

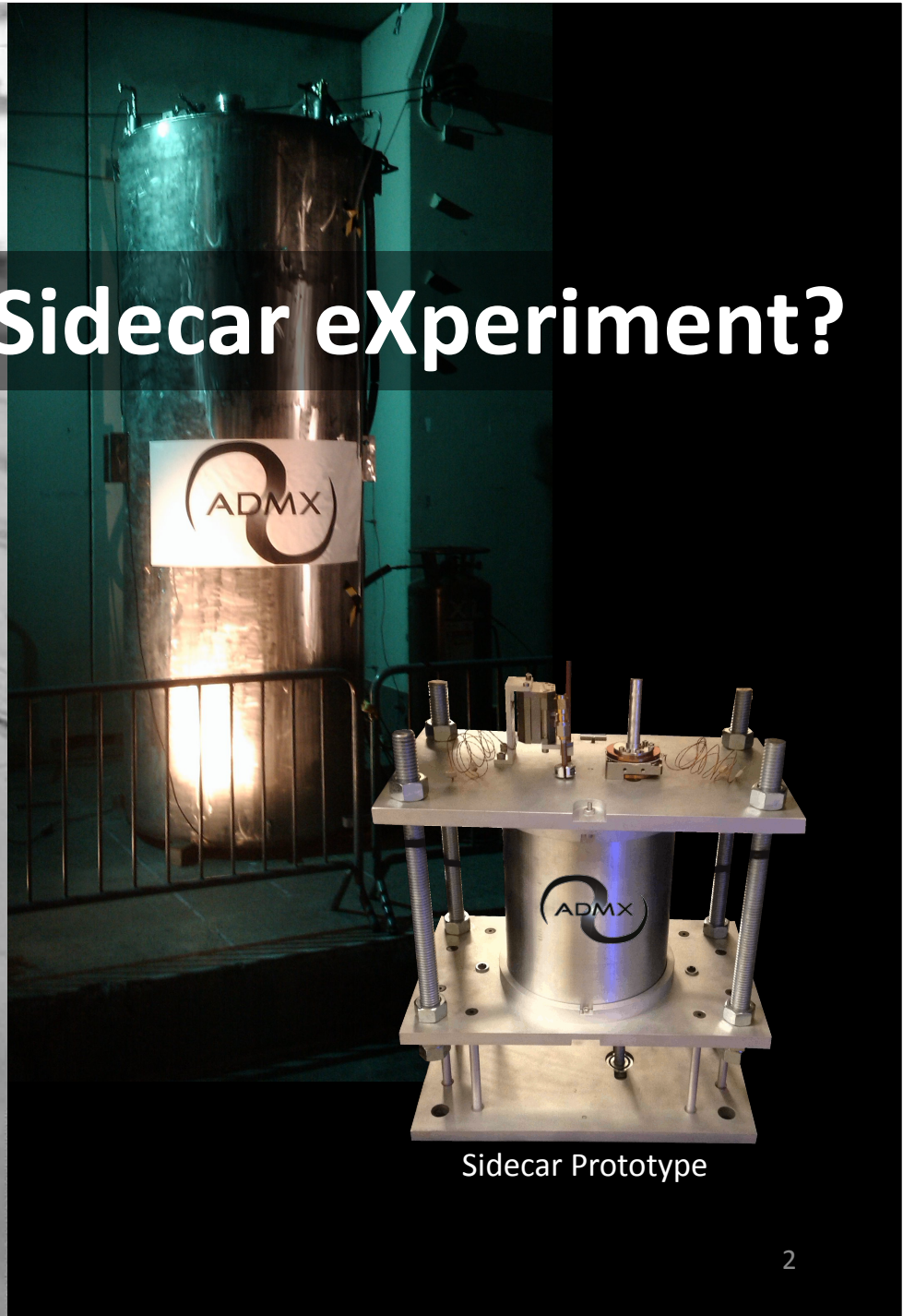
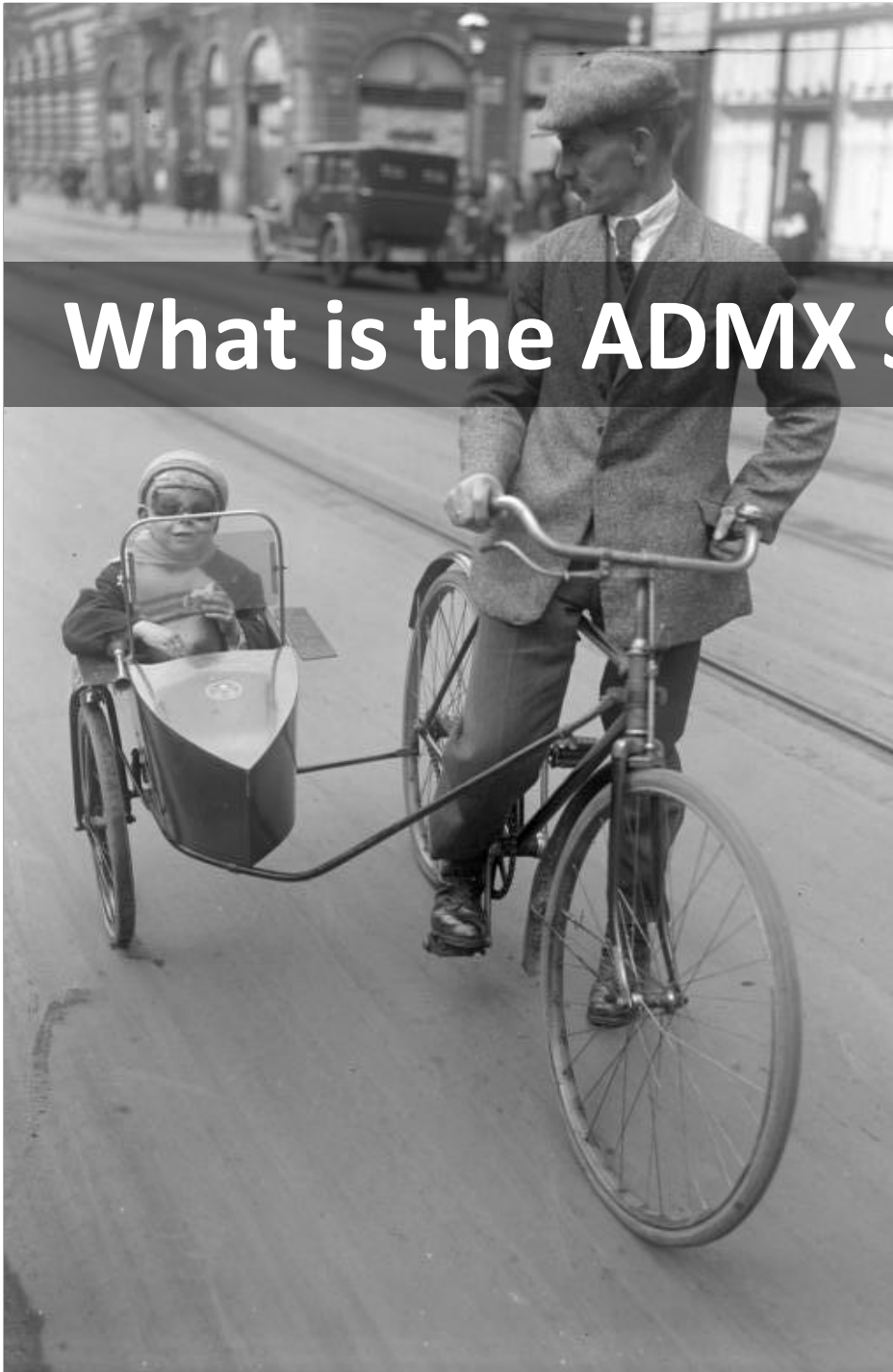
# Piezoelectric Tuning of Microwave Cavities for Axion Searches

Workshop on Microwave Cavity Design for Axion Detection  
Lawrence Livermore National Laboratory

August 25<sup>th</sup>, 2015

Christian Boutan

# What is the ADMX Sidecar eXperiment?



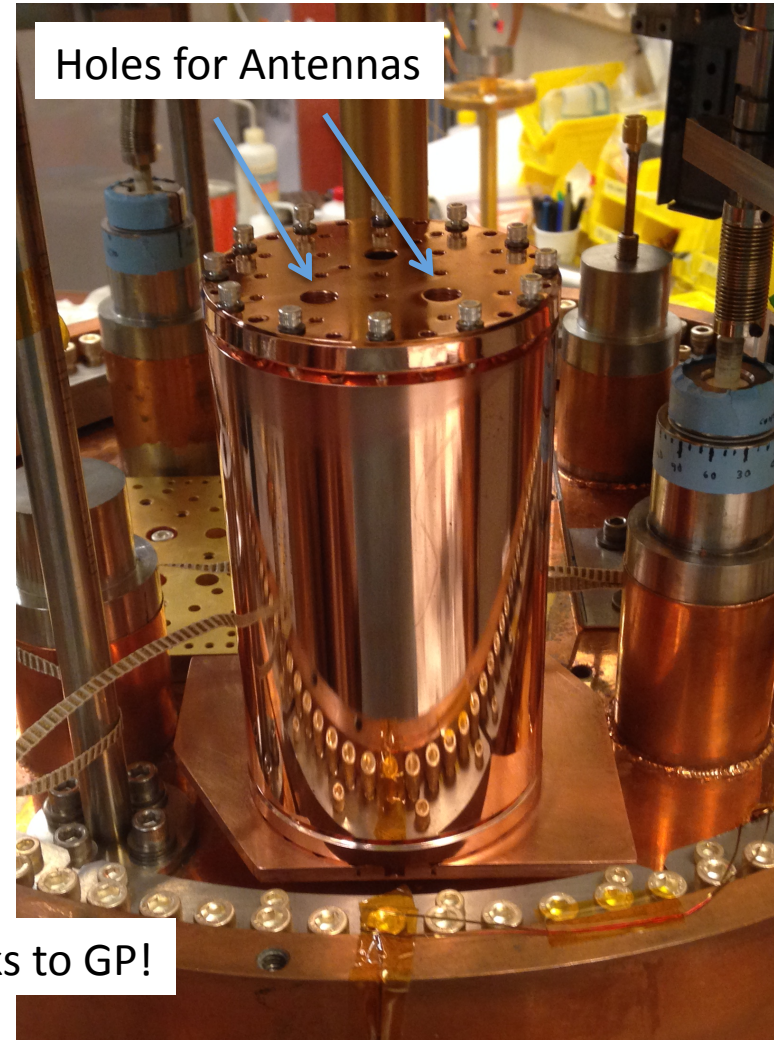
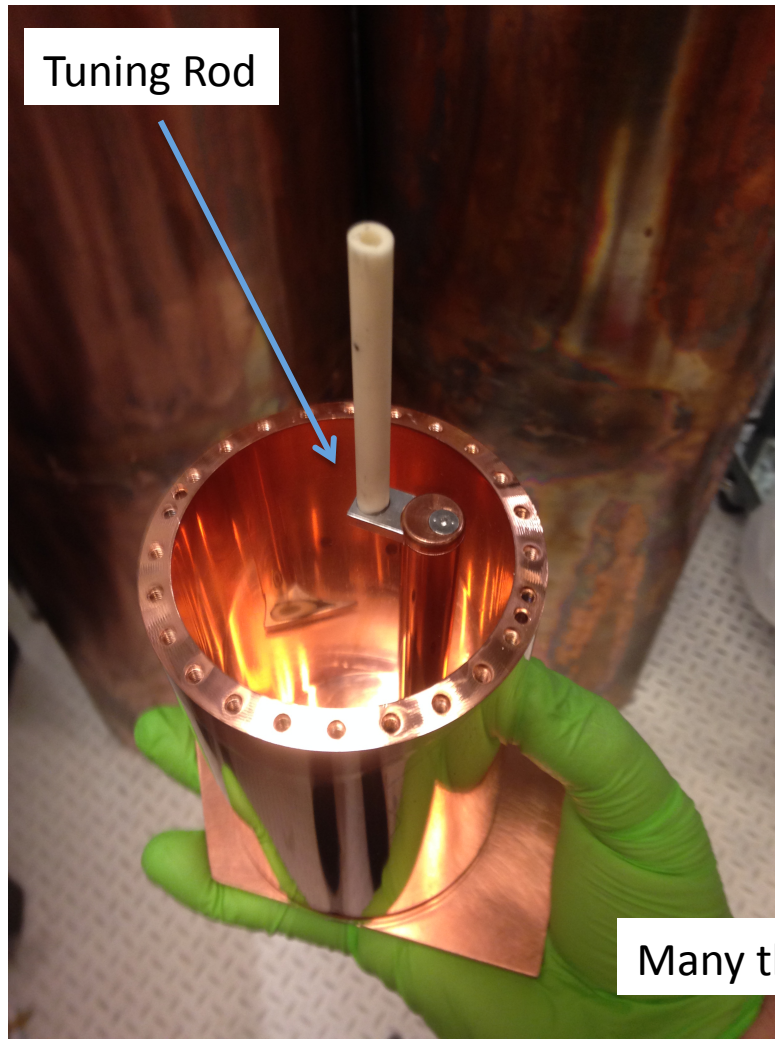
Sidecar Prototype

# Sidecar Cavity Mounted on Main Cavity

Sidecar  
Cavity



# Tuning Rod and Antennas



# Current Tuning Mechanism:

Warm Stepper Motors & Cold Gearboxes

## Problems:

- Cryogenic gearboxes frequently jam
- Heat leak limits base temperature
- “Backlash” makes tuning difficult

We need to implement an alternative way of translating motion to the tuning rod and antenna

(Opportunity to do R&D for future ADMX!)

G10 Rod

Gear Box

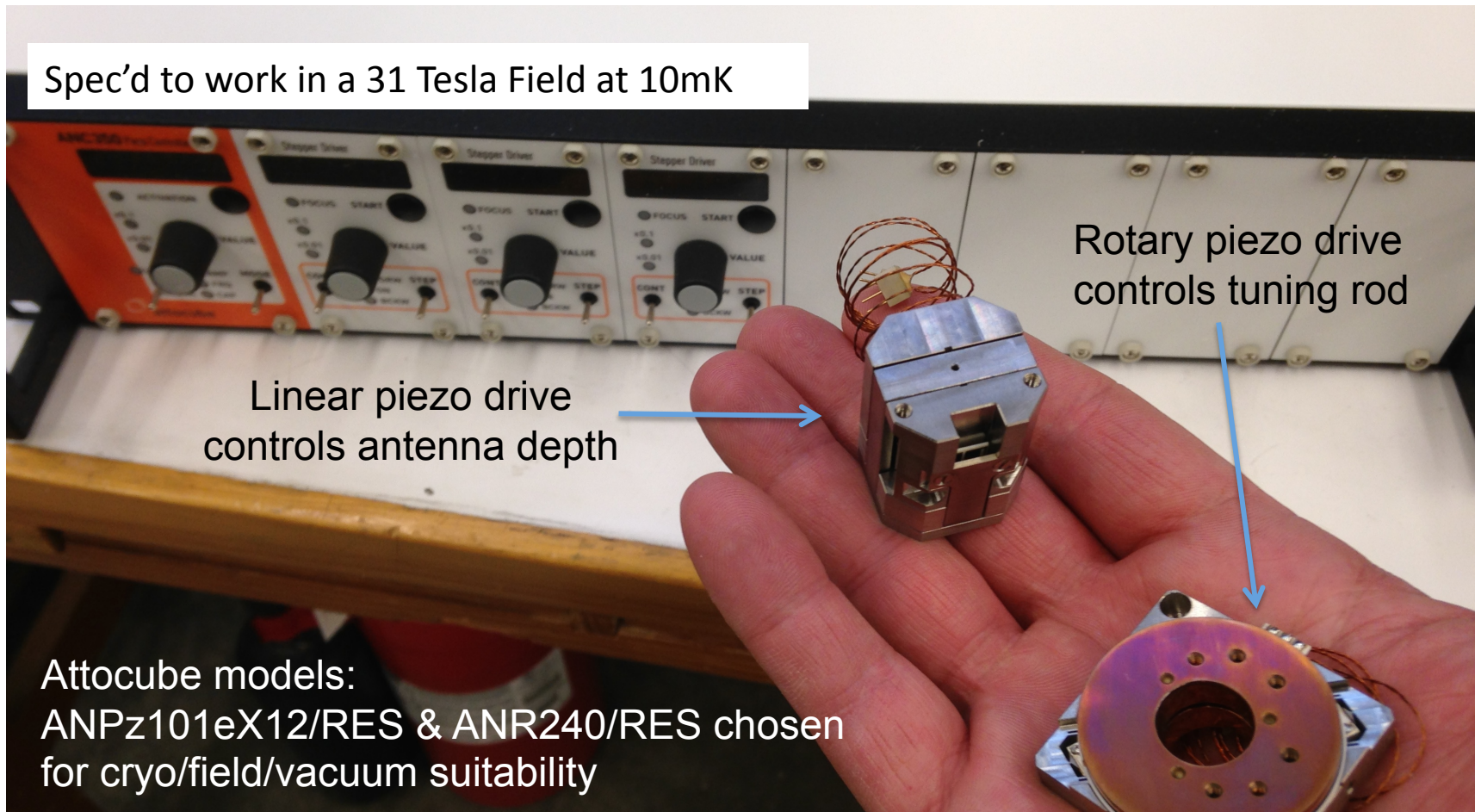
Sidecar Cavity

G10 Rod

Gear Box

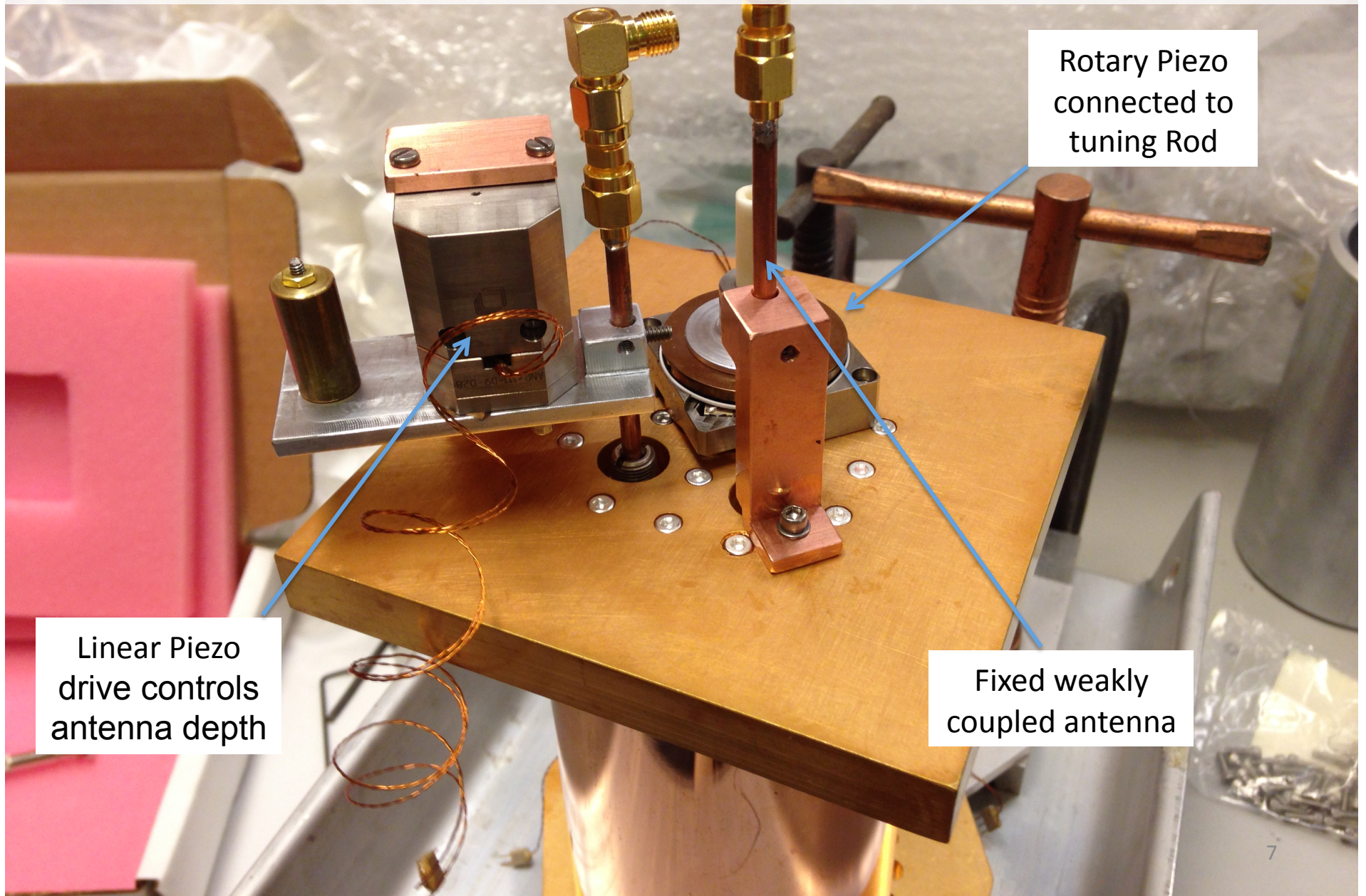
# Solution: Attocube Piezo Motors

Spec'd to work in a 31 Tesla Field at 10mK



Attocube models:  
ANPz101eX12/RES & ANR240/RES chosen  
for cryo/field/vacuum suitability

# Piezo Motors Mounted on Finished Cavity

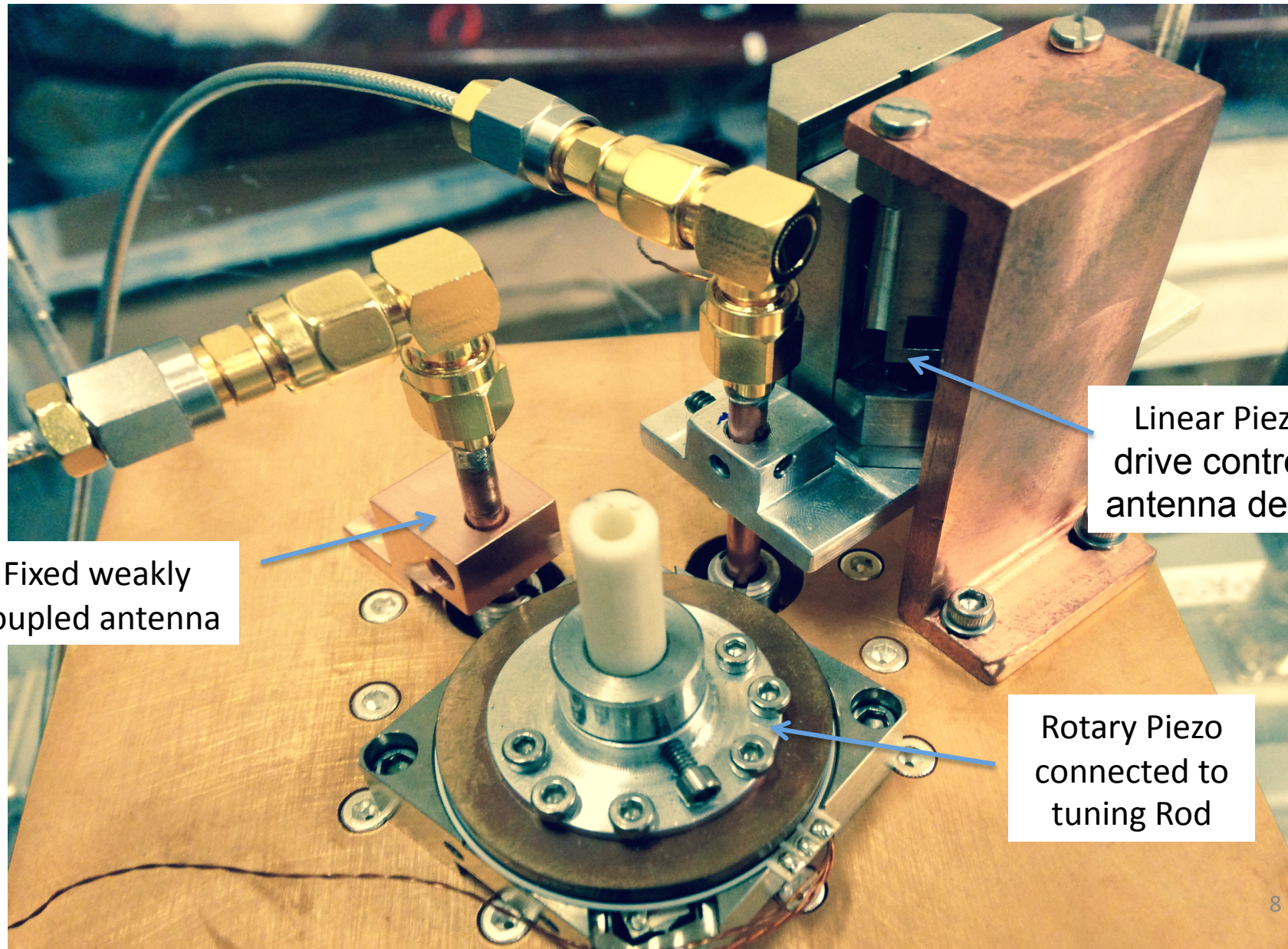


Linear Piezo drive controls antenna depth

Rotary Piezo connected to tuning Rod

Fixed weakly coupled antenna

# Piezo Motors Mounted on Finished Cavity



Fixed weakly coupled antenna

Linear Piezo drive controls antenna depth

Rotary Piezo connected to tuning Rod



# Challenges Overcome

- Mechanical Design: learned to keep linear actuator from jamming while moving antenna

- Modified control parameters (mostly line voltage) to accommodate longer cables inside ADMX insert

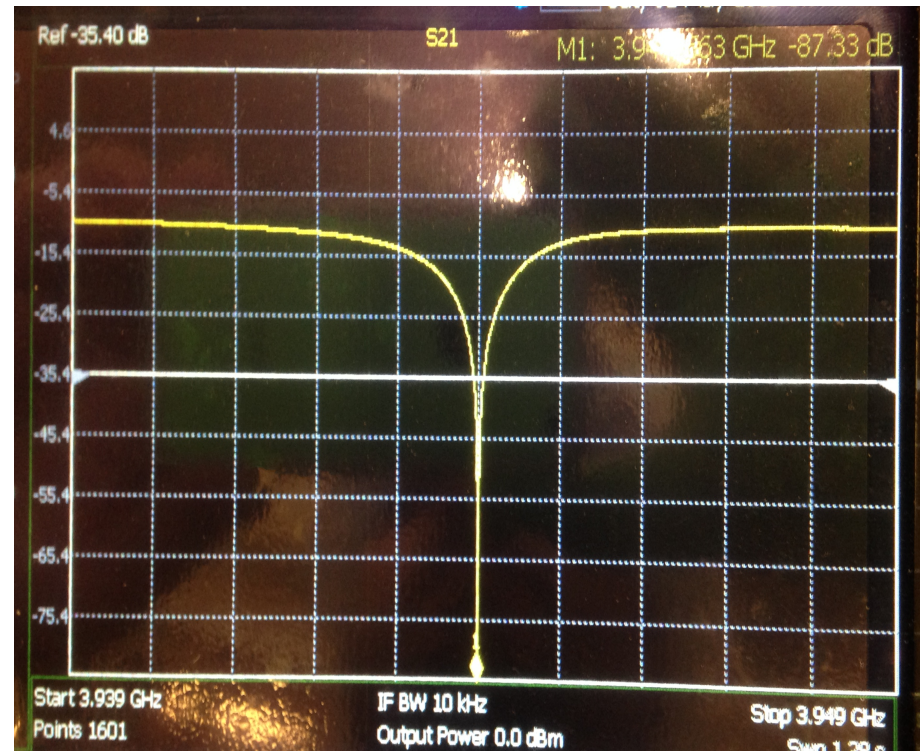
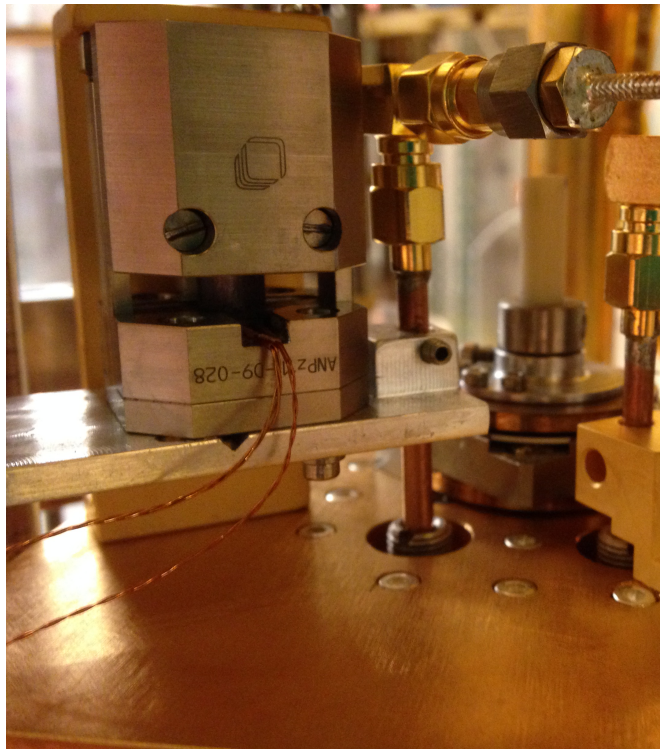
- Integrated system with ADMX DAQ



# Does this Rotary Piezo Tuning Mechanism Work?



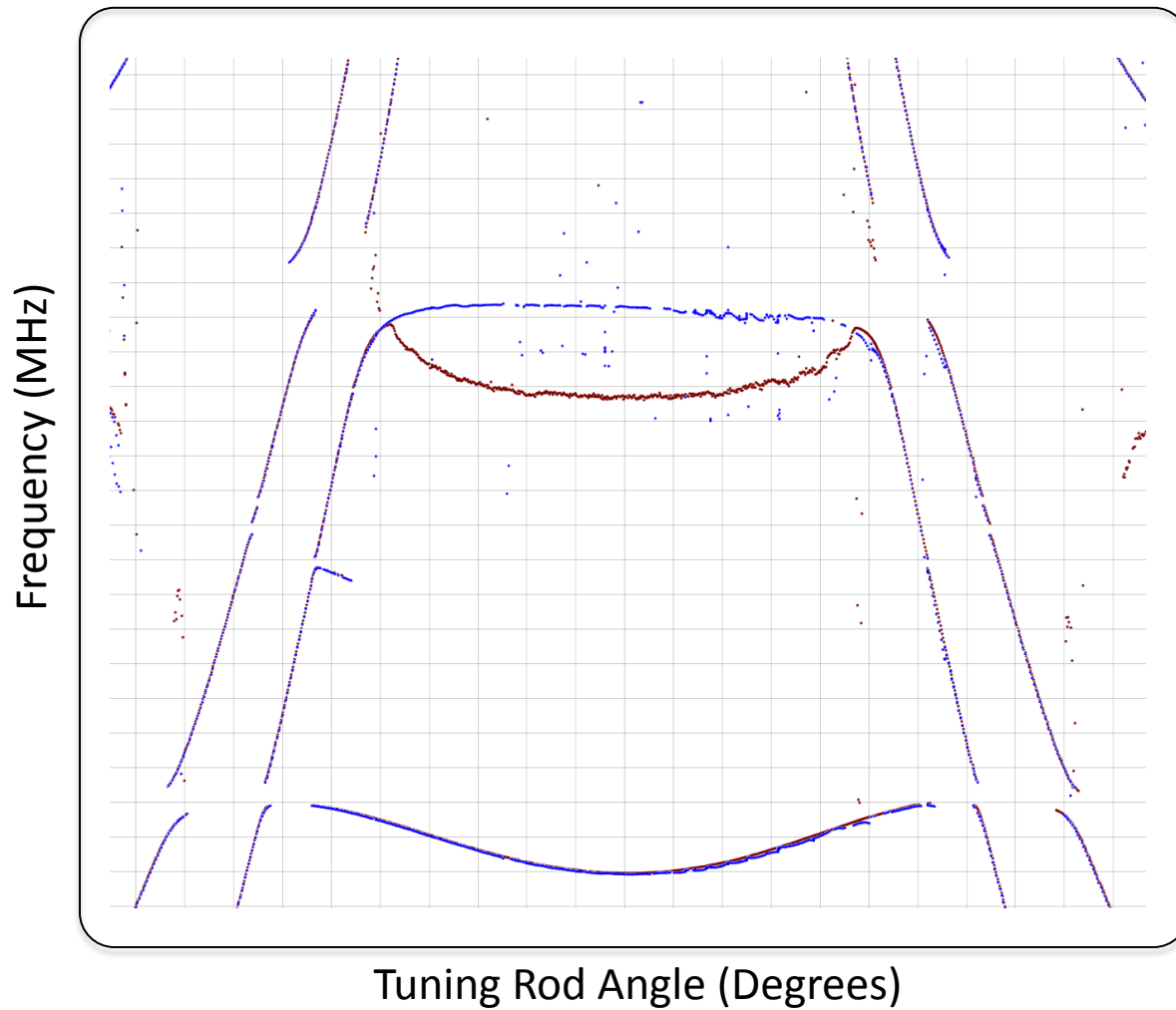
# Does this Linear Piezo Coupling Mechanism Work?



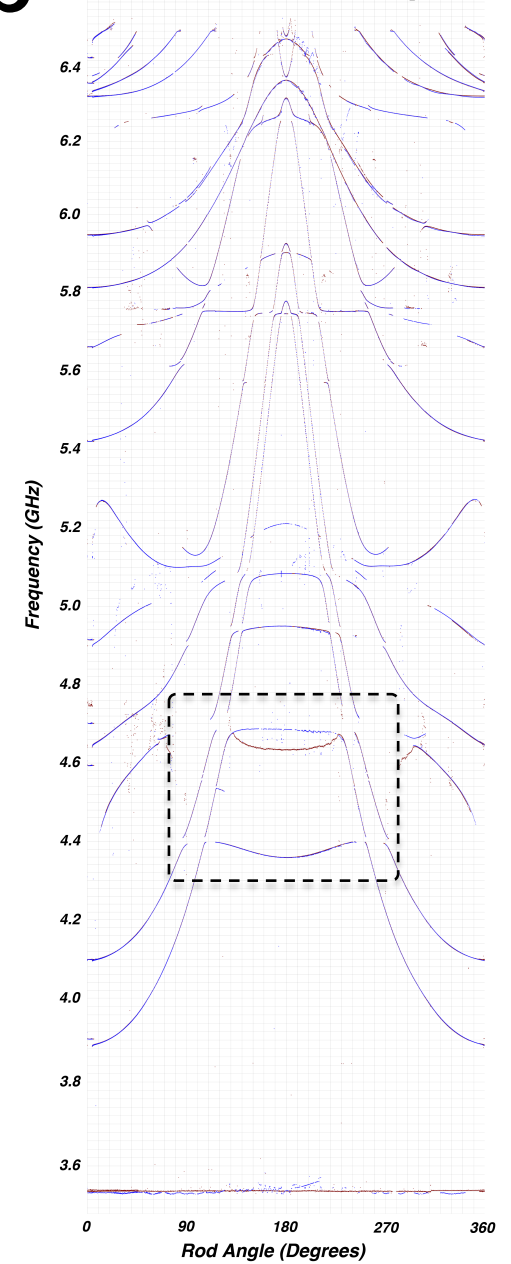
Time to watch another movie!

# Sidecar Modemap

Section of Modemap



*Sidecar Modemap*

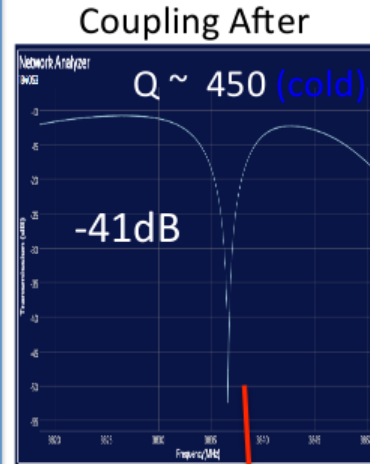
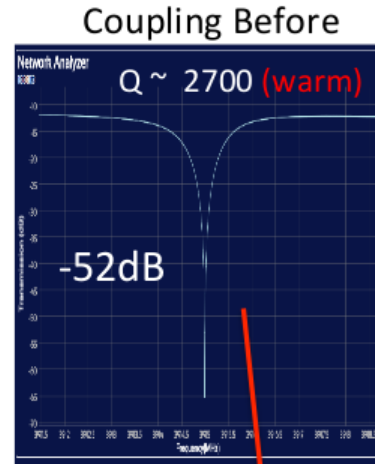


# Major Milestone: 77K Test



# Coupling before and after Cool Down

Antenna (critically coupled) was inserted approximately 5mm into the cavity

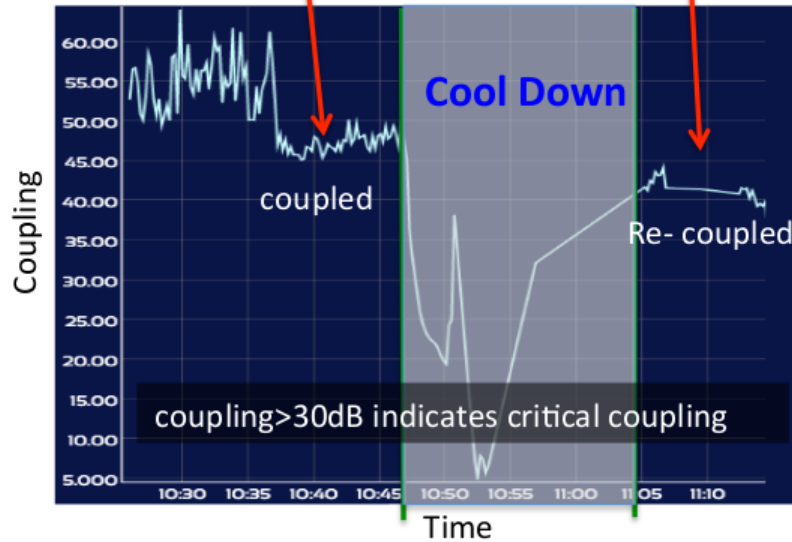


After the cool down, the antenna re-critically coupled with a depth of approximately 8mm.

Antenna Piezo Position



Coupling vs Time



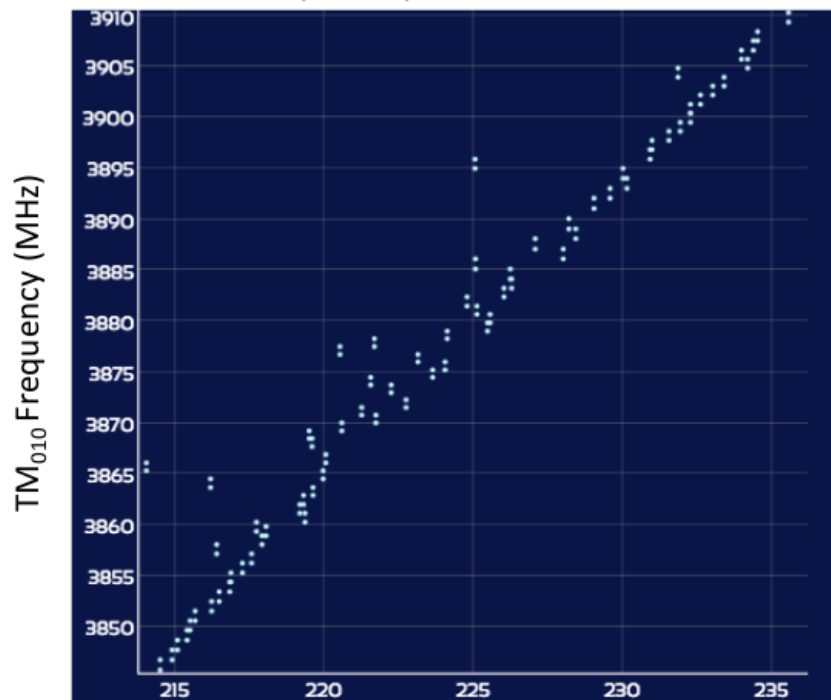
Antenna Piezo Position



# Tuning Tests

**Ability to Move Rod and Tune Frequency Demonstrated**

Frequency vs Rod Position



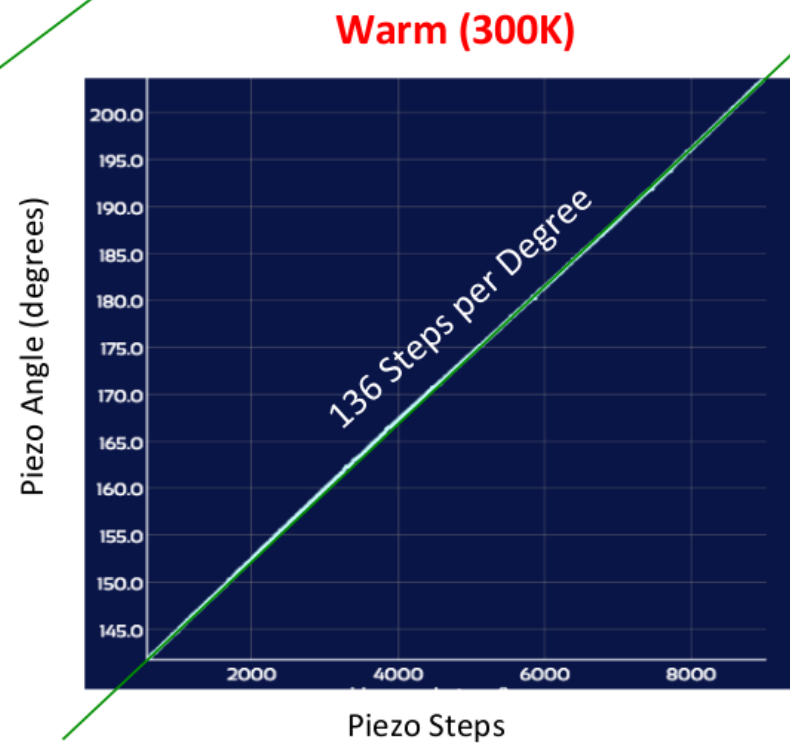
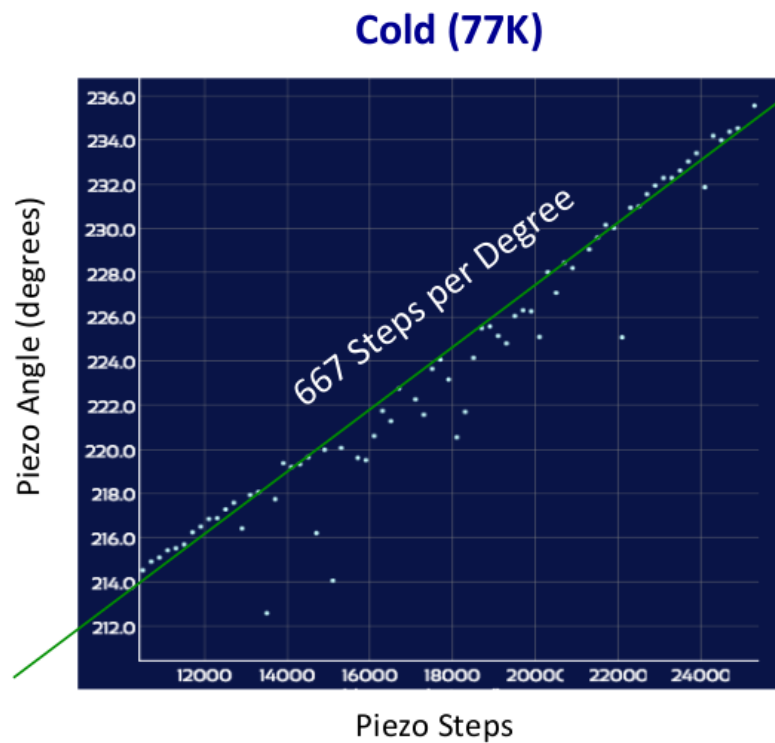
Rod Position (Degrees)

Rod Position vs Time



Time

# Calibrated Cold Step Speed





# Just Took it all Apart

So that I can heat sink the copper piezo block



# Sidecar Receiver Finished



# Data Taking Software Almost Finished

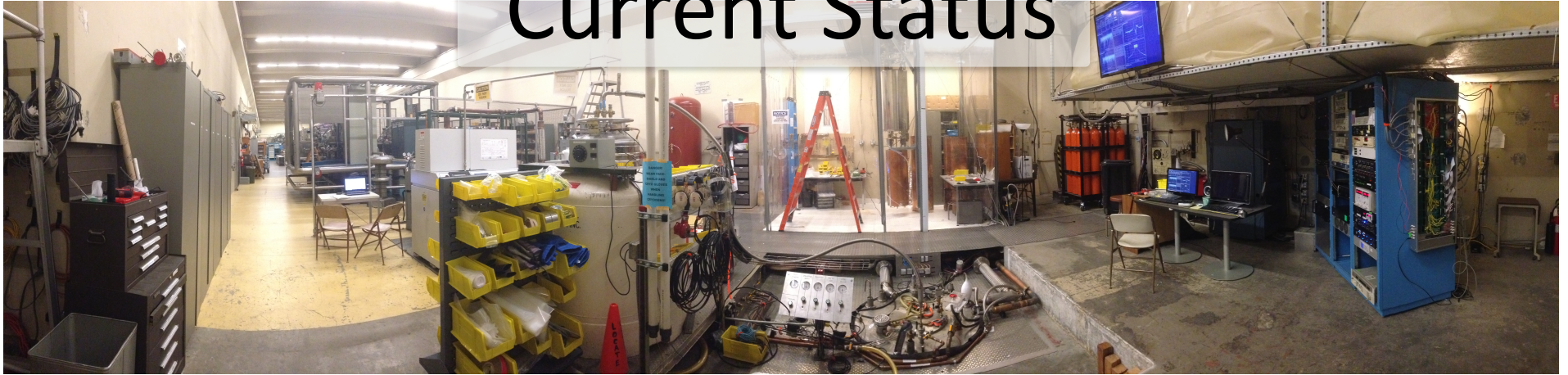


# Run Plan

- I will pick a start frequency somewhere between 3.9 and 5.8 GHz
- Scan Rate  $\approx$  50-100 MHz/Month
- Target Sensitivity:  $g_{a\gamma\gamma} \approx 10^{-14}$  (GeV $^{-1}$ )



# Current Status



- We have learned how to use piezo motors to operate cavity tuning and coupling
- 77K test performed, excellent performance of motors and cavity design
- Piezo/RF insert wiring is finished
- Piezo Motors are mounted and working!
- We will be taking data this fall.

Thanks!

ADMX