PLASMA PHYSICS

Requiem for a Heavyweight at Meeting on Fusion Reactors

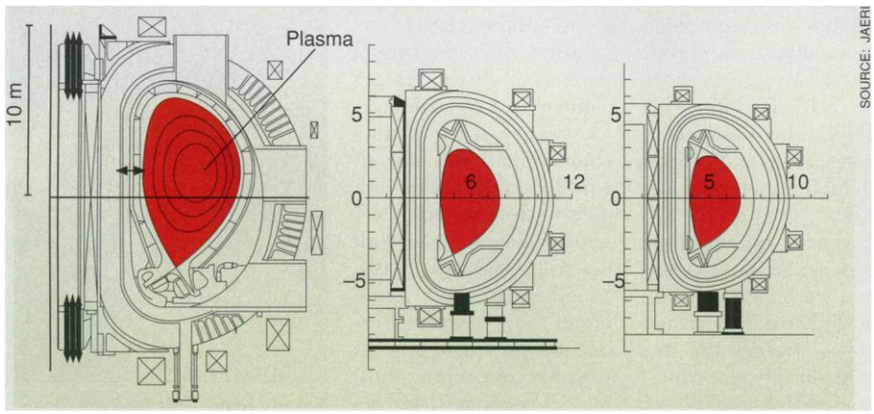
MADISON, WISCONSIN—The full-scale, $10 billion version of the proposed fusion power test-bed called ITER (for International Thermonuclear Experimental Reactor) appears to be defunct. After dimming for months as the project was beset by financial and technical criticism (*Science*, 2 January, p. 20), its prospects were all but extinguished here last week during a meeting* of fusion experts from U.S. universities, companies, and national laboratories. Not only did the $10 billion design find almost no support among U.S. scientists, but for the first time, a representative from Japan's fusion program openly floated designs for a smaller and less ambitious international machine—a roughly half-price version that has been dubbed an "ITER Lite." This scaled-down venture, unlike the original proposal, would not be designed to generate the self-sustaining fusion burn called ignition.

The Japanese proposal wasn't the only version of ITER Lite presented at the meeting. But because Japan is the most likely of the four ITER partners—Europe, Japan, Russia, and the United States—to host an ITER and to put up the largest share of the costs, the 29 April presentation here by Mitsuru Kikuchi of the Japan Atomic Energy Research Institute (JAERI) marked a turning point for the program, said participants. "Everyone recognizes that [the full-scale machine] just can't be mounted," says David Baldwin, senior vice president for the fusion group at General Atomics in San Diego.

"My personal opinion is that $10 billion is rather expensive," Hiroshi Kishimoto, JAERI's executive director, later told *Science*. "So it would be better to reduce the cost by optimizing the design." Adds Charles Baker, the ITER U.S. Home Team Leader and an engineering professor at the University of California, San Diego, "I think something in the 50% range ... may open up the possibility of [actual construction] happening."

Kishimoto, who until now has publicly insisted that no design changes could be considered, cautions that the full-scale version is still officially on the table: "It is not dead—not yet." Europe, too, still regards the original ITER as the collaboration's "reference base design," says a source within the European fusion program. But this source also says it may be necessary to shrink ITER in order to save it: "The notion that something with 50% cost reduction corresponding to a reduced mission might have a greater chance to be built is considered acceptable in Europe."

Even a half-priced ITER is too much for some U.S. researchers, however, who fear that the project will still be too large to win support in Congress or within the power industry. In an ITER Lite, "you would still have a very large, very expensive machine," says L. John Perkins, a fusion researcher at Lawrence Livermore National Laboratory in California. He and others favor a portfolio of much smaller, cheaper experiments that could show the way to more economically attractive power plants.



ITER Lite. Two schemes for a half-price alternative to the giant reactor are compared with the original *(left)*; the drawings show cross sections of the donut-shaped tokamak.

As originally envisioned, ITER would be a gigantic tokamak—a torus-shaped device threaded with magnetic field lines that confine hot, ionized gas, or plasma. The 16-meter donut would confine plasma for long enough to ignite in a self-sustaining thermonuclear fire, demonstrating the principle of fusion power as well as providing a test-bed for the superconducting magnets and materials that might be used in an actual power plant. But the U.S. Congress has warned against ITER's high cost and the vagueness of U.S. commitments to the project. Some scientists have also raised doubts about whether ITER could meet its original goal of igniting a fusion burn (*Science*, 6 December 1996, pp. 1600 and 1601). But although review panels in the United States repeatedly suggested slimming down the project, the Europeans and Japanese have officially rejected such a move until now.

The change comes after Japan's own economic problems led it to request a 3-year delay in any decision by the partners on whether to build ITER. More recently, in part reflecting that delay, the Department of Energy's (DOE's) 1999 budget request slashes U.S. funding for ITER by almost 75%, to $15 million. "The message has gone out that ... ITER is not going to survive," said Tom Cochran, a specialist in nuclear issues at the Natural Resources Defense Council in Washington, D.C., speaking to the forum here.

The 165 fusion scientists at the forum, which was intended partly to advise DOE on ways to continue the international collaboration during the delay, seemed to have absorbed that lesson already. When the participants were divided into six "breakout groups" and asked to come up with a range of possible next-step fusion experiments, not a single group even listed the original ITER as an option. But the groups' preliminary reports to the forum often mentioned scaled-down versions, along with even smaller devices that would study the physics of burning plasmas by using ordinary copper coils—rather than the delicate and costly superconductors—to produce magnetic fields.

In talks at the meeting, Kikuchi of JAERI, Miklos Porkolab and Joel Schultz of the Massachusetts Institute of Technology (MIT), and other researchers laid out designs for various versions of ITER Lite. The JAERI concept sets a lower performance target than that for the full-scale machine, down from ignition to a "power amplification"—the ratio of the fusion power output to the power used to heat the plasma—of 10 or 20. (Ignition would imply a ratio of infinity.) According to JAERI calculations, this less ambitious target would allow the overall diameter of the torus to be reduced by as much as 30%. And the lower fusion yield would allow the voluminous shielding that protects the ultracold superconductors to be pared down; in addition, the support structure would be reengineered for cost savings.

The MIT concept would also settle for something short of ignition. Moreover, it

* The Forum for Major Next-Step Fusion Experiments, sponsored in part by the University Fusion Association, 27 April to 1 May.

would exploit the vast engineering conservatism in the original design by cutting the shielding even further. Like ice cubes left out in the sun, the chilled magnet coils would take some time to warm up; they could still take at least a 300-second fusion pulse before slipping out of the superconducting state, explained Schultz.

In spite of the more modest scope of these machines, Kikuchi said they would be enough to gauge the performance of a demonstration power plant. The reason, he said, is that the fusion would still outweigh external heat sources as the major supplier of heat to the plasma, just as in a demo plant.

"They're all coming out with about the same answer" on size, cost, and performance, said Baker, the U.S. ITER leader, who characterized his reaction to the proposals as "very positive." But although some researchers at the forum shared Baker's assessment, others feared that a smaller ITER may prove to be a scientific dead end. Instead of seeking innovative ways to approach ignition, the concepts still rely heavily on simply scaling up current knowledge, said Michael Bell of the Princeton Plasma Physics Laboratory. Consequently, he said, "you're stuck with these horrendously large reactors. The conclusion is they're no good."

Mark Haynes, vice president for Washington operations at General Atomics, fears that ITER Lite may be a dead end politically as well. "My view is that most people in Congress are not going to view a half-price ITER substantially more favorably than a full-price ITER," he said to the forum. Or, as one U.S. plasma physicist said about the likely political outcome of backing the ITER Lites: "We're dead."

Baker argues, however, that U.S. domestic politics are beside the point, because the Japanese and Europeans would be the major funders of any ITER machine. "The real push to build it won't come from the U.S.," he says. The non–U.S. partners, agrees Anne Davies, head of the DOE's office of fusion energy sciences, "are in the driver's seat." But in a time of flat or declining budgets for fusion, nervous American fusion researchers are likely to view their next move as a critical chance to redirect their own program—whether or not an ITER remains on the world scene.

–James Glanz

With reporting by Dennis Normile in Tokyo.

U.S. R&D BUDGET

Euphoria Fades as Threats Emerge

David Goldston is not a psychiatrist, but he suspects that the scientific community may be suffering from bipolar disorder. As Representative Sherwood Boehlert's (R–NY) legislative director, Goldston watched researchers panic 3 years ago when cuts were projected in federal R&D spending and then grow euphoric this year as politicians spoke in support of R&D, all while overall spending patterns remained relatively constant. "Very little has changed," says Goldston, "but the mood swings are enormous."

Goldston delivered his diagnosis at last week's annual R&D colloquium sponsored by the American Association for the Advancement of Science (AAAS, which publishes *Science*). He was one of several speakers who warned that federal R&D agencies—with the exception of the National Institutes of Health (NIH)—face an uphill battle despite a favorable 1999 budget request from the president and a bipartisan coalition in Congress backing basic research. "It's going to be a very long struggle over domestic resources ... and it's not going to be pretty," warned Franklin Raines, outgoing director of the White House Office of Management and Budget.

That sobering view is based on the projected outcome of three current battles on Capitol Hill. The first is tobacco legislation, which the White House hopes will provide billions in new revenues to fund increases in R&D over the next 5 years. Although Raines sees a bipartisan Senate bill as evidence that the legislation remains alive, many Democratic and Republican lawmakers and their staffs are skeptical that a deal can be worked out this year. Even with a deal, there is intense disagreement over how to spend any windfall.

The second battle is over how to pay for a pending boost in highway spending. Raines and congressional sources estimate that the measure could cost $34 billion a year during the next 6 years. Legislators have several options: They could use the projected budget surplus, break the cost caps imposed under a previous deficit-reduction agreement between Congress and the Administration, or remove the highway bill from the general budget and, in essence, make it an entitlement. But Raines says the Administration opposes each of these approaches—as do plenty of Republicans. The only option may be to squeeze other domestic programs. "It's a real threat ... that could crowd out the R&D budget," said Kerri-Ann Jones, acting chief of the White House Office of Science and Technology Policy (OSTP), at the AAAS meeting. "We could be looking at a very significant reduction."

"It's going to be a very long struggle ... and it's not going to be pretty."
—Franklin Raines

The third wild card is a pending resolution by the House Budget Committee to slice $100 billion out of federal spending—mostly out of domestic programs—during the next 5 years and abolish the Commerce and Energy departments. If its contents were transformed into spending bills, "you can forget about any kind of increase ... even for NIH," said Raines. Although the resolution's hard line, authored by panel chair Representative John Kasich (R–OH), is unlikely to win broad support, it could still poison the political atmosphere against any increases in domestic spending programs.

None of these battles is likely to prevent a hefty NIH increase, say lawmakers and their aides, although Senator Arlen Specter (R–PA) warned at a hearing last week that the appropriations panel he chairs, which handles NIH's budget, likely will not receive any more money than last year. That means any increases for NIH would have to be carved from other programs under the panel's jurisdiction, such as labor and education. More threatened are the boosts requested by other agencies such as the National Science Foundation (NSF). "All those on the Hill who talked about big increases for R&D may not be able to deliver for anyone except NIH," says one White House official.

For Goldston, the message is not that Congress is unwilling to back R&D but that research is being eclipsed by larger issues. "The science budget isn't being driven by science. So get out there and lobby," he counsels.

How well researchers are lobbying is a matter of debate. NSF director Neal Lane, awaiting confirmation as OSTP chief, praised scientists for their "terrific" lobbying efforts to date. A few hours earlier, Raines had scolded researchers for their response to the president's request. "I'm somewhat surprised by the relative lack of comment on this initiative from the scientific community," said Raines. "Even though the president made this a major priority,