A Long-Range Plan for Nuclear Science

Administration acceptance of a "constant effort" program for nuclear physics caps a long fight to bring fiscal order to a chaotic field

Atom smashers. The very words dredge up visions of huge and expensive machines ripping the atomic nucleus apart in order to probe its innermost secrets. Although the largest and most costly accelerators are now built to allow high energy physicists to pry open the constituents of the nucleus, the price tags of medium energy machines for nuclear physics are nonetheless measured in units of $10 million, and facilities to be built in the mid-1980's or later have been discussed that will top $100 million in construction costs.

To inject some order into the process of deciding what kind of new facilities to build and where to locate them, the nuclear physics community last year produced a "long-range plan" for the field. The document enumerated several areas in which progress in understanding the nucleus could be expected, laid out a decade-long scenario for constructing the accelerators needed to produce the new knowledge, and set fairly specific funding guidelines for the agencies that support research in nuclear science. The plan is a conservative one that does not call for large increases in spending. Instead it opts for a "constant effort" research program and accepts the notion, realistic in these inflation-ridden times, that something old will have to go for each new facility constructed.

After a protracted period of discussion between the National Science Foundation (NSF) and the Department of Energy (DOE), the agencies endorsed the long-range plan and last August jointly transmitted it to the Office of Science and Technology Policy (OSTP). The plan has now been accepted by OSTP and by the Office of Management and Budget (OMB). Herman Feshbach, of the Massachusetts Institute of Technology and chairman of the Nuclear Science Advisory Committee (NSAC), the panel that counsels the agencies on nuclear science research, told his committee members at a November meeting, "We've gone as far as we can go in providing the country with a plan [for nuclear physics]." Agency officials caution that the levels of support called for in the plan will not likely be reached in next year's budget but only asymptotically over a longer period, unless the Republican Administration brings in dramatically new ideas about the funding of basic research.

In arriving at its long-range plan, the nuclear science community in some ways followed in the footsteps of high energy physicists, who have had a formal panel giving advice to DOE and its predecessor agencies since 1967 and who have had a "guaranteed" minimum level of funding in recent years. But nuclear physics is a much more diverse field. The problem is that many of the various subfields of nuclear science require costly accelerators of quite different kinds that operate in several energy ranges, all of which are capable of "fore-front" research. Moreover, nuclear physics machines number in the dozens, some of them being university facilities and some of them being located at DOE national laboratories. Feshbach admitted to *Science* that he "was told up and down by all the wise men in Washington that it would never be possible to get the nuclear science community together."

Over the years there have been a succession of studies of nuclear physics, many of them by ad hoc committees of the National Academy of Sciences. In the mid-1960's, reports of the study groups began to include recommendations for the establishment of a permanent committee to advise the funding agencies, much as the then recently established High Energy Physics Advisory Panel was doing for the old Atomic Energy Commission (AEC) in that field. But the idea was never acted on.

A 1976 budget crisis in nuclear physics changed the situation dramatically. By the time the situation had been resolved OMB had decided that nuclear research should join high-energy research in a protected status—that is, funding for these fields did not have to be justified as being relevant to solving the energy problem. Spin-offs of this development included the formation of a separate division of high energy and nuclear physics at the Energy Research and Development Agency (ERDA, an AEC successor) and a new receptiveness to the idea of a permanent nuclear advisory committee.

After several months of negotiations, NSF and ERDA agreed jointly to sponsor such a permanent advisory body. When NSAC opened for business in October 1977, just as ERDA became subsumed into DOE, William Fowler of the California Institute of Technology became its first chairman. Fowler is credited with holding the group together in its first year because he was listened to by every part of the nuclear community.

Getting an advisory committee was only half the battle. There was still no agreement in the nuclear science community as to what the priorities of the field were within a rather lean research budget. As its first order of business, for example, NSAC established a facilities subcommittee to recommend which proposals for new construction or upgrading of old accelerators should be accepted each year. But, in their deliberations, the subcommittee responded mainly to the proposals received that year. It was not able to consider them in the framework of a long-range plan that laid out a blueprint for what types of accelerators would be needed in the future. In the past, there had been a certain feast-or-famine aspect to funding for new construction, for example, which could not be dealt with without a plan.

By the middle of NSAC's second year it became terribly important to have a long-range plan. As James Leiss, DOE's director of high energy and nuclear physics put it, "Two years ago it was clear that nuclear science would be in difficulty if it didn't come up with something." In short, the political fact of life was that neither the Carter Administration nor the Congress was willing to support requests for expensive new projects in the absence of clear evidence that the nuclear scientists were unified and knew where they were going and what they needed in order to get there.

At Fowler's suggestion, Feshbach, who was taking over chairmanship of NSAC, also led the preparation of the now demanded long-range plan. The plan was written during a week-long sojourn on Cape Cod in the summer of 1979. According to Feshbach, the committee first decided on a financial strategy that would permit continuation of the present scientific effectiveness of the field. The strategy adopted was to count up the total capital investment in U.S. nuclear science laboratories (roughly $500

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million) and estimate the time to reach obsolescence (a maximum of 20 years). The cost of replacing facilities then comes out to be $25 million per year, but for various reasons the committee recommended that new construction and upgrading of older facilities be funded at an average of $20 million annually, as compared to the actual average in recent years of about $16 million.

NSAC considered three scales of facilities: small, medium, and giant. Of the 24 small facilities in existence, nearly all are Van de Graaffs or cyclotrons located at universities. One example of the seven medium size facilities is the Bates electron linear accelerator at the Massachusetts Institute of Technology, which is being upgraded from 400 million electron volts (MeV) to 750 MeV. Another is a pair of superconducting cyclotrons at Michigan State University that together will accelerate nuclei as heavy as uranium when the second one is completed in 1984 at a cost of $30 million. The two giant facilities now existing are the Los Alamos Meson Physics Facility (LAMPF) and the Lawrence Berkeley Laboratory relativistic heavy ion accelerator, the Bevalac. LAMPF is a half-mile-long linear accelerator that boosts intense beams of protons to 800-MeV energies in order to produce secondary beams of pimesons, muons, and neutrinos. The facility was completed in 1972 at a total cost of $57 million. The Bevalac is the result of the remarkable conversion of an ancient 2000-MeV proton-synchrotron to nuclear physics use by adding another Berkeley facility, the Super-HILAC, as a heavy ion injector.

Over the next decade, NSAC calculated, the $20-million-per-year construction budget would accommodate one small project annually and one medium facility every 3 or 4 years. Giant accelerators would be limited to one per decade and would have to be financed separately by special allocations and justified as being required by important national goals. Moreover, it would be necessary to provide for the operating costs of each new giant accelerator by closing down an existing large facility and by seeking an increase in funding for operations. Operating costs can be a very disruptive factor in maintaining balance in a diverse physics programs. When the Los Alamos facility was completed, it absorbed almost one-third of the DOE budget for operating expenses. But because there was no increase in total funding for operations, there was an obvious effect on other research efforts.

In other budget categories, NSAC argued for an average 3 percent per year increase (in addition to inflation) in operating funds from $113 million in fiscal 1980 to $132 million in fiscal 1986, and for an immediate increase in money for capital equipment and instrumentation to $14 million per year (from $10 million) to redress past neglect.

Having fixed on an overall scale of effort in nuclear science, NSAC had to decide how to parcel out the money to the various areas of research, whether to emphasize some areas and pull back in others, and so forth. The committee explicitly did not attempt to specify which institutions should receive new or upgraded facilities, however. It probably would have been surprising if it had worked out otherwise, but the committee nearly unanimously concluded that the present mix of activities in nuclear science was essential for the health of the field. Accordingly, the committee worked out a 5-year plan for operating expenses for the various subfields that reflected this balance. Into this plan, the report writers folded a schedule for construction of new facilities that included Van de Graaffs, linear accelerators, cyclotrons, and synchrotrons to accelerate electrons, light nuclei (protons through alpha particles), and heavy nuclei (through uranium) to low energies (20 MeV) and intermediate energies (200 MeV). There was also a call for computer facilities for theoreticians.

The next large project (although at $50 million it can just be incorporated within the $20 million annual construction budget) is a 2-billion-electron-volt (GeV) continuous (as opposed to pulsed) electron accelerator. Farther down the road could be a $150 million proton accelerator of sufficient energy to produce intense beams of K mesons and antiprotons, as well as beams of pi mesons having higher energy than now available. This machine would replace the Los Alamos meson facility. Another giant accelerator in the discussion stage is a $130 million facility that would boost heavy nuclei to ultrarelativistic energies of 20 GeV per nucleon and might also have a colliding beam capability in which heavy nuclei would crash head on, thus providing a collision energy equivalent to that in a fixed target machine of 800 GeV per nucleon. The accelerator would replace the Bevalac.

Since its formal transmittal to DOE and NSF a year ago, the long-range plan has been warmly received. The nuclear physics division of the American Physical Society, which is, as one physicist pointedly noted, the only elected body in nuclear physics, unanimously endorsed the plan last April. Officials at DOE were generally happy with the plan. But problems at NSF delayed the plan's acceptance. One hang-up was NSF's long-standing reluctance to take on long-term funding commitments, although the foundation has accepted some in the past. The official viewpoint was that it was unfair to single out nuclear science for preferred status, independent of whatever advances might occur in other fields that would change the desired overall balance of research support. A long series of negotiations ended when NSF's current physics director, Richard Deslattes, came up with wording for a strong endorsement that simultaneously reflected the agency's concerns. Thus, in the letter of transmittal to OSTP, Edward Freiman, director of energy research at DOE, and William Klemperer, director of mathematical and physical sciences at NSF, were able to write: "Within these budget realities it is the intent of our two agencies to follow the main features of the Long Range Plan in our program development over the next several years."

As always, the ultimate test of success in research funding is the President's budget, which will be made public next month, and Congress's response to it. With a long-range plan and community support for it, nuclear physicists are in the best position they have been in for a long time to argue for their interests.

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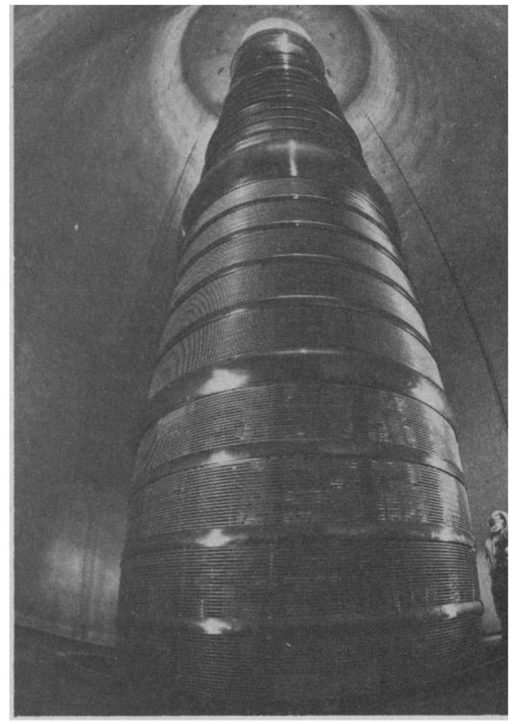

New Accelerator Dedicated

The Holifield Heavy Ion Research Facility at the Oak Ridge National Laboratory includes a 25-million-volt tandem Van de Graaff (electrostatic) accelerator for nuclei having atomic masses from 12 (carbon) to 160 (terbium). [*Source: Union Carbide Nuclear Division*]