

RF SYSTEM

K. AKAI

KEK

**KEKB Machine Advisory Committee
Mar. 1999**

Outline

- **RF system overview**

(Detail of ARES, SC and Crab cavities will be given in other talks.)

- **Construction**

- **Commissioning operation**

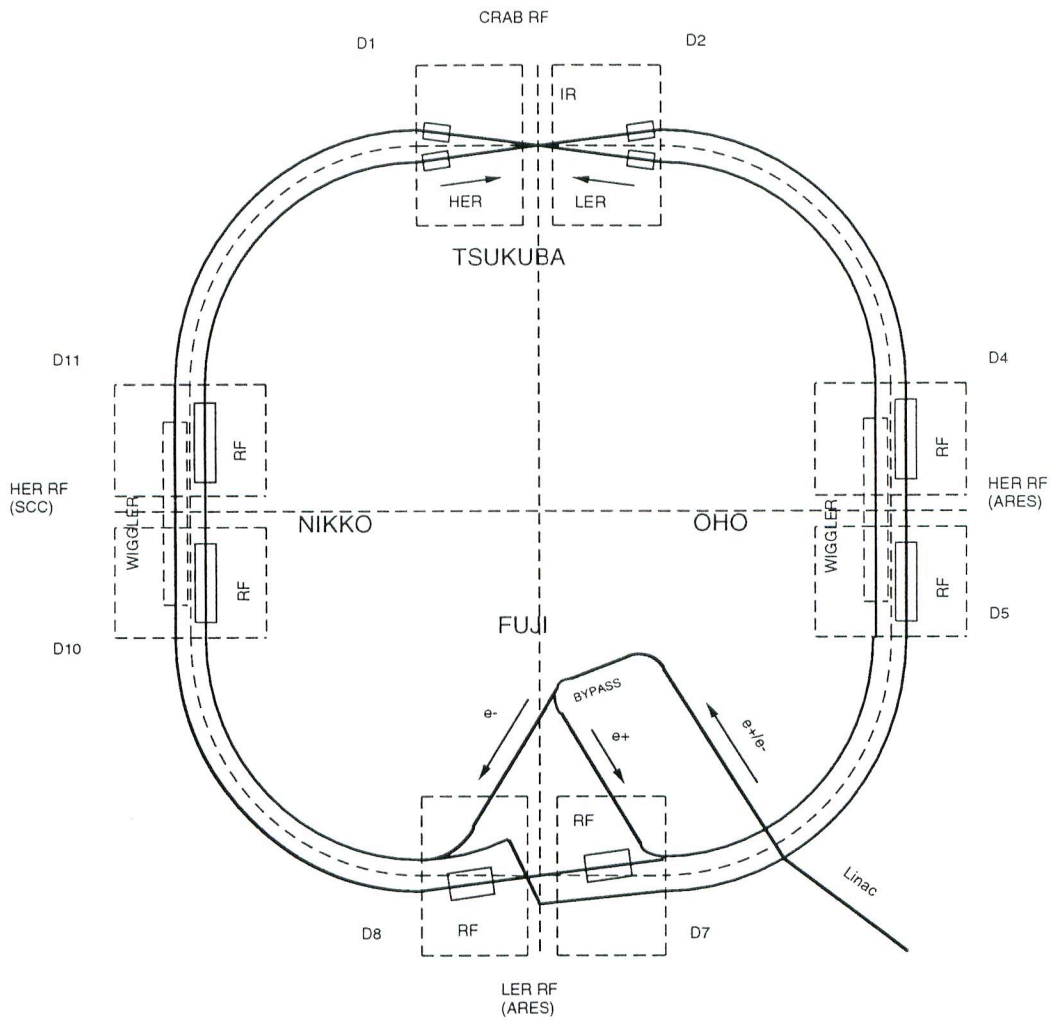
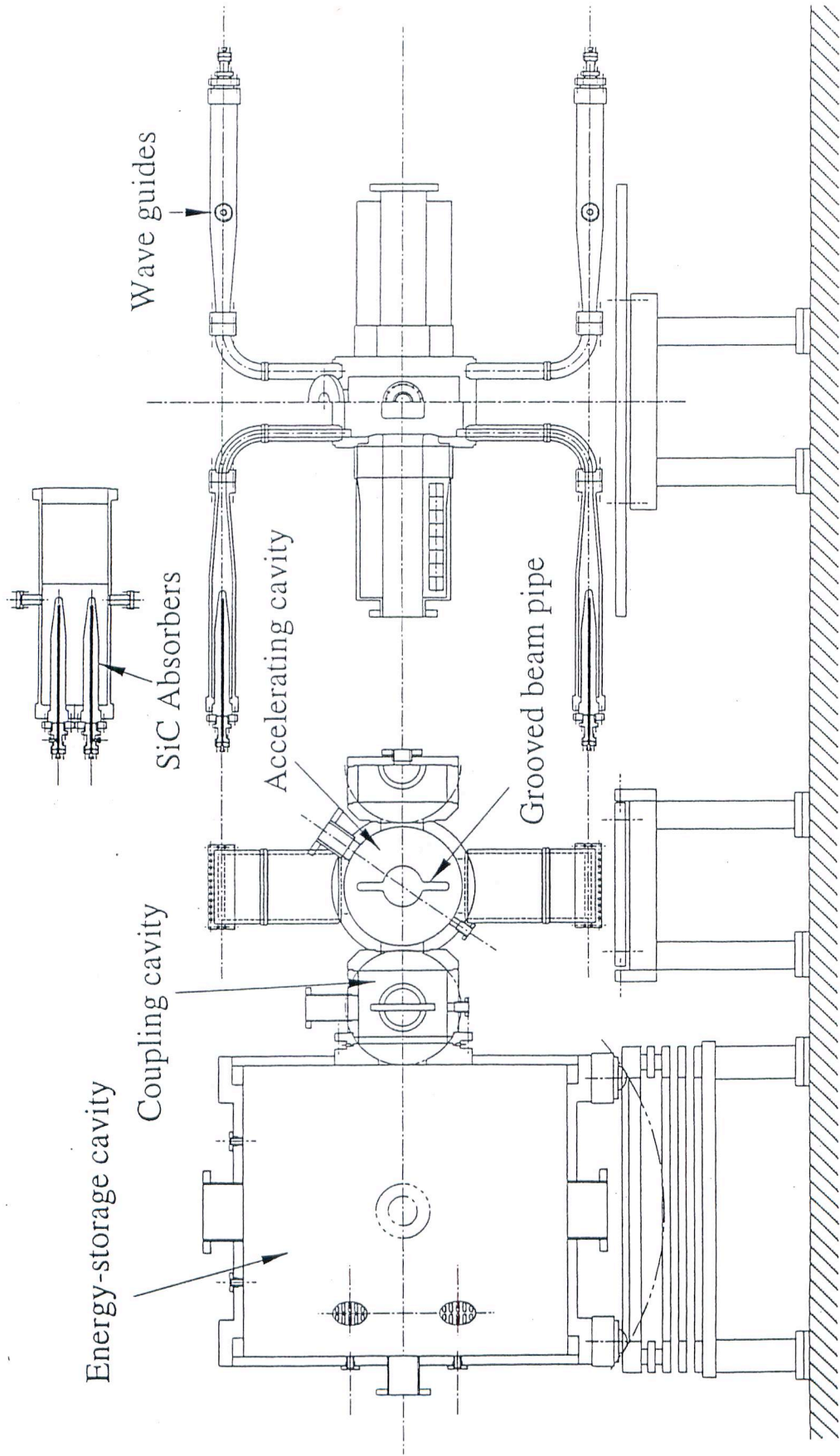
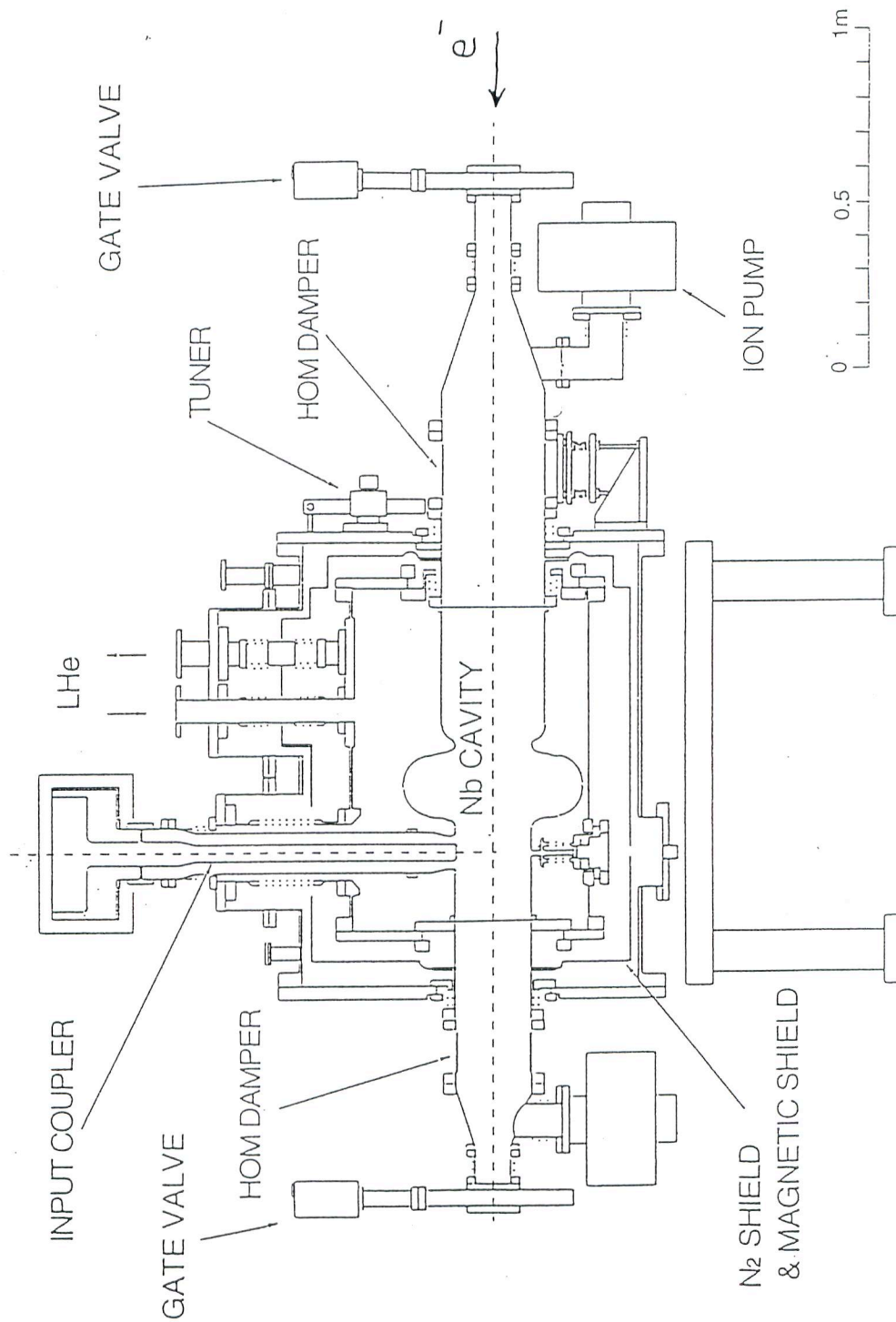


Figure 1: Layout of the RF stations around the KEKB ring.

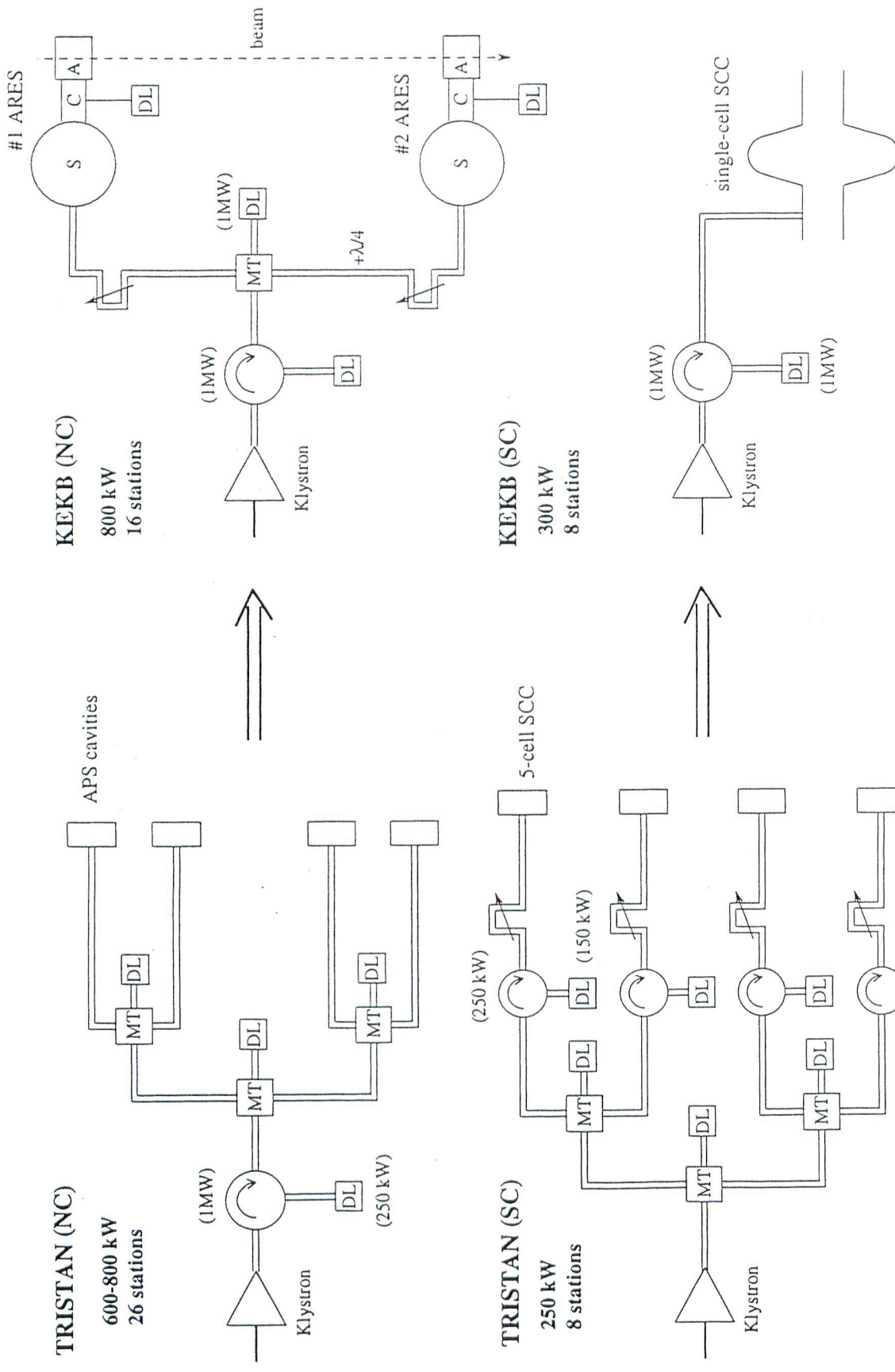


ARES cavity for KEKB



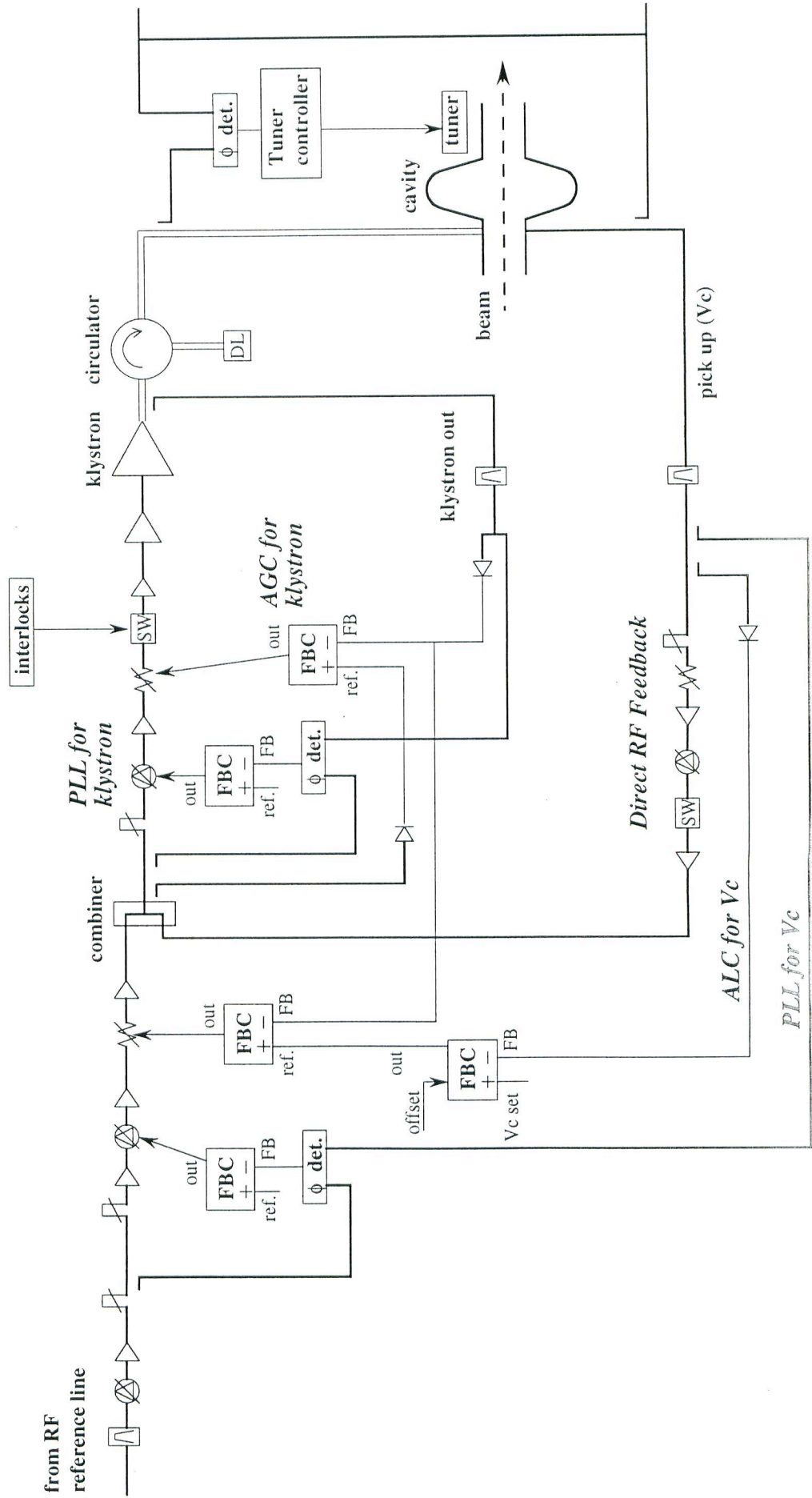
Superconducting Cavity for KEKB

Wave-Guide System of TRISTAN and KEKB



RF System for KEKB Superconducting Cavity

K. AKAI



RF-related Machine Parameters

	LER	HER	GeV
Beam energy	3.5	8.0	GeV
Beam current	2.6	1.1	A
Bunch length	4	4	mm
Synchrotron tune	0.01 - 0.02	0.01 - 0.02	
RF voltage	4.9 - 9.4	8.7 - 16.2	MV
RF frequency	508.887		MHz
Energy damping time	43 / 23*	23	ms
Radiation power	2.1 / 4.0*	3.8	MW
HOM loss	0.57	0.14	MW
Total beam power	2.7 / 4.5*	4.0	MW

*with wigglers for LER

Commissioning and Upgrade Strategy

- Construction of RF system goes in two phases:
 - (1) Commissioning (FY1998)
 - Provide necessary voltage to have $\sigma_z < 10\text{mm}$ and $v_s > 0.01$
----> $V_c > 3\text{ MV (LER)}$, $> 6\text{ MV (HER)}$
 - 50 % of full beam current can be stored.
 - (2) High luminosity run ($L=10^{34}\text{ cm}^{-2}\text{s}^{-1}$)
 - Provide full required voltage.
 - Store full beam current.
- Choice of accelerating cavities
LER: ARES
HER: SCC+ARES (hybrid)
- Crab cavity is being developed to meet potential need of crab crossing.

Number of Accelerating Cavities

revised, Mar. 1999

Ring	Station (cavity)	Commissioning Dec.1998	High Luminosity Run Nov.1999	FY2000

LER				
	Fuji (ARES)	12	20	20
	Total Vc	6 MV	10 MV	10 MV

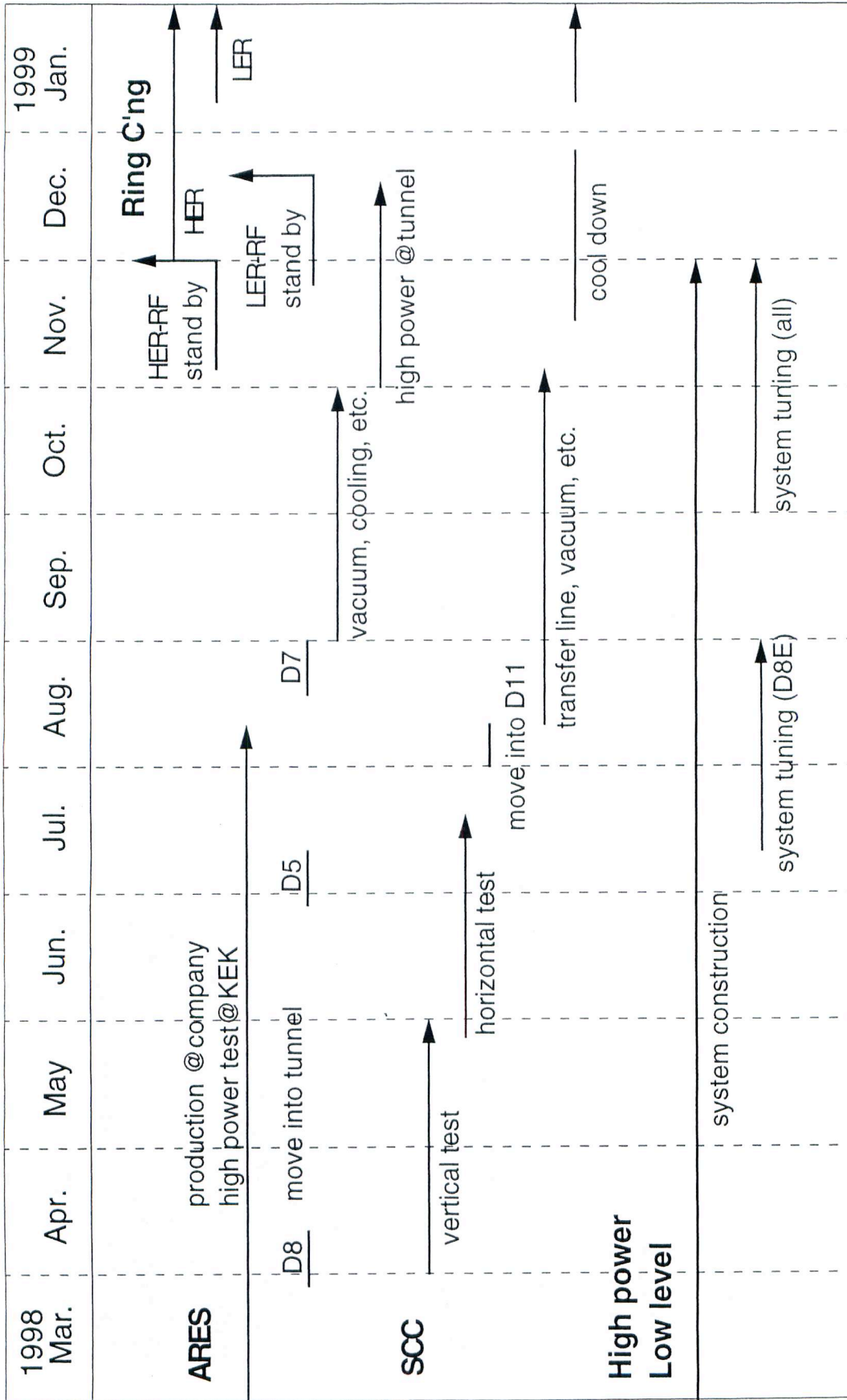
HER (hybrid)				
	Oho (ARES)	6	12	12
	Nikko (SCC)	4	4	8
	Total Vc	9 MV	12 MV	18 MV

(Total Vc is the design value assuming 0.5MV/ARES and 1.5MV/SCC.)

Example of RF Parameters

Ring	LER w/wiggler ARES	HER hybrid SCC+ARES
Cavity	-	10
Relative phase	deg.	
RF voltage	MV	17.9
Number of cavities		8 + 12
R/Q	Ω	93 / 14.8
Q_0		$>1 \times 10^9 / 1.1 \times 10^5$
Q_L ($\times 10^4$)		8.0 / 3.0
Input coupling		- / 2.7
Cavity voltage	MV/cav.	1.5 / 0.5
Input power	kW/cav.	250 / 340
Wall loss	kW/cav.	- / 154
Beam power	kW/cav.	250 / 250
Number of klystrons		8 / 6
Klystron power	kW	$\sim 270 / \sim 740$

RF System Construction History (since MAC98)



Commissioning operation

(1Dec,98---28Feb,99)

	LER	HER
RF for ring operation	> 800 hours (14Jan-28Feb)	> 1100 hours (13Dec-28Feb)
Number of cav.	12 NC	6 NC + 4 SC
Max. beam current	200 mA (~1000bunches)	242 mA (480bunches)
Nominal Vc	4 MV	8 MV (NC 1.8MV + SC 6.2MV)
Maximum Vc	(will be increased to 6MV)	10 MV
Beam power	175 kW @200mA	855 kW @210mA max = 204 kW/SC
HOM power@load	~100W/NC@200mA	~1kW/SC@210mA

RF system performance (general)

- RF system has been operating very stably. Total machine dead-time due to all RF troubles is less than 10 hours.
- No serious troubles have occurred in both ARES and SC cavities. The cavity performance is excellent. In particular, trip of SCC was only twice for three month operation of HER.
- Some troubles and cures taken:
 - Two 250kW dummy loads were damaged. ---> Replaced. Cooling improved.
 - Some control modules broke down. ---> Replaced.
 - One gate valve was closed. ---> Opened.
 - When HER beam is aborted, nearby arc sensors work due to noise. ---> More efforts for noise shielding required.

Operation of SCC from 9 Feb. to 25 Feb.

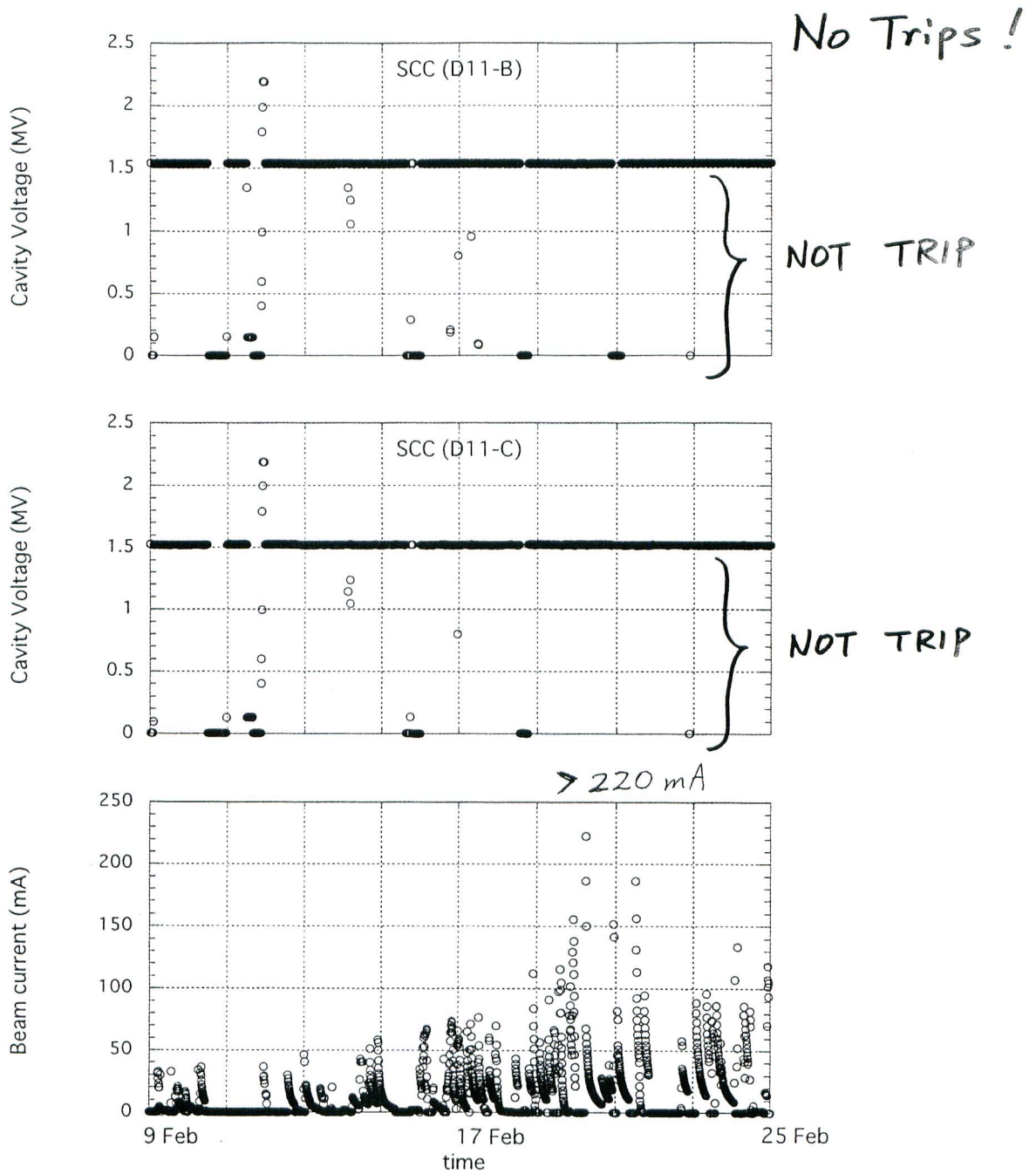
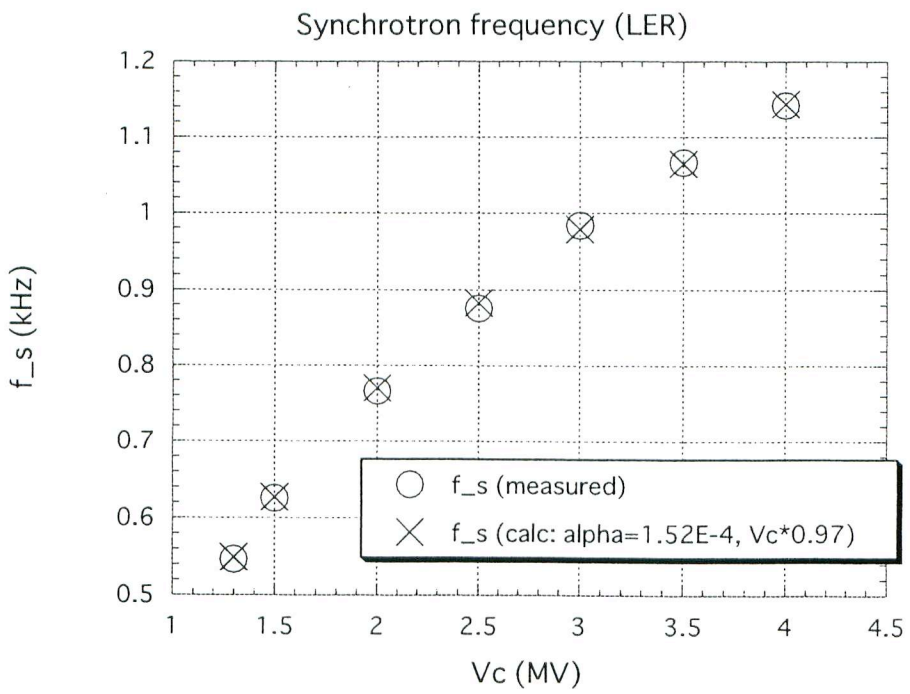
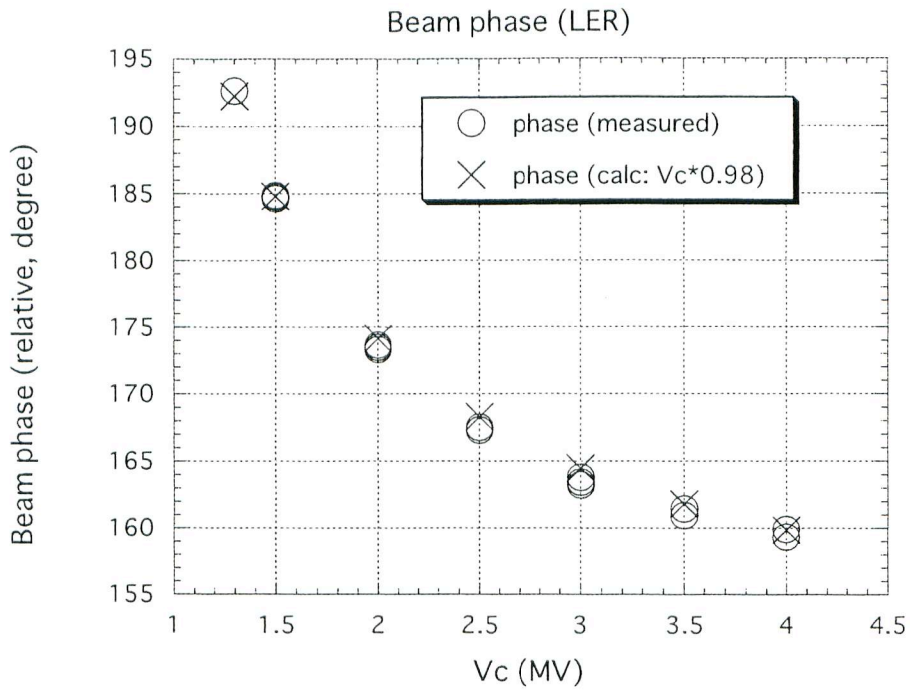
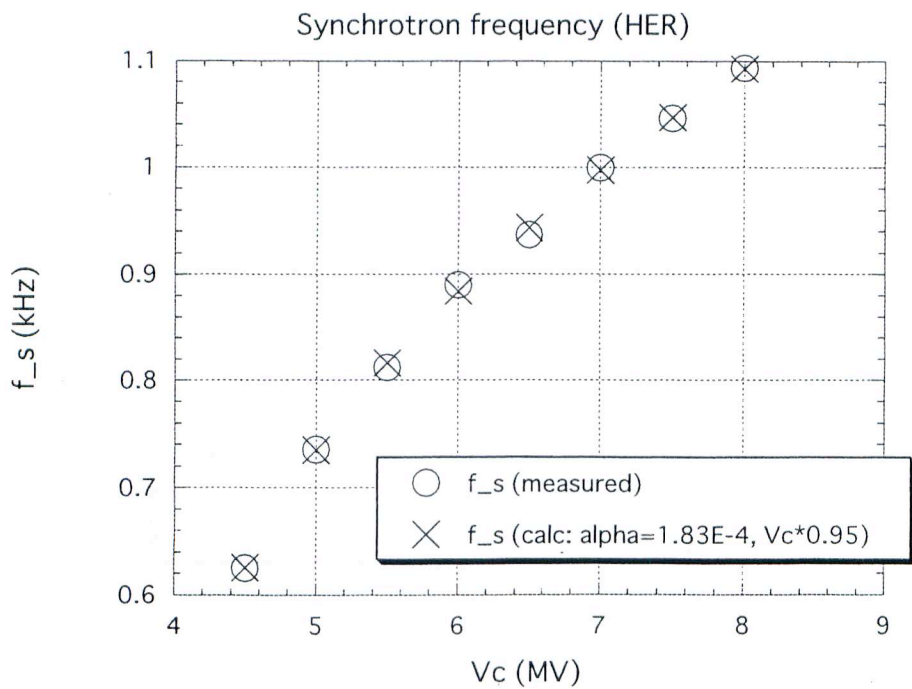
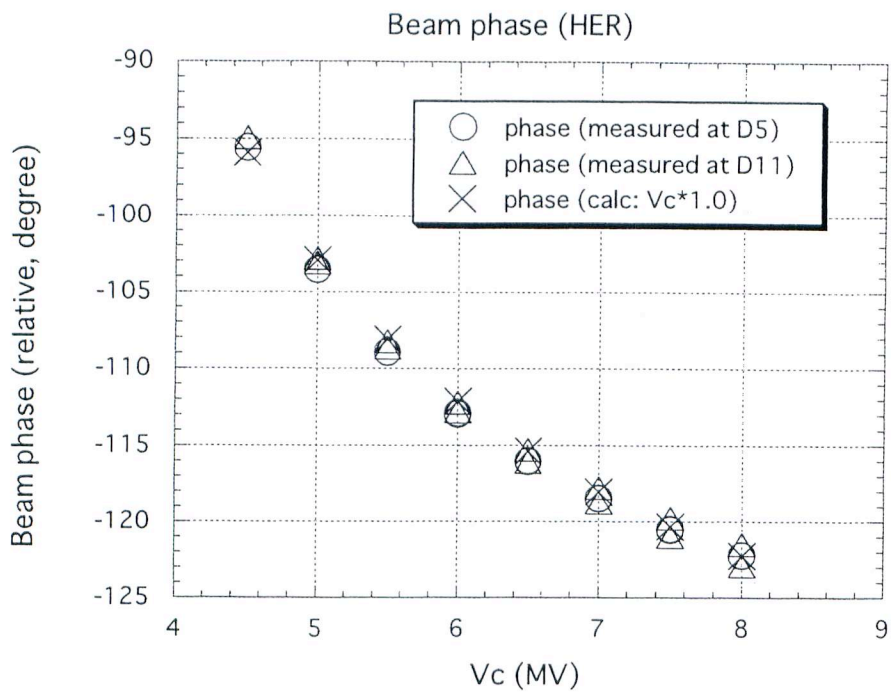


Figure: Operation of SCC from 9 to 25 Feb. 1999.
(top) Cavity voltage of D11-B,
(middle) that of D11-C, and
(bottom) HER beam current.

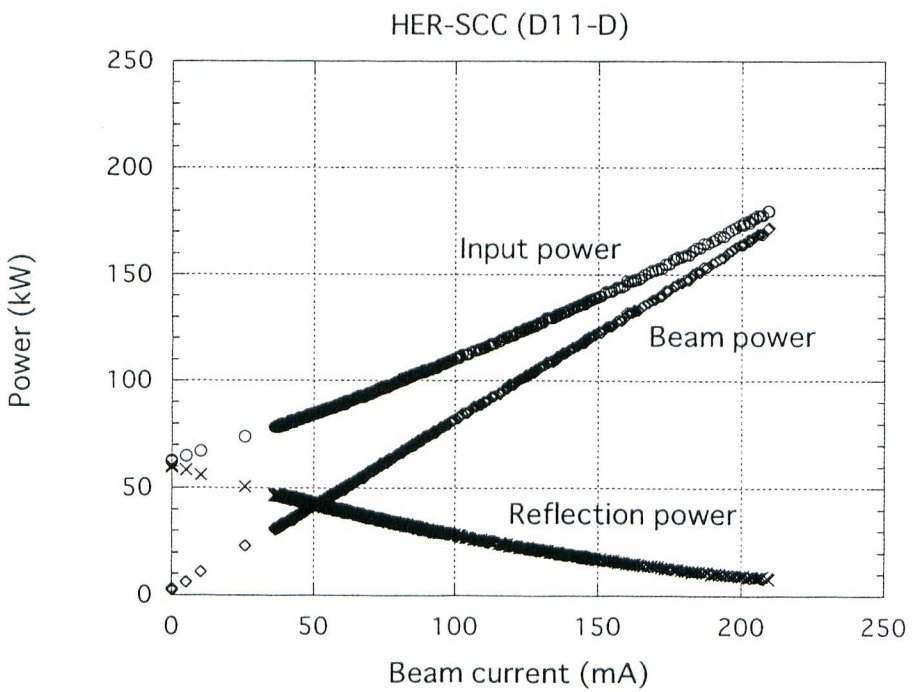
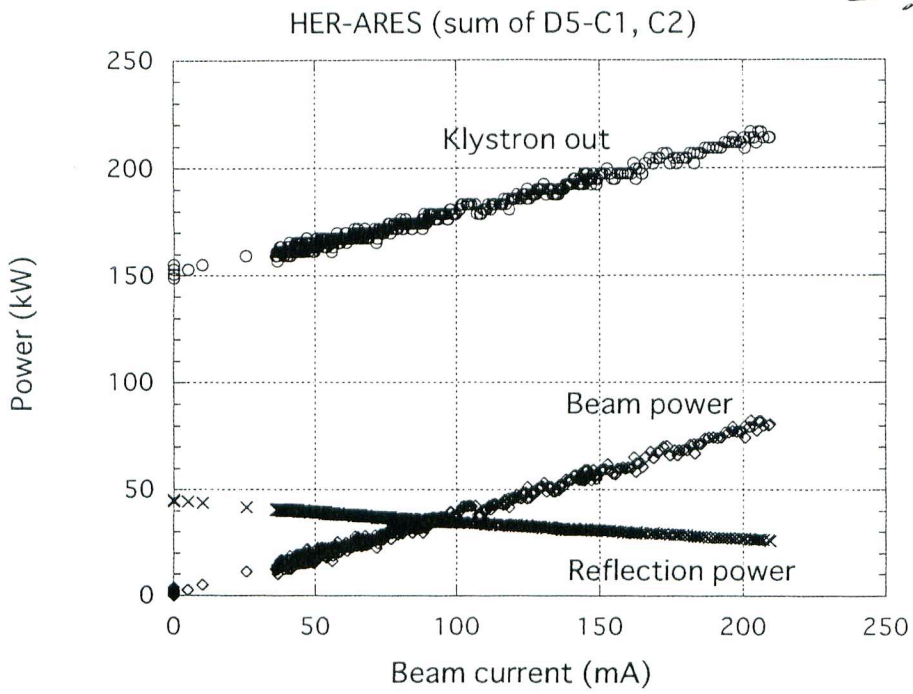
RF system performance (measurements)

- According to measurement of synchrotron tune and synchronous angle, calibration of total V_c is accurate within several %.
- Relative phase between stations was roughly adjusted. More fine adjustment will be done based on beam-loading.
- Power relations are reasonable. In particular, power from ARES coupling cavity agrees well with theory.
- No sign of HOM-induced beam instabilities has been observed.
(Calculated growth rate is about the same as the radiation damping rate at the full design current.)
- Amplitude of observed synchrotron oscillation is small.

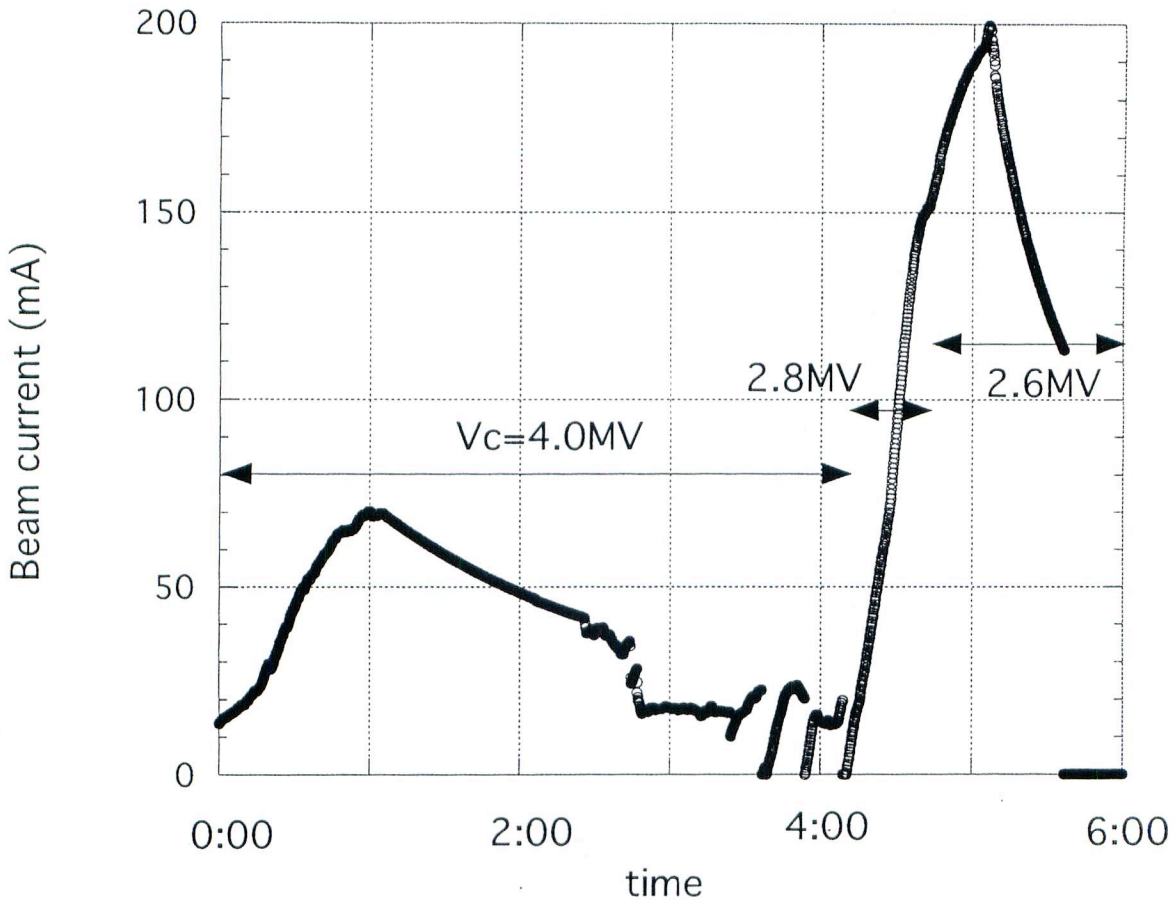




Ratio of V_c
ARES : SCC
= 2 : 5
(for 1 station)

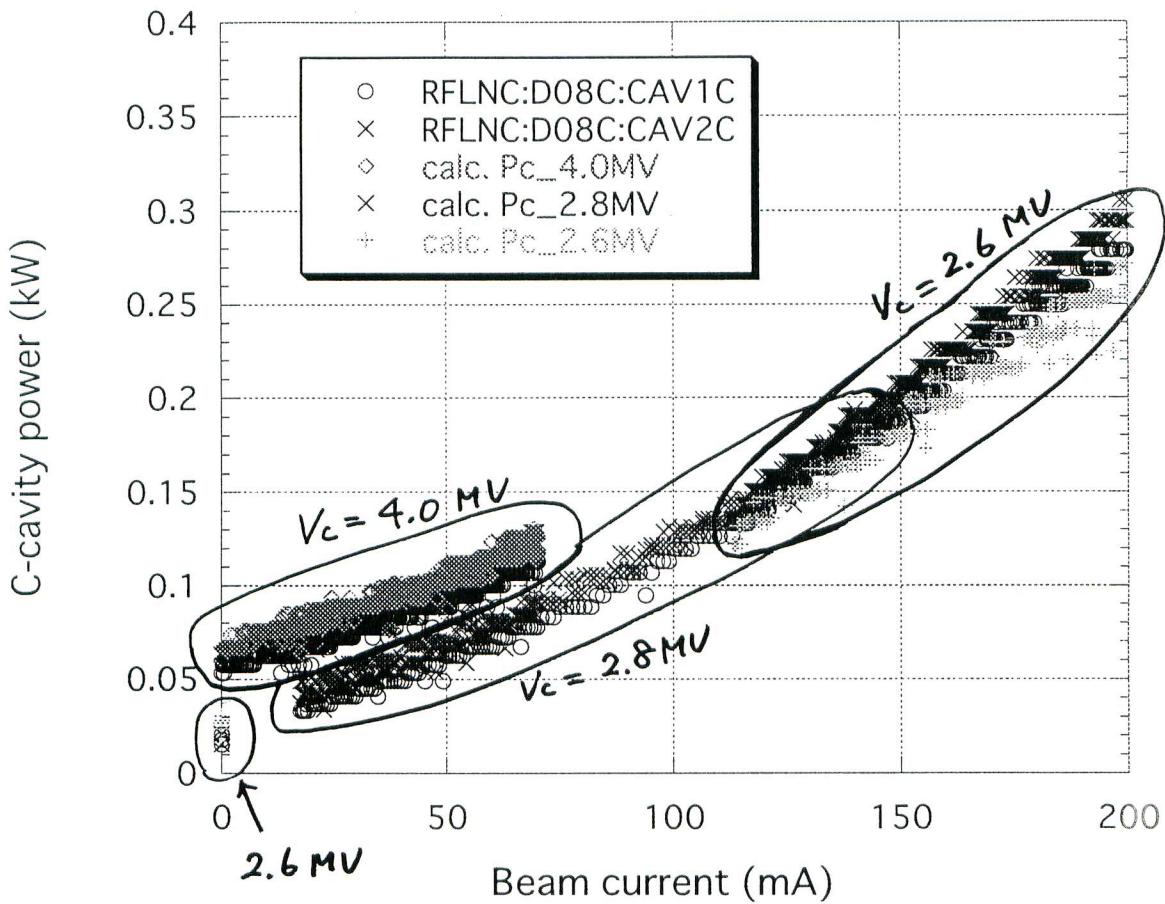


LER beam current (28 Feb.99)



Power from the Coupling Cavity of ARES (measurement and calculation)

ARES: C-cavity power (D8-C1,C2)



Conclusion

- RF system for the commissioning was completed by Dec. 1998.
- RF system has been stably operated through the commissioning.
- We will continue watching the performance for more high beam current.
- The upgrade will be completed by FY2000 to reach the design luminosity ($L=10^{34}$ /cm²s).