Low Cost Detectors for Teaching Nuclear and Particle Physics

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Abstract. Rather a lot of attention has been given of late to inexpensive radiation detectors. Since most commercial systems cost hundreds to thousands of Euro, this is a very welcome and important development. However, there are some serious caveats to the assertion that one can build construct a performant system for under the magical price of €100. This talk will introduce some such detector systems and discuss how costs can be kept to a minimum. Finally, a few ideas for possible experiments using one such system will be described

1 Introduction

Many commercial systems are available for detecting radiation in educational settings. These are often, but not exclusively, based on Geiger-Möller (GM) tubes. Such detectors are typically read out either with a simple counter (a "black box" giving the number of counts in a user-chosen time interval) or via proprietary electronics and software. Niether of these invites the student to understand what is going on in the detector, how the pulses are generated, or how they are processed. With the advent of inexpensive and easy to use electronics made possible via the "maker movement" systems of much lower cost and much higher transparency have become available.

2 The market

There are now several vendors of "do it yourself" kits for building Geiger counters [1], muon telescopes [2], and kits purporting to be $100 dollar muon detectors[3]. We have used those just listed in quasi-independent student research projects performed by groups of first year physics majors. We will discuss the results of these projects and how well each of the sytems performed. One drawback to any system based on GM tubes is that it is not possible to measure an energy spectrum of the observed radiation. Thus, other techniques are needed.

3 A local solution

Inspired by the available kits, we have also developed a new inexpensive detector. This system is not, however, based on GM tubes, but rather on scintillator coupled to silicon photomultipliers (SiPM). The SiPM is then read out via a low cost commercially available digital oscilloscope. With an appropriate choice of scintillator (LYSO, in our case), it is possible to obtain gamma ray energy spectra. We will discuss details of how well these detectors work (energy resolution, time resolution, efficiency) as well as how they can be used in both introductory and advanced physics labs. We also note that these spectrometers are competitive in terms of performance with systems costing 10 to 20 times as much. Their ease of use, openness, and low cost make them ideal for teaching laboratories.

Acknowledgements

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References (Vancouver numeration and APA Style)

[1] https://www.adafruit.com/product/483 (27 February 2018) is one such sytem
[2] http://www.muonhunter.com (27 February 2108). A muon telescope kit can be bought via this informative web site
[3] Axani, S. N., Conrad, J. M. & Kirby, C. The desktop muon detector: A simple, physics-motivated machine- and electronics-shop project for university students. *Am. J. Phys.* **85,** 948–958 (2017).