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TRAVEL REPORT

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ABSTRACT

The following report describes a 6 month visit to the Institute of High Energy Physics at Serpukhov, USSR. The difficulties surrounding successful pursuit of physics research in the USSR suggest the necessity of a realistic assessment of the goals of the scientific exchange program.

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Introduction

In a world which has become enured to the atrocities committed in the name of nationalism, there has been always some hope that the international spirit of fundamental science might serve as a model for expanding communications and resolving antagonisms between countries. This spirit has been particularly evident in physics where the revolutionary developments of this century owed so much to so many different nationalities. With the needs of modern physical research becoming more costly, the creation of the CERN Laboratory in Geneva, Switzerland has been regarded as an enormously successful realization of the international scientific cooperation achieved with the help of a growing sense of a European community.

In the course of often strained relations between the United States and the USSR, contacts with Russian physicists at conferences were sometimes almost the only ones permitted at other than the diplomatic level. Thus many physicists like myself have looked hopefully at the prospects for increasing scientific exchange as an opportunity both to develop an acquaintanceship with talented colleagues and to explore a pathway which might aid in further normalization of relations between countries.

In the last decade, the Soviet government has generously funded the construction of several large high energy particle accelerators, through by Western standards the research results of these expensive facilities have been disappointingly sparse. At a time when contracting funds for fundamental research have forced the closing of three American accelerators one might envision the possibility of American physicists actively collaborating with Soviets in the use of Russian facilities. In principle, this would bring advantages to both nations; the Americans would gain access to a significant research tool (the Serpukhov proton synchrotron) and the Russians would raise the level of scientific productivity of their own elementary particle physics program. More importantly one would hope that such collaboration might cross-fertilize scientific development in both countries.

The fact of the matter was that very few American physicists had worked for any extended period in the USSR. After the elaborate diplomatic negotiations for the Drickey experiment (1970-1971), Professor Robert Sard was allowed to work at Serpukhov only after he became associated with the Kienzle group from CERN, thus collaborating with the Soviets as a pseudo European (also 1970-1971). In 1972 Dr. Roland Johnson spent a year with the Prokoshkin group, participating as a member of the Lawrence Radiation Laboratory. To my knowledge this was the sum total of the American involvement in elementary particle physics research in the Soviet Union by 1973. In this report I shall describe my own experiences in trying to enlarge this American participation and my own conclusions about the possibilities for the future.

Getting There is Half the Fun

In January of 1973 for the variety of reasons given, I began to pursue the possibility of spending a sabbatical year in the USSR. For myself it was an ideal time to get away from the University of Michigan; we were about to settle into a long data run at Fermilab following a rather hectic series of experiments at the Argonne Laboratory. My children were still of preschool age and had proven themselves to be hardy travelers while my wife was enthusiastic about the possibility of learning about the Soviet system. The next two years of my life were spent in learning the ways and whims

of two vast government bureaucracies, theirs and ours.

Initially I discussed my interest with Dr. Bernard Hildebrand of the USAEC. I asked him for suggestions on how I might best approach the Russians; he felt that a direct personal letter from me would be the least formal and easiest way to establish contact.

Since I was working at Argonne Laboratory I also brought this matter up with Dr. Bruce Cork (then Associate Laboratory Director). Dr. Cork told me that Professor Prokoshkin at Serpukhov had expressed unhappiness that no qualified young Americans wanted to come to the USSR, particularly those with a strong background in computational techniques. I also talked with Professor Mukhin at NAL who acquainted me with the current Serpukhov research program and he also encouraged me to write directly to Professor Prokoshkin. As a result of all these conversations I wrote Prokoshkin on January 22 expressing my interest in coming to Serpukhov for a period of six months to a year and a thumbnail description of my interests. In particular, I was intrigued by the possibility of participating in the development of a neutral hyperon beam, a project I had proposed for the Argonne Laboratory some years earlier. I had also heard that the head of this group was a young Soviet physicist, Denisov, who was regarded extremely highly by everyone who knew him.

By April, 1973 I received no answer from Prokoskhin, which I was told was one of the standard hazards of dealing with the Russians. Conversations with personal friends outside the field of high energy physics yielded several conflicting suggestions on the proper protocol to be observed when trying to elicit a response from the Russian bureaucracy. These suggestions led in the following directions:

1. I contacted the international exchange secretariat of the National Academy of Sciences. They expressed interest and sympathy for my problem, but told me that the field of elementary particle physics was outside of their purview since it had been preempted by the agreements between the USAEC and the State Committee for Atomic Energy. The NAS understood that the USAEC had not been enthusiastic about the Russian-American exchange program, but there was little that the NAS could do to bypass this obstacle.

2. I telephoned Melvin Abrahams, the Chief of East-West Affairs, AEC Division of International Programs. I was first informed that the AEC had no interest in me since I was not an AEC employee. I argued that this was not quite so clear since I was working under an AEC contract at the University of Michigan and the AEC was at least paying my summer salary. This point was conceded but as it so turned out the current Russian-American agreement was about to expire and the successive agreement had not yet been signed, so that there really was no basis for Mr. Abrahams to provide me any assistance anyway. End of phone call.

3. I tried the more direct route of contacting the Russians at NAL. Professor Mukhin had returned to Serpukhov so I talked to Dr. Popov who I understood was a member of the State Committee. He suggested a second letter to Prokoshkin to remind him of my first. This also produced no result.

4. Before tossing in the towel and forgetting the whole thing, I called Ned Goldwasser at NAL and asked him if NAL would write Serpukhov in my behalf. The NAL letter to Professor Logunov was dated June 20.

On return from summer vacation in July, I found a reply from Dr. Logunov inviting me to come to Serpukhov and work with the hyperon beam group. Logunov's letter was dated July 3. Presumably it took another 4-6 weeks to clear its way through the Russian bureaucracy and arrive in the United States.

I informed Dr. Hildebrand of Logunov's invitation and discussed with him what I might be able to expect in the way of help from the AEC. He told me that Abrahams should be informed of my plans; consequently a copy of the Logunov letter was sent to the AEC to be distributed as necessary.

At this time our experiment at Fermilab was going through a critical phase so that I did very little about my future Russian trip until November when Hildebrand informed me that Abrahams was worried about the legal status of the Logunov letter. Since no mention was made of the USAEC - State Committee agreements, Abrahams felt that the AEC was not impelled to consider me as under their auspices. To straighten this out, I wrote a letter to Logunov asking for a clarification of my status.

Secondly, on Hildebrand's suggestion, I met with him and Abrahams in Washington to discuss any possible problems in light of the experience of other Americans at Serpukhov. Abrahams promised significant help in establishing an embassy mailing address in Moscow, shipment of personal belongings and arranging visas.

I waited for several months for a reply from Logunov. By February 1974 and still no word, I began to seriously doubt our chances of ever getting to Serpukhov. I communicated my nervousness to Hildebrand, but since the AEC had no direct communication with the State Committee he could not offer much help. Dr. Robert Wilson felt that the matter was really outside the bounds of Fermilab concerns and did not want to get further involved. Apparently my case was placed on the agenda of a joint Soviet-American "specialist meeting" held in Washington on Feb. 5, 1974, the results of which were never very clear to me.

It was with some relief that I finally received a second letter from Logunov at the end of February confirming our arrival in the USSR in July to begin work with the hyperon group. This letter also raised questions of my official affiliation which in turn led to renewed difficulties with the AEC. By this time, Mr. B.D. Hill was in the process of taking over Mel Abrahams' job as Chief, East-West Affairs, International Programs. In a singularly unpleasant phone call Mr. Hill informed me that the AEC had not the slightest interest in my welfare and certainly could see no reason to support my request for housing etc. in reciprocity for the treatment accorded the Russians at Batavia. Hildebrand intervened on my behalf at some point after this discussion and eventually I understand that some letter from the AEC was conveyed to the State Committee in Moscow defining my relationship in a more satisfactory manner.

I made a final trip to Washington sometime in May for a final farewell from Hildebrand and the East-West Affairs office where I received a sort of pat on the back as well as a list of "no-no's". I was also vectored over to some office in the State Department for additional information. Subsequent experience showed that none of the "information" provided was either reliable or helpful.

The last hurdle to any trip to the USSR is always the visa. We had heard all the usual horror stories about the Russian inability to provide such documents any earlier than eight hours before flight time, so we mailed our applications to the Soviet embassy about a month before departure. For reasons unknown, our applications were rejected with a single "nyet" and sent to of all places, a Virginia branch of the American Automobile Club. William Penkowsky from the AEC was

extremely helpful in ironing out these difficulties and he personally dealt with the Soviet embassy on our behalf. The Soviets eventually (2 days before departure) provided us with visas for the duration of only one month. The claim was that the Embassy in Washington was not empowered to issue a visa for any period longer. It was with some trepidation that we swallowed this story but the path had been so convoluted already that we weren't going to "chicken out" at this point.

The Land of Peace and Friendship

With some apprehension we landed at Sheremetyevo airport on July 8, 1974. We had tried to inform the Institute of High Energy Physics (IHEP) in Protvino of our travel plans but were uncertain if there would really be anyone at the Moscow airport to meet us. After a perfunctory customs inspection we found a rather flustered translator from the institute who ushered us to a waiting minibus for the interminable trip to our new home. After hearing many dismal descriptions of life in the USSR we were most pleasantly surprised to find that although the hall of our apartment building was drab and dirty, the apartment itself was pleasantly spacious and furnished with the best the Soviet system could provide. This included three bedrooms, living room, kitchen, and bath. The furniture was quite adequate including television set and radio-phonograph console (with which we listened to Voice of America). We ultimately found that our apartment was relatively luxurious by Protvino standards, available to about the top 5% to 10% of the local population (which in this science city was already a select segment of the total population). I had hoped the Institute would provide housing gratis, in reciprocity for the similar treatment of the Soviet physicists in Batavia so was quite happy to hear the next morning that my Russian hosts had acquiesced to this request. (I was told that we would not pay rent but would get a bill for utilities. Skeptical foreigners informed us that this might mean that the \$10/month rental for the apartment would be waived but the utilities bill would somehow come to \$100/month. In fact we never paid any utility fee whatsoever.) I was also told that our freedom of movement was proscribed within a 10 square kilometer area surround the village of Protvino. Beyond this distance would require permission of the International Bureau 24 hours in advance. In practice our local movement was limited by the radius that we could manage walking with our two small children (who became quite good hikers).

Following this introduction, I was met by Professor Adolf Mukhin who had first talked to me in Batavia about the research program at IHEP. He was anxious that I join his group, something I tried politely to decline since I was much more interested in the physics to be done in the projected hyperon beam discussed in my communications with Logunov. Murmuring something to the effect of "we shall see..." Mukhin put me in the hands of one of his colleagues who have me a brief tour of the large experimental hall where their group was completing preparations for a neutrino experiment.

I was told that one task of the group was a careful measurement of the pion and kaon fluxes from proton-nucleus collisions. They had attempted such a measurement some months previously with rather poor results. Mukhin had learned that I had worked with Alan Krisch on a similar experiment in 1967, and hoped that I could assist then now. For this project I could not muster the slightest bit of enthusiasm.

Without any opportunity to meet other experimental groups I was ushered to a meeting in Prokoshkin's office for a discussion of my "research program". After a minimum of pleasantries

Yuri Prokoshkin informed me that he had given some thought as to which experimental group I might work with. It boiled down to a choice of one, Mukhin's. I was extremely disappointed about not being able to work with Denisov but was told that was absolutely out of the question. Other groups such as Landsberg's, same story. It was made absolutely clear to me that the decision had been made and it would not be broken without an enormous amount of pressure. After less than 48 hours within the country, I did not see how I could get in a bitter argument with the effective director of the laboratory. In any other country, this would simply be a personal disagreement but here there seemed to be much more at stake. Considering the tenuousness of relations between the United States and the USSR, I was reluctant to poison in any way the tentative progress towards cooperation in fundamental particle research. So in spite of a year of plans to the contrary I found myself agreeing to work on an experiment in which I had no interest whatsoever.

For the next few days, I seethed in anger over this shoddy treatment. What I dearly wanted to do was talk with someone of the USAEC about the consequences of my "taking a walk" in protest. Communications in Protvino are not a simple matter and the only way this could have been done would have been through the American Embassy in Moscow. I had met Dr. Jack Tech, the scientific attaché, and in our brief talk, he had left me the impression that he hoped I would not complicate his life any further. I also knew that by and large no one in the AEC had a very comprehensive feeling for Russian-American relations either, so in the end I accepted the Russian conditions with as good grace as possible. This marked the termination of my hope of doing any interesting research during the next six months.

Needless to say, I had ample time to reflect on the reasons why I was cut off from working with the Denisov group. Prokoshkin had given the excuse that the hyperon beam was quite delayed in construction. I subsequently learned that this was true; the estimates were that the hyperon experiments were at least 18 months behind schedule. This fact could not have escaped Logunov when he wrote me in February, confirming my plans to collaboration on this project.

Basically there seemed to be two motives for the treatment I received. The strongest one seemed to center on the fear of some capitalist germ which might infect the innocent populace. The Soviet bureaucracy is absolutely paranoid when it comes to the possibility of Russian citizens conversing with foreigners, Americans most of all. We were selected for the honor of living in the apartment just above the local KGB officer, a man who inspired a certain dread among the citizenry. From this standpoint Mukhin's group was an ideal choice. Mukhin himself was a prominent local party ideologue and would have no problem in maintaining a sanitary relationship between myself and his own people.

Secondly Mukhin really needed some help. His group by and large consisted of a number of young but inexperienced physicists with the equivalent of Masters degrees and they were bogged down in a measurement of hadron yields from proton collisions using borrowed equipment with severe limitations. As I learned later, the group was under some criticism for their slow progress and tangible experimental results were required.

Mission Impossible

From a distance it is easy to scoff at the meager results from the Soviet efforts in high energy physics. At a closer perspective one begins to see the pyramid of obstacles that a physicist must

overcome and one is amazed when progress comes at all. In many ways the Serpukhov laboratory was unusually well off. The accelerator itself seemed to run reliably and with adequate intensity. In addition, through the collaborations with the French, CERN, and the Americans, IHEP had acquired a large amount of Western electronic equipment such as computers, oscilloscopes, photomultiplier, scalars, digital voltmeters and so on. The French had provided the Mirabelle bubble chamber and the components for the RF separated kaon beam feeding it. For their own part the Russians had committed eight million dollars to an ICL computer complex to satisfy the computational requirements of the laboratory. All of this comprises a considerable inventory of hardware, far greater than what is available to other Soviet laboratories. Thus, the paucity of research at Serpukhov has very little to do with the simple problem of lack of equipment. The reasons appear much more entwined in the nature of Russian society and no single administrative change is likely to affect the forseeable future for the Soviet high energy physics program. A consideration of these problems should put some boundary conditions on what the United States can expect to gain from Soviet-American collaborative efforts.

It seemed to me that the basic difficulties ultimately stem from two sources: the Soviet educational system and the administrative bureaucracy. First of all the Soviets appear to view the labor force as a mechanistic collection of parts, fitting together to form the machinery of a society. The educational system is assigned the task of converting the raw material of adolescence into a certain decreed number of welders, plumbers, doctors, physicists, musicians and so on and so forth. The individual to be processed is sent to the proper institute for whatever profession he or she is allowed to enter and after a certain number of years is given the requisite certificate. Certainly the better students get the better jobs upon graduation but the system essentially guarantees that all will eventually be employed in the field of their specialization. This is an especially attractive feature for the Russians for it means that having passed those early hurdles in one's youth one can look forward to indefinite security of job and social status, at least as long as one maintains political invisibility.

For traditional occupations (building trades, primary education, etc) where demand can be accurately forecast, such a system of social predestination makes a certain sense. However as the complexity of society increases, this stratification of intellectual skills opposes the rapid development of new areas of technology. In high energy physics the Soviet system has planned for a fixed number of Ph.D. level scientists supported by an equally fixed number of Masters level physicists-engineers. With the ancient Russian custom of separating research and teaching, the number of senior positions for Ph.D. personnel is rather low and so the educational pipeline restricts the output of broadly trained physicists to a bare trickle. This is augmented by a more narrowly trained group of people who have received the equivalent of a Masters degree.

In Mukhin's group, for example, there was one doctorate, (Mukhin, of course), one with a Candidate degree (equivalent to Ph.D.) and then a host of 10 to 12 with a Diplome (Masters). These junior members are in something of a box as far as their future is concerned. They can not acquire the higher degree, the ticket required for a position of research leadership. Even worse, they cannot shift into allied fields (such as computer science) without returning to school and going through the degree process all over again. These people have neither the research experience nor the stature to be able to propose or execute new experimental ideas of their own. This is exacerbated by the narrow specialization of each group member. For example, in Mukhin's group, there was

an online computer programmer, an offline computer programmer, a Monte Carlo programmer, and analog engineer, a digital engineer, and so on. Each member was responsible only for his own specialty so that when failures occurred in the experimental apparatus much effort was expended deciding which person had jurisdiction over the particular problem. The result was that the best of the junior supporting staff were bored, cynical, and frustrated.

With upward promotion blocked these people will remain frozen in their positions, denying employment to younger graduates. This difficulty is not unique to the Russians but it will be more severe because over-specialization immobilizes the work force, preventing any lateral redistribution.

The problems which face the senior physicists is of a quite different nature. Again, in the Soviet style, there seems to be no open competition of ideas for experiments unlike the practice in Western laboratories. In my opinion, the quality of the senior staff was quite good but the quixotic distribution of resources plus the overall lethargy of the personnel always succeeded in slowing progress to a snails pace.

It it impossible to neatly categorize the myriad of ways in which the Soviet system sabotages the efforts of the most ambitious. I can only offer a few examples of typical laboratory SNAFU's. The most blatent revolved around the ICL computer complex. This dual processor system purchased from the British for $8,000,000 dollars was a source of constant irritation for the Russians who used it and the small band of British field engineers assigned to repair it. Under the terms of the contract with ICL, the Russians had the prime responsibility for maintaining the monster. When all else failed (which was quite often) the British were called in to pick up the pieces and get it running again. Since this cost the Russians hard currency they did not like to give up until all their own efforts proved in vain. This meant that when the computer went down, it stayed that way for quite awhile.

One reason for the Soviet engineers' inability to maintain the machine stemmed from the training courses offered by ICL at the time of the initial contract. Under the terms of the contract a certain number of people were to be trained in proper equipment maintenance at the ICL factories in England. The heads of the IHEP computing department regarded this as a splendid junket for themselves and so the technicians who would eventually have to do the work never had the opportunity to learn their jobs.

I used the computing facility for a period of about three months. As a guess, I doubt that neither of the two processors were available more than 50% of the time. Towards the end of my stay a message appeared on the bulletin boards that no further output would be generated for the next two weeks because the laboratory had run out of line printer paper. This had to be purchased from England since Russian industry could not make paper of sufficient quality for use in fast printers. Again hard currency was involved and in the Russian manner, this purchasing decision had been indefinitely delayed. Thus although the Soviet government could sanction an $8 million dollar expenditure for capital equipment, they could not find the $20,000 required for the paper to keep it operating. This was also a problem for the American computers (Hewlett-Packard 2116) which had been purchased for online data acquisition. Although all four of these small machines were equipped with line printers, the Russians feared, that once the original stock of paper was exhausted, there would be no more.

As is well known Russian technology has been most deficient in the area of solid state electronics. Luckily for Serpukhov a good deal of equipment from CERN was retained from the early CERN-

IHEP collaborative experiments. Particularly valuable for Mukhin's group were the Tektronix oscilloscopes and a SEN multiscaler system manufactured about 10 years ago. The fast digital electronics were designed and built at Serpukhov. These modules operated with typical pulse widths of 50 nanoseconds and, although slow, were considered rather reliable. The digital interface for the proportional wire chambers was called "Russian CAMAC" (CAMAC is the name for a European electronic design standard which permits a simple, uniform modular interconnection between many external electronic measuring devices and a data acquisition computer).

As I came to learn later, every Russian laboratory invents its own electronics. Thus, in the most planned of all societies, the same engineering tasks must be repeated again and again, as each laboratory duplicates the work of all the others. Naturally, no standardization exists and, it seems, none is desired. After seeing the home-grown Russian CAMAC interface at Serpukhov, I was greatly surprised to see true CAMAC modules designed and built at Dubna which were at least a generation more sophisticated than anything at IHEP. As I learned later, the reason for the advanced technology was at least partially ideological. IHEP, being a purely Russian laboratory, could not admit technological inferiority by adopting an engineering standard created in Western Europe. Dubna was in theory an international laboratory, and could more freely take advantage of Western technology imported via the Warsaw-bloc member states. The Poles manufactured CAMAC crates with power supplies and these were brought to Dubna along with a certain number of Texas Instrument 7400 series chips for incorporation in various types of data acquisition equipment.

There were also a number of physical problems at Serpukhov which hampered the productivity of the laboratory. The most constricting was the design of the large experimental hall. This building housed all of the electronic experiments with the exception of the ν beam. Unfortunately in the interests of symmetry, the building was centered directly over the 70 GeV accelerator magnet ring. This architectural decision ensured that only about 1/3 of the area covered by the structure could be used for experiments. The result is that all the experimental beam lines are severly constricted in the traverse direction and no new ones can be created without severe disruption of the present scheme.

From the point of view of the current experimental program at IHEP, the greatest single shortcoming was the lack of a slow extracted proton beam. All meson beams were created on internal targets, so that it was hard to target more than one counter experiment at a time. This also made for severe radiation problems for both the accelerator magnet components and the experiment area. I understood that IHEP had been waiting for some time for the fabrication of the requisite components for the slow extracted beam but the Leningrad Magnet Works had not seen fit to deliver the goods. Apparently this is a theme not unheard of in other sectors of the Russian economy.

One of the things I found difficult to understand was the Russian work customs. When I arrived during the summer, most of the junior lab personnel were either on vacation or working in the local beet fields. Apparently the laboratory was affiliated with the neighboring "sovkhoz" (state farm). During the summer most everyone was required to spend one day a week in the fields cultivating the cabbages, carrots and so on. This activity peaked at harvest time in September and tailed off to zero in the winter. My suspicion was that the main purpose of this diversion of technical personnel was ideological but since the senior physicists were excused from labor, it emphasized the privileges of class in the "classless society". In any case, a number of people disliked the work intensely. As I understood it, it was just plain inefficient. No one knew much in advance which was his day to go

to the fields and often when you got there it took time to organize the teams, etc, etc. Since the people were not farmers anyway they tended to the careless. A walk around the fields outside of Protvino was a sad testimonial to the efficiency of this system.

During my 6 month stay, our group was afforded only 8 days of running time in the diffracted proton beam. With such a short time available, I expected that there would be a vigorous program of equipment testing prior to our data run. Such is not the Russian style and as a result our one data run was not very useful. Several new pieces of equipment were introduced into the electronics which had not been debugged at all. Most of the 8 days was spent in controversy between a programer and an engineer over who had scrambled the bits from the proportional counter interface. A month earlier, I had expressed concern over the adequacy of the Čerenkov counters and was given the advice that we should all simply hope for the best. Not surprisingly, the Čerenkov counters behaved exactly as I had calculated, astonishing the Russians no end. In an effort to improve the counters during the one week run, I suggested replacing one of the marginal Čerenkov counter photomultipliers. However the Čerenkov counter belonged to another group whose Čerenkov counter specialist was on vacation. Thus the tube could not be changed until his return two weeks later. And so on.

The Physics Program

I had the opportunity (after two months of negotiation) to visit four other high energy physics laboratories in the USSR; Dubna, ITEP in Moscow, Gatchina near Leningrad, and Yerevan in Armenia. It was clear that none of these other laboratories support anywhere near the level of activity that is at Serpukhov. For a variety of reasons indicated earlier, most of the experiments at IHEP have been in progress for quite some time. Yuri Prokoskhin runs the physics program at the laboratory and thus controls the flow of money and other resources. The result is that his experiment looks thoroughly professional from one end to the other and without doubt was the most successful one in operation. The Prokoshkin group was collaborating with a multinational consortium from CERN, consisting of Italians, Austrians, and Germans. The first phase of the experiment had been the measurement of the charge exchange reaction, $\pi^- p \rightarrow \pi^\circ n$. Subsequently the experiment has measured cross sections for production of other neutral mesons decaying to γ-rays and reported last year the discovery of a new one. By 1975 the CERN contingent was beginning to disband so I expect that by now the experiment is in completely Russian hands.

There was one other CERN group at IHEP under the leadership of Manneli who was collaborating with Dubna on a measurement of coherent meson production in nuclei. This experiment was just beginning in 1974 and the expectation was that it would be the last in the series of USSR-CERN collaborations.

Mukhin's group was heavily committed to the ν program. The laboratory had just completed the shielding for the ν beam which required something of the order of 10^3 cubic meters of iron and by November 1974 they obtained their first neutrino events in an optical spark chamber array. A good deal of money had been poured into the beam; the magnetic horn lenses to focus the hadrons were quite elegantly designed and machined. The detector was rather crude and the group was under a good deal of pressure to improve it.

Denisov's group were continuing their measurements of $\pi^- p$ elastic scattering into regions of higher momentum transfer (beyond t = 0.8 GeV^2). Nurushev was also continuing in his collabora-

tion with Saclay to determine the spin parameters of $\pi - p$ elastic scattering. I knew very little about Landsberg's group except that they were just completing some μp inelastic scattering experiments.

The bubble chamber effort was concentrated on Mirabelle, designed, built and maintained by the French. This collaboration was also nearing an end although the chamber was still getting quite a bit of beam time in 1974. The main output of this work appears to be two particle correlations from collisions with 40 GeV incident energy. The heavy liquid chamber, SKAT, was still under construction and was expected to play a major role in the neutrino program by the end of 1975.

All of the Russian groups mentioned above were based at IHEP. There was also a certain activity from groups at ITEP, Dubna, and Moscow Institute of Physics and Engineering. I had no contact with these people and my impression was that IHEP did not view their experiments with very high priority.

The experimental groups at the other laboratories are much less active. The Dubna accelerator is almost moribund as one might expect. There were two experiments in the process of being set up there; one to measure electron pairs from vector meson decay and another to look at proton collisions in a helium streamer chamber. There is some hope of accelerating light nuclei in the Dubna machine and this may extend its life for another few years. Incredibly, a large experimental hall was being constructed next to the accelerator; no one knew what would be put in this building once it was completed. The technical support at Dubna is excellent. The electronics group were making high quality printed circuit boards for their CAMAC modules, much better than anything at Serpukhov. I was particularly impressed with the design of some liquid hydrogen targets made by the target group. These were constructed with light styrofoam rings laminated together to form the outer vacuum jacket. The resulting system presented very little absorbing material for particles emitted over almost the entire 4π solid angle.

The Institute for Theoretical and Experimental Physics (ITEP) in Moscow seems to be dominated by theorists. The experimental program was beginning on the proton accelerator which had just been renovated to accelerate to 10 GeV protons. I talked at some length to one group who were planning to measure boson production in backward scattering reactions; they were most interested in the similar measurements of the Illinois Streamer Chamber experiments at Argonne. The people at ITEP were very proud of their computer network which was quite complex considering that there were only two experiments on the floor. The network consisted of four "Sigma-2" data acquisition CPU's in the experimental hall connected via a common bus to the two BESM-6 processors in the main computing center. The "Sigma-2" computers were brand-new; manufactured in one of the Eastern European countries. That was a recurring theme in all the laboratories I visited. The Russians have carbon copies of probably every minicomputer ever made in the USA. In addition to the Sigma-2 I saw copies of the Hewlett-Packard 2116 and both early and late versions of the PDP-8.

At Yerevan, as at ITEP, the theoretical physicists seemed more active. The physics institute has an electron accelerator with parameters similar to CEA but I only saw one experiment, a pion photoproduction measurement. The work on transition radiation is essentially complete and they hope to use these detectors at their high altitude cosmic ray station to separate pions from protons. I also visited the laboratory at Gatchina outside of Leningrad where there is a 2 GeV synchrocyclotron. The energy and intensity of this machine restricts the kind of work that can be done but the laboratory had a number of experiments in progress measuring cross sections at low

energy.

In my initial request to the State Committee for the Uses of Atomic Energy, I had indicated that I would be willing to give a lecture about our work in progress at Fermilab or the work just completed at Argonne. Only ITEP requested in advance that I present such a talk. However at both Dubna and Yerevan this was requested, after I arrived. The etiquette of all this was that if I had been invited to give a talk first, then the laboratory would be responsible for paying my expenses (i.e., hotel room, etc.) The State Committee had apparently instructed the laboratories on how I was to be treated and I was rather irritated by this whole business. I did give talks at Dubna and Yerevan but when I went to Leningrad, I left all slides and materials at home. My guide told me this was a very bad thing to do. Tough.

Getting Along in Protvino

From my earlier comments, it should be clear that I have nothing but enmity for the State Committee and government of which it is a part. These feelings certainly do not extend to the Russians with whom I worked nor to the many people who helped us during our stay. In particular the International Department was always extremely helpful in arranging transportation to Moscow and excursions to nearby points of interest. The CERN people provided us with transportation as well as the use of a myriad of items such as laundry machines, vacuum cleaners, bicycles, and so on. We also enjoyed the opportunity to see the occasional movies imported by the French Mirabelle group or the British ICL contingent. As we left Protvino at the end of 1974, it was clear that the European community would decrease drastically in the next year or so. Thus anyone going to IHEP now can expect many fewer amenities than were available to us.

As indicated earlier, the government (i.e., KGB) was quite nervous about any possible contacts with Russian citizens. It was not healthy for Russians to be in our apartment, at least singly. However at the end of our stay we held a party for our group which was attended by Mukhin, a trusted party member. As long as a reliable member of the Party is nearby, there are no problems. Also no problem is going to the Scientist's Club which is out in the open so nothing clandestine can be suspected. From here on out, all other social interactions become more problematic. There was one member of our group who was considered "poison" because of his Party membership and I was warned not to talk with others in his presence. I eventually came to understand that anything at all remotely "sensitive" should only take place with no one else present. What Russians are sensitive about comprises a list unimaginable for those of us reared in the West. It is important to remember that Russians who talk freely with Americans have nothing to gain and quite a lot to lose. In Protvino, the people enjoy a standard of living not available elsewhere and will not lightly jeopardize their future.

After a period of a year, I must confess that even now I use the telephone differently than I would have a few years ago. In light of recent history, perhaps this was good training for the future. The majority opinion in Protvino was that our apartment telephones were bugged but the walls were not. I would not completely discount the possibility of the latter either. Anything sensitive, my wife and I discussed outdoors but this did not inhibit general and specific cursing of the Soviet regime at home in the hopes it might possibly irritate (or interest) some KGB apparatchik. We were afflicted with one young girl of somewhat unstable background who came to visit our apartment

quite often and became an incessant pest. She tried to attach herself to other Europeans and for good and substantial reasons we believe she was at least a KGB informant. She displayed an unseemly interest in all our affairs and we reacted accordingly.

The moral of this story is that there is no way of really knowing who are the good guys and who are the bad guys. There is absolutely no substitute for good judgement and discretion.

Our Home Away From Home

One luxury for which we were most grateful was the access to some of the facilities at the American Embassy in Moscow. These included the use of the small food shop in the basement, the diplomatic pouch for getting mail in and out of the country, and the availability of D-cheques for use in the special food and clothing shops maintained by the Russians for the diplomatic corps and high-ranking Soviet officials. John Ward, the junior scientific attache, was enormously helpful in solving some of our problems and we owe him our gratitude.

At the same time it is necessary to mention aspects of the Embassy operations which appeared corrosive to the best interests of the State Department and the United States in general. Part of the problem stems from the siege mentality which affects all foreigners in the USSR, the diplomatic corps worst of all. This reached its nadir in the US Information Agency which ran the Cultural Affairs section. A more unpleasant group of minor functionaries would be hard to find even within the ranks of the Soviet bureaucracy. These people spent their working day in trying to find ever more ingenious ways of preventing the flow of any American newspaper, magazine or other media to the Russian public. Since the Soviet government was on their side all along, it was not a hard battle to win. At every opportunity we tried to obtain the Russian language publication, "America", to give to our friends at Protvino. Since this USIA publication was almost never available at the American Embassy in Moscow, I can only assume that perhaps it is being distributed to the Portugese instead. (The magazine was never on display where Russians could see it.)

We also listened to "Voice of America" occasionally on the Latvian radio set in our apartment at Protvino. The version we heard was the English language edition beamed to the Eastern Mediterranean area. In general, with some exceptions, the programming was dull and provincial.

These criticisms of the USIA, however, have little to do with the main work of the American Embassy. What disturbed us most about the Embassy personnel was their relative innocence of Russian history, custom, and language. As I understand it, this is a direct result of deliberate State Department policy to avoid hiring or training foreign service officers with comprehensive knowledge of any one particular area. Although such a policy may be defensible in general, in the Soviet Union it leads to a massive insensitivity for the local facts of life. The press corps in Moscow is not quite as cloistered and it is my firm opinion that a far better estimate of Russian strengths and weaknesses is available in the New York Times than what issues forth daily from Tschaikovsky Street.

What is to be Done?

I would like to close this report by posing a few questions about the future of Soviet-American collaborations in elementary particle physics. If some attempt can be made to answer these questions,

we may be better able to bridge a certain gap between hope and reality. First, I would like to hazard some guesses as to the future.

The safest assumption is that the Soviet support of high energy physics will not change markedly in the next decade. The Soviet government has an extraordinarily high regard for science, partly for economic and partly for ideological reasons. Nevertheless people at Serpukhov felt that the limits of government support have already been reached and without some revolutionary discovery with practical or military consequences, there will be no new major growth. One might expect one more large accelerator to be constructed five years from now, perhaps with the IHEP 70 GeV machine as injector. As I indicated earlier, the Western European groups have by now pretty much folded their tents at Serpukhov and there is no incentive for any Western group to attempt another experiment there in the future. I do not believe the Russians would like many more Americans in the USSR than absolutely necessary; those that come will be as socially quarantined as ourselves. This means that any future Soviet-American collaborations must center on the work at Fermilab (or PEP). With the SPS at CERN and PETRA at DESY coming online, foreign currency considerations as well as politics will make American facilities less attractive for the Russians.

Under these conditions what benefits can be expected from continued Soviet-American collaboration? I would strongly urge ERDA staff members to consider this question carefully for in my view our government has only the haziest notion of what American goals should be. Innocence has its virtues but not when negotiating with the Russians.

Since the purely scientific value of Soviet collaboration is likely to be minimal one might hope that the effects of social interaction will eventually transfer a better understanding of the USA to the governing Soviet elite. I suspect that such a hope rests on the history of the development of physics in America following the Second World War. In this country many of the leaders of the Manhattan Project continued their work in basic science following a path into what is now called high energy physics. Because of their earlier connection with atomic weapons, this group remained quite influential in government policy as well as in the scientific establishment. It is now thirty years after the dawn of the atomic age and so these ties between government and particle physics have suffered the natural losses of retirement and death. Barring any future implications of high energy physics for military hardware, one can not expect significant participation of particle physics in the higher reaches of our government. Such a situation must find an inevitable parallel within the Soviet structure.

It is with some sadness that I have come to these conclusions for I have a great respect for many of my Russian colleagues. The possibility of working jointly with them was an exciting idea made irrelevant by the exigencies of history and culture.

APPENDIX A

Communications with the Institute for High Energy Physics,
Serpukhov

January 22, 1973

Professor Yu. D. Prokoshkin
Institute of High Energy Physics
Post Office Box 35
Serpukhov, Moscow District
USSR

Dear Professor Prokoshkin:

In the summer of 1974 I expect to take a sabbatical leave of absence from the University of Michigan. At the suggestion of Dr. Bruce Cork, I am writing to ask you if there is any possibility of working with your experimental group at Serpukhov for a period of six to twelve months.

Since 1967 I have collaborated in a series of wire spark chamber experiments to measure the hyper-charge exchange reaction $\pi^+ p \to K^+ \Sigma^+$ in the region from 3 to 7 GeV/c. Currently we are taking data at the Argonne Laboratory on the double charge exchange reaction $\pi^- p \to K^+ \Sigma^-$ from 3 to 5 GeV/c which I hope to report on this summer. Later this year we expect to set up and run an elastic scattering experiment at NAL (experiment 7) to measure $pp, \pi^\pm p, K^\pm p$ differential cross sections up to 200 GeV/c. Throughout this work I have had particular responsibility for the digital hardware and software which has enabled us to compute these differential cross sections on line.

Professor Mukhin has given me a brief description of some of the experiments your group is engaged in. I would be particularly interested in the construction and use of a hyperon beam since I proposed building a similar facility for Argonne Laboratory a few years ago. (I also abandoned the project because the higher energy accelerators could do a better job.) If you feel there might be some opportunity for me to come to Serpukhov during 1974 I would be glad to provide more detailed personal information.

With many thanks for your consideration;

Sincerely,

Carl W. Akerlof
Associate Professor
University of Michigan

CWA:mc

May 1, 1973

Professor Yu. D. Prokoshkin
Institute of High Energy Physics
Post Office Box 35
Serpukhov, Moscow District
USSR

Dear Professor Prokoshkin:

About three months ago I wrote you concerning the possibility of working at Serpukhov for a period of six months to a year. To date I have had no reply. In order to clarify this ambiguous situation, I called Dr. Popov (currently visiting NAL) and he suggested that I send you a short note as a reminder.

Since I soon will expect to develop alternate plans, I would appreciate some response to my original inquiry.

Sincerely,

Carl W. Akerlof
Associate Professor
University of Michigan

CWA:jsd

June 30, 1973

Professor A.A Logunov
High Energy Physics Laboratory
Serpukhov
Moscow Region, USSR

Dear Professor Logunov:

Professor Carl W. Akerlof of the University of Michigan has informed me about his interest in spending a sabbatical leave at your laboratory. I am enclosing copies of two letters that he has written to Dr. Y.D. Prokoshkin, one on January 22, 1973 and the other on May 1, 1973.

I have known Professor Akerlof for a number of years. He first worked close to me at Cornell. More recently, as a Professor at the University of Michigan, he has been involved in the planning and design of one of the early elastic scattering experiments proposed to be done here at NAL. Professor Akerlof is a talented experimentalist with a great deal of experience with on line recording and analysis of data from counter experiments. He is enthusiastic about participating in the Serpukhov program. I am confident that there is much that he could contribute during an extended stay at your Laboratory.

One of the conditions that many diplomats seem to feel should be observed in arranging exchanges in high energy physics is that there should be some approach to a balance between visits of scientists from the USSR to laboratories of the U.S. and visits by U.S. scientists to laboratories in the USSR. At the present time, because the unique nature of the facilities at NAL, there is a tendency for an imbalance to develope in the exchange. It therefore seems to me that when physicists like Professor Akerlof develop an interest in participating in research in the USSR, that opportunity to provide better balance in the exchange should be exploited.

At the present time, we are very pleased with the collaborations that have brought the Nikitin group from Dubna and the Mukhin group from Serpukhov and ITEP to NAL. It is my sincere hope that exchanges of this kind can be further developed in the future.

Sincerely,

Robert R. Wilson

July 1973

Prof. Carl W. Akerlof
University of Michigan,
Argonne National Laboratory,
Argonne, Illinois
USA.

Dear Professor Carl W. Akerlof:

Your proposal to come to Serpukhov to participate in experimental research work at our accelerator was met with great interest. We will gladly welcome you at IHEP in the summer of 1974, so that you could take part in preparation for the experiment with the hyperon beam and carrying it out. By this time we would like to have your proposals and then to co-ordinate your research programme at IHEP.

Unfortunately, we have no possibility to pay your subsistence allowances.

Yours Sincerely,

A. Logunov,
Professor,
Director of IHEP.

November 26, 1973

Professor A.A. Logunov
Institute for High Energy Physics
Serpukhov near Moscow, USSR

Dear Professor Lugonov:

I am delighted to accept your invitation to work with the hyperon beam group at your laboratory. Tentatively, I plan to come to Serpukhov sometime in July 1974 if that is convenient with all concerned.

The United States Atomic Energy Commission (USAEC) has expressed some doubts about the bilateral agreements under which I would be visiting at the laboratory. I understand that such a visit could be covered under the September 28, 1972 agreement titled "Memorandum on Cooperation Between the U.S. Atomic Energy Commission and the USSR State Committee for the Utilization of Atomic Energy for Peaceful Uses" and also a similar memorandum signed July 21, 1973. If my stay is to be covered under the terms of these provisions, the USAEC has indicated that I would need a short note from you stating this explicitly.

Assuming that I will be covered by the agreements mentioned above, I understand that the host laboratory will be able to provide housing and medical services for myself and my family (wife and two small children). If there is someone I should contact in making arrangements for housing and visas, please let me know.

Many thanks for your help.

Sincerely,

Carl W. Akerlof

CWA:mmn

February 1974

Prof. Carl W. Akerlof
National Accelerator Laboratory
PO Box 500
Batavia, Illinois 60510
U.S.A.

Dear Professor C.W. Akerlof:

The IHEP is ready to receive you here in July 1974 to work with the hyperon beam group at our laboratory.

Assuming that you intend to come under the existing bilateral agreements on cooperation, the USAEC should formally apply to the USSR State Committee for Utilization of Atomic Energy.

As for the conditions of your stay here, the IHEP will be able to provide free medical services for you and your family. The rent for a three-bedroom apartment at Protvino will be about 100 roubles per month (gas, electricity and telephone included).

The IHEP will also facilitate in arranging necessary visas.

Please, send a word on your final decision as soon as possible.

With best regards,

A.A. Logunov,
professor, director of IHEP.

March 21, 1974

Professor A.A. Logunov
Director, IHEP
Serpukhov, Moscow region
USSR

Dear Professor Logunov:

Many thanks for your recent letter which clarified the conditions of our anticipated 6 month stay at your laboratory. I look forward to working with your colleagues on the hyperon beam experiment and will inform you of our exact date of arrival when our travel plans have been completed.

Best regards,

Carl Akerlof

CWA:aa

May 20, 1974

Professor A.A. Logunov
Institute for High Energy Physics
Serpukhov near Moscow, USSR

Dear Professor Logunov:

This is to inform you that I have made round trip airplane reservations to and from Moscow. We plan to arrive on July 8, 1974 via SAS flight 768 at 17:15 (see enclosed letter). At your advice, we can either continue on to Serpukhov or stay overnight in Moscow.

I have mailed visa applications to the Division of Consular Affairs at the Soviet Embassy in Washington, D.C., including copies of our correspondence. I hope that this information will be helpful in arranging the visas for myself and family.

Best regards,

Carl Akerlof

CA:gb

APPENDIX B

Expenses charged to ERDA contract during 6 months visit to the USSR:

Internal Travel $291.24
Summer Salary, 2 months