Neutrinoless Double Beta Decay

- Beta Decay: $n \rightarrow p + e^-$
- Double-Beta Decay: $2n \rightarrow 2p + 2e^- + 2$
- Neutrinoless Double-Beta Decay: $2n \rightarrow 2p + 2e^-$
  - This decay only works if Neutrinos are their own anti-particle
  - If Neutrinos are their own anti-particle it could explain the matter anti-matter imbalance
  - This would also explain why neutrinos have mass

Calibration System

- Using a collimated beta source with 3 axes of motion
- The collimator can be pointed in any direction along the inside of the detector from any position along the diameter
- The beta source will be used for all data collection while NuDot is still above ground
- The beta source allows for testing of directional reconstruction of events
- The calibration system will also be used to correct for timing offsets in PMTs and measure the timing uncertainties

NuDot

- 1/2 ton prototype for future liquid scintillator detectors
- Isotropic scintillation light is used to reconstruct when and where event occurs
- Cherenkov light from electrons used to determine direction and number of electrons
- This allows for the separation of background and signal
  - primary source of background is from solar neutrinos
  - Cherenkov and scintillation light is detected with photo-multiplier tubes (PMTs)
- 211 PMTs in the detector
- 151 fast-timing PMTs (< 200 picosecond uncertainty)
- 59 Larger PMTs for light collection

Electronics, Code, and Hardware

- Eventually NuDot will be underground and calibration needs to be completely remote
- My project was developing the electronics and code to move the collimator into position
- 3 stepper motors are used to move the collimator
  - A Raspberry Pi running python code are used to control the stepper motors
  - Rotary encoders are used to verify the position of the steppers

Next Steps

- Installation of electronics at Bates Lab in Massachusetts
- Testing the stepper motors under load
- Finalizing the code to control the motors
- Integrating the Raspberry Pi stepper controls with the data acquisition system
- Begin taking calibration data to demonstrate reconstruction capabilities