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UKRAINE AND THE JOINT INSTITUTE FOR NUCLEAR RESEARCH: EXPERIENCE AND PROSPECTS FOR COOPERATION

The article deals with focal points of bilateral cooperation between Ukraine and JINR for the last 20 years. It shows economic and innovative benefit of this collaboration, ways of development and improvement.

Keywords: research, physics, cooperation, and institute.

The Joint Institute for Nuclear Research (JINR) is an international intergovernmental research organization located in Dubna (Russia). The founders are 18 Member States. The main directions of theoretical and experimental research at the JINR include nuclear physics, elementary particle physics, and condensed matter studies.

Currently, the JINR members are Azerbaijan, Armenia, Belarus, Bulgaria, Vietnam, Georgia, Kazakhstan, North Korea, Cuba, Moldova, Mongolia, Poland, Russian Federation, Romania, the Slovak Republic, Uzbekistan, Ukraine, and the Czech Republic [12, 13, 14, and 4]. Also, at the government level, JINR has made cooperation agreements with Germany, Hungary, Italy, Republic of South Africa, Egypt, and Serbia [6, 15, 16].

The Ukrainian Soviet Socialist Republic as a constituent of the USSR joined the JINR since its establishment by virtue of Agreement signed on March 26, 1956 [10]. After the collapse of the Soviet Union, Ukraine became a member state of the JINR in 1991. In 1999, Ukraine signed the JINR Charter with reservations, insofar as, for that time, Ukraine had not confirmed its participation in the Convention on the legal status, privileges, and immunities of intergovernmental economic organizations in specific sectors of cooperation [7]. The highest governing body is the JINR Committee of Plenipotentiaries of 18 participating countries.

- 1992—1996, **Sergei Ryabchenko**, Correspondent Member of the National Academy of Sciences of Ukraine, Chairman of the State Committee on Science and Technology of Ukraine;
- 1996—1997, **Vladimir Storizhko**, Full Member of the National Academy of Sciences of Ukraine, Chairman of the State Committee on Science and Technology of Ukraine;
- 1997—1999, **Ilya Zalyubovskiy**, Corresponding Member of the National Academy of Sciences of Ukraine, Vice-Principal of the Kharkiv State University;
- 1999—2003, **Boris Grynyov**, Corresponding Member of the National Academy of Sciences of Ukraine, Deputy Minister of Science of Ukraine;
- 2004—2010, **Vadim Stogniy**, Deputy Minister of Education and Science of Ukraine, Deputy Chairman, Scientific Secretary of the Committee on the State Prize of Ukraine in the field of science and technology;

- from December 2010 till nowadays, **Boris Grynyov,** Full Member of the National Academy of Sciences of Ukraine, First Deputy Chairman of the State Agency of Ukraine for Science, Innovation, and IT Development; since September 2014, Director of the State Foundation for Fundamental Research of Ukraine [11].

The research policy of the Institute is determined by the International Scientific Council that, in addition to prominent scientists and researchers representing the member states, comprises also well-known physicists from Germany, Italy, USA, France, and the European Organization for Nuclear Research (CERN).

The members of the Scientific Board representing Ukraine, since 1992, are:

- From 1993 till nowadays, **Gennady Zinoviev**, Doctor of Physics and Mathematics, Professor, Head of Department of the Bogolyubov Institute for Theoretical Physics of the NAS of Ukraine;
- 1993: **Leonid Bulavin**, Professor, Dean of the Physics Faculty, Head of the Department of Taras Shevchenko Kyiv National University;
- 1993—2003: **Ivan Vyshnevsky**, Full Member of the NAS of Ukraine, Professor, Director of the Institute for Nuclear Research of the NAS of Ukraine;
- From 2008 till nowadays: **Boris Grynyov**, Full Member of the NAS of Ukraine, First Deputy Chairman of the State Agency of Ukraine for Science, Innovation and IT Development;
- From 2013 till nowadays: **Anatoly Zagorodny**, Full Member and Vice-President of the NAS of Ukraine.

The Institute includes research laboratories, educational and scientific center and the JINR services. The JINR structure comprises seven research laboratories, each of which is comparable to a large research institute in terms of scope of research:

- The Frank Laboratory of Neutron Physics (NPL);
- The Bogolyubov Laboratory of Theoretical Physics (LTP);
- The Wechsler and Baldin Laboratory for High Energy Physics (WBLHEP);
- The Dzhelepov Laboratory of Nuclear Problems (LNP);
- The Fliorov Laboratory of Nuclear Reactions (LNR);
- The Information Technologies Laboratory (ITL); and
- The Radiation Biology Laboratory (RBL).

The Institute employs about 5,000 people, including more than 1,000 researchers, including full members and corresponding members of the National Academies of Sciences, more than 260 doctors and 630 candidates of sciences, and about 2,000 engineering and technical personnel.

The Plenipotentiary Representative of the Government of Ukraine currently employs 31 people including 11 from the Taras Shevchenko Kyiv National University, 4 from the Bogolyubov Institute of Theoretical Physics of the NAS of Ukraine, 2 from the Institute of Electrophysics and Radiation Technologies of the NAS of Ukraine, 3 from the Karazin Kharkiv National University, 2 from the Galkin Donetsk Physical-Technical Institute of the NAS of Ukraine, and 3 from the Institute for Nuclear Research of the NAS of Ukraine. The Institute of Applied Physics of the NAS of Ukraine and the Uzhgorod National University delegate one person each. Also, at JINR there are 4 family members of these employees. They are distributed among the laboratories as follows: 14 (13 + 1 family member) at the Frank Laboratory of Neutron Physics, 3 at the Bogolyubov Laboratory of Theoretical Physics, 5 (4 + 1 family member) at the Wechsler and Baldin Laboratory of High Energy Physics, 4 at the Dzhelepov Laboratory of Nuclear Problems, and 5 (3 + 2 family members) at the Fliorov Laboratory of Nuclear Reactions.

The JINR has a set of unique experimental facilities [1, 2, and 5]:

- Nuclotron, the only superconducting accelerator of protons and heavy ions in Europe;
- Isochronous cyclotrons U-400 and U-400M with record-breaking parameters of beams for experiments on the fusion of heavy and exotic nuclei;
- Phasotron, proton accelerator up to 680 MeV, used for radiation therapy;

- Source of resonance neutrons (IREN);
- One of the world best neutron pulsed reactor IBR-2;
- Cyclotron IC-100 used for applied research;
- Beam therapy complex based on modernized Phasotron;
- Microtron MT-25.

On the basis of *Nuclotron-M* modernized synchrotron, a new accelerator complex that includes a booster drive and NICA (Nuclotron based Ion Collider facility) ion collider is being constructed [18, 19].

The JINR has powerful and fast computation means integrated into global computer networks [17], which allows the Ukrainian researchers to get access thereto.

The JINR research program involves more than 200 research centers, universities, and corporations from 10 countries. The JINR collaborates with 25 organizations and universities of Ukraine, including the following organizations:

- The Bogolyubov Institute for Theoretical Physics (ITP) of the NAS of Ukraine;
- The Institute for Nuclear Research (INR) of the NAS of Ukraine;
- The Taras Shevchenko National University of Kyiv (KNU);
- The Institute of Electrophysics and Radiation Technologies (IERT) of the NAS of Ukraine;
- The *Kharkiv Physics and Technology Institute (KhPTI)*, National Research Center of the NAS of Ukraine;
- The Institute for Scintillation Materials (ISMA) of the NAS of Ukraine; and
- The *Kyiv Polytechnic Institute (KPI)* National Technical University of Ukraine.

It should be noted that since 2011, the JINR financial policy with respect to Ukraine has changed towards mutually beneficial cooperation (see Table below).

Direct cash that comes back to Ukraine exceeds the mandatory contributions.

The cooperation between the NAS of Ukraine and the JINR is progressing. In particular, the NAS is a party to the JINR-based International Innovative Nanotechnology Center, among the founders of which there is Ukraine [8, 9]. In addition, the Coordination Council for Cooperation between NAS, JINR and CERN has been founded under the NAS of Ukraine. The JINR is also an associate member of the International Association of Academies of Sciences headed by Borys Paton, Full Member and the President of the NAS of Ukraine [3].

The cooperation between the Small Academy of Sciences of Ukraine (SANU) and the JINR is also vigorously developing, including due to the Agreement on professional development of Ukrainian teachers and training of undergraduate and graduate students in the natural sciences signed in 2011, in the following directions:

- JINR-based scientific schools for the teaching staff (the program includes workshops, lectures, academic videoconferencing, visits to JINR laboratory departments);
- Participation of Ukrainian teachers and students in JINR-based forums (round tables on modern problems of physics and methods of teaching, mini-conferences for the students);

Ukraine's Contribution to JINR, CRR, and Personnel Expenses (USD thousand)

Ukraine's Contribution	Years			
	2011	2012	2013	2014
Planned Ukraine's contribution to JINR	2095.4	2493.5	2917.4	3384.2
Actual cash inflow from Ukraine (with due account for taxes)	1481.3	3409.3	2960.6	201.5*
Paid under contracts with Ukraine's suppliers	969.5	3970.8	4157.6	1121.5**
Ukraine's staff salary	270.7	362.8	344.7	198.4**

Note. *: in the first half of 2014; **: as of 01.07.2014

- Exchange with methodological developments; joint elaboration of educational and methodical materials;
- Videoconferences between JINR researchers and SASU students.

In 2011, the Bogolyubov program in theoretical physics was launched. Within the framework of this program, lectures, workshops, and schools in high-energy physics are held annually. It is aimed at implementing the joint research and educational projects of Ukrainian research institutes and JINR, in fundamental areas of theoretical physics to facilitate exchanging young researchers, post-graduate students, and masters between Ukraine and JINR.

The JINR actively collaborates with the KNU Faculty of Physics. In the Frank Laboratory of Neutron Physics, the researchers are jointly studying problems of condensed matter physics, including the structure and physico-chemical properties of nanosystems: magnetic fluids, solutions of surfactants, solutions of fullerenes, and nanodiamonds dispersion, A graduate residency program has been organized for KNU graduate students. Within the framework of cooperation, in the past 7 years, 10 PhD theses were prepared and defended, with more than 100 papers in peer-reviewed international journals published.

The Bogolyubov Institute for Theoretical Physics established by Nikolai Bogolyubov, who was its first Director, is involved in collaboration with the JINR as in Russia and in Ukraine, they jointly hold regular Bogolyubov conferences on problems of theoretical and mathematical physics. Also, they together contribute to the development of grid infrastructure of the ITF as parent organization within the Ukrainian academic GRID.

Fruitful cooperation between Ukraine and the JINR has been developing for many years in the field of scintillation detectors designed at the Institute for Scintillation Materials of the NAS of Ukraine: new materials, plastic scintillation crystals, have been created and successfully used in experiments related to particle physics and nuclear physics. In particular, detectors with "re-emitting" fibers have been designed within the framework of CDF joint research project in Dubna, by researchers from Dubna, Ukraine, Slovakia, Italy, and the United States (at the Enrico Fermi National Accelerator Laboratory Fermilab, USA, Batavia).

As part of the OPERA experiment (Italy), for the system of electronic detection of interaction vertex, more than 20,000 plates of scintillators having a length of 7 m have been installed. All plates were developed, produced, tested, and assembled in cooperation with a group of JINR researchers. This unique detector system has provided an essential creative and financial contribution of the JINR to the international OPERA experiment on searching neutrino oscillations. Special plastics used in Dubna and in Paris for fabricating the scintillation detectors were designed in Ukraine for the NEMO neutrino experiment (France). The unique crystals designed and manufactured at the ISMA are used today in the experiments on searching rare decays of mesons, on the accelerator in Zurich (Switzerland). It should be noted that in these cases, Ukraine contributed to the JINR by unique new materials and technologies instead of direct cash payments.

The cooperation between the Department of Nuclear Physics and Power Engineering and the JINR expands as the Institute of Electrophysics and Radiation Technologies of the NAS of Ukraine together with NRL and NPL performs studies in the field of radiation physics of solids. A group of researchers from the Institute of Nuclear Research of the NAS of Ukraine is engaged in theoretical calculations of the diffraction interactions of hyperons with nuclei for experiments performed in the LHEP. The JINR together with the *Kharkiv Physics and Technology Institute* National Research Center conducts theoretical research related to the experiments with polarized beams and polarized targets in high-energy physics and improvement of these systems. The cooperation of JINR and KhPTI NRC in the field of Grid technologies has been supported by two grants. As a result of the project, the computer systems of JINR and KhPTI have all necessary conditions for distributed analysis of CMS (CERN) experimental data, which

allows the Ukrainian researchers to be involved in the CMS experiment on an ongoing basis.

A similar project is being implemented with the ITF for the analysis of Alice (CERN) experimental data.

The development of fundamental research involves the creation of expensive experimental facilities. In fact, this is a factory for the production of scientific results. Sometimes, one country cannot create or buy them using its own resources. Therefore, often they combine efforts by collaboration. In this way, Ukraine develops its cooperation with JINR. Ukraine not only brings back its money paid as contributions, but also derives a direct profit from educational programs and improvement of qualifications for the personnel. In addition, the creation of a new generation of measuring systems requires unconventional engineering and technological solutions, as well as innovative products. This is realized in Ukraine and expands opportunities for Ukrainian researchers to get involved in international experiments.

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УКРАЇНА І ОБ'ЄДНАНИЙ ІНСТИТУТ ЯДЕРНИХ ДОСЛІДЖЕНЬ: ДОСВІД І ПЕРСПЕКТИВИ СПІВРОБІТНИЦТВА

Розглянуто основні аспекти двостороннього співробітництва України—ОІЯД за останні 20 років. Продемонстровані економічна та інноваційна вигоди процесу співпраці, шляхи розвитку та вдосконалення.

Ключові слова: дослідження, фізика, співпраця, інститут.

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УКРАИНА И ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ: ОПЫТ И ПЕРСТПЕКТИВЫ СОТРУДНИЧЕСТВА

Рассмотрены основные аспекты двухстороннего сотрудничества Украина–ОИЯИ за последние 20 лет. Показана экономическая и инновационная выгоды, пути развития и усовершенствования.

Ключевые слова: исследования, физика, сотрудничество, институт.

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