

# Scientific programme of the Joint Institute for Nuclear Research

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## **Abstract**

The Joint Institute for Nuclear Research (JINR) is a large, multidisciplinary, international, scientific centre in which fundamental research in modern elementary particle physics, nuclear physics, and condensed-matter physics is integrated with the development and application of the newest technologies and university education activity in related areas.

## **1 Introduction**

### **1.1 General information about the Joint Institute for Nuclear Research (JINR)**

The Joint Institute for Nuclear Research (JINR) in Dubna was established on the basis of the convention signed by the Plenipotentiaries of the governments of the Member States of JINR in March 1956 in Moscow. JINR was created in order to unify the intellectual and material potential of the Member States in order to study the fundamental properties of matter.

Dubna as a town of science was founded immediately after the end of World War II. In 1947 a group of scientists led by Academician I.V. Kurchatov initiated construction of the then largest accelerator of charged particles—the synchrocyclotron. The accelerator was commissioned in 1949. Extensive fundamental and applied investigations into the properties of nuclear matter immediately started at the newly established Institute for Nuclear Problems (INP) with its operating 680 MeV synchrocyclotron, headed by the young physicists M.G. Meshcheryakov and V.P. Dzhelepov, later world-renowned scientists.

After INP, the Electrophysical Laboratory of the USSR Academy of Sciences (EFLAN), headed by Academician V.I. Veksler, was set up in Dubna. A new accelerator, a synchrophasotron with record parameters for that time, was constructed at EFLAN.

In 1954 the European Organization for Nuclear Research (CERN) was established near Geneva to unite the efforts of Western European countries for studying the fundamental properties of matter.

About the same time, under the stimulus of the USSR Government, the countries then belonging to the socialist world took the decision to establish the Joint Institute for Nuclear Research in Dubna from the INP and EFLAN laboratories. The same year, specialists from 12 countries (Albania, Bulgaria, China, Czechoslovakia, East Germany, Hungary, Mongolia, N. Korea, Poland, Romania, USSR, and Vietnam) came to Dubna. The town became international, and investigations into many fields of nuclear physics of interest for research centres of the JINR Member States were launched there.

Many scientists and engineers from the Member States have been trained in the JINR scientific schools established by N.N. Bogoliubov, D.I. Blokhintsev (Fig. 1), G.N. Flerov, I.M. Frank, B.M. Pontecorvo, V.I. Veksler, and other outstanding physicists. The development of different scientific directions at JINR is connected with the names of A. Baldin, A. Logunov, M. Markov, D. Shirkov, A. Tavkhelidze, as well as L. Infeld and H. Niewodniczanski (Poland), G. Nadjakov (Bulgaria), H. Hulubei (Romania), L. Janossy (Hungary), N. Sodnom (Mongolia), Wang Gangchang (China), Nguyen Van Hieu (Vietnam), V. Votruba and J. Kozesnik (Czechoslovakia), H. Pose and K. Lanius (Germany), and others.

The Charter of the JINR was adopted in 1956, the text of which was revised in 1992 and more recently in 1999. In accordance with the Charter, the activities of the Institute are achieved on the basis of its openness, and the mutual and equal co-operation of all the interested parties to participate in research.



**Fig. 1:** N.N. Bogoliubov and D.I. Blokhintsev

The aim of the Institute is

- to carry out theoretical and experimental investigations on adopted scientific topics;
- to organize the exchange of experience when carrying out research and the exchange of information obtained as a result of these investigations through publication of scientific papers, holding of conferences, symposia, etc.;
- to promote the development of the intellectual and professional capabilities of the scientific personnel;
- to establish and maintain contacts with other national and international scientific organizations and institutes to ensure stable and mutual co-operation;
- to use the results of the investigations of an applied nature to provide supplementary financial resources for fundamental research by implementing them into industrial, medical, and technological developments.

The results of investigations carried out at the Institute can be used solely for peaceful purposes for the benefit of mankind. So until the late 1980s, Dubna was a centre that unified the efforts of leading research groups of nuclear sciences from socialist countries and the Soviet Union.

After the disintegration of the USSR, membership of JINR underwent the following changes: the majority of Eastern European countries, such as Poland, the Czech and Slovak Republics, Bulgaria, Romania, and others continue to be Member States and contribute to the budget. Germany remains as an observer and makes a substantial financial contribution. Most of the former Soviet Union republics, which became independent states, entered JINR as new members.

There are different ways to participate in the activities of the Institute: on the basis of full or associated membership, or bilateral and multilateral agreements in order to perform particular scientific programmes. The JINR Member States contribute financially to the Institute's activities and have equal rights in its management.

At present JINR has 18 Member States: Armenia, Azerbaijan, Belarus, Bulgaria, Cuba, Czech Republic, Georgia, Kazakhstan, D.P. Republic of Korea, Moldova, Mongolia, Poland, Romania, Russian Federation, Slovak Republic, Ukraine, Uzbekistan, Vietnam.

The JINR has special co-operation agreements concluded on the governmental level with Germany, Hungary, Italy, and recently with the Republic of South Africa. Positive preliminary negotiations with scientific officials of the USA, China, Greece, India and other countries are underway to conclude similar governmental agreements with these countries.

Among the major partners with whom JINR has long-term co-operation agreements are

- CERN, in the field of high-energy physics,
- IN2P3 (France), in the field of nuclear and particle physics,
- INFN (Italy), in the field of nuclear and particle physics,
- FNAL, BNL, SLAC and other research centres in the USA.

The activity of JINR in the territory of its host country, the Russian Federation, is carried out in accordance with the Russian Federal Law on Ratification of ‘The Agreement between the Government of the Russian Federation and JINR on the Location and Terms of Activity of JINR in the Russian Federation’. The Federal Law was approved by the Federation Council on 22 December 1999 and signed by the President of the Russian Federation, V. Putin, on 2 January 2000. The Federal Law came into force from the date of its official publication—6 January 2000.

This Agreement underlines the international legal capacity of JINR and grants it privileges and immunities in compliance with established practice for international intergovernmental organizations.

## **1.2 Governing and advisory bodies of JINR**

- Committee of Plenipotentiaries of the JINR Member States
- Finance Committee
- Scientific Council
- Programme Advisory Committee for Particle Physics
- Programme Advisory Committee for Nuclear Physics
- Programme Advisory Committee for Condensed Matter Physics.

The Committee of Plenipotentiaries of the Governments of the Institute Member States is the supreme body of the JINR and carries out its activities in the session order. Each member of the Institute has one representative in the Committee of Plenipotentiaries.

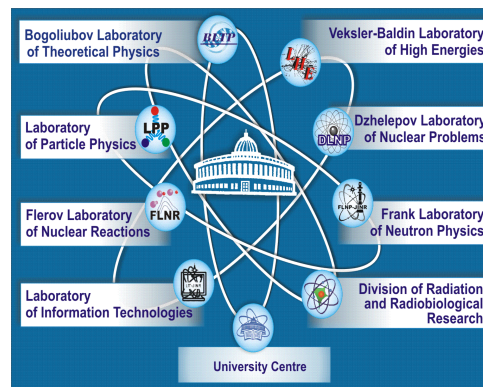
Scientific policy is developed and co-ordinated by the Scientific Council, whose members are eminent and well-known scientists from the Member States, as well as from CERN, Germany, Greece, France, Italy, Belgium, the Netherlands, China, India, and other countries.

Three Programme Advisory Committees (PACs) for Particle Physics, Nuclear Physics and Condensed Matter Physics are advisory bodies of the JINR Directorate and to the JINR Scientific Council in specific fields of research. The PACs hold their meetings twice a year.

### 1.3 JINR's structure and the main fields of research activities

The internal organization of the JINR is determined by scientific specialization. There are seven Laboratories at JINR and, by the scope of their scientific activities, each is comparable to a large research institution:

- Bogoliubov Laboratory of Theoretical Physics (BLTP)
- Veksler-Baldin Laboratory of High Energies (VBLHE)
- Laboratory of Particle Physics (LPP)
- Dzhelapov Laboratory of Nuclear Problems (DLNP)
- Flerov Laboratory of Nuclear Reactions (FLNR)
- Frank Laboratory of Neutron Physics (FLNP)
- Laboratory of Information Technologies (LIT).



All-Institute subdivisions are

- Division of Radiation and Radiobiological Research
- University Centre.

Several associate experimental physics workshops are also part of the Institute. It is equipped with everything necessary for manufacturing large-sized, non-standard facilities, electronics, and has technological lines for constructing detectors for physics.

In the past four decades JINR has grown into a large multidisciplinary physics centre. It employs over 5500 people, including 1300 scientists and about 2000 engineers and technicians.

The main fields of the Institute's activities are as follows.

- **Theoretical Physics**  
Quantum field theory and modern mathematical physics; Fundamental symmetries; Standard Model and beyond; Astroparticle physics; Nuclear structure near the drip line; Dynamics of few-body systems; Exotic properties of nuclear matter; Systems with strong correlations; Integrability; Self-organization; Disordered structures.
- **Elementary Particle Physics**  
Origin of mass; Nature of spin; Fundamental symmetries (including chiral symmetry); Nature of dark matter; Neutrino mass; Deconfinement; Search for supersymmetry.
- **Relativistic Nuclear Physics**  
Non-perturbative QCD; Spin effects in hadronic processes; Quark–gluon degrees of freedom; Asymptotics in nuclear collisions; Mechanism of hadronization and confinement; Heavy-ion collisions; Multiple production; Nuclear multifragmentation processes; Hypernuclei and  $\eta$  nuclei; Cumulative effects; Spin structure of light nuclei; Physics of resonances; Nuclotron; Superconducting magnet technology.
- **Heavy-Ion Physics**  
Nuclear reactions induced by beams of stable and radioactive nuclei; Synthesis and properties of transuranium and superheavy nuclei; Properties of nuclei close to proton and neutron drip lines; Chemistry of actinides and transactinides; Radioanalytical investigations; Heavy-ion accelerators; Production of secondary beams; Interaction of heavy ions with condensed matter.
- **Low- and Intermediate-Energy Physics**  
Fundamental physics phenomena and processes in nuclear physics; Rare decays of elementary particles and nuclei; Nonaccelerator particle physics; Nature and properties of the neutrino.
- **Nuclear Physics with Neutrons**  
Violation of fundamental symmetries in neutron-induced reactions; Beta-decay and electromag-

netic properties of the neutron; Ultracold neutrons; Nuclear data for science and technology; Ecological study with neutrons.

– **Condensed-Matter Physics**

Strongly correlated electron systems; Low-dimensional systems; Heterostructures; Quantum wells and dots; Quantum liquids; Chaos; Self-organization; Disordered systems; Polymers; Biopolymers; Biomembranes; Nanomaterials; Physics of surfaces.

– **Radiation and Radiobiological Research**

Radiobiology; Radiation genetics; Mutagenesis; Chromosomal aberration; Biophysics of photobiological processes; Target therapy; Radiation protection; Dosimetry; Neutron spectrometry; Radiation transport through matter.

– **Networks, Computing and Computational Physics**

Distributed high-performance computing infrastructure; High-speed networking; Information, algorithmic, and software support; Modelling of physical systems; Data processing and analytic calculations for physics problems; JINR's Grid segment and global Grid structures.

– **Educational Programme**

University-type education; Continuous education 'secondary school–higher education institution–research institution'; Postgraduate programmes; Extension of specialties; Collective use centres; International schools; JINR-based educational departments.

A unique choice of experimental facilities is available at this Institute. Apart from the still operational early accelerator, the 680 MeV Phasotron, they include the Nuclotron, a new, superconducting synchrotron for nuclei and heavy ions up to 6 GeV/n intended for relativistic nuclear physics studies; the U400 and U400M cyclotrons used for experiments on the synthesis of heavy and exotic nuclei, on the studies of their properties and heavy-ion reaction mechanisms; the IBR-2 reactor (mean power 2 MW, peak power 1500 MW) used for nuclear physics research with neutrons and condensed-matter studies. Also, several new facilities are being constructed at JINR, namely IREN, a new source of resonance neutrons, and DRIBs, the Dubna Radioactive Ion Beams project.

## 2 JINR scientific policy and the road map

### 2.1 Worldwide recognized traditions of scientific schools

The Institute is proud of the prominent scientists who worked at JINR. They made outstanding contributions to JINR's research programme and established scientific schools at Dubna. Among them is the famous theoretical physics school founded by professors N. Bogoliubov, D. Blokhintsev and M. Markov.

Another school on neutrino physics was founded by B. Pontecorvo who made the supposition about neutrino oscillations. Professor V. Veksler, a distinguished scientist, is the author of the Phase Stability Principle, being a base for modern accelerators. Professor G. Flerov is a prominent scientist and founder of heavy-ion physics at JINR. Laureate of the Nobel and State Prizes, Professor I. Frank made important contributions to the formation and development of various directions in physics: electrodynamics of a moving charged relativistic particle; nuclear and especially neutron physics. Relativistic Nuclear Physics is a new scientific direction established at JINR by Professor A. Baldin.

A very big contribution to the formation of the JINR scientific schools was made by the prominent scientists from the JINR Member States (see introduction). Our obligation and key strategic goal is to preserve the traditions of JINR schools and to train young scientists in the spirit of these traditions.

### 2.2 International collaboration

Broad international co-operation is one of the most important principles of JINR's activities. Almost all investigations are carried out in close collaboration with the JINR Member States scientific centres, as well as international and national institutions and laboratories around the world. JINR collaborates with

nearly 700 research centres and universities in more than 60 countries, including Germany, France, Italy, Japan, Switzerland, and the USA.

Over its 49 years of existence, first-class theoretical and experimental research programmes accomplished at JINR have led to a significant enrichment of fundamental nuclear science. JINR accounts for a half (about 40) of the total number of discoveries in particle and nuclear physics, registered in the former Soviet Union. About 500 research papers and reports representing approximately 3000 authors are submitted every year by JINR to editorial boards of journals in many countries and to organizing committees of conferences. JINR publications are sent to over 50 countries.

The Institute carries out theoretical and experimental research using its own basic facilities and those of other major scientific centres throughout the world. These facilities provide ample and unique opportunities for research in high-energy physics as well as in low- and intermediate-energy physics. Widely used are novel information technologies and computational physics methods, which, on the whole, maintain a modern level of research.

Here I would like to recall the words of the great Russian writer A. Chekhov, who said: “*Science cannot be national, in the same way that a multiplication table cannot be national. If a science becomes national, it ceases to be a science.*”

JINR is a perfect illustration of this idea.

### **2.2.1 Co-operation with CERN**

Our long-standing scientific partner is CERN. For more than 40 years the co-operation between JINR and CERN has been very fruitful and mutually beneficial. Though the general agreement between JINR and CERN was signed in 1992, nevertheless, the real co-operation between the two international organizations has a long and rich history. JINR scientists and engineers are actively involved in the current CERN experiments as well as in the preparation of future LHC projects. Today JINR participates in twenty-seven CERN projects. Among them: ATLAS, CMS, ALICE, LHC (accelerator complex), DELPHI (data analysis), DIRAC, HARP, NA45, NA48/1, NA48/2, NA49, NA58 (COMPASS) and others.

#### *2.2.1.1 Science bringing nations together*

A special page in our co-operation with CERN is the joint poster exhibition ‘Science Bringing Nations Together’.

Since 1997 when the first joint exhibition of this series was held at the University of Oslo (Norway), CERN and JINR have organized this exhibition every year. The exhibitions have been shown at UNESCO (1998), at the United Nation’s office in Geneva (1999), in the European Parliament in Brussels (2000), in Russia State Duma (2001), in Romania (2002), in Armenia (2003), in Russian Diplomatic Academy (2003), and in Greece (2005).

The dominant theme of the exhibition is that joining of creative efforts and material resources by scientists from various countries has become another important way for fruitful communication of peoples and mutual understanding between them.

### **2.2.2 Co-operation with Germany**

The Joint Institute has very fruitful relations with scientific centres in Germany. Since 1991, JINR has a special co-operation agreement concluded on the governmental level—namely BMBF—with Germany. At present JINR co-operates with 71 centres in Germany located in 47 cities.

Today the co-operation between JINR and German Scientific Groups is based on

- the BMBF–JINR Agreement, and
- Bilateral Agreements concluded between JINR and German Scientific Groups.

The co-operation in the field of High-Energy Physics at DESY was included in the JINR–BMBF Agreement in 1995. The Laboratory of Particle Physics of JINR and DESY co-operate in the experimental programme at the HERA electron–proton collider and in the R&D programme for the TESLA linear collider and Free-Electron Laser (FEL). The Dubna group has made important contributions in all fields of this collaboration.

In the HERMES Collaboration, the Dubna group has taken an active part in data analysis and detector upgrades. Many thousands of events for the deeply virtual Compton scattering processes have been collected at HERMES.

### **2.2.3 Co-operation with the USA**

JINR is implementing a wide scientific collaborative programme with US research laboratories. This co-operation is carried out in the fields of high-energy physics, heavy-ion physics, nuclear physics with neutrons, and accelerator technologies. At present, the Joint Institute for Nuclear Research collaborates with 75 US scientific centres located in 66 cities.

JINR is developing a successful collaboration with FNAL. At this Laboratory, groups of JINR scientists have been taking part in the experiments using the CDF and D0 detectors.

Another good example is the active collaboration with the Brookhaven National Laboratory. JINR scientists are participating in the design and construction of the electromagnetic calorimeters for the STAR detector.

## **2.3 JINR's Road Map**

First of all I would like to stress once more that fundamental studies remain the core mission of the Joint Institute. The ‘old’ challenging questions ‘What is the world made of?’ and ‘What holds it together?’ are still capturing the imagination and professional interests of physicist all over the world.

The evaluation of the Universe beginning from the Big Bang up to its modern state is a subject of particle physics studies (mainly at the early stages), as well as of nuclear and condensed-matter studies at later stages. The JINR research programme covers all three research directions. The investigations are being carried out both at in-home experiments and external experiments with JINR's participation. Thereby JINR enhances its role as a cluster scientific centre for its Member States, giving good opportunities for scientists to participate in research programmes of many other well-known centres in the world.

I would like to note that, since its very foundation, JINR has developed as a centre of Particle Physics. The first basic facilities of JINR—the synchrocyclotron and synchrophasotron—were at that time HEP accelerators with record parameters. Gradually the methods and approaches used in high-energy physics had an essential influence on other branches of science which were developed as new research directions at JINR: condensed-matter physics, nuclear physics with neutrons, radiobiology, and others.

We also consider our innovation activities to be of high importance. We must bring them to the commercial level, to get into the world high-tech market.

### **2.3.1 The Road Map in the field of Particle Physics**

To ensure the scientific excellence of JINR and maximize its scientific and technological output, we recently started to elaborate the Road Map—a strategic plan of the Institute's development in the fields of particle physics, nuclear physics, and condensed-matter physics for the next 10–15 years. The development of the Road Map is based on JINR's seven-year Programme (2003–2009) and our annual document—the Topical Plan for Research and International Co-operation. At the same time we consider

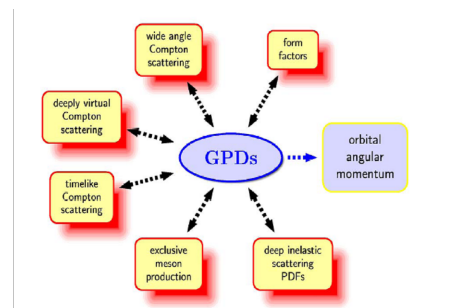
the Road Map as an important step for strategic planning of the overall research activity of the Institute based on the three main scientific directions: particle physics, nuclear physics, and condensed-matter physics. We intend to focus our efforts on the implementation of really ambitious projects.

When developing first proposals for the Road Map in the field of particle physics (as well as in other fields) we proceeded from the priorities in this area accepted today by the international physical community and our real capabilities. In the light of these statements we single out the following priorities:

- the origin of mass;
- the properties of neutrinos;
- the properties of the strong interaction including properties of nuclear matter;
- the origin of the matter–antimatter asymmetry in the Universe;
- the unification of particles and forces including gravity.

JINR’s research programme in the field of particle physics is aimed at solving these tasks based on the Nuclotron and external facilities.

Of special interest are studies on nucleon spin structure (Fig. 2) with JINR’s participation in DESY (HERMES experiment) and CERN (Compass project). In the future this research will take place in Serpukhov at the U-70 accelerator and also in the PAX experiment—a spin physics experiment at FAIR (GSI, Germany).



**Fig. 2:** Generalized Parton Distributions (GPD)

Neutrino physics is a traditional research direction for JINR and mainly connected with the name of Professor Bruno Pontecorvo, one of the founders of neutrino physics schools. The NOMAD and HARP experiments are almost completed and at present JINR is planning to participate actively in the OPERA experiment connected with tau neutrino appearance.

Another ambitious task in the field of particle physics is the CP-violation effect. Here we must mention first of all the NA48 experiment at CERN (Fig. 3). You know that the first evidence of direct CP violation has been obtained. This result was achieved in neutral kaon decays by the  $\epsilon'/\epsilon$  measurement with the world’s highest precision. Professor V. Kekelidze from JINR occupies the position of the NA48/2 Spokesperson until the end of 2005.

The new estimate of the upper limit for  $K_L$  decay on pion and two neutrinos branching ratio was obtained  $2 \times 10^{-7}$ ; confidence level is 90%. The JINR group contributed significantly to this experiment as well.

The verification of the Standard Model and the tasks beyond it are also traditionally in the focus of our interests. As an example I would like to mention a big success which has been achieved recently in the most precise top-mass measurement experiments (CDF and D0 projects) with the participation and remarkable contribution of JINR scientists (Fig. 4).

The JINR–INFN–FNAL team made a contribution of principal significance to the world’s most precise  $M_{\text{top}}$  measurement in the so-called ‘lepton + jets’ topology. The efforts of the team are aimed at significantly reducing the error of the  $M_{\text{top}}$  up to the  $2 \text{ GeV}/c^2$  level which will enable us to establish a new limit on the Higgs mass.



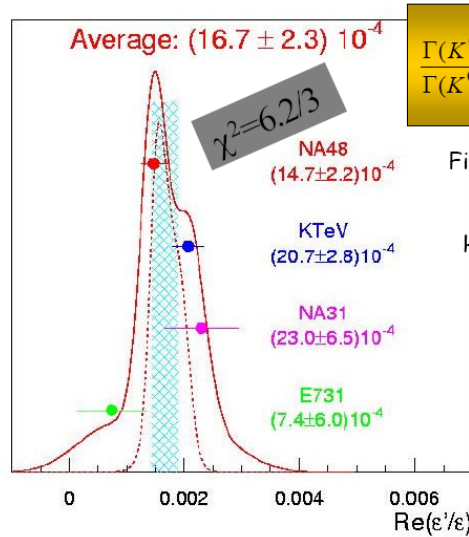


Fig. 3: World best measurement of direct CP violation in  $K^0$  decays

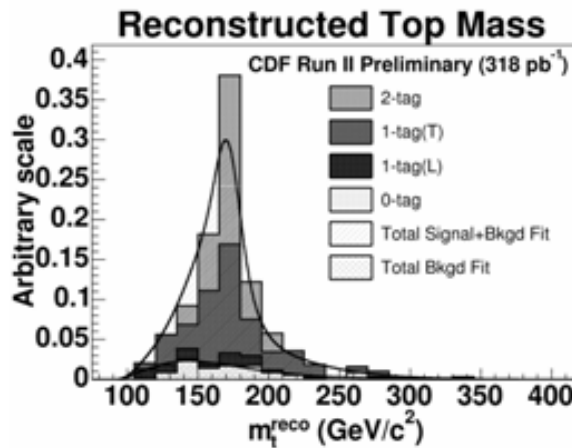


Fig. 4: World best:  $M_{\text{top}} = 173.5 + 3.7 / - 3.6(\text{stat.}) \pm 1.3(\text{syst.})$  ‘lepton + jets’ mode

### The Nuclotron accelerator complex

The Nuclotron accelerator (Fig. 5) is competitive with other world ion facilities for the acceleration of polarized deuterons and helium ions with an intensity higher than  $10^{11}$  particles/cycle. It can accelerate heavy ions up to uranium.

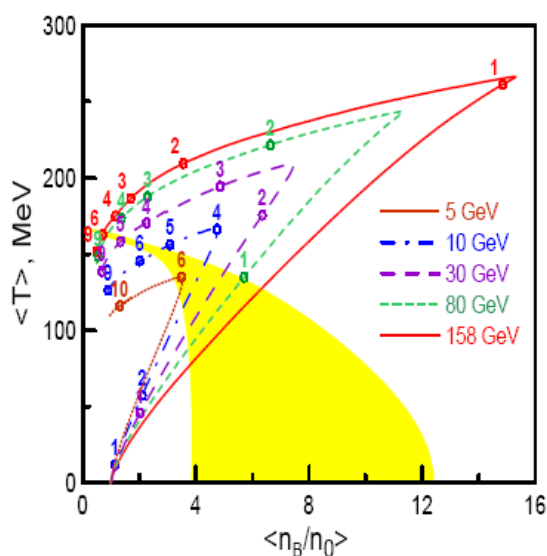
In the next few years the Nuclotron will be equipped with new sources both for polarized light ions and for heavy ions. The energy will be increased up to 6 GeV/nucleon. That will allow one to investigate spin structure of nucleons and nuclei and to study phase transitions in nuclear matter.

Among the challenging tasks carried out at the Nuclotron, of special interest is a search for the mixed phase corresponding to the first-order chiral phase transition and probably to the deconfinement transition (Fig. 6).

It is predicted by a group of JINR theoreticians (A. Sissakian, A. Sorin, M. Soleimanov, V. Toneev, G. Zinovjev *et al.*) that at the highest possible energies of the Nuclotron heavy-ion beams the mixed phase formation may become possible. This will open a new perspective in the physics programme of the Nuclotron.



**Fig. 5:** Nuclotron (superconducting synchrotron)



**Fig. 6:** Heavy-ion collisions in relativistic 3-fluid hydrodynamics

### 2.3.2 *The Road Map in the field of Nuclear Physics*

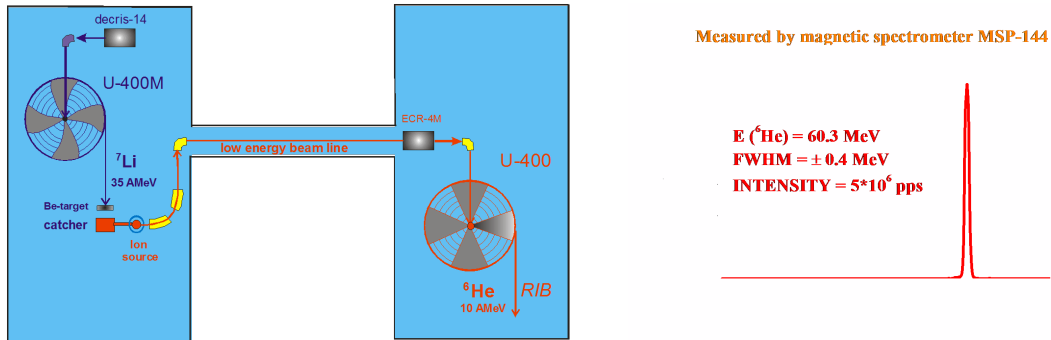
The priorities in heavy-ion physics are

- physics and chemistry investigations of the super heavy nuclei with  $Z \geq 112$ ; structure and properties of the neutron rich light exotic nuclei;
- acceleration technology;
- heavy-ion interaction with matter and applied research.

To accomplish these tasks the JINR FLNR Cyclotron Complex will be upgraded for producing intense beams of accelerated ions of stable ( $^{48}\text{Ca}$ ,  $^{58}\text{Fe}$ ,  $^{64}\text{Ni}$ ,  $^{86}\text{Kr}$ ) and radioactive ( $^6\text{He}$ ,  $^8\text{He}$ ) isotopes.

The main experimental facility of the Flerov Laboratory of Nuclear Reactions is the complex of two heavy-ion cyclotrons—U400 and U400M. For the last decade, heavy-ion physics has been the most dynamically developing area of low- and intermediate-energy physics and JINR has become one of the leading scientific centres in heavy-ion physics in the world.

Let me remind you that at the end of 1998, scientists of JINR, in collaboration with colleagues from the Lawrence Livermore National Laboratory (USA), synthesized a new, long-lived superheavy element with atomic number 114. This discovery crowned 35 years of international research efforts in search of the ‘stability island’ for superheavy nuclei. A wide resonance followed new experiments accomplished in 1999–2005 at the JINR U400 accelerator on the synthesis of new elements with atomic numbers 116, 118, 115 and 113.



**Fig. 7:** Cyclotron complex of JINR FLNR - DRIBS-1

During the last few years, the DRIBs facility (Dubna Radioactive Ion Beams) has been developed at JINR. The main task of this machine is to produce intense beams of accelerated ions of stable and radioactive isotopes. The first experiment with the  ${}^6\text{He}$  radioactive beam was carried out at DRIBs in 2005. The world record for intensity ( $5 \times 10^6$  pps) with this beam on the target was achieved (Fig. 7)

### 2.3.3 The Road Map in the field of Condensed-Matter Physics

The priorities are

- modernization of the IBR-2,
- condensed-matter research with neutrons,
- material science with heavy ions,
- radiobiological research.

The programme in the field of condensed-matter physics is oriented towards the use of nuclear-physical methods developed at JINR to solve topical problems of present-day natural sciences, concerned with the properties of matter in a condensed state.

The main facility here is the IBR-2 pulsed reactor (Fig. 8) which is in a phase of modernization. As a result JINR will have in operation a unique world-class pulsed neutron source—the only machine of this sort in the JINR Member States. Its parameters will be unique in many aspects which will allow a rich research programme for another 20–30 years. IBR-2 is included in a 20-year strategic programme of neutron scattering research in Europe.

Summarizing this part of my lecture I would like to note that while developing the Road Map we should take due account of the main supporting activities:

- theory of particle physics, nuclear physics, condensed-matter physics
- modern mathematical physics
- networking and computing
- training of young staff
- physics methods.



**Fig. 8:** IBR-2 pulsed reactor with neutron flux  $10^{16} \text{ n cm}^{-2} \text{ s}^{-1}$



**Fig. 9:** V.G. Kadyshevsky and A.N. Sissakian

### 3 Dubna as an educational centre

The educational programme plays an important role in the activities of JINR. It should be stressed that the concept of JINR's development is the integration of fundamental science, technological studies, and education. To achieve this task, in 1991 we established the JINR University Centre (Head: Dr S. Ivanova) and in 1994, together with the Russian Academy of Natural Sciences, the authorities and management of Moscow Region the 'Dubna' International University for Nature, Society, and Man (President: Academician V. Kadyshevsky, Vice-president: Professor A. Sissakian (Fig. 9), Rector: Professor O. Kuznetsov).

Since 1995, the University Centre of JINR has been offering postgraduate training. The University Centre offers graduate programmes in the fields of nuclear physics, elementary particle physics, condensed-matter physics, theoretical physics, technical physics, and radiobiology.

Our strategic plan is to develop JINR as a kind of 'superuniversity' centre with the aim of training specialists from the JINR Member States and other countries. These specialists will be engaged in the research activities in Dubna, as well as possibly joining future megaprojects like the LHC, TESLA, and others.

#### 4 Innovation activities

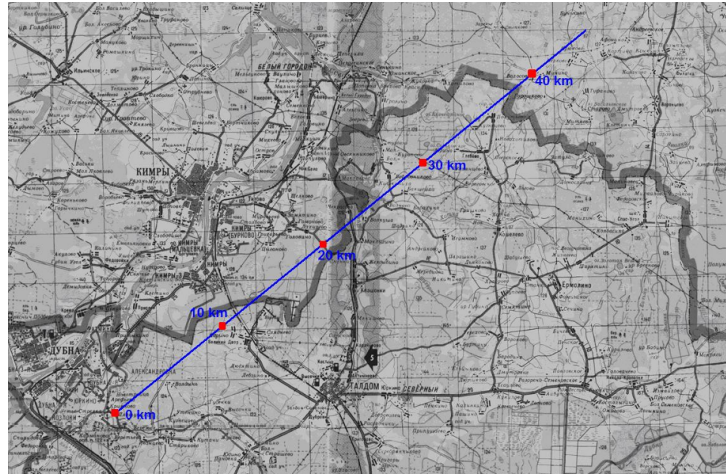
Along with fundamental research, which is the main direction of JINR's development, we have a large number of applied studies and activities, including development of high technologies:

- New technological developments, R&D and construction of detectors and large facilities for scientific research and applied studies.
- Multichannel amplitude analysers, fixed and portable spectrometers of nuclear radiation, portal monitors.
- Development of IT, including Grid technology
- Ecological monitoring using methods of nuclear physics analysis.
- New materials based on track membranes.
- Medical beams at the Phasotron, JINR's Med-Nuclotron.
- Ultrapure radioisotopes for nuclear medicine and ecology.
- Detector 'DVIN' for identification of explosives, fissile materials, and narcotic substances.

At the present time, we have a good basis for developing the so-called 'innovation belt' around the Institute. Based on the huge intellectual and industrial–technological potential of JINR, it is proposed to actively participate in the creation of a 'Dubna' technopark (including development of the JINR 'innovation belt') as well as in the use of the mechanism of private and state partnership for creating a Special Economic Zone in Dubna, in accordance with the legislation of the host country of our Institute. JINR will play the role of scientific leader in this partnership. The well-known Russian company AFK 'Sistema' will act as business partner. The administration of the city, the 'Dubna' international university, and a number of Dubna enterprises are also engaged in the process of technopark creation.

## 5 JINR's long-term research programme

Elaborating on the JINR Road Map it is noteworthy to consider a proposal of an ambitious large-scale project to be created in Dubna. Among the possible megaprojects we are considering is the ILC project (International Linear Collider, see Fig. 10).



**Fig. 10:** Possible location for the ILC in the vicinity of Dubna (Russia)

ILC is a collaborative international project aimed at the design of a high-energy, large-scale positron–electron collider. The ILC would provide a tool for scientists to address many of the most challenging tasks of the 21st century. We consider the proposal on ILC (or may be some other proposals on megaprojects) as a ‘maximum programme’ of JINR’s strategic development for approximately 20–25 years ahead.

## 6 Conclusion

We understand well that science is united. The methods, experience, and knowledge accumulated in high-energy physics research could be useful in other sciences too. We should think it over in order to find an appropriate interface with other actively developing branches of knowledge, for instance astroparticle physics and cosmology, informatics, nanotechnologies, biology and medicine, quantum computers, and others.

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