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Toni Feder

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Science in Japan gets back on its feet

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Given the extensive damage and deaths from Japan's triple disaster last spring—the earthquake, tsunami, and nuclear meltdown at the Fukushima Daiichi reactors—Japan's science community is not complaining about the hurdles to getting back on its feet. "We are patient," says Hirokazu Tamura, a nuclear physicist at Tohoku University, which was severely shaken by the Great East Japan Earthquake on 11 March. Tamura was one of the roughly 470 000 people who were initially displaced; six months later, more than 27 000 were still living in junior high school gymnasiums, hotels, and other makeshift quarters.

Most of the damage to science infrastructure is from the earthquake, which, at 9.0 on the Richter scale, was among the most powerful quakes on record. Some 34 national research institutions and 177 of Japan's 800 universities have reported varying degrees of damage, according to Mitsuyuki Ueda, a director for research promotion at Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT). But, he says, "it's very difficult to assess the damage. Each institute uses its own calculations to estimate the costs of repairs." Shoji Nagamiya, director of the Japan Proton Accelerator Research Complex (J-PARC) and president of the Physical Society of Japan, tallies the total cost to repair research infrastructures at $1 billion to $2 billion.

After the earthquake, many of Japan's research facilities shut down for inspections. Some required repairs and are not yet running, although all major experiments are expected to be up by next spring. The Japanese government estimates ¥19 trillion (about $250 billion) in total reconstruction costs over five years. The strategic plan for science and technology, adopted by the government in August, stresses the importance of S&T for building a sustainable society. The government has also kept its goal of investing 1% of gross domestic product into R&D. But how S&T will actually fare in a tight fiscal environment with competing demands is yet to be seen. Proposals for the next annual budget are due to be submitted to Japan's Diet in early 2012.

University suffers

Tohoku University is the largest of the handful of hard-hit campuses near the earthquake epicenter. Nobody was injured on campus, but several students from Tohoku and Kyoto universities were killed by the tsunami.

The university's cyclotron and electron accelerator were severely damaged by the earthquake. Several engineering buildings collapsed, and some walls of the physics building cracked. The ground outside the physics department sank by about 10 cm. Because of damage to the chemistry building, Tamura says, people were worried about the release of chemicals. Equipment in individual investigators' labs was broken.

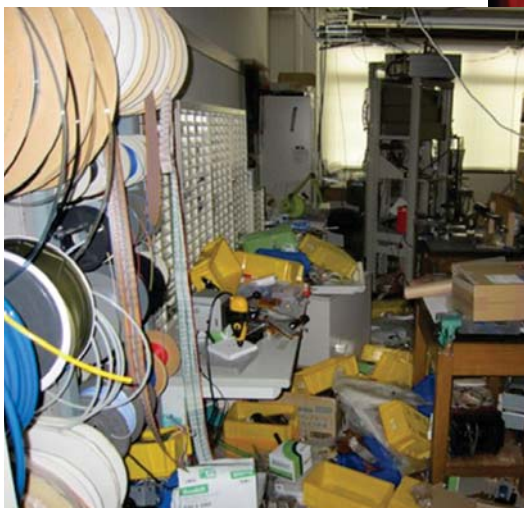
The government has so far given the university roughly $500 million. It will "probably take one or two years to recover everything," says Tamura. He estimates the damage in his own sixth-floor lab at about $500 000. Recovery is hampered, he says, not only by a lack of money, but also because of shortages in replacements and repair services for broken equipment.

But Tamura says he is "most seriously worrying about new students." Applications for physics graduate programs dropped 20% this year compared to last year. "I hear that some parents don't want their sons and daughters to go to the Tohoku area," he says. "They are worried about radiation and more earthquakes." The University of Tokyo, more than 300 km from the epicenter, received fewer applications this year, but Hiroaki Aihara, chair of the Japan Association of High Energy Physicists, says that could be due to the poor economy. Nationwide a few campuses have closed or moved, but most are open for business.

Recovery

The photon factory, injector linac, and other facilities at the Tsukuba campus of Japan's High Energy Accelerator Research Organization (KEK), around 300 km from the earthquake epicenter, suffered some damage. "There were many breached vacuum pipes, displaced magnets, and sheared detectors," says spokesperson Youhei Morita.

Damage was heavier at J-PARC, which is jointly run by KEK and Japan's Atomic Energy Agency. Located in Tokai, some 100 km from the earthquake epicenter, J-PARC's main accelerator and experimental areas survived the earthquake thanks to underpinnings up to 70 m deep. The site is also protected from tsunamis up to 8 m high; at J-PARC the level was 3 m. But damage to peripheral facilities was "severe," says Nagamiya. For example, nearly one-third of J-PARC's neutron beamlines were bent when the building that housed them sank. And roads, cables, power stations, and cooling towers suffered damage. Nagamiya estimates the J-PARC recovery will cost at least $50 million.



HIROKAZU TAMURA

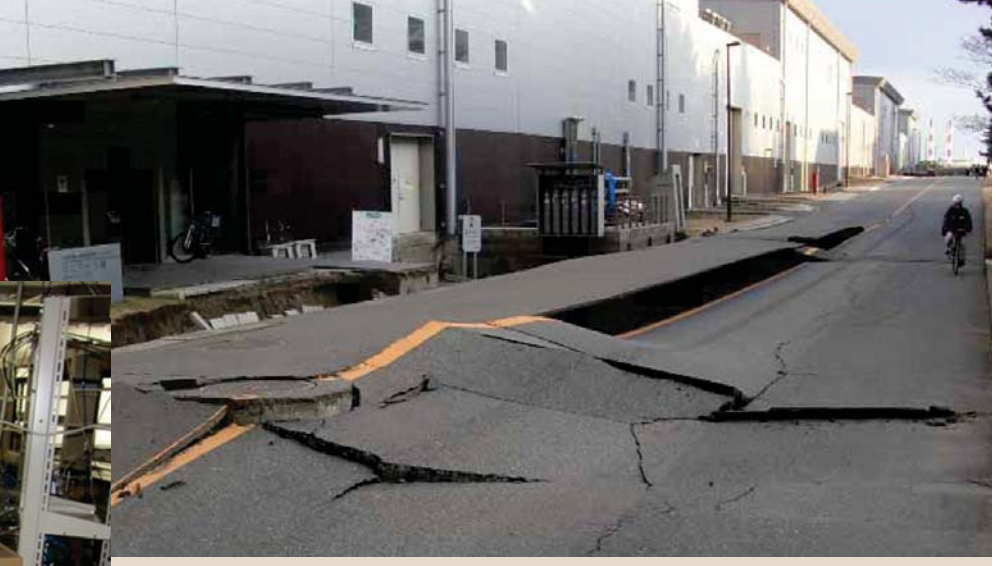
Recovery at both sites has been quick. The photon factory and injector linac at KEK had been fixed by late June, and experiments are set to restart this fall. At J-PARC, says Nagamiya, the aim is to restore beams to all facilities by December. Accordingly, fixing the road in front of the linac (see photo) and other things not necessary for the beams will wait until more money comes in from the government.

Also suffering damage was the Japanese hub of ITER, where magnets and heating systems for the international fusion test reactor were being developed. The site, in the city of Naka, is roughly 250 km from the earthquake's epicenter. The ITER team is working on a recovery strategy to minimize delays to the full project.

Going abroad

With experiments out of commission, says Aihara, "People are concentrating

SHOJI NAGAMIYA



A cracked road running in front of the linac at the Japan Proton Accelerator Research Complex and a physics lab at Tohoku University are examples of damage wreaked last March by the 9.0-magnitude Great East Japan Earthquake.

on analyzing data and writing papers." Notably, the T2K collaboration published results in July giving the first indication of muon neutrinos transforming into electron neutrinos (see PHYSICS TODAY, August 2011, page 18). The long-baseline experiment began in January 2010 and was abruptly halted by the earthquake; by then, about 2% of the targeted number of events had been collected.

"All the damage was minor, but we need to realign the beamline," says Francesca Di Lodovico, a T2K collaboration member based at Queen Mary, University of London. She arrived for a shift on the day of the earthquake. In Tokai (the "T" in T2K; the "K" is for Kamioka), she says, "there was no water, no electricity. Shops were not open." So, like many visiting researchers, Di Lodovico left. Japanese host institutions and foreign embassies advised foreigners to leave, both because of the crippled infrastructure and because of uncertainties about the Fukushima power plant accident. About 80% of foreign researchers located at the World Premier International Research Center Initiative institutes at Tohoku and Tsukuba left in the days following the disasters, says MEXT's Ueda. Most returned to Japan within a few weeks. (See the story on the international institutes in PHYSICS TODAY, December 2008, page 28.)

Akihiro Kondo was among the Japanese scientists who went abroad to pursue experiments. He spent part of the summer at the magnet lab at Los Alamos National Laboratory (see the story on page 25). The first week he was there, Kondo says, he couldn't go to the lab because of wildfires, but later he was able to resume his research. In addition, he says, "I learned a great deal about measurement techniques which have not been done in our laboratory." Other Japanese researchers have been invited to do experiments at facilities in unharmed locations in Japan and in other countries in Asia, Europe, and North America. The Spallation Neutron Source in Tennessee has provided beam time for more than 20 experiments from Japan.

Waiting for beam time

Many of Japan's nuclear physicists have been monitoring radioactivity and talking to the public about safety issues. Isao Tanihata of Osaka University set up a group of more than 350 nuclear physicists, medical scientists, and Earth scientists from around the country. The group screens people for radiation exposure in Fukushima and measures radioactivity in the region's soil and air. The data, he says, will be used to determine when evacuees can return and to monitor food safety, particularly the uptake of radioactivity by rice. Nagamiya estimates that 10% of J-PARC's physicists and engineers went to Fukushima to monitor and reduce radiation. For example, he says, a 50-cm layer of contaminated sand was removed.

At KEK, says Morita, "our radiation experts are responding to interviews by televisions, newspapers, and magazines. They explain the basic physics of radiation and some basic concepts of how citizens can protect themselves from radiation." Tamura, too, gives public talks every couple of weeks. "Many people are worried, particularly parents of small children," he says, adding that in his opinion "in Sendai [the city where Tohoku University is located] and in Tokyo, radiation levels

are low enough and people should not worry so much." He also took part in the soil contamination study organized by Tanihata. Those activities, Tamura says, "have nothing to do with our research. We are just waiting for our beam time."

Nuclear-power future?

Power restrictions have been in place since the nuclear accident. Nagamiya says that ongoing restrictions on electricity use are his "biggest headache." J-PARC and other power-consuming experiments will have a rough time if electricity restrictions continue. At the University of Tokyo, says Aihara, "we cut consumption by 30%" over the summer. That meant darker hallways, less air conditioning, not using elevators, and doing high-use activities at off-peak hours. "It took a couple of months to get used to it," he says.

Not surprisingly, public opinion in Japan has turned against nuclear power. The island nation gets about 30% of its electricity from nuclear reactors; oil provides 25%; natural gas 25%; and the rest is hydroelectric plus a small amount from renewable energy sources.

Over the past months, all of the country's nuclear power plants have been turned off for safety checks. A debate is raging over whether to phase out nuclear power; in the wake of the accident in Japan, Thailand froze its plans to build its own nuclear power plants, and Germany and Switzerland announced they would phase out nuclear power over the next decade or so. The Science Council of Japan recently presented the government with six different scenarios, from continuing to generate nuclear power to abandoning it altogether. The council analyzed the costs and benefits of each scenario. "Very active discussions are in progress," says Nagamiya, a member of the council, "but no consensus has yet been reached."

Unlike his predecessor, Japan's new prime minister, Yoshihiko Noda, who took office on 2 September, has come out in support of nuclear power for the future. "Nobody knows yet what will happen. It's a political decision," says Aihara. "But if the government does not allow reactors to come back, the overall power shortages will affect research."

Toni Feder

Universities seek culture change for improved STEM teaching

The Association of American Universities is pushing to institute new methodologies, but success will require big changes by academic departments.

Much has been said and written over recent decades about urgently needed improvements in the teaching of science, technology, engineering, and mathematics (STEM) at all levels of the US educational system. All manner of indicators of US students' pitiful performance in STEM relative to other nations have been aired. What's been lacking is a systematic adoption of new teaching methodologies that are proven to increase learning of STEM. But now an association of the nation's top research universities has decided the time has come to adopt better STEM teaching throughout their institutions.

In September the Association of American Universities, a group of 59 US and 2 Canadian public and private research universities, announced a five-year plan to propagate successful new STEM teaching modes. "AAU is not conducting another study or research project on STEM education," said association president Hunter Rawlings III, former president of Cornell University. "We are moving to implement the results of the latest research into science and math pedagogy." While specific methodologies vary, in general, more effective STEM teaching requires the active participation of students in the classroom.

A three-phase program

The initiative aims to improve the retention of students majoring in STEM fields and to raise the level of science literacy in other students. In its draft white paper on the five-year initiative, the AAU cited research showing that of the 25% of entering college freshmen who plan to major in STEM fields, more than 40% switch to non-STEM majors by graduation. The dropout rate is 50% for the physical sciences and 60% for mathematics, the white paper said, compared with 30% for the