2013

JOINT INSTITUTE FOR NUCLEAR RESEARCH

Joint Institute for Nuclear Research

Phone: (7-49621) 65-059
Fax: (7-495) 632-78-80
E-mail: post@jinr.ru
Address: JINR, 141980 Dubna, Moscow Region, Russia
Web http://www.jinr.ru

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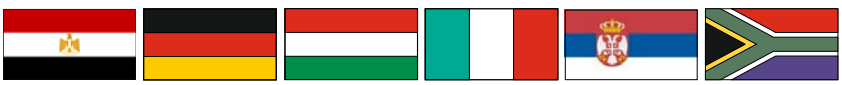
JINR MEMBER STATES

Republic of Armenia
Republic of Azerbaijan
Republic of Belarus
Republic of Bulgaria
Republic of Cuba
Czech Republic
Georgia
Republic of Kazakhstan
Democratic People's Republic of Korea
Republic of Moldova
Mongolia
Republic of Poland
Romania
Russian Federation
Slovak Republic
Ukraine
Republic of Uzbekistan
Socialist Republic of Vietnam



AGREEMENTS ON GOVERNMENTAL LEVEL ARE SIGNED WITH THE FOLLOWING STATES:

Arab Republic of Egypt
Federal Republic of Germany
Republic of Hungary
Italian Republic
Republic of Serbia
Republic of South Africa

CONTENTS

INTRODUCTION

The year 2013 became for the Joint Institute for Nuclear Research the time of crossing a kind of an equator on the way to implement the seven-year programme of development and was rich in outstanding events in all spheres of our international scientific centre. In particular, much progress was attained in the development of most important basic facilities of the Institute: the Nuclotron–NICA superconducting complex, a factory of superheavy elements, the DRIBs-III complex, a complex of cryogenic moderators and spectrometers for the IBR-2 reactor. New impressive results were obtained in rare decays and neutrino oscillations.

Groups of JINR scientists played an important role in upgrading LHC detectors at CERN and technical refining of the Large Hadron Collider, in obtaining new physics results on the basis of the data accumulated during LHC runs. One of the brightest results was the discovery of the Higgs boson at the CERN collider, and physicists from Dubna made their great intellectual contribution into it, as it was acknowledged by the world scientific community.

And now, let us discuss some achievements of the year in more detail. JINR theoreticians for the first time carried out systematic calculations for the three-loop beta-functions of the Standard Model (SM). The obtained results allow one to analyze the behaviour of the SM in the region of TeV and Planck energies. The experimental accuracy of measurements of the calculation parameters is sufficient to demonstrate the SM self-consistency up to energies of 10^{10} GeV.

A new concept was suggested of the grapheme-based tunnel FET. The main idea is in use of two grapheme electrodes with zigzag sides, divided with a narrow rift under the action of the common gate. It was shown that at room temperature this device possesses a distinct switching effect at low voltage in the gate and large coefficient of amplification.

The reaction $pep \to d + \nu_e$ was studied; it is important for the understanding of the neutrino origin with energy $E_\nu = 1.442$ MeV. The calculated neutrino flux turned out to be 40% larger than in calculations where the initial state was considered in two-body approximation; and it was in good agreement with experimental data from the BOREXINO collaboration.

The application of JINR about the discovery of four new superheavy elements submitted to the International Union of Pure and Applied Chemistry (IUPAC) confirms the well-founded leadership of Dubna scientists in heavy-ion physics. In addition, the processing of the results was completed of experiments on the studies of radioactive properties of isotopes of elements 115 and 117 and products of their α-decay synthesized in full fusion reactions $^{243}\mathrm{Am} + {}^{48}\mathrm{Ca}$ and $^{249}\mathrm{Bk} + {}^{48}\mathrm{Ca}$. The radioactive properties of all nuclei in decay chains of isotopes $^{294}117$ and $^{293}117$ coincide with the data measured in the first experiment on the synthesis of element 117 in 2009–2010. It is an independent confirmation of the discovery of new elements 115 and 117.

A factory for superheavy elements was continued to be built. It includes all the complex of the isochronous cyclotrons, which are under upgrading, to accomplish wide research in nuclear physics — both in superheavy elements and exotic nuclei, neutron-rich, light nuclei and innovative studies.

After the refurbishment of the IBR-2 reactor had been completed, the facility was in stable operation at the power of 2 MW providing for experiments at extracted neutron beams with a cryogenic moderator that allowed a 13-time increase of the neutron flux. In 2013, a user programme was successfully started at the upgraded complex of spectrometers of IBR-2. Specialists from 16 countries and JINR staff members conducted experiments in physics, material science, chemistry, biology and biophysics, geology and applied research. The operation of the first stage of the GRAINS reflectometer and experiments on the DN-6 diffractometer started. The latter is included into the list of the best facilities in the world for neutron studies of materials in the conditions of extreme exposure.

Experiments were conducted at the extracted beams from IREN to measure neutron spectra from the gallic neutron-generating target, activities were continued to work out a detailed technical project that concerned the accelerator structure of IREN and transition to the nonmultiplying neutron-generating target of natural uranium.

Physics research programme at the Nuclotron included results on the full energy of the accelerated beam at deuterium nuclei that exceeded 10 GeV. The stability in the operation of the Nuclotron was an important result in the tests of new systems and elements of the accelerator complex of the constructed booster. New systems for transition detecting, a system of diagnostics of the ring thermometry and sensors-thermometers were launched, along with diagnostics and extension of accelerator HF-systems' capabilities, and new power sources with unique characteristics. Many of these systems were developed in JINR Member States: Poland, the Czech Republic, Slovakia, Bulgaria, Romania, Ukraine, Belarus, and others.

A considerable success was achieved in the NICA project in the studies of carbon nuclei — the mode of stochastic cooling for loose and clustered beams was obtained for the first time at the facility and in Russia. This result has a key role in the implementation of the physics programme of development of the NICA complex.

Thanks to cooperation with China in the framework of the NICA project, tests were held in 2013 of high-temperature superconducting current conductors at maximal current. During the visit of RF Prime-Minister D. Medvedev to China, his meeting with Russian and Chinese scientists was held at the Institute of Plasma of the Chinese Academy of Sciences (Hefei). At the meeting representatives of JINR discussed with the Prime-Minister issues of support of the megaproject NICA. D. Medvedev promised to encharge the Government and the Russian Agency on Atomic Energy (Rosatom) with the corresponding tasks.

In 2013, the organization of an international tender to construct the NICA collider was completed. The group of companies and the amount of work were determined. The technical project of the collider underwent the RF state examination. A site for the construction of the accelerator was prepared with an account of all modern requirements.

Studies in neutrino physics and neutrino astrophysics were actively conducted. In particular, much progress was done in the establishment of a neutrino laboratory at the Kalinin NPS. It can become a unique experimental base for neutrino research at JINR and its Member States.

The BES-III collaboration (China) that includes a group of scientists from JINR reported an interesting result — the observation of a new charmonium-like state $Z_c(3900)$. It should be mentioned that specialists from JINR are one of the key programmers for data processing of the BES-III experiment.

A group of scientists from Dubna calibrated the flight module of the "Mercury Gamma and Neutron Spectrometer" (MGNS) that included a gamma spectrometer and a neutron detector for a new expedition to Mercury organized by the European Space Agency "BepiColombo".

In the framework of advanced radiobiological research, experiments were conducted at the U-400M accelerator on irradiation of cells of various organisms with accelerated neon ions with the energy 50 MeV/nucleon. In collaboration with Czech colleagues from the Institute of Biophysics, DNA structure damage in human cells was studied.

In late 2013, in collaboration with Italian colleagues from the National Institute of Cancer (Naples) and universities of Udine and Perugia, JINR physicists conducted experiments on animals at the proton beam of the JINR phasotron. The aim of the experiments was to test a new radioprotector synthesized by Italian specialists from the National Institute of Cancer (Naples). Now radiobiologists from JINR and Italy process and analyze the obtained results.

On the basis of CICC JINR a prototype of the centre of the Tier-1 level was developed for the CMS experiment (LYC, CERN). The Tier-1 centre will be used as a part of a global system of experimental data processing and event modeling data that come from the centre of the Tier-0 type (CERN), as well as the centres of the Tier-1 and Tier-2 levels, the global grid-system LHC — WLCG for the CMS experiment. The process is started to include a computer cluster with hybrid architecture into the computer infrastructure of CICC JINR.

In 2013, over 500 students of the basic chairs of MSU, MIPT, MIREA, the University "Dubna" and universities of JINR Member States took courses at the University Centre of JINR. Fifty persons from Armenia, Belarus, Germany, Moldova, RF and Ukraine studied at the postgraduate courses of JINR. Students from Egypt, the Czech Republic, Poland, Romania, Slovakia, Bulgaria, Ukraine, the USA, the Republic of South Africa, and Belarus had practice courses that were held in three stages.

The programmes of schools for physics teachers at CERN and JINR were supported by a grant of the JINR Directorate. Teachers not only from Russia but from other JINR Member States were invited to take part in these schools.

Young scientists of the Institute took part in competitions for the grants from the President and the Government. The Laureate of the competition for the grant from the President became the physicist-theoretician A. Bednyakov.

In 2013, important measures were taken to intensify contacts with other physics laboratories and international scientific organizations, aiming at a stronger

and closer integration of projects and JINR basic facilities into the European and world scientific research infrastructure. In the first place, one of the bright events of international activities of JINR is the acquisition of the observer status for JINR in such European scientific structures as the Strategic Working Group on Physics and Engineering Sciences of the European Strategy Forum on Research Infrastructures (ESFRI) and the Astroparticle Physics European Consortium (ApPEC).

In 2013, meetings of coordinating committees were held on JINR cooperation with the states JINR Associate members. The Permanent Committee on cooperation with the National Institute for Nuclear Physics (INFN, Italy) started its work. Leaders of international infrastructures visited JINR: ESFRI President B. Vierkorn-Rudolf, President of the European Physical Society L. Cifarelli, Director General of IAEA Y. Amano.

For the first time over many years the Plenipotentiary of Cuba F. Castro Dias-Balart, re-appointed by the government of the country, attended the session of the JINR Committee of Plenipotentiaries. Thus, new prospects for re-establishment of full participation of Cuba in JINR activities were outlined. For the first time as well, Serbia and Cuba paid their contributions into the JINR budget.

One of the outstanding events of the year was the International Workshop "Prospects for Cooperation in the NICA Megascience Project". It resulted in the signing of the Protocol of Intent by representatives of the governments of Belarus, Bulgaria, Germany, Kazakhstan, Russia, Ukraine. Hungary, India, Italy, China, Poland, the Czech Republic, the Republic of South Africa acted as observers. The Meeting encouraged the activation of JINR contacts in many trends. In particular, as a result of negotiations of JINR leaders and the President of the Helmholtz Association J. Mlinek, who headed the German delegation, an Agreement was concluded on the cooperation of JINR with the Helmholtz Association. In total, in 2013 JINR organized and held about 90 conferences, schools, meetings, including those that it organized jointly with other organizations.

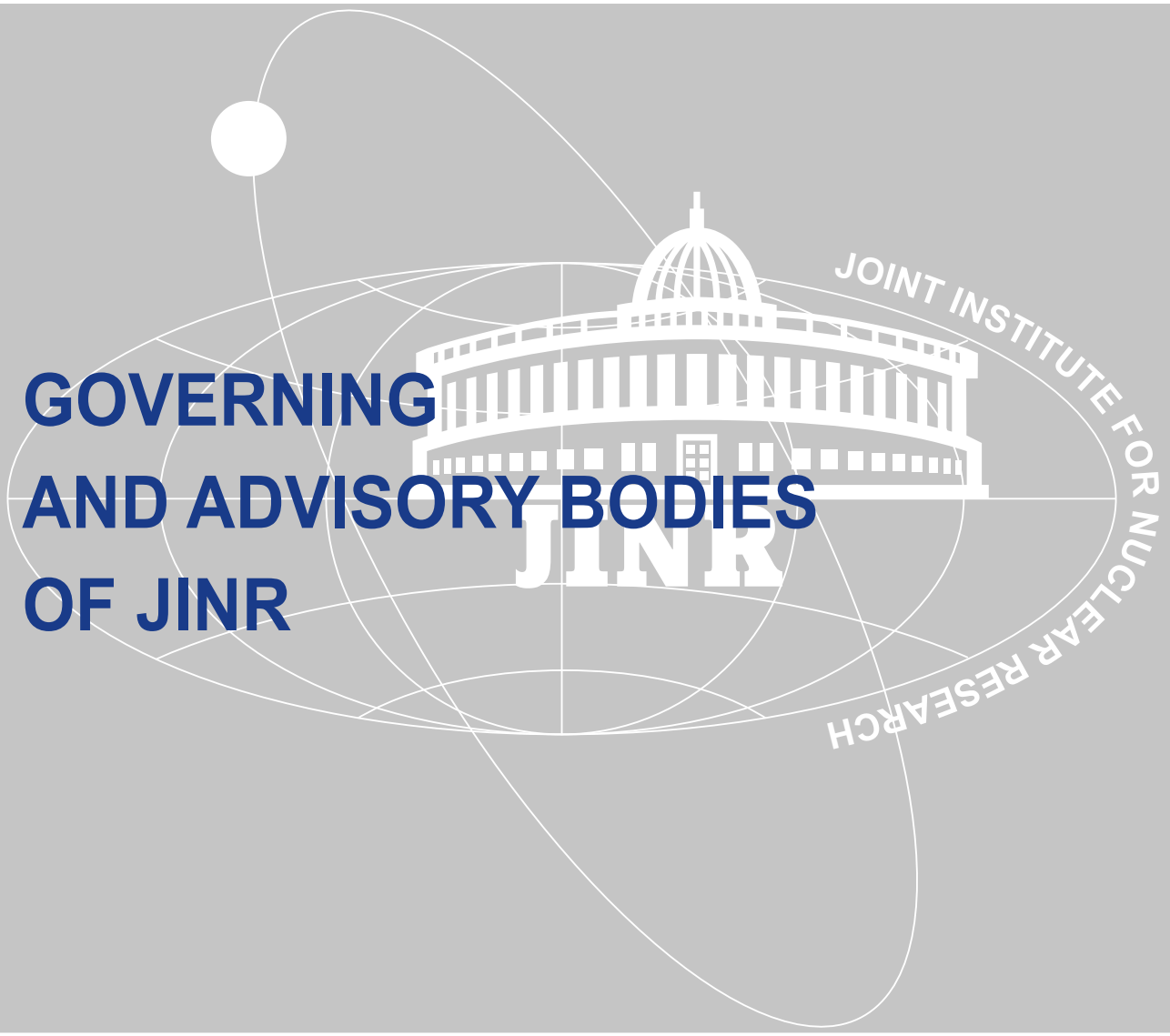
In 2013, the JINR system of administration and social infrastructure continued to be improved. Jubilees of the following outstanding scientists, who made a great contribution to the development of science and played an important role in the establishment and development of our Institute, were marked with celebrations: V. I. Vernadsky, I. V. Kurchatov, G. N. Flerov, V. P. Dzhelepov, B. M. Pontecorvo.

All these achievements demonstrate that the creative atmosphere and high requirements established by the Founders-Fathers help JINR to keep the leading positions as a large international physics centre and allow us to move firmly forward, according to the planned vector of development. They also impose great responsibility on us in the conditions of rivalry in the world scientific community.

V. Matveev
Director
Joint Institute for Nuclear Research

2013

GOVERNING AND ADVISORY BODIES OF JINR



ACTIVITIES OF JINR GOVERNING AND ADVISORY BODIES

SESSIONS OF THE JINR COMMITTEE OF PLENIPOTENTIARIES

A regular session of the Committee of Plenipotentiaries of the Governments of the JINR Member States was held on 25–26 March. It was chaired by the Plenipotentiary of the Slovak Republic, S. Dubnička.

The Committee of Plenipotentiaries (CP) considered the report "Recommendations of the 113th Session of the JINR Scientific Council (February 2012). Results of JINR Activities in 2012" presented by JINR Director V. Matveev. The CP concurred with the high appreciation by the Scientific Council of the scientific results achieved by the JINR staff in 2010–2012 and of the status of today's basic facilities and their upgrades, which on the whole is consistent with the Seven-Year Plan. However, an analysis of these results points to the need of making some adjustments in terms of financial support and time scales of the major projects, taking into account the available human resources. The CP commissioned the JINR Directorate to complete this work by the next session of the Scientific Council with a view to submitting an updated Plan for the Development of JINR for the years 2014–2016 and for the two subsequent years for approval at the CP session in November 2013. The CP endorsed the initiatives by the JINR Directorate towards greater integration into the European scientific community, including participation in the work of the European Strategy Group for Particle Physics, of which JINR is an observer. It also commissioned the JINR Directorate to take official steps towards observer status of JINR at CERN.

Based on the report "Execution of the JINR Budget in 2012" presented by V. Katrasev, Assistant Director of JINR for Financial and Economic Issues, the CP took note of the information presented. The Committee empowered the company "MS-Audit" to examine the JINR financial activity for the year 2013 and approved the plan for auditing this activity presented by the JINR Directorate. The CP commissioned the JINR Directorate and the Working Group for financial issues of JINR under the CP Chairman to finalize the principles for a new methodology being proposed for calculating the Member States' contributions to the JINR budget, taking into account the suggestions and remarks of individual Member States.

Regarding the report "Results of the Meeting of the JINR Finance Committee Held on 22–23 March 2013" presented by S. Kulhánek, Chairman of the Finance Committee, the CP approved the Protocol of this meeting. It also approved JINR's report on the execution of the budget for the year 2012 in expenditure amounting to US$124 704.5 thousand, with the summary account as of 01.01.2013 being US$603 164.8 thousand.

Due to changes in the legislation of the host country of JINR and in view of new challenges facing JINR, the CP commissioned the JINR Directorate and the Working Group for financial issues of JINR under the CP Chairman to analyze and propose amendments in the existing regulations: the "Financial Regulations", the "Internal Financial Rules", and the "Rules of Purchase and Sale of Equipment, Supplies and Other Items".

Regarding the auditors' report concerning the financial activity of JINR examined for the year 2012, presented by A. Sedyshev, Director of the company "MS-Audit", and with the recommendations of the Finance Committee taken into account, the CP approved this report and thanked the company for the high quality of its audit work.

Regarding the report "Further Development of the JINR Innovation Programme" presented by A. Ruzaev, Assistant Director of JINR for Innovation Development, the CP took note of the information presented. It endorsed the Directorate's project "Partnership in Innova-

tions" which foresees the obtaining by JINR of partner status in the European Commission for the implementation of cooperation in the interests of the Member States.

Based on the proposals for the "Election of Members of the JINR Scientific Council" presented by JINR Chief Scientific Secretary N. Russakovich, the CP established the membership of the Scientific Council comprising 50 persons and approved the list of members of the Scientific Council for a new term of five years. The Committee thanked Professors I. Antoniou (Greece), E. Batyrbekov (Kazakhstan), Gh. Căta-Danil (Romania), Chen Hesheng (China), J. Ellis (Switzerland), K. Królas (Poland), V. Kuvshinov (Belarus), A. Logunov (Russia), T. Muminov (Uzbekistan), W. Nawrocik (Poland), Nguyen Van Hieu (Vietnam), Pak Byong Sob (DPRK), J. Ružička (Slovakia), V. Sahni (India), P. Spillantini (Italy), R.-D. Heuer (Switzerland), and Š. Šaro (Slovakia) for the successful work accomplished by them as members of the JINR Scientific Council.

Regarding the information "Amendments in the Rules of Procedure of the JINR Scientific Council" presented by JINR Chief Scientific Secretary N. Russakovich, the CP approved the Rules of Procedure of the JINR Scientific Council with the amendments adopted at the 113th session of the Scientific Council.

The CP heard with interest and discussed the scientific reports "Prospects for Research in Neutrino Physics and Neutrino Astrophysics" presented by A. Olshevskiy, Director of the Dzhelepov Laboratory of Nuclear Problems, and "The Planck Mission of the European Space Agency" presented by P. Fiziev, Leading Researcher of the Bogoliubov Laboratory of Theoretical Physics, and thanked the speakers.

A regular session of the Committee of Plenipotentiaries of the Governments of the JINR Member States was held on 22–23 November. It was chaired by the representative of the Russian Federation, L. Ogorodova.

The Committee of Plenipotentiaries (CP) considered the report "Recommendations of the 114th Session of the JINR Scientific Council (September 2013). Brief Overview of the Results of JINR Activities in 2013 and Plans for 2014" presented by JINR Director V. Matveev. The CP approved the recommendations of the 113th and 114th sessions of the Scientific Council as well as the JINR Topical Plan of Research and International Cooperation for 2014. It recognized the important results produced by the JINR staff both in conducting physics research and in implementing the key objectives of the Seven-Year Plan, in particular: the significant progress in the construction and upgrade of major basic facilities: Nuclotron–NICA, DRIBs-III as well as the cryogenic moderators and the IBR-2 spectrometer complex; the new impressive results produced in the field of rare decays and neutrino oscillations; the new results of physics research and further development of detectors at the Large Hadron Collider as well as the consolidation effort at the LHC itself.

The Committee noted with satisfaction that the work being done by the JINR Directorate towards the establishment of working contacts with European Union countries had led, with the support of Plenipotentiaries of some JINR Member States, to the inclusion of JINR representatives in the ESFRI Strategy Working Group on Physical Science and Engineering.

Regarding the report "Results of the Meeting of the JINR Finance Committee held on 19–20 November 2013" presented by S. Kulhánek, Chairman of the Finance Committee, the CP approved the Protocol of this meeting. It commissioned the JINR Directorate to finalize and send to the Member States the draft texts of the "Regulation for Internal Audit" and of the "Regulation for the Procurement of Goods, Work and Services for Needs of the Joint Institute for Nuclear Research" in order to be considered at the CP session in March 2014.

The CP extended the action of the decision of the Committee of Plenipotentiaries of 25–26 November 2011 (Section VII, paragraph 2) on the suspension of the CP decision of 25–26 March 2011 (Section IV, paragraph 4). In future, in matters concerning taxation of its foreign workers, JINR should be guided by the CP decision of 20–23 September 1956 (Section V), with the inclusion of taxes in the contribution of a country which has sent a worker.

Based on the report "Draft Budget of JINR for the Year 2014, Draft Contributions of the Member States for the Years 2015, 2016, and 2017" presented by V. Katrasev, Assistant Director of JINR for Financial and Economic Issues, the Committee approved the JINR budget for the year 2014 with the total expenditure amounting to US$158.89 million as well as the contributions of the Member States for the year 2014. The Committee determined the provisional volumes of the JINR budgets in income and expenditure for the year 2015 amounting to US$180.73 million, for the year 2016 — US$207.40 million, and for the year 2017 — US$217.56 million. It also adopted the provisional sums of the Member States' contributions and of arrears payments for 2015, 2016, and 2017.

The Committee allowed the JINR Directorate to index the salary and tariff parts of the compensation package of all staff members, taking into account the possibilities afforded by the JINR budget in 2014, in accordance with the JINR Collective Bargaining Agreement for 2011–2013, as well as to limit the annual compensation of direct costs for personnel within the boundaries of a 30% increase of contribution, with account taken of the increase in the JINR budget.

The CP resolved to set up a Working Group of representatives of the Republic of Armenia, the Republic of Belarus, the Republic of Bulgaria, the Russian Federation, and Ukraine for the elaboration of principles for a new methodology to calculate the Member States'

contributions, fixing 2017 as the provisional year for the application of the new methodology.

Until a new methodology has been introduced, a rule will be adopted stipulating that if the contribution of any Member State calculated for the next fiscal year is lower than the direct costs for personnel sent by the Plenipotentiary of this Member State, then the Member State, in addition to its contribution, should pay a compensation in an amount equal to the excess of the direct costs for personnel over the contribution of the Member State.

The direct costs will be calculated as the sum of salary costs, additional labor, voluntary medical insurance and compensation of social costs in Russia for the second half of the year "n–2" and for the first half of the year "n–1", where "n" is the year for which contributions are calculated.

The CP suggested that the JINR Directorate study the possibility of a competitive recruitment of specialists sent by the Plenipotentiary of a country, beyond the contribution of this country at the expense of the JINR budget.

Regarding the report "Analysis of the Implementation of the Seven-Year Plan for the Development of JINR (2010–2016), Forecast for the Years 2014–2016 and for the Two Subsequent Years" presented by JINR Vice-Directors R. Lednický and M. Itkis, the CP appreciated the progress in implementing the Seven-Year Plan in the fields of particle physics and high energy heavy-ion physics, and in the fields of low- and intermediate-energy nuclear physics, nuclear physics with neutrons, and condensed matter physics.

Recognizing the efforts taken by the JINR Directorate to conduct a thorough analysis of the situation with the implementation of the major projects, including the NICA accelerator complex and the construction of the Factory of Superheavy Elements, the CP endorsed the conclusions presented in the reports on the need to implement the major projects of the Seven-Year Plan in full. It was underlined, however, that the analysis of the current situation pointed to the need of making some adjustments in the financial profiles and time scales of the most important projects.

The CP commissioned the JINR Directorate to organize work on a long-term plan for the development of JINR until 2020, taking into account the efforts towards the commissioning of new basic facilities — the NICA complex and the Factory of Superheavy Elements (DRIBs), the development of the research programme in the field of neutrino physics, the further development of the IBR-2 spectrometer complex, of the Information Technology Centre, as well as the implementation of the planned programmes of basic and applied research and the training of young scientists in the interests of the Member States and countries associated with JINR.

SESSIONS OF THE JINR SCIENTIFIC COUNCIL

The 113th session of the JINR Scientific Council took place on 21–22 February. It was chaired by JINR Director V. Matveev and Professor Gh. Stratan of the H. Hulubei National Institute for Physics and Nuclear Engineering (Bucharest).

V. Matveev informed the Scientific Council about the decisions of the session of the Committee of Plenipotentiaries of the Governments of the JINR Member States held in November 2012, about the major results obtained by JINR in 2012 and about the activities planned for 2013.

An analysis of the progress of the implementation of the Seven-Year Plan for the Development of JINR (2010–2016) was presented by Vice-Director R. Lednický in the fields of particle physics and high energy heavy-ion physics, and by Vice-Director M. Itkis in the fields of low- and intermediate-energy nuclear physics, nuclear physics with neutrons, and condensed matter physics.

The Scientific Council heard reports "Heavy-Ion Nuclear Physics at JINR: Prospects and Collaboration" presented by FLNR Scientific Leader Yu. Oganessian, "Prospects for JINR Research in Astrophysics and Neutrino Physics" by DLNP Deputy Director V. Bednyakov, and "Proposals for JINR's Participation in the Upgrades of the LHC and ALICE, ATLAS and CMS Detectors" by JINR Chief Scientific Secretary N. Russakovich.

The recommendations of the Programme Advisory Committees were reported by I. Tserruya (PAC for Particle Physics), W. Greiner (PAC for Nuclear Physics), and P. Alekseev (PAC for Condensed Matter Physics).

Elections of the Directors of FLNP and LIT were held at the session, and vacancies of positions in the directorates of JINR Laboratories were announced by the Scientific Council.

Proposals were presented for amendments in the Rules of Procedure of the Scientific Council.

Diplomas "Honorary Doctor of JINR", the 2012 B. Pontecorvo Prize and diplomas to the winners of JINR prizes for the year 2012 were awarded.

The Scientific Council heard the best reports by young scientists which had been delivered as poster presentations at the PAC meetings.

GOVERNING AND ADVISORY BODIES OF THE JOINT INSTITUTE FOR NUCLEAR RESEARCH

COMMITTEE OF PLENIPOTENTIARIES OF THE GOVERNMENTS OF THE JINR MEMBER STATES

Republic of Armenia	– S. Harutyunyan
Republic of Azerbaijan	– N. Mamedov
Republic of Belarus	– I. Vojtov
Republic of Bulgaria	– L. Kostov
Republic of Cuba	– F. C. Diaz-Balart
Czech Republic	– R. Mach
Georgia	– A. Khvedelidze
Republic of Kazakhstan	– K. Kadyrzhanov
D. P. Republic of Korea	– Li Je Sen
Republic of Moldova	– I. Tighineanu
Mongolia	– S. Davaa
Republic of Poland	– M. Waligórski
Romania	– N.-V. Zamfir
Russian Federation	– D. Livanov
Slovak Republic	– S. Dubnička
Ukraine	– B. Grynyov
Republic of Uzbekistan	– Not appointed
Socialist Republic of Vietnam	– Le Hong Khiem

Finance Committee

One representative of each JINR Member State

SCIENTIFIC COUNCIL

Chairman: V. Matveev
Co-Chairman: M. Waligórski (Republic of Poland)
Scientific Secretary: N. Russakovich

O. Abdinov	– Azerbaijan
T. Baatar	– Mongolia
C. Borcea	– Romania
M. Budzyński	– Poland
L. Cifarelli	– Italy
A. Dubničková	– Slovakia
M. Eliashvili	– Georgia
P. Fré	– Italy
S. Galès	– France
N. Giokaris	– Greece
B. Grynyov	– Ukraine
A. Harrison	– UK
M. Hnatič	– Slovakia
P. Jenni	– Switzerland
M. Jeźabek	– Poland
V. Kadyshevsky	– Russia
E. Kenzhin	– Russia
G. Khuukhenkhuu	– Mongolia
S. Kilin	– Belarus
Kim Son Hyok	– Democratic People's Republic of Korea
M. Kovalchuk	– Russia
G. Kulipanov	– Russia
V. Matveev	– Russia
J. Mnich	– Germany
D. Nagy	– Hungary
Nguyen Manh Shat	– Vietnam
I. Padrón Diaz	– Cuba
G. Piragino	– Italy
G. Poghosyan	– Armenia
S. Pospišil	– Czech Republic
I. Povar	– Moldova
E. Rabinovici	– Israel
V. Rubakov	– Russia
K. Rusek	– Poland
B. Sharkov	– Russia
N. Shumeiko	– Belarus
A. Skrinsky	– Russia
P. Spillantini	– Italy
M. Spiro	– France
H. Stöcker	– Germany
Ch. Stoyanov	– Bulgaria
Gh. Stratan	– Romania
V. Strazhev	– Belarus
N. Tonchev	– Bulgaria
Tran Duc Thiep	– Vietnam
M. Waligórski	– Poland
I. Wilhelm	– Czech Republic
A. Zagorodny	– Ukraine
G. Zinovjev	– Ukraine

Programme Advisory Committee for Particle Physics

Chairperson: I. Tserruya (Israel)
Scientific Secretary: A. Cheplakov

Programme Advisory Committee for Nuclear Physics

Chairperson: W. Greiner (Germany)
Scientific Secretary: N. Skobelev

Programme Advisory Committee for Condensed Matter Physics

Chairperson: V. Kantser (Moldova)
Scientific Secretary: O. Belov

INTERNAL ORGANIZATION OF THE JOINT INSTITUTE FOR NUCLEAR RESEARCH

DIRECTORATE

Director V. Matveev
Vice-Director M. Itkis
Vice-Director R. Lednický
Chief Scientific Secretary N. Russakovich
Chief Engineer G. Shirkov

Bogoliubov Laboratory of Theoretical Physics

Director V. Voronov

Research in
– symmetry properties of elementary particles
– field theory structures
– interactions of elementary particles
– theory of atomic nuclei
– theory of condensed matter

Frank Laboratory of Neutron Physics

Director V. Shvetsov

Research in
– nuclei by neutron spectroscopy methods
– fundamental properties of neutrons
– atomic structure and dynamics of solids and liquids
– high-temperature superconductivity
– reactions on light nuclei
– materials by neutron scattering, neutron activation analysis and neutron radiography methods
– dynamic characteristics of the pulsed reactor IBR-2

Veksler and Baldin Laboratory of High Energy Physics

Director V. Kekelidze

Research in
– structure of nucleons
– strong interactions of particles
– resonance phenomena in particle interactions
– electromagnetic interactions
– relativistic nuclear physics
– particle acceleration techniques
– interactions of multicharged ions in a wide energy range

Laboratory of Information Technologies

Director V. Korenkov

Research in
– provision of operation and development of the JINR computing and networking infrastructure
– optimal usage of international computer networks and information systems
– modern methods of computer physics, development of standard software

Dzhelepov Laboratory of Nuclear Problems

Director V. Bednyakov

Research in
– strong, weak and electromagnetic interactions of particles, particle structure
– nuclear structure
– nuclear spectroscopy
– mesoatomic and mesomolecular processes
– particle acceleration techniques
– radiobiology

Laboratory of Radiation Biology

Director E. Krasavin

Research in
– radiation genetics and radiobiology
– photo radiobiology and molecular biophysics systems
– radiation protection physics

Flerov Laboratory of Nuclear Reactions

Director S. Dmitriev

Research in
– properties of heavy elements, fusion and fission of complex nuclei, cluster radioactivity, reactions on an isomer hafnium target
– reactions with beams of radioactive nuclei, structure of neutron-rich light nuclei, nonequilibrium processes
– interactions of heavy ions with condensed matter
– particle acceleration techniques

University Centre

Director S. Pakuliak

Directions of activities:
– senior students' education
– JINR postgraduate courses
– school students' education
– staff training and retraining
– organization of schools and practice courses in JINR research trends

Central Services

– central scientific and information departments
– administrative and economic units
– manufacturing units

Resolution. General Considerations. The Scientific Council appreciated the progress in implementing the decisions of the Committee of Plenipotentiaries of the Governments of the JINR Member States taken at the session in November 2012, as presented in the report by JINR Director V. Matveev. The principal milestones of the Seven-Year Plan for the Development of JINR for 2010–2016 were noted to be reasonably consistent with the status of today's basic facilities and research programme of JINR. The Scientific Council regarded as very important the task of updating the Seven-Year Plan, taking into account the current status of its implementation as well as recent new developments with the technical projects of the major basic facilities, especially NICA and DRIBs-III.

Recommendations on Reported Activities. The Scientific Council took note of the analysis of the progress of the implementation of the Seven-Year Plan for the Development of JINR (2010–2016). On the whole, the most important results achieved in 2010–2012 were in line with the Seven-Year Plan, a fact deserving high appreciation. An analysis of these results pointed to the need of making some adjustments in terms of financial support and time scales of individual projects. The Scientific Council looked forward to completing this work by its next session with a view of submitting an updated Plan for the Development of JINR for the years 2014–2016 and for the two subsequent years at the session of the Committee of Plenipotentiaries in November 2013 for approval.

The Scientific Council highly appreciated the report "Heavy-Ion Nuclear Physics at JINR: Prospects and Collaboration". It thanked Professor Yu. Oganessian for his long and dedicated work which led JINR to become world leader in the field of the synthesis of superheavy elements.

The Scientific Council noted with interest the report "Prospects for JINR Research in Astrophysics and Neutrino Physics" presented by V. Bednyakov. It supported the activities in this area and recommended that JINR focus on the most important projects in which it could play the leading role and offer major contributions.

The Scientific Council welcomed the idea of constructing a new modern complex for neutrino studies on the site of the Kalinin Nuclear Power Plant in the Tver Region, not far from JINR. The unique features of this complex justifiably promise the production of results of the highest scientific value, in particular in addressing the problem of sterile neutrinos and reactor anomalies, which is certainly important in the context of raising the prestige of JINR and its attractiveness to young researchers from the Member States.

Concerning the proposals for JINR's participation in the upgrades of the LHC and ALICE, ATLAS and CMS detectors presented by Chief Scientific Secretary N. Russakovich, the Scientific Council supported these proposals, and looks forward to being regularly informed at future sessions about the progress of their implementation.

The Scientific Council took note of the progress report from the Update of the European Strategy for Particle Physics presented by the member of the Scientific Council P. Jenni (CERN). A series of draft statements was proposed by the European Strategy Group, of which JINR is an invited member, for approval by the CERN Council in May 2013. The Scientific Council encouraged the JINR Directorate to address the Committee of Plenipotentiaries for its approval of official steps towards observer status of JINR at CERN.

The Scientific Council noted the information on matters related to the publication of the JINR journals "Particle and Nuclei" and "Particle and Nuclei, Letters" presented by the scientific secretaries of these journals, A. Isaev and A. Dorokhov. These concern the new membership of the editorial board of "Particle and Nuclei", and the measures that would improve the organization of the activity of the journal "Particle and Nuclei, Letters", in particular the appointment of a new membership of the editorial board and the acceleration of issues of the electronic version of the journal. The Scientific Council looks forward to further successful work of these scientific journals.

Recommendations in Connection with the PACs. The Scientific Council concurred with the recommendations made by the PACs at their January 2013 meetings as reported at this session by Professors I. Tserruya, W. Greiner, and P. Alekseev.

Particle Physics Issues. The Scientific Council appreciated the progress in realization of the Nuclotron–NICA project, in agreement with the general schedule. It recognized the progress towards the starting of tests of new particle sources and of the booster construction as well as the progress in the intense R&D programme for the heavy-ion linac. It also supported the beginning of NICA building construction in 2013, which is vital to sustaining the project plan.

The PAC supported the recommendations for further improvements of the Nuclotron beam spill quality, and appreciated the reports about the new experimental results obtained with the Nuclotron beams.

The Scientific Council was pleased to note that fourteen new contributions had been added to the NICA White Paper. It strongly supported the PAC's recommendation on the in-depth analysis of many contributions to the White Paper to identify realistic measurements needed for validation of models and theories.

The Scientific Council noted with satisfaction the continuation of a fruitful dialog between the MPD team and the Detector Advisory Committee (MPD–DAC). It congratulated the MPD team on the significant progress made in prototyping and optimizing the detector elements, and welcomed the beginning of the TDR. The Scientific Council thanked the members of the MPD–

DAC for the detailed evaluation of the project and recommended the continuation of regular reviews.

The Scientific Council was pleased to note the considerable progress achieved by the BM@N project in developing the experimental facility and endorsed its continuation until the end of 2016.

The Scientific Council welcomed the PAC's recommendations on the continuation of the current first-priority projects and activities in particle physics, as outlined in the PAC report.

The Scientific Council supported the PAC's recommendations on the approval of JINR's participation in the upgrade programme of the ATLAS and CMS experiments under the general guidance of the JINR Directorate.

Nuclear Physics Issues. The Scientific Council welcomed the successful completion of the experiments on the synthesis of Element 117 at FLNR, which was an outstanding achievement in 2012, in addition to the international recognition of the discoveries of elements 114 and 116.

The Scientific Council noted the information concerning the current status of the development of the IREN facility, and appreciated the progress in the preparation of the research programme including the experimental techniques and instruments. The first results produced with the IREN Phase 1 facility are encouraging, and the activity for the development of the IREN source should continue to reach the design parameters. The Scientific Council looks forward to the assembly of the second accelerator station of IREN and to the improvement of the target within the shortest possible time.

The Scientific Council appreciated the progress of work on the DANSS detector being developed in collaboration with ITEP (Moscow) and the results of experiments with the pilot module DANSSino, which allowed a number of online tests to be performed, the efficiency of the shielding to be checked and real background conditions to be measured.

Condensed Matter Physics Issues. The Scientific Council highly appreciated the successful start of the User Programme at the IBR-2 spectrometer complex. It concurred with the PAC that the extension and implementation of this programme should remain one of the major activities at FLNP in 2013. The Scientific Council also supported the further development of the modernized reactor in terms of construction of new cold neutron moderators.

The Scientific Council appreciated continuation of work for the upgrade of FLNP instruments, in particular the efforts towards construction of the GRAINS new multifunctional reflectometer and commissioning of the upgraded EPSILON-MDS and SKAT diffractometers.

Regarding research in the field of astrobiology as a promising and dynamically developing scientific direction, the Scientific Council supported the PAC's recommendation for the opening of the new theme "Research on Cosmic Matter on the Earth and in Nearby Space; Research on the Biological and Geochemical Specifics of the Early Earth" for the period 2013–2015.

Common Issues. The Scientific Council highly appreciated the work conducted by the JINR University Centre, which carries out the overall coordination of the educational programme at JINR. It supported the recommendations of the PACs concerning the continuation of this activity under the new theme "Organization, Support and Development of the JINR Educational Programme" for the next five-year period.

Reports by Young Scientists. The Scientific Council noted with interest the following reports by young scientists that were selected by the PACs for presentation at this session: "The Kinetics of Cluster Growth in Polar Solutions of Fullerenes: Study of the C60/NMP Solution", "DANSSino: Pilot Version of the DANSS Neutrino Detector", "Precise $\sin^2(2\theta_{13})$ Measurements in the Daya Bay Reactor Neutrino Experiment", and thanked the speakers: N. Jargalan, I. Zhitnikov, and M. Gonchar. It strongly encouraged the continuation of reports by young scientists at future sessions.

Memberships of the PACs. As proposed by the JINR Directorate, the Scientific Council appointed Professor A. Korsheninnikov (Kurchatov Institute, Moscow, Russia) as a new member of the PAC for Nuclear Physics for a term of three years.

Awards and Prizes. The Scientific Council congratulated Professor A. Sigov on the award of the title "Honorary Doctor of JINR".

The Scientific Council approved the Jury's recommendations on the JINR prizes for 2012 in the annual scientific research competition in the fields of theoretical physics, experimental physics, physics instruments and methods, and applied physics.

The Scientific Council congratulated Professor E. Fiorini (University of Milan – Bicocca, Italy) on the award of the 2012 B. Pontecorvo Prize for his outstanding contributions to the experimental search of neutrinoless double-beta decay, in particular to the pioneering development of the semiconductor and cryogenic techniques applied for registration of this process. The Scientific Council thanked Professor E. Fiorini for his inspired presentation.

Elections and Announcement of Vacancies in the Directorates of JINR Laboratories. The Scientific Council elected by ballot V. Shvetsov as Director of the Frank Laboratory of Neutron Physics (FLNP) and V. Korenkov as Director of the Laboratory of Information Technologies (LIT), each for a term of five years. It also elected M. Veselský as Deputy Director of the Flerov Laboratory of Nuclear Reactions (FLNR), until the completion of the term of office of the FLNR Director.

The Scientific Council thanked A. Belushkin and V. Ivanov for their successful tenure as Directors of FLNP and LIT, respectively.

The Scientific Council announced the vacancies of the positions of Deputy Directors of FLNP and LIT, and of a Deputy Director of VBLHEP. The election for these positions took place at the 114th session of the Scientific Council.

Rules of Procedure. The Scientific Council supported the proposed amendments concerning the endorsed appointment by ballot of Deputy Directors of JINR Laboratories. It adopted an updated text of the Rules of Procedure of the JINR Scientific Council with account of the remarks given at this session and recommended their approval by the Committee of Plenipotentiaries.

Closing the session, JINR Director V. Matveev expressed sincere appreciation to the members of the Scientific Council on the occasion of the completion of their five-year term of service.

The 114th session of the JINR Scientific Council took place on 19–20 September. It was chaired by JINR Director V. Matveev and Professor M. Waligórski of the H. Niewodniczański Institute of Nuclear Physics and Oncology Centre (Kraków, Poland).

V. Matveev informed the Scientific Council about the progress in implementing the recommendations of its 113th session and of the decisions of the session of the Committee of Plenipotentiaries of the Governments of the JINR Member States (March 2013).

An analysis of the ongoing implementation of the Seven-Year Plan for the Development of JINR (2010–2016) and proposals for updates of the Plan were presented by Vice-Director R. Lednický in the fields of particle physics and high energy heavy-ion physics, and by Vice-Director M. Itkis in the fields of low- and intermediate-energy nuclear physics, nuclear physics with neutrons, and condensed matter physics.

The recommendations of the Programme Advisory Committees were reported by I. Tserruya (PAC for Particle Physics), W. Greiner (PAC for Nuclear Physics), and V. Kantser (PAC for Condensed Matter Physics).

Election of the Director of DLNP and the endorsement of appointments of Deputy Directors of FLNP, LIT, and VBLHEP were held, and vacancies of positions in the directorates of JINR Laboratories were announced.

The Scientific Council heard the scientific report "Reactor Neutrino Experiments: Status and Prospects" presented by DLNP Director A. Olshevskiy and the report "The Importance of Physics to the Economies of Europe" presented by the Vice-President of the European Physical Society and a member of the JINR Scientific Council, L. Cifarelli.

The Scientific Council heard the best reports by young scientists which had been recommended by the PACs. Diplomas to the winners of JINR prizes for the year 2012 were awarded.

Members of the Scientific Council attended the inauguration of a monument to V. Dzhelepov and B. Pontecorvo.

Resolution. General Considerations. The Scientific Council appreciated the progress in implementing the recommendations of its 113th session and the decisions of the session of the Committee of Plenipotentiaries of the Governments of the JINR Member States (March 2013) as presented in the report by JINR Director V. Matveev.

Among others, the Scientific Council recognized the following recent achievements:

— the significant progress in the development of major home facilities: Nuclotron–NICA, DRIBs-III as well as the cryogenic moderators and the spectrometers at the IBR-2 reactor;

— the new impressive results produced in the field of rare decays and neutrino oscillations;

— the important role of JINR's groups in the upgrade of the LHC detectors as well as the consolidation effort at the LHC itself; at the same time, the new results from recent LHC runs.

The Scientific Council was pleased to note the active work being done by the JINR Directorate to intensify cooperative contacts with other physics laboratories and international bodies such as CERN aimed at stronger integration of JINR's projects and facilities into European and worldwide research infrastructures.

Recommendations on Reported Activities. The Scientific Council appreciated the progress in implementing the Seven-Year Plan for the Development of JINR (2010–2016) presented by Vice-Directors R. Lednický and M. Itkis. In accordance with the recommendations of the Scientific Council, the JINR Directorate had carefully reviewed the situation with the implementation of the major projects, including the NICA facility, the construction of a Factory of Superheavy Elements, the research programme in the field of neutrino physics, and the further development of the spectrometer complex at the IBR-2 reactor. On the whole, the Scientific Council endorsed the conclusions presented in these reports.

The Scientific Council took note of the report "Reactor Neutrino Experiments: Status and Prospects" presented by DLNP Director A. Olshevskiy. It underlined the scientific importance of neutrino physics experiments and the significant role of JINR played in them.

The Scientific Council noted with interest the report "The Importance of Physics to the Economies of Europe" presented by L. Cifarelli. In 2012, the EPS commissioned the Centre for Economics and Business Research to conduct an independent economic analysis based on statistics in the public domain through Eurostat and covering 29 European countries. The detailed analysis performed over the period 2007–2010

enabled the contribution that physics makes to the European economy to be meaningfully compared to other sectors such as manufacturing, construction and retail. It was shown that businesses in physics-based sectors contribute very significantly to employment, innovation and growth in Europe. The EPS report highlighted the need to support physics at all levels: in education, research, business and industry. The Scientific Council appreciated the conclusions presented in the report and thanked Professor L. Cifarelli for it.

Recommendations in Connection with the PACs. The Scientific Council concurred with the recommendations made by the PACs at their June 2013 meetings as reported at this session by Professors I. Tserruya, W. Greiner, and V. Kantser.

Particle Physics Issues. The Scientific Council appreciated the good progress towards the realization of the Nuclotron–NICA project and congratulated VBLHEP on the stable operation of the Nuclotron as demonstrated in the successful accomplishment of Run 47 and on the realization of stochastic cooling for the first time at this facility and in Russia at large. It also supported the strategy of the Laboratory management for further improvements of the physics research programme and the active collaboration with the Nuclotron beam users.

The Scientific Council reaffirmed its strong support to the fixed target programme using Nuclotron beams and the BM@N experiment, viewing it as an essential element of the NICA project. It welcomed the PAC's recommendations on the formation of a BM@N Detector Advisory Committee similar to the very successful one established for the MPD. The Scientific Council encouraged the interaction between theorists and experimentalists in the process of the prioritization of the NICA White Paper contributions with the goal to develop a Physics Performance Report of BM@N and MPD.

The Scientific Council appreciated the significant progress made in prototyping detector elements for the MPD, noting the critical issues related to the MPD magnet manufacturing and to the NICA hall civil engineering. It also appreciated the important role of the Detector Advisory Committee (DAC), thanked the members of the MPD–DAC for the MPD project evaluation and recommended continuation of regular reviews.

The Scientific Council supported the PAC's recommendations on the continuation of the current activities in particle physics, as outlined in the PAC report.

Nuclear Physics Issues. The Scientific Council supported the recommendation made by the PAC to strongly encourage the JINR Directorate for securing not only the financial issues but also human resources needed for a successful achievement of the ambitious DRIBs-III project. It also concurred with the following first-priority tasks to be implemented in full under the JINR Seven-Year Plan: construction at JINR of the world's first Factory of Superheavy Elements (SHE), including construction and commissioning of a new accelerator, DC-280, and construction of a new building with experimental set-ups; implementation of the research programme on SHE synthesis using the U400 cyclotron; completion of the upgrade of the U400M cyclotron; preparatory and design work for the modernization of the experimental hall of the U400 cyclotron and for the upgrade of this facility.

The Scientific Council appreciated the high quality of the research underway and the important results produced at JINR in the field of neutrino physics, also the substantial contributions being made by JINR to the future neutrino experiments. The Scientific Council welcomed the idea of constructing a new laboratory at the Kalinin Nuclear Power Plant to become a unique experimental infrastructure for neutrino research for JINR and its Member States.

Emphasizing the need for continued support for priority areas of research, namely the synthesis and study of superheavy elements and the neutrino programme, the Scientific Council recommended that the Directorate take appropriate measures to maintain the world-leading role of JINR.

The Scientific Council recommended continuing scientific activities in nuclear theory as well as in nuclear physics and in nuclear physics with neutrons by BLTP and by FLNP, respectively, in 2014–2016 with first priority, within the themes reviewed by the PAC. The FLNP Directorate should accelerate the construction of the necessary beam infrastructure for the IREN facility.

The Scientific Council fully supported the proposal made by JINR Director V. Matveev to organize a workshop of competent specialists from Russia and elsewhere on nuclear transmutation in view of the preliminary results of JINR research of accelerator-driven systems.

Condensed Matter Physics Issues. The Scientific Council highly appreciated the smooth operation of the IBR-2 reactor after completion of its modernization as well as the first scientific results obtained with extracted neutron beams. The construction and development of the complex of cryogenic moderators at the reactor is also very important. The Scientific Council supported the PAC's recommendations on the extension of the theme "Development of the IBR-2 Reactor with a Complex of Cryogenic Neutron Moderators" for the period 2014–2016 and on the opening of a new project, "Construction of a Complex of Cryogenic Moderators at the IBR-2 Reactor", within this theme.

The Scientific Council appreciated the start of experimental work at the DN-6 diffractometer and at the GRAINS reflectometer as well as efforts towards the development of the NERA-PR spectrometer.

The Scientific Council supported the continuation of theory activities in the field of condensed matter physics

in 2014–2018 at BLTP under a new theme — "Theory of Condensed Matter". It also welcomed the opening of the new theme "Methods, Algorithms, and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data" at LIT for the period 2014–2016. In view of the progress in JINR educational activities, the Scientific Council appreciated the opening of the University Centre's new project "Development of Modern Education Programmes" for 2014–2016.

Reports by Young Scientists. The Scientific Council noted with interest the following reports by young scientists, which were recommended by the PACs for presentation at this session: "Small-Angle Scattering from Multi-Phase Systems: Investigation of the Crossover between Porod and Fractal Regimes" by E. Anitas, "Measurements of Muon Forward-Backward Asymmetry in Drell–Yan Processes with the CMS Experiment" by I. Gorbunov, and "Bivalve Mussels in Biomonitoring of the South Africa Atlantic Coastal Waters" by Z. Goryainova. The Scientific Council thanked the speakers for their excellent presentations.

Memberships of the PACs. The Scientific Council thanked the outgoing members: Professors L. Riccati (INFN, Turin, Italy) and Yifang Wang (IHEP, Beijing, China) for their successful work as members of the PAC for Particle Physics.

Prizes. The Scientific Council congratulated the laureates of the JINR prizes for 2012 — winners of the annual scientific research competition in the fields of theoretical physics, experimental physics, physics instruments and methods, and applied physics.

Election of the Co-chairman of the Scientific Council. The Scientific Council elected Professor M. Waligórski as Co-chairman of the Scientific Council for a term of three years.

Election and Announcement of Vacancies in the Directorates of JINR Laboratories. The Scientific Council elected V. Bednyakov as Director of the Dzhelepov Laboratory of Nuclear Problems for a term of five years. The Scientific Council thanked A. Olshevskiy for his successful tenure as Director of this Laboratory.

The Scientific Council endorsed the appointment of O. Culicov and E. Lychagin as Deputy Directors of the Frank Laboratory of Neutron Physics, Gh. Adam and T. Strizh as Deputy Directors of the Laboratory of Information Technologies, and A. Sorin as Deputy Director of the Veksler and Baldin Laboratory of High Energy Physics, until the completion of the terms of office of the directors of their respective Laboratories.

The Scientific Council announced the vacancies of the positions of Deputy Directors of the Dzhelepov Laboratory of Nuclear Problems. The endorsement of the appointment for these positions will take place at the 115th session of the Scientific Council.

The Scientific Council endorsed the proposal by the Director of the Frank Laboratory of Neutron Physics, V. Shvetsov, to announce the vacancy for the position of a third Deputy Director at this Laboratory. The endorsement of the appointment for this position will take place at the 115th session of the Scientific Council.

The Scientific Council announced the vacancies of the positions of Directors of the Veksler and Baldin Laboratory of High Energy Physics and of the Laboratory of Radiation Biology. The election for these positions will take place at the 116th session of the Scientific Council.

In Memory of Štefan Šáro. The Scientific Council deeply regretted the sad loss of Professor Š. Šáro (Comenius University, Bratislava, Slovakia), a member of the JINR Scientific Council during 1993–2013, who made outstanding contributions to the development of JINR and its international cooperation.

MEETINGS OF THE JINR FINANCE COMMITTEE

A meeting of the JINR Finance Committee was held in Dubna on 22–23 March. It was chaired by S. Kulhánek, a representative of the Czech Republic.

The Finance Committee considered the report "Recommendations of the 113th Session of the JINR Scientific Council (February 2013). Brief Overview of the Results of JINR Activities in 2012" presented by JINR Director V. Matveev. The Finance Committee highly appreciated the results produced by the JINR international staff in 2012. Taking note of the recommendations of the Scientific Council concerning the analysis of the progress of implementation of the Seven-Year Plan for the Development of JINR (2010–2016) and acknowledging that the results achieved in 2010–2012 are in line with the Seven-Year Plan, the Finance Committee emphasized the need of making some adjustments in the plan, which is particularly related to timely completion of technical projects for the major basic facilities — NICA and DRIBs-III. It looked forward to being presented a detailed update of the plan at the next meeting in November 2013.

Regarding the report "Regulatory Documents of JINR and Internal Audit Service" presented by S. Kulhánek, the Finance Committee recommended that

the Committee of Plenipotentiaries (CP) commission the JINR Directorate and the Working Group for financial issues of JINR under the CP Chairman to analyze and propose amendments in the existing regulations: the "Financial Regulations", the "Internal Financial Rules", and the "Rules of Purchase and Sale of Equipment, Supplies and Other Items", due to changes in the legislation of the host country of JINR and in view of new challenges facing JINR. It was also recommended that an Internal Audit Service be established at JINR.

Regarding the report "Execution of the JINR Budget in 2012" presented by V. Katrasev, Assistant Director of JINR for Financial and Economic Issues, the Finance Committee recommended that the CP take note of the information on the execution of the JINR budget in 2012 in expenditure — US$124 704.5 thousand, and in income — US$122 005.2 thousand, that the CP empower the company "MS-Audit" to examine the JINR financial activity for the year 2013 and approve the plan for auditing this activity presented by the JINR Directorate.

Based on the information presented by A. Sedyshev, Director of the company "MS-Audit", the Finance Committee recommended that the CP approve the auditors' report concerning the JINR financial activity for 2012 and that it thank "MS-Audit" for the high quality of its audit work.

The Finance Committee heard and discussed a report by V. Katrasev, Assistant Director of JINR for Financial and Economic Issues, concerning the new methodology being proposed for calculating the Member States' contributions to the JINR budget.

The Finance Committee thanked V. Korenkov, Director of the Laboratory of Information Technologies, for the informative scientific report "Prospects for the Development of the JINR Computing Complex" presented at this meeting.

A meeting of the JINR Finance Committee was held on 19–20 November. It was chaired by S. Kulhánek, a representative of the Czech Republic.

The Finance Committee heard the report "Recommendations of the 114th Session of the JINR Scientific Council (September 2013). Brief Overview of the Results of JINR Activities in 2013 and Plans for 2014" presented by JINR Director V. Matveev.

The Finance Committee welcomed the efforts by the JINR Directorate aimed at the formation of a consortium of countries willing to take part in the mega-science project for the construction of a superconducting heavy-ion collider, which had received a high expert evaluation from international organizations, in line with the instruction of the governmental commission of the Russian Federation of 5 July 2011.

The Finance Committee recommended that the Committee of Plenipotentiaries (CP) commission the JINR Directorate to organize work on a long-term plan for the development of JINR until 2020, taking into account the efforts towards the commissioning of new basic facilities — the NICA complex and the Factory of Superheavy Elements (DRIBs), as well as towards the implementation of the planned programmes of basic and applied research and the training of young scientists in the interests of the Member States and countries associated with JINR.

The Finance Committee noted the activities of the JINR Directorate towards gradual improvement of the managerial efficiency at JINR and pointed to the need to further update the documents of the JINR regulatory system with the current challenges and the experience of leading international scientific organizations taken into account. The Committee recommended that the CP commission the JINR Directorate to finalize and send to the Member States the draft texts of the "Regulation for Internal Audit" and of the "Regulation for the Procurement of Goods, Work and Services for Needs of the Joint Institute for Nuclear Research" in order to be considered at the CP session in March 2014.

The Finance Committee recommended that the CP extend the action of the decision of the Committee of Plenipotentiaries of 25–26 November 2011 (Section VII, paragraph 2) on the suspension of the CP decision of 25–26 March 2011 (Section IV, paragraph 4). In future, in matters concerning taxation of its foreign workers, JINR should be guided by the CP decision of 20–23 September 1956 (Section V), with the inclusion of taxes in the contribution of a country which has sent a worker.

The Finance Committee recommended that the CP set up a Working Group of representatives of the Republic of Armenia, the Republic of Belarus, the Republic of Bulgaria, the Russian Federation, and Ukraine for the elaboration of principles for a new methodology to calculate the Member States' contributions, fixing 2017 as the provisional year for the application of the new methodology.

Until a new methodology has been introduced, a rule should be adopted stipulating that if the contribution of any Member State calculated for the next fiscal year is lower than the direct costs for personnel sent by the Plenipotentiary of this Member State, then the Member State, in addition to its contribution, should pay a compensation in an amount equal to the excess of the direct costs for personnel over the contribution of the Member State.

The direct costs should be calculated as the sum of salary costs, additional labor, voluntary medical insurance and compensation of social costs in Russia for the second half of the year "n–2" and for the first half of the year "n–1", where "n" is the year for which contributions are calculated.

The Finance Committee recommended that the annual compensation of direct costs for personnel be limited within the boundaries of a 30% increase of contribution, with account taken of the increase in the JINR budget.

Based on the report "Draft Budget of JINR for the Year 2014, Draft Contributions of the Member States for the Years 2015, 2016, and 2017" presented by V. Katrasev, Assistant Director of JINR for Financial and Economic Issues, the Finance Committee recommended that the CP approve the JINR budget for the year 2014 with the total expenditure amounting to US$158.89 million as well as the contributions of the Member States for the year 2014. The Committee determined the provisional volumes of the JINR budgets in income and expenditure for the year 2015 amounting to US$180.73 million, for the year 2016 — US$207.40 million, and for the year 2017 — US$217.56 million. It also adopted the provisional sums of the Member States' contributions and of arrears payments for 2015, 2016, and 2017. It was also recommended to allow the JINR Directorate to index the salary and tariff parts of the compensation package of all staff members, taking into account the possibilities afforded by the JINR budget in 2014, in accordance with the JINR Collective Bargaining Agreement for 2011–2013.

Regarding the report presented by VBLHEP Deputy Director G. Trubnikov "Preparation of NICA Construction", the Finance Committee recognized the progress in the preparation of the Technical Design Project and construction work for the NICA complex and congratulated the JINR staff on the successful passing of the state examination for the project.

Taking note of the results of work of the international tender commission to select a general contractor for the construction of the NICA complex, the Finance Committee appreciated the efficient work done by the commission and endorsed the Directorate's efforts to attract companies from the Member States to participate in the tender.

The Finance Committee endorsed the rating of the participating companies presented: 1) CJSC "Strabag"; 2) PSJ (Czech Republic); 3) Budostal-3 (Poland), and commissioned the JINR Director to organize work for the preparation and signature of a General Contractor Contract until 10 February 2014.

The Finance Committee took note of the report by LIT Group Head M. Bashashin, in which information was presented concerning the transition to Platform 1C 8.2. "Industrial Enterprise Management" at JINR, the implementation of an electronic document flow system and the development of NICA project management software.

The Finance Committee thanked VBLHEP Group Head J. Mitrofanova for the interesting and informative report "Cryogenics at NICA".

MEETINGS OF THE JINR PROGRAMME ADVISORY COMMITTEES

The 37th meeting of the Programme Advisory Committee for Condensed Matter Physics was held on 21–22 January. It was chaired by Professor V. Kantser.

The Chairperson of the PAC presented a short overview of the PAC report delivered at the session of the JINR Scientific Council in September 2012 and information about the implementation of the recommendations taken at the previous PAC meeting. JINR Vice-Director M. Itkis informed the PAC about the Resolution of the 112th session of the JINR Scientific Council and about the decisions of the JINR Committee of Plenipotentiaries.

The PAC highly appreciated the successful start of the FLNP User Programme in 2012 at the IBR-2 spectrometer complex and the experiments already performed, noting that the extension and implementation of the User Programme at the IBR-2 spectrometers should remain one of the major activities at FLNP in 2013.

The PAC noted the information on the start-up of a cold neutron moderator at the modernized IBR-2 reactor, which makes it possible to perform experiments at a qualitatively new level. It also encouraged the JINR Directorate to purchase a new modern cryogenic refrigerator for cold moderators to be constructed.

The PAC reviewed status reports on upgrades of FLNP instruments. It expressed concern about the delay in the construction of the GRAINS new multifunctional reflectometer with horizontal sample plane. The PAC recommended that the management of this activity take all measures to complete the basic configuration of this instrument. It is expected that the results of first measurements with GRAINS would be presented at the next meeting of the PAC.

Concerning the report on the commissioning of the upgraded EPSILON and SKAT diffractometers and on beam 7A upon completion of the installation of new modernized neutron guides, the PAC suggested readjusting the background chopper and the collimator as well as improving the quality of vacuumization on beams 7A1 and 7A2 used for the EPSILON-MDS and SKAT instruments, respectively.

The PAC heard with great interest a proposal for the opening of a new theme and project: "Research on Cosmic Matter on the Earth and in Nearby Space; Research on the Biological and Geochemical Specifics of

the Early Earth", noting that the Laboratory of Radiation Biology is regarded as an excellent site for playing the central role in the project by setting up a cosmic dust data bank. The PAC called the attention of the proposers to the possibilities offered by nuclear analytical methods not yet foreseen in the proposal but available either at JINR or with its cooperation partners. The development of this research is important not only for exploration of basic aspects of the appearance and evolution of biological systems on the Earth in connection with space objects, but also for practical realization of space travelling. The use of physical methods of analysis is the general idea of the suggested theme. The PAC considered the proposed approaches to be an essential factor of progress in this new and dynamically developing scientific direction and recommended the opening of this new theme for the period 2013–2015.

The PAC heard a report on the activity of the University Centre (UC) within the framework of the theme "Organization, Support and Development of the Education Process at JINR". It approved the proposed continuation of this activity in 2014–2018 under a new theme entitled "Organization, Support and Development of the JINR Educational Programme", noting that in implementing this new theme, the UC should strengthen cooperation with leading universities of the Member States in order to attract young people to the implementation of the flagship projects at JINR.

The PAC heard with interest the following scientific reports: "Kinetic Effects in Fullerene Solutions" by T. Tropin and "Parametric Resonance in a System of Coupled Josephson Junctions" by Yu. Shukrinov, and noted their high quality.

The PAC took note of the information about the visiting session of the Bureau of the Division of Physiology and Fundamental Medicine of the Russian Academy of Sciences (DPFM RAS), held in Dubna on 27–28 June 2012. It particularly noted the DPFM RAS policy decisions reflecting the strategy of further space radiobiology research at JINR, and encouraged regular organization of scientific conferences as visiting sessions of RAS Divisions hosted by JINR.

The PAC considered the poster presentations by FLNP young scientists in the various fields of condensed matter physics. The poster "The Kinetics of Cluster Growth in Polar Solutions of Fullerenes: Study of the C60/NMP Solution" by N. Jargalan was selected as the best poster at this session. The PAC also noted two other high-quality posters: "Measurements of Beam Profiles at the IBR-2 Reactor" by A. Churakov and "Pressure-Induced Changes in Perovskite-Type Ferroelectrics" by S. Jabarov.

The 37th meeting of the Programme Advisory Committee for Nuclear Physics was held on 24–25 January. It was chaired by Professor F. Piquemal.

The Chairperson of the PAC meeting presented a report on the implementation of the recommendations taken at the previous meeting. JINR Vice-Director M. Itkis informed the PAC about the Resolution of the 112th session of the Scientific Council (September 2012) and about the decisions of the Committee of Plenipotentiaries (November 2012).

The PAC noted that the successful completion of the experiments on the synthesis of Element 117 was one of the most outstanding achievements in 2012, in addition to the international recognition of the discoveries of elements 114 and 116.

The PAC heard a report concerning the current situation with the development of the IREN facility, and appreciated the progress in the preparation of the research programme including the experimental techniques and instruments. The first results produced with the IREN Phase 1 facility are encouraging, but the activity for the development of the IREN source should continue to reach the parameters of the full project. The PAC looks forward to the assembly of the second accelerator station and to the improvement of the target within the shortest possible time.

The PAC took note of the report on the activity of the JINR University Centre (UC) within the framework of the theme "Organization, Support and Development of the Education Process at JINR". It recommended completion of the current theme in 2013 and the opening of a new theme "Organization, Support and Development of the JINR Educational Programme" for a period of five years (2014–2018), with first priority.

The PAC noted the report on the DANSS project being developed together with ITEP (Moscow). The aim is to develop an antineutrino detector based on solid plastic scintillators to monitor neutrino flux from the nuclear reactor and to search for the existence of sterile neutrinos. Mounting of the real DANSS detector was planned to be started in March 2013, during the planned interruption in the reactor operation. The experiments with the simplified pilot module DANSSino (1/25 part of the DANSS detector) allowed a number of online tests to be performed and the efficiency of the shielding together with the performance of the acquisition system to be checked.

The PAC heard a report on the scientific programme dedicated to first experiments with secondary beams of radioactive nuclei with ACCULINNA-2 fragment separator. It supported the suggestion to include a zero-degree spectrometer in this set-up in order to extend its experimental potential, in particular by providing invariant mass measurements.

The PAC heard a report dedicated to studies with beams of light exotic nuclei with the use of "A High-Resolution Magnetic Analyzer (MAVR)" — a new set-up which is essentially composed of an MSP-144 magnet and a quadrupole doublet and which is planned to be installed in the U400R cyclotron hall. It would operate either with primary beams or with radioactive ion beams delivered by the U400–U400M accelerator complex. The PAC recommended that a report con-

cerning the improvement of the MAVR mass analyzer resolving power with a more sophisticated time-of-flight system be presented at one of the forthcoming PAC meetings.

The PAC heard the scientific reports: "Investigation of T-odd Effects in Fission Induced by Polarized Neutrons" by Yu. Kopatch and "Ultracold Few-Body Processes in Atomic Traps" by V. Melezhik.

The PAC was pleased with the presentations of new results and proposals by young scientists in the field of nuclear physics research. Three best posters were selected: "DANSSino: Pilot Version of the DANSS Neutrino Detector" by I. Zhitnikov, "Influence of the Shell Structure of Colliding Nuclei in Fusion-Fission Reactions" by V. Litnevsky, and "An Algorithm for the Numerical Solution of Two-Dimensional Scattering Problem" by E. Koval and O. Koval. The PAC recommended that the report by I. Zhitnikov be presented at the 113th session of the Scientific Council in February 2013.

The 38th meeting of the Programme Advisory Committee for Particle Physics took place on 28–29 January. It was chaired by Professor I. Tserruya.

JINR Vice-Director R. Lednický informed the PAC about the Resolution of the 112th session of JINR Scientific Council (September 2012) and about the decisions of the JINR Committee of Plenipotentiaries (November 2012).

The PAC noted with interest the report on the realization of the Nuclotron–NICA project and recognized the progress achieved towards starting the tests of new particle sources, starting the booster construction and maintaining the intense R&D programme for the heavy-ion linac and future collider. It supported the beginning of the NICA building construction in 2013 as a very important decision, which allows sustaining the project plan.

The PAC appreciated the report about the stable operation of the Nuclotron during Run 46 (November–December 2012), encouraged the plans on further improvement of beam spill quality and welcomed the reports about the new experimental results obtained with the Nuclotron beams.

The PAC appreciated the new contributions to the NICA White Paper dedicated to the research programme of the NICA project. It recommended continuation of this important work and realization of in-depth analysis of the many contributions in the White Paper to identify realistic measurements needed for validation of models and theories, in coordination with the MPD and BM@N experiments.

The PAC acknowledged the continuation of an intensive and fruitful dialog between the MPD team and the MPD Detector Advisory Committee. It congratulated the MPD team on the significant progress made in prototyping detector elements and in optimizing the detector performance, and welcomed the beginning of TDR preparation and technical reports on the main subsystems.

The PAC noted with interest the reports on realization of the BM@N, Linear Collider, OPERA and BOREXINO projects and recommended their continuation. It appreciated the importance of JINR's participation in the upgrade of ALICE, ATLAS and CMS detectors at the LHC and recommended approval of these projects until the end of 2015, according to their focused identification of high-priority detector upgrade items.

The PAC noted with interest two scientific reports: "The First Lessons of the LHC: Higgs Boson and Supersymmetry" and "Dispersion Forces: Theory and Experiment" presented by D. Kazakov and I. Pirozhenko. It appreciated the report "Electromagnetic Calorimetry for JINR and CERN Experiments" presented by A. Nagaytsev about the successful tests of the electromagnetic calorimeter prototype with the new readout technology developed at JINR, and congratulated the team members on the important achievement towards further performance improvements of the COMPASS detector at CERN and the MPD at JINR.

There were more than 20 presentations in particle physics by young scientists from BLTP, DLNP, and VBLHEP at the poster session. The PAC selected the poster "Precise $\sin^2(2\theta_{13})$ Measurements in the Daya Bay Reactor Neutrino Experiment" presented by M. Gonchar to be reported at the session of the Scientific Council in February 2013.

The 38th meeting of the Programme Advisory Committee for Condensed Matter Physics was held on 17–18 June. It was chaired by Professor V. Kantser.

The Chairperson of the PAC presented a short overview of the PAC report delivered at the session of the JINR Scientific Council in February 2013 about the implementation of the recommendations taken at the previous PAC meeting. JINR Vice-Director M. Itkis informed the PAC about the Resolution of the 113th session of the JINR Scientific Council and the decisions of the JINR Committee of Plenipotentiaries.

The PAC heard with interest a report on the activities accomplished in 2011–2013 under the theme "Development of the IBR-2M Reactor with a Complex of Cryogenic Neutron Moderators" and a proposal for its extension for the period 2014–2016. The PAC was pleased to note that after completion of modernization the IBR-2 reactor operates trouble free at a power of 2 MW and provides implementation of the physics programme using extracted neutron beams in accordance with the plan including experiments with the CM 202 cryogenic moderator for neutron beams 7–11. The PAC emphasized that the major part of work towards the development and construction of the complex of cryogenic moderators is being carried out in the world for the first time. New scientific and technical so-

lutions being used for the development of the complex require a large amount of experimental research concerning the stage-by-stage implementation of the complex of cryogenic moderators. The PAC recommended continuation of this theme in 2014–2016.

Concerning the information on the scientific results in the field of condensed matter physics produced at the modernized IBR-2 reactor, the PAC underlined the importance of implementing the experimental physics programme in accordance with the user policy. It also emphasized the significance of continued work towards commissioning the physical instruments being upgraded on extracted neutron beam lines, also the necessity and relevance of the proposed activities for the development of new reactor safety-related equipment, in particular, a reserve movable reflector MR-2R.

The PAC was pleased with the report on the concluding theme "Theory of Condensed Matter and New Materials". It highly appreciated the results obtained in the main research directions: physical properties of complex materials and nanostructures, mathematical problems of many-particle systems. It also appreciated the interrelation between the ongoing theoretical studies and JINR experimental programmes. The PAC supported the continuation of theory activities in condensed matter physics in 2014–2018 under a new theme "Theory of Condensed Matter" that should incorporate development of analytical and numerical methods in studies of complex many-body and nanostructural systems which are of current interest in this field of modern physics.

The PAC took note of the written report on the concluding theme "Mathematical Support of Experimental and Theoretical Studies Conducted by JINR" and of the proposal for the opening of a new theme "Methods, Algorithms, and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data" within the research field "Networking, Computing, Computational Physics". Stressing the high level, relevance and demand of the proposed topic at JINR and its Member States, the PAC recommended the opening of the new theme for the period 2014–2016.

The PAC approved the proposal for the opening of a new project "Development of Modern Education Programmes" within the University Centre's new theme "Organization, Support and Development of the JINR Educational Programme" for 2014–2016. It especially noted the high level of the project's urgency, its significance for the improvement of education quality and for the involvement to science of talented young people from JINR Member States.

The PAC appreciated the beginning of experimental measurements with the DN-6 diffractometer and the new prospects for scientific research associated with the commissioning of this instrument. Taking into account that DN-6 becomes one of the world-leading instruments for neutron scattering studies of matter under extreme conditions, the PAC recommended that further development of this diffractometer and its introduction to the User Programme should remain one of the first-priority activities at FLNP.

The PAC was informed about the status of the GRAINS project on the construction of the new multifunctional reflectometer with horizontal sample plane at channel 10 of the IBR-2 reactor. It appreciated the start of experimental work at the reflectometer, expecting that the commissioning of the instrument first stage will be completed in 2013.

The PAC took note of the report on the current state of the NERA-PR spectrometer. It suggested that the quality of vacuumization of the neutron guide splitter be improved and the development of sample environments be completely supported.

The PAC heard with much interest the scientific reports: "Radiation Stability of Nanostructured Materials Irradiated with Heavy Ions of Fission Fragment Energy" by V. Skuratov, "Spin-Fluctuation Mechanism of High-Temperature Superconductivity in Cuprates" by N. Plakida, and "Neutron Sonde Microscopy for the Investigation of Magnetic Microstructures" by S. Kozhevnikov. It congratulated the authors on their outstanding results, and recommended continuation of the practice of scientific reports at its future meetings.

Considering the poster presentations by BLTP young scientists, the PAC selected the poster "Small-Angle Scattering from Multi-Phase Systems: Investigation of the Crossover between Porod and Fractal Regimes" presented by E. Anitas as the best poster at the session and recommended it to be reported at the session of the Scientific Council in September 2013. The PAC also noted two other high-quality posters: "Study of Electron Tunneling in Graphene–DNA–Graphene System" (O. Isaeva) and "Optical Conductivity of Systems with Strongly Correlated Electrons" (A. Vladimirov).

The PAC visited the Science and Production Complex "Beta" located in the Special Economic Zone (SEZ) "Dubna". It welcomed the organization of such visits to other sectors of the SEZ as well.

The 38th meeting of the Programme Advisory Committee for Nuclear Physics was held on 20–21 June. It was chaired by Professor W. Greiner.

The Chairperson of the PAC presented information concerning implementation of the recommendations taken at the previous meeting. JINR Vice-Director M. Itkis informed the PAC about the Resolution of the 113th session of the Scientific Council (February 2013) and the decisions of the Committee of Plenipotentiaries (March 2013).

The PAC heard a report concerning three years of work accomplished at FLNR under the Seven-Year Plan for the Development of JINR for 2010–2016. It highly appreciated the Laboratory's achievements in the main research areas, including the realization of the DRIBs-III project, which is proceeding according to the previously approved schedule. Taking into account

the significant extension of this project, the PAC recommended making adjustments to fully improve it in terms of budget and schedule. The following first-priority tasks should be implemented in full under the Seven-Year Plan: construction of the world's first Factory of Superheavy Elements (SHE), including construction and commissioning of the new DC-280 accelerator, and construction of a new building with experimental set-ups for the synthesis and studies of SHE properties; implementation of the research programme on SHE synthesis (at U400); completion of the upgrade of U400M and construction of the new ACCULINNA-2 separator for research on exotic radioactive nuclei. The PAC strongly encouraged the JINR Directorate to secure not only the financial issues but also the human resources needed for successful achievement of the ambitious DRIBs-III project.

The PAC heard a report on neutrino physics at JINR. It noted the high level of the research underway and the quality of the JINR contributions to the future neutrino experiments. The PAC welcomed the idea of constructing a new laboratory at the Kalinin Nuclear Power Plant which will be a unique experimental infrastructure for neutrino research for JINR and its Member States.

The PAC took note of the report on the closing theme "Nuclear Structure and Dynamics" and of the proposal for a new theme entitled "Theory of Nuclear Structure and Nuclear Reactions". The PAC highly appreciated the results obtained in the main research directions: nuclear structure far from stability, nucleus–nucleus collisions, few-body systems, nuclear dynamics at relativistic energies, properties of hot and dense nuclear matter. It supported the continuation of nuclear theory activities under the new theme for 2014–2018, with first priority.

The PAC heard a report on the theme "Investigations in the Field of Nuclear Physics with Neutrons" and of the proposal for its extension. It noted the large volume and high quality of work accomplished at FLNP within this theme, including the start of an experimental programme on nuclear data and applied studies using IREN and IBR-2, such as measurements of (n, p) and (n, α) reaction cross sections at neutron energies of several MeV. Significant progress was made in the experimental test of the weak equivalence principle using ultracold neutrons, in studies of peculiar T-odd effects in ternary fission. The PAC recommended that the research activities in nuclear physics be continued with first priority in 2014–2016 within the framework of this theme and that a new project "Development of IREN Facility" be prepared for presentation at its next meeting.

The PAC heard reports on the TRITON and GDH&SPASCHARM projects under the theme "Physics of Light Mesons" and proposals for their continuation. The TRITON project is aimed at obtaining new data for fusion reactions in hydrogen isotopes catalyzed by negative muons in an experiment that will be carried out at the JINR Phasotron. The analysis of the experimental data will allow the determination of yields in pt-synthesis with high accuracy. The GDH&SPASCHARM project is aimed, firstly, at the experimental study at the U70 accelerator (IHEP, Protvino) of the proton spin structure including the determination of gluon contribution to the proton spin in deep inelastic processes (SPASCHARM), and secondly, at the investigation of helicity dependence of the meson photoproduction with polarized photon beams at the MAMI microtron in Mainz (GDH). At this microtron, the world's first experimental value of one of spin polarizabilities of the proton was measured. The PAC appreciated the quality of preparation for the experiments as parts of the TRITON and GDH&SPASCHARM projects and recommended their extension for the years 2014–2016.

The PAC heard the scientific reports: "State of the Art in Neutron Activation Analysis at the IBR-2 Reactor" by M. Frontasyeva and "Research of Accelerator-Driven Systems at JINR and Their Development Prospects" by W. Furman. JINR Director V. Matveev proposed to organize a workshop of competent specialists from Russia and elsewhere on nuclear transmutation in view of the preliminary results of JINR research of accelerator-driven systems.

The PAC was pleased with the presentations of new results and proposals by young scientists in the field of nuclear physics research. The following were selected to be best posters: "Bivalve Mussels in Biomonitoring of the South Africa Atlantic Coastal Waters" by Z. Goryainova, "Active Moss Biomonitoring of Trace Element Distribution in Belgrade Canyon Streets" by M. Aničić, and "Boron-10 Gas Detector for Time-of-Flight Spectrometry with UCN" by S. Goryunov. The PAC recommended the poster by Z. Goryainova for presentation at the 114th session of the Scientific Council in September 2013.

The PAC members visited the Academician Alexey Sissakian Education Centre in the International University "Dubna".

The 39th meeting of the Programme Advisory Committee for Particle Physics was held on 10–11 June. It was chaired by Professor I. Tserruya.

The PAC was informed by JINR Vice-Director R. Lednický on the Resolution of the 113th session of the JINR Scientific Council (February 2013) and on the decisions of the JINR Committee of Plenipotentiaries (March 2013).

The PAC took note of the realization of the Nuclotron–NICA project and congratulated the NICA staff on the stable operation of the Nuclotron as demonstrated in Run 47, on the significant progress achieved in improving the beam quality and on the successful realization of stochastic cooling for the first time at the Nuclotron.

The PAC reaffirmed its strong support to the fixed target programme using Nuclotron beams and the BM@N experiment considering it as an essential and integral element of the NICA project. The PAC urged the BM@N management to seek the necessary resources and commitments from the collaborating institutions to ensure the timely realization of this programme in coordination with the machine schedule. In particular, a viable plan should be developed to have the Stage 1 detector set-up ready in time for the first Nuclotron beams.

Concerning the information presented on the progress towards the NICA White Paper, the PAC was pleased to note the first step made towards a prioritization of the White Paper contributions and recommended continuation of this important work encouraging collaboration between theorists and experimentalists in this process with the goal to develop a Physics Performance Report of BM@N and MPD.

The PAC took note of the MPD progress report, acknowledged the relevance of the NICA physics programme and supported the proposed experimental strategy for the first years of NICA running. It appreciated the significant progress made in prototyping detector elements and noted the critical issues related to the MPD magnet manufacturing and to the NICA hall civil engineering. The PAC welcomed the status of TDR preparation and supported the TPC technical project.

Noting with interest the presentation by H. Gutbrod on behalf of the MPD Detector Advisory Committee (DAC), the PAC appreciated the important role of the DAC in the MPD project evaluation and recommended continuation of regular reviews.

The PAC noted the progress achieved by the JINR physicists in upgrades of the LHC detectors and appreciated the scientific significance of the results obtained in the experiments during the first runs of the LHC. The PAC encouraged the group members to strengthen their talks at conferences, thesis awarded, and participation in the data analysis.

The PAC congratulated the JINR group and the BES-III collaboration on the interesting result — the observation of a new charged charmonium-like state $Z_c(3900)$, and recommended continuation of this project until the end of 2016.

The PAC appreciated the results of the closing theme "Theory of Elementary Particles", recognizing the interconnection of the theoretical studies and the JINR experimental programmes, and supported the continuation of theoretical research in elementary particle physics within a new theme "Theory of Fundamental Interactions" for the period 2014–2018.

The PAC appreciated the report on the closing theme "Modern Mathematical Physics: Gravity, Supersymmetry, Integrability". It noted the success in organizing international conferences, workshops and schools, and supported the continuation of activities in modern mathematical physics within a new theme "Modern Mathematical Physics: Strings and Gravity, Supersymmetry and Integrability" for the period 2014–2018.

The PAC supported the proposal for the opening of a new theme "Methods, Algorithms, and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data". Regarding the 'Development of numerical methods, algorithms, and software, computationally adapted to multicore and hybrid architectures' as a prime task of LIT, the PAC recommended approval of this theme for the period 2014–2016. For the other parts of the proposal, where LIT experts support and participate in research programmes not linked to the JINR IT infrastructure, the PAC requested clarification from the LIT management as to its strategy on how to distribute its resources, on which research areas to enter, and eventually on how to make the clients participate in covering the costs for this support.

Recognizing the need for substantial increase of the JINR IT resources and the importance of JINR's Tier-1 centre, the PAC recommended approval of the new "Information and Computing Infrastructure of JINR" for the period 2014–2016.

The PAC highly appreciated the successful results of educational programmes on modern theoretical physics, the organization of workshops and schools for students and young scientists, the training courses for students, graduates and PhD students from the Member States and other countries within the theme "Dubna International Advanced School of Theoretical Physics (DIAS-TH)". It supported the continuation of educational activities in theoretical physics within this theme for the period 2014–2018.

The PAC took note of the written reports for the DIRAC, PANDA, and CBM experiments, as well as reports for the COMPASS-II experiment and for the project "Study of Deep Subcritical Electronuclear Systems and Feasibility of Their Application for Energy Production and Radioactive Waste Transmutation Presented". It recommended their continuation until the end of 2016 (for the DIRAC experiment until the end of 2015).

The PAC highly appreciated the scientific report "Observation and Study of Unanticipated Charmonium-Like States at BES-III" presented by D. Dedovich.

The PAC noted with interest the poster presentations in particle physics by young scientists from BLTP, LIT, and VBLHEP. It selected the poster "Measurements of Muon Forward-Backward Asymmetry in Drell–Yan Processes with the CMS Experiment" presented by I. Gorbunov to be reported at the session of the Scientific Council in September 2013.

PRIZES AND GRANTS

The laureate of the **Bruno Pontecorvo Prize for the year 2013** is Professor Luciano Maiani (Sapienza University of Rome, Italy) — for his outstanding contributions to elementary particle physics, in particular to weak interaction physics and neutrino physics.

The Presidium of the Russian Academy of Sciences awarded the **V. G. Khlopin Prize for the year 2013** to Doctor of Physics and Mathematics S. N. Dmitriev (Joint Institute for Nuclear Research), for the cycle of papers "Identification and Study of Chemical and Nuclear Physics Properties of New Superheavy Elements of the D. I. Mendeleev Periodic Table of Elements".

The Scientific Council of the Institute for Nuclear Research, RAS, took the decision to award **the Prize in honour of Academician M. A. Markov for the year 2013** to Yu. G. Kudenko, Professor, Doctor of Physics and Mathematics, Head of the Department of High Energy Physics of INR RAS, and to A. G. Olshevskiy, Doctor of Physics and Mathematics, Director of the Dzhelepov Laboratory of Nuclear Problems, JINR. The Prize is awarded for the "Contribution into Research of Neutrino Oscillations in Experiments with Neutrino from Accelerators and Reactors and into Measurements of the Mixing Angle θ_{13}".

JINR PRIZES FOR 2013

I. Theoretical Physics Research

First Prize

"Theory of Spin Fluctuations and High-Temperature Superconductivity in Cuprates".

Authors: N. Plakida, S. Adam, G. Adam, A. Vladimirov, D. Ihle, V. Oudovenko.

Second Prize

"Transition Form Factor $\gamma\gamma^* \to \pi^0$ as a Precision Test for Collinear QCD".

Authors: A. Bakulev, S. Mikhailov, A. Pimikov, N. Stefanis.

II. Experimental Physics Research

First Prize

"Experimental Studies of Exotic Nuclei ^{26}S, ^{10}He, ^{6}Be and Development of Correlation Analysis Methods".

Authors: M. Golovkov, L. Grigorenko, L. Egorova, S. Krupko, Yu. Parfenova, S. Sidorchuk, R. Slepnev, G. Ter-Akopian, A. Fomichev, V. Chudoba.

Second Prizes

1. "High-Precision Tests of Lepton Universality in Charged Kaon Decays".

Authors: E. Goudzovski, V. Kekelidze, D. Madigozhin, Yu. Potrebenikov.

2. "Neutron Channeling in Layered Structures and Its Application for the Development of the Neutron Sonde Microscopy Method".

Authors: V. Ignatovich, S. Kozhevnikov, Yu. Nikitenko, Th. Keller, J. Major, F. Ott, F. Radu, A. Rühm, A. Thiaville, Yu. Khaydukov.

III. Physics Instruments and Methods

First Prize

"JINR Grid Infrastructure as a Component of Russian and Worldwide Grid".

Authors: N. Astakhov, S. Belov, A. Dolbilov, N. Gromova, V. Korenkov, N. Kutovskiy, V. Mitsyn, T. Strizh, E. Tikhonenko, V. Trofimov.

Second Prizes

1. "Development and Construction of the Pelletized Cold Moderator of the IBR-2 Reactor".

Authors: V. Ananiev, A. Belyakov, M. Bulavin, A. Verkhoglyadov, E. Kulagin, S. Kulikov, A. Kustov, K. Mukhin, I. Natkaniec, E. Shabalin.

2. "Diagnostic Systems for Low-Energy and Low-Intensity Beams of Radioactive Nuclei".

Authors: R. Astabatyan, M. Ivanov, R. Kavalov, S. Lukyanov, E. Markaryan, V. Maslov, Yu. Penionzhkevich, L. Perrot, R. Revenko, V. Smirnov.

IV. Applied Physics Research

First Prize

"Designing, Construction and Commissioning of the DC-110 Heavy-Ion Cyclotron Complex for the Industrial Production of Track Membranes".

Authors: S. Bogomolov, B. Gikal, G. Gulbekyan, S. Dmitriev, I. Ivanenko, G. Ivanov, N. Kazarinov, I. Kalagin, N. Osipov, S. Pashchenko.

Second Prizes

1. "Recent Advances on Cryomodule of International Linear Collider Update Using Ti and Nb Explosion Welding with Stainless Steel".

Authors: A. Basti, F. Bedeschi, Ju. Budagov, E. Harms, R. Kephart, S. Nagaitsev, V. Rybakov, B. Sabirov, Ju. Samarokov, G. Shirkov.

2. "Implementation of the Operation Mode of the AIC-144 Cyclotron (Poland) for the Proton Therapy of Eye Melanoma".

Authors: K. Daniel, K. Gugula, J. Sulikowski, I. Amirhanov, G. Karamysheva, I. Kiyan, N. Morozov, E. Samsonov.

Encouraging Prizes

1. "Spin Dependence of Cross Sections for Interaction of Antiprotons with Deuterium and ^{3}He Nuclei".

Authors: Yu. Uzikov, J. Haidenbauer.

2. "Development and Start-up of the Stochastic Cooling System for Nuclotron Ion Beams at the NICA Accelerator Complex".

Authors: V. Seleznyov, A. Sidorin, G. Trubnikov, N. Shurkhno, T. Katayama, R. Stassen.

GRANTS

In 2013, to implement scientific projects, the staff members of the Joint Institute for Nuclear Research received financial support of the Russian Foundation for Basic Research (RFBR) and funds of the RF Ministry of Education and Science.

The Russian Foundation for Basic Research financed JINR projects in the framework of the following competitions: "Ambitious Scientific Research Projects" — 53 projects; "Scientific Projects Implemented by Young Scientists" — 4 projects; "Scientific Research by Young Scientists from CIS Countries in Russian Scientific Institutions" and "Scientific Projects Implemented by Young Scientists under the Guidance of Candidates and Doctors of Science in RF Scientific Institutions" — 3 projects; "Fundamental Research-Based Projects" — 10 projects.

RFBR, together with the Belarusian Republican Foundation for Basic Research financed 1 project; together with the German Research Foundation — 3 projects; together with the State Foundation of Natural Sciences of China — 2 projects; together with the Ministry of Education, Culture and Science of Mongolia — 3 projects; together with the State Foundation for Basic Research of Ukraine — 2 projects; together with the National Centre for Scientific Research of France — 2 projects; together with the Society of Promoting Science of Japan — 1 project; together with the European Centre for Nuclear Research (CERN) — 3 projects.

RFBR rendered financial support to JINR for organization of 13 scientific conferences in the framework of the competitions "Organization of Russian and International Scientific Events in the Territory of Russia" and "Organization of Scientific Events for Young Researchers in the Territory of Russia".

Fourteen projects were financed in 2013 in the framework of the competition of research projects of the Belarusian Republican Foundation for Basic Research (BRFBR) and the Joint Institute for Nuclear Research.

Financial support was rendered in the competition of the programme "Scientific Electronic Library" to obtain the access to electronic scientific information resources of foreign publishing houses.

2013

INTERNATIONAL RELATIONS AND SCIENTIFIC COLLABORATION

COLLABORATION IN SCIENCE AND TECHNOLOGY

The main results of the international cooperation in science and technology of the Joint Institute for Nuclear Research in 2013 reflect the following data:

— joint research was conducted with scientific centres in the Member States, as well as with international and national organizations in other countries on 43 topics of first priority and 1 topic of second priority;
— to solve cooperation issues and questions of participation in scientific meetings and conferences, the Joint Institute sent 2823 specialists;
— for joint work and consultations, as well as for participation in meetings, conferences and schools held at JINR, 1944 specialists were received;
— 51 international scientific conferences and schools, 24 workshops and 15 meetings were organized and held;
— 16 scholarship holders worked at the Institute Laboratories.

The international cooperation of JINR is presented in agreements and treaties. Its development comprises joint experiments at basic facilities of physics centres, the acquisition of research data, preparation of joint publications of the joint research results, the supply of equipment and techniques for the interested sides, etc.

On 14–15 January, an international conference was held on the occasion of 40 years of cooperation between the Joint Institute for Nuclear Research and the National Institute of Physics of Nucleus and Elementary Particles of France (IN2P3). Renowned world leaders of joint research and young physicists who are involved in new international projects took part in the event. The scientific programme of the conference covered the aspects of cooperation between the centres and issues of development of nuclear physics experiments in France and Dubna.

JINR Director Academician V. Matveev opened the conference and said that the cooperation of scientists from Dubna and French scientific centres started in 1957 — a year after JINR was established — when two scientists from France worked in Dubna. In 1958, the Laureate of the Nobel Prize Frederic Joliot-Curie came to JINR on a visit. To commemorate this event, one of the first streets in Dubna and a square where the administration building of JINR is situated were called after the physicist. Later, an avenue called after Dubna appeared in the French city Caen. In 1972, the first official agreement was signed on cooperation between JINR and IN2P3. It was initiated by Academician N. N. Bogoliubov who headed the Joint Institute, and Jean Teillac, one of the pioneers of nuclear physics in France, a pupil and a follower of F. Joliot-Curie. By the decision of the JINR Scientific Council in 2007, the name of Jean Teillac was given to one of the alleys in the territory of the Institute.

Scientific Leader of the JINR Flerov Laboratory of Nuclear Reactions Academician Yu. Oganessian, who worked in the IN2P3 laboratory in Orsay for 18 months, made a report where he spoke about the beginning and development of ties among physicists from Dubna and France.

In the framework of the conference meetings of the Coordinating Committee were held on the issues of cooperation. The guests from France visited Laboratories of the Institute, basic and experimental facilities, and discussed in detail the current and future joint projects.

On 23–24 January, JINR Director V. Matveev visited Yerevan, Armenia. He had negotiations with President of the National Academy of Sciences of Armenia Radik Martirosyan of a deal to cooperate in science, innovations and education. The sides intend to conduct research in physics, nuclear power, nanotechnology, energy and information technologies together.

On 24 January, Acting Governor of the Moscow region A.Vorobiev visited JINR. He was received at the Flerov Laboratory of Nuclear Reactions, where the scientific leader of the Laboratory Yu. Oganessian, JINR Vice-Director M. Itkis and the Laboratory Director S. Dmitriev spoke to the guest about the research,

facilities and scientific achievements. A. Vorobiev was shown the part of the U-400M accelerator complex where new elements are synthesized, and the cyclotron IC-100 used for the production of track membranes.

A. Vorobiev also visited VBLHEP where he was shown the NICA/MPD complex which is under construction. The Laboratory Director V. Kekelidze talked about the research programme and the accelerator complex project.

A meeting with the Dubna citizens was held at the JINR Scientists' Club. Representatives of JINR, the city administration, the Special Economic Zone, the University "Dubna", the city-forming enterprises and public organizations took part in the event.

On 13 February, a delegation from Japan visited JINR. It included partners of the All-Russian Public Organization of Small and Medium Enterprises "Opora Rossii" (Russia's Pillar) — representatives of Japanese public organizations, corporations of innovations in medicine, and commercial companies. The guests visited LRB, FLNR, the Medical-Technical complex of DLNP. A round-table meeting and discussions with JINR leaders were held at the JINR Scientists' Club.

A representative delegation from Ukraine headed by Extraordinary and Plenipotentiary Ambassador of Ukraine in RF V. Elchenko visited JINR **on 20 February**. The delegation included staff members of the Embassy, the National Academy of Sciences of Ukraine, scientific research institutes, and Kiev National University.

At the JINR Directorate, the guests were informed about the history, structure and international cooperation of the Institute, as well as about the projects under implementation and scientific results acknowledged internationally. The sides discussed cooperation with Ukrainian scientists in all directions of research — in fundamental studies, innovations and educational programmes.

After the meeting at the JINR Directorate the guests were shown largest basic facilities at VBLHEP, FLNR, the Medical-Technical Complex of DLNP. To crown the visit, the members of the Ukrainian delegation finally had a meeting with Ukrainian JINR staff members at the JINR Scientists' Club.

On 22 February, members of the JINR Scientific Council, members of the Committee on JINR–INFN cooperation, and DLNP staff members participated in the opening ceremony of the memorial plate of the European Physical Society (EPS) at B. Pontecorvo's study at the Dzhelepov Laboratory of Nuclear Problems.

EPS President Luisa Chifarelli (the National Institute for Nuclear Physics, Italy) opened the ceremony. She stressed the fact that the centenary jubilee of Bruno Pontecorvo coincided with the 45th anniversary of the European Physical Society that was established to demonstrate the resolution of scientists to communicate regardless of their political views. According to her words, the idea to mark historic places with memorial plates was suggested in 2010 to stress the importance of scientific cooperation and solidarity of scientists in Europe. B. Pontecorvo's study at DLNP in JINR is the fourth place marked with the plate of the European Physical Society. The first memorial plate was installed in Rome at the E. Fermi Institute for Nuclear Research.

JINR Director V. Matveev characterized Bruno Pontecorvo as an outstanding physicist and a man who made a great contribution to the development of JINR and science in general. A new laureate of the Pontecorvo Prize, Professor of the University of Milano E. Fiorini, attended the opening ceremony.

The first meeting of the permanent committee on cooperation between the National Institute for Nuclear Physics (INFN, Italy) and JINR was held **on 22 February** at the Dzhelepov Laboratory of Nuclear Problems. It was attended by INFN representatives and staff members of the Embassy of Italy in RF, members of the JINR Directorate and representatives of Laboratories.

The agenda of the meeting included reports on research in elementary particle physics, nuclear physics and applied studies conducted at INFN. Leaders of JINR and its Laboratories gave reviews on activities at the Institute. Prospects of cooperation between the two centres were discussed.

In conclusion, an Agreement on cooperation between INFN (Pisa section) and JINR was signed in the framework of the previous multipurpose agreement between INFN and JINR.

The 23rd meeting of the Coordinating Committee on the implementation of the Agreement on cooperation between the Federal Ministry of Education and Research of Germany (BMBF) and JINR was held **on 28 February** at DESY (Hamburg, Germany). The JINR delegation was headed by JINR Director V. Matveev. Director General for the BMBF Department "Large Research Infrastructures, Energy and Basic Research" Dr. Beatrix Vierkorn-Rudolf headed the BMBF delegation. A two-day meeting on elaboration of recommendations on most perspective directions of research in the framework of the Agreement preceded meetings of the Committee.

The main scientific results of JINR activities of 2012, the programme of scientific research in 2013, the results of the first three years of implementation of the JINR Seven-Year Development Plan, modern trends of policy in the fields of fundamental natural sciences in Germany and Europe were discussed during the meeting. The sides noted with satisfaction the successful development of cooperation between scientists of JINR and Germany. The financial report on the expenditure of funds allocated by BMBF for the implementation of the Agreement was discussed in detail.

Members of the Committee visited the complex of the European X-Ray free electron laser XFEL, which

is being established, the research complex of the synchrotron radiation source PETRA-3, the free-electron laser in soft X-ray regions, FLASH, and the Center for Free-Electron Laser Science CFEL.

On 11–12 March, a workshop on joint research of the Budker Institute for Nuclear Physics (Novosibirsk) and JINR in the NICA project was held at the Veksler and Baldin Laboratory of High Energy Physics. The INP delegation included leading specialists in beam dynamics in colliders, electron cooling, high-frequency systems, magnetic systems, and power systems for accelerators. It was headed by Director of the Institute A. Skrinsky and his deputies E. Levichev and V. Parkhomchuk. A specialist in particle dynamics, one of the members of the international expert committee on the NICA project P. Zenkevich (ITEP, Moscow) took part in the workshop. JINR was represented by leaders of the project and system designers of the NICA complex.

The cooperation with INP on the NICA project started in 2008. At present, high-frequency stations for the booster are produced in Novosibirsk; physics specifications for the booster electron cooling system, the channel of beam transport from the Nuclotron into the collider and the collider high-frequency system have been worked out.

The current status of the project and results of the accomplished work were reported. In particular, it was decided that specialists from INP would conduct calculations of the ion dynamics in the collider, and take part in the elaboration and, possibly, production of the electron cooling system for the collider. An opportunity was also discussed to manufacture in Novosibirsk pulsed current septums for injection into the collider. The final variant of the pulsed magnetic-focusing system of the Nuclotron–collider channel was adopted taking into account that it would be designed and manufactured at INP. A cycle-by-cycle pattern of construction and launching was suggested of the collider high-frequency system. It will provide the timely start of the complex launching version. A possibility to produce in advance a barrier high-frequency station of the collider and test it at the Nuclotron was also discussed.

The participants of the workshop examined the present test bench for superconducting magnets and the hall for a production chain of the magnetic system elements. An excursion was organized to the VBLHEP accelerator complex which operates at present. The main result of the workshop was an agreement to involve INP specialists into the NICA project more actively.

Rosatom state corporation Deputy Director General, Head of the international relations department N. Spassky and accompanying persons visited JINR **on 5 April**. At the JINR Directorate, V. Matveev, M. Itkis, G. Shirkov, N. Russakovich, D. Kamanin, and A. Vinogradov received the delegation from Rosatom. The sides discussed opportunities to broaden cooperation between two organizations, including the sphere of non-nuclear applications, and use the UC of JINR in educational programmes of Rosatom. They also discussed issues of preparation of the visit of IAEA Director General Yukiya Amano to JINR. The guests had excursions to the Veksler and Baldin Laboratory of High Energy Physics and the Flerov Laboratory of Nuclear Reactions.

An official visit of JINR Director V. Matveev to the Fermi National Accelerator Laboratory (Fermilab, USA) at the invitation of the Fermilab Directorate was held **on 22–24 April**. The JINR Director was welcomed by Fermilab Director P. Odonne, Fermilab Deputy Director Young-Kee Kim, Associate Laboratory Director for Accelerators S. Henderson, DOE's Fermilab Site Office manager M. Weis and Deputy manager of DOE's Fermilab Site Office M. Bollinger, Associate Laboratory Director for Particle Physics G. Bock and Assistant Fermilab Director R. Rubinstein.

On 22 April, a Memorandum of Understanding between JINR and Fermilab, which provides scientific cooperation of the two scientific centers in implementation of the perspective Fermilab "Project X" was signed. The Memorandum also provides JINR–Fermilab cooperation in implementation of the NICA project and joint participation in a programme concerned with a project of the International Linear Collider (ILC).

V. Matveev held fruitful negotiations with spokespersons of experiments and projects where JINR was involved or planned to take an active part, with leaders of departments and scientists: "Project X" leader S. Holmes, LBNE (neutrino physics research) leader J. Strait, deputy leader of "Project X" in accelerator physics and technology S. Nagaitsev, Director of the FNAL centre on accelerator physics V. Shitsev, ORKA (rare decays of positively charged K-mesons) leader R. Tschirhart, co-leader of the Mu-2e experiment (rare conversion transitions of muons into electron) R. Bernstein, leader of the neutrino experiment NOvA (muon–electron oscillations of neutrino) J. Cooper, CDF leader R. Roser, leading theorist of FNAL U. Bardin, and others.

During his visit, the JINR Director met with scientists and experts from Russia, now working in Fermilab, as well as with a JINR group, which is performing work and research on joint plans with Fermilab. The JINR Director had an opportunity to get acquainted with an experimental facility in the framework of its preparation for "Project X", the ILC collider complex and the experiment Mu-2e.

Following the results of all the meetings, negotiations and discussions, an exchange of opinions between P. Odonne and V. Matveev was held on 24 April; the sides appreciated this three-day round in the Fermi National Accelerator Laboratory as highly successful and fruitful, facilitating a new level of scientific coopera-

tion between JINR and Fermilab. JINR Director Advisor G. Kozlov attended the meetings in Fermilab.

The 3rd Research Coordinated Meeting (RCM-3) related to the IAEA "Development, Characterization and Testing of Materials of Relevance to Nuclear Energy Sector Using Neutron Beams" was held **on 13–19 May** in the International Conference Hall. The overall objective of this event is to study structural materials (mainly, steel and alloys based on zirconium) and to develop new experimental methods, e.g., neutron tomography.

The present meeting continued the cycle of meetings in the framework of the IAEA project CRP-1575 (2009–2013) and has been organized by the International Atomic Energy Agency (IAEA), the Frank Laboratory of Neutron Physics of the Joint Institute for Nuclear Research (FLNP, JINR) and Rosatom State Nuclear Energy Corporation.

These meetings promote the use of advanced technique of neutron beams in materials studies to solve most urgent tasks in nuclear energy industry; they are to standardize experimental technology and methods of modeling and encourage new collaborations among the project participants.

Representatives of 18 IAEA member states from Europe, Asia, North and South America, and Australia took part in the current meeting. The participants made reports on the research they conducted, had an excursion to the pulsed reactor IBR-2 and saw sights of Dubna.

The meeting concluded in formulating main scientific trends to be continued in collaboration of research groups.

On 17 May, a working meeting with representatives of the European Commission was held at the JINR Directorate. The day before, the representatives of the European Commission took part in the meeting at the RF Ministry of Education and Science in Moscow. Their delegation consisted of the members of the executive committee of the European Union on issues of development of research infrastructure and coordination of joint work in megascience projects that are implemented at Russian scientific centres and JINR and are included into the Russian state programme for 2013–2020.

The following persons took part in the negotiations at the Ministry and then in Dubna: Head of the Ministry department of development of priority trends in science and technology S. Salikhov and his colleagues, Head of the European Commission Research Infrastructures department Anna Arano Antelo, EU experts — ex-Director General of CERN Robert Aymar, representative of CEA (Commisariat d'Energie Atomique, France) Suzanne Gotha Goldman, member of the European Strategy Forum on Research Infrastructures (ESFRI) Jean Moulin, Professor Steve Myers (CERN), GSI Director Horst Stocker (Germany), science and innovation Advisor at the EC office in RF Richard Burger (France), as well as official on the JINR side — VBLHEP Deputy Director A. Sorin who informed the participants on the status of the NICA project at Dubna.

On 17 May, the delegation from the European Commission was received at the JINR Directorate. They were greeted by JINR Director V. Matveev, JINR Vice-Director R. Lednický, JINR Chief Scientific Secretary N. Russakovich, VBLHEP Director V. Kekelidze, VBLHEP Deputy Directors A. Sorin and G. Trubnikov, Deputy Head of the international relations department D. Kamanin. The Institute Director and his colleagues presented the programme of scientific research at the Institute, spoke about international cooperation and involvement of JINR Member States and Associate Members in the projects from the Seven-Year Plan of JINR Development, giving special attention to the NICA project. Then the guests were invited to the Veksler and Baldin Laboratory of High Energy Physics to visit its main sites where the project NICA is underway and meet the Laboratory leading researchers.

Director General of the International Atomic Energy Agency Yukiya Amano and his accompanying persons visited JINR **on 18 May**. Head of IAEA got acquainted with a great interest with research activities and projects of the Veksler and Baldin Laboratory of High Energy Physics and the Flerov Laboratory of Nuclear Reactions. For many years JINR has been cooperating with IAEA in the sphere of training young specialists and organizing expert services. JINR Director V. Matveev, JINR Vice-Directors M. Itkis and R. Lednický, JINR Chief Scientific Secretary N. Russakovich, his Deputy D. Kamanin, FLNP Chief Engineer A. Vinogradov participated in a meeting at the JINR Directorate, where possibilities of enhancement of cooperation were discussed.

Leading scientists of the University of Turin and the Polytechnic University of Turin (Italy) — Deputy Director of the Department of Information Technology of the University of Turin Professor L. Lesmo, Vice-Rector for Research and Technology Transfer of the Polytechnic University of Turin Professor E. Macii, and Professor of Communication and Information of the Polytechnic University of Turin M. Marsan visited MIREA and JINR's LIT **on 22 May**.

LIT Director V. Korenkov, his Deputies Gh. Adam and T. Strizh welcomed the guests in the Laboratory of Information Technologies. Leaders of the Laboratory acquainted the guests with LIT activities, spoke about activities of the JINR University Centre; in their turn, the guests presented their universities and shared plans to establish an exchange of students and organize joint research programmes. The guests got acquainted with the LIT permanent displays — photo exhibitions dedicated to M. G. Meshcheryakov and D. I. Blokhintsev.

On 29 May, a delegation of Chinese scientists headed by Vice-Director of the Northwest Institute of Nuclear Technology (Xi'an, China) Professor Dongwei Hei visited the Frank Laboratory of Neutron Physics

(FLNP) of JINR. The delegation included staff members of the Institute: Director Executive Assistant Din Bin, Professor Wu Enchang, senior researchers Djan Djianfu and Sun Djaohuwei. The latter had a trainee course at the JINR Laboratory of Theoretical Physics. They presented their projects on the development and application of a highly intense source of gamma radiation on the basis of the inverse Compton scattering. The leaders of FLNP acquainted the guests with the main trends of research at the Laboratory. The Laboratory specialists shared their experience with the Chinese colleagues in developing a pulsed neutron source on the basis of the linear accelerator of electrons. The Chinese scientists visited the facilities IREN and REGATA, and the IBR-2 reactor.

At the end of the visit the guests expressed wishes to broaden their cooperation with FLNP in the studies of application of the neutron spectrometry methods and intentions to discuss an opportunity for Chinese scientists to come to FLNP for a long term and take part in joint research.

A delegation from the University of Nova Gorica (Slovenia) consisting of Rector D. Zavrtanik and Prorectors G. Bratina and M. Franko visited the Frank Laboratory of Neutron Physics of JINR **on 18 June**.

FLNP Director V. Shvetsov, Heads of departments A. Belushkin and D. Kozlenko acquainted the guests with research at the Laboratory. Leaders of the University of Nova Gorica were interested in the educational programme of the JINR University Center and opportunities to participate in international student practice courses.

On 10 July, the second meeting of the Scientific Council on heavy-ion physics in the RAS Presidium was held. It was organized in order to discuss issues connected to megascience projects in the territory of Russia. Chairman of the Council Academician Yu. Oganessian made a brief review about the activities of the Council after the first meeting held in Dubna in 2012. The basis for the Council work is partnership cooperation in the framework of two megaprojects — NICA (JINR) and FAIR (Darmstadt, Germany), in consolidation of scientific programmes and resources, including technological achievements in accelerators, detector physics and solution of tasks in the personnel policy and training of young scientists and specialists.

The participants of the meeting discussed the status of the accelerator complexes NICA (G. Trubnikov) and FAIR in Darmstadt (B. Sharkov). They heard the reports on superdense baryon matter (V. Kekelidze, A. Sorin), on the possible experiment U + U (G. Ter-Akopyan, I. Meshkov), on electron scattering on exotic nuclei in the programme NUSTAR (L. Grigorenko, S. Stepantsov), on the outcome of the meeting on problems of radiation risk related to safe interplanetary flights (E. Krasavin), on staff training (M. Strikhanov, V. Samsonov).

Chairman of the committee on high energy physics of the Academy of Sciences and the Ministry of Science of Israel Professor Eliezer Rabinovici (Jerusalem University) and Chairman of JINR PAC for Particle Physics Professor Itskhak Tserruya (the Weinzmann Institute of Science) visited JINR **on 11 July**.

V. Matveev, M. Itkis, V. Kadyshevsky, V. Kekelidze, A. Sorin, G. Trubnikov, and D. Kamanin received the guests at the Directorate. During the meeting, the sides discussed various aspects of scientific cooperation between JINR and scientific centres of Israel. The guests expressed their gratitude for the warm reception and hope for their visit to serve further continuation and development of all-round contacts.

The Israeli delegation visited detector and accelerator departments of the NICA complex at VBLHEP, the cyclotron complex at FLNR, the IBR-2 reactor at FLNP, and LIT. After that, a ceremony of signing of a framework Agreement between the Academy of Sciences of Israel and JINR was held. The Agreement stipulates the development of cooperation in experimental and theoretical physics, astrophysics and related technology, and organization of joint seminars and schools.

Rector of the Moscow State Technical University of Radioelectronics, Electronics and Automation (MIREA) S. Kudzh and Prorector on development A. Vernigora visited JINR **on 11 July**. They had a meeting with Director of the Joint Institute V. Matveev and visited Laboratories. Head of the base chair of JINR at MIREA "Electronics for Physics Facilities" A. Malakhov took part in the meeting. He told the guests about the chair activities where specialists for JINR and city enterprises were trained for more than a decade.

A delegation of scientists from the People's Republic of China visited JINR **on 6–9 August**. Head of the Department of Basic Research Programme of the PRC Ministry of Science and Technology Foo Xiaofeng, Director of the CAS Institute of Plasma Physics Li Jiangang, and staff members of that Institute — Assistant Director Song Yuntao and Deputy Head of Department Dun Shaohua came to get acquainted with research fields and facilities. JINR Director V. Matveev, JINR Scientific Leader V. Kadyshevsky, JINR Vice-Director M. Itkis, JINR Deputy Chief Scientific Secretary D. Kamanin, VBLHEP Director V. Kekelidze, VBLHEP Deputy Directors Yu. Potrebenikov, A. Sorin, and G. Trubnikov, and Chief Engineer of the basic facility Nuclotron G. Khodzhibagiyan received the guests.

Director of the CAS Institute of Plasma Physics Li Jiangang spoke about the Five-Year Plan of the scientific development, which is being implemented by the Chinese Academy of Sciences (CAS), and also about research, achievements and plans. This Institute is well known for its Experimental Advanced Superconducting Tokamak (EAST) that is a modification of the

HT-7 Tokamak developed in collaboration with Russian specialists. Today, the work on EAST is a part of the construction programme of an international experimental thermonuclear reactor ITER.

The guests visited FLNR and VBLHEP. The outcome of the meeting was the signing of a Memorandum of Cooperation.

A delegation from the Helmholtz Association of German Scientific Research Centres, headed by its President J. Mlynek, visited JINR **on 7–8 August**, with an aim to become acquainted with the operation of JINR basic facilities. On 8 August, Professor J. Mlynek and JINR Director V. Matveev signed an Agreement on scientific cooperation in various fields of research at JINR, including the NICA project.

On 8 August, an international meeting "Prospects for Cooperation in the Megascience Project NICA" was held. It was attended by representatives of Belarus, Bulgaria, China, the Czech Republic, Germany, Hungary, India, Italy, Kazakhstan, Poland, Russia, South Africa, and Ukraine. The delegations from Hungary and South Africa were headed by leaders of their diplomatic missions in Moscow.

In his opening speech, JINR Director Academician V. Matveev divided the audience into two groups: those who represented the countries that were ready to sign the Protocol of Intent, and the other group — the representatives of the countries-observers that could either accept all the requirements for their participation in the project or propose their own changes into the project concept in the course of the discussions.

VBLHEP Director V. Kekelidze spoke in detail about the development of the NICA collider. The technical design plan of the accelerator experimental complex has been worked out. 188 experts from 25 countries take part in the compilation of the "White Book". The first stage of the project — the Nuclotron upgrade — has been accomplished with technological elaborations and equipment developed by the specialists from Germany, the Czech Republic, Bulgaria, Ukraine, Belarus, and other countries. Contracts for the delivery of equipment and developments of high-tech elements have been signed with Russian scientific centres and enterprises. An international tender for the construction of a part of the project has been announced.

The participants of the meeting visited the Veksler and Baldin Laboratory of High Energy Physics and were acquainted with the process of the Nuclotron upgrade and the development of the production of superconducting magnets and elements of the MPD detector.

Representatives of the countries that are ready to actively collaborate in the project — Belarus, Bulgaria, Germany, Kazakhstan, Russia, and Ukraine — made short reports and spoke about their cooperation with JINR, special features of their involvement in the progress of the project, work-out and implementation of the programme of experimental research at the accelerator complex. Representatives of China, the Czech Republic, Italy, and Poland declared, on behalf of the scientific communities of their countries, their intention to take part in the development of the NICA collider, inform their state structures about it and strive for support.

The meeting concluded with the signing of the Protocol of Intent, signed on behalf of governmental structures by the representatives of Belarus, Bulgaria, Germany, Kazakhstan, Russia, Ukraine, and JINR.

A four-day visit to JINR of a group of professors of RSA universities was finished **on 11 October**. Professors of RSA universities and the cyclotron laboratory iThemba LABS visited JINR Laboratories and the University Centre to become acquainted with the activities of JINR. RSA professors shared their impressions with leading scientists of Laboratories, and discussed plans on enhancement of cooperation.

JINR Days in Bulgaria were held **on 10–13 October**. JINR Vice-Director Professor M. Itkis, Directors of JINR Laboratories Professor V. Voronov (BLTP), Professor V. Kekelidze (VBLHEP) and Professor V. Shvetsov (FLNP) attended this event. JINR representatives met with Bulgarian scientific leaders, directors of institutes that collaborate with Dubna, had negotiations on cooperation with Minister of Education and Science Professor A. Klisarova, Chairman of the Bulgarian Academy of Sciences S. Vodenicharov, with Chairman and members of the Parliamentary Committee on Education and Science, Rector of the St. Clement of Ohrid University of Sofia I. Ilchev, and gave lectures to Bulgarian colleagues.

In the BAS Institute for Nuclear Research and Nuclear Energy M. Itkis spoke about nuclear physics research at JINR and V. Voronov spoke about cooperation of JINR BLTP and INRNE BAS. V. Shvetsov presented a lecture "Research on Condensed Matter Physics at JINR" in the Institute of Metal Science, V. Kekelidze presented his lecture on the status and prospects of the NICA project in Sofia Technical University.

Members of the delegation from Dubna and the Commission of the Nuclear Regulatory Agency of Bulgaria on cooperation with JINR, headed by JINR Plenipotentiary of Bulgaria L. Kostov, participated in a round-table discussion of issues of cooperation of Bulgarian scientific and educational centers with JINR. Members of the JINR delegation heartily congratulated L. Kostov on his 60th birthday and presented to him a congratulatory address and an anniversary gift on behalf of the multinational team and the Directorate of the Joint Institute for Nuclear Research.

On 14–15 October, Head of the Centre for Complex Ecological Studies of the Nuclear Physics Institute, Kazakhstan, V. Glushchenko visited JINR. He was shown the work of the sector of neutron activation analysis and applied research of FLNP, and had a discussion of possible trends of joint studies. First, it is

biomonitoring of atmosphere fallouts of heavy metals and radionuclides in the territory of Kazakhstan, with the aim to include the Republic of Kazakhstan into the UN Programme on air pollution in Europe and Asia. There are opportunities at FLNP and the Centre to collaborate together with colleagues from Georgia and Moldova in bionanotechnology. The cooperation will also provide exchange of experience in instrumental methods for radioecological and ecological studies, improvement of qualification that includes exchange of specialists and their probation courses, search for new trends of joint research in the framework of financing beyond the budget (RFBR, NATO, EU, etc).

On 23 October, RF Prime Minister of the Russian Federation D. Medvedev visited the Institute of Plasma Physics in the Chinese city of Hefei. There he had a meeting with Russian and Chinese scientists. One of the leaders of this project Deputy Director of the JINR Veksler and Baldin Laboratory of High Energy Physics G. Trubnikov participated in this meeting and told the Prime Minister about the megascience project of an experimental accelerator complex NICA in Dubna. D. Medvedev promised him to render support to the project and encharge the RF government and Rosatom with the task.

Ambassador Extraordinary and Plenipotentiary of the Republic of Serbia to RF S. Terzić accompanied by the First Counselor of the Embassy M. Zercović and Defence Attaché Z. Stojković visited JINR **on 6 November**.

JINR Chief Scientific Secretary N. Russakovich, FLNR Deputy Director Professor A. Popeko and Head of the International Cooperation Department D. Kamanin welcomed the guests at a meeting in the JINR Directorate. N. Russakovich acquainted the members of the Serbian delegation with the history and structure of JINR, its basic facilities and directions of scientific research, international contacts of JINR, results of world-class research, large projects and seven-year plans. After that, the guests visited the Flerov Laboratory of Nuclear Reactions and the accelerator complex NICA which is being developed in VBLHEP.

After the excursion the sides discussed necessary steps for further cooperation. In particular, the Ambassador delivered the invitation to the JINR Directorate on behalf of the Minister of Education, Science and Technological Development T. Jovanović to meet and discuss practical issues of participation of Serbia in JINR.

Minister of Education, Science and Technological Development of the Republic of Serbia T. Jovanović received Head of the JINR International Cooperation Department D. Kamanin and the Serbian Coordinator of cooperation with JINR C. Petrović from the Vinča Institute of Nuclear Sciences **on 8 November** in Belgrade. The meeting was attended by Assistant Minister R. Žikić and Scientific Director of the "Vinča" Department of Physics N. Nešković.

The meeting was devoted to discussion of formal issues of cooperation and, in particular, planning of Serbian contribution to the JINR budget. The progress and prospects of cooperation of scientists from Serbia and Dubna were discussed. The Minister was particularly interested in experimental work on solid state physics which is being conducted at the Vinča Institute with the participation of specialists from Dubna and using JINR educational opportunities.

A delegation from the Czech Republic headed by Minister of Education, Youth and Sports D. Štys visited JINR **on 22–24 November**. The delegation also included the Charge d'Affaires of the Czech Republic in the Russian Federation M. Klučar, Deputy Minister of Education, Youth and Sports T. Hruda, Head of Economic Section of the Czech Embassy M. Bašta, Third Secretary of the Embassy J. Pytlíček, members of the Committee on Cooperation with JINR, as well as journalists of the Czech media. The purpose of the visit was discussion of further participation of the Czech Republic in JINR, in particular opportunities for enhancement of cooperation, collaboration in educational programmes, innovation, participation of the Czech high-tech firms in construction of JINR basic facilities. A presentation of a dwelling house number 8 in Stroitelei Street, which was completely overhauled jointly by JINR and the Czech construction firm ASARKO, was included into this visit agenda. The reconstructed building will be used as a hotel for JINR staff members who work under contract at the Institute.

At a meeting at the JINR Directorate during the discussion of issues of cooperation positive experience of work with the Czech companies, including production of high-tech equipment for the JINR basic facilities, such as vacuum systems for the NICA project from the company VACUUM PRAGUE, was repeatedly stressed. Intentions to continue and expand such initiatives were expressed. In addition, importance of educational programmes for training of students and young scientists was noted along with scientific research activities. Excursions in JINR Laboratories and the Special Economic Zone were held for the representatives of the Czech Republic.

A representative delegation from Romania headed by Minister Delegate for Higher Education, Scientific Research and Technological Development M. Costoiu, Ambassador Extraordinary and Plenipotentiary of the Russian Federation in Romania V. Soare and Romanian Plenipotentiary at JINR N. Zamfir visited the Joint Institute for Nuclear Research **on 23 November**. The delegation included representatives of Ministry and Embassy, heads of leading Romanian universities, and journalists.

It was voiced at a meeting at the JINR Directorate that participation in JINR is a strategic investment for Romania, and it is very important for teams of scientists

to define areas of further research; in particular, to develop the already established cooperation in accelerator themes. In addition, there is a desire to add economic cooperation to scientific cooperation.

JINR Director Academician V. Matveev said in his turn that JINR intends to organize further work so that information about it would be available and clear for all JINR Member States. The guests visited experimental facilities in the Flerov Laboratory of Nuclear Reactions, the Frank Laboratory of Neutron Physics, the Veksler and Baldin Laboratory of High Energy Physics, as well as the Special Economic Zone.

CONFERENCES AND MEETINGS HELD BY JINR

Twelve conferences were the largest among the scientific conferences and workshops held at JINR in 2013.

XVII Scientific Conference for young scientists of the JINR Association of Young Scientists and Specialists (AYSS-2013) was held on 8–12 April at the Dzhelepov Laboratory of Nuclear Problems. The Conference was dedicated to the centenary of the birth of the outstanding Soviet physicist, Corresponding Member of the Academy of Sciences of the USSR Venedikt Dzhelepov. The programme of the Conference included main fundamental and applied research trends at JINR. Students, postgraduates, young scientists and specialists from JINR and other Russian and foreign scientific centres were active participants of the event, as well as leading scientists who gave lectures on most urgent fields of fundamental and applied research.

The opening day of the Conference featured the reports made by DLNP Director A. Olshevskiy, who spoke about the research at the Laboratory today, and Director of the Laboratory of Radiation Biology E. Krasavin who delivered a substantial report "V. P. Dzhelepov and Radiobiological Research at JINR".

The participants of the Conference made reports in 10 sections: theoretical physics; mathematical modeling and computer physics; elementary particle physics; modern methods of acceleration of charged particles and accelerator equipment; relativistic nuclear physics; experimental nuclear physics; applied research; information technology; condensed matter; radiation and radiobiological research. The programme of the Conference also included a general meeting of AYSS, elections of the new membership of the council, a round-table discussion, summing up the results of the year, and reports by participants of competitions for young scientists' prizes.

On 12 April — the day of V. P. Dzhelepov's centenary — leading Russian scientists spoke about the great scientist: S. Gershtein (IHEP), "Venedikt Petrovich Dzhelepov: Man and Scholar"; L. Ponomarev (NRC "Kurchatov Institute"), "Unflagging Enthusiasm of a Researcher". The premiere show of a documentary about the first director of the oldest laboratory of Dubna was held. In conclusion, results of the competition of the papers written by young scientists were announced.

The 21st European School of High Energy Physics was held on 5–18 June in Parádfürdő, Hungary.

The 2013 European School of High Energy Physics (formerly the CERN–JINR School of Physics) is jointly organized by the European Organization for Nuclear Research (CERN), Geneva, Switzerland and the Joint Institute for Nuclear Research (JINR), Dubna, Russia and together with the Wigner Research Centre for Physics of the Hungarian Academy of Sciences, Hungary.

One of the tasks of the event is the cultural exchange and contacts among young scientists. On the results of the competitive selection, the School was attended by over 115 students from 27 countries. The School is mainly supposed to attract those young specialists who study experimental high energy physics and prepare their Doctoral theses. As a rule, the participants of the School are not older than 25. Many of them work at the large Hadron Collider at CERN.

The students were divided into six groups for discussion sessions and involvement in collaboration projects. During this work they learn the skills of team building and improve their level of scientific knowledge. The poster session gives them an opportunity to discuss their studies in the informal atmosphere with senior colleagues. The scientific programme was as follows: Field Theory and the Electroweak Standard Model; beyond the Standard Model; Higgs Physics; Neutrino Physics; Cosmology; Flavour Physics and CP Violation; Practical Statistics for Particle Physicists; Quark–Gluon Plasma and Heavy-Ion Collisions; QCD for Collider Experiments; LHC Results — Highlights. The programme also included lectures, discussions, a poster session and exchange of student projects. Leading scientists from various countries, such as the USA, Russia and Western European states, delivered lectures.

On 14 June, CERN Director General Professor R. Heuer attended the School. He gave a lecture and took part in student discussions.

The 7th International Conference ***"Mathematical Modeling and Computational Physics"*** (MMCP 2013)

was held on 8–12 July at the Laboratory of Information Technologies. The Conference was organized by the Laboratory of Information Technologies (the Joint Institute for Nuclear Research), the Keldysh Institute of Applied Mathematics (KIAM) of the Russian Academy of Sciences (Moscow), the Institute of Experimental Physics (the Slovak Academy of Sciences, Kosice, Slovakia), the Technical University (Kosice, Slovakia), and the Pavol Jozef Safarik University (Kosice, Slovakia).

The scientific programme of the Conference was devoted to the use of distributed and parallel computing in science and technology; mathematical methods and tools of modeling complex systems; computational biophysics, chemistry and bioinformatics; mathematical methods and software for experimental data processing; methods and programs of computer algebra, quantum computing and their applications.

The Conference was attended by more than 200 scientists and specialists from 13 countries (Armenia, the Republic of Belarus, Bulgaria, Vietnam, Germany, Georgia, Moldova, Mongolia, Russia, Romania, Slovakia, Tajikistan, Ukraine) and from Russian scientific centers and universities, including CC RAS, IMPB RAS, ICS RAS, the Kurchatov Institute, NRNU MEPhI, LPI RAS, CEMI RAS, the Voronezh State University, the "Dubna" University, MSU, PFUR, SPSU, SSU, and TSU.

The opening day of the Conference started with the welcome speeches of LIT Director V. Korenkov and Director of the Keldysh Institute of Applied Mathematics B. Chetverushkin. The plenary session was opened by B. Chetverushkin with the report devoted to 3D algorithms of magneto-hydrodynamics intended for computations with high-performance parallel computing systems. A large number of reports were devoted to computational aspects of data processing in HEP. The reports on the development of effective and parallel event reconstruction algorithms for the CBM experiment (GSI, Darmstadt, Germany) attracted special interest. In particular, the reports delivered by V. Friese and I. Kisel (GSI, Darmstadt, Germany) reviewed computational approaches for experimental data processing and for online event reconstruction of the CMB experiment on high-performance computing platforms.

One of the traditional fields of computational mathematics covered during the Conference was a field that deals with the development of the methods of symbolic computing and computer algebra, and also with the development of the methods of quantum computing and their applications. In the framework of the Conference there was organized a separate section devoted to distributed and parallel computing.

Many reports were devoted to mathematical methods and developments of software tools for the research of complex physical, technological, biological and economic systems.

In total, there were made 34 plenary, more than 120 section and 25 poster reports. It should be emphasized that more research presented at the Conference was obtained in collaboration with scientists from different scientific centers of JINR Member States (Bulgaria, Romania, Slovakia, Mongolia, etc). The abstracts and the Conference programme are available on the official Conference website at: http://mmcp2013.jinr.ru.

The 11th International School-Seminar "Topical Problems in Microworld Physics" was held on 1–12 August at the holiday centre "Zolotye peski", Gomel, Belarus. The event was organized by the Joint Institute for Nuclear Research, the National Centre of Particle Physics and High Energy Physics, BSU, the Gomel department of NAS of Belarus, the Gomel State University after F. Skorina, the Gomel Technical University after P. Sukhoj, IP NAS of Belarus (Minsk), BFBR (Minsk). This time the School celebrated a jubilee — 40 years ago Belorusian scientists together with their colleagues from JINR established this tradition to hold international scientific and educational forums on particle physics and high energy physics in Belarus.

Scientists from CERN (Switzerland), DESY (Germany), SRI NP MSU after Lomonosov (Moscow, Russia), IHEP (Serpukhov, Russia), INP and ITP (Ukraine) made reports and gave lectures.

The main tasks of the 11th School-Seminar were, as at the previous schools, education of young scientists, discussions of new fundamental results in actively developing fields of modern physics, latest technology, exchange of information and experience in theoretical and experimental methods, establishment of business contacts and their strengthening among scientists from leading international and national scientific centres. The agenda of the School also included the dates and events connected with the programme: 55 years of JINR and the centenary of the birth of the outstanding Belorusian physicist Academician F. I. Fedorov.

Further development of high energy physics in Belarus is closely connected with the issue of training young specialists who are able to solve specific theoretical and experimental tasks at modern accelerator facilities. Education of such specialists is conducted at GSU after F. Skorina in the specialization "Computer Simulation of Processes in Physics", on the basis of fundamental university courses. According to the agreement between the UC of JINR and NCPPHEP BSU (Minsk), talented students from GSU have an opportunity to continue their studies at the UC JINR and take part in modern research in international collaborations on high energy physics.

The International Workshop ***"Supersymmetries and Quantum Symmetries"*** (***SQS'2013***) was held at the Bogoliubov Laboratory of Theoretical Physics from 29 July to 3 August. These biennial meetings

were initiated in 1989 by Professor V. I. Ogievetsky (1928–1996) and are regularly organized at BLTP.

This time, the main topics of the Workshop were: string theory, quantum and geometric aspects of supersymmetric theories, higher-spin theories, supersymmetric integrable models, quantum groups and noncommutative geometry, Standard Model and its supersymmetric extensions.

The attendance of the Workshop was 130 scientists. They represented Armenia, Australia, Belarus, Belgium, Bulgaria, Chile, the Czech Republic, France, Germany, Greece, India, Italy, Japan, the Netherlands, Peru, Poland, Russia, Serbia, Spain, Ukraine, the United Kingdom, and the USA. Among the participants there were leading experts in the theory of elementary particles, quantum field theory, gravitation and string theory, noncommutative geometry and integrable systems: E. A. Bergshoeff (University of Groningen), J. Buchbinder (Tomsk University), M. Vasiliev (the RAS Lebedev Physical Institute, Moscow), G. Zoupanos (the National Technical University, Athens), N. Kawamoto (Hokkaido University, Japan), O. Lechtenfeld (Hannover University), J. Lukierski (Wroclaw University), C. Munos (the Institute for Theoretical Physics, Madrid), D. Sorokin (Padova University), K. S. Stelle (the Imperial College, London), A. Tseytlin (the Imperial College, London, and the RAS Lebedev Physical Institute, Moscow), P. Fre (Torino University), and others. Like in the previous years, the meeting collected many actively working young researchers from Moscow, Saint-Petersburg, Tomsk, Ivanovo, Kharkov, Minsk and Yerevan, as well as from JINR. The organization of the SQS'2013 Workshop became possible due to the financial support from BLTP JINR, the Russian Foundation for Basic Research, the Dynasty Foundation, the Heisenberg–Landau, Blokhintsev–Votruba and the Bogoliubov–Infeld Programmes.

The results of SQS'2013 have once more highlighted the fundamental role of the theory of strings, supersymmetry and quantum symmetries in modern theoretical and mathematical physics, the importance of further studies in these directions, and the fruitfulness and effectiveness of the international scientific cooperation with the participation of JINR. More information on the Workshop is available at the website: http://theor.jinr.ru/sqs13/.

At the initiative of Academician V. Rubakov, ***a Visiting Session of the Physical Sciences Division of the Russian Academy of Sciences dedicated to the 100th anniversary of Bruno Pontecorvo's birth*** was held on 2–3 September in Dubna. It was attended by members of academic institutes, JINR Laboratories, and guests from abroad. The Session continued the series of events dedicated to the jubilee of B. Pontecorvo. The opening ceremony of the memorial plate of the European Physical Society took place on 22 February at the Dzhelepov Laboratory of Nuclear Problems, JINR, in the Memorial study of Bruno Pontecorvo; on 22 August, the scientist's birthday, the Moscow State University hosted XVI Lomonosov Conference, the first day of which was devoted to achievements in neutrino physics.

JINR Director V. Matveev opened the Session and welcomed the participants on behalf of the Physical Sciences Division of RAS. He stressed that it is in Dubna where Bruno Pontecorvo had worked for 33 years, his genius in physics matured.

D. Shirkov, V. Kadyshevsky, M. Sapozhnikov, and G. Mitselmakher shared their reminiscences of their meetings with B. Pontecorvo. A. Petrukhin recalled the social activities of Bruno Pontecorvo as an advocate of the society "Znaniye", supporting his memories with his own videos about their trips to Kamchatka (1966) and the Kurils Islands (1972).

V. Gavrin (INR RAS) remembered how the Baksan Neutrino Observatory was established and how Bruno Pontecorvo backed up this project in the Neutrino Council of RAS which he headed. The theme was taken up by G. Domogatsky (INR RAS), head of the International project "Baikal" in the framework of which the Baikal Neutrino Telescope was created.

The following review talks were given on the first day of the Session: "Neutrino Accelerator Long-Baseline Experiments: Results and Perspectives" by Yu. Kudenko (INR RAS), "Results of ICECUBE and Perspectives of Neutrino Astronomy" by K. Schpiring (DESY, Germany), and "Neutrinoless Double Beta-Decay" by A. Barabash (ITEP). All the speakers noted the influence of Bruno Pontecorvo on the establishment and development of the lines of research in neutrino physics that are of current importance.

The first day of the Session was completed by the memories of S. Bilenky; he shared them in a video conference from Vancouver (Canada).

On the second day of the Session presentations were made by A. Olshevskiy — "Results and Prospects for Neutrino Reactor Experiments", V. Gavrin — "Investigations of Low-Energy Neutrino at the Baksan Neutrino Laboratory", D. Gorbunov — "Sterile Neutrinos and Their Possible Role in Particle Physics and Cosmology", A. Derbin — "Experiments with Solar Neutrino", and V. Rubakov — "Prospects for Investigations in Neutrino Particle Physics and Astrophysics".

Closing the Session, G. Domogatsky noted a very good level of organization of the Session and high quality of the presentations. The jubilee event ended with the opening of the monuments to two scientists-comrades V. P. Dzhelepov and B. M. Pontecorvo that took place during the September session of the JINR Scientific Council.

The 24th International Symposium on Nuclear Electronics & Computing (NEC'13) was held on 9–16 September in Varna, Bulgaria. The Symposium

was organized by the Joint Institute for Nuclear Research (JINR), the European Organization for Nuclear Research (CERN) (Geneva, Switzerland), and the Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences (INRNE BAS) (Sofia, Bulgaria). The Symposium numbered 100 scientists from 13 countries, including Azerbaijan, Armenia, the Republic of Belarus, Bulgaria, Vietnam, Germany, Georgia, Russia, the USA, Ukraine, France, the Czech Republic, and Switzerland; and 25 participants among them were under 35. IBM and Quantum also provided sponsorship on organizing the Symposium.

In total, the Symposium presented 54 lectures and 33 posters; 19 lectures and 17 posters among them were made by JINR employees. All lectures are available on the web-portal at http://nec2013.jinr.ru/prog.php. Thirteen lectures and 11 posters were made by young scientists. A separate section was devoted to new experimental complexes: ELI-NP (Romania), NICA and DRIBs-III (JINR).

During the opening of the Symposium, the representative of CERN, Doctor T. Kurtyka, spoke about the status and plans of collaboration of CERN with the Eastern Europe countries; Doctor L. Mapelli and Chief Scientific Secretary of JINR, N. Russakovich, made reports on the future development of CERN and JINR, respectively.

Section on electronics was presented by the lectures of specialists from Bulgaria (G. Mitev, INRNE, BAS), JINR (Yu. Tsyganov, A. Voinov, A. Strekalovsky — FLNR; D. Dementyev, S. Vereshchagin — VBLHEP), Russia (E. Malankin, V. Shumikhin, A. Novikov — NRNU MEPhI), and CERN (W. Lustermann, G. Antchev, P. Levchenko).

In the section of accelerator and experiment automation control system and data acquisition lectures were made by I. Semenov from the project center ITER and by A. Ivanisov from the Russian department of the National Instruments company and also lectures by JINR employees: A. Kulikov (DLNP), I. Altinov and I. Morkovnikov (FLNP), I. Filippov (VBLHEP), and V. Zlokazov (LIT).

Different aspects of experimental data analysis were covered in the lecture of V. Palichik (LIT) and also in the lectures of young employees from JINR: P. Sharpov and R. Slepnev (FLNR), Yu. Stepanenko (DLNP).

Special focus was on the problems of storage management and access to big data. Lectures on this topic were made by the leading specialists in this field. Among them were P. Fuhrmann (DESY), A. Heiss (KIT), A. Klimentov (BNL), A. Peters (CERN), A. Vaniachine (ANL), I. Vukotic (UC), and D. Borshchev (the Quantum company).

The section on GRID technologies and high-performance computing was notable for the lectures of B. Jones (CERN), A. Tsaregorodtsev (CPPM-IN2P3-CNRS), and of the specialists from ITEP, V. Kolosov and I. Korolko.

Future development of LHC-computing was covered in the lectures of P. Hristov (CERN) and C. Wissing (DESY). Reports on computing of Tier-2 centers in Prague and RDMS CMS collaboration were made by M. Lokajicek (IP, Prague) and E. Tikhonenko (LIT). A separate section was devoted to the reports on GRID-computing in member countries of JINR: Azerbaijan (A. Bondyakov), Armenia (H. Oganezov), the Republic of Belarus (D. Yermak), Georgia (Z. Modebadze), and Ukraine (O. Shadura).

The major problem in operating support of grid-infrastructure is its monitoring. The report of Julia Andreeva, the chief of the Department of Information Technologies of CERN, who deals with development, implementation and support of the monitoring system for the WLCG project (Worldwide LHC Computing GRID), was devoted to the future development of this multifunction system. She noted substantial and long-standing contribution of the employees of LIT JINR to the development and testing of various components of this system.

Nowadays in Russia a big infrastructure project on the construction of Tier-1 computing centers for LHC experiments is being realized: such a center for ALICE, ATLAS and LHC experiments is going to be built in the Kurchatov Institute, and for the CMS experiments the centre will be built in JINR. The supervisors of the projects, V. Velikhov and V. Korenkov, made reports on the realization of these projects in their institutes.

The section devoted to innovative IT education was represented by professors from the "Dubna" University, JINR employees and professors from Varna, who successfully develop new approaches in teaching informatics, physics, mathematics, and astronomy.

The high point of the Symposium was the panel discussion on "Computing in High Energy Physics: Historical Aspects and Future Development", which included the review report of the leading figure in development of applied software R. Brun (CERN), as well as the report of a well-known specialist in the field of mathematical methods usage Professor G. Ososkov (JINR), and the report of the international WLCG project supervisor I. Bird (CERN). The discussion which was held by A. Klimentov (BNL, the USA) provided an opportunity to answer many questions which were interesting for young specialists, as well as for experienced physicists and engineers.

Semicentenary existence of this scientific forum is considered to be a very significant term. It is pleasant to admit that the level rises with each new conference, and the geography of participation of people from different countries expands. The Symposium aims at involvement of young specialists; and it should be said that the Organizers succeed in it not only quantitatively, but also qualitatively: the level of young participants is so high that the international jury finds it difficult to decide who the winner is. This time, after

heated discussions, the best young reporters and authors of posters were: E. Malankin and V. Shumikhin (NRNU MEPhI), E. Magradze (Goettingen, Germany), O. Shadura (Ukraine), S. Vereshchagin, V. Zager and D. Ponkin (JINR), and S. Khalilova (Azerbaijan).

During the Symposium, on CERN's initiative, a traditional meeting of Bulgarian teachers of physics was held, among the participants of which were the following lecturers: N. Russakovich, Yu. Panebrattsev, T. Kurtyka, L. Mapelli, R. Brun, and V. Korenkov.

In addition, the second (the first one was in 2011) international students' school was held, which took place in Varna's free university and hosted students from the "Dubna" International University, MSU, MEPhI, Saint Petersburg and Kyiv Universities, Bulgarian students, and students from Macedonia. Financial support was provided by JINR, INRNE, IBM, Quantum, and the Centre of National Intellectual Reserve of MSU. Among the students a competition in projects was held and the winners were declared.

In conclusion, it is worth noting marvelous organization of the Symposium (it was held in Varna for the 7th time) provided by our Bulgarian colleagues.

On 18 September, an International Seminar ***"20 Years since the Start-up of the Nuclotron and 60 Years of Research in High Energy Physics at LHEP"*** was held at the Veksler and Baldin Laboratory of High Energy Physics. The Seminar agenda also included the opening ceremony of the memorial plaque to L. G. Makarov and alley named after L. P. Zinoviev.

Opening the Seminar, JINR Director V. Matveev, on behalf of the Directorate and members of the Scientific Council, congratulated the veterans and all staff members on a double jubilee. Leading scientists of the Laboratory made reports on the development of the LHE–LHEP accelerator complex and most important scientific trends.

VBLHEP Director V. Kekelidze spoke about the main milestones of the development of the Laboratory experimental base, the scientific trends in the Laboratory research, international cooperation, contribution of VBLHEP scientists and specialists into the studies at largest accelerators of the world, and talked about the present status of work in the NICA/MPD project. Special features of the work in this project are in the wide attraction of international scientific community and leading accelerator centres of the world.

An awarding ceremony was held during the Seminar: VBLHEP Director V. Kekelidze was awarded the Diploma of Honorary Worker of Science and Technology of the Russian Federation; honorary certificates of the RF Ministry of Science and Education were presented to I. Golutvin, V. Zhabitsky, L. Zolin, V. Nikitin, Yu. Panebrattsev, A. Sidorin, and G. Trubnikov. Honorary certificates and letters of acknowledgement of Rosatom were given to a number of the Laboratory staff members. Besides, many staff members were awarded merit badges of JINR Directorate and Administration of Dubna.

The scientific programme of the Seminar included the reports "Development of the Accelerator Base of the Laboratory" by G. Trubnikov, "The Nuclotron and the History of Its Development" by A. Kovalenko and V. Nikitin, "The Synchrophasotron — the First Experiments" by V. Glagolev, "Physics at the Nuclotron" by A. Malakhov, "Kaon Physics" by V. Kekelidze, "The Nuclotron Structure Studies" by D. Peshekhonov, and "Involvement in LHC Projects" by A. Cheplakov.

A memorial plaque was inaugurated on the building where L. G. Makarov worked. He guided the work to develop the Nuclotron. An alley was named after L. P. Zinoviev who headed the work to develop the Synchrophasotron. Professors V. Kekelidze, A. Malakhov, and A. Kovalenko spoke at the ceremony and expressed deep gratitude to the predecessors for their dedicated service and invaluable contribution to the establishment and development of the Laboratory.

The 22nd Workshop of the CBM (Compressed Baryonic Matter) Collaboration was held on 23–27 September at JINR. Such meetings have been held two times a year since 2003, in Germany and CBM Member States alternately. CBM collaborants came to Dubna for a second time. They were 140 participants from JINR, institutes of Russia, Germany, Romania, India, Ukraine, Poland, Belarus, China, and the Czech Republic. The Workshop is held under the support of JINR, BMBF (Germany), and RFBR.

The participants of the CBM collaboration prepare the facility for experiments at the antiproton and heavy-ion accelerator complex FAIR in Darmstadt. The physics programme of CBM is aimed at thorough study of new properties of the superdense baryonic matter produced in nucleus–nucleus collisions at the beam energy of 2–45 GeV/*c*.

The Workshop is also important from the point of view of the work on the implementation of the NICA project at JINR as their scientific programmes are complementary. Pilot development of some detectors for the CBM experiment will be used for the MPD facility as well at the accelerator complex NICA. It also concerns the work-out of the software of the experiment and its physics programme.

At the present moment all collaboration groups have approached the conclusion of the preparation and delivery of technical design plans of CBM elements to the council of experts of FAIR. Some of them (the STS detecting system and the superconducting dipole magnet, where JINR takes an active part) have already been successfully checked, and the staff members remove minor problems and prepare technical plans. Eleven technical plans are to be prepared. The one on computing is also being elaborated. JINR staff members take an active part in it.

At the meeting of the collaboration council, elections were held of the CBM experiment spokesperson. Professor P. Singer (GSI) was elected for a second term.

The XV Workshop on High Energy Spin Physics (Dubna, October 8–12) continued a series of meetings, the first of which was held in Dubna in 1981 on the initiative of a prominent theoretical physicist L. I. Lapidus.

This meeting was characterized by a substantial attendance, with a larger than ever number of participants (125 persons) from different countries: Russia (24), the USA (10), Belarus (7), Poland (6), Germany (4), the Czech Republic (3), Italy (3), France (2), Slovakia (2), Iran (2), China (2) and by one person from Belgium, Bulgaria, India, Portugal, Sweden, Ukraine, and South Korea. As always, a lot of physicists from JINR (53) were involved.

The reason for the increasing popularity of the meeting is, apparently, the fact that this year has brought many new experimental results and above all the discovery and determination of the quantum numbers of the Higgs boson at the Large Hadron Collider (LHC), given in talks by A. Rinkevicius (USA) and Fang Yaquan (China).

Classical experiments on the study of the nucleon spin structure at high energies use both scattering leptons on polarized nucleons (HERMES, JLab, COMPASS) and collisions of the polarized protons (RHIC, IHEP, JINR). A number of reports at the Conference were dedicated to the development and application of the models based on parton distribution functions (PDF) (P. Zavada, the Czech Republic — the original covariant model of the nucleon; J. Soffer, France — quantum statistical model; and others). Several talks were devoted to the development of methods of experimental data processing and extraction of both polarized and unpolarized PDF. The report of D. Strozik-Kotlorz (Poland) was devoted to the development of the method of truncated Mellin moments and generalized evolution equations for these moments, and the talk of A. Sidorov (Dubna) demonstrated the particular importance of the knowledge of quark fragmentation functions for the determination of spin-dependent PDFs of sea quarks. New data of the COMPASS collaboration on measurement of single-spin asymmetries (F. Bradamante, Trieste), of quark fragmentation functions (N. du Fresne von Hohenesche, Mainz), and future plans (A. Bressin, Trieste) were presented.

The talk by X. Artru (France) proposed the development of simple explanation of the Collins effect and the effect of handedness in the model of sequential fragmentation of quark and offered a program of implementation of the model into Monte Carlo simulation.

Considerable interest and discussion were caused by new data of the JLab (USA) on measurement of the ratio of the electric and magnetic form factors of the proton carried out by "technique of the recoil polarization" presented at the meeting (Ch. Perdrisat, Williamsburg; V. Punjabi, Norfolk State University). Early measurements of the JLab showed that this ratio is not constant, as it had been believed for a long time, and decreases linearly with increasing momentum transfer Q^2. New data obtained in 2010 (GEp(3) experiment with JINR participation) point to a flattening of this ratio in $Q^2 = 6{-}8$ GeV^2. The proposed experiment GEp(5) will advance up to $Q^2 = 15{-}17$ GeV^2.

New data on the spin distributions of sea anti-u and anti-d quarks from the W^+ and W^- bosons production processes in polarized proton–proton collision were presented by the STAR collaboration (K. Barish, BNL), in good agreement with the predictions of the statistical model (J. Soffer). The polarization of gluons, however, is consistent with the results of its direct measurements by the COMPASS and PHENIX + STAR collaborations (K. Barish, BNL; Xu Qinghua, China). Its low value seems insufficient for resolving the so-called nucleon spin crisis.

The program of obtaining polarized proton and antiproton beams from the decay of Lambda particles at the U-70 of IHEP, Protvino, for spin studies at the SPASCHARM facility was presented by S. Nurushev. He stressed the importance of a comparative study of spin effects induced by particles and antiparticles. The talks related to the development of the VBLHEP accelerating complex of JINR were also presented in the program of the Conference (V. Ladygin, R. Kurilkin, S. Piyadin, E. Strokovsky — Dubna). They discussed some of the new proposals for research on the basis of the upgraded Nuclotron-M.

Special plenary and parallel sessions were devoted to the project of the NICA collider complex at JINR. The project has two phases. The first one is the construction of the collider and multi-purpose detector (MPD) for studies of heavy-ion collisions to be completed in 2017. The second phase includes the construction of the infrastructure for the acceleration of polarized protons and deuterons in the total energy range 12–27 GeV with luminosity $\geqslant 10^{32}$ cm$^{-2} \cdot$ s^{-1} for protons (talk of A. Kovalenko, Dubna) and a detector for the collision products (SPD) (reported by G. Meshcheryakov, Dubna). The proposed scheme allows the complex to operate with polarized (longitudinal and transversal) or unpolarized proton and deuteron beams. The main ideas proposed for the SPD centered around the nucleon spin structure using the Drell–Yan process of lepton pairs (R. Akhunzyanov, Dubna), direct photon (A. Gus'kov, Dubna), and the J/Ψ-mesons production. The possibility of 4π-geometry of the SPD for registration of pairs $e^{\pm}$, $\mu^{\pm}$ and direct photons can allow one to measure all leading TMD distribution functions of quarks and antiquarks in the nucleon. Some of them were measured recently in SIDIS experiments, some are still unmeasured. One of the main purposes is to check the fundamental QCD predictions for the change of the sign of the T-odd TMD in the Drell–Yan process compared with that of SIDIS. There were

also proposals for the study of spin processes in elastic pp-scattering (S. Shimanski and V. Sharov, Dubna), in particular, the so-called "Krisch-effect".

Special session on the development of the so-called analytic perturbation theory (APT) by Solovtsov–Shirkov was devoted to the blessed memory of Alexander P. Bakulev. Various aspects of the application of this theory as well as a difficult situation in QCD description of transition form factor $F_{\gamma\gamma^*\pi}$ were the subject of talks by O. Solovtsova (Gomel), A. Oganesian (ITEP, Moscow), N. Stefanis (Bochum), S. Mikhailov, O. Teryaev, A. Pimikov and D. Shirkov (JINR, Dubna) who had had a long collaboration with A. Bakulev.

The summary of the meeting was made in the final report by J. Soffer.

The success of the Conference was due to the support by the Russian Foundation for Basic Research, the International Committee for Spin Physics, Foundation "Dynasty", European Physical Society and the JINR programs for international collaboration: Heisenberg–Landau, Bogoliubov–Infeld and Blokhintsev–Votruba ones.

On 21–22 October, the 16th annual Conference ***"Science. Philosophy. Religion"*** was held in Dubna. It was organized by JINR and the Foundation of St. Andrew the First Called. The theme of the Conference was "Man Facing the Challenge of Advanced Information and Communication Technology".

The Conference was held with active participation and support of the Institute of Informatics Problems of RAS, the Institute of Scientific Information on Social Sciences (ISISS) of RAS, the Institute of Philosophy of RAS, Moscow Lomonosov State University, Moscow Orthodox Ecclesiastical Academy, and St. Tikhon's Orthodox Humanitarian University. Leading specialists in information and communication technology, eminent philosophers and theologists took part in the Conference.

The agenda of the Conference included seven plenary meetings and debates on the reports. On the whole, 28 reports were delivered. The participants discussed new opportunities, challenges, problems and endangerments that people have to encounter with the growing role of information/knowledge, information and communication technology. They discussed humanitarian aspects of wide application of information communication technology (ICT) in the modern world and changes in the structure of social communication as a result of interpenetration between media and ICT.

Please find the reports theses and their presentation on the ISISS RAS site http://www.inion.ru.

The 1st International African Symposium on Exotic Nuclei (IASEN-2013) was held on 2–6 December in Cape Town (the Republic of South Africa). The Symposium was jointly organized by the National Research Fund (NRF), the National Cyclotron Laboratory iThemba LABS and the Joint Institute for Nuclear Research. The first South African Symposium was attended by 150 scientists from 17 countries, including leaders of major research centers where radioactive nuclei beam factories are functioning, from Germany, France, Japan, and the USA.

At the 6th Symposium on Exotic Nuclei (EXON 2012), which was held in Vladivostok, scientists from institutions of South Africa were for the first time. Then, Director of the National Cyclotron Laboratory iThemba LABS Professor Zabulon Vilakazi had an idea to organize a similar conference in South Africa. This idea was supported during a round-table discussion by almost all leading participants of the Symposium.

IASEN-2013, similar to EXON, was devoted to the investigation of nuclei in extreme states; the following topics will be discussed: exotic nuclei and their properties, rare processes and decays, nuclear astrophysics, applications of exotic beams in materials research, and others.

A delegation of JINR scientists (23 persons) headed by JINR Director Academician V. Matveev participated in the Symposium. Leaders of three JINR Laboratories took part in the event: FLNR Deputy Director A. Popeko, FLNP Director V. Shvetsov and BLTP Director V. Voronov. A scientific school was organized the day before the opening of the Symposium for young participants where leading scientists gave lectures. JINR Vice-Director M. Itkis was one of them. In the framework of the Symposium the 13th meeting of the Coordinating Committee on RAS–JINR cooperation was held, as well as the workshop on the project "Fission and Clusterization of Heavy Nuclei". This project is implemented in the framework of this cooperation by FLNR and Stellenbosch University.

PARTICIPATION OF JINR IN INTERNATIONAL CONFERENCES

In 2013, JINR scientists and specialists took part in 390 international conferences and meetings.

The largest delegations representing JINR attended the following events: the Heraeus Seminar "Exploring the Neutrino Sky and Fundamental Particle Physics on Megaton Scale" (Bad Honnef, Germany); the 21st International Conference "Mathematics. Computer. Education" (Pushchino, Russia); the Scientific Session of the National Research Nuclear University MEPhI 2013 (Moscow, Russia); the 16th Moscow International

School of Physics (the 41st ITEPh Winter School) (Moscow, Russia); the NUSTAR Workshop (Darmstadt, Germany); the 47th Winter School of the Petersburg Institute of Nuclear Physics (PNPI) (Roshchino, Russia); the Seminar on Strategic Germany–JINR Collaboration Development (Hamburg, Germany); the 47th PNPI School on Condensed Matter Physics (Zelenogorsk, Russia); the Workshop on CBM Project (Darmstadt, Germany); the 12th Conference of Young Scientists and Specialists dedicated to the 50th anniversary of the Institute of Medical and Biological Problems (Moscow, Russia); the Workshop "Modern Nuclear Physics Methods of Condensed Matter Research" (Minsk, Belarus); the All-Russian Conference "Information and Telecommunication Technologies and Mathematical Modeling in High-Tech Systems" (Moscow, Russia); the Polynomial Computer Algebra Conference (St. Petersburg, Russia); the 4th International Particle Accelerator Conference (IPAC 13) (Shanghai, China); the Seminar in memory of B. V. Struminskiy "Color of Quarks" (Kiev, Ukraine); the 15th International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT-2013) (Beijing, China); the International School-Seminar "New Physics and Quantum Chromodynamics at External Conditions" (NPQCD-2013) (Dnepropetrovsk, Ukraine); XXVI HADES Collaboration Meeting (Prague, Czech Republic); the 5th International Workshop on Nuclear Fission and Fission-Product Spectroscopy (Caen, France); the 25th International Nuclear Physics Conference (Florence, Italy); the 113th Workshop on Beam Cooling and Related Topics (COOL'13) (Murren, Switzerland); the Workshop "Matrix Elements for Double-Beta Decay Experiments" (MEDEX'13) (Prague, Czech Republic); the 32nd International Workshop on Nuclear Theory (Rila, Bulgaria); the 21st International Workshop on High Energy Physics and Quantum Field Theory (QFTHEP-2013) (St. Petersburg, Russia); the 3rd International Conference on Theoretical Physics "Theoretical Physics and Its Applications" (Moscow, Russia); the 7th International Hadron Structure Conference (Tatranske Matliare, Slovak Republic); the 17th International Conference on Radiation Effects in Insulators (Helsinki, Finland); the International Workshop on Neutron Optics and Detectors (NOP&D 2013) (Ismaning, Germany); the 13th Baikal School on Physics of Elementary Particles and Astrophysics (Bolshie Koty, Russia); the International Conference on Neutron Scattering (ICNS 2013) (Edinburgh, UK); the 22nd International Laser Physics Workshop (LPHYS'13) (Prague, Czech Republic); the European Physical Society Conference on High Energy Physics (EPSHEP 2013) (Stokholm, Sweden); the International Workshop on Hadron Structure and Spectroscopy (IWHSS 2013) (Erlangen, Germany); the Conference "Structural Aspects of Biocompatible Ferrocolloids" (Kosice, Slovak Republic); the International Conference on New Frontiers in Physics (Kolymbari, Greece); the 23rd Mazurian Lakes Conference on Physics "Frontiers in Nuclear Physics" (Piaski, Poland); the 12th International Conference on Molecular Spectroscopy (Cracow-Bialka Tatranska, Poland); the 23rd International Workshop on Charged Particle Accelerators (Alushta, Ukraine); the 15th International Workshop on Computer Algebra in Scientific Computing (CASC 2013) (Berlin, Germany); the 46th PANDA Collaboration Meeting (Bochum, Germany); the 22nd European Conference on Few-Body Problems in Physics (EFB22) (Cracow, Poland); the School and Practice on High Energy Physics "Lattice QCD and QCD Phenomenology" (Kiev, Ukraine); the Workshop on the Project of Heavy-Ion Injector for NICA Complex (Frankfurt, Germany); the 1st International Symposium on Computational Materials and Biological Sciences (Tokyo, Japan); the 11th European Conference on Applied Superconductivity (Genoa, Italy); the Workshop for Young Scientists with Research Interests Focused on Physics at FAIR (FAIRNESS 2013) (Berlin, Germany); the International School on Nuclear Physics, Neutron Physics and Applications (Varna, Bulgaria); the 20th International Conference on Cyclotrons and Their Applications (Vancouver, Canada); the Symposium in Honour of Bruno Pontecorvo for the Centenary of the Birth (Pontecorvo 100) (Pisa, Italy); the Workshop on Small-Angle Scattering and Reflectometry "MURomets-2013" (Gatchina, Russia); the 8th Forum of Creative and Scientific Intelligentsia of CIS Member States (Minsk, Belarus); the 9th International Conference "Nuclear and Radiation Physics" (ICNRP'2013) (Almaty, Kazakhstan); the Scientific Workshop on the Emission of Prompt Gamma-Rays and Related Topics (Sremski Karlovci, Serbia); the 20th Nuclear Physics Workshop "Marie and Pierre Curie" (Kazimierz Dolny, Poland); the International Conference on "Radiation Biology and Radiation Protection" (Ulaanbaatar, Mongolia); the NEMO3/SuperNEMO International Collaboration Meeting (Bratislava, Slovak Republic); the All-Russian Conference "Membranes-2013" (Vladimir, Russia); the 2nd Russian–Spanish Congress on Particle and Nuclear Physics at All Scales, Astroparticle Physics and Cosmology (St. Petersburg, Russia); the International Conference "Nucleus-63": "Fundamental Problems of Nuclear Physics and Atomic Energy" (Moscow, Russia); the International Conference "Physics in the LHC Era" (Tbilisi, Georgia); the 15th All-Russian Scientific Conference "Digital Libraries: Perspective Methods and Technologies, Digital Collections" (RCDL'2013) (Yaroslavl, Russia); the Nuclear Track Emulsion Workshop (Sinaia, Romania); the 1st Engineering Conference "Autodesk Simulation — Innovative Engineering Analysis Techniques" (St. Petersburg, Russia); the Small Triangle Meeting on Theoretical Physics (High Tatras, Slovak Republic); the International Conference on High Energy Physics "Physics in Atlas" (Baku, Azerbaijan); the 14th Conference on Space Biology

and Medicine dedicated to the 50th anniversary of the RAS Institute of Medical and Biological Problems (Moscow, Russia); the Scientific School for Physics Teachers at the European Organization for Nuclear Research (CERN 2013) (Geneva, Switzerland); the Symposium on Supercritical Fields (Frankfurt, Germany); the International Session-Conference of the RAS DPhS Nuclear Physics Section "Physics of Fundamental Interactions" (Protvino, Russia); the International Symposium "Entrance Channel Effect on the Radiation Mechanism in Heavy-Ion Collisions" (Messina, Italy); the 27th International Congress on Laser Medicine (Florence, Italy); the 2nd International Conference "Multiscale Modeling of Structures, Structure of Substance, Nanomaterials and Nanotechnologies" in memory of Professor A. N. Nikitin (Tula, Russia); the Invenio User Group Workshop 2013 (Julich, Germany); the International Scientific Conference "Radiobiological Basis for Radiotherapy" (Moscow, Russia); the 1st National Conference on Applied Superconductivity (Moscow, Russia); the 2nd IAEA Research Coordination Meeting on Development of an Integrated Approach to Routine Automation of Neutron Activation Analysis (Vienna, Austria); the 47th PANDA Collaboration Meeting (Darmstadt, Germany); the School on Polarized Neutron Physics (Peterhof, Russia); the Workshop "Symmetry in Integrable Systems — SIS'13" (Hannover, Germany); the 9th International Workshop "Application of Lasers and Storage Devices in Atomic Nuclear Research" (Poznan, Poland); the 6th Spring School "JINR Days in Bulgaria" (Bachinovo, Bulgaria); the 21st International Seminar on Interaction of Neutrons with Nuclei (ISINN-21) (Alushta, Ukraine); the International Symposium "Nuclear Physics: Present and Future" (Boppard, Germany); the Conference of JINR Young Scientists (Alushta-2013) (Alushta, Ukraine); the 5th International Conference on Contemporary Physics (Ulaanbaatar, Mongolia); the European School on High Energy Physics (CERN–JINR School) (Parádfürdő, Hungary); the 21st International Colloquium "Integrable Systems and Quantum Symmetries" (Prague, Czech Republic); the International Workshop on Non-Accelerator New Physics dedicated to the centenary of birth of Bruno Pontecorvo (NANPino-2013) (Valdai, Russia); the 3rd International School "Symmetries and Integrable Systems" (Tsakhkadzor, Armenia); the 28th International Conference "Symmetries and Spin" (SPIN-PRAHA2013 and NICA-SPIN2013) (Prague, Czech Republic); the 7th Joint Workshop of JINR BLTP and APCTP (Asian Pacific Centre of Theoretical Physics, South Korea) "Modern Problems in Nuclear and Elementary Particle Physics" (Bolshiye Koty, Russia); the 12th International School-Seminar on Topical Problems of Microworld Physics (Gomel, Belarus); the 16th Lomonosov Conference on Physics of Elementary Particles (Moscow, Russia); the 2013 SKLTP–BLTP Joint Workshop on Physics of Strong Interaction (Beijing, China); the 16th Annual Conference of RDMS CMS Collaboration (Yerevan, Armenia); the 8th International Seminar in memory of V. P. Sarantsev "Problems of Charged Particle Accelerators" (Alushta, Ukraine); the 24th International Symposium on Nuclear Electronics and Computing (Varna, Bulgaria); the International Conference "New Trends in High Energy Physics" (Alushta, Ukraine); the JINR–Timisoara Western University Summer School on Small-Angle Neutron Scattering and Complementary Methods for "Smart Materials" Investigation (Timisoara, Romania); the 1st International African Symposium on Exotic Nuclei (IASEN 2013) (Cape Town, Republic of South Africa).

DEVELOPMENT OF THE JINR INTERNATIONAL COLLABORATION AND RELATIONS OF THE YEAR 2013

1.	Number of short-term visits to JINR by specialists from the Member States (not counting Russian specialists)	1088
2.	Number of visits of specialists from other countries, including visits of specialists from the associated countries	856 472
3.	Number of visits by JINR specialists to the Member States	1218
4.	Number of visits to international conferences and research centres of other countries, including visits to the associated countries	1605 636
5.	Number of conferences, schools, and meetings held by JINR	89
6.	Number of JINR fellows	16
7.	New cooperation agreements (memorandums of understanding), addendums to existing ones	19

LIST OF CONFERENCES AND MEETINGS HELD BY JINR IN 2013*

No.	Name	Place	Date	Number of participants
1.	40 Years of IN2P3–JINR Collaboration Workshop	Dubna	14–15 January	46
2.	Session of the Programme Advisory Committee for Condensed Matter Physics	Dubna	21–22 January	62
3.	Session of the Programme Advisory Committee for Nuclear Physics	Dubna	24–25 January	62
4.	Session of the Programme Advisory Committee for Particle Physics	Dubna	28–29 January	70
5.	BOREXINO *pp*-Analysis Working Group Meeting	Dubna	28–31 January	19
6.	11th Winter School on Theoretical Physics	Dubna	28 January – 3 February	35
7.	113th Session of the JINR Scientific Council	Dubna	21–22 February	71
8.	School-Seminar "Introduction to Condensed Matter Physics Models" (within the framework of the Bogoliubov Programme)	Chernogolovka, Russia	25 February – 1 March	20
9.	23rd Meeting of the Coordination Committee on Implementation of the BMBF–JINR Agreement	Hamburg, Germany	26 February – 1 March	16
10.	International Workshop on Spin Physics at NICA (NICA-SPIN)	Dubna	17–19 March	29
11.	Meeting of the JINR Finance Committee	Dubna	22–23 March	64
12.	Session of the Committee of Plenipotentiaries of the Governments of the JINR Member States	Dubna	25–26 March	100
13.	International Conference "V.I.Vernadsky and Atomic Science"	Dubna	27 March	40
14.	17th Research Workshop "Nucleation Theory and Applications"	Dubna	1–30 April	57
15.	School-Seminar "Integrable Structures in Quantum Field Theory"	Dubna	8–12 April	26
16.	17th Scientific Conference of JINR Young Scientists and Specialists	Dubna	8–12 April	131
17.	4th JIRN–CERN School on Information Technology "Grid and Advanced Information Systems"	Dubna	22–26 April	49
18.	International Student Practice, the First Stage — Practice for ARE Students	Dubna	12 May – 2 June	22
19.	9th International Workshop "Application of Lasers and Storage Devices in Atomic Nuclear Research"	Poznan, Poland	13–16 May	93
20.	3rd Research Coordinated Meeting (RCM-3) Related to the IAEA CRP "Development, Characterization and Testing of Materials of Relevance to Nuclear Energy Sector Using Neutron Beams"	Dubna	13–19 May	27
21.	4th Joint ARE–JINR Coordination Committee Meeting	Dubna	14 May	14
22.	5th Spring JINR–Bulgaria School on Nuclear Physics	Blagoevgrad (Bachinovo), Bulgaria	15–18 May	60
23.	21st International Seminar on Interaction of Neutrons with Nuclei (ISINN-21)	Alushta, Ukraine	20–25 May	90
24.	16th International Workshop on Computer Algebra	Dubna	21–22 May	30
25.	International Festive Colloquium dedicated to the centenary of the birth of Professor G. N. Flerov	Dubna	24 May	167
26.	International Symposium "Nuclear Physics: Presence and Future"	Boppard, Germany	29 May – 5 June	50

*A number of conferences were held jointly with other organizations.

No.	Name	Place	Date	Number of participants
27.	2nd Conference of Young Scientists and Specialists (Alushta-2013)	Alushta, Ukraine	2–9 June	69
28.	5th International Conference on Contemporary Physics	Ulaanbaatar, Mongolia	3–6 June	100
29.	Workshop of the Baikal Collaboration	Dubna	4–6 June	55
30.	European School of High Energy Physics (a CERN–JINR School)	Parádfürdő, Hungary	5–18 June	120
31.	International Workshop "Prospects for Experimental Research on the Nuclotron Beams"	Dubna	6–7 June	32
32.	7th Training for CIS Young Scientists	Dubna	9–29 June	21
33.	International Workshop "Prospects for Technique of Nuclear Track Emulsion"	Dubna	10–11 June	43
34.	Session of the Programme Advisory Committee for Particle Physics	Dubna	10–11 June	70
35.	GERDA Collaboration Meeting	Dubna	11–14 June	71
36.	21st International Colloquium "Integrable Systems and Quantum Symmetries"	Prague, Czech Republic	12–16 June	98
37.	Session of the Programme Advisory Committee for Condensed Matter Physics	Dubna	17–18 June	61
38.	Session of the Programme Advisory Committee for Nuclear Physics	Dubna	20–21 June	59
39.	Workshop for Polish Teachers "JINR"	Dubna	22–30 June	27
40.	School for Physics Teachers from the JINR Member States	Dubna	23–29 June	32
41.	International Workshop on Non-Accelerator New Physics dedicated to the centenary of birth of Bruno Pontecorvo (NANPino-2013)	Valdai, Russia	24–29 June	60
42.	International Conference "Neurophysiological Aspects of Radiation Risk in the Context of Interplanetary Flight Safety"	Dubna	26–27 June	95
43.	3rd International School "Symmetries and Integrable Systems" (SIS-2013)	Tsakhkadzor, Armenia	3–13 July	68
44.	International Student Practice, the Second Stage — Practice for Students from the JINR Member States and Other Countries	Dubna	7–28 July	75
45.	Advanced Study Institute (28th International Conference) "Symmetries and Spin" (SPIN-PRAHA2013 and NICA-SPIN2013)	Prague, Czech Republic	7–13 July	98
46.	International Conference "Mathematical Modeling and Computational Physics"	Dubna	8–12 July	171
47.	Meeting of the RAS Council on Heavy-Ion Physics	Dubna	10 July	40
48.	7th Joint Workshop of JINR BLTP and APCTP "Modern Problems in Nuclear and Elementary Particle Physics"	Bolshiye Koty, Russia	14–20 July	45
49.	Helmholtz International School "Physics of Heavy Quarks and Hadrons"	Dubna	15–28 July	65
50.	17th Summer School for Young Scientists and Specialists	Dubna (Lipnya)	19–21 July	60
51.	IN2P3–BLTP Workshop "Recent Achievements in Nuclear Theory"	Dubna	22–27 July	28
52.	Training Inspection and Seminar on Physical Protection of Nuclear Facilities	Dubna	23–26 July	20
53.	International Workshop "Supersymmetries and Quantum Symmetries" (SQS'2013)	Dubna	29 July – 3 August	116

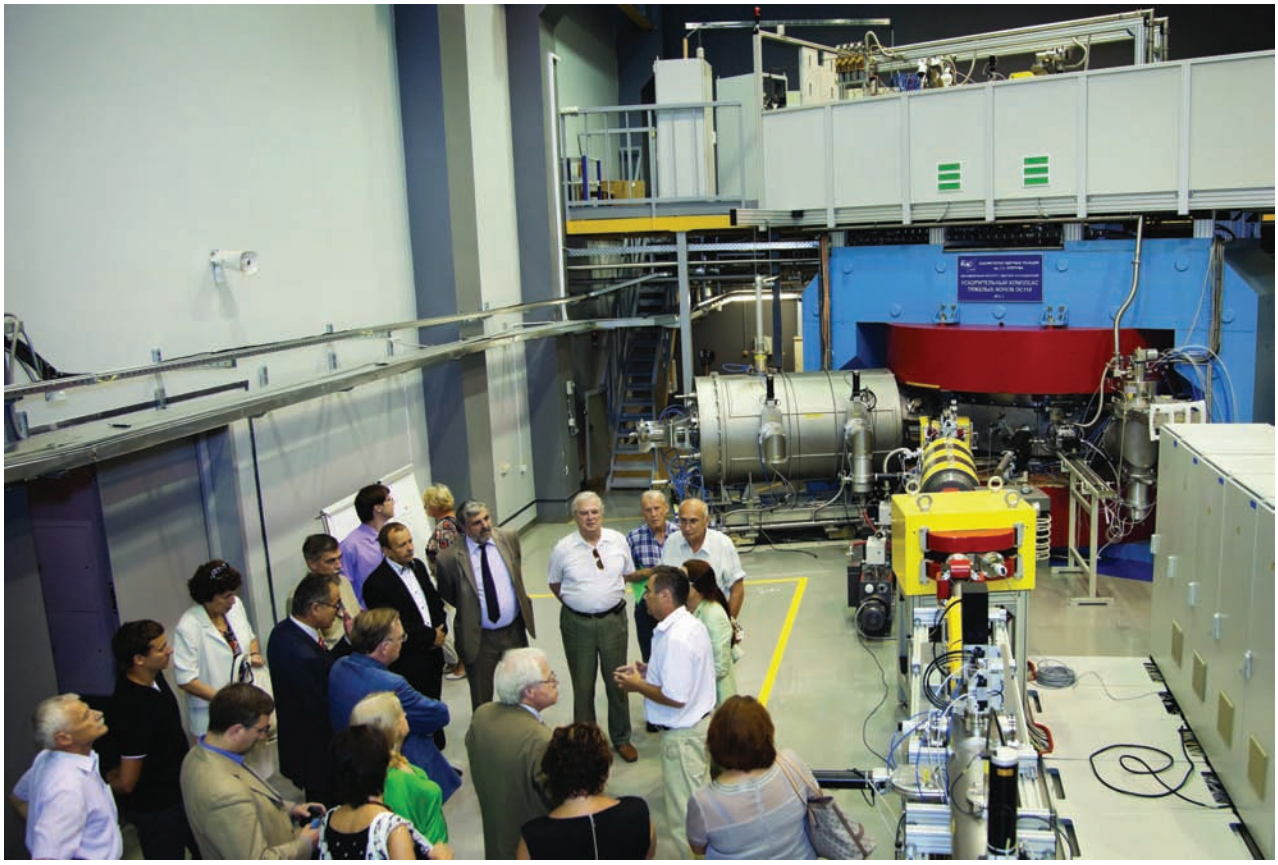
No.	Name	Place	Date	Number of participants
54.	Scientific Tour in JINR for Students from Warsaw University	Dubna	29 July – 3 August	22
55.	Gomel International School-Seminar "Topical Problems of Microworld Physics"	Gomel, Belarus	1–12 August	130
56.	International Workshop "Prospects for Cooperation in the NICA Megascience Project"	Dubna	8 August	56
57.	JINR–BMBF Workshop on the Long Pulse Based Neutron Instrumentation	Dubna	18–21 August	41
58.	2013 SKLTP–BLTP Joint Workshop on Strong Interaction	Beijing, China	22–26 August	60
59.	16th Lomonosov Conference on Elementary Particle Physics	Moscow, Russia	22–28 August	300
60.	Euroschool on Exotic Beams	Dubna	25 August – 1 September	42
61.	Seminar dedicated to the 100th anniversary of birth of B. M. Pontecorvo	Dubna	2–3 September	120
62.	8th International Scientific Workshop in Memory of Professor V. P. Sarantsev "Problems of Charged Particle Accelerators"	Alushta, Ukraine	2–6 September	62
63.	Helmholtz International School "Cosmology, Strings and New Physics"	Dubna	2–14 September	70
64.	International Student Practice, the Third Stage — Practice for Students from South Africa	Dubna	9–29 September	55
65.	24th International Symposium on Nuclear Electronics and Computing	Varna, Bulgaria	9–16 September	110
66.	International Seminar "20 Years since the Start-up of the Nuclotron and 60 Years of Research in High Energy Physics at LHEP"	Dubna	18 September	177
67.	114th Session of the JINR Scientific Council	Dubna	19–20 September	70
68.	CBM Workshop	Dubna	23–27 September	137
69.	International Conference "New Trends in High Energy Physics"	Alushta, Ukraine	23–29 September	30
70.	International Meeting on COMET Experiment	Dubna	30 September – 5 October	48
71.	15th Workshop on High Energy Spin Physics (DSPIN-13)	Dubna	8–12 October	107
72.	NICA Machine Advisory Committee (NICA MAC)	Dubna	17–18 October	25
73.	16th International Conference "Science. Philosophy. Religion"	Dubna	21–22 October	105
74.	5th Dubna Youth Scientific School "Management of Innovations"	Dubna	24–26 October	57
75.	International Youth Scientific School "Modern Neutronography"	Dubna	28 October – 1 November	53
76.	5th Session of the Joint Coordination Committee ARE–JINR	Cairo, Egypt	30–31 October	9
77.	4th International Scientific School "Instruments and Methods of Experimental Physics. Electronics and Automatics of Experimental Facilities"	Dubna	5–9 November	80
78.	Symposium "German-Dubna Astroparticle Projects: Status and Perspectives"	Dubna	11–13 November	46
79.	3rd Report Seminar of the National Group of Ukraine at JINR	Dubna	18–20 November	36

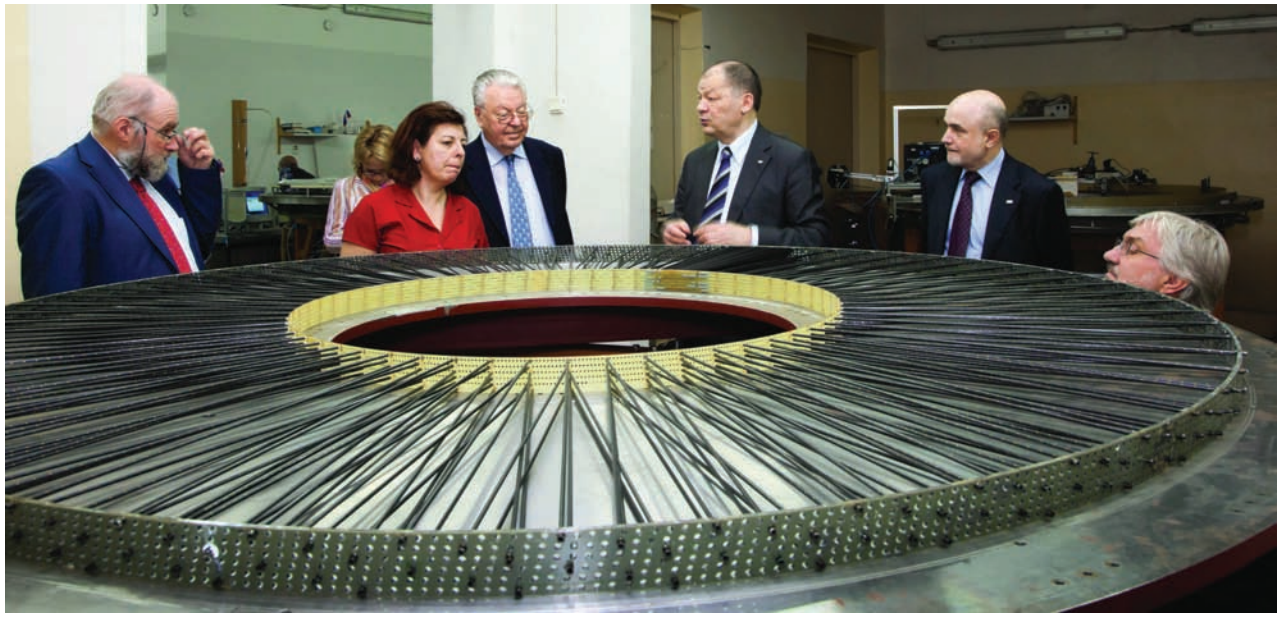
No.	Name	Place	Date	Number of participants
80.	Meeting of the JINR Finance Committee	Dubna	19–20 November	82
81.	Session of the Committee of Plenipotentiaries of the Governments of the JINR Member States	Dubna	22–23 November	120
82.	Memorial Seminar devoted to the 90th anniversary of birth of Professor M. F. Likhachev	Dubna	25 November	50
83.	JINR–UVT Summer School on Small-Angle Neutron Scattering and Complimentary Methods for "Smart Materials" Investigation	Timisoara, Romania	25–27 November	20
84.	Workshop of the Baikal Collaboration	Dubna	26–28 November	55
85.	1st International African Symposium on Exotic Nuclei	Cape Town, South Africa	2–6 December	136
86.	Session of the Joint RSA–JINR Coordinating Committee	Cape Town, South Africa	3 December	15
87.	Round Table "Cooperation of Schools, Higher Education Institutes and Enterprises in Training of Personnel for Dubna and Moscow Region Economies"	Dubna	11 December	70
88.	Moscow Regional Youth Innovation Forum	Dubna	18 December	170
89.	Workshop "Problems of Supersymmetry Integrable Systems"	Dubna	23–25 December	30

The Joint Institute for Nuclear Research is an international intergovernmental scientific research organization, the activities of which are based on principles of openness for participation to all interested states and of their equal, mutually beneficial collaboration.

Dubna, 19–20 September. The 114th session of the JINR Scientific Council

Dubna, June.
Regular meetings of the Programme Advisory Committees





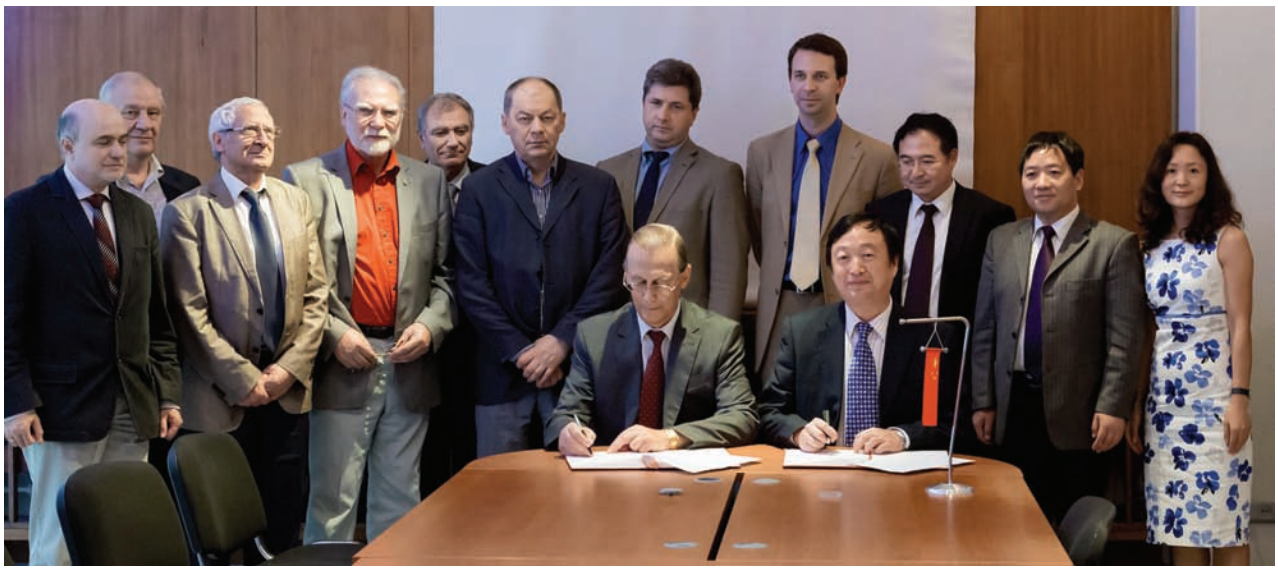
Dubna, 17 May. Representatives of the European Commission on a visit to JINR

Dubna, 14–15 January. The International Conference devoted to the 40th anniversary of the cooperation between JINR and the National Institute of Physics of Nucleus and Elementary Particles of France (IN2P3)

Dubna, 22 February. INFN (Pisa section) – JINR Agreement on cooperation is signed

Dubna, 11 July. The ceremony of signing a framework Agreement between the Academy of Sciences of Israel and JINR

Dubna, 7 August. Signing of the Memorandum of Understanding between JINR and China

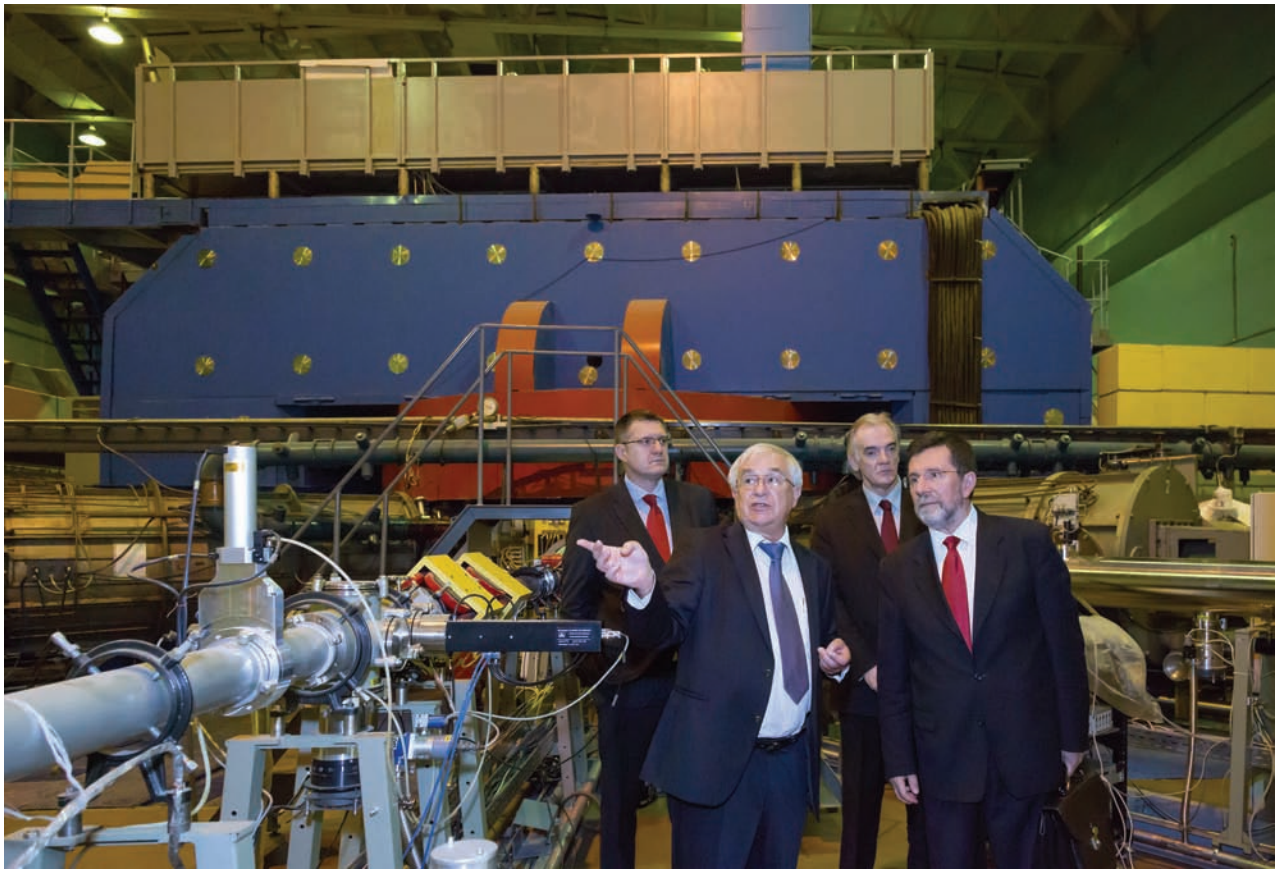


Dubna, 18 May. Director General of the International Atomic Energy Agency Yukiya Amano (the 5th right) on a visit to Dubna to be acquainted with the activities at JINR

Dubna, 8 February. The All-Institute colloquium devoted to the Day of Science

Hefei (China), 23 October. VBLHEP Deputy Director G. Trubnikov informs RF Prime Minister D. Medvedev about the NICA project at the meeting of D. Medvedev with Russian and Chinese scientists at the Institute of Plasma Physics of the Chinese Academy of Sciences

Dubna, 6 November. Ambassador Extraordinary and Plenipotentiary of the Republic of Serbia to RF S. Terzić on a visit to JINR



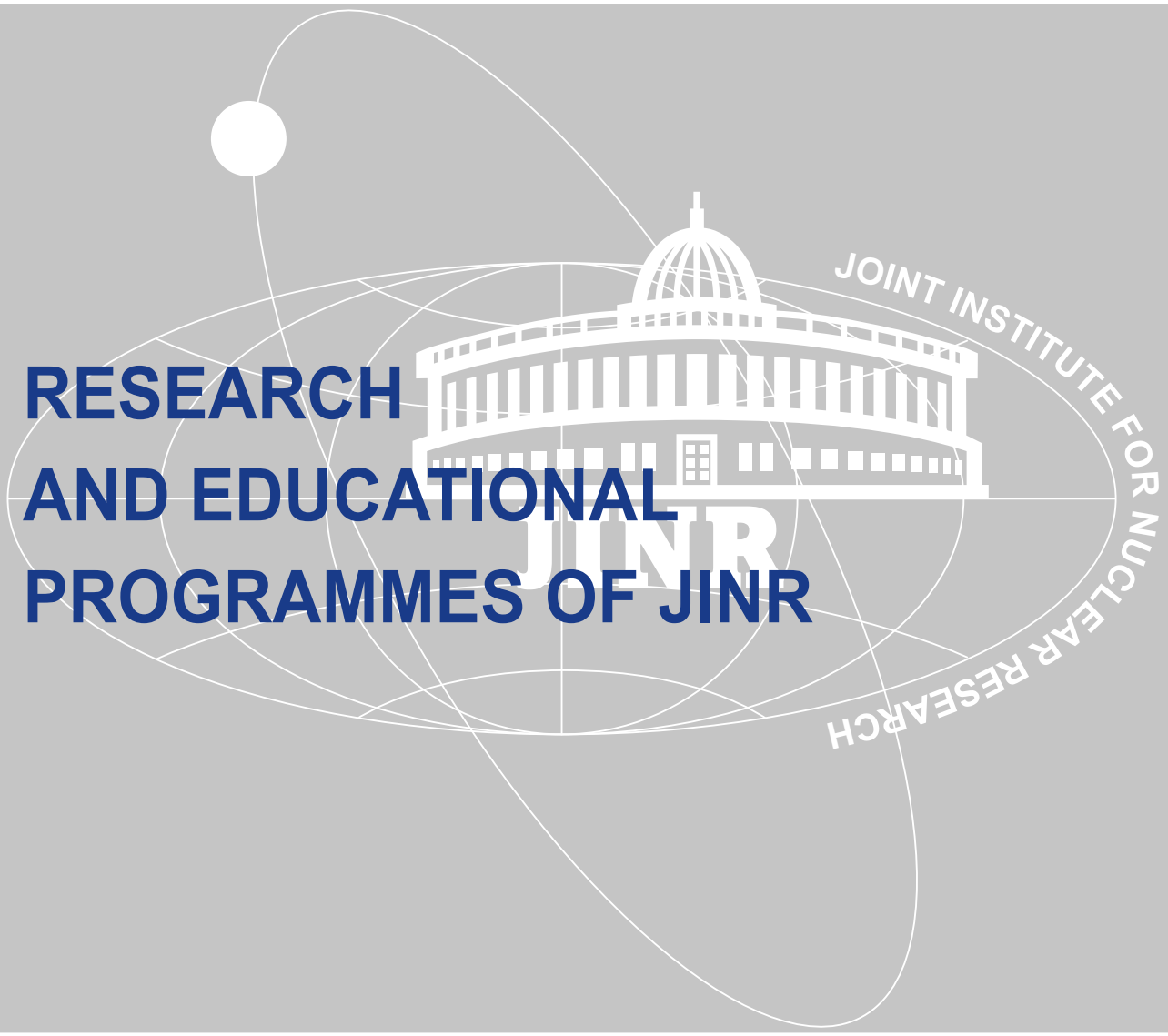
Dubna, 22–24 November. A delegation from the Czech Republic, headed by Minister of Education, Young People and Sport D. Štys, on a visit to JINR

Dubna, 23 November. A delegation from Romania visits JINR

Dubna, 7–11 October. Teachers from universities of the RSA on a visit to JINR

Cape Town (RSA), 2–6 December. Participants of the 1st International African Symposium on Exotic Nuclei (IASEN-2013)

2013



RESEARCH AND EDUCATIONAL PROGRAMMES OF JINR

BOGOLIUBOV LABORATORY OF THEORETICAL PHYSICS

At the Bogoliubov Laboratory of Theoretical Physics (BLTP), studies were carried out on the following four themes: Theory of Elementary Particles; Nuclear Structure and Dynamics; Theory of Condensed Matter and New Materials; Modern Mathematical Physics: Gravity, Supersymmetry, Integrability. An important component of the BLTP activities is theoretical support of experimental research to be carried out within major international projects with the participation of JINR as well as Dubna based experimental programmes of JINR Laboratories. The research resulted in more than 400 publications in peer-reviewed journals and proceedings of international conferences. Most of the results were obtained in cooperation with scientists from the JINR Member States, Brazil, China, Egypt, Germany, Italy, France, Serbia, Spain, and other countries. The Laboratory has become a site for organization of international conferences, workshops, schools for young scientists in various fields of theoretical physics. In 2013, more than 900 scientists participated in 13 international conferences, workshops and schools organized at the Laboratory. In 2013, the international collaboration was supported by grants of the Plenipotentiaries of Bulgaria, the Czech Republic, Poland, the Slovak Republic, Hungary, Romania and the JINR Directorate; the collaboration with German theorists was based on the Heisenberg–Landau Programme; with Armenia, on Smorodinsky–Ter-Martirosyan Programme; with Polish theorists, on the Bogoliubov–Infeld Programme; with Czech theorists, on the Blokhintsev–Votruba Programme; and Romanian theorists, on the Titeica–Markov Programme. Collaboration with scientists from Western Europe was carried out in the framework of the JINR–INFN, JINR–IN2P3 agreements and was also supported by RFBR–CNSF, RFBR–DFG, RFBR–CNRS. The agreements for collaboration between the Bogoliubov Laboratory and CERN TH, KEK, APCTP (South Korea), ITP CAN (Beijing) are functioning. Much attention was paid to recruiting young researchers, students, and post-graduate students to the Laboratory within the research and education project "Dubna International Advanced School of Theoretical Physics" (DIAS-TH), in particular. More than 80 PhD students and young scientists from the JINR Member States participated in the DIAS-TH schools. The Laboratory plays the role of the training center for young scientists and students from many countries. Currently, about one third of the scientific personnel are young scientists and PhD students. Within the JINR fellowship programme for nonmember states several young researchers from Argentina, China, India, Japan, Mexica, South Korea, Tajikistan and Turkey have been working at BLTP on the long-term basis.

SCIENTIFIC RESEARCH

Theory of Elementary Particles

Theoretical investigations were continued in the framework of the following projects:

- Standard Model and Its Extensions;
- QCD Parton Distributions for Modern and Future Colliders;
- Physics of Heavy and Exotic Hadrons;
- Mixed Phase in Heavy-Ion Collisions.

In the Yang–Mills theory with $N = (1,1)$ supersymmetry in $D = 6$ dimensions within the spinor helicity and on-shell superspace formalism, the scattering amplitudes on mass shell were studied. This formalism

leads to an effective and straightforward technique reducing the calculation to a set of scalar master-integrals. The four-point amplitude was calculated in one and two loops in the planar limit. All integrals are UV and IR finite and expressed in terms of logs and polylogs of transcendentality level 2 at one loop, and 3 and 4 at two loops. The all-loop asymptotical limit at high energy was obtained which exhibits the Regge-type behaviour. The exact expression for the intercept is obtained in the planar case [1].

A new formalism for computing and including both the perturbative and nonperturbative QCD contributions to the scale evolution of average gluon and quark jet multiplicities was developed. The new method is motivated by recent progress in timelike small-x resummation obtained in the MS-bar factorization scheme. The next-to-next-to-leading-logarithmic (NNLL) resummed expressions, which represent generalizations of previous analytical results, were obtained. It was shown that a global fit of gluon and quark jet multiplicities to all available experimental data sets results in the statistical and theoretical uncertainties both not exceeding 5% for scales above 10 GeV. It was finally proposed to use the jet multiplicity data as a new way to extract the strong-coupling constant. Including all the available theoretical input within our approach, $\alpha_s(M_Z) = 0.1199 \pm 0.0026$ was obtained in the MS-bar scheme for 5 active quarks in an approximation equivalent to next-to-next-to-leading order enhanced by the resummations of $\ln(x)$ terms through the NNLL level and of $\ln(Q^2)$ terms by the renormalization group, in excellent agreement with the present world average [2].

In a series of papers [3], the three-loop beta-functions for fundamental parameters of the Standard Model were calculated. The obtained results allowed one to analyze the behaivoir of the SM in the region of Plank energies and stimulated the research dedicated to the problem of vacuum stability. In addition, the beta-functions for the gauge constants and the parameters of the Higgs field potential are generalized to the case of matrix Yukawa couplings.

The polarized Bjorken sum rule at low momentum transfers in the range $Q = 0.22-1.73$ GeV up to the four-loop level was analyzed in the framework of the QCD perturbation theory and the singularity-free analytic perturbation theory (APT). It was shown that the usage of the two-loop APT allowed one to describe the precise low-energy JLab data down to $Q \sim 300$ GeV and extract the higher twist corrections in a reliable way [4].

A regularization procedure for the integral curvature invariants on manifolds with conical singularities in the presence of squashed cones was proposed. This allows one to calculate the entanglement entropy for the entangling surfaces which have extrinsic curvatures. A case of invariants which are quadratic polynomials of the Riemann curvature is elaborated in different dimensions and applied to several problems related to the entanglement entropy. The results are in complete agreement with computations of the logarithmic terms in the entanglement entropy of 4D conformal field theories [5].

The rare decays of heavy hadrons containing b-quark attract increasing attention in connection with the search for new physics effects at the LHC. In a series of papers [6, 7], a systematic analysis of rare decays of λ_b-baryon was carried out. Within the covariant quark model developed in Dubna, all possible form factors characterizing the b-quark transitions to s-quark in the entire kinematic region of the momentum transfer squared were calculated. The differential rates, the asymmetry parameters and the widths of rare and nonleptonic decays were calculated by means of the obtained form factors. Using the model-independent helicity methods we have written down a three-fold joint angular decay distribution for the cascade decay $\lambda_b \to \lambda(\to p\pi) + J/\psi(\to l^+l^-)$. The given formula is already used by experimentalists in the analysis of the angular distributions in the rare decays of λ_b-baryon.

The complete contribution of corrections of an order of $m\alpha^7$ and the contribution of the leading corrections of an order of $m\alpha^8$ to the energies of ρ-vibrational transitions in the molecular ions of hydrogen H_2^+ and HD^+, and in the antiprotonic helium atoms were calculated [8]. That allows one to infer the atomic mass of the electron and electron-to-(anti)proton mass ratio with fractional uncertainty of $(1-0.8) \cdot 10^{-10}$. For comparison, the CODATA recommended value for the atomic mass of electron has fractional uncertainty of $4.1 \cdot 10^{-10}$.

The applicability domain was studied for a QTF based approach with covariant wave packets as the in- and out-states, which describes the neutrino flavor transitions. The approach incorporates the so-called Grimus-Stockinger (GS) theorem which defines the asymptotics of the generalized neutrino propagator at large distances. The extended GS theorem was formulated and proved. It was shown that the preasymptotic corrections could lead to the observable effects of breakdown of the classical inverse-square law (ISL) at short but macroscopic distances. A statistical analysis of available reactor data suggests that the ISL violation could be fully or partially responsible for the reactor anomaly observed in SBL experiments [9].

Transition form factors of pseudoscalar mesons in the space- and time-like regions are studied by means of the anomaly sum rule (ASR) — an exact nonperturbative relation which is a consequence of the dispersive representation of axial anomaly. The analytical continuation of ASR to the time-like region allows one to link the axial anomaly with the vector meson dominance model [10].

Within the factorized handbag model, the transversity effects in the light-vector-mesons production were analyzed. It was shown that transversity Generalized Parton distributions H_T and E_T are extremely important in the description of the spin density matrix elements (SDMEs) and spin asymmetries in a transversely

polarized target for the ρ-meson production. The obtained results are in good agreement with the data of HERMES and COMPASS experiments [11].

Within the QCD analysis of the COMPASS and HERMES data on the pion and kaon multiple production, the new parameterizations of the fragmentation functions were obtained, which can eliminate differences in the results of analysis of the polarized DIS and SIDIS data [12].

It was demonstrated that the ligh-by-light hadronic corrections to the muon anomalous magnetic moments due to the contributions of light pseudoscalar and scalar mesons and dynamical quark loop cannot explain the sharp disagreement between experimental observations and theoretical prediction of the Standard Model [13].

It was shown that large anomalous chromomagnetic moment of quarks, induced by complex topological structure of QCD vacuum, plays an important role in the different high-energy reactions. In particular, this interaction should lead to large spin effects in the reactions with polarized hadrons [14].

The light-cone QCD sum rules for the electromagnetic nucleon form factor were derived including the next-to-leading-order corrections for the contribution of twist-three and twist-four operators and the self-consistent treatment of the nucleon mass corrections [15].

The dynamics of color fields as generated by configurations of relativistic particles with Abelian and non-Abelian ($SU(2)$) charges was studied in the classical limit. Though the chromodynamic (non-Abelian) systems generally show Coulomb-like features in analogy with electrodynamics, a very peculiar feature in the non-Abelian case is that the presence of the non-Abelian additional term in the chromoelectric and chromomagnetic fields creates a kind of "color charge glow", which is manifested as a distinct color wave disturbance. The phenomenon may be relevant to the hadronization phase in ultrarelativistic heavy-ion collisions, where the partonic state is governed by strong local color fluctuations [16].

It was shown that within the lattice QCD, the large-scale topological gluon configurations play a major role in the change of thermal gauge field ensembles at the deconfinement phase transition in gluodynamics as well as at the crossover phenomenon in full QCD. It was demonstrated that the topological susceptibility can be used as an indicator for deconfinement phase transition [17].

Modern Mathematical Physics

The topics of main focus in the theme were:
- Supersymmetry and Superstrings;
- Quantum Groups and Integrable Systems;
- Quantum Gravity and Cosmology.

The R-matrix acting in the tensor product of two spinor representation spaces of Lie algebra $so(d)$ was thoroughly studied. The corresponding Yang–Baxter relation was proved and the underlying local Yang–Baxter equation was established [18].

A new method of searching for the integrals of motion in dilaton gravity was developed; some additional integrals of motion in affine gravity were found, and static/cosmological states were investigated. The possibility of cosmological inflation driven by the homogeneous and isotropic Yang-Mills field $SU(2)$ was investigated in different models [19].

A possible connection between two second-order theories of gravity, Galilean gravity, and teleparallel gravity was studied. By using the conformal transformation method, we constructed from the third-order Galilean action some auxiliary action, which can be covariantly generalized only in theories with torsion. On this way, a new second-order phenomenological Lagrangian was obtained, which may be useful for cosmological applications and for construction of a new second-order theory of gravity [20].

A number of integrable one-scalar spatially flat cosmologies were built. Their behavior was examined in several cases, and some general lessons on this type of systems, whose potentials involved combinations of exponential functions, and on similar nonintegrable ones were drawn. These include the need for the scalar to emerge from the initial singularity while climbing up sufficiently steep exponential potentials ("climbing phenomenon") and the inevitable collapse in a Big Crunch whenever the scalar tries to settle at negative extrema of the potential. The links between these types of potentials and "brane supersymmetry breaking" were elaborated on — a mechanism that ties together string scale and scale of supersymmetry breaking in a class of orientifold models. Under some assumptions, the extended objects of these vacua can inject inflationary phases with discrete values of the spectral index that are determined by the number of unwrapped dimensions of the branes and by the inverse power with which the string coupling g_s enters into their world-volume actions. An NS fivebrane, which is interestingly unstable in this class of models, when wrapped on a small internal cycle would yield a spectral index that is amusingly close to the experimentally favored PLANCK value $n_s \sim 0.96$ [21].

The electromagnetic vacuum energy was considered in the presence of perfectly conducting plane and a ball with dielectric permittivity ε and with magnetic permeability $\mu, \mu \neq 1$. The Casimir repulsion in the system is caused by the magnetic permeability of the ball. In the case of a perfectly permeable sphere, $\mu \to \infty$, the vacuum energy was estimated numerically. The short- and long-distance asymptotes corresponding to the repulsive force and respective low-temperature corrections and high-temperature limits were found for a wide range of μ. The constraints on the Casimir repulsion in this geometry were established [22].

A method to construct the on-shell component actions for the theories with $1/2$ partial breaking of global

supersymmetry within the nonlinear realization (coset) approach was proposed. An example of the component action of $N = 1$ supermembrane in $D = 4$ constructed within our procedure was examined in detail [23].

A class of $d = 1$ sigma models of the Wess–Zumino type on the $SU(n|1)/U(n)$ fermionic cosets was constructed. Both classical and quantum models were considered. The unitarity of the quantum models was poven by introducing the metric operator on the Hilbert space of the quantum states, so that all their norms became positive-definite. It was shown that the quantum $n = 2$ model exhibited hidden $SU(2|2)$ symmetry [24].

The general formulation of $N = 1$ supersymmetric self-dual Abelian gauge theory involving auxiliary chiral spinor superfields was constructed. Self-duality in this context was just $U(N)$ invariance of the nonlinear interaction of the auxiliary superfields. A few instructive examples of a procedure to generate self-dual $N = 1$ models with higher derivatives in this approach were considered [25].

Based on the nonlinear realization method, we proposed a method for construction of component actions on the mass surface for supersymmetric fields with half violated global supersymmetry [26].

The relations between minimal dilatonic gravity and $f(R)$ gravity theories were established, and strict conditions for their global equivalence were studied [27].

In the studies of quantum integrable models with $GL(3)$ trigonometric R-matrix, it was proved that the set of nested Bethe vectors was closed under the action of the elements of the monodromy matrix [28].

The existence of pseudotoric structures on any toric symplectic manifold was proved and the conjecture was presented which states that given by this construction exotic monotone Lagrangian tori are Hamiltonian non-isotopic to the standard Liouville tori [29].

Nuclear Structure and Dynamics

In 2013, investigations within the area "Nuclear Structure and Dynamics" were carried out in accordance with the four projects:

- Nuclear Structure Far from Stability Valley;
- Nucleus–Nucleus Collisions and Nuclear Properties at the Low Energies;
- Exotic Few-Body Systems;
- Nuclear Structure and Dynamics at the Relativistic Energies.

Within the QRPA, the partial restoration of the isospin symmetry was achieved. This was accomplished by separating the renormalization parameter g_{pp} of the particle–particle proton–neutron interaction into the isovector and isoscalar parts. The isovector parameter needs to be chosen to be essentially equal to the pairing constant $g_{\rm pair}$, so no new parameter is needed. For the $0\nu\beta\beta$ decay, the Fermi matrix element M_f is substantially reduced, while the full matrix element M^{ov} is reduced by $\sim 10\%$. Moreover, the fulfillment of the requirement that the $2\nu\beta\beta$ Fermi matrix element vanishes is also achieved unlike in the previous version of the method [30].

The action of the long-range residual force on the expectation value of observables in the nuclear ground states was evaluated by finding optimal values for the coefficients of the canonical transformation which connects the phonon vacuum state with the (quasi)particle ground state. We compare the ground-state wave functions, obtained using the presented approach, with those obtained using the conventional random phase approximation (RPA) and its extended version ERPA. The problem with overbinding of the nuclear ground state calculated by using the RPA was shown to be removed if one sticks to the prescriptions of the present approach. The reason being that the latter conforms to the original variational formulation. Calculations were performed within the two-level Lipkin–Meshkov–Glick model [31].

The influence of the coupling between one- and two-phonon terms in the wave functions and the tensor force effects on properties of Gamow–Teller states has been studied [32]. It was found that the beta-decay half-lives are decreased by these effects. Calculations are in good agreement with the available experimental data for the $N = 50$ isotones. A prediction for the beta-decay half-life of ^{76}Fe that is important for stellar nucleosynthesis has been done.

The nature of $E1$ low-energy strength (LES), often denoted as a "pygmy" dipole resonance, was analyzed within the random phase approximation (RPA) in ^{208}Pb by using Skyrme forces in a fully self-consistent manner. The first overview is given by the strength functions for the dipole, compressional, and toroidal operators. A more detailed insight is gained by averaged transition densities and currents where the latter provide a very illustrative flow pattern. The analysis revealed a clear isoscalar toroidal flow in the low-energy bin 6.0–8.8 MeV of the LES and a mixed isoscalar/isovector toroidal/compression flow in the higher bin 8.8–10.5 MeV. Thus the modes covered by LES embrace both a vertical and an irrotational motion. The simple collective picture of LES as oscillations of the neutron excess against the nuclear core is not confirmed [33].

A collective model able to describe the chiral rotation and vibration was proposed and applied to the system of one $h_{11/2}$ proton particle and one $h_{11/2}$ neutron hole coupled to triaxial rigid rotor. It goes beyond the mean-field approximation, includes quantum fluctuations in the chiral degree of freedom, and restores the chiral symmetry. The potential energy and the mass coefficients are obtained and included in the collective Hamiltonian. It is shown that for chiral rotations, the partner states become more degenerate with increasing angular momentum [34].

The isotopic dependence of the complete fusion (capture) cross section was analyzed in the reactions $^{130,132,134,136,138,140,142,144,146,148,150}\mathrm{Xe} + {}^{48}\mathrm{Ca}$ with stable and radioactive beams. It was shown for the first time that the neutron-rich nuclei $^{186-191}\mathrm{W}$ can be reached with relatively large cross sections by complete fusion reactions with radioactive ion beams at incident energies near the Coulomb barrier. A comparison between the complete fusion and fragmentation reactions for the production of neutron-rich W and neutron-deficient Rn isotopes was performed [35].

Using an improved scission-point model, the mass distributions were calculated for induced fission of even Hg isotopes with mass numbers from $A = 174$ to 196. With increasing A of a fissioning $^{A}\mathrm{Hg}$ nucleus, the mass distribution evolves from the symmetric one for $^{174}\mathrm{Hg}$ to the asymmetric for isotopes close to $^{180}\mathrm{Hg}$ and back to a more symmetric for $^{192,194,196}\mathrm{Hg}$. In the fissioning Hg isotopes their excitation energy weakly influences the shape of the mass distribution. In $^{180,184}\mathrm{Hg}$, the mass distributions of fission fragments remain asymmetric even at high excitation energies [36].

The concept of dynamical adiabatic states, originally proposed to describe one-electron atom(ion)–ion collision systems was developed and the properties of the corresponding dynamical adiabatic potential energy curves were studied for a complete range of internuclear distances R. The advantages of a dynamical adiabatic basis are threefold. First, it is compatible with the boundary conditions. Second, rotational transitions are transformed into radial transitions via a type of hidden crossings in contrast with the standard adiabatic basis. And third, the ionization process can be described by using a basis of the complete discrete orthogonal wave packets, which is much more satisfactory for the process compared with the standard adiabatic approach [37].

A nonperturbative theoretical approach to treat collisions with generic anisotropic interactions in quasi-one-dimensional geometries was developed. This approach avoids the limitations of pseudopotential theory and allows one to include accurately long-range anisotropic interactions. For ultracold dipolar collisions in a harmonic waveguide, it predicts dipolar confinement-induced resonances (DCIRs) which are attributed to different angular momentum states. The analytically derived resonance condition reveals in detail the interplay of the confinement with the anisotropic nature of the dipole-dipole interactions. The results obtained are in excellent agreement with *ab initio* numerical calculations confirming the robustness of the presented approach. The exact knowledge of the positions of DCIRs may pave the way for the experimental realization of, e.g., Tonks-Girardeau-like or super-Tonks-Girardeau-like phases in effective one-dimensional dipolar gases [38].

A new, essentially stronger bound on the rotation of a spectral subspace of a self-adjoint Hamiltonian under generic additive perturbations was found. The proof of this bound is based on using a new $\sin 2\theta$ theorem that provides a local estimate on the maximal angle between unperturbed and perturbed spectral subspaces. Another ingredient of the proof is the triangle inequality for maximal angles between arbitrary subspaces of the Hilbert space [39].

The results of analysis of elastic scattering and breakup processes in interactions of the $^{11}\mathrm{Li}$ nucleus with protons are presented. The hybrid model of the microscopic optical potential (OP) was applied. This OP includes the single-folding real part, while its imaginary part was derived within the high-energy approximation theory. For $^{11}\mathrm{Li} + p$ elastic scattering, the microscopic large-scale shell model (LSSM) density of $^{11}\mathrm{Li}$ was used. The depths of the real and imaginary parts of OP were fitted to the elastic scattering data at 62, 68.4, and 75 MeV/nucleon, being simultaneously adjusted to reproduce the true energy dependence of the corresponding volume integrals. The role of the spin-orbit potential was studied and predictions for the total reaction cross sections were made. Also, the cluster model, in which $^{11}\mathrm{Li}$ consists of a $2n$-halo and the $^{9}\mathrm{Li}$ core having its own LSSM form of density, was adopted. The respective microscopic proton-cluster OPs were calculated and folded with the density probability of the relative motion of both clusters to get the whole $^{11}\mathrm{Li} + p$ OP. The breakup cross sections of $^{11}\mathrm{Li}$ at 62 MeV/nucleon and momentum distributions of the cluster fragments were calculated. The analysis of the single-particle density of $^{11}\mathrm{Li}$ within the same cluster model accounting for the possible geometric forms of the halo-cluster density distribution was performed [40].

The generalized Breit–Wheeler process, i.e., the emission of e^+e^- pairs off a probe photon propagating through a polarized short-pulsed electromagnetic (e.g., laser) wave field, was analyzed. We showed that the production probability was determined by the interplay of two dynamical effects. The first one was related to the shape and duration of the pulse and the second one is the nonlinear dynamics of the interaction of $e^{\pm}$ with the strong electromagnetic field. The first effect manifests itself most clearly in the weak-field regime, where the small field intensity is compensated by the rapid variation of the electromagnetic field in a limited space–time region, which intensified the few-photon events and could enhance the production probability by orders of magnitude compared to an infinitely long pulse. Therefore, short pulses may be considered as a powerful amplifier. The nonlinear dynamics in the multiphoton Breit–Wheeler regime plays decisive role at large field intensities, where effects of the pulse shape and duration are less important. In the transition regime, both effects must be taken into account simultaneously. We provide suitable expressions for the e^+e^- production probability for kinematic regions which can be used in transport codes [41].

Theory of Condensed Matter

Theoretical investigations within the theme "Theory of Condensed Matter and New Materials" were continued in the framework of the following projects:

• Physical Properties of Complex Materials and Nanostructures;

• Mathematical Problems of Many-Particle Systems.

A microscopic theory of high-temperature superconductivity in cuprates was formulated within the extended Hubbard model in the limit of strong correlations ($U \gg t$). It was shown that the kinematic spin-fluctuation interaction played the major role in the d-wave superconducting pairing while the intersite Coulomb repulsion and electron-phonon interactions are small [42].

The peculiarities of symmetry breaking, symmetry transformations and the related physical effects in finite quantum systems were investigated. It was shown that for finite systems with a sufficiently large number of particles, crossover transitions became sharp, so that symmetry breaking happened similarly to that in macroscopic systems. These concerns, in particular, global gauge symmetry breaking, related to the Bose–Einstein condensation and superconductivity, or isotropy breaking, related to the generation of quantum vortices, and the stratification in multicomponent mixtures [43].

A detailed analysis of the problem of possible magnetic behavior of the carbon-based structures was fulfilled to elucidate and resolve some unclear and disputable issues, in particular, the peculiar and contradictory experimental results. It was concluded that the results of the previous studies, where the "ferromagnetism" was detected in pure graphene, were incorrect. Rather, graphene was strongly diamagnetic, similarly to graphite. It was shown that the traces of a quasi-magnetic behavior, which some authors observed in their samples, should be attributed to induced magnetism due to the impurities, defects, etc. This conclusion was confirmed in the most recent experiments by the Geim–Novoselov group [44].

The critical exponents of the model of polymer chains were derived for the case when the ends of chains were located in local areas separated by a large distance exceeding the persistence length [45].

A new solution of the Yang–Baxter equation, the most complicated among known ones, was constructed, which was determined by an integral operator with an elliptic hypergeometric kernel. This led to new solvable models of spin chains with continuous values of spins [46].

A three-parametric family of integrable totally asymmetric models of interacting particles with factorized steady state was proposed. The Bethe equations were obtained for the model on the periodic lattice, and the expression for the Green function of the Markov equation was conjectured for the model on the infinite lattice [47].

The phase behavior in a double-strand DNA was considered. It was shown that T_c is the point of the infinite order phase transition. The specific behavior of the order parameter, free energy, and correlation functions was addressed [48].

A survey is given of the theory and applications of a new class of special functions of mathematical physics — elliptic hypergeometric functions [49].

The book is devoted to the review of the original results of the author in the theory of integrable $s = 1/2$ quantum spin chains with the exchange constants proportional to the inverse square hyperbolic sine (infinite chains) and the Weierstrass elliptic function with a real period which equals the number of lattice sites (chains with periodic boundary conditions) [50].

Tunnel current was calculated in a contact made of both graphene monolayers and bilayers with two possible packings and orientations of the crystal lattice. For zigzag termination, it was found that the tunnel current exhibits characteristic peaks due to localized edge states, which leads to a pronounced ON/OFF effect under the influence of the gate voltage. The switching effect was found to be absent in the case of graphene contacts with armchair termination, and increasing bias voltage provokes only an increase in the conductivity [51].

The auxiliary lattice spin and itinerant dopon degrees of freedom of the spin-dopon formulation of the $t-J$ model were shown to be confined in the emergent $U(1)$ gauge theory generated by the electron no double occupancy constraint. This constraint is enforced by the requirement of an infinitely large spin-dopon coupling. As a result, the $t-J$ model is equivalent to a Kondo–Heisenberg lattice model of itinerant dopons and localized lattice spins at infinite Kondo coupling at all dopings. We show that a Fermi-liquid treatment of the large vs. small Fermi surface crossing in the cuprates, which heavily relies on the Luttinger count, leads to inconsistencies and it is automatically excluded form the $t-J$ model framework [52].

The presence of a charge density wave (CDW) along a stack of coupled Josephson junctions (JJs) in layered superconductors was demonstrated. The transformation of a longitudinal plasma wave to CDW and transitions between different types of CDWs were described. The effect of the external electromagnetic radiation on the states corresponding to CDW differs crucially from the case of the single JJ. Shapiro steps in JJ along the stack does not correspond directly to the frequency of external radiation but demonstrates different voltages reflecting the voltage distribution of rotating and oscillating Josephson junctions in the stack [53].

DUBNA INTERNATIONAL ADVANCED SCHOOL OF THEORETICAL PHYSICS (DIAS-TH)

In 2013, the research and education project DIAS-TH was successfully continued. There were the following activities in the framework of DIAS-TH:

- XI Winter School on Theoretical Physics (January 28 – February 3);
- XVII Research Workshop "Nucleation Theory and Applications" (April 1–30);
- Helmholtz International Summer School–Workshop "Physics of Heavy Quarks and Hadrons" (July 15–28);
- Helmholtz International School "Cosmology, Strings and New Physics" (September 2–14);
- Regular seminars for students and postgraduates were organized;
- Computer processing of videorecords of lectures was continued;
- Web-site of DIAS-TH was supported.

Preliminary Plans for 2014

- XII Winter School on Theoretical Physics (February 2–8);
- XVIII Research Workshop "Nucleation Theory and Applications" (April 1–30);
- Helmholtz International Summer School "Nuclear Theory and Astrophysical Applications" (July 21 – August 1);
- Helmholtz International School "Lattice QCD, Hadron Structure and Hadronic Matter" (August 25 – September 6).

CONFERENCES AND MEETINGS

- XXI International Colloquium "Integrable Systems and Quantum Symmetries", June 12–16, Prague, Czech Republic;
- III International School "Symmetry in Integrable Systems and Nuclear Physics", July 7–13, Tsakhadzor, Armenia;
- Advanced Study Institute "Symmetries and Spin", July 7–13, Prague, Czech Republic;
- VII APCTP–BLTP/JINR Joint Workshop "Modern Problems in Nuclear and Elementary Particle Physics", July 14–19, Bolshye Koty, Irkutsk region;
- IN2P3–BLTP Workshop "Recent Achievements in Nuclear Theory", July 22–27, Dubna;
- International Workshop "Supersymmetries and Quantum Symmetries (SQS'2013)", July 29 – August 3, Dubna;
- KLFTP/CAS–BLTP/JINR Workshop "Nuclear Problems", August 26–30, Beijing;
- XV International Workshop "High-Energy Spin Physics (DSPIN2012)", October 8–12, Dubna;
- Armenia–Dubna Workshop "Problems of Integrable (Supersymmetric) Systems", December 25–26, Dubna.

COMPUTER FACILITIES

In 2013, two high-performance servers have been purchased for replacement of the aged servers theor.jinr.ru and thproxy.jinr.ru. To accelerate the data transfer between BLTP servers, the technology of 10 Gbit/s Ethernet has been introduced. Forty high-performance PCs were purchased. Several packages of licensed software have been acquired: network licenses for Intel Cluster Studio for Linux, additional network licenses for Wolfram Mathematica, large pools of software from Adobe, ABBYY, Design Science. The wireless WiFi network comprised of 20 access points covering the whole main BLTP building has been constructed.

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VEKSLER AND BALDIN LABORATORY OF HIGH ENERGY PHYSICS

The activity of the V. I. Veksler and A. M. Baldin Laboratory of High Energy Physics in 2013 was focused on the implementation and further development of the NICA project (the Nuclotron-NICA, MPD and BM@N subprojects) and the participation in current researches in various world-class accelerator centers.

THE MOST IMPORTANT RESULTS IN THE DEVELOPMENT OF THE ACCELERATOR COMPLEX

Development and Running of the Basic Facilities

Development of LHEP's accelerator complex in 2013 was aimed at construction of systems and elements for newly created accelerator facilities of the NICA complex.

There were two Nuclotron runs (the 47th and the 48th) in 2013 with the total duration of 2000 hours. The proposed physics research programme, for which 60% of the beam time was allocated, is almost completed. During acceleration shifts of the runs, there were carried out works aimed both to enhance the capabilities of the accelerator complex for the current physics research programme implementation and to test the equipment and operation modes of the newly created facilities of the NICA complex — the booster and collider.

Nuclotron-NICA

Among the most significant achievements obtained during the runs, there are the following:

• A new quench detection system was put into operation [1].

• A new source of light ions on the base of modern Nd-YAG solid-state laser was put into test operation during Run 48.

• Works on the stepwise increase of the ion energy were continued. In the course of Run 47, the beam extraction for the experiments within the framework of the physics research programme was accomplished at the energy of 4.8 GeV/nucleon. The experiments with carbon nuclei were carried out at the energy of 5.15 GeV/nucleon during Run 48. At the end of the run, a beam of carbon nuclei was accelerated to the maximal design field of the dipole magnets — 2 T, which corresponds to the energy of about 5.7 GeV/nucleon.

• Field pulsations on the plateau were reduced by more than an order; it was demonstrated that it is possible to obtain the direct current ratio of about 90%

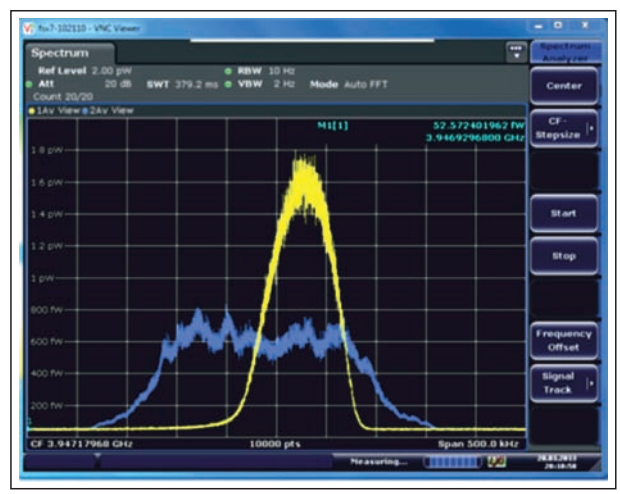

Fig. 1. Spectrum of the longitudinal shot noise of the beam at the 3048th revolution harmonic frequency. The bottom curve (blue) — immediately after the injection, yellow curve — after 8 minutes of cooling. Deuteron energy is 3 GeV/nucleon, beam intensity is 10^9 particles

at slow extraction. The possibility of slow extraction at the spill duration of up to 20 s was also demonstrated.

• A segment of the NICA complex's ACS based on the Tango software complex was put into test operation.

• Elements of the acceleration system and diagnostics devices dedicated to the NICA complex's Booster were tested.

• During Run 47, stochastic cooling for longitudinal degree of freedom of a coasting deuteron beam using the method of notch filter was implemented for the first time in Russia (Fig. 1). In Run 48, the works on cooling were continued with carbon nuclei — cooling was carried out for a coasting beam as well as for a focused one.

NICA

The year 2013 was a crucial one in the sense of the NICA construction. The State Expertise for the NICA civil construction has been successfully fulfilled. For the first time, an international tender for the construction company has been organized. The works on the building site preparation for the NICA complex have been started.

The following main results were achieved in construction of new elements for the NICA complex:

• Testing a new source of polarized particles was started.

• In April–May 2013, the first run was carried out with the test source of multicharged heavy ions KRION-6T and the work at this source has been going on almost uninterruptedly since August. Gold beam generation was demonstrated in the charge state of 30^{+}–32^{+} required for injection into the Booster at the level of 50% of the designed value. The source is being prepared for acceleration of heavy ions at the Nuclotron.

• In 2013, the BEVATECH company produced and prepared sections of the HILac heavy ion linear accelerator for copper plating. The start of the equipment delivery to JINR is expected in May of 2014. Redesign was elaborated of the building dedicated for the HILac allocation; renovation works were started.

• It is planned to do major repairs of Building 1 in order to prepare it for placing the magneto-optical structures, systems and equipment of the Booster. Initial data for technical design specification were prepared, and repairs design elaboration was put out to tender.

• Production of accelerating stations of the Booster is near completion at the BINP, SB of RAS, check assembly was performed and testing was started. In order to provide conditions for stations testing at JINR, there was renovated a building where the test bench will be placed.

• Works on preparation for mass production of the Booster magnets were actively conducted. Building 217 was renovated and the necessary transport connection between the building and LHEP's cryogenic complex was laid.

• An area for superconducting winding production was prepared. A 15 kA current source for testing magnets was produced in Slovakia, delivered to JINR and tested. A satellite refrigerator was produced in Germany, delivered to JINR and prepared for starting-up. In cooperation with GSI a system for magnetic field measurement was developed. Start of serial production of the Booster magnets is scheduled for the first half of 2014.

ILC

The main results achieved by the team participating in the preparation of the project in 2013 are:

Linac-200 Test Bench

Commissioning of the second Linac-200 segment (50 MeV) is under completion. The first launch of the IR FEL prototype based on the electron linac and undulator was performed. An electron beam with the energy of about 18 MeV passed through the undulator. IR radiation with the wavelength of about 14 um and power of 30 mW was registered. Commissioning of the electron beam diagnostics for energy and phase parameter measurement was finished. The upgrade of the temperature control system of the first segment was performed Commissioning of the FEL prototype on the base of the electron linac and wiggler is being developed.

DC Photoinjector Test Bench

The start-up of the DC photoinjector prototype was carried out. The prototype consists of a 12 kV photogun; a focusing magnet with correction coils; the first station of the electron bunch emittance measurement system; a video monitor; a Faraday cup and driver lasers ($\lambda = 266$ nm, $\tau_{\rm pulse} = 75$ ps, $\tau_{\rm pulse} = 15$ ns). Using a 75-ps laser driver ($E_{\rm pulse} = 1$ mJ) the charge of 1.2 nC (corresponding current of ~ 16 A) was extracted from the holed photocathode (metal mesh).

THE MOST IMPORTANT EXPERIMENTAL RESULTS

CMS

The major efforts of the JINR group participating in the CMS experiment have been focused on studying various processes involving muon-pair production in order to test the Standard Model (SM) predictions and on the search for new physics beyond it.

The dimuon mass spectrum was studied; the forward–backward asymmetry of muon pairs was defined as well as differential cross section of their production in the Drell–Yan process in the range of invari-

ant masses from 15 to 1500 GeV. The measured values are in good agreement with the NNLO theoretical predictions of the SM.

Combined analysis of the data on production of dimuons and dielectrons allowed one to exclude with 95% confidence level the existence of new neutral gauge bosons from the extended gauge sector with Standard-Model-like couplings $M_{\mathrm{ZSSm}} < 2950$ GeV and for the superstring-inspired Z_ψ below 2600 GeV. The RS1-graviton mass limits made up about 2390 and 2030 GeV for the couplings $c = 0.10$ and 0.05, respectively.

Based on the 2012 data, the analysis of QCD multijet events was carried out aimed at search for microscopic semiclassical and quantum black holes predicted at the TeV-scale. The obtained values of the minimal mass of a black hole were 4.7–6.3 TeV depending on the formation and evolution mechanisms for the values of fundamental multidimensional Planck mass $M_D \leqslant 5$ TeV.

The Higgs boson properties were investigated further. The analysis of data on the channel of its decay into 2 neutral gauge bosons and the further decay into 4 leptons allowed for the more precise measuring of the Higgs mass, which made up $m_{\mathrm{H}} = (125.8 \pm 0.5\,(\mathrm{stat.}) \pm 0.2\,(\mathrm{syst.}))$ GeV; for a combined analysis of channels of the decay into a photon pair and 4 leptons — $m_{\mathrm{H}} = (125.7 \pm 0.3\,(\mathrm{stat.}) \pm 0.3\,(\mathrm{syst.}))$ GeV [2]. The analysis of angular distributions of Higgs decay products allowed excluding almost all the states with the spin and parity inconsistent with the SM Higgs boson.

ALICE

The JINR group taking part in the ALICE experiment is focused on studying Bose–Einstein correlations. In 2013, ALICE took data with the minimum bias trigger ($6 \cdot 10^7$ events) of p–Pb collisions at 5.02 TeV. The first results of the femtoscopic correlation analysis were obtained for charged kaon pair production in p–Pb collisions at 5.02 TeV per nucleon pair (Fig. 2). The special experimental analysis of charged kaon purity selection in Pb–Pb at 2.76 TeV was performed and new results for femtoscopic R_{inv} were obtained. New results for $\phi \to K^+K$ production were obtained [3].

ATLAS

The LHEP team involved in the experiment is participating in several analyses, in particular, in the analysis of the associative WH/ZH production.

The ongoing work is aimed at improving criteria of the signal event selection and at optimizing the list of variables to be used for background suppression. The achieved results were reported at the meetings of the ATLAS Higgs working group. The joint efforts of the working group members on cut-flow analysis of the available experimental data did not show any confident excess of events over the SM background. The invariant mass spectrum of two b-jets is presented in Fig. 3

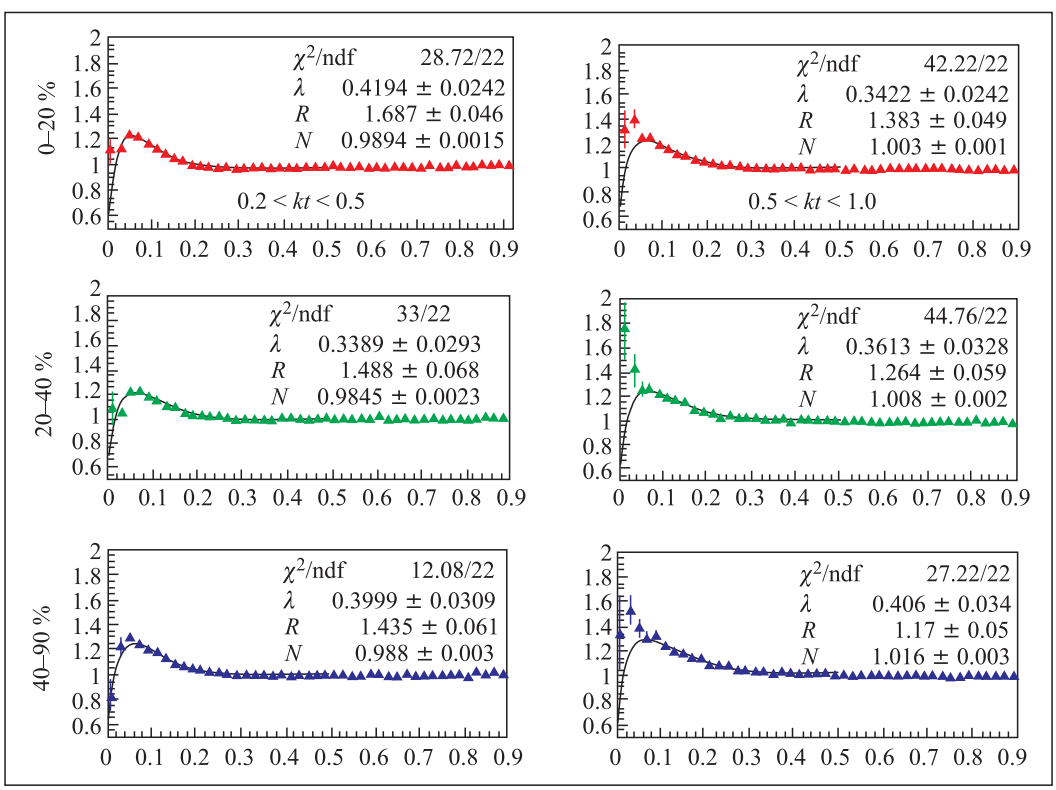

Fig. 2. Correlation functions versus q_{inv} for charged kaon pairs obtained in p–Pb collisions at 5.02 TeV, at different transverse momentum of the pairs and event centrality 0–20%, 20–40%, 40–90%. The curves are the special fit results

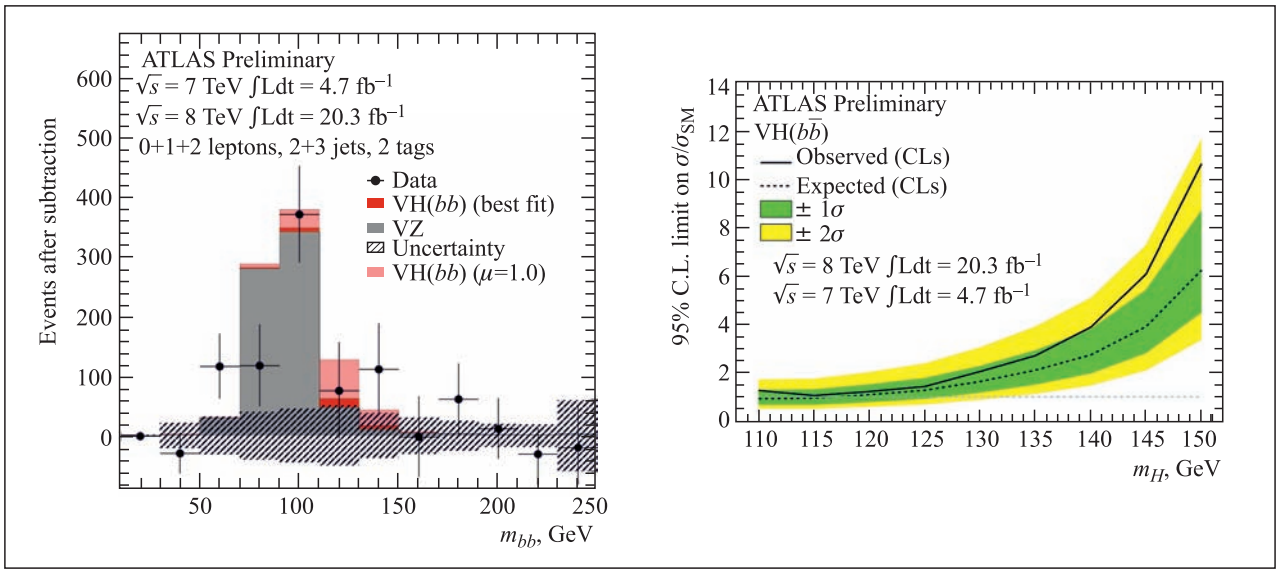

Fig. 3. Invariant mass of two b-jets (left) and 95% C.L. upper limit for the Higgs boson production in VH processes (right)

with all the backgrounds subtracted except the di-boson processes

The upper limit for cross section of the Higgs boson production in association with a vector boson is 1.4 times higher than that predicted by the SM.

The results of this work were presented at conferences and published [4].

The performance of the ATLAS liquid argon hadronic end-cap calorimeter was carried out taking into account the expected degradation of the read-out electronics at the total integrated luminosity of 3000 fb^{-1}. The experimental data obtained in irradiation tests with protons (Zurich) and neutrons (Rez and Dubna) were used as the input parameters for the analysis. Degradation of the preamplifier's gain and its nonlinearity were parameterized as the function of the collected doze which changes depending on the motherboard location inside the ATLAS cryostat. A full GEANT-4 based Monte-Carlo simulation was performed for di-jet events including effects of the preamplifier's degradation. The obtained results demonstrate that radiation damage of preamplifiers results in significant deterioration of the signal, therefore the exchange of the HEC cold electronics is required for operation at the HL-LHC environment.

NA62 and NA48/2 Experiments

The NA62 experiment is devoted to studying the very rare charged kaon decay into charged pion and two neutrinos. The responsibilities of JINR in this experiment (together with CERN) are R&D and full production of straw tracker detectors working with a high spatial resolution in vacuum environment, development of simulation and reconstruction of software for the straw tracker. In addition, the data analysis of the NA48/2 experiment and of NA62 special runs of 2007–2008 is continued.

The main results obtained in 2013 are:

1. The mass production of straw tubes is finished at JINR. More than 6500 straws were manufactured; the long-term overpressure test is in progress. About 15% of the straw tubes are completely tested and delivered to CERN.

2. Work on assembling, testing and delivering the chamber modules to CERN is in progress according to the schedule.

3. Tests of the 64-straw prototype with cosmic rays aimed to measure straw resolution and to study new front-end and read-out electronics are continued. Analysis of the 2012 experimental data from the 64-straw prototype working in vacuum environment is in progress.

JINR team has been continuing the NA48/2 experiment data analysis.

With the determining contribution of the JINR scientists, the first experimental observation of new decay channel $K^{\pm} \to \pi^0\pi^{\pm}e^+e^-$ was obtained. Preliminary branching ratio measurement result agrees with the theoretical prediction, based on SM. The data analysis is in progress (Fig. 4).

The $K^{\pm} \to \pi^{\pm}\gamma\gamma$ rare decay width was measured and its dynamic properties were studied based on the world's largest statistics — 149 decay candidates with the background at 10% level. Branching ratio in the full kinematic range assuming a particular chiral perturbative theory description is measured to be $\mathrm{Br} = (0.910 \pm 0.075) \cdot 10^{-6}$.

A series of NA48/2-NA62 publications devoted to high precision test of the lepton universality in charged kaon decays was nominated in 2013 for the JINR prize. The result of the ratio $R_K = \Gamma(K_{e2})/\Gamma(K_{\mu 2})$ measurement, based on about 150000 reconstructed $K^{\pm} \to e^{\pm}\nu$

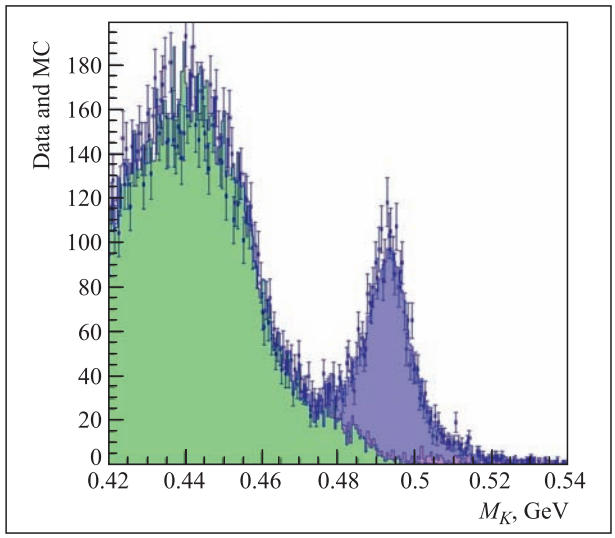

Fig. 4. The first observation of the charged kaon decay to $\pi^0\pi^\pm e^+e^-$

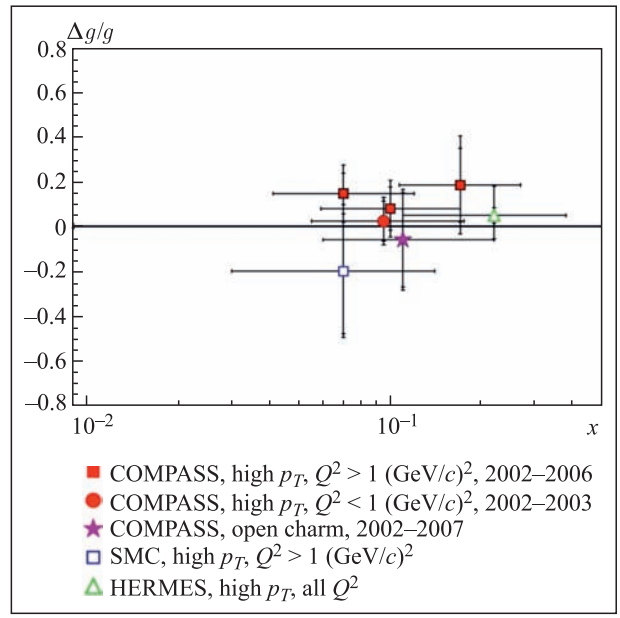

Fig. 5. A compilation of gluon polarization measurements from open charm (star) and high-p_T hadron production

decays collected in 2007 and 2008 with 11% background, is in agreement with the SM calculation: $R_K = (2.488 \pm 0.010) \cdot 10^{-5}$.

High precision measurements of these decays allow us to test the SM and search for new physics beyond it as well as to contribute to the Perturbative Chiral Model development [5].

COMPASS Experiment

In 2013, the activities of the JINR team were focused on preparing the detector to the Drell–Yan process measurements, which are planned to be performed in 2014–2015, and on the study of the General Parton Distributions (GPD), which are planned to be done in 2016. JINR responsibilities in COMPASS consist in production of the main part of the new electromagnetic calorimeter (ECAL0).

The JINR team has been continuing data analysis. In 2013, the COMPASS collaboration presented the results on gluon polarization measured via spin asymmetries from open charm production [6] (Fig. 5). These results were obtained in scattering 160 GeV polarized muons off longitudinally polarized protons and deuterons. The data were taken by the COMPASS collaboration between 2002 and 2007.

At leading order QCD accuracy, the average gluon polarization is determined as $\langle \Delta g/g \rangle$ LO $= -0.06 \pm 0.21\,(\text{stat.}) \pm 0.08\,(\text{syst.})$ at the scale $\langle \mu^2 \rangle \sim 13$ GeV^2 and an average gluon momentum fraction $\langle x \rangle \sim 0.11$. For the first time, the average gluon polarization was also obtained at next-to-leading order QCD accuracy as $\langle \Delta g/g \rangle$ NLO $= -0.13 \pm 0.15\,(\text{stat.}) \pm 0.15\,(\text{syst.})$ at the scale $\langle \mu^2 \rangle \sim 13$ GeV^2 and $\langle x \rangle \sim 0.20$.

With the active involvement of the JINR team, the analysis of experimental data on production of Λ, $\Sigma(1385)$ and $\Xi(1321)$ hyperons in muon DIS off a ^{6}LiD target was carried out. The relative yields of $\Xi(1385)^+$, $\Sigma(1385)^-$, anti-$\Sigma(1385)^-$, anti-$\Sigma(1385)^+$, $\Xi(1321)^-$, and anti-$\Xi(1321)^+$ hyperons decaying into $\Lambda(\text{anti-}\Lambda)\pi$ were measured. The heavy hyperon to antihyperon yield ratios were found to be in the range from 3.8% to 5.6% with a relative uncertainty of about 10%. The received results were used to tune the parameters of the LEPTO Monte-Carlo generator.

Multiplicities of charged hadrons produced in deep inelastic muon scattering off a ^{6}LiD target were measured as the function of the DIS variables x_{Bj}, Q^2, W^2 and the final state hadron variables p_T and z.

STAR

The JINR group taking part in the STAR experiment at RHIC was actively involved in the energy scanning programme on studying hadron production in Au–Au collisions at the energies $\sqrt{s}_{NN} = 7.7$, 11.5, 19.6, 27, 39 GeV. The statistics was acquired allowing search for signs of phase transitions in nuclear matter and for localization of the critical point. It was found that R_{CP} ratio, elliptic flow for mesons, baryons and their antiparticles; ratio of particle yields in Au–Au collisions depend on the transversal pulse and energy of the collision [7].

The experiment data were processed and preliminary results were obtained on spectra of charged hadron production in Au–Au collisions at the energies $\sqrt{s}_{NN} = 7.7$, 11.5, 19.6, 27, 39 GeV at high transversal pulses.

The participation in the STAR polarization programme was continued by measurement of double-spin asymmetries of jet production and single-spin transversal and longitudinal asymmetries in order to obtain spin-dependent gluon and quark (valence and sea) distributions.

NA61 Experiment

The JINR group involved in the ion part of the NA61/SHINE experiment is carrying out the systematic studying of nucleus–nucleus reactions occurring in Pb–Pb collisions and investigating reactions with medium-sized nuclei (Xe and Ar) as well as with light nuclei (Be). From December 2012 to March 2013 the experiment took data from Be–Be collisions having finished the energy scanning which had been started in 2011 [8].

The first preliminary results were obtained on the ^{7}Be–^{9}Be collision as well as on the $p-p$ reaction. Preliminary data on $p-p$ and $p-C$ (Long Target) reactions at 31 GeV/c required for the neutrino experiment T2K were acquired. The analysis of data on the cosmic ray programme is in progress.

The NA49 collaboration has been investigating a broad range of hadronic reactions at the CERN SPS. The main aim of the experiment is the studying of hadronic matter at the highest temperature and densities in the search for the onset of quark–gluon deconfinement and the QCD predicted critical point of strongly interacting matter.

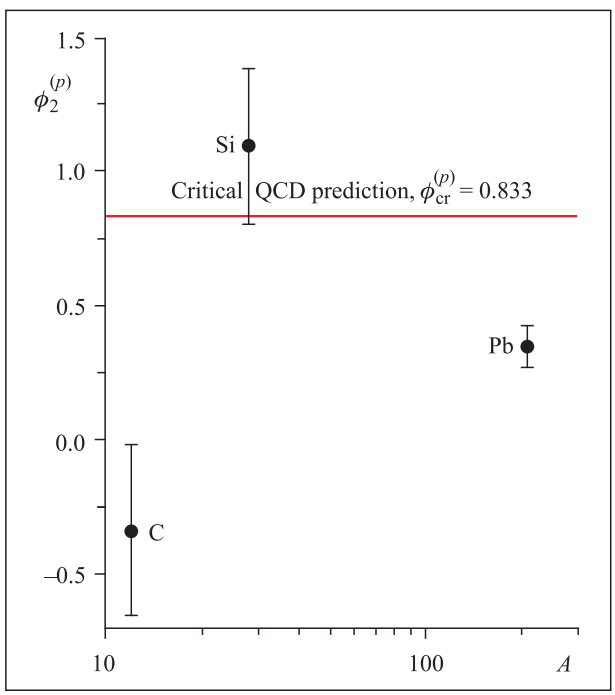

Fig. 6. The obtained value of the proton intermittency ϕ_2 in Si–Si collisions at 158 $A \cdot$GeV indicates fluctuations approaching in size the prediction of QCD

There is an indication obtained in correlation analysis of the data on Si–Si scattering at 158 GeV, that the proton intermittency ϕ_2 exceeds QCD limit corresponding to the phase transition (Fig. 6).

Experiments at the Nuclotron Carried out during the 2013 Year Runs

About 60% of the beam time of Runs 47 and 48 was used for the current experiments and for the detector beam tests. In particular, the following experiments used this time:

FAZA-3 Experiment

In the framework of the FASA-3 experiment, the total time scale of the multifragmentation process was measured: it happens in 120 fm/s after the collision of a deuteron beam with the Au target. Thus, the time of hot nucleus expansion was measured for the first time [9].

Energy and Transmutation Project

Spectral characteristics of neutrons generated by the deuteron beam at the subcritical Quinta setup, which contains 512 kg of natural uranium, were experimentally investigated in 2012–2013 in the framework of the project.

In order to measure spectral dependences of the neutrons, semiconductor breakdown detectors with threshold converters in the energy range of incident deuterons of 1–8 GeV were used.

The behavior dependences of high-energy part of the spectrum $E_n > 20$ MeV on the energy of incident deuterons were obtained. The experiments demonstrated the following:

• The fission process is going efficiently in the subcritical setup with the uranium mass of 512 kg and the radius of 12 cm; the obtained value of power gain is 2.5. This value achieved plateau in the wide energy range 1–8 GeV (Fig. 7).

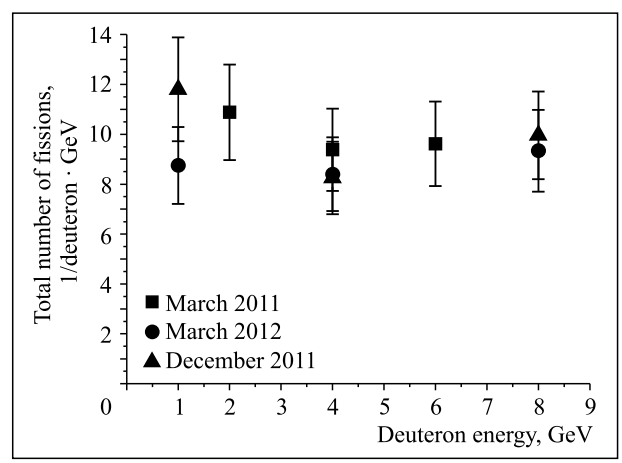

Fig. 7. Power gain as a function of energy in units of fissions per 1 deuteron and per 1 GeV, the 2011–2013 runs

• The total escape of the neutron with the energy $E_n > 20$ MeV was measured; it made up 80%.

• It was discovered that with the deuteron energy getting higher, the content of the fast neutrons (with the energy $E_n > 20$ MeV) in escape was increasing from 6 to 12%.

The transmutation rate of ^{237}Np radioactive isotopes was studied as well as its dependences on the incident particle energy. The increase of the reaction rate with the deuteron energy rise was demonstrated. This result indicates that transmutation efficiency rises with the increase of particles energy.

DSS Project

In the DSS experiment carried out at the inner target of the Nuclotron, there were obtained new experimental data on angular dependence of the cross section of elastic deuteron–proton scattering at the deuteron energies of 1300, 1500 and 2000 MeV.

New experimental data were obtained on deuteron fragmentation reaction with detection of two protons for various kinematic configurations at the initial deuteron energies of 300, 400, and 500 MeV.

Preliminary results were presented at the international conferences HS2013 and EFB22.

The data on tensor analyzing powers A_y, A_{yy}, A_{xx} and A_{xz} were obtained for the $dd \to tp$ reaction at the deuteron energy of 200 MeV [10].

Experiments in Preparation

BM@N Project

The BM@N project is a fixed target experiment which was proposed as implementation of the first stage of the NICA project. In that framework, to advance the BM@N project preparation, the following activities were accomplished in 2013:

• The BM@N experimental zone was cleaned, the zone contour was created. The counting room was ready. The dipole magnet was set to the nominal position and commissioned at the 80% of the nominal current.

• R&D works on the warm resistive plate chambers for the BM@N TOF detector are in progress. For the region of high hit rate ($\sim$ 4 kHz/cm^2) it is proposed to use 12-gap "warm" RPCs with 0.5 mm thick inner glass, gas gap of 220 μm, and 32 strips of 10×160 mm. The expected time resolution is $\sim$ 65 ps, efficiency — $>$ 94%. Operational temperature is 45 °C. For the region of low hit rate ($\sim$ 400 Hz/cm^2) it is proposed to use 10-gap RPCs with 0.7 mm thick glass, gas gap of 300 μm, 16 strips of 18×580 mm and the number of chambers — 36. These planes will have time resolution $<$ 60 ps and efficiency $\sim$ 98% and will operate at room temperature. An option to use resistive plate chambers produced from low-resistivity glass for the high hit rate range is under development.

• A new option for the inner tracker based on the GEM technology was proposed and now is under consideration. The preliminary simulation for GEM-based inner tracker demonstrated the possibility to select hyperons. A triple GEM detector prototype of 10×10 cm (250×250 $X-Y$ strips, 400 μm pitch) produced by the CERN workshop will be tested during the next Nuclotron run.

• The prototype module of Zero Degree Calorimeter successfully passed beam and cosmic ray tests with several PMT and HV dividers. Technical design of the ZDC support was prepared. The support will be produced by NKMZ (Kramatorsk, Ukraine). 50% (65 k$) is paid in December 2013. Delivery time is October 2014.

• The work on putting outer tracking system elements into operation is in progress.

• Three housings for 12×12 cm scintillation fiber hodoscope were delivered in October 2013 from Dechin, Czech Republic. Two detectors are under construction.

• Two Cherenkov T_0 detectors are produced and are ready for tests.

Progress with the MPD Subsystems

A substantial progress has been recently achieved in the TPC manufacturing, fabrication of ECAL modules, completion of the R&D stage for the TOF and TOF TDR preparation.

A step forward was made in evaluating the MPD technical project. The TDR preparation was discussed at the last MPD-AC meeting. The MPD TOF technical project will be presented in June 2014.

The following results were achieved in the development of subsystems:

MPD Magnet

The technical design of the MPD solenoid is completed (JINR and Neva-Magnet Ltd. (St.-Petersburg)). The technical description and assembly drawings passed the international expert evaluation led by T. Tailor (CERN), who noted high-level professional knowledge and excellent drawing quality. The next steps which are planned for 2014 — the international tender opening and start of the construction.

TPC

In 2013, the design, construction and tests of prototypes for TPC elements (RoC; FEE; laser, gas and cooling systems) were fulfilled. Production of the TPC Field Cage and RoC was started.

ECAL

In 2013, the facility for the ECAL module production was established by JINR and the Institute for Scintillation Materials (Kharkov, Ukraine). The technology for production of a trapezoidal ECAL module has been proven. The certification procedure for MAPD wafers was developed. Production of photodetector units was organized. The feasibility of mass production of ECAL modules was investigated. The first study of the ECAL performance with particle beams and cosmic rays was performed.

During the beam test in December, the performance of two ECAL modules with different WLS-fibers was studied; ECAL read-out electronics (amplifiers and

ADCs) was tested and energy scan with electron beam ($E_e = 1.6$ GeV) was performed.

TOF

The main results achieved in 2013:

• The design of the TOF geometry and module was optimized.

• The Nuclotron beam line for tests was upgraded.

• mRPC performance: efficiency, rate, capability and time resolution were studied (Fig. 8).

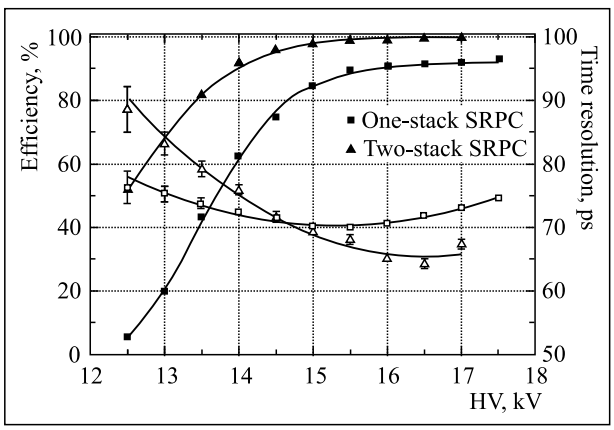

Fig. 8. Time resolution (□, △) and efficiency (■, ▲) for an MPD TOF mRPC with strip read-out. Results of the Nuclotron'13 beam tests

• TOF TDR has been prepared.

• The experimental area and counting room were fully equipped with instrumentation for test measurements and data analysis.

Straw Tubes

The following items were performed in 2013:

• development and production of the outside ring for the engineering wheel prototype were finished,

• development and production of two flexible 24-channel mother-boards (MB),

• assembling of the fragment of the outside gas manifold for one of the MBs,

• study of the straightness of the 60 cm long straws.

FFD

• There was purchased a full set of photomultipliers produced by the Photonis company for FFD modules production.

• The final mechanical design of FFD modules was developed.

• Under the agreement between the V. G. Khlopin Radium Institute (Saint-Petersburg) the modules were developed and tested with the final version of the electronics.

• The full set of quartz radiators was produced for detector modules.

• The system of time calibration of FFD channels with picosecond laser was elaborated and the main parts were purchased for its production.

• The prototypes of the system of low-voltage power supply and LVDS signal receiving from electronics of detector modules were developed, produced, and tested.

• In cooperation with the TOF group, there was performed a study of characteristics of the produced FFD modules at the Nuclotron deuteron beam (March and December runs, 2013).

MPD Simulation Group

A large amount of work on simulation of the MPD subsystems and different reactions was performed in 2013. The software packages were heavily modernized. In particular: the realistic MPD magnetic field map was installed into reconstruction software; the system of distributed data storage and processing was deployed at the computer clusters of LHEP and LIT; new algorithm for the search for the clusters on the TPC pad place was prepared, tested, and installed in the MPD software.

INNOVATIONS

R&D with the Use of Straw Tubes

Detectors based on thin-wall drift tubes possess a number of advantages: they are transparent in the sense of the material budget, have good space/time parameters and relatively low cost. One of the disadvantages is the spatial resolution which is not good enough in comparison to Micro Pattern Gas Detectors (σ of the MPGD is better than 100 μm).

The conducted R&D demonstrated that the straw can operate in the mode of transition from the limited proportionality (saturation) mode to the high current mode with gas mixture $PrCO_2$ $(80/20)$ at the pressure ranging from ~ 3 to 4 bar. The spatial resolution of the straw in this mode is increasing up to ~ 40 μm [11].

To test the straws' readiness for long-term operation in that transient mode, their radiation stability was checked by X-ray irradiation at the test bench. For ~ 2600 hours of irradiation, the average charge made up 4.2 C per 1 cm of the straw length. Degradation of the energy resolution was not observed.

The study of the transient mode between the low and high current modes for straws filled with $ArCO_2$ gas mixture at the pressure of 3 bar showed its feasibility for high-precision registration of charged particles. The transient mode does not develop in the self-quenching streamer mode at the pressure within this range; and, at the anode diameter of 30 μm or less it also has high stability and enough radiation tolerance.

Two-Phase and Three-Phase Separationless Flow-Meters for Oil Production

The two-phase flow-meter "oil-salty water" for oil production was designed at LHEP. It consists of a gamma-densitometer (GD) with radioactive source ^{137}Cs and a narrowing device. The flow-meter was tested on the test facility "oil-gas-salt water" at the TUV SUD NEL company (Glasgow, Scotland). The results showed [12] that the flow-meter meets the State Standard requirements (GOST R8.615-2005) to determine volumetric and mass flow rates of crude oil in the range of water cuts $0 < w < 95\%$. Such competitive measuring devices are not produced in the Russian Federation.

The obtained experience allowed us to design a three-phase four-component separationless flow-meter for "oil-gas-formation water" mixtures. This is a combination of a spectrometric gamma-densitometer and a combined narrowing device. The characteristics of the flow-meter were studied on the State Special Primary Standard of the Unit of Mass Flow Rate of Gas-Liquid Mixtures GET-195-2011 (VNIIR, Kazan) in November, 2013. The preliminary analysis confirmed the operability of the flow-meter, definiteness of its characteristics and their repeatability in all the ranges of the preset parameters of "oil emulator-water", "oil emulator-gas" and "water-gas" gas-liquid mixtures.

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DZHELEPOV LABORATORY OF NUCLEAR PROBLEMS

NEUTRINO PHYSICS AND RARE PHENOMENA

In 2013, the DLNP group within the **Daya Bay** collaboration performed two new analyses of the number of interaction events involving antineutrinos produced by the Daya Bay and Ling Ao reactors in the near/far detectors filled with Gd-doped liquid scintillator. The first analysis [1] was aimed at searching for antineutrino disappearance using the rate-only information (ignoring antineutrino energy) and about three times larger number of events than was used in the 2012 analysis which led to the discovery of the nonzero value of θ_{13} value. As a result the value $\sin^2 2\theta_{13} = 0.089 \pm 0.01\,(\text{stat.}) \pm 0.005\,(\text{syst.})$ was found. The second analysis [2] was based on even larger statistics and antineutrino energy information. The result was a further improved value of the oscillation amplitude $\sin^2 2\theta_{13} = 0.090^{+0.008}_{-0.009}$ and the mass-squared difference $\Delta m^2_{ee} = 2.59^{+0.19}_{-0.20}$.

In 2013, the **OPERA** experiment continued to analyze the data collected at the CNGS neutrino beam over the period of 2008–2012. During five years of operation, OPERA collected about 18,000 neutrino interactions in the detector target, among them 56 charm events, 32 electron-neutrino events, and 3 tau-neutrino events. The discovery of the third tau-neutrino event in the muon mode was reported at the summer conferences. Now the analysis of the data continues at ten institutes in Japan and Europe (including JINR), where the automatic scanning stations are available. In 2013, efficiencies and backgrounds in the detector were revised. With these new estimations, observation of the three tau-neutrino events has a significance of 3.4σ, which is the evidence for $\nu_\mu \to \nu_\tau$ oscillations in the appearance mode.

In 2013, the main result of the collaboration **Borexino** is a new measurement of the geo-neutrino flux [7]. The results of the first stage of the Borexino experiment on the solar neutrino measurements are summarized in [8], where details of the previous measurements performed and new results of searching for seasonal variations of the Be-7 neutrino flux are presented. A paper on the study of the muon flux backgrounds [9] was published. The Borexino data were used to set limits on the heavy sterile neutrino mixing in the 8B decay. These limits are tighter than those obtained in previous laboratory-based experiments using nuclear reactors and accelerators [10].

In 2013, the **EDELWEISS** collaboration was busy testing and calibrating newly installed detectors with active rejection of the surface background. Novel 800-g FID detectors with a significantly increased fiducial volume were commissioned. Developed in 2012–2013, the FID800 detectors technology, fully interdigitized 800-g detectors with all surfaces covered by ring electrodes, shows at least an order-of-magnitude improvement of surface background suppression. About 10 kg of new detectors were tested and calibrated in 2013. Together with the new detectors the whole experimental setup was updated in 2013. First of all, the cryogenic system and shielding were improved, and new fast data acquisition was used [11, 12].

The **NEMO-3/SuperNEMO** project is aimed to search for neutrinoless double-beta decay ($0\nu\beta\beta$), which would be an indication of new fundamental physics beyond the Standard Model, such as the absolute neutrino mass scale, the nature of neutrino (either Dirac or Majorana), and neutrino hierarchy. Observation of $0\nu\beta\beta$ would also help to resolve the topical puzzles of fundamental physics: CP violation, leptogenesys, GUTs. The main advantage of the NEMO-3 /SuperNEMO project is a unique potentially zero-background tracking-calorimetric equipment, which allows obtaining full $\beta\beta$-signature consisting of electron

tracks and energies measured in the Geiger chamber and the calorimeter, respectively. This will allow testing the $0\nu\beta\beta$-mode mechanism if discovered. The final analysis of the NEMO-3 data was carried out in 2013. The obtained limit $T_{1/2}$ $(0\nu\beta\beta) > 1.1 \cdot 10^{24}$ y (90% C.L.) corresponds to the limit on the effective neutrino Majorana mass $\langle m_e \rangle < 0.3{-}0.8$ eV, which is compatible with the best world $\beta\beta$-results [13]. The analysis of the final NEMO-3 "$\beta\beta$-factory" results ($0\nu\beta\beta$ and $2\nu\beta\beta$ modes for ^{100}Mo, ^{82}Se, ^{116}Cd, ^{130}Te, ^{150}Nd, ^{96}Zr, and ^{48}Ca) is in progress [14].

The **GERDA** experiment is aimed to search for the neutrinoless double-beta decay of ^{75}Ge using naked HPGe detectors of enriched ^{76}Ge which are immersed in liquid argon (LAr). Phase-I of the GERDA experiment was completed in 2013. Data for analysis were collected between November 2011 and May 2013 with a total exposure of 21.6 kg·y. The ultralow background level of $1 \cdot 10^{-2}$ counts/keV·kg·y was achieved after pulse shape discrimination. No signal was observed and a lower limit was obtained for the half-life of the neutrinoless double-beta decay of ^{76}Ge, $T_{1/2} > 2.1 \cdot 10^{25}$ y (90% C.L.). The combination with the limits from the previous HdM and IGEX experiments yields $T_{1/2} > 3.0 \cdot 10^{25}$ y (90% C.L.), and in this case the probability of the positive effect corresponding to $T_{1/2} = 1.19 \cdot 10^{25}$ y is estimated at 0.02% [15, 16]. Intensive preparation for GERDA Phase-II started.

In 2013, the **Baikal** project moved from trying out the elements of the detector to mounting the first cluster of the NT100 neutrino telescope with an effective volume of 1 km^3. During the winter expedition of 2013, three full-scale strings of the cluster were assembled and the setup was put into operation as a complete detector with all elements and systems of the cluster. The primary analysis of the data showed highly stable operation of the detecting elements and confirmed the expected accuracy of the measuring systems and the efficiency of the calibration methods as well as the event selection and noise suppression procedures.

A system for remote control and monitoring of the telescope was developed and constructed. Analysis of the results obtained in the field tests of pilot strings for the NT100 detector showed a quite high quality of the main string elements, such as the optical detection system, data acquisition and transfer system, cable lines and basic units. The scene is set for commissioning in 2015 the first cluster of the NT100 neutrino telescope comparable in aperture with the ANTARES detector.

HIGH-ENERGY PHYSICS

In 2013, the search for supersymmetric particles by **ATLAS** at the LHC in $p{-}p$ collisions at the initial energy of 8 TeV was continued. The data with the integrated luminosity 20 fb^{-1} were analyzed in final states containing at least one isolated lepton (electron or muon), with and without b-jet requirements, and large missing transverse momentum. No significant excess above the Standard Model expectation is observed. The results are used to set limits on s-particle masses for various simplified models covering the pair production of gluinos, first and second generation s-quarks and top s-quarks. Limits are also set on the MISUGRA/CMSSM model and on the parameters of the minimal Universal Extra Dimension model [17].

Predictions were made that a signal of the Fock states in proton, intrinsic charm (IC), could be observed at ATLAS in the production of prompt photons or vector bosons (W) in $p{-}p$ collisions accompanied by the c- or b-jets, respectively. The MC calculations showed that inclusion of these states in the PDF could increase spectra of photons or c- and b-jets, and leptons from the W decay versus their transverse momentum by a factor of about 2–3 at large p_T ($p_T > 100$ GeV/c) in comparison to the calculations that do not include the IC contribution.

A new theoretical interpretation of the ATLAS data on spectra of charged hadrons produced in $p{-}p$ collisions at not large transverse momenta was made. The distribution of the nonperturbative gluons at small transverse momenta was calculated and its parameters were found from the best description of the ATLAS data. It was shown that analyzing these data one could find information about the saturation scale of the gluon distribution at low transfer momentum squared Q^2 [18, 19].

The main results of the **CDF** project are the "Tevatron average" mass of the top quark obtained with the total uncertainty reduced to 0.87 GeV/c^2, study of the correlations in high-multiplicity charged hadron events, Dubna tests of the LYSO-type crystals to be used as elements of the e.m. calorimeter for the Mu2e experiment at FNAL, and tests of the scintillator counter efficiency in the neutron beam.

Using top-antitop pairs at the Tevatron proton-antiproton collider, the **CDF** and **D0** Collaborations with the Dubna group contribution measured the top quark mass in different final states for integrated luminosities up to 8.7 fb^{-1}. The combination of these measurements results in a more precise value of the mass than any individual decay channel can provide. Considering the correlated uncertainties, the resulting

Tevatron average mass of the top quark is $M_{\rm top} = (173.20 \pm 0.51\,({\rm stat.}) \pm 0.71\,({\rm syst.}))$ GeV/c^2, which corresponds to a total uncertainty of 0.87 GeV/c^2, which has a precision of $\pm 0.50\%$ [20], making this the most precise determination of the top-quark mass.

In 2013, the R&D was done for the future experiments at FNAL: tests of LYSO-type crystals to be used as elements of a new-generation e.m. calorimeter of the Mu2e FNAL experiment; tests of the scintillator counter efficiency in the neutron beam; a comparison of $30 \times 30 \times 130$ mm crystals from SICCAS, Saint-Gobain and Zecotek. For the Mu2e Collaboration, the effect of the neutron background on the Mu2e cosmic ray veto system was investigated and test measurements of the plastic scintillator counter were performed on the neutron beam line of the IBR-2 facility at JINR, Dubna [21].

In 2013, the Dubna group participating in the **D0** experiment, Fermilab, completed a new measurement of the important processes which were produced in proton-antiproton collisions at the summed Tevatron beam energy of 1.96 TeV and had highly energetic photons and associated jets in the final state. The comparison of the results [22] with the predictions of Quantum Chromodynamics indicated the necessity to refine the theoretical tools for describing strong interactions in a number of kinematical regions like the regions of large and small values of direct photon transverse momentum and for explaining the dependence on the relative orientations of the photon and the jet.

Within the framework of the **DIRAC** experiment, analysis of πK data collected in 2008–2010 was completed, the lifetime of $K^+\pi^-$ and π^+K^- atoms was preliminary estimated at $\tau = 2.5^{+3.0}_{-1.8}$ fs. Preliminary analysis of the $\pi\pi$ data collected in 2008–2010 was completed. About 22000 $\pi^+\pi^-$ atom breakup events were identified which doubles the statistics for $\pi^+\pi^-$ atom lifetime measurement. Preliminary analysis of the 2011–2012 data allowed the first observation of the long-lived states of $\pi^+\pi^-$ atoms.

The **SANC** project includes theoretical predictions for many three- and four-particle Standard Model (SM) processes at the one-loop precision level (QCD and EW NLO). The main result of 2013 is updating and creation of new versions of Monte-Carlo tools (integrator and generator) for the analysis of the LHC data with allowance for the interplay of the next-to-leading (NLO) QCD and EW corrections [23, 24]. These tools, complemented with calculation of NNLO QCD contributions using programs by other groups, were already used for the analysis of the LHC data.

The **BES-III** experiment at the Beijing electron-positron collider BEPC-II continued to take data in 2013. The main goal was to collect data in the energy range 4.2–4.4 GeV to study XYZ states. The largest statistics was obtained around resonances $Y(4260)$ and $Y(4360)$. In March 2013, the BES-III experiment announced observation of a new charged charmonium-like state $Z_c(3900)$ in a system of a charged pion and a J/ψ resonance [25]. Later this observation was independently confirmed by the BELLE experiment and then by the CLEO-c data. The properties of the new state imply that it consists of at least four quarks unlike conventional mesons and baryons. Thus, this observation provides strong evidence that exotic hadrons which were predicted by QCD and then were hunted for about 30 years, do exist. Later, a similar state was observed in the reaction $e^+e^- \to DD^*$ [26].

The data samples collected with the BESIII detector operating at the BEPCII storage ring at center-of-mass energies from 4.009 to 4.420 GeV allowed the transition $e^+e^- \to \gamma X(3872)$ to be observed for the first time with a statistical significance of 6.3σ. The measured mass of $X(3872)$ is $(38719 \pm 0.7\,({\rm stat.}) \pm 0.2\,({\rm syst.}))$ MeV/c^2, in agreement with previous measurements. The products of the cross section $\sigma(e^+e^- \to \gamma X(3872))$ and the branching fraction $B(X(3872) \to \pi^+\pi^- J/\psi)$ at center-of-mass energies 4.009, 4.229, 4.260, and 4.360 GeV are also measured [27].

Using the largest sample of $\psi(3770) \to DD$ events collected in 2010–2011, the BES-III experiment provided the most precise measurement of ${\rm Br}(D^+ \to \mu^+\nu_\mu) = (3.71 \pm 0.19\,({\rm stat.}) \pm 0.06\,({\rm syst.})) \cdot 10^{-4}$ [28]. This measurement together with the CKM matrix element $|Vcd|$ determined from a global Standard Model fit, implies the weak decay constant value $f_{D^+} = (203.2 \pm 5.3 \pm 1.8)$ MeV. Additionally, using this branching fraction measurement together with a Lattice QCD prediction for f_{D^+}, we find $|Vcd| = 0.2210 \pm 0.0058 \pm 0.0047$. In either case, these are the most precise results for these quantities to date.

The orbital ultrahigh-energy cosmic ray (UHECR) detector **TUS** is prepared for launching on-board the Lomonosov satellite in 2014. The TUS space experiment is aimed to study the energy spectrum and arrival distribution of UHECR at energies above $\sim 10^{20}$ eV. The detector consists of a large Fresnel-type mirror-concentrator ~ 2 m^2 in area and a photo-receiver placed in its focal plane (matrix of 16×16 PM tubes with a spatial resolution in the atmosphere near 5 km). The final TUS apparatus preflight tests were carried out in 2013 in assembly with the Lomonosov space platform. JINR and the "Space Regatta" consortium of the Korolev center participated in the design, production and measurements of optical parameter of the segmented Fresnel mirror which is completely fulfilled [29].

Measurements of the CR spectrum, composition and anisotropy in the wide energy interval are an important part of the particle physics study. The energy range 10^{14}–10^{16} eV is crucial for understanding the CR origin, acceleration, and propagation in our Galaxy. The available data do not enough adequately interpret the nature of the "knee" in the framework of the CR acceleration mechanisms. The real progress in solving the problem would be possible

only with a long-term and large-aperture satellite experiment like **NUCLEON,** which will supply statistically conclusive data. The JINR responsibility is the production of the NUCLEON trigger system, which includes a two-level trigger system of six scintillator strip layers and FE and DAQ electronics. Three trigger modules were produced and were tested in assembly with other detectors in the CERN SPS beam during 2009–2013.

One of the latest SPS heavy ion beam tests was carried out in February 2013. It was found that the charge measurement system discriminates the nuclei up to $Z \sim 30$ with an accuracy of 0.2–0.3, which is sufficient both for discriminating separate primary CR components and for studying the abundance of secondary nuclei in CRs at high energies [30]. The NUCLEON detector is planed to be launched with the Sojuz rocket in 2014 for 3–5 years of data taking.

LOW- AND INTERMEDIATE-ENERGY PHYSICS

The **SPRING** experiments were carried out with the ANKE setup at the COSY accelerator in the field of intermediate-energy hadron physics using polarized proton (deuteron) beams and/or polarized hydrogen (deuterium) jet targets. Studies of spin observables were carried out in the double polarized approach, i.e., with the use of a polarized deuteron beam and a polarized hydrogen target. In the quasi-free reaction $\vec{n}\vec{p} \to \{pp\}_s\pi^-$ at 353 MeV per nucleon, the spin correlation coefficients $A_{x,x}$, $A_{y,y}$ and the vector analyzing power A_y were measured [31]. Combined partial wave analysis of these data together with previous results on the differential cross section and A_y for $p\vec{p} \to \{pp\}_s\pi^0$ led to three different acceptable solutions. This ambiguity can only be resolved by measuring the spin correlation coefficient $A_{x,z}$ using a longitudinally polarized beam, which is planned for 2014.

For the first time in the quasi-free kinematics of ANKE, the spin correlation coefficients $A_{x,x}$ and $A_{y,y}$ were measured [32] in the reaction $\vec{n}p \to d\pi^0$ for neutron energies close to 353 and 600 MeV. The results are in good agreement with SAID predictions for the isotope-related reaction $pp \to d\pi^+$ no sign for any breaking of isotope invariance was found.

The differential cross section and two tensor analyzing powers A_{xx} and A_{yy} were measured for the reaction $d\vec{p} \to \{pp\}_s n$ at the deuteron energies 1.2, 1.6, 1.8, and 2.27 GeV. At 1.2 and 2.27 GeV the hydrogen target was also polarized which allowed the spin correlation parameters C_{xx} and C_{yy} to be measured. The results essentially complement the neutron–proton part of the SAID data base. Excitation of $\Delta(1232)$ isobar was studied [33] for the same reaction at 1.6, 1.8, and 2.27 GeV. Analysis of the differential cross section showed that the results could be described only partly by direct excitation of Δ in the single-pion exchange mechanism.

The **MEG** experiment is one of the PSI "flagship" particle physics experiments at the proton accelerator facility in Switzerland. The goal of the experiment is the search for the $\mu \to e\gamma$ decay with a branching ratio sensitivity of 10^{-13} in order to explore the region predicted by many theoretical models beyond the Standard Model. In 2013, the collaboration presented the analysis of a data sample of $3.6 \cdot 10^{14}$ muons stopped on the target, which was collected by the MEG experiment at the Paul Scherrer Institute (2009–2011) aimed at the detection of the lepton flavor violating muon decay $\mu^+ \to e^+\gamma$. No excess over the background expectations was observed: a new upper limit on the branching ratio of this decay is set at $5.7 \cdot 10^{-13}$ (90% C.L.) [34]. This limit is four times more stringent than the previous world best limit set by MEG.

Developing on the rare pion and muon decay results of the PIBETA experiment, the **PEN** collaboration performed precise measurement of the $\pi^+ \to e^+\upsilon(\gamma)$ decay branching ratio ($\mathrm{BR}_{\pi e2}$), at the Paul Scherrer Institute to reduce the current 40 times lag of the experimental accuracy behind theory to $\sim (6-7)$. Because of large helicity suppression, $\mathrm{BR}_{\pi e2}$ is uniquely sensitive to contributions from non-$(V-A)$ physics, making this decay a particularly suitable subject of study. Even at the current accuracy, the experimental value of $\mathrm{BR}_{\pi e2}$ provides the most accurate test of lepton universality. During the runs in 2008–2010, PEN accumulated over $2 \cdot 10^7 \pi^+ \to e^+\upsilon$ ($\pi e2$) events; a comprehensive maximum-likelihood analysis is currently under way. The new data will also lead to improved accuracy of the earlier PIBETA results on radiative π and μ decays.

In 2013, the full-scale test of the experimental installation **TRITON** was performed. In February 2013 in the course of preparation of the Phasotron infrastructure, a technical run was carried out to optimize the parameters of the negative muon beam channel in the low-background laboratory. The following results were obtained: muon pulse at 100 MeV/c, beam intensity $1.4 \cdot 10^4$ μ/s at the accelerator current of 0.5 μA. The experimental run with the polystyrene dummy target was performed in March 2013 to test simultaneously the registration and data collection systems. The cryogenic

tests of the target were conducted in November 2013 using the acquired cryogenic equipment (MKC MCMP-1504-5/20) with a cooling capacity of 10 W at 20 K. The accuracy of maintaining the temperature of liquid hydrogen in the target for a long time (tens of hours) is no worse than 0.1 K. In December 2013, a 10-hour session of physical measurements was conducted with a target filled with liquid hydrogen and exposed to the muon beam. As many as 140 significant muon stops in hydrogen per second were obtained. The baseline energy and time spectra of experimental events of muon-catalyzed fusion in pure (without addition of tritium) hydrogen were measured. The measured yield of 10^5 γ-rays with energy $E_\gamma = 5.5$ MeV from the muon catalysis process in the $pd\mu$ system (at a natural deuterium concentration of 10^{-4} volume fraction) indicates correct operation of all components of the facility [35].

The activity carried out in 2013 within the **MUON** project was aimed at studying the behavior of the polarized muons in condensed matter. In diamond, it occupies the tetrahedral interstitial site (MuT) or bond-centre site (MuBC). The behaviour of the muonium in two polycrystalline diamond samples and in the sample composed of a few single-crystal synthetic diamonds was investigated. The value obtained for the constant of the hyperfine interaction of the muon and the electron at MuT in the synthetic diamond samples is in agreement with that for the natural diamond. The muon spin relaxation rates in the MuT and MuBC states in the synthetic and natural samples of the IIa and IIb type are similar. It was found that in the IIa type single-crystal sample at 150 K, the contributions of the diamagnetic muon, MuT, and MuBC fractions are 1.5%, 57%, and 8.1%, respectively. The missing fraction of the muon polarization was 33.4%. It is known that for MuBC there is a certain "magic" field where the muon spin precession frequency is nearly independent of the orientation of the crystal. This effect allows observing a MuBC [36].

Within the **NN-GDH** project, in the experiment on Compton scattering of polarized photons at the polarized proton target performed by A2 collaboration at the MAMI C accelerator, the world's first estimate was obtained for the proton spin polarizability, which is a fundamental structure constant describing the proton spin response to the changing electromagnetic field. This result opens, in principle, a possibility for a precision study of nucleon spin structure in electromagnetic interactions. Within the framework of the "complete experiment" program, the world's first measurements of the polarization observables E, G in the photoproduction of π^0 and η mesons and pion pairs on the protons and deuterons were performed using the beams of circularly and linearly polarized photons with a maximum energy of 1.5 GeV from the MAMI C accelerator and the target with longitudinal polarization of protons and deuterons. These data (in combination with the earlier results for the observables T and F) form a basis for amplitude and multipole analyses of individual meson photoproduction channels [37, 38].

APPLIED RESEARCH AND ACCELERATORS PHYSICS

In 2013, the DLNP Department of New Accelerators was busy working on the project of the superconducting cyclotron **SCC250** intended for acceleration of protons to an energy of 250 MeV, which is considered to be optimal for the full-depth of penetration in an human body ($\sim$ 32 cm) and treatment of deep internal tumors. In the SCC250 cyclotron, beam current will be modulated by changing the current of the internal ion source with a frequency of up to 1 kHz, which will allow implementing a new promising proton therapy method based on active scanning with intensity-modulated beams.

Development of the magnetic system of the proton therapy cyclotron is based on the main parameters of the cyclotron with allowance for the interaction with other systems of the cyclotron: RF system, extraction system, cryogenic system. The ion orbital frequency found from the simulation of the magnetic field and beam dynamics is 37 MHz. In a cyclotron with four sectors and accelerating electrodes whose angular length is 45°, the optimum acceleration mode is the fourth one. If the SCC250 cyclotron operates with the fourth harmonic mode, the resonant frequency should be 148 MHz. Computer model of the cavity with the design frequency and the accelerating voltage increasing along the radius was developed, and simulation of the beam dynamics in the acceleration and extraction areas were performed.

The series of simulations and experiments on the cyclotron **AIC-144** was aimed at optimizing acceleration and extraction of the beam with a proton energy of $\sim$ 60.5 MeV for eye melanoma therapy. The energy spread in the extracted bunch of protons was minimized by tuning the phase motion of the accelerated beam which allowed obtaining the Bragg peak decrease of $\sim$ 0.8 mm at a level of 10–90%, a record value among the cyclotrons used for eye therapy. The development specification is prepared for the software for measurement of phase motion parameters of an accelerated bunch of protons [39].

The main goals of theme **"Medical and Biological Researches with the JINR Hadron Beams"** are to carry out medicobiological and clinical investigations on cancer treatment, to upgrade equipment and instrumentation, and to develop new techniques for treatment of malignant tumours and for associated diagnostics with medical hadron beams of the JINR Phasotron in the DLNP medicotechnical complex (MTC) [40].

The regular sessions of proton therapy aimed to investigate its efficiency to treat different kinds of neoplasm were performed in collaboration with the Medical Radiological Research Centre (Obninsk) and the Radiological Department of the Dubna hospital. During the year, seven treatment sessions, total duration of 25 weeks, were carried out. Seventy-three new patients were fractionally treated with the medical proton beam. The total number of the single proton irradiations (fields) was about 4500. Other 15 patients were irradiated with the "Rokus-M"Co-60 gamma-therapy unit. A computerized system for verification of boluses — irregular-shape proton beam decelerators, manufactured at the MTC workshop using a CNC milling machine — was designed and constructed. The quality control of the boluses increases the "quality assurance" level of the performed radiotherapy.

Together with the Division of Radiation Dosimetry, the Institute of Nuclear Physics (Prague, Czech Republic), measurements of secondary-particle background in the patient treatment room were carried out using the thermoluminescent, track, and silicon MEDIPIX detectors; and LET spectra of the JINR Phasotron therapeutic proton beam were studied using the LIULIN and MEDIPIX detectors. In collaboration with the Great Poland Cancer Centre (Poznan, Poland), the experiments at the proton beam with radiochromic films and a heterogeneous "Alderson phantom" simulating human anatomy were continued to verify all technological stages of the preparation and procedure for therapeutic irradiation. The results confirmed high accuracy of matching of the maximum dose distribution with the irradiated target and were reported at the Particle Therapy Cooperative Group Meeting 52 (Essen, Germany, June 2013).

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FLEROV LABORATORY OF NUCLEAR REACTIONS

In 2013, the FLNR scientific programme on heavy ion physics included experiments on the synthesis and study of properties of heavy and exotic nuclei using ion beams of stable and radioactive isotopes, studies of nuclear reaction mechanisms, heavy ion interaction with matter, applied research and development of acceleration technology. These research fields were represented in three laboratory topics:

- Synthesis and properties of nuclei at the stability limits (9 subtopics);
- Radiation effects and physical bases of nanotechnology, radioanalytical and radioisotope investigations using the FLNR accelerators (5 subtopics);
- Accelerator complex of ion beams of stable and radioactive nuclides (DRIBs-III) (9 subtopics).

In 2013, the operation time of the U400 and U400M FLNR cyclotrons amounted to 11400 h.

DRIBs-III. ACCELERATOR COMPLEX OF ION BEAMS OF STABLE AND RADIOACTIVE NUCLIDES

DRIBs-III (Dubna Radioactive Ion Beams) is one of the core JINR projects. The high-priority tasks approved by JINR's Programme Advisory Committee (PAC) for Nuclear Physics and Scientific Council, which have to be fully implemented within the Seven-Year Plan for JINR Development, include the following:

- development of the world's first SHE Factory, commissioning of a new DC-280 accelerator, construction of a new experimental hall and experimental setups for synthesis and investigation of the properties of SHEs;
- implementation of the scientific programme on SHE synthesis (U400 accelerator);
- completion of works on the U400M modernization and the development of a new ACCULINNA-2 separator for carrying out research on exotic radioactive nuclei;
- completion of preparatory and design works for the renovation of the U400 experimental hall and the modernization of the U400 accelerator to enable timely reconstruction in 2017;
- construction of a new JINR FLNR building (total of 1500 m^2) to conduct scientific research on the application of heavy-ion beams in nanotechnology.

The following project tasks were fulfilled in 2013:

1. The DC-280 cyclotron:

- The cyclotron magnet construction is underway under the contract with the Novokramatorsk Machine-Building Plant.
- The construction of the axial injection system was completed.
- The tendering process continued for the manufacture of the main parts of the accelerator.

2. Experimental hall:

- The design works (project preparatory phase I) were completed. The project was approved by the State Expert Evaluation Department (Glavgosekspertiza of Russia).
- Bulk earthworks were completed, deep foundation was laid.

3. Laboratory building:

- General construction works were completed.

• Engineering and manufacturing equipment was assembled.

• Experimental equipment assembly is underway.

4. Reconstruction of the U400 experimental hall:

• Design works were completed (project preparatory phase I) under the contract with Kometa, a joint-stock company.

5. While developing the ACCULINNA-2 setup in 2013, the following equipment was manufactured under the contract with SigmaPhi:

• a dipole D2 magnet,

• 13 quadrupole magnets,

• 2 sextupole magnets.

In 2013, technical specifications were prepared covering requirements for equipment location in the experimental hall of the JINR FLNR building No. 101. The load-bearing structures of the building were examined and a 2014 equipment assembly schedule was prepared. Moreover, power cables were purchased, requirements and technical specifications for the zero spectrometer were prepared, and a proposal from SigmaPhi to manufacture the magnet was received.

6. As part of the GALS Project, optical tables and a dye laser were purchased in 2013. Laser rooms and a measuring room were made ready for experiments, and a ventilation and cooling system was installed. The rest of the equipment (i.e., a Nd:YAG laser, optoelectronics, etc.) is to be purchased, installed, and tested in 2014. Hence, first experiments on selective resonance laser ionization will be conducted in 2014.

7. In 2013, vacuum and high-voltage testing of the VASSILISSA separator was successfully completed. The modernized recoil separator was commissioned in May 2013. Transmission measurements and separator tuning were carried out using an α-source mounted at the target position and a ^{22}Ne beam incident on a ^{198}Pt target. The measurements showed an increase in the transmission efficiency up to 5% (the size of the focal plane detector was $\sim 60 \times 60$ mm).

Overall, the implementation of the DRIBs-III project can be evaluated as satisfactory. However, it is worth noting that the construction of the experimental hall has fallen behind schedule.

Ion Sources. The production of new rare-isotope ion beams is one of the core scientific activities at FLNR. The Metal Ions from Volatile Compounds (MIVOC) Method was chosen to produce ions, such as ^{58}Fe and ^{50}Ti. The $(C_5H_5)_2Fe$ compound was used to produce Fe ion beams. The experiments on production of Ti ion beams were conducted at an ion-source test bench using natural and enriched compounds of titanium $(CH_3)_5C_5Ti(CH_3)_3$. Following a series of successful tests, the $^{50}Ti^{5+}$ ion beam was accelerated at the U400 cyclotron. The intensity of the injected $^{50}Ti^{5+}$ beam was about 50 μA. The operational experience with the ion source has been excellent in terms of stability and reliability during the commissioning period. The compound consumption rate was 2.4 mg/h, and consequently, the ^{50}Ti consumption amounted to 0.52 mg/h.

A new compact type of liquid He-free superconducting electron-cyclotron-resonance (ECR) ion source, designed and built jointly with the Laboratory of High Energy Physics (LHEP), JINR, will be used as a high-charge-state heavy-ion injector for the MC400 cyclotron. The axial magnetic field was produced by a superconducting magnet, whereas the radial plasma confinement was achieved by a hexapole magnet made of NdFeB. To improve the performance of the ion source when producing high-charge-state ions (e.g., Xe^{+30}), the source was upgraded by increasing the microwave frequency up to 18 GHz. Preliminary tests at this frequency demonstrated that the ion source could successfully produce medium-charge-state ions.

SYNTHESIS AND PROPERTIES OF NUCLEI AT STABILITY LIMITS

Synthesis of New Elements. In 2013, the analysis of the results of experimental study on the properties of radioactive isotopes of elements 115 [1] and 117 [2] was completed, and their α-decay products formed in the $^{243}\mathrm{Am} + {}^{48}\mathrm{Ca}$ and $^{249}\mathrm{Bk} + {}^{48}\mathrm{Ca}$ complete fusion reactions were studied. The experiments were carried out using the JINR FLNR gas-filled recoil separator in collaboration with the laboratories at Oak Ridge (ORNL), Livermore (LLNL), Knoxville (UT), Nashville (VU), and Dimitrovgrad (RIAR).

Three ^{294}117 and eleven ^{293}117 nuclei were registered in the $^{249}\mathrm{Bk} + {}^{48}\mathrm{Ca}$ reaction. The radioactive properties of the 12 nuclei in the decay chains of ^{294}117 and ^{293}117 are the same as those found in the first experiment on synthesis of element 117 in 2009–2010. The ^{289}115 isotope was observed in the cross reactions $^{243}\mathrm{Am}\,(^{48}\mathrm{Ca},\,2n)\,^{289}115$ and $^{249}\mathrm{Bk}\,(^{48}\mathrm{Ca},\,4n)\,^{293}117 \rightarrow {}^{289}115$. When formed as a result of a direct nuclear reaction with subsequent α decay of the mother nucleus ^{293}117, the decay properties of the nucleus and its α-decay products (Fig. 1) are identical in both reactions.

Chemistry of Transactinides. The cryodetector working at the temperature gradient from room temperature to -60°C was considerably upgraded in 2013. The setup comprises a sealed gas transport system,

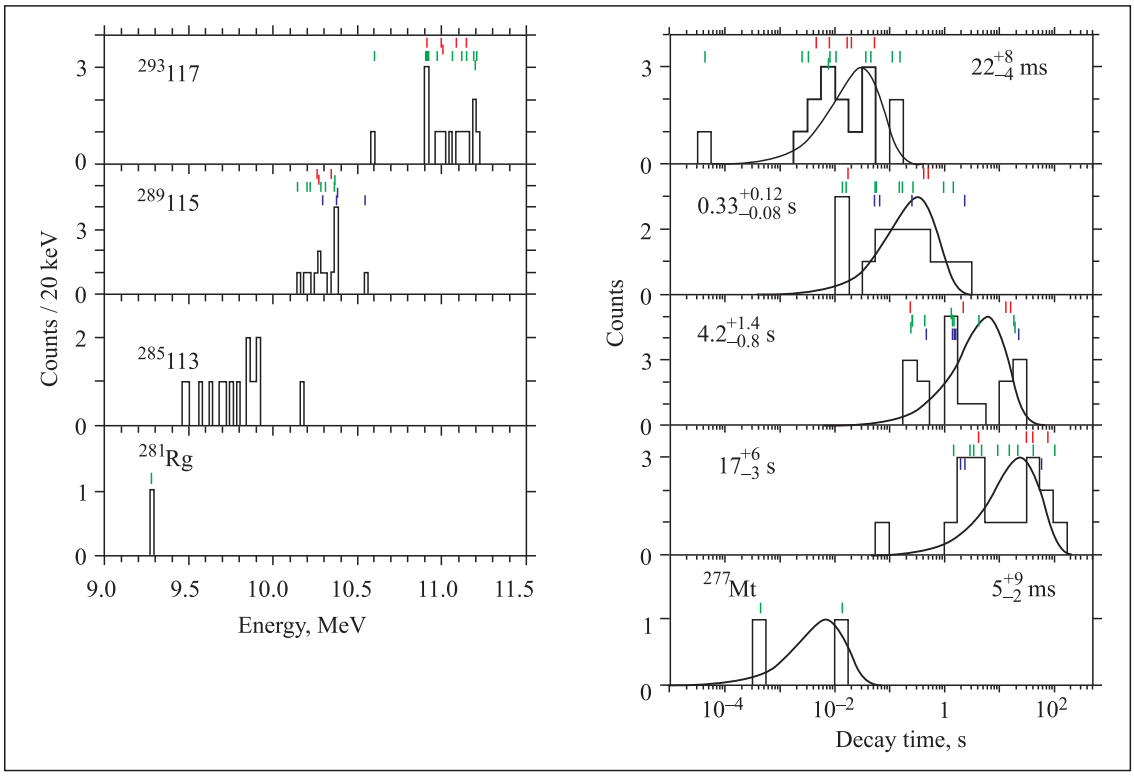

Fig. 1. Energy spectra of α particles (left) and decay time distributions (right) for ^{277}Mt–^{293}117. The values measured earlier in the reactions ^{249}Bk (^{48}Ca, $4n$) ^{293}117 and ^{243}Am (^{48}Ca, $2n$) ^{289}115 are represented by the spectral lines. The curves represent exponential distributions $dN/d\log(t)$ for the given half-lives

a target chamber, and a trap for aerosol particles, water, and oxygen.

The detection system consists of four detecting modules containing semiconductor detectors. Each module comprises two four-strip silicon detectors covered with gold. The He–Ar mixture was used to transport radionuclides to the detection system. The cryodetector was used to study the properties of element 113 in the fusion reaction ^{243}Am (^{48}Ca, $3n$) ^{288}115. The ^{284}113 isotope was produced as a result of the α decay of the isotope ^{288}115. The ^{243}Am targets were irradiated with a ^{48}Ca beam at 273 MeV delivered by the U400 cyclotron of FLNR. A total radiation dose amounted to $2.0 \cdot 10^{19}$. Five decay chains of element 113 were observed in the experiment. The results on the isotope decay energy and lifetimes were compared with those of previous studies and showed good agreement with them. The measurements confirmed the volatility of element 113. Moreover, two decay chains of the isotope ^{283}Cn and five decay chains of the isotope ^{285}Cn were produced with a 278-MeV ^{48}Ca ion beam impinging the ^{242,244}Pu targets.

VASSILISSA Separator. The recoil nuclei separator SHELS (Separator for Heavy ELements Spectroscopy) was put into operation in 2013, following successful vacuum and high-voltage tests. An α source and the fusion reactions ^{22}Ne (^{238}U, $4{-}5n$) $^{255-256}$No, ^{22}Ne (^{208}Pb, $4n$) ^{226}U, and ^{22}Ne (^{206}Pb, $4n$) ^{224}U were used to carry out transmission measurements, equipment tests, and fine tuning of the separator. The obtained data are under analysis. In November 2013, test measurements were carried out using a ^{50}Ti ion beam. As a result, the transport efficiency of Rf evaporation residues was measured at the target position of the SHELS separator. The transmission efficiency for the ^{209,210}Ra evaporation residues produced in the reaction with the ^{50}Ti beam and the ^{164}Dy target was estimated at 40%. The spontaneous fission of ^{256}Rf and the α decay of ^{257}Rf were measured in the complete fusion reaction $^{50}\mathrm{Ti} + {}^{208}\mathrm{Pb} \rightarrow {}^{258}\mathrm{Rf}^{*}$. The most important results are published in [3, 4].

Mass Spectrometer MASHA. In 2013, the data obtained in test experiments aimed at measuring the operating speed and efficiency of separation of short-lived mercury isotopes produced in the $^{40}\mathrm{Ar} + {}^{144}\mathrm{Sm}$ fusion reaction were analyzed. The separation time and efficiency were found to be (1.8 ± 0.5) s and 7%, respectively [5]. The results are consistent with the data obtained at the ISOLDE (CERN) facility.

The mass measurements of ^{283}Cn synthesized in the $^{48}\mathrm{Ca} + {}^{238}\mathrm{U}$ reaction were performed at the U400M cyclotron. A rotating uranium oxide target, irradiated for a total of 670 h, was deposited on the titanium-backing foil. The flux of ^{48}Ca ions which passed through the target was $1.9 \cdot 10^{18}$. No decay events of ^{283}Cn were registered.

Dynamics of Heavy-Ion Interaction, Fission of Heavy and Superheavy Nuclei. An experiment aimed to investigate the fission channel $^{260}\mathrm{No} \rightarrow {}^{208}\mathrm{Pb} + {}^{48}\mathrm{Ca} + 4n$ in the reaction $^{22}\mathrm{Ne}$ (106 MeV) $+ {}^{238}\mathrm{U}$ was conducted at the FLNR U400M cyclotron. Fission fragments were detected by the two-arm time-of-flight spectrometer CORSET. The mass-energy distributions of fission fragments of ^{260}No were measured. As a result, an increase was observed in the fragment yield in the mass region around 52/208 amu, which corresponded to the formation of a fissioning pair of two magic nuclei Ca/Pb. It is worth of note that the largest mass asymmetry ever recorded for neutron-induced fission of actinide nuclei is $\eta = 2.5$, whereas in the experiment super asymmetric fragments exhibit $\eta = 4.3$.

Within the framework of cooperation with the Accelerator Laboratory of the University of Jyväskylä (Finland), the Department of Physics of the University of Naples (INFN, Italy), and GSI (Germany), the mass-energy distributions of binary fragments were measured in the reaction $^{88}\mathrm{Sr} + {}^{176}\mathrm{Yb}$ at the JYFL K130 accelerator, energy and the centre-of-mass angles being $E_{\mathrm{lab}} = 435$ MeV and 30°–140°, respectively. The dissipation of large amounts of kinetic energy was observed for a significant part of binary fragments, which indicated the presence of deep inelastic transfer reactions. An enhanced yield was observed of heavy fragments with masses around 190–200 amu, caused by the influence of proton shells with $Z = 28,\ 82$. This behavior can be attributed to the net mass transfer of about 20–25 nucleons between the projectile and target. The data analysis revealed that the relative contribution of multinucleon transfer reactions to the capture cross section mainly depends on the reaction entrance channel properties. For target-like fragments heavier than the target, the excitation was about 30–50 MeV, which ledto an increased probability of the formation of nuclei surviving after the emission of 3–5 neutrons. Unexpected high yields of products heavier than the target confirm the possibility of producing neutron-rich isotopes in multinucleon transfer reactions at low energies. This result is particularly important for the synthesis of new superheavy elements [6, 7].

Yu. M. Itkis defended her Ph.D. thesis in 2013. The thesis was devoted to the study of the properties of mass and energy distributions of fission and quasifission fragments produced in reactions induced by ^{22}Ne, ^{26}Mg, ^{36}S, and ^{58}Fe, leading to the formation of $^{266,271,274}\mathrm{Hs}^*$ ($Z = 108$) at energies below and above the Coulomb barrier.

Structure of Exotic Nuclei. In 2013, experiments were carried out at the ACCULINNA fragment separator to study the two-proton decay ($2p$ decay) branches of the excited state in ^{17}Ne formed in the $^{18}\mathrm{Ne} + {}^{1}\mathrm{H} \rightarrow d + {}^{17}\mathrm{Ne}$ reaction. The experiments were aimed to acquire data on the decay branches for the "true" $2p$ decay of the first excited state of ^{17}Ne ($J^\pi = 1/2^+$, $E^* =$ 1.288 MeV). The $1/2^+$ state undergoes an M1 γ transition from an excited state back to the nuclear-stable ground state. The observation of a weak branch for the "true" $2p$ decay is important. The investigation of this new type of radioactive decay can provide more information on the nuclear structure of ^{17}Ne, which can be treated as the so-called "Borromean" three-body ($^{15}\mathrm{O} + 2p$) cluster structure. The astrophysical aspects are also essential. As found earlier, even a very weak ($\Gamma_{2p}/\Gamma_\gamma \approx 0.01-0.001\%$) $2p$ decay branch for the $1/2^+$ state would testify to the bypass of the ^{15}O waiting point in the rp-process nucleosynthesis by the two-proton capture reaction $^{15}\mathrm{O} + 2p$. A new approach was used to carry out experimental measurements for ^{17}Ne undergoing $2p$ decay, overall energy resolution being no less than 100 keV FWHM. Such a high resolution is required to unambiguously isolate a "true" $2p$-decay signal of the $1/2^+$ state from protons sequentially emitted from the decay of two high-lying ^{17}Ne states at an energy of 1.908 MeV and $E^* = 1.764$. The partial data analysis together with the measurements to date yields a limit of $\Gamma_{2p}/\Gamma_\gamma < 0.1\%$. A limit of $\Gamma_{2p}/\Gamma_\gamma < 0.01\%$ is expected following the complete data analysis.

In 2013, the data obtained in experimental studies on the low-energy excitation spectrum of the superheavy helium isotope ^{10}He formed in the two-neutron transfer reaction $^{8}\mathrm{He} + {}^{3}\mathrm{H} \rightarrow {}^{10}\mathrm{He} + p$ [8] continued to be analyzed.

Reactions with Beams of Light Stable and Radioactive Nuclei. In 2013, the FLNR group continued developing multiwire proportional chambers and diagnostic systems for low-intensity ion beams ($\leqslant 10^7$ pps). The specialists of the GANIL group, who actively designed and tested these systems, are interested in their future implementation at the SPIRAL2 facility at GANIL, France.

In 2013, the FLNR group conducted a series of experiments aimed to shed additional light on structural peculiarities of the isotopes ^{9,10}Be and ^{10}B. The experiments were carried out at the U120 cyclotron at the Nuclear Physics Institute (NPI), Řež (Czech Republic), and the cyclotron of the Jyväskylä University (Finland). As a result, the angular distributions of differential cross sections were measured for the $^{9}\mathrm{Be}\,(\alpha, \alpha')\,{}^{9}\mathrm{Be}^*$, $^{9}\mathrm{Be}\,(\alpha, {}^{3}\mathrm{He})\,{}^{10}\mathrm{Be}$, and $^{9}\mathrm{Be}\,(\alpha, t)\,{}^{10}\mathrm{B}$ reactions. The optical model (OM) and the distorted-wave Born approximation (DWBA) were used to analyze the calculated dependencies. As an example, the experimentally measured angular distributions of differential cross sections for the $^{9}\mathrm{Be}\,(\alpha, \alpha')\,{}^{9}\mathrm{Be}^*$ reaction and the results of the data analysis are presented in Fig. 2. The value of $9/2^-$ was assigned to the spin and parity for the excited state in ^{9}Be at 11.28 MeV. The obtained data are also essential for astrophysics.

Fruitful scientific cooperation with other research centres continued. In particular, an experiment was conducted at the ALTO radioactive beam complex,

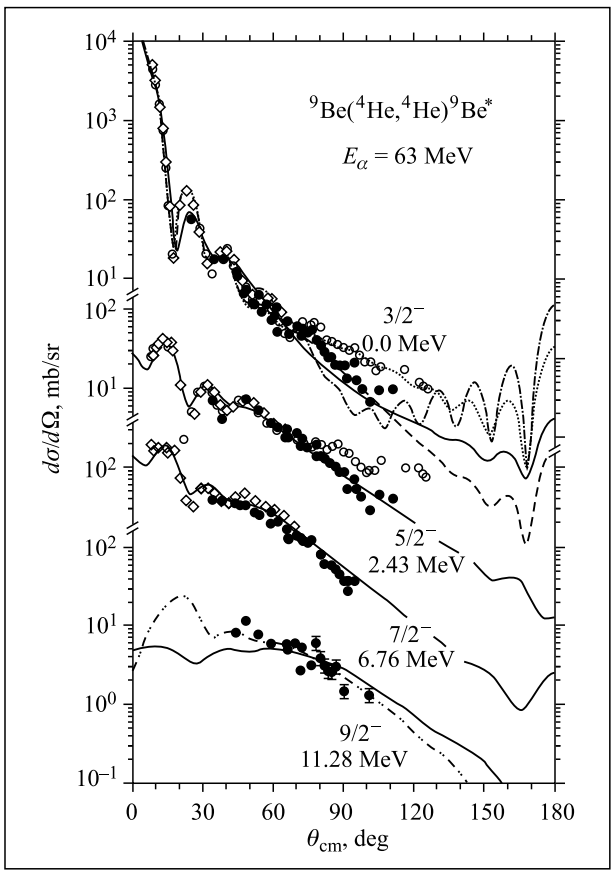

Fig. 2. The differential angular distributions of the ground and excited states of ^{9}Be in the $^9\mathrm{Be}\,(\alpha,\alpha')\,^9\mathrm{Be}^*$ reaction. The symbols denote experimental data, and the curves represent the analysis results within the optical model and the distorted-wave Born approximation

Orsay (France), aimed to measure beta-delayed neutron emission probabilities for ^{82,83,84}Ga using the TETRA 4π neutron detector developed in Dubna.

The most important 2013 results are published in [9, 10].

Theoretical and Computational Physics. The problems related to the production of neutron-rich heavy nuclei in multinucleon transfer reactions at low-energy collisions of heavy ions were studied [11]. It has been shown that reactions with actinide beams and targets are of special interest for synthesis of new neutron-rich transfermium nuclei and yet unknown nuclei with the closed neutron shell $N = 26$, which have the greatest impact on the process of nucleosynthesis. Calculated cross sections appeared to be high enough and the experiments proposed can be carried out at the existing accelerators.

Fast fall of cross sections and a drastic decrease of life-times of nuclei with $Z > 120$, obtained in the fusion reactions, make considerable difficulties and are responsible for uncertainties in further development of the physics of superheavy elements. All possible reaction mechanisms (fusion of stable and radioactive nuclei, multinucleon transfer and processes of neutron capture) that may be used for synthesis of superheavy elements were studied in detail [12]. New experiments were proposed aimed at the synthesis of superheavy nuclei located between those synthesized in the reactions of "cold" and "hot" fusion, as well as at the production of long-lived neutron-rich isotopes of superheavy elements, including those located in the centre of the "stability island".

The effect of channels of collective excitations and neutron rearrangement on subbarrier fusion cross sections for atomic nuclei was investigated [13]. Comparison with previous studies suggests that the subbarrier fusion enhancement is not limited to the case of intermediate neutron transfer with positive Q values. A significant subbarrier fusion enhancement was also observed in the case when colliding nuclei are resistant to collective excitations. Moreover, experimental studies with several prjectile-target combinations were proposed.

The knowledge base on low-energy nuclear physics allocated on the website http://nrv.jinr.ru/nrv was extended with the partial support from the JINR–RSA cooperation programme. Several new models were added to the knowledge base, including: (i) a GRAZING code based programme for calculating few-nucleon transfer cross sections; (ii) an EPAX code based programme for calculating yields of reaction products in intermediate-energy heavy-ion fragmentation processes.

RADIATION EFFECTS AND PHYSICAL BASES OF NANOTECHNOLOGY, RADIOANALYTICAL AND RADIOISOTOPE INVESTIGATIONS USING FLNR ACCELERATORS

The investigation of track-etched nanopores continued in several directions. A method was developed based on measurements of electrical conductivity as a function of time. It allows reconstruction of longitudinal profiles of symmetric nanopores. The new approach can be useful for sensor applications of nanopores. Recrification properties of single- and multi-pore asymmetric membranes were experimentally compared. The pore profiles in PET track-etched membranes were also studied using the ion energy-loss spectroscopy [14].

A method was developed for producing photocatalytic nanocomposite membranes by directly modifying the surface of PET track-etched membranes with silver and titanium. It was found that membrane surface has excellent self-cleaning and superhydrophobic properties.

An investigation was undertaken on changes of metal elemental composition in an atmosphere of high-pressure hydrogen and deuterium irradiated with 10–23-MeV γ quanta [15].

The cross-sectional transmission electron microscopy (XTEM) and scanning electron microscopy (SEM) were used to study nanocrystalline ZrN samples implanted with a 30-keV He beam ($5 \cdot 10^{16}$ cm^{-2}) and subsequently irradiated with 167-MeV Xe ions (10^{14} cm^{-2}). It was found that post-irradiation heat treatment induced formation of blisters due to helium segregation. The XTEM and SEM analyses showed helium blistering was suppressed under high-energy Xe ion irradiation. This result has considerable practical value for simulation of radiation damage in reactor materials caused by fission fragments [16, 17].

The influence was studied of high ionization induced by swift Bi ions ($E = 710$ MeV) on the development of gas blisters in silicon implanted with deuterium ($E = 12.5$ keV) and helium ($E = 25$ keV) ions during 500°C post-radiation annealing. The light microscopy, TEM, ERD, and thermal desorption spectroscopy (TDS) were used.

For the first time ever, significant reduction (even full suppression, e.g., in deuterium) of blister and flake formation was accomplished. The analysis results revealed that radiation-induced desorption of deuterium and helium occurs during their irradiation with swift bismuth ions.

Nanostructured materials were used to study the distribution of 4- and 5-valent elements. The reactions $^{118}\mathrm{Sn}(\gamma, n)\,^{117m}\mathrm{Sn}$ and $^{196}\mathrm{Pt}\,(\gamma, n)\,^{195m}\mathrm{Pt}$ were studied to produce radioisotopes for biomedical research.

A rapid method is currently being developed for the analysis of Po in soil and plants. Studies have also been initiated on the behaviour of volatile elements and decay products of uranium and thorium in the oil shale fly ash [18, 19].

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FRANK LABORATORY OF NEUTRON PHYSICS

In 2013, the Frank Laboratory of Neutron Physics' scientific programme was aimed at obtaining new results under four research themes of the JINR Plan for Scientific Research and International Scientific and Technical Cooperation: in condensed matter physics ("Investigations of Nanosystems and Novel Materials by Neutron Scattering Methods", 04-4-1069-2009/2014, headed by V. L. Aksenov, A. M. Balagurov and D. P. Kozlenko); in neutron nuclear physics ("Investigations in the Field of Nuclear Physics with Neutrons", 03-4-1104-2011/2013, headed by V. N. Shvetsov and Yu. N. Kopatch); in development of the FLNP basic facilities ("Development of the IBR-2M Reactor with a Complex of Cryogenic Moderators of Neutrons", 04-4-1105-2011/2013, headed by A. V. Belushkin and A. V. Vinogradov); in development of the IBR-2 spectrometers and computation complex ("Novel Development and Creation of Equipment for the IBR-2M Spectrometers Complex", 04-4-1075-2009/2014, headed by V. I. Prikhodko and S. A. Kulikov).

CONDENSED MATTER PHYSICS

The greater part of experimental research was carried out on the spectrometers of the modernized IBR-2 reactor.

In 2013, within the framework of the User Programme, 195 proposals for conducting experiments were received from 17 different countries. The received proposals covered a broad spectrum of neutron research in physics (41%), materials science (22%), chemistry, geosciences, biology and applied sciences (constituting the rest 37%). Of the received proposals, 158 were admitted for realization.

Scientific Results. The crystal and magnetic structure of multiferroic $RbFe(MoO_4)_2$ has been studied [1]. In this compound a spontaneous electric polarization occurs due to the fact that the inversion symmetry of the crystal structure is broken because of the occurrence of noncollinear antiferromagnetic ordering. In addition, Fe magnetic moments in the trigonal structure of $RbFe(MoO_4)_2$ (space group P-3m1) form a two-dimensional magnetic triangular lattice, where magnetic coupling between the magnetic planes is 25 times weaker than the in-plane coupling. With increasing pressure a structural phase transition to the monoclinic C2/c phase with a phase coexistence in a wide pressure range was observed. The antiferromagnetic (AFM) symmetry for the trigonal phase is characterized by a propagation vector $q = (1/3, 0, k_z)$. With a rise in pressure, an increase in the k_z value from 0.45 to 0.48 and in the Néel temperature with a pressure coefficient of 0.09 GPa^{-1} was observed. No evidence of the formation of the magnetic ordering in the high-pressure monoclinic phase was found down to a temperature of 1.5 K.

On the HRFD diffractometer the investigations of electrodes in lithium-ion accumulators [2] have continued. The experimental data have made it possible to follow more closely the stages of Li intercalation into graphite with the successive formation of several LiC_n phases and a reversible transition $LiFePO_4 \leftrightarrow FePO_4$. The comparison of charging/discharging processes in batteries with a cathode of pure LFP and LFP containing $\sim 1\%$ vanadium (LFPV) has demonstrated that in the latter case a significantly greater fraction of the anode material undergoes a transition into a final LiC_6

phase because of a smaller relative mass of graphite as compared to fluorine ferrophosphate. The analysis of changes in the microstructure of a vanadium-doped cathode has shown a significant increase in the degree of structure imperfection, which correlates with the best electrochemical properties of LFPV as compared to LFP.

On the basis of the small-angle neutron scattering analysis, a continuous spatial transition of the carbon state from crystalline diamond (sp^3-hybridization) inside the particle to a graphite-like state (sp^2-hybridization) at DND surface has been suggested. Such a transition makes it possible to combine the experimentally observed shift in the mean scattering length density of DND as compared to pure diamond (which is indicative of the presence of a non-diamond component in the DND structure) and the diffusive character of the particle surface, which can be deduced from the deviation from Porod's law [3]. The proposed profile is of a simple power-law type and due to a number of specific features explains a homogeneous decrease in the total scattering intensity at the contrast variation. A spherical "core-shell" representation of DND particles used previously, which gives a reasonable thickness of a non-diamond shell of about 0.5 nm, can be considered as an approximation to the continuous density profile reflecting naturally the diamond–graphite transition in terms of the averaged scattering length density. Along with it, this profile naturally suggests that non-diamond transitional bonds (presumably sp^{2+x}-bonds) are mainly concentrated close to the particle surface. It also allows one to directly determine the parameters of the particle size distribution function.

At the REMUR spectrometer the magnetic state of the layer nanostructure Ta(10 nm)/V(150 nm)/$Fe_{0.7}V_{0.3}$(1 nm)/V(1.2 nm)/$Fe_{0.7}V_{0.3}$/Nb(150 nm)/Si composed of ferromagnetic and superconducting layers has been studied by polarized neutron reflectometry. Three phenomena were supposed to take place in this nanostructure. The first one was assumed to be an antiferromagnetic ordering of the pair of $Fe_{0.7}V_{0.3}$(1 nm) layers in an external magnetic field. The second effect was supposed to concern the magnetization of the superconducting pair by ferromagnetic layers, which would result in magnetization of the superconducting layer. Finally, the third phenomenon was presumed to be the formation of a domain structure with small domain sizes and zero mean magnetization. During the measurements the temperature and magnetic field strength were varied in the ranges of 1.3–110 K and 30 Oe – 9.5 kOe, respectively. The neutron scattering with a maximum at a temperature of 8 K (which is below the temperature of superconducting transition in the niobium layer) was observed in the range of 1.3–10 K. The obtained experimental data are indicative of the existence (in a certain temperature range below the superconducting transition temperature) of a domain lattice phase where a rotation of the magnetization vector takes place and which is characterized by two directions. The latter is testified by a strong scattering, which cannot be explained only by the scattering in the vertical direction. The absence of neutron scattering in the second direction suggests that the lattice constant in this direction lies in the range below one thousand angströms. These observations are the first direct experimental evidence of a cryptoferromagnetic phase in superconducting ferromagnetics, which is the appearance of an antiferromagnetic ordering at the scale of superconducting coherent length (size of a superconducting pair). At the same time, the magnetic period of the cryptoferromagnetic state was found to be an order of 1000 times less than the size of usual domains in ferromagnetics (microns).

A process of spontaneous phospholipid vesicle formation in the presence of calcium ions has been studied by small-angle neutron scattering (Fig. 1). For the first time, the behavior of intermembrane distance in the transition region has been considered in detail for the membranes in both liquid and gel phases. It has been shown that the transition of the system from the bound to the unbound state in both phases has a continuous character, which is rather unusual for gel phases. The earlier theoretical studies on gel phases suggested that on addition of calcium ions to lipid multilayer membranes there should be a sharp transition of membranes from the bound to the unbound state, since there are no undulations in the gel phase. The investigations performed have shown that there is a significant contribution of undulation forces to membrane interactions. The critical calcium ion concentrations at which the studied transition takes place in gel (0.3 mM) and liquid (0.4 mM) phases have been obtained together with the direct determination of the affinity constants for calcium ions with respect to lipid membranes (22 M^{-1} and 24 M^{-1} in gel and liquid phases, respectively).

When operating nuclear facilities, a surveillance programme of witness specimens positioned at the inner wall of the reactor cavity serves as an important source of information on the changes in the properties of vessel steels, which tend to worsen as a result of neutron irradiation. It is necessary to control the level of residual stresses after welding in the reconstituted witness specimens. On the FSD diffractometer, experiments have been carried out to study the distribution of residual stresses in witness specimens that develop after electron-beam welding (EBW) and laser beam welding (LBW). The experimental results have shown that the level of residual stresses for an LBW sample is much higher than for an EBW sample and ranges to 550 MPa in the weld region. This supports the well-known fact that among all methods the application of electron-beam welding results in the lowest level of residual stresses in welds. This is most probably due to a low heat input of the EBW process (4–5 times lower than, for example, in arc welding) which significantly reduces the deformation of a final product. In addition, the diffraction peak broadening was used to determine the level of residual

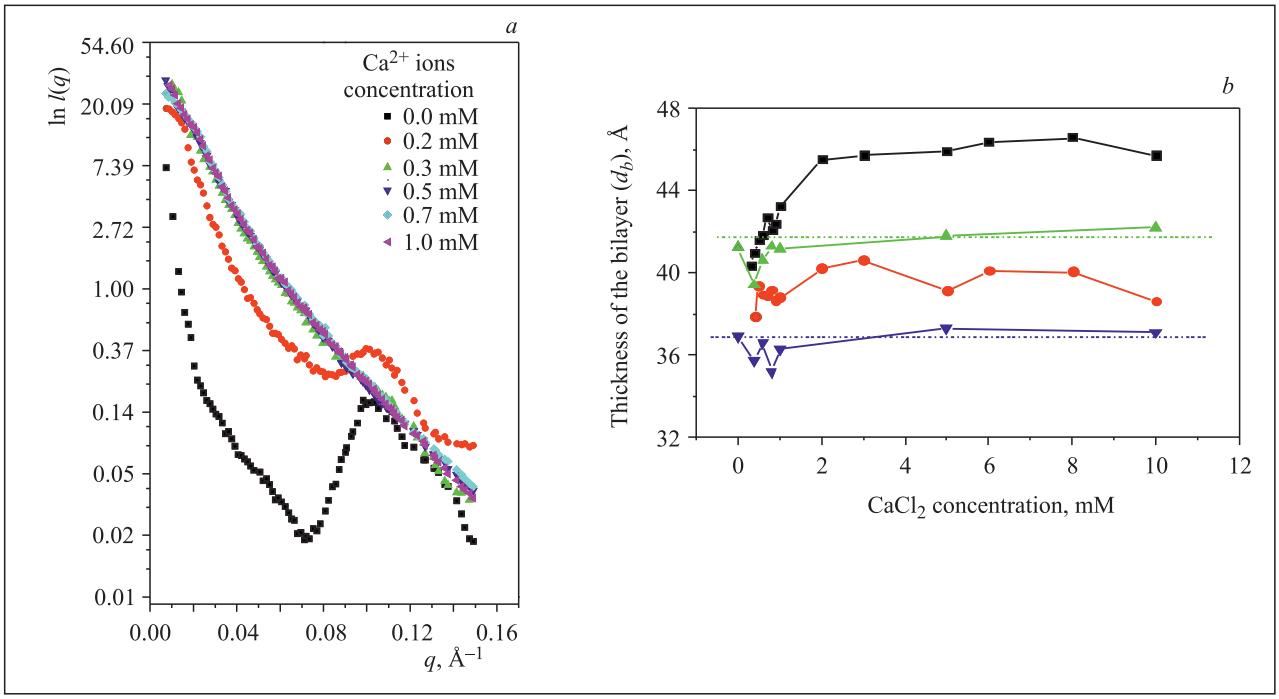

Fig. 1. *a*) Small-angle neutron scattering curves from multilayer DMPC membranes (1% wt) in the water/$CaCl_2$ solution for molar concentrations of Ca^{2+} ions: 0.0, 0.2, 0.3, 0.5, 0.7 1.0 mM. *b*) Concentration dependence of the bilayer thickness: for unilamellar vesicles prepared by extrusion: ▲ — at $T = 15\,^{\circ}$C; ▼ — at $T = 55\,^{\circ}$C and for spontaneously formed unilamellar vesicles: ■ — at $T = 15\,^{\circ}$C; ● — at $T = 55\,^{\circ}$C

microstrains, which directly characterizes the density of dislocations in a material being studied. The microstrain in the EBW specimen amounts to $3.5 \cdot 10^{-3}$ and is slightly higher in the LBW specimen — $4.5 \cdot 10^{-3}$. This effect is accompanied by a considerable (~ 2.5 times) increase in microhardness in weld seam regions. The observed increase in microhardness is likely to be the result of the formation of martensite (or martensite-bainite) structure in welds and heat-affected zones.

Instrument Development. Work to develop and test sample environment devices for the new DN-6 diffractometer has been carried out. High-pressure cells with diamond anvils with an operating range up to 15 GPa (culet diameter of 0.8 mm) and 50 GPa (culet diameter of 0.5 mm) have been purchased. The first experiments have demonstrated a possibility of their successful application in experiments with DN-6.

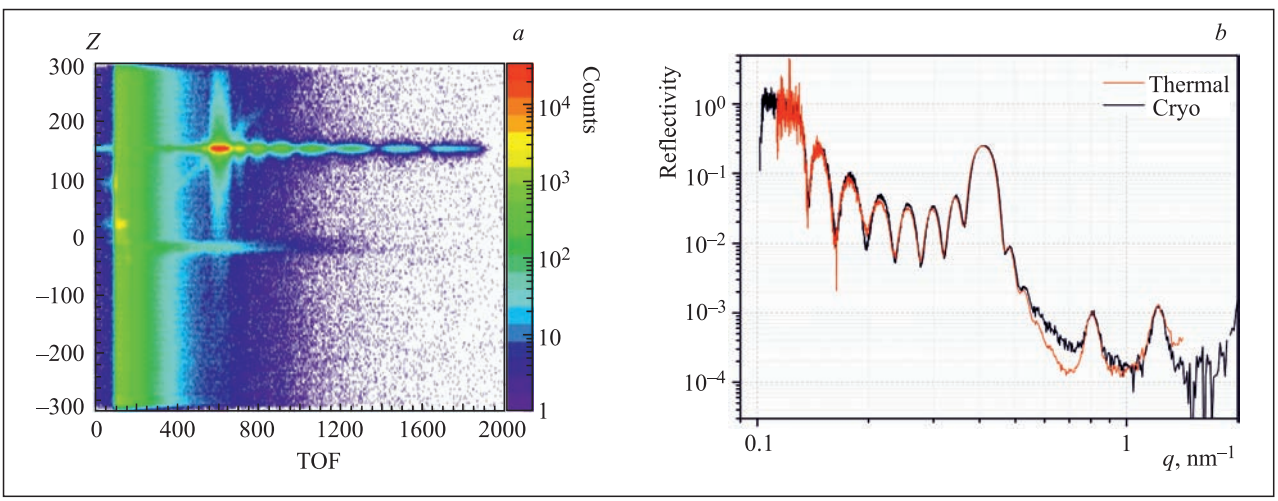

Fig. 2. *a*) 2D spectrum of non-polarized neutron beam reflected from a layer structure [Ni(8.4 nm)Ti(7 nm)]×8/Floatglass (MIRROTRON Ltd., Hungary) obtained on the GRAINS reflectometer in a cryogenic operating mode of the moderator; data are represented in coordinates Z (detector channel width 0.35 mm) — Time-Of-Flight (channel width 32 μs). *b*) Reflectivity curves for the same system measured in thermal and cryogenic operating modes of the moderator

The operation of the first-stage of the GRAINS reflectometer has started. Beam profiles have been measured and optimized for different configurations of the reflectometer elements. The experimental estimations of the total flux of non-polarized thermal neutrons (wavelength above 0.05 nm) after deflector have been made in thermal ($2\cdot10^6$ cm$^{-2}\cdot$s^{-1}) and cold ($1\cdot10^6$ cm$^{-2}\cdot$s^{-1}) operating modes of the moderator. Time-of-flight spectra have been optimized over the fast neutron background. The first reflectivity curves for standard systems have been obtained in two operating modes of the moderator (Fig. 2). During the start-up the first experiment to study the oxidation effect on the structure of thin titanium films on a glass substrate has been carried out in the framework of the development of new coatings for neutron optical devices.

The development and construction of a prototype of a radiography spectrometer on beam 14 continued. A vacuum collimation system has been manufactured and installed on the beam. A CCD-camera-based imaging system has been produced and tested on beam 12.

NEUTRON NUCLEAR PHYSICS

In 2013, at FLNP the scientific activity in the field of neutron nuclear physics was carried out in the following traditional directions: investigations of time and space parity violation processes in neutron-nuclear interactions; studies of the fission process; experimental and theoretical investigations of fundamental properties of the neutron; gamma spectroscopy of neutron-nuclear interactions; atomic nuclear structure, obtaining of new data for reactor applications and for nuclear astrophysics; experiments with ultracold neutrons. In 2013, the IREN facility operated for physical experiments for about 1050 h.

A mobile reconfigurable gamma-spectrometer system nGamma has been developed and tested. The system is intended for studying nuclear reactions with the emission of gamma rays induced by neutrons of various energies. In the initial (minimum, test) configuration it consists of 24 NaI(Tl) gamma-ray detectors mounted on two rings. The energy and time characteristics of individual sections of the system have been determined experimentally. By using the system, the energy dependence of neutron flux density has been measured at a distance of 60 m from a neutron-generating target of the IREN pulsed neutron source.

A 12-detector (2 modules of 6 NaI(Tl) crystals each) gamma-spectrometer system "Romashka", designed to study resonance radiative capture (and fission) of nuclei by neutrons, has been assembled and tested on beam 4 of the IREN facility.

In 2013, the adjustment of the experimental setup AURA for measuring the energy dependence of angular anisotropy of slow neutrons scattered by noble gases in order to determine the (n,e)-scattering length was in progress. At present, the AURA setup is placed on a 15-m flight path of beam 2 of the IREN facility.

The activities carried out in cooperation with the Czech Technical University in Prague on the application of pixel silicon detectors for detecting charged particles emitted in fission are in progress. In 2013, the measurements of ternary spontaneous fission of ^{252}Cf using TimePix detectors were carried out at FLNP in collaboration with the Technical University in Prague. The $\Delta E{-}E$ technique, which allows charge identification of light charged particles, was used to identify ternary particles. A thin silicon detector (12 μm) was used as a ΔE-detector and a pixel detector TimePix with a 300-μm-thick sensor layer as an E-detector.

In 2013, a setup for precision measurements of prompt fission neutron multiplicity depending on the mass distributions of fission fragments and their total kinetic energy was designed and constructed.

The experimental and theoretical investigations of the (n,p), (n,α) reactions induced by fast neutrons continued. The experiments are carried out at the Van de Graaff accelerators EG-5 at JINR FLNP (Dubna, Russia) and EG-4.5 of the Institute of Heavy Ion Physics of Peking University (Beijing, China). Data on the neutron reactions with the emission of charged particles induced by fast neutrons are of much interest for studying the mechanisms of nuclear reactions and atomic nuclear structure. In addition, these data are of importance in choosing engineering materials and in performing calculations in the development of new facilities for nuclear power engineering. At the end of 2013, the measurements of the ^{66}Zn$\,(n,\alpha)\,^{63}$Ni and ^{144}Sm$\,(n,\alpha)\,^{141}$Nd reactions at $E_n = 4$ MeV were conducted, thus completing a series of measurements that started a year ago. The measurements of the ^{54}Fe$\,(n,\alpha)\,^{51}$Cr reaction were also carried out at $E_n = 5.5$ and 6.5 MeV. The energy spectra of charged particles were obtained and the data treatment is in progress. The data treatment for the measurements of the ^{57}Fe$\,(n,\alpha)\,^{54}$Cr and ^{63}Cu$\,(n,\alpha)\,^{60}$Co reactions at $E_n \sim 4.0{-}6.5$ MeV has been completed. A comparison with the available library estimates and with the data obtained by other authors has been performed (Figs. 3 and 4). The analysis reveals a significant discrepancy between the estimates given by different nuclear data libraries, while no experimental data are available for ^{57}Fe isotope. The available data for ^{63}Cu from two rather old measurements in the range of several MeV show a considerable discrepancy.

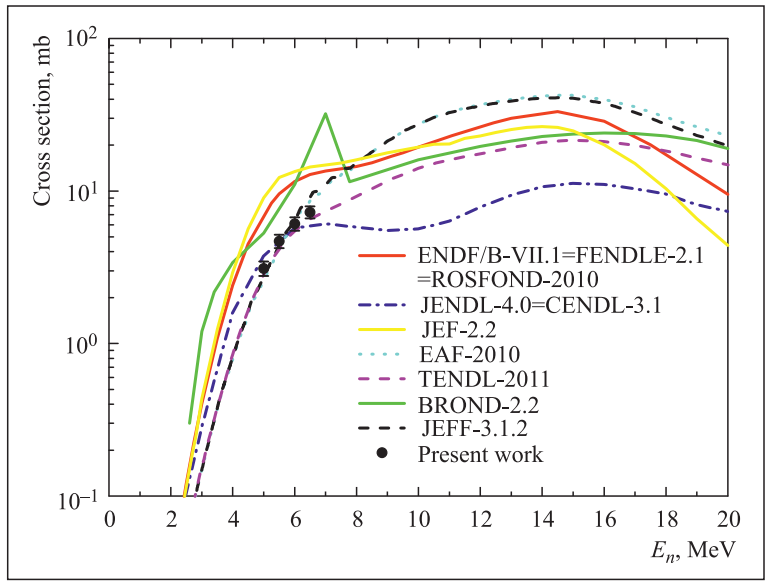

Fig. 3. The obtained cross sections of $^{57}\mathrm{Fe}\,(n,\alpha)\,^{54}\mathrm{Cr}$ in comparison with the available library estimates and with the data obtained by other authors

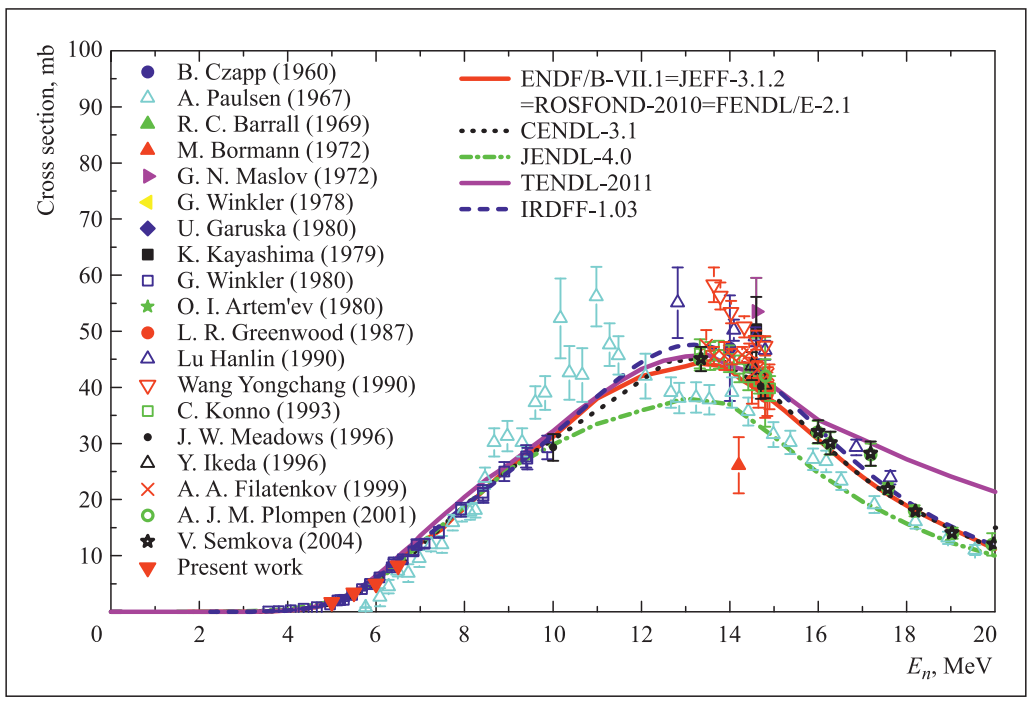

Fig. 4. The obtained cross sections of $^{63}\mathrm{Cu}\,(n,\alpha)\,^{60}\mathrm{Co}$ in comparison with the available data and estimates

Test measurements have been carried out to test the idea of using a cavity of solid methane for producing a cold neutron flux at the end of a neutron guide with thermal neutrons. The measurements were done in 2013 on the DIN-2PI instrument on beam 2 of the IBR-2 reactor. The results show that one can obtain the neutron spectrum close to that from the cold reactor source by using the thermal neutron beam inside the methane cavity. The albedo of solid methane for cold neutrons is close to the calculated value. Thus, the idea of a helium UCN source inside a cold cavity at the end of a neutron guide with thermal neutrons appears feasible. The next step in the development of the given idea is to construct a prototype of the source to test the solutions for a number of technical problems.

In 2013, the radiation tests of scintillators and megatile samples of the CMS setup (CERN) were performed. It was necessary for the optimization of the conditions for future experiments. The neutron spectrum at IREN is close to that at the CMS hadron calorimeter. The samples were irradiated by the total fluence of 10^{12} cm^{-2}. Then during three weeks the

induced activity was measured at two distances from the sample.

The work on the active moss-transplant biomonitoring of airborne trace elements made it possible to study the air pollution in the centre of Belgrade, Serbia, as well as in Greater Thriasion Plain, Attica, one of the most ecologically unsafe regions of Greece.

The results of complex investigations of air pollution using mosses and lichens as well as of water ecosystem using mollusks and oysters near a growing port in Cape Town (Saldanha Bay, the Atlantic Ocean near the West coast of the Republic of South Africa) have aroused considerable interest among environmental specialists of the RSA and willingness to cooperate in this research area.

In cooperation with the Western Cape University (South Africa), the NAA study of coal fly ash from the Matla coal power station in the Mpumalanga Province in South Africa has been conducted.

The elemental composition of microbiological samples and the efficiency of accumulation of zinc and other metals by Spirulina biomass were determined using the NAA technique on the IBR-2 reactor. This study was awarded with a gold medal at the V European Exhibition of Creativity and Innovation EUROINVENT 2013, Iaşi, Romania, in the category "PhD research project".

THE IBR-2 PULSED REACTOR

The IBR-2 research nuclear facility is operated under Rostechnadzor license No. ГН-03-108-2614 of 27 April 2012.

In 2013, in accordance with the license requirements, the specialized organizations, in cooperation with the IBR-2 personnel, performed the scheduled work on the technical evaluation and assessment of the remaining life of the technological reactor equipment. The activities to prolong the service life of the equipment of the IBR-2 safety-related systems have been completed.

Since January 2013 regular IBR-2 cycles of physical experiments have been carried out at a power of 2 MW with the CM-202 moderator operating either in the water or cryogenic mode depending on the schedule of the physical start-up of the cold moderator.

From September 13 to 19, a fresh fuel assembly was loaded into the IBR-2 reactor core and the reactor was brought to criticality in a steady-state operation mode followed by an assessment of the efficiency of the loaded fuel assembly and of the integrated efficiency of the regulating units of the control and safety system. The reactor was turned on to a power of 250 kW followed by an assessment of the efficiency of the loaded fuel assembly at pulsed criticality.

The table presents data on the IBR-2 operation for physics experiments in 2013.

In 2013, in accordance with the contract with the JSC "Dose" the dosimetry equipment for the stationary radiation monitoring system (RMS) of IBR-2 was delivered. Its installation and adjustment began.

Data on the IBR-2 operation for physics experiments

No. cycle	Period	Moderator type	Reactor operation for physics experiments, h
1	January 22–30	Cryogenic	176
2	February 11–22	Water	260
3	March 18–29	Cryogenic	264
4	April 9–20	Water	242
5	May 21 – June 6	Water	281
6	September 23 – October 4	Water	262
7	October 14–22	Water	169
8	October 24 – November 1	Cryogenic	174
9	November 11–18	Water	170
10	November 21–23	Cryogenic	44
11	November 29 – December 13	Water	330
12	December 17–26	Cryogenic	206
		Total:	2578

NOVEL DEVELOPMENT AND CONSTRUCTION OF EQUIPMENT FOR THE IBR-2 SPECTROMETER COMPLEX

In January 2013, during the last and longest operation cycle of the moderator at a reactor power of 2 MW, research activities were carried out in the framework of the CM-202 commissioning programme. All in all, during the start-up period there were six CM operation cycles with fresh loadings of beads composed of a frozen mixture of mesitylene and m-xylene with the duration of the cycles ranging from several to 178 hours. As a result of the analysis of the CM-202 operation in the specified cycles, the key questions, which are important for ensuring efficient and long-term operation of the moderator, were answered:

• Time of loading beads into the moderator chamber — minimum 4 h. Loading proceeds without jams and noticeable defragmentation of beads at a gas flow rate of 1.2–1.5 g/s and a temperature of 80–85 K.

• Hydraulic resistance of the contour and parameters of a gas blower ensure a helium flow rate of 6 g/s.

• A KGU-700/15 cryogenic refrigerator cools beads in the CM-202 chamber at a reactor power of 2 MW down to an average temperature of 32–33 K (design value is 23–25 K).

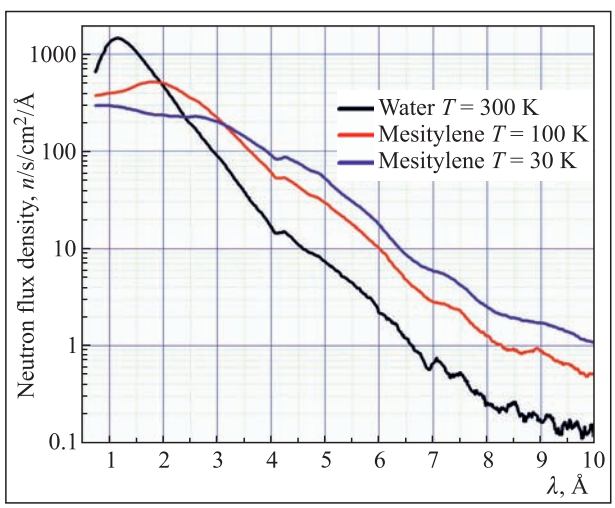

Fig. 5. The differential neutron flux density at the location of a PSD detector for an empty chamber (black line) and for the filled one at temperatures of 100 and 30 K

• Gain factor for cold neutrons with wavelengths of 8–10 Å is 13–14 (Fig. 5), design value is up to 20 at 20 K. Degradation in the cold neutron (6–10 Å) flux for 350 MW · h is no more than 5–7%; the flux of neutrons with shorter wavelengths increases with a radiation dose.

• Discharge of the spent liquid proceeds rather quickly; the initial solution viscosity increases no more than 10 times after operating for 7.3 days.

• Filling of the chamber and subsequent discharge of mesitylene have no effect on the reactivity of the IBR-2 reactor.

The modernization of the detector system for the DN-12 diffractometer for investigations of microsamples at high pressures, as well as of the automation systems for the Fourier diffractometers, has been completed: HRFD (6 control channels) and FSD (12 channels) were modernized, and a new system was developed and constructed for the GRAINS spectrometer (26 channels).

In 2013, a prototype of a scintillation counter of the ASTRA detector for the FSD diffractometer was manufactured and tested at a test stand with a source. The construction of a section consisting of four scintillation counters of the detector ASTRA is in progress.

Seven sets of digital and analog MPD-32 units for data acquisition and accumulation systems for the IBR-2 spectrometers have been manufactured and adjusted. The DAQ systems assembled from these units have been put into operation on the YuMO, DN-12 spectrometers mentioned earlier, and also the systems for the FSD and HRFD diffractometers have been completed and are in the adjustment stage.

In 2013, a new universal graphical user interface (GUI) on the basis of PyQt and matplotlib (introduced on the YuMO, NERA-PR, SKAT, and REMUR spectrometers) was developed. Operation library for reflectometers (REMUR, REFLEX, and GRAINS) and programmes for visualization (SpectraViewer) and adjustment (ICE) were improved on demand of the users. Over the past year, a new significantly improved version of the system for remote monitoring of parameters and control of spectrometers (WebSonix) was prepared, which is now in trial operation on the SKAT and YuMO spectrometers.

CONFERENCES AND MEETINGS

In 2013, two scientific schools for advanced training of young scientists were organized at the Frank Laboratory of Neutron Physics: the V International Neutron School for Young Scientists and Students "Modern Neutron Diffraction Studies: Interdisciplinary Research of Nanosystems and Materials" (October 28 – November 1, Dubna) and the IV International Scientific School for Young Scientists and Students "Instruments and Methods of Experimental Nuclear Physics. Electronics and Automatics of Experimental Facilities"

(November 5–8, Dubna). These Schools were dedicated to the fundamental and applied aspects of research in the fields of neutron physics, condensed-matter physics, and materials science. These Schools were attended by students, postgraduates and young specialists from Russia and nine JINR Member States.

On May 13–17, the 3rd Research Coordinated Meeting (RCM-3) related to the IAEA coordinated research project "Development, Characterization and Testing of Materials of Relevance to Nuclear Energy Sector Using Neutron Beams" was held in Dubna.

On May 20–25, the XXI International Seminar on Interaction of Neutrons with Nuclei (ISINN-XXI) was held in Alushta. The Seminar was held under the banner of the 50th anniversary of neutron activation analysis at JINR.

On August 18–21, FLNP in collaboration with the Federal Ministry of Education and Research of Germany (BMBF) organized a meeting "Instrument Development on Long Pulse Neutron Sources". The event was aimed at discussing current trends in the development of facilities for neutron scattering on the sources operated in pulse mode.

On November 11–14, Tula (Russia) hosted the II International Conference "Multiscale Modeling of Structures, Composition of Matter, Nanostructured Materials and Nanotechnologies" dedicated to the memory of Professor A. N. Nikitin, who used to work at FLNP. The Frank Laboratory of Neutron Physics was the co-organizer of this event.

On November 25–27, the Joint JINR–Romania International School on Small-Angle Neutron Scattering and Complementary Methods of Research of "Smart" Materials was held in West University of Timisoara. The School was held in the framework of the TIM 2013 Physics Conference.

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LABORATORY OF INFORMATION TECHNOLOGIES

The investigations performed at the Laboratory of Information Technologies (LIT) during 2013 in the framework of JINR's field of research "Networks, Computing, and Computational Physics" were focused on two first-priority themes, namely, "Information, Computer and Network Support of the JINR's Activity" and "Mathematical Support of Experimental and Theoretical Studies Conducted by JINR". The cooperation with other JINR laboratories involved the participation of the LIT staff in research work within 25 themes of the JINR Topical Plan for research and international cooperation.

The JINR Central Information and Computer Complex (CICC) provides the largest share to the Russian Data Intensive Grid (RDIG) contribution to the global WLCG/EGEE/EGI grid infrastructure which provides a virtual organization support within international projects, the LHC experiments included. During 2013, the CICC ran almost 5 million tasks, the overall CPU time exceeding 130 million hours (in HEPSpec06 units). The JINR grid site is one of the most effective Tier-2 level sites in the WLCG (Worldwide LHC Computing Grid) infrastructure.

In 2013, based on the JINR CICC, a prototype of the CMS data processing centre of the Tier-1 level was created.

NETWORKING, COMPUTING, AND INFORMATION SUPPORT OF JINR ACTIVITY

During 2013, important work was carried out toward strengthening the reliable operation and achieving further development of the JINR networking and information infrastructure. The key components of this infrastructure are the telecommunication data links, the local area network, the CICC and the primary software, the grid-technology environment included, integrating the information resources of the Institute in a unified environment accessible to all users.

JINR Telecommunication Data Links. In 2013, reliable work of the high-speed computer communication channel Dubna–Moscow was secured. The connection with scientific networks and Internet used the following telecommunication links: CERN (10 Gbps), RBnet (10 Gbps), Moscow scientific networks (10 Gbps), RUNet (10 Gbps), RadioMSU (10 Gbps), and E-arena (10 Gbps). The throughput of the reserve data link was increased to 10 Gbps in 2013.

Table 1 summarizes the distribution, over the JINR subdivisions, of the incoming and outgoing traffics (if the incoming traffic exceeded 3 TB).

Table 1

Subdivision	Incoming, TB	Outgoing, TB
LIT	79.40	42.95
VBLHEP	65.93	47.59
DLNP	60.08	153.07
FLNP	34.28	88.31
Administrative Management Offices	17.07	66.57
BLTP	15.23	15.3
Remote access node	14	2.65
University "Dubna"	11.99	16.42
FLNR	11.87	2.68
JINR's Hotel & Restaurant Complex	11.57	1.54
LRB	9.56	1.69
Joint-Stock Company "Dedal"	5.99	0.583
Recreation centre "Ratmino"	3.25	1.51

Table 2

Scientific and educational networks	File exchange (p2p)	Web-resource	Social networks	Multimedia	Software	Dubna nets
91%	6.98%	1.24%	0.69%	0.06%	0.03%	0.0%

In 2013, the amount of the overall incoming JINR traffic, including the general access servers, Tier-1 and CICC, was 2656.35 TB. The weights of the various incoming traffic categories are shown in Table 2.

JINR Local Area Network (LAN). In 2013, the work was focused on the further improvement of the JINR LAN performance as well as on the provision of users with some supplementary possibilities.

The construction of the 10-Gb backbone network was completed: all the JINR laboratories and subdivisions were connected to the JINR 10-Gb optical network through switches with 10-Gb network interfaces Cisco Catalyst 3560E-12D. A virtual platform technology was grasped for network servers securing a set of standard services to the JINR network management and was implemented for SuperMicro servers and InfiniBand switches. In frames of the LAN user support, the capabilities of the mail- and proxy-services have been expanded. The authorization service of the JINR central computer complex was transferred to LDAP-registration, and decisions were analyzed concerning the authorization of other JINR services with a unified access password. VoIP-telephony with the opportunity of voice connection with JINR from any point of the world was put into operation in 2013. The JINR Content Server has been put into operation. It allows one to complete the construction of the system of videoconferencing enabling real-time record and reproduction of streaming video.

In 2013, the JINR LAN included 7368 network elements and 11593 IP addresses; 3884 users are registered within the network; there were more than 1500 users of mail.jinr.ru service as well as 1301 users of digital libraries and 864 remote VPN users.

JINR Central Information and Computing Complex. At present the CICC computing farm comprises 2560 64-bit central processors and a data storage system with a total capacity of 1800 TB. The central CICC network router is connected to the main border router of the JINR network at 10 Gb Ethernet.

A project of modernization of the systems of electric power supply and precision air-conditioning in the JINR CICC has been worked out; its realization will begin in the first quarter of 2014.

The computing facilities and storage systems are managed by a basic software (BS) that provides a way for using the CICC resources both by international projects for distributed computing (WLCG, FUSION, BIOMED, HONE, PANDA, CBM, BES, NICA/MPD, etc.) and by local JINR users.

The basic CICC operating system is OS Linux (the distribution Scientific Linux — SL6 with architecture x86_64). The CICC is supplied with a set of freely distributed compilers for various programming languages (C/C++/Fortran, etc.) which are standard compilers for the Unix-like OS. The Intel compilers are complemented with effective tools for developing multithreaded code supporting the OpenMP standard. For the development of parallel programs using the MPI (Message Passing Interface) package, MPI libraries are established for the programming languages C, C++ and Fortran.

A special batch server and work nodes provide batch processing of jobs either launched from the interactive machines by local users or received from the global WLCG environment. The storage and update of the user certificates for the protection of user resources and tasks within grid systems are secured by the service X509 PX (ProXy). This is the main method of monitoring the registered users in the WLCG project. The distributed file system CVMFS (CernVM File System) which is installed and stored on the CERN servers, is fully supported on the cluster. It provides access to the software of the collaborations ALICE, ATLAS, CMS, LHCb, and BES.

Two systems of storage and access to data dCache and XROOTD, enable the data handling both for the local JINR users and for the WLCG users and collaborations. Two implementations of the XROOTD data access system provide the necessary user interfaces to data for three international collaborations: ALICE, PANDA, and CBM. All the storage systems are implemented under the hardware data protection mechanism RAID6.

A few CICC specialized machines support the local and outer users within the international collaborations of the projects NICA/MPD and PANDA.

Table 3

Laboratory/ group	CPU time, kSi2K · h	Astronomical time, kSi2K · h	Number of jobs
MPD	1390015.86	1399986.59	64770
LRB	972527.78	96827.22	1158
BLTP	835919.13	793977.43	7190
LIT	454857.09	86331.86	1713
DLNP	363724.39	218444.15	8917
COMPASS	193236.73	195613.12	8764
VBLHEP	187185.90	196224.81	3952
BES	110510.37	116310.71	35680
FLNP	71114.43	71436.82	352
FLNR	20127.82	414.77	25
PANDA	1660.02	14308.12	94688

Table 3 provides the 2013 summary on the use of the CICC by the JINR subdivisions and user groups, except for the tasks within the grid projects.

JINR Grid Environment. In 2013, outstanding work was carried out within the global large-scale grid projects "Worldwide LHC Computing Grid" (WLCG, http://lcg.web.cern.ch/LCG/) and "European Grid Infrastructure" (EGI-InSPIRE — Integrated Sustainable Pan-European Infrastructure for Researchers in Europe, http://www.egi.eu/projects/egi-inspire/). The JINR CICC, entering the global grid infrastructure as a grid site JINR-LCG2, provides support to the computations within 8 virtual organizations (alice, atlas, biomed, cms, dteam, fusion, hone, lhcb) and offers possibilities for using grid resources for the experiments BES and PANDA.

Special mention is to be made of the JINR grid site T2_RU_JINR, which is a Tier-2-level centre within the global CMS computer infrastructure and one of the 8 grid sites of this structure within the RDMS CMS collaboration. This enables both physical data modeling and complete analysis of real physical data on the JINR CICC resources in strict compliance with the procedures defined within the global grid infrastructure of the CMS experiment [1].

The prototype of a CMS Tier-1-level centre was created at LIT based on the JINR CICC. The CMS Tier-1 centre will be part of the global system for processing experimental data and event simulation data coming from the Tier-0-level centre (CERN) as well as from Tier-1- and Tier-2-level centres of the global WLCG grid system for the CMS experiment [2]. For the time being, the Tier-1 prototype comprises 1200 64-bit processors, a 660-TB storage system and a 72-TB tape storage. In the near future the storage will be expanded up to 2000 TB.

The maintenance of the grid site at JINR is done through 22 servers under the EMI2/EMI3 system (WLCG middleware). Table 4 summarizes data on using the JINR CICC infrastructure by VO within the RDIG/WLCG/EGI.

Table 4

VO	CPU time, HEPspec06 · h	Number of jobs
atlas	46 784 736	2 727 612
cms	33 328 168	903 071
alice	24 070 600	665 274
lhcb	23 180 600	225 182
biomed	2 214 388	263 086
bes	420 768	42 727
hone	338 352	21 548
fusion	307 160	17 930
ops	1148	113 897
Total	130 645 920	4 980 327

In 2013, the modeling of the data storage and processing system for the NICA accelerator complex was actively pursued. The software package GridSim was chosen as a platform for the simulation model of the system. The created system allows one to perform various computer experiments with the objects under study without the need of their physical realization. The simulation process allows the definition of the minimally required equipment for data transfer, processing and storage to evaluate the necessary performance margins of the equipment making possible the desired future development prospects, to test the functionality of the system revealing its bottlenecks [3].

A modern approach to the creation of cloud autonomous grid infrastructures, intended for solving various problems in the field of cloud and grid technologies, was proposed and implemented [4]. Carrying out research, development, tests and training in the field of grid technologies using production grid infrastructures looks less effective from the viewpoint of the goal achievement rate and use of hardware resources than solving similar tasks on specialized complexes. On the basis of the developed approach, a specialized cloud complex in the CICC structure (comprising both software and hardware components) was created.

Information and Software Support. In 2013, work was in progress on the modernization, filling in with information and development of visualization means for representing the retrieval results in the repository of scientific publications and documents of the open access JINR Document Server (JDS) (http://jds.jinr.ru/), an electronic archive-repository developed in the framework of the international programme Open Access Initiative (OAI) on the basis of the CDS Invenio software (Fig. 1). One of the goals of creating JDS is to provide a mechanism of evaluating the efficiency of the scientific efforts of the JINR staff. To this purpose, new applications for JDS are developed using the methods of information visualization and statistical data acquisition, which allow one to extend the efficiency of using JDS and to estimate the scientific activity [5].

A pilot project was undertaken on the joint exploitation of the information systems ADB2 (JINR) and APT EVM (Earned Value Management) system (CERN) for the NICA project management by a BCWP (budgeted cost of work performed) method. Within the ADB system, a functional module has been elaborated and implemented for the control of the hierarchical structure of the work (WBS) within the NICA project, the accounting of the project expenses was implemented under observance of the approved WBS, and reports were prepared concerning the plan-fact analysis of the finance indicators of the NICA project.

During 2013, work was in progress on the actualization of the software environment, databases and contents of the LIT/JINR information sites http://lit.jinr.ru, http://www.jinr.ru, http://wwwinfo.jinr.ru as well as on the support and modernization of administrative data-

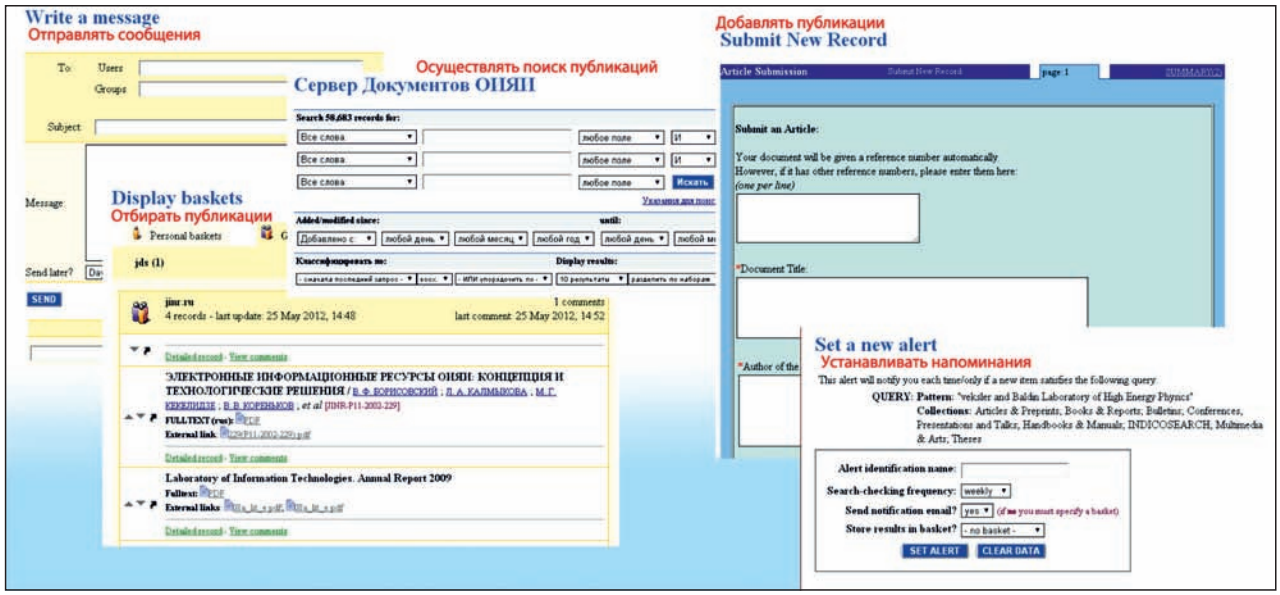

Fig. 1. User interfaces of the information services of the JDS repository of scientific publications. The interface allows users to search for publications, collect publications in "baskets", direct information to other users, to make reminding, etc.

bases (in cooperation with the JINR STD AMS). For the JINR Management, the "System of the interactive formation of the topical plan for research in scientific organizations (using the JINR as an example)" was developed and prepared for testing and launching in preproduction operation.

In 2013, active work was conducted on the creation and storage of electronic documents related to the scientific and administrative activity of the Institute and LIT, according to the conception formulated by the JINR Scientific-Organizational Department (information on the operation of the JINR basic facilities, the sessions of the JINR Scientific Council, etc.), and the provision of the Internet access to them. In continuation of the previous efforts, work was conducted on the development, creation, and support of information websites, sites of various conferences, workshops, symposia (FLNP — RCM-3, DLNP — RCRC-2014, LIT — RCDL-2014), as well as the organization of hosting websites upon the request of the organizers (the site of the JINR Publishing Department, the site of the weekly journal "Dubna", etc.) or upon the requests of the JINR Laboratories: FLNP (ISINN), FLNR (IASEN-2013), VBLHEP (on the project E&T-RAW) and others.

In view of the rapid development of the programming technologies for parallel calculations, in particular MPI, this tendency has found its reflection in the JINRLIB program library as well. The following strategy of paralleling has been formulated: the library program prepared for work in the MPI environment should function successfully at any amount of NP parallel processes involved in solving an applied task. This idea has been successfully realized at paralleling some JINRLIB programs. Besides, the Library site was reconstructed: its design was changed; a new section was added for the programs with the use of the MPI technology. In order to improve the quality of statistics of using the programs, a counter of the amount of downloads has been added to the site frequency counter.

MATHEMATICAL SUPPORT OF EXPERIMENTAL AND THEORETICAL STUDIES CONDUCTED BY JINR

One of the main objectives of this research field at LIT is to provide the mathematical, algorithmic and software support of the experimental and theoretical research underway at JINR. In 2013, the results obtained by LIT researchers were published in 2 monographs and in more than 170 papers, 72 articles being published in peer-reviewed journals. Fifty-eight reports were presented at Russian and international conferences. Below there is a brief report of some results obtained.

Within the ATLAS experiment, the service WebEmon was implemented on the base of WebIS. It is a service of Web-access to the Event Monitoring service of DAQ ATLAS which realizes the monitoring of event acquisition (raw data events). The previous version, Event Dump, could work only within the TDAQ. The WebEmon environment allows users, by utilizing HTTP inquiries, to receive separate events in XML format. To make WebEmon functional, an event converter

from a raw event format into XML was realized. The new service works in TDAQ ATLAS. As part of work on the remote monitoring in the ATLAS experiment, a new component WEBIS-EXT has been developed to provide a way of receiving information updates from the IS server ("subscribe" for information), located inside Point1, through WEB. From early July to September the component was on a test WEB server for Point1 in ATLAS. After successful testing, it has been transferred to the standard WEB server for Point1 in ATLAS.

For the CMS experiment, within the Detector Performance Group (DPG) of this experiment on cathode-strip chambers (CSC) (V. Palchik, LIT staff member, is a co-head of this group) using data of proton–proton collisions, the efficiency of the local reconstruction and spatial resolution of CSC has been estimated. A new algorithm of the track-segment reconstruction in CSC was developed. The results of this work were reported at CMS meetings and international conferences.

For the CBM experiment, a general structure of the geometrical database of the experiment has been developed. A program was implemented for converting the magnet geometry into the developed database. User Requirements Document has been designed for a component database.

The opportunity of registration of the $J/\psi \to e^+e^-$ decays generated in AuAu collisions has been investigated at a beam energy of 25 GeV/nucleon at the CBM installation (Darmstadt, Germany). To extract signal events in the conditions of a dominating background, special criteria of selection have been developed and an optimal thickness of the target has been chosen. An effective technique of determining critical borders for the specified criteria of selection has been suggested. It is shown that the used criteria allow collecting reliably and quickly a comprehensible statistics of the $J/\psi \to e^+e^-$ decays [6].

In a vicinity of effective mass for electronic (or hole) states of spheroidal quantum points in the presence of external fields, schemes of the perturbation theory have been constructed within the Kantorovich method and adiabatic method. The eigenvalues and eigenfunctions obtained in both analytical and numerical form are applied to the analysis of spectral and optical characteristics of spheroidal quantum points in a homogeneous electric field [7].

Research has been performed on the entangled spin evolution of two heavy constituents of the bound state of driving in a strong laser field in the framework of quasi-classical approximation. The motion of the bound state as a whole was analyzed in a classical way by using an exact solution to the Newton motion equations obtained beyond the framework of a standard dipole approximation with a full account of the magnetic field effects. At the same time, the evolution of the spin constituents exposed to a laser field was described in a quantum mechanical way. The spin matrix of density was defined as a solution to von Neumann equations with an effective Hamiltonian describing a spin-laser interaction along a classical trajectory of the bound state. Based on the obtained solution, the evolution of concurrence of the spins which initially were in an uncorrelated or maximally entangled Verner state was calculated [8].

The processes of scattering and decay of ^{11}Li at a proton energy of 60–80 MeV/nucleon have been investigated on the basis of a hybrid model of the microscopic optical potential. It was shown that within this approach it is possible to reproduce the experimental data on elastic scattering. The influence of spin-orbital

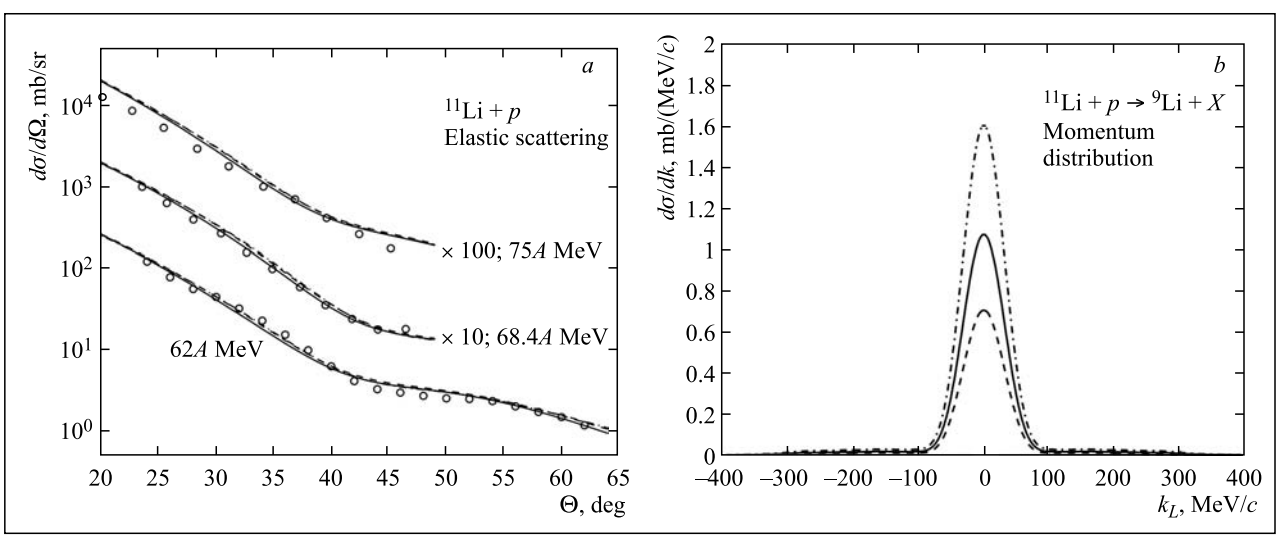

Fig. 2. *a*) Differential cross sections for ^{11}Li + p elastic scattering calculated using two forms of the ^{11}Li density, obtained within the Dynamical Cluster Model (solid line) and Large Scale Shell Model (dashed line). *b*) Predictions of the momentum distributions of ^{9}Li fragments from breakup reactions ^{11}Li + $p \to {}^{9}$Li + X within the DCM cluster model

potential on the agreement with experimental data was studied. Predictive calculations of full cross sections of the reaction and pulse distributions of the ^{11}Li decay products have been performed. On the basis of the dynamic two-cluster model of ^{11}Li, a one-particle density of this nucleus was constructed [9]. The results are presented in Fig. 2.

The MPI implementation of the method of 2D and 3D computations of the evolution of temperature fields and the dynamics of phase transitions in materials bombarded with high-energy heavy ions and pulsed ion beams has been developed. Description of the thermal physical processes was carried out in the framework of a modified thermal spike model based on a system of two coupled equations of heat conductivity describing thermal processes in electron and ion subsystems of the irradiated target, respectively. The numerical solution to these equations is performed in a cylindrical coordinate system both in an axially symmetric case (2D) and taking into account symmetry breakdown (3D). Simulation of the dynamics of phase transitions was realized in the framework of the enthalpy approach. It is shown that the results of the numerical simulations are in agreement with known experimental estimates of sizes of tracks produced in the samples irradiated with heavy ions [10].

The collisions of nanoclusters with a metallic solid surface have been simulated by the molecular dynamics method, and dependences of the penetration depth of the cluster atoms into the material upon the energy of the beam projectile particles, the size of the nanoclusters and the frequency of the pulse source of the nanoclusters have been studied. The dependence of thickness of the surface layer in terms of the new structure which is produced as a result of the irradiation of the material with nanoparticles upon the above-mentioned parameters of the beam of projectile nanoclusters has been investigated. The dependence of penetrating of the cluster atoms in the target material and the thickness of a deposited layer upon the quantity of atoms in the incoming clusters, the frequency of the pulse source in case of an irradiation with the cluster beams has been found. It is shown that there is a dependence of characteristics of various energy modes (soft landing, droplet spreading and implantation) upon the number of atoms in the incoming clusters. The investigated problems can be of interest for the production of materials of the surface layer with new physical and chemical properties, essentially distinct from those of the basic material [11].

Kinematically complete theoretical calculations and experimental data for the transfer ionization in $H^+ + He$ collisions at 630 keV/u have been reported. The experiment and theory are compared at the most detailed level of fully differential cross sections in the momentum space. This allows one to unambiguously identify contributions from the shake-off and binary encounter mechanisms of the reaction. It is shown that the simultaneous electron transfer and ionization are highly sensitive to the quality of the trial initial-state wave function of helium [12].

Differential cross sections (MDCS) have been calculated for the vertical photo-double ionization of diatomic nitrogen with coincidence detection of the ejected electrons, for fixed and random orientations of the inter-nuclear axis, using a correlated product of two two-center continuum Coulomb functions for the description of the two ejected electrons, which satisfies exact asymptotic conditions. To check the approach,

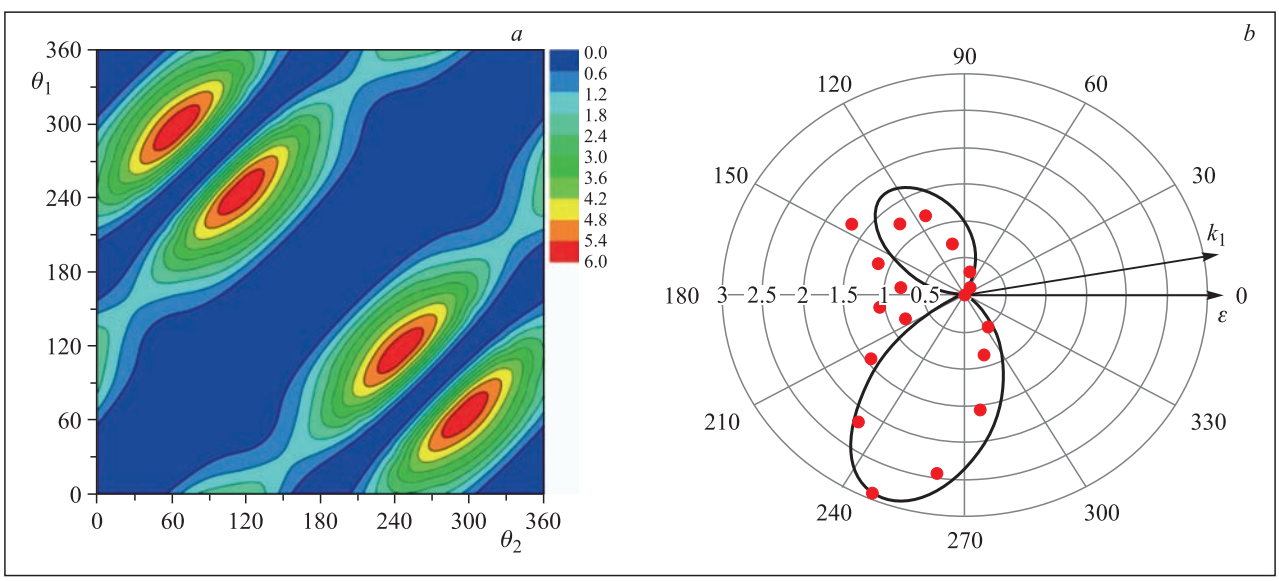

Fig. 3. The results of numerical simulations of the full differential cross section in the plane of scattering angles (*a*) and comparison of theoretical predictions with experimental data for the hydrogen molecule (*b*)

cross sections of photo-double ionization of the diatomic hydrogen were calculated for which extensive experimental and theoretical results are available. The results on diatomic hydrogen evidence the significant influence of the initial state electron correlations in the target (Fig. 3). In the case of diatomic nitrogen, the photo-double ionization of the $^3\sigma_g$ orbital resulting in $^1\sigma_g$ state of the residual N_2^{2+} ion was only considered. The obtained results are in agreement with the symmetry properties of the MDCS and give the optimal electron ejection angles. A comparison was also made with the results obtained by a Gaussian parametrization method [13].

A mathematical model of reparation of wrongly coupled DNA bases in bacterial cells *Escherichia coli* has been developed. The key ways of implementation of this mechanism are quantitatively described on the basis of present-day experimental data. Five basic ways of removing mistakes with participation of different DNA exonucleases are tracked in detail. The developed model will find wide application to the problem of studying the radiation-induced mutagenesis [14].

A continuous analogy of the Newton method with inner iteration has been proposed for solving a system of linear algebraic equations. The implementation of the inner iterations is carried out in two ways. The first fixes the number of inner iterations in advance, while the second one uses an inexact Newton method for solving a linear system of equations that arises at each stage of outer iterations. Some new choices of the iteration parameter and of the forcing term which ensure the convergence of the iterations have been proposed. The method with inner iteration is quadratically convergent, and therefore it can compete with other iterations such as successive over relaxation with an optimal relaxation parameter for a strictly diagonally dominant system. Moreover, the proposed method is applicable not only for the system with a strictly diagonal dominant matrix, but also for a system the matrix of which is not Hermitian and non-positive definite [15].

Two new high-accuracy finite-difference schemes have been developed for the numerical solution of the initial boundary-value problem of Burgers equation. The Burgers equation is a one-dimensional analogue of the Navier–Stokes equation describing the liquid dynamics and it possesses all its mathematical properties. Besides, the Burgers equation belongs to the class of a few partial derivative nonlinear equations the analytical solution of which are known, a property which allows using it as a test model for the comparison of the features of various numerical methods. The first scheme, intended for a numerical solution of the equation of heat conductivity, has the sixth order of approximation in the spatial variable and the third order in the time variable. The second scheme is used for finding a numerical solution to the Burgers equation on the basis of the connection between the equation of heat conductivity and the Burgers equation. The scheme also has a sixth order of approximation on the spatial variable. The numerical results obtained using test examples are in good agreement with the analytical solutions of the Burgers equation and reproduce the expected order of approximation of the suggested schemes [16].

A boundary method of weighed residuals with discontinuous basis functions has been developed for solving, with high accuracy, linear elliptic boundary-value problems with respect to scalar or vector functions. The method is a generalization of the least squares method with t-elements. The obtained projective-mesh schemes show the 7th degree of accuracy in the scalar case for two- and three-dimensional polynomials, while in the vector case the 6th degree of accuracy is reached. A high rate of the hp-convergence of the approximated solutions is demonstrated using examples of some model two- and three-dimensional linear problems of magnetostatics [17].

INTERNATIONAL COOPERATION

The research work at the Laboratory is carried out in close cooperation with scientists and specialists of the JINR Member States as well as of many research centres of other countries. Some examples of such cooperation should be particularly stressed.

In cooperation with German researchers, a two-dimensional numerical model has been developed in view of nonlinear properties of materials for research on the distributions of current and magnetic field as well as for calculation of losses in superconductors on the basis of the finite element method and software package Comsol Multiphysics. The developed model has been successfully applied to designing and assembling superconducting cables of complex configuration [18].

In cooperation with Bulgarian scientists, a numerical research has been performed on the complexes of localized structures in two dynamic systems described by the damped-driven nonlinear Schrödinger (NLS) equation and the double sine-Gordon equation (2SG). The numerical analysis is based on continuation of corresponding stationary solutions on parameters and a numerical solution linearized eigenvalue problem for the

analysis of stability and bifurcations. Multisoliton complexes of NLS were investigated for a case of weak and zero dissipation. The properties of multifluxon solutions of 2SG were analyzed depending on the second harmonic parameter [19].

In cooperation with Romanian researchers, within the anisotropic non-diagonal Bianchi type-II, VIII and IX space-time models, it has been shown that the off-diagonal components of the corresponding metric impose severe restrictions on the components of the energy momentum tensor. The loop quantum cosmology of the Bianchi type-II string cosmological model in the presence of a homogeneous magnetic field has been studied in [20].

In cooperation with French scientists, the coupled dynamics of low-lying modes and various giant resonances were studied with the help of the Wigner function moments method on the basis of time-dependent Hartree–Fock equations in the harmonic oscillator model including spin-orbit potential plus quadrupole–quadrupole and spin–spin residual interactions. New low-lying spin-dependent modes were analyzed. Special attention was paid to the spin scissors mode [21].

CONFERENCES AND MEETINGS

The 4th School on Information Technologies "Grid and Advanced Information Systems" was held at JINR on April 22–26 under the auspices of the Joint Institute for Nuclear Research and the European Organization for Nuclear Research. The organizers were the JINR Laboratory of Information Technologies and the Advanced Information Systems Group at CERN General Infrastructure Services Department. The goal of the School is to share the knowledge gained and expanded at JINR and at CERN in the field of modern information technologies, thus attracting and preparing students to work in this field. More than 50 students from the leading universities of Moscow and Moscow Region attended the event: MEPI, MIPT, MPEI, the Baumann State Technical University, Dubna University, as well as students from the University of Science and Technology in Krakow, Poland.

The traditional two-day Workshop on Computer Algebra was held at the Laboratory of Information Technologies on May 21–22. More than 30 scientists from universities and scientific institutes of Bucharest, Moscow, St. Petersburg, Ivanovo, and Dubna took part in this Workshop. Twenty-eight reports were presented.

The 7th International Conference "Mathematical Modeling and Computational Physics" (MMCP 2013) was held on July 8–12 at the Laboratory on Information Technologies. The Conference was organized by LIT, the Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences (Moscow), the Institute of Experimental Physics of the Slovak Academy of Sciences, the Technical University, and the Pavol Jozef Safarik University (Kosice, Slovakia). The scientific programme of the Conference was devoted to the use of distributed and parallel computing in science and technology; mathematical methods and tools of modeling complex systems; computational biophysics, chemistry and bioinformatics; mathematical methods and software for experimental data processing; methods and programs of computer algebra, quantum computing and applications. The Conference was attended by more than 200 scientists and specialists from 13 countries and from numerous Russian scientific centres and universities. A total of 34 plenary, more than 120 section and 25 poster reports were made. It should be emphasized that an important fraction of the reports presented at the Conference were made by LIT specialists in collaboration with scientists from different JINR Member-State institutes. This demonstrates the significance of ongoing investigations at LIT and the interest in them shown by the researchers from those countries.

The 24th International Symposium on Nuclear Electronics & Computing (NEC'13) was held on September 9–16 in Varna, Bulgaria. The Symposium was organized by the Joint Institute for Nuclear Research, the European Organization for Nuclear Research (CERN) and the Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences (Sofia). 2013 is the jubilee year of NEC: fifty years since the first conference, held in Budapest in 1963. The Symposium was attended by 100 scientists from 13 countries, with 25 participants being under 35. Participation of young scientists was supported by special grants afforded by JINR and CERN. The companies IBM and Quantum also provided their sponsorships. A separate section on the opening day of the Conference was devoted to the new experimental complexes ELI-NP, NICA and DRIBs-III. The Symposium attendees heard 54 lectures and 33 posters; 19 lectures and 17 posters were presented by JINR employees. Thirteen lectures and 11 posters were made by young scientists.

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LABORATORY OF RADIATION BIOLOGY

In 2013, the Laboratory of Radiation Biology (LRB) continued activities within the framework of Theme 04-9-1077-2009/2014 "Research on the Biological Effect of Heavy Charged Particles with Different Energies" in the following fields: fundamental radiobiological and radiation genetics research with heavy charged particles; research on the effect of accelerated heavy particles on the nervous system and eye structures; molecular dynamics research; mathematical modeling of radiation-induced effects; and radiation research and radiation protection of JINR's basic facilities and the environment. Work was started on Theme 04-9-1112-2013/2015 "Research on Cosmic Matter on the Earth and in Nearby Space; Research on the Biological and Geochemical Specifics of the Early Earth".

RADIATION GENETICS AND RADIOBIOLOGY

Research was continued on the regularities and mechanisms of the induction and repair of DNA double-strand breaks (DSBs) in human cells under exposure to ionizing radiations of different quality. With the use of the fluorescent microscopy method involving immunocytochemical staining of γ-H2AX and 53BP1 proteins in human fibroblast nuclei, a comparative analysis of the specifics of DNA DSB formation was performed

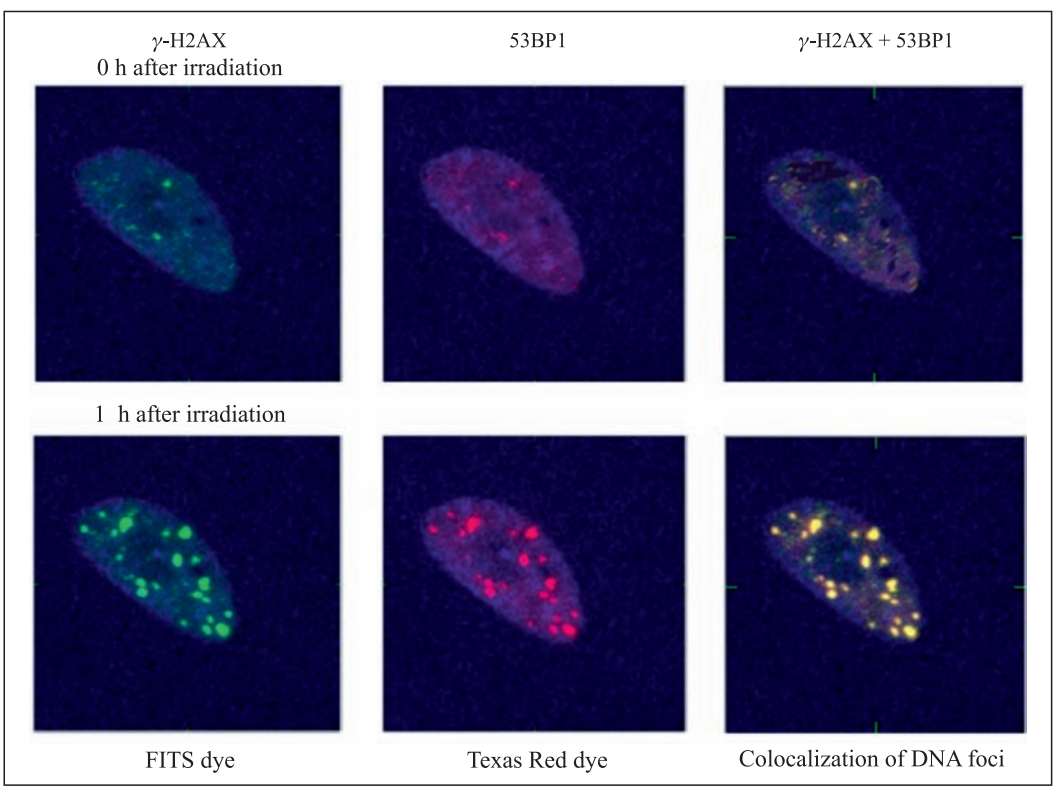

Fig. 1. Colocalization of γ-H2AX and 53BP1 DNA foci in human skin fibroblast nuclei 1 h after irradiation with ^{60}Co γ rays at 1 Gy

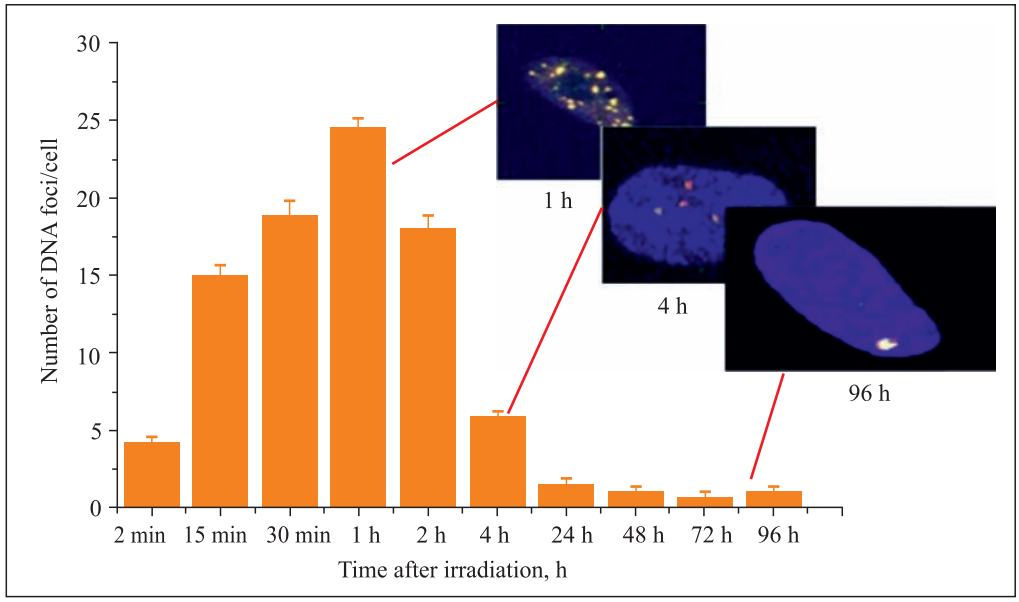

Fig. 2. DNA DSB repair kinetics in human fibroblasts after irradiation with ^{60}Co γ rays at 1 Gy

and the kinetics was studied of the repair of this type of damage induced by ^{60}Co γ rays and accelerated ^{20}Ne ions (50 MeV/nucleon energy and linear energy transfer (LET) of 130 keV/μm) [1–4]. The kinetics of the formation of radiation-induced DNA foci was studied for γ irradiation at 1 Gy. It was shown that the formation of radiation-induced DNA foci begins in the first minutes and peaks one hour after exposure (Fig. 1). Four hours after exposure, the number of DNA foci sharply drops, which points to the efficient DNA DSB repair. Some of the DNA foci, though, remain in cells for up to 96 h of post-irradiation incubation (Fig. 2). Most likely, those are the most severe DNA lesions that are part of DNA focus clusters.

The use of different repair inhibitors (wortmannin, benzamide, and NU 7026) allowed evaluating the contribution of non-homologous end joining to the total repair of DNA DSBs in human lymphocytes induced by ^{60}Co γ rays. It was established that for γ irradiation, DNA DSB yield in control and in the presence of the repair inhibitor wortmannin is practically the same (Fig. 3, *a*). In the presence of wortmannin, as opposed to control, DNA DSB yield increases for up to 6 h of post-irradiation cell incubation, which indicates that non-homologous repair makes the main contribution to the overall DNA repair process in human lymphocytes (Fig. 3, *b*).

Research on the regularities and mechanisms of radiation-induced apoptosis in human lymphocytes was continued. Different apoptosis pathways (receptor-mediated, mitochondrial, caspase-independent, etc.) are initiated by a number of factors. In particular, radiation-

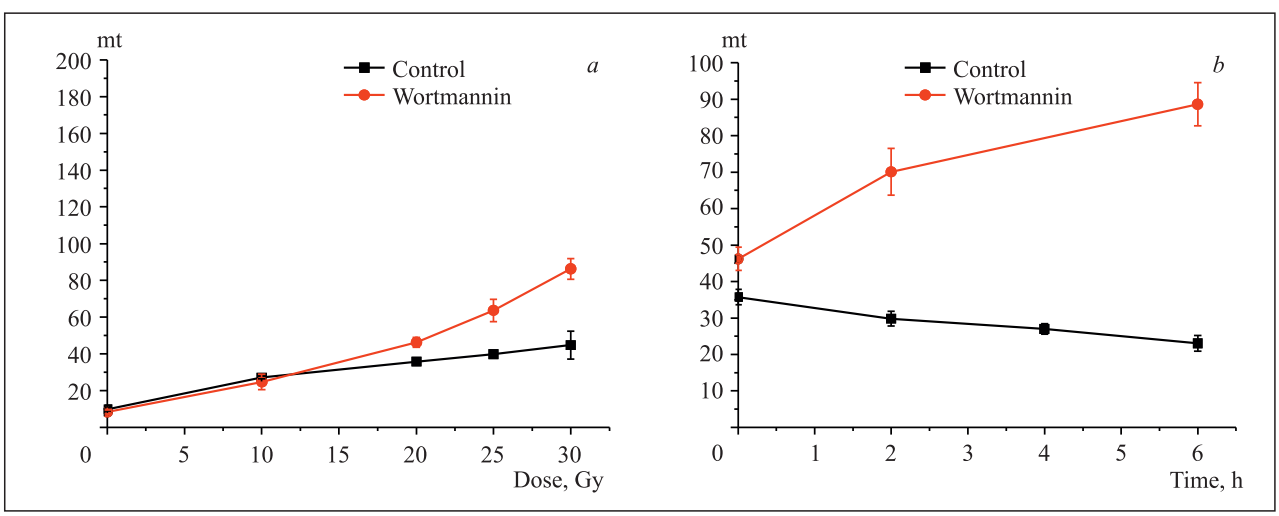

Fig. 3. A dose dependence of DNA DSB formation (*a*) and repair kinetics (*b*) in human lymphocytes in the presence of the non-homologous end joining inhibitor wortmannin (10 μM) after exposure to ^{60}Co γ rays at 20 Gy

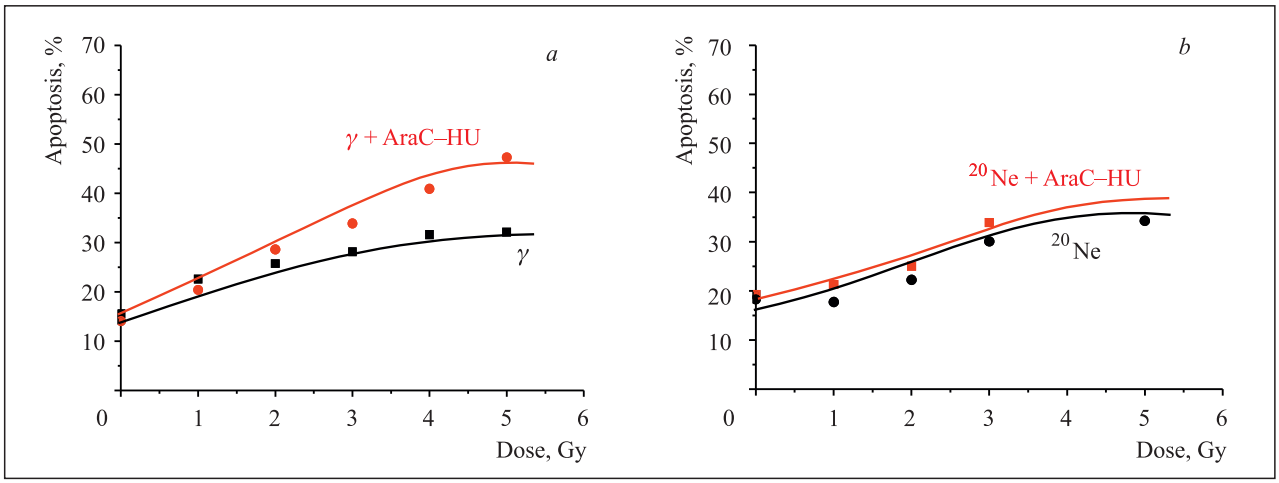

Fig. 4. A dose dependence of apoptosis induction in human lymphocytes 24 h after exposure to ^{60}Co γ rays and accelerated ^{20}Ne ions

induced apoptosis is initiated by DNA DSBs. There is no detailed knowledge of the relations between the different stages of programmed cell death that are its main independent stages: initiation, the effector phase, and degradation. Also, data on the influence of densely ionizing radiations on apoptotic death induction are practically absent. Of great interest is thus studying apoptosis induced by radiations with different LET in the presence of different repair and apoptosis protein inhibitors. With increasing LET, a significant attenuation of the radiosensitizing effect of the used inhibitors is observed, which seems to be connected with a change in the spectrum of the DNA lesions forming with increasing LET and a decrease in the yield of lesions from which, in the presence of inhibitors, enzymatic DNA DSBs can emerge that initiate radiation-induced apoptosis (Fig. 4).

To clear up the P53 protein role in the process of the apoptotic death of human lymphocytes, the PFT-α inhibitor was used. Dose dependences of apoptotic cell induction were studied for ^{60}Co γ rays and accelerated ^{20}Ne ions (Fig. 5). In the presence of the PFT-α inhibitor, an effective decrease in apoptotic cell induction is observed compared with control for both γ rays and accelerated heavy ions [5].

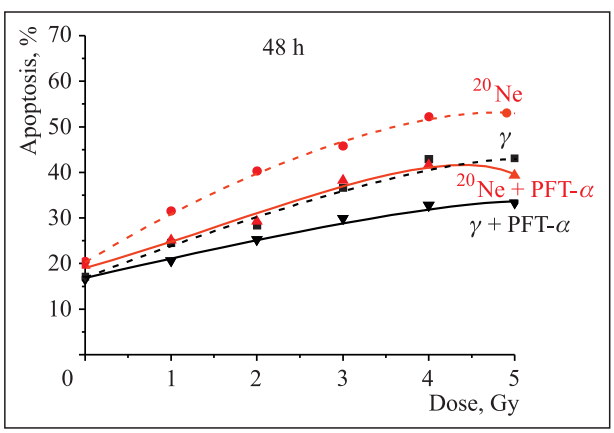

Fig. 5. Apoptosis induction in human lymphocytes 48 h after irradiation with ^{60}Co γ rays and accelerated ^{20}Ne ions in the presence of the PFT-α inhibitor of the P53 protein

To evaluate the effect of the inhibitors cytosine arabinoside (AraC) and hydroxyurea (HU) on apoptosis induction in human lymphocytes, a dependence of the dose change factor (DCF) on LET was plotted for the radiations used in the study (Fig. 6).

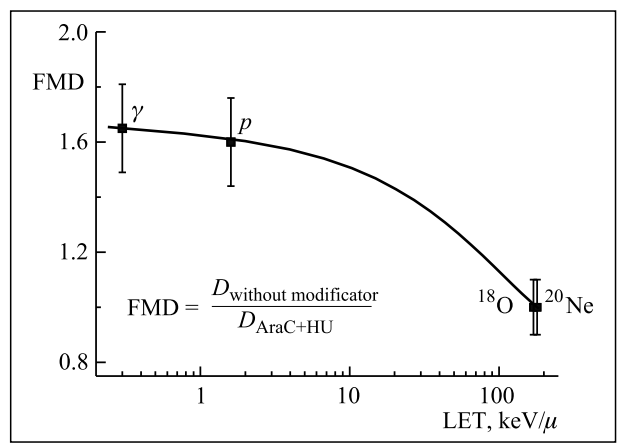

Fig. 6. The AraC and HU modifying effect on apoptosis induction in human lymphocytes under exposure to radiations with different LET

The yield of reactive oxygen species (ROS) was estimated in Cal 51 cells of human breast carcinoma after exposure to ^{60}Co γ rays at 0.5, 1, and 3 Gy. As a ROS indicator, the fluorescent dye CM-H_2DCFDA was used. The survival rate S was determined as the ratio of the dye fluorescence intensity (in relative fluorescence units, RFU) in the irradiated samples to that in the non-irradiated samples. Fluorescence intensity was measured with a Synergy H1m microplate reader during 24 h after irradiation. It was found that irradiation

induces long-lived ROS, the yield of which increases with the dose (Fig. 7). The highest ROS level was observed after 15–24 h incubation. These data indicate that low doses can cause oxidative stress in the cell, which is considered to be the main factor responsible for the delayed consequences of irradiation.

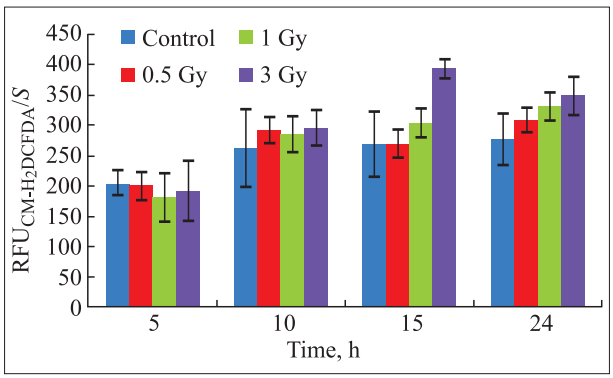

Fig. 7. Radiation-induced ROS yield in Cal 51 cells after exposure to ^{60}Co γ rays. The abscissa axis shows post-irradiation cultivation time; the ordinate axis shows CM-H_2DCFDA fluorescence intensity for wavelengths of 485 nm (ex) and 528 nm (em) normalized to the survival rate S

In experiments on mammalian cells, research was continued on radiation-induced mutagenesis under densely ionizing radiations. For accelerated ^{20}Ne ion exposure at 0.5, 1, and 2 Gy, it was established that its manifestations depended on the time of irradiated cell seeding (mutation expression time) in a selective nutrient medium with 6-thioguanine. Figure 8 shows the frequency of radiation-induced mutants for different seeding times and the frequency of similarly grown spontaneous mutants. After 4-day expression, the spontaneous and radiation-induced mutagenesis frequency was $1.2 \cdot 10^{-5}$. When the expression time was increased to 10–12 d, a decrease in the mutagenesis level was observed. At longer times, an increase was observed in the frequency of mutant colonies of cells irradiated in the studied dose range. The maximal mutagenesis level of $3.2-3.6 \cdot 10^{-5}$ was observed for the expression time of 20–26 d, which corresponds to approximately 40–50 cell generations (the Chinese hamster cell division cycle lasts 10–12 h). Further, the radiation-induced mutant frequency decreased. When seeding was done 30–45 d after, it was on the level of spontaneous mutagenesis. Earlier research allows suggesting that the increased level of radiation-induced mutagenesis is determined by increased chromosome and genome instability of the irradiated cell population.

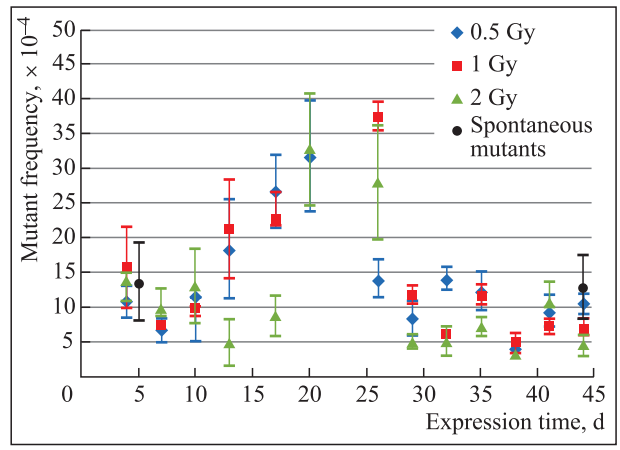

Fig. 8. Spontaneous and radiation-induced mutagenesis levels after accelerated ^{20}Ne ion exposure at 0.5, 1, and 2 Gy versus mutant expression time

In cooperation with the National Institute of Cancer in Naples and University of Udine, Italy, research was started on the radioprotective properties of the recombinant form of manganese-containing superoxide dismutase (rMnSOD). Preliminary results, which were obtained for 170 MeV proton irradiation of mice at 4 Gy, indicate that rMnSOD has a certain therapeutic effect. The effect was evaluated by bone marrow cellularity

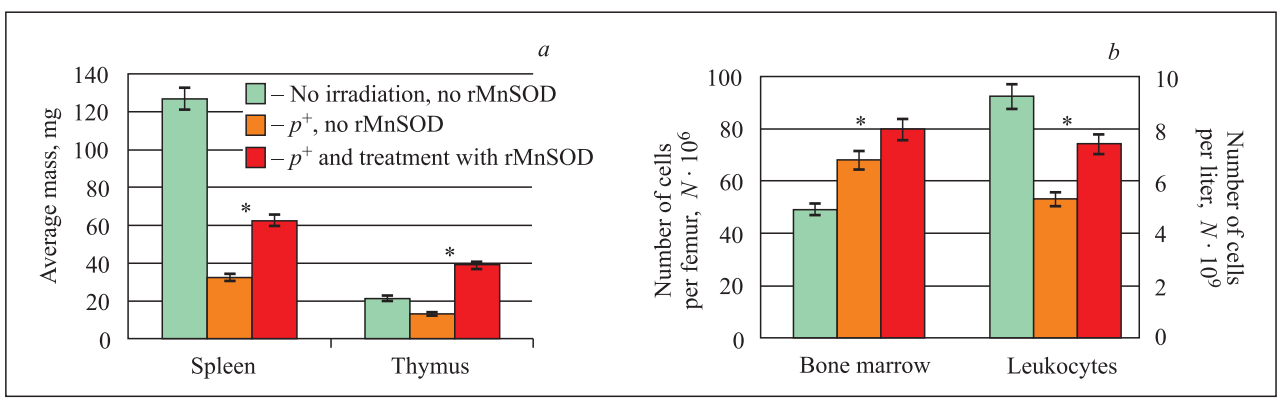

Fig. 9. The influence of rMnSOD on spleen and thymus mass (*a*) and bone marrow cellularity and the leukocyte level (*b*) in mice 7 d after 170 MeV proton irradiation at 4 Gy ($p \leqslant 0.01$)

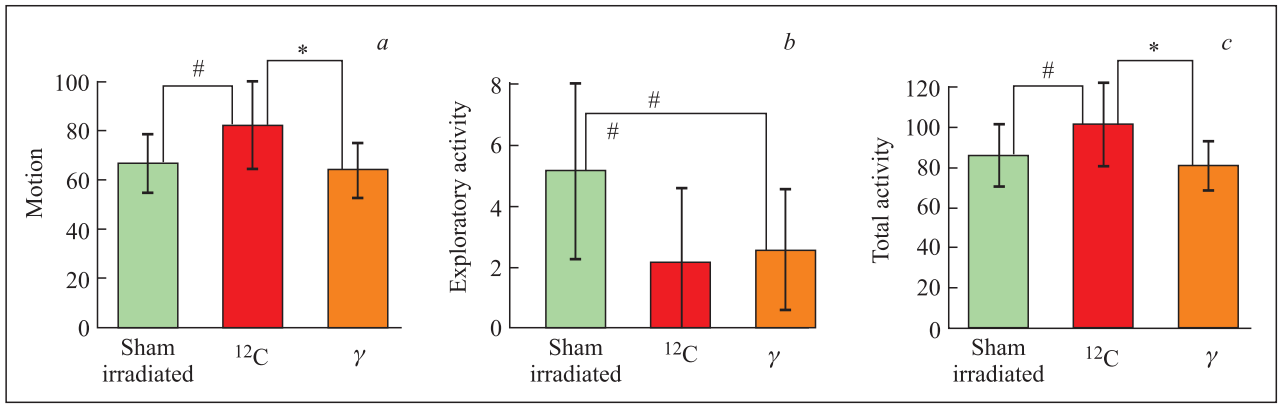

Fig. 10. Open field test indicators 30 d after animal irradiation with 500 MeV/nucleon ^{12}C ions and γ rays at 1 Gy ($\pm$SD; #$p \leqslant 0.05$; $^{*}p \leqslant 0.01$ against the Mann–Whitney U-criterion): *a*) motion activity measured by the number of sector border crossings; *b*) cognitive activity evaluated by the number burrow reflex manifestations; *c*) total animals' activity indicator

indicators, the leukocyte level in peripheral blood, and spleen and thymus mass, which were measured in parallel with regular introduction of the preparation during 7 d after irradiation (Fig. 9).

In cooperation with specialists of the Institute of Higher Nervous Activity and Neurophysiology of the Russian Academy of Sciences (RAS) and the RAS Institute of Biomedical Problems, an experiment was performed to evaluate the behavioral reactions of rats long after irradiation with ^{12}C ions (500 MeV/nucleon $\sim$ 10 keV/μm) at 1 Gy. The results of the open field test measurements are comparable with the γ-irradiation data. The measurements indicate that there are differences between the effects observed 30 d after irradiation with heavy nuclei and γ rays at the same dose. The effect of accelerated carbon ions consisted in increasing motion activity and inhibiting cognitive activity of the animals, while γ irradiation had a significant effect concerning only the latter indicator (Fig. 10, *a, b*). The rats' total activity increased by 18% after irradiation with ^{12}C ions, but γ irradiation caused no significant differences from the control values. Considerable differences were observed between the results obtained with sparsely and densely ionizing radiations (Fig. 10, *b, c*).

PHOTORADIOBIOLOGICAL RESEARCH

The effect of genotoxic factors (methylnitrosourea (MNU) and ionizing radiation) on the mouse retina was studied. It was found that the retina is able to recover spontaneously its functional activity and provide the adaptive response of its photoreceptors *in vivo* after genotoxic exposures. A preliminary retina exposure to a non-toxic MNU dose makes it more resistant to a further cytotoxic dose of the agent. It was shown that the retina's adaptive response to MNU is associated with the suppression of effector apoptotic caspase-3 and a decrease in the photoreceptor death level in the retina. Proton irradiation of the mature retina at 1 Gy also leads to an adapting effect: the retina becomes resistant to a further cytotoxic exposure to MNU. The effect of the retina's radiation hormesis shows up as a decrease in the apoptosis frequency in the nuclear layer of photoreceptors and goes along with an increase in DNA DSB repair efficiency in retinal cells [6, 7].

MATHEMATICAL MODELING OF RADIATION-INDUCED EFFECTS

Mathematical modeling of DNA DSB repair in mammalian and human cells was continued. Models were developed of the three main damage repair mechanisms: non-homologous end joining (NHEJ), homologous recombination (HR), and single-strand anneal (SSA) through direct repeats. The proposed model approach was applied to the description of the kinetics of the repair of DNA DSBs induced by X rays, γ rays, and accelerated oxygen, silicon, and iron ions in a wide LET range of 0.2–440 keV/μm. The models allowed generalization of a large amount of experimental data on the time characteristics of specific stages of NHEJ, HR, and SSA. In particular, quantitatively described were the kinetics of the Ku70/80 complex binding with

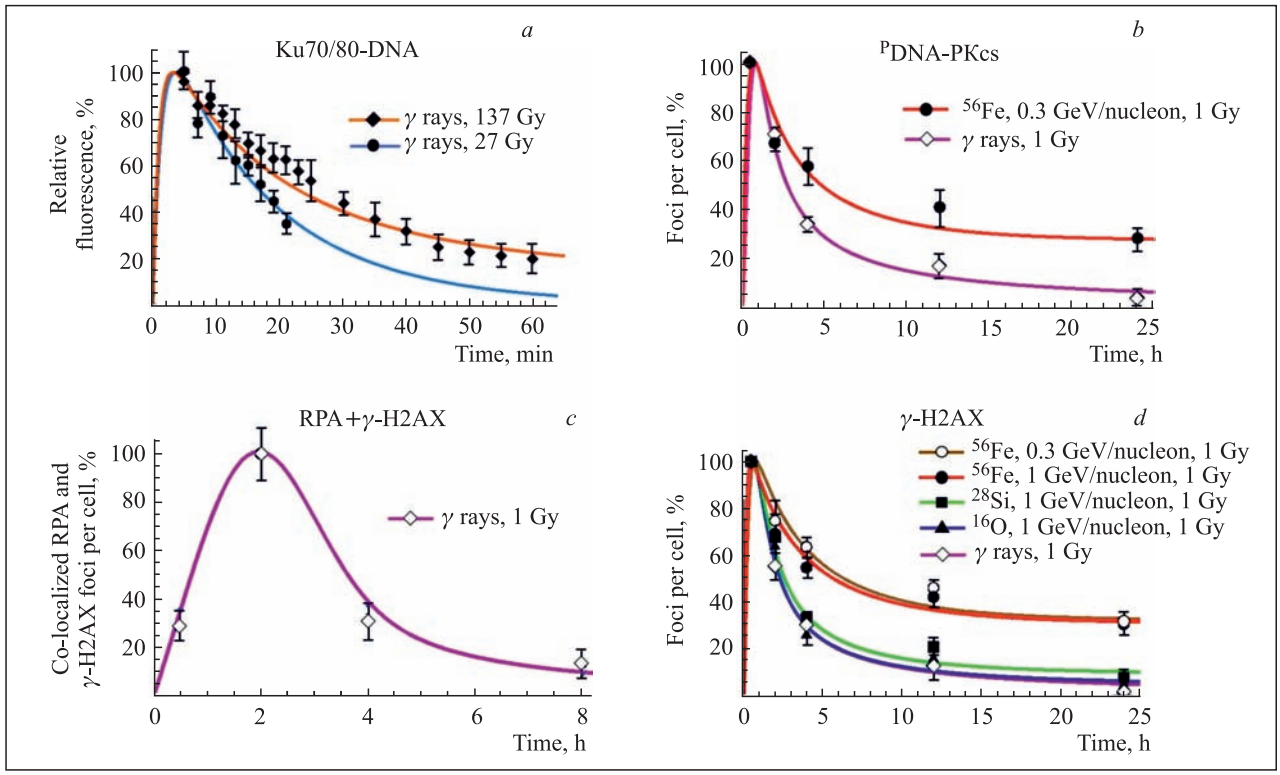

Fig. 11. Estimation of the kinetics of specific stages of the repair of DNA DSBs induced by ionizing radiations with different physical characteristics: *a*) the kinetics of the Ku70/80 complex binding with DNA DSBs in an XR-V15B Chinese hamster fibroblast culture (the dots are experimental data (Reynolds et al., 2012)); *b*) DNA-PKcs level change in a HSF42 human skin fibroblast culture (the dots are experimental data (Asaithamby et al., 2008)); *c*) RPA and γ-H2AX focus colocalization in a GM637H culture of embryonic lung fibroblasts (the dots are experimental data (Balajee and Geard, 2004)); *d*) γ-H2AX focus level change in a HSF42 human skin fibroblast culture (the dots are experimental data (Asaithamby et al., 2008))

DNA DSBs and the change of the level of phosphorylated DNA-dependent protein kinase (DNA-PKcs) and the RPA, Rad51, and γ-H2AX foci in cells of different organisms (Fig. 11). With the use of the proposed approach, it seems to be possible to predict the efficiency of DNA DSB repair for ionizing radiations with different physical characteristics.

Results were published of research carried out in collaboration between specialists of Cairo University (Egypt) and JINR's Laboratory of Radiation Biology and Laboratory of Information Technologies. The work was concerned with the mathematical modeling of mismatched DNA base repair (MMR) and evaluation of its role in the induced mutation process in bacterial cells [8, 9]. The mathematical model proposed in this research allowed establishing interrelation between the molecular mechanisms responsible for the removal of the nucleotides that were wrongly inserted by DNA polymerase V during SOS response and determining the MMR position in the hierarchy of the repair systems connected with the induced mutation process.

With the use of the cluster analysis algorithms proposed before, energy deposition in separate brain neurons of rats irradiated with accelerated ^{12}C ions at 1 Gy was calculated. The energy and dose distribution was evaluated for solid models of pyramid neurons of the CA1 region of the hippocampus (Fig. 12). For microdosimetric calculations, solid models of neurons of different types were developed based on experimental data on brain cell morphology [10–12].

Results were obtained on the mathematical modeling of electrophysiological characteristics of brain neurons for varying different parameters of synaptic transmission. With the use of a post-tetanic efficiency model of the dendritic spine of neurons in the CA3 region of the hippocampus (Murzina G. B., Silkis I. G., 1997), the synaptic potential of the membrane was evaluated for different values of the Ca^{2+} ion gradient, which can change under exposure to different chemical and physical agents, including, presumably, ionizing radiations (Fig. 13).

Changes in the conductivity of ion channels were calculated depending on the Ca^{2+} membrane potential. The modeling results are expressed as the values of the gate variables m, n, and h of the Hodgkin–Huxley equation (Fig. 14).

Along with the NMDA receptor expression model that was proposed earlier, these results can be used for clearing up the molecular mechanisms responsible for

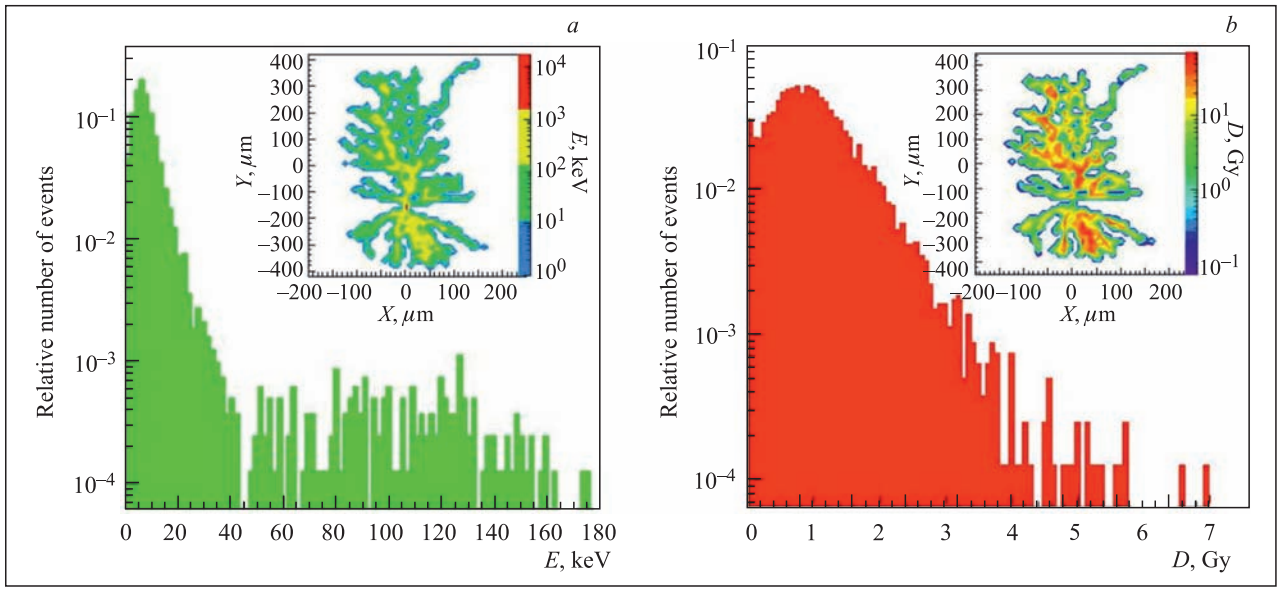

Fig. 12. Calculated distributions of energy E (*a*) and dose D (*b*) in the solid model of a pyramid neuron in the CA1 region of the rat hippocampus for irradiation with 500 MeV/nucleon ^{12}C ions. The insertions show energy and dose distributions in the neuron body in the XY plane. The projectile particle direction is the Z axis

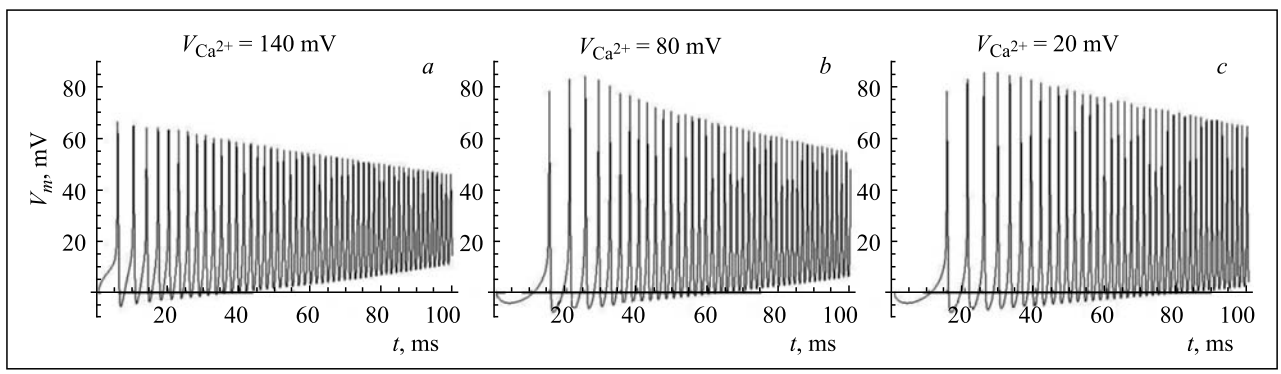

Fig. 13. Membrane potential change on the membrane of the dendritic spine of a pyramid neuron of the CA3 region of the hippocampus for different calcium ion gradient V_{Ca}^{2+} values

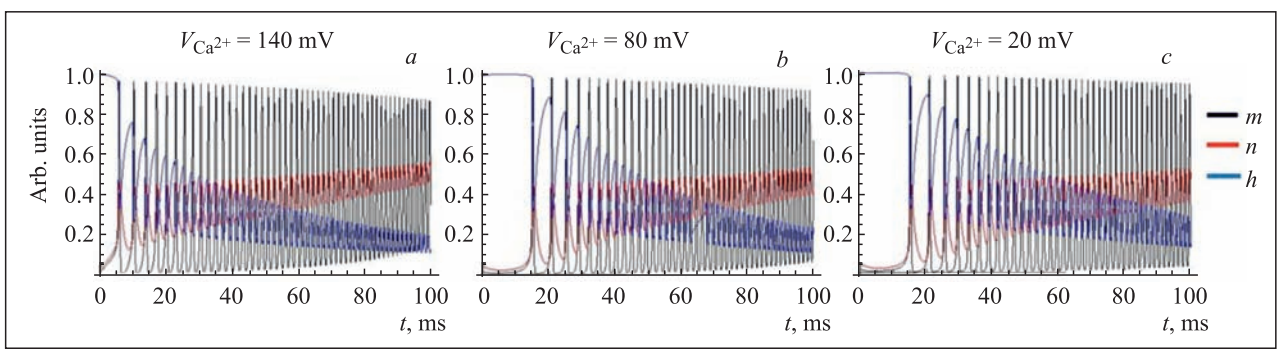

Fig. 14. Estimation of changes in the gate variables $m, n,$ and h of the Hodgkin–Huxley equation for different calcium ion gradient V_{Ca}^{2+} values

disorders in the functional activity of neurons after exposure to heavy charged particles.

The influence was studied of radiation or chemical exposure-caused heterogeneities in synaptic bonds on pulse propagation. An interaction between a pulse and an heterogeneity can result in pulse delay, reflection, compression and decomposition down to its decay [13].

In the course of nonlinear DNA model research, soliton conformational excitation types were identified

that had not been known before: localized sections with an increased spiral twist. It is suggested that such solitons can participate in the regulation of DNA unwinding by topoisomerases [14].

A nonlinear dynamics model of cell cytoskeleton microtubules was proposed. A mathematical apparatus was developed for studying such systems. Both analytically and numerically, the main solution types were obtained that describe nonlinear localized oscillations and the propagation of structure transitions in a microtubule ensemble. The found solution types allow clearing up the picture of the mechanisms of the transfer of energy and transport proteins along microtubules during intracellular processes [15].

COMPUTER MOLECULAR MODELING OF BIOPHYSICAL SYSTEMS

With the use of molecular dynamics (MD) methods, the structural and functional properties of the DNA photolyase enzyme were studied [16]. DNA photolyase is a light-activated enzyme that repairs a UV-induced cyclobutane–pyrimidone dimer in damaged DNA. A series of MD calculations was performed in which 3D protein models of DNA photolyase in a water solution were built, and the topology of the intermolecular potential field of cofactors (the FAD and MHF chromophores) was preliminarily reconstructed (Fig. 15). The modeling results point to the high mobility of the FAD molecule in comparison

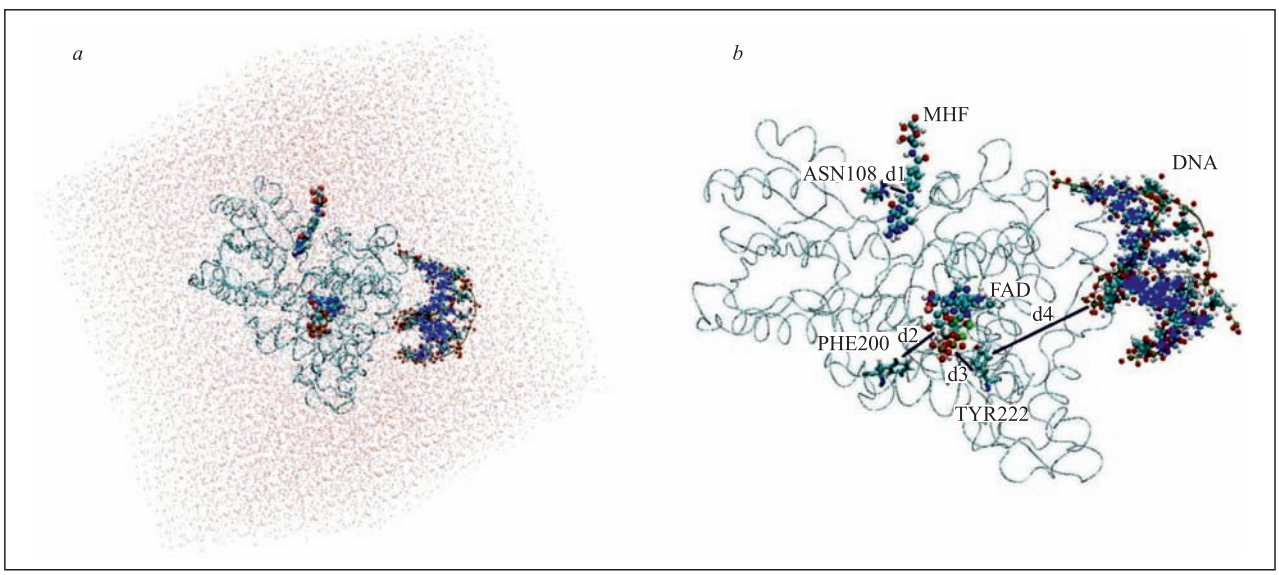

Fig. 15. *a*) A molecular dynamics model of the DNA photolyase enzyme with two chromophore cofactors. The enzyme is solvated in a periodic cubic cell. *b*) The d1–d4 distances show the locations of different parts of the system during their molecular dynamics changes and interactions

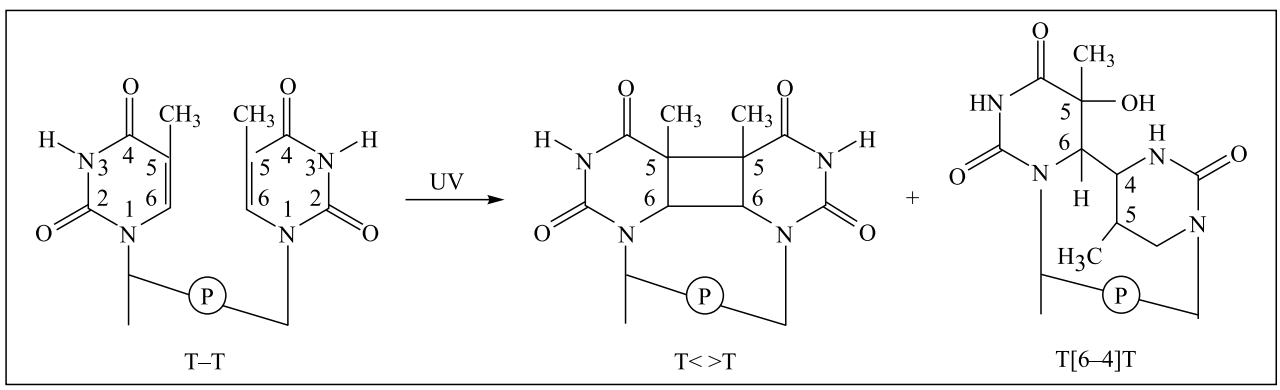

Fig. 16. Two main DNA lesions as a result of UV irradiation: (1) T<>T merging of two neighboring nucleotides — thymines — in the DNA structure, i.e., cyclobutane–pyrimidone dimer formation; (2) T[6–4]T pyrimidine–pyrimidone photoproduct

with other fragments of the protein complex of DNA photolyase.

The reconstruction of the relaxed structure of the FAD molecule points to a transition of its conformational state from the U-closed to the I-open shape. Such behavior of the FAD molecule inside the enzyme's chromophore centre can be one of the key factors in the process of damaged DNA structure repair, which is followed by the formation of a "wrong" cyclobutane: the pyrimidone dimer (Fig. 16). The high mobility of the FAD chromophore and the role of enzyme binding in the region of the interaction of the FAD molecule with the damaged DNA section (T<>T cyclobutane–pyrimidone dimer) can determine the process of DNA repair by the DNA photolyase enzyme. The obtained results are conductive to the solution of the problem of identifying the mechanisms of DNA repair by this enzyme.

Research was continued on the photochemical and photophysical properties of the G-proteins, in particular, the visual pigment rhodopsin [17–19].

PROTECTION PHYSICS AND RADIATION RESEARCH

Two radiobiological sessions were conducted at the 52 MeV/nucleon ^{20}Ne ion beam of the MC-400M cyclotron of the Flerov Laboratory of Nuclear Reactions. For automated irradiation of a large number of thin biological samples, the ACCULINNA separator-based Genome-M facility was used. During these sessions, the facility was calibrated and methods of ion beam quality control were worked out. The irradiated samples included human peripheral blood lymphocytes, mammalian and human cell cultures, and yeast cells. The interest in ^{20}Ne ions is determined by high values of their linear energy transfer (120–150 keV/μm), inducing severe clustered damage in biological structures.

A radiobiological session was held at the 500 MeV/nucleon ^{12}C ion beam of the Nuclotron, the Veksler and Baldin Laboratory of High Energy Physics. A large experimental programme was fulfilled, which included, in particular, irradiation of laboratory rats and primates for studying the effect of heavy ion exposure on animals' cognitive functions. The urgency of this research is determined by the prospects of long-term manned flights beyond the Earth's magnetosphere.

Work was continued on the prediction of the radiation conditions at the planned booster synchrotron of the NICA complex using the Monte Carlo based MCNPX code for calculating radiation transport in matter. The spatial distributions of skyshine neutrons and γ rays around the Nuclotron were measured (Fig. 17). Neutron spectra were measured beyond the shielding of the MC-400M cyclotron experimental hall for acceleration of ^{20}Ne ions up to 52 MeV/nucleon.

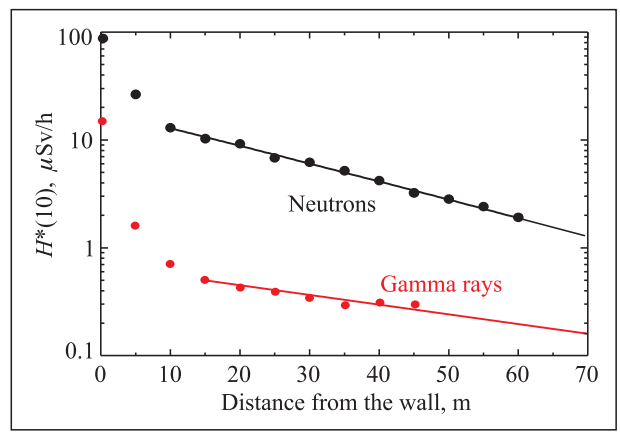

Fig. 17. Radial distributions of the ambient equivalent dose rate of skyshine neutrons and γ rays from the Nuclotron for deuteron acceleration up to 4.1 GeV/nucleon

RESEARCH ON COSMIC MATTER ON THE EARTH AND IN NEARBY SPACE

Reactions were analyzed of chemical compound synthesis from formamide NH_2COH (an HCN hydrolysis product) under ionizing radiation. The reactions were realized under 165 MeV proton irradiation at the Phasotron (the Dzhelepov Laboratory of Nuclear Problems, JINR) in the presence of different catalysts isolated from meteorites of different classes. Based on these experiments, an important conclusion was made that in the system "formamide – meteorite matter + ionizing radiation", prebiotic compounds (precursors of nucleic acids, proteins, metabolic cycles, and metabolism) emerged in notable amounts. Under exposure to UV and/or heating, no prebiotic compounds were produced. This research can shed light on the origin of life not only on the Earth, but also in the Universe.

CONFERENCES AND EDUCATION

In 2013, LRB staff members participated in nine conferences in Russia and five conferences abroad.

Jointly with the Physiology and Fundamental Medicine Department of the Russian Academy of Sciences (RAS), RAS Council on Heavy Ion Physics, and RAS Institute of Biomedical Problems, a two-day conference was held entitled "Neurophysiological Aspects of the Radiation Risk. On the Problem of Interplanetary Flight Safety". The conference was concerned with the following issues: the effect of high-energy heavy charged particles on the structures and functions of the central nervous system; neurophysiology of higher nervous activity; mathematical modeling of the molecular mechanisms of the synaptic transmission of the nervous system signals; and evaluation of the radiation risk of manned interplanetary flights.

The Biophysics Department of Dubna University continued its education activity. Total enrollment in the Human and Environmental Radiation Safety specialty is 48 students; four postgraduates attend the Radiobiology specialty programme. In 2013, eight new students were accepted to the Department. Ten students successfully completed their graduate programmes and received engineer-physicist diplomas. The Department of Cemistry, Geochemistry, and Cosmochemistry offers a Molecular Dynamics course to graduate students of Dubna University.

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11. *Bayarchimeg L., Batmunkh M., Belov O. V.* Reconstruction of the Neural Cell Morphology for Microdosimetric Calculations // Intern. School "Hands-on Research in Complex Systems", Trieste, Italy, July 1–12, 2013. P. 21–22.
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14. *Zdravković S. et al.* Mathematical Procedures Used in Nonlinear Dynamics of Microtubules // Book of Abstr.: II International Seminar "Nonlinear Phenomenology Advances". St. Petersburg, 2013. P. 7.
15. *Bugay A. N.* New Types of Solitonic Excitations in a Nonlinear Helicoidal Model of DNA and Their Biological Significance // Ibid. P. 7.
16. *Dushanov E. et al.* Molecular Dynamics Research on the Conformational Behavior of the DNA Photolyase

Enzyme // Part. Nucl., Lett. 2013. V. 10, No. 6. P. 974–985 (in Russian).

17. *Feldman T., Ostrovsky M., Kholmurodov Kh.* Studies on Retinal Chromophore Functions of Visual Pigment Rhodopsin in Normal and Pathology Versions // Abstr. of the 1st ISCMBS, International Symposium on Computational Materials & Biological Sciences, Waseda University, Tokyo, Japan, Sept. 10–12, 2013.
18. *Kholmurodov Kh. et al.* Molecular Dynamics Studies of Chromophores Conformational Behavior of the Visual Pigment Rhodopsin and DNA Photolyase Enzyme // Proc. of the Intern. Conf. on Condensed Matter Physics, devoted to 85th anniversary of Academician A. A. Adhamov, Dushanbe, Tajikistan, Oct. 17–18, 2013. Donish Publishers, 2013. P. 51.
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International Student Practices. The International Student Practice in JINR Fields of Research has been organized since 2004 on the initiative of the UC, MEPI, MIPT, a number of Polish universities and the Czech Technical University for senior students from the JINR Member States and the countries that have concluded government-level agreements with JINR. Since 2007, due to the increase of applications for participation, the Practice has been held in several stages. For the duration of the International Student Practice, 870 people have become its participants (see Figs. 1 and 2), 200 of them being students from Polish universities. Since 2007, students from South Africa (186 people) and since 2009 students from Egypt (86) have been taking part in the event.

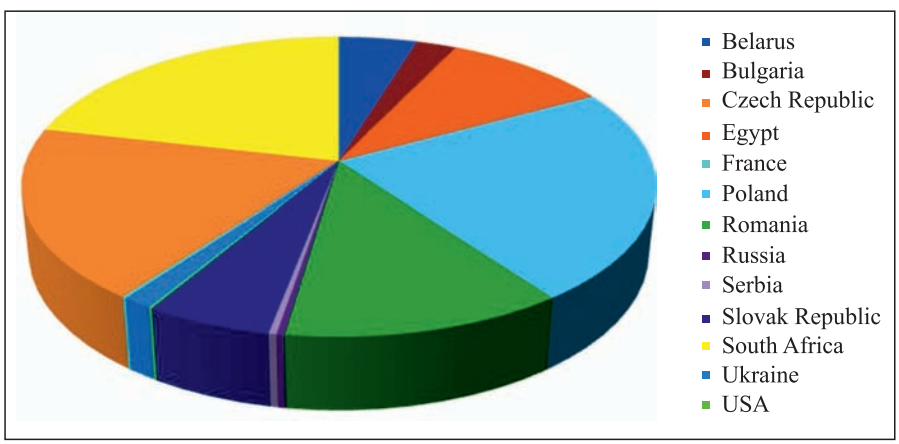


Fig. 1. Number of International Practice participants by countries (2004–2013)

The annual Student Practice in JINR Fields of Research 2013 was held in three stages. The Practice programme traditionally included introductory lectures on the research conducted in the JINR laboratories, excursions to the basic facilities and work on education-and-research projects. The total number of Practice 2013 participants came up to 126 students from Belarus, Bulgaria, Czech Republic, Egypt, Poland, Romania, Slovakia, South Africa, Ukraine, and USA.

On 13 May – 3 June, 18 students from Egypt worked on their education-and-research projects prepared by LIT, BLTP, LRB and FLNP specialists. The second stage of the International Student Practice (7–28 July) was attended by 70 students from the Czech Republic, Poland, Romania, Slovakia, Bulgaria, Ukraine and USA. The participants in the final third stage (9–29 September) were 26 students from South Africa and 10 students from Belarus. The participants

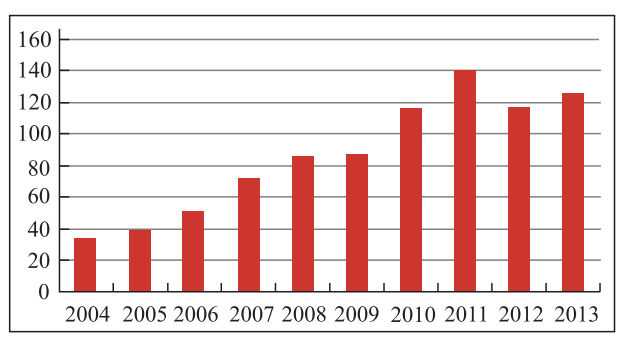


Fig. 2. Number of International Practice participants in 2004–2013

in the second and the third stages of the Practice 2013 worked on the projects prepared by FLNR (17 projects), FLNP (10), BLTP (8), DLNP (7), LIT (3), LRB (3), and VBLHEP (2).

The list of education-and-research projects on the UC website comprises 50 projects, of which 19 were prepared by FLNR specialists, 10 by specialists of FLNP.

The report-presentations of the students on their executed projects are available on the UC website, Practice pages, section "Events".

JINR-Based Educational Process. In 2013, the University Centre trained 509 students from the basic departments of MSU, MIPT, MIREA, Dubna University and JINR Member-State universities. The UC organized summer practical and undergraduate training courses for 100 students from MIPT, MIREA, Dubna University, St. Petersburg and Tula State Universities, Tomsk Polytechnic University, National Taras Shevchenko University of Kiev, Belarus National University of Informatics and Radioelectronics and Skorina Gomel State University. The UC website (http://uc.jinr.ru/) training course database was upgraded (both English and Russian versions) in the sections: particle physics and quantum field theory (26 courses), nuclear physics (21), condensed matter, physics of nanostructures and neutron physics (16), physics research facilities (7), information technologies (8), mathematical and statistical physics (12).

JINR Postgraduate Courses. In 2013, JINR postgraduate courses were attended by 50 students from Armenia, Belarus, Germany, Moldova, Russia and Ukraine (Fig. 3).

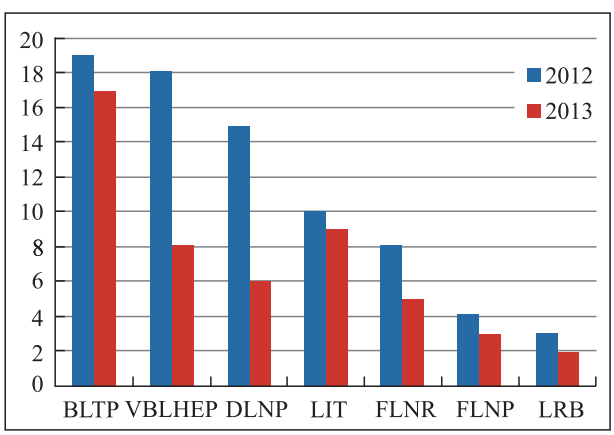


Fig. 3. Distribution of UC postgraduate students over JINR laboratories in 2012 and 2013

The distribution of UC postgraduate students over specialties in 2012 and 2013 is shown in the table.

Distribution of UC postgraduate students by specialties in 2012 and 2013

Specialty	Number of postgraduate students	
	2012	2013
Theoretical Physics (01.04.02)	19	14
Nuclear and Elementary Particle Physics (01.04.16)	22	12
Mathematical Simulation and Numerical Methods (05.13.18)	7	6
Physics Experiment Techniques, Instrument Physics, and Physics Research Automation (01.04.01)	7	5
Mathematical and Software Support of Computers, Computational Complexes, and Networks (05.13.11)	5	4
High Energy Physics (01.04.23)	4	3
Solid State Physics (01.04.07)	3	3
Radiobiology (03.01.01)	3	2
Charged Particle Beam Physics and Accelerator Techniques (01.04.20)	7	1

Organization of Scientific Schools for Teachers of Physics at JINR and CERN. The UC, in collaboration with CERN, continues organizing international scientific schools for teachers of physics from the Member States both at JINR and at CERN. On 23–29 June, Dubna hosted another School for teachers of physics from JINR Member States. The School was attended by 24 teachers and 9 students from Russia, Belarus and Bulgaria. The School programme traditionally included lectures on popular science by the leading JINR specialists, excursions to JINR experimental facilities and laboratories, video conferences with CERN, teachers' presentations on modern physics teaching trends and a scientific seminar for high school students.

On 3–9 November, the Scientific School for teachers of physics from JINR Member States was held at CERN (Geneva). The School was attended by 30 teachers of physics representing the following cities: Moscow, Aprelevka (Moscow Region), Volgograd, Volgorechensk (Kostroma Region), Volzhskiy (Volgograd Region), Voronezh, Zarechniy (Penza Region), Kazan, Kondopoga, Novoyurievo (Tambov Region), Nizhniy Novgorod, Ozersk (Chelyabinsk Region), Petrozavodsk, Petropavlovsk-Kamchatsky, Rybinsk, Samara, St. Petersburg, Sterlitamak, and Zhlobin (Belarus).

Information on the organization and holding of Schools is available on "Virtual Academy of High Energy Physics" (http://teachers.jinr.ru/).

School-Seminar "Integrable Structures in Quantum Field Theory". In April 2013, in the framework of Bogolyubov JINR–Ukraine Programme on theoretical physics, the School-Seminar "Integrable Structures in Quantum Field Theory" for 20 students and post-

graduates from JINR, MIPT, National Research University of Higher School of Economics (NRU HSE) and National Taras Shevchenko University of Kiev (Ukraine) was organized by the JINR UC together with MIPT, NRU HSE, Kharkevich Institute for Information Transmission Problems of RAS and Bogolyubov ITP of Ukraine NAS.

"Russian Reporter" Summer School Physics Workshop "The 105th Element". In summer 2013, a physics workshop "The 105th Element" in the framework of Summer School programme organized by the magazine "Russian Reporter" was held in Dubna. For 30 participants of the workshop "The 105th Element" and a workshop on science journalism, excursions and lectures were organized by the Institute specialists. The programme included a JINR–CERN video conference.

Video Conferences. The JINR University Centre continues to provide assistance in organization of video conferences. Live video is provided through a videoconferencing management system of JINR, where by using the UC duplex access point one can take part in a meeting, ask questions and speak in the debate.

In 2013 the following video conferences were held:

— a teleconference between the JINR UC and State Funded Educational Institution of Further Education for Children "Centre of Creative Development and Liberal Arts Education for Gifted Children POISK", Stavropol;

— a video conference JINR UC – Kislovodsk, School No. 17, in the framework of the scientific practical web-seminar "Research Activities of Students as a Basis for the Implementation of a System-Active Approach";

— a video conference between the Laboratory for Space Studies of Ulyanovsk Section of Volga Branch of the Tsiolkovsky Academy of Cosmonautics of Ulyanovsk State University and CERN;

— a video conference of the boarding school named after A. N. Kolmogorov of Moscow State University (SUC MSU), Moscow schools No. 1329 and No. 57 and Elektrostal schools with CERN;

— a video conference JINR UC – Tikhvin, Lyceum No. 8 – Kislovodsk, School No. 17 "Neutron Physics: Obtaining and Using Neutrons";

— a video conference Moscow City Palace of Children (Youth) Creativity – CERN "Research in High Energy Physics".

Organization of Visits. In 2013, orientation lectures and excursions to the JINR laboratories were organized for students from MEPI (30), Tver State University (25), and for 16 Polish students (Warsaw). Excursions, video conferences and classes in the physical lab for schoolchildren from Dmitrov (19), Dubna (67), Moscow (137), Odintsovo (30), Tver (32), Yaroslavl (29), for 20 students from Kennedy School physics group (Berlin, Germany), for 25 winners of the II Championship of the project "CanSat in Russia", as well as excursions for Dubna residents in the framework of the programme "Popularization of Scientific Knowledge" (34), were arranged.

Work with Schoolchildren and Teachers. For 25 high-school students from Dubna, classes in physics were held twice a week within the school period. During the period of introductory visits, workshops and physics demonstrations were organized for school groups in the UC physical laboratory.

Training and Retraining of Workers, Engineers and Employees. Seventy staff members of the Institute were trained at the training courses for personnel maintaining facilities subordinate to Rostechnadzor.

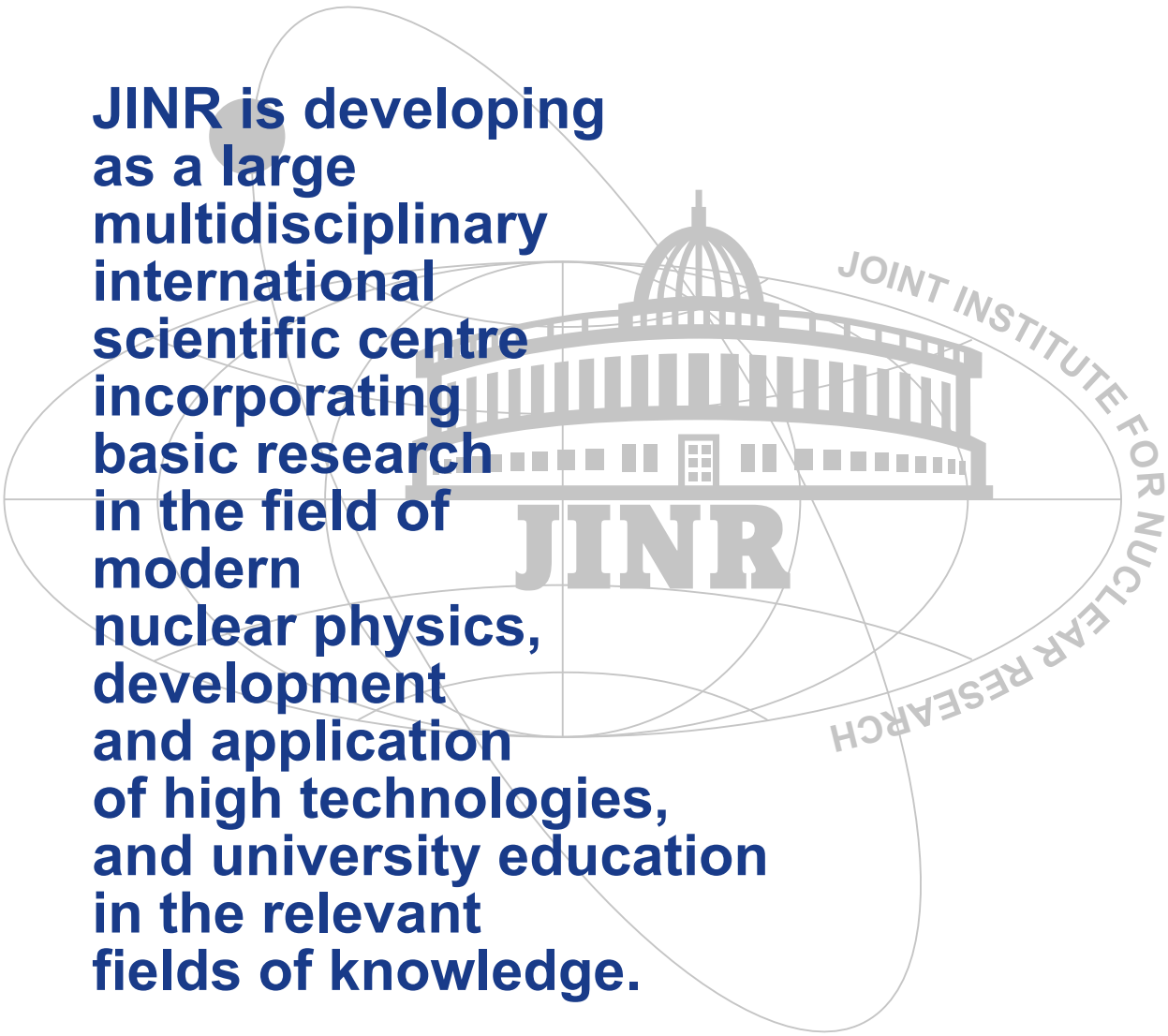
In 2013, six members of the Institute improved their skills at various seminars organized by academic institutions of Moscow; 116 staff members of JINR were trained at the courses organized by JINR and certified by JINR Central Certification Commission. In 2013, certification by the Territory Certification Commission of Rostechnadzor of 20 Institute executives and specialists in the normative legal acts and normative-technical documents stating requirements for industrial safety in various fields of supervision was organized. In 2013, six students from the Moscow Region Industrial-Economic and Agrarian-Technological Colleges were trained at JINR.

The UC continues to run an English language course for postgraduate students and JINR staff members, and a Russian language course for foreign specialists.

UC Study Guides. In 2013, the following UC study guides were published:

- *S. V. Ulyanov, G. P. Reshetnikov.* "Intelligent Computing Technologies";
- *D. Dinev.* "High-Energy Heavy-Ion Accelerators".

JINR is developing as a large multidisciplinary international scientific centre incorporating basic research in the field of modern nuclear physics, development and application of high technologies, and university education in the relevant fields of knowledge.



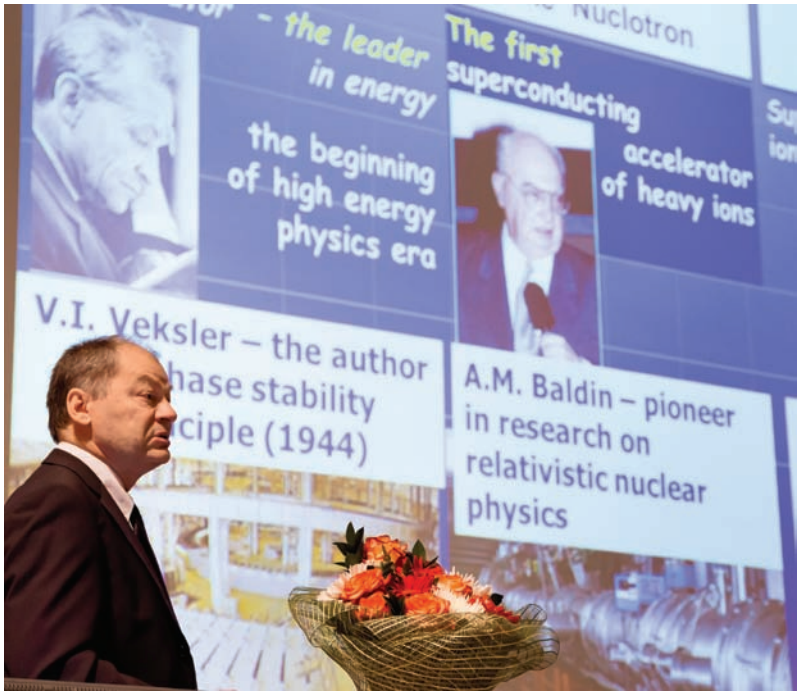
Bogoliubov Laboratory of Theoretical Physics, 14 October.
Inauguration ceremony of a memorial plaque to Academician A. N. Sissakian

Bogoliubov Laboratory of Theoretical Physics, 22 July.
Participants of the Helmholtz Summer School on Physics of Heavy Quarks and Hadrons

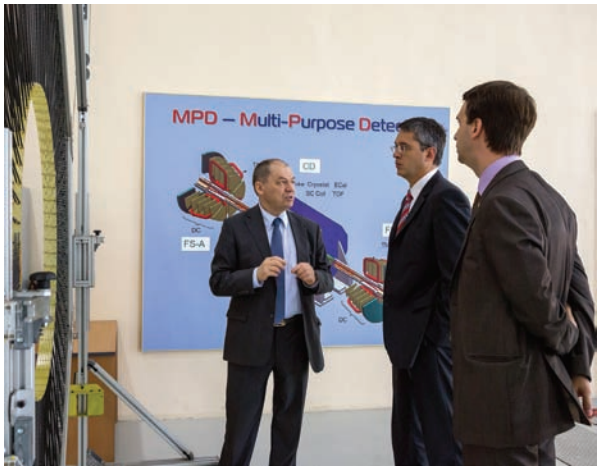
Bogoliubov Laboratory of Theoretical Physics, 13 September.
The Helmholtz International School “Cosmology, Strings and New Physics”

Dubna, 23 September. The 22nd Workshop of the CBM collaboration

Dubna, 18 September.
Inauguration of a memorial plaque
to L. G. Makarov and of an alley named after
L. P. Zinoviev



Veksler and Baldin Laboratory of High Energy Physics, 18 September.
The International Seminar “20 Years since the Start-up of the Nuclotron and 60 Years of Research in High Energy Physics at LHEP”



Dubna, 8 August. The International Workshop “Prospects for Cooperation in the NICA Megascience Project”

Veksler and Baldin Laboratory of High Energy Physics. Technical site of the assembling and certification procedure of superconducting magnets

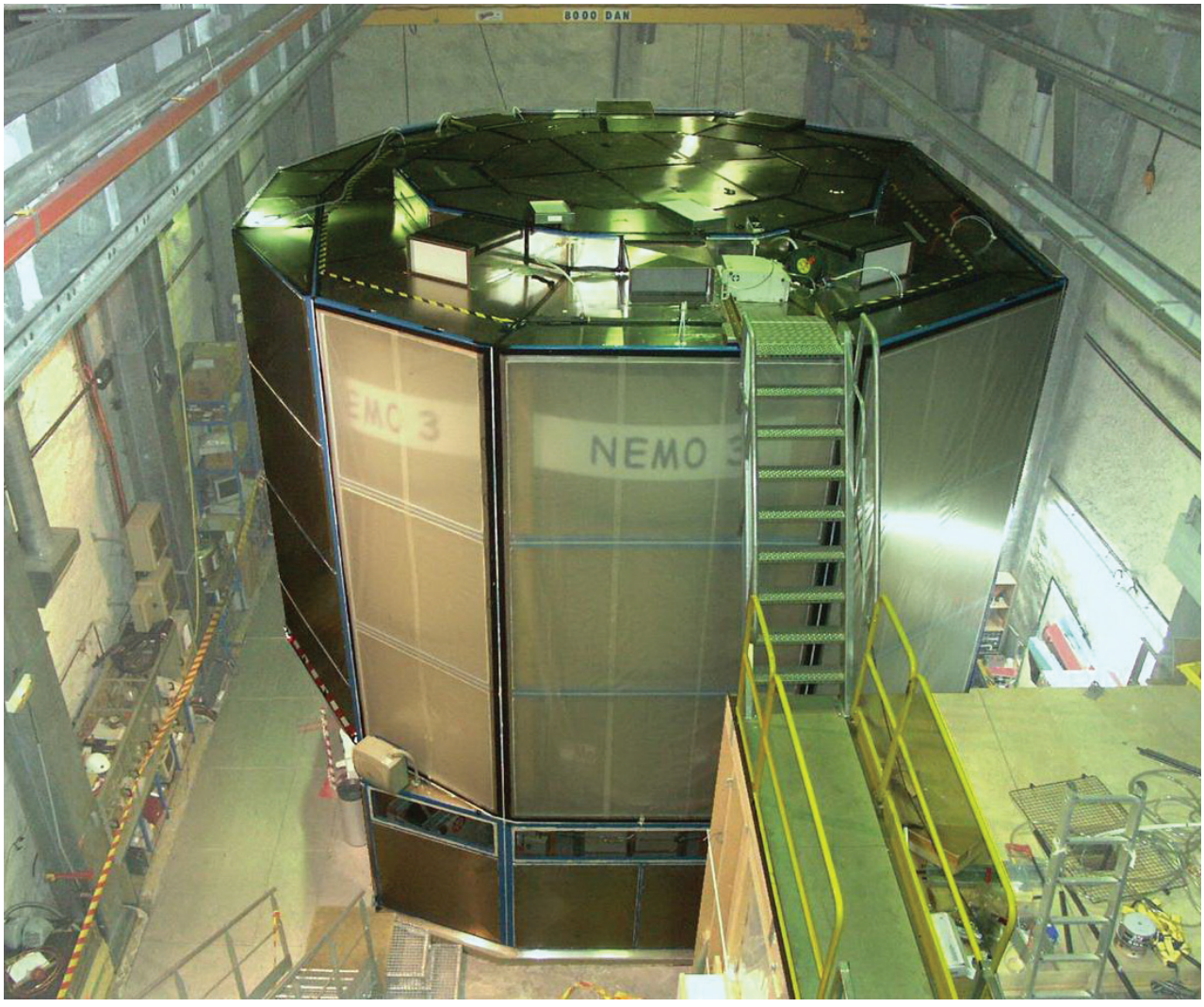
Dubna, the V. Vysotsky alley. The monument to V. P. Dzhelepov and B. M. Pontecorvo

Dzhelepov Laboratory of Nuclear Problems, 22 February. The opening ceremony of a memorial plate of the European Physical Society on the entrance door to B. Pontecorvo's study

Dzhelepov Laboratory of Nuclear Problems, 8–12 April.
Participants of XVII Scientific Conference for Young Scientists, dedicated to the centenary of the birth of V. P. Dzhelepov

Kalinin NPS (Russia). Participants of the DANSS experiment

The Modane underground laboratory (France). The set-up NEMO III



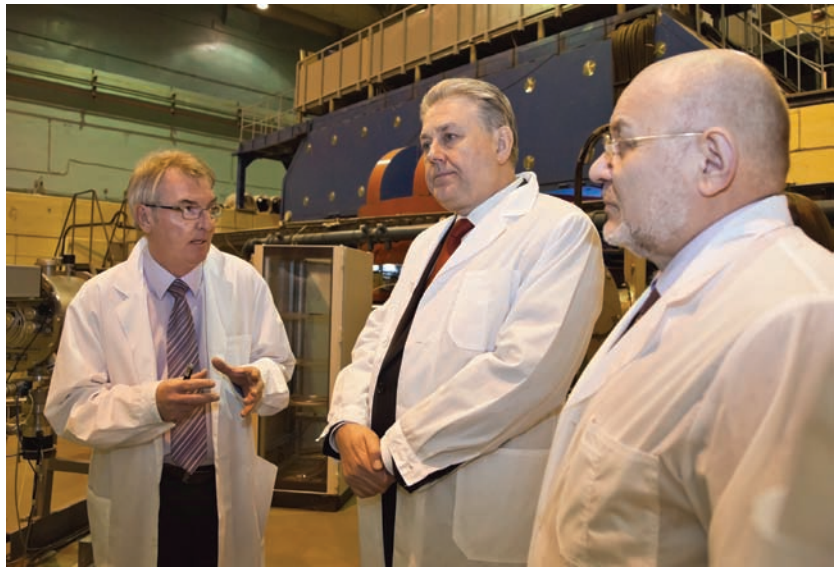
Dubna, 16–17 December. JINR Neutrino Programme meeting

Dubna, 2 September. A visiting session of the Physical Sciences Division of RAS dedicated to the 100th anniversary of B. Pontecorvo's birth

Dubna, 2 October. Participants of the 11th meeting of the COMET collaboration

Dubna, 24 January. Acting Governor of the Moscow Region A. Vorobiev on a visit to JINR, seen here at the Flerov Laboratory of Nuclear Reactions (*photo by Yu. Tarakanov*)

Dubna, 26 August. Participants of the European School on Exotic Beams



Dubna, 20 February. A delegation from Ukraine headed by Ambassador Extraordinary and Plenipotentiary of Ukraine to RF V. Elchenko (centre) on a visit to JINR

Dubna, 24 May. The ceremonial meeting dedicated to the centenary of the birth of the founder and first director of JINR LNR Academician G. N. Flerov. Flower-laying ceremony at the monument to the scientist


ЛАБОРАТОРИЯ ЯДЕРНЫХ РЕАКЦИЙ
им. Г.Н. ФЛЕРОВА, ОИЯИ
DRIBs-III (Dubna Radioactive Ions Beams)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Frank Laboratory of Neutron Physics, 25 October.
Laboratory seminar on the occasion of the 105th anniversary of the birth of Academician I. M. Frank

Frank Laboratory of Neutron Physics. The spectrometer for polarized neutrons REMUR

Frank Laboratory of Neutron Physics. The Fourier diffractometer for analysis of internal stresses with the method of high resolution neutron diffraction FSD

Frank Laboratory of Neutron Physics.
The spectrometer DN-12 for studies of microsamples with the method of neutron scattering at high pressure

Laboratory of Information Technologies, 8 July. Participants of the International Conference "Mathematical Modeling and Computational Physics"

Varna (Bulgaria), 9–16 September. Participants of the Symposium on Nuclear Electronics & Computing

Dubna, 26 June. The conference “Neurophysiological Aspects of Radiation Risk in the Context of Interplanetary Flight Safety”

Frank Laboratory of Neutron Physics, 13 February. A Japanese delegation on a visit to JINR

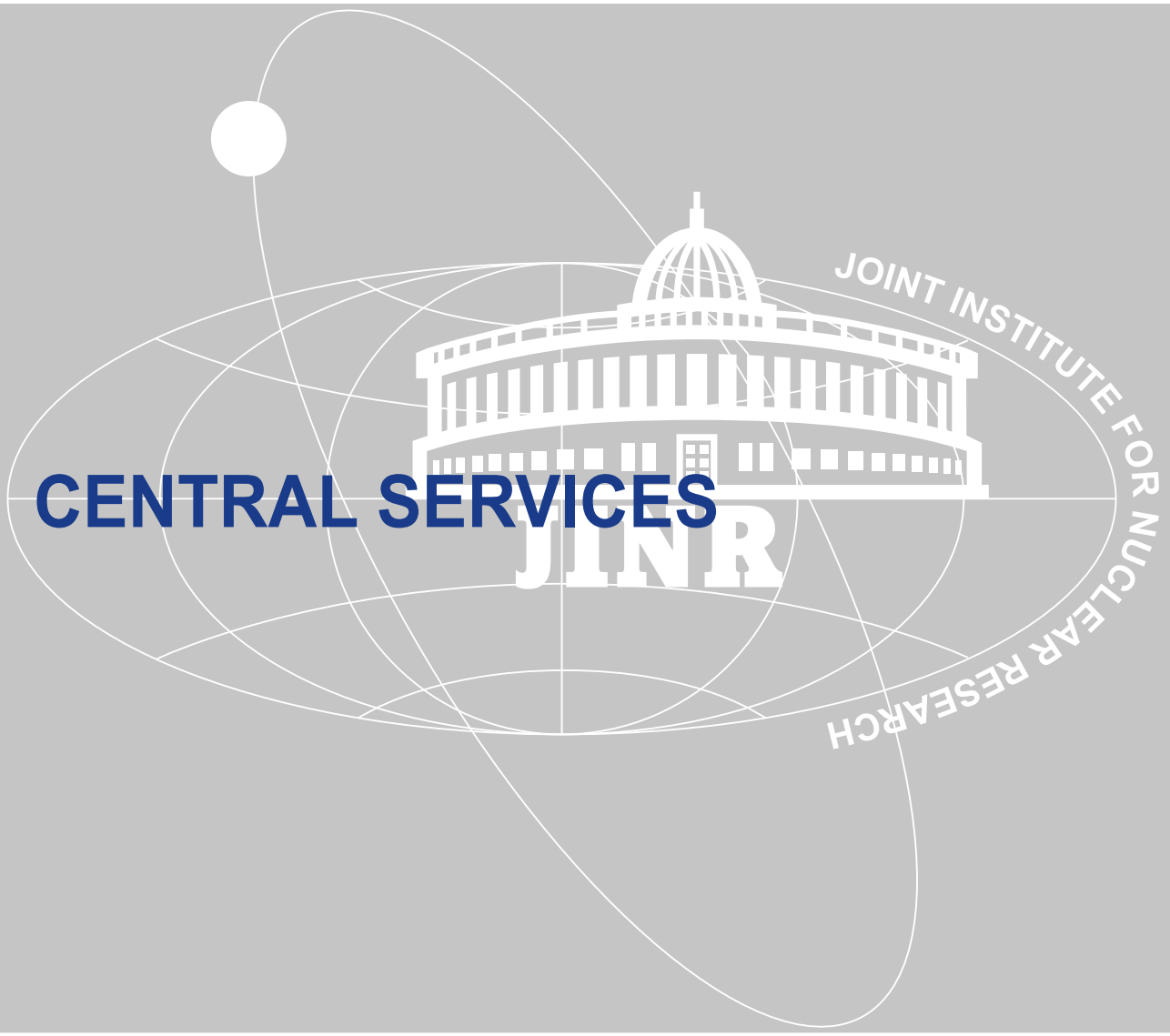
Ulaanbaatar, 2 October. Participants of the International Conference “Radiation Biology and Radiation Protection”

Dubna, 25 June. Organizers and students of the JINR–CERN school for physics teachers from the JINR Member States

Dubna, May. Students from Egypt carry out research projects at JINR Laboratories in the framework of the International Student Practice 2013

Dubna, July. The International Practice in JINR trends of research, stage two

2013



CENTRAL SERVICES

PUBLISHING DEPARTMENT

In 2013, the Publishing Department issued 141 titles of publications and 50 titles of official documents.

A total of 29 collections of report theses, proceedings of various conferences, schools and workshops organized by JINR, monographs, booklets and other editions were published. Among them were: the Proceedings of XX International Seminar on Interaction of Neutrons with Nuclei (ISINN-20) (Alushta, Ukraine, 21–26 May 2012), the Proceedings of the workshop "Relativistic Nuclear Physics: From Hundreds of MeV to TeV" (Slovakia, Stara Lesna, 17–23 June 2012), the Selected Proceedings of CMS workshop "Perspectives on Physics and CMS at Very High Luminosity, HL-LHC" (Alushta, 2012), the book "Russia at CERN" and others.

The JINR Annual Report for the year 2012 (Russian and English versions) was published.

"Bruno Maximovich Pontecorvo. To the Centenary of the Birth" is the title of a book devoted to the outstanding physicist Academician B. M. Pontecorvo. The book included an autobiography of the scientist, the complete bibliographic list of his works and the main dates of his life and career.

A second edition of the book "Nikolai Nikolaevich Govorun. To the 80th Anniversary of the Birth" was issued. It contains essays about the life and scientific activities of the distinguished scientist, as well as memoirs about him written by his colleagues, pupils, friends and relatives.

In December 2013 a collection "40 Years of Cooperation between JINR (Dubna) and IN2P3 (France)" was issued. Its articles discuss various fields of long-standing scientific cooperation among physicists of the Joint Institute for Nuclear Research and the National Institute of Nuclear Physics and Particle Physics of France.

In 2013 six issues of the journal "Physics of Elementary Particles and Atomic Nuclei" that included 12 reviews were published. Issues 2 and 3 contain 37 reports presented at the international conference "Advances of Quantum Field Theory" (Dubna, 4–7 October 2011). Issue 6 contains 20 plenary reports of the 20th International Symposium on Spin Physics (SPIN-2012) (Dubna, 17–22 September 2012).

Seven issues of the journal "Physics of Elementary Particles and Atomic Nuclei, Letters" were published. They include 126 papers.

The bulletin "JINR News" was continued to be published in Russian and English. Fifty issues of the JINR weekly newspaper "Dubna: Science, Cooperation, Progress" were published in 2013.

Two editions in the series of the JINR UC study guides were issued. These were the manuals "Atomic Nucleus Models" by R. V. Jolos and "Accelerators of High Energy Heavy Ions" by D. Dinev.

In the framework of exchange of scientific publications, the organizations that cooperate with JINR (in above 40 countries of the world) received JINR publications: JINR preprints and communications, the information bulletin "JINR News", JINR Annual Reports, the journals "Particles and Nuclei" and "Particles and Nuclei, Letters".

The Publishing Department forwarded over 150 papers and reports on the results of research conducted by JINR scientists to the editorial boards of journals, to various conferences, symposia, meetings and schools held both in JINR Member States and in other countries. Papers by JINR staff members were published in the journals "Nuclear Physics", "Theoretical and Mathematical Physics", "Instruments and Experimental Techniques", "Radiation Biology. Radioecology", "Crystallography", "Journal of Surface Investigation. X-ray, Synchrotron and Neutron Techniques", "Journal of Physics", "Nuclear Instruments and Methods" and other periodicals.

To keep readers of the Science and Technology Library timely informed about new publications received, express bulletins of STL and of the Licensing and Intellectual Property Department are issued by the Publishing Department. "The Bibliographic Index of Papers Published by JINR Staff Members in 2012" was issued.

The Publishing Department fulfilled numerous orders of the laboratories to produce posters, Xerox copies and book binding. Over 110 thousand various forms were printed for experimental information processing and other purposes. Some JINR editions issued in 2013 were printed on the new digital printer Konica Minolta.

SCIENCE AND TECHNOLOGY LIBRARY

In 2013, the JINR Science and Technology Library rendered services to 3714 readers. 13 147 copies of publications were given out. As of 1 January 2014, the Library stock amounted to 433 945 copies, 189 654 of them being in foreign languages. 237 publications ordered by readers were received via the interlibrary loan system. On the whole, the Library received 3110 copies of books, periodicals, preprints and theses from all compiling sources, including 1406 publications in foreign languages. All the new publications were registered in the central catalogues, branch catalogues and in the information system Liber.

The weekly express bulletins "Books", "Articles", "Preprints" (156 issues) were published, including 14 017 titles. Electronic versions of the bulletins are distributed among 100 addresses via e-mail. Subscription is available via the scientific library website in the section "Services". The exhibitions of new acquisitions of books, preprints, periodicals and theses were arranged weekly. They displayed 2521 publications. Eight topical exhibitions were organized.

The electronic catalogues of books, journals, articles, preprints and theses are online at http://lib.jinr.ru/cat.htm. The total number of requests to the JINR electronic catalogues was 6000. The service of online ordering of literature via OPAC (Online Public Access Catalogue) continued to be available for the users.

"The Bibliographic Index of Papers Published by JINR Staff Members in 2012" (1465 titles) was prepared by the JINR Science and Technology Library and published by the JINR Publishing Department. The Index is available on the Library website, in the section "Services". The database of papers of JINR scientists (bibliographic descriptions of papers since 1987) is Internet accessible.

1165 JINR preprints and communications published in 1987–1988 have been scanned and added to the electronic catalogue.

The Library received 154 titles of periodicals. Due to the Library subscription to the foreign journals, JINR scientists have access to full text electronic versions of these journals.

The Scientific Electronic Library is used by the readers very actively. The total number of requests to the electronic journal versions through the Scientific Electronic Library and sites of foreign publishing houses was 100 000. Due to the Library participation in the RFBR and the NEICON Consortium, JINR scientists are provided with the electronic access to the full text versions of journals of the publishing houses Wiley, Elsevier, Springer, IOP, of the American Physical Society, American Institute of Physics, Nature Publishing Group, as well as of the journal "Science".

Within the framework of the project "History of JINR and Dubna in Books, Journals and Central Newspapers", 89 new bibliographic records have been introduced.

In 2013, in exchange for JINR publications printed by the JINR Publishing Department, the Library received 550 publications from 20 countries. Of them 160 issues were from Russia, 13 from Romania, 28 from Ukraine, 227 from Germany, 4 from Italy, 5 from the USA, 10 from France, 35 from Japan, and 33 from CERN.

In 2013, within the framework of the Liber information system database, the input of documents to electronic catalogue was for: books — 3357 titles, journals — 1782 numbers, preprints — 1734 titles, theses and author's abstracts — 131 titles, book articles — 519 titles, and journal articles — 13 584 titles. As of 1 January 2014, the number of records introduced into the Liber information system was 227 426.

LICENSING AND INTELLECTUAL PROPERTY DEPARTMENT

In 2013, the activities of the Licensing and Intellectual Property Department (LIPD) were conducted in the following areas:

Industrial Intellectual Property Protection. Contacts continued with the Federal Institute of Industrial Property (FIIP) of the RF Federal Service for Intellectual Property (Rospatent) on applications for JINR patents that underwent the formal FIIP expertise of Rospatent in 2012–2013.

Changes, alterations and clarifications were agreed upon and included on the application documents according to the comments rendered by FIIP experts. In order to define the technical level of new elaborations made by JINR staff members for the purpose of patentability, a number of elaborations by JINR staff members were inspected: objects of legal protection were defined and classified according to the International Patent Classification (IPC); analogues and prototypes were searched. Reports on patent studies were prepared.

For nine elaborations, together with the authors, application packets were prepared and sent to the RF Rospatent to obtain the patents for:

— An induction cyclic accelerator of electrons;
— A method to determine deflection angle;
— A drift chamber for work in vacuum;
— A method to obtain coherent radiation;
— A method of particle registration with drift-tube based detectors;
— A device to measure the tube stretching value in straw detectors;
— A method to manufacture an adapter to connect the resonator with the cryomodule cover of the collider;
— A method to manufacture mono- and oligo-pore membranes;
— A method to measure dimensions of the comet nucleus.

Six RF patents were received:

— "Cyclic Accelerator of Charged Particles", author: G. N. Dolbilov;
— "Coordinate Gas-Filled Detector", authors: I. A. Zhukov, V. V. Myalkovsky, V. D. Peshekhonov, S. V. Rabtsun, N. A. Russakovich, N. D. Topilin;
— "A Gas-Dynamic Method to Register Balls That Move in a Cylinder Tube", authors: T. B. Petukhova, V. K. Shirokov, E. P. Shabalin;
— "Pelletized Cold Neutron Moderator", authors: V. D. Ananiev, A. V. Belyakov, M. V. Bulavin, A. E. Verkhoglyadov, S. A. Kulikov, A. A. Kustov, K. A. Mukhin, E. P. Shabalin, D. E. Shabalin;
— "A Cryogenic Pellet Batcher for the Cold Neutron Moderator", authors: S. A. Kulikov, A. N. Fedorov, E. P. Shabalin;
— " A Multileaf Collimator for Proton Ray Therapy", author: A. V. Agapov.

In 2013, 43 JINR patents were supported.

The computer program "The Local Monitoring System of the Computer Complex Litmon" by V. V. Korenkov, V. B. Mitsyn, and P. V. Dmitrienko was registered in Rospatent (certificate on the state registration No. 2013617287).

Patents and Information. In 2013, 145 issues of the Rospatent official gazette "Inventions. Utility Models" were received at JINR. The information published in the bulletins was processed with respect to the JINR topics. The processing results were presented in 12 issues of the LIPD bulletins "Patents" distributed in departments of JINR. The Department stock is 3053 Rospatent bulletins.

The LIPD internet page was regularly updated on the JINR website.

Standardization. The standard library was supplemented with: 30 new intergovernmental and state RF standard documents (GOSTs), 12 GOST directories and standard information directories for 2013, directories of national standards and technical conditions, guidelines, recommendations and regulations issued in 2013. Over 132 alterations were introduced into relevant documents of the standard library files and subscribers' copies on

the basis of these norm documents (ND). More than 16 GOST official copies were distributed in the departments for permanent use. The departments regularly obtained information on new ND and alteration in GOSTs.

Database and automatic search for norm documentation were developed on the basis of the LIPD archives. The access to the database (about 11 600 positions) was organized on the web page of LIPD.

"The Catalogue of Normative Legal Acts and Norm Documentation Used at the Joint Institute for Nuclear Research to Conduct Activities in the Field of Usage of Atomic Energy" was introduced into operation (JINR catalogue АЭ-2013) compiled on the basis of catalogue П-01-01-2013 chapter II "State Regulation of Safety in the Usage of Atomic Energy" approved with the order of the Federal Service on Ecological, Technological and Atomic Surveillance No. 385 of 4 September 2013.

Alterations were introduced into the "Index of Normative Legal Acts and Norm Documents Used at JINR" of 1 March 2005. Data on intergovernmental standards (GOST), national standards of the Russian Federation (GOST RF) and other normative-technical documentation applied at the Joint Institute for Nuclear Research were updated for the year 2013.

Licensing. In 2013, JINR re-issued two licenses of the Federal Service on Ecological, Technological and Atomic Surveillance and one license of the Ministry of Education of the Moscow Region for the types of activities under their surveillance.

2013

ADMINISTRATIVE ACTIVITIES

FINANCIAL ACTIVITIES

The Committee of Plenipotentiaries of the Governments of the JINR Member States passed the budget for 2013 of US$143 222.45 thousand for scientific research, construction of basic facilities and other work related to JINR activities.

The budget income in 2013 was shaped at the expense of JINR Member States' contributions, means obtained through agreements on scientific and technical cooperation with the countries that are not JINR members and other sources. The actual receipt of money during the year was US$135 459.7 thousand.

The actual expenses of the Institute in all trends are demonstrated in the following table:

	Chapter	Actual expenses in 2013 (in thous. US dollars)	%
I.	Scientific research	74 165.0	58.4
II.	Basic facilities' operation	8646.5	6.8
III.	Laboratories' infrastructure	18 995.7	15.0
IV.	JINR infrastructure	25 204.5	19.8
	TOTAL	**127 011.7**	**100.0**

STAFF

As of 1 January 2014, the total number of the staff members at the Joint Institute for Nuclear Research was 4667.

Working at JINR are: RAS Academicians V. G. Kadyshevsky, V. A. Matveev, Yu. Ts. Oganessian, M. A. Ostrovsky, D. V. Shirkov; RAS Corresponding Members V. L. Aksenov, E. A. Krasavin, I. N. Meshkov, A. A. Starobinsky, G. V. Trubnikov, G. D. Shirkov; Members of other state Academies of Sciences V. A. Moskalenko, I. Zvara, R. M. Mir-Kasimov, A. Hrynkiewicz; 257 Doctors of Science, 579 Candidates of Science, including 80 Professors and 23 Assistant Professors.

In 2013, 335 people were employed and 261 people were discharged because of engagement period expiry and for other reasons.

AWARDS

Director of the Veksler and Baldin Laboratory of High Energy Physics V. D. Kekelidze was awarded a badge ***"Honorary Worker of Science and Technology of RF"***.

For the service for JINR, long-standing and fruitful work, the title ***"Honorary JINR Staff Member"*** was conferred on 25 staff members of the Institute. In 2013, 71 JINR staff members were awarded the departmental badge of Honour in Labour ***"Veteran of Atomic Energy Industry"***. A number of staff members of the Institute were presented other departmental, city and Institute awards.

Responsible for the preparation of the Annual Report: B. Starchenko

The Annual Report was prepared by
D. Chudoba
S. Dotsenko
N. Golovkov
E. Ivanova
T. Kiseleva
I. Koshlan
G. Kuzmina
S. Nedelko
S. Pakuliak
D. Peshekhonov
D. Podgainyj
S. Sidorchuk
I. Shcherbakova
I. Titkova
L. Tyutyunnikova
A. Vasiliev

Translation by
M. Aristarkhova
T. Avdeeva
S. Chubakova
L. Galimardanova
O. Kronshtadtov
I. Kronshtadtova
M. Potapov
G. Sandukovskaya
S. Savinykh

Design by
Yu. Meshenkov

Photography by
P. Kolesov
E. Puzynina

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Компьютерная верстка *И. Г. Андреевой, Т. А. Савельевой*

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Издательский отдел Объединенного института ядерных исследований
141980, г. Дубна, Московская обл., ул. Жолио-Кюри, 6.
E-mail: publish@jinr.ru
www.jinr.ru/publish/