nor monetary contributor, for internationally launched major facilities." So now, with the limited funding available, PPPL will focus on "smaller, innovative projects, and leverage more off international efforts in fusion energy," says Princeton's Davidson. "The US used to be a major player in fusion research," adds Meade. "But now we are becoming more of a follower than a leader."

One project that does have the go-ahead is the National Spherical Torus Experiment (NSTX), which will produce a nearly spherical plasma. For a given magnetic field, the spherical configuration can confine plasma at a higher pressure than can the conventional torus, says Meade. Since the power produced is proportional to the square of the pressure, NSTX could be an important step toward developing smaller, more economical tokamaks. A collaboration involving several institutions, NSTX will be built at PPPL. Some existing infrastructure and parts from other facilities—including TFTR—will be used. "It's an $80 million machine for $20 million," says Meade. Construction will begin this spring, and the first experiments are scheduled to start in 1999.

Other activities include providing design support and consulting to the Korean Basic Science Institute in Taejan, South Korea, where scientists are building a superconducting tokamak similar to the Tokamak Physics Experiment that was to have been built at Princeton. And PPPL scientists are considering building a stellarator—for which, unlike tokamaks, magnetic confinement is steady state and does not require a large current to flow in the plasma. "Tokamak technology is much further along than stellarator technology," says Meade. "But the next step in producing energy commercially is a big, expensive one. The strategy is to do lower-cost research now, and to continue to develop scientific foundations, so that in better times, or when our energy situation changes, we'll be ready to make the best decisions."

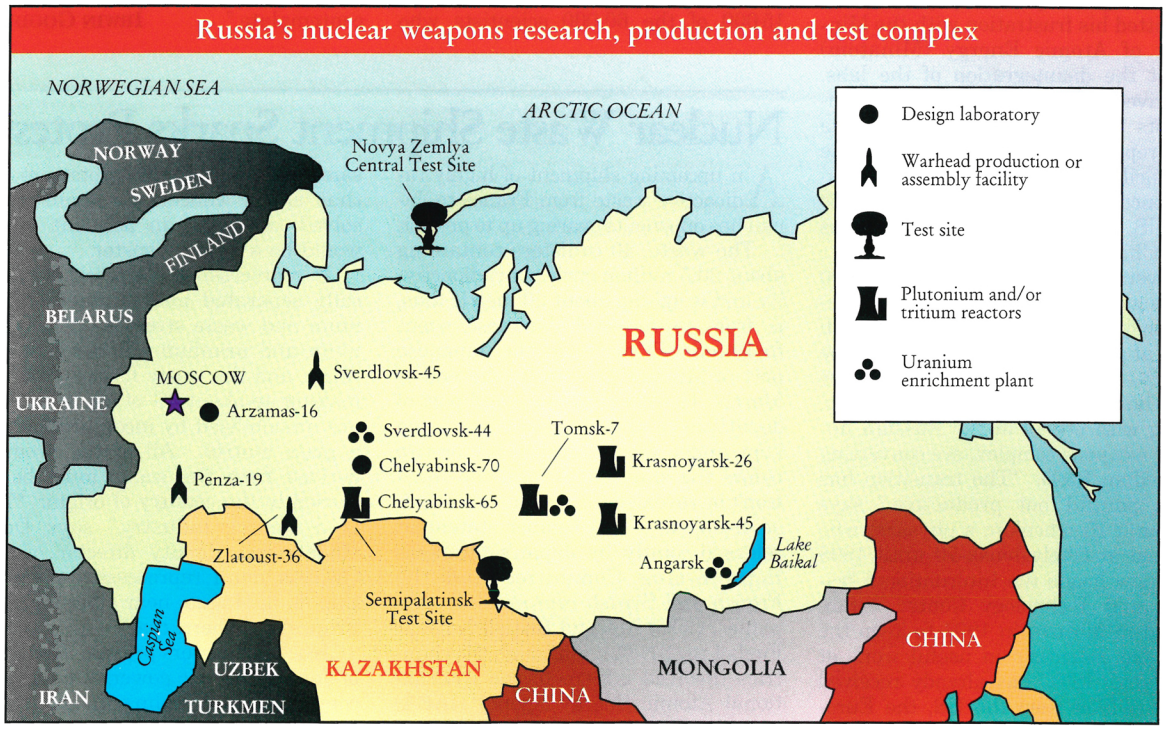
Meanwhile, William Happer, who, with Jeremiah Ostriker, heads the search for a new PPPL director, says Davidson did a "super job," and that he "doesn't know anyone who could have done it better." Princeton's John Schmidt will serve as interim director until the post is filled. **TONI FEDER**

Suicide and Resignation at Russian Nuclear Weapons Labs Symbolizes Plight of Scientists and Increases Fears in West

Among the defining events in Russia's retreat from superpower status was the suicide of one of the country's leading nuclear weapons scientists. The death of Vladimir Nechai, a theoretical physicist who had directed the nuclear weapons laboratory at Chelyabinsk-70 for the past eight years, has stunned the nation. It came only weeks after Vladimir Belugin resigned as director of Arzamas-16, in lighter moments often called "Las Arzamas"—a play on Los Alamos, the US's leading nuclear weapons laboratory.

On 30 October, Nechai was found shot dead in his office, a pistol beside him and a note for his wife, which requested that his body be buried in the town that was built around Chelyabinsk-70, which got its name as a post office box for the "closed city." The lab has been renamed the All-Russian Scientific Research Center of Technical Physics and the town of 46 000 is now called Snezhinsk. Nechai's personal motivations in ending his life may never be known, but his death has been portrayed among scientists and in the press as a symbol of the decline and fall of Russian science.

At 61, Nechai headed the Center of Technical Physics and was both the manager of the sprawling closed city, secluded in the southern end of the Ural Mountains, and a brilliant weapons designer who had been awarded the Lenin Prize. Colleagues said Nechai, normally calm and cheerful, had become increasingly disturbed by the deepening financial crisis in Russia, which had left many of his staff unpaid since June. Nechai once told



STEVEN GITOMER

NECHAI (RIGHT) WITH EVGENIY AVORIN, director of research at Arzamas-16 and now acting director of the lab.

Sigfried Hecker, director of the Los Alamos National Laboratory, that he had used bank loans to pay his workers.

Boris Murashkin, a physicist at Chelyabinsk-70, explained in a telephone interview that "possibly the main reason" for Nechai's suicide was "his pain in facing workers who haven't been paid in five months or more. He seemed despondent in explaining that the government couldn't pay for work on which the country's defense depends."

Though conditions at Arzamas-16 are just as troubled as those at Chelyabinsk-70, Belugin stepped down, scientists say, because of ill health. But Belugin, a particle physicist, has admitted his frustration with the Ministry of Atomic Energy (Minatom) about the disintegration of the labs. Deprived of adequate funds to pay scientists and technicians, to purchase and repair equipment and to operate the facility, the weapons labs have experienced a "brain drain," mainly to the US, Europe, Middle East countries and China.

Even so, Arzamas-16, about 200 miles southeast of Moscow, and Chelyabinsk-70 continue to operate with staff at about 75% of their levels in the 1980s—though weapons design is now less than 20% of the work. These labs, along with others in the Russian nuclear weapons complex, are converting to civilian R&D. "The transition has been painful but productive," says Vladimir Kruchenkov, a physicist who worked at Chelyabinsk-70 until 1993 and now heads the International Science and Technology Center, established in Moscow in 1994 to keep the weapons scientists in useful work at the labs. ISTC has already received $140 million from the US, the European Union, Japan and Sweden for the direct support of Russian scientists with expertise in nuclear weapons and other sensitive military technologies.

The nonmilitary projects are varied—among them, piezoelectric nanotechnology, fibrous composites, plutonium storage methods, pollution detection devices, and nuclear reactor safety. In a recent review of ISTC, the US National Research Council found the program "successful and effective" in reducing the incentive for Russia's nuclear weapons scientists and engineers to peddle their expertise to rogue governments or terrorist groups. Because of the persistent risk of nuclear proliferation, the research council urged the US government to continue funding ISTC through 2003.

In contrast to other efforts by Western governments to prevent weapons scientists from emigrating, ISTC's money is paid directly to each Russian scientist engaged in nonmilitary work. At Chelyabinsk-70, 1300 of the 5000 scientists are getting ISTC paychecks. According to Glenn Schweitzer, ISTC's first director and author of a new book on its origins (*Moscow DMZ: The Story of the International Effort to Convert Russian Weapons Science to Peaceful Purposes*, M. E. Sharpe, Armonk, N. Y., 1996), the program reaches about 15 000 of the 60 000 scientists who worked in the former Soviet Union on nuclear, biological and chemical weapons and the missiles for delivering them.

The ISTC program makes an end run around Minatom and the laboratory directors in "hiring" former defense scientists, unlike most of the other technical assistance efforts to promote civilian R&D and to stabilize the nuclear weapons complex in the former Soviet Union. After an infusion of $100 million from George Soros, the Budapest-born international financier, between 1992 and 1995, private assistance to civilian science has all but vanished. Other efforts, including the $1.5 billion allocated by the US Congress since 1992 for the Defense Department's Cooperative Threat Reduction program (usually known as Nunn–Lugar funds, after US Senators Sam Nunn of Georgia and Richard Lugar of Indiana who conceived it), have been stymied by the requirement that the money be spent jointly with US contractors.

The US Department of Energy has established a lab-to-lab program that attempts to account for nuclear materials in Russia's weapons complex. The first lab-to-lab visit took place in 1992 when Nechai, Belugin and other Russian scientists visited Los Alamos, Livermore and the Nevada test site, and US scientists went to Arzamas-16 and Chelyabinsk-70, as well as other labs. "It was an historic exchange," recalls Los Alamos's Hecker. "What's happening to stabilize Russian weapons science is in the best interests of world arms control. The alternative is so fraught with peril it is terrifying to contemplate." **IRWIN GOODWIN**

Nuclear Waste Shipment Sparks Protests

An upcoming shipment of highly radioactive waste from France to Japan has opponents gearing up to protest.

The waste, 40 canisters containing about 20.5 million curies of radioactivity and weighing about 20 metric tons, is from reprocessed Japanese spent fuel, and will arrive at the Japanese port of Mutsu-Ogawara by the end of March. However, the date and port of departure of the shipment are being kept under wraps until a day or two before the ship leaves, and the route won't be revealed until a day after that, according to a 4 December statement released jointly by Japan's Overseas Reprocessing Committee and the French and British reprocessing companies, COGEMA and British Nuclear Fuels Ltd (BNFL). Although the countries involved adhere to the International Atomic Energy Agency (IAEA) safety standards, the protesters say that safety concerns remain unresolved, and that an accident at sea would be a major disaster.

In reprocessing, spent fuel is chemically separated into plutonium, uranium and waste streams. The plutonium and uranium are recovered for reuse, and the waste fission products, making up about 3% of the spent fuel, are immobilized by incorporation into a glass matrix. All of the products derived from the waste must be returned to the country of origin: "This is a service industry," says Denis Hugelmann, deputy director of COGEMA's main reprocessing plant, at Cap de la Hague, near Cherbourg, on France's northern coast.

Nuclear reactors provide about 30% of Japan's electric power, and Japan is committed to recycling its spent fuel.