Properties of the Piezoelectric Actuator

OPEN SOURCE INSTRUMENTS

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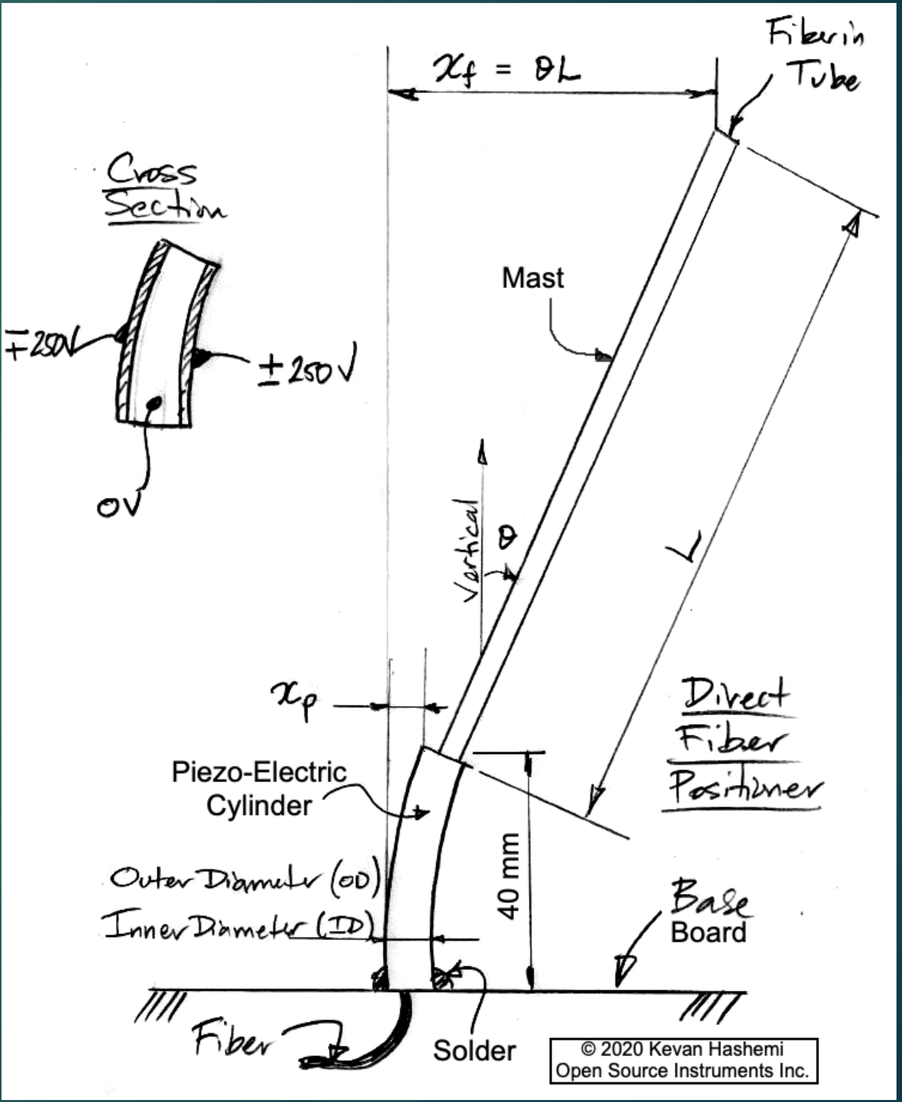
Abstract

- We propose a method for mounting optical fibers to provide spectroscopy of celestial objects
- Our spectrograph is unique in its method of travel. All fibers move simultaneously with one direct move using an electrically complex yet mechanically simple mechanism
- This would allow for telescopes to gather light from more objects which are far away and close together

Design

- We move the fibers by soldering piezo-electric actuators to a rigid base on a 5mm grid
- By applying +/- 250V to the four electrodes of the actuator we can angle the fiber by 6.3mrad (3.8mm square motion)
- Using our system, each fiber can be positioned with a precision of 10um rms
- Bending of the actuator is greatly exaggerated in the diagram to demonstrate movement

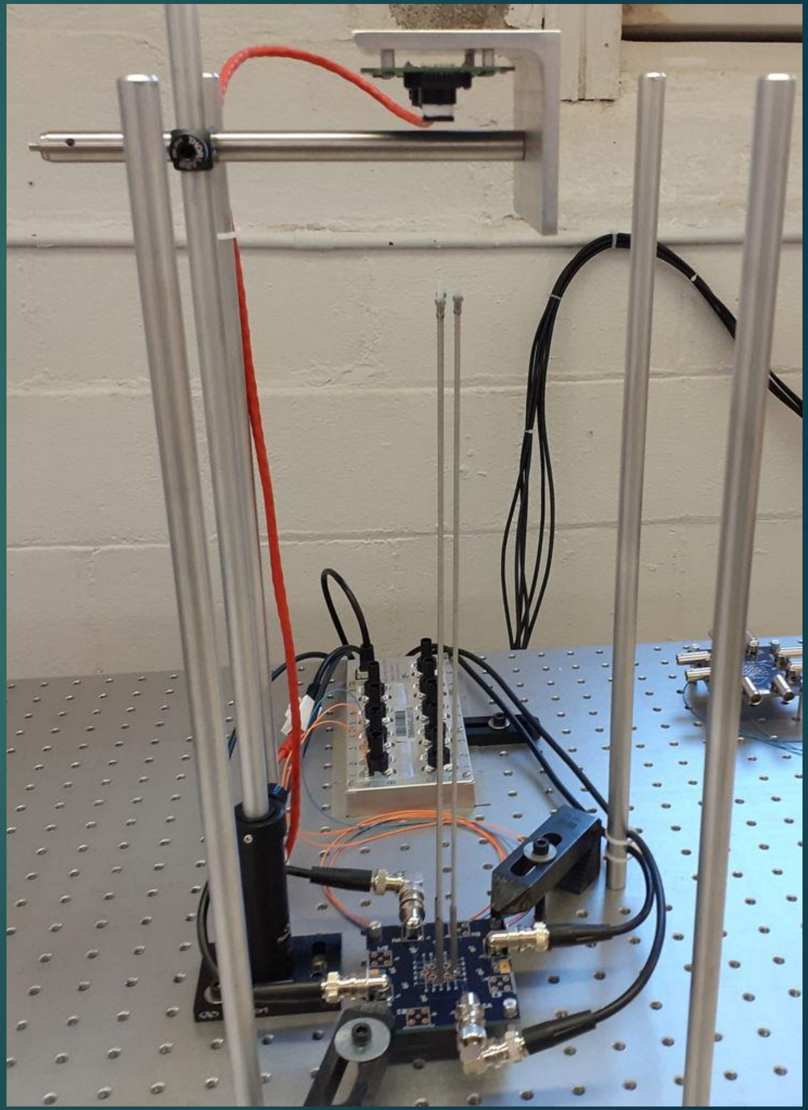


Objectives

- We plan to develop a system with 50,000 fibers on a 650cm diameter focal plane
- This will help with large-scale cosmological searches such as telescopes with a focus on dark energy research
- Measure 1 billion spectra over 10 years

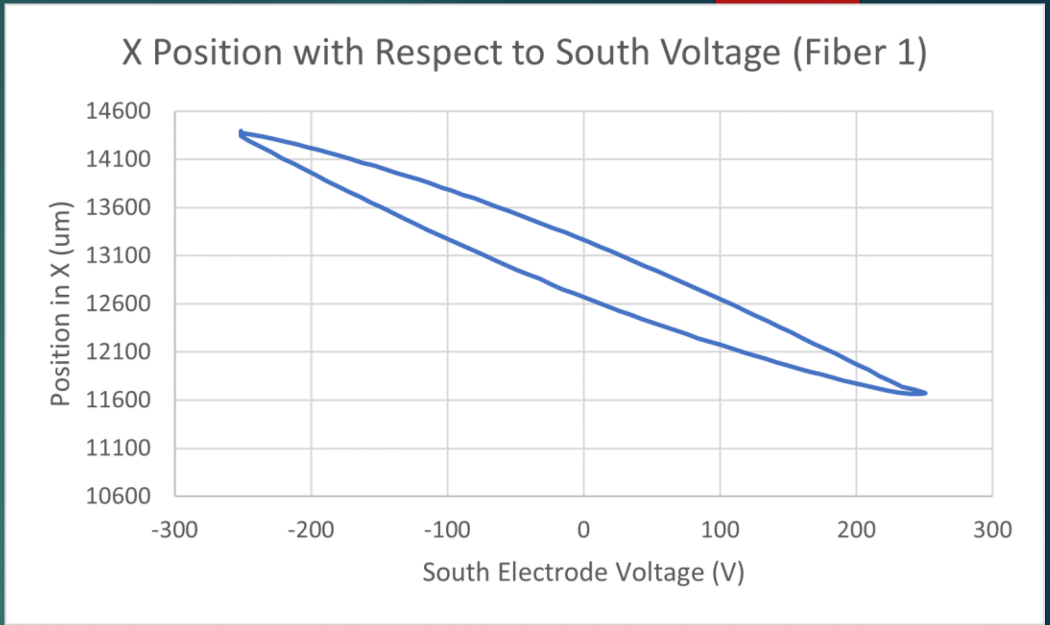
Experimental Design

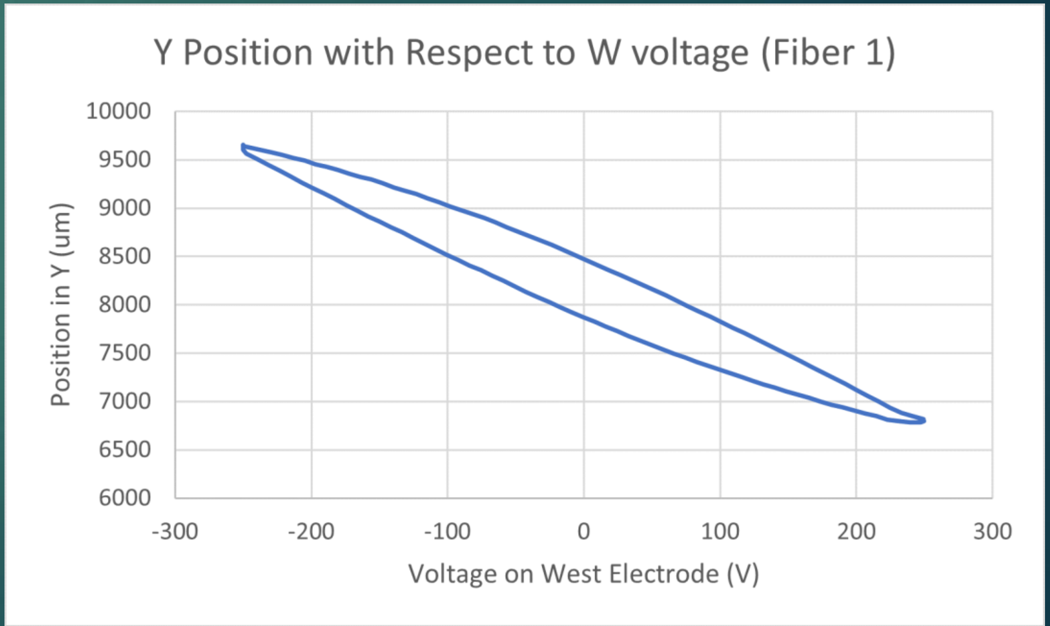
- A circuit controls the voltage applied, the injectors shine light through the bottom of the fiber, and a camera takes pictures of the fiber tip
- With a camera able to view the fiber's position, we can perform creep and hysteresis experiments



Hysteresis

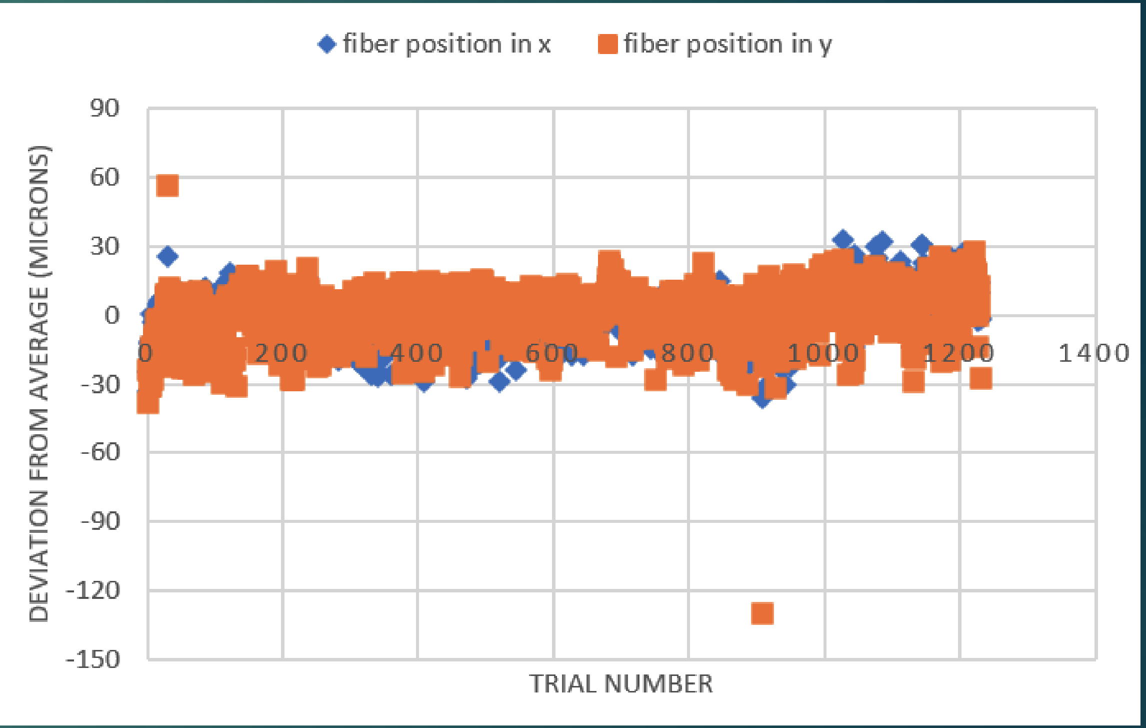
- Figures 1 (above) and 2 (below): We center the fiber in one direction (voltage on either East/West electrodes or North/South electrodes) and move it in the other to observe the actuator's hysteresis.
- The previous movement of the actuator has an impact on its current movement
- We observe 700um of hysteresis at the fiber tip





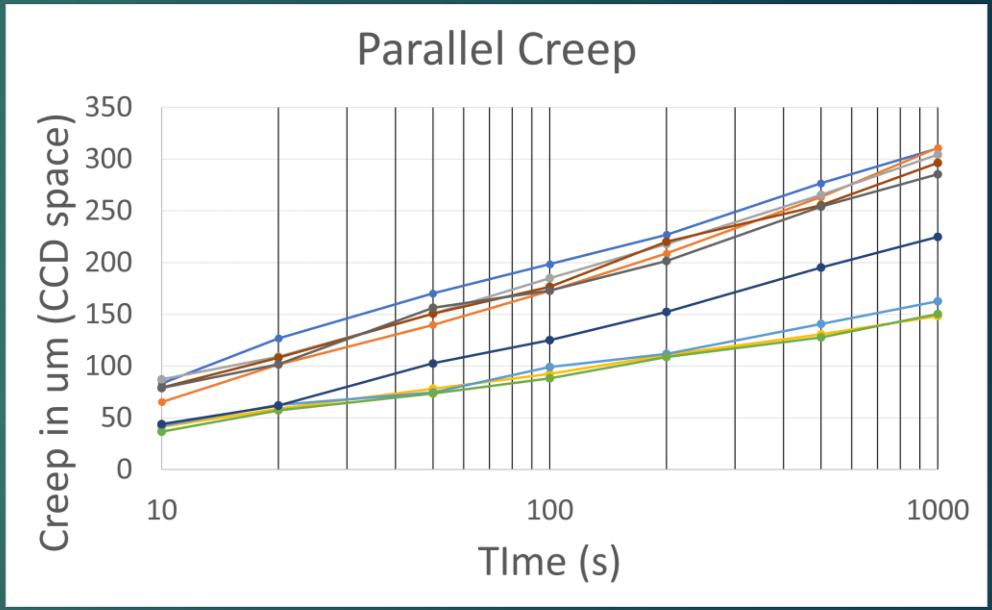
Spiral Reset Procedure

- To eliminate hysteresis, we perform a spiral reset procedure, spiraling the fiber in towards the center
- We graph the deviation from the mean of each fiber position upon completing the spiral reset procedure
- The standard deviation in x and y were 10um and 11um respectively



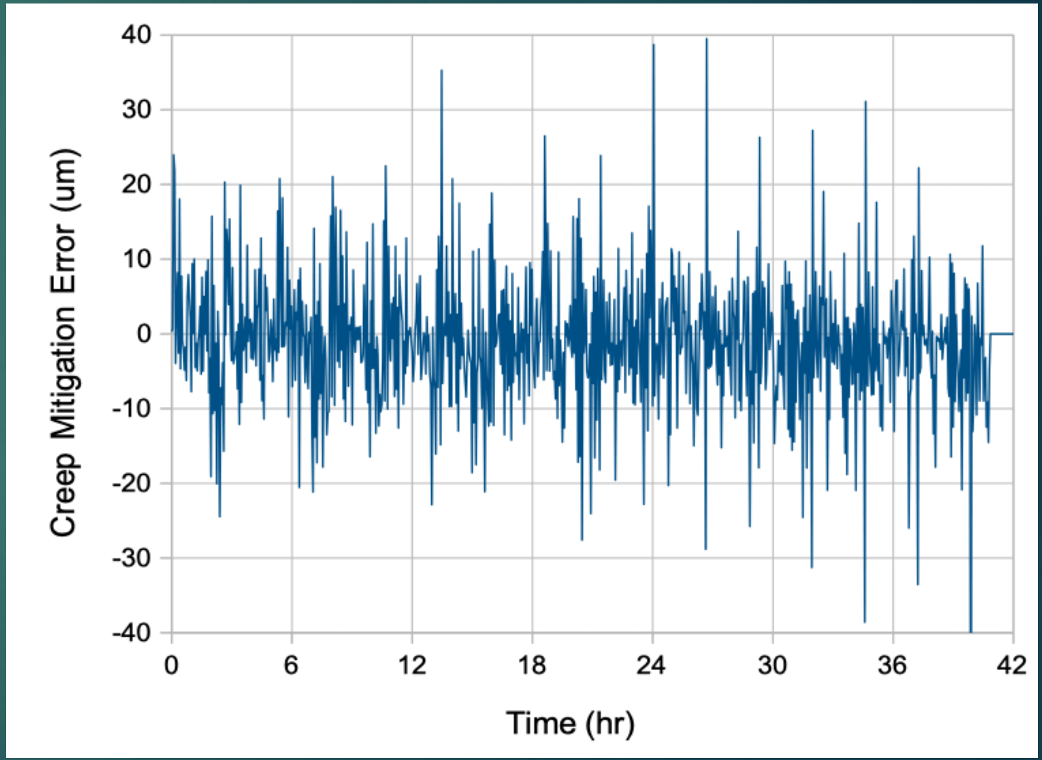
Creep

- Leaving the fibers in place, we notice that they drift over time
- Performing multiple different movements, we move the fiber in one direction and observe its movement over time as we attempt to leave it in one place
- Measuring the movement parallel to the initial movement of the fiber, we notice that the creep in the parallel direction is well-modeled by a logarithmic plot
- The majority of creep is experienced in the parallel direction



Mitigating Creep

- We measure creep mitigation error over 40 hours
- We were able to reduce the error to <10 um rms



Conclusions

- The piezo-electric actuators have a lot of potential for spectroscopy instrumentation
- The two major hurdles to using them are creep and hysteresis
  - Through our creep experiments, we were able to reduce the error to <10um rms
  - Our spiral reset procedure mitigates hysteresis by returning the fiber to its original position to within 10 um.