Nuclear Beta Spectroscopy for the ^{6}He Experiment

SADHANA SURESH

2017 INT REU

FINAL PRESENTATION

Outline

Motivation for ^{6}He experiment

Background Information
- Weak Interaction
- Helicity/Chirality

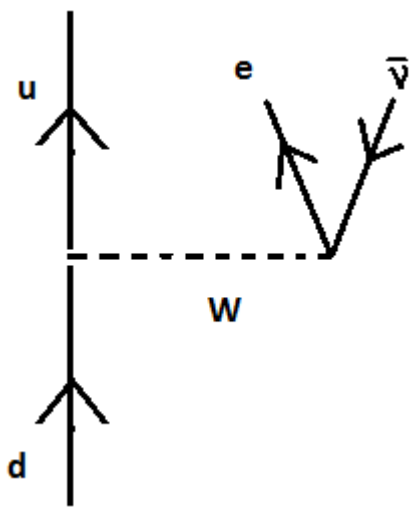
Detector
- Purpose
- Components and Operation
- Setup

Results

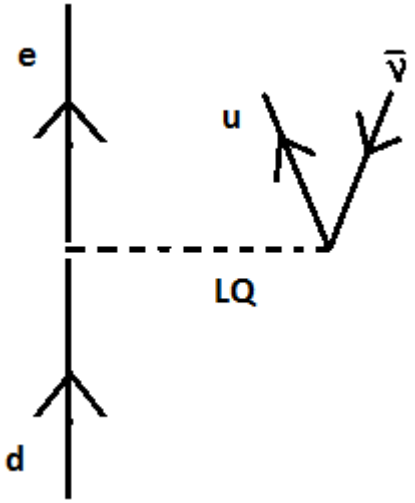
Future Plans

Motivation for ^{6}He Experiment

- Beta Spectroscopy
- Search for BSM physics
- Chirality flipping interactions



Standard Model Interaction



New physics – Grand Unified Theory

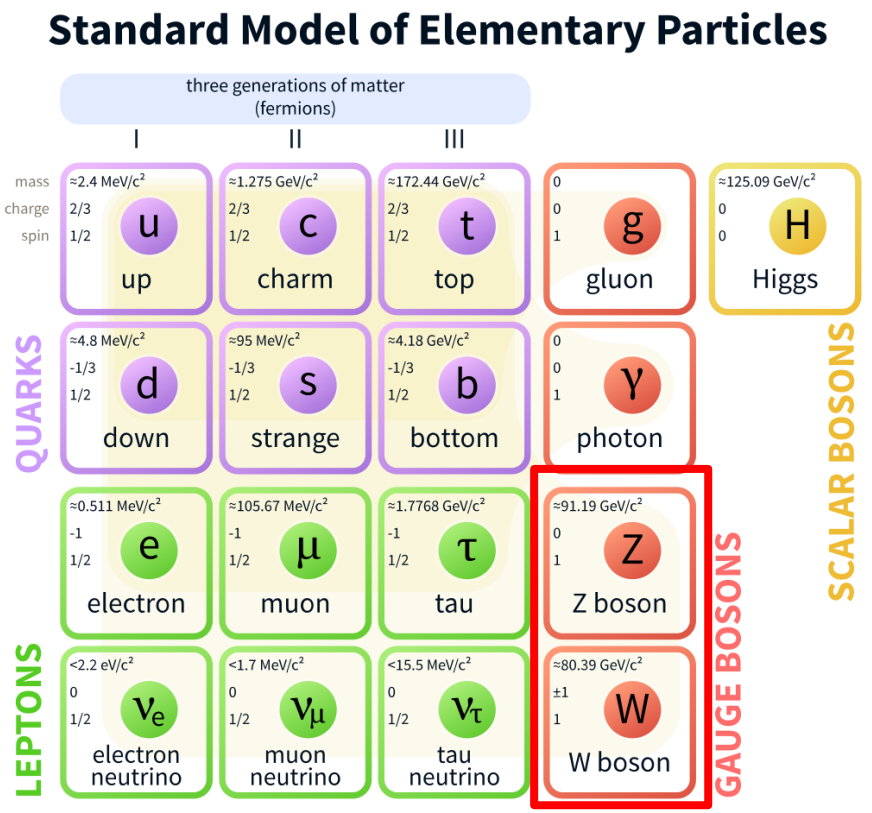
Background – Weak Interaction

Basic Facts

- 1 of 4 Fundamental Forces
- Responsible for Beta Decay
- Mediated by the W^+, W^-, and Z bosons

Interaction Hamiltonian – Only Left handed Vector and Axial Vector components

$$H_{\text{int}}^{VA} = \sum_{i=V,A} (\bar{\psi}_p O^i \psi_n)[(C_i + C_i')\bar{\psi}_e^L O_i \psi_\nu^L]$$



Interaction Hamiltonian

$$H_{\text{int}}^{VA} = \sum_{i=V,A} (\bar{\psi}_p O^i \psi_n)[(C_i + C_i')\bar{\psi}_e^L O_i \psi_\nu^L + (C_i - C_i')\bar{\psi}_e^R O_i \psi_\nu^R] + \text{h.c.}$$

$$+ \; H_{\text{int}}^{ST} = \sum_{i=S,T} (\bar{\psi}_p O^i \psi_n)[(C_i + C_i')\bar{\psi}_e^R O_i \psi_\nu^L + (C_i - C_i')\bar{\psi}_e^L O_i \psi_\nu^R] + \text{h.c.}$$

New physics – right-handed currents and chirality flipping interactions

Background – Fierz Interference

$$H_{int} = H_{VA} + H_{ST}$$

Fermi's Golden Rule: $\Gamma_{a\to b} = \frac{2\pi}{\hbar}[< f|H_{int}|i >]^2 \rho$

$[< f|H_{int}|i >]^2$ will cause cross terms – Fierz Interference

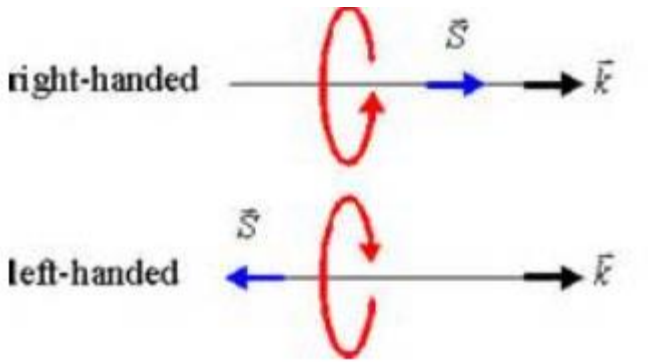
$$b \approx \pm\Re\left[\alpha\left(\tilde{C}_S + \tilde{C}'_S\right) + \beta\left(\tilde{C}_T + \tilde{C}'_T\right)\right]$$

$$\frac{dW}{dt} \approx \frac{dW_0}{dt}\left(1 + r(E) + R(E) + \frac{m}{E}b\right)$$

α = 0 for pure Gamov-Teller Transition (like ^{6}He)

Background – Helicity and Chirality

Helicity : $\frac{\boldsymbol{S}\cdot\mathbf{p}}{|\boldsymbol{S}||\mathbf{p}|}$



Not Lorentz Invariant

Chirality:

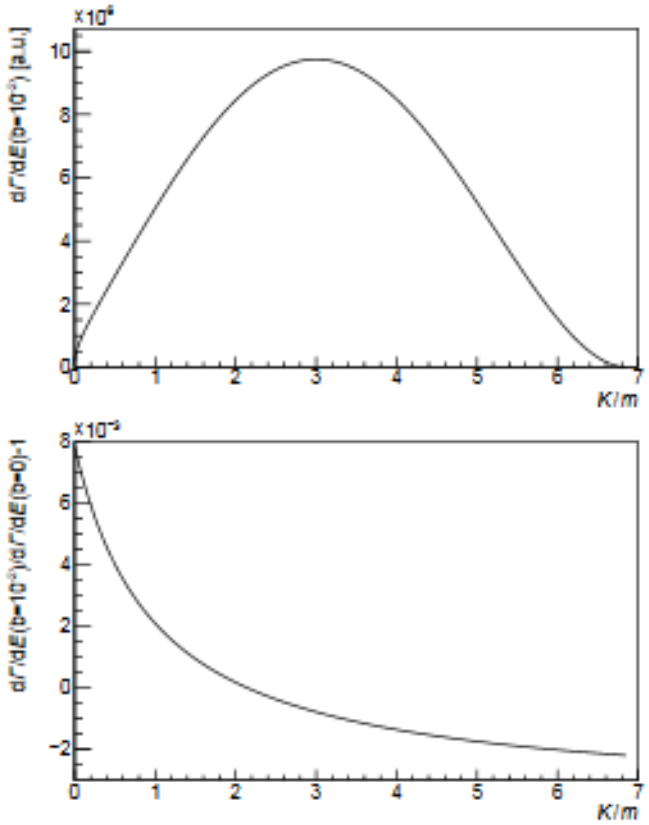
- spin projection unto "internal velocity" direction
- $\Delta t \Delta E \geq \frac{\hbar}{2}$ and v = c
- $$u_{\uparrow}(E,p) = \sqrt{\frac{1+\frac{p}{E}}{2}}\,\phi_{\uparrow}(+c) + \sqrt{\frac{1-\frac{p}{E}}{2}}\,\phi_{\uparrow}(-c)$$
- Linear combination of forward and backward motion

Beta Spectra from ^{6}He

- Emitted betas will undergo cyclotron motion
- Due to relativity – the frequency of motion is related to energy:

$$f_c = \frac{\omega_c}{2\pi} = \frac{1}{2\pi}\frac{eB}{\gamma m} \qquad \gamma = \frac{K+m}{m}.$$

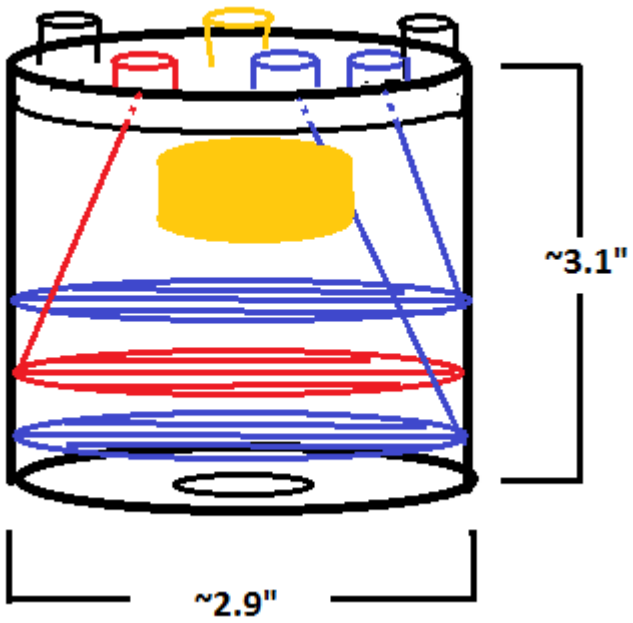
- Experiment will sample frequencies at varying B
- Detector will normalize spectra by monitoring the number of ^{6}He atoms



My REU Project

Detector

Diagram



Components

-Wire Chamber
  - Anode (red)
  - Cathodes (blue)

-Silicon Detector

-High Voltage Connection

-Gas Input Valve

Detector

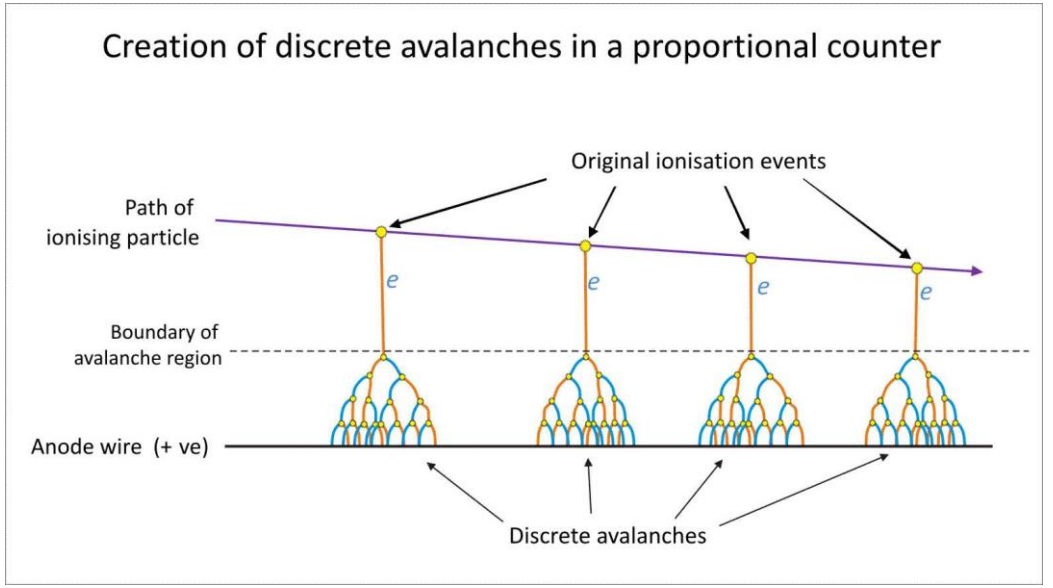
Wire Chamber

- β particles will ionize gas atoms
- High voltage (2800 V) accelerates dislodged charged particles
- Charged particles will continue to ionize gas atoms (avalanche)
- Charge will collect on wires – induce a current

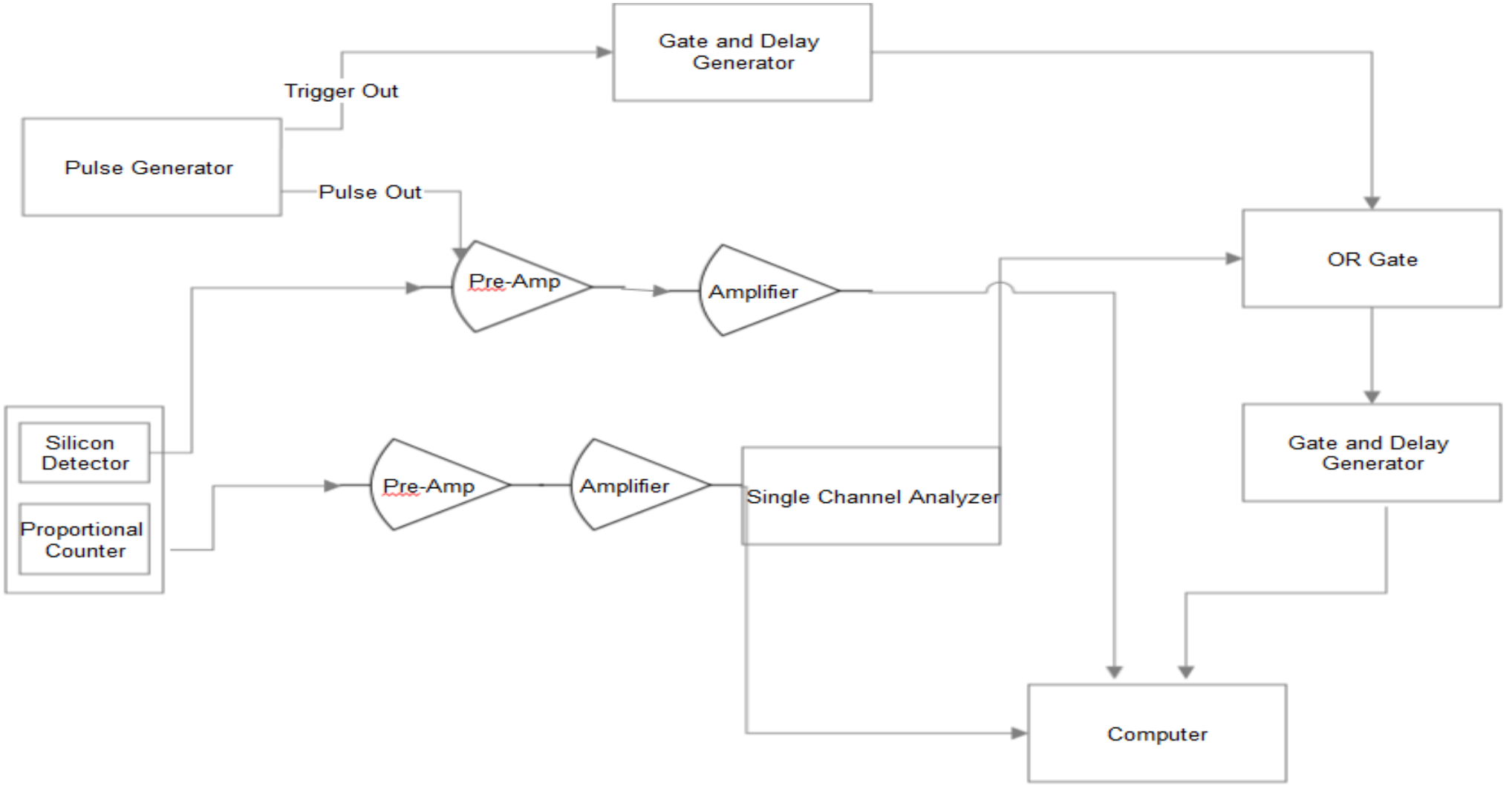
Silicon Detector

- B particle will continue to Silicon detector
- Semiconductor detector

Coincidence is set up – highly sensitive to Betas but not background

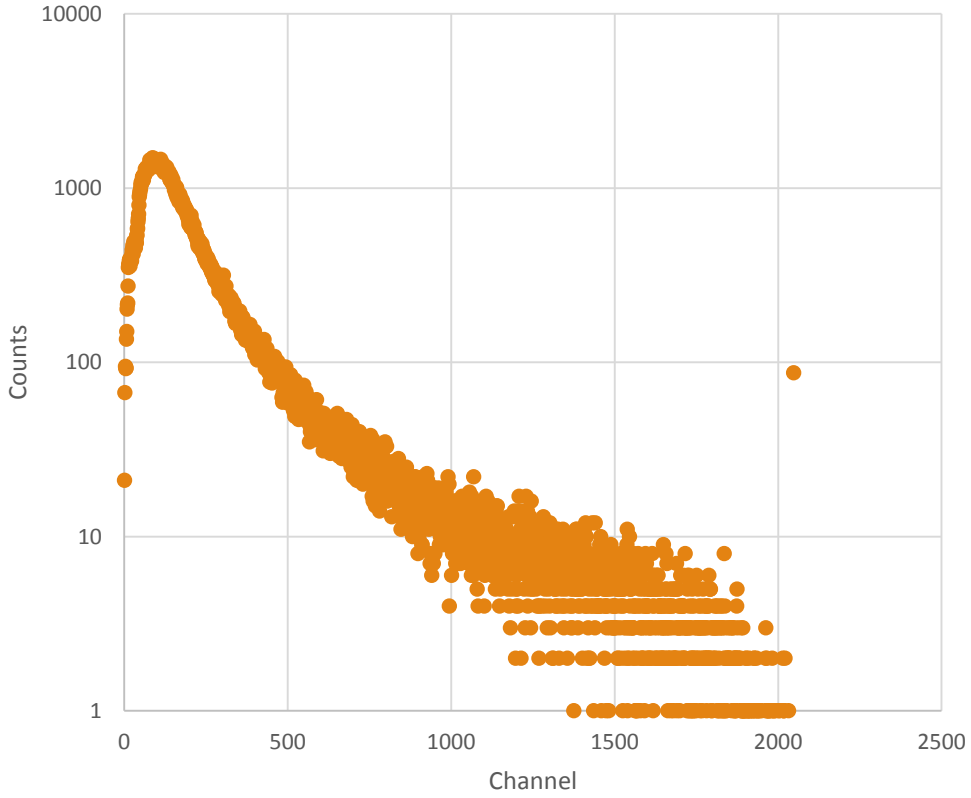


Detector- Setup

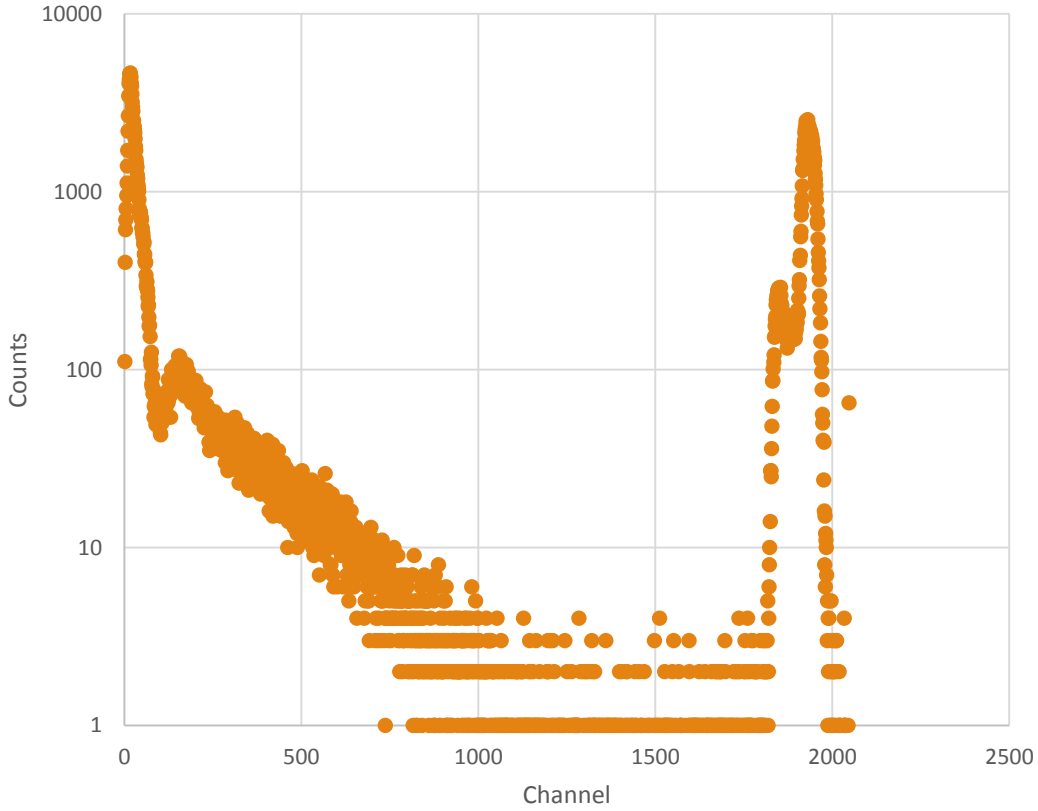


Results - Spectra

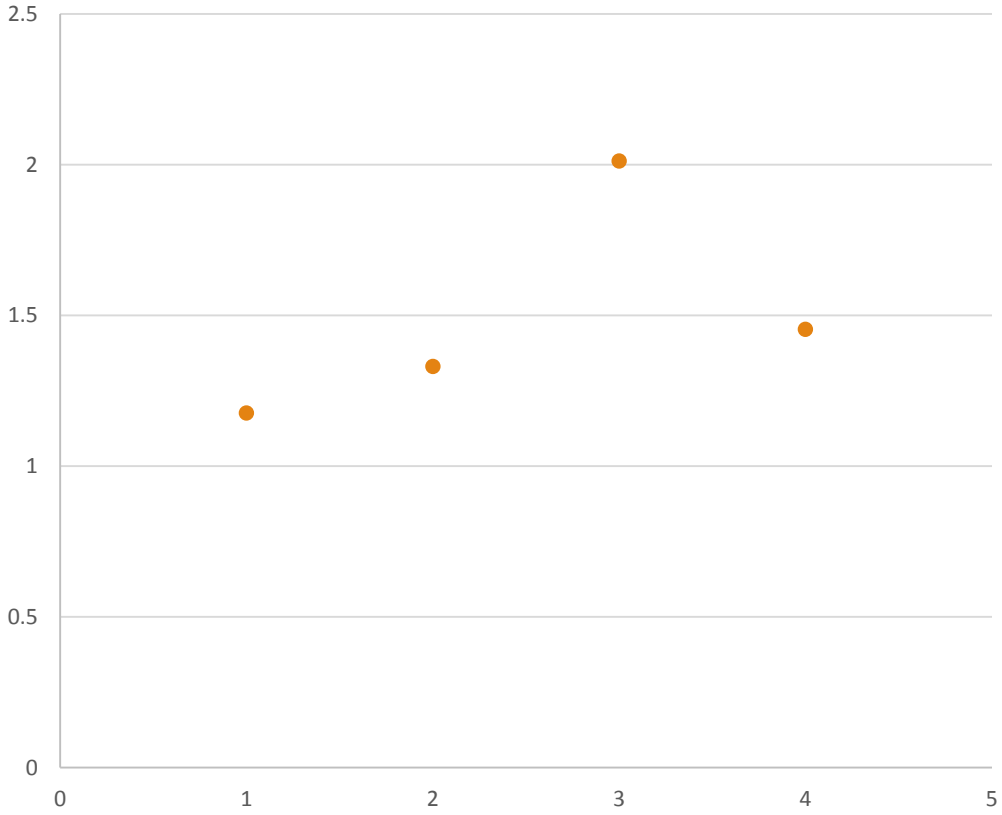
Proportional Counter



Silicon Detector



Results - Analysis



Net Counts	Uncertainty	Residuals
1.175	0.005	-45.5957
1.332	0.006	-13.1242
2.013	0.008	78.05663
1.454	0.006	8.303193

Future Plans

- Reduce noise – possibly with Mylar sheet over Silicon detector
- Take background for each trial
- Stabilize the Beta source

Acknowledgements

- NSF and INT REU
- Faculty and Staff at UW Physics and CENPA
- Dr. Alejandro Garcia and his group

References

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