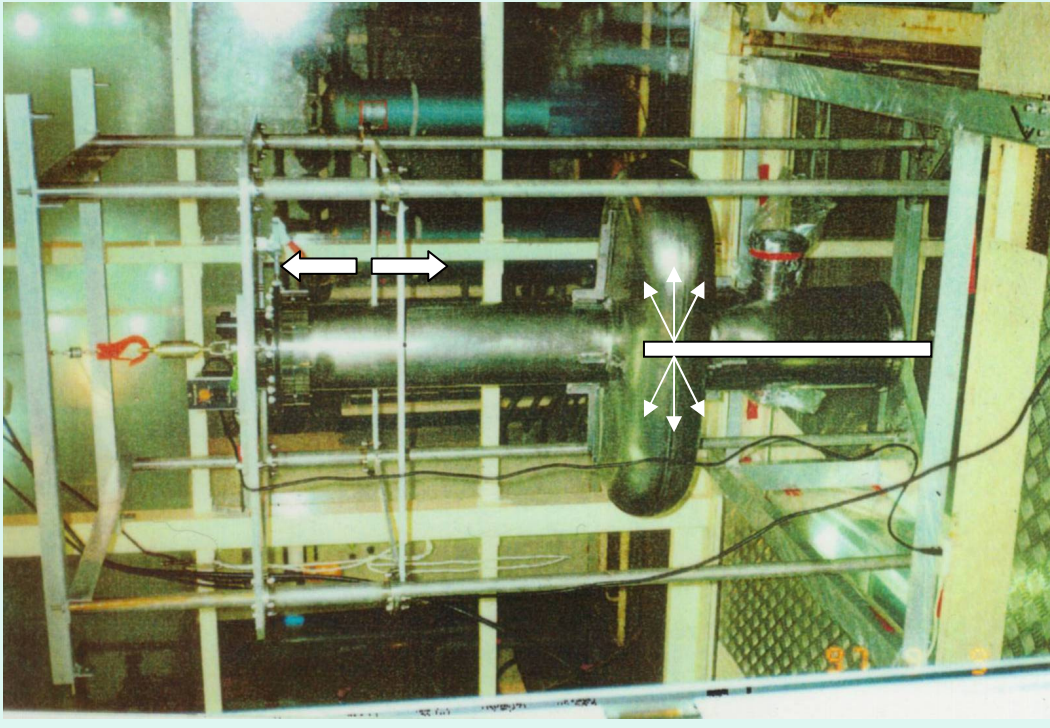
Electro Polishing



Annealing & HPR



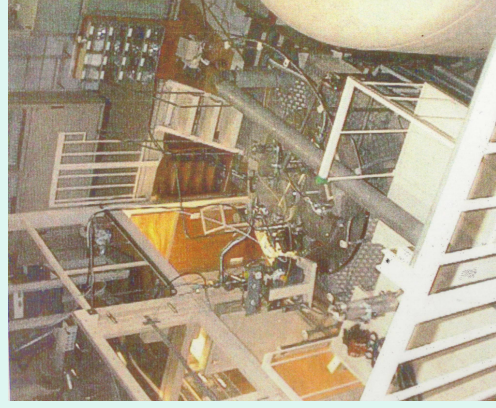
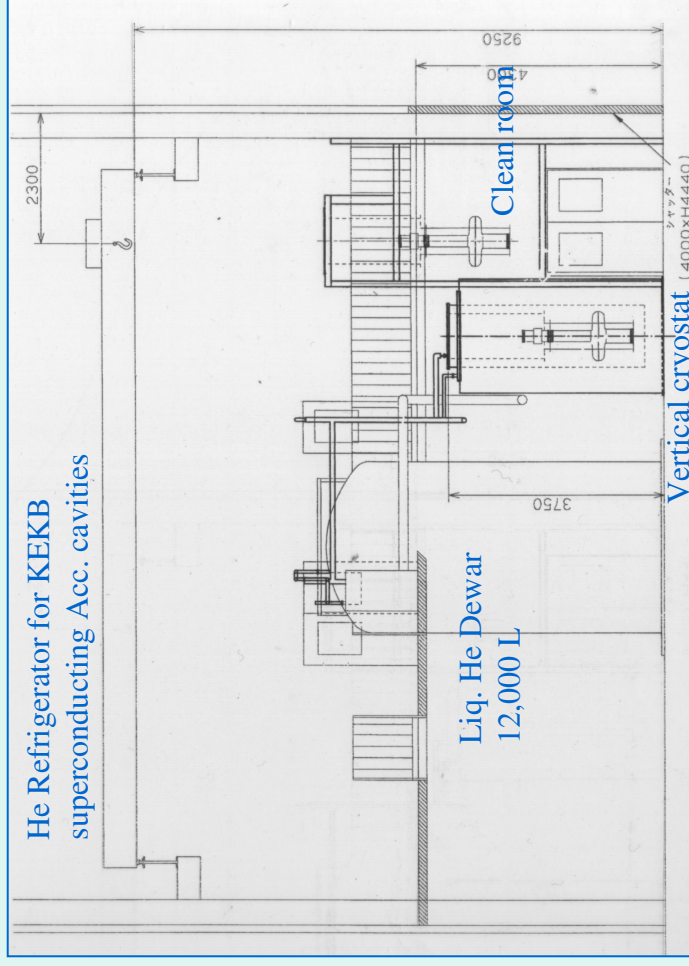
Annealing at 700°C for 3 hours



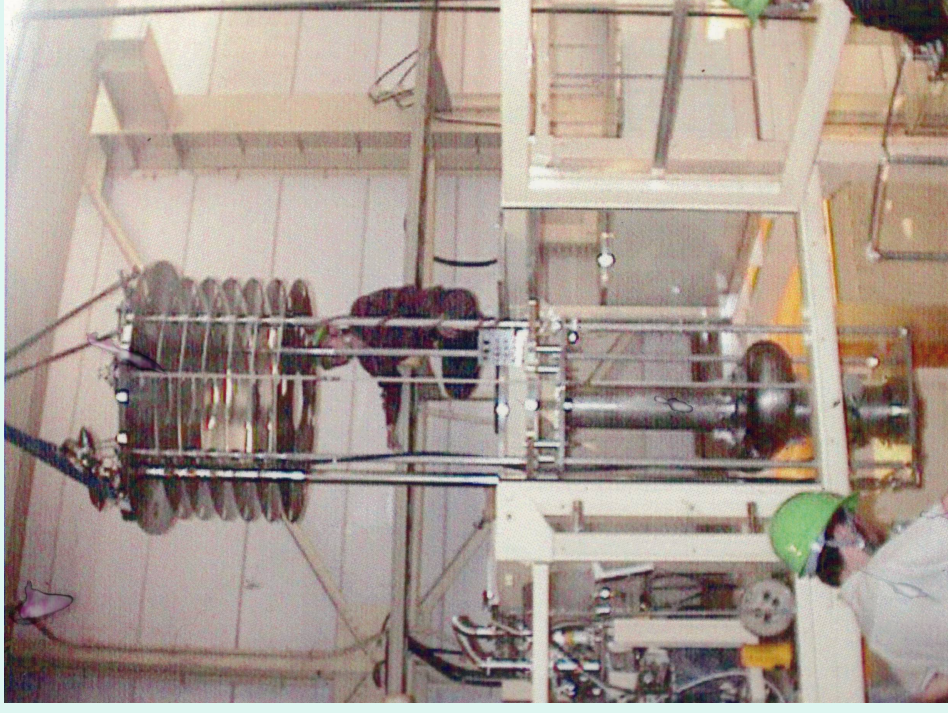
High Pressure Water Rinsing
by 80 bar Ultra-Pure water

Rotation & Up-Down Motion

Cold Test Stand for KEKB Crab Cavity

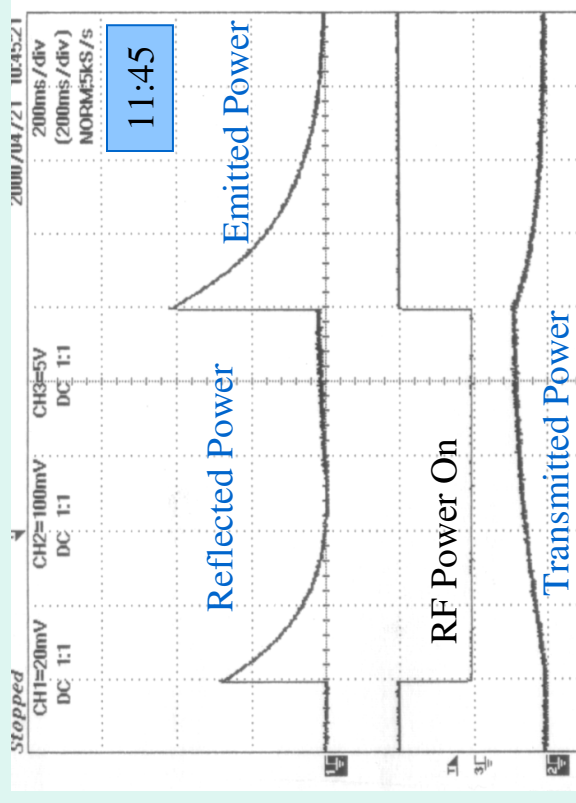
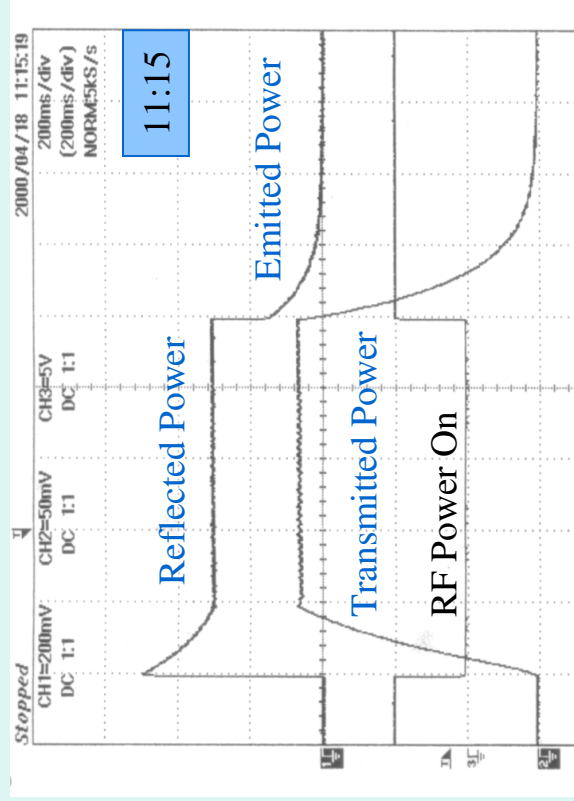
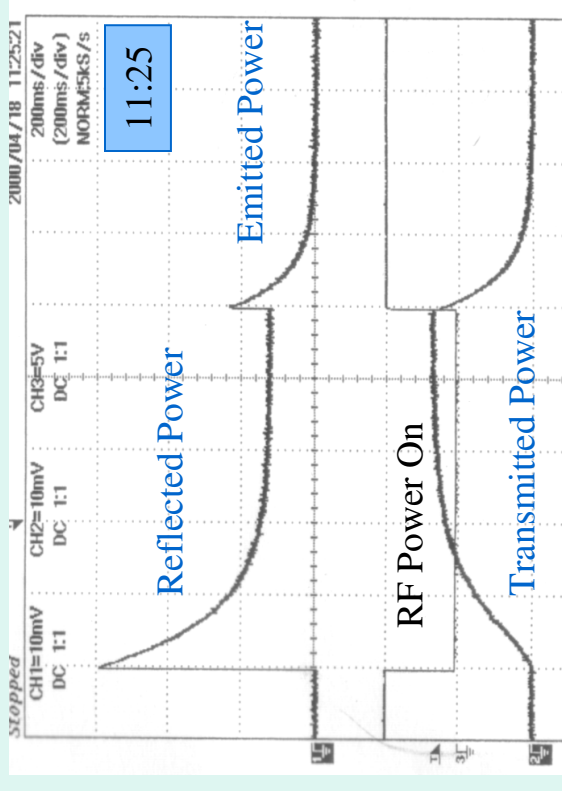
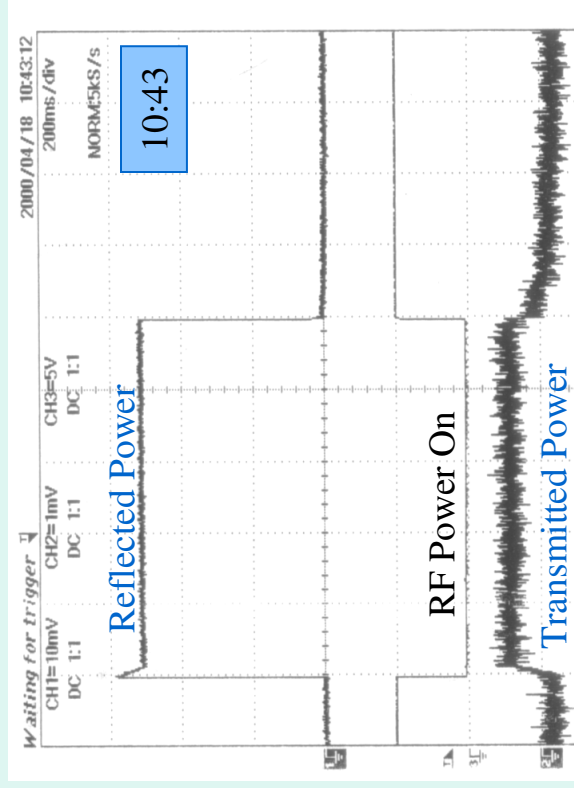


The crab cavity is set in the vertical cryostat



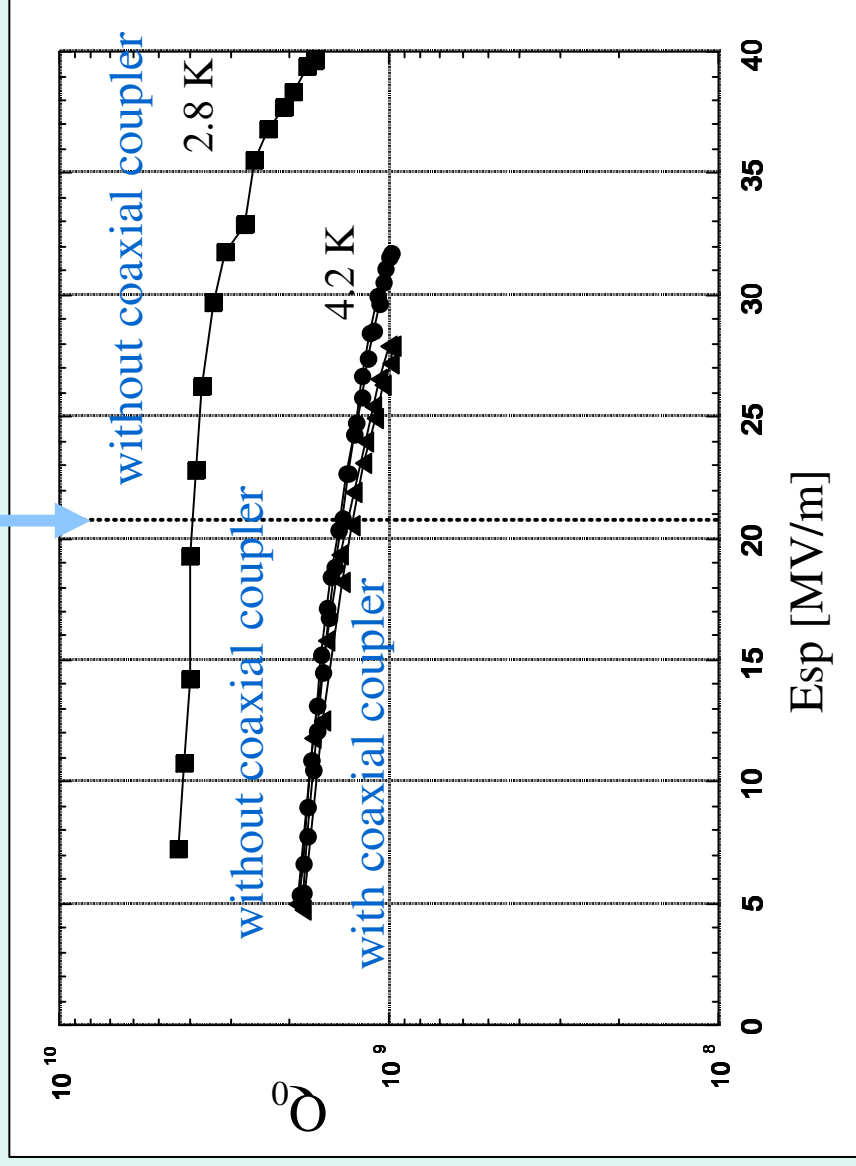
The crab cavity is taken out from clean room to install into the vertical cryostat.

Multipactoring in Crab Cavity with Coaxial Coupler



Test Result of KEKB Crab Cavity #1

Design Esp

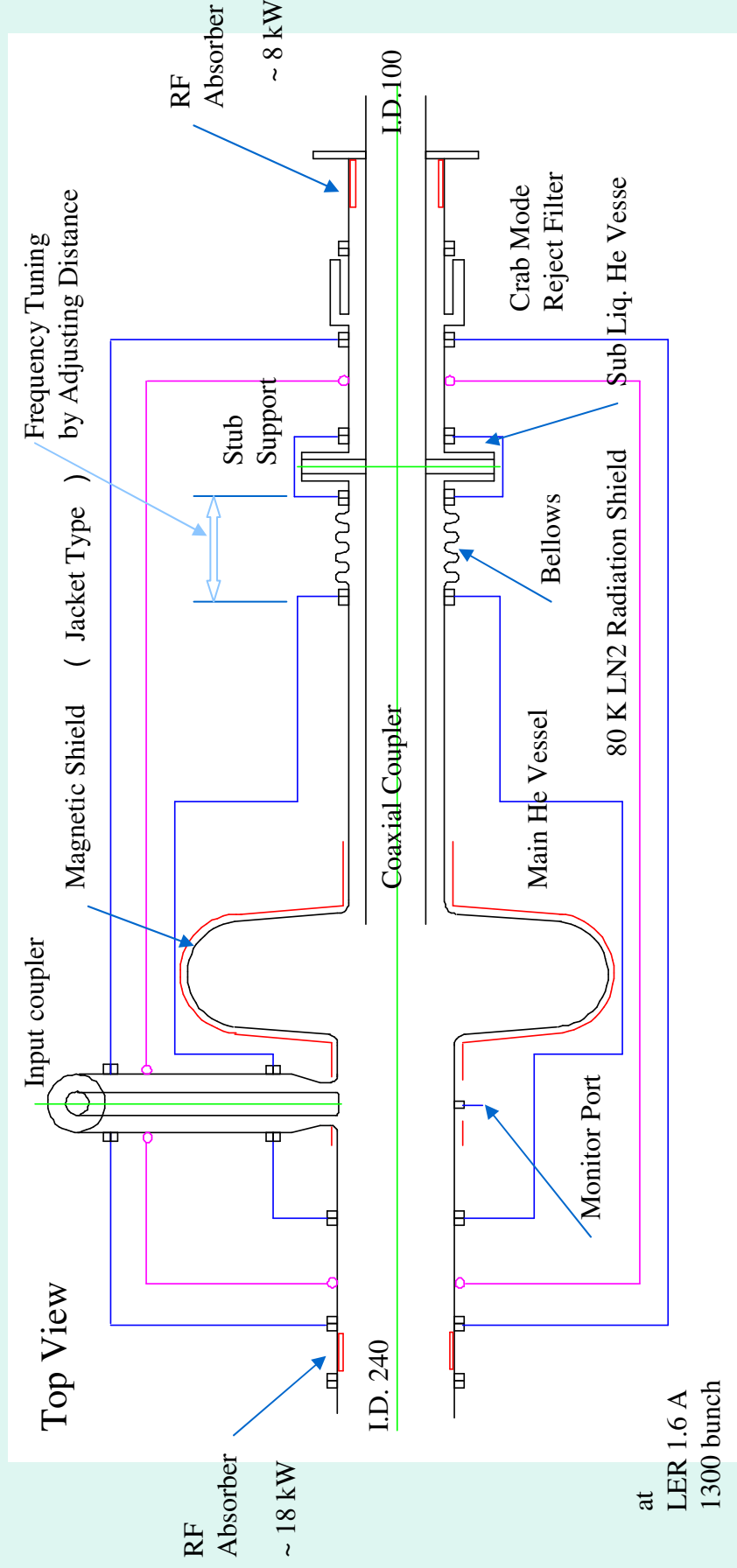


Crab Cavity #2
Same Performance!

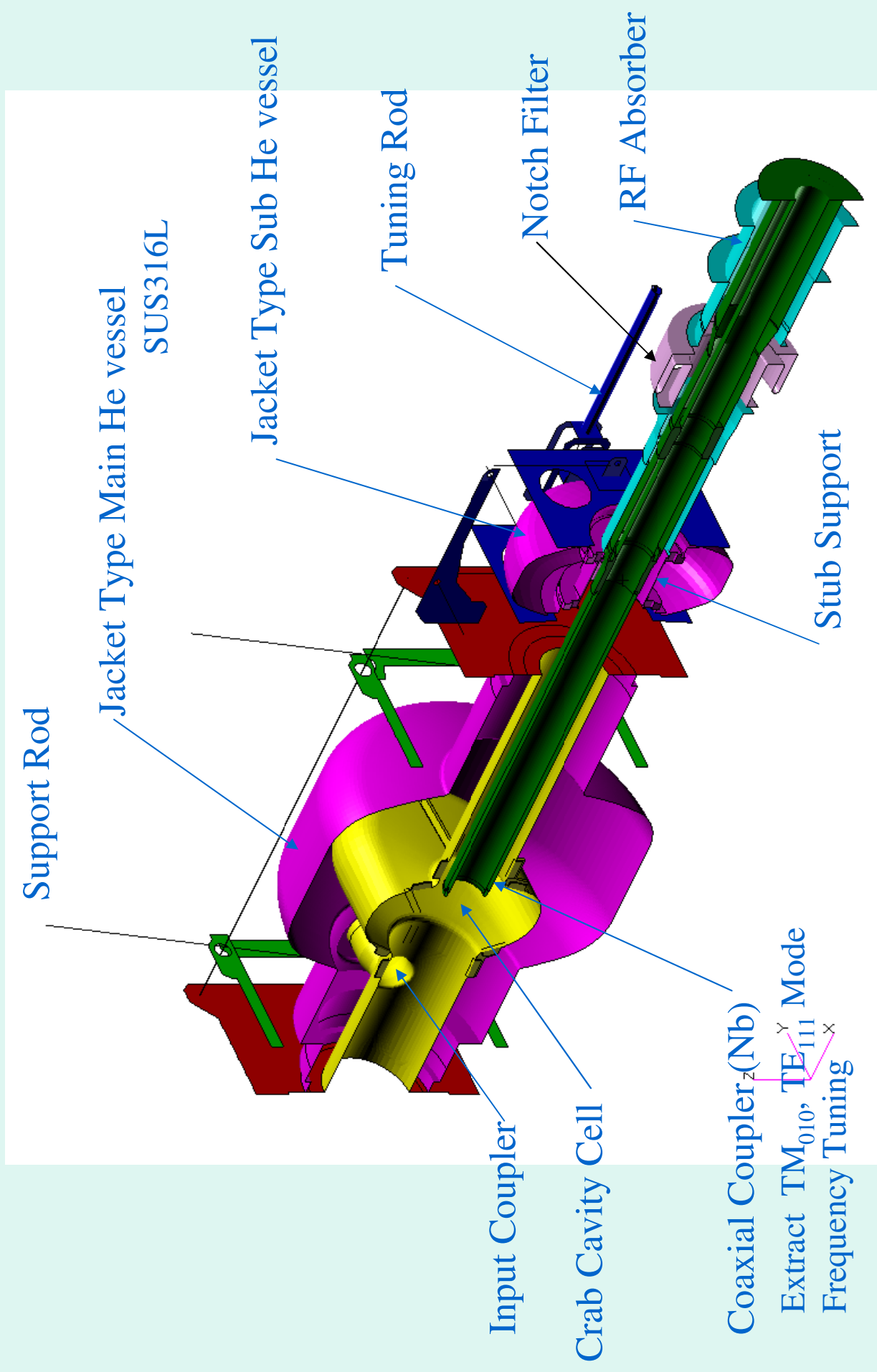
- Fabrication and Surface Treatment
- RF Performance Test with a Coaxial Coupler
- Multipacting could be overcome by RF process.

Conceptual Design of Cryostat for KEKB Crab Cavity

- ⇒ *Frequency Tuning Coaxial Coupler 28.3 kHz / mm*
- ⇒ *Stub-Support -- Mechanical Support & Cooling of Coaxial Coupler*
- ⇒ *Jacket-type Helium Vessel*
- ⇒ *Jacket-type Magnetic Shield*

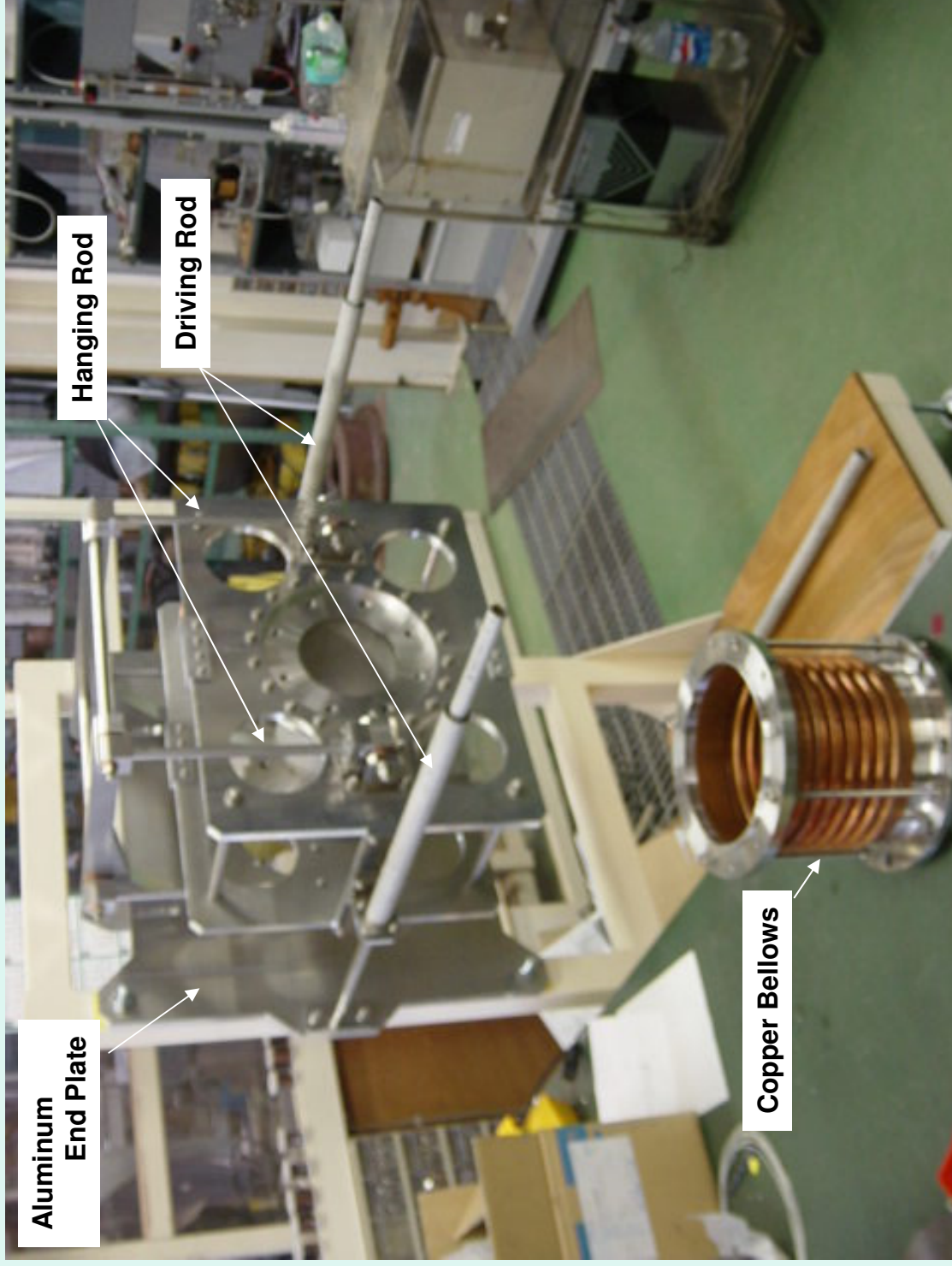


Crab Cavity in He Vessel (3D)



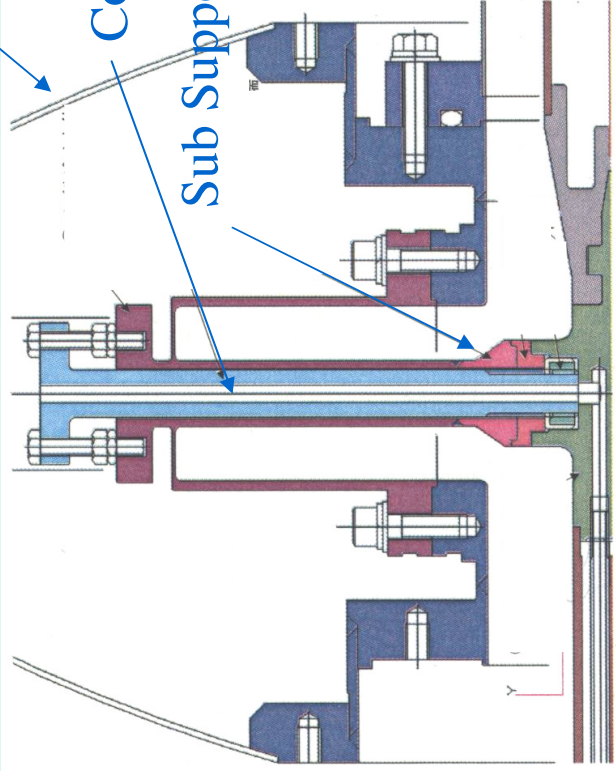
Support Structure for Coaxial coupler

Mock-up Model

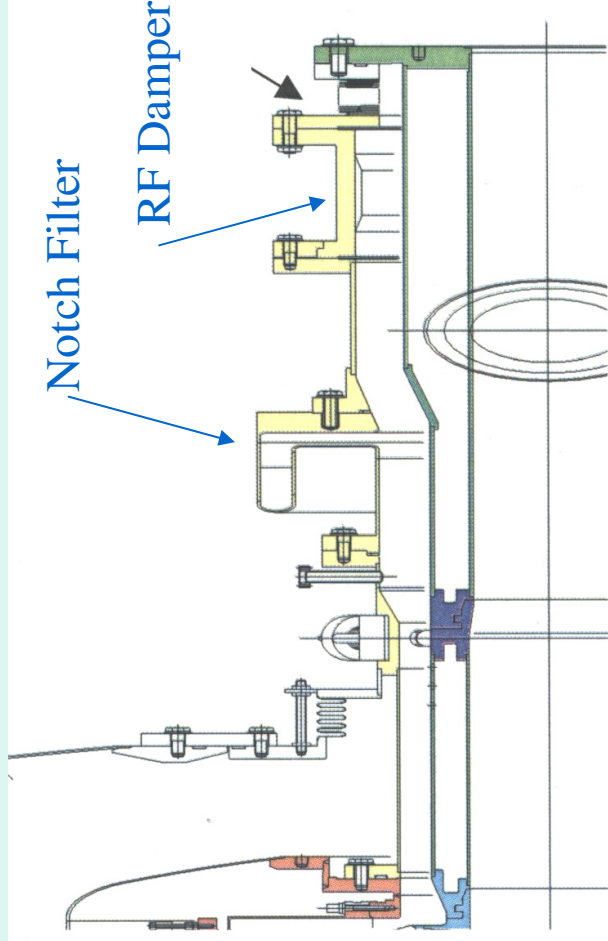


Coaxial Coupler & Stub Support

Jacket Type Sub He vessel



Stub Support Part (Detail)



Coaxial Cavity Inner Conductor

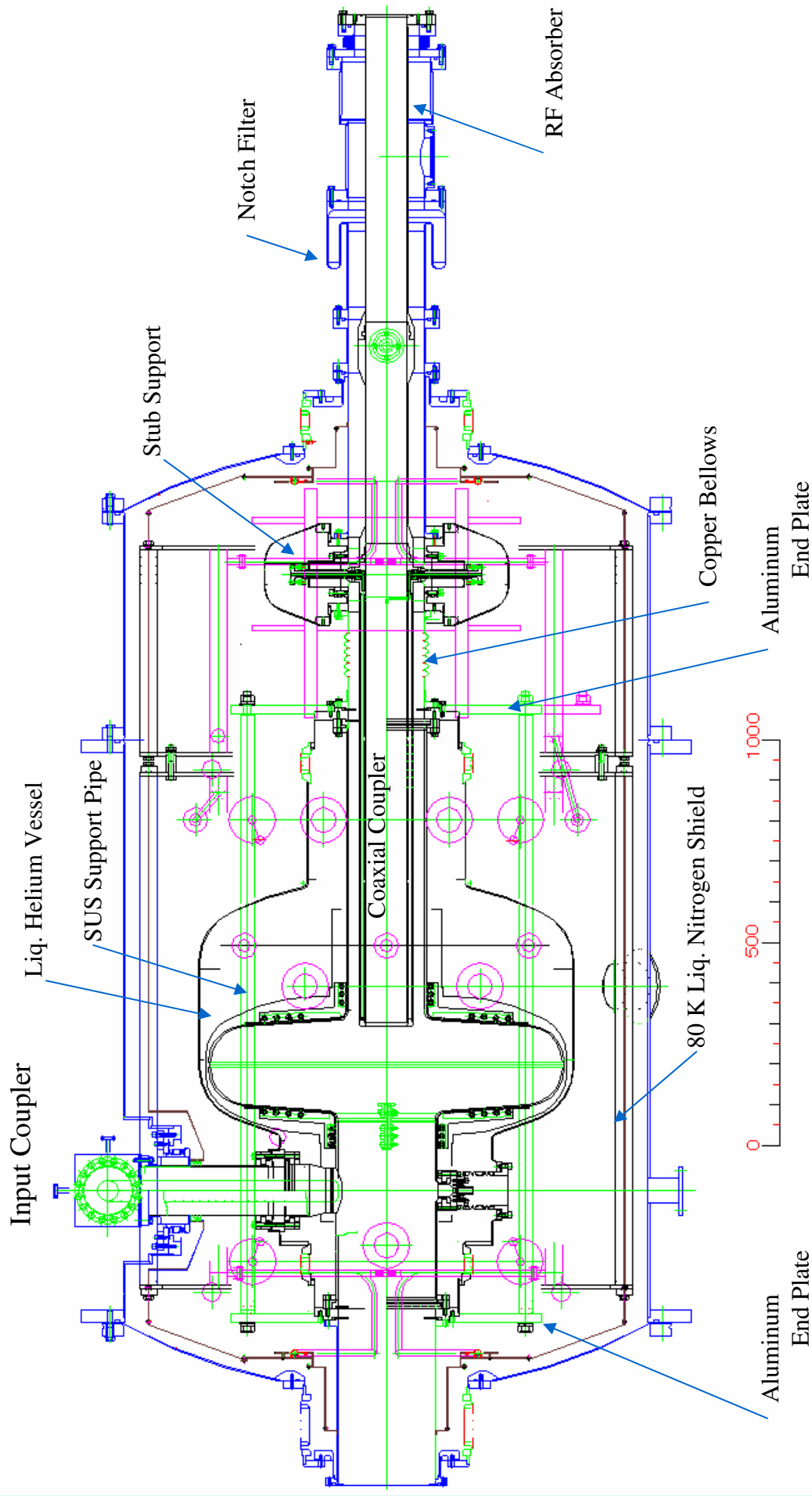
⇨ Taper Structure for HOM Damping

Crab Cavity in Cryostat Top View

Heat Loss

80K 110 W

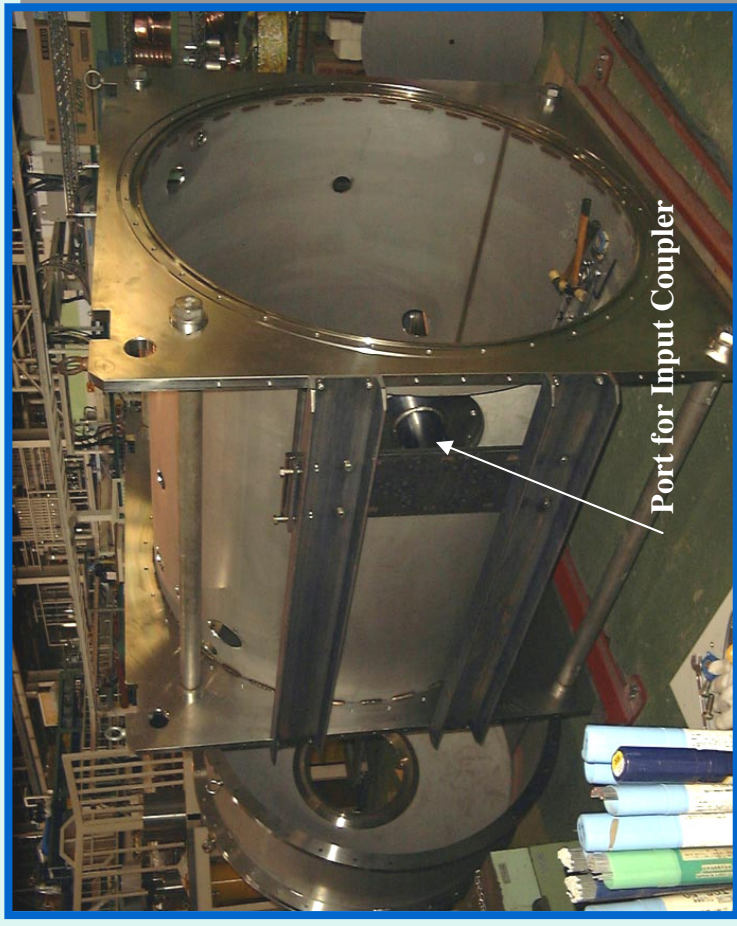
4.2K 15 W



Cryostat Vacuum Chamber



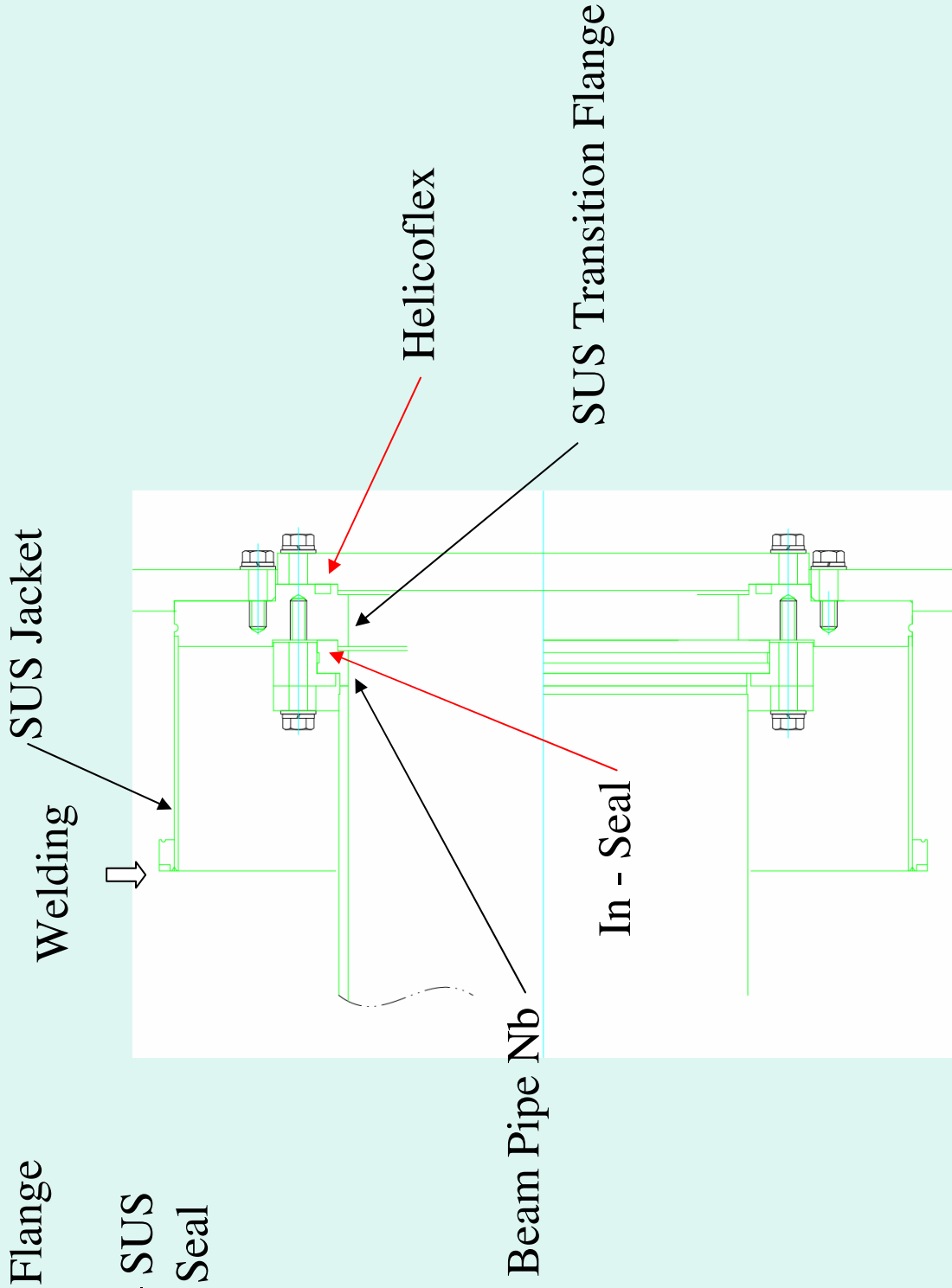
Proto-type cryostat for Crab cavity
is now constructing at KEK.



Transition Flange 1

Transition Flange

Niobium – SUS
by Indium Seal



Transition Flange 2

Cool-down Test

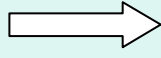
Transition Flange
Leak Tight?

No Leak!

Easy to Assemble?

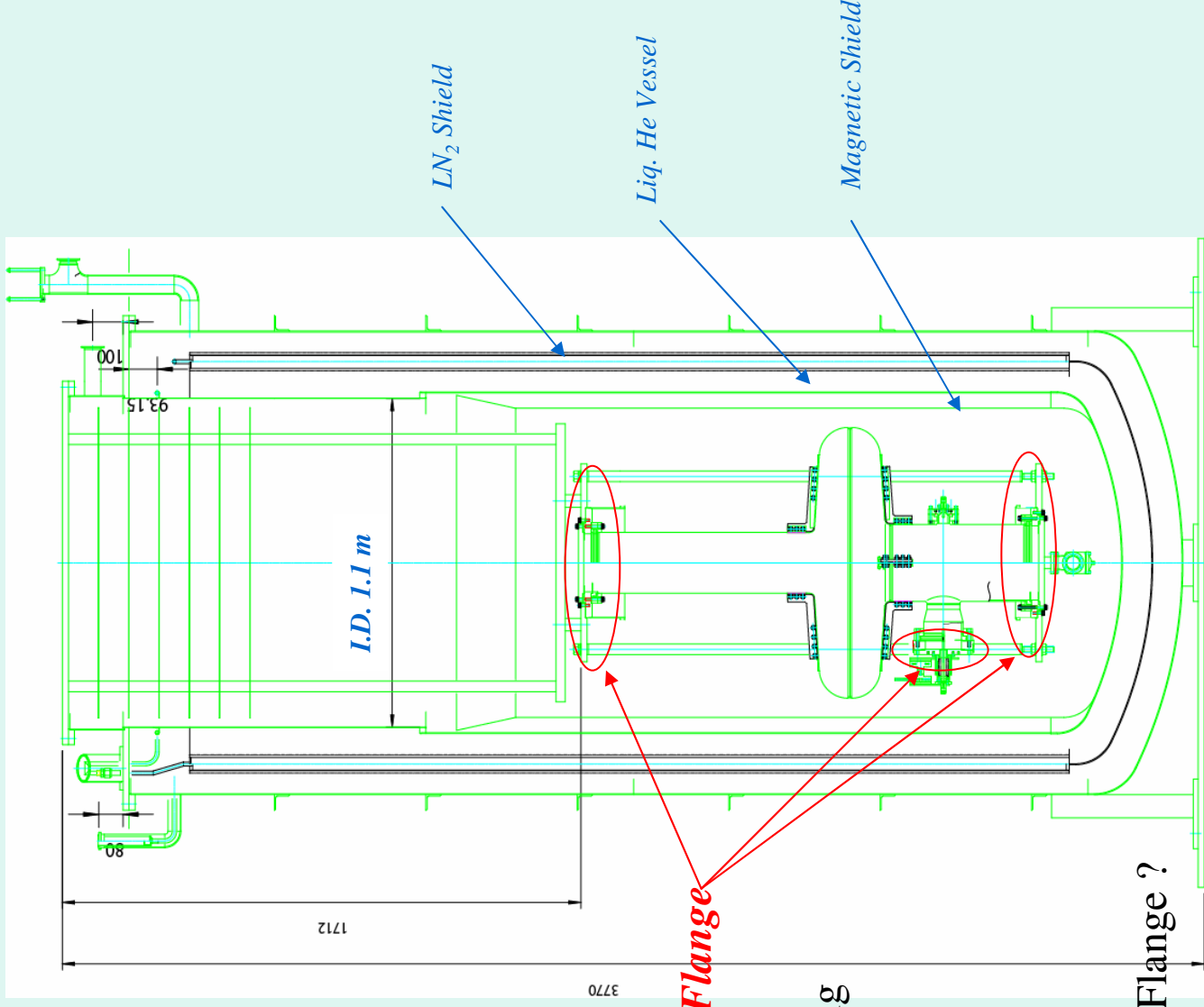
Quick Assembling!
(*Helicoflex*)

Degradation of Qo
Contamination during Assembling



High Pressure Water Rinsing

with In Seal at Transition Flange ?



HPR for Crab Cavity with Transition Flange

New HPR Facility at KEK

Transition Flange

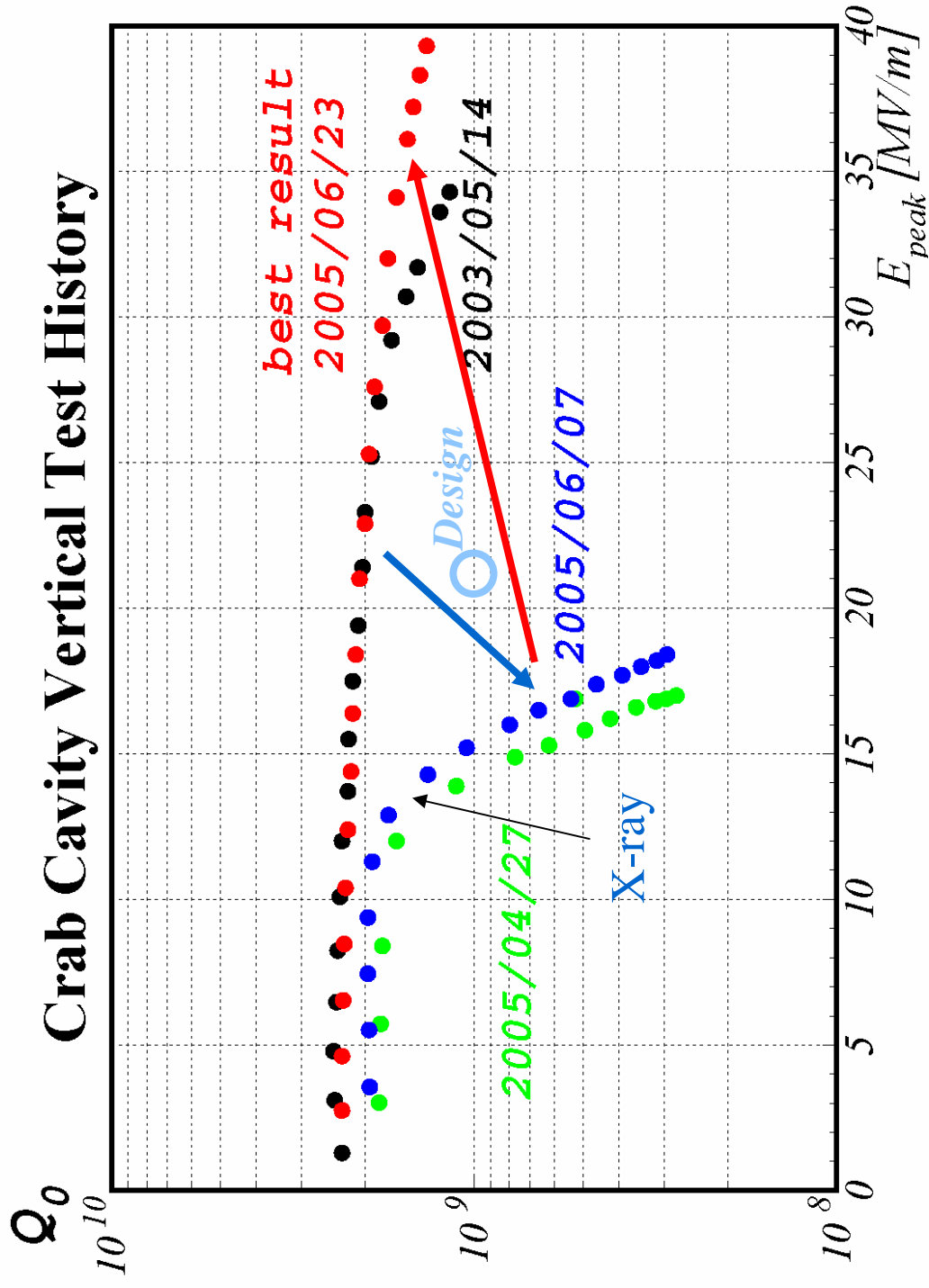


Transition Flange



Nozzle

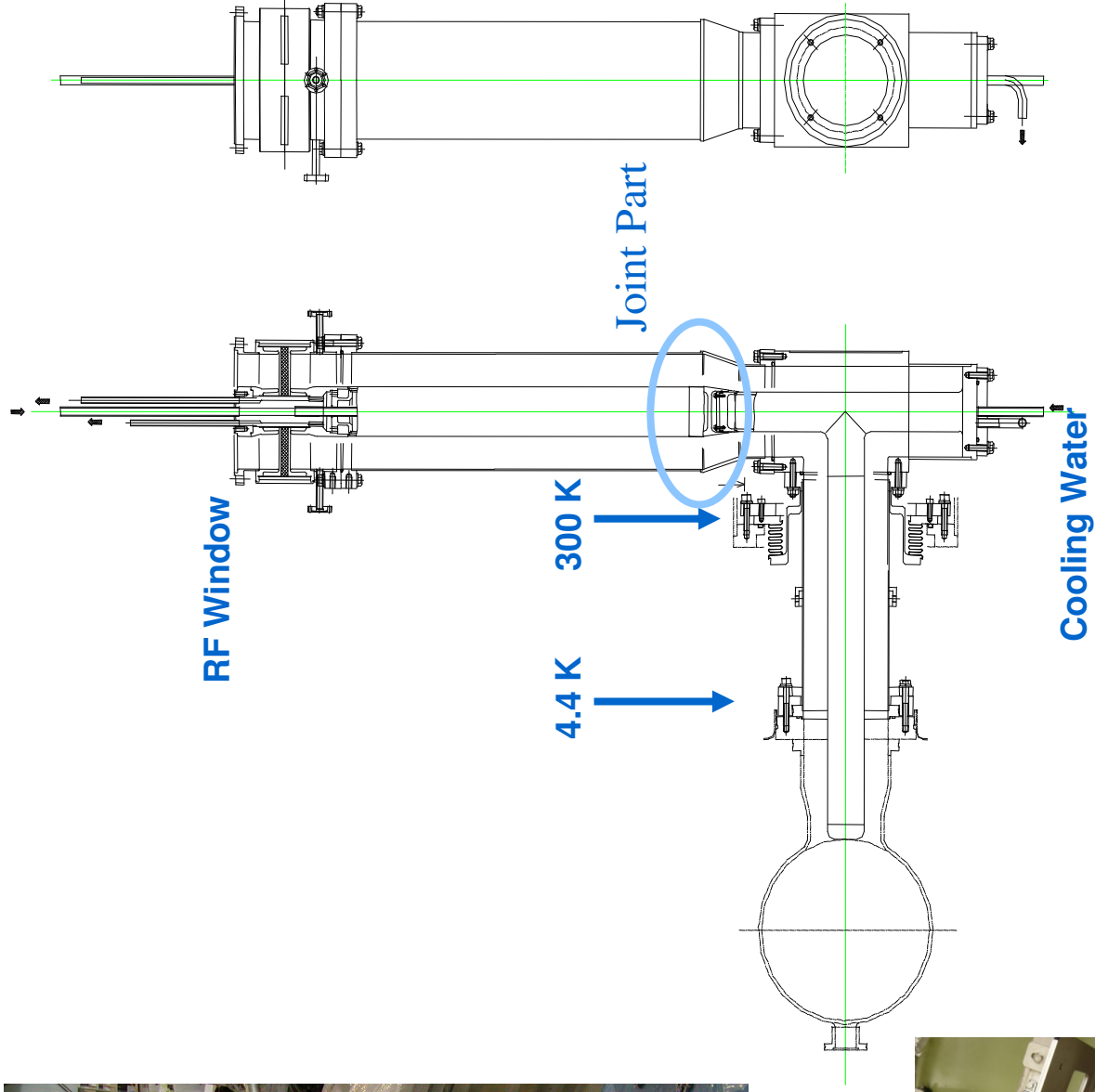
Test Result of KEKB Crab Cavity #2



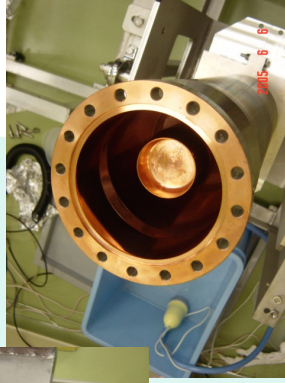
Input Coupler



Cooling Water



Joint Part

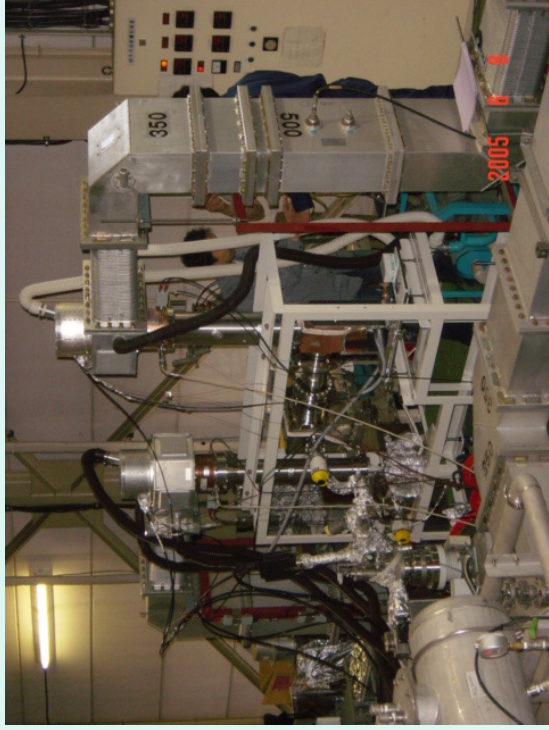
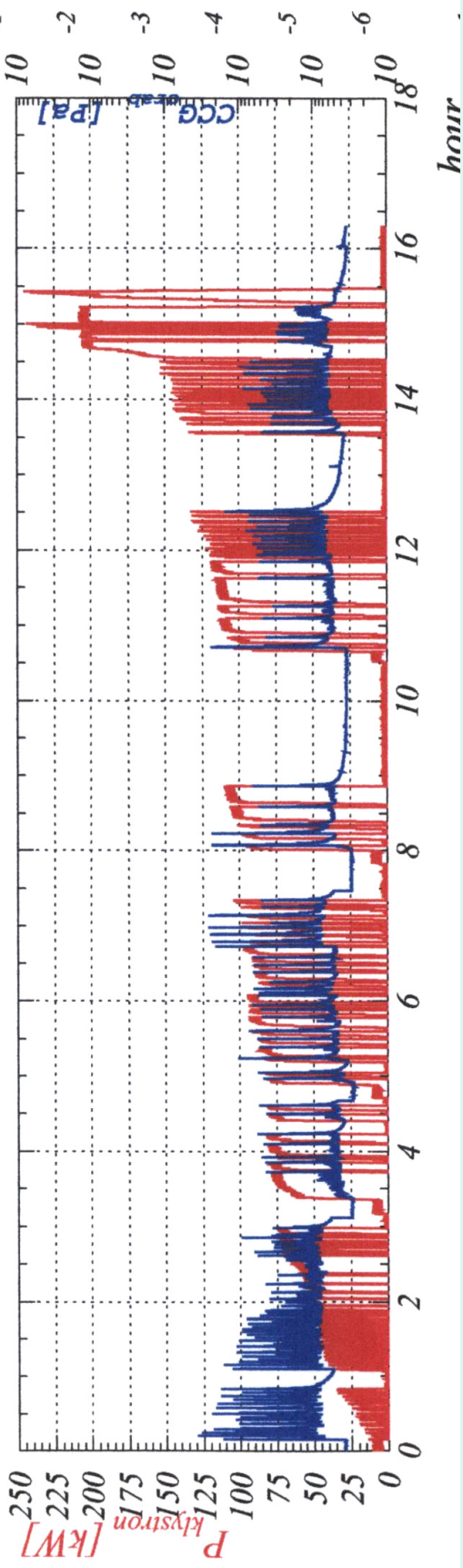


Aging of Prototype Input Coupler for KEKB Crab Cavity

Traveling Wave Test

250kW

Crab test coupler (05/06/09 ~ 05/06/13) ↓



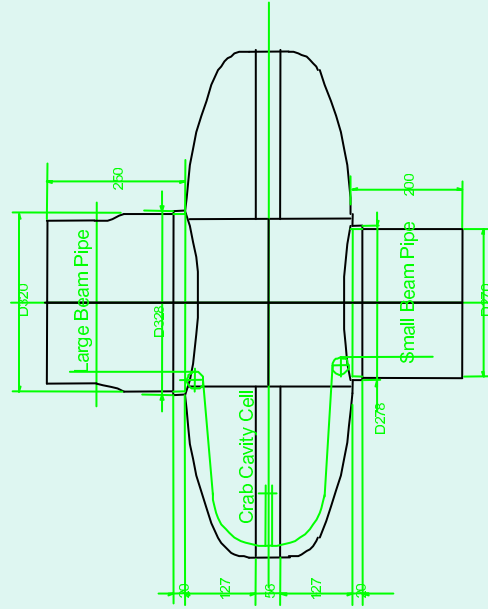
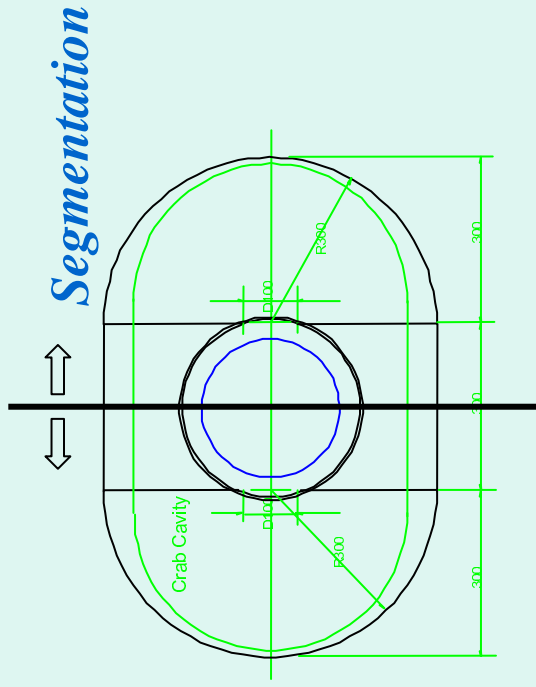
Standing Wave Test

Reach 200kW !

High Power Test Stand

Magnetic Shield (Jacket Type)

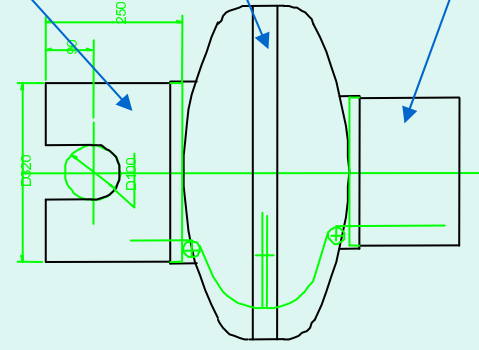
Permalloy 3t



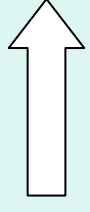
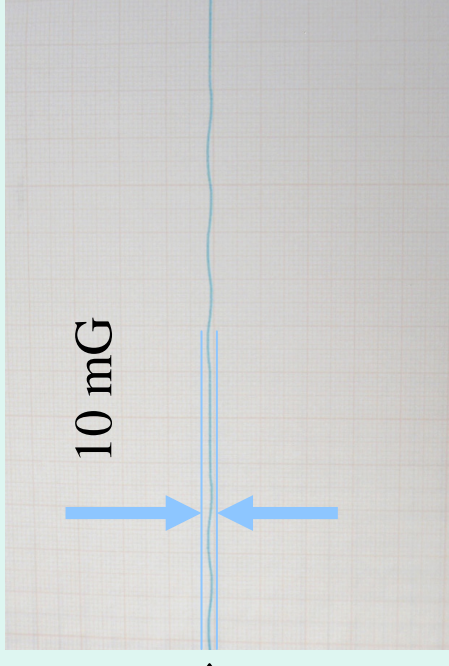
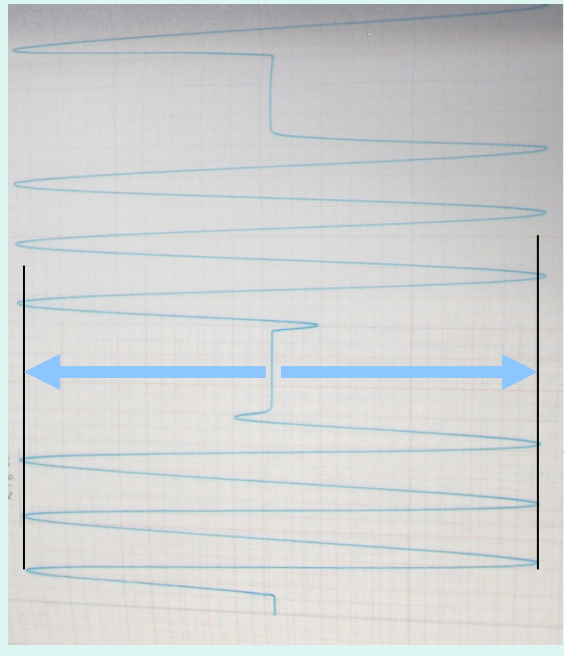
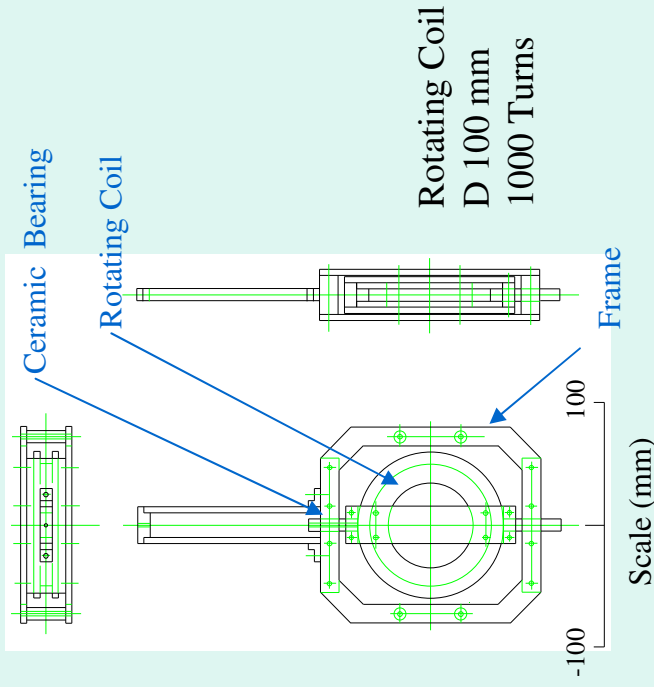
Large Beam Part

Cell Part

Small Beam Part



Shielding Effect / Jacket Type (Geomagnetism)



With Jacket Type Shield

No Shield

Summery

- We could fabricate 2 full size crab cavities which have satisfactory RF performance for KEKB crab crossing.
- A prototype cryostat for crab cavity is now under fabrication.
- Installation of 2 crab cavities in “Nikko” straight section of KEKB was decided in 2004.
- Two crab cavities is now fabricating on schedule.
- These 2 crab cavities will be installed in KEKB in Feb. 2006 for beam test.