ASTROPHYSICS

"Little" Cosmic Ray Observatory Aims to Make a Big Mark

In a field in which bigger is usually better, what can you hope to achieve with a new experiment that's only a quarter as large as its well-established rival? Plenty, say 117 physicists mainly from Japan and the United States who have just started taking data with a cosmic ray observatory that covers 730 square kilometers of western Utah.

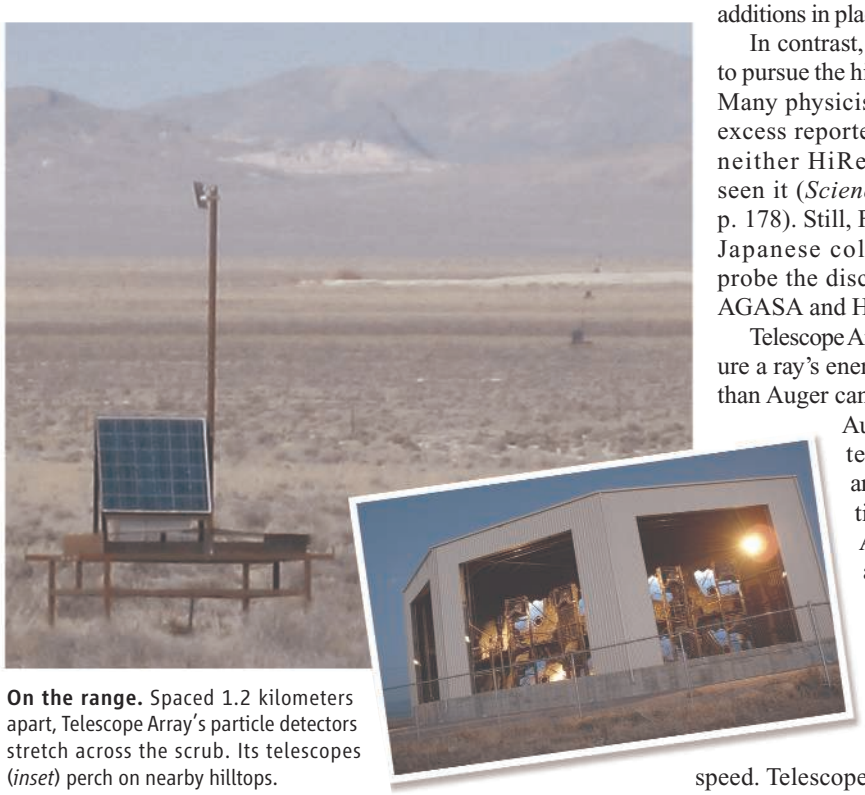
Dubbed Telescope Array, the observatory aims to spot the most energetic subatomic particles from space. Such ultrahigh-energy cosmic rays pack as much energy as a golf ball hitting a fairway, and they strike Earth at a rate of 1 per century per square kilometer. Interest in them grew 10 years ago, when Japanese physicists reported an odd excess of the highest energy rays. It surged last year, when the gargantuan Pierre Auger Observatory in Argentina traced the rays to certain galaxies (*Science*, 9 November 2007, p. 896).

Telescope Array aims to test the Auger result and to decipher the nature of the rays. It enters the fray as an underdog: Although it's bigger than the city of Chicago, it's only a quarter the size of Auger, which has been taking data since 2004. But team members say Telescope Array has key technological advantages, and others say it may be better for pursuing certain questions. "This is a very important experiment," says Veniamin Berezinsky, a theorist at Gran Sasso National Laboratory in Assergi, Italy.

The Telescope Array collaboration formed when two rival groups merged. Physicists measure the energies of cosmic rays in exa–electron volts, and in 1998, researchers with the Akeno Giant Air Shower Array (AGASA) near Tokyo reported seven rays with energies above 100 EeV. By 2002, they saw 11. That was about 10 times more than expected; if the rays were protons, then on average, interactions with the cosmic microwave background should have sapped their energy to 60 EeV before they had traveled 200 light-years.

Some theorists took the excess as evidence that the rays were born in decays of exotic particles lingering nearby. But physicists with the High Resolution Fly's Eye (HiRes) detector in Dugway, Utah, argued that there was no excess: They saw only two such rays. The HiRes and AGASA groups studied the rays using different techniques, however. So to resolve the discrepancy, they eventually decided to build an array that would use both.

When a cosmic ray strikes the atmosphere, it sets off an avalanche of particles called an extensive air shower. AGASA sampled the shower using 111 particle detectors spread over 100 square kilometers. The shower also causes the air to fluoresce, and HiRes studied that light using twin batteries of telescopes. Telescope Array comprises 503 particle detectors and 38 telescopes in three batteries.



On the range. Spaced 1.2 kilometers apart, Telescope Array's particle detectors stretch across the scrub. Its telescopes (*inset*) perch on nearby hilltops.

Japan put up $13 million for the $16 million array, but researchers never considered constructing it there. "Building a fluorescence detector in Japan is impossible," says Masaki Fukushima of the University of Tokyo. "Because of the humidity, the transparency of the air is very limited." The project got its inapposite name because the Japanese had previously proposed an array of 10 telescopes with no particle detectors. "Once you propose something you don't change the name, because no one will know what you're talking about," says Pierre Sokolsky of the University of Utah, Salt Lake City. "So even though it makes no sense, the name stuck."

Because it's bigger, Auger will see more of the rare rays above 60 EeV. So Sokolsky plans to focus on lower energies and especially on a kink in the spectrum of rays near 4 EeV that might mark the point at which rays from within our galaxy peter out and those from beyond take over. The team has proposed a "low-energy extension" of 100 more-tightly-spaced detectors and two more telescope stations to measure showers with between 0.03 EeV and 10 EeV. "For this, the Telescope Array and especially the low-energy extension is an excellent instrument," Gran Sasso's Berezinsky says. Auger should have similar additions in place in 2009.

In contrast, Fukushima hopes to pursue the highest energy rays. Many physicists now doubt the excess reported by AGASA, as neither HiRes nor Auger has seen it (*Science*, 13 July 2007, p. 178). Still, Fukushima and his Japanese colleagues hope to probe the discrepancy between AGASA and HiRes.

Telescope Array will also measure a ray's energy more precisely than Auger can, Fukushima says. Auger comprises four telescope batteries and nearly 1500 particle detectors. But Auger's detectors are of tanks of water, which produces light called Cherenkov radiation when a particle zips through it at near-light speed. Telescope Array's detectors are sheets of plastic scintillator that emit light through another mechanism. "Definitely we are measuring the cosmic rays in a different way and with better energy resolution," Fukushima says.

Ultimately, Auger and Telescope Array may be forced to work together. The Telescope Array team hopes someday to expand its observatory, and the Auger team plans to build a far-bigger array in Colorado in a few years. The two arrays could end up being combined, Sokolsky says. "Whatever we scientists might think about it, that's going to be imposed on us by the funding agencies," he predicts. For now, however, the competition is on. **–ADRIAN CHO**

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