Low-Q IP-BPM & S-band BPM for ATF2

Hyoung Suk Kim

Kyungpook National University, KOREA

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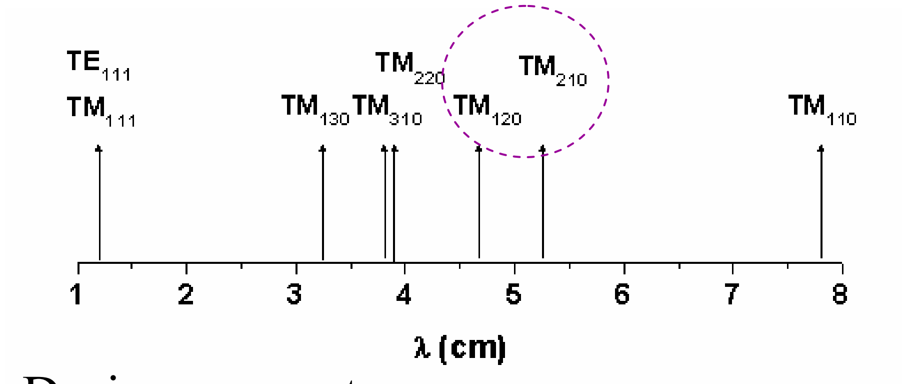
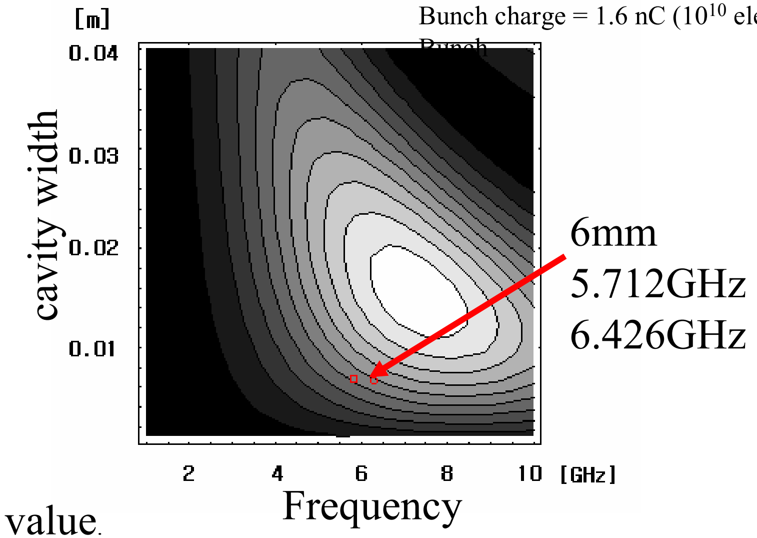
Overview of ATF IP-BPM

1. Mode spectrum of ATF IP-BPM & operating point

ATF beam parameters ;
Beam energy = 1.3GeV
Bunch length = 8mm
Bunch charge = 1.6 nC (10^{10} electrons)





2. Design parameter

TABLE Design value.

Mode	f (GHz)	Q_0	β	Q_{ext}
X	5.712	5300	1.4	3900
Y	6.426	4900	2.0	2440

3. Characteristics

⇒ Narrow gap to be insensitive to the beam angle.
⇒ Small aperture (beam tube) to keep the sensitivity.
⇒ Separation of x and y signal.
⇒ Signal decay times for x and y are ~ 110 and 60 ns, respectively.(3-bunch beam 150ns)

Overview of low-Q IP-BPM

1. Strategy for new design

⇒ Basic idea is same with ATF IP-BPM.
⇒ Larger coupling slot dimension was considered to decrease signal decay time for sensor cavity.
⇒ Stainless steel as cavity material is considered to decrease signal decay time for reference cavity.
⇒ Signal decay times for sensor (x and y) and reference signals are ~ 20 and ~ 30 ns, respectively.

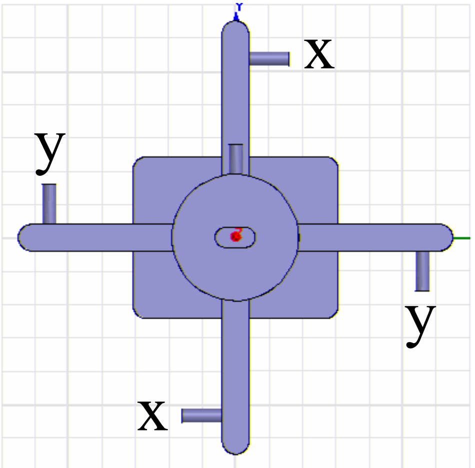
2. Design parameter

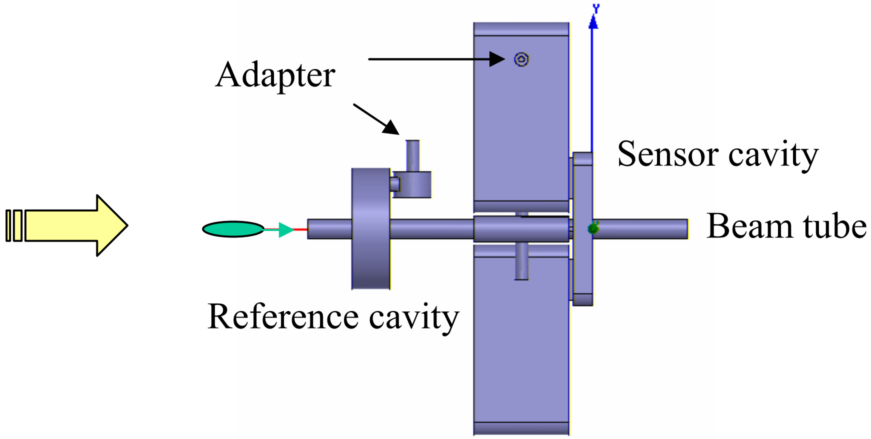
TABLE Design value.

Mode	**f (GHz)**	Q_0	β	Q_{ext}
X	5.712	5900	8	730
Y	6.426	6020	9	670
Ref	6.426	1170	0.0117	100250

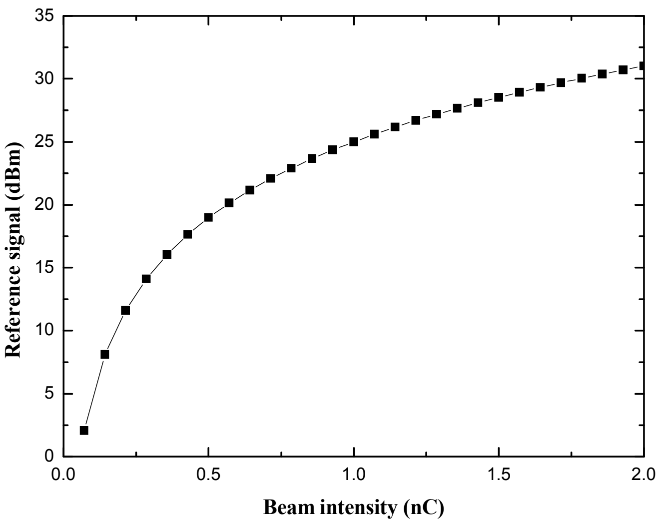
Design of Low-Q IP-BPM

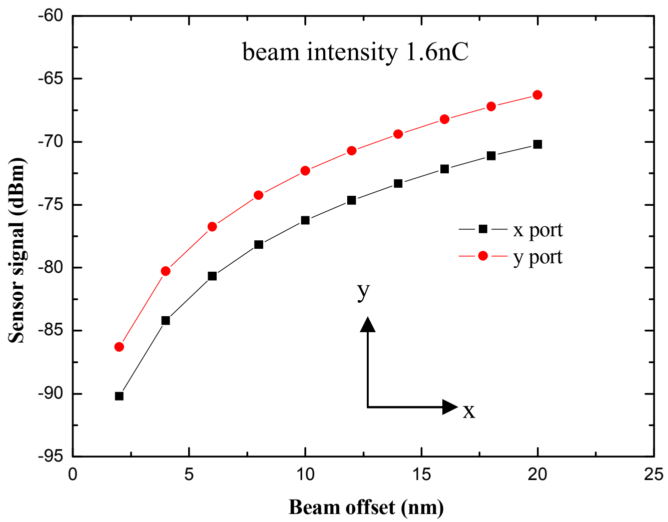
3. Designed model



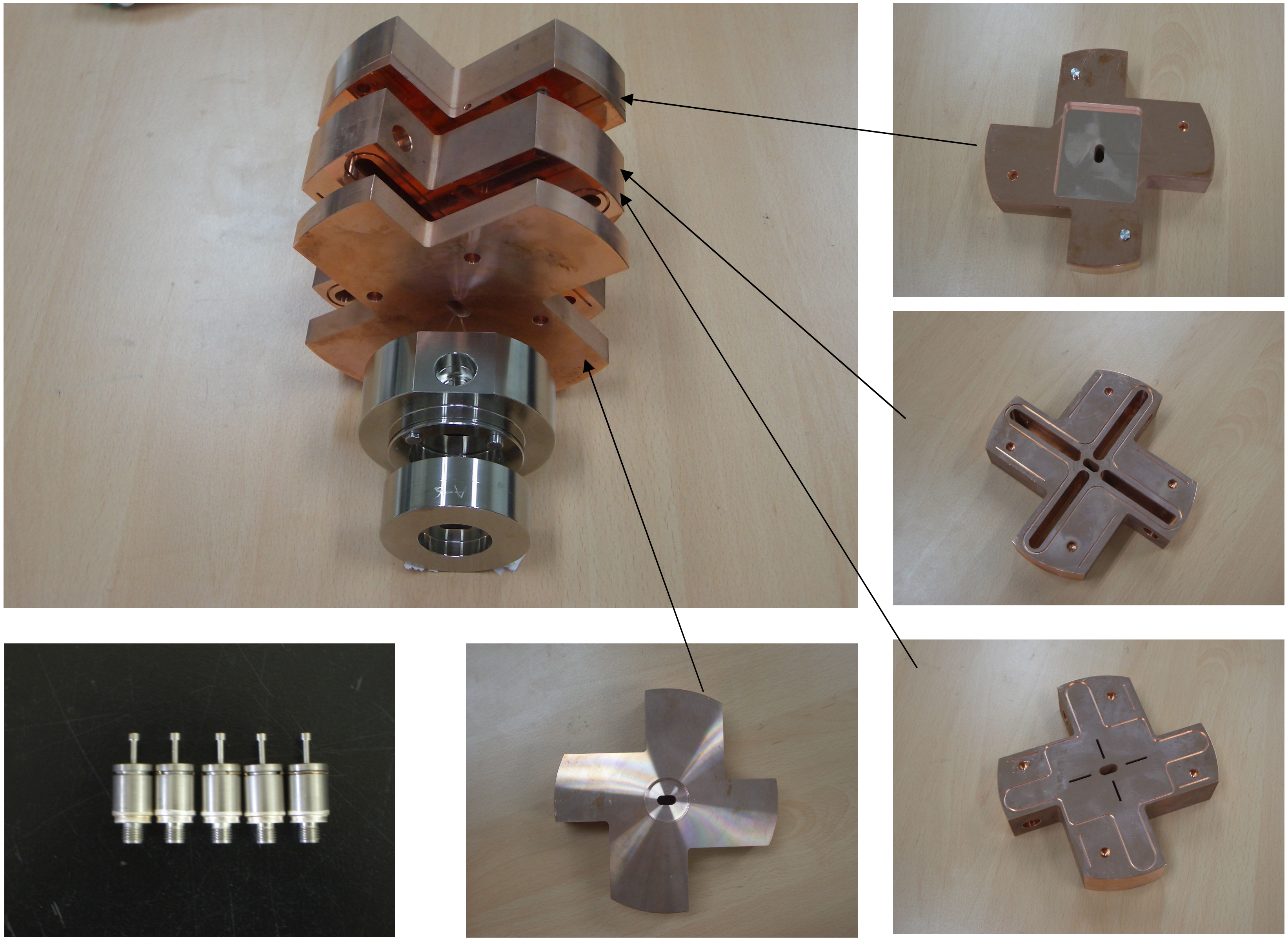


4. Calculated position signal



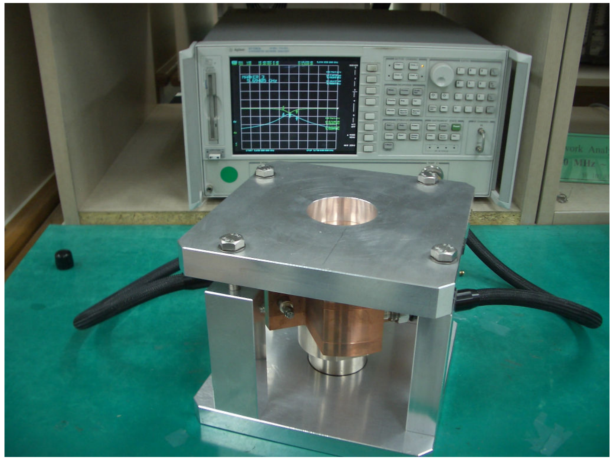
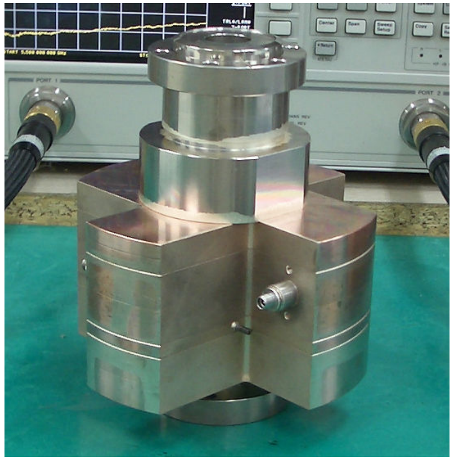
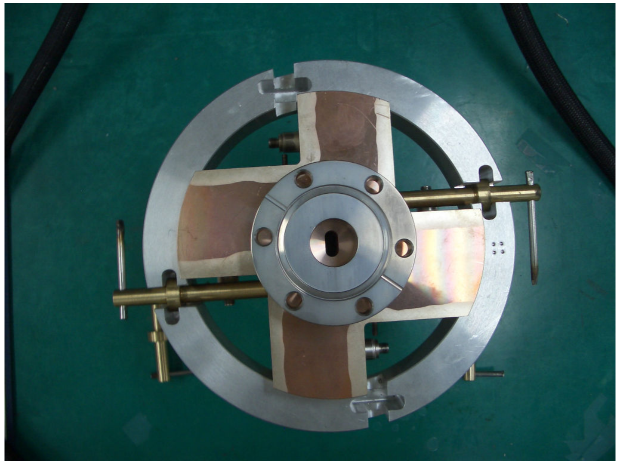


Fabrication of Low-Q IP-BPM



RF test of low-Q IP-BPM

1. Experimental setup for RF test

Before brazing After brazing

2. Reflection measurement for prototype Low-Q IP-BPM

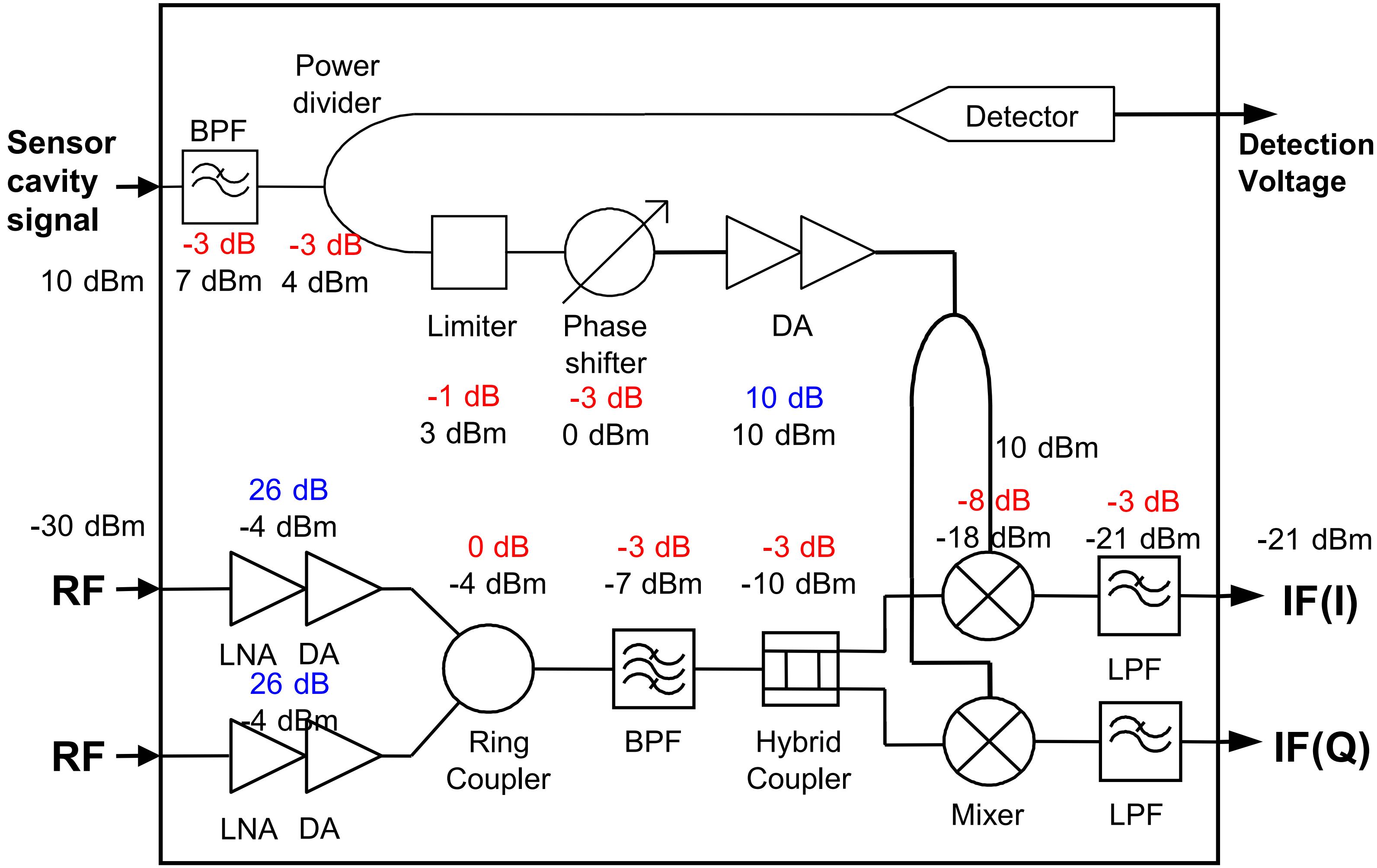
Before brazing

Port	Freq. (GHz)	Q_L	Q_{ext}
X1	5.697	695	939
X2	5.697	695	942
Y1	6.417	526	689
Y2	6.417	530	692

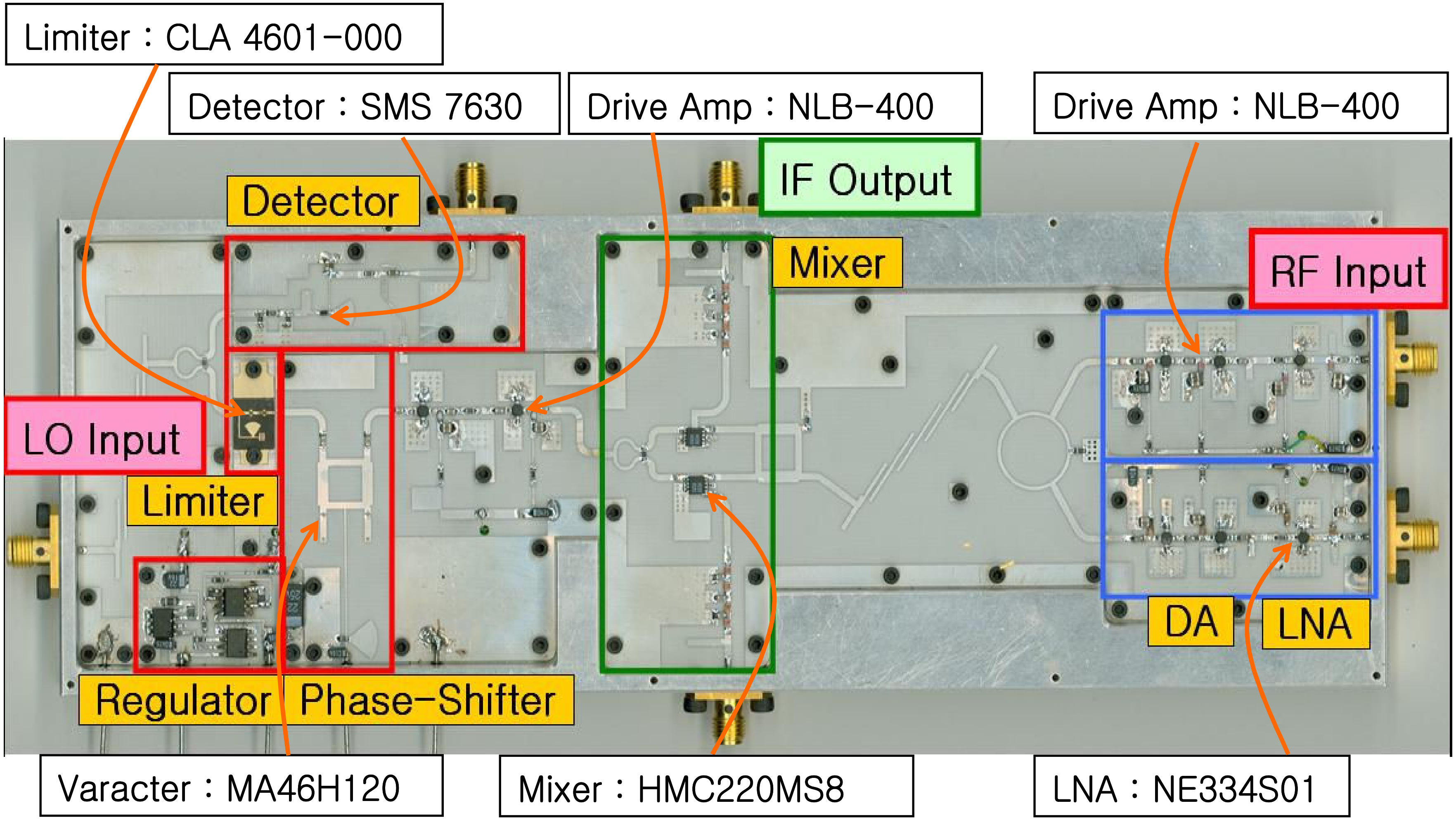
After brazing

Port	Freq. (GHz)	Q_L	Q_{ext}
X1	5.718	762	1120
X2	5.718	762	1025
Y1	6.442	499	590
Y2	6.443	503	723

Block Diagram for electronics



Layout for electronics

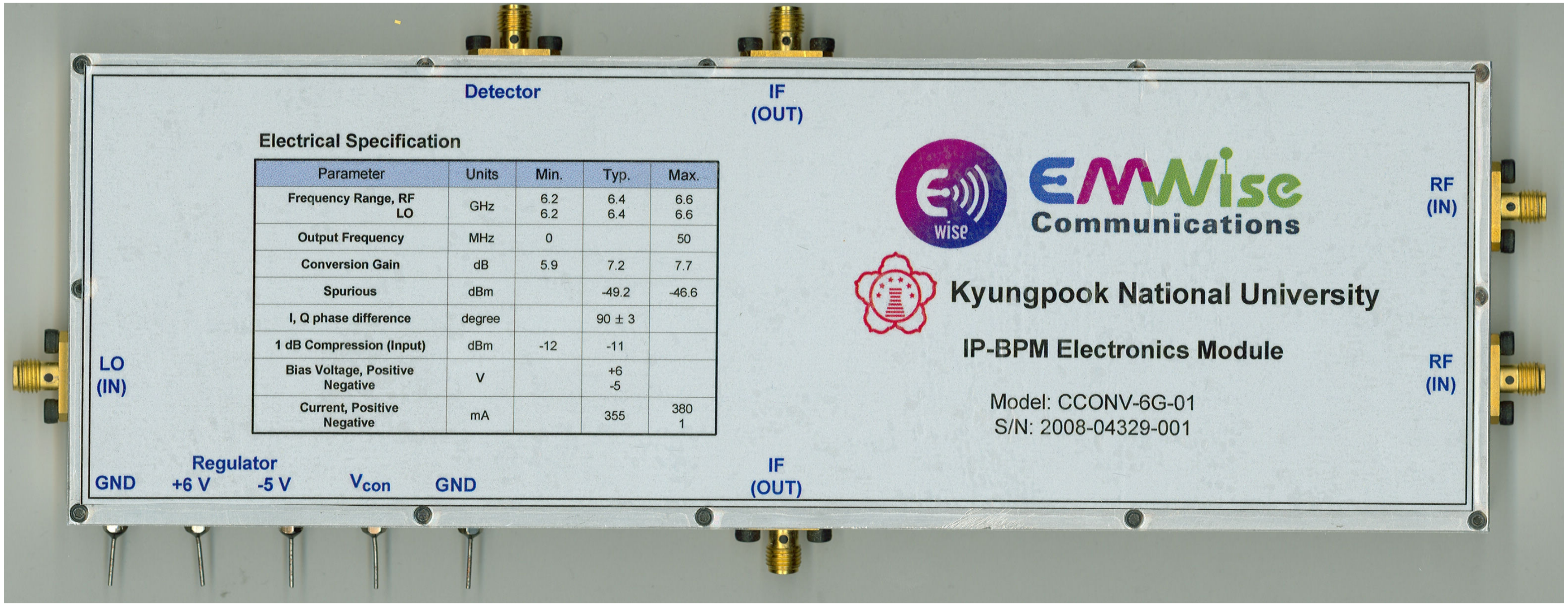


Electronics Module

Electrical Specifications

Parameters	Units	Min.	Typical	Max.
Frequency Range, RF LO	GHz	6.2 6.2	6.4 6.4	6.6 6.6
Output Frequency	MHz	0		50
Conversion Gain	dB	5.9	7.2	7.7
Spurious	dBm		-49.2	-46.6
I, Q phase difference	degree		90 ± 3	
1 dB Compression (Input)	dBm	-12	-11	
Bias Voltage, Positive Negative	V		+6 -5	
Current, Positive Negative	mA		355	380 1

Electronics Module



Requirements for S-band BPM in ATF2

1. Purpose of S-band BPM

=> To control beam orbit at final focus beam line in ATF2.

=> To do BBA(beam-based alignment) with 1 μm at final focus beam line in ATF2.

(BPM resolution of a few hundreds nm should be satisfied.)

2. Dynamic range

=> A few mm

3. Diameter of beam tube

=> 40 mm

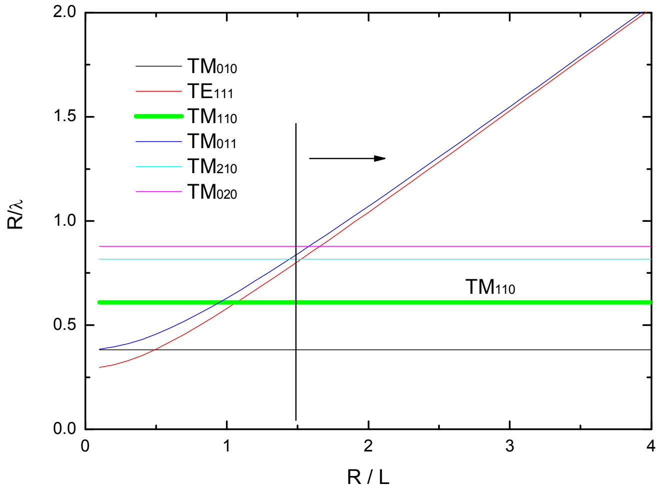
4. Signal decay time

=> ~ 35 ns

=> For 2878 MHz, Q_L is ~ 650

Investigation of initial parameters

1. Classification of eigen-mode in cylindrical cavity



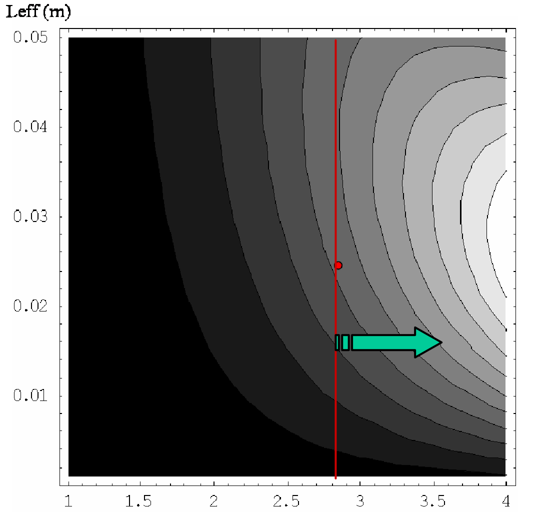
$$\omega_{mnp} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \sqrt{\left(\frac{x_{mn}}{R}\right)^2 + \left(\frac{p\pi}{l}\right)^2}$$

$$\lambda_{mnp} = \frac{2\pi}{\sqrt{\left(\frac{x_{mn}}{R}\right)^2 + \left(\frac{p\pi}{l}\right)^2}}$$

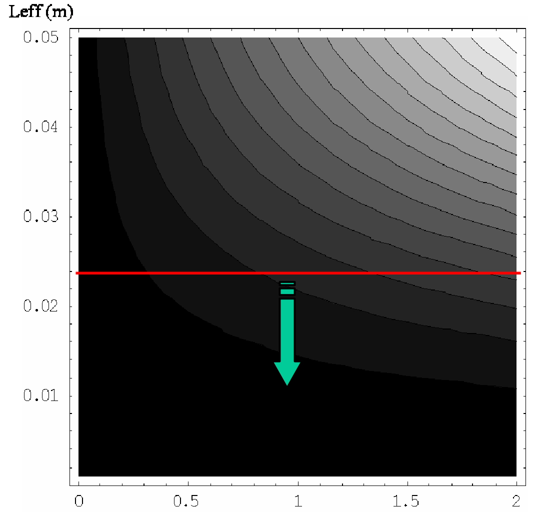
$$\Rightarrow R = 0.60988 \times \lambda = 0.60988 \times 10.5\text{cm}$$
$$= 6.4\text{cm for S-band TM}_{110}$$
$$\Rightarrow L < R/1.5 \approx 4.3\text{cm may be desired}$$

R/L ~ 6cm/1.2cm

2. Cavity length effect



dipole mode position signal



dipole mode angle signal

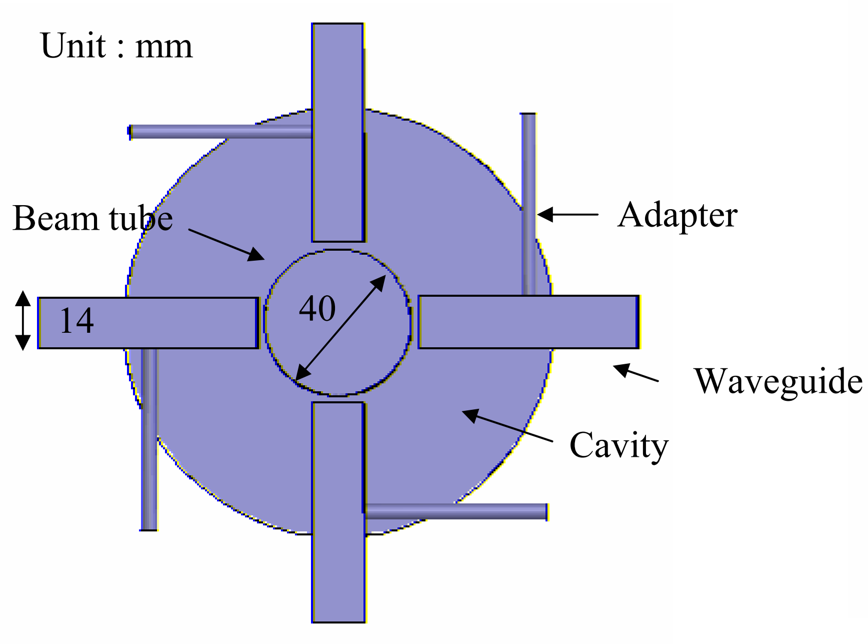
Design of S-band BPM

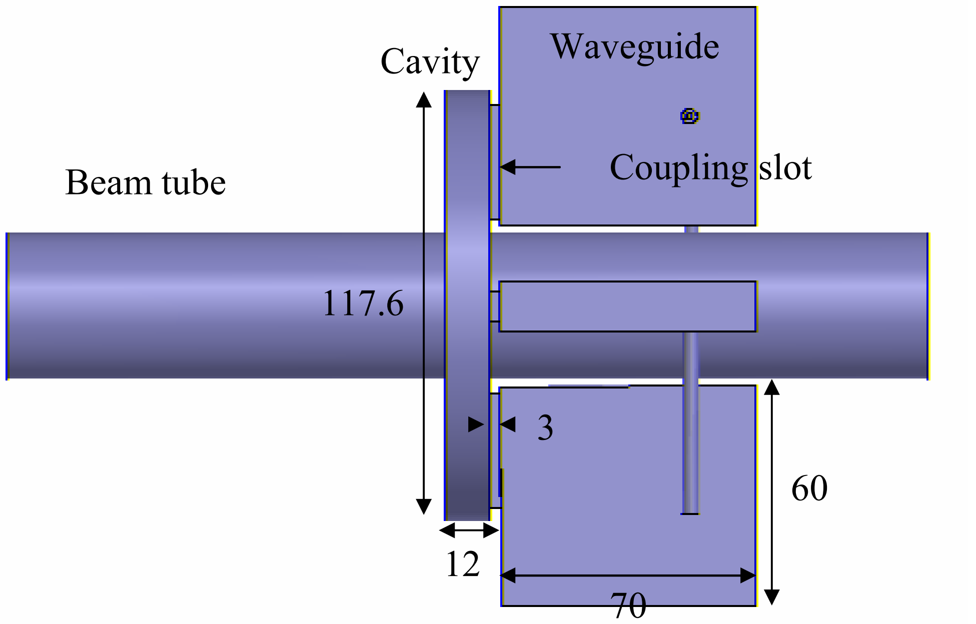
1. Design parameter

TABLE Design value.

Mode	f (GHz)	Q_0	β	Q_{ext}
Dipole	2.878	5075	6.8	750

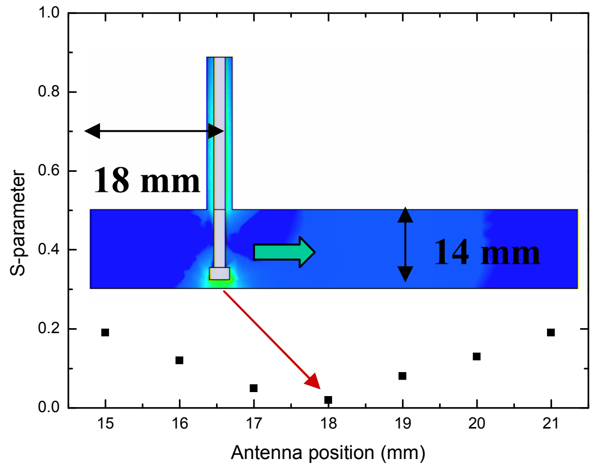
2. Dimension of low-Q S-band BPM

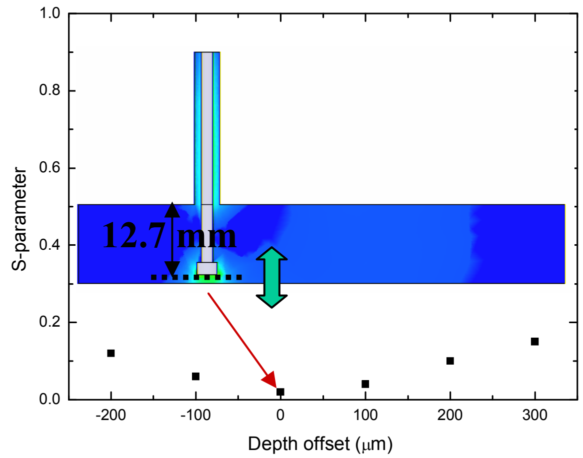




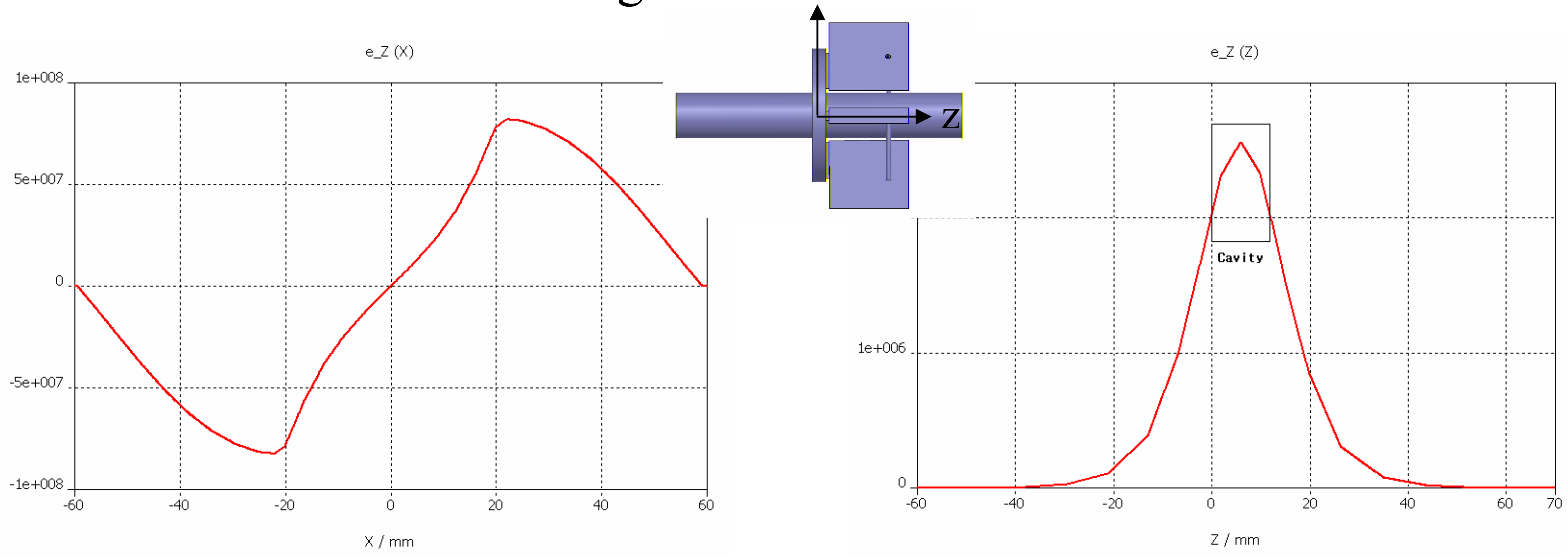
Design of S-band BPM

3. Misalignment sensitivity in wave guide part



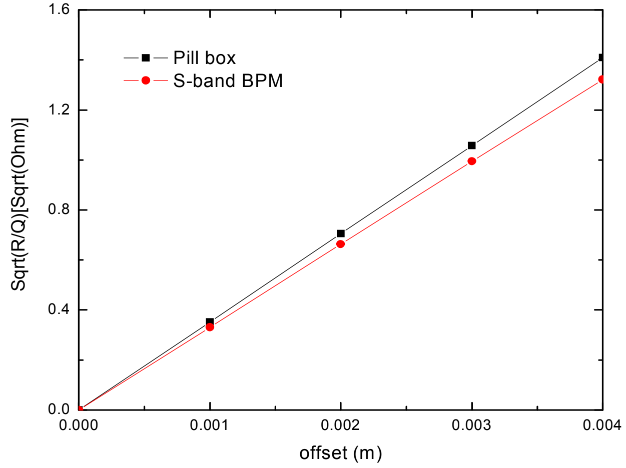


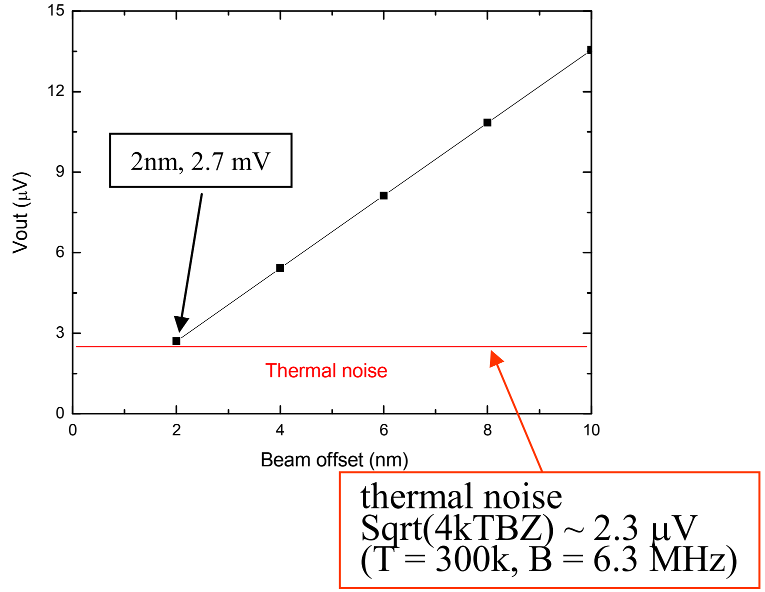
4. Electric field distribution along axis



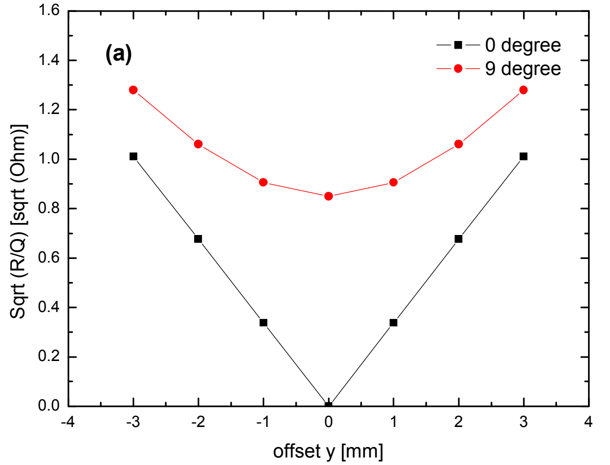
Design of S-band BPM

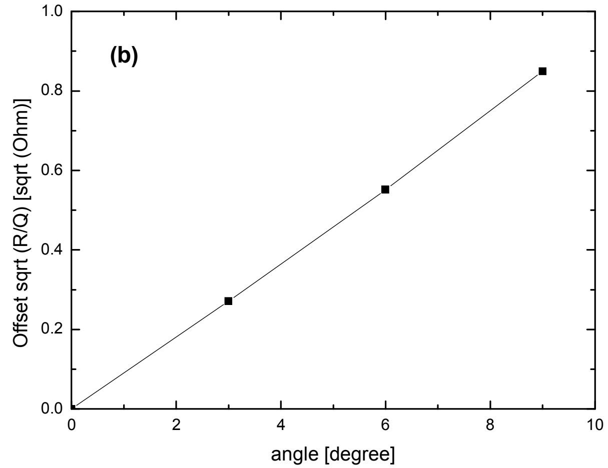
5. Position signal





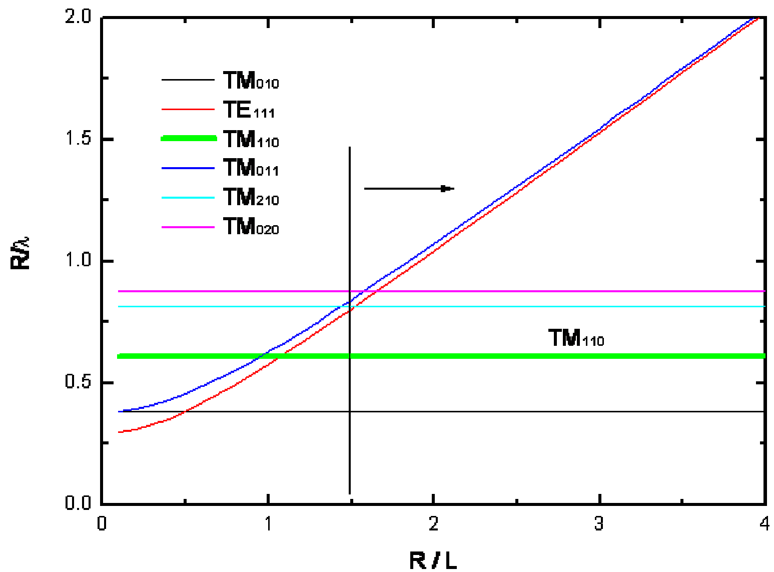
6. Angle signal

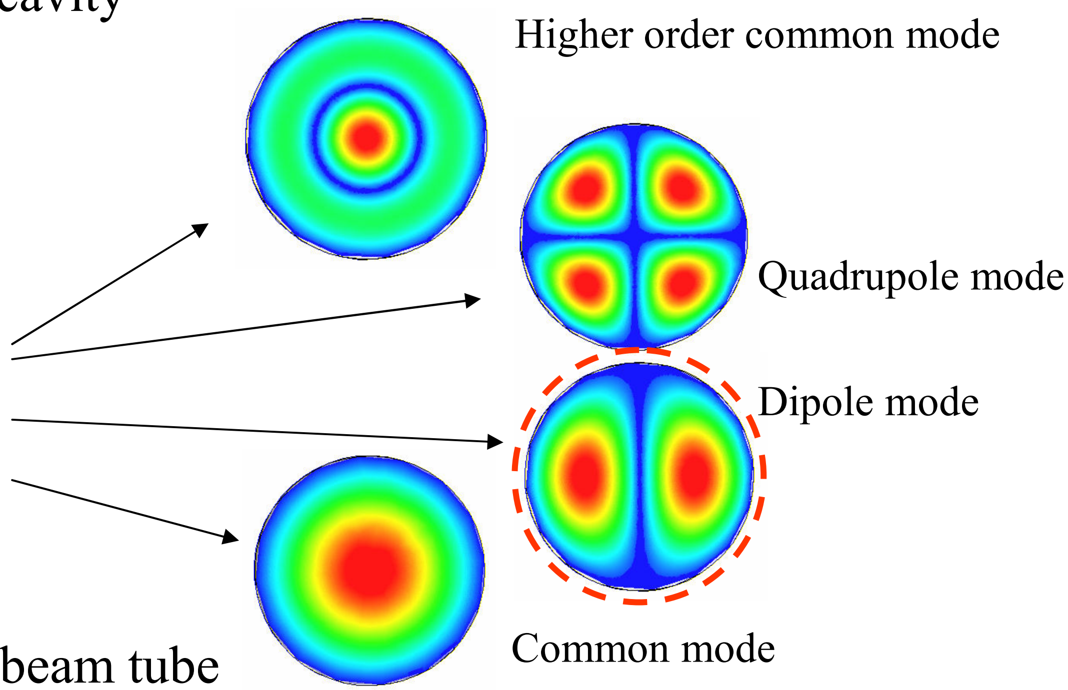




Investigation of common-mode contamination

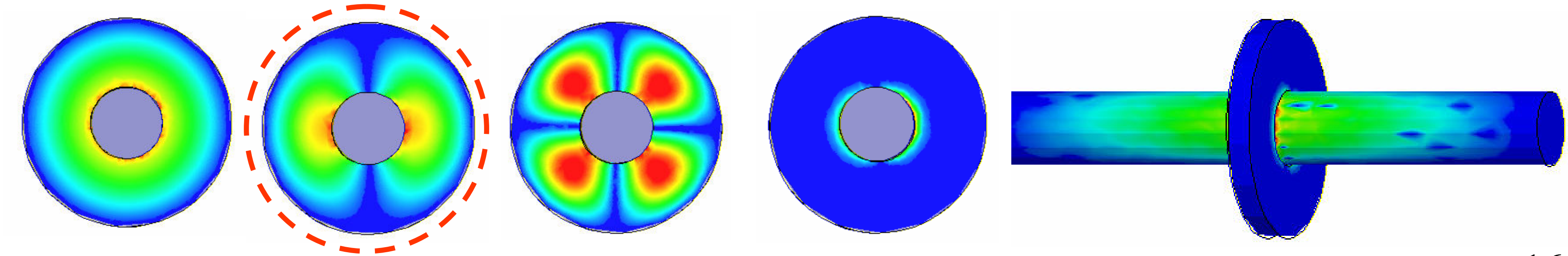
1. Mode classification for pill box cavity



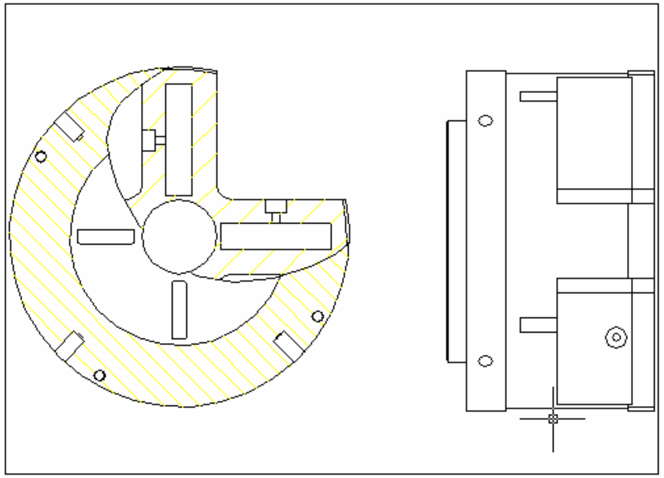


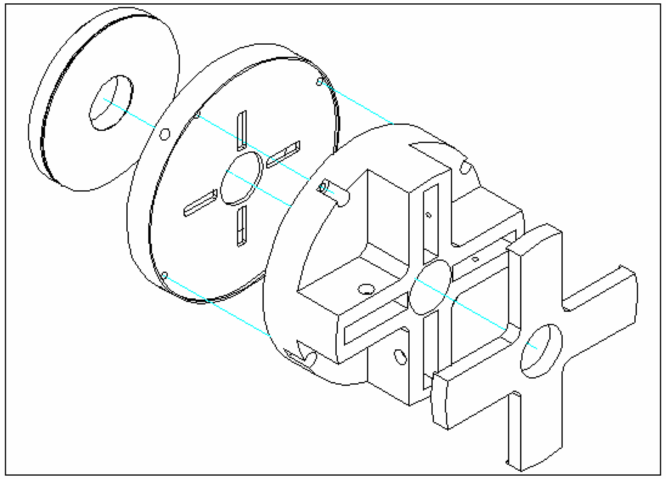
2. Mode for cavity combined with beam tube

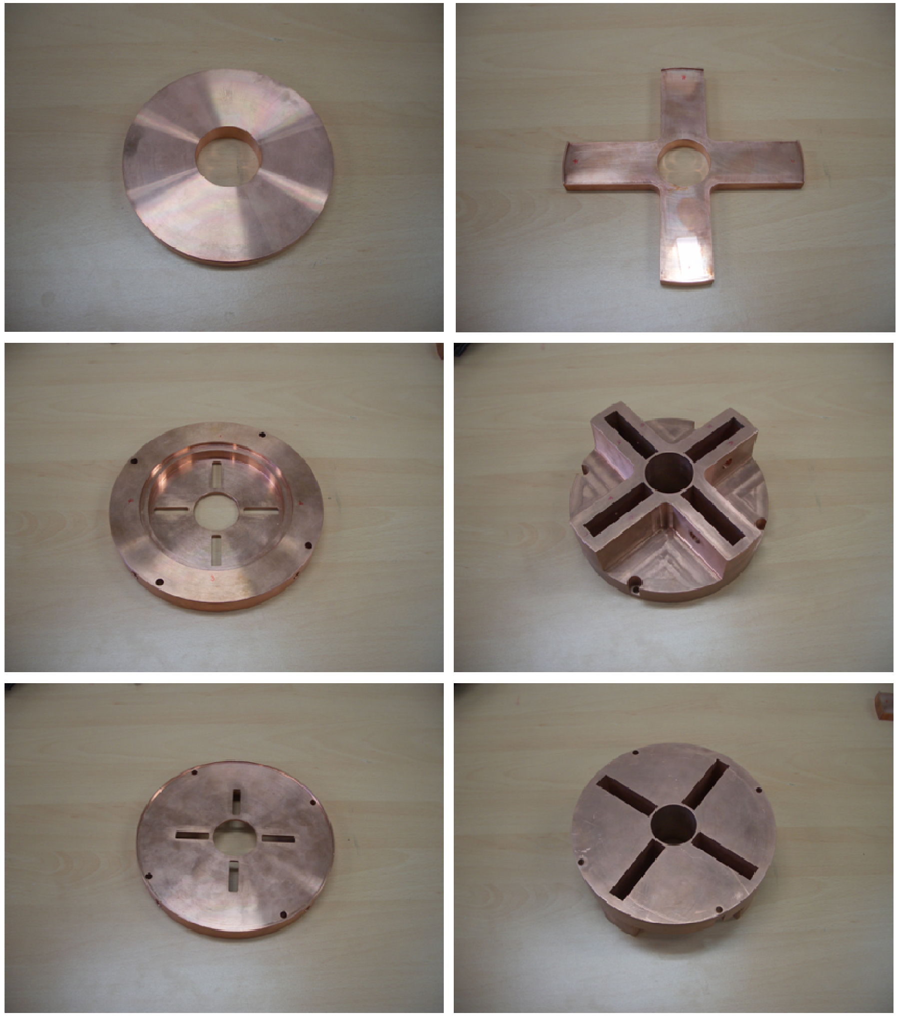
Common Dipole Quadrupole There is no higher order common mode with beam tube



Fabrication of S-band BPM (cold test)



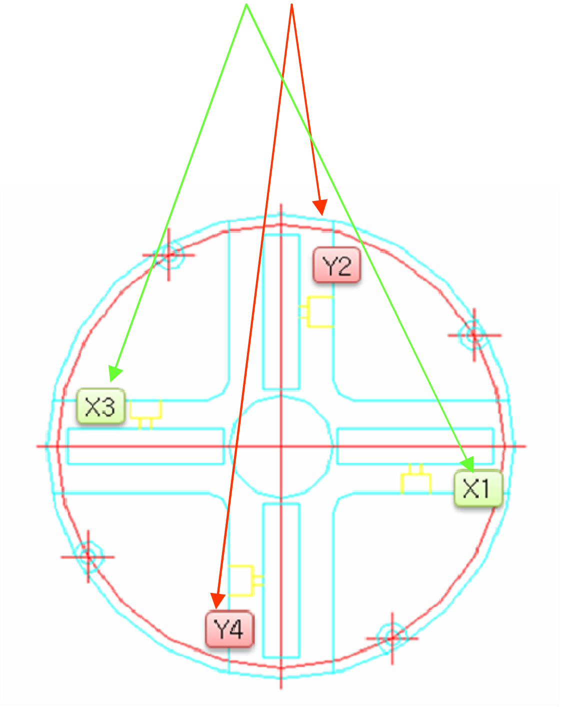


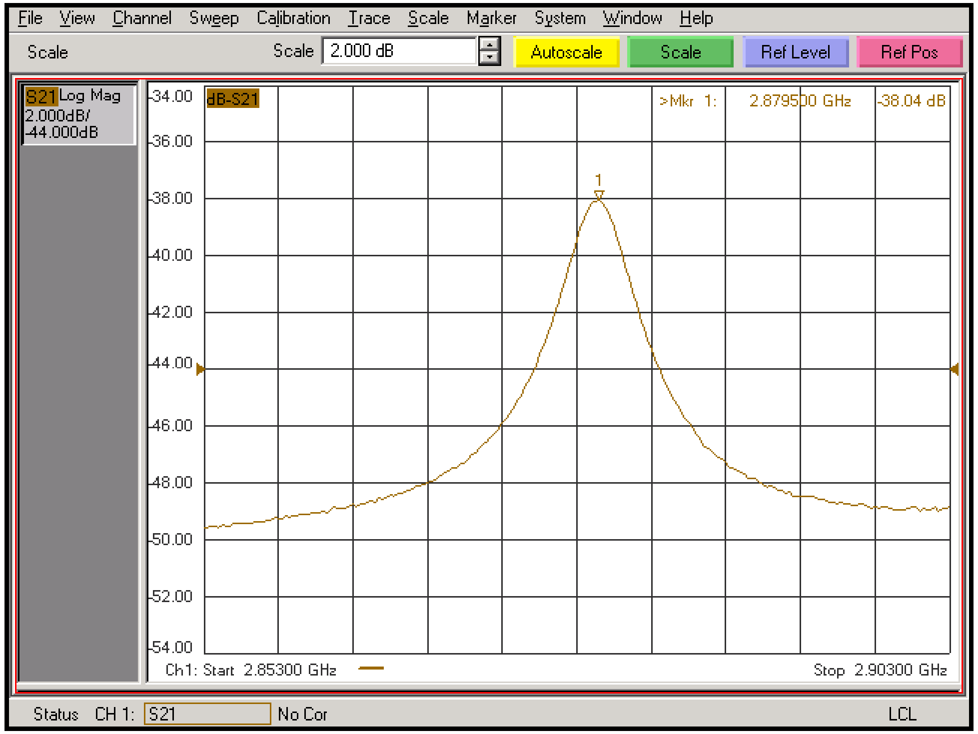


Cold test of S-band BPM

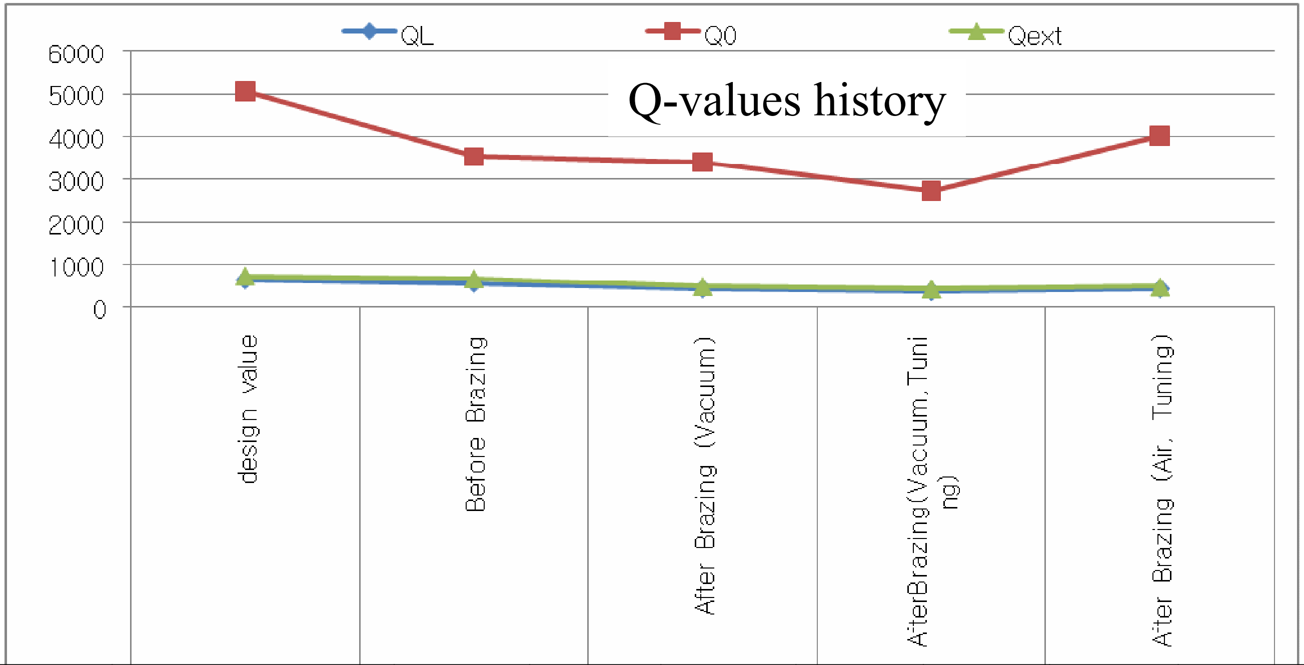
Isolation -38dB @ 2.8795GHz in vacuum

x-y isolation meas.





Cold test of S-band BPM



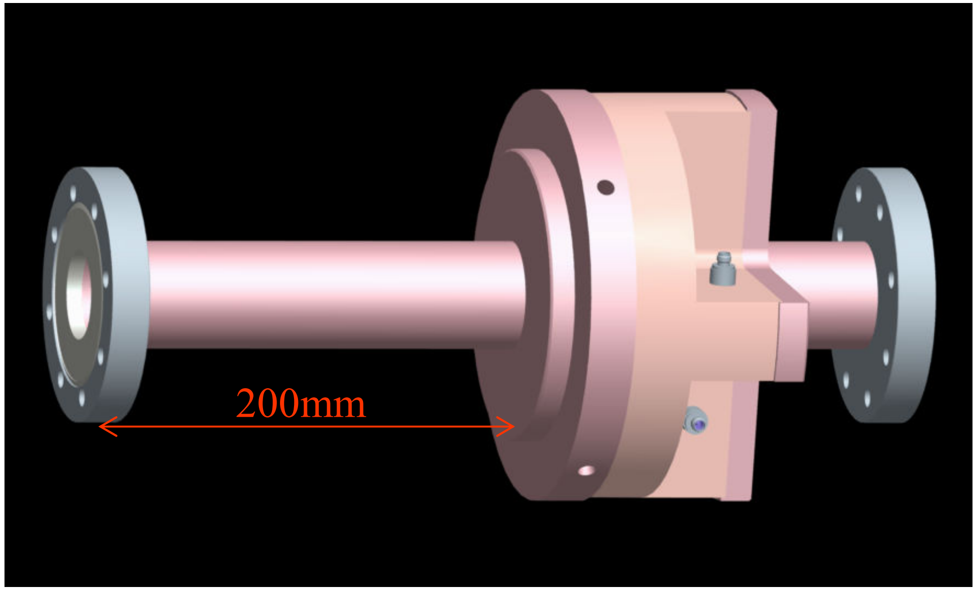
Port	Measurement status	f(GHz)	Δf (MHz)	S parameter (mag)	β	Q_L	Q_0	Q_{ext}
Refl.X1	design value	2.87800			6.80	650	5075	750
	Before Brazing	2.87800		0.16	5.16	576	3547	687
	After Brazing (Vacuum)	2.87950	6.50	0.13	6.70	443	3408	509
	After Brazing(Vacuum,Tuning)	2.87950	7.50	0.14	6.10	384	2726	447
	After Brazing (Air, Tuning)	2.87875	6.50	0.11	8.10	443	4030	498

Signal decay time : 36ns(HFSS design value) / 21ns (cold test sample)

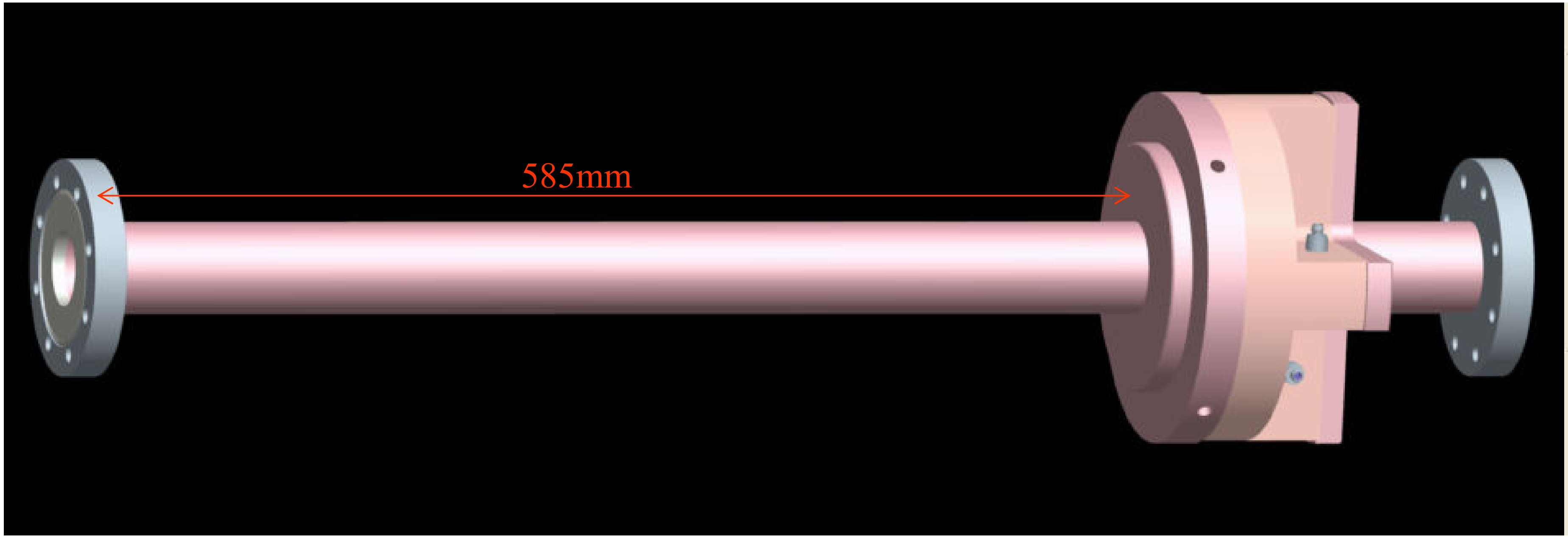
SBPM (cold test) sample sent to LAPP

Fabrication of S-band BPM (hot test)

SBPM for Sextupole Magnets



SBPM for Quadrupole Magnets



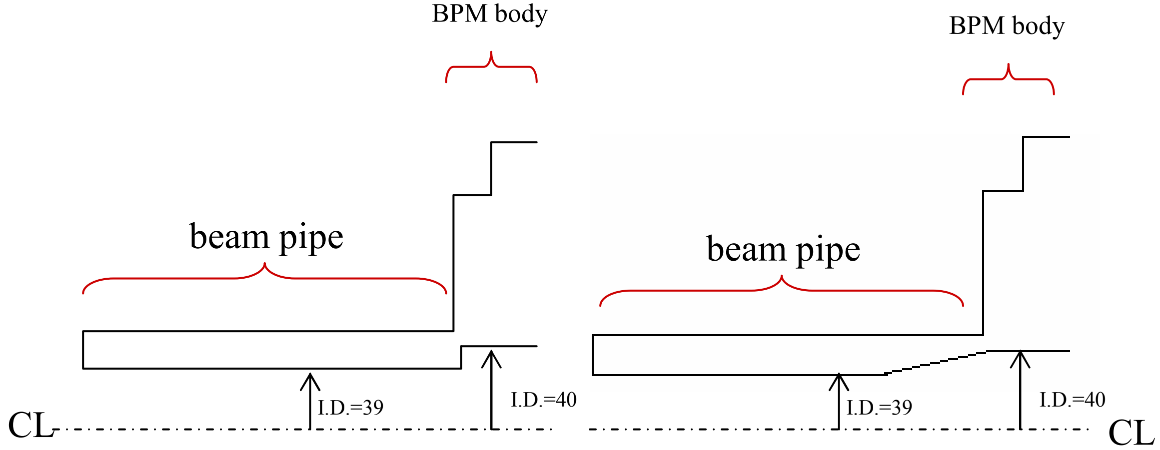
Fabrication of S-band BPM

Size of the Cu beam pipes to be attached to the SBPM

Material (C1020 also is OK.)	Size (mm)	Quantity (ea)	Usage
OFC_C10100	I.D=Φ40, O.D<Φ48, length: 200mm	3	For SM
OFC_C10100	I.D=Φ40, O.D<Φ48, length: 65mm	3	For SM
OFC_C10100	I.D=Φ40, O.D<Φ48, length: 595mm	2	For QM
OFC_C10100	I.D=Φ40, O.D<Φ48, length: 90mm	2	For QM

Future plan

- Experiments with the IPBPM-electronics will be discussed with KEK.
- We are investigating the inner diameter of the beam pipe for the SBPM.
  - HFSS simulation for the inner diameter change effect on the SBPM (this week).
  - in the case of not negligible effect ; order small quantity from US company (www.h-tube.com, w/ Cherrill's help)
  - in the case of no significant effect ; prepared by KEK in 2-3 weeks but O.D.=47mm / I.D.=39mm (C1020 class is OK, w/ Terunuma's help)



- After decision on the beam pipe issue, fabrication of one S-band BPM as the final type will be finalized in KNU soon.
- Three S-band BPMs as the final type will be fabricated in KNU in series.