4 Cavity Package Test in STF

STF Phase-1

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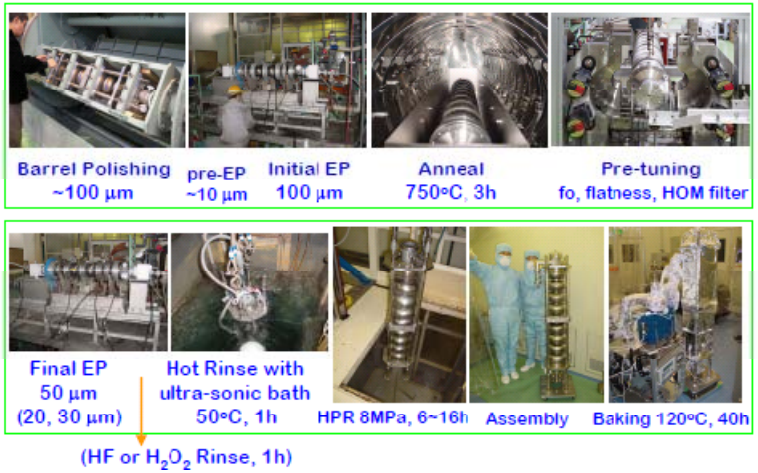
Tesla - Like Cavity Package Cryo-Module Test

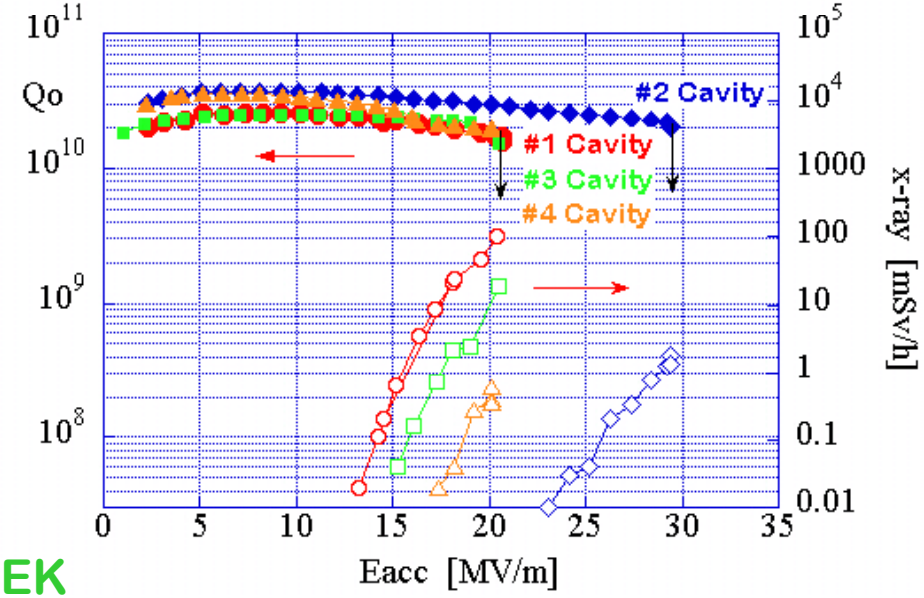
- One Cavity Package ; Sep. ~ Nov. , 2007
- 4 – Cavity Package ; May ~ Dec. , 2008

Outline

- Cavity Package Assembly into the Cryo-module
- Input Coupler Performance
- Cavity High Field Performance
- Mechanical Tuner Performance
- Piezo Tuner Performance
- Mechanical Vibration Modes
- Lorentz Force Detuning
- Summary

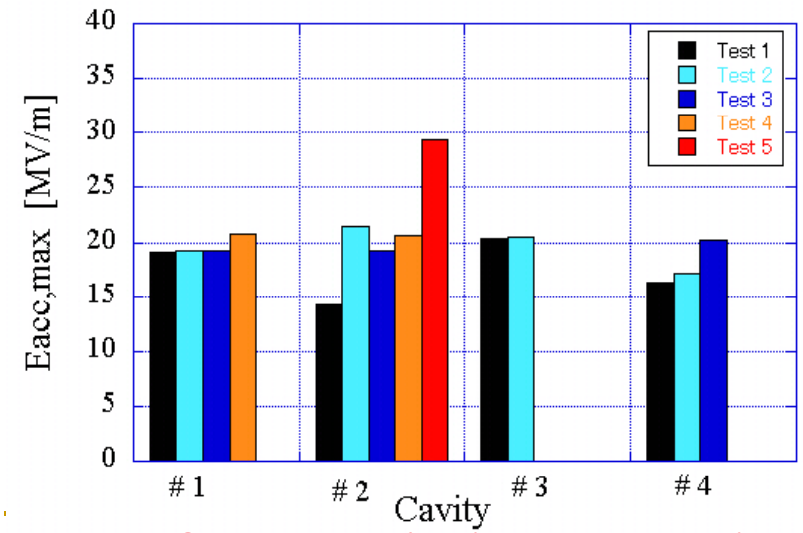
Vertical Tests of STF-BL#1, #2, #3, #4 Cav.





Surface treatment at Nomura Co.

Assembly & Vert. tests in AR-East at KEK



14 tests for 1year (Feb. 2006 ~Feb. 2007)

March, 2007

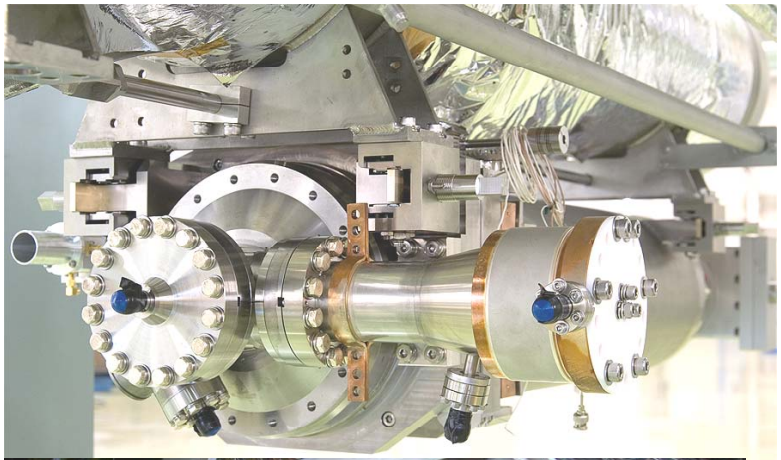
String Assembly in Clean Room

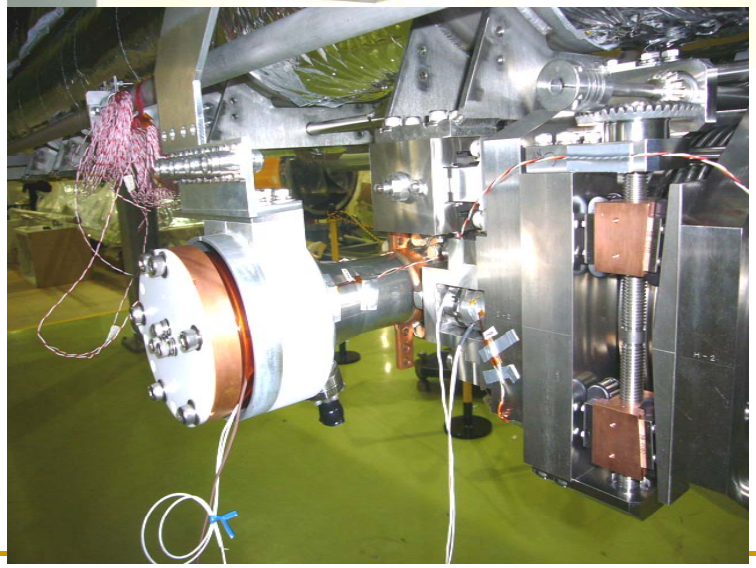
Class 10

Class 1000 to Outside

January, 2008

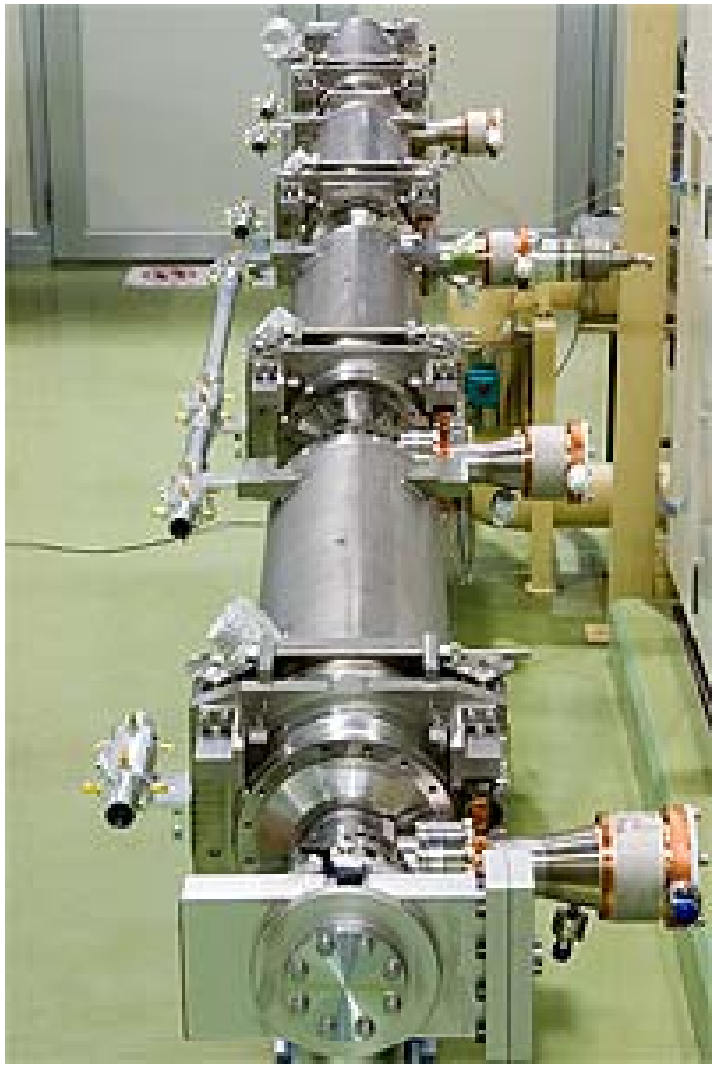
Cavity Assembly





Alignment of Four Cavities

February , 2008'



Cryomodule Cold Mass Assembly

February ~ March, 2008'

Installation in the STF Tunnel

First cool-down, May, 2008'
Warm couplers, June, 2008'

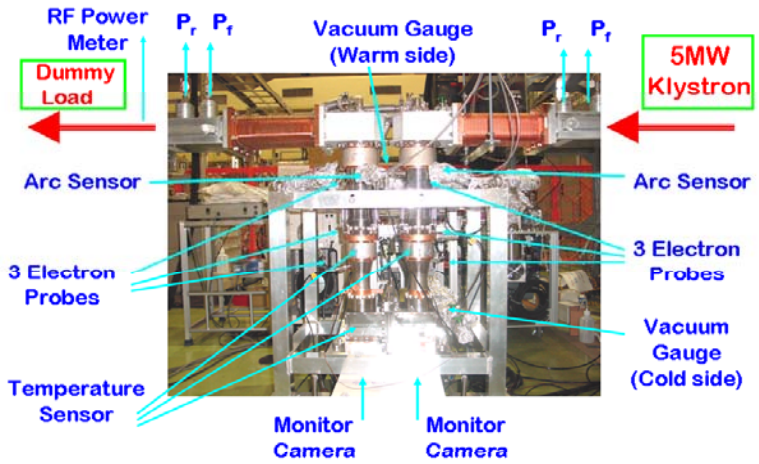
August, 2008'
High power RF distribution system

High power tests of
#2 cavity (29.4 MV/m in V.T)
July, 2008

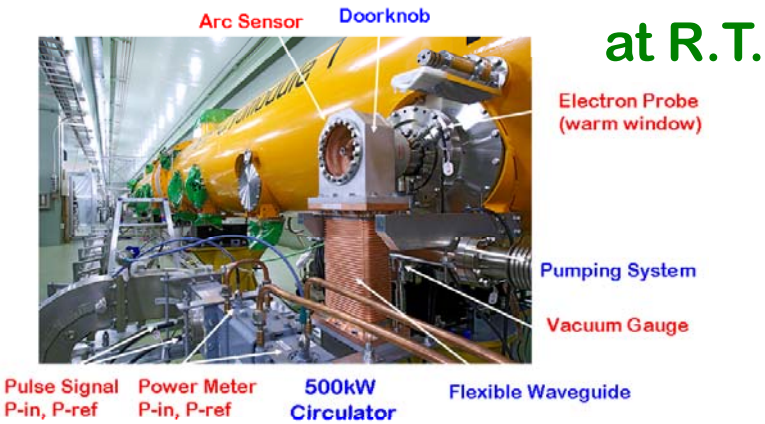
High power tests of #1, #3, #4 cavity
Operation with four cavities
Sept. ~ Dec. , 2008

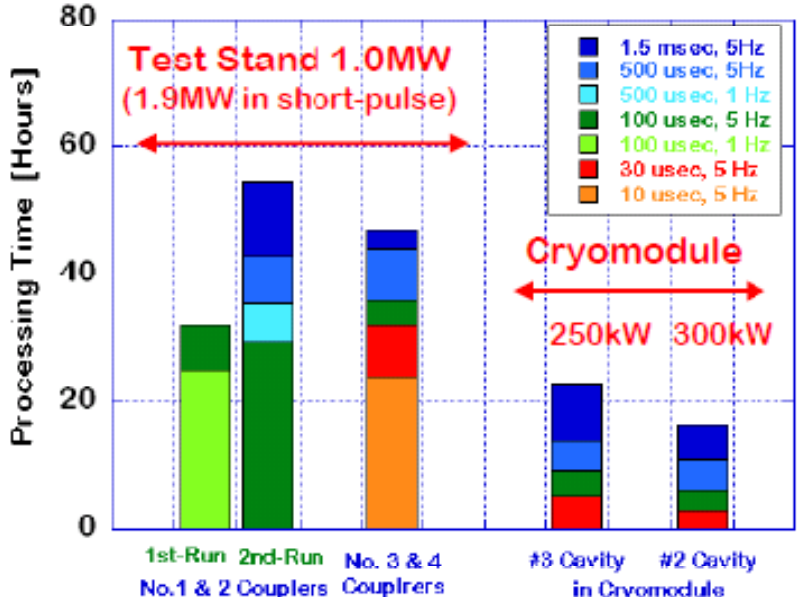
Processing of Input Couplers in STF Phase-1.0

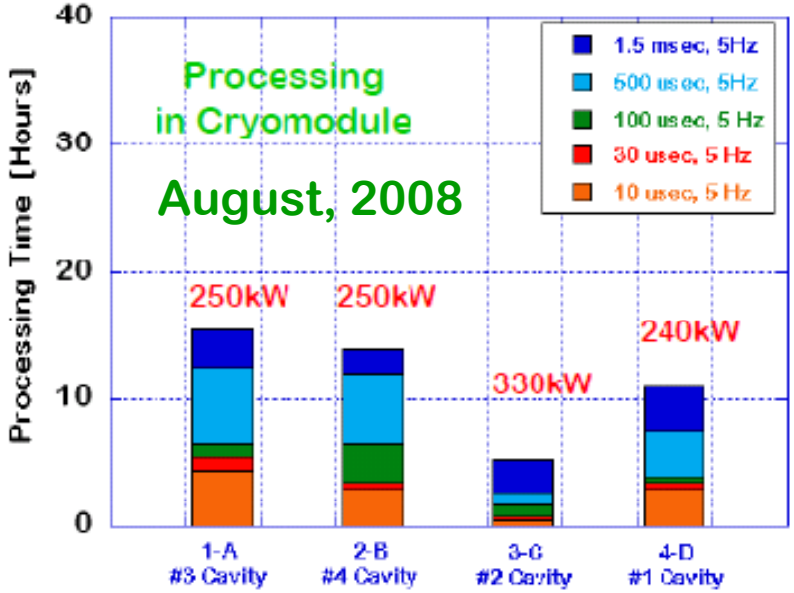
Processing in Test Stand



Processing in Cryomodule at R.T.







Stable Pulsed Operation ; STF Phase-1.0

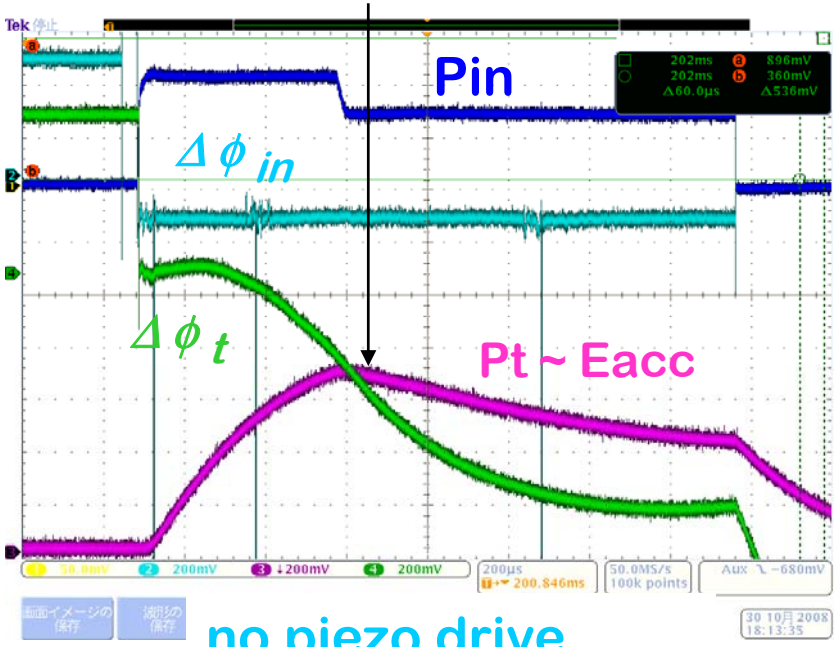
Best Result ; obtained Eacc,max in #2 Cavity

1.5 msec, 5 Hz operation

Oct, 2008'

RF Feedback / OFF

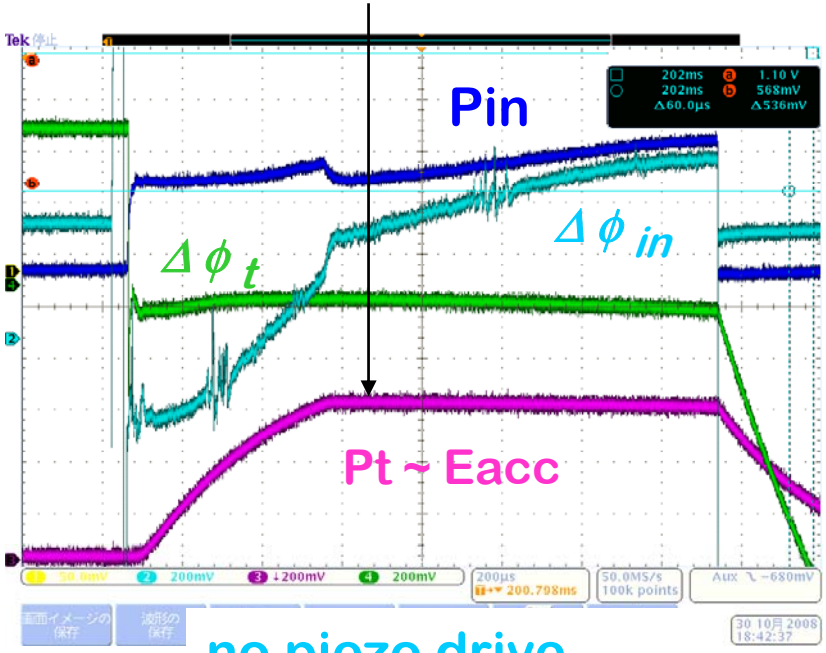
32.7 MV/m



no piezo drive
no pre-detuning

RF Feedback / ON

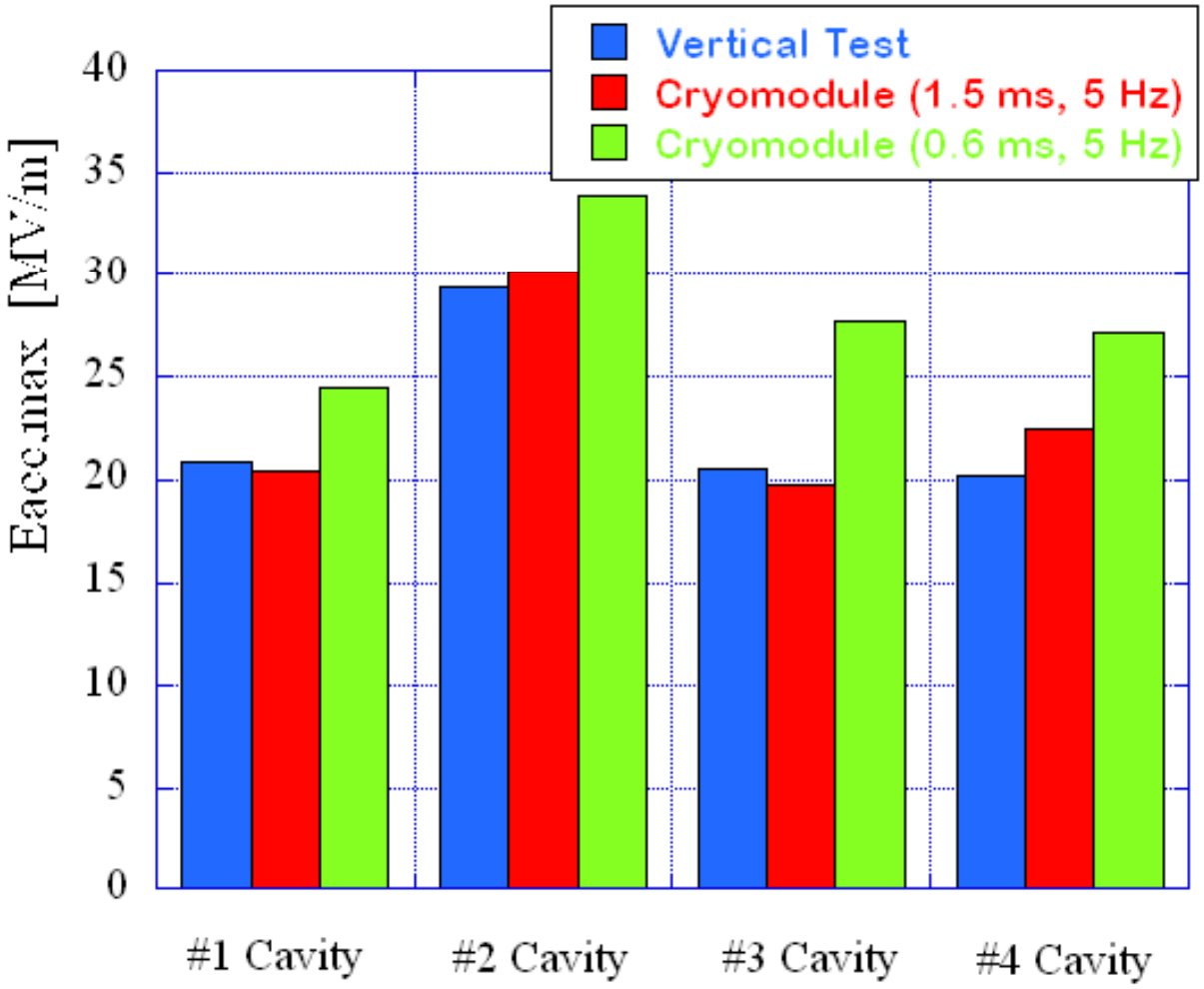
30.1 MV/m



no piezo drive
no pre-detuning

Comparison of achieved Eacc,max

November, 2008

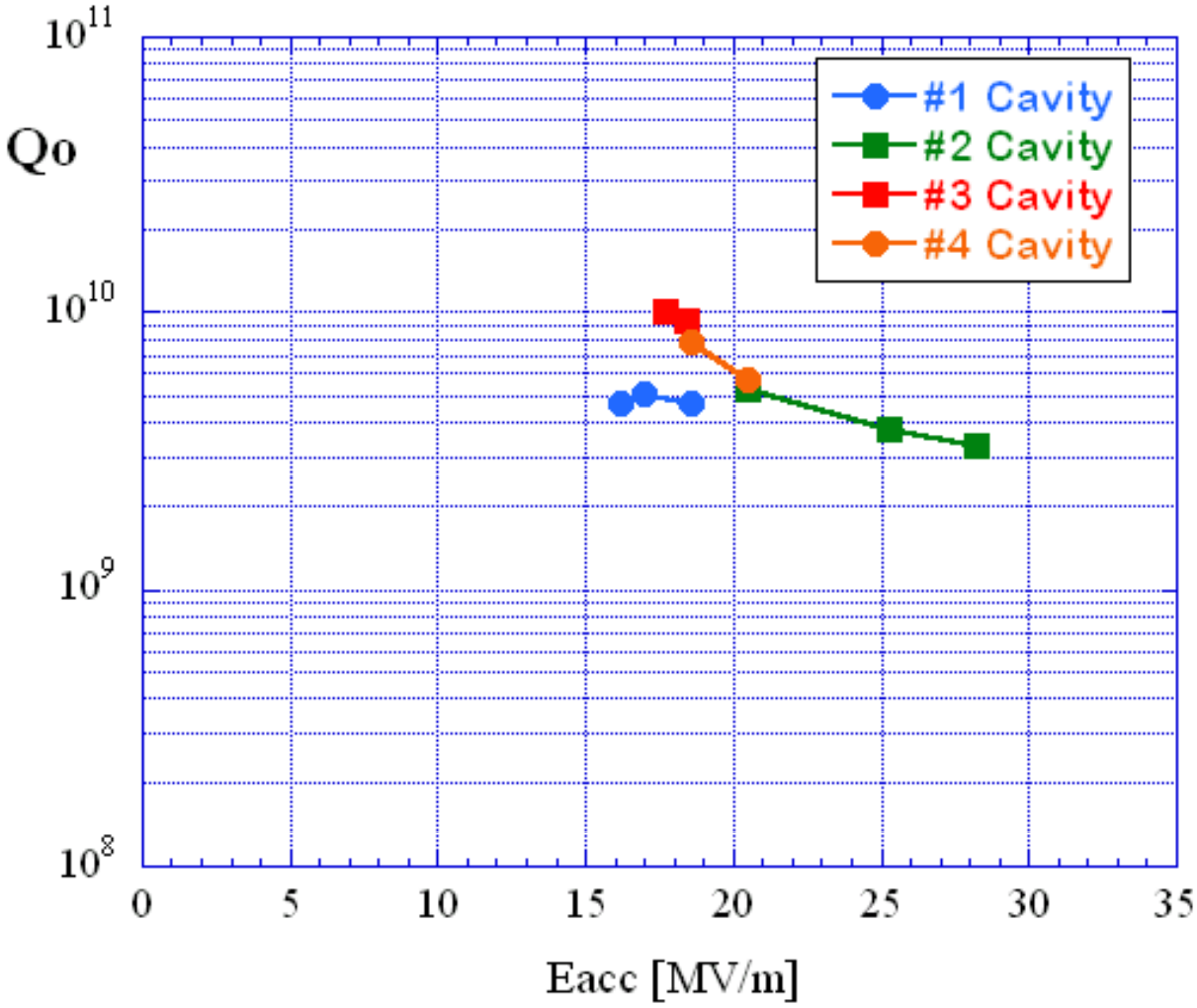


RF FB / ON

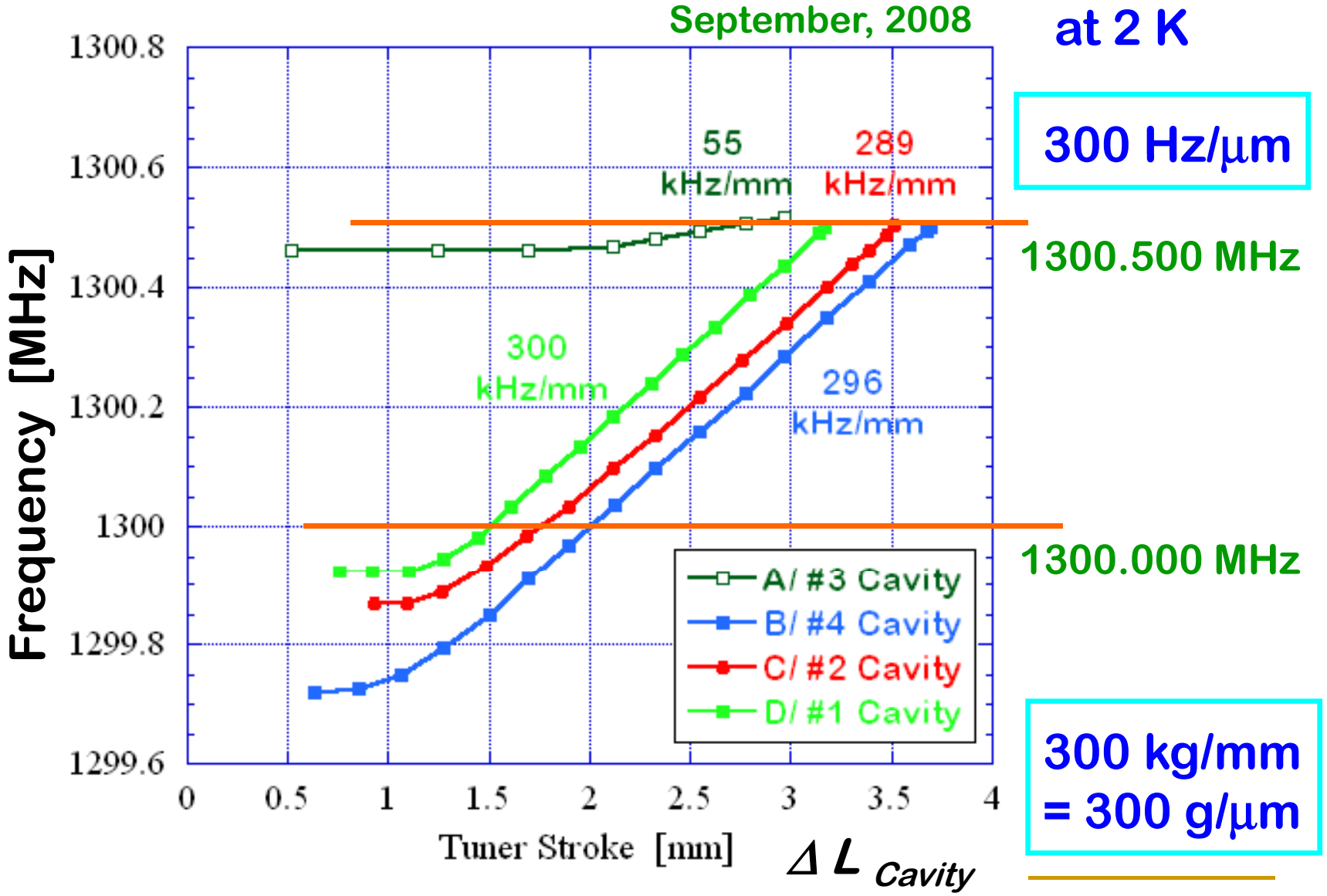
Ave. Eacc,max (V.T)
= 22.7 MV/m

Ave. Eacc,max (Cryo.)
= 23.2 MV/m

Dynamic RF Loss Measurement

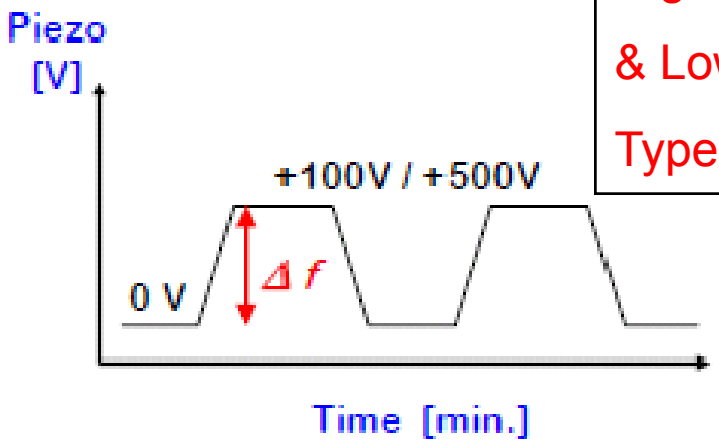


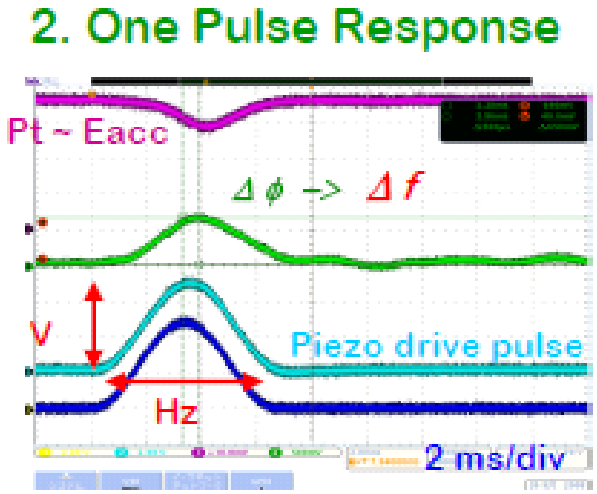
Tuner Stroke in STF Phase-1.0

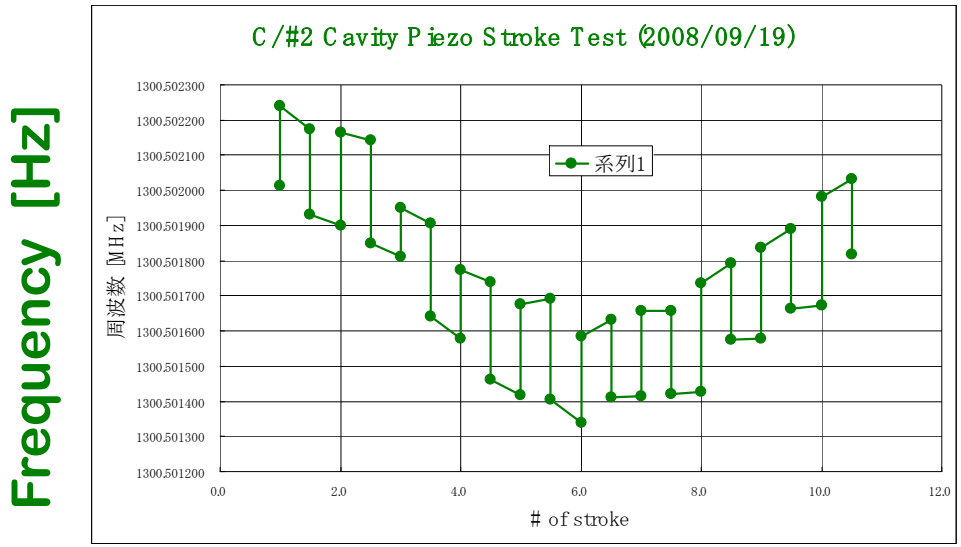


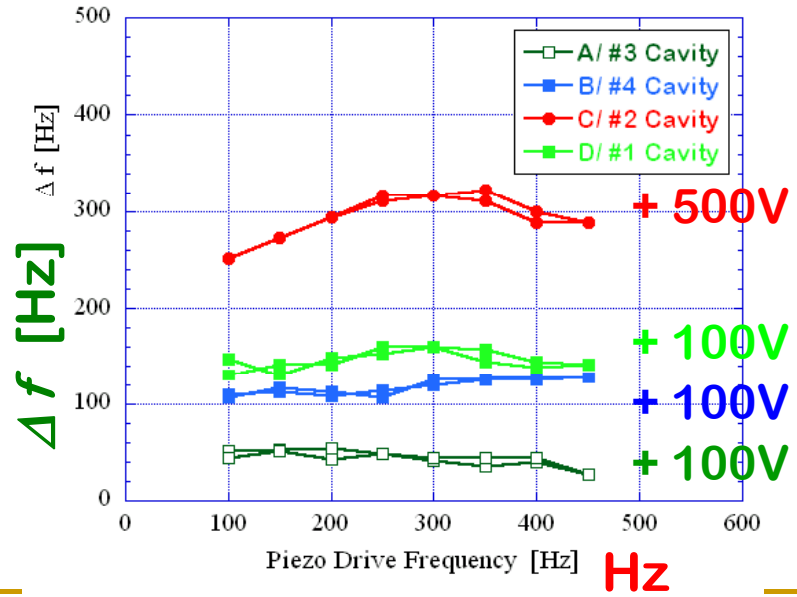
Piezo tuner performance in STF Phase-1.0

High Voltage
& Low Voltage
Type Piezo

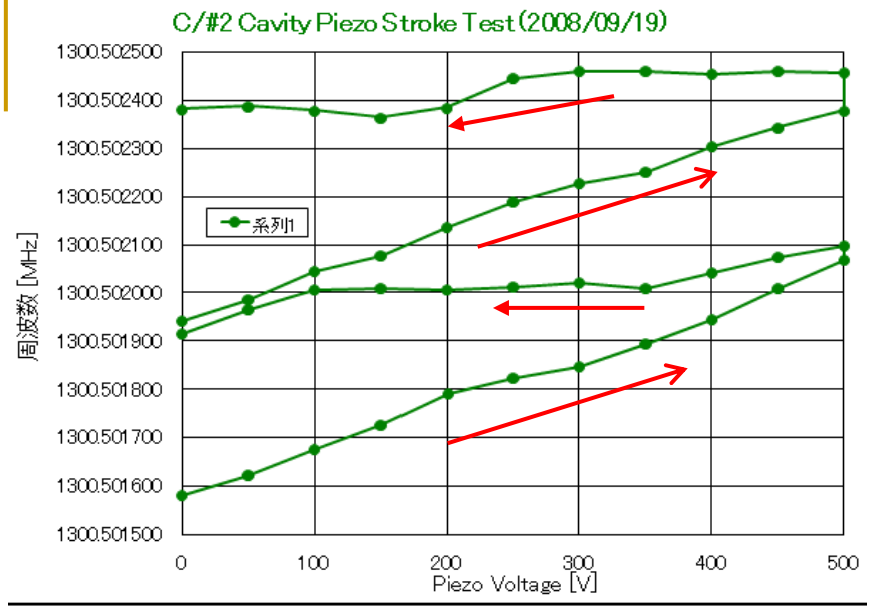


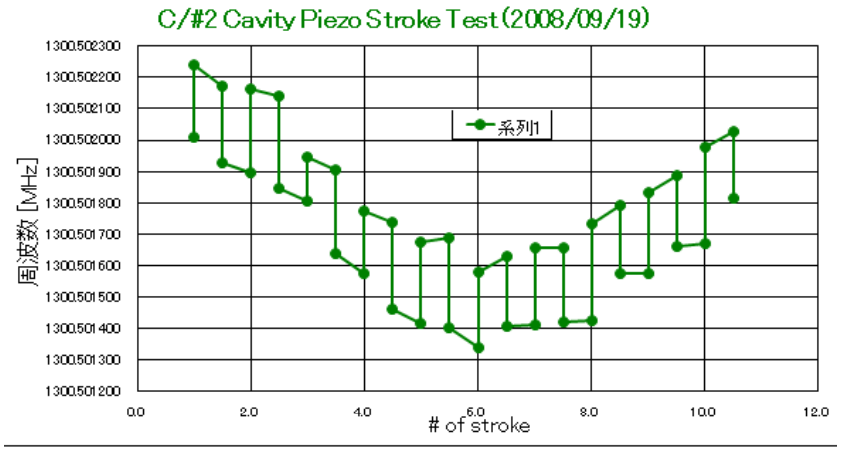


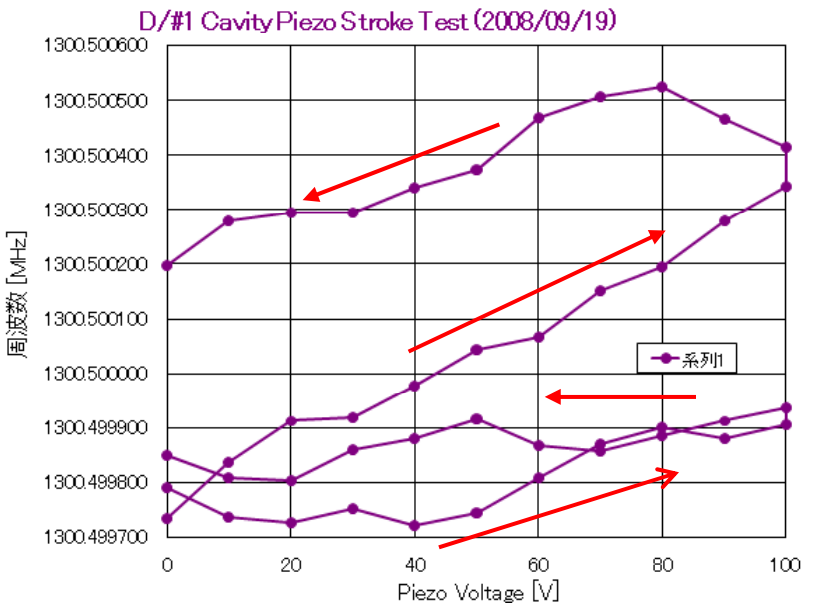


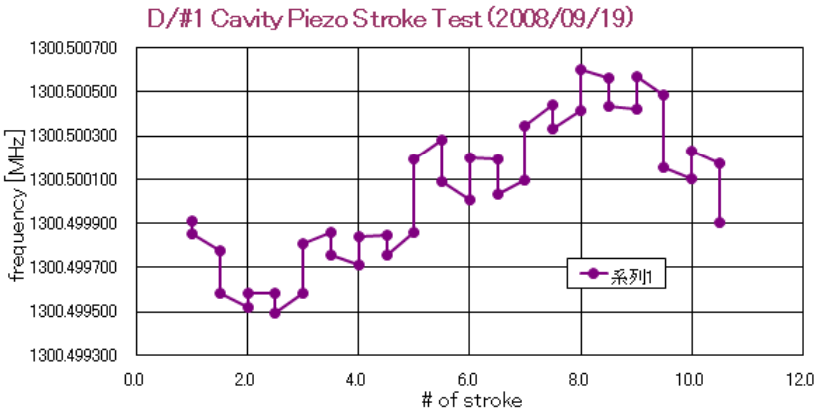


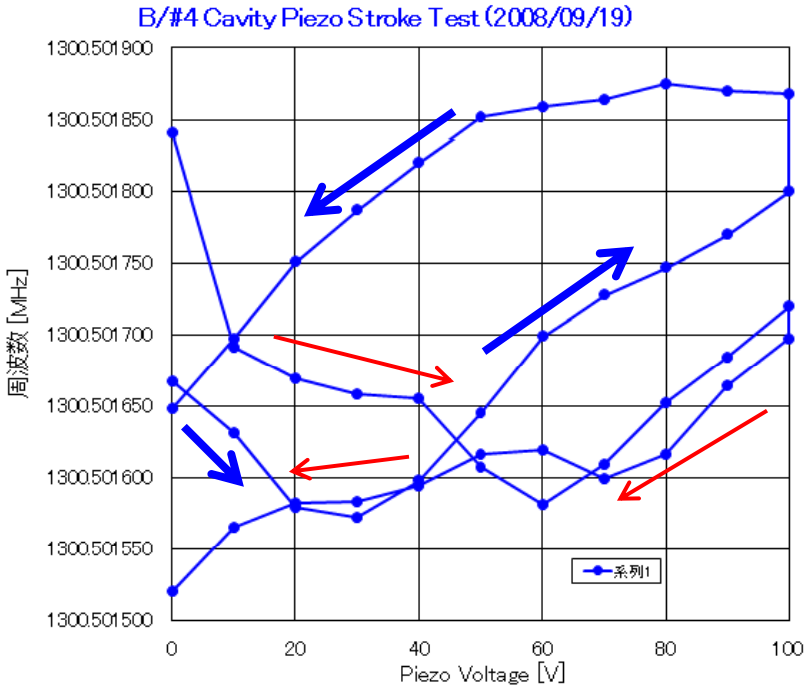
$\Delta f_{ave.} = 247$ Hz

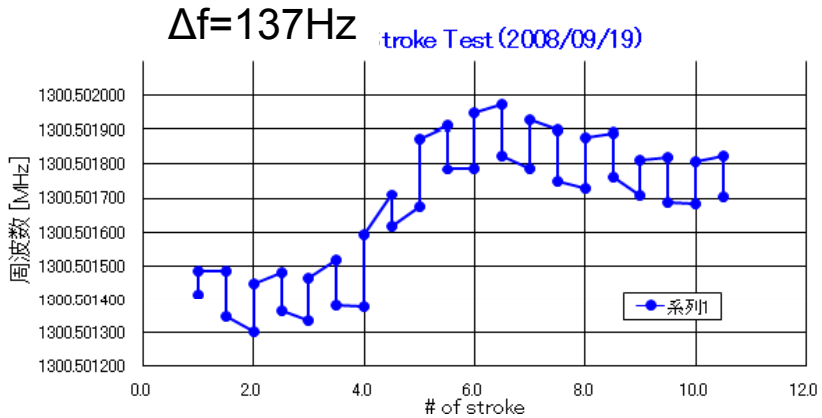

C/#2 Cavity Piezo Stroke Test (2008/09/19)
周波数 [MHz]
Piezo Voltage [V]
系列1


C/#2 Cavity Piezo Stroke Test (2008/09/19)
周波数 [MHz]
# of stroke
系列1


D/#1 Cavity Piezo Stroke Test (2008/09/19)
周波数 [MHz]
Piezo Voltage [V]
系列1

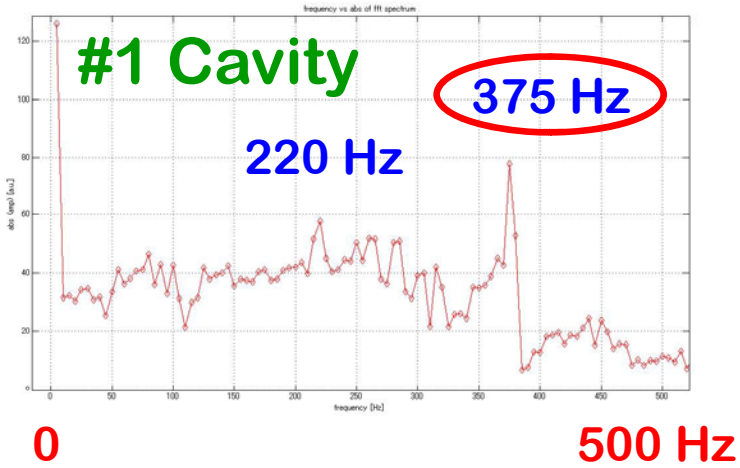

D/#1 Cavity Piezo Stroke Test (2008/09/19)
frequency [MHz]
# of stroke
系列1

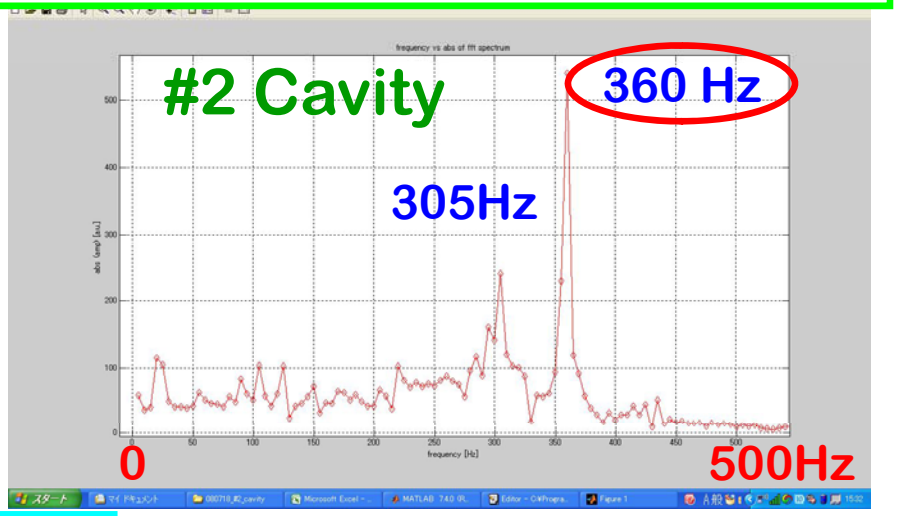

B/#4 Cavity Piezo Stroke Test (2008/09/19)
周波数 [MHz]
1300.501900
1300.501850
1300.501800
1300.501750
1300.501700
1300.501650
1300.501600
1300.501550
1300.501500
0
20
40
60
80
100
Piezo Voltage [V]
系列1

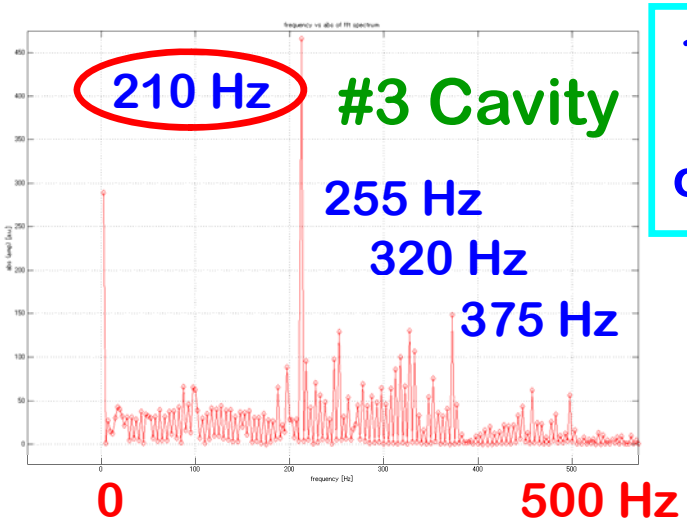

Δf=137Hz
troke Test (2008/09/19)
周波数 [MHz]
1300.502000
1300.501900
1300.501800
1300.501700
1300.501600
1300.501500
1300.501400
1300.501300
1300.501200
0.0
2.0
4.0
6.0
8.0
10.0
12.0
# of stroke
系列1

Mechanical Vibration Modes in STF Phase-1.0

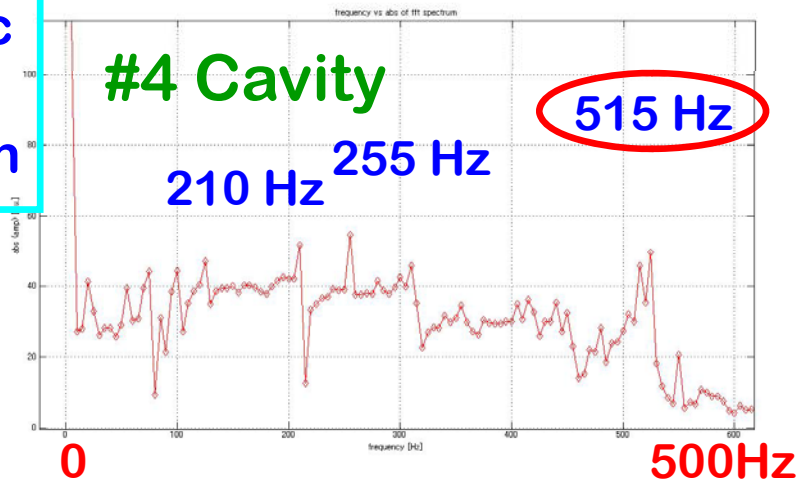
Simulation ; 0. 54 Hz, 1. 204 Hz, 2. 376 Hz, 3. 548 Hz







1.5 msec
5 Hz
operation

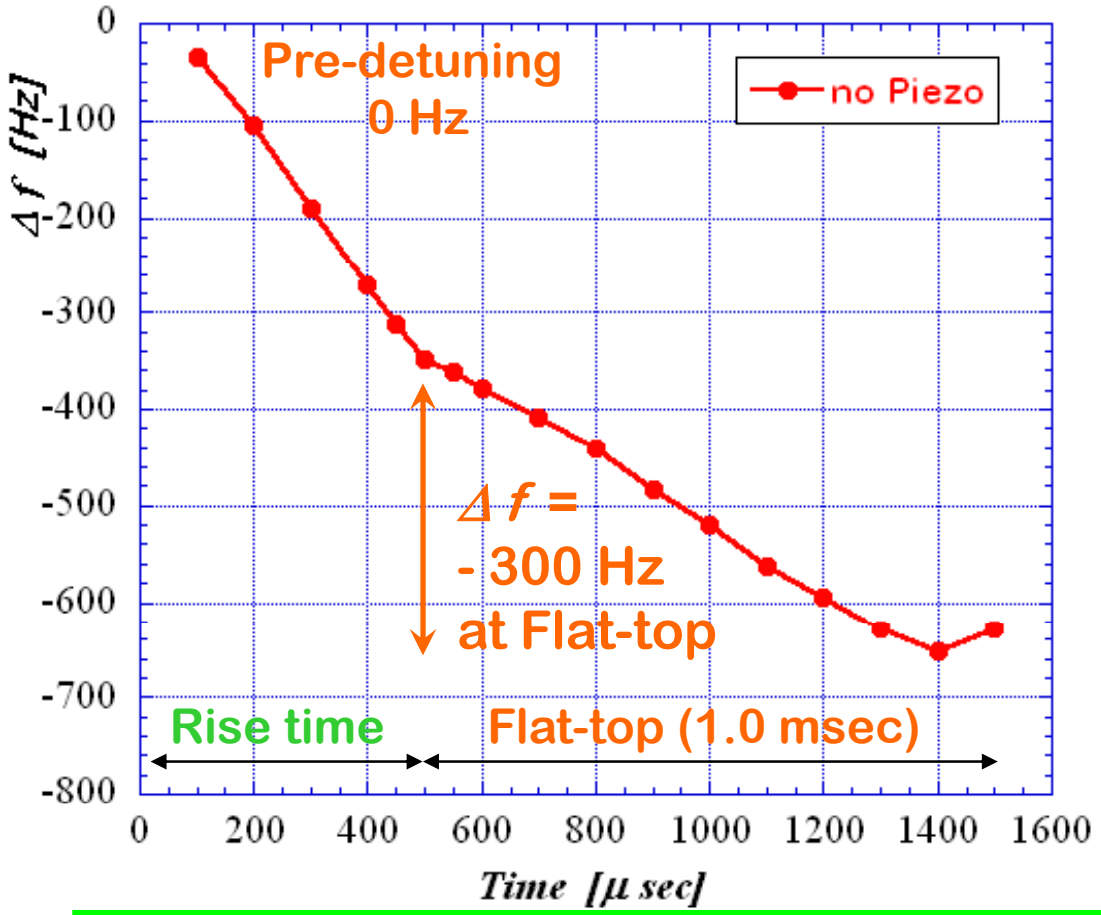


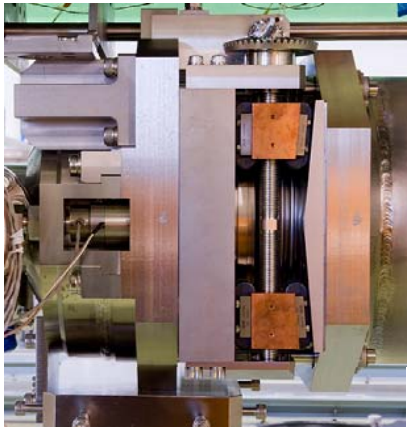
Mechanical Oscillation Modes (Longitudinal)

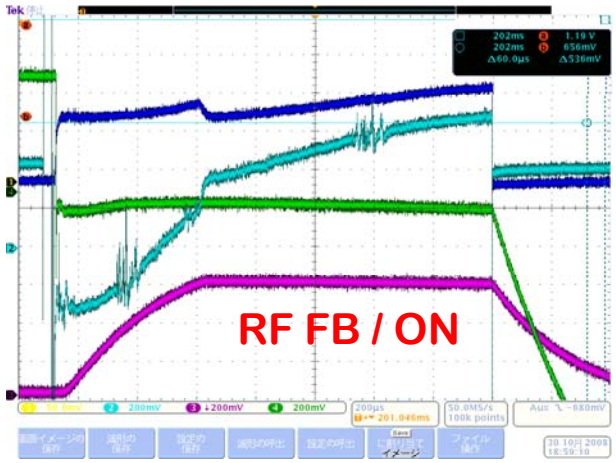
A (#3)	B (#4)	C (#2)	D (#1)	Simulation
85 Hz		87		
207	208	213	210	204Hz --- 1 / 9 π
244	250			
261			260	
270				
281			282	Piezo Excited
287				RF Excited
300	305	300	302	Both
			320	
355			355	
		367	372	376Hz --- 2 / 9π
	436	433	434	
	447			
	507			
	513		512	
			535	548Hz --- 3 / 9π

Lorentz force detuning in STF Phase-1.0

STF-BL#2 Cavity, Eacc = 29.6 MV/m







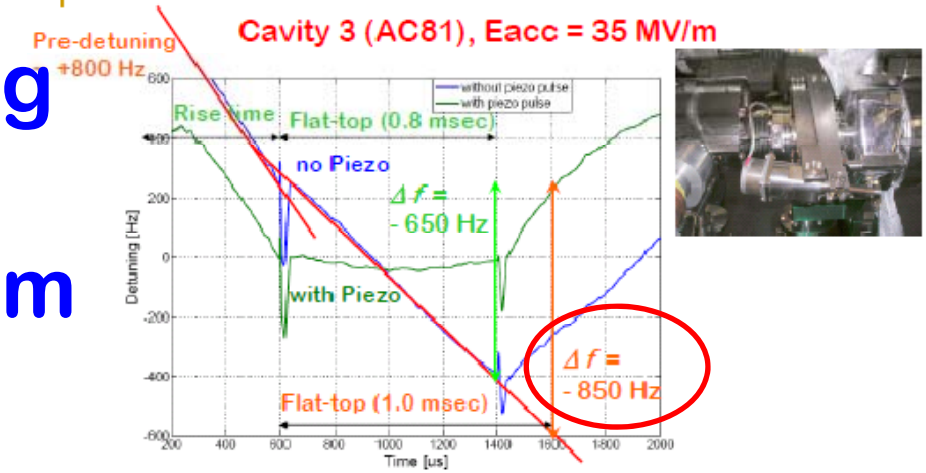
$\Delta f \propto Eacc^2$

Δf = - 340 Hz (Eacc = 31.5 MV/m, Flat-top = 1.0 msec)

Lorentz force detuning in TTF Cavities with a different tuner system

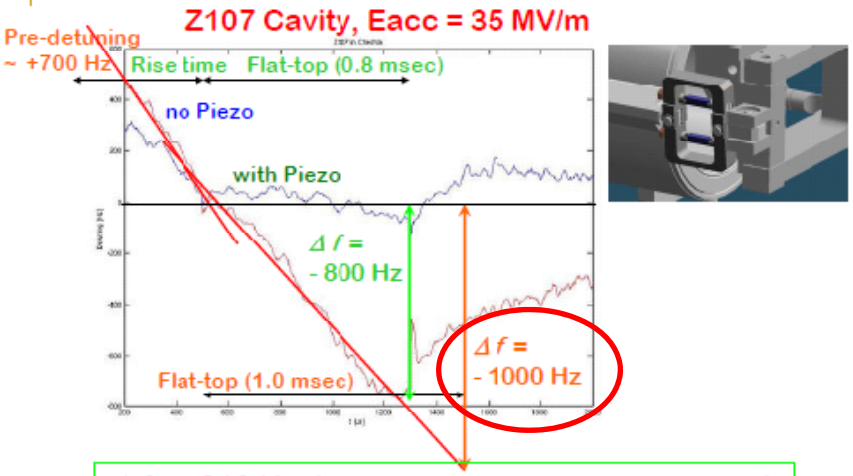
Δ f at Eacc = 31.5 MV/m, Flat-top = 1.0 msec

Saclay Tuner tested in Module 6 (by L. Lilje)



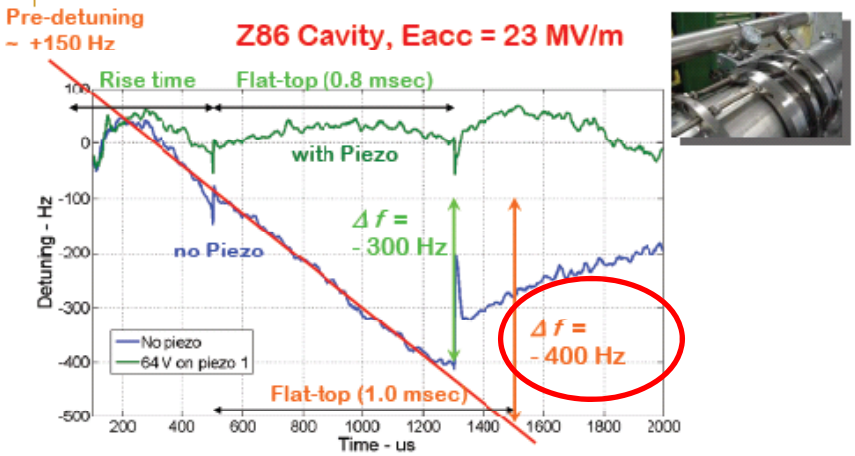
Δ f = - 690 Hz (Eacc = 31.5 MV/m, Flat-top = 1.0 msec)

Saclay Tuner tests for XFEL (by L. Lilje)



Δ f = - 810 Hz (Eacc = 31.5 MV/m, Flat-top = 1.0 msec)

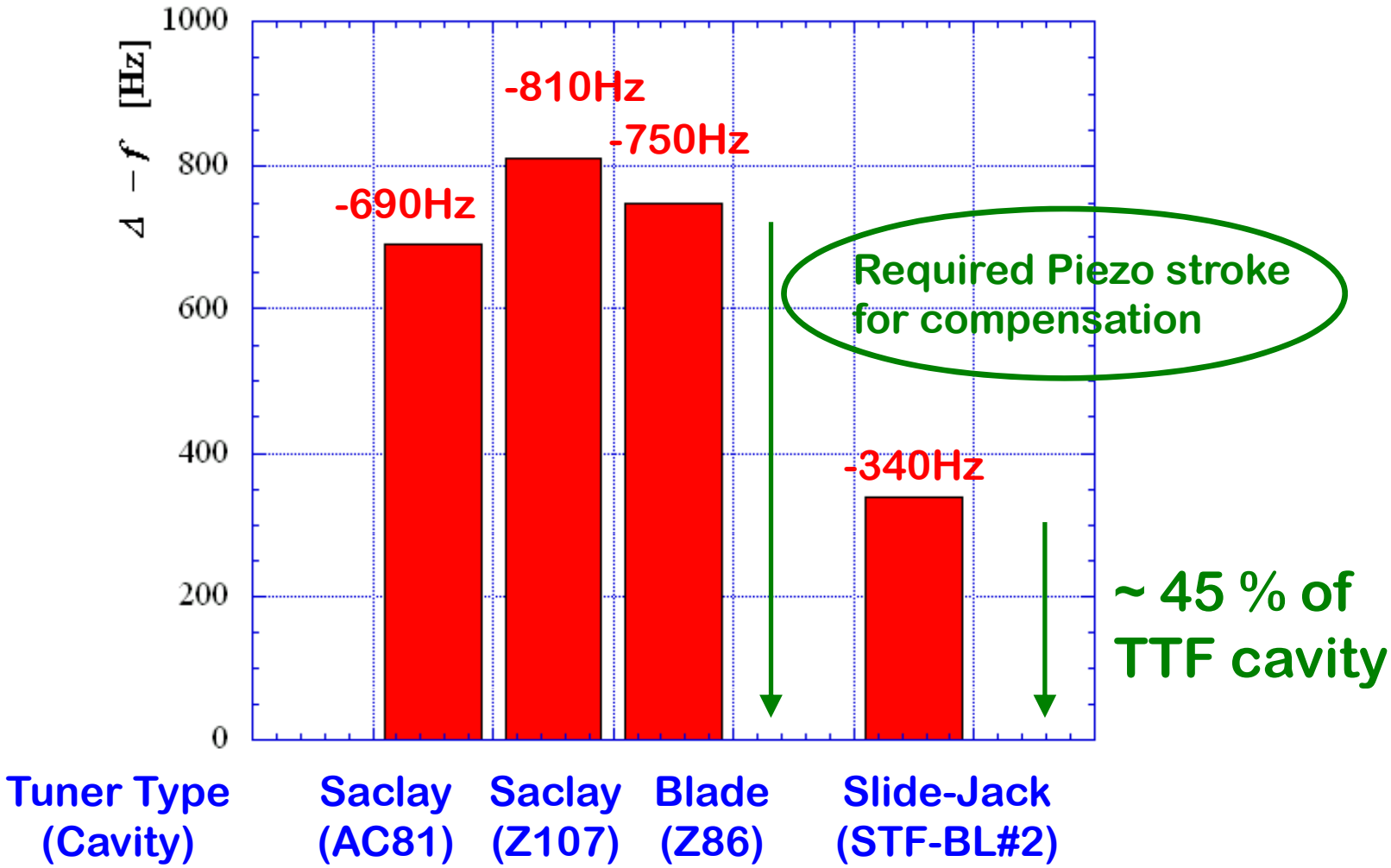
Blade Tuner tested in CHECHIA (by L. Lilje)



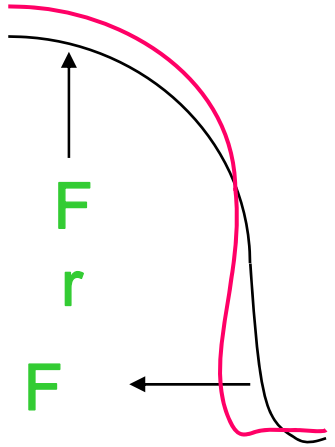
Δ f = - 750 Hz (Eacc = 31.5 MV/m, Flat-top = 1.0 msec)

Comparison of Lorentz force detuning

Δf at Eacc = 31.5 MV/m and Flat-top = 1.0 msec



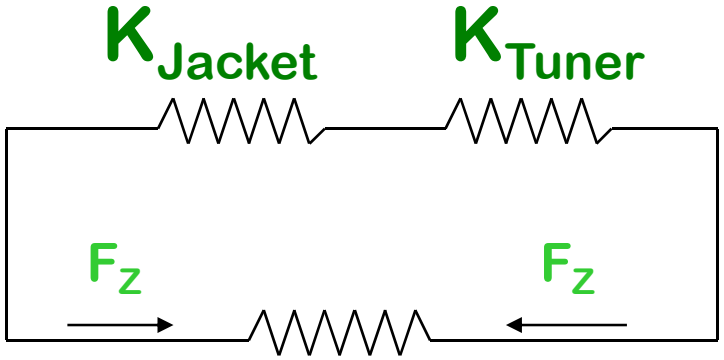
Stiffness of STF-BL Cavity-Tuner System



Lorentz Force Detuning

95 N / μm
(endplate, cylinder, flange)

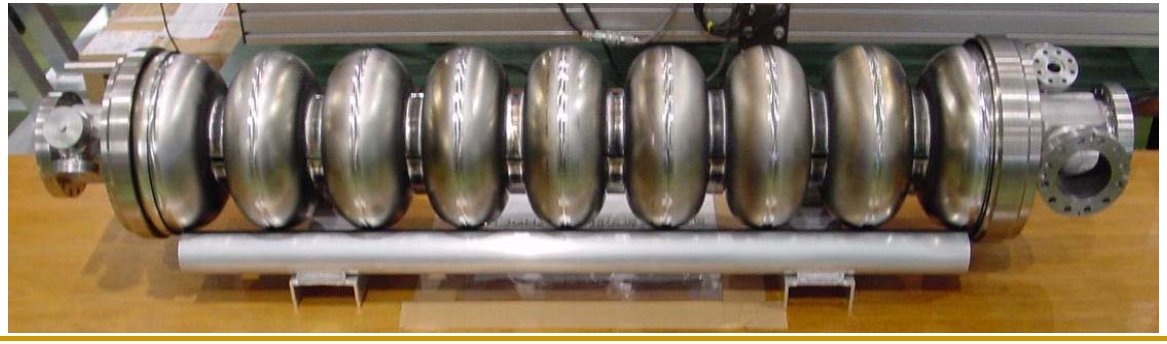
290 N / μm
(slide-jack, piezo)



K_{Cavity} 3 N / μm

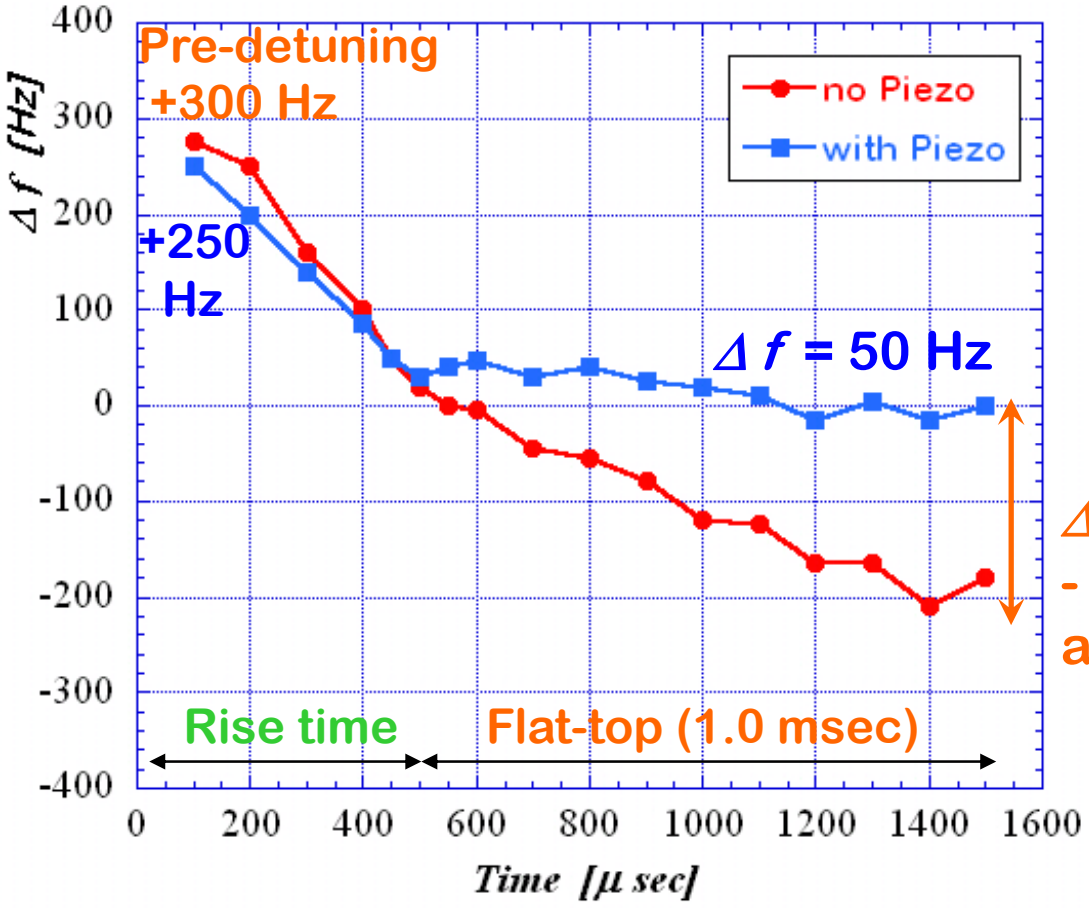
$$\frac{1}{K_S} = \frac{1}{K_{Jacket}} + \frac{1}{K_{Tuner}}$$

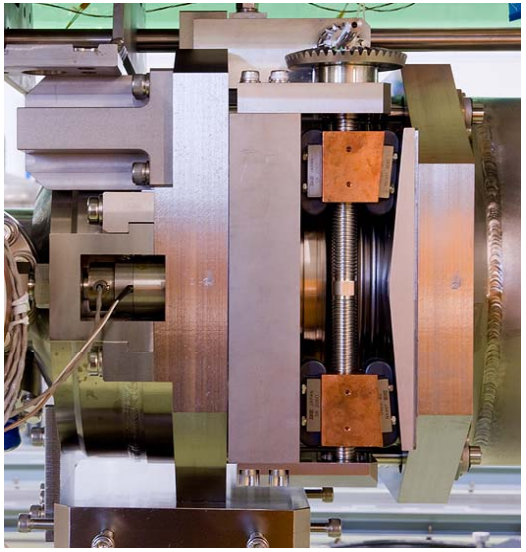
K_S = 72 kN / mm



Lorentz detuning Compensation

STF-BL#2 Cavity, Eacc = 26 MV/m





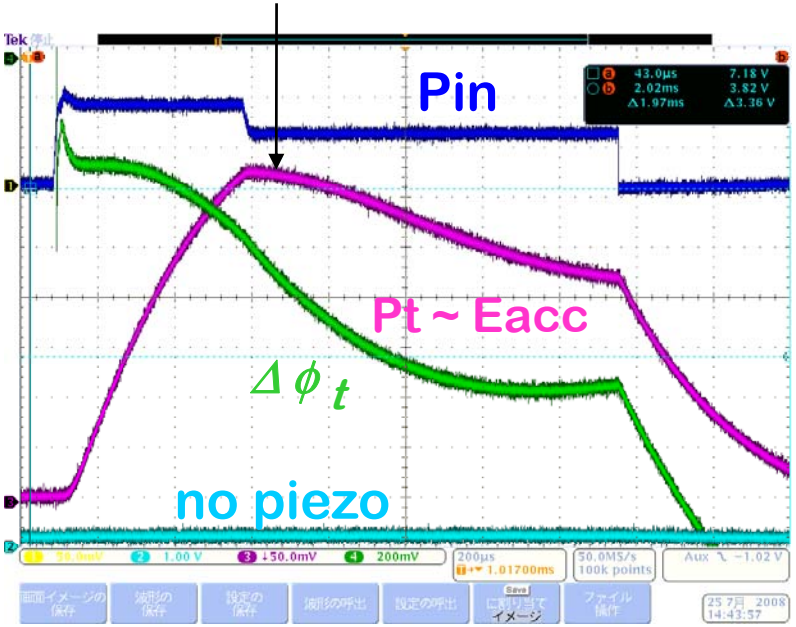
Δ f =
- 200 Hz
at Flat-top

Stable Pulsed Operation ; STF Phase-1.0

July, 2008'

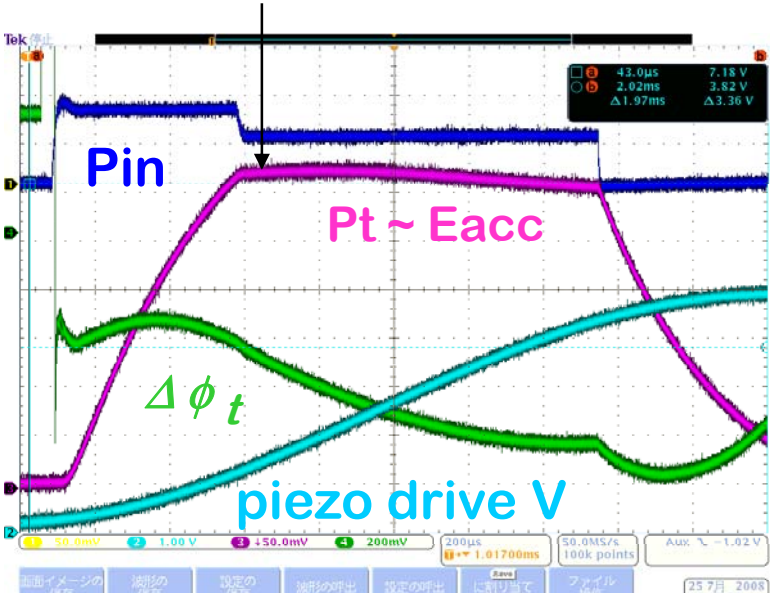
1.5 msec, 5 Hz operation

No compensation
28.1 MV/m



f = 1300.500000 MHz

Compensation by
Piezo and Pre-detuning
28.1 MV/m



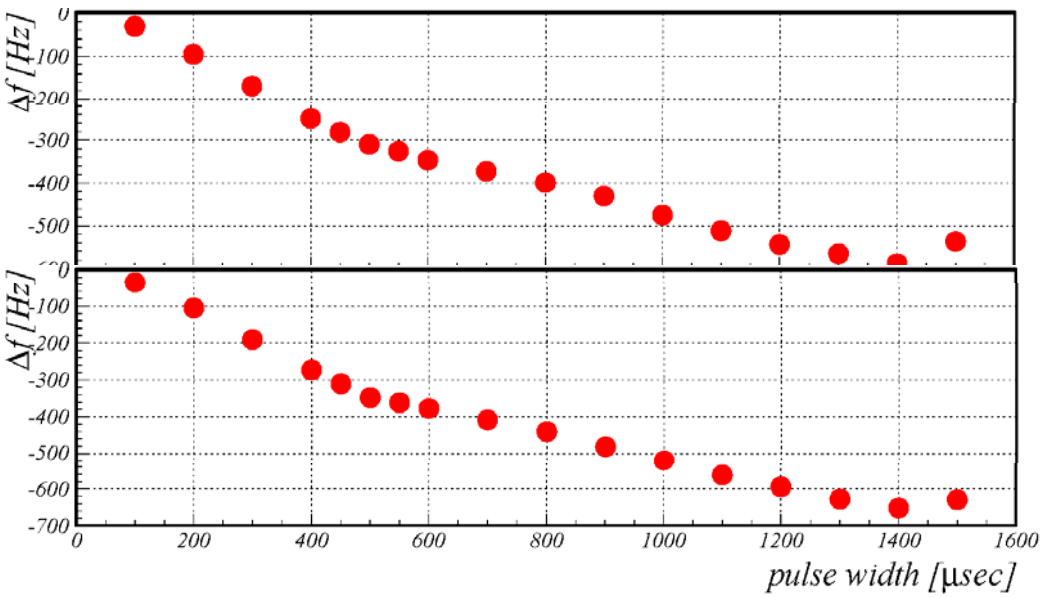
Pre-detuning, Δf_D = +200 Hz
Piezo, 250 Hz, 500 V, -0.2 ms

Summary

- Almost all the components are working as expected.
- Piezo tuning is not reproducible, provably because of friction in Jacket support system.

Summary

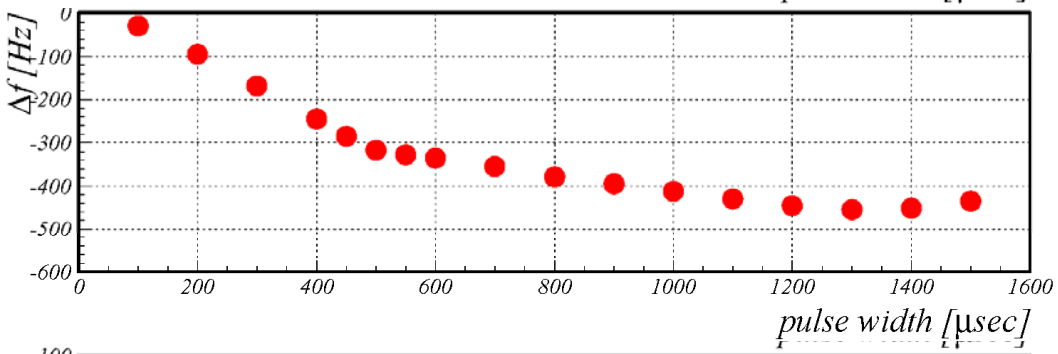
- A stable pulsed operation at high fields was confirmed in four cavities.
- No degradation of the Eacc,max was observed in the cryomodule tests.
- Compensation of Lorentz force detuning was successfully demonstrated at 28 MV/m by a piezo tuner and pre-detuning.
- Four cavity operation by vector-sum is scheduled in the next month.



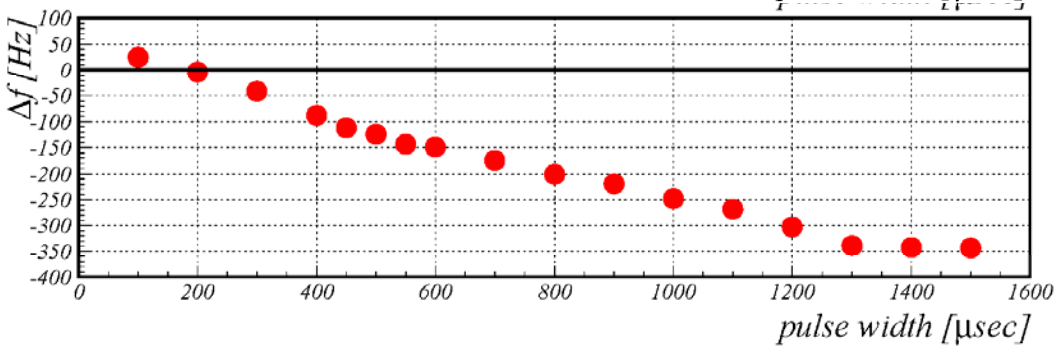
C#2 Cavity 28.3 MV/m

Feed-back on

C#2 Cavity 29.6 MV/m
Feed-back on

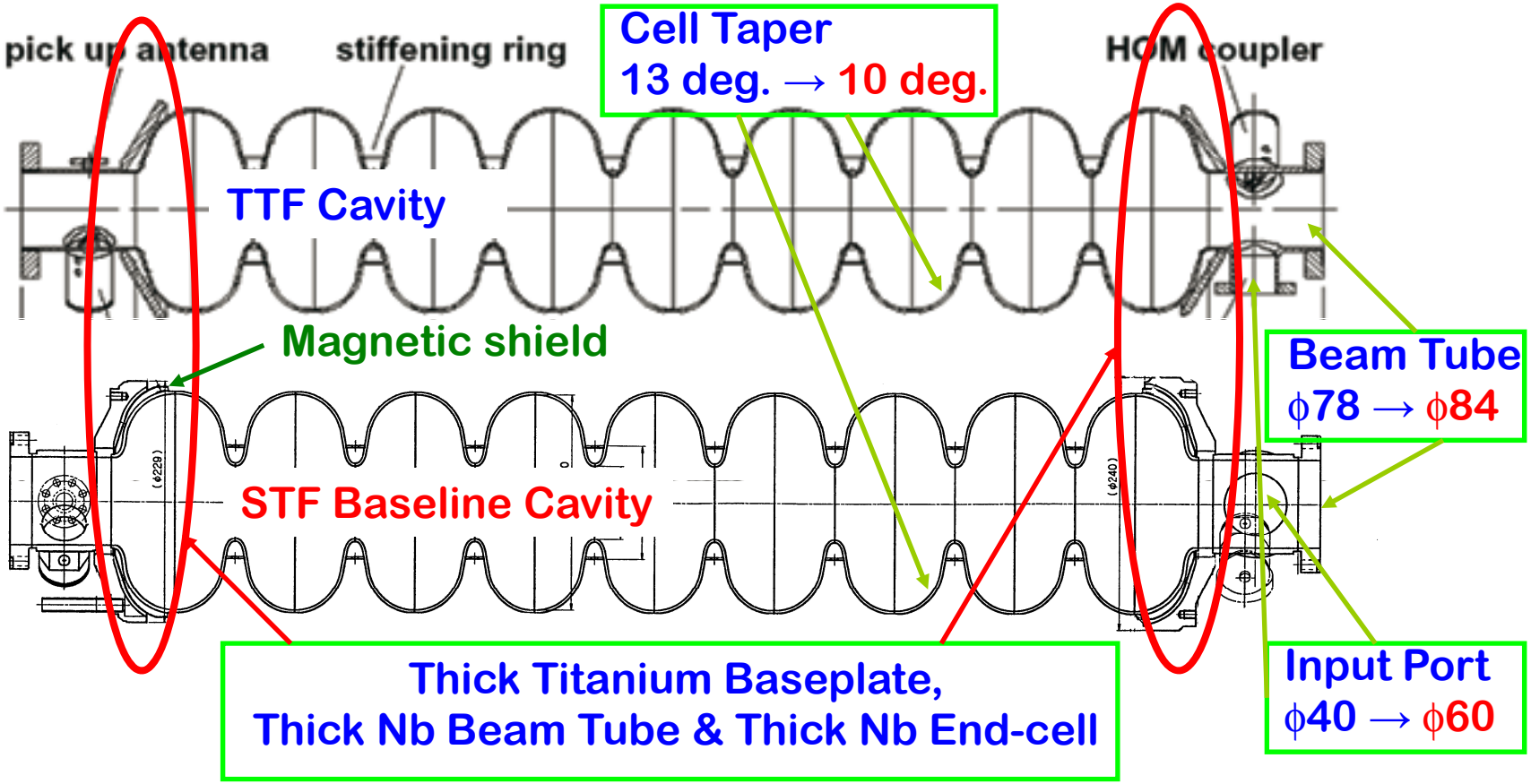


C#2 Cavity 28.6 MV/m
Feed-back off



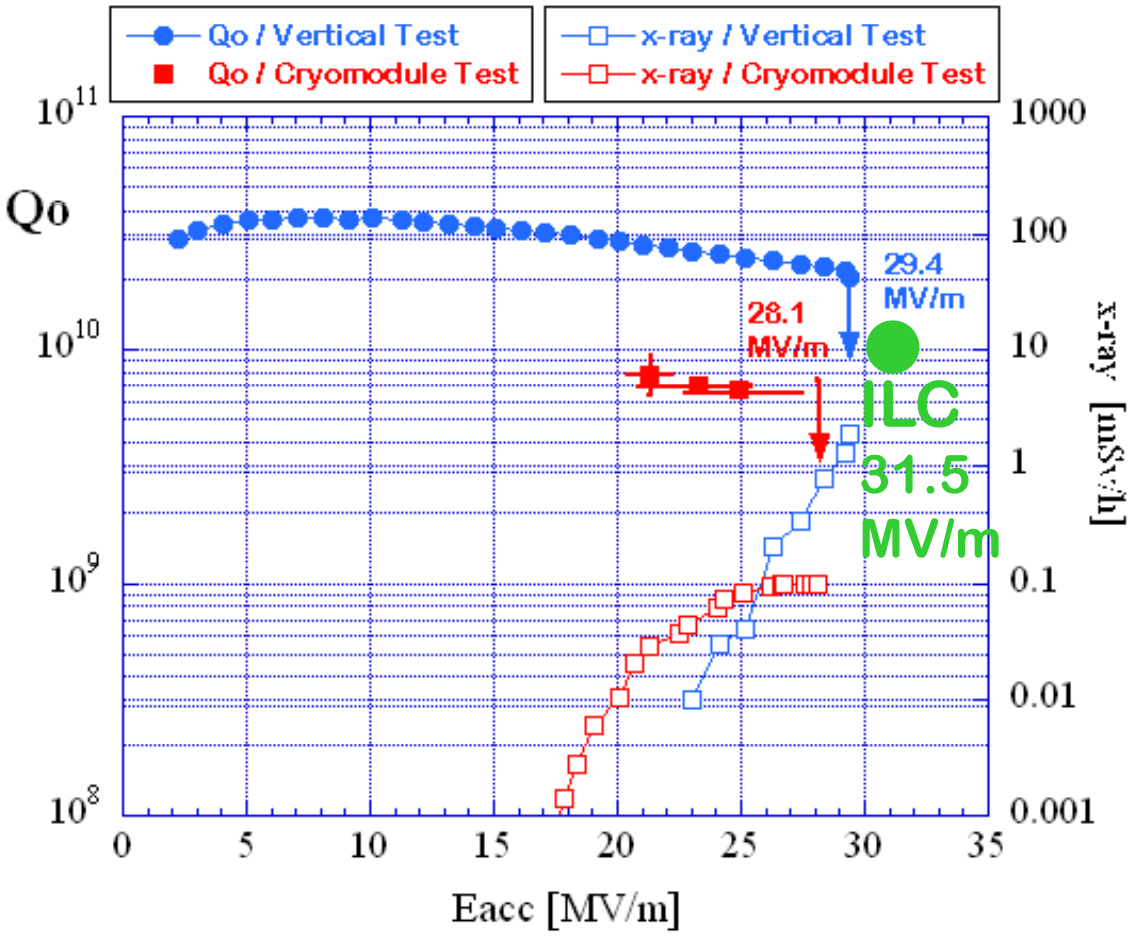
A#3 Cavity 19.4 MV/m
Feed-back off

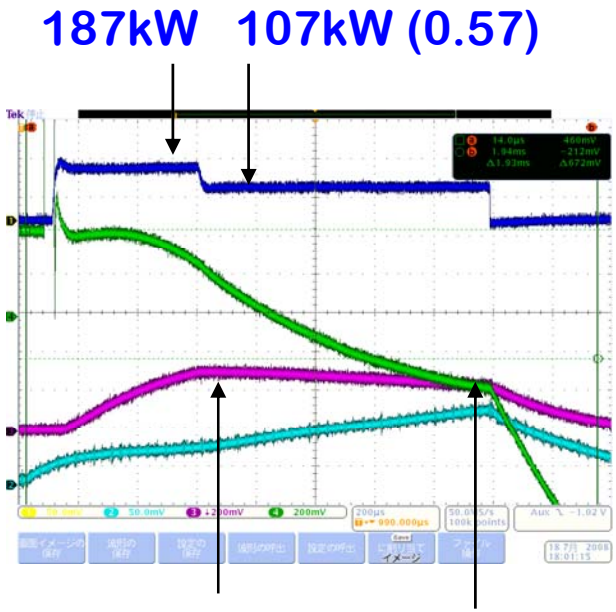
STF Baseline Cavity ; Improved Stiffness



	STF Baseline Cavity	TTF Cavity	
Stiffness of Cavity Sys.	72 kN/mm	22 kN/mm	
Lorentz Detuning at flat-top	Δf = - 150 Hz	Δf = - 500 Hz	Estimation at 31.5 MV/m

Qo - Eacc in #2 Cavity ;
Dynamic rf loss measurement





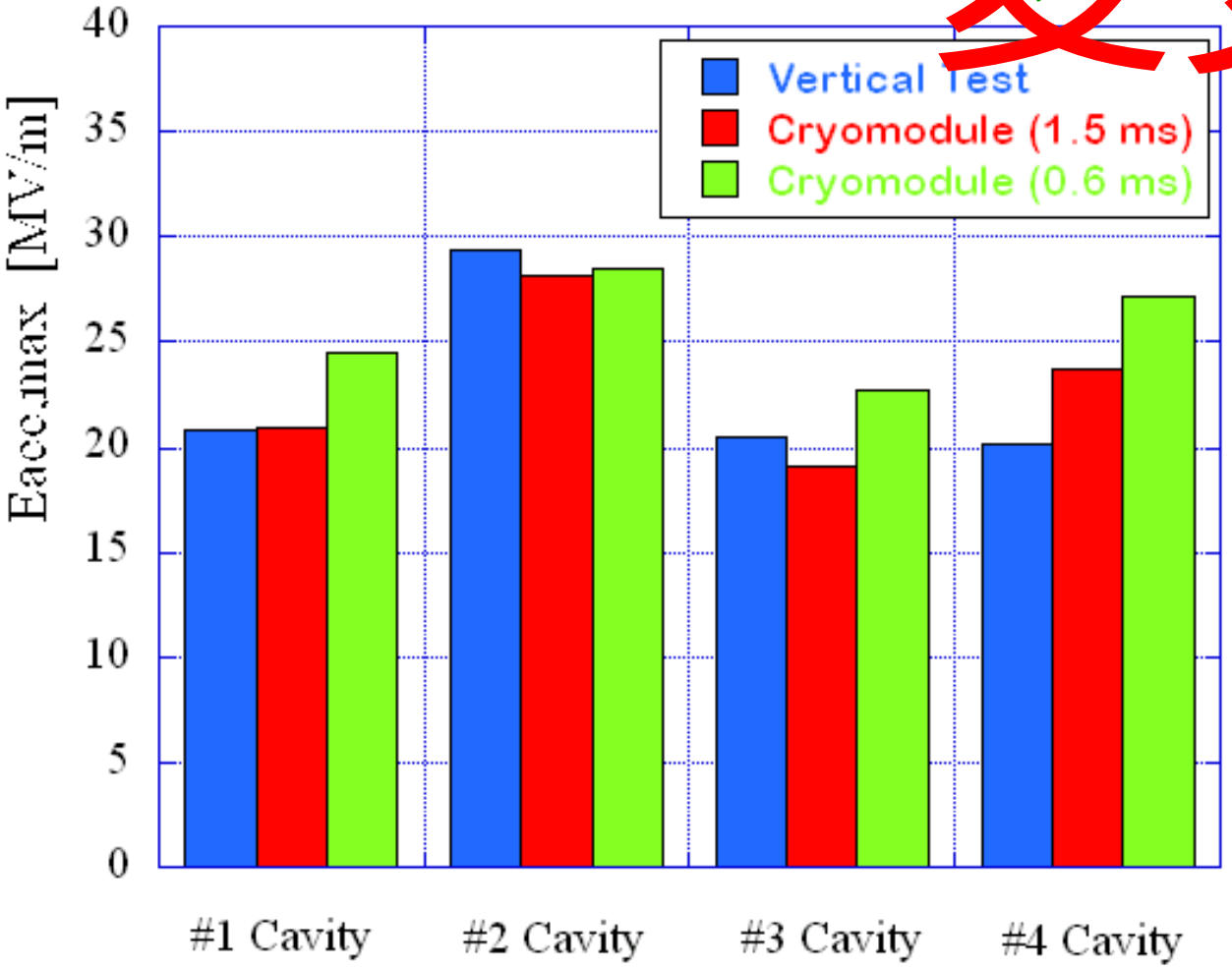
Ave. 24.9 MV/m
Duty = 0.83 %
Static loss = 9.9 W
RF loss = 0.8 W
Qo = 6.8 E+9

No Compensation
No RF Feedback

Comparison of achieved Eacc,max

変更

October, 2008



5 Hz

5 Hz

Ave. Eacc,max (V.T)
= 22.7 MV/m

Ave. Eacc,max (Cryo.)
= 23.0 MV/m

Expectation of operational ave. Eacc
= 23 / 1.1 = 21 MV/m

Beam Energy Gain
= 21 x 4 = 84 MeV

Purpose of Cryomodule Tests in STF Phase-1.0

. To check the performance as a total sc cavity system;

(Finding out the improvement points)

. To confirm a stable pulsed operation at higher fields;

(Comparison of Eacc,max between V.T & Cryo.)

. To demonstrate the compensation of

Lorenz force detuning by a piezo tuner;

(Effectiveness of a stiff cavity support structure)

Comparison of Lorentz force detuning

Δf at Eacc = 31.5 MV/m and Flat-top = 1.0 msec