

Mu2e Tracker Straw Tensioning

By:

David Benirschke

Purdue University, Calumet

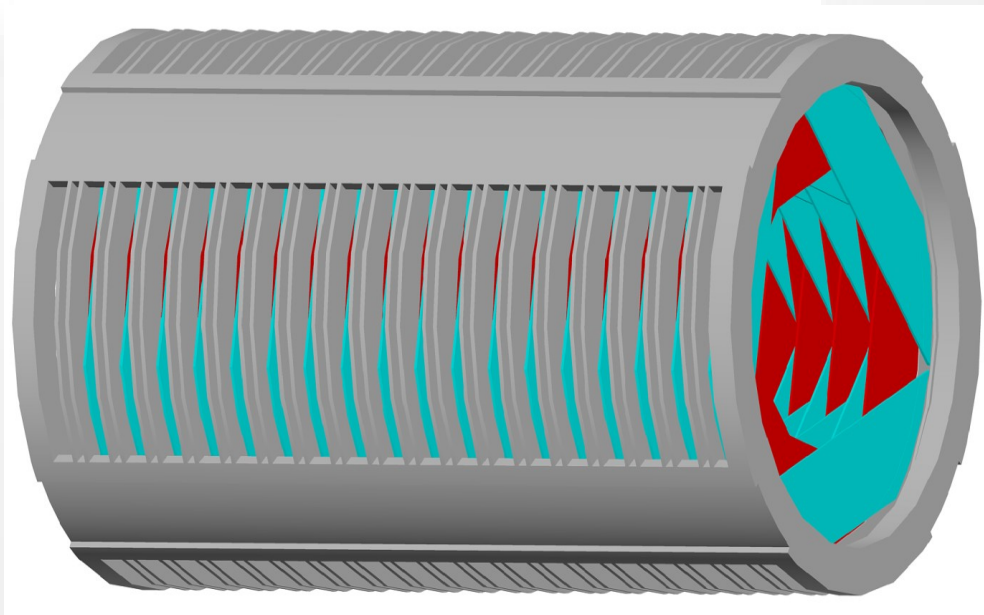
Supervised by: Vadim Rusu and Aseet Mukherjee
Fermilab National Accelerator Lab

Outline

- What is the tracker and why do we need to worry about straw tensioning?
- Concept of method
- Realization of method
- Results

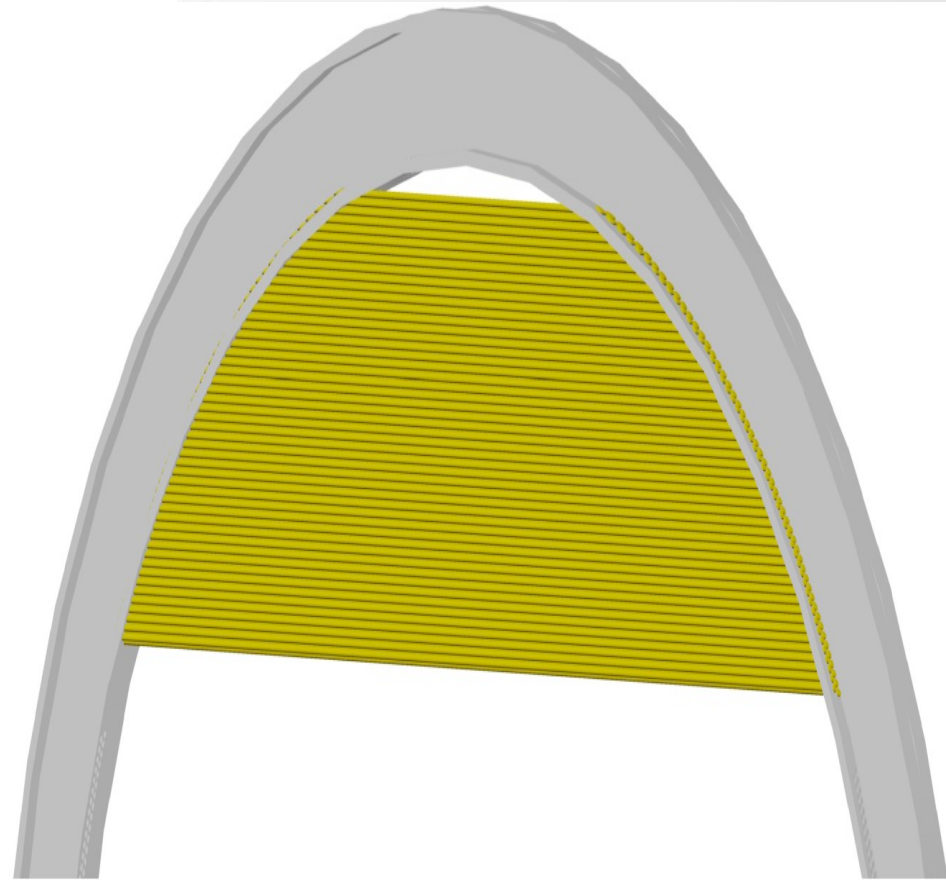
What is the Tracker?

- “The Mu2e tracker is designed to accurately measure the trajectory of electrons in a uniform 1 Tesla magnetic field in order to determine their momenta.” Mu2e conceptual design report
- Red indicates drift chambers filled with ionizing gas used for detection



Why Straw Tensioning?

- Drift chambers have two parts
 - Outside straws (Ground)
 - Sensing wire (High Voltage)
- Need to center sensing wire
- 2 newtons to be centered
- Due to drift must be 7 newtons



Guitar

- Each string on a guitar has a preferred mode of vibration
 - Produces consistent tone
- Tone can be altered by 2 processes
 - Tuning(Tensioning)
 - Placing fingers on neck(length)

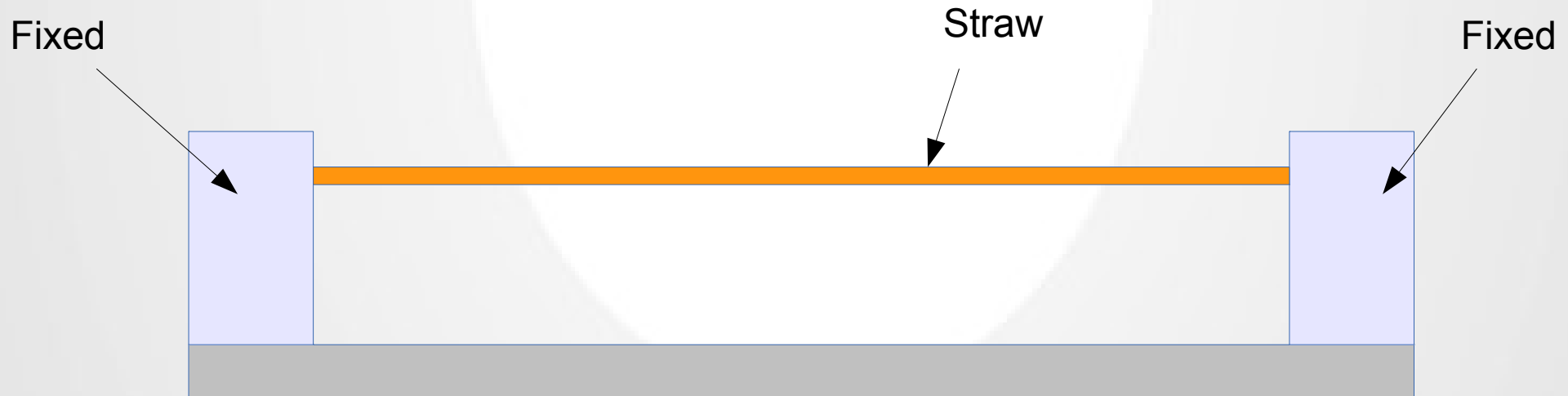
$$f_n = \frac{n * \sqrt{\left(\frac{T}{\rho}\right)}}{(2 * L)}$$



Concept

- Control length of straw ✓
- Constant mass density ✓
- Measure frequency?

$$f_n = \frac{n * \sqrt{\left(\frac{T}{\rho}\right)}}{(2 * L)}$$

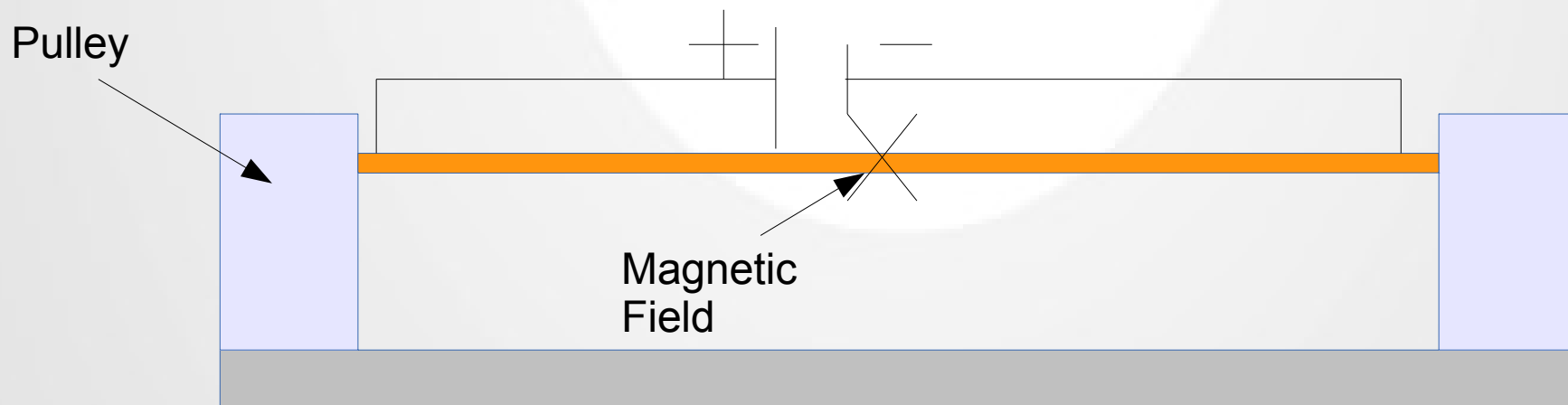


More Problems

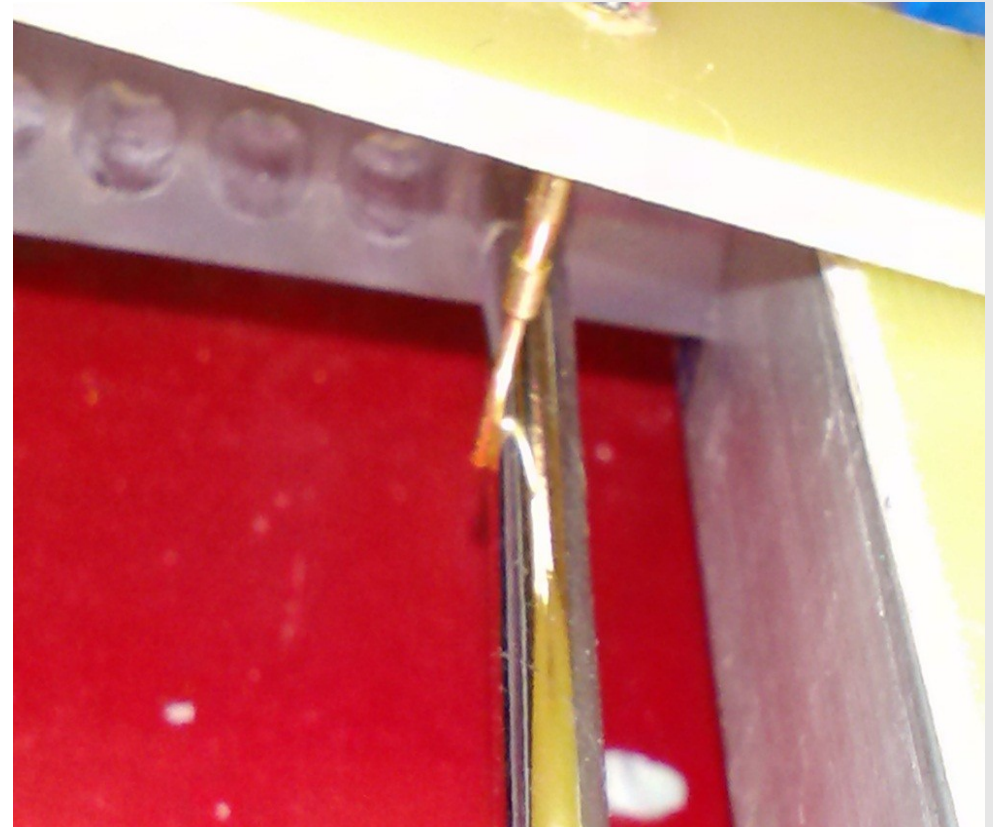
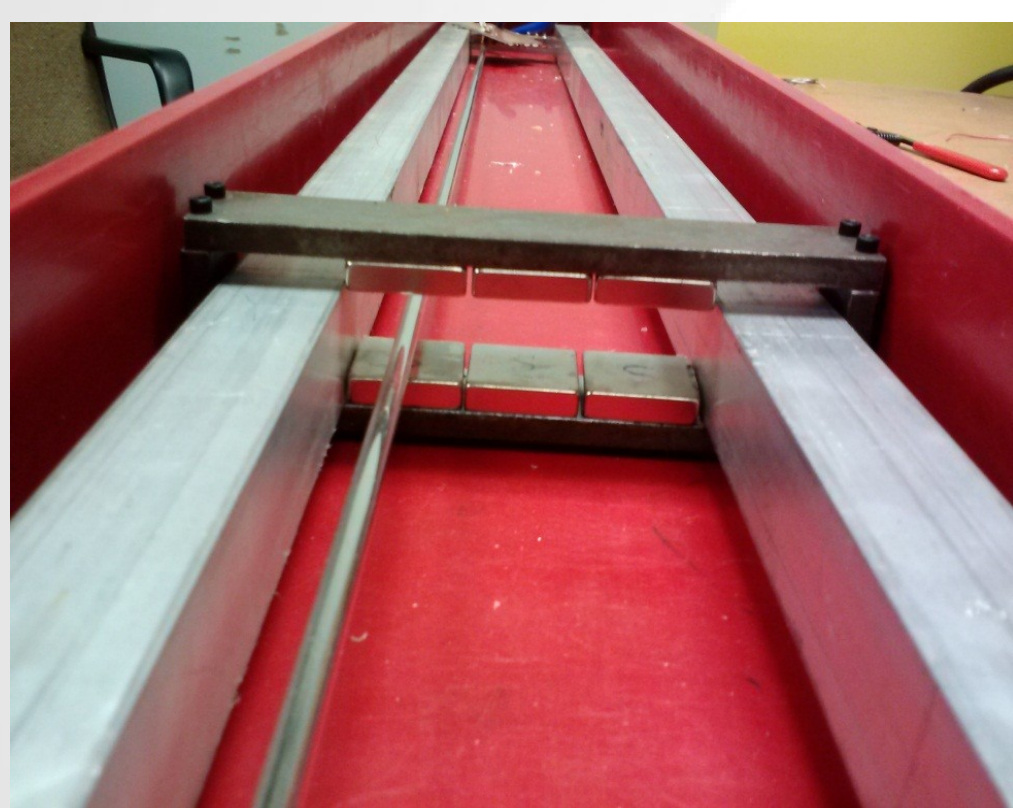
- Straw deviates from string behavior
 - Mass distribution is not linear
 - Straw has rigidity
- Formula does not work
- Straws must be tested while in the detector
 - 1mm separation between straws

Setup

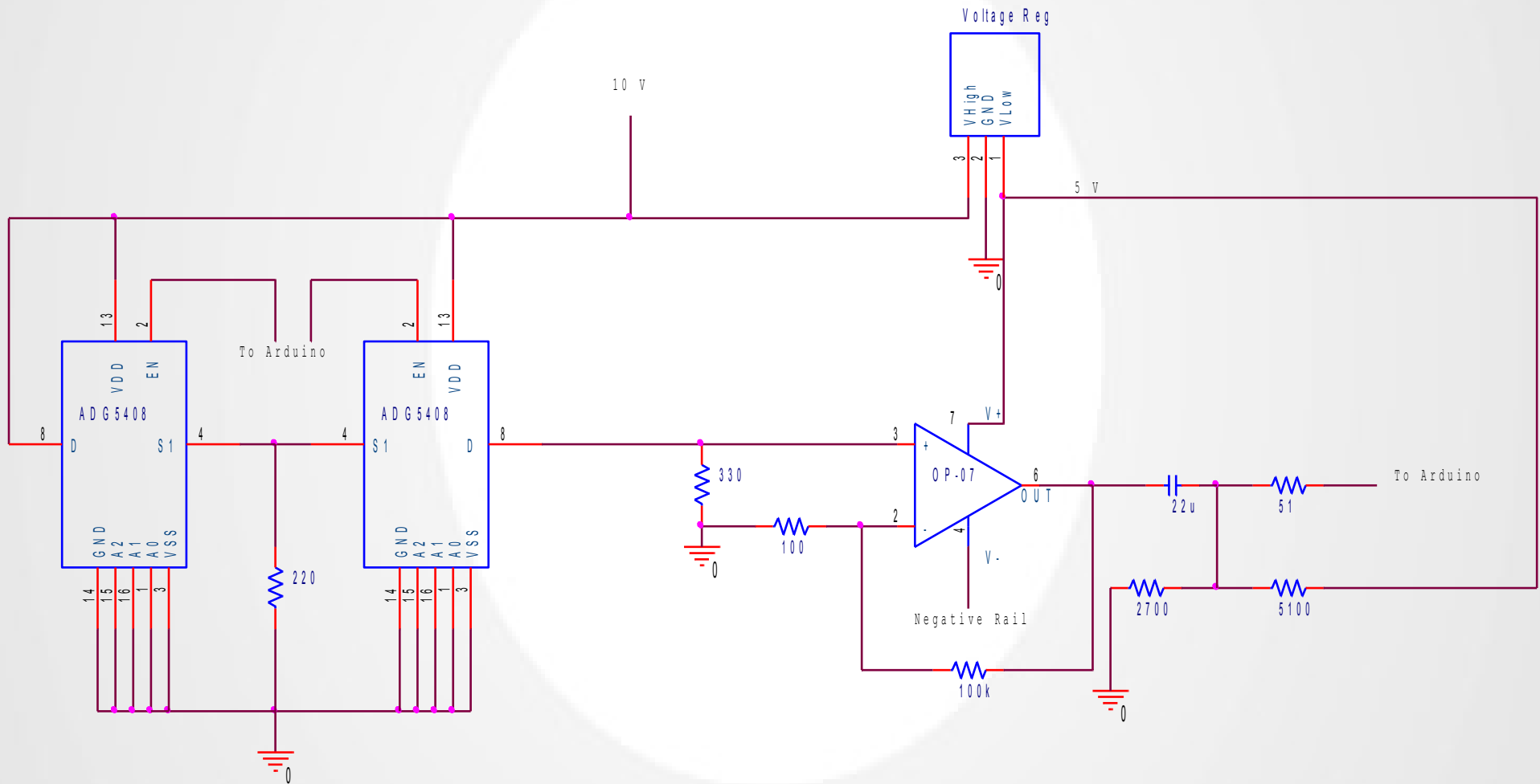
- Pulley to control tension
- Place straw in magnetic field and attach to battery
 - By right-hand rule straw will be forced upward
- Vibrating conductor produces emf
- Amplify to determine frequency



Realization

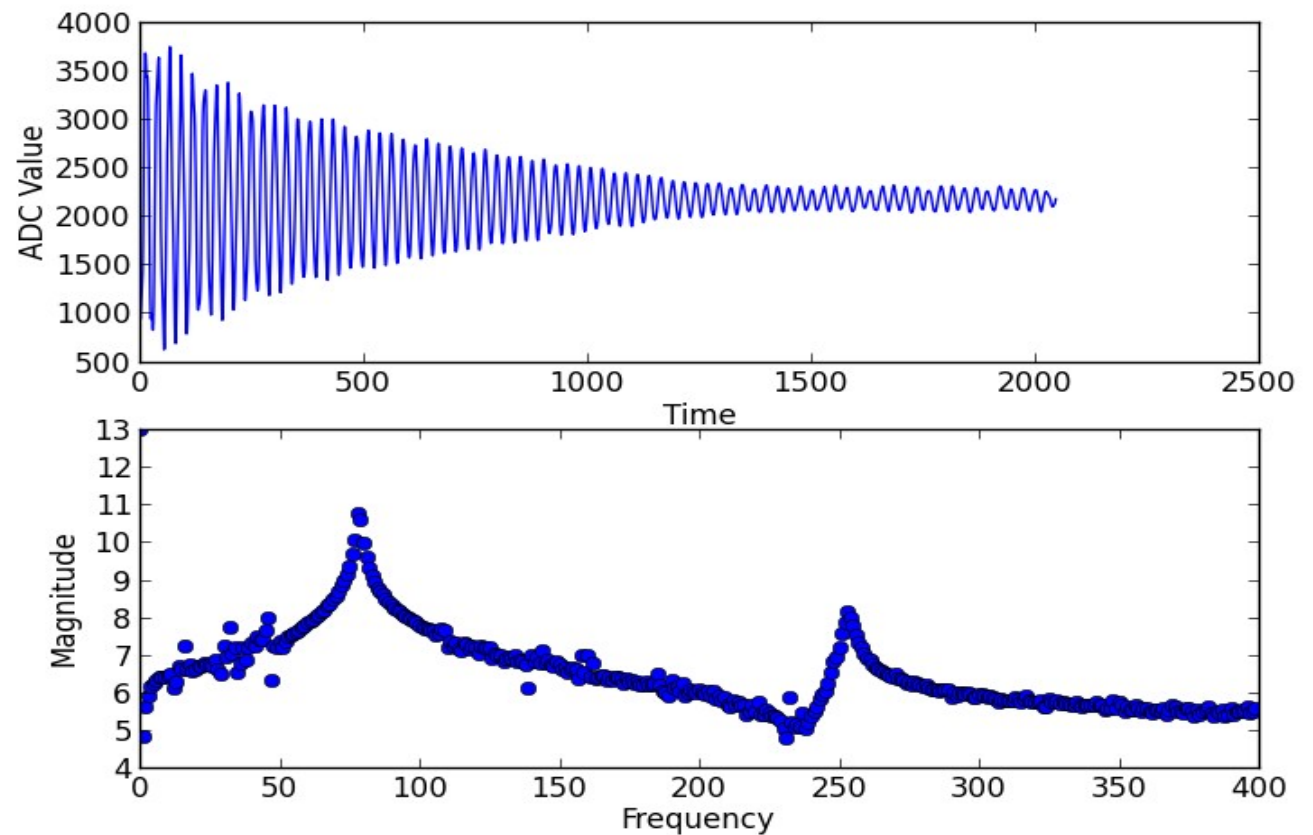


Circuit



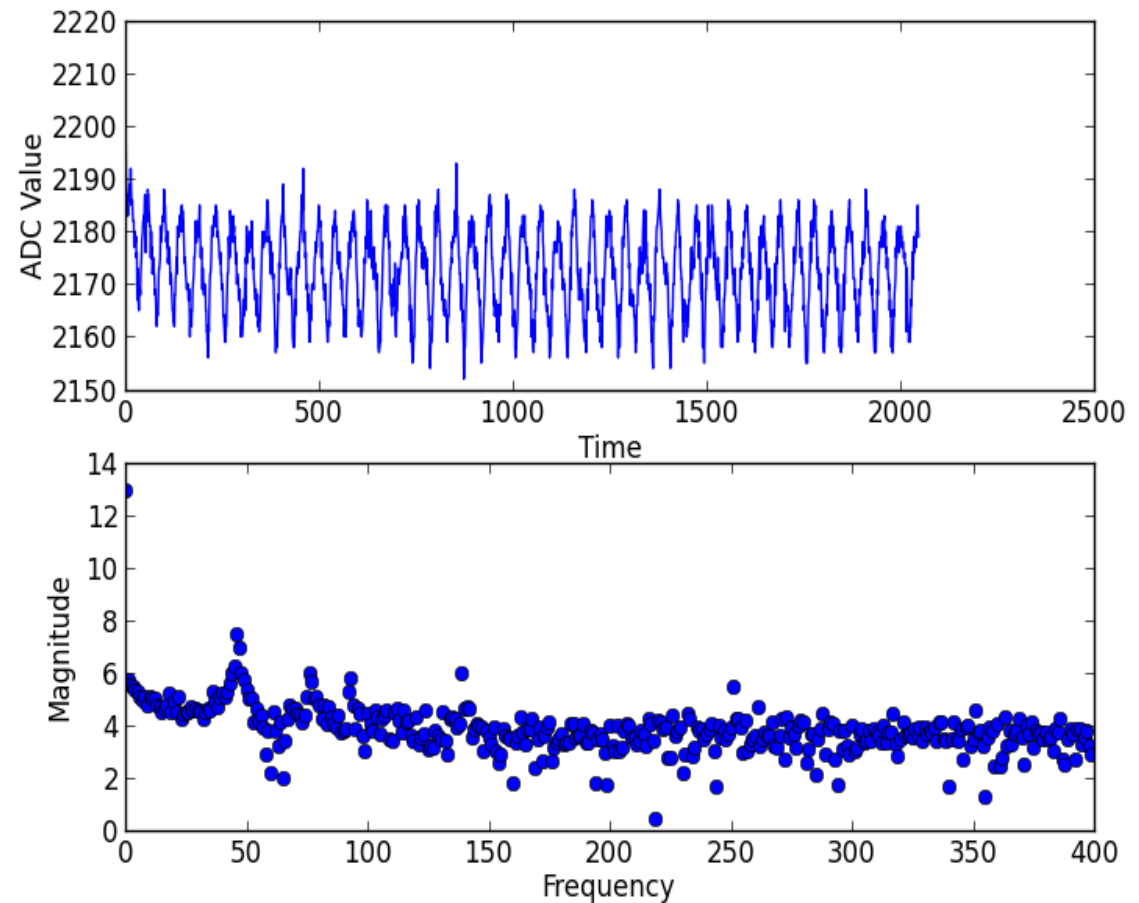
Measurement

- Amplified by 2000
- Recorded using 12 bit ADC on Arduino Due
- Take FFT

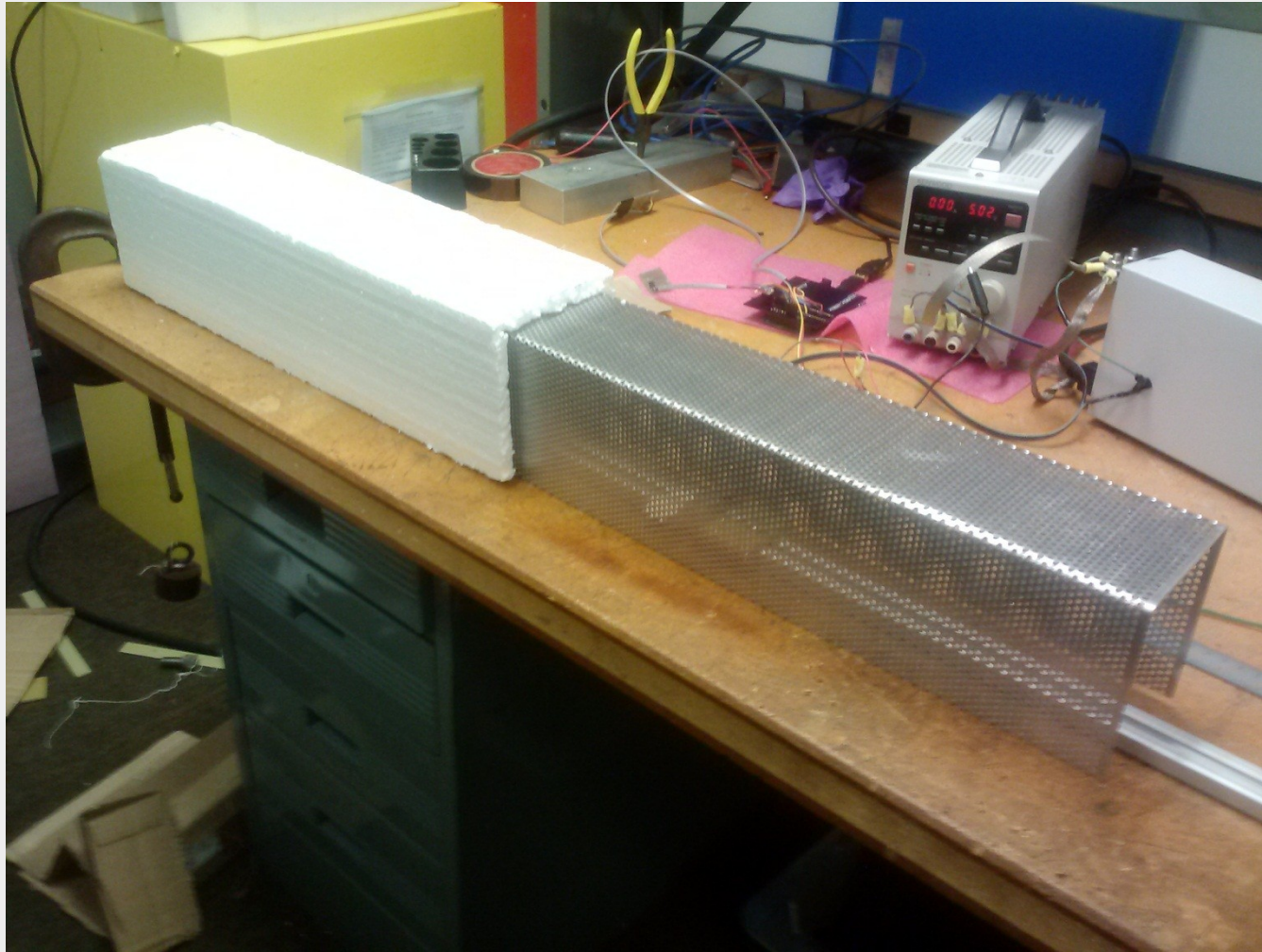


Noise

- 3 sources of noise
 - Electrical
 - Mechanical
 - Electromagnetic



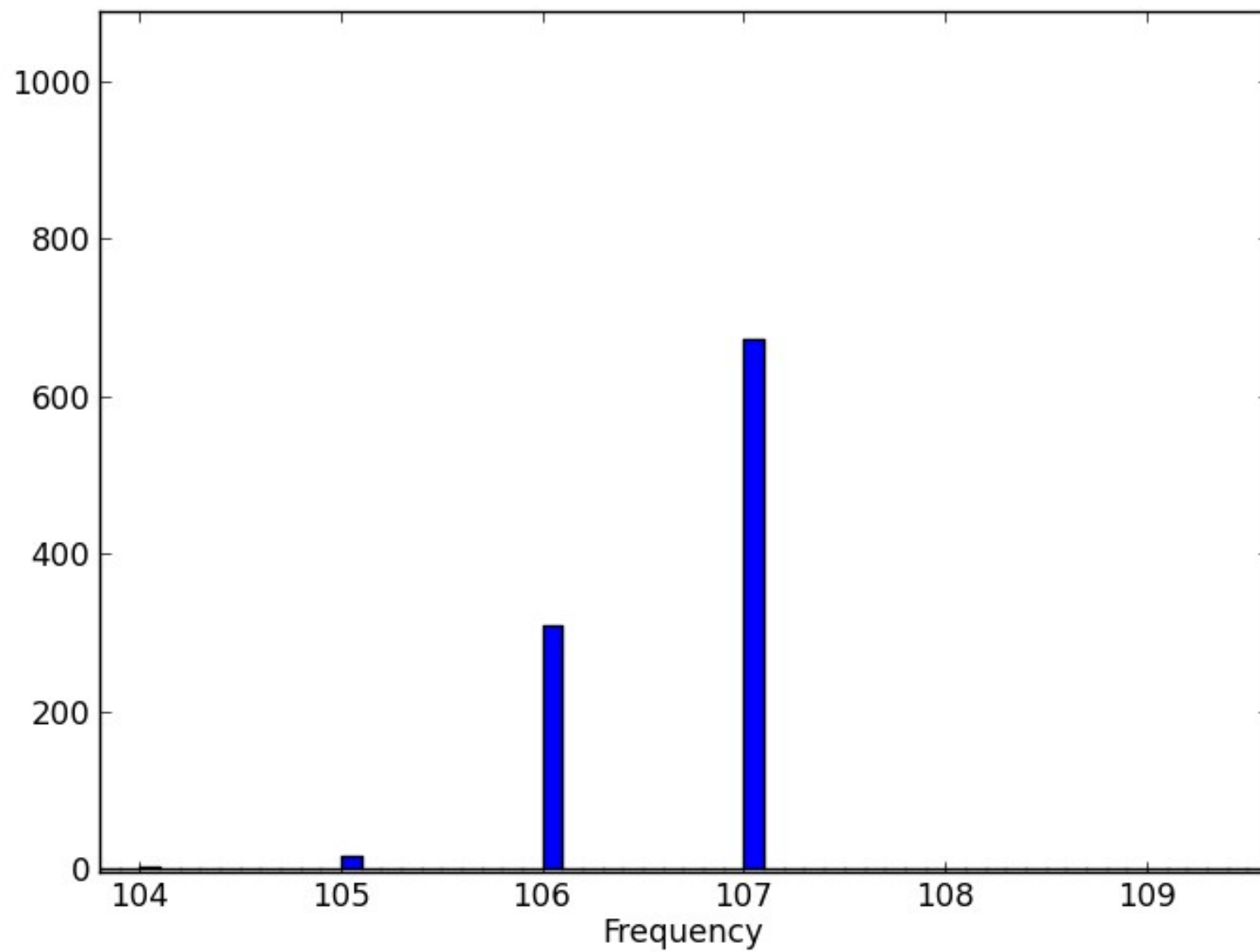
Noise Reduction



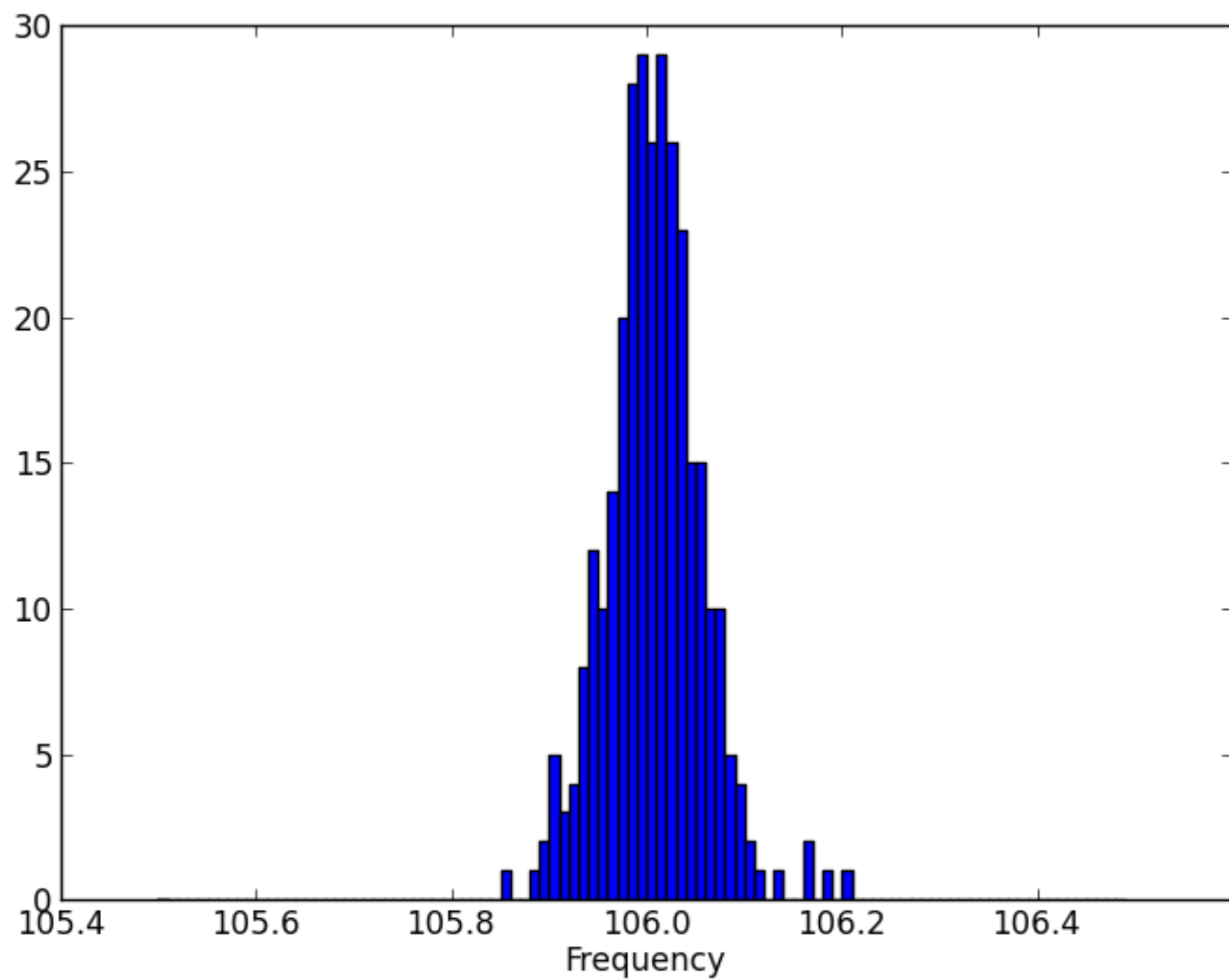
Analysis

- Tried three methods to fix frequency value
 - Max
 - Average
 - Curve fit
- Taken about third harmonic
 - Gives smaller error
 - Ex. $f_1 = 80 \text{ Hz} \Rightarrow f_3 = 240 \text{ Hz}$
 - Accuracy of ± 1
 - $f_1 = 80 \pm 1/3$

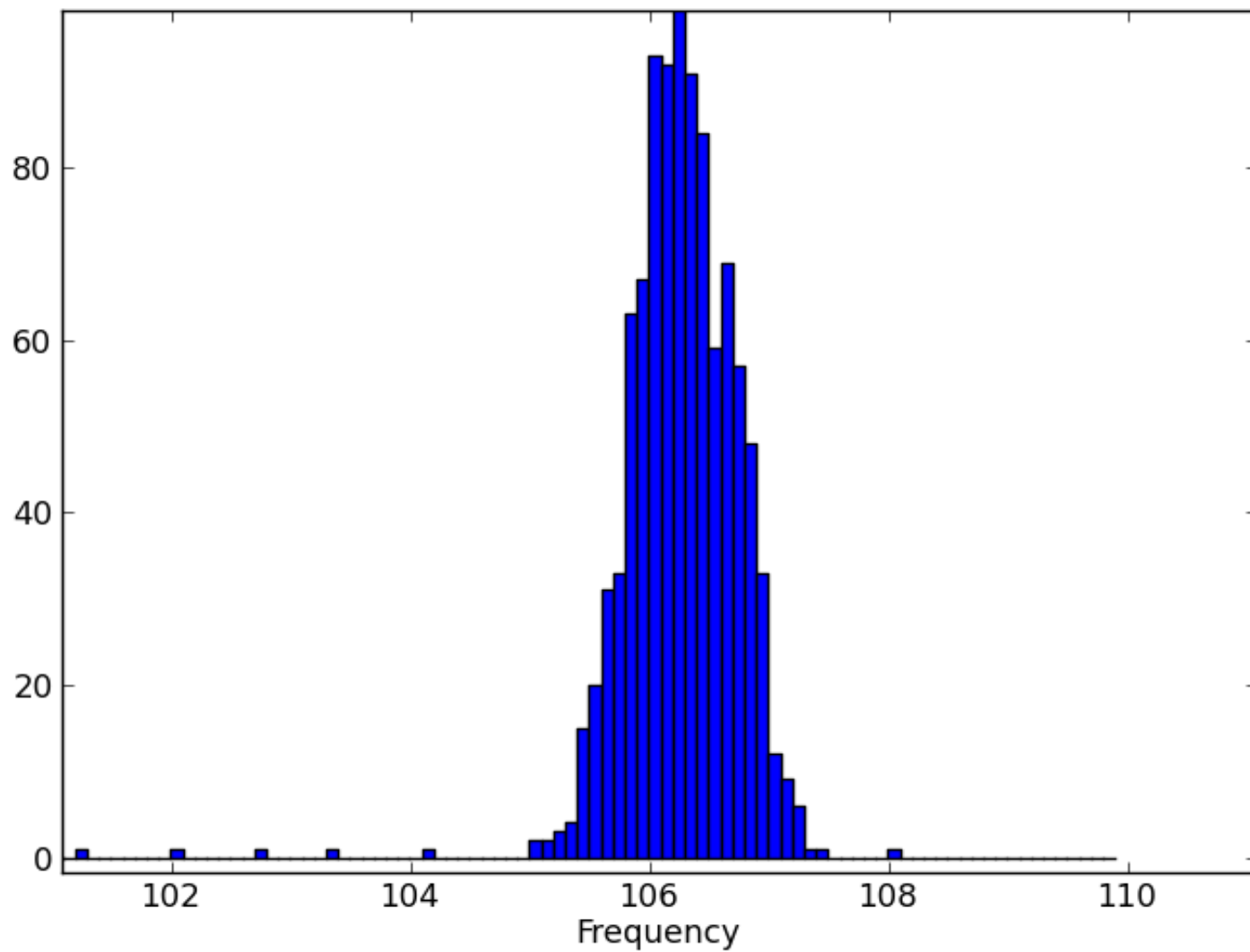
Max



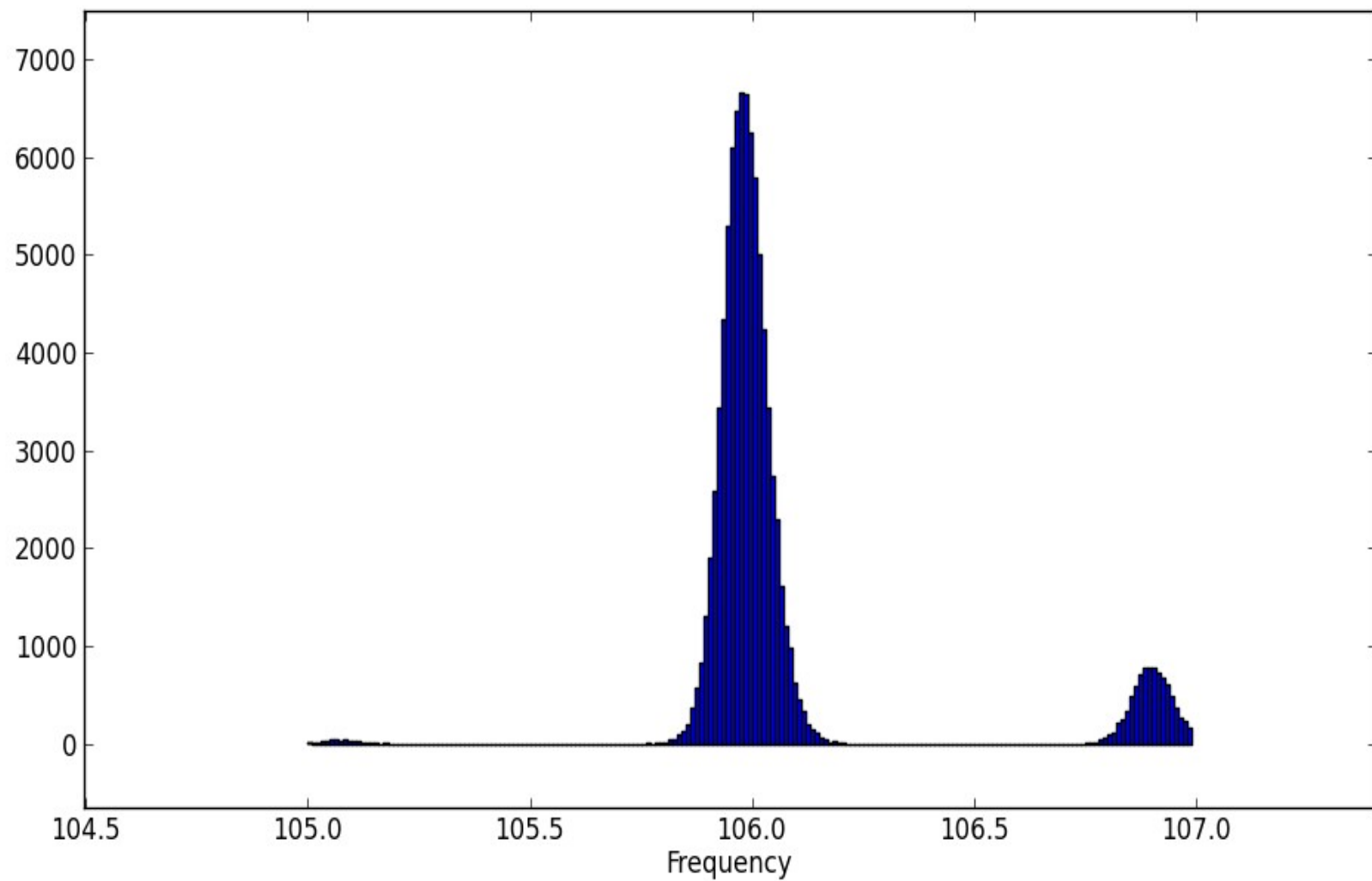
Average



Curve fit



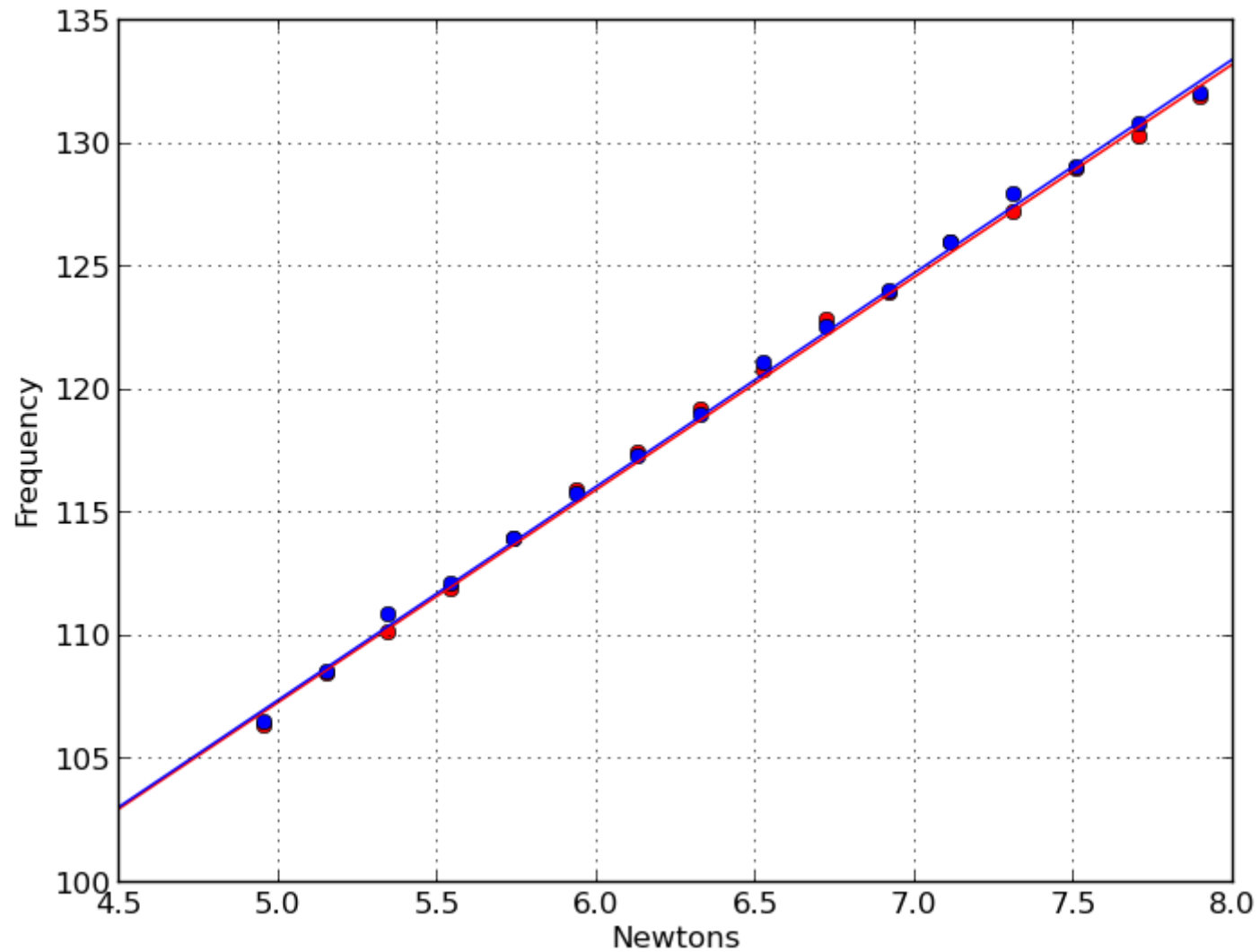
Decision



Frequency vs. Humidity



Long Straw

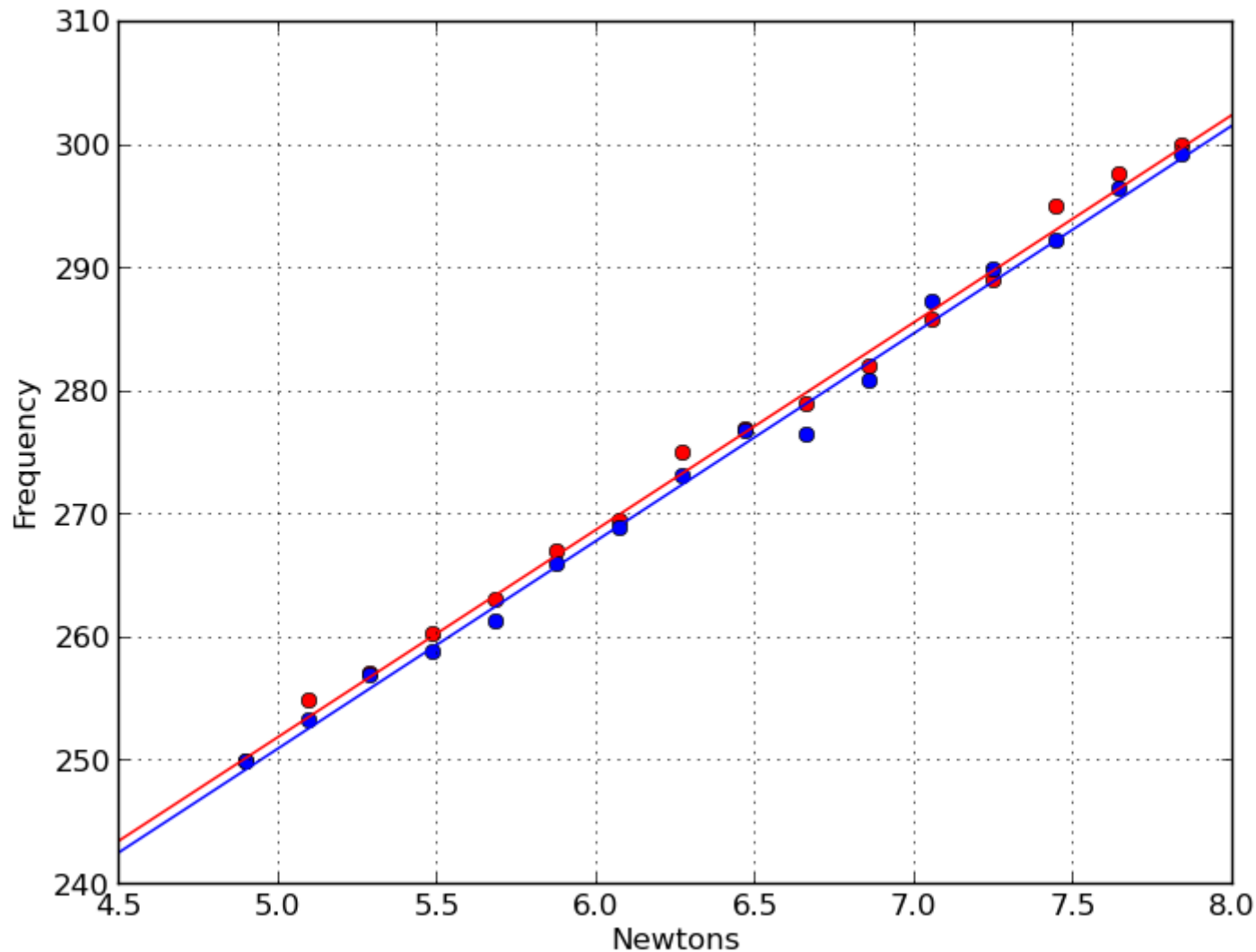


124.5 cm

Red = $8.65x + 64.13$

Blue = $8.68x + 64.05$

Short Straw



Length = 63.5 cm
Red = $16.85x + 167.76$
Blue = $16.87x + 166.72$

$124.5 / 63.5 = 1.96$
 $8. \times 1.96 = 16.96$

Conclusion

- $F \propto 1/L$
- $F \propto T$
- Need to complete
 - Larger range for humidity
 - Verify true for more lengths

Thank You!

- Any Questions?