

ERL 2-cell Cavity Piezo Tuning Status

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KEK 9/23/06

Piezo Tuner Activities

**Two cell 1.3 GHz Copper Cavity with
Stainless steel helium vessel and INFN/DESY Blade Tuner
5 2-cells in injector cryomodule**

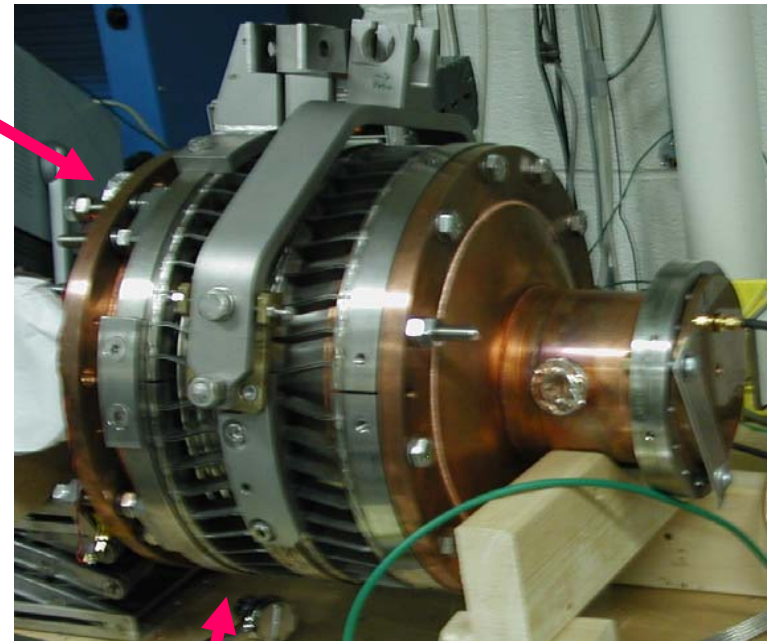
6 mm stack Noliac Piezo elements

**Goal: Piezo element will fine tune the
cavity resonance at hundred Hz Level
due to micro-phonics. (very high-Q
cavities)**

~5 μm extension \rightarrow 1 kHz shift.

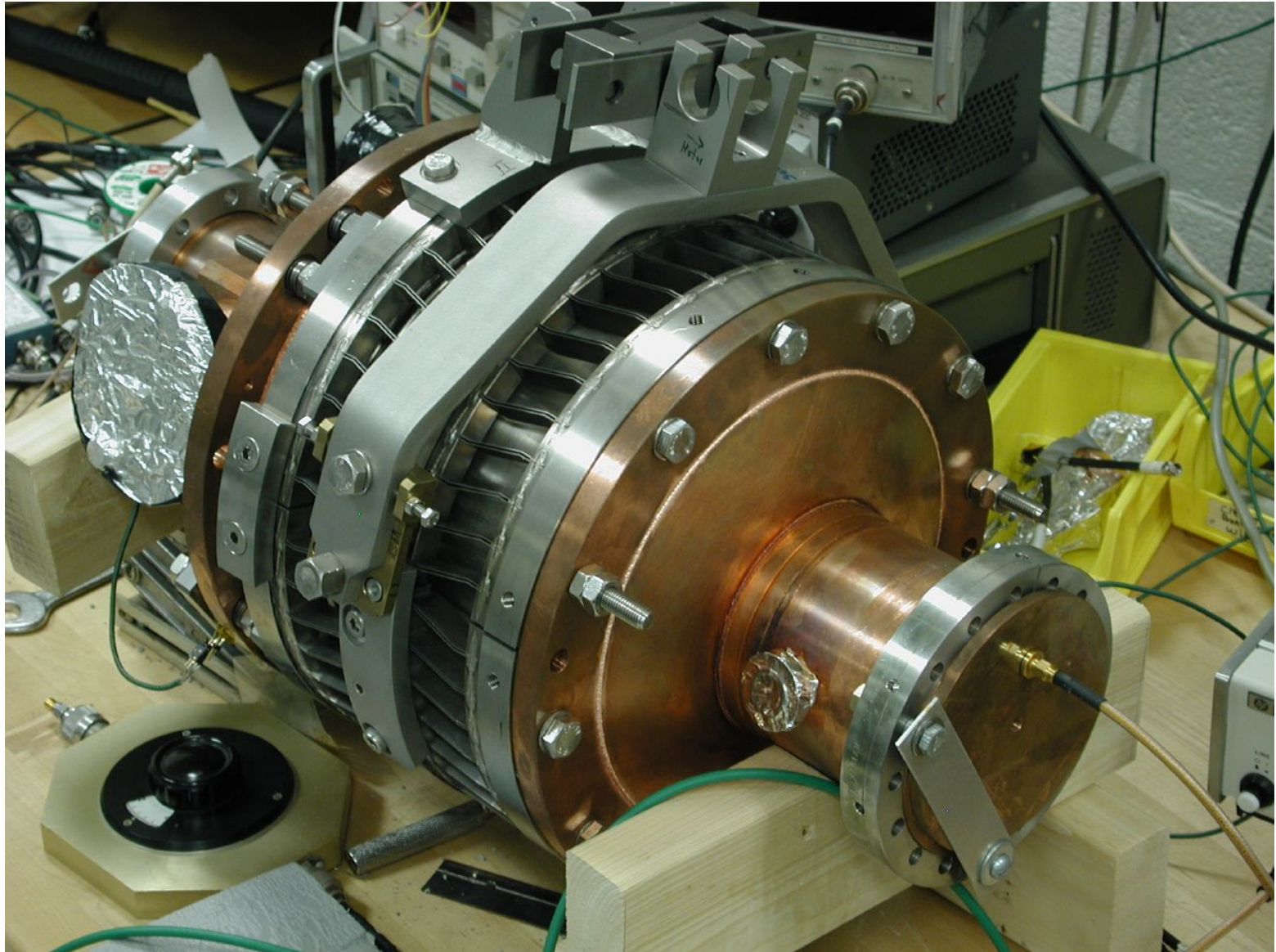
All elements under compression

**Piezo element in compression against
Belleville washers. (~5 μm movement)**

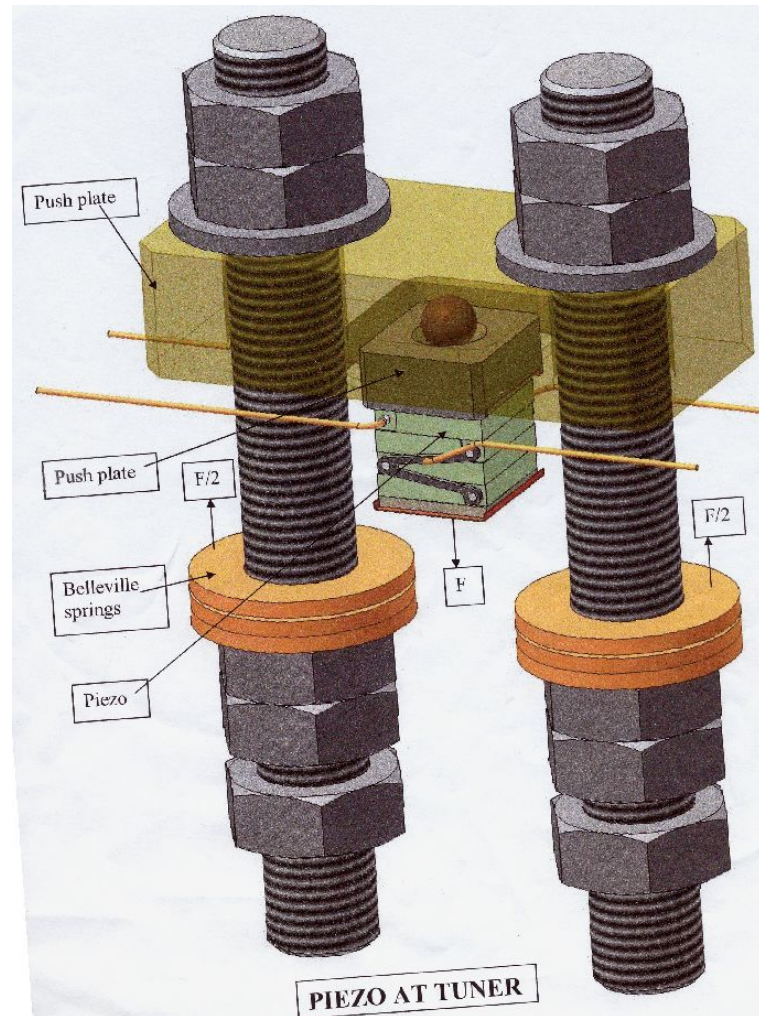


Blade Tuner

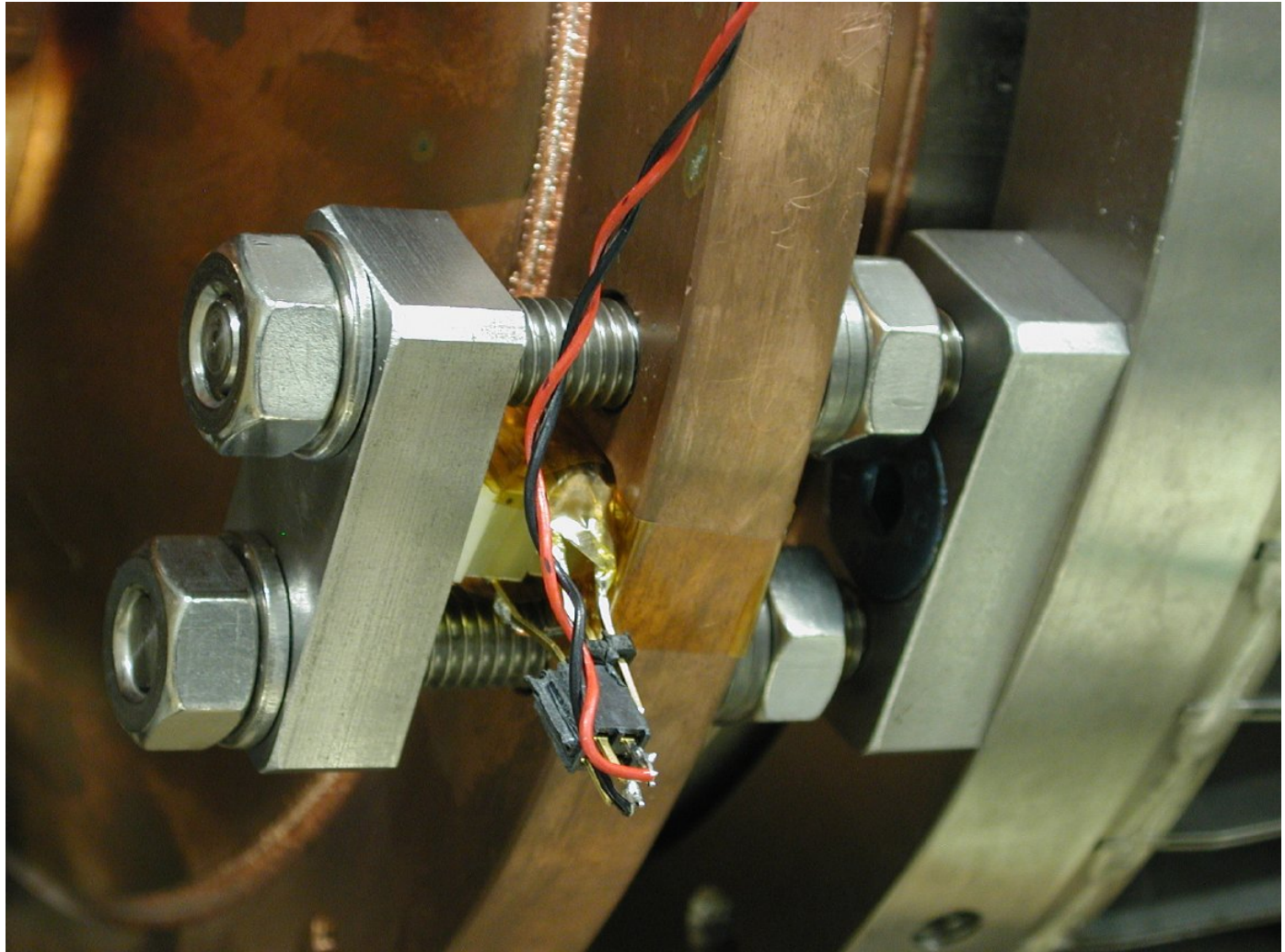
Cavity Assembly



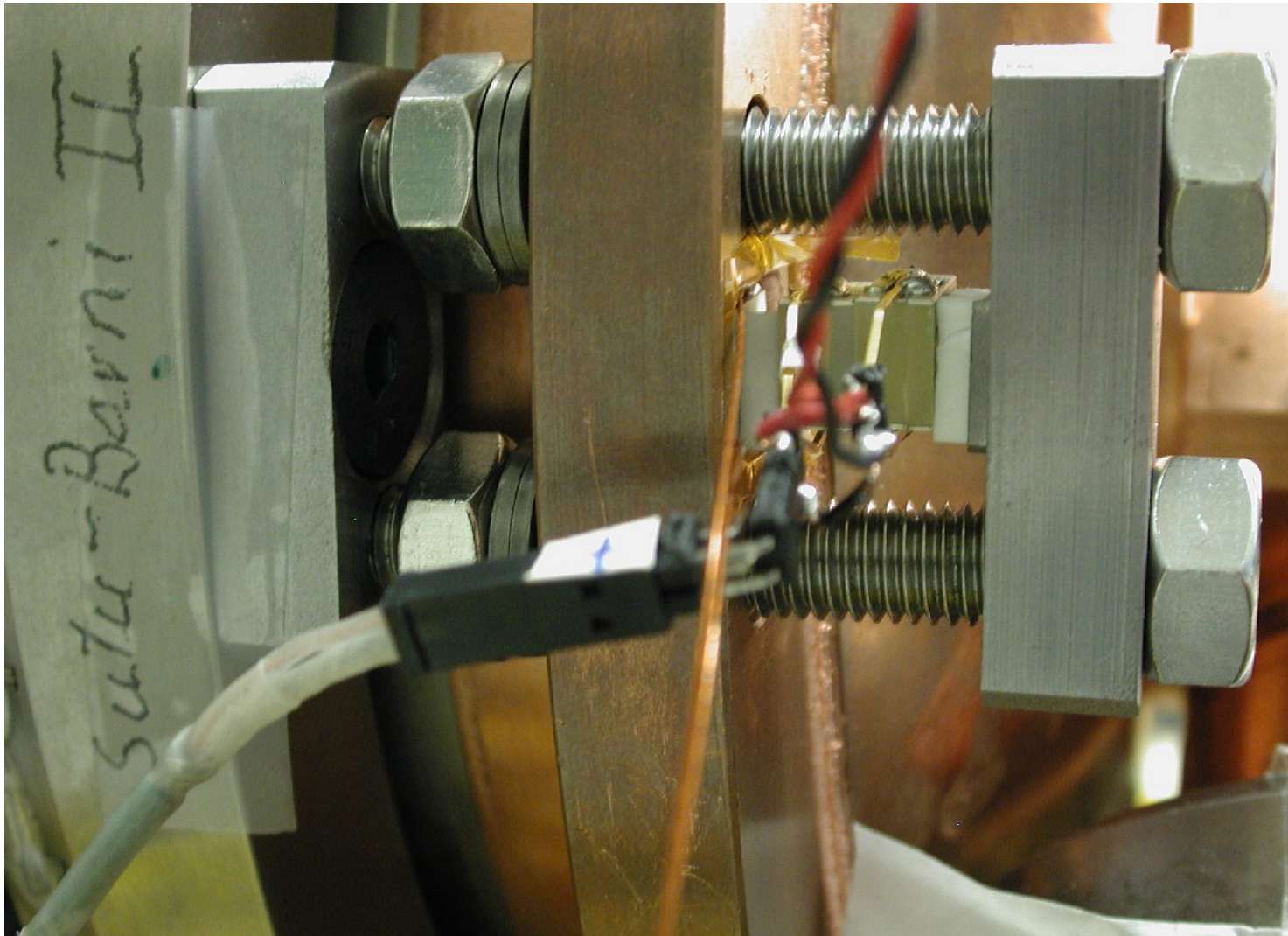
Piezo Assembly Design



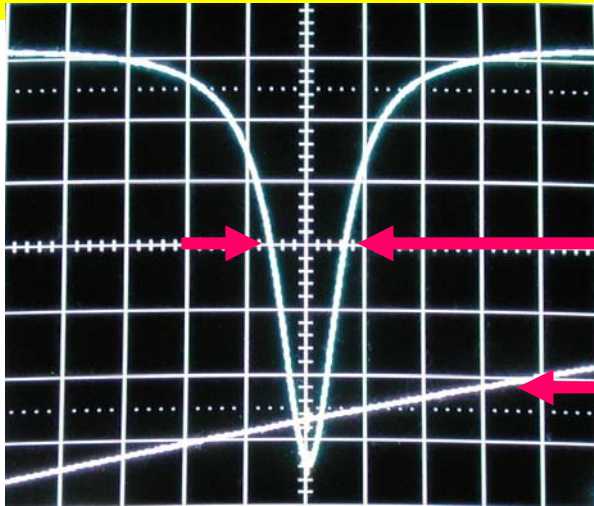
Close-up of Piezo Assembly



Piezo Assembly Closeup



Measurements of Piezo Movement



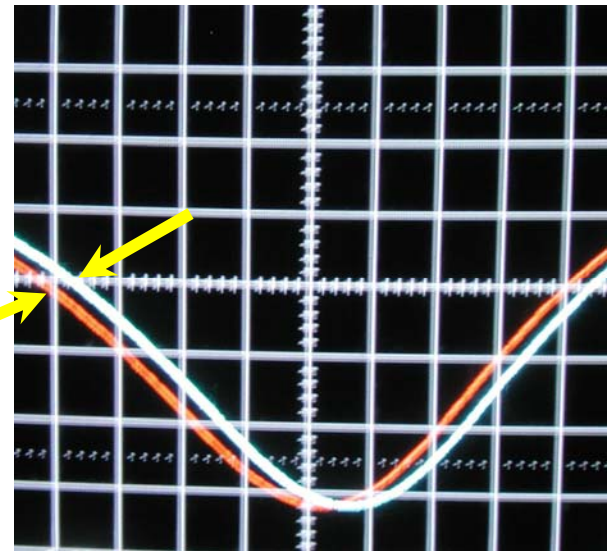
Resonance FWHM 52 kHz

VCO Ramp Generator
(sweep RF frequency)

Resonance Shift

Piezo Potential 10V \rightarrow 180V

ΔF (sweep) $\sim 1.5\text{KHz}$

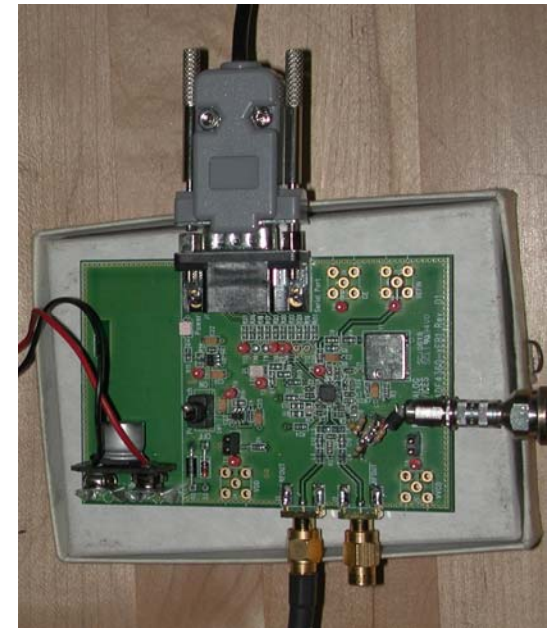


Low Noise Stable Oscillator & Amplifiers Needed

RF field detector measures Resonance

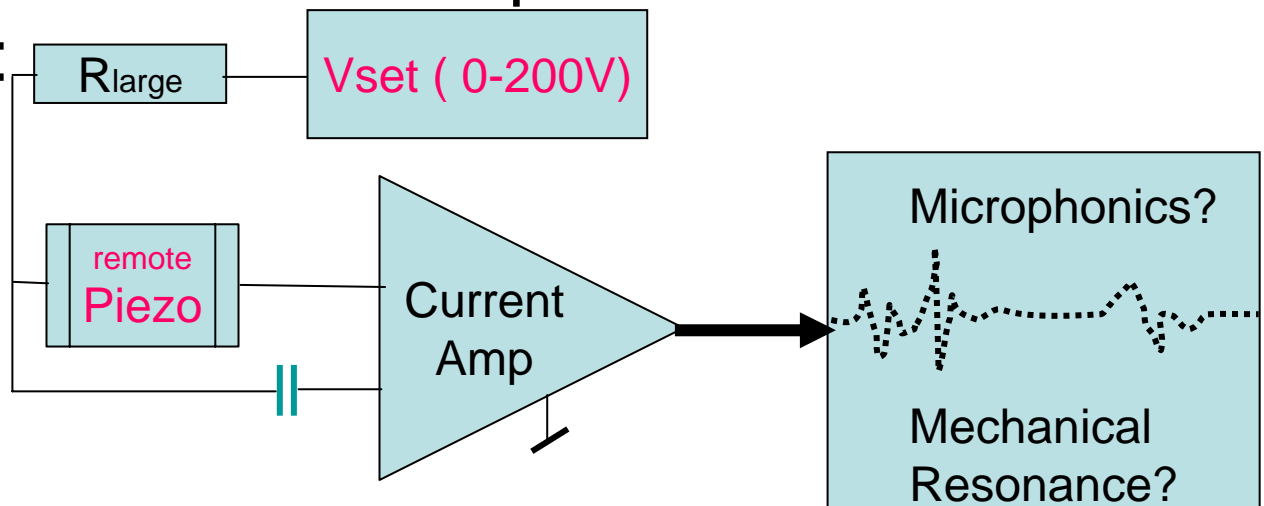


**Stable 1.3 GHz Clock
AD4560-5 Eval Board
Modified for ext. VCO ref.
Short Term Stability ~300Hz
(PLL not Locked)**



Additional Tasks Some Under Way

- Add Stepping Motor and harmonic drive
- Understand Mechanical Hysteresis
- Optimize piezo preload
- Study Movement using longer Piezo Driver
- Test with Cold Niobium Cavity
- Mechanical Resonances: Explore transducer possibilities:



Work With Fermilab

- Collaboration established between Penn, Fermilab, and INFN on tuners and piezo integration
- Provide co-axial tuners for assembly with 1st cryomodule and Horizontal Test Facility

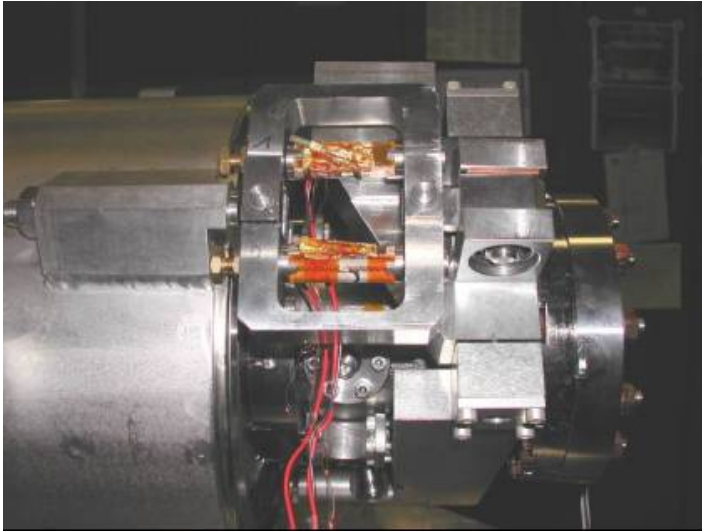
Piezo Measurements at Fermilab

For Ruben Carcagno

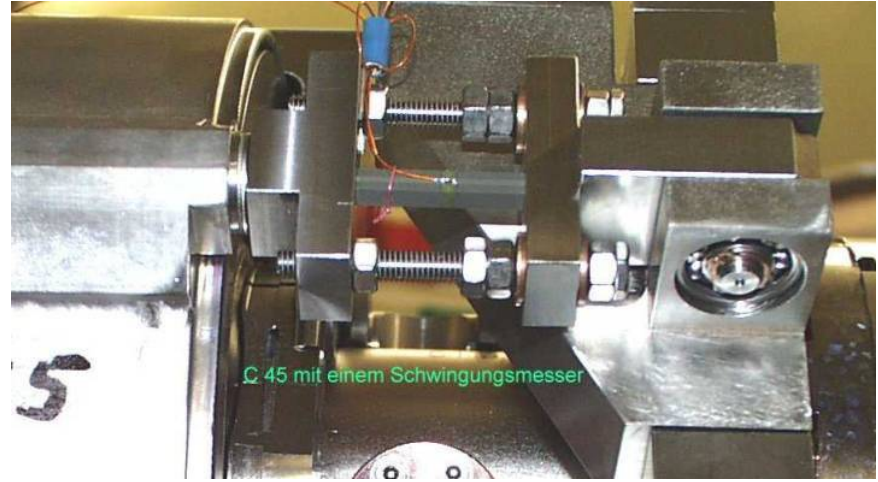
Fermilab

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Dual vs Single Piezo tuner (DESY Design)



The current dual-piezo DESY bracket design does not perform well due to preload loss after cooldown and interaction with stepping motor action to bring the cavity to 1.3 GHz



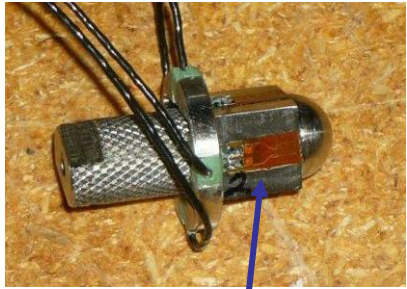
The plan for CC2 test at SMTF is to go back to the simpler single-piezo DESY design, perform mechanical modeling, and add diagnostics instrumentation (strain gauges, RTD, capacitance measurements) to understand preload changes

CC2 Piezo Tuner Status

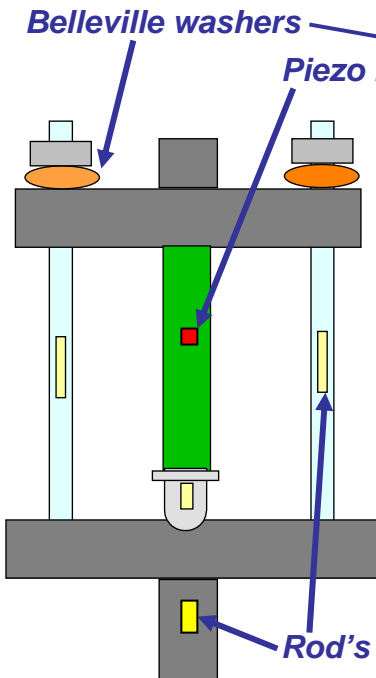
(FNAL Design)

Re-design Single Piezo fixture:

- to accommodate longer 36mm (instead of 30mm) PI Ceramic Piezo (more stroke at 4K);
- to add parts (bullet) to reduce shearing forces on Piezo;
- to instrument bullet and parts of fixture:



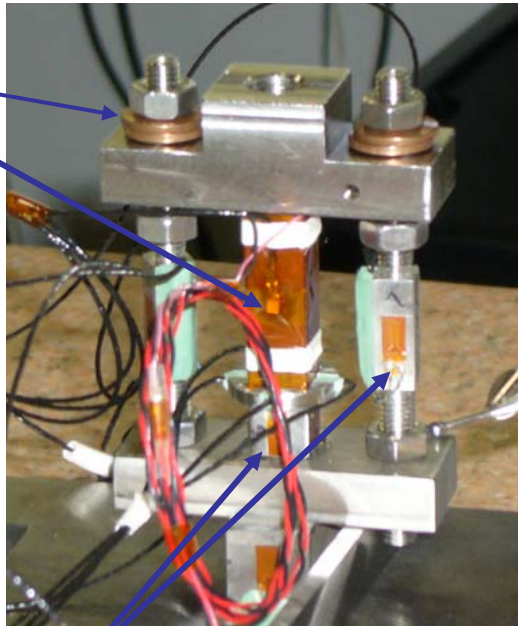
Bullet's SGs (4)



Belleville washers

Piezo RTD

Rod's and Bracket's SGs



✓ to control static preload on Piezo during fixture assembly;

✓ to monitor static preload on Piezo when stepping motor engaged (at RT & 4K);

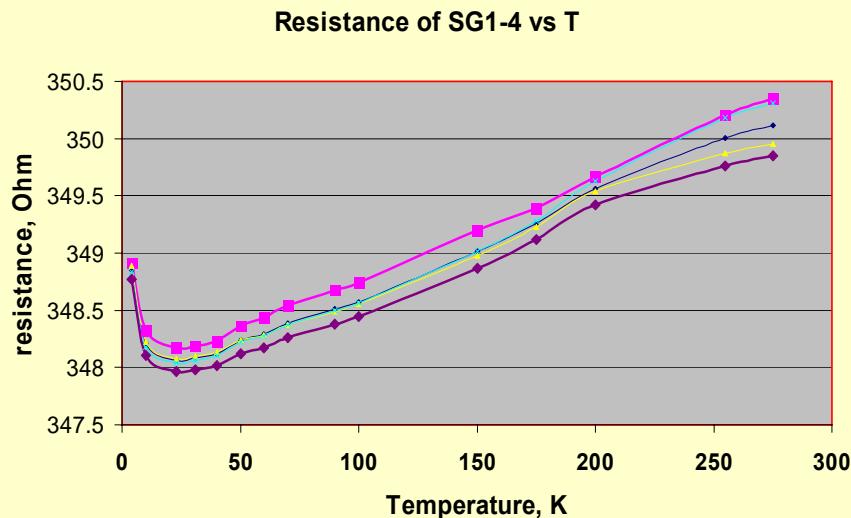
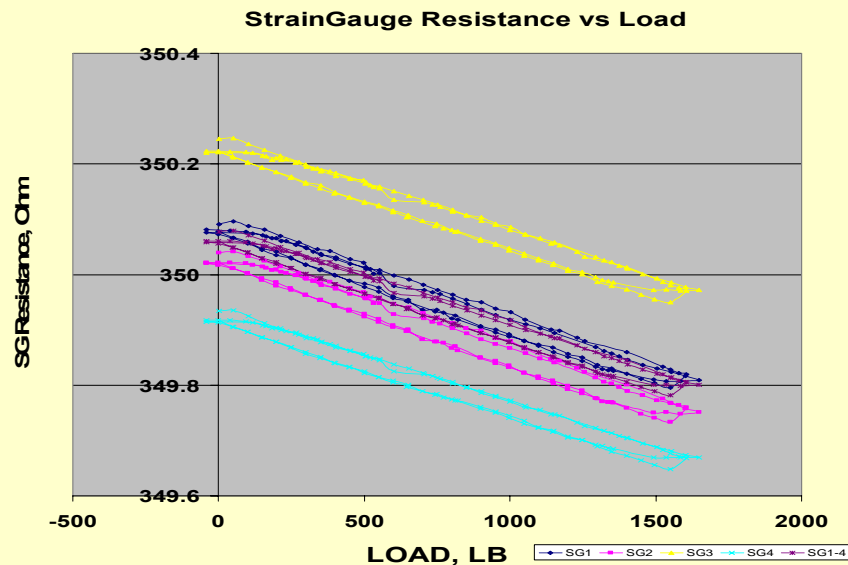
✓ to monitor static preload on Piezo during cooldown and warmup;

✓ to monitor *T* of Piezo during high frequency operation

**11 STRAIN GAUGES
2 RTDs**

Transferring FNAL's Magnet R&D technology to Fast Tuner R&D Program

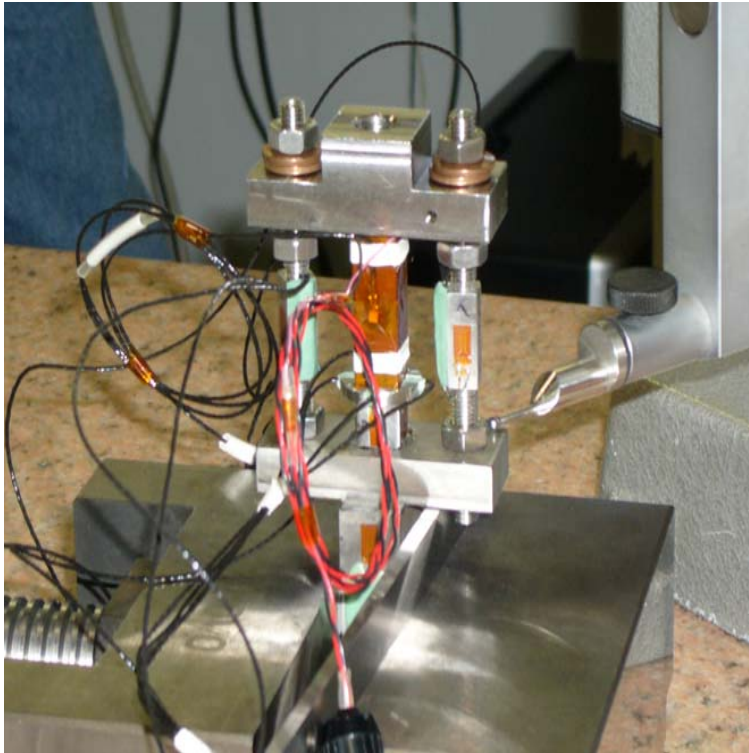
**Technical Division facility for SG
Calibration at Temperature range
300K-4K and Load range 0-20,000Lb**



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CC2 Fast Tuner Fixture Assembly



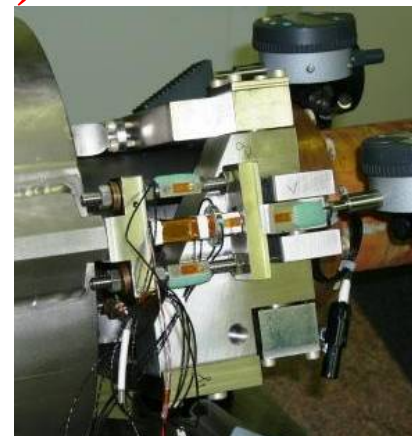
Combination of Mechanical tool & Bullet's
SG resistance measurements to assembly fixture
with controlled Piezostack preload

$$\text{Load}_{\text{piezo}} = \Sigma \text{SG}_{1,2,3,4} / 4 = \underline{\underline{550 \text{ lb}}}$$

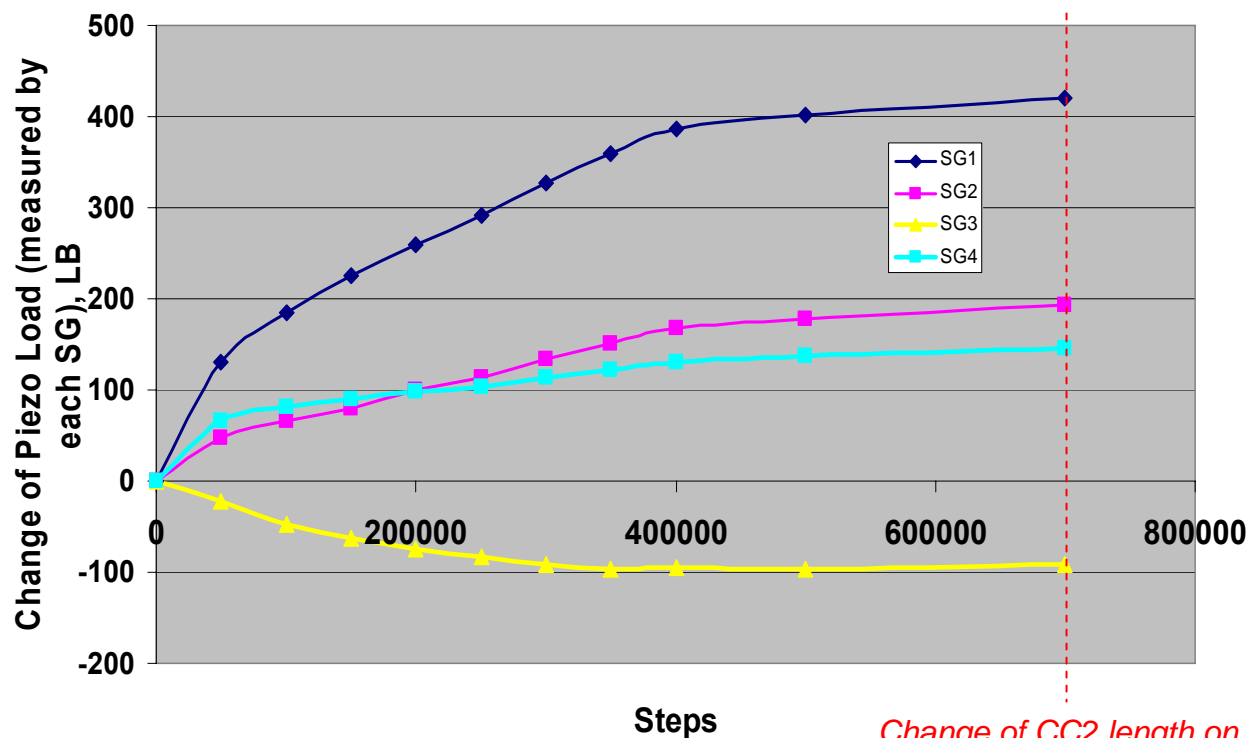
Fast Piezo Tuner fixture and Slow Tuner interaction

Measurements at Room Temperature ($T=300K$)

Slow (step motor) & fast (piezo) tuners interact to each other, so the force applied to piezo will change by moving the step motor... So far it was a problems with previous DESY fast tuners..There were NO ANY instrumentation to monitor piezo unload...

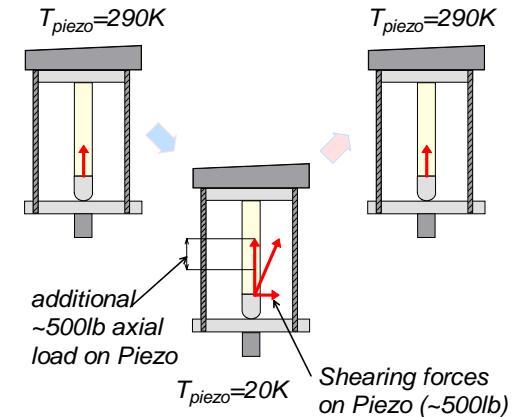
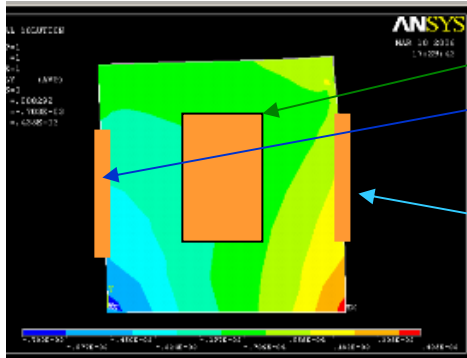
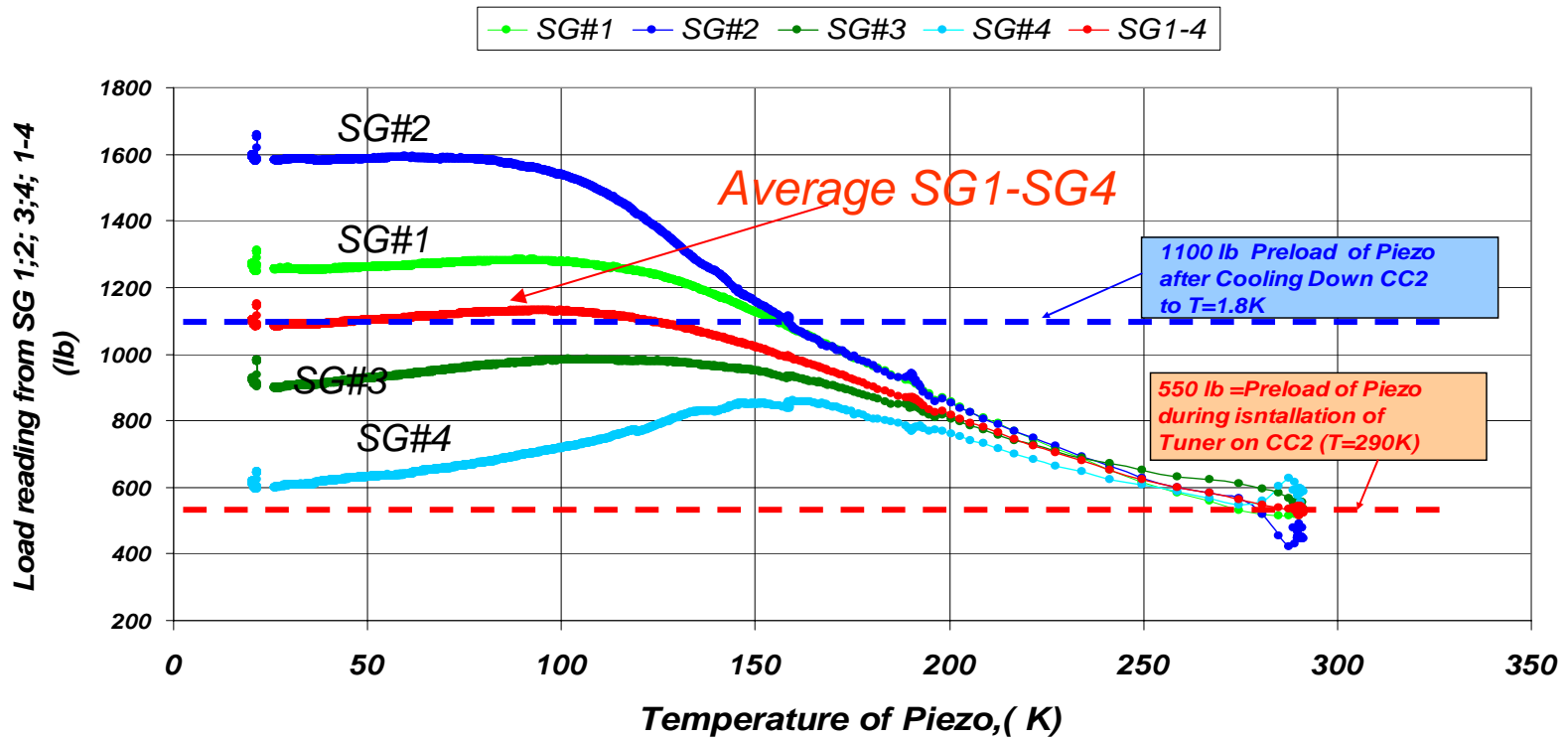


Load on bullet's SG1-4 vs Stepping Motor steps

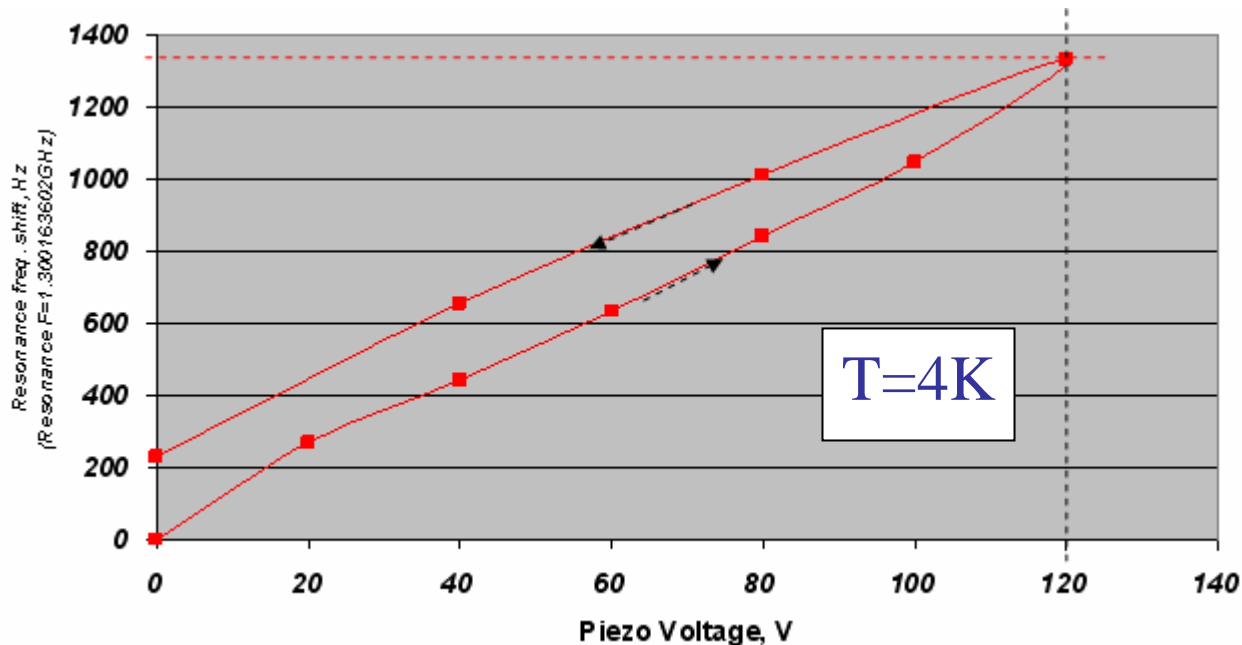


*Result:
Unload of Piezo
will not exceed (200lb)
= 30% of initial preload*

Preload on Piezoactuator during cooldown & warmup of CC2 (reading from bullet's SGs)



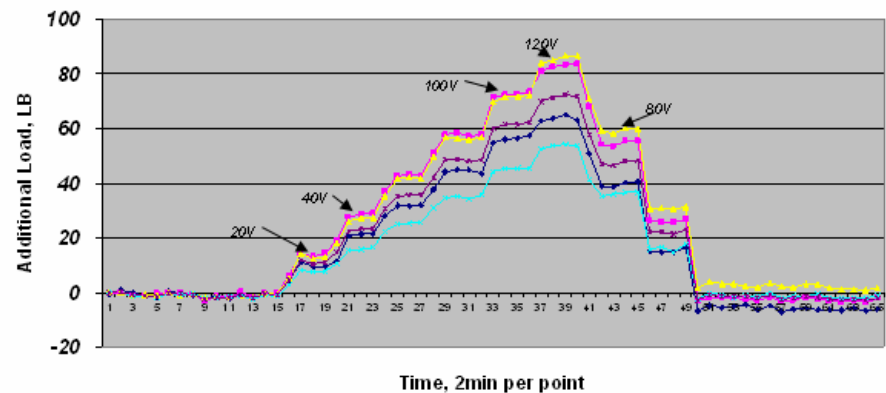
Piezo Tuner Test –Static Tuning Range



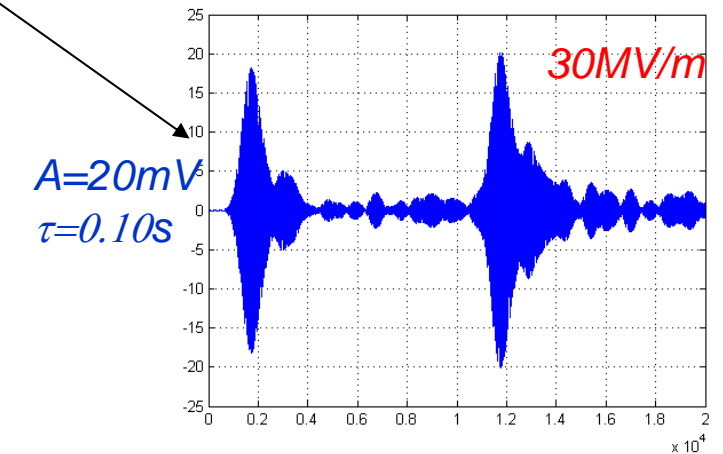
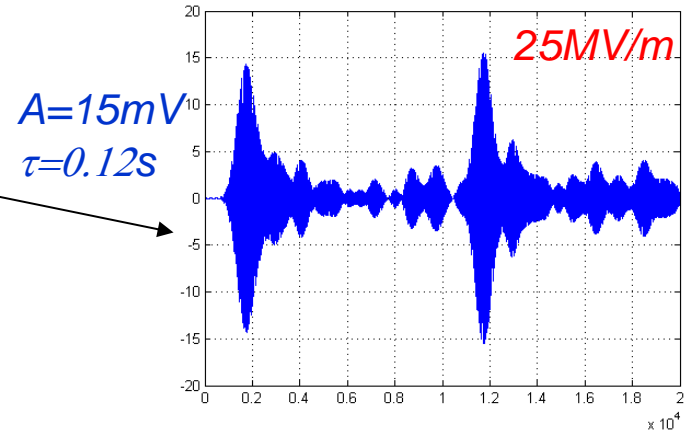
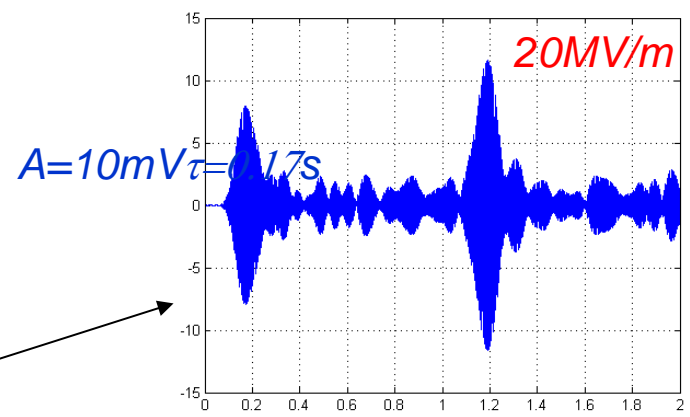
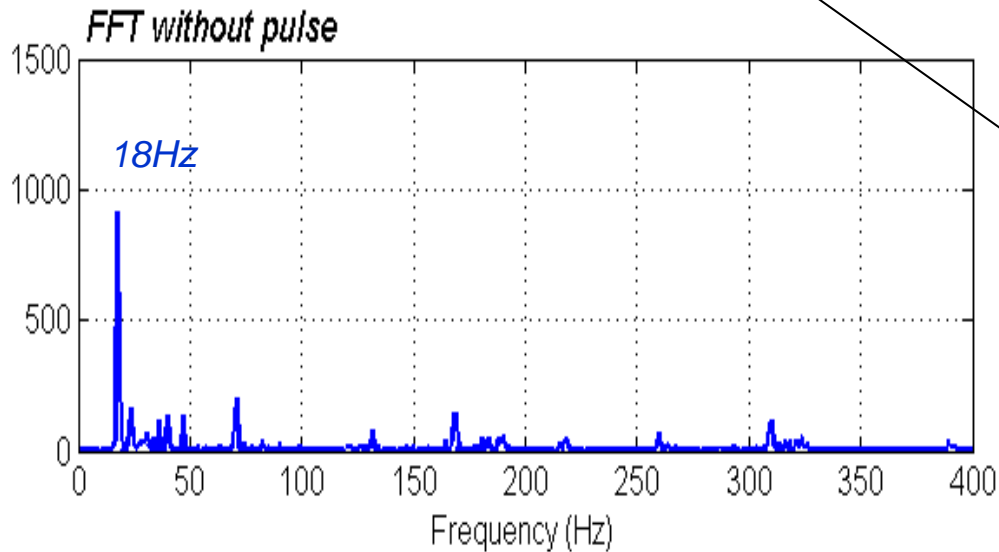
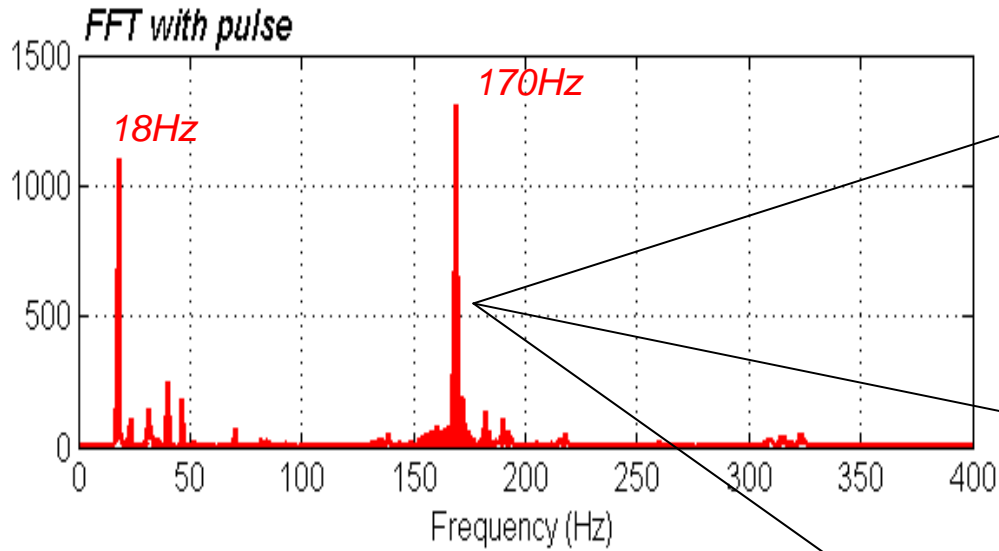
Cavity resonance frequency increase as a function of Piezo Tuner static voltage. Total static tuning range ~ 1300 Hz, corresponding to a CC2 length change of ~ 6.5 microns

Piezo load increase for different piezo voltages measured by bullet strain gauges. The average increase for 120 Volts is ~ 60 lbs.

Additional Load on Bullet vs Time
(Piezo voltage changes(V) 0-20-40-60-80-100-120-80-40-0)



CC2 Microphonics measurements.
Pulse mode operation. Piezo => sensor.



High Precision Data Acquisition System for Fast Piezo Tuner.

(Strain Gauges & RTD Slow Scan system & Piezo Driver)

RTD Current Source (10^{-6} A)
SG Current Source (10^{-3} A)

DVM HP 3458A

Switch Boxes

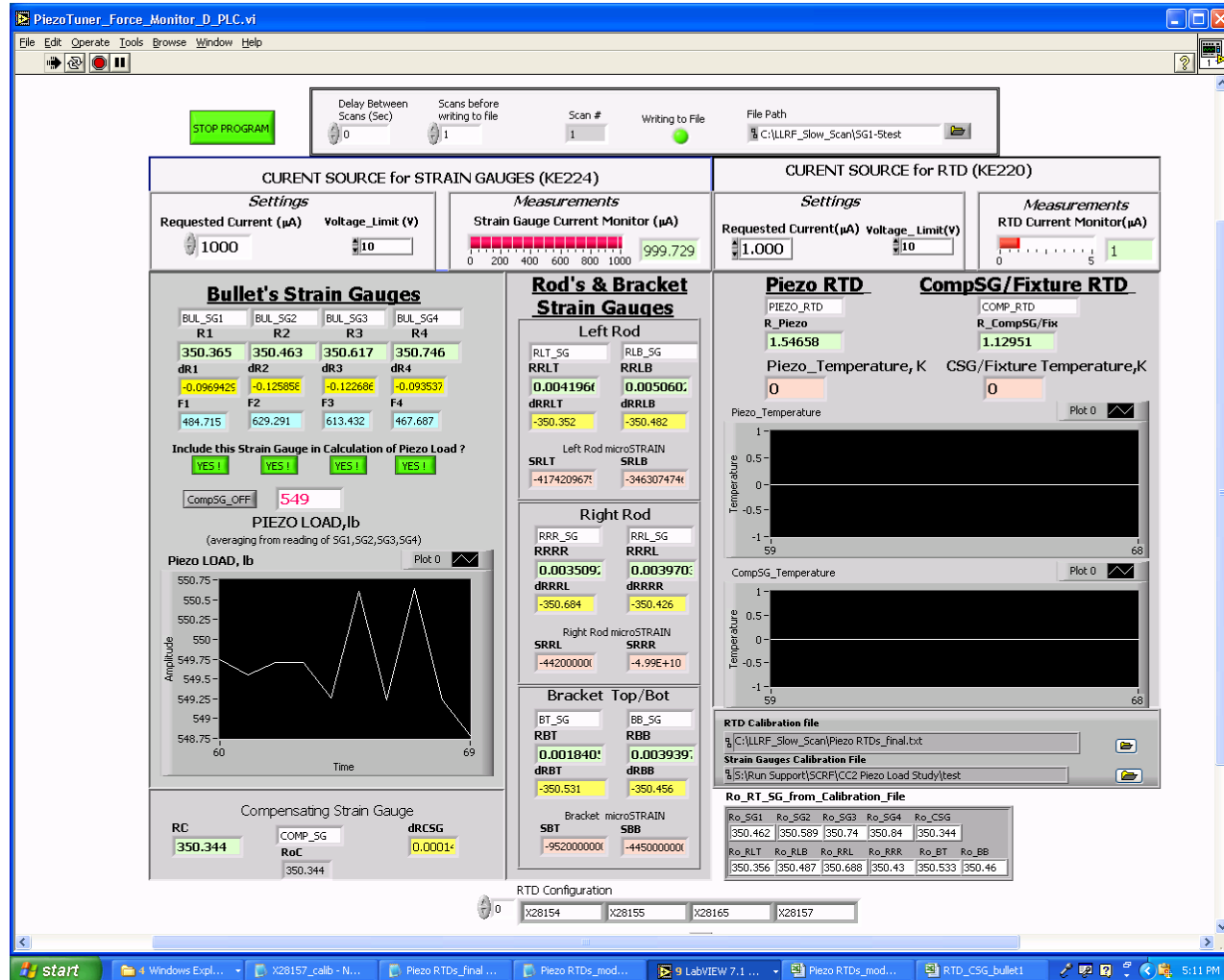
Piezo Power Driver

NI/PXI system
FET Multiplexer NI PXI-2501
FPGA RIO NI PXI-7833

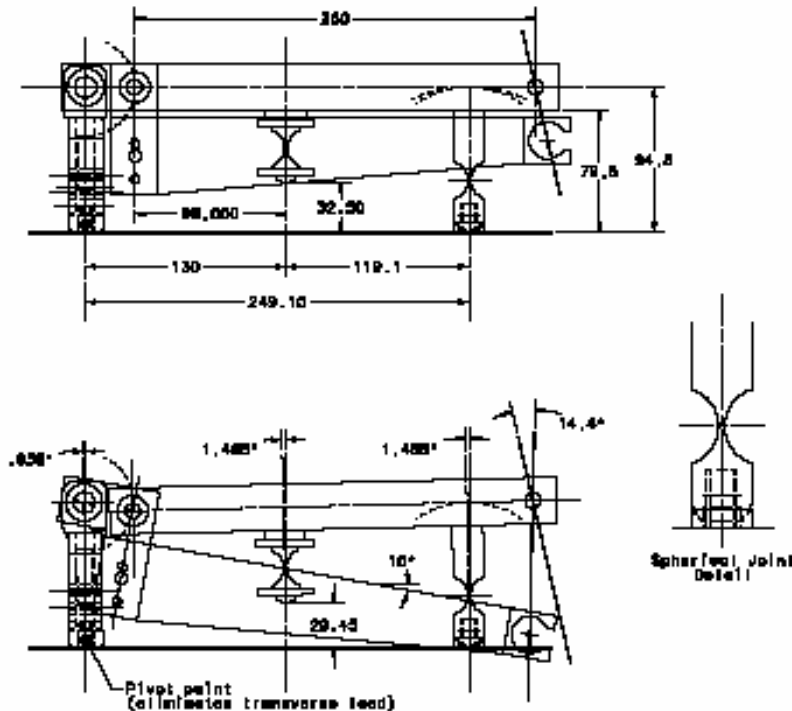


Labview Program to monitor Strain Gauges & RTD

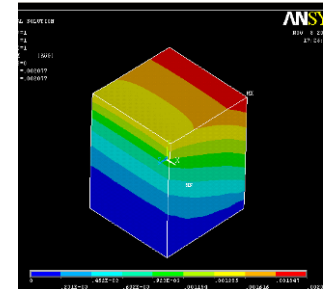
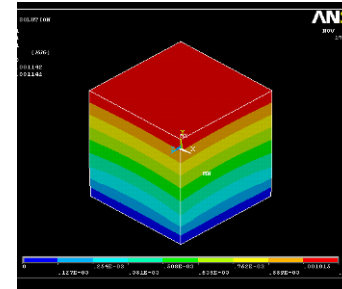
*data logging and on-line monitoring:
forces on Piezostack; Strain on elements of Fast Tuner Fixture
& Temperature of Fixture and Piezostack*



We were able to compare our measurements with M E Simulation Software results



Kinematics scheme of tuner illustrated large bending angle on the Piezo Tuner Fixture



*ANSYS simulation of bullet's for axial and transversal loads.
Experimental results and simulation shown quite large shearing forces applied to Piezo...
Which could drastically decrease lifetime of Fast Tuner.*