phase collision energy. And discovering supersymmetric particles or additional Higgs states at the LHC with masses near or above 500 GeV would argue the urgency of proceeding to the linear collider's 1-TeV upgrade. "But there's little chance of getting approval for the ILC before the LHC has seen something interesting," says the University of Chicago's Melvyn Shochet, chair of the High Energy Physics Advisory Panel (HEPAP) to DOE and NSF.

Schedule realities

If all goes well, including adequate and timely funding, the GDE report concludes that ILC construction could begin in 2012 and be completed by 2019. But at a HEPAP meeting in Washington, DC, just one week after the report's release, DOE Undersecretary for Science Raymond Orbach urged a more realistic view of the schedule and worried aloud about its consequences.

"Negotiating an international structure, selecting a site, obtaining firm financial commitments, and building the machine," Orbach warned, "could take us well into the mid-2020s, if not later." Fermilab's Tevatron and SLAC's B factory are scheduled for shutdown by 2010. So Orbach's prognosis would leave the US particle-physics community without a collider for at least 15 years. In that light, he urged the community to come up with a productive program of lesser initatives to fill the uncomfortably long gap.

Barish looks at Orbach's protracted schedule as a "useful kick in the pants." He responds that "finishing the ILC before the end of the next decade will require, in parallel with the engineering design work, a major effort to organize the international collaboration, divide up responsibilities, and get commitments from governments."

Bertram Schwarzschild

Industry supplants academia as career of choice

From the 1940s through the 1980s, most physicists entering the job market snapped up positions in academia, shunning industrial posts, but that trend reversed itself by the early 1990s.

The days when a newly minted physicist automatically sought his or her first job at a college or university, expecting to conduct academic research, publish papers, teach, or do all three, are over. Today that physicist is far more likely to find work in industry, where his or her job is tightly linked to developing commercial products.

That's one of the findings that has surfaced from 134 interviews with physicists working at 14 large corporate labs across the US. Conducted by the American Institute of Physics's Center for History of Physics, the History of Physicists in Industry (HOPI) project, which concludes this December, sought to determine the nature and extent of physics-related record-keeping at domestic corporations and institutions, but the project expanded to include questions on physicists' career paths and the infrastructure of industrial R&D, among other issues. This summer the HOPI staff plans to publish preliminary findings and recommendations on how individual and corporate labs can preserve records that document physicists' contribution to innovation.

Physicists interviewed—who ranged in age from mid-30s to early 80s—said that through the 1970s, academia was considered the career of choice for physicists entering the job market. Those who chose industrial work over pursuing a job in a university setting typically had either a personal tie to the company that hired them or an offer to work at one of the few industrial labs in the US where academic-style research was then encouraged.

Trained for academia

Jim Hollenhorst, senior director of intellectual property strategy at Agilent Technologies Inc in Santa Clara, California, earned his PhD in physics in 1979 from Stanford University, where he learned he would be expected to look for work in academia after completing his degree and postdoc.

"There were two places in industry where you could hold your head up high: Bell Labs and IBM," Hollenhorst said. "They were OK because they were enough like academia. Any other job would have been frowned upon."

Hollenhorst later accepted an offer from Bell largely because of its research-oriented culture, but also because of a better salary and the fact he would be working on products that might be helpful to many. "I could have my cake and eat it too," he said.

Through most of the 1980s, HOPI staff found, academia remained the career of choice. Still, an increasing number of physicists entering the job market chose to seek work in industry, citing higher salaries as an important factor. By the 1990s, things had changed: More physicists wanted to and did work in industry than in academia. That trend continues today.

The HOPI findings agree with a 2001 NSF report (http://www.nsf.gov/statistics/issuebrf/nsf01332/sib01332.pdf). According to the NSF document, more than one-third (36%) of physicists who received PhDs from 1946 through 1965 were working in industry in 2001, while almost half (49%) had jobs in academe. For physicists entering the job market in the late 1990s, the numbers invert. Of those who earned PhDs between 1996 and 2000, more than half (57%) were working in industry in 2001, while less than one-third (31%) had academic positions.

Charlie Duke, retired vice president of Xerox Corp and a research professor of physics at the University of Rochester in New York, said an erosion in federal funding for both academic research and instruction in the physical sciences has been a driver of the shift in physicists' career choices. Those dollars, he said, are now being directed toward research on treatment of illness and disease.

"Fifty years ago when I started off, Russia had just tested the thermonuclear bomb and launched the first space satellite, so physics was hot. Everybody was pouring money into physics because it was important for defense," explained Duke, who was interviewed as part of the HOPI project. "It was a time when physics was clearly vital to the economic and defense future of this country. That's still true, but it's not so well appreciated. The situation has evolved—today biotechnology and information technology are the superstars."

Research product

But like Hollenhorst, many others interviewed for the HOPI project also cited their wish to be involved in developing commercial products—tools, appliances, devices—that could help people or simplify their lives in some way. Doug Allan, a senior research associate in the glass research department at Corning Inc in Corning, New York, said that going into academic research, where the principal product is a published paper with little influence outside of the academic realm, would not be as satisfying.

"I became disillusioned and frustrated with the lack of interest in the results of theoretical work. I felt the calculations my colleagues and I were

Joe Anderson of the American Institute of Physics's Center for History of Physics interviews Darlene J. S. Solomon, chief technology officer and vice president of Agilent Laboratories, in Santa Clara, California. Solomon was among 134 physicists working in industry who were interviewed by staff from the history center for its History of Physicists in Industry project.

doing were only being read by colleagues of like minds but not by people who needed to know—people who were inventing materials and chasing after [commercial] opportunities," said Allan, who earned his PhD in theoretical physics from MIT in 1982 and started at Corning in 1984.

"At first I thought I'd go into industry for four or five years and then go off and teach somewhere. But I was really enjoying what I was doing. If you like to see your ideas get incorporated into something that affects society, this is fun," Allan said.

Depending on the company, collaboration with universities may or may not be a goal, the HOPI project found. Some physicists interviewed said their employers don't like to collaborate with universities because it slows the R&D process. In the academic setting, once a research project has been funded, there is little of the financially driven urgency found in industry to finish the research, develop the product, and get it into the market, said HOPI project historian Orville Butler.

"The corporate need to make a profit runs counter to the academic need to publish information. . . . Some [interviewees] said that within a company, they have weekly schedules. If you don't accomplish your [development] goal, you have to address that. In academia they've got their funding and they don't have a concept of making a profit," Butler said.

Another deterrent to such collaborations is academia's requisite to publish research results. "Academics want to publish papers, but that might fly in the face of [industry's] proprietary requirements," Butler said. He noted that at one company, several physicists who were recently completing postdocs had to delay publishing their papers for a couple of years until the company secured patents on their research.

Still, universities sometimes have instruments or know-how that industry wants, said Allan. "There are areas where we don't want to do [the research] all ourselves, so it makes sense to get a university involved. You just know that if you expect to get work out of a university, it will take longer."

Lab location

Whether a company locates its research labs close to its manufacturing plants depends on the purpose of the research, according to the HOPI findings. Proximity of research to manufacturing, according to Duke, is particularly desirable when research is aimed specifically at creating new products or businesses for a firm. But companies whose main goal is to improve established product lines favor placing their research labs close to their plants. Butler said some interviewees argued that proximity to a plant allows plant staff to feed manufacturing skills, knowledge, and problems back into the research operation.

"It's always best to have people close together who are working on the same problem. That's when the best innovations come, when people from different backgrounds and with different approaches work together," said Hollenhorst.

Complicating the need to have people

from different disciplines working in close proximity is the ever-broadening global economy, respondents pointed out. Many companies believe it's important to have a presence in the non-US markets where they are selling products. That requirement could strain a company's financial resources. But electronic communications have made it easier to establish and maintain that presence without unduly increasing costs, some respondents said.

"Generating successful new products requires the combination of input from both customers and researchers in order to ensure that the products truly meet customer needs," said Duke. "In a global economy, this requires global research facilities housing collaborative groups that typically communicate via the internet."

For more information on the project, contact Joe Anderson at janderso@aip.org or Orville Butler at obutler@aip.org.

Karen H. Kaplan

Interim sites for spent nuclear fuel are of limited value

With the future of nuclear power in the US linked to the resolution of what to do with thousands of tons of radioactive waste at commercial nuclear reactors, a new American Physical Society report concludes that moving the spent fuel to interim storage sites offers no significant economic, safety, or security benefits if the planned permanent waste repository at Yucca Mountain, Nevada, isn't substantially delayed.

With waste piling up at the 103 operating US nuclear reactors and the future of Yucca Mountain legally and politically stalled, pressure has been mounting from some members of Congress and the nuclear industry to develop a system of interim storage sites.

But according to the APS report, *Consolidated Interim Storage of Commercial Spent Nuclear Fuel*, "there are no technical barriers to long-term safe and secure interim storage of spent nuclear fuel" at the nuclear plant sites where it now resides. The report also says that consolidating the spent fuel at several regional interim storage sites "would not significantly change the overall safety and security risks associated with its storage."

The report was released just as the US Department of Energy offered a new legislative proposal to Congress in hopes of advancing the long-delayed development of the Yucca Mountain repository. The DOE proposal, sent to Capitol Hill by energy secretary Samuel Bodman, would allow the federal government to take control of the land around the mountain, eliminate the 70 000-metric-ton cap on disposal capacity, and streamline licensing procedures. DOE officials have said they hope to have the repository operating by 2017. (See PHYSICS TODAY, May 2006, page 25.)

But Yucca Mountain faces two significant hurdles. Senate majority leader Harry Reid is from Nevada and has repeatedly said he will not allow the federal repository to open in his state. And still unresolved is a 2004 US Court of Appeals ruling against a 10 000-year groundwater safety standard the Environmental Protection Agency had set for Yucca Mountain. That standard was about 290 000 years short of the time a National Academy of Sciences study said the radioactive waste would be dangerous.

Former Nuclear Regulatory Commission chairman John Ahearne, who cochaired the APS study with the University of New Mexico's Roger Hagengruber, said the report doesn't tie its recommendations or conclusions to Yucca Mountain other than to note that "there are no compelling cost savings . . . so long as Yucca Mountain is not delayed well beyond its currently planned opening." The report concludes that "there is sufficient space at all operating nuclear reactors to store all spent nuclear fuel in pools and in existing or additional dry casks." That storage space is sufficient to last "for the duration of the plant licenses," the report says.

Although interim storage sites can't be justified on economic, safety, or security grounds, the report notes that "consolidated storage could facilitate the decommissioning of sites with reactors that have been shut down." Ahearne said that nine sites could be completely decommissioned if the stored spent fuel could be removed, "but how valuable that is, we didn't try to assess."

Another positive effect of interim storage sites, the report says, is that "their implementation would establish a process for taking Federal title to commercial spent fuel and decouple private sector nuclear power plant operators from the long-term spent-fuel management problem." That would remove "a potential obstacle to siting new nuclear power plants and to continued operation for existing plants."

Steven Kraft, director of used fuel management for the Nuclear Energy Institute (NEI), said the report's conclusion that interim storage could help clear the way for construction of new nuclear power plants "was the real headline." Kraft, who made a presentation to the APS study group as the report was being developed, said he took exception to the report's conclusion that interim storage would provide no "compelling economic benefit" if Yucca Mountain opens on time.

Kraft said the federal government was supposed to take possession of commercially generated spent fuel in 1998, "and they are nine years behind." Given the federal record on spent fuel and the political and technical problems that plague Yucca Mountain, few involved in the nuclear industry believe the repository will open by 2017. But that aside, Kraft said, "only if you look at interim storage in the narrowest sense, of one spent fuel storage site versus another, can you say there is no economic benefit. If you put [interim storage] in the context of keeping existing plants running and enabling the building of new ones, then there is significant economic benefit. What [NEI is] trying to do is create conditions in which new plants can go forward."

Although currently no efforts in Congress are under way to create interim storage facilities, Senator Pete Domenici (R-NM) included language in a report that accompanied an energy and water appropriations bill in the last Congress that would have forced states with commercial nuclear reactors to create a "separate facility within the state or at a regional facility" to store spent fuel. The bill wasn't successful, and the problem of what to do with the spent fuel remains.

Ahearne spent much of March briefing members of Congress and officials from the Nuclear Regulatory Commission and DOE about the study.

Jim Dawson

Campaign aims at scientists and engineers

For physicist and US Representative Rush Holt (D-NJ), the decision in 1998 to leave his job as assistant director of the Princeton Plasma Physics Laboratory and run for Congress wasn't too surprising. His father, Rush Dew Holt,