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Body of story:

The road trip to Boston took months to plan.

By September, the scientists and engineers at RIT’s Center for Detectors were ready. They loaded equipment worth nearly a million dollars into the back of a rented truck and left for Massachusetts General Hospital Francis H. Burr Proton Therapy Center to “borrow” the proton accelerator.

During the week, the proton beam channels energy from atoms to destroy cancer cells in patients; on the weekends, the accelerator doubles as a radiation source for simulating space’s harsh atmosphere. RIT engineer Brandon Hanold had booked the facility for the weekend of Sept. 7 and 8 to irradiate three detectors RIT developed for NASA exoplanet missions.

“The detectors were incrementally dosed with 60 MeV (monoenergetic) protons,” says Hanold, lead engineer at RIT’s Center for Detectors. “They were given 10 times the expected dose for a typical mission lifetime of an instrument in space.”

The search for Earth-like planets beyond our solar system requires instruments designed to withstand radiation exposure. High-energy particles in space, like cosmic rays, degrade the performance of detectors over time. Absorbed particles disrupt the ability to capture photons—or packets of light—the elementary particles that carry electromagnetic radiation in different wavelengths. Photons carry information recorded in bandwidths that astronomers read like sheet music.

“Light is mysterious,” says Kim Kolb, a Ph.D. student in RIT’s Chester F. Carlson Center for Imaging Science. “Photons come from a star. The star tells us about our universe—How far the light travelled to get here, how far back in space we’re looking, how stars form and die, how planets form. It’s not that we need that information tomorrow. But you don’t get it without collecting photons. It’s hard to put a price tag on exploration. We don’t know its value.”

Before leaving for Boston, Kolb tested, characterized and calibrated the detectors, collected baseline data for post-radiation comparison. Hanold and engineer Joong Lee designed a radiation-testing program compatible with the hospital’s proton accelerator.

“Logistically, this testing was not easy,” Hanold says. “Our detector testing system is large, requires many different components, and is very specialized. A lot of time has gone into designing our system to work at radiation facilities.”

The three detectors were secured in a vacuum-sealed container kept at a chilly 300 Kelvin or **X** Farenheit. (It’s cold in space,” Kolb notes.) The proton beam reached the devices through a side window outfitted in the side of the canister, or dewar. Small doses irradiated the detectors a couple seconds at a time, simulating 10, 25 and 50 years in space

The team tested how usable the detectors remained when damaged by radiation. They tested the detectors in between doses and monitored them for 24 hours to measure decay. They continued to test the devices two weeks later as the radiation reached a settling point.

“The goal is to make something that’s indestructible,” Kolb says. “We’re interested in how this device architecture holds up to radiation damage.”

The team expected to see a higher dark current, or residual charge created within the device itself, and “afterpulsing” or feedback in the photon detector, both of which produce noise.

“The important question to answer is if the increase in dark current is temporary or permanent, and if temporary, how long will it take for the dark current to reduce back to the pre-radiation level,” Hanold says.

“Like so many technological advances, detectors were made possible by a host of developments, including better understanding of materials, better processing and microelectronics,” says Donald Figer, director of the Center for Detectors in RIT’s College of Science.

The hallmark of the technology RIT tested at Massachusetts General is its elegant solution to the “read noise” that muddies the signal as photons hit the sensor. The Geiger Mode Avalanche Photodiodes (GM-APDSs) are digital, not analog, devices and assign each incoming photon a “0” or a “1.”

“Eliminating an entire source of noise is a huge deal,” Kolb says.

Geiger Mode Avalanche Photodiodes are array-based single photon imaging detectors developed by the Massachusetts Institute of Technology Lincoln Laboratory and advanced in partnership with RIT’s Center for Detectors. The Gordon and Betty Moore Foundation funded the RIT-Lincoln Lab project for optical and infrared detectors for the Thirty Meter Telescope, a future ground-based instrument.

This fall, Kolb won a NASA Earth and Space Science Fellowship in support of her doctoral research comparing and contrasting three different single-photon detectors. The technology yielding higher resolution imagery will influence the next generation of satellites.

Improved detectors resolve images better, whether used for astronomy or adapted for biomedical imaging. While photoreceptor cells in the human eye make sense of energy produced in the optical or visible wavelength—a narrow segment of the electromagnetic spectrum—imaging detectors are cameras that read signals in wavelengths the human eye is not privy to see. Detectors provide another way to follow photons into space, to look down at earth or deep into our bodies.

“We can look into the human body,” Kolb says. “A photon can tell you where the cancer is. It might be the difference between one more photon, one more bead of light.”

Detector technology advanced for scientific exploration holds societal benefits, from new methods of biomedical imaging to remote sensing applications that monitor the health of the planet or the safety of a nation, Figer notes.

Even the GPS technology that guided Hanold, Kolb and Joong to Massachusetts General is commercially available today complements of the NASA space program.

END QUOTE from FIGER

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Caption: Kim Kolb presented a paper at the X conference in Florence, Italy, in October describing the pre- and post-radiation results of the detectors irradiated at Massachusetts General Hospital.

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