RELIGION & PHILOSOPHY

after Solidarity's suppression at the end of 1981.

But even as it speaks out against martial law, the Polish church, now led by Archbishop Jozef Glemp, strongly opposes *all* violence. Christ forgave his oppressors, Glemp observed in January 1982; "this is our Christian way, our difficult way."

SCIENCE & TECHNOLOGY

The Future of Fusion

"Fusion Energy: Still an Elusive Target" by William Metz, in *High Technology* (Jan.-Feb. 1982), P.O. Box 2810, Boulder, Colo. 80322.

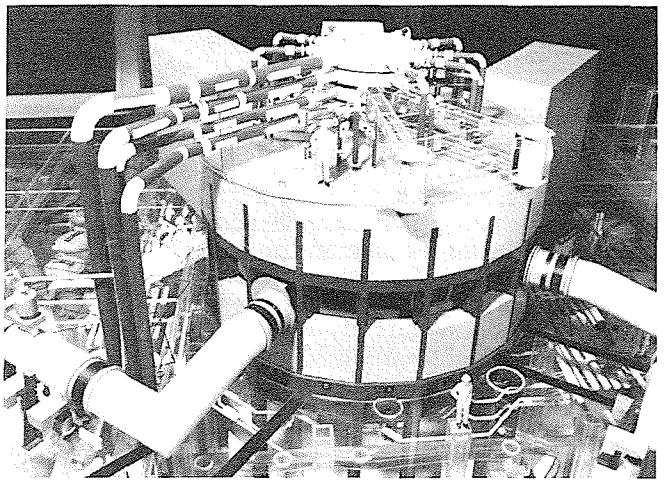
Despite talk of scientific "breakthroughs" and despite genuine progress, fusion power—energy produced by fusing nuclei of light atoms, such as hydrogen—is a long way from being a practical reality. Some difficult problems need to be solved first, says Metz, a Washington-based energy consultant.

Fusion, by contrast with fission, promises, in theory, to be a safe, clean, and inexhaustible source of energy. But scientists have been grappling for three decades with the physics involved in confining and heating two rarified gases (deuterium and tritium, both hydrogen isotopes) to temperatures hotter than the sun. "Inertial" and "magnetic" fusion have been the two main approaches.

In inertial fusion, a laser or particle beam is used to heat and compress a pellet of fuel until it detonates, the fuel's own inertia keeping it confined long enough for the reaction to take place. This process seems much less promising than it did during the 1960s and early '70s. But scientists at the University of California's Lawrence Livermore Laboratory, home of the 10-kilojoule "SHIVA" laser, have not given up hope and are planning a 300-kilojoule "NOVA" laser for the late '80s. Experts now predict, however, that a 1,000-kilojoule laser [1 kilojoule = 0.948 Btu] will be needed just to test the concept.

The currently favored approach is magnetic fusion, in which magnetic fields are used in complex configurations to keep the fuel confined. Significant advances have been made in recent years. In 1978, a small tokamak (a doughnut-shaped device invented by the Soviets) at Princeton University reached a temperature of 70 million degrees Celsius. This was still below the minimum 100 million degrees Celsius that would be needed for the reaction to produce more energy than it uses. A larger, $314-million Tokamak Fusion Test Reactor is now under construction at Princeton and is due to begin operating late this year. Other large tokamak projects are being built in Europe, the Soviet Union, and Japan.

Researchers are sure that fusion's scientific feasibility will be demonstrated during this decade. But then comes the tough part: building a



A model of the Tokamak Fusion Test Reactor now under construction at Princeton. The $314 million reactor is designed to produce about 20 megawatts of fusion power.

Courtesy of the Princeton Plasma Physics Laboratory.

full-scale reactor. "Power engineers cringe," Metz notes, "at the thought of a [tokamak] reactor that switches its output from thousands of megawatts of thermal energy to zero many times a day; the thermal shock to reactor materials would be unprecedented." Moreover, in operation, the inner wall of a tokamak's reaction chamber would become highly radioactive and would often need to be replaced—using techniques that do not yet exist. Radioactive waste thus generated would require disposal. Accidents involving release of radioactivity would be possible.

"The environmental and safety advantages of fusion" over fission, concludes Metz, "are not automatic and will depend upon choices that have not yet been made."

Greek City in Afghanistan

"An Ancient Greek City in Central Asia" by Paul Bernard, in *Scientific American* (Jan. 1982), P.O. Box 5969, New York, N.Y. 10017.

Scholars have long suspected that a Greek colonial state flourished in what is now Soviet Tadzhikistan and Afghanistan, in the second and third centuries B.C. But aside from some coins, no traces of the rumored "1,000 cities" of Hellenic Bactriana could be found. Now, in northwestern Afghanistan, close to the Soviet border, a French archaeological team reports it has unearthed the ruins of Ai Khanum, Bactriana's eastern capital under the Greeks.

The gymnasium, homes, and theater of this wealthy city reveal col-