Crab Cavity
- R&D Efforts / Results and Future Plan -

Crab Cavity R&D Group
K. Hosoyama

KEKB and Supercinducting Crab Cavity

RF Performance Test

Test Results **Esp** = 27 MV/m with Coaxial Coupler

Horizontal Cryostat for KEKB Crab Cavity

Jacket type Liquid Helium Vessel

Frequency Tuning

Cryogenic System for KEKB Supercnducting Crab Cavity

Satellite Refrigeration System

High Performance Liquid Helium Tansfer Line

KEKB Superconducting Crab Cavity

Crab Crossing

Characteristic of KEKB Crab Cavity

RF Issues

Squashed Cell Shape Cavity

- Round Cell Shape Cavity ----> Unwanted Degenerative Mode
- Squashed Cell Shape Cavity ----> Push the frequecy upward

Higher Order Mode / Lower Order Mode Dumped Cavity

- Larger Beam Pipe for Higher Order Mode (HOM)
- Coaxial Coupler for TM010 Lower Order Mode

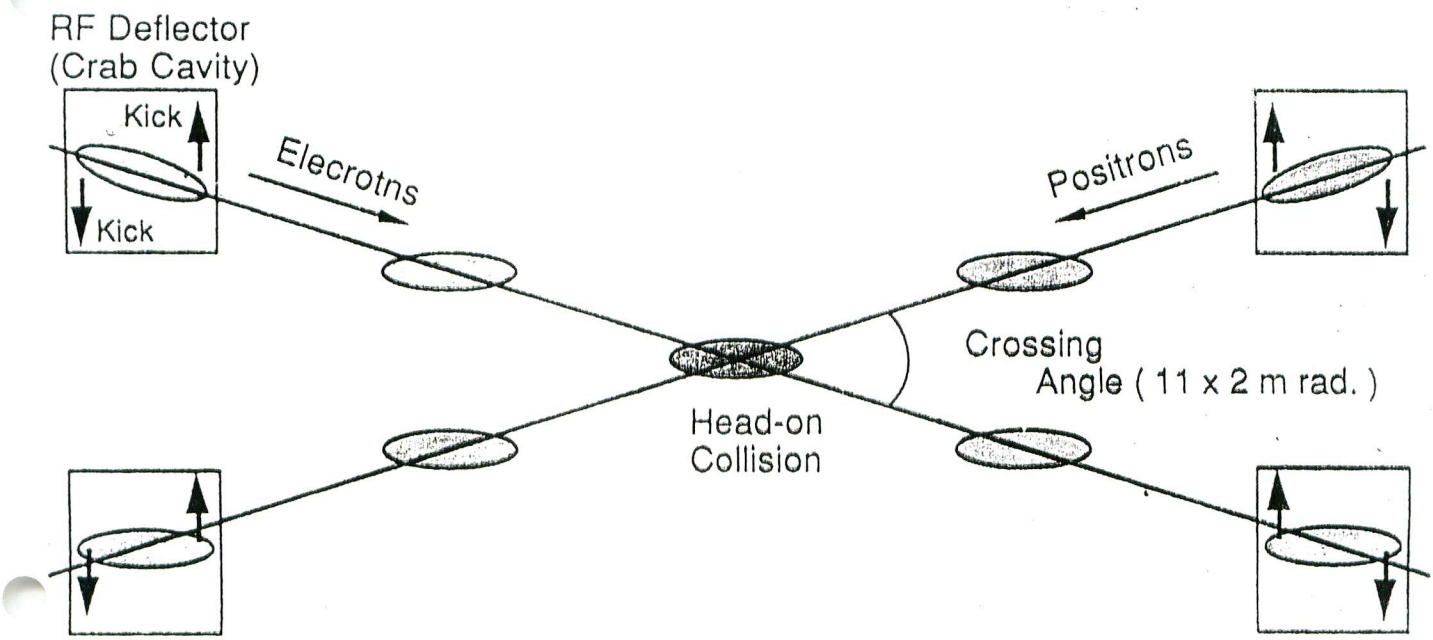
Higher Operation Feild Esp = 21 MV/m

Why we use the crab crossing ?

The crab crossing scheme allows a large crossing angle collision without introducing any synchrotron-betatron coupling resonances. 2,3)

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

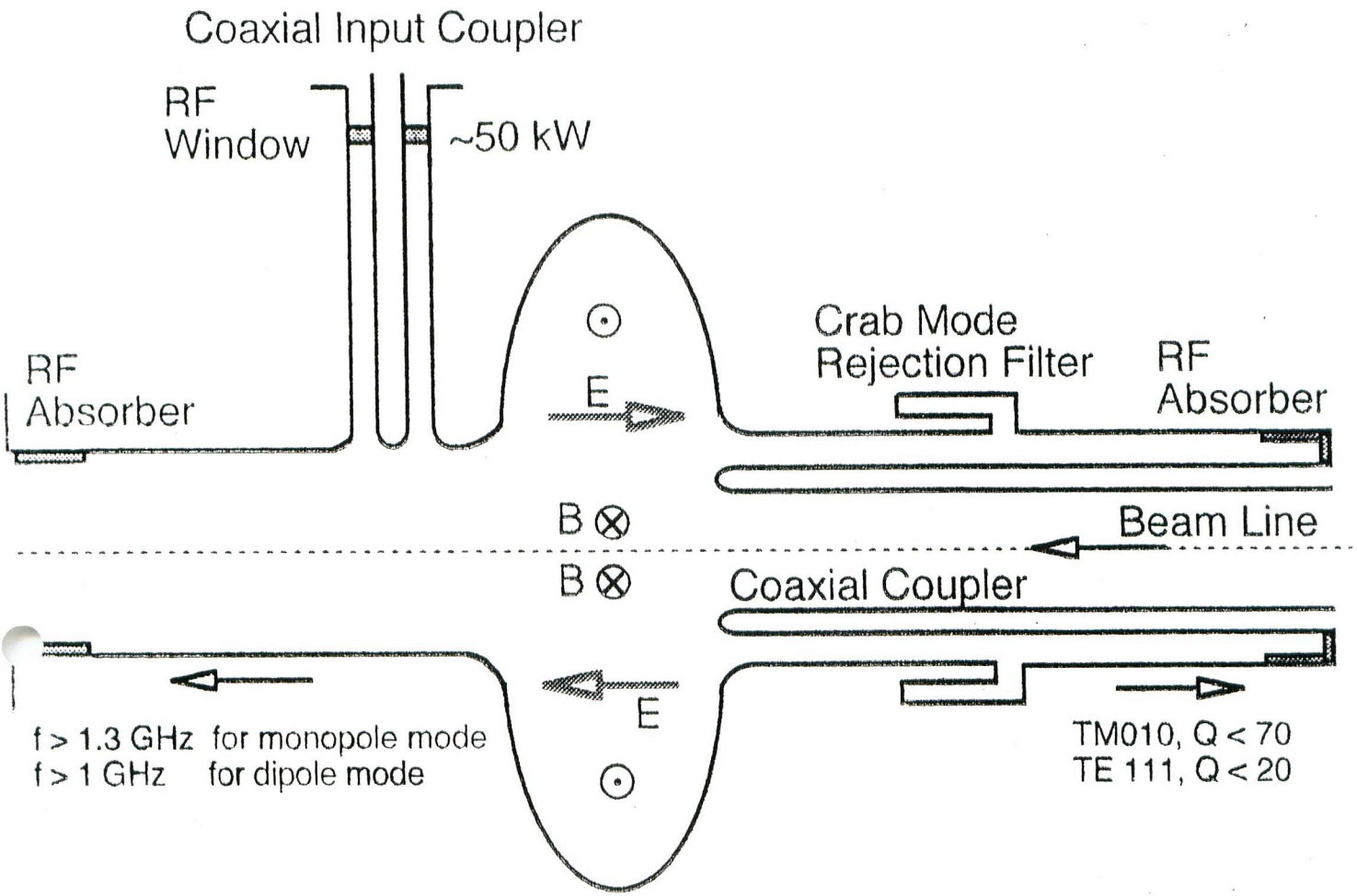
Crab crossing scheme

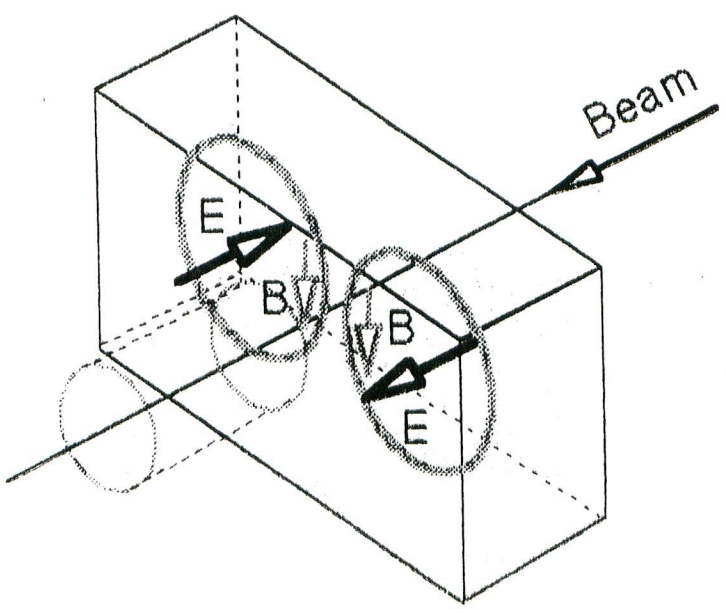


Why we use the superconducting cavity ?

To achieve the crab crossing we need large kick voltage!

	LER	HER	
Beam Energy	3.5	8.0	GeV
RF Frequency	508.887		MHz
Crossing Angle	± 11		mrad
βx	0.33	0.33	m
$\beta crab$	20	100	m
Required kick	1.41	1.44	MV



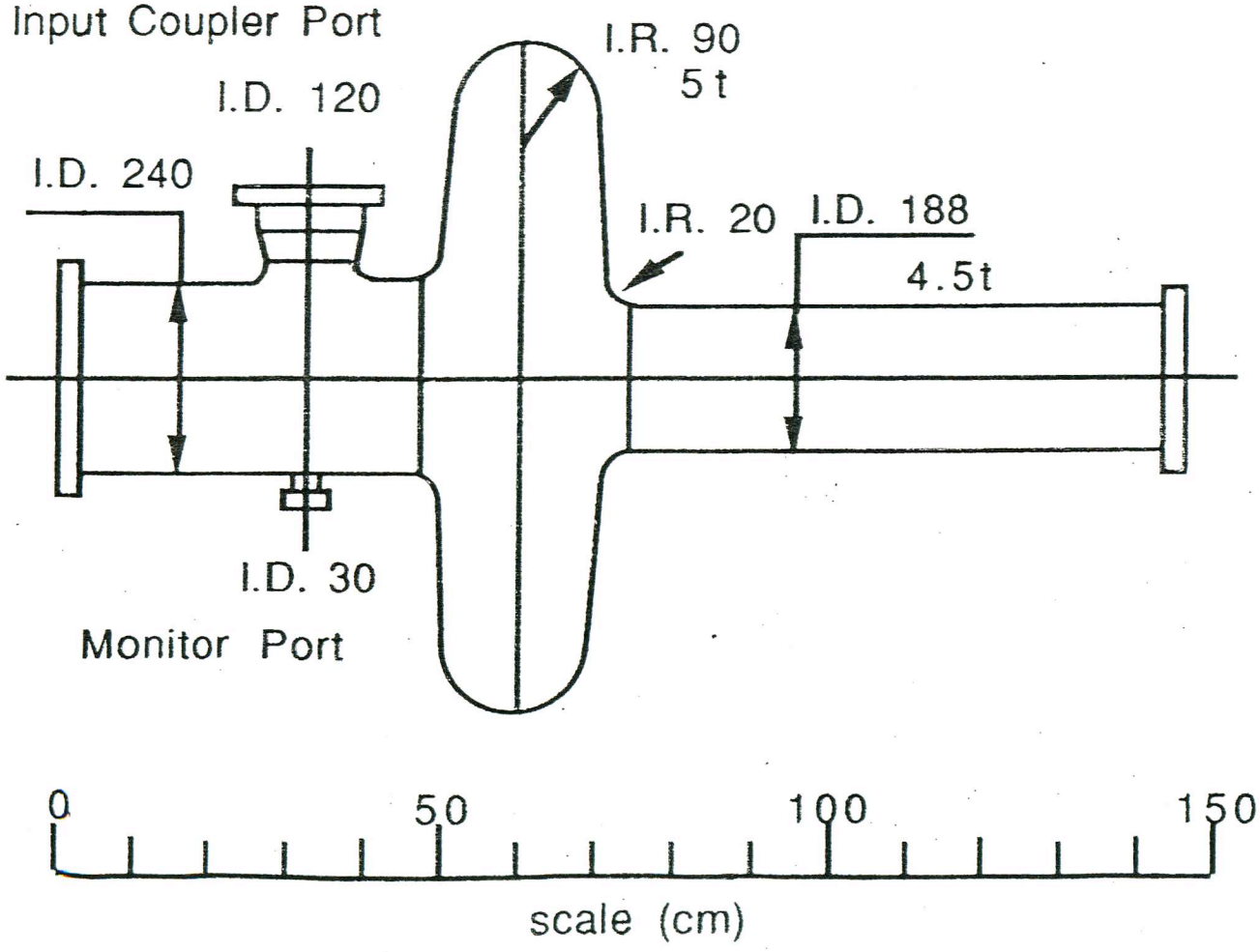


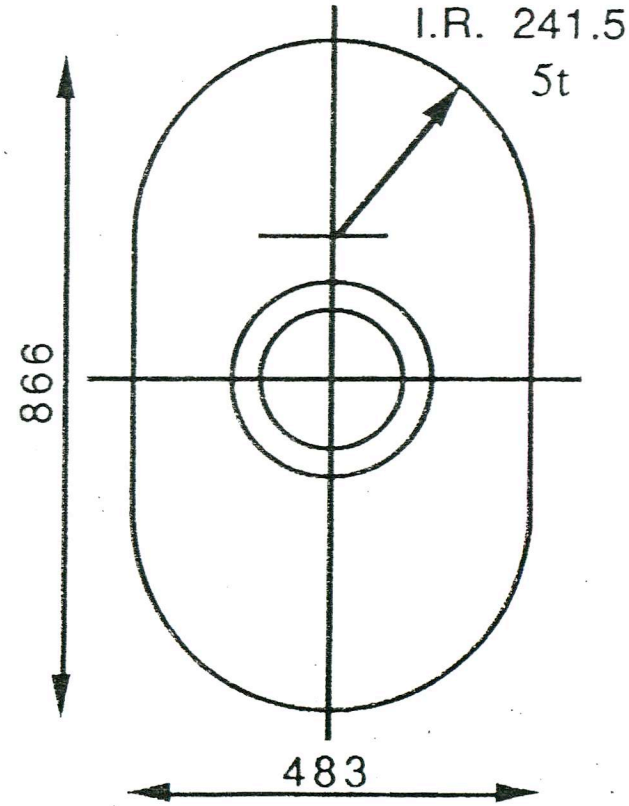
Crab Cavity Design Concept

SUPERCONDUCTING CRAB CAVITY FOR KEKB

RF parameters for Crab Cavity

Frequency	501.7	MHz
R/Q	46.7	Ω
Γ	220	
Esp/Vkik	14.4	MV/m/MV
Hap/Vkik	415	Oe/MV





RF Performance Test

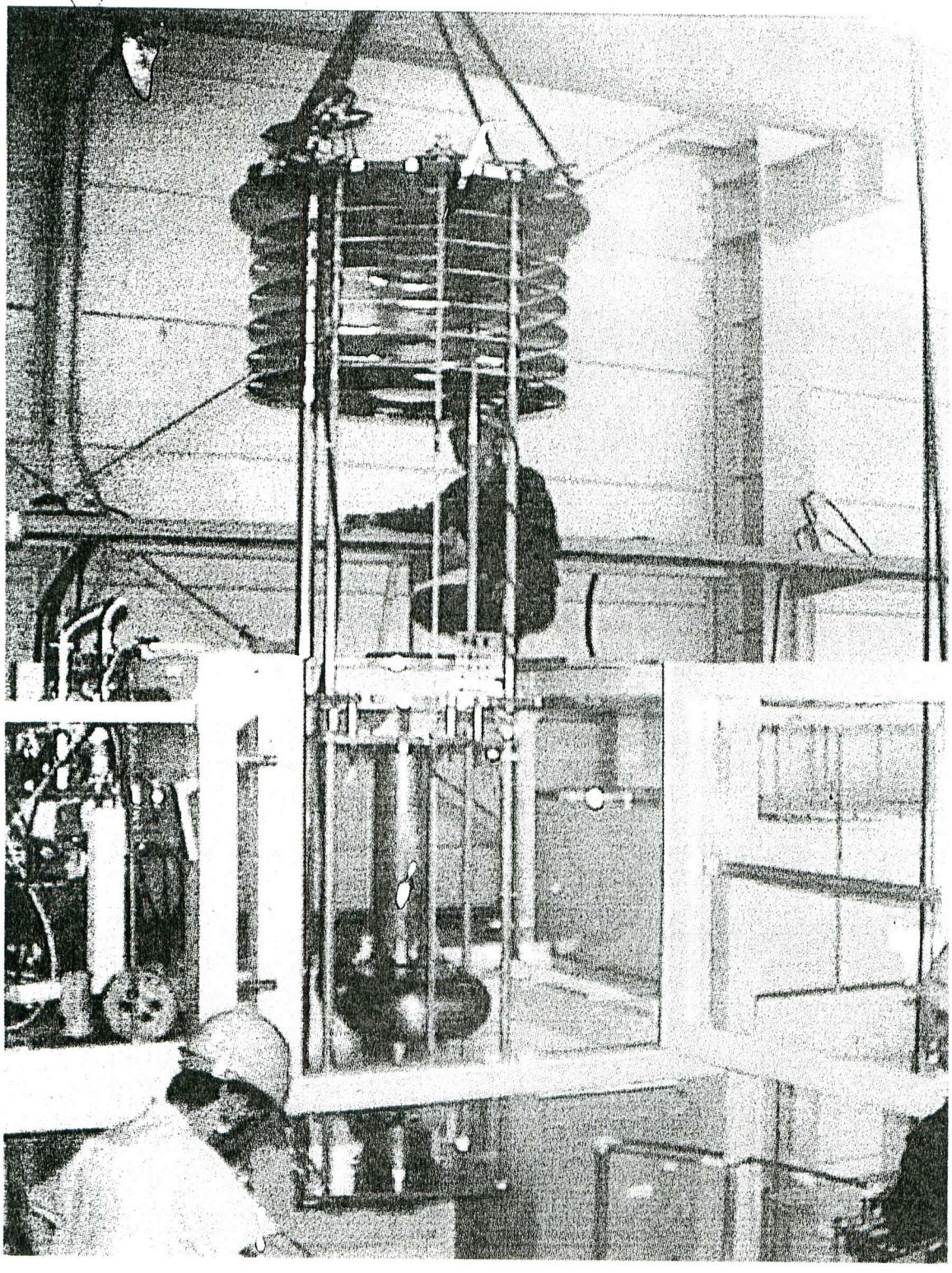
Crab Cavity RF Performance

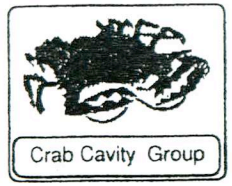
Full Scale Model

Operation at 4.2 K

Operation at 3.8 K Option for High Performance Operation

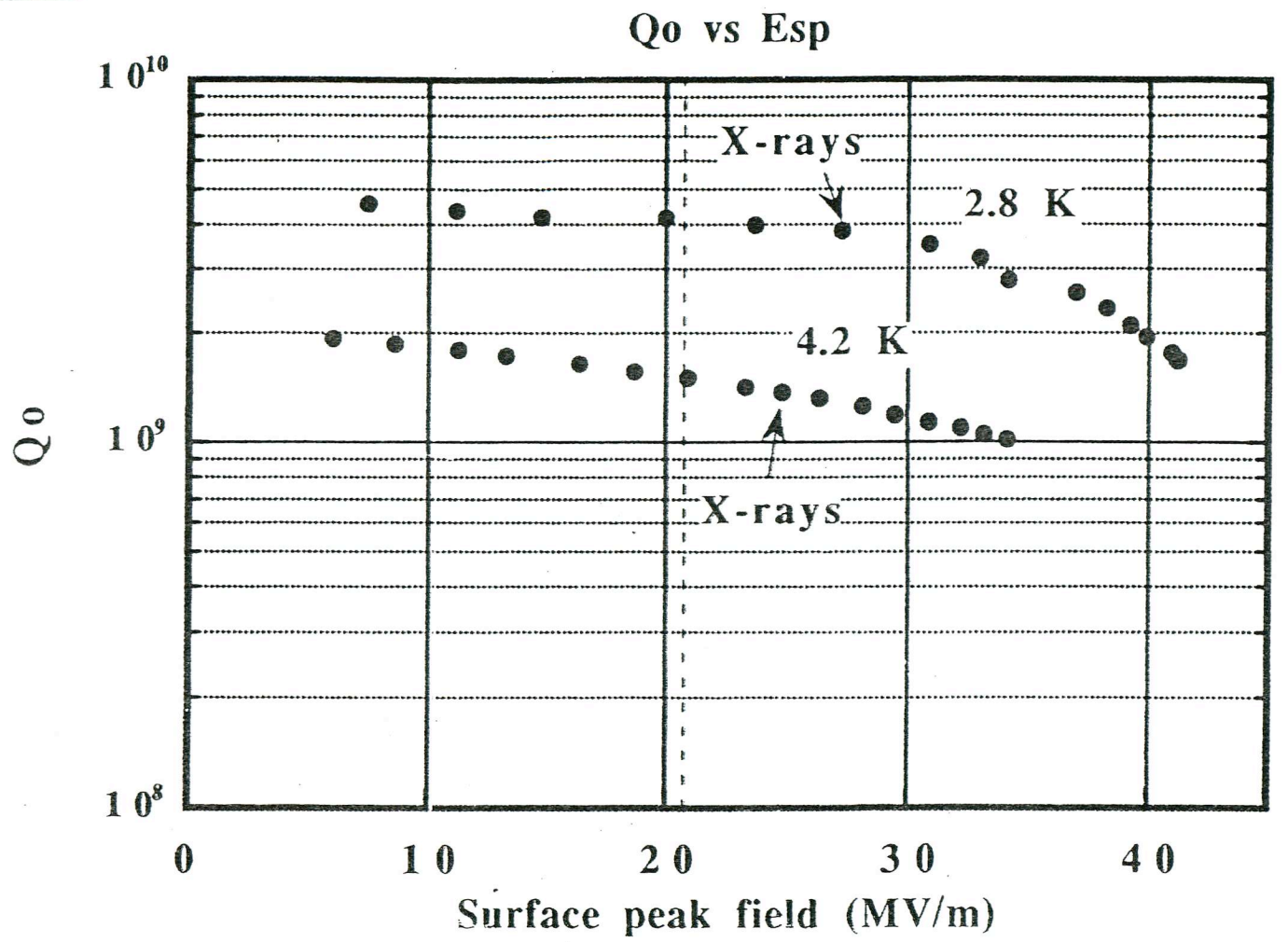
Full Scale Model with Coaxial Coupler

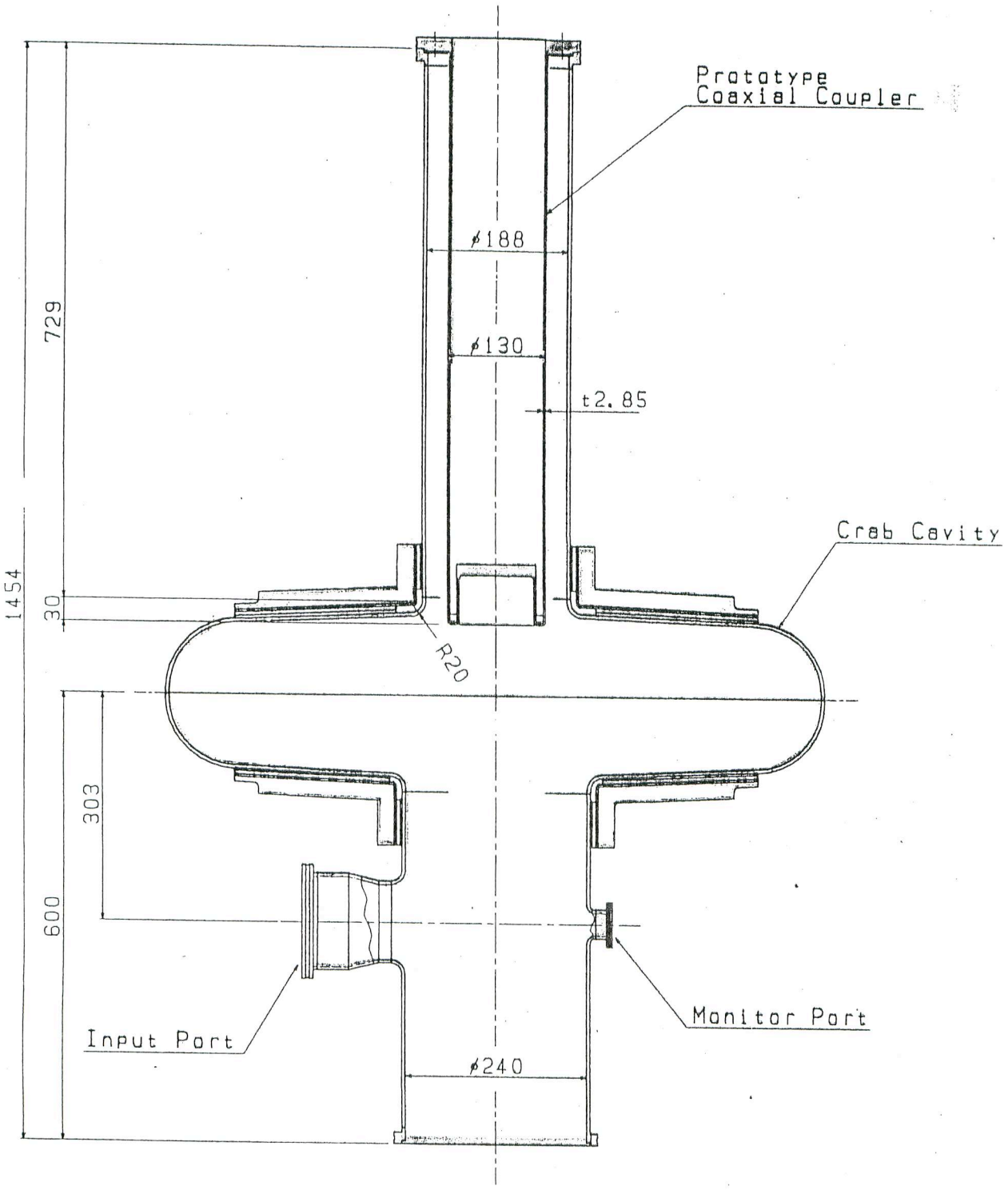




By Lower Operation Temperature

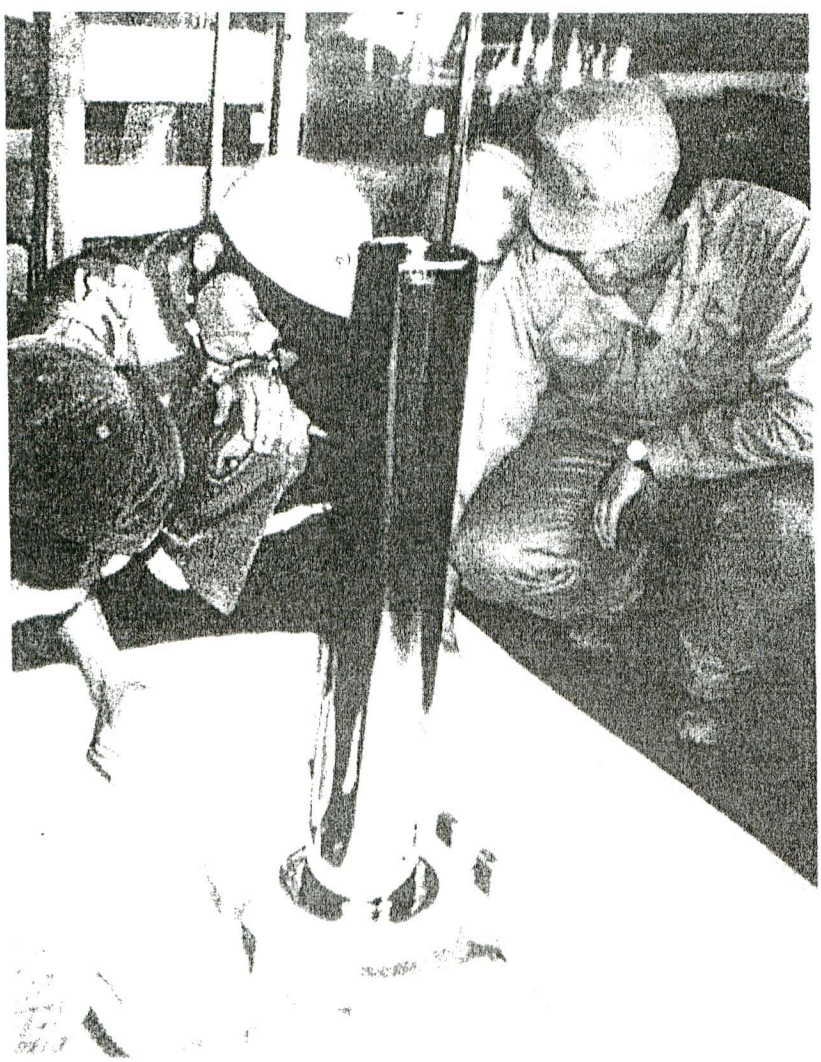
Higher Performance Could Be Achieved !





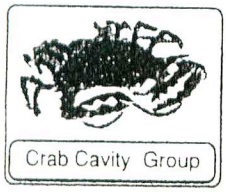
Cross section of the Crab Cavity with the Prototype Coaxial Coupler

簡易型同軸部

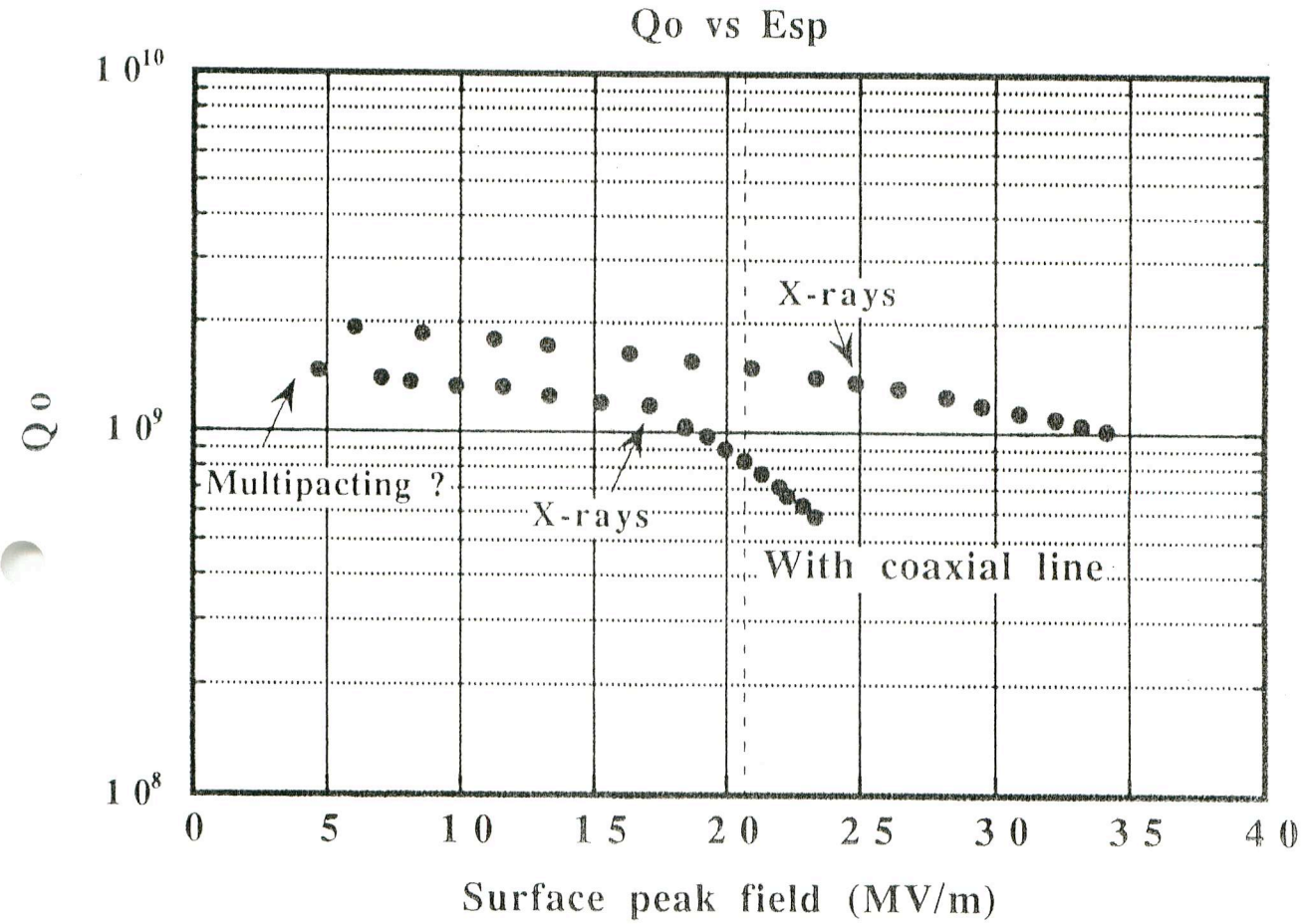


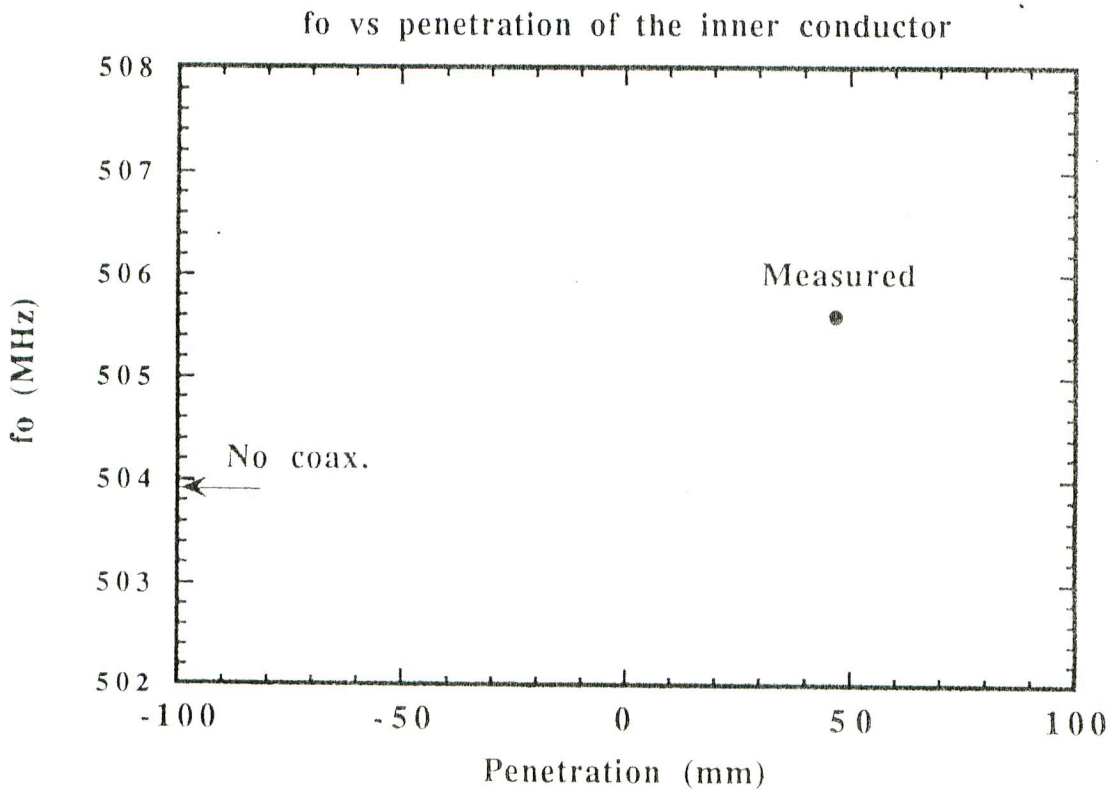
Simplified Coaxial Line

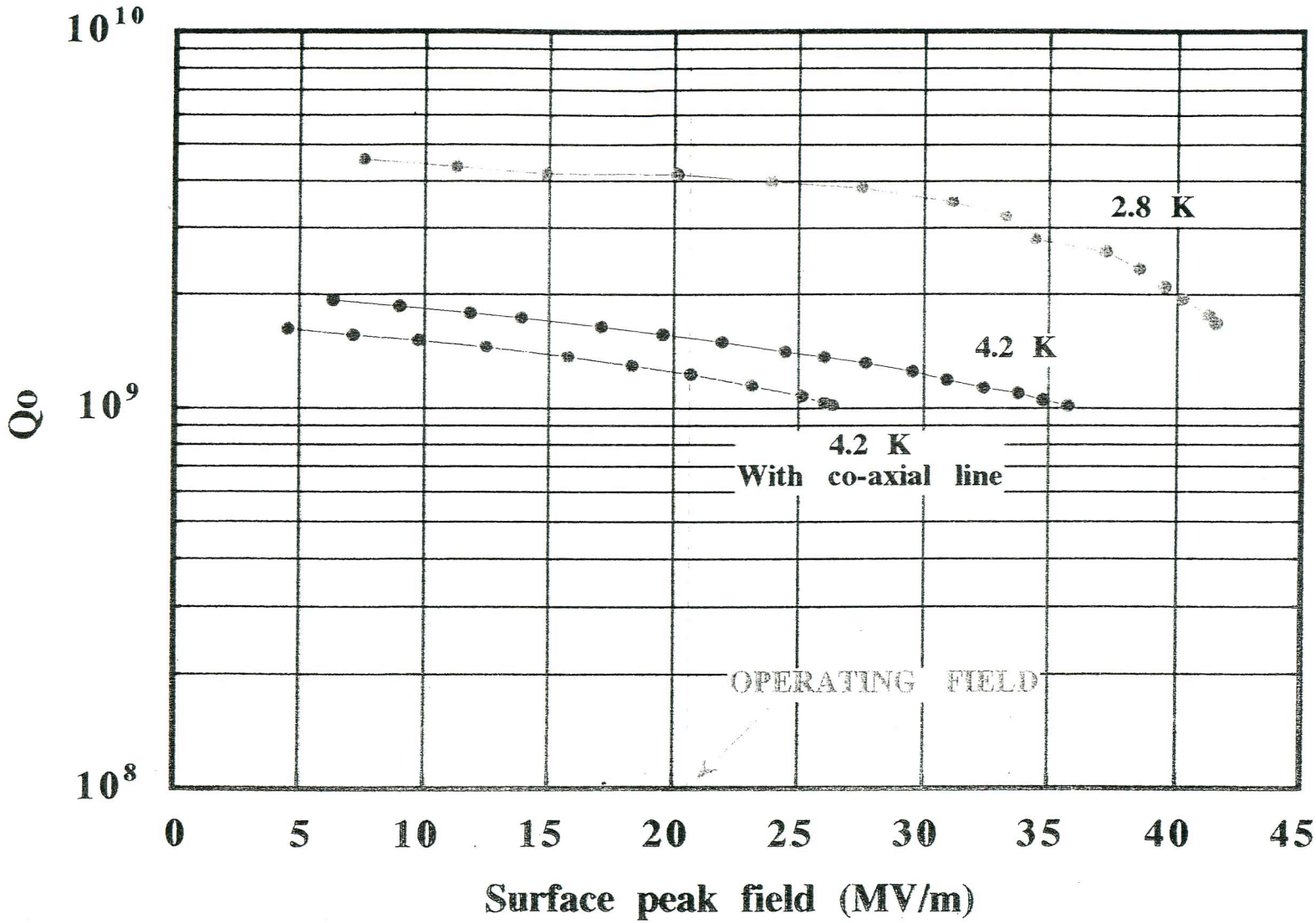
高エネルギー加速器研究機構



Full Scale Crab Cavity with Coaxial Coupler






10^{10}
10^{9}
10^{8}
Q_0
2.8 K
4.2 K
4.2 K
With co-axial line
OPERATING FIELD
0
5
10
15
20
25
30
35
40
45
Surface peak field (MV/m)

Horizontal Cryostat for KEKB Crab Cavity

Cryostat ----- Jacket Type Liqud Helium Vessel

Installtion into Tsukuba Straight Section (Limited Space)

---> Cryostat Small Size and Light Weight

High RF Performance Crab Cavity

---> Assembling in Dust Free Condition

---> High Pressure Water Rinsing after Pre-Assembling

Coaxial Coupler

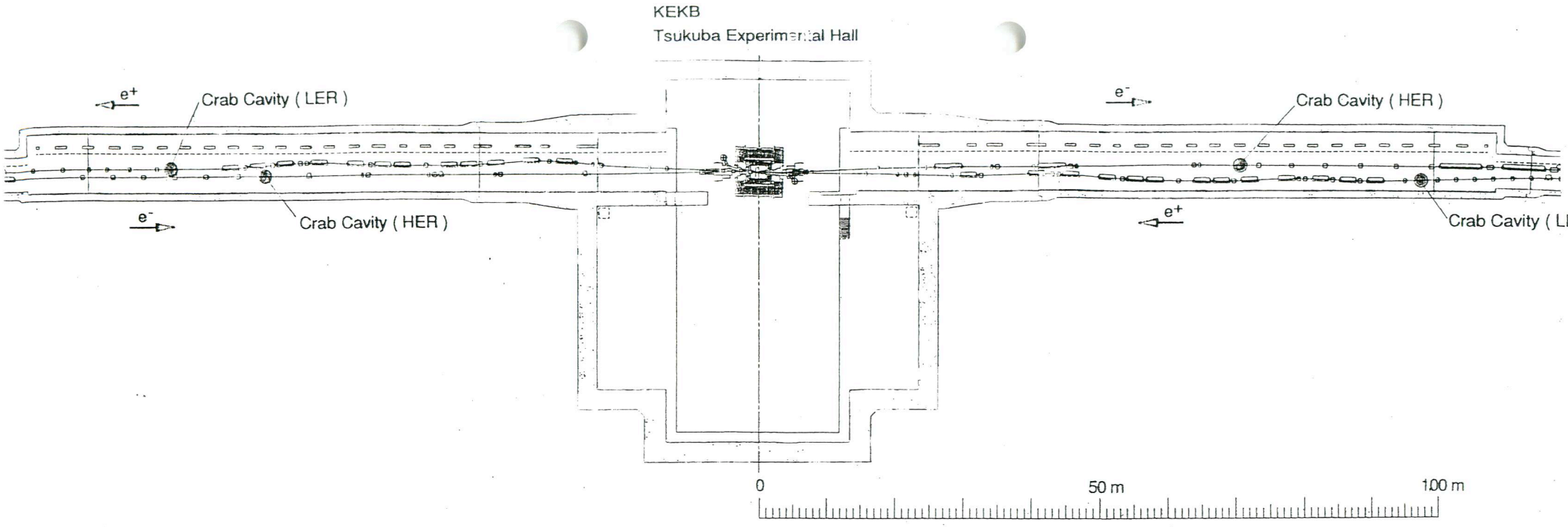
Stub-Support

Rigid Structure No Vibration Problem

Cooling Path Through the Support

Frequency Tuning

---> Adjust the Position of Coaxial Coupler



Crab Crossing Scheme

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βcrab	20	100	m
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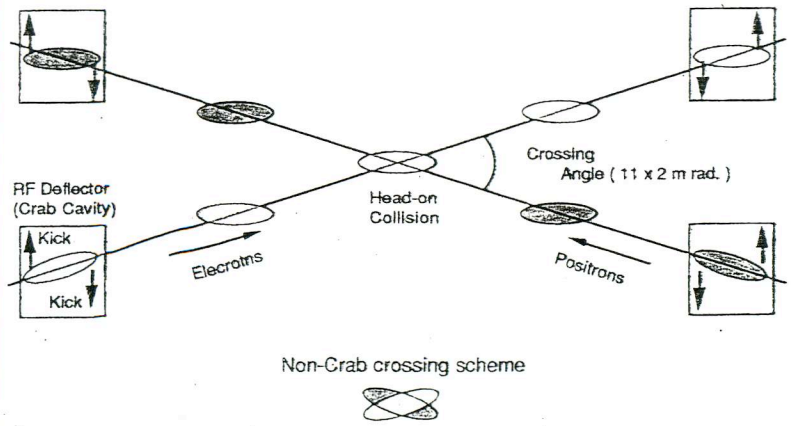

Non-Crab crossing scheme

The Crab crossing scheme allows a large crossing angle collision without introducing any synchrotron-betatron coupling resonances. 2,3)

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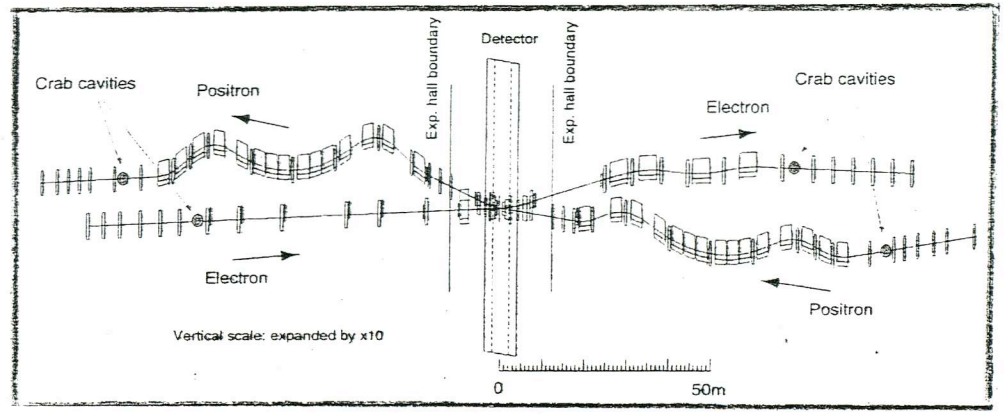
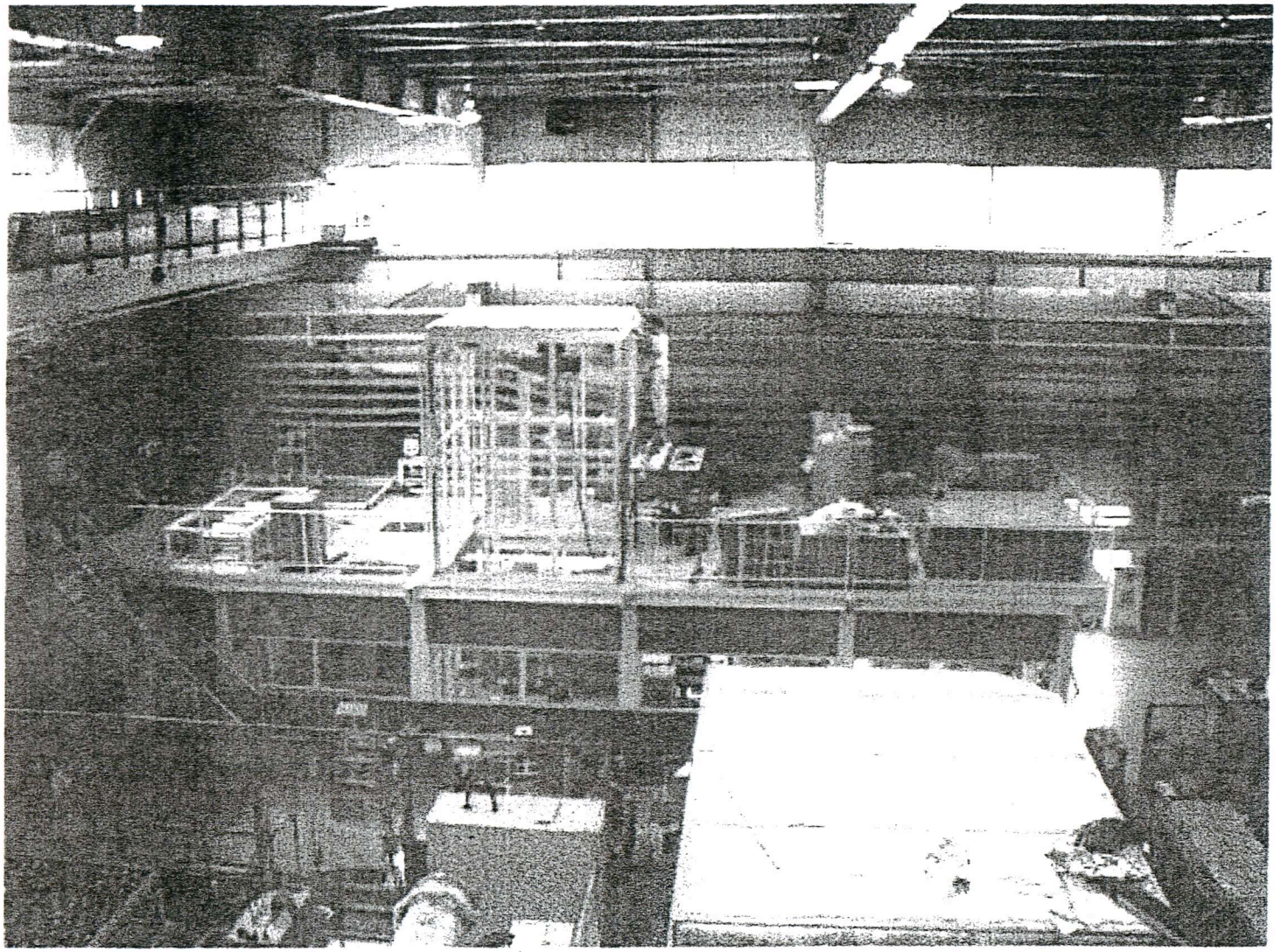
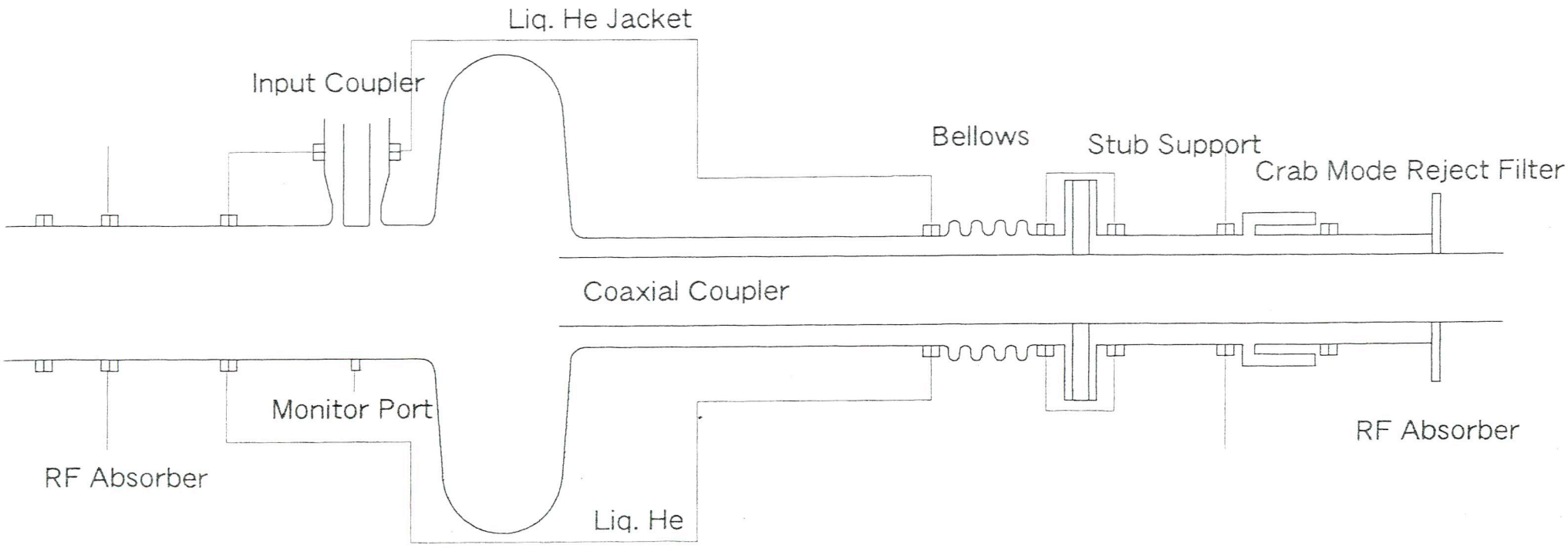




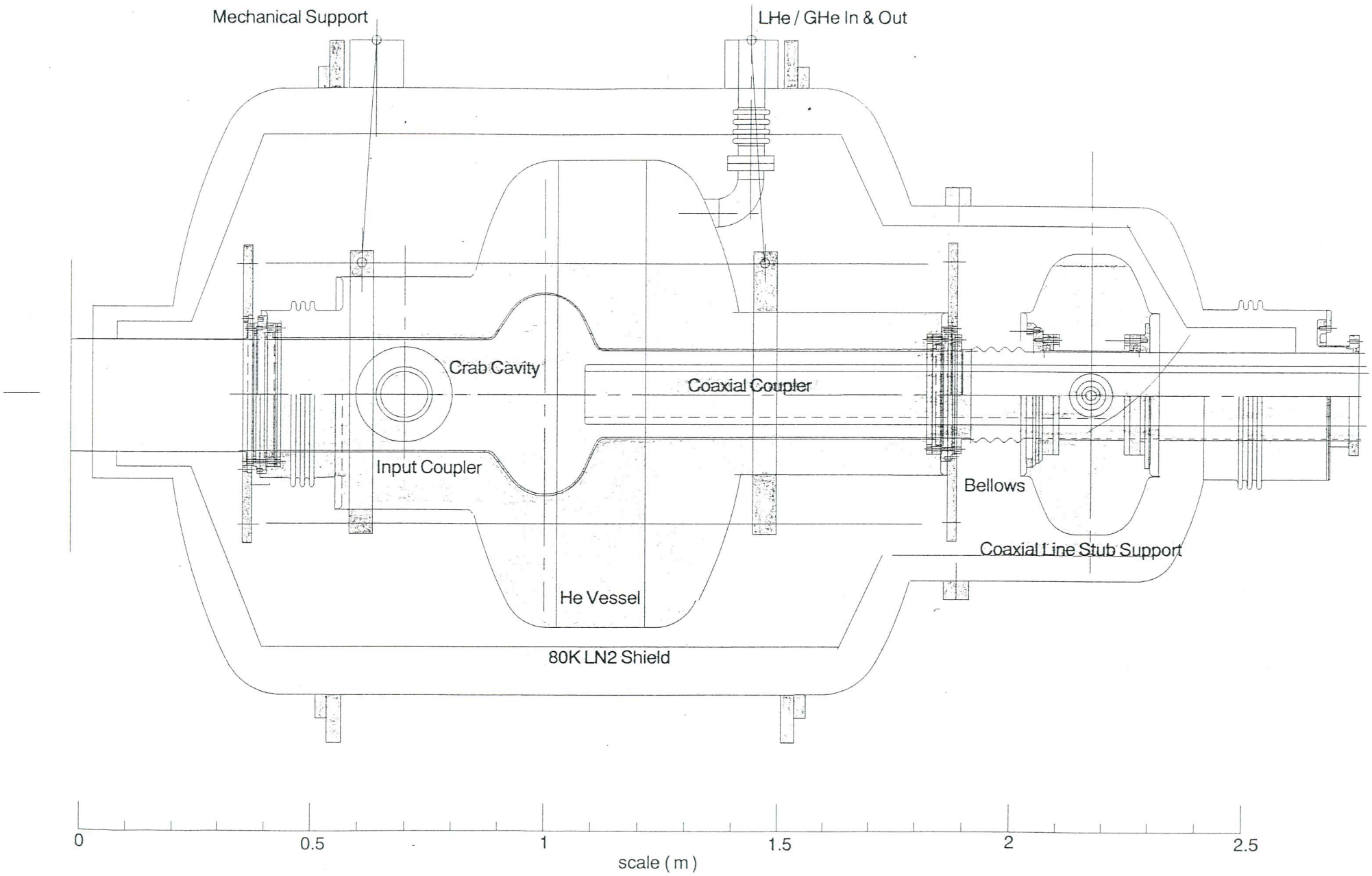
Frequency Tuning by Coaxial Coupler Bellows

Stub Support Mechanical Support & Cooling of Coaxial Coupler Tip by Liq. He

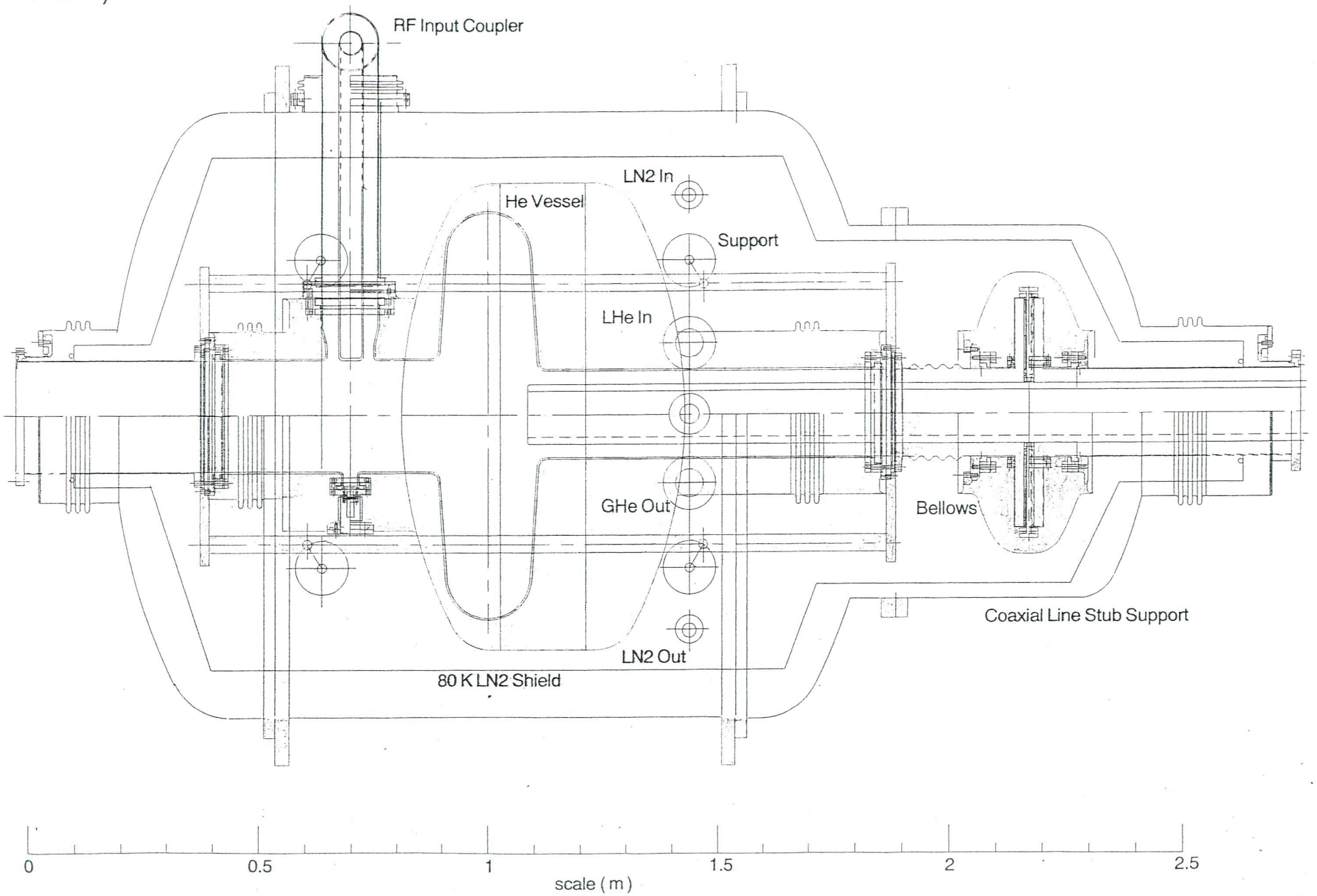
Jacket Type Helium Vessel



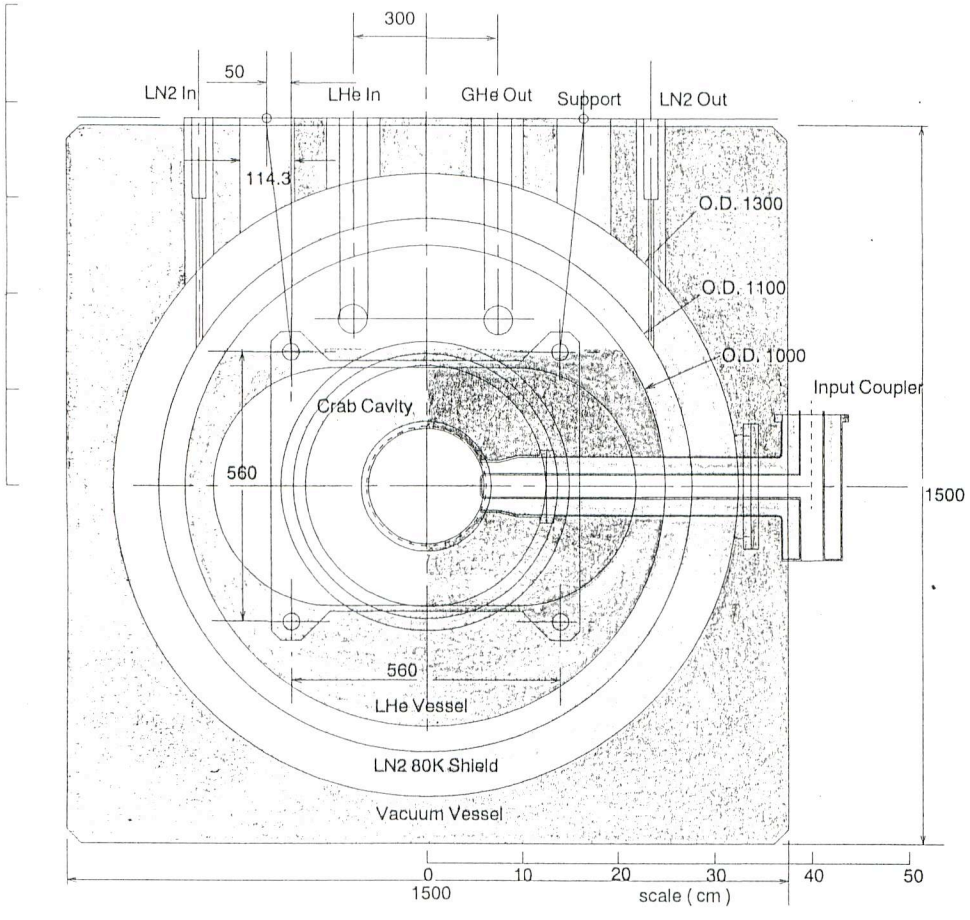
CRYOSTAT FOR KEKB CRAB CAVITY
(SIDE VIEW)

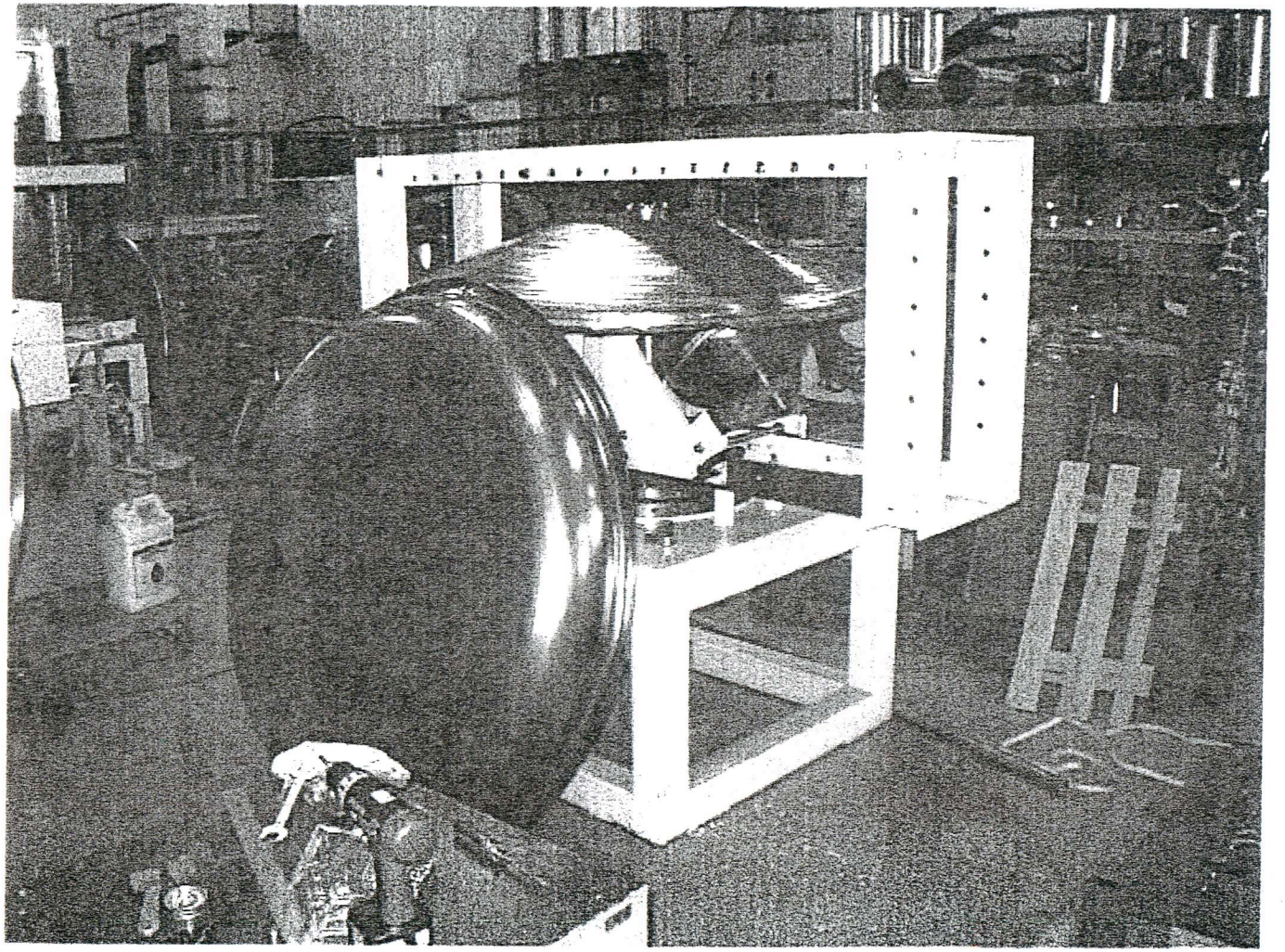


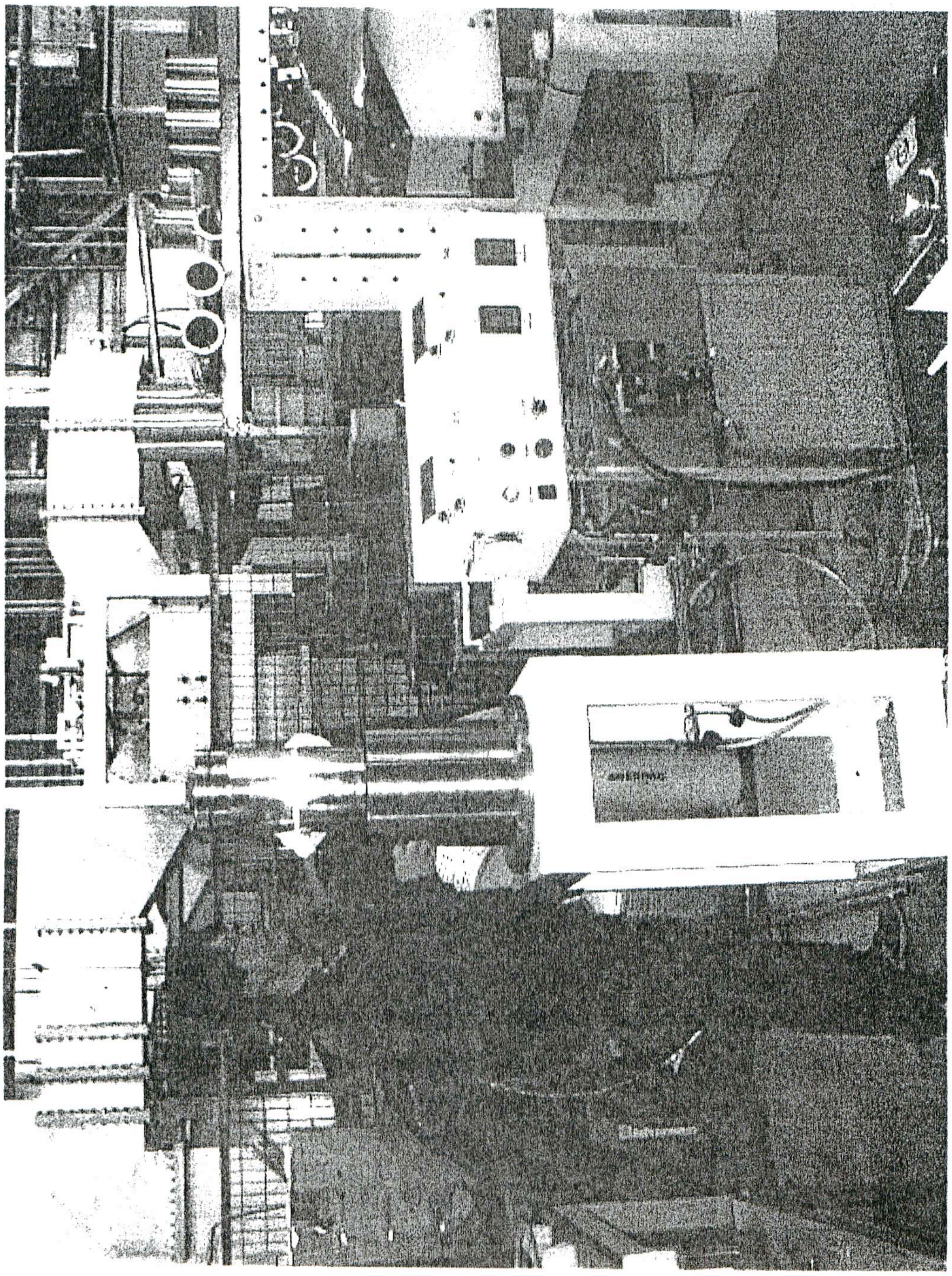
CRYOSTAT FOR KEKB CRAB CAVITY
(TOP VIEW)

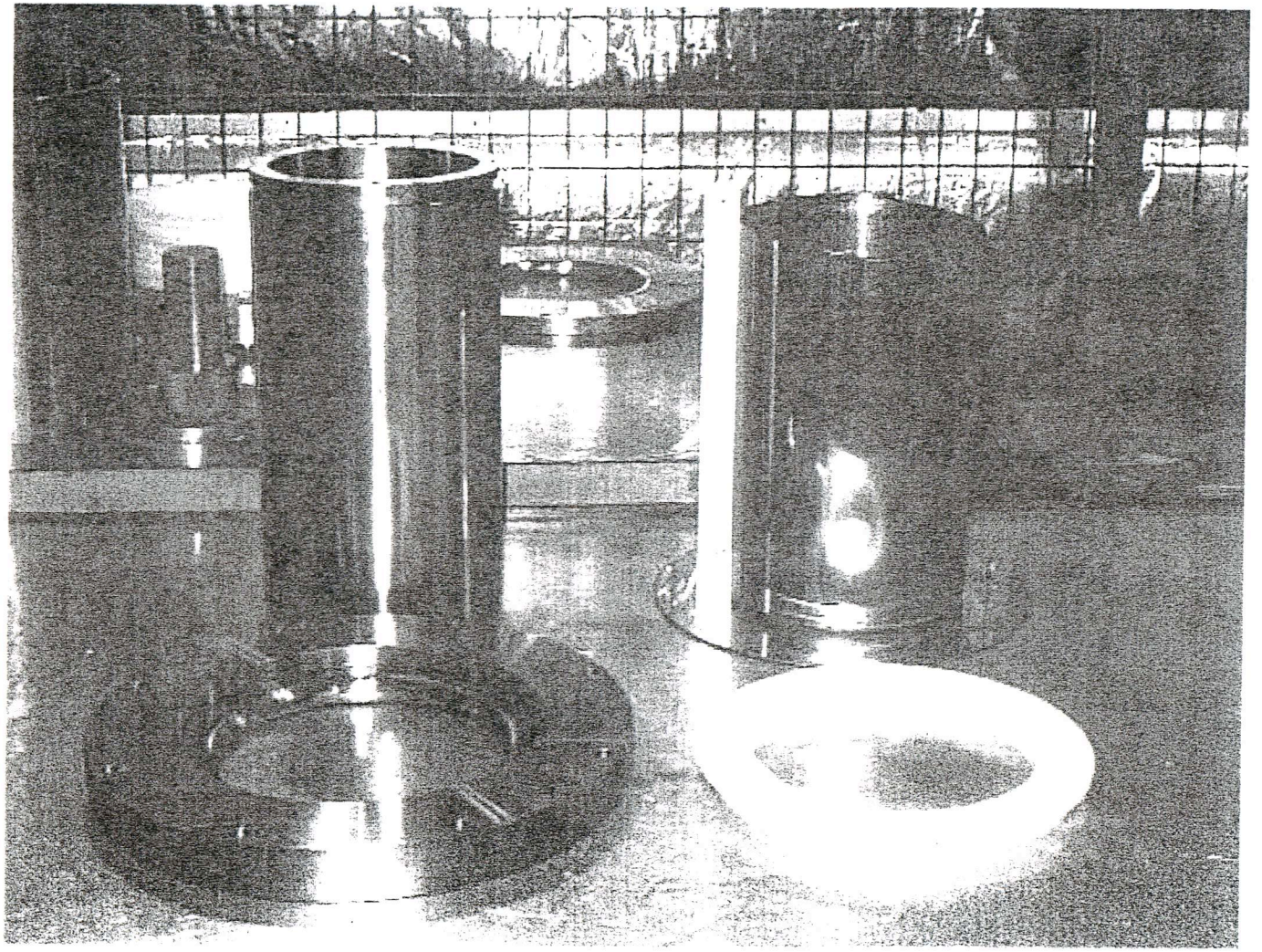


CRYOSTAT FOR KEKB CRAB CAVITY









Cryogenic System for Crab Cavities

Requierd Refrigeration Power ~1kW at 4.4K for 4 Crab Cavities

Satellite Refrigeration System

Surplus Refrigeration Power of Nikko Cryogenic system used for SCC
Helium Refrigeror 8kW at 4.4 K KEKB SSC 3 kW

Why Satellite Refrigeration System?

Simple Helium Refrigeration System with no Turbo-Expander

Size of the System is about 1/2 of Ordinary Refrigeration System

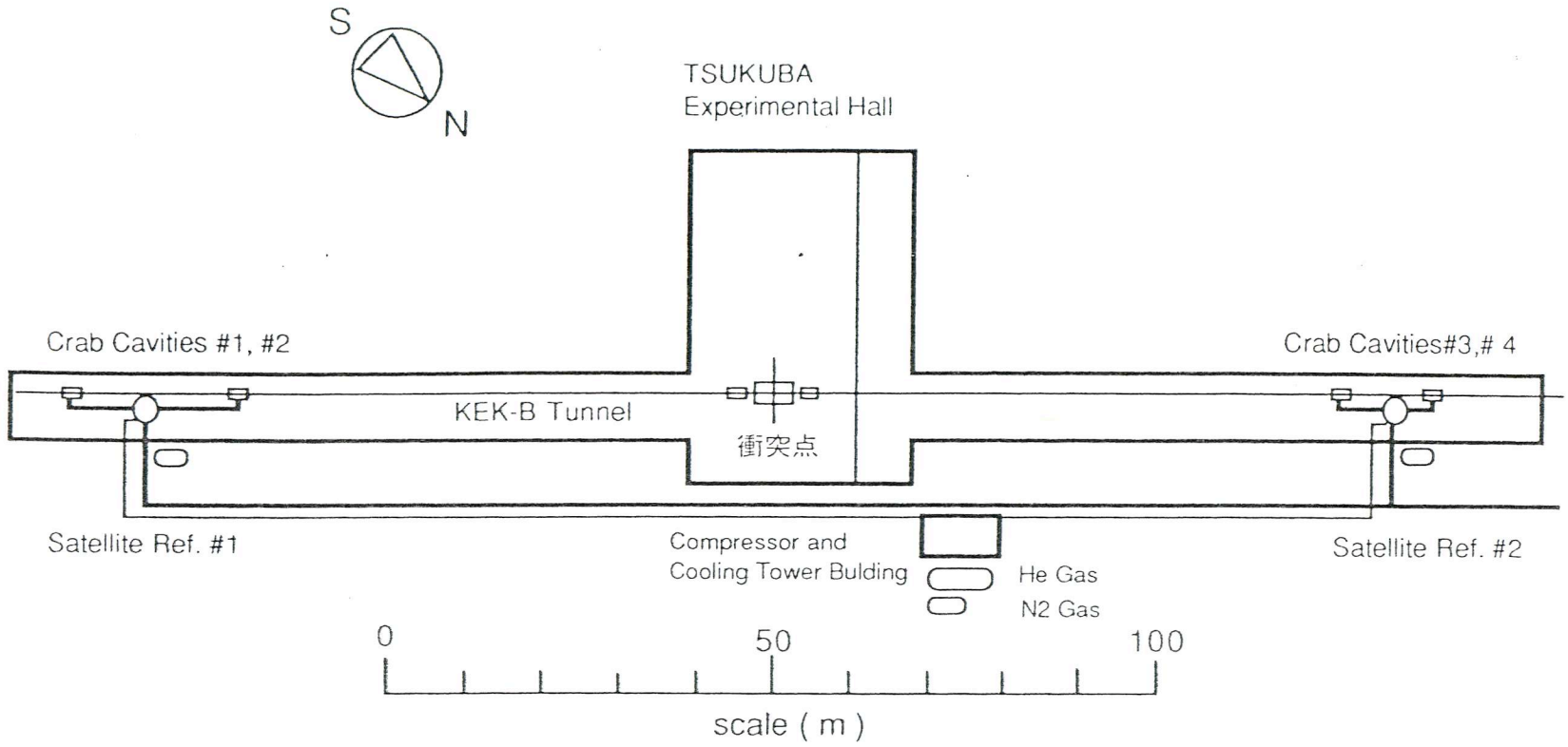
Low Construction and Operation Cost

High Performance Transfer Line (about 1km long)

High Performance Liq. He Transfer Line
Heat Loss ~ 0.05 W/m

KEK-B Crab Cavity Cryogenic System

Dec. 1996
K.Hosoyama



Heat Load of Crab Cavity Cryogenic System

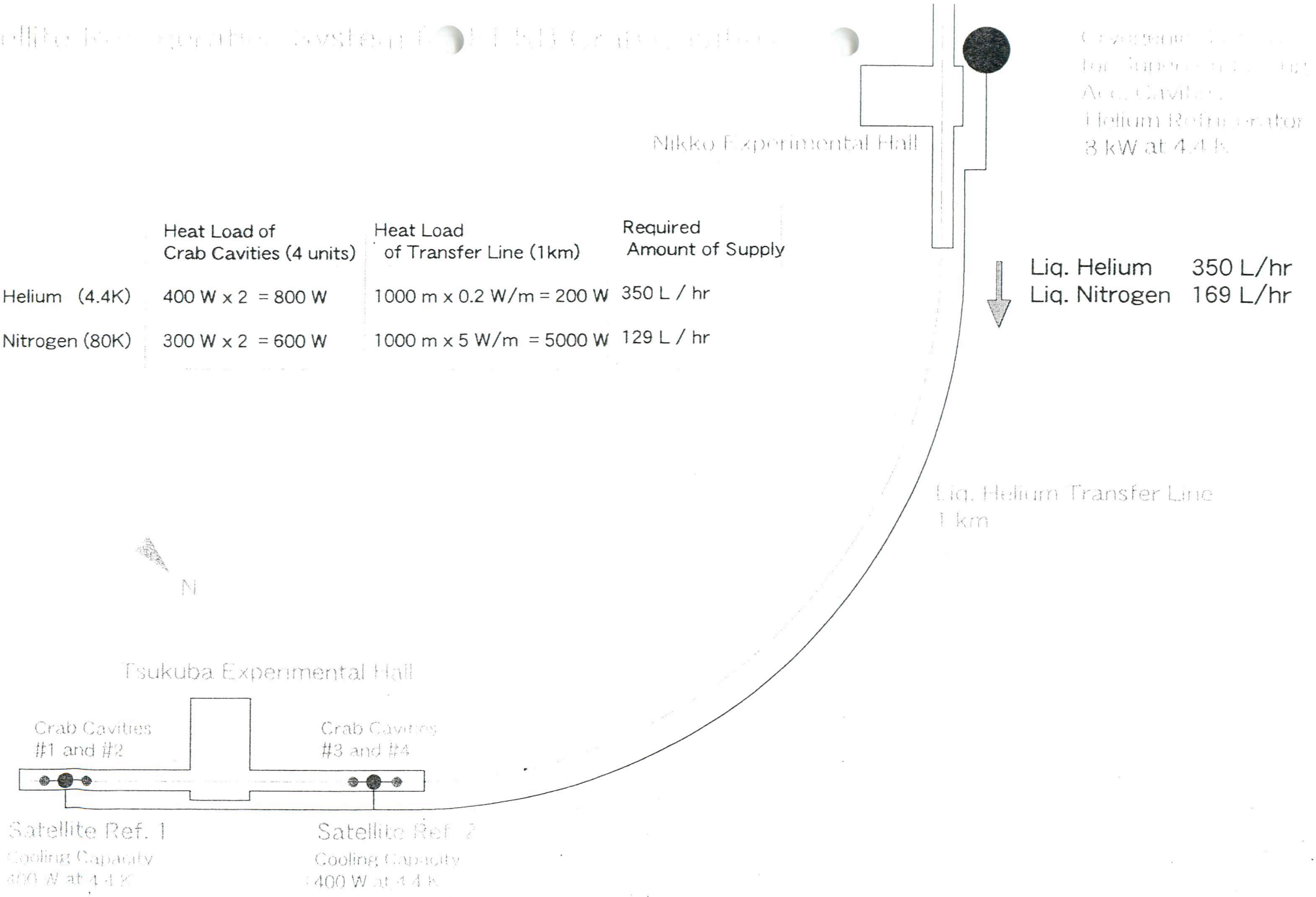
	RF loss	Cryostat	Transfer Line etc.	Total	2 Crab Cavities	50% Safety Margin
Case 1	43 W	+ 25 W	+ 30 W	= 98 W	98 W x 2 = 196 W	294 W
Case 2	86 W *	+ 25 W	+ 30 W	= 141 W	141 W x 2 = 282 W	423 W

RF Loss

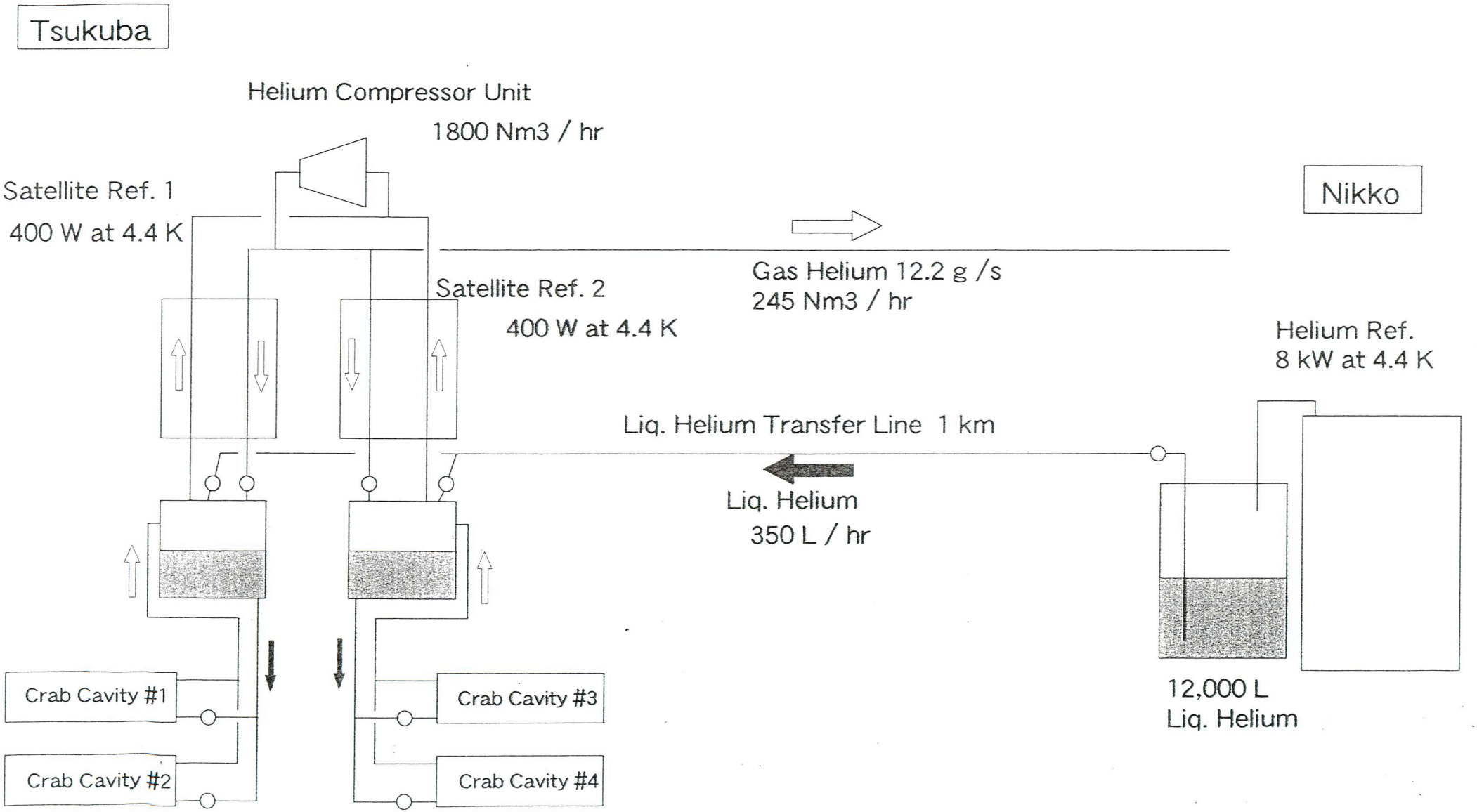
Case 1 $Q_0 = 1 \times 10^9$ RF Loss = 43 W

Case 2 $Q_0 = 5 \times 10^8$ RF Loss = 86 W

	Heat Load of Crab Cavities (4 units)	Heat Load of Transfer Line (1km)	Required Amount of Supply
Liq. Helium (4.4K)	400 W x 2 = 800 W	1000 m x 0.2 W/m = 200 W	350 L / hr
Liq. Nitrogen (80K)	300 W x 2 = 600 W	1000 m x 5 W/m = 5000 W	129 L / hr



Satellite Refrigeration System for KEKB Crab Cavities



Cross Sections of Transfer Lines