# Searching for Neutrinoless Double-Beta Decay

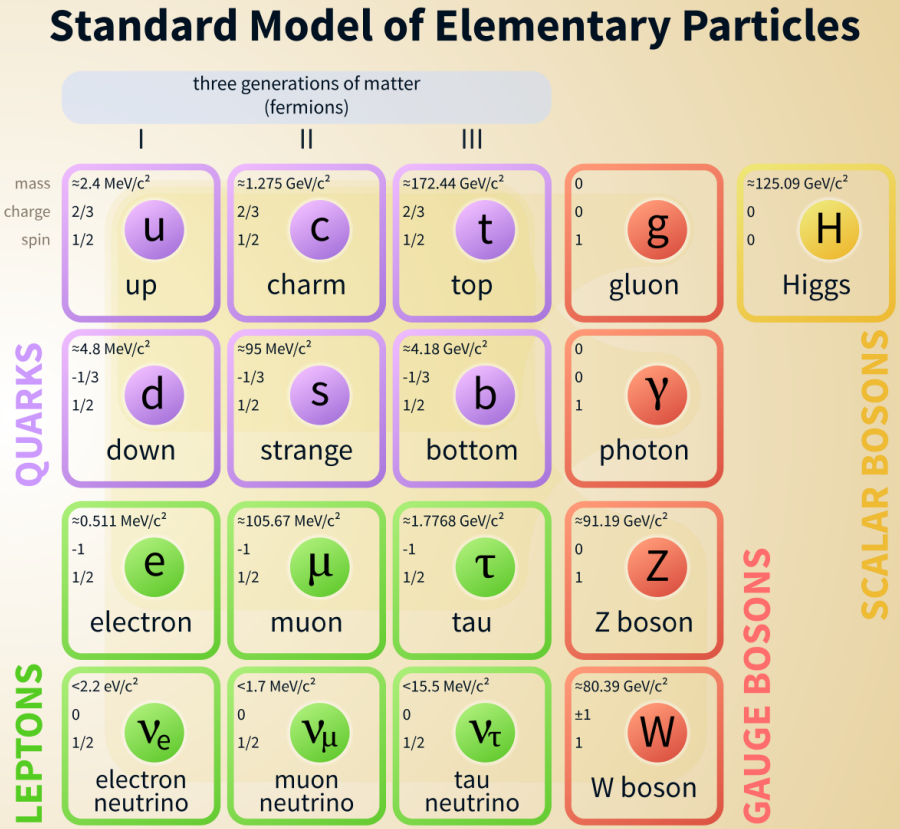
# Overview

- **Neutrino Review**
  - **Motivations of the Majorana Project**
- **My Contributions**
  - **Surface-Level Radiation Background Spectra**
  - **Glorified Bathroom Scale**
- **Current Progress and Future Plans**

# Introduction and Theory

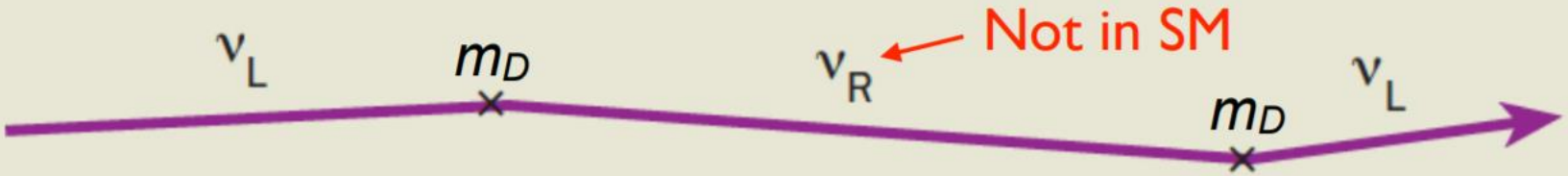
# Standard Model Neutrino Review

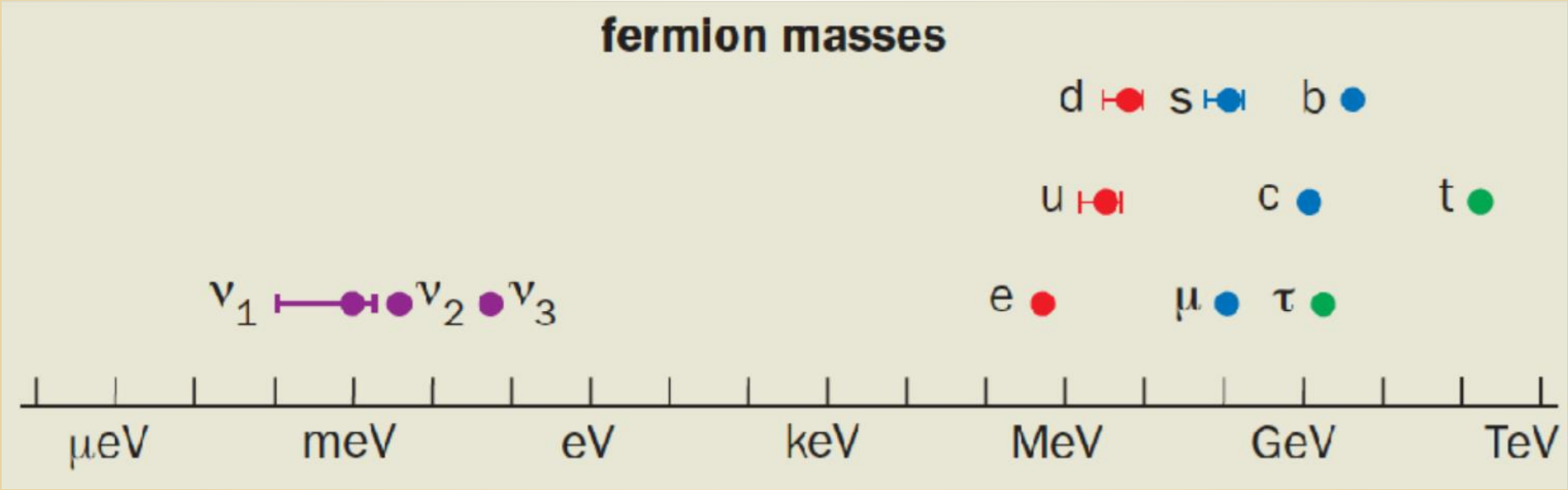
- q = 0
- color = 0
- spin = ½
- 3 flavors (e, μ, τ)
- left-handed ν, right-handed anti-ν
- Only forces: Weak, (Gravity)



# Questions left unanswered

- **Neutrinos have mass!**
  - **Then where is right-handed neutrino?**



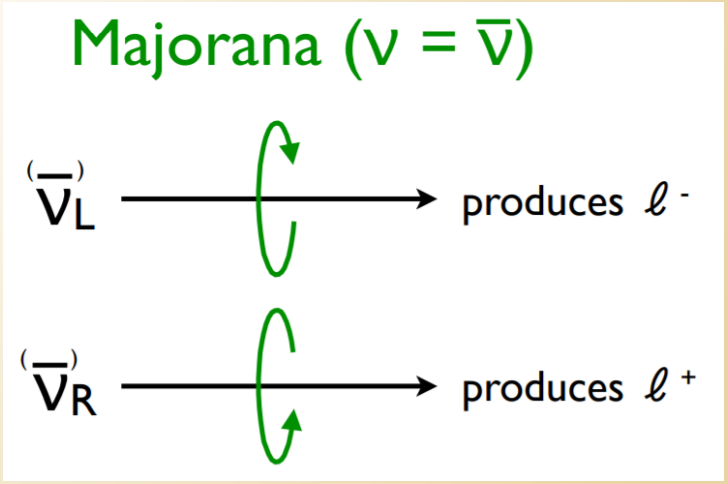






H. Murayama, Physics World (May 2002).

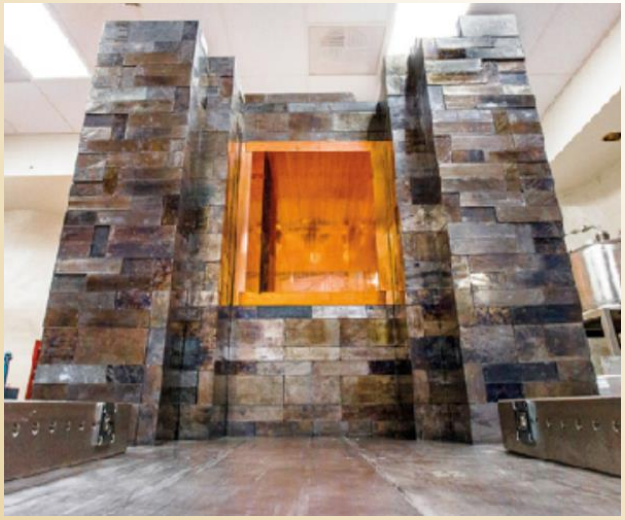
# Majorana Explanation

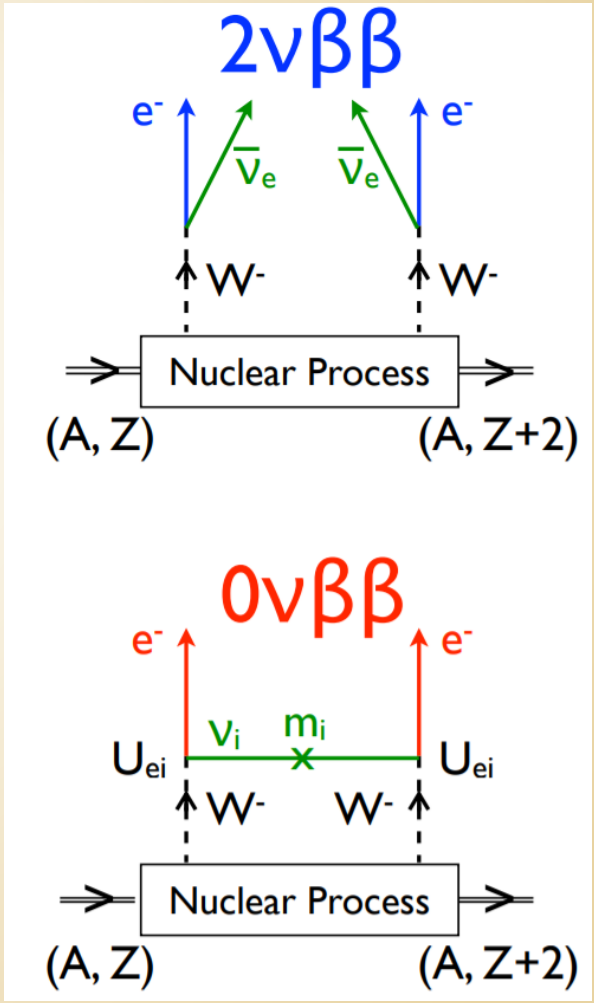
- **Definition of Majorana Particle**
  - **A fermion that is its own antiparticle**
- **What this means for neutrino**
  - **Leptogenesis**
  - **Possibility of annihilation in Double-Beta Decay**



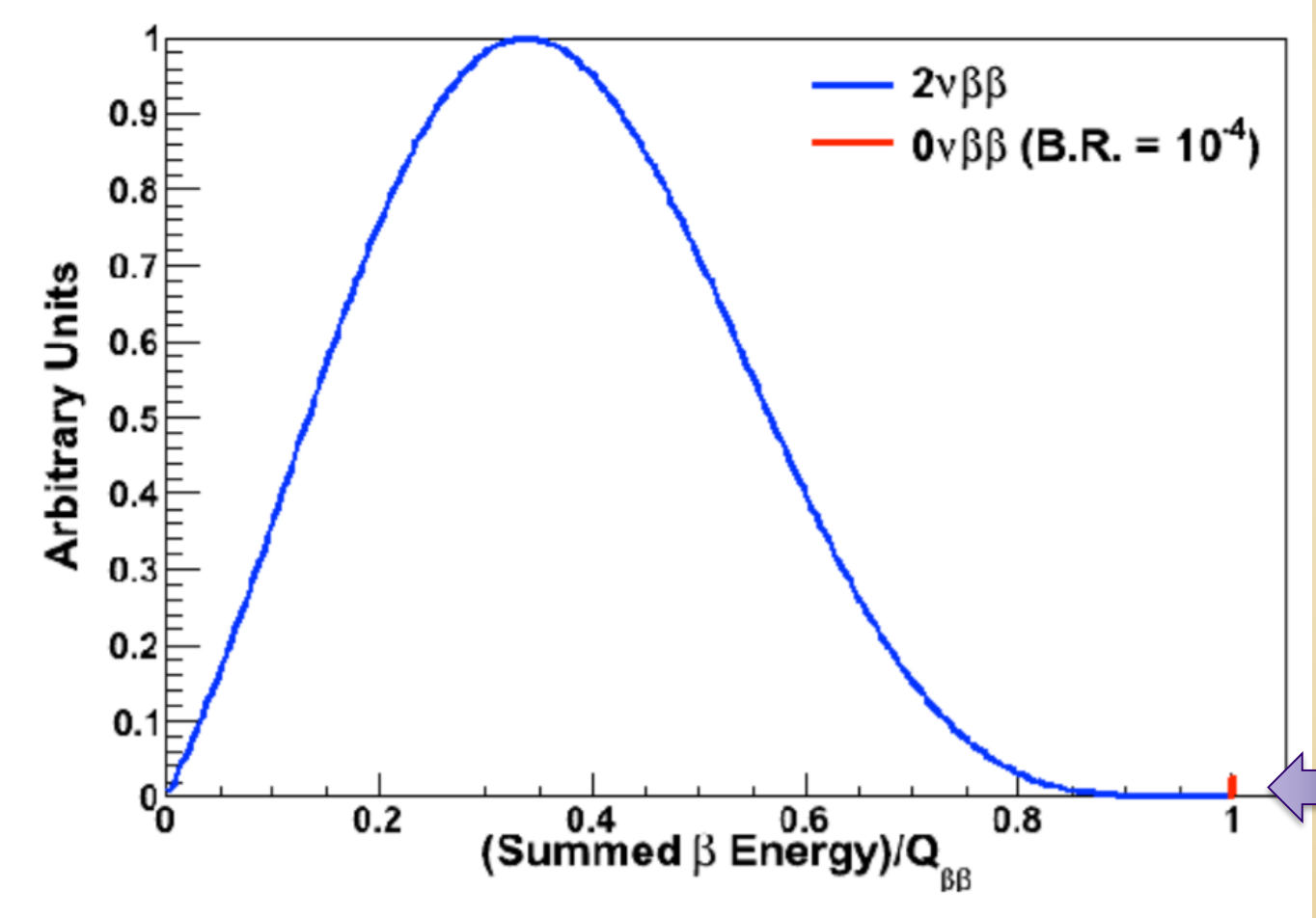
# Majorana Collaboration Experiment

- **Overview of Double-Beta Decay**
  - **Z to Z+2 transition**
    - **Emission of 2 electrons and 2 electron anti-neutrinos**
  - **How to look for it**





# Neutrinoless Double-Beta Decay

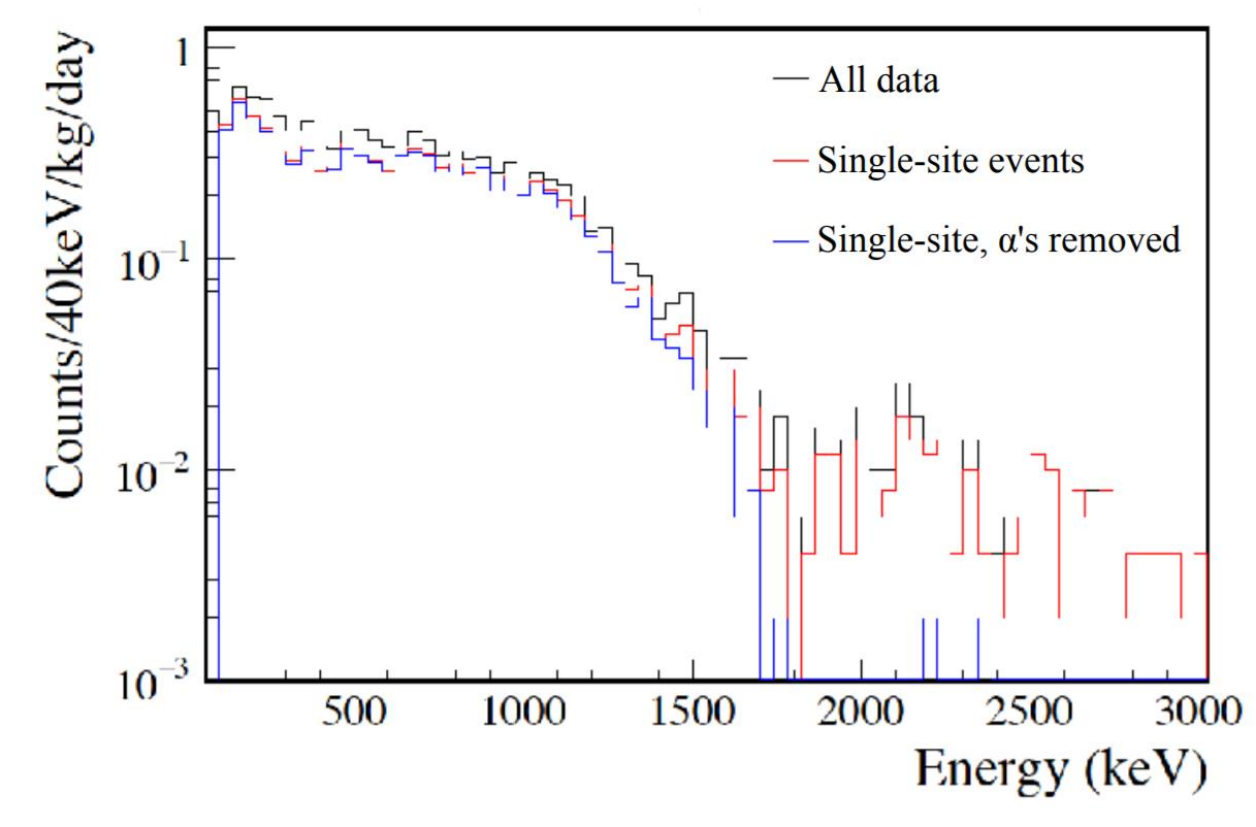



Goal

# My Contribution

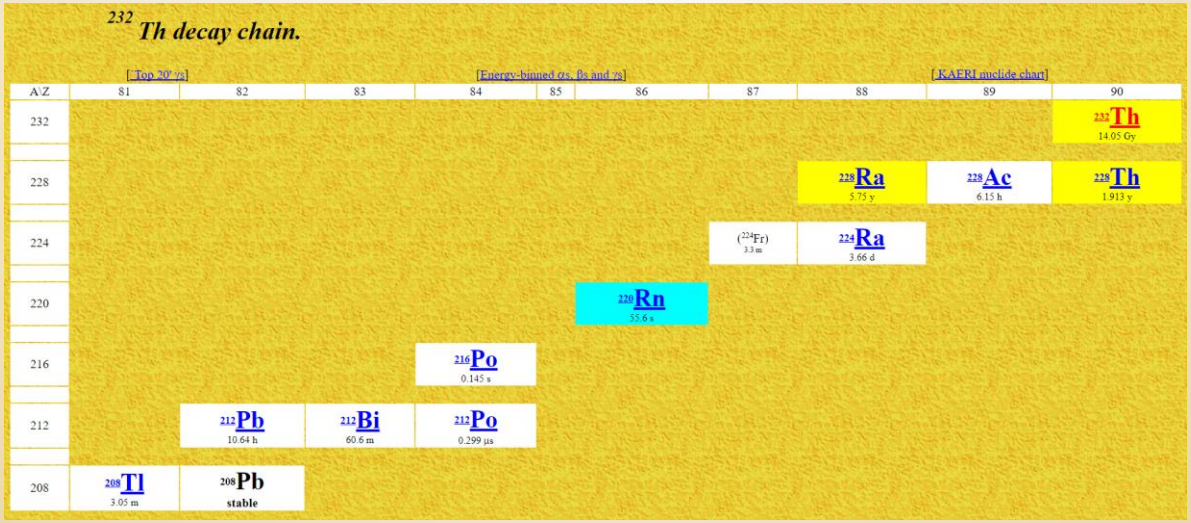
# Background Spectrum Analysis

- **Motivations**
  - **Characterize background radiation**



# Background Spectrum Analysis

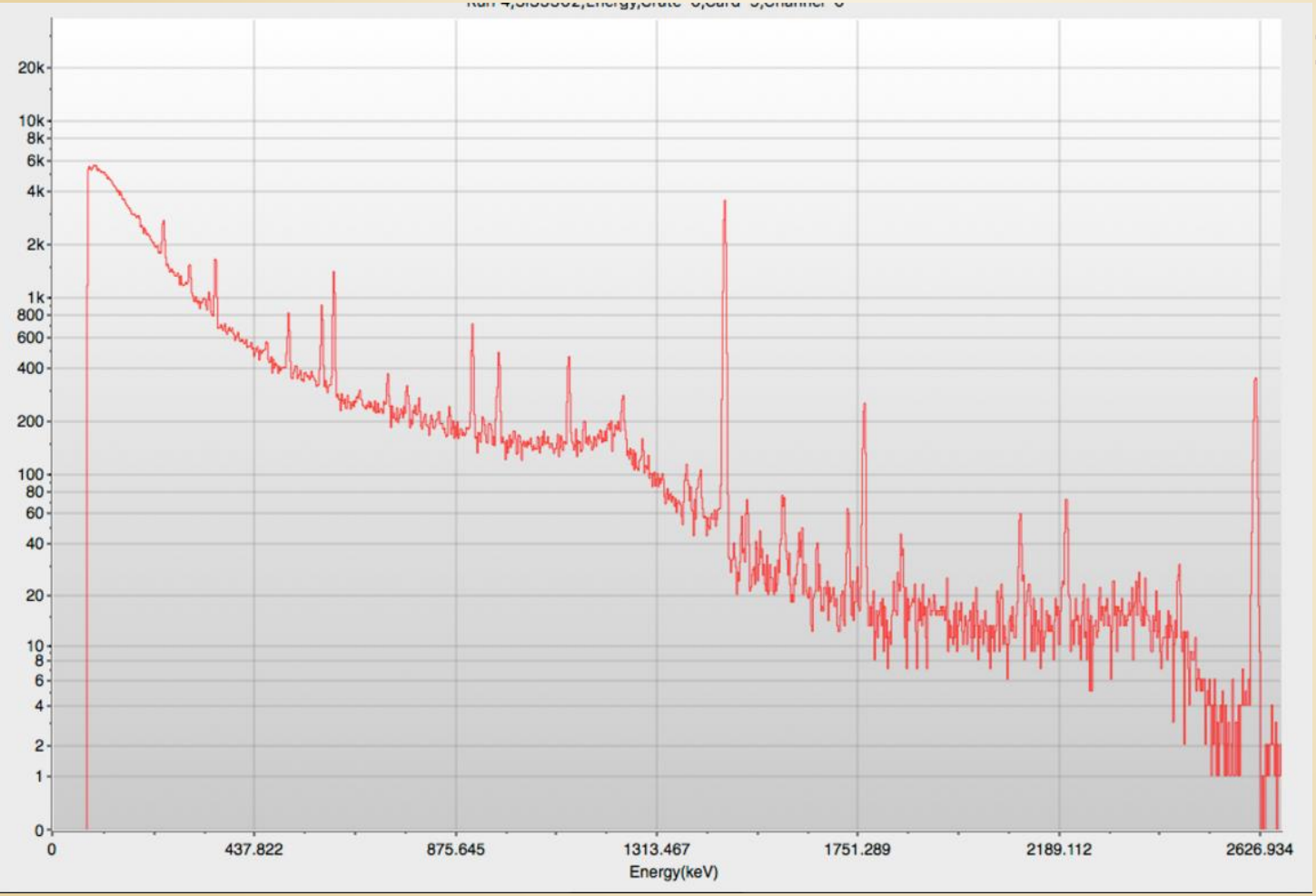
- **Overview of Thorium, Potassium, and Uranium Decay Chains**
  - **Present in nearly all materials made on Earth**
  - **Problems: Give off radiation in our observation range, increasing background**
  - **Grants ability to better analyze demonstrator data**



# Analysis of Spectrum Background Data

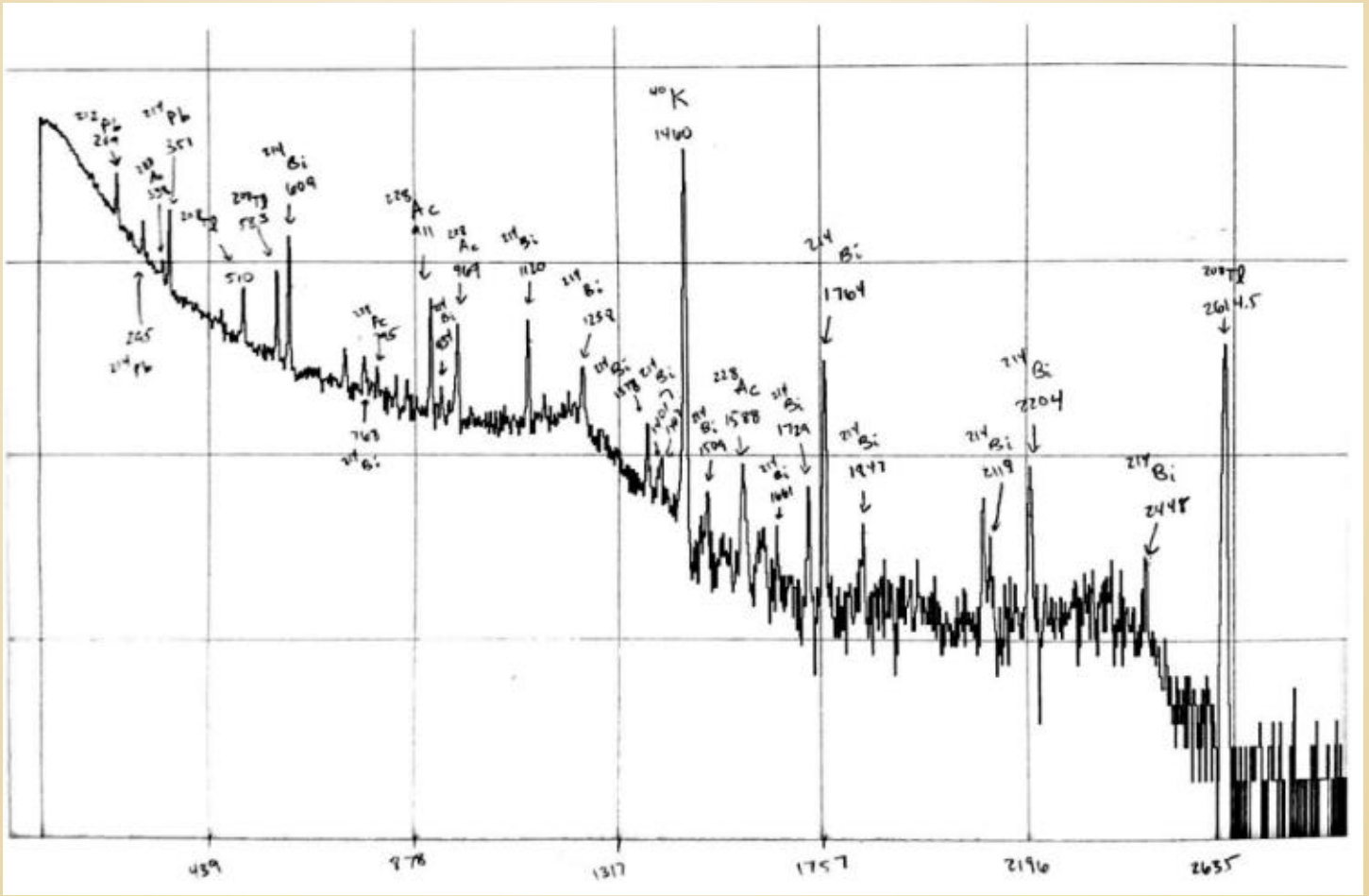
- **Goals**
  - **To be able to identify specific sources of background radiation counts**
  - **To watch background counts decrease with shielding**

# Spectral Readout



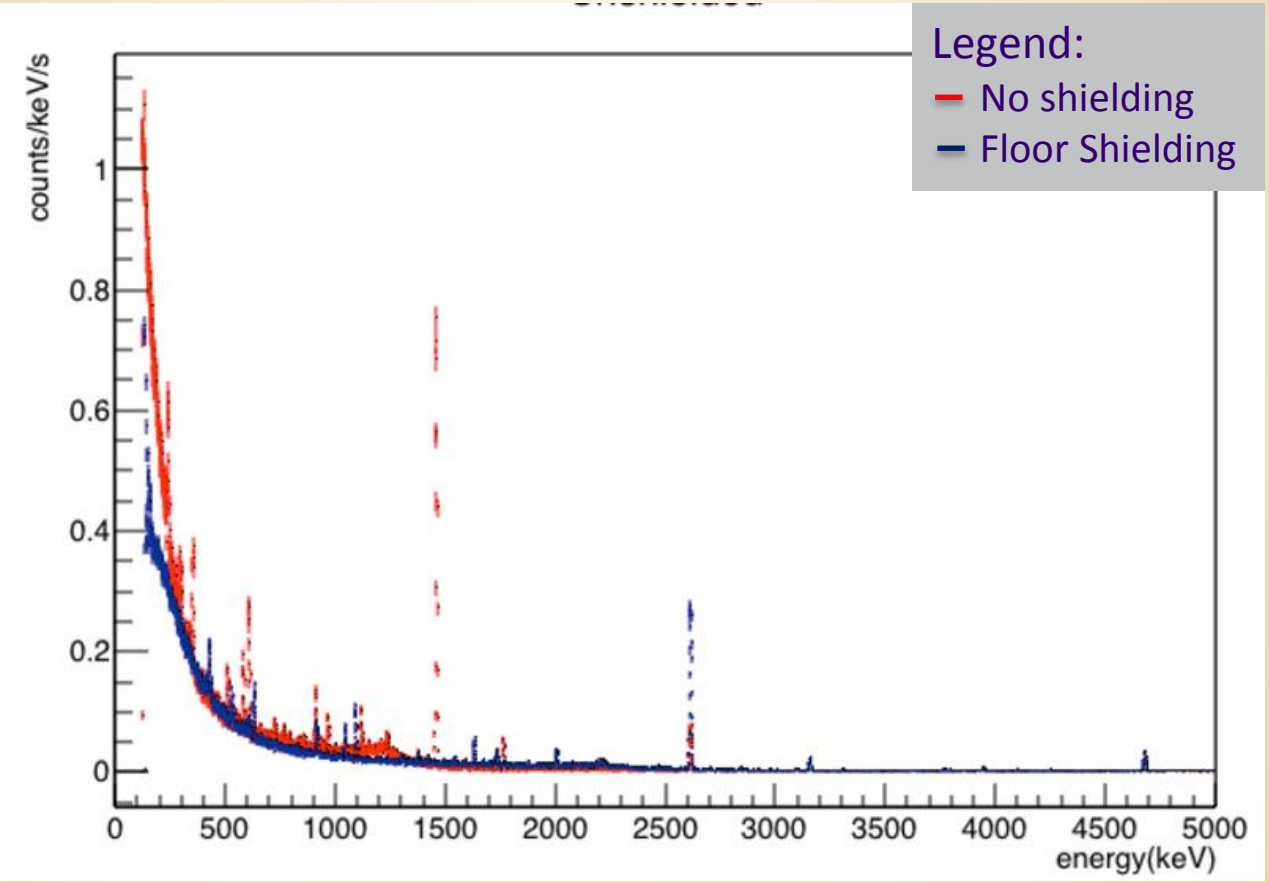

- **Notice:**
  - **Largest Peaks**
  - **Compton Scattering**

# Analyzed Spectrum



# Lowering Background through Lead Shielding

- **Overlaid histograms of floor shielding vs. no shielding**

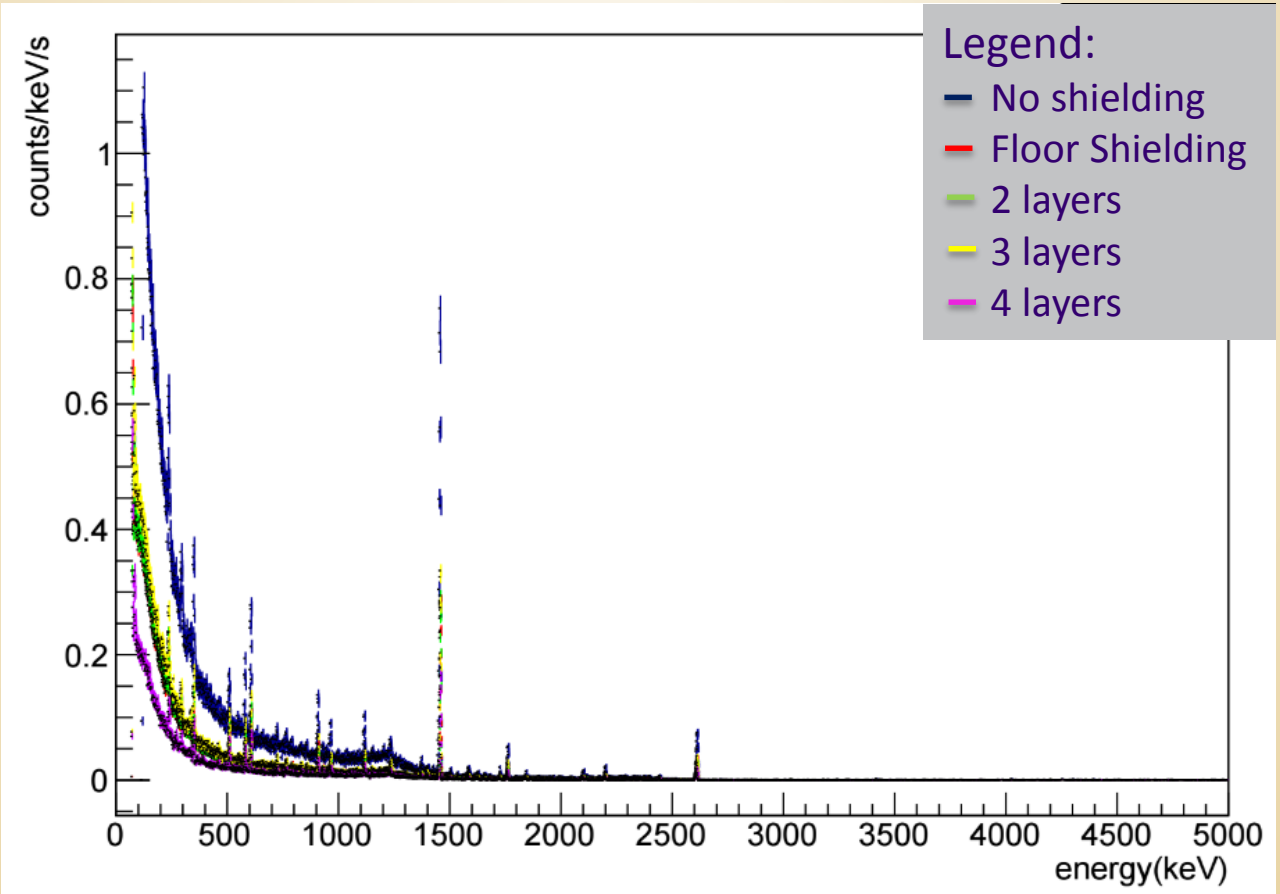





Graph by Zachary Wuthrich

# Lowering Background through Lead Shielding

> **Overlaid Histograms of Multiple Layers of Shielding**





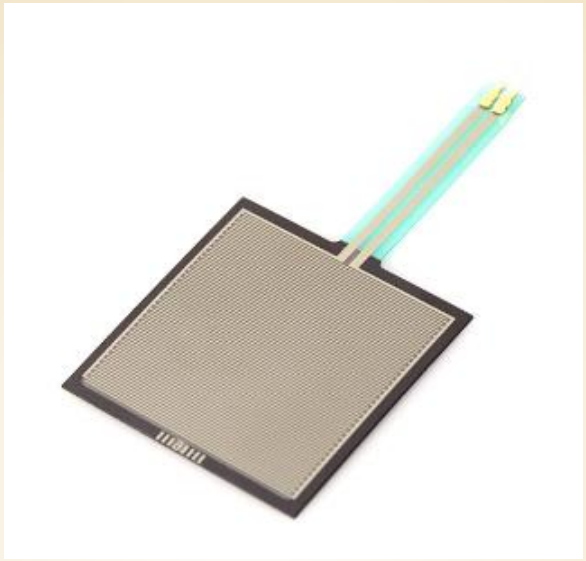

Graph by Zachary Wuthrich

# Vibration Resistant Scale

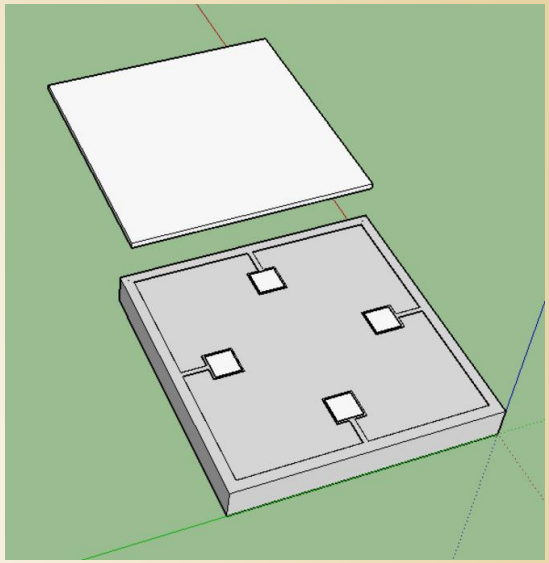
- **Goals and Motivations**
  - **To develop a scale that can be relied upon to keep track of Liquid Nitrogen volume in detector**
  - **To have more vibration dampening than current scale, to lessen background noise**

# Design

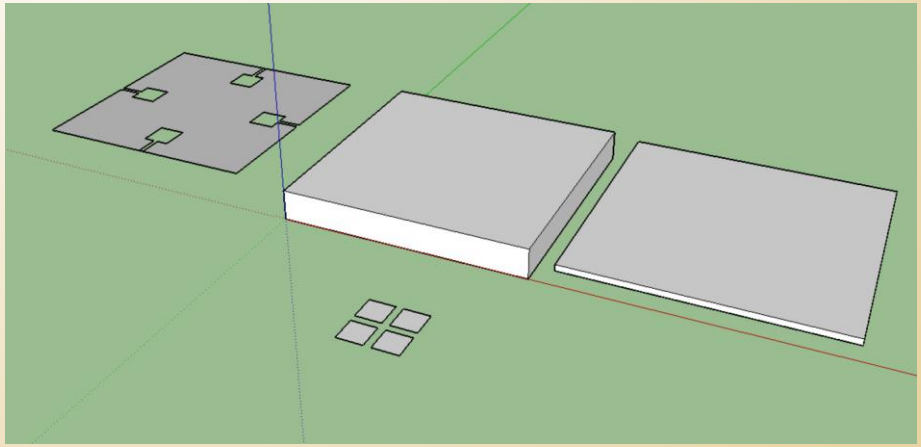
- **Force Sensitive Resistor (FSR)**
  - **Operating Weight: 100g-10kg**
  - **Dimensions: 1.75in x 1.75in**
- **Scale Design**
  - **(30cm x 30cm)***
  - **Adj. to 40cm**



(a)

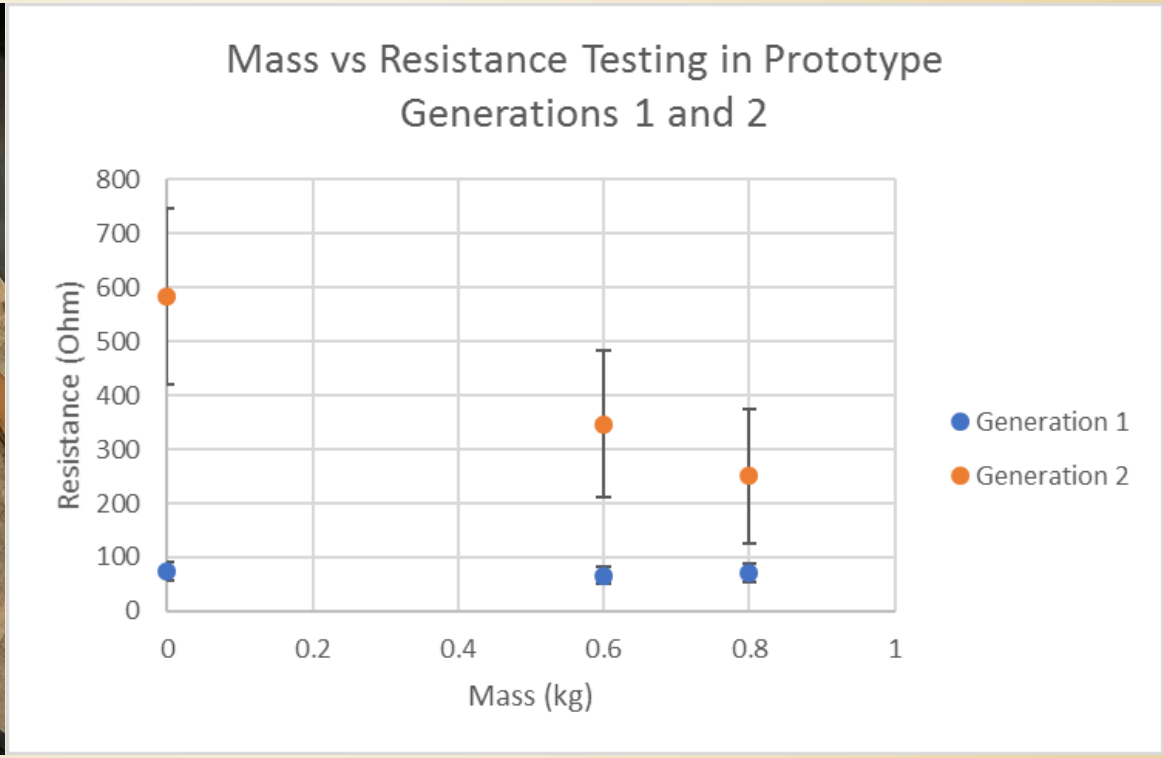


(b)

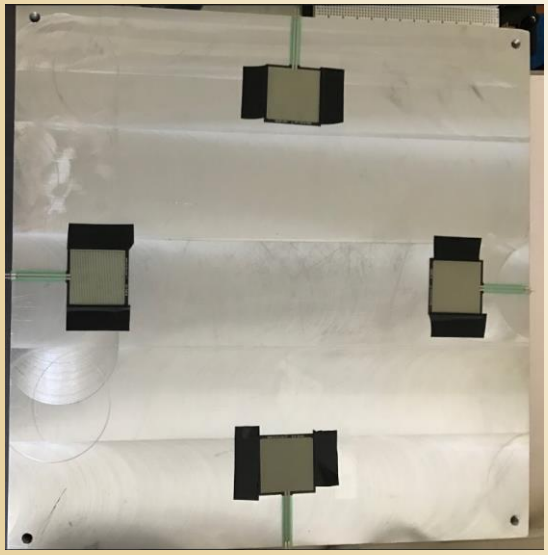


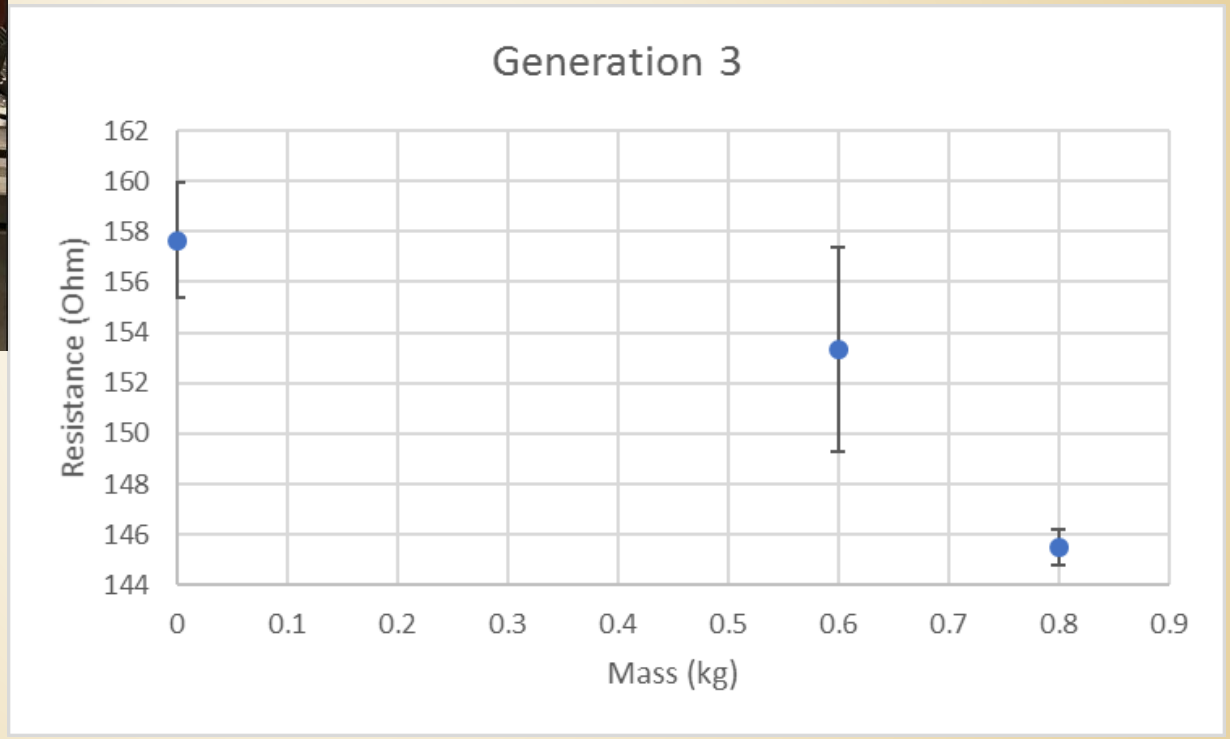
(c)

# Scaled Scale Prototype Generations 1 and 2



# Scale Generation 3





# Conclusions and Future Plans

# You can't see them, but they are everywhere

- **Conclusions**
  - **With further background elimination, the search for Neutrinoless Double-Beta Decay may come to an end, and bring with it some answers to the questions of the universe**
  - **Machining is hard**
- **Next Steps**
  - **Fine-tuning and installing scale**
  - **Majorana collaboration with rival GERDA**

# Acknowledgements


- **NSF, INT, CENPA**
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- **Jason Detwiler and Group Members**
- **My Fellow REU Class**
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