TEACHERS AND RESEARCHERS EXPLORING AND COLLABORATING

PolarTREC STEM Experience Report

Eric Thuma

Antarctic Neutron Monitors For Solar Study

PolarTREC Expedition Page

https://www.polartrec.com/expeditions/antarctic-neutron-monitors-for-solar-study

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Janet Warburton and Judy Fahnestock
Education Project Managers
Arctic Research Consortium of the US (ARCUS)
3535 College Rd. Suite 101
Fairbanks, AK 99709
(907) 474-1600
info@polartrec.com
www.polartrec.com

The Science Explained

My experience at McMurdo Station involved the study of neutrons caused by cosmic radiation from the Sun. The Sun can be very active. Changes in the Sun's active surface can result in the ejection of high energy particles (from solar flares, coronal mass ejections, or related phenomena). Some of these particles can get sent toward the Earth. As they hit the atmosphere they can collide with the nuclei of atoms in they atmosphere. These collisions can cause the nuclei to break up. Neutrons are part of what comes out of such collisions. So studying such collisions can help us learn about solar activity. That is of great interest to astronomers but it can also have major consequences on the Earth. For example, the ionosphere is a region of the atmosphere that becomes ionized by cosmic rays. So greater amounts of cosmic radiation can cause changes in that layer. This can block GPS signals as they try to penetrate the atmosphere. It can also cause interference in the high frequency radio waves that travel through the ionosphere. Also, the charged particles that comprise cosmic rays can cause problems in the electronics. Whenever charged particles are moving near a conductor they can cause additional currents in the conductor. These currents can be bad for electronics (like the instruments in satellites or the avionics in airplanes). This can even cause problems in the electrical infrastructure. The small currents caused in your cell phone by cosmic rays are unlikely to be damaging but if the currents are forced into something of the scale of a power line it can be a problem, particularly because power lines are set up for an AC current but cosmic rays would produce something more like a direct current. For example, in 1989 the entire Canadian province of Quebec was blacked out as a result of a solar storm.

Air shower image in the Old CosRay Building. Photo by Eric Thuma.

Cosmic radiation can also possibly have health effects. Normally at ground level this is a very small risk because we are protected by the atmosphere. Even when traveling in an airplane it is probably not a major concern because there is still some shielding happening and the time spent in the air is small. But it is something aviation professionals should keep informed about. It is particularly important to study cosmic rays at the poles because the levels of cosmic radiation are higher near the Earth’s poles because particles can become trapped in the Earth’s magnetic field and follow the field to the poles. This is becoming an area of even greater interest because in recent years more and more flights are going over the North Pole and other arctic regions. Furthermore, the distribution of cosmic rays on the surface of the Earth is not uniform. So we want to study cosmic rays in a number of locations if we want to understand them. There are many facilities over the globe that study cosmic rays. However, the locations near the poles are particularly important because charged particles coming from the sun can be deflected toward poles by the Earth's magnetic field. So Antarctica is the perfect place to study them. This is one of the reasons why the neutron monitors are the longest continuously running scientific experiment on the continent of Antarctica. This gives you some idea of the variety of scientific disciplines that take place at the poles. Many people would easily guess that there is a lot of exciting climate science or biological studies taking place at the poles. But there is some important physics and cutting edge astronomy happening there too.

Neutron Monitors in Cross Section. Photo by Eric Thuma

So the detection of neutrons at the surface of the Earth, particularly near the Earth's poles is very important. But detecting neutrons can be tricky. They don't have an electrical charge. Detecting charged particles is easy. You can fill a tube with a gas, expose it to a high voltage, and ground the outside. Any charged particle entering the gas will want to go either to the charge or the ground. That creates a current which you can measure. However, we can't do that with neutrons. However, there is an isotope of Boron that is particularly good at absorbing neutrons (Boron 10). When Boron 10 absorbs a neutron it breaks up. Specifically, it breaks up into Lithium 7 and Helium. When produced, both of those will have enough energy to ionize some gas in the detector thus creating detectable charge.

The Field Experience

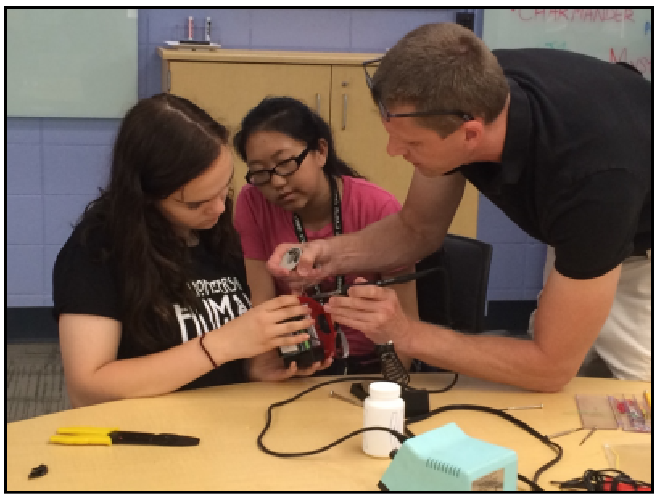
During my PolarTREC expedition I worked with Dr. Jim Madsen from the University of Wisconsin River Falls on the CosRay Neutron Monitors that are used at McMurdo Station to study cosmic radiation. The neutron monitors were to be shipped to the South Korean Jang Bogo Station. This required the disassembly of the NM64 monitors. This entailed removing them from the housing, removing polyethylene shielding, removing and repairing Boron Triflouride tubes, and transferring over 20 tons of lead to shipping containers. The IGY neutron monitor was also broken down for shipment to UWRF. The CosRay building was then shut down. By photographically documenting the process I was provided with a valuable resource in presenting topics in nuclear physics. No diagram or explanation could possibly be as valuable in explaining neutron detection

as those photos. After the neutron monitors were prepared for shipping Dr. Madsen and the remainder of the team went on to South Pole Station and I remained behind in McMurdo. This provided me with a valuable opportunity to arrange for some impromptu outreach and work with other scientists. I had the opportunity to visit the McMurdo Ice Shelf with Dr. Doug MacAyeal. This was very illustrative and provided me with valuable field experience.

Transition Zone to the McMurdo Ice Sheet. Photo by Dr. Doug MacAyeal.

Bringing it Back to the Classroom and Community

I look forward to sharing this experience with my students, friends, and colleagues. My students have benefitted already by gaining an appreciation of the breadth of polar science and well as gaining exposure to the details of Antarctic travel. This has been no small source of inspiration for them. As a practical matter, the experience has lead me to redesign my unit on nuclear physics and develop new lessons in conjunction with the staff of the University of Wisconsin, River Falls. I am also in the process of developing a presentation and new lessons in nuclear physics with the staff of Michigan State University. Furthermore, my students were able to mirror my research through a cosmic ray detector located at my school. My experience with the Neutron Monitors served as an excellent motivation for this student research. I will be sharing training experience and other information with teachers within my district during professional development meetings and with teachers outside of the district during meetings of professional organizations. The experience has made me a valuable resource on nuclear physics as well as polar science. I fully intend to make the most of this role and disseminate the details of my experience to students, educational professionals, and the public at large.



Eric Thuma helps two Upward Bound students with their robot. Photo by Kate Miller.