ILC activity at JINR and proposals of ILC sitting in the Dubna region

G. Shirkov
JINR, Dubna

CERN, January 12, 2007
<table>
<thead>
<tr>
<th>Language</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>Joint Institute for Nuclear Research: International Scientific Centre</td>
</tr>
<tr>
<td>Russian</td>
<td>Объединенный институт ядерных исследований</td>
</tr>
<tr>
<td>Ukrainian</td>
<td>Інститут уніфікованого дослідництва ядерних відкриттів</td>
</tr>
<tr>
<td>Romanian</td>
<td>INSTITUTUL UNIFICAT DE CERCETARI NUCLEARE</td>
</tr>
<tr>
<td>Hungarian</td>
<td>ZJEDNOCZONY INSTYTUT BADAŃ JĄDROWYCH</td>
</tr>
<tr>
<td>Chinese</td>
<td>联合国原子能研究机构</td>
</tr>
<tr>
<td>Vietnamese</td>
<td>VIỆN LIÊN HIEP NGHIỄN CỬU HẠT NHÀN</td>
</tr>
<tr>
<td>Tajik</td>
<td>БИРІККЕН ЯДРОЛЫҚ ЗЕРТТЕУ ИНСТИТУТЫ</td>
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<tr>
<td>Lithuanian</td>
<td>INSTITUTO UNIFICADO DE INVESTIGACIONES NUCLEARE</td>
</tr>
<tr>
<td>Czech</td>
<td>SPOJENÝ ÚSTAV JADERÝCH VÝSKUMOV</td>
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<tr>
<td>Kyrgyz</td>
<td>ОБЪЕДИНИНИЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ</td>
</tr>
<tr>
<td>Slovak</td>
<td>SPOJENÝ ÚSTAV JADERÝCH VÝSKUMÚ</td>
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</tbody>
</table>
Joint Institute for Nuclear Research (JINR) is an international intergovernmental organization located in Dubna, Russian Federation, about 120 km north of Moscow.
The agreement on the establishment of JINR was signed on 26 March 1956 in Moscow.
<table>
<thead>
<tr>
<th>JINR Member States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
</tr>
<tr>
<td>Azerbaijan</td>
</tr>
<tr>
<td>Belarus</td>
</tr>
<tr>
<td>Bulgaria</td>
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<tr>
<td>Cuba</td>
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<tr>
<td>Czech Republic</td>
</tr>
<tr>
<td>Georgia</td>
</tr>
<tr>
<td>Kazakhstan</td>
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<tr>
<td>Democratic People’s Republic of Korea</td>
</tr>
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<td>Moldova</td>
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<td>Mongolia</td>
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<tr>
<td>Poland</td>
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<tr>
<td>Romania</td>
</tr>
<tr>
<td>Russia</td>
</tr>
<tr>
<td>Slovak Republic</td>
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<tr>
<td>Ukraine</td>
</tr>
<tr>
<td>Uzbekistan</td>
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<td>Vietnam</td>
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### Basic Documents

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
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<tbody>
<tr>
<td>26.03.1956</td>
<td>Foundation of JINR</td>
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<tr>
<td>23.09.1956</td>
<td>Adoption of the JINR Charter</td>
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<tr>
<td>1.02.1957</td>
<td>JINR was registered by UN</td>
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<tr>
<td>23.06.1992</td>
<td>Renewed Charter signed</td>
</tr>
<tr>
<td>24.09.1997</td>
<td>UNESCO – JINR Agreement</td>
</tr>
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</table>
Cooperation with Russia

JINR’s partners are 150 institutions located in 40 cities of Russia
International Cooperation

JINR’s partners are about 700 institutions located in 60 countries, including 337 institutions and universities from the JINR Member States.
Cooperation with CERN

The Twenty Member States of CERN

Member States (Dates of Accession)

Member States (Dates of Accession)

JINRDubna

Cooperation with CERN

ATLAS

CMS

CMS
Committee of Plenipotentiaries

Scientific Council
- PAC for Particle Physics
- PAC for Nuclear Physics
- PAC for Condensed Matter Physics

Directorate

Finance Committee
- Scientific-Technical Council
- 8 Laboratories
- University Centre
- Office of Administration
JINR has grown into a large multi-branch physics centre. It employs about 5500 people, including 1300 scientists. Among the scientists there are full members (academicians) and corresponding members of Academies of Sciences, more than 260 Doctors of Sciences and 650 Candidates of Sciences.
JINR is a large multidisciplinary scientific centre incorporating:

- basic research in frontier particle, nuclear and condensed matter physics,
- development and application of high technologies, and
- university education in the relevant fields of knowledge.
Discoveries

37 discoveries, 46 diplomas and prizes of Russia, Bulgaria, Romania, Czech Republic, Uzbekistan and Georgia including:

- 1958: Theory of superfluidity and superconductivity
- 1960: Anti-sigma-minus-hyperon
- 1963: Element 102
- 1973: Quark counting rules
- 1988: Colour as a new quantum number
- 1999: Element 114
- 2000: Element 116
- 2001: Element 118
- 2003: Elements 115 and 113
University Education

University Centre of JINR

University "DUBNA"

Lectures

Training
JINR’s facilities

Nuclotron (superconducting synchrotron) has been operating since 1993

Cyclotron U400 has been operating since 1979

Cyclotron U400M has been operating since 1993

Phasotron (synchrocyclotron) has been operating since 14.12.1949

Neutron pulsed source IBR-2 has been operating since 1984
Operation in 2005 (in total)

- **Nuclotron**: Planned - 2500 hours, Actual - 2008 hours
- **IBR-2**: Planned - 2000 hours, Actual - 2091 hours
- **U-400**: Planned - 5900 hours, Actual - 5721 hours
- **U-400M**: Planned - 3100 hours, Actual - 3177 hours
- **Phasotron**: Planned - 265 hours, Actual - 265 hours
Nuclotron of Baldin-Veksler Laboratory of High Energy

NUMBER OF USER’S GROUPS - 14

ACCELERATED BEAMS - p, d, He, C, B, Mg, N^{6+}, N^{7+}, Ar^{16+}, Fe^{24+}

BEAM ENERGIES - 0.5 - 3.0 GeV/u, (nuclei) 5.7 GeV (protons)
FLEROV LAB ACCELERATORS

U200
IC-100
U400
U400M
DRIBs-I
MT-25

FLEROV LAB ACCELERATORS

G. Shirkov, Basic Facilities, April 2006
**Fundamental Investigations:**
- DUBTO - Resonant behaviour of the both the pp$\pi$- and nn$\pi$+ systems, produced in $\pi$4He interaction.
- MUON – Investigation of the muon properties and the muon interactions with matter.
- FAMILON - The study of the two-particle muon decay on an electron and golston's massless boson.
- $\mu$-CATALISIS- Measurements of muon catalyzed fusion cycling rate temperature dependence in a binary mixture D/T in the temperature range 40-300 K.

**Applied investigations:**
- Cancer therapy;
- (~100 patients per year)
- SAD- Subcritical Assembly Driven by Proton Accelerator
Main results in 2005:

I. Total running time of IBR-2: 2091 hours
II. Modernization of IBR-2
III. Dismantling of IBR-30
IV. New Movable Reflector (MR-3)
V. New Fuel Loading
New Basic Facilities Under Construction

IREN: DRIBs: LINAC-800:

ILC test bench and FELs

High intensity pulsed source of resonance neutrons

Dubna Radioactive Ion Beams
IREN – Intense REsonance Neutron source

(facility is under construction at FLNP)

IREN consists:
• powerful (10KW) electron linac LUE-200
• plutonium subcritical multiplied target

$E_{e,\text{beam}} = 200$ MeV
$W_{\text{beam}} = 10$ kW
$f = 150$ Hz

Multiplying subcritical target
$F\text{uel} - \text{Pu}$
$W_{\text{loss}} = 12$ kW
$K_{\text{eff}} = 0.97$
$\phi = 10^5$ s$^{-1}$
$\Delta t = 400$ ns

neutron-beams
LINAC – 800

LINAC-800 parameters:
• energy – 800 MeV
• average current – 50 mA

Applications of LINAC-800:
• Test Facility for ILC (photoinjector, SRF cavities traced with electron beam)
• Free Electron Lasers
• Material modification

First beam – April 2006

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FEL1</th>
<th>FEL2</th>
<th>FEL3</th>
<th>FEL4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron energy, MeV</td>
<td>30-60</td>
<td>30-70</td>
<td>50-110</td>
<td>120-280</td>
</tr>
<tr>
<td>Radiation wavelength, µm</td>
<td>20-150</td>
<td>5-30</td>
<td>1-6</td>
<td>0.15-1.2</td>
</tr>
<tr>
<td>Bunch charge, nC</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Peak current, kA</td>
<td>50-70</td>
<td>50-70</td>
<td>50-70</td>
<td>150-250</td>
</tr>
<tr>
<td>Bunch length, mm</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>0.5-0.8</td>
</tr>
<tr>
<td>Norm. emittance, mm.mrad</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Energy spread, keV</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>450-750</td>
</tr>
<tr>
<td>Micropulse repet. rate, MHz</td>
<td>19.8 / 39.7 / 59.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macropulse duration, µs</td>
<td>5-10</td>
<td>5-10</td>
<td>5-10</td>
<td>5-10</td>
</tr>
<tr>
<td>Repetition rate, Hz</td>
<td>1-100</td>
<td>1-100</td>
<td>1-100</td>
<td>1-100</td>
</tr>
</tbody>
</table>
ILC siting and conventional facilities in Dubna region

International Intergovernmental Organization

Joint Institute for Nuclear Research

Dubna, Russia
Milestones of JINR activity in ILC

November 2005 – International Program Advisory Committee proposed to investigate an opportunity to construct the ILC in the Dubna region

December 2005 – GDE in Frascati – A.N. Sissakian with first proposals from JINR to be involved into global accelerator project and Dubna siting;

January 2006 – a special workgroup on ILC was created at JINR

January 2006 – JINR Scientific Council encourages JINR to be involved in the ILC design effort and supports the intention of JINR to participate in the ILC project and the possible interest of JINR to host the ILC

March 2006 – JINR Committee of Plenipotentiaries approved SC recommendation;

March 2006 – visit of European GDE director Prof. B. Foster to Dubna;

May 2006 – European GDE in DESY - Detailed information from JINR as from sample site;

July 2006 – GDE in Vancouver – Documentation from JINR to BCD with RSPI estimation on CFS (Site Assessment Matrix);
Milestones of JINR activity in ILC

**November 2006** – **GDE in Valencia** – Documentation from JINR to RDR with new RSPI estimation on CFS (Work Breakdown Structure) officially submitted. Participation of JINR representative in a GDE Directorate round table; JINR (Dubna) is officially approved by GDE Director as sample site for ILC hosting. RDR will include information about Dubna sample site. Detailed Cost Estimation on subsystems from JINR will be in TDR;

**December 2006** – Directorate of approved the unification of a few accelerator projects (ILC, X-FEL&FLASH, CLIC, LEPTA and some others) in one scientific theme under the leadership of A.Sissakian and G.Shirkov in order to concentrate the recourses and manpower at JINR;

**26 December 2006** – The ILC activity at JINR was considered at the special meeting in the Russian Academy of Science.
PROPOSALS of the ILC SITING - 50 KM LINE

IDEAL - "CUT AND COVER" CONSTRUCTION

IDEAL - "ROCK" CONSTRUCTION
EUROPEAN SAMPLE SITE - CERN

Longitudinal Section
EUROPEAN SAMPLE SITE - DESY

Longitudinal Section
AMERICAS SAMPLE SITE

Longitudinal Section
Dubna Siting: Layout of ILC in the Moscow Region

- Dubna city
- Volga river
- 500 kV power line
- Moscow region
- Tver region
Advantages of the ILC construction in Dubna:

1. The presence of JINR as a basic scientific and organizational structure. JINR is an international intergovernmental organization, which includes 18 Member States and 4 States, which are associated members.

2. The proposed territory is extremely thinly populated and practically free of industrial structures, rivers and roads. The proposed placement of the accelerator tunnels in relatively dry drift clay excludes the influence on abyssal distribution of the underwater.

3. The area is absolutely steady seismically and has stable geological characteristics.

4. A flat relief and the unique geological conditions allow one to place ILC on a small depth (about 20 m) and to perform construction of tunnels, experimental halls and other underground objects with the least expenses, including open working.

5. The extremely attractive feature of placing the ILC complex on the chosen territory is a unique opportunity to solve the problem of value at the purchase of land. Prevalent legal practice makes it possible to get the land of the ILC location to permanent free use just as it has been done for JINR, according to the agreement between JINR and the RF government.
6. There are sources of the electric power of sufficient capacity in the area of the ILC construction: transmission line of 500 kV, the Konakovo electric power station (EPS) and the Udomlia atomic power plant (APP).

7. The developed system of transport and communication services, advantageous location, good highways and railways, water-way (the Volga river basin), good position in the European region;

8. Presence of a modern network and information infrastructure, including one of the largest center in Europe the “Dubna” Satellite Communication Center.

9. A special the economic zone established in Dubna in December, 2005 provides preferential terms for development and manufacture of high technology technical production.

10. Dubna has a powerful scientific and technical potential. The developed infrastructure makes it possible to involve additionally specialists from world scientific centers into the already formed international collective of highly-qualified scientific manpower providing comfortable conditions for them to work. This guarantees a high quality of investigations on ILC and obtaining of new research results of fundamental scientific importance.
In front: Russian Satellite Communications Center
In the background: the starting point of ILC layout, between Dubna and Volga rivers
The ILC linear accelerator is proposed to be placed in the drift clay at the depth of 20 m (at the mark of 100.00 m) with the idea that below the tunnel there should be impermeable soil preventing from the underlying groundwater inrush. It is possible to construct tunnels of the accelerating complex using tunnel shields with a simultaneous wall timbering by tubing or falsework concreting.

Standard tunnel shields in the drift clay provide for daily speed of the drilling progress specified by the Project of the accelerator (it is needed for tunnel approximately 2.5 y’s).
The northern part of Moscow region and the neighboring regions have a developed system of objects of generation and transmission of electrical energy. There are first-rate generating stations: the Konakovo EPS (electric power station, ~30 km from Dubna) and the Udomlia APP (atomic power plant, ~100 km from Dubna).

Two trunk transmission lines with the voltage 220 kV and 500 kV pass through the territory of Dubna.

The investigation of possibilities of the power supply for the accelerator and its infrastructure with the total power up to 300 MW gives the following variant: Construction of the power line - 220 kV, 35÷40 km long, directly from the center of generation – the Konakovo EPS to the Central Experimental Zone of the accelerator with a head step-down substations 220/110 kV.

It will require the investment in larger amount but the cost of power obtained directly from the centers of generation will be lower for 40÷50 % (from 0.05$ per 1kWh down to 0.02-0.03 $ per 1kWh in prices of 2006).
Documentation and Cost Estimation

July 2006 (for Vancouver GDE): JINR prepared and filled the necessary documents for possible ILC hosting to BCD (Conventional Facilities part), so called Site Assessment Matrix.

Official document from Russian State Project Institute (RSPI, Moscow) with estimations on:
• Conventional facilities cost
• Siting (tunnel, land acquisition) cost and time schedule
• Energetic and power cost
• Operational cost
• Labor cost

The overall value on consolidated estimated calculations in the prices of year 2006 for civil engineering work, underground and surface objects of the main construction gives the sum in order of 2,3 B$, including 1 B$ of costs of the tunnels construction for linear accelerator, all its technological systems and mines.

Cost of power supply objects which will provide electric power directly from generator sources with special (favorable) cost of energy (tariff) is of order of 170 M$.

November 2006 (for Valencia GDE):
JINR prepared and filled the necessary documents as a sample site for possible ILC hosting to RDR (Work Breakdown Structure - WBS) – in a special required format with all the details on infrastructure parts. This document was also prepared with RSPI and submitted by Design Cost Board of GDE.
New Project at JINR: Preparation of proposals for JINR participation in design, manufacturing and testing of the Linear Collider element prototypes

**Project leaders:**

A.N. Sissakian  
G.D. Shirkov

**Period:** 2007-2009

**Expected results in 2007:**

- Preparation of works of JINR;
- Participation in estimations and design of ILC elements
PREPARATION OF PROPOSALS FOR JINR PARTICIPATION IN DESIGN, MANUFACTURING AND TESTING OF THE LINEAR COLLIDER ELEMENT PROTOTYPES

Theme leaders: A.N. Sissakian, G.D. Shirkov

Participating countries and international organizations: Byelorussia, Germany, Italy, Russia, USA, Japan, Ukraine, Greece.

Problem and the main goal of investigation: Preparation of proposals for JINR participation in the development of International Linear Collider (ILC).

Expected results at completion phase of theme or projects: Fulfillment of scientific research and design construction works (SR&DCW) in physics and techniques of accelerators, in precision laser metrology and preparation of proposals for the project of JINR participation in international collaboration on the ILC construction.
<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Person in charge at the Laboratory</th>
<th>Key executors and number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elaboration of photoinjector prototype (DLNP, LPP)</td>
<td>I.N. Meshkov, G.V. Trubnikov</td>
<td>Meshkov I.N. + 8, Tyutyunnikov S.I., Kobets V.V. + 3.</td>
</tr>
<tr>
<td>Calculation of electron beam dynamics in the injector (DLNP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculation of electrical and magnetic fields of complex configuration (DLNP)</td>
<td>S.B. Vorozhtsov, G.V. Trubnikov</td>
<td>V.B. Vorozhtsov + 3, G.V. Trubnikov + 2.</td>
</tr>
<tr>
<td>Project of the complex for radiation stability studies (VBLHE)</td>
<td>L.N. Zaitsev</td>
<td>L.N. Zaitsev + 2.</td>
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<tr>
<td>Engineering survey and design developments DLNP, OGE, GSPI</td>
<td>Yu.N. Denisov, G.V. Trubnikov, V.I. Boiko</td>
<td>Yu.N. Denisov + 5. G.V. Trubnikov, V.I. Boiko</td>
</tr>
</tbody>
</table>
LHE ground

Machinery Hall #2: Possible place for location of the Test Bench for experiments on superconducting RF cavities. Adv: Large hall, Power supply, Water supply, very close to systems for liquid Helium and other cryogenics.
LNP ground

Building 118
Location of constructed LINAC-800.
Test of RF accelerator sections and cryo modules LINAC with super-

LINAC-800 – first electron beam on 27.04.2006
LNP ground

Building 108 (LEPTA project)
2 experimental Halls (water, power, …)

Test Bench for Photo Injector
Photoinjector prototype

Several visits and officially organized collaboration with:

1. KEK (Tsukuba, Japan). Visits: June 2006 (I.Meshkov,G.Trubnikov) – signed MoU, October-November (50 days) – Dr. Yu.Korotaev, I.Kryachko for experiments with new KEK RF photogun (participation in design, assembly, tests of injector elements, study of different gun regimes). Collaboration in design and creation of new laser system for KEK “ILC drive beam”.

2. BINP (Novosibirsk). Visit of G.Shirkov and G.Trubnikov. Collaboration on photocathodes manufacturing and vacuum test benches for their assembly (P.Logachev, E.Levichev)


4. DESY (Hamburg and Zeuthen sites), December 2006, visits and negotiations of G.Shirkov and G.Trubnikov. Decision to collaborate and to coordinates activities in ILC at JINR with X-FEL & FLASH at DESY
Design of 4th generation cryomodule prototype

- International collaborative Effort in the three regions
- Design changes are towards nailing down slot length of components
  - Costing should be straight-forward from TTF (and possibly XFEL) experience
Collaboration with INFN (Pisa). Scientist from JINR for almost a year actively works in design bureau at INFN (Pisa). The task is to learn software and standards of cryomodule elements design (ANSYS, I-DEAS)

Several working design documents are created and successfully submitted by INFN and ZENON (Milan). Plans for the 2007 – to have few persons from JINR design bureau at INFN to be involved in.

**Support Posts and Brackets**

At JINR the activity on cryogenic diagnostics is already started and rather well developing and challenging.
Test bench with e-beam at LINAC-800

First beam obtained. Beam with energy of about 20-40 MeV – 2007. A lot of users (including possible ILC – irradiation of detector parts with beam) are ready (Dr.G.Shelkov & team).

Laser metrology

JINR developed test bench at CERN for precise laser metrology. Results of Aug’06 0.5 micron precision of laser beam position measurement on the base of 40m is achieved. At JINR it is planned to set this complex at b.118 (base is 2x250m).

Civil engineering

Very fruitfut collaboration with GSPI. All official documentations (Site Assessment Matrix, Work Breakdown structure, geological and geodetical characteristics) was made by GSPI in the frame of Contracts with JINR. Work is actively going on.

Damping Ring magnetic system simulations

Dr. N.Morozov (with group) in collaboration with INFN-LNF (S.Guiducci) works on design and modeling of magnetic system elements of DR. In near future plans is design and creation of those elements prototype at JINR Workshop and providing their test.
VII International scientific workshop to the memory of Prof. V.P. Sarantsev
Problems of Charged Particle Accelerators:
Electron-positron Colliders

Joint Institute for Nuclear Research (Dubna, Russia) and
Budker Institute of Nuclear Physics (Novosibirsk, Russia)
Alushta (Crimea, Ukraine), September 02-08, 2007

Topics:
- ILC and linear electron-positron colliders
- Circular electron-positron colliders and factories
- New methods of acceleration and applied accelerators

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I.N. Meshkov e-mail: meshkov@jinh.ru
JINR, Dubna, Moscow region, Russia, 141980

Organizing Committee:
Shirkov G.D. – chairman
Levchenk E.B. – vice-chairman
Sumbaev A.P. – scientific secretary
Kuzin M.V.
Petrichenko M.V.
Trunin G.V.
Trunin G.N.
Pinn R.V.
Gorbachev E.V.
Sustina A.V. – secretary

Program Committee:
Meshkov I.N. – chairman
Lebedev A.N. – vice-chairman
Trunin G.V. – scientific secretary
Aizatsky N.I.
Levchenk E.B.
Shatunov Yu.M.
Shirkov G.O.
Sumbaev A.P.
Welcome to JINR (Dubna)
Welcome to JINR (Dubna)
Welcome to JINR (Dubna)