Cold War Rivals Find Common Ground

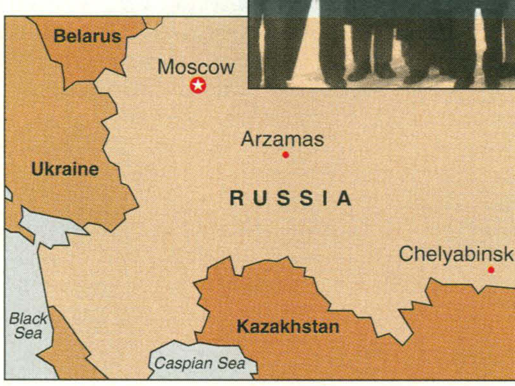
Nuclear weapons scientists from the United States and the former Soviet Union have been quietly collaborating on a range of research projects. The goal: to keep the lid on the bomb

On 23 September 1993, a group of Russian scientists threw an extraordinary, impromptu party for visiting colleagues from the United States. The venue was Arzamas 16, a supersecret research institute that had been one of two nuclear weapons labs in the Soviet Union; the partygoers were Russian and American researchers who had spent most of their professional lives trying to combat what the others were doing. As Steve Younger, a physicist at Los Alamos National Laboratory, describes it, one of the Russians brought in an accordion and started to play. "People started to dance," he says. "Russians dancing with Americans. This was amazing. These were people who for 40 years stared at each other across the Iron Curtain, who developed the weapons of the Cold War, and here they were laughing and dancing. I remember thinking here were the victors of the Cold War."

The occasion was the completion of the first in a series of joint scientific experiments between weapons scientists at Arzamas 16 and their counterparts from Los Alamos, one of a growing web of such collaborations linking weapons scientists at labs scattered throughout the former Soviet Union to Los Alamos, Lawrence Livermore, and Sandia National Labs. The collaborations, which have expanded in the past year, extend from pure science to the gritty business of helping the Russians develop and implement modern accounting methods and technology to safeguard their extensive stockpiles of nuclear materials. The most tangible result so far of these collaborations was unveiled last month: the first working prototype of a modern nuclear safeguards system that could be implemented in Russian laboratories.

Younger, who heads the Los Alamos team, calls it, quite simply, "the future: the nuclear superpowers working together to control the spread of nuclear materials, one of the most serious security threats facing the world today." But the collaborations are not just aimed at safeguarding materials; they are also intended to safeguard knowledge by providing challenging research work for Russian weapons scientists—people who, as Georgia Senator Sam Nunn (D) recently put it, "are all capable of demanding and receiving hundreds of thousands, if not millions, of dollars in reimbursement for services rendered to Third World countries or terrorist groups."

Officials in the State Department and the Department of Energy (DOE) say that these lab-to-lab collaborations have flourished out of the limelight while government-to-government attempts to solve the same problems have moved at a snail's pace through the morass of bureaucracy and politics on both sides. "The politicians have been worrying about national dignity and so forth," says Sid Drell, former director of the Stanford Linear Accelerator Center and a longtime analyst of defense and nuclear weapons issues, "while the scientists are just doing superb work."



Let's go in from the cold. Weapons lab directors Sig Hecker *(in white sweater)* and John Nuckolls *(fourth from left)* meet Arzamas head Vladimir Belugin *(third from right)* for first time in 1992. They set up links with Chelyabinsk and Arzamas labs.

Bridging the curtain

The labs first began building bridges across the former Iron Curtain when the Soviet Union began showing signs of splintering. The failed coup against Mikhail Gorbachev in 1991 provided the driving force, sparking anxiety in Washington over the dangers posed by Russia's nuclear weapons and materials. In an interview with *Science* last year, Los Alamos Director Sig Hecker recalled a key meeting with then–Energy Secretary James Watkins in December 1991. Hecker remarked that the head of Arzamas 16 probably has some good ideas for keeping the lid on Russian's bombmaking capabilities. Watkins' response: "Why don't you go ask him?"

Two months later, in February 1992, Hecker and John Nuckolls, then director of Livermore, were on a plane to Russia for a historic first meeting with their counterparts at Arzamas 16 and its sister lab, Chelyabinsk 70. That the directors of these labs were acknowledging each other's existence, let alone meeting in person; that Nuckolls and Hecker were allowed into the labs and their surrounding cities—cities that had never appeared on official Soviet maps—was indicative not only of the new freedom under the policy of *perestroika*, or openness, but also the seriousness with which both sides viewed the problems Hecker and Nuckolls had come to discuss.

During the communist regime, the authorities in Moscow provided Chelyabinsk 70 and Arzamas 16 with the foremost researchers and equipment in the Soviet Union, and those who worked there were among the most privileged. By the time Hecker and Nuckolls arrived, however, the central government had stopped sending money to the labs, and the once-entitled researchers received no pay, no medical care—indeed, often no food.

Hecker and Nuckolls came away from their meetings with a clear message: The best way to prevent talent and nuclear materials from leaving the labs would be to allow and encourage Russian weapons scientists to collaborate with the West. The heads of Arzamas 16 and Chelyabinsk 70, Vladimir Belugin and Vladimir Nechai, respectively, had told them that such collaborations would provide the Russian researchers with an income, although a small one, and perhaps more important, legitimacy in their own scientific communities. And that, says Hecker, "would buy them support from the Russian government, since funding was very difficult to come by and the government had to make tough choices."

The following spring DOE and the Department of State drew up an informal memo of understanding allowing potential collaborations between the laboratories to proceed without going through formal government channels. The major caveats were that the collaborations would have to be consistent with State Department policy and that there could be no joint research on sensitive areas, such as nuclear weapons or materials. Even with that official blessing, building the collaborations was a delicate process, says Drell. The labs were "afraid of publicity causing some reaction in Congress about money going to Russian scientists, and the Russians were very sensitive about things being said publicly" about their ultrasecret research programs.

Homemade infrastructure

The first U.S. weapons scientists returned to Russia in June 1992 to work out collaborative research topics they should pursue. Although the Russian labs had been conducting mostly applied weapons work, says Hecker, they also had flourishing basic science programs: "Since they had rather little contact with their own—and also the international—scientific community, they did take care of scientific underpinning with anything associated with weapons themselves." As a result, the labs were doing advanced research in everything from internal confinement fusion to software and computing.

It was in these areas, he says, where the collaborations would be most productive. Livermore scientists quickly set up collaborations with a number of Russian laboratories on laser and optics research, two disciplines in which Livermore excelled. Researchers from Sandia established collaborations in metallurgy, materials research, and computing with scientists at the Kurchatov Institute in Moscow as well as at laboratories in Belarus, Ukraine, and Kazakhstan. Among other collaborations, for instance, Sandia researchers began working with scientists at the Khlopin Radium Institute in St. Petersburg on chemical means of separating long-lived radionucliides such as cesium and strontium from radioactive waste, and with researchers from the Urals Polytechnic Institute on determining the properties of metals by altering the nucleation of the crystals during freezing of the metallic melt.

LOS ALAMOS

Explosive charge. One of a series of Los Alamos–Arzamas experiments on explosively driven pulsed power.

The Los Alamos researchers concentrated on cementing relationships with the scientists at Arzamas, working in particular on a technology initiated by Andrei Sakharov known as explosively driven pulsed power, which is used to generate ultrahigh magnetic fields, an area in which the Russian weapons scientists were at least on a par with—if not ahead of—the West.

The Russians at Arzamas had constructed compact, high-explosive–driven pulsed power generators, which could instantaneously release megajoules of energy. "Pulsed power," Younger explains, "is when you store up a bunch of electrical energy in a capacitor bank and then discharge it rapidly through the experiment, sort of like a titanic flash in your camera." That titanic flash can be used to study matter under extreme conditions—anything from high-temperature superconductors to nuclear explosives—as well as, potentially, for nuclear fusion. "We have used pulsed power to drive plasma implosions, as well as a variety of electron accelerators and rail guns," says John Shaner, deputy director of the Center for International Security Affairs at Los Alamos. "The Russians were ahead in terms of the power and energy of their systems. … [They were] using their generators to do solid state and materials research in high magnetic fields, and high-power applications, like driving electron beams. You couldn't find a more compelling parallel development, with the Russians putting considerably more resources into the technology."

In August 1993, the Los Alamos scientists went to Arzamas for the first time to set up diagnostic equipment, which would be used to test the electrical performance of an Arzamas pulsed-power generator that created ultrahigh magnetic fields. "We saw places no Westerner had ever seen," says Younger. The U.S. scientists later described the Arzamas living conditions as spartan and the security as tight. The facilities and equipment were first-rate by Russian standards, although perhaps 15 years behind the West in terms of technical sophistication. As in all Russian laboratories, the researchers lacked the modern computing equipment of the West but made up for it with what the Los Alamos researchers thought were ingenious solutions. The Russians, in turn, says Younger, thought the Americans were too dependent on computers. "You have forgotten how to think," they told the Los Alamos researchers.

The collaboration started awkwardly. There were language problems—at first all conversation required interpreters, and Shaner says he now advises his researchers to "never underestimate their ability to be misunderstood." And mutual suspicions dogged the early collaborations. "When we started out," says Younger, "they were all spies and we were all spies, and it took a while to understand that we were all just scientists trying to do our jobs."

Research Bridges Span the Nuclear Abyss

The program of collaborations between scientists at the U.S. Department of Energy's (DOE's) weapons laboratories and their counterparts in the former Soviet Union was the first formal response to a potential crisis: how to keep thousands of weapons scientists who had suddenly lost their funding from selling their expertise to the highest bidder. The lab-to-lab collaborations (see main text) have since been supplemented by three new programs that are also aimed at providing challenging research work for weapons scientists from the former Soviet Union:

- *The Industrial Partnering Program (IPP).* Started by DOE and the State Department, with a budget this year of $35 million, the IPP aims to employ former Soviet weapons scientists on technologies that may be suitable for commercialization. The program then tries to find a U.S. industrial partner to develop the most promising of those technologies in a joint venture. The projects run the gamut from flat panel displays to oil and gas technology.
- *The International Science and Technology Center.* It took 2 years of discussions to get it going, but this multinational agency, with offices in Moscow and Kiev, is now spending $60 million to fund 130 scientific projects involving some 8200 scientists and engineers previously engaged in weapons programs. Projects include everything from muon catalyzed fusion to the environmental impact of a second-generation supersonic transport.
- *The Department of Defense's (DOD's) Defense Conversion Program.* DOD plans to spend $110 million redirecting the defense industry of the former Soviet Union to peaceful purposes. Among the projects: A firm that used to build naval ships is now building prefabricated housing units for demobilized strategic rocket forces in Ukraine.

–G.T.

The first joint experiment between Los Alamos and Arzamas, on 22 September, was "a very high-pressure event," says Younger. "The Minister of Atomic Energy was out of the country, but he had been requesting daily reports on the progress." The Arzamas researchers had built a specific generator design they claimed was going to be particularly useful for very high energy pulsed experiments, but those claims had never been verified. So the Los Alamos researchers brought over diagnostic equipment, hooked it up to the Russian generator, and tested its performance, which more than lived up to the Arzamas claims. It was in the glow of that success that the impromptu party took place that evening, symbolizing to Younger and everybody else involved that the old rivalries of the Cold War were finally buried.

Moving on from science

It wasn't long after those festivities that the lab-to-lab collaborations moved from science to nuclear-related issues. The incentive came when the German government last spring intercepted nuclear materials that had apparently been smuggled out of the former Soviet Union. DOE Undersecretary Charles Curtis quickly asked the national labs what they could do to help safeguard nuclear material in the former Soviet Union. And DOE allocated $2 million to cover expenses for collaborations that would include scientists from all six DOE labs that have worked on nuclear safeguard systems in the United States: Los Alamos, Livermore, Sandia, Brookhaven National Laboratory, Oak Ridge National Laboratory, and the Pacific Northwest Laboratory.

Over the telephone, Younger and Radii Ilkaev, chief scientist of Arzamus 16, worked out a program of cooperation on the development of a system to catalog and control nuclear materials in Ilkaev's lab. They hoped that this prototype system could eventually be modified and extended to other laboratories throughout Russia.

The first Russian scientists visited Los Alamos last August for training on modern materials protection, control, and accounting (MPC&A) systems, and U.S. scientists began traveling to Arzamas to set up a test-bed MPC&A system using Russian and American equipment. The U.S. weapons scientists were also pursuing agreements to do the same at Chelyabinsk and the Kurchatov Institute.

The major focus of the MPC&A work is not the nuclear weapons themselves, but the large portion—estimated at between one third and one half—of all the Russian nuclear materials that are in the form of metal, scrap, and waste. "If you've got a nuclear weapons component," says T. J. Trapp, the Los Alamos program manager for nuclear materials, "then it's either there or it isn't. When you've got fifty kilos of plutonium in 100 drums of scrap, that's much harder to keep track of." The material confiscated in Germany, for instance, was not from weapons but separated out from scrap and junk, says Trapp.

Historically, the Soviet Union controlled such material using fences, guns, guards, and dogs. The technology needed for effective safeguards is not advanced or top secret, notes Trapp. It consists of off-the-shelf components, everything from radiation detectors and computer accounting programs to railroad cars for safely transporting nuclear material and weapons, and technologies for separating out fissile material from waste and junk and storing it in a transportable and easily safeguarded form. "This is not a matter of needing new inventions," he says.

The system set up for last month's demonstration, says Ron Augustson, a Los Alamos researcher who helped organize the demonstration, was a "liberal mixture of their technology and ours." A computerized accounting system supplied by Los Alamos, for instance, kept track of all the various MPC&A

Bottling Up the Ingredients for a Bomb

One of the biggest problems facing U.S. researchers trying to help their Russian counterparts devise better safeguards on nuclear materials is knowing where to start. "There may be as many as 100 different institutes and operating facilities that have nuclear materials—research institutes, plutonium fabrication facilities, chemical processing facilities, and so on—and each has a different set of requirements," says T. R. Koncher, an administrator at the Lawrence Livermore National Laboratory. "We're just in the process of understanding who supports whom, who has what roles and responsibilities, and how much infrastructure really exists and what to do about it."

The Department of Energy's (DOE's) lab-to-lab program (see main text) is attacking the problem by dividing up the nuclear materials in the former Soviet Union—the highly enriched uranium and plutonium that can be used to make a bomb—into five different sectors, says Mark Mullen, a Los Alamos National Laboratory administrator who chairs the laboratory steering committee for the program. The initial goal is to establish collaborations for safeguarding the nuclear material in each of these sectors. They include:

- The nuclear weapons controlled by the Russian Ministry of Defense. Last December, the U.S. and Russian governments signed an agreement called Warhead Technical Exchange to begin safeguarding that material. Technical exchanges between the relevant institutions began in January and February, but so far little has been accomplished. Funding for the program comes through the defense programs at DOE as well as the Department of Defense.
- The nuclear weapons complex of the Russian Ministry of Atomic Energy, known as Minatom. The various Minatom laboratories have large amounts of nuclear material, which will only get larger as nuclear weapons are dismantled and the ingredients returned to the Minatom complex. The DOE lab-to-lab program is establishing collaborations with a half-dozen Minatom laboratories, says Mullen, including Arzamas 16 and Chelyabinsk 70, and Tomsk 7 and Mayak, which are both production sites for nuclear weapons.
- Minatom's civilian nuclear complex, composed of institutes working on reactor technology. A DOE team is presently working with the Institute of Physics and Power Engineering at Obninsk, which has two critical assemblies for reactor physics research, with several tons of highly enriched uranium and plutonium. The project began in January, and funding comes from the DOE lab-to-lab budget.
- Russian research and development institutes not associated with Minatom. One example is the Kurchatov Institute, where researchers from the six DOE labs have recently set up a safeguard system at an assembly used for reactor criticality tests.
- The naval nuclear sector, which encompasses the nuclear submarines and nuclear-powered icebreakers of the former Soviet Navy, all of which rely on highly enriched uranium. DOE is just beginning discussions, says Mullen, on what U.S. researchers can do to help strengthen nuclear materials protection accounting and control in that sector.

The bottom line, says Mullen, is that no single program will successfully address the nuclear materials problem in Russia. "The more different pathways we pursue," he says, "the more likely we will be to make headway, and the more likely we will be to find the right people to work with."

–G.T.

radiation detectors, while the Arzamas researchers provided the software for it. Los Alamos added gamma ray and neutron detectors and data analysis programs for measuring plutonium isotopic composition, while the Arzamas scientists provided a "passport system" that records a radiation signature for a given radioactive item that can then be checked at any later time to make sure that it hasn't been processed to extract fissile material.

Throughout the spring, the researchers will be holding workshops to teach the technology and philosophy of modern MPC&A systems to Russian operators. The next step, says Augustson, is to take the equipment from the demonstration facility and put it into real facilities: "We want to go through certification that this equipment will really work before we put it into routine use." Meanwhile, Sandia researchers and collaborators from the five other labs have helped upgrade the physical protection at a test reactor at the Kurchatov Institute and safeguard nuclear material, says Younger, that "was previously, it's safe to say, at risk" and now is not.

Paying their way

These interactions have been so successful that the Department of Energy has allocated $15 million for nuclear material control through the lab-to-lab interactions and expects to expand that to $40 million in fiscal year 1996. No money has been allocated beyond this year to continue the non-nuclear collaborations, however. The U.S. researchers will have to pay their own way through discretionary funds in the laboratories, while hoping their Russian colleagues can get funding through the International Science and Technology Center (see box on p. 489), which is supported by the State Department.

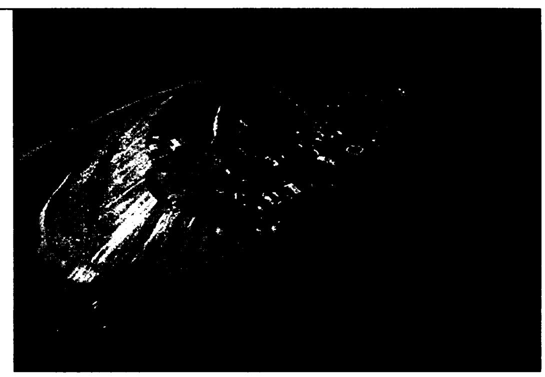
Participants from the national laboratories are optimistic about the progress on the safeguard systems, but they caution that the ultimate success of the systems will largely be determined by the Russians. Right now, says Younger, "the Russians have proposed moving further and faster than the Americans can keep up with." But T. R. Koncher, who coordinates programs at Livermore related to the former Soviet Union, notes: "We can build the infrastructure, [but] the Russians are still the ones that are going to really have to implement it at their operating facilities."

Researchers involved in the collaborations are also keeping a wary eye on Washington. Until recently, the national laboratories have been very quiet about the collaborations. They worried about offending the Russians on one side, and about attracting the attention of U.S. politicians who may look askance at U.S. tax dollars supporting Russian weapons scientists, even in a good cause. Now that the collaborations are beginning to get some publicity, Younger says: "I live in constant fear that somebody in the government—and there are a huge number of people in the government who think they're responsible for interactions with Russia—will say 'Stop.' "

–**Gary Taubes**

OPTICAL ASTRONOMY

ESO and Chile Begin to Clear the Air


ESO

Flat top. The Very Large Telescope site at Paranal.

European astronomers must sometimes rue the fact that some of the best conditions anywhere in the world for ground-based optical astronomy happen to be in Chile. The eight-nation European Southern Observatory (ESO), lured by the clear air of the arid Atacama desert in northern Chile, has built 14 telescopes there since the 1960s, and it is now constructing its most ambitious project so far in the same area: the Very Large Telescope (VLT), a set of four 8-meter instruments that will operate together as if they were a single 16-meter telescope. But politically, the skies over ESO's new venture have been far from cloudless; in fact, they have been downright stormy. A series of squabbles, ranging from labor disputes to land claims, escalated last month to a full-blown crisis when a Chilean court official and police forced their way into ESO's offices at the VLT site, confiscated papers, and demanded that construction be halted pending a legal challenge to ESO's ownership of the land.

The incident may, however, finally lead to a clearing of the air. ESO, claiming that the move violated international law, put heavy diplomatic pressure on Chile to sign a new agreement that confirms the legal status of the VLT project while meeting long-standing concerns of local workers and astronomers. The agreement, which was signed last week at ESO headquarters in Garching, Germany, does not resolve the legal dispute over ownership of the VLT site, but ESO officials hope it will pave the way for a settlement. "It's not the end, but it is a turning point," says ESO Council Chair Peter Creola, an official in Switzerland's Federal Department of Foreign Affairs.

The agreement, which now goes to the Chilean Congress and ESO's Council (*Science*, 21 April, p. 355), is meant to put to rest issues that have festered ever since ESO decided in the 1980s to build the VLT in Chile. In 1988, the Chilean government, then a military dictatorship, gave ESO the site on Cerro Paranal, some 650 kilometers from its main observatory at La Silla. The government also declared, in an exchange of letters with ESO, that privileges ESO had enjoyed at La Silla under an agreement signed in 1963 were extended to the entire country. These privileges, which are common to most international organizations such as the United Nations and CERN, include immunity from the taxes and laws of the host country.

When democracy was restored in 1990, however, some groups in the country felt that Chile had gained little from the deal. Local astronomers wanted a guaranteed share of observing times, Chilean workers at La Silla demanded better union representations, and some politicians claimed that the donation of the Paranal site was not legal. The situation went from bad to worse when descendants of 18th-century war hero Admiral Juan Latorre claimed that they owned some of the Paranal land and filed suits against both the government and ESO.

To resolve some of these problems, ESO has been trying for several years to negotiate a supplementary agreement with Chile to make the extension of the 1963 convention to the rest of the country more legally watertight—a move that would effectively shield the organization from the suit filed by the Latorre family. In return, the new agreement would guarantee Chilean astronomers 10% of the observing time on all of ESO's telescopes in the country and incorporate Chilean labor law into work practices at both observatories. Last summer, with the top of Paranal leveled off and ready for construction but the supplementary agreement not finished, ESO decided to go ahead and ship the first parts of the telescopes from Europe to Chile (*Science*, 19 August 1994, p. 1026). That bold move seemed justified when, in November, a draft of the agreement was finally completed. "We were led to believe signing and ratification would follow quickly," says ESO spokesperson Richard West.

Events did not go so smoothly, however. "There were lots and lots of postponements," says Creola. "The government wanted to be sure of support in Congress, but there was some animosity toward ESO because of the