RESEARCH IN HIGH-ENERGY PHYSICS AT NSC KIPT (70th anniversary of lithium nucleus disintegration)

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The report delivered at celebration of the 70th anniversary of work on artificial splitting the lithium nucleus with protons in NSC KIPT

PACS: 29.85

The development of investigations in high-energy physics (HEP) is closely related round the world to Nuclear Physics. In our Institute, they are the natural continuation of work on artificial splitting the lithium nucleus with protons. The 70th anniversary of this event is celebrated today.

It is also significant that two of the scientists who performed that experiment, namely, K.D. Sinel'nikov and A.K. Val'ter, were the inspirers of creating the experimental basis for the HEP and conducting these investigations at our Institute. Academician A.K. Val'ter took over the direct supervision of all the work that remained the main concern of the last years of his life.

By the beginning of the fifties, nuclear physics had already achieved much success in investigations of atomic nucleus and military-purpose use of internal nuclear energy. The investigations opened up new possibilities of using this energy for peaceful purposes, or, broadly speaking, of using nuclear processes in various fields of science, engineering, and medicine. And we are the witness of how widely these possibilities are used by the mankind.

However, at that time nuclear physicists were unable to solve the most fundamental problems such as: what was the structure of nuclear constituents - protons and neutrons? What was the nature of strong interactions of nucleons in nuclei?

It became evident that it was necessary to turn to another level of investigating the structure of subnuclear substance, which is characterized by space dimension of $< 10^{-13}$ cm. For that purpose it was necessary to have accelerators for energies of tens, hundreds, thousands of megaelectron-volts (MeV). Programs of those investigations were progressing rapidly in many developed countries. As a result, there came a new world of "elementary" particles, the number of which many times exceeded the number of elements in the periodic table.

A new line of research in the HEP was formed, that gained a support throughout the civilized world. The USSR started to bring into life the program of constructing high-energy accelerators of protons, electrons. It was decided to build at our Institute the electron linear accelerator for the then record energy of 4 GeV. The preference given to our Institute was evidently due to the fact that at Kharkov there was already experience of electron acceleration and of making accelerating systems for high-energy accelerators (Ya.B. Fainberg, N.A. Khizhnyak and others). There were successful theoretical investigations on quantum electrodynamics and elementary particles (A.I. Akhiezer and his followers).

By 1965, a 300 MeV accelerator and the first line of the 2 GeV accelerator with intermediate experimental halls were created under the direction of A.K. Val'ter. The build-up of energy up to 4 GeV was found to be unreasonable.

The main body in the team of physicists participating in designing experimental halls, physical equipment included the people who had learned in the school of experience in nuclear physics (A.K. Val'ter, N.G. Afanas'ev, P.I. Vatset, S.G. Tonapetyan, V.I. Voloshchuk, A.Ya. Kolesnikov and others) together with experienced engineers, technicians, laboratory assistants.

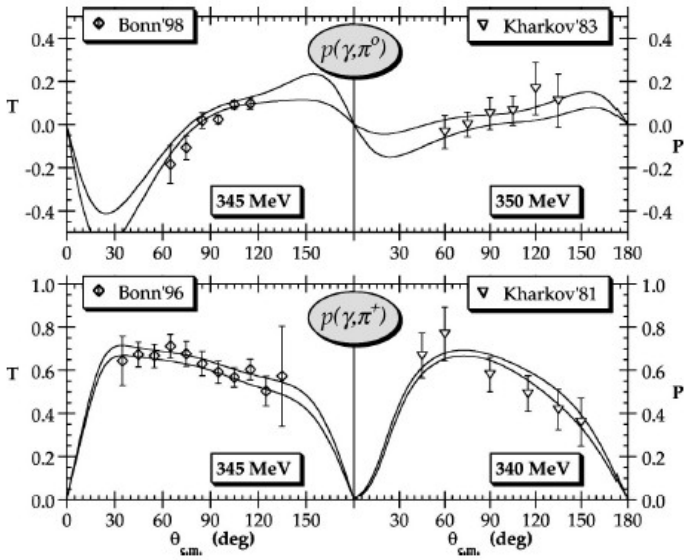
In mastering the theoretical aspects of HEP, of great benefit to the experimenters were the lectures given by our theorists A.I. Akhiezer, E.V. Inopin, D.V. Volkov, P.I. Fomin, M.P. Rekalo and others. Those lectures were issued as preprints which served as useful manuals for young scientists to meet the minimum requirements for a Candidate's degree.

By the middle seventies, the 300 MeV and 2 GeV accelerators had a great complex of the up-to-date facilities: magnetic spectrometers with multichannel systems of particle detection; spark, diffusion, freon chambers; polarized and quasimonochromatic photon beams; polarized target of protons and deuterons, fast electronics, on-line systems. None of the scientific laboratories in the world possessed that complex of techniques. Much work was done to improve the scientific level, efficiency and quality of investigations, to train scientific and technical personnel.

The Institute became the leading center in the Soviet Union that investigated electromagnetic processes and took the worthy place in the world science scientific community. Here, All-Union seminars and international meetings were regularly held.

The research program embraced a wide circle of problems on elementary particle physics, high-energy nuclear physics, and electrodynamic processes in the matter.

Most of the experimental results were entirely new at that time. A major part of them gained a wide recognition of specialists. They are used in surveys, are included in the world data banks, and are stimulatory to theoretical developments and new experimental investigations. Some of those data remain unique to the present day. In particular, our data on the polarization parameters measured in the single pion photoproduction on nucleon were included into the world spread SAID compilation [1]. These data are used in the most recent publications, for example [2]. In the KIPT the multipole analysis of this reaction now has been provided by A.S. Omelaenko, a member of the Baryon Resonance Analyses Group (BRAG collaboration). The figure below represents one of the cases where our data are the single source of information about the polarization values.



Prediction of the T asymmetry and the polarization of the final nucleons P for the $p(\gamma,\pi^0)$ and $p(\gamma,\pi^+)$ reactions vs the c.m. pion production angle, compared to the existing experimental data. The figure is taken from the LEGS's article [2]

The of P.I. Vatset and V.I. Voloshchuk on the photodisintegration of helium-4 got the State Prize for 1977. Based on the experimental results obtained, 11 Doctor's Theses and 60 Candidate's Theses were defended.

The NSC KIPT gathered a team of highly qualified specialists who had a topical program for the development of accelerator equipment, new facilities for experiments, means of data processing and interpretation. A scientific cooperation with related institutions of the Union and foreign countries was developing.

The hard times experienced by our country could not help affecting the progress of HEP investigations at our Institute. In 1993, experiments using 300 MeV and 2 GeV accelerators were stopped because of the absence of the necessary financing. However, the work on the analysis of data obtained earlier, on their comparison with the present-day theoretical calculations continues today. Meanwhile, the HEP is developing vigorously in the world. In the last decades, discoveries have been made in the HEP that are comparable with the discoveries of the end of the 19th century and of the beginning of the 20th century. These discoveries have radically changed the concepts of fundamental constituents of substance and the laws of interaction between them. A single nature has been established for electromagnetic and weak interactions described by the electroweak theory. The notion of a quark-gluon structure of hadronic matter arose and was firmly established. Quantum chromodynamics claiming the role of the strong interaction theory was created. It has been realized that the atomic nucleus cannot be presented as a system of protons and neutrons. At certain conditions, a quark-gluon structure of both the proton and the neutron should manifest itself in nuclei. A tight connection of HEP with cosmology and astrophysics was established. All these achievements have posed new problems before the HEP, the solution of which calls for the creation of still more powerful facilities.

The experience in HEP research, accumulated at the Institute, a certain authority proposal enjoined among the world scientific community have provided the possibility for our scientists to be involved in the international cooperation on HEP. All possible things are done at the Institute to support these activities.

Take, for example, the collaboration with the Jefferson Laboratory (USA), where the-best-in-the-world electron accelerator operates. Here, on proposal of V.G. Gorbenko and with the participation of his group a Meller polarimeter was constructed to perform precision measurements of accelerated electrons. The polarimeter is now widely used to obtain unique data on the hadronic structure. The Laboratory has very good prospects for the development. The maintenance of this collaboration and its extension in the processing and interpretation of experimental data is of significant importance.

The collaboration with Russia makes it possible to keep our long-standing scientific contacts and to establish new contacts with Western countries, to use the equipment available with us in experiments at 10 GeV and 70 GeV accelerators in Dubna and Protvino, respectively. This collaboration is performed by A.A. Lukhanin's group.

A particular place belongs to the collaboration with the largest international organization - CERN, with which Ukraine signed in 1993 the Agreement on scientific-technical cooperation. At CERN, the construction of the most powerful accelerator in the world - LHC (Large Hadron Collider) with four detectors ATLAS, CMS, ALICA, LHC-b is being completed. The complex is expected to be put into operation in 2007. The facilities will be used to investigate the most fundamental problems of subnuclear matter. It should be particularly emphasized that here one of the problems is the search for a new type of particles (superparticles) predicted by the supersymmetry theory that was created at NSC KIPT by D.V. Volkov.

By the CMS collaboration (L.G. Levchuk as a spoke person), together with the "Monocrystal" Institute, about 22 000 scintillation plates were made for the front hadronic calorimeter of the CMS detector. The tests for the quality of the plates have demonstrated that they fully meet the requirements of the project.

At NSC KIPT, the first line of a specialized Linux-Cluster has been created, where calculations are made to elucidate the possibility of observing (with the CMS detector) the Higgs boson with a mass of up to 1000 GeV, and also, of generating the proton-proton interaction events at an energy of 15 GeV in the context of the collaboration program on the preparation for processing the experimental data.

Six thousand events (total information volume of about 6 Giga-bytes) were generated and communicated via Internet to the CERN Data Base. The Cluster is already now an acting cell of the international network GRID being created to solve current problems of HEP (calculations, simulation and processing of experimental data). The immediate tasks call for a two-fold increase in the computational powers of the Cluster by the end of 2002, and a sequential build-up of the channel capacity up to about 1 Giga-byte by 2007.

By the ALICE collaboration (N.I. Maslov as a spoke person), the characteristics of microstrip detectors are investigated for the inner tracking system of the ALICE detector; for this purpose the present-day experimental facilities have been created. Simultaneously, the work is being done to use these detectors for applied purposes, e.g., in medical tomographs.

By the LHC collaboration (Yu.N. Ranyuk as a spoke person), the Institute participates in the creation of the hadron detector; for this purpose the production of special steel components is launched at the Institute. The work is being performed according to schedule.

The main goal of international collaboration is the participation of our specialists in obtaining, processing and interpreting the experimental data on the basis of present-day theories. And if our participation is restricted only to creating facilities at foreign accelerators, then, in the strict sense, it won't fully justify our expenditures and efforts.

All civilized countries, without exception, whether large or small, support the HEP investigations. They realize that the present-day scientific-technical revolution is the result of research into the fundamental properties of the matter, and these investigations must be continued.

Up to now, there has been no direct utilization of HEP results obtained. But it should be recollected that up to the thirties of the last century there were little who expected any practical applications from nuclear physics. Moreover, in the middle thirties there were attempts at the Leningrad Physical-Technical Institute to put an end to nuclear subjects.

Yet, the "by-product" of HEP has already found wide application, e.g., the world network WWW, computers, superconductivity, tomography, accelerating facilities. It is quite possible that the power engineering problems will be solved on the basis of HEP scientific-technical developments. And it is not inconceivable that the worldwide GRID system (being developed for distributed calculations, data bases, HEP data processing), where our Institute is already participating, will become the base for revolutionary changes in the sphere of science similarly to what has happened with the WWW system for informatics.

A tremendous role belongs to HEP in creating the intellectual potential of the community, in preparing the highest qualification specialists, and in the organization of education.

The estimates of economists show that the "by-product" has already given the benefit that several orders of magnitude exceed the costs expended for HEP investigations. The current stage and the trends in the HEP development are characterized by an increasingly growing international cooperation, integration of technical and intellectual potentials of states. The degree of participation demonstrates the scientific-technical level of states and strengthens their international authority.

In Ukraine, the NSC KIPT still retains the scientific-technical potential that is capable to gain the worthy place of the country in HEP investigations provided that not in a very distant future the State starts to give the appropriate support to this most basic field of physical science.

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