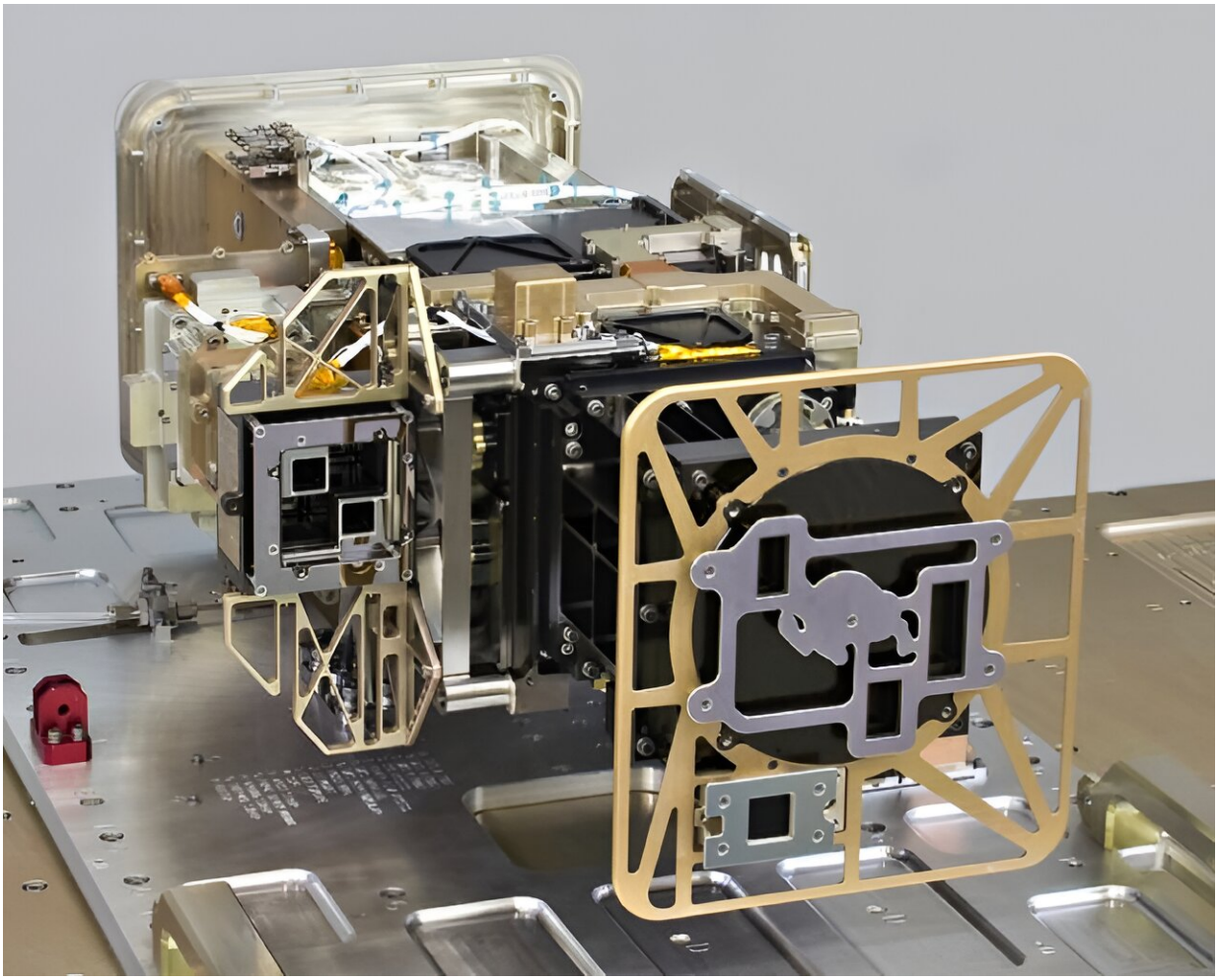
Space instruments provide early warnings for solar flares

June 21 2024, by Daniel Strain



CU Boulder's Ralphie logo emblazons all four EXIS instruments. Credit: LASP

When a solar flare leaps out from around the sun, a small fleet of scientific instruments designed and built at the University of Colorado Boulder form a first line of defense—spotting these massive eruptions before any other instrument in space, then relaying the information to Earth in seconds.

On June 25, the fourth and final instrument in this suite, known as the Extreme Ultraviolet and X-ray Irradiance Sensors (EXIS) program, is scheduled to launch into space. It will fly aboard the Geostationary Operational Environmental Satellite-U (GOES-U)—the latest in a series of GOES-R satellites that monitor weather on Earth from orbit. GOES-U, which will be renamed GOES-19 once it reaches geostationary orbit, will blast off from NASA's Kennedy Space Center in Florida on a SpaceX Falcon Heavy rocket.

The event marks the culmination of nearly 20 years of work for scientists and engineers at CU Boulder's Laboratory for Atmospheric and Space Physics (LASP).

"It's bittersweet," said Frank Eparvier, associate director for science at LASP and lead scientist for EXIS. "It's like sending your kid off to college. There's a sense of sadness that all of this long, preparatory work is ending, but pride and excitement that the goal of that work is becoming reality."

The new EXIS instrument, which looks a bit like a souped-up toaster oven, will join three more nearly identical instruments, each orbiting Earth on a different GOES-R satellite. One hovers above the East Coast of the United States. Another is above the West Coast, while the third sits in storage in space, waiting to be called into duty if a problem arises with one of the other satellites.

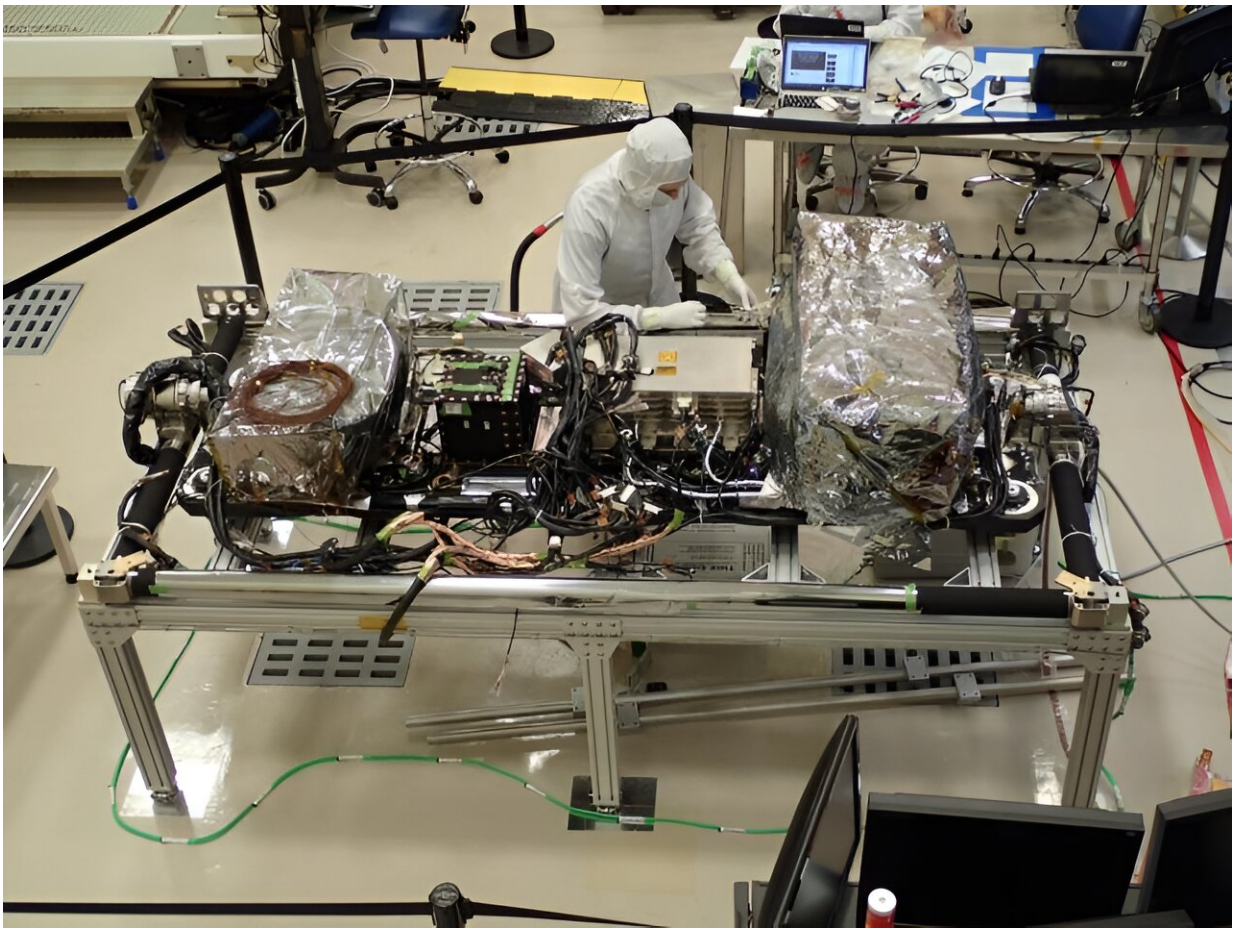
They've already built an impressive scientific legacy. The GOES

program, a joint effort between NASA and the National Oceanic and Atmospheric Administration (NOAA), keeps a close eye on events like hurricanes, tropical storms and more. But the EXIS instruments track a different kind of weather: "space weather," or various processes that begin around the sun and can influence conditions around our planet, sometimes in disastrous ways.

"If we want to understand these things that can affect our technology and safety on Earth, we need to look at the source, and that's the sun," Eparvier said.

Dan Baker, director of LASP, noted that the institute is proud of its decades-spanning contributions to the GOES program.

"LASP is the only academic institution providing major hardware for the GOES-R series," Baker said. "LASP has consistently delivered on time and on budget and demonstrated the highest levels of success for the operational needs of NOAA and the U.S. government," he said. "In fact, LASP has been a model for how to design, build, test and operate space instrumentation in an operational context."



A technician installs an EXIS instrument onto the solar pointing platform of the GOES-T satellite, which launched in 2022. Credit: NOAA Satellites

Northern lights

For Eparvier, the launch also represents the achievement of an old dream.

When he was an undergraduate student at the University of Wisconsin-Madison in the 1980s, Eparvier spent a summer working night shifts at a local candle factory. One night, he was driving home along the shores of Wisconsin's Lake Winnebago when he saw faint lights floating in the

sky. He had spotted an aurora, a light show high in Earth's atmosphere that arises from activity around the sun.

"It was a major solar storm, and I sat there until three in the morning on my chaise lounge looking at the aurora," Eparvier said. "That really got me interested: What is it? Why is it?"

Years later, EXIS gave him the opportunity to dig into those very questions.

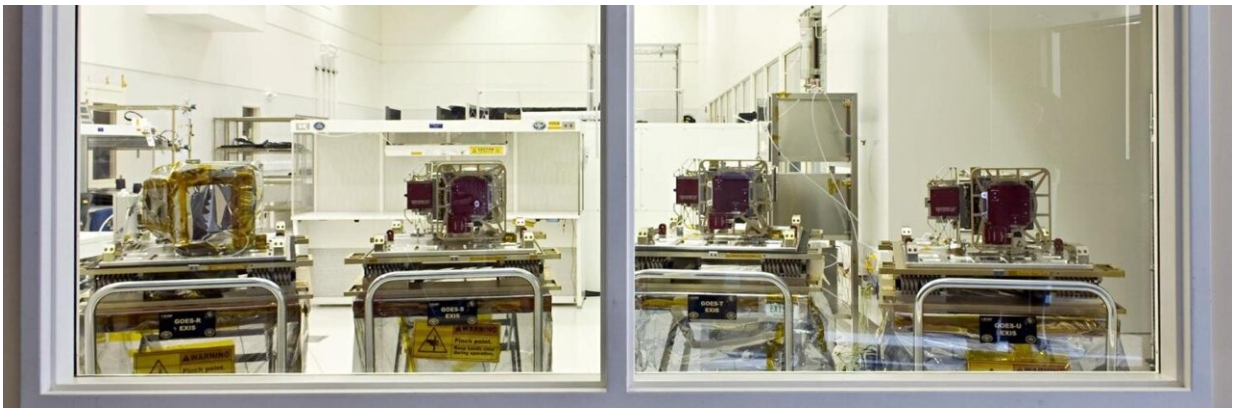
Eparvier explained that each EXIS instrument includes two sensors: an X-Ray Sensor (XRS) and an Extreme Ultraviolet Sensor (EUVS). XRS, as its name suggests, picks up X-ray radiation streaming from the sun. It's also attuned to detect the first hints of a flare exploding from the sun.

Such bursts of energy can send charged particles hurtling toward our planet—in some cases, giving rise to auroras, like the one Eparvier witnessed in Wisconsin. In other cases, fast moving, energetic particles coming from the sun can endanger electronics or even human bodies in orbit.

EUVS is a different beast. It homes in on fluctuations in the sun's activity that cause Earth's atmosphere to inflate and deflate, as if the entire planet is breathing. If the atmosphere inflates too much, it can drag down satellites in orbit.

Scientists at NOAA use information from both types of sensors to give timely guidance to satellite operators and others across the globe to help them navigate safely through space.

"EXIS really is providing an asset to the entire world," Eparvier said.



In this photo, which Frank Eparvier refers to as the "EXIS nursery," the four, nearly identical instruments sit side-by-side in a clean room at LASP. Credit: LASP

Generational project

Getting these important tools off the ground, however, was no easy feat. The LASP team began working on EXIS in 2005—LASP scientist Tom Woods led the concept development—and built all four instruments at the same time. The first launched in 2016 and the second and third in 2018 and 2022.

The team also designed those instruments to withstand a harsh environment, Eparvier said. The GOES satellites orbit Earth from what are known as "geostationary" orbits, which circle the planet from a distance of more than 22,000 miles in space—a region with a lot of radiation.

Over the years, more than 100 engineers and scientists at LASP worked to make EXIS a reality. They included Phil Chamberlin who started on the project as a doctoral student in the 2000s. He said the project was a

perfect opportunity for budding researchers like him to learn the ins and outs of designing space instruments.

"The EXIS team is first-class and absolutely amazing, and owe my career to them," said Chamberlin, now a senior research associate at LASP. "They trusted me with a lot of responsibility and gave me the freedom, to a point, to figure things out and design things myself."

The final instrument is leaving for space soon. But all Eparvier has to do is open his computer to see EXIS data streaming back to Earth. In May 2024, for example, a series of flares from the sun rocked the planet, generating auroras that stretched as far south as Florida. He and his colleagues were among the first people on Earth to see the events coming.

And just like all those years ago on Lake Winnebago, he took the time to appreciate the lights in the sky.

"My wife and I went up to the Wyoming border and joined a group of people on a friend's piece of land," Eparvier said. "We sat there and took amazing pictures of the aurora."

Provided by University of Colorado at Boulder

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