Joint Institute for Nuclear Research: Overview of Activities

Latchesar K. Kostov
Vice-Director of JINR

Joint Institute for Nuclear Research

SCIENCE BRINGING NATIONS TOGETHER

The beginning

- The Joint Institute for Nuclear Research is an international intergovernmental organization
- Established on 26 March 1956 by eleven founding States.
- JINR is situated in Dubna city, the Moscow Region, the Russian Federation
- The aim - uniting the efforts, scientific and material potentials of its Member States for investigations of the fundamental properties of matter.

Signing the Convention on the establishment of the JINR, March 1956

Governing Bodies

- Committee of the Plenipotentiaries of the governments of all Member States
  - Budget
  - Scientific council
  - Director
- Financial committee
- Scientific council

JINR Scientific Council and Program Committees

Joint Institute for Nuclear Research

International intergovernmental organization

Established on **26 March 1956** and registered with the United Nations
Located in Dubna, Russian Federation

JINR IS A MEMBER OF 39 COLLABORATIONS AT SCIENTIFIC CENTRES AROUND THE WORLD

>900 PARTNER NETWORK ORGANIZATIONS

230M$ budget

JINR in Figures:

- 16 Member States
- 5260 staff members
- 1200 researchers
- 1000 Doctors and Candidates of Sciences
- 2000 engineers and technicians
- 1500 scientific publications per year
- over 70 international conferences and workshops per year
- 800 partner universities, educational and research centres in more than 70 countries

Unique Park of Basic Facilities:

- World's Top Pulsed Neutron Source
- Heavy Ion Accelerators in a Wide Energy Range
- Megascience Project: Superconducting Collider NICA

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

7-YEAR PLAN FOR THE DEVELOPMENT OF JINR (2024-2030)

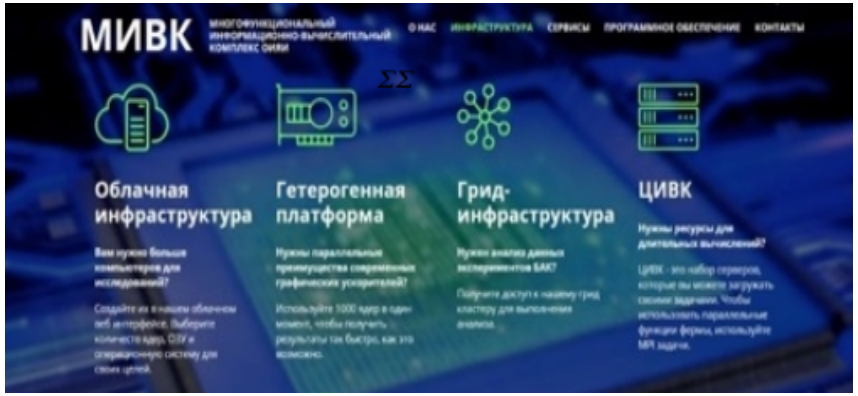
Relativistic Heavy Ion & Spin Physics
NICA complex

Low Energy Nuclear Physics
SHEF, DRIBS-III accelerator complexes

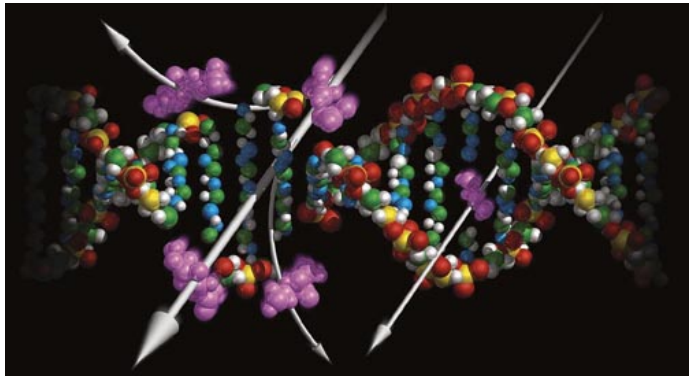
Condensed matter research and Neutron physics (IBR-2M reactor)

Neutrino & Astroparticle physics
Baikal-GVD neutrino telescope

IT and High Power Computing
MICC (Govorun supercomputer, GRID)



Life Sciences
Radiation biology, Proton therapy



THEORETICAL PHYSICS (Bogoliubov Laboratory of Theoretical Physics)

Theory of Fundamental Interactions

Theory of Atomic Nucleus

Theory of Condensed Matter

Modern Mathematical Physics

Interlaboratory cooperation

Research and educational project

DIAS-TH

"Dubna International Advanced School of Theoretical Physics"

VBLHEP Hot and dense nuclear matter in heavy-ion collisions

DLNP
Neutrino physics

MLIT
Lattice QCD calculations

FLNR
Superheavy and exotic nuclei

DLNP *Few-body systems, Exotic nuclei*

FLNP
Condensed Matter, New materials

FLNR
Nanoporous 2D membranes, Ion irradiation

MLIT Computational methods for nuclear physics and quantum chemistry

Human strategy:

- ❑ Attraction of leading scientists
- ❑ Attraction of young researchers
- ❑ Stimulation of scientific activity

Scientific strategy:

- ❑ Extension of international collaboration
- ❑ Keeping up with current scientific trends
- ❑ Interplay of research and education

Veksler and Bladin Laboratory of High-Energy Physics

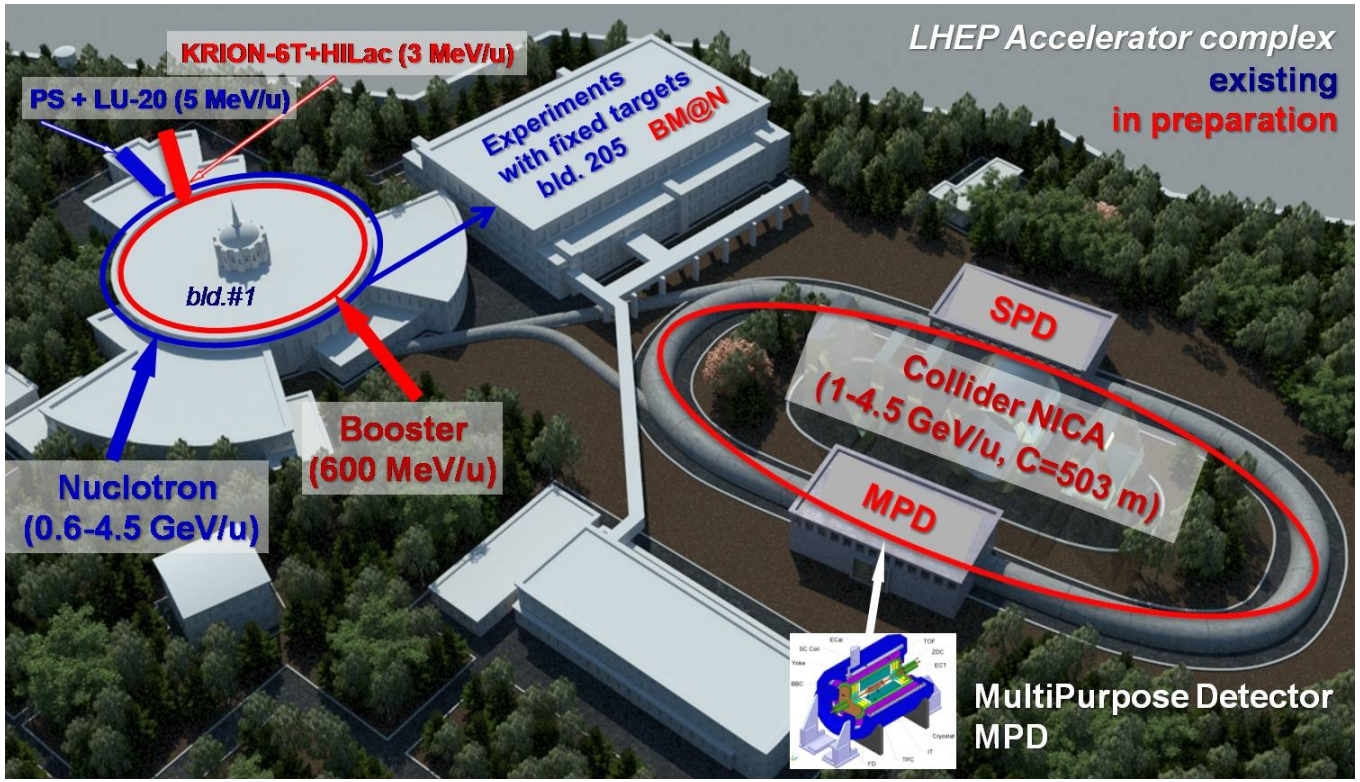
- relativistic heavy ion physics
- spin physics
- urgent issues of elementary particle physics related to checking of the Standard Model
- search for new physics beyond the Standard Model borders and CP-violation

RELATIVISTIC HEAVY ION PHYSICS & SPIN PHYSICS

NICA NUCLOTRON-BASED ION COLLIDER FACILITY

nica.jinr.ru

Nuclotron-based Ion *Collider* fAcility (NICA)



NICA
Nuclotron-based
Ion Collider fAcility

Main targets:

- study of hot and dense baryonic matter at the energy range of max baryonic density
- investigation of nucleon spin structure, polarization phenomena
- development of accelerator facility for HEP @ JINR

NEUTRINO AND ASTROPARTICLE PHYSICS

Dzhelepov Laboratory of Nuclear Problems

Scientific directions :

– Double beta decay, neutrino nature -- Majorana or Dirac; Nuclear matrix elements

– Fundamental neutrino properties (magnetic moment, mixture with a sterile state, etc)

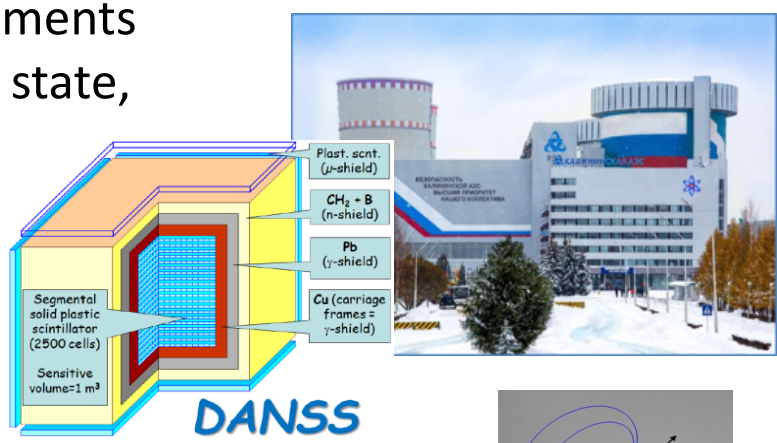
– Monitoring of nuclear reactors with neutrino detectors

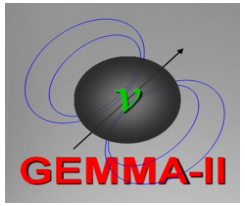
– Direct and indirect search for Dark Matter

– Investigation of galactic and extragalactic neutrino sources

– Atomic processes accompanying radioactive decay

– Applied directions of research





The major aims:

– BAIKAL-GVD: Observation of ultra-high energy astrophysical neutrinos; identification of their sources and nature

– DANSS: precision measurement of the spectrum of reactor antineutrinos

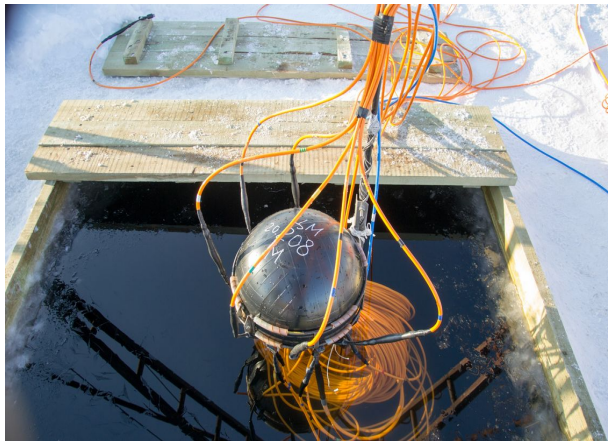
– RICOCHET: New physics with precision measurements at reactors.

– vGeN: search for magnetic moment of neutrino

– LEGEND: neutrinoless double-beta decay at 10^{28} years

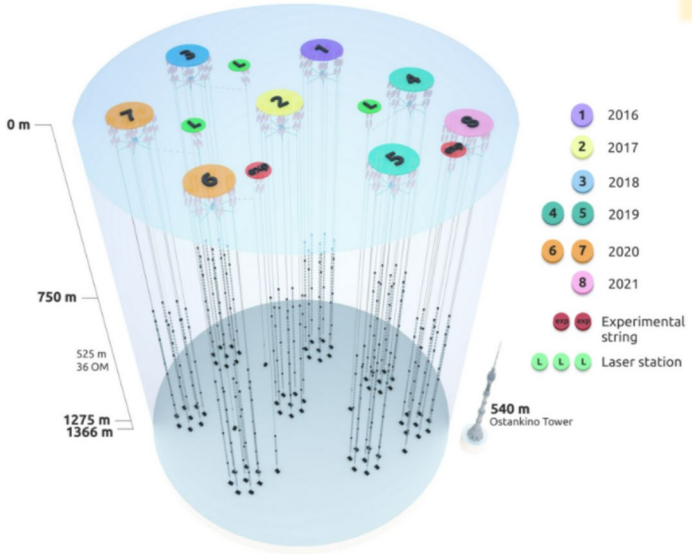
– Radiochemistry plus spectroscopy for astrophysics and nuclear medicine

Baikal-GVD Project



Baikal-GVD: Identification of astrophysical sources of ultra-high energy (exceeding tens of TeV) neutrinos. Actuality: their sources are still unknown. The identification of sources will help to elucidate mechanisms of galaxies creation and evolution.

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 second phase of the Baikal-GVD neutrino telescope will begin at the turn of 2025 and is scheduled for completion in 2030, when the facility will have more than 20 clusters (approximately 6000-7000 optical modules) with an effective volume of about or above 1 km3.

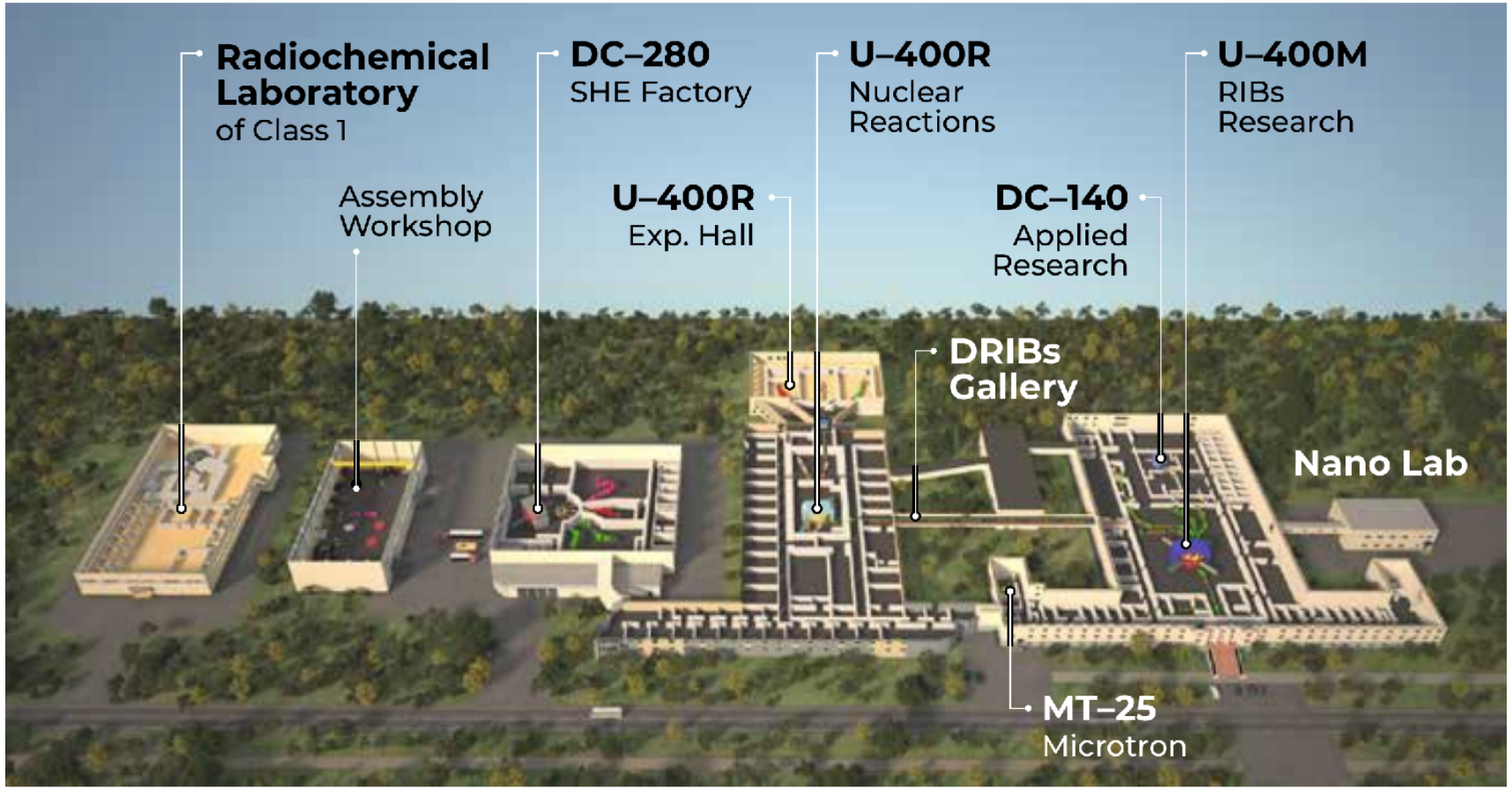
Year	Number of clusters	Number of OMs
2016	1	288
2017	2	576
2018	3	864
2019	5	1440
2020	7	2016
2021	8	2304
2022	10	2880
2023	12	3456
2024	14	4032
2025	16	4600

Baikal-GVD: flagship experiment of JINR with a **leading role** in the collaboration.
Gain new experience in the detector design, construction, deployment, maintenance, simulation and data analysis. **Expected breakthrough discoveries**.
SAC: light sensors, data transmission, radio-antennas + optics => New Quality and Efficiency

Flerov Laboratory of Nuclear Reactions

- experimental research in the synthesis and studies of nuclear structure and chemical properties of new superheavy elements
- fusion and fission reactions and multi-nucleon transfer in heavy-ion collisions
- studies of the properties of nuclei on the border of the nucleon stability and mechanisms of nuclear reactions with accelerated radioactive nuclei
- studies of interaction of heavy ions with various materials (polymers, semiconductors, electronic components of space equipment, etc.)

LOW ENERGY NUCLEAR PHYSICS



BASIC FACILITY — DRIBS-III ACCELERATOR COMPLEX

Нобелий 102 $5f^{14}$ No [259] Nobelium	Лоуренсий 103 $5f^{14}6d^{1}$ Lr [266] Lawrencium	Резерфордий 104 $6d^{2}$ Rf [267] Rutherfordium	Дубний 105 $6d^{3}$ Db [268] Dubnium	Борий 107 $6d^{5}$ Bh [270] Bohrium
Флеровий 114 Fl [289] Flerovium	Московий 115 Mc [290] Moscovium	Ливерморий 116 Lv [293] Livermorium	Теннессин 117 Ts [294] Tennessine	Оганесон 118 Og [294] Oganesson

10 new elements have been discovered at JINR

Strategic Research Directions:

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

SUMMARY OF EXPERIMENTS: 2020–2023

240 new events of synthesis of superheavy nuclides

VS.

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

36 isotopes decays were studied

6 new isotopes were discovered:
^{286}Mc, ^{276}Ds, ^{275}Ds, ^{272}Hs, ^{268}Sg, ^{264}Lr

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

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

Laboratory of neutron physics

NEUTRON PHYSICS

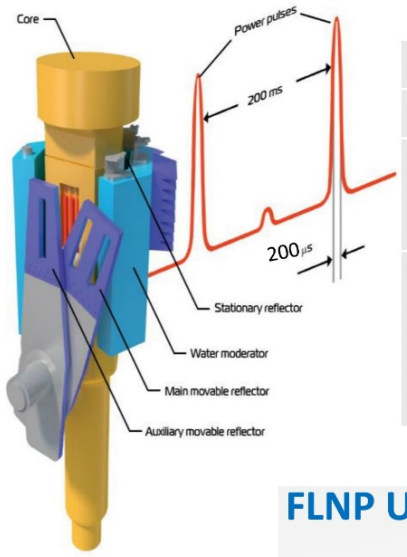
- Ultra-cold neutron physics;
  - Neutron lifetime;
  - Weak equivalence principle check. EDM?
  - Neutron quantum states in gravitational field;
- Neutron scattering for condensed matter studies
  - Diffraction at high pressure;
  - Soft matter;
  - Nanostructurized magnetic materials;
  - Energy selective neutron radiography and tomography;
- Nuclear physics with neutrons
  - Nuclear data for engineering and astrophysics;
  - Fundamental symmetries violation in neutron-nucleus interaction;
  - Applied research;

IBR-2 REACTOR
PULSED NEUTRON SOURCE
AVERAGE POWER – 2 MW
PEAK POWER – 2 GW

CONDENSED MATTER PHYSICS WITH NEUTRONS

Frank Laboratory of Neutron Physics
Лаборатория нейтронной физики им. И.М. Франка

NEUTRONS

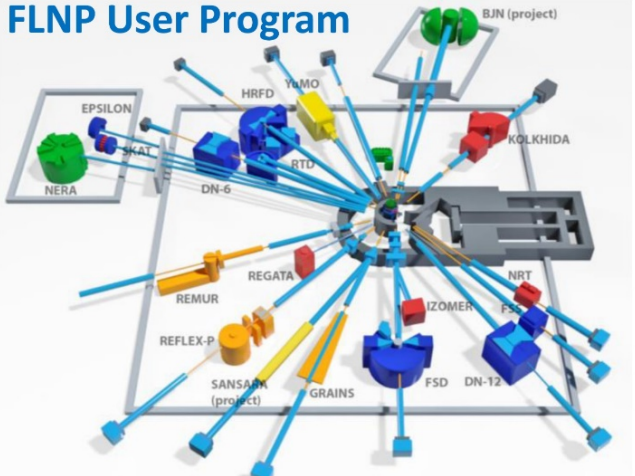


Average power, MW	1.8
Fuel	PuO_2
Pulse half-width, μs: fast neutrons thermal neutrons	 200* 340
Thermal neutron flux density from moderator surface: - time average - burst maximum	 ~ 10^{13} n/cm^2·s ~ 10^{16} n/cm^2·s

Typical Number of Operating Days per year

2500 h per instrument

FLNP User Program



- ▶Nanosystems and Soft Matter (YuMO, GRAINS, REFLEX, REMUR, SANSARA-project)
- ▶Atomic and Magnetic Structure (RTD, DN-6, DN-12, SKAT, EPSILON, FSD, HRFD)
- ▶Lattice and Molecular Dynamics (NERA, BJN-project)
- ▶Neutron Activation Analysis (REGATA)

Research in
– structure and dynamics of functional materials
– nanomaterials for energy storage
– materials by neutron scattering, neutron activation analysis, neutron radiography and complementary methods

http://flnp.jinr.ru

X-RAYS

SAXS/WAXS/USAXS

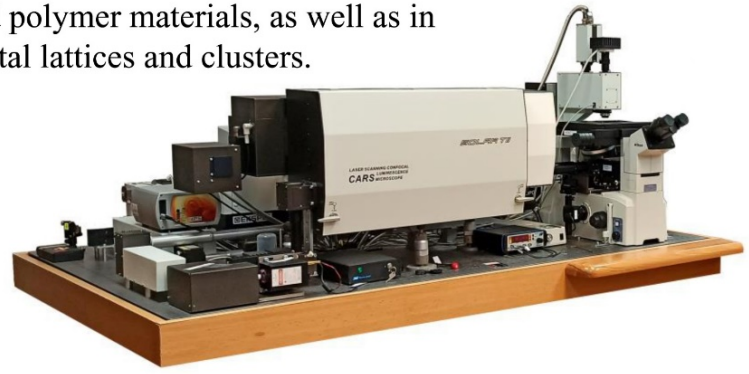
Analysis of particle size distribution, crystallization rates and lamellar structure of semi crystalline polymers. Size and shape analysis of surfactants or proteins in solutions. In situ studies of nanostructure transitions and others.

DIFFRACTOMETER

Analysis of phase composition and type of crystal structure and microstructural parameters of polycrystalline materials (films, nanomaterials and solid objects).

RAMAN SPECTROSCOPY

Analysis of nature of chemical bonds in organic molecules and polymer materials, as well as in inorganic crystal lattices and clusters.

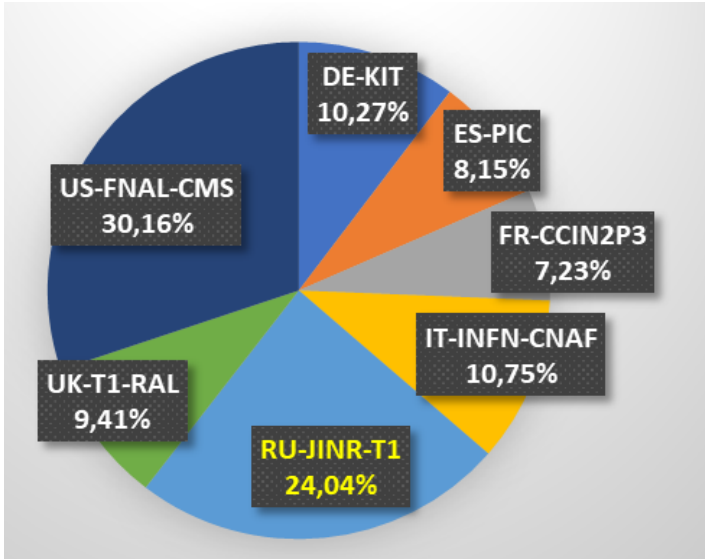


INFORMATION TECHNOLOGIES

JINR GRID INFRASTRUCTURE

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

JINR Tier-1 for CMS CERN is number one (by efficiency, power, volume)



Distribution by CPU Work (HS23 hours) among CMS Tier1 worldwide

•Hyperconverge ecosystem
•Full power: **2.2 Flops** for GP

•Network speed **>300 GB/s**
•**17th in the IO500**

•Scalable solutions, on require
•Data Lakes system
•Curcuit of the back cooling
•The most energy efficient in Russia (PUE = 1.06)

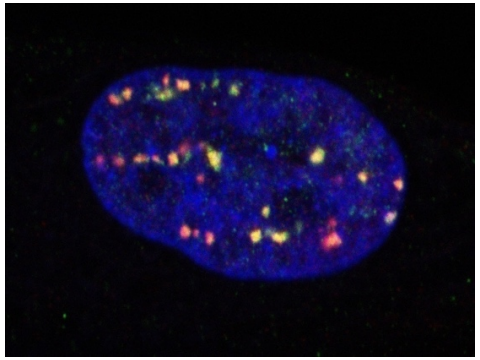
GOVORUN KEY PROJECTS

- 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)

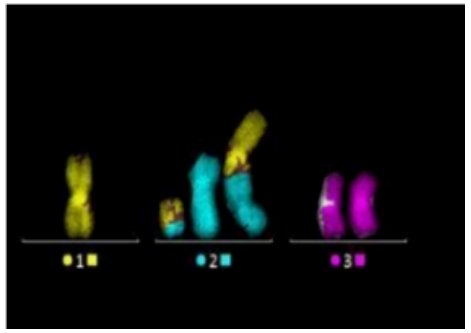
RADIATION RESEARCH IN LIFE SCIENCES

MAIN RESEARCH FIELDS:

Molecular Radiobiology

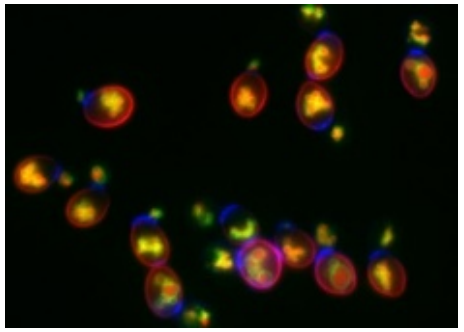


Radiation Cytogenetics

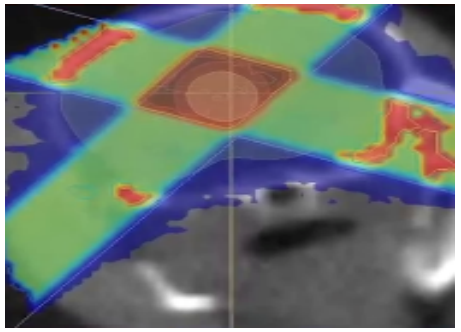


Radiation Physiology

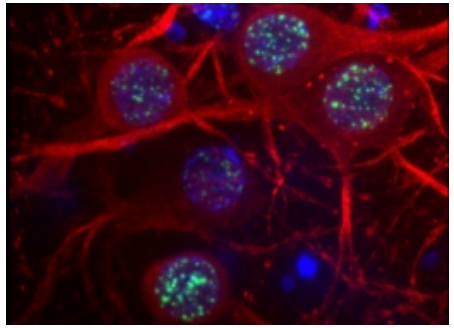
Radiation Genetics



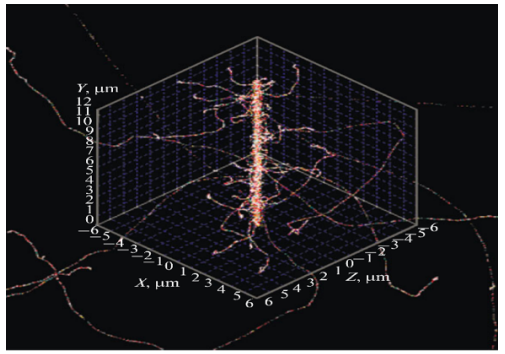
Clinical Radiobiology



Radiation Neuroscience

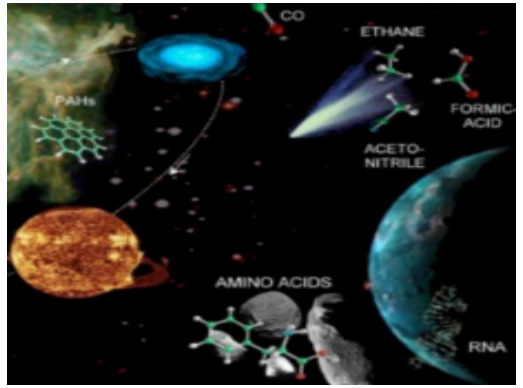


Mathematical Modeling



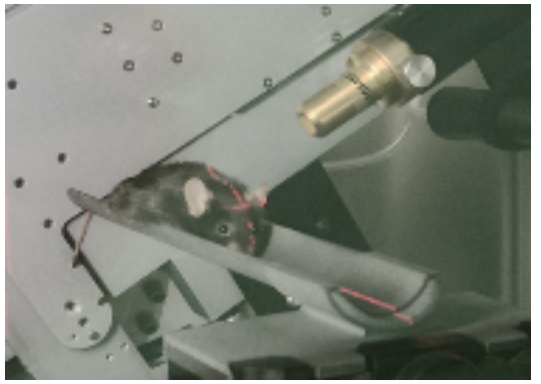
Radiation Research

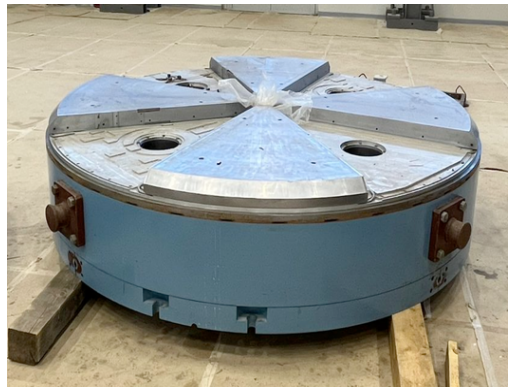
Astrobiology



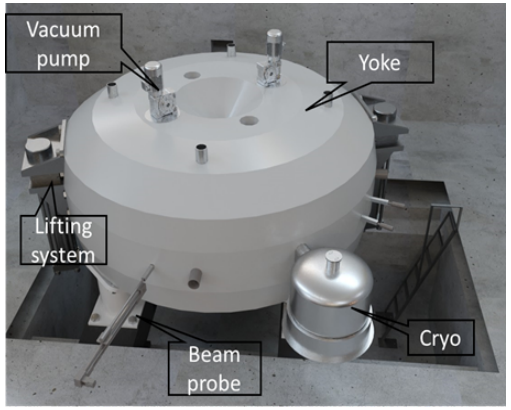
INTERNATIONAL CENTRE FOR NUCLEAR TECHNOLOGIES RESEARCH

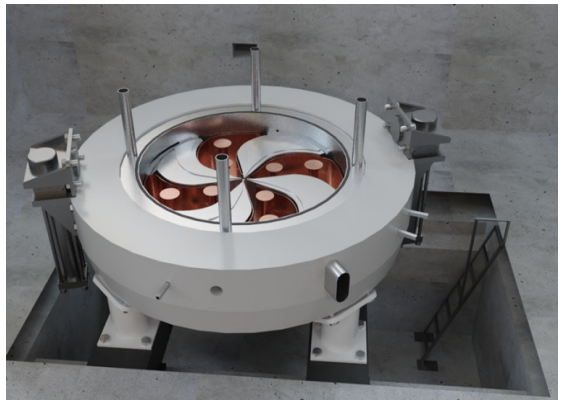
- **Radiation Biology @ LRB**, OMICS technologies, radiation neuroscience, new approaches for radiation therapy, targeted delivery of drugs and radionuclides, radioprotectors;
- **ARIADNA.** Applied beams@NICA: radiobiological studies (400-800 MeV/n); irradiation of electronics and material science (3; 150-350 MeV/n); nuclear physics (1-4.5 GeV/n);
- **DC140 cyclotron:** Space electronics testing, radiation material science, new generation of track membranes;
- **MSC230 cyclotron:** research and beam therapy: treatment planning; radiomodificators for γ– and p- therapy, flash-therapy, pencil beam (10 μA, >5 Gr/l @ 50 ms pulse).
- **Radiochemical Laboratory Class-I** for production of radioisotopes (Ac^{225}, ^{99m}Tc), nuclear medicine R&D in photonuclear reactions @ 40MeV e-accelerator.





DC-140 (construction phase)

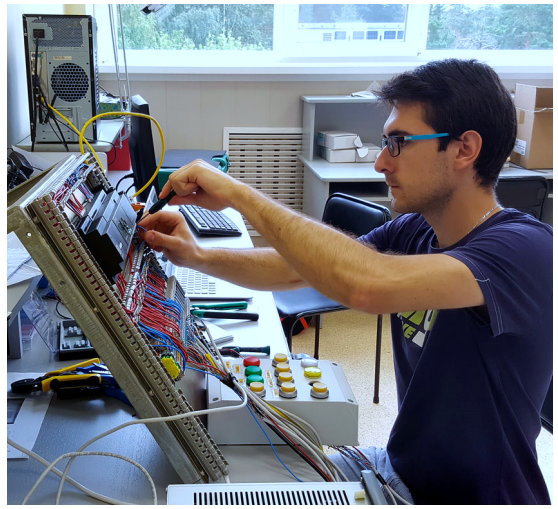




MSC-230 (general view)

Human Capacity Building Programmes

- **International Student Practice uc.jinr.ru/en/project-database**
- **START Programme start.jinr.ru**
- **INTEREST Programme interest.jinr.ru**



Annual Conference organised by the JINR Association of Young Scientists and Specialists **ayss-2022.jinr.ru**

JINR SUPPORTS talented scientists and engineers

who can conduct research within the JINR scientific programmes, or propose and lead new scientific projects at the international level

JINR Postdoctoral Research Fellowship Programme

- PhDs from all over the world
- Under the age of 40

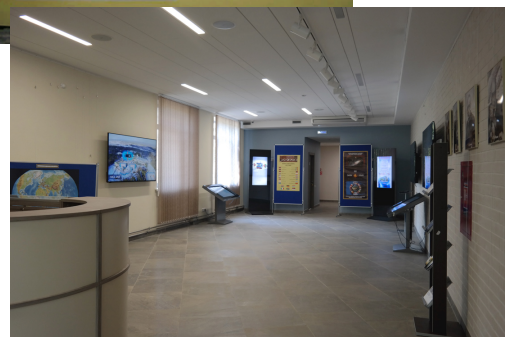
http://www.jinr.ru/careers-en/postdoc_programme_en/

JINR Research Scholarship Programme

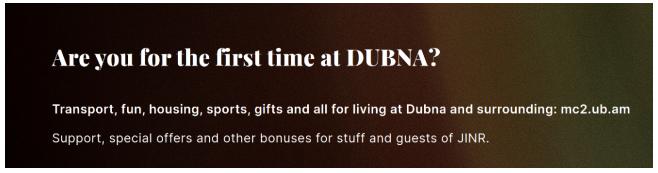
- Scientists or engineers with at least an MSc degree from all over the world
- Under the age of 60

Employment contract for the selected applicants

SOCIAL ENVIRONMENT



JINR Visit Centre



Unofficial guide
https://mc2.ub.am/en

JINR Club of scientists

JINR Conference Centre

JINR Cultural Centre "Mir"

JINR Stadium "Nauka"

JINR Tennis Courts

Swimming Pool "Archimedes"

Hotel Complex "Dubna"

JINR Resort "Dubna" (Black sea)

JINR Yacht Club

International Culture at JINR

Joint Institute for Nuclear Research

SCIENCE BRINGING NATIONS TOGETHER

JINR

DOSCIENCE@DUBNA