CEBAF wins praise for design, but its future is uncertain

It is the best of times and the worst of times for CEBAF. Best, because the Continuous Electron Beam Accelerator Facility, which has been mired in sharp controversy for three years, acquired an experienced director last May and a significant design change in December—both enthusiastically welcomed by four different review panels. Worst, though, because the proposed cw electron accelerator, which is to use superconducting rf cavity technology, appears as a new start in President Reagan's fiscal 1987 budget—its novel approach making it vulnerable to Congressional budget-cutting action.

Not only does CEBAF now present a concept quite different from the technology that was recommended in 1983 by the Nuclear Science Advisory Committee and approved by the Department of Energy, but as a budget item of about $25 million it is likely to be at risk in a year when Congress finds itself in the self-imposed straitjacket of the Gramm–Rudman–Hollings law, which limits the fiscal 1987 budget deficit to no more than $144 billion. If the White House and Congress cannot reach agreement on where to wield the budget ax, CEBAF might be among the discretionary domestic projects to fall victim to the automatic mechanism that will whack $40 billion or more from the total Federal budget for the next fiscal year, beginning on 1 October. Thus the design change couldn't have come at a more inopportune time.

DOE has championed a cw (rather than pulsed) electron accelerator ever since an NSAC panel headed by Peter Barnes of Carnegie–Mellon University went beyond earlier ideas and recommended a machine capable of covering an energy range of 0.5 to 4 GeV, the largely unexplored transition region between the nucleon–meson and quark–gluon regimes (PHYSICS TODAY, September 1982, page 18). While Stanford's linear accelerator produces electron energies in excess of 24 GeV, it does so only in short pulses, which are unsuited for critical coincidence measurements.

Hermann Grunder (left) explains early cyclotron, designed by Ernest O. Lawrence, and later accelerators to John S. Herrington during a tour of the Bevalac at Lawrence Berkeley Laboratory last April. A month later, Grunder became director of CEBAF, which Herrington has approved for construction start-up in fiscal 1987.

Neophyte picked. Using the criteria set by the Barnes panel for the new machine, DOE conducted a competition to determine who would design, build and operate the accelerator. Early in 1983 five groups vied for the distinction. The proposals were examined by another NSAC panel, this one operating as a peer review group under the chairmanship of D. Allan Bromley of Yale. The Bromley panel, to most everyone's surprise, recommended the proposal submitted by a neophyte among accelerator builders, Southeastern Universities Research Association, which had relied in part on the proven technology of SLAC, where SURA's principal designer, James S. McCarthy, once worked.

The loser in the competition, Argonne National Laboratory, sought to forestall DOE's final decision by attacking SURA's conservative design and unseasoned accelerator builders (PHYSICS TODAY, July 1983, page 57). In response, SURA tried to outflank Argonne with its considerable political forces. One of SURA's advantages over Argonne is that its 35 member colleges and universities lodge in 12 southeastern states and the District of Columbia. Senators and Congressmen from some of those states serve as chairmen or ranking members of key committees that review the programs and control

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the appropriations of the Energy Department—a factor that did not concern the Bromley panel but does carry weight with DOE. Argonne counterattacked with some top politicians of its own, reaching almost as far as the White House. In the end, though, Argonne withdrew from the battleground rather than fight DOE, influential members of Congress and the scientific panels that chose the SURA proposal on technical grounds.

Even so, attacks on SURA broke out again when DOE requested $5 million in the fiscal 1985 budget for CEBAF's organization, research and conceptual design, and another $2 million to actually break ground at a flat, piny woodland site four miles northwest of downtown Newport News, Virginia. This time the opposition came from some highly respected physicists who contended that Congress should allocate more money to improving existing machines instead of funding CEBAF and that, anyway, new theories argued for energies higher than 4 GeV. To add to SURA's problems, another NSAC report caused some confusion in Congress about the importance of a cw electron accelerator. The report, a 1983 *Long-Range Plan for Nuclear Science*, clearly assumed the electron accelerator would be built quickly "as a national user facility" but called a relativistic heavy-ion collider "the highest-priority new scientific opportunity within the purview of our science" (PHYSICS TODAY, September 1984, page 55).

Congress's response was swift—and painful. It expressed bewilderment about what facilities nuclear physicists really want. Abhorring ambiguity, Congress reduced DOE's request for R&D funds for CEBAF and eliminated all construction money for fiscal 1985. To bring order to the situation, Alvin W. Trivelpiece, DOE's director of energy research, and George A. Keyworth II, the President's science adviser at the time, asked for still another NSAC review of the accelerator. This time the result was an indisputable endorsement. Though admitting there is some uncertainty about the precise energy reach needed for exploring the nucleon substructure and the quark-gluon force that is described by the theory of "color" interactions (quantum chromodynamics), the NSAC panel, this time headed by Erich W. Vogt of the University of British Columbia, hailed the 4-GeV CEBAF as the "accelerator of choice" (PHYSICS TODAY, November 1984, page 59).

Because CEBAF construction had already been approved by the White House for the 1985 budget, only to be deferred by Congress, Trivelpiece reasoned that DOE should again propose its start in fiscal 1986. This time the Office of Management and Budget decided otherwise, under the dictum imposed by David A. Stockman, then its director, that there would be no new starts in 1986. Still, CEBAF got $5 million to continue developing design and engineering plans (PHYSICS TODAY, April, page 59). Discouraged by the lack of action, some nuclear scientists feared CEBAF was doomed by its history of political wrangling as well as by continued opposition from a few influential members of the community.

Then came two events nobody had figured on. The first was the choice of Hermann A. Grunder, deputy director for general science at Lawrence Berkeley Laboratory, as director of CEBAF. Grunder, who served on the Bromley panel that selected the SURA proposal, admits that he turned down an earlier offer two years ago to run the facility, content to wait for a long-promised synchrotron-radiation source for Berkeley's Center for Advanced Materials. About a year ago, however, it was made clear to him that he was the odds-on favorite to run CEBAF. "Both Al Trivelpiece and Jay Keyworth twisted my arm so much I thought it would fall off," Grunder says, laughing. "When Ed Knapp [the Los Alamos physicist who headed the CEBAF search committee] took hold of my other arm, I knew it was time to give in." In May, Grunder arrived at CEBAF.

Notable idea. The second development had its start about the time Grunder was recruited for CEBAF. In separate discussions, Stanley Kowalski of MIT and Alfred W. Maschke, then at Brookhaven (and now with TRW Inc), urged that Grunder discard the concept of a room-temperature pulsed traveling-wave linac with a pulse-stretcher ring capable of delivering a continuous beam, and consider instead a continuous-wave linac using superconducting radiofrequency cavities to accelerate electrons. On a visit to Berkeley, Grunder discussed the idea with Maury Tigner, director of the Superconducting Super Collider design group, who suggested that he talk with Helmut Piel at the University of Wuppertal about such a design. A consultant to two accelerators now being built in Europe, CERN's Large Electron–Positron machine and DESY's HERA, Piel is known as "the Pope of Superconductivity."

"After meeting with Piel," Grunder recalls, "things began to converge. Maschke told me that CEBAF with superconducting cavities would be 'duck soup.' I found that hard to believe. But after my meeting with Piel, things began to fall wonderfully in place."

Although a superconducting option had been examined by the technology subpanel of the Bromley panel (a group chaired, in fact, by Grunder) in 1982–83, the technology was not well enough advanced at that time to make it an acceptable choice. Developments in the past two years, however, particularly coming from the design efforts for HERA and SSC and from work at Cornell, have altered the situation drastically (see page 19).

At a lengthy review of CEBAF technology last July and August, some 50 accelerator experts—among them Maschke, Piel, Ray Alvarez (Lawrence Livermore), Jean Mougey (Saclay), Ronald Sundelin (Cornell) and Christoph Leemann, who is the first Governor's Distinguished CEBAF Professor at the University of Virginia—considered standing-wave and superconducting linac designs as the most technically promising and cost-effective alternatives to the traveling-wave structure of the original McCarthy concept. When all three technologies were compared, it was clear that the superconducting cw linac was the way to go.

In this approach, an electron gun injects a steady stream of electrons, bunched to the linac's rf and preaccelerated to 0.05 GeV, into the first of two parallel linacs connected end to end by recirculating arcs bent by magnetic fields. As the beam circulates around the structure four times, it passes through 25 cryostats containing a total of 200 superconducting cavities in each linac. In the recirculation arcs, the beams are spread, then recombined and injected into the linac again. On any of the passes, the cycle of spreading the beam lines in the arcs can be interrupted at the end of the second linac so that a discrete beam at an energy of 0.5–4 GeV may be extracted and sent on to experimental end stations. Each of the cavities consists of five cells, made of niobium and shaped like Scottish curling stones. The cavities are paired and enclosed in a self-contained cryostat with liquid helium, making their replacement quick and easy. A total of 400 cw klystrons provide the rf power that is fed through the cryostats to the cavities.

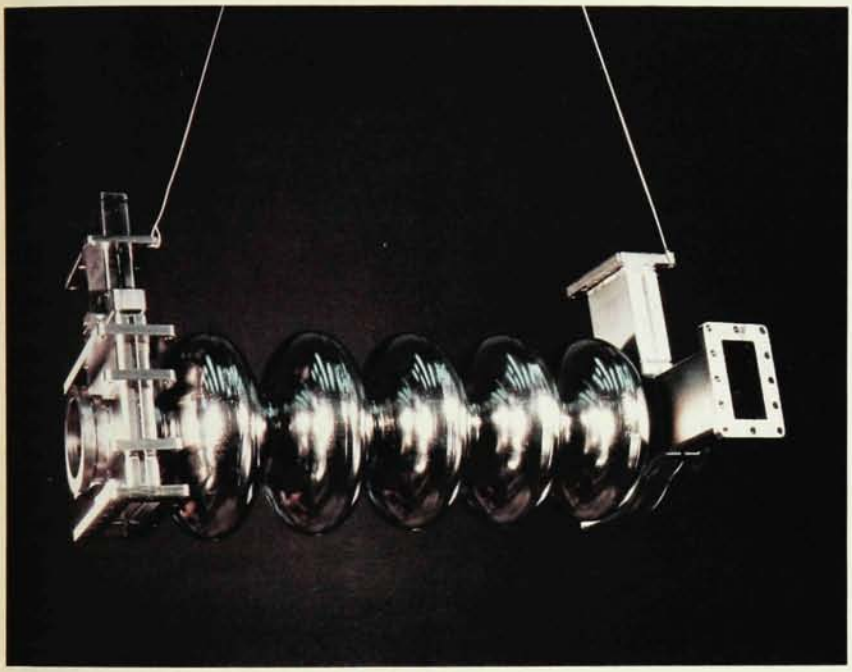
The advantages of an accelerator with superconducting cavities over other designs are many: Without a pulse-stretcher ring, the design is conceptually simpler; the accelerator produces a beam of higher emittance and smaller momentum spread as well as a duty factor of 100%; ac power consumption is likely to be reduced by a factor of 3 (to 8 MW, including the power necessary to refrigerate the cavities) because of the lower energy losses in superconducting components and magnets; the accelerator has the operational flexibility of delivering cw beams at three energies simultaneously; and it has the potential for reaching an energy of 6 GeV, possibly without modifications,

and—with greatly improved accelerating cavities—reaching 10 or perhaps even 16 GeV.

Grunder insists that CEBAF's potential for upgrading is of paramount importance. An accelerator is an expensive, long-term investment that none but the Federal government can make. So the scientific community and accelerator designers must anticipate ways of meeting the research demands in the future. "By developing a machine capable of reaching higher energies," says Grunder, "we have a cost-effective advantage." The Bromley panel had noted earlier that one of the competitive aspects of the SURA design as compared with the concept submitted by the Argonne group was its upgrading potential.

One of the bugaboos at the technology review was the fear of beam breakup in the recirculator arcs. It turns out that both calculations and demonstrations of the CEBAF design have been done at Cornell for the planned CESR II storage ring that the National Science Foundation decided to turn down two years ago. Indeed, the basic technology for CEBAF has been developed in the past decade at Cornell, CERN and Wuppertal. In addition, rf superconductivity has been successfully demonstrated since 1978 by Argonne in accelerating heavy ions.

The key question for CEBAF is whether superconducting niobium cavities can be produced on schedule at a reasonable cost. Interatom, a subsidiary of West Germany's Siemens AG, has produced high-precision, high-purity niobium cavities for CERN, DESY, and Wuppertal–Darmstadt machines exceeding the specifications of the CEBAF cavities. In addition, another German company, Dornier, a subsidiary of Daimler–Benz, has produced cavities for DESY. At least two US firms, TRW and Babcock and Wilcox, have indicated they are prepared to fabricate the CEBAF components. Grunder has ordered two cavities from Interatom, for delivery this year to test in cryogenic models.



Superconducting rf cavities such as this one will be the key components of CEBAF. Each of the five cells in this cavity is made of niobium and heated in liquid yttrium to improve the thermal conductivity and stabilize the cell against thermal breakdown.

Question mark. Another question mark in the earlier design was the requirement for extremely high-powered klystrons requiring 40 MW peak power and 130 kW average power, which would push the state of the art. The new concept avoids this altogether by requiring off-the-shelf klystrons. What's more, the cryogenic system for the superconducting CEBAF is well within current commercial capabilities.

With such clear advantages to the superconducting design, Trivelpiece asked CEBAF in September to examine the concept and, if it was considered practical, to produce a design. The result was that Grunder and SURA's board of directors decided in early October to adopt the superconducting concept originally conceived for CESR II. However, altering the design at this stage, Trivelpiece feared, could give rise to untimely political questions. It might be necessary to convince Congress that the great transformation in CEBAF can be done to the satisfaction of the nuclear-physics community and at a cost not to exceed the original estimate of between $230 million and $240 million. In anticipation of the inevitable questions at the DOE budget hearings to be held by Congress in the next few months, Trivelpiece called for a series of reviews of the facility's technology, cost and management.

The first, conducted last November by a group of accelerator and cryogenic specialists under the cochairmanship of David Hendrie, director of DOE's Division of Nuclear Physics, and Lewis E. Temple Jr, director of the department's Construction, Environment and Safety Division in the Office of Energy Research, hails the proposed design. It concludes that the superconducting rf technology "is appropriate for the CEBAF design goals of 4 GeV and 200 microamps at high duty factor. Furthermore, given the recent progress in developing competent suppliers of the proposed 1500-MHz superconducting Nb cavities, we believe that this, along with the planned R&D, [makes] possible an FY 1987 construction start." Moreover, it finds, building the machine according to the new scheme is likely to be no more costly than with the earlier design. The report gives a resounding pat on the back to CEBAF's staff, which, in the few months it has been examining the proposed design alongside an international group of accelerator experts, has provided "a convincing case" for the new technology. The only problem, the panel finds, is that additional staff need to be hired in the fields of superconducting rf technology and cryogenics. Even without such specialists, the Hendrie–Temple report observes, "the assembled CEBAF 'team' is an impressive group. The creation of this dynamic, motivated group of outstanding personnel is a tribute to CEBAF management."

Another study was performed for SURA by a "blue-ribbon" panel of nuclear and accelerator physicists consisting of NSAC chairman John Schiffer (Argonne), John C. Browne (Los Alamos), Robert E. Hughes (Associated Universities Inc), Leon Lederman (Fermilab), Norman F. Ramsey (Harvard), Burton Richter (SLAC) and David Shirley (Lawrence Berkeley), as well as Bromley and Knapp. After the panel's daylong visit to CEBAF's headquarters in early December, Schiffer sent its report to SURA's president, Harry Holmgren (University of Maryland). "The superconducting design," the report states, "appears to be a major improvement over the original

design and very appropriately builds on the enormous worldwide progress in rf superconductivity over the past several years.... The possibility of going to even higher energies [than 4 GeV] at some future time is a desirable feature of the new CEBAF design. However, the additional costs associated with [a major upgrade] should be made very clear ($8 million was mentioned), in order to avoid any suspicion that there are major hidden costs associated with it."

Cautionary notes. In addition, writes the panel, "Serious attention must soon be given to the experimental program. CEBAF is not just an accelerator, but also a complex of detection systems that are essential components of the research facility. If these detectors are not properly designed [and built] the accelerator facility will be much less effective than it could be, and it will take a long time to make improvements." The panel cautions that the detector projects described to it "do not seem to make full use of modern techniques." It recommends that one of the first jobs for CEBAF's scientific director, whose appointment the panel considers to be "urgent," is to review the needs of the machine's potential users, the advances in spectrometers and other detector components and the operations of such notable facilities as Los Alamos, the MIT accelerators and Canada's TRIUMPF.

Indeed, argues the Schiffer panel, "CEBAF must be a *NATIONAL* facility." After all, writes the panel, CEBAF "is the single largest new facility for nuclear physics in the decade. Every effort must be made to shed its regional image and to strongly encourage the participation of universities and laboratories throughout the US and the world."

Finally, the Schiffer report observes that the anticipated peak of 100 full-time scientists, engineers and technicians during construction of the machine "seems small for a project of this complexity. Every effort should be made to farm out design, engineering and construction of components and systems to other laboratories and industry." And while the panel notes that plans to assemble a cadre of scientists are "proceeding slowly," it congratulates Grunder for "the quality and vitality of leadership... and the remarkable progress towards the goals of CEBAF that have been made in the short time during which he has been director.... [Grunder's] leadership in the technical accelerator design, in decisions regarding new key appointments and in interactions with state and Federal government augur very well for the future. CEBAF has been plagued by a lack of adequate leadership in the past and SURA deserves considerable credit in having been able to attract Grunder."

If Senate and House members need guidance about questions to ask of CEBAF, they would do well to read the Schiffer panel's report first. They might also peruse the report prepared by DOE's Temple and his group as a guide to what Grunder plans to do to respond to the Schiffer panel's suggestions. Temple is convinced that Grunder has matters well in hand and that he has commitments from outstanding physicists and others to join CEBAF when Congress appropriates funds for its start. As for costs, Grunder figures that the new design can be built for about the same price tag as the previous design—$236 million.

As Congress prepares to look at CEBAF, the General Accounting Office is working on a study of the facility—including its cost and management—ordered by Senator J. Bennett Johnston, the Louisiana Democrat. As ranking minority member on the Appropriations Subcommittee on Energy and Water Development and Committee on Energy and Natural Resources, Johnston, who is unusually knowledgeable about accelerator physics (having been tutored on occasion by SLAC's Wolfgang K. H. Panofsky), led a crusade two years ago to slow down CEBAF's construction. Considering the design change that's being proposed, Johnston may have done the nuclear-physics community a good turn.

In this case, Johnston is an example of one man's power to change a situation—sometimes inadvertently. Another example is Grunder. John McTague, President Reagan's acting science adviser since Keyworth's departure, claims that Grunder is "living proof that one man can make a difference."

—IRWIN GOODWIN

Washington Ins and Outs:

New faces at DOD, DOE and White House

Ronald L. Kerber, associate dean of Michigan State University's College of Engineering and professor of electrical and mechanical engineering, has taken a leave to serve as deputy undersecretary of Defense for research and advanced technology. In this job he is responsible for planning, review and oversight of the Pentagon's $5.3-billion science and technology program, which is carried out in 73 DOD-sponsored laboratories and through grants or contracts to universities and other institutions. The position is also central to the long-running negotiations over the issue of open scientific communication of research data.

Until Kerber was sworn in on 30 December, the post had been filled on an acting basis by Colonel Donald I. Carter since the resignation of Edith Martin, who left a year and a half ago to become a vice president of Boeing. In accepting his Pentagon appointment Kerber, an expert on lasers who holds a PhD from Caltech, had to resign from the APS panel studying directed-energy weapons.

Retired four-star Admiral Sylvester R. Foley Jr became assistant secretary of Energy for defense programs on 23 December, succeeding William W. Hoover, who resigned a month before. In his new position Foley directs the nation's nuclear-weapons research, development, testing and production. A graduate of the Naval Academy, the Air War College and the Naval War College, he also got an MA in international affairs from George Washington University in Washington, D.C. During a 35-year Navy career, Foley served as deputy chief of Naval Operations for plans, policy and operations, commander of the Seventh Fleet and commander of the Pacific Fleet.

Donald K. Stevens, who has been deputy associate director of the Department of Energy's Office of Energy Research since 1981, has moved up to associate director, with responsibility for direction of the Basic Energy Sciences program. BES supports about 1200 research projects in materials, chemical, nuclear, geophysical, engineering and advanced energy sciences. He succeeds Richard H. Kropschot, who retired earlier in 1985.

Vice Admiral John M. Poindexter, appointed White House national security affairs adviser by President Reagan last December, graduated at the top of the Naval Academy class of 1958 and earned a PhD in nuclear physics from Caltech, where he did his postdoc work with Rudolf Mössbauer. Unlike his immediate predecessor, Robert C. McFarlane, and most previous occupants of the office, including Henry Kissinger and Zbigniew Brezinski, Admiral Poindexter refuses to meet with news reporters. While other security advisers usually took the lead in foreign-policy and arms-control matters, to the consternation of several secretaries of state, Poindexter, by contrast, apparently views his job as a low-profile position and prefers to remain all but invisible to the public. □