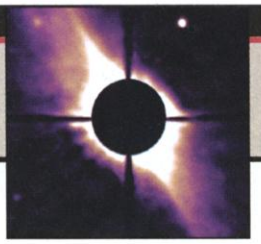

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HIGH-ENERGY PHYSICS

Shock Wave May Have Knocked Out Japanese Neutrino Detector

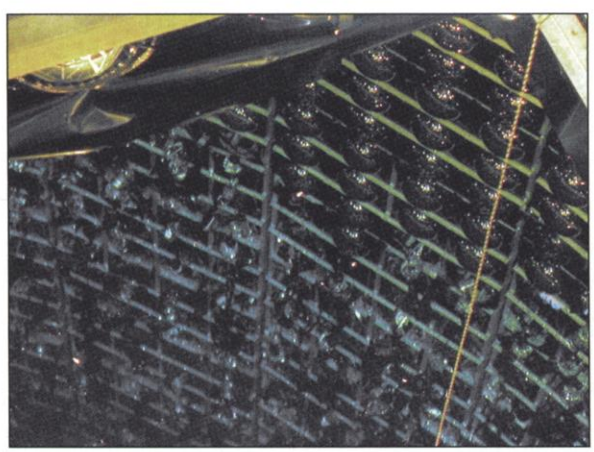
TOKYO—The tank was three-quarters full on the morning of 12 November when the technicians in the control room of the $100 million Super-Kamiokande neutrino observatory heard a roar that lasted half a minute or more. When it was over, all the finely tuned light-detecting sensors below the water had imploded, and the observatory lay crippled. It may be 2007 before the facility is back at full capacity, and repairs could cost $15 million to $25 million, but scientists and government officials have vowed to resume some experiments within a year.

"We will rebuild the detector, there is no question," says Yoji Totsuka, a professor at the University of Tokyo's Institute for Cosmic Ray Research and director of the observatory, located 230 kilometers west of Tokyo deep in a mine. "It's inconceivable that it would not be rebuilt," says Henry Sobel, a University of California, Irvine, physicist and spokesperson for the U.S. side of the collaboration.

The underground lab made headlines worldwide in 1998 when it provided convincing evidence that neutrinos have mass. That finding, which many physicists believe is worthy of a Nobel Prize, ran counter to decades of theoretical predictions. The data strongly suggest that a certain type of neutrino from the atmosphere is "disappearing" by changing, or oscillating, into another type of neutrino the detector can't see. By the laws of quantum mechanics, only particles that have mass can oscillate.

Neutrinos cannot be detected directly. So Super-Kamiokande contains 50,000 tons of highly purified water in a tank 39 meters in diameter and 41 meters high lined by 11,146 photomultiplier tubes. The tubes watch for a characteristic glow, known as Cerenkov radiation, that results from the rare interaction of neutrinos and atomic particles in the water.

Observations were halted in July for maintenance, and workers drained the tank for the first time since the facility was completed in 1996 to replace some 100 burned-out tubes. The accident occurred as the tank was being refilled in preparation for the resumption of experiments in December. The water had reached the 41st of 51 rows of tubes when the implosion took place, destroying all 7000 tubes that were submerged.



Popped. A view down into the Super-Kamiokande neutrino detector taken after the 12 November accident shows several rows of intact photomultiplier tubes at the top of the tank and shattered tubes below.

Officials have yet to determine what triggered the accident, although the most likely theory is that a tube on the floor of the tank burst and started a shock wave that was amplified in the water to set off a chain reaction of implosions. The shock also apparently cracked the tank. Totsuka says an existing tube could have been damaged by pressure from workers standing on thick Styrofoam pads placed atop the tubes during repairs, or perhaps one of the replacement tubes was defective. However, he also notes that a smaller version of the current facility ran for more than a decade without encountering any such problems.

While the investigation continues, scientists are already planning how to get back online. The facility's main governmental sponsor, the Ministry of Education, Culture, Sports, Science, and Technology, is prepared to help. "We want to provide not just financial support but whatever support we possibly can to restore the facility so it can restart observations as soon as possible," says Minister Atsuko Toyama.

A priority is restarting the K2K experiment, in which an accelerator at the High Energy Accelerator Research Organization (KEK) in Tsukuba will shoot a stream of neutrinos 250 kilometers to the underground tank. Results from this so-called long-baseline experiment are considered more reliable because scientists will know the precise number of neutrinos being aimed at the detector instead of having to infer them based on theory. The KEK physicists recently reported results showing that the probability of no oscillation is less than 3% (*Science*, 2 November, p. 987). They hope to restart this experiment before the accelerator is shut down in 2 to 3 years.

Totsuka says that it may also be possible to resume experiments within a year with only half the full complement of tubes and then add the rest as they are manufactured, a process that could take several years. "This would give us reduced sensitivity, but we would still be able to search for atmospheric neutrinos in addition to running the K2K experiment," he says. The facility would not have the sensitivity to detect most solar neutrinos, however.

The long-term goal is to be at full strength by 2007, when Japan's planned $2.7 billion High Intensity Proton Accelerator Facility is scheduled to come online. The proton accelerator, a joint project of KEK and the Japan Atomic Energy Research Institute (JAERI), is under construction at JAERI's campus in Tokai, Ibaraki Prefecture. This accelerator has been designed to send Super-Kamiokande 20 times as many neutrinos as in the K2K experiment, allowing researchers to tease out more details of just how neutrinos oscillate and probe other neutrino properties. "We've barely scratched the surface of understanding neutrinos," says John Learned, a Super-Kamiokande collaborator at the University of Hawaii, Manoa.

Support for rebuilding Super-Kamiokande goes beyond the collaborators. "Super-Kamiokande has provided some of the most important results in physics and astronomy in the past decade and has the potential for con-

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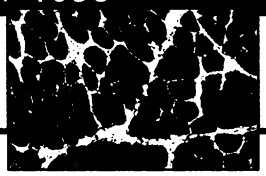


tinuing to make great contributions if restored to its full capacity," says John Bahcall, a neutrino expert at the Institute for Advanced Study in Princeton, New Jersey. "If I had the necessary skills, I would [go] to Japan to help with the repairs."

Equally encouraging is the supportive stance taken by the education ministry. Akira Yoshikawa, head of the ministry's Research Institutes Division, says that "the minister well understands the importance of this facility." Sobel says that he hopes to meet soon with officials at the Department of Energy, which funds the U.S. side of the collaboration, to see what support it might be able to provide. **–DENNIS NORMILE**

SPACE SCIENCE

European Programs Face Another Squeeze

European space scientists got an unsettling sense of déjà vu last week. The European Space Agency (ESA) had asked its 15 member governments for a 4% annual increase for its much-praised science program, but instead, government ministers meeting in Edinburgh approved only 2.5%—barely enough to keep up with inflation. A similar setback occurred in 1999, which means that space science funds have been stagnant for 6 years.

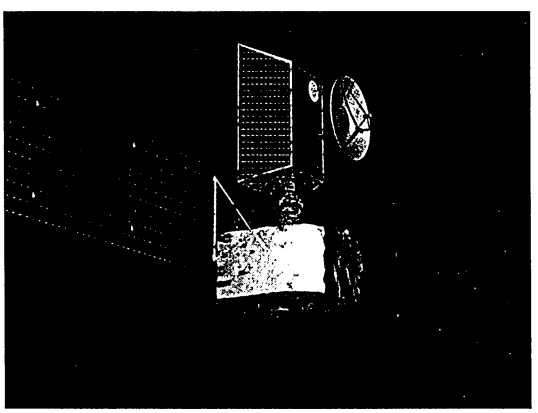
In contrast, Galileo, a program to build a European version of the U.S. Global Positioning System, and a plan to upgrade the Ariane 5 launcher received substantial boosts. "It's utterly unjust," says physicist Hans Balsiger of the University of Bern in Switzerland, a former chair of ESA's Science Program Committee (SPC). "I can see no reason why we are treated worse than everyone else."

The delegates also sent a strong signal of disapproval to the U.S. government on moves to cut back the size of the international space station. They reluctantly approved funds to meet ESA's obligations to the project, but they froze some 60% of the money until NASA makes clear its funding plans for the station and the number of astronauts that will live and conduct research there. SPC vice chair Giovanni Bignami, director of space science at the Italian Space Agency, called this a "wise decision," adding, "I would have made [the amount held back] bigger."

The SPC will meet early next month to decide how to carve up $1.65 billion for space science in 2002–06. Researchers contacted by *Science* believe that most missions planned for launch before 2010 seem secure, but some later ones, such as the Bepi-Colombo mission to Mercury, may have to be delayed. Missions beyond that, still in their planning stages, are threatened. David Southwood, ESA's head of science, told those meeting in Edinburgh that Gaia, an astrometry mission, was the most likely casualty. "Something has to give," he told *Science*.

Apart from the science program, to which all ESA members must contribute, a new optional program to develop missions to look for signs of life in the solar system, called Aurora, also got shortchanged. ESA had asked for $35 million to plan a series of robotic missions to other planets, moons, asteroids, and comets but came away with just $12 million. This should be just enough to set the ball rolling, however. "We can create a plan," says Paul Murdin, director of space science at the British National Space Centre. Italy had been one of the prime movers behind the Aurora project, but following a change of government last month the promised funds were not forthcoming.

Although space science was out of favor at the meeting, Ariane 5—the latest in a line of rockets that now account for more than half of all commercial launches worldwide—got a warm endorsement. It will be upgraded to increase its payload capacity, at a cost of $620 million. And in a groundbreaking collaboration with the European Union, ESA will launch its own fleet of 21 navigation satellites to help planes, trucks, ships, and even hikers pinpoint their positions with centimeter accuracy. Member governments pledged $470 million to design and develop the system, more than ESA asked for. **–DANIEL CLERY**



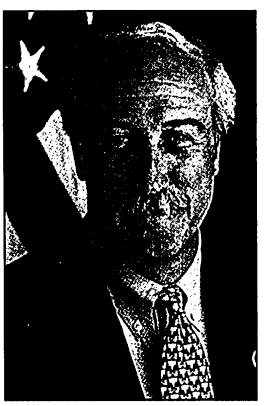
Stretched? Some medium-term projects such as the Bepi-Colombo mission may be delayed.

CREDITS: (LEFT TO RIGHT) ESA; AP PHOTO

SPACE SCIENCE

Insider Takes Over At NASA

Just over a week ago, Sean O'Keefe was publicly criticizing NASA for cost overruns and poor management. Now those problems are his responsibility. President George W. Bush nominated O'Keefe, 45, currently the deputy director of the Office of Management and Budget (OMB) and an influential Washington insider, on 14 November to NASA's top job, vacated on 16 November by Dan Goldin.



Connected. O'Keefe is plugged into the Bush White House.

O'Keefe's assignment is clear. "He is being sent to NASA to ensure fiscal responsibility," says one senior Administration official. "He will force things to be on time and on budget." Another manager who has worked closely with O'Keefe calls him "the consummate dealmaker." He has close connections to both Bush presidents and to Vice President Dick Cheney, having served in the first Bush Administration as Navy secretary and Defense Department comptroller. Senate confirmation is expected to be speedy.

O'Keefe's immediate task likely will be to address the concerns of NASA's international space station partners, who are angry at moves to scale back from six to three astronauts on the station, initiated by O'Keefe at OMB. European ministers warned in a press conference on the day of O'Keefe's nomination that they are prepared to scale back their own support in protest (see previous story). Meanwhile, NASA will be hard-pressed to resolve station cost overruns even if it adheres to O'Keefe's more modest version.

A second major crisis is brewing in the outer planet exploration program. Congress put $30 million into the 2002 budget for a flyby of Pluto, a program the White House