Characterizing VUV Light Sources for SiPM Testing

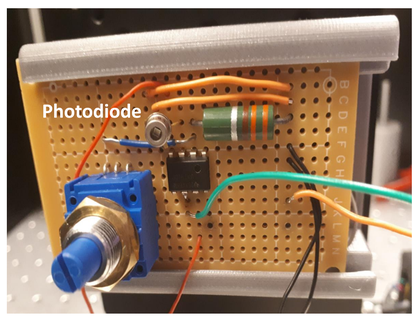
Megan Cvitan (Supervisor: Thomas Brunner)
McGill University – Summer 2019

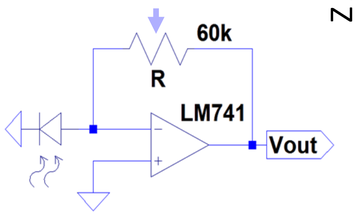
Goals

- nEXO is a proposed tonne-scale liquid Xe detector that will search for neutrinoless double beta decay in ^{136}Xe.
- The experiment will use **SiPMs** to detect scintillation light in Xe[1].
- This project aims to characterize various VUV light sources in order to use them to test these SiPMs.

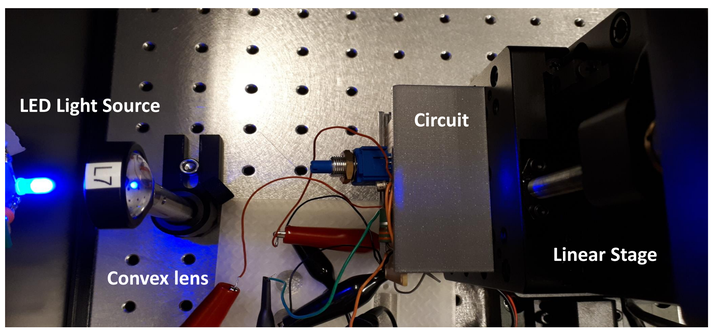
Experimental Setup

- A photodiode mounted on a linear stage performs scans of an arbitrary light source; it was tested with a visible blue LED before transitioning into UV range.
- A transimpedance amplifier circuit was built and tested to optimize the performance of the photodiode.





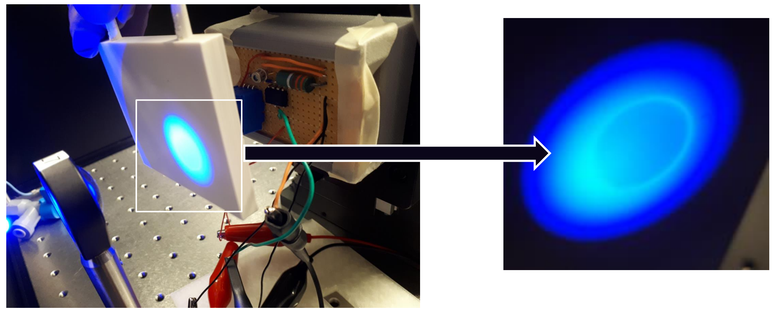
Photodiode detector circuit, where the output was read by an oscilloscope.



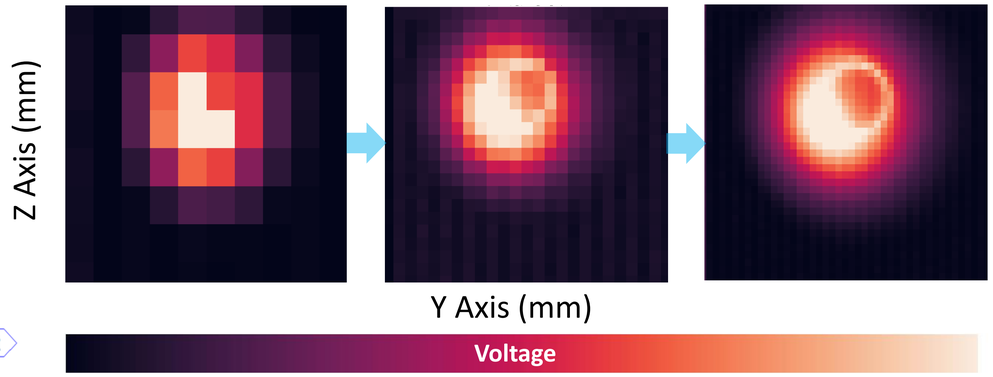
An image of the blue LED is focused through a convex lens and onto the grid-shaped path of the photodiode, which is controlled by the linear stage. The circuit is kept in place by a 3D-printed holder.

Imaging Techniques

- A **linear stage system** was used to move the photodiode at specified intervals in a grid pattern.
- We collected voltage data with a Rigol oscilloscope after the linear stage reached its designated position.



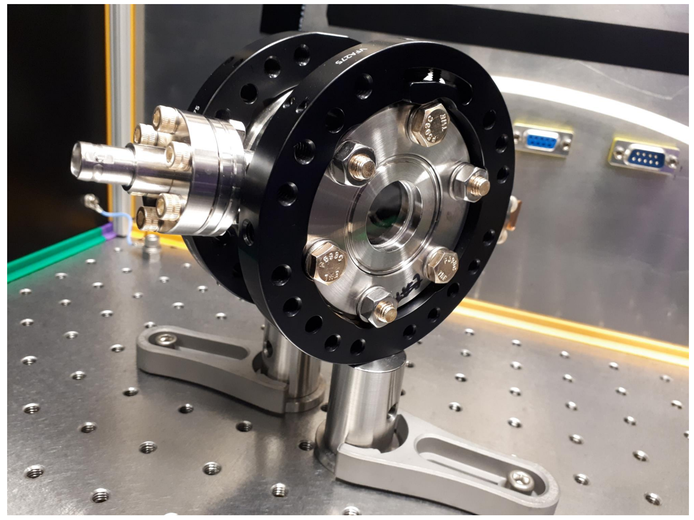
The LED source that is being imaged.



50x50 mm grid scan at various increments. (left) 5 mm increments with no aperture, (middle) 2 mm interval with aperture, and (right) 1 mm interval with aperture.

Preliminary Testing and Early Conclusions

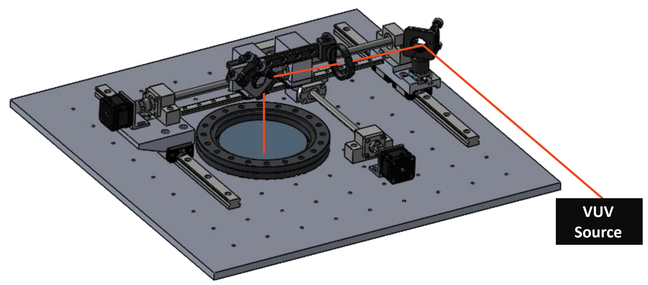
- After ensuring that the photodiode responded to light pulses in photovoltaic mode, the movement of the linear stage and the data collection were automated.
- The minimum step size of the linear stage is 0.02 mm.
- The resolution of the scan is significantly improved with the addition of a 0.5 mm aperture, as seen above.
- Reconstructing the original LED image demonstrates effectiveness in the measurement of spatially resolved light intensity.



An example of VUV light is the ^{252}Cf source developed in the Brunner Neutrino Laboratory by previous students.

Future Directions

- Unknown light distributions from the the **^{252}Cf source** can be mapped with the linear stage system and a VUV sensitive photodiode.
- The diffuse light from the ^{252}Cf source can then be collimated and focused down to the single-pixel scale on the test SiPMs for nEXO.
- Once the emissions are quantified, the ^{252}Cf can be used as a light source for quality control testing of SiPMs for nEXO with close to single SPAD resolution.



CAD model of optical rail system used for testing SiPMs for nEXO[2]. A VUV source, such as an **electroluminescent light** source or the ^{252}Cf source, can be focused to a beam and flashed onto an array of cooled-down SiPMs.

References

1. arXiv:1805.11142v2
2. Image credit: Xiao Shang

Acknowledgements

I acknowledge the revisions and contributions from Tsvetelin Totev, Soud Al Kharusi, Tianyang Yu, Thomas McElroy and my colleagues in the Brunner Neutrino Laboratory. Thank you to Professor Thomas Brunner for his support and guidance.