Beam Position Monitor system for KEKB

by Masaki Tejima, KEK

1 BPM Head

(1) Features

(2) Fabrication

(3) Mapping for calibration

(4) Installation

(5) Alignment

2 Signal processing system

(1) Signal process

(2) Calibration for transmission line

3 Control system

(1) Process of local IOC

(2) Process of central IOC

4 Performance

(1) Present performance

(2) Trouble

1 BPM Head

(1) Features

Electrostatic pickup electrode (Figure 1)

- The diameter of button is small; ø12mm to reduce the pickup beam power.
- N-type connector was adopted to transfer the beam power safely through a tough feed-through with sufficient mechanical strength and power capacity,
- The coaxial line has special structure that is, non-axially-symetric to suppress the higher-order mode resonance in the electrode

BPM Block(Figure 2)

- Two stainless steel flames were mounted on copper block to minimize mechanical deformation of the head.
- The assembly of a unit employed for brazing processes to keep the mechanical accuracy.

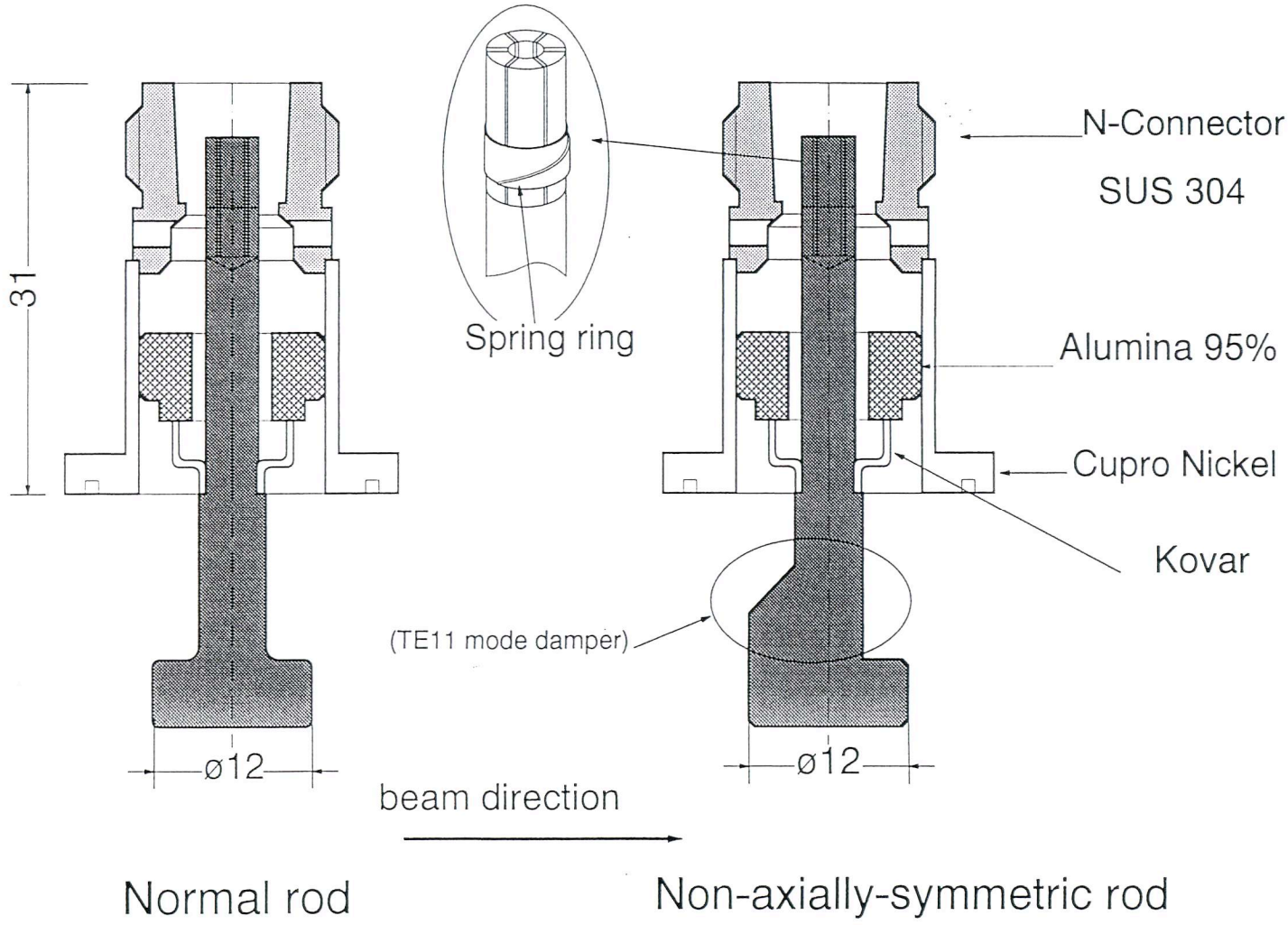
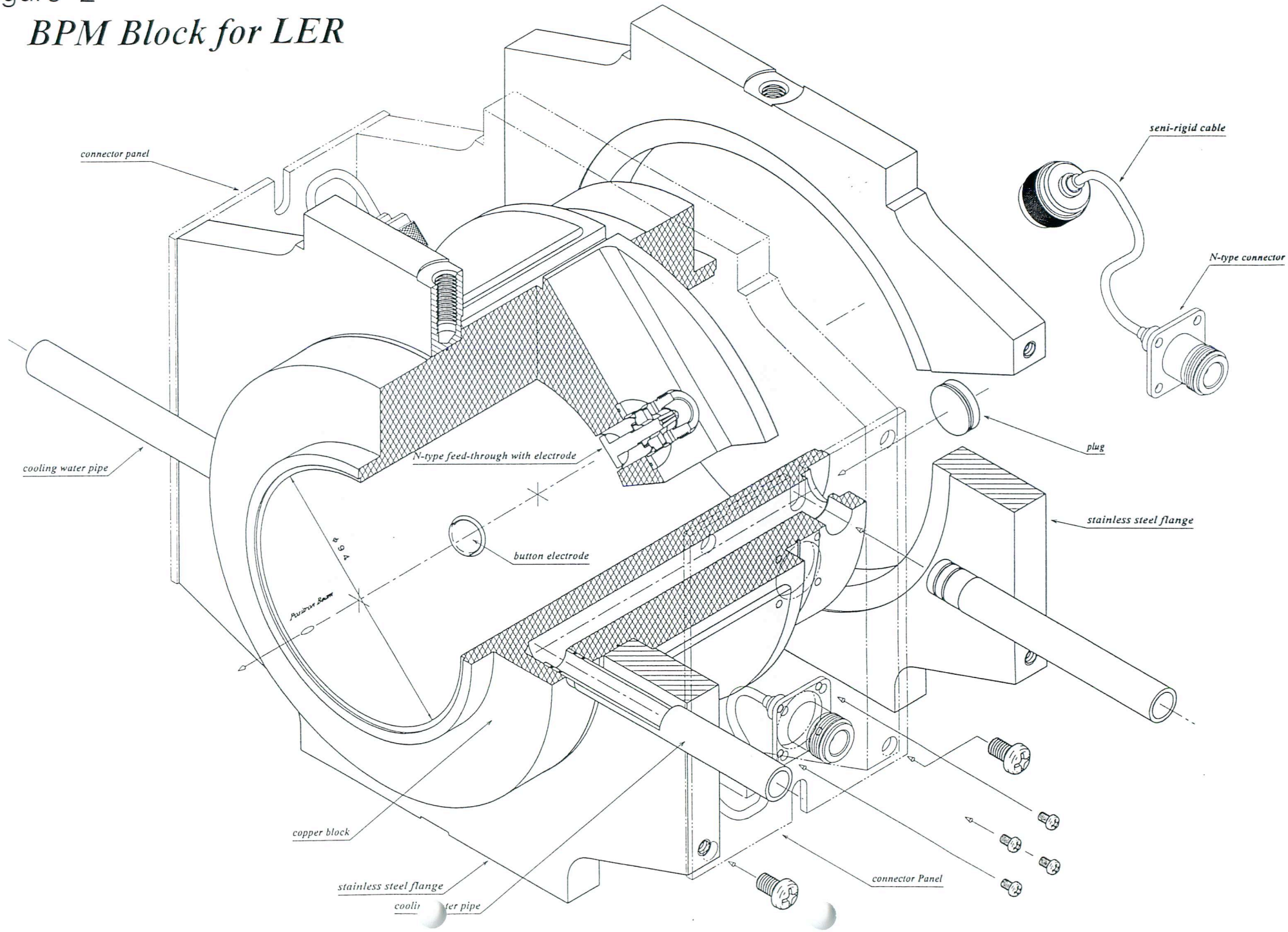


Figure 1 Button Electrode for BPM

Figure 2

BPM Block for LER



by H,Ishii

(2) Fabrication

BPM heads except IR region. (Figure 3)

5 kinds of BPMs: Copper blocks

3 kinds of BPMs: Alluminum blocks

BPM heads for IR region. (Figure 4)

8 kinds of BPMs: Aluminum blocks

2 kinds of BPMs: Stainless steel chambers

(3) Mapping for calibration

All BPMs except QCS's BPM were calibrated by mapping stand before welding process of vacuum chamber and BPM head.

(Table: Summary of Mapping for calibration)

(4) Installation

After the welding process, BPM vacuum chamber was supported firmly and precisely at the end of a Q-magnet.

(Figure 5: Support of BPM head on Q-Magnet)

(5) Alignment

Setting error against the reference of Q-magnet were measured by special device with laser displacement sensors.

(Figure 6: Distribution of allignment data)

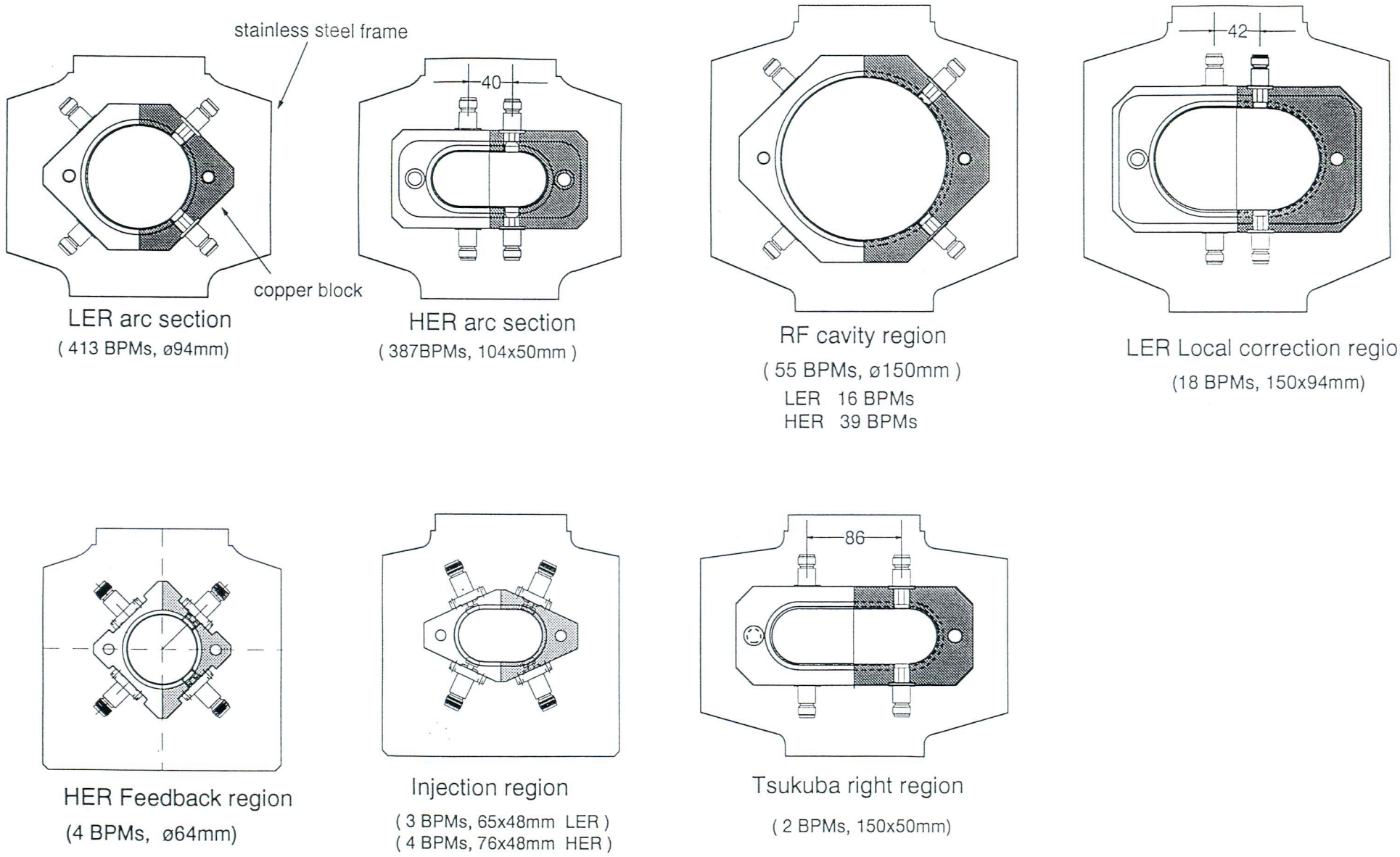
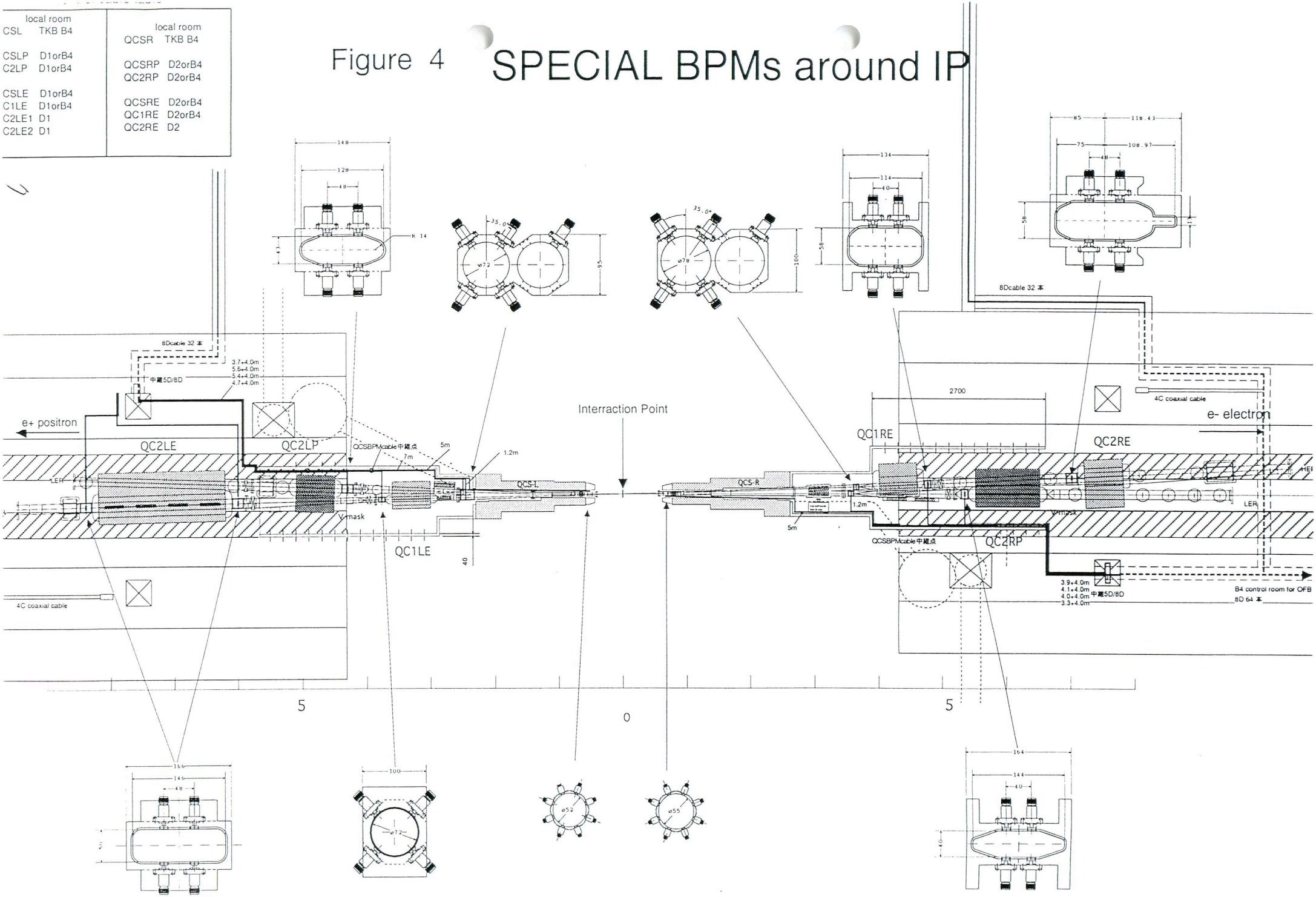


Figure 3 BPM Heads for KEKB

Figure 4 SPECIAL BPMs around IP

local room	
CSL	TKB B4
CSLP	D1orB4
C2LP	D1orB4
CSLE	D1orB4
C1LE	D1orB4
C2LE1	D1
C2LE2	D1

local room	
QCSR	TKB B4
QCSRP	D2orB4
QC2RP	D2orB4
QCSRE	D2orB4
QC1RE	D2orB4
QC2RE	D2



98/06/16 by Teiima

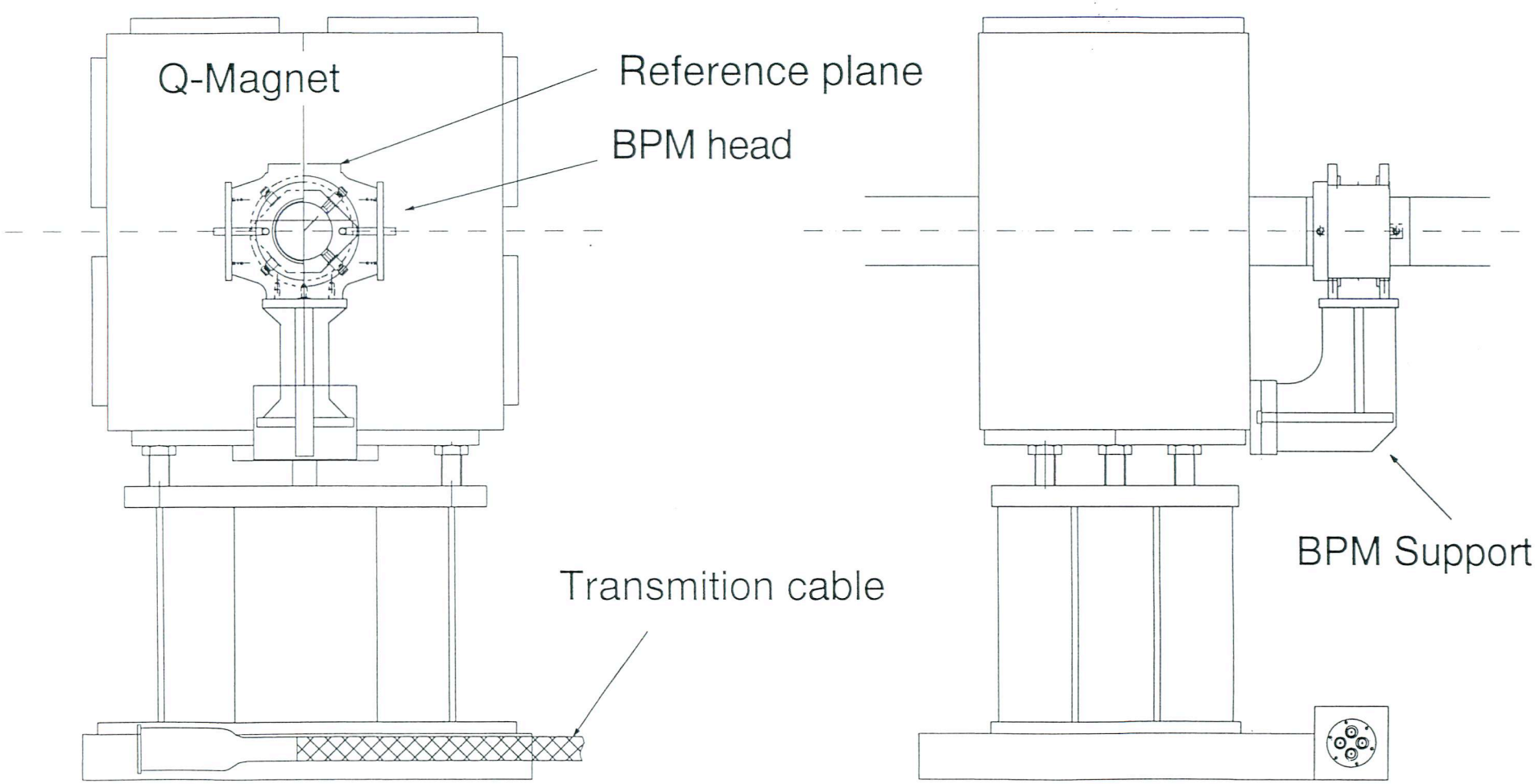
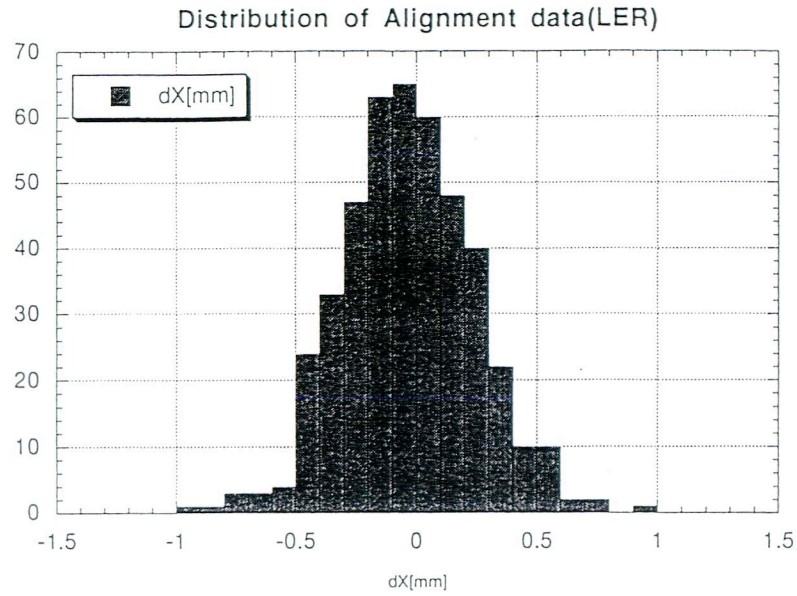
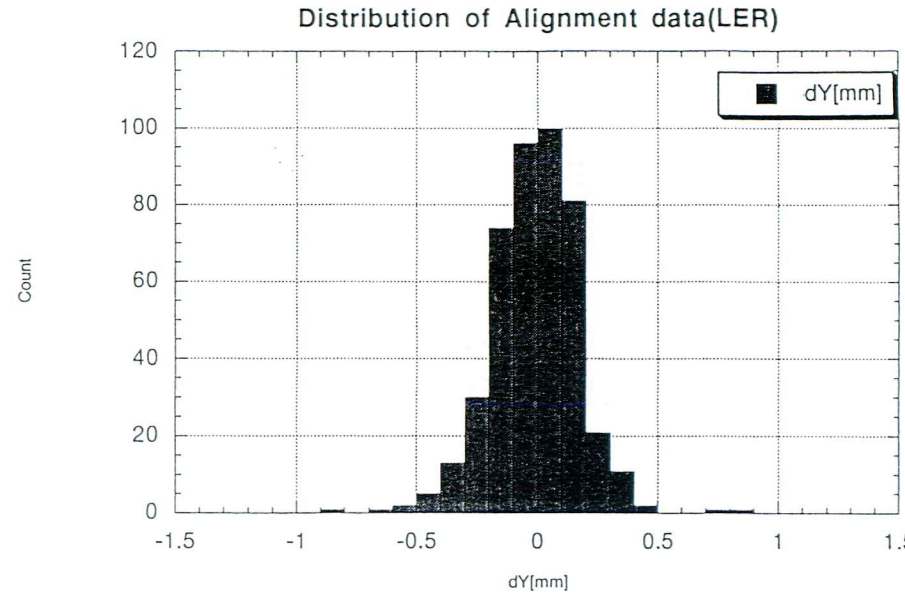


Figure 5 Support of BPM head on Q-Magnet

Table Summary of Mapping data

					Average value[mm]			
	Shape	Dimension[mm]	Number	Location	X_offset	Y_offset	Kx	Ky
1	Racetrack	50•104	400	HER_ arc section	0.101	-0.149	18.75	27.63
2	Round	ø64	4	HER_Feedback section	0.310	0.276	22.49	22.57
3	Racetrack	50•150	4	HER_Tsukuba right	0.142	-1.292	15.97	111.49
4	Racetrack	48•65	4	HER_Injection	0.150	0.184	18.32	20.98
5	Round	ø150	65	HER/LER_RF section	0.221	-0.437	53.79	53.86
6	Round	ø94	430	LER_arc section	-0.028	0.018	33.20	33.23
7	Racetrack	94•150	26	LER_local correction	-0.102	-0.304	50.63	34.65
8	Racetrack	48•76	3	LER_Injection	-0.143	0.564	16.57	29.50
9	Round	ø72	1	HER_IR(QC1LE)	0.573	0.328	25.28	25.34
10	Rectangle	58•114	1	HER_IR(QC1RE)	0.211	0.114	23.36	28.60
11	Rectangle	50•146	1	HER_IR(QC2LE)	0.179	-0.032	17.42	35.86
12	Rectangle	50•146	1	HER_IR(QC2LE)	0.151	-0.264	17.47	35.84
13	Special	58•(150+22.88)	1	HER_IR(QC2RE)	0.098	0.055	21.24	34.98
14	Racetrack	43•128	1	LER_IR(QC2LP)	0.003	2.397	14.36	37.72
15	Octagon	52•144	1	LER_IR(QC2RP)	-0.127	0.505	13.56	28.24


Distribution of Alignment data(LER)
dX[mm]
Count
dX[mm]
70
60
50
40
30
20
10
0
-1.5
-1
-0.5
0
0.5
1
1.5


Distribution of Alignment data(LER)
dY[mm]
Count
dY[mm]
120
100
80
60
40
20
0
-1.5
-1
-0.5
0
0.5
1
1.5

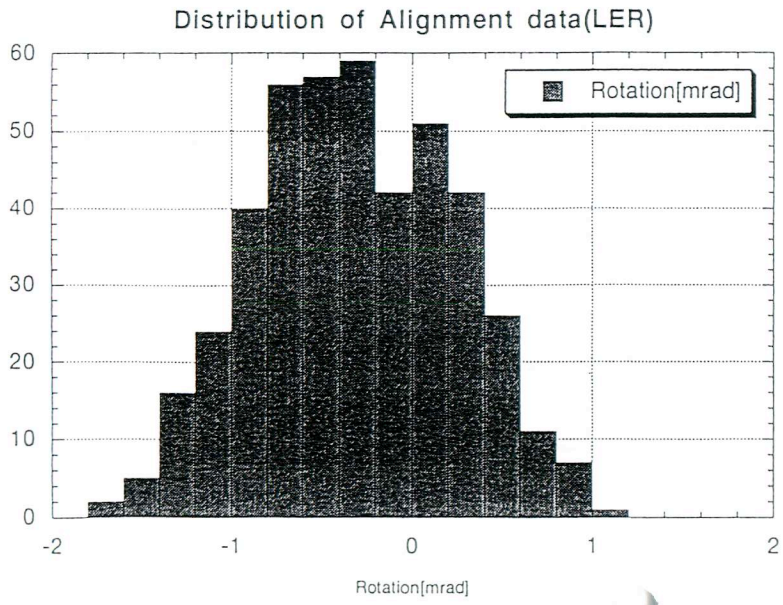
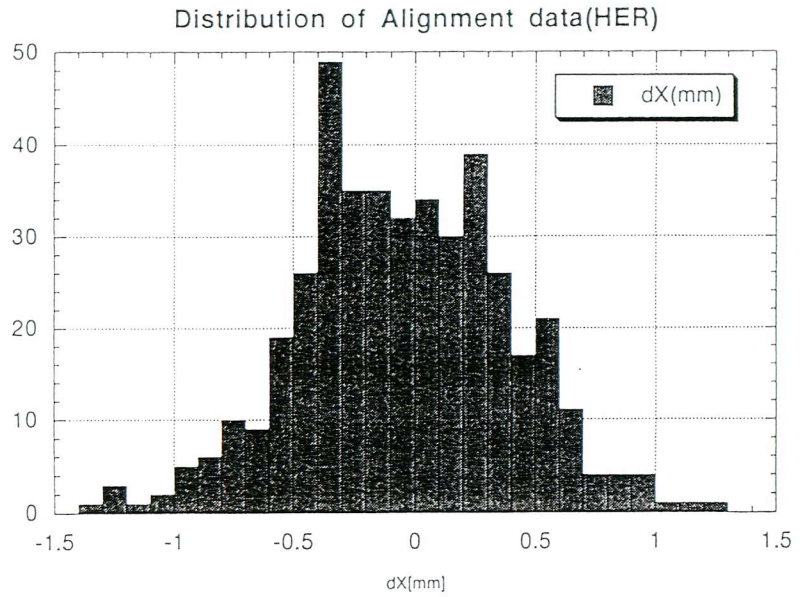
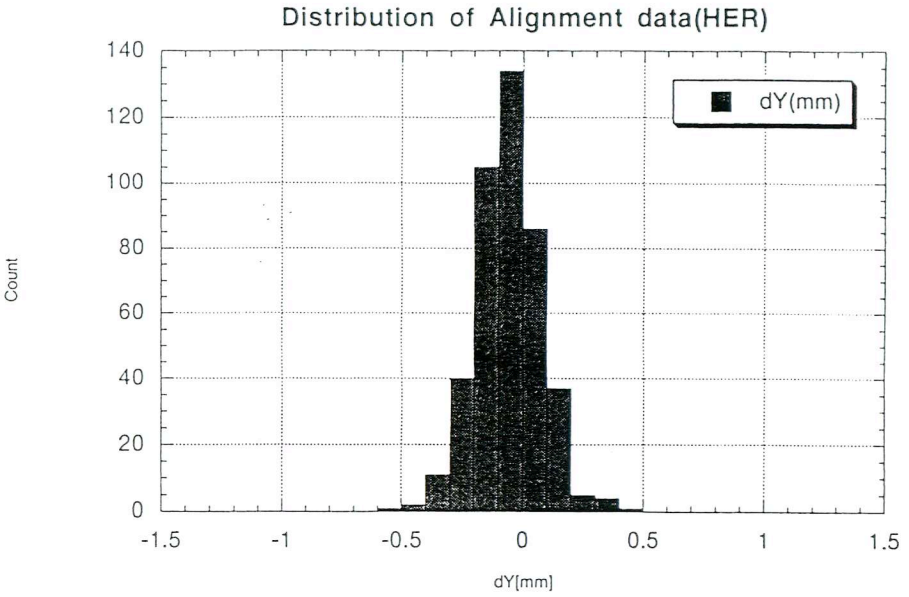

Distribution of Alignment data(LER)
Rotation[mrad]
Count
Rotation[mrad]
60
50
40
30
20
10
0
-2
-1
0
1
2

Figure 6 - LER


Distribution of Alignment data(HER)
dX(mm)
Count
dX[mm]
50
40
30
20
10
0
-1.5
-1
-0.5
0
0.5
1
1.5


Distribution of Alignment data(HER)
dY(mm)
Count
dY[mm]
140
120
100
80
60
40
20
0
-1.5
-1
-0.5
0
0.5
1
1.5

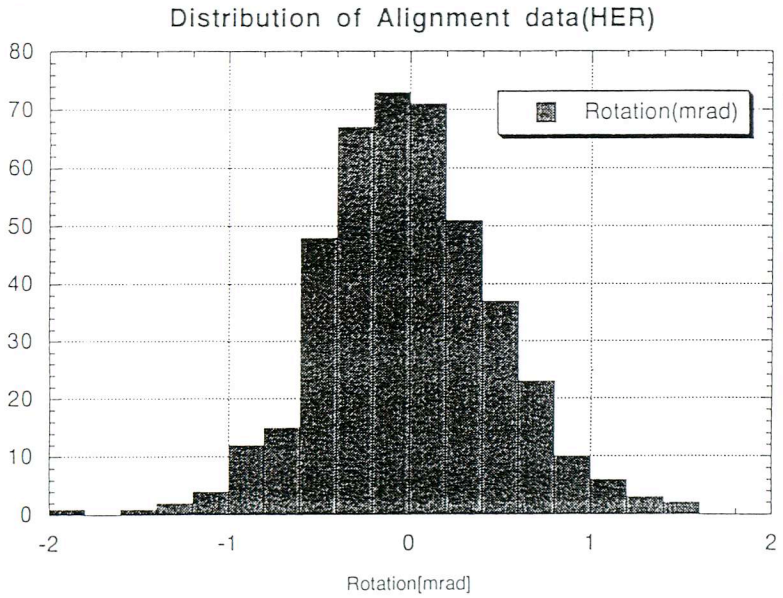

Distribution of Alignment data(HER)
Rotation(mrad)
Count
Rotation[mrad]
80
70
60
50
40
30
20
10
0
-2
-1
0
1
2

Figure 6 - HER

2 Signal processing system

(1) Signal processing

Signal treatment

The same signal treatment as TRISTAN BPM system.
Detection of a higher component of the revolution frequency.

- Four picked up signals transmitted by independent cable are processed by a common detector.
- One front-end processes 4 BPMs (2 of LER & 2 of HER)
- Detection frequency : 1.018 GHz (twice RF frequency)
- VXI board

a) RF signal detector : (Figure 7)

Super heterodyne (IF signal; 20KHz)
ADC converts IF signal directory (100KHz sample)
Digital Signal Processor (spectrum analyses)
Four channel multiplex
Programmable attenuator(75dB step 5dB)

b) Dual four channel multiplexer : (Figure 8)

PIN diode SW (fast switching <10μsec)

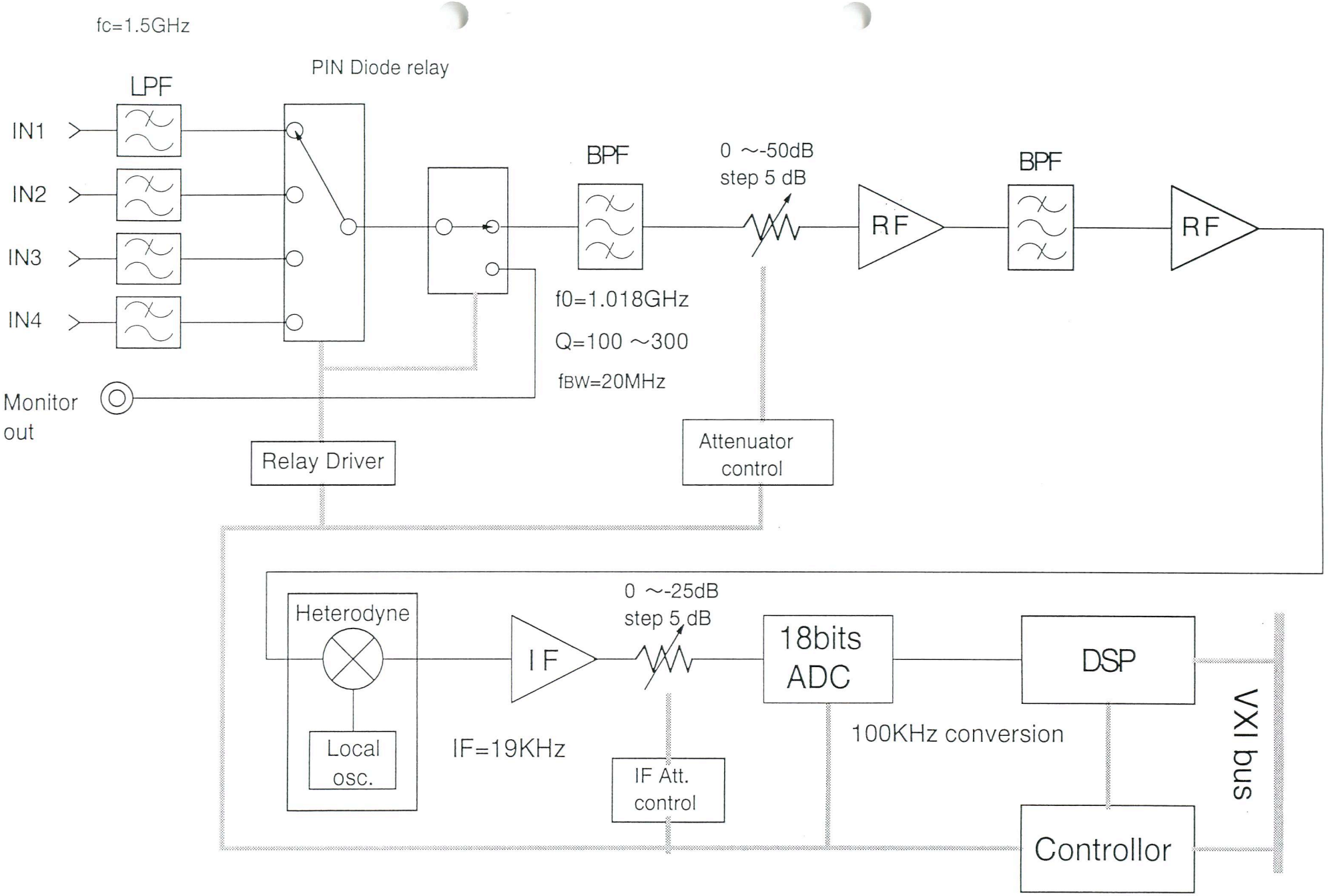


Figure 7 Block diagram of RF signal detetor

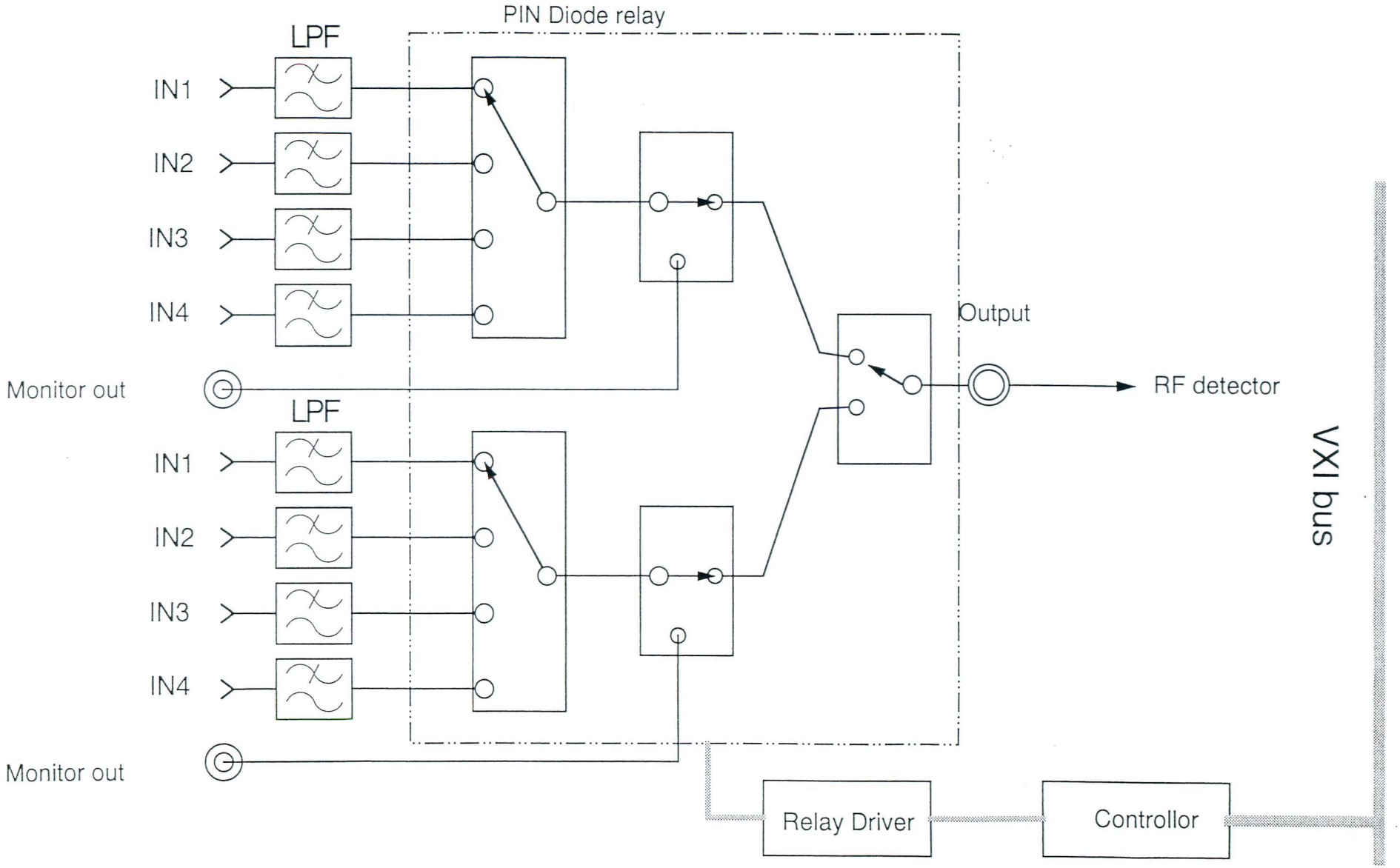


Figure 8 Block diagram of RF Multiplexer

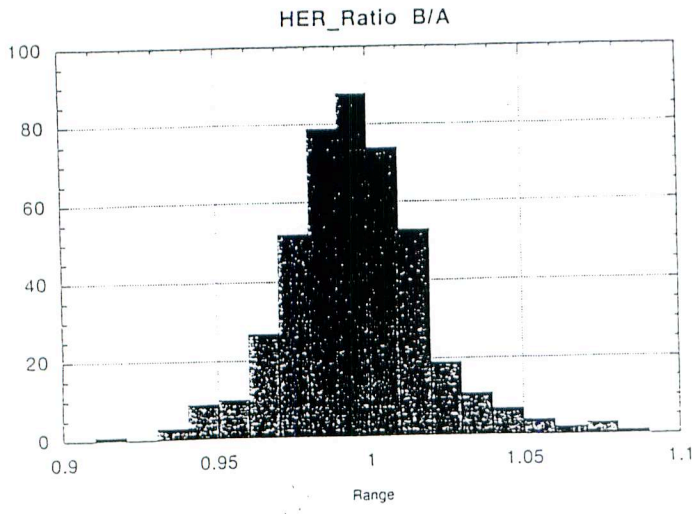
(2) Calibration for transmission line

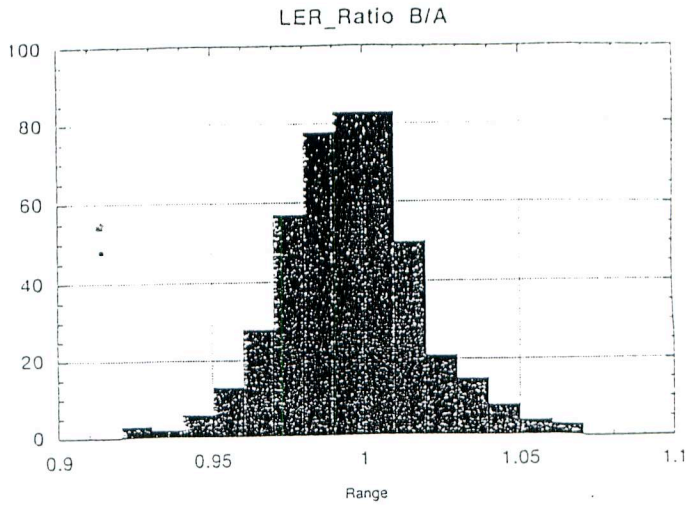
According to a loss factor of a long cable and an attenuation of a low pass filter and RF switch, each gain of transmission line are different.

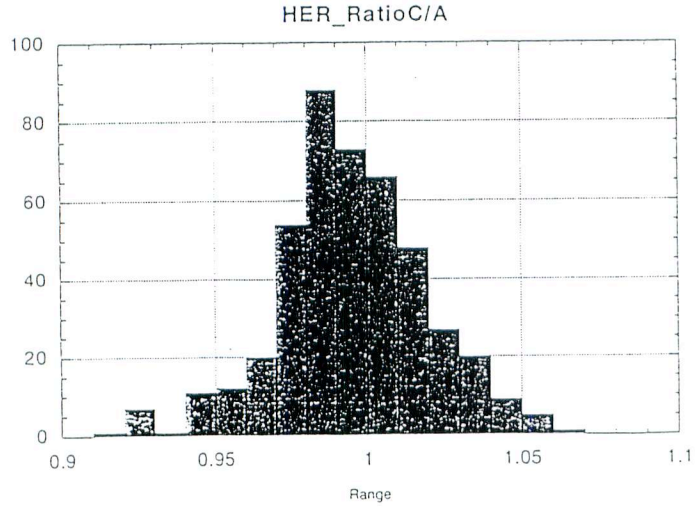
Each gain ratio of all BPMs were calibrated by a distributor with four outputs(1.018GHz).

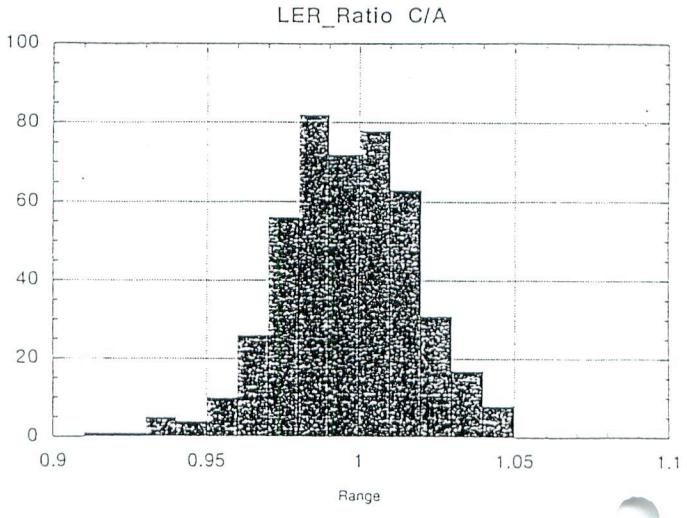
These calibration data are used for correction of raw data measured by detector.

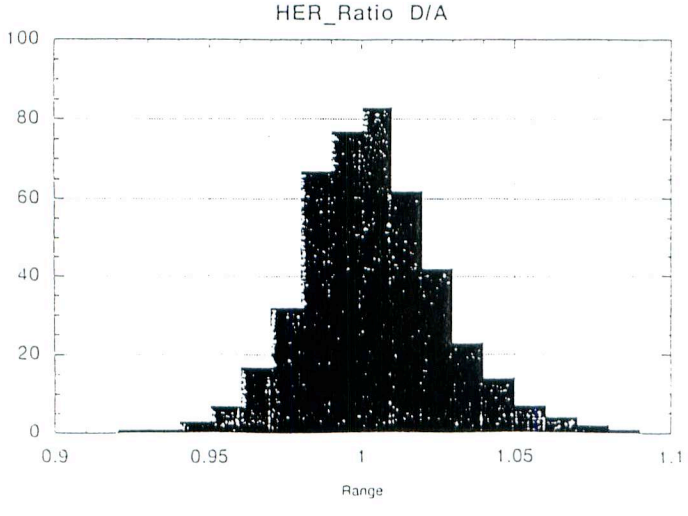
(Figure 9 Distribution of Calibration data for transmission line)











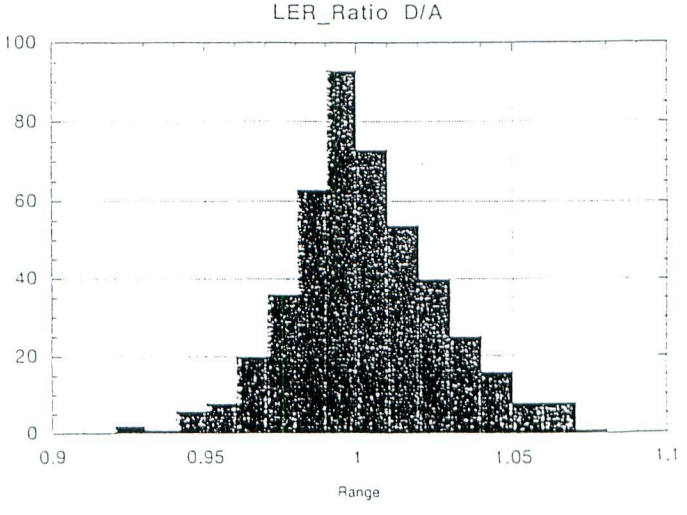


Figure 9 Distribution of calibration data for transmission line

3 Control system

ALL electronics units were installed in VXI mainframes distributed into 20 local control buildings.
Two front-end signal processors and four dual 4 ch multiplexers are set into a VXI mainframe.
Six VXI mainframes were connected a VME system for EPICS IOC by the high speed Multisystem eXtension Interface bus (MXI).

(Figure 10: Schematic of the BPM system)

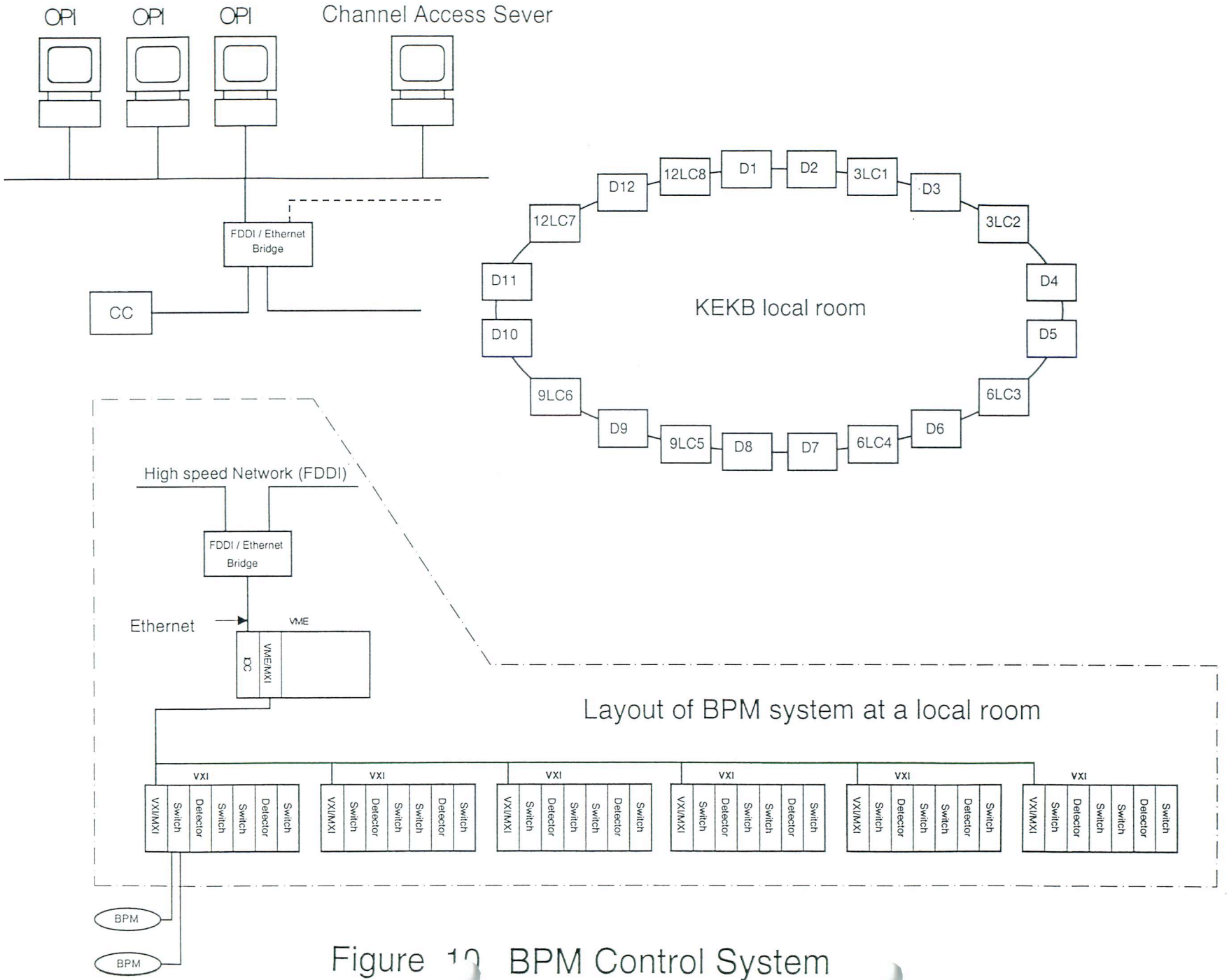


Figure 10 BPM Control System

(1) Process of local IOC

- setting attenuation
- Selection of channel on multiplexer
- Reading out data
- Correcting gain ratio
- Test status (RF/IF AMP overload , ADC overflow)
- Averaging

Read-out data are stored into Epics waveform record and send to IOC (CC) at central control building.

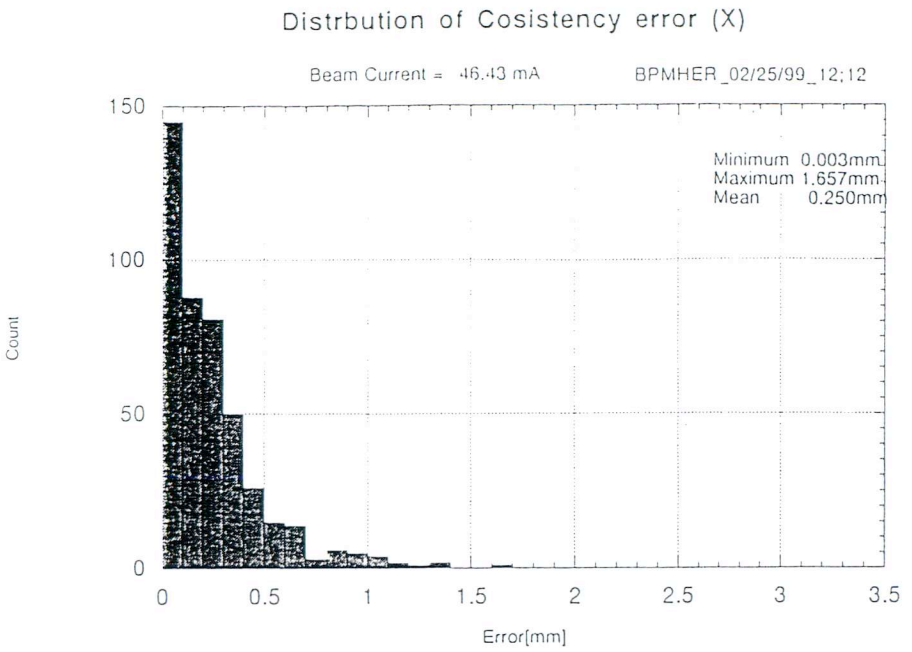
(2) Process of central IOC

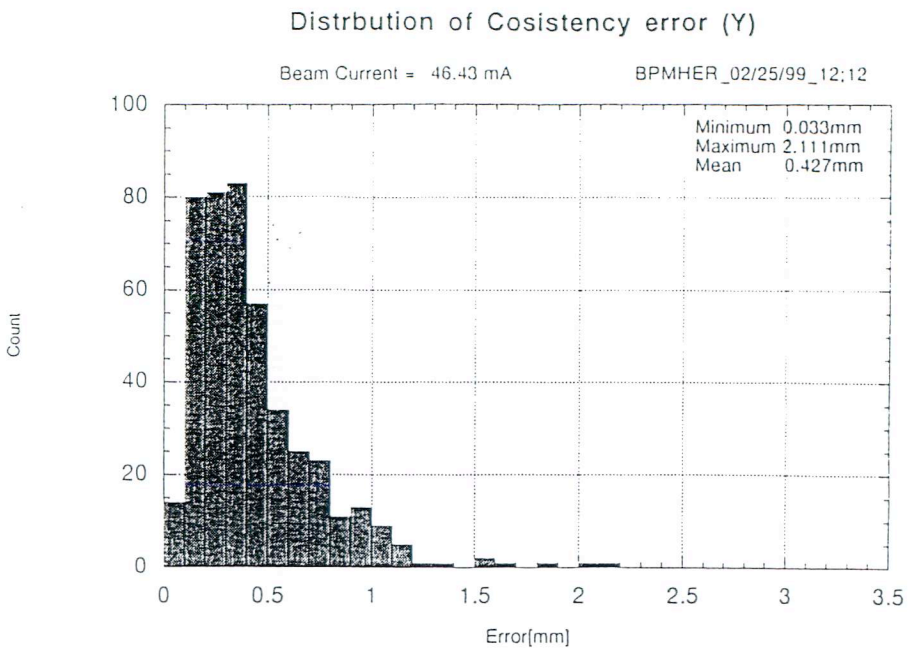
- Calculation to convert form raw data to position data
- Correcting alignment data(dx, dy, rotation)
- Renewal of each record for BPM
- Consistency check to reject a false data

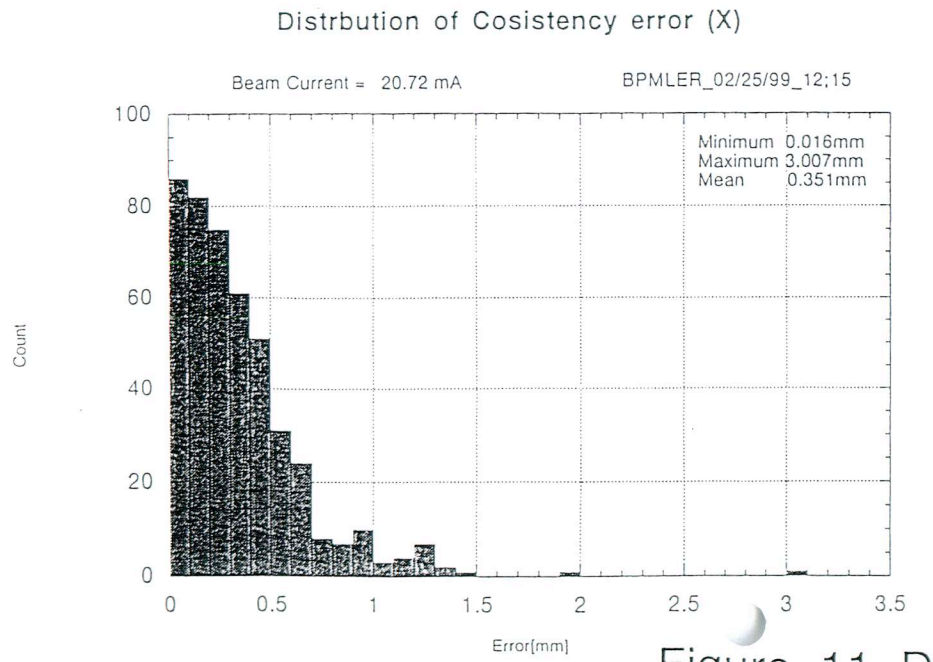
  We measure the four electrode outputs(A,B,C,D), usually beam position are calculated by four outputs. Then the position is also able to obtain from only three electrode outputs. If all electrode signals are correct, the result from combinations of (ABCD), (ABC), (BCD), (CDA), (DAB) are sure to be corresponence.

Present BPM system is agree with deviations less than 0.5mm

(Figure 11)







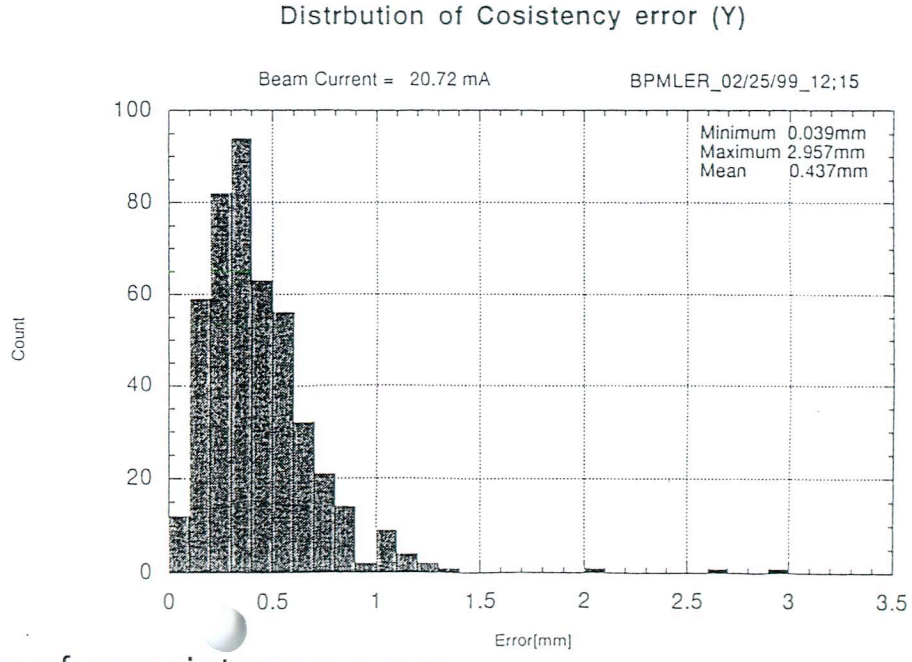


Figure 11 Distribution of consistency error

4 Performance

(1) Present performance

- The position resolution was confirmed better than a few μm,
- The COD measurement completed within a short time of 2 second per ring
- The system is capable of measuring from a beam current range of 1 mA .
- The offset error is estimated about 0.5mm for the large consitesy erorr of 3 elecrodes position.
- The relative accuracy is less than about 1%.

(2) Troubles

- Wrong cabling (about 30 BPMs)
- Wrong signal due to many HOM signals (IR region & Injection region)