Questions surround NASA's shutdown of an international cosmic-ray instrument

The detector aboard the International Space Station could be turned back on if a new proposal passes peer review. But it's unclear who might operate it.

In February NASA quietly pulled the plug midway through the expected three-year life of a functioning cosmic-ray detector attached to the outside of the International Space Station (ISS). The unusual step came after a majority of scientists in the Cosmic Ray Energetics and Mass for the ISS (ISS-CREAM) collaboration rejected outright NASA's demand to replace the project's principal investigator (PI), University of Maryland (UMD) physicist Eun-Suk Seo, with the agency's hand-picked successor. "We asked the University of Maryland and the science team to make changes," says NASA astrophysics program director Paul Hertz. "They did not make those changes, so we did not continue the mission." A three-sentence note at the top of the ISS-CREAM collaboration's webpage was the only notice of the project's demise. NASA was providing $1.2 million a year for ISS-CREAM operations. It paid $22.4 million to build, launch, and install the refrigerator-sized device on the ISS. South Korea, home to two universities in the collaboration, contributed an additional $10 million.

Hertz says the agency will entertain proposals to resume ISS-CREAM operations. The collaboration "did not generate any science in its first year," he says, noting that reviewers recommended against continuing the project under its existing leadership. "It's up to somebody to write a proposal and demonstrate that if we were to turn it on and give them money, then we would get science, and the science would be worth the money."

ISS-CREAM was installed on the ISS in August 2017 to study properties of high-energy cosmic rays that are believed to originate from the universe's most violent events (see PHYSICS TODAY, May 2010, page 15). The four-instrument detector was adapted for spaceflight from a set of similar instruments, known as CREAM, that were carried aloft on seven high-altitude balloon flights over Antarctica beginning in 2004. Seo was PI on that project.

ISS-CREAM was meant to complement other cosmic-ray detectors, such as the Alpha Magnetic Spectrometer (see PHYSICS TODAY, June 2013, page 12) and Japan's Calorimetric Electron Telescope (both also installed on the ISS), by studying very-high-energy (10^{12} eV to 10^{15} eV) cosmic-ray particles, which range in mass from protons to iron nuclei. ISS-CREAM's two principal instruments are a tungsten sampling calorimeter built by UMD and a silicon charge detector (SCD) contributed by Sungkyunkwan University (SKKU). A third instrument, a boronated scintillator detector (BSD), was built by a team of researchers from the Pennsylvania State University (PSU), Northern Kentucky University, and NASA's Goddard Space Flight Center. Kyungpook National University contributed detectors located above and below the calorimeter to distinguish electrons from protons. France's Laboratory of Subatomic Physics and Cosmology and the National Autonomous University of Mexico also contributed calorimeter components.

NASA

THE ISS-CREAM DETECTOR is the rightmost rectangular shape at the bottom of the photograph. To its right is the Japanese module of the International Space Station.

The ISS-CREAM payload on the space station was expected to generate 10 times as much data as were acquired during the 161 days of balloon experiments, and the cosmic-ray data would be cleaner due to elimination of atmospheric interactions. Before ISS-CREAM, the highest-energy cosmic rays could only be inferred from secondary-particle air showers seen with ground-based telescopes, says Jon Paul Lundquist, a postdoc working under Seo. That indirect process was used to calculate the energy of the highest-energy cosmic ray ever observed (3.2×10^{20} eV), at the now-closed Fly's Eye detector in 1991 (see PHYSICS TODAY, January 1998, page 31).

Internal conflict

A UMD spokesperson declined to comment on the ISS-CREAM cancellation. Seo and other members of her team say that university research administrators had agreed to NASA's demands, which included replacing Seo as PI with Scott Nutter, a Northern Kentucky University physics professor who had been named the collaboration's data manager. "It's natural that the university has to be concerned about its overall relationship with NASA," Seo says. UMD is one of the largest academic recipients of NASA funding.

Since last summer, collaborators from UMD and the South Korean universities had fought with Nutter over the coding of data taken from their respective instruments to a common format for analysis. At a January meeting, UMD and Korean members—representing by far the majority of the collaboration—presented to NASA astrophysics division staff a letter that rejected Nutter's November designation as PI and "disbarred" him from the collaboration. "We didn't say no to NASA. We said no to their choice of PI," says Lundquist.

In the aftermath, NASA turned off the ISS-CREAM device, terminated the UMD grant on one week's notice, and withdrew the grant funds that hadn't been disbursed. Hertz says NASA consulted with the Korean government before the shutdown but notes that the Korean contribution was made to UMD, not through NASA.

Seo says she declined to sign the rejection letter. "I accepted [Nutter] because I had no choice. I had to work with him." She says she was willing to do whatever it took to keep the collaboration alive.

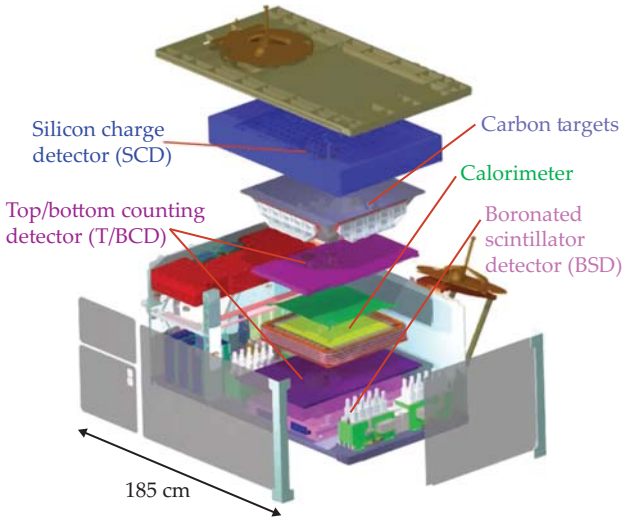
As data manager, Nutter tried to make each detector team organize and structure its data in a way that would smooth collaboration-wide analysis. "He organized a unified software structure we would all have access to, where each instrument team could contribute their own software, but from that archive, all of us could run the full analysis," says PSU physicist Stephane Coutu, a member of the BSD group. "Scott worked hard to bring every part of the instrument together as a whole," he says, including visiting with collaborators in Korea "to help sort out SCD behavior issues." The reviewers too, praised Nutter, saying he had "significantly improved the organization and development of analysis code."

But researchers from UMD and the two Korean teams took an opposing view. Il Park, an SKKU professor who headed the SCD contingent, says Nutter failed to provide collaboration-wide data that incorporated calibrations and computed derived science quantities such as tracking, charge, and energy. Lundquist says the coding changes demanded by Nutter were unnecessary and a distraction from the science. "There was over a decade of code base and data structures that the individuals who know the detectors best created," says Lundquist. Forming a unified structure from that base should have been "extremely straightforward," he says. But Nutter insisted that his coding method be used, Lundquist says.

The Korean collaborators also didn't object to NASA's naming someone other than Nutter as PI, says Park. They suggested Coutu, who declined the job.

Nutter insists that he never wanted the PI job, but he ultimately accepted when NASA officials told him no one else would take it. "The choices were termination or me stepping up to the PI position."

Seo says that NASA would have to clarify the degree of control and oversight the agency would have over a modified mission before she would consider submitting a proposal to resume operating the device. Unusually, NASA did not classify ISS-CREAM as a spaceflight mission, but funded it under a research grant. The project was therefore subjected to a less rigorous set of qualification requirements and agency oversight than are space missions. "We thought [ISS-CREAM] was an interesting idea to try," says Hertz. "Can we take a research-level payload in a research program and put it on the ISS and get space-quality science out of it?"



A SCHEMATIC of the ISS-CREAM instrument showing the four detectors included in the refrigerator-sized device. (Courtesy of the UMD Cosmic Ray Physics Laboratory.)

For ethical and scientific reasons, turning ISS-CREAM over to a different collaboration would be problematic, notes Seo. "It would be a nightmare if anyone else tried to use it and to claim the data, and a nightmare situation for me to accept or not to accept results" if they conflicted with those of the original collaboration.

Disbarring NASA's choice

In January 2018, six months into the mission, a NASA review team identified problems with ISS-CREAM, including an understaffed instrument control center at UMD, lagging data analysis, and poor communications among the various instrument teams. Based on the review recommendations, in April NASA appointed Nutter as data manager and brought in former Goddard engineer James Dickey to a new position of mission operations manager.

A follow-up in September 2018 by NASA and external reviewers reported that both data management and mission operations had improved significantly. But the review noted that only 50 days' worth of science-quality data had been collected during ISS-CREAM's first year and said competent leadership of the calorimeter measurements and analysis—the UMD team's responsibility—was lacking.

Without changes to the project's leadership, the review stated, "it is not likely that significant scientific results will be produced within the remaining time of the nominal three-year mission." It recommended replacing Seo as PI with "someone with sufficient knowledge and experience in cosmic ray science, familiarity with the details of the four subsystems, and clear leadership capability." In the event a new PI couldn't be found, the review recommended termination, "as additional investments are unlikely to result in substantial scientific return under the current leadership of the project."

Seo and other collaborators take issue with Hertz's and reviewers' complaints regarding ISS-CREAM's low scientific productivity. Researchers were on track to meet the grant application's timetable for reporting results, says Lundquist, who notes that 10 abstracts for presentations of results have been submitted for the International Cosmic Ray Conference next month.

As for the relative dearth of usable data, Park says that it took the better part of a year to calibrate the instrument and be assured that it wouldn't be damaged by energetic particles during ISS transits of the South Atlantic Anomaly in Earth's inner Van Allen radiation belt. Such a lengthy break-in period is "typical and always true for all high-energy particle experiments," he says.

Out of work

Five postdocs and one other scientist on the UMD team, meanwhile, have continued to analyze data from the terminated mission without pay. Lundquist says he is moving to South Korea to work at SKKU for a couple months at half the salary he'd been getting from the NASA grant.

NASA offered the six out-of-work UMD scientists positions at the nearby Goddard campus to work on closing out ISS-CREAM. It also offered to consider them for unspecified permanent positions. But in a letter to NASA's astrophysics division manager, all six declined, saying the offer appeared to be an effort to further divide the ISS-CREAM team.

Lundquist says the episode should raise concerns about the degree to which NASA micromanages its grantees. "It seems highly unusual for a funding agency to reach their hands into a collaboration and demand these specific conditions," he says.

But Hertz says that NASA conducts reviews of all its space missions at the end of their "prime mission," period. "I would say that termination happens seldom but not never."

Other astrophysics missions were terminated after such reviews were performed, including the *Wide-field Infrared Survey Explorer* and the *Extreme Ultraviolet Explorer*. *WISE* was put into hibernation in 2011 after its hydrogen coolant was depleted, but it was later reactivated to look for near-Earth asteroids (see PHYSICS TODAY, March 2015, page 19). *EUVE* operated for more than eight years before its deactivation in 2001.

As a research grant, ISS-CREAM's prime mission period was one year, with extended operation contingent on passing reviews, Hertz says.

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