the next 5 years waiting for something to be built," says Harold Furth, director of the Princeton Plasma Physics Laboratory. But Furth adds that several experiments in the United States and abroad demonstrated that neutral beams would be effective for TFTR. "We knew very well that it would work. TFTR would not have gone ahead without knowing that," says Furth.

But at Livermore they were building a huge machine based on fundamentally new and untested principles. "They were stuck with having to build something on a large scale while at the same time trying to understand the basic physics," says Lidsky.

Says Fowler: "You could debate the decision, but it wasn't illogical. Building big machines is a mixture of lead times, resources, prudence, and gambling. The question to ask is: were our extrapolations reasonable or weren't they? We think they were reasonable." Clarke admits, "It was a high-risk experiment, but it wasn't totally crazy. . . . Each of these decisions seemed reasonable at the time."

Unfortunately, TMX-U was not wildly successful. Though confinement times were good, plasma density was low. It was difficult to get the density up. One problem was that cold ions would swamp the thermal barrier. Whether MFTF-B, with its own thermal barriers, would work any better than TMX-U is anybody's guess. The machine to test the principles sits in Building 431 at Livermore.

"No one believes MFTF-B would fail. But nobody is absolutely certain it would work either," says Dean. "It was a very risky kind of experiment performed on a grand scale. A major facility based on unfounded physics. People knew that going in," says MIT's Kesner.

Clarke's decision to close down the program at Livermore was a difficult one. "It would have been so much easier if I had a technical failure to point to," says Clarke. Faced with large cuts to the fusion program's budget, Clarke says that he was forced to slash mirrors to maintain stable funding for tokamaks. It was a tremendous blow to Fowler as well as Livermore. For years, the laboratory had been churning out a stream of proposals and reports, full of color photographs and drawings, loaded with hopeful timelines and filled with a language of optimism about the future of fusion energy.

As for the future of the mirror program now, there seems to be none. While a few at Livermore pretend to remain optimistic that MFTF-B will someday be put to use, it is a hope that will almost certainly be dashed. Because MFTF-B still lacks diagnostic equipment and additional heating elements, it would take at least another 18 months to make the machine operational. Fowler estimates it would also cost an additional $250 million to get worthwhile results from MFTF-B. This is a check that will never arrive. "We'll give ourselves a couple more years and then decommission the thing," Clarke says. As it stands, the machine costs $2 million a year just to keep in mothballs. Asked what would happen if his office were given another $100 million next year, Clarke answers that the money would go to tokamaks, not mirrors.

Fowler is resigned to the fact that it is again a one-horse race. This summer, Livermore began to uncrate and reassemble an old tokamak that DOE transferred from MIT to Livermore. MIT's Alcator-C machine now sits in a small alcove, dwarfed by MFTF-B. Hoping to use a free electron laser to drive the current in Alacator-C, Fowler and what remains of his team are joining other researchers around the world who are trying to make the tokamak a steady-state machine. "Now is the time to find out if the tokamak is a reactor or not, a time to resolve old issues, to either turn up or turn down the wick," says Fowler.

During the program's peak in 1984, some 500 people worked on the mirror project at Livermore. About 150 are left. Many who left the mirror program have gone on to other projects under Livermore's umbrella. More than a few are now involved in Star Wars research, for it is not a tremendous leap to go from fusion research to work on particle beam weapons. Of the 70 physicists who once worked for Fowler, about half remain. The others have moved on—to positions in small companies around San Francisco, to tokamak programs. One team hauled some of MFTF-B's diagnostic equipment to Japan and are now involved with GAMMA-10, one of the last of the mirror machines. Fowler and Logan are working on conceptual designs for the International Thermonuclear Experimental Reactor (ITER), a collaborative effort by the United States, the European Community, Japan, and the Soviet Union. A bitter pill, ITER is a tokamak.

The last holdout is Post, who has been working on mirror machines since 1952. Post refuses to work on tokamaks. His current project is yet another mirror machine, but unlike MFTF-B, this one would fit in the trunk of a car. Post's present research team involves not hundreds, but two graduate students. "It's not over yet," says Post. "It's possible neither tokamaks nor mirrors will turn out to be the one. In fusion, anytime you think you're right, you're usually wrong." ■

WILLIAM BOOTH

APS Panel Disowns Council Statement

Virtually all the authors of an influential report on laser and particle beam weapons, issued last April by the American Physical Society (APS), have taken the unusual step of publicly denouncing a statement by the APS council that was based in part on their own findings. They believe that the council's statement politicized their work and undermined its credibility.

The statement, which was issued the day after the report was made public in April, argued against early deployment of any elements of President Reagan's Strategic Defense Initiative (SDI), and said "the SDI program should not be a controlling factor in U.S. security planning and arms control." In making that argument, the council cited the panel's findings that directed-energy devices currently fall far short of the performance levels required for ballistic missile defenses and that at least a decade of intensive research will be needed to provide the technical basis for decisions on whether SDI systems based on them would be effective and survivable (*Science*, 1 May, p. 509).

In a letter published in the October issue of *Physics Today,* 14 of the 17 authors of the report state: "We object to being included in the council's statements on matters neither we nor they studied." Harvard physicist Nicolaas Bloembergen, who cochaired the panel that produced the report, says the panel scrupulously avoided statements that went beyond technical analysis of directed-energy technologies. "We had hours of debate to stop falling into that trap," he says. But the council's statement, he believes, undercut the nonpolitical nature of the report. "It was very embarrassing to members of the study group."

Val Fitch of Princeton University, the current APS president, says in a published response to the letter "in retrospect, it might have been better if the council had not restated some of the conclusions of the study panel. It was always intended that the DEW [directed-energy weapons] study stand clearly alone." He told *Science* that the council had been debating for 2 years making a statement on SDI, and said "it was a little unfortunate that the statement came out so soon after the report was released."

In any case, Fitch points out that although the report itself received widespread attention, the council's statement sank almost without trace. Press accounts at least had no difficulty separating the two and deciding which was the more important. ■

COLIN NORMAN