to build beam lines, about \$30 million of which came from industry.

APS's original (1987) total budget estimate was \$800 million. With primary funding provided by the Department of Energy, the total project cost—which includes preconstruction research and development, and operating costs during construction—now stands at \$811 million. Of that amount, APS's projected total construction (capital) budget is \$467 million, which is only 2% more than the figure predicted in 1987. Moncton explained that Congress had decreased some yearly allocations for APS below the planned budget profile, necessitating later spending increases. Still, increased efficiency actually would have brought the project in under both the original and the revised budgets, but DOE recently authorized the \$18 million "underrun" to be spent on additional beam lines and user laboratories.

'Stuff you can hold'

Ednor Rowe, associate director of accelerator development at the Synchrotron Radiation Center at the University of Wisconsin, told us that "APS will make possible experiments that would not have even been considered previously" because the low intensity of most existing beams—typically four orders of magnitude less brilliant than APS's—severely limits analysis of complex materials. When asked to define the expanded scope of materials science afforded by APS, Moncton said, "Stuff you can hold in your hand, as opposed to quasars or quarks. We're in the ten orders of magnitude between about a tenth of an angstrom and a centimeter. I'm talking about polymers, superconductors, catalysts, genes, drugs, viruses and other complex things that require these higher-intensity beams to deduce the structures—the simple structures have been solved."

Unlike the electrons that France's ESRF accelerates to make its hard x rays, APS's positrons clear the path when they run into the occasional ion lurking in the near vacuum. (Plus, their use essentially eliminates a set of nonlinear, ion-related instabilities that could lower efficiency.) APS also accelerates these positrons to an energy higher than ESRF's electrons. "Those two things," said Moncton, "should give us a significant advantage in generating high-energy x rays, say, above 20 keV."

Moncton and others predict that these high-energy x-rays will provide great new capabilities in materials science. Until such predictions are tested, however, much of the talk is excited speculation: For the most part, these photons simply haven't been available previously.

The 10% solution

With memories of the Superconducting Super Collider and its rapidly increasing budget still vivid, one is inclined to ask, How was this big-science project completed according to the original plans? Among a variety of factors, Moncton singles out DOE's providing "a healthy budget for preconstruction research and development," which allowed the APS project—in distinct contrast to earlier synchrotron projects—to build prototypes of all the critical elements in advance.

Moncton also said that the APS administrators relied on experienced scientists and managers who, recognizing at the outset that they could not eliminate problems, instead strove to keep problems "small" and their solutions manageable. The reasoning, according to Moncton, was that so long as solutions took only a small fraction, say less than 10%, of total project personnel and financial resources, they could be handled within schedule and budget contingencies without derailing other project activities. For example, when APS workers found leaks in some of the machine's linac waveguide flanges (which were designed with an old technology), they fixed the flanges temporarily; eventually the devices will be replaced.

Hard x rays abroad

ESRF, in Grenoble, France, is the only other operating synchrotron light source comparable to APS. (Another hard-x-ray source is being built in Japan.) ESRF, which began commissioning its accelerator in 1992, greeted its first users last September. Fifteen beam lines are now being used, with seven more scheduled to come on line by the end of the year. ESRF has exceeded its initial design goals in intensity—the current is now 175 mA—as well as in current lifetime, which is 30 hours for a 5-mA single bunch; in emittances, which are 3.8×10^{-9} m rad horizontal and 3.8×10^{-11} m rad vertical; in stability, which is 1% horizontal and 10% vertical; and in brilliance, which is 2×10^{19} photons s^{-1} mm^{-2} $mrad^{-2}$ per 0.1% wavelength interval at 1 Å from a 1.6-meter-long undulator.

In Pohang, South Korea, six and a half years after the genesis of the idea and two months ahead of schedule, the Pohang Accelerator Laboratory has completed construction of a 2-GeV electron synchrotron light source. PAL Director Tong-Nyong Lee told PHYSICS TODAY that the Pohang Light Source can best serve those experiments that require vacuum ultraviolet light and x rays up to 12 keV.

Dedicated in December, PLS cost the equivalent of about \$190 million, 60% of which came from the Pohang Iron and Steel Company and the remaining 40% from the Ministry of Science and Technology of the Korean government. The facility will accept its first outside users in July.

The PLS was constructed with two beam lines, one for x rays and the other for vuv applications, but part of this year's operating budget of about \$17 million will go toward the construction of three new lines, expected to be completed by the end of 1995. One of the new lines, for x-ray lithography, is the first at PLS to belong to an industrial user, Gold Star Electron Company. This summer the laboratory hopes to raise the electrons' energy to 2.5 GeV.

DENIS F. CIOFFI

CEBAF to Begin Probing the Nucleus with Electrons

The first experimenters will shortly be shooting 0.5–4-GeV electrons into nuclear targets at the Continuous Electron Beam Accelerator Facility, in Newport News, Virginia. A gleam in physicists' eyes in the 1970s, CEBAF became part of a Department of Energy long-range plan in 1979, was approved in 1983, and began to be constructed in 1987. According to David Hendrie of the Office of Energy Research in DOE's division of nuclear physics, in 1991 CEBAF's budget was "re-baselined," with new accounting procedures that then predicted a total project cost of about \$515 million. Four years later, the project is being completed on time and within that budget. (See PHYSICS TODAY, August 1993, page 17, for a detailed description of CEBAF.)

The combination of a continuous electron beam—rather than a pulsed beam—and fixed targets—instead of colliding beams—will allow CEBAF experimenters to investigate quarks and gluons in great detail. The facility has marked its scientific mission with three primary goals:

▷ to elucidate the quark and gluon structure of the proton and the neutron
▷ to understand the structure of the nucleus at the quark level
▷ in support of the first two goals, to

discover new phenomena, such as states involving gluonic excitation.

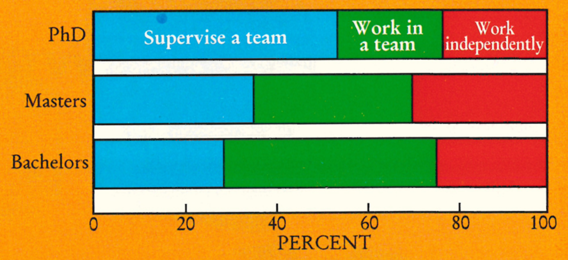
The latest research-proposal review, completed in February, brings the number of approved experiments to 76, with more than 500 participants from 20 countries and more than 100 institutions. Because these experiments will investigate the internal particle structure of protons and neutrons, John Domingo, associate director for physics at CEBAF, says that the distinction between nuclear and particle physics is "now rather arbitrary," reflecting a maturation of both science and technology.

In explaining the ability to keep to the revised budget and schedule, CEBAF Director Hermann Grunder said that the project's built-in contingencies were tight but realistic, and that the scientists recognized "that as much as you might like, there are things you can't do" if you expect to stay within the budget. For example, users wanted a high-powered (500–1000 watts) cryogenic target but will have to settle for 250 watts, at least in the early days.

Hendrie said that he expects "great physics" from the new machine. Further information about CEBAF can be found on the World Wide Web at http://www.cebaf.gov/.

Stat of the Month

Environment of industrial physicists by highest degree

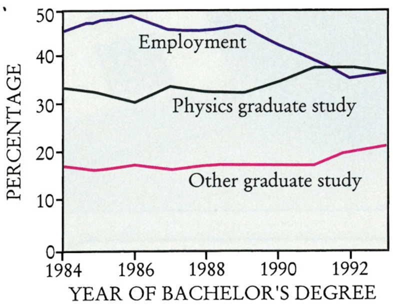


Three-fourths of physicists employed in the private sector either work in teams or supervise a team. Half of those who work independently report that customer and client contact is a significant responsibility. In general, physicists in industry use interpersonal skills extensively and report that working with people is among the most rewarding aspects of their jobs.

Source: AIP Education and Employment division (stats@aip.org).

Report Shows Directions of 1992–93 Physics Bachelors

The latest study from the education and employment statistics division of the American Institute of Physics reports an end to the decline in the percentage of physics bachelors going directly into employment. This change is illustrated by the accompanying graph, taken from the "1992–93 Bachelor's Degree Recipients Report," by Patrick J. Mulvey. Tying the work to findings from other surveys, Mulvey told PHYSICS TODAY that he expects a continuing increase in the percentage choosing the job market after obtaining an undergraduate degree.



POSTBACCALAUREATE PLANS of physics bachelors, 1984–93. The number of graduates has remained relatively flat, averaging about 4900 since 1984.

The report, which contains other statistical information about 1992–93 physics and astronomy graduates, may be obtained from AIP, Education and Employment Statistics Division, One Physics Ellipse, College Park MD 20740-3843. Single copies are free, and multiple copies may be provided on request.

Despite Sabotage, LEP Expected on Schedule at CERN

During the weekend nights of 11–12 February, a technically sophisticated staff member at the European Laboratory for Particle Physics surreptitiously removed about 1300 electronic components from the control systems of CERN's Proton Synchrotron and Proton Synchrotron Booster. According to news accounts of the event, the employee initially demanded that his ex-wife, who also works at CERN, be fired. The culprit admitted his actions early on the following Monday morning, and after several days' searching the missing equipment was found on the site, undamaged.

CERN management reports that reassembly is proceeding well. Although the formal start-ups of the machines themselves will be delayed one or two weeks, the PS is already accelerating protons, and the program of the Large Electron Positron collider "will almost certainly go ahead on schedule," according to CERN Director General Christopher Llewellyn Smith.

The two accelerators had been down since mid-December for routine maintenance and upgrading, and the sabotage caused no additional equipment damage or danger to personnel. Reattachment of the many disconnected cables—more than 5000 in the PSB alone, with some 200 actually cut—means that careful readjustment and calibration will be necessary.

Dupree Will Lead AAS in 1996

As of 1 June, Andrea K. Dupree will be the president-elect of the American Astronomical Society. After completing a one-year term in that position, she will serve a two-year term as AAS president. Dupree, who holds a PhD from Harvard University, is a senior astrophysicist at the Smithsonian Astrophysical Observatory, part of the Harvard–Smithsonian Center for Astrophysics.

In other results of the AAS election, Neta A. Bahcall of Princeton University was elected to a three-year term as vice president, and Arlo U. Landolt of Louisiana State University was elected AAS secretary. The three newly elected councilors are Leo Blitz (University of Maryland), Jeffrey L. Linsky (University of Colorado) and Anneila I. Sargent (Caltech). Jason A. Cardelli (Villanova University) and Derck Massa (Applied Research Corp) were elected to the nominating committee. Patrick S. Osmer of Ohio State University was nominated to serve on the US national committee of the International Astronomical Union. ■