FERMILAB-POSTER-19-080-PPD

Using Charge-Coupled Devices to Characterize Neutron Events

Dylan Smith – Department of Physics and Astronomy, Michigan State University
Erik Ramberg – Fermi National Accelerator Laboratory

Introduction

- Ultra-cold neutrons (UCNs) < 300 neV of kinetic energy
- Useful for studying position-dependent quantum states, as they are only influenced by Earth's gravity
- Precise measurements involving dark matter, dark energy, and quantum gravity
- Detecting neutrons involves the reaction in a coated CCD of

$$^{10}B + n \rightarrow {}^{7}Li + \alpha + free\ energy$$

- A simulation software package called The Stopping and Range of Ions in Matter (SRIM) uses Monte Carlo methods to track ions in a chosen target

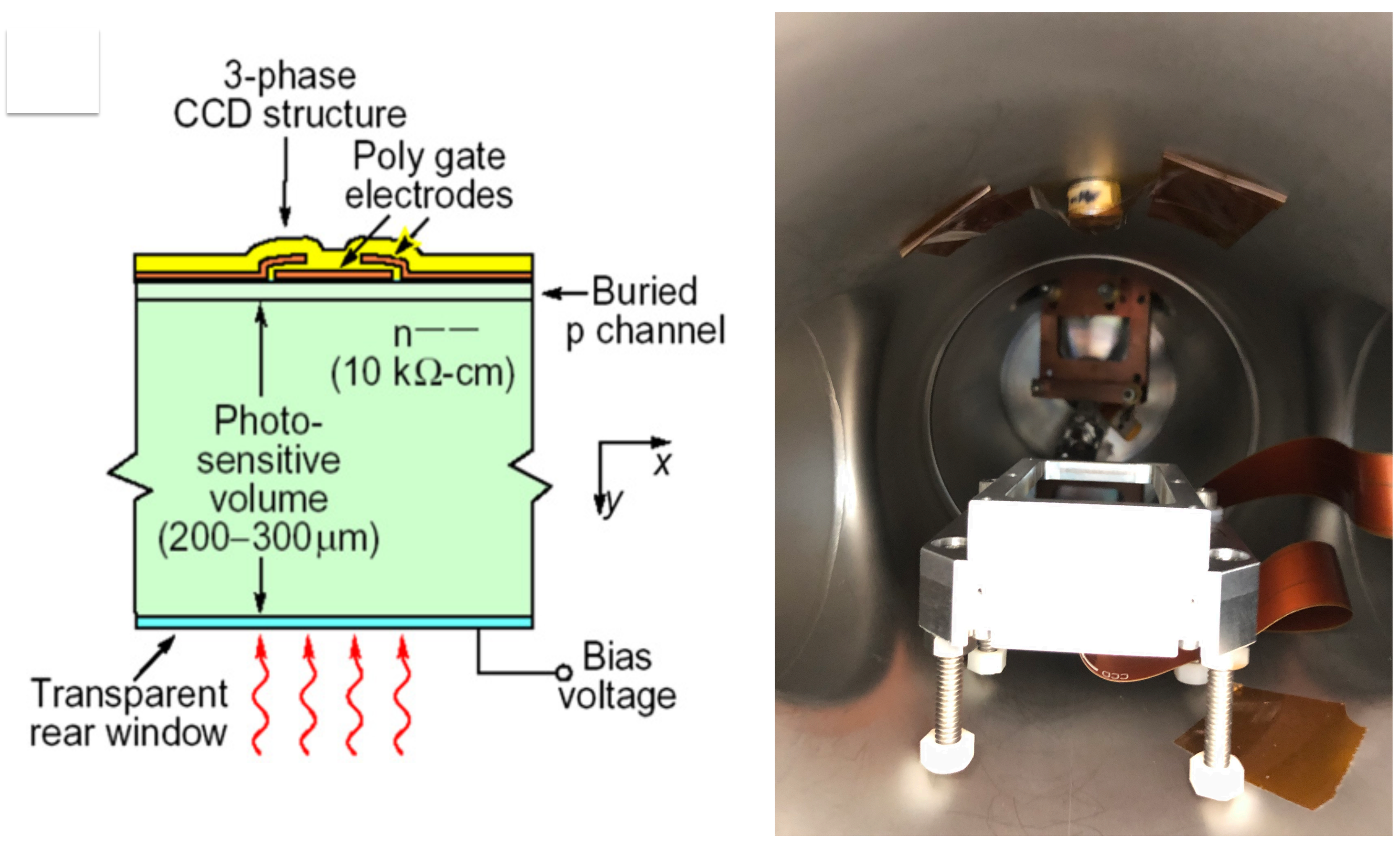

Fig. 1: Diagram of Boron-coated CCD design (left) and picture of CCD set-up (right)

Methods

- Performed calibrations/measurements on uncoated CCD
- The purpose of this is to ensure its viability and send it to Los Alamos National Laboratory to be coated in ^{10}B
- CCD is placed in a 10^{-4} Torr vacuum chamber at 140 K
- The CCD is connected to a Low Threshold Acquisition (LTA) device, which converts the CCD hits into an image file
- The CCD was characterized by ^{55}Fe and ^{252}Cf sources
  - ^{55}Fe is used to determine the gain and noise of the CCD
  - ^{252}Cf is used to measure penetrating hits on the CCD
- SRIM is used to determine a correlation between incident ion angle and 2D variances

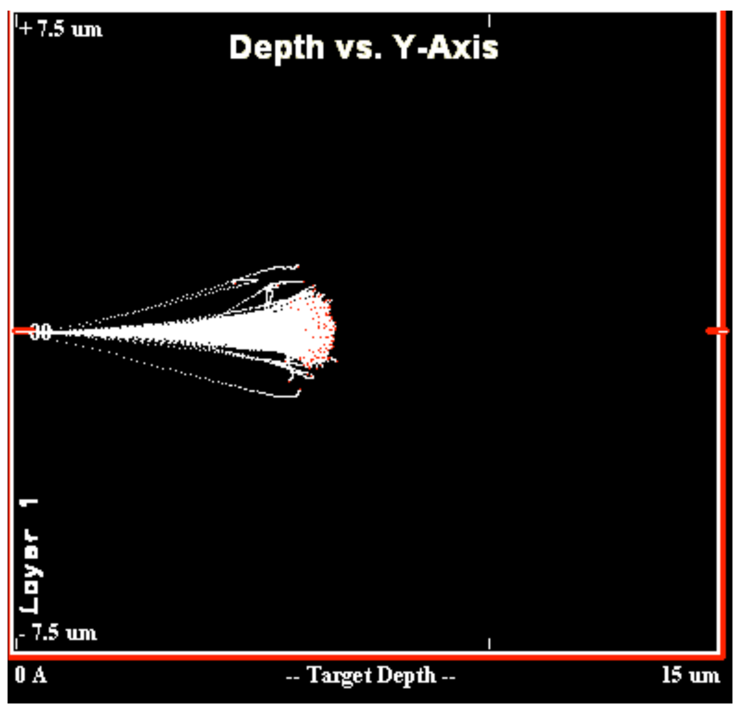

Fig. 2: SRIM output of α particle hitting a silicon target at 1.7 MeV. 1000 tracks are shown

Results

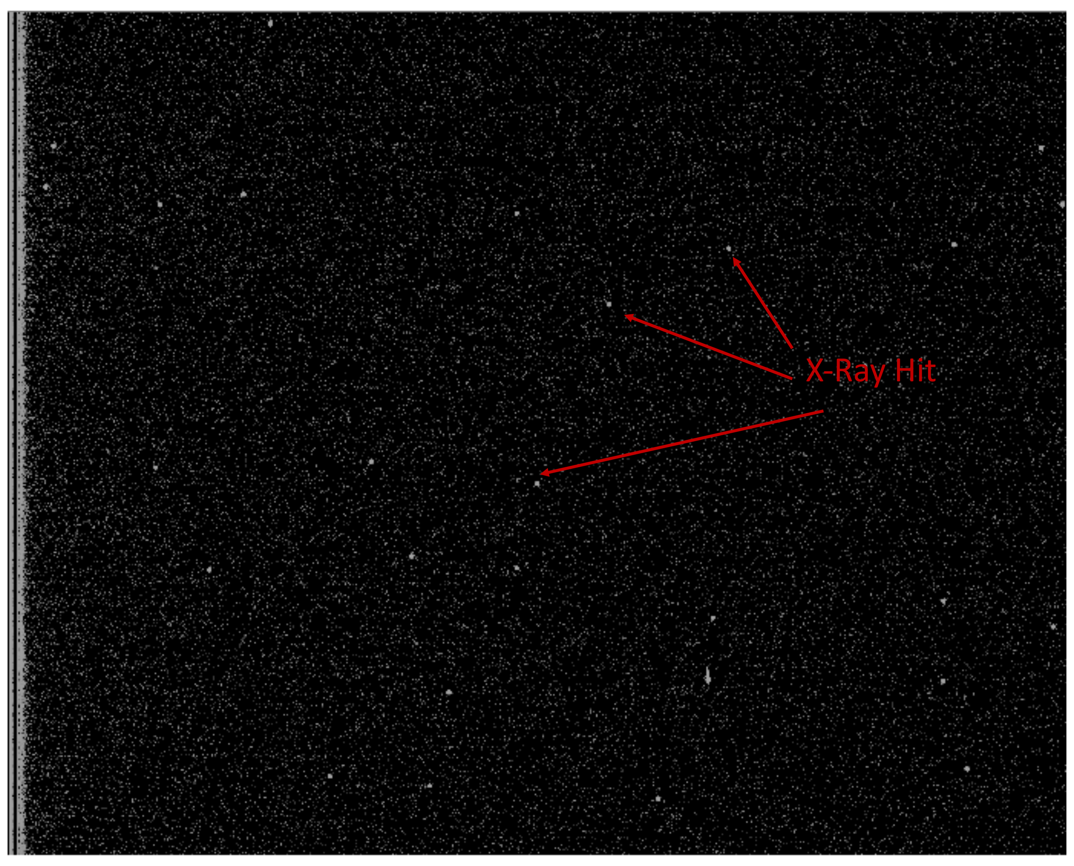

Fig. 3: CCD image with an ^{55}Fe source. The slightly-brighter dots are the x-ray events

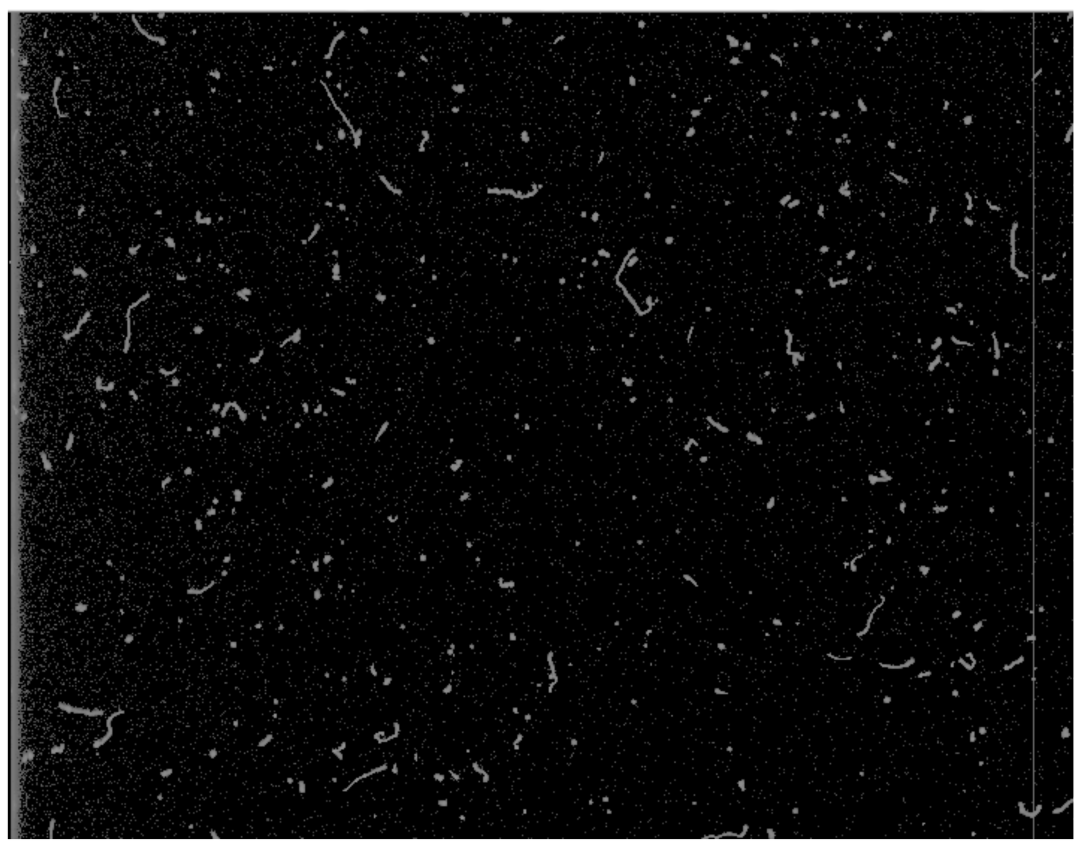

Fig. 4: CCD image with a ^{252}Cf source.

Discussion/Conclusions

- Values calculated from ^{55}Fe:
  - Gain = 48.2 ADU/e^-
  - Noise = 11.5 e^-
- Large amount of hits with ^{252}Cf source shows that the CCD is working properly
- Still working on finding correlation between variance and angle in SRIM

Acknowledgements

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.

References

1. E. Ramberg, J. Estrada, V. Nesvizhevsky, *High Position Resolution Imager for Mapping Gravitational Quantum States using Ultra Cold Neutrons,* DOE HEP National Laboratory Announcement Number: LAB 19-2077

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.