High Schools JOIN THE SEARCH for MOST ENERGETIC Particles in the Universe

by Greg Snow
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Photo by Michael Brands

Before taking off in a balloon at Snowmass last summer, Heather Zorn (left), Greg Snow, Jeffrey Wilkes and Hans Berns compare notes and repair instrumentation with state-of-the-art duct tape.

They were looking for extra-terrestrials, and they weren't going to quit just because the clock said 5:00 p.m. on a beautiful summer afternoon in the Rocky Mountains.

These high school teachers and students had been working for hours, assembling their scintillation detectors, checking them for light leaks with flashlights and oscilloscopes, and calibrating them for the appropriate discriminator thresholds. They weren't expecting a phone call from ET, or "Contact" with Jodie Foster, but they were on the verge of making their first observation of a bona fide, real-life extraterrestrial—a high-energy cosmic ray that had traveled to earth from a distant galaxy.

The scene was Snowmass, Colorado last July 19. The gathering was the week-long workshop to inaugurate SALTA, the Snowmass Area Large-scale Time-coincidence Array. The SALTA workshop was one ingredient in the Education and Outreach project, organized by Elizabeth Simmons of Boston University, associated with the 2001 Summer Study on the Future of High Energy Physics.

The workshop's goal was to plant seeds in Colorado and Illinois, hoping the seeds will grow into full-scale members of the North American Large-scale Time-coincidence Array—a continent-wide consortium of partnerships between university physics departments and nearby high schools to study extensive cosmic-ray air showers, an exciting subfield of frontier astro-particle physics research.

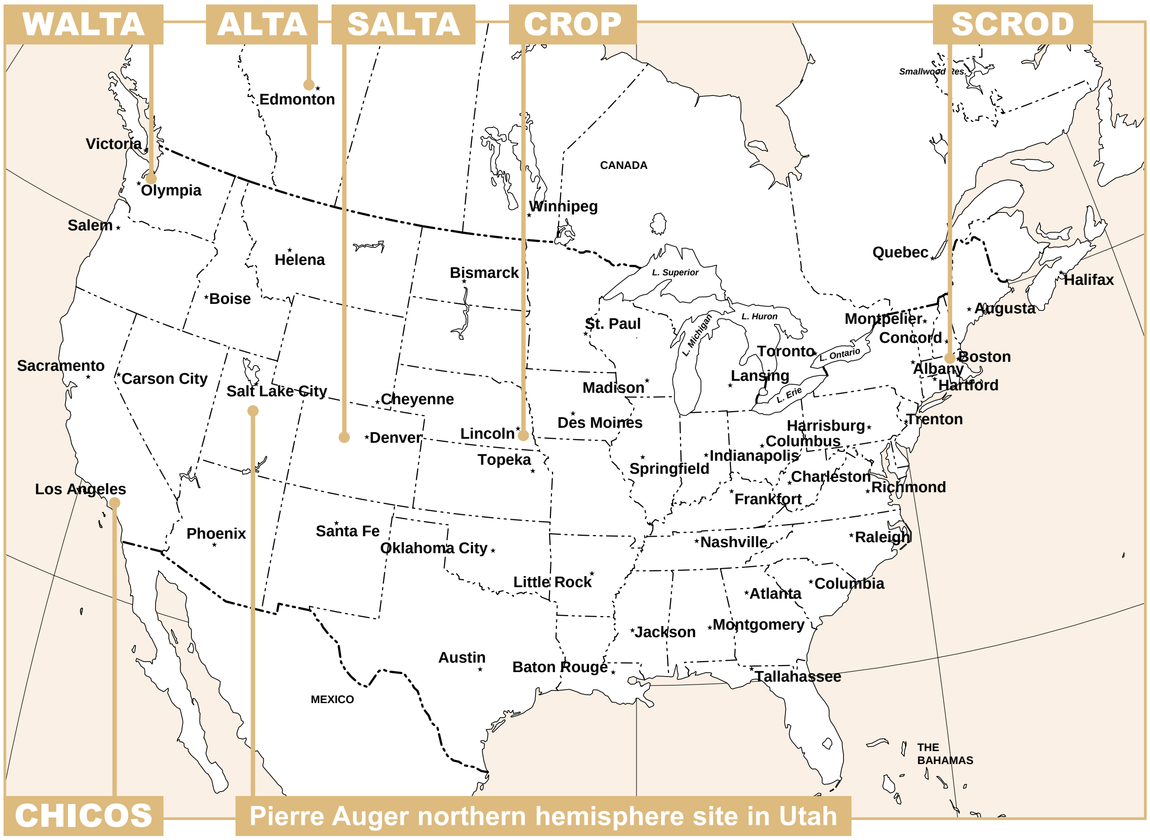
The origin and acceleration mechanism for ultra high energy cosmic rays are unknown, but they clearly must come from a catastrophic astrophysical phenomenon, such as an active galactic nucleus or the collision of two remote galaxies. It is possible that when one UHECR strikes the earth, it is accompanied by a burst of such particles that could shower an entire continent. We can only see them with detectors distributed over very large distances, all operating simultaneously with GPS time-stamping of their recorded events—exactly as the NALTA arrays will operate. But even if we do not observe such fantastic bursts, we can at least set a limit on the frequency of their occurrence—a legitimate and important scientific result.

Greg Snow is a physicist on DZero and the Pierre Auger Observatory, and a member of Fermilab's Board of Overseers. He runs the Cosmic Ray Observatory Project in Nebraska with colleague Daniel Claes.

On the Web

North American Large-scale Time-coincidence Array, with links to each regional project home page

http://csr.phys.ualberta.ca/nalta/



NALTA– North American Large-scale Time-coincidence Array

WALTA (WAshington Large area Time coincidence Array), University of Washington, Seattle, WA, USA.
ALTA (Alberta Large area Time coincidence Array), University of Alberta, Edmonton Alberta, Canada.
SALTA (Snowmass Area Large-scale Time coincidence Array), detectors installed in high schools in the Roaring Fork Valley area of Colorado.
CROP (the Cosmic Ray Observatory Project), University of Nebraska, Lincoln, NE, USA.
SCROD (School Cosmic Ray Outreach Detector), Northeastern University, Boston, MA, USA
CHICOS (California HIgh school Cosmic ray ObServatory), Caltech, UC/Irvine and Cal State/Northridge, California, USA.

A major NALTA goal is the education and recruitment of young scientists. Nebraska's Cosmic Ray Observatory Project has demonstrated the success of partnering universities with high school teachers and students—a few of the participants from CROP's first year in 2000 have decided to attend the University of Nebraska and major in physics, based on their summer and academic-year experiences working alongside university researchers.

The SALTA workshop in Snowmass brought together four high school teams from Colorado (Aspen, Basalt, Carbondale, Leadville) and one from Illinois (Wheaton North). A team consisted of a physics teacher plus three or four students with at least one year remaining before graduation. After bringing their equipment back home, the school teams embark on a series of experiments to exercise their detectors and practice making measurements in which statistical errors must be understood. For example, a vertical stack of detectors can be used to measure the small decrease of cosmic-ray rate with increasing barometric pressure. The higher the barometric pressure, the greater the density of the atmosphere between the earth and outer space, which means more cosmic rays are absorbed before reaching the earth's surface.

On this particular afternoon in Snowmass, the five high school teams were competing to see who could get their cosmic-ray telescope set up first, to start counting the coincidences signaling the passage of cosmic-ray muons through all four of their detectors. Tables, chairs, and cardboard boxes were gathered to create supports to stack the 2x2-foot scintillator panels on top of each other. Signal cables were connected to discriminators, and discriminator outputs were connected to logic units which were set to register "four-fold" coincidences of detector signals. Visual scalers, previously set to zero, started racking up counts.

MOST ENERGETIC
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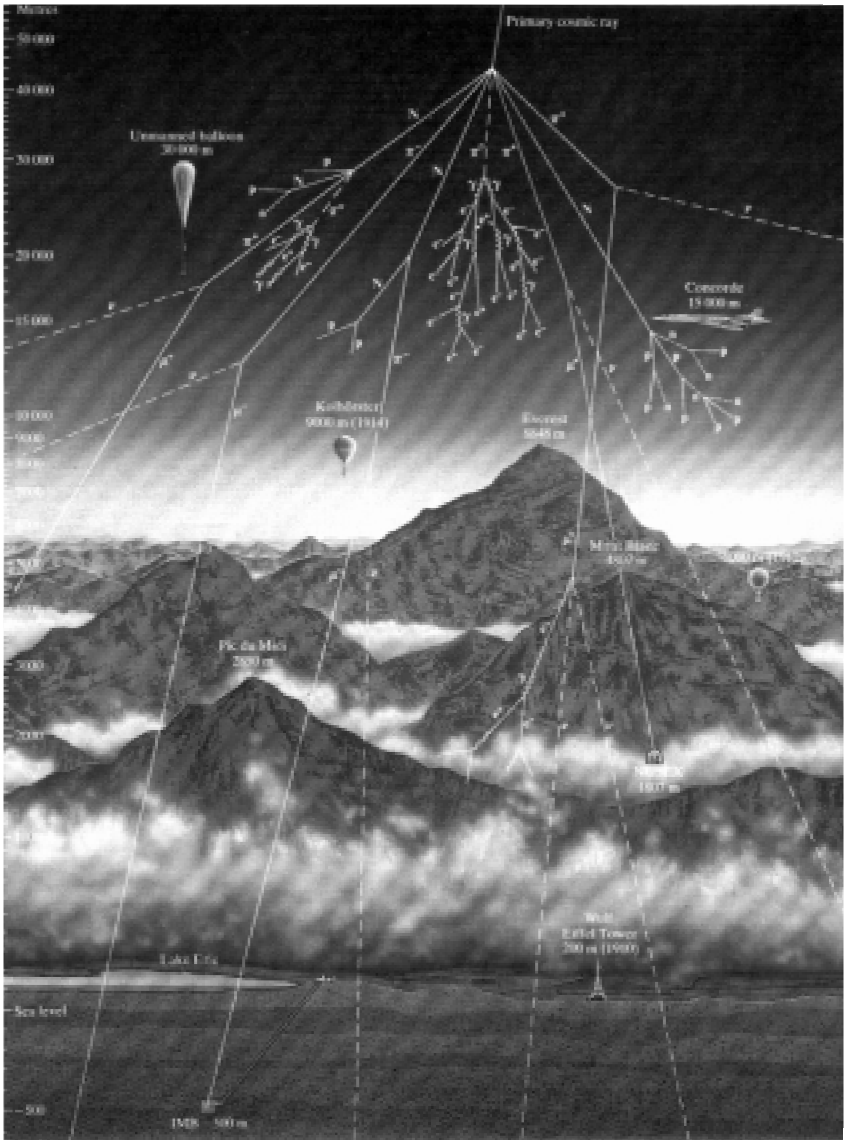


Development of Giant Cosmic Ray Shower in Earth's Atmosphere

The earth is constantly bombarded by subatomic particles from space. The energy spectrum of these particles reaches far higher than any terrestrial accelerator could hope to probe. When these high-energy cosmic rays reach earth, they interact with the atoms making up the earth's atmosphere. These high-energy interactions create an immense shower of particles, traveling in a cone centered on the direction that the original cosmic ray particle was traveling. At the highest energies, a single shower can be detected at the earth's surface over an area on the order of 100 square kilometers. If groups of cosmic rays to reach the, earth, the effective detection area of these multiple showers can be much greater. (Courtesy of NALTA)

"We're up and running!" declared Michelle Ernzen, a physics teacher from Lake County High School in Leadville, Colorado—the highest-elevation school in the United States.

Minutes later, Eric Livergood, an 11th grader from Wheaton North High School near Fermilab (elevation: about 600 feet above sea level), checked the scaler hooked to his school's detectors.

"Look!" Livergood exclaimed. "One ... two ... now five counts!"

Soon, all five detector stacks were counting cosmic rays. Kids and teachers stood back, took a breath, and slowly started comparing the counting rates measured by the different detector sets.

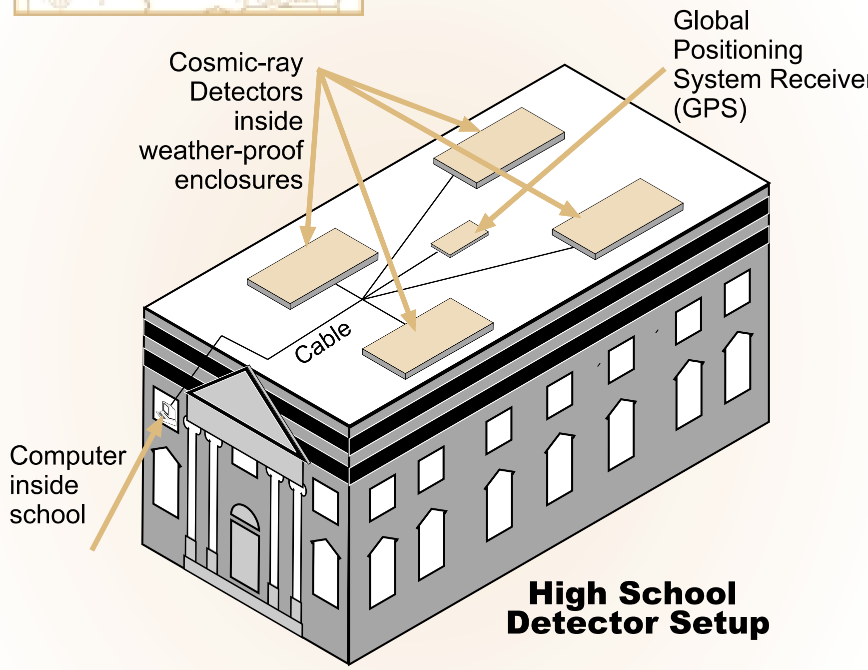
Heather Zorn, a physics graduate student from the University of Washington in Seattle, stood in the corner, quietly observing the flurry of activity. Then she sprang into action.

"Why don't we connect the five telescopes together," she said, "I mean count the coincidence of coincidences—then we'll have an extensive air shower array."

Signal cables were hastily strung from telescope to telescope, connected to a central logic unit and visual scaler, and the array of detectors started registering the passage of many particles through the room at the same time, the signature of a giant air shower initiated in the earth's atmosphere by a high-energy cosmic ray. But the event rate seemed much higher than what we observe at schools in Lincoln, Nebraska.

"Of course," Heather said. "The elevation is over 8,000 feet here in Snowmass—Lincoln is much closer to sea level."

Heather had demonstrated this same effect the previous weekend, when she participated in a reenactment of the famous 1912 balloon flight of Austrian physicist Victor Hess, who first measured the increase of the cosmic ray flux with altitude ("Balloon Flight Launches Cosmic Ray Education Project," *FERMINEWS*, vol. 24, no. 12, July 27, 2001).



NALTA Photo

SALTA students gluing photomultiplier tubes to scintillator panels at the Snowmass workshop.

The high school teams work from a more stable platform, mounting their weatherproof detectors on the school rooftop when they return with their apparatus. By spreading the detectors several meters apart in a horizontal plane, they create an array sensitive to extensive air showers. Several schools operating their own arrays a few miles apart, and synchronizing their data with a Global Positioning System (GPS) time stamp, can observe observe air showers created by the highest-energy primary cosmic rays known to man. Such cosmic particles (mainly protons, and the nuclei of light atoms) are hundreds of millions of times more energetic than the protons accelerated at Fermilab's Tevatron, and the air showers they create can spray billions of particles simultaneously over an entire city.

Physicists based in Aspen serve as local mentors for the SALTA schools in Colorado. Members of Fermilab's Graduate Student Association play the same role in Illinois, with Wheaton North a possible future hub for similar efforts near Fermilab. And within a year, the SALTA schools will use the World Wide Web to share their data and experiences with teachers and students in the other NALTA locations—just as physicists do in national and international collaborations.

SALTA is indebted to several several benefactors: a grant from an anonymous donor, the donation of a huge number of scintillation counters and photomultiplier tubes previously used by the Chicago Air Shower Array (CASA) in Utah, the long-term loan of electronic modules and oscilloscopes from Fermilab, and the participation of NALTA member physicists from the University of Alberta, Montana State University, University of Nebraska, and University of Washington. The NALTA physicists divided the Snowmass workshop days between classroom sessions and laboratory sessions, learning the physics of cosmic rays and particle detectors, then refurbishing and operating the recovered CASA detectors.

The equipment for these distributed cosmic-ray detectors might be second-hand, but there is no questioning their capability to perform "real science." High-school based detectors will not compete with measurements made by large-scale cosmic-ray experiments such as AGASA in Japan, HiRes in Utah, and the Pierre Auger Observatory in Argentina. But the NALTA arrays can make a unique contribution—and perhaps produce publishable physics results.

The excited voices of high school students at Snowmass, describing their first experiences with extraterrestrials, told us our field has a receptive audience and an energetic future. Stay tuned for news on our progress, and keep an eye out for cosmic ray researchers at a high school near you.