Capturing More Gamma Rays

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Stefan Funk wants to improve ground-based gamma ray imaging systems. Today's best instruments have their limits, Funk noted, and newer, more sensitive equipment is required to enter the next stage of astrophysical research. A physicist with the joint SLAC/Stanford Kavli Institute for Particle Astrophysics and Cosmology, Funk received funding for a Laboratory Directed Research and Development project to develop components capable of boosting gamma ray telescope speed and precision while keeping costs down.

Each year, the lab director sets aside a maximum of eight percent of the lab budget for LDRD projects to encourage innovative research and development.

"LDRD money is a great tool to do this kind of work," Funk said. LDRD funding goes exclusively to new projects, rather than established research programs, allowing scientists to explore special projects and innovative ideas.

Funk and his collaborators from the Advanced Gamma-ray Imaging System have a handful of objectives for the next generation of gamma ray telescopes. Among others, they want to explore the origins of cosmic rays and to uncover signals of dark matter in gamma rays.

Dark matter is a mystery substance; it does not emit light, and so cannot be seen, even by the finest telescopes. Scientists know it exists because of its gravitational pull on other objects in space. Physicists believe it is possible that dark matter particles annihilate, or disappear into a flash of energy, leaving behind bursts of gamma rays. Funk points out that if this idea is correct, then it would be possible for gamma ray telescopes to detect the traces of this annihilated dark matter.

Cosmic rays, on the other hand, are a much older scientific quandary. Discovered more than 100 years ago, these highly energetic particles arrive at Earth from unknown origins. Cosmic rays consist of protons and electrons accelerated to energies unimaginable here. Their acceleration disperses gamma rays in their wake.

"We have to study gamma ray signals to find something about particles," Funk said. "We want to use the gamma rays to study high energy processes in the universe."

To do this, the researchers want to capture more gamma rays and pinpoint their direction of origin with much better accuracy than current instruments. Currently, there are four ground-based gamma ray telescope systems, staggered across the globe from Namibia, Africa to the Canary Islands. Each location has between two and four telescopes. Funk and his peers hope to one day boost that number to the range of 50 to 100 instruments to increase the data output. But the scientists would also like to step up telescope quality by improving the digital cameras telescopes use to capture and record gamma rays.

In order to capture snapshots from the rapid stream of gamma rays colliding with the earth's atmosphere, scientists use a camera that exposes for only a few nanoseconds. So the camera must be both fast and sensitive. And there is more to data collection than just light exposure—cameras then interpret the incoming signal, convert it into a digital readout, and store that readout on a computer. Funk and his collaborators are finding ways to sharpen camera sensitivity and cut costs at each of these critical steps by developing a better electronic chip and a new light-detection device.

The new light detectors, known as Multi-Anode photomultipliers, will be similar to standard photomultipliers, vacuum tubes used to boost faint light so that it can captured as pixels on a digital sensor. But the new devices will provide better light sensitivity and generate many more pixels. Funk and his collaborators intend to increase the number by at least an order of magnitude compared with current instruments, to more than 10,000 pixels.

The custom-designed chip, known as TARGET for TeV Array Readout GSa/s External Trigger, converts data from the light detectors into a digital signal. The group is collaborating with the University of Hawaii to build and test it, seeking increased reliability and a decreased price tag. "We're redesigning it for improved performance," Funk said. "Our aim is to make cameras cheaper, more robust and more reliable."

Provided by SLAC National Accelerator Laboratory

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