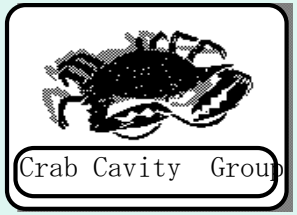


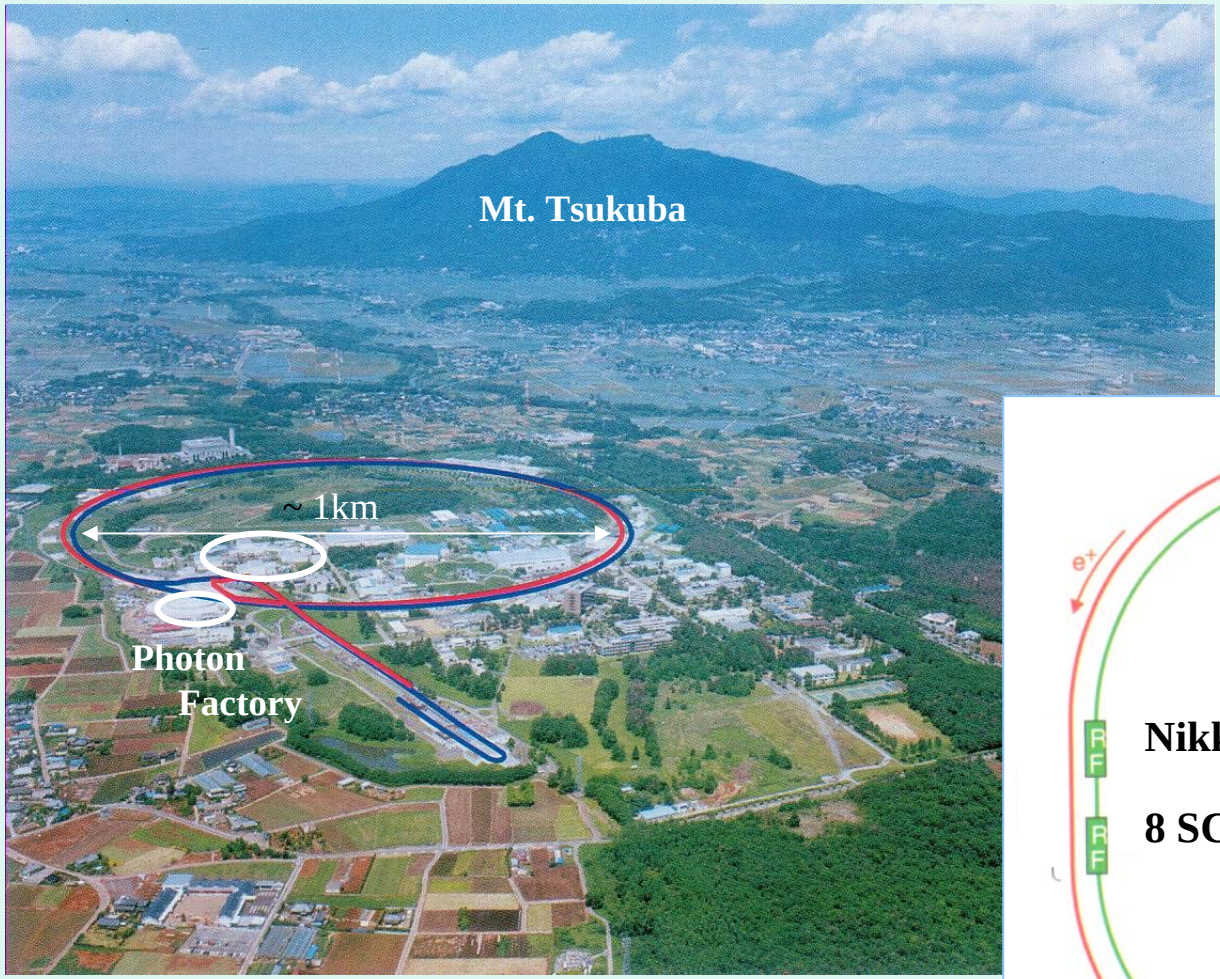
Crab Cavity Operation at the KEKB-Factory

- Status and Prospect of Crab Cavity

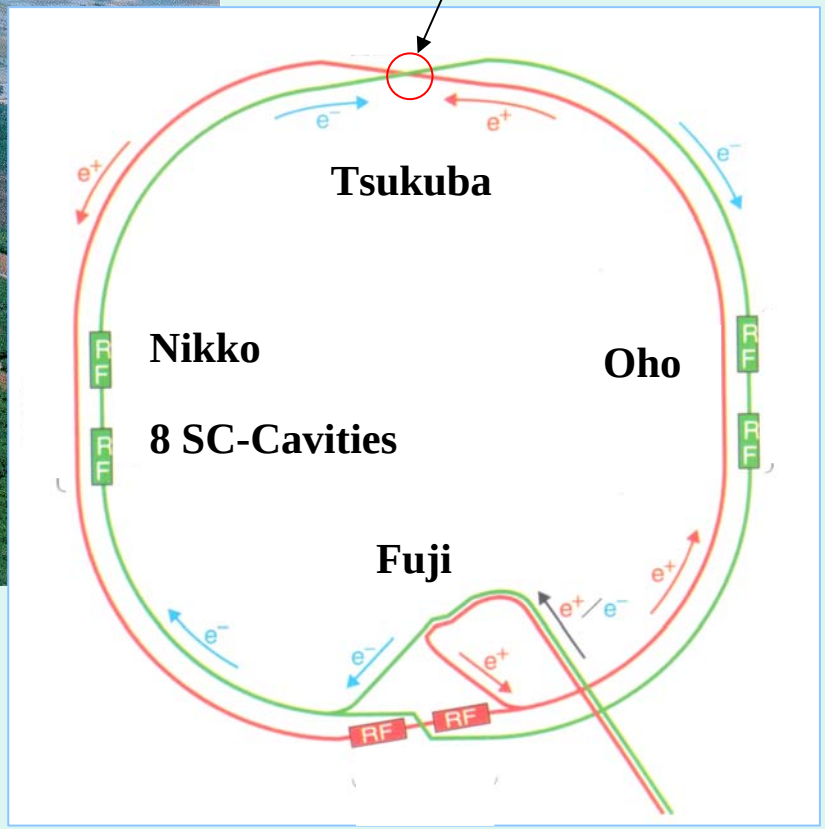
KEK Crab Cavity R&D Group
K. Hosoyama

KEKB
Crab Crossing Scheme
KEKB Superconducting Crab Cavity
RF Performance Test
Cryostat for KEKB Crab Cavity
Construction Schedule
Summary

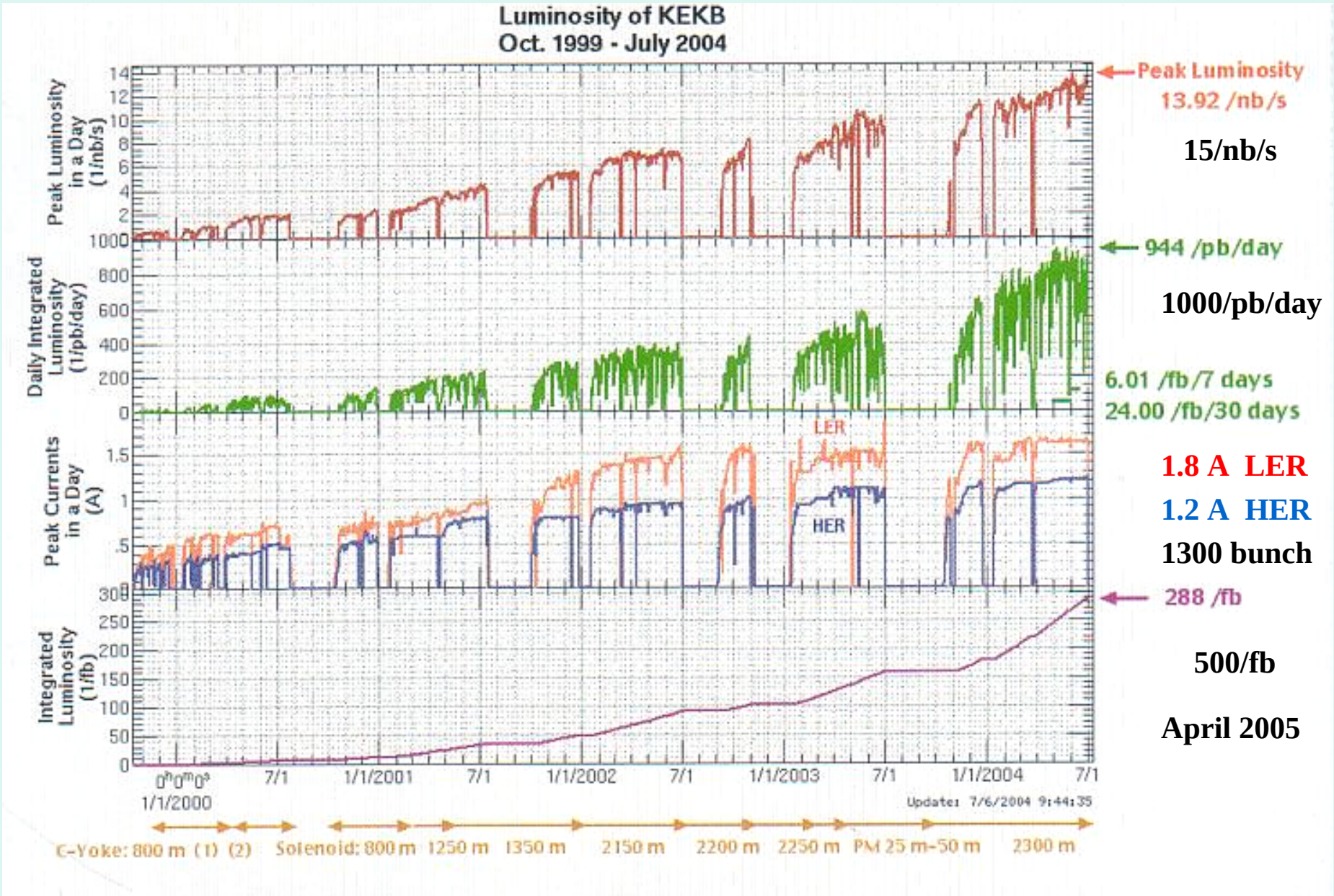
KEKB Electron-Positron Collider



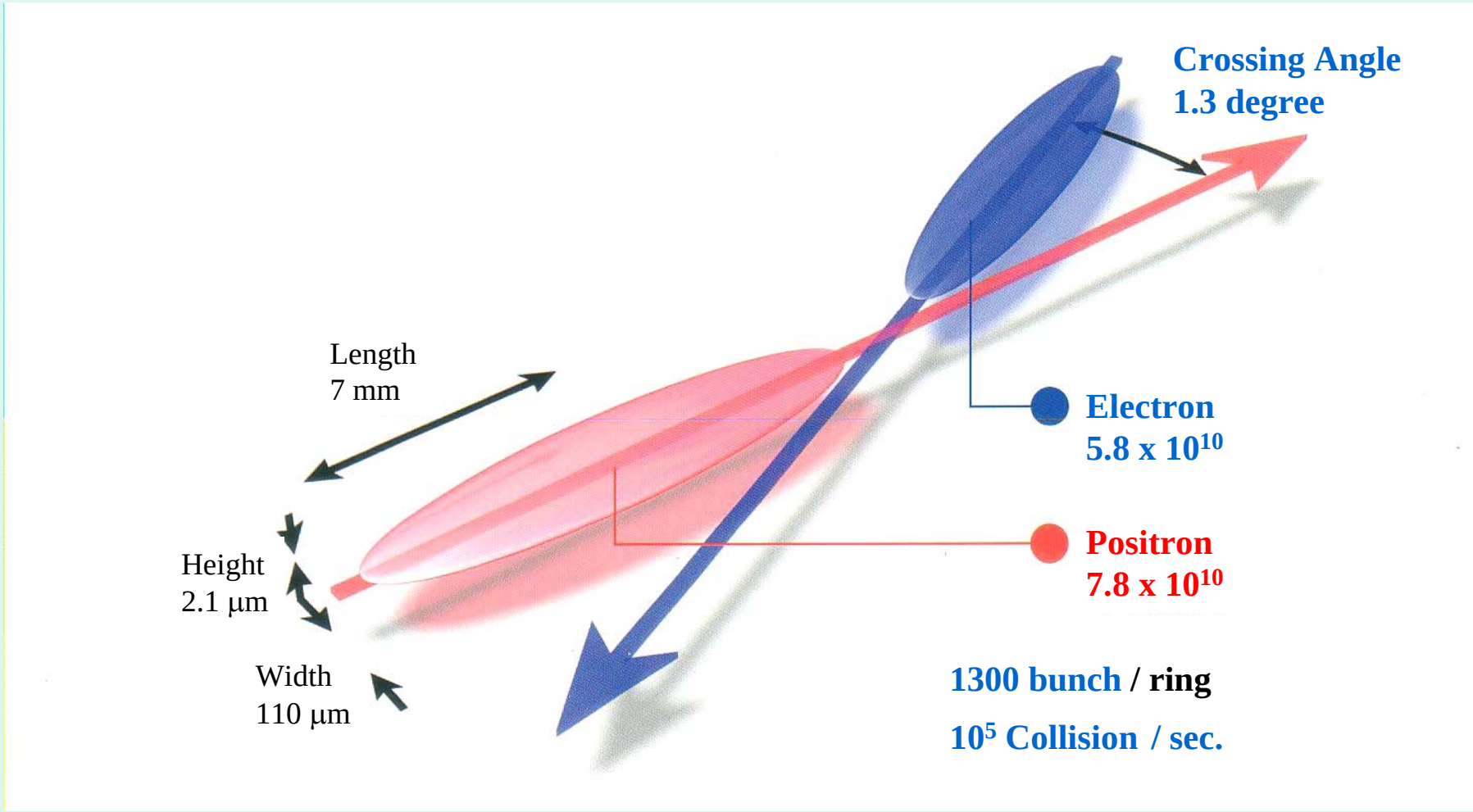
LER	3.5 GeV
HER	8.0 GeV
RF freq.	508.9 MHz
Cross. Ang.	11x 2 mrad.



History of KEKB Operation



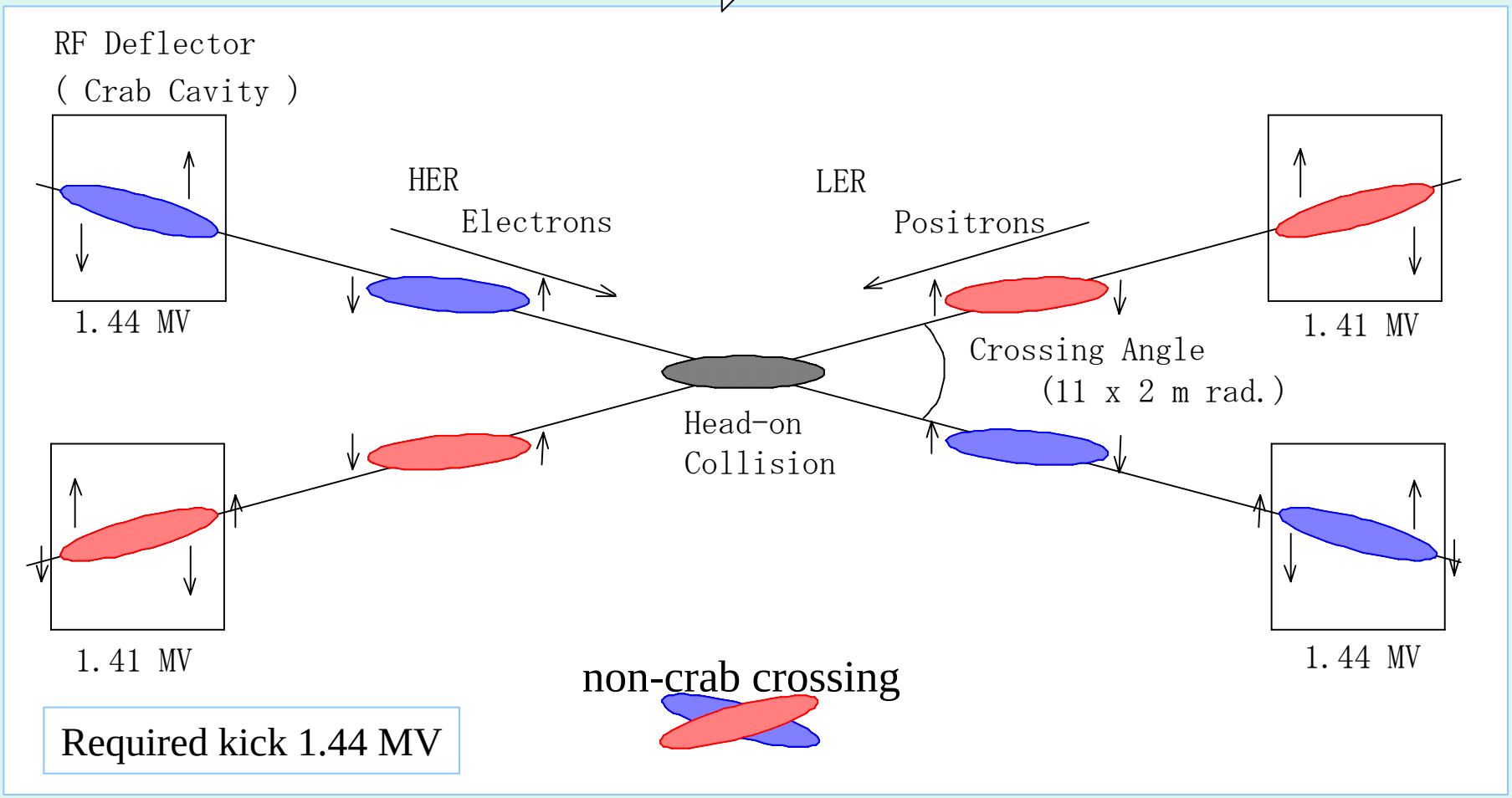
KEKB Finite Crossing Scheme



KEKB Crab Crossing (Original)

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



Required kick 1.44 MV

New Crab Crossing Scheme

Installation of 2 Crab Cavities in “Nikko Straight Section”!

Beam-bunch wiggle around the whole ring!

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

Cooling power of the cryogenic system: 8 kW at 4.4K

Heat Load of Acc. Cavities: ~ 3kW

Enough cooling power for Crab Cavities

We have decided installation of 2 Crab Cavities on Feb. 2006.

FY 2004

Fabrication of 2 Crab Cavities

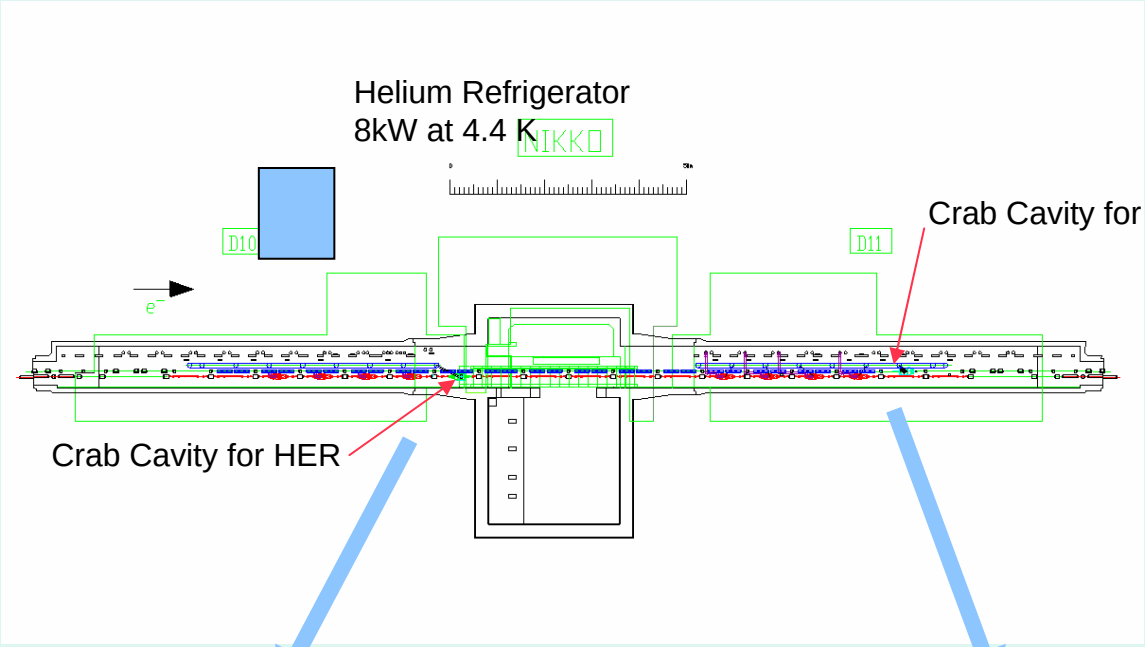
Task Force for Crab Cavity has been established!

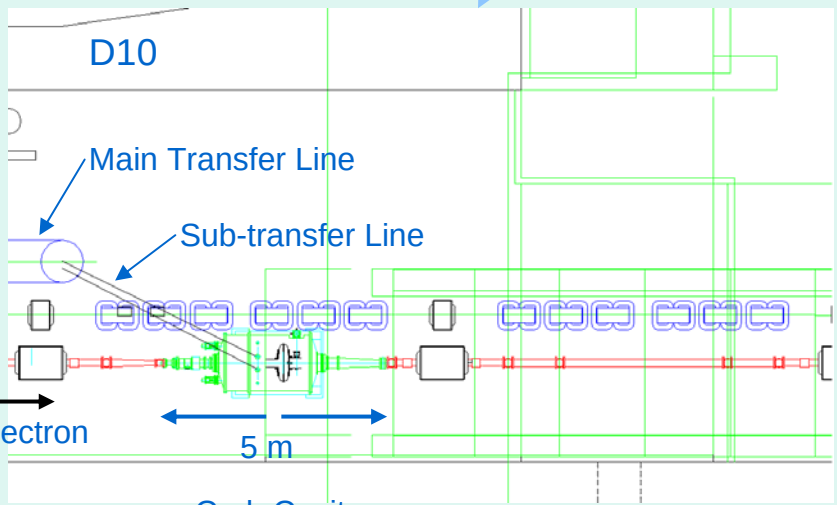
Sub-groups: Optics & Beam Dynamics, Vacuum, RF, Cryogenics, HOM, …

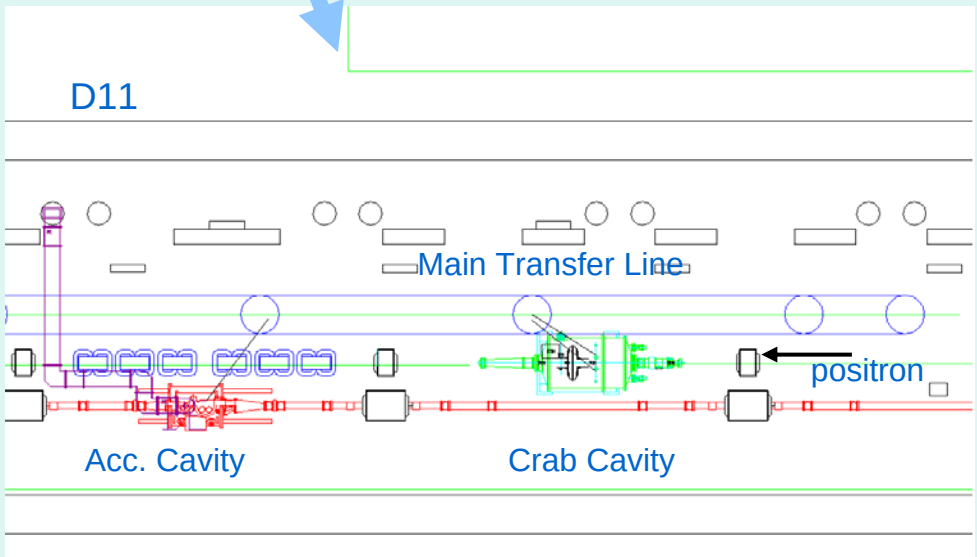
FY 2005

We will start to construct 2 cryostats for the Crab Cavities.

Layout of Crab Cavities in Nikko

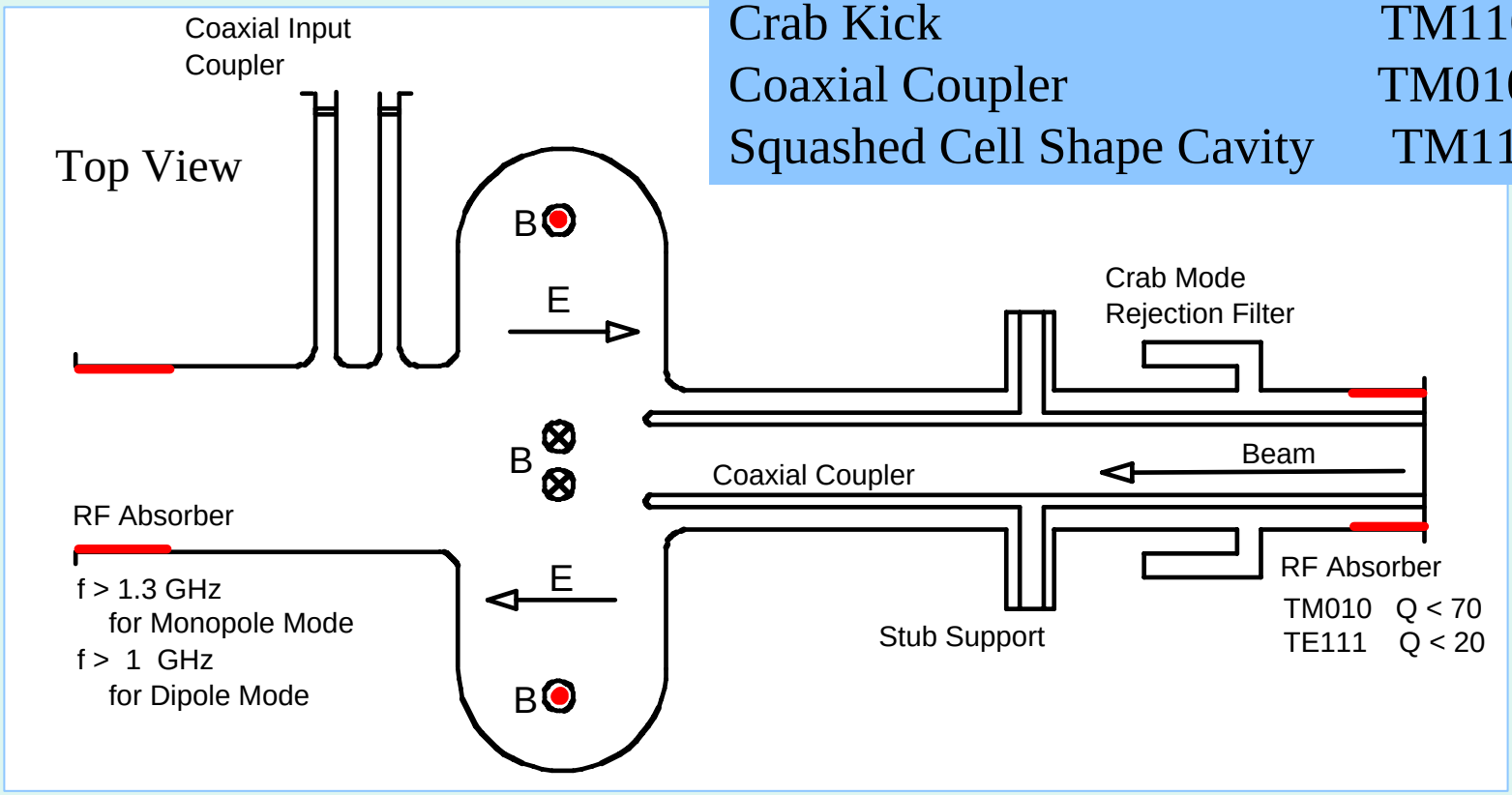






Conceptual Design of KEKB Crab Cavity

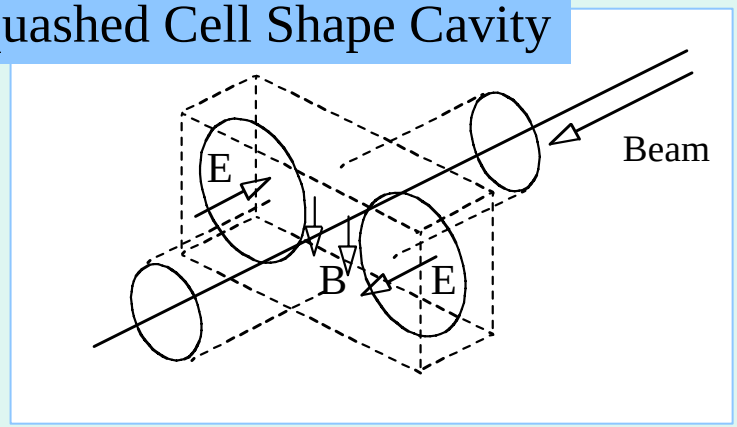
Crab Kick	TM110 B-field
Coaxial Coupler	TM010, TE111
Squashed Cell Shape Cavity	TM110*



⇨ 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”!

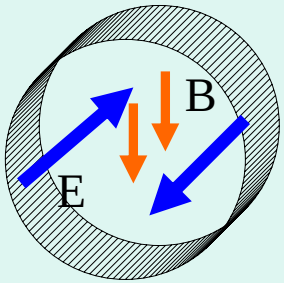
Squashed Cell Shape Cavity



Why squashed cell shape cavity?

TM110

500MHz

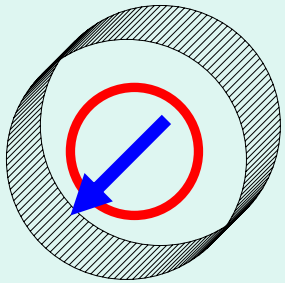


Crab Mode

Unwanted Mode

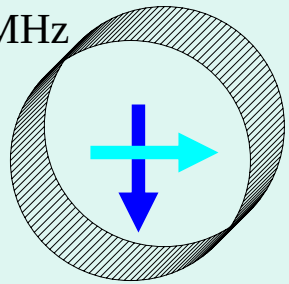
TM010

324MHz



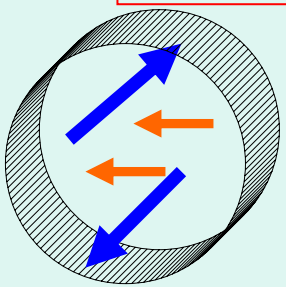
TE111

720MHz



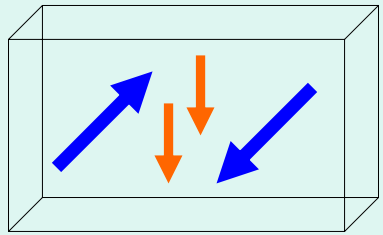
TM110

500MHz



TM110 - like Mode

500MHz

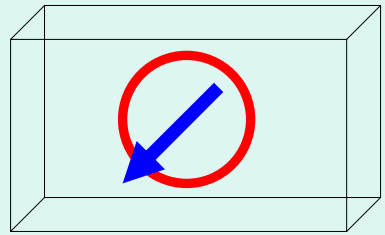


Crab Mode

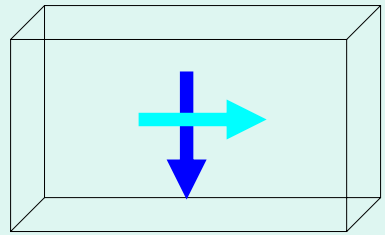
Unwanted Mode

TM010 - like Mode

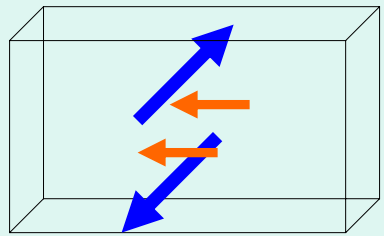
413.3MHz



650.5 MHz / 677.6MHz

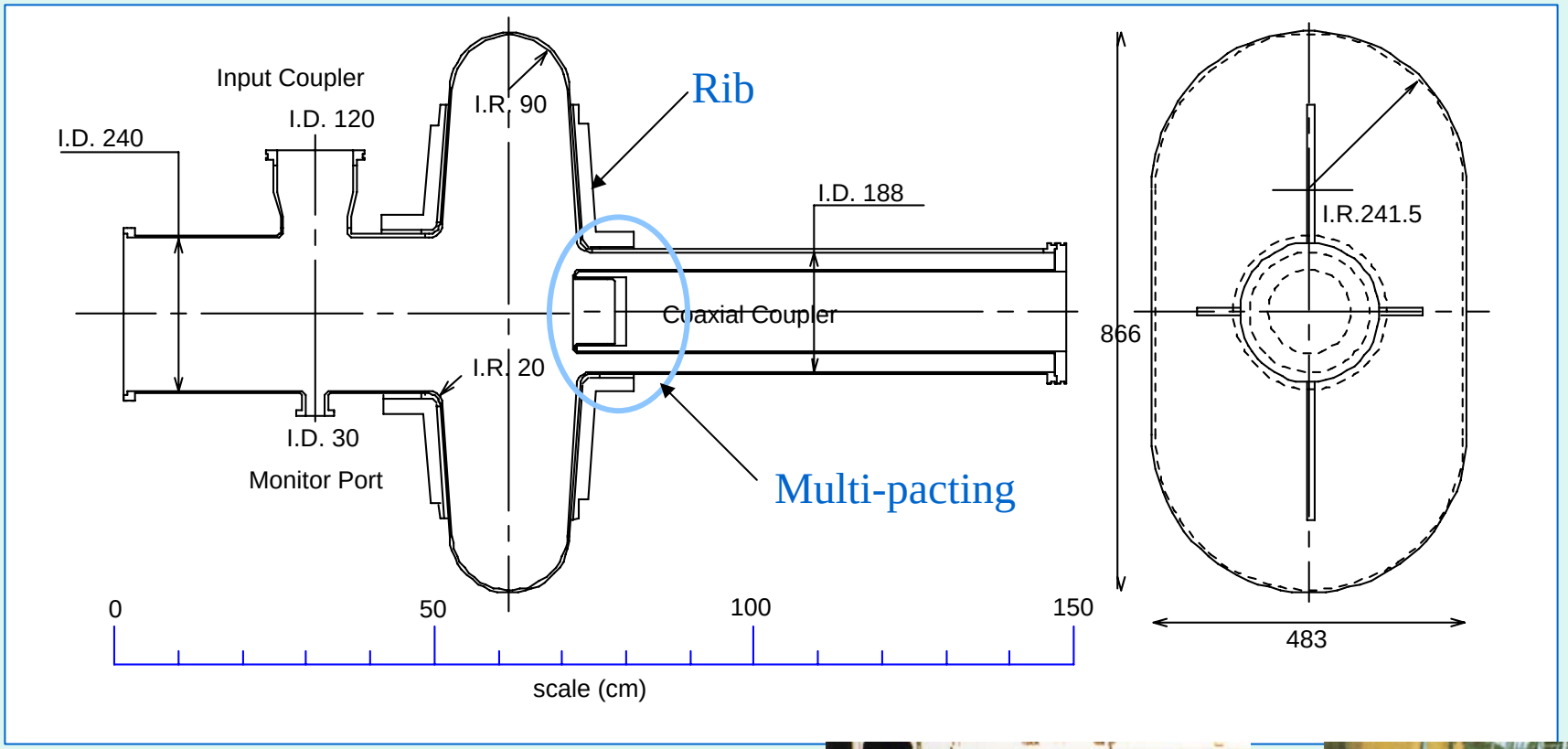


700MHz



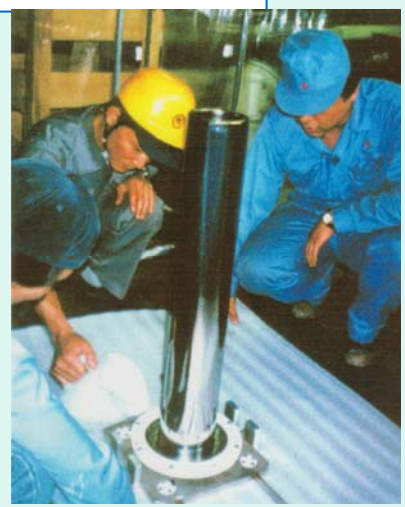
The squashed cell shape cavity scheme was studied extensively at Cornell in 1991 and 1992 for CESR-B under KEK-Cornell collaboration.

KEKB Superconducting Crab Cavity



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

Simplified Coaxial Coupler

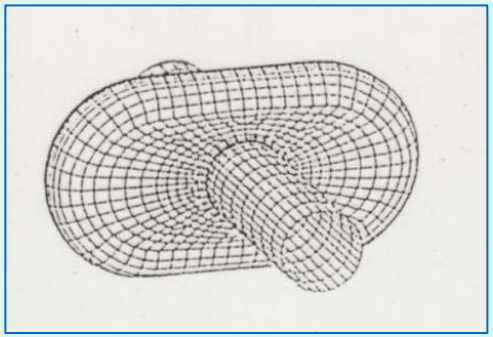


Mechanical Issue

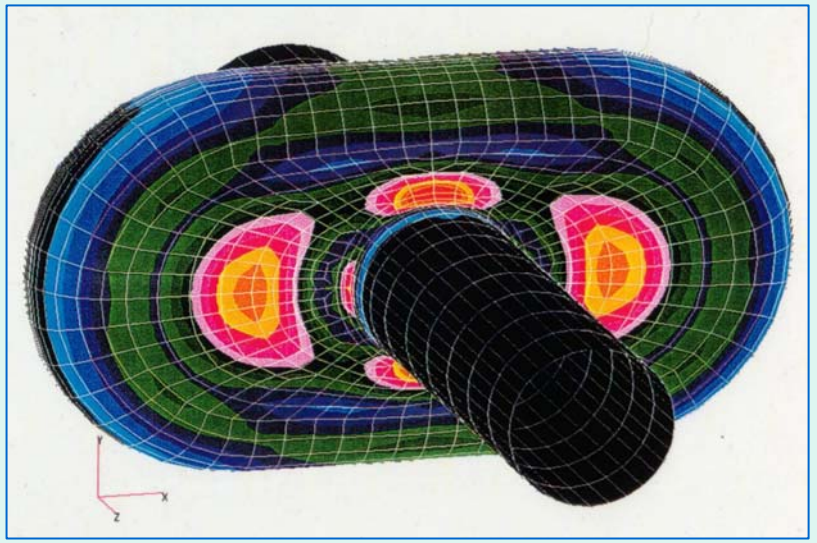
t = 4 mm

σ_{Max} = 17.6 kgf / mm^2 > σ_a

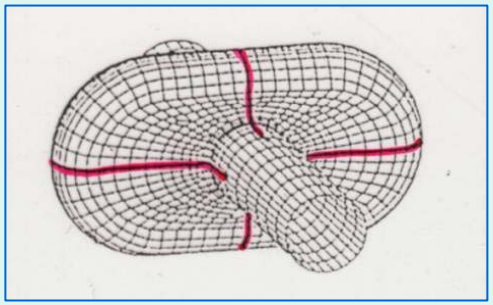
σ_a = 8.1 kgf / mm^2 for Nb

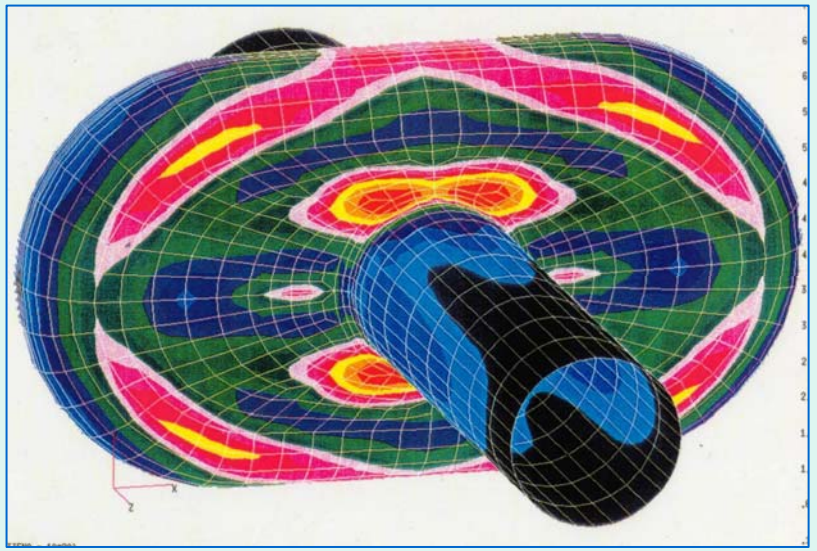


No Rib



t = 4 mm + 4 - Ribs



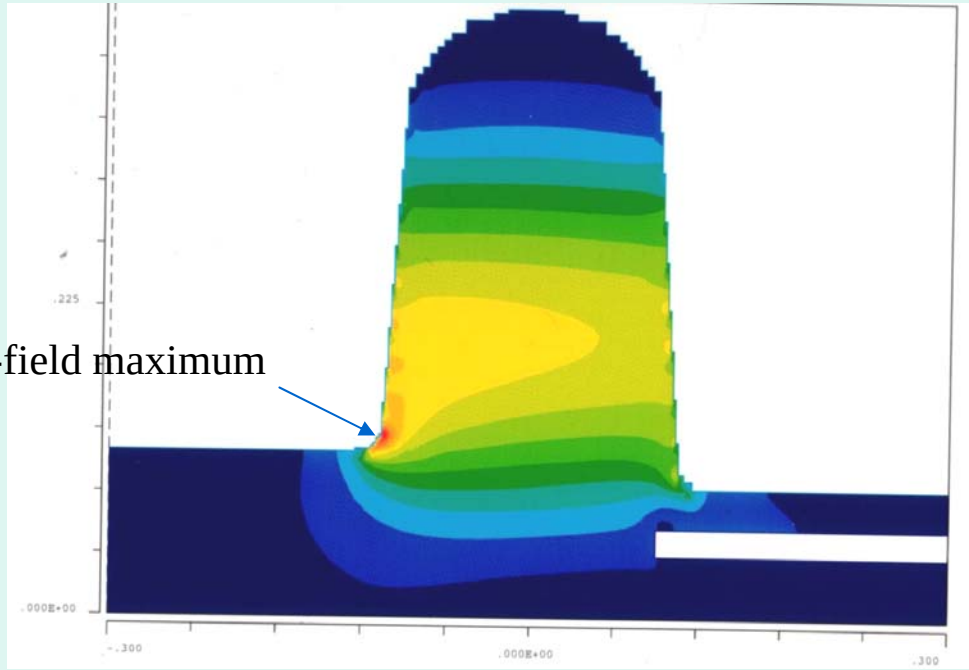


σ_{Max} = 7.41 kgf / mm^2 < σ_a

Conditions : Pressure 1.333 kg/cm^2
Both Ends Free

Electromagnetic Field in Crab Cavity by MAFIA

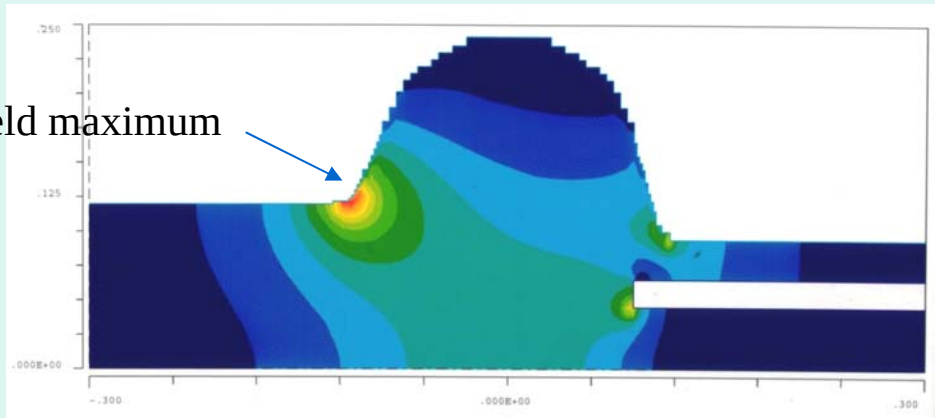
Electric Field in Crab Cavity



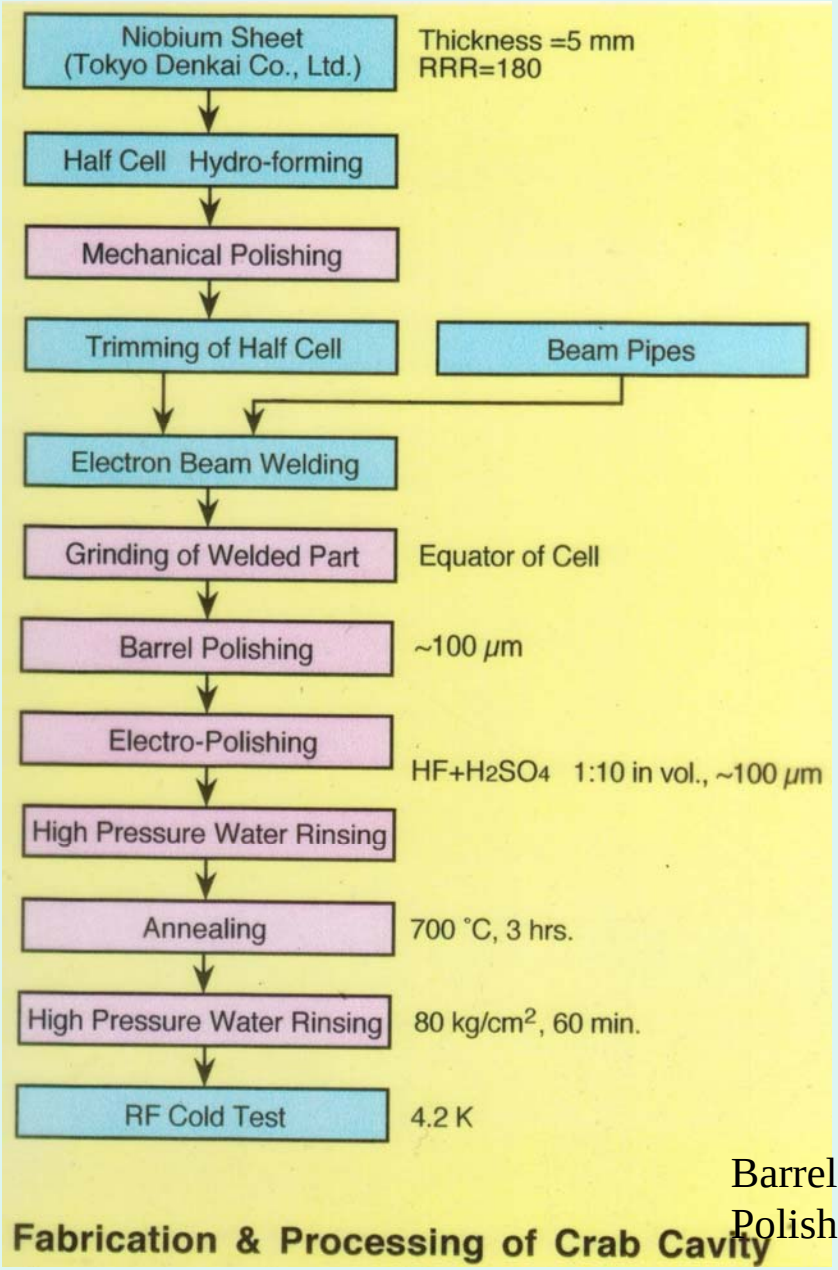
RF parameters for Crab Cavity

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

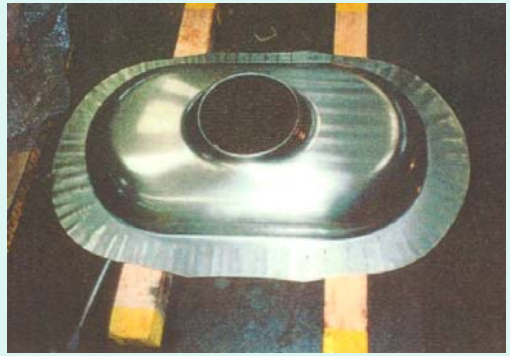
Magnetic Field in Crab Cavity

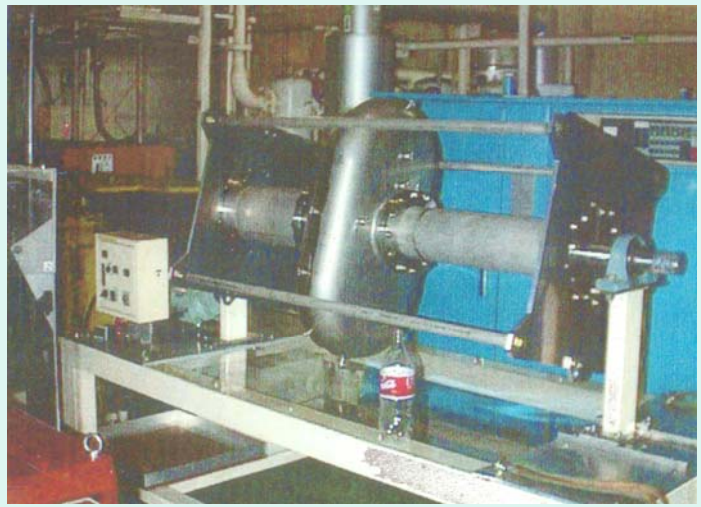


Fabrication of Crab Cavity



Nb
Half Cell





Barrel
Polishing

Crab Half-Cell Forming at MHI

From Y. Yamamoto Report

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.

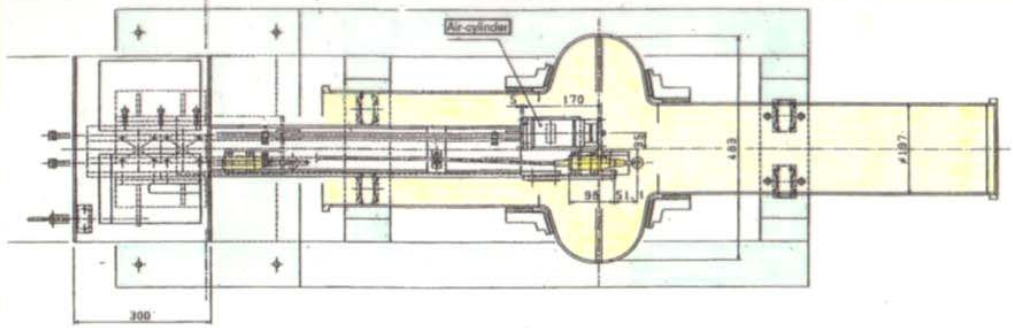
Grinding Machine

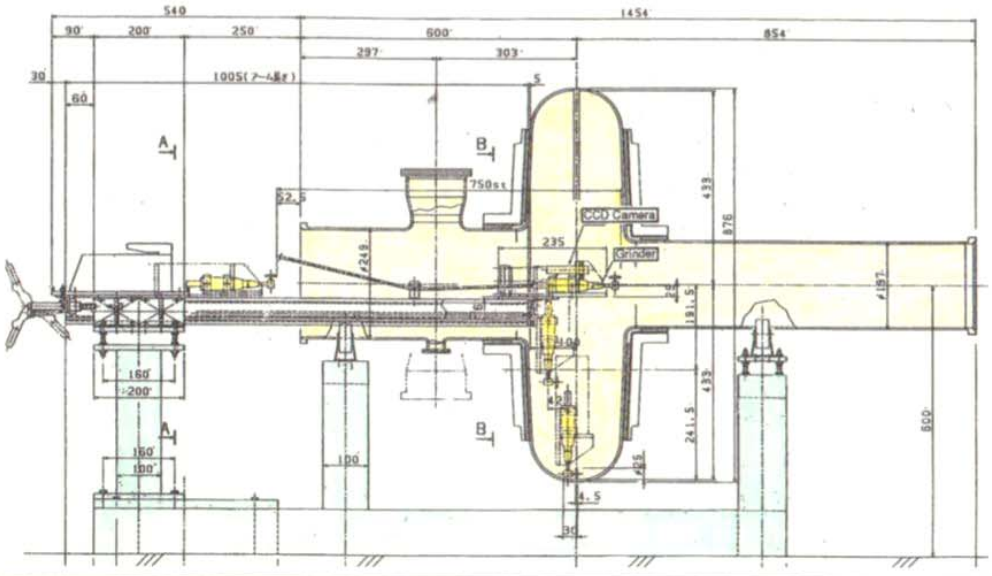
KEK ENGINEERING NOTE

SUBJECT: Crab Cavity
Grinding Machine

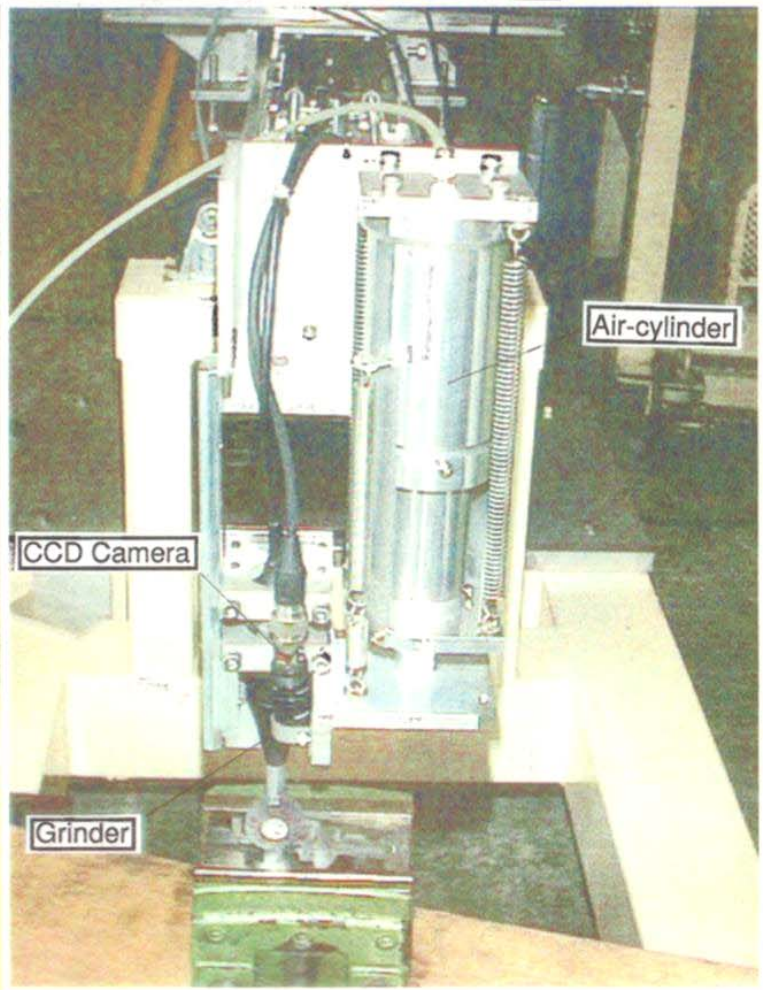
DATE:

NAME:

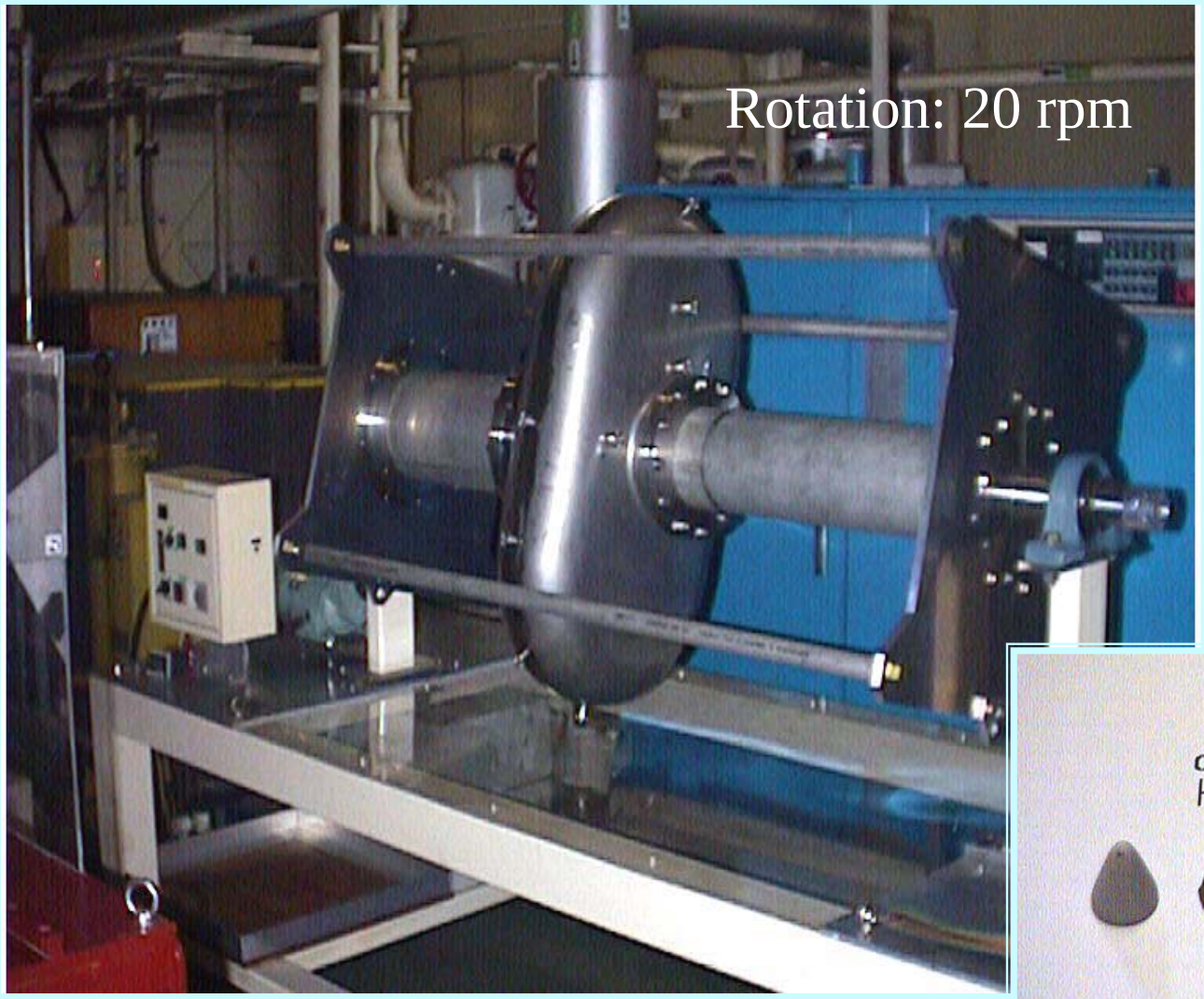




Grinding Machine for Crab Cavity

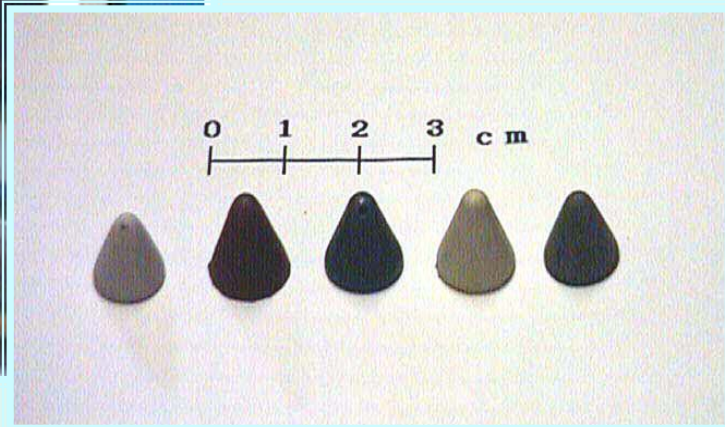


Barrel Polishing



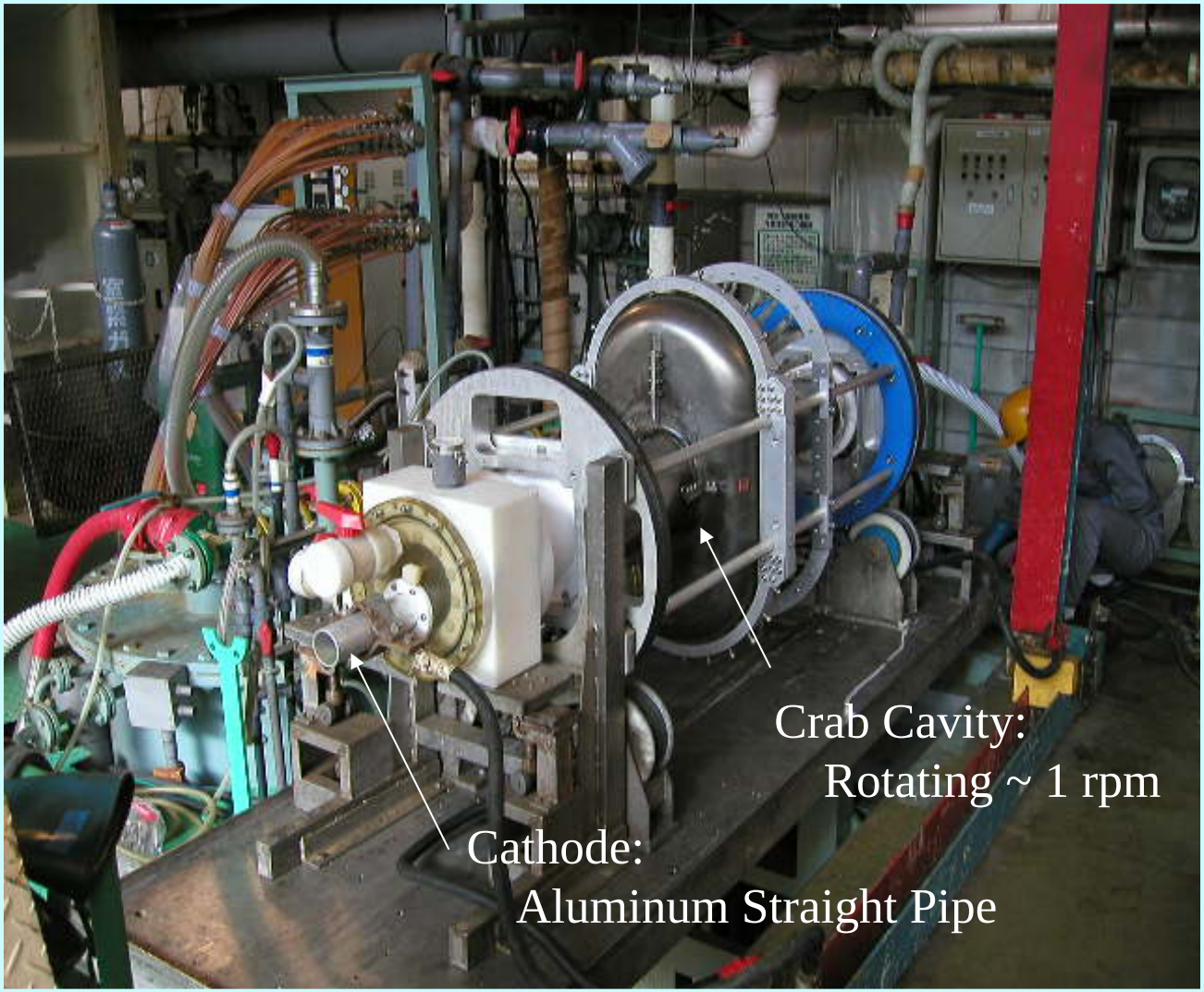
Rough
Medium
Fine

~114 hr

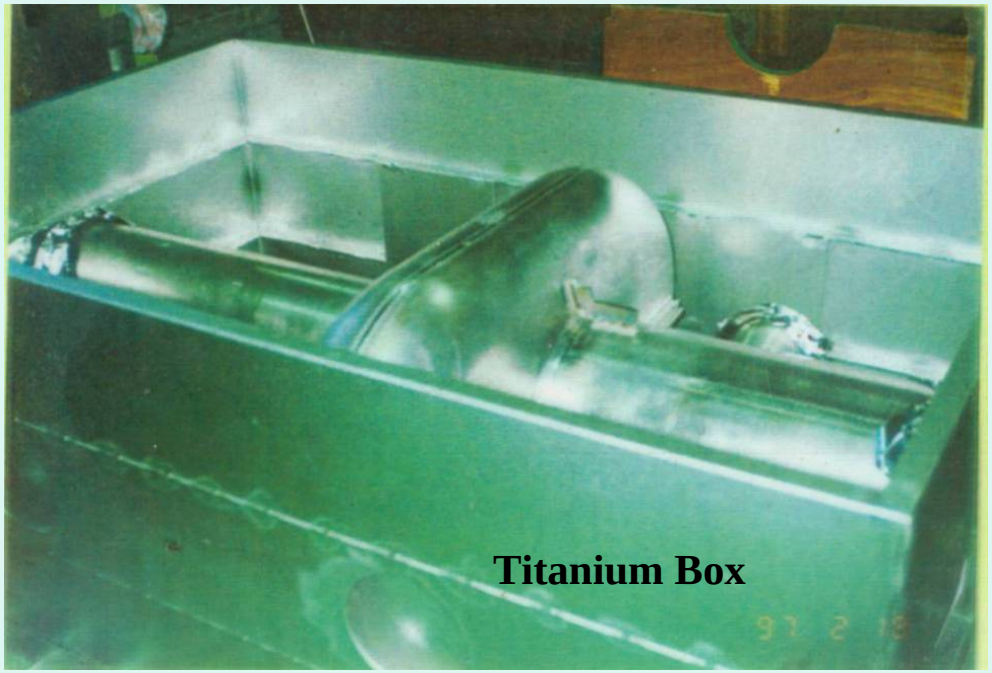


Barrel Chip

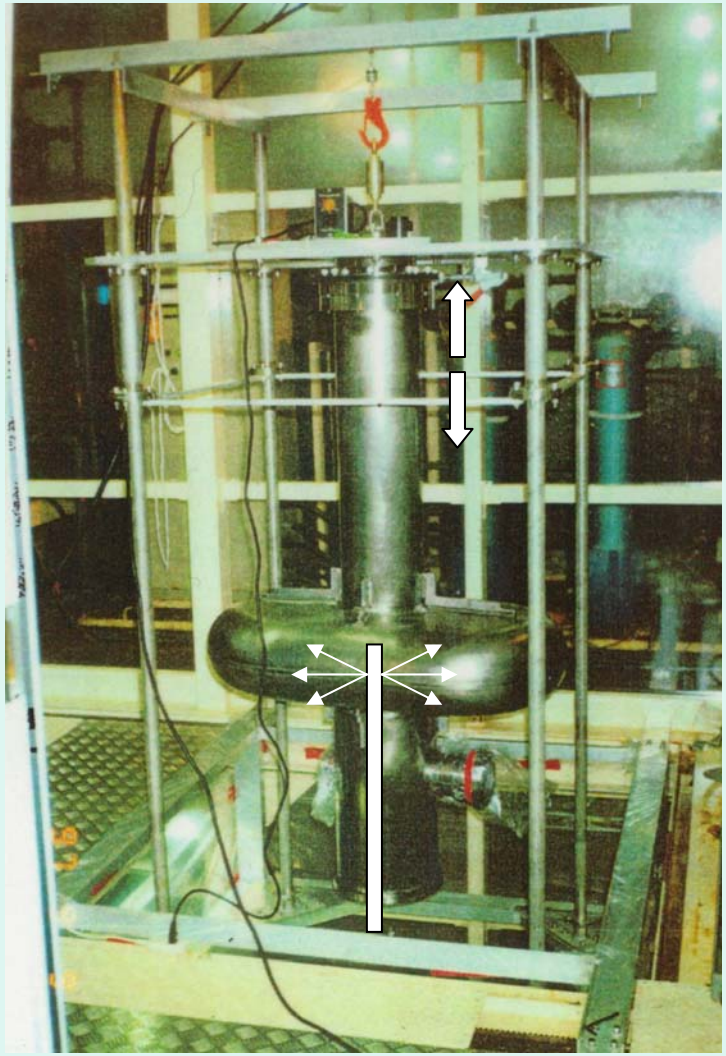
Electro Polishing



Annealing & HPR



Annealing at 700^{0}C for 3 hours

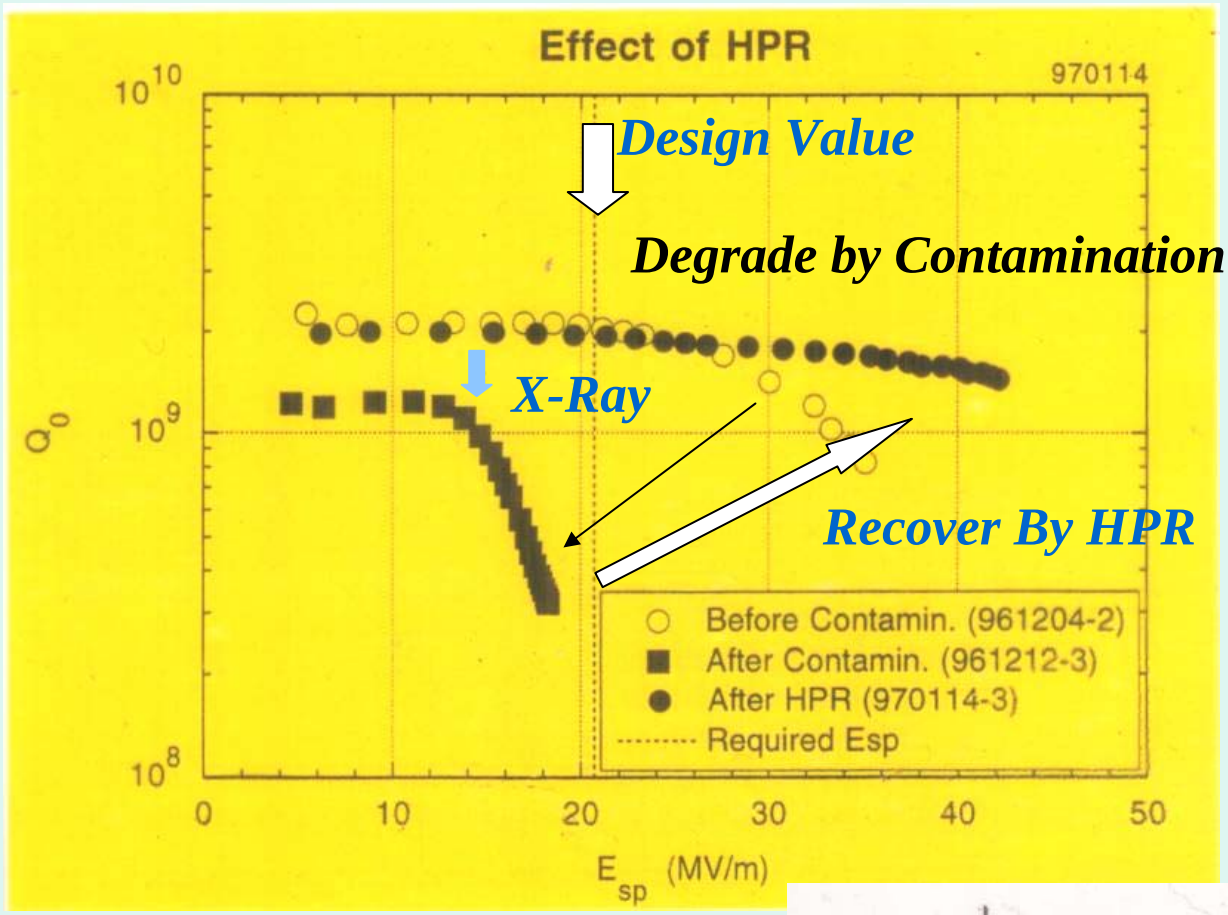


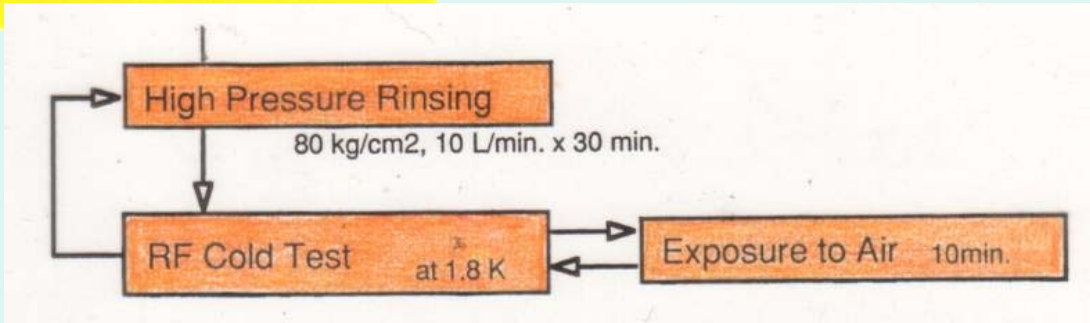
High-Pressure Water Rinsing by 80 bar Ultra-Pure water

Rotation & Up-Down Motion

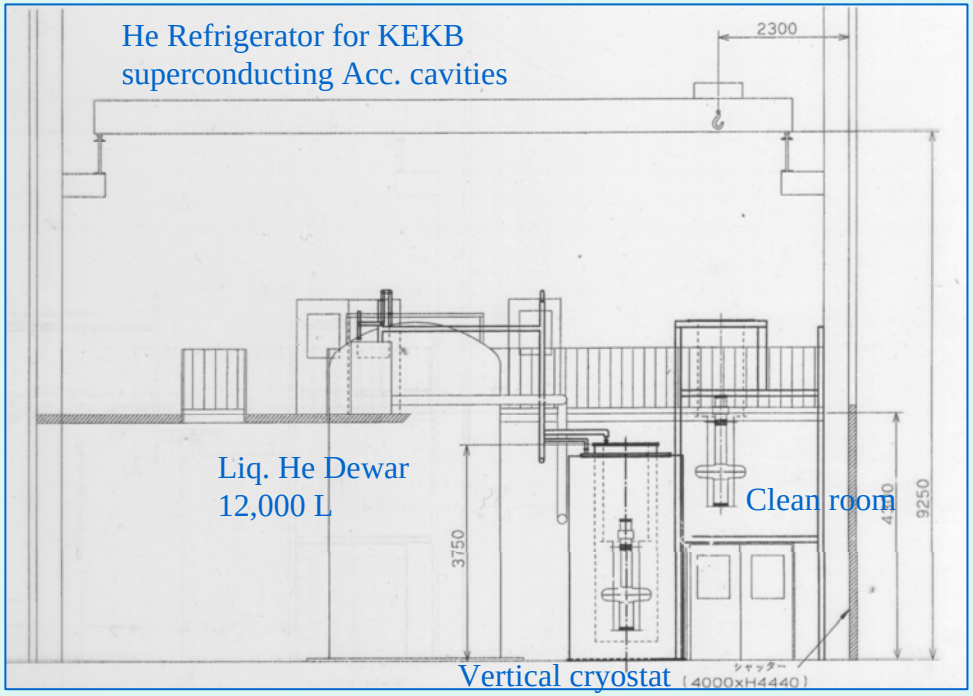
Effect of High-Pressure Rinsing

1/3 Scale Model
1.5 GHz





Cold Test Stand for KEKB Crab Cavity



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

The crab cavity is set in the vertical cryostat

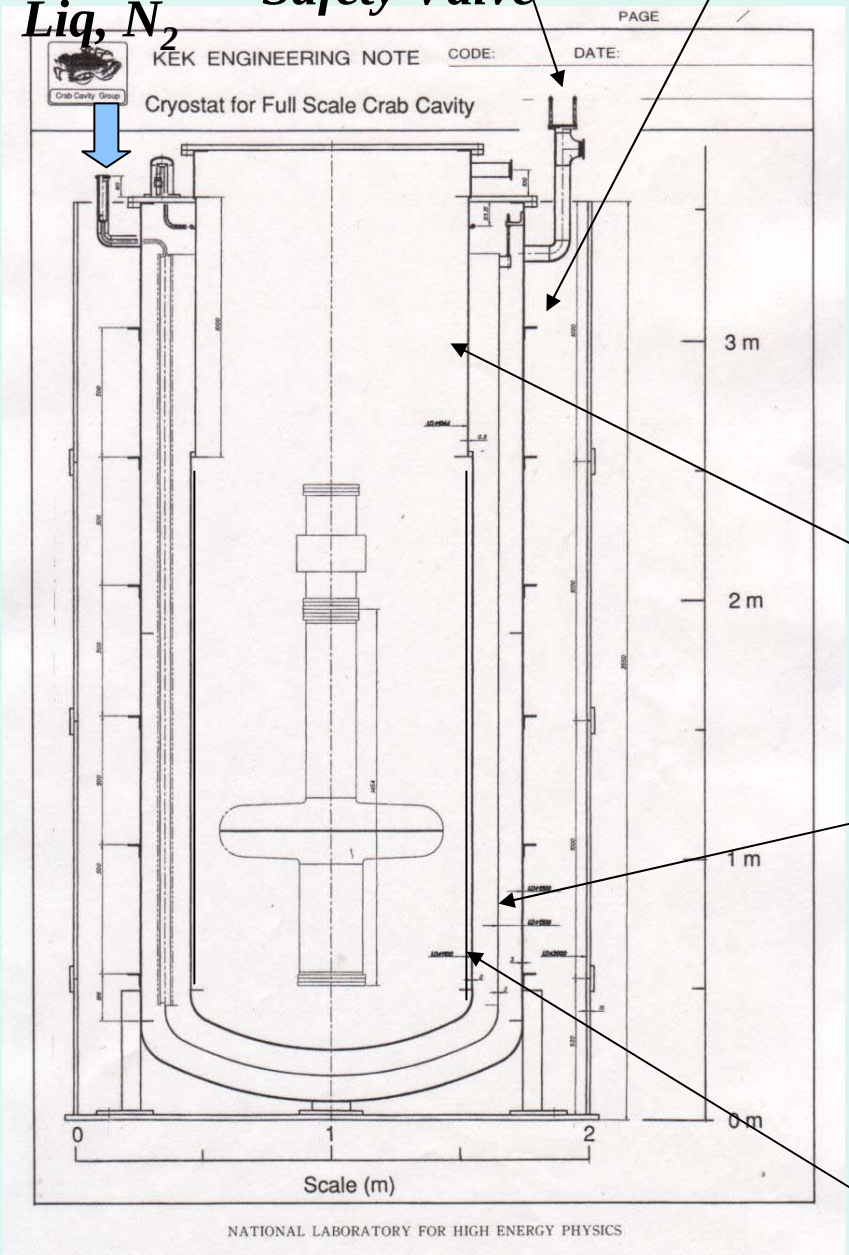
Vertical Cryostat

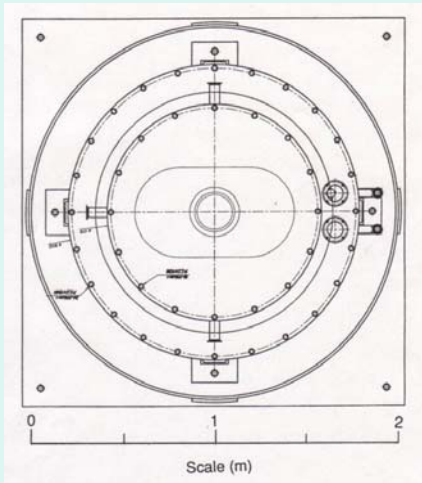
Safety Valve

Liq, N_2

Sand for Radiation Shield

Iron Block 100 mm Thick and Lead Sheet





Inner Dia. 1100 x 0.8 t

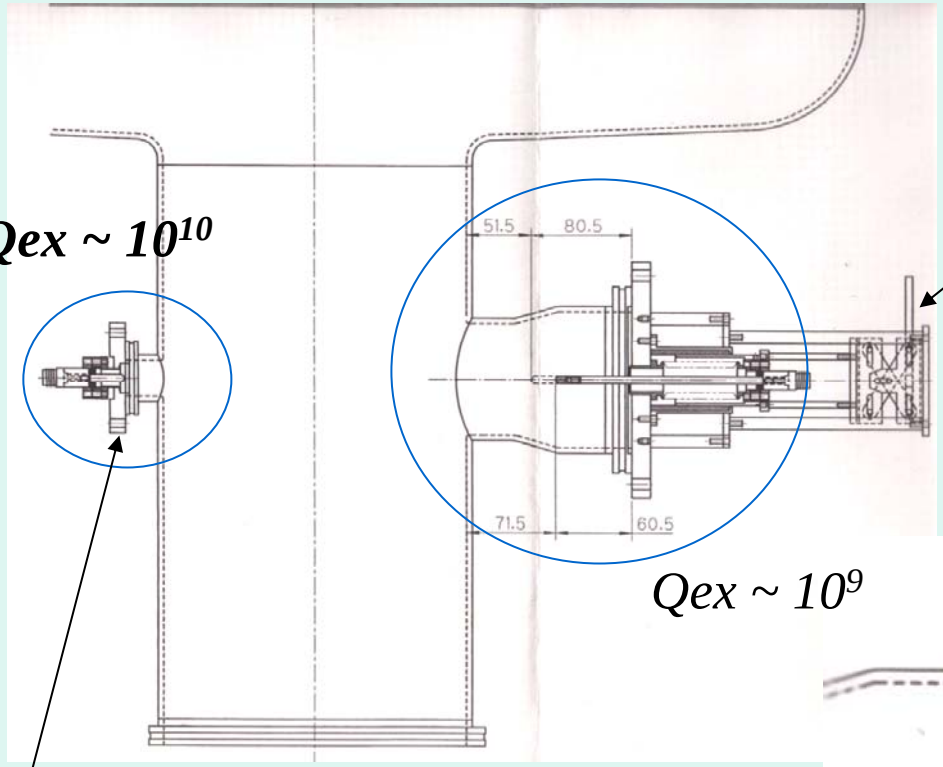
Depth 3500

Heat Loss ~ 3W

Aluminum 80 K Thermal Shield

Magnetic Field

Input Coupler

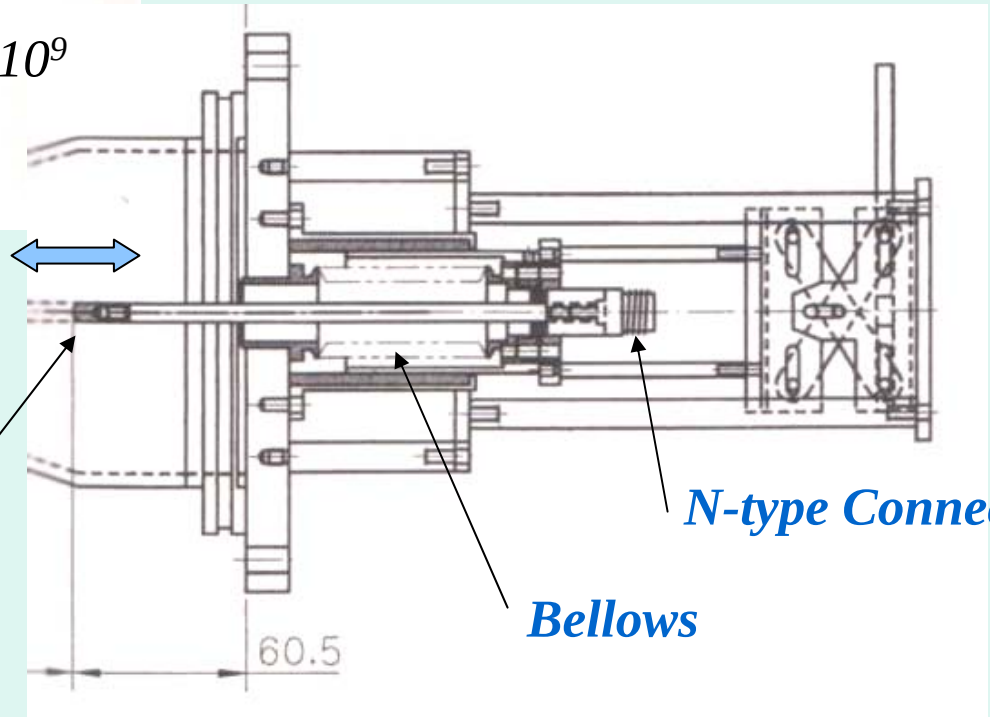


Qex ~ 10^{10}

Qex ~ 10^{9}

Position Adjust Mechanism

Detail of Input Coupler Part



Coupler for Transmit Power

Input Coupler

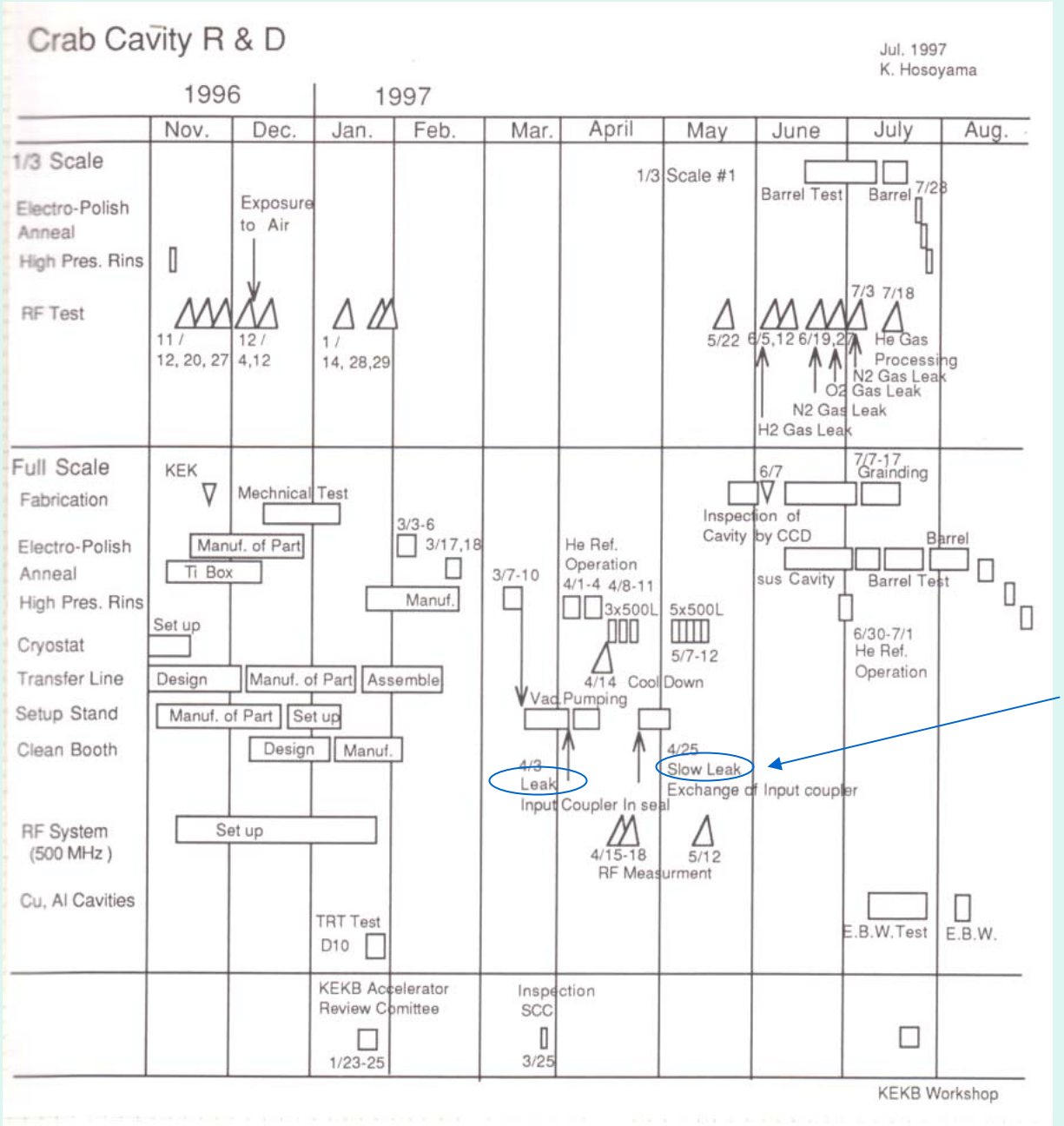
Bellows

N-type Connector

History of Crab Cavity R & D

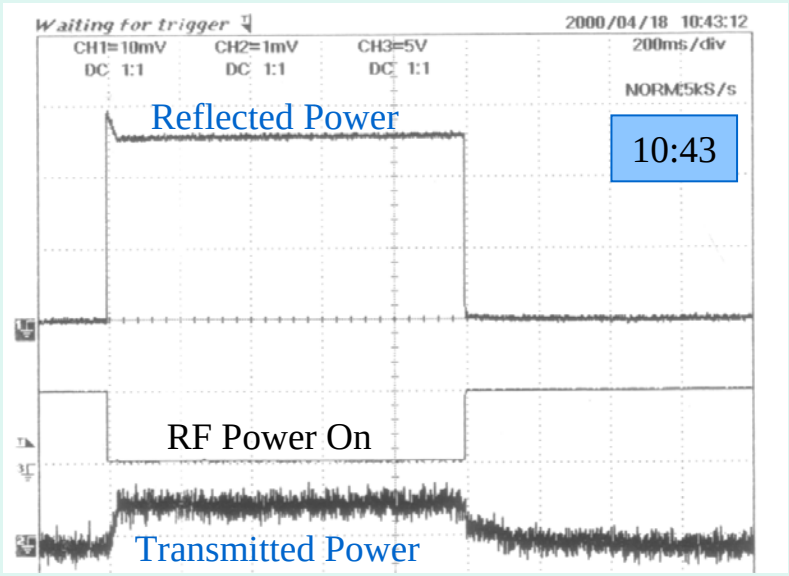
1/3 Scale Model

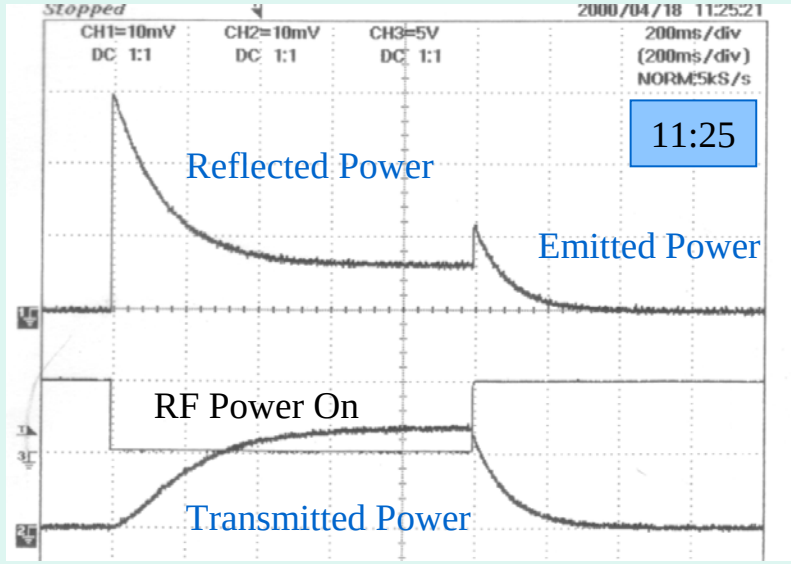
Full Scale Model

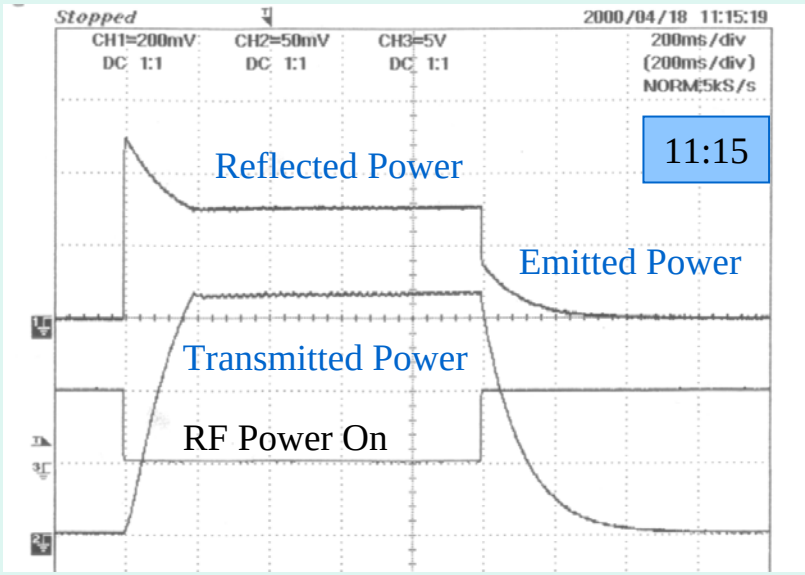


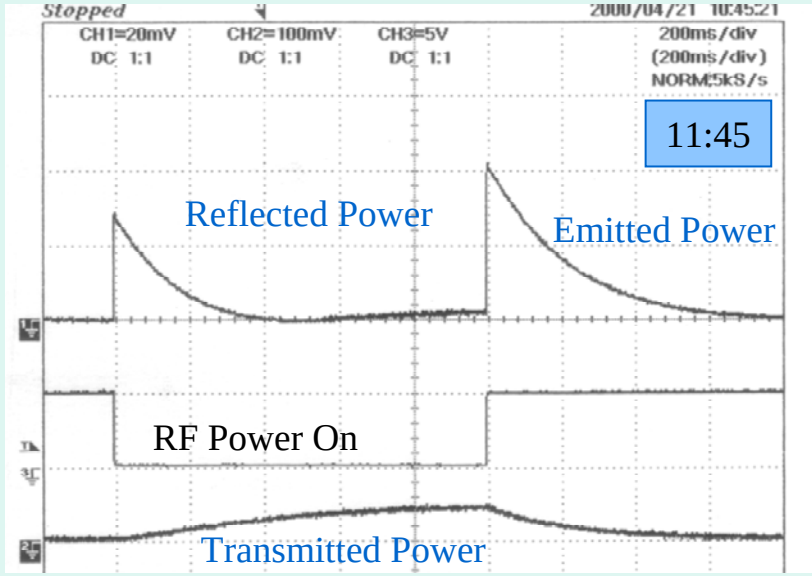
Many Failures !

Multipactoring in Crab Cavity with Coaxial Coupler

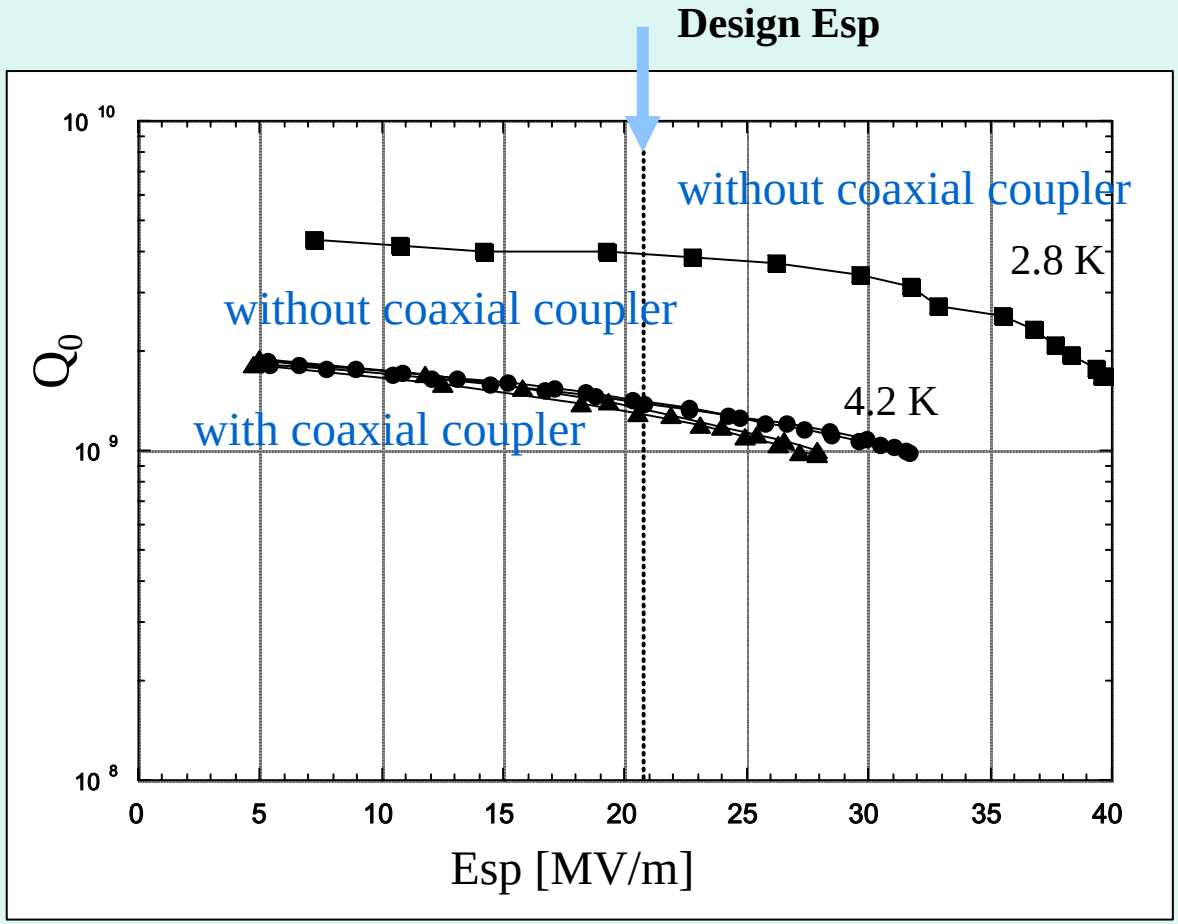








Test Result of KEKB Crab Cavity #1

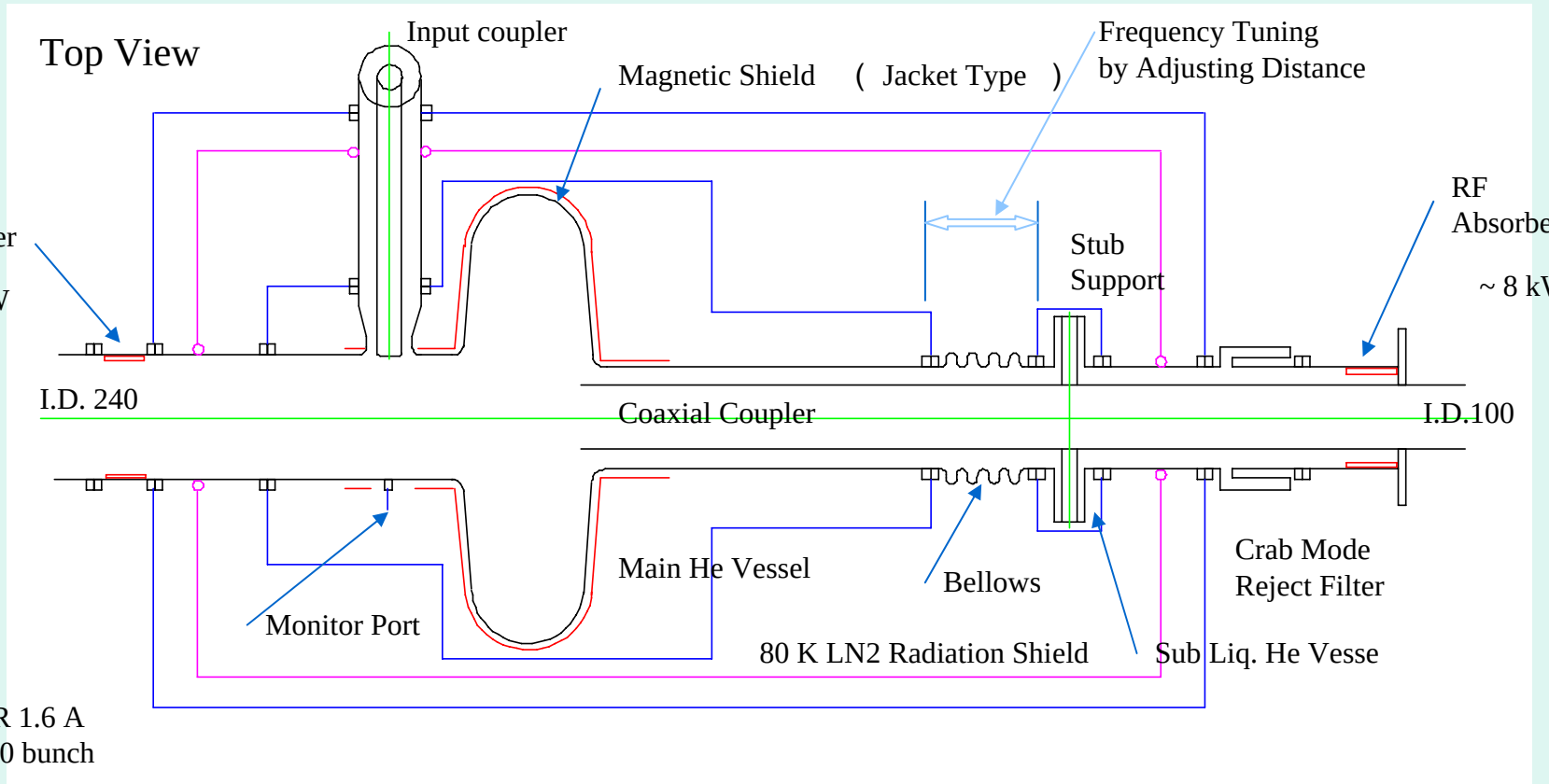


Crab Cavity #2
Same Performance!

⇨ 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

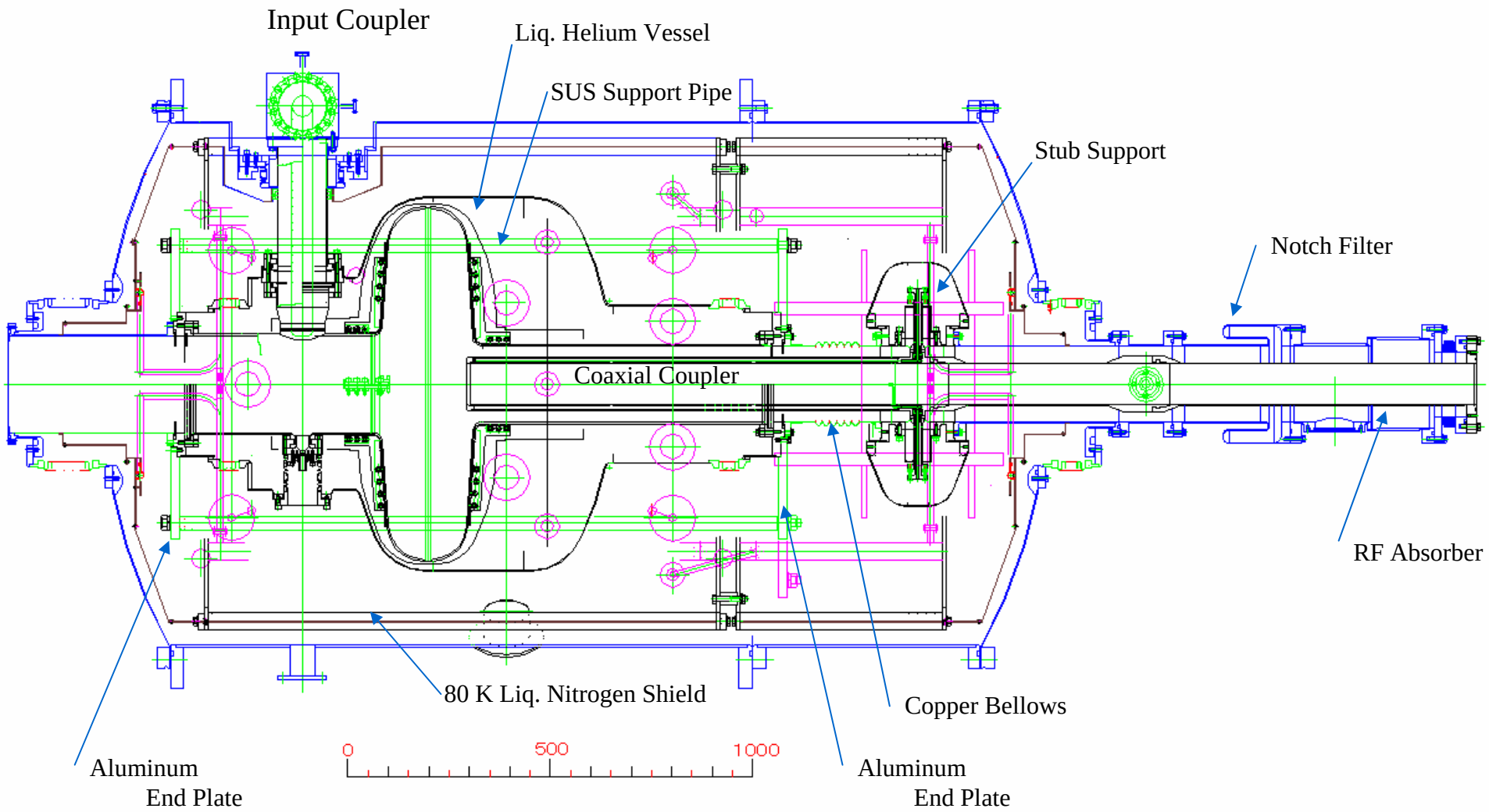
- ⇨ *Frequency Tuning Coaxial Coupler **28.3 kHz / mm***
- ⇨ *Stub-Support -- Mechanical Support & Cooling of Coaxial Coupler*
- ⇨ *Jacket-type Helium Vessel*
- ⇨ *Jacket-type Magnetic Shield*



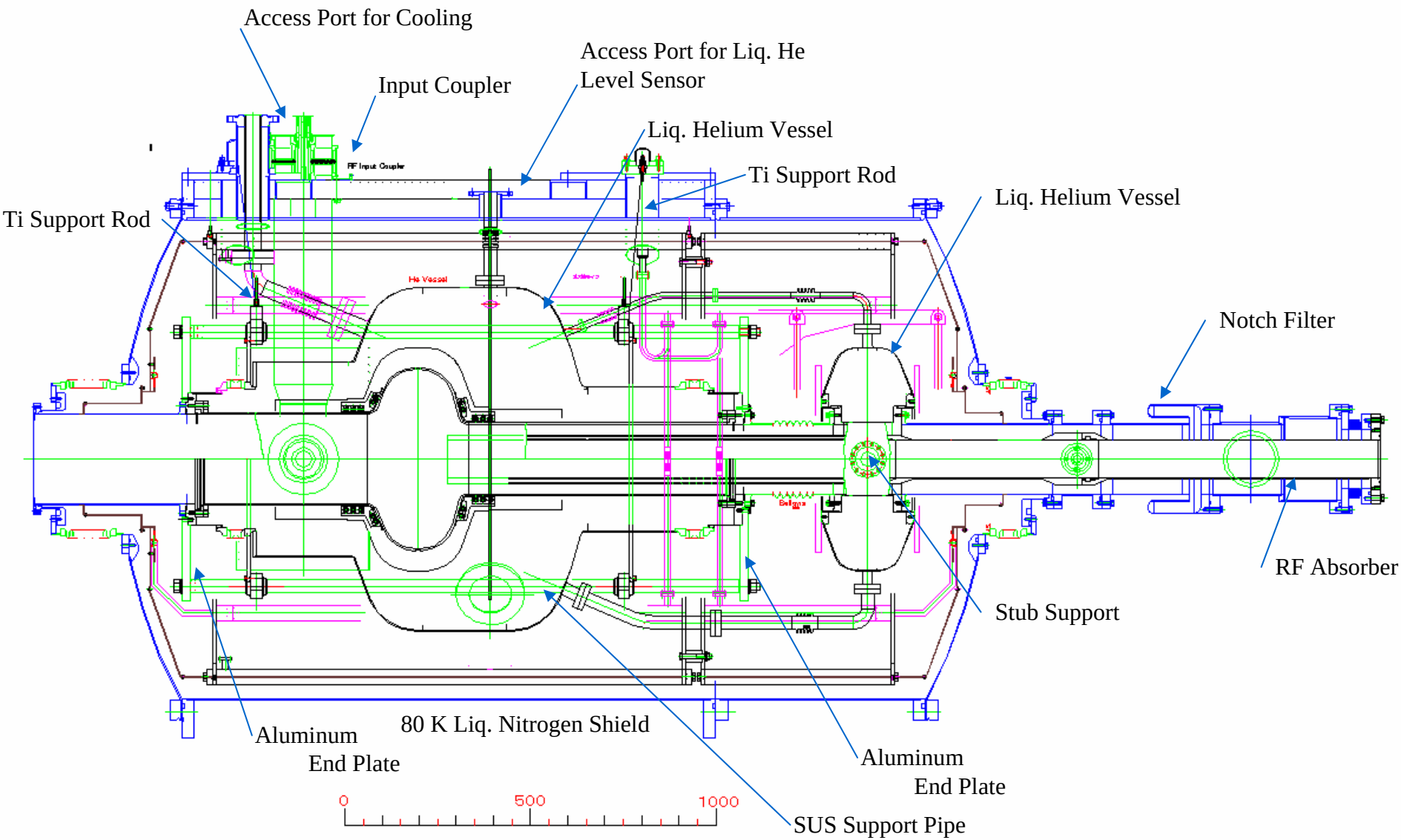
Crab Cavity in Cryostat Top View

Heat Loss

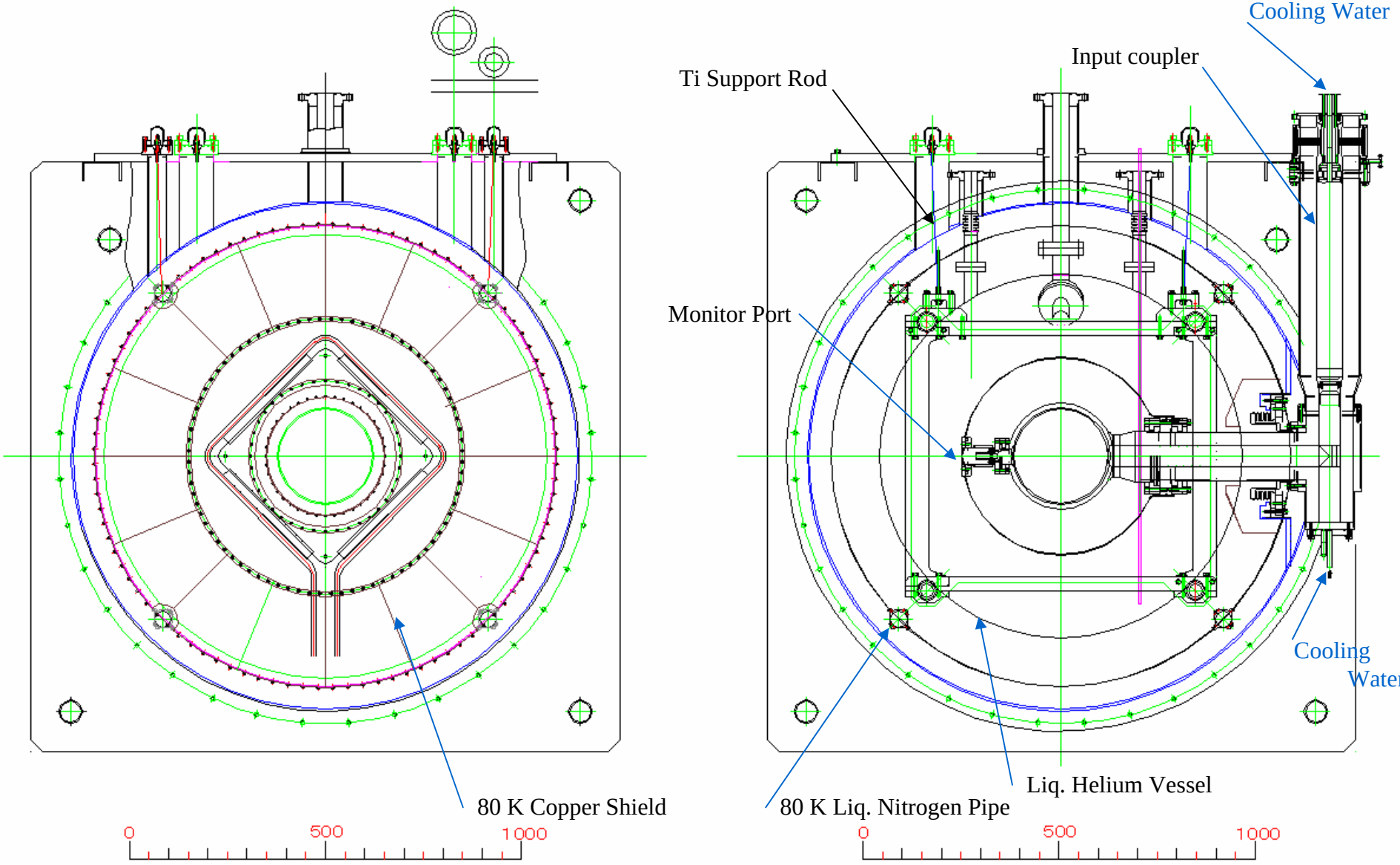
80K	110 W
4.2K	15 W



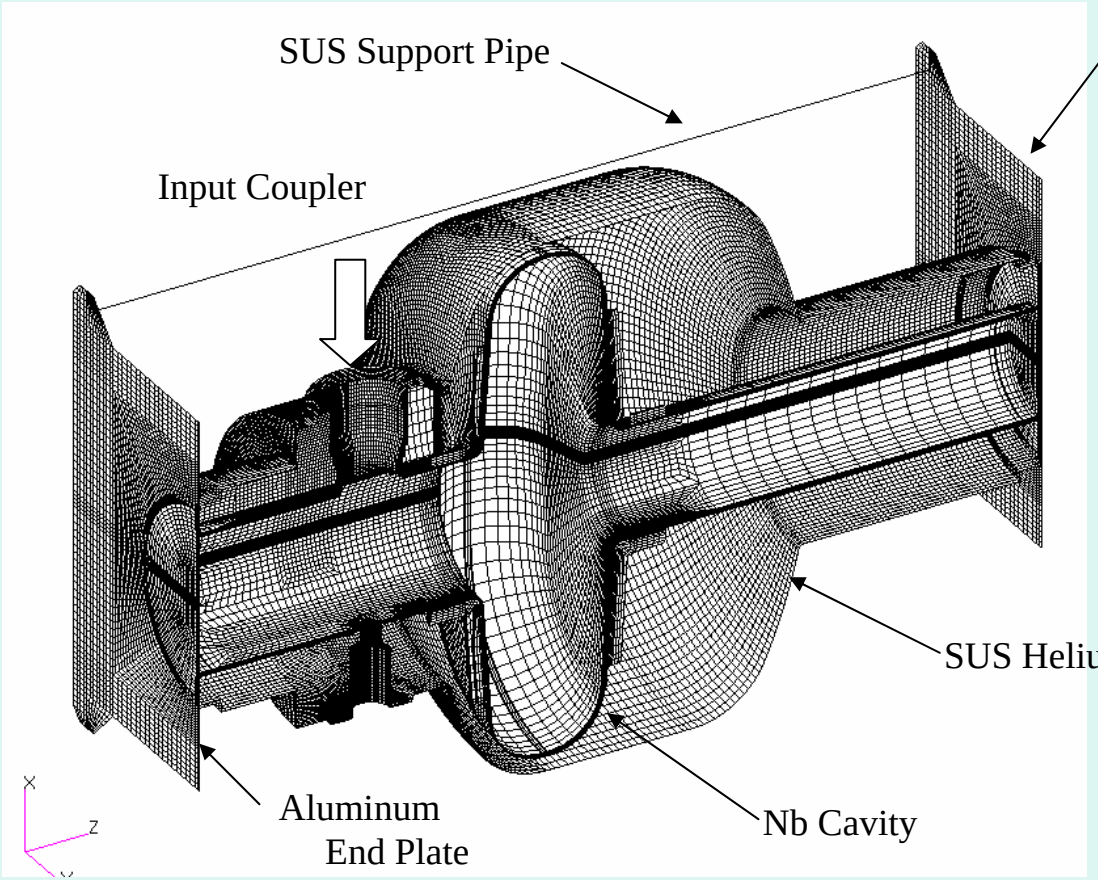
Crab Cavity in Cryostat: Side View



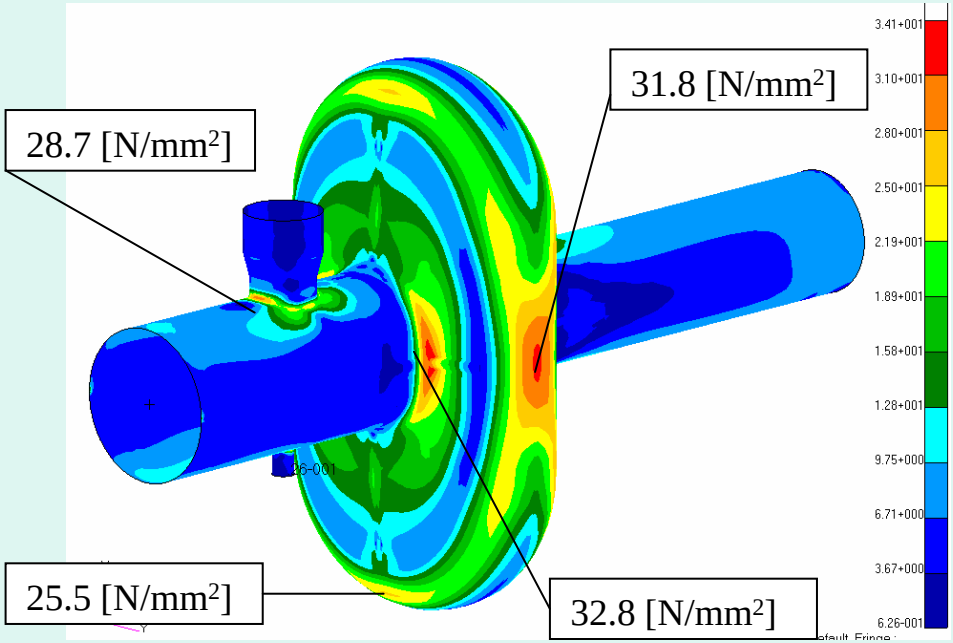
Crab Cavity in Cryostat: Front View



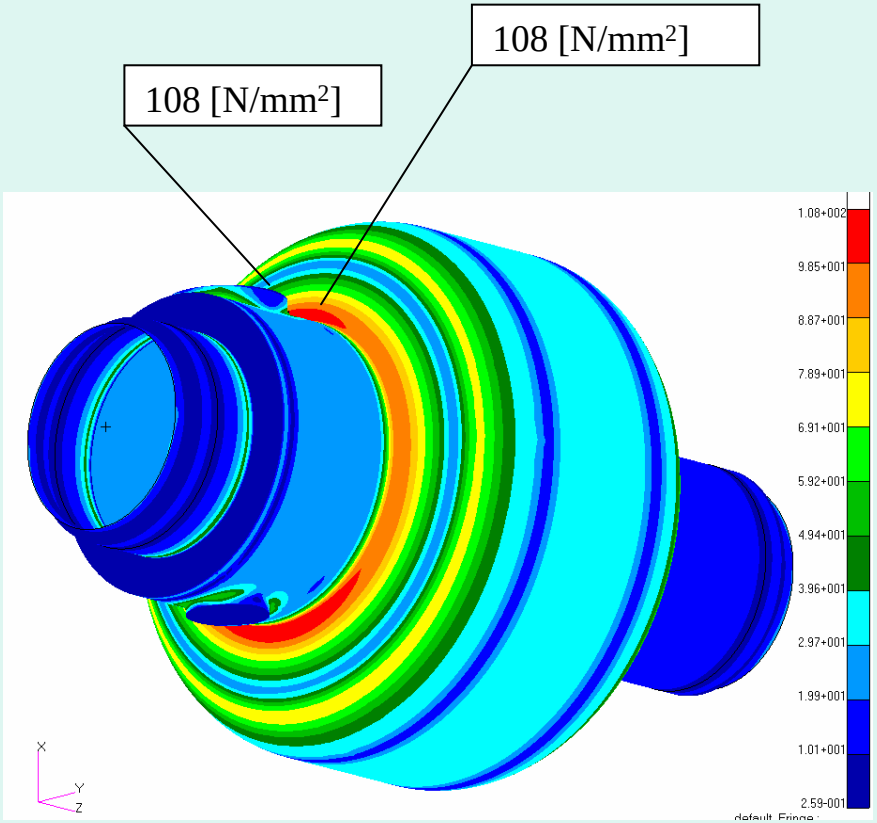
Stress Analysis of Cavity & Helium Jacket



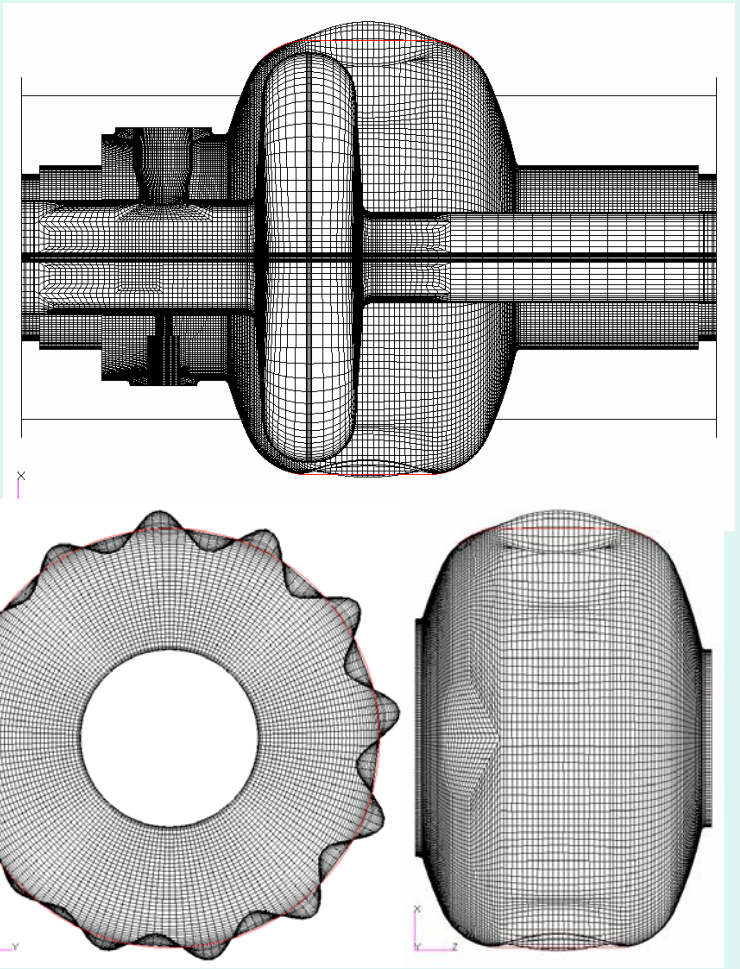
Stress Analysis of Crab Cavity & Helium Jacket



Tresca Stress

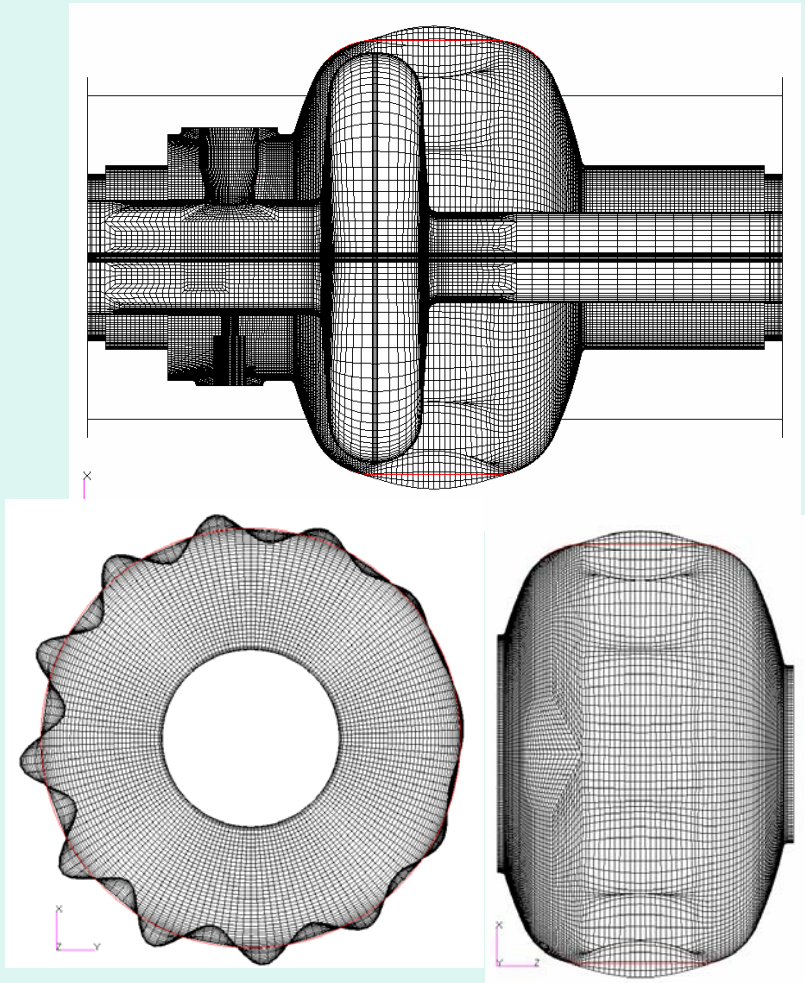


Buckling Helium Jacket



1st Mode

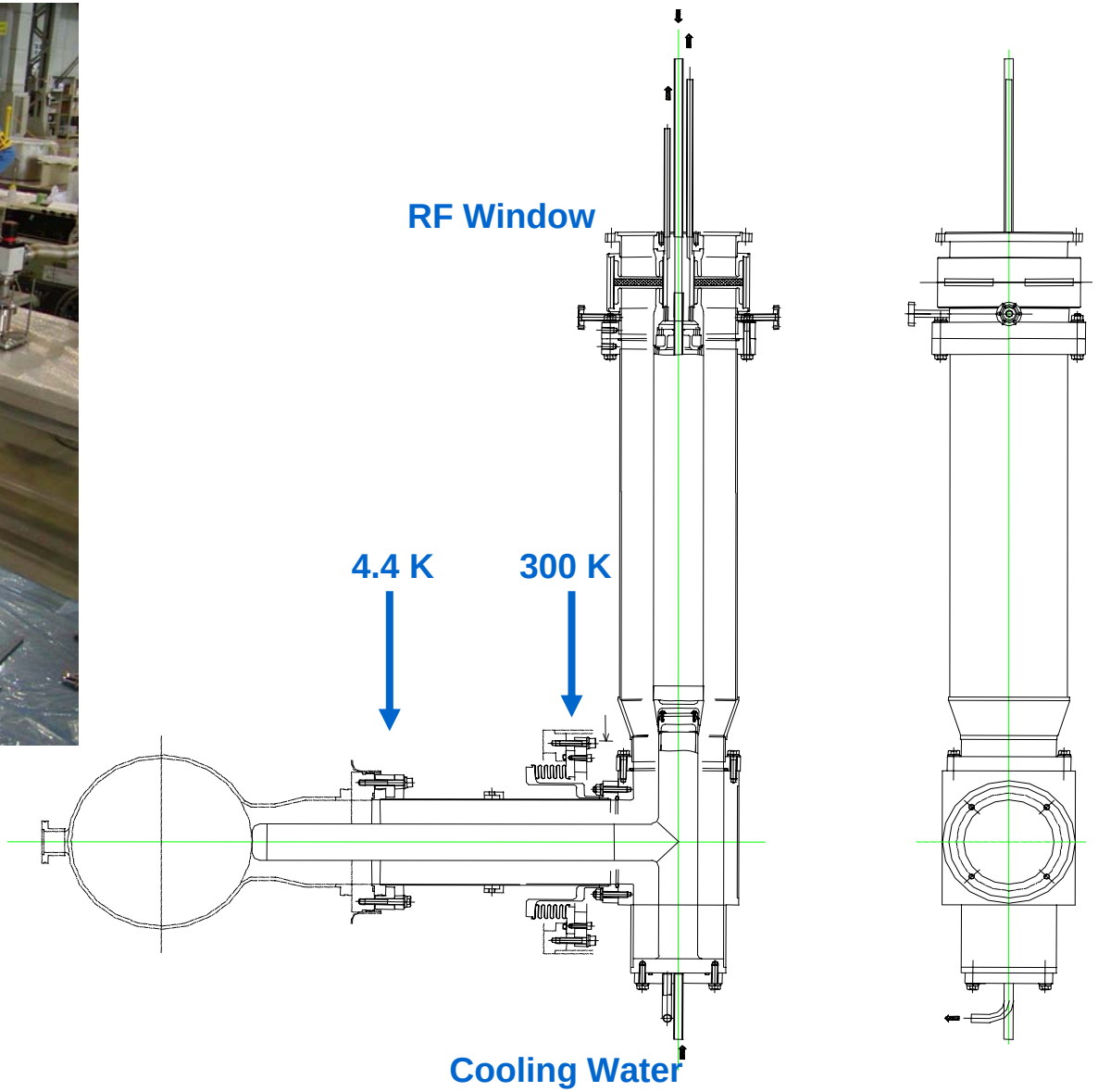
Buckling Load : 0.3218 [MPa]



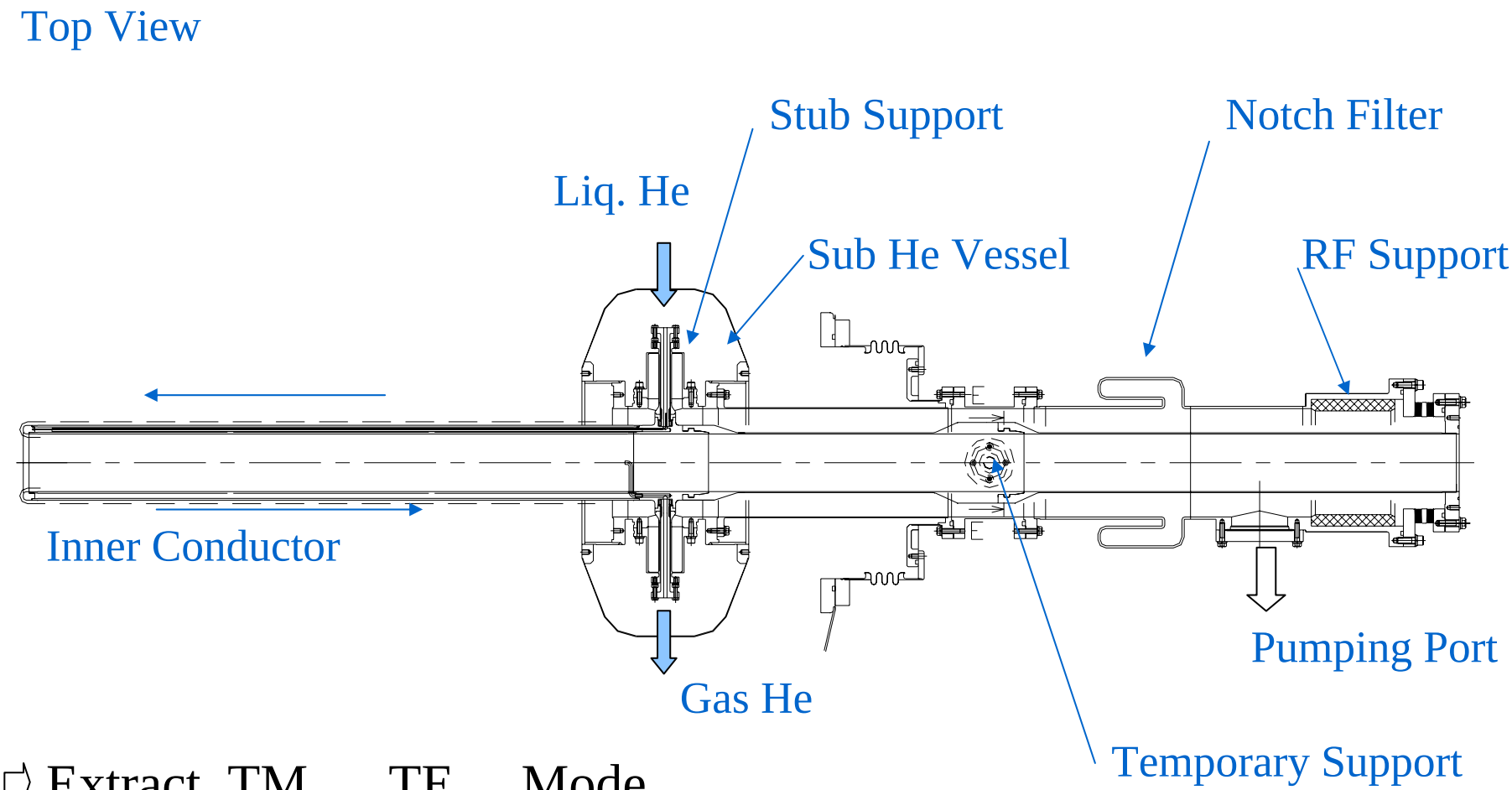
2nd Mode

Bucking Load : 0.3219 [MPa]

Input Coupler

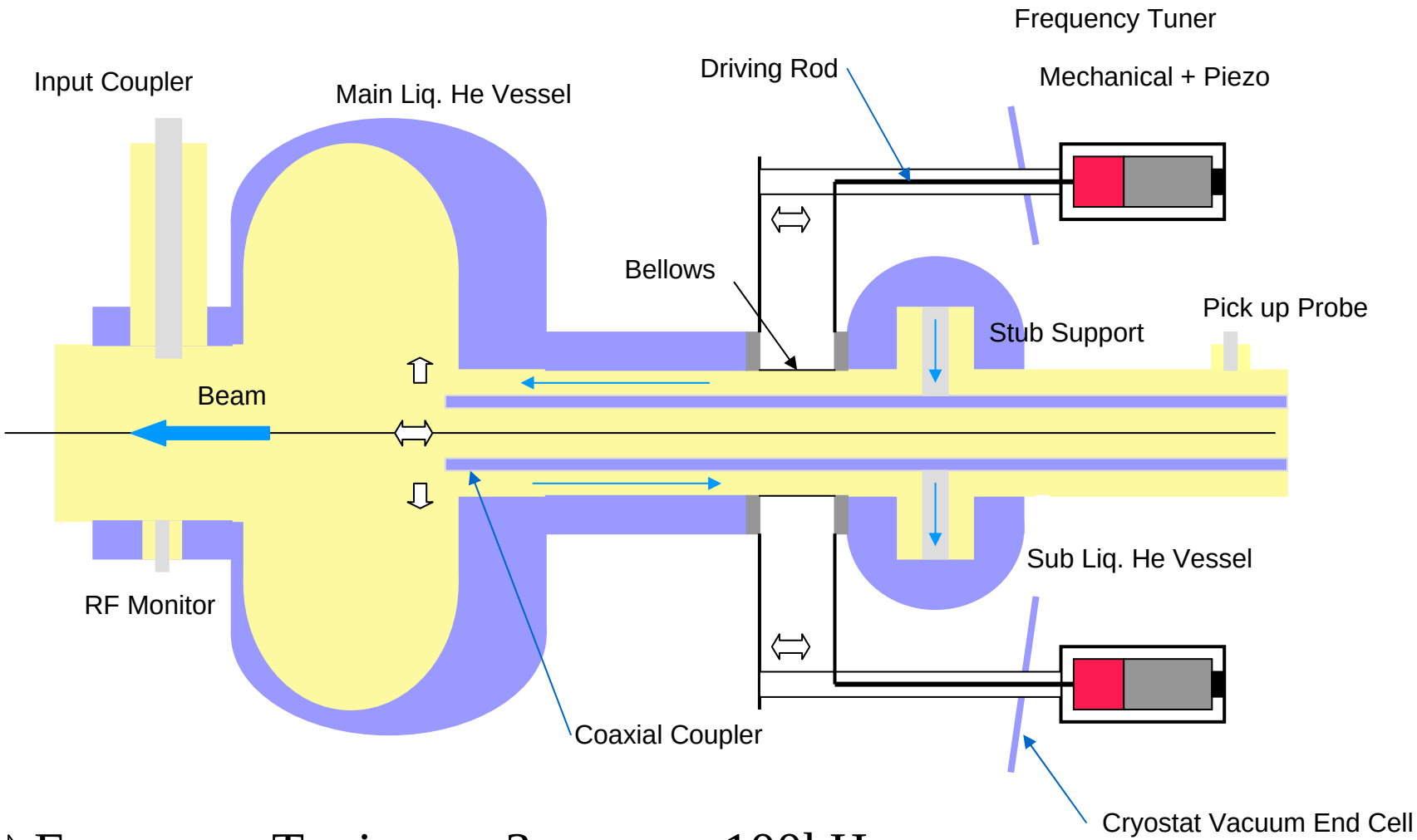


Coaxial Coupler



- Extract TM_{010}, TE_{111} Mode
- Frequency Tuning

Frequency Tuning Mechanism

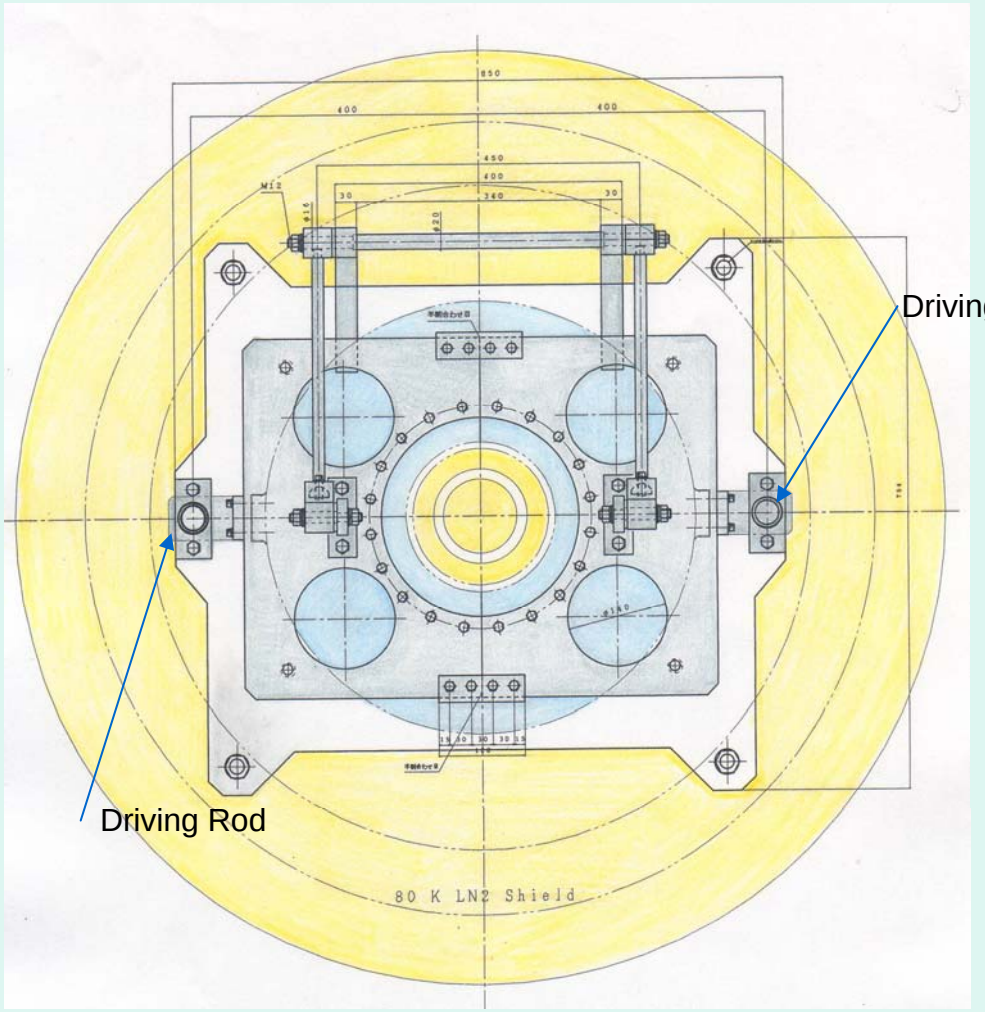


⇨ Frequency Tuning 3 mm ~100kHz

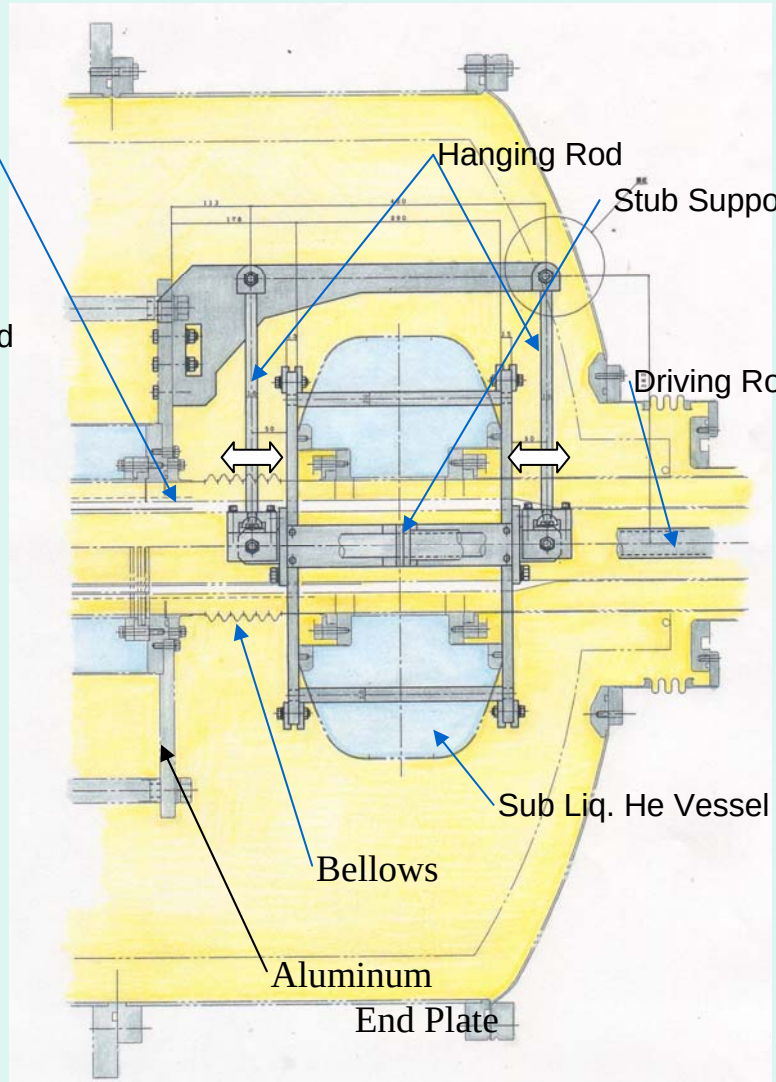
⇨ Adjust the Tip Position

Frequency Tuner

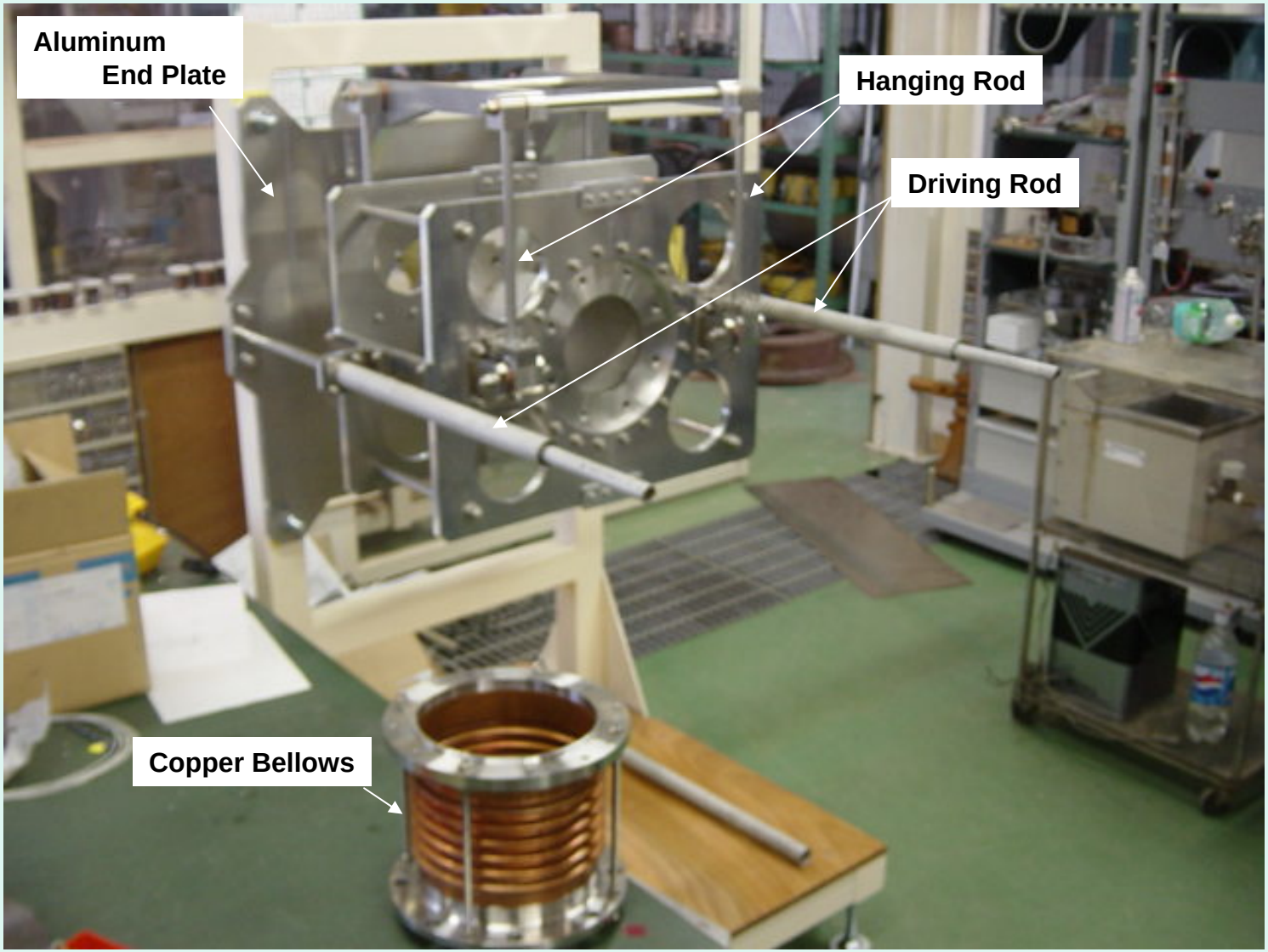
Front View



Side View



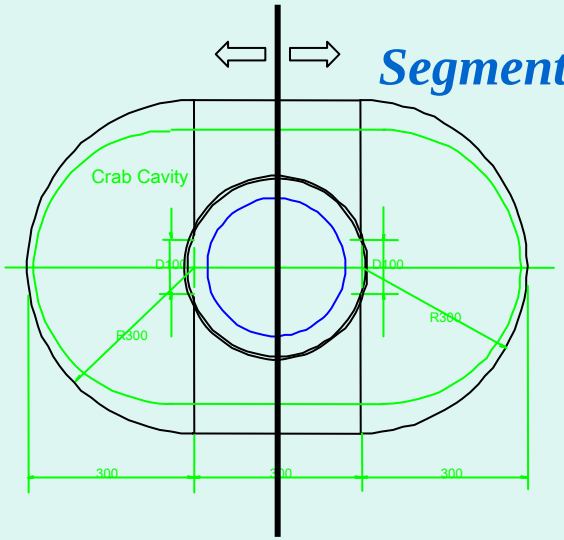
Test Stand for Frequency Tuner

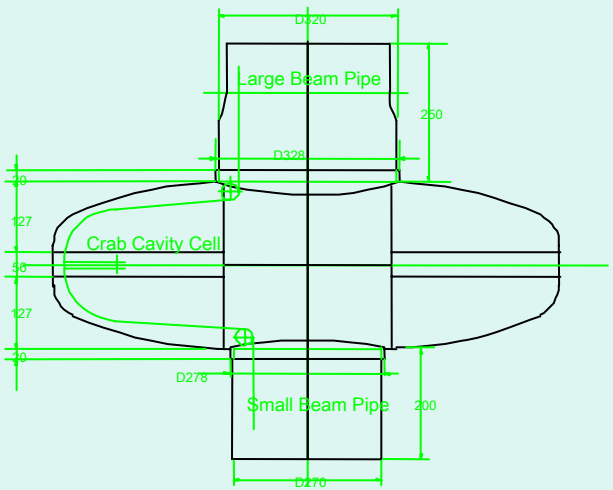


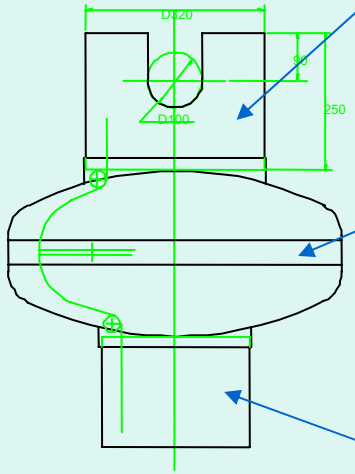
Magnetic Shield (Jacket Type)

Permalloy 3t

Segmentation







Large Beam Part

Cell Part

Small Beam Part

Fabrication of Bellows

Press Unit and Pressure Water Pump

Set the Female Die

Fabricated 5-cell Bellows

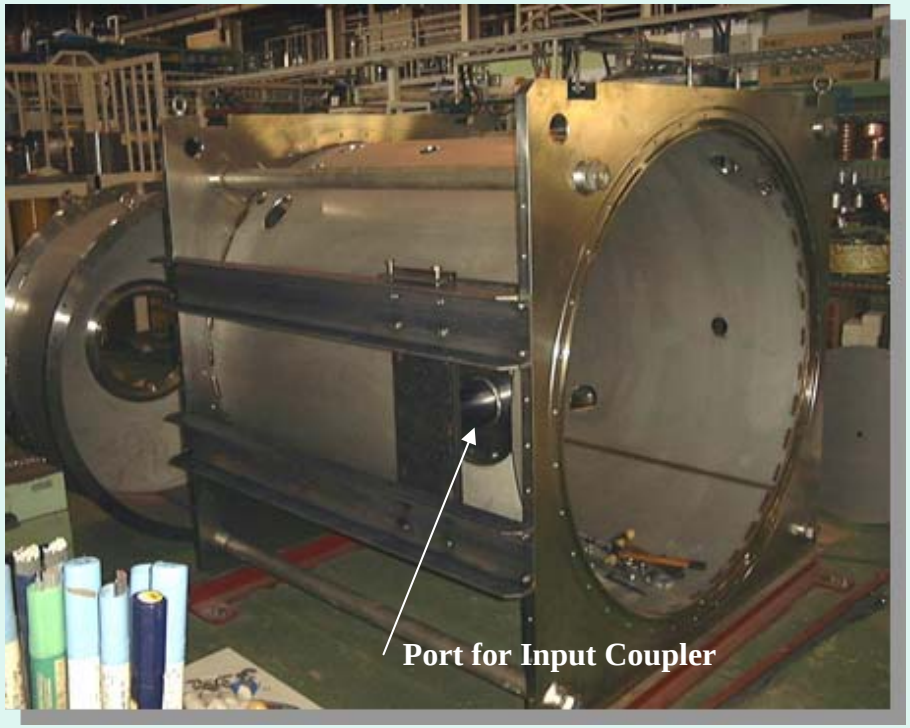
Female Die and Outer Guide Pipe

Fabrication of End Shell

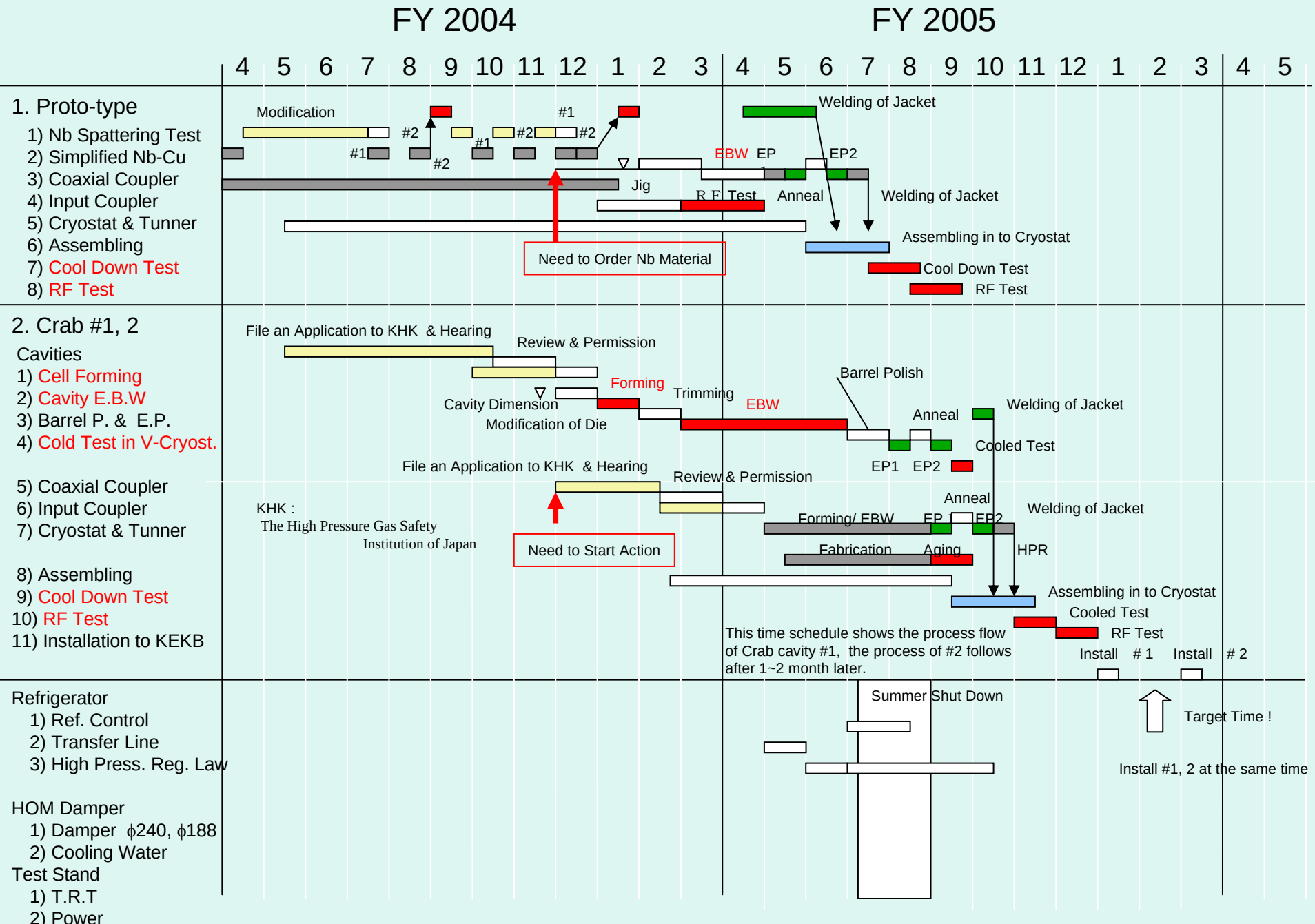
ϕ 1200, 2 t SUS 316L
End Shell for Vacuum Vessel

ϕ 920, 2 t SUS 316L
End Shell for Helium Vessel

Cryostat Vacuum Chamber



Time Schedule for KEKB Crab Cavities



Summary

- Installation of two Crab Cavities in “Nikko” was decided in 2004.
- A prototype cryostat for Crab Cavity is now under fabrication.
- Two Crab Cavities are now being fabricated on schedule.
- These Crab Cavities will be installed in KEKB in Feb. 2006.