Photo courtesy of Joe Willie

The solar flare problem

How does a high school in upstate New York become a hot spot for monitoring the correlation between cosmic rays and solar flares?

The story goes back to a flier from the University of Rochester about an outreach program called QuarkNet in the spring of 2000. It announced a three-week summer institute for high school science teachers that involved building a muon telescope for classroom use. The idea immediately appealed to me.

That summer, I learned that a muon is a heavier, unstable version of the electron. I also discovered that a muon telescope bears only a faint resemblance to an optical telescope; instead of light, the instrument detects high-speed charged particles (mainly muons) hitting the Earth from space.

When I returned to Naples High School that fall, my physics students and I began to use my paddle-shaped telescope to "map the sky." Using a device I built, dubbed the "Willie Wheel" by another teacher, we pointed the muon telescope at numerous points in the sky and recorded cosmic rays. We found, for example, that fewer muons strike the ground on cloudy days than on sunny days.

I challenged my students to propose and test their own hypotheses. They signed up for "detector time" and ran their own experiments, discovering connections between cosmic-ray muon rates and barometric pressure, geomagnetic activity, and time of day.

I moved to Pittsford Mendon High School in 2002. To conduct long-term studies of cosmic rays, my new students and I placed a detector in my classroom and programmed it to measure muon rates every hour. Once a month, I would download the data and my students and I would analyze it.

In October 2003, scientists reported large solar flares, known for disrupting telecommunications. Ken Cecire, Education Specialist and QuarkNet staff teacher from Hampton University, forwarded to all QuarkNet teachers an email in which people were speculating what the effect of solar activity would be on cosmic-ray rates. He asked if anyone in the QuarkNet community, which includes hundreds of schools in several countries, had operated a muon detector at the time of the flares.

Within days my students and I were sending graphs of our data to schools around the world. Our data showed a dramatic decrease in muon rates following a flare that my students dubbed the "Halloween Solar Storm;" I realized that the Mendon Muon Research program had become a significant resource for cosmic-ray studies.

My students presented their results to my QuarkNet mentor, Kevin McFarland, physics professor at the University of Rochester and director of the Physicists And Rochester Teachers Inventing Classroom Experiments (PARTICLE) program. Each spring, the university hosts a PARTICLE conference. Impressed by our results, McFarland encouraged us to build a larger muon detector using material that he could obtain from an old Fermilab experiment.

The following year, two of my students collaborated with a group of other students and high school teachers to build this new detector, the "mother of all paddles." One student, Jeff Melville, took charge of the data acquisition programming for the new detector, frequently calling engineers at Fermilab to figure out how to process such a huge stream of data. In the fall of 2004, the detector began operation. Because of a 100-fold increase in our detection capability, our automated system now posts muon rates on the Internet every five minutes.

My greatest satisfaction is to see my students experience the thrills and agonies of doing real research in a way that traditional high school labs, using "cookbook" instructions and close-ended goals, never can. I feel our project demystifies modern scientific research and provides students with skills and insights that will help them meet the challenges of an increasingly complex, technological world.

I am thrilled that my students and I have made significant contributions to cosmic ray research, and I'm looking forward to our next discovery.

Joe Willie

Joe Willie teaches physics at Pittsford Mendon High School. When not chasing cosmic rays, he can be found skiing down Bristol Mountain or tending to his garden, which he notes is also affected by the highly variable weather in upstate New York. Information on PARTICLE, the University of Rochester program affiliated with QuarkNet, is at www.pas.rochester.edu/particle/. QuarkNet is funded by the National Science Foundation and the Office of Science of the Department of Energy.