The Fusion Community Picks up the Pieces

The Burning Plasma Experiment is gone, but fusion scientists are united on where the program should go next

LIKE RODNEY DANGERFIELD, FUSION SCIENTISTS in the United States get very little respect. Skeptics routinely deride as impractical their lofty vision of a future of almost unlimited energy; Congress frequently treats their budgets rudely; and their slow but steady progress toward machines that can produce usable power is often overlooked or ignored. They even had to endure a recent blast in the National Academy of Sciences publication *Issues in Science and Technology* from a Northeastern University political scientist who argues for shutting down the entire program because it cannot hope to win consistent long-term political support. The consensus among such skeptics could be summarized by one nonfusion physicist who quips: "Fusion energy looks quite promising about 15 years down the road. But it has always looked quite promising about 15 years down the road."

At first glance, the program's recent history would seem to confirm the skeptics' views. Several years of tight budgets and abrupt shifts in policy and personnel at the Department of Energy (DOE) reduced the program's scope to a single technology—the tokamak reactor—and demoralized scientists (*Science*, 23 June 1989, p. 1434). Then last fall, once the community had appeared to unite behind an ambitious timetable for fusion development, came a severe blow: On the advice of a hastily convened expert panel, DOE decided to cancel plans for what was to have been the next major tokamak in the fusion program, the $1.8 billion Burning Plasma Experiment (BPX).

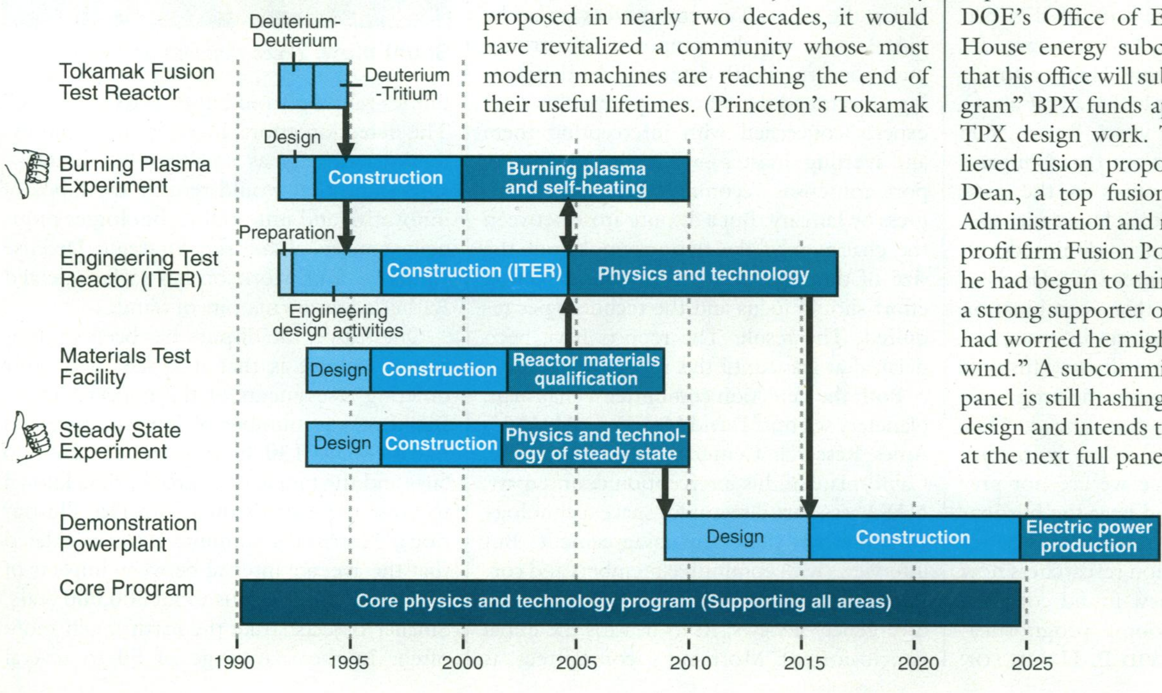
Surprisingly, in spite of these setbacks the fusion community seems to be more determined now than at any time in the past few years. In just under 6 months, it has gone from complete disarray to near consensus on its near-term goals, with broad agreement on how to plug the gap left by BPX's demise, and DOE's top energy science official has made a new commitment to keeping the fusion program on track. This new consensus will get a severe test over the next few months, however, as the fusion budget makes its way through Capitol Hill.

The key will be whether Congress will agree to the plan to restructure the program to accommodate the loss of BPX. That machine would have given physicists their first chance to study the physics of power generation by "burning" plasma—heating it to a point where the energy produced by fusion of deuterium and tritium nuclei could sustain the reaction. As the first major U.S. facility proposed in nearly two decades, it would have revitalized a community whose most modern machines are reaching the end of their useful lifetimes. (Princeton's Tokamak Fusion Test Reactor [TFTR], for instance, is scheduled to shut down in 1995.) And, perhaps most important, it would have served as the first in a series of ambitious stepping stones toward DOE's stated goal of building a demonstration fusion power plant by 2025.

These plans came crashing down last fall when a DOE advisory panel chaired by Nobel Prize–winning physicist Charles Townes recommended canceling BPX because tight energy research budgets had made the machine unaffordable. But in a quick recovery from what fusion scientists invariably refer to as a "frustrating" and disappointing decision, they have shuffled plans for a "steady state" tokamak and a multibillion-dollar international fusion effort known as the International Thermonuclear Experimental Reactor (ITER). If Congress goes along, they believe these changes will keep the demonstration power reactor on schedule.

After several months of deliberation, DOE's fusion advisory committee is nearly ready to unveil an initial design for a steady state tokamak now informally known as TPX, for the Tokamak Physics Experiment. While not a new idea, TPX has risen in priority as a result of BPX's demise and is now poised to be the centerpiece of the U.S. domestic effort. It should be capable of maintaining a heated plasma for at least 1000 seconds—much longer than the 1- or 2-second "bursts" current reactors can achieve. Unlike BPX, the $400 million machine would not achieve the temperatures and densities needed for ignition, but it would produce valuable data on tokamak performance.

So far, TPX has the full backing of the department: William Happer Jr., director of DOE's Office of Energy Research, told a House energy subcommittee 2 weeks ago that his office will submit a request to "reprogram" BPX funds appropriated last year for TPX design work. That announcement relieved fusion proponents such as Stephen Dean, a top fusion official in the Carter Administration and now director of the nonprofit firm Fusion Power Associates, who says he had begun to think Happer might not be a strong supporter of the fusion program: "I had worried he might leave it twisting in the wind." A subcommittee of the DOE fusion panel is still hashing out the details of TPX design and intends to present them in public at the next full panel meeting on 18 March.



Fusion's timetable. *With BPX out, the Steady State Experiment has risen in priority.*

The BPX cancellation has also led to some rethinking of plans for ITER. A joint project of Europe, Japan, the United States, and the Russian Republic now in the first year of a $1 billion, 6-year engineering design phase, ITER was originally scheduled to make use of data produced by both BPX and what is now TPX. Physicists had hoped to use ITER "not to learn, but to confirm" data from these facilities, says Robert Conn, chairman of DOE's fusion advisory panel and a plasma physicist at the University of California at Los Angeles. Without data from BPX, however, fusion researchers say they will have to study ignition physics in ITER for much longer than originally planned—a minimum of 6 to 10 years, instead of 5 to 6. This delay "compromises" ITER's pace and scope and increases the technical risk of meeting the long-term DOE goals, Conn says.

In an effort to soften the blow on ITER, Conn's panel has recently proposed that DOE consider a "complementary" program that would lighten the burden on ITER by producing important data first. The top priority, Conn says, would be a 14 MeV neutron source for the design and testing of "low-activation" materials for lining confinement chambers. Such materials are less likely to become radioactive under the heavy neutron flux produced by fusion reactions. This facility is likely to be expensive, however, perhaps costing as much as $600 million. And although DOE has placed such a facility on its timetable, it has not proposed how it would pay for it.

Budgetary uncertainties, in fact, continue to cast a cloud over the fusion community's plans. Researchers have taken heart from DOE's official commitment to its fusion timetable (see chart), drawn up 2 years ago and since adopted as part of DOE's National Energy Strategy. And they are delighted by a promise from Happer to increase the fusion budget by 5% a year above inflation for the next 5 years. But outside critics are quick to point out that Congress has dashed similar promises in the past. William Kay, a Northeastern University specialist on the politics of technological development, writes in the Winter 1991 *Issues in Science and Technology* that a combination of long time horizons, enormous costs, and technological uncertainty will cause fusion's financial demands to outstrip the program's available funding in the years ahead. "The program is already dying a slow budgetary death," he writes. "Since we are not prepared to do the work and bear the burdens to make fusion energy a success, it is better that we not go on." Fusion researchers now must prove that their new-found cohesion can confound such gloomy prognostications. ■ DAVID P. HAMILTON

A Rocky Watch for Earthbound Asteroids

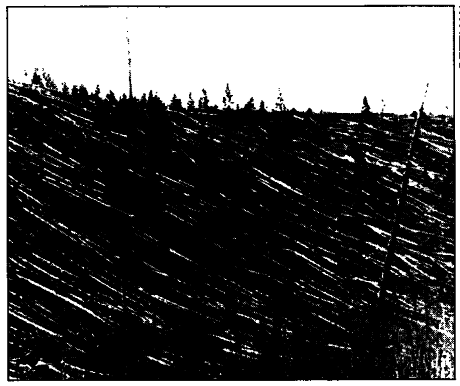
A NASA study is seeking ways to avert collisions—but participants argue about which asteroids to watch for

IT SOUNDS LIKE A SCENE IN A SCIENCE FICTION novel: Nuclear weapons experts meet with top astronomers behind closed doors to seek ways of protecting Earth from cosmic catastrophe. The cast of characters in this opus includes nuclear weapons designer Edward Teller and some 70 other scientists, and the plot devices are a global telescope network, Star Wars technology and another jarring reminder of the cold war, the neutron bomb (see box). Yet those were the elements of a January meeting at Los Alamos, convened by the National Aeronautics and Space Administration (NASA). It was the latest in a series of get-togethers that, beginning in 1990, have addressed the ultimate environmental hazard: the conceivable destruction of civilization by the impact of a comet or asteroid.

Evidence that this is not science fiction can be found in scores of impact craters around the world, in the explosion of a large meteor or small comet fragment over Siberia in 1908, and in the global catastrophe that may have wiped out the dinosaurs. Still, your memory of science fiction might lead you to think that scientists would quickly unite in the face of this newly recognized threat to the species. Not quite. The January meeting attempted to patch a schism that had become apparent soon after NASA, prompted by Congress, began the study. Two committees set up by NASA—one largely composed of astronomers concerned with detecting the threatening objects and the other of space technology experts concerned with intercepting them and averting disaster—were scheduled to report consensus recommendations to Congress by January. But a dispute arose between the chairmen of the two groups about the size of the objects on which the detection effort should focus and the technologies required. The result: The reports have been delayed at least until this month.

Both the detection committee's chairman, planetary scientist David Morrison of NASA's Ames Research Center in Mountain View, California, and his interception counterpart, NASA associate director for space technology John Rather, deny any disagreement. But interviews with committee members and correspondence seen by *Science* reveal a sharp divergence of views. At its heart is the initial conclusion of Morrison's committee, as stated in a preliminary draft obtained by *Science*: "The greatest risk from cosmic impacts is associated with asteroids a few kilometers in diameter." The draft goes on to recommend the construction of a $50 million global detection network called Spaceguard, consisting of six 100-inch telescopes fitted with charge-coupled devices. That technology would give 20 years' warning of asteroids bigger than about 1 kilometer across—time enough to divert them, perhaps with nuclear warheads (see box).

When Rather learned about the detection committee's recommendation last fall, he protested to Morrison that it amounts to turning a blind eye to "a whole class of [smaller] objects having destructive capa-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Slight blow. *Trees downed at Tunguska.*

bilities ranging from kilotons to gigatons." The detection effort, he argued, should extend to objects as small as 50 meters—something that would require the kinds of innovative and untested technologies originally conceived for the Strategic Defense Initiative. But Morrison has so far rejected Rather's arguments out of hand.

One reason the dispute has been so difficult to resolve is that it is fed by sharply differing assessments of the impact hazard. Based on the number of impact craters on Earth—some 130 have been identified so far—and the tangle of asteroid orbits known to cross the Earth's own path (see illustration), Morrison's committee has calculated that the average interval between impacts of kilometer-size objects is about 500,000 years. Smaller objects strike the earth much more often: In the size range of 50 to several