

Epitaph for Aladdin: Is its end, like Mark Twain's, premature?

The decision by the National Science Foundation in early June to disconnect from the Aladdin light source at the University of Wisconsin's Synchrotron Radiation Center near Stoughton is characterized by NSF's director Erich Bloch as "regrettable but inevitable." Bloch's action was as traumatic as issuing a death certificate. "Just about everyone connected with Aladdin is affected—the university, NSF, the users, the whole synchrotron radiation community," says Bloch. "It's a high-risk project that just didn't work out. That's sad, but we need to be realistic: If we hang onto a project that's in trouble for too long, we may foreclose all our options for doing something better in the future."

The decision means that NSF also has pulled the plug on a three-year plan to spend \$25 million upgrading the performance of Aladdin, which still doesn't shine brightly enough after four years of adjustments. NSF, having already spent nearly \$11 million on the facility since 1977, will cease its support at the end of this fiscal year on 30 September. The agency stopped paying for capital equipment for Aladdin on 1 July. NSF's budget for the machine in fiscal 1985 alone is \$3.2 million, largely representing efforts to modify the injector microtron to provide higher instantaneous current, to improve the radiofrequency system to intensify the beam, and to stabilize the beam itself. The budget request for Aladdin in fiscal 1986 is about \$3.5 million, which NSF presumably will now spend in other ways—though some of the money, according to Bloch, will go toward relocating Aladdin's users at other synchrotron light sources.

Upgrade study. Only last December, the chancellor of Wisconsin's Madison campus, Irving Shain, who had been named principal co-investigator by NSF a few months earlier, informed the facility's users that the agency endorsed the idea of upgrading Aladdin. Then came a five-month upgrade study and two short reviews in rapid succession that identified Aladdin's problems last May as far more serious and costly than anyone had imagined. After reading the panel reports and

talking to accelerator experts, Bloch concluded that Aladdin wasn't likely to achieve the magical glow that its legendary name suggested.

On 20 June, Bloch informed the National Science Board, NSF's policy-making body, of his verdict. "There were no cheers, but there were no tears either," he recalls. Bloch's action came just as the Department of Energy's Energy Research Advisory Board was reviewing last year's report by the National Research Council on *Major Facilities for Materials Research and Related Disciplines* (PHYSICS TODAY, September, page 57), which recommended that the government should give high priority, among several projects in materials sciences, to constructing two synchrotron radiation facilities—a 6-GeV machine producing maximum brightness in the 10-keV region, where most x-ray research is performed, and a 1–2-GeV storage ring with insertion devices that would provide optimal flexibility for vacuum ultraviolet and soft x rays. In proposing this, the Research Council committee, headed by Frederick Seitz of Rockefeller University and Dean Eastman of IBM, had endorsed the conclusions of a DOE *ad hoc* panel, led by Peter Eisenberger of Exxon and Michael L. Knotek, then at Sandia National Laboratory. Several months earlier, the Eisenberger-Knotek committee had unanimously agreed that "steps be taken to assure the timely completion of NSLS [the National Synchrotron Light Source at Brookhaven] and SRC [the Synchrotron Radiation Center at Wisconsin]." Only then, concluded the Eisenberger-Knotek report, should the government undertake building a 6-GeV facility, followed by a 1–2-GeV light source (PHYSICS TODAY, February 1984, page 48).

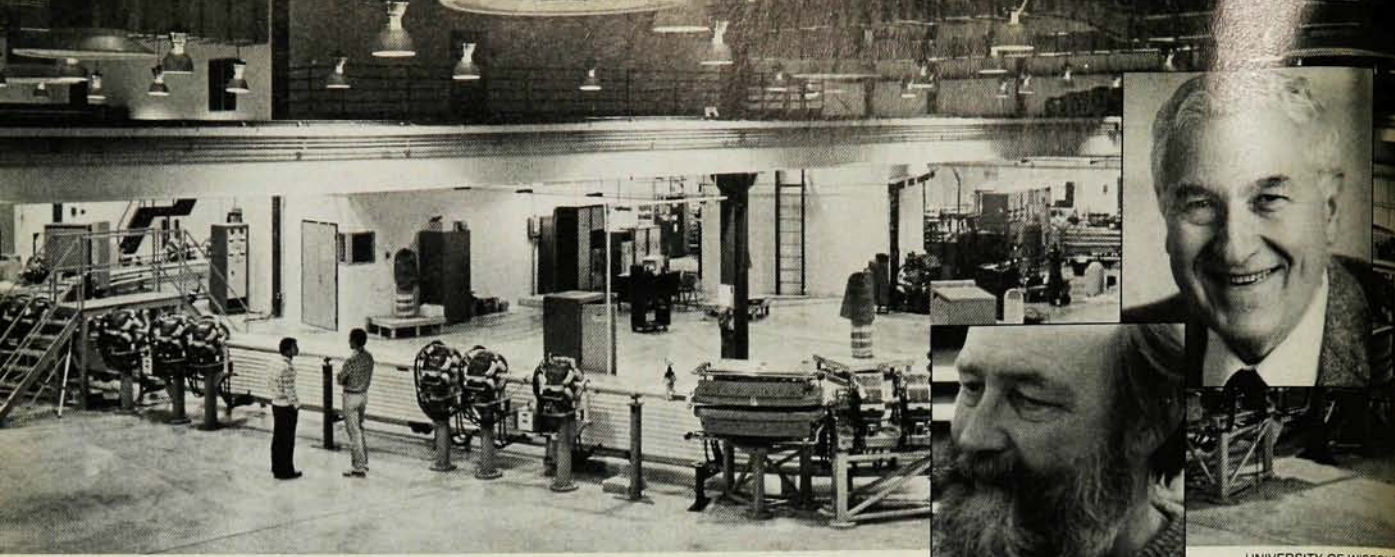
By last May, however, the situation had changed. At that time, as ERAB chairman Ralph S. Gens wrote to DOE in conveying his board's report, Aladdin's adversity was well known. Accordingly, Gens argued, the proposed 1–2-GeV synchrotron project becomes "more urgent." Gens's letter included a warning that DOE should not repeat the mistakes NSF made with Aladdin.

If DOE proceeds with a new synchrotron radiation facility, wrote Gens, it is acutely important that "a soundly conceived program of pre-construction R&D be carried out prior to a commitment to build [and] it is equally important that the project be carried out with a solid knowledge of cost, schedule and anticipated performance."

ERAB's cautionary note is exactly right in retrospect, says John P. McTague, deputy director of the White House Office of Science and Technology Policy. A UCLA chemist who ran NSLS at Brookhaven from 1981 until he came to Washington in 1983, McTague admits to bearing "deep scars" received "through excessive optimism that these machines can be built and operated with considerable ease." Aladdin, he claims, "isn't worth saving if we figure the costs and delays ahead, along with the uncertainties of its performance. For \$18 million, or what it would take to ensure the kind of machine that researchers want to use, we could get a good start on a world-class 1–2-GeV facility that might be built at a total cost of around \$70 million."

'Lessons of Isabelle.' Unfortunately, asserts McTague, Aladdin's failure to live up to expectations "doesn't help at all in winning approval from Congress" for an expensive new project in a period when the number 1 budget priority is reducing the nation's huge fiscal deficit. "We are likely to hear declarations on Capitol Hill," he says, "about the 'lessons of Isabelle'"—a reference to Brookhaven's half-finished Colliding Beam Accelerator, which the DOE killed in 1983 on the advice of its High-Energy Physics Advisory Panel and OSTP after spending some \$190 million (PHYSICS TODAY, December 1983, p.41).

Epitaphs for Aladdin from Washington notwithstanding, Wisconsin's Shain prefers to think, as Mark Twain said about reports of his death, that the account of the facility's untimely end is exaggerated. Though the university is not prepared to pay for the proposed upgrade, it is committed, says Shain, to continue operating and improving Aladdin through next June out of research endowment funds and user



Aladdin light source has been the object of many studies since 1983, when its beam current failed to reach the intended value. Since then, University of Wisconsin chancellor Irving Shain (top right) became co-investigator, while its designer, Ed Rowe, raised the beam current.

contributions. The intention is to demonstrate by then that the machine is reliable and useful to researchers, even if its light is still less intense than once advertised.

A group of principal users, from Argonne, Iowa State and the University of Wisconsin, among others, gathered at Aladdin on 22–23 July to decide for themselves how the machine performed. But the true test of Aladdin will come next October, when the users' advisory committee, headed by David W. Lynch of Iowa State University, who served briefly in 1983 as Aladdin's acting associate director, meet to examine and evaluate the facility. "It's our expectation," says Shain, "that Aladdin will be the premier light source in the country."

Aladdin has already lived up to one expectation. As a prominent character in *The Arabian Nights*, Aladdin is known as "obstinate, disobedient and mischievous"—a striking likeness to Wisconsin's cantankerous electron storage ring. Aladdin got its start in 1977, a year after it was championed by a National Research Council report on the need for facilities dedicated to synchrotron radiation. From the outset, the light sources at Wisconsin and Brookhaven were on similar construction schedules. But when the Brookhaven facility began operating in 1981, Aladdin was nowhere near ready.

MURA's last gasp. While the concept for Aladdin was original, it was based on experience gained in building and running a smaller 0.24-GeV storage ring named Tantalus, the last gasp of the Midwest University Research Association. In the 1950s, when MURA had grand illusions of becoming a rival to Brookhaven and Berkeley in accelerator physics, Tantalus was designed by a team under Ednor Rowe of Wisconsin. Set among neat cornfields, it became

the centerpiece of Wisconsin's Synchrotron Radiation Center. Rowe, who became director of Tantalus and the Radiation Center, rightly reasoned a decade later that the next logical development was a ring of higher energy and brightness.

During that decade, however, Tantalus was plagued by indifference. Before it went out of business, the Atomic Energy Commission handed over its sponsorship to the Defense Advanced Research Projects Agency, which turned it over to the Air Force Office of Scientific Research, which tossed it to NSF in 1974. So, when Rowe conceived Tantalus II around that time, he approached NSF. Unsure of itself as the patron of a large facility, NSF decided against the idea and, instead, took the more cautious and less costly approach of establishing some experimental stations around an already existing high-energy storage ring at Stanford. But a few years later, at the urging of the materials sciences community to establish additional x-ray facilities, Stanford and Brookhaven vied for funds to expand. Undaunted by the opposition, Rowe proposed that Wisconsin should concentrate on serving the ultraviolet research community. Aladdin was designed with this in mind.

Rowe's proposal to NSF in 1976 called for only two straight sections in a storage ring capable of holding electron current of 100 mA and energy of 750 MeV for more than a hour's running time. It estimated the commissioning of the facility in 1981 at under \$5 million. With that price tag, even then, it seemed like a shoestring operation, but an NSF peer group termed the proposal "outstanding." As NSF was preparing its fiscal 1978 budget request for Aladdin, the agency concluded it wouldn't be any more expensive to build a square machine with four long

sections laid out with rounded corners. At each corner, three dipole magnets would bend the electron beam into the curved trajectory required for synchrotron radiation, which would be emitted from 36 ports, three in each bending magnet. The intense light from each port could be divided and shared by three beam lines that channel the radiation to experimental stations. Later on, the straight sections could take on special insertion devices (wigglers) for producing x rays.

Frail shoestring. Right from the start, though, the shoestring was too frail for Aladdin to be off and running. In Aladdin's first years, 1978 and 1979, the nation began experiencing double-digit inflation, causing steep cost increases for building materials and scientific equipment. The cost of the foundation and shell for the Synchrotron Radiation Center, estimated at \$600 000, to be shared by the university's research fund and Wisconsin's State Building Commission, shot up to more than \$1.3 million. The university scraped up another \$350 000. The rest came from Aladdin construction funds. "It was painful," says Rowe.

To satisfy NSF that he was keeping costs to a minimum, Rowe omitted some equipment that accelerator physicists considered essential, even then. Among the apparatus left out were diagnostic instruments to monitor the position of the beam in the storage ring and a cooling vacuum chamber. Their absence were later to prove critical in the misbehavior of Aladdin.

The university viewed Aladdin as a fairly low-priority in-house project. All its business was done through the Physical Sciences Laboratory, which is widely recognized as a "job shop." As such, Rowe needed the lab's approval for virtually everything, and the lab, in turn, proved stingy with NSF's money

to convey an image of fiscal prudence. As a consequence, Aladdin's staff was kept purposely small to hold down costs. When additional physicists and engineers were needed, they would come either from the lab or not at all. Rowe lost his innocence during his first two years with Aladdin.

Beam users. Fortunately for Aladdin, most beam lines and experimental stations, which can cost as much if not more than the storage ring, were built and paid for by its outside users, following a practice initiated by Brookhaven with participating research teams, or PRTs. At Aladdin, the Canadian National Research Council is one of the PRTs. The others are from US universities and national labs. In exchange for providing and maintaining beam lines and end stations, the PRTs get unrestricted use of about 75% of Aladdin's running time. The rest of the time, the general user community has access to the instruments.

In one central technical detail, Aladdin is a departure from other large electron storage rings. Others possess a small linear accelerator and a booster synchrotron, because no storage ring is capable of accelerating an electron beam from zero energy to 1 GeV or more. Aladdin, by contrast, has a racetrack microtron, similar in design to Tantalus's electron injector. The microtron, as the name suggests, drives the electrons in racetrack-shaped orbits. As the energy increases, the size of the orbit increases, as in a cyclotron, but rather than being spiral-shaped, the larger racetracks have one straight section in common. After 20 orbits, electrons at energies of 0.1 GeV are squirted into Aladdin. When a sufficient number of electrons are pumped in to reach the design current of several hundred milliamperes, Aladdin is supposed to take over and boost the beam to its top energy.

This is where the trouble arises. Until this year, Aladdin had accumulated and accelerated currents of only 2.5 mA to an energy of 0.75 GeV. Attempts to store significantly larger currents resulted in the loss of the entire beam. It is well understood that electron beams are more subject to instabilities at low energy than at high, where the emission of synchrotron radiation is more intense, which calms the beam considerably. One of Aladdin's troubles lurked amid ions trapped in the beam, a situation that plagued the Brookhaven light source, but is now being resolved. Although more clearing electrodes were installed in Aladdin, the effects of trapped ions are more severe than at Brookhaven because the beam accumulates more slowly.

By the spring of 1983, Rowe and his coworkers were vexed with Aladdin. So were officials at NSF, which had

heretofore taken a rather lackadaisical attitude about the facility. Then, confronted by a Wisconsin proposal for a three-year renewal, Marcel Bardon, acting assistant director for mathematical and physical sciences, and Lewis H. Nossanow, director of materials research (the division that oversees Aladdin), ordered a technical review of the machine and a scientific review of proposed research. The two review panels agreed in their findings: There appeared to be no design flaws that prevented Aladdin from working; the scientific justification for its completion and operation was strong; but significant additions in staff and resources were essential, along with changes in its management structure.

The university's initial response was to become more directly involved. It took the Synchrotron Radiation Center out from under the Physical Sciences Lab and made it a separate unit in the graduate school. It organized an executive committee of university scientists to oversee the facility and began searching for qualified accelerator physicists and engineers. It soon discovered what national laboratories and other centers had already known—that there is a critical shortage of US accelerator physicists, with only Cornell University predominant in producing postdocs. (The scarcity of accelerator scientists is attributed by many to the lack of cachet and opportunities in a profession that prizes theoreticians and experimentalists.)

Revolving door. Rowe was freed of administrative chores to become assistant to Aladdin's director, and Keith Symon of Wisconsin was elevated to acting director while Shain and the executive committee continued looking for permanent managers. After Symon suffered a mild heart attack, the facility seemed to have a revolving door for acting directors and associate directors. After several weeks as acting director, David L. Huber, another Wisconsin physicist, recently was named director, and the university has widened its search for accelerator experts. "There's an element of a chicken-and-egg problem here," says Knotek, newly named director of Brookhaven's NSLS. "Aladdin desperately needs additional talent for NSF to commit itself to the project, but the right people have been reluctant to join Aladdin until NSF or some other agency makes a real commitment."

Last September, Bardon and Nossanow, with several more reviews in their hands, gave Bloch, newly arrived as NSF director, a full briefing on the situation. One of the options they offered was to terminate Aladdin. The most recent review at the time found Boyce McDaniel of Cornell and Ewan Paterson of SLAC agreeing that the

only sure way to attain 100 mA or more was by full-energy injection. Bloch consulted Alvin W. Trivelpiece, DOE's director of energy research, and together they decided on another round of reviews, involving three panels of management teams and accelerator experts. To some at Wisconsin, it looked as if Aladdin was being reviewed to death.

One panel, consisting of accelerator experts from Argonne, Berkeley and SLAC, along with Wisconsin people, devised an upgrade proposal that called for \$18.1 million for equipment, plus about \$7 million for operations over the next three years. In the end, the panel reported, Aladdin would be expected to achieve 100 mA at 0.8 GeV for a three-hour lifetime by 1 January 1988 and 500 mA at the same energy six months later. Such a schedule was dependent, said the panel, upon three key factors—namely, that funding begins this July, that a full-energy injector is purchased from Scanditronix, the Swedish firm that built the booster synchrotron injector for BESSY in West Germany, and that such DOE accelerator physicists as Yanglai Cho of Argonne continue to work on Aladdin.

Team approach. All three recommendations may be difficult to achieve. Without a government agency coming to the rescue, the university is unlikely to heap so much money on Aladdin's upgrade. What's more, Scanditronix has promised to construct the injector 26 months after getting a firm order, at a price of \$7 million. DOE is reluctant to assume responsibility for Aladdin, especially after another review headed by L. Edward Temple, who is in charge of the department's project evaluation team. The committee concluded in late May that six more months were needed before the upgrade proposal would be in good enough shape to assure that the project would succeed. For starters, the Temple committee called for the appointment of a permanent director and associate directors "as soon as possible," as well as the addition of a "leadership team" consisting of a project manager, two more accelerator physicists and two more "senior, experienced, seasoned" engineers. "Failure to assemble this team would jeopardize the probable success of the project," the report states. What's more, a "hard-headed, precision" engineering approach needs to be adopted to deal with Aladdin's problems. High on the list of problems: verification of the bedrock and grout layer in which the storage ring is set, to make sure of their stability; thorough measurement of the ring magnets; evaluation of the existing vacuum chamber; reconsideration of the proposed new synchrotron injector, to be sure it meets the anticipated operational needs.

What bothered the Temple group most was that some senior people at Aladdin seemed to have a faulty understanding of the upgrade concept. Thus, when key questions were asked, the committee got such responses as "I'll have to reinvestigate the question of stainless steel versus aluminum for the vacuum chamber." What appealed to the Temple committee and an overview NSF panel, led by Lyle H. Schwartz of the National Bureau of Standards, was that Yanglai Cho and four accelerator experts from Argonne had been able to improve the performance of the machine to its present level during a brief stay early this year. Indeed, between last December and May, Aladdin's beam intensity was increased to 20 mA at 800 MeV, and since then it has reached nearly 30 mA. But, it wasn't Cho and his Argonne colleagues that made the difference, says a member of the upgrade study, Albert Hofmann of SLAC. "The improvements were made mainly by Rowe and Wisconsin people," he asserts. "Personally, I find it a pity that the machine is in bad repute. I believe the machine could be made useful without the need of an \$18-million upgrade."

Another view of those most responsible for raising Aladdin's beam current comes from Robert Kustom, an Argonne accelerator physicist who served on the upgrade study team. "There's no question of Cho's contribution," Kustom says, "and it's clear the Wisconsin people haven't received adequate credit for improving the beam. Nor has Tat Khoe [an accelerator theorist at Argonne], who identified the ion trapping problem at the turn of the year and told us Aladdin wouldn't get much above 5 mA until something was done about it. He did some more calculations and wrote a Light Source Note last January identifying clearing electrodes as the way to deal with the problem." Rowe independently thought of the solution about the same time. Adds Kustom: "Quite honestly, I'm sorry that Ed Rowe is generally considered the scapegoat for Aladdin's problems. As principal investigator, he deserves some blame, of course. As PI, that's where the buck stops. But there's plenty of blame to go around." NSF's Nosanow agrees. "The agency must share blame because we weren't keeping a careful watch," he says.

So far, Wisconsin's political representatives in Congress have not come to Aladdin's help, preferring instead to sit it out. But Aladdin has not gone unnoticed in Washington. In its report on the DOE budget for fiscal 1986, the House Subcommittee on Energy Development and Applications, concerned about the cancellation of some research projects in the past few years, such as Brookhaven's Isabelle and the Clinch

River Breeder, called on the agency to inform it by 1 August on how Aladdin's proposed upgrade might fulfill the Research Council's recommendation for a 1-2-GeV synchrotron radiation facility. The DOE report, now undergoing final revision, lists six options. These range from Wisconsin's current plan to attempt to improve the machine without major expenditures, to the proposed upgrade with the Swedish-built injector, on up to the most expensive option, which calls for starting anew. The new machine would require \$41 million for the bare minimum of a storage ring, magnets, rf, and vacuum system, plus about \$15 million for beam lines and other equipment, \$10.5 million for buildings and \$5 million for design and management costs.

Case in point. Ironically, just when Aladdin's future is in most doubt, the facility is operating better than ever. Two beam lines are functioning and a third was expected to be operational by the end of July. To the 70 users gathered on 22 July, the real issue is whether the machine will be stable and

reliable. They are also concerned about moving to Brookhaven or Stanford—both of which have a shortage of beam time and a scarcity of floor space—should Aladdin prove unacceptable. At the end of the day, more than 40 users had signed a statement saying they were convinced that "Aladdin without modification is capable of providing stable usable beams of synchrotron radiation for world-class research," and urging NSF "in the light of new evidence" to fund the machine in its present configuration. Operating the machine routinely at about 30 mA would require about \$3 million per year of nonuniversity money, Huber calculates.

"From a national perspective, our case for operating Aladdin is persuasive," says Huber. He expects the users to help Wisconsin make that case before NSF, and failing to gain further support, Huber plans to mobilize the users to appeal for funds from DOE and possibly the Navy. He knows that Aladdin's ultimate survival will depend on users "making a big noise."—IG

Academies study high-tech export controls

The National Academies of Sciences and Engineering announced on 13 June the formation of a 21-member panel to weigh the costs and benefits of such national security laws as the recently amended Export Administration Act of 1979 and the Arms Export Control Act of 1976, which are meant to deprive potential adversaries of militarily useful data and technologies as well as advanced weapons systems. By enforcing such laws, sometimes arbitrarily and often aggressively, Washington at times has thwarted the nation's high-tech industries from engaging in the competitive international marketplace, only to see Warsaw Pact nations turn to other countries for dual-use strategic items (microelectronics in particular).

The panel will examine the effectiveness and the consequences of export restrictions and other controls that are intended to limit or eliminate the transfer of militarily sensitive technologies to possible adversaries. In addition, it will seek to establish priorities among alternative control measures. In effect, the study group is expected to do for US industry what an earlier panel did in its report on the effects of national security controls on the open exchange of scientific and technical data in academic research.

A 1982 report by the Academies on university research, *Scientific Communications and National Security* (PHYSICS TODAY, November 1982, page 69), was one of the opening shots fired in

retaliation to what was then a guerrilla war by the Pentagon against the academic tradition of the wide dissemination of scientific work. More commonly known as the Corson Report, after Dale Corson, president emeritus of Cornell University and head of the study, it called on the Pentagon to establish appropriate guidelines and procedures to keep open the channels of scientific communication. The Corson panel preferred that the government "build tall fences around small fields of research" and concentrate not on the uncertain goal of "protecting what we have" but on advancing "[our] strategic lead time"—in other words, "security by accomplishment."

One of the panel's major issues was resolved on 27 June, when both houses of Congress, by voice vote, passed an amended Export Administration Act, which had expired last year but continued to operate under a presidential order. The act, signed into law by President Reagan on 12 July, leaves the operation of export control much as before. The act is intended to speed up the licensing of exports to US allies and hold down more rigorously the export of items the Pentagon considers militarily critical.

The panel is under the chairmanship of Lew Allen Jr, director of Caltech's Jet Propulsion Laboratory. A physicist with a PhD from the University of Illinois, Allen is a retired Air Force general who has served as chief-of-staff for the Air Force and director of the National Security Agency. —IG