

Modifications of Cosmic Watch Muon Detectors for Deployment at Letchworth State Park

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Background

For an American Physical Society funded physics outreach project, fifteen Cosmic Watch cosmic ray muon detectors, designed at MIT, are being assembled by students at Geneseo. Over the summer of 2020, ten detectors will be deployed within Letchworth State Park to educate park visitors about cosmic rays. After September, the detectors will be redeployed elsewhere.

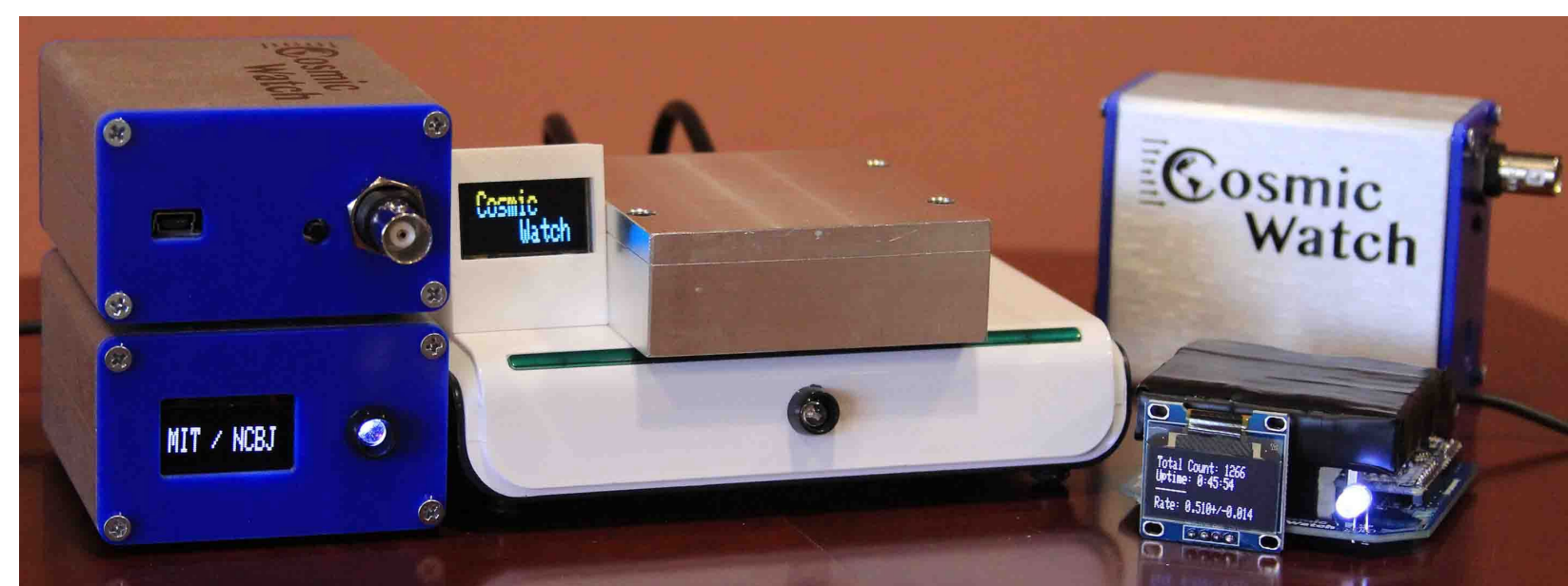


Image source: cosmicwatch.lns.mit.edu

Deployment

The Cosmic Watch detectors and power battery packs will be placed in weather-proof enclosures around the park.



Photos by Keith Walters

What is a Cosmic Ray Muon?

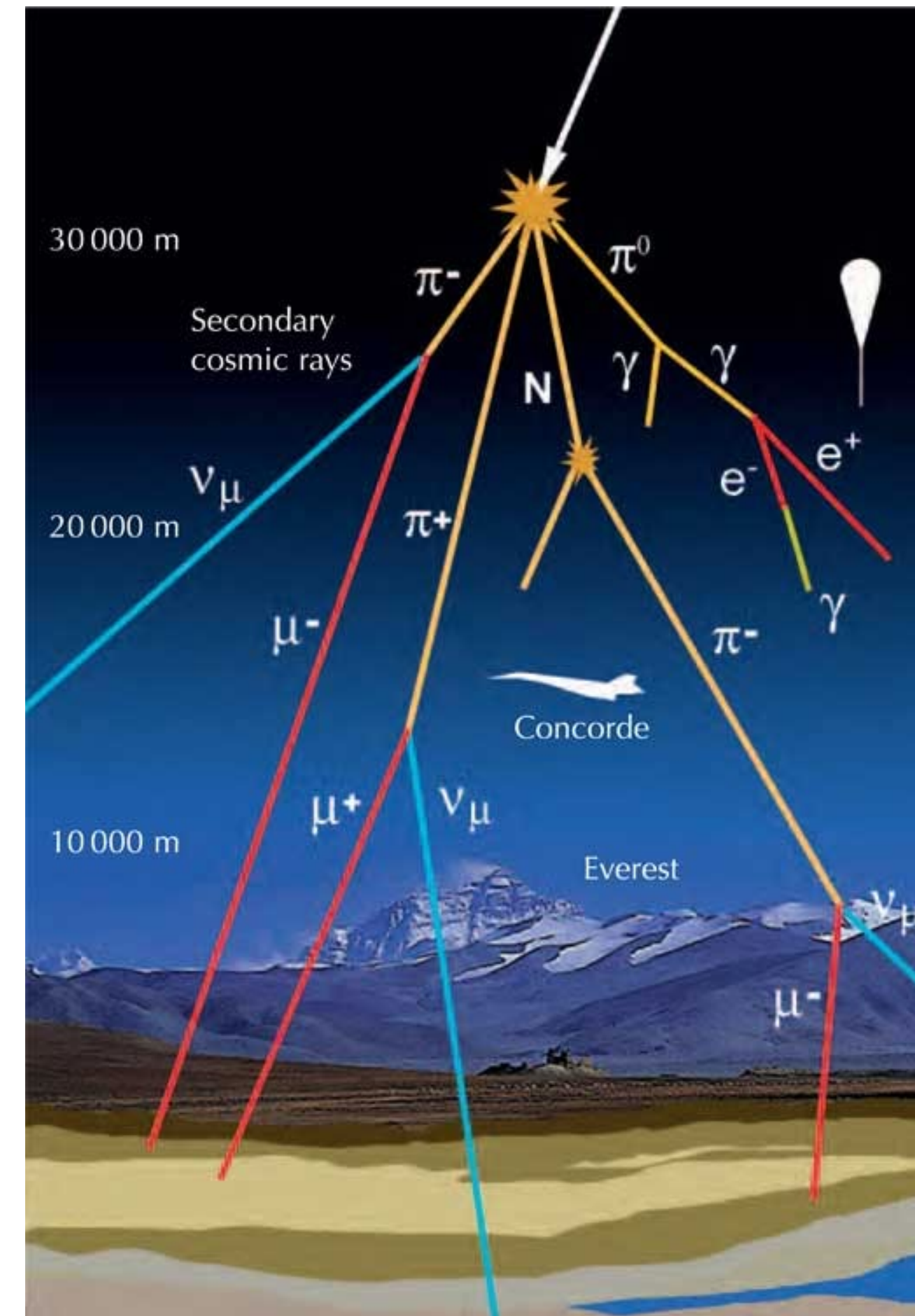


Image source: physicsopenlab.org

A muon is an unstable subatomic particle with the same charge as an electron, but with a mass about 207 times greater. Cosmic ray muons are created by interactions between cosmic rays and atoms in the Earth's upper atmosphere. Muons shower the surface of the Earth at relativistic speeds (99.98% of the speed of light). Extending your palm out flat, about two or three muons pass through your hand every second.

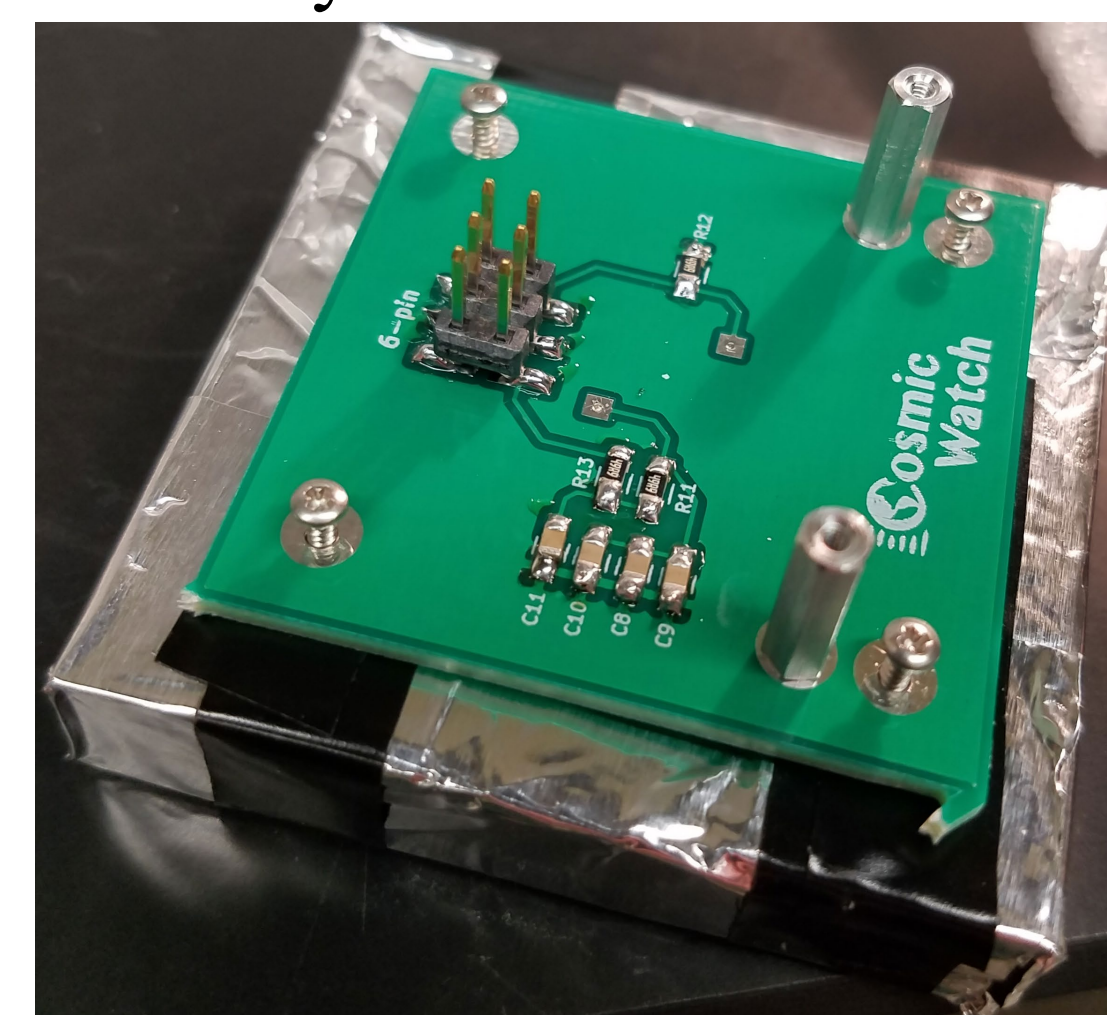
Muon detector arrays can be used to determine the direction of cosmic events such as supernovae. Muon detectors can also be used in computers as true random number generators.

Cosmic Watch Muon Detectors

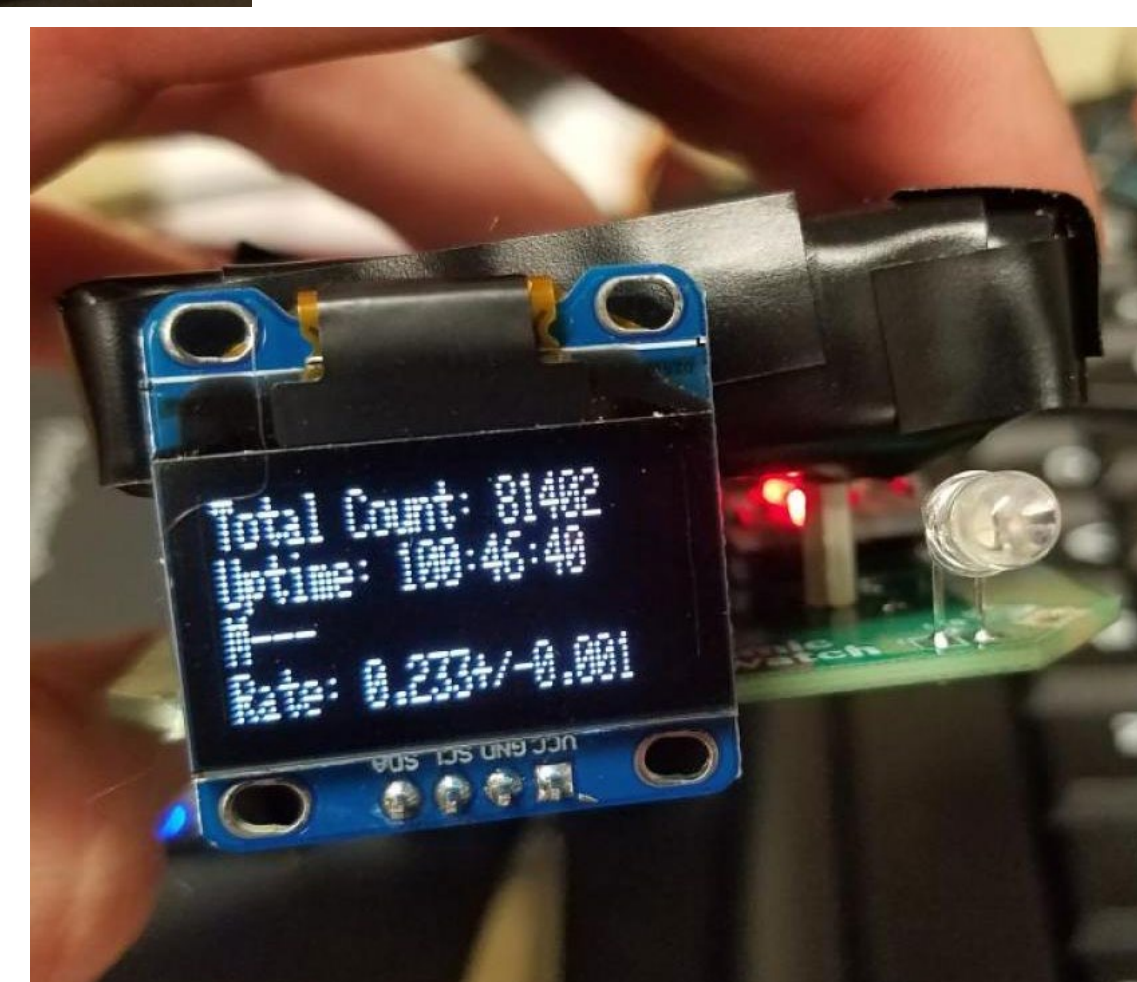
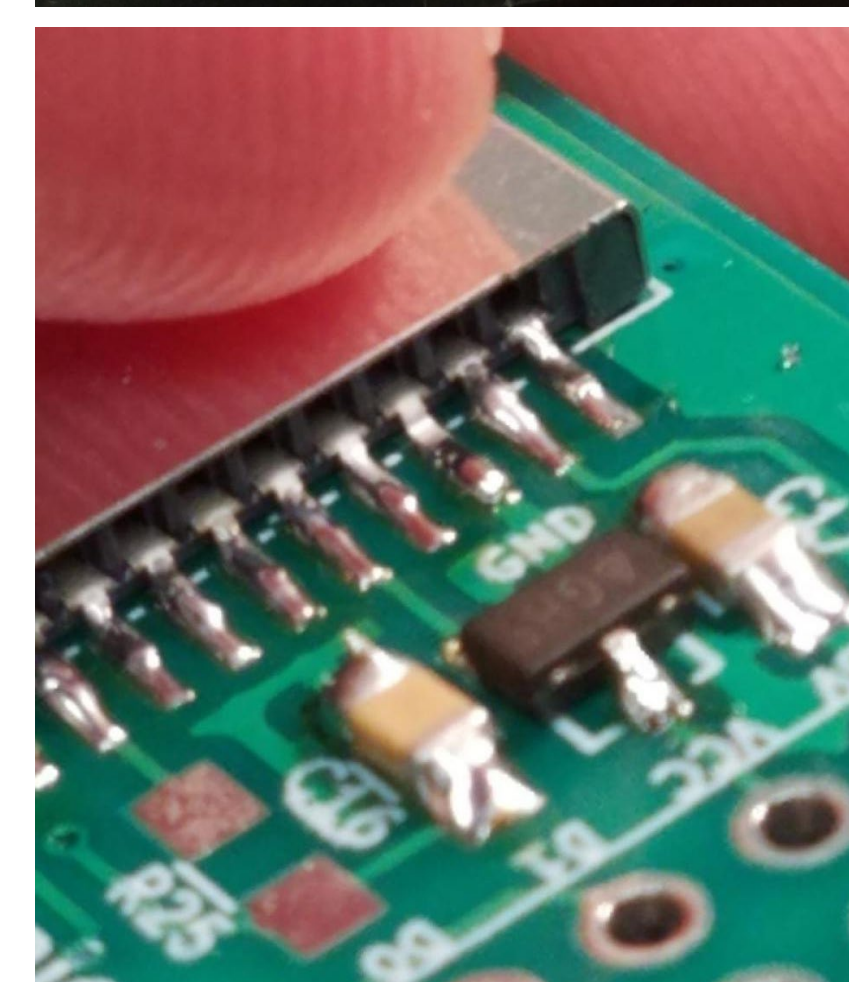


Photo by Keith Walters

Cosmic Watch Muon detectors, designed at MIT, are small, inexpensive DIY Muon detectors. The muon detection rate and cumulative count are displayed on a small OLED screen, with an LED flashing every time a muon passes through the detector's scintillator. Each incidence is also logged to a removable micro SD card.



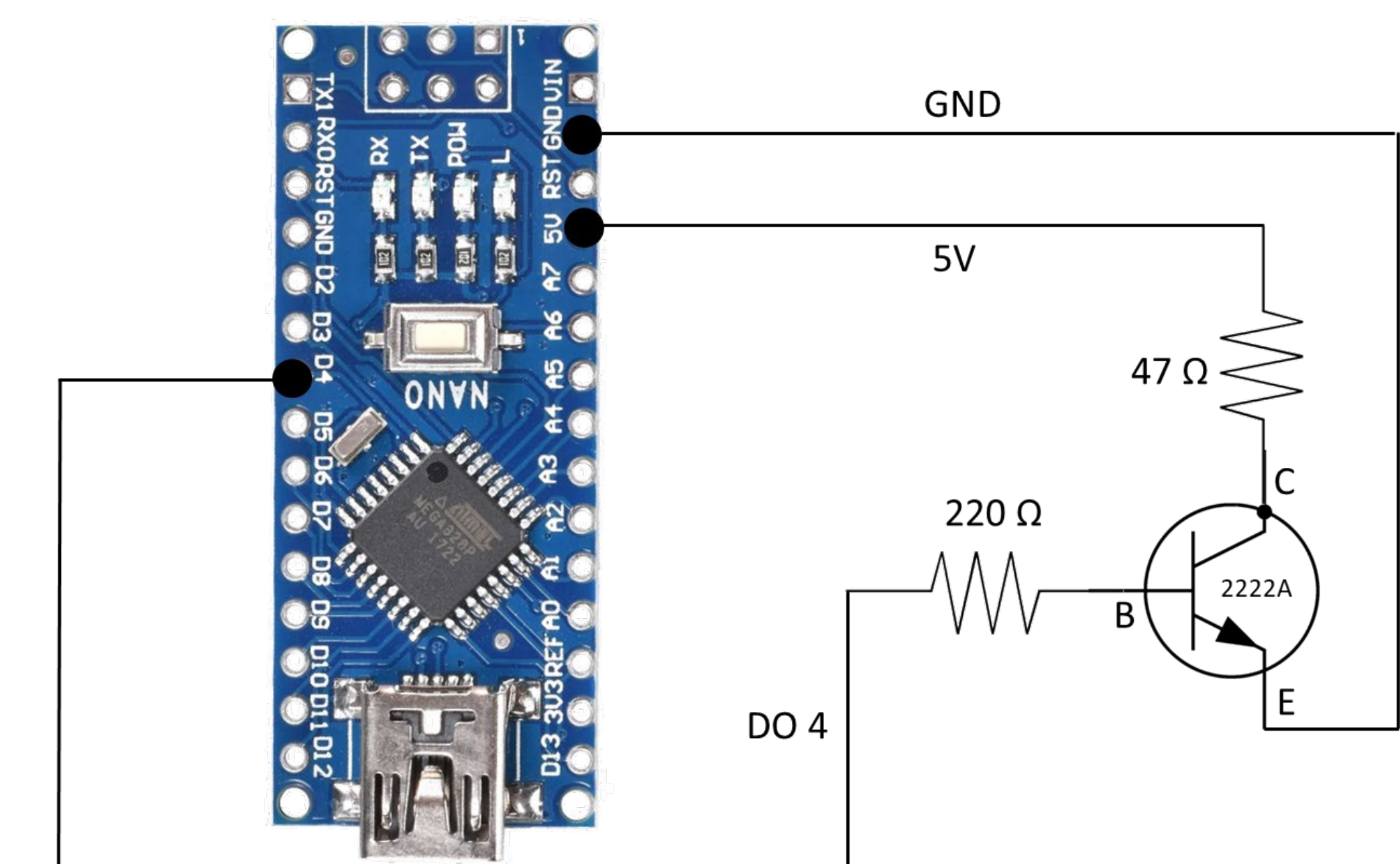
Muons enter a plastic *scintillator* (left), covered in aluminum foil and black electrical tape. Due to the scintillator's material properties, the high energy muons cause the plastic to scintillate/ luminesce. These photons are then detected by a silicon photo multiplier (SiPM) mounted to the scintillator. The main circuit board then filters the voltages from the SiPM to count only voltages corresponding to muon incidences.



A close-up of some of the soldering done for the SD shield (left) and the original OLED count display for the muon detector (right)

Modifications

To prepare the detectors for deployment in the outdoors, modifications have been made to the original Cosmic Watch design. Each detector will be powered by its own lithium-ion battery. However, the base power draw of the detector is below the threshold of most Li batteries, and this causes the battery to turn itself off. Detector hardware has been modified to generate repeated current pulses to keep the battery active. The modification consists on of a transistor and two resistors mounted to each detector to draw an extra 500 mW for less than 500 ms at approximately 12 second intervals.



Stay alive circuit. This simple software-controlled pulse circuit draws an extra 100 mA for a short period of time at irregular intervals.



A lithium-ion battery pack will be used to power the detector. Battery packs will be replaced along with the SD card weekly.

Since the official Cosmic Watch software doesn't allow for the OLED and SD card to work simultaneously, customized open-source software found on [GitHub](https://github.com) was used to accomplish this goal. The image below shows the new interface.



The OLED output display shows the total number of muon counts on the first line, the elapsed time on the second line, the detected SiPM voltage on the third line, and the rate of muons per second on the bottom line.

Funded in part by the American Physical Society Outreach Grant