RF System

(Feb.25　15:50-16:10　K.Akai)

RF System for KEKB Upgrade

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Machine Advisory Committee

25 Feb. 2002

Beam parameters and requirements

	KEKB		Super-B	
	LER	HER	LER	HER
Beam current (A)	2.6	1.1	9.4	4.1
Energy loss/turn (MeV)	1.6	3.5	1.2[a]	3.5
Loss factor assumed (V/pC)			40[b]	50[b]
Total beam power (MW)	4.5	4.0	18.4	16.0
(Radiation loss) (MW)	4.0	3.8	11.3[a]	14.3
(Parasitic loss) (MW)	0.5	0.2	7.1[b]	1.7[b]
Bunch length (mm)	4		3	

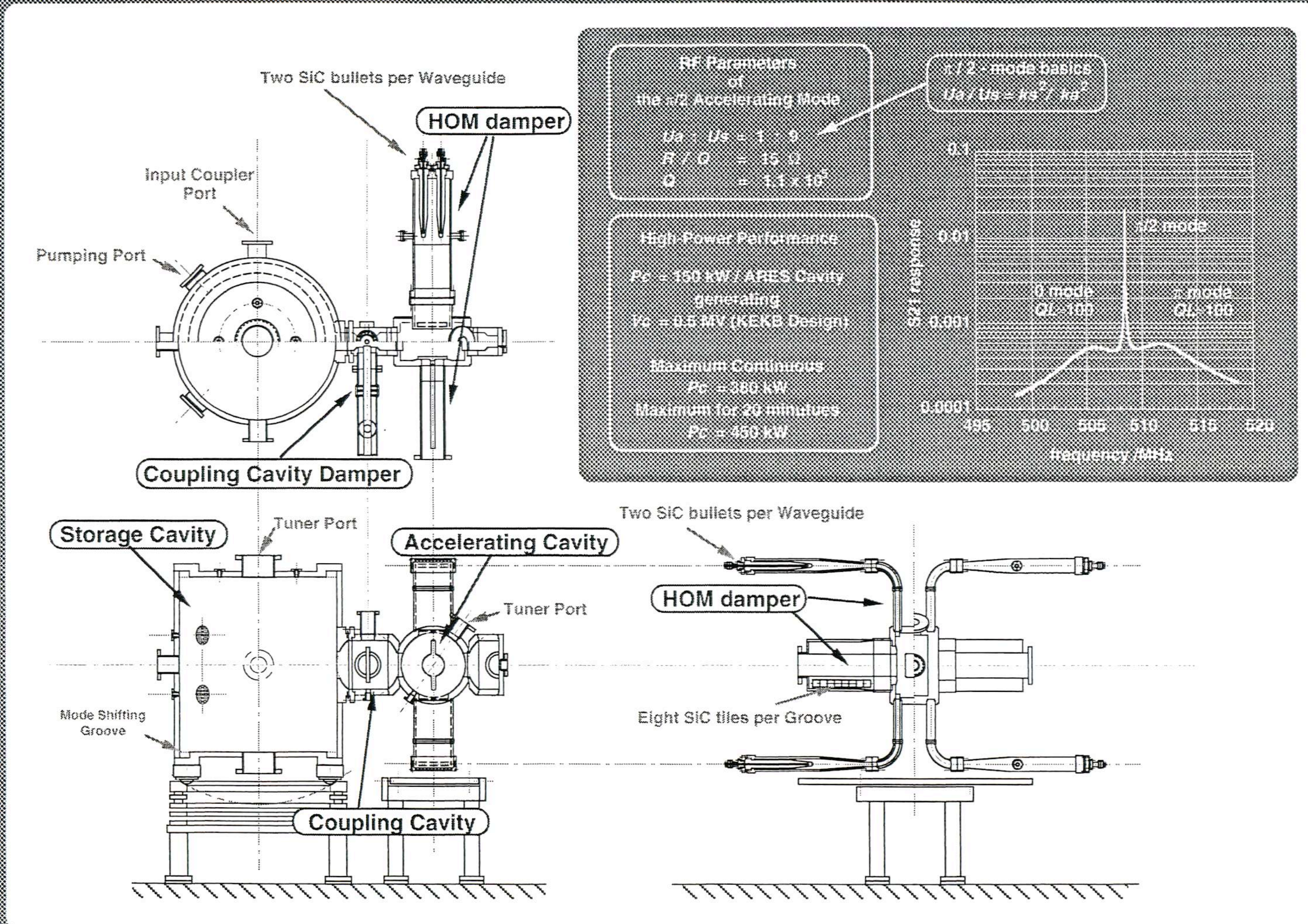
(a) Energy loss of 0.4 MV due to wiggler magnets is included.
(b) Total loss factors shown are assumed values.

- Very large HOM loss at cavities.
- Large amount of RF power required.
- Heavy beam-loading should be cured.

Base plan of upgrading

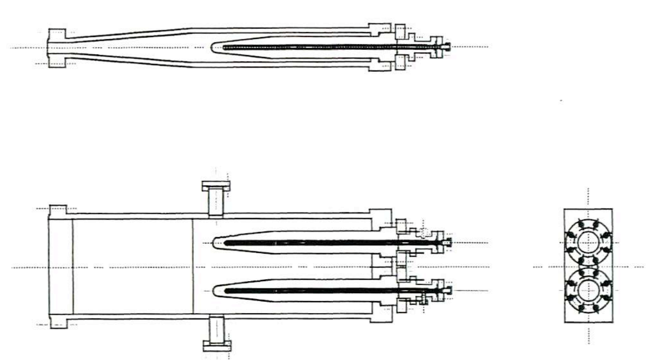
- **The existing RF system will be used as much as possible:**
  - **RF frequency: same as KEKB (509 MHz).**
  - **Cavity: the ARES and SCC with necessary improvements and modification.**
- **Advantages:**
  - **Most of existing components and facilities can be reused.**
  - **Reduces cost, man power, and construction period.**
  - **Unknown technical issues are relatively small.**

The ARES cavity



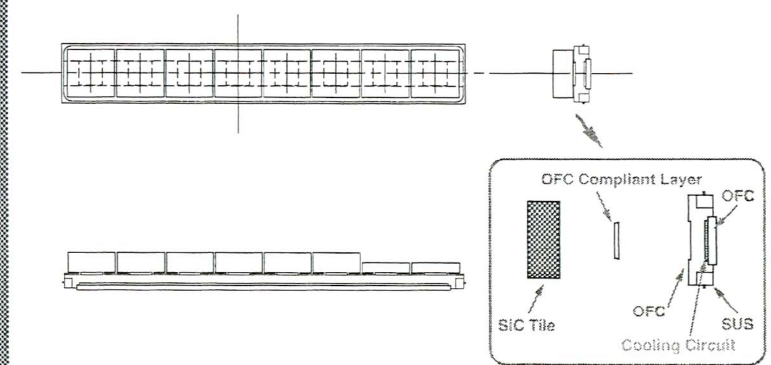
HOM LOADS

Bullet-shape sintered SiC Ceramic Absorber



- Two absorbers (ø55mm x 400mm) per HOM waveguide.
- Power capability tested up to 3.3 kW (CW) per absorber.

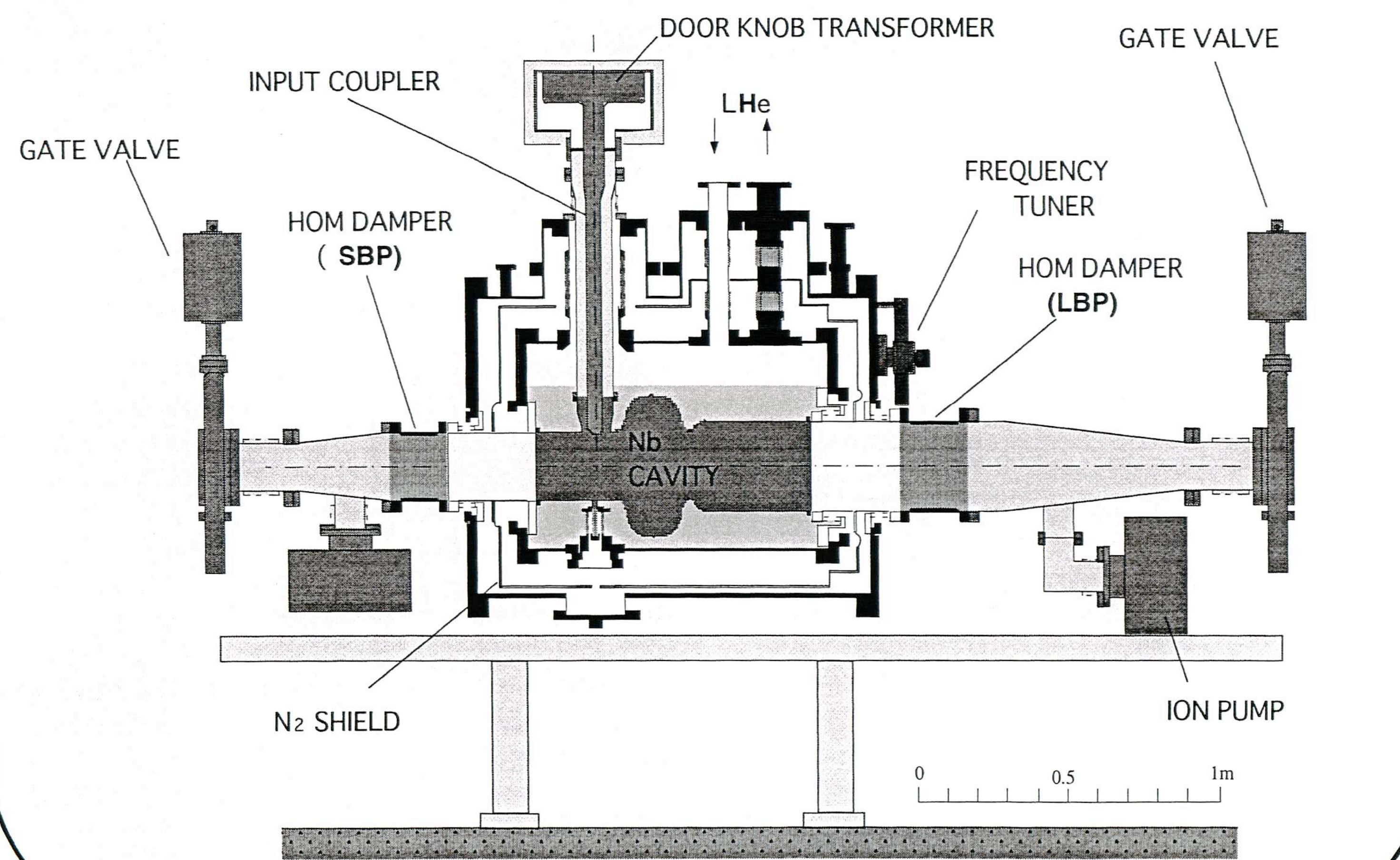
SiC Ceramic Tiles for GBP HOM Load



- Eight SiC tiles (48mm x 48mm x 20mm, or 10mm) per groove.
- Power capability upgraded up to 0.5 kW by brazing tiles to a copper plate cooled by water.

Superconducting Damped Cavity for KEKB

T. Furuya



Very large HOM power

- **Improve HOM dampers (R&D).**
- **Try to reduce loss factors.**

	KEKB operated	bench-tested	Super-B estimated	
SCC-HOM damper	7.5	12	56	(kW/cavity)
ARES-HOM damper	2	26	100	
ARES-damper @coupling cav.	3	20	40	

Other changes required for cavities

- **Reinforce cooling and protection for input couplers (ARES, SCC).**
- **Reinforce the damper at C-cavity (ARES).**
- **Eliminate taper section to reduce loss factor (SCC).**
- **Readjust resonant frequency of A-cavity of ARES for larger detuning.**
- **Increase input coupling (reduce loaded-Q)**

  - **Details of cavity upgrade will be given by T. Kageyama and T. Furuya.**

Large amount of RF power required

- **Total beam power is 4 times as high as KEKB.**
  - **Klystron max. output is 1.2 MW (CW).**
  - **Input couplers have been tested up to about 1 MW.**

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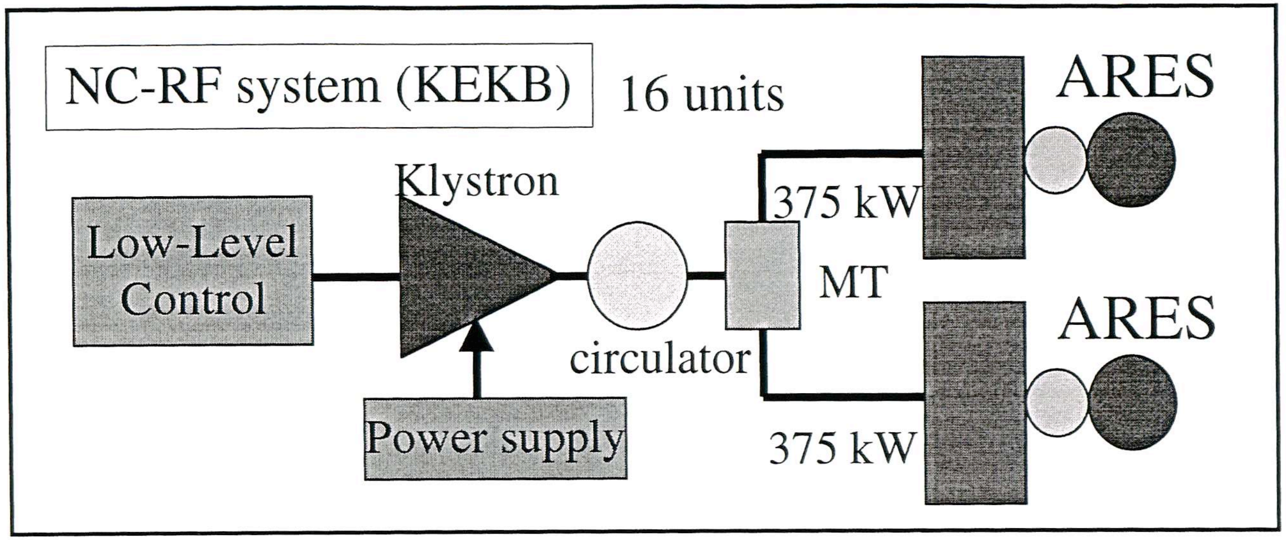
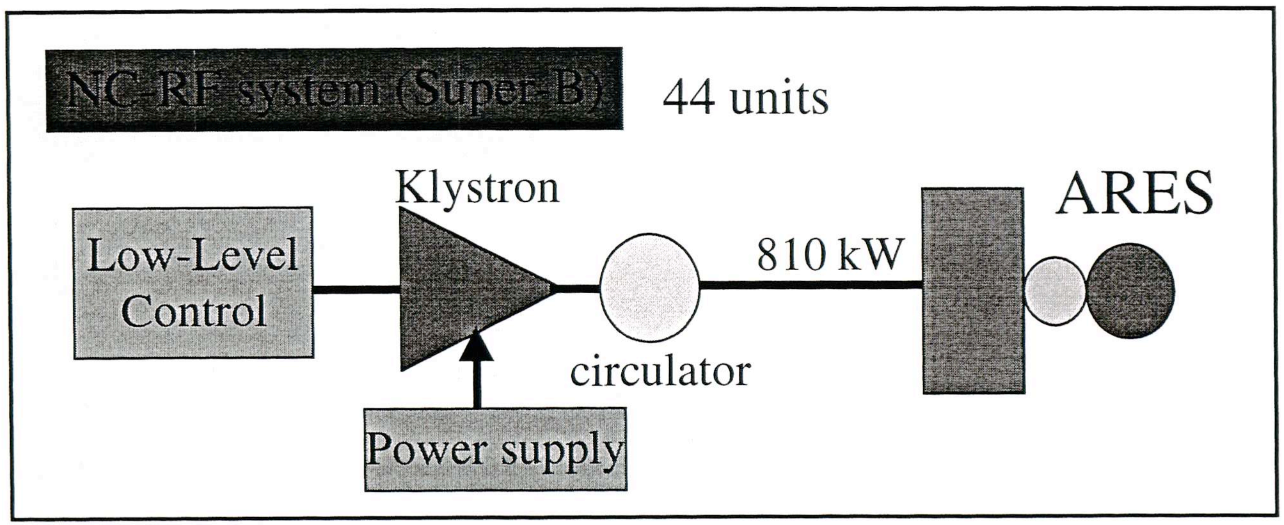
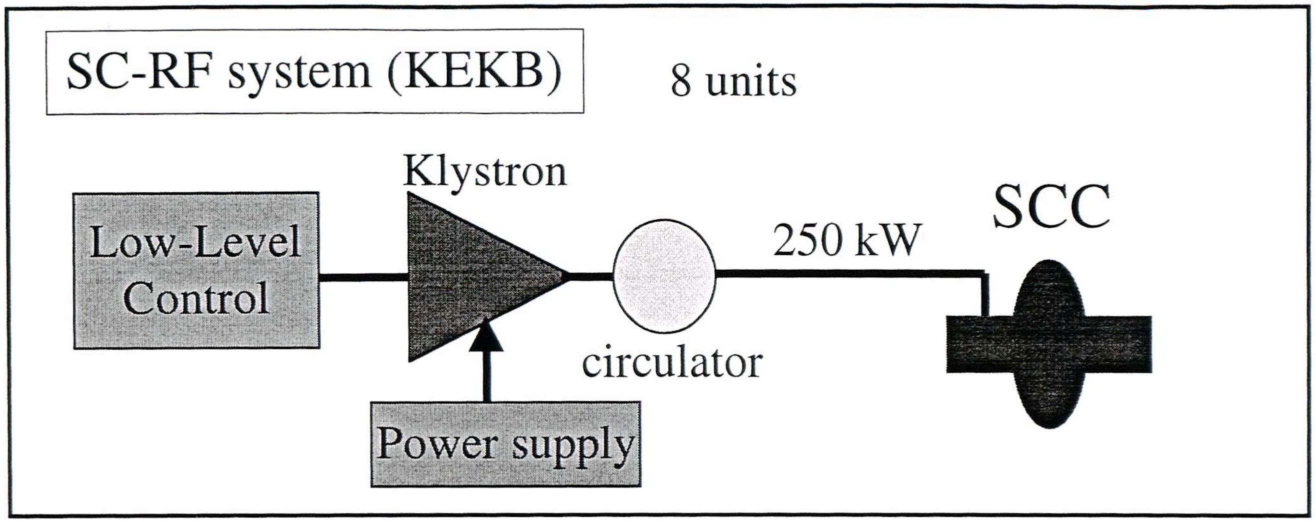
- **Higher power fed to each cavity than KEKB.**
  - **Change to 1 ARES/klystron configuration.**
- **Increase the number of RF stations (more than double).**

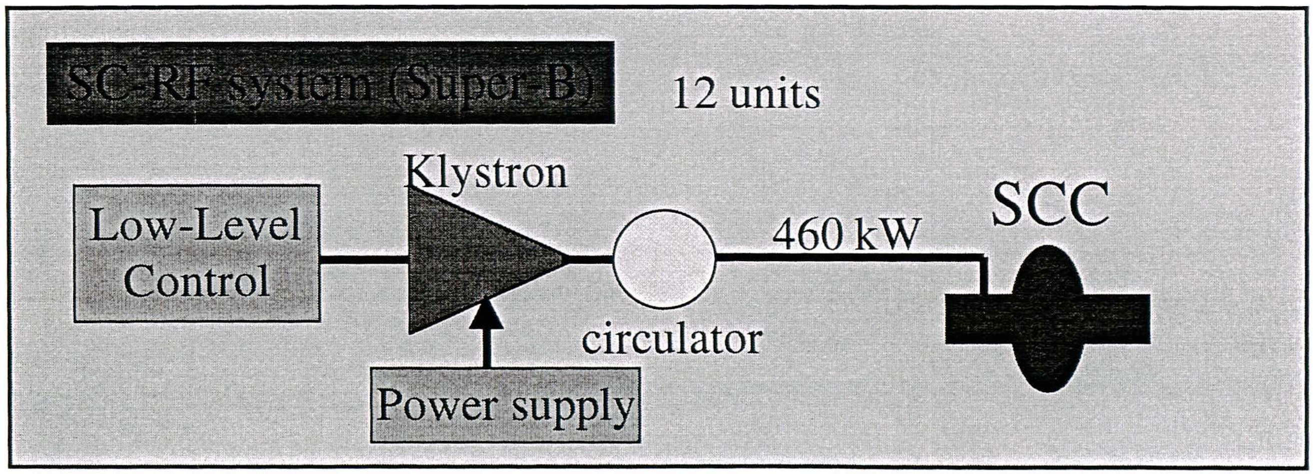


NC-RF system (KEKB)
16 units
Klystron
Low-Level Control
Power supply
circulator
MT
375 kW
375 kW
ARES
ARES



[redacted]
44 units
Klystron
Low-Level Control
Power supply
circulator
810 kW
ARES

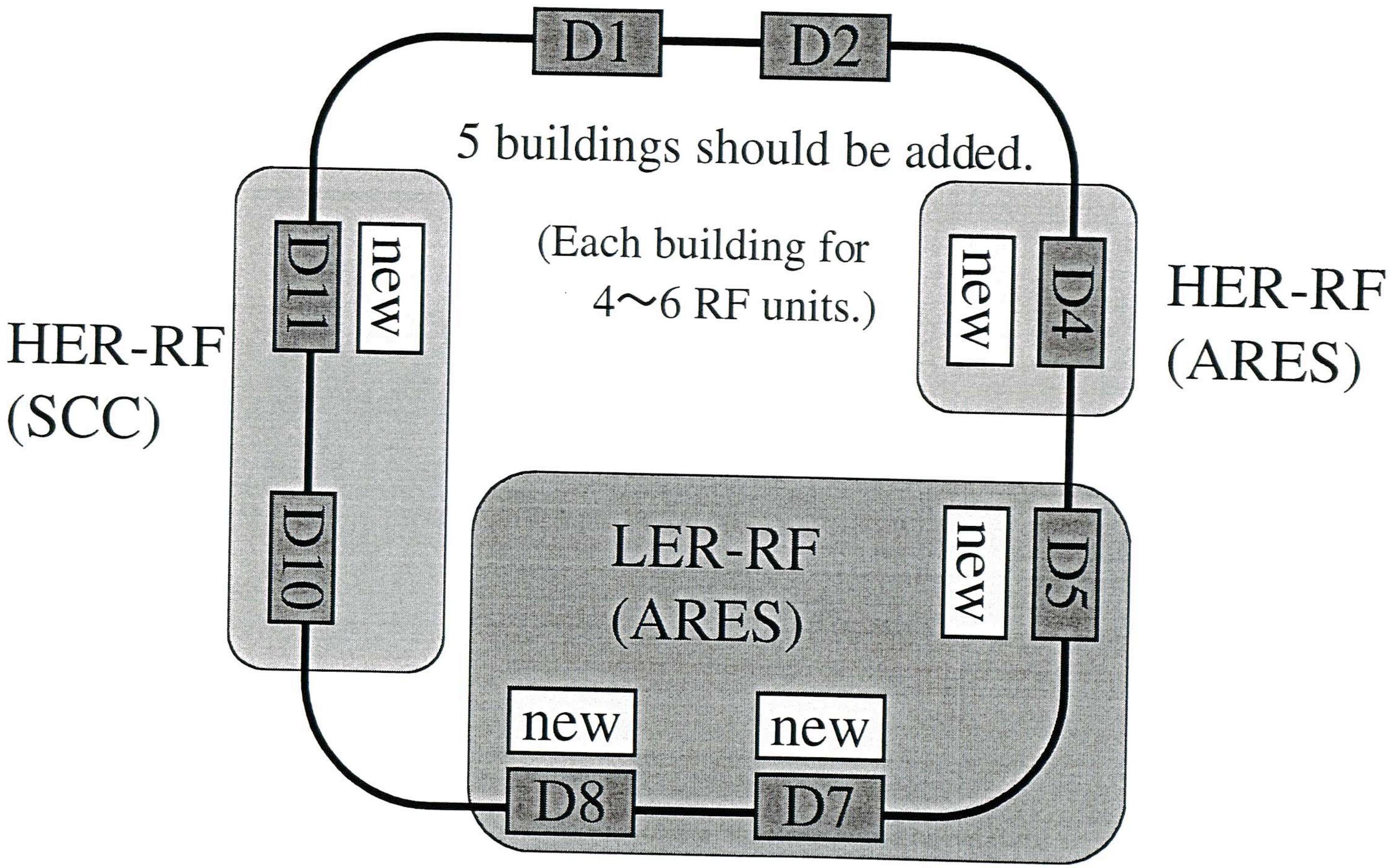

SC-RF system (KEKB)
8 units
Klystron
Low-Level Control
250 kW
SCC
circulator
Power supply


SC-RF system (Super-B)
12 units
Klystron
Low-Level Control
460 kW
SCC
circulator
Power supply

RF parameters

Ring	LER	HER		
Beam current (A)	9.4	4.1		
Wiggler magnets	yes (half)	no		
Energy loss/turn (MeV)	1.2	3.5		
Loss factor (V/pC)	40	50		
Radiation loss power (MW)	11.3	14.3		
Parasitic loss power (MW)	7.1	1.7		
Total beam power (MW)	18.4	16.0		
Total RF voltage (MV)	14	23		
				(Total)
Cavity type	ARES	ARES	SCC	ARES / SCC
No. of cavities	28	16	12	44 / 12
Voltage /cav. (MV)	0.5	0.5	1.3	
Input coupling	5.4	5.4	-	
Loaded-Q value (x10E4)	1.7	1.7	4.0	
Beam power /cav. (kW)	660	660	460	
Wall loss /cav. (kW)	150	150	-	
Detuning frequency (kHz)	71	31	74	
Klystron power (kW)	850	850	480	
No. of klystrons	28	16	12	56
Total AC plug power (MW)	40	23	10	73

Layout of RF stations



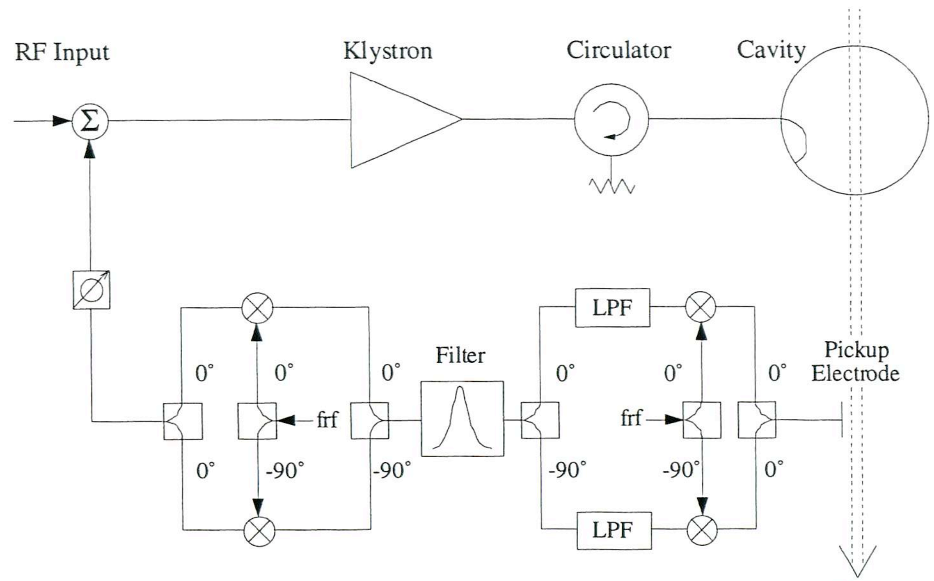
Heavy beam-loading on the accelerating mode

- **Longitudinal instability**
    - **Growth rate of the -1 mode caused by large detuning is very high (~10^4), even with ARES and/or SCC.**
  - **Strong damping by feedback with comb filter is inevitable.**
  - **Zero-mode stabilization should also be improved.**
- **Beam phase modulation due to abort gap**
    - **Abort gap of KEKB has been reduced (1 μs → 0.5 μs).**
  - **Further reduction to 0.2 μs is required.**
    - $\Delta\phi = 5.2^\circ$ **(LER 9.4A @0.2 μs gap)**

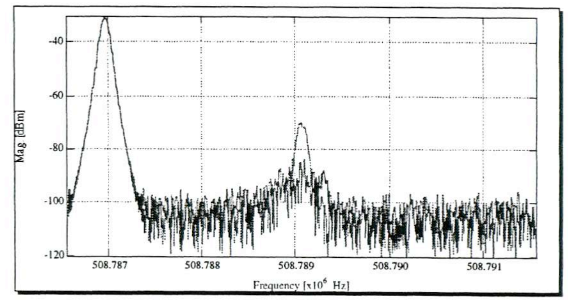
Feedback with comb filter for the -1 mode

- **Successfully operating in KEKB.**
- **Much higher gain (>30dB) required for Super-B.**

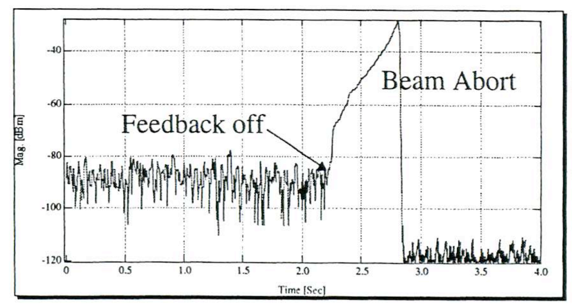
Block diagram of the -1 Mode Damping System



Feedback on/off (I_b= 890 mA, Detuning -60 kHz)
BW = 1kHz, Gain = 15 dB



Feedback on/off (I_b= 1.0 A, Detuning -60 kHz)



Main R&D issues

- **HOM dampers**
  - **also Input couplers and Damper at C-cavity,**
- **Impedance estimation**
- **RF control**
  - **Feedback for zero mode and -1, -2 modes**
- **Klystron and high-power system**
  - **Reduce crowbar trips**
  - **Improve reliability of dummy loads**
- **Beam test of improved system**

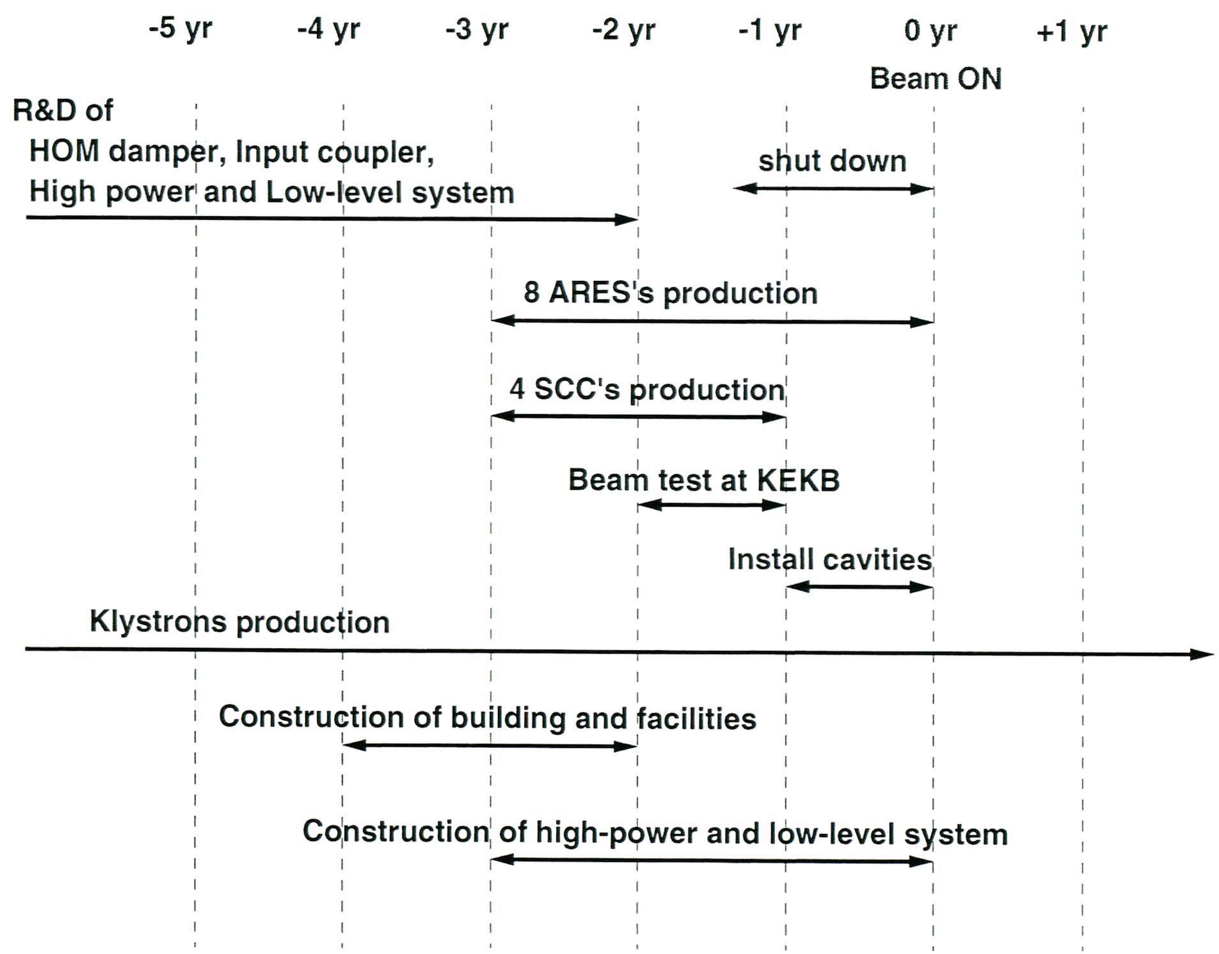
Cost estimation

- **R&D (about 7 Oku-Yen?)** 1 Oku-yen ~0.8 M$
- **Improvements and modification of existing components (6.4 Oku-Yen)**
- **Construction of additional units (88 Oku-Yen)**

	KEKB	Super-B required	to be added	cost/unit (oku-yen)
ARES cav.	32	44	12	0.8
SC cavity	8	12	4	1.25
RF system	24	56	32	2.3

- **Total cost is about 100 Oku-Yen.**
- **(electricity, cooling system, buildings are NOT included.)**

Schedule


-5 yr
-4 yr
-3 yr
-2 yr
-1 yr
0 yr
+1 yr
Beam ON
R&D of
HOM damper, Input coupler,
High power and Low-level system
shut down
8 ARES's production
4 SCC's production
Beam test at KEKB
Install cavities
Klystrons production
Construction of building and facilities
Construction of high-power and low-level system