The Do-It-Yourself Geiger-Muller (DIYgm): Practical Experience with Construction and Planned Technical Enhancements

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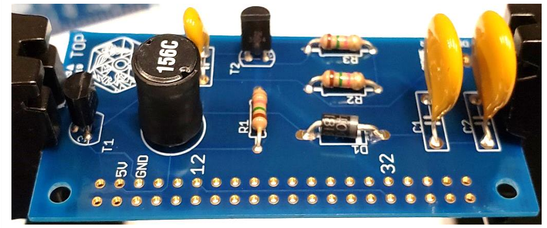
Abstract

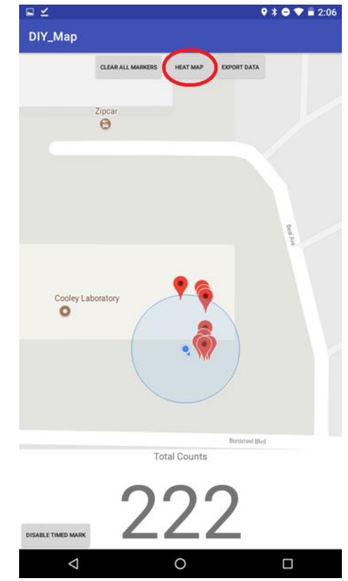
A simple circuit for a Geiger Muller (GM) radiation survey meter, coupled to a Raspberry Pi computer, was designed as an outreach project for the general public and high school students. Its construction from detailed instructions, which include soldering and the 3D printing of a case, was initially tested by undergraduate students with different majors. Demonstration and characterization of the systems were employed as parts of senior health physics, graduate medical physics, and graduate applied radiation measurements laboratory courses. Several alterations in the printed circuit board design resulted, namely increasing its size to render the hand-soldering process easier for inexperienced individuals, elimination of a physical switch, and power by an external rechargeable battery. The case printing instructions were adapted to include customization with the builder's initials and modifications for a different 3D printer. The software, a cellphone application, was enhanced to include improved mapping capability for both Android and iOS systems. While surplus US fallout shelter tubes are usable, GM tubes from the former Soviet Union were found to have the advantage of a lower operational voltage. An undergraduate team is currently focused on additional enhancements based upon continuously accumulating experience. Such work includes not only the reduction of the potential for small shocks, but the development software methods generally applicable to radiation survey instruments interfaced with computers. This ongoing research includes precision localization, feedback mechanisms for surveying speed and thoroughness, improved data display, and communications for pooling of information collected by multiple detectors (crowdsourced measurements). The overall system is further being modified for incorporation into a stationary radiation monitoring system also being designed for outreach.

DIYgm Smart Detector Construction and Operation



◄ *Fig. 1: Completed DIYgm circuit*

► *Fig. 2: Assembled DIYgm with casing made using a university provided 3D-printer. Symmetrical design of the two case parts simplifies production. Alligator clips were chosen for attaching GM tubes due to the versatility for studying different tube types.*



◄ *Fig. 3: DIYgm Android application displaying data through Google maps. Count rate is collected with GPS coordinates provided by the cellphone.*

Documentation/Manuals
- Assembly
- Software
- 3-D Printing
- Demonstrations
- Advanced Experiments
- Price List and Suppliers

DIYgm Learning Objectives: Fundamentals in Radiation Sciences

Electrical Engineering: Design, analysis, testing, operation and production
- Electrical components
- Electrical circuits
- Bread boards and printed circuit boards
- Manual and automated soldering
- Reuse/recycling/disposal of electronics
- Automated electronics assembly
- Powering devices

Computer Engineering: Software and hardware
- Embedded systems (Raspberry Pi)
- Cellphone applications
- Mapping, GPS, and display software

Nuclear Engineering: Radiation and radiation detection
- Radioactivity and decay
- Radiation interactions
- Radiation detector types
- Geiger counters
- Geiger counter characteristics

Radiation Protection (Health Physics)
- Environmental radiation (background)
- Naturally occurring radiation
- Radioactive consumer products
- Radiation risks
- Radiation surveys

DIYgm Testing

Circuits created and tested
- Undergraduate researcher team
- Health and medical physics courses
- Radiological measurements lab course

Most common documented failures
- Components soldered together
- Components raised too high to fit case

Experiments performed
- Voltage plateau and hysteresis effects
- Dead time using two-source method
- Shielding attenuation
- Inverse square law effects
- Solid angle measurements

Feedback
- Good experiment for students new to the subject material
- Case needs to be optimized further
- Graduate students desired more advanced labs

Future work
- Continue to improve detection system
- Compare DIYgm with other systems
- Perform signal analysis to better characterize electronic properties
- Continue to develop and improve manuals and educational materials
- Develop more advanced experiments that coincide with testing standards

Current Student Team

Tristan Blackledge, Long Kiu Chung, Calvin Huang, Andrew Kent, Kyle Liebler, Max Li, Gillian Mosher, Jordan Noey, Ismael Padilla-Rivera, Geric Pan, Samantha Romano, Braden Saltus, Marlee Trager

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Consortium for Monitoring, Technology, and Verification

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