A Conversation with Lev Dmitrievich Ryabev

Based on interviews by Siegfried S. Hecker on April 26, 2014 and July 9, 2015

L. D. Ryabev is deputy director at VNIIEF and advisor to S. V. Kirienko, director of the State Atomic Energy Corporation (Rosatom). He began his nuclear career as scientist at VNIIEF in 1956, and during the past 59 years has been largely responsible for most of Russia's nuclear weapon enterprise, including as director of VNIIEF, minister of Medium Machine Building and first deputy minister of Minatom.

◆◆ What brought the United States and Russia together to cooperate on nuclear issues after the fall of the Soviet Union?

Lev Ryabev: We knew about the need to cooperate with the Americans long before the end of the Soviet Union. The United States had a similar view. Three factors contributed to this need: 1) the natural progression of arms control negotiations and cooperation; 2) the unique interconnected characteristics of nuclear activities on the global scale, especially in the wake of major accidents on nuclear power plants of the United States, the Soviet Union, and other countries; and 3) emerging global challenges that required joint solutions.

For decades, each side engaged in a nuclear arms race, building more and more nuclear weapons. When we reached the point of tens of thousands of nuclear weapons on each side, we realized how great were the dangers to humankind. Once our leaders realized that this race was not leading anywhere, we began to reduce our stockpiles of nuclear weapons and started the process of arms control negotiations to reach some equilibrium in issues of security and to reduce the level of confrontation.

These negotiations brought US and Soviet scientists together for the first time as members of technical working groups that tried to deal with scientific challenges of verifying these arms control treaties; for example, the Threshold Test Ban Treaty. This also led to the Joint Verification Experiment (JVE). In the run-up to the JVE, we were so eager to exchange experiences and show how good each side was. The JVE experience was like a dam was breached.

So, the development of life itself pushed each side toward cooperation. The only alternative to cooperation was increased tension and return to the arms race, which we could not do. At that time, the political situation was favorable and scores of people wanted to work together. So, it was not accidental that when the Soviet Union dissolved, the people were

S. S. Hecker and L. D. Ryabev after the July 9, 2015, interview at the former ISTC building in Moscow.

ready to cooperate. Viktor N. Mikhailov, with his background (science and nuclear), knew that cooperation was necessary. He became the first minister of the Ministry of Atomic Energy (Minatom).

We also realized that activities within the nuclear sphere are unique. Before the end of the Soviet Union, we understood that the problems posed by nuclear energy or nuclear weapons activities are global and connected. We arrived in the nuclear century all in one boat—a movement by any one will affect everyone. In nuclear energy, for example, a nuclear reactor accident in one country reflects on nuclear reactors everywhere, even if the reactor designs are different. In nuclear weapons, if one country has an accident or problem storing nuclear weapons or fissile materials, this is a problem for the whole world and not just for that country.

We were doomed to work on these things together, which pushed us toward cooperation.

I want to emphasize that even before the fall of the Soviet Union, we had these needs fully developed. The end of the Soviet Union may have brought these needs up faster, but the Russian side was already prepared by 1992 to enter a new stage of cooperation with Americans.

◆◆ Can you briefly describe your history in the Soviet nuclear complex?

Ryabev: I began to think about nuclear weapons in Grade 9. I thought that was how I could take part in the defense of my country. We were all children of the war. At age 14, I wanted to enlist in artillery school, but they did not let me because of poor eyesight. Although I wondered why could not I wear glasses and still shoot the cannon? Then 1949 came, when the first nuclear explosion was performed. I said to myself, "That's where I must go."

So once I graduated from high school, I went to Moscow to find where they trained specialists of this profile. With all the secrecy that existed then, in the days of Stalin and Beria, how could I possibly find this? But in the Bauman Institute, someone advised me to go to Moscow Mechanical Institute—today it is called the Moscow Engineering and Physics Institute. They hinted that this might be the place where such specialists were trained.

So, I applied and I got enrolled. Nothing was happening until after my fourth year. I was simply studying metal physics to be a metallurgist. After we finished four years, we were summoned to the dean's office and offered to go to the department of N. N. Semyonov,

Nobel laureate in chain reactions. And it was only in the Institute of Chemical Physics, where he was director, they finally started to teach us the physics of explosions, gas dynamics, and explosives. Our professors were specialists who had worked in Sarov, only we learned about this many years later. In 1956 our group of graduates, a few people, were sent to Sarov. They said, just take the train to Shatki, do not leave the railcar, it will bring you to the right place. So I worked in Sarov for the next twenty-two years.

◆◆ And in the end of these twenty-two years in Sarov, did you finish as director?

Ryabev: When I arrived, I was immediately put in the gas-dynamic sector to conduct explosive experiments. Now it is called the Institute of Explosion Physics. In 1972, I was appointed acting director of VNIIEF, and then I became director in 1974. In 1978, I stepped down as director in Sarov and left for Moscow. In 1984 I was appointed deputy minister of Medium Machine Building, and in 1986 the first deputy minister and then minister. In 1989 I was appointed deputy prime minister [of the Soviet Union]. In 1991 the Soviet Union collapsed. I went back to the Ministry of Atomic Energy (Minatom) and in 1993 became the first deputy minister for nuclear weapons and nuclear power until 2002. Now I am a deputy director at VNIIEF and advisor to S. V. Kirienko, director of the State Atomic Energy Corporation (Rosatom).

◆◆ When the Soviet Union ended, how did it affect the nuclear complex and Minatom? Did US cooperation play a role then?

Ryabev: Several factors were at play all at once. Nuclear weapons reduction, which was a good process in terms of global political situation, certainly dramatically affected our complex. The production of nuclear warheads was reduced. The utilization of munitions, decommissioning and dismantling of warheads started in earnest. This was a challenge. Then we began to shut nuclear reactors for the production of weapons-grade plutonium and enrichment of weapon-grade uranium. So the nuclear weapons complex workload was reduced, people were getting released, and it was necessary to remove nuclear weapons from Ukraine, Kazakhstan and Belarus. In addition to that, in the same period, we stopped nuclear testing. And, finally, this was also a difficult period of economic crisis in Russia. The existing Soviet Union economic ties were torn. All in all, it was a difficult and challenging period.

It was necessary to find sources of financing. What was important in this respect? It was critical that Minatom was kept together after the end of the Soviet Union, although it was not easy. Many ministries were merged, disbanded, or restructured in 1992–1993. Some officials had proposed to separate the weapons and energy parts of Minatom, which would have been very detrimental to the atomic industry. Even within the industry, there were debates on that, but Boris Yeltsin supported those who defended the unity of the industry. After discussions with Mikhailov, E. P. Velikhov, and other industry specialists, Yeltsin ruled to leave the ministry intact and, under the new name of Minatom, keep the same structure and basic funding system.

Because we preserved the single structure, we retained the part that brought profits to Minatom—uranium enrichment, nuclear power stations, and so on. The minister—V. N. Mikhailov—was able to take part of the profits to support, among others, the nuclear weapons complex specialists.

The HEU-LEU program also gave the minister funds to spend on the weapons complex. This eased the financial stress on the institutes somewhat during the hard economic times.[1]

Yeltsin also made Minatom a special ministry outside of the traditional ministries structure that reported directly to the president. This represented Yeltsin's commitment and understanding of the importance of the nuclear weapons complex during this difficult period. There was no way to avoid the hard economic situation, and Minatom and the weapons complex had economic difficulties. In this difficult period the president, of course, at the insistence of Mikhailov and other scientists, provided support. In particular, we set a benchmark for the level of wages based on the national minimum wage. I think, we were allowed to pay a salary up to twenty times the minimum wage. And on this basis, we were able to substantiate our budget requests. Mikhailov was personally engaged in wage levels, and he personally oversaw how we paid wages at each enterprise. Such was the nature of the times.

I want to emphasize that we used every source of funding, such as agreements under the International Science and Technology Center (ISTC), the Nunn-Lugar programs, assistance for the creation of nuclear materials storage facilities, conversion of reactors, physical protection of facilities and so forth, a variety of sources. And I believe that this aid certainly helped us to survive this difficult period. I cannot say that without this help, we would have died—of course not—but I do believe, and we are grateful in this regard, that it was support; in fact, considerable support. Although the United States, of course, pursued their own benefits, and we pursued ours. In the end, this worked to our benefit.

◆◆ The US side was very concerned during this period about brain drain; specifically, the possibility that Russian scientists would sell their knowledge or skills to aspiring nuclear countries or non-state actors. Did you share this concern?

Ryabev: Absolutely not. I understood that the Americans had this concern, but I did not share it. We were confident in our people. We knew our scientists, and we knew they were professionals who would not, despite financial difficulties, sell their knowledge. As I said about my own life path, we came into this business to defend the country. And, looking back from today, this confidence was justified. A quarter of a century has passed, and we lost practically no one. On the other hand, the leaders of Rosatom were nuclear specialists. That is, they knew our people and the people knew them. I speak of Mikhailov, N. P. Voloshin, head of the department, and other specialists. Still, lab-to-lab was also important to us and very helpful.

[1] HEU-LEU, or highly-enriched uranium to low-enriched uranium, was a downblending of nuclear material from Russian warheads that provided fuel for US nuclear power plants through a 1993 agreement.

◆◆ How did you initially get involved in lab-to-lab?

Ryabev: I knew about the lab-to-lab already around the end of March 1992 when I came to the ministry. As soon as Mikhailov became minister in March 1992, he invited me to work with him. At that time, I was preparing to go back to work in Arzamas (VNIIEF in Sarov), by invitation of scientists and Director V. A. Belugin. But such was not my destiny. I became involved in the lab-to-lab quite early, in May 1992, via the ISTC. I actually took the ISTC position to somehow combine these processes: the lab-to-lab and the ISTC. In May 1992, I got a list of questions from Anne Harrington in the State Department. She wrote how do we start this collaboration through the ISTC? And since then, I was pulled in to the ISTC. And then there were the Reis [Reis-Ryabev] and Moniz agreements, i.e. they were all interwoven activities—lab-to-lab, ISTC, negotiations, signing of agreement—because they all went together. We know that the lab-to-lab also relied on the agreements. My position as First Deputy Minister helped to coordinate between all areas of cooperation.

◆◆ You were involved with the ISTC throughout its entire duration in Russia. How did it happen? And how did you view the ISTC then and do now?

Ryabev: After May 1992, I was drawn deeper and deeper into the ISTC, first through the ISTC governing board and then as chair of the nuclear industry council responsible for vetting projects. I believed it was important to promote cooperation, especially among the weapons labs. I took this job because I thought I could work through the bureaucracies as someone who understood the bureaucracies.

ISTC was a good vehicle because it provided the funds, opportunity to travel, publications, and so on, and some funds went directly to scientists through direct contracts within lab-to-lab. Through the interaction between laboratories we formulated scientific and technical issues and programs while the funding for many of these programs, many—not all—came through the ISTC channels. I thought the ISTC was a very useful and important program, and I was very much in favor of it. I liked the ISTC process by which scientists devised an idea, put together a team, and then got approved for direct financing because it helped breed independent, self-reliant scientists. It was also an ideal situation for a scientist wanting to start a technical project because it helped them avoid the normal intermediate bureaucratic steps. The ISTC also funded scientists to attend international conferences, exposing them to other specialists working on these subjects. I felt this expanded their intellectual horizon and helped them see their place in the world. The ISTC was very important in creating independent scientists with leadership capabilities.

◆◆ What role did the lab-to-lab cooperation play in the post-Soviet transformation of the Russian nuclear weapons complex?

Ryabev: It was important to us for two sets of reasons. First, US programs provided financial help to Russia during a time in which we had major financial difficulties. For example, ISTC

helped fund scientists, and the US government funded the Fissile Material Storage Facility, as well as assistance on nuclear materials protection, control, and accounting of other facilities. We still had enough finances, even during the hardest times, to support the necessary security of our facilities and materials. But the changes in circumstances after the end of the Soviet Union required changes in our security practices, with new security for insider threats, for example. Despite the challenges, we have never lost any materials or any weapons, and the needed technical upgrades to deal with new security threats were implemented quickly. The nuclear weapons complex became more compact and manageable. The collaborative work on the common problems of safe storage and transport of weapons and materials, and on stockpile stewardship gave us a better understanding of how to improve nuclear safety.

Second, cooperation served as an important relief valve for Russian scientists. The Soviet system had been closed for decades, and the sudden openness encouraged Russian scientists to share their work and interact internationally with their colleagues. For a scientist, recognition of other specialists is very important. He must compare where he fits with his activities, how his results are perceived. He should not be insulated. And it was in those years that weapons scientists got an opportunity to travel abroad, with their travel expenses paid, meet at conferences, attend seminars, and participate in experiments. I was in Los Alamos, and I saw our specialists who worked on the Atlas facility. I saw Stephen Younger come here, and enthusiastically tell me how he works with Vladimir Chernyshev and other specialists in explosive magnetic generators. All of this new collaboration improved morale during a difficult time and helped some of our specialists to switch to civil applications.

◆◆ Could you expand on the challenges you faced with new security circumstances in the early 1990s? As you know, in the United States there was much concern about what were called loose nukes and inadequately secured nuclear materials.

Ryabev: Firstly, there have been no loose nukes. Comprehensive control at all stages of the life cycle was established in its most rigorous form. There were rumors, even in Russia, and even in our media, of some sort of nuclear briefcases, small warheads. It was complete nonsense propagated by people who had nothing to do with nuclear weapons. I claim this so positively because I've been to some of the military technical bases and, of course, to all our Minatom facilities. [At each one,] we passed all stages of control and personally observed how the work was organized.

On [the issue of] securing nuclear materials, we faced accelerated nuclear disarmament and dismantling of nuclear weapons and nuclear materials. The inflow of this stream of nuclear materials from Ukraine, Kazakhstan and Belarus increased sharply. Our storage facilities for nuclear weapons were overflowing. And then we decided—at an accelerated pace, in spite of the complexity of the financial situation—we had to urgently build the most modern storage. We found the money and built these facilities. They have a lot of protective barriers, including protection against attacks from above and against any possible terrorists. There's also a thorough system of control there with automatic accounting, control, automation of processes of placement, selection of qualified personnel, and training. They were run by experienced people.

But in the early 90s, we faced the following phenomenon in the institutes where there were nuclear materials. During the decades of our activities, we were protected from external threats, and suddenly there began to appear—we felt it in the few cases—internal threats. This was not at the nuclear weapons assembly-disassembly enterprises but at the institutes. They, firstly, did not have a lot of material, and secondly, maybe they had slightly lower discipline. People were vetted, admitted to work for Minatom, and then they suddenly decided they could get a certain material gain. And there were a few cases that involved some hundreds of grams. It forced us to completely rework the system of accounting and control and to install detectors for nuclear materials to catch its possible removal. In particular, VNIIEF did a lot to create these security devices for control and install them at the Minatom facilities. It was also one of the elements of cooperation. In some cases, we did it on our own, sometimes with lab-to-lab, and in some cases with the help of external program funding.

◆◆ We cooperated in some areas that were quite sensitive, like Warhead Safety and Security Exchange (WSSX). How hard was it to convince your government that cooperation in these areas was necessary and beneficial?

Ryabev: This was not a major problem. Mikhailov and the scientists at each institute were professionals with many years of experience, and they knew where the boundaries lay. There were clear areas where cooperation was good and necessary and did not present security or confidentiality problems. In many cases, we could collaborate on interesting scientific questions, and that collaboration would have benefits for the weapons programs without jeopardizing security. For example, we worked together on stockpile stewardship and the science that supported it through joint work on computing, modeling, magnetic explosive generators, and other areas of physics. This cooperation did not provide practical solutions that were applicable to nuclear warheads, but it deepened our understanding of fundamental science and stimulated an intellectual scientific atmosphere at our institutes on these issues. This in turn had positive impact on Russian scientists working directly on stewardship of our nuclear weapons. I dealt with some of these security issues with the ISTC, where I was responsible for vetting projects. At ISTC, I could tell which projects were possible and which were not. I felt that the programs on nuclear warhead safety and security were important and did not go beyond acceptable boundaries.

◆◆ I understand that there were a number of factors pushing us toward cooperation. As you mentioned, we recognized common problems, had challenges reducing our arsenals, and also had the JVE. Still, it seems to me that it was a big step to talk about scientific cooperation on nuclear warheads in 1993–1994. Did you see warhead discussions as a big step or just the next logical part of discussion?

Ryabev: We anticipated it and knew that we needed to discuss the warheads issue at some point. There was no way to deal with these issues except through cooperation—the alternative was to return to the time when we opposed each other again. It was crucial for

both sides to derive benefits from this cooperation. I told Rose Gottemoeller this at the time.[2] If only one side was benefiting from the cooperation, there would be suspicion.

Everything we did was focused on how to reduce the nuclear dangers we faced. The professionals understood this, and they wanted to cooperate on warhead issues. All of the security programs—WSSX, physical protection, control, and accounting—grew out of professionals wanting to work together.

◆◆ What specific guidelines did you get from your government concerning the scope of cooperation in more sensitive areas like warheads safety?

Ryabev: Nothing as detailed as PDD-47 (the 1996 Presidential Decision Directive). The political guidance from the government, namely Yeltsin, was very general. One, we needed a comprehensive test ban treaty; two, zero yield; and three, comprehensive monitoring. From that guidance, Minatom (namely Mikhailov and Ryabev) discussed these needs. Then, the specialists at the nuclear institutes wrote the detailed instructions. Of course, the Minatom people did have to work under the general coordination of the MFA (Ministry of Foreign Affairs)—namely, G. V. Berdennikov who chaired the group. As for the details of the WSSX agreement, Minatom wrote them under the general direction of MFA. That draft was then given to the government [the Yeltsin administration]. With the CTBT in place, both US and Russia had to maintain the safety and security of their nuclear arsenals. To this end, we had to establish the appropriate scientific and technical base to develop the scientific and technical methods of monitoring nuclear warheads and nuclear charges and to upgrade the skills of personnel. Both parties were equally interested in the successful resolution of these issues. Otherwise we would not have come to an agreement on the CTBT. We could not have done that without joint review of problems and a certain level of trust, as well as without mutual understanding what it was necessary to do for the safety of our nuclear arsenals.

◆◆ What was your perspective on the other defense conversion programs like Nuclear Cities Initiative (NCI) and Initiative for Proliferation Prevention (IPP)?

Ryabev: Yes, I thought NCI was useful. I remember when our cooperation expanded beyond the nuclear weapons institutes and into the closed cities. When we downsized the nuclear weapons complex, we needed to transition our workers into civil sectors, so we studied the American example at Los Alamos and Oak Ridge. I especially remember Oak Ridge, which provided their former employees with capital investment and some equipment to start their own businesses.

NCI helped people in the closed cities cross a psychological barrier, exposing them to industry and business. I visited Sarov several years ago and went to a business made up of former VNIIEF employees that manufactures vibration sensors—Rosatom may provide

[2] Rose Gottemoeller was responsible for all nonproliferation cooperation with Russia and the Newly Independent States in the US Department of Energy, first as Assistant Secretary and Director for Nonproliferation and National Security and subsequently as Deputy Undersecretary of Energy for Defense Nuclear Nonproliferation.

orders for them from its companies. The business has its pluses and minuses and ups and downs, of course, but the people that work there are 100 percent changed people. They are now completely independent. If I were at VNIIEF, I would want to hire these people because they are independent thinkers.

NCI helped give us experience in these matters. That experience was not always good experience, but either way it helped us for the future.

Russia is now coming back to these conversion issues. VNIIA, for example, still runs a business for manufacture of automated control components for nuclear power stations and thermal power plants. This year, the output in the nuclear non-military sector was 60 billion rubles, and Rosatom aims to increase this number by three times in the next few years.

It is understandable that by itself, the NCI delivered modest results, but the conversion effort as a whole made a certain difference. So, in some ways, it succeeded.

◆◆ One of the most promising projects was the Fresenius company kidney dialysis project with Avangard. Ann Heywood of the Lawrence Livermore National Laboratory and I managed to line up significant investments from NCI and Fresenius, but in the end the Russian government would not allow the type of access Fresenius required for a profitable enterprise. Can you explain what happened, and how did you manage to complete the conversion of the Avangard plant?

Ryabev: With the Fresenius project at Avangard, we did come close. They already manufactured prototypes. And individual devices even worked in Moscow hospitals.

◆◆ And then we had a big contract ready with Fresenius, but they wanted 24-hour access, and you and I had a long discussion about this.

Ryabev: But, you know, it could have been solved by other methods, the way we do it now. Now close to Sarov, outside of the barbed wire, we set up an industrial park. And there all non-weapon activities are now intensively developed. Therefore, we should have fundamentally solved the problem of urgent access, I think, by simply going over the fence. VNIIEF now goes this way.

◆◆ Lev Dmitrievich, I looked back at my notes from our discussion, and actually you had some very good advice at the time. I was explaining to you that the Germans insisted on 24-hour access. And you said, do not push for that now. You do not need it right now. You said, once they build all of this material, and you have all of this investment, of course we will give them the access. But do not insist on it upfront.

Ryabev: You are right. After all, when we did not have anything to prove . . . Let's say, I give you access and you use it for some other purpose. When the fish has swallowed the hook, then we can continue to gradually pull it out.

◆◆ I am going to put this answer in here because you gave us very good advice, but I could not convince the Germans.

Ryabev: You know, in terms of conversion in this period, we should have done it a little differently. We should have selected something concrete—one, two, three—a few projects and go through the entire chain of steps to the end, down from the market research, marketing opportunities, the level of prices, and so on. People who have worked and are working in our closed cities, they naturally have no marketing experience, market knowledge, understanding of business plans, etc. And frankly, among American officials, I have not seen a person who knew well how to approach this problem. Yes, the Americans tried to bring in industry people like Motorola… [But the point is,] we should have started with small projects and gone all the way to the end. I know how one Sarov private company works, a business for vibration sensors technology. They design and manufacture vibrometer devices. They somehow found a niche and now they fit. They have been in business now for many years and work quite well, with good wages, and the people are happy. This is a kind of example that we missed.

◆◆ You make it clear that Minatom and later Rosatom defense conversion proceeded at a good pace by itself. When did Minatom begin its defense conversion work? Also, which were the most important conversion efforts?

Ryabev: We started conversion in the nuclear industry in 1988, back in the Soviet times. I believe that the problem of conversion as such still exists for us. By 2020, the plants and institutes of the nuclear weapons complex must produce 200 billion rubles of civilian output. Now it is about 60 billion. Therefore, this area of activity has not stopped. On the contrary, it continues to expand. For example, in Sarov they organized production of metal constructions for nuclear power plants. In Zlatoust-36—one of the remaining nuclear weapon assembly-disassembly plants in the Chelyabinsk region—they launched production of metalworking machines. In the Research Institute of Automatics (VNIIA) they have an established production of field devices for thermal [light-water] nuclear power plants.

Conversion rapidly moves on because life really pushes us. They may say whatever they say, but the sphere of nuclear weapons activity is shrinking. We have stopped two of the plants for the assembly and disassembly of nuclear weapons, Avangard (Sarov) and PO Start at Penza-19 (Zarechny). We removed all the weapons and nuclear materials. Everything was transported to a specially built storage site. They still have some defense orders, but it is not related to nuclear activities. Of course, at both Penza-19 and Avangard it is clear that they did not receive this decision positively, but we said that there would be simply no other option. We gave them a couple of years, and in a couple of years everything must be wrapped up. It was very difficult for me personally as well.

But when we started the defense conversion in 1988, we had some directions in mind. We wanted to start the design and manufacturing of supercomputers, back then…

And now in Sarov they make dozens of desktop computers of 1 to 5 teraflops. They sell dozens of machines a year. They keep close ties with the automotive industry, with the space sector, aviation and so on. They have reached a fairly high level in the creation of machines with parallelization. That last machine I saw was 25 teraflops, that is, trillions of operations per second. VNIIEF made it for one of the Rosatom institutes.

◆◆ You remember, we started the Sarov Open Computing Center many years ago.

Ryabev: Since then, we have gone VERY far, very far.

◆◆ What about IPP, which changed official names from the Industrial Partnership Program to the Initiative for Proliferation Prevention?

Ryabev: It is hard from my perspective to distinguish between IPP and NCI because they dealt with similar issues. One aspect was development of export controls for future reactor designs like fast-reactors. We worked closely with the Americans to build in export controls to these reactors. Of course, these issues remain quite important given the expansion of nuclear energy. I also remember the nuclear submarines program, which had some program assistance from the United States, which is still ongoing. This program received a state award recently in recognition of its success.

◆◆ What do you think about the future of our cooperation? I think we never missed a meeting in which you did not talk about the importance of the future of nuclear energy. Do you still think that cooperation in this field is important?

Ryabev: I believe that cooperation is of fundamental importance; critical importance. I believe that no one country, even as rich as the United States or China today, can solve today's problems by itself. I still believe firmly that we need to cooperate. Some issues have been dealt with but others have not yet been resolved. In particular, as you well know, the future of nuclear energy is associated with the creation of fast reactors. Today, my position is, we cannot say what the coolant will be—sodium or lead or gas. Therefore, each of these options has its pluses and minuses, but one party cannot immediately identify them all. This year we introduced the BN-800, an 800-megawatt, sodium-cooled fast reactor.

In addition, take the problem of transmutation. For decades, the issue has not been solved anywhere. Multiple loop—reactor, processing, fabrication. Again, reactor, processing, fabrication. All of this must be addressed. As of today, America has not solved the issue of waste disposal. And neither have we. And so on. Key issues of the future of nuclear power still are around and are not getting solved. So I want to say again that we have the broadest field for action in these matters.

I am also certain that new issues will come up that will require our cooperation. We have nonproliferation, countering nuclear terrorism, and nuclear safety. In science, there is need to cooperate. For example, I believe that we should collaborate on your

National Ignition Facility. At VNIIEF they also work on implosions of tiny capsules with techniques such as explosives, magnetic compression, and lasers. They are interested to see if one can achieve pure fusion. So, the Lawrence Livermore National Laboratory facility is of interest to them. There are so many promising areas—thermonuclear inertial physics, issues of detection of radioactive materials and undeclared nuclear activities, quite a few scientific areas related to stockpile stewardship. Just recently, Vladimir Putin met Russian Academy of Sciences President V. E. Fortov, and Putin told him that Russian and American cooperation in science and space should continue.

Our job is to convince our respective leaderships that we must keep working together. The only alternative is suspicion, return to an arms race, and increased tension. We must not go in that direction.