High Power Test Results of LL Cavity Package in the STF0.5 Program at KEK

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Abstract

We have successfully made high power test with a LL cavity package in the STF0.5 program at KEK in January to March 2008. One LL cavity package was installed in a cryomodule which could include four packages maximum. This module has been successfully operated at 15-18MV/m. In this paper, we will report the results on the cavity performance, high power capacitive coupled input coupler performance and Lorenz detuning compensated piezo tuner and ball screw mechanical tuner.

Introduction

Purposes of the STF0.5

- Coaxial capacitive high power input coupler dose work at 2K?
- Coaxial screw ball tuner system dose work at 2K?
  LL shape cavity is how sensitive to the Lorentz Detuning?
- Have the experience of cavity string assembly and integration.
- Nb/SUS joint at the Helium vessel base-plate is leak tight at 2K?
- SUS Helium vessel has no problem ?
- Even the cavity performance is limited about 18MV/m, we have to know the performance change at 2K.

STF0.5 High Power Test

Cavity Integration

String Assembly and Cryomodule Integration

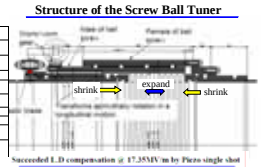
Investigate what kinds of problem would be there in all the processes: cavity fabrication to high power test in the cryomodule

Coaxial Ball Screw Tuner System

Comparison of Tuner Designs

		Screw Ball	Jack	Blade	Saclay-II
Location	Motor	80K or out of vac. vessel	Out of Vac. vessel	He vessel	Beam tube
	Piezo	80K or out of Vac. vessel	End plate	He vessel	END plate
Tuner mechanism		Coaxial ball screw	Slide Jacky	Twist	Lever type
Motor driving power		0.06g/5μm, 0.1W			
Piezo tuning range		~2000			
Resolution [Hz]	Motor	0.1			
	Piezo	0.1			
$\frac{df}{dz}$ [Hz/μm]		368	320		320
$\frac{df}{dF}$ [Hz/mN]		36.4	80	13	

Structure of the Screw Ball Tuner



Lorentz Detuning Compensation Tuner System @ KEK

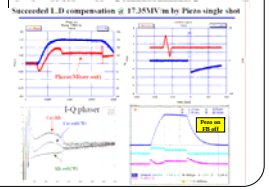
1) Use well established technology
2) Rigidity during handling
3) Wide Range Tuning Design
4) Easy Replacement
5) Less heat loss
6) Less X-ray Damage
7) Keep the possibility to move out of vacuum chamber

→ Screw Ball Tuner; → Mechanical resonance; → Locate both tuners around 100K shield

Coaxial screw ball tuner

NO BCD yet for ILC

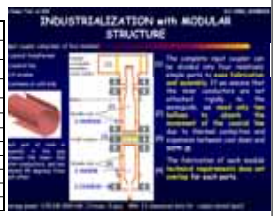
Succeeded L.D compensation @ 17.35MV/m by Piezo single shot



Coaxial Capacitive Input Coupler

Input Coupler Designs

		CC-coupler	STF-BL	TTF-III
Designed RF Power [kW]		500 (2000)	350(1300)	250(1000)
Pulse width [ms]		1.3 (1.5)	1.3(1.5)	1.3
Repetition [Hz]		5	5	10
Average rf power [kW]		3.25	2.3	3.2
RF processing time [hr]		16	50	20
Thermal Loss [W]	80K Static	1.24	5	6
	80K Dynamic	1.5	3	3
	5K Static	0.54	1.1	0.5
	5K Dynamic	2.0	0.2	0.1
	2K Static	1.8e-4	0.05	0.06
	2K Dynamic	0.18	0.03	negligible

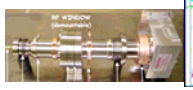


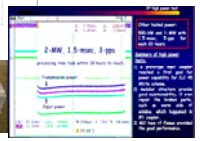
Coaxial capacitive input coupler

By H.Matsumoto and S.Kazakov

Successfully demonstrated the high power performance up to 2MW!

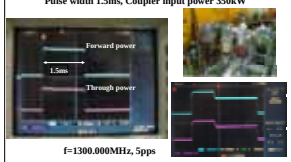
The specification: 500kW, 1.5msec, 5Hz @ 45MV/m operation





Succeeded Coupler Performance in STF module

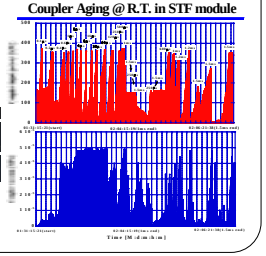
Pulse width 1.5ms, Coupler input power 350kW



f=1300.000MHz, 5pps

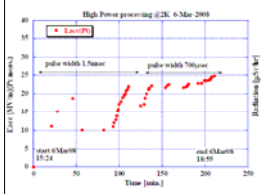
After the first high power test, this coupler was disassembled and kept in class 10 clean room for 4 months exposing air. Then high power tested again at the test stand.

Coupler Aging @ R.T. in STF module

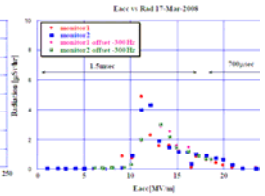


Cavity Performance

Cavity High Power Aging



Cavity Processing



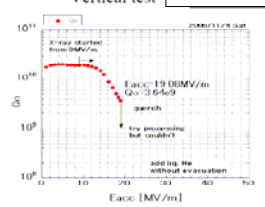
Radiation Measurement

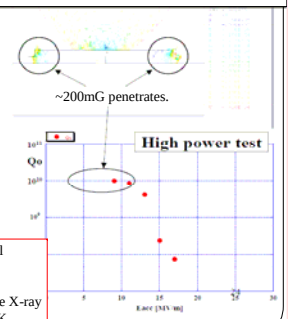
Eacc= 1 – 17MV/ @ 1.5ms, 18-25MV/m @700 f=1300.133342Hz @ -300Hz off-set

Radiation is very small, less than 5μSv/hr.

Qo-Eacc curve measured in the high power test

Magnetic penetration simulation by N. Ouchi and M.Masuzawa

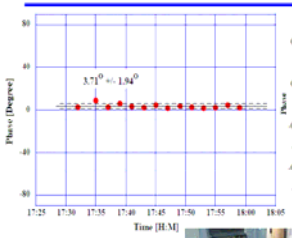


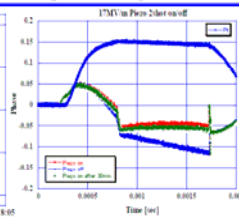


1) After the vertical test, we took the ethanol rinsing but the effect was not seen.
2) The contamination problem in the cavity dressing will be not so serious because the X-ray was much less during RF processing at 2K.
3) The reason of the low Q problem at 2K will be the poor magnetic shielding due to the current complex He-vessel structure, which can improve.

Piezo tuner operation for Lorentz compensation

Phase variation in 30 minutes operation @ 17MV/m





Simulation Result for the Static

	Old Model (Asymmetric)	New Model (Symmetric)
Axial Force Deformation (Tuning)		
Axial Spring Constant (Measured)	48 N/μ	48 N/μ
Axial Spring Constant (Assumed)		
Axial Tuning Sensitivity (Measured)	0.32 kHz/μ	0.38 kHz/μ
Axial Tuning Sensitivity (Computed)	0.37 kHz/μ	
Lorentz Force Deformation (Detuning)		
Static Detuning @40 MV/m (Computed)		-2.0 kHz
Static Detuning Coefficient (Computed)		-1.3 Hz/(MV/m)^2
Maximum Radial Expansion @40 MV/m (Computed)		0.16 μ
Axial Length Contraction @40 MV/m (Computed)		1.4 μ
Sum of Axial Forces @40 MV/m (Computed)		49 N

~15 % lower than simulation

Static → Mechanical Pulse response → Pulse

15MV/m	-281Hz
31.5MV/m	-1240Hz
40MV/m	-2000Hz

Scaled the result of STF0.5

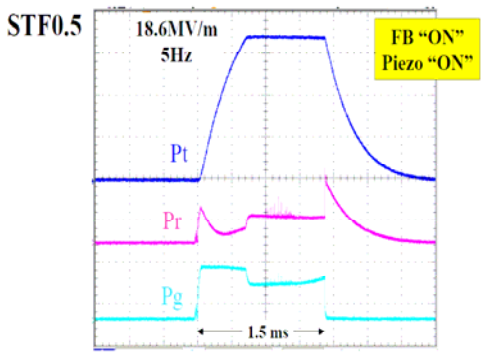
Should be smaller

Similar to TESLA Cavity

15MV/m	-138Hz
31.5MV/m	~ -600Hz ?
40MV/m	~ -1000Hz ?

Accomplishment of the STF0.5

Successful high power operation @ 18.6MV/m on Ichiro 9-cell cavity



The success of the 18.6MV/m operation

Summary

- CC Input coupler works well.
  2MW was fed at the room temperature RF conditioning.
  Operated up to 250kW at 2K without any problem.
- Coaxial screw ball tuner works fine, The Piezo tuner system has confirmed to compensate the Lorentz Detuning up to 18MV/m.
- The sensitivity of the Lorentz Detuning of LL cavity is similar to the TESLA cavity.
- LL cavity was high power tested up to 18MV/m.
  The high gradient cavity R&D is the key issue for the further R&D.