2.6GHz SRF cavity tuner for DarkPhoton experiment

Yu. Pischalnikov *, C. Contreras-Martinez, I. Gonin, T. Khabiboulline, O. Melnychuk, S. Posen, O. Pronitchev, J. C. Yun

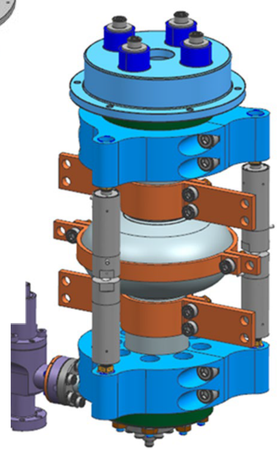
FNAL, Batavia, IL 60510, USA

FERMILAB-POSTER-22-150-TD.

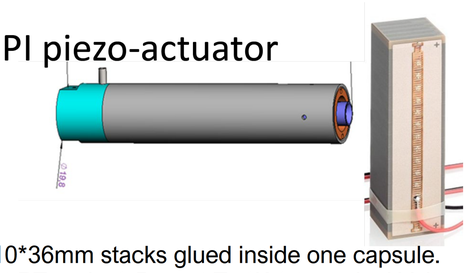
NAPAC 2022

MOPA39

There are several experiments ongoing at FNAL that require frequency tuning of bare (undressed) SRF cavities when they are cooled down and operated inside dilution refrigerator. One of these experiments is for the search of dark photons using a 2.6 GHz SRF cavity. The limited heat capacity of a dilution refrigerator prevents using a stepper motor for an SRF cavity tuner. The tuner for the 2.6 GHz SRF cavity will be equipped with encapsulated piezo actuators that will deliver long and short-range frequency tuning. Design of the tuner and results of the testing cavity/tuner system at ambient environment and at T = 77 K will be presented.

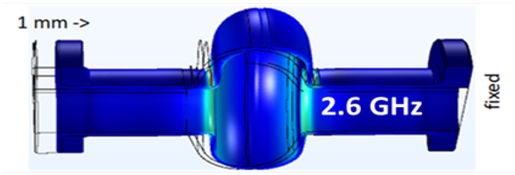


PI piezo-actuator



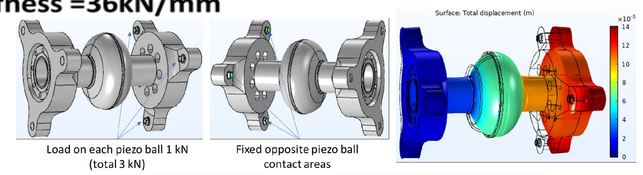
Two PICMA 10*10*36mm stacks glued inside one capsule.
Stroke is 38um at RT and ~4-5um at T=4K (at nominal Voltage 120V).
Actuator will deliver 2*5=10um.
At T<70K piezo could operate at -120 to +120V that will increase stroke up to ~20um.
Efficiency of the tuner/frame is 80% … we are expecting stroke ~15um… that will deliver tuning range ~150kHz.

ANSIS Simulations/ Tuner design optimization

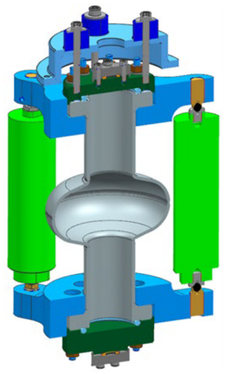


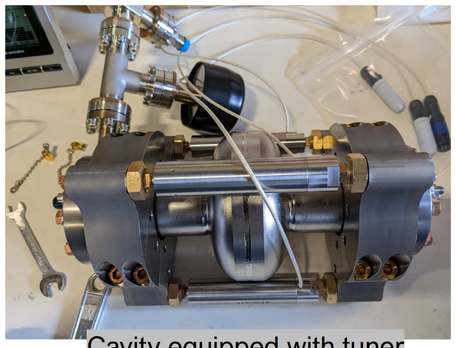
dF/dL=9.9kHz/um

Stiffness =36kN/mm



Tuning of the warm cavity

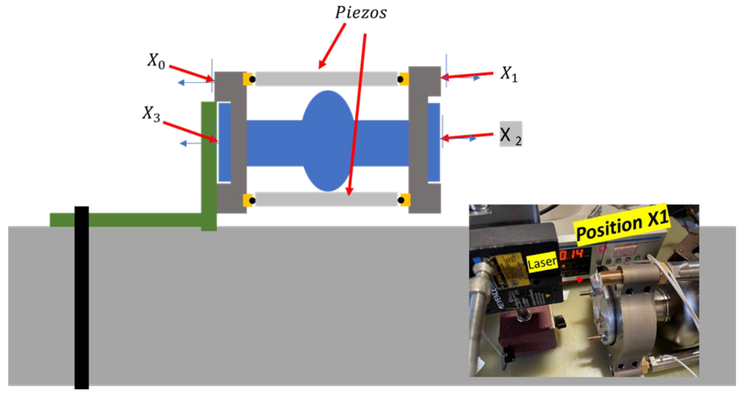




Cavity equipped with tuner and ready for VTS (2K) test

	Cycle	Number of piezo under voltage	V_{piezo}	f, [MHz]	df, [kHz]	cavity response, kHz/V
piezo preload 60kHz	1	3 piezo	0	2592.42	128	2.56
			50	2592.548		
	1	1 piezo	0	2592.424	40	0.8
			50	2592.464		
200kHz	2	3 piezo	0	2592.63	340	2.83
			120	2592.970		
	2	1 piezo	0	2592.63	120	1.00
			120	2592.75		

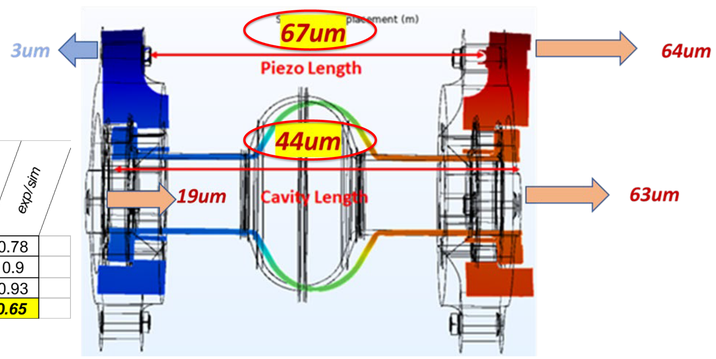
Measurements of warm tuner efficiency



Test of cavity inside LN2

V=60V applied to all three piezo-actuators	
	dF [kHz]
Cavity @293K with air inside RF volume	159
Cavity @77K with LN2 inside RF volume	72.5

Taking in account cavity df/dL difference between air & LN2 we could estimate that piezo actuator has ~50% of stroke remained at 77K (compare to T=293K)



	simulations/ specifications	*experiment*	*exp/sim*
$\Delta f/\Delta L$, [kHz/um]	9.9	7.7	0.78
$\Delta L_{cavity}/\Delta L_{piezo}$, [%]	74	66	0.9
Piezo stroke at V=120V, [um]	72	67	0.93
			0.65

Summary

Parameters of the tuner, measured at ambient environment and at LN2, agreed with expected from simulations.
Based on preliminary measurements expected tuner range at T<1K will be ~100kHz that likely will cover required range for Dark Photon experiment.
Test at 2K expected in August 2022.

**pischaln@fnal.gov*