



Two 10\*10\*18mm piezo (glued together)  
Run both piezo simultaneously

# TESTING OF THE PIEZO-ACTUATORS AT HIGH DYNAMIC RATE

## OPERATIONAL CONDITIONS \*

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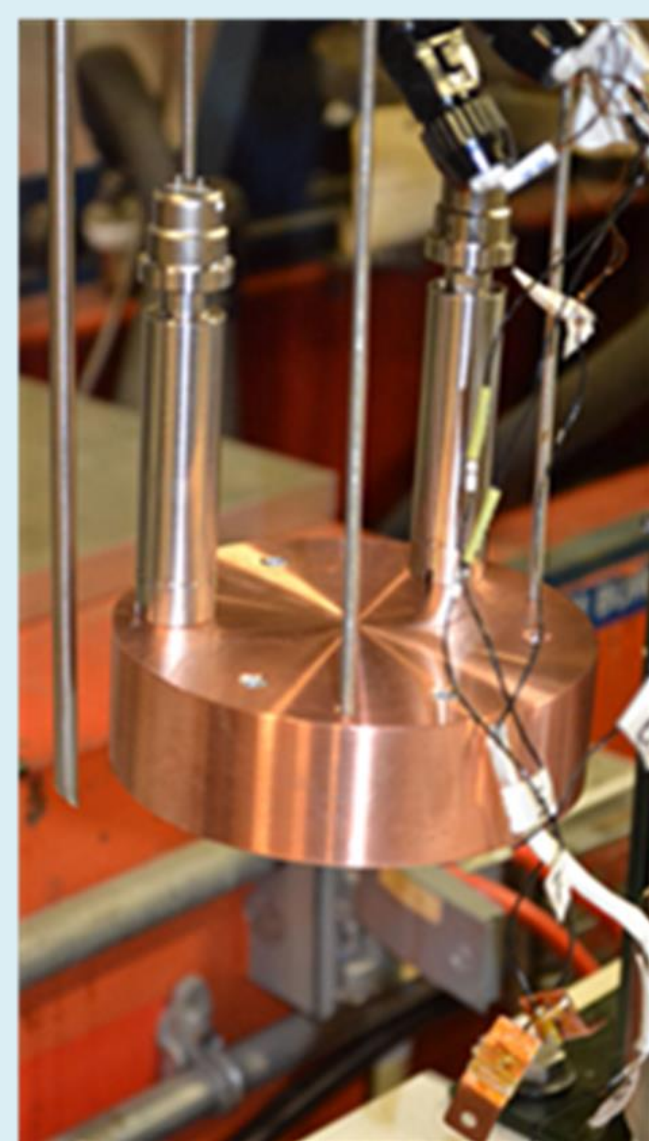
Reliability of the piezo-actuators that deployed into SRF cavity tuner and operated at high dynamic rate operational conditions made significant impact on the overall performance of the SRF linacs. We tested at FNAL piezo-actuators P-P-844K075 that were developed at Physik Instrumente for LCLS II project. Even these actuators were developed for CW linac we tested them at high dynamic rate inside cryogenic/insulated vacuum environment. Results of the tests will be presented. Different modes of the piezo-actuators failure will be discussed.

### Designated Facility at FNAL

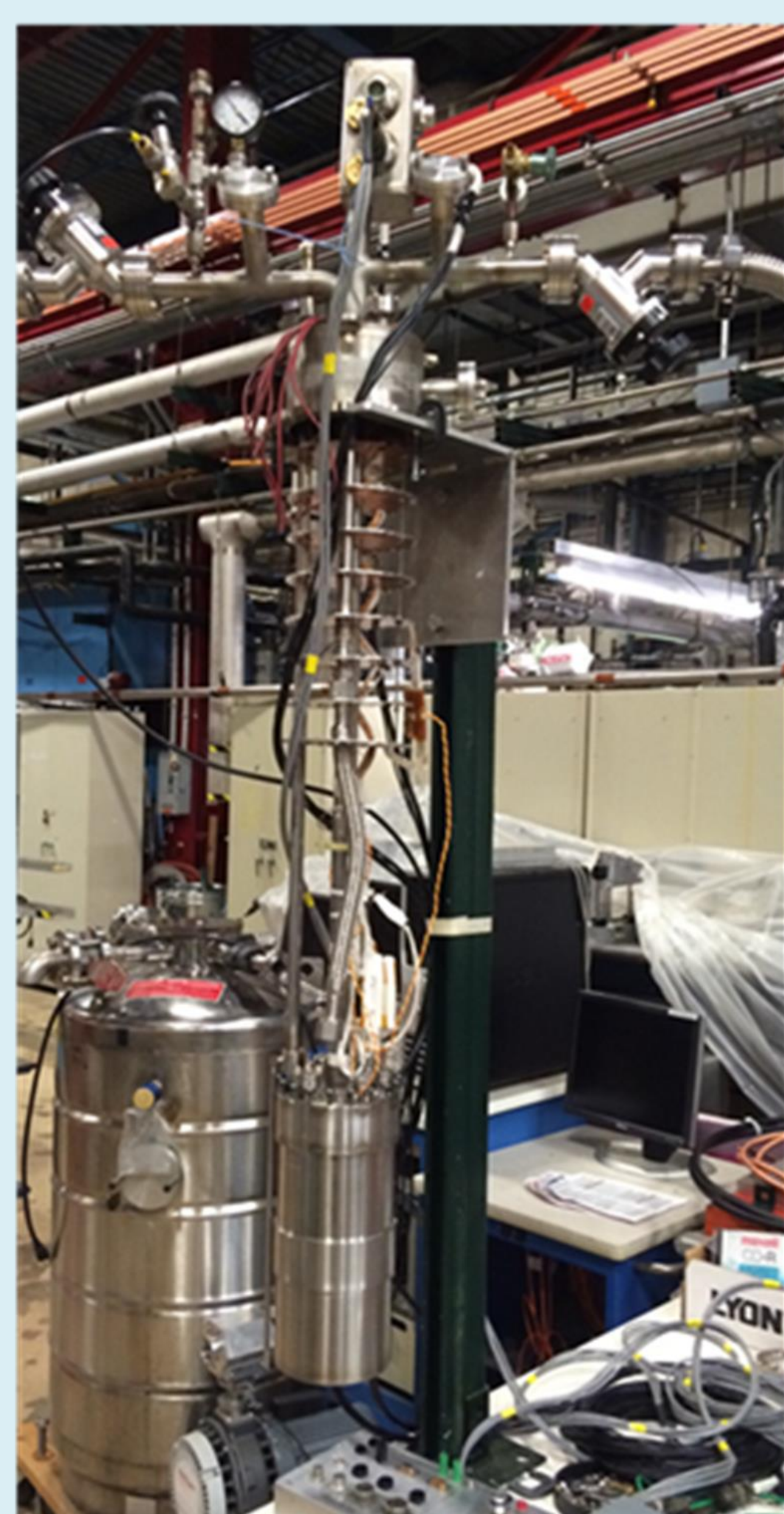
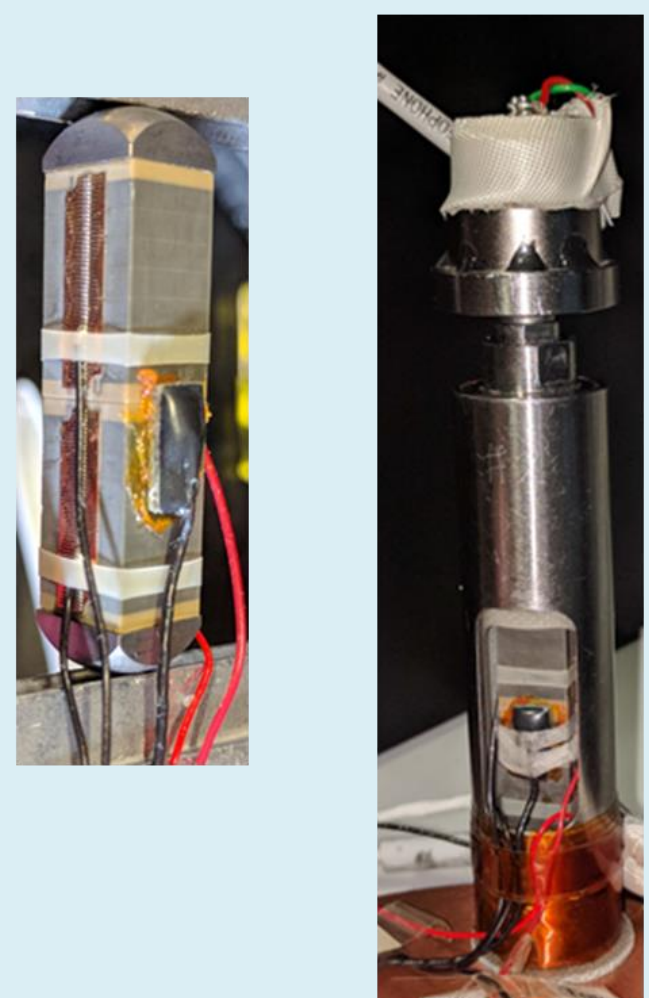


Insert into LHe dewar with cryo/vacuum and electrical connections

Capsules (up to 5) with Piezo-stacks Mounted on the copper block

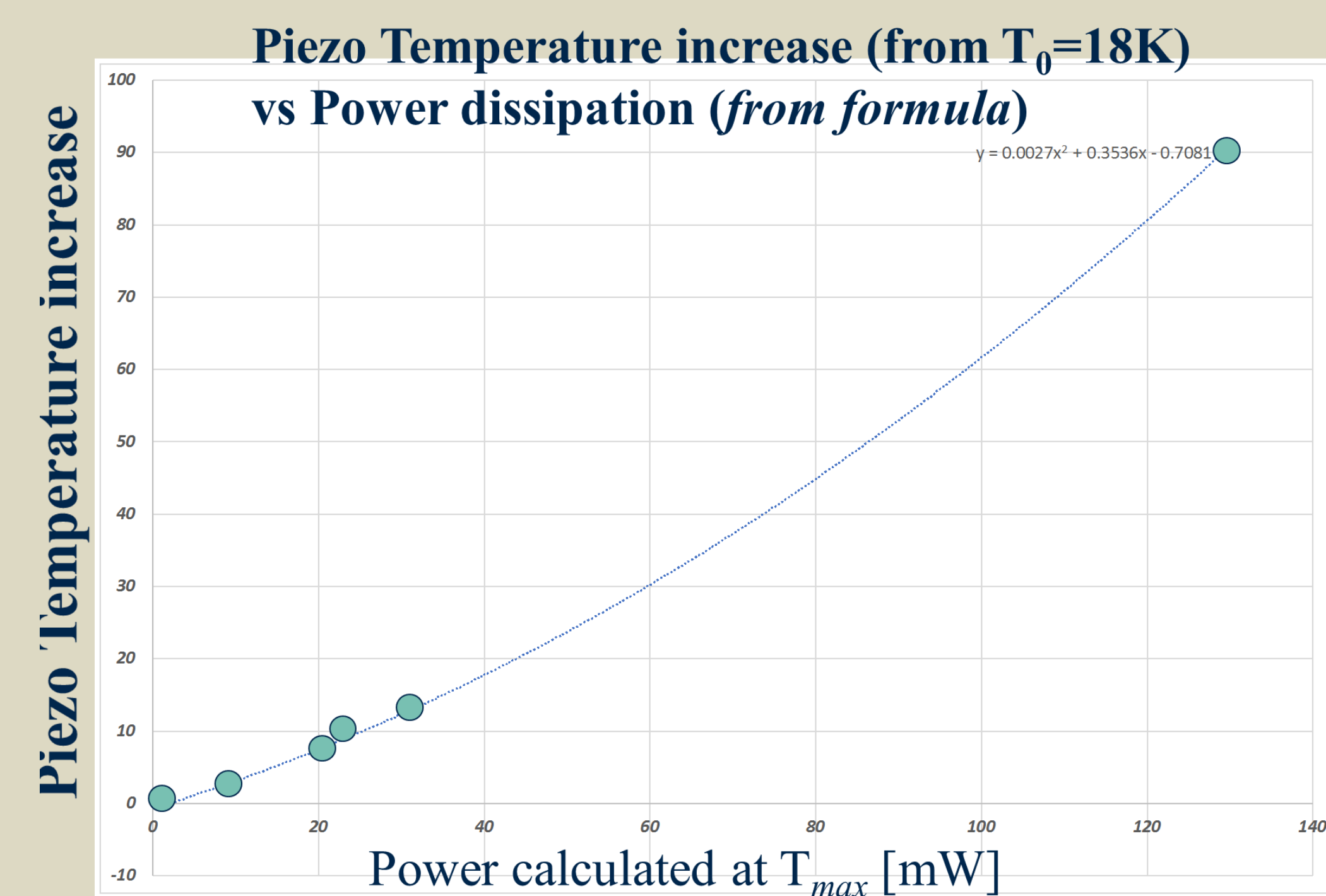
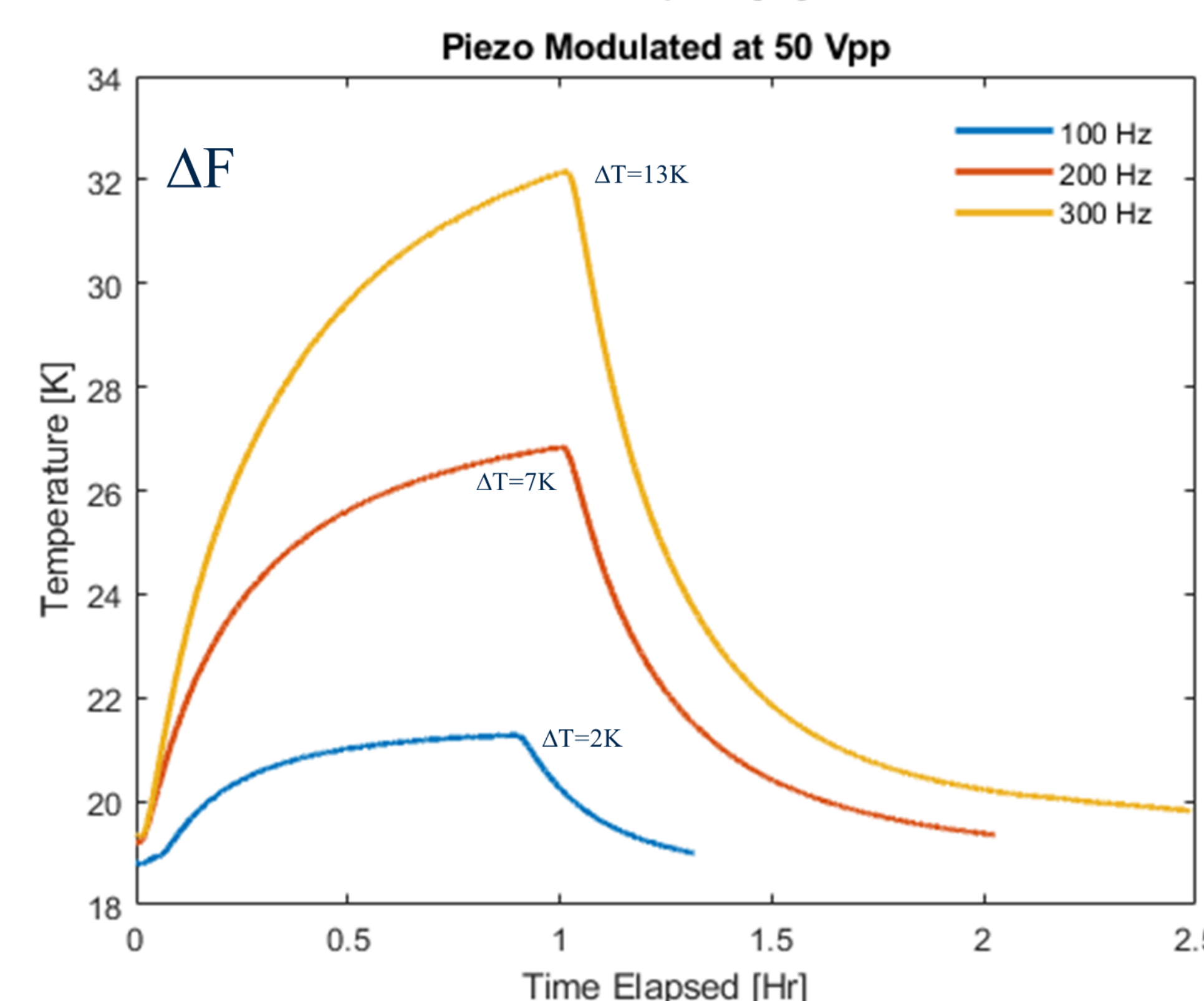
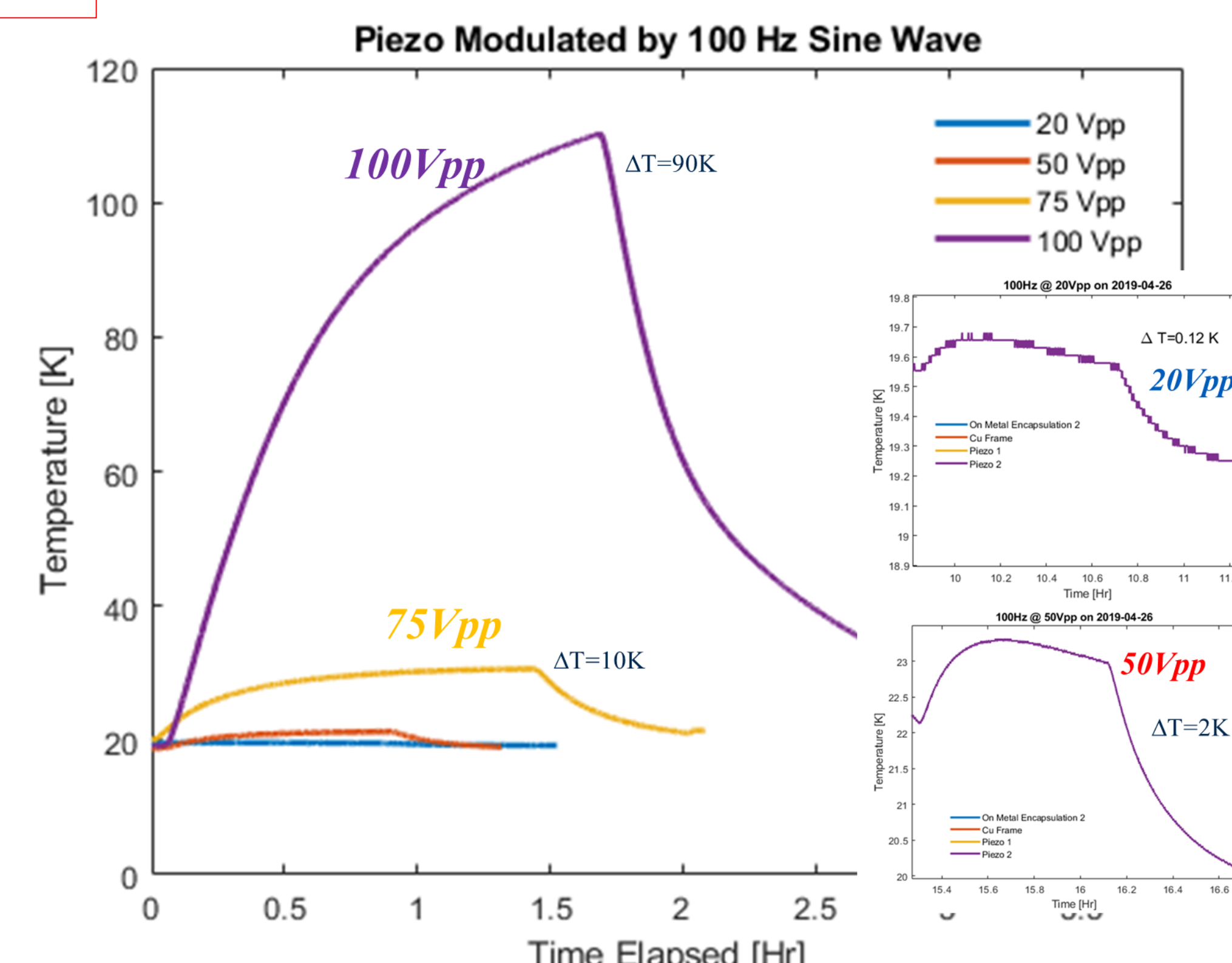
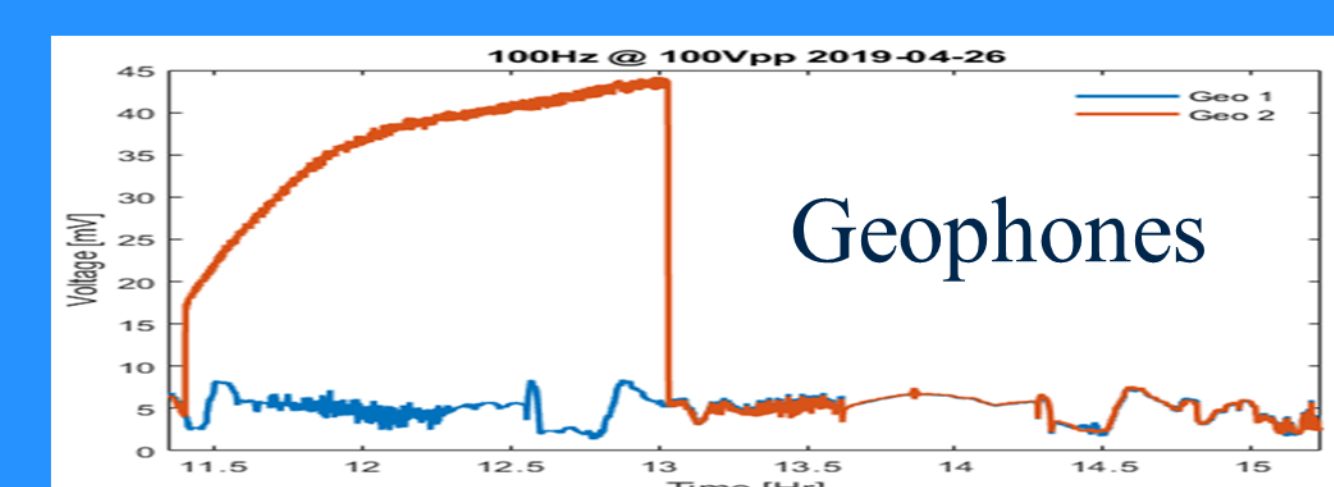
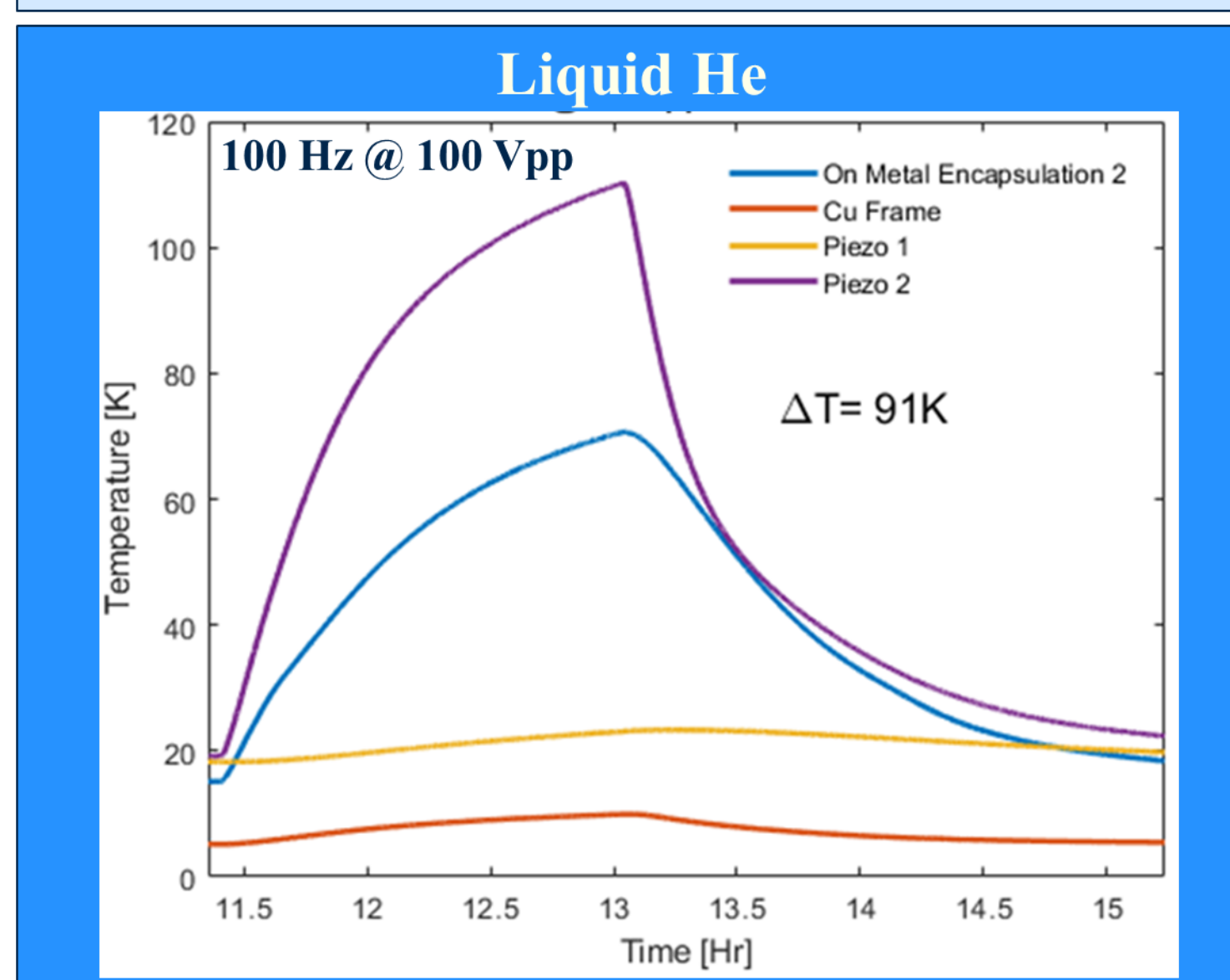
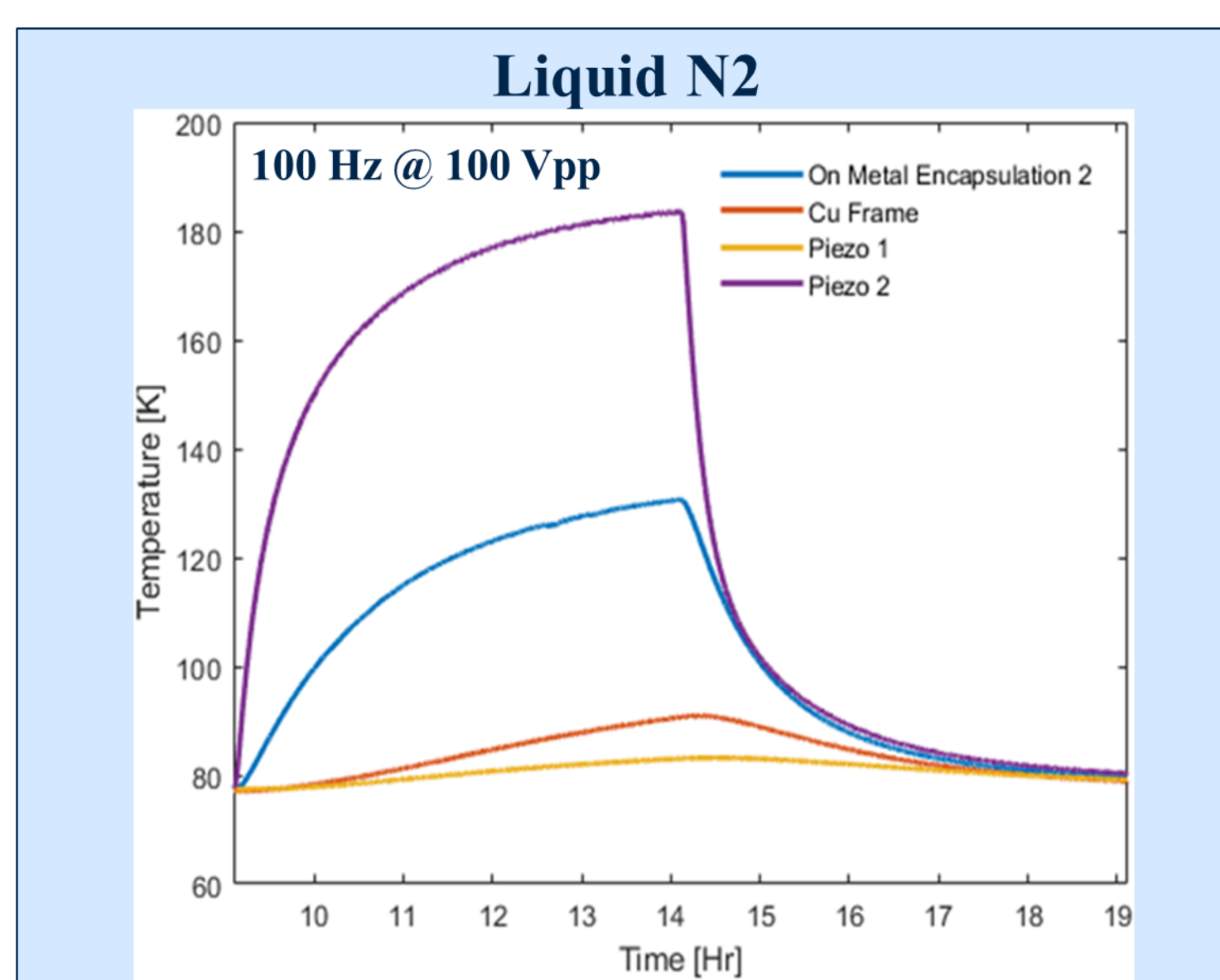
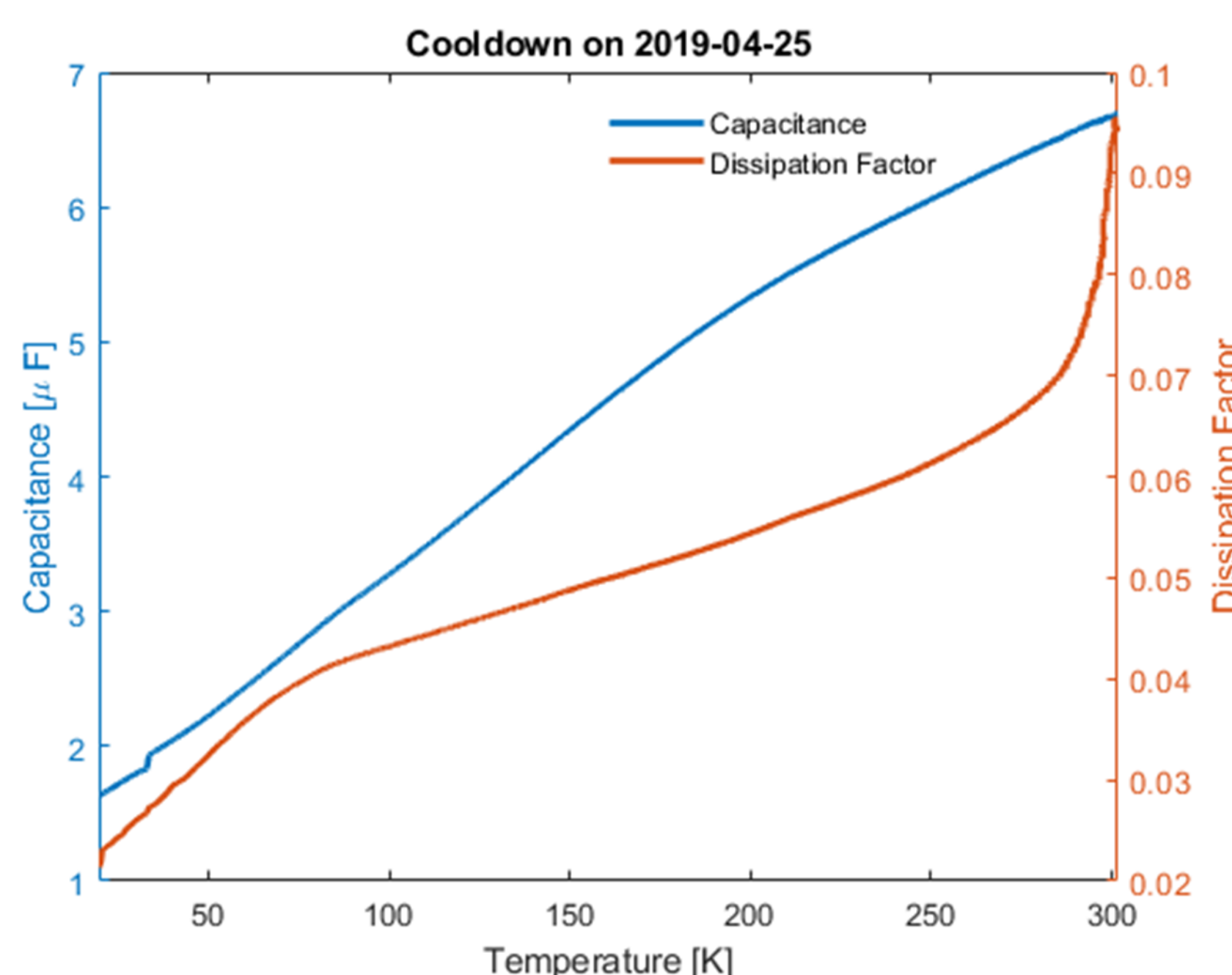


- RTD (Cernox) –to mount on Piezos  
- Geophones (to monitor piezo stroke)

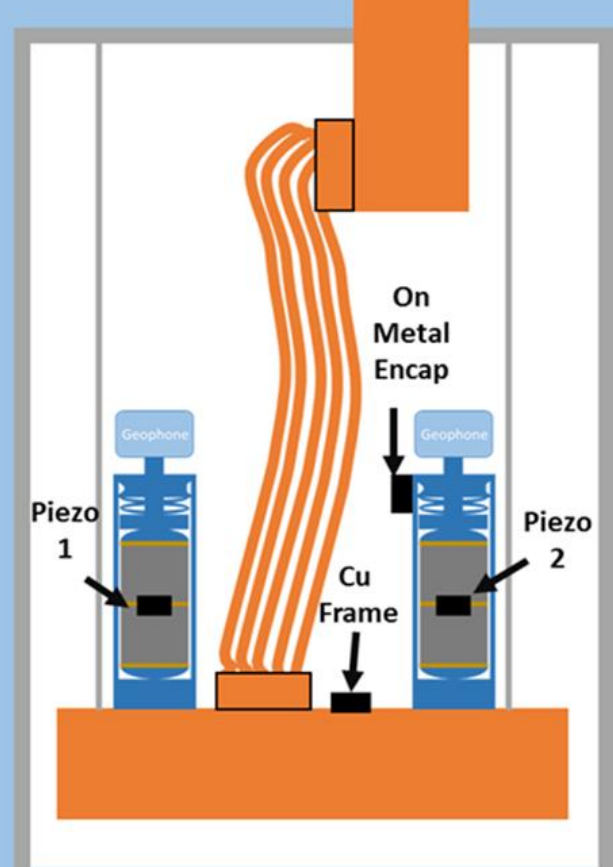


- 4 Cernox RTDs: 2 sensors placed in the middle of the stacks, one in the encapsulation and one in the Cu frame  
- Kept under vacuum ( $10^{-3}$  Torr) to replicate conditions in cryomodule ( $10^{-6}$  Torr)  
- Copper braid used for heat transfer  
- Geophone used to measure motion of the piezo

$$P = \frac{\pi}{4} \cdot f \cdot C \cdot \tan(\delta) \cdot U_{p-p}^2$$



Liquid N2 or He



LiqLevel

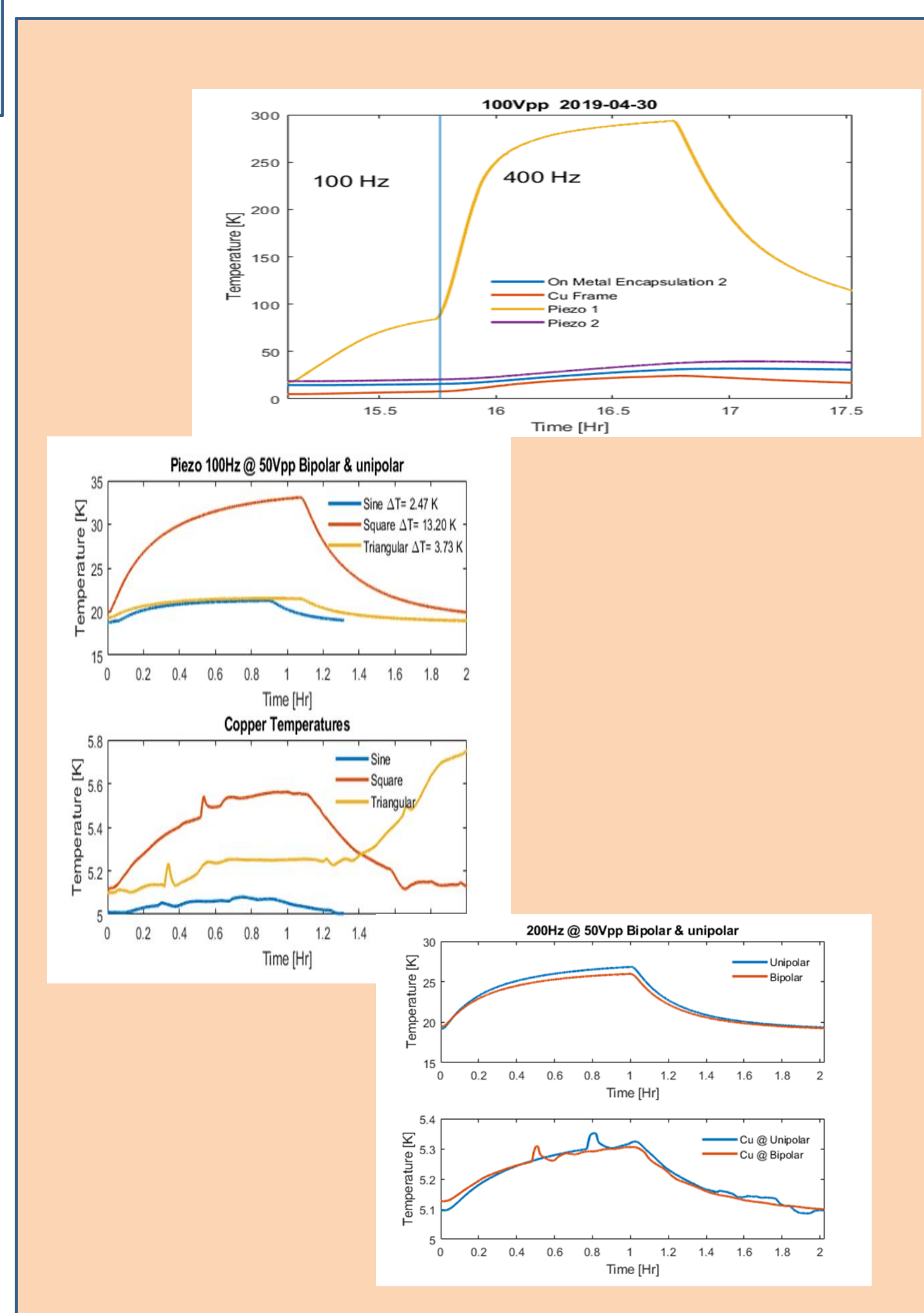
- Only the top stack on piezo 2 was stimulated with a sine wave form
- Sine wave form is at 100% duty cycle
- Temperature of the 4 sensors recorded all the time
- Liquid Level readout allowed to estimate consumption of the LHe for different operational regimes.
- Amplitude from Geophone help monitor stroke of the piezo

### Summary

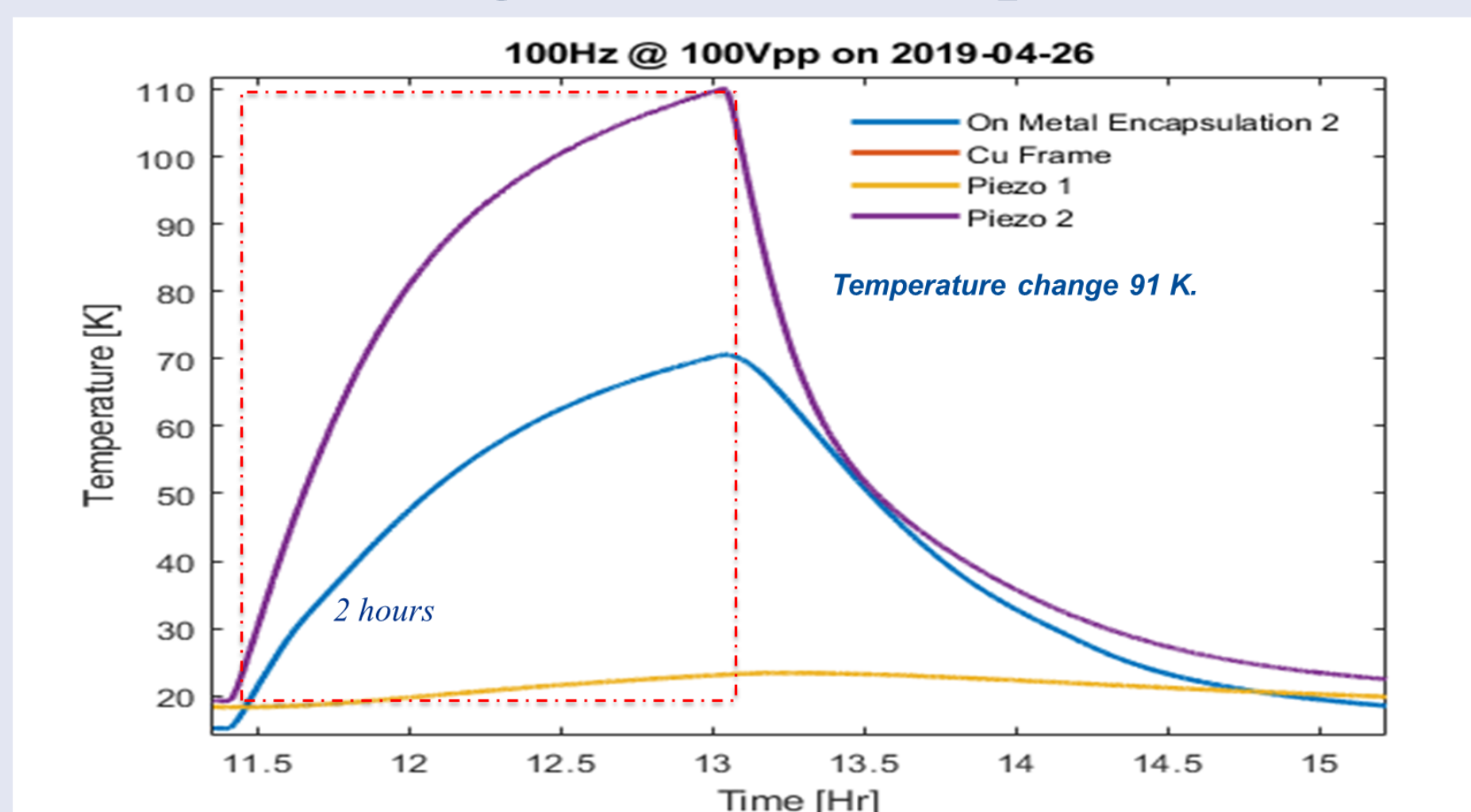
Longevity of the piezo-actuators when operated at high dynamic rate inside cryogenic/insulated vacuum environment need to be address in the initial stage of the tuner design.

We demonstrated that PI piezo-actuator when operated at high rate (100Hz) and at Vpp close to nominal voltage (Vpp=100V) will be quickly self-heated above T=100K (from T=20K when idle).

In real tuners piezo-actuator capsule separated from massive tuner frame with low conductivity ceramics balls... as results it will be warm up even faster than in test-stand environment....



### Energy deposited by piezo (estimated from calculations) and measured through LHe consumption



$P = \frac{\pi}{4} \cdot \text{Disp} \cdot C \cdot f \cdot V^2$   
 $P_{max} \sim 150-200mW$   
Assuming that piezo deposited 2 hours with  $P=200mW$  (that is overestimation ~2times)  
We will come up with 1.4kJ of energy deposition

During less than 2 hours run Dewar lost 9.8L of LHe.  
static loss (no signal on piezo) 0.13L/hour  
9.5L of LHe=1.18kg  
Latent heat of LHe 21kJ/kg  
To boil 1.2kg of LHe required 25kJ of energy

**25kJ(cryo) VS 1.4kJ(piezo)**  
**?????**