JOINT INSTITUTE FOR NUCLEAR RESEARCH

science brings nations together

DUBNA | 2022

WWW.JINR.INT

THE JOINT INSTITUTE FOR NUCLEAR RESEARCH is an international intergovernmental organization, a world-famous scientific centre that integrates fundamental theoretical and experimental research with the development and application of the advanced technology and university education.

The Joint Institute possesses a wide range of experimental facilities, including the pulsed fast-neutron reactor and heavy ion accelerators with a wide range of nuclei and energies. The JINR Development Strategy focuses on the advancement of the scientific infrastructure and the construction of new basic facilities.

The megascience project on the construction of the superconducting heavy ion collider NICA is being implemented at the Joint Institute. JINR plays a significant role in the implementation of the megascience project on the construction of the Baikal–GVD deep-underwater neutrino telescope. 10 new elements have been discovered at JINR. JINR has a unique neutron pulsed reactor IBR–2 for research in neutron nuclear physics and condensed matter physics.

RESEARCH DIRECTIONS

Theoretical Physics

Relativistic Heavy Ion Physics

Spin Physics

Particle Physics

Low Energy Nuclear Physics

Nuclear Neutron Physics

Condensed Matter Physics

Neutrino & Astroparticle Physics

Life Sciences: **Radiobiology**, **Biomedicine**, **Structural Biology**, **Astrobiology**, **Ecology**

IT & High-performance computing

Outreach & Education

7 JINR Laboratories, each being comparable with a large research institute in the scale of investigations performed.

Frank Laboratory of Neutron Physics
flnph.jinr.ru

Veksler and Baldin Laboratory of High Energy Physics
lhep.jinr.ru

Flerov Laboratory of Nuclear Reactions
flerovlab.jinr.ru

Dzhelepov Laboratory of Nuclear Problems
dlnp.jinr.ru

Meshcheryakov Laboratory of Information Technologies
lit.jinr.ru

Bogoliubov Laboratory of Theoretical Physics
theor.jinr.ru

Laboratory of Radiation Biology
lrb.jinr.ru

Dear colleagues and friends,

The Joint Institute for Nuclear Research in Dubna is an integral part of a global family of unique internatio-nal research centres. Our mission is to provide the highest quality of the scientific agenda for cutting-edge research and discoveries aimed to understand the fundamental properties of matter.

The JINR Long-Term Development Strategy up to 2030 and beyond is designed to strengthen our common global scientific family. The core research fields at JINR are Low-Energy Nuclear Physics, Relativistic Heavy-Ion and Spin Physics, Particle Physics, Neutrino and Astroparticle Physics, Condensed Matter and Neutron Nuclear Physics, Radiobiology and Nuclear Medicine, Theoretical Physics, Information Technologies & High-Performance Computing. The foundation of the Institute is its world recognised scientific schools. The idea of neutrino oscillations, 10 new superheavy elements discovered, ultracold neutrons, superfluidity of the nuclear matter, postradiation recovery of cells, quantum field theory, harmonical superdimension in supersymmetry, a new generation of neutron pulsed reactors and hyper convergent heterogeneous computing cluster — these are only some of visible scientific subjects associated with modern JINR.

Our Institute and its laboratories are also setting the agenda at the forefront innovations. To name just a few of these frontiers: novel materials and energetics, biomedicine, quantum technologies, data science, etc.

JINR is of course about Basic Science. No doubt that the quality of our scientific product is mainstaying on essential issues reinforcing us as a modern dynamic international intergovernmental scientific organization: worldwide scientific cooperation, science diplomacy, friendly social environment, digitalisation, innovation policy.

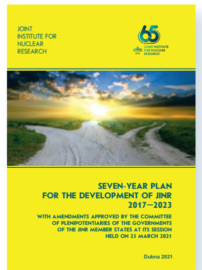
Our international team is diverse but united through the passion for research and sharing the value of international cooperation. The JINR Sofia Declaration highlights the value of international scientific and technological integration in solving the tasks of strengthening peace, mutual understanding, and socio-economic progress of all the countries.

JINR is open to attracting new partners and even entire regional clusters: science brings nations together. We feel obligated to use our scientific and integrating potential to promote peaceful scientific and technological progress in different parts of our planet.

Please, enjoy this brochure and become our missionary. On behalf of the JINR team I wish you pleasant acquaintance with our International Research Centre.

Grigory Trubnikov

Director of JINR



Seven-year plan for JINR development (PDF)

JINR Strategy (PDF)

JINR MEMBER STATES AND ASSOCIATE MEMBERS

JINR has at present 19 Member States: Armenia, Azerbaijan, Belarus, Bulgaria, Cuba, the Czech Republic, Arab Republic of Egypt, Georgia, Kazakhstan, D. P. Republic of Korea, Moldova, Mongolia, Poland, Romania, Russia, Slovakia, Ukraine, Uzbekistan, and Vietnam. Participation of Germany, Hungary, Italy, the Republic of South Africa, and Serbia in JINR activities is based on bilateral agreements signed on the governmental level.

The Supreme governing body of JINR is the Committee of Plenipotentiaries of the governments of all 19 Member States. According to its Charter, the Institute exercises its activities on the principles of openness to all interested states for their participation and equal and mutually beneficial cooperation.

ORGANIZATION, MISSION AND GOALS

The Institute was established with the aim of uniting the efforts, scientific and material potential of its Member States for investigations of the fundamental properties of matter. Over 65 years JINR has accomplished a wide range of research and trained scientific staff of the highest quality for the Member States. The research policy of JINR is determined by the Scientific Council, which consists of eminent scientists from the Member States as well as famous researchers from China, France, Germany, Greece, Hungary, India, Italy, Switzerland, the USA, the European Organization for Nuclear Research (CERN), and others. JINR possesses a unique set of experimental physical facilities for research in elementary particle physics, nuclear physics, and condensed matter physics.

Each of 7 laboratories of JINR can be compared with a large scientific research institution. The concept of further development of JINR as a multidisciplinary international centre for fundamental research in nuclear physics and related fields of science and technology implies efficient use of theoretical and experimental results, as well as methods and applied research at JINR in the sphere of high technology through their application in industrial, medical and other kinds of technical development. The strategy of JINR is to develop scientific and technology potential of the JINR Member States. The Institute's development strategy is detailed in the Seven-Year Plan for the Development of JINR.

39 OBSERVERS PARTNER ORGANIZATIONS COLLABORATIONS

AYSS

3 ANNUAL CONFERENCES PER YEAR

998 PARTNER NETWORK ORGANIZATIONS

JINR DOSCIENCE@DUBNA

ASSOCIATION OF YOUNG SCIENTISTS AND SPECIALISTS

The Association is an active community uniting more than 1,000 young people under 35 working at JINR. It runs 3 annual conferences, as well as schools, workshops, and seminars, popularises scientific knowledge, and spreads information about JINR. Another goal of the Association is to provide help to the staff with social issues and organize social and cultural events.

JINR PARTNERS:

- CERN
- FAIR/GSI *Germany*
- BNL, FNAL, LBNL, RNL *USA*
- IN2P3, GANIL, ILL *France*
- IHEP, ASIPP *China*
- INFN *Italy*
- iThemba LABS *RSA*
- PSI *Switzerland*
- KEK, HK *Japan*
- RAS, NRC KI, ROSATOM *Russia*

INTERNATIONAL DIALOGUE FOR SCIENTIFIC INTEGRATION AND SCIENCE DIPLOMACY

Full text

SOFIA DECLARATION

A Declaration highlights the value of international scientific and technological integration in solving the tasks of strengthening peace, mutual understanding, and socio-economic progress of all the countries. The document was adopted on 22 November 2021, at the session of the Committee of Plenipotentiary Representatives of the Governments of the JINR Member States held in Bulgaria.

JINR'S RANK

in the worldwide rating of **International Intergovernmental Research Organizations**

2 PERSONNEL

6 natural science only BUDGET

9 BUDGET

The list of the Intergovernmental Research Organizations is received from the open database of the Yearbook of International Organizations. Information on budget and staff is taken from the annual reports of the organizations.

NICA: NUCLOTRON-BASED ION COLLIDER FACILITY

SEARCH FOR NEW STATES OF NUCLEAR MATTER

Megascience project for research into the critical states of nuclear matter under extreme conditions, which occurred after the Big Bang at early stages of the Universe evolution using high-intensity heavy ion beams.

nica.jinr.ru

NICA covers an energy range where most important and interesting physics appears to take place — transition from hadronic to partonic effect dominance, possible appearance of first order phase transition in QCD phase diagram, transition from baryon to meson dominance in particle production.

NICA PARAMETERS

Range of nuclei:
from hydrogen to bismuth, including gold

Energy of extracted beams:
up to **4.5 GeV/N**

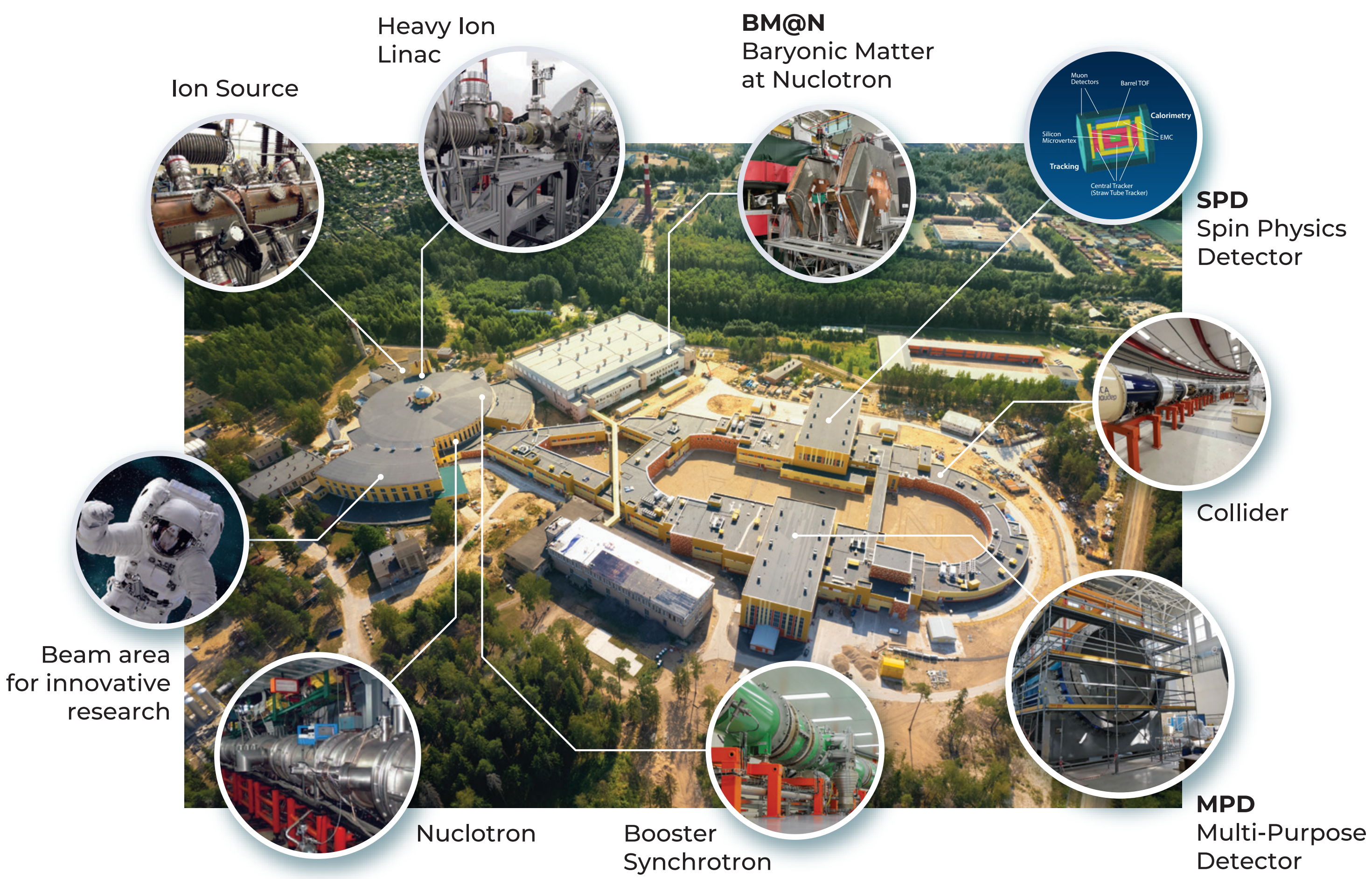
Intensity (per second):
Heavy ions — **$5 \cdot 10^{8}$**
Protons — **10^{10}**

Designed luminosity:
Heavy ions — **10^{27} cm^{-2}/s^{-1}**

Light nuclei, polarised protons and deuterons — **10^{32} cm^{-2}/s^{-1}**

$\sqrt{S}$=4–11 GeV/N
Energy

Collider ring circumference
503 m



NICA

AT PRESENT

100% of **dipole and quadrupole magnets** manufactured and tested for the project

95% of general **construction works** completed

The project is 85% ready

ARIADNA beamlines

APPLIED RESEARCH INFRASTRUCTURE FOR ADVANCE DEVELOPMENT AT NICA FACILITY

Channels for transporting charged particle beams and irradiation stations are being developed at NICA. They are designed for research in the fields of life sciences, radiation material science and radiation resistance of electronics, development of advanced technologies for nuclear power problems.

JINR IN EXTERNAL EXPERIMENTS ON PARTICLE PHYSICS

Involvement in external experiments — for mutual benefit from the exchange of new scientific information and technological know-how with the emphasis on the tasks initiated or supported by JINR groups.

In LHC experiments at CERN, JINR physicists participate in analyses of data obtained and in the detectors upgrades.

A few precision laser inclinometers, unique devices for measuring the Earth's surface inclinations developed by JINR scientists, were installed in the LHC tunnel for ATLAS experiment. JINR inclinometers are also used at Garni Geophysical Observatory in Armenia, where PLIs help seismologists.

Search for beyond Standard Model phenomena: CMS, ATLAS, COMET

Spin and orbital momentum composition of the proton: COMPASS/AMBER

Spectroscopy of charmed particles production in electron-positron annihilations: BES–III

Also @ CERN: ALICE, SPS, NA62, NA64

RHIC@BNL — beam energy scan made by the STAR collaboration is one of the key components of the NICA physics programme and STAR members engagement is above rubies. FAIR/GSI projects are also beneficial for NICA:

- silicon tracker technology in CBM will be implemented in BM@N and SPD experiments
- high speed electronics with PASTTRECK chip from HADES will be used for straw-tracker of SPD
- superconducting dipole magnet CBM, R&D for track gas detectors, and scintillation detectors with SiPM readout are very helpful in preparation of NICA experiments

NEUTRINO PHYSICS AND ASTROPHYSICS

Research programme in the fields of neutrino physics and astrophysics will include a number of projects, among which Baikal–GVD will become the main infrastructure and research project.

Baikal–GVD: Identification of astrophysical sources of ultra-high energy (exceeding tens of TeV) neutrinos. Topicality: their sources are still unknown.
The identification of sources will help to elucidate the mechanisms of galaxies creation and evolution. This unique scientific facility is an important tool of multi-messenger astronomy, a new powerful method to investigate the Universe.

baikalgvd.jinr.ru

Main advantage of Baikal–GVD: pure and t-stable water. Angular resolution of muon tracks 0.3–0.5 grad (IceCube: 0.5–1), angular resolution of shower direction 2–3 grad (IceCube: 15)

The Baikal–GVD Neutrino Telescope is the largest in the Northern Hemisphere and the second in size in the world. This neutrino detector is located in Lake Baikal 3.6 km away from the shore, at a depth of about 1,300 m. Baikal–GVD is one of the three neutrino telescopes across the world and, along with IceCube at the South Pole and ANTARES (now KM3NeT) in the Mediterranean Sea, is part of the Global Neutrino Network (**GNN**).

The Baikal–GVD Neutrino Telescope is being constructed by the international collaboration with a leading role of the RAS Institute for Nuclear Research (Moscow) and the Joint Institute for Nuclear Research.

more than **70** scientists & engineers

from **11** research centres
Russia Germany Poland the Czech Republic Slovakia Kazakhstan

In December 2021, the IceCube Neutrino Observatory at the South Pole announced the observation of a track, a candidate for the astrophysical neutrino with an estimated energy of about 172 TeV.
Four hours later, an interaction of another neutrino coming in from the same direction with an estimated energy of 43 TeV was found in the Baikal-GVD data.

The first 10 events were selected as astrophysical neutrino candidates after the analysis of the 2018–2020 data.

AT PRESENT

During the last Baikal expedition, the collaboration of the project successfully installed two new clusters of the neutrino telescope. Since 12 April, all 10 installed clusters have been collecting data.

Baikal–GVD launch in 2021

INSTALLED	in 2022	Total
Clusters	2	10
Optical Modules	684	2,988
Optics+acoustic cables, km	84	420
High-Voltage bottom cables, km	15	75

JINR PARTICIPATION IN NEUTRINO OSCILLATION EXPERIMENTS

- Determination of CP-violating phase: DUNE
- Determination of neutrino mass ordering: NOvA, JUNO
- Precise determination of elements of the lepton mixing matrix: JUNO, DUNE

Physical properties of neutrino

- Determine if a neutrino is a Majorana particle: SuperNEMO, GERDA–LEGEND
- Coherent elastic neutrino-nucleus scattering process at nuclear reactors: nuGEN (GEMMA)
- Sterile neutrino oscillation: DANSS

Dark Matter discovery

- Existence of the dark matter particles: DarkSide, EDELWEISS
- Sources of high-energy (exceeding tens of TeV) gammas: TAIGA
- Determination of nuclear matrix elements via muon capture: MONUMENT

Together, **Baikal–GVD and TAIGA** can provide a unique **multi-messenger observation** of the Universe integrated into the global astroparticle network.

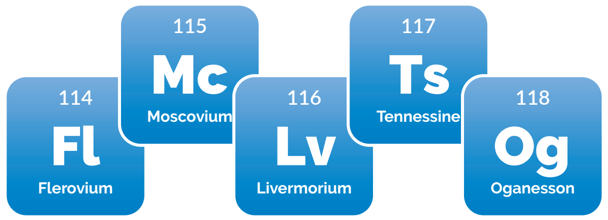
The discovery of **gravitational waves** is one of the most remarkable discoveries ever.

VIRGO

The VIRGO experiment aimed to search for gravitational waves. The JINR scientists installed on the VIRGO Interferometric Gravitational-Wave Antenna JINR's brand new laser inclinometer to improve the IGA sensitivity.

In this field, JINR conducts advanced experiments on the synthesis of new heaviest elements.

The scientific programme includes experiments on the study of nuclear and chemical properties of new superheavy elements, reactions of fission, fusion, and multinucleon transfer in heavy-ion collisions. Specialists fulfil the programme on the study of the properties of nuclei at the boundary of nucleon stability and the mechanisms of nuclear reactions with accelerated radioactive nuclei, as well as implement applied research. Experiments are conducted in wide international cooperation with the JINR Member States and leading nuclear centres of the world.



5 NEW superheavy elements that conclude **period 7** of the Periodic Table

have been discovered at JINR for the past **25 years**

The most significant result of Dubna scientists is the experimental proof of the existence of the **„island of stability“** of superheavy elements centred near Z=114 and N=184.

Record parameters of accelerated heavy ion beams have been achieved at the Superheavy Element Factory accelerator complex. The ^{48}Ca beam intensity exceeds 7 puA. The ^{40}Ar beam at the SHE Factory has reached its designed intensity of 10 puA.

AT PRESENT

The development of works in the fields of synthesis and property study of superheavy elements is associated with the creation of a new accelerator complex called the Superheavy Element Factory (SHE Factory) based on the DC–280 specialised cyclotron. The key task of the complex is to synthesise new chemical elements with atomic numbers 119, 120, and further, as well as to study in detail nuclear and chemical properties of the earlier synthesised superheavy elements.

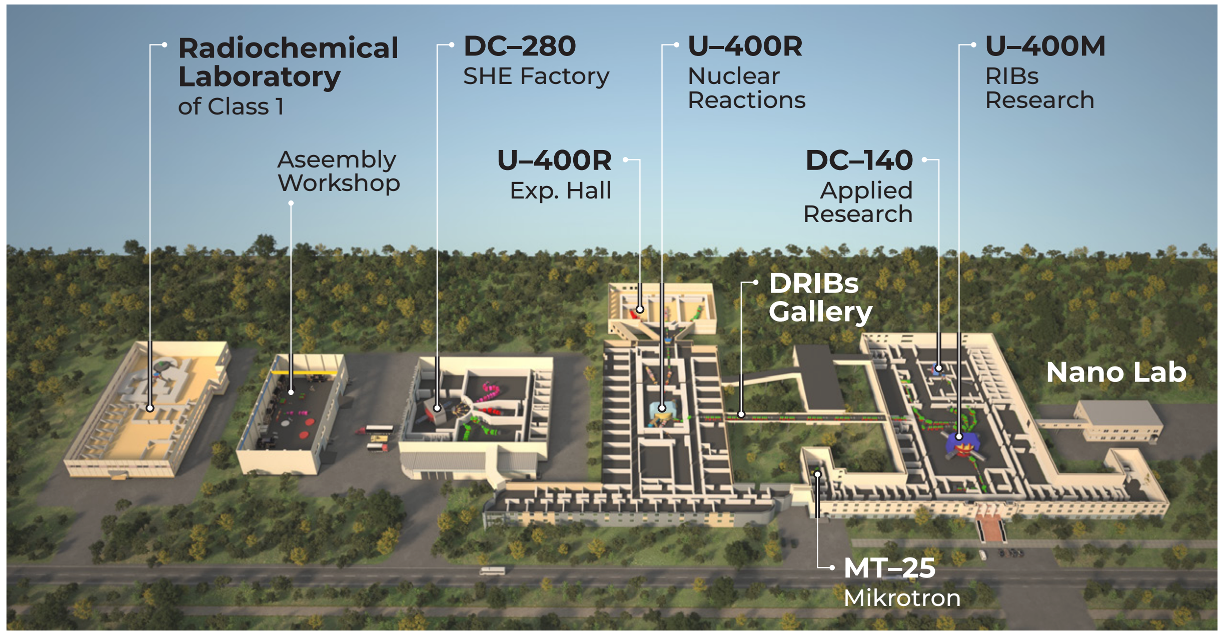
The first experiments at the SHE Factory started at the end of 2020 on the synthesis of elements 114 (flerovium) and 115 (moscovium). They have shown a significant (multiple) superiority of the new accelerator complex compared to facilities of the previous generation in both the efficiency of conducted experiments and the quality of the data obtained.

The scientific infrastructure of the SHE factory is gradually improving: accelerators U–400 and U–400M are developing, a new facility DC–140 is under construction for applied research in the fields of track membranes and material sciences.

Strategic Research Directions:

- Heavy and superheavy nuclei
- Light exotic nuclei
- Radiation effects and nanotechnologies
- Accelerator technologies

BASIC FACILITY — DRIBS-III ACCELERATOR COMPLEX



SUPERHEAVY ELEMENT Factory

SUMMARY OF EXPERIMENTS 2020–2022

236 new events of synthesis of superheavy nuclides

VS. ~100 events at all facilities in the world, including Dubna, since 1999

31 isotopes Decay properties

New isotopes:
^{287}Mc, ^{264}Lr, ^{276}Ds

New decay modes:
^{268}Db (alpha-decay)
^{279}Rg (spontaneous fission)

Test of target stability up to
7 puA of ^{48}Ca

In November 2021, **Yuri OGANESSIAN**, Scientific Leader of FLNR JINR, who has had new element 118 named after him for his pioneering contributions to transactinoid elements research, was awarded the UNESCO–Russia Mendeleev International Prize in the Basic Sciences *“to acknowledge his breakthrough discoveries extending the Periodic Table and for his promotion of the basic sciences for development at the global scale.”*

CONDENSED MATTER AND NUCLEAR NEUTRON PHYSICS

BASIC FACILITY — IBR–2 RESEARCH REACTOR

JINR has a long-standing history in advancing the nuclear-based experimental techniques for basic and applied research.

The IBR–2 JINR basic facility is the world's only research pulsed reactor of periodic action at fast neutrons. It makes the top 5 most "bright" neutron sources in the world. The most intense neutron fluxes at the moderator surface among the world's reactors: ~10^{16} n/cm^2/s
Power of 1,850 MW in pulse.

ibr-2.jinr.ru

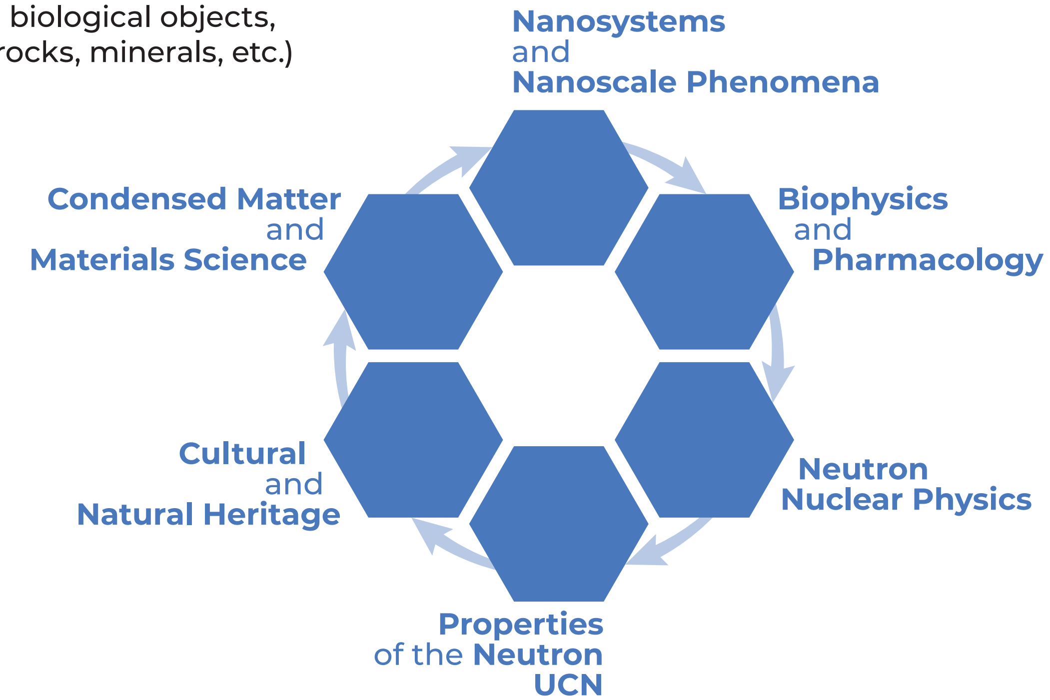
An ambitious scientific programme for the study of the neutron as an elementary particle, its application in the fields of nuclear physics, condensed matter physics and life sciences.

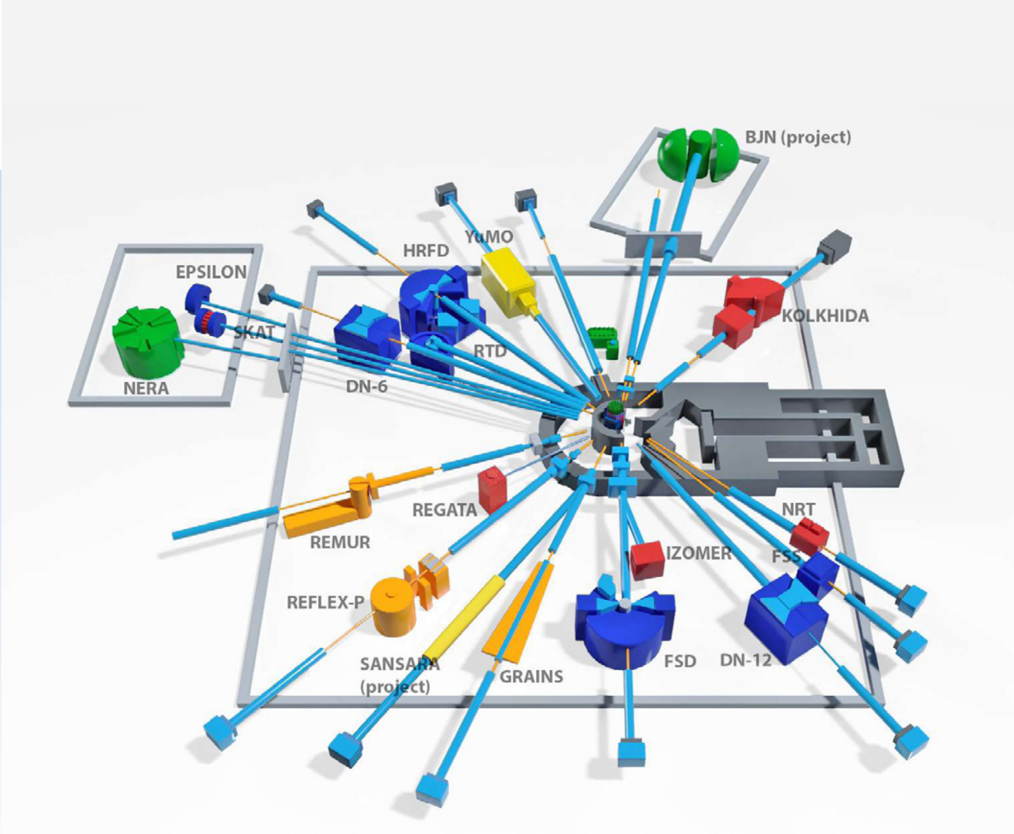
AT PRESENT

A wide user programme has been organized at the IBR–2 reactor. A set of 13 high-performance instruments (diffractometers, small-angle scattering instrument, reflectometers, inelastic scattering spectrometer, Neutron Activation Analysis Installation) are available for experiments in the framework of the IBR–2 user programme. More than 200 experiments are conducted at the reactor annually by scientists from around the world. Two other new instruments (a new stress diffractometer FSS and a facility for neutron imaging NRT) are presently under construction and two new projects are under development (SANSARA and BJN). It allows all interested scientists (physicists, chemists, biologists, geologists, materials scientists, etc.) to receive on a competitive basis the time to use facilities and highly qualified support from JINR leading specialists.

CONDENSED MATTER PHYSICS:

- study of the structure, dynamics, structural-optical properties, morphology of the condensed matter surface
- acquisition of new data on microscopic properties of the studied systems (strongly correlated electron systems, low-dimensional systems, heterostructures, polymers, colloid systems, biological objects, nanomaterials, rocks, minerals, etc.)
- measurement of internal stress in 3D materials and products
- experimental checking of theoretical predictions and models, discovery of new regularities



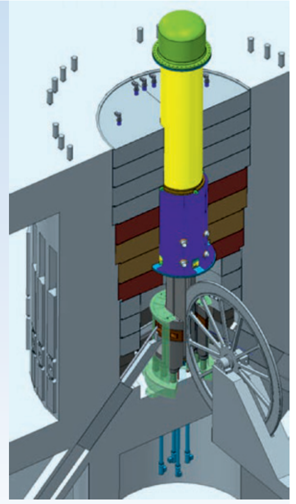


NUCLEAR PHYSICS:

- studies of neutron properties and physics of ultracold neutrons
- neutron-induced nuclear reactions
- fundamental, applied, and methodical research
- elaboration and development of neutron and other ionizing radiation detectors

JINR has proposed to build a new advanced neutron source of the 4th generation on its site — the pulsed fast reactor NEPTUNE with a power of up to 15 MW and nitride fuel.

In combination with modern complex of bispectral moderators, sample environment systems, and spectrometers, such a source promises to become one of the world best and to open unprecedented possibilities for scientists from the JINR Member States and worldwide for research in condensed matter physics, fundamental physics, chemistry, biology, geology, novel materials.



Schematic view of the **4th generation pulsed reactor**

IREN FACILITY

The second basic facility in this research field is the full-scale scientific research complex. 200–MeV linear accelerator LUE–200. Beam power of about 10 kW. Subcritical multiplying target.

IREN, a resonant neutron source based on a linear electron accelerator, serves to research in the field of nuclear physics. It provides up-to-date nuclear data, investigates issues related to the symmetries of fundamental interactions, develops a technique for elemental analysis of neutron resonances, and a programme of applied research for the study of cultural heritage objects.

LIFE SCIENCES

RADIOBIOLOGY, BIOMEDICINE, STRUCTURAL BIOLOGY, ASTROBIOLOGY, ECOLOGY

Dzhelepov Laboratory of Nuclear Problems

- Proton therapy of cancer
- Molecular genetics
- Detectors and tomography

Frank Laboratory of Neutron Physics

- Beamlines for neutron scattering
- Structural Biology
- Ecology

Laboratory of Radiation Biology

- Fundamental Radiobiology
- Radiation Neuroscience
- Clinical Radiobiology
- Mathematical Modelling
- Radiation Protection
- Astrobiology

Infrastructure for molecular, cellular and animal research

Meshcheryakov Laboratory of Information Technologies

- High performance computing
- System for biological data storage and processing
- Bioinformatics, Machine Learning

Flerov Laboratory of Nuclear Reactions

- Ion beams for cellular research
- Radionuclides synthesis for radiation medicine

Veksler and Baldin Laboratory of HEP

NICA ARIADNA

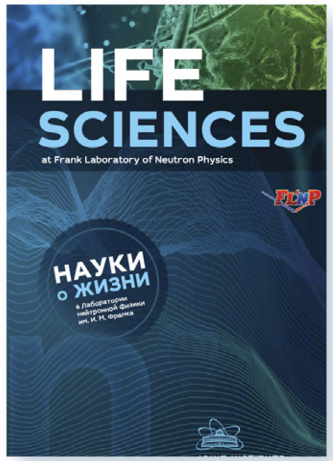
- Heavy ion beamlines for space radiobiology, technologies for beam therapy

Further plans: Development of vivarium, animal imaging and tomography, super-resolution microscopy; Equipment for multi-omics research; Construction of radiochemical class III lab blocks; R&D on compact irradiators for cell research.

JINR ADVANTAGES

- Multiple radiation sources with applied channels (protons, neutrons, heavy ions, radionuclides)
- Variety of complementary instruments for structural biology studies
- Infrastructure for large-scale animal research including on primates
- Member of International Biophysics Collaboration

Scientific research in general and life sciences in particular have always benefited from the development of large-scale scientific infrastructures. The examples of notable results obtained by scientists at the FLNP JINR in life sciences are presented in the booklet.



Life Sciences (PDF)

PROTON THERAPY AT JINR

Expertise since 1968.

BASIC FACILITY — PHASOTRON, A CYCLIC ACCELERATOR OF HEAVY CHARGED PARTICLES.

Ten beam channels at the Phasotron have been used for experiments with pi-mesons, muons, neutrons, and protons. Secondary beams are intended for medical research, mainly for medical treatment of oncological diseases.

JINR has worked out the method of conformal 3D irradiation of deep-seated tumours, where the dose distribution precisely conforms (up to millimetres) to the target shape. 1,300 patients underwent proton beam therapy at the JINR Medico-Technical Complex.

TREATMENT APPROACHES DEVELOPED FOR:

meningiomas, chordomas, chondrosarcomas, gliomas, acoustic neuromas, astrocytomas, aragangliomas, pituitary adenomas, AVMs, brain and other metastases; other neck and head tumours, melanomas, skin diseases, lung carcinoma metastases, breast cancer.

- A fundamentally new method to enhance the biological effectiveness of medical proton beams and gamma-ray units has been developed and patented by the LRB JINR.
- Worldwide-unique experiments were carried out to study the effect of high-energy heavy charged particles on the brain and behaviour of primates.
- JINR develops the hierarchy of mathematical models to simulate radiation-induced pathologies at different organization levels and time scales. Computational studies of molecular and genetic mechanisms of severe brain diseases, including Alzheimer disease and epilepsy, are in progress at the LRB, FLNP and MLIT.
- DLNP JINR conducts genetic research, in particular the determination of the longevity gene and the determination of the propensity to various allergic reactions.
- Owing to the research at IBR–2 neutron beamlines, there is a better understanding of origins of the relevant mechanisms for health protection and even its recovery.
- The method of neutron activation analysis is used at FLNP to help in assessing the safety of seafood, quality of wastewater treatment, environmental pollution.

LIFE SCIENCES

- The TANGRA collaboration on the platform of the FLNP JINR is developing a mobile setup based on the tagged neutron method for determining soil organic carbon (SOC) content.
- JINR in cooperation with the Space Research Institute of the Russian Academy of Sciences participates in the development and creation of neutron, gamma-ray, and charged particle detectors for spacecraft. Thus, the HEND and LEND high-energy neutron detectors work on board NASA orbiters; the DAN device on board the Curiosity rover is part of the Mars Science Laboratory.
- LRB JINR has developed and patented a novel accelerator-based technique of modelling of radiation fields with continuous particle energy spectra generated by the Galactic cosmic rays inside a spacecraft in deep space.
- In 2021, JINR issued a monograph about unique findings in the well-studied carbonaceous chondrite, which fell in 1864 in France near the village of Orgueil. Most of the fossilized microorganisms (microfossils) included in the Atlas were found by LRB JINR scientists. The monograph also considers some aspects of the transfer of life in space (the theory of panspermia).
- For the first time the synthesis of prebiotic compounds has been observed after irradiation of formamide and meteorite matter with high energy hadron beams.
- LRB and MLIT, jointly with the University of Belgrade, conduct research on the development and implementation of algorithms for automation of radiobiological research
- JINR has further plans to develop vibrational spectroscopy & microscopy: Raman and FT–I, as well as Micro-spectroscopic study of programmed cell death — NETosis and Apoptosis.

The Orgueil meteorite Atlas of microfossils (PDF)

ADVANCED INSTRUMENTS

SARRP

(Small Animal Radiation Research Platform) X-ray irradiation facility by Xstrahl company (Great Britain) designed for radiobiological studies on small laboratory animals. This is the only SARRP system installed in the territory of Russia and Eastern Europe.

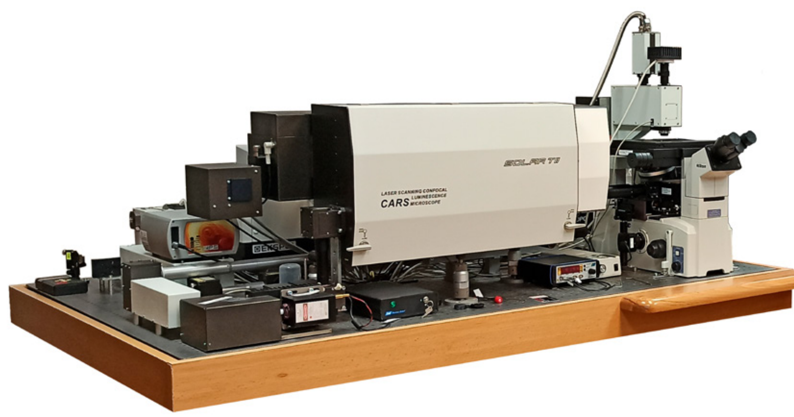
XEUSS 3.0

X-ray scattering station by XENOXS company provides study of the structure of materials and nanomaterials from atomic to nanoscale in real time with SAXS, WAXS, and USAXS methods. At the beginning of 2022, this was the only operating instrument of this class in the territory of Russia.

MULTIFUNCTIONAL “CARS” MICROSCOPE

Tasks:

- Raman, SERS, SECARS, and CARS spectroscopy and microscopy of biological objects: sensitive probes of lipids, lipid bilayers, proteins, thin and small objects; fast dynamic scanning and contrast chemical imaging;
- Exploration of structural and spectral characteristics of phosphors activated with various rare-earth elements;
- Plasmon-enhanced photo- and upconversion luminescence studies.



INFORMATION TECHNOLOGIES & HIGH-PERFORMANCE COMPUTING

BASIC INSTRUMENT — MULTIFUNCTIONAL INFORMATION AND COMPUTING COMPLEX AT JINR

Theoretical Research, Data Processing & Storage, Experimental Data Analysis, Big Data, Quantum Computing, Machine & Deep Learning.

Network infrastructure with a bandwidth of up to 4x100 Gbit/s, distributed computing and data storage systems based on grid technologies and cloud computing, hyperconvergent high-performance computing infrastructure with liquid cooling for supercomputer applications.

JINR GRID INFRASTRUCTURE

- Tier–1 for CMS @ LHC
- Tier–2 for ALICE, ATLAS, CMS, LHCb, BES, BIOMED, MPD, NOvA, ILC, etc.

Telecommunication Channels:

- JINR–Moscow 3x100 Gbit/s,
- JINR–CERN (100 Gbit/s) and JINR–Amsterdam (100 Gbit/s), providing connection between Tier–0 (CERN) and Tier–1 (JINR),
- Local area network 2x100 Gbit/s,
- Distributed multisite cluster network between MLIT and LHEP 4x100 Gbit/s.
- HybriLIT Platform consists of the “Govorun” supercomputer and the “HybriLIT” education and testing polygon.

JINR CLOUD INFRASTRUCTURE

Neutrino experiments of JUNO, NOvA, Baikal–GVD.

Included in DICE — Distributed Information and Computing Environment (JINR & Member States).

The free resources of the JINR DICE were involved in the research of the SARS–CoV–2 virus at the Folding@Home platform.

A heterogeneous computing environment based on the DIRAC platform was created for processing and storing data of the experiments conducted at JINR.

GOVORUN SUPERCOMPUTER

Hyper-converged software-defined system

Total Peak Performance: 860 TFlops for DP

Storage performance >300 GB/s, DAOS technology (1st place among Russian supercomputers in IO500)

GOVORUN KEY PROJECTS

- NICA megaproject
- Calculations of the lattice quantum chromodynamics
- Research in the field of radiation biology
- Calculations of radiation safety of JINR facilities
- Govorun is included in the unified supercomputer infrastructure based on the National Research Computer Network of Russia (NIKS)

JINR is developing a unified information and computing environment, a scientific IT ecosystem that combines many different technological solutions, concepts, and techniques.

Promising areas of modern IT technologies developed at JINR are artificial intelligence and robotics, machine learning, quantum technologies and big data analytics.

INNOVATIONS

INTERNATIONAL CENTRE FOR NUCLEAR TECHNOLOGIES RESEARCH TO BE CREATED AT JINR

Development of technologies and methods in the fields of nuclear and radiation medicine, radiation materials science, advanced training of specialists for JINR Member States for radiation biology, medical physics, material studies

Main stages:

- Radiation biology: OMICS@LRB and neuroradiobiological studies. Radiation neuroscience. Approaches to increase radiosensitivity: pharmaceuticals, transgene systems, targeted delivery (molecular vectors) and radionuclide;
- ARIADNA: Applied beams@NICA (ions from MeV/N to GeV/N): radiobiological studies (400–800 MeV/N); radiation testing of semiconductor electronics (3; 150–350 MeV/N); nuclear physics @ 1–4.5 GeV/N.
  Full-scale start in 2023;
- New facility with DC–140 cyclotron for electronic component testing, radiation material science, track pore membrane research and production, etc.
  Period of realisation: 2021–2023;
- New research proton cyclotron MSC–230 for R&D in beam therapy: treatment planning, radiomodificators for photon and proton therapy, flash-therapy, pencil beam (10 μA, >5 Grey/litre target @ 50 ms pulse). The cyclotron is considered a pilot facility for a future medical centre.
  Period of implementation: 2021–2024 (beam start in 2023).
- New facility: Radiochemical Laboratory Class–I for production of radioisotopes (Ac225, 99mTc) for nuclear medicine in photonuclear reactions @ 40MeV Rhodotron accelerator.
  Period of realisation: 2022–2027.

JINR R&D

- Production of track membranes for water purification and plasmapheresis
- Design and construction of systems for detection of explosives and narcotics substances hidden in various containers, suitcases, safes, and parcels
- Design and construction of neutron detectors for investigation of novel functional materials on the nanoscale
- Performing reactor- and accelerator-based radiation hardness tests for electronic components of space and aviation technology and large scientific facilities

JINR Expertise

- Design and construction of neutron and gamma detectors for spacecraft
- Design and construction of superconducting magnets for large-scale scientific facilities for nuclear physics research
- Design and construction of dedicated accelerators for particle therapy
- Design and construction of accelerators for scientific research and production of track membranes

SOCHI Beamline is ready (Dec 2021)

Research in the field of theoretical physics at JINR is carried out by the Bogoliubov Laboratory of Theoretical Physics (BLTP) as well as by theoretical groups in the experimental laboratories. The BLTP is a unique centre for the organization and coordination of modern investigations in the field of theoretical physics. As one of the largest centres, BLTP acts as a "generator" of interdisciplinary studies and international cooperation, thus determining the global scientific agenda of both theoretical and experimental research.

The research topics in theoretical physics are related to fundamental problems of modern physics and those specified by the JINR basic facilities, primarily, the NICA project, as well as physics programmes of international collaborations (LHC, RHIC, FAIR, K2K, etc.). The Laboratory hosts world leading experts in quantum field theory and particle physics, modern nuclear physics, condensed matter physics, and mathematical physics. Pioneering results of the studies of Dubna theoreticians gained worldwide acknowledgement.

- **Theory of Fundamental Interactions**
- **Theory of Atomic Nucleus**
- **Theory of Condensed Matter**
- **Modern Mathematical Physics**

33% **of JINR publications**

	2017	2018	2019	2020	2021
Journal Publications	334	345	308	370	290
Conference proceedings	242	172	193	155	90

STUDENT PROGRAMMES

Offline **START**:
STudent **A**dvanced **R**esearch **T**raining
(ex-Summer Student Programme)

- Science / Engineering / IT
- From 3rd year BSc up to the end of 1st year of PhD
- All countries
- Two sessions per year: Summer Session (July–October) & Winter Session (January–June)
- 6–8 weeks of advanced-level experience of research in JINR scientific fields
- **students.jinr.ru**
- Launched in 2014, 270 participants

Online **INTEREST**:
INTErnational **RE**mote **S**tudent **T**raining

"JINR: get INTERESTed in science with us"

- Science / Engineering / IT
- From 2st year BSc up to the end of 1st year of PhD
- All countries
- The Programme runs in Waves, each Wave lasting for 4–6 weeks
- List of online research projects for students to apply for **interest.jinr.ru**
- Launched in 2020, 227 participants

Offline **ISP**:
International **S**tudent **P**ractices in JINR Fields of Research

"3-week introduction to JINR"

- Science / Engineering / IT
- From 3rd year BSc up to the end of 1st year of PhD
- Member States only
- 3 stages per year
- **uc.jinr.ru/en/isp**
- Launched in 2004, over 1,700 participants

OUTREACH PROGRAMMES

Scientific Schools for Science Teachers

"Bringing fundamental science closer to school"

- Member States only
- 1 week of lectures, visits and discussions
- **teachers.jinr.ru**
- Launched in 2009, over 900 participants

Scientific events for foreign school students

- Practicums, visits, lectures
- At the request of Member States

Online and offline visits to the JINR labs for university and school students

edu.jinr.ru
E-learning resource

Science festivals

SKILL IMPROVEMENT

Trainings for engineers

- Automation
- Vacuum Technology
- Electronics
- Radio Frequency Technology
- Particle detectors

EDUCATION

BLTP JINR

The BLTP JINR has traditional educational activities on the platform of the Dubna International School of Theoretical Physics (DIAS–TH) scientific and educational project for young scientists and students from many countries.

MLIT JINR

MLIT JINR has created an educational and research infrastructure based on the HybriLIT training and testing polygon, on the basis of which training courses on modern technologies of distributed computing and parallel programming are conducted for students and specialists from many countries.

MSU BRANCH IN DUBNA

The MSU branch in Dubna has been established on the initiative of JINR. It will use the Institute's abilities as a unique international organization in the Russian Federation to establish contacts and use scientific results and best educational practices through interaction with foreign partners, participation in international projects to train personnel for fundamental research in the JINR Member States.

PHYSICS AND MATHEMATICS LYCEUM

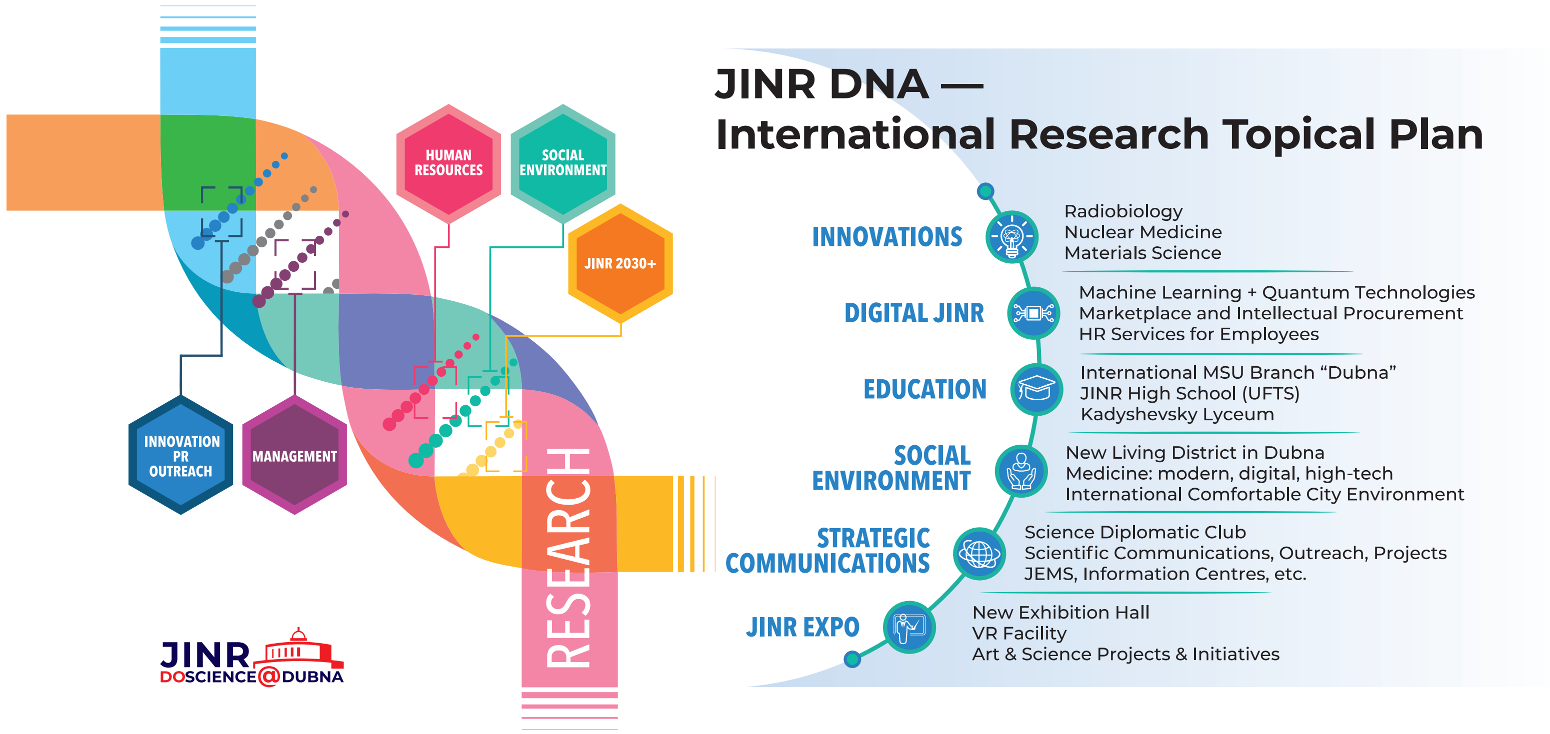
On the initiative of JINR, a physics and mathematics lyceum named after Academician V. G. Kadyshevsky was opened in Dubna. Best teachers of Dubna and Russia work there as part of the big teacher community of the lyceum. Children from JINR Member States are among students of the lyceum.

JINR INFORMATION CENTRES

To extend and strengthen the JINR research partner network, contribute to the training of scientific staff, and popularise science, JINR builds a network of its information centres.

The JINR Information Centre is a local "Embassy" and intermediary of JINR in science and education. Information centres aim to attract potential partners, staff members, and students. They initiate events to increase awareness about JINR. The key tasks of information centres are to popularise the results of international studies achieved at JINR, provide career guidance, and attract young people to science, including from the school age. Eight JINR Information Centres already operate in **Cairo** (Egypt), **Sofia** (Bulgaria), **Yerevan** (Armenia), **Vladikavkaz**, **Petropavlovsk-Kamchatsky**, **Arkhangelsk**, **Tomsk**, **Vladivostok** (Russia).

STRATEGY ARCHITECTURE



JINR REGIONAL COOPERATION APPROACH

NORTHERN AFRICA

JINR country
Egypt — Member State
10 partner organizations

Hub organization
AAEA — MoU since 2016

LATIN AMERICA

JINR country
Cuba — Member State
4 partner organizations

Partners in region
15 Brazil
6 Mexico
2 Argentina 2 Chile
1 Ecuador
1 Peru

SOUTH AFRICA

JINR country
South Africa — Associate Member
10 partner organizations

Partners in region
1 Botswana

SOUTH ASIA

Partners in region
24 India
3 Pakistan
1 Bangladesh
1 Sri Lanka

MEDITERRANEAN AND BALKANS

JINR countries
Bulgaria, Serbia

Partners in region
3 Israel
8 Turkey
5 Greece
5 Croatia, Montenegro, Slovenia

EASTERN AND SOUTH EASTERN ASIA

JINR country
Vietnam — Member State
10 partner organizations

Partners in region
21 China
5 Thailand
1 Indonesia

International Intergovernmental Organization
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POINT

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