Scientific program of the Joint Institute for Nuclear Research:

Victor A. Matveev

16 September 2017
Evora, Portugal
-- JINR: what and where
-- 7-Year Plan of JINR development for 2017-2023
its science priorities
-- Topmost results
-- Perspectives
-- Conclusion
Moscow Region

Dubna

JINR

Russia

6 - 19 September 2017

European School of HEP
JINR – International Intergovernmental Organization joining 18 member states and 6 associated states. It is located in the city of Dubna in 120 km to the north from Moscow.
JINR collaborates with more than 700 scientific centres and universities in 64 countries over the world.
JINR comprises 7 Laboratories, each being comparable with a large institute in the scale and scope of investigations performed.

- Dzhelepov Laboratory of Nuclear Problems
- Veksler and Baldin Laboratory of High Energy Physics
- Frank Laboratory of Neutron Physics
- Bogoliubov Laboratory of Theoretical Physics
- Laboratory of Information Technologies
- Flerov Laboratory of Nuclear Reactions
- Laboratory of Radiation Biology
- JINR University Centre
JINR in some figures

JINR`s staff members ~ 4750:
- Researchers ~ 1350
  including from the Member States (but Russia) ~ 450
- PhD and Full Doctors of Science ~ 1200
- Engineers and specialists ~ 2100
- Services ~ 1300

New 7-year Plan for JINR development for 2017 - 2023 has been approved in November 2016 by the JINR CP`s in Krakow, Poland.
JINR Research Experimental Facilities

- **Heavy Ion Superconducting Complex** **Nuclotron-NICA**
  - Physics of dense and hot baryon matter
  - Spin structure and dynamics of nuclear matter

- **Intensive pulsed neutron breeder reactor** **IBR-2M**
  - Condensed matter & Nuclear physics **IRENA**

- **High Power Cyclotron Complex and SHE Factory**
  - Superheavy elements and Exotic nuclei
  - Dubna Radioactive Ions Beam studies **DRIBs**

- **Complex of computing & information technologies**
  - Tier-1&2 complex for LHC and NICA **Big Data**

- **Neutrino Gigaton Volume Detector** **GVD at Baikal lake**
  - Neutrino Physics and Astrophysics **Nu@Kal.APS**

- **Accelerator facility for radiobiology and medical studies**
  - Hadron therapy, astrobiology, cosmic medicine
NICA (Nuclotron based Ion Collider Facility) - the flagship project in HEP of the Joint Institute for Nuclear Research (JINR)

High Baryon Density Frontier
Study of the principally new phase state of the nuclear matter – super dense and hot baryonic matter – the Quark-Gluon Plasma produced initially at the birth of our Universe by the Big Bang.
Structure and Operation Regimes

**Nuclotron (45 Tm)**
- Injection bunch: \(2 \times 10^9\) ions
- Acceleration up to 1 - 4.5 GeV/u

**Booster (25 Tm)**
- Storage of \((2 \div 4) \times 10^9\) ions
- Acceleration up to 600 MeV/u

**Linac LU-20**
- Ion sources

**Linac HILac**

**Fixed Target Area**

**Two SC Collider Rings**
- \(2 \times 22\) injection cycles
- 22 bunches per ring

**Stripping (80%)** \(^{197}\text{Au}^{31+} \Rightarrow ^{197}\text{Au}^{79+}\)
NICAS has the most interesting energy diapason (\(\sqrt{s_{NN}} \sim 10\) GeV) corresponding to the region of the maximal density of baryonic or nuclear matter which nobody has had yet achieved in the laboratories. Main Goal - studying the critical phenomena and phase transitions happened to appear in the Early Universe and presumably existing in the Neutron Stars.

- FAIR (Darmstadt) – Fixed target experiments
- NICA (ОИЯИ, Dubna) – Collider experiments
NICA is well suited for exploring the transition between the hadronic and q-g phases at the high net baryon density. This is the top priority of the NICA program.
The Neutron Star

- Highest density matter in the universe
  \[ M = 1 \sim 2 \, M_\odot, \quad R \sim 10 \sim 20 \, \text{km} \]
  \[ \Rightarrow \text{Density of the core} = 3 \sim 10 \rho_0 \quad (1 \sim 3 \, \text{Btons/cm}^3) \]
  \[ \rho_0: \text{nuclear density} \]

- Various forms of matter made of almost only quarks

Strange Hadronic Matter
  High density nuclear matter with hyperons (strange quarks)

Nuclear “Pasta”
  Nuclear + Neutron Matter
  Neutron Matter
    Superfluid
  Quark Matter
    Deconfined quarks
    Color superconductivity
NICA International collaboration

Belarus
NC PHEP BSU (Minsk)
GSU (Gomel)

...
...

Germany
GSI (Darmstadt)
JLU (Giessen)
UR (Regensburg)
Frankfurt/Main Univ.
FIAS
FZJ (Julich)
FAU (Erlangen)

...
...

Ukraine
BITP NASU, KSU (Kiev)
KhNU, KFTI NASU (Kharkiv)

Bulgaria
INRNE BAS (Sofia)
TU-Sofia
SU
ISSP BAS
LTD BAS
SWU
PU (Plovdiv)
TUL (Blagoevgrad)

Russia
INR RAS (Moscow)
NRC KI (Moscow)
BINP RAS (Novosibirsk)
MSU (Moscow)
LPI RAS (Moscow)
St.Pet. University
RI (St.Petersburg)

Poland
Tech. University (Warsaw)
Warsaw University
Fracoterm (Krakow)
Wroclaw University
INP (Krakow)

...
...

Czech Republic
TUL (Liberec)
CU (Prague)
Rzezh, ...

RSA
UCT (Cape Town)
UJ (Johannesburg)
iThemba Labs

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India

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Australia

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Azerbaijan

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CERN

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China

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France

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Georgia

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Greece

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JINR – INFN Agreement

Workshop in Dubna on Megaprojects - Russia, Italy,
Germany, France, China, Egypt,
South Africa Republic, others.

JINR – BMBF Agreement

CERN – JINR cooperation Agreement

JINR – FAIR Agreement
## NICA schedule

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</table>
SP magnets for NICA & FAIR

Serial fabrication of Booster magnets is going on

Procurement of magnet systems for NICA and FAIR is in progress
Cryogenic complex: new He liquefier put in operation

Most powerful in Russia

1000 l/h
The MPD superconducting magnet progress in 2017:
- SC cable – ordered, manufacturing is in progress
- Copper conductor for the trim coils – delivered to the supplier’s site
- Aluminium support cylinder for SC coil – ready
- Winding machines for SC solenoid and trim coils – in operation
- Cryogenic He refrigerator – designed and ordered
- Magnet yoke – 80% ready

Progress with subsystems:
- TPC Clean room (S=84 m² ISO-6)
- A TOF module
- Service wheel of the TPC flange
- Beam test of FFD module
- IT clean room
Progress in 2017

- Mass-production of MPD elements is getting closer (TPC, TOF, FFD, FHCal)
- TDR is ready for Stage’1 MPD elements, the evaluation by DAC is ongoing
- Magnet fabrication is progressing well, the yoke is ready for 80%, control assembling is planned for Oct. 2017.
- The MPD-NICA interface simulation has started
- The MPD Collaboration is growing: new groups from Mexico and Poland have joined it
BM@N - many new detector subsystems installed

5 GEM detectors 66 x 41 cm² + 1 detector 163 x 45 cm²

D beam 2.94, 4.0, 4.6 GeV/n (52-53 runs)
NICA Civil Construction

- September 2017
- > 4200 piles are already pressed in
- concrete works are in progress
...What NEXT ?...

Creation of supercritical Coulomb fields with merging bare Uranium beams)

“Collector ring”, C~150-200m

Radioactive ions

Fragment-Separator (~30m)

e- beam SC linac, 1 GeV, ~ 30m

1. Mass-spectroscopy of radioactive heavy ion beams in isochronous mode (using collider ring);
2. Merging of RI fragments in the collider ring
3. Scanning of massive nuclei PDF with colliding electron beam (up to ~ 1 GeV);

Merging $^{92+}_{235}$U beams
E~ 0,6 GeV/u
~ 11 Tm ring
INNOVATIONS @ NICA

Innovative cluster:
• Areas for an innovative and applied researches with use of linear accelerators and Nuclotron extracted beams;
• Areas for an innovative and applied researches on the booster and Nuclotron beams;

Infrastructure cluster:
• NICA user’s canter;
• IT complex for experimental data storage and analysis;

Education field:
• Areas equipped with use of modern technologies for school, university and special education (i.e. engineering, etc);
Magnetic measurements
Curved UHV chambers
Ultra-high vacuum
Collider pre-serial dipoles
High-temp Superconductivity
Ultra-modern technologies
Collider quadrupole
Multipole SC magnets
JINR and
Low Energy Heavy Ion Physics :

Physics of exotic nuclei
Super heavy nuclei
Critical Coulomb fields

$Z \alpha \sim 1$
Flerov Laboratory of Nuclear Reactions
Achievements and Perspectives

Quest for the Island of Stability of the Super Heavy Elements Frontier
New lands  Search for new Island of Stability

Island of Stability
shoal
Island of Stability
shoal

Predicted 50 years ago
In Dubna and Frankfurt

Sea of Instability

Peninsula

Continental

Neutron number

Proton number

Log(T_{1/2}, s)

1µs 1s 1h 1y 1My
May 2012:
Official approval of the name Flerovium for element 114
and the name Livermorium for element 116

30th December 2015:
Approval of the discovery of new elements:
113, 115, 117, and 118

- element 113: RIKEN (Japan)
- elements 115 and 117: JINR (Dubna) - LLNL (USA) – ORNL (USA) collaboration
- element 118: JINR (Dubna) – LLNL collaboration.

28th November 2016:
IUPAC approved names and symbols of new elements:
  Nihonium (Nh) for element 113,
  Moscovium (Mc) for element 115,
  Tennessine (Ts) for element 117,
  Oganesson (Og) for element 118.

All these elements were synthesized for the first time at the U-400 accelerator complex of the Flerov Laboratory of Nuclear Reactions of JINR.
Inauguration of elements 115 (Moscovium), 117 (Tennessine), 118 (Oganesson) 

Moscow Central House of Scientists of RAS 
March 2, 2017
<table>
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<tr>
<th>Дубнийум (Dubnium)</th>
<th>105</th>
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Периодическая таблица элементов Д.И. Менделеева (2016 год)

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<td>248</td>
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Дубнийум — элемент с атомным номером 105, который был открыт в 1974 году в Национальном ядерном центре в Дубне, Россия.
Mendeleev’s Table Today

11 of 18 elements discovered during last 60 years were first synthesized in Dubna
Physics of SHE – is the triumph of Mendeleev
Periodic Law connecting the chemical properties of elements with their atomic numbers

1834 - 1907
Yu. Oganessian.
“Nuclear at the Mass Limit, Discovery of SHN ” Seminar on NP of INPh April 4, 2017, MSU, Moscow
Synthesis and study of properties of superheavy elements.

Search for new reactions for SHE-synthesis.

Chemistry of new elements.

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<th>Ion energy [MeV/A]</th>
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<td>$^{238}$U</td>
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SuperHeavy Elements Factory (SHEF) included into the NuPECC Long-Range Plan

**Magnetic field measurements**

**Purpose:**
Mapping of the magnetic field distribution at different regimes

**Started:** end of June 2017

**Duration:** 2-3 months

Example of the measured magnetic field
SuperHeavy Elements Factory (SHEF)

ECR ion-source of the SHE Factory

New gas-filled separator
Separator for Heavy ELement Spectroscopy (SHELS)

Isotopes studied at SHELS
- gamma, EC, alpha
- SF (TKE, neutron multiplicity)

Proton number

Neutron number
Fragment separator ACCULINNA-2: future basic facility for light radioactive nuclei research

- First RIBs are obtained at ACCULINNA-2 in March 2017.

- Designed parameters (counting rate, purity, beam sport geometry) are confirmed.

- RI Beam intensities are on average 20 times larger than on existing ACCULINNA-1 setup and comparable with beams provided by leading centers.

- Setup is ready for the 1st experiment (planned for November 2017).

*included into the NuPECC Long-Range Plan*
DRIBS-III ACCELERATOR COMPLEX

Flerov Laboratory of Nuclear Reactions
basic directions of research:

- Heavy and superheavy nuclei
- Light exotic nuclei
- Radiation effects and physical groundwork of nanotechnology
- Accelerator technologies
Study of heavy and superheavy elements in the world

Advantages of JINR:
- wide range of accelerated ions;
- availability of actinide isotopes for targets;
- broad international cooperation (JINR member states; Livermore & Oak Ridge National Laboratories, Vanderbilt University, University of Tennessee, USA; Paul Scherer Institute, Switzerland, Univerisite Louis Pasteur, Universite Paris Sud, GANIL, France);
- longstanding traditions and a scientific school;
- full-time availability of an accelerator complex – SHE-Factory.

1 Berkeley National Laboratory, USA
2 GANIL, Caen, France
3 Helmholtz Centre GSI, Darmstadt, Germany
4 JINR, Dubna, Russia
5 IMP, Lanzhou, China
6 RIKEN, Wako, Japan
Nano Laboratory

- Scanning electron microscopes
- Atomic force microscopy
- X-Ray photoelectron spectroscopy
- Equipment for sample preparation
Heavy-Ion-born nanostructures

new composite materials:
• extended layers adhesion strength
• increased thermal resistance
• flexible printed circuit boards

Polymer composites produced with the use of track membranes nanotubes nanowires
Production of track membranes (IC-100)

Micrometers

Cleaning pharm prepares 4-7 mkm

Pre cleaning of water, 1 mkm

Plasmapherez Water cleaning, 0.4 mkm

Molecular sensors < 20 nm

Nanometers

UF activation 310 nm

NaOH 40-90°C

CH₃COOH

H₂O
JINR Neutrino Program

Astrophysical neutrino sources (BAIKAL GVD)
Sterile neutrino searches (DANSS/KNPP)

Coherent neutrino-nucleus scattering (vGEN)
Precise measurements of neutrino oscillations
(Daya Bay, BOREXINO, OPERA at LNGS)
Neutrino mass hierarchy (JUNO, NOvA)
Neutrinoless 2β – Decay search:
(SuperNEMO, GERDA, Majorana)

GVD at Baikal: Central Physics Goals:
- The Galactic and Extragalactic neutrino “point sources” in energy range > 3 TeV
- Diffuse neutrino flux energy spectrum, local and global anisotropy, flavor content
- Transient sources (GRB, ...)
- Dark matter – indirect search

Nu- sources:
Solar
Reactor
Accelerator
Astrophysical
Atmospheric
Geophysical
Neutrino experiments at Kalinin APS
(Tveri region, 285 km from Dubna)

Pressurised water reactor;
Termal power 3 100 MW;
Neutrino flux ~ \(6 \times 10^{20} \nu_e\)

GEMMA (Neutrino Magnetic Moment)

\(\nu\)GeN
(Coherent \(\nu\)-Ge scattering)

DANSS
(reactor monitoring and search for sterile neutrino oscillations)
Assembling of the First Cluster of the GVD at the Baikal lake, Start at March 2015
BAIKAL - GVD project

~2300 OM (2020)
8 clusters

Since April 2016 taking data

April 2017 Cluster №2

“Dubna” (2015)

“Dubna” cluster event
Run#229; event 1734
2015 15 June 21:23:29

8 clusters

300 m

~1 km

120 m

~600 m

~2300 OM (2020)
GVD-1 Project time line

2009-2010: R&D with single prototype strings
2011-2014: R&D with prototype cluster of 3 to 5 strings
2015: „DUBNA“ Demonstration cluster started to work

BAIKAL-GVD-1
2304 light sensors combined in 8 clusters of vertical strings at 750 – 1300 m depths.
Detection volume 0.4km³

Objectives:
• Neutrino astrophysics above few TeV
• Dark matter – indirect search
• Exotic particles – monopoles, Q-balls, nuclearites, ...

Cumulative number of full clusters and OMs

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster-288 OM</td>
<td>1 288</td>
<td>2 576</td>
<td>4 1152</td>
<td>6 1728</td>
<td>8 2304</td>
</tr>
</tbody>
</table>

Permanent data taking

Effective volume GVD-1 (cascades) ~ 0.4 km³
1957 – for the first time the hypothesis of neutrino oscillations has been issued at JINR in Dubna by the prominent physicist Bruno Pontecorvo
Neutron scattering & Nuclear Structure
Life Science Problems
Radiobiology & Astrobiology
Nuclear Ecology & Cosmic Medicine
Neutron Physics at JINR

One of the best sources in the world for thermal neutrons!

IBR-2 is included in the 20-year European strategic research program in the field of neutron scattering

Mean power: 2 MW
Pulse frequency: 5 Hz
Pulse width for fast neutrons: 200 μs
Thermal neutrons flux density on the moderator surface: $10^{13} n/cm^2/s$
Maximum in pulse: $10^{16} n/cm^2/s$
World trends in neutron scattering

- Studies of real time processes in condensed matter;
- Studies of condensed matter under extreme conditions (ultrahigh pressures);
- Magnetic excitations in strongly correlated electronic systems;
- Neutron imaging of cultural heritage objects.

Scientific research at the spectrometers of the JINR's IBR-2 reactor follows most of the modern trends and keeps up with the world competition.
The IBR-2 pulsed reactor of periodic action is included in the 20-year European strategic program of neutron scattering research.
Frank LNP Large-Scale Basic Facilities

The IBR-2M pulsed reactor of periodic action is included in the 20-year European strategic program of neutron scattering research.

Nanosystems and Nanotechnologies

Novel Materials

Biomedical Research

Engineering diagnostics.

Earth Sciences

Ecology testing

Main directions: Fundamental and applied research in condensed matter physics and related fields: biology, medicine, material sciences, geophysics, ecology studies, engineer diagnostics - aimed at probing the structure and properties of nanosystems, new materials and biological objects, and at developing new electronic, bio- and information nanotechnologies.
197 proposals
19 countries

Distribution by applicant’s affiliation
About 60 visiting users from more then 10 countries
Upgrading the spectrometers complex and serving the user community

DN-6 diffractometer

NRT spectrometer

GRAINS reflectometer

FSS spectrometer

microsamples under extreme conditions (P ≤ 0.5 Mbar)
radiography tomography
soft and liquid interfaces
bulk industrial components new advanced materials

2017 → 15 new instruments

2011

+ 2 new instruments for users

+ 64% more applications for experiments

User distribution by countries
Radiation Biology at JINR

Based on experiments at JINR's accelerators, the LRB resolved one of the central issues of radiobiology: the problem of the **genetic effectiveness of ionizing radiations**.

**Outlook for research**

- Study of the regularities and mechanisms of the effect of heavy charged particles on **eye structures**: the lens and retina;

- Evaluation of the risk of the damaging effect of ionizing radiations with different physical characteristics on **the nervous system and higher nervous activity** (regularities of nervous cell death; impairments of the intercellular signal transmission; and disorders in mental functions: learning, memory, behavior, and consciousness);

- Research on the mechanisms of the **genetic effect** of radiations with different physical characteristics (formation and repair of different DNA lesions; programmed cell death mechanisms; and genetic instability);

- **Mathematical modeling** of biophysical systems.

**Cosmic medicine and the Project “Man Fly to Mars”**
LRB’s main fields of research in 2017—2023

- Research on the regularities and mechanisms of molecular damage induction and repair in the DNA structure in mammalian and human cells for radiations with different linear energy transfer (LET) in vivo and in vitro.

- Obtaining comparative data on the regularities in the induction of gene and structural mutations in mammalian and lower eukaryotic cells under exposure to sparsely and densely ionizing radiations with different LET.

- Research on the mechanisms of the heavy ion-induced damage to the eye retina and its repair.

- Identification of the heavy ion-induced functional and morphological disorders in the central nervous system.

- Mathematical modeling of the effects of ionizing radiations with different LET at the molecular and cellular levels. Development and analysis of mathematical models of the molecular mechanisms of ionizing radiation-induced disorders in the CNS structure and functions.

- Astrobiological research will be focused on the problem that is central for understanding the production of the prebiotic compounds underlying the formation of the living systems: what is primary for the origin of life, genetics or metabolism?
Studying microfossils in meteorites

A prasinophyte alga in the Murchison meteorite. The absence of nitrogen in the spectrum indicates that this object is not a modern biocontamination.

A cyanobacterial thread with an apical heterocyst; bacterial sheaths and a frambooid (the Orgueil meteorite)
JINR LRB: Astrobiology

Collaboration: University of Viterbo, Sapienza University of Rome (Italy), and LRB (JINR)

Formamide

Proton beam

Formamide

Carboxylic acids

Amino acids

Nucleosides

Nucleobases

Sugars

Orgueil CI1 Meteorite, biofossils

\[ \Delta E_{\text{max}} = 5.5 \text{ MeV} \]

\[ \Delta E_x = 4.3 \text{ MeV} \]

energy 155 MeV
THEORETICAL STUDIES and INFORMATION TECHNOLOGIES (including GRID) are of utmost importance for the successful activities of the Joint Institute and research centres of the Member States.

Moscow M9
100 Gb/s

100 Gb/s links

DLNP
VBLHP
LIT
CICC
BLTP
FLNP

2017 European School of HEP
Computing in High Energy Physics and Nuclear Physics

**Grids**
- Collaborative environment
- Distributed resources

**Supercomputers**

<table>
<thead>
<tr>
<th>Peak Performance</th>
<th>27.1 PF 18,688 compute nodes</th>
<th>24.5 PF GPU</th>
<th>2.6 PF CPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>System memory</td>
<td>710 TB total memory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interconnect</td>
<td>Gemini High Speed Interconnect</td>
<td>3D Torus</td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td>Lustre Filesystem</td>
<td>32 PB</td>
<td></td>
</tr>
<tr>
<td>Archive</td>
<td>High-Performance Storage System (HPSS)</td>
<td>29 PB</td>
<td></td>
</tr>
<tr>
<td>I/O Nodes</td>
<td>512 Service and I/O nodes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Clouds**

**Big Data**
- Volume
- Velocity
- Variety
One of the main task of LIT in the next 7 years is to develop the Multifunctional Information and Computing Complex

**LIT IT-infrastructure is the one of JINR basic facilities**

- LAN: 10 Gbps
- WAN: 100 Gbps + 2x10 Gbps
- Tier-1: 4160 core, 5.4 PB disk, 8 PB tape
- CICC/Tier-2: 3500 core, 2PB disk
- HybriLIT: 252 CPU, 77184 GPU cores, 182 PHI-cores, 2.4 TB RAM, 57.6 TB HDD, 142 Tflops
- Cloud: 700 CPU, 1 TB RAM

**MICC: main components**

- JINR grid sites of WLCG/EGI: Tier-1 for CMS Tier-2 for ALICE, ATLAS, CMS, STAR, LHCb, BES, biomed, fermilab
- Cloud infrastructure
- Heterogeneous(CPU + GPU) computing cluster HybriLIT
- Off-line cluster and storage system for BM@N, MPD, SPD Storage and computing facilities for local users
- Network infrastructure
- Engineering infrastructure
Grid Tier-1 is one of the 7 centres in the world intended for large-scale processing of experimental and event-modeling data coming from the centres of Tier-0 (CERN), as well as Tier-1 and Tier-2 of the Worldwide Computing Grid WLCG for the CMS experiment. This component is considered as a prototype of the system of processing and storage of the experimental data from the mega-project NICA as a centre of Tier-0 and Tier-1.
Experiments
BM@N, MPD, CMS, ATLAS, ALICE, LHCb, COMPASS, PANDA, CBM, STAR, NOvA, BESIII, DIRAC, OPERA NEMO, Mu2e, NUCLON, HONE, FUSION BIOMED

Tier 2 & CICC

Tier-2 grid by user VO

CICC resources usage by JINR Laboratories

Tier-1 and Tier-2:
JINR in Worldwide LHC Computing Grid
One of the most important trends in the cloud technologies is the development of method of integrating various cloud infrastructures. In order to join the cloud resources of partner organizations from JINR Member State for solving common tasks as well as to distribute a peak load across them, a cloud bursting driver has been designed by the JINR cloud team. It allows one to integrate the JINR cloud with the partner clouds either OpenNebula-based one or any other cloud platform which supports Open Cloud Computing Interface (OCCI).

Besides, the JINR cloud is integrated into EGI Federated cloud thus enabling a possibility to use part of the JINR computing resources by EGI FedCloud Virtual Organizations.

The geographical location of the partner's organizations from JINR Member States whose cloud resources are integrated into the JINR cloud following the so-called “cloud bursting” model.
LIT traditional conferences and schools in 2017

International Conference “Mathematical Modeling and Computational Physics”

The 26th Symposium on Nuclear Electronics and Computing

The 26th symposium on nuclear electronics and computing will be held in Budva in the 25-29 September 2017, Montenegro, Budva, Becici. Organizers of the event are JINR and CERN.

The 2nd International School on heterogeneous computing infrastructure, programming, Big Data analytics, scientific visualization, supercomputing will be held in the framework of the Conference.

Total number of participants was 300 scientists from various Institutes and Universities of Armenia, Bulgaria, Russia, and others. During the conference, there was over 250 reports on a wide spectrum of problems in the field of mathematical modeling. Youth conference-school on mathematical modeling for NICA was held in the framework of the Conference.
Multidisciplinary research:

- Theory of Fundamental Interactions
- Theory of Nuclear Structure and Nuclear Reactions
- Theory of Condensed Matter
- Modern Mathematical Physics: Strings and Gravity, Supersymmetry, Integrability

Research and Education Project DIAS-TH:
“Dubna International Advanced School of Theoretical Physics”

Helmholtz International Summer Schools (HISS) Dubna
Theory: Science Policy

- Support of the JINR Experimental Programme;
- Development of research in Theoretical Physics on the basis of Advanced Mathematics;
- Strengthening of the efficiency of scientific staff through the interplay of research and education.
JINR UC Educational Programmes and 7-years Plan for the Development of JINR for the years 2017 - 2023

Educational Programmes: ranging from school students and teachers to the bachelor, master and PhD students realizing the principle “Attracting Youth to Science”

- Among JINR educational activities there are the outreach programmes, preparation of qualification works at either bachelor, master or PhD levels, International student practice at JINR, Summer student programs, training programmes for engineers etc.
- In 2017 JINR has applied to the Russian Government to enter the system giving the right of issue its own diploma of assigning the JINR PhD degree. And has got this right!
- JINR is going to create a special fond to support JINR postdoc positions at the major projects of the JINR basic facilities like NICA, SHE, GVD at Baikal lake etc.
JINR UC offers graduate programmes in the fields of:

- Elementary Particle Physics
- Nuclear Physics
- Theoretical Physics
- Condensed Matter Physics
- Technical Physics
- Radiobiology

JINR is a school of excellence for the Member States!
Bachelor’s, Master’s & PhD theses at JINR

JINR has departments (Chairs) of the major universities

MSU

SAINT PETERSBURG STATE UNIVERSITY

We enable students and postgraduates from the Member States Universities to prepare their qualifying theses at JINR
Schools at JINR
http://teachers.jinr.ru/

Schools at CERN

Bringing Science closer to School
JINR Social Infrastructure and its development

Swimming Pool 50 m

Concert Hall

Sport Hall

Football, Tennis, Hockey fields

Summer schools for children

Culture House

В.А. Матвеев_Астана_15.06.16
JINR and

INTERNATIONAL COOPERATION
Large scale physics

JINR participation in the world wide international collaborations:

CERN, FAIR, DESY, FNAL, BNL,
CNRS, LNGS at Gran Sasso, KEK,
T2K, Daya Bay and others ...

some examples
JINR – CERN strategic partnerships

- JINR actively participates in the LHC programmes including the ATLAS, CMS, ALICE and the Collider itself and planning to contribute to the LHC detectors upgrade.
- Besides, JINR participate in the four SPS projects:
  - Compass-II (NA58) – nucleon spin structure, hadron spectroscopy (with interests to future SPD at NICA);
  - NA61 – (intersects with BM@Nuclotron and MPD);
  - NA62 – CP-violation and rare decays;
  - NA64 – search for the dark photon;
- Accelerator development: CLIC, ILC, FCC, precise laser metrology,
- Computing and Information Technologies, WLCG, Tier-1
- Neutrino platform, nTOF, DIRAC, Educ.Teachers programs etc
JINR continues energy frontier research at the LHC with ALICE, ATLAS & CMS

Breakthrough in Experiments @ LHC:
The most important event in Particle Physics in XXI century is the discovery of the **Higgs Boson** at CMS and ATLAS at LHC

JINR will continue to be one of the main contributors to the ATLAS & CMS experiments on the Large Hadron Collider, two of the experiments that discovered the Higgs boson in 2012. In 2015, the LHC started its second run, at the highest energies ever harnessed for a scientific experiment.
Academician Vladimir Lobashov was pioneer of studies of P and CP-invariance as well as neutron and neutrino physics. His studies set the most stringent limits on neutron dipole moment and on neutrino mass in beta decay. He proposed new method for lepton flavor violation search in muon to electron conversion using pulsed proton beam which Fermilab is now using in mu2e experiment.

Search for neutrino-less conversion of a muon to an electron, \( \mu + N(A,Z) \rightarrow e + N(A,Z) \) at J-PARC with unprecedented sensitivity of \( \sim 10^{-15} \) (at Phase-1) and \( \sim 10^{-17} \) (at Phase-2).

The main task of the JINR physicists at the current stage: participation in creation of the experimental setup.

Two areas of the JINR full responsibility:
1) production of the straw tubes for the tracker;
2) test of crystals for the electromagnetic calorimeter
JINR in *Daya Bay*II (JUNO)

6 Antineutrino Detectors (ADs) give 120 tons total target mass.

6 commercial reactor cores with 17.4 GW total power.

Data taking

~200K events in close detectors

~30K in far detectors

Update precise measurement

\[
\sin^2 2\theta_{13} = 0.089 \pm 0.010 \text{ (stat)} \pm 0.005 \text{ (syst)}
\]

2017 European School of HEP
JINR @ NOvA neutrino experiment (FNAL)
JINR at NOvA – remote operation center in Dubna

- Developed infrastructure of the ROC–Dubna allows for non-interruptible continuous work
- Includes: stable and backed up internet connection, communication tools including international land-line, kitchen, etc.
- A computing monitoring system, based on Nagios, controls ROC–Dubna equipment and notifies JINR experts in case of trouble.
Applied Research: proton therapy and medical accelerators development

Proton Therapy at DLNP Phasotron

- Unique in Russia experience of application of conformal 3D therapy method
- About 100 patients per year since 2000
- Development of the project of PT Center

C400 SC Cyclotron Project for p & C Therapy together with IBA company & ASIPP (Hefei, China)
Recent development of the JINR international cooperation

Involving the new countries into the JINR

Brazil and India
New contacts gained recently in various topics at the Forums on developing the cooperation with JINR. Negotiations with the national agencies on atomic energy are in progress.

China
Strong interest to NICA and very active position of Chinese senior officials. Next high level event in JINR: 26/10/16 Multidisciplinary Forum China-JINR: June 2016

Turkey
Remarkable interest of a number of Turkish institutions to access the research facilities of JINR for scientific research and education.

Clusters of the countries in the world regions facilitated by Cuba, Egypt, South Africa, Vietnam
New contacts are already gained with the research organizations and universities of Guatemala, Tunis, Botswana, Thailand (to be continued)

Montenegro
Negotiations are going with the Ministry of Education and Sciences on the signing an Agreement with JINR

Visibility of JINR in Europe and in the World and involvement of young researchers are among the main JINR priorities

4 March 2014. Ambassadors of 11 Latin American countries visited JINR
“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”.

Anton Chekhov

(1860 – 1904)
Welcome to Dubna!

Thank you!

Our colleagues in member–states are saying: “JINR in Dubna – it is our common house on the bank of the great Russian river Volga”
Inauguration of element 117, Tennessine
TN, USA

Oak Ridge National Laboratory – 27.01.2017 – Inauguration of the 117 Element
BM@N experiment at the NICA
Fixed Target Area

Deuteron beam, $T_0 = 4.0, 4.6$ GeV/n

Carbon beam, $T_0 = 3.5, 4.0, 4.5, 5, 16$ GeV/n

Focus on testing and commissioning of the central tracker inside the analyzing magnet → 5 GEM detectors $66 \times 41 \text{cm}^2 + 2$ GEM detectors $163 \times 45 \text{cm}^2$ and a plane of the Si detector for tracking Test / calibrate ToF, $T0+$Trigger barrel detector, full ZDC, part of ECAL

Near-term plan:
heavy ions (Ar, Kr); GEM tracker (+ 4 detectors), Silicon detector (+ 2 planes)
International Scientific Schools for physics teachers and school students at JINR and CERN (647 participants from 8 countries since 2009, 52 in 2017)

- Qualification thesis (955 students and PhDs since 2013, 237 in 2017)
- International Student Practice (1294 parts since 2004, 140 in 2017)
- Summer Student Programme (128 parts since 2014, 49 in 2017)
- Engineering and Physics Training (since 2014)