



CRAB CAVITY R&D

K. Hosoyama

0. Crab Crossing and Crab Cavity
 1. 1/3 Scale Model (1500MHz)
 - a. Fabrication and Processing
 - b. RF Test
 2. Full Scale Model (500MHz)
 - a. Fabrication and Processing
 - b. Test Stand
 3. Cryogenic System for Crab Cavities
 - a. Cryogenic System for TRISTAN SCC
 - b. Cryogenic System for Crab Cavities
 - Satellite Refrigerator
 - c. R&D Program of High Performance Transfer Line

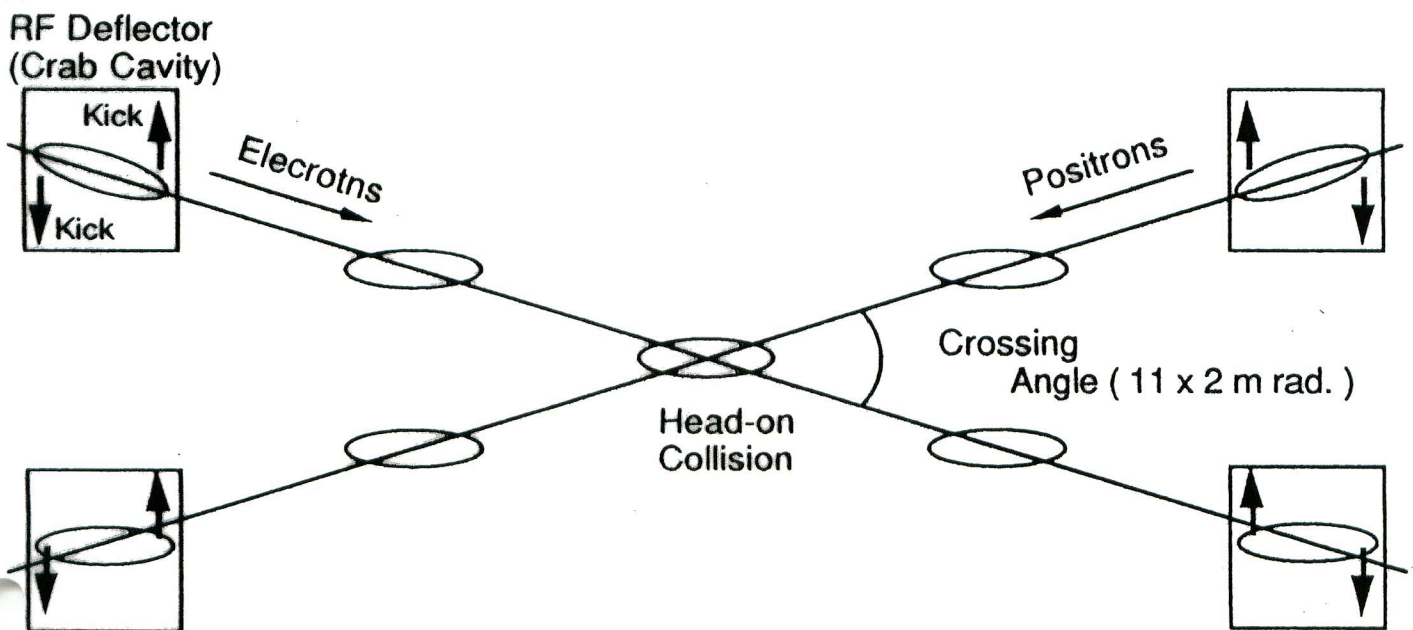
Why we use the crab crossing ?

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



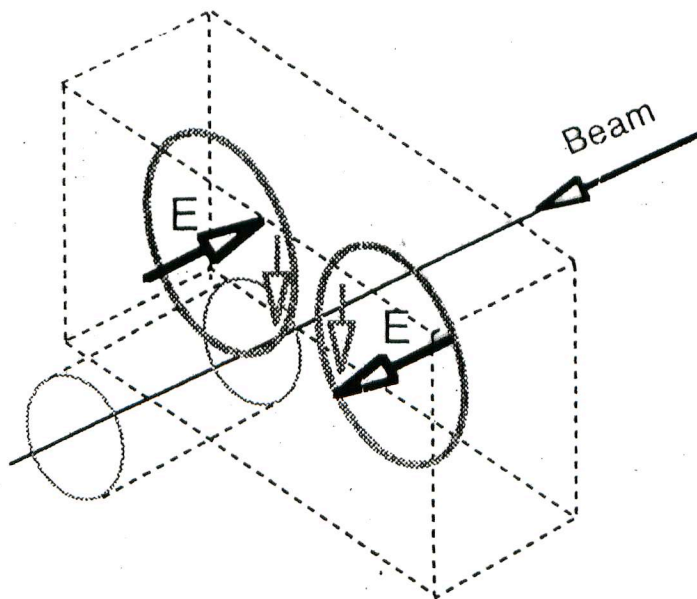
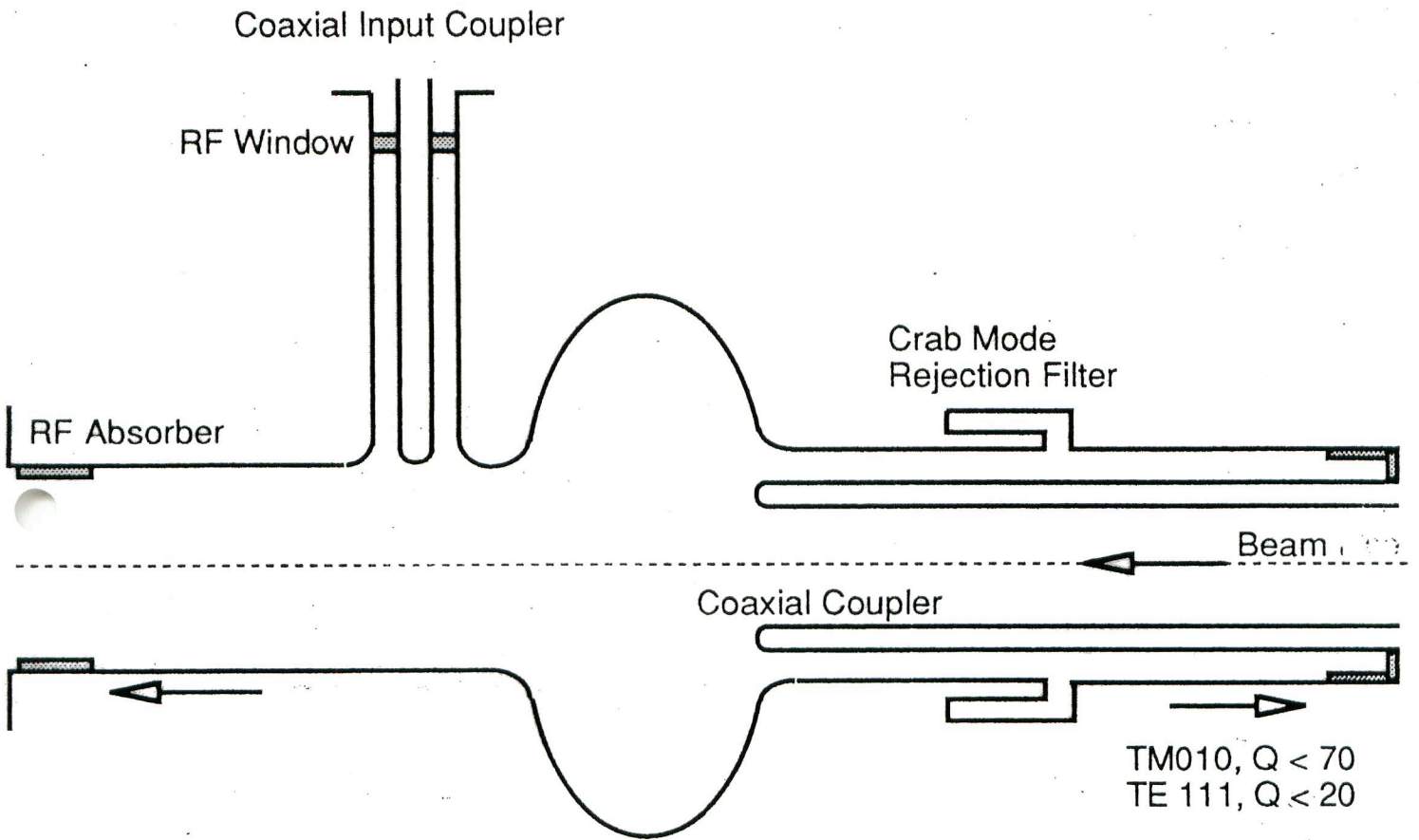
Why we use the superconducting cavity ?

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
β_x	0.33	0.33	m
β_{crab}	20	100	m
Required kick	1.41	1.44	MV

Crab Cavity Design Concept

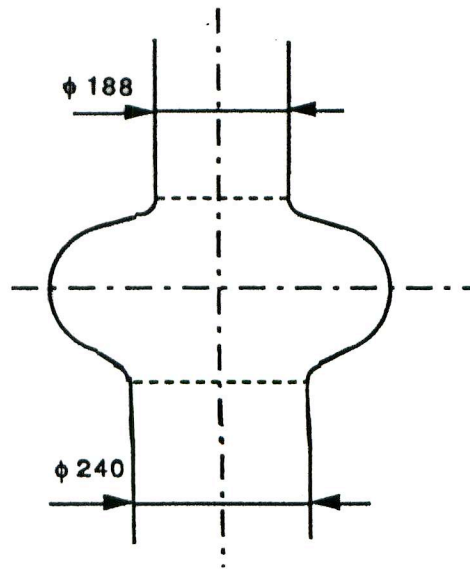
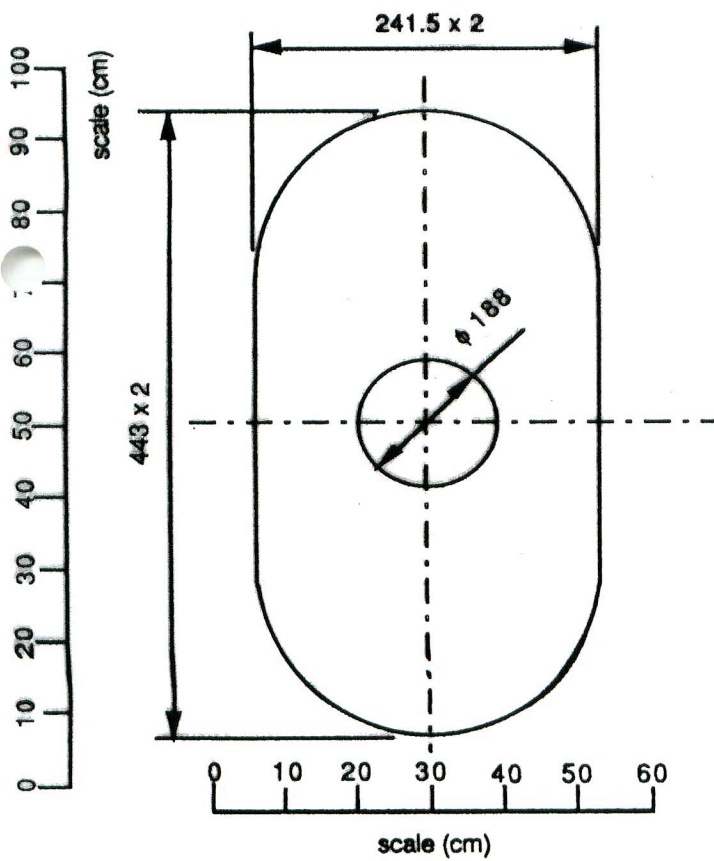
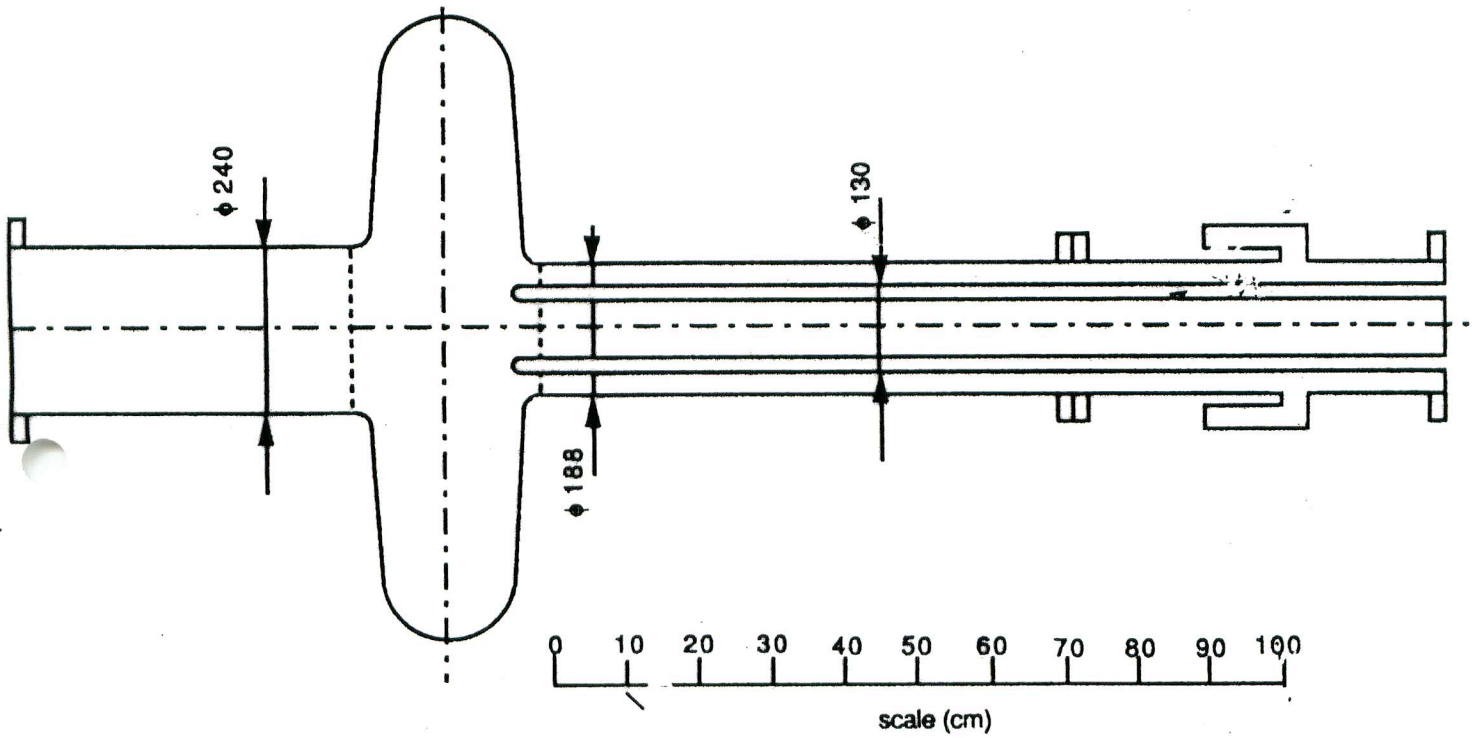
K. Hosoyama



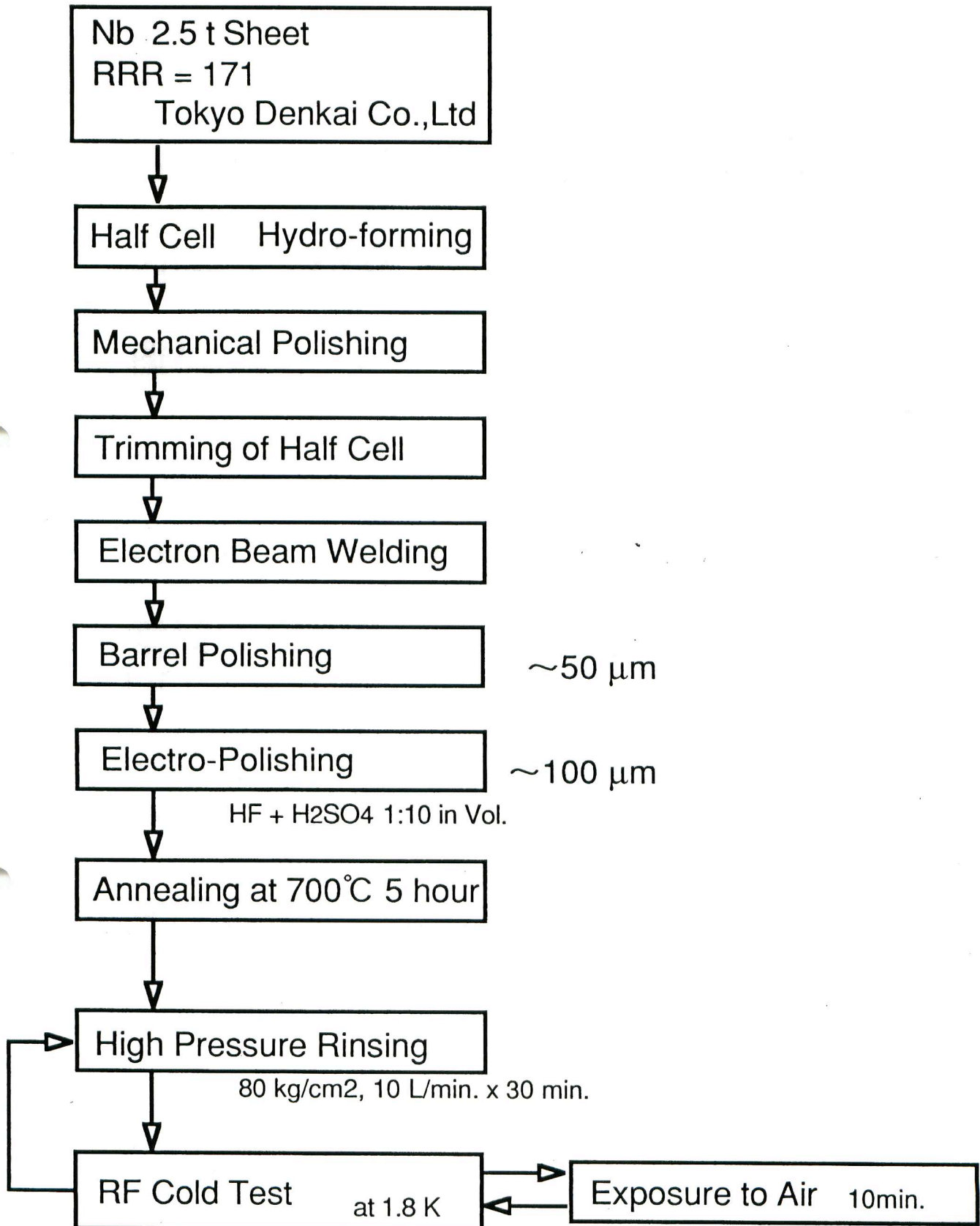


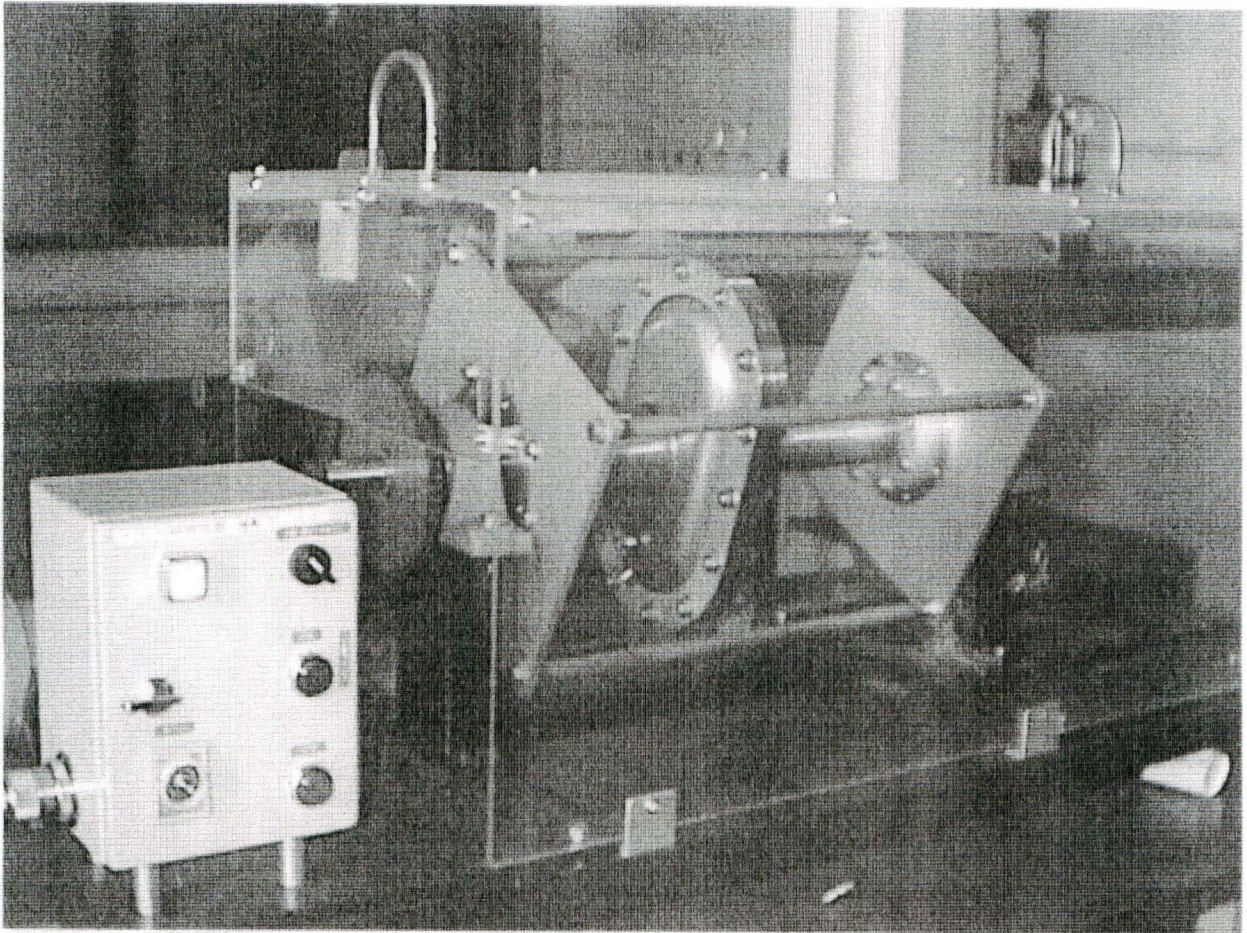
KEK-B Crab Cavity

Mar.24, 1995
K. Hosoyama
(revised from Mar. 16)



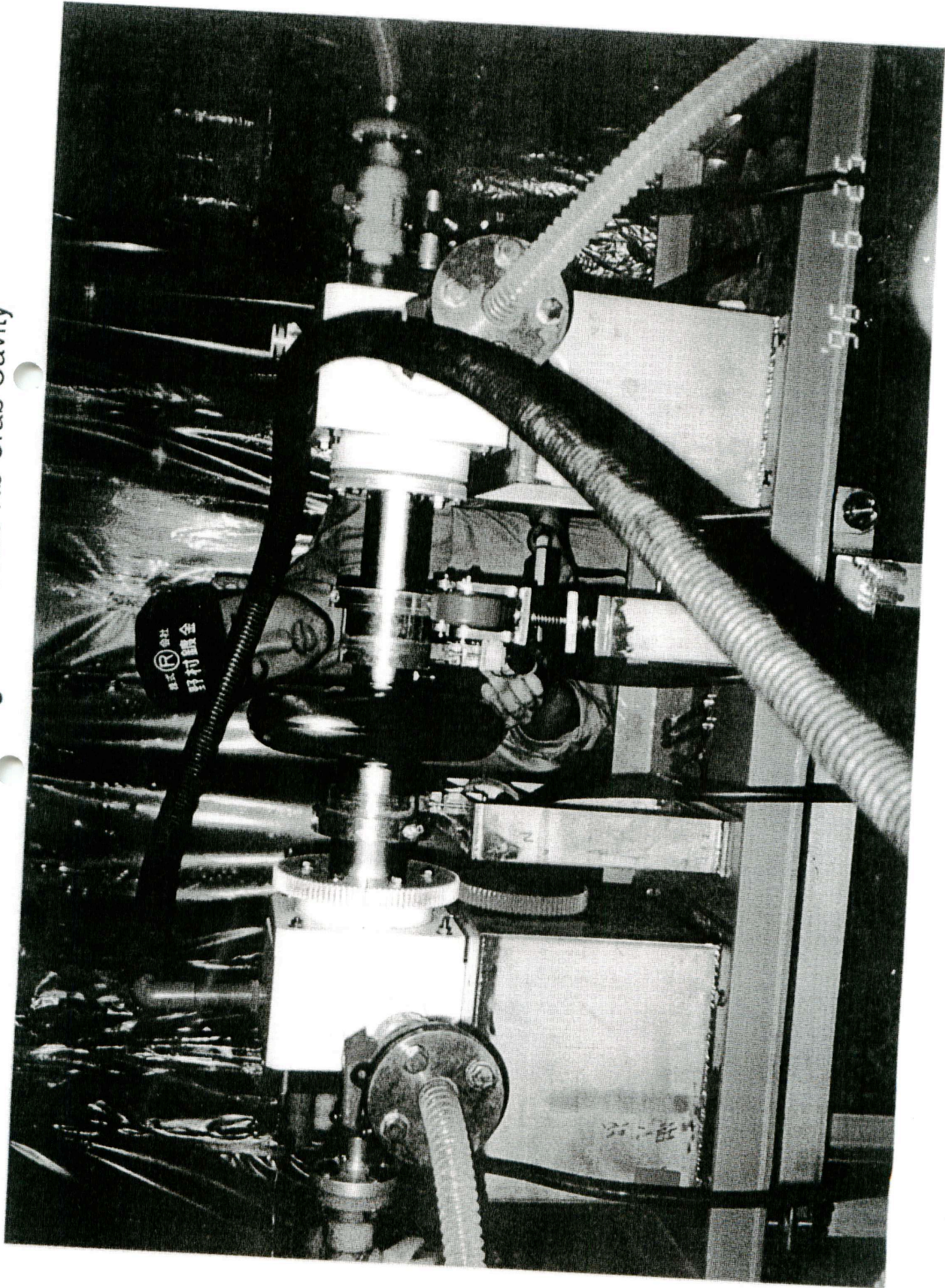
Fabrication and Processing of Crab 1/3 Scale Model

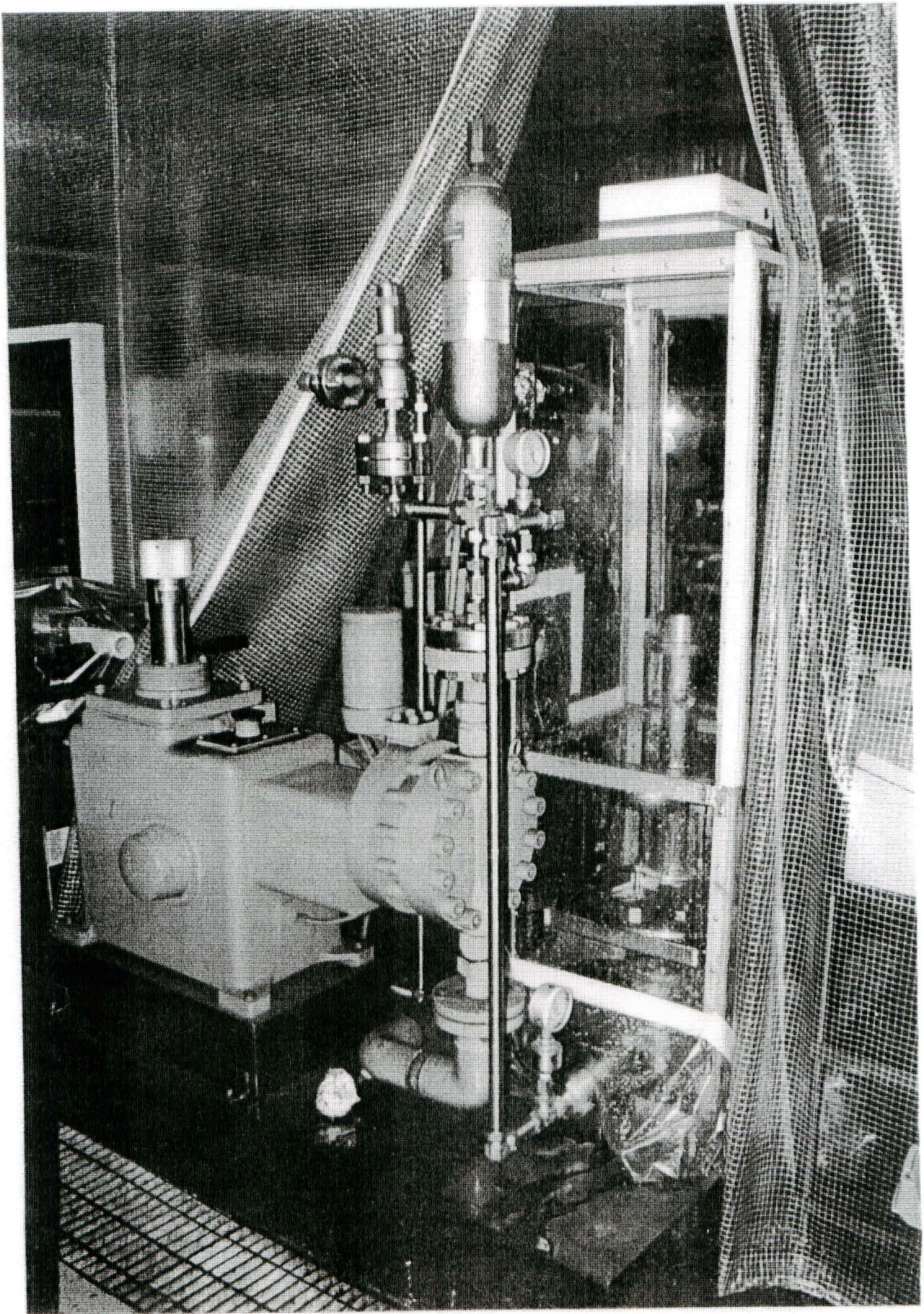




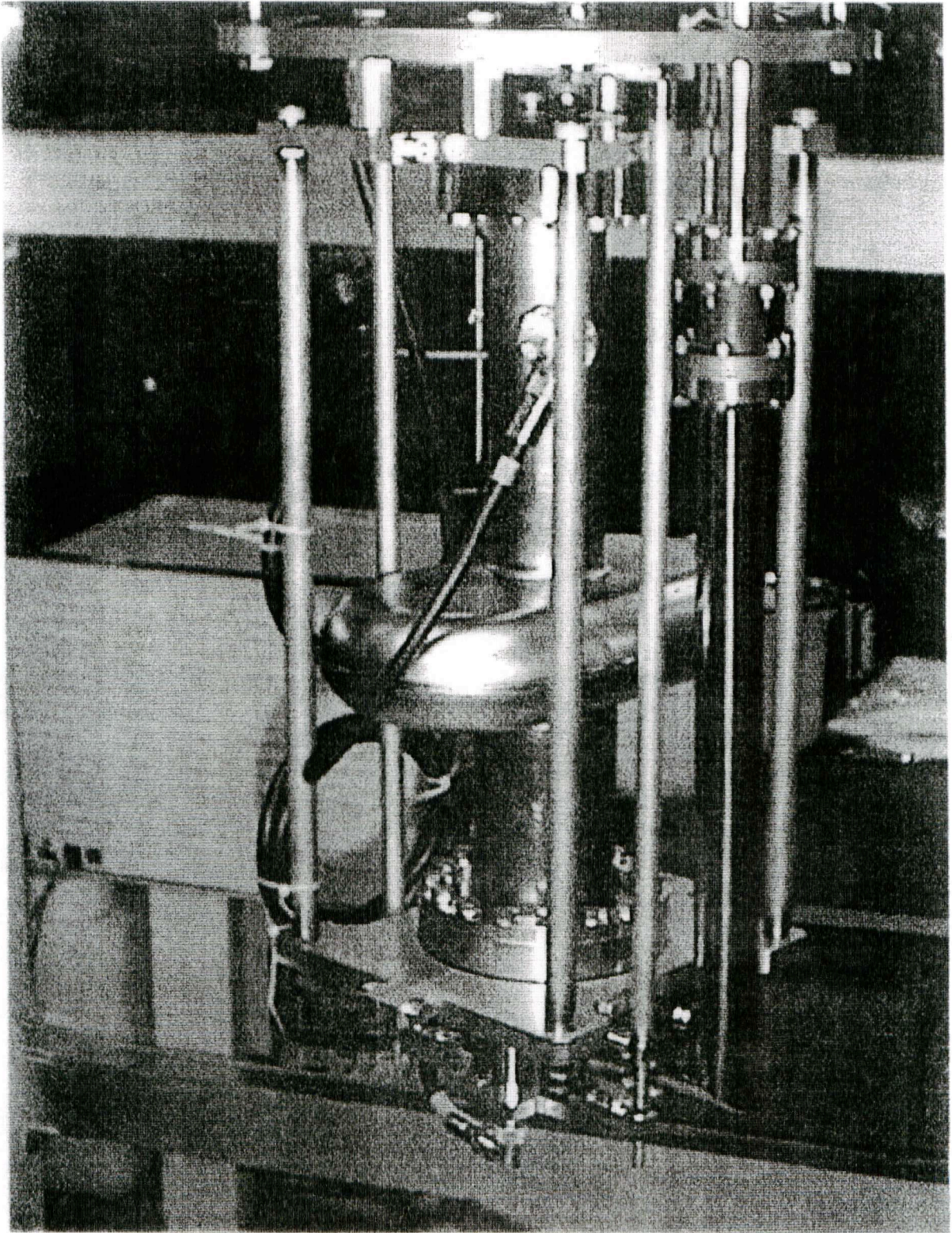
Barrel Polishing Machine for 1/3 Scale Model

Electro-Polishing of 1/3 Scale Nb Crab Cavity

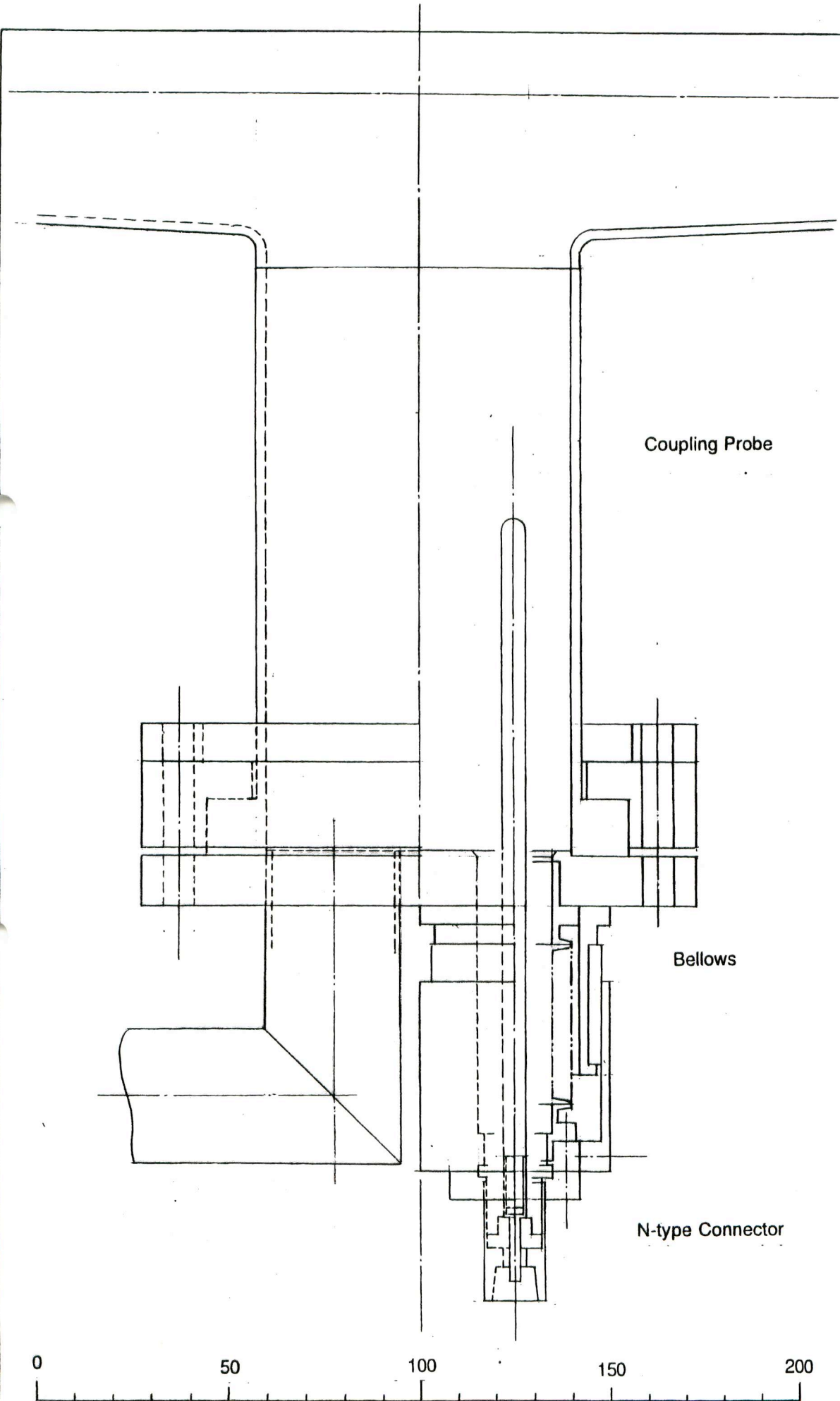




High Pressure Water Rinsing of 1/3 Scale Nb Crab Cavity



1/3 Scale Nb Crab Cavity (1.5 GHz)



Scale (mm)



KEK ENGINEERING NOTE
Crab Cavity 1/3 scale Model
E-field Decay in Beam Pipe

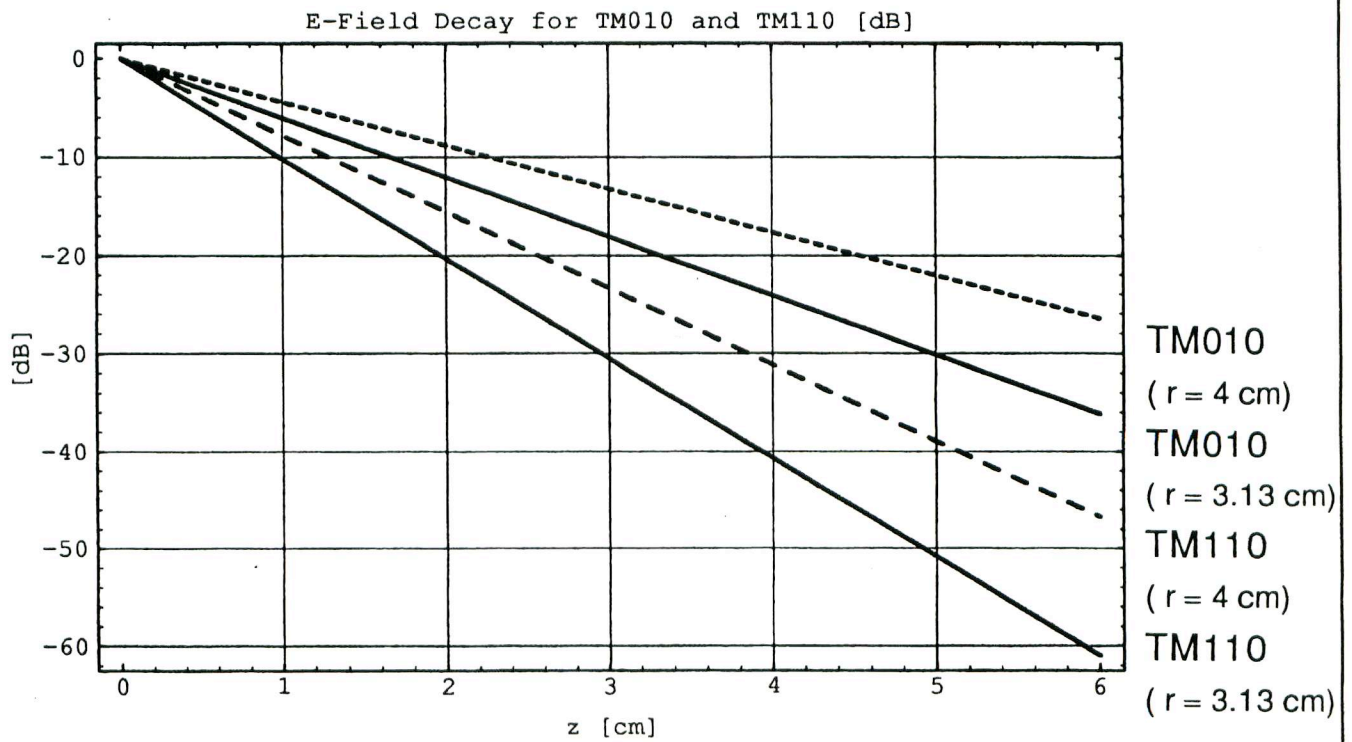
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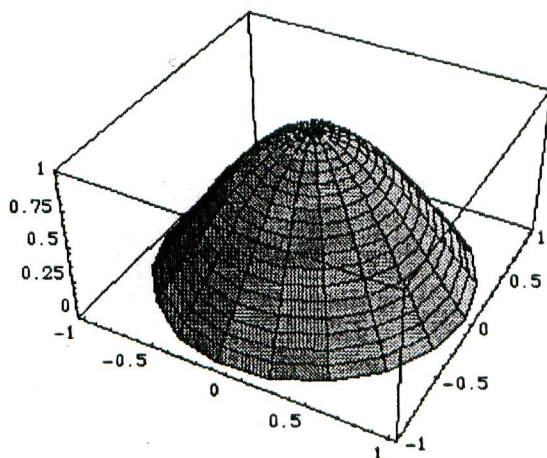
NAME:

K. Hosoyama

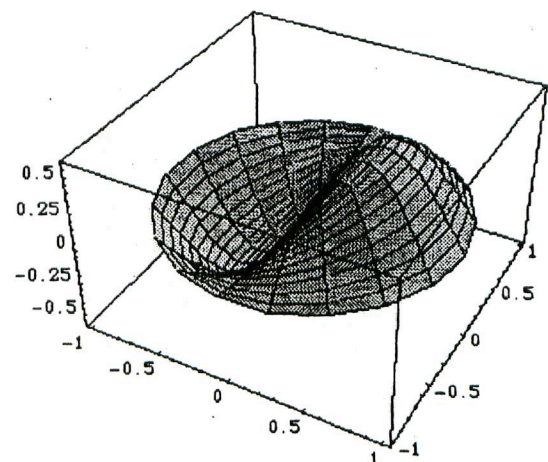
Ez - Field Decay for TM010 and TM110 in Beam Pipe



Ez - Field Profile TM010

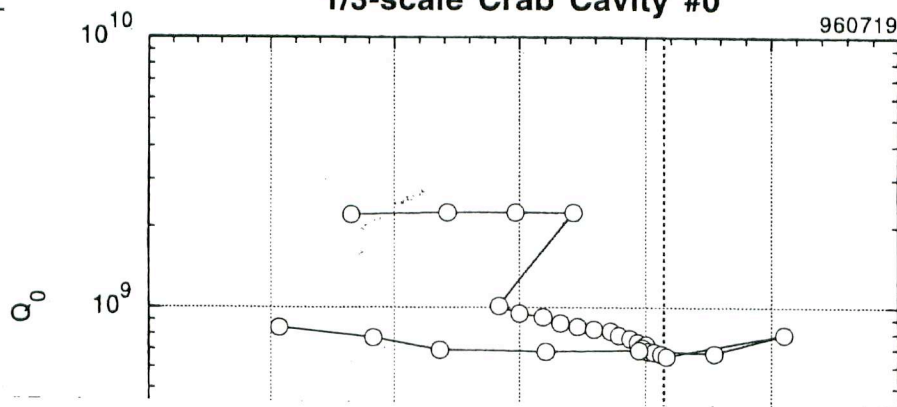


Ez - Field Profile TM110



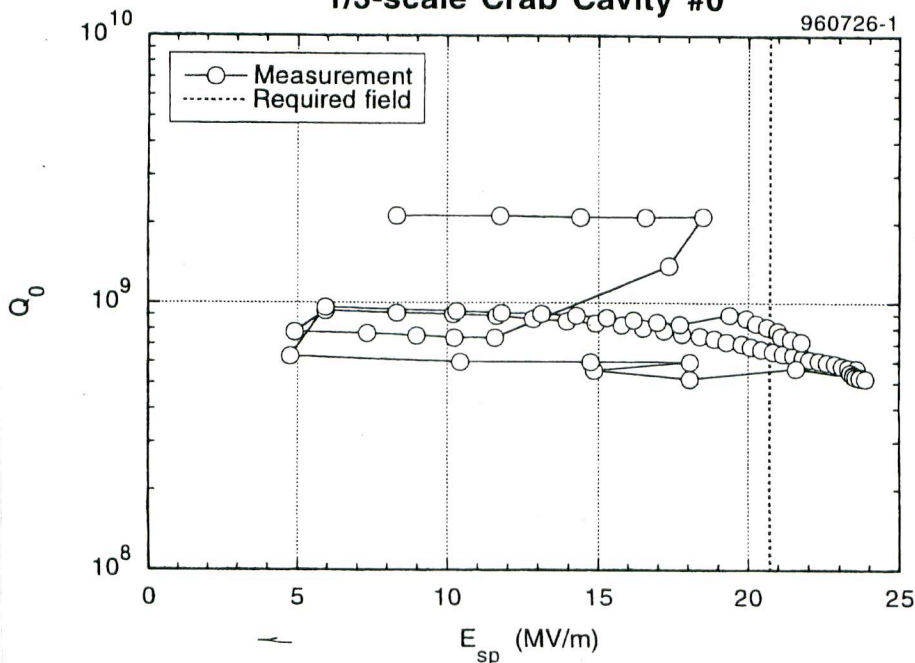


1/3-scale Crab Cavity #0



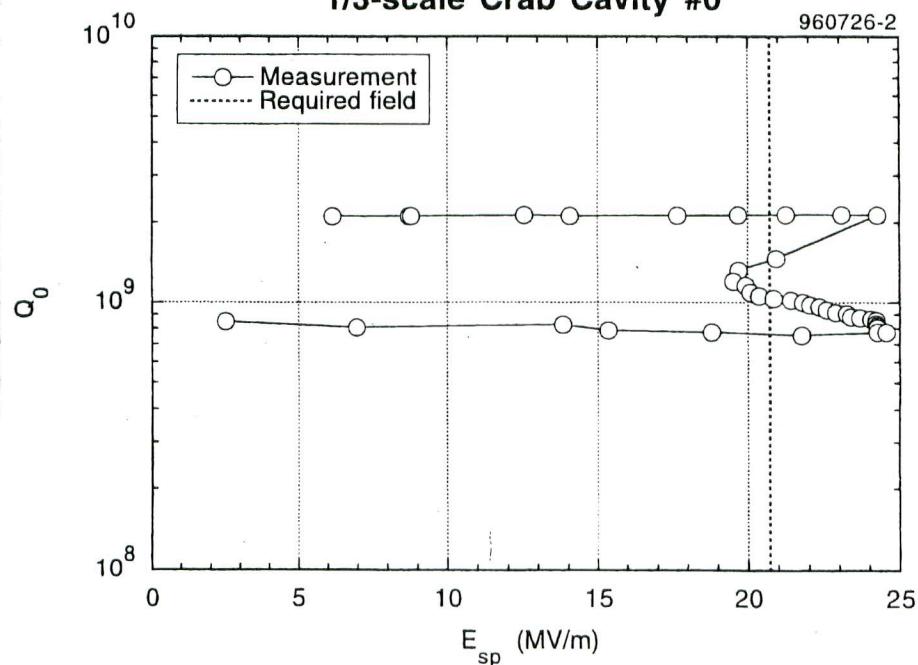
Nb Probe
(change from Cu)

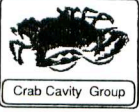
1/3-scale Crab Cavity #0



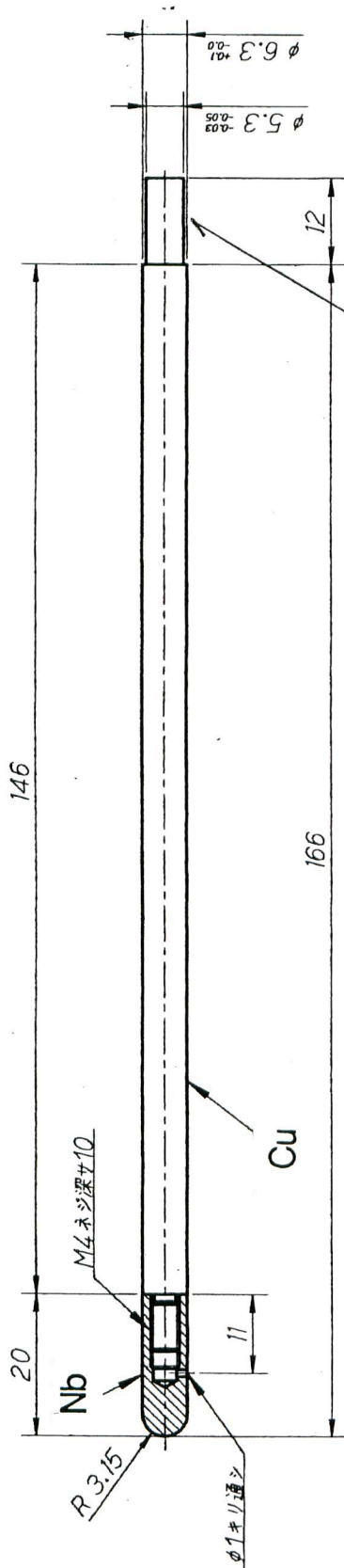
Poor Cooling
of Probe Part

1/3-scale Crab Cavity #0

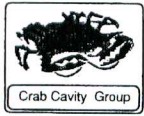




Coupling Probe (Nb + Cu) Type



- a) Insertion Joint
- b) Soldering
- c) Welding
- d) Screw Joint



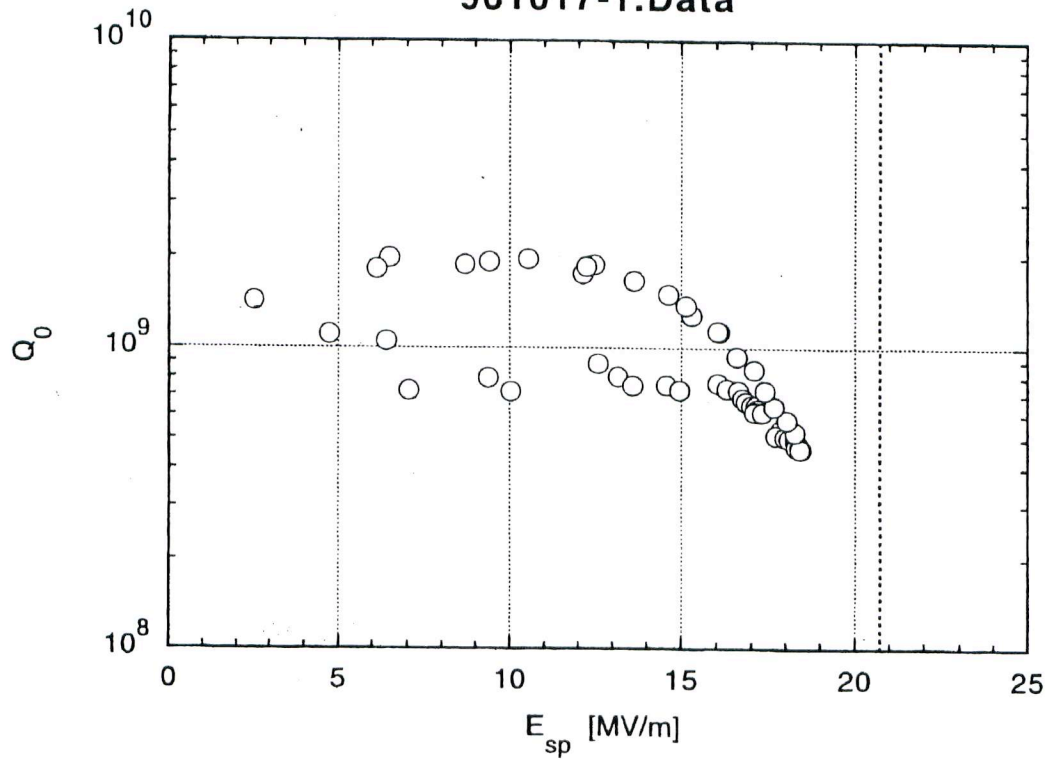
KEK ENGINEERING NOTE

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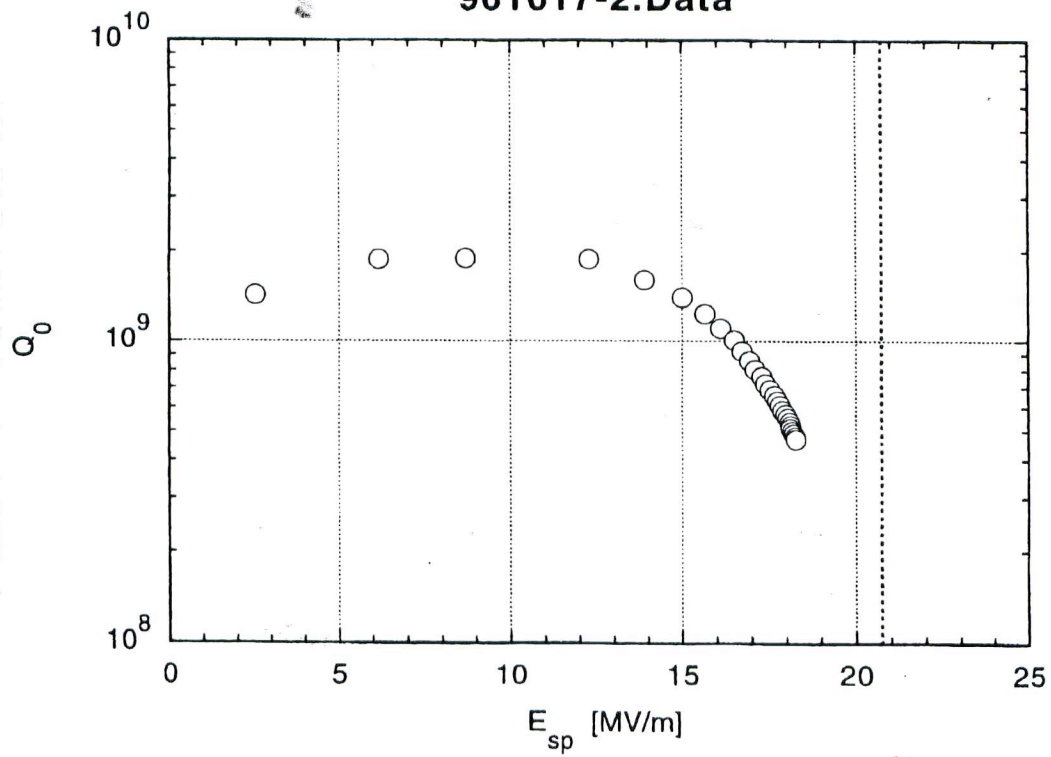
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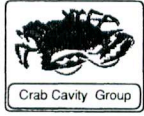
NAME:

961017-1.Data

Nb + Cu Probe
SolderingDegradation
by Flux

961017-2.Data





KEK ENGINEERING NOTE

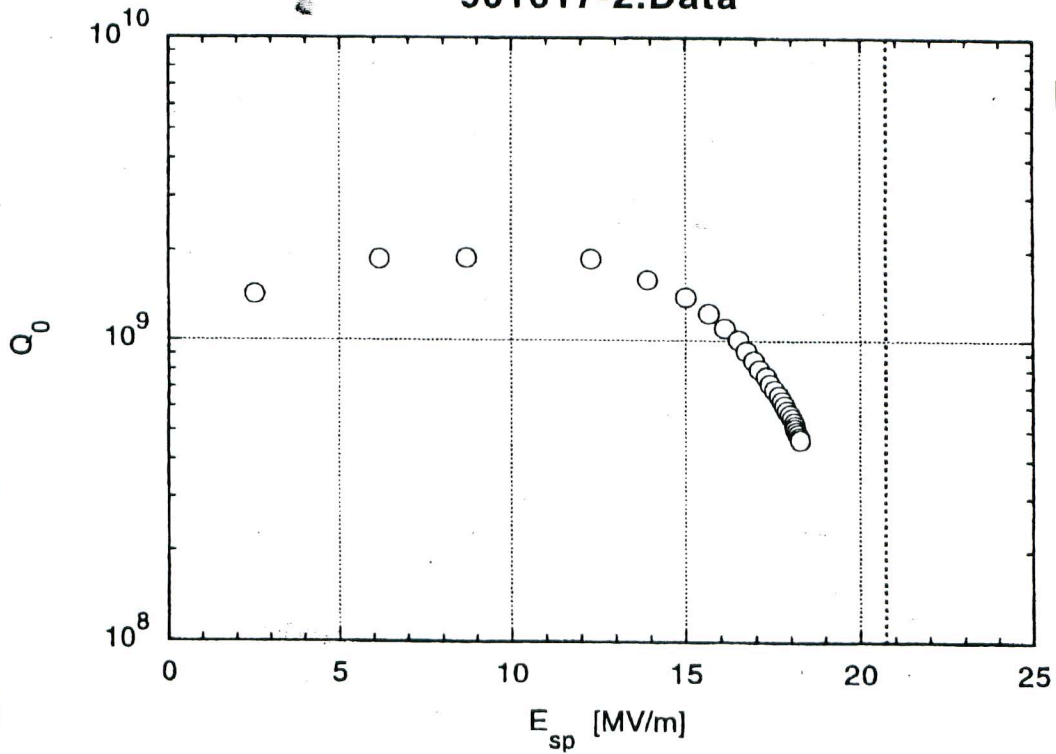
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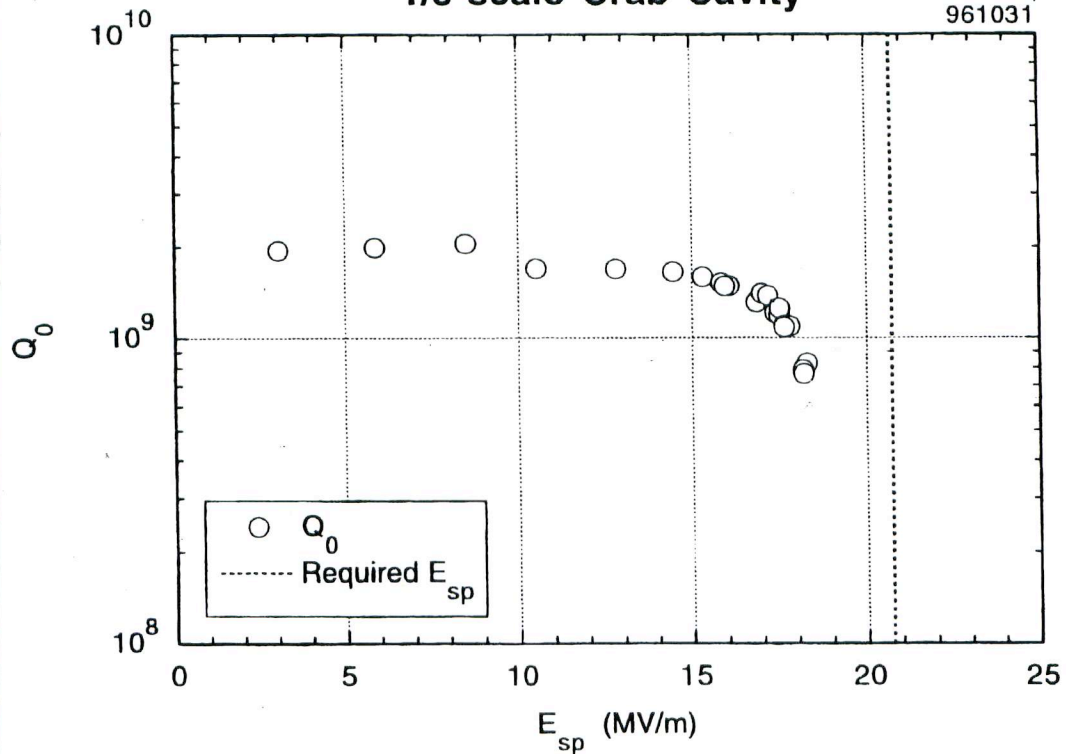
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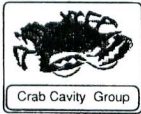
Nb + Cu Probe
Soldering

961017-2.Data

Warm-up
Improve Vacuum

1/3-scale Crab Cavity



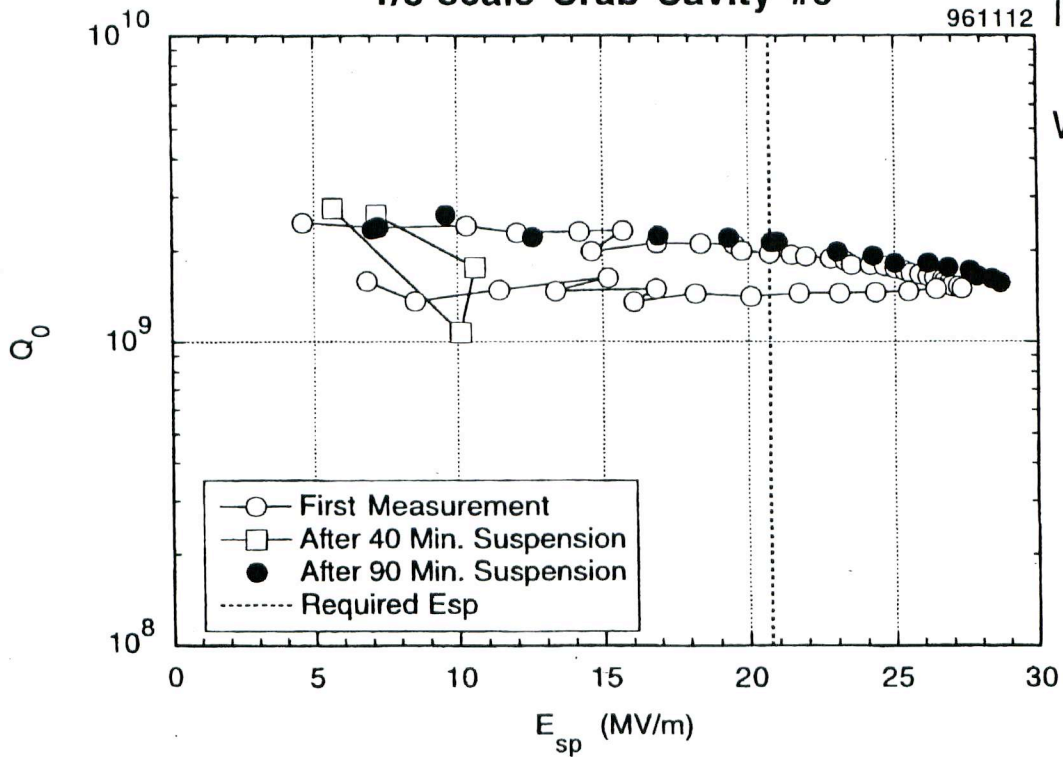


1/3-scale Crab Cavity #0

961112

Nb + Cu Probe
Insertion Joint

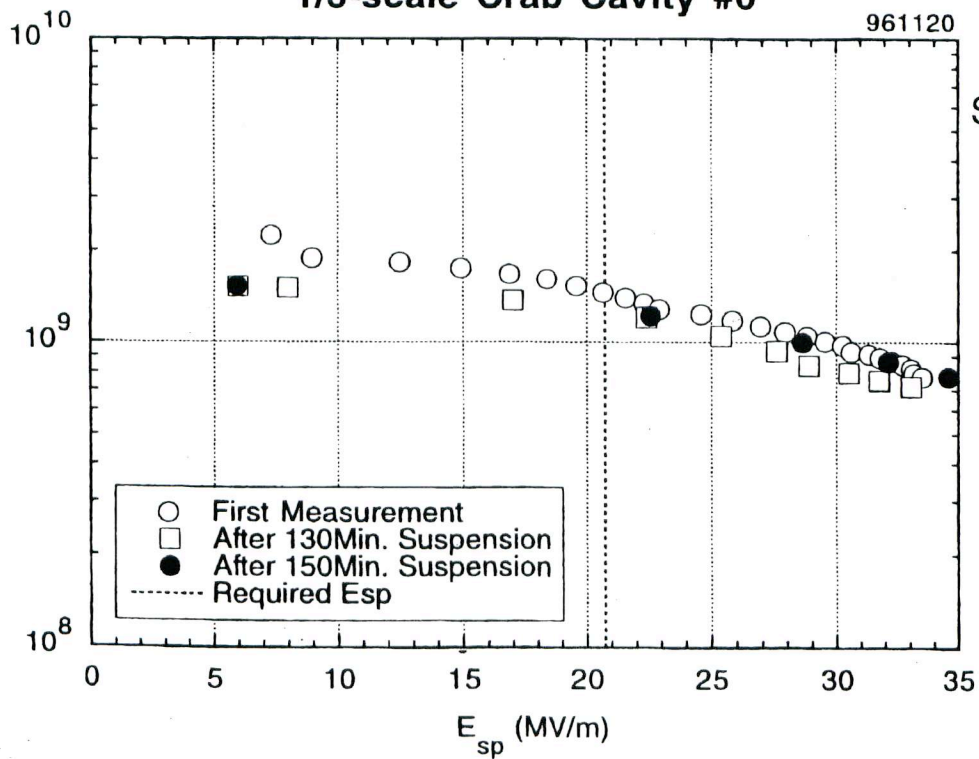
Weak Coupling

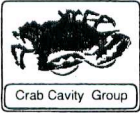


1/3-scale Crab Cavity #0

961120

Strong Coupling





KEK ENGINEERING NOTE

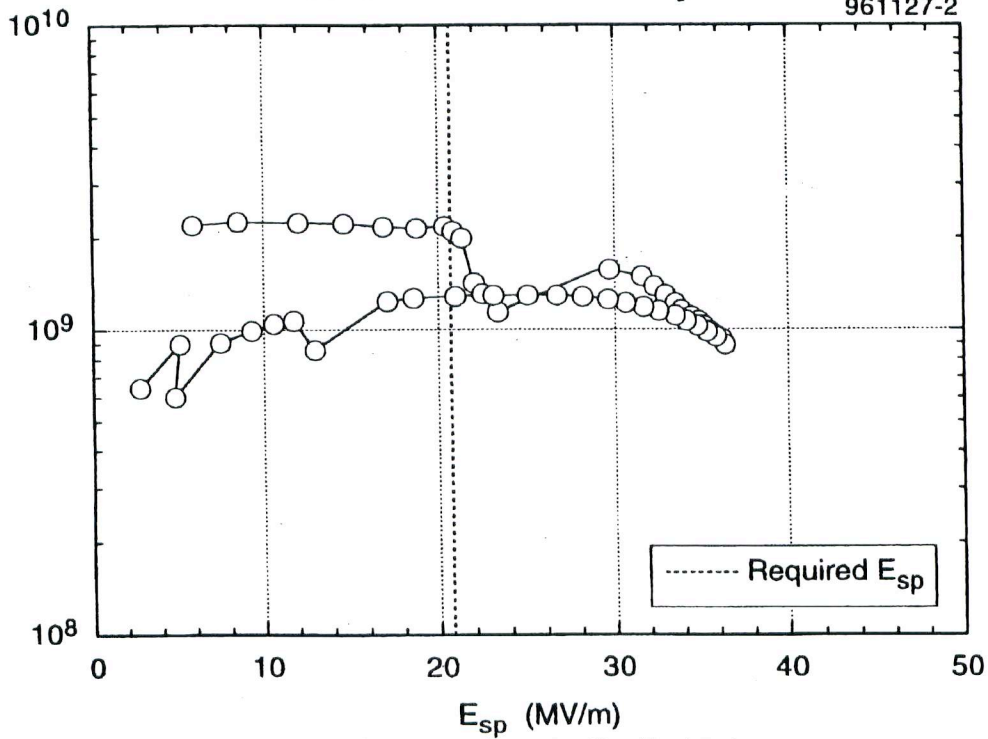
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NAME:

1/3-scale Crab Cavity #0

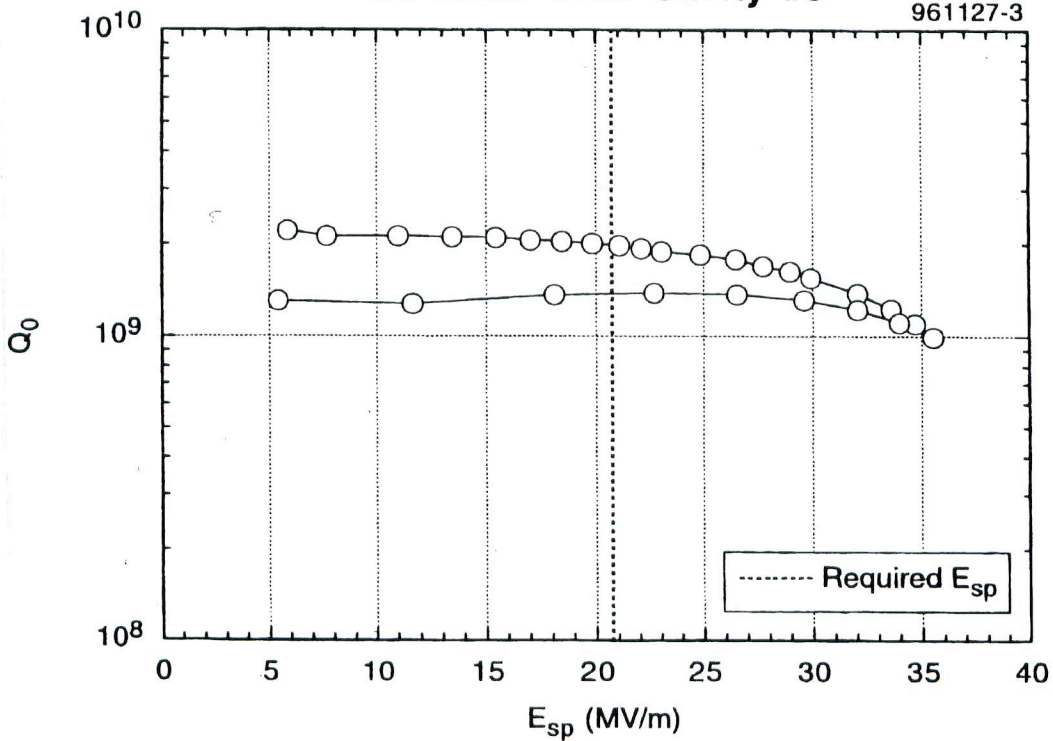
961127-2

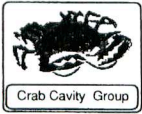
Nb + Cu Probe
Welding

----> Leak
 10^{-5} Torr
 Screw Joint

1/3-scale Crab Cavity #0

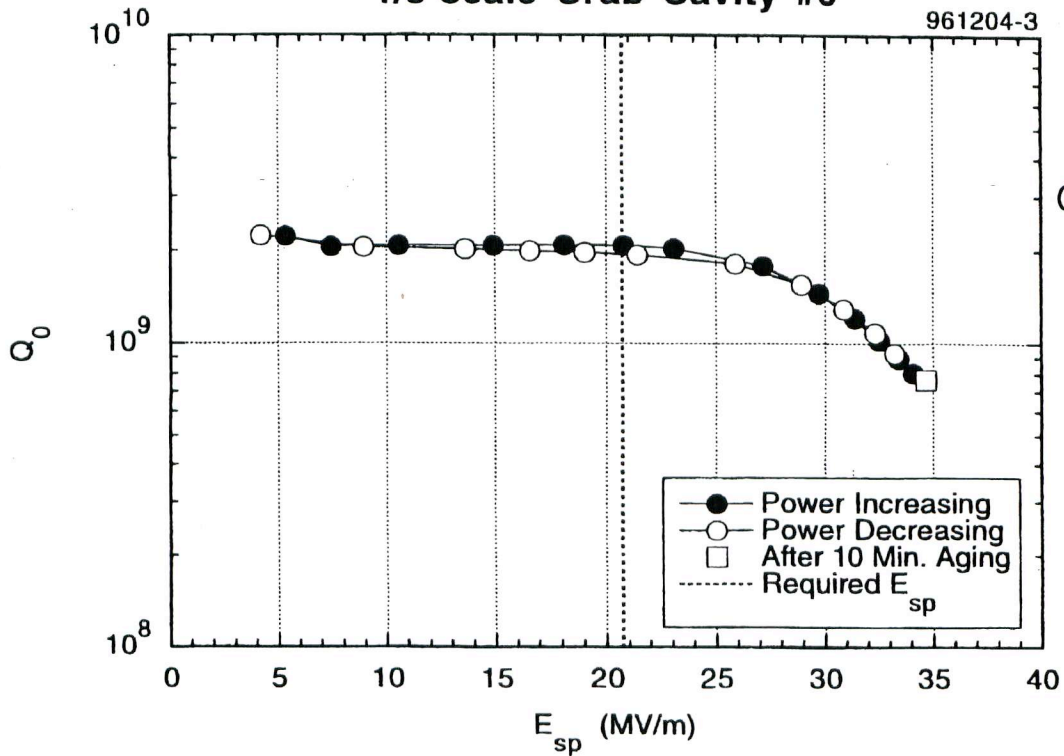
961127-3





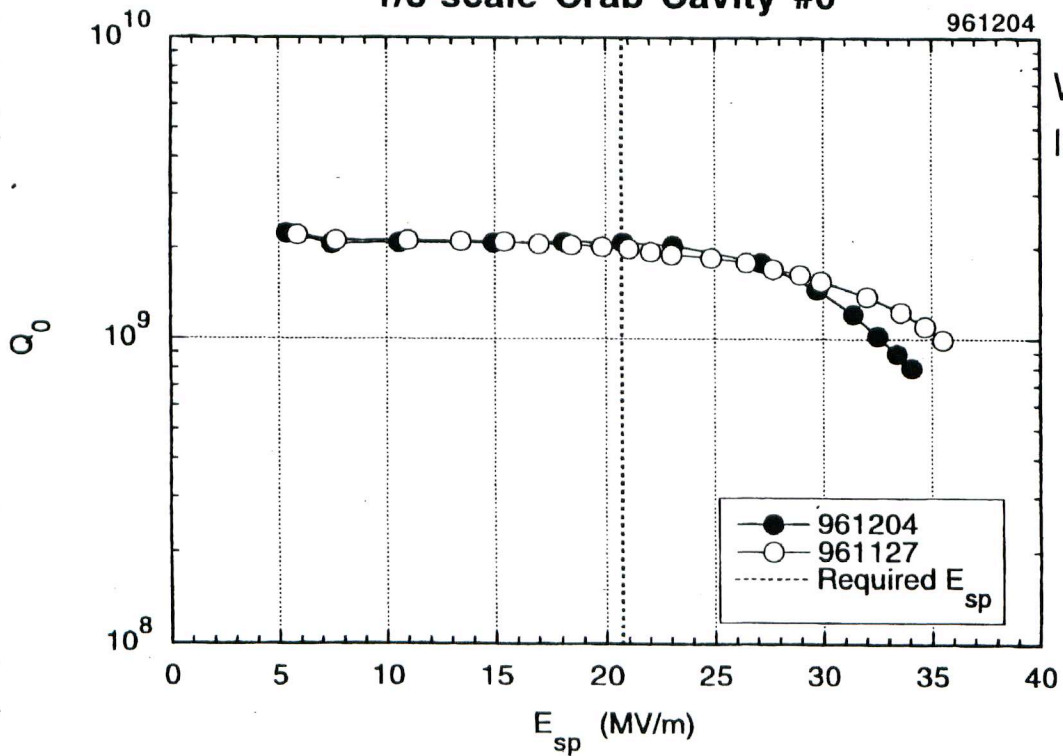
1/3-scale Crab Cavity #0

961204-3

Nb + Cu Probe
Screw JointGood Cooling
of Probe Part

1/3-scale Crab Cavity #0

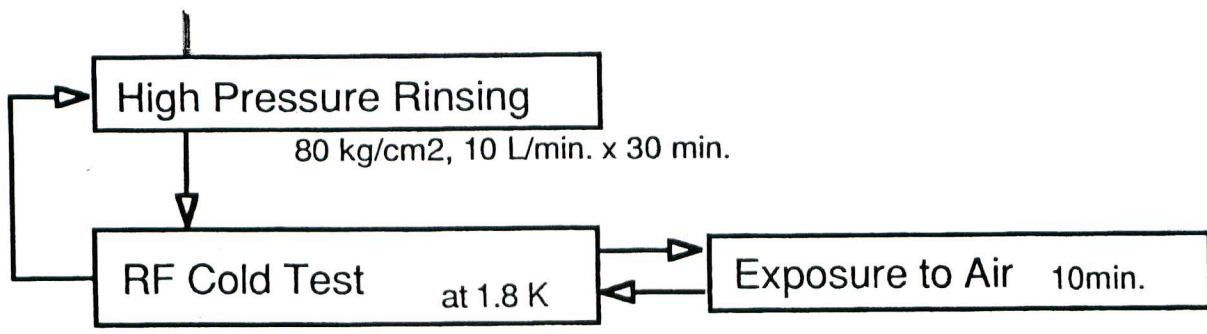
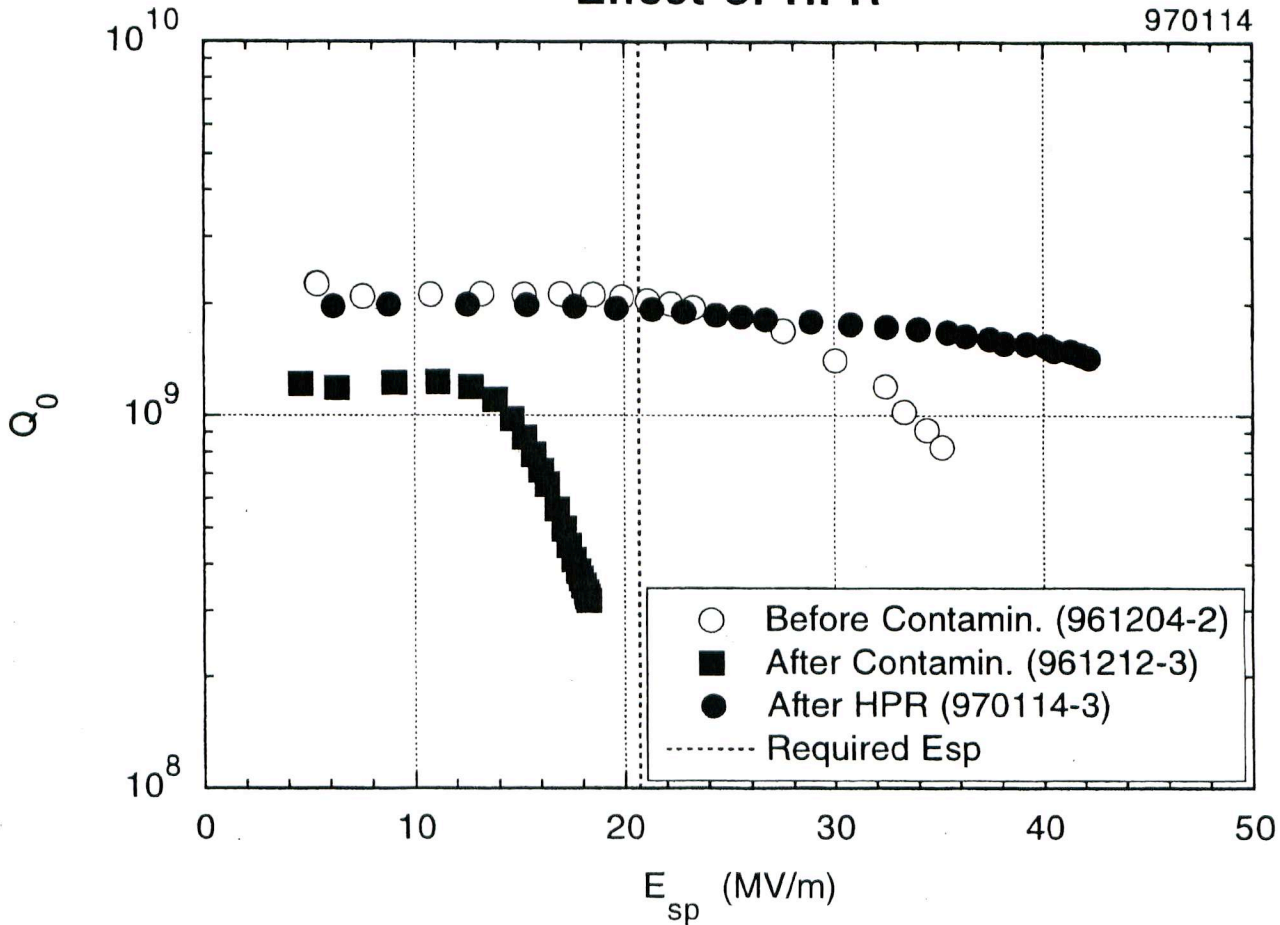
961204

Warm-up
Improve Vacuum



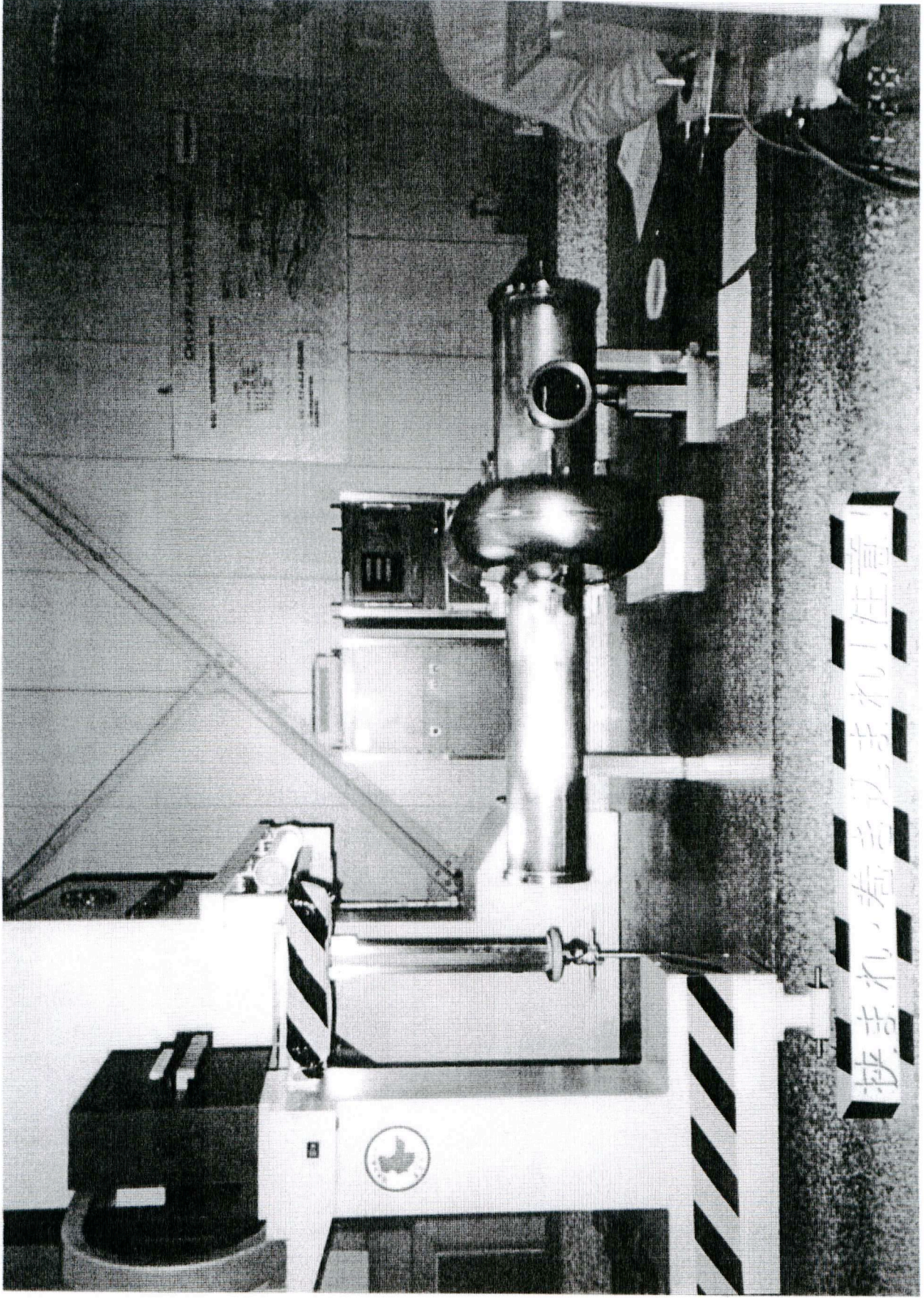
Effect of HPR

970114

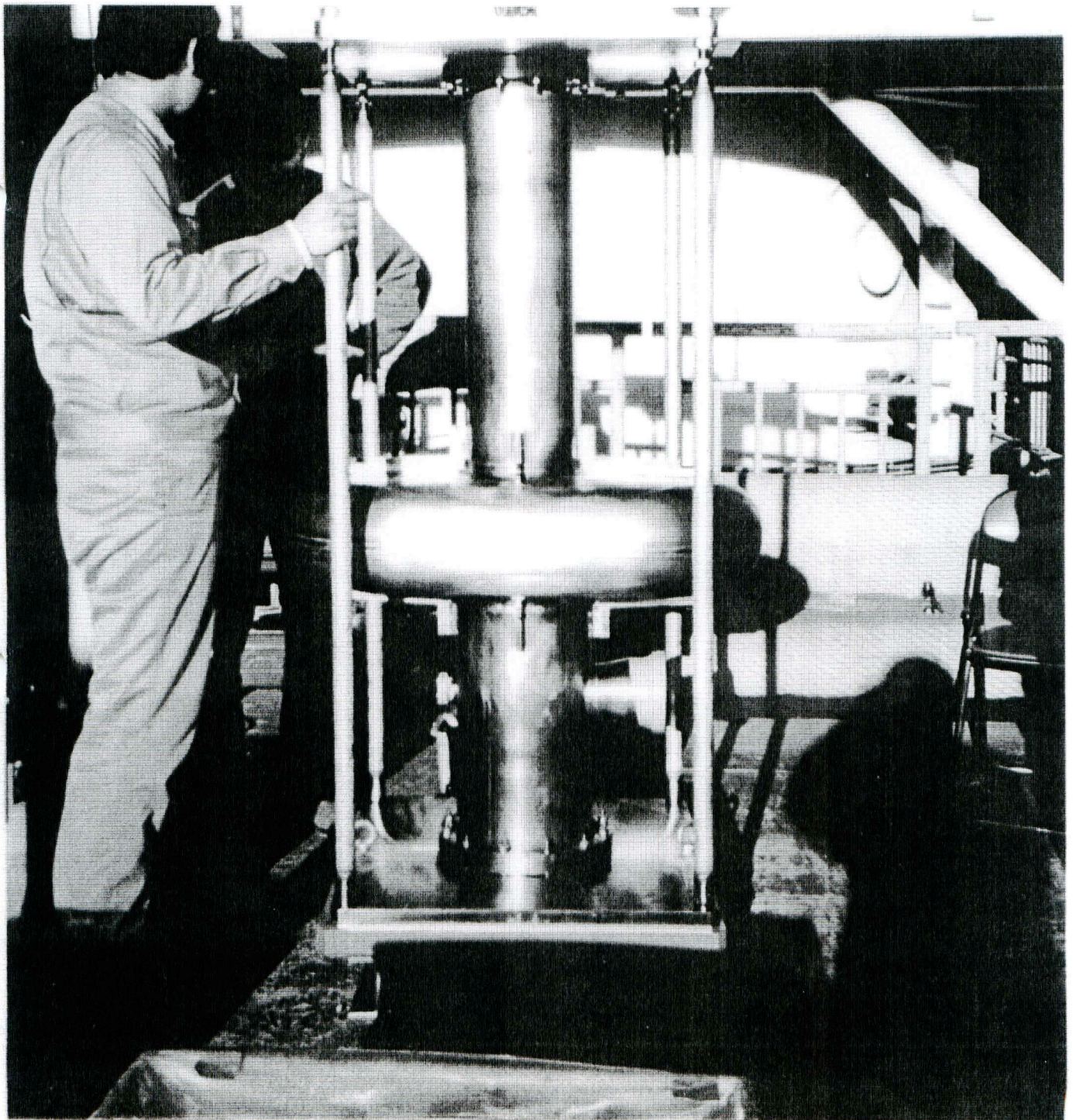




Full Scale 500MHz Nb Crab Cavity

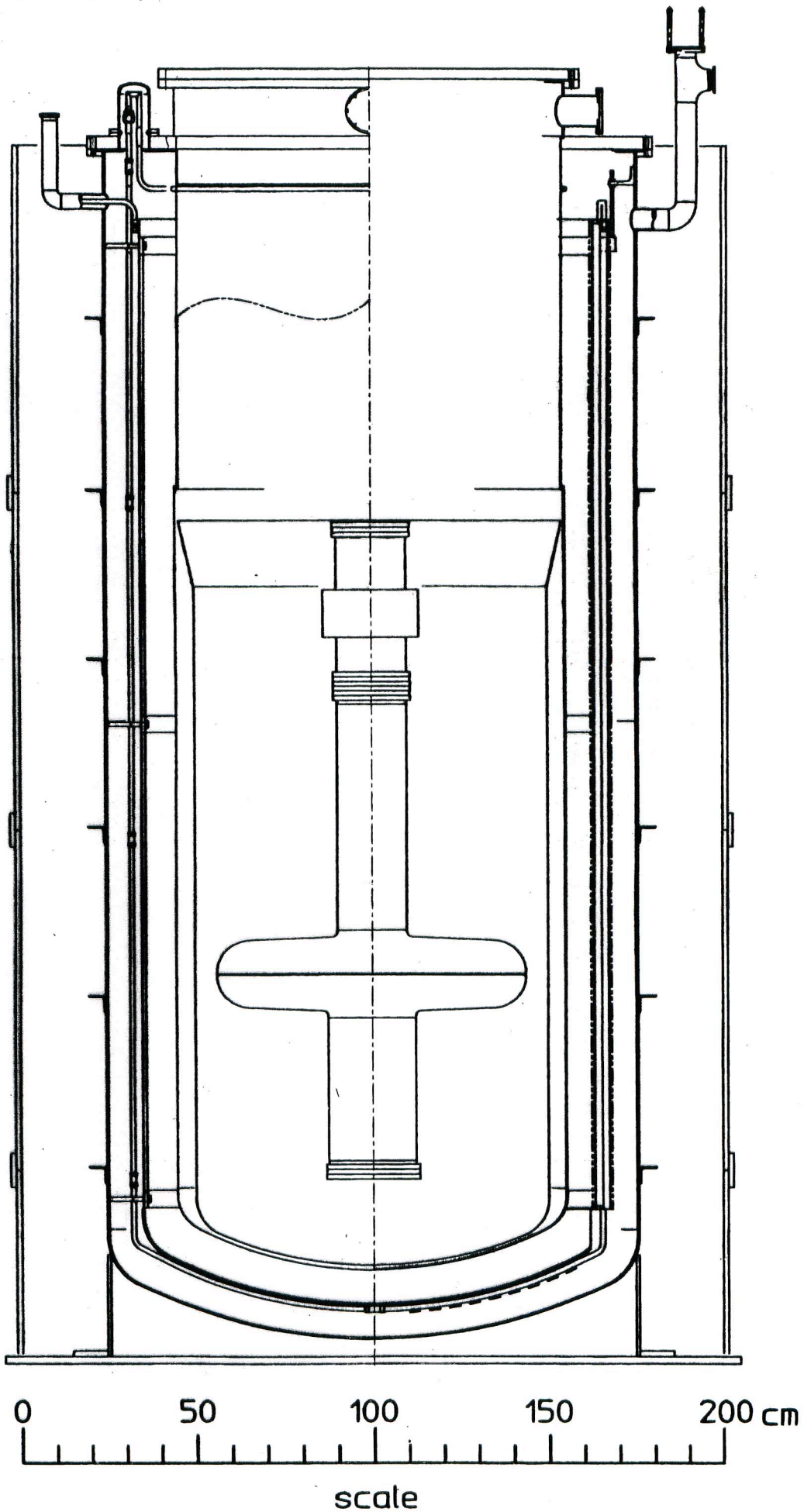


Full Scale 500MHz Nb Crab Cavity



Full Scale 500MHz Nb Crab Cavity

Vertical Cryostat for CRAB Full Scale Model
(I.D. 1100 x 3200)

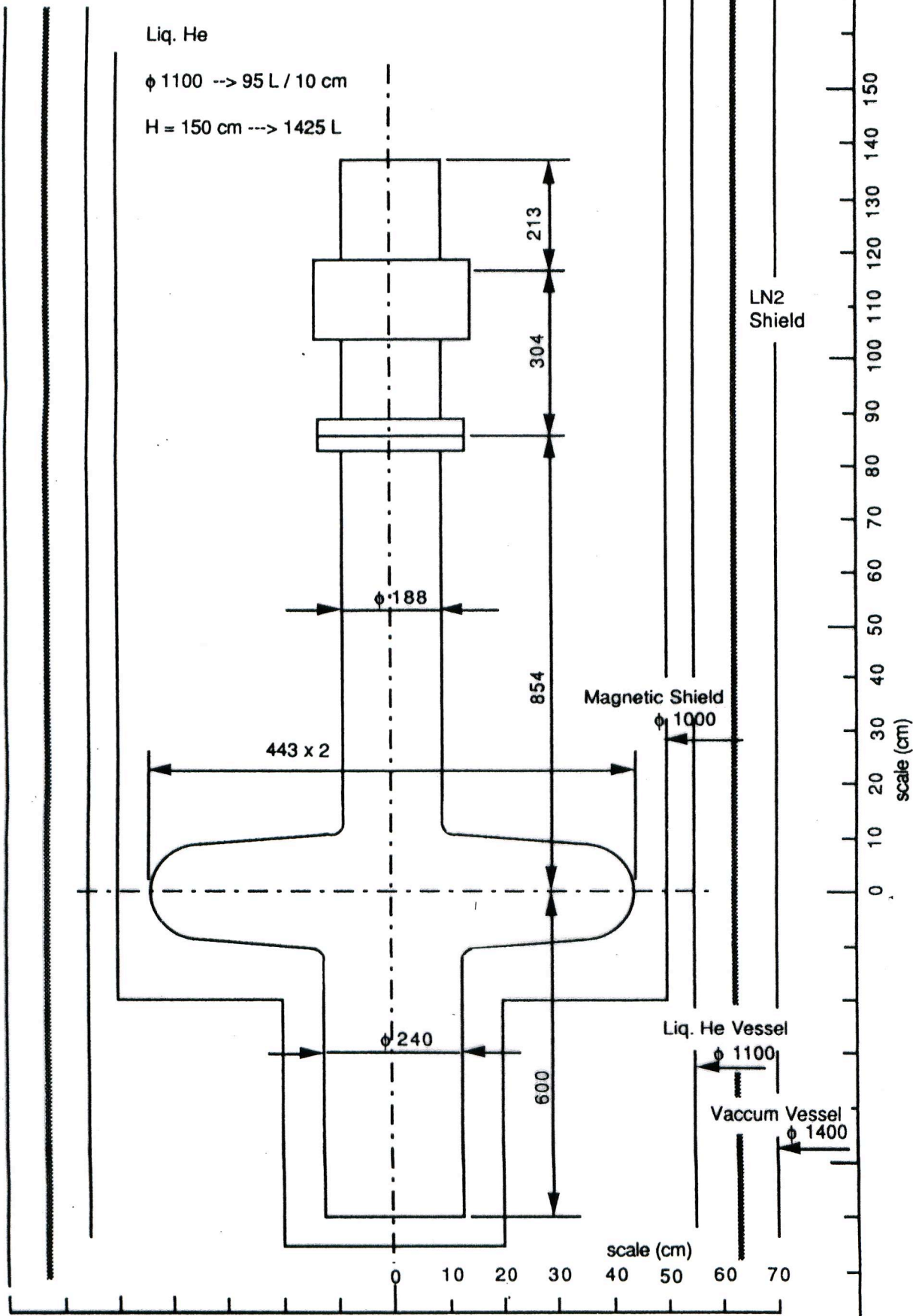




Vertical Cryostat for Full Size Crab Cavity Model

Case 1

Mar. 8, 1995
K. Hosoyama

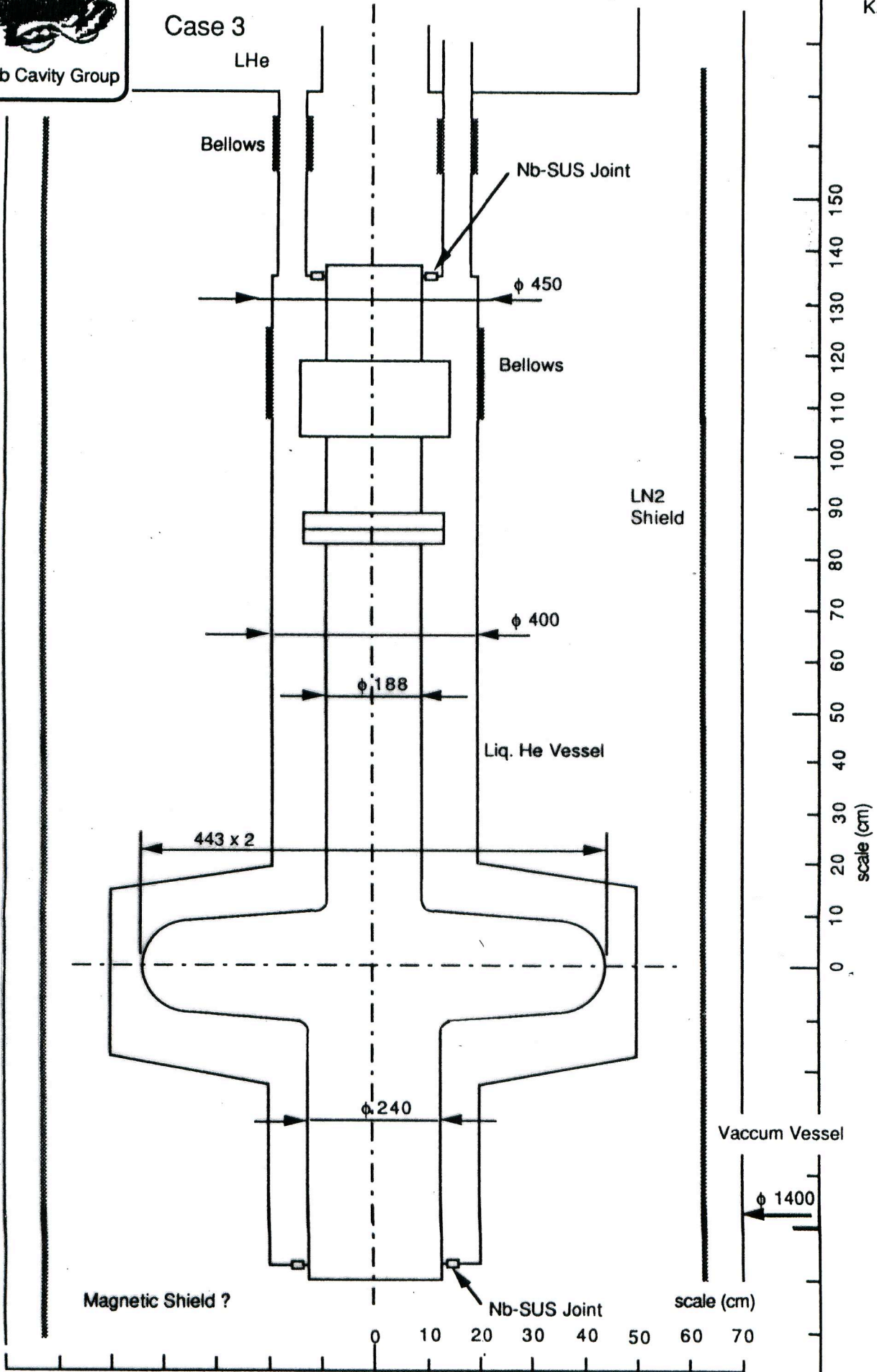


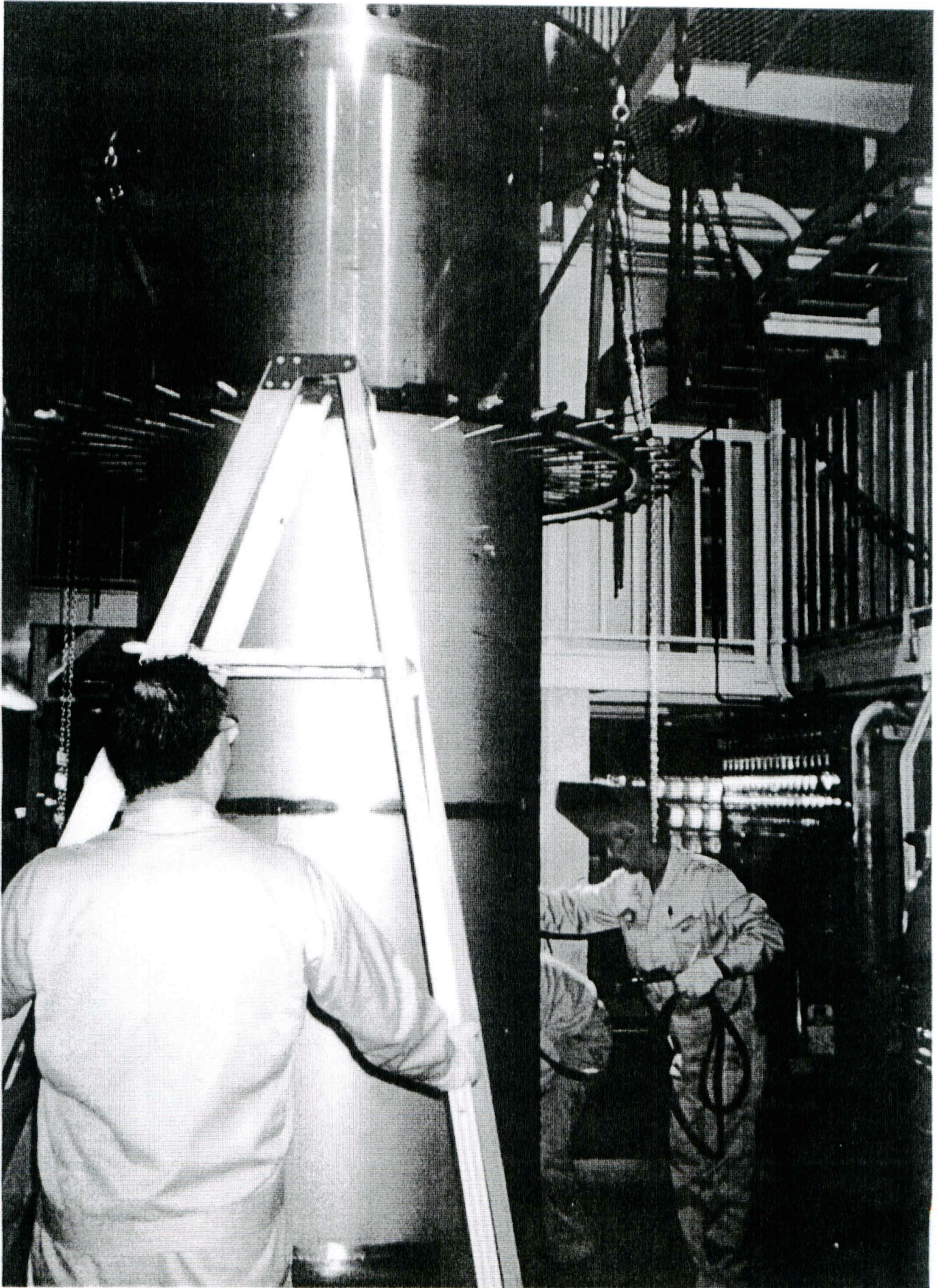


Vertical Cryostat for Full Size Crab Cavity Model

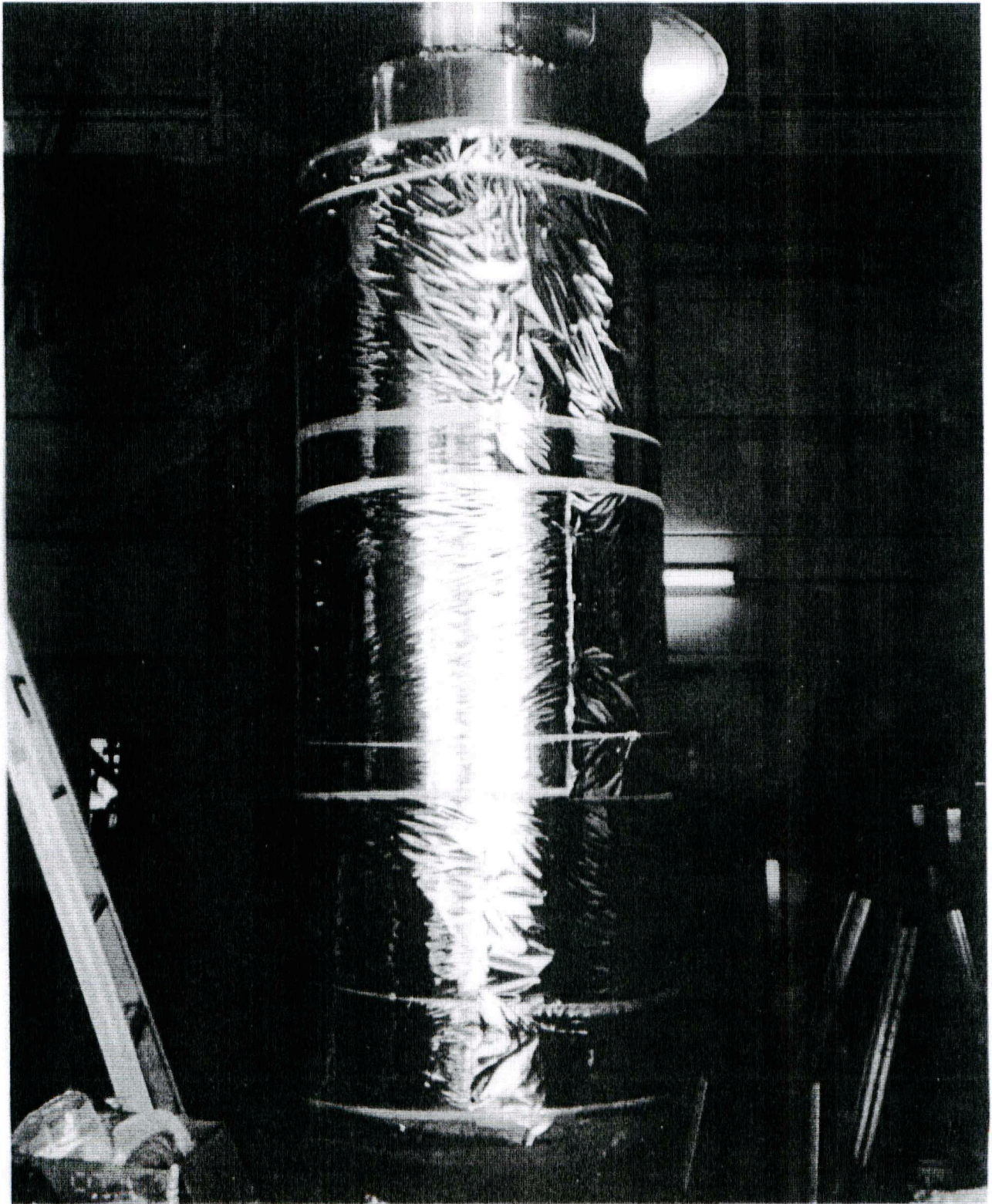
Case 3

Mar. 8, 1995
K. Hosoyama





Fabrication of Vertical Cryostat - Liq. He Vessel



Liq. He Vessel Wrapped with Multi-layer Super-Insulation



Vertical Cryostat - Vacuum Vessel and Liq. He Vessel

NIK-CLEANROOM

5250

3950

2610

CLEANROOM

CRYOSTAT

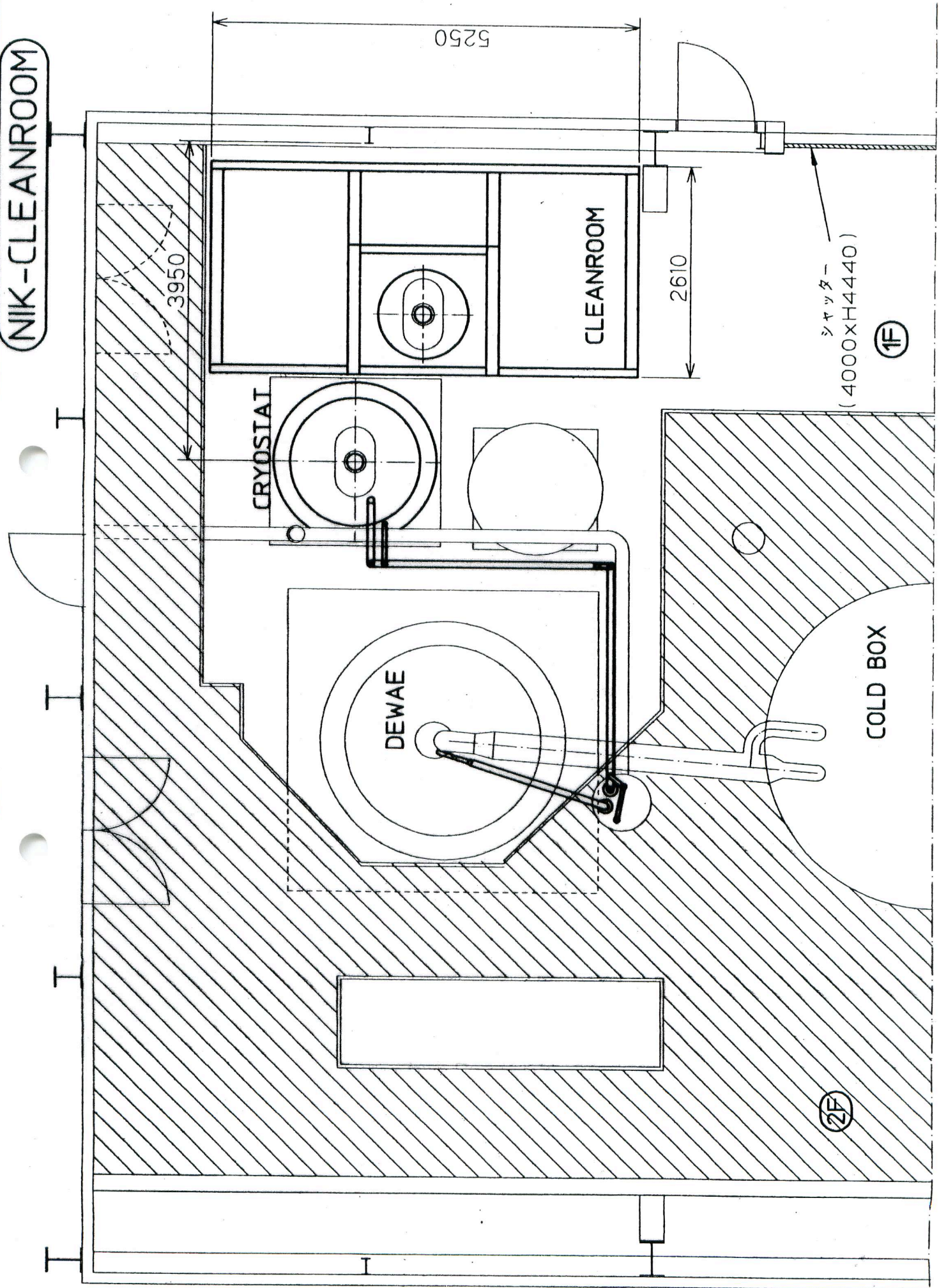
DEWAE

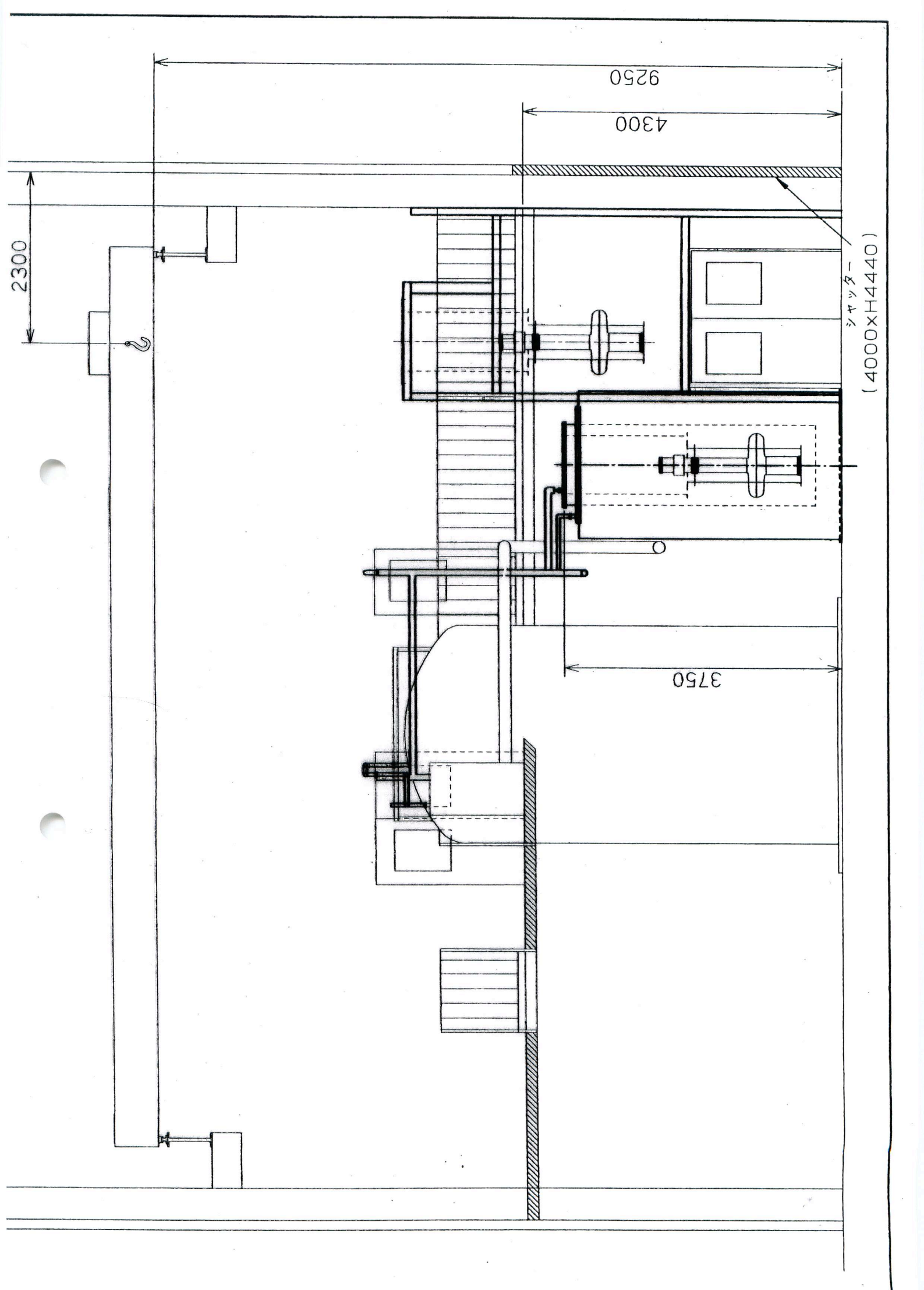
COLD BOX

シャッター
(4000XH4440)

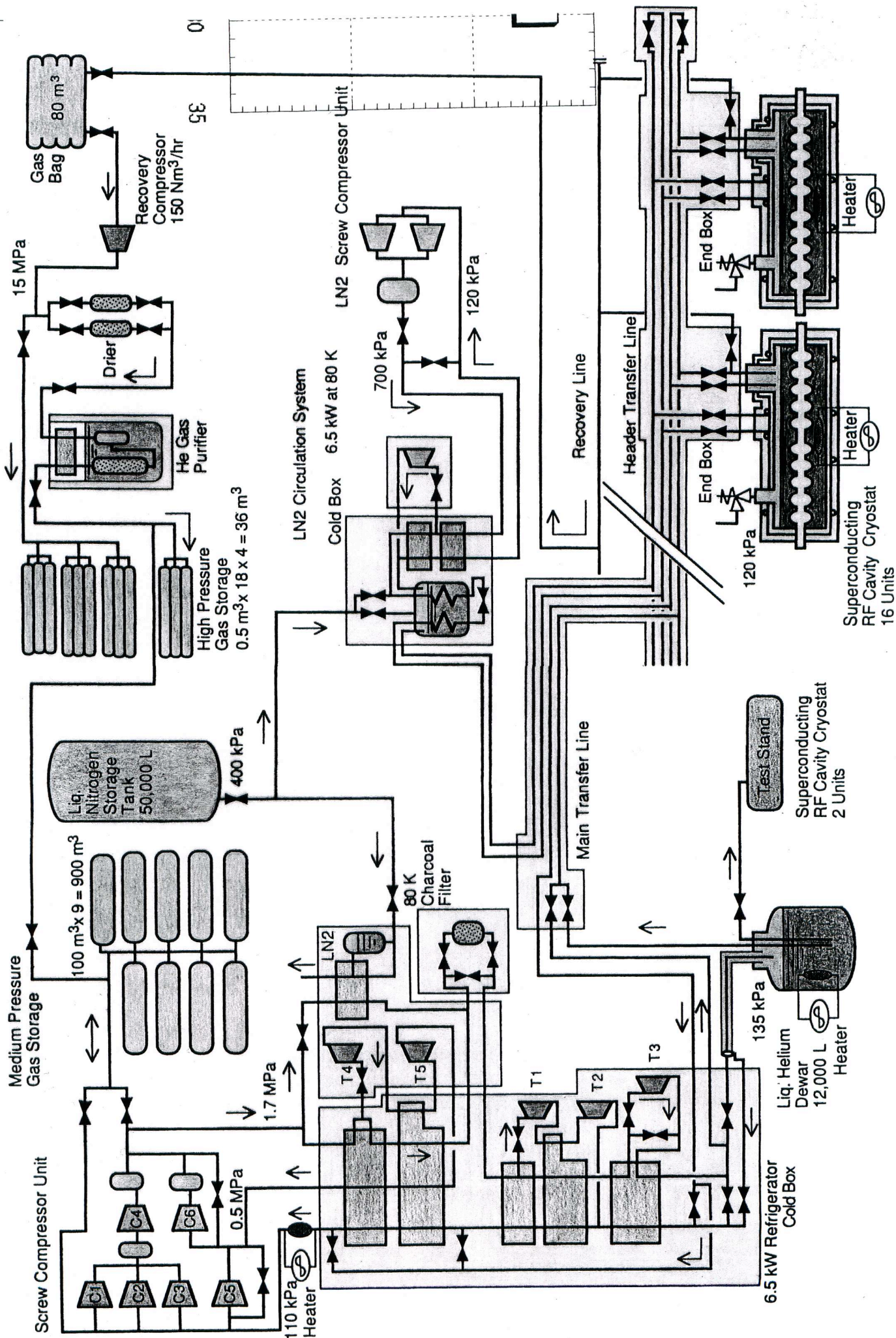
1F

2F

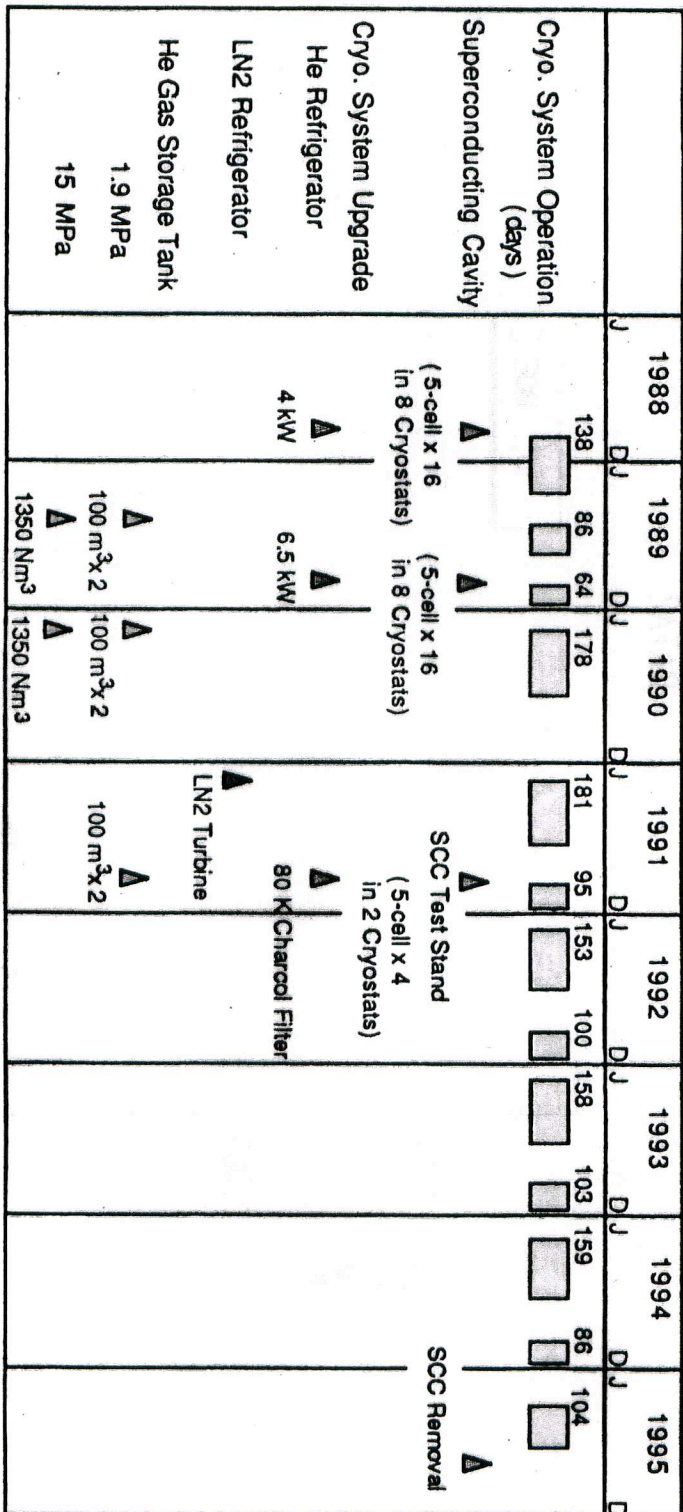




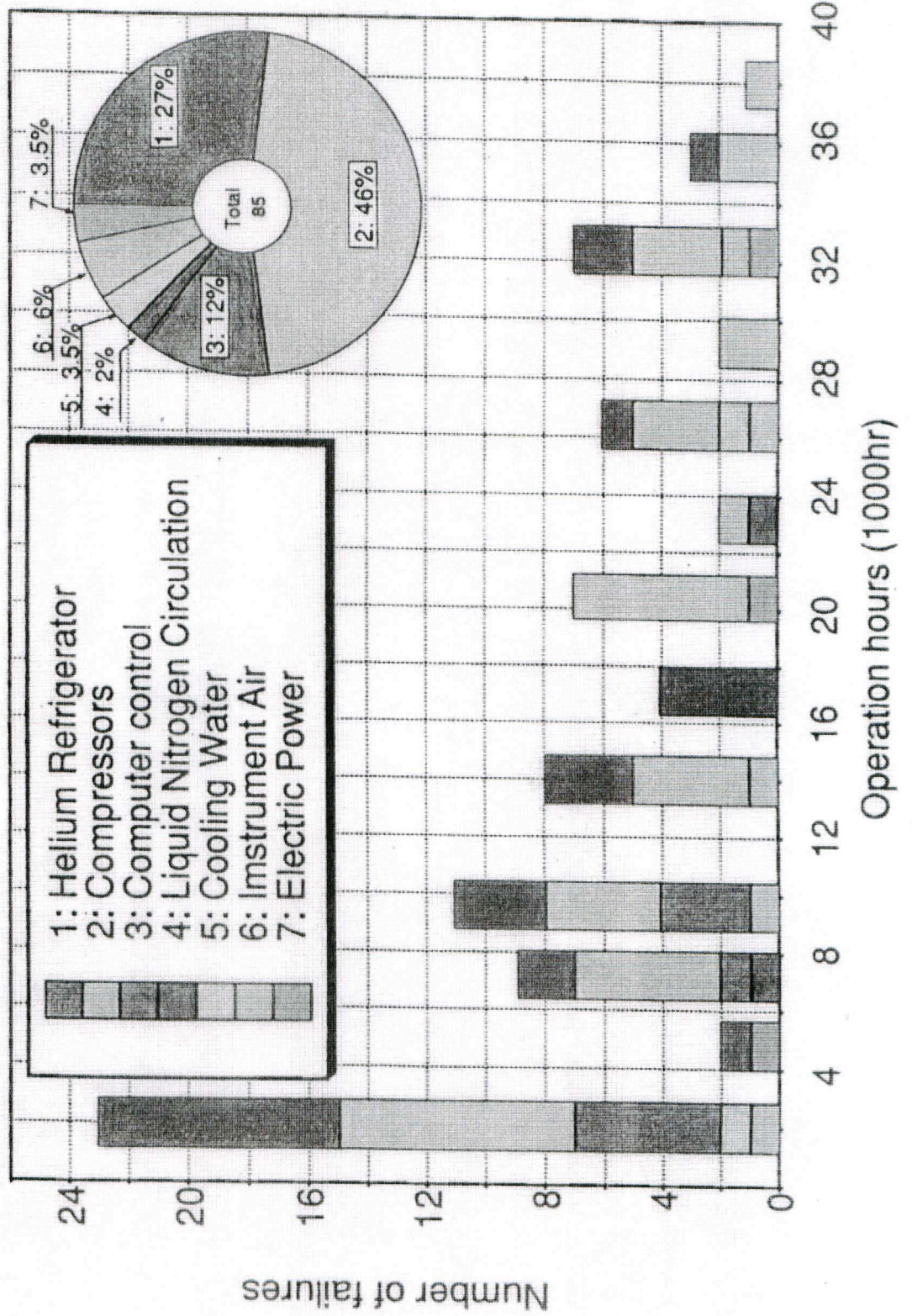
CRYOGENIC SYSTEM FOR TRISTON SUPERCONDUCTING RF CAVITIES



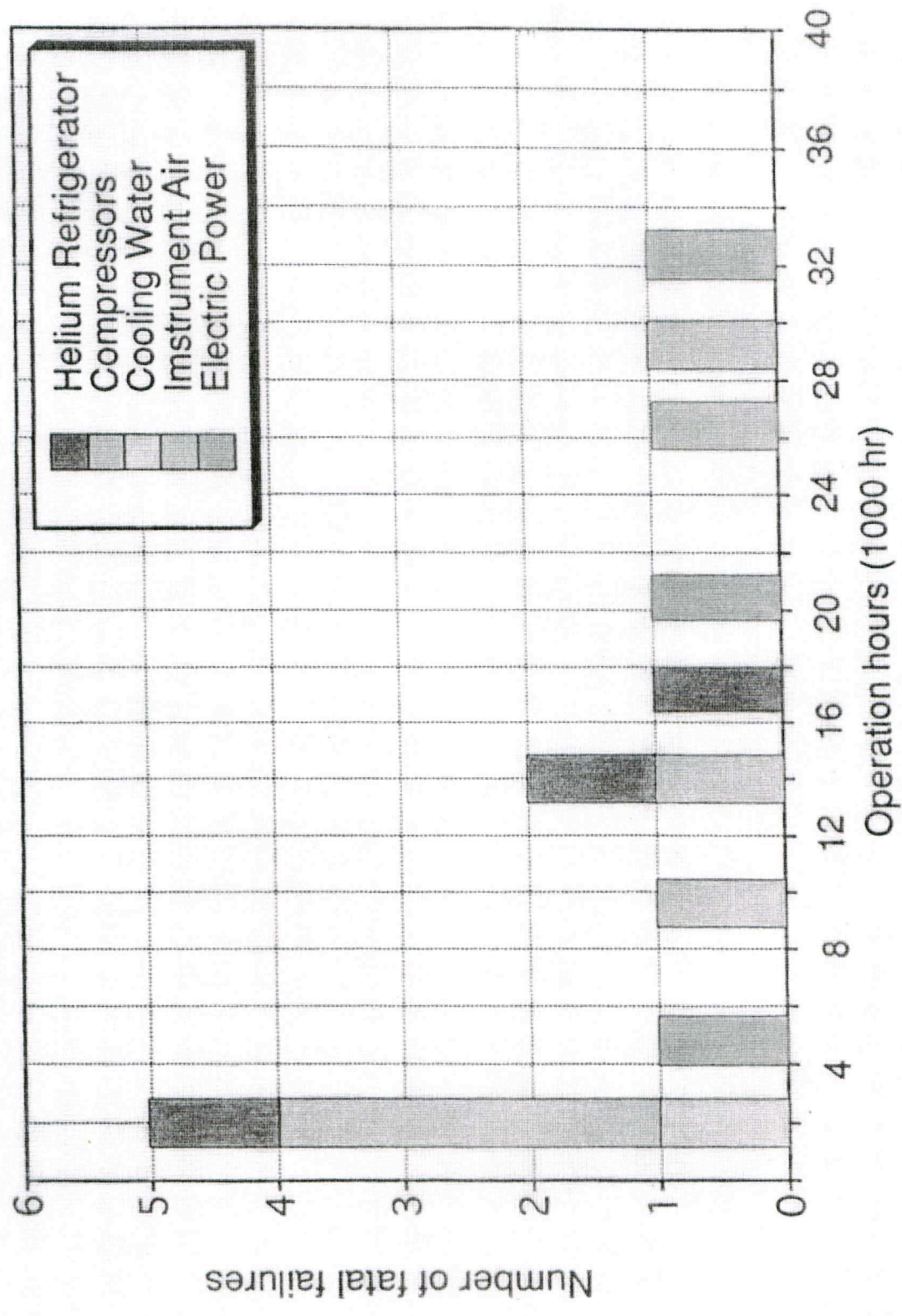
History of Operation and System Upgrade for TRISTAN Cryogenic System



Statistics of the failures during 7 years operation of TRISTAN SCC Cryogenics



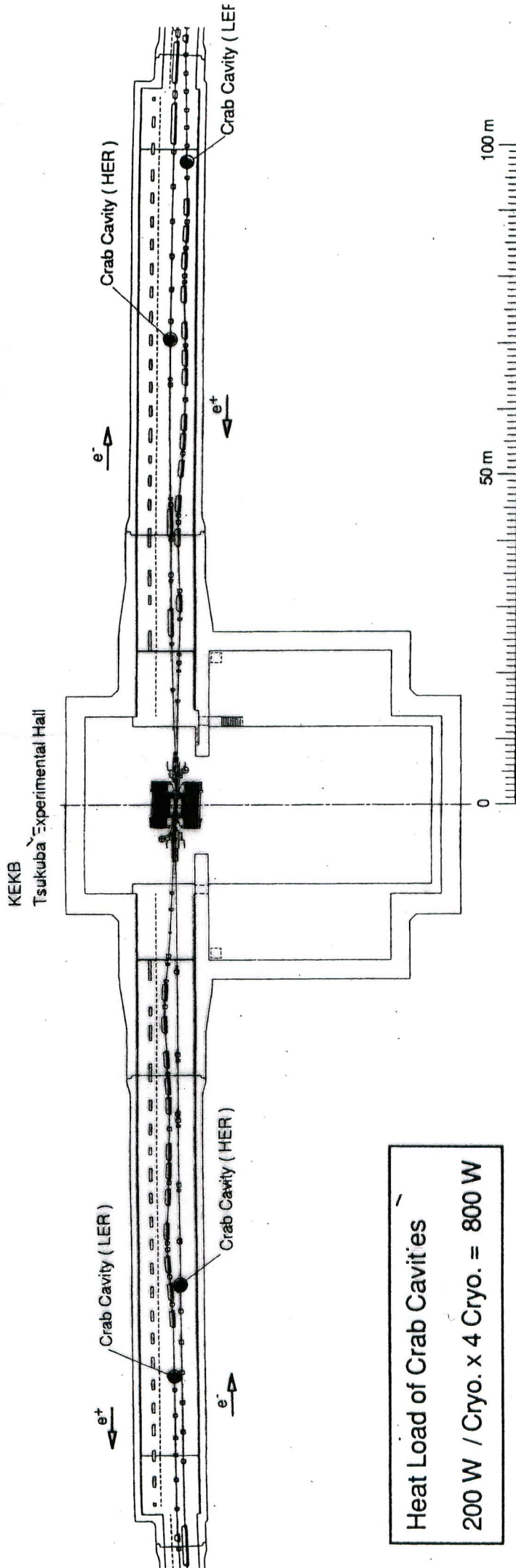
Statistics of the fatal failures



No.	Item Date	Failure (Action)	Downtime	
			Cryo. System	Beam
1.	Cold Box Nov.7, 1988	Low bearing gas pressure of T2 turbine (Restart)	4 hr + 36 hr*	—
2.	Helium Compressor (C3) Dec. 29, 1988	Oil leakage at the mechanical seal of the compressor unit (Replace of mechanical seals)	14 hr*	—
3.	Helium Compressor (C2) Jan. 14, 1989	Oil leakage at the mechanical seal of the compressor unit (Replace of mechanical seals and Restart)	8 hr*	—
4.	Helium Compressor Jan. 26, 1989	High discharge pressure of the compressor unit (Restart)	2 hr + 7 hr*	—
5.	Cooling Water Jan. 28, 1989	High temperature of oil due to failure of the cooling water [Repair of cooling water unit and Restart]	0.3 hr + 5 hr	—
6.	Electric Power May 3, 1989	Electric power outage due to thunderstorm (Restart)	2 hr	—
7.	Helium Compressor Jun.22, 1990	High temperature of oil due to incorrect set of thermal switch for interlock (Set correct value and Restart)	7 hr + 59 hr*	59 hr
8.	Cold Box May 29, 1991	Erroneous removal of a control relay during the operation (Restart)	0.5 hr + 3 hr*	3 hr
9.	Helium Compressor Jul. 8, 1991	High discharge gas temperature due to incorrect set value of thermal switch for interlock (Set correct value and Restart)	4 hr + 35 hr*	39 hr
10.	Cold Box Oct. 1, 1991	Turbine T1 trip due to excess amplitude of radial vibration (Restart)	1 hr + 4 hr*	—
11.	Electric Power Mar. 25, 1992	Electric power outage due to failure at transformer room (Restart)	1 hr + 8 hr*	9 hr
12.	Air Compressor Feb. 11, 1993	Low pressure of instrument air due to valve failure (Repair and Restart)	0.5 hr + 5 hr*	—
13.	Helium Compressor Nov. 25, 1993	Malfunction of unloaders due to failure of controller (Manual control of unloaders and Restart)	1 hr + 5 hr*	6 hr
14.	Electric Power Mar. 24, 1994	Electric power outage due to failure at substation (Restart)	0.5 hr + 8 hr*	8.5 hr

23.8 + 197. 124.5

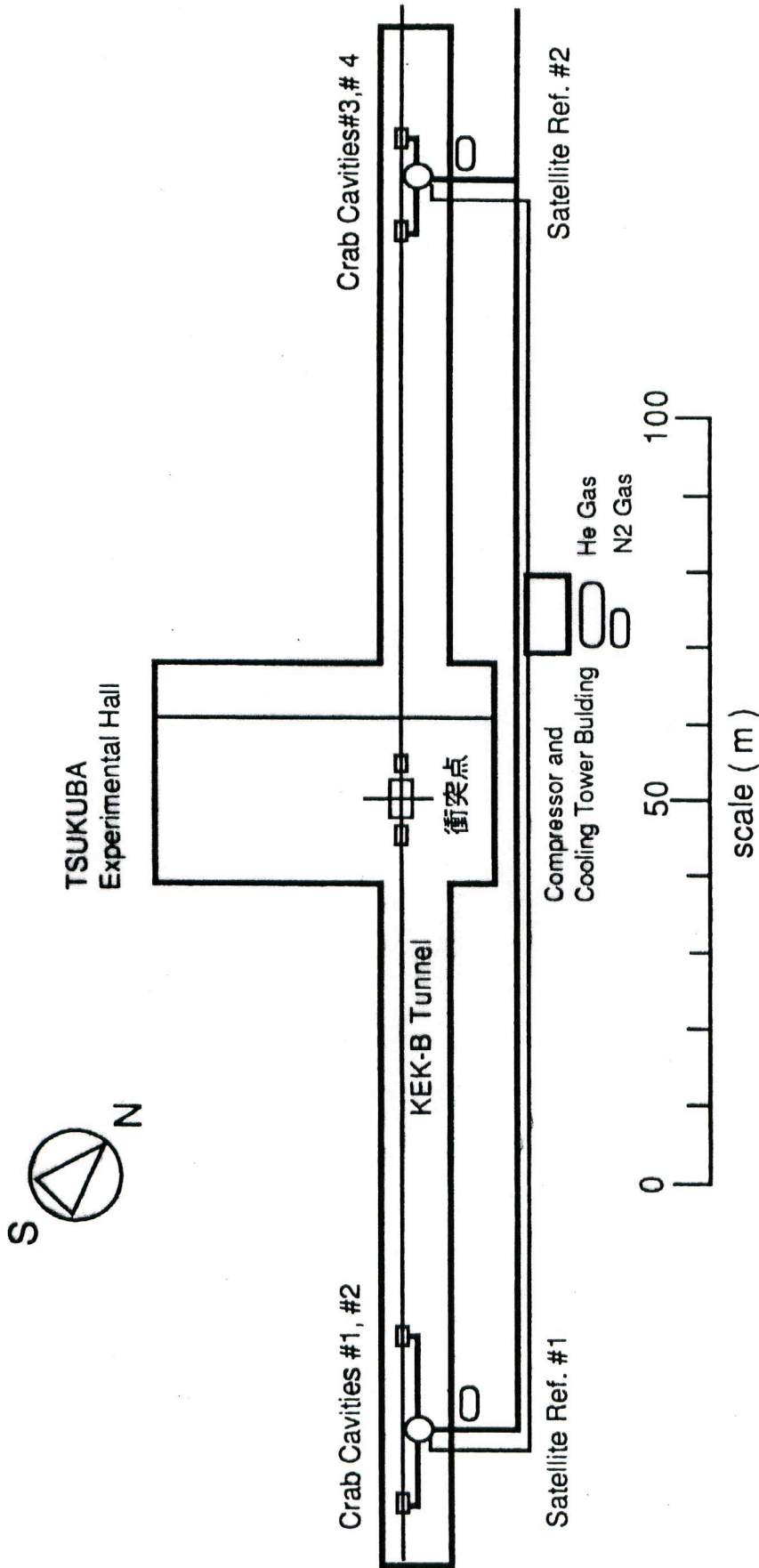
ARRANGEMENT OF KEKB CRAB CAVITIES



Heat Load of Crab Cavities
200 W / Cryo. x 4 Cryo. = 800 W

KEK-B Crab Cavity Cryogenic System

Dec. 1996
K.Hosoyama



Heat Load of Crab Cavity Cryogenic System

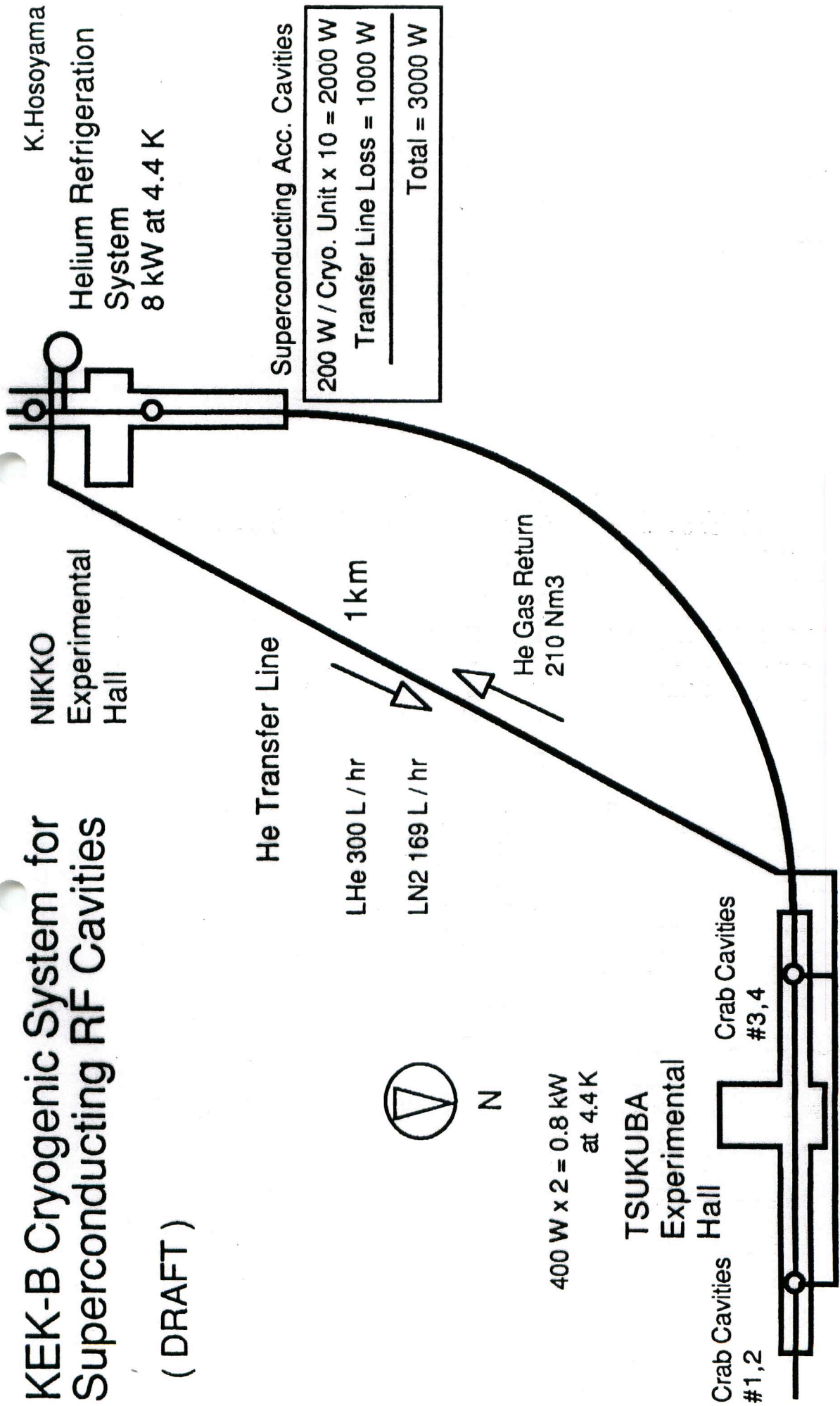
	RF loss	Cryostat	Transfer Line etc.	Total	2 Crab Cavities	50% Safety Margin
Case 1	43 W	+ 25 W	+ 30 W	= 98 W	98 W x 2 = 196 W	294 W
Case 2	86 W *	+ 25 W	+ 30 W	= 141 W	141 W x 2 = 282 W	423 W

$$Q_0 = 1 \times 10^9$$

$$Q_0 = 0.5 \times 10^9$$

KEK-B Cryogenic System for Superconducting RF Cavities

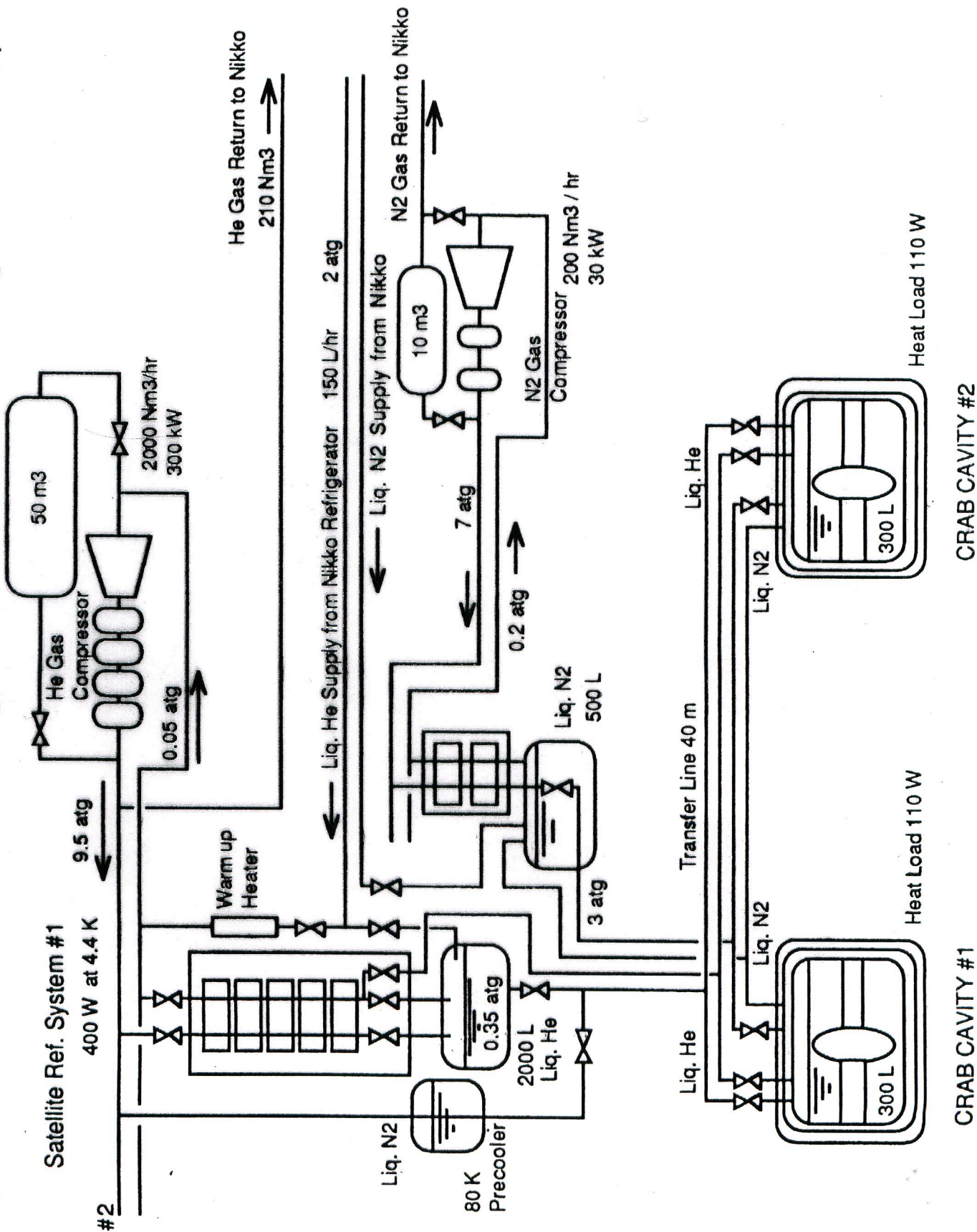
(DRAFT)

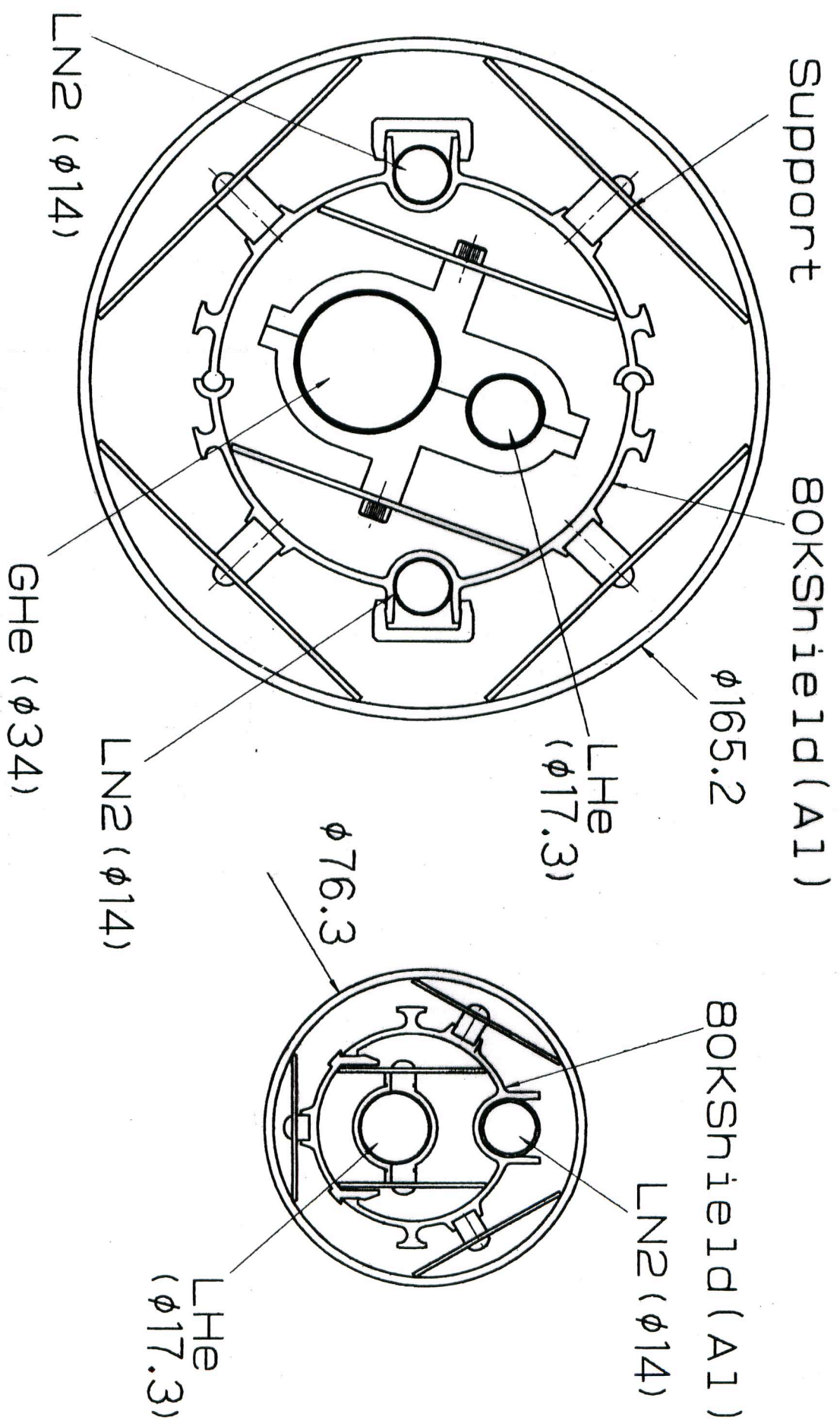


	Heat Load Crab Cavity 4 Units	He Transfer Line (1 km)	Liq. Helium Supply to Satellite
LHe (4.4 K)	400 W x 2 = 800 W	1000 m x 0.2 W / m = 200 W	300 L / hr
LN2 (80 K)	300 W x 2 = 600 W	1000 m x 5 W / m = 5000 W	129 L / hr

Cryogenic System for KEK-B CRAB Cavities

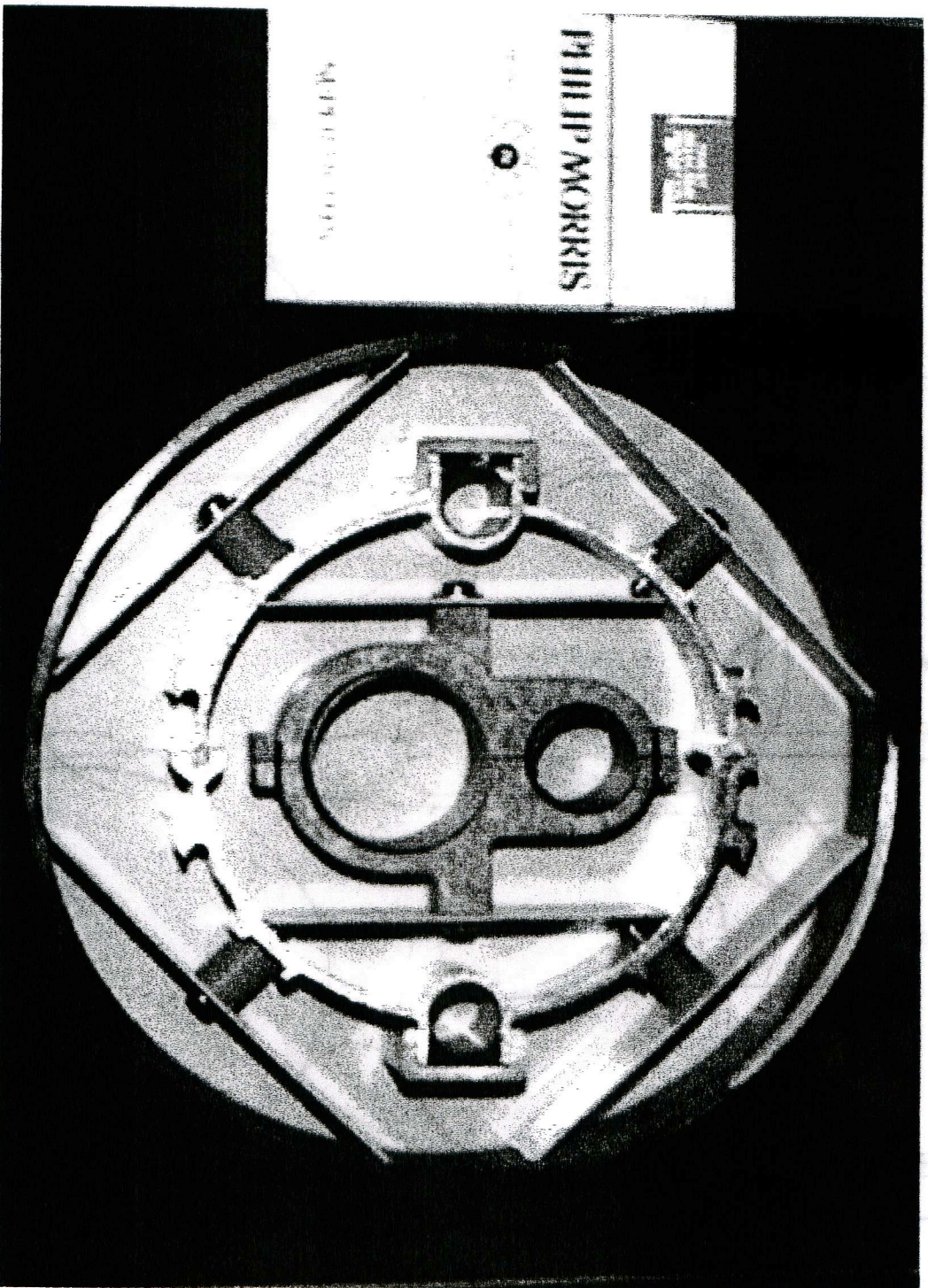
K. Hosoyama





High Performance Multi-channel Transfer Line

Developed at KEK



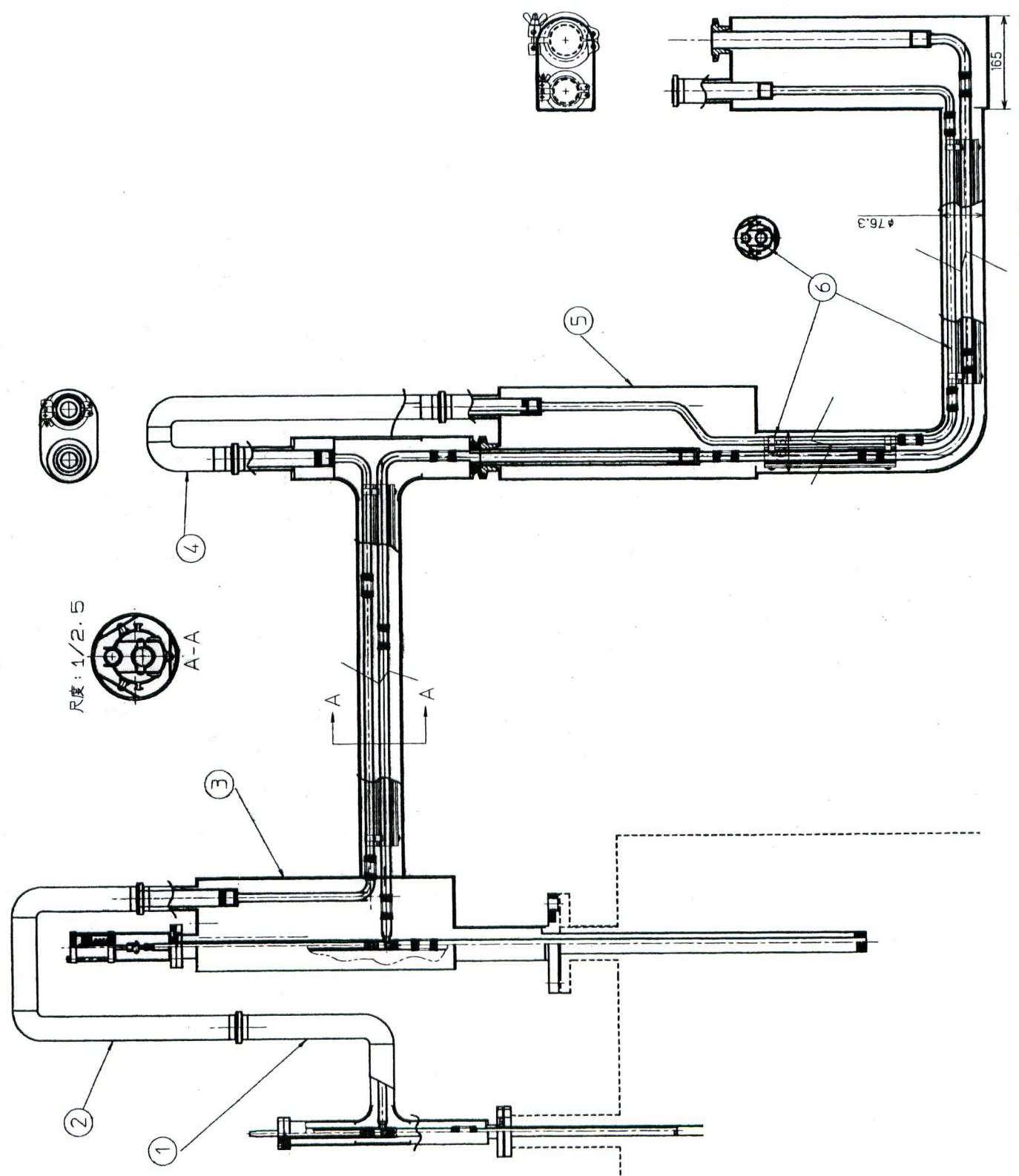
High Performance Multi-channel Transfer Line

Developed at KEK

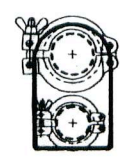
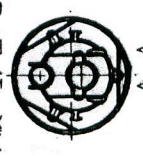
CRAB-TRT組立図

High Performance Multi-channel Transfer Line
Between Liq. He Dewar and Vertical Cryostat for Crab Cavity

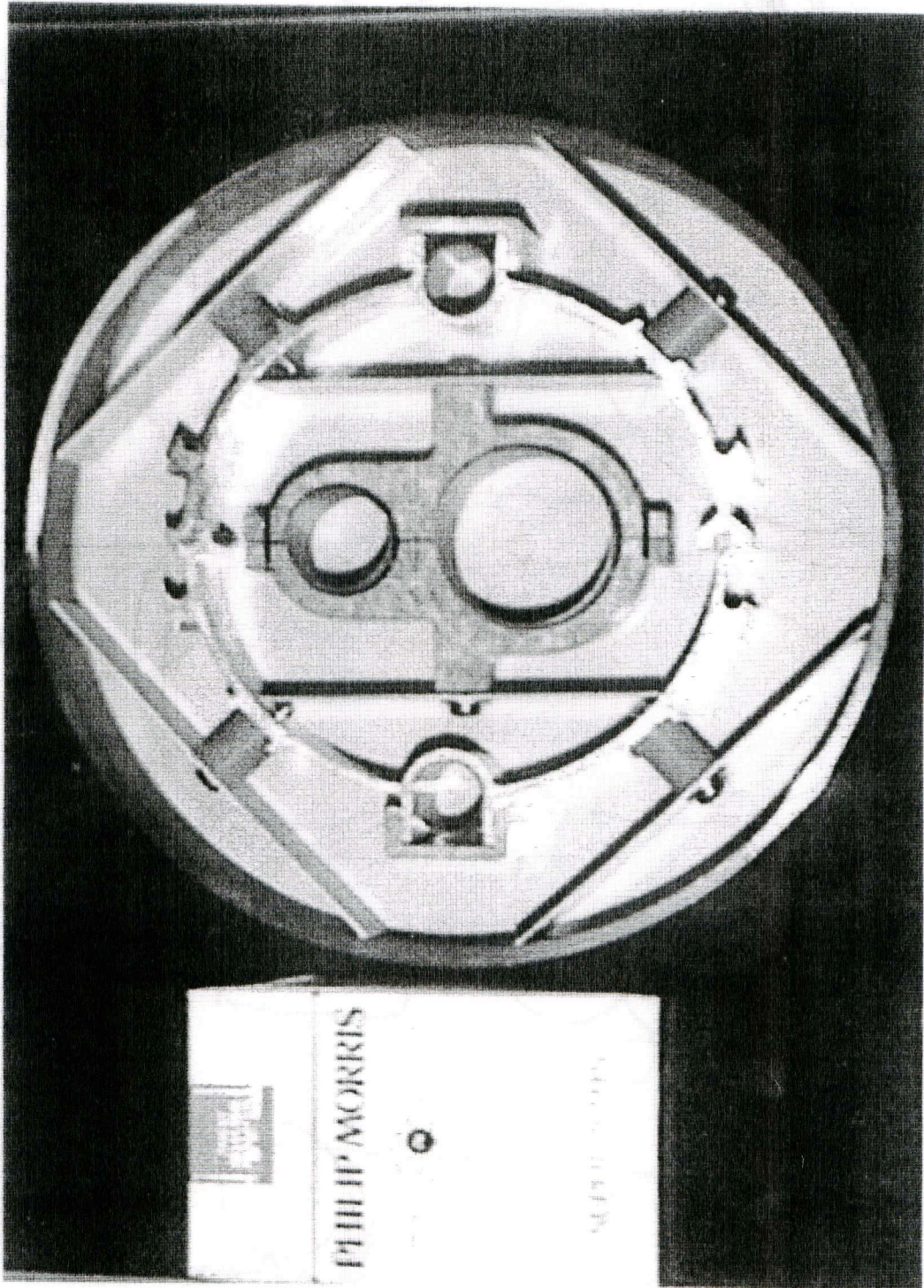
尺度: 1/5



尺度: 1/2.5



番号	名称	数量	単位	材料
6				
7				
6	LN2ケーブル			
5	MULTI2			
4	LN2TRT3			
3	MULTI1 (バルブ付き)			
2	LN2TRT2			
1	LN2TRT1 (バルブ付き)			
備考	名称			
	CRAB-TRT_全体図			
改訂	図番			
	CRAB-TRT_ALL			
改訂	設計	監製	承認	尺度
	KANEKIYO			1/5
1996/12/6	KANEKIYO			

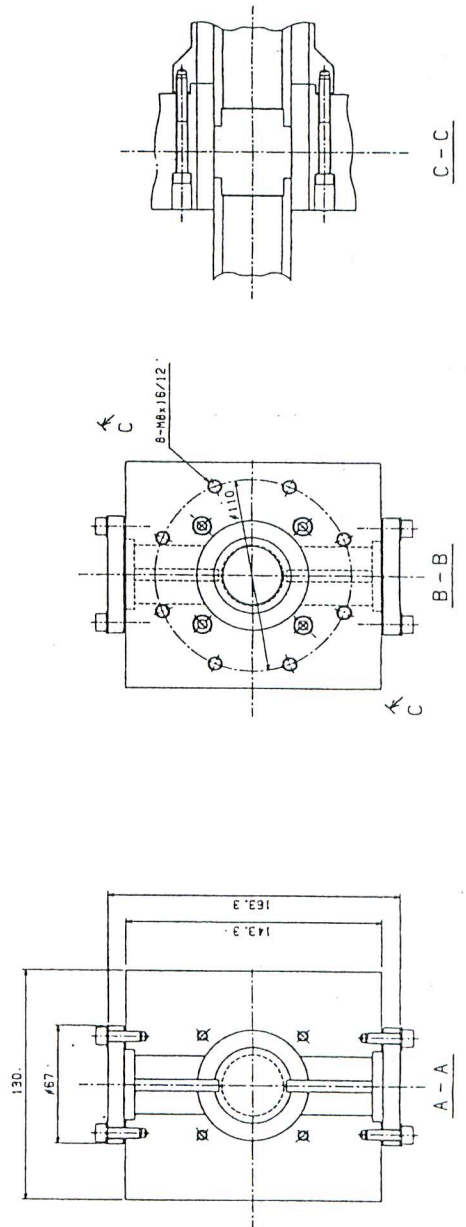
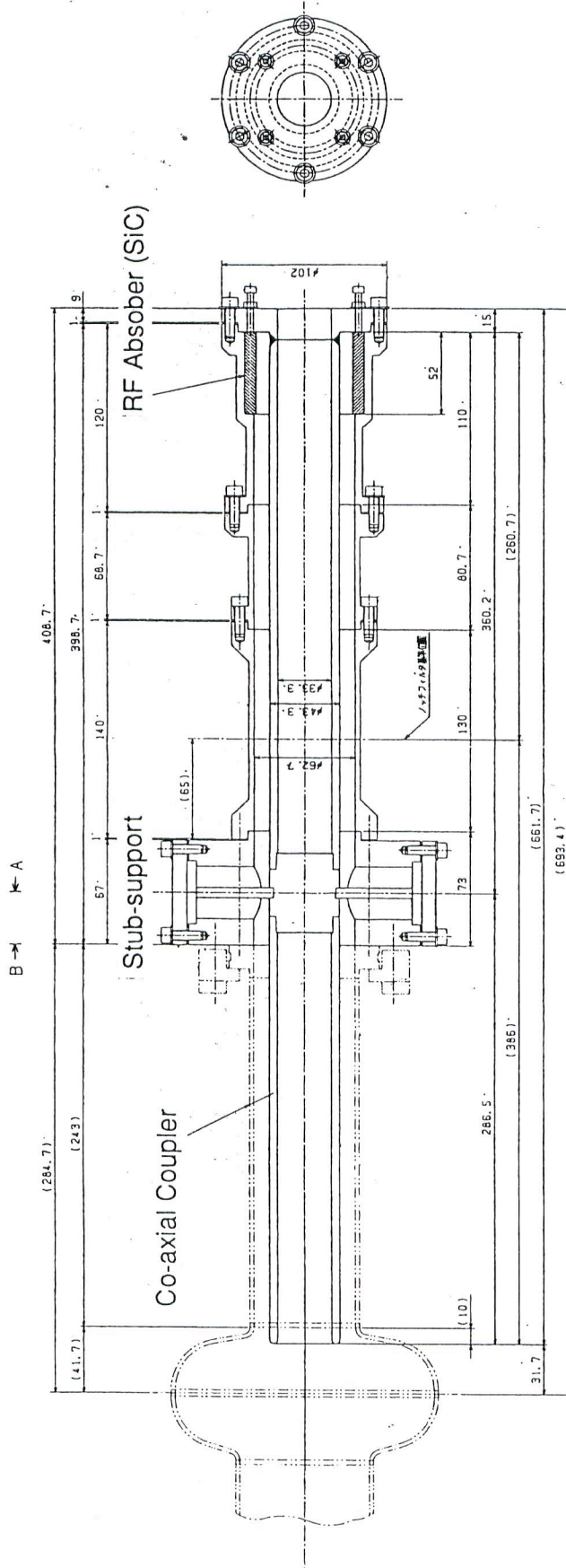


High Performance Multi-channel Transfer Line

Developed at KEK



Stub-supported Co-axial Coupler with RF Absorber (SiC) for 1/3 Scale Crab Cavity



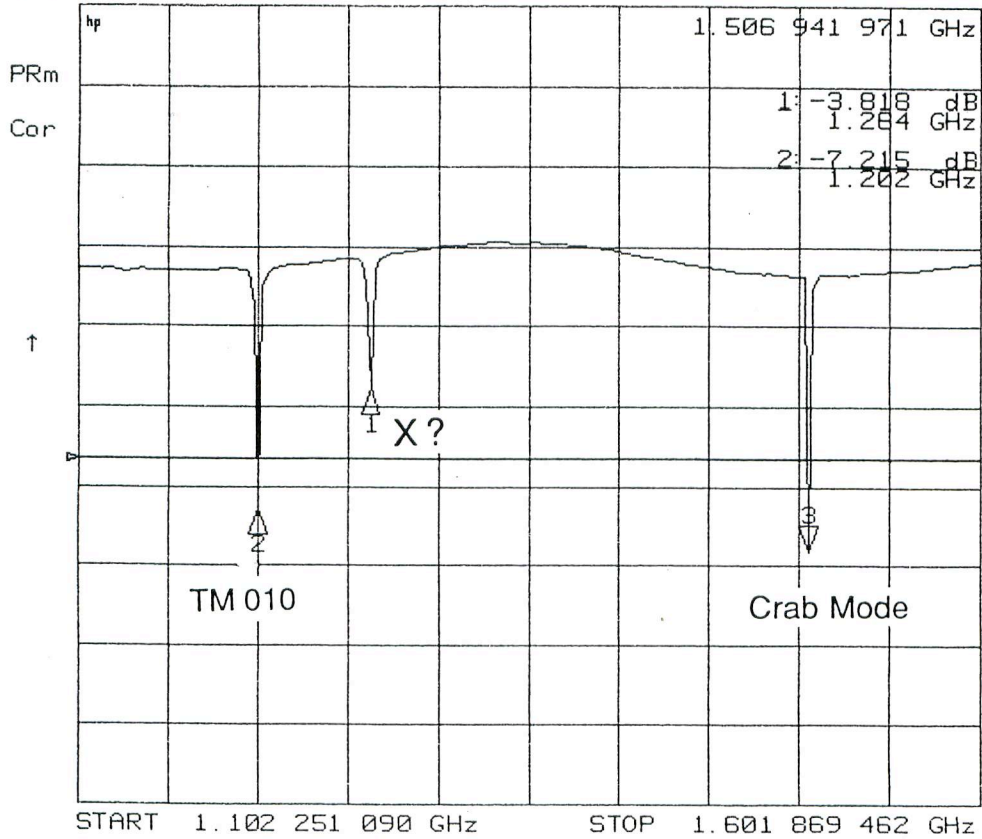
KEK ENGINEERING NOTE

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PAGE /

23 Nov 1996 19:16:39

CH1 S₁₁ log MAG 2.22 dB/ REF -5.826 dB 3: -8.444 dB

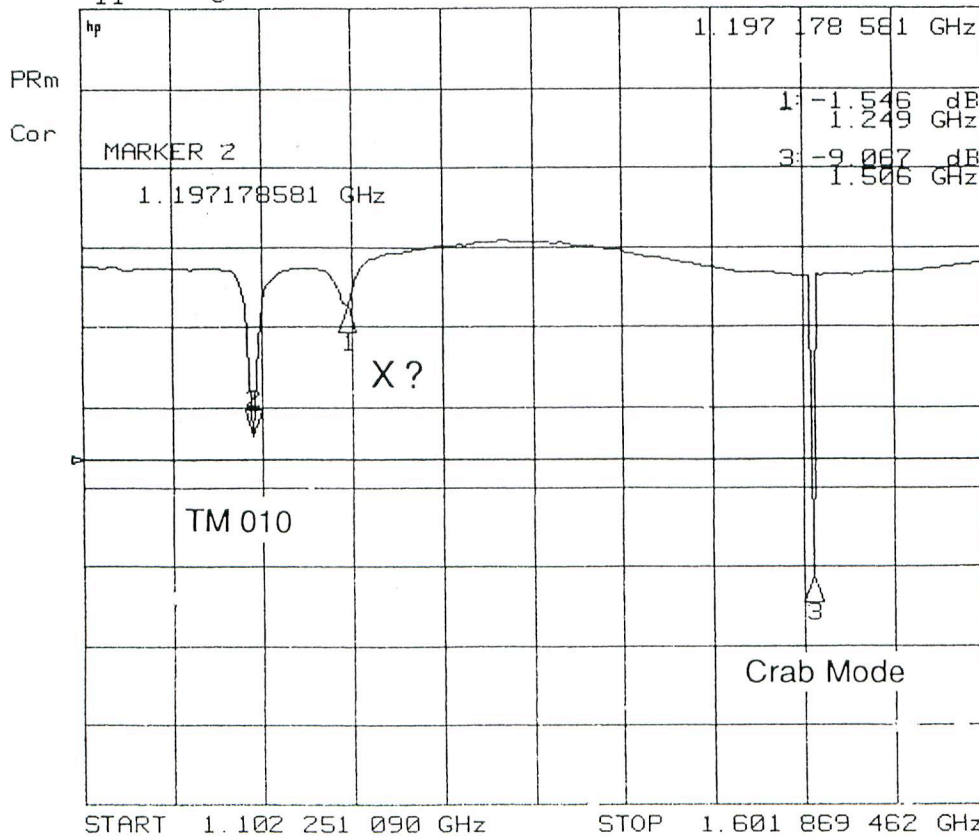


Co-axial Line
+ No RF Absorber

X?
New Mode
Produced
by Stub Support

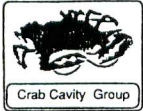
23 Nov 1996 19:21:51

CH1 S₁₁ log MAG 2.22 dB/ REF -5.826 dB 2: -5.182 dB



Co-axial Line
+ RF Absorber (SiC)

X?
New Mode
Produced
by Stub Support



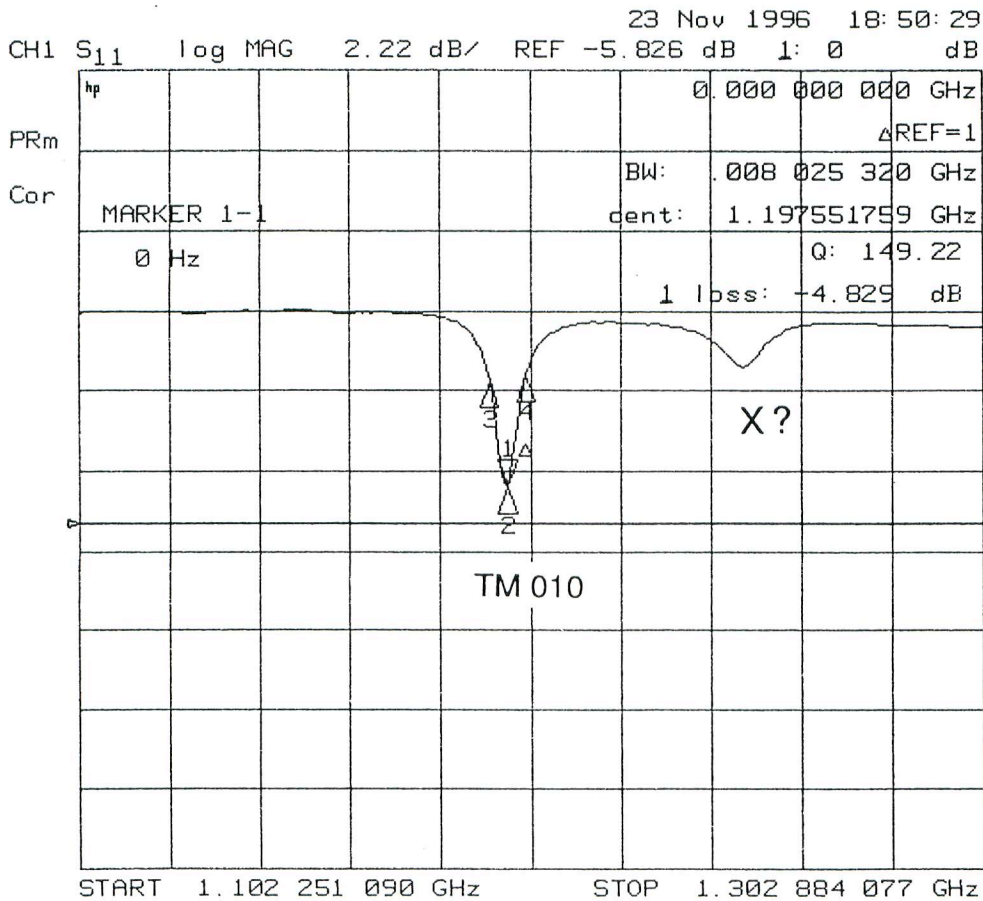
KEK ENGINEERING NOTE

CODE:

DATE:

NAME:

K. Hosoyama



X?
New Mode
Produced
by Stub Support

Co-axial Line
+ RF Absorber (SiC)

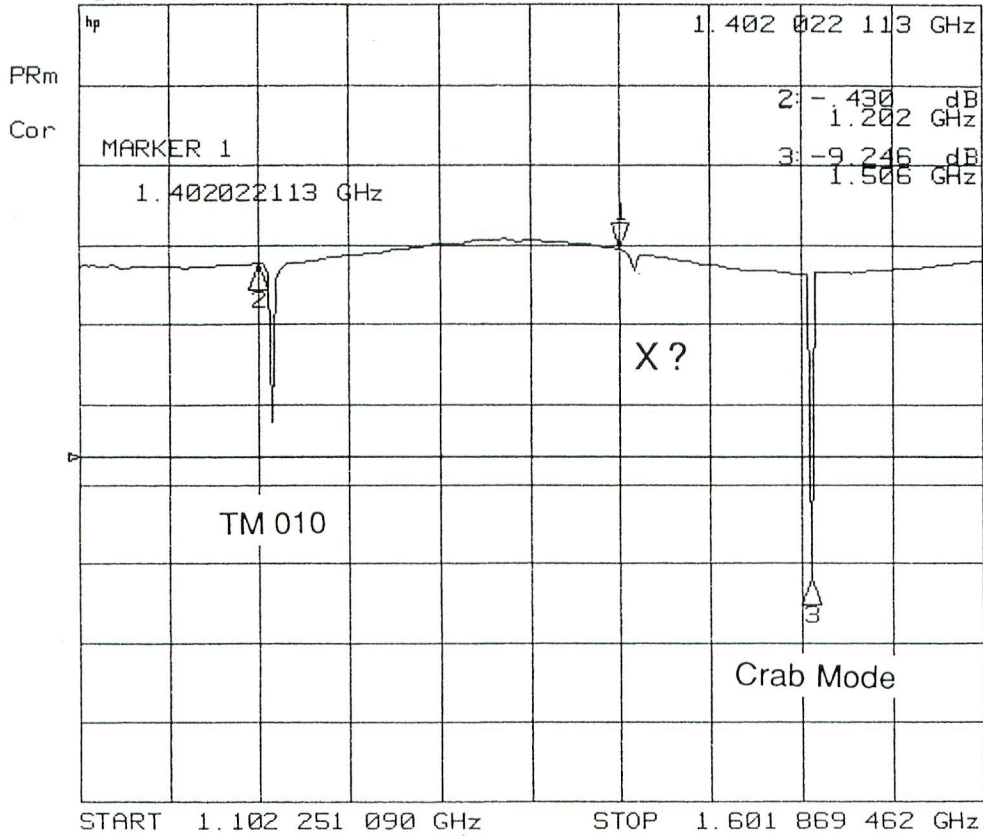
KEK ENGINEERING NOTE

CODE

PAGE /

23 Nov 1996 19:19:11

CH1 S₁₁ log MAG 2.22 dB/ REF -5.826 dB 1: -.054 dB

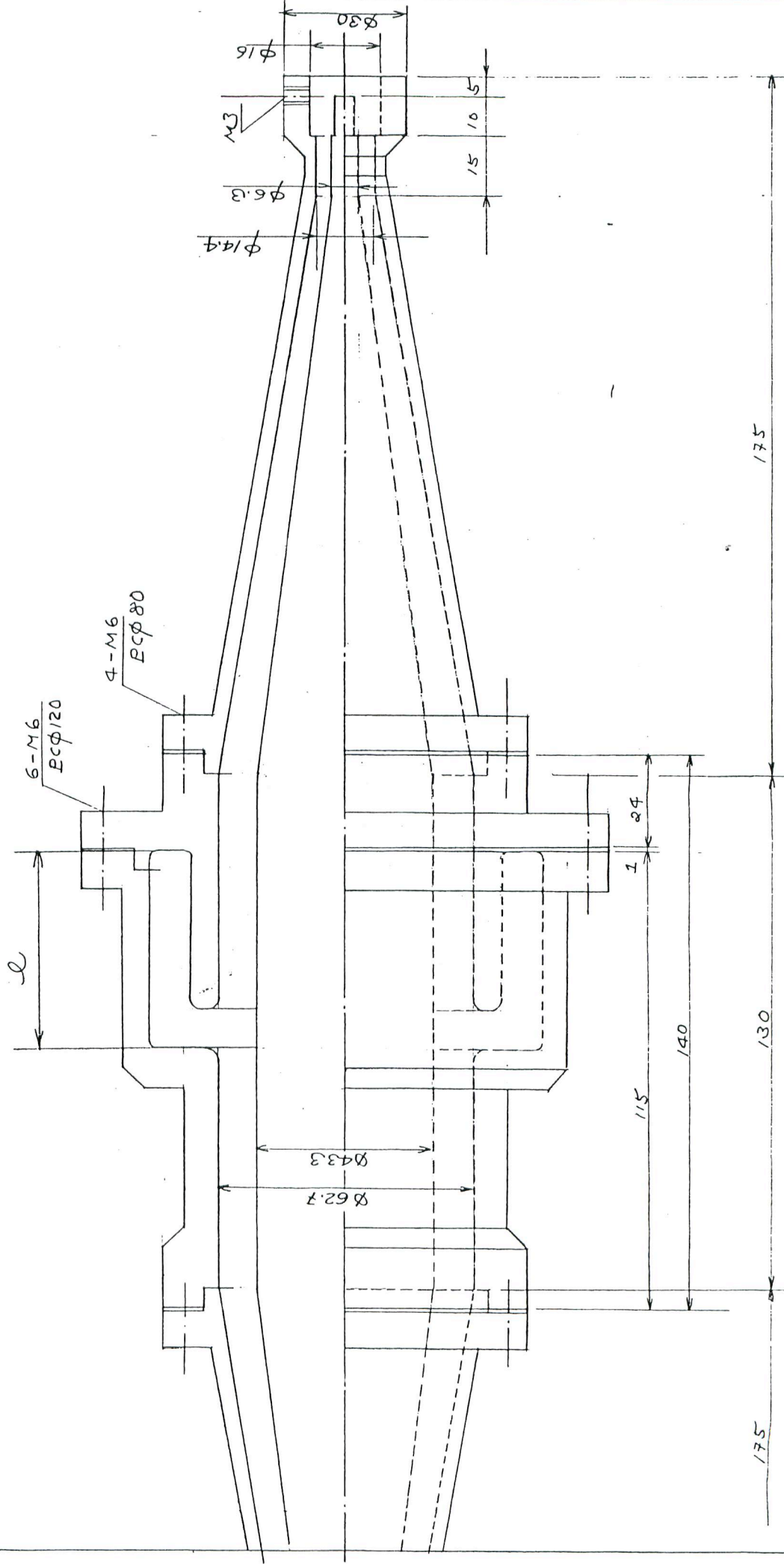


X?
New Mode
Produced by
Stub Support holes

Without Co-axial Inner Conductor
Without RF Absorber

縮尺 $1/1$.

枚数 3ルニ=54





KEK ENGINEERING NOTE

CODE:

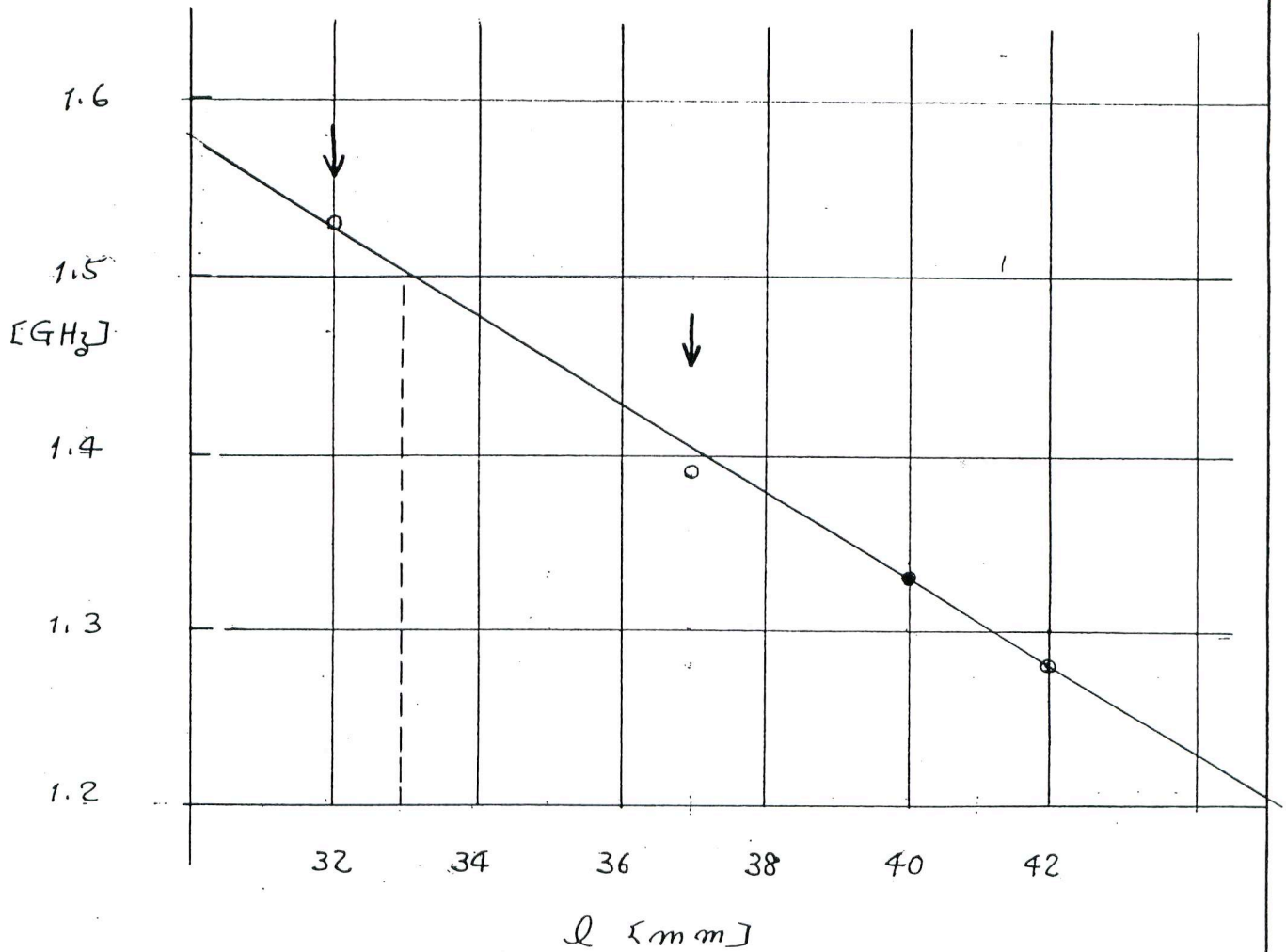
DATE:

Crab $\frac{1}{3}$ scale Model

NAME:

K. Hosoyama

Notch Filter 特性試験



KEK ENGINEERING NOTE

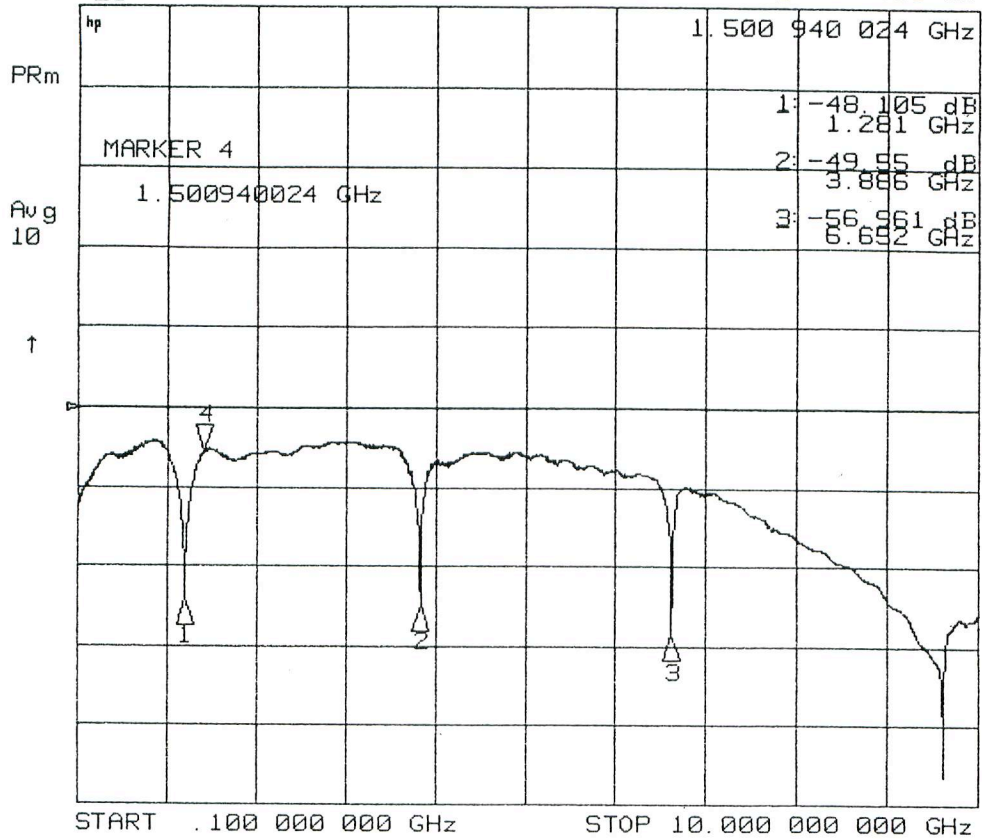
Match Filter

CODE

PAGE 1

23 Nov 1996 15:54:50

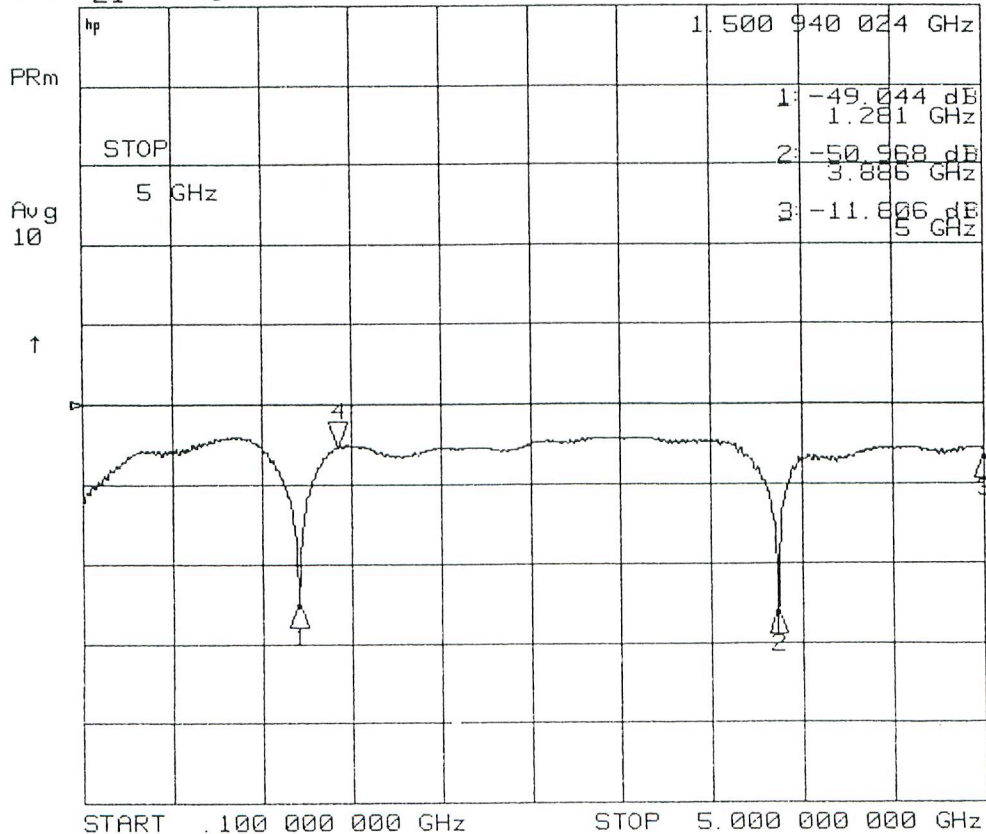
CH1 S₂₁ log MAG 20 dB/ .REF 0 dB 4: -11.013 dB



$l_c = 42 \text{ mm}$

23 Nov 1996 15:56:52

CH1 S₂₁ log MAG 20 dB/ REF 0 dB 4: -10.892 dB



KEK ENGINEERING NOTE

CODE

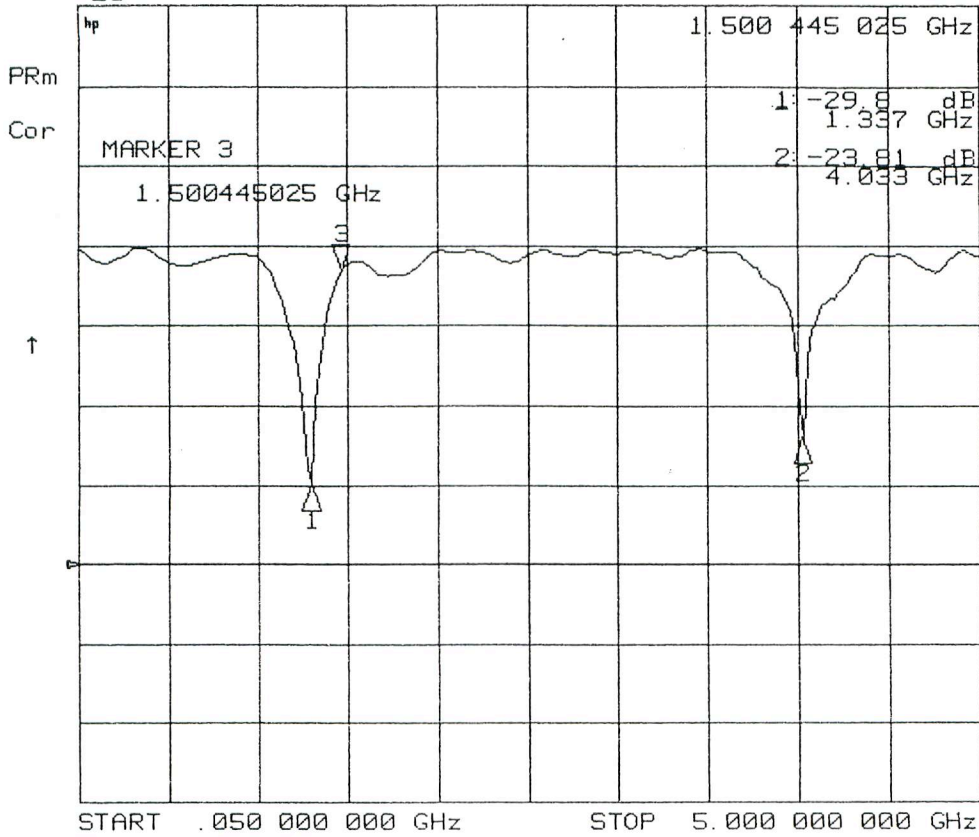
PAGE

2/

23 Nov 1996 17:58:03

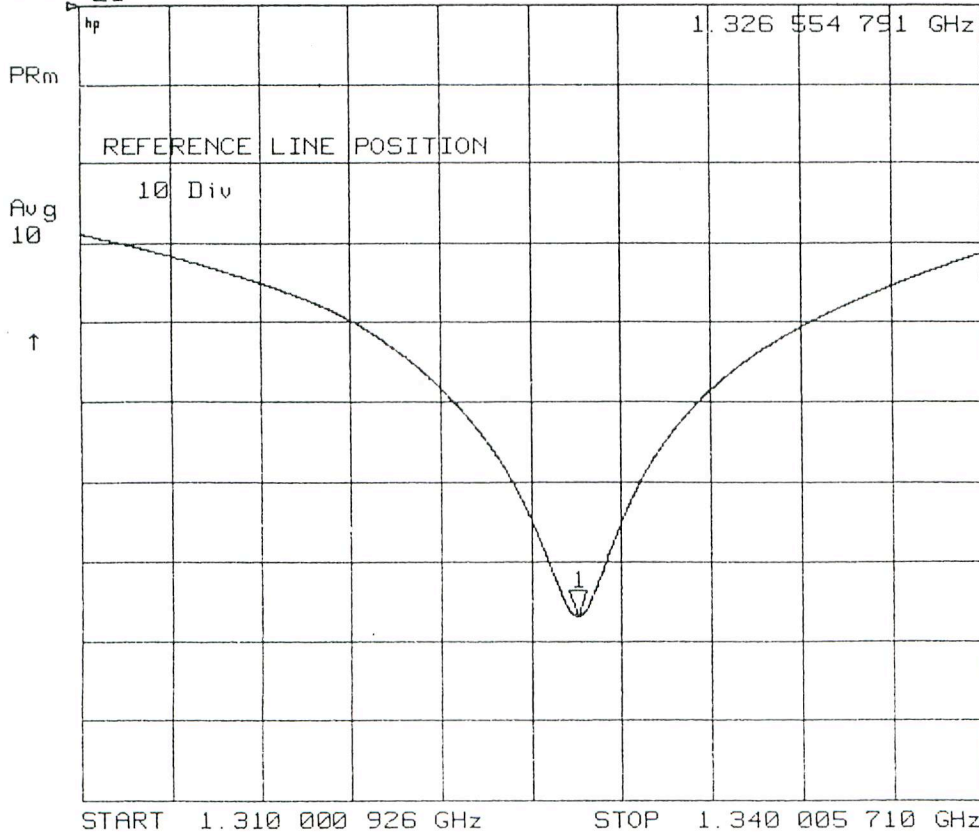
CH1 S₂₁ log MAG 10 dB/ REF -40 dB 3: -3.138 dB

l = 4.0 mm



23 Nov 1996 16:22:01

CH1 S₂₁ log MAG 5 dB/ REF -20 dB 1: -58.42 dB



KEK ENGINEERING NOTE

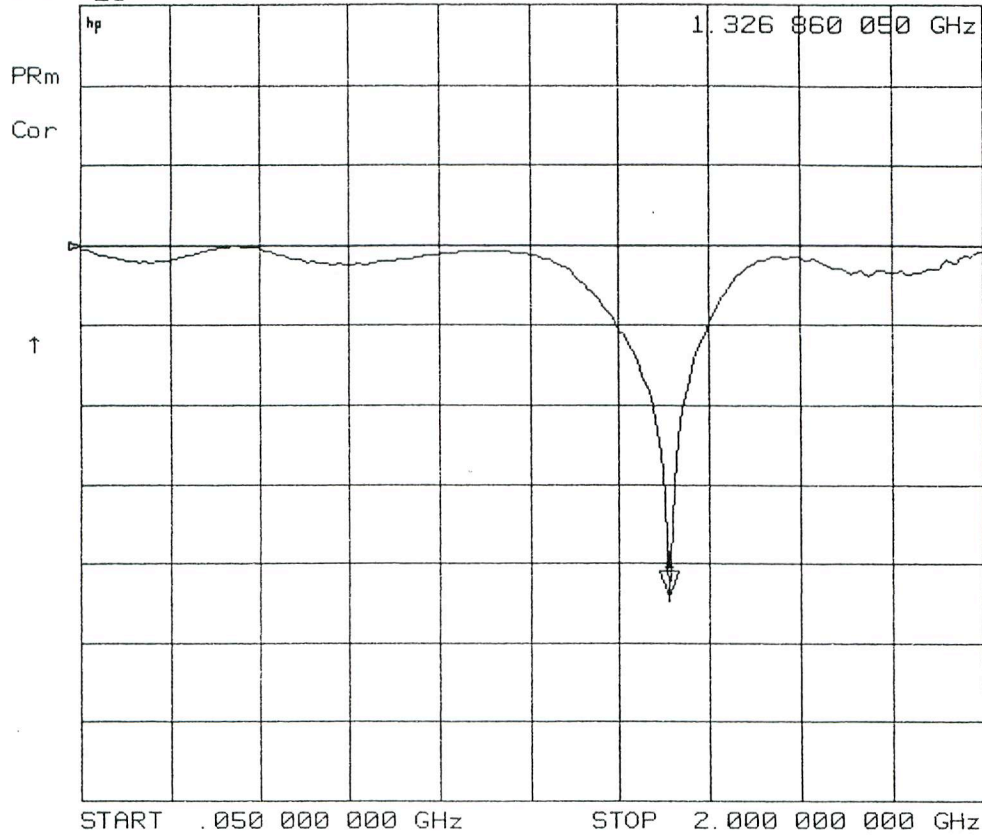
CODE

PAGE 3/

23 Nov 1996 17:17:51

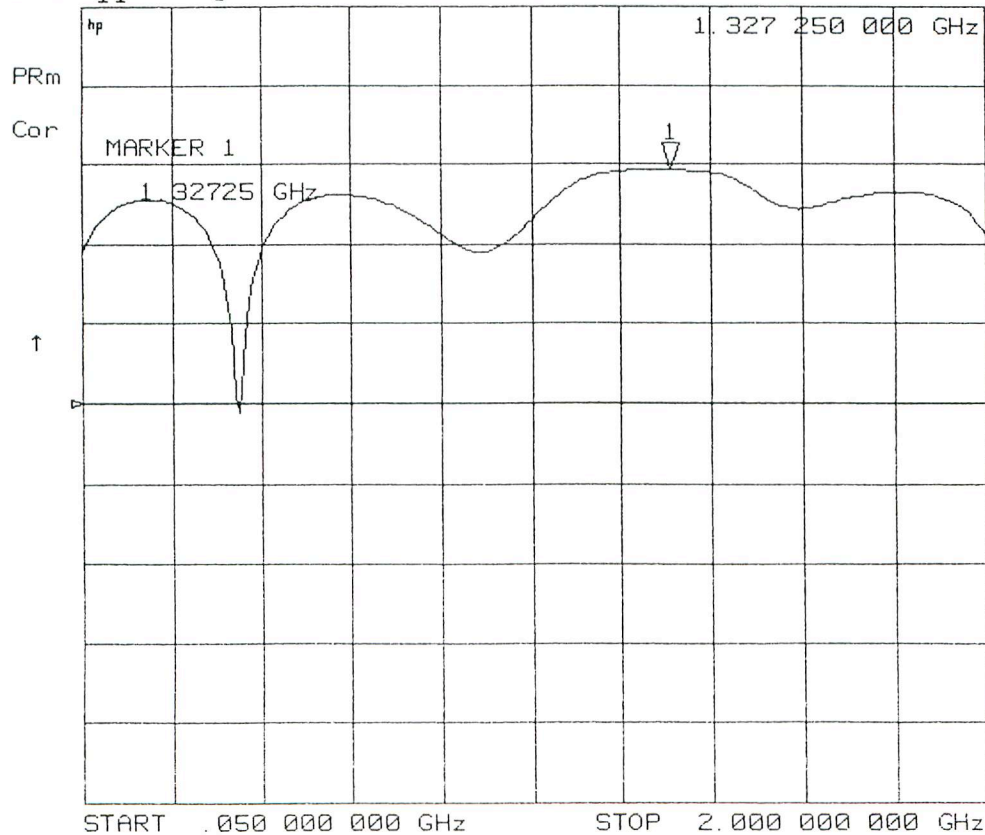
CH1 S₂₁ log MAG 10 dB/ REF -.000 dB 1: -44.298 dB

l = 40 mm



23 Nov 1996 17:29:23

CH1 S₁₁ log MAG 10 dB/ REF -30 dB 1: -.704 dB





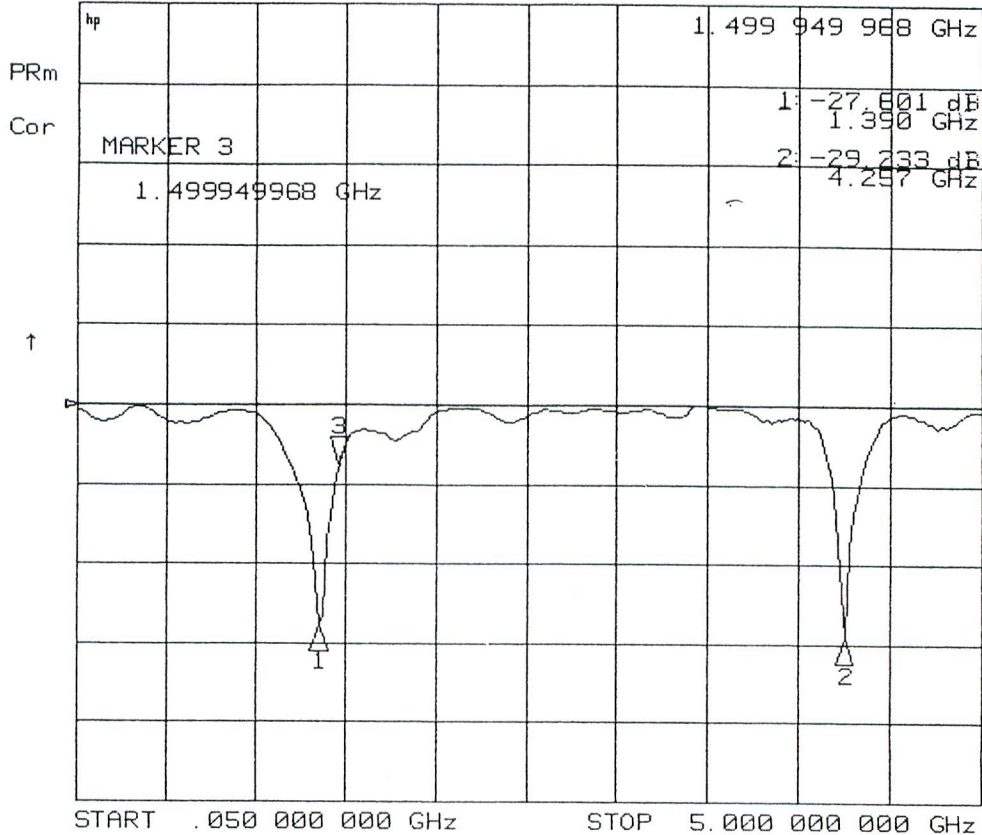
KEK ENGINEERING NOTE

CODE:

DATE:

NAME:

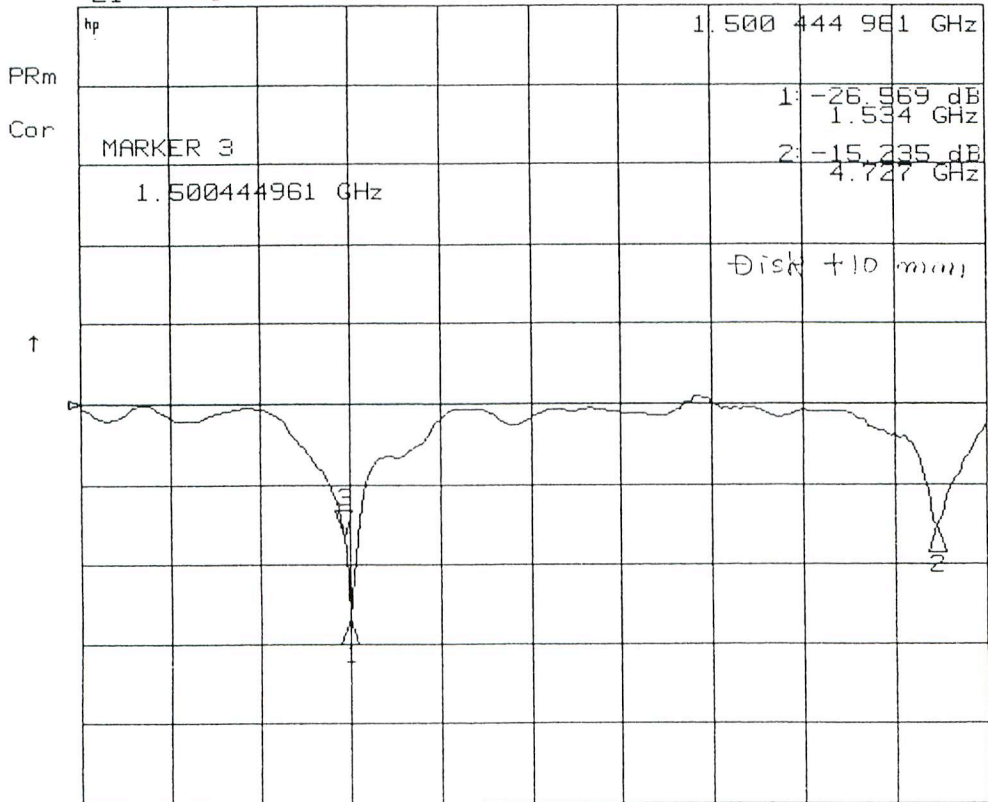
30 Dec 1996 12:32:36
 CH1 S₂₁ log MAG 10 dB/ REF 0 dB 3: -7.448 dB



- Disk + 5 mm
 (L = 37 mm)

START .050 000 000 GHz STOP 5.000 000 000 GHz

30 Dec 1996 13:03:31
 CH1 S₂₁ log MAG 10 dB/ REF 0 dB 3: -16.452 dB



Disk + 10 mm
 (L = 32 mm)

Disk + 10 mm

START .050 000 000 GHz STOP 5.000 000 000 GHz