Monitors & Feedback

(Feb.26　9:40-10:00　H.Fukuma)

Instrumentation and bunch feedback system in SuperKEKB

26th Feb. 2002

H. Fukuma, KEK

1. Beam parameters
2. Beam Position Monitor
3. Synchrotron Radiation Monitor
4. Bunch Feedback System

1. Beam parameters

Machine Parameters of the SuperKEKB

	LER	HER	
Horizontal Emittance	33	33	nm
Vertical Emittance	2.1	2.1	nm
x-y coupling	6.4	6.4	%
Beam current	9.4	4.1	A
Number of bunches	5018 (2% abort gap)		
Bunch current	1.87	0.817	mA
Bunch spacing	0.6		m
Half crossing angle	15		mrad
Luminosity reduction R_L	0.748		
ξ_x reduction $R_{\xi x}$	0.691		
ξ_y reduction $R_{\xi y}$	0.916		
Bunch length	3	3	mm
Radiation loss U_0	1.23	3.48	MeV/turn
Betatron tune ν_x / ν_y	45.515/43.57 ?	44.515/41.57 ?	
beta's at IP β_x^* / β_y^*	15/0.3	15/0.3	cm
beam-beam parameters ξ_x / ξ_y	0.068/0.05	0.068/0.05	
Beam lifetime	~150	~150	min.
Luminosity	1.0		$10^{35}/cm^2/sec$

2. Beam Position Monitor (BPM) (M. Tejima)

1) Requirement

- BPM is mainly used for

  Orbit correction and Optic correction such as beta, dispersion and X-Y coupling.

- Vertical emittance in SuperKEKB is larger than that in KEKB.

  SuperKEKB : 33 / 2.1nm (H / V)

  (KEKB :18 / 0.36 nm)

- Arc lattice in SuperKEKB is almost same as KEKB.

➔ Required position resolution will be same order of magnitude as KEKB.

(This should be confirmed after lattice design is fixed.)

2) Signal power and signal level

a) Power

	LER(e-)	HER(e+)
Beam Energy	3.5GeV	8GeV
Beam Current	9.4A	4.1A
Particles/bunch	16.5×10^{10}(1.87mA)	7.2×10^{10}(0.82mA)
Number of bunches	5018	5018
σ_z	3mm	3mm
RF	508.8MHz	508.8MHz

(1) LER BPM 9.4A, 5018bunches

For beam position at center of chamber

Button electrode : 8.9 [W] 39.5[dBm]

Circuit input : 0.056[W] 17.5[dBm] (100m cable)

: 0.34 [W] 25.3[dBm] (50m cable)

For beam position at 10mm from center of chamber (+6dB)

Button electrode : 35.5[W] 45.5[dBm]

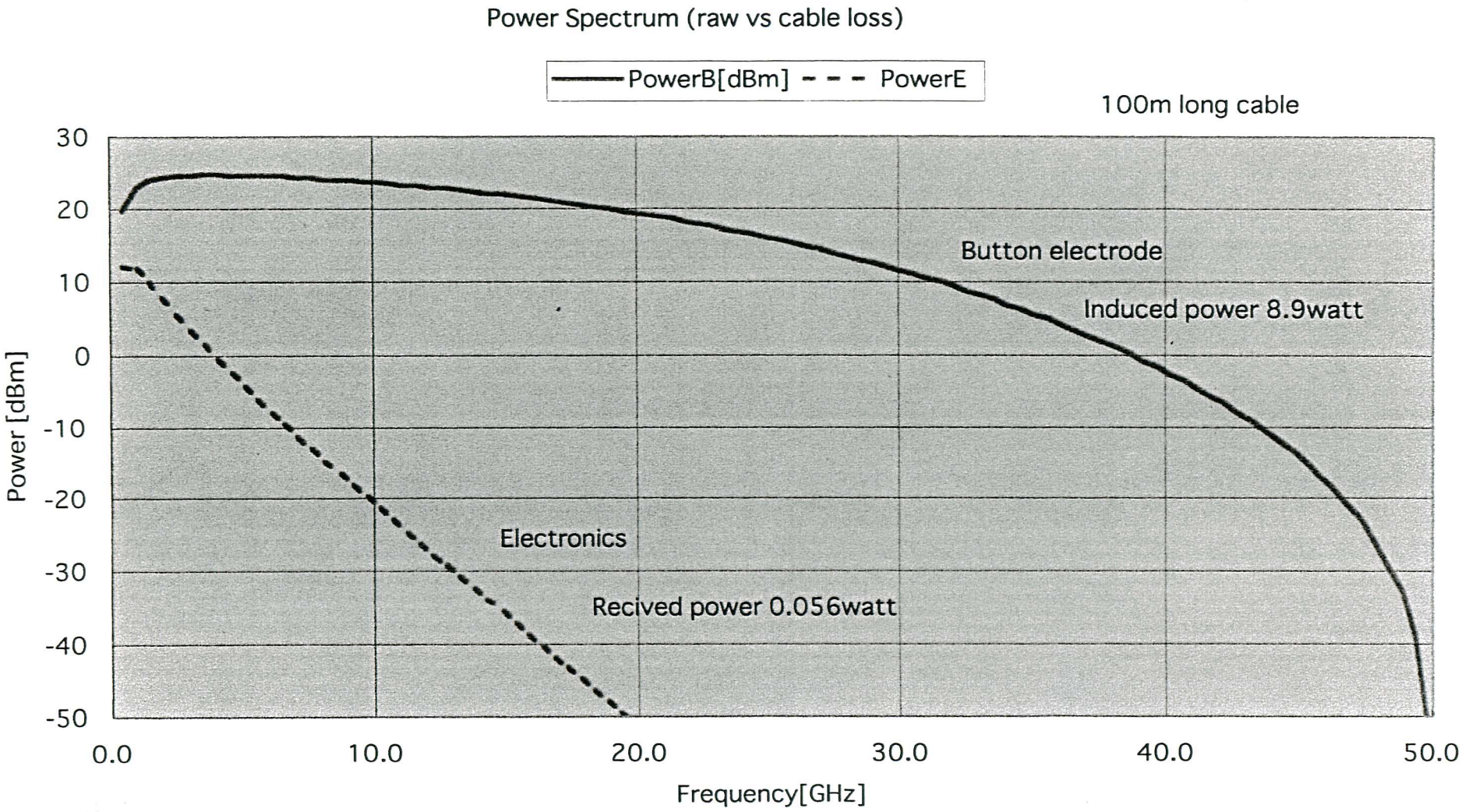
Button electrode : 0.22[W] 23.5[dBm] (100m cable)

: 1.35[W] 31.3[dBm] (50m cable)

(2) HER BPM 4.1A, 5018bunches

0.35 x LER power

Power spectrum



b) Signal level

KEKB BPM (measurement)

For beam position at center of chamber

	BPM type	Vpeak[V]	FWHM[psec]	Ibunch[mA]	Vpeak/mA
LER	94φ	1.28～1.5	292	0.6	2.24[V/mA]
HER	racetrack	1.44～1.6	299～326	0.5	3.01[V/mA]

Cable length 56m

For beam position at 10mm from center of chamber

LER : 4.5[V/mA] , HER: 6.0[V/mA]

SuperKEKB

LER : 8.4V/1.87mA bunch current

HER :4.9V/0.82mA bunch current

Input Signal of RF Switch

LER

BPM:LC2_QF4P.34(94φ)

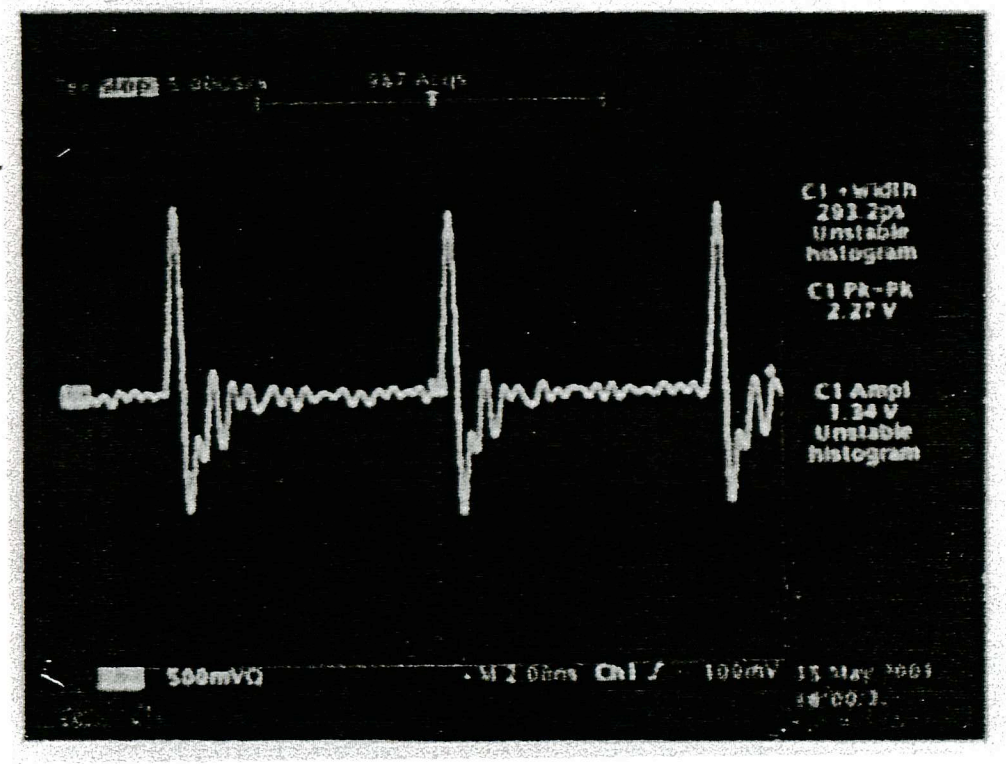
(x,y)<(±1,±1)mm

Cable Length= 56.2m

Vpeak=1.32V

I/bunch=0.59mA

Vpeak/mA=2.24V



TDS 684C digitizing oscilloscope (5G Sample/sec, Analog bandwidth 1GHz)

c) Maximum power and signal level of detector and multiplexer

	specification	SuperKEKB
max. input level	< +23dBm (total power)	1.35W(LER):31.3dBm 0.47W(HER):26.7dBm
max. allowable input	20V,100psFWMH 500Mpps	<8.4V/1.87mA(LER) <4.9V/0.82mA(HER)
programmable ATT	RF 0～55dB with 5dB step, IF 0～25 dB with 5dB step	

(assume10mm offset)

Change BPM button Diameter 12mm --> 6mm

	specification	SuperKEKB
max. input level	< +23dBm (total power)	0.098W(LER):19.9dBm 0.039W(HER):15.3dBm
max. allowable input	20V,100psFWMH 500Mpps	<2.1V/1.87mA(LER) <1.2V/0.82mA(HER)
programmable ATT	RF 0～55dB with 5dB step, IF 0～25 dB with 5dB step	

3) Upconverter

- Ante-chamber will be used in SuperKEKB.
- To avoid the effect of HOM from vacuum components,
  detection frequency 1 GHz -> 500MHz.
- Upconverter will be put in front of detector.

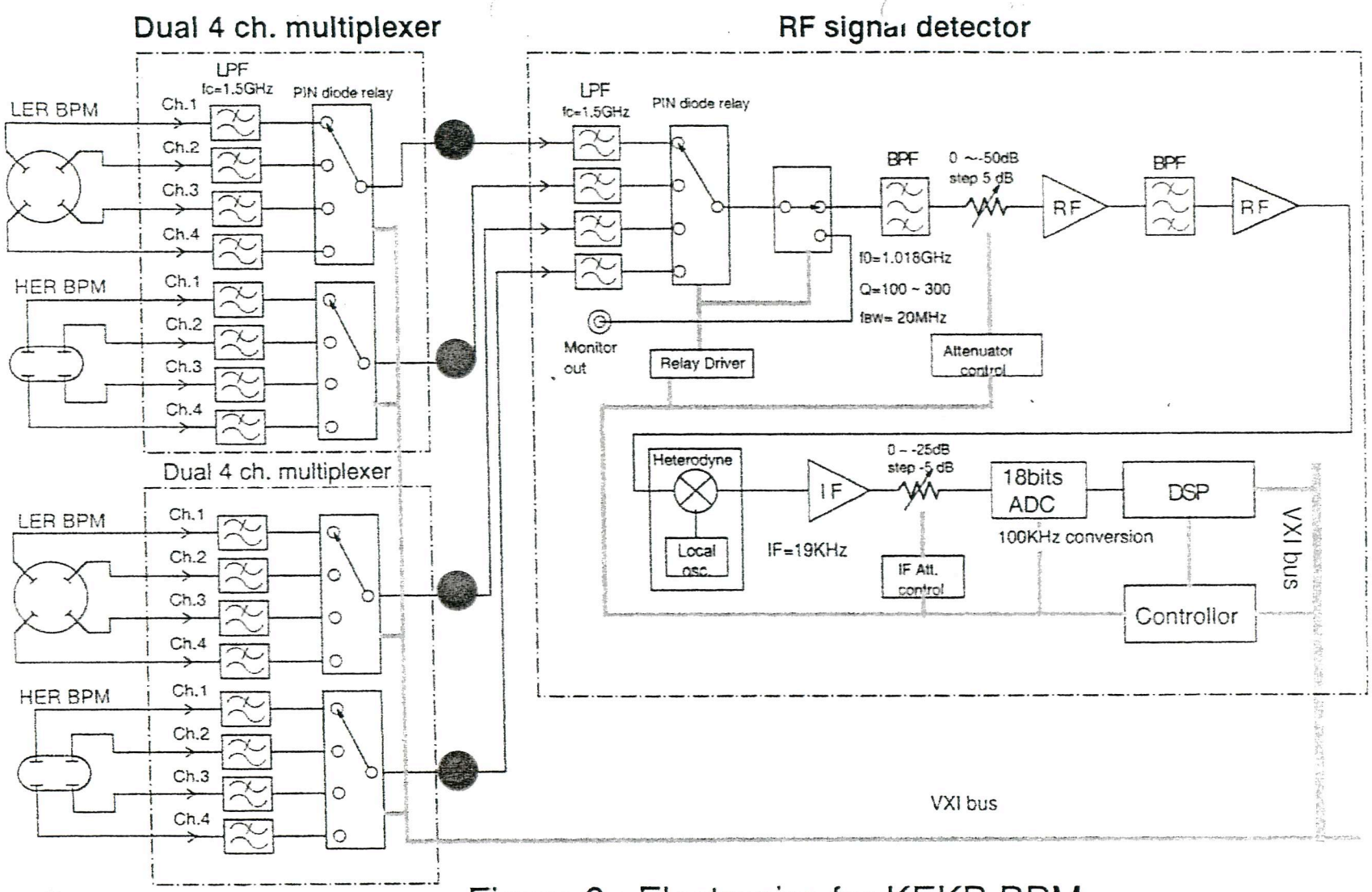


Figure 3 : Electronics for KEKB BPM

2. Synchrotron Radiation Monitor

(T. Mitsuhashi)

1) Design consideration

(I) Beam current will be increased about 5 times.

	KEKB	SuperKEKB
LER	96.4 W/mrad	292.1 W/mrad
HER	83.9 W/mrad	313.0 W/mrad

Change the incident angle from 45° to 9°.

-> Input SR power density to the mirror is reduced by 1/5.

(II) Beam sizes at the source points are not smaller than those in KEKB.

-> Use same diagnostics apparatus.

(III) Bunch length is 3/4 times shorter than that in KEKB.

4 mm -> 3 mm

In the streak camera measurement, the longitudinal aberration such as optical-path difference (OPD) can introduce error.

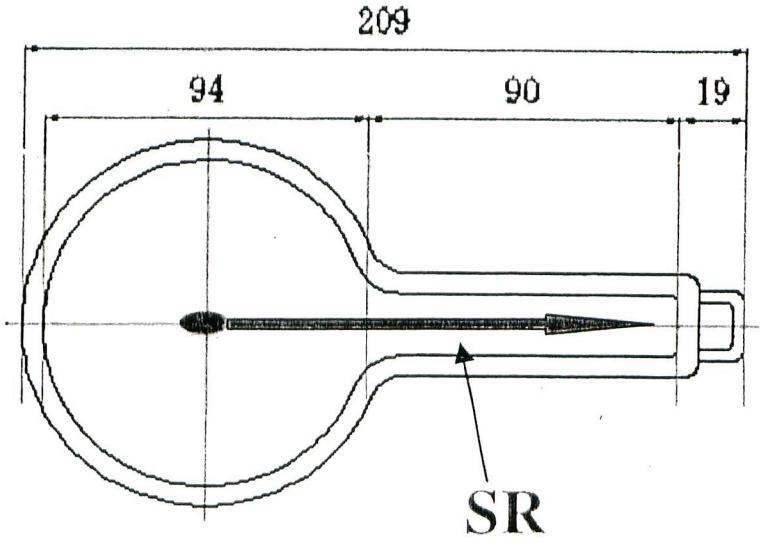
-> Use the reflective optics.

2) Extraction mirror system

- Reflection angle of the SR beam is only 8°.
- How to extract the SR beam from beam duct ?

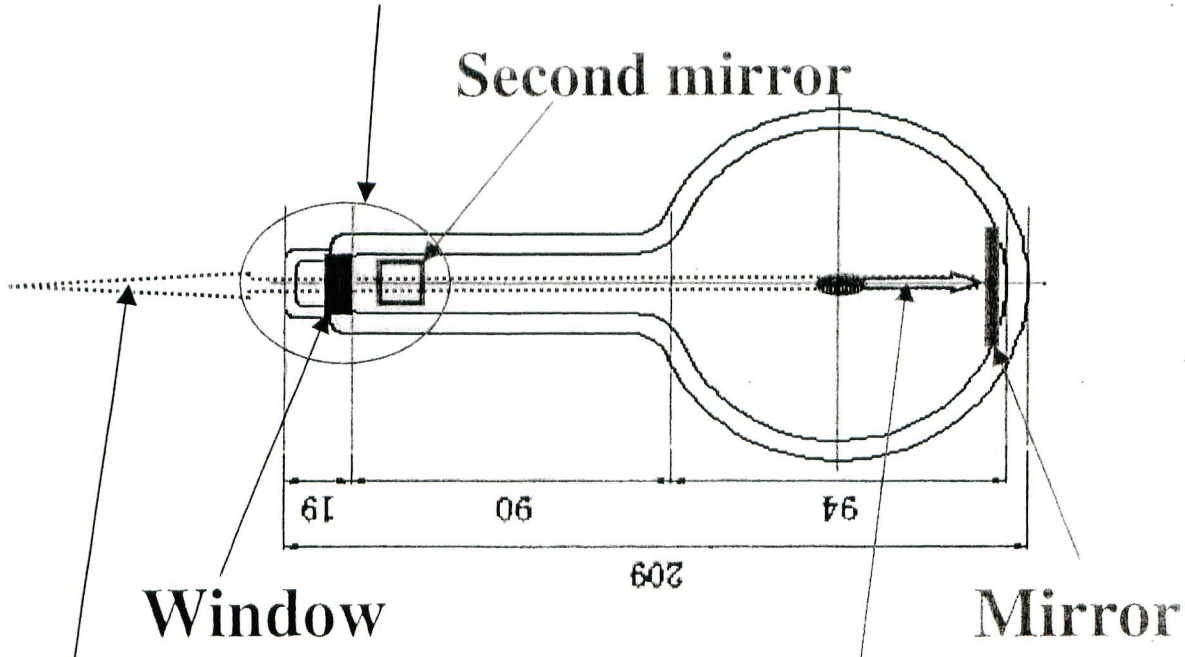
-> Add one more mirror and flip the ante-chamber.

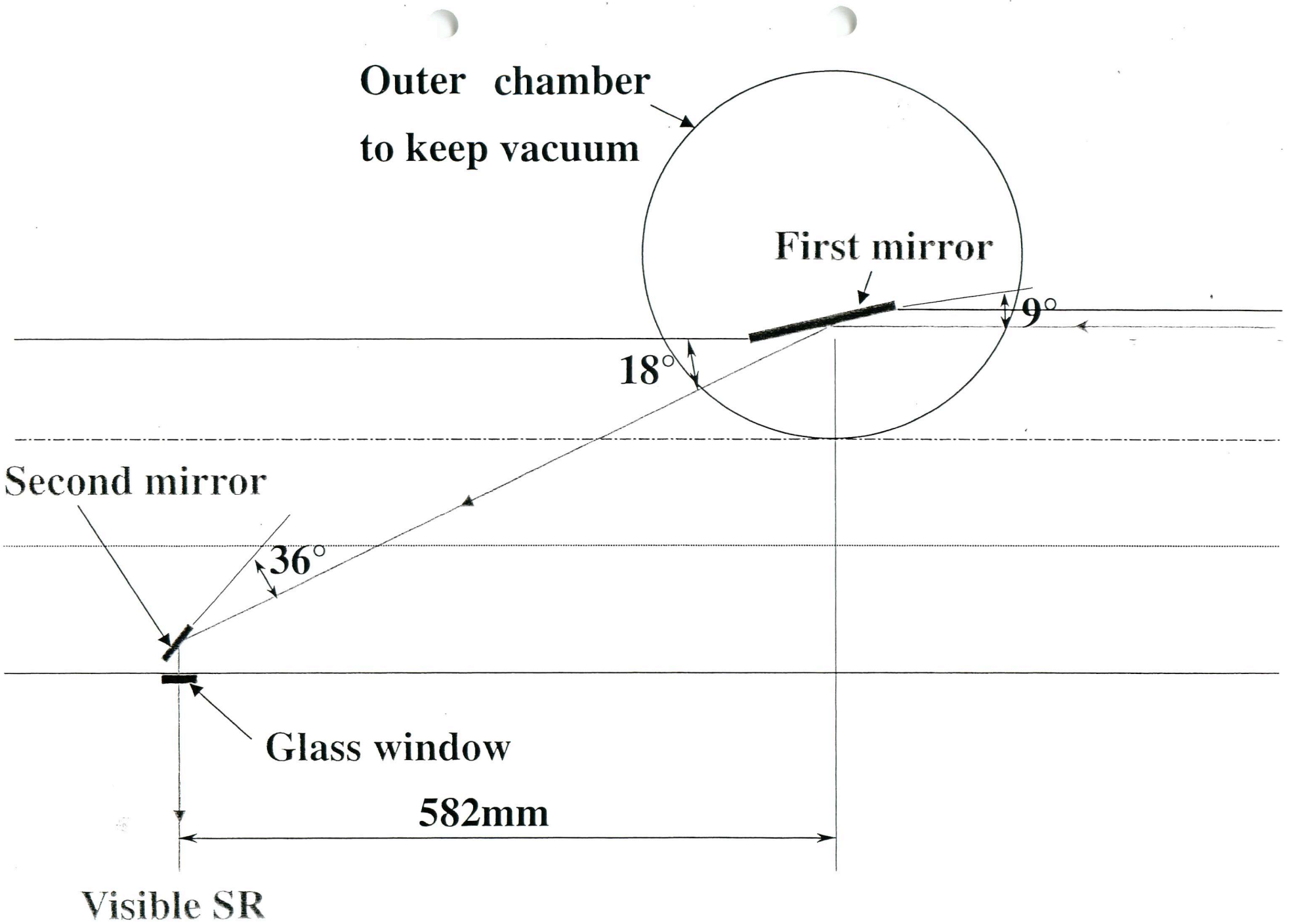
Normal usage of the ante-chamber



Irregular use of ante-chamber for the extraction of SR beam

Almost no invasion of electric field from the beam




Outer chamber
to keep vacuum
First mirror
9°
18°
Second mirror
36°
Glass window
582mm
Visible SR

3. Bunch feedback system

1) Growth time of coupled bunch instability(CBI)

Transverse

•Resistive wall

	LER	HER
I (A)	9.4	4.1
τ_g(ms)	1.7	1.1

•Cavity HOM

Not calculated yet.

•Electron cloud instability (HER)

1ms without solenoid (simulation by S.S.Win)

•Fast Ion instability in LER

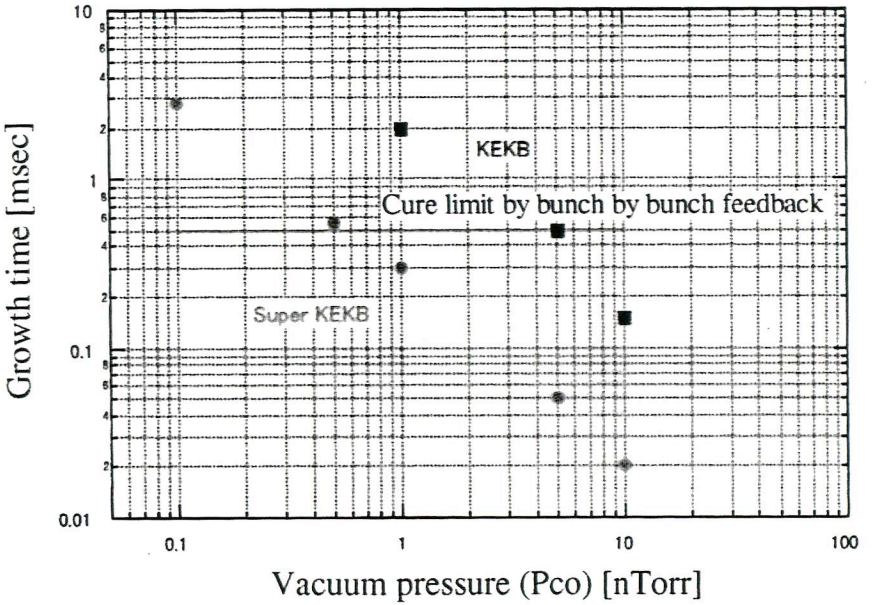
(simulation by M. Tawada)

1 nTorr 0.3 ms

5 nTorr 0.05ms

Fast Ion instability in LER will be very strong.

Relation between growth time and vacuum pressure at Super KEKB



Maximum damping time of present feedback system is about 0.5ms.

➔ Damping rate of transverse feedback system in LER should be increased by at least factor two.

Add another kicker ?

<u>Longitudinal</u>

•Cavity HOM

Not calculated yet.

2) To do list (M. Tobiyama)

A. In-vacuum components

Large beam current (10A)

Large bunch current(2mA)

Short bunch length (3mm)

i) Transverse kicker

- Transition between kicker and beam duct (heating)
- Calculation of beam power from kicker
- Heating of kicker chamber
- Structure of feed through
  - Support of electrodes
    - (lengthening by heating)

ii) Longitudinal kicker

- Test operation of present system

B. Electronics

i) Filter board, memory board

Re-fabricate

ii) Slow feedback

- Auto-correction of longitudinal beam phase
- Auto-correction of transverse offset