

# Cavity-Coupler Treatment & Testing

Preparation of crab cavities for KEKB

RF aging of input couplers.

17<sup>th</sup> September 2009 , LHC-CC09 at CERN

K.Nakanishi

# Fabrication Procedure of Crab Cavity

## Crab Cavity Cell

## Beam Pipe & Flange

MHI  
Kobe

**Nb Sheet** Tokyo Denkai  
5 mm t RRR = 180

**Nb Sheet**

**Half Cell Hydro-forming**

**Rolle**

**Mechanical Polishing & Trimming**

**Electron Beam Welding**

**Grinding of Welding Part** Cell Equator

KEK  
Tsukuba

**Barrel Polishing** ~ 100  $\mu\text{m}$

Nomura  
Plating  
Kanuma

**Electro-Polishing** EP 1  
~ 100  $\mu\text{m}$

**High Pressure Water Rinsing**

Kinzoku  
Giken  
Mito

**Annealing** 700  $^{\circ}\text{C}$  x 3 hr

**Electro-Polishing** EP 2  
~ 5  $\mu\text{m}$

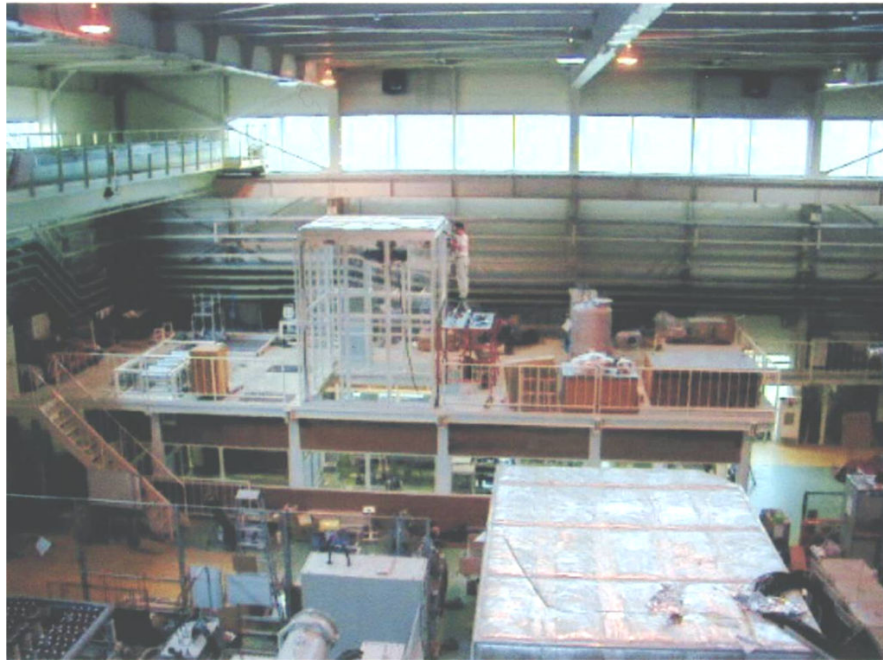
**High Pressure Water Rinsing**

80 bar. 60 min.

**Assembling for Cold Test**

**Cold Test in Vertical Cryo.**

# Fabrication Space. Barrel Polishing



Fabrication Space

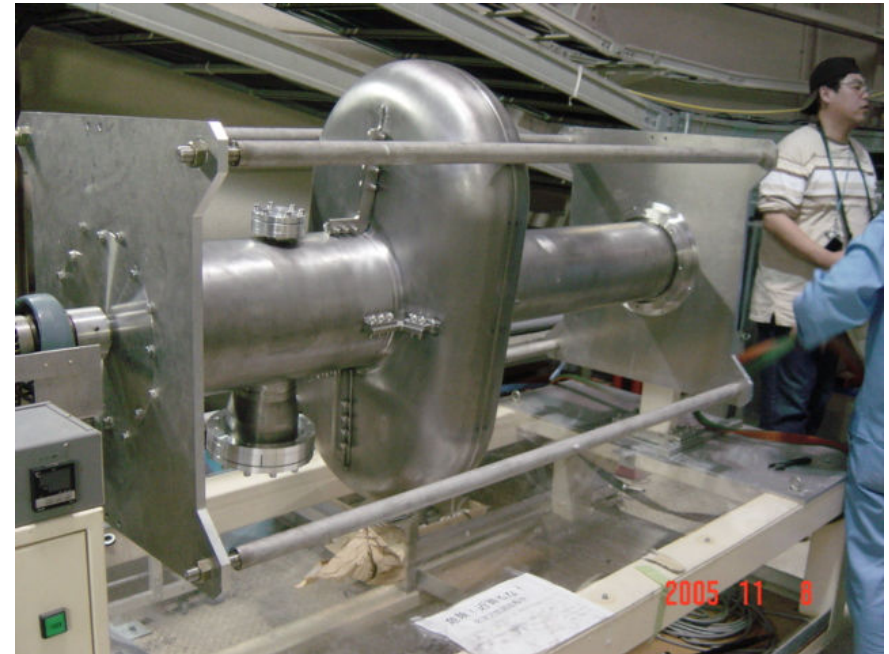
Clean room (class 100) for cavity assembling

Barrel Polishing

High pressure rinsing

Clean room for cryostat assembling

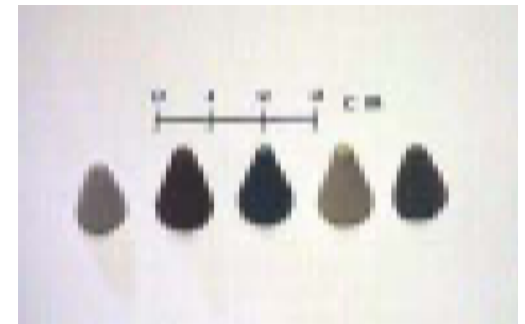
This area is shut down to expand ATF(2).



Barrel Polishing

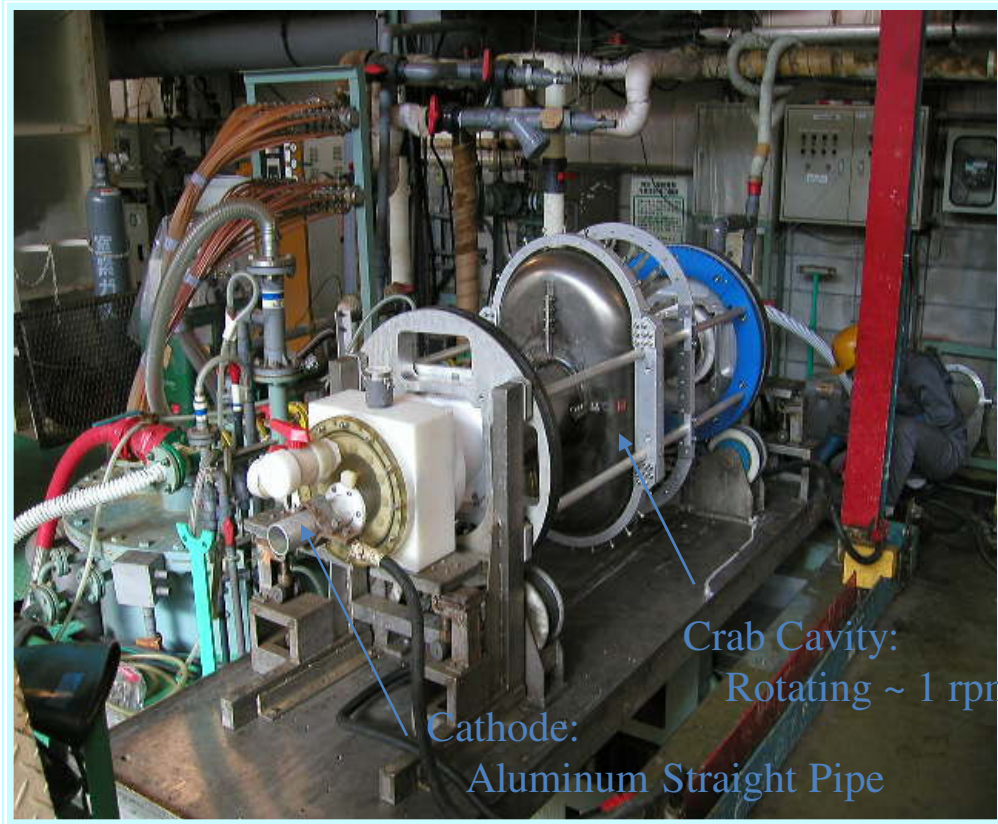
Polishing Time 312 Hr

20RPM



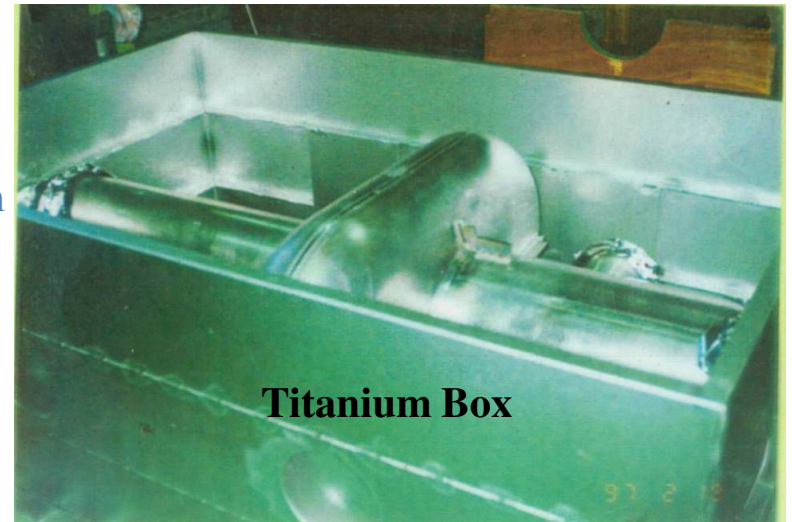
media

# Electro Polishing & Annealing



**Electro Polishing at Nomura Plating Ltd.**  
**This system was shut down.**  
**New EP system was established at STF in KEK**

EP 1 ~ 100  $\mu\text{m}$   
EP 2 ~ 5  $\mu\text{m}$



**Annealing at 700°C for 3 hours**  
**at Kinzoku Giken Ltd.**

# High Pressure Rinsing and Assembling for RF Cold Test



Set Flanges of Beam Pipes and Ports  
in Class 100 Clean Room

STF also has a clean room.



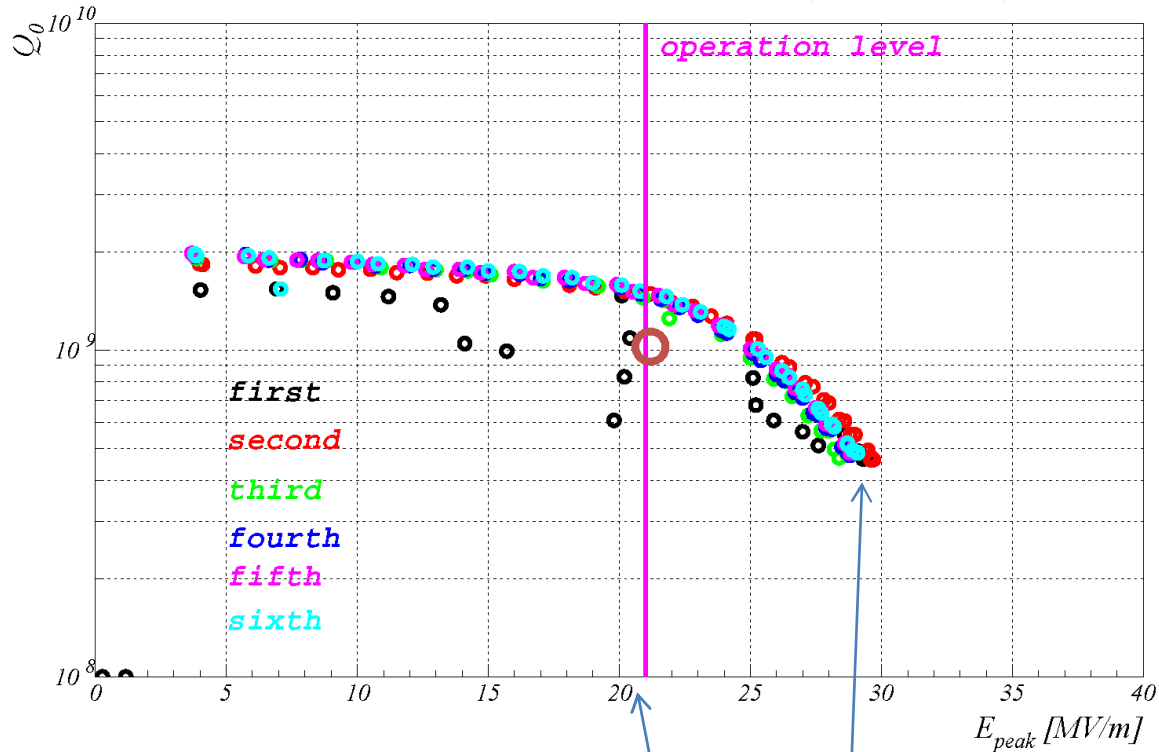
High Pressure Water Rinsing  
by 80 bar Ultra-Pure water

Rotation & Up-Down Motion

STF has other system.

# Test Result Crab Cavity for HER

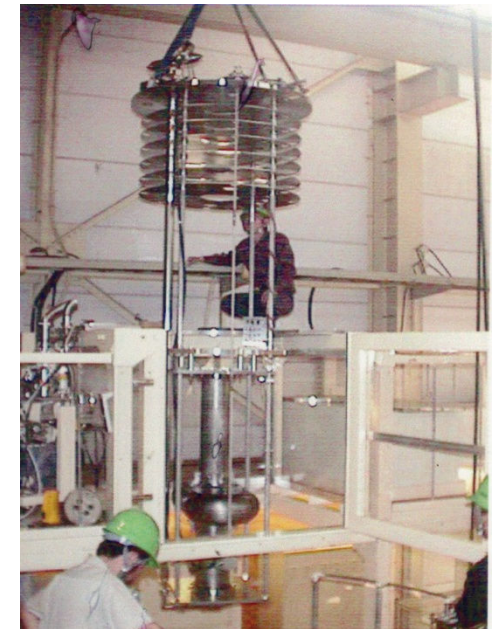
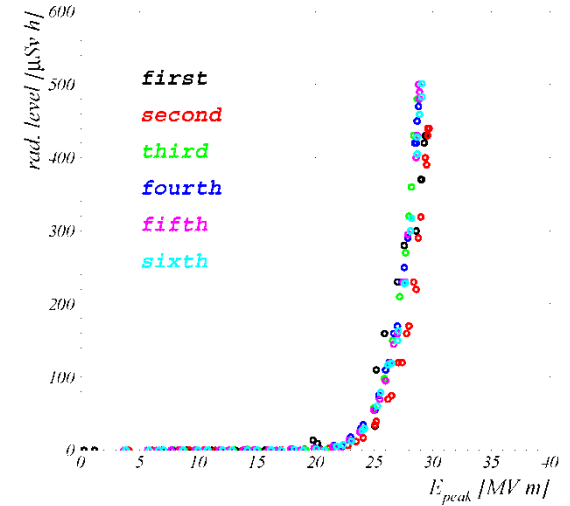
## HER Crab Cavity Vertical Test (2005/12/20)



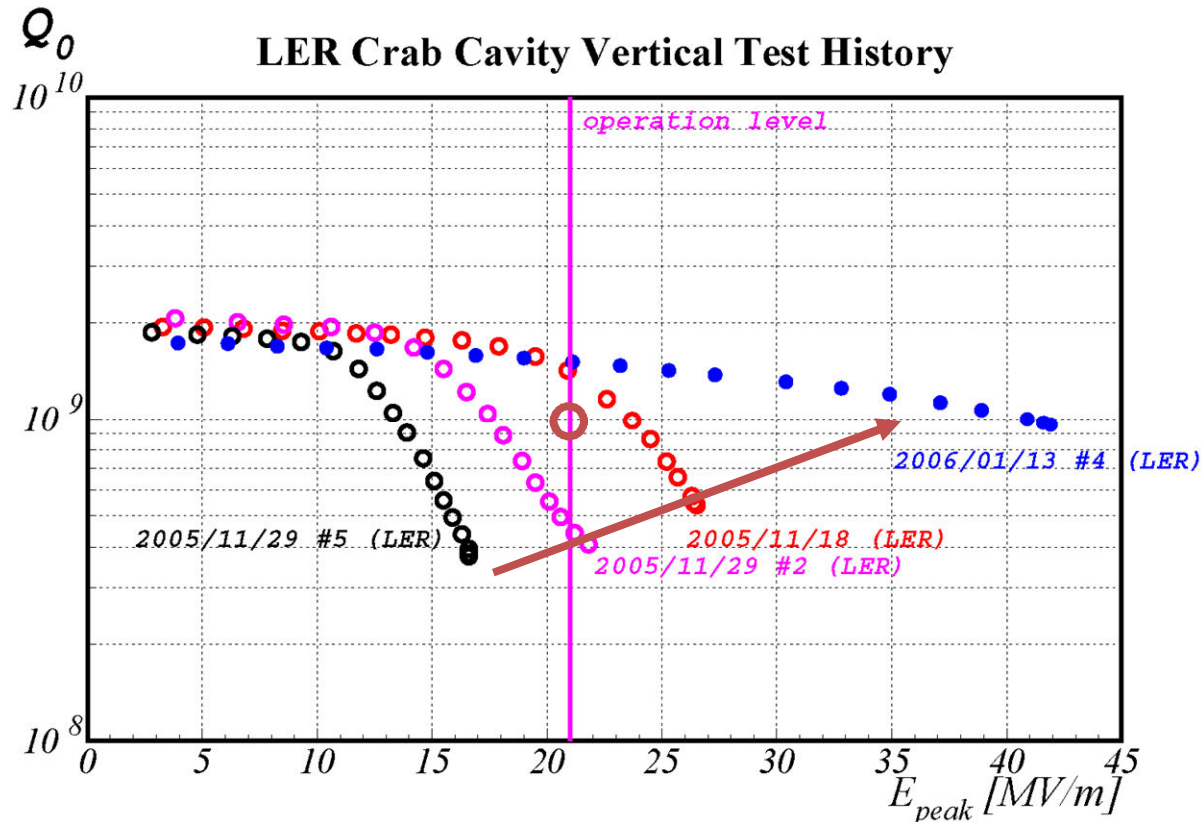
1.44MV

It was limited by capacity of RF power supply.

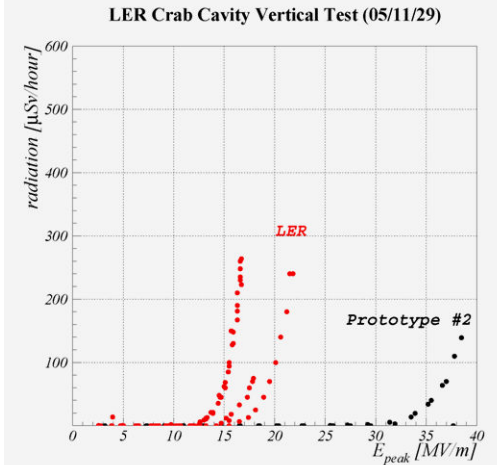
## Radiation Level during Vertical Test (05/12/20)



# Test Result Crab Cavity for LER



## X-Ray



Nov. 18 1<sup>st</sup> Test

↓  
H.P.R.

Nov. 29 2<sup>nd</sup> Test

Re-processing

Field Emission

EP2

Jan. 13 Test

Recovered !

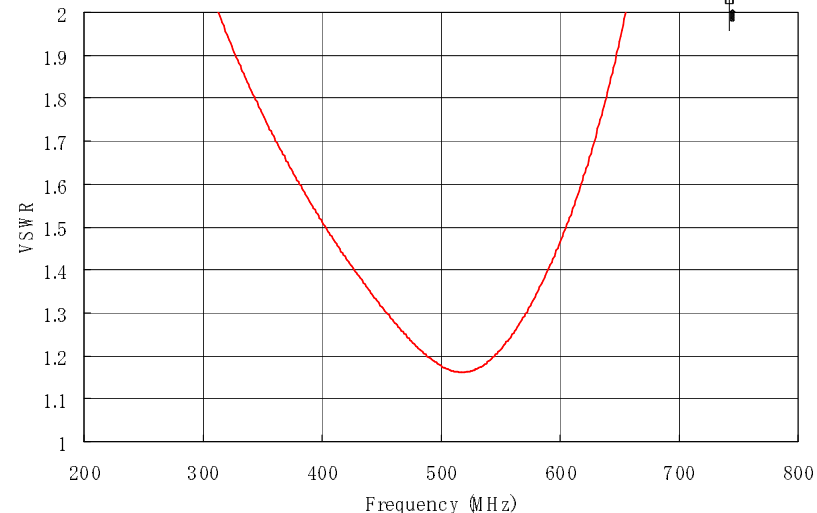
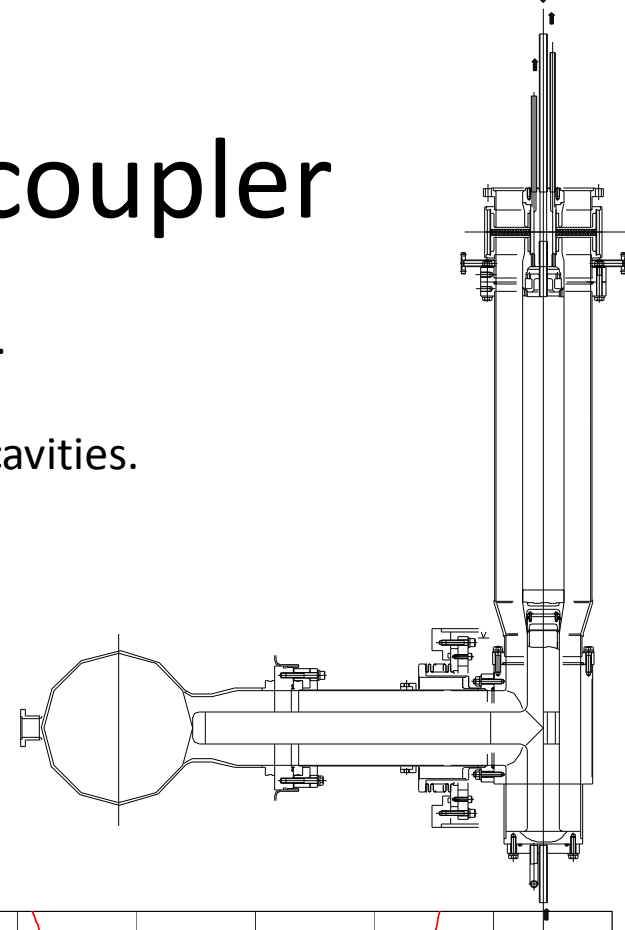
# Design of the input coupler

Detailed design of the input coupler was introduced last year.

It's features are following.

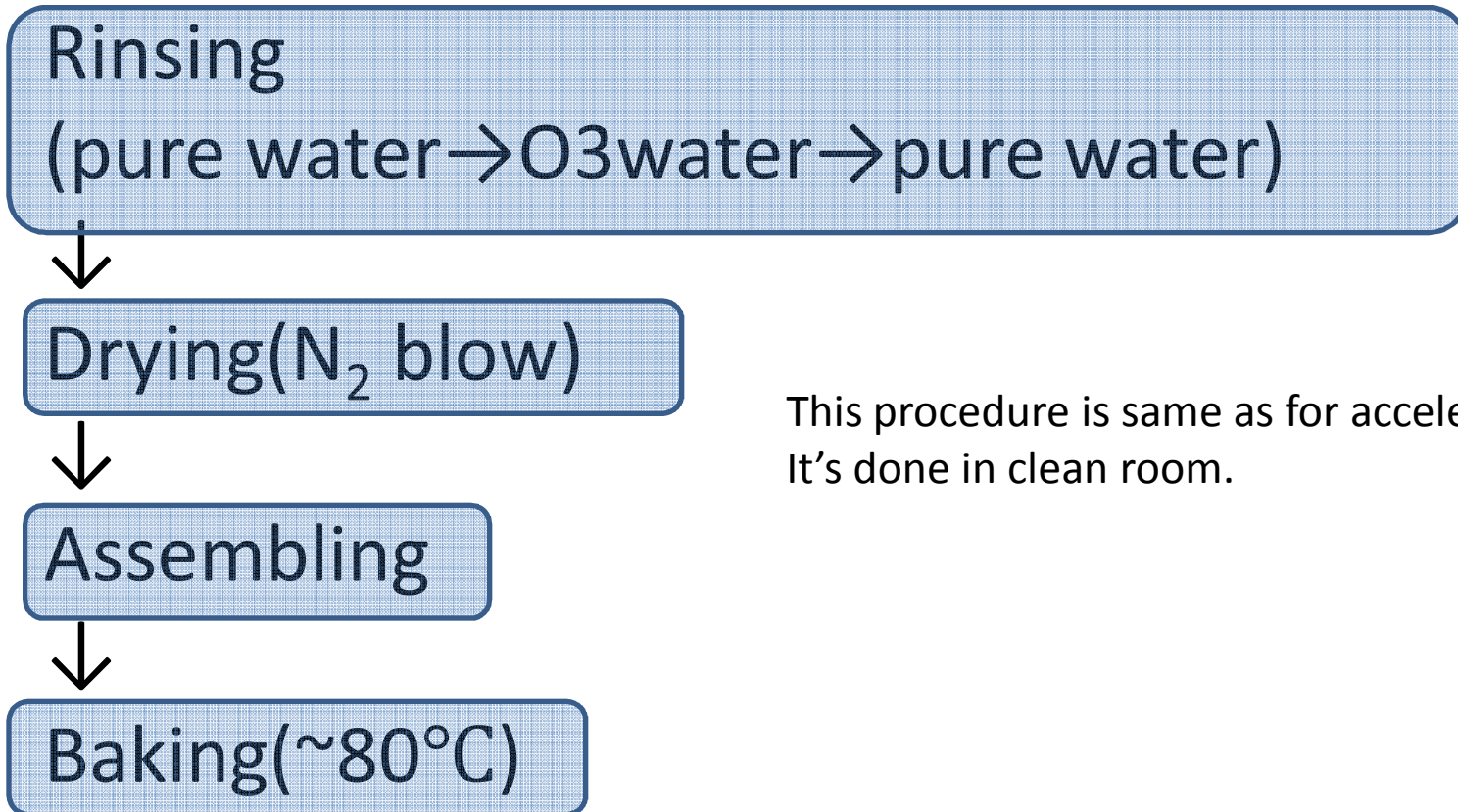
- The RF window is used that was designed for acceleration cavities.
- The maximum input power is 100kW.
- The input coupler has T-stub structure.
- The pass-band of T-stub is adjusted to operation frequency.

Item	Requirement	Reason
Diameter of outer conductor (vertical part)	151.9 mm	To use RF windows designed for acceleration cavities.
Diameter of inner conductor (vertical part)	66 mm	
Diameter of outer conductor (horizontal part)	120 mm	This size is same as acceleration cavity.
RF frequency	509 MHz	KEKB specification





# Coupler preparation



This procedure is same as for acceleration cavity.  
It's done in clean room.

# Tip of input couplers

prototype



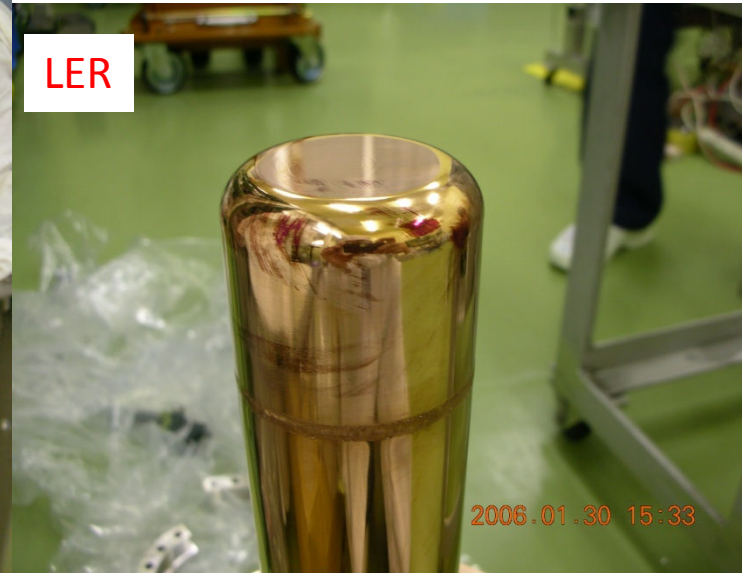
It looks good.

HER



It's not shiny.

LER

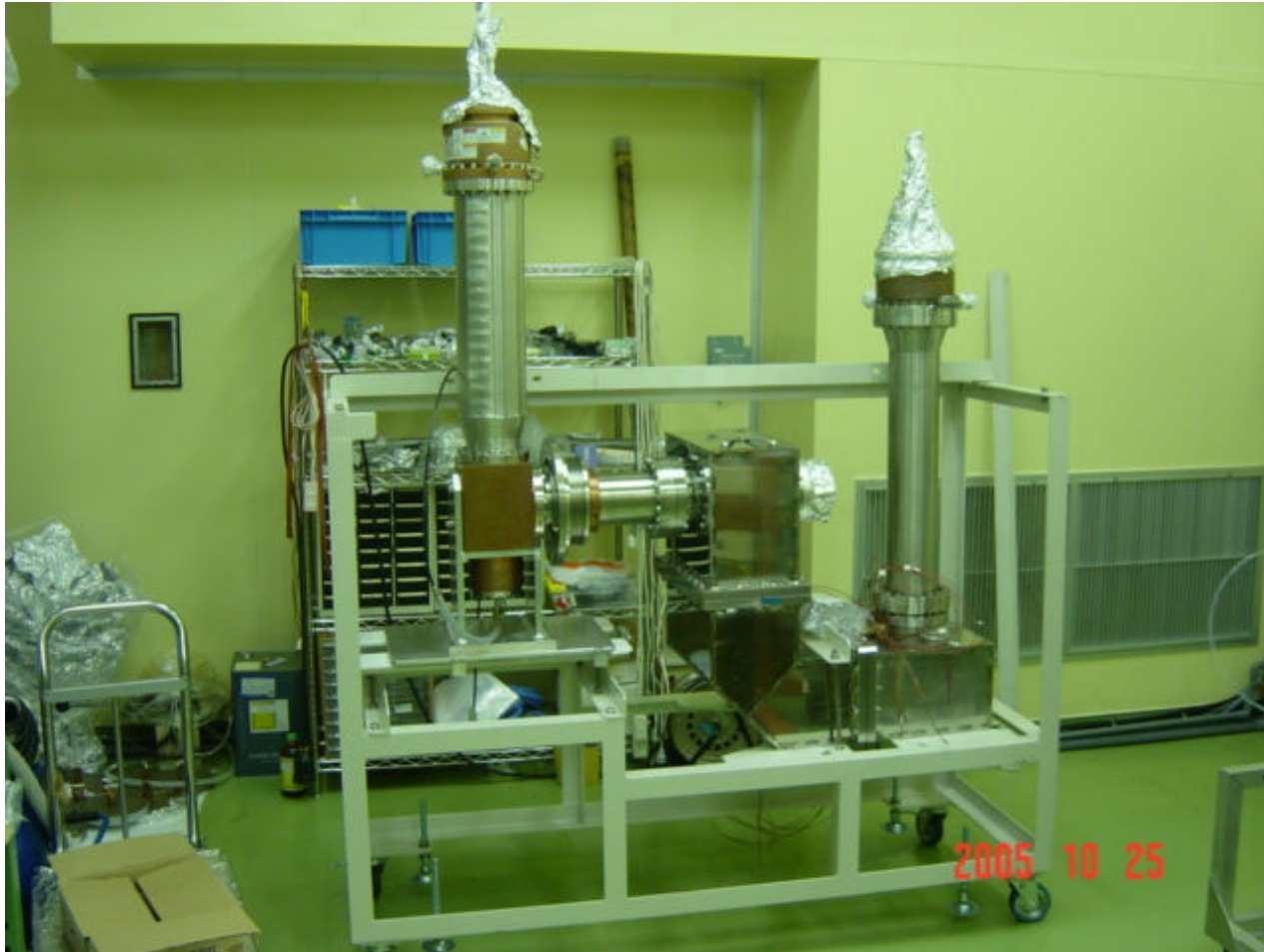


Some of purple stains were found.

# The coupler aging stand for acceleration cavity

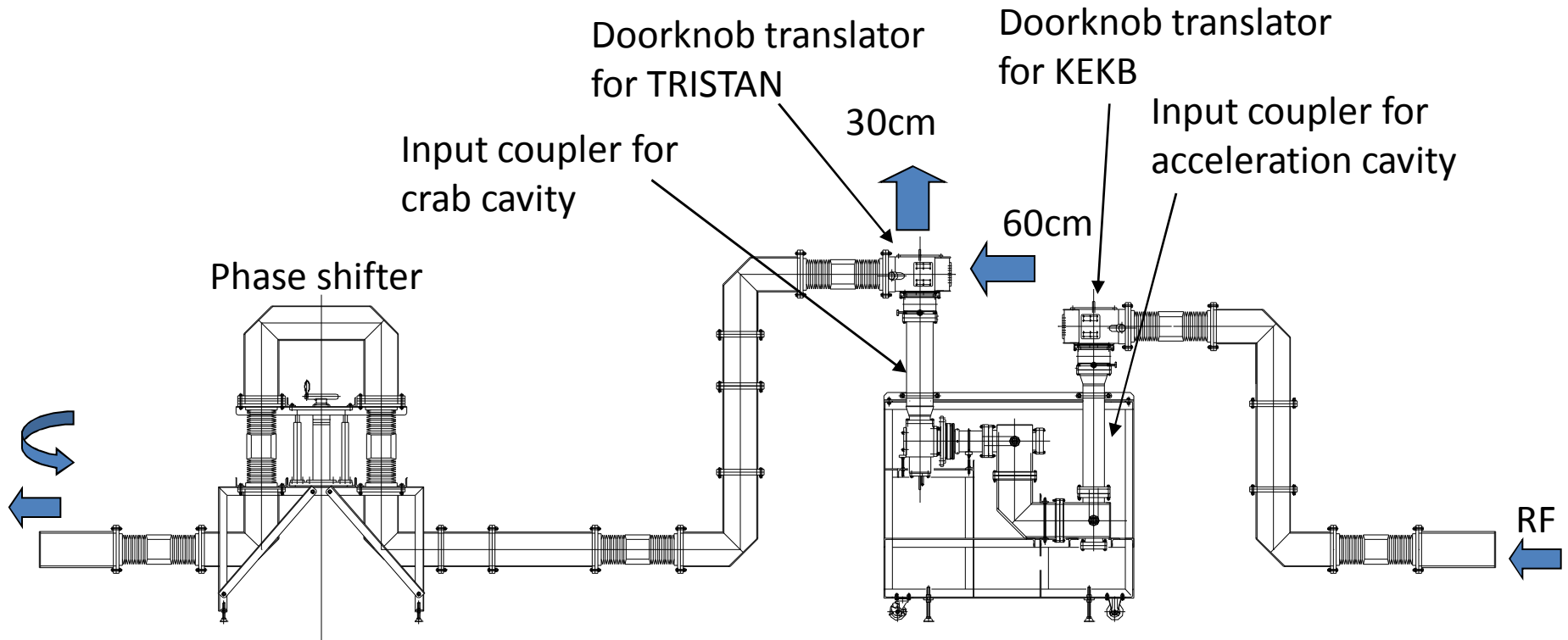


# The coupler aging stand for crab cavity

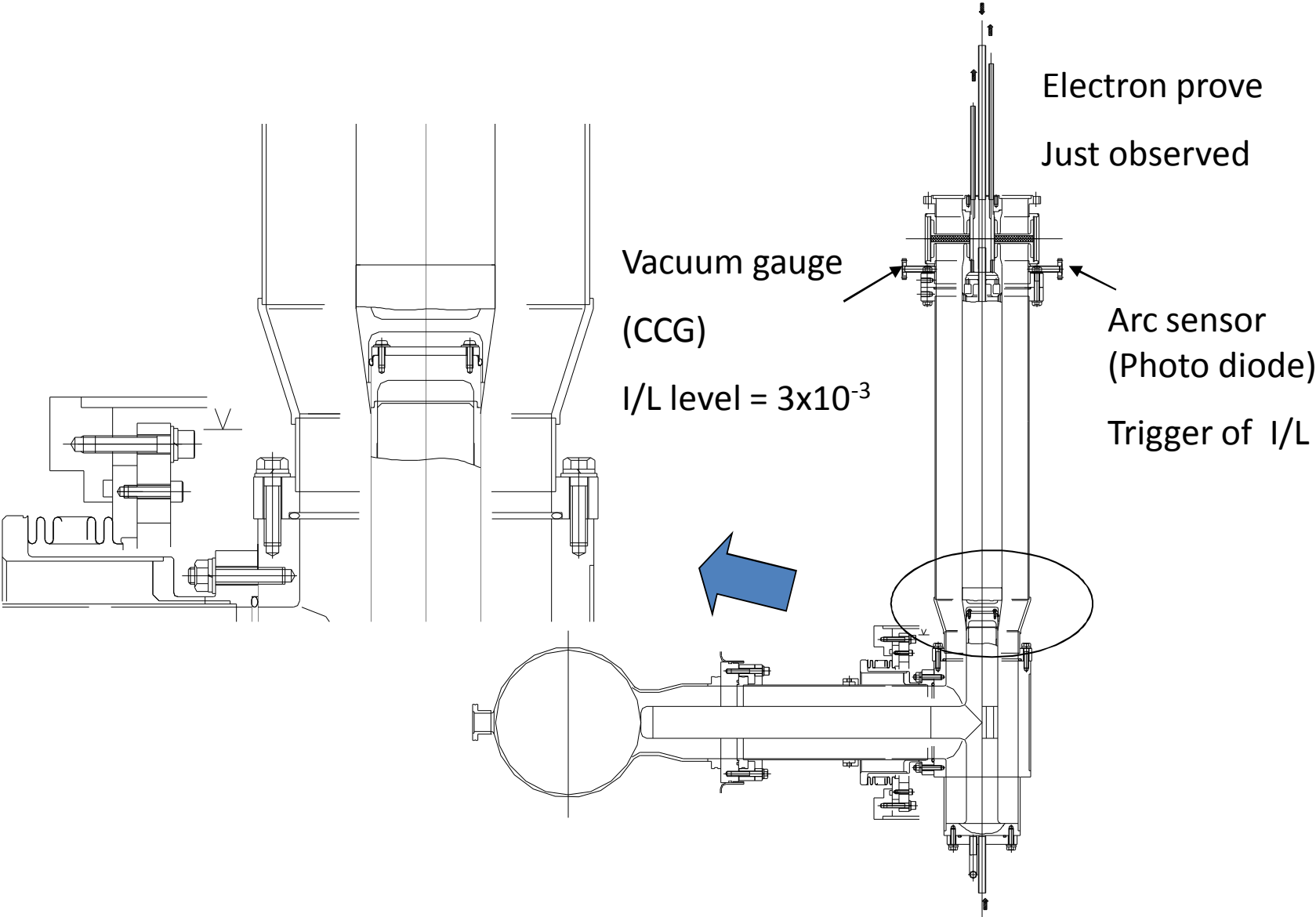


# Setup of the input coupler aging.

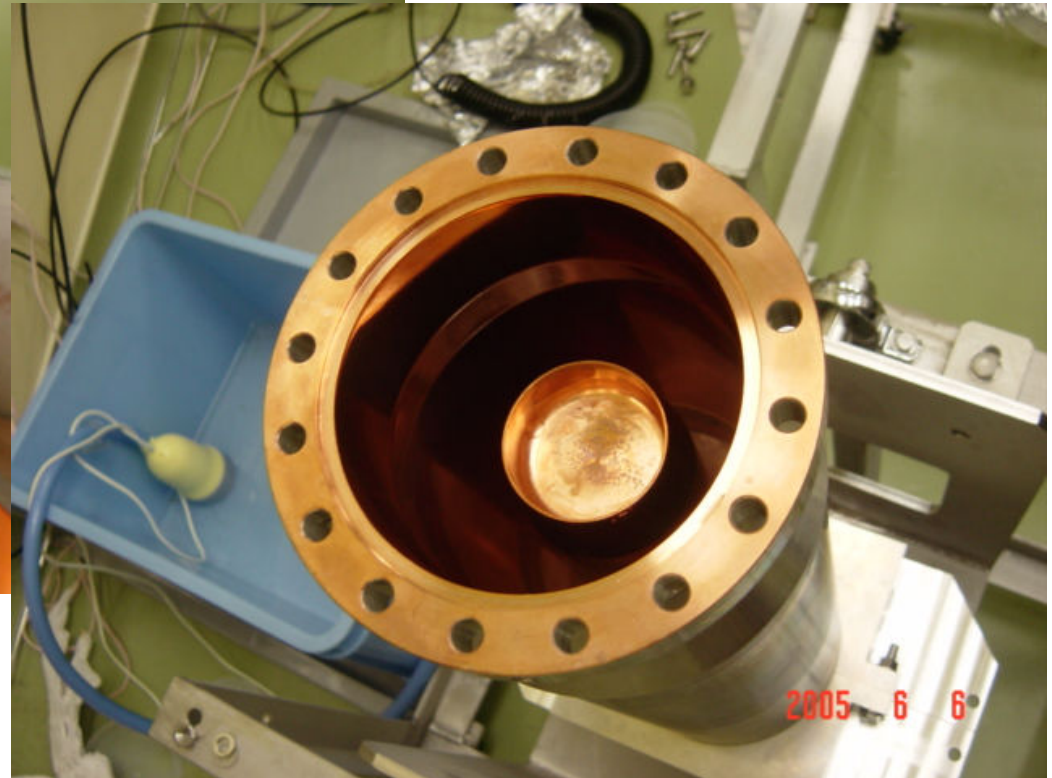
- Almost setups for acceleration cavities are available.
- The waveguide between two input couplers was made.
- An aging test will be started at the end of march.



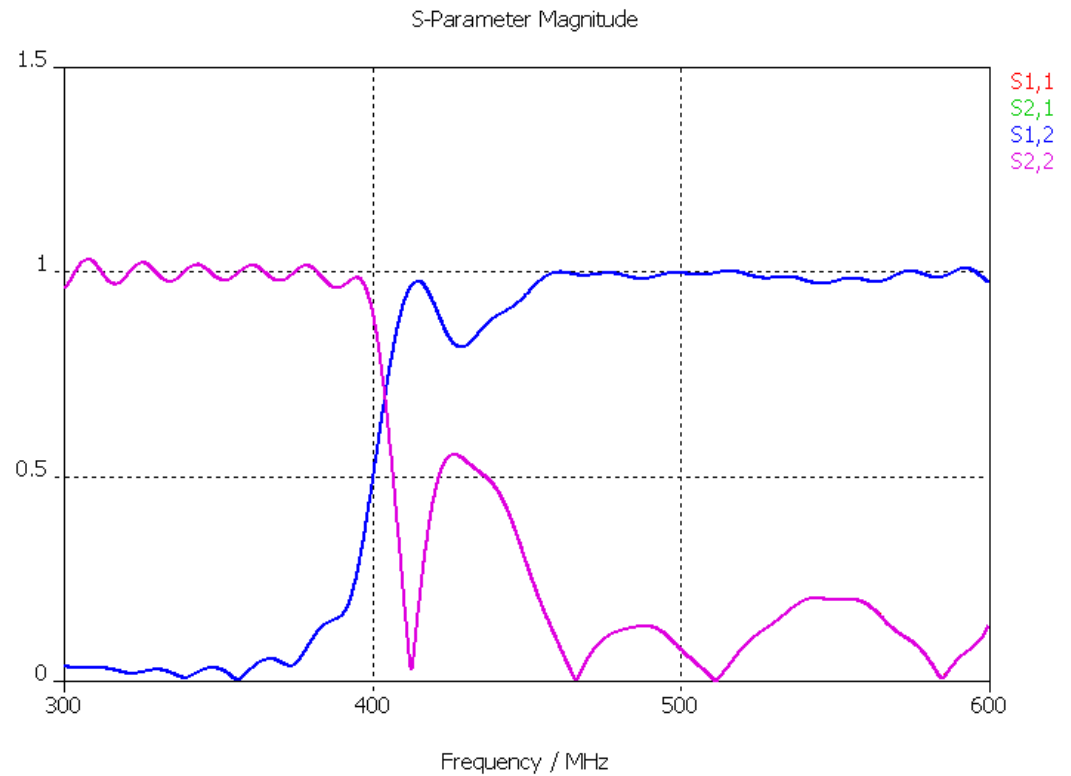
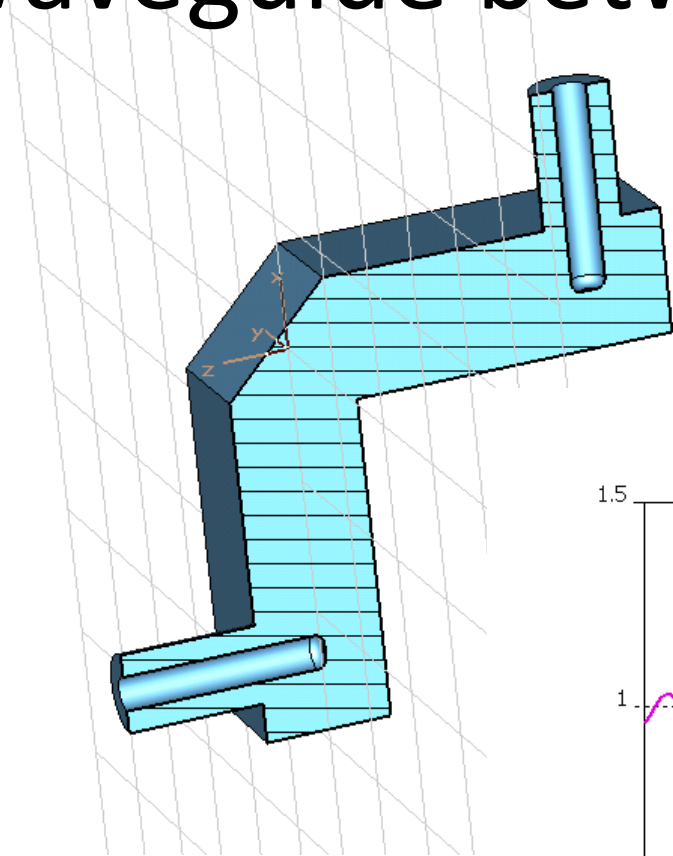
# Schematic view of the input coupler



# Connection part of the input coupler

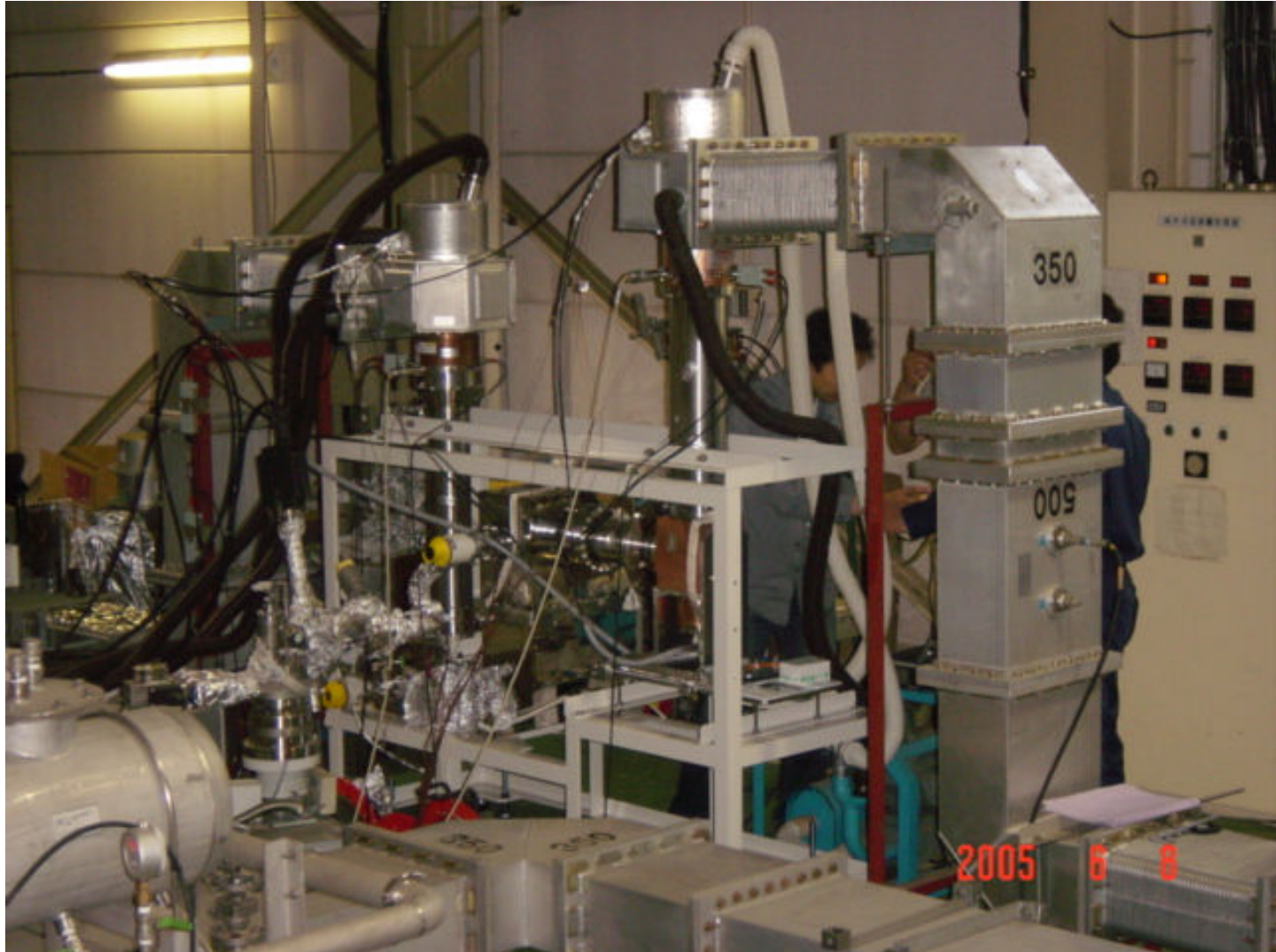


# Waveguide between two couplers

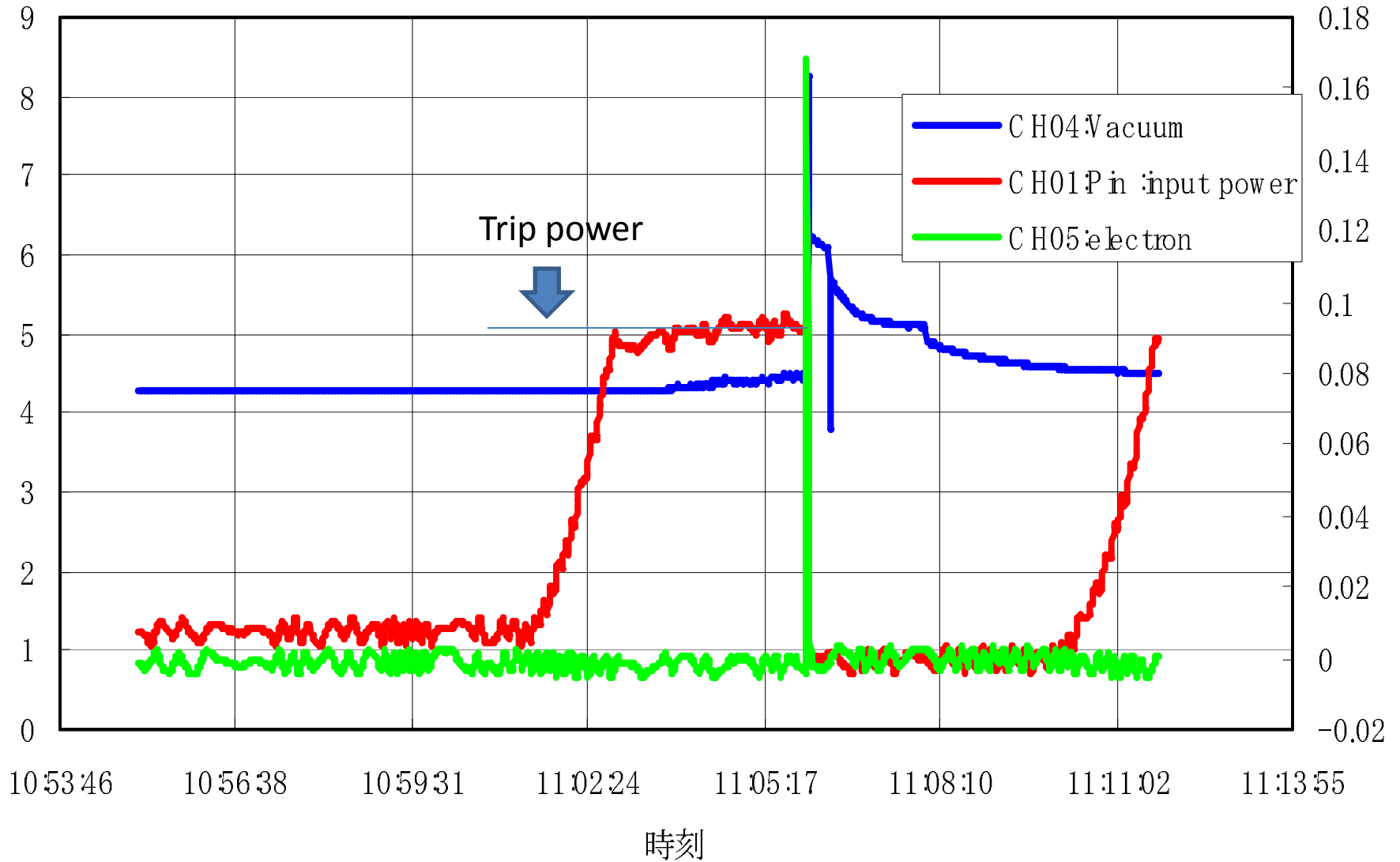




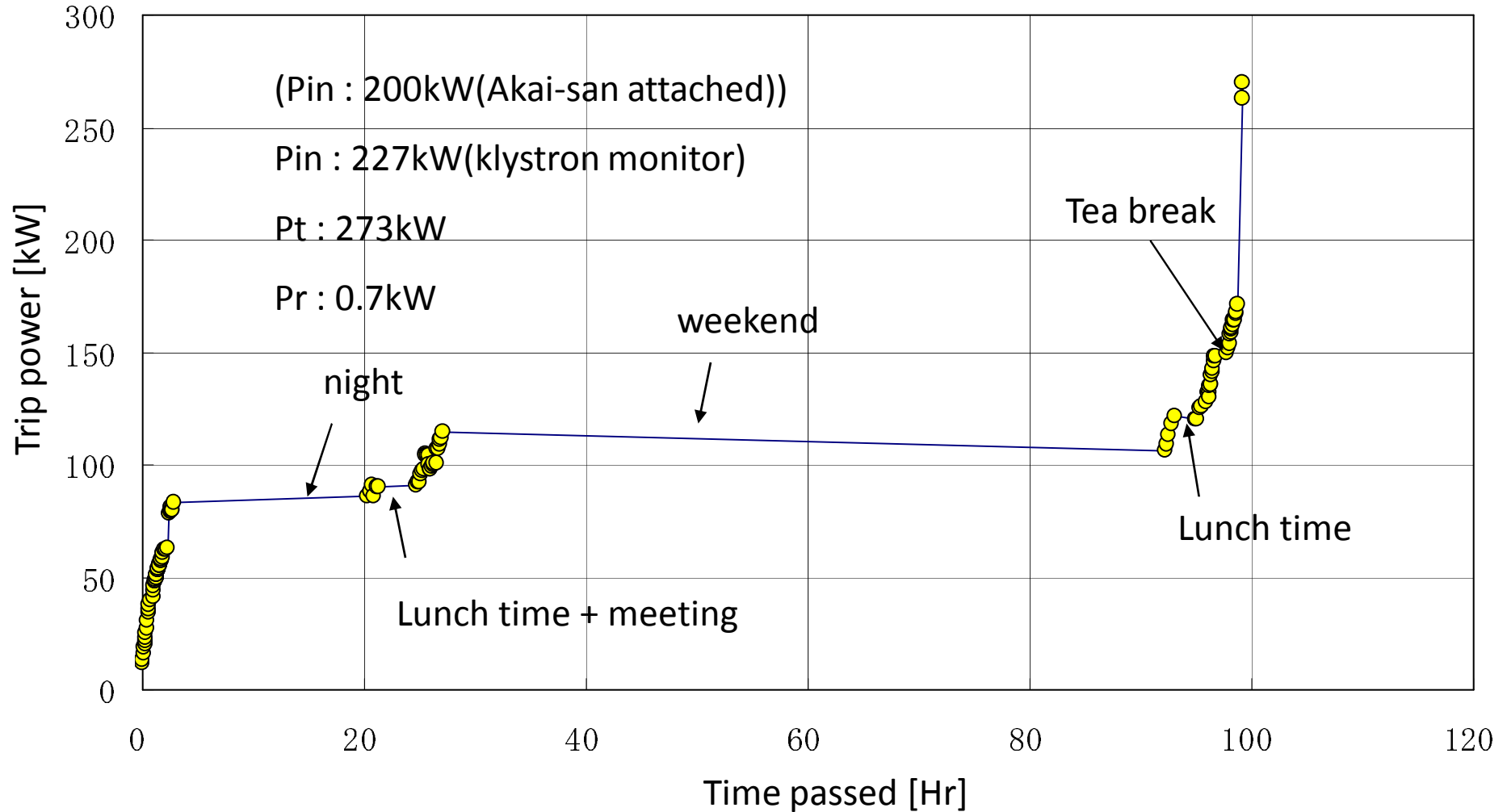
# Connected to klystron



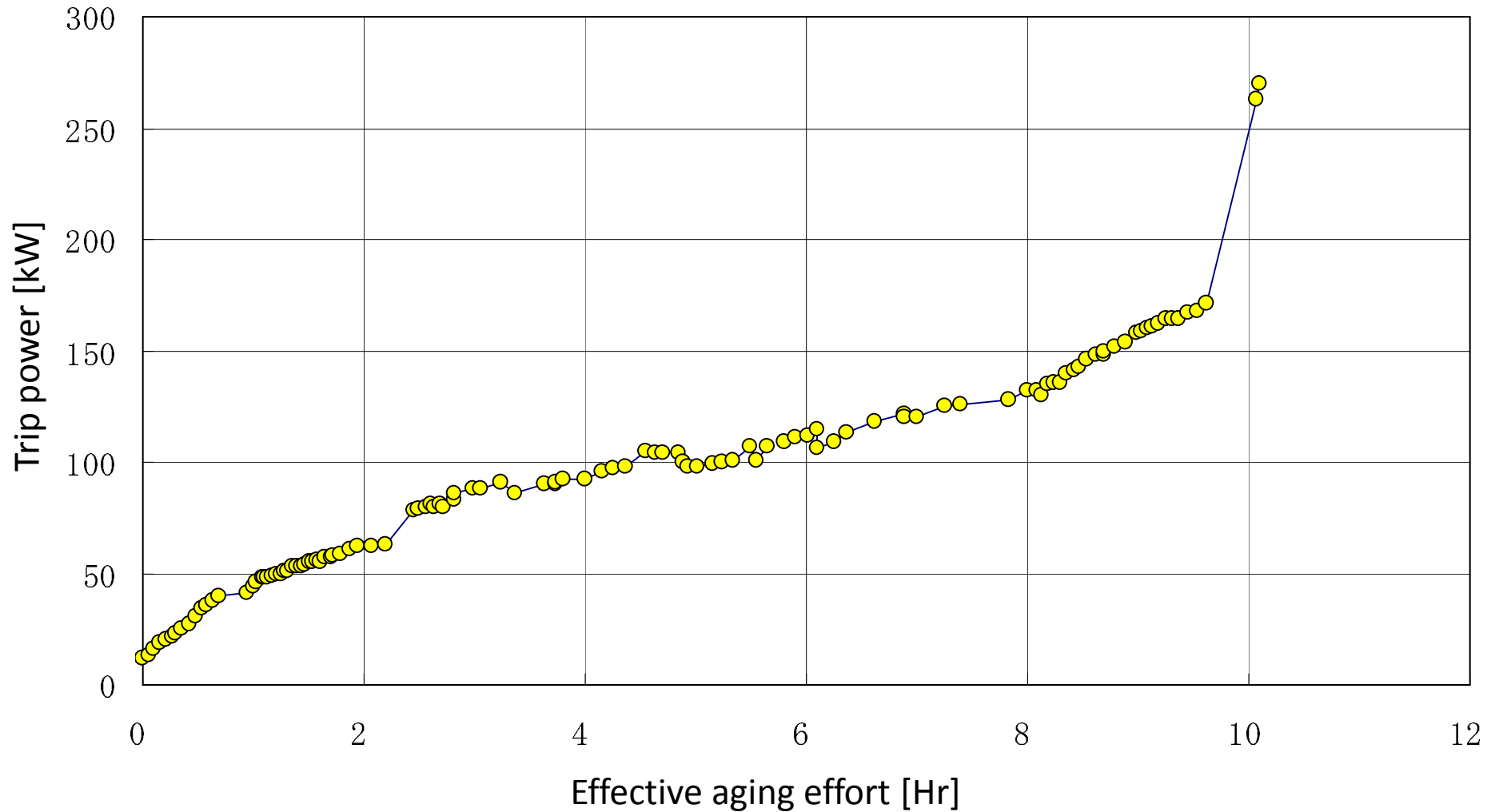
# Typical aging operation



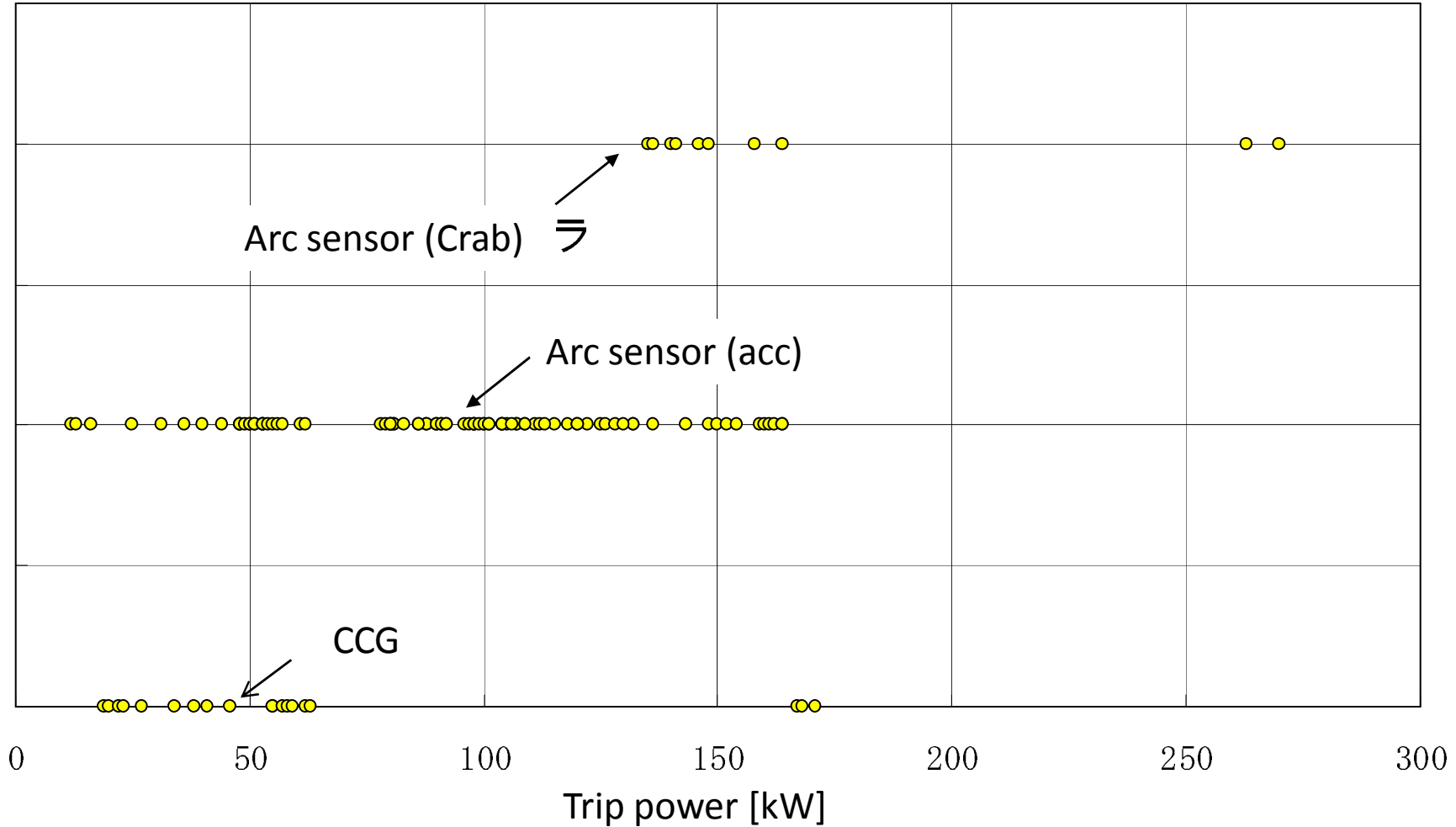
# Progress of trip power



# Progress of trip power

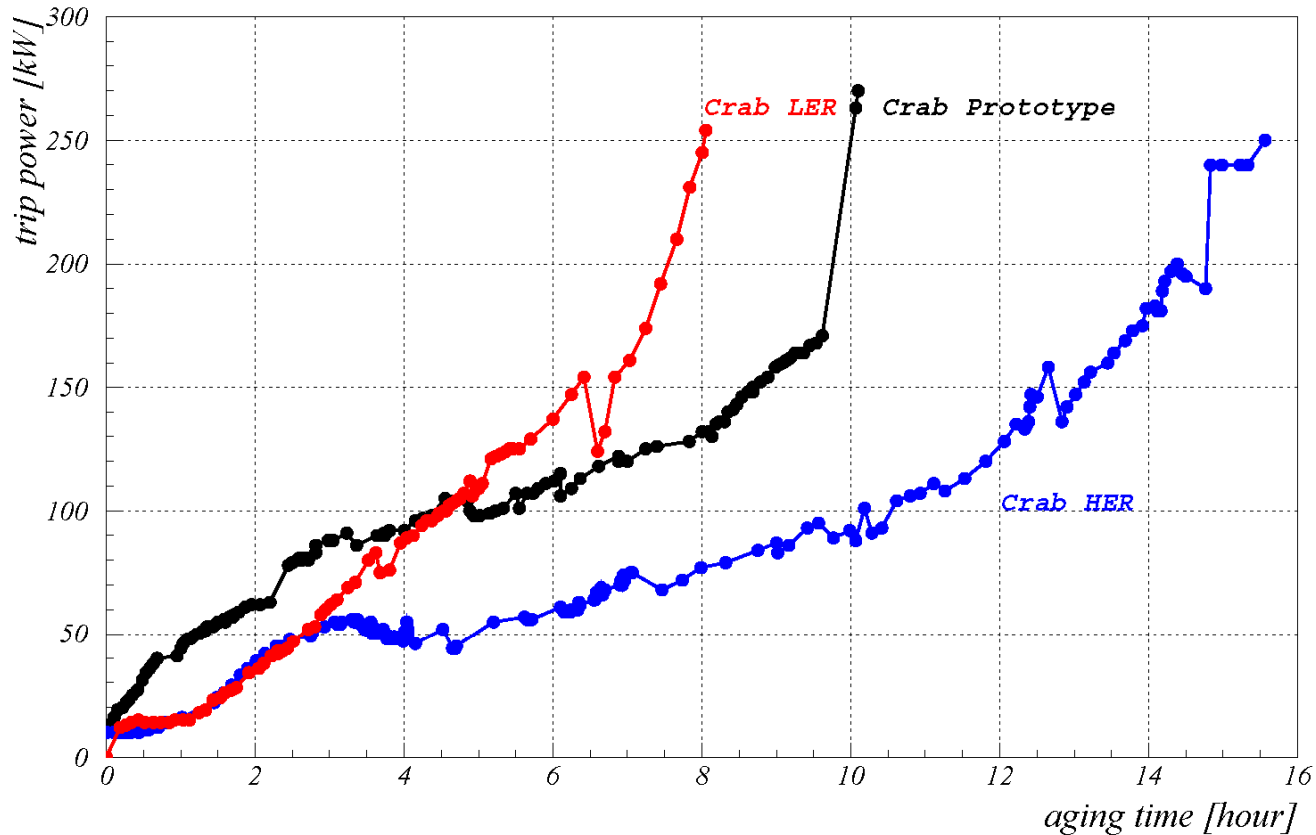


# Which sensor was triggered?

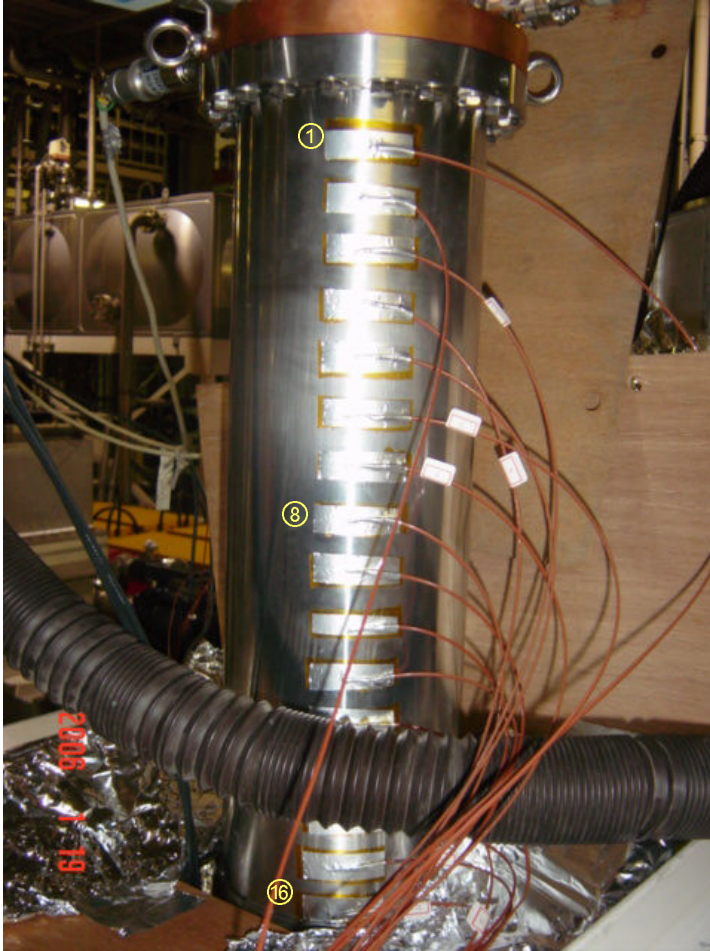


# Progress of trip power of input couplers

## Input Coupler Aging History Comparison

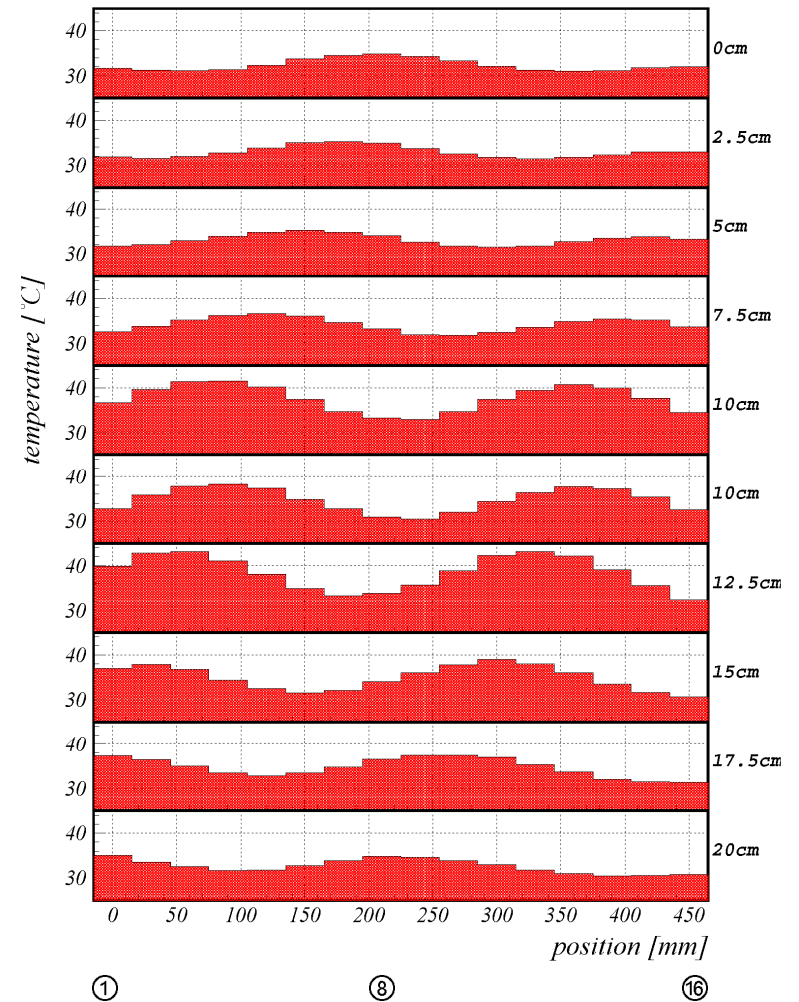


# Aging by tanding wave



16 thermo couples were attached every 3cm.

Crab HER Coupler for Standing Wave (06/01/19 ~ 06/01/20)



# Aging by standing wave until 200kW

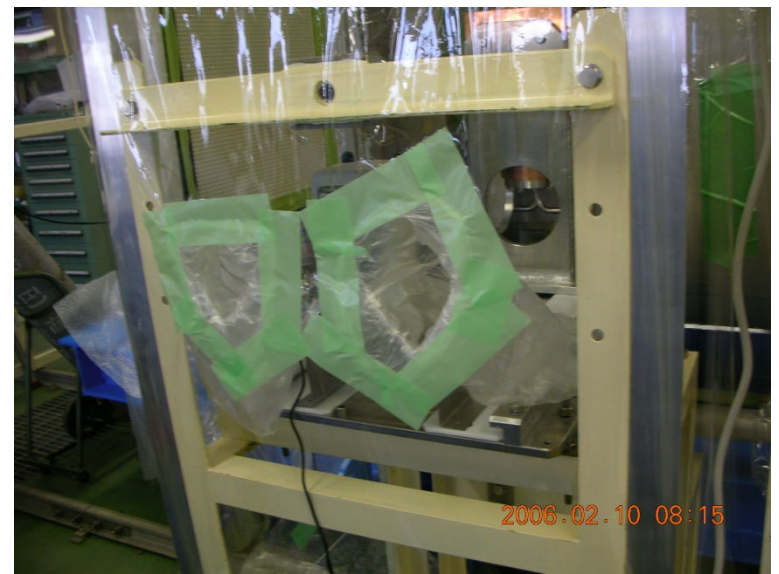
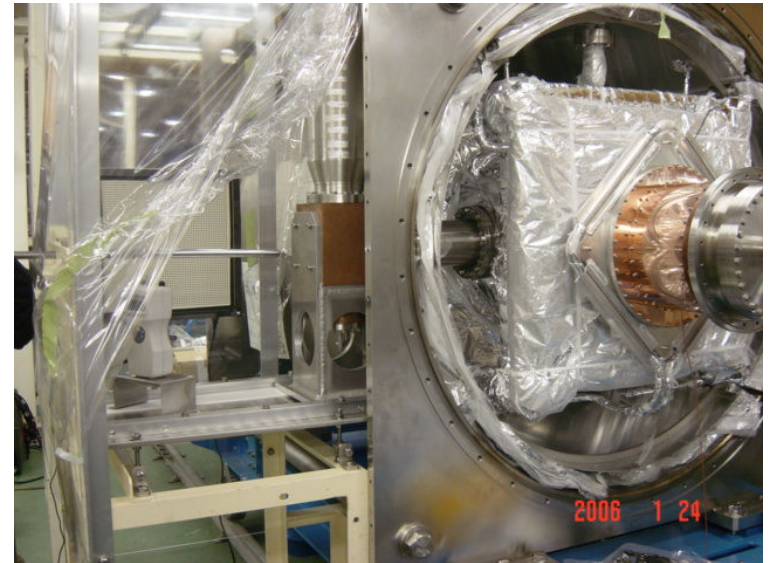
Offset	Aging effort [min]	Inter lock		
		arc ( crab)	arc(acc)	vacuum
0 cm	111	3	1	1
5 cm	5	0	0	0
10 cm	10	0	0	1
15 cm	84*	2	1	3
20 cm	31	0	0	3
25 cm	12	0	0	0
30 cm	12	0	0	0

We spend 4.5Hr to complete standing wave aging.

\*Peak of electric field hit the RF window.



# Assembling



The couplers were installed in handmade clean booth (less than class 20).

# Horizontal testing

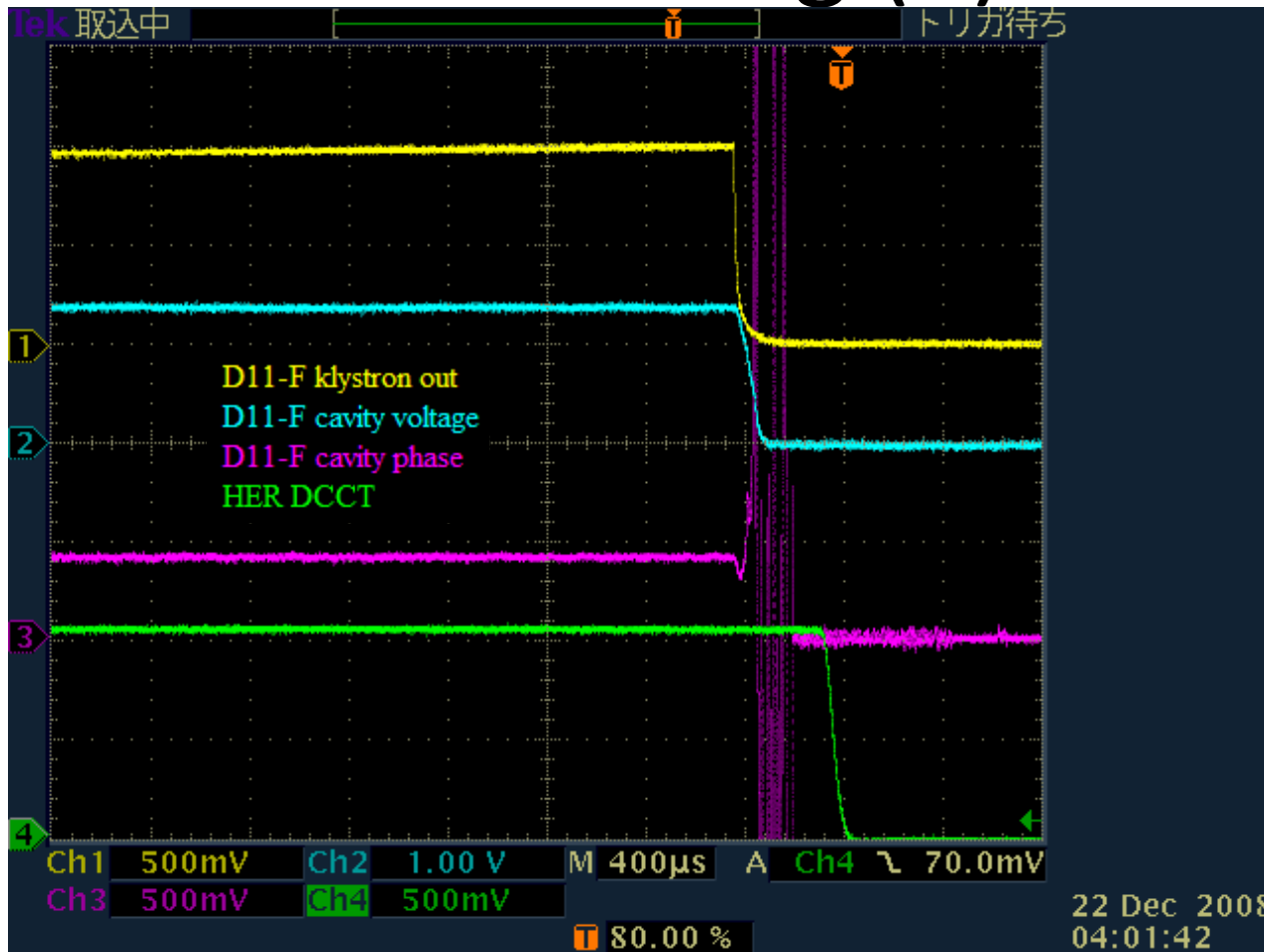
			$Q_L$		
	Input power	Observation	HER(Jun/2006)	HER(Nov/2006)	LER(Dec/2006)
RF power (1)	10kW	Band width	$1.59 \times 10^5$	$1.66 \times 10^5$	$1.86 \times 10^5$
RF power (2)	20kW	Decay time	$1.66 \times 10^5$	$1.34 \times 10^5$	$2.07 \times 10^5$
Simulation	(HFSS v9.2)		$1.66 \times 10^5$		

	Achieved $V_{kick}$	Applied RF Power
HER	1.8MV	120 kW
LER	1.93MV	55kW

$Q_0$  values at design kick voltage were higher than  $1 \times 10^9$ .



# RF abort log (1)



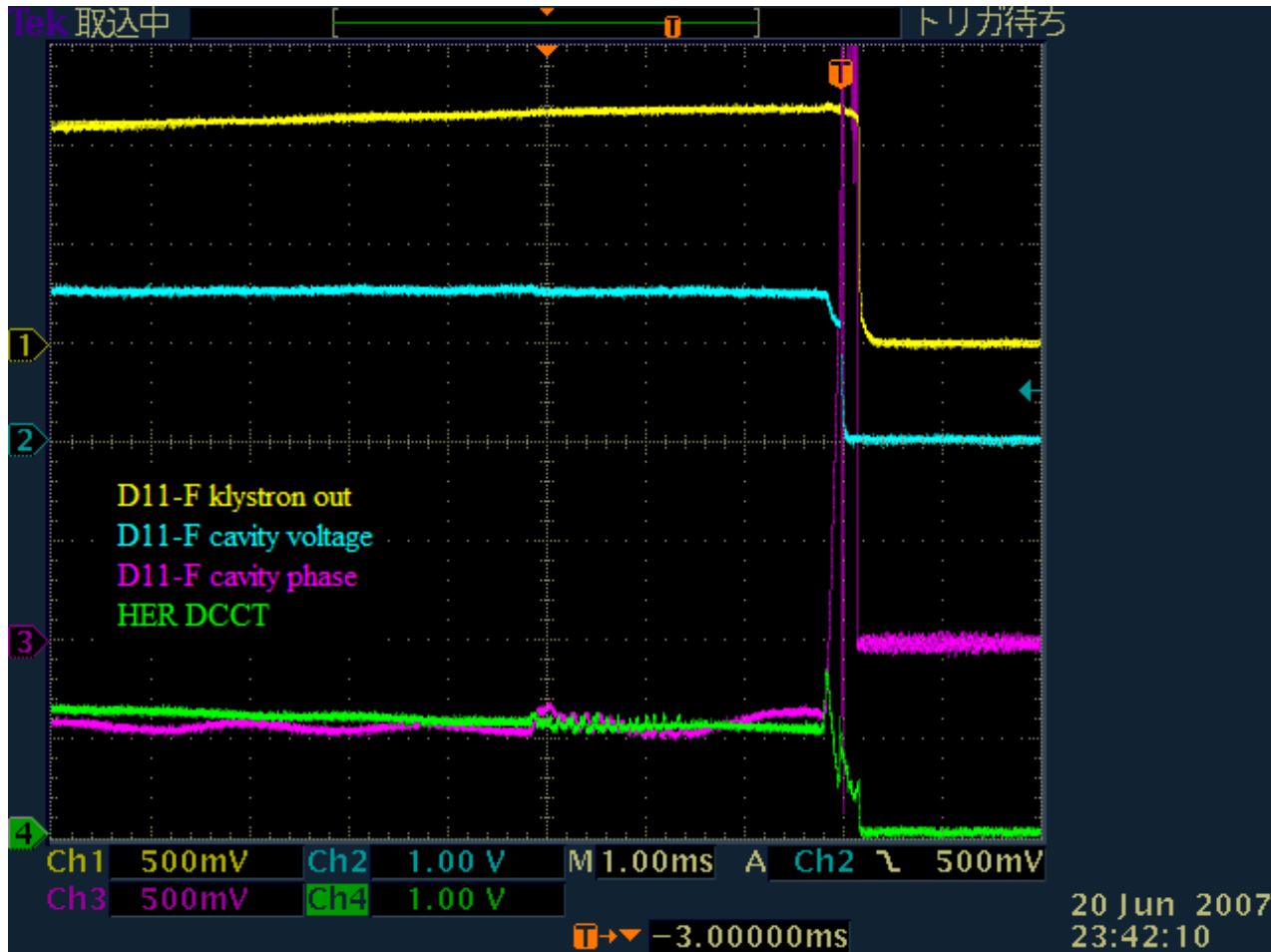
Break down detector was worked, because klystron output power was increased.

After RF turned off, beam phase looks unstable.

But beam was kept until beam abort.

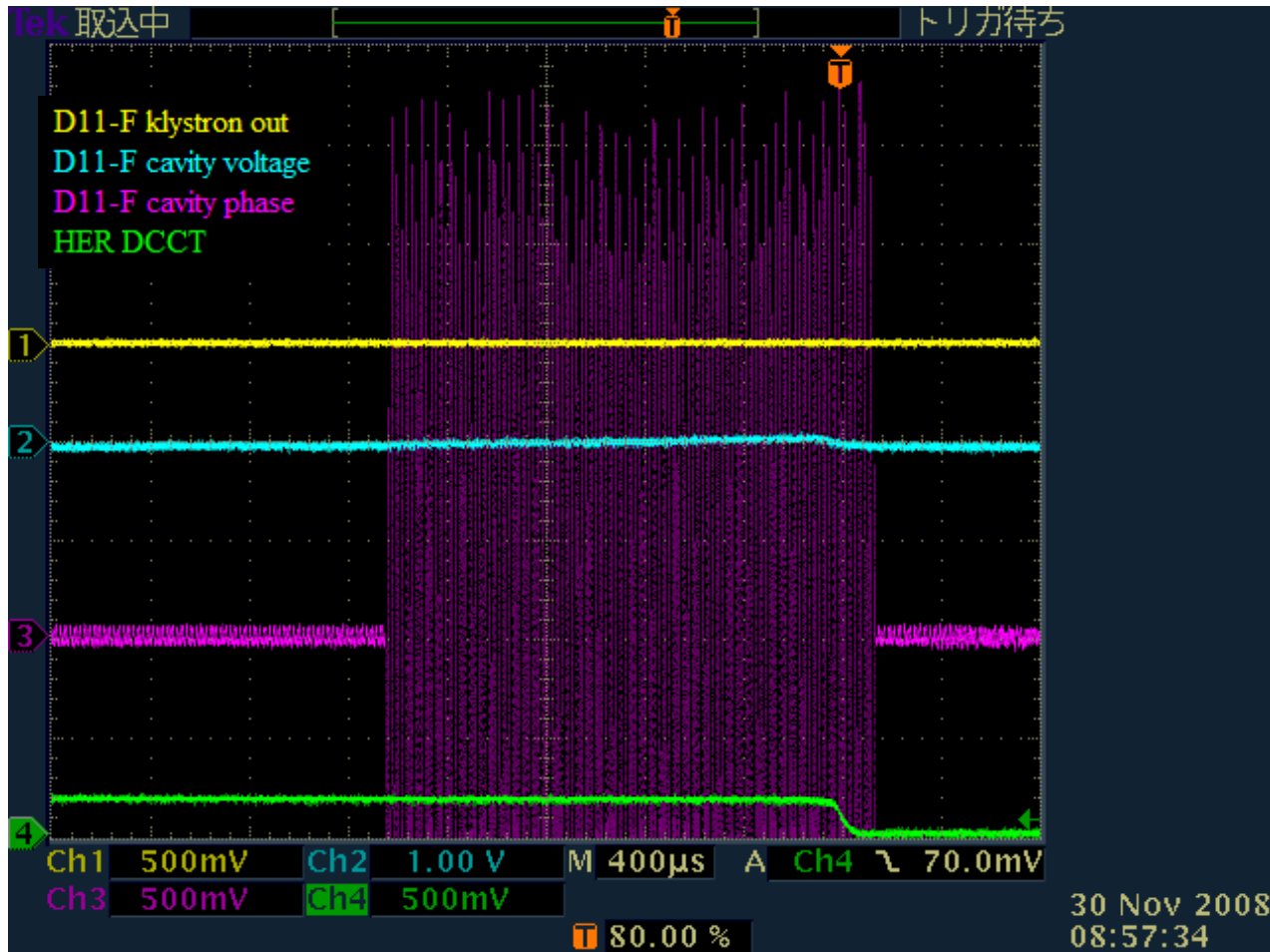
RF switch status is one of the I/L items. Because cavity vacuum was deteriorated, when beam was injected with no RF power and without detuning.

# RF abort log (2)



The cavity phase was unstable before RF turned off.  
Probably, discharge was occur near by input or pickup coupler.  
Finally, break down detector was worked.

# RF abort log (3)



Phase detector lose cavity phase. But RF was not turned off.  
Uncontrolled high power RF is harmful for the beam.  
In this case, I/L system of crab cavity could not detect this disturbance. (it is improved.)

# Summary

- EP stand, HPR, barrel polishing stand, clean rooms and RF test stands are available in KEK.
- Input coupler aging was done up to 250kW by traveling wave and 200kW by standing wave.
- 8~16 hour was spend to complete an input couple aging by traveling wave.
- About 4.5 hour was spend for standing wave aging.
- $Q_0$  and reachable  $V_{\text{kick}}$  were not deteriorated after assembling into the cryostat.