



Elimination of circulators at STF-1

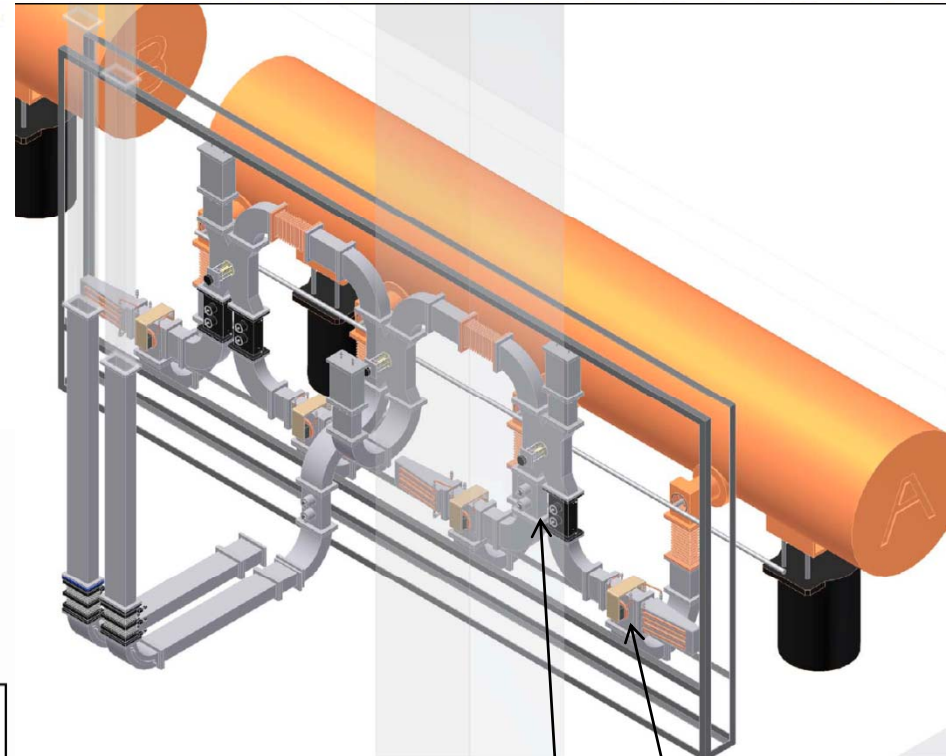
Shin Michizono (KEK)

- System configuration at STF-1
- LLRF stabilities without circulators
- Forward and reflection rf fields
- Low power measurements
- Comparison between low-power and high-power



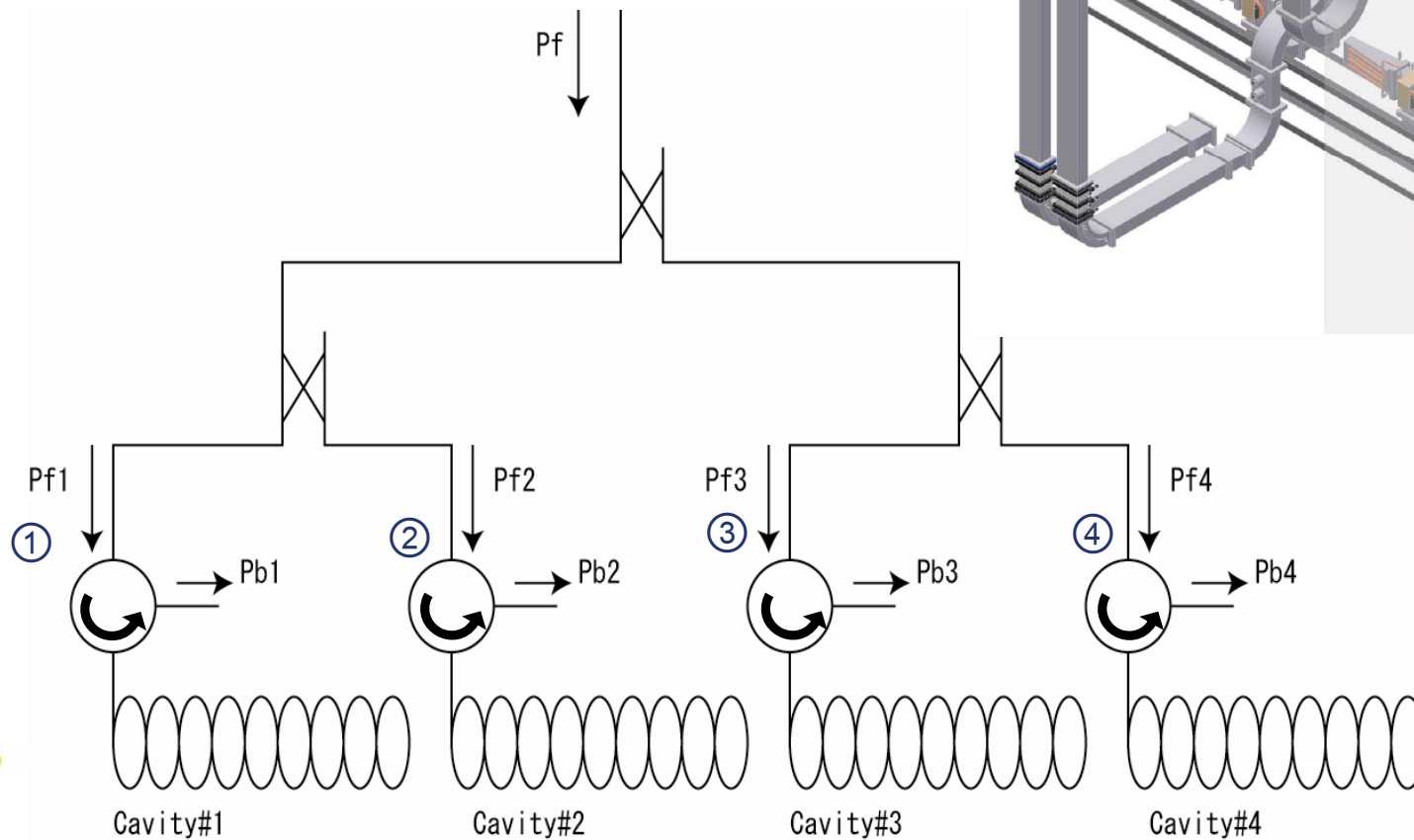
RF distribution system at STF-1

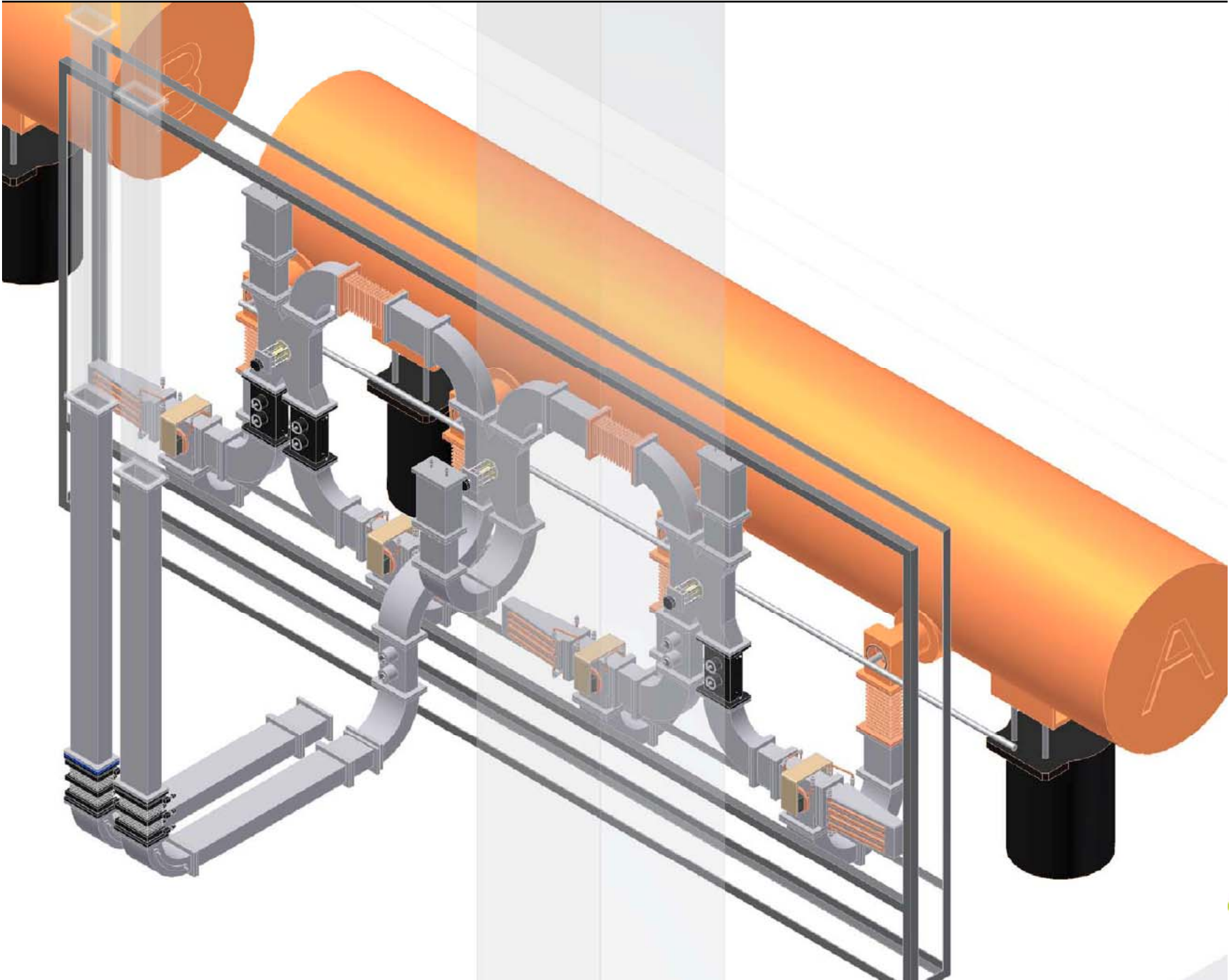
- A klystron drives 4 cavities via hybrid.
- Circulators are installed before the cavities.



circulator

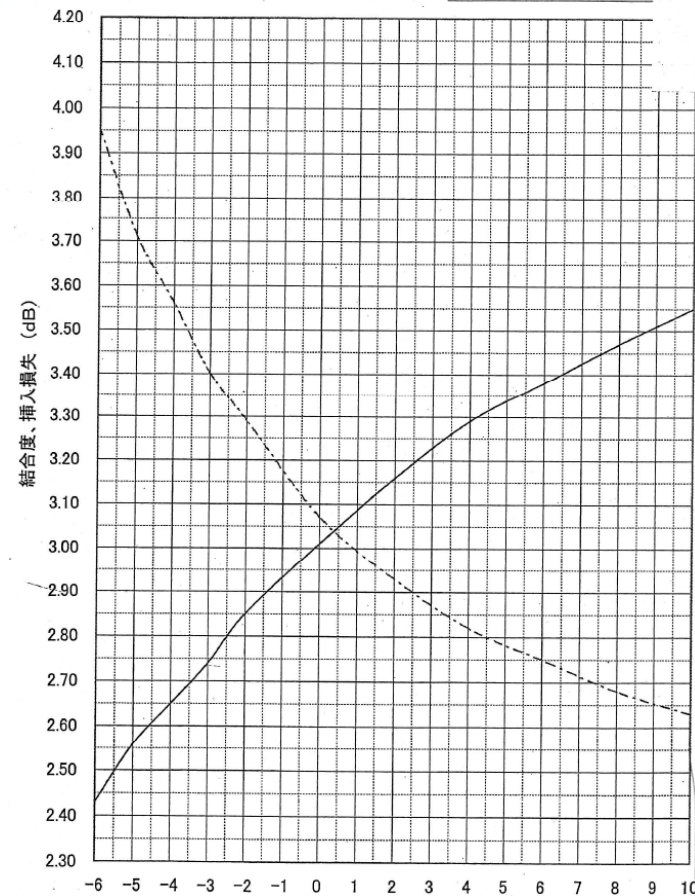
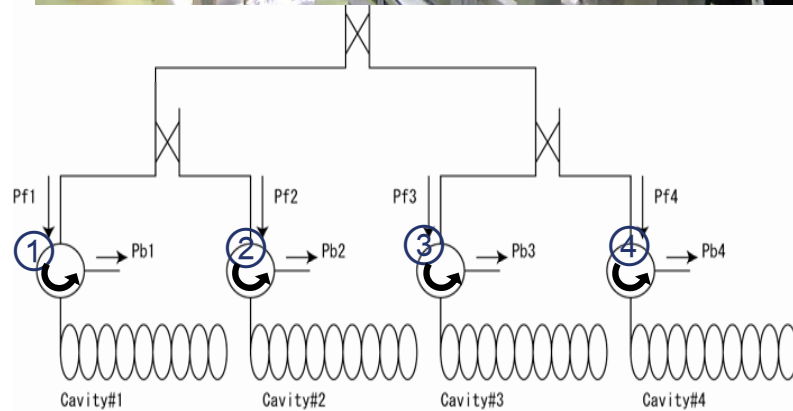
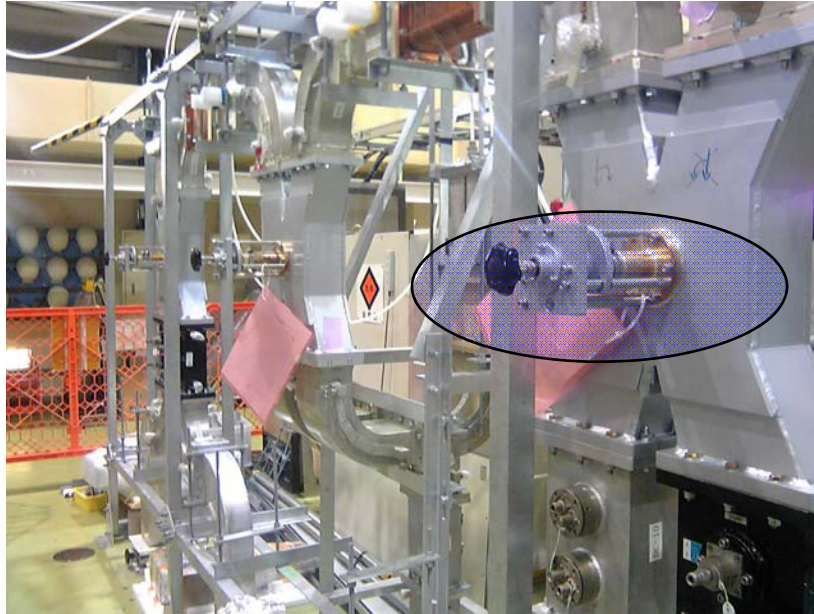
Hybrid







Variable hybrid

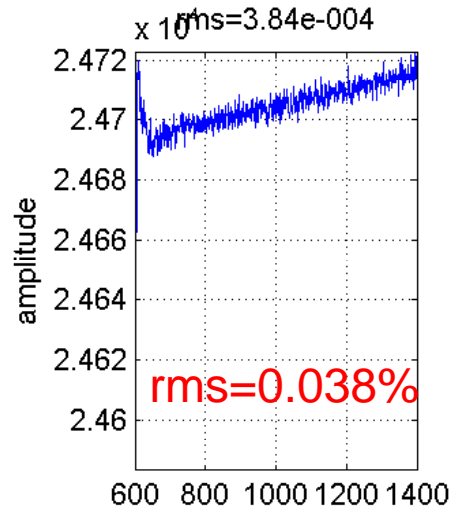


■ By changing a knob on hybrid, we can change the rf distribution ratio 2.4-4dB (+/-15% in power)

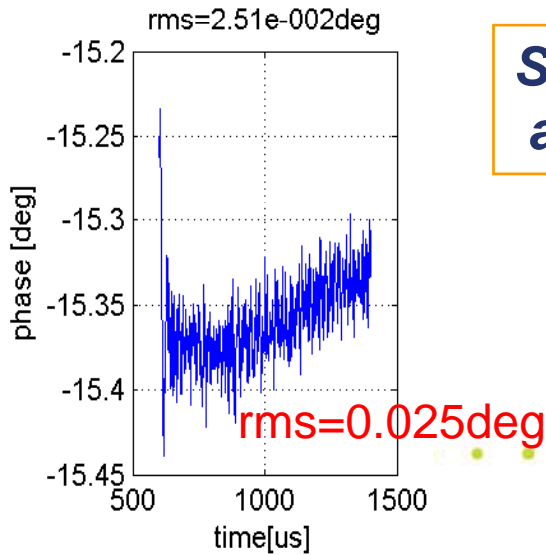
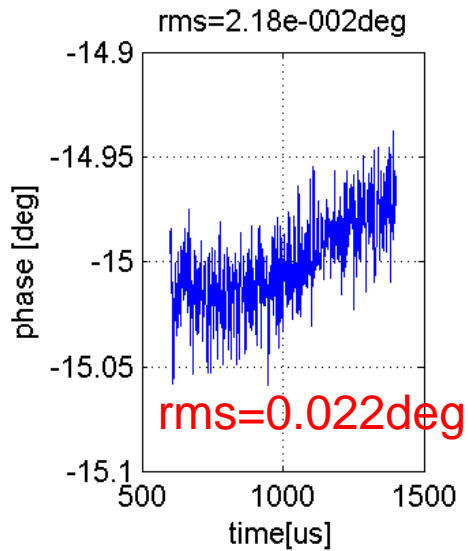
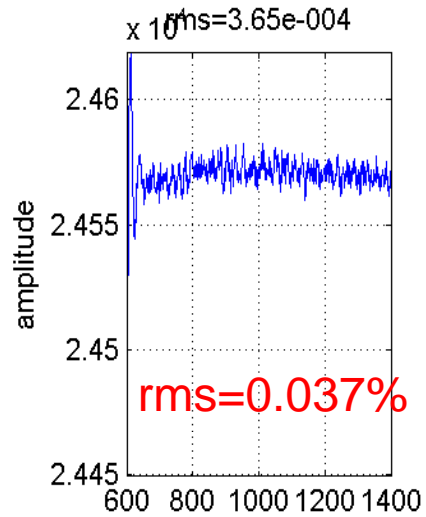


Comparison of Acc Field Stability

With Circulators



Without Circulators

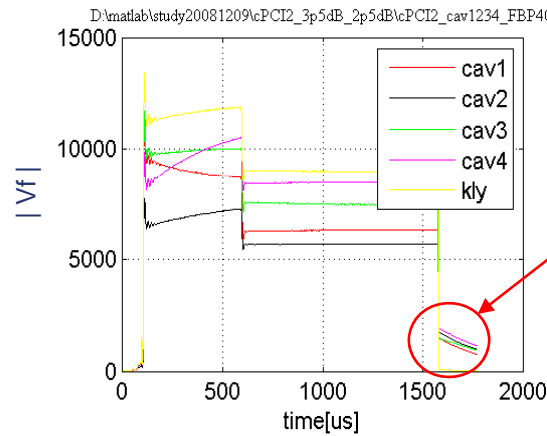
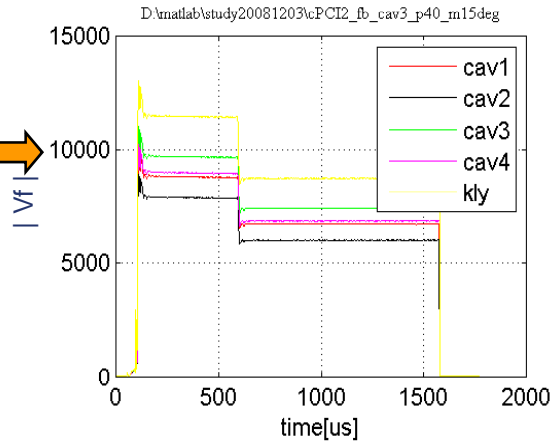


Stabilities of the Acc fields are almost same.

ilc Cavity Input Signals

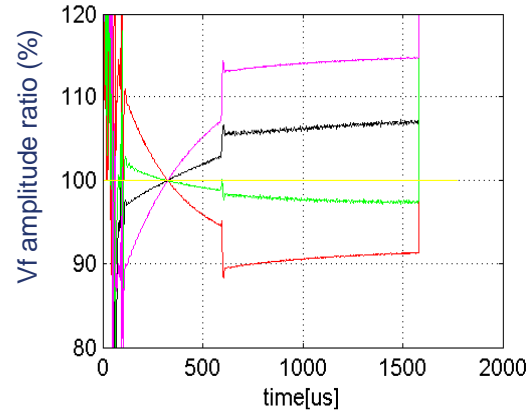
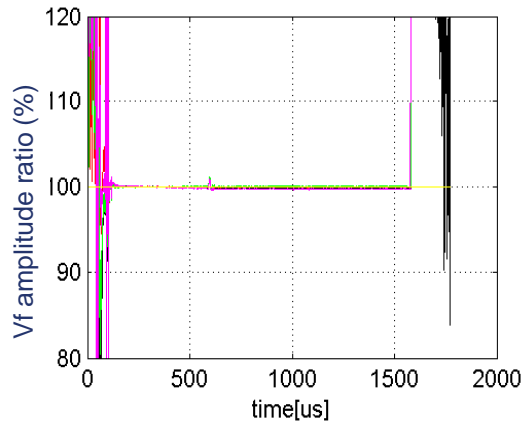
With circulators Without circulators

Cavity input



Cavity input exists even after RF off

Normalized by klystron output



Cavity input power is different due to the reflection



Results of Loaded Q measurement for cav1

Error of $Q_L \leq \pm 0.002 \times 10^6$

	condition	Loaded Q (cav. #1)	Pf_rf_off
(1)	With circulators	1.28E+06	0.206%
(2)	Without #1 circulator	1.22E+06	7.06%
(3)	Without #1 and #2 circulators, cavity #2 detune	1.40E+06	6.86%
(4)	Without all circulators, only cavity #2 detune	1.47E+06	5.02%
(5)	Without all circulators, cavities #2,#3 detune	1.34E+06	6.19%
(6)	Without all circulators, cavities #2,#3,#4 detune	1.35E+06	7.35%
(7)	Without all circulators, only cavity #2 detune (poor hybrid isolation 35dB ->25dB)	1.26E+06	20.3%
(8)	Without all circulators, cavities #2,#3 detune (poor hybrid isolation 35dB ->25dB)	1.23E+06	18.0%
(9)	Without all circulators, cavities #2,#3,#4 detune (poor hybrid isolation 35dB ->25dB)	1.17E+06	24.6%

■ Results of ((2), (3), (6)) are expected to be the same, but quite different.



Low power measurements

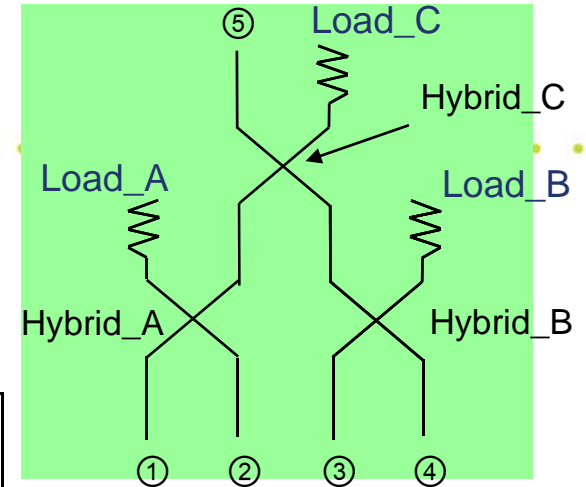
Stub-length@Hybrid (A, B, C)

Isolation Tests of Tree-type waveguide system

<default>

<poor isolation for each Hybrid>

		(0 mm, 10 mm, 0 mm)		(9.5 mm, 10 mm, 0 mm)		(-5 mm, 10 mm, 0 mm)		(-5.5 mm, +10 mm, +9 mm)	
		dB	deg.	dB	deg.	dB	deg.	dB	deg.
Port 1	S11	-44	-78	-24	151	-22	-41	-22	-9
Port 1-2	S21	-29	122	-21	145	-27	-21	-33	-41
Port 1-3	S31	-34	78	-35	75	-34	69	-28	133
Port 1-4	S41	-35	-15	-34	36	-33	30	-29	40
Port 1-5	S51	-6	19	-7	26	-6	20	-6	16



Tree-Type system

The reflection $|V_r|$ just after Power off is twice or less bigger than forward $|V_f|$



Calibrations of cavity, forward and reflection

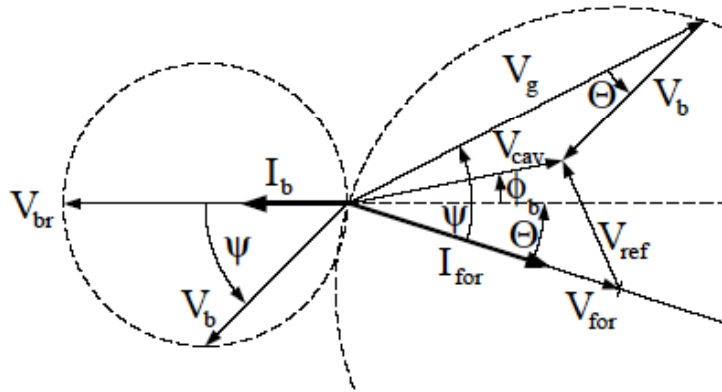
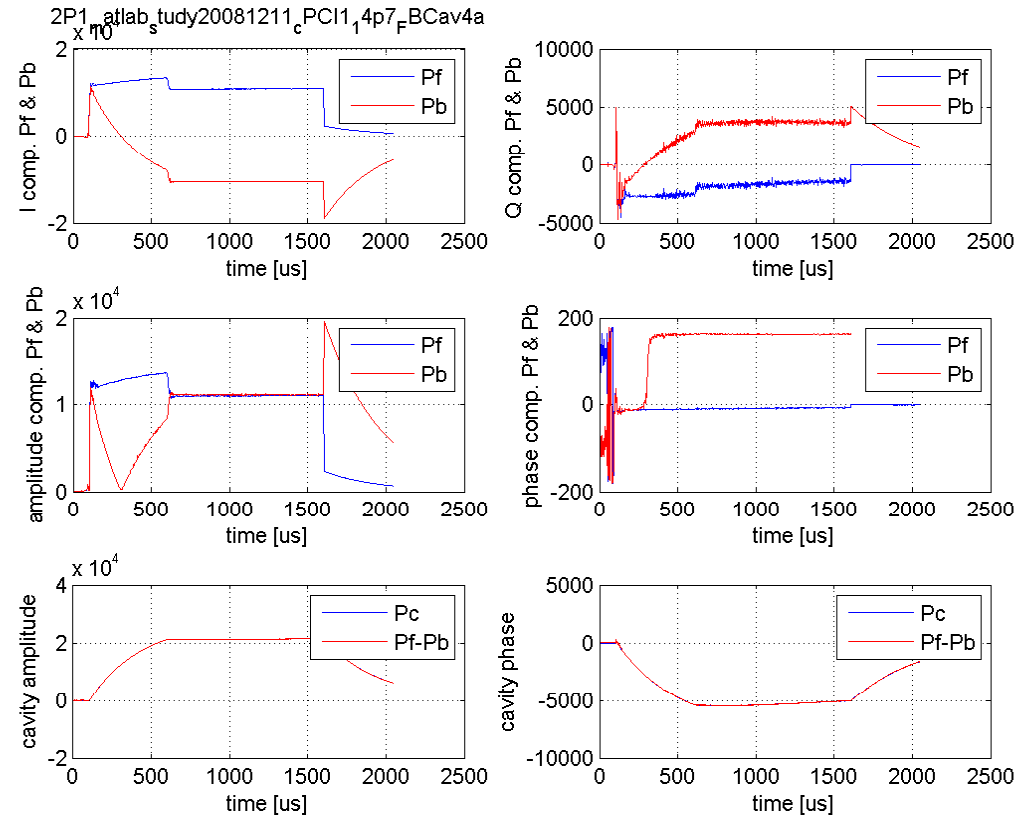


Figure 3.9: Vector diagram of generator- and beam-induced cavity. The angle ϕ_b denotes the beam phase.

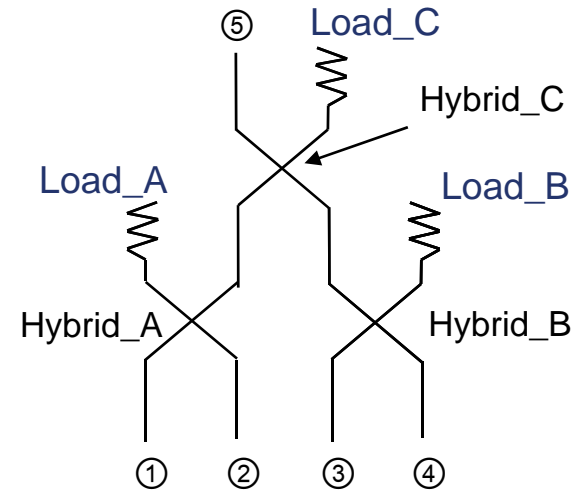
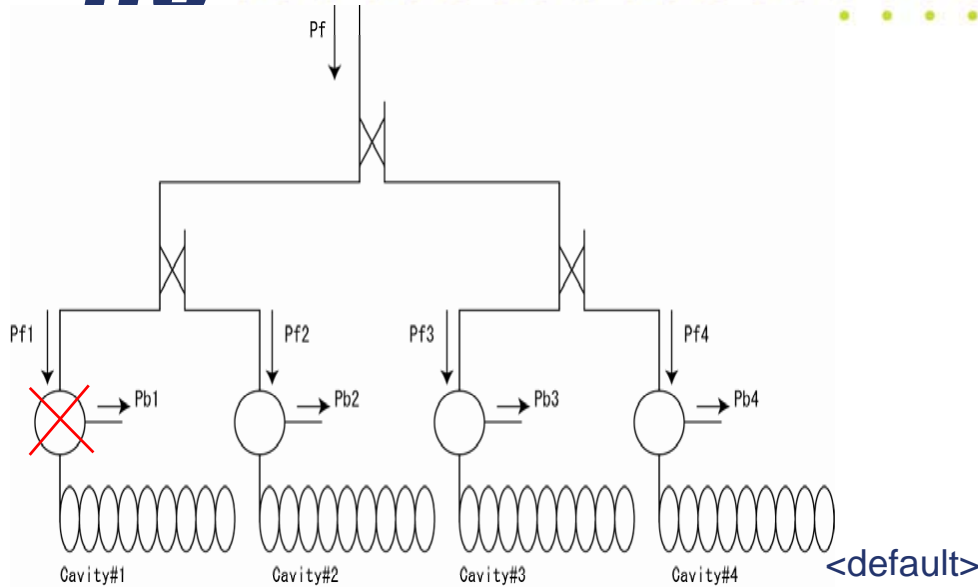
$$\vec{V}_{cav} = \vec{V}_{for} + \vec{V}_{ref}$$



- Cavity pickup signals were calibrated with the power meter.
- Fitting to the cavity pickup was carried out for forward and reflection signal.
- It is possible to compare the forward and reflection at different cavities.



Comparison between high power and low power test

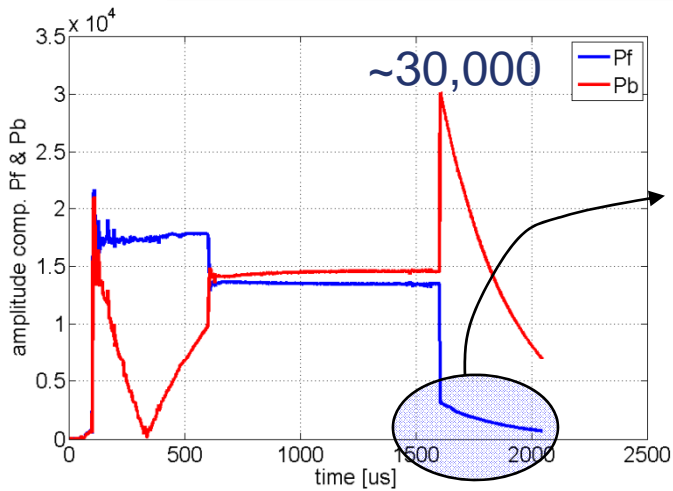
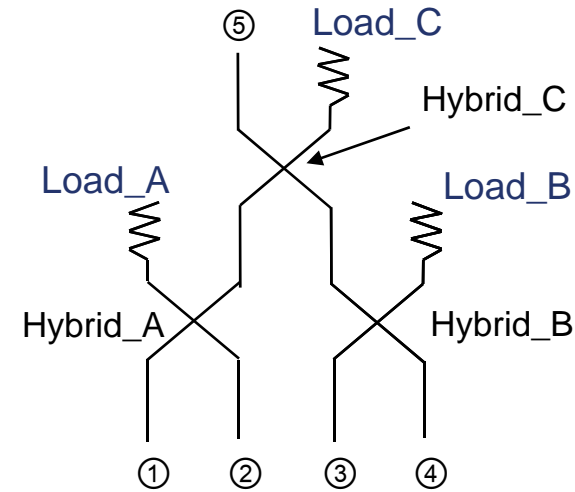
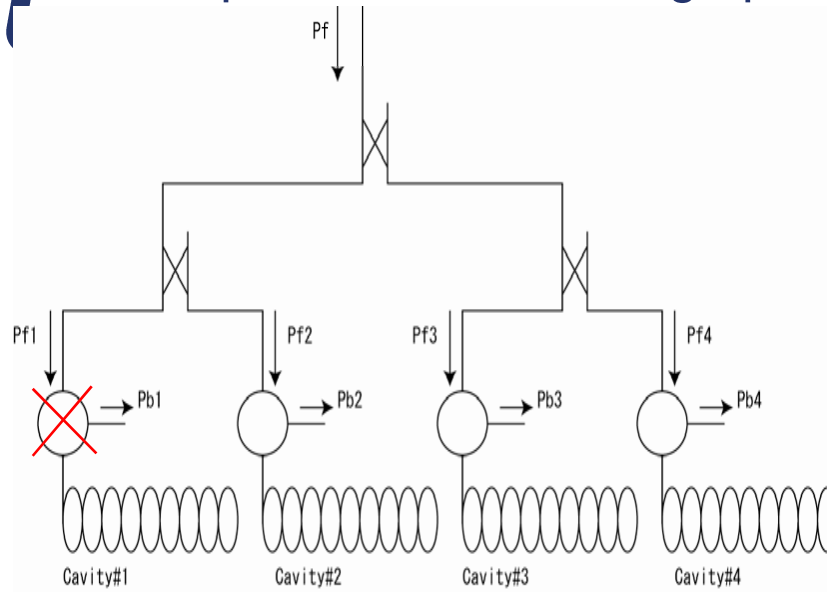


		(0 mm, 10 mm, 0 mm)			(-5 mm, 10 mm, 0 mm)	
		low-level	w/ circulators	w/o cir.#1	low-level	w/o cir.#1
Port 1	S11	-44	-45	-29	-22	-20
Port 1-2	S21	-29	-43	-30	-27	-26
Port 1-3	S31	-34	-42	-31	-34	-31
Port 1-4	S41	-35	-49	-34	-33	-34
Port 1-5	S51	-6			-6	

■ When the isolation is worse, high-power and low-power results agree well.



Comparison between high power and low power test (2)



	<default>		<poor isolation for each Hybrid>	
	w/ cir. (0,10,0)	w/o cir.1 (0,10,0) (-5,10,0)	w/o cir.1,2 (0,10,0) (-5,10,0)	
cav.1	136	944 3115	500 3722	
cav.2	166	844 1448	474 3152	
cav.3	196	756 866	138 389	
cav.4	86	541 611	140 292	

■ When two circulators were removed, effects to cav.#3 and #4 decreased. (~6dB less)



Summary Without Circulators

- ***Stabilities of the Acc fields are almost same.
Vector sum amplitude: 0.038-0.037%rms.
Vector sum phase:0.02-0.018deg.rms***
- ***Due to reflection wave,
Detune and Q_L can not be determined accurately.***
- ***High power and low power results agree well in case of
poor isolation.
High power effects (temperature, high-rf fields) induce the
difference in isolation(?)***