Electron beam diode technology has both advantages and disadvantages relative to other ICF drivers. In the first place, relativistic electron beam (REB) diode accelerators are based on the highly efficient and high-energy technology of electrical pulsed power. This means that REBs are most capable of attaining the necessary multi-megajoule energy and 100-trillion-watt power levels needed for ICF, and attaining these outputs at high system efficiency—upwards of 25% of the input electricity used to power the REB ends up in the beam, as compared to a fraction of a percent for the case of high-power glass lasers. (High-power lasers, such as the Lawrence Livermore National Lab Nova, are only now approaching the 100,000 joule energy level—see accompanying article.)

On the other hand, it is extremely difficult to focus REBs to the high power densities, and it is difficult to deposit the REB's energy within the short distance required for isentropic compression.

In the mid-1970s, REB technology proved capable of efficiently generating intense, high-current beams of light ions. (PBFA-II achieves 80% conversion from electron to ion beam; that is, 80% of the already high efficiency of the REB pulsed power technology is preserved.) Ions have even better pellet deposition properties than laser beams, in terms of meeting the stringent conditions needed for isentropic compression. 100% of the incident light ions are deposited within a very thin layer of the pellet, without pre-heating the interior fuel.

In 1984, a series of breakthroughs was achieved on PBFA-I in ion-beam focusing, which totally transformed the prospects for PBFA-II. When originally designed, PBFA-II was expected to at best *approach* fusion breakeven—production of as much fusion energy output as beam energy input—and to at least produce significant fusion burns. It was expected to produce multi-megajoule beams at a 100-trillion-watt power level, focusable to power densities of 100 trillion watts per square centimeter.

But light ion beam focusing experiments in 1984 and 1985 on the Sandia PBFA-I and Proto-I, experimentally demonstrated that much higher power densities were obtainable. It is now projected that PBFA-II will be capable of 3.5-million-joule energy pulses, produced in 50-nanosecond bursts at a delivered power level of 100 trillion watts, but with potential power densities of 10,000 trillion watts per square centimeter. This *100-fold improvement over original projections* is based on the scaling seen in beam focusing experiments on PBFA-I and Proto-I.

Fusion budget slashed

On Aug. 25, 1980, the U.S. House of Representatives passed a 20-year plan to develop commercial fusion, introduced by Rep. Mike McCormack (D-Wa.) and cosponsored by 159 congressmen (the vote was 365 to 7). The bill, HR 6308, mandated the Department of Energy to develop a plan to demonstrate the commercial feasibility of magnetic fusion energy by the turn of the century. The total cost authorized by the Congress was $20 billion over the 20-year period.

The McCormack bill motivated the need for an aggressive fusion program as follows: "The early development an export of fusion energy systems will improve the economic posture of the United States and ultimately reduce the pressures for international strife by providing access to energy abundance for all nations."

The accompanying figures tell the story of what has actually happened to the fusion budget in the intervening period, and particularly with the current Gramm-Rudman legislation. President Reagan's proposed FY 1986 budget was $8 million more than the $436.9 eventually adopted by the Congress for magnetic fusion research (pre-Gramm-Rudman), and $85 million *less* than that adopted for inertial confinement fusion. In the case of inertial confinement, the Gramm-Rudman cuts are still being made as we go to press.

	Magnetic fusion ($M)		Inertial confinement ($M)	
Fiscal year	Budget line	Constant 1972 dollars	Budget line	Constant 1972 dollars
1977	219.1	163.6	103.0	77.1
1978	316.3	224.3	111.9	79.4
1979	332.4	222.0	130.6	87.2
1980	355.9	224.1	144.1	90.8
1981	350.2	207.1	194.9	115.3
1982	394.1	219.6	208.8	116.3
1983	453.8	247.8	209.1	114.2
1984	447.1	259.0	190.0	110.1
1985	468.5	270.1	169.7	98.0
1986	436.9	254.6	254.6	98.7
Before Gramm-Rudman:				
	379.9	221.4	155.0	90.3
After Gramm-Rudman:				
	365.5	213.0	n.a.	n.a.