Near-Infrared Scintillation of Liquid Argon

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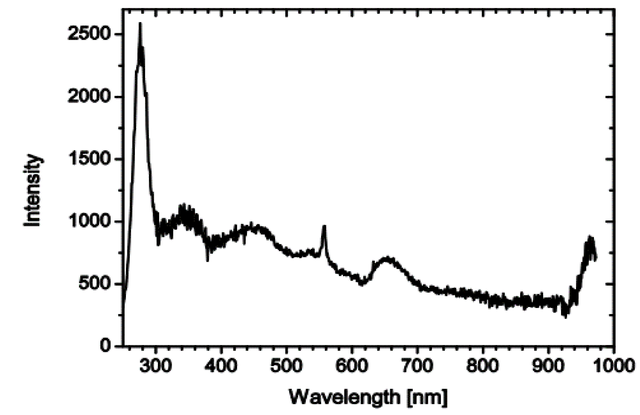
FERMILAB-POSTER-17-023-ND

August 2017

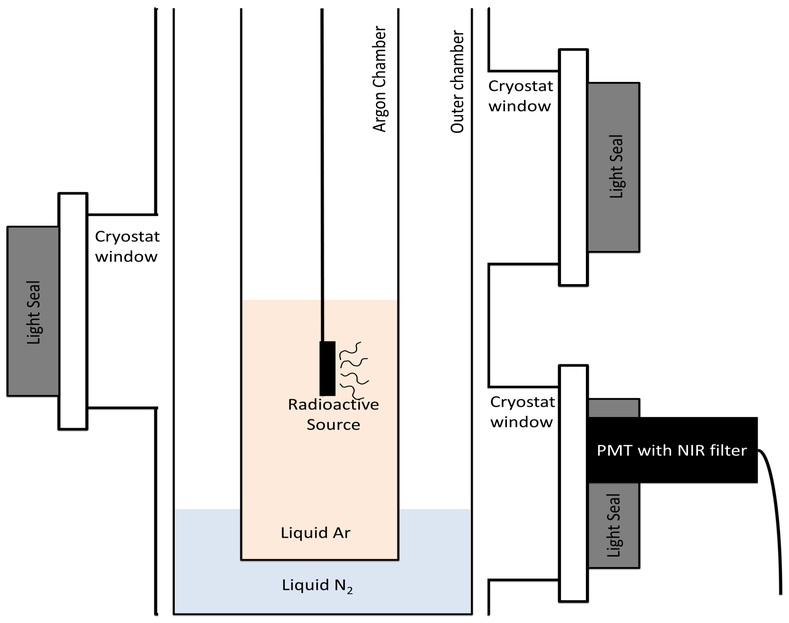
Background and Motivation

The scintillation of liquid argon in the vacuum ultraviolet (VUV) spectrum is well understood and used in a variety of experiments; however, this light is hard and expensive to detect, but recent research suggests that pure liquid argon may also scintillate in the near infrared (NIR) range. If that is the case, difficulties like wavelength shifters and Rayleigh scattering would no longer be problematic in large-scale liquid argon scintillation detectors. Previous groups have confirmed NIR scintillation in gaseous argon and have seen NIR absorption bands in all argon states [1]. The goal of this experiment is to test and eventually quantify the process of NIR scintillation in pure liquid argon.

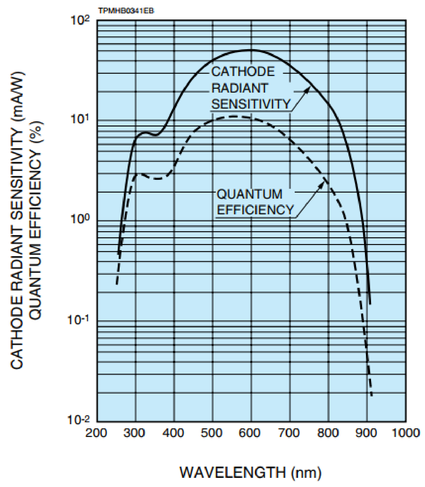


Emission Spectrum of Liquid Argon Taken by Heindl et al. [2]: The small peak in the mid-900 nm range is the contested region. The group who took this data considered it an artifact of their setup [3], but another group holds that it is, in fact, real [4].

The Experiment

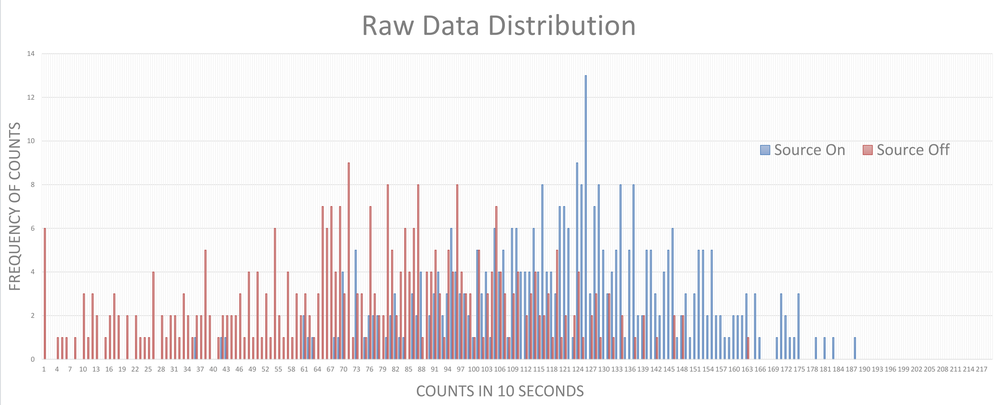


- LEDs with peak output at 850 nm were used to understand the PMT.
- Americium-241, a 5.4 MeV α-source, immersed in liquid argon (source on), excited and/or ionized the atoms so they could scintillate.
- Light with wavelength < 715 nm was filtered out.
- The number of times the photomultiplier tube (PMT) detected light over an interval of 10 seconds was counted.
- A computer recorded these counts over a period of several hours.
- The source was raised out of the liquid (source off) and the test was repeated.
- Because of the geometry of this setup, the acceptance of the PMT was approximately 0.6%.



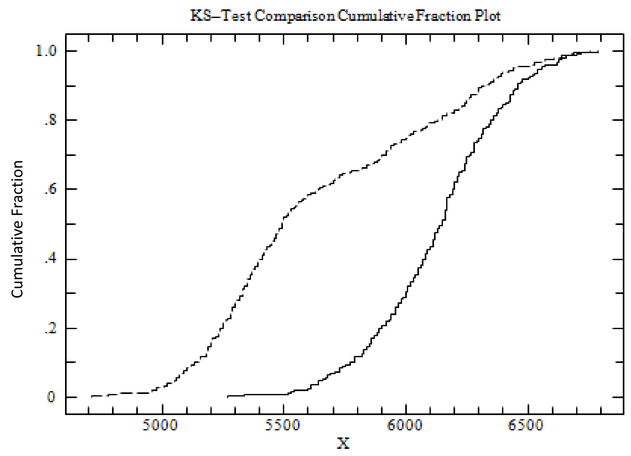
Cathode Radiant Sensitivity and Quantum Efficiency of the PMT used in this experiment as a function of wavelength (from catalog)

Preliminary Results



Source On		*Source Off*	
Mean	6126.225	Mean	5663.878
Standard Error	14.10994	Standard Error	17.91007
Median	6149.5	Median	5690.5
Mode	6166	Mode	5621
Standard Deviation	267.7172	Standard Deviation	339.8196
Sample Variance	71672.52	Sample Variance	115477.4
Kurtosis	0.009151	Kurtosis	-0.43984
Minimum	5274	Minimum	4842
Maximum	6790	Maximum	6543

- Compared distributions of source on and source off (above).
- Ran a Kolmogorov-Smirnov test on the two data sets.
  - Null hypothesis: The two sets come from the same physical process.
  - Dashed curve: source off
  - Solid curve: source on
  - D = 0.564 with P = 0.00, thus ruling out the null hypothesis.
- There are indications of a light signal which must be better understood. We also need to determine the source of the noise seen in the histogram above.



Future Work

The next step is to quantify and obtain a rough estimate of the amount of NIR light being emitted by the scintillating liquid argon. The ultimate goal is to use photodetectors with higher NIR sensitivity and improve the setup geometry to increase the acceptance.

References

[1] P. Lindblom and G. Solin, "Atomic Near-Infrared Noble Gas Scintillation I: Optical Spectra," Nucl. Instrum. Meth. **A 268** (1998) 204.

[2] T. Heindl et al., "The Scintillation of Liquid Argon," Europhys. Lett. 91 (2010) 62002 [arXiv:1511.07718].

[3] A. Neumeier et al., "Intense Infrared Scintillation of Liquid Ar-Xe Mixtures," Europhys. Lett. **106** (2014) 32001 [arXiv:1511.07722].

[4] A. Buzulutskov, A. Bondar and A. Grebenuk, "Infrared Scintillation Yield in Gaseous and Liquid Argon," Europhys. Lett. **94** (2011) 52001 [arXiv:1102.1825].

[5] T. Alexander et al., "Near-Infrared Scintillation of Liquid Argon," JINST **11 C03010** (2016) [arXiv:1603.02290].

Acknowledgments

- Ron Davis, William Miner, Christopher James, and Michael Jacobson for their help assembling the setup
- Katherine Cipriano, Frederick Schwartz, and Tyler Funk for their work on the cryogenics
- Paul Rubinov for his help and advice getting the setup to work
- Fermilab and the DOE for this opportunity and the funding
- My mentor, Carlos Escobar, for teaching and encouraging me and letting me help him in his research