EV batteries to be built. In a report it released in August 2009, the Electric Power Research Institute says modeling of lithium-ion battery designs indicates that battery costs to automakers will decline to a range of $250–$400 per kilowatt hour when production volumes increase to 100 000 or more packs per year. The Electrification Coalition, an ad hoc assemblage of automakers, fleet vehicle operators, battery manufacturers, and electric utilities, says the average cost today is about $600 per kilowatt hour. "No obstacle to [PHEV and EV] adoption has been as formidable as the development of battery technology," asserts the coalition's November report.

The industry is focusing its cost-reduction efforts on three major components of lithium-ion batteries, says Ford's Miller: the separator, a microporous film typically made of a polyolefin material; the cathode materials; and the electrolyte. According to the NRC report, the electrolyte is typically a solution of lithium hexafluorophosphate salt in a solvent blend of ethylene carbonate and various linear carbonates. Finding less energy-intensive manufacturing processes also will be key to reducing costs, Miller says. **David Kramer**

Accelerator school travels university circuit

With the use of accelerators on the rise, a mobile school aims to fill in where universities fall short.

"Why do you talk so much? Why don't you do something?" That barb 30 years ago by Wolfgang Panofsky, then director of SLAC, planted the seed that Brookhaven National Laboratory researcher Mel Month quickly nurtured into the US Particle Accelerator School (USPAS). The first session was held in 1981 at Fermilab. At the time, Panofsky and Month, an accelerator physicist at Brookhaven National Laboratory, were on a US Department of Energy (DOE) committee looking into accelerator education.


Month

Now, every January and June, a two-week session is hosted by a different US university, which approves the instructors and courses and offers academic credit to participants; in 1987, the USPAS switched its courses from a not-for-credit seminar style to a more rigorous university style. Typically, 12 courses are offered per session, with a mix of two-week core courses and one-week specialty courses. For example, at the session last month, which was sponsored by the University of California, Santa Cruz, and held in San Francisco, participants could take two-week courses at the undergraduate or graduate level in the fundamentals of accelerator physics, or a laboratory course in microwave measurements and beam instrumentation. Among the one-week offerings were synchrotron radiation instrumentation and applications, accelerator power electronics engineering, and project management for scientists and engineers. "Our goal is to provide a quality graduate program for people interested in accelerator science and technology," says USPAS director William Barletta. "How to build, operate, use, design, or just be fascinated by accelerators."

Filling a gap

"The bottom line is that accelerator research and development at universities is insufficient to support strong faculty lines," says Barletta. For starters, he says, accelerator physics is an interdisciplinary field. And physics departments often don't hire in the field because of a prejudice that accelerator science is "just technology." That view was typified in a comment Panofsky made to Month before the USPAS got started: "Look, Mr. Month, the way it works is that high-energy physicists get the ideas and accelerator people implement them." In a turnaround a few years later, Panofsky told Month, "You are a hero." (To read Month's memoir about the USPAS, see the online version of PHYSICS TODAY.)

The USPAS focuses on all aspects of accelerators, but only occasionally on particular machines. "We did do specifics of the SSC [the Superconducting Super Collider, which was cancelled by the US Congress in 1993], but they were not as popular as the broader courses," says Month. For the past four years, an international group has held 10-day accelerator schools aimed at preparing for the International Linear Collider (ILC) and CLIC (the CERN-initiated Compact Linear Collider), two multibillion-dollar projects that are tending toward teaming up. Both the linear collider schools and the USPAS provide "intense academic training," says Barry Barish, who heads the ILC working group and has guest-lectured at the USPAS. "But there is only a small overlap. We are more specialized to collider issues."

CERN also runs an accelerator school twice a year, with the same aim as the USPAS—teaching what universities cannot offer. The CERN school moves among its European member nations and follows a seminar style. "The impact in Europe is huge," says Daniel Brandt, the school's director. "We train most of the people working in accelerators in Europe." In addition, some 10 European universities have formed the Joint Universities Accelerator School, which offers an annual, two-month-long undergraduate course in accelerator science. And the USPAS, CERN accelerator school, and particle accelerator laboratories in Asia and Russia have held joint programs. The last was in 2002. "We are hoping to get them going again," Barletta says.

Of the roughly 26 000 accelerators worldwide, says Barletta, only 1% are research machines with energies above 1 GeV; about 44% are for radiotherapy, 41% for ion implanters and surface modification of materials, 9% for industrial processing and research, 4% for biomedical and other lower-energy research, and 1% for making medical radioisotopes.

"Owing to the expanding need for accelerator scientists, we fight over graduates. We rob Peter to pay Paul. We try to steal employees even from other labs, even from across the ocean," says Maury Tigner, who notes that in the past couple of years, his group at Cornell University has "fought off four raids. It's pretty serious." Moreover, for the US, says Tigner, who has been involved in the USPAS from the beginning, "remaining a leader in accelerator development comes with enhanced abilities for materials science, medicine, and homeland security." Later this year, the USPAS, together with the DOE, plans to assess the total number of accelerator scientists and engineers needed across national labs, academia, and industry.

Intense, grueling, fun

The USPAS "makes a 15-week semester course into an intensive two-week course. For two weeks, you see nothing of the rest of the world," says Fernando Sannibale, a researcher at Lawrence Berkeley National Laboratory who attended several USPAS courses when he

WILLIAM A. BARLETTA

Cookie tins serve as pillbox cavities in Fernando Sannibale's undergraduate course on the fundamentals of accelerators, in the US Particle Accelerator School.

was a student in Rome and now teaches and serves on the school's curriculum committee. The two-week courses are for three credits, which typically corresponds to 45 teaching hours. The sessions are held in hotels, with three hours of lectures in the morning and another hour in the afternoon, simulations and experiments, homework and exams. "It's grueling," says Fermilab's Michael Syphers. "Every year I tell myself I won't [teach] again. But there is a six-month decay time, and I do it again. What I like about it is that we get a lot of students who are working at the national labs or in industry. They come wanting to learn, and they work very hard."

Satomi Shiraishi, a graduate student at the University of Chicago, has attended the USPAS several times, for the usual reason: "An accelerator course was not available to me at my university." In a course on medical accelerators and applications, for example, "we designed an accelerator for protons or ions and [learned] how to make it useful for treating cancer," she says. "The courses are very intense. That is part of the fun. You see these people every day and you spend evenings studying together. You become friends. Since the number of accelerator physics graduate students at each institution is small, this network is really important." Still, Shiraishi says, "I do sometimes wish there were more classes at universities, but [USPAS] is definitely a help in pursuing this field."

Indiana University offers a master's degree in accelerator science based on USPAS courses plus a thesis; eight people have completed the program since it was started in 1996. It is designed for people in the national labs and industry, says former USPAS director Shyh-Yuan Lee, who sends all of his Indiana students to USPAS courses. "There are many technicians who have only engineering degrees. If they would know a little beam physics or technology, they could become very innovative. Hopefully they get promoted and get better pay. We want people who have drive to do something, not see their work as just a nine-to-five job." Students pay about $80 per credit hour, Lee adds. "This is a minimum financial burden on them." But setting up such a master's program is tricky, Month says, because universities don't like being interfered with and they get less money per credit from USPAS courses than from their regular courses. "We went to other universities, like Stanford and Harvard, but they didn't go along with the idea," he adds.

These days, USPAS attendees are roughly split between graduate students and national lab employees, with a small number of people coming from industry. Over the years, more than 3200 people have attended USPAS courses. On average, about 150 students enroll each session—up from 130 a couple of years ago. "With more than around 140 attendees," says Barletta, "we start having trouble finding venues that are large enough and still affordable."

"High impact"

Until recently, Barletta says, "we have been able to give scholarships to every eligible student we felt was qualified. We never had to say no because there wasn't enough money." But the school's flat budget doesn't stretch as far anymore. Nine national labs, two universities, and the advanced technology office of the Department of Homeland Security's Domestic Nuclear Detection Office each contribute $30 000 a year; the DOE Office of High Energy Physics covers administrative costs; and the

labs and universities provide instructors. Meanwhile, hotels, textbooks, renting and shipping equipment, and other costs of the academic sessions are rising. "We are not in danger, but it's not as lush as it was," says Barletta, who is trying to raise more money. He notes that the number of scholarships had risen with the increased attendance, but has now had to be cut back to the previous level of about 60 per session.

No one doubts the importance of the USPAS to accelerator science. "The USPAS has had a very high impact on the field in that it makes possible the gathering of a broad range of experts that no single institution can pull together on its own," says Tigner. "Even Cornell"—one of the handful of US universities with a strong accelerator physics program—"does not have the breadth. We supply teachers. We send our graduate students, and sometimes outstanding undergraduates, to the schools."

The USPAS is "the organic result of that [lack of accelerator courses in universities]. We are supported by the labs so they get what they need," says Barletta. "A couple hundred of our former students are now intellectual leaders in the field." **Toni Feder**

Cuts to science budget moderated in Japan

Even as it breathes a sigh of relief, Japan's research community worries about the negative message the government's attack on science conveyed to the country's young people.

Last August the Democratic Party of Japan defeated the Liberal Democratic Party, which had held power for most of the past half century. The new government rode to victory with promises to make high-school education free, pay families a monthly allowance per child to encourage a higher birth rate, reduce the gas tax, and abolish highway tolls, among other things. Already in the red, the new government, headed by Prime Minister Yukio Hatoyama, who holds a PhD in industrial engineering from Stanford University, then set out to find ways to keep those promises.

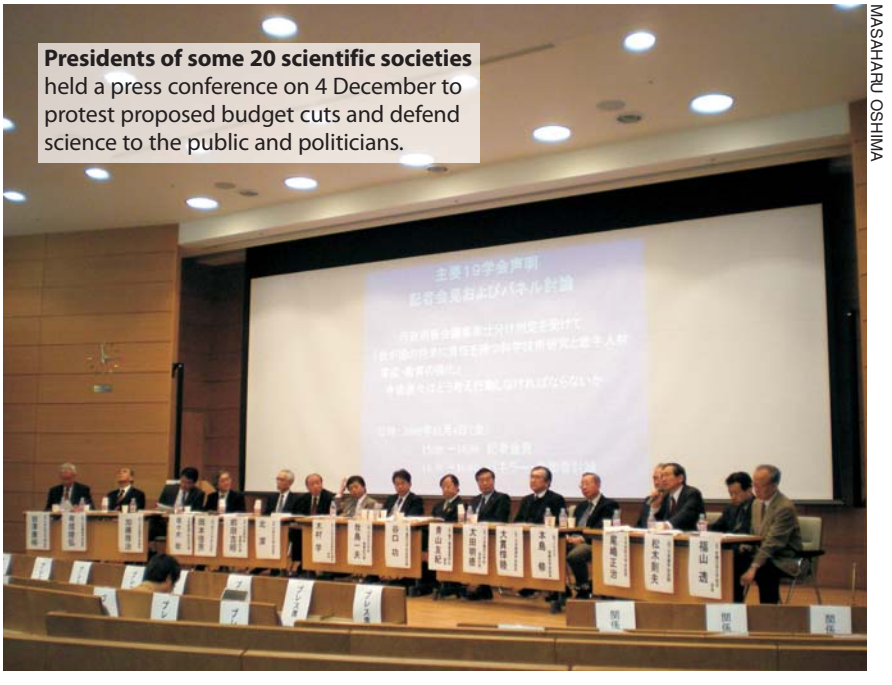
Unusual for Japan, the review process that ensued was open to the public. "I agree with the philosophy [of transparency], but it became a public torture," says Hitoshi Murayama, who splits his time between heading the Institute for the Physics and Mathematics of the Universe, a World Premier International Research Center Initiative (WPI) institute based in the Tokyo suburb of Kashiwa, and the University of California, Berkeley. In the fall, a working group of the so-called Government Revitalization Unit (GRU), a body created to carry out the review, heard presentations and then voted for termination, suspension, or reduction of funds for the next fiscal year, which begins on 1 April. "They are conducting public hearings on more than 400 government-funded programs, where a committee made up mostly of nonexperts judges the effectiveness of each program," Murayama said at the time.

Science and other funding lines in the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) got particular scrutiny, perhaps because that ministry has gained responsibility for funding high-school education and part of the child-allowance stipends. Paying for high school will cost about ¥390 billion ($4.3 billion) a year, or about 7% of MEXT's budget. In the end, the budget proposal issued by the finance ministry on 25 December steers clear of the crippling cuts that threatened science last fall, and public construction takes the brunt—with, for example, abandonment of a dam that was decades in the works. The budget is expected to get the final nod from Japan's Diet in March.

"What expense is this?"

"One of the most serious flaws I have noticed in the budget allocation process is that the evaluations of the projects in question were based on insufficient information," KEK director general Atsuto Suzuki wrote in an 8 December statement. He cited a discussion about a program within MEXT, during which a reviewer asked, "What expense is this?" A ministry official's answer was "It is a research expense for projects like Subaru [the telescope] and Super-Kamiokande [the neutrino observatory]," Suzuki wrote. "I saw the entire live stream on the Web on this issue, and know that there was only one question asked on the item during the interview with the ministry officials." Two of the reviewers voted to fund the program "as requested," six said to cut funding, and six said to cease funding, Suzuki continued.

In short order, the GRU working group recommended reducing funding by as much as 50% for the SPring-8 synchrotron light source, an ocean drilling project, a supercomputer, grants for young scientists, and the WPI, among other projects. Says Shig Okaya, a MEXT official, "It was a wide variety of people cutting the budget within a half hour. The public was fanatic about such a demonstrative, open-air debate. The screening process was very brutal, not very scientific, and focused heavily on cost and tangible return. It was like theater." Adds Murayama, "The fact



Presidents of some 20 scientific societies held a press conference on 4 December to protest proposed budget cuts and defend science to the public and politicians.

MASAHARU OSHIMA