tional view that growth is good." Both Ehlers and one of the biologists on the committee have been on the board of the West Michigan Environmental Action Council.

In connection with the proceedings leading to Ford's confirmation as Vice President, the Congressional Research Service (CRS) of the Library of Congress prepared an analysis of his legislative philosophy and voting record. Some of its findings are of particular interest to the scientific community. For instance, the CRS report said that Ford's recorded votes through the years 1949 to 1973 "reveal a consistent pattern of support for various aspects of higher education, with especially strong support for student aid proposals . . ." Also, his record was one of support for the National Institutes of Health research and training programs.

Ford has been a supporter of big technology projects, such as the supersonic transport and the space shuttle. As for military R & D, Ford has actively supported controversial projects such as the antiballistic missile system, the B-1 strategic bomber, and the Navy's nuclear aircraft carrier program.

Whatever his current reservations about the environmental movement, Ford has generally supported legislation for the control of air and water pollution. Furthermore, as shown by past speeches, Ford has looked with favor on the establishment of the Council on Environmental Quality and the Environmental Protection Agency. He also appears to be committed to the concept of creating a new department of energy and natural resources.

At this point, the common judgment of Ford as having been a conscientious but conventional and quite cautious legislator and minority leader appears to be valid. The future will demand of him greater political creativity and independence than has been required of him in the past. Freed from the political constraints of representing only a conservative midwestern Republican congressional district, Ford now has the chance—and the duty—to show that he is more than a "good listener."—LUTHER J. CARTER

Fermi National Accelerator Lab: Progress on a Grand Design

On clear nights the lighted double tower of the central high rise at the Fermi National Accelerator Laboratory dominates the soybean and corn fields of the Illinois prairie west of Chicago for miles around. The new landmark is the central laboratory building for the largest proton synchrotron in the world, and, because the big machine was built at a time of declining faith in federal science, it can be regarded not only as a scientific but as a political wonder.

The laboratory, on 6800 acres near the town of Batavia, was formally dedicated in May, less then 6 years after the first ceremonial spadeful of dirt was turned. The $250 million job was done within the time schedule and budget, no small achievement in an era when overruns are seemingly automatic on major projects. An accelerator is not really a big machine, however, but rather a vast array of systems and subsystems. It may take years of fine tuning and even extensive modifications to bring an accelerator up to its potential. And certainly the new accelerator at Batavia has suffered through its own awkward age. From the beginning, the aim has been to build an accelerator with a beam of the highest possible energy and intensity for the money available. The design of the machine was of necessity adventurous, and critics blamed some of the bolder innovations for a time of troubles—particularly a period in 1970 and 1971—when the frustrations were proportional to the scale of the machine. The defects were ultimately mastered and, especially during the last half year, the performance and reliability of the accelerator have risen rapidly; it has begun to produce, in the parlance of the discipline, "good physics" (*Science*, 14 Dec. 1973).

The ultimate verdict on the new accelerator, the inevitable comparisons with work being done at CERN (European Organization for Nuclear Research), Serpukhov, and SLAC (the Stanford Linear Accelerator Center has the second-largest machine in the United States) will take time, probably several years. This article, and another to follow, will not attempt an assessment of the state of the art at the new accelerator, but rather, so to speak, will report on the state of the artists and seek to convey some sense of how the lab is developing as an institution.

If an institution is the lengthened shadow of a man, as Emerson said, then the man in the case of the Fermi laboratory is its director, Robert R. Wilson. Wilson was picked well before ground was broken by Universities Research Association, Inc. (URA), the consortium of research universities which operates the lab under contract with the Atomic Energy Commission (AEC). Wilson has taken the project through the design and construction stages, nursed it through the growing pains, and now presides over an operational facility.

Wilson, now 61, belongs to the generation of physicists present at the creation of American high energy physics at the Radiation Lab at Berkeley in the 1930's. He was a charter member of the influential club of physicists who knew each other at Los Alamos during World War II. After the war, Wilson went to Cornell and took the lead in building and improving a series of high energy machines that were looked upon by his peers as combining technical elegance with economy.

In the late 1960's, when negotiations over the next giant step in accelerator building broke down, it was Wilson to whom the URA and AEC turned. A design team from Berkeley had been heirs presumptive to the next accelerator project, but dropped out when the AEC reduced the allotted funds to build the machine, and Illinois rather than the West Coast was selected as a site.

At Batavia, Wilson has turned out to be a good deal more than a member of the high energy physics establishment with a talent for accelerator design. His influence at Batavia encompasses everything from architecture and landscaping to management style and general atmosphere.

Although concern for the environment was widespread during the period when the accelerator was being built, Wilson expressed such concern with special flair. In a region where trees are at a premium, Wilson sought to save every one possible on the site. A sizable stand of trees near the central laboratory building is said to be a remnant of the *grand bois* which the first French explorers found and has been under Wilson's special protection. A small herd of buffalo is in residence and apparently thriving, and the area inside the 4-mile-in-circumference main ring of the accelerator is the site of a "prairie project" intended to return the farmland to its pristine state.

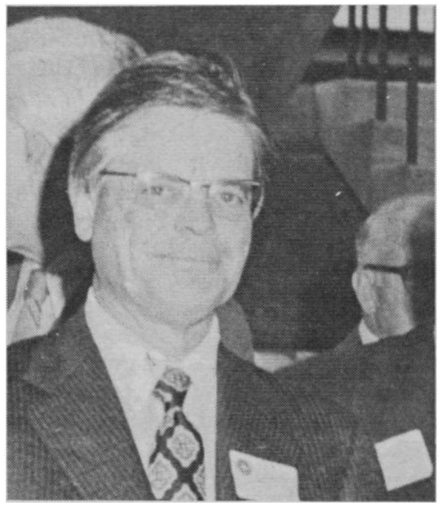
Combining the picturesque and the practical, Wilson made use of existing houses and farm buildings on the site, particularly by moving a number of them to the village of Weston and using them for work space and living quarters for visiting scientists.

The Wilson touch is ubiquitous. He even took a direct hand in designing the logo for the lab. It is a stylized composite of the dipole and quadrupole magnets in the accelerator's main accelerator ring. The Batavia accelerator was the first "separated function" machine, which means that the dipoles—which accelerate the beam—and the quadrupoles—which keep it focused—were separated. This was a major innovation that was to become standard design and is of course documented in the logo.

Wilson's major excursion into architecture was in taking a decisive role in designing the centerpiece high rise. In the process he went through 7 or 8 architects and 7 or 8 plans, but in the end the lab got a building of genuine distinction with a per-square-foot cost that satisfied the AEC.

Why a high rise in the middle of all that Illinois open space? Wilson acknowledges that they did consider a cluster of low, campus-type buildings. It might even have been a little more economical that way. But the choice of the high rise was motivated by a mixture of esthetics, psychology, and cost consciousness.

First, Wilson said that when he and the staff had first moved to Illinois and had been working in an office building in a nearby town, he was impressed by how much more attractive the flat, midwestern terrain looked from higher up. Perhaps more to the point, he thought that a concentration of offices and human traffic in a high rise would engender the kind of interactions between people he thought desirable.

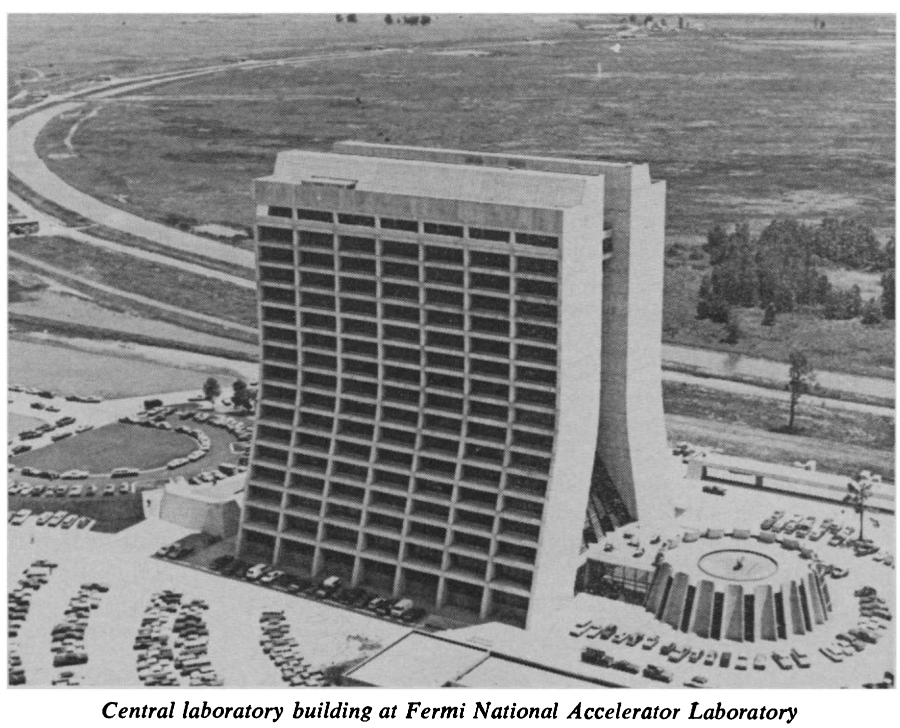


Robert R. Wilson

A striking feature is the "atrium," an open space rising several floors in the center of the building. The Illinois climate can be harsh and unfriendly, and the idea of the atrium, with its small trees and shrubs and mellow light filtered through the big windows at the end of the building, is obviously to suggest a hospitable oasis. (High energy physicists have been accustomed to migrating to accelerator laboratories to run their experiments. In the summer this often means taking their families along, and the flatlands of Illinois lack many of the amenities they find at the big labs on the coasts. A lot of effort at Batavia has gone into making a pleasant environment for scientists and, outside the lab, for their families.)

True to the principle of informality, Wilson's office and that of deputy director Edwin L. Goldwasser are on the second floor toward the front of the building, in the area close to a lounge where espresso coffee is available and people tend to gather to talk after lunch. Wilson and other top administrators work in open-plan offices thinly screened by more greenery. People can and do drift by to have a word with Wilson and others.

The open plan, which has merits of flexibility and economy, is not followed rigorously throughout the building. "Not all are enthusiastic about it," says Wilson. "Man wants to be in a cave. Physicists want an office to go into and close the door." The same pragmatism is reflected in Wilson's attitude toward the name of the lab. Known successively as "Weston" (for the village on the site) and "Batavia" (for the small town on the western fringe), and jocularly as "Dirksen Junction" (for the late Senate minority leader, Everett M. Dirksen, who was the political Moses for the place), the lab came to be called "NAL"—the initial letters of the National Accelerator Laboratory—by most people. After the formal naming of the lab in honor of Enrico Fermi, a truncated version of the full name—"FermiLab" has been used in lab handouts, perhaps because "FNAL" does not come trippingly to the tongue, but it is unclear whether it will catch on. Wilson's comment is that "The name will end up being what people call us."



Central laboratory building at Fermi National Accelerator Laboratory

While, in comparison to many science administrators, Wilson is a man of da Vincian versatility, he is by no means a one-man show. Goldwasser, who came to the lab from the University of Illinois, plays a complementary role. According to close observers he is less likely to assign tasks on a sink-or-swim basis than Wilson, and he is said to be in closer touch with the nuances of the experimental program. Often at the end of a meeting at which a problem is being discussed, it is Goldwasser who does the summing up.

In an operation as large as the lab, of course, it is difficult for an outsider to judge where credit is due. Often mentioned are the names of James Sanford, associate director for planning and programming, who carries much of the demanding task of working with visiting scientists, and Paul J. Reardon, associate director for accelerator division, responsible for making the machine run better and more often. And there are a number of people not necessarily at the top of the hierarchy who have made key contributions at various stages of the project. Some of those found the Wilson regime uncongenial

Complications Indicated for the Breeder

The breeder reactor program, which President Nixon elevated to top priority among energy R & D efforts in 1971, last year consumed $473 million, nearly half of the total U.S. energy R & D outlay. Officially its high status remains unchanged, but a number of signs suggest that the breeder may be in serious trouble.

Chief among these signs are sharply higher cost estimates for a demonstration breeder reactor that is to be built on the Clinch River near Oak Ridge, Tennessee. Although the Atomic Energy Commission has not finished revising its cost figures, the new price tag will reportedly be at least double the earlier $700 million figure and may be as high as $2 billion. Tom Nemzek, director of the breeder program, attributes the higher costs to a more realistic assessment of the project and to inflation, but the abrupt escalation is sure to attract renewed scrutiny of the program. Officials at the Office of Management and Budget are aware of the new cost figures and are known to take a dim view of the breeder's seemingly limitless drain on energy R & D resources.

Whether because of the complexity of the technology or the AEC's unrealistically low estimates, cost overruns have been endemic to the breeder program. A major test reactor, the Fast Flux Test Facility (FFTF), now being constructed in Hanford, Washington, rose from $87 million to $450 million, and the program as a whole has jumped from $2 billion to more like $5 billion, with actual construction on the demonstration reactor not due to start until next year. (Current expenditures on the breeder program thus do not include the cost of the demonstration plant, for which funding will begin in fiscal 1976.) The demonstration plant is to be built as a joint project between the AEC and the utility industry. But the industry's $250 million contribution, which was to have underwritten the major portion of the cost as the project was originally conceived, has now shrunk in comparison to the total price to a token participation in financing. And since energy officials have concluded that the breeder will play little or no role as a short-term energy option in Project Independence, the diversion of still more federal money from other urgent energy programs may meet considerable opposition. The alternative would seem to be still longer delays to the breeder project, pushing completion of the demonstration reactor into the mid-1980's.

Energy specialists at OMB are not the only ones aware of the breeder's problems. According to Manson Benedict, chairman of the nuclear panel of the Energy R & D Advisory Council, the government's senior energy advisory group, there is "a mounting feeling of uneasiness about costs and delays" in the breeder program, although he himself has not yet concluded that it is time to drop it. Such doubts among those in the technical community who would normally be the breeder's strongest proponents are significant.

The retirement of Congressmen Chet Holifield (D–Calif.) and Craig Hosmer (R–Calif.) this fall will deprive the breeder of two of its most devoted and powerful backers. Jurisdiction is still up for grabs in the Senate and the House over the soon-to-be-created Energy Research and Development Agency (ERDA), into which the breeder program, along with most other energy research, is scheduled to move. Several committees are vying for the assignment, and the future of the Joint Committee on Atomic Energy is uncertain. Amid the confusion, Congress is less likely to be in a position to dictate the fortunes of the breeder than at any time in the past decade.

The breeder is also encountering some difficulties within the AEC. The reactor design developed by the R & D half of the agency in cooperation with its industry partners specifies some "fall-back" safety features, which could be made a part of the demonstration reactor but which were to be left out unless needed. The regulatory branch of AEC, however, appears to have rejected this approach and will apparently require the inclusion of most of the fall-back items, at least until they can be proved unnecessary, thus shifting the burden of proof to the R & D team. That this revised safety philosophy will raise costs still further seems probable.

Even from the nuclear industry's professional press some discordant notes on the breeder can be heard. *Nuclear News* (August 1974, p. 55) journal of Nuclear Society, has published an article sharply critical of the breeder program and its present goals. The article and accompanying editorial bespeak a new era of candor in the usually closed ranks of the nuclear community. With other straws in the wind, it may reflect a sense that the breeder program will now have to be judged on its own merits rather than fostered as an inevitable follow-on to nuclear power. And while there is no indication of any serious sentiment outside of the environmental camp for canceling the program altogether, it is possible to read the signs as evidence that the breeder's cherished priority status may be, for the first time, seriously in doubt.

—ALLEN L. HAMMOND

and left. The ones remaining accept the Wilson style, if not uncritically. That management style as it affects both staff and visitors will be discussed in a second article.

Although Wilson and his staff run the lab with a generous measure of self-determination, their powers are by no means unlimited. The major premise is that the lab shall operate as a national facility. URA, the AEC contractor, is a consortium of universities (now numbering 52) that was organized to sponsor the new accelerator and to guarantee that it would operate without favoritism.

Most formal power over the lab is held by a board of trustees. The board is empowered to hire and fire the director and, as one observer put it, "with Wilson that's about the end of their authority."

The board has delegated management responsibility to the URA president, a part-time post so far always occupied by a university physicist. For most of the life of URA, the job has been held by Norman F. Ramsey of Harvard. According to observers, Ramsey, Wilson, and Goldwasser have had a working relationship that makes it possible to settle virtually all questions, save on major policy issues, without bothering the board much.

The remarkable degree of autonomy practiced at Batavia would not, of course, be possible without the cooperation of the AEC. The project, at the start, had the sympathy and interest of the AEC commissioners, who were relieved when Wilson came along and said he could build the accelerator for the $250 million available. And much credit is given to AEC officials on the scene who were willing to take a nonbureaucratic approach as long as Wilson's methods brought results.

Much of the flexibility in the lab's operations has depended on management's powers of discretion in using funds remaining from the $250 million in construction funds. About $30 million was available for work to improve the performance of the machine. After this year that whole sum will have been obligated.

With the "kitty" depleted, there will no longer be a cushion for the operating budget, whose rate of growth is lagging behind the rate projected as necessary for the lab to operate effectively. The operating budget was $28.4 million last year and is expected to be $36 million this year, instead of the $48 million projected. Despite this shortfall, FNAL has received relatively favored treatment in the high energy physics budget at large (*Science*, 23 August, Research News).

A major question at Batavia is about future funds for expansion. There is a sort of Daniel Boone effect in high energy physics; when physicists achieve a new energy level they pine to move on to the next frontier. This is true at Batavia. Part of the kitty is being used to build a prototype section of a superconducting magnet ring which could be used as an "energy doubler" in the same tunnel as the main ring. Using the present ring as a booster, the FNAL designers estimate that it would be possible to reach 1000 Gev.

There are other options for expansion, notably a proposal for a super superconducting ring 10 miles in circumference. Technically it would appear that the horizons are virtually unlimited for high energy physics, but fiscally this is far from true. The AEC, which has been a faithful patron of the discipline, faces a major reorganization, which could very possibly send high energy physics looking for a new guardian. And the federal budget situation in the next few fiscal years is unlikely to be very hospitable to basic research.

At Batavia an exhilarating atmosphere has been created and a new range of scientific opportunities opened up, but what may be just as important for the next phase in high energy physics is the Wilson style of doing more with less.—JOHN WALSH

Nuclear Fuel Reprocessing: GE's Balky Plant Poses Shortage

The General Electric Company helped put men on the moon, but GE seems to have met its technological Waterloo in the mundane field of nuclear fuel reprocessing. In one of the more spectacular failures of the nuclear age, GE has disclosed that the Midwest Fuel Recovery Plant which the company spent 6 years and $64 million building near Chicago does not work and will have to be virtually scrapped.

GE executives have told the Atomic Energy Commission that redesigning and rebuilding the chemical plant—which was to have been one of three operating in the United States by 1979—will take at least four more years and an additional $90 million to $130 million. The company's disclosure has shocked the utility industry, which is beginning to worry about an imminent national shortage of fuel reprocessing capacity. Some government authorities, moreover, see in GE's predicament a critical lesson for the energy industry as a whole: that the perils of pushing new technologies too fast are great and costly.

Reprocessing plants form the penultimate link in the nuclear fuel cycle. They receive used or "irradiated" fuel rods from nuclear power stations, chop the rods up into sausage-size pieces, and chemically extract the remaining uranium and its by-product plutonium for later recycling in new reactor fuel. Left over are intensely radioactive isotopes of cesium, strontium, and other elements that build up in fuel rods as they are used. These isotopes form the final waste of nuclear power generation.

The chemical processes used in such plants (mainly a solvent extraction method) have been around since World War II. Their development, in fact, is one of the heroic tales of the Manhattan bomb project. In a stupendous leap in scale during 1943–45, the project's engineers used chemical studies performed on half a milligram of plutonium as the basis for designing a massive, remotely operated processing plant at Hanford, Washington, that soon was extracting tens of kilograms of plutonium from the fuel of military production reactors. It was a "staggering" gamble, Henry D. Smyth later